MOTOTRBO™ REPEATER

PROFESSIONAL DIGITAL TWO-WAY RADIO SYSTEM

SLR 1000 Repeater Basic Service & Installation Manual

DECEMBER 2018

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MN003557A01-AF

Notice

Foreword

This manual covers all versions of the MOTOTRBO SLR 1000 Repeater, unless otherwise specified. It includes all the information necessary to maintain peak product performance and maximum working time, using levels 1 and 2 maintenance procedures. These levels of service go down to software issues or replacement of an accessory, commonly performed by local service centers, Motorola Solutions Authorized Dealers, self-maintained customers, and distributors.

CAUTION: These servicing instructions are for use by qualified personnel only. To reduce the risk of electric shock, do not perform any servicing other than what is contained in the Operating Instructions unless you are qualified to do so. Refer all servicing to qualified service personnel.

Related Links

Notations Used in This Manual on page 2
General Safety Precautions on page 2
Copyrights on page 3
Disclaimer on page 3
Trademarks on page 4

Notations Used in This Manual

Throughout the text in this publication, three types of notations are used to emphasize that safety hazards exist, and due care must be taken and observed.

NOTICE: An operational procedure, practice, or condition which is essential to emphasize.

CAUTION: CAUTION indicates a potentially hazardous situation which, if not avoided, **might** result in equipment damage.

WARNING: WARNING indicates a potentially hazardous situation which, if not avoided, **could** result in death or injury.

Symbol indicates areas of the product that pose potential burn hazards.

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General Safety Precautions

For more information, see General Safety and Installation Standards and Guidelines.

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European Union (EU) Waste of Electrical and Electronic Equipment (WEEE) directive

The European Union's WEEE directive requires that products sold into EU countries must have the crossed out trash bin label on the product (or the package in some cases).

As defined by the WEEE directive, this cross-out trash bin label means that customers and end-users in EU countries should not dispose of electronic and electrical equipment or accessories in household waste.

Customers or end-users in EU countries should contact their local equipment supplier representative or service centre for information about the waste collection system in their country.

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Disclaimer

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Notice

General Safety and Installation Standards and Guidelines

ATTENTION!

WARNING: For safe installation, operation, service and repair of this equipment, follow the safety precautions and instructions, as well as any additional safety information in Motorola Solutions product service and installation manuals and the Motorola Solutions R56 Standards and Guidelines for Communications Sites manual (which can be obtained by ordering CDROM 9880384V83). To obtain copies of these materials, contact Motorola Solutions as directed at the end of this section. After installation, these instructions should be retained and readily available for any person operating or servicing this repeater or working near it.

Failure to follow these safety precautions and instructions could result in serious injury or property damage.

The installation process requires preparation and knowledge of the site before installation begins. Review installation procedures and precautions in the Motorola Solutions R56 manual before performing any site or component installation. Personnel must use safe work practices and good judgment, and always follow applicable safety procedures, such as requirements of the Occupational Safety and Health Administration (OSHA), the National Electrical Code (NEC), and local codes.

The following are additional general safety precautions that must be observed:

- To continue compliance with any applicable regulations and maintain the safety of this equipment, do not install substitute parts or perform any unauthorized modifications.
- All equipment must be serviced by Motorola Solutions trained personnel.
- If troubleshooting the equipment while the power is on, be aware of live circuits which could contain hazardous voltage.
- Do not operate the radio transmitters unless all RF connectors are secure and all connectors are properly terminated.
- All equipment must be properly grounded in accordance with the Motorola Solutions R56 and specified installation instructions for safe operation.
- Openings between the fins on the chassis are provided for ventilation. Do not block or cover openings between the fins that protect the devices from overheating.
- Some equipment components can become extremely hot during operation. Turn off all power to the equipment and wait until sufficiently cool before touching.
- Maintain emergency first aid kits at the site.
- Never store combustible materials in or near equipment. The combination of combustible material, heat, and electrical energy increases the risk of a fire hazard.
- Equipment shall be installed in a site that meets the requirements of a “restricted access location,” per (UL60950-1 & EN60950-1), which is defined as follows: "Access can only be gained by service persons or by users who have been instructed about the reasons for the restrictions applied to the location and about any precautions that shall be taken; and access is through the use of a tool or lock and key, or other means of security, and is controlled by the authority responsible for the location."

- Ensure that the installation area can safely support the weight of the repeater.
- Burn hazard. The metal housing of the product may become extremely hot. Use caution when working around the equipment.
- RF energy burn hazard. Disconnect power to prevent injury before disconnecting and connecting antennas.
- Shock hazard. The outer shields of all Tx and Rx RF cables outer shields must be grounded per Motorola Solutions R56 manual.
- All Tx and Rx RF cables shall be connected to a surge protection device according to Motorola Solutions R56 manual. Do not connect Tx and Rx RF cables directly to an outside antenna.
- Attention Compliance with National and International standards and guidelines for human exposure to Electromagnetic Energy (EME) at Transmitter Antenna sites generally requires that persons having access to a site shall be aware of the potential for exposure to EME and can exercise control of exposure by appropriate means, such as adhering to warning sign instructions. See this installation manual and Appendix A of Motorola Solutions R56.
  This product complies with the requirements set forth by the European R&TTE regulations and applicable CENELEC standards concerning human exposure to Electromagnetic Energy (EME) at Transmitter Antenna sites. MOTOTRBO Repeater EME Assessment on page 132 in this manual includes an EME exposure analysis of a typical system configuration for this product.

  For a different system configuration than the typical configuration, compliance with applicable EME exposure standards (current versions of the EN50384, EN50385, IEC/IEEE 62704-2, and United States Federal Communication Commission, “Evaluating compliance with FCC guidelines for human exposure to radio frequency electromagnetic fields,” OET Bulletin 65 (Ed. 97-01), August 1997. Supplement C (Edition 01-01) to US FCC OET Bulletin 65 (Edition 97-01), “Additional Information for Evaluating Compliance of Mobile and Portable Devices with FCC Limits for Human Exposure to Radio frequency Emissions,” June 2001 standards for occupational and general public exposure, respectively) can be evaluated by either employing the indoor or outdoor methods illustrated in the typical system configuration EME exposure analysis included in MOTOTRBO Repeater EME Assessment on page 132 in this manual, or employing another suitable method among those described in the current version of the EN50383 standard.

  Once the occupational and general public compliance boundaries are determined, means to ensure that workers and people are outside the respective boundaries, for instance using appropriate signage or restricted access, should be implemented; if this is not possible or practically achievable for the specific system configuration, the configuration should be modified in order to make it possible. The R56 Standards and Guidelines for Communications Sites manual (which can be obtained by ordering CDROM 9880384V83) provides examples of signage that can be used to identify the occupational or general public compliance boundaries.

  Refer to product specific manuals for detailed safety and installation instructions. Manuals can be obtained with product orders, downloaded from https://businessonline.motorolasolutions.com, or purchased through the Motorola Solutions Aftermarket & Accessory Department.

  This is a class A product. In a domestic environment, this product may cause radio interference in which case the user may be required to take adequate measures.

Declaration of Conformity

This declaration is applicable to your radio only if your radio is labeled with the FCC logo shown below.

Declaration of Conformity
Per FCC CFR 47 Part 2 Section 2.1077(a)

Responsible Party

Name: Motorola Solutions, Inc.

Address: 1303 East Algonquin Road, Schaumburg, IL 60196-1078, U.S.A.

Phone Number: 1-800-927-2744

Hereby declares that the product:

Model Name: **SLR 1000**

conforms to the following regulations:

FCC Part 15, subpart B, section 15.107(a), 15.107(d), and section 15.109(a)

Class A Digital Device
This device complies with Part 15 of the FCC rules. This device complies with Industry Canada license-exempt RSS standard(s). Operation is subject to the following two conditions:

1. This device may not cause harmful interference, and
2. This device must accept any interference received, including interference that may cause undesired operation.

NOTICE: This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to part 15 of the FCC Rules and Industry Canada license-exempt RSS standard. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation.
If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- Reorient or relocate the receiving antenna.
- Increase the separation between the equipment and receiver.
- Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
- Consult the dealer or an experienced radio or TV technician for help.

Notice

MOTOTRBO SLR 1000 Repeater Supplemental Safety and Installation Requirements

CAUTION:
The MOTOTRBO SLR 1000 Repeater must be installed in a suitable, in-building location, or suitable outdoor location. A restricted access location is required when installing this equipment into the end system.

When installing the equipment, all requirements of relevant standards and local electrical codes must be fulfilled.

The maximum operating ambient temperature of this equipment is 60 °C, at sea level. Operating altitudes up to 5000 meters above sea level are supported, but maximum operating temperature shall degrade by 1 °C /1000 m elevation. Operation above 5000 may be feasible but operating specifications and parameters are not guaranteed, and reduced performance may result.

Notice

Environmental Information

Related Links

Material Content on page 9
Disposal of your Electronic and Electric Equipment on page 9
Disposal Guideline on page 10

Material Content

This is to declare that Motorola Solutions products comply with the EU Directive 2011/65/EU (Restriction of Hazardous Substance or RoHS-2) and India RoHS, including applicable exemptions, concerning the following substances:

- Lead (Pb) < 0.1% by weight (1000 ppm)
- Mercury (Hg) < 0.1% by weight (1000 ppm)
- Cadmium (Cd) < 0.01% by weight (100 ppm)
- Hexavalent Chromium (Cr6+) < 0.1% by weight (1000 ppm)
- Polybrominated Biphenyls (PBB) < 0.1% by weight (1000 ppm)
- Polybrominated Diphenyl Ethers (PBDE) < 0.1% by weight (1000 ppm)

NOTICE:

- The Motorola Solutions MOTOTRBO SLR 1000 Repeater system and its subsystems have been created in compliance with the environmental goals of the European Union's Restriction of Hazardous Substances (RoHS 2) Directive 2011/65/EU and the Waste Electrical and Electronic Equipment (WEEE) Directive 2012/19/EU as well as Motorola Solutions corporate goals to minimize environmental impact of its products.
- This Motorola Solutions policy is reflected throughout the entire design, procurement, assembly, and packaging process.
- In support of these efforts to provide environmentally-responsible products, comply with the information in the following sections regarding product disposal for systems being replaced.

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Disposal of your Electronic and Electric Equipment

Do not dispose of electronic and electric equipment or electronic and electric accessories with your household waste.

In some countries or regions, collection systems have been set up to handle waste of electrical and electronic equipment.

In European Union countries, contact your local equipment supplier representative or service center for information about the waste collection system in your country.

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Disposal Guideline

The European Union's WEEE directive symbol on a Motorola Solutions product indicates that the product should not be disposed of with household waste.

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Document History

The following major changes have been implemented in this manual since the previous edition:

Edition	Description	Date
MN003557A01-AA	Initial release of the MOTOTRBO *SLR 1000 Repeater Basic Service & Installation* manual	June 2017
MN003557A01-AB	Second release of the MOTOTRBO *SLR 1000 Repeater Basic Service & Installation* manual. • The Duplexer part numbers were updated in Appendix A.	August 2017
MN003557A01-AC	Third release of the MOTOTRBO *SLR 1000 Repeater Basic Service & Installation* manual. • Appendix E: MOTOTRBO Repeater EME Assessment updated.	December 2017
MN003557A01-AD	Fourth release of the MOTOTRBO *SLR 1000 Repeater Basic Service & Installation* manual. • Table 18: Auxiliary/Accessory Connector Callout Legend - Updated Pin 2, Pin 5, Pin 6 and Pin 8 information. • Appendix E: MOTOTRBO Repeater EME Assessment - Updated Reference of EN 50385: 2002 to EN 50385: 2017.	April 2018
MN003557A01-AE	Fifth release of the *SLR 1000 Repeater Basic Service & Installation*manual. • Figure 9: SLR1000 Repeater Model Numbering Scheme - Updated frequencies for band J. • Table 6: SLR1000 Frequency Ranges and Power Levels - Added VHF frequencies and VHF self-quieting frequencies. • Table 13: SLR1000 Repeater Specifications of the Transmitter Exciter Subsystem - Updated VHF values. • Added Figure 24: SLR1000 VHF Repeater Band Reject (Notch) Duplexer. • Updated Appendix A: A.1.1 Antennas and A.1.4 Duplexers • Appendix E: MOTOTRBO Repeater EME Assessment - Added E.3.3: Equivalent Plane Wave Power Density Evaluation; Updated E5 - EME Exposure Evaluation	November 2018
MN003557A01-AF	Sixth release of the *SLR 1000 Repeater Basic Service & Installation*manual.	December 2018

Edition	Description	Date
	• Declaration of Conformity added	
	• Changed Spurious Harmonics and Emissions figures for Repeater Specifications; • Industry Canada requirements added to SLR 1000 Repeater General Specifications;	January 2018

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Related Publications

Related Publications	Part No.
MOTOTRBO SLR 1000 Quick Start Guide	MN003581A01

Summary of Bands Available

The following table lists the SLR 1000 Repeater bands available in this manual.

For details, see Repeater Model Chart on page 44.

Frequency Band	Bandwidth	Power Level
VHF	136-174 MHz	1–10 W
UHF	400–512 MHz	1-10 W

Notice

Commercial Warranty

Related Links

Limited Commercial Warranty on page 25

Limited Commercial Warranty

This limited commercial warranty describes the conditions under, and period during, which the repeater is repaired, replaced, and what is not covered.

I. What This Warranty Covers And For How Long

MOTOROLA SOLUTIONS INC. (“MOTOROLA”) warrants the MOTOROLA manufactured Communication Products listed below (“Product”) against defects in material and workmanship under normal use and service for a period of time from the date of purchase as scheduled below:

Repeater	Two (2) Years
Product Accessories	One (1) Year

Motorola, at its option, will at no charge either repair the Product (with new or reconditioned parts), replace it (with a new or reconditioned Product), or refund the purchase price of the Product during the warranty period provided it is returned in accordance with the terms of this warranty. Replaced parts or boards are warranted for the balance of the original applicable warranty period. All replaced parts of Product shall become the property of MOTOROLA.

This express limited warranty is extended by MOTOROLA to the original end user purchaser only and is not assignable or transferable to any other party. This is the complete warranty for the Product manufactured by MOTOROLA. MOTOROLA assumes no obligations or liability for additions or modifications to this warranty unless made in writing and signed by an officer of MOTOROLA. Unless made in a separate agreement between MOTOROLA and the original end user purchaser, MOTOROLA does not warrant the installation, maintenance or service of the Product.

MOTOROLA cannot be responsible in any way for any ancillary equipment not furnished by MOTOROLA which is attached to or used in connection with the Product, or for operation of the Product with any ancillary equipment, and all such equipment is expressly excluded from this warranty. Because each system which may use the Product is unique, MOTOROLA disclaims liability for range, coverage, or operation of the system as a whole under this warranty.

II. General Provisions

This warranty sets forth the full extent of MOTOROLA's responsibilities regarding the Product. Repair, replacement or refund of the purchase price, at MOTOROLA's option, is the exclusive remedy. THIS WARRANTY IS GIVEN IN LIEU OF ALL OTHER EXPRESS WARRANTIES. IMPLIED WARRANTIES, INCLUDING WITHOUT LIMITATION, IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE, ARE LIMITED TO THE DURATION OF THIS LIMITED WARRANTY. IN NO EVENT SHALL MOTOROLA BE LIABLE FOR DAMAGES IN EXCESS OF THE PURCHASE PRICE OF THE PRODUCT, FOR ANY LOSS OF USE, LOSS OF TIME, INCONVENIENCE, COMMERCIAL LOSS, LOST PROFITS OR SAVINGS OR OTHER INCIDENTAL, SPECIAL OR CONSEQUENTIAL DAMAGES ARISING OUT OF THE USE OR INABILITY TO USE SUCH PRODUCT, TO THE FULL EXTENT SUCH MAY BE DISCLAIMED BY LAW.

III. State Law Rights

SOME STATES DO NOT ALLOW THE EXCLUSION OR LIMITATION OF INCIDENTAL OR CONSEQUENTIAL DAMAGES OR LIMITATION ON HOW LONG AN IMPLIED WARRANTY LASTS, SO THE ABOVE LIMITATION OR EXCLUSIONS MAY NOT APPLY.

This warranty gives specific legal rights, and there may be other rights which may vary from state to state

IV. How To Get Warranty Service

You must provide proof of purchase (bearing the date of purchase and Product item serial number) in order to receive warranty service and, also, deliver or send the Product item, transportation and insurance prepaid, to an authorized warranty service location. Warranty service will be provided by Motorola through one of its authorized warranty service locations. If you first contact the company which sold you the Product, it can facilitate your obtaining warranty service. You can also .

V. What This Warranty Does Not Cover

Defects or damage resulting from use of the Product in other than its normal and customary manner.

Defects or damage from misuse, accident, water, or neglect.

Defects or damage from improper testing, operation, maintenance, installation, alteration, modification, or adjustment.

Breakage or damage to antennas unless caused directly by defects in material workmanship.

A Product subjected to unauthorized Product modifications, disassemblies or repairs (including, without limitation, the addition to the Product of non-Motorola supplied equipment) which adversely affect performance of the Product or interfere with Motorola's normal warranty inspection and testing of the Product to verify any warranty claim.

Product which has had the serial number removed or made illegible.

Freight costs to the repair depot.

A Product which, due to illegal or unauthorized alteration of the software/firmware in the Product, does not function in accordance with MOTOROLA’s published specifications or the FCC type acceptance labeling in effect for the Product at the time the Product was initially distributed from MOTOROLA.

Scratches or other cosmetic damage to Product surfaces that does not affect the operation of the Product.

Normal and customary wear and tear.

VI. Patent And Software Provisions

MOTOROLA will defend, at its own expense, any suit brought against the end user purchaser to the extent that it is based on a claim that the Product or parts infringe a United States patent, and MOTOROLA will pay those costs and damages finally awarded against the end user purchaser in any such suit which are attributable to any such claim, but such defense and payments are conditioned on the following:

that MOTOROLA will be notified promptly in writing by such purchaser of any notice of such claim;

that MOTOROLA will have sole control of the defense of such suit and all negotiations for its settlement or compromise; and

should the Product or parts become, or in MOTOROLA's opinion be likely to become, the subject of a claim of infringement of a United States patent, that such purchaser will permit MOTOROLA, at its option and expense, either to procure for such purchaser the right to continue using the Product or parts or to replace or modify the same so that it becomes noninfringing or to grant such purchaser a credit for the Product or parts as depreciated and accept its return. The depreciation will be an equal amount per year over the lifetime of the Product or parts as established by MOTOROLA.

MOTOROLA will have no liability with respect to any claim of patent infringement which is based upon the combination of the Product or parts furnished hereunder with software, apparatus or devices not furnished by MOTOROLA, nor will MOTOROLA have any liability for the use of ancillary equipment or

software not furnished by MOTOROLA which is attached to or used in connection with the Product. The foregoing states the entire liability of MOTOROLA with respect to infringement of patents by the Product or any parts thereof.

Laws in the United States and other countries preserve for MOTOROLA certain exclusive rights for copyrighted MOTOROLA software such as the exclusive rights to reproduce in copies and distribute copies of such Motorola software. MOTOROLA software may be used in only the Product in which the software was originally embodied and such software in such Product may not be replaced, copied, distributed, modified in any way, or used to produce any derivative thereof. No other use including, without limitation, alteration, modification, reproduction, distribution, or reverse engineering of such MOTOROLA software or exercise of rights in such MOTOROLA software is permitted. No license is granted by implication, estoppel or otherwise under MOTOROLA patent rights or copyrights.

VII. Governing Law

This Warranty is governed by the laws of the State of Illinois, USA.

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Chapter 1

SLR 1000 Repeater

The Motorola Solutions SLR 1000 Repeater provides a modular, flexible analog and digital station designed for today's communication systems and for the future.

Related Links

Repeater Description on page 28
Repeater Operating Features on page 35
Repeater Frequency Ranges and Power Levels on page 36
Repeater Specifications on page 37
Repeater Theory of Operation on page 40
Basic Repeater Level Troubleshooting – RDAC and LEDs on page 41
Repeater Model Numbering Scheme on page 43
Repeater Model Chart on page 44

1.1
Repeater Description

The station is available for use in these configurations:

- Analog Conventional
- Digital (MOTOTRBO)
- MOTOTRBO DMR Tier 2 Conventional – Single Site
- MOTOTRBO DMR Tier 2 Conventional – IP Site Connect
- MOTOTRBO Capacity Plus Trunking
- MOTOTRBO Connect Plus Trunking
- MOTOTRBO Capacity Max Trunking
- MOTOTRBO Digital Voting

NOTICE: Certain software features enabled through Radio Management can be configured with the Online Help or with a regional representative. See the regional Ordering Guide to determine the features available within the respective regions.

The repeater can either be configured as a stand-alone repeater or as a repeater connected to a network, as in the case of operating in IP Site Connect mode. As a repeater, it listens on one uplink frequency, and then re-transmits on a downlink frequency, thus providing the RF interface to the field subscribers. When configured for analog station operation, the repeater is designed to operate with most existing analog systems, which enables a smooth migration to the MOTOTRBO system.

When configured for digital operation, the repeater offers additional services. The digital repeater operates in TDMA mode, which essentially divides one channel into two virtual channels using time slots; therefore the user capacity is doubled. The repeater utilizes embedded signaling to inform the field radios of the busy/idle status of each channel (time slot), the type of traffic, and even the source and destination information.

See the following figures and tables for connections, ports, LEDs, and their descriptions.

Figure 1: SLR 1000 Repeater Bottom View

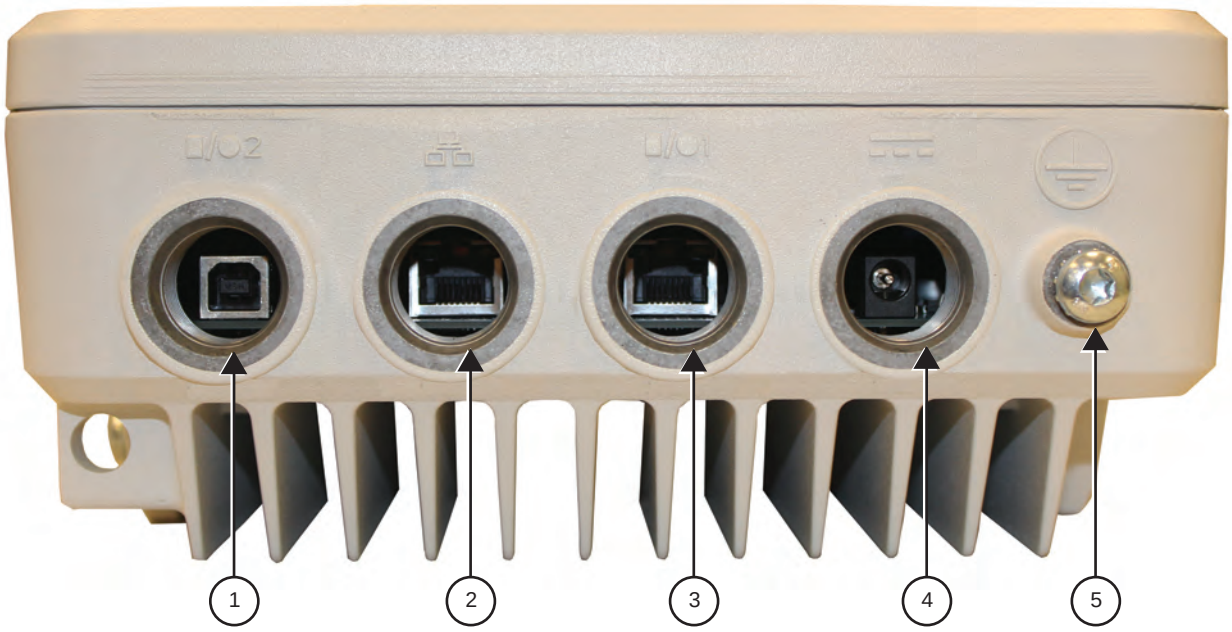

Table 1: SLR 1000 Repeater Bottom View Callout Legend

Label	Description
1	USB Port Programming Interface
2	Ethernet Port
3	Aux/Accessory Port
4	DC Power Inlet
5	Bonding Ground Connection

Figure 2: SLR 1000 Repeater Left View

Table 2: SLR 1000 Repeater Left View Callout Legend

Label	Description
1	Receiver RF (Rx) Input Cable Port
2	Option Dependent 1/GNSS Option Dependent 2/WLAN

Figure 3: SLR 1000 Repeater Right View

Table 3: SLR 1000 Repeater Right View Callout Legend

Label	Description
1	Transmitter RF (Tx) Output Cable Port
2	Pressure Equalization Vent

Figure 4: SLR 1000 Repeater Back View

Figure 5: SLR 1000 Repeater Padlock Opening

Figure 6: SLR 1000 Repeater Front View

Table 4: SLR 1000 Repeater Front View Callout Legend

Label	Description
1	Status
2	Ethernet Link/Network Connectivity
3	Reference (for future use)

Figure 7: SLR 1000 Repeater Connections

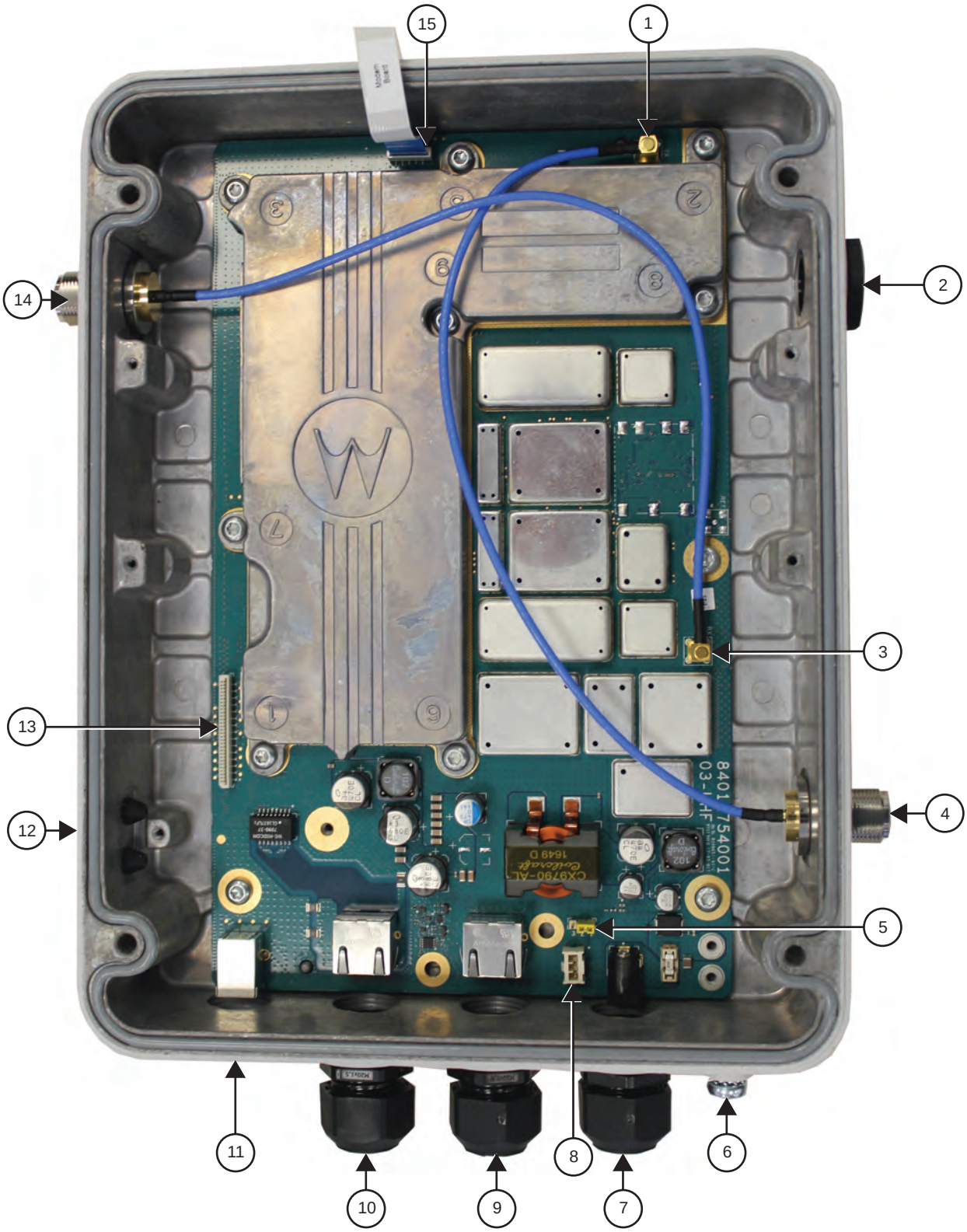

Table 5: SLR 1000 Repeater Connections Callout Legend

Label	Description
1	Transmitter RF (Tx) Output Board Connection
2	Pressure Equalizer Vent
3	Receiver RF (Rx) Input Board Connection
4	Transmitter RF (Tx) Output Cable Port
5	Jumper Connection to enable external on/off function
6	Bonding Ground Connection
7	DC Power Inlet
8	Header Connection for optional antenna switch
9	Aux/Accessory Port
10	Ethernet Port
11	USB Port Programming Interface
12	Option Dependent 1 and 2
13	Expansion Board Connection (for future use)
14	Receiver RF (Rx) Input Cable Port
15	Front Panel Flex Connector

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1.2

Repeater Operating Features

The SLR 1000 Repeater model provides the following features and interfaces.

Standard Features

- MOTOTRBO Conventional Operation (2-Slot TDMA, 4FSK Modulation)
- Analog Conventional Operation (FM)
- Continuous Duty Cycle Operation over -30 °C to +60 °C
- Meets or exceeds the following standards:
  - TIA603E
  - ETSI 086
  - ETSI 113
  - ETSI TS 102 361-1 Part 1: DMR Air Interface Protocol
  - ETSI TS 102 361-2 Part 2: DMR Voice and Generic Services and Facilities
  - ETSI TS 102 361-3 Part 3: DMR Packet Data Protocol
  - ETSI TS 102 361-4 Part 4: DMR Trunking Protocol
- Synthesized Frequency Generation
- Female N-type Antenna Connector (Tx)
- Female N-type Antenna Connector (Rx)

- Ethernet Port (Network)
- USB Port (Service)
- Four configurable GPIO ports (Digital)
- One configurable GPI port (Analog)
- One configurable GPO port (Analog)
- 1.5 PPM Frequency Stability (temperature AND 1-year aging) (VHF and UHF)
- Station Diagnostic Tests – fixed set of tests run upon start-up
- Physical Dimensions: 11" H x 9" W x 4" D (27.94 x 22.86 x 10.16 cm) without brackets or other peripheral equipment
- Weight: 10 pounds (4.56 kg) excluding other peripheral equipment

Motorola Solutions Network Interface

- IP Site Connect
- Repeater Diagnostics and Control (RDAC)
- Capacity Plus
- Connect Plus
- Capacity Max

Third Party Controller Interface

- Tone Remote Adapter

Additional Features

These features are shipped in a preset condition, but may be altered through the use of Radio Management.

- 64 Tx/Rx Frequencies – factory programmed with 1 Tx, 1 Rx
- 12.5 kHz or 25 kHz Operation – factory programmed to 12.5 kHz
- One Tx and one Rx (PL or DPL) Squelch Code per channel – factory programmed to CSQ
- Base Station Identification (BSI) – factory programmed as “BLANK” (“BLANK” disables BSI)
- Push-To-Talk (PTT) Priority – factory programmed to repeat path

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1.3

Repeater Frequency Ranges and Power Levels

The SLR 1000 Repeater is available in various UHF frequency ranges and power levels as specified in the following table.

Table 6: SLR 1000 Frequency Ranges and Power Levels

Frequency Band	Bandwidth	Power Level
VHF	136–174 MHz	1-10 W

Frequency Band	Bandwidth	Power Level
UHF	400–512 MHz	1–10 W

Self-Quieting Frequencies

When using an indoor antenna, there is a potential for degraded receiver performance with the following frequencies:

VHF	UHF
147.03125 MHz	400 MHz
150 MHz	403.2 MHz
153.6 MHz	422.4 MHz
	425 MHz
	441.6 MHz
	450 MHz
	460.8 MHz
	475 MHz
	480 MHz
	499.2MHz
	500 MHz
	518.4 MHz
	525 MHz

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1.4

Repeater Specifications

The SLR 1000 Repeater meets the following Radio Frequency (RF) operating specifications.

Table 7: SLR 1000 Repeater General Specifications (All Bands)

Parameter	Specifications
Number of Channels	64
Frequency Generation	Synthesized
Input Voltage DC	10.8–15.6 VDC
Station Weight	10 lbs (4.56 kg)
Temperature Range	-30 °C to +60 °C (-22 °F to +140 °F)
Ingress	IP65, NEMA 4
Antenna Connectors	Tx: N-type Rx: N-type
Modes of Operation	Half-Duplex/ Duplex

Parameter	Specifications
Height	11” (27.94 cm)
Width	9” (22.86 cm)
Depth	4” (10.16 cm)

Table 8: SLR 1000 Repeater Specifications

All specifications are in accordance to their respective TIA603E, ETSI 300 – 086, and ETSI 300 – 113 standards unless otherwise noted.

Parameter	Specifications	
	VHF	UHF
Input Power (All Modulations)		
Standby (13.6 VDC)	0.73 A	
10 W Transmit at Rated Power (13.6 VDC)	3 A	
Frequency Reference		
Internal Frequency Stability (PPM)	±0.5 PPM (temperature)	
Frequency Bands		
Electronic Bandwidth	136-174 MHz	400-512 MHz
Receiver		
Selectivity 25 kHz / 12.5 kHz (TIA603)	83/68 dB	80 dB/68dB
Selectivity 25 kHz / 12.5 kHz (ETSI)	70 dB/63 dB	
Sensitivity (12 dB SINAD)	0.3 uV	
Sensitivity (5% BER)	0.3 uV	
Intermodulation Rejection (TIA603E)	80 dB	
Intermodulation Rejection (ETSI)	70 dB	
Spurious Rejection (TIA603E)	85 dB	
Spurious Rejection (ETSI)	75 dB	
Conducted Spurious Emissions	-57 dBm	
Audio Distortion	<3%	
Audio Response	Per TIA/ ETSI	

[1] Typical performance under the following conditions (when applicable): Nominal VSWR conditions (VSWR <1.5:1)

Parameter	Specifications	
	VHF	UHF
FM Hum and Noise 25 kHz / 12.5 kHz	-50 dB/ -45 dB	
	Transmitter	
Rated Output Power (Continuous Duty)	1 – 10 W	
Intermodulation Attenuation	40 dB	
Adjacent Channel Power 25 kHz / 12.5 kHz	75 dB / 60 dB	
Modulation Fidelity (4FSK)	FSK Error 5% FSK Magnitude 1%	
Wideband Noise (1 MHz) @ Rated Pout	-152 dBc/ Hz	
Rated System Deviation	±2.5 kHz @ 12.5 kHz ±5.0 kHz @ 25 kHz	
Spurious Harmonics and Emissions	-40 dBm < 1 GHz, -30 dBm > 1 GHz	
Audio Distortion	< 3%	
Audio Response	Per TIA/ ETSI	
FM Hum and Noise 25 kHz / 12.5 kHz	-50 dB/ -45 dB	
FCC Identifier	ABZ99FT3096	ABZ99FT4100
Industry Canada		
IC Certification/Registration Number	109AB-99FT3096	109AB-99FT4100
IC Model Number	SLR 1000-VHF	SLR 1000-UHF
Tx/Rx Frequency Range	Tx: 138-174 MHz Rx: 138-174 MHz	Tx: 406.1-430 MHz and 450-470 MHz Rx:406.1-430 MHz and 450-470 MHz
FCC Emission Designators	11K0F3E 16K0F3E 7K60FXD 7K60F7D 7K60FXE	

Parameter	Specifications	
	VHF	UHF
	7K60F7E	
	7K60F7W	
	7K60FXW	

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1.5

Repeater Theory of Operation

The SLR 1000 Repeater provides the radio frequency (RF) link between the network infrastructure and the subscriber radios.

The repeater acquires inbound signals through its external receive (Rx) antenna and then amplifies, filters, and demodulates the signals into data or voice packets. From that point, the data is either forwarded to the repeater's transmitter to subscriber radios, and/or the data is delivered through a wired interface for distribution to networked repeaters, consoles, or other networked infrastructure.

The repeater consists of a single transceiver board. The transceiver board is comprised of three subsystems:

Receiver Subsystem

The Receiver subsystem is a dual heterodyne Receiver which receives the RF signal from the subscriber's transmitter. It then converts the resulting final Intermediate Frequency (IF) from an analog signal to that of a digital word in IQ signal format. Finally, the Receiver delivers the IQ signal, through the Synchronous Serial Interface (SSI) bus, to the Station Control subsystem for demodulation. Also, the Receiver subsystem provides its own metering and diagnostics through software, and self-contained calibration (no field tuning is needed for the Receiver subsystem).

Transmitter Subsystem

The Transmitter subsystem converts a two-port base band data signal, sent over the SSI bus from the Station Control subsystem, to an analog signal representation. The Exciter subsystem modulates the analog signal with a low-power RF transmitter carrier. The power modulated RF carrier is then amplified and delivered to the antenna. The Exciter subsystem constitutes the transmitter of the repeater. Also, the Exciter subsystem provides its own metering and diagnostics through software, and a self-contained calibration (no field tuning is needed for the Exciter subsystem).

The Transmitter subsystem delivers the amplified signal to the transmitter antenna port at a power level within the rated power band of the repeater, for transmission to the subscriber radios. In addition, it provides the following hardware functions for the repeater.

- Harmonic attenuation
- Inter-modulation attenuation (IMA) suppression
- RF power control (primary means)
- Meters for diagnostics
- Power rollback for temperature
- Self-Contained calibration (no field alignment is needed for the power amplifier).

Station Control Subsystem

The heart of the Station Control subsystem is the Texas Instruments DM8148 Host/ DSP processor. In general, the Station Control Module (SCM) controls the entire coordination of the repeater functions. Specifically, the Station Control subsystem provides for the following functions:

- Contains and runs the preloaded repeater software
- Manages inbound and outbound RF and Audio traffic
- Provides an on-board USB port for local configuring, alignment, and diagnostics through the following applications:
  - Radio Management Configuration Client (RM)
  - Tuner application
  - Repeater Diagnostic and Control (RDAC) software
- Provides an Ethernet port for IP site connectivity and remote RDAC
- Provides General Purpose Input/Output (GPIO) connectivity for third-party controller interfaces
- Provides analog repeater audio connectivity
- Data and Control to the Receiver subsystem through the Serial Peripheral Interface (SPI) and Synchronous Serial Interface (SSI) respectively
- Data and Control to the Exciter subsystem through the SPI and SSI respectively
- Control of the Transmitter's set power through the SPI
- Configuration and fault management
- Generates the internal station reference
- Provides control of the front panel indicator LEDs.

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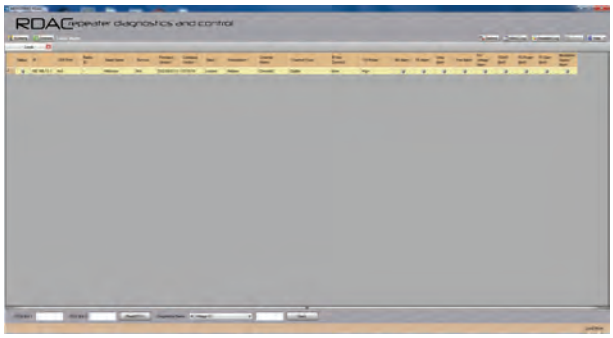
1.6

Basic Repeater Level Troubleshooting – RDAC and LEDs

Diagnostic tests are available for the Transceiver of the SLR 1000 Repeater.

If a problem occurs during station operation, it is logged as an alarm that is read with the Repeater Diagnostic and Control application (RDAC). See the following figure for the RDAC diagnostic screen.

Figure 8: RDAC Diagnostic Screen



Problems can be evaluated locally or remotely, as the station maintains an Alarm Log with the name of the alarm that failed since the last power-up. Through the RDAC application Alarm Log, the alarm messages aid in identifying the FRU that failed along with the fault condition.

After booting up the repeater, the three LEDs (Power/ Status, Network, and Reference LEDs) flash in unison.

The general status and condition of the SLR 1000 Repeater can be obtained by observing the three LED indicators on the front panel. The following tables indicate the LED symbols and their meaning, and identifies the information conveyed through the LED indicators.

Table 9: SLR 1000 Repeater Front Panel LED Indicators

LED	Definition
	Status
	Ethernet Link/ Network Connectivity
	Reference

Table 10: SLR 1000 Front Panel LED Definitions

LED Function Name	LED Color	LED State	Status Indication
Power/Status	Off	Off	Off
	Green	Solid	Operating normally, with DC power
	Red	Flashing	Repeater is disabled (by customer) **NOTICE:** The RDAC application is needed when the Status LED is red (solid or flashing). This status indicates a minor or major alarm. The RDAC application is used to identify the specific alarm and probable diagnosis to aid in identifying the FRU at fault.
		Solid	Not operational – major alarm
	Amber	Flashing*	Check the Alarm Log – alarm occurred and cleared but remains latched (configurable)
		Solid	Repeater Operational – minor alarm
Ethernet/ Network Connectivity	Off	Off	No Ethernet connection
	Green	Solid	Connectivity/ Linked
		Flashing	Attempting to connect to the system
Reference*	Off	Off	For future use

(*) Not supported in this release.

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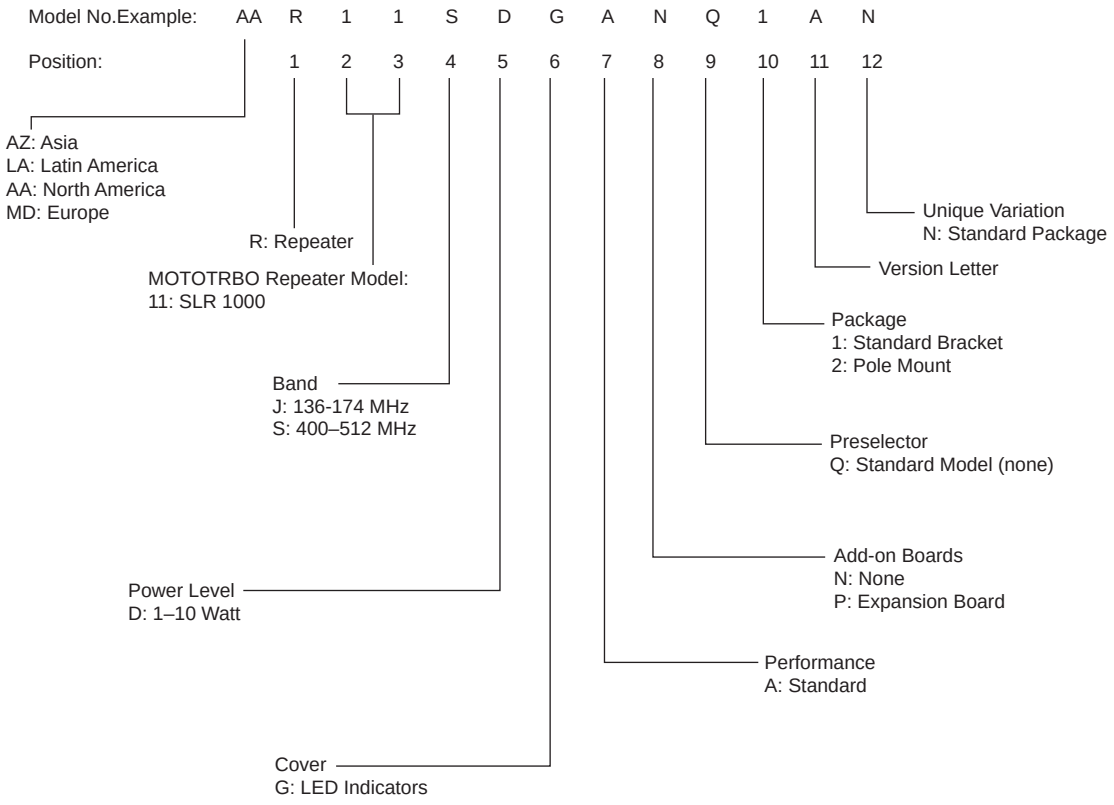
1.7

Repeater Model Numbering Scheme

The SLR 1000 Repeater model numbering scheme identifies the repeater model and the various options available.

Figure 9: SLR 1000 Repeater Model Numbering Scheme



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1.8

Repeater Model Chart

The model chart displays the model number, operating Radio Frequencies (RF), and output wattage of the SLR 1000 Repeater.

SLR 1000 Repeater, Model AAR11SDGANQ1AN and AAR11JDGANQ1AN		
Model	**Super Tanapa**	**Description**
VHF	PMUD3478AAANAA	136-174 MHz, 1-10 W, SLR 1000 Repeater
UHF	PMUE5247AAANAA	400-512 MHz, 1-10 W, SLR 1000 Repeater

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SLR 1000 Repeater on page 28

Chapter 2

SLR 1000 Satellite Receiver

Related Links

Satellite Receiver Description on page 45
Satellite Receiver Operating Features on page 45
Satellite Receiver Frequency Ranges on page 45
Satellite Receiver Specifications on page 46
Satellite Receiver Configuration on page 46
Basic Satellite Receiver Level Troubleshooting – RDAC and LEDs on page 46
Satellite Receiver Model Chart on page 47

2.1
Satellite Receiver Description

The main purpose of the Satellite Receiver is to eliminate "dead zones" in a communications system by improving the "talk-in" coverage on a particular receive frequency when used in a receiver voting system.

The Motorola Solutions SLR 1000 Repeater is not offered as an exclusive Satellite Receiver only model, rather the repeater can be configured through Radio Management to operate as a Satellite Receiver in a receive only mode of operation. As such, the context of this chapter assumes that the repeater is configured as a Satellite Receiver.

NOTICE: Configuring the repeater as a Satellite Receiver is only compatible with the MOTOTRBO Digital Voting feature.

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SLR 1000 Satellite Receiver on page 45

2.2
Satellite Receiver Operating Features

The SLR 1000 Satellite Receiver features are identical to the SLR 1000 Repeater, with the exception that all transmitter related functions are not applicable.

See the SLR 1000 Repeater Repeater Operating Features on page 35 for more details.

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SLR 1000 Satellite Receiver on page 45

2.3
Satellite Receiver Frequency Ranges

The supported frequency ranges of the SLR 1000 Satellite Receiver are identical to the SLR 1000 Repeater receive frequency ranges.

See the SLR 1000 Repeater Repeater Frequency Ranges and Power Levels on page 36 for more details.

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SLR 1000 Satellite Receiver on page 45

2.4

Satellite Receiver Specifications

The specifications of the SLR 1000 Satellite Receiver are identical to the SLR 1000 Repeater, with the exception that all transmitter related specifications are not applicable.

See the SLR 1000 Repeater Repeater Specifications on page 37 for more details.

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SLR 1000 Satellite Receiver on page 45

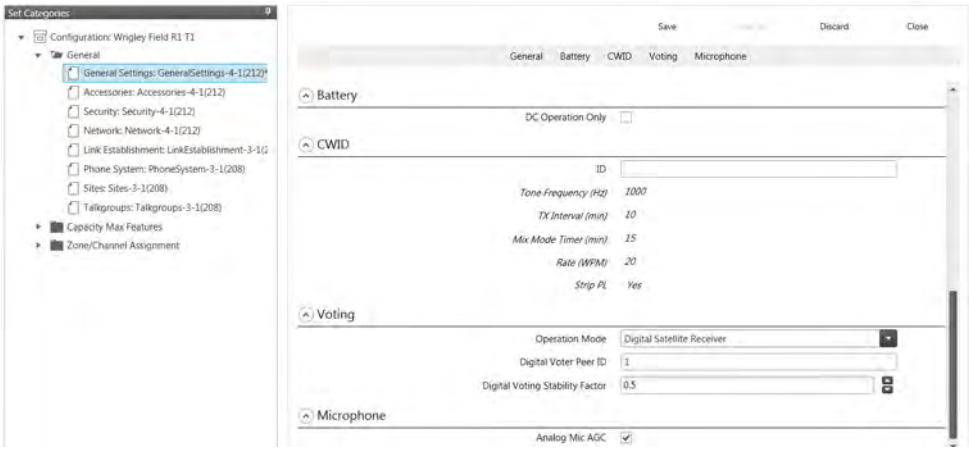
2.5

Satellite Receiver Configuration

The SLR 1000 Satellite Receiver is configured identical, other than setting the general personality configurations, set the **Operation Mode** parameter under the **General Settings** menu in Radio Management (RM) to **Digital Satellite Receiver**.

To locate where the **Operation Mode** field is located in the RM, see the following figure.

Figure 10: Operation Mode Configuration for Satellite Receiver Functionality



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2.6

Basic Satellite Receiver Level Troubleshooting – RDAC and LEDs

The SLR 1000 Satellite Receiver troubleshooting procedures are similar to the SLR 1000 Repeater with regards to the control, transmitter, and receiver sub-systems.

See the SLR 1000 Receiver Basic Repeater Level Troubleshooting – RDAC and LEDs on page 41 for more details.

NOTICE: When configured for receiver only operation, the repeater does not support any transmitter sub-system functions. As such, disregard all references to the transmitter section in SLR 1000 Repeater on page 28, including any transmitter related topics in the RDAC and the front panel LEDs.

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2.7

Satellite Receiver Model Chart

The SLR 1000 Satellite Receiver model chart is identical to the SLR 1000 Repeater.

See the SLR 1000 Repeater Repeater Model Chart on page 44 for more details.

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Chapter 3

SLR 1000 Transceiver Board

Related Links

Transceiver Board Description on page 48
Receiver Subsystem on page 50
Transmitter Subsystem on page 52
Station Control Subsystem on page 53

3.1
Transceiver Board Description

A general description, identification of inputs and outputs, and functional theory of operation for the Transceiver board are provided. The information provided is sufficient to give service personnel a functional understanding of the module, allowing maintenance and troubleshooting at the module level.

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SLR 1000 Transceiver Board on page 48

Related Links

Transceiver Board General Description on page 48
Input and Output Connections on page 48

3.1.1
Transceiver Board General Description

The Transceiver board provides the receiver, transmitter, and station control functionality for the repeater. Additionally, the external connections to the station are connected directly to the transceiver board.

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Transceiver Board Description on page 48

3.1.2
Input and Output Connections

The SLR 1000 Repeater has input and output connections on the transceiver board.

See Figure 11: SLR 1000 Repeater Transceiver Board Connector Locations on page 49 and Table 11: SLR 1000 Repeater Front View (without Top Cover) Callout Legend on page 49 for the locations and descriptions of the input and output external connections.

Figure 11: SLR 1000 Repeater Transceiver Board Connector Locations

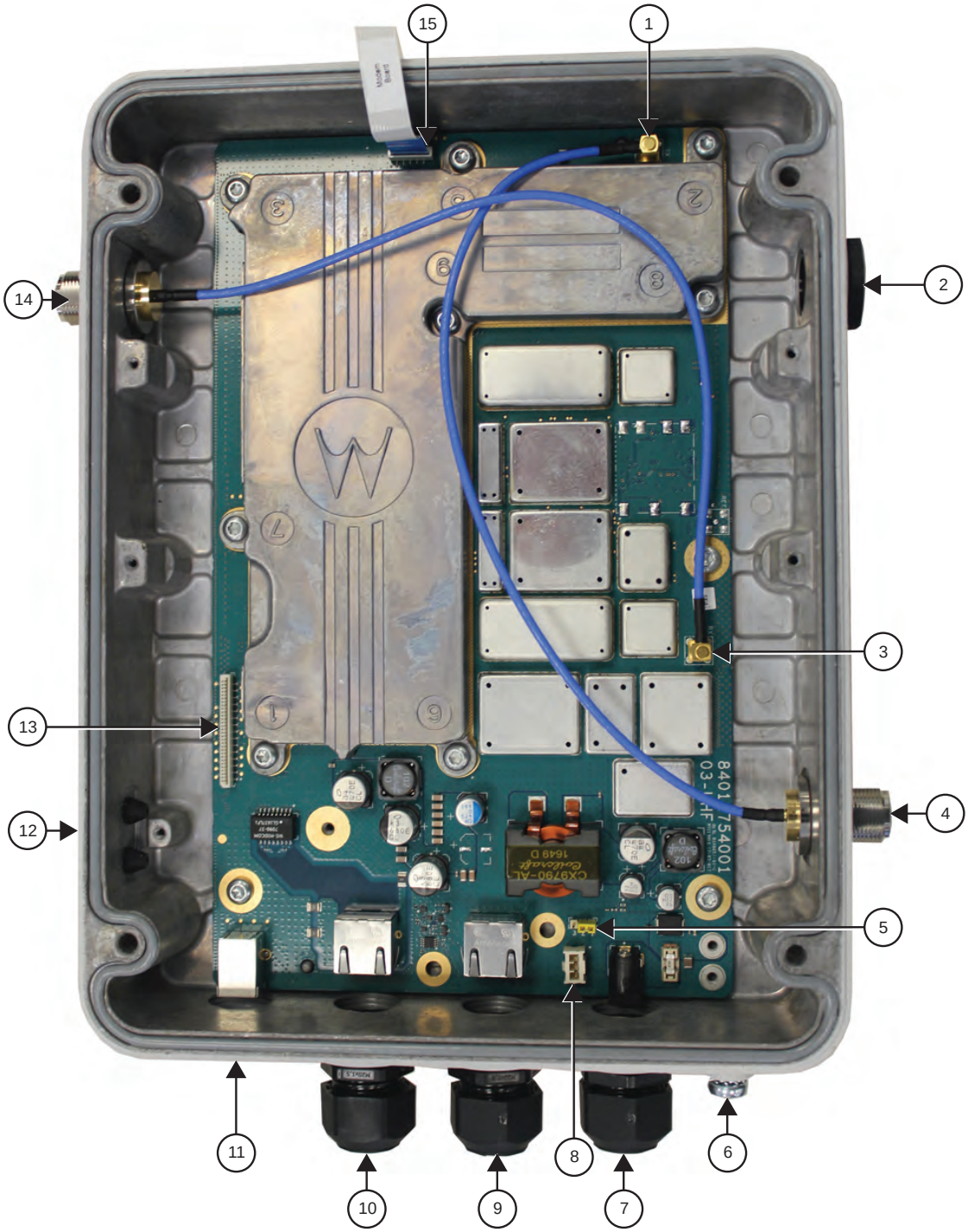


Table 11: SLR 1000 Repeater Front View (without Top Cover) Callout Legend

Label	Description
1	Transmitter RF (Tx) Output Board Connection
2	Pressure Equalizer Vent
3	Receiver RF (Rx) Input Board Connection

Label	Description
4	Transmitter RF (Tx) Output Cable Port
5	Jumper Connection to enable external on/off function
6	Bonding Ground Connection
7	DC Power Inlet
8	Header Connection for optional antenna switch
9	Aux/Accessory Port
10	Ethernet Port
11	USB Port Programming Interface
12	Option Dependent 1 and 2
13	Expansion Board Connection (for future use)
14	Receiver RF (Rx) Input Cable Port
15	Front Panel Flex Connector

Return to Process

Transceiver Board Description on page 48

Related Links

External On/Off Function on page 50

3.1.2.1
External On/Off Function

The external on/off function allows a user to control the SLR 1000 Repeater through an external switch if it is inconvenient to disrupt the main DC connection.

If the jumper is in the default position (across pins 1 and 2), the repeater is always On as long as DC is connected to a DC power inlet. However, if the jumper is across pins 2 and 3, then DC power must be supplied to pin 3 on the AUX connector (10.8–15.6 V) to enable the repeater.

Return to Process

Input and Output Connections on page 48

3.2
Receiver Subsystem

The Transceiver board includes the receiver circuitry for the station. A cable connects the board connector to an N-type connector on the upper left-hand side of the repeater.

See Figure 11: SLR 1000 Repeater Transceiver Board Connector Locations on page 49 for the location of the Receiver RF (Rx) Input Cable Port connector. The receiver section performs highly selective bandpass filtering and dual down-conversion of the desired RF signal. A custom Receiver IC then performs an analog-to-digital conversion of the desired received signal and outputs the digitized signal to the controller section through a serial synchronous interface. Included in the receiver section is:

Frequency Synthesizer Circuitry
Consists of a phase-locked loop and Voltage-Controlled Oscillator (VCO), generates the first LO injection signal.

Varactor-tuned Preselector Filter(s)
Provides bandpass filtering of the station Receiver RF input.

Receiver Front-End Circuitry
Performs filtering, amplification, and the first down conversion of the Receiver RF signal.

Receiver-specific piece of transceiver IC Circuitry
Consists of receiver-specific parts of a transceiver IC which performs the second down conversion, filtering, amplification, and analog-to-digital conversion of the receive signal.

Analog to Digital Converter (ADC) Circuitry
Converts analog Receiver status signals to digital format for transfer to the controller circuitry on the Transceiver board.

Return to Process

SLR 1000 Transceiver Board on page 48

Related Links

Receiver Subsystem Specifications on page 51

3.2.1
Receiver Subsystem Specifications

The following contains the SLR 1000 Repeater receiver subsystem Radio Frequency (RF) operating specifications.

Table 12: SLR 1000 Repeater Specifications of the Receiver Subsystem

Parameter	Specifications	
	VHF	UHF
Frequency Bands	136-174 MHz	400–512 MHz
Selectivity 25 kHz/ 12.5 kHz (TIA603E)	83 dB/55 dB	80 dB/55 dB
Selectivity 25 kHz/ 12.5 kHz (TIA603)	83 dB/68 dB	80 dB/68 dB
Selectivity 25 kHz/ 12.5 kHz (ETSI)	70 dB/ 63 dB	
Sensitivity (12 dB SINAD)	0.3 uV	
Sensitivity (5% BER)	0.3 uV	
Intermodulation Rejection (TIA603E)	80 dB	
Intermodulation Rejection (ETSI)	70 dB	
Spurious Rejection (TIA603E)	85 dB	
Spurious Rejection (ETSI)	75 dB	
Audio Distortion	<3%	
FM Hum and Noise 25 kHz/ 12.5 kHz	50 dB/ 45 dB	

Return to Process

Receiver Subsystem on page 50

3.3

Transmitter Subsystem

The Transmitter subsystem on the SLR 1000 Repeater Transceiver board provides the transmitter functions for the station. The Transmitter subsystem interfaces directly with the controller section, which provides control signals and monitoring, and routes transmit data to the Exciter.

A frequency synthesizer consisting of synthesizer circuitry and Voltage-Controlled Oscillator (VCO) circuitry generates the RF carrier. The Controller section of the transceiver board handles the exciter circuit control signals, monitoring, and audio processing. Included in the transmitter subsystem are:

Frequency Synthesizer Circuitry
Consists of a phase-locked loop and Voltage-Controlled Oscillator (VCO), generates a modulated RF signal at the transmitter carrier frequency.

RF Isolation Switch
Allows the controller section to turn on/off the Exciter RF input signal which greatly reduces signal leakage when the transmitter is de-keyed.

Analog to Digital Converter (ADC) Circuitry
Converts the analog transmitter status signals to the digital format for transfer, upon request, to the controller section of the Transceiver board.

Return to Process

SLR 1000 Transceiver Board on page 48

Related Links

Transmitter Subsystem Specifications on page 52

3.3.1

Transmitter Subsystem Specifications

The following contains the SLR 1000 Repeater transmitter subsystem Radio Frequency (RF) operating specifications.

Table 13: SLR 1000 Repeater Specifications of the Transmitter Exciter Subsystem

Parameter	Specifications	
	VHF	UHF
Frequency Range	136–174 MHz	400–512 MHz
Electronic Bandwidth	Full Bandwidth	
Output Power	10 W	
Harmonics	-76 dBc	

Return to Process

Transmitter Subsystem on page 52

3.4
Station Control Subsystem

The SLR 1000 Repeater Station Control Subsystem circuitry performs the digital signal processing, data formatting, and audio routing for the station and provides the external interfaces to the rest of the site.

The Station Control Subsystem is described in this section. A general description, identification of controls, indicators, and inputs/outputs, a functional block diagram, and functional theory of operation are provided.

The Station Control consists of seven main ICs:

- Texas Instrument DM8148 Host/DSP Processor
- EMMC Flash memory
- DDR3 memory
- Texas Instruments Power Management IC
- NOR Flash
- TI AIC3204 Codec

General controller functionality includes:

- Data and Control interface to the transceiver ICs
- Audio interface with CODEC IC
- UART interface to expansion board
- Intermodule communication (SPI, I2C)
- Ethernet port
- USB Device port
- External physical interfaces (connectors, LEDs, external references, and so on.)
- Station Reference Control

Return to Process

SLR 1000 Transceiver Board on page 48

Related Links

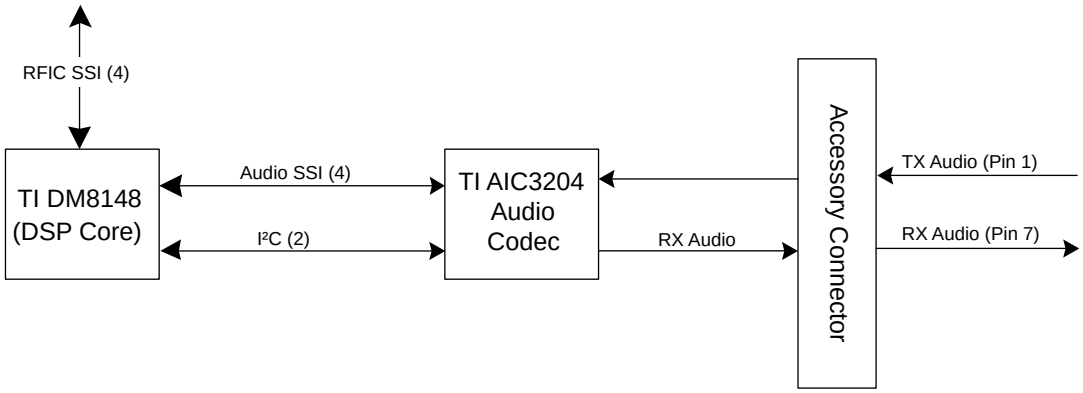
Station Control Audio on page 53
Station Control Interface on page 54

3.4.1
Station Control Audio

The analog audio stages of the SLR 1000 Repeater Station Control Audio are used exclusively for external accessories connected through the bottom RJ-45 accessory connector.

The critical components of the audio circuit are the TI DM8148 processor and a Texas Instruments AIC3204 dual channel audio codecs. Figure 12: SLR 1000 Repeater Audio Block Diagram on page 54 details the specific interconnects between the critical components.

Figure 12: SLR 1000 Repeater Audio Block Diagram



The DM8148 processor primarily handles the repeater digital audio. The TX RFIC generates a 24.576 MHz master clock (MCLK) that the DM8148 uses to drive its McASP SSI interface for the audio codecs. The bulk of the audio processing is done in the DaVinci's DSP core. The audio codecs contain DACs and ADCs and handle the conversion of the digital audio to analog audio and conversely.

There is one TX audio line routed in from the rear accessory connector. This line is TX Audio 1 (Pin 1, used for analog and slot 1 digital).

For the RX outputs, there is only one, which is connected to the accessory connector. RX Audio 1 on Pin 7 (used for analog and slot 1 digital).

Return to Process

Station Control Subsystem on page 53

3.4.2

Station Control Interface

The SLR 1000 Repeater Station Control Interface connects to the Ethernet connection on the Bottom Panel and to the Expansion Board Interface connection.

Bottom Panel Connections

See Bottom Panel Interfaces and Pin Location on page 57 for details.

Expansion Board Interface Connector

The expansion board interface uses a 30-pin vertical Low Insertion Force (LIF) connector. The location is detailed in Figure 11: SLR 1000 Repeater Transceiver Board Connector Locations on page 49. Table 11: SLR 1000 Repeater Front View (without Top Cover) Callout Legend on page 49 shows the pin number locations.

Return to Process

Station Control Subsystem on page 53

Chapter 4

SLR 1000 Front Panel

Related Links

Front Panel Description on page 55

4.1

Front Panel Description

The Front Panel board user interface includes three LED indicators. The board is connected to the modem interface through a flex cable. The LED indicators inform the user of the state of the repeater. The LED indications are transferred to the front panel through a serial peripheral interface.

Return to Process

SLR 1000 Front Panel on page 55

Chapter 5

SLR 1000 Bottom Panel

Related Links

Bottom Panel Description on page 56
Bottom Panel Interfaces and Pin Location on page 57

5.1
Bottom Panel Description

The Bottom Panel interface provides the electrical interconnection interface between the SLR 1000 Repeater and the end user's system.

The Bottom Panel interface includes the connectors necessary to program/configure the repeater,and interface the repeater to the power system, system controllers, LANs, and other communications and maintenance equipment.

The following provides a general description, identification of inputs/outputs and how the inputs are connected and sealed, and a pin-out listing for all connectors, including information on signal names, functions, and levels of the SLR 1000 Repeater Bottom Panel.

Figure 13: SLR 1000 Repeater Bottom Panel Connector Names and Locations on page 56 shows the various interface connector locations. Table 14: SLR 1000 Repeater Bottom View Callout Legend on page 56 lists the connector types and primary functions.

Figure 13: SLR 1000 Repeater Bottom Panel Connector Names and Locations

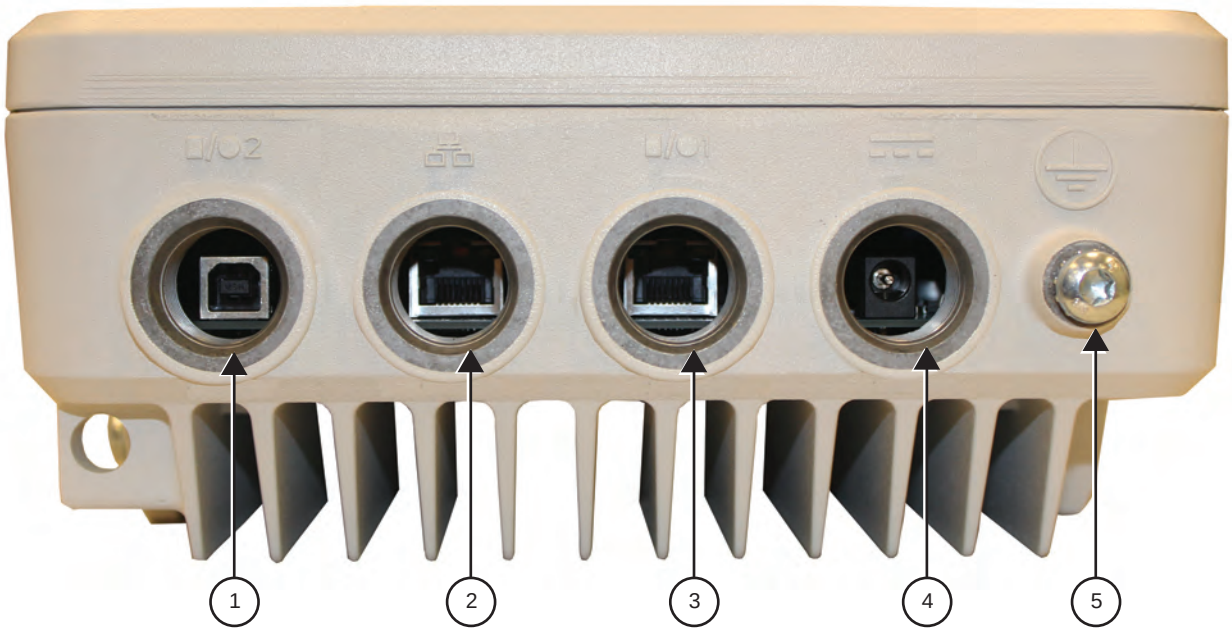


Table 14: SLR 1000 Repeater Bottom View Callout Legend

Label	Description
1	USB Port Programming Interface

Label	Description
2	Ethernet Port
3	Aux/Accessory Port
4	DC Power Inlet
5	Bonding Ground Connection

Return to Process

SLR 1000 Bottom Panel on page 56

5.2

Bottom Panel Interfaces and Pin Location

The following figures and tables describe and list the pin locations of the DC power inlet, USB, Ethernet, and Aux bottom panel interfaces for the SLR 1000 Repeater.

DC Power Inlet

The DC power inlet connector is a 2.1 X 5.5 Barrel type coaxial power connector receptacle panel. See the following figure and table for the location of the pins and a listing of the functional characteristics of the connector pins.

Figure 14: DC Power Inlet Connector

Table 15: DC Power Inlet Connector Callout Legend

Location	Type	Signal Characteristics
Inner	12 V	10.8 – 15.6 VDC 4 A (max)
Outer	Ground	

USB

Type B socket (Device Connection) that supports the USB 2.1 protocol standard. See the following figure and table for the location of the pins and a listing of the functional characteristics of the connector pins.

Figure 15: USB Connector

Table 16: USB Connector Callout Legend

Location	Pin Assignment	Type	Signal Characteristics
1	VBUS	USB Physical Layer	+5 VDC
2	D-		3.6 V differential data
3	D+		
4	GND		Ground

Ethernet

Fully compliant with IEEE and 802.3 and 802.3u standards. Supports 10Base-T, 100Base-Tx rates, full duplex, half duplex mode, and flow control. See the following figure and table for the location of the pins and a listing of the functional characteristics of the connector pins.

Figure 16: Ethernet Connector

Table 17: Ethernet Connector Callout Legend

Location	Pin Assignment	Type	Signal Characteristics
1	Ethernet Tx+	Ethernet Physical Layer	5 V differential data
2	Ethernet Tx-		
3	Ethernet Rx+		
4	Unused		N/A
5	Unused		N/A
6	Ethernet Rx-		5 V differential data
7	Unused		N/A
8	Unused		N/A

Auxiliary (Aux)/Accessory

This connection supports the analog interface to the SLR 1000 Repeater, which includes audio, station control, station indicators, and provisions for timing used in various system implementations. See the following figure and table for the location of the pins and a listing of the functional characteristics of the connector pins.

Figure 17: Auxiliary/Accessory Connector

Table 18: Auxiliary/Accessory Connector Callout Legend

Location	Pin Assignment	Type	Signal Characteristics
1	Tx Audio 1	Audio	Transmit Audio – Nominal input level is 80 mVrms for 60% deviation with scaling factor set to 100%. 600 Ω input impedance.
2	GPIO 6	Digital	Output Logic Low: 0.5 VDC max Output Logic High: Open Collector with 4.7 k pull-up to 5 V Input Logic Low: 0 – 0.8 VDC Input Logic High: 3.0 – 14 VDC
3	Ignition Sense Control		Controls power to the unit if the internal jumper is configured correctly.
4	Ground		
5	GPIO 7	Digital	Output Logic Low: 0.5 VDC max Output Logic High: Open Collector with 10 k pull-up to 5 V Input Logic Low: 0 – 0.8 VDC Input Logic High: 3.0 – 14 VDC
6	GPIO 9	Digital	Output Logic Low: 0.5 VDC max Output Logic High: Open Collector with 10 k pull-up to 5 V Input Logic Low: 0 – 0.8 VDC Input Logic High: 3.0 – 14 VDC
7	Rx Audio 1	Audio	Receiver Audio – Nominal output level is 330 mVrms (into a 50 k Ohm load) with a 60% deviation receive signal. 1000 Ω output impedance.
8	GPIO 4	Digital	Output Logic Low: 0.5 VDC max

Location	Pin Assignment	Type	Signal Characteristics
			Output Logic High: Open Collector with 4.7 k pull-up to 5 V Input Logic Low: 0 – 0.8 VDC Input Logic High: 3.0 – 14 VDC

Return to Process

SLR 1000 Bottom Panel on page 56

Chapter 6

SLR 1000 Test Equipment And Service Aids

Related Links

Recommended Test Equipment on page 62
Service Aids on page 62

6.1
Recommended Test Equipment

The list of equipment includes most of the standard test equipment required for servicing Motorola Solutions equipment.

Table 19: Recommended Test Equipment

Equipment	Example	Application
Service Monitor	Aeroflex 3920 Digital Radio Test Set or equivalent [2] http://www.aeroflex.com	Frequency/deviation meter, signal generator, oscilloscope, RF power meter for wide-range troubleshooting, and alignment.
Digital RMS Multimeter	Fluke 179 or equivalent http://www.aeroflex.com.	AC/DC voltage measurements.

Return to Process

SLR 1000 Test Equipment And Service Aids on page 62

6.2
Service Aids

Service aids are used for programming and troubleshooting the SLR 1000 Repeater and are available from Motorola Solutions.

Table 20: Service Aids on page 62 lists the service aids recommended for working on the repeater. Most are standard workshop equipment items, and any equivalent item capable of the same performance may be substituted for the item listed.

Table 20: Service Aids

Motorola Solutions Part Number	Description	Application
HSN1006_	Speaker	Listen to audio.

[2] Equivalency can be established with "all-in-one" service monitors and/or the individual functional components of a service monitor (such as RF Signal Generator, RF Spectrum Analyzer, RF Deviation Meter, RF Power Meter, and oscilloscope).

Motorola Solutions Part Number	Description	Application
HKVN4362_	Customer Programming Software (Motorola Online download)	Allows the technician to program, tune, and troubleshoot the repeater.
30009477001	Standard Type "A" to Type "B" USB Programming cable	Connects the repeater USB port for radio programming and data applications.
PMKN4166_	Repeater Rear Accessory Test Cable	Connects the repeater Aux/Accessory port to a microphone and speaker.
GMMN4063_	Microphone	To transmit audio.
RLN4460_	Test Box	Used to inject/ measure audio.
CB000174A02	DB-25 to RJ-45 Adapter	Used to connect the accessory test cable to the RJ-45 Aux/Accessory port.

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SLR 1000 Test Equipment And Service Aids on page 62

Chapter 7

SLR 1000 Performance Check or Testing

Related Links

Performance Check or Testing General Description on page 64
Transmitter Testing on page 64
Receiver Testing on page 67

7.1
Performance Check or Testing General Description

The SLR 1000 Repeater meets published specifications through the manufacturing process by utilizing high-accuracy laboratory-quality test equipment. The recommended field service equipment approaches the accuracy of the manufacturing equipment with few exceptions. This accuracy must be maintained in compliance with the equipment manufacturer's recommended calibration schedule.

NOTICE: Although these repeaters function in digital and analog modes, all testing is done in analog mode. Digital Repeater tests can be performed using an Aeroflex 3900 Series Service Monitor, if the DMR Digital Repeater Test Option is purchased. This auto testing could be performed in lieu of the following Manual testing.

Return to Process

SLR 1000 Performance Check or Testing on page 64

7.2
Transmitter Testing

Incorrect measurement signaling values of the SLR 1000 Repeater indicate a faulty module. Testing the transmitter circuitry is done by injecting and measuring signals using a Service Monitor (or equivalent). Measurement values within the acceptable range verify proper operation of the transceiver board and circuitry.

CAUTION: The SLR 1000 Repeater must be taken out of service to carry out performance testing procedures. Unless the repeater is already out of service, perform the procedures during off-peak hours to minimize disruption of service to the system subscribers.

While most module faults can be detected by running the repeater diagnostics, Verifying Transmitter Circuitry on page 65 provides a more traditional method of troubleshooting the transmitter circuitry and allows the service technician to make minor adjustments and verify proper operation of the repeater transmit circuitry.

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SLR 1000 Performance Check or Testing on page 64

Related Links

Required Transmitter Test Equipment on page 65
Verifying Transmitter Circuitry on page 65

7.2.1

Required Transmitter Test Equipment

Test equipment is required to perform procedures for performance checks or testing.

- Aeroflex 3920 Digital Radio Test Set (or equivalent)
- Microphone (GMMN4063_)
- Power Meter and Sensor
- Station Rear Accessory Test Cable
- Dummy Load (50 Ω, repeater wattage or higher)
- Aeroflex 3920 Digital Radio Test Set (or equivalent)
- Microphone (GMMN4063_)
- Power Meter and Sensor
- Station Rear Accessory Test Cable
- Dummy Load (50 Ω, repeater wattage or higher)
- DB25/RJ-45 Adapter

Return to Process

Transmitter Testing on page 64

7.2.2

Verifying Transmitter Circuitry

Perform this procedure to test the transmitter circuitry and verify that the measurement values are within the acceptable range and to verify proper operation of the transceiver board and circuitry.

Procedure:

1. Connect and set up the test equipment as shown in Figure 18: Test Equipment Setup for Verifying Transmitter Circuitry on page 66.
2. Apply input power to the repeater.
3. Press the PTT switch of the microphone.
4. Measure the output power by observing the reading on the in-line wattmeter.
5. If the transmitter output is not at the proper power (as set for a particular site), adjust the output power as described in the *Radio Management Online Help*.
6. If the transmitter output is at the proper power, set up the Service Monitor for a spectrum analyzer display.
   - **a** Press the PTT switch of the microphone and observe the display.

     The display should show a single frequency carrier.
   - **b** If the display shows multiple carriers evenly spaced about the carrier, suspect a faulty Exciter module or PA module.
   - **c** If the display shows a solid carrier but it is off frequency, suspect the following:
     - Faulty transceiver board
     - Faulty external 5/10 MHz reference source (if used)
   - **d** If the display shows a single carrier moving erratically, suspect a faulty transceiver board.
7. If display is proper, set up the Aeroflex 3900 Series Communications System Analyzer to display modulation.

a Press the PTT switch of the microphone and speak into the microphone.

b Verify that the display shows an audio signal.

c If the proper display is not obtained, suspect a faulty transceiver board.

8 Set the Aeroflex 3900 Series Communications System Analyzer for GEN/ MON MTR.

a Press the PTT switch of the microphone and speak loudly into the microphone to cause maximum deviation.

The display should read:

- 4.60 kHz maximum for a 25 kHz system
- 3.68 kHz maximum for a 20 kHz system
- 2.30 kHz maximum for a 12.5 kHz system

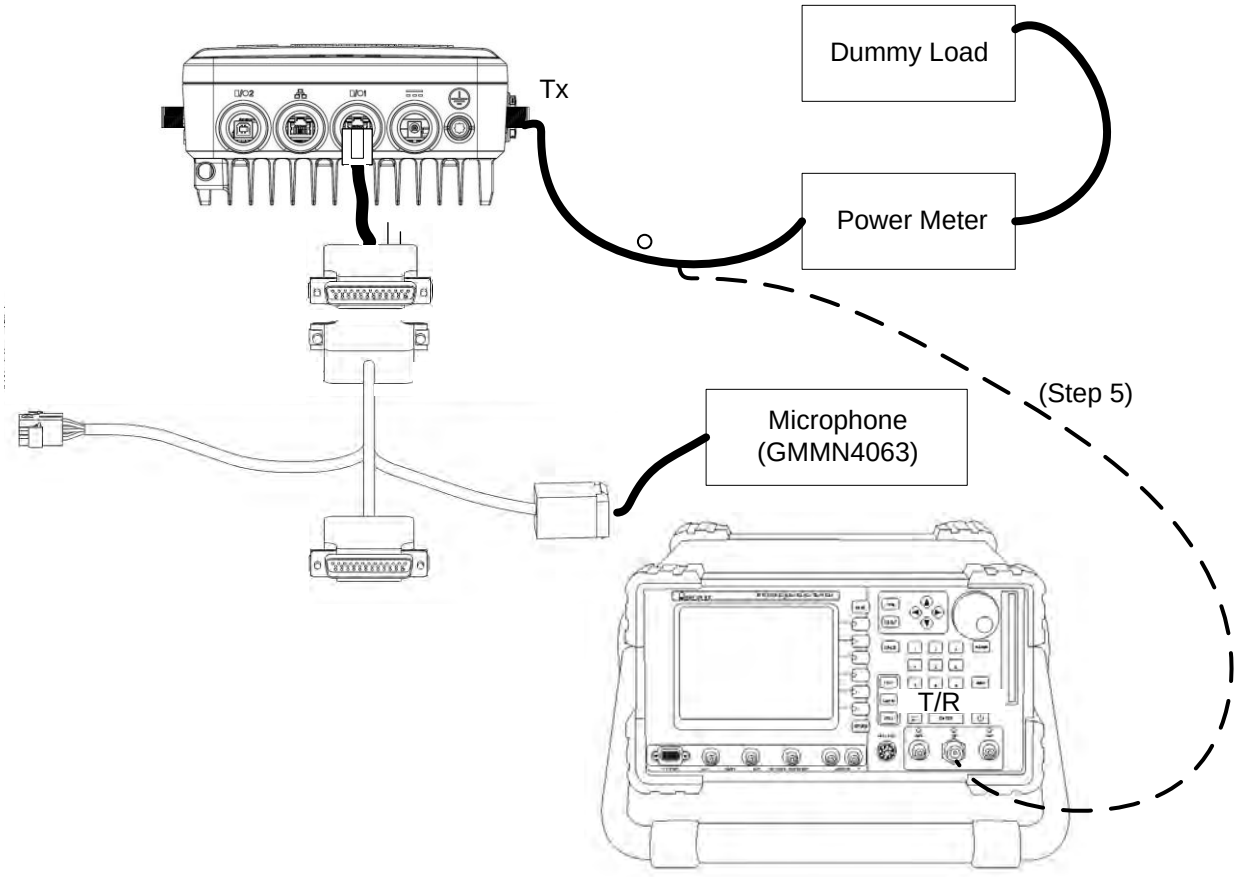
b If the proper display is not obtained, suspect a faulty transceiver board.

9 Verify that all displays and measurements are correct.

The transmitter circuitry may be considered to be operating properly. This completes the Verifying Transmitter Circuitry test procedure.

10 Remove the test equipment, restore the repeater to normal service, and (if applicable) return to the troubleshooting flow chart to resume the troubleshooting sequence.

Figure 18: Test Equipment Setup for Verifying Transmitter Circuitry



Return to Process

Transmitter Testing on page 64

7.3

Receiver Testing

Incorrect measurement signaling values of the SLR 1000 Repeater indicate a faulty module. Testing the Receiver circuitry is done by injecting and measuring signals using a Service Monitor (or equivalent). Measurement values within the acceptable range verify proper operation of the transceiver board and circuitry.

CAUTION:
The SLR 1000 Repeater must be taken out of service to carry out performance testing procedures. Unless the repeater is already out of service, perform the procedures during off-peak hours to minimize disruption of service to the system subscribers.

If the repeater is operating as a repeater, the transmit output from the repeater must be connected to a dummy load to prevent over-the-air broadcast during Receiver testing.

While most module faults can be detected by running the repeater diagnostics, Verifying Receiver Circuitry on page 67 provides a more traditional method of troubleshooting the Receiver circuitry and allows the service technician to make minor adjustments and verify proper operation of the Receiver circuitry on the repeater.

Return to Process

SLR 1000 Performance Check or Testing on page 64

Related Links

Required Receiver Test Equipment on page 67
Verifying Receiver Circuitry on page 67

7.3.1

Required Receiver Test Equipment

The following test equipment are required to perform the procedure:

- Aeroflex 3920 Digital Radio Test Set (or equivalent)
- Service Speaker (part no. HSN1006_)
- Station Rear Accessory Test Cable
- Dummy Load (50 Ω, repeater wattage or higher) required for repeaters only
- DB25/RJ-45 Adaptor

Return to Process

Receiver Testing on page 67

7.3.2

Verifying Receiver Circuitry

Perform this procedure to test the Receiver circuitry and verify that the measurement values are within the acceptable range, and to verify proper operation of the transceiver board and circuitry.

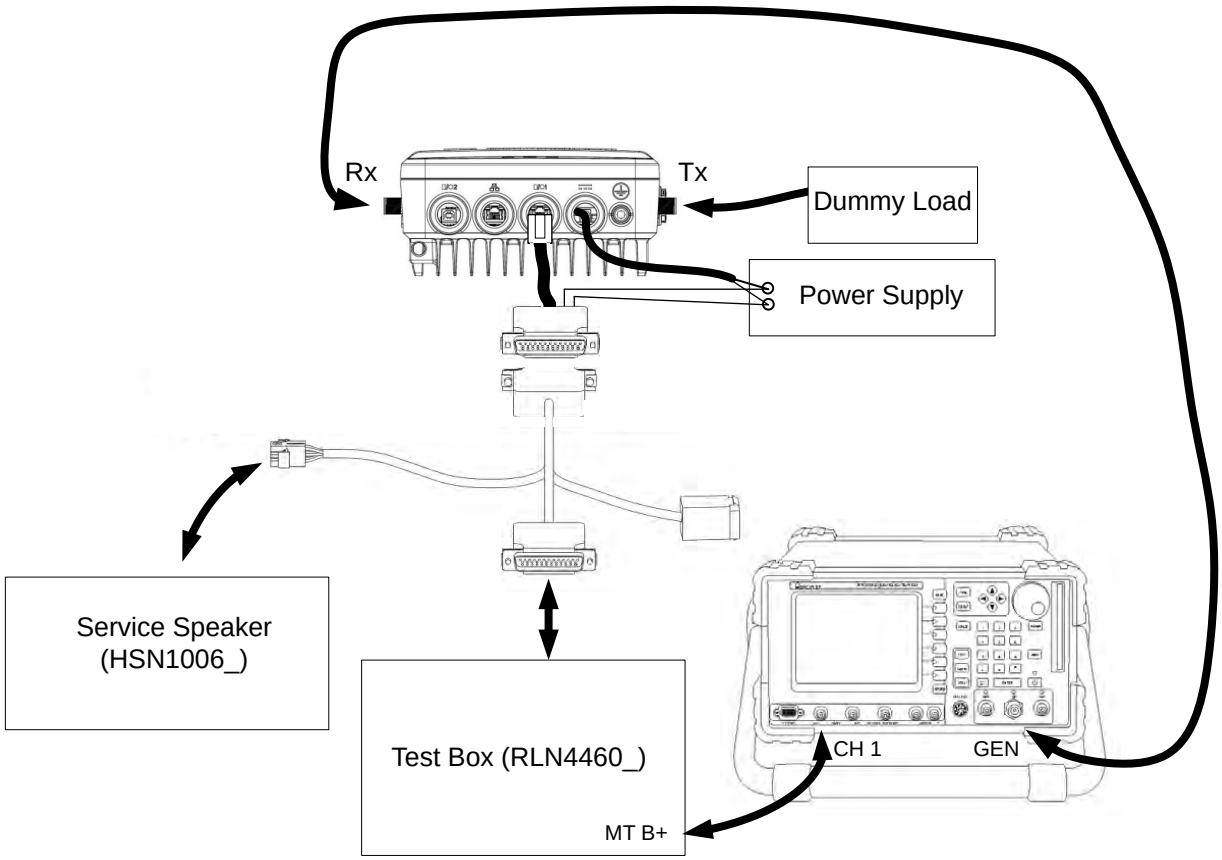
Procedure:

1. Connect the equipment as shown in Figure 19: Test Equipment Setup for Verifying Receiver Circuitry on page 69.

2. Set the service monitor to generate a 1.0 µV (-107 dBm) FM signal at the receiver frequency, modulated by a 1 kHz tone at 3 kHz deviation for 25 /30 kHz channel spacing, or 1.5 kHz deviation for 12.5 kHz channel spacing. The 1 kHz tone should be audible through the external speaker. If no audio is heard, suspect the following:
   - Faulty transceiver board
   - Faulty service monitor-to-station RF cable
   - Left panel to transceiver board cable unplugged
   - Faulty left panel to transceiver board cable
3. If audio is heard (the audio volume can be adjusted on the rear of the HSN1006), look at the oscilloscope window on the Aeroflex 3920 (or a separate O-Scope).
   - **a** Verify that the audio level sine wave measures between 0.75 to 1.5 Vpp.
   - **b** If not, connect to the tuner and increase the Rx audio level until the correct level is achieved. If the level cannot be obtained, suspect a faulty transceiver board.
4. Move the BNC cable from the scope CH 1 input to the Audio 1 input.
5. Change the System Monitor injection signal level to the noted levels in Table 8: SLR 1000 Repeater Specifications on page 38.
6. Measure the receiver 12 dB SINAD sensitivity.
   - **a** If the SINAD level is less than 12 dB, suspect a faulty transceiver board.
7. Verify that all displays and measurements are correct.

   The receiver circuitry may be considered to be operating properly. This completes the Verifying Receiver Circuitry test procedure.
8. Remove the test equipment, restore the repeater to normal service, and (if applicable) return to the troubleshooting flow chart to resume the troubleshooting sequence.

Figure 19: Test Equipment Setup for Verifying Receiver Circuitry



Return to Process

Receiver Testing on page 67

Chapter 8

SLR 1000 Programming and Tuning

Related Links

Programming and Tuning Introduction on page 70
Radio Management Setup on page 70
Repeater Tuning Setup on page 71
Tuning the Reference Oscillator on page 72
Tuning the Rx Audio Level Set on page 72
Tuning the Tx Audio Level Set on page 73
Modulation Limit Alignment on page 74
Tuning a Duplexer Module on page 76

8.1
Programming and Tuning Introduction

This section provides an overview of the MOTOTRBO Radio Management (RM) and the MOTOTRBO Tuner application for use on Windows 7, Windows 8, or Windows 8.1. These two MOTOTRBO applications are used for the configuration and alignment of the SLR 1000 Repeater .

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SLR 1000 Programming and Tuning on page 70

8.2
Radio Management Setup

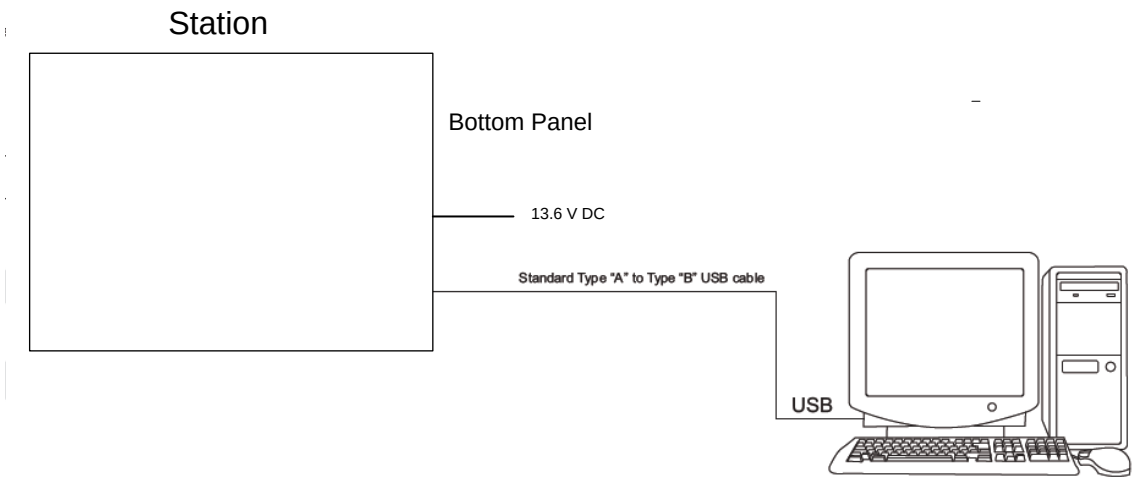
The Radio Management (RM) is used to program the SLR 1000 Repeater.

See Figure 20: Radio Management Setup on page 71 and Figure 11: SLR 1000 Repeater Transceiver Board Connector Locations on page 49 for the connectors on the repeater.

NOTICE: See the *Radio Management (RM) Online Help* for the programming procedures.

CAUTION: Computer USB ports can be sensitive to Electronic Discharge. Use proper ESD practices (wrist strap, grounding, and so on.) and do not touch exposed contacts on cables when connected to a computer.

Figure 20: Radio Management Setup



Return to Process

SLR 1000 Programming and Tuning on page 70

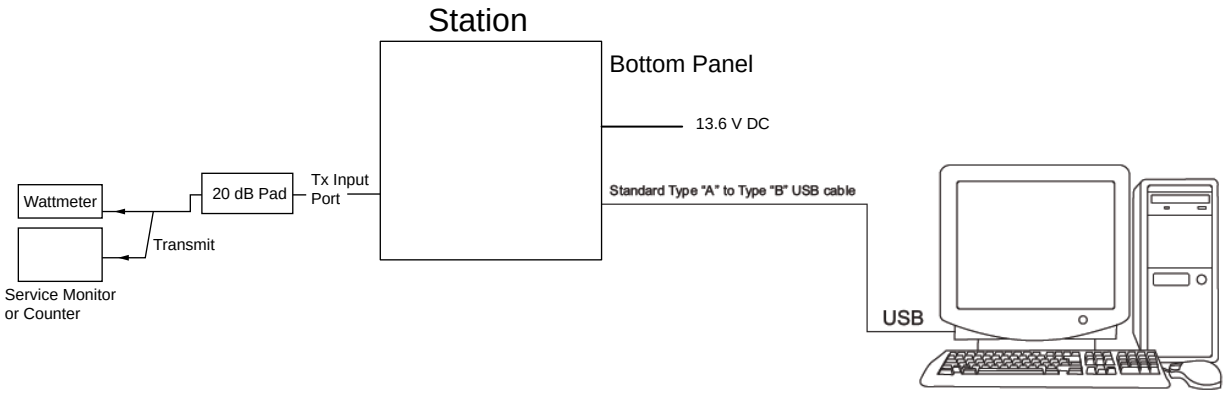
8.3

Repeater Tuning Setup

A personal computer (PC) with a Windows operating system, and the MOTOTRBO Tuner application are required to align the SLR 1000 Repeater. To perform the tuning procedures, the repeater must be connected to the PC and the test equipment setup as shown in Figure 21: SLR 1000 Repeater Tuning Equipment Setup on page 71 and Figure 11: SLR 1000 Repeater Transceiver Board Connector Locations on page 49 for the connectors on the repeater.

CAUTION: The high-speed solid-state antenna switch is only operable in Extended Range Direct Mode (ERDM) mode. Enable all channels as Extended Range Direct Mode before using the MOTOTRBO Tuner application, or possible damage to the antenna switch board may occur.

Figure 21: SLR 1000 Repeater Tuning Equipment Setup



Return to Process

SLR 1000 Programming and Tuning on page 70

8.4

Tuning the Reference Oscillator

The reference oscillator of the SLR 1000 Repeater provides the timing reference used for all frequency synthesizers and ensures their frequency accuracy.

This procedure is used to adjust the alignment of the reference oscillator. This alignment procedure should be done as maintenance schedules and regulations require. See Repeater Tuning Setup on page 71 for the repeater tuning equipment setup.

Prerequisites: Obtain the following:

- Wattmeter (Communication Analyzer)
- Service monitor or counter
- 20 dB pad
- Standard Type A to Type B USB cable
- Personal computer

Procedure:

1. Connect the repeater transmitter antenna port to a Communication Analyzer.
2. Power the repeater from either an AC or DC source.
3. Launch the Tuner application, and click **Read** to begin reading the repeater tuning software values.
4. In the tree view, select **TX**, then select **Ref Oscillator**.
5. Configure the currently operating frequency into the Communications Analyzer.
6. To key up the repeater, click **PTT Toggle**.
7. Adjust the working softpot value until the frequency is within the performance specifications (+/- 40 Hz for UHF) from the frequency point.
8. To de-key the repeater, click **PTT Toggle**.
9. To save the tuned softpot value into the repeater codeplug, click **Write**.

Return to Process

SLR 1000 Programming and Tuning on page 70

8.5

Tuning the Rx Audio Level Set

The procedure outlined in this section is used to set the receive output audio level from the repeater for a given RF deviation of the received RF signal. Perform this procedure any time the Rx audio level requires adjustment.

Prerequisites: Obtain the following:

- Wattmeter (Communication Analyzer)
- Service monitor or counter
- 20 dB pad
- Standard Type A to Type B USB cable
- Personal computer

Procedure:

1. Connect the repeater receiver antenna port to the Communication Analyzer.

2 Power the repeater from either an AC or DC source.

3 Launch the Tuner application and click **Read** to read the softpot values.

4 In the tree view, select **RX**, then select **Rx Rated Volume**.

5 Set the Communication Analyzer to output a -47 dBm RF signal modulated with a 1 kHz tone at 60% of full deviation on the tuning frequency.

The tuning frequency is the value displayed on the Tuner GUI under the heading **Frequency Points**.

NOTICE: The Tuner aligns this parameter in a 12.5 kHz channel spacing, so 60% is 1.5 kHz of deviation. If Radio Management (RM) is set for 25 kHz operation, the repeater automatically scales the deviation by a factor of two when it is outside the Tuner environment.
Programmed TPL and DPL squelch requirements are automatically disabled for the tuning frequency while in the Tuner environment.

6 Adjust the softpot value until the desired receive audio level is achieved at Pin 7 (in reference to ground) on the Aux connector. The ground connection provided by the Aux connector is Pin 4.

Figure 22: Auxiliary Connector

NOTICE: Optimally, load Pin 7 with the application loading used during normal operation of the repeater.

7 To save the new tuned softpot value into the repeater codeplug, click **Write**.

Return to Process

SLR 1000 Programming and Tuning on page 70

8.6
Tuning the Tx Audio Level Set

This procedure is used to allow adjustment of the transmitter audio level the repeater is expecting at the Aux connector. Adjusting this level set has the same effect as increasing or decreasing RF signal

deviation for a given transmit audio level. Perform this procedure any time the transmitter audio level requires adjustment.

Prerequisites: Obtain the following:

- Wattmeter (Communication Analyzer)
- Service monitor or counter
- 20 dB pad
- Standard Type A to Type B USB cable
- Personal computer

Procedure:

1. Connect the repeater transmitter antenna port to the Communication Analyzer.
2. Power the repeater from a DC source.
3. Apply a 1 kHz signal at the desired input level to Pin 1 (in reference to ground) on the Aux connector. The ground connection provided by the Aux connector is Pin 4. See Figure 22: Auxiliary Connector on page 73

   NOTICE: Optimally, load Pin 1 with the application source impedance used during normal operation of the repeater.
4. Launch the Tuner application and click **Read** to read the softpot values.
5. In the tree view, select **TX**, then select **Tx Audio Level**.
6. Enter the tuning frequency into the Communication Analyzer (the value displayed in the Tuner application under the heading **Frequency Points**.
7. To key up the repeater, click **PTT Toggle**.
8. Adjust the softpot value until the desired receive audio level is achieved at Pin 7 (in reference to ground) on the Aux connector.

   The ground connection provided by the Aux connector is Pin 4.

   NOTICE: The Tuner aligns this parameter in a 12.5 kHz channel spacing, so 60% is 1.5 kHz of deviation. If Radio Management (RM) is set for 25 kHz operation, the repeater automatically scales the deviation by a factor of two when it is outside the Tuner application.
9. To de-key the repeater, click **PTT Toggle**.
10. To save the new tuned softpot value into the repeater codeplug, click **Write**.

Return to Process

SLR 1000 Programming and Tuning on page 70

8.7

Modulation Limit Alignment

Modulation is a change or alteration in the signal. Any aspect of the signal can be changed, such as amplitude, frequency, phase, timing or repetition rate of pulses. Aligning the modulation limit sets the RF carrier wave of the frequency bandwidth of the SLR 1000 Repeater.

NOTICE: A modulation limit alignment is always required when the repeater is in digital mode. This alignment is not required if the repeater is used in repeat mode.

Return to Process

SLR 1000 Programming and Tuning on page 70

Related Links

Tuning the Modulation Limit (with no Tx Data and no PL) on page 75
Verifying the Modulation Limit (with no Tx Data and no PL) on page 76

8.7.1

Tuning the Modulation Limit (with no Tx Data and no PL)

Prerequisites: Obtain the following:

- Wattmeter (Communication Analyzer)
- Service monitor or counter
- 20 dB pad
- Standard Type A to Type B USB cable
- Personal computer

Procedure:

1. Connect the repeater antenna port to the attenuation pad, if necessary, before connecting to the Communication Analyzer.
2. Power the repeater from a DC source.
3. Apply a 1 kHz signal at 1.2 Vrms to Pin 1 of the Aux connector.

   Signal ground is Pin 4 of the Aux connector.
4. Launch the Tuner application.
5. To read the softpot values, click **Read**.
6. In the tree view, select **TX**, then select **Modulation Limit**.
7. Enter the tuning frequency into the Communication Analyzer (the value displayed on the Tuner application).
8. To key up the repeater, click **PTT Toggle**.
9. Adjust the softpot value until the maximum deviation is 92% of the rated system deviation (RSD).

   This adjustment is tested in a 12.5 kHz channel spacing, so 92% of 2.5 kHz is 2.3 kHz.
10. Set the modulation limit to 92% so that any additional deviation incurred by the transmitter VCOs over temperature is compensated for.

Channel Spacing (kHz)	RSD (kHz)	92% of RSD (kHz)	Tolerance (Hz)
12.5	2.5	2.3	+0/ -50

11. To de-key the repeater, click **PTT Toggle**.
12. To save the new tuned softpot value into the repeater codeplug, click **Write**.

Return to Process

Modulation Limit Alignment on page 74

8.7.2

Verifying the Modulation Limit (with no Tx Data and no PL)

Prerequisites: Obtain the following:

- Wattmeter (Communication Analyzer)
- Service monitor or counter
- 20 dB pad
- Standard Type A to Type B USB cable
- Personal computer

Procedure:

1. Connect the repeater antenna port to the attenuation pad, if necessary, before connecting to the Communication Analyzer.
2. Power the repeater from a DC source.
3. In Radio Management (RM), program the repeater with any frequency within the specified range of the repeater under test, and set the repeater for low power and disable the repeat path.
4. Apply a 1 kHz signal at 1.2 Vrms to Pin 1 of the Aux connector.

   Signal ground is Pin 4 of the Aux connector.
5. Key up the repeater by grounding Pin 2 of the Aux connector and measuring the deviation

   NOTICE: Radio Management must have Pin 2 configured as an active low with the PTT function.
6. De-key the repeater.

   The deviation should meet the limits shown in the following table.

Channel Spacing (kHz)	Relative Standard Deviation (RSD) (kHz)	92% of RS (kHz)	Tolerance (Hz)
12.5	2.5	2.3	+0/-50
20.0	4.0	3.68	+0/-80
25.0	5.0	4.6	+0/-100

NOTICE:

- The repeater is factory-tuned in accordance to this procedure and specification.
- Verification is performed outside of the Tuner application, such as in normal mode.

Return to Process

Modulation Limit Alignment on page 74

8.8

Tuning a Duplexer Module

The duplexer module is shipped untuned. Before installing the duplexer into the repeater, it must be tuned specifically to the transmit and receive frequency pairs of the repeater.

The duplexer module is composed of three low-pass/high-notch cavities and three high-pass/low-notch cavities. Each set of three cavities provides bandpass filtering for either the transmit RF signal or the receive RF signal. In general, the duplexer must be tuned so that the transmit cavity set passes the

transmit signal and rejects the receive signal. Concurrently, the receive cavity set must be tuned to pass the receive signal and reject the transmit signal.

Tuning is performed by injecting RF signals and making tuning adjustments (using the tuning rods and trimmer screws) while monitoring for maximum or minimum readings on the RF millivoltmeter. Field tuning the duplexer module requires the following general adjustments:

- Tune high-pass/low-notch cavities for maximum pass and reject response
- Tune low-pass/high-notch cavities for maximum pass and reject response
- Check high-pass/low-notch and low-pass/high-notch cavities for insertion loss
- Check high-pass/low-notch and low-pass/high-notch cavities for isolation

NOTICE: If the duplexer module is tuned and the specifications are within a large margin of error, the duplexer must be returned to the Motorola Solutions Support Center (SSC) for repair.

Prerequisites: Obtain the following test equipment:

- 2-port network analyzer
- Network analyzer cables
- Open/short/load calibration kit
- Two SMA female to MCX adapters
- N-male to SME female adapter
- Small crescent wrench
- T10 TORX bit and driver

Procedure:

1. Determine the transmit and receive frequencies, as follows:

   The less of the two frequencies is the LOW frequency and the greater of the two is the HIGH frequency. Choose a duplexer that includes both of these frequencies in its tuning range as indicated on the duplexer label.

   a. Loosen the tightening nut on the three cavities for each section (six total). See Figure 23: SLR 1000 UHF Repeater Band Reject (Notch) Duplexer on page 77 and Figure 24: SLR 1000 VHF Repeater Band Reject (Notch) Duplexer on page 78

   Figure 23: SLR 1000 UHF Repeater Band Reject (Notch) Duplexer

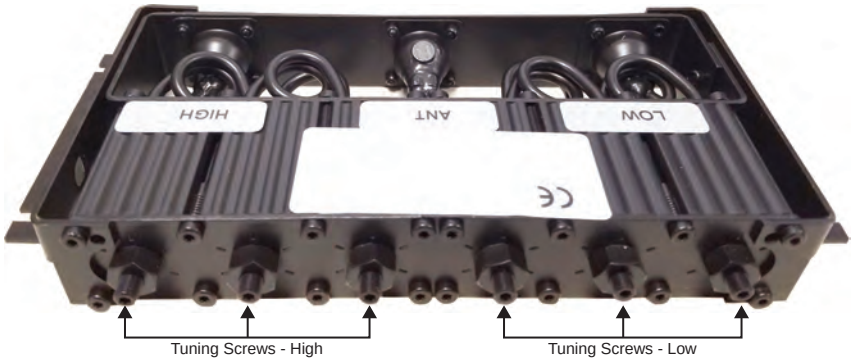
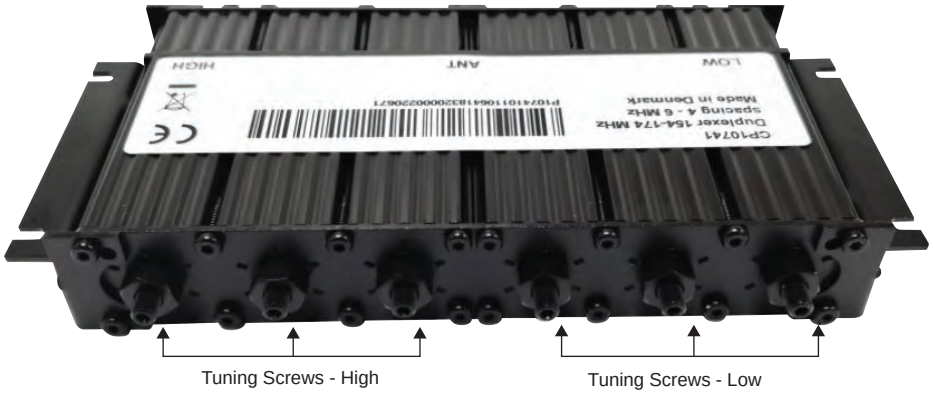


Figure 24: SLR 1000 VHF Repeater Band Reject (Notch) Duplexer



a On the network analyzer (or equivalent) set the start frequency to a LOW frequency – 3 MHz, and set the stop frequency to a HIGH frequency + 3 MHz.

b Using the sweep menu, adjust the power out to as high as possible, presumably 10 dBm.

c Perform a 2-port calibration.

2 View the s11 log mag return loss, as follows:

a Connect the LOW port on the duplexer to port 1 on the network analyzer.

b Connect the ANT port on the duplexer to port 2 on the network analyzer.

c Connect a 50 ohm load to the HIGH port on the network analyzer.

d Set marker 1 (M1) as the low frequency and marker 2 (M2) as the high frequency.

e Using the three T10 tuning screws on the LOW side, tune M1 for best return loss, s11.

The results should be better than -12 dB. The lower the number is best (such as, -20 dB is preferable than -10 dB). Shorter screws (turned clockwise) are for a lower frequency and longer screws (turned counterclockwise) are for a higher frequency. Keep all three screws for each port at about the same depth when tuning each section. Later in this tuning procedure, you may notice that the three LOW port screws are shorter than the three HIGH port screws.

f Connect the HIGH port on the duplexer to port 1 on the network analyzer.

g Connect a 50 ohm load to the LOW side on the duplexer.

h Tune the three screws on the HIGH side for a best return loss on M2.

3 View the s21 log mag insertion loss and rejection, as follows:

The goal is to keep M2 better than -1.7 dB (for example, -1.3 dB) and M1 less than -65 dB (for example, -67 dB). See Figure 25: Example for HIGH Port Tuning of the UHF Duplexer on page 79.

Figure 25: Example for HIGH Port Tuning of the UHF Duplexer

a Using the three T10 tuning screws on the LOW side, tune M2 for best insertion loss, s21, while keeping the isolation (M1) better than 65 dB.

The results should be better than -1.7 dB. Shorter screws (turned clockwise) are for a lower frequency and longer screws (turned counterclockwise) are for a higher frequency. Keep all three screws for each port at about the same depth when tuning each section. Later in this tuning process you may notice that the three LOW port screws are shorter than the three HIGH port screws.

b Connect the LOW side cable of the duplexer to port 1 on the network analyzer.

c Connect a 50 ohm load to the HIGH side of the duplexer.

The goal is to keep M1 better than -1.7 dB and M2 better than -65 dB. See Figure 26: Example for LOW Port Tuning of the UHF Duplexer on page 80.

Figure 26: Example for LOW Port Tuning of the UHF Duplexer

d Using the three T10 tuning screws on the HIGH side, tune M1 for best insertion loss, s21, while keeping the isolation (M2) better than 65 dB.

The results should be better than -1.7 dB. Shorter screws (turned clockwise) are for a lower frequency and longer screws (turned counterclockwise) are for a higher frequency. Keep all three screws for each port at about the same depth when tuning each section. Later in this tuning process you may notice that the three HIGH port screws are shorter than the three LOW port screws.

4 View the rejection of each port, as follows:

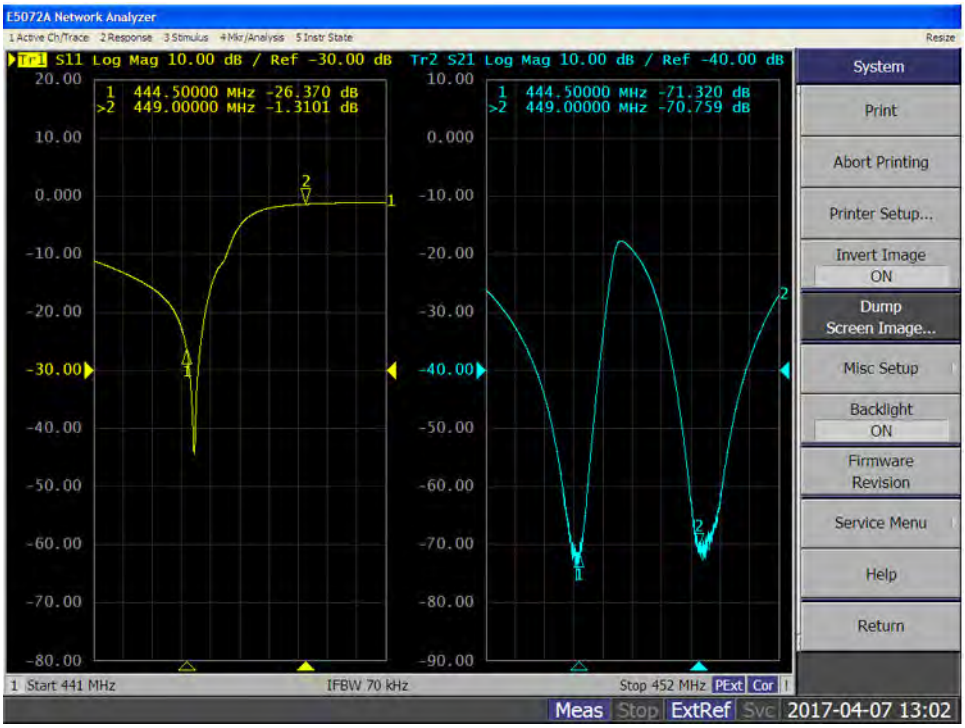
a Connect the LOW side of the duplexer to port 1 on the network analyzer.

b Connect the HIGH side of the duplexer to port 2 on the network analyzer.

c Connect a 50 ohm load to the ANT port on the duplexer.

d The results should be similar to Figure 27: Rejection of Each Port for UHF Duplexer on page 81

Figure 27: Rejection of Each Port for UHF Duplexer



5 Complete the tuning procedure, as follows:

a If the results are similar to Figure 27: Rejection of Each Port for UHF Duplexer on page 81 with better than -65 dB isolation between the LOW and HIGH ports of the duplexer, carefully tighten the nuts on the six T10 torque screws.

Tighten them slightly snug, not all the way. Be careful not to accidentally change the tuning of those screws.

b Observe the tuning so that the two DIPs are deeper than -65 dB. If so, continue to tighten the tuning nuts.

The duplexer is now tuned.

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Chapter 9

SLR 1000 Maintenance and Disassembly/Reassembly

Related Links

Routine Maintenance on page 82
Preventive Maintenance on page 82
Safe Handling of CMOS and LDMOS Devices on page 83
Installing a Duplexer on page 84
Installing a High-Speed Solid-State Antenna Switch on page 88

9.1
Routine Maintenance

The SLR 1000 Repeater and ancillary equipment have been designed with state-of-the-art technology and operate under software control, thus requiring minimal routine maintenance.

The Transceiver and the firmware it runs monitors and self-corrects all repeater operating parameters, making adjustments and tuning unnecessary.

If the equipment is installed in an area which meets the specified environmental requirements, the only routine maintenance task required is the calibration of the repeater reference oscillator circuit.

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SLR 1000 Maintenance and Disassembly/Reassembly on page 82

9.2
Preventive Maintenance

Periodic visual inspection and cleaning is recommended.

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SLR 1000 Maintenance and Disassembly/Reassembly on page 82

Related Links

Inspection on page 82
Cleaning on page 83

9.2.1
Inspection

Check that the external surfaces of the SLR 1000 Series Repeater are clean, and that all external controls and connections are in order. It is not recommended to inspect the interior electronic circuitry.

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Preventive Maintenance on page 82

9.2.2
Cleaning

Periodically clean smudges and grime from the exterior of the SLR 1000 Repeater with a soft cloth.

External surfaces include the top cover and repeater enclosure. Use a soft, non-abrasive cloth moistened in a 0.5% solution of mild dishwashing detergent and water solution. Use a second cloth moistened in clean water, and clean any dirt or debris from the heatsink fins.

The only factory recommended liquid for cleaning the printed circuit boards and their components is isopropyl alcohol (100% by volume).

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Preventive Maintenance on page 82

9.3
Safe Handling of CMOS and LDMOS Devices

Complementary metal-oxide semiconductor (CMOS) and laterally diffused metal-oxide semiconductor (LDMOS) devices are used in this family of stations, and are susceptible to damage by electrostatic or high-voltage charges. Damage can be latent, resulting in failures occurring weeks or months later. Therefore, special precautions must be taken to prevent device damage when disassembling, troubleshooting, and repairing.

Handling precautions are mandatory for CMOS/LDMOS circuits and are especially important in low humidity conditions.

DO NOT attempt to disassemble the repeater without first referring to the following CAUTION statement.

CAUTION: This repeater contains static-sensitive devices. Do not open the repeater unless you are properly grounded. Take the following precautions when working on this unit:

- Store and transport all CMOS/LDMOS devices in conductive material so that all exposed leads are shorted together. Do not insert CMOS/LDMOS devices into conventional plastic "snow" trays used for storage and transportation of other semiconductor devices.
- Ground the working surface of the service bench to protect the CMOS/LDMOS device. Use the Motorola Solutions Static Protection Assembly (part number 0180386A82), which includes a wrist strap, two ground cords, a table mat, and a floor mat, ESD shoes and an ESD chair.
- Wear a conductive wrist strap in series with a 100k resistor to ground. (Replacement wrist straps that connect to the bench top covering are Motorola Solutions part number 4280385A59).
- Do not wear nylon clothing while handling CMOS/LDMOS devices.
- Do not insert or remove CMOS/LDMOS devices with power applied. Check all power supplies used for testing CMOS/LDMOS devices to be certain that there are no voltage transients present.
- When straightening CMOS/LDMOS pins, provide ground straps for the apparatus used.
- When soldering, use a grounded soldering iron.
- Handle CMOS/LDMOS devices by the package and not by the leads. Before touching the unit, touch an electrical ground to remove any static charge that you may have accumulated. The package and substrate may be electrically common. If so, the reaction of a discharge to the case would cause the same damage as touching the leads.

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SLR 1000 Maintenance and Disassembly/Reassembly on page 82

9.4

Installing a Duplexer

Install a duplexer into the SLR 1000 Repeater when transmitting and receiving using one antenna.

Prerequisites: Obtain the following:

- Duplexer kit
- Four M3 screws (obtained from the repeater package)
- T20 bit screwdriver
- T10 bit screwdriver
- ¾ in. deep well socket

NOTICE: The duplexer must be tuned before being installed. See Tuning a Duplexer Module on page 76.

Procedure:

1. Turn off power to the repeater.
2. Disassemble the repeater, as follows:
   - **a** Turn the repeater over and remove the four M4 screws using a T20 bit.
   - **b** Hold the cover onto the chassis and carefully turn the repeater over.
   - **c** Slowly remove the top cover, making sure not to damage the front panel flex cable.
3. Disconnect the following cables. See Figure 28: SLR 1000 Repeater Front View (without top cover) on page 85.
   - **a** Disconnect the front panel flex cable from the front panel display board.
   - **b** Cut the tie wrap that secures the Tx and Rx cables.
   - **c** Disconnect the Rx cable from the Rx input board connection by gently pulling up.
   - **d** Disconnect the Tx cable from the Tx output board connection by gently pulling up.
   - **e** Remove the Tx cable by either cutting (recommended) the cable from the Tx output port or tie wrapping the cable.

     CAUTION: The Tx cable must not touch any components on the board.
   - **f** Remove the Rx cable from the Rx port opening in the chassis.

Figure 28: SLR 1000 Repeater Front View (without top cover)

Table 21: SLR 1000 Repeater Front View (without top Cover) Callout Legend

Label	Description
1	Transmitter RF (Tx) Output Board Connection
2	Receiver RF (Rx) Input Board Connection
3	Transmitter RF (Tx) Output Cable Port

Label	Description
4	Receiver RF (Rx) Input Cable Port
5	Front Panel Flex Connector

4 Install the duplexer into the repeater, as follows:

a Lay the front panel flex cable down across the board.

b Place the duplexer into the chassis and align the screw openings, as shown in Figure 29: SLR 1000 Repeater Front View (without top cover) with a Duplexer on page 87

c Insert the duplexer antenna port through the Rx port opening in the chassis.

d Reinstall the lockwasher and nut onto the antenna port. Torque to 20 in.-lbs using a ¾ in. socket.

e Insert the low-pass port cable into the Tx output board connection.

f Place the high-pass port cable underneath the duplexer and insert into the Rx input board connection.

g Secure the duplexer to the chassis with four M3 screws using a T10 bit. Torque to 13 in.-lbs.

h Reattach the front panel flex cable to the front panel display board, making sure not to bend the cable.

The cable stops at the black line.

i Place the top cover back onto the chassis, making sure not to pinch any cables.

j Hold the cover onto the chassis and carefully turn the repeater over.

k Reinstall the four M4 screws using a T20 bit. Torque to 26 in.-lbs.

5 Restore power to the repeater.

Figure 29: SLR 1000 Repeater Front View (without top cover) with a Duplexer

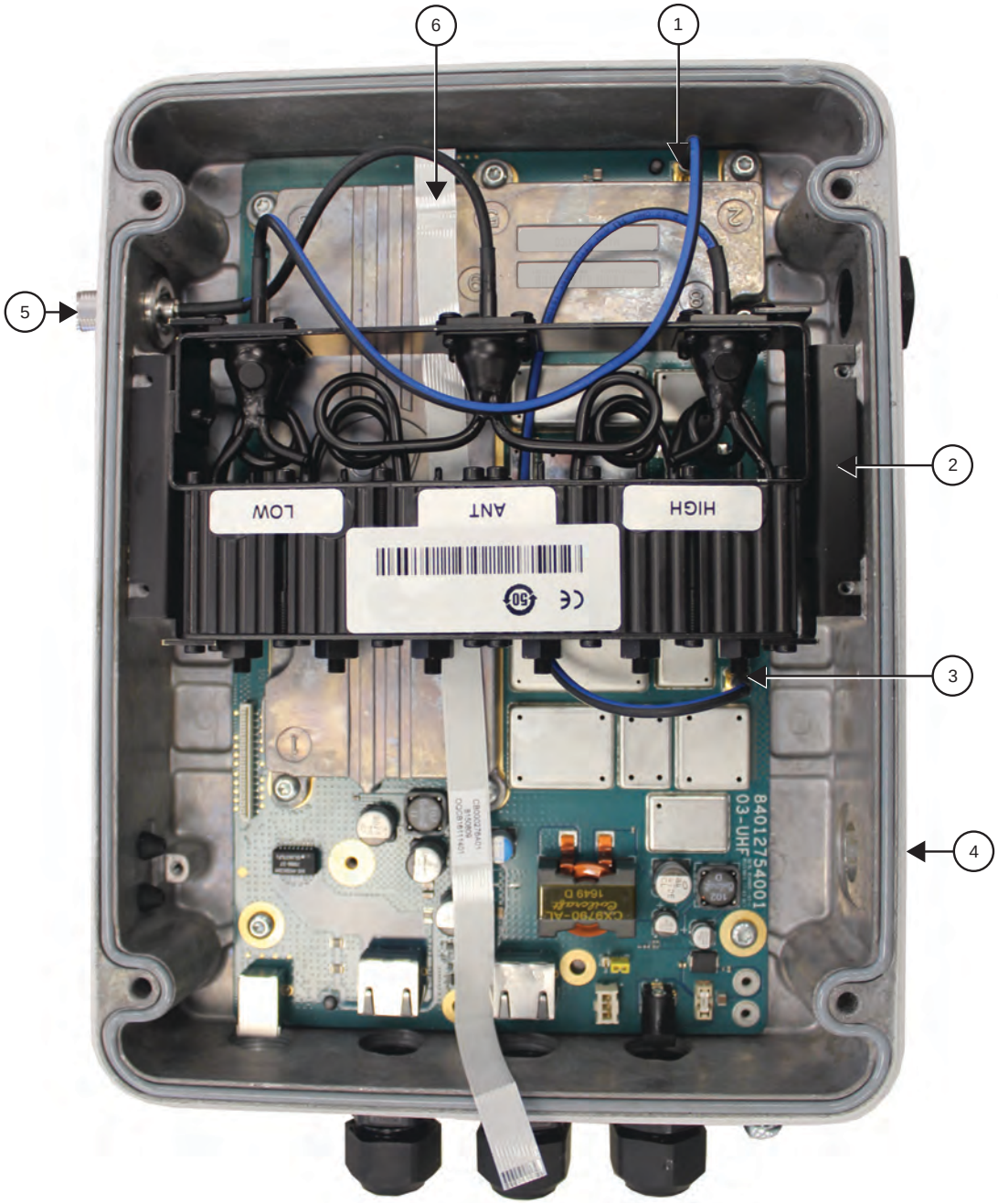

Table 22: SLR 1000 Repeater Front View (without top Cover) with a Duplexer Callout Legend

Label	Description
1	Transmitter RF (Tx) Output Board Connection
2	Duplexer
3	Receiver RF (Rx) Input Board Connection
4	Transmitter RF (Tx) Output Cable Port
5	Receiver RF (Rx) Input Cable Port

Label	Description
6	Front Panel Flex Connector

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SLR 1000 Maintenance and Disassembly/Reassembly on page 82

9.5

Installing a High-Speed Solid-State Antenna Switch

The high-speed solid-state antenna switch is required for a single antenna, single frequency operation. With the use of the antenna switch, the SLR 1000 Repeater can be configured as a Direct Mode Range Extender for use with the Extended Range Direct Mode feature. Alternatively, two separate antennas may be used for RX and TX operation, but a minimum of 40 dB isolation between the two antennas must be maintained.

CAUTION: The high-speed solid-state antenna switch is only operable in Extended Range Direct Mode (ERDM) mode and should not be installed in the repeater if all the channels are not enabled as Extended Range Direct Mode. Operating in any mode other than ERDM, may cause damage to the antenna switch board.

Prerequisites: Obtain the following:

- Contents of the antenna switch package. Consists of:
  - One antenna switch
  - Two M3 screws
  - Two Micro Coaxial (MCX) cables
  - One power cable
- T10 bit screwdriver
- T20 bit screwdriver

Procedure:

1. Turn off power to the repeater.
2. Disassemble the repeater, as follows:
   - **a** Turn the repeater over and remove the four M4 screws using a T20 bit.
   - **b** Hold the cover onto the chassis and carefully turn the repeater over.
   - **c** Slowly remove the top cover, making sure not to damage the front panel flex cable.
3. Disconnect the following cables. See Figure 30: SLR 1000 Repeater Front View (without top cover) on page 89.
   - **a** Disconnect the front panel flex cable from the front panel display board.
   - **b** Cut the tie wrap that secures the Tx and Rx cables.
   - **c** Disconnect the Rx cable from the Rx board connection by gently pulling up.
   - **d** Disconnect the Tx cable from the Tx board connection by gently pulling up.
   - **e** Remove the Tx cable by either cutting the cable from the Tx input port or tie wrapping the cable.

     CAUTION: The Tx cable must not touch any components on the board.

Figure 30: SLR 1000 Repeater Front View (without top cover)

Table 23: SLR 1000 Repeater Front View (without top Cover) Callout Legend

Label	Description
1	Transmitter RF (Tx) Output Board Connection
2	Receiver RF (Rx) Input Board Connection
3	Transmitter RF (Tx) Output Cable Port

Label	Description
4	Receiver RF (Rx) Input Cable Port
5	Front Panel Flex Connector

4 Install the antenna switch into the repeater, as follows:

a Place the antenna switch into the chassis and align the screw openings, as shown in Figure 31: SLR 1000 Repeater Front View (without top cover) with an Antenna Switch on page 91.

b Secure the antenna switch to the chassis with the two M3 screws using a T10 bit. Torque to 13 in.-lbs.

c Connect one end of the power cable into the P1000 connector on the antenna switch and the other end to the header connector on the repeater board.

d Connect one end of an MCX cable into the J1000/TX connector on the antenna switch and the other end to the Tx output board connection.

e Connect one end of the other MCX cable into the J1001/RX connector on the antenna switch and the other end to the Rx input board connection.

f Connect the Station Rx cable to the J1002/ANT connector on the antenna switch.

IMPORTANT: Ensure that the antenna cable is routed away from the Tx cable. See Figure 31: SLR 1000 Repeater Front View (without top cover) with an Antenna Switch on page 91.

g Reattach the front panel flex cable to the front panel display board, making sure not to bend the cable.

The cable stops at the black line.

h Place the top cover back onto the chassis, making sure not to pinch any cables.

i Hold the cover onto the chassis and carefully turn the repeater over.

j Reinstall the four M4 screws using a T20 bit. Torque to 26 in.-lbs.

5 Restore power to the repeater.

Figure 31: SLR 1000 Repeater Front View (without top cover) with an Antenna Switch

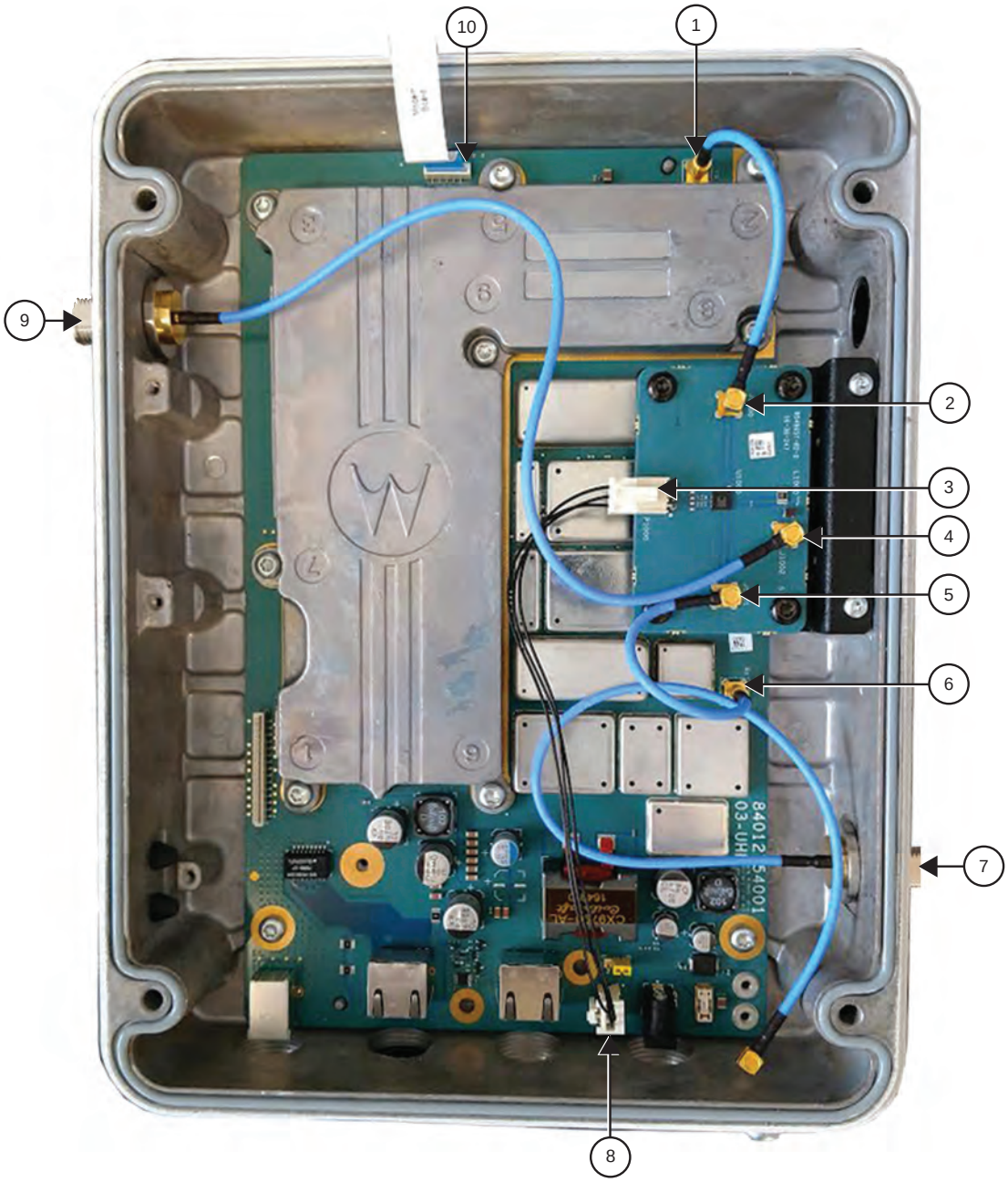

Table 24: SLR 1000 Repeater Front View (without top Cover) with an Antenna Switch Callout Legend

Label	Description
1	Transmitter RF (Tx) Output Board Connector
2	J1000 Connector
3	P1000 Connector
4	J1002 Connector
5	J1001 Connector

Label	Description
6	Receiver RF (Rx) Input Board Connector
7	Transmitter RF (Tx) Output Cable Port
8	Header Connector
9	Receiver RF (Rx) Input Cable Port
10	Front Panel Flex Connector

6 Enable with switch within Radio Management by performing the following steps:

a Click the green **Actions** icon.

b From the drop-down menu, select **Manage** → **Configurations**

c Right-click on the repeater and select **Edit**.

d Within the **General** category, select **Accessories**.

e In the **GPIO6** field, select **Tx/Rx Switch** and set the **Active Level** to **High**. Click **Save**.

f Within the **Zone/Channel Assignment** category, select **Zone**.

g Right-click on the channel and select **Edit**.

h In the **Extended Range Direct Mode** field, select **Enabled**. Click **Save**.

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SLR 1000 Maintenance and Disassembly/Reassembly on page 82

Chapter 10

SLR 1000 Installation

Related Links

Pre-Installation Considerations on page 93
SLR 1000 Repeater Package Contents on page 100
Mounting the SLR 1000 Repeater to a Wall or Ceiling on page 100
Mounting the SLR 1000 Repeater to a Pole on page 103
Electrical Connections on page 108
General Bonding and Grounding Requirements on page 114
General Cabling Requirements on page 115
Post Installation Checklist on page 115

10.1
Pre-Installation Considerations

Proper installation ensures the best possible performance and reliability of the repeater.
Pre-installation planning is required and includes considering the mounting location of the equipment in relation to input power, antennas, and system interfaces. Also to be considered are site environment conditions, the particular mounting method (several available), and required tools and equipment.

It is highly recommended to read the following before installing this type of equipment for the first time:

- this entire installation section before beginning the actual installation, and
- the Motorola Solutions Quality Standard Fixed Network Equipment Installation manual, R56 (which can be obtained by ordering CDROM 9880384V83), specifically refer to the information on ground connection for lightning protection.

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SLR 1000 Installation on page 93

Related Links

Installation Overview on page 93
Site Environmental Conditions on page 94
Equipment Mounting Methods on page 95
Equipment Ventilation on page 95
AC and DC Input Power Requirements on page 96
Site Grounding and Lightning Protection on page 97
Recommended Tools and Equipment on page 99
Equipment Unpacking and Inspection on page 99

10.1.1
Installation Overview

The following information is an overview for installing the repeater and the ancillary equipment.

Step-by-step procedures for each of the major installation tasks are then provided beginning in Mechanical Installation.

- Plan the installation, paying particular attention to environmental conditions at the site, ventilation requirements, and grounding and lightning protection.
- Unpack and inspect the equipment.
- Mechanically install the equipment at the site.
- Make necessary electrical and cabling connections, including the following:
  - DC input cabling
  - Coaxial cables to transmit and receive antennas
  - System cables
- Perform a post-installation function checkout test of the equipment to verify proper installation. To customize the repeater parameters per customer specifications (such as operating frequency, PL, codes, and so on.) see the *Radio Management (RM) Online Help*.

Return to Process

Pre-Installation Considerations on page 93

10.1.2
Site Environmental Conditions

The installation location of the SLR 1000 Repeater must follow precautions and be conducted in such a way so that access is limited to technicians with adequate training and skills.

CAUTION: The repeater is a natural-convection cooled device and may get hot when installed in hot and/or high solar load environments. Use of on-board antennas also creates a potential exposure to RF energy that must be considered.

The repeater may be installed in any suitable location meeting the restricted access criteria and not exceeding the equipment specifications for temperature and environmental exposure (ingress). Unit orientation, solar loading, antenna, and cable load quality may all affect the temperature and performance of the unit.

The environmental conditions are:

- Operating Temperature Range – Vertical orientation
  -30 °C (-22 °F) to +60 °C (+140 °F)

  The operating temperature range is the temperature measured close to the repeater, near the fin inlets (bottom). Other factors, such as orientation, solar loading, duty cycle, altitude, and VSWR can affect transmit power and/or maximum operating temperature range.
- Ingress
  The repeater has been designed to IP65/NEMA 4 ingress protection. It provides protection against blowing water and dust and can be deployed in harsh industrial indoor environments and/or outdoor applications where rain, snow, and dust are prevalent.
- Vibration and Loads
  The repeater hardware has been designed to survive high vibration and wind loads (up to 150 mph) encountered in outdoor environments and may be installed in vehicular environments when equipped with ruggedized mounting brackets or trunnions.

Return to Process

Pre-Installation Considerations on page 93

10.1.3
Equipment Mounting Methods

The SLR 1000 Repeater may be mounted on a wall, ceiling, or pole.

Return to Process

Pre-Installation Considerations on page 93

10.1.4
Equipment Ventilation

The SLR 1000 Repeater is a natural-convection or passively cooled device with no fans. Care must be taken in mounting the unit to ensure that fresh air can flow into the fin entrances and heated air can adequately escape.

Return to Process

Pre-Installation Considerations on page 93

Related Links

Ventilation for a Ceiling Mount on page 95
Ventilation for a Wall Mount on page 95

10.1.4.1
Ventilation for a Ceiling Mount

Ceiling mounting of the SLR 1000 Repeater requires that the bracket is mounted against the ceiling surface and that the unit is positioned with the fins facing up towards the ceiling for proper ventilation.

Fresh air flows into both ends of the fins and the heated air exhausts out the top of the fin channels. The mounting bracket (same as used for the wall mount) provides an adequate gap between the unit fin tips and the ceiling surface. The fin cooling effectiveness in this orientation is slightly lower than vertical wall mount orientations and some power shutback at high ambients may occur. It is not recommended to mount any optional AC power supplies onto the mounting bracket when in a ceiling orientation, as the exhaust air is restricted from rising and could overheat the power supply unit as well.

Return to Process

Equipment Ventilation on page 95

10.1.4.2
Ventilation for a Wall Mount

Wall mounting of the SLR 1000 Repeater requires that the bracket is mounted against the wall surface and that the unit is positioned with the fins running vertically for proper ventilation.

Fresh air flows into the bottom of the fins and the heated air exhausts out the top of the fin channels. Mounting of the unit with the fins running horizontally or other orientations other than vertical reduces the airflow through the fins and some power shutback at high ambients may occur. The wall mount bracket provides adequate gap and mounting provisions for integration of an optional AC power supply between the fins and the bracket. As airflow occurs bottom to top, the wall mount does not impact thermal performance in the vertical orientation.

Return to Process

Equipment Ventilation on page 95

10.1.5

AC and DC Input Power Requirements

This section describes the power requirements for the AC and DC inputs, as well as ground, battery, RF antenna, and system cable connections.

Return to Process

Pre-Installation Considerations on page 93

Related Links

DC Input Power Requirements on page 96
AC Input Power Requirements on page 96
Ground Connection on page 97
RF Antenna Connections on page 97
System Cable Connections on page 97

10.1.5.1

DC Input Power Requirements

A power supply must obtain the energy it supplies to its load, and any energy it consumes. This section describes the power requirements for the DC inputs.

The DC source operates from 10.8 VDC to 15.6 VDC (4A max). . This DC source must be located in the same building as the repeater, and it must meet the requirements of a SELV circuit. The appropriate DC disconnects and current limiting devices must be chosen and implemented per R56.

Return to Process

AC and DC Input Power Requirements on page 96

10.1.5.2

AC Input Power Requirements

A power supply must obtain the energy it supplies to its load, and any energy it consumes. This section describes the power requirements for the AC inputs.

For indoor applications, a standard indoor power supply with an IEC C13 appliance connector is available. The adapter may be combined with bracket BR000276A01 so that it can be integrated onto the wall mount bracket with the SLR 1000 Repeater or attached directly to the wall or ceiling.

Use a standard 3-wire grounded electrical outlet as the AC source.

CAUTION: The AC socket outlet must be installed near the equipment and must be easily accessible.

For outdoor applications, a sealed IP67 rated AC power converter is available. This unit may be attached directly to the wall mount bracket with the repeater. It includes water tight cable junction connectors and requires extra wiring, conduit, and/or similar provisions to connect to the AC source.

The outlet must be connected to an AC source capable of supplying a maximum of 500 VA. For a nominal 110/120 VAC input, the AC source must supply 2A max for both indoor and outdoor. Per R56, the minimum ampacity of the circuit (and protective breaker) feeding the repeater should be no less than 15A. For a nominal 220/240 VAC input, the ampacity requirements can be halved.

Return to Process

AC and DC Input Power Requirements on page 96

10.1.5.3
Ground Connection

The SLR 1000 Repeater is equipped with a ground screw on the bottom panel of the repeater.

Return to Process

AC and DC Input Power Requirements on page 96

10.1.5.4
RF Antenna Connections

The transmit and receive antenna RF connections are made using two separate connectors in the standard unit. Duplexer and antenna switch accessories are also available to allow duplexed, half duplexed, or simplex single antenna operation.

In addition, an integrated compact antenna accessory is available to facilitate mounting the antenna directly on the unit. If the duplexer or antenna switch accessories are not used, external antennas are required. Additionally, because the antenna is mounted directly to the repeater, it is not recommended to use the integrated antenna in applications where a direct lightning strike to the unit could occur as significant damage to the repeater and/or connected equipment could occur. Consult R56 manual for details and necessary provisions for surge protection on RF cable and antennas.

Return to Process

AC and DC Input Power Requirements on page 96

10.1.5.5
System Cable Connections

System connections are made through the Aux and/or Ethernet connectors on the bottom panel of the SLR 1000 Repeater.

Return to Process

AC and DC Input Power Requirements on page 96

10.1.6
Site Grounding and Lightning Protection

Adherence to standards ensures that a site is protected to the maximum degree and avoids lightning or other power surge-induced equipment failures and, under certain circumstances, personnel safety.

CAUTION: Proper site grounding and lightning protection are vitally important considerations. Failure to provide proper lightning protection may result in permanent damage to the radio equipment.

One of the most important considerations when designing a communications site is the ground and lightning protection system. While proper grounding techniques and lightning protection are closely related, the general category of site grounding may be divided into the following sections:

- Electrical Ground
- RF Ground
- Lighting Ground
- Equipment Grounding

Return to Process

Pre-Installation Considerations on page 93

Related Links

Electrical Ground on page 98
RF Ground on page 98
Lightning Ground on page 98
Equipment Grounding on page 98

10.1.6.1
Electrical Ground

Ground wires carrying electrical current from circuitry or equipment at the site is included in the category of electrical ground. Examples include the AC or DC electrical power used to source equipment at the site, and wires or cables connected to alarms or sensors at the site.

Return to Process

Site Grounding and Lightning Protection on page 97

10.1.6.2
RF Ground

This type of ground is related to the bypassing of unwanted radio frequency energy to earth ground. An example of RF grounding is the use of shielding to prevent or at least minimize the leakage of unwanted RF energy from communications equipment and cables.

Return to Process

Site Grounding and Lightning Protection on page 97

10.1.6.3
Lightning Ground

Providing adequate lightning protection is critical to a safe reliable communications site. RF transmission cables, and AC and DC power lines must all be protected to prevent lightning energy from entering the site.

Comprehensive coverage of site grounding techniques and lightning protection is not within the scope of this instruction manual, but there are several excellent industry sources for rules and guidelines on grounding and lightning protection at communications sites.

NOTICE: Motorola Solutions recommends the following reference source:
Motorola Solutions Quality Standards Fixed Network Equipment Installation Manual R56: (which can be obtained by ordering CDROM 9880384V83).

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Site Grounding and Lightning Protection on page 97

10.1.6.4
Equipment Grounding

The SLR 1000 Repeater is equipped with a ground screw on the bottom right of the repeater.

This screw is used to connect the repeater to the site grounding. All antenna cables, and AC and DC power cabling, should be properly grounded and lightning protected by following the rules and guidelines provided in the previous sections. Failure to provide proper lightning protection may result in permanent damage to the repeater.

Return to Process

Site Grounding and Lightning Protection on page 97

10.1.7

Recommended Tools and Equipment

In addition to the typical compliment of hand tools, the following tools and equipment are recommended for proper installation of the repeater equipment.

- Tarpaulin or plastic drop cloth or cover surrounding equipment while drilling concrete anchor holes.
- Vacuum cleaner for removing concrete dust caused by drilling.

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Pre-Installation Considerations on page 93

10.1.8

Equipment Unpacking and Inspection

This section describes ways to unpack and inspect the repeater equipment.

Unpack Equipment

Remove the repeater from the cardboard box. Remove the foam inserts and remove the repeater from the antistatic bag. Keep all packing components for future shipping of the repeater.

Initial Inspection

- After removing the repeater from the packaging, set on the surface for inspection. The front cover and main housing should be free of damage and should have no obvious scuffs or marks.
- The RF connectors should be free of damage. Connectors should not be bent with regard to the chassis. Threads on RF connectors should be free of debris and undamaged.
- Thoroughly inspect the equipment as soon as possible after delivery. If any part of the equipment has been damaged in transit, immediately report the extent of the damage to the transportation company and to Motorola Solutions.
- When a repeater is delivered from Motorola Solutions, it arrives in suitable packing materials. If the unpacked equipment is damaged, return it to Motorola Solutions in its original packaging.

  CAUTION: Equipment should be handled in its original packaging until it is delivered to its final destination. If the equipment is damaged while being moved without the original packaging, the warranty claim is not valid.

  Improper handling of the repeater may cause personal injury or damage to the repeater.

Return to Process

Pre-Installation Considerations on page 93

10.2

SLR 1000 Repeater Package Contents

Inspect the various parts and fittings within the SLR 1000 Repeater packing box. Verify that the following contents are included.

Table 25: SLR 1000 Repeater Package Contents

Description	Quantity
Safety Supplement Leaflet	1
DC Power Cable Assembly	1
Threaded M20 Seal Plugs (IP67/68)	4 (1 spare)
Cable Gland/Cord M20 Seal Cap (IP67/68)	4 (1 spare)
Wall-Mount Bracket	1
Serrated Hex Flange M6 Screws	4
SLR 1000 Repeater	1
M3 Screws	4
M4 Screws	4

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SLR 1000 Installation on page 93

10.3

Mounting the SLR 1000 Repeater to a Wall or Ceiling

Perform this procedure to mount the SLR 1000 Repeater to either a wall or to a ceiling.

NOTICE: A wall mount provides a vertical fin orientation. This orientation is required for high temperatures and maximum performance.

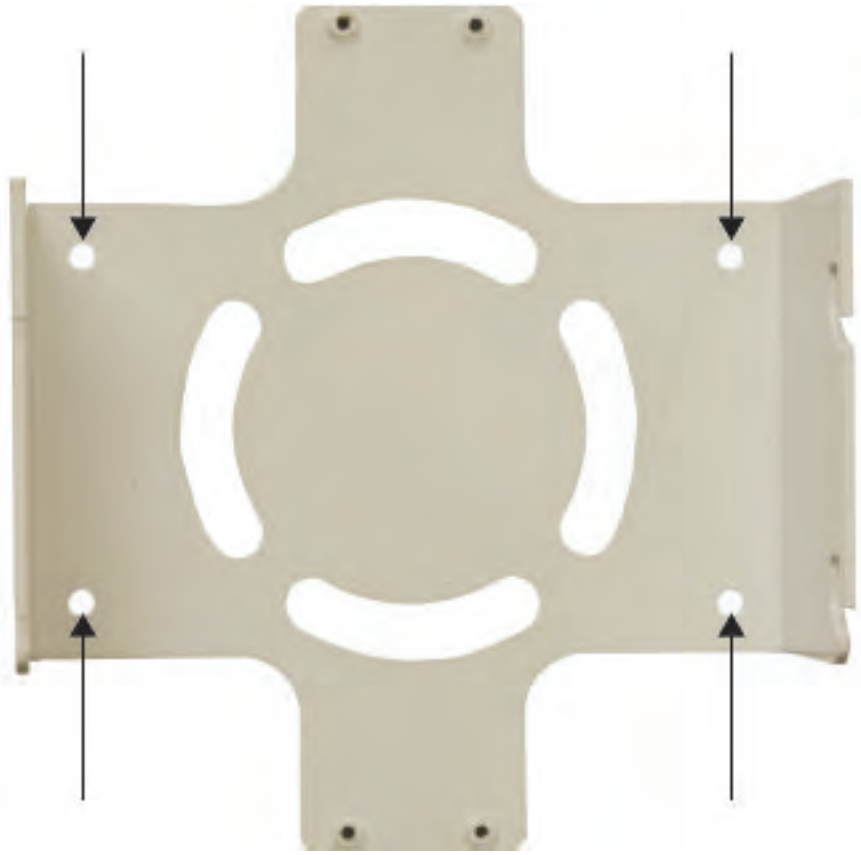
Prerequisites: Obtain the following:

- Contents of the repeater package. See SLR 1000 Repeater Package Contents on page 100.
- Four #10/32 lag bolts (not included in the repeater package).
- Torque wrench, adjustable wrench, or a ratchet with a 10mm socket

Procedure:

1. Attached the bracket to either the wall or ceiling using four #10/32 lag bolts. See Figure 32: Bracket Mounting Holes on page 101.

Figure 32: Bracket Mounting Holes



2 If using a power supply, mount using the four M4 T20 bit screws. Torque to 20 in.-lbs.

For an indoor power supply, attach the indoor PS bracket (part no. BR000276A01) to the wall mount bracket before installing. For detailed instructions on assembling the AC and DC cables on an outdoor power supply, see Assembling an Outdoor Power Supply on page 111.

3 Insert the four M6 screws into the repeater chassis side fins and partially tighten. See Figure 33: Location of Repeater M6 Screw Mounts on page 102.

Figure 33: Location of Repeater M6 Screw Mounts

4 Place the repeater chassis into the bracket by sliding the M6 screws into the receiving slots on the bracket. Torque to 60 in.-lb. See Figure 34: Bracket Receiving Slots on page 102.

Figure 34: Bracket Receiving Slots

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SLR 1000 Installation on page 93

10.4

Mounting the SLR 1000 Repeater to a Pole

Perform this procedure to mount the SLR 1000 Repeater to a pole.

Prerequisites: Obtain the following:

- PMLN7213_ Pole Mount Kit. Consists of:
  - One pole mount bracket
  - One ½ in. U-bolt
  - Two ½ in. bolts
  - Four ½ in. nuts
  - Two ½ in. washers
- Four M6 screws (supplied in the repeater package)
- Wall mount bracket (supplied in the repeater package)
- Torque wrench, adjustable wrench, or a ratchet with a 10mm socket
- Four M4 T20 bit screws (for a mounting a power supply, supplied in the repeater package)

When and where to use:
There are two possible options for the pole mount installation:

- Using a U-bolt with two ½ in. washers and four ½ in. nuts for poles with a diameter between 2 – 2.75 in.
- Using two band clamps for poles of any diameter. The band clamps are not included in the pole mount kit.

Procedure:

1. If using the U-bolt for installation, perform the following actions:
   - **a** Thread two of the ½ in. nuts onto the U-bolt.
   - **b** Place the U-bolt onto the pole and slide the pole mount bracket onto the U-bolt.
   - **c** Slide the wall mount bracket onto the U-bolt, with the receiving slots facing upwards, and place the two ½ in. washers then the two ½ in. nuts onto the U-bolt, one on each thread. Torque the outer nuts to 150 in./lb. See Figure 35: U-Bolt and Pole Mount Bracket Assembly on page 104.

Figure 35: U-Bolt and Pole Mount Bracket Assembly

d Tighten the inner nuts against the pole mount bracket and torque to 300 in.-lb.

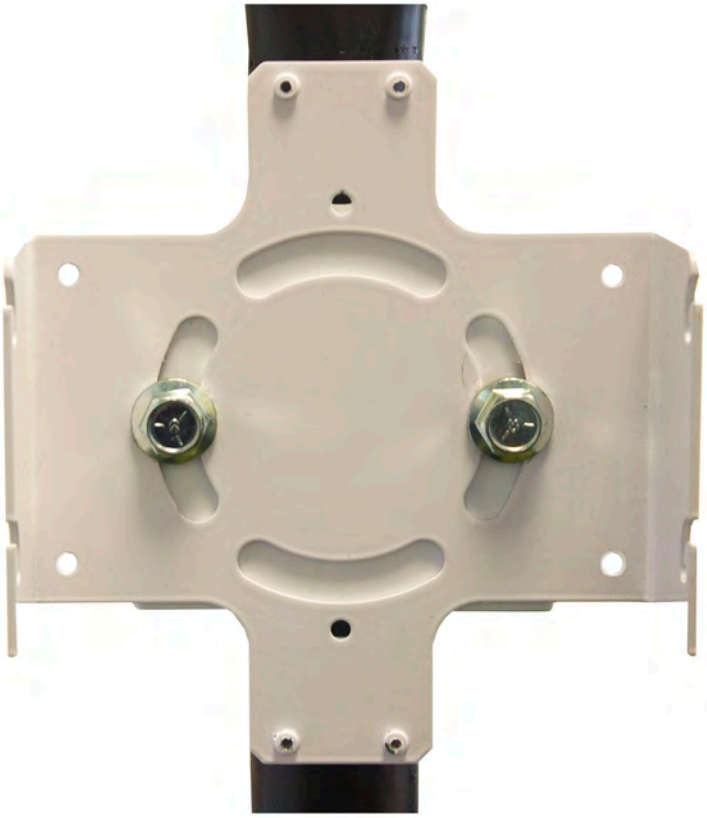
2 If using the band clamps for installation, perform the following actions:

a Slide the band clamps through the slots on the pole mount bracket and attach the bracket to the pole. See Figure 36: Band Clamps and Pole Mount Bracket on page 105

Figure 36: Band Clamps and Pole Mount Bracket

b Attach the wall mount bracket to the pole mount bracket, with the receiving slots facing upwards, using two ½ in. bolts and two ½ in. nuts. Torque to 300 in.-lb. See Figure 37: Wall Mount Bracket Attached to Pole Mount Bracket on page 105

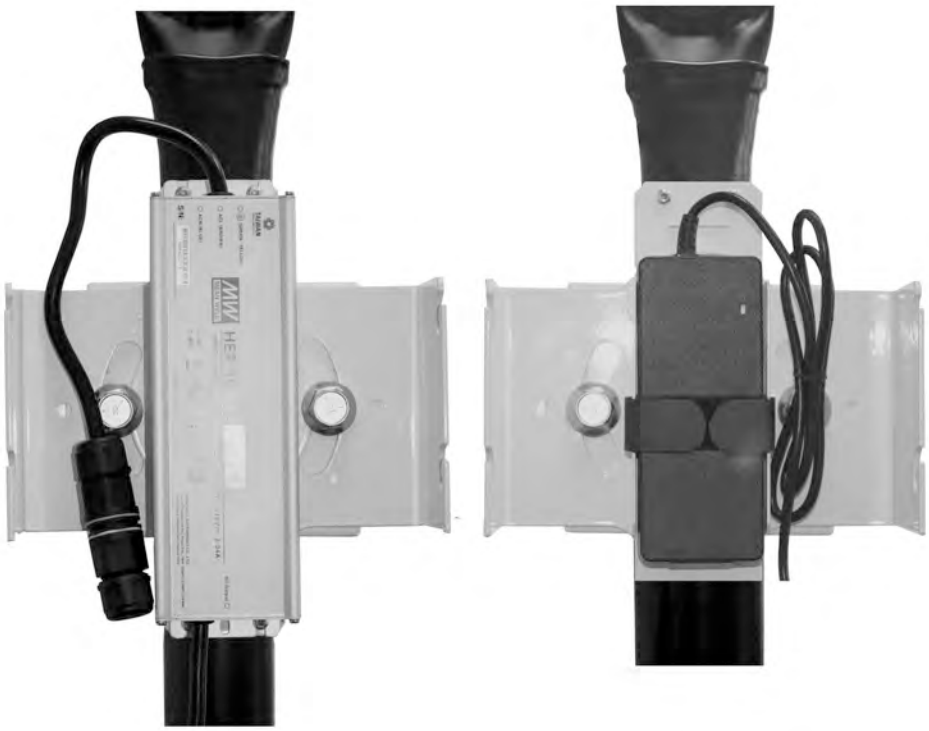
Figure 37: Wall Mount Bracket Attached to Pole Mount Bracket



3 If using a power supply, mount using the four M4 T20 bit screws. Torque to 20 in.-lbs.

For an indoor power supply, attach the indoor PS bracket (part no. BR000276A01) to the wall mount bracket before installing. For detailed instructions on assembling the AC and DC cables on an outdoor power supply, see Assembling an Outdoor Power Supply on page 111.

Figure 38: Power Supplies



4 Insert the four M6 screws, supplied in the repeater package, into the repeater chassis side fins and partially tighten. See Figure 39: Location of Repeater M6 Screw Mounts on page 107.

Figure 39: Location of Repeater M6 Screw Mounts

5 Place the repeater chassis into the bracket by sliding the M6 screws into the receiving slots on the bracket. Torque to 60 in.-lb. See Figure 40: Bracket Receiving Slots on page 107.

Figure 40: Bracket Receiving Slots

Return to Process

SLR 1000 Installation on page 93

10.5
Electrical Connections

After the repeater equipment has been mechanically installed, electrical connections must be made.

The electrical connections involve making the following connections to:

- power supply
- antenna coax cables
- system cables
- grounding

Figure 41: SLR 1000 Repeater Bottom Panel Connector Names and Locations on page 109 shows the position of the repeaters external connectors on the bottom panel of the repeater. Table 26: SLR 1000 Repeater Connector Types and Primary Functions on page 109 identifies the connector types and the primary function of the connectors.

Figure 41: SLR 1000 Repeater Bottom Panel Connector Names and Locations

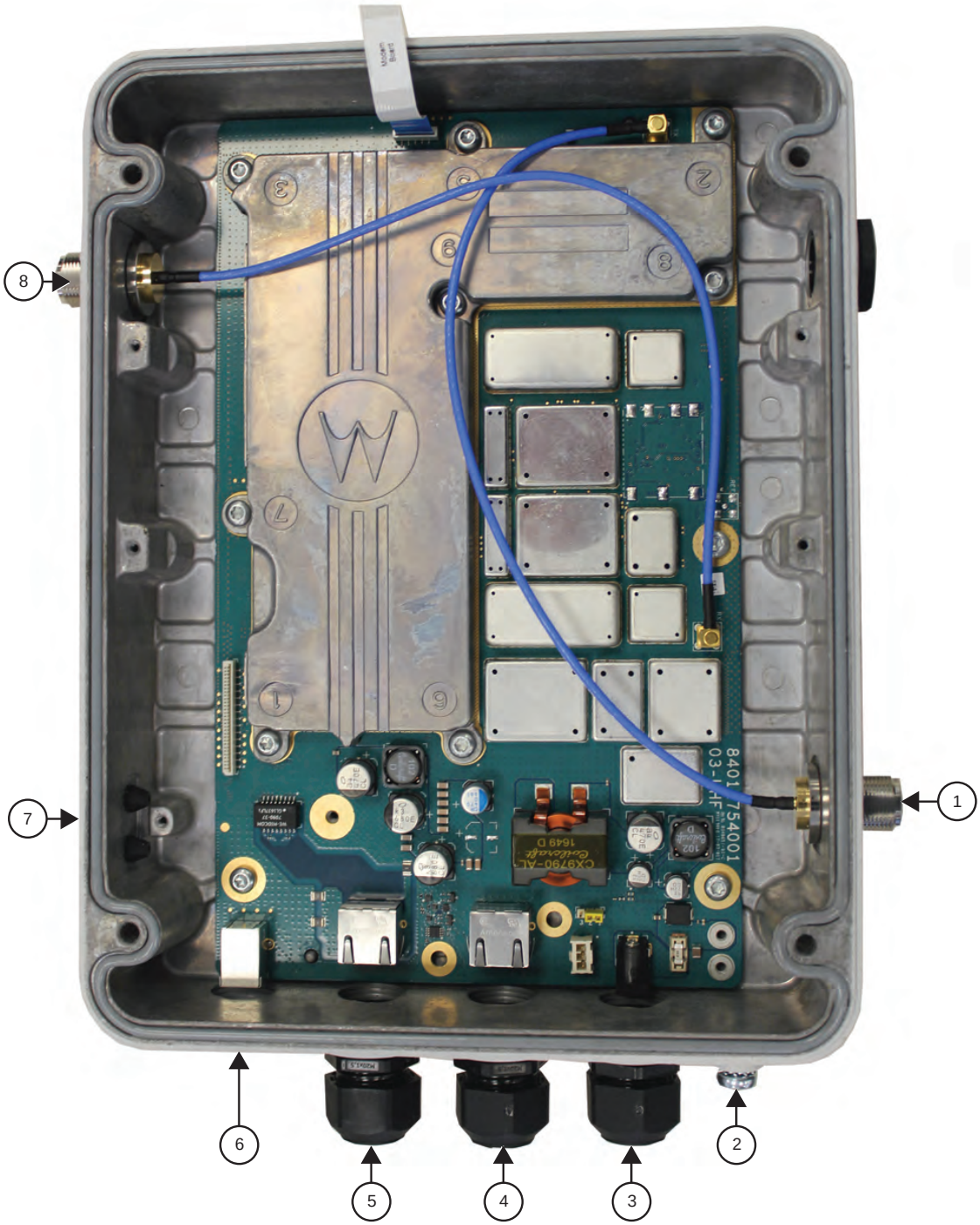


Table 26: SLR 1000 Repeater Connector Types and Primary Functions

Location	Connector Type	Function(s)
1	N-Type – Female	Receiver RF (Rx)
2	M6 TORX Screw	Bonding Ground Connection

Location	Connector Type	Function(s)
3	2.1 X 5.5 OD Barrel Connector	DC Power Inlet
4	RJ-45 – Aux/ Accessory	Rx Audio, Tx Audio, PTT, 1 PPS, and GPIO
5	RJ-45 – Ethernet	Network
6	Type B USB Socket	Programming Interface
7	Option Depend-ent	Option Dependent 1 and 2
8	N-Type – Fe-male	Transmitter RF (Tx)

Return to Process

SLR 1000 Installation on page 93

Related Links

Connecting the DC Input Power on page 110
Connecting the Indoor Adapter AC Input Power on page 111
Assembling an Outdoor Power Supply on page 111
Ground Connection on page 113
RF Antenna Connections on page 113
System Cable Connections on page 114
Installing Cable Grommet Connectors or Plugs on page 114

10.5.1

Connecting the DC Input Power

Each repeater comes with a 3-meter DC input cable with a barrel type connector output that connects to the repeater.

The DC source power is connected to the repeater through the DC power inlet connector as shown in Figure 41: SLR 1000 Repeater Bottom Panel Connector Names and Locations on page 109.

Longer runs of DC power require a junction box or splice connection of some type near the repeater so that larger gauge cable can be used and then connected to the DC barrel cable (cut to length as needed). Cable gauge and length should be carefully selected to ensure that nominal voltage at the supply does not fall below minimum specified.

The DC source must be located in the same building as the repeater, and it must meet the requirements of an SELV circuit.

CAUTION: Ensure that the appropriate voltage is connected with a nominal 13.6 VDC (10.8 – 15.6 VDC).
To provide adequate isolation and prevent EMC issues from impacting function, ensure that the placement of the DC power source and/or routing of the DC cable maintain a distance of a minimum of 0.5 m from the repeater antenna.

Procedure:

1. To seal the cable, thread the gland nut, then the cable gland over the barrel connector.
2. Insert the connector into the repeater then thread in the cable gland. Torque the cable gland to 55 in.-lb to compress.

3 Thread on the nut. Torque to 55 in.-lb to compress the gland and seal to the cable jacket.

   Ensure that the barrel connector is fully seated before final tightening of the gland nut.

Return to Process

Electrical Connections on page 108

10.5.2
Connecting the Indoor Adapter AC Input Power

AC/DC power supplies are available and operate from 100–240 VAC at 47–63 Hz AC input power. A standard 3-prong line cord is required to connect the power supply to the AC source.

CAUTION: Do not apply AC power to the SLR 1000 Repeater at this time. Make sure that the circuit breaker associated with the AC outlet is turned OFF.
The DC socket-outlet must be installed near the equipment and must be easily accessible.

Figure 41: SLR 1000 Repeater Bottom Panel Connector Names and Locations on page 109 shows the DC power inlet connector. Insert the plug into an appropriate grounded outlet.

The AC converter comes with a barrel connector output for the DC power that connects to the repeater.

Procedure:

1 To seal the cable, thread the cable gland nut, then the cable gland over the barrel connector.
2 Insert the connector into the repeater and then thread in the cable gland. Torque to 55 in.-lb to compress.
3 Thread on the nut and torque to 55 in.-lb to compress the gland and seal to the cable jacket.

   Ensure that the barrel connector is fully seated before final tightening of the gland nut.

Return to Process

Electrical Connections on page 108

10.5.3
Assembling an Outdoor Power Supply

The outdoor power supply provides the power source to an SLR 1000 Repeater that is located outdoors.

Procedure:

1 Identify the AC and DC locations of the power supply. The AC cable has three wires that are brown, blue, and green/yellow. The DC cable has two wires that are black and red.
2 Cut the cables to a length of 75mm (3 in.).
3 Strip 15mm (¾ in.) off the jacket.
4 Strip 4mm (¼ in.) off the wires.
5 Attach the AC wires to Joiner A (part no. CN001148A01). Torque to 1.5 in.-lb. See Figure 42: Attach AC Wires to Joiner A on page 112.

Figure 42: Attach AC Wires to Joiner A

6 Attached the DC wires to Joiner B (part no. CN001149A01). Torque to 1.5 in.-lb. See Figure 43: Attach DC Wires to Joiner B on page 112

Ensure the polarity is correct.

Figure 43: Attach DC Wires to Joiner B

7 Tighten all joiner nuts with a torque of 5.5 in.-lb.

Figure 44: Assembled SLR 1000 Repeater Power Supply

Return to Process

Electrical Connections on page 108

10.5.4

Ground Connection

The SLR 1000 Repeater is equipped with a ground screw on the bottom panel.

Figure 41: SLR 1000 Repeater Bottom Panel Connector Names and Locations on page 109 shows the location of the grounding screw. Connect the ground screw to the site ground point. The size of the wire used for this connection must be 6 AWG minimum.

CAUTION: See the Motorola Quality Standards Fixed Network Equipment Installation Manual R56 (which can be obtained by ordering CDROM 9880384V83), for complete information regarding lightning protection.
The repeater should only be connected to a battery supply that is in accordance with the applicable electrical codes for the end use country; for example, the National Electrical Code ANSI/ NFPA No. 70 in the U.S.

Return to Process

Electrical Connections on page 108

10.5.5

RF Antenna Connections

The transmit and receive antenna RF connections are made using two separate connectors.

Coax cables from the receive and transmit antennas must be connected to their respective connectors. The positions of these connectors are shown in Figure 2: SLR 1000 Repeater Left View on page 29 and Figure 3: SLR 1000 Repeater Right View on page 30. Their respective connector types are noted in Table 2: SLR 1000 Repeater Left View Callout Legend on page 30 and Table 3: SLR 1000 Repeater Right View Callout Legend on page 30.

When mounting an antenna directly to the repeater, the antenna must be positioned to extend either above or in front of the repeater, not along the body of the repeater.

Return to Process

Electrical Connections on page 108

10.5.6

System Cable Connections

The system connections are made through the Aux and/or Ethernet connectors on the bottom panel of the SLR 1000 Repeater.

The positions of the Aux and Ethernet connectors are shown in Figure 41: SLR 1000 Repeater Bottom Panel Connector Names and Locations on page 109.

See Auxiliary (Aux)/Accessory on page 59 for a description of the signaling that the Aux connector supports.

Return to Process

Electrical Connections on page 108

10.5.7

Installing Cable Grommet Connectors or Plugs

Cable sealing glands or cordgrips are used to seal the openings in the bottom of the SLR 1000 Repeater when a cable is used with the repeater.

The RJ-45 cables for LAN and GPIO connections must be field terminated on at least one end to allow the cables to be inserted through the cable gland. The cables are typically made to length on site in a typical installation. Solid plugs are provided to seal the USB Programming connector and any unused cable ports.

Prerequisites: Obtain a 1 in. torque wrench.

Procedure:

1. Insert unterminated data cable through the cable gland cap.
2. Insert unterminated data cable through the cable gland body.
3. Terminate the RJ-45 connector onto the cable and plug into the desired repeater connector.
4. Screw the cable gland body into the repeater opening. Torque to 55 in-lb.
5. Screw the cap to the cable gland. Torque to 55 in-lb.
6. If a cable gland is not used, seal the opening with a M20 threaded plug. Torque to 55 in-lb.

Return to Process

Electrical Connections on page 108

10.6

General Bonding and Grounding Requirements

Equipment should be attached to a grounding bar using solid or stranded 6 AWG copper wires.

See the Motorola Solutions R56 manual Standards and Guidelines for Communication Sites (which can be obtained by ordering CDROM 9880384V83) for more information on proper bonding and grounding at a site.

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SLR 1000 Installation on page 93

10.7
General Cabling Requirements

Diagrams for cabling are typically included in the system–specific configuration documentation provided by Motorola Solutions.

Also see the Motorola Solutions R56 manual Standards and Guidelines for Communication Sites (which can be obtained by ordering CDROM 9880384V83) for cabling standards.

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SLR 1000 Installation on page 93

10.8
Post Installation Checklist

After the repeater has been mechanically installed and all electrical connections have been made, power may now be applied and the repeater checked for proper operation.

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SLR 1000 Installation on page 93

Related Links

Apply Power on page 115
Verify Proper Operation on page 115
Repeater Codeplug Data Backup on page 116

10.8.1
Apply Power

Turn ON the circuit breaker controlling the AC source to the power converter that is supplying power to the repeater.

Return to Process

Post Installation Checklist on page 115

10.8.2
Verify Proper Operation

Operation of the repeater can be verified by:

- observing the state of the three LEDs on the front panel, and
- exercising radio operation.

CAUTION: Some repeater components can become extremely hot during operation. Turn OFF all power to the repeater and wait until sufficiently cool before touching the repeater.

Symbol indicates areas of the product that pose potential burn hazards.

Return to Process

Post Installation Checklist on page 115

Related Links

Front Panel LEDs on page 116

10.8.2.1
Front Panel LEDs

After turning on the repeater power (or after a repeater reset), the three LEDs on the repeater front panel:

- light for approximately one second to indicate that they are functional, then
- turn off for one second, then
- indicate the operational status of the repeater.

Return to Process

Verify Proper Operation on page 115

10.8.3
Repeater Codeplug Data Backup

Backup the repeater codeplug data by using the Radio Management (RM) on a computer.

Return to Process

Post Installation Checklist on page 115

Appendix A

Accessories

Related Links

Introduction on page 117

A.1
Introduction

Motorola Solutions provides the following approved accessories to improve the productivity of the SLR 1000 Repeater.

For a list of Motorola Solutions-approved accessories, visit the following web site: http://www.motorolasolutions.com.

Return to Process

Accessories on page 117

Related Links

Antennas on page 117
Power Supplies on page 118
Documentation on page 118
Duplexers on page 118
Antenna Switches on page 119
Mounting on page 119
Surge Arrestors on page 119
Service Tools on page 119

A.1.1
Antennas

Part No.	Description
HKAE4003_	External Repeater Mounted Antenna (400–460 MHz)
HKAE4004_	External Repeater Mounted Antenna (440–495 MHz)
HKAE4005_	External Repeater Mounted Antenna (490–530 MHz)
HKAD4003_	External repeater Mounted Antenna (136-154 MHz)
HKAD4004_	External Repeater Mounted Antenna (146–164 MHz)
HKAD4005_	External Repeater Mounted Antenna (160–174 MHz)

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A.1.2
Power Supplies

Part No.	Description
PMLN7773_	Indoor Power Adapter (includes AC/DC adapter and mounting bracket)
PMLN7771_	Outdoor Power Adapter Kit

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Introduction on page 117

A.1.3
Documentation

Part No.	Description
6880309T12	MOTOTRBO System Planner
9880384V83	CDROM for R56 manual
RVN5115_	MOTOTRBO CPS-RM and Tools DVD

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A.1.4
Duplexers

Part No.	Description	
HKFE4000_	UHF Duplexer, 400–430 MHz	5–6.5 MHz spacing
HKFE4001_	UHF Duplexer, 430–480 MHz	5–6.5 MHz spacing
HKFE4002_	UHF Duplexer, 480–527 MHz	5–6.5 MHz spacing
HKFE4003_	UHF Duplexer, 400–430 MHz	10–11.5 MHz spacing
HKFE4004_	UHF Duplexer, 430–480 MHz	10–11.5 MHz spacing
HKFE4005_	UHF Duplexer, 480–527 MHz	10–11.5 MHz spacing
HKFD1000_	VHF Duplexer, 136–156 MHz	4–6 MHz spacing
HKFD1001_	VHF Duplexer, 154–174 MHz	4–6 MHz spacing
HKFD1002_	VHF Duplexer, 136–156 MHz	6–10 MHz spacing
HKFD1003_	VHF Duplexer 154–174 MHz	6–10 MHz spacing

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A.1.5
Antenna Switches

Part No.	Description
PMLN7263_	Extended Range Direct Mode Antenna Switch

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A.1.6
Mounting

Part No.	Description
PMLN7213_	Pole Mount Kit

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Introduction on page 117

A.1.7
Surge Arrestors

Part No.	Description
DS11011110_	Extended Surge Arrestor, DC Power Outdoor
DSSCMM052020	Surge Arrestor, 120 VAC Outdoor with service breaker
DSSCMM05240	Surge Arrestor, 240 VAC Outdoor with service breaker
DSALPUF140	Surge Arrestor, Network
DSTUSXNFF	Surge Arrestor, RF, N-Type

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Introduction on page 117

A.1.8
Service Tools

Part No.	Description
PMKN4166_	Test Cable (for test box and external speaker)
30009477001	USB A to USB B Cable (for programming)
RLN4460_	Test Box
CB000174A02	DB25 to RJ-45 Adapter
PMLN7265_	Service Kit, SLR 1000 Miscellaneous Hardware

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Introduction on page 117

Appendix B

Replacement Parts Ordering

Related Links

Basic Ordering Information on page 121
Motorola Solutions Online on page 121
Mail Orders on page 122
Telephone Orders on page 122
Fax Orders on page 122
Parts Identification on page 122
Product Customer Service on page 123

B.1
Basic Ordering Information

Some replacement parts, spare parts, and/or product information can be ordered directly.

While parts may be assigned with a Motorola Solutions part number, this does not guarantee that they are available from Motorola Solutions Radio Products and Solutions Organization (RPSO). Some parts may have become obsolete and no longer available in the market due to cancellations by the supplier. If no Motorola Solutions part number is assigned, the part is normally not available from Motorola Solutions, or is not a user-serviceable part. Part numbers appended with an asterisk are serviceable by Motorola Solutions Depot only.

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Replacement Parts Ordering on page 121

B.2
Motorola Solutions Online

This section describes ways you can place your orders for the replacement parts.

Motorola Solutions Online users can access our online catalog at https://businessonline.motorolasolutions.com.

To register for online access:

- Have your Motorola Solutions Customer number available.
- Go to https://businessonline.motorolasolutions.com and click **Sign Up Now**.
- Complete the form and submit it.
- Or, call 1-800-422-4210 (for U.S. and Canada Service Centers only).

Contact your BDM to complete the set-up. Registration is completed within 24 to 48 hours.

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Replacement Parts Ordering on page 121

B.3
Mail Orders

Mail orders are only accepted by the US Federal Government Markets Division (USFGMD).

Motorola
7031 Columbia Gateway Drive
3rd Floor – Order Processing
Columbia, MD 21046
U.S.A.

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Replacement Parts Ordering on page 121

B.4
Telephone Orders

Radio Products and Solutions Organization (see note)
(United States and Canada)
7:00 AM to 7:00 PM (Central Standard Time)
Monday through Friday (Chicago, U.S.A.)
1-800-422-4210
1-847-538-8023 (United States and Canada)

U.S. Federal Government Markets Division (USFGMD)
1-877-873-4668
8:30 AM to 5:00 PM (Eastern Standard Time)

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Replacement Parts Ordering on page 121

B.5
Fax Orders

Radio Products and Solutions Organization (see note)
(United States and Canada)
1-800-622-6210
1-847-576-3023 (United States and Canada)

USFGMD
(Federal Government Orders)
1-800-526-8641 (For Parts and Equipment Purchase Orders)

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Replacement Parts Ordering on page 121

B.6
Parts Identification

Radio Products and Solutions Organization (see note)
(United States and Canada)

1-800-422-4210

NOTICE: The Radio Products and Solutions Organization (RPSO) was formerly known as the Radio Products Services Division (RPSD) and/or the Accessories and Aftermarket Division (AAD).

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B.7

Product Customer Service

Radio Products and Solutions Organization (United States and Canada)
1-800-927-2744

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Replacement Parts Ordering on page 121

Appendix C

Motorola Solutions Service Centers

Related Links

Servicing Information on page 124
Motorola Solutions Service Center on page 124
Motorola Solutions Federal Technical Center on page 124
Motorola Solutions Canadian Technical Logistics Center on page 124

C.1
Servicing Information

If a unit requires further complete testing, knowledge and/or details of component level troubleshooting or service than is customarily performed at the basic level, send the radio to a Motorola Solutions Service Center as listed or your nearest Authorized Service Center.

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Motorola Solutions Service Centers on page 124

C.2
Motorola Solutions Service Center

Motorola Elgin Repair Depot
2214 Galvin Drive
Elgin, IL
60124
Tel: 800-442-4210

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Motorola Solutions Service Centers on page 124

C.3
Motorola Solutions Federal Technical Center

10105 Senate Drive
Lanham, MD 20706
Tel: 1-800-969-6680
Fax: 1-800-784-4133

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Motorola Solutions Service Centers on page 124

C.4
Motorola Solutions Canadian Technical Logistics Center

181 Whitehall Drive
Markham, Ontario

L3R 9T1
Toll Free: 800-543-3222

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Motorola Solutions Service Centers on page 124

Appendix D

SLR 1000 Series Third-Party Controllers

Related Links

Third-Party Controllers Overview on page 126
Tone Remote Adapter on page 127

D.1
Third-Party Controllers Overview

The SLR 1000 Repeater interfaces with several third-party controllers through the 4-wire and GPIO/GPI interface afforded by the back panel AUX connector. This section covers the connections and signal levels between the third-party controllers and the repeater, as well as the audio path configuration needed through Radio Management (RM). This section is not a substitute for a more comprehensive instruction detailed in the vendor manuals of their respective third-party controllers.

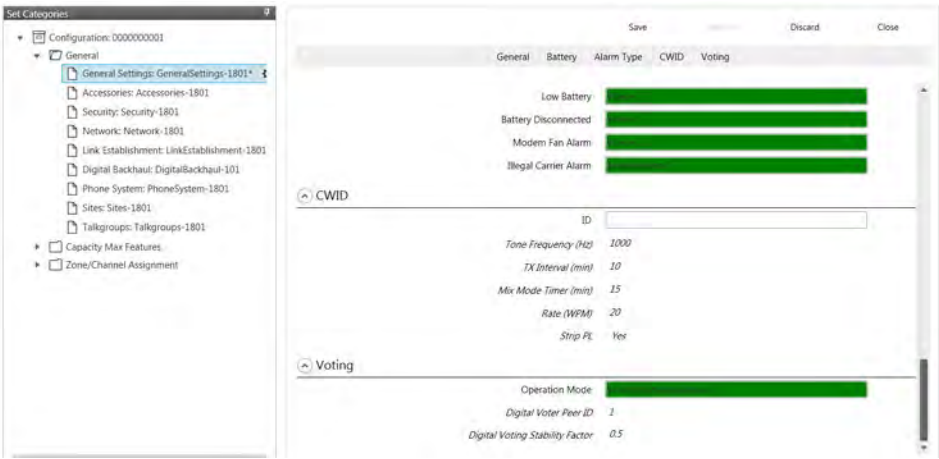
The third-party controllers supported by the repeater are as follows:

- Tone Remote Adapter (Motorola Model L3276)
- External Supply
- 2-Channel Steering Maximum

CAUTION: Do not hot swap any of the third-party controllers as this could (at a minimum) cause a malfunction with the repeater.

NOTICE: The repeater only supports the third-party controllers noted when it is configured in analog mode. The following screen capture shows the RM location to configure the repeater for analog mode.
If the third-party controllers are supplied power by the repeater, then the repeater must be in a powered off state when establishing (or removing) the connection to the repeater back panel connector.

Figure 45: Radio Management Settings to Configure SLR 1000 Repeater for Analog Mode



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SLR 1000 Series Third-Party Controllers on page 126

D.2

Tone Remote Adapter

When a dispatch console or deskset sends out signals to a remote repeater, it does so over a Wireline.

Two types of signals are sent:

- Audio signal
- Command signals (function tones) that are used to perform the remote control functions.

The SLR 1000 Repeater decodes function tones sent over a Wireline from a remote analog deskset or console through the Motorola Solutions Tone Remote Adapter (Model L3276). When properly configured, the Tone Remote Adapter performs the following functions with the repeater :

- Transmit and Receive Audio
- PTT
- Monitor
- Channel Select (up to two frequencies)
- Wildcard (such as, Repeater Knockdown)

See Motorola Solutions Tone Remote Adapter Manual (supplied with the Tone Remote Adapter) for specifications, operation, installation, alignment, programming, alternate configurations, and repair information.

Figure 46: Model L3276 Tone Remote Adapter

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SLR 1000 Series Third-Party Controllers on page 126

Related Links

Tone Remote Adapter Compatibility on page 128
Tone Remote Adapter Hardware Connections on page 128
Radio Management Configuration (For a 2-Channel Remote Control) on page 129
Tone Remote Adapter Settings on page 130

D.2.1

Tone Remote Adapter Compatibility

Model L3276 Tone Remote Adapter is compatible for all versions of SLR 1000 Repeater software and hardware.

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Tone Remote Adapter on page 127

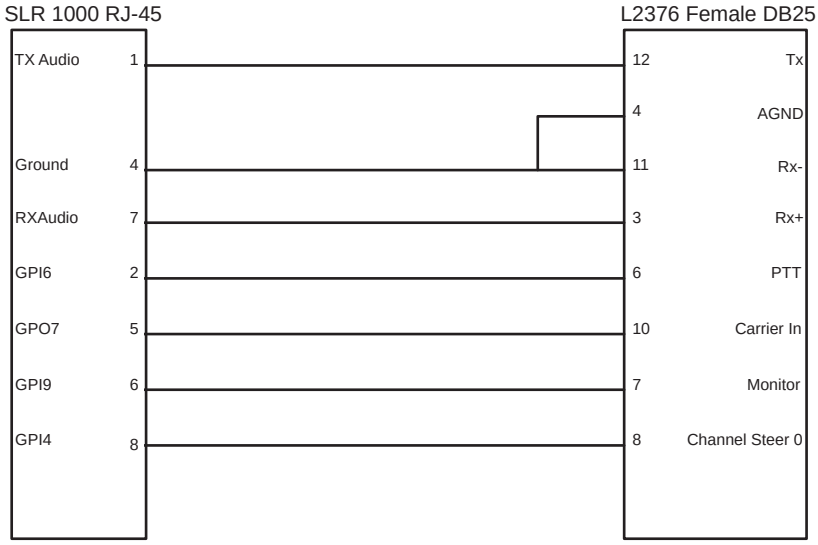
D.2.2

Tone Remote Adapter Hardware Connections

The connections between the SLR 1000 Repeater and the Tone Remote Adapter are facilitated with a multi-conductor cable connected between the J7 the repeater back panel AUX 25-Pin connector and that of the Tone Remote Adapter. The connection provides for the following signals:

- Transmit Audio
- Receiver Audio
- PTT
- COR
- Monitor
- Channel Steering
- Wild Card (such as Repeater Knockdown)
- Ground
  Signal connections are noted in Figure 47: Signal Connections Between SLR 1000 Repeater and Motorola L3276 25-Pin Connector for a 2-Channel Remote Control on page 128. The repeater connector and physical Pin locations are noted in the backplane interface board section of this manual. See Motorola L3276
  25-Pin manual for its connector and physical Pin locations. The part number for a pre-fabricated cable is noted in the repeater ordering guide.

Figure 47: Signal Connections Between SLR 1000 Repeater and Motorola L3276 25-Pin Connector for a 2-Channel Remote Control



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Tone Remote Adapter on page 127

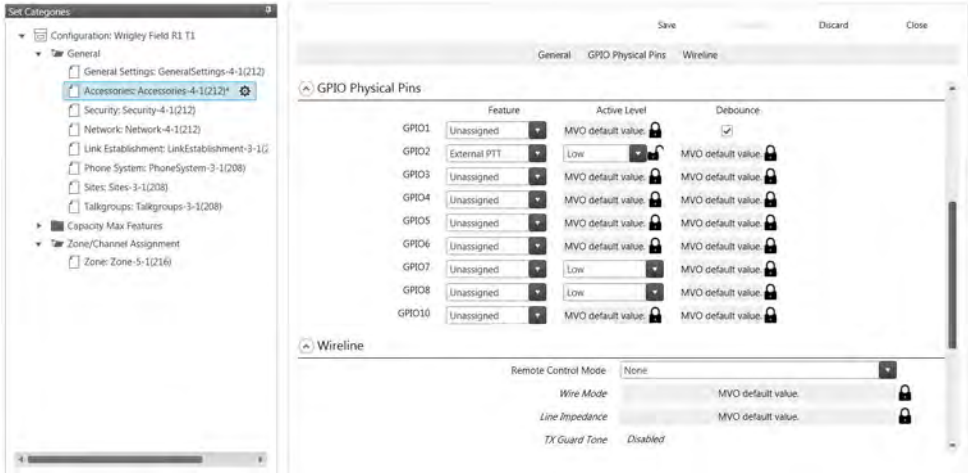
D.2.3

Radio Management Configuration (For a 2-Channel Remote Control)

The SLR 1000 Repeater is configured through the Radio Management (RM) application as shown in Figure 48: Radio Management Configuration for L3276 Tone Remote Adapter (for a 2-Channel Remote Control) on page 130. More specifically, the affected parameters are as follows:

- Audio Type
  - Filtered Squelch
- Analog Accessory Emphasis
  - De & Pre
- Disable Repeat Path
  - Un-Checked or Checked
- Tx Audio Priority
  - Set to 0 for console priority
- GPIO Pin number 2
  - Ext PTT
  - Active Low
- GPIO Pin number 5
  - CSQ Detect or PL/ Talk group Detect
  - Active Low
- GPIO Pin number 6
  - Monitor
  - Active Low
- GPIO Pin number 8
  - Channel Select 1
  - Active Low

Figure 48: Radio Management Configuration for L3276 Tone Remote Adapter (for a 2-Channel Remote Control)



NOTICE: This configuration is considered typical. The L3276 Remote Tone Adapter provides alternate configurations that are supported by the repeater as well. See the *L3276 Remote Tone Adapter* manual for additional details.

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Tone Remote Adapter on page 127

D.2.4

Tone Remote Adapter Settings

The input and output levels of the Tone Remote Adapter should be adjusted per the Tone Remote Adapter's instructions. The following sections give a brief overview of the high-level characteristics and typical Tone Remote Adapter settings for configuration with the SLR 1000 Repeater .

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Tone Remote Adapter on page 127

Related Links

Radio Rx on page 130
Radio Tx on page 131
Channel Steering on page 131
Monitoring on page 131
PTT on page 131
Wildcard 1 (optional) on page 131

D.2.4.1

Radio Rx

The Receiver audio yields 330 mV rms into 50 kΩ with an RF input signal deviating at 60% RSD. With the Remote Tone Adapter's own loading impedance, the "Radio Rx" signal delivered to the phone patch is at a high enough drive level to leave jumper S10 in the factory default position (position is "out").

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Tone Remote Adapter Settings on page 130

D.2.4.2
Radio Tx

The transmitter yields 60% RSD with 80mV rms into the Tx Audio port. The “Radio Tx” signal delivered by the Remote Tone Adapter is at a high enough drive level to leave jumper S9 in the factory default position (position A).

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Tone Remote Adapter Settings on page 130

D.2.4.3
Channel Steering

Leave Jumper S7 in position B (factory default) to match the SLR 1000 Series Repeater's active low setting for the Channel Steering 1 signaling.

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Tone Remote Adapter Settings on page 130

D.2.4.4
Monitoring

Leave jumper S8 in the “IN” position (factory default) to match the active low setting for the Monitor GPIO signaling.

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Tone Remote Adapter Settings on page 130

D.2.4.5
PTT

Leave jumper S5 in the “IN” position (factory default) to match the active low setting for the PTT GPIO signaling.

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Tone Remote Adapter Settings on page 130

D.2.4.6
Wildcard 1 (optional)

Leave jumper S6 in position A (factory default) to match the active low setting for the Repeater Disabled GPIO signaling.

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Tone Remote Adapter Settings on page 130

Appendix E

MOTOTRBO Repeater EME Assessment

NOTICE: The examples in this Appendix apply to a UHF band system configuration. For different frequency bands, applicable band-specific parameters should be employed to carry out the computations yielding band-specific compliance boundaries.

Related Links

Executive Summary on page 132
Device Characteristics on page 133
Exposure Prediction Model on page 134
Exposure Limits on page 139
EME Exposure Evaluation on page 139
Compliance Boundary Description on page 141
Product Put In Service on page 142
References on page 142

E.1
Executive Summary

Compliance versus EME (Electromagnetic Energy Exposure) limits is established with respect to the ICNIRP guidelines [1] and U.S. FCC regulations [2-3] in a typical system configuration of the MOTOTRBO SLR 1000 Repeater described in the following.

A computational assessment was carried out to provide an estimation of the EME exposure and compliance distances relative to the SLR 1000 Repeater Model FCC ID ABZ99FT3096 AAR11JDGANQ1AN and FCC ID ABZ99FT4100, Model AAR11SDGANQ1AN) equipped with HKAD4003, HKAD4004, HKAD4005, HKAE4003, HKAE4004, or HKAE4005 antennas for indoor installation and with the Andrew DB408-B antenna for outdoor installations.

The following tables provide the compliance distances for *general public* and *occupational-type* exposure, for the UHF frequency band, antennas, and other relevant parameters considered in this analysis of typical system configurations:

Table 27: Indoor EME Compliance Distances Based on the UHF Evaluation Example (applicable antennas: HKAE4003, HKAE4004, and HKAE4005)

Exposure Condition	Based on the Peak 1-g SAR FCC Limit	Based on the Peak 10-g SAR ICNIRP Limit	Based on the Whole-Body SAR Limit
General public exposure	46 cm	20 cm	20 cm
Occupational-type exposure	20 cm	20 cm	20 cm

Table 28: Outdoor EME Compliance Distances Based on the UHF Evaluation Example (applicable antenna: DB408-B)

Exposure Condition	Based on the Peak 1-g SAR FCC Limit	Based on the Peak 10-g SAR ICNIRP Limit	Based on the Whole-Body SAR Limit
General public exposure	20 cm	20 cm	20 cm
Occupational-type exposure	20 cm	20 cm	20 cm

The compliance distances in the preceding tables were derived based on the applicable IEC 62232:2017 standard [10] Specific Absorption Rate (SAR) prediction formulas. In several cases, the derived distance of 20 cm is very conservative because it is a minimum distance for the validity of the mentioned SAR formulas [10]. This distance may be reduced significantly for occupational-type exposure conditions by carrying out an analysis based on SAR measurements.

Table 29: Indoor EME Compliance Distances Based on the VHF Evaluation Example (applicable antenna:HKAD4003, HKAD4004 and HKAD4005)

Exposure Condition	Based on the ICNIRP reference Levels and FCC MPE Limits
General public exposure	59 cm
Occupational-type exposure	27 cm

The compliance distances in the table above were derived based on the applicable IEC 62232:2017 standard [10] and U.S. FCC OET Bulletin [2[power density prediction formulas. These formulas are conservative and the distance may be reduced by carrying out analysis based on SAR measurements.

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MOTOTRBO Repeater EME Assessment on page 132

E.2
Device Characteristics

The technical characteristics of the Model FCC ID ABZ99FT3096 AAR11JDGANQ1AN and FCC ID ABZ99FT4100 AAR11SDGANQ1AN are as follows:

- Transmit Frequency Range: 136-174 MHz and 400–512 MHz
- Maximum Power: 10 W
- Maximum Duty Cycle: 100%
- Antenna Information is summarized in the following table:

Table 30: Antenna Characteristics

Kit or Model Number	Frequency MHz	Type	Peak Gain dBi	Length m	3 dB Elevation Beamwidth, deg	3 dB Azimuth Beamwidth, deg
HKAD4003	136-154	monopole	-1.8	0.49*	100	Omni
HKAD4004	146-164	monopole	-1.3	0.49*	100	Omni

Kit or Model Number	Frequency MHz	Type	Peak Gain dBi	Length m	3 dB Elevation Beamwidth, deg	3 dB Azimuth Beamwidth, deg
HKAD4005	160-174	monopole	-0.6	0.49*	100	Omni
HKAE4003	400-460	monopole	3.4	0.40*	60	Omni
HKAE4004	440-495	monopole	3.2	0.40*	60	Omni
HKAE4005	490-530	monopole	3.4	0.40*	60	Omni
DB408-B	450-470	linear array	8.7	2.70	14	Omni

* This length represents the overall length of the MOTOTRBO SLR 1000 Repeater with the attached monopole antenna.

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MOTOTRBO Repeater EME Assessment on page 132

E.3

Exposure Prediction Model

This section describes the EME exposure prediction model based on a SAR evaluation. In the UHF band and based on reference levels and FCC Maximum Permissible Exposure (MPE) limits in the VHF band.

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MOTOTRBO Repeater EME Assessment on page 132

Related Links

SAR Evaluation Formulas on page 134
Implementation and Validation of SAR Formulas on page 137
Equivalent Plane Wave Power Density Evaluation on page 138

E.3.1

SAR Evaluation Formulas

The EME exposure prediction model is based on Clause B.4.2.2 of the IEC 62232:2017 standard, which defines a computational method for evaluating the whole-body average and localized SAR values to establish a conservative compliance distance from an antenna. Specifically, the formulas B.28, B.29, and B.30 from this standard were employed in the evaluation of typical system configurations of the SLR 1000 Repeater.

$$SAR_{\text{wb}}^{\text{a,ch}} = C(f) \cdot \frac{H_{\text{eff}}}{\tilde{A}^{\text{a,ch}}\ \tilde{B}^{\text{a,ch}}} \cdot \frac{\overline{P}_{\text{avg}}}{\phi_{\text{3dB}} \cdot L \cdot d} \cdot \left[1 + \left(\frac{4 \cdot \pi \cdot d}{\phi_{\text{3dB}} \cdot D \cdot L}\right)^2\right]^{-1/2} \quad \text{(B.28)}$$

$$SAR_{\text{10g}} = 25 \cdot SAR_{\text{wb}}^{\text{a}} \cdot \frac{\tilde{B}}{H_{\text{eff}}} \cdot \frac{1}{R_{\text{wb/10g}}} \quad \text{(B.29)}$$

$$SAR_{\text{1g}} = 20 \cdot SAR_{\text{wb}}^{\text{a}} \cdot \frac{\tilde{B}}{H_{\text{eff}}} \cdot \frac{1}{R_{\text{wb/1g}}} \quad \text{(B.30)}$$

where

$SAR_{\text{wb}}^{\text{a,ch}}$ denotes the whole-body SAR evaluated for adults, $SAR_{\text{wb}}^{\text{a}}$, or children, $SAR_{\text{wb}}^{\text{ch}}$;

$\tilde{A}^{\text{a,ch}}$ equals $\tilde{A}^{\text{a}}$ = 0,089 m for adults and $\tilde{A}^{\text{ch}}$ = 0,06 m for children;

$\tilde{B}^{\text{a,ch}}$ equals $\tilde{B}^{\text{a}}$ = 1,54 m for adults and $\tilde{B}^{\text{ch}}$ = 0,96 m for children;

d is the closest distance measured in metres from the antenna element to the evaluation point. If the distance to the antenna elements is not known, d may be taken consercatively as the distance to the antenna radome;

H_{eff} is the effective height of the body measured in metres;

L is the physical antenna array length measured in metres. The individual antenna lengths for each band shall be used for antennas covering more than one band;

$$R_{\text{wb/10g}} = \begin{cases} 1{,}5 & 300\text{MHz} < f \leq 2{,}5\ \text{GHz} \\ 1 & 2{,}5\ \text{GHz} < f < 5\ \text{GHz} \end{cases}$$

$$R_{\text{wb/1g}} = \begin{cases} 0{,}6 & 300\ \text{MHz} < f \leq 2{,}5\ \text{GHz} \\ 0{,}3 & 2{,}5\ \text{GHz} < f < 5\ \text{GHz} \end{cases}$$

H_{eff} shall be ecaluated using

$$H_{\text{eff}} = \begin{cases} L & H_{\text{beam}} < L \text{ AND } H_{\text{beam}} < \tilde{B} \\ H_{\text{beam}} & L \leq H_{\text{beam}} < \tilde{B} \\ \tilde{B} & \tilde{B} \leq H_{\text{beam}} \\ \tilde{B} & \tilde{B} \leq L \end{cases}$$

where

$H_{\text{beam}} = 2 \cdot d \cdot \tan(\theta_{3\text{dB}} / 2)$

Table B.17 – Definition of $C(f)$

f MHz	$C(f,d)$ 10^{-4} m³/kg	
300 to 900	$\left(3{,}5 + \frac{f - 300}{600}\right)\left(1 + \frac{0{,}8d}{400}\right)$	for 200mm $\leq d \leq$ 400mm
	$6{,}3 + \left(\frac{f - 300}{600}\right)1{,}8$	for d > 400mm
900 to 5 000	$4{,}5\left(1 + \frac{0{,}8d}{400}\right)$	for $d \leq$ 400mm
	8,1	for d > 400mm

As shown, the formulas are valid for a specific frequency range and distances. Based on the device and antenna characteristics the formulas are valid for evaluation of the upper bounds of localized and whole-body average SAR for exposures within the main beam of the antenna (front direction). Since this represents the most conservative exposure condition, the front direction compliance distance is also applied for all other directions to define conservative compliance boundaries in those directions.

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Exposure Prediction Model on page 134

E.3.2

Implementation and Validation of SAR Formulas

Formulas B.28, B.29, and B.30 from the IEC 62232:2017 standard were implemented in Mathcad 15.0 software as shown in the following formula with highlighted items being the input antenna parameters.

$Pavg := 10$ $\quad \varphi_3dB := 360\frac{\pi}{180}$ $\quad \theta_3dB := 60\frac{\pi}{180}$ $\quad D := 10^{\frac{3.4}{10}}$ $\quad Aa := 0.089$

$f := 530$ $\quad Ach := 0.06$

$d := 0.46$ $\quad L := 0.4$ $\quad Ba := 1.54$

$Bch := 0.96$

$A := Aa$ $\quad Hbeam := 2 \cdot d \cdot \tan\left(\frac{\theta_3dB}{2}\right)$

$B := Ba$

$$Rwb10g := \begin{cases} 1.5 & \text{if } (300 < f) \wedge (f \le 2500) \\ 1 & \text{if } (2500 < f) \wedge (f < 5000) \end{cases} \qquad Rwb1g := \begin{cases} 0.6 & \text{if } (300 < f) \wedge (f \le 2500) \\ 0.3 & \text{if } (2500 < f) \wedge (f < 5000) \end{cases}$$

$$Heff := \begin{cases} L & \text{if } (Hbeam < L) \wedge (Hbeam < B) \\ Hbeam & \text{if } (L \le Hbeam) \wedge (Hbeam < B) \\ B & \text{if } B \le Hbeam \\ B & \text{if } B \le L \end{cases}$$

$$C := \begin{cases} \left[3.5 + \frac{(f-300)}{600}\right]\left(1 + \frac{0.8d}{0.400}\right) \cdot 10^{-4} & \text{if } (0.2 \le d) \wedge (d \le 0.4) \wedge (300 \le f) \wedge (f < 900) \\ \left[6.3 + \frac{(f-300)}{600} \cdot 1.8\right] \cdot 10^{-4} & \text{if } (d > 0.4) \wedge (300 \le f) \wedge (f < 900) \\ \left[4.5\left(1 + \frac{0.8d}{0.400}\right)\right] \cdot 10^{-4} & \text{if } (0.2 \le d) \wedge (d \le 0.4) \wedge (900 \le f) \wedge (f \le 5000) \\ 8.1 \cdot 10^{-4} & \text{if } (d > 0.4) \wedge (900 \le f) \wedge (f \le 5000) \end{cases}$$

$$SAR_WB := C \cdot \frac{Heff}{Aa \cdot Ba} \cdot \frac{Pavg}{\varphi_3dB \cdot L \cdot d} \cdot \left[1 + \left(4 \cdot \pi \cdot \frac{d}{\varphi_3dB \cdot D \cdot L}\right)^2\right]^{-0.5}$$

$$SAR1g := 20 \cdot SAR_WB \cdot \frac{B}{Heff} \cdot \frac{1}{Rwb1g}$$

$$SAR10g := 25 \cdot SAR_WB \cdot \frac{B}{Heff} \cdot \frac{1}{Rwb10g}$$

The validation of this implementation was performed according to IEC 62232:2017 standard using the test input parameters from the following table of the standard:

- RF Power: 1 W
- Antenna Length: 1.3 m
- Gain: 18 dBi
- 3 dB elevation beamwidth: 6.5 deg
- 3 dB azimuth beamwidth: 65 deg
- Frequency: 2140 MHz

The SAR results computed using this implementation of the IEC 62232:2017 standard formulas B.28, B.29, and B.30, and a body mass of 46 kg agree with all the applicable reference results from the IEC 62232:2017 standard and are summarized in the following table. Therefore according to the standard, the implementation passes the validation test.

Table 31: Reference and Validation Results

Front Exposure (within main beam)		Separation Distance from the Antenna					
		0.2 m	1 m	5 m	10 m	15 m	20 m
SAR_{10g} [W/kg/W]	IEC 62232:2017 reference	0.40	0.10	0.017	0.0061	0.003	0.0018
	As implemented	*0.400*	*0.102*	*0.0170*	*0.00612*	*0.0030*	*0.00179*
SAR_{WB} [W/kg/W]	IEC 62232:2017 reference	0.020	0.0052	0.00086	0.00031	0.00018	0.00011
	As implemented	*0.0200*	*0.00516*	*0.000863*	*0.000310*	*0.000182*	*0.000107*

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Exposure Prediction Model on page 134

E.3.3

Equivalent Plane Wave Power Density Evaluation

Compliance evaluation with respect to the ICNIRP reference levels and U.S. FCC MPE limits in the VHF band is based on the IEC 62232:2017 standard clause B.4.2.1 for estimating the spatial-peak equivalent plane wave power density. Similar approach is also described in US FCC OET Bulletin [2]. Specifically the spherical formula B.15 from IEC 62232:2017 standard is used to calculate the spatial-peak equivalent power density:

$$S = \frac{P_{avg}\, G}{4\, \pi r^2}$$

where,

P_{avg} is power input to the antenna

G is peak power gain of the antena

R is the distance to the antenna

It should be noted that this formula is generally accurate in the far field region, however, as explained in section "Equations for Predicting RF Fields" in [2], it tends to over-predict power density in the near field and therefore can be used for making a conservative prediction.

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Exposure Prediction Model on page 134

E.4
Exposure Limits

Applicable guidelines and regulations are referenced for the EME exposure assessment. The SAR limits are those defined in the ICNIRP guidelines [1] and U.S. FCC regulations [2-3].

The ICNIRP guidelines are 10 W/kg for the peak spatially averaged SAR over 10 g and 0.4 W/kg for the whole-body average SAR in occupational-type exposure conditions, and 2.0 W/kg for the peak spatially averaged SAR over 10 g and 0.08 W/kg for the whole-body average SAR in general public exposure conditions.

The U.S. FCC regulations feature 8 W/kg for the peak spatially averaged SAR over 1 g and 0.4 W/kg for the whole-body average SAR in occupational-type exposure conditions, and 1.6 W/kg for the peak spatially averaged SAR over 1 g and 0.08 W/kg for the whole-body average SAR in general public exposure conditions.

The ICNRIP guidelines also define the reference levels and U.S. FCC regulations define the MPE limits in terms of equivalent plane wave power density. In the applicable VHF frequency range (136-174 MHz) it is 10W/m^2 in occupational-type exposure conditions and 2 W/m^2 in general public exposure conditions.

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E.5
EME Exposure Evaluation

The employed exposure evaluation method and results are equally applicable to both indoor and outdoor exposure conditions even though particular antenna models are meant specifically for only indoor (HKAD4003, HKAD4004, HKAD4005, HKAE4003, HKAE4004, and HKAE4005) or only outdoor (Andrew DB408-B) installation.

For each antenna models the maximum operating frequency and maximum RF power was used in SAR evaluation to produce the most conservative estimate of exposure within the respectively applicable frequency band. The distance from the antenna was minimized to arrive at the maximum exposure condition where SAR is still below the compliance limit. In many instances, however, even at the minimum formula validity distance of 20 cm, the SAR values are very small, especially for the occupational-type exposure limits. In those cases, this minimum distance of 20 cm was used to define the conservative compliance boundary.

Table 32: Compliance Distance in General Public Exposure (UHF) on page 140 shows the compliance distance for each evaluated UHF antenna in general public exposure condition alongside the

corresponding peak 1-g average and whole-body average SAR values derived from the IEC 62232:2017 formulas and applicable to evaluation of EME compliance with U.S. FCC regulations.

Table 32: Compliance Distance in General Public Exposure (UHF)

Antenna Kit or Model Number	Evaluation Frequency (MHz)	Compliance Distance (m)	Peak 1-g Average SAR (W/kg)	Whole-Body Average SAR (W/kg)
HKAE4003	460	0.45	1.57	0.016
HKAE4004	495	0.45	1.55	0.016
HKAE4005	530	0.46	1.56	0.016
Andrew DB408-B	470	0.20	0.59	0.018

Table 33: Compliance Distance in Occupational-Type Exposure (UHF) on page 140 shows the corresponding distances for occupational-type exposure conditions in UHF band.

Table 33: Compliance Distance in Occupational-Type Exposure (UHF)

Antenna Kit or Model Number	Evaluation Frequency (MHz)	Compliance Distance (m)	Peak 1-g Average SAR (W/kg)	Whole-Body Average SAR (W/kg)
HKAE4003	460	0.20	3.57	0.028
HKAE4004	495	0.20	3.60	0.028
HKAE4005	530	0.20	3.68	0.029
Andrew DB408-B	470	0.20	0.59	0.018

Table 34: Compliance Distance in General Public Exposure and Occupational-Type Exposure (UHF) on page 140 shows the compliance distance for each evaluated UHF antenna applicable to general public exposure and occupational-type exposure conditions and evaluated against the ICNIRP limits alongside the corresponding peak 10-g average and whole-body average SAR values.

Table 34: Compliance Distance in General Public Exposure and Occupational-Type Exposure (UHF)

Antenna Kit or Model Number	Evaluation Frequency (MHz)	Compliance Distance (m)	Peak 10-g Average SAR (W/kg)	Whole-Body Average SAR (W/kg)
HKAE4003	460	0.20	1.79	0.028
HKAE4004	495	0.20	1.80	0.028
HKAE4005	530	0.20	1.84	0.029
Andrew DB408-B	470	0.20	0.28	0.018

Table 35: Compliance Distance in General Public Exposure (VHF) on page 141 shows the compliance distance for each evaluated VHF antenna applicable to general public exposure conditions and

evaluated against the ICNIRP reference levels and FCC MPE limits alongside the corresponding peak equivalent plane wave power density values.

Table 35: Compliance Distance in General Public Exposure (VHF)

Antenna Kit or Model Number	Evaluation Frequency (MHz)	Compliance Distance (m)	Equivalent plane wave power density (W/m^2)
HKAD4003	136-154	0.52	1.94
HKAD4004	146-164	0.55	1.95
HKAD4005	160-174	0.59	1.99

Table 36: Compliance Distance in Occupational-Type Exposure (VHF) on page 141shows the compliance distance for each evaluated VHF antenna applicable to occupational-type exposure conditions and evaluated against the ICNIRP reference levels and FCC MPE limits alongside the corresponding peak equivalent plane wave power density values.

Table 36: Compliance Distance in Occupational-Type Exposure (VHF)

Antenna Kit or Model Number	Evaluation Frequency (MHz)	Compliance Distance (m)	Equivalent plane wave power density (W/m^2)
HKAD4003	136-154	0.23	9.9
HKAD4004	146-164	0.25	9.4
HKAD4005	160-174	0.27	9.5

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E.6

Compliance Boundary Description

The compliance boundary is defined as all surfaces of a cylinder surrounding the antenna with the minimum separation distance from the antenna established by the compliance distance from the proceeding tables in EME Exposure Evaluation on page 139. If there is an antenna attached to the repeater (indoor installation), the repeater enclosure is considered as part of the antenna.

For EME Exposure Evaluation in UHF band performed with respect to the U.S. FCC Regulation, this compliance distance for indoor installation is 46 cm for General Public exposure conditions and 20 cm for occupational-type exposure conditions. For the outdoor installations, the compliance distance is 20 cm for both general public and occupational-type exposure conditions.

For EME Exposure Evaluation in UHF band performed with respect to the ICNIRP guidelines, the compliance distance is 20 cm for indoor and outdoor installations and is applicable to both general public and occupational-type exposure conditions.

It should be noted that based on the foregoing analysis, the 20 cm distance is conservative for occupational exposure and may be reduced significantly by carrying out SAR measurements.

For the EME Exposure Evaluation in VHF performed with respect to both the ICNIRP guidelines and U.S. FCC Regulation, this compliance distance is 59 cm for General Public exposure conditions and 27 cm for occupational-type exposure conditions.

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E.7
Product Put In Service

Some regulations require that additional exposure assessments be performed when putting the product in service, to account for antenna site-specific circumstances such as the environment (for example, electromagnetic scatterers) and other antennas. In such cases, certain standards [7]–[10] may need to be considered to determine the most suitable compliance assessment methodology.

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E.8
References

1 International Commission on Non-Ionizing Radiation Protection (ICNIRP), "Guideline for Limiting Exposure to Time-Varying Electric, Magnetic, and Electromagnetic Fields", Health Physics, vol. 74, no. 4, pp. 494-522, April 1998.

2 United States Federal Communication Commission, "Evaluating compliance with FCC guidelines for human exposure to radio frequency electromagnetic fields", OET Bulletin 65, Ed. 97-01, Section 2 (Prediction Methods), August 1997.

3 US Code of Federal Regulations, Title 47, Volume 1, Sec. 1.1310 Radio frequency radiation exposure limits (Revised as of October 1, 2003). http://edocket.access.gpo.gov/cfr_2003/octqtr/47cfr1.1310.htm.

4 EN 50383:2010. Basic standard for the calculation and measurement of electromagnetic field strength and SAR related to human exposure from radio base stations and fixed terminal stations for wireless telecommunication systems (110 MHz–40 GHz). CENELEC (European Committee for Electrotechnical Standardization).

5 EN 50384:2002. Product standard to demonstrate the compliance of radio base stations and fixed terminal stations for wireless telecommunication systems with the basic restrictions or the reference levels related to human exposure to radio frequency electromagnetic fields (110 MHz–40 GHz). Occupational. CENELEC (European Committee for Electrotechnical Standardization).

6 EN 50385:2017. Product standard to demonstrate the compliance of radio base stations and fixed terminal stations for wireless telecommunication systems with the basic restrictions or the reference levels related to human exposure to radio frequency electromagnetic fields (110 MHz–40 GHz). General public. CENELEC (European Committee for Electrotechnical Standardization).

7 EN 50401:2006. Product standard to demonstrate the compliance of fixed equipment for radio transmission (110 MHz–40 GHz) intended for use in wireless telecommunication networks with the basic restrictions or the reference levels related to general public exposure to radio frequency electromagnetic fields, when put into service. CENELEC (European Committee for Electrotechnical Standardization).

8 EN 50400:2006. Basic standard to demonstrate the compliance of fixed equipment for radio transmission (110 MHz–40 GHz) intended for use in wireless telecommunication networks with the basic restrictions or the reference levels related to general public exposure to radio frequency electromagnetic fields, when put into service. CENELEC (European Committee for Electrotechnical Standardization).

9 EN 50492:2008. Basic standard for the in-situ measurement of electromagnetic field strength related to human exposure in the vicinity of base stations. CENELEC (European Committee for Electrotechnical Standardization).

10 IEC 62232:2017. Determination of RF field strength and SAR in the vicinity of radio communication base stations for the purpose of evaluating human exposure. IEC (International Electrotechnical Commission).

11 United States Federal Communication Commission, “Evaluating compliance with FCC guidelines for human exposure to radio frequency electromagnetic fields,” OET Bulletin 65 (Ed. 97-01), August 1997. Supplement C (Edition 01-01) to US FCC OET Bulletin 65 (Edition 97-01), “Additional Information for Evaluating Compliance of Mobile and Portable Devices with FCC Limits for Human Exposure to Radio frequency Emissions,” June 2001.

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Glossary of Terms and Acronyms

This glossary contains an alphabetical listing of terms and their definitions that are applicable to repeater products. All terms do not necessarily apply to all radios, and some terms are merely generic in nature.

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Alert tone

Audio signal produced by the station, providing feedback to the user.

> **See also:**
> Glossary of Terms and Acronyms

Analog

Refers to a continuously variable signal or a circuit or device designed to handle such signals.

> **See also:**
> Glossary of Terms and Acronyms

ASIC

Application Specific Integrated Circuit.

> **See also:**
> Glossary of Terms and Acronyms

AUX

Auxiliary.

> **See also:**
> Glossary of Terms and Acronyms

Band
Frequencies allowed for a specific purpose.

> **See also:**
> Glossary of Terms and Acronyms

CTCSS
Continuous Tone-Controlled Squelch Systems (PL).

> **See also:**
> Glossary of Terms and Acronyms

Clear
Channel modulation type in which voice information is transmitted over the channel using analog modulation.

> **See also:**
> Glossary of Terms and Acronyms

Conventional
Term used for standard non-trunked radio system (usually using TRC/DC console).

> **See also:**
> Glossary of Terms and Acronyms

CPS
Customer Programming Software: Software with a graphical user interface containing the feature set of a radio.

> **See also:**
> Glossary of Terms and Acronyms

Default
A pre-defined set of parameters.

> **See also:**
> Glossary of Terms and Acronyms

Digital
Refers to data that is stored or transmitted as a sequence of discrete symbols from a finite set; most commonly this means binary data represented using electronic or electromagnetic signals.

> **See also:**
> Glossary of Terms and Acronyms

DPL
Digital Private-Line: A type of digital communications that utilizes privacy call, as well as memory channel and busy channel lock out to enhance communication efficiency.

> **See also:**
> Glossary of Terms and Acronyms

DSP
Digital Signal Processor, microprocessor specifically designed to perform digital signal processing algorithms.

> **See also:**
> Glossary of Terms and Acronyms

EIA
Electronic Industries Association.

See also:
Glossary of Terms and Acronyms

ESD
Electro Static Discharge.

See also:
Glossary of Terms and Acronyms

EU
European Union.

See also:
Glossary of Terms and Acronyms

FCC
Federal Communications Commission.

See also:
Glossary of Terms and Acronyms

FM
Frequency Modulation.

See also:
Glossary of Terms and Acronyms

Frequency
Number of times a complete electromagnetic-wave cycle occurs in a fixed unit of time (usually one second).

See also:
Glossary of Terms and Acronyms

FRU
Field Replaceable Unit.

See also:
Glossary of Terms and Acronyms

FSK
Frequency Shift Keying.

See also:
Glossary of Terms and Acronyms

GNSS
Global Navigation Satellite System.

See also:
Glossary of Terms and Acronyms

GPIO
General Purpose Input/Output.

See also:

Glossary of Terms and Acronyms

IC
Integrated Circuit: An assembly of interconnected components on a small semiconductor chip, usually made of silicon. One chip can contain millions of microscopic components and perform many functions.

See also:
Glossary of Terms and Acronyms

IF
intermediate frequency.

See also:
Glossary of Terms and Acronyms

I/O
Input or Output.

See also:
Glossary of Terms and Acronyms

kHz
kilohertz: One thousand cycles per second. Used especially as a radio-frequency unit.

See also:
Glossary of Terms and Acronyms

LCD
Liquid-Crystal Display: An LCD uses two sheets of polarizing material with a liquid-crystal solution between them. An electric current passed through the liquid causes the crystals to align so that light cannot pass through them.

See also:
Glossary of Terms and Acronyms

LED
Light Emitting Diode: An electronic device that lights up when electricity is passed through it.

See also:
Glossary of Terms and Acronyms

MDC
Motorola Data Communications. 1200 or 4800 baud data signalling scheme.

See also:
Glossary of Terms and Acronyms

MHz
Megahertz: One million cycles per second. Used especially as a radio-frequency unit.

See also:
Glossary of Terms and Acronyms

MISO
Master In, Slave Out.

See also:
Glossary of Terms and Acronyms

MOSI
Master Out, Slave In.

> **See also:**
> Glossary of Terms and Acronyms

PA
Power Amplifier that transmits final RF signal to transmit antenna.

> **See also:**
> Glossary of Terms and Acronyms

PC Board
Printed Circuit Board. Also referred to as a PCB.

> **See also:**
> Glossary of Terms and Acronyms

PFC
Power Factor Correction.

> **See also:**
> Glossary of Terms and Acronyms

PL
Private-Line Tone Squelch: A continuous sub-audible tone that is transmitted along with the carrier.

> **See also:**
> Glossary of Terms and Acronyms

Programming Cable
A cable that allows the Radio Management to communicate directly with the radio using RS232.

> **See also:**
> Glossary of Terms and Acronyms

PTT
Push-to-talk; the switch located on the left side of the radio which, when pressed causes the radio to transmit.

> **See also:**
> Glossary of Terms and Acronyms

Radio Management
Software with a graphical user interface containing the feature set of a device.

> **See also:**
> Glossary of Terms and Acronyms

Receiver
Electronic device that amplifies RF signals. A Receiver separates the audio signal from the RF carrier, amplifies it, and converts it back to the original sound waves.

> **See also:**
> Glossary of Terms and Acronyms

Repeater
Remote transmit/receive facility that retransmits received signals in order to improve communications range and coverage.

See also:
Glossary of Terms and Acronyms

RF
Radio Frequency: The portion of the electromagnetic spectrum between audio sound and infrared light (approximately 10 kHz to 10 GHz).

See also:
Glossary of Terms and Acronyms

RSSI
Received Signal Strength Indicator; a dc voltage proportional to the received RF signal strength.

See also:
Glossary of Terms and Acronyms

Rx
Receive.

See also:
Glossary of Terms and Acronyms

SCM
Station Control Module; station controller.

See also:
Glossary of Terms and Acronyms

SELV
Separated Extra Low Voltage.

See also:
Glossary of Terms and Acronyms

Signal
An electrically transmitted electromagnetic wave.

See also:
Glossary of Terms and Acronyms

SINAD
Acronym for the ratio of signal plus noise plus distortion and noise plus distortion.

See also:
Glossary of Terms and Acronyms

SLR
Refers to Digital Professional Repeater model names in the MOTOTRBO Professional Digital Two-Way Radio System.

See also:
Glossary of Terms and Acronyms

Spectrum
Frequency range within which radiation has specific characteristics.

See also:
Glossary of Terms and Acronyms

SPI
Serial Peripheral Interface (clock and data lines); simple synchronous serial interface for data transfer between processors and peripheral ICs.

> **See also:**
> Glossary of Terms and Acronyms

Squelch
Muting of audio circuits when received signal levels fall below a pre-determined value. With carrier squelch, all channel activity that exceeds the radio's preset squelch level can be heard.

> **See also:**
> Glossary of Terms and Acronyms

TOT
Time-out Timer: A timer that limits the length of a transmission.

> **See also:**
> Glossary of Terms and Acronyms

TPL
Tone Private Line.

> **See also:**
> Glossary of Terms and Acronyms

Transceiver
Transmitter-Receiver. A device that both transmits and receives analog or digital signals. Also abbreviated as XCVR.

> **See also:**
> Glossary of Terms and Acronyms

Transmitter
Electronic equipment that generates and amplifies an RF carrier signal, modulates the signal, and then radiates it into space.

> **See also:**
> Glossary of Terms and Acronyms

Trunking
Radio control system which permits efficient frequency utilization and enhanced control features.

> **See also:**
> Glossary of Terms and Acronyms

Tx
Transmit.

> **See also:**
> Glossary of Terms and Acronyms

UHF
Ultra High Frequency.

> **See also:**
> Glossary of Terms and Acronyms

USB

Universal Serial Bus: An external bus standard that supports data transfer rates of 12 Mbps.

> **See also:**
> Glossary of Terms and Acronyms

VCO

Voltage-Controlled Oscillator; an oscillator whereby the frequency of oscillation can be varied by changing a control voltage.

> **See also:**
> Glossary of Terms and Acronyms

VCTCXO

Voltage Controlled Temperature Compensated Crystal Oscillator.

> **See also:**
> Glossary of Terms and Acronyms

VHF

Very High Frequency.

> **See also:**
> Glossary of Terms and Acronyms

VIP

Vehicle Interface Port.

> **See also:**
> Glossary of Terms and Acronyms

VSWR

Voltage Standing Wave Ratio.

> **See also:**
> Glossary of Terms and Acronyms

WLAN

Wireless Local Area Network.

> **See also:**
> Glossary of Terms and Acronyms