This instruction manual applies to the ETL600 Release 4 system.

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<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>A9CS</td>
<td>RF connection plate</td>
</tr>
<tr>
<td>AC</td>
<td>Alternating Current</td>
</tr>
<tr>
<td>ADC</td>
<td>Analog to Digital Converter</td>
</tr>
<tr>
<td>AF</td>
<td>Audio Frequency</td>
</tr>
<tr>
<td>AFC</td>
<td>Automatic Frequency Control</td>
</tr>
<tr>
<td>AGC</td>
<td>Automatic Gain Control</td>
</tr>
<tr>
<td>AIS</td>
<td>Alarm Indication Signal</td>
</tr>
<tr>
<td>ALS</td>
<td>Automatic Laser Shutdown</td>
</tr>
<tr>
<td>APLC</td>
<td>Analog Power Line Carrier</td>
</tr>
<tr>
<td>ASA</td>
<td>American Standards Association</td>
</tr>
<tr>
<td>AWG</td>
<td>American Wire Gauge</td>
</tr>
<tr>
<td>BER</td>
<td>Bit Error Rate</td>
</tr>
<tr>
<td>C</td>
<td>Common (terminal of switchover relays)</td>
</tr>
<tr>
<td>CCIR</td>
<td>International Radio Consultative Committee</td>
</tr>
<tr>
<td>Cigré</td>
<td>International Council on Large Electric Systems</td>
</tr>
<tr>
<td>CISPR</td>
<td>International Special Committee on Radio Interference</td>
</tr>
<tr>
<td>CODEC</td>
<td>Coder-Decoder</td>
</tr>
<tr>
<td>CRC</td>
<td>Cyclic Redundancy Check</td>
</tr>
<tr>
<td>DAC</td>
<td>Digital to Analog Converter</td>
</tr>
<tr>
<td>DAPSK</td>
<td>Differential Analog Phase Shift Keying</td>
</tr>
<tr>
<td>dB</td>
<td>Logarithmic unit for levels</td>
</tr>
<tr>
<td>dBm</td>
<td>Logarithmic unit for absolute levels</td>
</tr>
<tr>
<td>dBm0</td>
<td>Logarithmic unit for system levels</td>
</tr>
<tr>
<td>dBm0p</td>
<td>Logarithmic unit for psophometrically weighted system levels</td>
</tr>
<tr>
<td>dBr</td>
<td>Logarithmic unit for relative levels</td>
</tr>
<tr>
<td>DC</td>
<td>Direct Current</td>
</tr>
<tr>
<td>DCE</td>
<td>Data Circuit-terminating Equipment</td>
</tr>
<tr>
<td>DDS</td>
<td>Direct Digital Synthesis</td>
</tr>
<tr>
<td>DPLC</td>
<td>Digital Power Line Carrier</td>
</tr>
<tr>
<td>DSP</td>
<td>Digital Signal Processor</td>
</tr>
<tr>
<td>DTE</td>
<td>Data Terminal Equipment</td>
</tr>
<tr>
<td>E</td>
<td>Signaling wire from PAX</td>
</tr>
<tr>
<td>E40A</td>
<td>Type of cabinet</td>
</tr>
<tr>
<td>E40D</td>
<td>Type of cabinet</td>
</tr>
<tr>
<td>E5TC</td>
<td>ETL600R4 carrier combiner / Tx filter</td>
</tr>
<tr>
<td>E5TH</td>
<td>ETL600R4 RF hybrid / Tx filter</td>
</tr>
<tr>
<td>EMC</td>
<td>Electromagnetic Compatibility</td>
</tr>
<tr>
<td>Abbreviation</td>
<td>Full Form</td>
</tr>
<tr>
<td>--------------</td>
<td>-----------</td>
</tr>
<tr>
<td>EMI</td>
<td>Electromagnetic Interference</td>
</tr>
<tr>
<td>EN</td>
<td>Europäische Norm</td>
</tr>
<tr>
<td>EOC</td>
<td>Embedded Operation Channel</td>
</tr>
<tr>
<td>EPROM</td>
<td>Electrically Programmable Read Only Memory</td>
</tr>
<tr>
<td>ESD</td>
<td>ElectroStatic Discharge</td>
</tr>
<tr>
<td>FAQ</td>
<td>Frequently Asked Questions</td>
</tr>
<tr>
<td>FDM</td>
<td>Frequency Division Multiplex</td>
</tr>
<tr>
<td>FLASH</td>
<td>Electrically Programmable Read Only Memory</td>
</tr>
<tr>
<td>FPGA</td>
<td>Field Programmable Gate Array</td>
</tr>
<tr>
<td>FSK</td>
<td>Frequency Shift Keying</td>
</tr>
<tr>
<td>G4AI</td>
<td>Teleprotection interface</td>
</tr>
<tr>
<td>HF</td>
<td>High Frequency</td>
</tr>
<tr>
<td>HMI</td>
<td>Human Machine Interface</td>
</tr>
<tr>
<td>HMI600</td>
<td>User interface program for ETL600</td>
</tr>
<tr>
<td>HTML</td>
<td>Hyper Text Markup Language</td>
</tr>
<tr>
<td>HTTP</td>
<td>Hyper Text Transfer Protocol</td>
</tr>
<tr>
<td>HV</td>
<td>High Voltage</td>
</tr>
<tr>
<td>IEC</td>
<td>International Electrotechnical Commission</td>
</tr>
<tr>
<td>IP</td>
<td>Internet Protocol</td>
</tr>
<tr>
<td>IRIG-B</td>
<td>Standard interface for Time/Date synchronization</td>
</tr>
<tr>
<td>ITU-T</td>
<td>International Telecommunication Union-Telecommunication Standardization Sector</td>
</tr>
<tr>
<td>LAN</td>
<td>Local Area Network</td>
</tr>
<tr>
<td>LED</td>
<td>Light Emitting Diode</td>
</tr>
<tr>
<td>LF</td>
<td>Low Frequency</td>
</tr>
<tr>
<td>LFPT</td>
<td>Link Fault Pass Through</td>
</tr>
<tr>
<td>LOS</td>
<td>Loss Of Signal</td>
</tr>
<tr>
<td>M</td>
<td>Signaling Wire to PAX</td>
</tr>
<tr>
<td>MC / uC</td>
<td>Micro Controller</td>
</tr>
<tr>
<td>MDIX</td>
<td>Automatic Medium-Dependent Interface crossover</td>
</tr>
<tr>
<td>MOD600</td>
<td>ETL600 Modem in the DPLC channel</td>
</tr>
<tr>
<td>MUX600</td>
<td>ETL600 Data Terminal Multiplexer</td>
</tr>
<tr>
<td>N.A. / n.a.</td>
<td>Not Applicable or Not Available</td>
</tr>
<tr>
<td>NC</td>
<td>Normally Closed (terminal of switchover relays)</td>
</tr>
<tr>
<td>NO</td>
<td>Normally Open (terminal of switchover relays)</td>
</tr>
<tr>
<td>NSD570</td>
<td>Standalone Teleprotection Equipment</td>
</tr>
<tr>
<td>NSD600</td>
<td>ETL600 integrated Teleprotection Equipment</td>
</tr>
<tr>
<td>NSD70C</td>
<td>Standalone Teleprotection Equipment</td>
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<tr>
<td>NSK600</td>
<td>ETL600 modem in AF channel</td>
</tr>
<tr>
<td>O4CV</td>
<td>Compressed telephony interface</td>
</tr>
</tbody>
</table>
O4LE  AF interface
OFDM  Orthogonal Frequency Division Multiplex
P4EX  Extender board for tuning of E5TH
P4LM  Receive filter tuning adapter
P4LT  DSP module without LAN ports
P4LV  DSP module with LAN ports and digital transit ports
P4LX  DSP module with LAN ports, digital transit ports and additional serial ports
P4RX  ETL600 Rx filter
PAR   Peak to Average Ratio
PAX   Private Automatic telephony eXchange
PC    Personal Computer
PCB   Printed Circuit Board
PDH   Plesiochronous Digital Hierarchy
PE    Protective Earth
PE    Peak Envelope
PEP   Peak Envelope Power
PEV   Peak Envelope Voltage
PLC   Power Line Carrier
PLL   Phased Locked Loop
PSK   Phase Shift Keying
R1BC  Alarm Relay Module
R9AL  Earth Rail
RAM   Random Access Memory
RD    Receive Data
RFC   Request For Comments
RMS   Root Mean Square
RS-485 Data interface standard
RT    Receive Timing
RTP   Real-Time Transport Protocol
RTC   Real Time Clock
Rx    Receive(r)
SD    Send Data
SDH   Synchronous Digital Hierarchy
SMD   Surface Mounted Device
SNR   Signal to Noise Ratio
SONET Synchronous Optical Network
SSL/TLS Secure Socket Layer / Transport Layer Security
ST    Send Timing
STP   Shielded Twisted Pairs
<table>
<thead>
<tr>
<th>Term</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>TDM</td>
<td>Time Division Multiplex</td>
</tr>
<tr>
<td>TCP</td>
<td>Transmission Control Protocol</td>
</tr>
<tr>
<td>TPE</td>
<td>Teleprotection Equipment</td>
</tr>
<tr>
<td>TT</td>
<td>Terminal Timing</td>
</tr>
<tr>
<td>Tx</td>
<td>Transmit(ter)</td>
</tr>
<tr>
<td>UART</td>
<td>Universal Asynchronous Receiver Transmitter</td>
</tr>
<tr>
<td>UDP</td>
<td>User Datagram Protocol</td>
</tr>
<tr>
<td>UTP</td>
<td>Unshielded Twisted Pairs</td>
</tr>
<tr>
<td>V.11</td>
<td>Data interface standard</td>
</tr>
<tr>
<td>V.24</td>
<td>Data interface standard</td>
</tr>
<tr>
<td>V9MR</td>
<td>External cable for R1BC board</td>
</tr>
<tr>
<td>V9OF</td>
<td>External cable for G4AI board</td>
</tr>
<tr>
<td>V9OH</td>
<td>LAN cable</td>
</tr>
<tr>
<td>V9OS</td>
<td>External cable for O4LE board</td>
</tr>
<tr>
<td>V9OT</td>
<td>External cable for P4LT/V/X board</td>
</tr>
<tr>
<td>V9OU</td>
<td>External cable for P4LT/V/X board</td>
</tr>
<tr>
<td>V9OV</td>
<td>External cable for P4LT/V/X board</td>
</tr>
<tr>
<td>V9OW</td>
<td>External cable for P4LT/V/X board</td>
</tr>
<tr>
<td>V9OX</td>
<td>Transit cable (V.11)</td>
</tr>
<tr>
<td>V9OY</td>
<td>Patch panel (RS-485 / IRIG-B)</td>
</tr>
<tr>
<td>V9OZ</td>
<td>Patch panel (LAN)</td>
</tr>
<tr>
<td>V9PA</td>
<td>Interconnection cable between P7LP/Q and P7LF</td>
</tr>
<tr>
<td>V9PB</td>
<td>Power supply cable</td>
</tr>
<tr>
<td>VAC</td>
<td>Volt Alternating Current</td>
</tr>
<tr>
<td>VDC</td>
<td>Volt Direct Current</td>
</tr>
<tr>
<td>VLAN</td>
<td>Virtual Local Area Network</td>
</tr>
<tr>
<td>VoIP</td>
<td>Voice over IP</td>
</tr>
<tr>
<td>WAN</td>
<td>Wide Area Network</td>
</tr>
</tbody>
</table>
1. INTRODUCTION

The new ETL600 Power Line Carrier (PLC) equipment combines the advantages of "legacy" analog power line carrier systems (APLC systems) and digital power line carrier systems (DPLC systems) to achieve high dependability and easy adaptability to all requirements in the field of communication with power line carrier.

ETL600-050-1, ETL600-050-2 and ETL600-100-2 are the members of the ETL600 family. They are assembled in standard 19" racks, with 6 ASA-units height carrying plug-in modules.

Normally ETL600 is mounted in ABB’s standard cabinet E40A or E40D with a hinged 19" frame. External connections are wired to the front and to the back of the cabinet, providing easy access during installation, commissioning and maintenance. Although ETL600 is normally mounted in a standard cabinet type E40A or E40D, it can be mounted in any 19" rack or cabinet providing the required protection and air circulation.

ETL600 provides the necessary RF-filters, hybrids and coaxial connectors for connection to the line matching and coupling devices. With a wide range of interfaces it allows configurations and assemblies which meet the client's individual requirements best. These configurations are documented and explained in this manual.

1.1. Using the manual

The manual is written for service and operation personnel in the high voltage (HV) power line environment. All existing safety instructions in the client's environment have to be observed and only trained and instructed personnel should work with the equipment. The manual provides the necessary instructions for all the steps in the life-cycle of the equipment, e.g. from transport, storage, commissioning to maintenance, decommissioning and disposal. Please refer to the appropriate section for the particular step or function.

The different steps of transport, installation, testing and commissioning are normally made by various people. Safety instructions are therefore included in all the corresponding chapters and may so appear as double information.

In this manual, two types of persons dealing with the equipment are distinguished: Service personnel and operator.

The software version referred to in this instruction manual is 'HMI600 Version 4.xy'. Please refer to the document 'Compatibility requirements' in the annex for compatibility between Hardware, Firmware and Software of ETL600.

1.2. Application of the ETL600

The ETL600 Power Line Carrier system is used for communication on power lines between power system control centers, power stations and
sub-stations. The communication services supported by the ETL600 are:
- Telephony,
- Data,
- Teleoperation,
- Teleprotection

or combinations thereof as explained in chapter 3.

1.3. Requirements to be met by the operator

- The operator must have a general understanding of electronic and electrical systems.
- The operator must have a basic knowledge of PLC systems and its principles.
- In order to configure and program the equipment, the operator must be familiar with PCs under Windows environment.
- The operator is required to be reasonably careful in dealing with obvious hazards.
- The operator is required to understand and respect all warning labels in order to avoid any personnel injury or equipment damage.
- The operator is not allowed to perform any of the manipulations or procedures described in the following sections:
  - Chapter 6 'Assembly and Installation'
  - Chapter 7 'Commissioning'
  - Chapter 9 'Troubleshooting'
  - Chapter 10 'Storage, Decommissioning and Disposal'

1.4. Requirements to be met by the service personnel

- Service personnel must read and understand the instruction manual before working with the ETL600 equipment.
- The service personnel must follow the precautions for ESD protection while handling the modules.
- The service personnel must strictly follow all precautions and warnings which could cause personnel injury or damage to the equipment.
- It is highly recommended that the service personnel has attended a training course on the equipment.

1.5. Guarantee provisions

The manufacturer disclaims any responsibility for hazards and material damage, if the equipment is operated other than for its intended use as described in this manual or if the equipment is serviced by non qualified personnel.
2. SAFETY INSTRUCTIONS

2.1. Safety information

The ETL600 equipment itself is safe and without any risk. This is not valid for its containment and the peripheral surrounding, like the high voltage area and lines. Only service personnel is therefore allowed to execute all the steps and manipulations described in this manual. Some of the operations may also be carried out by operators, refer to section 1.

2.1.1. In this instruction manual

In this manual the safety instructions are marked as follows:

- **DANGER**: Information or do’s and don’ts to prevent serious personal injury or extensive equipment damage.

- **Caution**: Specific information or do’s and don’ts to prevent minor damage and operating problems.

- **Note**: Specific information with regard to the optimum use of the appliance.

2.1.2. On the equipment

On the Equipment, safety instructions are marked as follows:

- **DANGER**: Hazardous voltage and hazardous energy level. Beware of electric shock.

- **Caution**: Specific information to prevent minor damage and operating problems.

- **Caution hot surface**: Specific information to prevent personal injury or damage due to contact to hot surfaces.

- **Caution ESD**: Specific information to prevent equipment damage by electrostatic discharge.
2.2. **Basic principles**

The ETL equipment complies with the latest standards of engineering and the recognized safety regulations. In spite of this, hazards could arise with inappropriate operation of the equipment.

The ETL equipment should only be operated in fault free condition and within the guidelines lay down in the instruction manual.

2.3. **General instructions**

**Personnel qualification**

DANGER An authorized and properly trained personnel only is admitted to carry out programming, commissioning, maintenance, troubleshooting and work of the equipment.

**Instruction manual**

DANGER The instruction manual should be read and clearly understood before working on the equipment.

**Safety and monitoring facilities**

DANGER Mechanical safety facilities such as cover plates must not be removed or by-passed.

**Alteration**

DANGER Alteration of the equipment is not allowed.

**Warning labels**

DANGER Precautions and indications to hazardous voltages and hazardous energy level must be strictly observed.

2.4. **Product-specific instructions**

**Technical specifications**

DANGER The equipment must be operated within the technical specifications. Failure to do so may result in personal injuries or equipment damage.
Insertion and removal of plug-in modules

**Caution** Neither removing nor inserting of modules is permitted during power-up of the equipment. Preceding to plug in and out of modules, the power supply of the equipment has to be switched OFF.

There are two exceptions to this:

1. **Rx filter P4RX:**
   It has to be removed and inserted while the equipment remains powered when performing the Rx level adjustment procedure.

2. **Redundant power supply module B5LD:**
   It can be removed or inserted while the equipment remains powered by the other B5LD module in the rack.

**PCB Extenders**

**DANGER** For measuring purposes only the original PCB extenders P4LM and P4EX, designed to work with ETL600 equipment, must be used.

**ESD protection**

**Caution** The modules in this equipment contain devices, which can be damaged by electrostatic discharges. Appropriate measures must be taken before unpacking modules or withdrawing them from equipment racks. Essential precautions to prevent ESD damage when handling or working on modules are grounding straps for technical personnel and the provision of anti-static workbenches. Modules may only be shipped either in their original packing or installed in equipment racks.

**Transportation**

**Caution** The plug-in units must be carefully but firmly screwed into the racks to prevent them from falling out. Separately packed modules and other loose parts must be properly secured and suitably packed to avoid damage.

**Mechanical Installation**

**DANGER** The equipment must be mounted in a cabinet.
Cabinets, which are not secured to the floor, tip forwards when the hinged frame is opened. Do not open the hinged frame without precautions.

Electrical Installation

This is a Class I equipment as specified in IEC 60950-1. The equipment and the cabinet must be earthed. The equipment must be supplied over a miniature circuit breaker as described in section 6.7.1.

The circuit breaker for the power supply of the equipment must be switch OFF. The circuit breakers for optional equipment in the cabinet must be switch OFF.

Do not connect or disconnect energized cables to or from the equipment.

The isolating terminals from the external cables must be kept open during installation, maintenance and before storage, decommissioning and disposal.

Faston tabs on the cables connected to the rack P7LH, P7LP or P7LQ must be covered with an isolation sleeve. Unused faston connectors have to be covered.

Connecting a load between terminals NO (normally open) and NC (normally closed) is not allowed. Use only one contact set NO or NC.

Power supplies connected to alarm relay contacts must be short circuit and over current protected.

Fiber optic Installation

Class 1 Laser/LED Product.
**Optical connectors**

Clean all optical connectors by an approved method before making any optical connection. When making an optical connection, do not rotate the optical connector unnecessarily. When not connected, fit all optical plugs and couplings with captive caps.

**Damage to optical fibers**

When dressing fibers, take care not to exceed the minimum bend radius (typically 35 mm) and do not over tighten binders used for dressing as damage may result. When connecting other external cables or mounting the rear cover, ensure that the optical fibers are not bruised or crimped.

**Isolating covers**

Hazardous voltages and/or hazardous energy level behind the isolating covers. Before removing these covers, the isolating terminals of the external cables must be opened or the cables to the terminals must be disconnected.

**Work on the system**

Do not work on the system or connect or disconnect cables during periods of lightning activities.

**Unpressed button**

The 'RESET' button on the module G4AI should **not** be pressed while executing routine tests during normal operation, as this causes re-initialization of the module and blocks it for some seconds. During this time no commands can be transferred.

**Unused slots**

Unused slots in the equipment subracks must be covered with blanking plates.

**EMC**

This is a Class A equipment as specified in CISPR 22 (EN55022). In a domestic environment, this equipment may cause radio interference. In this case, the user may be required to take adequate measures.
External cables

**DANGER**

The shields of the external cables V9MR, V9OF, V9OI, V9OS and V9OT must be earthed at both cable ends using the shield clamps supplied with the cables.

Using HMI600 software

**Caution**

The link gets disturbed while using the options 'Tuning & Testing', activating a test tone, simulating alarms, measurement of frequency response & equalization etc. of the HMI600. Appropriate measures have to be taken especially in case protection signal transmission is being used.

**Caution**

During routine tests with the ETL600 in operation the Reset item in the Equipment menu of the HMI600 should not be activated, as this causes the equipment to be re-initialized and thus be blocked for some seconds. During this time no teleprotection commands can be transmitted.

P1LP

**DANGER**

Hazardous voltages and/or hazardous energy level at the heat sink.

Do not touch during operation.

**DANGER**

Heat sink should not be touched with conducting materials to avoid energy discharges and damage of the power amplifier.

**Caution**

Hot surface at heat sink

P4LT/P4LV/P4LX

**DANGER**

Hazardous voltages and/or hazardous energy level on the module and the cable.

Do not touch the module and the cable leads.

**Caution**

Connecting a load between terminals NO (normally open) and NC (normally closed) is not allowed. Use only one contact set NO or NC.
Caution

Power supplies connected to alarm relay contacts must be short circuit and over current protected.

---

R1BC

DANGER

Hazardous voltages and/or hazardous energy level on the module and the cable. Do not touch the module and the cable leads.

Caution

Connecting a load between terminals NO (normally open) and NC (normally closed) is not allowed. Use only one contact set NO or NC.

Caution

Power supplies connected to alarm relay contacts must be short circuit and over current protected.

---

O4LE, O4CV

DANGER

The phone interfaces on the modules O4LE and O4CV generate dangerous voltages up to 100 V. Don’t use the modules without upper and lower cover plates. Do not touch the open pins of the service phone connector, the leads of its cable, the pins of the external cable connector and the leads of the external cable.

---

G4AI

DANGER

Hazardous voltages and/or hazardous energy level on the module and the cable. Do not touch the module and the cable leads.

Caution

Connecting a load between terminals NO (normally open) and NC (normally closed) is not allowed. Use only one contact set NO or NC.

Caution

Power supplies connected to alarm relay contacts must be short circuit and over current protected.

---

Electrical strength test

Caution

Do not repeat any electrical strength tests. Improper test methods can cause severe damage to the equipment. Electric strength and earth continuity tests have been performed in the factory.
Commissioning

**Caution**
Do not close/establish the connections to the protection devices until NSD600 is properly commissioned.
3. STRUCTURE AND FUNCTION

3.1. Introduction

Transmission lines exhibit low attenuation in the carrier frequency range between 20 and 500 kHz. They are therefore a good means of communicating information over medium to long distances (20 to 100 km, or 100 to 500 km respectively). The maximum range of a PLC communications channel operating at approximately 80 kHz or less can reach up to 800 km, which cannot be matched by other means of communication that power companies have at their disposal (cables, optical fibres, pilot wires, normal radio or point-to-point radio) without repeaters or repeater stations.

By installing appropriate coupling devices and line traps in the power stations and substations, communications channels can be provided, which exhibit

- extremely high mechanical rigidity and high reliability of the interconnecting lines.
- lines and terminal equipment, which belong to and is permanently under the control of the power utility.
- low, relatively constant attenuation and moderate long-duration noise level (corona) under normal atmospheric conditions.
- breakers and load-break isolators.

The system includes means to combat burst noise, which minimize the possibility of false signals or unwanted commands. In spite of the additional cost represented by the coupling devices and line traps, especially at very high voltage levels, the overall cost of a PLC communications system is relatively low compared with other techniques and the cost relation becomes even more favorable with longer distances. These are the two main reasons why many power utilities prefer PLC for power system communication.

The PLC equipment is capable of transmitting information for a mixture of various services such as (refer to Fig. 3-1)

- telephony,
- teleoperation,
- data,
- teleprotection

simultaneously by combining all information into one single signal, which occupies a predefined bandwidth in the Radio Frequency (subsequently = RF) frequency range from typically 40 to 500 kHz, suitable for transmission via a power line. The amount of information which can be transmitted is limited by the bandwidth of the RF signal, which is typically 4 kHz or a multiple thereof. This is called the nominal bandwidth $B_n$ of the PLC equipment. For the backwards channel, a distinct frequency band also of size $B_n$ is used. This band is usually adjacent to the one of the forward channel, refer to Fig. 3-2 a. However, the bands can also be separated in frequency as shown in Fig. 3-2 b. ETL600 offers nominal bandwidths from 2 to 32 kHz and
can also be operated in the carrier frequency range from 500 kHz up to 1 MHz.

Fig. 3-1  ETL600 with a wide range of services

Fig. 3-2  Adjacent (a) and non-adjacent (b) frequency bands
For increased capacity and for redundancy, several PLC links can be operated in distinct frequency bands over the same power line, sharing the coupling devices.

The standard high frequency power output of the basic ETL600 unit is 50 W (47 dBm). This is for most cases adequate to ensure the required transmission quality. For severe operating conditions with high attenuation or high noise levels - e.g. on Extra High Voltage lines - the output can be raised to 100 W (50 dBm) by connecting a second power equipment in parallel with the first. Redundancy is obtained by coupling the two output amplifiers via an RF combiner and supplying each from an independent power source. Two types of equipment are thus distinguished:

- ETL600-050:   50 W terminal,
- ETL600-100:  100 W terminal.

For lines with low attenuation and low noise levels, the output power of both types may be decreased to 25 W (44 dBm), 12.5 W (41 dBm) or to any level equal to a positive integer dBm value.

Power line carriers are used in almost all the countries of the world to transfer information via HV transmission lines and have become an important instrument for the management and safety of electrical power systems. Of the possible PLC techniques, single sideband modulation with a 4 kHz spacing makes the best use of the available frequency bands and transmitting powers. This PLC technique has become widely used in Europe, mainly for reasons of cost and its capability of providing channels capable to carry speech, data and teleprotection signals simultaneously. International recommendations for the characteristics of line traps, coupling capacitors, PLC coupling devices and single sideband PLC equipment (IEC Publications 60353, 60358, 60481 and 60495) and also for the design of PLC links (IEC Publication 60663) have come into force. All the relevant CCIR and ITU-T recommendations in IEC Publication 60495 were taken into account. This ensures reliable coupling of channels at the Audio Frequency (subsequently = AF) interfaces in power system control centers, power stations and transformer stations between power utility PLC, normal radio, point-to-point radio and leased back-up links.
3.1.1. **APLC and DPLC services**

Around the year 1990, digital PLC (DPLC) equipment using highly bandwidth efficient modulation techniques appeared on the market. Compared to traditional analog PLC (APLC), DPLC offers a number of advantages:

- Enhanced transmission capacity for a given bandwidth
  - data channels running at a higher rate,
  - more speech channels.

- Easy integration of the PLC network into a larger digital network
  - 64 kbps channel as a tributary channel of a digital telecom network,
  - Digital data interfaces for lower speed data avoiding intermediate modems.

The ETL600 system supports both APLC and DPLC mode of operation. As explained in Cigré publication TB164, a digital PLC consists of 3 main building blocks:

- the RF front end,
- Signal converter,
- Digital time division multiplexer.

These building blocks can be found also in ETL600. However, as shown in Fig. 3-1, with an additional external multi service multiplexer / router, the strengths of digital PLC can be exploited even more.

Fig. 3-3a, b and c show the use of the nominal frequency band in case of pure APLC, pure DPLC or mixed APLC/DPLC mode of operation. For most operation modes, the APLC band - if present - comprises 1 to 3 AF channels of 4 kHz bandwidth each. Therefore, the width of the APLC band is 4, 8 or 12 kHz for 1, 2 or 3 AF channels, respectively. Alternatively or in addition to the APLC band, at most one DPLC band can be configured. The nominal band equals the sum of the APLC and DPLC bands and is 4 kHz wide or a multiple thereof.

By default, the APLC band is located below the DPLC band on the frequency scale as shown in Fig. 3-3c. This placement is referred to as erect ETL600 overall mode.

It is possible to operate the link in inverted overall mode if desired, with the effect that the signal spectra of Fig. 3-3 are mirrored with respect to the center frequency as shown in Fig. 3-4.

In erect mode, the nominal frequency $f_n$ is defined as the lower edge frequency of the nominal frequency band $B_n$, while in inverted mode, $f_n$ is the higher edge frequency.
Fig. 3-3 Use of nominal frequency band for pure APLC (a), pure DPLC (b) or mixed APLC/DPLC (c) operation in ETL600 erect mode

Fig. 3-4 Use of nominal frequency band for pure APLC (a), pure DPLC (b) or mixed APLC/DPLC (c) operation in ETL600 inverted mode

The settings 1 ... 5, 7 and 8 in Table 3-1 correspond to the rules given above. In addition to these, there are some special settings that deviate from the rules above appearing also in Table 3-1:
- Three AF channels with bandwidths of 3.2, 2.4 and 2.4 kHz, resulting in an APLC bandwidth of 8 kHz (Setting No. 6).
- Single purpose teleprotection with nominal bandwidth of 2 kHz (Setting No. 9).
- For nominal bandwidths of 4, 8, 12 kHz, a DPLC channel of 2 kHz can be configured in addition to an APLC channel of 2 kHz and 0, 1 or 2 APLC channels of 4 kHz (Settings No. 10, 11, 12).
- For nominal bandwidths of 8, 12 and 16 kHz, a DPLC channel of 6 kHz can be configured in addition to an APLC channel of 2 kHz and 0, 1 or 2 APLC channels of 4 kHz (Settings No. 10, 11, 12).

In all modes of operation, ETL600 complies to IEC publication 60495 “Single sideband power-line carrier terminals”. Wherever this standard isn’t directly applicable for DPLC, the requirements have been suitably adopted in order to allow the coexistence of APLC-, DPLC- and mixed mode APLC/DPLC-links on the same power line and in the same geographical area. This aspect has been addressed in Cigré publication TB164, where the principles of DPLC operation are explained.

In Table 3-1, vertical dashed arrows show where internal teleprotection devices NSD600 can be operated, if desired. All configurations allow the operation of at least one NSD600 device. In most cases, even two such devices can be used.

<table>
<thead>
<tr>
<th>Setting No.</th>
<th>No. of APLC channels</th>
<th>DPLC bandwidth [kHz]</th>
<th>ETL600 overall mode = Erect</th>
<th>ETL600 overall mode = Inverted</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>0 4</td>
<td><img src="image" alt="APLC Channel" /></td>
<td><img src="image" alt="APLC Channel" /></td>
</tr>
<tr>
<td>2</td>
<td>0</td>
<td>4 to 32</td>
<td><img src="image" alt="DPLC Channel" /></td>
<td><img src="image" alt="DPLC Channel" /></td>
</tr>
<tr>
<td>3</td>
<td>1</td>
<td>4 to 28</td>
<td><img src="image" alt="APLC Channel" /></td>
<td><img src="image" alt="DPLC Channel" /></td>
</tr>
<tr>
<td>Setting No.</td>
<td>No. of APLC channels</td>
<td>DPLC bandwidth [kHz]</td>
<td>Spectrum</td>
<td></td>
</tr>
<tr>
<td>------------</td>
<td>----------------------</td>
<td>----------------------</td>
<td>----------</td>
<td></td>
</tr>
<tr>
<td><strong>ETL600 overall mode = Erect</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>2</td>
<td>08</td>
<td>APLC (NSD600#1)(NSD600#2)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>( f_n ) ( f_n+B_n )</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>2</td>
<td>412 to 2432</td>
<td>APLC (NSD600#1)(NSD600#2)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>( f_n ) ( f_n+B_n )</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>3</td>
<td>08</td>
<td>APLC (NSD600#1)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>( f_n ) ( f_n+B_n )</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>3</td>
<td>012</td>
<td>APLC (NSD600#1)(NSD600#2)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>( f_n ) ( f_n+B_n )</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>3</td>
<td>416 to 2032</td>
<td>APLC (NSD600#1)(NSD600#2)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>( f_n ) ( f_n+B_n )</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>1</td>
<td>02</td>
<td>APLC (NSD600#1)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>( f_n ) ( f_n+B_n )</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>1</td>
<td>2 or 6 4 or 8</td>
<td>DPLC (Speech, NSD600#1)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>( f_n ) ( f_n+B_n )</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>2</td>
<td>2 or 6 8 or 12</td>
<td>DPLC (Speech, NSD600#1)(NSD600#2)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>( f_n ) ( f_n+B_n )</td>
<td></td>
</tr>
</tbody>
</table>

**Remark:** Gross bandwidths are 3.2 kHz for Ch1, 2.4 kHz for Ch2, and 2.4 kHz for Ch3.
### 3.1.2. Frequency allocation in AF channels

The frequency allocation of an AF channel is typically as depicted in Fig. 3-5. The pilot band, typically at the upper end of the AF frequency band, must be kept free because it is used by the PLC equipment for an auxiliary signal called 'pilot'. The pilot serves several purposes such as:

- frequency synchronization,
- automatic gain control (AGC),
- transmission of E- and M-telephone-signaling over the link,
- embedded operation channel (EOC) of the link,
- guard signal for the integrated teleprotection equipment NSD600.

![Fig. 3-5 Typical frequency allocation in a 4 kHz AF channel](image)

Many possibilities exist for the frequency allocation of the services into an AF channel due to:

- programmable speech bandwidth,
- programmable bandwidths for AF data channels depending on the required data rates,
- programmable center frequencies for AF data channels,
- programmable pilot frequencies.

Fig. 3-6 shows all relevant possibilities for the frequency allocation in a 4 kHz AF channel. Hatched areas indicate frequency bands which may

![Table 3-1 ETL600 frequency spectra](image)
be occupied by other services. Any combination of services occupying the frequency bands shown in the figure is allowed as long as these bands do not overlap.

The frequency allocation possibilities for the 3.2 and 2.4 kHz AF channels for the case “3 APLC channels in 8 kHz” (Setting No. 6 in Table 3-1) are shown in Fig. 3-7 and Fig. 3-8.

Fig. 3-9 shows the case of 2 kHz nominal bandwidth (Setting No. 9 in Table 3-1).

The narrow AF channel adjacent to MOD600 2 kHz or 6 kHz (Settings 10, 11 or 12 in Table 3-1) can be used as shown in Fig. 3-10 and Fig. 3-11.
Fig. 3-6 Use of ETL bandwidth for a 4 kHz AF channel
Fig. 3-7 Use of ETL bandwidth for channel 1 of the configuration “3 APLC channels in 8 kHz”
Fig. 3-8 Use of ETL bandwidth for channels 2 and 3 of the configurarion “3 APLC channels in 8 kHz”

Fig. 3-9 Use of ETL bandwidth for nominal bandwidth of 2.0 kHz
3.2. **System architecture**

ETL600 may be tailored to the specific needs of the application thanks to its modular architecture. The modules are housed in one or two standard 19" subracks as shown in Fig. 3-12 and Fig. 3-13. For the terminals to be operational, a minimal set of modules is needed shown with solid lines in the block diagrams of Fig. 3-14 to Fig. 3-16. This set is referred to as 'basic equipment'. Depending on the services needed by the application, additional modules may be inserted into the subrack in slots not occupied by modules of the basic equipment. DPLC operation and AF data channels may be activated with an appropriate data key. A large variety of possible equipment configurations results depending on data key and number and type of optional modules.
All possible configurations for the ETL600 equipment are shown in Fig. 3-12, Fig. 3-13 (front- and side-views) and Fig. 3-14 to Fig. 3-16 (block diagrams). Optional parts are drawn in dashed lines.

Legend for the figures in this section:

1: AF interface type O4LE (optional; for telephony, teleoperation and external teleprotection)
2: NSD600 teleprotection interface type G4AI (optional)
3: Compressed telephony interface type O4CV (optional)
4: Alarm relay module type R1BC (optional, in the rear)
5: DSP module type P4LT
6: DSP module type P4LV, with LAN and digital transit ports
7: DSP module type P4LX, with LAN, digital transit and additional serial ports
8: RF Hybrid and transmit filter type E5TH
9: Carrier combiner and transmit filter type E5TC
10: Power supply type B5LD
11: Receive filter type P4RX (optional)
12: 50 W power amplifier type P1LP (mounted in the rear)
13: Subrack type P7LP (required for ETL600-050-2)
14: Subrack type P7LQ (required for ETL600-100-2)
15: Subrack type P7LH (required for ETL600-050-1)
16: Subrack type P7LF (required for ETL600-050-2 and ETL600-100-2)

All modules are plugged from the front except where otherwise noted.

Connectors for interface cables are in the rear of the equipment, with the exception of the data connectors of the modules P4LT, P4LV, P4LX which are placed at the equipment front.

Fig. 3-12     ETL600-050-1, front and side view
Interface boards 1 (O4LE), 2 (G4AI) and 3 (O4CV) are required to support the APLC services telephony/teleoperation, teleprotection and the DPLC service compressed telephony. Up to four interface boards may be inserted in an ETL600-050-1 and up to seven interface boards in an ETL600-050-2 or ETL600-100-2. These boards galvanically separate the interface signals from the equipment and transform these signals into a form suitable for transmission over the equipments **Time Division Multiplexing** (TDM) bus and for **Frequency Division Multiplexing** (FDM) into the AF-channel(s), refer to Fig. 3-5.

The FDM concept allows the available frequency band to be shared between the teleprotection service and the other services by switching these off during transmission of teleprotection commands and thus making the full output power of the PLC equipment available to teleprotection. This technique is called 'boosting'.

---

**Fig. 3-13**  
ETL600-050-2, ETL600-100-2, front and side view

<table>
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<th>BR</th>
<th>BR</th>
<th>BR</th>
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<th>16R</th>
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<th>1&lt;sup&gt;b&lt;/sup&gt; or 2&lt;sup&gt;b&lt;/sup&gt; or 3&lt;sup&gt;b&lt;/sup&gt;</th>
<th>1&lt;sup&gt;b&lt;/sup&gt; or 2&lt;sup&gt;b&lt;/sup&gt; or 3&lt;sup&gt;b&lt;/sup&gt;</th>
<th>1&lt;sup&gt;b&lt;/sup&gt; or 2&lt;sup&gt;b&lt;/sup&gt; or 3&lt;sup&gt;b&lt;/sup&gt;</th>
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<th>1&lt;sup&gt;b&lt;/sup&gt;</th>
<th>2&lt;sup&gt;b&lt;/sup&gt; or 3&lt;sup&gt;b&lt;/sup&gt;</th>
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<tr>
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<td>Optional, up to 4 modules supported</td>
<td>Optional</td>
<td>Optional</td>
<td>ETL600050-2 only</td>
<td>ETL6000100-2 only</td>
<td></td>
</tr>
</tbody>
</table>
Fig. 3-14  Functional block diagram ETL600-050-1
Fig. 3-15 Functional block diagram ETL600-050-2
Fig. 3-16 Functional block diagram ETL600-100-2
3.2.1. Digital signal processing

The FDM-signals of all AF interface boards 1 (O4LE) are fed to the DSP module 5 (P4LT), 6 (P4LV) or 7 (P4LX) via TDM bus, where
- the pilot signals (one for each AF channel 1),
- the AF channel data signals,
- the NSD600 AF signals and
- the DPLC signal

are Single-SideBand (subsequently = SSB) modulated, combined into a single low frequency (LF) signal and converted to the desired RF band.

Traditionally, the conversion to the RF band has been achieved with several stages of frequency conversion and filtering implemented in analog technology. The reverse procedure was employed for recovering the LF signal. It required critical analog filters for achieving the desired filter characteristics.

However, in ETL600, the AF signal is first converted into a digital signal (a serial sequence of code words consisting of Zeros and Ones) by an analog to digital converter. This digital signal is processed by Digital Signal Processor (DSP) circuits located on the DSP module. Using suitable software algorithms, this digital data is manipulated by the DSPs to get another digital data stream which when reconverted into an analog signal gives the same effect as if the analog signal was SSB modulated into RF. The reverse procedure is employed for demodulation.

One advantage of this technique is that by just changing a few software parameters, a lot of settings such as carrier frequencies, pilot frequencies, orientation of the spectrum etc. can be changed.

Another important advantage is that a lot of hardware for modulation, demodulation, filtering etc. is eliminated, thereby reducing the failure rate of the equipment and the necessary tuning efforts drastically.

Also, due to the digital nature of the involved hardware, variations due to changes of climatic conditions (temperature, humidity) as observed with analog modulation techniques are virtually nonexistent.

3.2.2. Analog signal processing

The DSP module 5, 6 or 7 – after having combined and modulated the signals of all services to be transmitted by digital signal processing – converts the resulting signal into analog form and forwards it to the power amplifier 12.

The module 8 contains the RF hybrid, required to separate the transmitted RF signal from the received signal, and a transmit filter, which allows for parallel connection of several equipment to the same coupling device. The transmit filter can be placed either in the transmit

---

1 If no AF channels are configured, a pilot is provided in the DPLC band.
signal path or in the two wire signal path. Refer to section 3.3.8.2 regarding the difference between these two arrangements.

The output power may be doubled to 100 W by adding a second power amplifier 12 and the module 9, containing an additional transmit filter and the carrier combiner, required to combine the signals of both amplifiers into the 100 W output signal.

For supervision of the equipment, three alarm contacts are available and the equipment status is indicated with LEDs on the front.

An optional alarm relay module 4 can be mounted in the rear which features additional 8 alarm relays, giving a total of 11 alarm relay contacts.

For programming, testing, commissioning and in depth supervision of the equipment, the user interface program HMI600 - a Windows® application - is needed, which is an integrated part of ETL600. Access via intranet/internet and dial-up modems is supported by the HMI600 program. Refer to chapter 4 for more information about HMI600.

A single power supply module 10 supplies all equipment variants. If redundancy is required, a second, redundant module 10 can be plugged. The power supply voltage is 48 VDC. Other supply voltages require an external converter.
Module description

AF interface O4LE

The AF interface board O4LE is a universal interface for audio frequency signals. It supports the applications:

- Telephony,
- Teleoperation,
- External teleprotection.

These are the analog services described in section 3.4.

The unit is fully programmable via user interface program HMI600.

The hardware of one O4LE board can carry the telephony service for one AF-channel. The teleoperation and external teleprotection ports of one specific O4LE board can be assigned to at most two AF-channels, either channels 1 and 2, channels 2 and 3 or channels 1 and 3. When telephony is configured on this O4LE board, one of these two channels must be the channel carrying the telephony service.

Up to four digital filters can be configured on one O4LE board. These can be transit filters for through-connection of AF-signals in transit stations. When an O4LE board carries telephony functions, only two transit filters are available on that board, as two filters are required for speech filtering.

The board houses a digital signal processor (DSP) and associated peripheral circuits. The hardware comprises the following ports:

- Four 4-wire 600 Ohm AF ports AF1 to AF4. Port AF1 is also used for 4-wire telephony. External teleprotection equipment must be connected to port AF4.
- One 2-wire telephone port subscriber side (FXS). This port is also used for the service phone (socket at front plate). At any time, only one of the two ports is active. This is controlled by a switchover relay.
- One 2-wire telephone port office side (FXO),
- E&M telephone signaling ports,
- Telephone hybrid local/transit input port,
- External teleprotection boost input port,
- Relay with switchover contact for signaling the availability of the telephone channel,
- TDM bus port for internal communication with the P4LT/V/X board.

A buzzer on the board is activated to announce an incoming service phone call even if no service phone is plugged.
3.3.1.1. **Front plate**

'AL' LED red: **Module hardware alarm**
This LED is on, if a hardware alarm on the module is detected.

'RDY' LED green: **Module ready**
On as long as the module is in normal operation mode.
Flashes slowly during hardware alarm, flashes fast corresponding to E&M signaling.

'⚠️' LED yellow: **Module warning**
On as long as the module is not in normal operation mode and no module alarm is present.

SERVICE-PHONE:

'RDY' LED green: **Service phone ready**
On if the speech channel is available for the service phone.

'ENA' LED green: **Service phone enabled**
On if the service phone is enabled on the module.
Flashes if the service phone is ringing.

'RESET' Push button: **Reset**
When pressed, the module resets and fetches configuration data from flash EPROM.

Socket for the service phone

---

Fig. 3-17    Front plate O4LE
3.3.2. Teleprotection interface G4AI

3.3.2.1. Summary

The teleprotection interface includes:

- four input circuits equipped with optocouplers,
- four output circuits equipped with semiconductors (referred to as ‘solid state outputs’),
- two electro-mechanical output relays with change-over contacts (referred to as ‘relay outputs’).

All inputs and outputs are potential-free and galvanically isolated from ground and all other circuits.

The allocation of functions for each of these circuits or relays is programmed with the help of the user interface HMI600 (e.g. command input or a start input, command output or alarm output).

Note: Start inputs are not available for operating mode “Single purpose teleprotection NSD600 in 2 kHz nominal bandwidth”.

Safety is the most important factor considered in the design of this module. For example, there are screening plates mounted on both the soldered and the component side.

The internal signals are connected to the TDM-bus via C–type-plug of the module. The external signals are connected via F–type-plug to the external cable.

The input and the output circuits are protected against overvoltage and inverse polarity.

The in-service status of the module is indicated through the ready–LED ‘RDY’. Separate LEDs indicate the active status of each input, solid state output and relay output.

The various circuit alarms of the module are summated and indicated by the red alarm LED ‘AL’ provided on the front plate and sent further via TDM-bus to the DSP module P4LT/V/X.

The module can be reset by a push button on the front. Note that the equipment is not able to send and receive commands for some seconds after re-initialization.

3.3.2.2. Inputs

The input circuits can be programmed for four battery voltage ranges by setting corresponding jumpers. As an aid the jumper settings can be viewed in a list which is directly printed on the component side of the module.

The ranges for the nominal battery voltage are:

The switching threshold for the input command is about 75 % of the minimum nominal battery voltage for the chosen range.
A command is usually initiated by applying an external voltage to the input. Alternatively, an auxiliary on-board voltage of 24 VDC is available. It can be used to trip the input circuits by just closing an external contact. The protection relay should provide potential-free (dry) contacts for this purpose.

The input circuits are current limited, no external precautions have to be taken.

Each input can be programmed with the help of the user interface HMI600 for one of the many available functions, e.g.

- Input 1: Command A
- Input 2: Command C
- Input 3: Command D
- Input 4: Start input

Note: Start inputs are not available for operating mode “Single purpose teleprotection NSD600 in 2 kHz nominal bandwidth”.

The input signals are transferred to the DSP module type P4LT/V/X via the TDM bus. The signal processor on the G4AI module can detect component failures and thus prevents malfunctioning of the equipment. Such failures are indicated by the alarm LED provided on the module front plate and are also passed on to the P4LT/V/X module.

3.3.2.3. Solid state outputs

The signals to activate the solid state outputs arrive from the TDM-bus. The DSP on G4AI checks these signals and - when convinced about the validity - activates the assigned solid state contact(s).

In case of over-current duration for more than 6 ms (due to short circuit or large capacitive load), the output is blocked for about 0.75 s. After that, the output circuit is switched on again. This procedure is repeated and a module alarm is generated as long as the external over-current condition or short-circuit exists. The solid state outputs can therefore be considered as short circuit proof.

If the equipment is not powered, the solid state output switches are open.

Each output can be programmed with the help of the user interface HMI600 for one of the many available functions, e.g.

- Output 1: Command A
- Output 2: Command D
- Output 3: Unblocking
- Output 4: TPE1 link alarm
3.3.2.4. **Relay outputs**

The signal processing for the relay outputs is treated the same way as in case of the solid state outputs.

The operating contact (Normally Open - NO or Normally Closed - NC) of each relay can be selected by a corresponding jumper.

Each relay can be programmed with the help of the user interface HMI600 for one of the many available functions, e.g.:
- Relay 1: Command A
- Relay 2: TPE1 alarm

Although the relay contacts are of the 'heavy-duty' type, external precautions have to be taken for limiting the circuit current.
3.3.2.5. **Front plate**

- **'AL'** LED red: Module hardware alarm
  On if a hardware alarm on the module is detected.

- **'RDY'** LED green: Module ready
  On as long as the module is in normal operation mode.

- **'⚠️'** LED yellow: Module warning
  On as long as the module is not in normal operation mode and no module alarm is present.

- **'IN1 ... IN4'** LEDs green: Input 1, 2, 3, or 4
  On as long as input 1, 2, 3 or 4 is active.

- **'OUT1 ... OUT4'** LEDs green: Output 1, 2, 3 or 4
  On as long as solid state output 1, 2, 3 or 4 is active.

- **'REL1, REL2'** LEDs green: Relay 1, Relay 2
  On as long as relay output 1 or 2 is active.

- **'RESET'** Push button: Reset
  When pressed, the module resets and fetches configuration data from flash EPROM.

---

**Fig. 3-18** Front plate G4AI
3.3.3. **DSP module P4LT, P4LV, P4LX**

The DSP module is the heart of the ETL600 equipment. It performs the following main functions:

- Conversion of the signals from LF (Low Frequency) to RF (Radio Frequency) and vice versa
- DPLC modem MOD600
- Up to four AF modems NSK600
- Data-multiplexer MUX600
- Up to two integrated teleprotection devices NSD600
- Up to three pilot channels offering the functions:
  - EOC signaling
  - E- and M-signaling, independently on each APLC channel
  - AGC (Automatic Gain Control), independently for each APLC channel
  - Frequency synchronization
  - Supervision of the quality of the received pilot signals
  - Guard signal for integrated teleprotection equipment NSD600
- Automatic measurement of the frequency response of the APLC channels with calculation of the equalizer filters
- Serial port for entering settings and for supervision by means of PC, to be connected to the equipment either directly or via a modem link
- Hardware and software supervision for the complete equipment
- Bus-master for the ETL600 TDM-bus, for communication to optional O4LE and G4AI boards
- Three alarm relays with switch-over contacts for system alarm/cabinet alarm, hardware alarm and link alarm
- IRIG-B input for synchronization of the internal real time clock (RTC)
- A number of LAN ports, serial data ports and digital transit ports, the number depending on the board type as given by Table 3-2.
  The LAN ports (not available on P4LT) support the services
  - Switch (layer 2) or router (layer 3),
  - SNMP,
  - HMI over LAN.

<table>
<thead>
<tr>
<th>Type of port:</th>
<th>P4LT</th>
<th>P4LV</th>
<th>P4LX</th>
</tr>
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<td>V.24</td>
<td>2 ports</td>
<td>2 ports</td>
<td>4 ports</td>
</tr>
<tr>
<td>V.11</td>
<td>1 port</td>
<td>1 port</td>
<td>2 ports</td>
</tr>
<tr>
<td>Electrical LAN</td>
<td>-</td>
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<td>3 ports</td>
</tr>
<tr>
<td>Optical LAN 1)</td>
<td>-</td>
<td>1 port</td>
<td>1 port</td>
</tr>
<tr>
<td>Digital transit</td>
<td>-</td>
<td>2 ports</td>
<td>2 ports</td>
</tr>
</tbody>
</table>

Remark:
1) SFP module required on P4LV/X.
   If four electrical LAN ports are required, a 100 BaseT(X) electrical SFP transceiver can be plugged instead of an optical one.

Table 3-2 Number of V.24, V.11, LAN and digital transit ports for DSP modules type P4LT, P4LV and P4LX
All functions are executed by six DSPs, a microcontroller, an Ethernet controller (not available on P4LT), a Field Programmable Gate Array (FPGA) and associated peripheral circuits such as Analog to Digital Converter (ADC), Digital to Analog Converter (DAC), Buffer, Driver, Universal Asynchronous Receiver/Transmitter (UART), Watchdog Device, Random Access Memory (RAM), Flash Electrically Programmable Memory (Flash EPROM), clock oscillator, ±12V supervision, and more.

The frequency conversions AF to RF and RF to AF are implemented completely with digital signal processing so that no analog filters, mixers and the like are required, giving excellent thermal stability. This technique is called Direct Digital Synthesis (DDS).
3.3.3.1. **Front plate P4LT**

**LEDs:**
- **'RDY'** LED green: **System ready**
  Lights if the ETL600 system is in normal operation.
- **'P4LT'** LED red: **Module hardware alarm**
  Lights if a hardware alarm on P4LT is detected.
- **'SYS'** LED red: **Cabinet alarm / System alarm**
  Lights if a system alarm is present.
- **'HW'** LED red: **Hardware alarm**
  Lights if a hardware alarm on one or more of the ETL600 modules is detected.
- **'LNK'** LED red: **Link Alarm**
  Lights if the link for either channel is disturbed or for low receive level.
- **'△'** LED yellow: **System warning**
  Lights if the system is not in normal operation mode and no system alarm is present.

**Data port sockets:**
- **'HMI'** Socket for **HMI communication port** (9 pin RS-232 configured as DCE)
- **'IRIG-B'** Socket for **IRIG-B input** for RTC synchronization
- **'V.24 PORT 1'** Socket for **V.24 data port 1**
- **'V.24 PORT 2'** Socket for **V.24 data port 2**
- **'V.11 PORT 1'** Socket for **V.11 data port 1**

---

Fig. 3-19  Front plate P4LT
3.3.3.2. **Front plate P4LV**

**LEDs:**

- **'RDY'** LED green: *System ready*
  Lights if the ETL600 system is in normal operation.

- **'P4LV'** LED red: *Module hardware alarm*
  Lights if a hardware alarm on P4LV is detected.

- **'SYS'** LED red: *Cabinet alarm / System alarm*
  Lights if a system alarm is present.

- **'HW'** LED red: *Hardware alarm*
  Lights if a hardware alarm on one or more of the ETL600 modules is detected.

- **'LNK'** LED red: *Link Alarm*
  Lights if the link for either channel is disturbed or for low receive level.

- **'△'** LED yellow: *System warning*
  Lights if the system is not in normal operation mode and no system alarm is present.

**Data port sockets:**

- **'LAN 4'** Socket for LAN port 4 (requires SFP)
- **'LAN 3'** Socket for LAN port 3
- **'LAN 2'** Socket for LAN port 2
- **'LAN 1'** Socket for LAN port 1
- **'Digital transit'** 2 Sockets for Digital transit ports
- **'HMI'** Socket for HMI serial communication port (9 pin RS-232 configured as DCE)
- **'IRIG-B'** Socket for IRIG-B input for RTC synchronization
- **'V.24 PORT 1'** Socket for V.24 data port 1
- **'V.24 PORT 2'** Socket for V.24 data port 2
- **'V.11 PORT 1'** Socket for V.11 data port 1

---

Fig. 3-20 Front plate P4LV
3.3.3.3. **Front plate P4LX**

**LEDs:**
- **'RDY'** LED green: **System ready**
  Lights if the ETL600 system is in normal operation.
- **'P4LX'** LED red: **Module hardware alarm**
  Lights if a hardware alarm on P4LX is detected.
- **'SYS'** LED red: **Cabinet alarm / System alarm**
  Lights if a system alarm is present.
- **'HW'** LED red: **Hardware alarm**
  Lights if a hardware alarm on one or more of the ETL600 modules is detected.
- **'LNK'** LED red: **Link Alarm**
  Lights if the link for either channel is disturbed or for low receive level.
- **'△'** LED yellow: **System warning**
  Lights if the system is not in normal operation mode and no system alarm is present.

**Data port sockets:**
- **'LAN 4'** Socket for LAN port 4 (requires SFP)
- **'LAN 3'** Socket for LAN port 3
- **'LAN 2'** Socket for LAN port 2
- **'LAN 1'** Socket for LAN port 1
- 'Digital transit' 2 Sockets for Digital transit ports
- **'HMI'** Socket for HMI serial communication port
  (9 pin RS-232 configured as DCE)
- **'IRIG-B'** Socket for IRIG-B input for RTC synchronization
- **'V.24 PORT 1'** Socket for V.24 data port 1
- **'V.24 PORT 2'** Socket for V.24 data port 2
- **'V.24 PORT 3'** Socket for V.24 data port 3
- **'V.24 PORT 4'** Socket for V.24 data port 4
- **'V.11 PORT 1'** Socket for V.11 data port 1
- **'V.11 PORT 2'** Socket for V.11 data port 2

Fig. 3-21 Front plate P4LX
3.3.4. **Alarm relay module R1BC**

The alarm relay module type R1BC is mounted on the back side of the backplane P1LH or P1LF of the rack P7LH or P7LF, respectively.

8 power relays are mounted on the alarm relay module. Each of the relays can be programmed by jumpers on R1BC individually to one of three alarm sources: user alarms 1, 2 or 3.

Since each of the 8 relays is connected to three terminals, it is possible to use the relays individually as contact open (NO: contact open in case of alarm) or contact closed (NC: contact closed in case of alarm).

User alarms 1, 2 and 3 mentioned above are configurable by HMI600 via dialog-box 'Alarm relays on R1BC'. Various alarm sources from the local and the remote equipment can be selected for each of the user alarms. If several alarm sources are selected for a particular user alarm, these sources are summed (e.g. combined by a logical OR-function) to form the user alarm.

Programming of the jumpers on R1BC is done as follows:

- To program relay N to user alarm 1: insert jumper CA-N
- To program relay N to user alarm 2: insert jumper R1-N
- To program relay N to user alarm 3: insert jumper R2-N

where N is a number between 1 and 8.

**Example:**

If it is required that the link alarm criteria of the local and remote equipment are to be made available as a closed and as an open contact in case of alarm, we first program user alarm 1 with the HMI600 by crossing the 2 check boxes associated to 'Alarm 1/Local equipment/PLC link alarm' and 'Alarm 1/Remote equipment/PLC link alarm'. Next, we program relays 5 and 6 to user alarm 1 by inserting jumpers CA-5 and CA-6 on R1BC. A link alarm on either equipment - local or remote - is now indicated by a closed contact between terminals 2 and 3 of connector X5, and as an open contact between terminals 1 and 2 of connector X6 (see Fig. 3-22).

The connection to the relay contacts can be made directly at the terminals of the alarm relays module itself, or via the alarm cable V9MR on the terminal block at the rear of the cabinet (refer to section 6.7.3.5).
Caution
Connecting a load between terminals 1 and 3 of connectors X1, X2, X3, X4, X5, X6, X7 or X8 on R1BC is not allowed. Instead, connect the load either between terminals 1 and 2 or between 2 and 3 of these connectors.

Caution
Power supplies connected to alarm relay contacts must be short circuit and over current protected.

3.3.5. **Power supply B5LD**

The power supply B5LD converts the supply voltage of 48 VDC into the voltages required by the ETL600 modules. These voltages are internal to the equipment and not available externally.

The requirements for the power supply input are:

48 VDC +20 / -15 %, ripple ≤ 5 % peak to peak.

The internal voltages are monitored by the DSP module for undervoltage and overvoltage.
A second, redundant power supply module B5LD can be plugged into the equipment if required.

The power supply unit includes the following protective functions:

- Inrush current limiter,
- Power overload and no load protection,
- Overcurrent and short circuit protection,
- Overtemperature protection,
- Input protected against reversal of polarity,

### 3.3.6. Subrack P7LH

The subrack P7LH houses all modules of an ETL600-050-1. It has 4 slots for the insertion of the optional interface boards O4LE, G4AI or O4CV. Further it houses up to 2 power supplies B5LD (the second one is redundant), the RF hybrid - transmit filter E5TH, the DSP module P4LT, P4LV or P4LX and the optional receive filter P4RX. The optional alarm relay module R1BC, is mounted onto the backplane in the rear.

All boards except R1BC are plugged from the front side into the subrack. Connectors for interface cables are in the rear of the equipment with the exception of the data connectors of the DSP module that are on the equipment front.

### 3.3.7. 50 W power amplifier P1LP

The amplifier P1LP is mounted on the rear side of the subrack P7LP or P7LQ. In the power amplifier, the RF signal passes through preamplifiers to the driver circuits.

A combined current/voltage feedback ensures a minimum of distortion due to non-linearity and a constant output impedance.

The driver circuit provides the low source impedance necessary for the correct operation of the output amplifier stage.

The power amplifier output is protected against overload.

The signal amplified by the push-pull output stage is combined in the output transformer, from which it is passed to the high power transmitter filter located on the module E5TH or E5TC.

### 3.3.8. RF hybrid and transmit filter type E5TH

This module covers the functions RF hybrid and transmit filter. Moreover, it contains

- the RF line connector,
- the potentiometer for adjustment of the receive level,
- a LED to indicate Tx level alarm,
- a socket for monitoring the RF line signal,
• circuitry for establishing a local loop from transmitter output to receiver input,
• circuitry for prevention of interaction with parallel ETL systems in case of malfunction or deactivation of the own high power amplifier.

The RF hybrid decouples the receiver from its own transmitter. Its use is seen where the line attenuation is high, especially when transmitter and receiver bands are close together. The transmitter intermodulation products at the receiver input are correspondingly reduced by the transhybrid attenuation. Various jumpers and a potentiometer on the circuit board allow tuning of the hybrid for maximum transhybrid attenuation. For details, refer to the document “Commissioning Instructions” in the annex.

The transmit filter
• reduces spurious emissions due to non-linearity of the power amplifier,
• has a high impedance outside the transmit band, allowing further PLC units to be connected in parallel,
• protects the output amplifier from the voltage spikes on the power line caused by power system switching, faults and lightning.

The filter can be programmed by jumpers for the four bandwidths 4, 8, 16 and 32 kHz.

Center frequency and bandwidth of the filter can be selected with jumpers. A tuning screw allows exact tuning of the filter when the unit is put in tuning mode by placing appropriate jumpers. Refer to the document “1KHW002512 Tuning Instructions for ETL600R4 Tx RF Filter on E5TH/C” in the annex for details.

A mini coax connector “Tx monitor” is available on the front panel, to measure the Tx signal with an attenuation of 40 dB (e.g. 50 W output equals 7 dBm into a 75 Ohm termination).

By activating the local loop function offered by the HMI600 program, a local loop is established, i.e. the transmit signal is frequency shifted into the receive band and applied to the receiver. This allows testing of the PLC terminal without the need of a second equipment.

For ETL600-050, the module offers the choice between two different frontend topologies. For details, refer to section 3.3.8.2.
3.3.8.1. Front plate E5TH

'Tx ALARM' LED red: **Tx level alarm**
This LED is on, if the Tx level is lower than an adjustable threshold.

'Rx LEVEL' Potentiometer for adjustment of the receive level

'RF LINE MONITOR' Mini coax socket for Tx signal monitoring

'RF LINE' BNC socket for the RF signal

'L' Screw for tuning of the Tx filter

---

3.3.8.2. ETL600-050 front end topologies

For ETL600-050, when certain conditions are met, there is a choice between two topologies of the RF front end as shown in Fig. 3-24 a and b.

---

**Fig. 3-23** Front plate E5TH

**Fig. 3-24** The two possible RF front end topologies for ETL600-050
The selection of the desired topology is done with jumpers on the E5TH board.

Both topologies have specific advantages and disadvantages as listed in Table 3-3.

<table>
<thead>
<tr>
<th>Analog front end with Rx-filter (Fig. 3-24 a)</th>
<th>Analog front end without Rx-filter (Fig. 3-24 b)</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Rx filter required</td>
<td>+ No Rx filter required</td>
</tr>
<tr>
<td>- Return loss is low in the Rx frequency band</td>
<td>+ Return loss is high also in the Rx frequency band</td>
</tr>
<tr>
<td>+ Applicable for ETL600-050 and ETL600-100</td>
<td>- Only applicable for ETL600-050</td>
</tr>
<tr>
<td>+ Applicable for full range of nominal bandwidths</td>
<td>- Only applicable for nominal bandwidths of 16 kHz and less</td>
</tr>
<tr>
<td>+ Higher Rx selectivity and better suppression of spurious Tx signals due to halved Rx- and Tx-filter bandwidths</td>
<td>- Reduced selectivity in the Rx-signal-path due to wider Tx-filter</td>
</tr>
<tr>
<td>+ Lower frequency gap to parallel PLC due to narrower Tx filter</td>
<td>- Higher frequency gap to parallel PLC due to wider Tx filter</td>
</tr>
<tr>
<td>+ No restriction regarding the position of Tx- and Rx-bands</td>
<td>- Only applicable if Tx- and Rx-bands are adjacent</td>
</tr>
</tbody>
</table>

Table 3-3 Comparison of the two RF front end topologies for ETL600-050

3.3.9. **Carrier combiner and transmit filter E5TC**

This module covers the functions RF hybrid and transmit filter.

It is required only in case of the 100 W terminal ETL600-100. Its purpose is to sum the power output of the two 50 W amplifiers to achieve 100 W PEP output (Fig. 3-25).

A LED is provided at the front panel to indicate Tx level alarm for the second amplifier.

The transmit filter is identical to the one on the module E5TH but connected to the output of the second amplifier P1LP. It covers the same functions and is tuned in the same way as the Tx filter on E5TH.
3.3.9.1. **Front plate E5TC**

'Tx ALARM' LED red: **Tx level alarm**
This LED is on, if the Tx level is lower than an adjustable threshold.

'L' Screw for tuning of the Tx filter
3.3.10. **Receive Filter P4RX**

The receive filter is primarily used for the suppression of local and parallel transmitter signals. When it is unplugged, the filter input pins are automatically connected to the filter output pins on the backplane. The filter can be programmed to bandwidths 4, 8, 16 or 32 kHz.

In certain cases as explained in section 3.3.8.2, the receive filter may be omitted.

The input signal to the filter arrives from the RF hybrid, having passed the Rx level adjustment potentiometer. An attenuation circuit at the input ensures a defined load impedance for the following receive filter, that is almost independent of the potentiometer setting. The band pass receive filter obtains an input selectivity and suppresses primarily the transmitter signals of local parallel PLC equipment. The structure of the two-stage filter was chosen such that together with the tuning adapter P4LM, a simple tuning on site is possible.

A low noise, low distortion amplifier compensates for attenuation and filter losses, to achieve an input to output board gain of 0 dB.

The RXRF-IN coax connector on the front panel allows monitoring of the incoming Rx signal. It is not decoupled and thus can be used as a test input for the filter.

The RXRF-OUT coax connector on the front panel (decoupled, 50 Ohm) monitors the output voltage to the signal processing unit.

Center frequency and bandwidth of the filter are programmed by means of jumpers on the board. Fine tuning is done by adjusting the filter coils with the help of the tuning adapter P4LM. For details, refer to the P4RX Tuning Instructions in the annex.
3.3.11.  **Compressed telephony interface O4CV**

The compressed telephony interface board O4CV supports up to 4 telephony channels. The term “compressed” means that speech, DTMF, pulse code signalling and FAX are converted to a digital bitstream of a few kilobits per second for transmission over the link. Up to 3 resp. 4 O4CV boards can be plugged into one P7LH resp. P7LF rack, thus allowing a maximum of 12 resp. 16 compressed telephony channels per ETL600 link. A service phone is also supported.

The compressed telephony services are described in section 3.6.

The unit is fully programmable via user interface program HMI600.

The board houses a digital signal processor (DSP) and associated peripheral circuits. The hardware comprises the following ports:

- Four 4-wire 600 Ohm telephony ports with E&M signalling;
- Four E&M telephone signalling ports;
- Four 2-wire telephone ports office side (FXO) or subscriber side (FXS);
- One service phone port;
- One TDM bus port for internal communication with the P4LT/V/X board.

The service telephone can be plugged into a connector on the front plate of one of the O4CV boards of an ETL600 terminal. The service phone uses the same compressed telephony channel as one of the remaining ports for compressed telephony and can't be used when the channel is occupied by the other service.

A buzzer on the board is activated to announce an incoming service phone call even if no service phone is plugged.

LEDs are provided at the frontplate for visualization of the status of the board and the telephony channels.
3.3.11.1. Front plate O4CV

'AL' LED red: **Module hardware alarm**
This LED is on, if a hardware alarm on the module is detected.

'RDY' LED green: **Module ready**
On as long as the module is in normal operation mode.
Flashes slowly during hardware alarm.

'△' LED yellow: **Module warning**
On as long as the module is not in normal operation mode and no module alarm is present.

SERVICE-PHONE:

'RDY' LED green: **Service phone ready**
On if the speech channel is available for the service phone.

'ENA' LED green: **Service phone enabled**
On if the service phone is enabled on the module.
Flashes if the service phone is ringing.

Socket for the service phone

Fig. 3-27 Front plate O4CV
3.4. Analog Services

The analog services comprise the following applications:

Telephony
- Point-to-point hot line (direct phone),
- Remote subscriber,
- 4-wire PAX connection with E&M signaling,
- 2/4-wire PAX connection with E&M signaling and hybrid control,
- E&M signaling,
- Service phone.

Teleoperation
- Transmission of AF data signals from modems
- Programmable transit filters

Connection of external teleprotection equipment
- External teleprotection equipment instead of or in addition to the integrated NSD600
- Signal boosting control

The ports for all these applications are located on the O4LE board(s).

Note: For the “Single purpose teleprotection equipment in nominal bandwidth 2 kHz” no other services can be configured except for a service phone.
With the service phone enabled the speech bandwidth is automatically limited to 1600 Hz.

3.4.1. Telephony

One APLC channel of the ETL can carry one telephony channel, its upper edge frequency being programmable to 2.0, 2.2, 2.4, 2.6, 2.8, 3.0, 3.2 or 3.4 kHz. The speech signal is scaled to the nominal level of 0 dBm0 PE (weight = 1.0) for transmission over the link. To prevent saturation of the RF-signal in case the level of the incoming speech signal is excessively high, the speech signal inside the ETL is limited to a maximum level of +3 dBm0 PE.

For the case of 3 APLC channels in 8 kHz, the range of available speech bandwidths is restricted. For 2 kHz nominal bandwidth, the upper edge frequency of the speech band is 1.6 kHz.
3.4.1.1. **Point to point hot line (direct phone)**

![Diagram of point to point hot line]

In this application, a direct connection between two phones is established. As soon as either of the phones is picked up, the phone on the other side is ringing intermittently until it is picked up also. Input and output speech levels and ringer frequency are programmable. In order to improve the signal to noise ratio by up to 10 dB on noisy links, a compandor function can be enabled.

As long as the hot line is idle (both phones on hook), the service phone may utilize the speech channel. In any case, the direct phone has priority over the service phone.

3.4.1.2. **Remote subscriber**

![Diagram of 2-wire remote subscriber]

In this application, the ETL-link is inserted in the 2-wire loop between a subscriber phone and a PAX as shown in Fig. 3-29. The subscriber side of the link has to be programmed for operation mode 'Remote subscriber', while operation mode 'PAX 2-wire' has to be selected for the PAX side of the link. The speech levels from and to PAX and subscriber are programmable as well as the frequency of the ringing tone on the subscriber side. Both tone (DTMF and MFC) or pulse signaling are supported.

Alternatively, if the PAX allows connection of a remote subscriber over 4 wires with E&M-signaling, the PAX side terminal of the link can be programmed for operation mode '4-wire'. This mode of operation – shown in Fig. 3-30 – is to be preferred to that one shown in Fig. 3-29 as it has only one 2-wire section instead of two. The number of hybrids is reduced and so echo cancellation can be improved. For further functions available on the PAX side, refer to the following section.
For the PAX connections described above, the compandor can be enabled. The compandor improves the signal to noise ratio by up to 10 dB on a noisy link.

As long as the subscriber loop is idle, the service phone may utilize the speech channel. In any case, the subscriber loop has priority over the service phone.

3.4.1.3. **4-wire PAX connection with E&M signalling**

In this application, the ETL-link is inserted into a 4-wire trunk line as shown in Fig. 3-31.

Signaling is done via E- and M-wires. In order to improve the signal to noise ratio by up to 10 dB on noisy links, a compandor function can be enabled. The compandor can be activated permanently or it can be controlled by the input 'Local/Transit' driven by the PAX.

A galvanically isolated relay switch-over contact 'PAX blocking' indicates, if the speech channel of the PLC link is interrupted or distorted by excessive line noise. During these periods, E&M signaling is not available and the speech signal is squelched.

All three signals: E-wire, M-wire and Local/Transit can be inverted independently. All signaling wires are galvanically isolated. The PAX only needs a dry relay contact to control M-Wire and Local/Transit input, since ETL600 provides an extra voltage source for these inputs.

As long as the trunk line is idle, the service phone may utilize the speech channel. In any case, the trunk line has priority over the service phone. To determine whether the trunk line is busy, the states of E- and M-wires are monitored: If at least one of these is in the active state, the trunk line is considered busy.
3.4.1.4. 2/4-wire PAX connection with E&M signaling and hybrid control

Fig. 3-32 2/4-wire PAX connection with E&M and hybrid control

In this application, a 4-wire as well as a 2-wire circuit is provided. The PAX selects one of the two circuits depending on the control input 'Local/Transit' of the O4LE board carrying the service.

This type of operation may be required with older PAX's that use 4-wire circuits for transit connections and 2-wire circuits for local subscriber connections.

It should be noted that the 2-wire Rx path is always connected independent of the condition of the 'Local/Transit' control line. Therefore, speech and signaling tones can always be received at the 'PAX2W' terminals.

When the circuit is busy, the E- and M-wire are active. It is also possible to control the compandor with the 'Local/Transit' line.

Since the best intelligibility improvement is obtained when one compression and one expansion process takes place, the compandor is only employed in the 2-wire local subscriber stations but not in the 4-wire transit stations.

3.4.1.5. E&M signaling

For some applications, the AF signal of a first ETL-link has to be forwarded to a second link via teleoperation ports – this is called 'transit operation'. If also a telephony application is forwarded, but a PAX is not connected to the transit equipment, E&M signaling must be forwarded too. In this case, the operation mode “E&M signaling” should be selected at the transit equipments.

3.4.1.6. Service phone

Fig. 3-33 Service phone

The service phone can be used in combination with all previously described telephony operation modes. However, these modes always have priority over the service phone.
The phone is plugged into the socket on the O4LE front plate. As soon as the handset is picked up, a buzzer on O4LE in the opposite equipment generates an intermittent audible tone. If a phone is plugged on the opposite O4LE, it will generate an intermittent ringing signal simultaneously. The ringing stops as soon as the service phone on the opposite side is picked up.

In- and output speech levels and ringer frequency for the service phone are programmable.

During periods of excessive line noise, the speech signal is not squelched in contrast to the other telephony operation modes.

Compador is always active for service phone.

### 3.4.1.7. Display E&M signaling at front LEDs

The internal state of E&M signaling wires can be monitored by uploading the status with HMI600 or by watching the LEDs on the O4LE front panel. Inverting one or both of these wires has no effect on the LEDs.

An example of a successful establishment of a connection is shown in Fig. 3-34.

![Fig. 3-34 State of LEDs corresponding to internal E&M](image)

By watching the LEDs, it is easy to see whether a remote PAX is working or not. If the remote PAX is not answering, the upper LED 'RDY' won't flash. This is shown in Fig. 3-35.

![Fig. 3-35 State of LEDs showing to internal E&M when one PAX is not working correctly](image)
3.4.2. **Teleoperation**

3.4.2.1. **Ports**

Three galvanically isolated teleoperation 4-wire ports AF2, AF3 and AF4 are provided on each O4LE board. A fourth port AF1 is available if no 4-wire telephony is configured. Each port consists of an input and an output port with an impedance of 600 Ohms. The frequency range of the ports is between 300 and 4000 Hz. Signals within this frequency range are transmitted transparently over the link. Each output port can be squelched individually during periods of excessive line noise. Each port can be connected individually to either one of two AF-channels. Each port may be used either in mode 'disconnectable' or mode 'non-disconnectable':

- In mode 'disconnectable', the signal applied to the input port is suppressed during the transmission of teleprotection command signals. This allows to assign more power to the teleprotection signal during command transmission.
- In mode 'non-disconnectable', the signal applied to the input port is not suppressed during the transmission of teleprotection command signals. This mode has to be chosen when the short signal interruptions (typically less than 100 ms) caused by teleprotection command transmission in mode 'disconnectable' cannot be tolerated. As a consequence, the available power for teleprotection command signals is reduced accordingly.

For more information on the management of signal levels for teleprotection, refer to section 3.4.3 'External teleprotection' and to section 5.2.17 'Signal boosting for teleprotection devices'.

3.4.2.2. **Transit filters**

The frequency bands of the signals injected into the teleoperation input ports are subject to the following restrictions:

- Each frequency band must lie in the range from 300 to 4000 Hz.
- The frequency bands must not overlap.
- The frequency bands must not overlap the pilot band.
- The frequency bands must not overlap the speech band, if speech is used.
- The frequency bands must not overlap the NSD600 guard signal band, if NSD600 is used with own guard signal.

Refer to Fig. 3-6 to Fig. 3-11 for information about the frequency bands occupied by speech, pilot or NSD600 guard.

To ensure that the signals injected into the teleoperation input ports do not violate the above restrictions, frequency selective filters called 'transit filters' can be inserted into the input or output ports. A large number of frequency characteristics, some of them equalized for low group delay variation, are available for each of these transit filters, (Fig. 3-36).
A maximum of two transit filters are available on each O4LE board when speech is configured. When no speech is configured, a maximum of four transit filters per O4LE board are supported.

![Diagram of transit filter cutoff frequencies](image)

**Fig. 3-36** Transit filter cutoff frequencies selectable in steps of 60 Hz

If the AF signal of a first ETL-link has to be forwarded to a second link via teleoperation ports – this is called 'transit operation' - , the pilot signal of the first link must not be forwarded to the second link since each link maintains its own pilot channel independent of the others. A transit filter has to be used that passes the desired data frequencies but blocks the pilots. By connecting

- E-wire and M-wire of the two equipment for out of band signaling,
- the HMI ports of the two equipment via Null modem or RS-485 station bus for management data,

information carried by the pilot channel can still be forwarded to the other link. The necessary connections are indicated in Fig. 3-37. Several possibilities exist for the placement of the transit filters:

1. in the AF outputs of both equipment,
2. in the AF inputs of both equipment,
3. in the AF in- and outputs of both equipment.

The first possibility is the standard solution. If for some reason this is not possible, or if noise picked up on the AF line connecting the two equipment has to be suppressed, possibilities 2 or 3 have to be chosen. Note that each transit filter adds its group delay response to the overall group delay response of the links.

---

3 RS-485 cables according to Fig. 6-19 or equivalent required for ETL600
In the signal path of each input port, a programmable attenuator/amplifier is provided, to adapt the signal level at the port to the internal level of the ETL600. On the output side, a similar programmable attenuator/amplifier restores the signal strength to the level required at the output port.

3.4.3. **External teleprotection**

At most one teleoperation port per APLC channel can be configured for connection to the external teleprotection equipment type NSD570 or NSD70C. The ETL600 does not squelch the signal coming from the opposite external teleprotection equipment during periods of excessive line noise.

An external boost input, whose polarity can be inverted if desired, is available for each external teleprotection port. If this input is enabled, the NSD570/NSD70C signal fed into the port is boosted by up to 9 dB and all disconnectable input signals are disconnected as long as the external boost input is activated. By disabling the external boost input, no boosting and disconnecting will take place. Boosting of the built in NSD600 teleprotection devices have priority over boosting of an external teleprotection equipment. Boosting of an external teleprotection signal on APLC channel 1 has priority over boosting of an external teleprotection signal on channel 2 which in turn has priority over boosting of an external teleprotection signal on channel 3.

**Note:** Certain rules - regarding alarm and signal weight settings or configuration of the boost ratio - have to be observed if commands of long duration or even persistent commands are to be transferred with external teleprotection over ETL600 (please refer to Chapter 5 for details).

**Note:** At beginning and end of NSD600 teleprotection commands, external teleprotection equipment might raise an SNR alarm. This is due to the large transients produced by the boosted NSD600 trip signal, when this signal is switched on or off.
Disabling all-pass filter and equalizer of channels used for external teleprotection equipment lowers the signal delay of these channels by some ms thereby reducing the command transfer time accordingly. However - as stated in section 3.5.1.1 - operation of NSK600 modems over the same channels will be degraded or even impossible when switching off all-pass filter and equalizer.

3.5. Data Communication

ETL600 offers a variety of options for data communication: two different types of modems for transmission over the PLC link and a range of physical interfaces to be used with various transmission formats.

3.5.1. NSK600 Modem

The NSK600 is a new, fully programmable set of modems for data transmission over power line carrier (PLC) links. For data transfer rates of up to 1’200 bps it works with frequency shift keying (FSK) as used in previous generation NSK modems; for 2’400, 4’800 and 9’600 bps it works with differential amplitude and phase shifted keying (DAPSK).

FSK modulated NSK600 signals can be through connected from one ETL600 link to another via AF teleoperation ports offered by the O4LE board. This is called AF transit operation. The number of AF transits depends on the channel quality and the data rate. AF transit operation for DAPSK modulated NSK600 channels is not recommended with the following exception: One AF transit (connecting 2 links) is allowed for a DAPSK channel with adaptive equalizer.

NSK600 allows efficient low-cost link utilization, and since it comprises four independent modems that are included into the DSP module P4LT/V/X, no additional hardware is required.

NSK600 has been designed using digital signal processor (DSP) and field programmable gate array (FPGA) technology. This makes it very reliable and it requires no maintenance or periodic adjusting.

NSK600 features:

- Data rates: ≤ 150, ≤ 225, ≤ 300, ≤ 600 and ≤ 1200 bps with FSK; 2400, 4800 and 9600 bps with DAPSK. The FSK modems with data rates of ≤ 1200 bps are available with two different bandwidths.
- Compatibility with the following ITU-T standards for telecommunication:
  - R.37 (100 Bd)
  - R.38a (200 Bd within 480 Hz bandwidth)

4 If one or more of the modems are configured for 9600 bps, only three NSK600 modems are supported.
- R.38b (200 Bd within 360 Hz bandwidth)
- V.23 (1200 Bd within 2400 Hz bandwidth)

- Receive data regenerator (only for FSK)
- Half-duplex or full-duplex operation
- Signal quality supervision (SNR): An SNR alarm is raised if the signal quality is inadequate. Refer to section 9.5.2.2.
- Adaptive equalizer (only for DAPSK)
- Standard data interface: ITU-T V.24, TIA/EIA RS-232

The NSK600 can be used in many applications that require multiple or single data transmission channels over power line carrier. Carrier keying allows the modem to be used in a point to point link or in a multipoint network.

Similar to the teleoperation ports described in section 3.4.2.1, each NSK600 modem can be configured for disconnectable or non-disconnectable operation:

- In mode 'disconnectable', the modem signal is suppressed during the transmission of teleprotection command signals. This allows to assign more power to the teleprotection signal during command transmission.

- In mode 'non-disconnectable', the modem signal is not suppressed during the transmission of teleprotection command signals. This mode has to be chosen when the short signal interruptions (typically less than 100 ms) caused by teleprotection command transmission in mode 'disconnectable' cannot be tolerated. However, due to transients at the beginning and at the end of command signals, bit errors may occur at these instants. As a consequence of choosing the mode 'non-disconnectable', the available power for teleprotection command signals is reduced accordingly.

3.5.1.1. APLC channel conditioning for operation of the modems

Operation of NSK600 modems over badly conditioned channels is degraded particularly for the higher data rates. Therefore, channel conditioning is recommended or - in case of higher data rates - even required. Two different means for channel conditioning are available: All-pass filter and static APLC channel equalizer. In addition, adaptive equalizers are available for DAPSK channels as an alternative to all-pass filter and (static) equalizer.

3.5.1.1.1. All-pass filter

For each APLC channel, an all-pass filter can be enabled located on the transmitter side of the link. By default, the all-pass filter for all APLC channels is disabled.

Activating the all-pass filter is required for NSK600 1200 Bd FSK channels. Lower rate FSK channels also work with the all-pass filter disabled, however with somewhat reduced performance. NSK600
DAPSK channels also require the all-pass filter unless their adaptive equalizer is enabled.

### 3.5.1.1.2. APLC channel equalizer

The equalizer is located on the receiver side of the link. By default, the equalizer is disabled for all APLC channels.

APLC Channel equalization is required for all APLC channels carrying DAPSK channels unless their adaptive equalizer is enabled.

APLC Channel equalization is recommended also for the FSK channels.

Refer to document 1KHW001494 “APLC Channel equalization” in the Annex for details.

Both – all-pass filter and APLC channel equalizer – increase the delay of the APLC channel by some ms. This must be respected when external teleprotection equipment is operated over the same channel. Internal teleprotection is not affected.

### 3.5.1.1.3. Adaptive equalizer

Adaptive equalizers are enabled by default for the DAPSK channels. For these DAPSK channels,
- good transmission quality is maintained thanks to the adaptive equalizers even when the frequency response of the PLC link changes over time;
- all-pass filter and equalizer in the associated APLC channel are not effective (and not required), should they be enabled.

The performance of NSK600 DAPSK channels with adaptive equalizers is equal or better than with the static APLC channel equalizer.

ABB has filed a patent for the method of equalizer adaptation. The adaptive equalizers can be disabled for individual DAPSK channels. In the latter case, APLC channel conditioning with all-pass filter and static equalizer in the associated APLC channel is then required.

### 3.5.1.2. Data Regeneration with FSK Modems

The NSK600 modems using FSK modulation provide transparent transmission of a binary anisochronous data signal. Ideally, the received data signal is an exact delayed replica of the transmitted data signal. In reality, the received data signal shows isochronous distortion due to

- the non-flat frequency response of the transmission channel,
- noise and non-linear distortion on the transmission channel,
- implementation losses of the modems.

When the data signal satisfies certain conditions, isochronous distortion can be reduced using nonlinear processing. This is called regeneration.
Note: FSK modem data regeneration is only possible when data transfer rate corresponds to the configured nominal data rate.

Regeneration requires that the time between transitions of the data signal is an integer multiple of a fixed time interval. This interval is called “Nominal bit length”. SCADA protocols usually pack the data into telegrams. Inside telegrams, no pauses are allowed between characters, so that the above condition is fulfilled. However, between telegrams, a pause of some minimum length is required. If the regenerator is capable of recognizing these pauses, regeneration can also be used for SCADA protocols.

In order to save transmission bandwidth, polling of multiple RTUs over PLC is often done using one single communication channel. Only one RTU is allowed to transmit at any moment. In such cases, the data carrier detector handshake line (DCD) can be used to recognize the pauses between telegrams.

Generally, regeneration brings an advantage only if several FSK channels are connected in tandem. As a rule of thumb, isochronous distortion at the input of any FSK channel should be lower than 25%. The regenerator in the receiver of the preceding FSK channel should be enabled if this condition is not met.

NSK600 modems offer data regeneration as a parameter: refer to “Data regeneration” in section 5.3.4.8 for details.

3.5.1.3. Required data transmission format parameter for DAPSK

Opposed to transparent transmission with FSK, modems using DAPSK modulation do not provide transparent transmission.

DAPSK modems are based on transmission of characters. Therefore, when using NSK600 modems with data transfer rates of 2'400, 4'800 or 9'600 bps, the exact data format of the DTE connected to the interface has to be configured for the V.24 port in terms of the amount of data bits, stop bits and parity: Refer to section 5.3.4.6 for details.

3.5.2. MOD600 Modem

The MOD600 modem converts digital data to an analog signal in the DPLC channel and vice versa. The supported data transfer rates are:

9.6, 11, 12, 14.4, 16, 19.2, 24, 28.8, 32, 36, 38.4, 40, 48, 56, 64, 72, 76.8, 80, 96, 112, 128, 144, 153.6, 160, 192, 224, 256, 288, 307.2, 320 kbps,

the upper limit being restricted by the choice of the DPLC bandwidth, refer to Table 3-4. The MOD600 bandwidths of 2, 4, 6, 8, 12, 16, 20, 24 kbps.

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5 Only for MOD600 bandwidth 2 kHz
24, 28 or 32 kHz are automatically selected according to the configured bandwidth of the DPLC channel.

<table>
<thead>
<tr>
<th>MOD600 bandwidth [kHz]</th>
<th>Max. MOD600 data rate with setting “High Efficiency” [kbps]</th>
<th>Max. MOD600 data rate with setting “Low delay” [kbps]</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.0</td>
<td>11.0</td>
<td>11.0</td>
</tr>
<tr>
<td>3.5</td>
<td>40.0</td>
<td>28.8</td>
</tr>
<tr>
<td>4.0</td>
<td>40.0</td>
<td>32.0</td>
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<tr>
<td>6.0</td>
<td>48.0</td>
<td>40.0</td>
</tr>
<tr>
<td>8.0</td>
<td>80.0</td>
<td>64.0</td>
</tr>
<tr>
<td>12.0</td>
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<td>16.0</td>
<td>160.0</td>
<td>128.0</td>
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<tr>
<td>20.0</td>
<td>192.0</td>
<td>160.0</td>
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<tr>
<td>24.0</td>
<td>224.0</td>
<td>192.0</td>
</tr>
<tr>
<td>28.0</td>
<td>256.0</td>
<td>224.0</td>
</tr>
<tr>
<td>32.0</td>
<td>320.0</td>
<td>256.0</td>
</tr>
</tbody>
</table>

Table 3-4 Max. MOD600 data rates

The fallback/fall-forward option enables the data rate to be automatically adjusted to ensure a sufficiently low BER under varying transmission conditions. In this way a maximum data throughput is achieved at any time. The quality of the communication channel is continuously monitored and the most favorable of the five programmable data transfer rates is selected accordingly. The BER is estimated continuously and the data rate is reduced if the estimate exceeds a preset limit. Respectively increased again as soon as the quality of the communication channel improves sufficiently. Data transmission is interrupted for some seconds when the data transfer rate changes.

The modulation method used by MOD600 is block oriented: Data are transmitted in packets of length \( N = 64, 128, 256 \) or 512 (orthogonality interval). Data throughput and delay are increased with increasing packet length. A guard interval of length \( L = 8, 16, 32 \) or 64 introduced between the data packets allows for channel response and line echoes to die off before the next data packet starts. Data throughput is decreased while data delay is increased with increasing length of the guard interval. The tradeoff between delay and data throughput is evident from Table 3-4.

MOD600 has special means to combat against two kinds of transmission channel impairments:

- Forward error correction (RS):
  This type of error correction may be useful when the link is disturbed by intermittent narrowband interferers. If a suspicion arises that this may be the case, it is recommended to test if the
activation of Reed Solomon (=RS) forward error correction improves the situation.

- Narrowband interference detection: When narrowband interferers are present in the MOD600 frequency band, data throughput may be increased by enabling narrowband interference detection. Upon startup of the communication, the frequencies of narrowband interferers are detected and in the sequel no longer used by MOD600. This allows to spend more power to the frequencies not impaired by narrowband interferers. A considerable improvement of the transmission quality can be expected provided the frequencies of the narrowband interferers are stable. ABB has filed a patent for this method.

3.5.3. **MUX600 DPLC Channel Multiplexer and V.24 Port Sharing**

![MUX600 block diagram](image)

**Fig. 3-38 MUX600 block diagram**

MUX600 consists of a DPLC channel multiplexer for transmission of individual channels over one aggregate channel on MOD600 modem, a port sharing device for channel sharing of up to four V.24 ports and some switches for assignment of the V.24 ports to NSK600 modems or to the DPLC channel multiplexer.
3.5.3.1. **DPLC channel multiplexer**

No multiplexer is required when only LAN traffic or only one single V.11 data stream has to be transmitted via MOD600. Otherwise, all data from the interfaces pass the DPLC multiplexer, which combines up to 23 individual channels into a single aggregate channel. The multiplexer is configured indirectly by configuring the services to be transmitted via MOD600 such as V.11, V.24, digital transit, LAN data or compressed telephony. The aggregate channel is transmitted through the MOD600 modem.

The multiplexer transmitter adds a frame to the aggregate stream of the MOD600 modem. Each frame has a duration of 10 ms. This frame duration is constant for every MOD600 data transfer rate.

As depicted in Fig. 3-39, the frame comprises a preamble word (PRE) for synchronization followed by the individual channels (CHx). When the aggregate data transfer rate is higher than the sum of all individual channel rates plus the preamble, the frame is filled-up (FIL).

Each individual channel in this frame comprises a user data field (UDF) of the length of nominal bit rate increased by two bits (ADJ). This allows speed adjustment for tolerances of connected DTEs. For compressed telephony channels, the two ADJ bits are not required.

![Frame diagram](image)

- **PRE**: Preamble field (length: 9 bit)
- **CHx**: Channel x (individual transmission channel)
- **UDF**: User Data Field (length: nominal bps)
- **ADJ**: Speed adjustment (length: 2 bit)
- **FIL**: Frame fill-up (length: variable)

**Fig. 3-39** DPLC channel multiplexer framing

**Note:** When defining the data transfer rate of the aggregate channel for configuration, note that the framing overhead depends on the number of individual channels transmitted.

The required gross data rate for each MOD600 profile can be calculated according to the following formula:
\[ \text{GrossDatarate} [\text{bit/s}] = \text{NetDatarate} [\text{bit/s}] + \frac{1000}{10[\text{ms}]} \times (9[\text{bit}] + 2[\text{bit}] \times \text{Channels}) \]

where:
- \( \text{GrossDatarate} \) is the required aggregate rate of MOD600 modem;
- \( \text{NetDatarate} \) is the sum of all individual channel data transfer rates;
- 10 ms is the frame length;
- 9 bit is the preamble for synchronization of the frame;
- 2 bit are used for speed adjustment per each channel;
- Channels is the number of configured channels other than compressed telephony channels.

The multiplexer detects the data transfer rate being used by MOD600 and automatically adjusts its own operation accordingly.

If the DPLC modem reduces its data transfer rate due to poor transmission conditions (fallback), the data transfer rate of the aggregate channel also has to be reduced and this means that the data transfer rates of individual channels have to be reduced or the channels switched off. Five different data transfer rate profiles for the aggregate channel and each individual channel can be defined for this purpose.

External data terminals can be connected to the channels as follows:
- Four LAN interfaces for Ethernet traffic at data transfer rates from 9'600 bps up maximum available data rate for MOD600 (not available for P4LT);
- One or two V.11 interfaces for synchronous data transfer at data transfer rates from 9'600 bps up to maximum available data rate for MOD600;
- Two or four V.24 interfaces for asynchronous data transfer at data transfer rates from 200 to 19'200 bps\(^6\).
- Up to 16 compressed telephony interfaces, all at data transfer rates of either 5300 or 6300 bps.

For details about the different data terminals refer to section 3.5.4. For details about the compressed telephony interfaces refer to section 3.6.

### 3.5.3.2. V.24 port sharing

This feature permits sharing of one modem transmission channel (NSK600 or MOD600) with up to four V.24 port interfaces. Additional switches allow the physical through-connection of available V.24 data ports to available modem transmission channels (NSK600 modem or MOD600 modem).

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\(^6\) ETL600 Rel.4.0.0: 1’200 to 19’200 bps
The implementation is based on simple channel broadcasting towards all connected DTEs while data signals from the connected DTEs are handled according to port priorities. The priorities are such that Port 1 priority > Port 2 priority > Port 3 priority > Port 4 priority. Data from a connected DTE is only accepted if all other shared ports with higher priorities are idle. The decision whether a shared port is idle or busy depends on the selected method of flow control, using either hardware handshake or data activity.

Typical applications for ports sharing are SCADA systems that poll their RTUs over the same transmission channel. With four possible ports sharing one channel, the following applications are realizable:

- Up to 4 local RTUs
- Up to 3 local RTUs with one digital transit connection
- Up to 2 local RTUs and two digital transit connections (T-line).

3.5.4. **Data port interfaces**

Different physical interfaces are provided for data communication: each of the available interface type is suitable for specific transmission formats.

3.5.4.1. **LAN (not available for P4LT)**

Four Ethernet ports are available. Three of them are electrical auto-sensing 10Base-T/100Base-TX with auto MDI/MDIX and one of them requires an optical SFP transceiver to be fitted (optional).

The ports support the services

- LAN over PLC,
- SNMP,
- HMI over LAN.

These services can be enabled or disabled individually. Available data transfer rates are 9.6 to 320 kbps, where the highest rate is always limited by the available MOD600 modem data rate on a specific PLC link. In case Ethernet is the only service to be transferred over MOD600, the multiplexer MUX600 may be bypassed. Otherwise, all data to MOD600 is directed via MUX600.

The electrical physical interfaces are RJ-45 connectors with pin-out according to TIA/EIA-568-B.

The service “LAN over PLC” operates in one of two user selectable modes: Switch mode and router mode. The following 2 sections explain the behaviour of these modes.
3.5.4.1.1. **Switch mode (layer 2)**

In this mode, each ETL600 implements a layer 2 switch with the ports LAN 1, LAN 2, LAN 3, LAN 4 and PLC. The switch is MAC self-learning with ageing function, IEEE 802.1q VLAN compatible and supports VLAN priorities. Link Fault Pass Through (LFPT) may be enabled.

![LAN ports in switch mode](image)

3.5.4.1.2. **Router mode (layer 3)**

In this mode, each ETL600 implements a layer 3 router between the ports LAN 1, LAN 2, LAN 3, LAN 4 and the PLC port. The IP addresses of the LAN ports are identical, i.e. there is no routing between the LAN ports. Link Fault Pass Through (LFPT) may be enabled. Priorities can be set individually for each port.

![IP networks for router mode](image)

Traffic is only forwarded by the router if the destination IP network matches one of up to 16 configurable routes. The gateway of routes to IP networks reachable via PLC link must be the PLC port of the remote ETL600.

3.5.4.2. **V.11**

One interface according to ITU-T V.11 is available on P4LT and P4LV, two are available on P4LX.
These interfaces are limited to synchronous application for transmission with MOD600 (only one port) or DPLC channel multiplexer (one or two ports). Available data transfer rates are 9.6 to 320 kbps, where the highest rate is always limited by the available MOD600 modem data rate on a specific PLC link.

Maximum generated deviation from nominal data rate for any V.11 channel is ±1 ppm.

Flow control of V.11 interfaces is implemented via the clock line and signaling ("Indicate") line in the following manner:

- When the data transfer rate is greater than zero, indicate is asserted;
- When the data transfer rate is zero, indicate is de-asserted;

For parameters that are configurable for V.11 interfaces, refer to section 5.3.4.5.

The physical interface are DB15 connectors with the pin-out compliant to ISO 4903. For detailed pin-out information refer to section 6.7.3.4.1.

3.5.4.3. V.24

Two interfaces according to ITU-T V.24 are available on P4LT and P4LV, four are available on P4LX.

These interfaces are limited to asynchronous full-duplex communication, for a variety of applications:

- V.24 interfaces with NSK600
  With NSK600 modem, data transfer rate is limited to a maximum of 9'600 bps.

- V.24 interfaces with DPLC channel multiplexer
  With DPLC channel multiplexer, data transfer rate is limited from 200 to 19'200 bps.

- V.24 with channel sharing
  V.24 port sharing is possible both for an NSK600 modem and for one DPLC multiplexer channel.

- SCADA applications using telegram based protocols for communication between master and RTUs:
  - ABB proprietary protocol RP570 / RP571 based on IEC 60870-1-5 FT1.2 with 8 data bits, 1 stop bit and even parity;
  - ABB proprietary implementation of asynchronous DNP3.0 based on IEC 60870-1-5 FT3 with 8 data bits, 1 stop bit and no parity.
  - Maximum supported telegram length for these two protocols is 255 characters.

Maximum allowed deviation from nominal data rate for any application is ±400 ppm.

For parameters that are configurable for V.24 interfaces, refer to section 5.3.4.6.
The physical interface is a Sub-D 9 pole connector with pinout compliant to EIA/TIA 574 for TD, RD, RTS, CTS, DCD and SGND signals. For detailed pinout information refer to section 6.7.3.4.2.

3.6. Compressed telephony

One O4CV board supports up to 4 compressed telephony channels. Apart from the mode “2/4-wire PAX connection with E&M signaling and hybrid control”, the same telephony modes are supported as for analog telephony. While analog telephony channels can be used for any kind of analog signals within the bandwidth of the telephony channel, O4CV compressed telephony channels accept only 4 types of signals:

- Speech,
- Call progress tones,
- DTMF signalling,
- Fax.

Transit connections of compressed telephone channels over up to 6 ETL600 links in series are supported, thereby reducing the number of coding and decoding operations per channel to one. Refer to section 5.3.6 for details.

3.6.1. Point to point hot line (direct phone)

In this application, a direct connection between two phones is established. As soon as either of the phones is picked up, the phone on the other side is ringing intermittently until it is picked up also. In-and output speech levels, impedance scheme and ringer frequency are programmable.

As long as the hot line is idle (both phones on hook), the service phone may utilize the compressed telephony channel. In any case, the direct phone has priority over the service phone.
3.6.2. **Remote subscriber**

![Diagram](image1)

**Fig. 3-43** 2-wire remote subscriber

In this application, the ETL-link is inserted in the 2-wire loop between a subscriber phone and a PAX as shown in Fig. 3-43. The subscriber side of the link has to be programmed for operation mode 'Remote subscriber', while operation mode 'PAX 2-wire' has to be selected for the PAX side of the link. The speech levels from and to PAX and subscriber, the impedance scheme and the frequency of the ringing tone on the PAX and subscriber sides are programmable.

Alternatively, if the PAX allows connection of a remote subscriber over 4 wires with E&M-signaling, the PAX side terminal of the link can be programmed for operation mode 'PAX 4-wire with E- & M-wire'. This mode of operation – shown in Fig. 3-44 – is to be preferred to the one shown in Fig. 3-43 as it has only one 2-wire section instead of two. The number of hybrids is reduced and so echo cancellation can be improved. For further functions available on the PAX side, refer to the following section.

![Diagram](image2)

**Fig. 3-44** 4-wire remote subscriber

As long as the subscriber loop is idle, the service phone may utilize the compressed telephony channel. In any case, the subscriber loop has priority over the service phone.

3.6.3. **4-wire PAX connection with E&M signalling**

![Diagram](image3)

**Fig. 3-45** 4-wire PAX connection with E&M

In this application, the ETL-link is inserted into a 4-wire trunk line as shown in Fig. 3-45. Signalling is done via E- and M-wires.
E- and M-wire signals can be inverted independently. All signalling wires are galvanically isolated. The PAX only needs a dry relay contact to control the M-Wire input, since ETL600 provides an extra voltage source for this input.

As long as the trunk line is idle, the service phone may utilize the compressed telephony channel. In any case, the trunk line has priority over the service phone. To determine whether the trunk line is busy, the states of E- and M-wires are monitored: If at least one of these is in the active state, the trunk line is considered busy.

3.6.4. **Service phone**

Fig. 3-46 Service phone

The service phone shares the compressed telephony channel with a compressed telephone service according to one of the previously described operation modes. However, these modes always have priority over the service phone.

The phone is plugged into the socket on the front plate of the first, i.e. leftmost O4CV board in the rack. As soon as the handset is picked up, a buzzer on the first O4CV board in the opposite equipment generates an intermittent audible tone. In addition, the LED “ENA” on the O4CV front-plate flashes. If a phone is plugged on the opposite O4CV, it will generate an intermittent ringing signal simultaneously. The ringing stops as soon as the service phone on the opposite side is picked up.

In- and output speech levels, impedance scheme and ringer frequency for the service phone are programmable.

3.7. **Internal Teleprotection**

3.7.1. **Introduction**

The sizes, complexity and power ratings of high voltage networks emphasize the need for highly reliable protection systems. Protection is based on information derived from the power system at one or more points. Fast and selective protection applied to circuits with geographically separated terminals, such as cables and overhead lines, requires information interchange between these terminals.

Teleprotection equipment (TPE) transmit the tripping signals from the protection equipment in high voltage grids of electricity utilities, between power system control centers, power stations and substations. Teleprotection links using power line carrier (PLC) channels are the most economical way of performing all the tasks associated
with transmitting tripping signals. In case of power line carrier as a telecom link the requirements are especially high since the protection commands are transferred within faulty sections of the power grid.

Since any communication system is subject to interference and noise of various forms, the performance of a teleprotection equipment is commonly described in terms of security, dependability and transmission time. Further characteristics are the bandwidth of analog equipment and the signaling rate of digital equipment. Interference and noise on the communication link must neither simulate a command at the receiving end when no command signal was transmitted (security), nor impair the ability to convey commands correctly and promptly (dependability).

Security, dependability, transmission time and bandwidth (or signaling rate) are interrelated and interchangeable parameters. High security and high dependability together with short transmission time and narrow bandwidth are therefore conflicting requirements. But the emphasis can always be placed on dependability or security or speed, depending on the application. A blocking protection scheme, for instance, needs a short transmission time and a high dependability, while a permissive tripping scheme needs a short transmission time with good security and a high dependability. Direct transfer tripping schemes, by contrast, require very high dependability and security, achieved at the expense of a longer transmission time.

The above mentioned protection schemes are explained in section 3.7.5.

Up to two individual NSD600 TPE systems - each transmitting four protection commands - can be operated in the ETL600 PLC equipment. They are suitable for handling the tripping signals in blocking, permissive and direct transfer tripping schemes. Four commands enable parallel circuit lines to be protected with permissive tripping of the line protection and direct transfer tripping of a compensator or the breaker back-up protection for example.

By using micro-processor techniques and digital signal processing, the NSD600 is able to ideally fulfill the high performance demands when transmitting tripping signals via PLC.

The full version of the teleprotection equipment NSD600 comprises at least one additional module, the teleprotection interface type G4AI, which is directly inserted into the power line carrier equipment type ETL600.

Besides some specific jumper settings (i.e. the command tripping voltage of the G4AI inputs), all parameters are configurable by means of the windows based user interface HMI600 for the ETL600 system. For the same reason commissioning, testing and maintenance also becomes easy.

The use of the NSD600 in conjunction with ETL600 and HMI600 is documented and explained in this chapter.
3.7.2. **Intended use of NSD600**

The teleprotection equipment type NSD600 is designed as an optional service to be used exclusively together with PLC equipment type ETL600.

The NSD600 fully complies with the Product Standard IEC 60834-1 for teleprotection equipment of power systems. It further meets or exceeds the requirements according the European EMC Directive 89/336/EEC and the Low Voltage Directive 73/23/EEC.

Two individual NSD600 systems can be configured. They are always assigned to the first two APLC channels with 4 kHz bandwidth, if available, or - in case of a mixed mode dual channel ETL600 – one NSD600 is assigned to the APLC and one NSD600 to the DPLC channel.

In conjunction with one APLC channel, the DPLC channel requires its own guard signal for the NSD600 (which is not necessary without TPE in the DPLC).

If only data communication is used at all, one NSD600 can also be assigned to this DPLC channel (of any bandwidth).

A special ETL600 mode of operation offers three AF channels with bandwidths of 3.2, 2.4 and 2.4 kHz, resulting in an APLC bandwidth of 8 kHz. In this case one optional NSD600 can be configured in the 3.2 kHz channel.

A special ETL600 mode of operation with only one APLC channel and a nominal bandwidth of 2 kHz offers single purpose teleprotection NSD600 and a service phone as an option.

NSD600 is excellent for transmitting direct transfer tripping, permissive tripping, or blocking signals via a PLC communications channel between the ends of power transmission lines. Except for the single purpose teleprotection in 2 kHz nominal bandwidth, NSD600 is not suitable for steady-state signals, because it normally uses the speech band of the APLC channel or partly uses the band of the DPLC channel and speech as well as data communication is thus interrupted whilst tripping signals are being transferred.

The programmable external teleprotection equipment type NSD570 which operates at higher frequencies than the speech band is recommended for steady-state signals of any duration or if more than four protection commands have to be transmitted in the same APLC channel. NSD570 should be used with single tone command signals for transmission over power line carriers, i.e. for obtaining best practical signal-to-noise ratio.

NSD600 operated in the 3.2 kHz or 4 kHz APLC channel or in the DPLC channel can convey up to four independent commands, simultaneously transmitted in any possible combination.

Four commands permit, for example, the protection of dual-circuit lines and direct tripping for reactor or breaker failure protection.

Single purpose teleprotection NSD600 in 2 kHz nominal bandwidth can convey up to three independent commands, simultaneously...
transmitted in any possible combination, and a fourth command having priority over the other three commands. This command can be used for direct tripping application, e.g. for all-phase tripping in phase segregated line protection schemes.

The independent commands of the NSD600 can be individually configured for direct transfer tripping, permissive tripping or blocking schemes in order to ideally fit the requirements of the application.

An unblocking (deblocking) output used in protection schemes with overreaching first zones can be configured on one of the various outputs. Should the PLC channel break down, i.e. neither guard nor active tripping signals are being received, the unblocking contacts close for a preset period (e.g. 200 ms).

Application details are to be found in section 3.7.5.

All local and remote equipment features and parameters are selected and programmed by means of the user interface type HMI600. All status-, configuration- und alarm-messages are also accessible from remote.

An integrated event recorder (refer to section 3.8) and trip counters are provided (command start/stop events, alarm events and manipulation events are recorded and stored with time stamp in a non-volatile memory).

3.7.3. Structure of NSD600

The NSD600 signals are processed completely digitally by a DSP (Digital Signal Processor) on the DSP module type P4LT/V/X of the basic ETL600 equipment and by a DSP on the Teleprotection Interface type G4AI, so the firmware for the NSD600 resides on both modules.

The NSD600 comprises at least one teleprotection interface type G4AI. As contact multipliers or to exploit all possible NSD600 functions, additional interface modules can be directly plugged into reserved slots of the PLC equipment. However the user will not be allowed to select the position of the modules. He must only select the number of required inputs/outputs and the HMI600 will first check the possibility of using the selected modules and then allocates the positions for them.

Commands of the two TPE can not be mixed on the same teleprotection interface type G4AI, i.e. there is at least one G4AI module necessary for each of the two possible TPE. The tabs of the HMI600 user interface software for configuration of the teleprotection interfaces G4AI are correspondingly assigned as “G4AI – TPE1” and “G4AI – TPE2”.

3.7.4. Features

- Modular design

  Appropriate grouping of the functions into the signal processing module and protection interface modules. The teleprotection
interface type G4AI is inserted into the ETL600 rack type P7LH or P7LF.

Two individual NSD600 teleprotection equipment are configurable in the APLC and DPLC channels of the ETL600 system.

- **Advanced technology, digital signal processing**
  
  High equipment availability and reliability due to carefully selected components which have passed rigorous qualification tests.

  Using digital signal processing technologies, the NSD600 meets the stringent requirements for command transmission over PLC links even under adverse channel conditions. Algorithms optimized for PLC channels ensure safe and reliable operation as well as short transmission times even under extremely difficult conditions.

- **Up to 4 independent commands per NSD600**
  
  Duplex transmission of permissive tripping or blocking commands and direct transfer tripping commands in protection schemes for single or dual circuit lines including breaker failure protection.

  In its minimum configuration with one teleprotection interface type G4AI, the NSD600 can convey up to four commands.

- **Versatile application**
  
  The independent commands of the NSD600 can individually be configured for direct transfer tripping, for blocking or for permissive tripping schemes. Due to a patented dynamic adaptation, the command signals are received at the remote end in the shortest possible time, even if the channel is disturbed.

  Adaptive algorithms especially developed for this type of teleprotection equipment adjust themselves continuously to the prevailing channel conditions and achieve even under worst-case conditions the high degree of security against loss of genuine, respectively acceptance of false tripping commands.

- **Signal boosting**
  
  By switching off speech and data communication for a short time, the best use is made of the available transmitter power to guarantee reliable transmission of every tripping signal sequence.

- **Two tripping criteria**
  
  Incorrect operation due to a single fault is prevented by processing guard and active signals separately.

- **No additional bandwidth required**
  
  NSD600 requires no extra bandwidth in its default configuration because it uses the pilot of the corresponding PLC channel as guard signal and the speech band as command channel.
• **Easy to configure and to service**
  
  A serial interface port is provided on the front panel of the DSP module P4LT/V/X for connecting a PC which enables operating and equipment information to be viewed.

  Configuration, supervision and adapting to the field requirements of both the local and remote equipment is done by means of the user interface HMI600 which operates under the MS-Windows platform.

• **Integrated event recorder and trip counters**
  
  More than 2500 command start/stop and more than 2500 alarm & manipulation events can be recorded and stored with time stamp in a non-volatile memory. The event recorder can be synchronized to an external time signal (e.g. GPS receiver) for accurate time stamping. The display of command events is possible in text and graphical views on the HMI600.

  In addition to the event recorder integrated “trip counters” for each sent and received command support investigations in case of faults or abnormal conditions in the high voltage network.

• **Command outputs during channel failure**
  
  By means of the HMI600 interface, the user can program how the command outputs respond to a link alarm, i.e. to SNR alarm or Rx level alarm:

  - alarm does not influence the command outputs (state according current trip signal evaluation),
  - alarm sets command outputs to guard state (blocked),
  - alarm sets command outputs for direct tripping to guard state and command outputs for permissive tripping or blocking to command state,
  - received commands are “frozen” at the outputs in case of an interrupted or disturbed link.

• **Universal teleprotection interface type G4AI**
  
  The teleprotection interface provides four opto-coupler inputs and four solid-state outputs plus two heavy duty (electro-mechanical) relay outputs with change-over contacts.

  Each G4AI input can individually be configured for:

  - Not used (Off)
  - Tx Command A, B, C or D
  - Start criterion from protection relay

  **Note:** Start inputs are not available for operating mode “Single purpose teleprotection NSD600 in 2 kHz nominal bandwidth”.

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Each G4AI output can individually be configured for:

- Not used (Off)
- Rx Command A, B, C or D
- Complete loss of incoming signals ('unblocking')
- Rx Guard signal (present)
- Tx Command A, B, C or D acknowledge
- G4AI alarm
- TPE alarm, TPE link alarm, TPE hardware alarm
- User alarm 1 or 2

If more input/output contacts are needed to convey the above mentioned signals or for duplicating the command I/Os for example (redundancy or double-pole tripping), further G4AI modules can simply be inserted into the rack (slot number according HMI600).

The command interfaces to the protection relays are potential-free and isolated from ground and all other circuits.

The command and alarm signals are connected to isolating terminals (4 mm²) by special connecting cables which plug into the rear of the teleprotection interfaces.

- **Easy to test**

  Cyclic and manual loop tests allow in-service testing of the teleprotection channel (round trip).

  Self-monitoring arrangements continuously determine the operational status of the equipment.

  A local test mode can be activated for checking the teleprotection input/output circuits by internally looping the commands back to the same interface module G4AI.

- **Element Management Networks**

  An embedded operation channel (EOC) allows remote NSD600 configuration and monitoring from one end.

  When the ETL600 equipment is integrated in a network management system, each NSD600 can be accessed with HMI600 via a unique equipment identification number.

  Remote access to the equipment via the Internet or a Corporate Network (Intranet) is possible via a LAN port (optional).

### 3.7.5. Applications

The NSD600 is designed for transferring four commands in blocking, permissive tripping and direct transfer tripping schemes (applications).

When the NSD600 is operated in the 3.2 or 4 kHz APLC channel or in the DPLC channel, its four commands are configurable independently from each other regarding the application requirements and they can be transmitted simultaneously in any possible combination.

The single purpose teleprotection NSD600 in 2 kHz nominal bandwidth provides three commands that are configurable independently from
each other regarding the application requirements. They can be transmitted simultaneously in any possible combination. A fourth command has priority over these three independent commands, it can be used for direct tripping schemes.

One teleprotection interface G4AI provides four opto-coupler inputs and four solid-state outputs plus two heavy duty (electro-mechanical) relay outputs with change-over contacts. The inputs/outputs on the interface module are programmable; if a command requires two output contacts, for example, both outputs can be assigned to one interface or even to different interfaces. More inputs/outputs are easily achieved by inserting additional relay interfaces.

3.7.5.1. Permissive Tripping Schemes

Permissive transfer tripping is the most frequently used scheme for the protection of transmission lines. The transfer tripping link between the protection equipment at the ends of the line ensures that all faults can be cleared in the time of the first zone along 100% of the line. In a permissive scheme, the transfer tripping signal from the NSD600 is connected in series with a local criterion (protection starting, directional decision or phase selection) and tripping can only take place at the receiving end, if a transfer tripping signal is being received and the local protection relay detects a fault in the direction of the protected line. The reception of a spurious tripping signal caused by interference on the communications channel cannot therefore give rise on its own to unwanted tripping. On the other hand, a delayed transfer tripping signal may mean that a fault on the line is tripped in the time of zone 2 instead of undelayed in zone 1.

High dependability and a short transmission time therefore take priority over security in a permissive scheme.

The following configuration and settings of the most important parameters are recommended for all permissive transfer tripping schemes, i.e. underreaching and overreaching distance protection and directional comparison:

- Command application: permissive
- Command output type: solid state
- Command prolongation: 10 ms

The corresponding configuration, setup and further programming instructions are to be found in section 5.3.6.

According to IEC 60834-1, Figure 21, the requirements for permissive tripping commands are:

- transmission time $T_{ac}$ of less or equal than 20 ms,
- with a dependability $P_{mc}$ of less than 1E-03,
- at a signal-to-noise ratio $SNR$ of 6 dB,
- with a security $P_{uc}$ of less than 1E-04.

The NSD600 performance is even better (see annex, Technical Data).
3.7.5.2. Direct Transfer Tripping

Typical applications for direct transfer tripping are breaker back-up protection, compensator protection and power transformer protection; line protection with direct transfer tripping would be an exception. The requirements with respect to transmission time are generally not too demanding.

In the case of direct transfer tripping, the tripping command from the teleprotection equipment goes directly to the circuit-breaker tripping coil. Thus a spurious tripping signal resulting either from interference or human error will cause unwanted, usually three-phase tripping of the line and will block the operation of any auto-reclosure relay.

A genuine transfer tripping signal, on the other hand, must on no account be lost whether there is interference on the communications channel or not, because then a line fault would not be isolated with correspondingly serious consequences.

Extremely high security and high dependability are therefore more important than transmission time for direct transfer tripping.

In order to fulfill these requirements, the NSD600 uses dual tone tripping signals. Dual tone signals provide the necessary additional security against incorrect interpretation of speech, audio signals coupled into the system and incorrect manipulations on the equipment.

The following configuration and settings are recommended for breaker failure protection, compensator protection and power transformer protection (but not for steady-state signals):

- Command application: direct
- Command output type: solid state or relay
- Command prolongation: 100 ms min.
- Command outputs: set to the guard state (blocked) in case of a SNR or level alarm

According to IEC 60834-1, Figure 21, the requirements for direct tripping commands are:

- transmission time Tac of less or equal than 40 ms,
- with a dependability Pmc of less than 1E-04,
- at a signal-to-noise ratio SNR of 6 dB,
- with a security Puc of less than 1E-06.

The NSD600 performance is even better (see annex, Technical Data). The rate of unwanted commands Puc for noise bursts of 200 ms duration and the worst possible signal-to-noise ratio is theoretically always less than 1E-09 for the NSD600 direct tripping commands. Since this extremely high level of security is achieved without blocking the unit, the NSD600 is capable of tripping without intentional delay at any time as soon as a signal-to-noise ratio of about 6 dB is regained.
The following configuration and settings are recommended for *line protection with direct transfer tripping*:

- **Command application**: direct
- **Command output type**: solid state
- **Command prolongation**: 20 ms

The corresponding configuration, setup and further programming instructions are to be found in section 5.3.6.

### 3.7.5.3. Blocking Schemes

In a blocking scheme no tripping signals are transmitted along the faulted line. Instead the blocking schemes of all the surrounding healthy lines transmit signals to their remote ends *to prevent tripping* of the overreaching relays there.

The protection equipment of a blocking scheme usually consists of distance relays with overreaching first zones measuring into the line and reverse-looking directional units. A through-fault is seen by the directional unit which sends a signal to block the distance relay on the healthy line behind it. For a fault on the line, the reverse-looking directional units at the two ends do not send blocking signals and the overreaching first zones trip their respective circuit-breakers.

A teleprotection equipment for a blocking scheme has to fulfill only modest requirements. An incorrect signal (fault on the protected line) cannot prevent tripping, but only delay it. The loss or appreciable delay of the blocking signal for a fault in the overreach section of an adjacent line will, however, cause false tripping of the protected line.

Since the overreaching first zones of the relays have to be delayed sufficiently long to allow time for a blocking signal to be received, a short transmission time for the blocking signal is essential.

It follows from these considerations that a short transmission time and good dependability are more important than security.

The following configuration and settings are recommended for a *blocking line protection scheme*:

- **Command application**: blocking
- **Command output type**: solid state
- **Command prolongation**: 0 ms

The corresponding configuration, setup and further programming instructions are to be found in section 5.3.6.

According to IEC 60834-1, Figure 21, the requirements for blocking commands are:

- transmission time $T_{ac}$ of less or equal than 15 ms,
- with a dependability $P_{mc}$ of less than $1 \times 10^{-3}$,
- at a signal-to-noise ratio $SNR$ of 6 dB,
- with a security $P_{uc}$ of less than $1 \times 10^{-3}$.

The NSD600 performance is even better (see annex, Technical Data).
3.7.5.4. Unblocking

The standard NSD600 includes an unblocking function.

An 'unblocking' command used in directional comparison or in permissive tripping schemes with overreaching first zone can be allocated to one or more outputs on the relay interface module. Note that 'unblocking' commands are not transmitted from the remote end, but automatically produced by certain types of line faults.

Should PLC communication be almost completely lost, e.g. in the seldom case of a phase-to-phase fault involving the phases used for PLC coupling in the immediate vicinity of the station, or in the case of single-phase PLC coupling, the transmission of transfer tripping signals cannot be absolutely guaranteed. Without a tripping signal a distance relay will only trip in its second time step. The purpose of the unblocking function is to avoid this delay. It does so by closing the unblocking contacts of the NSD600 for 200 ms in the event of a PLC channel failure, i.e. when the NSD600 is receiving neither guard nor tripping signals. This 'emergency' feature can be used in different ways:

- to switch the reach of the distance relay (under/overreaching first zone)
- as an enabling signal by connecting the unblocking output contact in parallel with the tripping signal output of the NSD600. This is used above all in the case of permissive overreaching blocking schemes.

One or two of the potentially-free relay outputs located on the teleprotection interface type G4AI are usually configured to signal the unblocking command.

3.7.5.5. Protecting Dual-Circuit Lines

Dual-circuit lines often form important links in power systems at the higher system voltages. The line protection is usually supported by a breaker failure protection scheme.

An NSD600 with two commands set for permissive tripping and with two commands programmed for direct tripping is sufficient for the two line protection signals and the two breaker failure direct tripping signals. All commands can be transmitted and received with one single teleprotection interface type G4AI.

Important dual-circuit lines (132 kV to 400 kV) are often equipped with 1st and 2nd main protections supported by breaker failure protection on each circuit. Logically, redundant communication channels should also be installed such that the protection of both circuits remains fully intact should one set of equipment fail due to a defect or human error, or be out of commission for servicing.

The NSD600 with its four transfer tripping signals is especially well equipped to efficiently handle the tripping commands generated by redundant main and breaker failure protection schemes for a dual-circuit line. An extremely reliable overall scheme would comprise two
sets of PLC and NSD600 equipment, the NSD600's having the need of only one relay interface for four transfer tripping signals each. A corresponding example of a *redundant* teleprotection scheme can be seen in Fig. 3-47.

**Note:**

The single purpose teleprotection NSD600 in 2 kH nominal bandwidth also provides four commands but only three are independent and can be transmitted simultaneously in any combination. The fourth command is prioritized and overrides the other commands. It is used in direct tripping schemes.

![Diagram of teleprotection scheme](image)

MP1: 1st main protection  
MP2: 2nd main protection  
BFP: breaker failure protection  
+ overvoltage protection  
+ compensator protection  
CF: coupling filter

**Fig. 3-47** Redundant protection of a dual-circuit line

The settings for the permissive main protection commands should as given in section 3.7.5.1 and those for the direct tripping commands as given in section 3.7.5.2.

### 3.7.5.6. Protecting Single-Circuit Lines

One or two signals - one for a permissive scheme and possibly a direct transfer tripping signal - are usually sufficient when protecting lines in the low to medium voltage range.
This task can be easily accomplished with the NSD600 using one relay interface. Since the interface has four input and six output circuits, further functions can be activated, e.g. start input, unblocking or redundant command output. One of the commands is programmed to be “permissive” with short transmission time and the other to “direct”.

The following recommended settings thus result:

Command output type: solid state
Application of command 1 permissive
Application of command 2 direct
Command prolongation for command 1: 10 ms
Command prolongation for command 2: 100 ms

The corresponding settings and further programming instructions are to be found in section 5.3.6.

Important single-circuit lines (400 kV to 800 kV) are always equipped with duplicated main protection, breaker failure protection and perhaps a generator shutdown / load shedding facility. Two ETL600 links, each with a four-command NSD600, are then arranged in a fully duplicated teleprotection scheme according to Fig. 3-48.

Such an arrangement requires the transmission of three or four transfer tripping signals, one permissive signal for each of the main protections, a direct transfer tripping signal for the breaker failure scheme and perhaps a direct transfer tripping signal for the generator shutdown / load shedding facility.

In this case the NSD600 is again equipped with one relay interface at least. Additional interfaces may be plugged into reserved slots if more functions are to be used.

The teleprotection interface type G4AI is used for the two main protection commands (A, B), and for the direct tripping commands (C, D). The settings for the permissive commands should be those given in section 3.7.5.1 and for the direct tripping command those given in section 3.7.5.2.

Note: The single purpose teleprotection NSD600 in 2 kHz nominal bandwidth also provides four commands but only three are independent and can be transmitted simultaneously in any combination. The fourth command is prioritized and overrides the other commands. It is used in direct tripping schemes.
An especially high availability of the communications channel may be specified at important power lines of the highest voltage range. A second set of PLC and NSD600 equipment is recommended in these situations. The command inputs and outputs of which are simply connected in parallel.

**3.7.5.7. Phase Segregated Line Protection**

An NSD600 with its four commands can also be used for phase-segregated protection of a three-phase line. The permissive commands A, B and C then mean 'permission to trip phase A, B, or C'; in the event of a 2-phase or 3-phase fault, the direct command D means 'permission to trip all three phases'.

The single purpose teleprotection NSD600 in 2 kHz nominal bandwidth is especially suited for this protection scheme if the available bandwidth in the power line network is limited and no other services must be provided by the ETL600 system (e.g. data, teleoperation).
3.7.5.8. Relaying Tripping Signals Through Intermediate Stations

In relatively seldom cases it is necessary for protection tripping signals to be relayed through intermediate (repeater) stations. One possibility in the repeater station is to connect two NSD600’s via teleprotection interfaces back-to-back, but this has the disadvantage that each repeater station increases the end-to-end transmission time by the standard channel transit time (the operating times are connected in series).

Better performance from the transmission time point of view is achieved by establishing a wide-band AF four-wire link between the two PLC units in the repeater station. Pilot blocking filters have to be installed because of system requirements to prevent the pilot signal from passing through the repeater station. Each PLC link increases the delay by 5 to 6 ms.

The lack of pilot continuity is overcome by arranging for the NSD600 units at the two terminal stations to generate their own guard signals using a frequency within the band which will pass through the repeater station. The corresponding setting information for selecting an independent guard signal is to be found in section 5.3.6. This arrangement has the disadvantage that the ETL pilot signal and superimposed data channels are only disconnected on the first line section when a command is injected. Therefore the maximum boost level has to be carefully calculated (adapted to the ETL600 link for the second line section).

No teleprotection interfaces may be inserted into the PLC equipment in the repeater station and the NSD600 has to be switched off as well in this station when using the operating mode described in the paragraph above! Speech in the TPE channel(s) of the ETL600 may only be transferred between the end stations in this particular case.

Note: It is recommended to relay the commands in the intermediate station on a contact basis at the teleprotection interface(s), thus enabling the boosting facility on each line section.

The drawback of a higher end-to-end transmission time under noise-free conditions is compensated by much higher dependability when the channel is disturbed (which is usually the case while commands have to be transferred).

Note: With single purpose teleprotection NSD600 in 2 kHz nominal bandwidth, no AF four-wire link between two PLC units can be established in the repeater station. The commands have to be relayed on a contact basis via the teleprotection interfaces.
3.7.6. **Performance criteria**

3.7.6.1. **General**

A fundamental requirement in all the applications that teleprotection equipment is used in, is that command signals are communicated reliably at the highest possible speed (transmission time). In the event of a fault on the protected unit, the command signals must be received at the remote end in the shortest possible time even if the channel is disturbed by the fault (dependability).

On the other hand, interference on the communications channel must never cause unwanted operation of the protection by simulating a tripping signal when there is no fault on the power system (security). The most important features of a teleprotection equipment are therefore transmission time, dependability and security. From the communications engineering point of view, the bandwidth or data rate a teleprotection equipment uses must also be taken into account.

By **security** is understood that the receiver does not generate spurious tripping signals in the presence of interference on the communications channel.

**Dependability** characterizes the receiver's ability to recognize a genuine tripping signal within a given time *in spite* of interference on the communications channel.

It is obvious that to demand maximum security at the same time as maximum dependability is contradictory and one can only be increased at the expense of the other.

The NSD600 uses dual tone command signals. This transmission type prevents an unintended tripping by a discrete sine tone.

**Note:** Maloperation can mean both fail to trip (sometimes called underfunction) and false trip (sometimes called overfunction).

3.7.6.2. **Transmission time**

Traditional teleprotection have a set of fixed signal evaluation times for which the equipment delivers the requested performance (transmission time, dependability and security).

For example three different evaluation times could be found: one for blocking (Tev1, fast), one for permissive tripping (Tev2, medium) and one for direct tripping (Tev3, slow), each selection being compliant with the requested security and dependability for the given application.

Once the equipment is programmed for direct tripping (Tev3, slow) for example, it will not trip very fast even if the actual prevailing channel conditions would permit to do so.
For NSD600, this disadvantage can be avoided by using patented dynamic adaptation. Inside the NSD600 three receivers are connected in parallel: a fast one (Tev1), a medium one (Tev2) and a slower one (Tev3). All three comply with the requested security for a given application (user programmable) such as blocking, permissive tripping or direct tripping.

If now the actual channel condition during command transmission is good, the NSD600 will decide to trip with its fast receiver (Tev1) and not wait for the medium (Tev2) or slower one (Tev3). If the actual channel condition is worse, it will not trip with receiver Tev1 but wait for receiver Tev2 or even Tev3 to trip.

With this in mind, shorter transmission times can therefore be expected on average, compared with traditional solutions.

Moreover, the decision threshold for accepting a trip is permanently and smoothly adapted to the actual prevailing received noise power: from "low" for good channels to "high" for noisy channels. This prevents noise from producing unwanted trips.

### 3.7.6.2.1. Nominal transmission time (T0)

The nominal transmission time T0 is the transmission time measured under noise-free transmission conditions i.e. there is no interference on the channel. It is measured with nominal signal levels at the transmitter output and the receiver input. The ETL600 RF terminals are connected back-to-back via an artificial line with nominal attenuation.

T0 is the time elapsed between the instant of change of state at the input terminals of the teleprotection interface type G4AI and the instant of the corresponding change of state at the output terminals.

The nominal transmission time T0 is composed of three terms:

\[
T_0 = T_{\text{i/o}} + T_g + T_{\text{ev}}
\]

- **T_{\text{i/o}}** Switching times of the teleprotection interfaces at the transmitting and receiving end, \( T_{\text{i/o}} \approx 1 \text{ ms} \) if a solid state output is used or approx. 8 ms if a relay contact is used for the command.

- **T_g** ETL600 internal delay (group delay of the filters, SSB conversion, TDM-bus, etc; approx. 4 to 5 ms).

- **T_{\text{ev}}** Signal evaluation time in the NSD600 receiver. It depends on the settings of the command application. Since there is no channel interference when measuring T0, the dynamic adaptation is not in operation and the fastest receiver (Tev1) will always become effective.

<table>
<thead>
<tr>
<th>NSD600</th>
<th>Tev1 [ms]</th>
<th>Tev2 [ms]</th>
<th>Tev3 [ms]</th>
</tr>
</thead>
<tbody>
<tr>
<td>in 3.2, 4 kHz or in DPLC channel</td>
<td>4.125</td>
<td>8.25</td>
<td>16.5</td>
</tr>
<tr>
<td>in 2 kHz nominal bandwidth</td>
<td>5.25</td>
<td>10.5</td>
<td>21.0</td>
</tr>
</tbody>
</table>
3.7.6.2.2. **Maximum actual transmission time (Tac)**

The user can choose one of three programmable applications for each command. This determines the level of security for the evaluation of the related tripping signals. Severe disturbances (noise or interferences) on the transmission path may occasionally introduce an additional delay of a few milliseconds compared to the nominal transmission time T0. This delay is generally higher at the same signal-to-noise ratio (SNR) for commands with higher security requirements.

The maximum actual transmission time Tac is the maximum transmission time encountered under noisy channel conditions for a defined dependability and SNR. It is measured with continuous white noise applied to the RF input of the ETL600 receiver.

Commands which are not received within a certain Tac are considered as lost or missed commands (refer also to section 3.7.6.4 'Dependability').

The actual transmission time of the NSD600 is measured, for example, by means of the manual or cyclic loop tests, refer to section 3.7.8.13 and 3.7.8.14.

3.7.6.3. **Security**

The NSD600 with its dynamic adaptation of the receiver provides the best security / dependability trade-off for the chosen command application at lowest possible transmission time.

Security is expressed as the "worst case" false signal rate (probability of unwanted commands Puc) for blocks of noise of 200 ms duration. "Worst case" is defined as the level of interference at which the guard signal is completely suppressed.

The security level Puc is fixed for each of the possible command applications.

**Security Measurements**

All security measurements were performed according to the procedures prescribed in IEC 60834-1.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Noise burst</td>
<td>200 ms</td>
</tr>
<tr>
<td>Duration of pause</td>
<td>200 ms</td>
</tr>
<tr>
<td>Noise bandwidth</td>
<td>4 kHz</td>
</tr>
<tr>
<td>SNR</td>
<td>0 dB ... -30 dB</td>
</tr>
</tbody>
</table>

Security is determined by coupling bursts of white noise of high amplitude into the communications channel. The number of bursts injected and the number of false commands they cause at the receiving end are counted.
The probability of unwanted commands is then calculated according to the following relationship:

\[ P_{uc} = \frac{N_{uc}}{N_B} \]

\( P_{uc} \) = probability of an unwanted command  
\( N_{uc} \) = number of unwanted commands received  
\( N_B \) = number of noise bursts injected

### 3.7.6.4. Dependability

For analog channels, dependability is expressed as the signal-to-noise ratio (SNR) for a noise bandwidth of 4 kHz, which must be maintained during the transmission of a tripping signal to enable that it can be received within a given actual transmission time \( T_{ac} \) (usually a multiple of \( T_0 \)). The probability of missing a command \( P_{mc} \) at that SNR and \( T_{ac} \) must be < 1E-03 for blocking and permissive tripping commands and < 1E-04 for direct tripping commands.

#### Dependability Measurements

All dependability measurements were performed according to the procedures prescribed in IEC 60834-1.

- Command duration: \( 3 \times T_0 \)
- Duration of pause: \( 2 \times \) command duration
- Noise bandwidth: 4 kHz
- SNR: -10 dB … +20 dB
  - continuous white noise

Dependability is determined by sending a large number of commands to the remote station. The number of commands transmitted and the number of commands received within a specified time (normally 1.3 x \( T_0 \), 1.5 x \( T_0 \), 2 x \( T_0 \) and 3 x \( T_0 \)) are recorded. The lower the signal-to-noise ratio at the input of the receiving NSD600, the fewer the commands which will be received in the prescribed time.

The following applies for a sufficiently high number of transmitted commands:

\[ P_{mc} = \frac{(N_T - N_{R})}{N_T} \]

\( P_{mc} \) = probability of missing a command  
\( N_T \) = number of commands transmitted  
\( N_{R} \) = number of commands received
3.7.7. Operating principle

The NSD600 uses the pilot signal of the ETL600 as a guard signal (default setting). It is continuously evaluated on the receive side. In case of insufficient signal quality (signal-to-noise ratio or signal level) the NSD600 initiates an alarm.

For special purpose, e.g. transit relaying of NSD600 signals in a repeater station, a separate guard signal for the teleprotection may be programmed (this is not applicable for the single purpose teleprotection NSD600 in 2 kHz nominal bandwidth). It is then located above the chosen speech frequency band (2.0, 2.2 or 2.4 kHz).

In the command state, the NSD600 interrupts the guard signal (ETL-pilot or NSD-own guard) and transmits the tripping signal - representing the command(s) injected at the G4AI input(s) - within the ETL600 speech frequency band. The tripping signal can be boosted to the maximum available transmitter power. Speech and selected data signals (set as 'disconnectable') on all PLC channels are interrupted during the short time of command transmission.

A start criterion from the protection relay may be used to prepare the channel for transmission of protection signals by switching off speech in advance.

Note: Start inputs are not available for operating mode “Single purpose teleprotection NSD600 in 2 kHz nominal bandwidth”.

If the duration of a command transmission exceeds five seconds (default setting), an alarm will be given at the transmit end and the guard signal as well as speech and superimposed data channels are switched on again.

As an option, the trip duration on the receive side can also be monitored. If monitoring is enabled and the command reception exceeds the configured duration, alarm is given and the corresponding output(s) are set to the guard state.

If the single purpose teleprotection NSD600 in 2 kHz nominal bandwidth is used, Tx trip monitoring may be disabled if required, because no other services are supported that would have to be disconnected during transmission of protection signals - persistent commands are therefore permitted in this operating mode. Nevertheless the maximum output power for the tripping signals is limited to a configurable duration (up to 60 s). After that, the boost ratio is reduced to its minimum value, i.e. the tripping signal is sent with nominal level.

For the NSD600 in all other channels, commands of long duration (e.g. between 5 and 60 s) shall only be allowed when the own guard signal is used (to be set via HMI600). The ETL pilot signal will then not be switched off whilst these commands are transmitted. Therefore all the services assigned to the pilot channel are still available (EOC, frequency synchronization (if needed), AGC, E&M signaling).
As soon as the receiver recognizes the missing guard signal and simultaneously detects a valid tripping signal of adequate quality, the associated command is relayed to the designated output(s).

Simultaneous reception or simultaneous loss of a tripping signal and the guard signal leads to an alarm. In the latter case, the output(s) programmed for the unblocking function are activated for a preset duration (default setting: 200 ms).

At the receiver side speech is interrupted as long as a command is given to the outputs. This prevent the command tones to be relayed for an unduly long time to other line sections, e.g. via a switchboard.

Seven preset frequencies corresponding to the various commands or command combinations are provided in the speech frequency band of the 3.2 kHz or 4 kHz APLC channels. The same frequency band (300 Hz to 2000 Hz) will be used in the DPLC channel for the seven trip frequencies. For the single purpose teleprotection NSD600 in 2 kHz nominal bandwidth five trip frequencies are provided (300 Hz to 1600 Hz).

All commands or their combinations are represented by dual-tone tripping signals for obtaining short command transmission time in the PLC channel at almost the best practical signal-to-noise ratio. Dual-tone tripping signals also give added security against speech and interference, e.g. an audio frequency generator.

An automatic or manually initiated loop testing routine checks the teleprotection channel. The test signal, which is transmitted in the same way as a genuine tripping signal, is recognized by the receiver and "echoed" back to the transmitter.

By making use of the carrier pilot for monitoring the quiescent/guard state of the tripping channel and the speech band for transmitting the tripping signals, the NSD600 does not require any PLC bandwidth of its own.

Signals are processed completely digitally by a signal-processor, i.e. signal generation at the transmitting end and filtering and evaluation of the guard and tripping signals at the receiving end. The only A/D and D/A converters are at the RF section of the PLC equipment. Digital processing eliminates calibrating, as well as the influences of ageing and temperature fluctuations.

Adaptive algorithms especially developed for PLC channels adjust themselves continuously to the prevailing PLC channel conditions and achieve even under worst-case conditions the high degree of security against loss of genuine, respectively acceptance of false tripping commands, which is essential for protection signals.
3.7.8. **Functional description**

3.7.8.1. **General**

The NSD600 can be operated in one or two 4 kHz APLC channels of the ETL600 as well as in the first 3.2 kHz channel of the “three APLC in 8 kHz” mode or as single purpose teleprotection in 2 kHz nominal bandwidth.

In case of a dual-channel ETL600 with one APLC and one DPLC, the second NSD600 can also be operated in the DPLC.

One NSD600 is also available in the “DPLC only” mode of the ETL600.

Each TPE operates in one of the channels APLC1, APLC2, DPLC. The association TPE x to the channels is fixed:

<table>
<thead>
<tr>
<th>Available Channels</th>
<th>Channel of TPE1</th>
<th>Channel of TPE2</th>
</tr>
</thead>
<tbody>
<tr>
<td>APLC1</td>
<td>APLC1, 300 ... 2000 Hz</td>
<td>n.a.</td>
</tr>
<tr>
<td>4 kHz</td>
<td>300 ... 1600 Hz</td>
<td></td>
</tr>
<tr>
<td>2 kHz nominal bandwidth</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DPLC</td>
<td>DPLC</td>
<td>n.a.</td>
</tr>
<tr>
<td>APLC1, DPLC</td>
<td>APLC1, 300 ... 2000 Hz</td>
<td>DPLC (own guard)</td>
</tr>
<tr>
<td>APLC1, APLC2, DPLC</td>
<td>APLC1, 300 ... 2000 Hz</td>
<td>APLC2, 300 ... 2000 Hz</td>
</tr>
<tr>
<td>APLC1, APLC2, APLC3, DPLC</td>
<td>APLC1, 300 ... 2000 Hz</td>
<td>APLC2, 300 ... 2000 Hz</td>
</tr>
<tr>
<td>APLC1, APLC2, APLC3 (in 8 kHz) or APLC1, DPLC of 2 or 6 kHz</td>
<td>APLC1, 300 ... 2000 Hz</td>
<td>n.a.</td>
</tr>
<tr>
<td>APLC1, APLC2, APLC3 (in 12 kHz)</td>
<td>APLC1, 300 ... 2000 Hz</td>
<td>APLC2, 300 ... 2000 Hz</td>
</tr>
</tbody>
</table>

Table 3-5 Channel association for TPE1 and TPE2

In conjunction with one APLC channel, the DPLC channel requires its own guard signal for the NSD600 (which is not necessary without TPE in the DPLC).

A detailed description of the ETL600 operating principle and the various channel allocations can be found in sections 3.1 and 3.2.

3.7.8.2. **Speech bandwidth**

The NSD600 supports all programmable speech channels (2.0, 2.2, 2.4, 2.6, 2.8, 3.0, 3.2 and 3.4 kHz) when using the ETL600 pilot as a guard signal. The trip frequencies are always transmitted in the band 0.3 to 2.0 kHz. Adequate filtering is performed to separate the band from superimposed teleoperation channels.

An own guard signal is only provided for the following speech channels: 2.0, 2.2 and 2.4 kHz.
For single purpose teleprotection in 2 kHz nominal bandwidth, the trip frequencies are transmitted in the band 0.3 to 1.6 kHz. Optionally, this band is used also for speech via service phone.

To avoid additional transmission delays, the non-equalized receive signal is used for processing of the NSD600 tripping signals.

### 3.7.8.3 Guard signal

Default setting for the NSD600 guard signal in a 4 kHz APLC channel is the ETL600 pilot at 3840 Hz. The disposable teleoperation band is then limited from 120 Hz above selected speech up to 3600 Hz (refer to Fig. 3-6 and Fig. 3-49).

Default setting for the NSD600 guard signal in the 3.2 kHz APLC channel is the ETL600 pilot at 3120 Hz. The disposable teleoperation band is then limited from 120 Hz above selected speech up to 2880 Hz (refer to Fig. 3-7).

If the ETL600 pilot signal is shifted from its default value to lower frequencies, teleoperation channels may only be allocated with a frequency margin of ±240 Hz from the center of the pilot channel.

For special purpose, e.g. transit relaying of NSD600 signals in a repeater station, a separate guard signal for the teleprotection may be programmed in the 3.2 kHz and in 4 kHz APLC channels. It is then located above the chosen speech frequency band. This is however possible only for the following speech channels: 2.0, 2.2 or 2.4 kHz (example for 4 kHz APLC channel see Fig. 3-50).

A gap of 480 Hz has to be reserved for the own guard signal of the NSD600. The disposable teleoperation band is therefore limited from 480 Hz above selected speech up to 3000 Hz in the 3.2 kHz APLC channel and up to 3720 Hz in 4 kHz APLC channels.

If no speech is configured in the 3.2 kHz or 4 kHz APLC channel, the own guard signal is allocated in the band 2000 Hz to 2480 Hz. Please note that also in this case the band 300 Hz to 2000 Hz must not be occupied by other services (refer to sections 3.7.8.19 and 3.7.8.20).

The single purpose teleprotection NSD600 in 2 kHz nominal bandwidth always uses the ETL600 pilot at 1800 Hz as guard signal (refer to Fig. 3-9). No teleoperation band is available in this operating mode, only a speech band from 300 to 1600 Hz for the optional service phone.
If two TPE are configured, one in the APLC and one in the DPLC channel, a band of 500 Hz is always reserved in the DPLC channel for the guard of TPE2. The trip frequencies of TPE2 are located in the DPLC channel at the same AF band as in a standard APLC channel of 4 kHz (at the upper or at the lower end of the DPLC channel, depending whether it is configured as "erected" or "inverted"; refer to section 3.1.1 for details). The same applies for TPE1 in the "DPLC only" mode of the ETL600.

The performance figures NSD600 for security, dependability and transmission time are almost identical when using an own guard signal or when using the ETL600 pilot as a guard signal.

The nominal guard signal level depends on the configured services (S-value) minus all not disconnectable signals. Its minimum level is -6 dBm0 PE (for details refer to sections 5.2.10 till 5.2.14).
3.7.8.4. **Command signals**

3.7.8.4.1. **Dual-tone principle**

Protection commands are transmitted by the NSD600 using “dual tone” tripping signals, i.e. two (tripping) frequencies simultaneously sent - each having half the amplitude of a corresponding single tone command. Transmitting two discrete frequencies gives added security against speech and interference, e.g. an audio frequency generator.

Compared to single tone command signals, the multiplex dual tone command signal has the same amplitude (peak envelope power), but 3 dB lower rms power since each tone is transmitted at a 6 dB lower voltage level.

In order to reduce the transmission time, the NSD600 tripping signals are not relayed through the equalizer. The NSD600 receiver is therefore designed that it is able to handle a wide range of magnitude distortion within the speech band.

Fig. 3-51 shows the dual-tone principle used in the 3.2 kHz and in 4 kHz APLC channels as well as in the DPLC channel, i.e. with seven trip frequencies in the band 300 to 2000 Hz.

The single purpose teleprotection NSD600 in 2 kHz nominal bandwidth also uses the dual-tone principle with five trip frequencies in the band of 300 to 1600 Hz.

![Dual-tone principle](image)

3.7.8.4.2. **Trip frequencies**

**NSD600 in 3.2 or 4 kHz APLC channel or in DPLC channel**

The following seven preset frequencies given below are provided in the trip frequency band 0.3 … 2.0 kHz:

<table>
<thead>
<tr>
<th>Frequency</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>F1 = 356 Hz</td>
<td>Guard signal</td>
</tr>
<tr>
<td>F2 = 598 Hz</td>
<td>Trip signal</td>
</tr>
<tr>
<td>F3 = 841 Hz</td>
<td></td>
</tr>
<tr>
<td>F4 = 1083 Hz</td>
<td></td>
</tr>
<tr>
<td>F5 = 1325 Hz</td>
<td></td>
</tr>
<tr>
<td>F6 = 1568 Hz</td>
<td></td>
</tr>
<tr>
<td>F7 = 1810 Hz</td>
<td></td>
</tr>
</tbody>
</table>

With seven frequencies 21 dual tone tripping signals can be achieved. 16 of them are used by the NSD600 to transmit its four independent commands and their combinations plus a test signal.
**NSD600 in 2 kHz nominal bandwidth**

The following five preset frequencies given below are provided in the trip frequency band 0.3 … 1.6 kHz:

Trip signal frequencies

- $F_1 = 569$ Hz
- $F_2 = 760$ Hz
- $F_3 = 950$ Hz
- $F_4 = 1140$ Hz
- $F_5 = 1331$ Hz

With five frequencies 10 dual tone tripping signals can be achieved. 9 of them are used by the NSD600 to transmit its three independent commands and their combinations, one prioritized command plus a test signal.

In both the above cases the nominal tripping signal level with minimal boosting (0…6 dB) has the same value as the test signal level, it is 0 dBm0 PE or equal to the guard level (whatever is higher).

### 3.7.8.4.3. Command assignment to trip frequencies

NSD600 in 3.2 or 4 kHz APLC channel or in DPLC channel

<table>
<thead>
<tr>
<th>Input Signal</th>
<th>F1</th>
<th>F2</th>
<th>F3</th>
<th>F4</th>
<th>F5</th>
<th>F6</th>
<th>F7</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td></td>
<td>x</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>B</td>
<td></td>
<td></td>
<td></td>
<td>x</td>
<td>x</td>
<td></td>
<td></td>
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<tr>
<td>AB</td>
<td></td>
<td></td>
<td>x</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>C</td>
<td></td>
<td></td>
<td></td>
<td>x</td>
<td>x</td>
<td></td>
<td></td>
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<tr>
<td>AC</td>
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<td></td>
<td></td>
<td></td>
<td>x</td>
<td>x</td>
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<tr>
<td>BC</td>
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<tr>
<td>ABC</td>
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<td></td>
<td>x</td>
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<tr>
<td>D</td>
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<td></td>
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<td>x</td>
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<tr>
<td>BD</td>
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<td></td>
<td></td>
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<tr>
<td>BCD</td>
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</tr>
<tr>
<td>ABCD</td>
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<td></td>
</tr>
<tr>
<td>Test</td>
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<td></td>
<td></td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>Not used</td>
<td></td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Not used</td>
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<td></td>
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<tr>
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<td></td>
<td></td>
<td>x</td>
<td>x</td>
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<tr>
<td>Not used</td>
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<td></td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

Table 3-6 Command assignment to trip frequencies
Table 3-7 Command assignment to trip frequencies

<table>
<thead>
<tr>
<th>Input Signal</th>
<th>F1</th>
<th>F2</th>
<th>F3</th>
<th>F4</th>
<th>F5</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>B</td>
<td>x</td>
<td>x</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>AB</td>
<td>x</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C</td>
<td></td>
<td>x</td>
<td>x</td>
<td></td>
<td></td>
</tr>
<tr>
<td>AC</td>
<td>x</td>
<td></td>
<td>x</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BC</td>
<td>x</td>
<td></td>
<td>x</td>
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<td>ABC</td>
<td>x</td>
<td>x</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>D</td>
<td></td>
<td></td>
<td></td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Test</td>
<td></td>
<td>x</td>
<td></td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>Not used</td>
<td>x</td>
<td></td>
<td></td>
<td>x</td>
<td></td>
</tr>
</tbody>
</table>

**Note:**

In order to improve security against unwanted operation, the NSD600 receiver will ignore all received frequency pairs which would activate one or more commands not configured to any G4AI output of the equipment.

Example:

Of the 4 available commands A, B, C and D, command D is not configured to any G4AI output of the equipment. The NSD receiver of the equipment then considers only:
- the frequency pair belonging to the command A and
- the frequency pair belonging to the command B and
- the frequency pair belonging to the command C and
- the frequency pairs belonging to the command combinations A&B, A&C, B&C, A&B&C and
- the frequency pair belonging to the test command, and ignores all other frequency pairs, i.e.
- the frequency pair belonging to the command D and

### 3.7.8.5. Boosting

Signal boosting in connection with a PLC channel means that the power used for transmitting tripping signals is stepped up in relation to the quiescent state (i.e. the guard signal).

During the transmission of tripping signals, the communication of the DPLC as well as the communication of speech, teleoperation channels (set as 'disconnectable') and modem signals superimposed on the speech in all channels is switched off (this includes the pilot signals in APLC channels without TPE). The total transmitter power is available now for the tripping signals. This ensures the best possible signal-to-noise ratio at the receiving NSD600. The ratio between the powers of
the boosted transfer tripping signals and the guard signal is referred to as the boost ratio and is normally expressed in decibel (dB).

The boost ratio which can be achieved depends on what other service signals can be switched off while tripping signals are being transmitted. This in turn is dependent on just how many signals the ETL600 has to handle and for this reason, the boost ratio is calculated automatically by the HMI600 after configuring the equipment.

It may be necessary to select some teleoperation channels to be 'not disconnectable' later, the boost ratio is accordingly decreased then by the HMI600 (a corresponding warning note will appear on the screen).

Since both TPE interrupt the DPLC channel and all disconnectable signals in all channels for command transmission (including speech and pilot signals that are not used as TPE guard signals), much higher boost ratios are possible compared to earlier PLC systems. However, the maximum boost ratio is limited to 18 dB, it can be decreased via HMI600 to a value between the minimum boost ratio (which depends on the difference between the guard and the test tone level; can vary from 0 dB to 6 dB) and the calculated boost ratio established by the HMI600 (depends on the services that are configured and can be switched off; can vary from the minimum boost ratio up to 18 dB).

If two internal TPE are configured, both NSD600 have the same weight, i.e. they can use half of the disconnectable weight for boosting their signals.

With single purpose teleprotection NSD600 in 2 kHz nominal bandwidth the boost ratio setting range is from 7 dB to 18 dB without optional service phone enabled and from 12 dB to 18 dB with service phone.

Further information on boosting is to be found in section 5.2.17 in this instruction manual.

**Note:** The NS600 loop test is performed at the test level of 0 dBm 0 PE or at guard signal level (whatever is higher; i.e. if the guard level is between –6 dBm 0 PE and 0 dBm 0 PE, the minimum boost ratio is between 6 dB and 0 dB).

The loop test is thus performed under more exacting conditions than those of boosted tripping signals.

### 3.7.8.6. Input/Output Command Handling

#### 3.7.8.6.1. General

The following parameters are selectable individual for each command by means of the HMI600:

- Tx Input Command On-Delay (0…10 ms, step 1 ms; default 0 ms)
- Tx Input Command Prolongation (0…3000 ms, step 1 ms; default 0 ms for all applications)
- Max Tx Trip Monitoring (1…60 s, step 1 s; default 5 s)  
- Rx Output Command Duration (30…1000 ms, step 1 ms; default 100 ms)
- Rx Output Command Prolongation (0…3000 ms, step 1 ms; default blocking 0 ms, permissive 10 ms, direct 100 ms)
- Max Rx Trip Monitoring (1…60 s, step 1 s; default 5 s)

The following picture illustrates the miscellaneous parameters, except Max Tx and Rx Trip Monitoring (the delay introduced by input / output circuits of G4AI and by TDM-bus processing is disregarded):

---

7 When the single purpose teleprotection NSD600 in the 2 kHz APLC channel is selected, the Max Tx Trip Monitoring can be switched off individual per command (but a timed Tx power reduction is active instead).

8 Preselection necessary, valid for all commands (instead of “prolongation”): commands are actuated at the outputs only for this configured time.

9 Preselection necessary, valid for all commands (instead of “duration”): commands are relayed to the outputs as long as the tripping signal is received, plus this optional prolongation time (default setting).

10 Max Rx Trip Monitoring can be switched off individual per command.
3.7.8.6.2. **Tx Input Command On-Delay**

**Note:**
To configure an input command on-delay has a direct influence on the transmission time of the equipment. It is delayed correspondingly and thus means an artificial deterioration of the equipment performance. Normally the receiver at the remote station decides whether it was a genuine command of adequate length or only a transient spark on a command input. Therefore the command inputs are not delayed per default setting.

For some special applications a "pick up time" for the command inputs has to be configured. A command is transmitted only after the corresponding command input was activated for a preset delay time.

The preset input command on-delay is configurable for each command separately in the range of 0 ms (default setting) to 10 ms.

3.7.8.6.3. **Tx Input Command Prolongation**

A Tx input command prolongation ensures a steady tripping signal at the RF output even in the event of discontinuations of the command(s) being injected at the G4AI input(s).

**Caution**
With a Tx input command prolongation of 0 ms, the receiver at the remote station decides whether a received command of adequate length was genuine or only a transient spark on a command input. However, with a Tx input command prolongation > 0 ms, even a short command e.g. produced by such a spark is extended in length such that the receiver may interpret it as a genuine command.

A Tx command prolongation can be programmed for each command separately in the range of 0 ms (default setting) to 3 seconds.

3.7.8.6.4. **Max Tx Trip Monitoring**

The duration of each single command injected at the relay interface inputs is separately and continuously monitored.

Alarm is given and the guard signal is transmitted instead of the tripping signal should the command duration exceed a predefined value (5 seconds per default, programmable for each command separately in the range of 1 to 60 seconds). Also the boost criterion is set inactive and the interrupted speech and data channels are re-connected again.

For the single purpose teleprotection NSD600 in 2 kHz nominal bandwidth, Max Tx Trip Monitoring may be switched off individually per command, because no other services can be configured that would have to be disconnected during transmission of commands.
Note: If the duration of a command is monitored (and therefore a corresponding G4AI alarm will be raised when the command is injected for longer than the configured time), certain rules regarding the setting of the pick-up times for the link and user alarms have to be observed (please refer to Chapter 5 for details).

3.7.8.6.5. Timed Tx Power Reduction for NSD600 in 2 kHz nom. bandwidth

The operating mode “Single purpose teleprotection NSD600 in 2 kHz nominal bandwidth permits transmission of persistent commands. Nevertheless the maximum output power for tripping signals is only available for a limited time in this mode. The time can be programmed in the range from 1 to 60 seconds (10 seconds per default) and is valid for all commands in common. If commands are injected for longer than the configured time, the boost criterion is set inactive and the tripping signal is sent with the loop test level further on (refer to section 3.7.8.13).

3.7.8.6.6. Rx Output Command Duration

Via the HMI600 the user can choose between “Rx Output Duration” and “Rx Output Prolongation”. This preselection is then applicable for all commands in common. It decides whether the commands shall be actuated for a fixed (limited) duration only at the outputs or whether the commands are relayed to the outputs as long as the tripping signal is received (with a certain prolongation, if required; refer to section 3.7.8.6.7). The latter is the default setting.

If this feature is enabled, the Rx output command duration can be set in the range of 30 to 1000 ms (step 1 ms; default 100 ms) individually for each command. This means that the command signal at the corresponding G4AI output will have a constant duration, independent of the length of the received tripping signal.

3.7.8.6.7. Rx Output Command Prolongation

A Rx output command prolongation ensures steady commands at the G4AI outputs even in the event of discontinuations of the tripping signal being received at the RF input.

If this feature is enabled, a Rx output command prolongation can be programmed for each command separately in the range of 0 ms to 3 seconds. The default setting depends on the chosen application of the command (blocking: 0 ms, permissive tripping: 10 ms, direct tripping: 100 ms). If freezing of commands during link failure is activated, the minimum prolongation time is 100 ms.

The receiver of the NSD600 compensates the command duration without prolongation for almost equal pulse width as the transmitted command at the remote station.
3.7.8.6.8. **Max Rx Trip Monitoring**

Monitoring is programmable ON/OFF for each Rx command, i.e. a limitation of the command duration at the receiver site can also be enabled (default setting = OFF).

The duration of each single command received and relayed to the relay interface output(s) is separately and continuously monitored (if the Max Rx trip monitoring alarm is enabled for this command).

Alarm is given and the command output is set inactive should the command duration exceed a predefined value (if monitoring is enabled: 5 seconds per default, programmable via HMI600 in the range of 1 to 60 seconds).

**Note:** If the duration of a command is monitored (and therefore a corresponding TPE alarm will be raised when the command is received for longer than the configured time), certain rules regarding the setting of the pick-up times for the link and user alarms have to be observed (please refer to Chapter 5 for details).

3.7.8.7. **Start Inputs**

**Note:** Start inputs are not available for operating mode “Single purpose teleprotection NSD600 in 2 kHz nominal bandwidth”.

A start criterion from the protection relay may be used to prepare the TPE channel for transmission of protection signals by switching off Tx&Rx speech in the corresponding APLC channel in advance.

In case the TPE operates in the DPLC channel, MOD600 is not switched off by the start signal.

In case there is no speech in the TPE channel, the disconnectable data channels in the TPE channel are not switched off by the start signal.

One start signal per TPE can be configured on the input(s) of the teleprotection interface type G4AI. The interruption of speech is limited to 1 second, beginning with the first start input being activated. Should no command be injected, alarm is given after the maximum programmed Tx trip monitoring alarm pick-up time plus 1 second to compensate the allowed interruption. The alarm will stay as long as the start input is active.

**Note:** Start inputs are not needed for the operating mode “Single purpose teleprotection NSD600 in 2 kHz nominal bandwidth” because no speech is supported and the optional service phone is normally not used during command signal transmission (but while commissioning or maintaining the equipment as examples).
3.7.8.8. **Unblocking**

An „unblocking“ command used in directional comparison or in permissive tripping schemes with overreaching first zone can be allocated to one or more outputs on the teleprotection interface module. Note that „unblocking“ commands are not transmitted from the remote end, but automatically produced by certain types of line faults (PLC channels).

At time when neither tripping nor guard signals are being received, or when the total signal level in the 2 kHz band is lower than the configured unblocking threshold (range from –20 dB to –10 dB; default –14 dB from nominal level), an unblocking pulse of a predefined duration is generated which can be signaled by one or more outputs on the relay interface type G4AI.

The internal signal evaluation time to detect the unblocking condition is typical less than 20 ms. It is possible to define an extra on-delay via HMI600 in the range of 0 to 100 ms (default 20 ms).

The unblocking pulse duration is set to 200 ms per default but can be varied in the range of 50 to 500 ms.

The unblocking threshold is valid for both, the signal level in the speech band as well as the signal level in the guard channel (i.e. the unblocking signal is only released if both levels are below the threshold and the condition “neither tripping nor guard signals being received“ is fulfilled too).

3.7.8.9. **Command Outputs During Link Failure**

By means of the HMI600, the user can program how the command outputs respond to a channel failure, i.e. to SNR alarm or Rx level alarm in the corresponding channel of the TPE. The following alternatives are available:

a) All command outputs assume states in accordance with current input tripping signal processing, i.e. they disregard the TPE link alarm (default setting).

b) All command outputs are set to their quiescent/guard states (i.e. blocked).

c) The outputs configured for direct tripping are set to guard state and the outputs configured for permissive tripping or blocking are set to command state.

d) Received commands are immediately “frozen” at the command outputs in case of an interrupted or disturbed link.

These settings apply to all signals in the case of units equipped for several commands.

The corresponding HMI600 settings are given in section 5.3.6.

Alternative a) is the default setting when the units are supplied from the works. With this setting the NSD600 responds normally to changes.
in the status of the input signals. This is permissible in spite of the 
alarm condition, due to the high security of tripping signal evaluation.

Sometimes setting b) is preferred to setting a), for example, when 
redundant sets of communications equipment are installed.

Setting c) is only used in seldom cases with overreaching or blocking 
protection schemes having special logics and in certain instances for 
blocking auto-reclosure relays.

Setting d) “freezing of commands” is used when commands of long 
duration are transferred and they should not be interrupted at the 
command outputs when the link is lost or disturbed by noise bursts.

The response of the command outputs according to b) and c) become 
effective after an internal alarm processing time (e.g. less than 
1 second for low level alarm) from the instant the alarm condition 
arises and remain so throughout the alarm condition and for a further 
processing time of the same quantity after it disappears.

The alarm condition pick-up time and the hold time for the command 
outputs according to b) and c) can be further delayed by 0 to 
15 seconds (default pick up: 10 s; default hold: 0 s). This might be 
necessary if, for example, clamping of the command outputs should be 
avoided in case of recurrent noise bursts on the power line, produced 
by switching operations involving slow speed isolators. The 
interference so generated is characterized by high amplitude and 
relatively long duration of up to 8 seconds.

No alarm condition pick-up time and no hold time for the command 
outputs according to d) can be configured. There is also no internal 
alarm processing time for detecting SNR alarm or Rx level alarm 
applicable, received commands are immediately “frozen” in case of a 
link failure. They are only removed from the command outputs if a 
valid guard signal of at least 100 ms length or another command signal 
is detected.

3.7.8.10. Tx Command Acknowledge

Each injected Tx command A to D can be reflected from the 
processing unit P4LT/V/X to one of the various outputs on the 
teleprotection interfaces type G4AI (configurable by means of the 
HMI600) to acknowledge that the corresponding command was sent 
e.g. Ack Tx command A). This is, however, no confirmation that the 
command has also been received by the opposite station.

Each of the acknowledging outputs is operated as long as the 
corresponding commands are sent (incl. Tx input command on-delay 
and Tx input command prolongation).

3.7.8.11. Rx Guard Signaling

The state of the NSD600 guard receiver can be signaled by the DSP 
module type P4LT/V/X to one of the various outputs on the 
teleprotection interface type G4AI (configurable by means of the 
HMI600). Reception of the ETL600 pilot signal (when used as guard 
signal) or the own NSD600 guard with adequate signal quality means
that the corresponding solid state output is closed or the coil of the selected relay contact is energized.

**Note:**
No pick up or hold times are programmable for the Rx guard output. Therefore, outputs configured for Rx guard may bounce for certain Rx levels or signal to noise ratios.

### 3.7.8.12. Blocking of AGC

If the NSD600 receiver accepts the signal as a genuine tripping command (no ETL-pilot signal and a tripping signal at the proper frequencies in the speech band), speech in the corresponding APLC channel is interrupted and the automatic gain control (AGC) in this channel and in all APLC channels without an internal TPE is blocked. The latter is necessary to prevent the ETL600 gain from increasing as a result of the missing pilot signal whilst tripping signals are being received.

If the NSD600 uses an own guard signal, the AGC will not be blocked during command reception.

The single purpose teleprotection NSD600 in 2 kHz nominal bandwidth permits the transmission of persistent commands but with reduced output power after a certain time. The AGC is blocked also in this operating mode as long as a genuine command is received. Due to disturbances on the power line the "long term" tripping signal with reduced level may be temporary lost and the AGC would increase the gain during these short term interruptions. To avoid unduly gain factors and saturation or overmodulation of the receiver, the AGC blocking level must be set not lower than 16 dB below the nominal pilot signal level (refer to section 5.3.2.3).

### 3.7.8.13. Cyclic Loop Test

An cyclic loop test sequentially checks the integrity of the teleprotection channel. The test signal simulates the transmission of a genuine tripping signal and is recognized as such at the receiving end, from whence it is echoed back to the transmitter. The test is deemed successfully, providing the transmitter receives the echo. If it does not, the test is repeated and alarm is given should the results of three subsequent trials be negative.

The loop test signal is transmitted with a test tone level of 0 dBm0 PE or with the guard level, whichever is higher. The first cyclic loop test is sent 10 minutes after power-on the equipment.

In case the TPE is operated in an APLC channel, the speech and the guard signal in the TPE channel are switched off, the ETL pilot signal and superimposed data channels remain active during a cyclic loop test. Exceptions:

- If no speech is configured in the TPE channel, the disconnectable data channels are switched off to obtain the necessary transmitter power.
- If the TPE uses the ETL pilot as guard signal, it will be switched off by the cyclic loop test.

In case the TPE is operated in the DPLC channel, the MOD600 signal and the pilot/guard signal in the DPLC channel are switched off during the cyclic loop test.

**Note:** To avoid periodic interruptions of the MOD600 transmission, the cyclic loop test should not be activated when the TPE is operated in the DPLC channel.

Providing the cyclic loop test is enabled by HMI600, a test signal with its own frequency is transmitted to the opposite station and reflected back - depending on the programming - once every 1/3/6/12/24 hours.

The test signal is processed in the same way as a normal tripping signal (interruption of the guard signal and transmission of a test frequency for 36 ms). The reception of the reflected signal must take place between 6 ms and 120 ms after sending it, which ensures that all the functions required for transmitting a tripping signal are fully tested.

Whenever an automatically initiated loop test is not correctly received, the next automatically initiated loop test will be performed 5 minutes later and the warning **Loop test failed once or twice** is issued immediately. When more than two consecutive loop tests fail, the alarm **Loop test failed more than twice** is issued and the warning **Loop test failed once or twice** is removed. As long as the loop tests fail, the interval between automatically initiated loop tests will stay at 5 minutes. The first successful loop test after one or more failed loop tests will remove the above mentioned warning or alarm immediately, and the next automatically initiated loop test will take place after the configured loop test interval time. Note that, quality of the transmission channel permitted, the loop test can be correctly executed even if the guard signal is permanently lost. The loss of the guard signal is, however, signaled by both ETL600 and NSD600.

The testing facilities impair in no way the ability of the equipment to respond to a protection command, i.e. a genuine tripping command is always given priority over all tests.

If a cyclic loop test cannot be sent regularly due to a command being transmitted at that time, the NSD600 will try to resend it in intervals of 1 minute. An event recorder entry does only take place when the loop test could actually be released, i.e. after the command transmission has stopped.

The loop test includes automated measurement of the transmission time, i.e. half the measured transmission time for both directions there and back plus a delay for one relay interface input and output circuit is recorded.

The signal used for this test has the same parameters as the command with the highest application requirements regarding security.
3.7.8.14. **Manual Loop Test**

The loop test can also be initiated manually from any station via the HMI600. The result of the test can be viewed in a window. The actual measured transmission time is displayed (half the value of both directions there and back, plus a delay for one input and one output circuit of a teleprotection interface type G4AI, which can not be included in this test).

If the reflection of a manually transmitted test signal is not correctly received, it is correspondingly displayed in the loop test window.

**Note:** If a pick-up time for the command inputs is programmed (Tx Input Command On-Delay; refer to section 3.7.8.6.2), it is not included in the measured transmission time!

The signal used for this test has the same parameters as the command with the highest application requirements regarding security.

A manually initiated loop test is transmitted in the same way as the cyclic loop test.

3.7.8.15. **Local Test Mode**

Each NSD600 can separately be set via HMI600 to a local operating mode for checking the relay interfaces, e.g. for measuring the command prolongation.

In this operating mode, which is indicated by the 'warning' LEDs and via the HMI600 by the alarm message 'LOCAL TEST MODE', the command input signal is looped via the TDM-bus by the TPE processor on the DSP module P4LT/V/X back to the corresponding command output of the same local teleprotection equipment.

Commands can for example be initiated from the protection relay (separated from the protected objects!) or with the help of external contact and battery voltage.

**Caution** During the test mode the guard signal is continuously transmitted to the opposite station. Commands can not be transferred between the stations when the equipment is in the local test mode.

3.7.8.16. **Command Counters**

For both TPE an individual counter is incremented and stored in the non-volatile memory for each transmitted and received command as well as for the unblocking condition and the activation of the start signal via the configured input(s).

It is possible to reset the counters individually or all at once via the HMI600. Date and time of the last reset of each counter are recorded in non-volatile memory as part of the system status.
The counter range before overflow is $> 10^9$.

**Note:** If external command counters are used, their counter reading may differ from the internal command counters due to different response times, especially for short commands and if electromechanical counters are used. An appropriate Rx command prolongation time should be programmed to ensure proper activation of external counters.

### 3.7.8.17. Alarms Sources

Self-testing routines continuously monitor the operational status of the NSD600. In case the alarm source does not allow the safe reception of a command, the outputs are blocked.

A list of alarm messages and their causes can be found in section 9.5.

The alarm concept of the ETL600 including NSD600 is described in section 9.2.1.

The following criteria are continuously monitored and produce alarms (the list is not final):

- **Signal-to-noise ratio low.**
  The SNR alarm threshold for all applications is 7 dB for alarm pickup and 10 dB for release of the alarm. The SNR scale of the alarm threshold is related to the nominal level of the test signal.

- **Guard signal level out of limits.**
  The guard signal level alarm is configurable from ± 3 to ± 12 dB related to nominal guard level.

- **Cyclic loop test failure (> 3 attempts)**

- **Tx single component failure (from relay interface; after > 1 second)**

- **Rx single component failure (guard and tripping signals being either received simultaneously or completely lost; after > 1 second)**

- **Tx command duration (sending the guard signal, speech and the disconnectable channels again after a predefined time; default 5 seconds; may be switched off for NSD600 in 2 kHz nominal bandwidth)**

- **Rx command duration (if monitoring is enabled: blocking the command output(s) after a predefined time; default 5 seconds)**

- **Checksum error (program memory failure; instantaneous -> equipment will reboot automatically, an event recorder entry will be added)**

- **Rx command overload (from each FET output of the relay interfaces; instantaneously)**

- **System clock error**

- **Power supply voltage low**
3.7.8.18. **Alarm / Warning Contacts**

Following NSD600 alarms can be signaled individually per TPE on any output of G4AI (it is noted that the alarm signals of only one TPE can be signaled on the same G4AI, as it applies for the commands too):

- G4AI alarm (hardware and TDM-bus problems; only the G4AI module concerned does activate its alarm relay)
- TPE link alarm (SNR and level alarm)
- TPE hardware alarm (NSD600 related hardware problems on G4AI and P4LT/V/X)
- TPE alarm (summary alarm of NSD600 problems)
- User Alarm 1 (settings identical to those of alarm relay 1 on R1BC)
- User Alarm 2 (settings identical to those of alarm relay 2 on R1BC)

The NSD600 alarms “TPE hardware alarm”, “TPE link alarm”, TPE interface alarm” and “TPE warning” can individually be signaled or can be combined and signaled as TPE summary alarm on R1BC.

The alarm pick-up time and the alarm hold time can be set in the range from 0.1 to 120 seconds. They are valid for all alarms in common (PLC, Data, TPE). For the user alarms mentioned above, the pick-up and hold times can be configured independently. Default setting for all pick-up times: 10 seconds; default setting for all hold times: 1 second.

**Note:** If a Tx or Rx command duration of > 10 seconds is enabled, the alarm pick-up times for the link and user alarms have to be configured correspondingly (refer to Chapter 5 for details).

The relay contacts on G4AI are operated in the same way than the alarm relays of the R1BC interface, i.e. the “alarm” condition is the same as the “power off” state of the equipment (relay coil not energized). On both modules the user can still choose – by using the corresponding output contacts - whether the alarm contact shall be “normally open” or “normally closed”.

The solid-state outputs on G4AI are operated differently. An alarm condition is signaled with a conducting (energized) FET. Therefore the “alarm” condition is not the same as the “power off” state of the equipment. For this reason it is recommended to configure alarm signals on relay contacts only.

Both type of output contacts are activated only after the programmed alarm delay time has elapsed. The same applies for the alarm hold time. The LEDs of the outputs on G4AI correspond with the state of the contacts, i.e. they also light up only if the alarm delay time has elapsed and they will light on for the duration of the alarm hold time.
3.7.8.19. Interference in Speech Band
The NSD600 is under normal operating conditions secure against:

- Speech
- Sweep tones in speech band
- Test tones of the PLC equipment (generated via HMI600)
- DTMF signaling (according to CCITT-48430 or ITU-T Q.23)
- MFC signaling (for direct tripping commands only)

Under certain circumstances an NSD600 alarm may arise, e.g. when a discrete frequency of a tone generator meets a trip frequency, but no unwanted command will be activated.

3.7.8.20. Compatibility with Inband Modem Signals
Generally speaking, modem signals have to be avoided in the trip frequency band. They should be allocated above speech or in other channels of the ETL600.

Caution
NSK600 modems are not allowed in the NSD600 trip frequency band (neither FSK- nor DAPSK modems).

3.8. Event Recorder
3.8.1. General
The event recorder integrated in the HMI600 program (refer to chapter 4) registers special events of the ETL600 system, provides them with an accurate time stamp and stores the information sequentially into a non volatile memory.

The resolution of the events which can be discriminated between is 1 ms.

There are two different kind of events (they are recorded into two different blocks of the memory):

- the NSD600 command events
- the ETL600 and NSD600 alarm, warning & manipulation events

Note: The NSD600 command and alarm events, warning & manipulation events of TPE1 and TPE2 are recorded in the same event recorder memory.

The maximum number of events per block is 2600 (i.e. 2600 command events and 2600 alarm & manipulation events). If more than 2600 events per block occur, the eldest events are deleted and the 1000 newest events of each block are preserved.

The timing information for the event recorder is provided by the real time clock (RTC) on the DSP module type P4LT/V/X. The date and
time is set via the user interface HMI600. If the accuracy of this time setting procedure and the RTC is not sufficient, an external synchronization source can be used (e.g. from a GPS receiver).

In case of a power supply failure the RTC is buffered for more than 24 hours.

The events are displayed by means of the HMI600. There are two views available: a text based view and a graphic view. The graphic view gives the possibility to compare files with command event information from different equipment on one display.

### 3.8.2. NSD600 Command Events

The event recorder acquires the timing information of all commands when they appear on the TPE DSP on the P4LT/V/X interface (delay of inputs/outputs Teleprotection Interface and TDM-bus not considered!). This means that the commands are recorded as they appear on the transmission channel (Tx/Rx). The times when the commands appear at the I/Os of G4AI may be calculated, if required (according to the programmed input on-delay/prolongation times and output prolongation time of the command).

The command entry in the event recorder listing is “Tx/Rx Command A/B/C/D On/Off”. In order to distinguish between two teleprotection equipment TPE1 and TPE2, the corresponding designation is added beforehand (i.e. “TPE1 Rx Command A off”).

The following events are recorded as NSD600 command events:

- Start time and end time of all commands transmitted
- Start time and end time of all commands received
- Start and end time of an unblocking pulse
- Start time and end time of the activation of the configured “Start” input(s)

**Note:** Start inputs are not available for operating mode “Single purpose teleprotection NSD600 in 2 kHz nominal bandwidth”.

All these events are stored in the same block. The maximum number of command events is 2600.

To upload the command events from the ETL600 equipment use:
**Equipment / Commissioning and maintenance / Event recorder / Upload events.**

### 3.8.3. Alarm, Warning & Manipulation Events

The event recorder acquires the alarms as they appear on the alarm relays. Meaning after a pick up and with a hold time.

The alarm entry in the event recorder listing is “PLC link alarm” or “PLC link alarm cleared” for example. In order to distinguish between two teleprotection equipment TPE1 and TPE2, the corresponding number is added (i.e. “TPE1 hardware alarm”).
The following events of the local device are recorded as alarm & manipulation events:

- Start time, end time and time of a change in any PLC low level alarm or warning
- Start time, end time and time of a change in any DATA low level alarm or warning
- Start time, end time and time of a change of the TPE1 low level alarm or warning
- Start time, end time and time of a change of the TPE2 low level alarm or warning
- Start time, end time and time of a change of communication errors on the TDM-bus
- Time when a loop test was sent, was reflected or failed
- Time when a manual loop test was initiated (by means of HMI600)
- Time when the configuration was downloaded or stored to EPROM
- Time when a firmware version was downloaded
- Time when switched back to the previous configuration
- Time when a new date and time was set
- Time when the equipment started up
- Time when a manual reset was conducted
- Number of lost events in case of overload

All these events are stored in the same block. The maximum number of alarm & manipulation events is 2600.

To upload the alarm events from the ETL600 equipment use:

Equipment / Commissioning and maintenance / Event recorder / Upload events.

3.8.4. Upload events

To upload and display the events in the user interface HMI600 use:

Equipment / Commissioning and maintenance / Event recorder / Upload events

The user can choose between uploading the command events or the alarm events or both of them. Further he has the choice to read all events or only from a certain date and thereafter. Date and time are entered in the form: DD MM YY and HH MM.

Uploading and processing the events can take quite some time depending on the number of events which has to be read. The progress of the uploading can be seen in the status bar of the user interface HMI600. The upload may be interrupted by pressing the red stop button in the tool bar.
3.8.5. **Upload counters**

To upload the NSD600 command counters from ETL600 into the user interface HMI600 use:

**Equipment / Commissioning and maintenance / Event recorder / Upload counters**

Refer to 3.7.8.16 for more information.

3.8.6. **Reset counter**

To set the NSD600 command counters back to zero use:

**Equipment / Commissioning and maintenance / Event recorder / Reset counter**

The user has to be connected to the ETL600 equipment with read and write access.

The counters can be reset all at once or individually selected.

3.8.7. **Set clock**

To set the ETL600 system clock use:

**Equipment / Commissioning and maintenance / Event recorder / Set clock**

This dialogue enables the setting of the Real Time Clock (RTC) on the DSP module P4LT/V/X. The actual time of the PC will be downloaded to the ETL600 with the **Download date/time to RTC** button.

Pressing the button **Upload date/time from RTC** reads the date and the time information from the ETL600 system.

The user has to be connected to the ETL600 equipment with read and write access to perform the operations mentioned above.

The RTC power supply is buffered by a capacitor. The time and date information will be maintained for about one day.

If the accuracy of this time setting procedure or the accuracy of the RTC is not sufficient, an external clock can be used.

3.8.8. **RTC synchronization from an external clock**

An external clock source can be supplied to increase the accuracy of the ETL600 system time. The clock signal has to be provided in the **IRIG-B format** at TTL compliant **level** and has to be connected to the corresponding input on the front panel of the DSP module P4LT/V/X.

The IRIG-B format only informs about the time and the number of days having passed in the current year but not about the number of the year. So the date and time has to be set once manually in the ETL600 to supply the system with information about the current year. Refer to **Set clock** for the procedure about how to set the date and time.

3.8.9. **Views**

The events are displayed by means of the HMI600. There are two views available. A text based view for all kind of events and a graphic view for the command events. The graphic view gives the possibility to
analyze files with command event information from different equipment on one display.

3.8.9.1. **Text view**

There are two ways to switch to the text view. If the events are already uploaded, use View / Display Events to change to the event recorder text view.

If no events have been uploaded so far, use:
Equipment / Commissioning and maintenance / Event recorder / Upload events
to read the events. When the upload has finished, the HMI600 switches to the event recorder text view.

The events are displayed in chronological order. The command events and the alarm events are listed in two different tables, one below the other. The information is given as follows: DATE / TIME / EVENT.

By pressing the right mouse button the following menu appears:

- **Extend alarms**:
  This will extend the alarm text and the exact information about what alarm condition occurred is given. The extension of the alarms can take some time. The status bar will inform about the progress.

- **Graphic view**:
  This will switch to the graphic view. Refer to Section Graphic view for more information.

3.8.9.2. **Graphic view**

The graphic view displays the sequence of command events in the time domain. The user can specify which events he wants to see in one view. It is possible to analyze files with command event information from different equipment in one display.

It is possible to zoom or scroll in the time domain.

The graphic view display is subdivided into 4 views (view 1 to 4). In the lower part of each view the information about date and time is provided. In the upper left corner the following information can be seen:

- View number
- Time per division in Days / Hours / Minutes / Seconds / Milliseconds per division
- Zoom Mode: In/Out

First of all, the user has to set up his views. After that zoom out enables faster finding of the events. Then zoom in to analyze the command event information in more detail.

3.8.9.3. **Set up the views**

Press the right mouse button / Set up views. The ‘Select events’ dialog box appears.
• Choose the **window** that events shall be analyzed from
• Choose **view** (view 1, 2, 3 or 4)
• Select the events from the **event** frame (with a **left mouse click**)
• Press the **Add>>** button

The command now appears in the **selected events** frame. Repeat this procedure to add more events to the view. It is possible to add up to four different events to one view.

If events of different equipment has to be analyzed, the events can be uploaded and stored into a *.et6 file (**File / Save as**) Then open the different files (**File / open**). Switch to the ‘Graphic View’ and press **right mouse button / Set up views**. Now files can be selected in the ‘Window’ selection box of the ‘Select events’ dialogue box.

### 3.8.9.4. Zooming the Graphic View

For zooming the graphic view, press the **left mouse button** in the black view area. Keep the button pressed and move the mouse in horizontal direction.

If the zoom mode is ‘zoom in’, the resolution in the time domain will increase, otherwise in ‘zoom out’ mode it will be decreased.

Pressing the **left mouse button** without moving the mouse will toggle between the zoom mode.

### 3.8.9.5. Scrolling the Graphic View

For scrolling the graphic view, press the **left mouse button** in the grey view area with the information about time and date. Keep the button pressed and move the mouse in horizontal direction.

### 3.8.9.6. Right mouse button

By pressing the right mouse button the following choices are possible:

- **Set zoom mode in/out**
  Refer to the explanations above.
- **Set up views**
  Refer to the explanations above.
- **Set start / end time**
  Set the start and the end time of the graphic view to seek for events in a certain time span.
- **Scroll**
  Refer to the explanations above.
- **Text view**
  Switch back to the event recorder text view.

### 3.8.9.7. Import events into a spreadsheet or word processing tool

To import events into a third party tool (e.g. Microsoft® Excel):
• Change to the events text view
• Select the events to export and copy them to the clipboard (Ctrl+C),
• Change to the third party tool and insert the copied events.
4. USER INTERFACE PROGRAM

4.1. Introduction

The HMI600 software has been developed to program, tune, test, commission, operate and maintain the ETL600 equipment. It is a Windows based PC software with the user friendly features offered by the Windows environment.

The HMI600 software supports
- Configuration of ETL600 terminals,
- Tuning and testing of the local ETL600 terminal,
- Commissioning of ETL600 links,
- Supervision of ETL600 terminals.

For most of the operations supported by the HMI600, the PC has to communicate with the ETL600 terminal. Several possibilities exist for this communication:

- Direct connection with a cable,
- Connection via dial-up modem,
- Connection via intranet/internet,

For a description of these communication modes, refer to section 4.4. Some functions of the HMI600 can also be used in the 'Off line' mode, that is without communication to an equipment. Data entered into the HMI600 in this mode can be saved to file for later use or information fetched previously from equipments and recorded to files using the HMI600 can be analyzed and visualized later with the HMI600 in the 'Off line' mode.

Caution

The link gets disturbed while using certain functions offered by the HMI600. However, when 'Read access' is checked in the 'Connect' dialog box, it is not possible to activate these special functions. Care has to be taken especially in case protection signaling is being used.
4.2. Installation

4.2.1. System requirements

The PC on which HMI600 is to be installed must have one of the operating systems Windows XP, Windows Vista or Windows 7 installed. A screen resolution of at least 1024 x 768 resolution is recommended.

For communication with the ETL600 via cable or modem, one of the COM ports or USB ports of the PC should be free or the PC should have a intranet/internet connection. In case of a USB port, a USB to RS-232 converter is required (refer to section 4.4.2).

4.2.2. Install HMI600

1. Insert installation disk into the CD drive of your PC.
2. From the Windows Start menu, choose Run…, Browse…, change to the CD drive, double click the program setup.exe on the CD and click OK.
3. Follow the instructions given by the installation program.

Note: To perform the installation, you need administrator rights on the PC.

4.3. Using HMI600

To run the program HMI600, double click on the icon 'HMI600'. A window showing the ABB logo appears and the Connect dialog box is opened on top of it. The window can be used in two basic modes 'Off line' or 'On line' depending on the entries in the Connect dialog box.

Off line mode:

In this mode, there is no exchange of data associated with the window and an data of an ETL600 equipment. To choose this mode, either

- Click Off line followed by OK in the Connect dialog box or
- Close the Connect dialog box or
- Press the Escape-key.

On line mode:

In this mode, data associated with the window can be exchanged with data of an ETL600 equipment. Consequently, in order for this mode to work, a physical communication channel must exist between PC and equipment. Several possibilities exist for this communication channel, which are described in section 4.4.

With File / New, additional windows can be opened. Each of these windows can be used in Off line or On line mode. Each window in On line mode is connected to one ETL600 terminal. That way it is possible to connect to several terminals at the same time. In order for
this to work, physical communication channels must exist between PC and all terminals. Terminals which are connected together for this purpose are said to form an element management network. Refer to section 4.5 on how to build up such networks.

4.4. **Communication to the ETL600**

To establish the communication between HMI600 and an ETL600 terminal,

- communication media like cables, modems, network cards, servers must be properly installed and configured,
- the communication parameters of the various devices participating in the communication must be correctly set,
- the Logon operation must be executed using menu **Equipment**, click **Connect**.

4.4.1. **Specifying a Write password**

After having successfully connected to the equipment as described in the following sections, it is possible to specify and download a Write password. Once this has been done, equipment settings can’t be changed without entering the correct password before.

**Caution**

Never forget a password which has been downloaded to the equipment. The only way to reset a forgotten password is to send the P4LT/V/X board of the equipment back to the supplier for repair.

To specify or change a Write password, point to **Options / Communications / Change Write Password**, enter the old password (if any), enter the new password, retype the new password and click **OK** to download the password to the equipment.

4.4.2. **Direct connection via RS-232 cable**

The easiest way for HMI600 to communicate with an ETL600 terminal is via RS-232 cable. The PC must be equipped with a COM port or a USB port. In the latter case, a USB to RS-232 converter is required.
4.4.2.1. Communication media

When directly connecting the PC to the ETL600, a one-to-one cable (9 pole female to 9 pole male) is used, provided the COM port of the PC has a 9 pole connector. In case the COM port of the PC has a 25 pole RS-232 connector, an adapter (25 pole female to 9 pole male) is needed. The cable distance between the PC and the P4LT/V/X depends upon shielding of the cable, the conductor size, the baud rate used, cable capacitance and the EMI/EMC environment in which the cable is installed. As per the specifications of RS-232 it can be typically 15 meters. However, it can be lower or higher depending upon the above parameters.

In case a USB to RS-232 converter is used, data throughput might be degraded depending on the model. The following models of USB to serial converters have been tested successfully:

<table>
<thead>
<tr>
<th>USB to Serial Converter #1</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Manufacturer</td>
<td>BAFO</td>
</tr>
<tr>
<td>Country of origin</td>
<td>China</td>
</tr>
<tr>
<td>Model</td>
<td>BF-810</td>
</tr>
<tr>
<td>Driver</td>
<td>Version 1.5.0.0 from <a href="http://www.bafo.com">www.bafo.com</a></td>
</tr>
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</table>

<table>
<thead>
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<th>USB to Serial Converter #2</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Manufacturer</td>
<td>ATEN (Distributed by Maxxtro)</td>
</tr>
<tr>
<td>Country of origin</td>
<td>Taiwan</td>
</tr>
<tr>
<td>Model</td>
<td>UC-232A</td>
</tr>
<tr>
<td>Driver</td>
<td>Original ATEN-Driver on CD</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>USB to Serial Converter #3</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Manufacturer</td>
<td>SEWELL</td>
</tr>
<tr>
<td>Country of origin</td>
<td>China</td>
</tr>
<tr>
<td>Model</td>
<td>SW-1301</td>
</tr>
<tr>
<td>Driver</td>
<td>Original SEWELL-Driver on CD</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>USB to Serial Converter #4</th>
<th></th>
</tr>
</thead>
<tbody>
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<td>Manufacturer</td>
<td>MARSON</td>
</tr>
<tr>
<td>Country of origin</td>
<td>Taiwan</td>
</tr>
<tr>
<td>Model</td>
<td>MT609-2</td>
</tr>
<tr>
<td>Driver</td>
<td>Original MARSON-Driver on Floppy-Disk</td>
</tr>
</tbody>
</table>

4.4.2.2. Communication settings

In the HMI600, open the dialog box Options / Communications..., select Direct connection, choose the right Port (COM1, 2, 3, …) and set the Timeout to 3 s or higher. Click OK to accept the settings.

Note: Some COM ports offered by the dialog may not be supported by the PC. Refer to the Device Manager of the PC for a list of valid COM ports.
4.4.2.3. **Logon to the equipment**

Point to **Equipment / Connect** to open the **Connect** dialog box. Select **Logon**, accepting the default value of 0 for the **Equipment address**. Select **Local** to connect to the local and **Remote** to connect to the remote equipment via narrowband EOC (refer to section 4.5.2). If parameters have to be downloaded to the equipment, uncheck **Read access only**. If a **Write password** has been downloaded into the equipment previously and if Read/write access is desired, enter the correct **Write password**. If immediately after logon, configuration and/or status data are to be uploaded, check the boxes **Upload configuration** and/or **Upload status**. Finally, click **OK**.

Using direct connection to the equipment provides the user with administrator permissions.

The status of the communication can be deduced from the color of the circle-button in the toolbar:

<table>
<thead>
<tr>
<th>Color</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grey</td>
<td>Communication inactive (Off line mode)</td>
</tr>
<tr>
<td>Red</td>
<td>HMI600 waits for an answer from the equipment. By clicking the red circle, the communication is interrupted.</td>
</tr>
<tr>
<td>Green</td>
<td>Communication ready (On line mode)</td>
</tr>
</tbody>
</table>

**Note:** When an unsupported COM port has been selected in the previous step (refer to section 4.4.2.2), an error message will pop up: “Could not open COM port”.

4.4.3. **Communication via phone modems**

HMI600 can communicate with ETL600 via phone modems.

**Fig. 4-2 Communication via phone modems**

4.4.3.1. **Communication media**

4.4.3.1.1. **Modems**

The phone modems should be capable of transmitting at least 9'600 bps. Modems compatible to ITU-T V.32 or higher fulfill this requirement. The highest data rates are obtained with ITU-T V.90 (or higher) modems. Also make sure that the modems data format can be set to 8 data bits, even parity bit, one stop bit.
4.4.3.1.2. **Cables**

For the connection between modem and ETL600, a 9 pin null modem cable has to be used:

<table>
<thead>
<tr>
<th>Connector 1 (9 pin male)</th>
<th>Connector 2 (9 pin male)</th>
</tr>
</thead>
<tbody>
<tr>
<td>pin</td>
<td>pin</td>
</tr>
<tr>
<td>1</td>
<td>not connected</td>
</tr>
<tr>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>4</td>
<td>6</td>
</tr>
<tr>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>6</td>
<td>4</td>
</tr>
<tr>
<td>7</td>
<td>8</td>
</tr>
<tr>
<td>8</td>
<td>7</td>
</tr>
<tr>
<td>9</td>
<td>not connected</td>
</tr>
</tbody>
</table>

**Caution**

There are other “null modem cables” with different pin assignment available!
Make sure that the one you use matches exactly with the pin assignment mentioned above.

In case the modem has a 25 pole RS-232 connector, an adapter (25 pole male to 9 pole female) is needed. On the ETL600, plug the cable into the HMI socket on the front plate of P4LT/V/X.

For the connection between modem and PC, a 9 pole 1:1 modem cable (female to male) is required. In case the COM port of the PC has a 25 pole RS-232 connector, an adapter (25 pole female to 9 pole male) is needed.

4.4.3.2. **Communication settings**

In the dialog box **Options / Communications...**, select **Phone modem**, choose the correct **Modem** and set the **Timeout** to 3500 ms or higher. Click **OK** to accept the settings.

4.4.3.2.1. **Configuration of the modems**

**Modem connected to PC:**

Install this modem on the PC using **Settings / Control panel / Modems**.

**Modem connected to P4LT/V/X:**

This modem has to be configured as follows:

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Modem at P4LT/V/X:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baud rate</td>
<td>57’600 baud</td>
</tr>
<tr>
<td>Data bits</td>
<td>8</td>
</tr>
<tr>
<td>Parity</td>
<td>even</td>
</tr>
<tr>
<td>Stop bits</td>
<td>1</td>
</tr>
</tbody>
</table>
To configure the modem, use a terminal program (e.g. HyperTerminal) to send the configuration commands to the modem. As these commands differ depending on the type of the modems used, it is not possible to specify a common configuration sequence for all modem types. Please refer to your modem dealer or the example below for further information.

Example:
Configuration of a ZyXEL U-90E Modem for connection to P4LT/V/X:

The modem is to be configured to the settings given by column 'Modem at P4LT/V/X' of the previous table with the help of the program HyperTerminal. Connect the modem to one of the COM-ports of the PC with a 9 pole 1:1 modem cable (female to male). In case the COM port of the PC has a 25 pole RS-232 connector, an adapter (25 pole female to 9 pole male) is needed. Start hyperterminal, select the correct COM port and set the Baudrate to 57'600 Bd, connect to the modem and type at. The modem should answer with OK. If your modem returns garbage characters, retype at to adapt the modems autobaud function to your baud rate. Do not send any other characters (e.g. return) before at. This may disturb your modems autobaud functionality. If you don't get any answer check your connections, the modem settings and try again.

Now enter the following commands to setup the modem: The modem should always send OK to confirm your entry.

Command:    Explanation:
atz4          Load factory settings to get a defined modem setting.
ate0         Command echo off //delete.
ats0=1        Set the number of rings on which the modem will answer automatically. S0=0 disables the auto answer.
ats20=3       Sets the speed of the serial interface to 57’600.
ats15=8       Set the modem to even parity and a character length of 11 (1 start bit , 8 data bits, 1 parity bit, 1 stop bit). The terminal program now might receive some garbage characters, which can be ignored.

Change the communication settings of the PC to the modem using Settings / Control panel / Modems and of hyperterminal to 57’600 Baud, 8 bits, even parity, 1 stop bit. When typing at, the modem should answer with OK.

atat&w0        Save the settings to profile 0.
atz0          Load profile 0 and set profile 0 as power-on profile.
4.4.3.2.2. **Configuration of HMI600**

In the dialog box **Options / Communications...**, select **Phone modem**, choose the correct **Modem** and set the **Timeout** to 3500 ms or higher.

4.4.3.3. **Logon to the equipment**

Point to **Equipment / Connect** to open the **Connect** dialog box. Select **Logon**, accepting the default value of 0 for the **Equipment address**. Select **Local**. If parameters have to be downloaded to the equipment, click on **Read & write access**. If a **Write password** has been downloaded into the equipment previously and if Read/write access is desired, enter the correct **Write password**. If immediately after logon, configuration and/or status data are to be uploaded, check the boxes **Upload configuration** and/or **Upload status**.

Click the **Dial** button. Choose **Add item** and enter **Station Name**, **Phone Number** and – if required – **Country Code** and **Area Code** for the remote modem. After clicking **Connect**, the modem performs the necessary actions to establish a dialing connection. As soon as the connection is made, the color of the circle-button in the toolbar turns to green.

Communication to the equipment via phone modem provides the user with administrator permissions.

To disconnect the phone connection, use **Equipment / Disconnect phone modem**.

4.4.4. **Communication via Intranet/Internet/LAN/WAN**

HMI600 can communicate with ETL600 via Internet/Intranet/LAN/WAN.

4.4.4.1. **Communication media**

The PC with the HMI600 acts as client and must have Internet/Intranet/LAN/WAN access.

On the equipment side, the internet/intranet must be connected to any of the ETL600 LAN ports\(^\text{11}\). Straight-through or crossover Ethernet

\(^{11}\) P4LV or P4LX required. Not available with P4LT.
cables can be used as the LAN ports have automatic crossover capability (Auto-MDIX).

**4.4.4.2. Communication settings**

Configuration of HMI600

In the dialog box Options / Communications..., select Internet connection, specify in the frame Server the IP address and set Encryption to SSL. The TCP port number is then fixed at 5001. If Encryption is set to None, communication to ETL600R4 is not possible. Set the Timeout to 10 s or higher.

Click OK to accept the settings.

Configuration of LAN600:

This configuration must be made with a direct connection to ETL600 (Options / Communications / Direct connection).

First, the LAN interface must be made available for HMI600 access: Under Configuration / Services, tab Data communication, frame Data ports, select one of the options offering LAN ports, e.g. 1 V.11 / 2 V.24 / Transit / 4 LAN from the dropdown menu. In the tab LAN, activate the checkbox HMI over LAN. In addition, if a LAN connection to the remote equipment via PLC link is required, also activate the checkbox LAN over PLC.

Second, the LAN interface must be configured under Configuration / LAN600. In the tab General, enter the IP address, Subnet mask and Default gateway. The IP address must correspond to the one entered into the HMI600 client under Options / Communications as described above. Subnet mask and Default gateway are relevant if the HMI600 client is not inside the local network.

**4.4.4.3. Logon to the equipment for serial connection**

Point to Equipment / Connect to open the Connect dialog box. Select Logon, accepting the default value of 0 for the Equipment address. Select Local to connect to the local and Remote to connect to the remote equipment via narrowband EOC (refer to section 4.5.2).

Note: For access via RS-485 station bus, as described in section 4.5.1, an Equipment address other than 0 must be used.

If parameters have to be downloaded to the equipment, select Read & write access in the frame Access rights. Otherwise accept Read access. For Read & write access, the correct Write password must be entered. The default Write password is empty and can be changed under Options / Change Write Password, provided the old password is known.

If immediately after logon, configuration and/or status data are to be uploaded, check the boxes Upload configuration and/or Upload status.
Finally, click **OK**.

The status of the communication can be deduced from the color of the upwards pointing arrow or of the circle-button in the toolbar:

| Grey: | • Communication inactive (Off line mode) |
| Red: | • HMI600 waits for an answer from the equipment. By clicking the red circle, the communication is interrupted. |
| Green: | • Communication ready (On line mode) |

Table 4-1 Communication status indications

**Note:** When an unsupported COM port has been selected in the previous step (refer to section 4.4.2.2), an error message will pop up: “Could not open COM port.”

As shown in Table 4-2, certain LAN600 operations are not possible with serial connection, even with **Read & write access**.

<table>
<thead>
<tr>
<th>LAN600 menu item</th>
<th>Read access</th>
<th>Read &amp; write access</th>
</tr>
</thead>
<tbody>
<tr>
<td>Download configuration</td>
<td>--</td>
<td>x</td>
</tr>
<tr>
<td>User administration</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Change own password</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Upload, add/ delete user</td>
<td>--</td>
<td>x</td>
</tr>
<tr>
<td>Change access level</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Certificate management</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Generate certificate</td>
<td>--</td>
<td>x</td>
</tr>
<tr>
<td>Upload certificate</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Import, export, remove certificate</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Upload user activity log</td>
<td>--</td>
<td>x</td>
</tr>
<tr>
<td>Restart alarm polling</td>
<td>--</td>
<td>x</td>
</tr>
<tr>
<td>Logout</td>
<td>--</td>
<td>--</td>
</tr>
</tbody>
</table>

Table 4-2 LAN600 operations for serial connection

4.4.4.4. **Logon to the equipment for internet/intranet connection**

Point to **Equipment / Connect** to open the **Connect** dialog box. Select **Logon**, accepting the default value of 0 for the **Equipment address**. Select **Local** to connect to the local and **Remote** to connect to the remote equipment via narrowband EOC (refer to section 4.5.2).

In the frame **Login LAN600**, enter a valid **User name** and associated **Password**. Note that this password is not the same as the **Write password** mentioned in section 4.4.1.

**Note:** User name and Password are case sensitive.
Initially, by factory default, the following user names, associated password and user permissions are available:

<table>
<thead>
<tr>
<th>User name</th>
<th>Password</th>
<th>Permissions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Administrator</td>
<td>welcome</td>
<td>admin</td>
</tr>
<tr>
<td>Service</td>
<td>welcome</td>
<td>modify</td>
</tr>
<tr>
<td>Operator</td>
<td>welcome</td>
<td>view</td>
</tr>
</tbody>
</table>

Table 4-3  Default users

Refer to section 4.4.4.5.1 for details regarding the permissions.

Selecting **Read & write access** in the frame **Access rights** is restricted to users with **admin** or **modify** permission. When doing so, these users must enter the correct **Write password**. The default **Write password** is empty and can be changed under **Options / Change Write Password**, when the old password is known.

If parameters have to be downloaded to the equipment, select **Read & write access** in the frame **Access rights**. Otherwise accept **Read access**.

If immediately after logon, configuration and/or status data are to be uploaded, check the boxes **Upload configuration** and/or **Upload status**.

Finally, click **OK**.

If the addressed ETL600 can be reached over the LAN connection, it sends its public key and its certificate back to HMI600. If the certificate sent is unknown to HMI600, the certificate status is displayed. The user has three options:

1. “Accept temporarily”:
   The certificate is accepted for one HMI600 session only. Next time when logging in on the same ETL600 the message is displayed again. This option shall be used only in trustworthy networks and if the certificate is known by the user.

2. “Do not accept”:
   The certificate is not accepted and hence the connection refused. This option shall be used if the certificate is unknown or if connected through an untrusted network.

3. “Accept permanently”:
   The certificate is accepted and stored on the HMI600 client PC. In subsequent sessions, the SSL/TLS connection to the same ETL600 is established without user interaction. This option shall be used only in trustworthy networks and if the certificate is known by the user.
Note: If the LAN access to ETL600 is over an untrusted network it is highly recommended to upload the certificate locally by direct connection to the ETL600 equipment as described in section 4.4.2 and distribute it to the HMI600 clients used for LAN access. The certificate management of HMI600 supports certificate import/export for such cases (refer to section 4.4.4.6).

If the default or an invalid certificate (e.g. one with expired date) is received, the option “Accept permanently” is disabled.

In both cases it is highly recommended to generate a new certificate on LAN600 which can then be accepted and stored permanently on the HMI600 client as described above.

Note: For security reasons, the default passwords have to be changed immediately after the first installation of HMI600.

The password complexity is checked by HMI600. It must consist of at least six characters with at least one letter, one number and one special character.

The status of the communication can be deduced from the color (grey, red or green) of the circle-button in the toolbar. Refer to Table 4-1 for the meaning of the colors.

To terminate the HMI600 session in case of SSL/TLS connection, use **Connect / LAN600 / Logout**. After 30 minutes of inactivity, the SSL/TLS connection is closed automatically.

The SSL/TLS connection will also be closed automatically if for any reason the network connection between HMI and ETL600 is interrupted for more than about 15 s.

**4.4.4.5. User administration**

In the submenu **Connect / LAN600 / User administration**
- users can be added or deleted;
- permissions and the own password can be changed.

These operations require admin permission, except changing the own password, which is allowed for all users.

- To add a new user, enter the user name, the password (with confirmation) into the respective text fields, select the desired permission by clicking the appropriate radio button and click the button **Add**. The new user appears in the user table.

- To change the permission of a user already appearing in the user table, select the user in the table, click the appropriate radio button below the table and click the button **Change access**.
- To delete users, select them in the user table and click the button **Remove all selected**.

- To change the own password, enter the new password and confirmation in the text boxes at the bottom of the dialog box and click the button **Change password**.

To close the user administration dialog, press the button **Quit**.

### 4.4.4.5.1 Permissions

**View:**
A user with **View** permission can monitor the operation of an ETL600 but can neither disturb a link nor change any data stored in the equipment. This corresponds to **Read access** when using a serial connection for HMI600. **Read & write access** can’t be selected by users with **view** permission. For LAN600 operations, refer to Table 4-4.

**Modify:**
A user with **Modify** permission having selected **Read & write access** – apart from having all rights of the view permission - can make changes to the configuration or execute other functions in the connected ETL600. Some of these functions can disturb or disable the operation of the equipment. This corresponds to **Read & write access** when using a serial connection for HMI600. For LAN600 operations, refer to Table 4-4.

**Admin:**
A user with **Admin** permission – apart from having all rights of the modify permission - can execute all **LAN600** operations as shown in Table 4-4.

<table>
<thead>
<tr>
<th>LAN600 Menu item</th>
<th>View</th>
<th>Modify</th>
<th>Admin</th>
</tr>
</thead>
<tbody>
<tr>
<td>Download configuration</td>
<td>--</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>User administration:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Change own password</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Upload, add/ delete user</td>
<td>--</td>
<td>--</td>
<td>x</td>
</tr>
<tr>
<td>Change access</td>
<td>--</td>
<td>--</td>
<td>x</td>
</tr>
<tr>
<td>Certificate management:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Generate certificate</td>
<td>--</td>
<td>--</td>
<td>x</td>
</tr>
<tr>
<td>Upload certificate</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Import, export remove certificate</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Upload user activity log</td>
<td>--</td>
<td>--</td>
<td>x</td>
</tr>
<tr>
<td>Restart alarm polling</td>
<td>--</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Logout</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
</tbody>
</table>

Table 4-4 LAN600 operations for SSL/TLS-LAN connection

### 4.4.4.5.2 Upload user activity log

The user activity log can be uploaded and displayed by HMI600 using **Equipment / LAN600 / Upload user activity log**. For this operation, the **Admin** permission is required. The user activity log shows the following LAN600 events:
### 4.4.4.6. Certificate management

The HMI over LAN communication makes use of the SSL/TLS protocol for secure communication over IP networks. SSL/TLS provides server authentication by public key certificates. LAN600 in the ETL600 acts as server and sends its certificate during the login process to the HMI600 client. If the certificate is already stored on the client, the connection to LAN600 is established without further user interaction. Otherwise, the user has to manually accept or refuse the certificate. Details of the login process can be found in section 4.4.4.3.

The submenu **Connect / LAN600 / Certificate management** provides the following functions to manage certificates on LAN600, HMI600 and HMI600 client.

<table>
<thead>
<tr>
<th>Event</th>
<th>Id</th>
</tr>
</thead>
<tbody>
<tr>
<td>Log-in successful</td>
<td>1110</td>
</tr>
<tr>
<td>Log-in failed - Unknown user</td>
<td>1120</td>
</tr>
<tr>
<td>Log-in failed - Wrong password</td>
<td>1140</td>
</tr>
<tr>
<td>Log-out (user logged out)</td>
<td>1210</td>
</tr>
<tr>
<td>Log-out by user inactivity (timeout)</td>
<td>1220</td>
</tr>
<tr>
<td>Configuration download successful</td>
<td>1320</td>
</tr>
<tr>
<td>Configuration upload successful</td>
<td>1330</td>
</tr>
<tr>
<td>Configuration stored successfully</td>
<td>1322</td>
</tr>
<tr>
<td>Firmware download successful</td>
<td>1340</td>
</tr>
<tr>
<td>Configuration download failed</td>
<td>1420</td>
</tr>
<tr>
<td>Configuration upload failed</td>
<td>1430</td>
</tr>
<tr>
<td>Configuration storage failed</td>
<td>1422</td>
</tr>
<tr>
<td>Firmware download failed</td>
<td>1440</td>
</tr>
<tr>
<td>User account created successfully</td>
<td>2110</td>
</tr>
<tr>
<td>User account deleted successfully</td>
<td>2120</td>
</tr>
<tr>
<td>User password changed successfully</td>
<td>2210</td>
</tr>
<tr>
<td>User permission changed successfully</td>
<td>2161</td>
</tr>
<tr>
<td>User account creation failed</td>
<td>2130</td>
</tr>
<tr>
<td>User account deletion failed</td>
<td>2140</td>
</tr>
<tr>
<td>User password change failed</td>
<td>2220</td>
</tr>
<tr>
<td>User permission change failed</td>
<td>2331</td>
</tr>
<tr>
<td>User activity log file deleted by user</td>
<td>3420</td>
</tr>
<tr>
<td>Manual reset</td>
<td>5110</td>
</tr>
<tr>
<td>Date and time set successfully</td>
<td>8020</td>
</tr>
<tr>
<td>New certificate generated successfully</td>
<td>8030</td>
</tr>
<tr>
<td>System startup successful</td>
<td>8040</td>
</tr>
<tr>
<td>Date and time setting failed</td>
<td>8220</td>
</tr>
<tr>
<td>New certificate generation failed</td>
<td>8230</td>
</tr>
</tbody>
</table>

Table 4-5 User activity log events

With each event, date, time and device are also recorded.
Generate on LAN600:
In order to generate a new self-signed certificate, specify the number of days that the certificate needs to be valid (allowed values are between 1 and 20000) and click on the button Generate on LAN600. This operation can take up to 2 minutes, during which certificate upload should not be performed.

Note: For security reasons, the certificate on LAN600 should be regenerated periodically.

Upload from LAN600:
By clicking the button Upload from LAN600, the certificate stored on LAN600 is uploaded to HMI600.

Add to HMI store:
Once a certificate has been uploaded from LAN600 it can be saved on the HMI600 client by clicking the button Add to HMI store.

Import certificate:
LAN600 certificates which have been uploaded to other clients can be imported and added to the local HMI certificate store by clicking the button Import certificate.

Export certificate:
In order to distribute locally stored certificates to other HMI600 clients they can be exported by selecting the certificate in the HMI certificate store table and clicking the button Export certificate.

Remove certificates:
Certificates can be removed from the local HMI certificate store by selecting the certificates in the HMI certificate store table and clicking the button Remove all selected.

To close the Certificate management dialog, press the button Quit.

4.5. Element management networks

4.5.1. RS-485 station bus

If management access from one PC to several ETL600 terminals in a substation is desired, the management HMI ports of these terminals can be connected together via RS-485-bus available at the HMI port of P4LT/V/X at the ETL600 front as shown in Fig. 4-4. The PC must be connected via remote inquiry kit R7AP to the RS-485 bus. Of course, this network of terminals can also be reached from a remote location according to Fig. 4-1, Fig. 4-2 or Fig. 4-3, replacing the single ETL600 terminals shown in these figures by the network of terminals as depicted in Fig. 4-4.

12 RS-485 cables according to Fig. 6-19 or equivalent required for ETL600
In order to distinguish the terminals from each other, a unique address called **Equipment address** must be given to all terminals participating in the network. The **Equipment address** is a number between 1 and 65,000. It has to be configured for each terminal prior to connecting the management ports together to form the network.

### 4.5.2. Embedded operation channel (EOC)

The remote equipment of an ETL600 link can always be reached without own equipment address via the built in Narrowband EOC, Fig. 4-5, which uses the pilot signal of the ETL600 terminals. This is done by selecting **Remote** in the dialog box **Equipment / Connect** of HMI600. However, the transmission rate of the Narrowband EOC is 100 bps, which is sufficient for alarm monitoring, but might be tedious for more sophisticated tasks like remote measurement of signals in the terminal, which involve a much larger amount of data than alarm monitoring.

If in both terminals of a link **LAN over PLC** is activated and if the remote terminal is configured for **HMI over LAN**, the remote terminal can be reached via Broadband EOC by using the communication settings **Options / Communications / Internet connection** and specifying the **IP address** of the remote terminal. Then - to connect to the remote terminal - select **Local** in the dialog box **Equipment / Connect**. In the frame **Login LAN600**, specify **User name** and **Password**. These entries must match one of the users in the user table of the remote equipment. The Broadband EOC uses the LAN connection between the ETL600 terminals to exchange EOC data. Thus, the data rate of the Broadband EOC is limited by the data rate of the LAN connection which is much higher than what is
offered by the Narrowband EOC. However, MOD600 must be up and running for the broadband EOC to work.

In the common situation, where several links are connected in tandem (chain of links), all terminals can be reached from either side of the chain by connecting the management ports of the terminals together via Null modems or via RS-485 bus \(^{13}\) as shown in Fig. 4-6.

T-offs in substations can be handled by connecting the management ports of the involved terminals via RS-232/RS-485 converters as shown in Fig. 4-4.

Fig. 4-6  Chain of ETL600 links

4.5.3. Network protocol

The network protocol used by the ETL600 terminals is connectionless in the sense that all messages circulating in the network are routed to all terminals attached to the network. Only the addressed terminal will execute the commands contained in the message and generate an answer. Closed loops are not allowed in the network. In the example of Fig. 4-7, a closed loop exists between substations A and C. All messages exchanged between substations A and C will be transmitted over a data channel of 9'600 bps as well as over the 100 bps EOC channel of the PLC link between terminals A3 and C3. Unless the EOC of the PLC link A3-C3 is disabled for network management by proper configuration via HMI600 (by not checking the box Network management: EOC enabled in the HMI600 dialog box Configuration / System / Channel settings), the network will not operate properly. Thus the EOC must be disabled for network management in this case.

A further valuable feature of the ETL600 network protocol is the possibility of connecting several PCs at various points to a network. In Fig. 4-7, in addition to the PC in the control center, another PC has

\(^{13}\) RS-485 cables according to Fig. 6-19 or equivalent required for ETL600
been connected to the management port of terminal B1 in substation B. The network will transport independently all HMI600 messages between the PCs and all the terminals attached to the network. This is achieved by entering a network address similar to the equipment address into the HMI600 running on the PCs. Permissible values for PC network addresses are from 65001 to 65500, to be entered into the HMI600 dialog box **Options / Communications / Address of HMI600**.

For supervision of the whole network, the function **Alarm polling** can be used, accessible under the **Network** menu. This function works also for a mixed network of ETL500 Rel.3 and ETL600 links.

**SNMP**

SNMP supervision of a network consisting of ETL500 Rel.3 and/or ETL600 terminals is possible by configuring LAN600 on one of the ETL600 terminals of the network. This ETL600 terminal acts as an SNMP agent, when the SNMP function on LAN600 is enabled (refer to section 5.3.4.3). It collects information about the other ETL terminals of the network by making use of the alarm polling mechanism (refer to section 9.2.9). An SNMP management station collects the information provided by the SNMP agent and interprets it with the help of the management information database (MIB), which can be found in the subfolder **SNMP_MIB** of the HMI600 installation directory.
The management station can use the services getRequest and getNextRequest to collect information about all ETL terminals connected to the network. For each terminal, the following identification attributes are provided:

- Equipment Address,
- Link No,
- Equipment name,
- Cabinet No.,
- Equipment No.,
- Equipment type.

These attributes are part of the system configuration of each ETL terminal.

The agent generates traps (spontaneous messages) whenever

- an ETL terminal (re-)appears in the network,
- an ETL terminal can no longer be reached over the network,
- the alarm state of an ETL terminal changes, i.e. an alarm starts or ends in any of the accessible ETL terminals.

Each trap comes with a timestamp, generated by the RTC of the ETL600 terminal used as SNMP agent. Therefore, the timestamp indicates the time when the ETL was polled, which is different from the time of the start/end of the alarm or the (dis-)appearance of the ETL in the network, respectively.

Whenever a terminal in the network is changed, the alarm polling should be restarted, which causes all devices in the network to be re-polled for their device information. This operation is initiated via HMI600 using Equipment / LAN600 / Restart alarm polling.

Warnings are treated the same way as alarms, the only difference being the alarm severity code:

Severity code = 1 indicates an ETL warning,
Severity code = 2 indicates an ETL alarm.
4.6. **Operation**

All functions of the HMI600 are accessible via the following 8 menu-items, displayed at the top of the program window: **File, Edit, View, Equipment, Configuration, Network, Options, Window** and **Help**.

Off line operation is covered mainly by the menus **Configuration** and **File**, while On line operation is addressed mainly with the menus **Equipment** and **Network**. The functions offered by menu **Equipment** are only available after an equipment has been connected to the HMI600 as described in section 4.4.

Important procedures for tuning & testing and for commissioning & maintenance of the equipment are described in separate documents. These documents can be found in the annex of this instruction manual.
4.7. **Data management**

The configuration data of the ETL600 can reside in several locations:

1. In the RAM of a PC.
2. As a data file on the hard disc of a PC or on other media.
3. In the volatile RAM of the modules P4LT/V/X, O4LE, G4AI of the ETL600.
4. In the non-volatile flash EPROM of the modules P4LT/V/X, O4LE, G4AI of the ETL600.

In addition to the above, a printout of the configuration data can also be taken for storage on paper. The configuration file can be generated off line and downloaded later into the equipment. The following figure shows the data management in pictorial form.

![Data Management Diagram](image)

**Fig. 4-9** Data-Management, Data-Flow

The procedures for transferring data between the locations all have distinct names. As shown in the figure, there is no direct possibility of data transfer from equipment EPROM to file: The operations **Reset**, **Upload** and **Save** have to be executed in sequence. To transfer data from file to EPROM, the operations **Open**, **Download**, **Store** have to be executed.

Due to safety reasons, the HMI600 program treats the download procedure as a temporary operation: After a predefined timeout to be specified by the user, the equipment automatically performs a reset operation, so that the system is rebooted, thereby undoing all changes caused by the download operation by fetching the complete system configuration data saved in EPROM previously. Should faulty settings have been downloaded, resulting in loss of a PLC link, this feature brings back the link into life automatically after the specified timeout.
4.8. **Compatibility**

The ETL600 system consists of

1. **Hardware**, consisting of a number of modules;
2. **Firmware**, residing on some of the modules and making the processors on these modules execute various functions such as modulation, digital filtering etc.;
3. **PC based software** HMI600, implementing the user interface for configuration, monitoring and testing of the equipment.

The compatibility aspects explained in this section are coupled to exchange of data between two items such as modules, terminals, links, configuration files or HMI600 programs. Compatibility regarding the exchange of operational information like speech, teleoperation signals, teleprotection signals, … is not addressed here.

The compatibility rules and relations for the present and all previous ETL600 releases are summarized in the document ‘Compatibility requirements for ETL600’.

4.8.1. **ETL600 releases, release numbers, version numbers, type codes**

To understand the explanations in the following sections, the terms 'ETL600 release', 'release number', 'version number', 'type code' need to be explained.

An ETL600 system release, identified by a release number, is a product of defined functionality comprising hardware modules, firmware and software. Firmware and software are identified with version numbers of the form NN.nn., e.g. 5.08 (leading zeros may be omitted). Releases are identified by release numbers of the form RR.r, e.g. 3.1 (leading zeros may be omitted). Hardware modules are identified with type codes consisting of 4 characters like P7LH, G4AI or P4LT. Sometimes, a fifth character – the revision index - is appended to identify an upgraded version of a module. Example: P4LTA would be an upgraded version of P4LT; P4LTB would be an upgraded version of P4LTA and so on.

**Note:** The information content of type codes in case of modules containing firmware depends on the possibility to download firmware from HMI600 into the module:

- If for a module firmware download is not possible, the type code of that module identifies the hardware **including** the firmware version.
- If for a module firmware download is possible, the type code of that module identifies the hardware **excluding** the firmware version. The download files for the firmware of such modules are included on the HMI600 disc. Example: O4LE
4.8.2. Compatibility between modules of a PLC terminal

The modules of an ETL600 terminal must belong to the same release as given by Table 1 in the document 'Compatibility requirements for ETL600'.

4.8.3. Compatibility between the two ETL600 terminals of a link

Apart from the exceptions given in section 4.1 of the document 'Compatibility requirements for ETL600', the two ETL600 terminals of a link must belong to the same release. A warning 'Inconsistent firmware on local and remote equipment' will be generated by the terminals if this rule is not respected.

4.8.4. Compatibility of HMI600 to ETL600 terminals

The compatibility relations between HMI600 and an ETL600 terminal can best be explained referring to Fig. 4-10. As shown, the compatibility issue is coupled to the data transfer operations 'Upload' and 'Download'. Testing of these operations for the present and for past releases of ETL600 terminals is part of the system tests carried out for each release of the ETL600 system.

![Fig. 4-10 HMI600 compatibility relations](image)

Generally, an specific HMI600 version will be fully compatible to ETL600 terminals of the same release.

It will have restricted compatibility (symbol 'U' in Fig. 4-10; definition: refer to the explanations below) to a number of past releases.

Updates of hard-, firm- or software will generally inherit the compatibility relations from its predecessors. Thus for each HMI600 version there is a compatibility range – shown graphically in Fig. 4-10 - containing all ETL600 releases and updates thereof to which it is compatible (fully or restricted). It is identical to the compatibility range mentioned in section 4.8.5.

A specific HMI600 version will not be compatible (symbol 'X' in Fig. 4-10) to all releases and updates thereof which are not within the HMI compatibility range.
**Restricted compatibility**: In a situation of restricted compatibility, when starting an upload or download operation, messages will sometimes be displayed informing about some unavailable function and corrective action. One such situation arises when new functions have been added for a new release, which will not be known by previous releases.

**Note:** Inquire about the most recent HMI600 version each time new ETL600 modules are purchased.

### 4.8.5. Compatibility of HMI600 to configuration files

The compatibility relations between HMI600 and a configuration file can best be explained referring to Fig. 4-11. As shown, the compatibility issue is coupled to the operation 'File / Open'. Testing of this operation for configuration files generated by the present and by past HMI600 versions is part of the system tests carried out for each release of the ETL600 system.

A specific HMI600 version is fully compatible to a configuration file, if all information contained within the file can be correctly read (Operation File / Open).

It will have restricted compatibility (symbol '△' in Fig. 4-11; definition: refer to the explanations below) to configuration files generated by HMI600 programs of a number of past releases.

Updates of an HMI600 program will generally inherit the compatibility relations from its predecessors. The **compatibility range** of a specific HMI600 version – shown graphically in Fig. 4-11 – comprises all HMI600 versions whose configuration files can be opened by that version.
version. It is identical to the compatibility range mentioned in section 4.8.4.

A specific HMI600 version will not be compatible (symbol 'X' in Fig. 4-11) to all HMI600 versions which are not within the HMI compatibility range.

**Restricted compatibility**: In a situation of restricted compatibility, when starting a File/Open operation, messages will sometimes be displayed informing about some unavailable function and corrective action. One such situation arises when existing functions have been changed for a new release, which will not be displayed correctly by the new HMI600 program.

### 4.9. Uninstalling HMI600

To uninstall the HMI600 software, open the Windows Start menu and choose Settings / Control Panel / Add/Remove programs. All currently installed programs are listed in the combo-box on the tab Install/Uninstall. In this combo-box, select the version of HMI600 which has to be uninstalled and click Add/Remove... Click Yes on the message box which pops up to get a wizard which guides through the uninstall operation.
5. CONFIGURATION AND SET-UP

5.1. Introduction

The configuration of the ETL equipment including AF interfaces and teleprotection has to be done according to document ‘Programming and Testing Instructions for the ETL600 Rel. 4 Equipment’.

The two major steps of the procedure are: Programming and Testing. Each of these steps consists of a number of substeps with associated instructions listed in the document. Each substep is documented in a report to be filled out during the procedure. Templates for these reports – one for programming and one for testing - are included in the document. These reports should be kept for reference as long as the equipment is in use.

Hardware programming is made by inserting or removing jumpers while the equipment is unpowered. After the equipment is powered up, software settings are entered via the HMI600 menu ‘Configuration’. Usually these settings are saved to a file, which is downloaded to the equipment later during testing of the system.

Note: The configuration download operation will only be successful when the system components (including the HMI600 program) are compatible. To verify this, refer to document ‘Compatibility Requirements for ETL600’. In case of uncertainty, use the newest available HMI600 version.

Testing is done with the equipment powered, and all test procedures are supported by HMI600, menu ‘Equipment / Tuning and Testing’.

5.2. System levels and level settings

The level of the RF output signal generated by the ETL equipment is given by the AF signals applied to the active input ports of the ETL as well as some settings like nominal RF output power.

For a successful operation of the system, it is important to correctly determine the levels of the AF signals applied to the active input ports and to enter these levels into the HMI600 for configuration of the system.

In the ETL as it is tradition for PLC systems, signal levels are specified in logarithmic units such as dB, dBm, dBr, dBu, dBm0, dBm0p which are explained in the following sections. The definitions are roughly consistent with those given in IEC 60495, but due to the digital signal processing used extensively in the ETL600, some extensions and deviations have been necessary.
5.2.1. **Power definitions**

5.2.1.1. **Mean power**

The mean power of a signal with voltage $x(t)$ is given by

$$P_{\text{mean}}(x) = \lim_{T \to \infty} \frac{1}{T} \int_{-T/2}^{T/2} x^2(t) \, dt$$

where $R_0$ is the impedance at the point where the voltage $x(t)$ is measured.

5.2.1.2. **Peak power**

The peak power of a signal with voltage $x(t)$ is given by

$$P_{\text{peak}}(x) = \frac{1}{R_0} \max \left[ x^2(t), -\infty < t < \infty \right]$$

where $R_0$ is the impedance at the point where the voltage $x(t)$ is measured.

5.2.1.3. **Peak envelope power (PEP)**

The peak envelope power (PEP) of a signal with voltage $x(t)$ is equal to the mean power of a sine wave that has the same peak power as $x(t)$.

$$P_{\text{PE}}(x) = \frac{1}{2} P_{\text{peak}}(x) = \frac{1}{2R_0} \max \left[ x^2(t), -\infty < t < \infty \right]$$

where $R_0$ is the impedance at the point where the voltage $x(t)$ is measured.

The PEP has been defined by IEC60495 as a measure for the usable output power of a PLC power amplifier.

5.2.2. **Voltage definitions**

5.2.2.1. **RMS voltage**

The RMS (Root Mean Square) voltage of a signal with voltage $x(t)$ is given by

$$U_{\text{RMS}}(x) = \sqrt{\lim_{T \to \infty} \frac{1}{T} \int_{-T/2}^{T/2} x^2(t) \, dt}$$


5.2.2.2. Peak voltage

The peak voltage of a signal with voltage $x(t)$ is given by

$$U_{peak}(x) = \max\{|x(t)|, \ -\infty < t < \infty\}$$

(5)

5.2.2.3. Peak envelope voltage

In analogy to section 5.2.1.3 one can define the peak envelope voltage (PEV) of a signal with voltage $x(t)$ as the RMS voltage of a sine wave that has the same peak voltage as $x(t)$:

$$U_{PE}(x) = \frac{1}{\sqrt{2}} U_{peak}(x)$$

$$= \frac{1}{\sqrt{2}} \max\{|x(t)|, \ -\infty < t < \infty\}.$$  

(6)

5.2.3. Absolute level definitions—analog signal processing

The term “absolute” is optional, but must be mentioned to distinguish from system levels (refer to section 5.2.7) or relative levels (refer to section 5.2.8), when this should not be clear from the context.

5.2.3.1. Absolute power level

The absolute power level defines by how many dB the mean power $P$ of a signal $x$ is greater or smaller than the reference power of 1 mW:

$$L [dBm] = 10 \log \left( \frac{P_{mean}(x)}{1 \text{ mW}} \right).$$

(7)

where $P_{mean}(x)$ is given by equation (1).

5.2.3.2. Absolute peak power level

The absolute peak power level defines by how many dB the peak power $P$ of a signal $x$ is greater or smaller than the reference power of 1 mW:

$$L [dBm \ peak] = 10 \log \left( \frac{P_{peak}(x)}{1 \text{ mW}} \right),$$

(8)

where $P_{peak}(x)$ is given by equation (2).
5.2.3.3. **Absolute peak envelope power (PEP) level**
The absolute peak envelope power (PEP) level defines by how many dB the peak envelope power $P$ of a signal $x$ is greater or smaller than the reference power of 1 mW:

$$L \left[ dBm \ PE \right] = 10 \times \log \left( \frac{P_{PE}(x)}{1 \ mW} \right),$$

(9)

where $P_{PE}(x)$ is given by equation (3).

5.2.3.4. **Absolute voltage level**
The absolute voltage level defines by how many dB the RMS voltage $U$ of a signal $x$ is greater or smaller than the reference voltage of 775 mV:

$$L_u \left[ dBu \right] = 20 \times \log \left( \frac{U_{RMS}(x)}{775 \ mV} \right),$$

(10)

where $U_{RMS}(x)$ is given by equation (4).

5.2.3.5. **Absolute peak voltage level**
The absolute peak voltage level defines by how many dB the peak voltage $U$ of a signal $x$ is greater or smaller than the reference voltage of 775 mV:

$$L_u \left[ dBu \ peak \right] = 20 \times \log \left( \frac{U_{peak}(x)}{775 \ mV} \right),$$

(11)

where $U_{peak}(x)$ is given by equation (5).

5.2.3.6. **Absolute peak envelope voltage level**
The absolute peak envelope voltage level defines by how many dB the peak envelope voltage $U$ of a signal $x$ is greater or smaller than the reference voltage of 775 mV:

$$L_u \left[ dBu \ PE \right] = 20 \times \log \left( \frac{U_{PE}(x)}{775 \ mV} \right),$$

(12)

where $U_{PE}(x)$ is given by equation (6).

5.2.4. **Absolute level definitions - digital signal processing**
Within ETL600, most signal processing operations are executed by digital signal processors (DSPs). Continuous analog signals are represented by time sequences of sampling values. Each sampling value $X(n)$ is a dimensionless digit in fixed or floating point representation.
In analogy to analog signals, we define the following levels for digital signals:

Absolute mean or RMS level:

\[
L_{[dBm]} = 20 \log \left( \lim_{n \to \infty} \left( \frac{1}{n} \sum_{n=-n/2}^{n/2} X^2(n) \right) \right)
\]

\[
= 10 \log \left( \lim_{n \to \infty} \left( \frac{1}{n} \sum_{n=-n/2}^{n/2} X^2(n) \right) \right). \tag{13}
\]

Absolute peak level:

\[
L_{[dBm \ peak]} = 20 \log \left( \max \{|X(n)|, -\infty < n < \infty \} \right)
\]

\[
= 10 \log \left( \max \{|X^2(n)|, -\infty < n < \infty \} \right). \tag{14}
\]

Absolute peak envelope level:

\[
L_{[dBm \ PE]} = -3 + 20 \log \left( \max \{|X(n)|, -\infty < n < \infty \} \right)
\]

\[
= -3 + 10 \log \left( \max \{|X^2(n)|, -\infty < n < \infty \} \right). \tag{15}
\]

As the signal samples \(X(n)\) are dimensionless values, the levels given above are neither voltage nor power levels. But in analogy to the levels defined for analog signals, we use the terms "voltage level" or "power level" according to the above formulas also for digital signals.

### 5.2.5. Absolute psophometrically weighted level \(L_{0p} \ [dBm0p]\)

This is basically the same as \(L_0\), but the index "p" indicates a psophometrically-weighted level, which is generally defined according to ITU-T. This weighting is only used in connection with the specification of noise levels on speech channels. The equivalent noise bandwidth of the psophometrically-weighted filter is 1.74 kHz.
5.2.6. **Conversion between power and voltage levels**

For digital signals, no conversion is necessary, because power and voltage levels are not distinguished.

For analog signals, the following formula applies:

\[
L_u [dBu] = L [dBm] + 10 \times \log \left( \frac{1mW \times R_0}{(775mV)^2} \right) \\
= L [dBm] + 10 \times \log \left( \frac{R_0}{600 \text{ Ohm}} \right). \tag{16}
\]

where \( R_0 \) is the impedance of the measuring point.

Thus for an impedance of 600 Ohms, the voltage level \( L_u \) is equal to the power level \( L \).

Example:

The power level at the 75 Ohm RF output of a PLC equipment is 40 dBm. What is the voltage level \( L_u \)?

\[
L_u = 40 \text{ dBm} + 10 \times \log \left( \frac{75 \text{ Ohm}}{600 \text{ Ohm}} \right) \\
= 31 \text{ dBu}.
\]

5.2.7. **System power level \( L_0 \) [dBm0]**

The system power level \( L_0 \) is used in order to define the level of a signal in a system regardless of the measuring point.

The dBm0 value defines by how many dB a signal is greater or less than a reference signal, which thus is defined to have a system power level of 0 dBm0. In the ETL, the reference signal is the average nominal speech level at the two-wire output.

The system power level is a property of the signal and doesn’t depend on the measuring point. As such, it is used to define signal levels without reference to a specific measuring point.

Each signal has specific average (dBm0), peak (dBm0 peak) and peak envelope (dBm0 PE) system power levels.

5.2.8. **Relative power level \( L_{rel} \) [dBr]**

The relative power level \( L_{rel} \) defines the signal levels at various points of a system without reference to the applied signals.

The dBr value is the difference between absolute power level \( L \) and system power level \( L_0 \):

\[
L_{rel} [dBr] = L [dBm] - L_0 [dBm0]. \tag{17}
\]

The relative power level is a property of the measuring point and doesn’t depend on the signal.
5.2.9. **Level measurements**

Test sockets allow the measurement of some internal signal levels. In case of decoupled test sockets, this is possible without influence on the signals being measured. However, the voltage level at the test socket depends on the input impedance of the measuring set being used. Therefore, this impedance must be specified for each test socket of the equipment. For ETL600, input impedances of 50 and/or 75 Ohms are specified.

The decoupling circuitry of the test socket normally amplifies or attenuates the level to be measured by a certain amount in order to bring it in a range suitable for measurement. The power level $L$ of the internal signal to be measured can then be calculated from the power level $L_{ts}$ indicated by the test set via the relationship

$$L_{[dBm]} = L_{ts_{[dBm]}} + A_{ts_{[dB]}},$$  \hspace{1cm} (18)

where $A_{ts_{[dB]}}$ is a correction depending on the impedance at the measurement point, on the impedance of the measuring set and on the amplification or attenuation of the decoupling circuit of the test socket.

**Example:**
For the line monitor test socket on E5TH, we have $A_{ts} = 50$ dB for a measuring set input impedance of 75 Ohms. A measured power level $L_{ts}$ of -10 dBm indicates a power level $L$ of -10 + 50 = 40 dBm equivalent to 10 Watts at the RF connector, which is the measuring point. If the measurement was made with a test tone of level $L_0 = 0$ dBm, the signal at the RF connector is shown to have a relative level of $L_{rel} = 40$ dBr. This follows from equation (17).

5.2.10. **Signal weights**

A multi-purpose PLC equipment transmits different kinds of individual signals such as speech, teleprotection and various modem and pilot signals. Each of these signals occupies an associated frequency band. All signals are summed up, the resulting sum signal is transposed to RF and is amplified by the power amplifier, which is peak power limited, the maximum power being specified by the PEP of the amplifier. The sum of the PEPs of the individual signals is limited by the maximum PEP of the amplifier, otherwise the amplifier will saturate. It is therefore mandatory to keep track of the PEPs of the individual signals that have to be transmitted.

A simple method is used to set the PEPs of the individual signals in the transmitter before superposition. A dimensionless number called “weight” is defined for each individual signal. The scaling is done such that the PEP of each individual scaled signal is proportional to its weight. There are two exceptions to this simple scaling method: The weights of the MOD600 signal and of NSD600 guard signal are not fixed but depend on the weights of the other signals.

The peak envelope system level $L_0$ of any signal can be calculated from the signal weight $w$ with the formula
\[ L_o [\text{dBm}0 \ PE] = 20 \times \log(w) \].

(19)

Table 5-1 lists the peak envelope system levels [dBm0 PE] and their associated weights for ETL600. It also gives the PE to mean level difference. All entries except “NSD600 test command signal” and “MOD600” must appear also in the signal selection dialog box for O4LE teleoperation ports of HMI600.

<table>
<thead>
<tr>
<th>Types of AF signals</th>
<th>System level [dBm0 PE]</th>
<th>Weight</th>
<th>Level difference PE to mean [dB]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Speech with 3 dB safety margin</td>
<td>+3</td>
<td>1.41</td>
<td>3</td>
</tr>
<tr>
<td>VFT channels and modems</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>50 Bd or 100 Bd channel</td>
<td>-12</td>
<td>0.25</td>
<td>2</td>
</tr>
<tr>
<td>200 or 300 Bd channel</td>
<td>-9</td>
<td>0.35</td>
<td>2</td>
</tr>
<tr>
<td>600 Bd channel</td>
<td>-3</td>
<td>0.71</td>
<td>2</td>
</tr>
<tr>
<td>1200 Bd-above-speech channel</td>
<td>-3</td>
<td>0.71</td>
<td>1.5</td>
</tr>
<tr>
<td>1200 Bd-V.23 channel 1) 2)</td>
<td>0</td>
<td>1.0</td>
<td>1.5</td>
</tr>
<tr>
<td>NSK5 2400 Bd channel</td>
<td>0</td>
<td>1.0</td>
<td>1.5</td>
</tr>
<tr>
<td>NSK600 2400 bps channel</td>
<td>-3</td>
<td>0.7</td>
<td>7</td>
</tr>
<tr>
<td>NSK600 4800 bps channel</td>
<td>+3</td>
<td>1.4</td>
<td>7</td>
</tr>
<tr>
<td>NSK600 9600 bps channel</td>
<td>+9</td>
<td>2.8</td>
<td>7</td>
</tr>
<tr>
<td>Pilot tone not used as NSD600 guard signal or default NSK570/NSD70C guard signal</td>
<td>-6</td>
<td>0.5</td>
<td>0</td>
</tr>
<tr>
<td>Pilot tone used as NSD600 guard or NSD600-own-guard 3)</td>
<td>20*log(W NSD600guard)</td>
<td>W NSD600guard</td>
<td>0</td>
</tr>
<tr>
<td>AMX500 2 kHz</td>
<td>+3</td>
<td>1.4</td>
<td>10</td>
</tr>
<tr>
<td>AMX500 4 kHz</td>
<td>+9</td>
<td>2.8</td>
<td>10</td>
</tr>
<tr>
<td>MOD600 4)</td>
<td>20*log(W MOD600)</td>
<td>W MOD600</td>
<td>10</td>
</tr>
</tbody>
</table>

Table 5-1 System levels and associated weights

Remarks:

1) For single channel equipment with 2400 Bd VFT channels or with 1200 Bd-V.23 channels operated in stand alone mode (no speech or other low speed VFT channels being used) the weighting factor can be raised to 2 in order to fully exploit the available transmit power.

2) If in a single channel equipment a 1200 Bd-V.23 channel is operated in parallel with other low speed VFT channels, the weighting factor 1 (as for 1200 Bd V.23 operation in dual-channel equipment) has to be used.

3) Refer to section 5.2.14.

4) Refer to section 5.2.13.
A number of factors are taken into account when determining the weights, such as
- the bandwidth occupied by the signal,
- the SNR for adequate performance,
- the PEP to average ratio of the signal,
- the importance of the service provided by the transmission of the signal.

Example:
Given that the weight of a speech channel 300 to 2000 Hz is 1.41, what should be the weight of a 100 Bd VFT channel?

<table>
<thead>
<tr>
<th>Contribution</th>
<th>100 Bd VFT channel</th>
<th>Speech channel 300-2000Hz</th>
<th>Difference (expressed in dB)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Noise bandwidth</td>
<td>150 Hz</td>
<td>1700 Hz</td>
<td>10*log(1700/150) = 10.5 dB</td>
</tr>
<tr>
<td>SNR for adequate performance</td>
<td>16.5 dB</td>
<td>20 dB</td>
<td>3.5 dB</td>
</tr>
<tr>
<td>PEP to average</td>
<td>2 dB</td>
<td>3 dB</td>
<td>1.0 dB</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td>15.0 dB</td>
</tr>
</tbody>
</table>

It turns out that the 100 Bd VFT channel is superior to the speech channel mainly in two aspects: It has a smaller noise bandwidth and requires a lower SNR. The differences of all contributions add up to 15 dB, so that for the 100 Bd VFT channel, a weight of 0.25 should be chosen: 20*log(1.41/0.25)= 15 dB.

5.2.11. The S-value

The sum of the weights w_i of all individual signals to be transmitted over the link is called “S-value”:

\[ S = \sum_{i=1}^{N} w_i \]  

The following remarks have to be made to this equation:

1. The S-value describes the signals to be transmitted by the system while all active internal TPEs and all connected external TPEs are in the guard-state (quiescent state).

2. Regarding the TPEs, the weights of the guard signals have to be used.

3. Correction terms w_{corr RMS} and w_{corr} have to be added as explained later in sections 5.2.12 and 5.2.17. Considering their effect on the S-value, these terms can be interpreted as additional signals, which however are physically not present.

The peak envelope levels of the contributions of the individual signals at the RF connector are given by

\[ L_i [dBm \ PE] = L_{RF} [dBm \ PE] + 20 \log \left( \frac{W_i}{S} \right) \].

\[ \text{(21)} \]
where $L_{RF}$ is the PEP of the aggregate RF signal.

### 5.2.12. RMS power correction

Depending on the equipment configuration, a correction weight $w_{\text{corr, RMS}}$ is added to the S-value such that the RMS power of the RF signal is never higher than 50 W for ETL600-050 or 100 W for ETL600-100.

### 5.2.13. Weight of the MOD600 signal

For a high data rate, the DPLC service needs a high SNR of 30 dB or more. Thus a high weight should be given to the MOD600 signal. As a consequence, most of the RF power would be given to the MOD600 signal, so that only little power would be left for the APLC signals, resulting in low performance of the analog services. This problem is avoided by specifying the MOD600 weight such that the level of the MOD600 signal is always a fixed number of dB below the available RF power. This leads to the following formula for the MOD600 signal weight:

$$w_{\text{MOD600}} = v_{D2A} \cdot S_{\text{APLC}}^4,$$  \hspace{1cm} (22)

where

- $S_{\text{APLC}}$ = Sum of the weights of all signals in all APLC channels;
- $v_{D2A}$ = DPLC to APLC weight factor.

The value of the factor $v_{D2A}$ is configurable by HMI600. The following settings are possible:

<table>
<thead>
<tr>
<th>MOD600 weight setting =</th>
<th>low</th>
<th>medium</th>
<th>high</th>
<th>proportional</th>
</tr>
</thead>
<tbody>
<tr>
<td>$v_{D2A}$</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>min(3, $B_{\text{DPLC}}/B_{\text{APLC}}$)</td>
</tr>
</tbody>
</table>

Table 5-2  DPLC to APLC weight factor

where

- $B_{\text{DPLC}}$ = Bandwidth of the DPLC channel;
- $B_{\text{APLC}}$ = Sum of the bandwidths of all APLC channels.

According to Table 5-2, the value for $v_{D2A}$ lies in the range between 1 and 3. For $v_{D2A} = 1$, the PE-power of the sum of all APLC signals and DPLC signals are equal. For $v_{D2A} = 3$, the PE-power of the sum of all APLC signals is 12 dB below RF-PEP, while the PE-power of the DPLC signal is 2.5 dB below RF PEP.

To increase the level of the MOD600 signal in case the weight of the sum of the APLC signals is low, (22) is replaced by the formula

$$w_{\text{MOD600}} = v_{D2A} \cdot \max \left( \frac{4}{1 + v_{D2A}}, S_{\text{APLC}}^4 \right).$$  \hspace{1cm} (23)
This ensures that the weight of the MOD600 signal is always at least \( \frac{8}{(1 + V_{D2A})} \) times higher than the weight of the ETL600 pilot or NSD600 guard signal.

5.2.14. Weight of the NSD600 guard signal

When a DPLC is configured, it can take a considerable amount of the available RF power as explained in section 5.2.13. When teleprotection commands are transmitted, the MOD600 signal and other disconnectable signals are switched off, so that more power can be given to the teleprotection. This is called boosting, refer to section 5.2.17. The additional power improves the dependability of teleprotection. However, there are limits to this technique: The teleprotection guard signal, which is transmitted when the teleprotection is inactive i.e. during the quiescent state, doesn’t profit from boosting. On the contrary: when a strong MOD600 signal is present, the level of the guard signal is reduced. To improve this situation, the NSD600 guard signal – which always has a weight of at least 0.5 corresponding to a system level of -6 dBm0 PE – gets a higher weight so that its RMS power is at most 18 dB below the PE power of the boosted NSD600 command signal.

In case of the single purpose teleprotection equipment NSD600 with nominal bandwidth of 2 kHz, the weight of the guard signal is given by

\[
W_{NSD600\text{guard}} = \frac{S}{10^{BR/20}},
\]

(24)

where BR is the NSD600 boost ratio in dB set by HMI600. This formula agrees with (25) (page 5-15) for \( \sum_{non-disc.} w_j = 0 \).

When the ETL600 pilot acts as NSD600 guard, it obtains the weight of the NSD600 guard signal, else the ETL600 pilot has the standard weight of 0.5.

5.2.15. Internal teleprotection devices NSD600

Regarding internal teleprotection equipment (TPE), the following cases can be distinguished:

1. No internal TPE,

2. One NSD600 (called “TPE1” or NSD600#1),

3. Two NSD600 (called “TPE1” or NSD600#1 and “TPE2” or NSD600#2).

Each internal TPE operates in one of the channels APLC1, APLC2 or DPLC. The association to the channels is fixed. Thus, operation of TPE2 is only possible if ETL600 is configured for at least two channels. The following cases are possible:
Table 5-3  Association of internal TPEs to channels

Remarks to Table 5-3:

1) TPE2 is not available when ETL600 is configured for one APLC channel plus a DPLC channel of 2 or 6 kHz (refer to Table 3-1).
2) TPE2 is not available when ETL600 is configured for 3 APLC channels in 8 kHz (refer to Table 3-1).

5.2.16.  External teleprotection device NSD570/NSD70C

The AF signals for NSD570/NSD70C are connected to O4LE ports configured for external teleprotection. Only one port per O4LE board – namely port AF4 - can be configured as external teleprotection port. The boost command is applied to the external boost input of the respective O4LE board. Normally, one single NSD570/NSD70C per channel is connected to an external teleprotection port. However, it is also possible to connect several NSD570/NSD70C devices in parallel to an external teleprotection port. Special rules must be followed in this case regarding the port and system level settings. Refer to the NSD570 operating instructions regarding these rules.

The priority rules for boosting are given in section 5.2.17.2.

5.2.16.1.  Guard signal of external NSD570/NSD70C

The NSD570/NSD70C signal in the quiescent state, called the guard signal, has a system level of -6 dBm0 PE per default. Without boosting, the level of the NSD570/NSD70C tripping signal is also -6 dBm0 PE.

The internal boosting facility of the NSD570/NSD70C has to be disabled for operation over an ETL link. Instead, the boosting is performed by the ETL600 when the external boost input is activated. The boost ratio used by ETL600 for boosting of the NSD570/NSD70C tripping signal is calculated automatically by the HMI600 program.
Note: As mentioned in sections 5.2.13 and 5.2.14, the NSD600 guard gets a higher weight when a strong MOD600 signal is present. It is recommended to assign the same weight also to the NSD570/NSD70C guard signal when configuring the teleoperation port (by means of the HMI600, refer to Section 5.3.3.5).

5.2.16.2. Command signal of external NSD570/NSD70C

It is assumed that the Tx trip duration monitoring is enabled in the external teleprotection device and the guard signal is transmitted instead of the tripping signal should the command duration exceed the predefined value. It is further assumed that the boost criterion of the external teleprotection device is set inactive after the allowed Max Tx trip monitoring time.

Note: The programmed alarm pick up times of the ETL600 must be equal or higher than the programmed Tx trip monitoring time of the external teleprotection device.

5.2.16.3. Persistent commands with external teleprotection

If persistent commands shall be transmitted with the external teleprotection devices, e.g. NSD570/NSD70C, the boost criterion may not be applied to the external boost input of the respective O4LE board.

Note: The internal boosting facility of the NSD570/NSD70C may be enabled for this purpose, but consequently the weight of the tripping signal has to be considered when configuring the teleoperation port (by means of the HMI600, refer to Section 5.3.3.5).

5.2.17. Signal boosting for teleprotection devices

"Boosting" means "Increasing the power of a TPE signal" (TPE = TeleProtection Equipment) relative to the level of the guard signal during the transmission of a tripping signal. This can be done only if some other signals are switched off. Otherwise clipping of the PLC signal would occur.

Loop test commands of NSD600 are boosted to a system level of 0 dBm0 PE except if the level of the guard signal is higher than this. In the latter case, the NSD600 loop test commands are transmitted with the guard signal level, i.e. they are not boosted.

A correction term $w_{corr}$ is included in the calculation of the S-value in case the sum of the weights of the configured speech channels is too low for transmitting the NSD600 loop test command.
Internal TPE – i.e. TPE integrated in ETL600 – are NSD600 devices. In case of two internal TPE, each of these gets half of the available output power for boosting.

External TPE such as ABB’s NSD570, NSD70C, NSD 70 or teleprotection equipment from other manufacturers are standalone analog TPE connected to one of ETL600s external teleprotection ports. For each APLC channel, up to one external teleprotection port can be configured.

5.2.17.1. Disconnectable and non-disconnectable ports or signals

The amount of boosting depends on how many of the signals to be transmitted by the PLC link may be disconnected during the transmission of the tripping signals. Each of the teleoperation ports of the ETL600 can either be set to disconnectable or to non-disconnectable mode:

- The input signal path of a **disconnectable port** is disabled during the transmission of tripping signals, thereby suppressing all signals entering the PLC terminal via this port for the duration of the teleprotection command. The signals suppressed like that are called **disconnectable signals**. The power of disconnectable signals is automatically given to the teleprotection tripping signal by the ETL600. Signals occupying all or part of the band between 300 to 2000 Hz where an NSD600 device is operating must be disconnectable, as this band must be kept free for transmission of the NSD600 tripping signals.

**Caution**

For tolerated signals in the NSD600 trip frequency band. Refer to sections 3.7.8.19 and 3.7.8.20.

For APLC channels with NSD600 operation, all signals which use the band between 300 to 2000 Hz (or part of it) must be disconnectable.

- The output signal path of a **disconnectable port** is disabled, if the NSD600 teleprotection system is transmitting or receiving a tripping signal. The output signal path is not affected, when an external teleprotection system, like a NSD570/NSD70C is transmitting or receiving a tripping signal.

- The input and output signal paths of a **non-disconnectable port** are not disabled during the transmission of tripping signals. The signals entering the PLC terminal via such a port are called **non-disconnectable signals**. The power of non-disconnectable signals is not available for the teleprotection tripping signal.

5.2.17.2. Boost Ratio

The ratio between the PE power of the boosted teleprotection signal and the PE power of the unboosted signal is called **Boost Ratio (BR)** and is normally expressed in decibels.

The boost ratio for any TPE device x is calculated by the system according to the formula:
\[ BR_x = 20 \log \left( S - \sum_{non-disc.} w_i \right) - 20 \log \left( w_{\text{TPEx guard}} \right), \]  

where

- \( BR_x \) is the boost ratio of TPEx,
- \( S \) is the S-value,
- \( \sum_{non-disc.} w_i \) is the sum of the weights of the non-disconnectable signals including the guard signals of the other TPEs,
- \( w_{\text{TPEx guard}} \) is the weight of the guard signal of TPEx.

In case of internal TPE, an upper limit to the boost ratio can be specified by HMI600.

### 5.2.17.3. Priority rules for boosting

Boosting of internal teleprotection devices NSD600 has priority over boosting of external teleprotection devices.

If several external teleprotection devices are operated over the same ETL link, only one of them will be boosted at the same time. The priority rules are described in the box below:

- Boosting for NSD570/NSD70C in channel 1 is disabled while one or both NSD600 devices are boosted.
- Boosting for NSD570/NSD70C in channel 2 is disabled while NSD570/NSD70C in channel 1 is boosted or while one or both NSD600 devices are boosted.
- Boosting for NSD570/NSD70C in channel 3 is disabled while NSD570/NSD70C in channel 1 or channel 2 or while one or both NSD600 devices are boosted.

### 5.3. Configuration with HMI600

In this section it is explained how to create a configuration with the HMI600 for a ETL600 equipment. It is recommended to work through the next sections step by step. After this, a configuration is created which should be stored in a file. The procedure to do so is described in section 5.3.5.

The configuration is entered step by step in various dialog boxes available in the menu Configuration as described in the following sections. Several methods are used to ensure that the configuration is valid before it is downloaded to the equipment, such as removing or inactivating buttons, data entry fields, tabs, dialog boxes or displaying pop-up windows that inform about invalid entries. Incompatibilities between data entered into a dialog box and data entered previously in other dialog boxes are sometimes treated in a different way: Such incompatibilities are recorded in a list to be displayed with View / Display configuration check results or by clicking the red
exclamation mark in the toolbar. When the color of the exclamation mark is grey, the list is empty.

**Note:** Incompatibilities of the configuration must be corrected manually until the **configuration check results** list is empty. Otherwise, the configuration can’t be downloaded to the equipment.

To download a configuration to the equipment, choose **Equipment / Download configuration**. Make sure that **Write access** has been enabled either in the **Connect** dialog box or by choosing **Equipment / Set write access**.

If only the LAN600 configuration needs to be changed, it can be downloaded separately using **Equipment / LAN600 / Download configuration**. This avoids a restart of the whole equipment.

Usually the configuration settings of the two terminals of a link must match or be mirrored for the services of the link to be operational. Thus changing settings in both terminals of a link one after the other leads to temporary loss of some or all link services. The following procedure ensures correct reconfiguration of both terminals of a link:

1. Connect to the remote ETL600 terminal according to 4.5.2.
2. Download the new configuration for the remote terminal (**Equipment / Download configuration**). Due to interrupted services, a message box might appear indicating a communication timeout. Corresponding alarms will be raised by the local terminal. The timeout message indicates that after reconfiguration of the remote P4LT/V/X board, the communication to the slave boards (O4LE, G4AI, O4CV) of the remote terminal was lost, so that it wasn’t possible to change the configuration of these boards.
3. Open a second HMI600 window (**File / New**) and connect to the local ETL600 terminal.
4. Download the new configuration for the local terminal. This should re-establish the communication services between the two terminals.
5. Switch to the first HMI600 window (connected to the remote terminal) and once again download the new configuration for the remote terminal. In contrast to step 2, no timeout message should pop up this time, indicating the complete reconfiguration of the remote terminal including slave boards.
6. Store the remote configuration to flash (**Equipment / Store configuration to Flash**).
7. Switch to the second HMI600 window (connected to the local terminal) and store the local configuration to flash.

If step 5 should not be successful, the communication to the remote terminal can be re-established by reverting to the previous configuration. If the remote terminal is unattended, it suffices to wait until the configuration timer in the remote terminal started at step 2 runs out.
5.3.1. Services

In the dialog box Connect, which appears after starting up HMI600 or if HMI600 is already running - after selecting File / New, choose Off line. Close the dialog box by pressing Ok.

Point to Configuration / Services to get a dialog box with a number of tabs. Of these, the leftmost tab Type has to be configured first.

Note: Configuration data entered into the three tabs of the dialog Configuration / Services must be complete before proceeding to the settings for these services.

According to the configured services, the required number of O4CV, O4LE and G4AI boards are assigned to the equipment.

5.3.1.1. Type

On the tab Type:

- Choose the type of equipment: ETL640, ETL680, ETL600-050-1, or ETL600-050-2, ETL600-100-2.
  For the configuration of ETL640 or ETL680, refer to the ETL600R3 instruction manual 1KHW001489.

- Set the desired RF output power to 12.5, 25, 50 or 100 W PEP as required. Note that the 100 W setting is only available for the type ETL600-100-2.

- Choose the nominal bandwidth Bn [kHz] as required. Values of 2, 4, 8, 12, 16, 20, 24, 28, 32 kHz are possible.

Note: For the “Single purpose teleprotection equipment in nominal bandwidth 2 kHz” no other services can be configured except a service phone.
With the service phone enabled the speech bandwidth is automatically limited to 1600 Hz.

- Select the number of APLC channels. Depending on the nominal bandwidth, at most 3 such channels are possible. Refer to Table 3-1, page 3-8 for the supported configurations.

The bandwidth of the DPLC channel in the rightmost field follows from the nominal bandwidth and the number of APLC channels.

5.3.1.2. Data communication

On the tab Data communication,

- In the frame Data ports,
  - select 1 V.11 / 2 V.24, if a P4LT board is to be inserted into the equipment;
  - select 1 V.11 / 2 V.24 / Transit / 4 LAN, if a P4LV board is to be inserted into the equipment;
  - select 2 V.11 / 4 V.24 / Transit / 4 LAN, if a P4LX board is to be inserted into the equipment;
• In the frame MUX600 terminal multiplexer,
  - check the box **DPLC channel multiplexing** unless only LAN traffic or one single V.11 data channel has to be transmitted over the DPLC channel.
  - check the box **V.24 port sharing**, if several V.24 ports have to be connected to one of the V.24 data channels. Only one of the data terminals connected to the shared ports may then generate data at any time.

• In the frame **NSK600 modems**, the available NSK600 modems (up to 2 or 4 depending on the entry in the frame **Data ports**) can be associated to the configured APLC channels.

5.3.1.3. **Compressed telephony**

This tab is only available if **DPLC channel multiplexing** has been configured in the tab **Data communication**. Choose the desired number of 2- and 4-wire as well as the number of transit compressed telephone channels. Refer to section 5.3.6 for a description of the transit channels. The sum of all compressed telephony channels including transit channels is limited to 16. A service phone can be enabled on one of the 2- or 4-wire channels. The data rate of the channels may be configured to 5300 or 6300 bps. The latter offers slightly better speech quality. For the transit channels, a selection **Master** or **Slave** is required. If a star topology is required in the transit station, the **Master** setting must be chosen for the star station and the **Slave** setting for the remaining stations.

5.3.1.4. **APLC channels 1, 2 and 3**

The tabs **APLC channel 1**, **APLC channel 2**, **APLC channel 3** are only shown if these channels have been configured (refer to section 5.3.1.1). For each of the configured channels,

• In the frame **Telephony**,
  - select the telephony operation mode according to Table 5-4.
<table>
<thead>
<tr>
<th>Telephony operation mode</th>
<th>Local equipment</th>
<th>Remote equipment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Point to point hot line</td>
<td>2-Wire telephony available</td>
<td>2-Wire telephony available</td>
</tr>
<tr>
<td>Remote subscriber – 2-wire</td>
<td>2-Wire telephony available</td>
<td>2-Wire telephony available</td>
</tr>
<tr>
<td>Remote subscriber – 4-wire *</td>
<td>2-Wire telephony available</td>
<td>4-Wire telephony available</td>
</tr>
<tr>
<td>4-wire PAX connection with E&amp;M signaling</td>
<td>4-Wire telephony available</td>
<td>4-Wire telephony available</td>
</tr>
<tr>
<td>2/4-wire PAX connection with E&amp;M signaling and hybrid control</td>
<td>4/2-Wire telephony available</td>
<td>4/2-Wire telephony available</td>
</tr>
<tr>
<td>E&amp;M signaling</td>
<td>E- &amp; M-wire available</td>
<td>E- &amp; M-wire available</td>
</tr>
<tr>
<td>Service phone</td>
<td>Service phone available</td>
<td>Service phone available</td>
</tr>
</tbody>
</table>

* Telephone set connected to local equipment

Table 5-4 Telephony operation modes

- In the frame **Teleoperation**,  
  - select the **Number of ports** that have to be supported.

- In the frame **External Teleprotection**,  
  - check the box **External Teleprotection available**, if such a device (e.g. NSD570) is to be connected to the ETL600.

### 5.3.1.5. *Internal teleprotection*

On the tab **Internal teleprotection**,  

- In the frame **Channel allocation**, select the number of Teleprotection devices (TPE). Depending on the settings in the **Type** tab, one or two internal TPE can be activated.

- In the frame **Teleprotection ports TPE1**, enter the number of required in- and outputs of TPE1.

- In the frame **Teleprotection ports TPE2**, enter the number of required in- and outputs of TPE2.

**Note:** The number of required Teleprotection Interfaces type G4AI is determined by the HMI600 using the following rules:

- Each interface provides four inputs and four solid state outputs (maximum 28 when no other modules are plugged in the channel rack).

- Each interface provides two relay outputs (maximum 14 when 7 modules G4AI are plugged).

- Each TPE can only use inputs and outputs of its own teleprotection Interface(s).
5.3.1.6. **LAN**

This tab is only shown if LAN ports have been configured (refer to section 5.3.1.2). When **LAN over PLC** is disabled, LAN traffic is not forwarded via PLC link and the LAN ports operate in **Switch (Layer 2)** mode. For LAN traffic to be forwarded over the link, **LAN over PLC** must be enabled. The mode **Router (Layer 3)** can’t be selected unless **LAN over PLC** is enabled.

In both modes, the functions **SNMP** and/or **HMI over LAN** can be enabled or disabled independently.

5.3.2. **System**

Point to **Configuration / System** to get a dialog box with the 4 tabs **Equipment settings**, **Channel settings**, **Alarm settings** and **Alarm relays on R1BC**.

5.3.2.1. **Equipment Settings**

Remarks for tab **Equipment settings**:

- All data entered into the fields **Link No.**, **Equipment name**, **Cabinet No.**, **Equipment No.**, **Equipment type** are interpreted as character strings.

- In the field **Equipment address** a number between 0 and 65'000 must be entered. The default value of 0 can be used as long as just one single link is accessible from HMI600. However, if several links are connected to a network whose elements are to be managed from one single HMI600, unique **Equipment addresses** have to be assigned to all terminals prior to connecting them to the network, so that the terminals can be addressed individually by HMI600. Refer to section 4.5 for more details.

- The default value for the HMI datarate in the ETL600 is 57’600 bps. If this rate is changed, it must be changed accordingly in the HMI600 under **Options / Communications**.

- The 2 frames on the right side named **Modules in rack P7LH/P7LP/P7LQ** and **Modules in rack P7LH/P7LF** are intended to record the presence of those modules in the ETL600 racks which otherwise would not be recorded by HMI600.

**Note:** Whether the checkbox **P4RX: Receive filter** is checked or not has an influence on the jumper settings of the RF hybrid / transmit filter E5TH.

The alarm monitoring for the receive filter P4RX is controlled by the checkbox **Monitoring on** in the frame **P4RX present** of the dialog **Configuration / System / Alarm settings**.
5.3.2.2. **Channel Settings**

Remarks for tab Channel settings:

- The selectable **Tx** and **Rx nominal frequencies** are such that the nominal bands are within the range from 16 to 1000 MHz. However, depending on the required filter bandwidth, the range of available filter center frequencies might be smaller than this.

- By pressing the button **Swap Tx and Rx frequ.**, the **Tx** and **Rx nominal frequencies** are exchanged.

- The setting for **Max. power (PEP) [dBm]** is limited by the value of **RF-PEP [W]** entered in the dialog box **Configure Services / Type** according to the following table:

<table>
<thead>
<tr>
<th>RF-PEP [W]</th>
<th>Max. power (PEP) [dBm]</th>
</tr>
</thead>
<tbody>
<tr>
<td>12.5</td>
<td>≤ 41</td>
</tr>
<tr>
<td>25</td>
<td>≤ 44</td>
</tr>
<tr>
<td>50</td>
<td>≤ 47</td>
</tr>
<tr>
<td>100</td>
<td>≤ 50</td>
</tr>
</tbody>
</table>

Table 5-5  Limits for Max. power (PEP) [dBm]

Depending on the Tx nominal frequency, lower limits than given by Table 5-5 might apply.

- The radio buttons **Erect (APLC low, DPLC high)** and **Inverted (DPLC low, APLC high)** in the frame **ETL600 overall mode** choose the Erect or Inverted mode according to table Table 3-1 on page 3-8.

- For most configurations, the pilot frequencies if the pilots in the APLC channels can be chosen. The frequency of the pilot in the DPLC channel is fixed.

- If in the frame **Network management** the checkbox **EOC enabled** is unchecked, the EOC is not used for element management networking as described in section 4.5.3.

- If in the frame **Event recorder** the checkbox **Ext. real time clock available** is checked, the ETL600 expects that an external IRIG-B synchronization signal is applied at the socket “IRIG-B” on the front plate of P4LT/V/X. If this signal is missing, a PLC interface alarm is issued.

- If in the frame **Automatic frequency control** the checkbox **AFC enabled** is unchecked, the Rx carrier frequency is no longer synchronized to the received signal. This setting can be used to improve the performance of external modems such as AMX500 at low bandwidths, which are sensitive to minor frequency variations which are inevitably introduced by any AFC.
Note: For the measurement of the frequency response (Equipment / Commissioning and maintenance / Frequency response) the AFC must be enabled.

5.3.2.3. **Alarm Settings**

Remarks for tab **Alarm settings:**

- In the frames on the left side, pickup and hold times can be selected for
  - Hardware- and interface alarms,
  - Link alarm,
  - User alarm 1,
  - User alarm 2,
  - User alarm 3.

- In the frames **Pilot level**, alarm thresholds for the Rx pilot level can be set. After uploading the system status, the actual Rx pilot levels are displayed in the frames. By pressing the button **Calculate thresholds**, the pilot level alarm thresholds are set 12 dB below the actual Rx pilot levels.

- In the frames **SNR level**, alarm thresholds for the SNR can be set. The indicated SNR are evaluated by measuring the noise levels in the pilot channels, transforming them to a bandwidth of 2 kHz and referring them to a signal of 0 dBm0. After uploading the system status, the actual SNR of each channel are displayed in the frames. The default values for the SNR alarm thresholds are 12 dB.

- In the frames **AGC blocking level**, blocking levels for the AGC of the channels can be set. In case the remote ETL600 at the opposite side of the link is switched off, AGC starts to increase the gain until it reaches the blocking level. By pressing the button **Calculate thresholds**, the AGC blocking levels are set 16 dB below the actual Rx pilot levels.

- If in the frame **P4RX present** the checkbox **Monitoring on** is ticked, the removal of the receive filter P4RX will generate a hardware alarm.

5.3.2.4. **Alarm relays on R1BC**

Remarks for tab **Alarm relays on R1BC:**

- In the frames **User alarm 1**, **User alarm 2** and **User alarm 3**, the 3 user alarms are formed by ticking the appropriate check boxes. Up to 32 different high level alarms can be selected independently for forming each user alarm. Half of these high level alarms are from the local equipment, the other half from the remote equipment. The latter are transmitted via EOC over the link. Refer to section 9.2 for more information about high level alarms.
On the alarm relay board R1BC, the user alarms are routed to by jumpers to the alarm relays 1 to 8 as described in section 3.3.3.2. The jumper settings may be documented by corresponding entries in the frame Relay configuration.

5.3.3. Analog Services

5.3.3.1. Telephony

Point to Configuration / Telephony to get a dialog box with tabs CH1, Slot N..., and/or CH2, Slot N..., and/or CH3, Slot N..., depending on the required telephony services entered previously under Configure services, section 5.3.1.3.

In the frame Operation mode, activate the required service.

In the frame PAX, set the speech levels and choose the polarities of the E-, M- and Local/transit-wires (the latter is for hybrid control).

In the frame Subscriber, direct phone, set the speech levels and choose the ringer frequency.

In the frame Service phone, click Service phone enabled and set the speech levels as required.

In the frame Speech filter, choose the upper cutoff frequency for speech. This setting applies to all telephony modes and is responsible for the availability and frequency of an own guard signal for NSD600 (refer to section 5.3.6).

Note: The cutoff frequency of the speech filter is responsible for the availability and the frequency of an NSD600 own guard signal.

5.3.3.2. Level settings of teleoperation ports, introduction

A little background is useful when configuring a teleoperation port to understand structure and the various tuning possibilities. Physical basics are explained in section 5.2.

In Fig. 5-1, the line of life of an input signal is shown, entering at the terminal of AF interface O4LE through the ETL600 up to the RF terminal, which is connected to the coupling device. Only the input path of one teleoperation port is depicted. A non transit application is assumed. Settings which can be done in HMI600 are marked with a finger symbol.
Fig. 5-1 Signal levels from AF terminal to RF terminal

An external device, which is not shown, sends an input level, which can be configured in by HMI600. The signal passes the terminal of the AF interface and is present in the internal ETL600 system.

Levels of external AF devices are mostly given in dBm (600 Ohm), dBm, ‘dB at 600 Ohm’ or dBm (RMS), which means all the same. In what follows, the unit dBm (RMS) is used. It is the average power level. A standard true rms volt meter is measuring dBu (RMS) with a high impedance and calculating the dBm(RMS) value considering a reference impedance, e.g. 600 Ohm, 75 Ohm, ….

For the system ETL600, the RMS levels have to be converted to Peak Envelope Power (PEP) levels expressed in dBm (PEP). With these PEP levels, the peak voltage at any point in the system can be determined and compared to the allowed maximum to avoid clipping. For conversion of RMS to PEP levels, the peak to average ratio must be known, which is characteristic for a specific type of signal:

$$
\text{dBm (PEP)} = \text{dBm (RMS)} + 20 \times \log\left( \frac{U_{\text{peak}}}{\sqrt{2} \times U_{\text{rms}}} \right)
$$

valid for 600 Ohm.

For each type of signal, an associated system power level expressed in dBm0 PE is defined as explained in section 5.2.10. System levels and associated weights are given in Table 5-1 on page 5-8. The following relation holds between a weight and the associated system level:

$$
\text{dBm0 PE} = 20 \times \log(\text{weight})
$$

The difference between dBm PE levels and dBm0 PE levels is called relative level and expressed in dBr as explained in section 5.2.8. In the configuration text generated by the HMI600, the relative level is given for each configured teleoperation in- and output-port. The sum of the weightings of all signals to be transmitted by the ETL600, called the S-
value, is also given in the configuration text. Refer to section 5.2.11 for more information about the S-value.

5.3.3.3. Teleoperation port not used for transit operation

From menu Configuration click ‘Configuration / Teleoperation, ext. teleprotection’

Switch a port on:
1. Select the port you want to configure.
2. If the service(s), which run(s) over the port, can be interrupted when a teleprotection command is transmitted or received locally: Click On – disconnectable.
   In case the service mustn’t be interrupted by a teleprotection command, click On - non disconnectable.
3. Activate Squelch at SNR alarm, if the output of port should be muted in case of low signal to noise ratio. Typically the squelch function is activated for modem applications.
   The signal to noise ratio is calculated in the pilot channel. The limit for activating the link alarm and for squelching the AF ports can be configured in Configuration / System / Alarm settings.

Configure input level:
From the sheet Configure Teleoperation, ext. teleprotection’ click:
4. Specify signal.
5. Select the correct ‘Reference signal’. Normally this is given by external device connected to the port.
6. Select the correct ‘Input level’ for the signal, which in the configuration printout appears as 'Reference signal level input'. It is the output level of the external device. Recommended values are – 6.0 dBm or less.
7. Select either the unit dBm (RMS) or dBm (PEP). In the HMI600, the peak to average ratio for many signal types are stored.
   If you are not sure, you should select dBm (RMS).
8. If the input signal consists of a superposition of the reference signal and other signals, check these signals in the list named ‘Signals after selected filter considered for input level and input weight’.

Note: For non transit application, it is normally not necessary to check additional signals in the list ‘Signals after selected filter considered for input level and input weight’!
Note: The checkbox Other signals in the list 'Signals after selected filter considered for input level and input weight' must be used for signals
- that have system weights other than specified in Table 5-1;
- for which none of the other checkboxes apply. This is the case e.g. for ETL600 pilot signals with guard functionality having a weight other than 0.5.

The associated system level $L_0$ in dBm0 PE must be chosen from the combo box. $L_0$ can be calculated from the signal weight with the formula

$$L_0 \, [\text{dBm0 PE}] = 20 \times \log(\text{weight}).$$

Configure output level:
9. Click Next to configure the output port characteristics.
10. Select the Output level for your application. It is the input level of the external device connected to the port.
11. Also check all other signals present at the output in the list named 'Signals after selected filter considered for output level'.

HMI600 calculates the Max. output level and compares it with the max. output level of the teleoperation port. However, the input capability of the external device should also be checked.
If the Max. output level is too high, two possibilities solve the problem: either reducing the output level or inserting an appropriate output filter at this output port to filter away some of the signals, thus reducing the number of signals to be checked in the list 'Signals after selected filter considered for output level'.
12. Click Finish.

Configure an input and/or an output filter, if necessary:
From the sheet 'Configure Teleoperation, ext. teleprotection':
13. For an input filter, press the button Select filter in section Input filter.
14. Select Standard transit filter for a filter without group delay equalization or select Special transit filter for a filter with group delay equalization.
15. Select the frequency range of the filter.
16. Click OK.

To configure an output filter, repeat steps 13 to 15 except that the button Select filter to be pressed in step 13 is in section Output filter instead of section Input filter.

From the sheet 'Configure Teleoperation, ext. teleprotection':
Configure all other teleoperation ports:
17. Repeat configuration steps 1 to 15 for all other teleoperation ports
18. Close the sheet 'Configure Teleoperation, ext. teleprotection' by clicking OK.

5.3.3.4. Teleoperation port used for transit operation

The procedure of configuration is very similar to the procedure explained above.

Switch a port on:
1. Select the port to be configured.
2. If the service(s), which run(s) over the port, can be interrupted when a teleprotection command is transmitted or received locally, click **On – disconnectable**.
   In case the services mustn’t be interrupted by a teleprotection command, click **On - non disconnectable**.

Note: All services routed via this port have to be considered.
If a teleprotection system is configured at this equipment and the transit port is configured as **On - disconnectable**, all services routed via this port are interrupted!

3. Deactivate Squelch at SNR alarm. The squelch functionality should work nearby the port, where the external device is connected.

Configure the transit filter:

From the dialog 'Configure Teleoperation, ext. teleprotection':
4. Select filter from the Output filter section.

Note: To select an output filter is the standard solution for a transit AF operation as described in the functional description of O4LE, chapter 3. In any case, the passband of the selected filter must not include the pilot band.

5. Select **Standard transit filter** for a filter without group delay equalization or select **Special transit filter** for a filter with group delay equalization.
Note: Preferably use a Special transit filter if one with an appropriate passband is available!
When a special transit filter has been selected, the all-pass filter of the associated channel should also be activated.
To activate the All-pass filter: From the menu Configuration click System, click Channel settings, enable All-pass filter for group delay equalization (transmitter sided).
If the services to be routed via the AF port are not sensitive to group delay distortion, as in the case of speech, a Standard transit filter can be used.

6. Select the frequency range of the filter.
7. Click OK.

Configure input level:
From the sheet 'Configure Teleoperation, ext. teleprotection' click:
8. Specify signal.
9. First select a suitable 'Reference signal'. Normally, this is the signal of the most important service routed via this port.

Note: The same Reference signal at the connected AF output port of the other equipment has to be selected!

10. All signals routed via this port must be selected in the list ‘Signals after selected filter’ in the Input sheet. Signals, which are rejected by the transit filter must not selected. E.g. don’t select the pilot!

Note: This is very important, because for every selected signal the HMI600 reserves a certain output power at the end amplifier. If signals entering the port are not declared in the list, the amplifier might clip and the operation of the PLC link will be disturbed!

11. Select the correct ‘Input level’ for the signal, which in the configuration printout appears as ‘Reference signal level input’. It is the output level of the external device. Recommended values are –6.0 dBm or less.
12. Select either the unit dBm (RMS) or dBm (PEP). HMI600 knows and considers the peak to average ratio for many applications. If you are not sure of selection, you should select dBm (RMS).

Note: The unit dBm (RMS) or dBm (PEP) must be configured as unit of the output level at the other AF port connected to this AF port of the other equipment. It is a good rule to configure the unit of all connected AF ports to the same value. Different selection at the both connected AF ports can lead to a clipping end amplifier!

Configure output level:

13. Click **Next** to configure the output port characteristics.

14. As **Output level** the input level of the connected AF port of the other equipment has to be selected.

15. Also check all other signals in the list ‘**Signals after selected filter**’ displayed in the ‘Output’ sheet, which are present at the output port. Signals rejected by the transit filter must not be selected. E.g. don’t select the pilot! The **Max. output level** shall not exceed 4.0 dBm (PEP). If the **Max. output level** is too high, two possibilities solve the problem: either reducing the output level or inserting an appropriate output filter at this output port to filter away some of the signals, thus reducing the number of signals to be checked in the list ‘**Signals after selected filter**’ of the ‘Output’-sheet.

16. Click **Finish**.

Finish the configuration of AF ports:

17. Close the sheet Configure Teleoperation, ext. teleprotection’ by clicking OK.

5.3.3.5. **Teleoperation port used for external teleprotection**

If teleprotection signals are routed through input or output filters, the additional time delay introduced by these filters in the order of ms must be taken into account.

The proposed default weight of the port can be changed as described in 5.3.3.2 or 5.3.3.3 by choosing “Other signals” as Reference signal.
5.3.4. **Data Communication**

Point to **Configuration / Services… / Type** to set number of APLC channel with bandwidth as well as bandwidth for the DPLC channel. This is a general prerequisite for data communication with ETL600 and is explained in section 5.3.1.2.

5.3.4.1. **Data Communication Services**

When APLC & DPLC channels are set, point to **Configuration / Services… / Data Communication** to select the quantity of required V.11, V.24, digital transit and LAN ports in the frame **Data ports**. This selection will define what kind of DSP module will be required: P4LT, P4LV or P4LX.

For transmission of only LAN traffic or of only one V.11 channel over the DPLC channel, leave **DPLC channel multiplexing** unchecked. To enable the DPLC channel multiplexer, check **DPLC channel multiplexing**.

Up to four V.24 ports can share one communication channel either on NSK600 or on MOD600: Checking **V.24 port sharing** enables this functionality.

Select the number of required NSK600 modems per each enabled APLC channel.

**Note:** The selection of the NSK600 modems also defines the V.24 port interfaces that will be used for the respective modem.

**Note:** If NSK600 modems with data rates above 600 bps are used, the all-pass has to be configured in the corresponding APLC channel (refer to tab **Channel settings** under **Configure system**).

Exception: No all-pass filter is required for APLC channels carrying only DAPSK channels with adaptive equalizers.

**Note:** NSK600 modems with data rates above 1200 bps (DAPSK modems only) usually require an equalization of the corresponding APLC channel (refer to instruction “APLC Channel Equalization” in the annex of this manual).

Exception: No ALPC channel equalization is required for APLC channels carrying only DAPSK channels with adaptive equalizers.
5.3.4.2. Assignment of Data Ports to the Modems

Point to Configuration / Data port to modem assignment ... to assign all utilized ports to a modem and to configure the corresponding communication parameters. The latter can be set after selection of the modem by clicking the buttons Port N, where N is the port number.

Note: When configuring data communication for an ETL600 link, both terminals of the link must have the same configurations for the utilized modems, interfaces, protocols and data transfer rates to operate.

5.3.4.3. LAN port settings – router mode

Point to Configuration / LAN600 to configure the LAN ports and associated functions. The settings are grouped into the tabs General, IP routes, Port priorities, LFPT and SNMP, when the Router (Layer 3) mode has been chosen under Configuration / Services / LAN.

5.3.4.3.1. General

In the frame IP settings LAN ports, the common IP address, Subnet mask and Default gateway of all LAN ports can be configured. The latter is used if none of the routes defined in the frame IP routes matches the destination network.

Note: In Router mode, there is no routing between the LAN ports. IP addresses and subnet masks are identical for all LAN ports.

In the frame IP settings PLC port, the IP address and Subnet mask of the PLC port can be configured.

Frame Port settings: Here the LAN ports can be enabled individually. For the ports LAN 1, LAN 2 and LAN 3, the default communication mode is Auto negotiation. If required, these settings can be changed individually for each port to 10 Mbps half duplex, 10 Mbps full duplex, 100 Mbps half duplex or 100 Mbps full duplex. For the LAN 4 port, which uses the SFP transceiver, the setting is fixed to 100 Mbps full duplex.

For each port, Flow control can be enabled. If enabled, IEEE 802.1 PAUSE frames are sent back in case of traffic congestion.

For the LAN 4 port, automatic laser shutdown (ALS) according to ITU-T G.664 (optical safety procedures) with automatic restart is enabled by default but can be disabled if required.

In the frame PLC options, for traffic via the PLC link, TCP/IP header compression according to RFC 1144 and/or Robust header compression according to RFC 3095 can be enabled. The latter reduces the UDP/IP and RTP/UDP/IP (VoIP) packet headers considerably. Up to 16 parallel UDP/IP and/or RTP/UDP/IP data flows...
can be compressed at the same time. Flows exceeding the number 16 are transmitted uncompressed.

In the frame Queueing profile, one of the alternatives Weighted 8,4,2,1 or Strict may be chosen. For the setting Weighted 8,4,2,1, the frames sent over the PLC link are taken in a weighted fashion from the 4 priority queues, such that the rate of frames coming from a higher priority queue is twice as high as that of the next lower priority queue. In contrast, for the setting Strict, frames waiting in one of the queues are only transmitted if all higher priority queues are empty.

5.3.4.3.2. IP routes

In router mode, up to 16 IP routes can be specified, each consisting of an IP address, Subnet mask and Gateway. Subnet mask must be chosen such that it has only adjacent ones, e.g. 255.255.255.0 or 255.255.63, but not 255.255.255.1. Traffic for other destinations will be sent to the Gateway.

5.3.4.3.3. Example for IP routing

Consider Fig. 5-2. Access to the rest of the world is via the network at the top (dotted cloud). Default gateway for the ETL600 in station A is gateway GW1, while for the ETL600 in station B it is GW2. The gateways of the ETL terminals in stations A (GW2) and B (GW3) must know the routes to the networks 192.168.2.0, 192.168.3.0 and 192.168.4.0, because these networks are not reachable via default gateways. In station A, the gateway to these networks is the ETL in station B, i.e. 11.0.0.2, because they are only reachable via PLC link. From station B, the networks 192.168.3.0 and 192.168.4.0 are reached via gateways 192.168.2.2 and 192.168.2.3, respectively.
5.3.4.3.4. **Port priorities**

In the frame **Ports**, each LAN port can be given a priority between 1 (= low) and 4 (= high). When **Port priorities support** is enabled, in case of traffic congestion over the PLC link, data waiting for transmission over the PLC link is forwarded in the sequence given by the priorities given to the LAN ports.

5.3.4.3.5. **LFPT (Link Fault Pass Through)**

In the frame **Link Fault Pass Through**, the association between remote and local LAN ports for link fault pass through can be specified by activating the check boxes.
If LFPT is enabled (frame **LFPT support**), the local port states follow the remote port states for the specified associations. If the PLC port is down, local states of ports with LFPT association are down independently of the remote port states.

### 5.3.4.3.6. SNMP

This tab is only present if SNMP has been enabled in **Configuration / Services / LAN**. The dialog contains the following 4 frames:

**Management stations**: Here the IP addresses together with the trap ports of up to 5 SNMP management stations as well as the **SNMP version** (1 or 2) can be entered. The IP address and the trap port of a management station together specify the location where the SNMP agent sends its traps to.

**List of devices for alarm polling**: Here the equipment addresses of the ETL500 or ETL600 terminals to be monitored - i.e. polled for presence and alarms - can be entered. These terminals must be part of an element management network as described in section 4.5. A maximum of 64 equipment addresses can be added in the list.

**Alarm polling interval time**: Here one of three options for the polling times and frequencies can be chosen:

- **Daily**: All terminals have to be polled once a day, starting each day at a specific time to be entered.
- **Hourly**: Each hour, all terminals have to be polled once, starting at the beginning of each hour.
- **Every … minutes**: All terminals have to be polled each … minutes, where a number between 1 and 1440 can be entered for the number of minutes.

**SNMP**: Here the community string can be entered. Default is “ABB ETL600 Default Community”. The SNMP agent checks the community string of all requests and only responds in case it is correct. Otherwise, it discards the request and does not respond.

### 5.3.4.4. LAN port settings – switch mode

Point to **Configuration / LAN600** to configure the LAN ports and associated functions. The settings are grouped into four tabs: **General**, **VLAN ports**, **VLAN table**, **LFPT** and **SNMP**, when the **Switch (Layer 2)** mode has been chosen under **Configuration / Services / LAN**.

#### 5.3.4.4.1. General

Frame **IP settings LAN ports**: The three settings **IP address**, **Subnet mask**, **Default gateway** can be configured, which are required for the applications **SNMP** and **HMI over LAN**. Refer to section 3.5.4.1.

The frames **Port settings**, **PLC options** and **Queueing profile** are as described under 5.3.4.3.1 for the router mode.
5.3.4.4.2. VLAN ports

The settings in this tab together with those in the next tab VLAN table allow to establish port based VLANs either between local and/or remote LAN ports. A port based VLAN ID (PVID) according to IEEE 802.1Q can be associated to any of the LAN ports and the PLC port. The allowed range for PVID is 1 … 4094 \(^{14}\).

Frame VLAN support: The checkbox Enabled must be checked for the VLAN support to be active. When unchecked, all entries in the tabs VLAN ports and VLAN table are retained for possible later reuse.

Frame VLAN ports: Here, for each port, PVID, Accept ingress and Ingress filter can be specified. The effects of the 4 possible combinations of the Accept ingress and Ingress filter settings per port are described in Table 5-6.

<table>
<thead>
<tr>
<th>Accept ingress</th>
<th>Ingress filter</th>
<th>Port behavior</th>
</tr>
</thead>
<tbody>
<tr>
<td>All</td>
<td>Off</td>
<td>All frames – untagged or tagged – with any VID are accepted. Untagged frames get tagged with the PVID.</td>
</tr>
<tr>
<td>All</td>
<td>On</td>
<td>All untagged frames are accepted and get tagged with the PVID. Tagged frames are only allowed to ingress if the port is a member of the VLAN (as specified in the VLAN table).</td>
</tr>
<tr>
<td>Tagged only</td>
<td>Off</td>
<td>Only tagged frames with any VID are accepted.</td>
</tr>
<tr>
<td>Tagged only</td>
<td>On</td>
<td>Only tagged frames with a VID where the port is member of (as specified in the VLAN table) are allowed to ingress.</td>
</tr>
</tbody>
</table>

Table 5-6 VLAN ingress settings

Note that

1) inside the switch, all frames are tagged;
2) the PVID is only used when Accept ingress is set to All and when incoming frames are untagged.

Recommendations for setting up the ingress behavior:

LAN ports: Ingress should be as restrictive as possible, i.e. set Accept ingress to Tagged only and Ingress filter to On, if all incoming frames to be transferred over the link are tagged.

PLC port: Ingress should be as open as possible, i.e. set Accept ingress to All and Ingress filter to Off.

\(^{14}\) Upon ingress, frames with a VLAN ID of 0 will be tagged with the PVID.
The radio button **HMI/SNMP** indicates the port to use for HMI/SNMP access. For access to both terminals of the link, the port must be member of at least one VLAN which is available on both terminals of the link, and the HMI/SNMP client must be a member of this VLAN.

### 5.3.4.4.3. **VLAN table**

The content of the **VLAN table** is only interpreted if **VLAN support** is enabled in the tab **VLAN ports**.

For up to 16 VLAN IDs (VIDs), the priority behavior of the switch can be specified for the frames having passed the ingress filter.

- Tagged frames with VIDs not matching one of the 16 VIDs are discarded.

- The treatment of tagged frames with VIDs matching one of the 16 VIDs depends on the setting **Force priority**:
  - If **Force priority** is active, the priority given in the table is used by the switch and the priority in the tag is ignored but remains unchanged in the tag.
  - If **Force priority** is inactive, the priority given in the tag is used by the switch and the priority in the table is ignored.

**Priority:** Each VLAN can be given a priority between 0 (= low) and 7 (= high) according to IEEE 802.1q. In case of traffic congestion over the PLC link, data waiting for transmission over the PLC link is forwarded in the sequence given by the priorities given to the VLANs.

**Note:** LAN600 uses only 4 priority queues. Priorities n and n+1 use the same queue, where n = 0, 2, 4 or 6.

For each VID and each LAN port as well as the PLC port, one can choose between the 3 settings according to Table 5-7.

<table>
<thead>
<tr>
<th>Setting</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>- -</td>
<td>Port is not member of the VLAN and frames with the indicated VID are not allowed to egress this port</td>
</tr>
<tr>
<td>T</td>
<td>Port is a member of the VLAN and frames are to egress tagged.</td>
</tr>
<tr>
<td>U</td>
<td>Port is a member of the VLAN and frames are to egress untagged.</td>
</tr>
</tbody>
</table>

Table 5-7  VLAN Table settings

Recommendation for setting up the egress behavior of the PLC port: Use **T** = Tagged for the traffic of all VLANs to be transferred over the link.

### 5.3.4.4.4. **LFPT (Link Fault Pass Through)**

Refer to section 5.3.4.3.5.
5.3.4.4.5. **SNMP**

Refer to section 5.3.4.3.6.

5.3.4.4.6. **Example for VLAN trunking and filtering**

Refer to Fig. 5-3. A number of networks have been established in the substations A and B connected by the ETL600 link:

- VLANs 1, 2 and 3: Clients exist in both substations; they have to be interconnected by the link.

- VLAN 4: Clients exist only in substation B, but in 2 physically separated networks; they have to be interconnected by the switch in the ETL600-B.

- VLAN 5: Clients exist only in substation A; traffic from these arrives at the switch in the ETL600-A; it shouldn’t ingress into the switch.

- LAN (untagged): Clients exist in both substations; they have to be interconnected by the link.

![VLAN trunking and filtering diagram]

**Remarks to the solution shown in Fig. 5-3:**

- All traffic over the PLC link is tagged except for the untagged LAN.

- Inside the switches, untagged frames are tagged with the VID 999.

- VLAN 5 traffic can’t ingress into the switch in the ETL600-A, because VLAN 5 does not appear in the VLAN table and the ingress filter of the LAN 2 port is activated.
- VLAN 4 frames are transferred between the LAN 2 and LAN 3 ports of the switch in the ETL600-B, but are not transferred over the link, because according to the VLAN table, the PLC port of the switch in the ETL600-B is not a member of VLAN 4.

- The setup would also work if one or both encircled entries “U” in the lower right corner of the VLAN tables in Fig. 5-3 would be set to “T”. The difference would be that the frames of the untagged LAN would no longer be transmitted untagged over the link, but tagged with the VID 999.

5.3.4.5. **V.11 port settings**

When a DPLC channel has been configured, each available V.11 port can be assigned to a MOD600 channel, if the DPLC channel multiplexer is enabled. If the multiplexer is disabled, only V.11 port 1 can be used.

To assign a V.11 port to the modem, select **MOD600 modem** from the drop down list. To disable the port, select **Off**.

For each enabled V.11 port, the parameters Clock/data phasing and Clock direction can be configured.

5.3.4.5.1. **V.11 Clock/data phasing (edge)**

For synchronous data transmission, the instant of reading and writing data in relation to the clock signal can be selected from a drop-down list. The following four possibilities are available:

- DCE: D-out valid on pos edge / D-in valid on pos edge;
- DCE: D-out valid on pos edge / D-in valid on neg edge;
- DCE: D-out valid on neg edge / D-in valid on pos edge;
- DCE: D-out valid on neg edge / D-in valid on neg edge.

Fig. 5-4 shows the resulting waveforms for clock and data. The writing of data (receive data) coincides with either the positive or negative-going edge of the clock signal. The same applies to reading data (transmit data).

![Clock and data waveforms](image)

**Fig. 5-4** Data in relation to clock signal

The edge setting has to be adjusted to suit the data terminal, if there are too many bit errors or any slipping occurs.

**Note:** The system might operate correctly for a while even though the clock edge is not set correctly.
5.3.4.5.2. **V.11 Clock direction**

The following settings are possible:

1. **Clock from ETL, Clock master (Default):**
   The interface will provide the clock for the DTE generated by the local MOD600 modem.

2. **Clock from ETL, Clock slave:**
   The interface will provide the clock for the DTE generated by the remote MOD600 modem.

3. **Codirectional:**
   The interface provides a clock input for the data received from the DTE as well as a clock output for the data sent to the DTE.

The default setting must be used for data transmission over one single ETL600 link (Fig. 5-5). For transit data transmission over several PLC links, all transit stations must be configured for clock “Codirectional”, while one of the two end stations must be configured for “Clock from ETL, Clock master”, the other for “Clock from ETL, clock slave” (Fig. 5-6). Note that for Codirectional operation, the Control input (C) of the V.11 interface is used for the Tx Clock input.

---

**Fig. 5-5**  
V.11 data transmission over one single PLC link
V.11 Port parameters:

Clock Direction
- From ETL, Clock master
- From ETL, Clock slave
- Codirectional (default)

Clock Direction
- From ETL, Clock master
- From ETL, Clock slave
- Codirectional

Clock Direction
- From ETL, Clock master
- From ETL, Clock slave
- Codirectional

Clock Direction
- From ETL, Clock master
- From ETL, Clock slave
- Codirectional

Fig. 5-6 V.11 data transmission transit over two PLC links

Note: For V.11 transit data transmission over several ETL600 links, the V.11 data rate must be the same for all links. In particular, if (some of) the links are operated with fallback/fall-forward enabled, the V.11 data rate must be the same for all MOD600 aggregate data rates.

5.3.4.6 V.24 port settings

Any NSK600 modem that has been assigned to an APLC channel in Configuration / Services / Data communication is automatically assigned to the corresponding V.24 port and enabled. No further assignment of these ports is possible, nor can they be disabled without disabling the corresponding modem.

When a DPLC channel has been configured, each remaining V.24 port can be assigned to a MOD600 channel, if the DPLC channel multiplexer is enabled. If the multiplexer is disabled,

- no V.24 port can be assigned to MOD600,
- only either LAN or V.11 port 1 can be assigned to MOD600.

To assign a V.24 port to the modem, select MOD600 modem from the corresponding drop down list. To disable ports, select Off.

To activate port sharing, go to Configuration / Services / Data communication and activate V.24 port sharing in the frame MUX600 terminal multiplexer. Then under Configuration / Data port to modem assignment, frame V.24, select MOD600 modem (port sharing) or NSK600 modem 1 (port sharing) for port 1. After this is done, up to 3 further ports – depending on availability - can be activated for port sharing. All shared ports have identical parameter configuration. By clicking the Port 1 button in the frame V.24, these
parameters can be configured exclusively on port 1 and will be automatically transferred to the other shared ports.

The following parameter can be configured for each enabled V.24 port with the respective selection from the concerned drop down list:

- **Data rate [bps]:**
  - ≤ 100, ≤ 200, ≤ 600, ≤ 1200, 2400, 4800 and 9600 for NSK600. The FSK modems with datarates of ≤ 200 and ≤ 1'200 bps are available in two versions with different bandwidths.

  **Note:** Applications with NSK600 modem that run at a data transfer rate that is lower than 2'400 bps (FSK modems) are protocol transparent and need no further parameter configuration.

- **ETL600 Rel.4.0.0:**
  - 1200, 2400, 4800, 9600 and 19200 for MOD600 modem.

- **ETL600 Rel.4.0.1 and later:**
  - 200, 300, 600, 1200, 2400, 4800, 9600 and 19200 for MOD600 modem.

- **Data bits:** 5, 6, 7 or 8.

- **Stop bits:** 1 or 2.

- **Parity:** None, Odd, Even

- **Protocol:**
  - **Character based protocol:** this is the configuration for general asynchronous data communication based on individual character transmission. This selection allows unrestricted parameter configuration for the number of data bits, stop bits and parity mode;

  - **RP570/RP571 / FT1.2:** this is the configuration for SCADA applications using the ABB proprietary protocol RP570/RP571 based on IEC60870-1-5 FT1.2 with 8 data bits, 1 stop bit and even parity;

  - **Asynchronous DNP 3.0:** this is the configuration for SCADA applications using the proprietary implementation of asynchronous DNP3.0 based on IEC60870-1-5 FT3 with 8 data bits, 1 stop bit and no parity.

- **Three different flow control modes are available:**

  - **Hardware handshake:**
    An RTS request from DTE (e.g. RTU) to the V.24 port is granted CTS when the corresponding transmission channel is available in transmit direction (multiplexer frame is synchronized for MOD600 or data carrier is operational for NSK600). As soon as CTS is granted, dataflow is permitted through the corresponding channel in transmit direction. In case of port sharing operation, no collision detection with other
V.24 ports transmitting on the same channel is implemented. When the DTE clears RTS to the V.24 port, CTS is cleared accordingly. If the corresponding V.24 port is connected to an NSK600 modem, the RTS request enables the data carrier of the modem and CTS is granted as soon as the carrier is available. Towards the DTE, DCD is signaled whenever the transmission channel is available in receive direction (received multiplexer frame is synchronized for MOD600 or receive carrier is operational for NSK600).

- **CTS always on:**
  Independently from any RTS request by the DTE, CTS is always granted. Dataflow is always permitted through the corresponding channel in transmit direction. In case of port sharing operation, all active shared ports are disabled except the one with the lowest number.
  For NSK600 modem, this flow control mode permanently enables the carrier on the AF signal in transmit direction. Towards the DTE, DCD is signaled whenever the transmission channel is available in receive direction (received multiplexer frame is synchronized for MOD600 or receive carrier is operational for NSK600)

- **Data sensitive:**
  This mode does not require handshaking signals from the DTE connected to the V.24 port. Dataflow from the TD terminal is connected to the corresponding transmission channel independently of its availability.
  For NSK600 modem transmission, as soon as data activity is detected on the port, the carrier on the AF signal is enabled. In case of port sharing operation, all active shared ports are disabled except the one with the lowest number.
  Dataflow to the RD terminal (to DTE) is always granted.

**Note:** For datarates $\leq 1200$ bps with NSK600 modem transmission (FSK modems), data sensitive flow control is not available.

- For V.24 ports, **Jabber timeout (100 s)** is available and can be enabled by checking the corresponding checkbox in the monitoring parameter section of the dialog box.

**Note:** When jabber timeout is activated, flow control must be set to **Hardware handshake** or **Data sensitive**.

When enabled, a timer is started as soon as RTS is activated (flow control set to **Hardware handshake**) or the DTE starts sending data (flow control set to **Data sensitive**). If RTS is active for more than 100 s (flow control set to **Hardware handshake**) or the DTE continuously sends data for more than 100 s (flow control set to **
Data sensitive), dataflow to the transmission channel is interrupted, CTS cleared, Jabber Halt Alarm activated and – for FSK modems – the carrier signal switched off. This condition is restored as soon as RTS turns inactive or the DTE stops sending.

Note: Except for special cases, use jabber timeout only when AF channel sharing or V.24 port sharing is used.

5.3.4.7. V.24 transit operation

If V.24 data have to be forwarded from one to another link, a 9 pin null modem cable as described in section 4.4.3.1.2 must be used.

Remarks:
- The port parameters must be configured identically in both ETL600 terminals (HMI600: Configuration / Data Port to modem assignment / Port xy).
- CTS always on is the preferred setting for the transit station, if the V.24 Port Sharing mode is not enabled (because the modem signal is then always on and consequentially there is no Carrier-On delay after a quiet phase with no data transmission).

5.3.4.8. NSK600 settings

Point to Configuration / NSK600 ... to open the dialog box for configuration of the utilized NSK600 modems. To configure a modem, select the corresponding tab. To add or remove a modem, refer to section 5.3.4.1.

On the tab, the following information is displayed: the APLC channel assignment and the V.24 port associated to the modem.

The following signal settings can be configured with the appropriate selection of radio buttons, drop down list or checkbox for each NSK600 modem:

- **Status:**
  - Off: the modem is not operational, communication is interrupted;
  - On – disconnectable: the modem is operational, communication will be interrupted during transmission of a teleprotection command;
  - On - non disconnectable: the modem is operational and communication will not be interrupted during transmission of a teleprotection command.

- **Adaptive equalizer:**
  This setting is only available for DAPSK channels.
  - On: The receive signal of the associated DAPSK modem passes an adaptive equalizer, bypassing the standard equalizer of the associated APLC channel. Should the all-pass filter of
the associated APLC channel be enabled for the transmit signal of the modem, it is bypassed as well.

- **Off**: The adaptive equalizer of the associated DAPS K modem is disabled. Channel conditioning is required by enabling equalizer and all-pass filter in the associated APLC channel.

**Note:** The setting must be the same for both modems of a DAPS K link.

- **AF**: The data rate and bandwidth that have been set in the V.24 port configuration dialog box are displayed for information. The desired center frequency can be selected in steps of 60 Hz, except for modems with 1200 Bd and 9600 bps where the center frequency is preset.

**AF channel sharing operation:**
This setting is only available for NSK600 modems with data rates \( \leq 1200 \) bps, i.e. for FSK modems. When checked, a weight of 0 is associated to the corresponding NSK600 modem signal. This allows different NSK600 modems to share one AF channel when higher level protocols insure that these modems are not transmitting at the same time. For all modems involved in the AF channel sharing operation, flow control must be set to **Hardware-Handshake**. Moreover, for these modems, it is recommended to enable Jabber timeout (refer to section 5.3.4.6).

**Note:** For AF channel sharing of different NSK600 modems, all modems except one need to have the box **AF channel sharing operation** checked.

**Note:** AF channel sharing is not supported for NSK600 DAPS K modems.

- **Data regeneration**: This feature allows regeneration of transparent transmitted data for data transfer rates \( \leq 1200 \) bps (i.e. FSK modems). For 2400, 4800 and 9600 bps (DAPS K modems), data recovery is automatically done. The following possibilities are available:

  - **On**;
  - **Off**.

**Note:** FSK modem data regeneration is only possible when the effective data transfer rate corresponds to the selected nominal data rate.

Particularly for transit applications, this feature should be enabled in all transit stations. For details about data regeneration, refer to section 3.5.1.1.3.
5.3.4.9. **MOD600 settings**

Point to **Configuration / MOD600** ... to open the dialog box for configuration of the MOD600 modems. To modify the bandwidth for the modem refer to section 5.3.1.1.

The following signal settings can be configured for MOD600 modem with the appropriate selection of radio buttons or drop down list:

- **Status:**
  - **Off:** the modem is not operational, communication is interrupted;
  - **On – disconnectable:** the modem is operational; communication will be interrupted during transmission of a teleprotection command.

- **Operating mode:** every DPLC link must consist of one **Master** and one **Slave** station. In case of digital transit operation, the rules as described in section 5.3.6 have to be respected.

- **MOD600 weight:** this parameter defines the splitting of the transmitted power between DPLC signals (MOD600) and remaining APLC signals.
  - **Low:** DPLC & APLC signals have the same PEP (peak envelope power);
  - **Medium:** DPLC signal has twice the PEP of the APLC signal;
  - **High:** DPLC signal has three times the PEP of the APLC signal;
  - **Proportional:** PE voltage is distributed proportionally to the bandwidth taken by DPLC and APLC signals \( BW_{DPLC} / BW_{APLC} = PEV_{DPLC} / PEV_{APLC} \)

- **Interrupt timeout:** **Low (0.3 s), High (1.5 s)**
  This parameter defines the time for the modem to perform a restart when a channel interruption occurs.

- **Transmission optimized for:** **Low delay, ..., High efficiency**
  A trade-off between highest possible datarate and lowest possible transmission delay time can be configured.

The configurations of the data rate for the MOD600 modems for the 5 fallback/fall-forward profiles must be done in descending order with the highest selected data rate on the left and the lowest on the right. The efficiency curve in the technical data, section “Broadband data (MOD600)” can be used to select the lowest and highest data rate according to the expected lowest and highest SNR.

**Example:**
The bandwidth of the DPLC channel is 8 kHz and the SNR in 4 kHz is between 21 and 39 dB. The difference between SNR in 4 kHz and in band SNR is \( 10^{\log(8\ kHz/4\ kHz)} dB \), i.e. 3 dB. Thus, the in band SNR range is 18 to 36 dB. To ensure reliable operation at these SNR, we specify an SNR margin of 3 dB. From the
efficiency curve, the efficiency is 2 bps/Hz at 18-3=15 dB and 7 bps/Hz at 36-3=33 dB in band SNR, corresponding to data rates of 8 kHz*2 bps/Hz = 16 kbps at 15 dB and 8 kHz*7 bps/Hz = 56 kbps at 33 dB.

To ensure data transmission without frequent interruption, data rate increase/decrease from one profile to the next should correspond to an SNR difference of not more than about 6 dB. As a rule of thumb, this is equivalent to a difference in kbps between the data rates of at most about one and a half times the DPLC channel bandwidth in kHz.

Example:
The bandwidth of the DPLC channel is 8 kHz and the lowest and highest data rates are 16 kbps and 56 kbps. The difference between the data rates should be not higher than about 1.5*8 kbps = 12 kbps. Thus, possible data rates for the profiles are 56, 48, 40, 28.8 and 16 kbps.

When the DPLC channel multiplexer is enabled and a number of data communication channels are transmitted over the MOD600 modem, an individual setting for the data channels must be configured for each of the MOD600 data rate profiles.

When configuring the data rates for these channels, the sum of all rates added to the multiplexer overhead must not exceed the selected aggregate data rate of the modem. HMI600 will indicate the profiles that are not compliant to this requirement by highlighting in red color.

Remarks:
• For LAN and V.11, data rate selection from 9600 bps to the maximum datarate allowed for the configured MOD600 bandwidth is possible, or the ports can be turned Off.
• For V.24 data rate selection refer to section 5.3.4.8. Here the data transmission can just be turned On with its configured transmission rate or turned Off.
• The settings for compressed telephony can be made after pressing the button Compressed telephony. Each telephony channel may be turned On or Off for each data rate profile.

Note: In case several compressed telephony channels are configured, the first of these channels should be given highest priority, because it is shared with the service phone channel.

MOD600 can be forced to operate constantly with one of the defined data rate profiles, without fallback/fall-forward under varying channel conditions, by selecting the desired profile with the corresponding radio button. Using the efficiency curve mentioned above, make sure that the data rate is low enough to ensure reliable data transmission at the expected worst case in band SNR.

Example:
The bandwidth of the DPLC channel is 8 kHz and the worst case SNR in 4 kHz is 21 dB. The difference between SNR in 4 kHz and in band SNR is
10*log(8 kHz/4 kHz) dB, i.e. 3 dB. Thus, the worst case in band SNR is 18 dB. To ensure reliable operation at this SNR, we specify an SNR margin of 3 dB. From the efficiency curve, the efficiency is 2 bps/Hz at 18-3=15 dB, corresponding to a data rate of 8 kHz*2 bps/Hz = 16 kbps.

Advanced configuration is available for transmission optimization in special cases. The following settings can be made:

- Enable narrowband interference detection,
- Enable forward error correction (RS),
- Orthogonality interval N,
- Guard interval L.

Refer to section 3.5.2 for more information about these settings.

5.3.5. Compressed telephony

Compressed telephony requires that a DPLC channel under Configuration / Services / Type and DPLC channel multiplexing under Configuration / Services / Data communication are configured.

Point to Configuration / Services / Compressed Telephony to select the number of 2-wire, 4-wire and transit compressed telephony channels. The sum of these channels must not be higher than 16. It can be further restricted depending on the other configured services.

Refer to section 5.3.6 for the configuration of digitally compressed transit telephone channels.

A service phone can be enabled in two different ways:

1. By clicking the checkbox Service phone multiplexed to channel with 2-wire interface, the service phone shares the channel with a 2-wire compressed telephony channel. This requires that at least one 2-wire compressed telephony channel is configured.

2. Alternatively, by clicking the checkbox Service phone multiplexed to channel with 4-wire interface, the service phone shares the channel with a 4-wire compressed telephony channel. This requires that at least one 4-wire compressed telephony channel is configured.

The 2- or 4-wire telephony service that shares the channel with the service phone always has priority over the service phone.

A combo box in the frame Data rate of telephony channels allows selecting the data rate of the compressed telephony channels. Higher data rate means higher speech quality. The FAX service operates with 4.8 kbps with either telephony data rate.

Each configured compressed telephony channel appears in a separate tab under Configuration / Compressed telephony. The tabs are named CH x, Port y, Nzz, where x is the channel number and zz is the slot number of the O4CV board carrying the channel at interface port y.
(y = 1…4). Each tab either refers to a 2-wire telephony service or to a 4-wire telephony service.

5.3.5.1. **2-wire compressed telephony channels**

In case of 2-wire telephony, radio buttons in the frame **Operation mode** under **Configuration / Compressed telephony / CH x, Port y, Nzz** allow selecting the desired telephony mode: **Hot line direct telephone, Remote subscriber** or **PAX 2-wire**. Refer to sections 3.6.1 and 3.6.2 for a description of the 2-wire modes.

In the frame **Interface 2-wire**, select the desired speech input- and output levels in dBm, the ringer frequency in Hz and the impedance scheme using the combo-boxes. A table showing the circuit and component values of the available impedance schemes is displayed when clicking on the button **Help impedance**.

If a service phone is configured, the checkbox **Service phone enabled** must be checked in the frame **Service phone**. In this frame, select the desired speech input- and output levels in dBm, the ringer frequency in Hz and the impedance scheme using the combo-boxes for the service phone.

Clicking the button **Set defaults** sets default values for the speech levels, the ringer frequency and the impedance scheme.

When facing echo problems with 2-wire telephony channels, a combination of the following measures might help:
- setting a lower speech output level,
- setting a higher speech input level,
- selecting a different impedance scheme.

5.3.5.2. **4-wire compressed telephony channels**

In case of 4-wire telephony, click the radio button **PAX 4-wire with E- & M-wire** in the frame **Operation mode** under **Configuration / Compressed telephony / CH x, Port y, Nzz**. Refer to sections 3.6.2 and 3.6.3 for a description of the 4-wire modes.

In the frame **Interface 4-wire**, select the desired speech input- and output levels in dBm. In addition, checkboxes are provided for inverting the polarity of E- and M-wires and enabling a line echo canceller if required.

Clicking the button **Set defaults** sets default values for the speech levels.

Checking the checkbox **Enable speech filter** activates extra low-pass filters in the speech in- and output signal-paths. The cut-off frequency of these filters can be chosen in the range 2000 to 3400 Hz in steps of 200 Hz using the combo-box **Cutoff frequency [Hz]**. These speech filters must be activated in case the speech interface is connected to an analog speech port of another PLC equipment in order to suppress incoming pilot and superimposed data signals at the input side and frequency components of the decompressed speech signal above the cut-off frequency of the speech filter at the output side.
For transit applications to further compressed telephony channels, the checkbox **Analog transit mode** in the frame **Transit** must be checked. This disables any analog filtering of the speech signals and the echo cancellers in the input and output signal paths, thereby improving the speech quality. For sufficient quality of the speech signals, not more than 3 compressed telephony links should be connected in transit.

### 5.3.6. MUX600

This tab is only available if under **Configuration / Services / Compressed Telephony** in the frame **Transit operation mode** at least one transit channel has been configured. Note that the sum of 2-wire, 4-wire and transit compressed telephony channels must not be higher than 16.

Compared to traditional analog transit connections of compressed speech channels, digital transit connections have much less delay and don’t suffer from speech quality degradation, both produced by the speech decompression and compression operations required for analog speech transit.

By connecting the digital transit ports of up to five ETL600 terminals together, a digital transit node is established. By proper configuration of the terminals, compressed telephone channels may be digitally connected in transit between the terminals of the node in a point to point (in case of two terminals) or point to multipoint fashion (in case of more than two terminals).

Up to 5 digital transit connections in series are supported, i.e. up to 6 ETL600 links may be connected in a chain.

For nodes consisting of 2 terminals, one of them – arbitrarily selected - must be configured as digital transit master, the other as digital transit slave.

For nodes with more than 2 terminals, a single terminal is configured as transit master, namely the one with transit channels to all other terminals. The remaining terminals have to be configured as digital transit slaves. A node consists of 1 master and up to 4 slaves. No digital transit channels may be established between the digital transit slaves of an node.
The settings “Digital transit master” and “Digital transit slave” are distinct from the settings “MOD600 master” and “MOD600 slave” as described in section 5.3.4.9. However, for correct digital transit operation, the master/slave settings for digital transit and MOD600 must be coordinated such that in the intermediate nodes, digital transit data is always exchanged between terminals set to “MOD600 master” and terminals set to “MOD600 slave”.

In the following, the configuration and operation of digital transit compressed telephony channels is explained for the example depicted in Fig. 5-7.

Five substations A, B, C, D and E are connected via four ETL600 PLC links A→B, B→C, C→D and B→E. A PAX located in substation A has to be connected to remote subscribers in each of the other substations. Moreover, hot lines have to be established between substations B and C, C and D, B and D as well as B and E. In addition, it is requested to operate service phones over each of the four links.

As shown in Fig. 5-7, two digital transit nodes are required:
- Node B in substation B with three ETL600 terminals B→A, B→C and B→E;
- Node C in substation C with two ETL600 terminals C→B and C→D.

As shown in the figure, ETL600 terminal B→A is configured as digital transit master for node B, as it has transit channels to both other terminals of the node, B→C and B→E.
As for node C, terminal C→B has arbitrarily been selected as transit master and terminal C→D as transit slave.

The digital transit ports of the ETL600 terminals forming a node must be connected in series by 1:1 cables such that a chain is formed, as shown in Fig. 5-8 for substation B. Each cable can have a length of up to 50 m.

The interconnection rules for transit nodes are
- The equipment configured as digital transit master must be the beginning of the chain, with a transit cable inserted in the socket **Digital transit / to slave** and no cable inserted in the socket **Digital transit / to master**.
- Each cable connects a **Digital transit / to slave** port of an ETL600 terminal with a **Digital transit / to master** port of another ETL600 terminal.

The sequence of the slaves in the chain is arbitrary.

The MOD600 master/slave settings in the digital transit nodes B and C have been chosen such that the terminals exchanging digital transit data have opposite settings as shown in Fig. 5-7 and the following table:
### Terminals exchanging digital transit data

<table>
<thead>
<tr>
<th>Terminals exchanging digital transit data</th>
<th>MOD600</th>
<th>Digital transit</th>
</tr>
</thead>
<tbody>
<tr>
<td>ETL600 B→A with ETL600 B→C</td>
<td>Slave</td>
<td>Master</td>
</tr>
<tr>
<td></td>
<td>Master</td>
<td>Slave</td>
</tr>
<tr>
<td>ETL600 B→A with ETL600 B→E</td>
<td>Slave</td>
<td>Master</td>
</tr>
<tr>
<td></td>
<td>Master</td>
<td>Slave</td>
</tr>
<tr>
<td>ETL600 C→B with ETL600 C→D</td>
<td>Slave</td>
<td>Master</td>
</tr>
<tr>
<td></td>
<td>Master</td>
<td>Slave</td>
</tr>
</tbody>
</table>

For terminals not belonging to a transit node, the association of O4CV telephony ports to MUX600 channels – called “mux channels” in the sequel - is fixed. Using HMI600, it can be viewed with Configuration / MOD600 / Compressed telephony.

The following rules help in the planning process:

1. Mux channels are used in the sequence 1, 2, 3, … , 16.
2. The service phone – if configured – is always using mux channel 1.
3. The association of mux channels to transit channels by the transit master is such a transit channel is connected to the mux channel with the same number.
4. The association of mux channels to transit channels by transit slaves is 1 : 1 but otherwise free; i.e. any transit channel can be connected to any mux channel.

As an example, the HMI600 configuration for ETL600 terminal B→A is done as follows:

**Configuration / Services / Type:** Configure a DPLC channel

**Configuration / Services / Data communication:**
- Frame Data ports: Choose one of the options offering Transit.
- Frame MUX600 terminal multiplexer: Activate DPLC channel multiplexing

**Configuration / Services / Compressed telephony:**
- Select 1 channel with 2-wire compressed telephony interface
- Activate checkbox Service phone multiplexed to channel with 2-wire interface
- Frame Transit operation mode: Activate Master and select 3 Transit channels.

**Configuration / MOD600 / Signal settings / Operating mode:**
- If not yet correct, set to Slave.

**Configuration / Compressed telephony:**
- Frame Operation mode: Choose Remote subscriber
- Frame Service phone: Activate Service phone enabled

**Configuration / MUX600:**
- Connect mux channel 1 to O4CV CH1, Port 1, N2
- Connect mux channel 2 to Transit CH2
- Connect mux channel 3 to Transit CH3
- Connect mux channel 4 to Transit CH4

**Configuration / MOD600 / Compressed telephony:** Switch On or Off mux channels 1 to 4 for profiles 1 to 5 as desired.

### 5.3.7. NSD600

Point to Configuration / NSD600 to get a dialog box with the tabs TPE 1, TPE 2, Supervision TPE 1, Supervision TPE 2 and G4AI N71.

Additional tabs G4AI N11, G4AI N22, G4AI N28, G4AI N34, G4AI N54 and G4AI N65 can be present depending on the required number of NSD600 ports entered previously under **Configure services**.

Remarks for the tabs TPE 1 / TPE 2:
- Each of the four commands A, B, C, D can be set under **Application** to **Off**, **Blocking**, **Permissive**, **Direct**.

**Note:** It is recommended to configure the commands A to D in ascending order regarding security requirements of the application (example: command A for blocking, B and C for permissive, D for direct tripping).

**Note:** If the single purpose teleprotection NSD600 in 2 kHz nominal bandwidth is used, command D is only configurable for **Off** and **Direct** tripping.

- For each command the following input command parameters can individually be configured and modified from the default settings: **Tx Input On-Delay**, **Tx Input Prolongation**, **Max Tx Trip Monitoring**.

**Note:** Pickup times for link and user alarms must be set to values higher than the configured **Max Tx Trip Monitoring** time.

**Note:** If the single purpose teleprotection NSD600 in 2 kHz nominal bandwidth is used, **Max Tx Trip Monitoring** can be enabled or disabled for each command independently (if enabled, the parameter for the max trip duration can be modified from its default value).

- **Max Rx Trip Monitoring** can be enabled by checking the corresponding box (if checked, the parameter for the max Rx trip duration can be modified from its default value).
Note: Pickup times for link and user alarms must be set to values higher than the configured Max Rx Trip Monitoring time.

- By activating a radio button it can be chosen whether all commands are actuated at the outputs as long as the corresponding tripping signal is received (and possibly prolonged; radio button **Rx Output prolongation**) or whether all commands are actuated for a fixed duration only, irrespective of the length of the received tripping signal (radio button **Rx Output Duration**). In both cases the parameters can be modified from its default values for each command individually.

Note: If in the supervision tab **freezing of commands** is activated, **Rx Output Duration** is disabled and **Rx Output prolongation** is at least 100 ms.

- Either the **ETL pilot** can be selected or a special NSD600 **Guard signal** can be used. The frequency of the NSD600 own guard signal depends on the speech bandwidth entered under **Configure telephony**, refer to section 5.3.3.1. Possible values for the speech bandwidth are 2000, 2200 or 2400 Hz. For a speech bandwidth of 2600 Hz and higher, the NSD600 must use the ETL pilot as guard signal.

Note: If the single purpose teleprotection NSD600 in 2 kHz nominal bandwidth is used, no choice for the guard signal is provided (fixed ETL pilot at 1800 Hz).

In the field **Guard signal** the **Power guard level** in **[W]** and **[dBm]** is displayed instead.

The Power guard level can be varied by means of the boost ratio setting (default is 12 dB).

- Furthermore on these tabs the **Boost ratio** can be selected (depends on the configured and disconnectable services), the **Cyclic loop test** can be enabled and the **Loop test interval** can be determined (1, 3, 6, 12 or 24 hours).

Note: It is recommended to finish configuration of all the other services before the NSD600 boost ratio is set (in order to let the HMI600 determine the max. possible boost ratio that can be programmed).

Note: Per default the box **Auto select max** is checked in the frame **Power boosting**. This means that the maximal possible boost ratio is used for the tripping signals. By un-checking the box, a pull-down menu is enabled and a lower boost ratio can be chosen.
**Note:** If the single purpose teleprotection NSD600 in 2 kHz nominal bandwidth is used - where transmission of persistent commands is permitted - the time when the power of the command signal is set back to loop test level can be chosen by entering the Timed Tx power reduction in [s] (the Auto select max checkbox is not available as the maximum output power is used for transmitting commands during the chosen time).

**Note:** To avoid periodic interruptions of the MOD600 transmission, the cyclic loop test should not be activated when the TPE is operated in the DPLC channel.

Remarks for the tabs **Supervision TPE 1 / Supervision TPE 2:**

- In the frame Unblocking the Threshold, the Extra on-delay and the Pulse duration can be modified from the default settings.
- How the command outputs should respond in case of a level or SNR alarm of the NSD600 concerned (TPE link alarm) can be chosen in the frame Command outputs during link failure. Additionally a Pick up time (after the alarm condition has been detected) and a Hold time (after the alarm condition has disappeared) can be configured.
- The Guard level alarm settings are valid for the corresponding TPE only (they are different and independent from the settings made under Configuration / System / Alarm settings for the alarm threshold of the pilot levels; even if the NSD600 uses the ETL-pilot as guard signal).

**Note:** If the radio button Rx Output Duration is activated on tab TPE1 or TPE2, the following settings in the frame Command outputs during link failure are not possible:
- direct to guard state, others to command state
- freezing of commands.

Vice versa, if one of the two settings mentioned above is chosen, Rx Output Duration on tab TPE1 or TPE2 is not configurable.

If freezing of commands is chosen, Pick up time and Hold time can not be varied (set to 0 s).

Remark for the tabs **G4AI N11, …, G4AI N71:**

- The various NSD600 signals (commands, alarms, acknowledges, etc.) can be mapped to the designated Inputs and Outputs on
these tabs. It is noted that – for a certain G4AI – the configurable signals are all from the same TPE.

- The selections made in the frame Jumper settings for each input port (Nominal input voltage or Contact only) and for each relay output (Relay contact NO/NC) are for information purpose only; the corresponding jumpers must be set on the interface modules G4AI.

Note: In order to improve security against unwanted operation, the NSD600 receiver will ignore all received frequency pairs which would activate one or more commands not configured to any G4AI output of the equipment.

Example: Of the 4 available commands A, B, C and D, command D is not configured to any G4AI output of the equipment. The NSD receiver of the equipment then considers only:
- the frequency pair belonging to the command A and
- the frequency pair belonging to the command B and
- the frequency pair belonging to the command C and
- the frequency pairs belonging to the command combinations A&B, A&C, B&C, A&B&C and
- the frequency pair belonging to the test command, and ignores all other frequency pairs, i.e.
- the frequency pair belonging to the command D and

5.4. Use of HMI600 files

Data entered into HMI600 as described in section 5.3 can be saved to file. The default extension of such files is et6. The data can be loaded back anytime into HMI600 from these files for modifications or for downloading to an ETL600 terminal connected to HMI600.

To save the data to file, point to File / Save or File / Save As.

To reload data from a previously stored file, open the file using File / Open.

To view the information recorded in a file after having opened it, use the View menu.
6. ASSEMBLY AND INSTALLATION

The installation of the equipment can only be successfully accomplished, if it is properly planned beforehand. Planning should not only take the present situation into account; future system expansion must also be included.

6.1. Safety instructions

Personnel qualification

DANGER
An authorized and properly trained personnel only is admitted to carry out programming, commissioning, maintenance, troubleshooting and work of the equipment.

Transportation

Caution
The plug-in units must be carefully but firmly screwed into the racks to prevent them from falling out. Separately packed modules and other loose parts must be properly secured and suitably packed to avoid damage.

Mechanical Installation

DANGER
The equipment must be mounted in a cabinet.

DANGER
Cabinets, which are not secured to the floor, tip forwards when the hinged frame is opened. Do not open the hinged frame without precautions.

Electrical Installation

DANGER
This is a Class I equipment as specified in IEC 60950-1. The equipment and the cabinet must be earthed.
The equipment must be supplied over a miniature circuit breaker as described in section 6.7.1.

DANGER
The circuit breaker for the power supply of the equipment must be switch OFF.
The circuit breakers for optional equipment in the cabinet must be switch OFF.

DANGER
The isolating terminals from the external cables must be kept open during installation, maintenance and before storage, decommissioning and disposal.
DANGER

Faston tabs on the cables connected to the rack P7LH, P7LP or P7LQ must be covered with an isolation sleeve. Unused faston connectors have to be covered.

Work on the system

DANGER

Do not work on the system or connect or disconnect cables during periods of lightning activities.

Isolating covers

DANGER

Hazardous voltages and/or hazardous energy level behind the isolating covers. Before removing these covers, the isolating terminals of the external cables must be opened or the cables to the terminals must be disconnected.

Unused slots

DANGER

Unused slots in the equipment subracks must be covered with blanking plates.

External cables

DANGER

The shields of the external cables V9MR, V9OF, V9OI, V9OS and V9OT must be earthed at both cable ends using the shield clamps supplied with the cables.

DANGER

Do not connect or disconnect energized cables to or from the equipment.
Insertion and removal of plug-in modules

**Caution**
Neither removing nor inserting of modules is permitted during power-up of the equipment. Preceding to plug in and out of modules, the power supply of the equipment has to be switched OFF.

There are two exceptions to this:

1. Rx filter P4RX:
   It has to be removed and inserted while the equipment remains powered when performing the Rx level adjustment procedure.

2. Redundant power supply module B5LD:
   It can be removed or inserted while the equipment remains powered by the other B5LD module in the rack.

**PCB Extenders**

**DANGER**
For measuring purposes only the original PCB extenders P4LM and P4EX, designed to work with ETL600 equipment, must be used.

**ESD protection**

**Caution**
The modules in this equipment contain devices, which can be damaged by electrostatic discharges. Appropriate measures must be taken before unpacking modules or withdrawing them from equipment racks. Essential precautions to prevent ESD damage when handling or working on modules are grounding straps for technical personnel and the provision of anti-static workbenches. Modules may only be shipped either in their original packing or installed in equipment racks.

**P4LT/P4LV/P4LX**

**DANGER**
Hazardous voltages and/or hazardous energy level on the module and the cable. Do not touch the module and the cable leads.

**Caution**
Connecting a load between terminals NO (normally open) and NC (normally closed) is not allowed. Use only one contact set NO or NC.

**Caution**
Power supplies connected to alarm relay contacts must be short circuit and over current protected.
R1BC

DANGER
Hazardous voltages and/or hazardous energy level on the module and the cable.
Do not touch the module and the cable leads.

Caution
Connecting a load between terminals NO (normally open) and NC (normally closed) is not allowed. Use only one contact set NO or NC.

Caution
Power supplies connected to alarm relay contacts must be short circuit and over current protected.

P1LP

DANGER
Hazardous voltages and/or hazardous energy level at the heat sink.
Do not touch during operation.

DANGER
Heat sink should not be touched with conducting materials to avoid energy discharges and damage of the power amplifier.

Caution hot surface
Hot surface at heat sink

O4LE, O4CV

DANGER
The phone interfaces on the modules O4LE and O4CV generate dangerous voltages up to 100 V. Don't use the modules without upper and lower cover plates. Do not touch the open pins of the service phone connector, the leads of its cable, the pins of the external cable connector and the leads of the external cable.

G4AI

DANGER
Hazardous voltages and/or hazardous energy level on the module and the cable.
Do not touch the module and the cable leads.

Caution
Connecting a load between terminals NO (normally open) and NC (normally closed) is not allowed. Use only one contact set NO or NC.
Caution

Power supplies connected to alarm relay contacts must be short circuit and over current protected.

Commissioning

Caution

Do not close/establish the connections to the protection devices until NSD600 is properly commissioned.

6.2. Unpacking and transport

6.2.1. Inspection upon receipt

Check that the consignment is complete immediately upon receipt. Immediately notify the nearest ABB company or agent, should departures from the delivery note, the shipping papers or the order be found.

6.2.2. What to do if there is transport damage

Visually inspect all the material when unpacking it. Where there is evidence of transport damage, lodge a claim immediately in writing with the last carrier, notify the nearest ABB company or agent and also ABB Switzerland Ltd, address to be found in document 1KHM010296 Repair an Return Procedure in the annex.

6.2.3. Precautions to avoid transport damage

Insert the modules carefully but firmly into the racks so that they cannot fall out. Modules and other loose parts that are packed separately must be packed and secured such as to preclude damage.

6.3. Installation

6.3.1. Place of installation and ambient conditions

The room where the equipment is installed should be free of dust, the floor covered if possible with a semiconducting plastic flooring material and cement floors and walls should be suitably painted.

The room must be well ventilated so that the temperature is in the range +10 to +45 °C and the relative humidity between 30 and 70 %. Lead/acid batteries must not be in the same room.

6.4. Cabinet

The standard equipment is supplied in an ABB cabinet Type E40A or E40D. These cabinets are equipped with hinged frames and are suitable for installation:

- standing against a wall,
- back-to-back,
- side-by-side,
- standing alone.

A gap of 2 to 3 cm should be left between cabinets standing side-by-side to permit single cabinets to be removed without difficulty. Leave sufficient space in front to avoid damage when the hinged frame is opened. There must generally be enough room for carrying out maintenance and for using the associated instruments.

Do not install equipment cabinets in corners, which would hinder opening the hinged frame and working on the cabinet.

Free access is especially important in the case of cabinets not equipped with a hinged frame. Cabinets are normally erected on a pedestal or as a suite of cabinets on a platform to facilitate cleaning of the floor and routing of cables.

6.4.1. **Grounding system**

The grounding system must go out radially from the station ground rail. On no account may there be any loops that would permit circulating ground currents.

Every cabinet must have its own ground conductor (gauge > 25 mm²) connected by adequately rated cable lugs to the station ground rail. The ground connection to the cabinet shall be clearly visible and made to the designated ground terminal.

For safety reasons, looping ground conductors to or from neighboring cabinets or other equipment is not permissible.

6.4.2. **Installing racks in cabinets**

While being installed, the equipment must be switched off and no external connections may be made to it.

Pay attention when determining the cabinet layout that air can circulate freely around the equipment and overheating cannot take place. To this end, sufficient space as shown in the following photographs must be left between the racks.

6.4.3. **External cables**

Some cables are shielded. As shown in the following photographs, the shields must be earthed at both cable ends using the shield clamps supplied with the cables. Use plastic binders to fix the position of the cables so that the shield clamps are not exposed to high mechanical forces caused by the cables.
6.5. **Dimension drawings**

The indicated dimensions are in mm.

6.5.1. **ETL600-050-1**

![Dimensions ETL600-050-1](image)

Fig. 6-1 Dimensions ETL600-050-1
6.5.2. **ETL600-100-2, ETL600-050-2**

![Diagram of ETL600-100-2, ETL600-050-2 dimensions]

Fig. 6-2 Dimensions ETL600-100-2, ETL600-050-2
6.6. Photographs

Fig. 6-3 Front view of the ETL600-050-1 equipment equipped with P4LX and interfaces O4LE (slots N02, N08), O4CV (slot N14), G4AI (slot N20)

Fig. 6-4 Rear view of the ETL600-050-1 equipped with the alarm relay module R1BC
Fig. 6-5  Front view of the ETL600-100-2 equipment equipped with P4LX and interfaces O4LE (slots N24, N30), O4CV (slots N36, N42, N48), G4AI (slots N54, N60)
Fig. 6-6  Rear view of the ETL600-100-2 equipped with the alarm relay module R1BC
Fig. 6-7  The plate A9CS for connection of external RF coaxial cable

Fig. 6-8  The terminal block for connection of power supply
Fig. 6-9  Terminal block of cable V9OF for NSD600

Fig. 6-10  The cabinet bottom
Fig. 6-11  Krone type terminal block used for data or telephony interfaces

All cables are mechanically secured to the earth plate by plastic cable binders. Shield clamps are used to galvanically connect the cable shields to the earth plate.
6.7. **External Connections**

Cable access is normally from a cable duct beneath the cabinet. However, suitable openings are available for fitting in the roof of the cabinet, where cables have to enter from above. This requires the replacement of the standard roof plates by plates fitted with dust-tight cable glands.

6.7.1. **Auxiliary Supply**

The ETL600 can be equipped with one or two power supply modules type B5LD for 48 VDC supply.

The auxiliary supply connections are over a miniature circuit breaker (MCB) for each power supply module:

<table>
<thead>
<tr>
<th>Equipment type</th>
<th>MCB type</th>
<th>Nominal current</th>
<th>Order number</th>
</tr>
</thead>
<tbody>
<tr>
<td>ETL600-050</td>
<td>S202P-K10</td>
<td>10 A</td>
<td>2CDS282001R0427</td>
</tr>
<tr>
<td>ETL600-100</td>
<td>S202P-K16</td>
<td>16 A</td>
<td>2CDS282001R0467</td>
</tr>
</tbody>
</table>

From each circuit breaker, the cable V9PB goes to supply connections at the rear of the rack P7LH, P7LP or P7LQ. The connections are:

- **+** Positive battery pole DC supply
- **-** Negative battery pole DC supply
- **PE** Protective earth

6.7.2. **Coaxial Cable**

A BNC coaxial connector for the RF signal is provided on the front of the module E5TH. However when the ETL600 is mounted in a cabinet, the RF signal is internally wired to a plate mounted inside the cabinet. The external RF coaxial cable has to be connected to this plate. Refer to the photograph in section 6.6.

6.7.3. **Interfaces**

Connections to the various interfaces are made with cables equipped with connectors or connector blocks that are normally mounted in the back of the cabinet. The following table lists the interfaces and the corresponding cables. The length of the cables is 2.5 m except when otherwise noted. The table also lists the recommended wire sizes for the connector blocks.

The cable shields must be connected to earth.
<table>
<thead>
<tr>
<th>Board</th>
<th>Interface</th>
<th>External cable</th>
<th>Type of connector or connector block</th>
<th>Connector side:</th>
<th>Recommended cable wire size</th>
<th>Wire size range / stripping length</th>
</tr>
</thead>
<tbody>
<tr>
<td>P4LT, P4LV, P4LX</td>
<td>V.11</td>
<td>V9OW</td>
<td>Sub-D 15 pole female</td>
<td>Shielded twisted pair (STP)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>RS-232, V.24</td>
<td>V9OU</td>
<td>Sub-D 9 pole female</td>
<td>Shielded twisted pair (STP)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>RS-485, IRIG-B</td>
<td>V9OV</td>
<td>Sub-D 9 pole female</td>
<td>Shielded twisted pair (STP)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>LAN, Digital transit</td>
<td>V9OH</td>
<td>RJ-45</td>
<td>Shielded twisted pair (STP)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Alarm contacts</td>
<td>V9OT</td>
<td>Screw type terminals (Phoenix)</td>
<td>0.5 mm²</td>
<td>Solid: 0.2 to 4.0 mm²</td>
<td>Stranded: 0.2 to 2.5 mm² Stripping length: 10 mm</td>
</tr>
<tr>
<td></td>
<td>Station bus RS-485</td>
<td>R7AP</td>
<td>LSA Plus Quick Connect (Krone)</td>
<td>Solid 0.5 mm, 0.2 mm PVC insulation. Shielded twisted pair (STP)</td>
<td>Solid, one wire: 0.4 to 0.8 mm. Solid, two wires: 0.4 to 0.65 mm, both wires must have the same diameter.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>R1BC Alarm contacts</td>
<td>V9MR</td>
<td>Screw type terminals (Phoenix)</td>
<td>0.5 mm²</td>
<td>Solid: 0.2 to 4.0 mm²</td>
<td>Stranded: 0.2 to 2.5 mm² Stripping length: 7 mm</td>
</tr>
<tr>
<td>O4LE</td>
<td>Telephony, tele-operation, ext. tele-protection</td>
<td>V9OS *) **)</td>
<td>LSA Plus Quick Connect (Krone)</td>
<td>Solid 0.4 mm, 0.2 mm PVC insulation. Shielded twisted pair (STP)</td>
<td>Solid, one wire: 0.4 to 0.8 mm. Solid, two wires: 0.4 to 0.65 mm, both wires must have the same diameter.</td>
<td></td>
</tr>
<tr>
<td>O4CV</td>
<td>Telephony *) **)</td>
<td>V9OI</td>
<td>LSA Plus Quick Connect (Krone)</td>
<td>Solid 0.4 mm, 0.2 mm PVC insulation. Shielded twisted pair (STP)</td>
<td>Solid, one wire: 0.4 to 0.8 mm. Solid, two wires: 0.4 to 0.65 mm, both wires must have the same diameter.</td>
<td></td>
</tr>
<tr>
<td>G4AI</td>
<td>Tele-protection commands, -alarms ) **)</td>
<td>V9OF</td>
<td>Screw type terminals (Phoenix)</td>
<td>0.5 mm²</td>
<td>Solid: 0.2 to 4.0 mm²</td>
<td>Stranded: 0.2 to 2.5 mm² Stripping length: 7 mm</td>
</tr>
</tbody>
</table>

Table 6-1 List of cables with wire sizes for connector blocks

*) Also available without LSA Plus Quick Connector with various lengths to be used for terminating on main distribution frame.

**) The shields of these cables must be earthed at both cable ends using the shield clamps supplied with the cables.

LSA Quick Plus quick connect is manufactured by KRONE. With this system the connections to the AF interfaces can be made quickly without soldering. A push-on tool (referred to as a KRONE tool), which...
is supplied as an accessory, permits insulation displacement, connection and cutting of the wire at the same time. For best results, a solid wire of 0.5 mm diameter with a PVC insulation of 0.2 mm thickness should be used.

6.7.3.1. **AF Interface O4LE**
The AF universal interface module O4LE has following main functions:
- telephony
- teleoperation
- external teleprotection equipment

The external connections are divided on two Krone connection strips: Telephony and Teleoperation.

The cable V9OS has 16 pairs.

The cable shield must be connected to earth.

6.7.3.1.1. **Analog Telephony**
The first connection strip is for telephony connections as shown in Fig. 6-12.

The interface programmed for 2 wire subscriber, for point-to-point operation or remote end subscriber or PAX side subscriber should be connected to terminals 0a / 0b.

The interface programmed for 2 Wire / 4 Wire, E&M operation should be connected as follows:
- 2 wire speech to terminals 8a / 8b.
- 4 wire speech Tx to terminals 1a / 1b.
- 4 wire speech Rx to terminals 2a / 2b.
- M wire to terminals 4a / 4b.
  It is activated by positive potential provided on terminal 4b, i.e. PAX should provide a potential free contact.
- E signal to terminals 3a / 3b.
- Transit connection / compandor control to terminals 5a / 4b.
  It is activated by positive potential provided on terminal 4b, i.e. PAX should provide a potential free contact.
- PAX blocking to terminals 6a, 6b and 7a.
  These changeover relay contacts indicate bad SNR.

The interface programmed for 4 Wire, E&M operation should be connected as follows:
- 4 Wire speech Tx should to terminals 1a / 1b.
- 4 Wire speech Rx should to terminals 2a / 2b.
- M wire to terminal 4a / 4b.
  It is activated by positive potential provided on terminal 4b, i.e. PAX should provide a potential free contact.
- E signal to terminals 3a / 3b.
- PAX blocking to terminals 6a, 6b and 7a.
  These changeover relay contacts indicate bad SNR.

6.7.3.1.2. **Teleoperation**

The second connection strip is for teleoperation / external teleprotection connections as shown in Fig. 6-12.

There are four 4-wire input / output ports available: AF1, AF2, AF3 and AF4.

Port AF1 is normally used for telephony. When speech is not necessary this port can be used for teleoperation channel.

Port AF1:
Input – 1a / 1b (Telephony connection strip in Fig. 6-12)
Output – 2a / 2b (Telephony connection strip in Fig. 6-12)

Port AF2:
Input – 3a / 3b (Teleoperation connection strip in Fig. 6-12)
Output – 4a / 4b (Teleoperation connection strip in Fig. 6-12)

Port AF3:
Input – 5a / 5b (Teleoperation connection strip in Fig. 6-12)
Output – 6a / 6b (Teleoperation connection strip in Fig. 6-12)

Port AF4:
Input – 7a / 7b (Teleoperation connection strip in Fig. 6-12)
Output – 8a / 8b (Teleoperation connection strip in Fig. 6-12).

External protection signaling equipment has to be connected to port AF4 only. Boosting (terminal 9a) for external protection equipment is activated by positive potential provided on terminal 9b. I.e. the protection signaling equipment should provide a potential free contact.
Fig. 6-12 Connections for AF interface O4LE, cable V9OS
6.7.3.2. **Compressed telephony interfaces O4CV and O4CVa**

The cable V9OI consists of 20 pairs. The external connections are divided on two Krone connection strips as shown in Fig. 6-13 for O4CV and Fig. 6-14 for O4CVa. O4CVa is identical to O4CV, except for the M-wire terminals, as can be seen by comparing Fig. 6-13 with Fig. 6-14.

The interfaces programmed for 4-wire, E&M operation should be connected as follows:

- 4-wire speech inputs for channels 1 to 4 to terminals 1a / 1b, 5a / 5b, 9a / 9b of strips 1 and 3a / 3b of strips 2, respectively.
- 4-wire speech outputs for channels 1 to 4 to terminals 2a / 2b, 6a / 6b, 0a / 0b of strips 1 and 4a / 4b of strips 2, respectively.
- M-wires for channels 1 to 4 to terminals 4a / 4b, 8a / 8b of strips 1 and 2a / 2b, 6a / 6b of strips 2, respectively.
  The wires are activated by positive potential provided on the b-terminals, i.e. PAX should provide potential free contacts.
- E-wires for channels 1 to 4 to terminals 3a / 3b, 7a / 7b of strips 1 and 1a / 1b, 5a / 5b of strips 2, respectively.

The interface programmed for 2 wire operation for channels 1 to 4 should be connected to terminals 7a / 7b, 8a / 8b, 9a / 9b, 0a / 0b of strips 2, respectively.

The cable shield must be connected to earth.
Fig. 6-13
Connections for compressed telephony interface O4CV, cable V901
Fig. 6-14  Connections for compressed telephony interface O4CVa, cable V9OI
6.7.3.3. **Teleprotection Interface G4AI**

The teleprotection interface includes:

- Four input circuits equipped with optocouplers
- Four output circuits equipped with MOS – FET semiconductor
- Two output relays

These circuits are available for customer connections by means of cable V9OF, shown in Fig. 6-15.

**Caution**

The polarity should be observed while doing the connections.

<table>
<thead>
<tr>
<th>Input 1</th>
<th>Input 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Terminal 1</td>
<td>Terminal 3</td>
</tr>
<tr>
<td>Terminal 2</td>
<td>Terminal 4</td>
</tr>
<tr>
<td>Terminal 5</td>
<td>Terminal 7</td>
</tr>
<tr>
<td>Terminal 6</td>
<td>Terminal 8</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Input 3</th>
<th>Input 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Terminal 5</td>
<td>Terminal 7</td>
</tr>
<tr>
<td>Terminal 6</td>
<td>Terminal 8</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Output 1</th>
<th>Output 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Terminal 9</td>
<td>Terminal 11</td>
</tr>
<tr>
<td>Terminal 10</td>
<td>Terminal 12</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Output 3</th>
<th>Output 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Terminal 13</td>
<td>Terminal 15</td>
</tr>
<tr>
<td>Terminal 14</td>
<td>Terminal 16</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Relay 1</th>
<th>Relay 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Terminal 17</td>
<td>Terminal 19</td>
</tr>
<tr>
<td>Terminal 18</td>
<td>Terminal 20</td>
</tr>
</tbody>
</table>

The V9OF cable is made of following elements:

- 20 terminal-block
- F-connecting plug
- 25 core shielded cable (each core 0.25 mm²)

The isolating terminals allow the testing of G4AI or the protection relays with the cable installed. The output relay contacts are connected to the terminals by two cores each for increased current load.

The cable shield must be connected to earth.
Fig. 6-15 Connections for teleprotection interface G4AI, cable V9OF
6.7.3.4. **DSP module P4LT/P4LV/P4LX**

The data interface sockets of the DSP module P4LT/V/X are located at the front plate. Three types of sockets are used:

- Sub-D 15 pole for V.11 ports,
- Sub-D 9 pole for HMI port (RS-232 or RS-485), IRIG-B port and V.24 ports,
- RJ-45 for digital transit and LAN ports.

The connector for the alarm relays cable is located at the rear. The cable shields must be connected to earth.

6.7.3.4.1. **V.11 cable V9OW**

![Diagram of V.11 cable connected to V.11 port]

**Fig. 6-16** V.11 cable connected to V.11 port
6.7.3.4.2. **RS-232 / V.24 cable V9OU**

Fig. 6-17 RS-232 / V.24 cable connected to HMI port
Fig. 6-18   RS-232 / V.24 cable connected to V.24 port
6.7.3.4.3. **RS-485 / IRIG-B cable V9OV**

Fig. 6-19 RS-485 / IRIG-B cable V9OV connected to HMI port (RS 485 station bus) and patch panel V9OY

Fig. 6-20 RS-485 / IRIG-B cable connected to IRIG-B port
6.7.3.4.4. **LAN / Digital transit cable V9OH**

The pin numbering of the RJ-45 connectors for the LAN and the Digital transit ports is shown in Fig. 6-21.

![Figure 6-21](image)

**Fig. 6-21** Pin numbering of the RJ-45 connectors for the LAN and the digital transit ports

![Figure 6-22](image)

**Fig. 6-22** LAN / digital transit cable V9OH connected to LAN port and to patch panel V9OZ
Fig. 6-23  LAN / digital transit cable V9OH connected to digital transit to master port

Fig. 6-24  LAN / digital transit cable V9OH connected to Digital transit to slave port
6.7.3.4.5. **Alarm relays cable V9OT**

The cable shield must be connected to earth.

**Caution**
Connecting a load between terminals NO (normally open) and NC (normally closed) is not allowed. Use only one contact set NO or NC.

**Caution**
Power supplies connected to alarm relay contacts must be short circuit and over current protected.
6.7.3.5. **Relay Module R1BC**

Eight relays with switchover contact are provided. Each relay or alarm contact can be switched to any one of three user alarms. Each user alarm bus can be programmed with HMI600 to respond to a desired combination of alarm criteria.

All alarm relays in the ETL600 equipment are picked up during a no fault condition. This is indicated with a dashed line on the alarm contact. Example: Terminals 1 and 2 of V9MR are closed when no alarm is present. Terminals 2 and 3 are closed when an alarm is present. Terminals 2 and 3 are also closed when the power to the ETL600 is switched off.

The cable shields must be connected to earth.

**Caution**  
Connecting a load between terminals NO (normally open) and NC (normally closed) is not allowed. Use only one contact set NO or NC.

**Caution**  
Power supplies connected to alarm relay contacts must be short circuit and over current protected.
Fig. 6-26  Connections to the alarm relay module R1BC
6.7.3.6. **Remote inquiry kit R7AP**

The remote inquiry kit R7AP allows to connect RS-232 ports to an RS-485 station bus, for element management networking as described in Chapter 4 'User Interface Program'. While ETL600 has its RS-485 bus signals available at the HMI connector on the front plate of P4LT/V/X, ETL500 requires R7AP for conversion of RS-232 to RS-485 interface signals. The R7AP base plate can be mounted in a standard 19 inch frame. If used for ETL500, the plate is mounted directly below the channel rack P7LH/P7LF, and the special 9 pole serial cable V9KH – included in the kit – has to be inserted between ports COM1 of P4LT/V/X and COM N located on the front plate of the remote inquiry kit. The RS-485 bus is formed by connecting all TD(A) wires, all TD(B) wires and all GND wires at the KRONE connection strip of all R7AP in a substation together. To minimize reflections, a linear network structure should be formed instead of a star structure as shown in Fig. 6-27.

**Fig. 6-27** Connections for an RS-485 station bus

**Fig. 6-28** Connections for remote inquiry kit R7AP
6.7.4. **Interconnection of interfaces**

Table 6-2 shows cables and patch panels for interconnection of V.11, RS-485, IRIG-B, digital transit or LAN interfaces.

<table>
<thead>
<tr>
<th>Interface</th>
<th>Type</th>
<th>Device</th>
<th>Interconnection cable to be used at patch panel terminals</th>
</tr>
</thead>
<tbody>
<tr>
<td>V.11</td>
<td>V9OX</td>
<td>Transit cable</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Sub-D 15 male to</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Sub-D 15 male</td>
<td></td>
</tr>
<tr>
<td>RS-485, IRIG-B</td>
<td>V9OY</td>
<td>Patch panel</td>
<td>Shielded twisted pair (STP) cable 120 Ohm,</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Sub-D 9 pole male</td>
<td>ABB identity number</td>
</tr>
<tr>
<td>Digital transit,</td>
<td>V9OZ</td>
<td>Patch panel</td>
<td>1KHW001554R0001,</td>
</tr>
<tr>
<td>LAN</td>
<td></td>
<td>1 x RJ-45</td>
<td>(2 pairs, stranded 0.22 mm²)</td>
</tr>
</tbody>
</table>

Table 6-2  Interconnection cables and patch panels

6.7.4.1. **V.11 Transit connection cable V9OX**

![Fig. 6-29  V.11 Transit connection with cable V9OX](image-url)
6.7.4.2. *Patch panel V9OY (Sub-D 9 pole male)*

Fig. 6-30 Patch panel V9OY (Sub-D 9 pole male)

6.7.4.3. *Patch panel V9OZ (1 x RJ-45)*

Fig. 6-31 Patch panel V9OZ (1 x RJ-45)
7. COMMISSIONING

7.1. Safety instructions

Personnel qualification

**DANGER** An authorized and properly trained personnel only is admitted to carry out installing, programming, commissioning, maintenance, troubleshooting and work of the equipment.

Mechanical Installation

**DANGER** The equipment must be mounted in a cabinet.

**DANGER** Cabinets, which are not secured to the floor, tip forwards when the hinged frame is opened. Do not open the hinged frame without precautions.

Work on the system

**DANGER** Do not work on the system or connect or disconnect cables during periods of lightning activities.

Insertion and removal of plug-in modules

**Caution** Neither removing nor inserting of modules is permitted during power-up of the equipment. Preceding to plug in and out of modules, the power supply of the equipment has to be switched OFF.

There are two exceptions to this:

1. Rx filter P4RX:
   It has to be removed and inserted while the equipment remains powered when performing the Rx level adjustment procedure.

2. Redundant power supply module B5LD:
   It can be removed or inserted while the equipment remains powered by the other B5LD module in the rack.

Unused slots

**DANGER** Unused slots in the equipment subracks must be covered with blanking plates.
Isolating covers

**DANGER**

Hazardous voltages and/or hazardous energy level behind the isolating covers. Before removing these covers, the isolating terminals of the external cables must be opened or the cables to the terminals must be disconnected.

PCB Extenders

**DANGER**

For measuring purposes only the original PCB extenders P4LM and P4EX designed to work with ETL600 equipment, must be used.

ESD protection

**Caution ESD**

The modules in this equipment contain devices, which can be damaged by electrostatic discharges. Appropriate measures must be taken before unpacking modules or withdrawing them from equipment racks. Essential precautions to prevent ESD damage when handling or working on modules are grounding straps for technical personnel and the provision of anti-static workbenches. Modules may only be shipped either in their original packing or installed in equipment racks.

Using HMI600 software

**Caution**

The link gets disturbed while using the options 'Tuning and Testing', activating a testtone, simulating alarms, measurement of frequency response & equalization etc. of the HMI600. Appropriate measures have to be taken especially in case protection signal transmission is being used.

P1LP

**DANGER**

Hazardous voltages and/or hazardous energy level on the module and the cable. Do not touch during operation.

**DANGER**

Heat sink should not be touched with conducting materials to avoid energy discharges and damage of the power amplifier.

**Caution hot surface**

Hot surface at heat sink.
P4LT/P4LV/P4LX

**DANGER**  Hazardous voltages and/or hazardous energy level on the module and the cable.  Do not touch the module and the cable leads.

R1BC

**DANGER**  Hazardous voltages and/or hazardous energy level on the module and the cable.  Do not touch the module and the cable leads.

O4LE, O4CV

**DANGER**  The phone interfaces on the modules O4LE and O4CV generate dangerous voltages up to 100 V.  Don’t use the modules without upper and lower cover plates.  Do not touch the open pins of the service phone connector, the leads of its cable, the pins of the external cable connector and the leads of the external cable.

G4AI

**DANGER**  Hazardous voltages and/or hazardous energy level on the module and the cable.  Do not touch the module and the cable leads.

7.2.  *Checking the line of communication*

It is essential that the behavior and characteristics of the line of communication between the sets of PLC terminal equipment be checked prior to finally commissioning.  This is necessary to confirm the design criteria used for engineering the system, respectively if the criteria were inaccurate, to take the appropriate corrective action.

The line of communication comprises:

a)  the coaxial cable linking the PLC equipment with the coupling device.

b)  the coupling device between the remote end of the coaxial cable and the LV side of the coupling capacitor.  The coupling device includes the main coupling filter and protective devices.

c)  the line traps in the power line between the junction of the coupling capacitor with the power line and the substation.

d)  the HV power line itself as propagation medium.
7.2.1. Return loss

The return loss $A_r$ is a measure of the quality of impedance matching between the PLC transmitter and the load (input impedance of the coaxial cable).

It is defined by the following equation:

$$A_r = 20 \log \left| \frac{Z_0 + Z}{Z_0 - Z} \right|$$

$Z_0$ rated impedance
$Z$ actual input impedance

A low value signifies a poor match, which results in a reduced transfer of power from the PLC transmitter onto the transmission line. The main disadvantage, however is the intermodulation phenomenon and associated cross-talk it causes.

The level of return loss should be measured in the equipment room at the coaxial cable input. The instruments used and the test set-up can be seen from Fig. 7-1 and Fig. 7-2. A typical return loss characteristic is shown in Fig. 7-3. In the case of short lines (line attenuation < 15 dB), the remote end must be terminated at rated impedance.

The measurement of the return loss over the total bandwidth of the coupling filter and the PLC line traps is recommended. Wherever possible, the measurements should be carried out twice under the following conditions:

- HV transmission line grounded behind the line trap
- HV transmission line open behind the line trap

If the minimum return loss is in the range 6 to 12 dB, the value of the input impedance should also be measured. In cases where the magnitude of the system impedance is too low or too high, an improvement can be achieved by changing the rated impedance of the RF hybrid (75 Ohms). Where this is not possible, the output power must be reduced in accordance with the following relationship to avoid non-linear distortion:

$$A_{dB} = \frac{1}{4} (12 - A_{r_{min}})$$

Minimum values of return loss < 6 dB indicate either a defective coupling or PLC line trap, or an unacceptable property of the transmission line.

In such instances, the coupling equipment at both ends of the line must be checked using a dummy load as follows:

1. Carefully ground the LV end of the coupling capacitor.
2. Interrupt the connection between the coupling filter and the coupling capacitor and terminate with a dummy load as shown in Fig. 7-5 or Fig. 7-6.
3. Measure the return loss of the coupling filter within the rated frequency band.

The instruments and test set-up are shown in Fig. 7-1 and a typical return loss characteristic for a bandpass coupling filter in Fig. 7-4.

Appreciable discrepancies between the measured results and the nominal characteristic point to defective components and the filters must be checked individually.

**SELECTIVE LEVEL METER SPM 32/33**

- Input impedance: appr. 5 kOhm
- Output impedance: approx. 10 Ohm

**GENERATOR PS 33**

- Return loss measuring bridge

---

Instruments:

1. Signal generator: Acterna PS 33
2. Selective level meter: Acterna SPM 32/33

---

Fig. 7-1 Instruments and test circuit for measuring return loss
Phase-to-ground
CF coupling filter
BT balancing transformer

Z₀ nominal impedance
Z actual input impedance

Phase-to-phase or between line circuits

\[ a_r = 20 \log \left| \frac{Z₀ + Z}{Z₀ - Z} \right| \]

Fig. 7-2 Test circuit for measuring return loss under practical conditions with the transmission line as load
Fig. 7-3  Typical return loss characteristic under practical conditions with the transmission line as load

Fig. 7-4  Typical return loss characteristic at rated load
### 7.2.2. Line attenuation

The line attenuation should be measured over the whole frequency range of the coupling filter and of the line traps. If possible these measurements should be carried out with the transmission line...
grounded behind the line traps. The test circuit is shown in Fig. 7-7 and Fig. 7-8.

Unexpectedly high attenuation or fluctuations of attenuation of several dB's within just a few kHz would indicate a defective line trap or extremely unusual characteristics of the line itself. It is essential that the cause is found and corrected before the PLC equipment is finally commissioned.

$$a_{tot} = 20 \log \frac{V_0}{2V_1} + 10 \log \left( \frac{R_1}{R_0} \right)$$

Fig. 7-7 Test circuit for measuring line attenuation in the case of single-phase coupling
7.3. **Commissioning of the PLC equipment**

Commissioning of the PLC equipment can commence once the measurements of the line of transmission have produced satisfactory results. The following items should be checked before switching on the auxiliary supply. Any discrepancies and anomalies must be rectified.

7.3.1. **Preliminary tests and checks**

- Check that the cabinet is earthed in accordance with regulations.
- Check the polarity of the auxiliary supply connections.
- Check that the external connections go to the correct terminals in the cabinet according to the specific drawings for the plant.
- Check that all the internal cables are fitted and correctly inserted.
- Check that all the units according to the specific layout diagram for the plant are fitted and in the correct locations.
- Check that all programming and settings in the units are in accordance with the specific settings for the plant.

7.3.2. **Tests according to the commissioning instructions**

The equipment was carefully tested and calibrated according to document ‘Programming and Testing Instructions ETL600 Rel. 4’ prior to delivery and therefore all the internal signal levels will already be at their correct values. Thus only those settings need to be carried out, which are influenced by the practical operating conditions on site.
The ‘Commissioning Instructions ETL600 Rel. 4’ are available in the annex of this manual.

The frequency response of the PLC channel can be checked and equalized according to the document ‘Equalization Instructions ETL600 Rel. 4’ in the annex.

Caution

Do not close/establish the connections to the protection devices until the internal (NSD600) and external teleprotection equipment are properly commissioned.
8. OPERATION AND MAINTENANCE

8.1. Safety instructions

Personnel qualification

DANGER An authorized and properly trained personnel only is admitted to carry out installing, programming, commissioning, maintenance, troubleshooting and work of the equipment.

Warning labels

DANGER Precautions and indications to hazardous voltages and hazardous energy level must be strictly observed.

Mechanical Installation

DANGER The equipment must be mounted in a cabinet.

DANGER Cabinets, which are not secured to the floor, tip forwards when the hinged frame is opened. Do not open the hinged frame without precautions.

Electrical Installation

DANGER The isolating terminals of the external cables must be kept open during installation, maintenance and before storage, decommissioning and disposal.

Work on the system

DANGER Do not work on the system or connect or disconnect cables during periods of lightning activities.

Caution The ‘RESET’ button on the module G4AI should not be pressed while executing routine tests during normal operation, as this causes re-initialization of the module and blocks it for some seconds. During this time no commands can be transferred.

Alteration

DANGER Alteration of the equipment is not allowed.
Safety and monitoring facilities

**DANGER** Mechanical safety facilities such as cover plates must not be removed or by-passed.

Isolating covers

**DANGER** Hazardous voltages and/or hazardous energy level behind the isolating covers. Before removing these covers, the isolating terminals of the external cables must be opened or the cables to the terminals must be disconnected.

Insertion and removal of plug-in modules

**Caution** Neither removing nor inserting of modules is permitted during power-up of the equipment. Preceding to plug in and out of modules, the power supply of the equipment has to be switched OFF.

There are two exceptions to this:

1. Rx filter P4RX: It has to be removed and inserted while the equipment remains powered when performing the Rx level adjustment procedure.
2. Redundant power supply module B5LD: It can be removed or inserted while the equipment remains powered by the other B5LD module in the rack.

Unused slots

**DANGER** Unused slots in the equipment subracks must be covered with blanking plates.

PCB Extenders

**DANGER** For measuring purposes only the original PCB extenders P4LM and P4EX, designed to work with ETL600 equipment, must be used.
ESD protection

**Caution**

ESD

The modules in this equipment contain devices, which can be damaged by electrostatic discharges. Appropriate measures must be taken before unpacking modules or withdrawing them from equipment racks. Essential precautions to prevent ESD damage when handling or working on modules are grounding straps for technical personnel and the provision of anti-static workbenches. Modules may only be shipped either in their original packing or installed in equipment racks.

Using HMI600 software

**Caution**

The link gets disturbed while using the options ‘Tuning & Testing’, activating a test tone, simulating alarms, measurement of frequency response & equalization etc. of the HMI600. Appropriate measures have to be taken especially in case protection signal transmission is being used.

**Caution**

During routine tests with the ETL600 in operation the **Reset** item in the **Equipment** menu of the HMI600 should **not** be activated, as this causes the equipment to be re-initialized and thus be blocked for some seconds. During this time no commands can be transmitted.

**P1LP**

**DANGER**

Hazardous voltages and/or hazardous energy level at the heat sink. Do not touch during operation.

**DANGER**

Heat sink should not be touched with conducting materials to avoid energy discharges and damage of the power amplifier.

**Caution**

Hot surface at heat sink

**P4LT/P4LV/P4LX**

**DANGER**

Hazardous voltages and/or hazardous energy level on the module and the cable. Do not touch the module and the cable leads.
R1BC

**DANGER** Hazardous voltages and/or hazardous energy level on the module and the cable.
Do not touch the module and the cable leads.

O4LE, O4CV

**DANGER** The phone interfaces on the modules O4LE and O4CV generate dangerous voltages up to 100 V. Don’t use the modules without upper and lower cover plates. Do not touch the open pins of the service phone connector, the leads of its cable, the pins of the external cable connector and the leads of the external cable.

G4A1

**DANGER** Hazardous voltages and/or hazardous energy level on the module and the cable.
Do not touch the module and the cable leads.

**Caution** The following safety instructions must be strictly observed to prevent injury to persons and damage to plant.

- It is important that this instruction manual is read and fully comprehended by all people involved including personnel that has already undergone training and is otherwise qualified before changing the configuration or carrying out maintenance etc.
- Take note of the instructions in section 6.2.3 to avoid damage to the equipment while being transported.
- Cabinets that have not been secured to the floor can tip forwards when the hinged equipment frame is opened.
- Safety devices such as cover plates must not be removed or bypassed.
- Pay attention to high-voltage warnings.
- Before switching on the power supply, check that the circuit is protected by a miniature circuit breaker and the equipment/cabinet is properly grounded and check the polarity and value of the power supply.
- It is not permitted to insert or withdraw modules during operation; the power supply must be switched off first.
- The modules contain CMOS integrated circuits that can be damaged by electrostatic discharge. It is important to take certain precautions to prevent electrostatic discharge before removing the
packing or withdrawing them from the racks. Indispensable precautions to avoid ESD damage are earthing of people working on the modules and a working surface that protected against electrostatic discharge. Only transport modules in their original packing or installed in racks.

- It is not permitted to modify the equipment in any way.

8.2. **Operation**

8.2.1. **Normal Operation**

During operation, the status of the equipment can be ascertained from the LED signals on the front plates of the individual modules, respectively by viewing the equipment status with the user interface HMI600.

In normal fault-free operation, only the green stand-by LED 'RDY' on all modules are lit. All the other red LEDs are for alarms and they should be off. Checking the equipment status via HMI600 produces the response 'NO ALARM'.

An inadmissible operating condition is signaled by the red LED 'AL' on the front of the unit concerned and the nature of the alarm can be queried via HMI600.

Send and receive command counters and an event recorder are standard equipment. The display of both can be done by means of the HMI600. The counters and the event log retain their information even if the supply is interrupted because they are stored in a nonvolatile memory.

In case a PC with HMI600 software is available for continuous monitoring of the PLC equipment, the 'Alarm monitoring' option in the HMI600 can be enabled to keep both the local and remote equipment under continuous monitoring.

8.2.2. **Faulty Operation**

Refer also to chapter 9 'Troubleshooting'.

If the ETL600 system is in normal operation, a green LED 'RDY' on the front plate of P4LT/V/X is on to indicate that the system is ready.

A faulty operation will be indicated by red LEDs. In case there is a fault on the line or with the modules, red LEDs in the field above the 'HMI' Sub-D connector light up. The description of the various alarm LEDs on P4LT/V/X is as follows:

- The red LED ('P4LT' or 'P4LV' or 'P4LX') at the top right side: There is a problem with the hardware of P4LT/V/X (DSPs, Flash EPROM, UART etc.).
- The yellow LED (⚠️, Warning) at the middle left side: It indicates that the equipment is not in normal operation mode. The link is OK.
- The red LED ('LNK', link alarm) at the bottom left side: It indicates that the link for one of the channels is down. This could be
because of not receiving the Rx RF at all or unsatisfactory level of the received pilot level.

- The red LED (‘HW’, hardware alarm) at the bottom right side: It indicates that there is a problem with the other hardware of the ETL600. The P4LT/V/X may be functioning OK.
- The red LED (‘SYS’, System or Cabinet alarm) at the middle right side: It operates when either the hardware alarm (HW) or the link alarm (LNK) operates or when an interface alarm is present.

Refer to chapter 9, section 9.5 'List of alarms and corrective actions' for details about causes of alarms and remedies.

In case the optional alarm module R1BC is used, the contacts will also operate for the above criteria if the corresponding high level alarms of the subsystems were selected by means of the HMI600.

The alarm polling (section 9.2.9) or event recorder (section 3.8) functions of HMI600 can be used to see the details of the alarms.

8.3. Maintenance

All the modules of ETL600 are subjected to a comprehensive final functional testing after manufacturing. The complete PLC equipment is then calibrated and tested as a unit before leaving the works.

Most functions such as generation of pilot, AF filtering, AF to RF conversion, RF filtering before power amplifier, RF & AF channel settings etc. are performed digitally by software using DSPs. Hence these operations are not subject to ageing. The processor includes a number of self-monitoring functions which - together with the NSD600 loop test performed at periodic intervals - check the operation of the DSP module and the availability of the communications channel as a whole.

The parameters governing the operating characteristics are all determined by the HMI600. The stability of these settings and thus also of the equipment as a whole is assured over a long period of time.

Nevertheless, testing at periodic intervals is recommended. The frequency of testing depends very much on the operating conditions in the particular installation, but should not be less than once every two years. The following periodic measurements are recommended.

8.3.1. Periodic functional checks

It is important that the reasons for readings, which diverge widely from values recorded during commissioning, are found, even if this means checking the entire equipment.

Checking and testing must be carried out by qualified and authorized personnel only, using suitable instruments. Incorrect settings can impair the proper operation of the equipment.
8.3.1.1. **Check alarm status for ETL600 element management networks**

To check the alarm status of a number of ETL600 terminals forming an element management network, the function 'Alarm polling' (menu **Network**) can be used. The alarm status of the addressed terminals is polled in selectable intervals and in case of any alarm, the alarm text is recorded on file and displayed on the screen.

8.3.1.2. **Check alarm events**

The alarms stored by the built in event recorder of the ETL600 terminals can be inspected. Upload the stored events by activating **Equipment / Commissioning and maintenance / Event recorder / Upload events**.

8.3.1.3. **Check status data**

The status data of both the local and remote equipment can be uploaded in the HMI600, using the function **Equipment / Upload status**. A printout of the status data can be taken for documentation purpose and compared with the previous status data.

8.3.1.4. **Check frequency response**

The frequency response of the link can be measured and compared with the former measurement using HMI600. For this purpose use the function **Equipment / Commissioning and maintenance / Frequency response**. If found necessary, the existing equalizer may be changed with the function **Equipment / Commissioning and maintenance / Select equalizer**. Refer to 'Equalization Instructions ETL600 Rel. 4' for details.

**Caution**

During frequency response measurements the link is not operational.

8.3.1.5. **Check AF levels**

The HMI600 AF measurement function can be used to check the levels of the various AF signals transferred over the ETL600 link. The function is accessible with menu **Equipment / Commissioning and maintenance / Measure AF**. It is possible to select the AF channel and whether the measurement has to be effected at the Tx side or at the Rx side.

**Note:** TPE trip signals can be viewed only at the Rx side but not at the Tx side.

8.3.1.6. **Check MOD600 modem status**

Interpreting the MOD600 modem status information is a quick way to assess the quality of the MOD600 data transmission. The information is contained in the equipment status, but can also be accessed with
the dialog Equipment / Commissioning and maintenance / MOD600 modem status. By activating Cyclic update in this dialog, the information is periodically refreshed, allowing the observation of the modem behavior over time. Table 8-1 gives explanations to the various status parameters.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>SNR at startup</td>
<td>The value “SNR at startup” is an estimation of the inband signal to noise ratio in dB taken at start-up/restart time of the modem.</td>
</tr>
<tr>
<td>EPSM</td>
<td>The EPSM value is an estimation of the inband signal to noise ratio in dB. While the SNR value is estimated only at startup/restart of the modem, the EPSM value is permanently updated during data transmission. In contrast to the “Delta sigma” value, the EPSM value is basically independent of the selected datarate.</td>
</tr>
<tr>
<td>Block error rate</td>
<td>The block error rate is the ratio between the number of blocks with one or more errors and the number of transmitted blocks. MOD600 transmits the data in blocks, adding a checksum to each block in the transmitter, enabling the receiver to distinguish errorless blocks from blocks with one or more errors. The value is rounded down to the next power of 10, i.e. a value of -4 means a block error rate between 1E-3 and 1E-4. The bit error rate is typically 100 to 1000 times smaller than the block error rate. The length of a block roughly equals N/B, where N is the orthogonality interval (explained in section 3.5.2) and B is the modem bandwidth. The value is permanently updated during data transmission. The value is used as a criterion to restart the modem when fallback/fall-forward is activated.</td>
</tr>
<tr>
<td>Maximal data rate</td>
<td>The maximum possible data rate, measured at start-up/restart time of the modem. This value is independent of the configured MOD600 data rates.</td>
</tr>
<tr>
<td>Current data rate</td>
<td>The current data rate is the selected data rate of the modem, which must be equal to or lower than the maximal data rate. Unless the communication is interrupted, the value is equal to the configured data rate or – in case fallback/fall-forward is activated – to one of the 5 configured data rates.</td>
</tr>
</tbody>
</table>
### Parameter Explanation

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Explanation</th>
</tr>
</thead>
</table>
| Delta sigma        | Delta sigma is a positive number indicating the quality of the received modem signal. The higher the value, the better the quality and the smaller the bit error rate.  
A value > 10 means good quality.  
The value increases when the data rate is lowered.  
The value is permanently updated during data transmission.  
The value is used as a criterion to restart the modem when fallback/fall-forward is activated. |
| Synchronization state | The synchronisation state of the modem is a number between 0 and 15.  
A value of 0 means that data transmission is currently interrupted.  
A value of 15 means that data transmission is ongoing.  
During startup/restart, the modem state runs through all numbers between 0 and 15 in ascending order. |

Table 8-1 MOD600 modem status parameters

#### 8.3.1.7. Check NSD600 functions

**a) Checks during operation:**

The ability of the equipment to function correctly can be checked by executing a manually initiated loop test: from the Equipment menu point to Commissioning and maintenance and click NSD600 send looptest. Providing the signal transmitted by the test is received back again within the allowed time window, the actual transmission time will be displayed. If not, a corresponding alarm message will appear ('Manual loop test failed').

**Caution**

The 'RESET' button on the module G4AI should not be pressed while executing routine tests during normal operation, as this causes re-initialization of the module and blocks it for some seconds. During this time no commands can be transferred.

**Caution**

During routine tests with the ETL600 in operation the Reset item in the Equipment menu of the HMI600 should not be activated, as this causes the equipment to be re-initialized and thus be blocked for some seconds. During this time no commands can be transmitted.

If the loop test fails in at least two consecutive attempts, the equipment must be taken out of service and tested according to b) below.
Tuning & testing procedures - refer to b) below – will interrupt the normal operation of the equipment.

b) Removing the equipment from service for testing:

1. Switch off the equipment and open all the isolating terminals to the protection afterwards.
2. Switch on the equipment again by closing the circuit breakers.
3. Choose the menu **Equipment / Tuning & testing**, click the **Test NSD600** button and set the local test mode by clicking **Set local loop**.
4. Check that the unit is indeed in the local test mode (corresponding Warning message after uploading status: ‘Warning: Local RF loopback on’).
5. Inject commands at the local terminal blocks and check the local command outputs for correct operation (to be done in relation to the Programming and Testing Instructions in the annex).
6. Choose the menu **Equipment / Tuning & testing**, click the **Test NSD600** button and set the local test mode to off by clicking **Normal operation**.
7. Check that the unit is indeed in the normal operation mode (no alarm and warning messages after uploading equipment status 'No alarm'; if alarm messages appear refer to section 9.5).
8. Initiate a manual loop test: from the **Equipment** menu point to **Commissioning and maintenance** and click **NSD600 send looptest**.
9. Providing no failure has been observed and all the alarm signals have reset, close the isolating terminals again.
10. If required, synchronize the trip counters in local and remote stations by resetting them via HMI600 (menu **Equipment / Commissioning and maintenance / Event recorder / Reset counter** -> reset all counters).

c) Checking the entire link:

If a defect cannot be located with the help of the above tests, the procedure for commissioning NSD600 described in the 'Commissioning Instructions' available in the annex of this instruction manual must be repeated for the units at both ends of the line.

Refer to section 9.5 for the causes of alarm messages displayed by HMI600 after uploading equipment status and appropriate steps to be taken.
Note: Replace any modules found to be faulty. Repairing modules on site is not recommended.
9. TROUBLESHOOTING

In case of failure of communications between the two stations of the PLC link, the fault could either be caused by the power line itself, either or both of the PLC equipment or the coupling arrangement. A systematic approach helps in tracking the fault in the shortest possible time.

9.1. Safety instructions

Personnel qualification

DANGER An authorized and properly trained personnel only is admitted to carry out installing, programming, commissioning, maintenance, troubleshooting and work of the equipment.

Mechanical Installation

DANGER The equipment must be mounted in a cabinet.

DANGER Cabinets, which are not secured to the floor, tip forwards when the hinged frame is opened. Do not open the hinged frame without precautions.

Work on the system

DANGER Do not work on the system or connect or disconnect cables during periods of lightning activities.

Alteration

DANGER Alteration of the equipment is not allowed.

Safety and monitoring facilities

DANGER Mechanical safety facilities such as cover plates must not be removed or by-passed.
Isolating covers

**DANGER** Hazardous voltages and/or hazardous energy level behind the isolating covers. Before removing these covers, the isolating terminals of the external cables must be opened or the cables to the terminals must be disconnected.

Insertion and removal of plug-in modules

**Caution** Neither removing nor inserting of modules is permitted during power-up of the equipment. Preceding to plug in and out of modules, the power supply of the equipment has to be switched OFF.

There are two exceptions to this:

1. Rx filter P4RX: It has to be removed and inserted while the equipment remains powered when performing the Rx level adjustment procedure.
2. Redundant power supply module B5LD: It can be removed or inserted while the equipment remains powered by the other B5LD module in the rack.

Unused slots

**DANGER** Unused slots in the equipment subracks must be covered with blanking plates.

PCB Extenders

**DANGER** For measuring purposes only the original PCB extenders P4LM and P4EX designed to work with ETL600 equipment, must be used.

ESD protection

**Caution ESD** The modules in this equipment contain devices, which can be damaged by electrostatic discharges. Appropriate measures must be taken before unpacking modules or withdrawing them from equipment racks. Essential precautions to prevent ESD damage when handling or working on modules are grounding straps for technical personnel and the provision of anti-static workbenches. Modules may only be shipped either in their original packing or installed in equipment racks.
Using HMI600 software

Caution The link gets disturbed while using the options 'Tuning & Testing', activating a testtone, simulating alarms, measurement of frequency response & equalization etc. of the HMI600. Appropriate measures have to be taken especially in case protection signal transmission is being used.

P1LP

DANGER Hazardous voltages and/or hazardous energy level at the heat sink.
Do not touch during operation.

DANGER Heat sink should not be touched with conducting materials to avoid energy discharges and damage of the power amplifier.

Caution Hot surface at heat sink

P4LT/P4LV/P4LX

DANGER Hazardous voltages and/or hazardous energy level on the module and the cable.
Do not touch the module and the cable leads.

R1BC

DANGER Hazardous voltages and/or hazardous energy level on the module and the cable.
Do not touch the module and the cable leads

O4LE, O4CV

DANGER The phone interfaces on the modules O4LE and O4CV generate dangerous voltages up to 100 V. Don’t use the modules without upper and lower cover plates. Do not touch the open pins of the service phone connector, the leads of its cable, the pins of the external cable connector and the leads of the external cable.

G4AI

DANGER Hazardous voltages and/or hazardous energy level on the module and the cable.
Do not touch the module and the cable leads.
Caution

Read the following safety instructions carefully before attempting to locate faults.

- Fault-finding may only be conducted by properly trained personnel that have been authorized to do so.
- It is not permitted to insert or withdraw modules during operation; the power supply must be switched off first.
- The modules contain CMOS integrated circuits that can be damaged by electrostatic discharge. It is important to take certain precautions to prevent electrostatic discharge before removing the packing or withdrawing them from the racks. Indispensable precautions to avoid ESD damage are earthing of people working on the modules and a working surface that is protected against electrostatic discharge. Only transport modules in their original packing or installed in racks.
- The modules are manufactured according to the latest SMD technology. Repair at the component level is therefore neither intended nor recommended. As a rule, corrective action is confined to locating and replacing defective modules.
- Dangerous voltages can occur on the connections to the modules DSP module P4LT/V/X, alarm relay module R1BC and teleprotection interface G4AI. Take care not to touch these connections under any circumstances.
- It is not permitted to modify the equipment in any way.

9.2. Alarms

The alarm concept of the ETL600 system is designed to

- detect and locate the sources responsible for abnormal operation of the system,
- provide information about the kind of problems detected.

Fig. 9-1 shows the six major fault locations of a PLC link. By combining the alarm information of both terminals of the link, it is possible to locate the source of a problem (Table 9-1).

Fig. 9-1 The six major fault location areas of a PLC link
### Table 9-1  Fault location of an ETL600 link

<table>
<thead>
<tr>
<th>Equipment A</th>
<th>Equipment B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hardware Alarm</td>
<td>Hardware Alarm</td>
</tr>
<tr>
<td>Interface Alarm</td>
<td>Interface Alarm</td>
</tr>
<tr>
<td>Link Alarm</td>
<td>Link Alarm</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Error caused by:</th>
</tr>
</thead>
<tbody>
<tr>
<td>- - - - - - -</td>
</tr>
<tr>
<td>- - - - - - -</td>
</tr>
<tr>
<td>- - - - - - -</td>
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<td>- - - - - - -</td>
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<td>- - - - - - -</td>
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<tr>
<td>- - - - - - -</td>
</tr>
</tbody>
</table>

Legend:
- Alarm present
- Alarm absent
x Don't care

### 9.2.1. Alarm concept

The concept distinguishes between alarms, warnings and events.

An alarm indicates that the ETL600 system is not functioning according to specification.

As shown in Fig. 9-2, alarms are generated by hardware components and by software processes of the local ETL600 terminal. Some alarms are exchanged between the local and the remote terminal.

A warning indicates that the ETL600 terminal is not in the normal operation state. An example for this is when the ETL600 terminal operates in a test mode.

An event is a snapshot of the alarm state of the ETL600 terminal recorded together with date and time.

The purpose of the alarms and warnings is to help the user in localization and identification of faults and abnormal operating conditions.
9.2.2. **Warnings**

Warnings are used to signal that an equipment is not in normal operation state, but otherwise working properly. Examples:

- Measurement of frequency response
- Tuning of RF filters
- Equipment running with temporary configuration
- Dummy load plugged

Warnings are collected and reported via the same mechanisms as alarms.

Warning LEDs are provided on the front panels of P4LT/V/X, O4LE, O4CV and G4AI. Their color is yellow.

9.2.3. **Grouping of alarms**

Alarms and warnings can be grouped acc. to several criteria (Fig. 9-3):

- **Service:** PLC, TPE1, TPE2, DATA
- **Hardware:** Circuit boards of the ETL600 terminal
- **Alarm source:** Hardware, Link, Interface

In Fig. 9-3,

- alarm groups are indicated with frames,
text entries in bold refer to top-level or high-level alarms.

dots show where low-level alarms and warnings signaled by ETL600 exist

9.2.4. Affected services

The services PLC, TPE1, TPE2 and DATA are distinguished:

- TPE1 alarms relate to the teleprotection subsystem #1 only, i.e. NSD600#1.
- TPE2 alarms relate to the teleprotection subsystem #2 only, i.e. NSD600#2.
- DATA alarms relate to data transmission only, i.e. the subsystems MOD600, MUX600, NSK600, LAN600 and associated data interfaces.
- PLC alarms relate to the core functions of the ETL600 terminal as well as to the services telephony, teleoperation, external teleprotection.
9.2.5. **Affected hardware**

The boards P4LT/V/X, O4LE, O4CV and G4AI each have own means to detect hardware faults. A transmitter alarm indicates faults in the RF units. The DC converter B5LD is supervised by monitoring the voltages of its supply outputs. Plug-out loops are provided for RF hybrid and Rx filter.

9.2.6. **Alarm source**

Apart from alarms caused by hardware faults, alarms can be caused by the state of the signals at the interface connectors.

The most important of these is the RF connector. A link alarm will be issued if the quality of the received RF signal is insufficient.

For other interface connectors, specific interface alarms are issued in case the ETL600 detects that the signal at the connector is out of specification. Examples of such signals are:

- IRIG-B synchronization input
- RS-232 data inputs
- Teleprotection command inputs and outputs

9.2.7. **Alarm hierarchy**

Four different hierarchic alarm levels can be distinguished:

- Top-level alarms/warnings
- High-level alarms/warnings
- Low-level alarms/warnings
- Detail alarms/warnings

9.2.7.1. **Top-level alarms/warnings**

These alarms/warnings relate to the ETL600 terminal as a whole. There are 5 such alarms/warnings: System or cabinet alarm, Link alarm, Hardware alarm, Interface alarm and Warning. LEDs on the front plate of P4LT/V/X show the status of each except Interface alarm. Relays with switchover contacts are provided on P4LT/V/X for the top-level System, Hardware and Link alarms.

Top-level alarms/warnings are derived from high-level alarms/warnings by combining high-level alarms/warnings as shown in Fig. 9-3.

9.2.7.2. **High-level alarms/warnings**

High-level alarms relate to services of the ETL600 terminal: PLC, TPE1, TPE2, DATA (Fig. 9-3).

Each high-level alarm is derived from a number of low-level alarms according to Fig. 9-4. Pickup and hold times are specified as follows:

- Hardware alarms: Pickup and hold times for hardware alarms can be entered via HMI600.
- Interface alarms: Same pickup and hold times as for hardware alarms are effective.
- Link alarms: Pickup and hold times for link alarms can be entered via HMI600.
- Warnings: A pickup time of 10 s and a hold time of 1 s are used for warnings.

Low-level alarms

<table>
<thead>
<tr>
<th>Pick up time</th>
<th>Hold time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low-level</td>
<td>High-level</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Fig. 9-4  Derivation of high-level alarms

9.2.7.3. Low-level alarms/warnings

Most low-level alarms/warnings are directly generated by a hardware device or a software process. However, some are derived by combining a number of detail alarms. This is the case for most alarms generated by the slave boards O4LE, O4CV and G4AI.

Low-level alarms/warnings are recorded by the event recorder and are contained in the polled alarm messages.

9.2.7.4. Detail alarms/warnings

Detail alarms/warnings are directly generated by a hardware device or a software process on the O4LE, O4CV and G4AI boards.

Detail alarms/warnings are neither recorded by the event recorder nor contained in the polled alarm messages. However, they are displayed in the HMI600 status and alarm views.

9.2.8. Alarm outputs

9.2.8.1. Alarm status display

The status display of HMI600 shows all alarms of all levels. In addition, the three User alarms (refer to section 9.2.8.3.2) are also shown.

9.2.8.2. LEDs

All alarm LEDs are red, Warning LEDs are yellow. There are alarm/warning LEDs on the front plate of the following boards: P4LTV/X, G4AI, O4LE, O4CV, E5TH, E5TC.

All alarm and warning LEDs are switched on/off only after the corresponding pickup or hold time has elapsed, refer to section 9.2.7.2.
9.2.8.2.1. **LEDs on P4LT/V/X**

Refer to Table 9-2.

<table>
<thead>
<tr>
<th>LED</th>
<th>Colour</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>RDY</td>
<td>Green:</td>
<td>Lights continuously while the system is in normal operating condition. Otherwise it is flashing.</td>
</tr>
<tr>
<td></td>
<td>Yellow</td>
<td>Lights up when the top-level <strong>Warning</strong> is active.</td>
</tr>
<tr>
<td>SYS</td>
<td>Red</td>
<td>Lights up when the top-level <strong>SYSTEM alarm</strong> is active.</td>
</tr>
<tr>
<td>LNK</td>
<td>Red</td>
<td>Lights up when the top-level <strong>LINK alarm</strong> is active.</td>
</tr>
<tr>
<td>HW</td>
<td>Red</td>
<td>Lights up when the top-level <strong>HARDWARE alarm</strong> is active.</td>
</tr>
<tr>
<td>P4LT P4LV P4LX</td>
<td>Red</td>
<td>Lights up when <strong>P4LT/V/X hardware alarm</strong> or <strong>P4LT/V/X interface alarm</strong> is active.</td>
</tr>
</tbody>
</table>

Table 9-2 The six LEDs on the front plate of P4LT/V/X

9.2.8.2.2. **Alarm LED on G4AI**

The G4AI alarm LED (red) lights when a hardware alarm or an interface alarm has been detected on the board.

9.2.8.2.3. **Alarm LED on O4LE**

The O4LE alarm LED (red) lights when a hardware alarm has been detected on the board (There are no interface alarms for the O4LE board).

9.2.8.2.4. **Alarm LED on O4CV**

The O4CV alarm LED (red) lights when a hardware alarm has been detected on the board (There are no interface alarms for the O4CV board).

9.2.8.2.5. **Alarm LED on E5TH and on E5TC**

These red LEDs signal a Tx level alarm. They light up if the level of the RF transmit signal is lower than an adjustable threshold.

9.2.8.3. **Alarm relays**

Electromechanical relays are specially suited for alarms because closed relay contacts can signal an alarm even if the system is not powered. There are alarm relays on the following boards: P4LT/V/X, R1BC, G4AI, O4LE.
9.2.8.3.1. *Alarm relays on P4LT/V/X*

The three alarm relays on P4LT/V/X are equipped with switchover contacts and controlled by three top-level alarms:

- SYSTEM or CABINET alarm,
- HARDWARE alarm,
- LINK alarm.

The relays are de-energized if the respective alarms are present.

9.2.8.3.2. *Alarm relays on R1BC*

R1BC is an optional alarm relay board with 8 relays mounted on the backplane of ETL600. Each relay has one switchover contact and is controlled by one of the three alarms “User alarm 1”, “User alarm 2” or “User alarm 3” by inserting appropriate jumpers on R1BC. The user alarms are individually configurable by means of HMI600 to any combination of high-level alarms and warnings of the local and the remote ETL600 terminal. As shown in Fig. 9-2, the high-level alarms of the remote terminal are transmitted via EOC to the local terminal.

Pickup and hold times of the three user alarms can be configured by HMI600 for each alarm independently.

9.2.8.3.3. *Alarm relays on G4AI*

There are two relays on G4AI. A normally closed contact is available for each relay by inserting appropriate jumpers on G4AI. HMI600 allows to individually select the alarm that controls each relay from the following lists:

- G4AI for TPE1: G4AI for TPE2:
  - TPE1 alarm
  - TPE1 hardware alarm
  - TPE1 link alarm
  - G4AI alarm
  - User alarm 1
  - User alarm 2

For the User alarms, refer to section 9.2.8.3.2.

The G4AI alarm (= G4AI hardware alarm OR G4AI interface alarm) is detected on the module itself. The same pick up and hold times as for the high level alarms are applicable for this output signal, refer to section 9.2.7.2.

9.2.8.3.4. *Alarm relay on O4LE*

The alarm relay on O4LE is called “PAX blocking”, because its intended use is to signal to a telephone exchange connected to O4LE whether the telephone channel is available. Therefore, this relay is controlled by the PLC link alarm of the APLC channel carrying the telephony service.
9.2.9. **Alarm polling**

The alarm polling facility of HMI600 accessible under the menu item **Network** allows to get a quick overview of the alarm state of all terminals of an ETL600 element management network. The alarms of all connected terminals are recorded in a PC under control of the HMI600 program.

Once the list of devices to be polled has been entered under **Network / List of devices**, the alarm polling for the network can be switched on and off with a single keystroke **Ctrl+A**. Alternatively, this can be done with **Network / Alarm Polling On/Off**. With alarm polling enabled, all devices on the list are polled by HMI600 at specified intervals (daily, hourly, every xx minutes) as specified under **Network / Set interval of Multi Alarm Polling** and the alarms coming back – if any – written to files (one file per day) with date- and timestamps supplied by the PC. The recorded alarms can be viewed in several ways with the functions under **Network / Alarm list**.

When LAN600 settings have been changed such that the recorded alarms are affected, the new LAN600 settings will be ignored for alarm polling when it has been activated before the LAN600 settings have been changed. In this case, the function **Equipment / LAN600 / Restart alarm polling** can be used to make the new LAN600 settings effective.

If a device cannot be reached, a communication error will be recorded for that device.

All alarms except detail alarms are collected via alarm polling. These are:

- Alarms and warnings referring to the P4LT/V/X-board.
- For each configured O4LE-board:
  - One HW alarm and one warning.
- For each configured O4CV-board:
  - One HW alarm and one warning.
- For each configured G4AI-board:
  - Two HW alarms, two interface alarms and one warning.

**Detail alarms are accessible only via equipment status upload.**

Note: A mixed alarm polling operation mode with ETL500 and ETL600 devices - both polled by the HMI600 alarm polling facility - is possible. Nevertheless the low level alarm messages of the ETL500 may differ from those of the ETL600 system (please check the corresponding Instruction Manual Chapter 9 for explanation and corrective actions).
9.2.10. **Alarm event recorder**

All alarms/warnings except detail alarms are recorded as events in non-volatile memory on P4LT/V/X. An alarm event is a snapshot of the ETL600 alarm state together with a date/time stamp. The recorded events can be uploaded to the PC and viewed with the help of the HM600 program.

The event recorder is described in section 3.8.

9.3. **Some basic checks**

It is advisable to do the following basic checks **before energizing a PLC link**. This minimises the chances of a fault in the first place and also reduces the time of troubleshooting in case there is any.

- It is essential to check the communication line (as described in Chapter 7) especially in the frequency band in which the PLC link will be used.
- In case modems are used to access P4LT/V/X, it essential to first check the communications over modems before really trying to access the equipment. Often the faults are found in wrong settings of the modem.
- Ensure that the coaxial cable is properly connected to the equipment. Check whether the supply voltage to be applied to the equipment is correct.
- Ensure that all the modules are properly inserted in their correct slots.
- Check that the external connections are correct as per plant drawings.

9.3.1. **Internal teleprotection equipment**

9.3.1.1. **Loop test**

When in operation, the unit can be tested with the aid of the loop test. The signal used for this test has the same parameters (security and dependability) as the command configured for the application with the highest requirements regarding security.

It can be initiated manually at any time by choosing the **Equipment** menu, pointing to **Commissioning and maintenance** and clicking **NSD600 send looptest**.

It can also be executed automatically every 1, 3, 6, 12 or 24 hours by correspondingly configuring the NSD600 in its **TPE** tab.

9.3.1.2. **Local test mode**

The NSD600 can be set to a local operating mode for checking the relay interfaces, e.g. for measuring command prolongation. In this operating mode, which is indicated by a warning message in the status...
display and the warning LED on the P4LT/V/X module, the command input signal is looped by the processor back to the command output of the local teleprotection interface.

9.3.1.3. **Event Recorder and Command Counters**

The integrated event recorder and the counters for each command support investigations in case of faults or abnormal conditions in the high voltage network. The event recorder can be synchronized to an external GPS receiver for accurate time stamping in all the different locations where ETL600 equipment is used. Therefore it is possible to directly compare and analyze the logs of several ETL600/NSD600 devices in a network where a failure occurred. The display of events is possible in text and graphical views on the HMI600.

Refer to section 3.8 for a detailed description of the event recorder.

9.4. **Frequently asked questions**

**Question:** The 'Connect' operation is not successful. What can I do to correct this problem?

**Answer:** Check all hardware and its settings forming the communication path, starting at the PC and ending at the equipment. The section 'Communication to the ETL600' in chapter 4 gives the relevant information. If the communication path is made up of several sections as in case of connection via modem, intranet/internet, dedicated data channel and/or via EOC, proceed in steps, checking the path sections in sequence starting at the side of the PC.

**Question:** The PLC link doesn't work. What can I do to correct this problem?

**Answer:** Check the alarms: If there is a hardware alarm at either side of the link, the reason of it must be found and the problem corrected. Upload the equipment status and study the alarm messages given by the HMI600. One single problem can produce a number of such messages.

If for both equipments of the link no hardware alarms are reported (anymore), the problem has to be sought in the link. Upload the equipment status and study the alarm messages given by the HMI600. It is helpful if it is possible to restrict the problem to one of the following 3 cases:

1. Excessive signal attenuation,
2. Excessive line noise,
3. Excessive distortion.

Case 1: Check the RF settings ([Configuration / System / Channel settings](#)) and the hardware on the RF-side. Check the tuning of the RF transmit and receive filters and the adjustment of the Rx RF level.
potentiometer. Work along the RF path: RF cables, RF terminating plate, RF coupling filter. Check the frequency response of the line.

Case 2: The level of the line noise is given by the high voltage line itself and by the atmospheric conditions along the line. The only way to combat the noise is to increase the RF signal power or to reduce the RF signal bandwidth.

Case 3: Look out for other equipment parallel PLC terminals connected to the same line. Check for signal saturation in the RF signal path.

Question: Some alarms are present, signaled by alarm relay contacts and/or alarm LEDs.

Answer: Upload status data to see the details about the causes of the alarms. If both hardware and link alarms are present, first remove the cause of the hardware alarm. After this has been done, upload system status once again and – if a link alarm should still be present – find the cause of the link alarm. Check whether the alarm threshold levels are appropriate.

Question: How are the outputs on the Teleprotection Interface G4AI operated, if they are configured as alarm outputs? And what about the LEDs of the outputs on the front panel?

Answer: The relay contacts on G4AI are operated in the same way than the alarm relays on the DSP module P4LT/V/X or on the Alarm Relay Module R1BC, i.e. the “alarm” condition is the same as the “power off” state of the equipment (relay coil not energized). On all modules the user can still choose – by using the corresponding output contacts - whether the alarm contact shall be “normally open” or “normally closed”.

The solid-state outputs on G4AI are operated differently. An alarm condition is signaled with a conducting (energized) FET. Therefore the “alarm” condition is not the same as the “power off” state of the equipment.

Both type of output contacts are activated only after the programmed alarm delay time has elapsed. The same applies for the alarm hold time.

The LEDs of the outputs on G4AI correspond with the state of the contacts, i.e. they also light up only if the alarm delay time has elapsed and they will light on for the duration of the alarm hold time.

Question: Data communication over NSK600 modems with datarates of 2400 bps or higher doesn’t work. What could be the reason?

Answer: NSK600 modems with datarates of 2400 bps or higher require equalization of the APLC channel used by the modem for proper operation. Channel equalization is done with the help of all-pass filter and APLC channel equalizer or with adaptive equalizers.
Refer to document 1KHW001494 “APLC Channel equalization” in the Annex for details.

9.5. **List of alarms and corrective actions**

In what follows, lists of alarm text messages and their corresponding explanation and fault elimination instructions (*in italic*) are given for each alarm category PLC, TPE and DATA.

9.5.1. **PLC**

9.5.1.1. **PLC hardware alarm**

<table>
<thead>
<tr>
<th>HMI600 Alarm Text</th>
<th>Explanation and corrective actions (the latter in italics)</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Frontend DSP stopped working</td>
<td>The Frontend DSP / Upconverter DSP / NSD600 DSP / NSK600 DSP / MOD600 DSP on P4LT/V/X stopped working for more than 1 s longer than the configured pickup time for hardware alarms, followed by an automatic reset of the system. The reason can be faulty P4LT/V/X hardware or excessive EMI, possibly in combination with poor substation grounding and/or not properly grounded cable shields. <strong>Connect the shields of cables to ETL600 to ground as described in chapter 6. Improve the grounding of ETL600, specially the connections between the buried earth grid and substation ground, substation ground and cabinet, cabinet and (swing) frame, (swing) frame and equipment rack.</strong> If external EMI effects can be excluded and the error message appears repeatedly, replace P4LT/V/X.</td>
</tr>
<tr>
<td>• Upconverter DSP stopped working</td>
<td></td>
</tr>
<tr>
<td>• NSD600 DSP stopped working</td>
<td></td>
</tr>
<tr>
<td>• NSK600 DSP stopped working</td>
<td></td>
</tr>
<tr>
<td>• MOD600 DSP stopped working</td>
<td></td>
</tr>
<tr>
<td>• Master DSP program memory CRC error</td>
<td>A memory error has been detected in the memory of the Master DSP / Frontend DSP / Upconverter DSP / NSD600 DSP / NSK600 DSP on P4LT/V/X. The reason can be faulty P4LT/V/X hardware or excessive EMI, possibly in combination with poor substation grounding and/or not properly grounded cable shields. <strong>Connect the shields of cables to ETL600 to ground as described in chapter 6. Improve the grounding of ETL600, specially the connections between the buried earth grid and substation ground, substation ground and cabinet, cabinet and (swing) frame, (swing) frame and equipment rack.</strong> If external EMI effects can be excluded and the error message appears repeatedly, replace P4LT/V/X.</td>
</tr>
<tr>
<td>• Frontend DSP program memory CRC error</td>
<td></td>
</tr>
<tr>
<td>• Upconverter DSP program memory CRC error</td>
<td></td>
</tr>
<tr>
<td>• NSD600 DSP program memory CRC error</td>
<td></td>
</tr>
<tr>
<td>• NSK600 DSP program memory CRC error</td>
<td></td>
</tr>
<tr>
<td>HMI600 Alarm Text</td>
<td>Explanation and corrective actions (the latter in italics)</td>
</tr>
<tr>
<td>--------------------------------</td>
<td>-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>• Right power supply failed</td>
<td>The indicated power supply B5LD is not working properly. Check for overload by removing the module R1BC (mounted on the backplane of P7LH or P7LF) and the modules in the subrack P7LH or P7LF sequentially until only the power supply B5LD and P4LT/V/X are left in the subrack. Unplug all cables to P4LT/V/X. Replace B5LD. If the error persists, replace P4LT/V/X.</td>
</tr>
<tr>
<td>• Left power supply failed</td>
<td></td>
</tr>
<tr>
<td>• +12 V undervoltage</td>
<td>Undervoltage detected on the +12 V / −12 V / +5 V rails supplied by the power supply B5LD. Check for overload on the +12 V / −12 V / +5 V supplies by removing the module R1BC (mounted on the backplane of P7LH or P7LF) and the modules in the subrack P7LH or P7LF sequentially until only the power supply B5LD and P4LT/V/X are left in the subrack. Unplug all cables to P4LT/V/X. Replace B5LD. If the error persists, replace P4LT/V/X.</td>
</tr>
<tr>
<td>• -12 V undervoltage</td>
<td></td>
</tr>
<tr>
<td>• +5 V undervoltage</td>
<td></td>
</tr>
<tr>
<td>• +12 V overvoltage</td>
<td>Overvoltage detected on the +12 V / −12 V / +5 V rails supplied by the DC-DC converter B5LD. Replace the DC-DC converter B5LD. If the error persists, replace P4LT/V/X.</td>
</tr>
<tr>
<td>• -12 V overvoltage</td>
<td></td>
</tr>
<tr>
<td>• +5 V overvoltage</td>
<td></td>
</tr>
<tr>
<td>• +3.3 V undervoltage</td>
<td>Over- or undervoltage detected on the +3.3 V / 1.8 V rails on P4LT/V/X. Disconnect all cables to P4LT/V/X. Switch off the power to ETL600 and switch it on again after some seconds. If the error persists, replace P4LT/V/X.</td>
</tr>
<tr>
<td>• +3.3 V overvoltage</td>
<td></td>
</tr>
<tr>
<td>• +1.8 V undervoltage</td>
<td></td>
</tr>
<tr>
<td>• +1.8 V overvoltage</td>
<td></td>
</tr>
<tr>
<td>• Event recorder not operational</td>
<td>Storing of events to the nonvolatile flash memory wasn’t successful. Check if a valid data key is mounted on P4LT/V/X. Make sure that no firmware download is in progress. Switch off the power to ETL600 and switch it on again after some seconds. If the error persists, replace P4LT/V/X.</td>
</tr>
</tbody>
</table>
## Troubleshooting

<table>
<thead>
<tr>
<th>HMI600 Alarm Text</th>
<th>Explanation and corrective actions (the latter in italics)</th>
</tr>
</thead>
</table>
| **RF receiver input overdriven** | The RF receive signal to P4LT/V/X exceeds the maximum allowed level. The reasons can be  
- Excessive noise on the power line,  
- Distortion produced by parallel PLC transmitters,  
- Distortion produced by the own transmitter,  
- Poor return loss seen into the coupling device,  
- Insufficient selectivity of the Rx filter or – if no Rx filter is used – of the Tx filter.  
*Twist the Rx level potentiometer on the RF hybrid slowly anticlockwise until the alarm disappears. If the alarm persists or if the link performance (SNR, datarates) is not satisfying, repeat the following Tuning and Testing procedures:*  
- Tune Tx RF filter,  
- Adjust Tx RF level,  
- Adjust Tx alarm level,  
- Tune Rx RF filter,  
- Adjust Rx RF level,  
*Then repeat the commissioning procedure as described in chapter 7.* |
| **No valid data key** | The data key is missing or it doesn’t cover the configured services of ETL600.  
*Insert a data key onto P4LT/V/X that covers the configured services.* |
| **RF receive filter missing** | The receive filter P4RX on position in rack P7LH or P7LF has been removed. This will degrade the performance of the link due to missing selectivity in the receive signal path.  
*Reinsert P4RX or - when the filter is not necessary for the application - disable P4RX presence detection in the menu 'Alarm settings'.* |
| **O4LE hardware alarm** | At least one of the O4LE boards reports an alarm.  
*Switch off the power to ETL600 and switch it on again after some seconds. If the error persists, find the faulty O4LE board(s) by studying the TDM bus communication alarms (section 9.5.4). Replace the faulty O4LE board(s).* |
| **O4LE board missing** | At least one configured O4LE board doesn’t answer or is not plugged at the correct position in the rack.  
*Verify if all boards are firmly plugged in at the correct positions in the rack P7LH/P7LF according to HMI600 (View / Display configuration). Switch off the power to ETL600 and switch it on again after some seconds. If the error persists, find the faulty O4LE board(s) by studying the TDM bus communication alarms (section 9.5.4). Replace the faulty O4LE board(s).* |
### HMI600 Alarm Text

#### Explanation and corrective actions (the latter in italics)

<table>
<thead>
<tr>
<th>HMI600 Alarm Text</th>
<th>Explanation and corrective actions (the latter in italics)</th>
</tr>
</thead>
<tbody>
<tr>
<td>• O4CV hardware alarm</td>
<td>At least one of the O4CV boards reports an alarm. <strong>Switch off the power to ETL600 and switch it on again after some seconds. If the error persists, find the faulty O4CV board(s) by studying the TDM bus communication alarms (section 9.5.4). Replace the faulty O4CV board(s).</strong></td>
</tr>
<tr>
<td>• O4CV board missing</td>
<td>At least one configured O4CV board doesn’t answer or is not plugged at the correct position in the rack. <strong>Verify if all boards are firmly plugged in at the correct positions in the rack P7LH/P7LF according to HMI600 (View / Display configuration). Switch off the power to ETL600 and switch it on again after some seconds. If the error persists, find the faulty O4CV board(s) by studying the TDM bus communication alarms (section 9.5.4). Replace the faulty O4CV board(s).</strong></td>
</tr>
<tr>
<td>• Low RF level at power amplifier output</td>
<td>The RF transmit signal measured at the RF hybrid is below threshold or missing or the Tx alarm level is misadjusted. <strong>Check the transmit signal path and/or readjust the alarm threshold as described in menu Tuning and testing / Adjust Tx alarm level.</strong></td>
</tr>
</tbody>
</table>

### 9.5.1.2. PLC link alarms

#### Explanation and corrective actions (the latter in italics)

<table>
<thead>
<tr>
<th>HMI600 Alarm Text</th>
<th>Explanation and corrective actions (the latter in italics)</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Low SNR in channel 1</td>
<td>The signal to noise ratio is below the alarm threshold on APLC channel 1/2/3. The reasons may be excessive noise on the power line or high attenuation of the RF signal on the power line. <strong>Reduce the SNR alarm threshold (Configuration / System / Alarm settings / SNR level APLC channel 1/2/3) and/or increase the Tx power of the remote terminal.</strong></td>
</tr>
<tr>
<td>• Low SNR in channel 2</td>
<td></td>
</tr>
<tr>
<td>• Low SNR in channel 3</td>
<td></td>
</tr>
<tr>
<td>• No Rx pilot detected in channel 1</td>
<td>ETL600 received no pilot on channel 1/2/3. <strong>Make sure that the channel settings of both link terminals match and that the signal attenuation of the power line is as expected.</strong></td>
</tr>
<tr>
<td>• No Rx pilot detected in channel 2</td>
<td></td>
</tr>
<tr>
<td>• No Rx pilot detected in channel 3</td>
<td></td>
</tr>
<tr>
<td>• Low Rx pilot level in channel 1</td>
<td>The Rx pilot level on channel 1/2/3 is below the alarm threshold. <strong>Make sure that the channel settings of both link terminals match. Check the received pilot level (Equipment / Upload status). Correct the pilot level alarm threshold (Configuration / System / Alarm settings / Pilot level APLC channel 1/2/3)</strong></td>
</tr>
<tr>
<td>• Low Rx pilot level in channel 2</td>
<td></td>
</tr>
<tr>
<td>• Low Rx pilot level in channel 3</td>
<td></td>
</tr>
</tbody>
</table>
### 9.5.1.3. PLC interface alarms

<table>
<thead>
<tr>
<th>HMI600 Alarm Text</th>
<th>Explanation and corrective actions (the latter in italics)</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Date mismatch between int. and ext. clock</td>
<td>The date information from the on-board RTC and the external IRIG source are contradictory. Set the time of the on-board RTC to the correct data by means of HMI600.</td>
</tr>
<tr>
<td>• No ext. real time clock sync. signal detected</td>
<td>The signal for the external IRIG source can not be detected anymore. Check the IRIG source and the cable connection.</td>
</tr>
</tbody>
</table>

### 9.5.1.4. PLC warnings

<table>
<thead>
<tr>
<th>HMI600 Alarm Text</th>
<th>Explanation and corrective actions (the latter in italics)</th>
</tr>
</thead>
<tbody>
<tr>
<td>• EOC communication failure</td>
<td>The transmission of data via embedded operation (EOC) channel 1 is disturbed. Make sure that identical firmware versions are in use in both local and remote equipments. Check if the quality of the receive signal in terms of SNR and receive level is adequate. Reset ETL600. If the error persists, replace P4LT7V/X.</td>
</tr>
<tr>
<td>• Could not receive data from EOC</td>
<td></td>
</tr>
<tr>
<td>• Could not send data to EOC</td>
<td></td>
</tr>
<tr>
<td>HMI600 Alarm Text</td>
<td>Explanation and corrective actions (the latter in italics)</td>
</tr>
<tr>
<td>-------------------</td>
<td>----------------------------------------------------------</td>
</tr>
<tr>
<td>• AGC or pilot(s) switched off or tuning tone(s) switched on</td>
<td>At least one of the tests switches under <strong>Equipment / Tuning and Testing / Test PLC-link</strong> or <strong>Equipment / Commissioning and maintenance / Test PLC-link</strong> is active.</td>
</tr>
</tbody>
</table>
| • Equipment in tuning or testing mode | The ETL600 is not in normal operation mode. Reasons for that might be  
- any test switch is active,  
- any Tuning and Testing procedure is ongoing,  
- frequency response measurement is ongoing,  
- Local RF loopback is active |
| • Different firmware versions on local and remote equipment | Different firmware versions on local and remote equipment are in use.  
*Use identical firmware in both equipments.* |
| • Active configuration not stored to EPROM | A test configuration is active which will be lost when the associated test configuration timer runs out.  
*Store the configuration to EPROM, stopping the test configuration timer, or reset the system, thereby overwriting the test configuration.* |
| • Local RF loopback on | The local loopback has been activated.  
*When the tests are terminated, deactivate the local loopback via HMI600.* |
| • O4LE warning | A warning is present on at least one of the O4LE boards.  
*Check O4LE status for detailed information.* |
| • O4CV warning | A warning is present on at least one of the O4CV boards.  
*Check O4CV status for detailed information.* |
| • Power amplifier warning | P4LT/V/X receives a warning from the power amplifier. One of the two 50 W amplifiers P1LP used to generate the 100 W output may be faulty.  
*Replace the faulty modules* |
| • Event recorder block rotation | The event recorder has performed a block rotation. This happens automatically if the nonvolatile memory assigned to the event recorder is full. Some of the memory is freed by discarding the oldest recorded events. |
| • Channel measurement for equalizer in progress | The frequency response measurement is in progress either from local end or remote end.  
*The alarm will disappear when the measurement is complete or use 'Interrupt remote activity' option to stop the measurement.* |
### 9.5.1.5. O4LE detail alarms

<table>
<thead>
<tr>
<th>HMI600 Alarm Text</th>
<th>Explanation and corrective actions (the latter in italics)</th>
</tr>
</thead>
</table>
| • TDM bus communication failure | Communication with the P4LT/V/X board is disturbed.  
*Make sure that the board is firmly plugged in. Unplug the board and check if all pins of the connector to the backplane are present and not bent. If the error message appears repeatedly, replace the O4LE board.* |
| • Initialization of UART failed | The UART / PLL is not / the CODECS are not properly working.  
*Switch off the power to ETL600 and switch it on again after some seconds. If the error persists, replace the faulty O4LE.* |
| • Initialization of PLL failed | |
| • Initialization of CODECs failed | |
| • Data exchange error at CODECs | |

### 9.5.1.6. O4LE detail warnings

<table>
<thead>
<tr>
<th>HMI600 Alarm Text</th>
<th>Explanation and corrective actions (the latter in italics)</th>
</tr>
</thead>
</table>
| • Active configuration not stored to EPROM | A test configuration for the board is active which will be lost when the associated test configuration timer runs out.  
*Store the configuration to EPROM, stopping the test configuration timer, or reset the system, thereby overwriting the test configuration timer.* |
| • Overload detected: service phone and subscriber not operational | The 2-wire subscriber or service phone port is overloaded.  
*Unplug the wires connected to the ports. Check the wires for short circuits and check the subscriber and service telephone sets. If the error persists, replace the board.* |

### 9.5.1.7. O4CV detail alarms

<table>
<thead>
<tr>
<th>HMI600 Alarm Text</th>
<th>Explanation and corrective actions (the latter in italics)</th>
</tr>
</thead>
</table>
| • TDM bus communication failure | Communication with the P4LT/V/X board is disturbed.  
*Make sure that the board is firmly plugged in. Unplug the board and check if all pins of the connector to the backplane are present and not bent. If the error message appears repeatedly, replace the O4CV board.* |
| • No valid voice key | The voice key plugged onto the O4CV board is missing or invalid.  
*Plug in a valid O4CV voice key.* |
<table>
<thead>
<tr>
<th>HMI600 Alarm Text</th>
<th>Explanation and corrective actions (the latter in italics)</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Insufficient voice key</td>
<td>The voice key plugged onto the O4CV board is not sufficient for the configured services of the board.</td>
</tr>
<tr>
<td></td>
<td><strong>Plug in an O4CV voice key covering the configured services.</strong></td>
</tr>
<tr>
<td>• DC voltage present on FXS interface</td>
<td>A DC voltage is applied to a 2-wire interface configured for connection to a telephone set.</td>
</tr>
<tr>
<td></td>
<td><strong>Ensure that no PAX is connected to a 2-wire interface which is configured as &quot;Hot line direct phone&quot; or &quot;Remote subscriber&quot; and reset the O4CV board.</strong></td>
</tr>
<tr>
<td>• Emergency firmware is active</td>
<td>The firmware in the flash memory of the board is invalid.</td>
</tr>
<tr>
<td></td>
<td><strong>Download a valid O4CV firmware.</strong></td>
</tr>
<tr>
<td>• Initialization of software application failed</td>
<td>The initialization of the board was not successful.</td>
</tr>
<tr>
<td>• Initialization of SLIC parameter table failed</td>
<td><strong>Switch off the power to ETL600 and switch it on again after some seconds. If the error persists, download a valid O4CV firmware.</strong></td>
</tr>
<tr>
<td>• Run-time error in application software</td>
<td>An error occurred during operation of the board.</td>
</tr>
<tr>
<td>• Run-time error on 2-wire interface bus</td>
<td><strong>Switch off the power to ETL600 and switch it on again after some seconds. If the error persists, download a valid O4CV firmware.</strong></td>
</tr>
<tr>
<td>• Over-temperature on components of 2-wire interface measured</td>
<td>At least one of the 2-wire subscriber, hot line direct telephone or service phone ports is overloaded.</td>
</tr>
<tr>
<td></td>
<td><strong>Unplug the wires connected to the ports. Check the wires for short circuits and check the subscriber and telephone sets. If the error persists, replace the board.</strong></td>
</tr>
<tr>
<td>• Memory CRC error</td>
<td>A memory error has been detected in the memory of the DSP on O4CV. The reason can be faulty O4CV hardware or excessive EMI, possibly in combination with poor substation grounding and/or not properly grounded cable shields.</td>
</tr>
<tr>
<td></td>
<td><strong>Connect the shields of cables to ETL600 to ground as described in chapter 6. Improve the grounding of ETL600, specially the connections between the buried earth grid and substation ground, substation ground and cabinet, cabinet and (swing) frame, (swing) frame and equipment rack.</strong></td>
</tr>
<tr>
<td></td>
<td><strong>If external EMI effects can be excluded and the error message appears repeatedly, replace the O4CV board.</strong></td>
</tr>
</tbody>
</table>
### HMI600 Alarm Text | Explanation and corrective actions (the latter in italics)
---|---
- Slot mismatch between configuration and rack position | The board is not plugged at the correct position in the rack. Verify that the board is plugged in at the correct position in the rack P7LH/P7LF according to HMI600 (View / Display configuration).

### 9.5.1.8. O4CV detail warnings

<table>
<thead>
<tr>
<th>HMI600 Alarm Text</th>
<th>Explanation and corrective actions (the latter in italics)</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Temporary configuration is active</td>
<td>A test configuration for the board is active which will be lost when the associated test configuration timer runs out. Store the configuration to EPROM, stopping the test configuration timer, or reset the system, thereby overwriting the test configuration timer.</td>
</tr>
<tr>
<td>• Default configuration is active</td>
<td>There is no valid configuration in the flash memory. Download a configuration.</td>
</tr>
</tbody>
</table>
| • Synchronization failure on Ch x | Synchronization not possible on channel x. No valid voice data frames received. Incorrect configuration of digital transit or missing/defective O4CV on remote end.  

**Note:** For this warning, the O4CV warning LED is not activated, as it indicates a problem in a remote equipment or link.  

Check if all O4CV boards in the terminals using digital transit are present and operational. Check the digital transit cables and the digital transit configuration of these terminals using the rules given in section 5.3.6 (Configuration / Services / Compressed telephony / Transit operation mode and Configuration / MUX600). |
| • AIS detected on Ch x | Alarm indication signal detected on channel x. Digital transit or PLC link failure on previous link.  

**Note:** For this warning, the O4CV warning LED is not activated, as it indicates a problem in a remote equipment or link.  

Verify if all links involved in digital transit communication with the local link are operational. Check the digital transit cables and the digital transit configuration of the terminals of these links using the instructions in section 5.3.6 (Configuration / Services / Compressed telephony / Transit operation mode and Configuration / MUX600). |
9.5.2. **Data**

9.5.2.1. **Data hardware alarms**

<table>
<thead>
<tr>
<th>HMI600 Alarm Text</th>
<th>Explanation and corrective actions (the latter in italics)</th>
</tr>
</thead>
</table>
| • NSK600 DSP stopped working | The NSK600 DSP / MOD600 DSP on P4LT/V/X stopped working for more than 1 s longer than the configured pickup time for hardware alarms, followed by an automatic reset of the system. The reason can be faulty P4LT/V/X hardware or excessive EMI, possibly in combination with poor substation grounding and/or not properly grounded cable shields.  
*Connect the shields of cables to ETL600 to ground as described in chapter 6. Improve the grounding of ETL600, specially the connections between the buried earth grid and substation ground, substation ground and cabinet, cabinet and (swing) frame, (swing) frame and equipment rack.*  
*If external EMI effects can be excluded and the error message appears repeatedly, replace P4LT/V/X.* |
| • MOD600 DSP stopped working | A memory error has been detected in the memory of the NSK600 DSP on P4LT/V/X. The reason can be faulty P4LT/V/X hardware or excessive EMI, possibly in combination with poor substation grounding and/or not properly grounded cable shields.  
*Connect the shields of cables to ETL600 to ground as described in chapter 6. Improve the grounding of ETL600, specially the connections between the buried earth grid and substation ground, substation ground and cabinet, cabinet and (swing) frame, (swing) frame and equipment rack.*  
*If external EMI effects can be excluded and the error message appears repeatedly, replace P4LT/V/X.* |
| • NSK600 DSP program memory CRC error | The FPGA on P4LT/V/X is not operational.  
*Reset the system. If the error persists, replace P4LT/V/X.* |
| • FPGA not operational | The Piggyback board on P4LV/X is not operational.  
*Check the if the piggyback board on P4LV/X is correctly mounted and that the connection pins to the main board are not bent and inserted in the associated sockets. If this doesn’t help, replace P4LV/X.* |
| • Piggyback on P4LV/X missing or wrong type | In both terminals of the link, MOD600 is configured as Master. MOD600 might work for a while but suddenly fail.  
*Set the MOD600 operation mode to Slave in one of the link terminals (Configuration / Configure MOD600 / Operating Mode).* |
### Data link alarms

<table>
<thead>
<tr>
<th>HMI600 Alarm Text</th>
<th>Explanation and corrective actions (the latter in italics)</th>
</tr>
</thead>
</table>
| • No MOD600 pilots detected | No MOD600 pilots have been detected.  
Make sure that  
- the channel settings of both link terminals match,  
- one link terminal has the MOD600 operational mode set to 'Master', the other to 'Slave',  
- the status of the remote MOD600 is 'On'  
(Configuration / MOD600 / Signal settings / Status). |
| • MOD600 synchronization failed | MOD600 data transmission is stopped because the local MOD600 receiver can’t synchronize to the signal arriving from the remote MOD600 Tx.  
Make sure that  
- the MOD600 settings of both link terminals match,  
- the received signal quality in terms of SNR is at least as high as required for the configured MOD600 gross data rate.  
- one link terminal has the MOD600 operational mode set to 'Master', the other to 'Slave',  
- the status of the remote MOD600 is ‘On’  
(Configuration / MOD600 / Signal settings / Status). |
| • NSK600 modem 1 low SNR  
• NSK600 modem 2 low SNR  
• NSK600 modem 3 low SNR  
• NSK600 modem 4 low SNR | The signal quality measured by the NSK600 modem 1/2/3/4 Rx is inadequate for data transmission with reasonable performance.  
Check the signal quality displayed in the status view. A value below 18 means inadequate signal quality. The reasons might be excessive line noise and/or nonlinear distortion.  
Try to improve the channel equalization described in the annex document 1KHW001494 e.g. by:  
- switching on channel equalization if not yet done;  
- redoing the frequency response measurement in case static APLC channel equalization is used;  
- enabling/disabling the adaptive equalizer. This is only possible for DAPSK channels. |
<table>
<thead>
<tr>
<th>HMI600 Alarm Text</th>
<th>Explanation and corrective actions (the latter in italics)</th>
</tr>
</thead>
<tbody>
<tr>
<td>• NSK600 modem 1 no Rx signal detected</td>
<td>The NSK600 modem 1/2/3/4 doesn't detect a valid Rx signal. The alarm is not available for NSK600 FSK channels unless flow control set to “CTS always on”. Verify the presence of the Rx signal <em>(Equipment / Commissioning and maintenance / Measure AF)</em>. Make sure that - the remote equipment is operational and correctly configured, - the communication channel is not interrupted.</td>
</tr>
<tr>
<td>• NSK600 modem 2 no Rx signal detected</td>
<td></td>
</tr>
<tr>
<td>• NSK600 modem 3 no Rx signal detected</td>
<td></td>
</tr>
<tr>
<td>• NSK600 modem 4 no Rx signal detected</td>
<td></td>
</tr>
<tr>
<td>• MUX600 frame synchronization failure</td>
<td>MUX600 has lost frame synchronization. All data channels handled by MUX600 are interrupted. Reasons can be: - MOD600 data transmission is interrupted, - High BER for MOD600 data transmission, - MUX configuration is not identical on both terminals of a link.</td>
</tr>
</tbody>
</table>

9.5.2.3. **Data interface alarms**

<table>
<thead>
<tr>
<th>HMI600 Alarm Text</th>
<th>Explanation and corrective actions (the latter in italics)</th>
</tr>
</thead>
<tbody>
<tr>
<td>• V.24 port 1 data jabber halt</td>
<td>The external data terminal connected to V.24 port 1/2/3/4 has been transmitting data into the port continuously for more than 100 s. The respective data port has been blocked. To bring the port back to normal operation, either - Stop the external data terminal such that it generates no more data, if flow control (Configuration / data port assignment / Port) is set to ‘Data Sensitive’. - Deactivate the RTS handshake line of the respective port, if flow control (Configuration / data port assignment / Port) is set to ‘Hardware-Handshake’. - Disable jabber timeout.</td>
</tr>
<tr>
<td>• V.24 port 2 data jabber halt</td>
<td></td>
</tr>
<tr>
<td>• V.24 port 3 data jabber halt</td>
<td></td>
</tr>
<tr>
<td>• V.24 port 4 data jabber halt</td>
<td></td>
</tr>
<tr>
<td>HMI600 Alarm Text</td>
<td>Explanation and corrective actions (the latter in italics)</td>
</tr>
<tr>
<td>---------------------------</td>
<td>-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
</tbody>
</table>
| • Digital transit no sync | If the equipment is configured as digital transit master, there is no response from any digital transit slave. If the equipment is configured as digital transit slave, the synchronization to the master is not possible.  
  Verify if all links involved in digital transit communication are operational. Check the digital transit cables and the digital transit configuration of the terminals of these links using the instructions in section 5.3.6 ([Configuration / Services / Compressed telephony / Transit operation mode and Configuration / MUX600](#)). |
| • Digital transit missing Rx data | No Rx data on at least one of the configured digital transit channels.  
  Verify if all links involved in digital transit communication are operational. Check the digital transit cables and the digital transit configuration of the terminals of these links using the instructions in section 5.3.6 ([Configuration / Services / Compressed telephony / Transit operation mode and Configuration / MUX600](#)). |
| • LAN alarm               | The underlying detail alarms are  
  - the SFP transceiver is not (correctly) plugged,  
  - the SFP laser is not correctly working,  
  - the LAN600 user file can’t be accessed,  
  - LAN600 start-up failed.  
  *In the first two cases, check the SFP transceiver and replace when faulty.*  
  *In the 3rd and 4th case, replace P4LV/X.* |
9.5.2.4. **Data warnings**

- **LAN warning**

  The underlying detail warnings are:
  1. default LAN600 configuration loaded,
  2. default LAN600 users loaded,
  3. default SSL key loaded at startup,
  4. SNMP alarm table full,
  5. IP address conflict,
  6. RTC update failed,
  7. active configuration not stored to EPROM,

  Cases 1 to 3: The warning disappears if the default settings are changed.
  Case 4: The SNMP client can’t store all alarms to be recorded.
  Case 5: Another device in the network uses the same IP address.
  Case 6: The periodic update of the time from the RTC failed. This can happen temporarily during high processing load of LAN600.
  Case 7: The warning disappears when the active configuration is stored to EPROM (Equipment / Store configuration to FLASH).

9.5.3. **TPE**

The alarm and warning messages in the following tables are shown for one TPE. An identical set of messages is implemented for each TPE.

9.5.3.1. **TPE hardware alarms**

<table>
<thead>
<tr>
<th>HMI600 Alarm Text</th>
<th>Explanation and corrective actions (the latter in italics)</th>
</tr>
</thead>
<tbody>
<tr>
<td>• DSP stopped working</td>
<td>The TPE DSP on P4LT/V/X stopped working for more than 2 s longer than the configured pickup time for hardware alarms, followed by an automatic reset of the system. The reason can be faulty P4LT/V/X hardware or excessive EMI, possibly in combination with poor substation grounding and/or not properly grounded cable shields. Connect the shields of cables to ETL600 to ground as described in chapter 6. Improve the grounding of ETL600, specially the connections between the buried earth grid and substation ground, substation ground and cabinet, cabinet and (swing) frame, (swing) frame and equipment rack. If external EMI effects can be excluded and the error message appears repeatedly, replace P4LT/V/X.</td>
</tr>
<tr>
<td>HMI600 Alarm Text</td>
<td>Explanation and corrective actions (the latter in italics)</td>
</tr>
<tr>
<td>-------------------</td>
<td>----------------------------------------------------------</td>
</tr>
</tbody>
</table>
| • DSP program memory CRC error | A memory error has been detected in the memory of the TPE DSP on P4LT/V/X. The reason can be faulty P4LT/V/X hardware or excessive EMI, possibly in combination with poor substation grounding and/or not properly grounded cable shields.  
  Connect the shields of cables to ETL600 to ground as described in chapter 6. Improve the grounding of ETL600, specially the connections between the buried earth grid and substation ground, substation ground and cabinet, cabinet and (swing) frame, (swing) frame and equipment rack.  
  If external EMI effects can be excluded and the error message appears repeatedly, replace P4LT/V/X. |
| • G4AI board missing | At least one configured G4AI board doesn't answer or is not plugged at the correct position in the rack.  
  Verify if all boards are firmly plugged in at the correct positions in the rack P7LH/P7LF according to HMI600 (View / Display configuration). Switch off the power to ETL600 and switch it on again after some seconds. If the error persists, find the faulty G4AI board(s) by studying the TDM bus communication alarms (section 9.5.4). Replace the faulty G4AI board(s). |
| • G4AI hardware alarm | An alarm is present on one of the G4AI boards  
  Check G4AI status for detailed information. |

9.5.3.2. **TPE link alarms**

<table>
<thead>
<tr>
<th>HMI600 Alarm Text</th>
<th>Explanation and corrective actions (the latter in italics)</th>
</tr>
</thead>
</table>
| • Low Rx guard level  
• High Rx guard level | The level of the TPE guard signal is out the range set by HMI600 (e.g. Configuration / NSD600 / Alarm TPE1 / Guard level alarm), i.e. the AGC couldn't restore the Rx signal level to the correct range.  
  Make sure that  
  - the system level of the guard signal of the remote equipment is equal to the one in the local equipment,  
  - the AGC gain [dB] is equal to the system level of the guard signal [dBm0 PE] minus the received guard level [dBm PE],  
  - the Rx guard level is not below the AGC blocking level (Configuration / System / Alarm settings). |
<table>
<thead>
<tr>
<th>HMI600 Alarm Text</th>
<th>Explanation and corrective actions (the latter in italics)</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Low SNR</td>
<td>SNR not sufficient, i.e. the SNR is lower than the SNR required (SNR alarm pick up threshold 7 dB; SNR alarm release threshold 10 dB). Check line conditions or coupling devices.</td>
</tr>
<tr>
<td>• Neither trip nor guard received</td>
<td>Either the trip or the guard signal have been suppressed on their way over the communication channel. Check line conditions or coupling devices.</td>
</tr>
<tr>
<td>• Both trip and guard received</td>
<td>Probably discrete frequency injected at remote end. Look for possible sources of injected signals at the frequencies of the guard signal or the trip signals. Remove the disturbing signals.</td>
</tr>
<tr>
<td>• Loop test failed more than twice</td>
<td>The loop test failed at least three times. Check remote equipment for correct operation. Check line conditions or coupling devices.</td>
</tr>
</tbody>
</table>

### 9.5.3.3. TPE interface alarms

<table>
<thead>
<tr>
<th>HMI600 Alarm Text</th>
<th>Explanation and corrective actions (the latter in italics)</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Outputs set to predefined state</td>
<td>TPE outputs have been set to the predefined state as configured by means of the HMI600 (under Configuration / NSD600 / Supervision TPE1 / Command outputs during link failure) for either &quot;Are set to guard state (blocked)&quot; or &quot;Direct to guard state, others to command state&quot;.</td>
</tr>
<tr>
<td>• Max Rx command duration exceeded</td>
<td>A command has been received of duration longer than the configured maximum (e.g. Configuration / NSD600 / TPE1 / Max Rx Trip Duration has been exceeded).</td>
</tr>
</tbody>
</table>

### 9.5.3.4. TPE warnings

<table>
<thead>
<tr>
<th>HMI600 Alarm Text</th>
<th>Explanation and corrective actions (the latter in italics)</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Active configuration not stored to EPROM</td>
<td>A test configuration for TPE is active which will be lost when the associated test configuration timer runs out. Store the configuration to EPROM, stopping the test configuration timer, or reset the system, thereby overwriting the test configuration.</td>
</tr>
<tr>
<td>• Local test loop active</td>
<td>Local test loop is active for TPE (e.g. Equipment / Tuning and Testing / Test internal teleprotection).</td>
</tr>
<tr>
<td>• Loop test failed once or twice</td>
<td>The next cyclic loop test will be sent within 5 minutes.</td>
</tr>
</tbody>
</table>
### HMI600 Alarm Text

<table>
<thead>
<tr>
<th>HMI600 Alarm Text</th>
<th>Explanation and corrective actions (the latter in italics)</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Test signal transmitted or received</td>
<td>A TPE test signal has been transmitted or received.</td>
</tr>
<tr>
<td>• G4AI warning</td>
<td>A warning is present on at least one of the G4AI boards. <em>Check G4AI status for detailed information.</em></td>
</tr>
</tbody>
</table>

### 9.5.3.5. G4AI detail hardware alarms

<table>
<thead>
<tr>
<th>HMI600 Alarm Text</th>
<th>Explanation and corrective actions (the latter in italics)</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Tx single component failure at input 1-4</td>
<td>One component of the redundant circuitry of a command input is faulty. <em>Replace the faulty G4AI board.</em></td>
</tr>
<tr>
<td>• Program memory CRC error</td>
<td>A memory error has been detected in the memory of the DSP of the board. The reason can be faulty G4AI hardware or excessive EMI, possibly in combination with poor substation grounding and/or not properly grounded cable shields. <em>Connect the shields of cables to ETL600 to ground as described in chapter 6. Improve the grounding of ETL600, specially the connections between the buried earth grid and substation ground, substation ground and cabinet, cabinet and (swing) frame, (swing) frame and equipment rack.</em> <em>If external EMI effects can be excluded and the error message appears repeatedly, replace the G4AI board.</em></td>
</tr>
<tr>
<td>• Synchronization to P4LT/V/X lost</td>
<td>Communication with the P4LT/V/X board is disturbed. <em>Make sure that the board is firmly plugged in. Unplug the board and check if all pins of the connector to the backplane are present and not bent. If the error message appears repeatedly, replace the G4AI board.</em></td>
</tr>
<tr>
<td>• Slot mismatch between configuration and rack position</td>
<td>The board is not plugged at the correct position in the rack. <em>Verify that the board is plugged in at the correct position in the rack P7LH/P7LF according to HMI600 (View / Display configuration).</em></td>
</tr>
<tr>
<td>• TDM bus communication failure</td>
<td>TDM bus communication of the board is disturbed. <em>Make sure that the board is firmly plugged in. Unplug the board and check if all pins of the connector to the backplane are present and not bent.</em></td>
</tr>
</tbody>
</table>
### Troubleshooting June 2012 9-33

#### HMI600 Alarm Text  
Explanation and corrective actions  
(the latter in italics)

- **Hardware error at output 1-4**  
  A hardware error at one of the solid state outputs has been detected.  
  *Switch off the power to ETL600 and switch it on again after some seconds. If the error persists, replace the faulty board.*

- **Max Tx command duration exceeded at input 1-4**  
  The length of at least one Tx command applied to command inputs exceeds the max. allowed duration.  
  *Verify that the device generating the Tx command is operating correctly.*

- **Overcurrent at solid state output 1-4**  
  One or several of the solid state outputs are overloaded.  
  *Check for short circuits between the wires connected the output ports, check the impedance of the load.*

#### 9.5.3.6.  
**G4AI detail interface alarms**

n.a.

#### 9.5.3.7.  
**G4AI detail warnings**

| HMI600 Alarm Text | Explanation and corrective actions  
|-------------------|-----------------------------------|
| **Active configuration not stored to EPROM** | A test configuration for the board is active which will be lost when the associated test configuration timer runs out.  
  *Store the configuration to EPROM, stopping the test configuration timer, or reset the system, thereby overwriting the test configuration timer.* |

#### 9.5.4.  
**TDM Bus communication alarms and warnings**

In addition to the alarms and warnings listed in the previous tables, HMI600 reports separately the following TDM bus errors and warnings:

| HMI600 Alarm Text | Explanation and corrective actions  
|-------------------|-----------------------------------|
| **Error communicating with slot N…** | TDM bus communication with the board at slot N… is disturbed.  
  *Make sure that the correct type of board is firmly plugged in at slot N… Unplug the board at slot N… and check if all pins of the connector to the backplane are present and not bent.* |

| Error on board at slot N… | An alarm is present on the board at slot N…  
| Check the status of the board at slot N… for detailed information. |
### Troubleshooting

<table>
<thead>
<tr>
<th>HMI600 Alarm Text</th>
<th>Explanation and corrective actions (the latter in italics)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Warning on board at slot N…</td>
<td>A warning is present on the board at slot N… Check the status of the board at slot N… for detailed information.</td>
</tr>
</tbody>
</table>

### 9.6. Replacement of faulty items

Modules may only be replaced by properly trained personnel authorized to do so. Strictly observe the safety instructions at the beginning of this section.

Modules may not be withdrawn or inserted while the equipment is in operation. Switch off the power supply and disconnect external cables first.

As stated earlier, replacement of faulty items can be done only at module level and not component level since surface mount technology is used for components of most of the modules. While replacing a faulty module with a new module, ensure that the fault is not due to some incorrect external wiring or mode of operation. Else even the new module will go faulty. Remember to program correct jumpers / strapping on the new module before replacement.

### 9.7. Dispatch for repairs

A module identified and confirmed to be faulty should be sent for repairs to ABB. It should be packed preferably in the original packing or in anti-static bags with additional mechanical protection to avoid damage during transport. It should be accompanied by a short description of the observed fault.

ABB is not responsible for a module received which was damaged during transport. The financial implications of the repairs depends upon the agreement with the client.

Refer to document ‘1KHM010296 Repair and Return Procedure’ in the annex.

### 9.8. Support

Refer to document ‘1KHM010297 - Need Support for your Communication System?’ in the Annex.
10. STORAGE, DECOMMISSIONING AND DISPOSAL

10.1. Safety instructions

Personnel qualification

DANGER An authorized and properly trained personnel only is admitted to carry out installing, programming, commissioning, maintenance, troubleshooting and work of the equipment.

Mechanical Installation

DANGER The equipment must be mounted in a cabinet.

DANGER Cabinets, which are not secured to the floor, tip forwards when the hinged frame is opened. Do not open the hinged frame without precautions.

ESD protection

Caution ESD The modules in this equipment contain devices, which can be damaged by electrostatic discharges. Appropriate measures must be taken before unpacking modules or withdrawing them from equipment racks. Essential precautions to prevent ESD damage when handling or working on modules are grounding straps for technical personnel and the provision of anti-static workbenches. Modules may only be shipped either in their original packing or installed in equipment racks.

Electrical Installation

DANGER The circuit breaker for the power supply of the equipment must be switch OFF.

DANGER The circuit breakers for optional equipment in the cabinet must be switch OFF.

DANGER Do not connect or disconnect energized cables to or from the equipment.

DANGER The isolating terminals from the external cables must be kept open during installation, maintenance and before storage, decommissioning and disposal.
10.2. Storage

The specified conditions for storage are stated in the Technical Data ETL600 Rel. 4.

The cabinet should be stored in its original wooden frame and plastic cover. Make sure that the plastic cover is undamaged. Where the equipment has to be stored for a long period, precautions to prevent corrosion must be taken. This is especially important in humid climates.

Storage of modules should be preferably in the original packing or in antistatic bags with additional mechanical protection.

10.3. Decommissioning

The decommissioning of the equipment should be done in the following steps.

- First of all the application, in which the equipment is used, must be disabled. This is of special importance when protection signaling is used.
- Switch OFF the equipment. Isolate and disconnect the external power supply given to the equipment.
- Open the isolating terminals from the external cables.
- Disconnect the external wiring of the equipment. This should be done carefully using the plant drawings so that some other wiring does not get disconnected by mistake.
- Disconnect the RF coaxial cable. In case the cabinet is to be dismounted, unstrap the RF cable and remove it from the cabinet.
- In case the complete cabinet is to be dismounted, the bolts for fastening the cabinet to the base frame or floor must be carefully removed giving support to the cabinet at the same time. The cabinet can now be lifted and dismounted. It is preferable to keep the cabinet in horizontal position if no external support can be given to the cabinet in vertical position.
- In case only the ETL600 subrack is to be removed from the cabinet, first disconnect the internal wiring and power supply between the ETL600 subrack and the terminal blocks. Now dismount the subrack by unscrewing the screws from the front.
- If the ETL600 subrack or its modules are to be reused, they should be handled and packed properly following precautions for ESD protection.

10.4. Disposal

For disposal, the regional and national regulations for electrical and electronic waste have to be followed.

The modularity of the equipment allows to separate component boards and casing, thus giving the opportunity for recycling.
11. OPTIONS

11.1. Basic equipment

The basic ETL600 Release 4 equipment without any optional interfaces consists of

<table>
<thead>
<tr>
<th>Module Description</th>
<th>ETL600 -50-1</th>
<th>ETL600 -50-2</th>
<th>ETL600 -100-2</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Subrack type P7LH</td>
<td>X</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>2. Subrack type P7LF</td>
<td>-</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>3. Power supply type B5LD</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>4. DSP module P4LT/V/X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>5. Receive filter type P4RX (optional if certain conditions are met)</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>6. RF hybrid / Transmit filter type E5TH</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>7. Carrier combiner / Transmit filter type E5TC</td>
<td>-</td>
<td>-</td>
<td>X</td>
</tr>
<tr>
<td>8. Power subrack type P7LP</td>
<td>-</td>
<td>X</td>
<td>-</td>
</tr>
<tr>
<td>9. Power subrack type P7LQ</td>
<td>-</td>
<td>-</td>
<td>X</td>
</tr>
<tr>
<td>10. Power amplifier type P1LP</td>
<td>X</td>
<td>X</td>
<td>X (twice)</td>
</tr>
</tbody>
</table>

11.2. Optional equipment

11.2.1. Optional modules

11.2.1.1. AF interface type O4LE

This is the interface for telephony (2 and 4 wire), for teleoperation and for external teleprotection.

11.2.1.2. Teleprotection interface type G4AI

This is the interface module for the optional internal teleprotection equipment type NSD600.

11.2.1.3. Compressed telephony interface type O4CV

This is the interface module for digitally compressed telephony.

11.2.1.4. Alarm relay module type R1BC

The R1BC is an optional module with relays which can be programmed to be activated when certain local or remote alarms and warnings are present.
### 11.2.1.5. Cables

Refer to chapter 6 for the type of the cables.

<table>
<thead>
<tr>
<th>Module / Cable(s)</th>
<th>Application</th>
</tr>
</thead>
<tbody>
<tr>
<td>O4LE / V9OS</td>
<td>The cable is required for external wiring of the teleoperation inputs &amp; outputs. The cable is also used for transit operation or to connect the NSD570 / NSD70C protection equipment. The cable is required for external wiring of the 4W E&amp;M circuit. The cable is required for external wiring of the 2W port configured in subscriber interface or PAX interface.</td>
</tr>
<tr>
<td>O4CV/ V9OI</td>
<td>The cable is required for external wiring of the compressed telephony ports.</td>
</tr>
<tr>
<td>G4AI / V9OF</td>
<td>The cable is required for external wiring of the teleprotection signals</td>
</tr>
<tr>
<td>R1BC / V9MR</td>
<td>The cable is required for extension of contacts of the programmable alarm relays.</td>
</tr>
<tr>
<td>P4LT/V/X / V9OH</td>
<td>This cable is required for connection to the LAN and digital transit ports.</td>
</tr>
<tr>
<td>V9OT</td>
<td>This cable is required for extension of contacts of the alarm relays on P4LT/V/X.</td>
</tr>
<tr>
<td>(Off-the-shelf cable)</td>
<td>For the connection of a PC to the “HMI” SUB-D connector on the front plate, an additional “off-the-shelf” 1 to 1 / 9-pole cable is required or, alternatively, for connection of an external modem to the SUB-D connector on the front plate, an additional null modem / 9-pole cable is required.</td>
</tr>
<tr>
<td>V9OU</td>
<td>This cable can be used for the connection of a PC to the serial HMI port on the front plate and is required for connection of external devices to the V.24 ports.</td>
</tr>
<tr>
<td>V9OW</td>
<td>This cable is required for the connection of external devices to the V.11 ports on the front plate.</td>
</tr>
<tr>
<td>V9OV</td>
<td>This cable is required for connection of external devices to the HMI port (when used as RS-485 station bus port) and to the IRIG-B port on the front plate.</td>
</tr>
<tr>
<td>V9OX</td>
<td>This cable is required for transit connection of V.11 ports.</td>
</tr>
<tr>
<td>V9OY</td>
<td>This patch panel for a Sub-D 9 pole male connector can be used for IRIG-B or RS-485 signals.</td>
</tr>
<tr>
<td>V9OZ</td>
<td>This patch panel can be used for LAN and digital transit ports.</td>
</tr>
<tr>
<td>Module / Cable(s)</td>
<td>Application</td>
</tr>
<tr>
<td>------------------</td>
<td>---------------------------</td>
</tr>
<tr>
<td>P7LH, P7LP, P7LQ / V9PB</td>
<td>DC power supply cable</td>
</tr>
<tr>
<td>E5TH / V9MX</td>
<td>RF coaxial cable</td>
</tr>
</tbody>
</table>

11.2.2. **Optional facilities**

Following is a list of additional facilities which can be ordered with the equipment.

11.2.2.1. **User Interface Program**

The HMI600 software installation program is available on CD-ROM. It is a Windows based software with the user friendly features of the Windows environment. Refer to chapter 4 for details about HMI600.

11.2.2.2. **Cabinet type E40A or E40D with accessories**

The ETL600 can be mounted in an E40A or E40D type of cabinet which also includes various accessories such as rails for mounting terminal blocks, cable channels etc.

11.2.2.3. **Personal Computer**

The PC on which HMI600 is to be installed must provide Windows as operating system. Refer to section 4.2.1 for system requirements.

11.2.2.4. **PC connection set**

This set contains a 9 pole 1:1 serial cable with Sub-D connectors for connection to the COM-port of the PC. In addition, an USB-to-serial converter type V9OP is included in case the PC is not equipped with a COM-port but provides an USB serial interface.

11.2.2.5. **RF connection plate A9CS**

The RF connection plate A9CS is available in the following versions:

- for standard 75 unbalanced cable
  (2 surge arrestors 800 V)
- with the hybrid transformer A1AC
  (surge arrester 800 V)
- with the 3 dB attenuator A1AD
  (surge arrester 800 V)
- with the impedance transformer A1AE for 150 Ohms balanced cable (galvanically isolated) or 50 Ohms unbalanced cable (surge arrester > 420 V)
11.2.2.6. **Filter tuning set ETL600R4**

The set contains the tuning adapter P4LM, the adapter P4EX and coaxial cables for tuning of the ETL600 Rx and Tx filters.

11.2.2.7. **Krone tool kit**

The kit contains the tool required to connect wires to the LSA Quick Plus Connect (Krone) terminal block.

11.2.2.8. **Remote inquiry kit R7AP**

The kit contains the interface and cables needed for connecting a PC to the RS-485 station bus. Refer to section 4.5.1 for a description of the RS-485 station bus and of the possibilities for remote access to such a bus. Existing ETL500 systems or dial up modems can also be connected to this station bus via one R7AP kit.

11.2.2.9. **Service Telephone Q8AB**

The telephone set includes a cable to be connected to the service telephone socket at the front plate of the AF interface O4LE.

11.3. **Service keys**

The basic equipment ETL600 covers all the services described in this Instruction Manual, but with compressed telephony, MOD600 and NSK600 modems disabled. Service keys are required to enable these services. Physically, these keys are hardware devices – due to their shape also called “iButtons” - to be mounted on the boards carrying the services. Service keys can be exchanged anytime if more services need to be enabled.

11.3.1. **Data key for MOD600 and NSK600 modems**

The DSP modules P4LT, P4LV, P4LX require a data key, due to its shape also called “iButton”. There are six types of keys as shown in Table 11-1. The keys are marked with a colored label specifying the maximum number of modems that can be used.

```
<table>
<thead>
<tr>
<th>Order Number:</th>
<th>Number of modems:</th>
<th>Color of iButton label:</th>
</tr>
</thead>
<tbody>
<tr>
<td>1KHW001480R0001</td>
<td>0 MOD600, 0 NSK600</td>
<td>White</td>
</tr>
<tr>
<td>1KHW001480R0002</td>
<td>0 MOD600, 2 NSK600</td>
<td>Blue</td>
</tr>
<tr>
<td>1KHW001480R0003</td>
<td>0 MOD600, 4 NSK600</td>
<td>Green</td>
</tr>
<tr>
<td>1KHW001480R0004</td>
<td>1 MOD600, 0 NSK600</td>
<td>Yellow</td>
</tr>
<tr>
<td>1KHW001480R0005</td>
<td>1 MOD600, 2 NSK600</td>
<td>Orange</td>
</tr>
<tr>
<td>1KHW001480R0006</td>
<td>1 MOD600, 4 NSK600</td>
<td>Red</td>
</tr>
</tbody>
</table>
```

1) Only 3 NSK600 modems are available, if one or more of the NSK600 modems are configured for 9600 bps. Not required for P4LT, P4LV.

Table 11-1  Available data keys for P4LT/V/X
Note: When using the HMI600 in the off-line operation mode, all the parameters for MOD600 and NSK600 channels can be configured without restrictions. But downloading of the corresponding settings to the equipment is only possible if the appropriate data key is mounted on P4LT/V/X.

Note: A data key must always be mounted on P4LT/V/X even if no MOD600 and no NSK600 modems are needed (in this case the white key is required, refer to Table 11-1). For mounting the data key, refer to the Programming and Testing instructions 1KHW002609 in the annex.

11.3.2. Voice key for compressed telephony

Each O4CV board requires a voice key, due to its shape also called "iButton". There are two types of voice keys: One for 2 compressed telephony channels, the other for 4 compressed telephony channels (Table 11-2). If several O4CV modules are used in an ETL600 terminal, at most one of them can have a key for 2 compressed telephony channels. The remaining ones must have keys for 4 compressed telephony channels.

<table>
<thead>
<tr>
<th>Order Number</th>
<th>Number of compressed telephony channels</th>
<th>iButton label</th>
</tr>
</thead>
<tbody>
<tr>
<td>1KHW001480R0007</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>1KHW001480R0008</td>
<td>4</td>
<td>4</td>
</tr>
</tbody>
</table>

Table 11-2 Available voice keys for O4CV

Note: When using HMI600 in off-line operation mode, all the parameters for compressed telephony channels can be configured without restrictions. But downloading of the corresponding settings to the equipment is only possible if the appropriate voice keys are mounted on the O4CV boards.
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2 Tuning of ETL600 Rel.4 Rx RF Filter P4RX 1KHW002584-EN
3 Tuning of ETL600 Rel.4 Tx RF Filter on E5TH/C 1KHW002585-EN
4 Programming and Testing of ETL600 Rel.4 1KHW002609-EN
5 System Test Report ETL600 Rel.4 1KHW002568-EN
6 APLC Channel Equalization for ETL600 1KHW001494-EN
7 Commissioning of ETL600 Rel.4 1KHW002586-EN
8 Commissioning Report ETL600 Rel.4 1KHW002587-EN
9 Firmware Download for ETL600 Rel.4 1KHW002589-EN
10 Anomaly List for ETL600 1KHW001497-EN
11 Repair and Return Procedure (with Fault Report Form) Support Process 1KHM010296-EN 1KHM010297-EN
12 Technical Data ETL600 Rel.4 1KHW002590-EN
Power Line Carrier Equipment: Series ETL600

Compatibility Requirements for ETL600

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   6.12 Release 3.2.2 16
   6.13 Release 3.2.3 17
   6.14 Release 3.4.0 17
   6.15 Release 3.5.0 17
   6.16 Release 4.0.0 17
   6.17 Release 4.0.1 17

1 Purpose of document

This document describes the compatibility requirements for the ETL600 system.

2 General

The ETL600 system consists of
1. Hardware, consisting of a number of modules;
2. Firmware, residing on some of the modules and making the processors on these modules execute various functions such as modulation, digital filtering etc.;
3. PC based software, implementing the user interface for configuration, testing and monitoring of the equipment.
3  Release and Version Management

ABB continuously enhances the ETL600 system by upgrading hardware, firmware and software. An ETL600 system release, identified by a release number, is a product of defined functionality comprising hardware modules, firmware and software.

Firmware and software are identified with version numbers of the form NN.nn., e.g. 5.08 (leading zeros may be omitted).

Releases are identified by release numbers of the form RR.r.d, e.g. 3.1.0 (leading zeros may be omitted). RR indicates the main release, r the sub-release and d the update version inside a sub-release.

Hardware modules are identified with type codes consisting of 4 characters like P7LC, G4AI or P4LT. Sometimes, a fifth character - the revision index - is appended to identify an upgraded version of a module. Example: P4LTa is an upgraded version of P4LT; P4LTb would be an upgraded version of P4LTA and so on.

Note: The information content of type codes in case of modules containing firmware depends on the possibility to download firmware from HMI600 into the module:

- If for a component firmware download is not possible, the type code of that component identifies the hardware including the firmware version. Example: Microcontroller on P4LT/U/V/X
- If for a module firmware download is possible, the type code of that module identifies the hardware excluding the firmware version. The download files for the firmware of such modules are included on the HMI600 Software & Documentation CD. Example: O4LE

4  Compatibility rules

- Rule Nr. 1:
  The modules of an ETL600 terminal and the firmware on these modules must belong to the same release as given by Table 1. If an equipment contains modules of different releases, it will generally not work correctly.

- Rule Nr. 2:
  Apart from the exceptions described in section 4.1, the two ETL600 terminals of a link must belong to the same release.
  If this rule is violated, the EOC of the link will generally not work correctly. Corresponding warning messages will be generated by HMI600.

- Rule Nr. 3:
  The HMI600 software must have full or restricted compatibility to the ETL600 terminals being connected to.
  The term “restricted compatibility” is used when the functionality has been changed between releases as long as the HMI600 program can handle these changes in a reasonable way.

4.1  Compatibility between Rel. 3 and Rel. 4

Most services offered by ETL600 Rel. 4 are compatible with Rel. 3.1 and higher. The following list shows all compatible services:

- APLC services including speech and teleoperation
- NSD600
- NSK600
- MOD600 (DPLC bandwidths 2 kHz and 6 kHz are only available in Rel. 3.2 and higher)

Make sure that these services are configured identically and that the number of interfaces and ports are the same on both terminals of the link.

The LAN600 services are not compatible. As a consequence LAN over PLC between ETL600 Rel.3 (RF-Converter P4LUa with P1LA) and ETL600 Rel.4 (RF-Converter P4LV or P4LX) is not possible. As a workaround, ETL600 Rel.3 equipment can be upgraded to Rel. 3.5.0. This involves replacement of P4LU by P4LV or P4LX.
## 5 ETL600 Releases

<table>
<thead>
<tr>
<th>Release</th>
<th>Compatible hardware, firmware and software</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>ETL600</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Rel. 1.0.1</strong></td>
<td>- Software HMI600 version 1.22,</td>
</tr>
<tr>
<td></td>
<td>- Software SVR600 version 1.00 or higher,</td>
</tr>
<tr>
<td></td>
<td>- Firmware ETL600 version 1.28 on module P4LT/P4LTa or P4LU/P4LUa,</td>
</tr>
<tr>
<td></td>
<td>- Microcontroller firmware version 1.10 or higher on module P4LT/P4LTa or P4LU/P4LUa,</td>
</tr>
<tr>
<td></td>
<td>- Firmware O4LE version 2.14 or higher on module O4LE/O4LEa,</td>
</tr>
<tr>
<td></td>
<td>- Firmware G4AI version 3.00 or higher on module G4AI/G4Ala,</td>
</tr>
<tr>
<td></td>
<td>- ETL640/ETL680:</td>
</tr>
<tr>
<td></td>
<td>Power subrack P7LA with hardware modules P1LA, B5LA or B5LC, E5TX, P3LE/P3LEa, P3LG,</td>
</tr>
<tr>
<td></td>
<td>Channel subrack P7LC with hardware modules B4LE, P4LT/P4LTa or P4LU/P4LUa, P4RX,</td>
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<tr>
<td></td>
<td>earth rail R9AL and optional hardware modules O4LE/O4LEa, G4AI/G4Ala, R1BC,</td>
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<tr>
<td></td>
<td>External cables V9OW/V9OU/V9OV/V9OT (for P4LT/P4LTa or P4LU/P4LUa), V9MR (for R1BC), V9OS (for O4LE/O4LEa), and V9OF (for G4AI/G4Ala),</td>
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<tr>
<td></td>
<td>- Optional remote inquiry set R7AP,</td>
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<tr>
<td></td>
<td>- Service telephone Q8AB,</td>
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<tr>
<td></td>
<td>- Circuit breaker B9AS.</td>
</tr>
<tr>
<td><strong>ETL600</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Rel. 1.0.2</strong></td>
<td>- Software HMI600 version 1.24 or higher,</td>
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<tr>
<td></td>
<td>- Software SVR600 version 1.00 or higher,</td>
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<tr>
<td></td>
<td>- Firmware ETL600 version 1.31 or higher on module P4LT/P4LTa or P4LU/P4LUa,</td>
</tr>
<tr>
<td></td>
<td>- Microcontroller firmware version 1.10 or higher on module P4LT/P4LTa or P4LU/P4LUa,</td>
</tr>
<tr>
<td></td>
<td>- Firmware O4LE version 2.14 or higher on module O4LE/O4LEa,</td>
</tr>
<tr>
<td></td>
<td>- Firmware G4AI version 3.00 or higher on module G4AI/G4Ala,</td>
</tr>
<tr>
<td></td>
<td>- ETL640/ETL680:</td>
</tr>
<tr>
<td></td>
<td>Power subrack P7LA with hardware modules P1LA, B5LA or B5LC, E5TX, P3LE/P3LEa, P3LG,</td>
</tr>
<tr>
<td></td>
<td>Channel subrack P7LC with hardware modules B4LE, P4LT/P4LTa or P4LU/P4LUa, P4RX,</td>
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<tr>
<td></td>
<td>earth rail R9AL and optional hardware modules O4LE/O4LEa, G4AI/G4Ala, R1BC,</td>
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<tr>
<td></td>
<td>External cables V9OW/V9OU/V9OV/V9OT (for P4LT/P4LTa or P4LU/P4LUa), V9MR (for R1BC), V9OS (for O4LE/O4LEa), and V9OF (for G4AI/G4Ala),</td>
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<td></td>
<td>- Optional remote inquiry set R7AP,</td>
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<tr>
<td></td>
<td>- Service telephone Q8AB,</td>
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<td></td>
<td>- Circuit breaker B9AS.</td>
</tr>
<tr>
<td>Release</td>
<td>Compatible hardware, firmware and software</td>
</tr>
<tr>
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<td>--------------------------------------------</td>
</tr>
</tbody>
</table>
| **ETL600 Rel. 1.0.3** | - Software HMI600 version 1.26 or higher,  
- Software SVR600 version 1.00 or higher,  
- Firmware ETR600 version 1.34 on module P4LT/P4LTa or P4LU/P4LUa,  
- Microcontroller firmware version 1.10 or higher on module P4LT/P4LTa or P4LU/P4LUa,  
- Firmware O4LE version 2.14 or higher on module O4LE/O4LEa,  
- Firmware G4AI version 3.00 or higher on module G4AI/G4Ala,  
- ETL640/ETL680:  
  - Power subrack P7LA with hardware modules P1LA, B5LA or B5LC, E5TX, P3LE/P3LEa, P3LG,  
  - Channel subrack P7LC with hardware modules B4LE, P4LT/P4LTa or P4LU/P4LUa, P4RX, earth rail R9AL and optional hardware modules O4LE/O4LEa, G4AI/G4Ala, R1BC,  
  - External cables V9OW/V9OU/V9OV/V9OT (for P4LT/P4LTa or P4LU/P4LUa), V9MR (for R1BC), V9OS (for O4LE/O4LEa), and V9OF (for G4AI/G4Ala),  
- Optional remote inquiry set R7AP,  
- Service telephone Q8AB,  
- Circuit breaker B9AS. |
| **ETL600 Rel. 1.0.4** | - Software HMI600 version 1.26 or higher,  
- Software SVR600 version 1.00 or higher,  
- Firmware ETR600 version 1.36 or higher on module P4LT/P4LTa or P4LU/P4LUa,  
- Microcontroller firmware version 1.10 or higher on module P4LT/P4LTa or P4LU/P4LUa,  
- Firmware O4LE version 2.14 or higher on module O4LE/O4LEa,  
- Firmware G4AI version 3.00 or higher on module G4AI/G4Ala,  
- ETL640/ETL680:  
  - Power subrack P7LA with hardware modules P1LA, B5LA or B5LC, E5TX, P3LE/P3LEa, P3LG,  
  - Channel subrack P7LC with hardware modules B4LE, P4LT/P4LTa or P4LU/P4LUa, P4RX, earth rail R9AL and optional hardware modules O4LE/O4LEa, G4AI/G4Ala, R1BC,  
  - External cables V9OW/V9OU/V9OV/V9OT (for P4LT/P4LTa or P4LU/P4LUa), V9MR (for R1BC), V9OS (for O4LE/O4LEa), and V9OF (for G4AI/G4Ala),  
- Optional remote inquiry set R7AP,  
- Service telephone Q8AB,  
- Circuit breaker B9AS. |
<table>
<thead>
<tr>
<th>Release</th>
<th>Compatible hardware, firmware and software</th>
</tr>
</thead>
<tbody>
<tr>
<td>ETL600</td>
<td>- Software HMI600 version 1.41 or higher,</td>
</tr>
<tr>
<td>Rel. 2.0.0</td>
<td>- Software SVR600 version 1.00 or higher,</td>
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<tr>
<td></td>
<td>- Firmware ETL600 version 1.47 or higher on module P4LT/P4LTa or P4LU/P4LUa,</td>
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<tr>
<td></td>
<td>- Microcontroller firmware version 1.10 or higher on module P4LT/P4LTa or P4LU/P4LUa,</td>
</tr>
<tr>
<td></td>
<td>- Firmware O4LE version 2.14 or higher on module O4LE/O4LEa,</td>
</tr>
<tr>
<td></td>
<td>- Firmware G4AI version 3.00 or higher on module G4AI/G4Ala,</td>
</tr>
<tr>
<td></td>
<td>- Firmware R1LA version 1.13 on module R1LA,</td>
</tr>
<tr>
<td></td>
<td>- ABB-ETL-MIB version 1,</td>
</tr>
<tr>
<td></td>
<td>- ETL640/ETL680: Power subrack P7LA with hardware modules P1LA, B5LA or B5LC, E5TX, P3LE/P3LEa, P3LG,</td>
</tr>
<tr>
<td></td>
<td>- Channel subrack P7LC with hardware modules B4LE, P4LT/P4LTa or P4LU/P4LUa ¹), R1LA, P4RX, earth rail R9AL and optional hardware modules O4LE/O4LEa, G4AI/G4Ala, R1BC,</td>
</tr>
<tr>
<td></td>
<td>- External cables V9OW/V9OU/V9OV/V9OT/V9OX/V9OY (for P4LT/P4LTa or P4LU/P4LUa), V9OH/V9OZ (for P4LUa), V9MR (for R1BC), V9OS (for O4LE/O4LEa), and V9OF (for G4AI/G4Ala),</td>
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<tr>
<td></td>
<td>- Optional remote inquiry set R7AP,</td>
</tr>
<tr>
<td></td>
<td>- Service telephone Q8AB,</td>
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<td></td>
<td>- Circuit breaker B9AS.</td>
</tr>
<tr>
<td>Notes:</td>
<td>¹) The module R1LA is only compatible with P4LUa, not with P4LU and P4LT/P4LTa.</td>
</tr>
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</table>

<table>
<thead>
<tr>
<th>Release</th>
<th>Compatible hardware, firmware and software</th>
</tr>
</thead>
<tbody>
<tr>
<td>ETL600</td>
<td>- Software HMI600 version 2.08 or higher,</td>
</tr>
<tr>
<td>Rel. 2.1.0</td>
<td>- Software SVR600 version 1.00 or higher,</td>
</tr>
<tr>
<td></td>
<td>- Firmware ETL600 version 2.06 on module P4LT/P4LTa or P4LU/P4LUa,</td>
</tr>
<tr>
<td></td>
<td>- Microcontroller firmware version 1.10 or higher on module P4LT/P4LTa or P4LU/P4LUa,</td>
</tr>
<tr>
<td></td>
<td>- Firmware O4LE version 2.14 or higher on module O4LE/O4LEa,</td>
</tr>
<tr>
<td></td>
<td>- Firmware G4AI version 3.12 or higher on module G4AI/G4Ala,</td>
</tr>
<tr>
<td></td>
<td>- Firmware R1LA version 1.13 on module R1LA,</td>
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<tr>
<td></td>
<td>- ABB-ETL-MIB version 1,</td>
</tr>
<tr>
<td></td>
<td>- ETL640/ETL680: Power subrack P7LA with hardware modules P1LA, B5LA or B5LC, E5TX, P3LE/P3LEa, P3LG,</td>
</tr>
<tr>
<td></td>
<td>- Channel subrack P7LC with hardware modules B4LE, P4LT/P4LTa or P4LU/P4LUa ¹), R1LA, P4RX, earth rail R9AL and optional hardware modules O4LE/O4LEa, G4AI/G4Ala, R1BC,</td>
</tr>
<tr>
<td></td>
<td>- External cables V9OW/V9OU/V9OV/V9OT/V9OX/V9OY (for P4LT/P4LTa or P4LU/P4LUa), V9OH/V9OZ (for P4LUa), V9MR (for R1BC), V9OS (for O4LE/O4LEa), and V9OF (for G4AI/G4Ala),</td>
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<td></td>
<td>- Optional remote inquiry set R7AP,</td>
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<td></td>
<td>- Service telephone Q8AB,</td>
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<td></td>
<td>- Circuit breaker B9AS.</td>
</tr>
<tr>
<td>Notes:</td>
<td>¹) The module R1LA is only compatible with P4LUa, not with P4LU and P4LT/P4LTa.</td>
</tr>
<tr>
<td>Release</td>
<td>Compatible hardware, firmware and software</td>
</tr>
<tr>
<td>---------</td>
<td>---------------------------------------------</td>
</tr>
</tbody>
</table>
| **ETL600 Rel. 2.1.1** | - Software HMI600 version 2.10 or higher,  
- Software SVR600 version 1.00 or higher,  
- Firmware ETL600 version 2.07 on module P4LT/P4LTa or P4LU/P4LUA,  
- Microcontroller firmware version 1.10 or higher on module P4LT/P4LTa or P4LU/P4LUA,  
- Firmware O4LE version 2.14 or higher on module O4LE/O4LEa,  
- Firmware G4AI version 3.12 or higher on module G4AI/G4AIA,  
- Firmware R1LA version 1.13 on module R1LA,  
- ABB-ETL-MIB version 1,  
- ETL640/ETL680: Power subrack P7LA with hardware modules P1LA, B5LA or B5LC, E5TX, P3LE/P3LEa, P3LG,  
- Channel subrack P7LC with hardware modules B4LE, P4LT/P4LTa or P4LU/P4LUA 1), R1LA, P4RX, earth rail R9AL and optional hardware modules O4LE/O4LEa, G4AI/G4AIA, R1BC,  
- External cables V9OW/V9OU/V9OV/V9OT/V9OX/V9OY (for P4LT/P4LTa or P4LU/P4LUA), V9OH/V9OZ (for P4LUA), V9MR (for R1BC), V9OS (for O4LE/O4LEa), and V9OF (for G4AI/G4AIA),  
- Optional remote inquiry set R7AP,  
- Service telephone Q8AB,  
- Circuit breaker B9AS. |
| **Notes:** | 1) The module R1LA is only compatible with P4LUA, not with P4LU and P4LT/P4LTA. |

| **ETL600 Rel. 2.2.0** | - Software HMI600 version 2.21 or higher,  
- Software SVR600 version 1.00 or higher,  
- Firmware ETL600 version 2.08 or higher on module P4LT/P4LTa or P4LU/P4LUA,  
- Microcontroller firmware version 1.10 or higher on module P4LT/P4LTa or P4LU/P4LUA,  
- Firmware O4LE version 2.14 or higher on module O4LE/O4LEa,  
- Firmware G4AI version 3.12 or higher on module G4AI/G4AIA,  
- Firmware R1LA version 1.14 on module R1LA,  
- ABB-ETL-MIB version 1,  
- ETL640/ETL680: Power subrack P7LA with hardware modules P1LA, B5LA or B5LC, E5TX, P3LE/P3LEa, P3LG,  
- Channel subrack P7LC with hardware modules B4LE, P4LT/P4LTa or P4LU/P4LUA 1), R1LA, P4RX, earth rail R9AL and optional hardware modules O4LE/O4LEa, G4AI/G4AIA, R1BC,  
- External cables V9OW/V9OU/V9OV/V9OT/V9OX/V9OY (for P4LT/P4LTa or P4LU/P4LUA), V9OH/V9OZ (for P4LUA), V9MR (for R1BC), V9OS (for O4LE/O4LEa), and V9OF (for G4AI/G4AIA),  
- Optional remote inquiry set R7AP,  
- Service telephone Q8AB,  
- Circuit breaker B9AS. |
<p>| <strong>Notes:</strong> | 1) The module R1LA is only compatible with P4LUA, not with P4LU and P4LT/P4LTA. |</p>
<table>
<thead>
<tr>
<th>Release</th>
<th>Compatible hardware, firmware and software</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>ETL600</strong>&lt;br&gt;<strong>Rel. 3.0.0</strong></td>
<td>- Software HMI600 version 3.07 or higher,&lt;br&gt;- Software SVR600 version 1.00 or higher,&lt;br&gt;- Firmware ETL600 version 3.05 or higher on module P4LTa or P4LUa ¹&lt;sup&gt;1)&lt;/sup&gt;,&lt;br&gt;- Microcontroller firmware version 1.12 or higher on module P4LTa or P4LUa ¹&lt;sup&gt;1)&lt;/sup&gt;,&lt;br&gt;- Firmware O4LE version 2.14 or higher on module O4LE/O4LEa,&lt;br&gt;- Firmware G4AI version 3.12 or higher on module G4AI/G4Al,&lt;br&gt;- Firmware R1LA version 1.16 on module R1LA,&lt;br&gt;- Firmware O4CV version 1.20 on module O4CV,&lt;br&gt;- ABB-ETL-MIB version 1,&lt;br&gt;- ETL640/ETL680: Power subrack P7LA with hardware modules P1LA, B5LA or B5LC, E5TX, P3LE/P3LEa, P3LG,&lt;br&gt;- Channel subrack P7LC with hardware modules B4LE, P4LTa or P4LUa ¹&lt;sup&gt;1)&lt;/sup&gt; ²)&lt;sup&gt;1)&lt;/sup&gt;, R1LA, P4RX, earth rail R9AL and optional hardware modules O4LE/O4LEa, G4AI/G4Ala, O4CV, R1BC,&lt;br&gt;- External cables V9OW/V9OU/V9OV/V9OT/V9OX/V9OY (for P4LTa or P4LUa), V9OH/V9OZ (for P4LUa), V9MR (for R1BC), V9OS (for O4LE/O4LEa), V9OF (for G4AI/G4Ala) and V9OI (for O4CV),&lt;br&gt;- Optional remote inquiry set R7AP,&lt;br&gt;- Service telephone Q8AB,&lt;br&gt;- Circuit breaker B9AS.</td>
</tr>
</tbody>
</table>

**Notes:**

1) ETL600 Releases 3.0.0 and higher do no longer support the hardware modules P4LT and P4LU. Modules of type P4LTa or P4LUa are required.

2) The module R1LA is only compatible with P4LUa, not with P4LTa.

| **ETL600**<br>**Rel. 3.1.0** | - Software HMI600 version 3.20 or higher,<br>- Software SVR600 version 1.00 or higher,<br>- Firmware ETL600 version 3.10 or higher on module P4LTa or P4LUa <sup>1)</sup>,<br>- Microcontroller firmware version 1.12 or higher on module P4LTa or P4LUa <sup>1)</sup>,<br>- Firmware O4LE version 2.14 or higher on module O4LE/O4LEa,<br>- Firmware G4AI version 3.12 or higher on module G4AI/G4Al,<br>- Firmware R1LA version 1.21 on module R1LA,<br>- Firmware O4CV version 1.21 on module O4CV,<br>- ABB-ETL-MIB version 1,<br>- ETL640/ETL680: Power subrack P7LA with hardware modules P1LA, B5LA or B5LC, E5TX, P3LE/P3LEa, P3LG,<br>- Channel subrack P7LC with hardware modules B4LE, P4LTa or P4LUa <sup>1)</sup> ²)<sup>1)</sup>, R1LA, P4RX, earth rail R9AL and optional hardware modules O4LE/O4LEa, G4AI/G4Ala, O4CV, R1BC,<br>- External cables V9OW/V9OU/V9OV/V9OT/V9OX/V9OY (for P4LTa or P4LUa), V9OH/V9OZ (for P4LUa), V9MR (for R1BC), V9OS (for O4LE/O4LEa), V9OF (for G4AI/G4Ala) and V9OI (for O4CV),<br>- Optional remote inquiry set R7AP,<br>- Service telephone Q8AB,<br>- Circuit breaker B9AS. |

**Notes:**

1) ETL600 Releases 3.0.0 and higher do no longer support the hardware modules P4LT and P4LU. Modules of type P4LTa or P4LUa are required.

2) The module R1LA is only compatible with P4LUa, not with P4LTa.
## Release Compatible hardware, firmware and software

### ETL600 Rel. 3.2.0
- Software HMI600 version 3.3.0 or higher,
- Software SVR600 version 1.0.0 or higher,
- Firmware ETL600 version 3.20 or higher on module P4LTa or P4LUa †,  
- Microcontroller firmware version 1.12 or higher on module P4LTa or P4LUa †,
- Firmware O4LE version 2.14 or higher on module O4LE/O4LEa,
- Firmware G4AI version 3.13 or higher on module G4AI/G4Ala,
- Firmware R1LA version 1.23 on module R1LA,
- Firmware O4CV version 1.21 or higher on module O4CV,
- ABB-ETL-MIB version 1,  
- ETL640/ETL680: Power subrack P7LA with hardware modules P1LA, B5LA or B5LC, E5TX, P3LE/P3LEa, P3LG,  
- Channel subrack P7LC with hardware modules B4LE, P4LTa or P4LUa †2, R1LA, P4RX, earth rail R9AL and optional hardware modules O4LE/O4LEa, G4AI/G4Ala, O4CV, R1BC,  
- External cables V9OW/V9OU/V9OV/V9OT/V9OX/V9OY (for P4LTa or P4LUa), V9OH/V9OZ (for P4LUa), V9MR (for R1BC), V9OS (for O4LE/O4LEa), V9OF (for G4AI/G4Ala) and V9OI (for O4CV),  
- Optional remote inquiry set R7AP,  
- Service telephone Q8AB,  
- Circuit breaker B9AS.

### Notes:
1) ETL600 Releases 3.0.0 and higher do no longer support the hardware modules P4LT and P4LU. Modules of type P4LTa or P4LUa are required.
2) The module R1LA is only compatible with P4LUa, not with P4LTa.

### ETL600 Rel. 3.2.1
- Software HMI600 version 3.3.0 or higher,
- Software SVR600 version 1.0.0 or higher,
- Firmware ETL600 version 3.20 or higher on module P4LTa or P4LUa †,  
- Microcontroller firmware version 1.12 or higher on module P4LTa or P4LUa †,
- Firmware O4LE version 2.14 or higher on module O4LE/O4LEa,
- Firmware G4AI version 3.13 or higher on module G4AI/G4Ala,
- Firmware R1LA version 1.24 on module R1LA,  
- Firmware O4CV version 1.22 or higher on module O4CV,  
- ABB-ETL-MIB version 1,  
- ETL640/ETL680: Power subrack P7LA with hardware modules P1LA, B5LA or B5LC, E5TX, P3LE/P3LEa, P3LG,  
- Channel subrack P7LC with hardware modules B4LE, P4LTa or P4LUa †2, R1LA, P4RX, earth rail R9AL and optional hardware modules O4LE/O4LEa, G4AI/G4Ala, O4CV, R1BC,  
- External cables V9OW/V9OU/V9OV/V9OT/V9OX/V9OY (for P4LTa or P4LUa), V9OH/V9OZ (for P4LUa), V9MR (for R1BC), V9OS (for O4LE/O4LEa), V9OF (for G4AI/G4Ala) and V9OI (for O4CV),  
- Optional remote inquiry set R7AP,  
- Service telephone Q8AB,  
- Circuit breaker B9AS.

### Notes:
1) ETL600 Releases 3.0.0 and higher do no longer support the hardware modules P4LT and P4LU. Modules of type P4LTa or P4LUa are required.
2) The module R1LA is only compatible with P4LUa, not with P4LTa.
<table>
<thead>
<tr>
<th><strong>Release</strong></th>
<th><strong>Compatible hardware, firmware and software</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>ETL600</strong>&lt;br&gt;<strong>Rel. 3.2.2</strong></td>
<td>- Software HMI600 version 3.30 or higher,&lt;br&gt;- Software SVR600 version 1.00 or higher,&lt;br&gt;- Firmware ETL600 version 3.20 or higher on module P4LTa or P4LUa&lt;sup&gt;1)&lt;/sup&gt;,&lt;br&gt;- Microcontroller firmware version 1.12 or higher on module P4LTa or P4LUa&lt;sup&gt;1)&lt;/sup&gt;,&lt;br&gt;- Firmware O4LE version 2.14 or higher on module O4LE/O4LEa,&lt;br&gt;- Firmware G4AI version 3.13 or higher on module G4AI/G4Ala,&lt;br&gt;- Firmware R1LA version 1.25 on module R1LA,&lt;br&gt;- Firmware O4CV version 1.22 or higher on module O4CV,&lt;br&gt;- ABB-ETL-MIB version 1,&lt;br&gt;- ETL640/ETL680: Power subrack P7LA with hardware modules P1LA, B5LA or B5LC, E5TX, P3LE/P3LEa, P3LG,&lt;br&gt;- Channel subrack P7LC with hardware modules B4LE, P4LTa or P4LUa&lt;sup&gt;1)&lt;/sup&gt;2), R1LA, P4RX, earth rail R9AL&lt;sup&gt;3)&lt;/sup&gt; and optional hardware modules O4LE/O4LEa, G4AI/G4Ala, O4CV, R1BC,&lt;br&gt;- External cables V9OW/V9OU/V9OT/V9OX/V9OY (for P4LTa or P4LUa), V9OH/V9OZ (for P4LUa), V9MR (for R1BC), V9OS (for O4LE/O4LEa), V9OF (for G4AI/G4Ala) and V9O1 (for O4CV),&lt;br&gt;- Optional remote inquiry set R7AP,&lt;br&gt;- Service telephone Q8AB,&lt;br&gt;- Circuit breaker B9AS.</td>
</tr>
</tbody>
</table>

**Notes:**

1) ETL600 Releases 3.0.0 and higher do no longer support the hardware modules P4LT and P4LU. Modules of type P4LT<sub>a</sub> or P4LU<sub>a</sub> are required.
2) The module R1LA is only compatible with P4LUa, not with P4LTa.
3) R9AL is an integrated part of channel subrack P7LC since mid of 2010.
## Compatible hardware, firmware and software

<table>
<thead>
<tr>
<th>Release</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>ETL600</strong></td>
<td><strong>Rel. 3.2.3</strong></td>
</tr>
<tr>
<td>-</td>
<td>Software HMI600 version 3.30 or higher,</td>
</tr>
<tr>
<td>-</td>
<td>Software SVR600 version 1.00 or higher,</td>
</tr>
<tr>
<td>-</td>
<td>Firmware ETL600 version 3.21 or higher on module P4LTa or P4LUa ¹,</td>
</tr>
<tr>
<td>-</td>
<td>Microcontroller firmware version 1.12 or higher on module P4LTa or P4LUa ¹,</td>
</tr>
<tr>
<td>-</td>
<td>Firmware O4LE version 2.14 or higher on module O4LE/O4LEa,</td>
</tr>
<tr>
<td>-</td>
<td>Firmware G4AI version 3.13 or higher on module G4AI/G4Ala,</td>
</tr>
<tr>
<td>-</td>
<td>Firmware R1LA version 1.25 on module R1LA,</td>
</tr>
<tr>
<td>-</td>
<td>Firmware O4CV version 1.22 or higher on module O4CV,</td>
</tr>
<tr>
<td>-</td>
<td>ABB-ETL-MIB version 1,</td>
</tr>
<tr>
<td>-</td>
<td>ETL640/ETL680: Power subrack P7LA with hardware modules P1LA, B5LA or B5LC, E5TX, P3LE/P3LEa, P3LG,</td>
</tr>
<tr>
<td>-</td>
<td>Channel subrack P7LC with hardware modules B4LE, P4LTa or P4LUa ¹², R1LA, P4RX, earth rail R9AL ³ and optional hardware modules O4LE/O4LEa, G4AI/G4Ala, O4CV, R1BC,</td>
</tr>
<tr>
<td>-</td>
<td>External cables V9OW/V9OU/V9OV/V9OT/V9OX/V9OY (for P4LTa or P4LUa), V9OH/V9OZ (for P4LUa), V9MR (for R1BC), V9OS (for O4LE/O4LEa), V9OF (for G4AI/G4Ala) and V9OI (for O4CV),</td>
</tr>
<tr>
<td>-</td>
<td>Optional remote inquiry set R7AP,</td>
</tr>
<tr>
<td>-</td>
<td>Service telephone Q8AB,</td>
</tr>
<tr>
<td>-</td>
<td>Circuit breaker B9AS.</td>
</tr>
</tbody>
</table>

### Notes:

1. ETL600 Releases 3.0.0 and higher do no longer support the hardware modules P4LT and P4LU. Modules of type P4LTa or P4LUa are required.
2. The module R1LA is only compatible with P4LUa, not with P4LTa.
3. R9AL is an integrated part of channel subrack P7LC since mid of 2010.
### Compatible hardware, firmware and software

<table>
<thead>
<tr>
<th>Release</th>
<th>Compatible hardware, firmware and software</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>ETL600</strong>&lt;br&gt;Rel. 3.4.0</td>
<td>- Software HMI600 version 4.00 or higher,&lt;br&gt;- Software SVR600 version 1.00 or higher,&lt;br&gt;- Firmware ETL600 version 3.32 or higher on module P4LTa or P4LUa&lt;sup&gt;1)&lt;/sup&gt;,&lt;br&gt;- Microcontroller firmware version 1.12 or higher on module P4LTa or P4LUa&lt;sup&gt;1)&lt;/sup&gt;,&lt;br&gt;- Firmware O4LE version 2.14 or higher on module O4LE/O4LEa,&lt;br&gt;- Firmware G4AI version 3.13 or higher on module G4AI/G4Ala,&lt;br&gt;- Firmware R1LA version 1.25 on module R1LA,&lt;br&gt;- Firmware O4CV version 1.23 or higher on module O4CV/O4CVa,&lt;br&gt;- ABB-ETL-MIB version 1,&lt;br&gt;- ETL640/ETL680: Power subrack P7LA with hardware modules P1LA, B5LA or B5LC, E5TX, P3LE/P3LEa, P3LG,&lt;br&gt;- Channel subrack P7LC with hardware modules B4LE, P4LTa or P4LUa&lt;sup&gt;1)&lt;/sup&gt;&lt;sup&gt;2)&lt;/sup&gt;, R1LA, P4RX, earth rail R9AL&lt;sup&gt;3)&lt;/sup&gt; and optional hardware modules O4LE/O4LEa, G4AI/G4Ala, O4CV/O4CVa, R1BC,&lt;br&gt;- External cables V9OW/V9OU/V9OV/V9OT/V9OX/V9OY (for P4LTa or P4LUa), V9OH/V9OZ (for P4LUa), V9MR (for R1BC), V9OS (for O4LE/O4LEa), V9OF (for G4AI/G4Ala) and V9OI (for O4CV/O4CVa),&lt;br&gt;- Optional remote inquiry set R7AP,&lt;br&gt;- Service telephone Q8AB,&lt;br&gt;- Circuit breaker B9AS.</td>
</tr>
</tbody>
</table>

**Notes:**

1) ETL600 Releases 3.0.0 and higher do no longer support the hardware modules P4LT and P4LU. Modules of type P4LT<sub>a</sub> or P4LU<sub>a</sub> are required.

2) The module R1LA is only compatible with P4LUa, not with P4LTa.

3) R9AL is an integrated part of channel subrack P7LC since mid of 2010.
<table>
<thead>
<tr>
<th>Release</th>
<th>Compatible hardware, firmware and software</th>
</tr>
</thead>
</table>
| ETL600 Rel. 3.5.0 | - Software HMI600 version 4.00 or higher,  
- Software SVR600 version 1.00 or higher,  
- Firmware ETL600 version 4.00 or higher on module P4LTb, P4LV or P4LX 1),  
- Microcontroller firmware version 1.12 or higher on module P4LTb, P4LV or P4LX 1),  
- Firmware O4LE version 2.14 or higher on module O4LE/O4LEa,  
- Firmware G4AI version 3.13 or higher on module G4AI/G4Ala,  
- Firmware R1LB version 1.02 or higher on module R1LB 2),  
- Firmware O4CV version 1.23 or higher on module O4CV/O4CVa,  
- ABB-ETL-MIB version 1,  
- ETL640/ETL680: Power subrack P7LA with hardware modules P1LA, B5LA or B5LC, E5TX, P3LE/P3LEa, P3LG,  
- Channel subrack P7LC with hardware modules B4LE, P4LTb, P4LV or P4LX 1,2), P4RX, earth rail R9AL 3) and optional hardware modules O4LE/O4LEa, G4AI/G4Ala, O4CV/O4CVa, R1BC,  
- External cables V9OW/V9OU/V9OV/V9OT/V9OX/V9OY (for P4LTb, P4LV or P4LX), V9OH/V9OZ (for P4LUa), V9MR (for R1BC), V9OS (for O4LE/O4LEa), V9OF (for G4AI/G4Ala) and V9OI (for O4CV/O4CVa),  
- Optional remote inquiry set R7AP,  
- Service telephone Q8AB,  
- Circuit breaker B9AS. |

**Notes:**

For the latest HMI600 and firmware versions, please refer to the latest ETL600 Rel. 4.

1) Firmware ETL600 version 4.00 and higher does no longer support the hardware modules P4LTA and P4LUa. Modules of type P4L TB, P4LV or P4LX are required.

2) The module R1LB is an integrated part of P4LV and P4LX.

3) R9AL is an integrated part of channel subrack P7LC since mid of 2010.
<table>
<thead>
<tr>
<th>Release</th>
<th>Compatible hardware, firmware and software</th>
</tr>
</thead>
<tbody>
<tr>
<td>ETL600</td>
<td>- Software HMI600 version 4.00 or higher,</td>
</tr>
<tr>
<td>Rel. 4.0.0</td>
<td>- Firmware ETL600 version 4.00 or higher on module P4LTb, P4LV or P4LX ¹),</td>
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<tr>
<td></td>
<td>- Microcontroller firmware version 1.12 or higher on module P4LTb, P4LV or P4LX ¹),</td>
</tr>
<tr>
<td></td>
<td>- Firmware O4LE version 2.14 or higher on module O4LEa,</td>
</tr>
<tr>
<td></td>
<td>- Firmware G4AI version 3.13 or higher on module G4Ala,</td>
</tr>
<tr>
<td></td>
<td>- Firmware R1LB version 1.02 or higher on module R1LB ²),</td>
</tr>
<tr>
<td></td>
<td>- Firmware O4CV version 1.23 or higher on module O4CV/O4CVa,</td>
</tr>
<tr>
<td></td>
<td>- ABB-ETL-MIB version 1,</td>
</tr>
<tr>
<td></td>
<td>- Subrack type P7LH (required for ETL600-050-1) with hardware modules P1LP, P4RXa,</td>
</tr>
<tr>
<td></td>
<td>P4LTb, P4LV or P4LX ¹²), E5TH, B5LD, earth rail R9AZ and optional hardware modules</td>
</tr>
<tr>
<td></td>
<td>O4LEa, G4Ala, O4CV/O4CVa, R1BC,</td>
</tr>
<tr>
<td></td>
<td>- Subrack type P7LP (required for ETL600-050-2) with hardware modules P1LP, E5TH,</td>
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<tr>
<td></td>
<td>B5LD,</td>
</tr>
<tr>
<td></td>
<td>- Subrack type P7LQ (required for ETL600-100-2) with hardware modules P1LP, E5TH,</td>
</tr>
<tr>
<td></td>
<td>B5LD, E5TC,</td>
</tr>
<tr>
<td></td>
<td>- Subrack type P7LF (required for ETL600-050-2 and ETL600-100-2) with hardware modules</td>
</tr>
<tr>
<td></td>
<td>P4RXa, P4LTb, P4LV or P4LX ¹²), earth rail R9AZ and optional hardware modules O4LEa,</td>
</tr>
<tr>
<td></td>
<td>G4Ala, O4CV/O4CVa, R1BC,</td>
</tr>
<tr>
<td></td>
<td>- External cables V9OW/V9OU/V9OV/V9OT/V9OX/V9OY (for P4LTb, P4LV or P4LX),</td>
</tr>
<tr>
<td></td>
<td>V9OH/V9OZ (for P4LV or P4LX), V9MR (for R1BC), V9OS (for O4LEa), V9OF (for G4Ala)</td>
</tr>
<tr>
<td></td>
<td>and V9OI (for O4CV/O4CVa),</td>
</tr>
<tr>
<td></td>
<td>- Optional remote inquiry set R7AP,</td>
</tr>
<tr>
<td></td>
<td>- Service telephone Q8AB.</td>
</tr>
</tbody>
</table>

**Notes:**

¹) Firmware ETL600 version 4.00 and higher does no longer support the hardware modules P4LTa and P4LUa. Modules of type P4LTb, P4LV or P4LX are required.

²) The module R1LB is an integrated part of P4LV and P4LX
### Release | Compatible hardware, firmware and software
--- | ---
**ETL600 Rel. 4.0.1** | - Software HMI600 version 4.01 or higher,
- Firmware ETL600 version 4.00 or higher on module P4LTb, P4LV or P4LX ¹,
- Microcontroller firmware version 1.12 or higher on module P4LTb, P4LV or P4LX ¹,
- Firmware O4LE version 2.14 or higher on module O4LEa,
- Firmware G4AI version 3.13 or higher on module G4Ala,
- Firmware R1LB version 1.03 or higher on module R1LB ²,
- Firmware O4CV version 1.23 or higher on module O4CV/O4CVa,
- ABB-ETL600R4-R1LB.mib version 1,
- Subrack type P7LH (required for ETL600-050-1) with hardware modules P1LP, P4RXa, P4LTb, P4LV or P4LX ¹², E5TH, B5LD, earth rail R9AZ and optional hardware modules O4LEa, G4Ala, O4CV/O4CVa, R1BC,
- Subrack type P7LP (required for ETL600-050-2) with hardware modules P1LP, E5TH, B5LD,
- Subrack type P7LQ (required for ETL600-100-2) with hardware modules P1LP, E5TH, B5LD, E5TC,
- Subrack type P7LF (required for ETL600-050-2 and ETL600-100-2) with hardware modules P4RXa, P4LTb, P4LV or P4LX ¹², earth rail R9AZ and optional hardware modules O4LEa, G4Ala, O4CV/O4CVa, R1BC,
- External cables V9OW/V9OU/V9OV/V9OT/V9OX/V9OY (for P4LTb, P4LV or P4LX), V9OH/V9OZ (for P4LV or P4LX), V9MR (for R1BC), V9OS (for O4LEa), V9OF (for G4Ala) and V9OI (for O4CV/O4CVa),
- Optional remote inquiry set R7AP,
- Service telephone Q8AB.

### Notes:

¹) Firmware ETL600 version 4.00 and higher does no longer support the hardware modules P4LTa and P4LUa. Modules of type P4LTb, P4LV or P4LX are required.

²) The module R1LB is an integrated part of P4LV and P4LX.

Table 1
6 Release notes

6.1 Release 1.0.2
Changes relative to Release 1.0.1:
- Software HMI600 Version 1.24 and Firmware ETL600 Version 1.31:
  Various improvements of MOD600.
- Hybrid P3LEa:
  Correction of anomaly concerning the socket “RF line monitor”.

6.2 Release 1.0.3
Changes relative to Release 1.0.2:
- Minor MOD600 performance improvements.

6.3 Release 1.0.4
Release 1.0.4 includes the following improvements relative to Release 1.0.3:
- Support of actual and previous versions of the Dummy Load P3LK for RF-loopback operation
  (testing mode).
- Performance optimization of NSD600 for blocking simultaneous with data transmission at low
  temperatures.
An upgrade at the next occasion from a previous release is recommended but not mandatory.

6.4 Release 2.0.0
Additions relative to Release 1.0:
- NSD600 in 2 kHz APLC channel
- LAN interface
- G.703.1 interface
- V.11 transit operation
- ETL640 (40 W output power):
  Tx filters with 8 kHz bandwidth for center frequencies 28 … 40 kHz (steps 0.5 kHz) added

6.5 Release 2.1.0
Release 2.1.0 includes the following improvements relative to Release 2.0.0:
- ETL680 (80 W output power):
  Tx filters with 8 kHz bandwidth for center frequencies 28 … 40 kHz (steps 0.5 kHz) added
- Anomaly eliminated (see 1KHW001497 Anomaly List for ETL600):
  Time-limited “persistent” commands of NSD600 in 2 kHz APLC channel
An upgrade at the next occasion from a previous release is recommended but not mandatory.

6.6 Release 2.1.1
Release 2.1.1 includes the following improvements relative to Release 2.1.0:
- ETL680 (80 W output power):
  Tx filters with 4 kHz bandwidth for center frequencies 40…500 kHz (steps 0.5 kHz) added
- Anomaly eliminated (see 1KHW001497 Anomaly List for ETL600):
  Configuration file incompatibility
An upgrade at the next occasion from a previous release is recommended but not mandatory.
6.7 **Release 2.2.0**

Release 2.2.0 includes the following improvements relative to Release 2.1.1:

- ETL600 SNMP agent: configurable management station trap ports
- HM600 program arguments: internet connection to equipment possible (enables integration in ABB communication network management system “FOXMAN”)

An upgrade at the next occasion from a previous release is recommended but not mandatory.

6.8 **Release 3.0.0**

Release 3.0.0 includes the following improvements relative to Release 2.2.0:

- Compressed telephony interface O4CV

An upgrade at the next occasion from a previous release is recommended but not mandatory.

6.9 **Release 3.1.0**

Release 3.1.0 includes the following improvements relative to Release 3.0.0:

- Adaptive Equalizer for NSK600 modems using DAPSK modulation
- Minor LAN600 performance improvements
- Minor start-up optimization of module O4CV

An upgrade at the next occasion from a previous release is recommended but not mandatory.

6.10 **Release 3.2.0**

Release 3.2.0 includes the following improvements relative to Release 3.1.0:

- MOD600 above speech:
  - Two new DPLC bands of either 2 kHz or 6 kHz which are combined with a 2 kHz analog speech band to a total bandwidth of 4 kHz or 8 kHz (additionally, one or two standard APLC channels of 4 kHz can be configured in a total bandwidth of 8 or 12 kHz respectively 12 or 16 kHz)
- TCP/IP header compression according to Van Jacobsen (RFC 1144) also available in “Bridging” mode
- Robust header compression (ROHC) according to RFC 3095 for UDP/IP and RTP/UDP/IP packets (e.g. VoIP) in “Bridging” and “IP Routing” mode
- HM600 over LAN:
  - Remote broadband access via DPLC channel possible (in addition to remote narrowband access via EOC)

An upgrade at the next occasion from a previous release is recommended but not mandatory.

6.11 **Release 3.2.1**

Release 3.2.1 includes the following improvements relative to Release 3.2.0:

- Compressed telephony interface O4CV:
  - Bugfix of infrequent voice key read error.
- LAN interface R1LA:
  - Bugfix of start up problem. R1LA now always starts up properly also when no “Routing / IP Bridging” is configured (if only the service “SNMP” is configured, for example).

An upgrade at the next occasion from a previous release is recommended but not mandatory.

6.12 **Release 3.2.2**

Release 3.2.2 includes the following improvements relative to Release 3.2.1:

- LAN interface R1LA:
  - Bugfix of start up problem. R1LA now always starts up properly also when receiving IP traffic during the boot process.

An upgrade at the next occasion from a previous release is recommended but not mandatory.
6.13 Release 3.2.3

Release 3.2.3 includes the following improvements relative to Release 3.2.2:

- RF-Converter module P4LTa or P4LUa:
  Bugfix of infrequent data key read error.

An upgrade at the next occasion from a previous release is recommended but not mandatory.

6.14 Release 3.4.0

Release 3.4.0 includes the following improvements relative to Release 3.2.3:

- V.24 ports: TVN/TVP levels corrected.
- 100 Bd FSK modem supports data rates much smaller than 100 Bd.
- Line echo canceller available on compressed telephony 4-wire interface (O4CV).

An upgrade is only needed if the the above features are required.

6.15 Release 3.5.0

Release 3.5.0 is a combination of the current Release 3 racks and RF units with the new RF-Converter module P4LTb, P4LV or P4LX.

Compared to the RF-Converter module P4LUa, the modules P4LV and P4LX provide the following features:

- Four port Ethernet/IP switch/router (R1LB).
- Digital transit for compressed voice channels.

An upgrade is only needed if the the above features are required.

6.16 Release 4.0.0

Release 4.0.0 is a combination of the new Release 4 racks and RF units with the new RF-Converter module P4LTb, P4LV or P4LX.

Compared to the Release 3 racks and RF units, the new Release 4 racks and RF units provide the following features:

- Three equipment configurations: compact single rack 50 W version with 4 slots for O4LE/O4CV/G4AI, dual rack 50 W or 100 W version with 7 slots for O4LE/O4CV/G4AI.
- Increased output power and RF frequency range (50 W or 100 W up to 1 MHz).
- Single or redundant power supply for all equipment versions.

Compared to the RF-Converter module P4LUa, the modules P4LV and P4LX provide the following features:

- Four port Ethernet/IP switch/router (R1LB).
- Digital transit for compressed voice.

If the above features are required, existing ETL600 Release 3 equipment can be upgraded with P4LV or P4LX to Release 3.5.0, allowing a link to be composed of ETL600 Release 3 and ETL600 Release 4 equipment.

6.17 Release 4.0.1

Release 4.0.1 includes the following improvements relative to Release 4.0.0:

- HMI600 command line interface modified (for use with R1LB).
- MUX600/MOD600: V.24 ports support additional data rates 200, 300 and 600 bps.
- Minor bugs fixed in HMI600 and R1LB.

An upgrade at the next occasion from the previous release is recommended.
Powerline Carrier Equipment: Series ETL600

Tuning Instructions for ETL600R4 Rx RF Filter P4RX

Contents

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2 Programming .................................................................................................. 2
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3 Tuning the individual filter circuits................................................................... 3
  3.1 Procedure for tuning the coils L1 and L2 ............................................. 4
4 Checking the gain and amplitude response of the filter ................................. 4
  4.1 Procedure to check the gain setting..................................................... 5
  4.2 Procedure to check the amplitude response........................................ 6
5 Test circuits..................................................................................................... 7

Test conditions:

- Temperature range: 10 °C to 40 °C.

List of test equipment:

<table>
<thead>
<tr>
<th>PC with Windows XP, Vista or Windows 7</th>
<th>HMI600 software</th>
<th>Newest version</th>
</tr>
</thead>
<tbody>
<tr>
<td>PC ☻ P4LV/X cable</td>
<td>1:1 serial RS-232</td>
<td></td>
</tr>
<tr>
<td>Rx filter tuning adapter</td>
<td>P4LM</td>
<td></td>
</tr>
<tr>
<td>Coaxial cable SSMB to BNC</td>
<td>V9MW</td>
<td></td>
</tr>
<tr>
<td>Coaxial cable SSMB to SSMB</td>
<td>V9PC</td>
<td></td>
</tr>
<tr>
<td>Level meter, wide band or selective, 10 kHz to 1 MHz.</td>
<td>SPM-33A (Acterna) or equivalent; featuring both wide band as well as selective measurements</td>
<td></td>
</tr>
<tr>
<td>Input impedance preferably 50 Ohm input; 75 Ohm may also be used.</td>
<td></td>
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</tr>
<tr>
<td>Plastic tuning screwdriver</td>
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<td></td>
</tr>
</tbody>
</table>

Notes:

- Level measurements during tuning & checking amplitude response of P4RX are relative. Hence any ordinary wide band or selective level meter with a frequency range 10 kHz to 1000 kHz can be used. Normally a wide band level meter will be sensitive enough. If more sensitivity is required, use a selective one. Be careful when using a wide band meter, as unwanted signals may disturb the measurement.

- The Rx filter tuning adapter P4LM can be used also for tuning of the Rx filters in ETL 41 and ETL500. However, if two shorting wires are present on P4LM, they must be removed. The position of these 2 shorting wires - if present - will be across C1-C9 & C2-C10, under the sub-board of the tuning adapter.
1 General

The Rx filter P4RX is tuned using the Rx tuning adapter P4LM and the user interface program HMI600. Before tuning, the filter programming jumpers must be set according to the programming tables stored in HMI600. Controlled by HMI600, the DSP module generates the test frequencies required for tuning of the filter.

2 Programming

The filter is programmed with jumpers. With the jumpers, the mode of the coils (series or parallel connection), the required capacitors and filter termination resistors are selected. Moreover, the amplifier gain is set by jumpers.

The required jumper settings are generated by the HMI600 program, depending on the chosen center frequency and nominal bandwidth. To set the jumpers, the top shielding cover of the P4RX board must be removed.

It is assumed that the equipment has been configured as required before executing the procedures described in this document.

Remove the top shielding cover from the P4RX board by loosening the two mounting screws and carefully pull-off the top cover. A screwdriver may be inserted in the slot adjacent to the screw to help lifting the cover.

2.1 Procedure for setting the required jumpers

1. Switch on the power of the ETL600, start up HMI600 on the PC, log on to the local ETL600 using equipment ID 0 and Read & write access, with Upload configuration as well as Upload status enabled.
2. On the Equipment menu, click Tuning & testing. A warning message box appears, informing that the normal operation of the link will be interrupted.
3. Click OK to get the Tuning & testing dialog box.
4. Click Tune Rx RF filter to get the Tuning Rx RF filter dialog box. In the frame Rx RF filter characteristics, deactivate the checkbox Auto-select standard filter if not yet done.
   
   Note: Once the filter has been selected, in order not to loose the filter settings, the checkbox Auto-select standard filter must not be activated anymore.
5. Check if the correct filter center frequency f0 and bandwidth are shown in the frame Rx RF filter characteristics. If these values shall be modified, select them from the drop down lists.
6. Place the jumpers according to the table shown in the frame Jumper settings P4RX (Receive filter): “0” means no jumper, “1” means jumper placed.
7. Clicking Ok to stores the filter settings in the equipment configuration. Clicking Cancel discards the filter settings.

The jumpers are stored in a plastic (anti static) bag fixed to the printed circuit board. Put the jumpers on the indicated positions, with the open side of the jumpers on top. Carefully check if the jumpers are positioned correctly, as wrong positioned jumpers may cause problems when tuning the filter. A wrong positioned jumper may not always be detected by the filter verification check!

Put the remaining (spare) jumpers back into the plastic bag for future use. Put the top cover back into its place and fasten the screws. Now the filter is ready for tuning.
3 Tuning the individual filter circuits

Once the Rx filter is programmed with jumpers for the required frequency band, its two individual circuit stages must be tuned with the help of the Rx filter tuning adapter P4LM and the HMI600 program. The tuning frequency generated by the DSP board is fed into P4LM via the RF line monitor using a coaxial cable (SSMB to BNC, V9MW). Refer to Figure 1 in chapter 5 for the test circuit. The Rx filter tuning adapter provides facilities for tuning the individual filter circuit stages.

The tuning adapter P4LM supports also the tuning of 3-stage filters. But as the filter on P4RX has 2 stages, the L2 jumper setting on the P4LM tuning adapter is not used. That’s why the coil L2 of the P4RX filter must be tuned by setting the tuning adapter for tuning of L3, as described in section 3.1.

Note: The adjuster screws in the coils L1 and L2 must be handled very carefully. Never turn these screws beyond their stop position! The screws have plastic M2 threads, which may be damaged easily! Only very little force is needed to break the screws at the lower end of the adjustment range when turning-in the screws.

To remove a damaged screw, first remove the top and bottom shield covers. With a small screwdriver (1.5 mm), try to turn the remaining part of the adjuster screw out of the coil (from the bottom side). Replace the adjuster screw with a new one of the same type, and reassemble the shield covers before tuning.
3.1 Procedure for tuning the coils L1 and L2

Refer to Figure 1, chapter 5.

1. Switch off the power of the ETL600, pull E5TH out of the rack and set the board to Tune Rx filter mode: Jumpers MH1, MH2, MH5 inserted, jumpers MH3 and MH4 removed. Insert E5TH into the rack.

   In case of an ETL600-100-2 equipment additionally pull E5TC and set the board to Tune Rx filter mode: Jumper MC2 inserted and jumper MC1 removed. Insert the E5TC into the rack.

2. Set P4LM as follows for tuning coil L1 of P4RX:
   - Connect the SSMB connector RF Monitor OUT on E5TH to the BNC connector IN on P4LM using the cable V9MW
   - Position of S1 : NORM
   - Position of S2 : TUNE
   - Position of S3 (select coil) : L1
   - Connect the BNC connector OUT of P4LM to the input of the level meter with the input impedance set to 50 Ohm, 75 Ohm or high impedance.

3. Plug P4RX on top of P4LM.

4. Switch on the power of the ETL600, start up HMI600 on the PC, log on to the local ETL600 using equipment ID 0 and Read & write access, with Upload configuration as well as Upload status enabled.

5. On the Equipment menu, click Tuning & testing.
   A warning message box appears, informing that the normal operation of the link will be interrupted.

6. Click OK to get the Tuning & testing dialog box.

7. Click Tune Rx RF filter to get the Tuning Rx RF filter dialog box.

8. Check if the correct filter center frequency f0 and bandwidth are shown.

9. Click Activate f1.

10. Using a plastic screwdriver, slowly turn the adjuster screw of coil L1, until the voltage at the level meter is minimized.
    The coil L1 is tuned now.

11. Select coil L2 by setting jumper S3 on P4LM to position L3(!) and repeat the procedure by clicking Activate f2 to tune coil L2 of P4RX. Note that jumper position L2 of S3 is not used for P4RX.

12. Click Deactivate frequency.

13. Click Cancel.
    The filter is tuned now.

4 Checking the gain and amplitude response of the filter

The ripple of the pass band and the selectivity of the filter are verified when checking the amplitude response.

The P4RX board may be checked when plugged directly in the rack, e.g. without the Rx filter tuning adapter P4LM. This way the influence of the tuning adapter on the filter is eliminated.

For these tests the mini coax (SSMB) connectors on the P4RX front panel are used. The upper connector labeled “RX RF-IN” is now used as a test input. The lower connector labeled “RX RF-OUT” is connected to the level meter preferably set to 50 Ohm input impedance. Refer to Figure 2 in chapter 5.

For these tests, the level meter should preferably have an input impedance of 50 Ohm, but 75 Ohm may also be used. A correction factor for this case is given below. The level of the test signal from the RF Line Monitor socket is quite low. In case a wide band level meter is not sensitive enough, use a more sensitive selective level, but in general a wide band level meter will be adequate.

A level meter like SPM-33 can also be set to high input impedance (approx. 6 kOhm). A 50 Ohm BNC “feed-through” termination plugged directly on the input socket of the level meter converts it into a 50 Ohm instrument. Set the scale units to dB.
4.1 Procedure to check the gain setting

Refer to Figure 2, chapter 5.

1. Plug P4RX directly into the rack.
2. Leave the jumpers MH1, MH2, MH5 on E5TH (in case of ETL600-100-2: also leave the jumper MC2 on E5TC) as described in section 3.1, step 1.
3. Connect the RF Line Monitor SSMB connector (having 320 Ohm output impedance) on E5TH to the input of the level meter set to 50 or 75 Ohm input impedance.
4. In the Tuning Rx RF filter dialog box, click Check Rx RF filter … to get the dialog box Check filter. Click Activate f0. Read the level in dB, designate this measured level as A.
5. Connect the RF Line Monitor SSMB connector on E5TH to the RX RF-IN (having 50 Ohm input impedance) SSMB connector on the P4RX board.
6. Connect the Rx RF-OUT SSMB connector of the P4RX board (having 50 Ohm output impedance) to the input of the level meter set to 50 or 75 Ohm input impedance. Read the indicated level in dB, designate this measured level as B.
7. (B-A) is the gain of the P4RX board. Now the following condition should be fulfilled:
   - If a 50 Ohm level meter is used:
     • for F0 ≤ 500 kHz: (B-A) = 0 dB ±1.5 dB
     • for F0 > 500 kHz: (B-A) = 0 dB +1.5 dB / -3.0 dB
   - If a 75 Ohm level meter is used:
     • for F0 ≤ 500 kHz: (B-A+1.3 dB) = 0 dB ±1.5 dB
     • for F0 > 500 kHz: (B-A+1.3 dB) = 0 dB +1.5 dB / -3.0 dB
4.2 Procedure to check the amplitude response

Refer to Figure 2 in chapter 5.

**Note:** Do not use any of the previously measured values for the process described hereafter.

1. Plug the P4RX module directly into the rack.
2. Leave the jumpers MH1, MH2, MH5 on E5TH (in case of ETL600-100-2: also leave the jumper MC2 on E5TC) as described in section 3.1, step 1.
3. Connect the **RF Line Monitor** SSMB connector on E5TH to the **RX RF-IN** SSMB connector on P4RX (having 50 Ohm input impedance).
   
   Connect the level meter set to 50 or 75 Ohm input impedance to the **Rx RF-OUT** SSMB connector on P4RX (having 50 Ohm output impedance).
4. In the **Tuning Rx RF filter** dialog box, click **Check Rx RF filter** to get the dialog box **Check filter**.
5. Click **Activate f0** and follow the instructions given in the dialog box.
6. Click **Activate f0 – 0.5·BRx** ($B_{Rx} = 4, 8, 16$ or 32 kHz). Measure the voltage at **Rx RF-OUT** in dB and verify the pass condition given in the dialog box.
7. Click **Activate f0 + 0.5·BRx** ($B_{Rx} = 4, 8, 16$ or 32 kHz). Measure the voltage at **Rx RF-OUT** in dB and verify the pass condition given in the dialog box.
8. If the pass conditions in steps 6 and 7 are fulfilled, the pass band ripple of the filter is within specifications.
9. With the next tests, the filter selectivity is checked.
   
   Click **Activate f0 – 2·BRx** ($B_{Rx} = 4, 8, 16$ or 32 kHz). Measure the voltage at **Rx RF-OUT** in dB and verify the pass condition given in the dialog box.
10. Click **Activate f0 + 2·BRx** ($B_{Rx} = 4, 8, 16$ or 32 kHz). Measure the voltage at **Rx RF-OUT** in dB and verify the pass condition given in the dialog box.
11. If the pass conditions in steps 9 and 10 are fulfilled, the selectivity of the filter is within specifications.
12. Click **Deactivate frequency** and **Close**.
13. Click **Cancel**.
14. Switch off the power of the ETL600, pull E5TH out of the rack and set the board to **Normal** mode:
    
    Jumpers MH3, MH4 inserted and jumpers MH1, MH2, MH5 removed.
    
    Insert E5TH into the rack.
    
    **In case of an ETL600-100-2 equipment** additionally pull E5TC and set the board to **Normal** mode:
    
    Jumper MC1 inserted and jumper MC2 removed. Insert the E5TC into the rack.
5 Test circuits

Figure 1: Test circuit for tuning L1 and L2 on P4RX

Notes:

1. For checking the signal path from the DSP board to the BNC socket IN of P4LM, switch S1 of P4LM can be put to position SET. Then the BNC socket IN of P4LM is directly connected to BNC socket OUT of P4LM.

2. Normally S1 of P4LM is set to NORM.

3. On P4LM, jumper S3 has to be in position L1 to tune P4RX coil L1 and in position L3(!) to tune P4RX coil L2. Position L2 of jumper S3 on P4LM is not used!
Figure 2: Test circuit for verifying the P4RX gain amplitude response

Note: The P4RX board is plugged directly in the rack, without tuning adapter!
Powerline Carrier Equipment: Series ETL600

Tuning Instructions for ETL600R4 Tx RF Filter on E5TH/C

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3 Tuning of the filter circuit .......................................................................................................3
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Test conditions:
- Temperature range: 10 °C to 40 °C.

List of equipment:

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>PC</td>
<td>Windows XP, Vista or Windows 7</td>
</tr>
<tr>
<td>HMI600</td>
<td>Software Newest version</td>
</tr>
<tr>
<td>Cable PC</td>
<td>P4LT/V/X 1:1 Sub-D 9 pole serial RS-232</td>
</tr>
<tr>
<td>Level meter</td>
<td>Wide band or selective, 10 kHz to 1 MHz, high input impedance (e.g. several kOhm)</td>
</tr>
<tr>
<td>Coaxial cable</td>
<td>SSMB to BNC V9MW</td>
</tr>
</tbody>
</table>

Note: Please refer to 1KHW001490 for compatibility between software HMI600, firmware and hardware of ETL600.
1 General

The Tx filter located on the modules E5TH and E5TC is tuned using the user interface program HMI600. Before tuning, the filter programming jumpers must be set according to the programming tables stored in HMI600. Controlled by HMI600, the DSP module generates the test frequencies required for tuning of the filter.

2 Filter programming

The filter is programmed with jumpers. With the jumpers, the coils and the required capacitors are selected. The required jumper settings are generated by the HMI600 program, depending on the chosen nominal frequency and bandwidth.

It is assumed that the equipment has been configured as required before executing the procedures described in this document.

2.1 Procedure for setting the required jumpers

1. Switch on the power of the ETL600, start up HMI600 on the PC, log on to the local ETL600 using equipment ID 0 and Read & write access, with Upload configuration as well as Upload status enabled.

2. On the Equipment menu click Tuning & testing.
A warning message box appears, informing that the normal operation of the link will be interrupted.

3. Click OK to get the Tuning & testing dialog box.

4. Click Tune Tx RF filter to get the Tuning Tx RF filter dialog box. In the frame Tx RF filter characteristics, deactivate the checkbox Auto-select standard filter if not yet done.

Note: Once the filter has been selected, in order not to loose the filter settings, the checkbox Auto-select standard filter must not be activated anymore.

5. Check if the correct filter center frequency f0 and bandwidth are shown in the frame Tx RF filter characteristics. If these values shall be modified, select them from the drop down lists.

6. Switch off the power of the ETL600, pull E5TH – and in case of ETL600-100-2 also E5TC – out of the rack and remove the housing of these modules as described in section 4.1.

7. Place the jumpers on E5TH – and in case of ETL600-100-2 also on E5TC – as indicated in the frame Jumper settings E5TH/E5TC (Transmit filter): “0” means no jumper, “1” means jumper placed.

8. In case of ETL600-100-2: Place the jum pers on E5TC as indicated in the frame Jumper settings E5TC (Combiner).

9. Clicking Ok to stores the filter settings in the equipment configuration. Clicking Cancel discards the filter settings.

10. Install the housing of the module E5TH module – and in case of ETL600-100-2 also of the E5TC module – as described in section 4.2.
3 Tuning of the filter circuit

Once the Tx filter is programmed with jumpers for the required frequency band, its coil must be tuned. The tuning frequency is generated by the DSP module and fed into E5TH / E5TC via the associated amplifier P1LP. For the tuning, the E5TH / E5TC filter housing must be installed.

3.1 Tuning procedure for ETL600-050-1 and ETL600-050-2 (50 W terminals)

Refer to the test circuit shown in Figure 2, chapter 4.

Note: Keep the module E5TH and the amplifier P1LP used during the tuning procedure always together. Exchanging one of those parts requires retuning of the Tx filter from the beginning!

1. Switch off the power of the ETL600, pull E5TH out of the rack and set the board to Tx filter tuning mode: Jumpers MH1, MH2, MH4, MH5 inserted, jumper MH3 removed. Insert E5TH into the rack.
2. Connect the RF Line Monitor socket at the front E5TH front panel to the level meter in wideband mode and set to high input impedance.
3. Switch on the power of the ETL600, start up HMI600 on the PC, log on to the local ETL600 using equipment ID 0 and upload configuration and status of the equipment.
4. Choose the Equipment menu and click Tuning & testing. A warning message box appears, informing that the normal operation of the link will be interrupted.
5. Click OK to get the Tuning & testing dialog box.
6. Click Tune Tx RF filter to get the Tuning Tx RF filter dialog box.
7. Check if the correct filter center frequency f0 and bandwidth are shown in the frame Tx RF filter characteristics.
8. Click Activate f1 in the frame Tx RF filter tuning.
9. Turn the adjuster screw of coil L until the voltage at the level meter is minimized. If an end stop is reached before reaching a minimum, go to section 3.3 “End stop reached”.
10. Click Deactivate frequency and Cancel.
11. Switch off the power of the ETL600, pull E5TH out of the rack and set the board to Normal mode: Jumpers MH3, MH4 inserted and jumpers MH1, MH2, MH5 removed. Insert E5TH into the rack.
3.2 Tuning procedure for ETL600-100-2 (100 W terminals)

Refer to the test circuit shown in Figure 2, chapter 4.

Note: Keep the modules E5TH, E5TC and the amplifiers P1LP used during the tuning procedure always together. Exchanging one of those parts requires retuning of the Tx filters from the beginning!

1. Switch off the power of the ETL600, pull E5TH out of the rack and set the board to Tune Tx filter 1 or 2 mode: Jumpers MH1, MH2, MH4, MH5 inserted and jumper MH3 removed. Insert E5TH into the rack.
2. Pull E5TC out of the rack and set the board to Tune Tx filter 1 mode: Jumpers MC2, MC3 inserted and jumpers MC1, MC4 removed. Insert E5TC into the rack.
3. Connect the RF Line Monitor socket at the front E5TH front panel to the level meter in wideband mode and set to high input impedance.
4. Switch on the power of the ETL600, start up HMI600 on the PC, log on to the local ETL600 using equipment ID 0 and upload configuration and status of the equipment.
5. Choose the Equipment menu and click Tuning & testing. A warning message box appears, informing that the normal operation of the link will be interrupted.
6. Click OK to get the Tuning & testing dialog box.
7. Click Tune Tx RF filter to get the Tuning Tx RF filter dialog box.
8. Check if the correct filter center frequency f0 and bandwidth are shown in the frame Tx RF filter characteristics.
9. Click Activate f1 in the frame Tx RF filter tuning.
10. Turn the adjuster screw of coil L on the E5TH front panel until the voltage at the level meter is minimized. If an end stop is reached before reaching a minimum, go to section 3.3 “End stop reached”.
11. Click Deactivate frequency and Cancel.
12. Switch off the power of the ETL600, pull E5TC out of the rack and set the board to Tune Tx filter 2 mode: Jumpers MC2, MC4 inserted and jumpers MC1, MC3 removed. Insert E5TC into the rack.
13. Switch on the power of the ETL600, start up HMI600 on the PC, log on to the local ETL600 using equipment ID 0 and upload configuration and status of the equipment.
14. Choose the Equipment menu and click Tuning & testing. A warning message box appears, informing that the normal operation of the link will be interrupted.
15. Click OK to get the Tuning & testing dialog box.
16. Click Tune Tx RF filter to get the Tuning Tx RF filter dialog box.
17. Check if the correct filter center frequency f0 and bandwidth are shown in the frame Tx RF filter characteristics.
18. Click Activate f1 in the frame Tx RF filter tuning.
19. Turn the adjuster screw of coil L on the E5TC front panel until the voltage at the level meter is minimized. If an end stop is reached before reaching a minimum, go to section 3.3 “End stop reached”.
20. Switch off the power of the ETL600, pull E5TH out of the rack and set the board to Normal mode: Jumpers MH3, MH4 inserted and jumpers MH1, MH2, MH5 removed. Insert E5TH into the rack.
21. Pull E5TC out of the rack and set the board to Normal mode: Jumpers MC1, MC3, MC4 inserted and jumper MC2 removed. Insert E5TC into the rack.
3.3 End stop reached

If a coil has reached its end stop, then one should select an alternative jumper combination for the capacitors. If the tuning coil is at its left end-stop, then the next larger combination capacity is to be selected. If the tuning coil is at its right end-stop, then the next smaller combination capacity is to be selected.

1. If the tuning coil is at its left end-stop, click on the button Left end-stop reached in the frame Coil L of the Tuning Tx RF filter dialog box. Alternatively, if the tuning coil is at its right end-stop, click on the button Right end-stop reached in the frame Coil L of the Tuning Tx RF filter dialog box. A new jumper combination is displayed in the frame Jumper setting E5TH/E5TC (Transmit filter).

2. Place the jumpers as indicated in the frame Jumper settings E5TH/E5TC (Transmit filter): “0” means no jumper, “1” means jumper placed.

3. Turn the adjuster screw of coil L until the voltage at the level meter is minimized. If the end stop is reached before reaching a minimum, repeat steps 1 and 2.

4. Continue the tuning procedure where it was left before entering the end stop reached procedure.

Clicking the Default button in the frame Coil L restores the original capacitor jumper combination.

4 Removing and installing the housing of E5TH / E5TC

4.1 Removing

To set the required jumpers, the housing of the printed circuit board (PCB) holding the filter components has to be removed. To do so, remove the two screws indicated in Figure 1 on the front panel of the E5TH or E5TC module and the four screws in the corners of the rear cover of the filter housing. Using a pen, mark the slot where the board is inserted into the housing and carefully slide the PCB with the attached rear cover of the housing out to the rear.

![Figure 1: Screws to remove and insert on front panel of E5TH / E5TC](image)
4.2 Installing

Reinsert the PCB with the attached rear cover of the housing from the rear into the marked slot of the housing and slide it towards the front panel. Caution: The transparent light guide for the Tx ALARM LED which pops out over the front edge of the PCB must be aligned with the associated hole in the front panel before completely sliding in the PCB. Otherwise the light guide may break. Align the PCB with the front panel so that the two screws marked in Figure 1 can be screwed in from the front side. Do not yet tighten them. Insert the four screws in the corners of the rear cover and screw them in partly. Finally, tighten the two screws on the front panel and after that the four screws in the corners of the rear cover.

When reassembling the E5TH / E5TC module, take care not to break the transparent light guide for the Tx ALARM LED. It must be aligned with the associated hole in the front panel when sliding the PCB towards the front panel. This requires inserting the PCB in the correct slot of the housing, i.e. the one that was marked before removing the housing.

5 Test circuit

Figure 2: Test circuit for tuning of the Tx filters in ETL600 Rel.4 terminals
Powerline Carrier Equipment: Series ETL600

Programming and Testing Instructions ETL600R4

This document describes programming and testing of power line carrier equipment ETL600 Rel.4, including the teleprotection system NSD600.

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A Programming Instructions for the ETL600R4 Equipment
A.1 General
A.2 Create a configuration for the equipment using HMI600
A.3 Hardware
A.4 Settings for basic equipment ETL600
A.5 Settings for alarm unit R1BC, if present
A.6 Settings for NSD600 interface G4AI, if present
A.7 Check service keys

B Testing Instructions for the ETL600 Equipment.
B.1 General
B.2 Check power supply B5LD
B.3 Connect to the equipment, download configuration and prepare for tuning & testing
B.4 Change configuration, if necessary
B.5 Transmitter
B.6 Receiver
B.7 Equalization of APLC channels
B.8 Testing of R1BC, if present
B.9 Configure Real Time Clock (RTC)
B.10 Testing of NSD600 with interface G4AI, if present
B.11 Testing of O4LE, if present
B.12 Testing of the V.11 ports
B.13 Testing of the V.24 ports
B.14 Testing of the LAN ports
B.15 Testing of O4CV, if present
B.16 Documentation
B.17 Manual reset

ETL600R4 Hardware Checks: .............................................................. A1 - A3
ETL600R4 System Test Report: ........................................ Refer to document 1KHW002568

The terminal designations in this document apply to terminals blocks for 10 wire pairs.

Test conditions:

- Temperature range: 10 °C to 40 °C.
- The connections for the tests can be made either at the test sockets on the front of the equipment or at the terminals.
Basic test equipment

PC with Windows XP, Vista or Windows 7
HMI600 software Newest version
Cable PC ⇔ P4LT/V/X 1:1 Sub-D 9 pole serial RS-232
Digital multimeter GMC METRAhit one, or equivalent
Level meter True RMS with a frequency range up to 1 MHz

Optional test equipment

Level generator PS-33A (Acterna) or equivalent
Selective level meter SPM-33A (Acterna) or equivalent
Storage oscilloscope Fluke 190C ScopeMeter or equivalent
Rx tuning adapter P4LM HENF 209665
Data tester PFA-35 (Acterna) or equivalent
Ethernet Tester CMA3000 (Anritsu) or equivalent

Notes:

- This document is part of instruction manual 1KHW002582.
- Please refer 1KHW001490 for compatibility between software HMI600, firmware and hardware of ETL600.

Designations and abbreviations used:

<table>
<thead>
<tr>
<th>Designation</th>
<th>Meaning</th>
</tr>
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<tbody>
<tr>
<td>___________</td>
<td>Measured value</td>
</tr>
<tr>
<td>[ ... ]</td>
<td>Programmed value</td>
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<tr>
<td>[ D ]</td>
<td>Preferred setting (default)</td>
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<tr>
<td>[ X ]</td>
<td>Test passed or jumper is set</td>
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<tr>
<td>[ ]</td>
<td>Not tested or jumper is not set</td>
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<tr>
<td>P4LT</td>
<td>Module type</td>
</tr>
<tr>
<td>BER</td>
<td>Bit error ratio</td>
</tr>
<tr>
<td>Def.</td>
<td>Default value</td>
</tr>
<tr>
<td>equ.</td>
<td>Equipment</td>
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<tr>
<td>f_lo</td>
<td>Lower frequency, usually meant as low cut-off frequency</td>
</tr>
<tr>
<td>LED</td>
<td>Light Emitting Diode</td>
</tr>
<tr>
<td>HMI600</td>
<td>User interface program for ETL600 running on a PC</td>
</tr>
<tr>
<td>N02</td>
<td>Position in rack: Slot number N02</td>
</tr>
<tr>
<td>Rx</td>
<td>Receiver</td>
</tr>
<tr>
<td>Tx</td>
<td>Transmitter</td>
</tr>
<tr>
<td>PC</td>
<td>Personal computer</td>
</tr>
<tr>
<td>(T.02/..1)</td>
<td>Connector 1 of terminal block connected to board at rack position N02</td>
</tr>
</tbody>
</table>
A Programming Instructions for the ETL600R4 Equipment

A.1 General

All RF channel settings, all settings of telephony- and teleoperation-ports, most settings of the integrated teleprotection system NSD600 are performed with the configuration program HMI600. Typically these data are configured off-line and stored as a file on a disk. All these settings are loaded from a file – the ETL600 configuration file *.et6 – and downloaded to the equipment. The download of hardware settings such as jumpers or the presence or absence of modules without access to the TDM bus is just for documentation and the correctness of this information must be verified in the course of this instruction.

The most important settings are the RF Tx and Rx carrier. A few settings have to be adjusted with the equipment e.g. the Tx RF level. Most of these tuning, testing and adjustment procedures are supported by HMI600.

First the hardware settings of the analogue passive modules, such as the Tx- and Rx-Filter must be done. For these hardware settings, refer to the applicable instructions. All steps and measurements have to be documented in the protocol starting with page A1 of this document and in the separate document 1KHW002568 System Test Report ETL600R4.

Follow conscientiously and step-by-step this instruction and the equipment will work properly!

A.2 Create a configuration for the equipment using HMI600

Create a configuration for your equipment with HMI600. This is described in the instruction manual 1KHW002582, section 5, ‘Configuration and set-up’.

If a preconfigured file exists, open this file. Make sure, that you have opened the right file by displaying the configuration text on screen (View / Display configuration) and check the entries of ‘Equipment identification’.

A.3 Hardware

A.3.1 Racks

Check in the configuration file (View / Display hardware settings only) if the racks (P7LP, P7LQ, P7LF, P7LH) correspond to the hardware. If entries are wrong, they can be corrected in the dialog Configuration / Services / Type and Configuration / Services / RF-PEP [W] by selecting the correct entries as shown in the following table:

<table>
<thead>
<tr>
<th>Configuration / Services / Type</th>
<th>Configuration / Services / RF-PEP [W]</th>
<th>Resulting equipment type</th>
<th>Racks</th>
</tr>
</thead>
<tbody>
<tr>
<td>ETL600-050-1</td>
<td>12, 5, 25, 50</td>
<td>ETL600-050-1</td>
<td>P7LH</td>
</tr>
<tr>
<td>ETL600-050-2, ETL600-100-2</td>
<td>12, 5, 25, 50</td>
<td>ETL600-050-2</td>
<td>P7LP, P7LF</td>
</tr>
<tr>
<td></td>
<td>100</td>
<td>ETL600-100-2</td>
<td>P7LQ, P7LF</td>
</tr>
</tbody>
</table>

A.3.2 Modules

Make sure that all assemblies are mounted in the correct rack at the correct position as given by the configuration file (View / Display hardware settings only) under the headings Modules in rack P7LH, Modules in rack P7LP, Modules in rack P7LQ, Modules in rack P7LF.

The type of the DSP module is given by the following table:

<table>
<thead>
<tr>
<th>Configuration / Services / Data Communication / Data ports</th>
<th>Allowed DSP module types</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 V.11 / 2 V.24</td>
<td>P4LT, P4LV, P4LX</td>
</tr>
<tr>
<td>1 V.11 / 2 V.24 / Transit / 4 LAN</td>
<td>P4LV, P4LX</td>
</tr>
<tr>
<td>1 V.11 / 4 V.24 / Transit / 4 LAN</td>
<td>P4LX</td>
</tr>
</tbody>
</table>

If entries regarding the receive filter P4RX, alarm relay module R1BC and/or the number of power supply modules B5LD are wrong, they can be corrected in the the dialog Configuration / System / Equipment settings, frames Modules in rack P7LH, Modules in rack P7LP, Modules in rack P7LQ or Modules in rack P7LF.
The numbers of O4LE, O4CV and G4AI boards depend on the entries made in the dialog box Configuration / Services.

A.3.3 SFP transceiver
If the LAN 4 port is configured, check if the SFP transceiver is fitted on the P4LV/X module.

A.3.4 Spare plates
The front of the racks should be completely covered. Check if all spare plates are present.

A.4 Settings for basic equipment ETL600

A.4.1 Power amplifier P1LP
Set the jumpers on the power amplifier(s) P1LP as specified by the configuration file (View / Display hardware settings only).

A.4.2 Settings for the RF hybrid on module E5TH
Set the jumpers for the RF hybrid on module E5TH as given in the configuration view (View / Display hardware settings only).
Also put the jumpers for standard tuning of the RF hybrid on E5TH.

A.5 Settings for alarm unit R1BC, if present
Set the jumpers on R1BC as given in the configuration file (View / Display configuration) under the heading R1BC settings.

A.6 Settings for NSD600 interface G4AI, if present
Set the jumpers for each G4AI module as listed in the configuration file (View / Display hardware settings only). For access to the jumper plugs, remove the cover of G4AI at the component side.

A.6.1 Tripping of the inputs
Set the jumpers for each G4AI module as listed under “Tripping of the inputs” in the configuration file (View / Display hardware settings only).

A.6.2 Nominal input voltage
Set the jumpers for each G4AI module as listed under “Nominal input voltage” in the configuration file (View / Display hardware settings only).

A.6.3 Relay contacts
Set the jumpers for each G4AI module as listed under “Relay contacts” in the configuration file (View / Display hardware settings only).

A.6.4 Concluding work
Mount the cover of the G4AI modules at component side.

A.7 Check service keys
Depending on the desired services, an appropriate data key has to be installed on P4LT / P4LV / P4LX and appropriate voice keys on the O4CV boards. Physically, the keys are circular button-like devices called “iButtons” and have to be inserted into their sockets (also called “retainers”) on P4LT / P4LV / P4LX and O4CV.

A.7.1 P4LT / P4LV / P4LX data keys
Six different types of keys exist, identified by colored labels. Refer to the ETL600 instruction manual 1KHW002582 at the end of chapter 11 for more information. The number of required
MOD600 and NSK600 modems decides about the color of the needed data key, which is displayed in the configuration file (View / Display hardware settings only / Equipment identification / Needed data key on P4L<T/U/V/X>). Data keys with colors offering more modems than required will work as well. This is shown in the following table:

<table>
<thead>
<tr>
<th>Needed data key on P4LT / P4LV / P4LX</th>
<th>Keys which will work as well as the needed key</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Blue</td>
</tr>
<tr>
<td>White</td>
<td>✓</td>
</tr>
<tr>
<td>Blue</td>
<td>✓</td>
</tr>
<tr>
<td>Green</td>
<td></td>
</tr>
<tr>
<td>Yellow</td>
<td></td>
</tr>
<tr>
<td>Orange</td>
<td></td>
</tr>
<tr>
<td>Red</td>
<td></td>
</tr>
</tbody>
</table>

Check if the data key mounted on the P4LT / P4LV / P4LX board is valid according to the table above.
Please ask your local representative about the update procedure if the data key is not sufficient or if no data key is installed on P4LT / P4LV / P4LX.

When the new data keys are available, proceed as described in the procedure “Replace data key” below.

A.7.2 O4CV voice keys

Two different types of keys exist, identified by the numbers 2 or 4 corresponding to the maximum number of compressed telephony channels that can be used on each O4CV board. Refer to the ETL600 instruction manual 1KHW002582 at the end of chapter 11 for more information. The needed voice key for each O4CV board is displayed in the configuration file (View / Display configuration / Equipment identification / Needed voice key on O4CV) under the headings O4CV CONFIGURATION at slot N... The 4 channel voice key works also if the needed voice key is a 2 channel key. If several O4CV modules are used in an ETL600 terminal, at most one of them can have a 2 channel key. The remaining ones must be equipped with 4 channel keys.

Check if the voice keys mounted on the O4CV boards are valid as given by the HMI600 configuration view.
Please ask your local representative about the update procedure if the voice key is not sufficient or if no voice key is installed on one or more of the O4CV boards.

When the required voice keys are available, proceed as described in the procedure “Replace voice key” below.

Replace data or voice key (if required)
The service personnel must follow the precautions for ESD protection while handling the modules.

ESD protection

The modules in this equipment contain devices, which can be damaged by electrostatic discharges. Appropriate measures must be taken before unpacking modules or withdrawing them from equipment racks. Essential precautions to prevent ESD damage when handling or working on modules are grounding straps for technical personnel and the provision of anti-static workbenches. Modules may only be shipped either in their original packing or installed in equipment racks.
Insertion and removal of plug-in modules

Caution
Neither removing nor inserting of modules is permitted during power-up of the equipment. Preceding to plug in and out of modules, the power supply of the equipment has to be switched OFF.

There are two exceptions to this:

1. Rx filter P4RX:
   It has to be removed and inserted while the equipment remains powered when performing the Rx level adjustment procedure.

2. Redundant power supply module B5LD:
   It can be removed or inserted while the equipment remains powered by the other B5LD module in the rack.

1. Switch off the equipment.
2. Loosen the four mounting screws and pull out the P4LT/P4LV/P4LX or O4CV module. In case of the O4CV module, remove the cover plates by bending them slightly so that they can be drawn out of the notches in the mounting bolts.
3. Removal of the installed data or voice key, if any:
   Limit deflection of socket latches to just free the iButton edge from retained state. Avoid applying excess force to latches. The socket is shown in Figure 1.
4. Insertion of the new data or voice key:
   Apply appropriate back pressure at the opposite side of the P4LT/P4LV/P4LX or O4CV board before the data or voice key is inserted into the socket.
   Closely align the axis of the iButton and the socket. The socket then latches the flange of the iButton. The socket is shown in Figure 1.
5. In case of the O4CV module, reinstall the cover plates. Insert the P4LT/P4LV/P4LX or O4CV module back into the rack and tighten the four mounting screws.
6. Switch on the equipment.
B Testing Instructions for the ETL600 Equipment.

B.1 General

Most of the testing for the ETL600 system can be done with assistance of HMI600. For some adjustments like Tx RF level, Rx RF level etc. the permissible limits are calculated by the HMI600 and displayed in the dialog boxes.

The pilot signal is QPSK modulated to accommodate both Signaling and Embedded Operations Channel. As a result, the level of the pilot signal changes continuously so that its exact level cannot be measured.

The Tx filter on E5TH and the Rx filter P4RX (if used) have to be tuned before testing.

An attenuator with 75 Ohm impedance and a minimum attenuation of 15 dB is inserted between two terminals to simulate a power line. For testing, the attenuation between the two terminals is chosen as follows:

<table>
<thead>
<tr>
<th>Max. output power (PEP)</th>
<th>Equipment type</th>
<th>Attenuation</th>
<th>Switches of standard ‘80 Watt-attenuator’ (minimum = 15 dB)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>+3 dB</td>
<td>+6 dB</td>
</tr>
<tr>
<td>50 W  ETL600-050, 1 channel, no MOD600</td>
<td>31 dB</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>100 W  ETL600-100, 1 channel, no MOD600</td>
<td>34 dB</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>50 W  ETL600-050, 2 channels, no MOD600</td>
<td>25 dB</td>
<td></td>
<td></td>
</tr>
<tr>
<td>100 W  ETL600-100, 2 channel, no MOD600</td>
<td>28 dB</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>50 W  ETL600-050, 3 channels, no MOD600</td>
<td>21 dB</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>100 W  ETL600-100, 3 channels, no MOD600</td>
<td>24 dB</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>50 W  ETL600-050, with MOD600</td>
<td>18 dB</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>100 W  ETL600-100, with MOD600</td>
<td>21 dB</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

B.1.1 Visual checks before switching ON the equipment.

DANGER Check the wiring of protective earth to the equipment. Check, if a protective earth wire of at least 25 mm² has been connected visibly to the earth bolt of the cubicle.

In case of battery supply: Check if the positive pole (+) of the battery is grounded. If it is, place an earth jumper to the positive pole of the cubicle supply.

Note: Now switch on the equipment.

B.2 Check power supply B5LD

Check the DC supply voltage and verify that the green LED on the front panel of the right and – if any – of the left power supply module B5LD is/are lit.

There is no access to the internal DC voltages generated by B5LD. However, hardware alarms will be generated if these voltages go outside their limits.

B.3 Connect to the equipment, download configuration and prepare for tuning & testing

1. Start the HMI600 program, open the preconfigured file and connect to the equipment as described in the instruction manual, 1KHW002582, chapter 4, section ‘Communication to the ETL600’.
2. From the **Equipment** menu, click **Download configuration**. The keys are checked and error messages appear if any of them is not sufficient. Compatibility checks are performed to verify that the firmware versions in the equipment belong to the same release as the HMI600. If not, an error message pops up. Depending on the message, an earlier version of HMI600 must be used and/or the firmware of some modules must be upgraded. The latter is described in the document 1KHW002589 Firmware Download for ETL600.

3. If the download operation is possible, a message box appears informing that the link will be cut off for a few seconds. Click **Yes**.

4. The **Test configuration time** dialog box has been opened. Click **OK**.

5. HMI600 now compares the equipment identification from the file with the identification in the equipment. If it is different, a warning message box appears. Click **OK**. This starts the download configuration process.

6. A dialog box informs you, that the configuration has not been stored in the nonvolatile flash EPROM and asks you if you want to do so. Click **Yes**. The configuration data are now stored in the flash EPROMs. This process needs some seconds. Please wait until the color of the **stop** button in the toolbar changes from red to grey. The actual status of the process is displayed in the status bar.

7. From the equipment menu, click **Tuning & testing**. This opens a dialog box, which informs you that activating tests in the following dialog boxes may cause malfunctions of the PLC-link.

8. Click **OK** and the **Tuning & testing** dialog box appears.

**B.4 Change configuration, if necessary**

In case configuration parameters have to be changed, refer to section 5 of the instruction manual, chapter ‘Configuration and Setup’.

**B.5 Transmitter**

The frequency in the APLC bands when converted in to the RF band will have an additional offset of -150 Hz. This has been done to simplify the filtering by DSP. The frequency shift when reconverted to the AF band will be restored.

**B.5.1 Programming of Tx RF filter**

The transmit filter on the module E5TH is programmed and tuned according to 1KHW002585. The center frequency, bandwidth and associated jumper positions are supplied by HMI600.

In case of ETL600-100, the module E5TC is present, holding a second transmit filter. It must also be tuned according to 1KHW002585.

**B.5.2 Settings for RF hybrid on E5TH**

The jumper settings depending on the presence or absence of the Rx filter are shown in the view **View / Display hardware settings only** under the heading **E5TH in rack P7LH at slot N54** or **E5TH in rack P7LQ at slot N54**.

**B.5.3 Tune Tx RF filter**

The Tx filter(s) is/are tuned according to the ETL600R4 Tx filter tuning instructions 1KHW002585.

**B.5.4 Adjust Tx RF level**

The Tx RF level is adjusted with help of the HMI600 program.

Open the **Adjust Tx level** dialog box under **Equipment / Tuning & testing**. Click the buttons **Select** and then **Start**. The obtained setting accuracy is better than ± 0.2dB. Thus, by measuring the Tx level, the setting precision can’t be improved.
Adjustment procedure in case the level needs to be verified by external measurement equipment:

1. In the Tuning & testing dialog box click Adjust Tx RF level. This opens the Adjust Tx RF level dialog box.
2. Remove the remote equipment by disconnecting the coaxial cable from the RF LINE socket at the E5TH front panel.
3. Connect a 75 Ohm termination resistor or attenuator dimensioned for ≥ 50 W (ETL600-050) or ≥ 100 W (ETL600-100) to the RF LINE socket.
4. Click Start.
5. Measure the level at the RF LINE MONITOR socket on the E5TH front panel with a level meter having 75 or 50 Ohm input impedance.

Note: The tolerance of the level at the test socket RF LINE MONITOR is ± 0.2 dB. Thus, if the level meter has a tolerance of ± X dB, the resulting tolerance for the adjusted Tx level is ± (X + 0.2) dB.

Alternatively, measure the test tone level at the RF LINE socket via an attenuator required in order not to overdrive the input of the level meter. In this case, the tolerance of the attenuator must also be taken into account.

6. Adjust the value in the Tx RF level [dB] field, download it by clicking Start / Set and measure the test tone level again. Continue until the measurement corresponds to the permissible value displayed in the dialog box.

B.5.5 Adjust Tx alarm level

The Tx alarm level threshold is adjusted with the help of HMI600, the LED(s) TX-LVL-AL and the potentiometer(s) TX-LVL-AL ADJUST (R1805) in the rear of the backplane of the power amplifier(s) P1LP. In case of ETL600-100, there are two such potentiometers, one on each P1LP backplane, which both have to be tuned.

1. In the Tuning & testing dialog box, click Adjust Tx alarm level.
2. Click Activate Tx alarm level.
3. Turn the potentiometer(s) TX-LVL-AL ADJUST in the rear of the backplane(s) P1LP of the rack P7LH, P7LP or P7LQ clockwise until the associated TX-LVL-AL LED(s) to the right of the potentiometer(s) go(es) on.
4. Check that the Tx ALARM LED(s) on E5TH – and in case of ETL600-100 also on E5TC – light(s). After the programmed delay time, the Hardware alarm on the front plate of P4LT/P4LV/P4LX appears. The relay contacts on the cable V9OT Pin 2-3 are closed.
5. Turn the potentiometer(s) TX-LVL-AL ADJUST slowly anticlockwise until the TX-LVL-AL LED(s) go(es) off.
6. Click OK. The Alarm LED(s) go(es) off and the contacts open after the programmed delay.

Note: Exact measurement of the programmed delay times is not essential.

B.6 Receiver

B.6.1 Programming of Rx RF filter

The receive filter type P4RX is programmed, tuned and checked according to 1KHW002584. The center frequency, bandwidth and associated jumper positions are supplied by HMI600.

B.6.2 Tune Rx RF filter

The tuning is done with help of the Rx filter tuning adapter P4LM in accordance with the document 1KHW002584 ‘Tuning of ETL600R4 Rx RF Filter P4RX’.

B.6.3 Adjust Rx RF level

The Rx RF level is adjusted using HMI600 program.

1. In the Tuning & testing dialog box click Adjust Rx RF level.
2. Follow the instructions given in the dialog box.
Note: The number of adjustment steps depends on the presence of the Rx filter P4RX (configured with Configuration / System / Equipment settings / Assemblies in rack P7LC).

3. After all adjustment steps have been executed, click Close to close the dialog box.

B.6.4 Tune RF hybrid on E5TH

The goal of hybrid tuning is to increase the trans-hybrid loss, thereby reducing the amount of signal from the local transmitter entering the local receiver. Tuning is done while the equipment is energized and connected to the (artificial) line by setting the appropriate line balancing network jumpers for the hybrid on the E5TH board. These jumpers can be accessed by plugging the E5TH unit on the extender board P4EX.

Tuning is not required in the test field. If for some reasons – e.g. to get a customer approval – the tuning is done in the test field, it has to be repeated during commissioning later on site when the equipment is connected to the line.

If the hybrid is not tuned, the following default settings for the line balancing network must be used: Jumpers R2, L17 and C3 inserted and the potentiometer R1101 set to mid position (indicated by 50).

Procedure for tuning the hybrid:

1. Insert the PCB extender type P4EX in place of the E5TH module into the rack and plug E5TH on top of it.
2. Connect the artificial line to the RF LINE socket of the equipment.
3. Remove all line balancing jumpers R0 … R4, L0 … L17 and C0 … C17 on E5TH and set the potentiometer R1101 to mid position (indicated by 50).
4. In the Equipment menu of HMI600, click Tuning & testing. This opens the Tuning & testing dialog box.
5. Click Tune RF hybrid. This opens the Tune RF hybrid dialog box.
6. Click Start measurement and wait until the measured Rx RF level appears in the dialog box.

Note: It is possible that the operator phone of remote equipment is ringing during the measurement. This has no effect on the measurement.

HMI600 selectively measures the level of the RF signal from the own transmitter. In the following, this level is set to a minimum with the aid of the balancing network:
- resistance with one of the jumpers R0 … R4 and the potentiometer R1101,
- inductance with one of the jumpers L0 … L17,
- capacitance with one or several of the jumpers C1 to C17.

7. Reduce the measured Rx RF level by moving the R-jumper between R4, R3, R2, R1 and R0. When the best jumper position has been found, turn potentiometer R1101 until a first minimum is reached.
8. Search for a lower minimum by moving the L-jumper sequentially from L17 (largest inductance) to L1 (smallest inductance). L17 produces the smallest inductive current and L1 the largest. If jumper L17 does not produce any reduction, set jumper L0 which means no inductive current.

When the best jumper position for the inductance has been found, turn potentiometer R1101 until a minimum is reached.

Note: Only one L jumper (L0 to L17) may be inserted at any time

9. Search for a lower minimum by moving the C-jumper sequentially from C1 (smallest capacitance) to C17 (largest capacitance). More than one jumper may be inserted in parallel to increase the capacitance.

When the best jumper position for the capacitance has been found, turn potentiometer R1101 until a minimum is reached.

Click Stop measurement and Cancel to close the dialog box.

10. Remove the extender board P4EX and reinsert the E5TH module into the rack.
Note: If the coaxial cable (connection to the line) is removed or reconnected during the test, a rattling sound of a few seconds duration caused by the loop back relay on E5TH may occur. This happens only when E5TH is plugged on top of P4EX and has no influence on the performance.

Note: The transhybrid loss that has been achieved by tuning the hybrid is equal to the increase of the measured RF level when the RF cable is unplugged. If it is higher than 20 dB, the tuning can be considered as successful and may be terminated.

B.6.5 Link alarm indication
Trigger the link alarm by interrupting the RF connection (disconnecting the RF line coaxial cable). After the programmed delay time the link alarm relay on P4LT/V/X operates. The relay contacts, terminals 5 and 6 at the cable V9OT, are closed. Now restore the RF connection. The Alarm LED’s go OFF and the contacts will open after the programmed delay.

B.7 Equalization of APLC channels
Refer to 1KHL001494 ‘APLC Channel Equalization for ETL600’. The document is put into a short instruction in sections B.7.1 and B.7.2.

B.7.1 Measure frequency response
It is assumed, that
- the RF tuning of the remote equipment is already finished. If it isn’t finished, tune the remote equipment.
- the link works and all alarms are cleared.
Measure the frequency response as described in 1KHW001494 ‘APLC Channel equalization for ETL600’:
1. Select Equipment / Commissioning and maintenance / Frequency response / APLC channel 1, APLC channel 2 or APLC channel 3, respectively.
2. In the following message box click OK and wait until measurement is done. The dialog box Select equalizer appears.

B.7.2 Select Equalizer
For each APLC channel, an equalizer can be selected under Equipment / Commissioning and maintenance / Select Equalizer / APLC channel 1, APLC channel 2 or APLC channel 3, respectively.
Channel equalization is required for all DAPSK channels and recommended also for the FSK channels.
1. Select the new equalizer:
   In the field New equalizer, activate checkbox Amplitude response equalisation only.
2. External teleprotection equipment connected to ETL600 suffer from the additional delay introduced by the equalizer. To reduce this delay, select type None or Short in the frame New equalizer of the dialog box Select equalizer.
   If delay is uncritical, select type Middle or Long in the frame New equalizer of the dialog box Select equalizer.
3. View the amplitude response by clicking View. If the amplitude response is acceptable, go back to the Select equalizer dialog and select the viewed settings again. Download the new equalizer settings by clicking Download. The equipment is reset now.
4. Wait until the equipment has restarted. The new equalizer is active now.
5. Exit.
B.8 Testing of R1BC, if present

For testing the R1BC, refer the client specific setting instructions. Depending upon the programmed criteria, activate the required alarms using the following table. Check the contact closure of the programmed relays on R1BC. Restore the link after this test is completed.

<table>
<thead>
<tr>
<th>Alarm on R1BC</th>
<th>Action to enforce the alarm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Warning LED on P4LT/V/X</td>
<td>Activate a testtone in the ‘Adjust Tx RF level’ dialog box</td>
</tr>
<tr>
<td>Link alarm</td>
<td>Disconnect the RF line coaxial cable</td>
</tr>
<tr>
<td>Hardware (HW) alarm</td>
<td>Unplug the RF hybrid</td>
</tr>
<tr>
<td>Interface alarm, P4LT/V/X alarm</td>
<td>In case an external real time clock is configured and connected: Disconnect the clock input to P4LT/V/X. In case no external real time clock is configured: Configure it (dialog box ‘Configuration / System / Channel settings / Event recorder: Ext. real time clock sync available’).</td>
</tr>
<tr>
<td>System alarm (i.e. cabinet alarm)</td>
<td>Enforce either Link alarm or HW alarm</td>
</tr>
</tbody>
</table>

B.9 Configure Real Time Clock (RTC)

The real time clock has to be set to the actual date and time for proper operation of the event recorder.

B.9.1 Setting real time clock

Setting the date and time using HMI600:

1. On the Equipment menu, click Commissioning and maintenance, click Event recorder and click Set Clock.
2. In the Real Time Clock (RTC) dialog box, check if PC time and PC date are correct.
3. Click Download date/time to RTC
   This sets the RTC to the given date and time.
4. Click Upload date/time from RTC
   The date and time displayed at Read RTC date & time part of the Real Time Clock (RTC) box should be correct.
5. Click Cancel

B.9.2 Testing external real time clock synchronization (if available)

The external clock source with IRIG-B format has to be connected to the IRIG-B port at the front panel of P4LT/V/X via external cable V9OV.

Testing the external synchronization using HMI600:

1. Set the time on the PC a few hours back/forward
2. On the Equipment menu point to Commissioning and maintenance menu point to Event recorder and click Set Clock.
3. Click Download date/time to RTC. This sets the RTC to the wrong time.
4. Click Upload date/time from RTC. The date and time displayed at Read RTC date & time part of the Real time Clock (RTC) box should be correct and not correspond to the PC-date/time setting.
5. Click Cancel.
6. Set the time on the PC back to the correct time
B.10 Testing of NSD600 with interface G4AI, if present

B.10.1 Inputs

How to activate an input command depends on the jumper settings on G4AI.

- G4AI input programmed as ‘contact and battery voltage’:
  Inject a signal at input port with the voltage level U1 according to the jumper settings on G4AI (24 VDC, 48 VDC, 110 VDC, 220 VDC)
- G4AI input programmed as ‘contact only’:
  Short circuit the input port

The way to activate the input port is the same for a Tx command input and a start input. Activate the input port and check, if the IN LED lights.

B.10.2 Outputs

Depending upon the programmed criteria, activate the required action using the following table. Check the contact closure of the programmed outputs on G4AI.

Set the link back to an alarm free operation after this test.

<table>
<thead>
<tr>
<th>Output on G4AI</th>
<th>Action to enforce the output</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rx command</td>
<td>Inject a Tx command at the corresponding input at the remote station</td>
</tr>
<tr>
<td>Unblocking</td>
<td>Disconnect the RF line coaxial cable</td>
</tr>
<tr>
<td>Rx guard</td>
<td>Disconnect the RF line coaxial cable</td>
</tr>
<tr>
<td>Ack Tx command</td>
<td>Inject a Tx command at the corresponding input</td>
</tr>
<tr>
<td>TPE link alarm</td>
<td>Disconnect the RF line coaxial cable</td>
</tr>
<tr>
<td>TPE alarm</td>
<td>Disconnect the RF line coaxial cable</td>
</tr>
<tr>
<td>TPE hardware alarm</td>
<td>Inject a Tx command of length &gt; Max. Tx Trip Duration</td>
</tr>
<tr>
<td>G4AI alarm</td>
<td>Inject a Tx command of length &gt; Max. Tx Trip Duration</td>
</tr>
<tr>
<td>User alarm 1</td>
<td>Depends upon programmed alarm criteria</td>
</tr>
<tr>
<td>User alarm 2</td>
<td>Depends upon programmed alarm criteria</td>
</tr>
</tbody>
</table>

B.10.3 NSD600 loop test

The NSD600 is tested by issuing a loop test via HMI600.

In the Commissioning & maintenance … dialog box click NSD600 send loop test / TPE1 and – if TPE2 is configured – NSD600 send loop test / TPE2.

If the loop test is successful, a dialog box indicating the loop test time (T_{Link}) appears. Click OK to close the dialog box.

B.10.4 Command transmission time

Check the transmission time of the NSD600 commands over the link, e.g. by means of an oscilloscope.

How to activate an input command depends on the jumper settings on G4AI.

- G4AI input programmed as ‘contact and battery voltage’:
  Inject a signal at input port with the voltage level U1 according to the jumper settings on G4AI (24 VDC, 48 VDC, 110 VDC, 220 VDC)
- G4AI input programmed as ‘contact only’:
  Short circuit the input port

Transmit at few commands with a command / pause duration of about 100 ms / 1000 ms and measure the actual transmission time for the command from the local station to the remote station.
Note: The nominal transmission time as given in the technical data shall serve as a guideline for the mean value of several commands.

**B.10.5 Reset counters**

After NSD600 testing reset the counters by using HMI600. From the **Equipment** menu point to **Commissioning and maintenance** menu point to **Event recorder** and click **Reset counter**.

In the Reset Counter box click check box **Reset all counters**

Click **OK**

**B.11 Testing of O4LE, if present**

**B.11.1 Service phone**

Only a functional test must be done. The buzzer, the ringing of the connected service phone, and the audibility between the two service phones will be tested.

**B.11.2 Hot line direct phone**

The following tests must be done if the operation mode ‘Hot line direct phone’ is configured.

1. A functional test must be done to check the ringer. Connect on both sides of link a phone, make a call from one side to remote and vice versa.
2. Check the Output level of speech:
   Use coupling bridges similar to that, shown in Figure 2. The resistor R should be chosen to 500 Ohm, included the resistance of the two coils. If the coupling bridge has polarity, check first polarity of the subscriber interface at the cable terminals.
3. Feed a 800 Hz tone, with the configured level from remote side into remote equipment.
   Take a measurement of the output level at the local equipment. It should be in ±1 dB range of the configured output level from the local equipment.

![Figure 2](SUBSCR_Mess3.dsf)

**B.11.3 ‘Remote subscriber’, remote is Pax 2-wire**

The following tests must be done if the operation mode ‘Remote subscriber’ is configured at the local equipment and the operation mode ‘Pax 2-wire’ is selected at the remote equipment.

1. A functional test must be done to check the ringer. Connect a phone, at local equipment and feed into remote PAX2W connection a ringing tone with 25 Hz and about 25 VAC.
Connect a 2.2 kOhm resistor between PAX2W input and generator! The generator needn’t be programmed with a special ringing sequence. Now the phone should ring in a typical sequence.

2. Check the Output level of subscriber:
   Use coupling bridges similar to that, shown in Figure 3. The resistor R should be chosen to 500 Ohm, included the resistance of the two coils. If the coupling bridge has polarity. Check first polarity at external cable of appropriate O4LE, terminal telephony, 0a-0b and observe polarity of external voltage source.

3. Feed a 800 Hz tone, with the configured level from remote side into remote equipment. Take a measurement of the output level at the local equipment. It should be in 1 dB range of the configured output level from the local equipment.

B.11.4 ‘Remote subscriber’, remote is Pax 4-wire

The following tests must be done if the operation mode ‘Remote subscriber’ is configured at the local equipment and the operation mode ‘Pax 4-wire’ is selected at the remote equipment.

1. A functional test must be done to check the ringer. Connect a phone, at local equipment and activate M-WIRE at the remote equipment. If M-WIRE is configured as ‘inverted’, contacts at terminal, telephony, 4a-4b must be opened, otherwise closed. The phone should ring in a typical sequence.

2. Check the Output level of subscriber:
   Instead of phone use a coupling bridge similar to that, shown in Figure 3. The resistor R should be chosen to 500 Ohm, included the resistance of the two coils. If the coupling bridge has polarity. Check first polarity at terminal, telephony, 0a-0b. At remote side generator can be direct connected to AF1-IN, at terminal, telephony, 1a-1b. M-WIRE should be activated.

3. Feed a 800 Hz tone, with the configured level from remote side into remote equipment. Take a measurement of the output level at the local equipment. It should be in 1 dB range of the configured output level from the local equipment.

B.11.5 Pax 2-wire

The following tests must be done if the operation mode ‘Pax 2-wire’ is configured at the local equipment.

1. Check the Output level of Pax 2-wire interface:
   Use coupling bridges similar to that, shown in Figure 4. The resistor R should be chosen to 500 Ohm, included the resistance of the two coils. If the coupling bridge has polarity. Check first polarity at appropriate, telephony, 0a-0b and observe polarity of external voltage source.
2. Feed a 800 Hz tone, with the configured level from remote side into remote equipment. Take a measurement of the output level at the local equipment. It should be in 1 dB range of the configured output level from the local equipment.

3. Check PAX-BLOCKING relay. In normal operation contacts at terminal, telephony, 6b-7a should be closed and contacts 6a-6b should be open. Check it. Switch off the remote equipment, after the programmed delay time the link alarm occurs. Now contacts at terminal, telephony, 6b-7a should be open and contacts 6a-6b should be closed. Check it.

4. Check PAX-BLOCKING relay. In normal operation contacts at terminal, telephony, 6b-7a should be closed and contacts 6a-6b should be open. Switch off the remote equipment, after the programmed delay time the link alarm occurs. Now contacts at terminal, telephony, 6b-7a should be open and contacts 6a-6b should be closed.

![Diagram](PAX2W_Mess5.dsf)

Figure 4

B.11.6 Pax 4-wire, remote is Pax 4-wire

The following tests must be done if the operation mode ‘Pax 4-wire’ is configured at the local equipment and the operation mode ‘Pax 4-wire’ is selected at the remote equipment.

1. Toggling the M-WIRE at remote equipment, E-WIRE output should toggle simultaneously at local equipment. Note: E-WIRE is a switching contact without inherent voltage source and without polarity.

2. Activate M-WIRE at both equipments. If M-WIRE is configured as 'inverted', contacts at terminal, telephony, 4a-4b must be opened, otherwise closed.

3. Feed a 800 Hz tone, with the configured level from remote side into remote equipment. Take a measurement of the output level at the local equipment. It should be in 1 dB range of the configured output level from the local equipment.

4. Check PAX-BLOCKING relay. In normal operation contacts at terminal, telephony, 6b-7a should be closed and contacts 6a-6b should be open. Switch off the remote equipment, after the programmed delay time the link alarm occurs. Now contacts at terminal, telephony, 6b-7a should be open and contacts 6a-6b should be closed.

B.11.7 Pax 4-wire, remote is ‘Remote subscriber’

The following tests must be done if the operation mode ‘Pax 4-wire’ is configured at the local equipment and the operation mode ‘Remote subscriber’ is selected at the remote equipment.

1. Toggling the hook contact of remote equipment, E-WIRE output should toggle simultaneously at local equipment. Switching of hook contact can simulated by closing
the subscriber contacts at terminal, telephony, 0a-0b. Note: E-WIRE is a switching contact without inherent voltage source and without polarity.

2. Check the Output level of speech:
   Instead of subscriber, use coupling bridge similar to that, shown in Figure 2. The resistor R should be chosen to 500 Ohm, included the resistance of the two coils. If the coupling bridge has polarity. Check first polarity at terminal, telephony, 0a-0b.

3. Activate M-WIRE at local equipments. If M-WIRE is configured as ‘inverted’, contacts at terminal, telephony, 4a-4b must be opened, otherwise closed.

4. Feed a 800 Hz tone, with the configured level from remote side into remote equipment. Take a measurement of the output level at the local equipment. It should be in 1 dB range of the configured output level from the local equipment.

5. Check PAX-BLOCKING relay. In normal operation contacts at terminal, telephony, 6b-7a should be closed and contacts 6a-6b should be open. Switch off the remote equipment, after the programmed delay time the link alarm occurs.

B.11.8 Pax 4/2-wire
The following tests must be done if the operation mode ‘Pax 4/2wire’ is configured at both ends of the link.

1. Toggling the M-WIRE at remote equipment, E-WIRE output should toggle simultaneously at local equipment. Note: E-WIRE is a switching contact without inherent voltage source and without polarity.

2. Activate M-WIRE at both equipments. If M-WIRE is configured as ‘inverted’, contacts at terminal, telephony, 4a-4b must be opened, otherwise closed. Note: It is assumed, that LOCAL/TRANSIT is deactivated.

3. Feed a 800 Hz tone, with the configured level from remote side into AF1-IN of remote equipment.

4. Take a measurement of the output level at AF1-OUT of the local equipment. It should be in 1 dB range of the configured output level from the local equipment.

5. Take a measurement of the output level at P2W-OUT of the local equipment. It should be in 1 dB range of the configured output level from the local equipment.

6. Activate LOCAL/TRANSIT at remote equipment. If LOCAL/TRANSIT is configured as ‘inverted’, contacts at terminal, telephony, 5a-4b must be opened, otherwise closed.

7. Feed a 800 Hz tone, with the configured level from remote side into P2W-IN of remote equipment. Note: the input levels of AF1-IN and P2W-IN are normally configured different.

8. Take a measurement of the output level at P2W-OUT of the local equipment. It should be in 1 dB range of the configured output level from the local equipment.

9. Check PAX-BLOCKING relay. In normal operation contacts at terminal, telephony, 6b-7a should be closed and contacts 6a-6b should be open. Switch off the remote equipment, after the programmed delay time the link alarm occurs. Now contacts at terminal, telephony, 6b-7a should be open and contacts 6a-6b should be closed.

B.11.9 Transit mode for E&M wire
The following tests must be done if the operation mode ‘Transit mode for E&M wire’ is configured at the local equipment.

1. Toggling the M-WIRE at remote equipment, E-WIRE output should toggle simultaneously at local equipment. Note: E-WIRE is a switching contact without inherent voltage source and without polarity.

B.11.10 Testing of the teleoperation ports
For testing the teleoperation ports, first nominal signal levels must be fed into the teleoperation input port with a level generator. The output level at the other side of the link must then be measured and compared to the nominal output level. An example of a link configuration is given below.
First method:
This method only works, if identical Reference signal and identical level unit for the reference signal, dBm (RMS) or dBm (PEP) is selected on both sides of link.

1. Determine the correct input level fed into the remote equipment.
   The Reference signal level input, listed in the configuration printout of the remote equipment should be fed into AFx-IN of the remote equipment.

2. Determine expected output level of AFx-OUT of local equipment.
   The Reference signal level output of AFx-OUT of the local equipment is the expected output level.

3. Take the measurement with a selective level meter.

Second method:
This method works with any configuration of AF ports, which are switched on.

1. Determine the correct input level fed into the remote equipment.
   The Reference signal level input, listed in the configuration printout of the remote equipment should be fed into AFx-IN of the remote equipment.

2. Calculate expected output level of AFx-OUT of local equipment.
   \[ L_{\text{out}} = L_{\text{in}} - L(\text{Rel. Input Level})_{\text{remote}} + L(\text{Rel. Output Level})_{\text{local}} \]

3. Take the measurement with a selective level meter.

Example:
Applying the first method to the configuration given below, a sinus with –9.0 dBm is fed into remote equipment. The tone is expected with –6.0 dBm at AFx-OUT of local equipment.

Applying the second method to the configuration given below, a sinus with –9.0 dBm is fed into remote equipment. Calculating the expected output level at local equipment with the formula above results to:

\[ L_{\text{out}} = -9.0 \text{ dBm} - (-4.00 \text{ dBr}) + (-1.00 \text{ dBr}) \]

The expected output level \( L_{\text{out}} \) is just as applying the first method –6.0 dBm.

### Equipment REMOTE
**TELEOPERATION**

- Port AFx: Disconnectable at CH1
- Squelch: Disabled
- Reference signal: 600 Bd FSK
- Reference signal level input: -9.00 dBm (RMS)
- Reference signal level output: -9.00 dBm (RMS)
- Weight of port: 0.71
- Max. output level: -7.00 dBm (PEP)
- Relative input level: -4.0 dBr
- Relative output level: -4.0 dBr
- Input filter: None
- Output filter: None

### Equipment LOCAL
**TELEOPERATION**

- Port AFx: Disconnectable at CH1
- Squelch: Disabled
- Reference signal: 600 Bd FSK
- Reference signal level input: -6.00 dBm (RMS)
- Reference signal level output: -6.00 dBm (RMS)
- Weight of port: 0.71
- Max. output level: -4.00 dBm (PEP)
- Relative input level: -1.0 dBr
- Relative output level: -1.0 dBr
- Input filter: None
- Output filter: None

**B.11.11 Teleoperation port AF1**

If the port AF1 is not used for a telephony application and if the port is switched to 'On – disconnectable' or 'On – non disconnectable', take the measurement as described in B.11.10.
B.11.12 Teleoperation port AF2
If the port is switched to ‘On – disconnectable’ or ‘On – non disconnectable’ take the measurement as described in B.11.10.

B.11.13 Teleoperation port AF3
If the port is switched to ‘On – disconnectable’ or ‘On – non disconnectable’ take the measurement as described in B.11.10.

B.11.14 Teleoperation port AF4
If the port is switched to ‘On – disconnectable’ or ‘On – non disconnectable’ take the measurement as described in B.11.10.

B.11.15 Teleoperation AF4 used for ext. Teleprotection
After having performed the measurement B.11.14:
1. Recalculate expected output level of AF4-OUT by adding the NSD570 boost value, available in the configuration view (View / Display Configuration / Effective boost value ext. TPE1/2/3).
2. Activate the EXT-BOOST input at the remote equipment. If EXT-BOOST is configured as ‘inverted’, contacts at terminal, teleoperation, 9a-9b must be opened, otherwise closed.
3. Take the measurement at AF4-OUT of local equipment.

B.12 Testing of the V.11 ports
The V.11 ports are tested on correct settings and bit errors using data test equipment.
1. Check the port settings in the configuration (Configuration / Data port to modem assignment) and use the same settings in the test equipment.
2. Connect data testers to corresponding ports on both the local and remote ETL600 equipment. If there is only one data tester available, the digital data stream has to be looped on the remote equipment.
3. Perform a BER test during the required time. The recommended number of bits to transmit is $10^7$.

B.12.1 V.11 Port 1
If used, perform a BER test as described above.

B.12.2 V.11 Port 2
If used, perform a BER test as described above.

B.13 Testing of the V.24 ports
The V.24 ports are tested on correct settings and bit errors using data test equipment.
1. Check the port settings in the configuration (Configuration / Data port to modem assignment) and use the same settings in the test equipment.
2. Connect data testers to corresponding ports on both the local and remote ETL600 equipment. If there is only one data tester available, the digital data stream has to be looped on the remote equipment.
3. Perform a BER test during the required time. The recommended number of bits to transmit is $10^7$.

B.13.1 V.24 Port 1
If used, perform a BER test as described above.

B.13.2 V.24 Port 2
If used, perform a BER test as described above.
B.13.3 **V.24 Port 3**  
If used, perform a BER test as described above.

B.13.4 **V.24 Port 4**  
If used, perform a BER test as described above.

B.14 **Testing of the LAN ports**  
For the applications bridging and routing, the LAN ports are tested for bit errors using Ethernet test equipment.  
1. Connect the Ethernet tester to the LAN ports of the local and remote ETL600 equipment.  
2. Perform a throughput and errored frame test during the required time. The recommended number of frames to transmit is $10^4$.  

In some cases, pinging can be used as a quick test:  
- In mode "IP routing (Static routes)", both the local and the remote R1LA can be pinged;  
- In modes "IP routing (Forward All)" and "Bridging", the local R1LA can be pinged.

B.14.1 **LAN port 1**  
If used, perform a BER test as described above.

B.14.2 **LAN port 2**  
If used, perform a BER test as described above.

B.14.3 **LAN port 3**  
If used, perform a BER test as described above.

B.14.4 **LAN port 4**  
If used, perform a BER test as described above.

B.14.5 **HMI over LAN**  
For the application HMI over LAN, test if HMI600 can be connected to the LAN port used for HMI over LAN access of the ETL600 terminal.

B.15 **Testing of O4CV, if present**

B.15.1 **Slot positions of O4CV boards**  
Refer to the configuration view of HMI600 for the O4CV slot positions.

B.15.2 **Service phone**  
Only a functional test must be done. The buzzer, the ringing of the connected service phone and the audibility between the two service phones are tested.

B.15.3 **Hot line direct phone**  
The following tests must be done if the operation mode ‘Hot line direct phone’ is configured at both the local and remote equipment.  
1. A functional test must be done to check the ringer. Connect on both sides of link a phone, make a call from one side to remote and vice versa.  
2. Check the output level of speech:  
   Use coupling bridges similar to the ones shown in Figure 5. The resistor R should be chosen to 500 Ohm, the resistance of the two coils included. If the coupling bridge has polarity, check first polarity at appropriate external cable.  
3. Feed an 800 Hz tone with the configured level from remote side into remote equipment.  
   Take a measurement of the output level at the local equipment. It should be in $\pm 5$ dB range of the configured output level of the local equipment.
B.15.4 ‘Remote subscriber’, remote is Pax 2-wire

The following tests must only be done if the operation mode ‘Remote subscriber’ is configured at the local equipment and the operation mode ‘Pax 2-wire’ at the remote equipment.

1. A functional test must be done to check the ringer. Connect a phone at local equipment and feed into remote PAX2W connection a ringing tone with 25 Hz and about 25 VAC. Connect a 2.2 kOhm resistor between PAX2W input and generator! The generator needn’t be programmed with a special ringing sequence. Now the phone should ring in a typical sequence.

2. Check the output level of subscriber:
   Use coupling bridges similar to the ones shown in Figure 6. The resistor R should be chosen to 500 Ohm, the resistance of the two coils included. If the coupling bridge has polarity, check first polarity of the subscriber interface at the cable terminals and observe polarity of external voltage source.

3. Feed an 800 Hz tone with the configured level from remote side into remote equipment. Take a measurement of the output level at the local equipment. It should be in ±5 dB range of the configured output level of the local equipment.
B.15.5 ‘Remote subscriber’, remote is Pax 4-wire

The following tests must only be done if the operation mode ‘Remote subscriber’ is configured at the local equipment and the operation mode ‘Pax 4-wire’ at the remote equipment.

1. A functional test must be done to check the ringer. Connect a phone at local equipment and activate M-WIRE at the remote equipment. If M-WIRE is configured as ‘inverted’, contacts at terminal, telephony, 4a-4b must be opened, otherwise closed. The phone should ring in a typical sequence.

2. Check the output level of subscriber:
Instead of phone use a coupling bridge similar to the one shown in Figure 7. The resistor R should be chosen to 500 Ohm, included the resistance of the two coils. If the coupling bridge has polarity, check first polarity of the subscriber interface at the cable terminals. At remote side, M-WIRE must be activated.

3. Feed an 800 Hz tone with the configured level from remote side into remote equipment. Take a measurement of the output level at the local equipment. It should be in ±5 dB range of the configured output level of the local equipment.

![Figure 7](image-url)

B.15.6 Pax 2-wire

The following tests must only be done if the operation mode ‘Pax 2-wire’ is configured at the local equipment and the operation mode ‘Remote subscriber’ at the remote equipment.

1. Check the output level of Pax 2-wire interface:
Use coupling bridges similar to the ones shown in Figure 8. The resistor R should be chosen to 500 Ohm, included the resistance of the two coils. If the coupling bridge has polarity, check first polarity of the subscriber interface at the cable terminals of the remote equipment and observe polarity of external voltage source.

2. Feed an 800 Hz tone with the configured level from remote side into remote equipment. Take a measurement of the output level at the local equipment. It should be in ±5 dB range of the configured output level of the local equipment.
B.15.7 Pax 4-wire, remote is Pax 4-wire

The following tests must only be done if the operation mode ‘Pax 4-wire’ is configured at both local and remote equipment.

1. Toggling the M-WIRE at remote equipment, E-WIRE output should toggle simultaneously at local equipment. Note: E-WIRE is a switching contact without inherent voltage source and without polarity.

2. Check the output level of Pax 4-wire interface:
   Activate M-WIRE at both equipments. If M-WIRE is configured as 'inverted', M-wire contacts at the cable terminals must be opened, otherwise closed.

3. Feed an 800 Hz tone with the configured level from remote side into remote equipment. Take a measurement of the output level at the local equipment. It should be in ±5 dB range of the configured output level of the local equipment.

B.15.8 Pax 4-wire, remote is ‘Remote subscriber’

The following tests must only be done if the operation mode ‘Pax 4-wire’ is configured at the local equipment and the operation mode ‘Remote subscriber’ at the remote equipment.

1. Toggling the hook contact of remote equipment, E-WIRE output should toggle simultaneously at local equipment. Switching of hook contact can simulated by closing the subscriber contacts at the cable terminal of the remote equipment. Note: E-WIRE is a switching contact without inherent voltage source and without polarity.

2. Check the output level of Pax 4-wire interface:
   Instead of subscriber, use coupling bridge similar to the one shown in Figure 7. The resistor R should be chosen to 500 Ohm, included the resistance of the two coils. If the coupling bridge has polarity, check first polarity of the subscriber interface at the cable terminals.

3. Activate M-WIRE at local equipment. If M-WIRE is configured as ‘inverted’, M-wire contacts at the cable terminals must be opened, otherwise closed.

4. Feed an 800 Hz tone with the configured level from remote side into remote equipment. Take a measurement of the output level at the local equipment. It should be in ±5 dB range of the configured output level of the local equipment.
B.16 Documentation

After the testing is complete, take a printout of the configuration and status data.

1. Click the green Upload arrow in the HMI600 toolbar with the left mouse button. This starts configuration and status upload from the equipment. The status is displayed in the window.
2. From the File menu, click Print to print the status data.
3. From the View menu, click Display configuration.
4. From the File menu, click Print to print the configuration data.
5. From the File menu, click Save As to save the active document to disk with the Serial No. of the ETL600 coded in the file name, e.g. HE400327B0.ET6. All settings you have made while working in the document will be saved to the new file, including the last measured AF and frequency response.

B.17 Manual reset

Reset ETL600 with HMI600 (Equipment / Reset) or by switching off and on the power and wait until all alarms disappear.
<table>
<thead>
<tr>
<th>No.</th>
<th>Action</th>
<th>Rack or module</th>
<th>Item to be programmed or fitted</th>
<th>Selected alternative or setting</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>A.1</td>
<td>General</td>
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<td></td>
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</tr>
<tr>
<td>A.2</td>
<td>Create a configuration file using HMI600</td>
<td>HMI600</td>
<td>[ ]</td>
<td></td>
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<tr>
<td>A.3</td>
<td>Hardware</td>
<td></td>
<td></td>
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<tr>
<td>A.3.1</td>
<td>Racks</td>
<td></td>
<td></td>
<td></td>
<td>Refer to config file</td>
</tr>
<tr>
<td></td>
<td>Configuration file shows the correct racks.</td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>A.3.2</td>
<td>Modules</td>
<td></td>
<td></td>
<td></td>
<td>Refer to config file</td>
</tr>
<tr>
<td></td>
<td>All modules in the racks are mounted at the correct positions according to configuration file.</td>
<td></td>
<td></td>
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</tr>
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<td></td>
<td>Type of DSP module</td>
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<td>P4LT</td>
<td></td>
</tr>
<tr>
<td></td>
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<td></td>
<td>P4LV</td>
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<td>P4LX</td>
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<td>A.3.3</td>
<td>SFP transceiver</td>
<td>P4LV/X</td>
<td>[ ]</td>
<td></td>
<td>Refer to config file</td>
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<tr>
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<td>SFP transceiver fitted</td>
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<tr>
<td>A.3.4</td>
<td>Spare plates</td>
<td></td>
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</tr>
<tr>
<td></td>
<td>All spare plates mounted</td>
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<td></td>
<td></td>
<td>Equipment front completely covered</td>
</tr>
<tr>
<td>A.4</td>
<td>Settings for basic equipment ETL640/80</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>A.4.1</td>
<td>Power amplifier P1LP</td>
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<td>J1 … J12</td>
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<tr>
<td></td>
<td>Jumpers set according to configuration file</td>
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<td>A.4.2</td>
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### Hardware Checks ETL600

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### Hardware Checks ETL600

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<td>A.7</td>
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<td>P4LV or P4LX</td>
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<td>Valid voice keys mounted</td>
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SYSTEM TEST REPORT

Powerline Carrier Equipment: Series ETL600R4

Project: ............................................

ABB Order N°: ............................................

Station: ............................................

Link: ............................................

Equipment N°: ............................................

Frequency:  

   Tx = ..........kHz   Rx = ..........kHz

Direction: ............................................

System Test Report contains

- ETL600: System Test Report  Pages B1 to B17
- HMI600: Printout of Configuration  Pages ..............
- HMI600: Printout of Status  Pages ..............
- Test ETL600: List of used Test-instruments  Pages ..............

The tuning of the equipment is in accordance with the following instructions:

- Programming and Testing of ETL600R4  1KHW002609-EN
- Compatibility Requirements for ETL600  1KHW001490-EN
- Tuning of ETL600R4 Rx RF Filter P4RX  1KHW002584-EN
- Tuning of ETL600R4 Tx RF Filter on E5TH and E5TC  1KHW002585-EN
- APLC Channel Equalization for ETL600  1KHW001494-EN
- Firmware Download for ETL600R4  1KHW002589-EN
- Technical Data ETL600R4  1KHW002590-EN
SAFETY INSTRUCTIONS

Please refer to chapter 2 of ETL600R4 instruction manual 1KHW002582.

Designations and abbreviations used:
Refer to 1KHW002609-EN Programming and testing of ETL600R4

REVISION

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<th>Page (p.)</th>
<th>Description</th>
<th>Date</th>
<th>Dept./Init.</th>
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<td>Be</td>
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<td>B</td>
<td>c. B.10.4</td>
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### System Test Report ETL600R4

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<td>B.2.1</td>
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<td>MCB</td>
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<td>Ripple on 48V DC</td>
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<td>Lit</td>
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</tbody>
</table>

| B.3      | Connect to the equipment, download configuration and prepare for tuning & testing | |                   |       |             |
|          | Connect to the equipment | Check communication between PC and P4LT/V/X | | [ ]   |             |
|          | Download configuration | Download successful | | [ ]   |             |
|          | Activate the Tuning & testing dialog box | Prepare Tuning & testing | | [ ]   |             |

| B.4      | Change configuration, if necessary | |                   |       | [ ]         |

| B.5      | Transmitter | |                   |       |             |
| B.5.1    | Programming of Tx RF filter | |                   |       | E5TC E5TH   |
|          | Refer to 1KHW002585 Tuning Instructions for ETL600R4 | | |  | [ ] [ ] D  |
|          | Tx RF Filter on E5TH/C | | | | [ ] [ ] D  |
|          | Bandwidth = 4 kHz | E5TH/E5TC | Refer | [ ]   | [ ] D       |
|          | Bandwidth = 8 kHz | E5TH/E5TC | to | [ ]   | [ ] D       |
|          | Bandwidth = 16 kHz | E5TH/E5TC | document | [ ]   | [ ] D       |
|          | Bandwidth = 32 kHz | E5TH/E5TC | 1KHW002585 | [ ]   | [ ] D       |
|          | Center frequency | E5TH/E5TC | \( f_{Tx} = \_\_\_\_\_\_ \) kHz | [ ]   | [ ] D       |

| B.5.2    | Settings for RF hybrid on E5TH | |                   |       |             |
|          | Jumpers for operation mode set | according to dialog box View / Display hardware settings only, under the heading E5TH in rack P7L? at slot N?? | | E5TH | H1 ... H13 |
|          | | | | [ ] |             |

---

1 As the channel frequencies were not known at test time, the system was tested with temporarily inserted factory-owned filter(s), programmed and tuned to a standard frequency and bandwidth.
### B.5.3 Tune Tx RF filter

**Test procedure**
- Mark if not configured: Check if the Tx RF filter is configured.
- Mark if not tuned: Check if the Tx RF filter is tuned.
- Dialog box ‘Tune Tx RF filter’
- E5TH, E5TC

**Permissible values**
- Refer to doc. 1KHW002585

**Units**
- E5TC
- E5TH

**Test result**
- D

### B.5.4 Adjust Tx RF level

**Test procedure**
- Dialog box Adjust Tx RF level:
- Click Select and then Start
- Mark if the Tx level is not measured
- Measured Tx level is within tolerance

**Permissible range**
- RF LINE MONITOR or RF LINE socket at E5TH front panel

### B.5.5 Adjust Tx alarm level

**Test procedure**
- Dialog box: Adjust Tx alarm level
- Follow the instructions given in the dialog box
- Tx ALARM indication: E5TH and - in case of ETL600-100 – E5TC
- State of HW alarm relay after programmed delay:
- Pins 2-3 of V9OT cable
- Closed
- Turn \( \Phi \) potentiometer(s) TX-LVL-AL ADJUST on P1LP till TX-LVL-AL LED(s) off.
- Tx alarm indication: E5TH and - in case of ETL600-100 – E5TC
- State of HW alarm relay after programmed delay:
- Pins 2-3 of V9OT cable
- Open
- Click OK.

### B.6 Receiver

#### B.6.1 Programming of Rx RF filter

**Test procedure**
- Refer to 1KHW002584
- Tuning of ETL600R4 Rx RF Filter P4RX
- Bandwidth = 4 kHz
- Bandwidth = 8 kHz
- Bandwidth = 16 kHz
- Bandwidth = 32 kHz
- Center frequency

**Permissible values**
- Refer
- 1KHW002584

**Units**
- kHz

### B.6.2 Tune Rx RF filter P4RX, if present

**Test procedure**
- Dialog box ‘Tune Rx RF filter’
- P4RX, P4LM

**Permissible values**
- Refer to doc. 1KHW002584

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2 As the channel frequencies were not known at test time, the system was tested with temporarily inserted factory-owned filter(s), programmed and tuned to a standard frequency and bandwidth.
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<th>Test procedure</th>
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<th>Test result</th>
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<td>Dialog box: Tuning &amp; testing… Dialog box: Adjust Rx RF level</td>
<td>Value indicated in dialog box.</td>
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<td>Link alarm LED on P4LT LED to be OFF</td>
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<td>B.7.2</td>
<td>Select Equalizer</td>
<td>In menu Equipment / Commissioning and maintenance / Select equalizer / APLC channel 1, APLC channel 2 or APLC channel 3</td>
<td>Mark if not configured:</td>
<td></td>
<td>Ch 1 Ch 2 Ch 3 [ ] [ ] [ ] [ ]</td>
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<tr>
<td></td>
<td></td>
<td>HMI600</td>
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<td></td>
<td>Ch 1 Ch 2 Ch 3 [ ] [ ] [ ] [ ]</td>
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<tr>
<td>B.8</td>
<td>Testing of R1BC, if present</td>
<td>Mark if not configured:</td>
<td></td>
<td></td>
<td>[ ]</td>
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<td></td>
<td></td>
<td>Corresponding N/C contacts on R1BC.</td>
<td>Closed</td>
<td></td>
<td>[ ]</td>
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<tr>
<td></td>
<td></td>
<td>Corresponding N/C contacts on R1BC.</td>
<td>Open</td>
<td></td>
<td>[ ]</td>
</tr>
<tr>
<td>B.9</td>
<td>Configure Real Time Clock (RTC)</td>
<td>Menu: Equipment, Commissioning and maintenance, Eventrecorder, Set clock Download date / time to RTC</td>
<td>Dialog box</td>
<td>Actual time and date</td>
<td>[ ]</td>
</tr>
<tr>
<td>B.9.1</td>
<td>Setting real time clock</td>
<td></td>
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<tr>
<td>Test No.</td>
<td>Test procedure</td>
<td>Test point</td>
<td>Permissible value</td>
<td>Units</td>
<td>Test result</td>
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<tr>
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<tr>
<td>B.9.2</td>
<td>Testing external real time clock synchronization (if available)</td>
<td>Mark if not configured:</td>
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<td></td>
<td>[ ]</td>
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<tr>
<td></td>
<td>Menu: Equipment, Commissioning and maintenance, Eventrecorder, Set clock Download date/time to RTC Dialog box Wrong time Upload date/time from RTC Dialog box Correct time</td>
<td></td>
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<td>B.10</td>
<td>Testing of NSD600 / G4AI, if present</td>
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<tr>
<td>B.10.1</td>
<td>Inputs</td>
<td>Mark if not configured:</td>
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<tr>
<td></td>
<td>Input 1 IN1</td>
<td>Terminal, (T.../1) – (T.../2)</td>
<td>U1, see System settings</td>
<td>V DC</td>
<td>N02 N08 N14 N20 N24 N30 N36 N42 N48 N54 N60</td>
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<tr>
<td></td>
<td>Activate Input 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Check LED IN1</td>
<td>LED IN1</td>
<td>ON</td>
<td></td>
<td>N02 N08 N14 N20 N24 N30 N36 N42 N48 N54 N60</td>
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<tr>
<td></td>
<td>Input 2 IN2</td>
<td>Terminal, (T.../3) – (T.../4)</td>
<td>U2, see System settings</td>
<td>V DC</td>
<td>N02 N08 N14 N20 N24 N30 N36 N42 N48 N54 N60</td>
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<td></td>
<td>Activate Input 2</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>Check LED IN2</td>
<td>LED IN2</td>
<td>ON</td>
<td></td>
<td>N02 N08 N14 N20 N24 N30 N36 N42 N48 N54 N60</td>
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<td></td>
<td>Input 3 IN3</td>
<td>Terminal, (T.../5) – (T.../6)</td>
<td>U3, see System settings</td>
<td>V DC</td>
<td>N02 N08 N14 N20 N24 N30 N36 N42 N48 N54 N60</td>
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<td>Activate Input 3</td>
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<td></td>
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<td></td>
<td>Check LED IN3</td>
<td>LED IN3</td>
<td>ON</td>
<td></td>
<td>N02 N08 N14 N20 N24 N30 N36 N42 N48 N54 N60</td>
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<td></td>
<td>Input 4 IN4</td>
<td>Terminal, (T.../7) – (T.../8)</td>
<td>U4, see System settings</td>
<td>V DC</td>
<td>N02 N08 N14 N20 N24 N30 N36 N42 N48 N54 N60</td>
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<td></td>
<td>Activate Input 4</td>
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<td></td>
<td>Check LED IN4</td>
<td>LED IN4</td>
<td>ON</td>
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<td>N02 N08 N14 N20 N24 N30 N36 N42 N48 N54 N60</td>
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<td>B.10.2</td>
<td>Outputs</td>
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<td></td>
<td>Enforce action for OUT1.</td>
<td>Terminal, (T.../9) – (T.../10)</td>
<td>Closed</td>
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<td>N02 N08 N14 N20 N24 N30 N36 N42 N48 N54 N60</td>
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<td></td>
<td>Check Output 1, OUT1:</td>
<td>LED OUT1</td>
<td>ON</td>
<td></td>
<td>N02 N08 N14 N20 N24 N30 N36 N42 N48 N54 N60</td>
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<td>Enforce action for OUT2.</td>
<td>Terminal, (T.../11) – (T.../12)</td>
<td>Closed</td>
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<td>Check Output 2, OUT2:</td>
<td>LED OUT2</td>
<td>ON</td>
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<td>Enforce action for OUT3.</td>
<td>Terminal, (T.../13) – (T.../14)</td>
<td>Closed</td>
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<td>Check Output 3, OUT3:</td>
<td>LED OUT3</td>
<td>ON</td>
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<td>N02 N08 N14 N20 N24 N30 N36 N42 N48 N54 N60</td>
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<td>Check Output 4, OUT4:</td>
<td>LED OUT4</td>
<td>ON</td>
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<td>Enforce action for relay 1 REL1 close/open</td>
<td>Terminal, (T.../17) – (T.../18)</td>
<td>Refer G4AI programming</td>
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<td>N02 N08 N14 N20 N24 N30 N36 N42 N48 N54 N60</td>
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<td>Check LED REL1</td>
<td>LED REL1</td>
<td>ON</td>
<td></td>
<td>N02 N08 N14 N20 N24 N30 N36 N42 N48 N54 N60</td>
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<tr>
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<td>Enforce action for relay 2 REL2 close/open</td>
<td>Terminal, (T.../19) – (T.../20)</td>
<td>Refer G4AI programming</td>
<td></td>
<td>N02 N08 N14 N20 N24 N30 N36 N42 N48 N54 N60</td>
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<td>Test No.</td>
<td>Test procedure</td>
<td>Test point</td>
<td>Permissible value</td>
<td>Units</td>
<td>Test result</td>
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<td>B.10.3</td>
<td><strong>NSD600 loop test</strong></td>
<td>Mark if not configured:</td>
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<td></td>
<td>TPE1  TPE2</td>
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<tr>
<td></td>
<td>Check Actual transmission time $T_{\text{Link}}$</td>
<td>HMI600</td>
<td>$&lt; 1.3*T_0$</td>
<td>ms</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Menu: Equipment, Commissioning and maintenance, NSD600 send loop test</td>
<td>[ ]</td>
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<td>B.10.4</td>
<td><strong>Command transmission time</strong></td>
<td>Command A: Mark if not configured:</td>
<td></td>
<td></td>
<td>TPE1  TPE2</td>
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<tr>
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<td></td>
<td>Terminal: Refer HMI600</td>
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<tr>
<td></td>
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<td>Tx command A: $(T20/1)-(T20/2)$ [ ]</td>
<td></td>
<td>ms</td>
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<td></td>
<td>Rx command A: $(T20/9)-(T20/10)$ [ ]</td>
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<td></td>
<td>Command B: Mark if not configured:</td>
<td></td>
<td></td>
<td>TPE1  TPE2</td>
</tr>
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<td></td>
<td>Terminal: Refer HMI600</td>
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<td></td>
<td></td>
<td>Tx command B: $(T20/3)-(T20/4)$ [ ]</td>
<td></td>
<td>ms</td>
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<tr>
<td></td>
<td></td>
<td>Rx command B: $(T20/11)-(T20/12)$ [ ]</td>
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<td>Command C: Mark if not configured:</td>
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<td></td>
<td>TPE1  TPE2</td>
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<td></td>
<td>Terminal: Refer HMI600</td>
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<td></td>
<td></td>
<td>Tx command C: $(T20/5)-(T20/6)$ [ ]</td>
<td></td>
<td>ms</td>
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<td></td>
<td></td>
<td>Rx command C: $(T20/13)-(T20/14)$ [ ]</td>
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<tr>
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<td></td>
<td>Command D: Mark if not configured:</td>
<td></td>
<td></td>
<td>TPE1  TPE2</td>
</tr>
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<td></td>
<td></td>
<td>Terminal: Refer HMI600</td>
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<tr>
<td></td>
<td></td>
<td>Tx command D: $(T20/7)-(T20/8)$ [ ]</td>
<td></td>
<td>ms</td>
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<td></td>
<td></td>
<td>Rx command D: $(T20/15)-(T20/16)$ [ ]</td>
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<tr>
<td>B.10.5</td>
<td><strong>Reset counters</strong></td>
<td>Menu: Equipment, Commissioning and maintenance, Eventrecorder, Reset counter, OK:</td>
<td>HMI600</td>
<td>All counters = 0</td>
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<tr>
<td>Test No.</td>
<td>Test procedure</td>
<td>Test point</td>
<td>Permissible value</td>
<td>Units</td>
<td>Test result</td>
</tr>
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<td>B.11</td>
<td>Testing of O4LE</td>
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<tr>
<td>B.11.1</td>
<td><strong>Service Phone</strong></td>
<td>Mark if not configured:</td>
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<tr>
<td></td>
<td>Pick up the phones and talk.</td>
<td>Service phone, at front panel</td>
<td>Remote service</td>
<td>N02</td>
<td>N08 N14</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>phone rings, buzzer</td>
<td>N24</td>
<td>N30 N48</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>drones, talk is</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>possible</td>
<td>N02</td>
<td>N08 N14</td>
</tr>
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<td></td>
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<td></td>
<td>N24</td>
<td>N30 N48</td>
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<td>B.11.2</td>
<td><strong>Hot line direct phone</strong></td>
<td>Mark if not configured:</td>
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<td>Pick up the phone, wait, pick up</td>
<td>Direct phone</td>
<td>Remote direct</td>
<td>N02</td>
<td>N08 N14</td>
</tr>
<tr>
<td></td>
<td>remote phone</td>
<td></td>
<td>phone rings until</td>
<td>N24</td>
<td>N30 N48</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>phone is picked up.</td>
<td></td>
<td></td>
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<td></td>
<td>Measure Output level.</td>
<td>Feed into rem. equ. at</td>
<td>Configured Output</td>
<td>dBm(600</td>
<td>N02 N08 N14</td>
</tr>
<tr>
<td></td>
<td></td>
<td>terminal telephony 0a-0b</td>
<td>level ±1 dB</td>
<td>Ω)</td>
<td>N24 N30 N48</td>
</tr>
<tr>
<td></td>
<td>Feed 800 Hz with configured</td>
<td>Measure at terminal telephony</td>
<td>(Def.: -7.0 dBm)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>input level of remote subscriber</td>
<td>0a-0b</td>
<td></td>
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</tr>
<tr>
<td>B.11.3</td>
<td>**Remote subscriber. At remote equ.</td>
<td>Mark if not configured:</td>
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</tr>
<tr>
<td></td>
<td>is Pax 2-Wire**</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Test Ringer: Feed ringing voltage</td>
<td>Feed into rem. equ. at</td>
<td>Subscriber must</td>
<td>dBm(600</td>
<td>N02 N08 N14</td>
</tr>
<tr>
<td></td>
<td>(25 VAC, 25 Hz, R = 2.2 kΩ) into</td>
<td>terminal telephony 8a-8b</td>
<td>ring</td>
<td>Ω)</td>
<td>N24 N30 N48</td>
</tr>
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<td></td>
<td>remote PAX 2-Wire</td>
<td>Measure at terminal telephony</td>
<td></td>
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<td>Measure Output level.</td>
<td>0a-0b</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Feed 800 Hz with configured</td>
<td>Feed into rem. equ. at</td>
<td>Configured Output</td>
<td>dBm(600</td>
<td>N02 N08 N14</td>
</tr>
<tr>
<td></td>
<td>input level of remote PAX.(Def.: 0.0</td>
<td>terminal telephony 8a-8b</td>
<td>level ±1 dB</td>
<td>Ω)</td>
<td>N24 N30 N48</td>
</tr>
<tr>
<td></td>
<td>dBm)</td>
<td>Measure at terminal telephony</td>
<td>(Def.: -7.0 dBm)</td>
<td></td>
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<td>B.11.4</td>
<td>**Remote subscriber. At remote equ.</td>
<td>Mark if not configured:</td>
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</tr>
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<td>is Pax 4-wire**</td>
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<td></td>
<td>Test Ringer: Activate M-WIRE of</td>
<td>Activate at Remote equ.</td>
<td>Subscriber must</td>
<td>dBm(600</td>
<td>N02 N08 N14</td>
</tr>
<tr>
<td></td>
<td>remote Pax 4-wire</td>
<td>at terminal telephony 4a-4b</td>
<td>ring</td>
<td>Ω)</td>
<td>N24 N30 N48</td>
</tr>
<tr>
<td></td>
<td>Measure Output level.</td>
<td>Feed into rem. equ. at</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Feed 800 Hz with configured</td>
<td>terminal telephony 1a-1b</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>input level of remote PAX.(Def.: -3.5</td>
<td>Measure at terminal telephony</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>dBm)</td>
<td>0a-0b</td>
<td></td>
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</table>

**Abbreviations:**
- N02: Not configured
- N08: Not configured
- N14: Not configured
- N24: Not configured
- N30: Not configured
- N48: Not configured
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<thead>
<tr>
<th>Test No.</th>
<th>Test procedure</th>
<th>Test point</th>
<th>Permissible value</th>
<th>Units</th>
<th>Test result</th>
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<tbody>
<tr>
<td>B.11.5</td>
<td>Pax 2-wire</td>
<td>Mark if not configured:</td>
<td></td>
<td>N02 N08 N14</td>
<td>N24 N30 N48</td>
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<tr>
<td></td>
<td>Measure Output level.</td>
<td></td>
<td>Configured Output level ±1 dB (Def.: -7.0 dBm)</td>
<td>dBm (600 Ω)</td>
<td>[ ] [ ] [ ]</td>
</tr>
<tr>
<td></td>
<td>Feed 800 Hz with configured input level of remote subscriber.(Def.: 0.0 dBm)</td>
<td></td>
<td></td>
<td>N02 N08 N14</td>
<td>N24 N30 N48</td>
</tr>
<tr>
<td>PAX-BLOCKING normal</td>
<td>Measure at terminal telephony 8a-8b</td>
<td></td>
<td>6a-6b is open, 6b-7a is closed</td>
<td></td>
<td>[ ] [ ] [ ]</td>
</tr>
<tr>
<td>PAX-BLOCKING blocked</td>
<td>Switch off remote equ., wait about 30 sec.</td>
<td></td>
<td>6a-6b is closed, 6b-7a is open</td>
<td></td>
<td>[ ] [ ] [ ]</td>
</tr>
<tr>
<td>B.11.6</td>
<td>Pax 4-wire. At remote equ. is Pax 4-wire</td>
<td>Mark if not configured:</td>
<td></td>
<td>N02 N08 N14</td>
<td>N24 N30 N48</td>
</tr>
<tr>
<td></td>
<td>Test E-Wire:</td>
<td>Terminal telephony 3a-3b</td>
<td>E-Wire must toggle</td>
<td></td>
<td>[ ] [ ] [ ]</td>
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<tr>
<td></td>
<td>Close and open at Remote equ. at terminal telephony 4a-4b</td>
<td></td>
<td></td>
<td>N02 N08 N14</td>
<td>N24 N30 N48</td>
</tr>
<tr>
<td></td>
<td>Measure Output level.</td>
<td></td>
<td>Configured Output level ±1 dB (Def.: -3.5 dBm)</td>
<td>dBm (600 Ω)</td>
<td>[ ] [ ] [ ]</td>
</tr>
<tr>
<td></td>
<td>Feed 800 Hz with configured input level of remote PAX (Def.: -3.5 dBm). (Activate at terminal telephony 4a-4b on both equ.)</td>
<td></td>
<td></td>
<td>N02 N08 N14</td>
<td>N24 N30 N48</td>
</tr>
<tr>
<td>PAX-BLOCKING normal</td>
<td>Measure at terminal telephony 6a-6b, 6b-7a</td>
<td></td>
<td>6a-6b is open, 6b-7a is closed</td>
<td></td>
<td>[ ] [ ] [ ]</td>
</tr>
<tr>
<td>PAX-BLOCKING blocked</td>
<td>Switch off remote equ., wait about 30 sec.</td>
<td></td>
<td>6a-6b is closed, 6b-7a is open</td>
<td></td>
<td>[ ] [ ] [ ]</td>
</tr>
<tr>
<td>B.11.7</td>
<td>Pax 4-wire. At remote equ. is Remote subscriber</td>
<td>Mark if not configured:</td>
<td></td>
<td>N02 N08 N14</td>
<td>N24 N30 N48</td>
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<tr>
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<td>Test E-Wire:</td>
<td>Terminal telephony 3a-3b</td>
<td>E-Wire must toggle</td>
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<tr>
<td></td>
<td>Toggle hook of phone. (Close and open at Remote equ. at terminal telephony 0a-0b)</td>
<td></td>
<td></td>
<td>N02 N08 N14</td>
<td>N24 N30 N48</td>
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<tr>
<td></td>
<td>Measure Output level.</td>
<td></td>
<td>Configured Output level ±1 dB (Def.: -3.5 dBm)</td>
<td>dBm (600 Ω)</td>
<td>[ ] [ ] [ ]</td>
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<tr>
<td></td>
<td>Feed 800 Hz with configured input level of remote subscriber.(Def.: 0.0 dBm)</td>
<td></td>
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<td>N02 N08 N14</td>
<td>N24 N30 N48</td>
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<td>PAX-BLOCKING normal</td>
<td>Measure at terminal telephony 2a-2b</td>
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<td>6a-6b is open, 6b-7a is closed</td>
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<tr>
<td>PAX-BLOCKING blocked</td>
<td>Switch off remote equ., wait about 30 sec.</td>
<td></td>
<td>6a-6b is closed, 6b-7a is open</td>
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<td>Test No.</td>
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<td>Test point</td>
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<td>Units</td>
<td>Test result</td>
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<td>E-Wire must toggle</td>
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<td>Test E-Wire:</td>
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<td>Close and open at Remote</td>
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<td>N24 N30 N48</td>
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<td>equ. at terminal telephony</td>
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<td></td>
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<td>N24 N30 N48</td>
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<td>4a-4b</td>
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<td>Feed 800 Hz with configured</td>
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<td>input level of remote PAX</td>
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<td>4a-4b on both equ..</td>
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<td>input level of remote PAX</td>
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<td>(Def.: -3.5 dBm).</td>
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<td>4a-4b on both equ.)</td>
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<td>Feed 800 Hz with configured</td>
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<td>(Activate at terminal telephony</td>
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<td>4a-4b on both equ.)</td>
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<td>Measure at terminal</td>
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<td>telephony 6a-6b, 6b-7a</td>
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<td>6b-7a is closed</td>
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<td>PAX-BLOCKING blocked</td>
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<td>Measure at terminal</td>
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<td>telephony 6a-6b, 6b-7a</td>
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<tr>
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<td>6a-6b is closed</td>
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<tr>
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<td>6b-7a is open</td>
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<td>B.11.9</td>
<td>Transit mode for E&amp;M wire</td>
<td>Mark if not configured:</td>
<td>E-Wire must toggle</td>
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<td>N02 N08 N14</td>
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<td>Test E-Wire:</td>
<td>Terminal telephony 3a-3b</td>
<td></td>
<td></td>
<td>N02 N08 N14</td>
</tr>
<tr>
<td></td>
<td>Close and open at Remote</td>
<td></td>
<td></td>
<td></td>
<td>N24 N30 N48</td>
</tr>
<tr>
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<td>equ. at terminal telephony</td>
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<td>N24 N30 N48</td>
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<tr>
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<td>4a-4b</td>
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<td>Test No.</td>
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<td>Test point</td>
<td>Permissible value</td>
<td>Units</td>
<td>Test result</td>
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<td>B.11.10</td>
<td>Testing the teleoperation ports</td>
<td>Mark if not configured:</td>
<td>N02/N08 N14 N20</td>
<td>[ ] [ ] [ ] [ ] [ ]</td>
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<tr>
<td>B.11.11</td>
<td>Teleoperation AF1, if not used for telephony</td>
<td>Fed input level, [dBm], @ 800 Hz at AF1-IN of remote.</td>
<td>N02/N24: ______±1</td>
<td>N02/N24: ______±1</td>
<td>N02/N24: N08/N08: N14/N14: N20/N20: N24/N24: N30/N30: N42/N42: N48/N48: N54/N54:</td>
</tr>
</tbody>
</table>
## Test No. 11.15

**Teleoperation AF4 used for ext. teleprotection**

- Test EXT-BOOST:
  - Fed input level, [dBm], @ 800 Hz at AF4-IN
  - N02/N24: _________±1
  - N08/N30: _________±1
  - N14/N48: _________±1

- Mark if not configured:
  - Activate at remote equ. at terminal teleop. 9a-9b
  - Feed into rem. equ. at terminal teleop. 7a-7b
  - Measure at terminal teleop. 8a-8b

- **Test result**
  - Expected Output level at AF4-OUT: N02/N24: _________±1
  - N08/N30: _________±1
  - N14/N48: _________±1
  - Measured Output level at AF4-OUT: N02/N24: _________
  - N08/N30: _________
  - N14/N48: _________

## Test No. 12

**Testing of V.11 ports**

- **B.12.1 V.11 Port 1**
  - Mark if not configured:
  - BER test Front plate P4LT/V/X, V.11 PORT 1
  - BER ≤ 10^-6 during ____ sec

- **B.12.2 V.11 Port 2**
  - Mark if not configured:
  - BER test Front plate P4LX, V.11 PORT 2
  - BER ≤ 10^-6 during ____ sec

## Test No. 13

**Testing of V.24 ports**

- **B.13.1 V.24 Port 1**
  - Mark if not configured:
  - BER test Front plate P4LT/V/X, V.24 PORT 1
  - BER ≤ 10^-6 during ____ sec

- **B.13.2 V.24 Port 2**
  - Mark if not configured:
  - BER test Front plate P4LT/V/X, V.24 PORT 2
  - BER ≤ 10^-6 during ____ sec

- **B.13.3 V.24 Port 3**
  - Mark if not configured:
  - BER test Front plate P4LX, V.24 PORT 3
  - BER ≤ 10^-6 during ____ sec

- **B.13.4 V.24 Port 4**
  - Mark if not configured:
  - BER test Front plate P4LX, V.24 PORT 4
  - BER ≤ 10^-6 during ____ sec
<table>
<thead>
<tr>
<th>Test No.</th>
<th>Test procedure</th>
<th>Test point</th>
<th>Permissible value</th>
<th>Units</th>
<th>Test result</th>
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<td>B.14</td>
<td>Testing of LAN ports</td>
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<td>B.14.1</td>
<td>LAN Port 1</td>
<td>Mark if not configured:</td>
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<td></td>
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<td>Test of throughput</td>
<td>Front plate P4LV/X, LAN PORT 1</td>
<td>Throughput</td>
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</tr>
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<td></td>
<td>% errored or missing frames</td>
<td>Front plate P4LV/X, LAN PORT 1</td>
<td>≤ 0.5% errored or</td>
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</tr>
<tr>
<td></td>
<td>of transmitted frames.</td>
<td></td>
<td>missing 128-byte</td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td>frames during</td>
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<td></td>
<td></td>
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<td>______ sec</td>
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<td>B.14.2</td>
<td>LAN Port 2</td>
<td>Mark if not configured:</td>
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<td></td>
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<td>Test of throughput</td>
<td>Front plate P4LV/X, LAN PORT 2</td>
<td>Throughput</td>
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<td>Front plate P4LV/X, LAN PORT 2</td>
<td>≤ 0.5% errored or</td>
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<td>of transmitted frames.</td>
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<td>missing 128-byte</td>
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<td>B.14.3</td>
<td>LAN Port 3</td>
<td>Mark if not configured:</td>
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<td>Test of throughput</td>
<td>Front plate P4LV/X, LAN PORT 3</td>
<td>Throughput</td>
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<td>% errored or missing frames</td>
<td>Front plate P4LV/X, LAN PORT 3</td>
<td>≤ 0.5% errored or</td>
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<td>of transmitted frames.</td>
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<td>missing 128-byte</td>
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<td>B.14.4</td>
<td>LAN Port 4</td>
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<td>of transmitted frames.</td>
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<td>missing 128-byte</td>
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<td>HMI over LAN</td>
<td>Test of connectivity</td>
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<td>Units</td>
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<td>B.15</td>
<td>Testing of O4CV</td>
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<td>B.15.1</td>
<td>Slot positions of O4CV boards</td>
<td>Record slot positions of O4CV boards</td>
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<td>Refer to HMI600 configuration view</td>
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<td>O4CV#1: N______</td>
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<td>O4CV#2: N______</td>
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<td>O4CV#3: N______</td>
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<td>O4CV#4: N______</td>
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<td>B.15.2</td>
<td>Service Phone</td>
<td>Mark if not configured:</td>
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<td>Service phone, at front panel of O4CV#1</td>
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<td>B.15.3</td>
<td>Hot line direct phone</td>
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<td>B.15.4</td>
<td>Remote subscriber. At remote equ. is Pax 2-Wire</td>
<td>Mark if not configured:</td>
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<td>Subscriber must ring</td>
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</tbody>
</table>

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**Test No. 1**

**Test procedure:** Testing of O4CV

**Test point:** Slot positions of O4CV boards

**Permissible value:** Refer to HMI600 configuration view

**Test result:**

- O4CV#1: N______
- O4CV#2: N______
- O4CV#3: N______
- O4CV#4: N______

---

**Test No. 2**

**Test procedure:** Service Phone

**Test point:** Mark if not configured: Service phone, at front panel of O4CV#1

**Permissible value:** Remote service phone rings, buzzers drones, talk is possible

**Test result:**

- [ ]

---

**Test No. 3**

**Test procedure:** Hot line direct phone

**Test point:** Mark if not configured: Direct phone

**Permissible value:** Remote direct phone rings until phone is picked up

**Test result:**

- [ ]

---

**Test No. 4**

**Test procedure:** Remote subscriber. At remote equ. is Pax 2-Wire

**Test point:** Mark if not configured: Subscriber must ring

**Permissible value:** Configured output level ±5 dB (Def.: -7.0 dBm)

**Test result:**

- O4CV#1: O4CV#2: O4CV#3: O4CV#4:
  - P1 P2 P3 P4 P1 P2 P3 P4
  - [ ] [ ] [ ] [ ] [ ] [ ] [ ]
  - [ ] [ ] [ ] [ ] [ ] [ ] [ ]
  - [ ] [ ] [ ] [ ] [ ] [ ] [ ]
  - [ ] [ ] [ ] [ ] [ ] [ ] [ ]

---

**Notes:**

- Feed 800 Hz with configured input level of remote subscriber (Def.: 0.0 dBm).
- Measure output level.
- Test Ringer: Feed ringing voltage (25 VAC, 25 Hz, R = 2.2 kΩ) into remote PAX 2-Wire.
- Measure output level.
- Feed 800 Hz with configured input level of remote PAX. (Def.: 0.0 dBm)
<table>
<thead>
<tr>
<th>Test No.</th>
<th>Test procedure</th>
<th>Test point</th>
<th>Permissible value</th>
<th>Units</th>
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<tr>
<td>B.15.5</td>
<td>Remote subscriber. At remote equ. is Pax 4-wire</td>
<td>Mark if not configured:</td>
<td>Subscriber must ring</td>
<td></td>
<td>[ ]</td>
</tr>
<tr>
<td></td>
<td>Test Ringer:</td>
<td>Mark if not configured:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Activate M-WIRE of remote Pax 4-wire.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Measure output level.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Feed 800 Hz with configured input level of remote PAX. (Def.: -3.5 dBm)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Feed into rem. equ. at terminals 1a-1b, 5a-5b, 9a-9b of term.bl.2 for ports P1, P2, P3 or 3a-3b of term.bl.2 for port P4</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Measure at terminals 7a-7b, 8a-8b, 9a-9b, 0a-0b of term.bl.2 for ports P1, P2, P3, P4</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B.15.6</td>
<td>Pax 2-wire</td>
<td>Mark if not configured:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Measure output level.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Feed 800 Hz with configured input level of remote subscriber. (Def.: 0.0 dBm)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Feed into rem. equ. at terminals 1a-1b, 5a-5b, 9a-9b, 0a-0b of term.bl.2 for ports P1, P2, P3, P4</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Measure at terminals 7a-7b, 8a-8b, 9a-9b, 0a-0b of term.bl.2 for ports P1, P2, P3, P4</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B.15.7</td>
<td>Pax 4-wire. At remote equ. is Pax 4-wire</td>
<td>Mark if not configured:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Test E-Wire:</td>
<td>Mark if not configured:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Close and open M-Wire at rem. equ. at terminals 4a-4b, 8a-8b of term.bl.1 for ports P1, P2 or 2a-2b, 6a-6b of term.bl.2 for ports P3, P4</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Measure output level.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Feed 800 Hz with configured input level of remote PAX (Def.: -3.5 dBm).</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(Activate at terminals 4a-4b, 8a-8b of term.bl.1 for ports P1, P2 or 2a-2b, 6a-6b of term.bl.2 for ports P3, P4 on both equ.)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### Test Procedure

<table>
<thead>
<tr>
<th>Test No.</th>
<th>Test procedure</th>
<th>Test point</th>
<th>Permissible value</th>
<th>Units</th>
<th>Test result</th>
</tr>
</thead>
<tbody>
<tr>
<td>B.15.8</td>
<td>Pax 4-wire. At remote equ. is Remote subscriber</td>
<td>Mark if not configured: Terminals 3a-3b, 7a-7b of term.bl.1 for ports P1, P2 or 1a-1b, 5a-5b of term.bl.2 for ports P3, P4</td>
<td>E-Wire must toggle</td>
<td>dBm (600 Ω)</td>
<td>[ ]</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Feed into rem. equ. at terminals 7a-7b, 8a-8b, 9a-9b, 0a-0b of term.bl.2</td>
<td>Configured output level ±5 dB (Def.: -3.5 dBm)</td>
<td>[ ]</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Measure at terminals 2a-2b, 6a-6b, 0a-0b of term.bl.1 for ports P1, P2, P3 or 4a-4b of term.bl.2 for port P4</td>
<td>[ ]</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**B.16 Documentation**

Make a printout of equipment configuration and status data.

Save the "*.et6" file on disk with Serial No. of ETL coded in the file name, e.g. HE400327B0.ET6

**B.17 Manual reset**

[ ]
CUSTOMER ACCEPTANCE

The acceptance form is completed by ABB and the customer representative once all equipment tests detailed in this document have been performed successfully. Customer acceptance form is part of the test report.

<table>
<thead>
<tr>
<th>Testfield</th>
<th>ABB Switzerland Ltd</th>
</tr>
</thead>
<tbody>
<tr>
<td>Department</td>
<td>PSNEX</td>
</tr>
</tbody>
</table>

| Date:           | ............................  |
| Test Engineer:  | ___________________________
| Supervisor:     | ___________________________

**FAT Witnessed**

| Date:           | ............................  |
| Engineer:       | ___________________________

| Date:           | ............................  |
| Engineer:       | ___________________________

| Date:           | ............................  |
| Engineer:       | ___________________________

| Date:           | ............................  |
| Engineer:       | ___________________________

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| Engineer:       | ___________________________

| Date:           | ............................  |
| Engineer:       | ___________________________
Power Line Carrier Equipment: Series ETL600

APLC Channel Equalization for ETL600

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List of equipment:

PC with Windows XP, Vista or Windows 7
HMI600 software
PC <> P4LT/U/V/X cable 1:1 serial RS-232

Note:

- Please refer 1KHW001490 for compatibility between software HMI600, firmware and hardware of ETL600.
1 Purpose of document

This document describes the equalization process for the equipment ETL600, supported by the PC program HMI600.

2 Abbreviations and Definitions

PLC link: Two ETL600 terminals using a power line for signal transmission.
Local/Remote: To distinguish between the two terminals of a PLC link, one of them is referred to as 'local equipment', the other one as 'remote equipment'. Both directions of a link are equalized separately.

Note: To access the remote equipment, log ON using the equipment address of the remote equipment. This is especially applicable for chapters 4, 5, 6, 8.2.2 and 10.

Channel: An ETL600 PLC link offers up to three AF channels for transmission of analog signals. Each channel is equalized separately.

Equalizer: A filter that flattens the amplitude and/or group delay response of a channel.

BER: Bit error ratio

3 Equalizer concept

The ETL600 has an integrated equalizer separately for each configured channel. Two operation modes are available: Amplitude equalization only and combined amplitude with group delay equalization. The resulting amplitude response of each channel (with the selected equalizer and none) can be viewed with the HMI600 software before activation and during operation without interrupting services on the link.

It is possible to change later an active equalizer with amplitude equalization only to one with combined amplitude and group delay equalization and vice versa (with short interruption of the link due to equipment reset).

Instructed personnel can choose between 4 possible equalizer settings: None (no equalizer), short, medium or long equalizer.

Note: After changing RF settings (Tx, Rx nominal frequency or overall channel mode), all active equalizers have to be updated.

Note: After changing the number of APLC channels from or to 3 channels in 8 kHz, all active equalizers have to be updated.

Note: Frequency response measurements in case of 3 channels in 8 kHz produce out of band noise signals which could impair other services:
1. The measurement of channel 1 disturbs the RF frequency range from fn down to fn - 800 Hz in erect mode or from fn up to fn + 800 Hz in inverted mode.

2. The measurement of channel 2 disturbs the AF frequency range up to 1750 Hz in channel 3.

3. The measurement of channel 3 disturbs the RF frequency range from fn + Bn to fn + Bn + 1600 Hz in erect mode or from fn - Bn down to fn - Bn - 1600 Hz in inverted mode.
Note: When in the APLC channel to be equalized internal teleprotection is configured with own guard, the frequency response measurement will show a peak at the frequency of the own guard, because the own guard must not be switched off during the frequency response measurement. As the signal for the teleprotection receiver doesn’t pass the equalizer, the teleprotection performance is not influenced in any way by the equalizer. Moreover, the peak usually is not perceived by other analogue services (speech, teleoperation) that might be present on the channel, because these services must suppress the own teleprotection guard signal anyway by suitable filters.

Note: In case of nominal bandwidth $B_n = 2$ kHz, the resulting equalizer is not useful. Do not activate any equalizer.

3.1 None (no equalizer)

The equalizer is bypassed. This setting is working during first power up of the ETL600 equipment until instructed personnel measures the channel and chooses another equalizer. There is no added system delay. This is the best possible value for the system group delay. Note that the operation mode 'Amplitude response equalization only' or 'Combined group delay and frequency response equalization' has no effect in this case.

3.2 Short equalizer

The short equalizer compensates the amplitude response of the channel with a minimum of additional delay. This additional delay can be viewed in the 'Select equalizer' box.

If 'Amplitude response equalization only' is selected, no group delay equalization is performed. The resulting amplitude response is acceptable.

If 'Combined group delay and frequency response equalization' is selected, a combined amplitude and group delay equalizer is activated. Due to the additional group delay equalization, the equalized channel amplitude response could have quite a ripple. Group delay distortion up to 1 ms can be equalized.

Please note that the additional group delay equalization must only be activated if there is a modem present on that channel and the performance is better than with the 'allpass filter for group delay equalization' enabled only (in 'Configuration' / 'System' / 'Channel Settings'). The default setting is 'Amplitude response equalization only' enabled.

Always check the amplitude response of the short equalizer in the pilot channel if used in conjunction with external protection system before activation through instructed personnel.

3.3 Medium equalizer

The medium equalizer compensates the amplitude response of the channel with additional delay. This additional delay can be viewed in the 'Select equalizer' box.

If 'Amplitude response equalization only' is selected, no group delay equalization is performed. The resulting amplitude response is good.

If 'Combined group delay and frequency response equalization' is selected, a combined amplitude and group delay equalizer is activated. Due to the additional group delay equalization, the equalized channel amplitude response could have quite a ripple. Group delay distortion up to 1.5 ms can be equalized.

Please note that the additional group delay equalization must only be activated if there is a modem present on that channel and the performance is better than with 'allpass filter for group delay equalization' enabled only (in 'Configuration' / 'System' / 'Channel Settings'). The default setting is 'Amplitude response equalization only' enabled.

Always check the amplitude response of the medium equalizer in the pilot channel if used in conjunction with external protection system before activation through instructed personnel.
### 3.4 Long equalizer

The long equalizer compensates the amplitude response of the channel with additional delay. This additional delay can be viewed in the 'Select equalizer' box.

If 'Amplitude response equalization only' is selected, no group delay equalization is performed. The resulting amplitude response is excellent.

If 'Combined group delay and frequency response equalization' is selected, a combined amplitude and group delay equalizer is activated. Due to the additional group delay equalization, the equalized channel amplitude response can have a ripple. Group delay distortion up to 2 ms can be equalized.

Please note that the additional group delay equalization must only be activated if there is a modem present on that channel and the performance is better than with 'allpass filter for group delay equalization' enabled only (in 'Configuration' / 'System' / 'Channel Settings'). The default setting is 'Amplitude response equalization only' enabled.

Always check the amplitude response of the long equalizer in the pilot channel if used in conjunction with external protection system before activation through instructed personnel.

Note: The equalizer is applied on the receive signal whereas the allpass filter is applied on the transmit signal. As a consequence the equalizer has to be configured on the receiving equipment and the allpass filter on the transmitting equipment.

### 4 Establishing a new equalizer

To establish a new equalizer, use the following step-by-step procedure:

1. Measure the frequency response of the channel to equalize ('Equipment' / 'Commissioning & maintenance' / 'Frequency response').
2. Check the equalized frequency response with the 'View' button in 'Select Equalizer' of the desired channel. If you are not satisfied with all new equalizers, repeat the measurement. If you decide not to change the running equalizer, quit the 'Select Equalizer' dialog box with the 'Cancel' button.
3. Activate the chosen equalizer with the 'Download' button in 'Select Equalizer'. The new settings are downloaded, stored in the EPROM and the equipment is reset.

Note:

- External protection equipment, voice, teleoperation and modems will be automatically disconnected during the channel measurement.
- Due to sporadic noise and other disturbance during measurement, the measured channel response can be quite noisy. In this case it is advised to repeat the channel measurement. During measurement of the channel, each appearing sporadic noise could jam the measurement.
- Depending on the configured alarm pick-up and setup time some alarms could appear for a short moment during channel measurement.
- During channel measurement, NSD600 teleprotection commands can still be transmitted without further delay. The measurement will be cancelled as soon as NSD600 commands are transmitted. If this happens, the measurement must be repeated.
- A system reset is performed automatically after downloading new equalizer settings. As a consequence the link transmission will be interrupted completely for a moment.

### 5 Equalizing a channel

In this section the letter 'X' names the channel to equalize. This can be channel 1, 2 or channel 3. Do not mix up the channel during the whole equalization process. The selected channel from the remote to the connected ETL600 system will be equalized.
Please note that equalizing a channel over the EOC network or on the remote side may take several 10 minutes.

Make a connect with write access to the desired ETL600 equipment and upload the configuration. Select in the menu bar 'Equipment' / 'Commissioning and maintenance' / 'Frequency response' / 'APLC channel X'. A dialog box appears telling the user that he is going to disable the system. By pressing the 'Cancel' button, no channel measurement will be started. By selecting the 'Yes' button, a channel measurement on channel X from the remote to the local ETL600 terminal will be started. This is also the last chance to abort an equalizer selection process without interrupting normal services.

Note: During measurement of the frequency response of the selected channel, voice, data and external protection are automatically switched off for about one minute. Corresponding alarms may appear. Protection signal transmission is only possible with NSD600.

After up to 5 minutes, the measurement is finished and the dialog box 'Select equalizer' appears. The amplitude response of the link from remote equipment to the connected ETL600 can be viewed for channel X.

With the help of the 'Select equalizer' dialog box, it is possible to select the best possible equalizer for a specific purpose. When this dialog box first appears, the active equalizer is easily recognised in the 'Actual equalizer' field. The equalizer delay describes the additional delay added by the equalizer. The less this delay is, the better it is for applications with external teleprotection equipment. Please note that the internal teleprotection NSD600 is working independently from this equalizer delay. The average ripple describes the average ripple left in the complete AF band by the equalizer. By selecting the desired equalizer before pressing the 'View' button, the frequency response is visible with and without the equalizer.

In order to return to the 'Select Equalizer' dialog box, select 'Equipment' / 'Commissioning and maintenance' / 'Select equalizer' / 'APLC channel X' again. It is possible to repeat this procedure again and again.

If the amplitude response with the equalizer is quite 'noisy', the measurement went wrong due to sporadic noise on the high voltage line during the measurement. In this case repeat the measurement by selecting 'Equipment' / 'Commissioning and maintenance' / 'Frequency response' / 'APLC channel X'.

Note: If a system reset or configuration download is performed after a frequency response measurement before downloading new equalizer settings, all measurement data are lost.

Discarding a new equalizer: If after several measurements all new equalizers have worse results than the actual equalizer, it is better to leave the old equalizer unchanged by quitting 'Select equalizer' with the 'Cancel' button.

Activating a new equalizer: After finding a new equalizer suitable, select the new desired equalizer in 'Equipment' / 'Commissioning and maintenance' / 'Select Equalizer' / 'APLC channel X'. Then press the 'Download' button. A dialog box appears which warns the user of an ETL600 system reset. By pressing 'Yes', the selected equalizer settings will be downloaded, stored in the EPROM and after the restart the new equalizer will be activated.

6 Changing the length or mode of a running equalizer

The length ('None', 'Short', 'Middle', 'Long') and/or the mode ('Amplitude response equalization only', 'Combined group delay and amplitude response equalization') of a running equalizer can be changed without performing a new frequency response measurement. In this case the new equalizer is based on the measurement of the actual equalizer.

Please note that after downloading the new settings, the equipment is reset in order to activate the new equalizer. This leads to a short interruption of services on the whole ETL600 link, not only of the affected channel.

In order to display the frequency response of an equalizer select in 'Equipment' / 'Commissioning and maintenance' / 'Select equalizer' / 'APLC channel X' the equalizer settings of the
equalizer you would like to view and click on the 'View' button. By pressing 'Cancel' the window can be closed without further action.

Changing the equalizer length or equalizer mode: Select the length and mode of the desired equalizer and press the 'Download' button. A dialog box appears which warns the user of an ETL600 system reset. By pressing 'Yes', the selected equalizer settings will be downloaded, stored in the EPROM and after the restart the new equalizer will be activated.

7 Remote equalizer manipulation

Equalizing a channel or changing the equalizer settings can also be done on the remote ETL600 equipment or anywhere else in the ETL600 network. Using the EOC (in most cases) for remote access can take several 10 minutes for a complete equalizer operation. Be patient.

It is recommended only to equalize the remote equipment, not any ETL600 further away in an ETL600 EOC network. In this case a complete channel equalization will take around 20 minutes.

Connect to the desired ETL600 station with the corresponding equipment ID or with the remote button. Don’t forget to set the write access with the correct password. Then follow the procedure described in chapter 5 and 6 depending on the desired equalizer action. The procedure is the same except of the longer waiting periods until the necessary data is transmitted over the 100 bps EOC.

8 Application specific equalizer choices

8.1 Rules if external teleprotection in the selected channel is used

If external teleprotection is used on a channel, following additional points must be considered and understood before equalizing this channel:

Caution

During frequency response measurement, the transmission path of external teleprotection equipment will be automatically interrupted without further warnings. For the duration of the measurement, no teleprotection commands can be transmitted.

Select the shortest possible equalizer (smallest additional added delay) with flat amplitude response in the external teleprotection channel. If possible use 'Amplitude response equalization only'.

8.2 Equalizer for NSK600 modems with data rates of 2.4, 4.8 and 9.6 kbps

Starting with ETL600 Rel.3.1, an adaptive equalizer is available for 2.4, 4.8 and 9.6 kbps NSK600 modems.

8.2.1 ETL600 Rel.3.0 or earlier ETL600 releases

By default the long equalizer in connection with the 'Amplitude response equalization only' setting is used for NSK600 modems with data rates of 2.4, 4.8 and 9.6 kbps. Additionally the allpass filter has to be enabled on the transmitting equipment ('allpass filter for group delay equalization' setting in 'Configuration' / 'System' / 'Channel Settings'). If the performance of the modem is unsatisfactory, the equalizer mode can be changed to 'Combined group delay and frequency response equalization'.

In order to evaluate the modem performance a BER test equipment transmitting pseudo random data should be used. Which equalizer to choose is based on the measured BER. Alternatively the equalizer yielding the better signal quality (during transmission of random data) in the NSK600 status can be selected.

8.2.2 ETL600 Rel.3.1 or later ETL600 releases

By default, the adaptive equalizer is enabled for NSK600 modems with data rates of 2.4, 4.8 and 9.6 kbps ('Configuration' / 'NSK600' / 'NSK600 modem N' / 'Signal Settings' / 'Adaptive
equalizer' / 'On'). The static channel equalizer and the all-pass filter – should they be enabled - are bypassed. The advantage of the adaptive equalizer is that it adapts to changing channel characteristics.

If for some reason the adaptive equalizer needs to be disabled, the channel equalization procedure as described in section 8.2.1 is required. However, the adaptive equalizer will usually be the better choice, as for most transmission channels encountered in practice it outperforms the static channel equalizer.

9 Recommended procedure to equalize a channel

1. Logon to the desired ETL600 using the HMI600 dialog 'Equipment' / 'Connect' with 'Read & Write access' enabled, correct Equipment ID, correct password and with the checkbox 'Upload configuration' selected.
2. Start channel measurement by selecting 'Equipment' / 'Commissioning and maintenance' / 'Frequency response' / 'APLC channel X'.
3. Wait until the window 'Select equalizer' appears.
4. View the frequency response of the desired equalizer with the 'View' button. By default, 'Amplitude response equalization only' is active. With 'Equipment' / 'Commissioning and maintenance' / 'Select equalizer' / 'APLC channel X', it is possible to go back into the 'Select equalizer' dialog box.
5. If the channel measurement is noisy, repeat the measurement with 'Equipment' / 'Commissioning and maintenance' / 'Frequency response' / 'APLC channel X' and go back to point 4.
6. Select with 'Equipment' / 'Commissioning and maintenance' / 'Select Equalizer' / 'APLC channel X' the desired new equalizer with the desired group delay equalization mode and press the 'Download' button. The equipment is reset now.
7. Wait until the equipment has restarted. The new equalizer is active now.
8. Exit.

10 Recommended procedure to change the equalizer settings

1. Logon to the desired ETL600 using the HMI600 dialog 'Equipment' / 'Connect' with 'Read & Write access' enabled, correct Equipment ID, correct password and with the checkbox 'Upload configuration' selected.
2. Select the desired channel with 'Equipment' / 'Commissioning and maintenance' / Select equalizer / 'APLC channel X'.
3. View the frequency response of the desired equalizer with the 'View' button. It is also possible to change only the group delay equalization mode. With 'Equipment' / 'Commissioning and maintenance' / 'Select equalizer' / 'APLC channel X', it is possible to go back into the 'Select equalizer' dialog box.
4. If the user doesn’t want to change the equalizer settings, press 'Cancel' to exit the dialog box.
5. Select with 'Equipment' / 'Commissioning and maintenance' / 'Select Equalizer' / 'Channel X' the desired actual equalizer with the desired group delay equalization mode and press the 'Download' button. The equipment is reset now.
6. Wait until the equipment has restarted. The new equalizer is active now.
7. Exit.
Powerline Carrier Equipment: Series ETL600

Commissioning Instructions ETL600R4

This document describes programming and testing of power line carrier equipment ETL600 Rel.4, including the teleprotection system NSD600.

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ETL600 Commissioning Report: .........................Refer to document 1KHW002587

The terminal designations in this document apply to terminals blocks for 10 wire pairs.

Test conditions:

- Temperature range: 10 °C to 40 °C.
- The connections for the tests can be made either at the test sockets on the front of the equipment or at the terminals.
Basic test equipment

PC with Windows XP, Vista or Windows 7
HMI600 software Newest version
Cable PC⇔P4LT/V/X 1:1 Sub-D 9 pole serial RS-232
Digital multimeter GMC METRAhit one, or equivalent
Level meter True RMS with a frequency range up to 1 MHz

Optional test equipment

Level generator PS-33A (Acterna) or equivalent
Selective level meter SPM-33A (Acterna) or equivalent
Storage oscilloscope Fluke 190C ScopeMeter or equivalent
Rx tuning adapter P4LM HENF 209665
Data tester PFA-35 (Acterna) or equivalent
Ethernet Tester CMA3000 (Anritsu) or equivalent

Notes:
- This document is part of instruction manual 1KHW002582.
- Please refer 1KHW001490 for compatibility between software HMI600, firmware and hardware of ETL600.

Designations and abbreviations used:

<table>
<thead>
<tr>
<th>Designation</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>[ ... ]</td>
<td>Programmed value</td>
</tr>
<tr>
<td>[ ] D</td>
<td>Preferred setting (default)</td>
</tr>
<tr>
<td>[ X ]</td>
<td>Test passed or jumper is set</td>
</tr>
<tr>
<td>[ ]</td>
<td>Not tested or jumper is not set</td>
</tr>
<tr>
<td>B5LA</td>
<td>Module type</td>
</tr>
<tr>
<td>BER</td>
<td>Bit Error Ratio</td>
</tr>
<tr>
<td>Def.</td>
<td>Default value</td>
</tr>
<tr>
<td>EOC</td>
<td>Embedded Operation Channel</td>
</tr>
<tr>
<td>equ.</td>
<td>Equipment</td>
</tr>
<tr>
<td>f_lo</td>
<td>Lower frequency, usually meant as low cut-off frequency</td>
</tr>
<tr>
<td>LED</td>
<td>Light Emitting Diode found on the front panel</td>
</tr>
<tr>
<td>HMI600</td>
<td>User Interface Program for ETL600 running on a PC</td>
</tr>
<tr>
<td>N02, N08</td>
<td>Position in rack. Slot number N02, N08</td>
</tr>
<tr>
<td>Rx</td>
<td>Receiver</td>
</tr>
<tr>
<td>Tx</td>
<td>Transmitter</td>
</tr>
<tr>
<td>PC</td>
<td>Personal Computer</td>
</tr>
<tr>
<td>(T.02/..1)</td>
<td>Connector 1 of terminal block connected to board at rack position N02</td>
</tr>
</tbody>
</table>
C Commissioning Instructions for the ETL600 Equipment

C.1 General
Most of the commissioning tests (including fully automatic equalization) for the ETL600 system can be done with the help of PC based software HMI600. It is assumed, that all assembled Tx filters and Rx filter are tuned. Under normal conditions only level adjustments will be done during commissioning. It is required to work through the document ‘Programming and Testing of ETL600R4’, 1KHW002609, which is dispatched along with the equipment, before starting the commissioning.

In case of some adjustments like Tx RF level, Rx RF level etc. the permissible limits are calculated by the HMI600 and displayed in the dialog boxes.

The pilot signal is QPSK modulated to accommodate both Signaling and Embedded Operations Channel. As a result, the level of the pilot signal changes continuously (by about 3 dB) due to which its exact level cannot be measured.

The equipment must be tested using a standard cable impedance or in local loop mode before connecting the equipment via the coupling device to the power line.

ESD protection

The modules in this equipment contain devices, which can be damaged by electrostatic discharges. Appropriate measures must be taken before unpacking modules or withdrawing them from equipment racks. Essential precautions to prevent ESD damage when handling or working on modules are grounding straps for technical personnel and the provision of anti-static workbenches. Modules may only be shipped either in their original packing or installed in equipment racks.

Insertion and removal of plug-in modules

Neither removing nor inserting of modules is permitted during power-up of the equipment. Preceding to plug in and out of modules, the power supply of the equipment has to be switched OFF.

There are two exceptions to this:

1. Rx filter P4RX:
   It has to be removed and inserted while the equipment remains powered when performing the Rx level adjustment procedure.

2. Redundant power supply module B5LD:
   It can be removed or inserted while the equipment remains powered by the other B5LD module in the rack.
The local loop can be established or interrupted with the following operation:

<table>
<thead>
<tr>
<th>Establish local loop</th>
<th>From the HMI600 menu <strong>Tuning &amp; testing</strong>, choose <strong>Test PLC-link</strong> and check <strong>Local RF loopback on</strong>. When MOD600 is configured, it must be configured as Master. The configuration must be changed temporarily for local loop operation in case it is configured as Slave. The alarm “Both MOD600 configured as Master” that will be generated during local loop operation can be ignored.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interrupt local loop</td>
<td>From the HMI600 menu <strong>Tuning &amp; testing</strong>, choose <strong>Test PLC-link</strong> and uncheck <strong>Local RF loopback on</strong>.</td>
</tr>
<tr>
<td>Return to normal operation</td>
<td>Interrupt the local loop as described above. For MOD600 operation, if - for local loop operation - the configuration of MOD600 had to be changed from Slave to Master, change the configuration back to its original state.</td>
</tr>
</tbody>
</table>

Note: After establishing the local loop, wait until Link Alarm disappears.

Caution: Entering one of the procedures of the HMI600 menu **Tuning & testing** disturbs the operation of the link.

C.1.1 Checking the line of communication
It is essential that the behavior and characteristics of the line of communication between the sets of PLC terminal equipment be checked as described in the instruction manual, 1KHW002582, chapter 7, ‘Commissioning’.

C.1.2 Visual checks before switching ON the equipment.

DANGER
Check the wiring of protective earth to the equipment. Check, if a protective earth wire of at least 25 mm² has been connected visibly to the earth bolt of the cubicle.

In case of battery supply: Check if the positive pole (+) of the battery is grounded. If it is, place an earth jumper to the positive pole of the cubicle supply.

Note: Switch the equipment ON now.

C.2 Check power supply B5LD
Check the DC supply voltage and verify that the green LED on the front panel of the right and – if any – of the left power supply module B5LD is/are lit.
There is no access to the internal DC voltages generated for the equipment. However in case these voltages are outside their limit, it will be indicated by a hardware alarm.
C.3 Connect to equipment, upload configuration

The equipment is managed by the HMI600 program via a serial connection. The equipment identification and necessary channel settings are noted.

1. Start the HMI600, open the preconfigured file and connect to the equipment as described in the instruction manual, 1KHW002582, chapter 4, section ‘Communication to the ETL600’.
2. On the File menu click New. This opens the Connect dialog box.
3. Click Logon, Equipment ID, with ID 0.
4. Click Read & Write access
5. Click Upload configuration
6. Click OK. The equipment configuration is uploaded to the PC.

C.4 Change configuration, if necessary

If configuration parameters have to be changed, refer to of the instruction manual, 1KHW002582, chapter 5 ‘Configuration and Set-up’.

C.4.1 Reducing output power, if necessary

At step C.1.1, return loss of line was determined in the used frequency range. The smallest (e.g. worst) value of the return loss in the used frequency range is noted as \( A_{\text{r min}} \).

If the return loss of line is worse than 12 dB, output power must be reduced. Only in this case:

1. Calculate the reduction of output power, noted as \( A_{\text{red}} \)

\[
A_{\text{red}} = 3 - \frac{A_{\text{r min}}}{4},
\]

\( A_{\text{r min}} \) and \( A_{\text{red}} \) in [dB].

2. Determine the new value for max output power by using the table:

<table>
<thead>
<tr>
<th>Equipment type</th>
<th>Max output power reduced:</th>
</tr>
</thead>
<tbody>
<tr>
<td>ETL600-050 50 W</td>
<td>Max power (PEP) ≤ 47 dBm - ( A_{\text{red}} )</td>
</tr>
<tr>
<td>ETL600-100 100 W</td>
<td>Max power (PEP) ≤ 50 dBm - ( A_{\text{red}} )</td>
</tr>
</tbody>
</table>

3. On the Configuration menu click System... and then click the Channel settings tab. Enter the new value in the Max. power (PEP) field.
4. Click OK.
5. On the Equipment menu click Download configuration
6. Store configuration to the flash eprom. On the Equipment menu click Store configuration to FLASH. Answer all dialogs with Yes or OK.

C.5 Transmitter

The Tx RF level and the Tx alarm threshold levels were adjusted during final testing in the works. The Tx alarm threshold needs to be changed only in case the output power had to be reduced in the previous step.

C.5.1 Adjust Tx RF level

Note: This step is required only if the Tx filter had to be retuned or exchanged after the final testing in the works.
The Tx RF level is adjusted with help of the HMI600 program.

Open the Adjust Tx level dialog box under Equipment / Tuning & testing. Click the buttons Select and then Start. The obtained setting accuracy is better than ± 0.2 dB. Thus, by measuring the Tx level, the setting precision can't be improved.

Adjustment procedure in case the level needs to be verified by external measurement equipment:

1. In the Tuning & testing dialog box click Adjust Tx RF level. This opens the Adjust Tx RF level dialog box.
2. Remove the remote equipment by disconnecting the coaxial cable from the RF LINE socket at the E5TH front panel.
3. Connect a 75 Ohm termination resistor or attenuator dimensioned for ≥ 50 W (ETL600-050) or ≥ 100 W (ETL600-100) to the RF LINE socket.
4. Click Start.
5. Measure the level at the RF LINE MONITOR socket on the E5TH front panel with a level meter having 75 or 50 Ohm input impedance.

Note: The tolerance of the level at the test socket RF LINE MONITOR is ± 0.2 dB. Thus, if the level meter has a tolerance of ± X dB, the resulting tolerance for the adjusted Tx level is ± (X + 0.2) dB.

Alternatively, measure the test tone level at the RF LINE socket via an attenuator required in order not to overdrive the input of the level meter. In this case, the tolerance of the attenuator must also be taken into account.

6. Adjust the value in the Tx RF level [dB] field, download it by clicking Start / Set and measure the test tone level again. Continue until the measurement corresponds to the permissible value displayed in the dialog box.

C.5.2 Adjust Tx alarm threshold level, if output power was modified

The Tx alarm level threshold is adjusted with the help of HMI600, the LED(s) TX-LVL-AL and the potentiometer(s) TX-LVL-AL ADJUST (R1805) in the rear of the backplane of the power amplifier(s) P1LP. In case of ETL600-100, there are two such potentiometers, one on each P1LP backplane, which both have to be tuned.

1. In the Tuning & testing dialog box, click Adjust Tx alarm level.
2. Click Activate Tx alarm level.
3. Turn the potentiometer(s) TX-LVL-AL ADJUST in the rear of the backplane(s) P1LP of the rack P7 LH, P7 LP or P7 LQ clockwise until the associated TX-LVL-AL LED(s) to the right of the potentiometer(s) go(es) on.
4. Check that the Tx ALARM LED(s) on E5TH – and in case of ETL600-100 also on E5TC – light(s). After the programmed delay time, the hardware alarm on the front plate of P4 LT/P4 LV/P4 LX appears. The relay contacts on the cable V9 OT Pin 2-3 are closed.
5. Turn the potentiometer(s) TX-LVL-AL ADJUST slowly anticlockwise until the TX-LVL-AL LED(s) go(es) off.
6. Click OK. The Alarm LED(s) go(es) off and the contacts open after the programmed delay.

Note: Exact measurement of the programmed delay times is not essential.

C.6 Receiver

C.6.1 Adjust Rx RF level

The Rx RF level is adjusted using the HMI600.

1. In the Tuning & testing dialog box click Adjust Rx RF level.
2. Follow the instructions given in the dialog box.

Note: It is really necessary to disconnect the RF line coaxial cable of the local equipment as well as to plug out the Rx filter P4RX!!!
Note: The number of adjustment steps depends on the presence of the Rx filter P4RX (configured with Configuration / System / Equipment settings / Modules in rack P7LH/P7LF).

Note: In case of a large frequency gap between Tx and Rx frequency bands:
- the rated level in the second adjustment step can be up to 40 dB higher than in the first adjustment step,
- the rated level in the second adjustment step can't be attained when the Rx pot reaches its stop position during adjustment.

Note: If in doubt about the effective line attenuation, enter the lowest possible attenuation.

Note: The increase of the receive level due to parallel PLC links can be calculated as follows:

$$G \, [dB] = 20 \cdot \log \left( 1 + \sum_{i=1}^{N} 10^{\frac{(P_i - P_0)}{20}} \cdot H(d_i) \right)$$

Each term of the summation is the contribution of one parallel PLC link and is given by

$$P_i = \text{PEP of the local transmitter of the i-th parallel link},$$

$$P_0 = \text{PEP of the local ETL600 transmitter},$$

$$H(d_i) = \begin{cases} 
\frac{2 \cdot K}{\sqrt{(1 - d_i^2 + K^2)^2 + 4 \cdot d_i^2}} & \text{for configurations with Rx-filter,} \\
\frac{2}{\sqrt{d_i^2 + 4}} & \text{for configurations without Rx-filter,}
\end{cases}$$

$$d_i = \left( \frac{f_i - f_0}{f_0 - f_l} \right) \cdot \frac{f_0}{1.5 \cdot B_0},$$

$$f_i = \begin{cases} 
\text{Lower edge frequency of the nominal Tx band of the local transmitter of the } \\
i\text{-th parallel link, if this band is above the frequency band of the local ETL600 receiver} \\
or \\
\text{Upper edge frequency of the nominal Tx band of the local transmitter of the } \\
i\text{-th parallel link, if this band is below the frequency band of the local ETL600 receiver,}
\end{cases}$$

$$f_0 = \begin{cases} 
\text{Center frequency of the Rx-filter of the local ETL600 terminal} \\
or \text{if no Rx-filter is used} \to \text{Center frequency of the Tx-filter of the local ETL600 terminal,}
\end{cases}$$

$$B_0 = \begin{cases} 
\text{Bandwidth of the Rx-filter of the local ETL600 terminal} \\
or \text{if no Rx-filter is used} \to \text{Bandwidth of the Tx-filter of the local ETL600 terminal,}
\end{cases}$$

$$K = 0.9.$$

3. After all adjustment steps have been executed, click Close to close the dialog box.
C.6.2 Connect RF cable and set alarm thresholds
Now connect the RF cable to the ETL600.
If the remote equipment is operational, set the alarm thresholds:

1. On the Equipment menu click Upload status.
2. On the Configuration menu click System... and then click the Alarm settings tab.
3. Click the button Calculate thresholds. This sets the alarms thresholds for pilot level, SNR level and the AGC blocking level of each configured APLC channel to the following values:
   - Pilot level alarm threshold: Actual pilot level – 12 dB
   - SNR alarm threshold: 12 dB
   - AGC blocking level: Actual pilot level – 16 dB
4. Close the dialog box by clicking OK.
5. On the Equipment menu click Download configuration.
6. Click Yes, OK and Yes in the following message boxes (default buttons).

C.6.3 Check link alarms
If the remote equipment is operational, the link alarm of the local equipment should be OFF in a few seconds.
Verify that the link alarm of the remote equipment is OFF as well. There are several ways to do that:
- Connect to the remote equipment with HMI600 and upload the status.
- Program one of the R1BC user alarms to the link alarm of the remote equipment and view this user alarm in the alarm status of the local equipment
- Activate alarm polling for the remote equipment.

C.6.4 Tune RF hybrid E5TH
The goal of hybrid tuning is to increase the trans-hybrid loss, thereby reducing the amount of signal from the local transmitter entering the local receiver. Tuning is done while the equipment is energized and connected to the line by setting the appropriate line balancing network jumpers for the hybrid on the E5TH board. These jumpers can be accessed by plugging the E5TH unit on the extender board P4EX.

Note: If no special requirements for trans-hybrid loss must be met, the default jumper settings for the line balancing network may be used:

Note: The trans-hybrid loss that has been achieved by tuning the hybrid is equal to the increase of the measured RF level when the RF cable is unplugged. If it is higher than 20 dB, the tuning can be considered as successful and may be terminated.

Procedure for tuning the hybrid:
1. Insert the PCB extender type P4EX in place of the E5TH module into the rack and plug E5TH on top of it.
2. Connect the artificial line to the RF LINE socket of the equipment.
3. Remove all line balancing jumpers R0 … R4, L0 … L17 and C0 … C17 on E5TH and set the potentiometer R1101 to mid position (indicated by 50).
4. In the Equipment menu of HMI600, click Tuning & testing. This opens the Tuning & testing dialog box.
5. Click Tune RF hybrid. This opens the Tune RF hybrid dialog box.
6. Click Start measurement and wait until the measured Rx RF level appears in the dialog box.
Note: It is possible that the operator phone of remote equipment is ringing during the measurement. This has no effect on the measurement.

HMI600 selectively measures the level of the RF signal from the own transmitter. In the following, this level is set to a minimum with the aid of the balancing network:
- resistance with one of the jumpers R0 ... R4 and the potentiometer R1101,
- inductance with one of the jumpers L0 ... L17,
- capacitance with one or several of the jumpers C1 to C17.

7. Reduce the measured Rx RF level by moving the R-jumper between R4, R3, R2, R1 and R0. When the best jumper position has been found, turn potentiometer R1101 until a first minimum is reached.

8. Search for a lower minimum by moving the L-jumper sequentially from L17 (largest inductance) to L1 (smallest inductance). L17 produces the smallest inductive current and L1 the largest. If jumper L17 does not produce any reduction, set jumper L0 which means no inductive current.
When the best jumper position for the inductance has been found, turn potentiometer R1101 until a minimum is reached.

Note: Only one L jumper (L0 to L17) may be inserted at any time

9. Search for a lower minimum by moving the C-jumper sequentially from C1 (smallest capacitance) to C17 (largest capacitance). More than one jumper may be inserted in parallel to increase the capacitance.
When the best jumper position for the capacitance has been found, turn potentiometer R1101 until a minimum is reached.

Click Stop measurement and Cancel to close the dialog box.

10. Remove the extender board P4EX and reinsert the E5TH module into the rack.

Note: If the coaxial cable (connection to the line) is removed or reconnected during the test, a rattling sound of a few seconds duration caused by the loop back relay on E5TH may occur. This happens only when E5TH is plugged on top of P4EX and has no influence on the performance.

Note: The transhybrid loss that has been achieved by tuning the hybrid is equal to the increase of the measured RF level when the RF cable is unplugged. If it is higher than 20 dB, the tuning can be considered as successful and may be terminated.

C.6.5 SNR pilot
1. In menu Equipment click Upload status.
2. Check signal to noise ratio (SNR) of the pilots of the configured APLC channels.

C.7 Equalization
Refer to 1KHW001494 ‘APLC Channel Equalization for ETL600’. The document is put into a short instruction, printed in the following chapters C.7.1 and C.7.2.

Note: The equalization routine can also be done at the remote equipment via EOC communication.

Note: If telephony is configured with a speech cut off frequency of 3400 Hz in any of the APLC channels, the equalizer must be enabled for each of these channels. When configuring the equalizer (dialog box Equipment / Commissioning and maintenance / Select equalizer), press the radio buttons Long and Amplitude equalization only.
C.7.1 Measure frequency response

It is assumed, that
- the RF tuning of the remote equipment is already finished. If it isn’t finished, tune the remote equipment.
- the link works and all alarms are cleared.

Measure the frequency response as described in 1KHW001494 ‘APLC Channel equalization for ETL600’:

1. Select Equipment / Commissioning and maintenance / Frequency response / APLC channel 1, APLC channel 2 or APLC channel 3, respectively.
2. In the following message box click OK and wait until measurement is done. The dialog box Select equalizer appears.

C.7.2 Select Equalizer

For each APLC channel, an equalizer can be selected under Equipment / Commissioning and maintenance / Select Equalizer / APLC channel 1, APLC channel 2 or APLC channel 3, respectively.

1. Select the new equalizer:
   In the field New equalizer, activate checkbox Amplitude response equalisation only.
2. External teleprotection equipment connected to ETL600 suffer from the additional delay introduced by the equalizer. To reduce this delay, select type None or Short in the frame New equalizer of the dialog box Select equalizer.
   If delay is uncritical, select type Middle or Long in the frame New equalizer of the dialog box Select equalizer.
3. View the amplitude response by clicking View. If the amplitude response is acceptable, go back to the Select equalizer dialog and select the viewed settings again. Download the new equalizer settings by clicking Download. The equipment is reset now.
4. Wait until the equipment has restarted. The new equalizer is active now.
5. Exit.

C.8 Testing of R1BC, if present

For testing the R1BC, refer to the client specific setting instructions. Depending upon the programmed criteria, activate the required alarms using the following table. Check the contact closure of the programmed relays on R1BC. Restore the link after this test is completed.

<table>
<thead>
<tr>
<th>Alarm on R1BC</th>
<th>Action to enforce the alarm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Warning LED on P4LT/V/X</td>
<td>Activate a testtone in the ‘Adjust Tx RF level’ dialog box</td>
</tr>
<tr>
<td>Link alarm</td>
<td>Disconnect the RF line coaxial cable</td>
</tr>
<tr>
<td>Hardware (HW) alarm</td>
<td>Unplug the RF hybrid.</td>
</tr>
<tr>
<td>Interface alarm, P4LT/V/X alarm</td>
<td>In case an external real time clock is configured and connected: Disconnect the clock input to P4LT/V/X.</td>
</tr>
<tr>
<td></td>
<td>In case no external real time clock is configured: Configure it (dialog box ‘Configuration / System / Channel settings / Event recorder: Ext. real time clock sync available’).</td>
</tr>
<tr>
<td>System alarm (i.e. cabinet alarm)</td>
<td>Enforce either Link alarm or HW alarm</td>
</tr>
</tbody>
</table>

C.9 Configure Real Time Clock (RTC)

The real time clock has to be set to the actual date and time for proper operation of the event recorder.
C.9.1 Setting real time clock

Setting the date and time using HMI600:

1. Open the menu Equipment / Commissioning and maintenance / Eventrecorder / Set Clock.
2. In the Real Time Clock (RTC) dialog box, check if PC time and PC date are correct.
3. Click Download date/time to RTC
   This sets the RTC to the given date and time.
4. Click Upload date/time from RTC
   The date and time displayed at Read RTC date & time part of the Real Time Clock (RTC) box should be correct.
5. Click Cancel

C.9.2 Test external real time clock synchronization, if available

The external clock source with IRIG-B format has to be connected to the IRIG-B port at the frontplate of P4LT/V/X via external cable V9OV.

Testing the external synchronization using HMI600:

1. Set the time on the PC a few hours back/forward
2. On the Equipment menu point to Commissioning and maintenance menu point to Eventrecorder and click Set Clock.
3. Click Download date/time to RTC. This sets the RTC to the wrong time.
4. Click Upload date/time from RTC. The date and time displayed in the frame Read RTC date & time should be correct and not correspond to the PC-date/time setting.
5. Click Cancel.
6. Set the time on the PC back to the correct time

C.10 Testing of NSD600 with interface G4AI, if present

Designations and abbreviations used:

<table>
<thead>
<tr>
<th>Designation</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>(T.02/.1)</td>
<td>Connector 1 of terminal block connected to rack position N02</td>
</tr>
</tbody>
</table>

The NSD600 transmission time is tested by sending a loop test over the link.
NSD600 with interfaces G4AI is tested by applying test commands at the G4AI inputs and measuring these test commands at the G4AI outputs.

To get back the input commands at the outputs of the local equipment, a local loop is necessary. The local loop can be established according to chapter C.1.

Make a printout of the actual configuration of the equipment using HMI600 and test all G4AI inputs and outputs.

C.10.1 Loop test transmission time over power line

The NSD600 loop test transmission time is checked using HMI600.

1. In the dialog box Commissioning and maintenance, click NSD600 send loop test / TPE1 and – if TPE2 is configured – NSD600 send loop test / TPE2.
   If the loop test is successful, a dialog box indicating half of the loop test time ($T_{Link}$), e.g. the one-way transmission time, appears.
7. Click OK to close the dialog box.

Note: Transmission times of twice the nominal transmission time as given in the technical data shall serve as a guideline for the upper limit.
C.10.2 Command transmission time
Check the transmission time of the NSD600 commands with the equipment operating via local loop. The local loop can be established according to chapter C.1.

How to activate an input command depends on the jumper settings on G4AI.
- G4AI input programmed as ‘contact and battery voltage’:
  Inject a signal at input port with the voltage level U1 according to the jumper settings on G4AI (24VDC, 48VDC, 110VDC, 220VDC)
- G4AI input programmed as ‘contact only’:
  Short circuit the input port

Transmit at few commands with a command / pause duration of about 100ms / 1000ms and measure the nominal transmission time \(T_{\text{nominal}}\) of the local looped command.

- Note: The measured transmission time \(T_{\text{nominal}}\) does not include the channel delay.
- Note: The nominal transmission time as given in the instruction manual shall serve as a guideline for the mean value of several commands.

Get the link to normal operation as described in chapter C.1.

C.10.3 Reset counters
After NSD600 testing is done, reset the counters by using HMI600.
1. Open the dialog Equipment / Commissioning and maintenance / Eventrecorder / Reset counter.
2. In the Reset Counter box, click the check box Reset all counters.
3. Click OK.

C.11 Testing of O4LE, if present
The AF interface O4LE is tested by applying a test signal at the input ports and measure this signal at the output ports. To get the input signals at the local output ports a local loop is necessary. The local loop is established according to chapter C.1.

Make a printout of the actual configuration of the equipment using HMI600 and test all ports, which are not in the off state.

C.11.1 Service phone
The following test must be done if the ‘Service phone’ is enabled.
Get the equipment in local loop operation according to chapter C.1. The service phone cannot be tested completely in the local loop mode.
1. Pick up the phone and speak. You should hear yourself clearly. If a feedback tone occurs, you should increase the input level and/or decrease the output level of the service phone in the configuration.

C.11.2 Hot line direct telephone
The following tests must be done if the operation mode ‘Hot line direct telephone’ is configured. Get the equipment in local loop operation according to chapter C.1. This operation mode cannot be tested completely in the local loop mode.
1. Measure the voltage at open loop condition. Disconnect the phone for this measurement.
2. Check audibility of phone:
   If the chosen phone is available, test the audibility:
   Pick up the phone and speak. You should hear yourself clearly. If a feedback tone occurs, you should increase the difference between input level and output level of the ‘subscriber, direct phone’ in the configuration.
C.11.3 ‘Remote subscriber’

The following tests must be done if the operation mode ‘Remote subscriber’ is configured.

Get the equipment in local loop operation according to chapter C.1. This operation mode cannot be tested completely in the local loop mode.

1. Measure the voltage at open loop condition:
   Disconnect phone and take the measurement.

2. Check audibility of phone:
   If the chosen phone is available, test the audibility:
   Pick up the phone and speak. You should hear yourself clearly. If a feedback tone occurs, you should increase the difference between input level and output level of the ‘subscriber, direct phone’ in the configuration.

C.11.4 Pax 2-wire

The following test must be done if the operation mode ‘Pax 2-wire’ is configured.

Get the equipment in local loop operation according to chapter C.1. Relevant AF measurements cannot be achieved at the 2-wire interfaces in the local loop mode.

1. Check PAX-BLOCKING relay. In normal operation or local loop mode contacts at terminal, telephony, 6b-7a should be closed and contacts at 6a-6b should be open.
   Interrupt local loop according to chapter C.1, after the programmed delay time the link alarm occurs. Now contacts at terminal, telephony, 6b-7a should be open and contacts 6a-6b should be closed.

2. Restore local loop.

C.11.5 Pax 4-wire

The following tests must be done if the operation mode ‘Pax 4-wire’ is configured.

Get the equipment in local loop operation according to chapter C.1.

1. Toggling the M-WIRE input, E-WIRE output should toggle simultaneously.
   Note, E-WIRE is a switching contact without inherent voltage source and without polarity.
   Activate M-WIRE. If M-WIRE is configured as ‘inverted’, E-WIRE contact at the cable terminals must be opened, otherwise closed.

2. Feed an 800 Hz tone, with the configured input level into AF1-IN. Take a measurement of the output level at AF1-OUT. It should be in 1 dB range of the configured output level.

3. Check PAX-BLOCKING relay. In normal operation contacts at terminal, telephony, 6b-7a should be closed and contacts 6a-6b should be open.
   Interrupt local loop according to chapter C.1, after the programmed delay time the link alarm occurs. Now contacts at terminal, telephony, 6b-7a should be open and contacts 6a-6b should be closed.

C.11.6 Pax 4/2-wire

The following tests must be done if the operation mode ‘Pax 4/2wire’ is configured.

Get the equipment in local loop operation according to chapter C.1.

1. Toggling the M-WIRE input, E-WIRE output should toggle simultaneously.
   Note, E-WIRE is a switching contact without inherent voltage source and without polarity.
   Activate M-WIRE. If M-WIRE is configured as ‘inverted’, E-WIRE contact at the cable terminals must be opened, otherwise closed.
   Note: It is assumed, that LOCAL/TRANSIT is deactivated.

2. Feed a 800 Hz tone with the configured input level into AF1-IN.

3. Take a measurement of the output level at AF1-OUT of the local equipment. It should be in 1 dB range of the configured output level from the local equipment.

4. Take a measurement of the output level at P2W-OUT of the local equipment. It should be in 1 dB range of the configured output level from the local equipment.

5. Activate LOCAL/TRANSIT equipment. If LOCAL/TRANSIT is configured as ‘inverted’, contacts at terminal, telephony, 5a-4b must be opened, otherwise closed.

6. Feed again a 800 Hz tone, with the configured input level into AF1-IN.
7. Take a measurement of the output level at AF1-OUT of the local equipment. Level of AF1-OUT should be 40 dB below of the configured output level from the local equipment.

8. Check PAX-BLOCKING relay. In normal operation contacts at terminal, telephony, 6b-7a should be closed and contacts at 6a-6b should be open. Interrupt local loop according to chapter C.1. after the programmed delay time the link alarm occurs. Now contacts at terminal, telephony, 6b-7a should be open and contacts at 6a-6b should be closed.

C.11.7 Transit mode for E&M wire

The following test must be done if the operation mode ‘Transit mode for E&M wire’ is configured at the local equipment. Get the equipment in local loop operation according to chapter C.1.

1. Toggling the M-WIRE input, E-WIRE output should toggle simultaneously.
   Note, E-WIRE is a switching contact without inherent voltage source and without polarity.

C.11.8 Testing the teleoperation ports

For testing the teleoperation ports, first nominal signal levels must be fed into the teleoperation input port with a level generator. The output level at the other side of the link must then be measured and compared to the nominal output level. An example of a equipment configuration is given below.

Get the equipment in local loop operation according to chapter C.1.

1. The Reference signal level input, listed in the configuration printout should be fed into AFx-IN.
2. The Reference signal level output of AFx-OUT, listed in the configuration printout is the expected output level.
3. Take the measurement with a selective level meter.

Example:

Applying above method to the configuration given below, a sinus with –9.0 dBm is fed into AFx-IN. The tone is expected with –9.0 dBm at AFx-OUT of local equipment.

<table>
<thead>
<tr>
<th>Equipment:</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>TELEOPERATION</td>
<td></td>
</tr>
<tr>
<td>Port AFx:</td>
<td>Disconnectable at CH1</td>
</tr>
<tr>
<td>Squelch:</td>
<td>Disabled</td>
</tr>
<tr>
<td>Reference signal:</td>
<td>600 Bd FSK</td>
</tr>
<tr>
<td>Reference signal level input:</td>
<td>-9.00 dBm (RMS)</td>
</tr>
<tr>
<td>Reference signal level output:</td>
<td>-9.00 dBm (RMS)</td>
</tr>
<tr>
<td>Weight of port:</td>
<td>0.71</td>
</tr>
<tr>
<td>Max. output level:</td>
<td>4.34 dBm (PEP)</td>
</tr>
<tr>
<td>Relative input level:</td>
<td>-4.0 dBr</td>
</tr>
<tr>
<td>Relative output level:</td>
<td>-4.0 dBr</td>
</tr>
<tr>
<td>Input filter:</td>
<td>None</td>
</tr>
<tr>
<td>Output filter:</td>
<td>None</td>
</tr>
</tbody>
</table>

C.11.9 Teleoperation port AF1

Omit this step is the port AF1 is used for telephony.

If the port is switched to ‘On - disconnectable’ or ‘On - non disconnectable’, take the measurement, described in C.11.8.

C.11.10 Teleoperation port AF2

If the port is switched to ‘On - disconnectable’ or ‘On - non disconnectable’, take the measurement, described in C.11.8.

C.11.11 Teleoperation port AF3

If the port is switched to ‘On - disconnectable’ or ‘On - non disconnectable’, take the measurement, described in C.11.8.
C.11.12 Teleoperation port AF4
If the port is switched to 'On - disconnectable' or 'On - non disconnectable', take the measurement, described in C.11.8.

C.11.13 Teleoperation AF4 used for ext. Teleprotection
After measurement C.11.12 is done.
1. Recalculate expected output level of AF4-OUT by adding the NSD70 boost value, shown in the configuration printout.
2. Activate the EXT-BOOST input. If EXT-BOOST is configured as 'inverted', contacts at terminal, teleoperation, 9a-9b must be opened, otherwise closed.
3. Take the measurement at AF4-OUT.

C.12 V.11 ports
The V.11 ports are tested on correct settings and bit errors using data test equipment.
1. Check the port settings in the configuration (Configuration / Data port to modem assignment) and use the same settings in the test equipment.
2. Connect data testers to corresponding ports on both the local and remote ETL600 equipment. If there is only one data tester available, the digital data stream has to be looped on the remote equipment.
3. Perform a BER test (recommended number of bits to transmit: ≥ 10^6).

C.12.1 V.11 Port 1
If used, perform a BER test as described above.

C.12.2 V.11 Port 2
If used, perform a BER test as described above.

C.13 V.24 ports
The V.24 ports are tested on correct settings and bit errors using data test equipment.
1. Check the port settings in the configuration (Configuration / Data port to modem assignment) and use the same settings in the test equipment.
2. Connect data testers to corresponding ports on both the local and remote ETL600 equipment. If there is only one data tester available, the digital data stream has to be looped on the remote equipment.
3. Perform a BER test (recommended number of bits to transmit: ≥ 10^6).

C.13.1 V.24 Port 1
If used, perform a BER test as described above.

C.13.2 V.24 Port 2
If used, perform a BER test as described above.

C.13.3 V.24 Port 3
If used, perform a BER test as described above.

C.13.4 V.24 Port 4
If used, perform a BER test as described above.
C.14 Testing of the LAN ports
For the applications bridging and routing, the LAN port 1 is tested for bit errors using Ethernet test equipment.

1. Connect the Ethernet tester to LAN port 1 of the local and to the associated LAN port of the remote ETL600 equipment.
2. Perform a throughput and errored frame test during the required time. The recommended number of frames to transmit is $10^4$.

Pinging can be used as a quick test:
- Both the local and the remote LAN600 can be pinged.

C.14.1 LAN port 1
If used, perform a BER test as described above.

C.14.2 LAN port 2
If used, perform a BER test as described above.

C.14.3 LAN port 3
If used, perform a BER test as described above.

C.14.4 LAN port 4
If used, perform a BER test as described above.

C.14.5 HMI over LAN
For the application HMI over LAN, test if HMI600 can be connected to the LAN port used for HMI over LAN access of the ETL600 terminal.

C.15 Testing of O4CV, if present

C.15.1 Slot positions of O4CV boards
Refer to the configuration view of HMI600 for the O4CV slot positions.

C.15.2 Service phone
The following test must be done if the ‘Service phone’ is enabled.
Get the equipment in local loop operation according to chapter C.1. The service phone cannot be tested completely in the local loop mode.

1. Pick up the phone and speak. You should hear yourself clearly. If a feedback tone occurs, you should increase the input level and/or decrease the output level of the service phone in the configuration.

C.15.3 Hot line direct phone
The following tests must be done if the operation mode ‘Hot line direct phone’ is configured. Get the equipment in local loop operation according to chapter C.1. This operation mode cannot be tested completely in the local loop mode.

1. Measure the voltage at open loop condition. Disconnect the phone for this measurement.
2. Check audibility of phone:
   If the chosen phone is available, test the audibility: Pick up the phone and speak. You should hear yourself clearly. If a feedback tone or excessive echo occurs, you should increase the difference between input level and output level in the configuration of the 2-wire interface.

C.15.4 Remote subscriber
The following tests must be done if the operation mode ‘Remote subscriber’ is configured. Get the equipment in local loop operation according to chapter C.1. This operation mode cannot be tested completely in the local loop mode.
1. Measure the voltage at open loop condition. Disconnect the phone for this measurement.

2. Check audibility of phone:
   If the chosen phone is available, test the audibility: Pick up the phone and speak. You should hear yourself clearly. If a feedback tone or excessive echo occurs, you should increase the difference between input level and output level in the configuration of the 2-wire interface.

C.15.5 Pax 2-wire
This operation mode cannot be tested in the local loop mode.

C.15.6 Pax 4-wire
The following tests must be done if the operation mode ‘Pax 4-wire’ is configured. Get the equipment in local loop operation according to chapter C.1.

1. Toggling the M-WIRE input, E-WIRE output should toggle simultaneously.
   Note: E-WIRE is a switching contact without inherent voltage source and without polarity.
   Activate M-WIRE. If M-WIRE is configured as ‘inverted’, E-wire contacts at the cable terminals must be opened, otherwise closed.

2. Feed an 800 Hz tone with the configured input level into the 4-wire input. Take a measurement of the output level at the 4-wire output. It should be in ±5 dB range of the configured output level.

C.16 Manual reset
Reset ETL600 with HMI600 (Equipment / Reset) or by switching off and on the power and wait until all alarms disappear.

C.17 Documentation
After the testing is complete, take a printout of the configuration and status data.

1. Click the green Upload arrow in the toolbar with the left mouse button. This starts the upload configuration and upload status from the equipment. The status is displayed in the window.

2. From the File menu, click Print. This prints the status data.

3. From the View menu, click Display configuration.

4. From the File menu, click Print.

Save the 'et6' file on a disk with the Serial No. of ETL coded in the file name. e.g. HE400327C0.et6.
COMMISSIONING REPORT

Powerline Carrier Equipment: Series ETL600R4

Project : ........................................

ABB Order N° : ........................................

Station : ........................................

Link : ........................................

Equipment N° : ........................................

Frequency :  Tx = ..........kHz           Rx = ..........kHz

Direction : ........................................

Commissioning Report contains

ETL600             System Test Report                         Pages  C1 to C15
HMI600             Printout of Configuration                  Pages ..............
HMI600             Printout of Status                           Pages ..............
Test ETL600        List of used Test-instruments              Pages ..............
................................................. ........................................ Pages ..............

The tuning of the equipment is in accordance with the following instructions:

Programming and Testing of ETL600R4                          1KHW002609-EN
Compatibility Requirements for ETL600                          1KHW001490-EN
Tuning of ETL600R4 Rx RF Filter P4RX                          1KHW002584-EN
Tuning of ETL600R4 Tx RF Filter on E5TH and E5TC              1KHW002585-EN
APLC Channel Equalization for ETL600                          1KHW001494-EN
Firmware Download for ETL600R4                               1KHW002589-EN
Technical Data ETL600R4                                       1KHW002590-EN

ABB Switzerland Ltd

Doc. no.  1KHW002587          Lang.  en          Rev. ind.  A          Page  C1
SAFETY INSTRUCTIONS

Please refer to chapter 2 of ETL600R4 instruction manual 1KHW002582.

Designations and abbreviations used:

<table>
<thead>
<tr>
<th>Designation</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>_______</td>
<td>Measured value</td>
</tr>
<tr>
<td>[  ...  ]</td>
<td>Programmed value</td>
</tr>
<tr>
<td>[  ] D</td>
<td>Preferred setting (default)</td>
</tr>
<tr>
<td>[  X  ]</td>
<td>Test passed or jumper is set</td>
</tr>
<tr>
<td>[  ]</td>
<td>Not tested or jumper is not set</td>
</tr>
<tr>
<td>B5LA</td>
<td>Module type</td>
</tr>
<tr>
<td>BER</td>
<td>Bit Error Ratio</td>
</tr>
<tr>
<td>Def.</td>
<td>Default value</td>
</tr>
<tr>
<td>equ.</td>
<td>Equipment</td>
</tr>
<tr>
<td>f_o</td>
<td>Lower frequency, usually meant as low cut-off frequency</td>
</tr>
<tr>
<td>LED</td>
<td>Light Emitting Diode found on the front panel</td>
</tr>
<tr>
<td>HM1600</td>
<td>User Interface Program for ETL600 running on a PC</td>
</tr>
<tr>
<td>N02, N08</td>
<td>Position in rack. Slot number N02, N08</td>
</tr>
<tr>
<td>Rx</td>
<td>Receiver</td>
</tr>
<tr>
<td>Tx</td>
<td>Transmitter</td>
</tr>
<tr>
<td>PC</td>
<td>Personal Computer</td>
</tr>
<tr>
<td>(T.02/..1)</td>
<td>Connector 1 of terminal block connected to board at rack position N02</td>
</tr>
</tbody>
</table>
## REVISION

<table>
<thead>
<tr>
<th>Rev. ind.</th>
<th>Page (p.) Chapter (c.)</th>
<th>Description</th>
<th>Date Dept./Init.</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>c. C.2</td>
<td>Measurement at MCB</td>
<td>2012-05-15 / Be</td>
</tr>
</tbody>
</table>

### Notes:

_________________________________________________________________________________________________________________________________________
________________________________________________________________________________________________________________________________________________________________________________________________
__________________________________________________________________________________________________________________________________________________________________________________________________

Sign Commissioning Eng.: ___________________________  Sign Witness Eng.: ___________________________
<table>
<thead>
<tr>
<th>Test No.</th>
<th>Test procedure</th>
<th>Test point</th>
<th>Permissible value</th>
<th>Units</th>
<th>Test result</th>
</tr>
</thead>
<tbody>
<tr>
<td>C.1.</td>
<td>General</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C.1.1</td>
<td>Checking the line of communication</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Line attenuation</td>
<td>P7LH, P7LP, P7LQ</td>
<td>PE wired</td>
<td>dB</td>
<td>[ ]</td>
</tr>
<tr>
<td></td>
<td>Return loss $A_r$</td>
<td>return loss $A_r$</td>
<td>P7LH, P7LP, P7LQ</td>
<td>dB</td>
<td>[ ]</td>
</tr>
<tr>
<td>C.1.2</td>
<td>Visual checks</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Proper wiring of protective earth</td>
<td>P7LH, P7LP, P7LQ</td>
<td>PE wired</td>
<td>[ ]</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Cubicle PE wired</td>
<td>Cubicle</td>
<td>PE wired</td>
<td>[ ]</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Proper wiring of power supply</td>
<td>P7LH, P7LP, P7LQ</td>
<td>polarity ok</td>
<td>[ ]</td>
<td></td>
</tr>
<tr>
<td></td>
<td>If the positive pole (+) of the battery is grounded, place an earth jumper to the positive pole (+) of the cubicle supply</td>
<td>Cubicle supply terminals</td>
<td>[ ]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>C.2.</td>
<td>Check power supply B5LD</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C.2.1</td>
<td>Battery supply 48V DC</td>
<td>MCB</td>
<td>46 to –56 V DC</td>
<td>[ ]</td>
<td>[ ]</td>
</tr>
<tr>
<td>C.2.2</td>
<td>Ripple on 48V DC</td>
<td>MCB</td>
<td>&lt; 1 V rms</td>
<td>[ ]</td>
<td>[ ]</td>
</tr>
<tr>
<td>C.2.3</td>
<td>Green LED</td>
<td>B5LD front panel</td>
<td>Lit</td>
<td>[ ]</td>
<td>[ ]</td>
</tr>
<tr>
<td>C.3.</td>
<td>Upload configuration</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C.4.</td>
<td>Change configuration, if necessary</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C.4.1</td>
<td>Reducing output power, if necessary</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Determine $A_{r \min} = \text{minimal value of } A_r$ as measured in C.1.1</td>
<td></td>
<td>$A_{r \min}$</td>
<td>dB</td>
<td>[ ]</td>
</tr>
<tr>
<td></td>
<td>Calculate output power reduction $A_{red}$:</td>
<td></td>
<td>$A_{red}$</td>
<td>dB</td>
<td>[ ]</td>
</tr>
<tr>
<td></td>
<td>No reduction, if $A_{r \min} \geq 12 \text{ dB}$:</td>
<td></td>
<td>$A_{red} = \max(0, (3 - A_{r \min} / 4))$</td>
<td>[ ]</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Decrease Max. power PEP by $A_{red}$</td>
<td>HMI600:</td>
<td>Configuration / System / Channel settings / Max. power (PEP)</td>
<td>[ ]</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Store configuration to flash</td>
<td>HMI600: Equipment / Store configuration to FLASH</td>
<td>[ ]</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Notes:

Sign Commissioning Eng.: [Sign Commissioning Eng.]
Sign Witness Eng.: [Sign Witness Eng.]
### Test Procedure

#### C.5. Transmitter

<table>
<thead>
<tr>
<th>Test No.</th>
<th>Test procedure</th>
</tr>
</thead>
<tbody>
<tr>
<td>C.5.1</td>
<td><strong>Adjust Tx RF level</strong></td>
</tr>
<tr>
<td></td>
<td>Dialog box: Adjust Tx RF level: Click Select and then Start</td>
</tr>
<tr>
<td></td>
<td>Mark if the Tx level is not measured</td>
</tr>
<tr>
<td></td>
<td>Measured Tx level is within tolerance RF LINE MONITOR or RF LINE socket at E5TH front panel</td>
</tr>
<tr>
<td></td>
<td>Permissible range indicated in dialog box</td>
</tr>
<tr>
<td>C.5.2</td>
<td><strong>Adjust Tx alarm level</strong></td>
</tr>
<tr>
<td></td>
<td>Dialog box: Adjust Tx alarm level</td>
</tr>
<tr>
<td></td>
<td>Follow the instructions given in the dialog box</td>
</tr>
<tr>
<td></td>
<td>Tx ALARM indication: E5TH and - in case of ETL600-100 – E5TC LED(s) to be ON</td>
</tr>
<tr>
<td></td>
<td>State of HW alarm relay after programmed delay: Pins 2-3 of V9OT cable Closed</td>
</tr>
<tr>
<td></td>
<td>Turn 3 potentiometer(s) TX-LVL-AL ADJUST on P1LP till TX-LVL-AL LED(s) go(es) off.</td>
</tr>
<tr>
<td></td>
<td>Tx alarm indication: E5TH and - in case of ETL600-100 – E5TC LED(s) to be OFF</td>
</tr>
<tr>
<td></td>
<td>State of HW alarm relay after programmed delay: Pins 2-3 of V9OT cable Open</td>
</tr>
</tbody>
</table>

#### C.6. Receiver

<table>
<thead>
<tr>
<th>Test No.</th>
<th>Test procedure</th>
</tr>
</thead>
<tbody>
<tr>
<td>C.6.1</td>
<td><strong>Adjust Rx RF level</strong></td>
</tr>
<tr>
<td></td>
<td>Menu: Equipment Commissioning and maintenance, dialog box: Adjust Rx RF level</td>
</tr>
<tr>
<td></td>
<td>Follow the instructions in the dialog box</td>
</tr>
<tr>
<td></td>
<td>Line attenuation: Dialog box __________ dB</td>
</tr>
<tr>
<td></td>
<td>Increase of receive level (due to parallel PLC links): Dialog box __________ dB</td>
</tr>
<tr>
<td></td>
<td>Adjustment performed</td>
</tr>
<tr>
<td>C.6.2</td>
<td><strong>Connect RF cable and set alarm thresholds</strong></td>
</tr>
<tr>
<td></td>
<td>Alarm thresholds set (Menu: Configuration / System / Alarm settings): Dialog box</td>
</tr>
</tbody>
</table>

---

1 If the remote equipment is operational

### Notes:

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Sign Commissioning Eng.: [Signature]

Sign Witness Eng.: [Signature]
## Commissioning Report ETL600R4

### Equipment HE

<table>
<thead>
<tr>
<th>Test No.</th>
<th>Test procedure</th>
<th>Test point</th>
<th>Permissible value</th>
<th>Units</th>
<th>Test result</th>
</tr>
</thead>
<tbody>
<tr>
<td>C.6.3</td>
<td>Check link alarms</td>
<td>Alarm status of the local equipment</td>
<td>No local link alarm</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Alarm status of the remote equipment</td>
<td>No remote link alarm</td>
<td></td>
<td></td>
</tr>
<tr>
<td>C.6.4</td>
<td>Tune hybrid on E5TH</td>
<td>Dialog box</td>
<td>Till minimum is read by HMI.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>C.6.5</td>
<td>SNR pilot</td>
<td>Upload status data of local equipment</td>
<td>HMI600</td>
<td>&gt; 15</td>
<td>dB</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SNR pilot</td>
<td>HMI600</td>
<td>&gt; 15</td>
<td>dB</td>
</tr>
<tr>
<td>C.7.1</td>
<td>Measure frequency response</td>
<td>In menu Equipment / Commissioning and maintenance / Frequency response / APLC channel 1, APLC channel 2 or APLC channel 3</td>
<td>HMI600</td>
<td></td>
<td></td>
</tr>
<tr>
<td>C.7.2</td>
<td>Select Equalizer</td>
<td>In menu Equipment / Commissioning and maintenance / Select equalizer / APLC channel 1, APLC channel 2 or APLC channel 3</td>
<td>HMI600</td>
<td></td>
<td></td>
</tr>
<tr>
<td>C.8.</td>
<td>R1BC, if present</td>
<td>Mark if not configured:</td>
<td>Corr. N/C contacts on R1BC.</td>
<td>Closed</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>HMI600</td>
<td>Corresponding N/C contacts on R1BC.</td>
<td>Open</td>
<td></td>
</tr>
<tr>
<td>C.9.</td>
<td>Configure Real time Clock (RTC)</td>
<td>Menu: Equipment, Commissioning and maintenance, Eventrecorder, Set clock</td>
<td>Dialog box</td>
<td>Actual time and date</td>
<td></td>
</tr>
</tbody>
</table>

### Notes:

- ..............................................................................................................................................................
- ..............................................................................................................................................................
- ..............................................................................................................................................................

**Sign Commissioning Eng.:**  
**Sign Witness Eng.:**
### Test No. C.9.2
**Test external real time clock synchronization, if available**

Menu: Equipment, Commissioning and maintenance, Eventrecorder, Set clock

<table>
<thead>
<tr>
<th>Test point</th>
<th>Permissible value</th>
<th>Units</th>
<th>Test result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Download date/time to RTC Dialog box</td>
<td>Wrong time</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Upload date/time from RTC Dialog box</td>
<td>Correct time</td>
<td></td>
<td>[ ]</td>
</tr>
</tbody>
</table>

### Test No. C.10.1
**NSD600 loop test**

Check Actual transmission time $T_{\text{link}}$

Menu: Equipment, Commissioning and maintenance, NSD600 send loop test

<table>
<thead>
<tr>
<th>Test point</th>
<th>Permissible value</th>
<th>Units</th>
<th>Test result</th>
</tr>
</thead>
<tbody>
<tr>
<td>HMI600</td>
<td>$&lt; 2 \times T_0$</td>
<td>ms</td>
<td></td>
</tr>
</tbody>
</table>

### Test No. C.10.2
**Command transmission time**

Command A

- Mark if not configured:
- Terminal: $(T71/1) - (T71/2)$ [ ]
- $(T\ldots/\ldots) - (T\ldots/\ldots)$ [ ]
- $(T71/9) - (T71/10)$ [ ]
- $(T\ldots/\ldots) - (T\ldots/\ldots)$ [ ]
- Refer HMI600
- Mean value $\leq T_0$
- $ms$ [ ]
- [ ] [ ]

Command B

- Mark if not configured:
- Terminal: $(T71/3) - (T71/4)$ [ ]
- $(T\ldots/\ldots) - (T\ldots/\ldots)$ [ ]
- $(T71/11) - (T71/12)$ [ ]
- $(T\ldots/\ldots) - (T\ldots/\ldots)$ [ ]
- Refer HMI600
- Mean value $\leq T_0$
- $ms$ [ ]
- [ ] [ ]

Command C

- Mark if not configured:
- Terminal: $(T71/5) - (T71/6)$ [ ]
- $(T\ldots/\ldots) - (T\ldots/\ldots)$ [ ]
- $(T71/13) - (T71/14)$ [ ]
- $(T\ldots/\ldots) - (T\ldots/\ldots)$ [ ]
- Refer HMI600
- Mean value $\leq T_0$
- $ms$ [ ]
- [ ] [ ]

**Notes:**

------------------------------------------------------------------------------------------------------------------

Sign Commissioning Eng.: [ ]
Sign Witness Eng.: [ ]

------------------------------------------------------------------------------------------------------------------
### Test Results

<table>
<thead>
<tr>
<th>Test No.</th>
<th>Test procedure</th>
<th>Test point</th>
<th>Permissible value</th>
<th>Units</th>
<th>Test result</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Command D</td>
<td>Mark if not configured:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Tx command D</td>
<td>(T71/7) – (T71/8)</td>
<td>Mean value</td>
<td>ms</td>
<td>TPE1 [ ]</td>
</tr>
<tr>
<td></td>
<td>Rx command D</td>
<td>(T71/15) – (T71/16)</td>
<td>≤ T0</td>
<td></td>
<td>TPE2 [ ]</td>
</tr>
<tr>
<td>C.10.3</td>
<td>Reset counters</td>
<td>Mark if not configured:</td>
<td></td>
<td></td>
<td>[ ]</td>
</tr>
<tr>
<td></td>
<td>Menu: Equipment, Commissioning and maintenance, Eventrecorder, Reset counter, OK:</td>
<td>HMI600</td>
<td>All counters = 0</td>
<td></td>
<td>[ ]</td>
</tr>
<tr>
<td>C.11.1</td>
<td>Service Phone.</td>
<td>Mark if not configured:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Pick up the phone and talk.</td>
<td>Service phone, at front panel</td>
<td>Own voice is audible without feedback or excessive echo</td>
<td></td>
<td>[ ]</td>
</tr>
<tr>
<td>C.11.2</td>
<td>Hot line direct phone</td>
<td>Mark if not configured:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Measure voltage at open loop condition</td>
<td>43 V … 52 V V DC</td>
<td>N02/N24:</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Pick up the phone and talk</td>
<td>Direct telephone</td>
<td>Own voice is audible without feedback or excessive echo</td>
<td></td>
<td>[ ]</td>
</tr>
<tr>
<td>C.11.3</td>
<td>Remote subscriber</td>
<td>Mark if not configured:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Measure voltage at open loop condition</td>
<td>43 V … 52 V V DC</td>
<td>N02/N24:</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Pick up the phone and talk</td>
<td>Subscriber telephone</td>
<td>Own voice is audible without feedback or excessive echo</td>
<td></td>
<td>[ ]</td>
</tr>
</tbody>
</table>
### Test C.11.4 Pax 2-wire

<table>
<thead>
<tr>
<th>Mark if not configured:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Measure at terminal telephony 6a-6b, 6b-7a</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Permissible value</th>
</tr>
</thead>
<tbody>
<tr>
<td>6a-6b is open</td>
</tr>
<tr>
<td>6b-7a is closed</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>N02</td>
</tr>
<tr>
<td>N08</td>
</tr>
<tr>
<td>N14</td>
</tr>
<tr>
<td>N24</td>
</tr>
<tr>
<td>N30</td>
</tr>
<tr>
<td>N48</td>
</tr>
</tbody>
</table>

### Test C.11.5 Pax 4-wire

<table>
<thead>
<tr>
<th>Mark if not configured:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Terminal telephony 3a-3b</td>
</tr>
</tbody>
</table>

| Test E-Wire: |
| Close and open M-wire at terminal telephony 4a-4b |
| Measure Output level. |
| Feed 800 Hz with configured input level of Pax (Default: -3.5 dBm). (Activate at terminal telephony 4a-4b) |

<table>
<thead>
<tr>
<th>PAX-BLOCKING normal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Measure at terminal telephony 6a-6b, 6b-7a</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Permissible value</th>
</tr>
</thead>
<tbody>
<tr>
<td>6a-6b is open</td>
</tr>
<tr>
<td>6b-7a is closed</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>N02</td>
</tr>
<tr>
<td>N08</td>
</tr>
<tr>
<td>N14</td>
</tr>
<tr>
<td>N24</td>
</tr>
<tr>
<td>N30</td>
</tr>
<tr>
<td>N48</td>
</tr>
</tbody>
</table>

### Test C.11.6 Pax 4/2-wire

<table>
<thead>
<tr>
<th>Mark if not configured:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Terminal telephony 3a-3b</td>
</tr>
</tbody>
</table>

| Test E-Wire: |
| Close and open M-wire at terminal telephony 4a-4b |
| Measure Output level at AF1. |
| Feed 800 Hz with configured input level (Def.: -3.5 dBm). (Activate at terminal telephony 4a-4b) |

<table>
<thead>
<tr>
<th>PAX-BLOCKING normal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Measure at terminal telephony 6a-6b, 6b-7a</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Permissible value</th>
</tr>
</thead>
<tbody>
<tr>
<td>6a-6b is open</td>
</tr>
<tr>
<td>6b-7a is closed</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>N02</td>
</tr>
<tr>
<td>N08</td>
</tr>
<tr>
<td>N14</td>
</tr>
<tr>
<td>N24</td>
</tr>
<tr>
<td>N30</td>
</tr>
<tr>
<td>N48</td>
</tr>
</tbody>
</table>

### Notes:

- Test results are recorded in the space provided.
- The test results are documented for each test point.
- The permissible values are specified for each test point.
- Units are noted for each test result.

---

Sign Commissioning Eng.: 
Sign Witness Eng.:
### Test Report

**Test No.**

<table>
<thead>
<tr>
<th>Test procedure</th>
<th>Test point</th>
<th>Permissible value</th>
<th>Units</th>
<th>Test result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test Local/Transit:</td>
<td>Feed into terminal telephony 1a-1b</td>
<td>Configured Output level – 40 dB or lower</td>
<td>dBm (600 Ω)</td>
<td>N02 N08 N14 N24 N30 N48</td>
</tr>
<tr>
<td></td>
<td>Feed into terminal telephony 8a-8b</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Measure at terminals telephony 5a-4b and 4a-4b.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PAX-BLOCKING normal</td>
<td>Measure at terminal telephony 6a-6b, 6b-7a</td>
<td>6a-6b is open</td>
<td>N02 N08 N14 N24 N30 N48</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>6b-7a is closed</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PAX-BLOCKING blocked</td>
<td>Measure at terminal telephony 6a-6b, 6b-7a</td>
<td>6a-6b is closed</td>
<td>N02 N08 N14 N24 N30 N48</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>6b-7a is open</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**C.11.7 Transit mode for E&M wire**

Mark if not configured:

<table>
<thead>
<tr>
<th>Test E-Wire:</th>
<th>Terminal telephony 3a-3b</th>
<th>E-Wire must toggle</th>
<th>N02 N08 N14 N24 N30 N48</th>
</tr>
</thead>
<tbody>
<tr>
<td>Close and open M-wire at terminal telephony 4a-4b</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**C.11.8 Testing the teleoperation ports**

**C.11.9 Teleoperation AF1, if not used for telephony**

Fed input level, [dBm], @ 800 Hz at AF1-IN

<table>
<thead>
<tr>
<th>Test result</th>
<th>Expected Output level at AF1-OUT</th>
<th>Measured Output level at AF1-OUT</th>
<th>N02 N08 N14 N24 N30 N42 N48 N54</th>
</tr>
</thead>
<tbody>
<tr>
<td>N02/N24:</td>
<td></td>
<td></td>
<td>N02/N24:</td>
</tr>
<tr>
<td>N08/N30:</td>
<td></td>
<td></td>
<td>N08/N30:</td>
</tr>
<tr>
<td>N14/N42:</td>
<td></td>
<td></td>
<td>N14/N42:</td>
</tr>
<tr>
<td>N20/N48:</td>
<td></td>
<td></td>
<td>N20/N48:</td>
</tr>
<tr>
<td>N54:</td>
<td></td>
<td></td>
<td>N54:</td>
</tr>
</tbody>
</table>

**C.11.10 Teleoperation AF2**

Fed input level, [dBm], @ 800 Hz at AF2-IN of remote.

<table>
<thead>
<tr>
<th>Test result</th>
<th>Expected Output level at AF2-OUT</th>
<th>Measured Output level at AF2-OUT</th>
<th>N02 N08 N14 N24 N30 N42 N48 N54</th>
</tr>
</thead>
<tbody>
<tr>
<td>N02/N24:</td>
<td></td>
<td></td>
<td>N02/N24:</td>
</tr>
<tr>
<td>N08/N30:</td>
<td></td>
<td></td>
<td>N08/N30:</td>
</tr>
<tr>
<td>N14/N42:</td>
<td></td>
<td></td>
<td>N14/N42:</td>
</tr>
<tr>
<td>N20/N48:</td>
<td></td>
<td></td>
<td>N20/N48:</td>
</tr>
<tr>
<td>N54:</td>
<td></td>
<td></td>
<td>N54:</td>
</tr>
</tbody>
</table>

**Notes:**

<table>
<thead>
<tr>
<th>Test result</th>
<th>Expected Output level at AF1-OUT</th>
<th>Measured Output level at AF1-OUT</th>
<th>N02 N08 N14 N24 N30 N42 N48 N54</th>
</tr>
</thead>
<tbody>
<tr>
<td>N02/N24:</td>
<td></td>
<td></td>
<td>N02/N24:</td>
</tr>
<tr>
<td>N08/N30:</td>
<td></td>
<td></td>
<td>N08/N30:</td>
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<tr>
<td>N14/N42:</td>
<td></td>
<td></td>
<td>N14/N42:</td>
</tr>
<tr>
<td>N20/N48:</td>
<td></td>
<td></td>
<td>N20/N48:</td>
</tr>
<tr>
<td>N54:</td>
<td></td>
<td></td>
<td>N54:</td>
</tr>
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</table>

**Sign Commissioning Eng.:**

**Sign Witness Eng.:**
<table>
<thead>
<tr>
<th>Test No.</th>
<th>Test procedure</th>
<th>Test point</th>
<th>Permissible value</th>
<th>Units</th>
<th>Test result</th>
</tr>
</thead>
<tbody>
<tr>
<td>C.11.11 Teleoperation AF3</td>
<td>Fed input level, [dBm], @ 800 Hz at AF3-IN of remote.</td>
<td>Mark if not configured:</td>
<td>Expected Output level at AF3-OUT</td>
<td>dBm (600 Ω)</td>
<td>Measured Output level at AF3-OUT</td>
</tr>
<tr>
<td></td>
<td>N02/N24: ______±1</td>
<td>Feed into terminal teleop. 5a-5b</td>
<td>N02/N24: ______±1</td>
<td>N02/N24: ______±1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>N08/N30: ______±1</td>
<td>Measure at terminal teleop. 6a-6b</td>
<td>N08/N30: ______±1</td>
<td>N08/N30: ______±1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>N14/N42: ______±1</td>
<td>ext. Boost not active.</td>
<td>N14/N42: ______±1</td>
<td>N14/N42: ______±1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>N20/N48: ______±1</td>
<td>N54: ______±1</td>
<td>N20/N48: ______±1</td>
<td>N20/N48: ______±1</td>
<td></td>
</tr>
<tr>
<td>C.11.12 Teleoperation AF4</td>
<td>Fed input level, [dBm], @ 800 Hz at AF4-IN of remote.</td>
<td>Mark if not configured:</td>
<td>Expected Output level at AF4-OUT</td>
<td>dBm (600 Ω)</td>
<td>Measured Output level at AF4-OUT</td>
</tr>
<tr>
<td></td>
<td>N02/N24: ______±1</td>
<td>Feed into terminal teleop. 7a-7b</td>
<td>N02/N24: ______±1</td>
<td>N02/N24: ______±1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>N08/N30: ______±1</td>
<td>Measure at terminal teleop. 8a-8b</td>
<td>N08/N30: ______±1</td>
<td>N08/N30: ______±1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>N14/N42: ______±1</td>
<td>ext. Boost not active.</td>
<td>N14/N42: ______±1</td>
<td>N14/N42: ______±1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>N20/N48: ______±1</td>
<td>N54: ______±1</td>
<td>N20/N48: ______±1</td>
<td>N20/N48: ______±1</td>
<td></td>
</tr>
<tr>
<td>C.11.13 Teleoperation AF4 used for ext. teleprotection</td>
<td>Test EXT-BOOST:</td>
<td>Mark if not configured:</td>
<td>Expected Output level at AF4-OUT</td>
<td>dBm (600 Ω)</td>
<td>Measured Output level at AF4-OUT</td>
</tr>
<tr>
<td></td>
<td>N02/N24: ______±1</td>
<td>Activate at terminal teleop. 9a-9b</td>
<td>N02/N24: ______±1</td>
<td>N02/N24: ______±1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>N08/N30: ______±1</td>
<td>Feed into terminal teleop. 7a-7b</td>
<td>N08/N30: ______±1</td>
<td>N08/N30: ______±1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>N14/N42: ______±1</td>
<td>Measure at terminal teleop. 8a-8b</td>
<td>N14/N42: ______±1</td>
<td>N14/N42: ______±1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>N20/N48: ______±1</td>
<td>N54: ______±1</td>
<td>N20/N48: ______±1</td>
<td>N20/N48: ______±1</td>
<td></td>
</tr>
<tr>
<td>C.12. V.11 ports</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C.12.1 V.11 Port 1</td>
<td>BER test</td>
<td>Mark if not configured:</td>
<td>Front plate P4LT/V/X, V.11 PORT 1</td>
<td>BER ≤ 10⁻⁵ during ___ sec</td>
<td></td>
</tr>
<tr>
<td>C.12.2 V.11 Port 2</td>
<td>BER test</td>
<td>Mark if not configured:</td>
<td>Front plate P4LX, V.11 PORT 2</td>
<td>BER ≤ 10⁻⁵ during ___ sec</td>
<td></td>
</tr>
</tbody>
</table>
### Test procedure

<table>
<thead>
<tr>
<th>Test No.</th>
<th>Test procedure</th>
<th>Test point</th>
<th>Permissible value</th>
<th>Units</th>
<th>Test result</th>
</tr>
</thead>
<tbody>
<tr>
<td>C.13.</td>
<td>V.24 ports</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C.13.1</td>
<td>V.24 Port 1</td>
<td>Mark if not configured: BER test Front plate P4LT/V/X, V.24 PORT 1</td>
<td>BER ≤ 10⁻⁵ during ____ sec</td>
<td>[ ]</td>
<td></td>
</tr>
<tr>
<td>C.13.2</td>
<td>V.24 Port 2</td>
<td>Mark if not configured: BER test Front plate P4LT/V/X, V.24 PORT 2</td>
<td>BER ≤ 10⁻⁵ during ____ sec</td>
<td>[ ]</td>
<td></td>
</tr>
<tr>
<td>C.13.3</td>
<td>V.24 Port 3</td>
<td>Mark if not configured: BER test Front plate P4LX, V.24 PORT 3</td>
<td>BER ≤ 10⁻⁵ during ____ sec</td>
<td>[ ]</td>
<td></td>
</tr>
<tr>
<td>C.13.4</td>
<td>V.24 Port 4</td>
<td>Mark if not configured: BER test Front plate P4LX, V.24 PORT 4</td>
<td>BER ≤ 10⁻⁵ during ____ sec</td>
<td>[ ]</td>
<td></td>
</tr>
<tr>
<td>C.14.</td>
<td>Testing of LAN port</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C.14.1</td>
<td>LAN Port 1</td>
<td>Mark if not configured: Test of throughput Front plate P4LV/X, LAN PORT 1</td>
<td>Throughput during ____ sec ≤ 0.5% errored or missing 128-byte frames during ____ sec</td>
<td>[ ]</td>
<td></td>
</tr>
<tr>
<td>C.14.2</td>
<td>LAN Port 2</td>
<td>Mark if not configured: Test of throughput Front plate P4LV/X, LAN PORT 2</td>
<td>Throughput during ____ sec ≤ 0.5% errored or missing 128-byte frames during ____ sec</td>
<td>[ ]</td>
<td></td>
</tr>
<tr>
<td>C.14.3</td>
<td>LAN Port 3</td>
<td>Mark if not configured: Test of throughput Front plate P4LV/X, LAN PORT 3</td>
<td>Throughput during ____ sec ≤ 0.5% errored or missing 128-byte frames during ____ sec</td>
<td>[ ]</td>
<td></td>
</tr>
</tbody>
</table>

### Notes:

- [ ] D 10'000
- [ ] Transmitted frames.

---

Sign Commissioning Eng.: Sign Witness Eng.:
<table>
<thead>
<tr>
<th>Test No.</th>
<th>Test procedure</th>
<th>Test point</th>
<th>Permissible value</th>
<th>Units</th>
<th>Test result</th>
</tr>
</thead>
<tbody>
<tr>
<td>C.14.4</td>
<td>LAN Port 4</td>
<td>Mark if not configured: Front plate P4LV/X, LAN PORT 4</td>
<td>Throughput during _____ sec</td>
<td></td>
<td>[ ]</td>
</tr>
<tr>
<td></td>
<td>Test of throughput</td>
<td></td>
<td>≤ 0.5% errored or missing 128-byte frames during __________ sec</td>
<td></td>
<td>[ ]</td>
</tr>
<tr>
<td>C.14.5</td>
<td>HMI over LAN</td>
<td>Test of connectivity</td>
<td>Connected</td>
<td></td>
<td>[ ]</td>
</tr>
<tr>
<td>C.15.</td>
<td>Testing of O4CV</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C.15.1</td>
<td>Slot positions of O4CV boards</td>
<td></td>
<td>O4CV#1: N_____</td>
<td></td>
<td>O4CV#1: N_____</td>
</tr>
<tr>
<td></td>
<td>Record slot positions of O4CV boards</td>
<td>Refer to HMI600 configuration view</td>
<td>O4CV#2: N_____</td>
<td></td>
<td>O4CV#2: N_____</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>O4CV#3: N_____</td>
<td></td>
<td>O4CV#3: N_____</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>O4CV#4: N_____</td>
<td></td>
<td>O4CV#4: N_____</td>
</tr>
<tr>
<td>C.15.2</td>
<td>Service Phone</td>
<td>Mark if not configured:</td>
<td></td>
<td></td>
<td>[ ]</td>
</tr>
<tr>
<td></td>
<td>Pick up the phone and talk.</td>
<td>Service phone, at front panel of O4CV#1</td>
<td>Own voice is audible without feedback or excessive echo</td>
<td></td>
<td>[ ]</td>
</tr>
<tr>
<td>C.15.3</td>
<td>Hot line direct phone</td>
<td>Mark if not configured:</td>
<td></td>
<td></td>
<td>[ ]</td>
</tr>
<tr>
<td></td>
<td>Measure voltage at open loop condition</td>
<td>Terminals 7a-7b, 8a-8b, 9a-9b, 0a-0b of term.bl.2 for ports P1, P2, P3, P4</td>
<td>40.8 V … 55.2 V</td>
<td></td>
<td>O4CV#1: P1 P2 P3 P4 P1 P2 P3 P4 P1 P2 P3 P4</td>
</tr>
<tr>
<td>Test No.</td>
<td>Test procedure</td>
<td>Test point</td>
<td>Permissible value</td>
<td>Units</td>
<td>Test result</td>
</tr>
<tr>
<td>---------</td>
<td>----------------</td>
<td>-----------</td>
<td>------------------</td>
<td>-------</td>
<td>-------------</td>
</tr>
<tr>
<td>C.15.4</td>
<td>Remote subscriber</td>
<td>Mark if not configured:</td>
<td>40.8 V ... 55.2 V</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Measure voltage at open loop condition</td>
<td>Terminals 7a-7b, 8a-8b, 9a-9b, 0a-0b of term.bl2 for ports P1, P2, P3, P4</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Pick up the phone and talk</td>
<td>Direct telephone at terminals 7a-7b, 8a-8b, 9a-9b, 0a-0b of term.bl2 for ports P1, P2, P3, P4</td>
<td>Own voice is audible without feedback or excessive echo</td>
<td></td>
<td></td>
</tr>
<tr>
<td>C.15.5</td>
<td>Pax 2-wire</td>
<td>Mark if configured:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C.15.6</td>
<td>Pax 4-wire</td>
<td>Mark if not configured:</td>
<td>Configured output level ±5 dB (Def.: -3.5 dBm)</td>
<td>dBm (600 Ω)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Test E-Wire:</td>
<td>E-Wire must toggle</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Close and open M-Wire at terminals 4a-4b, 8a-8b of term.bl.1 for ports P1, P2 or 2a-2b, 6a-6b of term.bl.2 for ports P3, P4</td>
<td>Terminals 3a-3b, 7a-7b of term.bl.1 for ports P1, P2 or 1a-1b, 5a-5b of term.bl.2 for ports P3, P4</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Measure output level.</td>
<td>Feed 800 Hz with configured input level of remote PAX (Def.: -3.5 dBm). (Activate at terminals 4a-4b, 8a-8b of term.bl.1 for ports P1, P2 or 2a-2b, 6a-6b of term.bl.2 for ports P3, P4)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Feed into terminals 1a-1b, 5a-5b, 9a-9b of term.bl.1 for ports P1, P2, P3 or 3a-3b of term.bl.2 for port P4</td>
<td>Measure at terminals 2a-2b, 6a-6b, 0a-0b of term.bl.1 for ports P1, P2, P3 or 4a-4b of term.bl.2 for port P4</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C.17.</td>
<td>Documentation</td>
<td>If possible, take printout of Configuration data for reference.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>If possible, take printout of Configuration data for reference.</td>
<td>Save the 'et6' file on disk with Serial No. of ETL coded in the file name, e.g. 'HE400327C.et6'.</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Notes: ..............................................................................................................................................................

Sign Commissioning Eng.: .......................................................... Sign Witness Eng.: ..............................................
## Pending Items List:

<table>
<thead>
<tr>
<th>Issue</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
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<td></td>
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<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Commissioning Approved:  
- [ ] YES  
- [ ] NO

### Exceptions Noted:  
- [ ] YES  
- [ ] NO

<table>
<thead>
<tr>
<th>Name of responsible</th>
<th>PSNP3</th>
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<tbody>
<tr>
<td>Signature &amp; Date</td>
<td></td>
</tr>
<tr>
<td>Company</td>
<td>ABB Switzerland Ltd</td>
</tr>
<tr>
<td></td>
<td>Consultant</td>
</tr>
<tr>
<td></td>
<td>Customer</td>
</tr>
</tbody>
</table>
Power Line Carrier Equipment: Series ETL600

Firmware Download for ETL600R4

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   3.6 Unsuccessful or incomplete firmware download to P4LT/V/X 7

List of equipment:

PC with Windows XP, Windows Vista or Windows 7
HMI600 software
Firmware download files
PC ◇ P4LT/V/X cable (9 pole 1:1 serial RS-232)

Note:

- Please refer 1KHW001490 for compatibility between software HMI600, firmware and hardware of ETL600.

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1 Purpose of document

This document describes the firmware download process for the equipment ETL600 Rel.4, supported by the PC program HMI600.

2 General

The HMI600 supports firmware download for the modules P4LT/V/X, O4LE, G4AI and O4CV. The firmware download gives the opportunity to update the equipment to the latest release or to modify a module ordered from stock to the actual release in the client's equipment.

The automatic release detection in the HMI600 identifies incompatibilities between firmware versions on the modules in an equipment before the configuration upload or download process is executed. If any incompatibility is recognized, the HMI600 will indicate that a firmware update has to be executed. In this case a configuration download is not possible. The automatic release detection doesn't detect if the latest release is installed. For information about available releases and about compatibility between software, firmware and hardware of the ETL600 system please refer to the document „Compatibility Requirements for ETL600“ (1KHW001490).

The firmware of module P4LT/V/X is stored in a non-replaceable FLASH memory and will be checked for integrity during the start-up procedure. Therefore, if a firmware download failed due to a power or communication failure, this will be detected and a so-called “emergency firmware” will be activated. This emergency firmware supports a firmware download only and is indicated by sequentially blinking (in anticlockwise direction) of all LEDs of the module P4LT/V/X.

2.1 Necessity for a firmware download

The automatic firmware download has to be used in the following cases:

1. Update of already configured equipment with automatic backup and restore of the configuration.
   Typically, this might become necessary when firmware versions are available with new functionality.

2. Update of non-configured equipment with download of the configuration settings from a file.
   Typically, this might become necessary after the assembly of the equipment.

3. HMI600 detects an incompatibility while downloading the configuration.
   Possible situations are if a configuration is downloaded to virgin equipment or the HMI600 has extended functionality, which is not provided by the firmware installed on the equipment.

4. HMI600 detects an incompatibility after extending the equipment.

5. HMI600 detects an incompatibility after exchanging a module.

6. If all LEDs of the module P4LT/V/X blinking sequentially in anticlockwise direction. In this case a corrupted firmware of the P4LT/V/X itself was detected and an application is running which allows a firmware update only.

2.2 Risks of a firmware download

The firmware download procedure should be performed exclusively by instructed service personnel. The operator is not allowed to perform this operation.

Caution
ACTIVATING A FIRMWARE DOWNLOAD WILL CAUSE MALFUNCTION OF THE PLC-LINK.

Caution
NEVER SWITCH OFF THE POWER TO THE EQUIPMENT WHILE A FIRMWARE DOWNLOAD IS IN PROGRESS.

Violation of this rule will produce a system with incomplete firmware on the modules of type G4AI, O4LE or O4CV, so that it will not work anymore. If this should happen, the affected board(s) have to be sent back for repair, specifying the firmware version(s) needed.
Caution

REMOVING EPROMS FROM A BOARD OR TRYING TO DO SO CAN RESULT IN IRREPAIRABLE DAMAGE TO THE BOARD.

Caution

Should the communication to the equipment be interrupted during the download process, correct the communication problem WITHOUT switching off the power to the equipment and restart the firmware download.

Caution

Firmware download should only be executed from PCs with a correctly installed Windows operating system. Do not use PCs that show signs of instability such as premature abnormal terminations of programs.

Caution

To prevent interruptions of the communication during firmware download, it is a good idea to:
- close all programs running on the PC except HMI600,
- stop any programs running on the PC in the background such as virus scanners,
- disable the screen saver of the PC,
before starting the firmware download.

Caution

Hands should be kept away from keyboard and mouse while a firmware download is in progress except when HMI600 prompts for interaction.

Caution

If a firmware download has to be executed, always use the Equipment address: 0 to logon the equipment. If the PC is connected to the RS-485 station bus, all ETL600 terminals except one have to be disconnected or switched off for that purpose. Normally the PC is therefore connected directly to the HMI interface (RS-232) on the front plate of the ETL600 terminal to be updated.

Caution

If the new firmware is incompatible with an already stored configuration, then the P4LT/V/X module will use the default configuration after completion of the firmware download.

The serial data rate of the P4LT/V/X default configuration is 57'600 bps. If any other serial data rate was configured before the firmware download (on the P4LT/V/X module and in the HMI600) and the module starts up with the default configuration, no further access via the HMI-COM port will be possible until the serial data rate of the HMI600 is readapted to this default data rate of the module (i.e. 57'600 bps).

2.3 Firmware download files

To perform a firmware download to the system, the download files supplied with the HMI600 software are needed. These files are stored in the release directory. The available releases can be found in the directory 'Firmware'. Make sure that the highest release is used for updating the equipment.

Example for a release directory:
C:\Program Files\ABB\HMI600\Firmware\Release 4.0\*.ldr

<table>
<thead>
<tr>
<th>Hardware module</th>
<th>Firmware file</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>P4LT/V/X</td>
<td>P4LT_***.ldr</td>
<td>P4LT_400.ldr</td>
</tr>
<tr>
<td>O4LE</td>
<td>O4LE_***.ldr</td>
<td>O4LE_214.ldr</td>
</tr>
<tr>
<td>G4AI</td>
<td>G4AI600_***.ldr</td>
<td>G4AI600_313.ldr</td>
</tr>
<tr>
<td>O4CV</td>
<td>O4CV_***.ldr</td>
<td>O4CV_123.ldr</td>
</tr>
<tr>
<td>R1LB</td>
<td>R1LB_***.ldr</td>
<td>R1LB_102.ldr</td>
</tr>
</tbody>
</table>
2.4 Firmware download parameters

The Firmware download dialog box contains a field with download parameters. Either an automatic firmware download or - by deactivating the check box - a user controlled firmware download can be chosen.

2.4.1 Automatic firmware download

This is the recommended method to download the firmware. The HMI600 executes all necessary actions for a proper operation. The checkbox Automatic firmware download has to be ticked. The download process compares the firmware version on the modules with the firmware version of the selected download files. The download to a module is not executed if the versions are equal. So only the modules are modified, which have not the same version as the selected download files.

2.4.2 User controlled firmware download

Note: Only for authorized and properly trained persons.

The user controlled firmware download provides the opportunity to modify one selected module in a system. Deactivating the checkbox for automatic firmware download enables the button Reset system. Please follow the instruction in the “Download status & progress instruction” window.

3 Firmware download

3.1 Update of non-configured equipment

1. On the File menu click Open. This opens the Open dialog box. Select the configuration file and click Open.
2. From the Equipment menu click Connect. This opens the Connect dialog box.
3. Click Read & Write access.
4. Click OK.
5. On the Equipment menu, click Commissioning and maintenance and then click Firmware download...
6. In the following message box click Yes if a malfunction of the PLC link is acceptable. This opens the Firmware download dialog box. Otherwise click No.
7. The checkbox Automatic firmware download has to be ticked.
8. Click Start firmware download to start the operation.
9. The following message box indicates which download files are used. Be sure that all files are from the same release directory.
   Click Yes to accept these files. This starts the firmware download. The HMI600 automatically performs the update and resets the system after the update is completed.
   Click No to select other files. This opens a file open dialog box for each kind of download file.
   Click Cancel to stop firmware download.
10. Wait until the Close button changes to the active state.
11. Click Close to leave the firmware download dialog box.
12. From the Equipment menu, click Download configuration. The license is checked and an error message appears if it is not sufficient. Compatibility checks are performed to verify that the firmware versions on the different modules in the equipment belong to the same release as the HMI600. If not, an error message pops up. Depending on the message, an earlier version of HMI600 must be used and/or the firmware of some modules must be upgraded.
13. If the **Download configuration** operation is possible, a message box appears, which indicates that the link will be cut off for a few seconds. Click **Yes**.

14. The **Test configuration time** dialog box has been opened by the HMI600. Click **OK**.

15. The HMI600 now compares the equipment identification from the file with the identification stored in the equipment. If it is different, a warning message box appears. Click **OK**. This starts the download configuration process.

16. A dialog box indicates, that the configuration has not been stored in the non-volatile flash EPROM and asks to do so. Click **Yes**. The configuration data are now stored in the flash EPROMs. This process needs some seconds. Please wait until the color of the stop button in the toolbar changes from red to grey. The actual status of the process is displayed in the status bar.

### 3.2 Update of already configured equipment

1. On the **File** menu click **New**. This opens the **Connect** dialog box.
2. Click **Logon**, **Equipment address: 0**
3. Click **Read & Write access**.
4. Click **Upload configuration**.
5. Click **OK**. This opens a HMI600 child window
6. On the Equipment menu, click **Commissioning and maintenance** and then click **Firmware download…**
7. In the following message box click **Yes** if a malfunction of the PLC link is acceptable. This opens the **Firmware download** dialog box. Otherwise click **No**.
8. The checkbox **Automatic firmware download** has to be ticked.
9. Click **Start firmware download** to start the operation.
10. The following message box indicates which download files are used. Be sure that all files are from the same release directory. Click **Yes** to accept these files. This starts the firmware download. The HMI600 automatically performs the update and resets the system after the update is completed. Click **No** to select other files. This opens a **file open** dialog box for each kind of download file. Click **Cancel** to stop firmware download.
11. Wait until the **Close** button changes to the active state.
12. Click **Close** to leave the **firmware download** dialog box.
13. Click **Download Configuration**.

### 3.3 HMI600 detects an incompatibility while downloading the configuration

The HMI600 configuration download detects an incompatible firmware in the equipment and calls for a firmware download.

1. The HMI600 alerts the incompatibility; in some cases the configuration is modified and correspondingly indicated by the HMI600.
2. On the Equipment menu, click **Commissioning and maintenance** and then click **Firmware download…**
3. In the following message box click **Yes** if a malfunction of the PLC link is acceptable. This opens the **Firmware download** dialog box. Otherwise click **No**.
4. The checkbox **Automatic firmware download** has to be ticked.
5. Click **Start firmware download** to start the operation.

6. The following message box indicates which download files are used. Be sure that all files are from the same release directory.
   - Click **Yes** to accept these files. This starts the firmware download. The HMI600 automatically performs the update and resets the system after the update is completed.
   - Click **No** to select other files. This opens a **file open** dialog box for each kind of download file.
   - Click **Cancel** to stop firmware download.

7. **Wait** until the **Close** button changes to the active state.

8. Click **Close** to leave the **firmware download** dialog box.

9. Download the modified configuration. Please refer to paragraph 3.1 step 12.

### 3.4 HMI600 detects an incompatibility after extending the equipment

1. On the **File** menu click **New**. This opens the **Connect** dialog box.
2. Click **Logon, Equipment address: 0**
3. Click **Read & Write access**.
4. Click **Upload configuration**.
5. Click **OK**. This opens a HMI600 child window.
6. On the **Configuration** menu click **Services** and choose new services.
7. On the **File** menu click **Save**. This opens the **Save as** dialog box. Click **Save**.
8. Close the HMI600 window (**File, Close**).
9. Switch off the equipment.
11. Switch on the equipment.
12. On the **File** menu click **Open**. This opens the **Open** dialog box. Select the previously saved configuration file and click Open.
13. From the **Equipment** menu click **Connect**. This opens the **Connect** dialog box.
14. Click **Read & Write access**.
15. Click **OK**.
16. From the **Equipment** menu click **Download configuration**. This process automatically checks the firmware compatibility of the new modules. If an incompatibility is detected proceed with chapter 3.3. If not, the firmware is fully compatible to the other modules in the equipment.

### 3.5 HMI600 detects an incompatibility after exchanging a module

If a module has to be exchanged in case of any damage, switch off the equipment, replace the new module and switch the equipment on again. The last configuration stored in a file can be used to update the equipment configuration.

The following steps describe connect and configuration download process with the HMI600.

1. On the **File** menu click **Open**. This opens the **Open** dialog box. Select the configuration file and click Open.
2. From the **Equipment** menu click **Connect**. This opens the **Connect** dialog box.
3. Click **Read & Write access**.
4. Click **OK**.
5. From the **Equipment** menu click **Download configuration**. This process automatically checks the firmware compatibility of the replaced module. If an incompatibility is detected
proceed with chapter 3.3. If not, the firmware is fully compatible to the other modules in the equipment.

3.6 Unsuccessful or incomplete firmware download to P4LT/V/X

If the HMI600 indicates to execute a firmware download, the following steps describe the process.

1. On the File menu click New. This opens the Connect dialog box.
2. Click Logon, Equipment address: 0
3. Click Read & Write access.
4. Click OK. This opens a HMI600 child window.
5. On the Equipment menu, click Commissioning and maintenance and then click Firmware download…
6. In the following message box click Yes if a malfunction of the PLC link is acceptable. This opens the Firmware download dialog box. Otherwise click No.
7. Uncheck the checkbox Automatic firmware download.
8. Verify that the Slot ID: is set to N45 [P4LT/V/X].
9. Click Start firmware download to start the operation.
10. This opens a Select firmware file for module P4LT dialog box. Browse to the folder where the firmware download files are stored – refer to 2.3. Select the file P4LT_***.ldr and click Open.
11. Wait approx. 10 minutes until the message box Firmware download successful will appear and click OK.
12. Click Reset system and wait until the Close button is accessible.
13. Click Close to leave the firmware download dialog box.
Power Line Carrier Equipment: Series ETL600

Anomaly List for ETL600

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1 Purpose

This document describes the currently known anomalies in the behavior of the ETL600 system. Such anomalies express themselves in unexpected system behavior not described in the instruction manual ETL600 Rel.3 (1KHW001489-EN) or ETL600 Rel.4 (1KHW002582-EN). This document is updated immediately after a new anomaly has been discovered and verified.
2 Anomalies

For each anomaly, the following information is given:
- the types of the hardware modules and/or the versions of firmware or software taken to be responsible for the observed anomaly,
- a description of the anomaly,
- a workaround (if any).

2.1 Deviation of level measured at the socket “RF LINE MONITOR” on P3LE

2.1.1 Hardware types, software and/or firmware versions

RF hybrid P3LE.

Note: This anomaly only applies to the initial version of the RF hybrid, designated “P3LE”, not “P3LEa” or later.

To find out the version, remove the RF hybrid and check the sticker on its backplane connector:
2.1.2 Description

The level measured at the socket "RF line monitor" deviates from its rated level (50 dB below the power at the RF output) as follows:

<table>
<thead>
<tr>
<th>Impedance</th>
<th>Deviation</th>
<th>Measured level at “RF line monitor” socket [dBm @ 50 Ohm]</th>
</tr>
</thead>
<tbody>
<tr>
<td>45 Ohm</td>
<td>-1.1 dB</td>
<td>RF output power [dBm] – 51.1 dB</td>
</tr>
<tr>
<td>75 Ohm</td>
<td>+1.2 dB</td>
<td>RF output power [dBm] – 48.8 dB</td>
</tr>
<tr>
<td>125 Ohm</td>
<td>+3.5 dB</td>
<td>RF output power [dBm] – 46.5 dB</td>
</tr>
</tbody>
</table>

2.1.3 Work around

Apply the corrections given in the table above when performing measurements at the "RF line monitor" socket.

Examples:

1) At the socket "RF line monitor", a level of -12.8 dBm @ 50 Ohm is measured. The line impedance is 75 Ohm. What is the power at the RF output?
   Answer: The power at the RF output is (-12.8 + 48.8) dBm = +36 dBm.

2) When adjusting the Tx RF level for +46 dBm PEP (dialog box Configuration / System / Channel settings / Max. power (PEP) [dBm]: = 46), a rated level of -14.1 ... -13.9 dBm @ 50 Ohm is specified in the dialog box Adjust Tx RF level for the "RF line monitor" socket. Which is the permissible range for the level to be measured at the "RF line monitor" socket?
   Answer: The tuning tone level must be adjusted until the measured level at the socket "RF line monitor" is in the range (-14.1 ... -13.9 dBm @ 50 Ohm)+1.2 dB = -12.9 ... -12.7 dBm @ 50 Ohm or -13.1 ... -12.9 dBm @ 75 Ohm.

Note: As indicated in the documents 1KHW001493 and 1KHW001495, where the Tx level adjustment procedure is described, the adjustment precision for the Tx level is limited by the tolerance for levels measured at the coax socket "RF line monitor".
2.2 Incorrect SNR evaluation for high weights of NSD600 guard signal

2.2.1 Hardware types, software and/or firmware versions
Software HMI600 Version 1.22 and higher,
Firmware ETL600 Version 1.28 and higher.

2.2.2 Description
The weight of the NSD600 guard signal can be much higher than the weight of the ETL600 pilot not used as NSD600 guard signal. The SNR evaluation is not correct for SNR above a limit that depends on the weight of the guard signal. This limit is shown in Fig. 2-1. When the SNR level alarm threshold is set above the limit, an SNR alarm will be generated although the actual SNR in the channel might be below the alarm threshold.

Note that in APLC channels where no NSD600 is configured, the SNR evaluation is correct.

![Fig. 2-1](image)

2.2.3 Work around
For channels where NSD600 is configured:
- Ignore the SNR indication in the ETL600 status if it is above the limit shown in Fig. 2-1.
- Set the SNR alarm threshold below the limit shown in Fig. 2-1.
2.3 Time-limited “persistent” commands of NSD600 in 2 kHz APLC channel

2.3.1 Hardware types, software and/or firmware versions
Software HMI600 Version 1.41,
Firmware ETL600 Version 1.47.

2.3.2 Description
The single purpose teleprotection NSD600 in 2 kHz APLC allows transmitting of persistent commands without alarm if the “Max Tx Trip Duration” monitoring checkbox is not marked (as shown in Fig. 2-2).

In release 2.0 the maximum Tx trip duration of the correspondingly configured command is time-limited to 55 hours and 55 minutes instead of infinite. After this time, alarm is raised and the guard signal is sent instead of the trip signal.

Fig. 2-2

2.3.3 Work around
None.
The anomaly is eliminated in release 2.1.0 which uses the following software/firmware versions:
- Software HMI600 version 2.08
- Firmware ETL600 version 2.06 on module P4LT/P4LTa or P4LU/P4LUa
- Firmware G4AI version 3.12 on module G4AI/G4Ala
2.4 Configuration file incompatibility

2.4.1 Hardware types, software and/or firmware versions
Software HMI600 Version 2.08 (release 2.1.0).

2.4.2 Description
The HMI600 version 2.08 (release 2.1.0) cannot open configuration files generated with HMI600 1.41 (release 2.0.0). Instead, a message box appears:

![Message box](image.png)

2.4.3 Work around
None.
The anomaly is eliminated in release 2.1.1, which uses the following software/firmware versions:
- Software HMI600 version 2.10
- Firmware ETL600 version 2.07 on module P4LT/P4LTa or P4LU/P4LUa

2.5 Limited fax transmission in photo mode with O4CV

2.5.1 Hardware types, software and/or firmware versions
Compressed Telephony Interface O4CV,
Software HMI600 Version 3.07,
Firmware O4CV Version 1.20.

2.5.2 Description
When transmitting a fax document in continuous tone grey-scale or color mode (according to ITU-T Recommendation T.30, Annex E) via a compressed telephony channel of interface O4CV, the transmission is stopped after the first page of the document or after 30 minutes when the first page has not been transmitted within this time.

2.5.3 Work around
- If possible, avoid fax transmission in continuous tone grey-scale or color mode.
- If for any reason continuous tone grey-scale or color mode is required, reduce resolution and color depth such that the transmission of one page does not take longer than 30 minutes and send the document page by page.

The anomaly is eliminated in release 3.1.0 which uses the following software/firmware versions:
- Software HMI600 version 3.20
- Firmware O4CV version 1.21 on module O4CV
2.6 Unreliable fax transmission in transit operation with O4CV

2.6.1 Hardware types, software and/or firmware versions
Compressed Telephony Interface O4CV,
Software HMI600 Version 3.07 and higher,
Firmware O4CV Version 1.20 and higher.

2.6.2 Description
In transit operation, i.e. when telephony channels of an ETL600 link are relayed to a second link by interconnecting the outputs and inputs of the corresponding O4CV modules, fax transmission does not work reliably.

2.6.3 Work around
None.

2.7 HMI600 displays incorrect permissible RF line monitor levels

2.7.1 Hardware types, software and/or firmware versions
Software HMI600 Version 4.00.

2.7.2 Description
For ETL600 Rel.4, i.e. for equipment types ETL600-050-1, ETL600-050-2 or ETL600-100-2, unless PEP is set to 50 W corresponding to 47 dBm, HMI600 displays incorrect permissible levels for RF line monitor (on E5TH) in the frame Test point and permissible values of the Dialog Equipment / Tuning and testing / Adjust Tx RF level:

![Test point and permissible values]

However, the displayed permissible level for the socket RF line (on E5TH) is correct.

2.7.3 Work around
Calculate the correct permissible RF line monitor levels from the displayed permissible RF line level
- by subtracting 50 dB in case a level meter with 75 Ohm impedance
- by subtracting 51.2 dB in case a level meter with 50 Ohm impedance
is used for the level measurement at the RF line monitor test socket on E5TH.
Example:
For PEP = 100 W, the displayed permissible RF line level is [39.9 ... 40.1 dBm] / 75 Ohm.
The correct permissible levels for the test socket RF line monitor are then:
[-10.1 ... -9.9 dBm] / 75 Ohm and [-11.3 ... -11.1 dBm] / 50 Ohm respectively.
The anomaly is eliminated in release 4.0.1 which uses the following software/firmware versions:
- Software HMI600 version 4.01
2.8 LAN600 router mode maloperation

2.8.1 Hardware types, software and/or firmware versions
LAN module R1LB,
Firmware R1LB Version 1.02.

2.8.2 Description
The LAN600 router mode does not work correctly if the LAN1 port is disabled.

2.8.3 Work around
In router mode the LAN1 port has to be enabled to allow correct operation.
The anomaly is eliminated in release 4.0.1 which uses the following software/firmware versions:
- Firmware R1LB version 1.03
# FAULT REPORT

Please fill-in a separate FAULT REPORT for each Item and send to PSNP4!

## SECTION 1: General Information

<table>
<thead>
<tr>
<th>Equipment Type:</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Module Type:</td>
<td></td>
</tr>
<tr>
<td>Serial / Release Number:</td>
<td></td>
</tr>
<tr>
<td>ABB Order No / Delivery date:</td>
<td>(only required for WARRANTY REPAIR)</td>
</tr>
<tr>
<td>Your Original PO No:</td>
<td>(only required for WARRANTY REPAIR)</td>
</tr>
</tbody>
</table>

## SECTION 2: Fault Description

- Problem occurred:  
  - during transport  
  - during installation  
  - during commissioning

- => Agent:  
  - in service  
  - other:  

- Fault description:  

## SECTION 3: Repair & Delivery Type

- Warranty Repair
- Express delivery
- Expedited repair
- Advance replacement
- Service Contract Number:  

## SECTION 4: Customer’s Address

<table>
<thead>
<tr>
<th>Reference: (Important for all clarifications)</th>
<th>DELIVERY Address for repaired Item(s)</th>
<th>BILLING Address (if different from Delivery Address)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Company:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Address:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Address:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Attn.:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Contact:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Telephone:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>E-Mail:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>FAX:</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

## SECTION 5: Fault Report issued by

<table>
<thead>
<tr>
<th>Name:</th>
<th>Company:</th>
<th>E-Mail:</th>
<th>City / Country:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

Date:  

---

Feb 2011 / FAULT REPORT/1KHM010296JE Repair & Return Procedure.xls
Repair & Return Procedure

A. GENERAL
All of ABB’s equipment and parts are warranted against defects in material and workmanship for a period as agreed in the ORDER or in the SERVICE CONTRACT. Please do always include a FAULT REPORT when sending any item(s) to ABB for Repair & Return.

Benefits of the Repair & Return Procedure:
- Quality of response
- Single Point-of-Entry to ensure the process efficiency and reliability
- Expedite service for all Service Contracts

B. REPAIR & RETURN PROCEDURE

1. Send Item(s) with Fault Report
   Please send FAULT REPORT also as E-Mail or a FAX and Airway Bill No. (AWB) to PSNP4.

2. Check Item(s) and Repair Type
   - In case of Warranty Repair or Service Contract:
     Send an acknowledgement of receipt of Item(s) to customer and repair item(s).
     => CONTINUE at point 5.
   - If OUT of Warranty Repair:
     Repair cost will be charged to customer.

3. Send an Offer to Customer
   within 5 working days after receiving Item(s) with FAULT REPORT.

4. Send Purchase Order

5. Repair Item(s)

6. Delivery of Items back to CUSTOMER

Address at ABB Switzerland:
ABB Switzerland Ltd
Power Systems
PSNP4 Repair Center
CH-5400 Baden / Switzerland

All of ABB’s equipment and parts are warranted against defects in material and workmanship for a period as agreed in the ORDER or in the SERVICE CONTRACT. Please do always include a FAULT REPORT when sending any item(s) to ABB for Repair & Return.

Item(s) for Repair
Guide to complete the FAULT REPORT

Please fill-in a separate FAULT REPORT for each Item and send to PSNP4!

C. Guide to complete the FAULT REPORT

- Completely fill-in all 5 sections of a separate FAULT REPORT for each Item.
- Include FAULT REPORT with Item(s) when returned to PSNP4.
- E-Mail or FAX copy of FAULT REPORT to PSNP4 - and also Airway Bill (AWB) No. if sent by airfreight.
- Include name and contact details of a technical person who can be contacted by the PSNP4 repair engineers to discuss technical issues related to the fault. This information shall be stated at Section 4 of the FAULT REPORT.
- Note down the equipment type to which the Item belongs to (e.g. FOX515, ETL600, NSD570) on the FAULT REPORT, Section 1.
- Note down serial number and release number (if any) of the faulty Item on the FAULT REPORT, Section 1.
- In case of SERVICE CONTRACT in force, the number of the SERVICE CONTRACT shall be indicated on the FAULT REPORT, Section 3.
- Advance Replacement:
  If you need an Advance Replacement, tick the respective field on the FAULT REPORT.
  A purchase order is required before shipment of the Advance Replacement. The customer will be invoiced for the full price of the Advance Replacement unit.
  Please note that PSNP4 does not guarantee that Replacement Items will be available, except for Replacement Items defined in a SERVICE CONTRACT.
- Unit for Checking:
  This service will be charged with US$ 500.00 for each unit.

D. Purchase Order for Out of Warranty Repair

After receiving modules with FAULT REPORT the Item(s) will be repaired if
- under warranty or
- under Service Contract
otherwise a quotation for the repair cost will be sent to the customer.

NO REPAIR will be started by PSNP4 until a Purchase Order for the amount quoted for repair is received by PSNP4. Items received by PSNP4 without a FAULT REPORT and Purchase Order will be placed in isolation and no repair actions will be started until all the above documentation is completed.

E. Packing

When packing the Item(s) anti-static bags shall be used to wrap-in item(s) carefully. Please ensure that the packing is sufficient to avoid damages during shipment. Ideally, item(s) shall be returned in the same packaging as it was supplied.

Any Item(s) received in damaged conditions, appearing to be caused from inadequate packing, will not be repaired until a purchase order covering repair cost of the additional damage is received by PSNP4.
NEED SUPPORT FOR YOUR COMMUNICATION SYSTEM?

1. Support request

2. Formal acceptance of price and delivery terms

3. Service delivery

Customer Support Center
utilitycommunications@ch.abb.com
or
+41 844 845 845

Goals of the process:
- Quality of response
- Short response time to customers
- Clear pricing of services
- Single Point-of-Entry to ensure process efficiency and reliability
TECHNICAL DATA ETL600 Rel.4


ETL600 complies with or exceeds the requirements according to IEC publication 60495, second edition, Sept. 1993, with reference to single sideband PLC equipment.

The integrated teleprotection equipment NSD600 complies with or exceeds the requirements according to IEC publication 60834-1 "Teleprotection Equipment of Power Systems - Performance and Testing – Part 1: Command Systems".

SYSTEM DATA

Operating mode 2 - wire frequency duplex
Modulation Single Side Band with suppressed carrier (SSB)
Multi-Carrier Modulation with Trellis Coding and Forward Error Correction
Single step frequency conversion with Direct Digital Synthesis (DDS)
Nominal bandwidth 2, 4, 8, 12, 16, 20, 24, 28, 32 kHz (each direction)
Edge frequencies at multiples of 500 Hz
Standards compliance IEC 60495, IEC 60834-1, IEC 60950-1, IEC 61000-6-2, IEC 61000-6-4 (EN 55022 / CISPR22, Class A)
Nominal transmit output power (PEP) ETL600-050: 50 W / +47 dBm
ETL600-100: 100 W / +50 dBm
The output power may be decreased via user interface program (HMI) in steps of 1 dB
RF frequency range 24 to 1000 kHz for nominal bandwidths ≥ 4 kHz
24 to 500 kHz for 2 kHz nominal bandwidth
Nominal output impedance 75 Ohm unbalanced
150 Ohm balanced (option)
Return loss ≥ 10 dB in the nominal Tx band
Tapping loss ≤ 1.5 dB at and beyond +/- 1.5 x Tx filter bandwidth from Tx filter center frequency
Receiver sensitivity -30 dBm Pilot level at the RF input
Receiver selectivity - at 300 Hz / 4 kHz from the band edges > 65 dB / > 75 dB for nominal bandwidth > 2 kHz
- at 300 Hz / 2 kHz from the band edges > 55 dB / > 65 dB for nominal bandwidth 2 kHz
Image rejection ≥ 75 dB
AGC (Automatic Gain Control) 40 dB dynamic range
Supply -48 VDC +20/-15%
Power consumption Normal operation @ 75 Ohm Dual tone modulation PEP @ 75 Ohm
ETL600-050 135 W 175 W
ETL600-100 210 W 280 W
Alarm relay outputs free changeover contacts
- System alarm / Cabinet alarm
- Hardware alarm
- Link alarm
- Interface alarm
- Warning
Event recording 2'600 time-stamped alarm & manipulation events, stored in non-volatile memory
Clock synchronizing input for IRIG-B available
AUDIO FREQUENCY SERVICES

No audio frequency services available for nominal bandwidth of 2 kHz

Application  Transparent transmission of analog voice-frequency signals like speech, teleoperation, VFT-modems, facsimile.

Number of AF channels for the transparent transmission of speech plus superimposed teleoperation signals:
- 0, 1, 2 or 3 channels with 4 kHz bandwidth each, or
- 3 channels of 3.2, 2.4 and 2.4 kHz bandwidth respectively, in 8 kHz total bandwidth,

Frequency offset  = 0 Hz

Number of speech channels At most one in each AF channel

Speech low-pass filter cut-off frequency - 2.0 kHz to 3.4 kHz, programmable in steps of 200 Hz, limited by AF channel bandwidth
- 1.6 kHz for nominal bandwidth of 2 kHz

Speech limiter +3 dBm0

Speech compandor on/off; according to ITU-T G.162

Telephony (analog)

No telephony services except service phone available for nominal bandwidth of 2 kHz

4-wire PAX interface with E&M
Impedance  600 Ohms, balanced
Input level range  -20 to +4 dBm
Output level range -20 to +5.5 dBm

2-wire subscriber interface (FXS)
Impedance  600 Ohms, balanced
Input level range  -17 to +4 dBm
Output level range -17 to +1 dBm
Ringing frequency  25 or 20 Hz, programmable
Ringing voltage  50 Vrms open circuit;
≥ 36 Vrms across 2.333 kOhm load
DC loop voltage  48 VDC ± 15% open loop

2-wire PAX interface (FXO)
Impedance  600 Ohms, balanced
Input level range  -17 to +4 dBm
Output level range -17 to +1 dBm
Ringing voltage detection range 20 to 130 Vrms / 17 to 55 Hz

Service telephone  Connector for 2-wire telephone set RJ11 on front panel

Telephony (digitally compressed)

Number of channels  ≤ 16 for ETL600-050-2, ETL600-100-2
≤ 12 for ETL600-050-1
Data rate  5.3 or 6.3 kbps programmable
Algorithm  MP-MLQ / ACELP according to ITU-T G.723.1
Modes Voice and FAX 4.8 kbps (automatic FAX detection)
Signalization  DTMF and Pulse-Code-Dialing
Echo canceller according to ITU-T G.168

Digital transit
Number of transit connections up to 5 (i.e. 6 telephony links in a chain)
Number of links per node up to 5 (1 master, up to 4 slaves)

4-wire PAX interface with E&M
Impedance  600 Ohms, balanced
Input level range  -20 to +5 dBm
Output level range -20 to +8 dBm

2-wire subscriber interface (FXS)
Impedance  programmable, see below
Input level range  -17 to +4 dBm
Output level range -17 to +1 dBm
Ringing frequency  16, 20, 25, 50 or 60 Hz, programmable
Ringing voltage  50 Vrms open circuit;
≥ 36 Vrms across 2.333 kOhm load
DC loop voltage  48 VDC ± 15% open loop
2-wire PAX interface (FXO)
- Impedance programmable, see below
- Input level range -17 to +4 dBm
- Output level range -17 to +1 dBm
- Ringing voltage detection range 20 to 130 Vrms / 15 to 65 Hz

Service telephone
- Connector for 2-wire telephone set RJ11 on front panel

Programmable impedances for 2-wire interfaces (FXS, FXO and service phone)

<table>
<thead>
<tr>
<th>Rs [Ω]</th>
<th>Rp [Ω]</th>
<th>Cp [nF]</th>
</tr>
</thead>
<tbody>
<tr>
<td>600</td>
<td>0</td>
<td>infinite</td>
</tr>
<tr>
<td>220</td>
<td>820</td>
<td>115</td>
</tr>
<tr>
<td>300</td>
<td>1000</td>
<td>220</td>
</tr>
<tr>
<td>900</td>
<td>infinite</td>
<td>1160</td>
</tr>
<tr>
<td>270</td>
<td>750</td>
<td>150</td>
</tr>
</tbody>
</table>

Teleoperation
- Number of ports ≤ 20
- Impedance 600 Ohms, balanced
- Input level -20 to +4 dBm
- Output level -20 to +8 dBm

Transit filters
- Number of filters ≤ 20
- Standard filters Programmable bandpass filters with cut-off frequencies selectable in steps of 60 Hz
- Group delay equalized filters - bandpass filters for teleoperation band above speech 2000, 2200 or 2400 Hz, or
  - 3'600 Hz lowpass filter

DATA SERVICES

No data services available for nominal bandwidth of 2 kHz

Data ports

V.11 ports
- Number of V.11/X.21/X.24 ports 1 or 2 (option), depending on configuration
- Data rates 9.6, 12, 14.4, 16, 19.2, 24, 28.8, 32, 36, 38.4, 40, 48, 56, 64, 72, 76.8, 80, 96, 112, 128, 144, 153.6, 160, 192, 224, 256, 288, 307.2, 320 kbps
- Clock direction from ETL600 codirectional

V.24 ports
- Number of V.24/RS-232 ports 2 or 4 (option), depending on configuration;
  with optional port sharing and jabber timeout for point-multipoint operation
- Data rates with MOD600:
  - ETL600 Rel.4.0.0: 1'200, 2'400, 4'800, 9'600 or 19'200 bps
  - ETL600 Rel.4.0.1 and later: 200, 300, 600, 1'200, 2'400, 4'800, 9'600 or 19'200 bps
  - with NSK600: according to selected NSK600 channel

V.24 port sharing device
- Number of shared ports up to 4 electrical
- Jabber timeout 100 s; can be disabled
- Application sharing of one data channel by several RTUs (Remote Terminal Units)

Digital transit ports (option)
- Number of digital transit ports 2 electrical, connector type RJ-45,
  to daisy-chain up to 5 ETL600 terminals by means of 1:1 Ethernet cables
  digitally compressed telephony

LAN ports (option)
- Number of LAN ports 3 electrical plus
  1 optical with SFP transceiver (optional, with automatic laser shutdown ALS)
- Programmable data rates 9.6, 12, 14.4, 16, 19.2, 24, 28.8, 32, 36, 38.4, 40, 48, 56, 64, 72, 76.8, 80, 96, 112, 128, 144, 153.6, 160, 192, 224, 256, 288, 307.2 kbps
- Connector electrical: 10/100BaseT: shielded twisted pair (STP), connector type RJ-45
  optical: 100 Mbps (SFP 850 nm MM or 1310 nm SM), connector type LC
- Link layer auto or manual negotiation (full/half duplex and 10/100Mbps)
  conforms to IEEE 802.3 / Ethernet II
Technical Data ETL600 Rel.4  ABB Switzerland Ltd

Services

- switch (layer 2) or router (layer 3), SNMP, HMI over LAN
- VLAN support according to IEEE 802.1q for switch
- Link fault pass through
- up to 16 static routes
- flow control
- 4 priority queues

Data compression (configurable)

- TCP/IP header compression according to RFC1144
- UDP/IP and RTP/UDP/IP header compression according to RFC 3095

Narrowband data (NSK600)

Application

Data transmission in bandwidth of less than 4 kHz, in point-point or point-multipoint applications (e.g. polling SCADA)

Number of narrowband modems

≤ 4 for data rates ≤ 4800 bps or
≤ 3 for data rates ≤ 9600 bps

Programmable bandwidth and data rates:

<table>
<thead>
<tr>
<th>Operational data rate [bps]</th>
<th>100 Bd</th>
<th>200 Bd narrow</th>
<th>200 Bd wide</th>
<th>600 Bd</th>
<th>1200 Bd V.23</th>
<th>1200 Bd narrow</th>
<th>2400 bps</th>
<th>4800 bps</th>
<th>9600 bps</th>
</tr>
</thead>
<tbody>
<tr>
<td>Data format</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nominal bandwidth [Hz]</td>
<td>240</td>
<td>360</td>
<td>480</td>
<td>960</td>
<td>2'400</td>
<td>1'640</td>
<td>840</td>
<td>1'680</td>
<td>3'360</td>
</tr>
<tr>
<td>Center frequency steps [Hz]</td>
<td>60</td>
<td>60</td>
<td>60</td>
<td>60</td>
<td>n.a.</td>
<td>1'660</td>
<td>60</td>
<td>60</td>
<td>n.a.</td>
</tr>
<tr>
<td>Equalizer</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
| Max. data rates above 2 kHz speech band | 1 x 1200 Bd (asynchronous, transparent), or 2 x 2400 bps, or 1 x 4800 bps (asynchronous, UART)

Broadband data (MOD600)

Application

Transmission of high-speed / high capacity data in bandwidth of 4 kHz or higher.

Number of broadband modems

1

Transmission bandwidth

2, 4, 6, 8, 12, 16, 20, 24, 28, 32 kHz

Programmable data rates

9.6, 11 \(^1\), 12, 14.4, 16, 19.2, 24, 28.8, 32, 36, 38.4, 40, 48, 56, 64, 72, 76.8, 80, 96, 112, 128, 144, 153.6, 160, 192, 224, 256, 288, 307.2, 320 kbps

\(^1\) Available only for transmission bandwidth 2 kHz

Fallback / fall-forward

According to 5 user-selectable data-rates

Switchover time

≤ 8 s for transmission bandwidth 4 kHz and default N/L settings
≤ 4 s for transmission bandwidth > 4 kHz and default N/L settings

Typical efficiency (data rate divided by bandwidth) in relation to SNR for default Delay/Efficiency setting:

![Graph](image)

Multiplexer (MUX600)

Application

Time-division multiplexing of a number of data and compressed telephony channels into an aggregate data stream

Number of channels

10 for data and 16 for compressed telephony

Multiplexing method

TDM, with data flow control and speed adaptation according to aggregate capacity
TELEPROTECTION (NSD600)

Application
Transmission of protection commands for line- and objects protection

Number of units
1 or 2 integrated NSD600

Number of commands
for each NSD600 in 3.2 kHz or 4 kHz APLC channels:
4 independent commands A, B, C, D, simultaneously transmitted, individually configurable for blocking, permissive or direct tripping, plus 1 test command T per NSD600.

Single purpose teleprotection NSD600 in the 2 kHz APLC channel:
3 independent commands A, B, C, simultaneously transmitted, individually configurable for blocking, permissive or direct tripping, 1 prioritized command D for direct tripping, overriding A, B, C, plus 1 test command T.

Command duration
Command suppression after 1 to 60 s, programmable in steps of 1 s (individual for each command), with alarm (back to guard state);

Single purpose teleprotection NSD600 in the 2 kHz APLC channel:
Unlimited (command suppression may be disabled individual for each command), with timed Tx output power reduction to pre-defined value after 1 to 60 s, programmable in steps of 1 s (common for all commands).

Unblocking output
Unblocking output contact closes for a predefined time (e.g. 200 ms) upon loss of Rx-signal (no trip and no guard)

Secure against
Noise (continuous or impulsive), speech and sweep tones, DTMF (CCITT 48430 or ITU-T Q.23) in-band signaling

Bandwidth requirement
Nil; command signal transmission in-band (alternate purpose, with signal boosting)

Guard signal
ETL-pilot signal, or own guard signal above speech band 2000, 2200 or 2400 Hz

Processing of received signal
Adaptive (to prevailing channel condition, always ensuring shortest transmission times)

Number and type of inputs
4 optocoupler per Teleprotection Interface G4AI

Method of tripping
Contact and battery, or dry contact

Voltage ranges
24 to 250 VDC, selectable in 4 ranges

Number and type of outputs
4 solid state relays and 2 mechanical relay contacts per Teleprotection Interface G4AI

Tripping voltage
5 to 250 VDC nominal

Tripping current
≤ 1 A carry / 2 A peak solid state
5 A carry / 20 A peak mechanical relay

HMI configurable
Command and alarm assignments to I/O ports, Command pick-up times, hold times, duration monitoring, State of command outputs during link alarm, Alarm and unblocking levels thresholds.

Test facilities
Manual or periodic loop test every 1, 3, 6, 12, 24 hours

Event logging
2'600 time-stamped command events, command counters; stored in non-volatile memory Clock synchronizing input for IRIG-B available

Teleprotection performance

NSD600 in 2 kHz, 3.2 kHz or 4 kHz APLC channels:

<table>
<thead>
<tr>
<th>Performance criteria</th>
<th>Description of measurement</th>
<th>Abbrev.</th>
<th>Blocking</th>
<th>Permissive tripping</th>
<th>Direct tripping</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nominal transmission time</td>
<td>Back-to-back operation, including PLC equipment delay and operating times of the teleprotection interface I/Os, noise free channel</td>
<td>T0 1)</td>
<td>≤ 10 ms 2)</td>
<td>≤ 11 ms’</td>
<td>≤ 12 ms’</td>
</tr>
<tr>
<td>Security - probability of an unwanted command</td>
<td>Probability of an unwanted command (200 ms noise, 200 ms pause, worst case SNR)</td>
<td>Puc</td>
<td>&lt; 1E-04</td>
<td>&lt; 1E-06</td>
<td>&lt; 1E-09</td>
</tr>
<tr>
<td>Dependability - probability of missing a command</td>
<td>Required channel condition</td>
<td>Pmc</td>
<td>&lt; 1E-03</td>
<td>&lt; 1E-03</td>
<td>&lt; 1E-04</td>
</tr>
<tr>
<td></td>
<td>For maximum actual transmission time</td>
<td>Tac 3)</td>
<td>14 ms / 15 ms</td>
<td>17 ms / 20 ms</td>
<td>22 ms / 26 ms</td>
</tr>
</tbody>
</table>

1) Valid for the solid state command outputs, add 5…8 ms for the relay contact command outputs.
2) With own NSD600 guard. Add 1 ms for ETL600 pilot with frequency > 3600 Hz as guard signal.
3) Add 1 ms for NSD600 in 2 kHz APLC channel plus 2 kHz DPLC channel.
**NSD600 in DPLC channel:**

<table>
<thead>
<tr>
<th>Performance criteria, description of measurement</th>
<th>Abbrev.</th>
<th>Blocking</th>
<th>Permissive tripping</th>
<th>Direct tripping</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Nominal transmission time</strong> (back-to-back operation, including PLC equipment delay and operating times of the teleprotection interface I/Os; noise free channel)</td>
<td>T₀¹</td>
<td>≤ 11 ms</td>
<td>≤ 12 ms</td>
<td>≤ 13 ms</td>
</tr>
<tr>
<td><strong>Security</strong> - probability of an unwanted command (200 ms noise, 200 ms pause, worst case SNR)</td>
<td>Puc</td>
<td>&lt; 1E-03</td>
<td>&lt; 1E-06</td>
<td>&lt; 1E-09</td>
</tr>
<tr>
<td><strong>Dependability</strong> - probability of missing a command</td>
<td>Pmc</td>
<td>&lt; 1E-03</td>
<td>&lt; 1E-03</td>
<td>&lt; 1E-04</td>
</tr>
<tr>
<td>required channel condition</td>
<td>SNR</td>
<td>6 dB</td>
<td>6 dB</td>
<td>6 dB</td>
</tr>
<tr>
<td>for maximum actual transmission time</td>
<td>Tac¹</td>
<td>15 ms</td>
<td>17 ms</td>
<td>22 ms</td>
</tr>
</tbody>
</table>

¹) Valid for the solid state command outputs, add 5…8 ms for the relay contact command outputs.

**Single purpose teleprotection NSD600 in 2 kHz APLC channel:**

<table>
<thead>
<tr>
<th>Performance criteria, description of measurement</th>
<th>Abbrev.</th>
<th>Blocking</th>
<th>Permissive tripping</th>
<th>Direct tripping</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Nominal transmission time</strong> (back-to-back operation, including PLC equipment delay and operating times of the teleprotection interface I/Os; noise free channel)</td>
<td>T₀¹</td>
<td>≤ 11 ms</td>
<td>≤ 12 ms</td>
<td>≤ 14 ms</td>
</tr>
<tr>
<td><strong>Security</strong> - probability of an unwanted command (200 ms noise, 200 ms pause, worst case SNR)</td>
<td>Puc</td>
<td>&lt; 1E-03</td>
<td>&lt; 1E-06</td>
<td>&lt; 1E-09</td>
</tr>
<tr>
<td><strong>Dependability</strong> - probability of missing a command</td>
<td>Pmc</td>
<td>&lt; 1E-03</td>
<td>&lt; 1E-03</td>
<td>&lt; 1E-04</td>
</tr>
<tr>
<td>required channel condition</td>
<td>SNR</td>
<td>6 dB</td>
<td>6 dB</td>
<td>6 dB</td>
</tr>
<tr>
<td>for maximum actual transmission time</td>
<td>Tac¹</td>
<td>17 ms</td>
<td>19 ms</td>
<td>30 ms</td>
</tr>
</tbody>
</table>

¹) Valid for the solid state command outputs, add 5…8 ms for the relay contact command outputs.

**USER INTERFACE PROGRAM (HMI600)**

- **Hardware and OS requirements**: PC with Windows XP, Windows Vista or Windows 7
- **Port for connection of service PC**: RS-232 / 9’600, 19’200, 57’600 bps
  - USB with optional interface converter
  - Ethernet
- **Integrated testing aids**
  - **Channel equalization**: Automatic, with graphical display of channel amplitude response
  - **Spectrum analyzer**: for graphical display of signal spectra in AF channels
  - **Auxiliary signals generation**: for tuning, testing and commissioning
- **Element management**
  - **Address range for up to 65’000 terminals**: Support of mixed ETL500 / ETL600 networks
  - **Firmware download and equipment settings local and remotely via Embedded Operation Channel (EOC) or via LAN600**: Support of mixed ETL500 / ETL600 networks
- **Secure sockets layer (SSL)**
  - **Version**: TLS 1.0
  - **Cipher algorithms**: RSA 1024, AES 128
  - **Certificate format**: X.509

This product includes software developed by the OpenSSL Project for use in the OpenSSL Toolkit. (http://www.openssl.org/)
This product includes cryptographic software written by Eric Young (eay@cryptsoft.com)
AMBIENT CONDITIONS

Operation
Climatic conditions IEC 60721-3-3, Class 3K5
Temperature range Within specification: -5 to +55 °C
Humidity ≤ 95%, < 28 g/m3, non-condensing

Mechanical conditions IEC 60721-3-3, Class 3M1
Vibration and shock IEC 60068-2-6, IEC 60068-2-27

Transport
Climatic conditions IEC 60721-3-2, Class 2K4
Temperature range -30 to +70 °C
Humidity ≤ 95%, < 28 g/m3, non-condensing

Mechanical conditions IEC 60721-3-2, Class 2M1
Vibration sinusoidal IEC 60068-2-6
Shock and free fall IEC 60068-2-27, IEC 60068-2-32 0.25 m / equipment is packed

Storage
Climatic conditions IEC 60721-3-1, Class 1K5
Temperature range -30 to +70 °C
Humidity ≤ 95%, < 28 g/m3, non-condensing

Mechanical conditions IEC 60721-3-1, Class 1M1

DIMENSIONS AND WEIGHTS

Equipment subracks: 19” wide conforming to standards IEC 60297 and DIN 41494
6 units high (1 unit = 44.45 mm)

<table>
<thead>
<tr>
<th>Dimensions / weight (without front cables)</th>
<th>Height</th>
<th>Width</th>
<th>Depth</th>
<th>Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>ETL600-050-1</td>
<td>308 mm</td>
<td>482 mm</td>
<td>301 mm</td>
<td>13 kg</td>
</tr>
<tr>
<td>ETL600-050-2</td>
<td>575 mm</td>
<td>482 mm</td>
<td>301 mm</td>
<td>16 kg</td>
</tr>
<tr>
<td>ETL600-100-2</td>
<td>575 mm</td>
<td>482 mm</td>
<td>301 mm</td>
<td>20 kg</td>
</tr>
</tbody>
</table>

Specifications subject to change without notice.

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or +41 844 845 845 (Call Center)
Fax +41 58 585 16 88
E-Mail utilitycommunications@ch.abb.com

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Do you find the publication readily understandable and logically structured? Can you make any suggestions to improve it?

Is the information sufficient for the purpose of the publication? If not, what is missing and where should it be included?

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Company ___________________________
Postal code __________ Town __________ Country ___________
IMPORTANT NOTICE!

The ETL600 equipment may only be installed, operated and maintained by trained personnel.

Experience has shown that reliable operation of our products is assured, providing the information and recommendations contained in these Operating Instructions are adhered to.

It is scarcely possible for the instructions to cover every eventuality that can occur when using technical devices and systems. We would therefore request the user to notify us directly or our agent of any unusual observations or instances, in which these instructions provide no or insufficient information.

In addition to these instructions, any applicable local regulations and safety procedures must always be strictly observed both when connecting up and commissioning this equipment.

Any work such as insertion or removal of soldered jumpers or setting resistors, which may be necessary, may only be performed by appropriately qualified personnel.

We expressly accept no responsibility for any direct damage, which may result from incorrect operation of this equipment, even if no reference is made to the particular situation in the Operating Instructions.

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