Theory of Operation of the

SPP-A941 ADLI MK4

Analog 900MHz Cordless Telephone

Revision History:

Revision	Description	Effective Date
0	1st released	July 05,00

Contents

1 General

The SPP-A941 ADLI(MK4) is based on the VTECH VT9151 ADL(MK4). The SPP-A941 ADLI(MK4), is a next generation product of 900 MHz analog cordless telephones. The SPP-A941ADLI(MK4) offers essentially the same functionality as the current VT9151 ADLI (MK4) .

1.1 Hardware

The SPP-A941 ADL(MK4) consists of a mobile handset and a fixed base unit. The handset contains one printed circuit boards (PCB) which hold all its electronics - the baseband audio circuits and the radio frequency (RF) circuits. The majority of the discrete components on the PCB are surface mount and use formats such as those in the 0603 size.

The base unit electronics are split over two PCBs — two main PCBs (one double sided and one single-sided) for the RF and audio electronics. The double-sided PCB contains the RF electronics and audio electronics. The single-sided PCB contains the line interface, power management, baseband controller and parts of audio chain circuits, and is comprised of through-hole (line interface) as well as surface-mount components (rest of the circuit). The single-sided PCB and double-sided PCB are connected together via flexible ribbon cable.

ITAD MK3 is same as SPP-A941MK2B.

1.2 Overview

This document describes the theory of operation of the SPP-A941 ADLI(MK4). Section 2 provides the technical description of the baseband audio module, including telephone line interface, power management circuits, audio circuits, and microcontroller unit (MCU) circuits. Though similar in some cases, there are sufficient differences that the handset and base unit baseband circuitry are described in separate subsections under each functional heading. Section 3 provides the technical description of the RF module, including the antenna circuits, receiver circuits, and transmitter circuits. Unlike the baseband, the handset and base unit RF circuitry are essentially identical, and any differences applicable are highlighted within the description of each functional heading.

2 *Baseband Module*

The baseband audio module includes circuitry for the telephone line interface (base only), power management function, audio connection, and the microcontroller.

The following sections explain the individual blocks in the baseband module in detail.

2.1 *Telephone Line Interface*

The SPP-A941 ADLI(MK4) telephone line interface couples audio and line signalling to and from the telephone line while isolating the phone from the telephone line. The interface provides basic operation for the audio and facilitates pulse dialling and ring detection. Isolation is achieved by inductively coupling audio through a transformer and by coupling line signalling through opto-couplers. The isolation is necessary for the phone to meet the FCC 1.5 kV high-pot requirement. The interface also provides protection from high voltage transients and surge currents.

2.1.1 Line Protection and Filtering

The audio signal from the central office or PBX is carried by the telephone line (tip and ring) to the phone jack. The two lines are also used to carry the ring signal (40 – 15 V_{rms}, 15.3 – 68 Hz) and various line signalling (i.e., DTMF, dial tone, etc.)

A fuse is installed in the telephone loop to limit the loop current to no greater than 250 mA. A varistor is used to limit the voltage across the line interface should a high voltage transient appear on the telephone line (i.e., lightning strike). Further high voltage protection (1.5 kV) is afforded by the audio transformer's isolation.

2.1.2 Ring Detect

The ring signal across the tip and ring is detected by an AC coupled opto-coupler. Zener diodes are used to set the threshold detection voltage and to meet the no-ring response/impedance requirement for EIA-470. Resistors limit the current flow into the opto-coupler and maintain the necessary ringing impedance as specified in EIA-470. The diode across the opto-coupler input provides a discharge path for the coupling capacitor during negative ring cycles.

On the opto-coupler output side, a pull-up resistor is used to set the transistor's collector current (i.e., sensitivity control) when a ring signal is detected. The output of the opto-coupler is connected to the MCU where the ring signal is analysed for validity. A typical ringing pattern from the central office is one second "on" and four seconds "off".

2.1.3 Pulse Dialling or Off-Hook Swit2.ch

For pulse dialling (8 - 11 pps, 58 - 64% break, interval 53 - 80 ms), an opto-coupler is used to make and break the telephone line loop. In order for the phone to function normally irrespective of the polarity of the tip and ring, a diode bridge is used to ensure the potential on the collector of the opto-coupler is positive with respect to its emitter. The opto-coupler input is connected to the MCU from which the required state of the opto-coupler is controlled. For pulse dialling, the opto-coupler is simply pulsed off and on at the appropriate rate. To set the phone off-hook, the opto-coupler is activated which closes the telephone loop.

2.1.4 Speech Circuit

To minimize cost, a speech network IC is not used in the SPP-A941 ADLI(MK4) design. Instead, an isolation transformer with supporting hardware is used to provide all the speech network functions. The speech circuit provides line impedance matching and sidetone cancellation.

Matching (or return loss) is optimised when the termination impedance equals the source impedance. The effective impedance looking into the SPP-A941ADL(MK4) is a combination of all the components' impedance in the line interface. This effective impedance was derived empirically by fine tuning the resistor across the audio transformer's secondary. The speech circuit matches a line impedance of 600 Ω (EIA-470: 4.5.2.3) while the transmit, receive and sidetone frequency responses are set with a 900 Ω line impedance (EIA-470:4.1.11 - 4.1.3).

The telephone line to audio signal conversion (or vice versa) is accomplished by transmitting audio to the transformer's secondary via a transmit amplifier, and a receive amplifier receives audio directly from the transformer's secondary.

Sidetone cancellation is accomplished by taking transmit audio (the sidetone) and resistively combining it with out-of-phase transmit audio. In a real-world situation, the match between the line interface and the telephone line is not perfect. This slight mismatch results in some transmit audio being enter into the receive direction. The sidetone cancellation signal in SPP-A941 ADL(MK4) is created by combining the transmit audio signal from another output of the transmit amplifier which are inherently 180° out-of-phase (i.e., the sidetone source), then feed to the receive path.

2.2 Power Management

2.2.1 Base Unit

SPP-A941 ADLI(MK4) base power circuits consist of DC power regulation and charging circuits for the handset. The base unit operates on a regulated 5 VDC power supply. The power is supplied to the regulator via a UL-approved 9 VDC, 200 mA power adapter. During normal operation, the base unit draws about 100 mA of current (with an additional 40 mA when the handset is in the cradles).

2.2.1.1 Power Supply

DC power is supplied to the base via a UL-approved AC-to-DC power adapter rated at 9 VDC, 200 mA. The power from the adapter is then regulated down to 5 VDC. Filter capacitors are connected to both sides of the 5 VDC regulator to ensure AC variations are eliminated form the power lines. All circuits except for the Tx RF chain are powered at all times. The Tx RF chain is controlled by the MCU by programming the RF chip and is turned on when communications with the handset is required. The Tx_PWR is switched off when the Tx RF chain is not needed to minimise the use of the RF spectrum space during the idle state.

2.2.1.2 Handset Charge Circuit

To reduce costs by keeping circuits simple, the handset charge circuit is designed to supply a charging current to a cradled handset regardless of whether the battery is fully charged or not. This current varies with the charge on the battery and is limited to 0.1 C or 10% of the battery capacity by a limiting resistor. The charge circuit is supplied directly from the 9 VDC, 200 mA power adapter which insures that power is available to charge the handset battery.

In the SPP-A941 ADLI(MK4), the handset battery has a capacity of 400 mAHr, thus the maximum charging current is set to approximately 40 mA. The specification of 0.1 C allows a battery to be constantly charged without damaging the battery. The handset charge circuit components have been selected to withstand shorting the charge contacts on the cradle. The handset charge circuit also provides a signal to the MCU for cradle detection.

2.2.1.3 ESD Protection

The charge contacts for the handset are vulnerable to electro-static discharge (ESD) because they are exposed to the outside world. Since the contacts are connected directly to the base circuits, ESD can damage some of the base internal circuits if no protection is implemented. Therefore, a number of measures have been taken to protect internal circuits from ESD damage.

Charge contact have LC filtering on them to bypass ESD. Low voltage spare gaps (arc at ~500 V based on 1 kV/mm electric discharge through air) are also implanted in the PCB layout between charge contacts and a special ESD ground. This ESD ground channels any ESD discharge directly to the telephone line and AC adapter, preventing discharges from entering the main circuits.

2.2.2 Handset

The SPP-A941 ADLI(MK4) handset power is supplied by a three-cell battery with a nominal voltage of 3.6 VDC. This voltage will direct apply to all circuit including the RF circuit part. The variation on the performance can fall within the tolerance.

In order to achieve a long standby time, the handset conserves power by "sleeping" when not in use and occasionally "waking up". In the "sleep" condition, the handset supplies power only to those circuits deemed essential for proper operation such as the MCU and memory. The RF chip will be programmed to "Inactive" mode and all operation will stop including the oscillator circuit. In the "wake-up" condition, the handset powers the RF chip to "Rxmode" that allow it to receive data. This function is necessary to detect if the base requires the handset to act on a condition such as an incoming call. With this sleep/wake-up sequence, handset is able to achieve a six-day stand-by time. To reduce the cost, external wake-up circuit are insteaded by entering "Ideal mode" or "Normal mode" that under MCU control.

2.2.2.1 Battery Maintenance and Low Voltage Detection

The battery is recharged via a cradle contact on the base. The handset has a corresponding charge contact at the bottom of the handset chassis. The charge contact is protected from a short to ground by a diode placed in line with the battery connection. The diode prevents the battery from discharging from