System Module

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Introduction

This chapter describes the system module for the RM-11 transceiver.

The baseband module includes the baseband engine chipset, the UI components, and the acoustic components. The RM-11 is a hand-portable, dual-band CDMA 800/1900 with AMPS. It has been designed using a DCT4 generation baseband (UEM/UPP) and RF module. RM-11 includes a template cutter and user-customizable template front and back covers. Other features include an integrated VGA camera, an IR, and a built-in flashlight.

The phone requires the BLD-3 battery with a nominal capacity of 780 mAh.

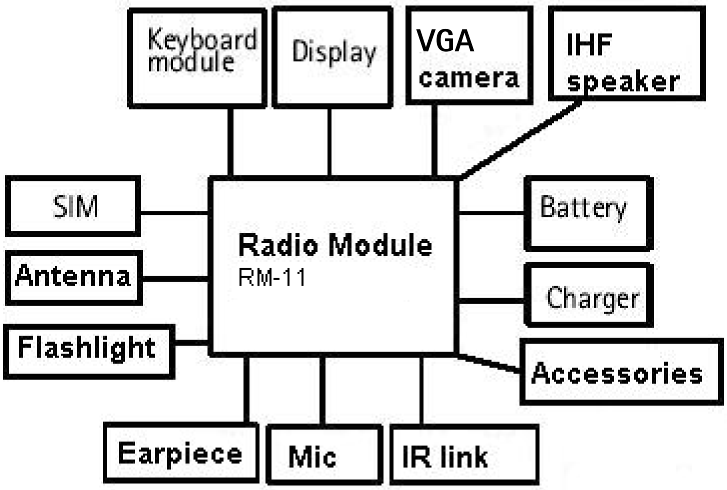

Figure 1: Interconnection diagram

BB Hardware Characteristics

Following are characteristics for the BB hardware:

- Hi-resolution (128x128 pixel) illuminated color display
- Active LCD pixel area: width 27.6mm X height 27.6mm
- ESD-proof keymat, with five individual keys for multiple key pressing
- Support for internal semi-fixed battery (Janette type BLD-3)
- Audio amplifier and SALT speaker for MIDI support
- Ringing volume 100dB @ 5cm (MIDI tones through SALT speaker)
- Stereo FM receiver as an accessory
- IrDa port/interface
- Internal vibra
- Supports voice dial activation via headset button
- Six white LEDs for the keymat on the UI board, and two for the LCD backlight in the LCD module
- Six-layer PWB, SMD with components on both sides of the PWB

Technical Summary

The baseband module is implemented using two main ASICs — the Universal Energy Management (UEM) and the Universal Phone Processor (UPP). The baseband module also contains an audio amplifier for MIDI support and a 128-Mbit Flash/ 8-Mbit SRAM combo IC. EMC shielding is implemented using a metallized plastic frame. On the other side, the engine is shielded with PWB ground openings. Heat generated by the circuitry is conducted out via the PWB ground planes. The RM-11 transceiver module is implemented on a 6-layer, FR-4 material PWB.

Functional Description

Modes of Operation

The RM-11 baseband engine has five different operating modes:

- No supply
- Acting dead
- Active
- Sleep
- Charging

No Supply Mode

In NO_SUPPLY mode, the phone has no supply voltage. This mode is due to the disconnection of the main battery or a low battery voltage level. The phone exits from NO_SUPPLY mode when a sufficient battery voltage level is detected. The battery voltage can rise either by connecting a new battery with VBAT > VMSTR+, or by connecting a charger and charging the battery voltage to above VMSTR+.

Acting Dead Mode

If the phone is powered off when the charger is connected, the phone is powered on and enters a state called Acting Dead. In this mode, no RF circuitry is powered up. To the user, the phone acts as if it is switched off. The phone issues a battery-charging alert and/or shows a battery charging indication on the display to acknowledge to the user that the battery is charging.

Active Mode

In active mode, the phone is in normal operation, scanning for channels, listening to a base station, transmitting, and processing information. There are several sub-states in the active mode depending on if the phone is in burst reception, burst transmission, etc. SW controls the RF regulators by writing the correct values into the UEM control registers. VR1A/B and VR2 can be enabled or disabled. VR4 - VR7 can be enabled, disabled, or forced into low quiescent current mode. VR3 is always enabled in active mode.

Sleep Mode

The phone enters Sleep mode when both the MCU and the DSP are in stand-by mode. Both processors control sleep. When the SLEEPX low signal is detected, the UEM enters Sleep mode. In this mode, the VCORE, VIO and VFLASH1 regulators are put into low quiescent current mode. All RF regulators — with the exception of VR2 and VR3 — are disabled in sleep mode. When the SLEEPX is set high and is detected by the UEM, the phone enters Active mode and all functions are activated. Sleep mode is exited either by the expiration of a sleep clock counter in the UEM, or by some external interrupt generated by a charger connection, key press, headset connection, etc. While in Sleep mode, the main oscillator is shut down and the baseband section uses the 32 kHz sleep clock oscillator as its reference.

Charging Mode

Charging can be performed in parallel with any other operating mode. The Battery Size Indicator (BSI) resistor inside the battery pack indicates the battery type/size. The resistor value corresponds to a specific battery capacity and technology. Under UPP software control, the UEM's AD converters measure the battery voltage, temperature, size, and current. The charging control circuitry (CHACON) inside the UEM controls the charging current delivered from the charger to the battery. The battery voltage rise is limited by turning the UEM switch off when the battery voltage has reached VBATLim (programmable charging cut-off limits are 3.6V, 5.0V, 5.25V). Measuring the voltage drop across a 0.22 Ohm resistor monitors the charging current.

RM-11 BB Functional Blocks

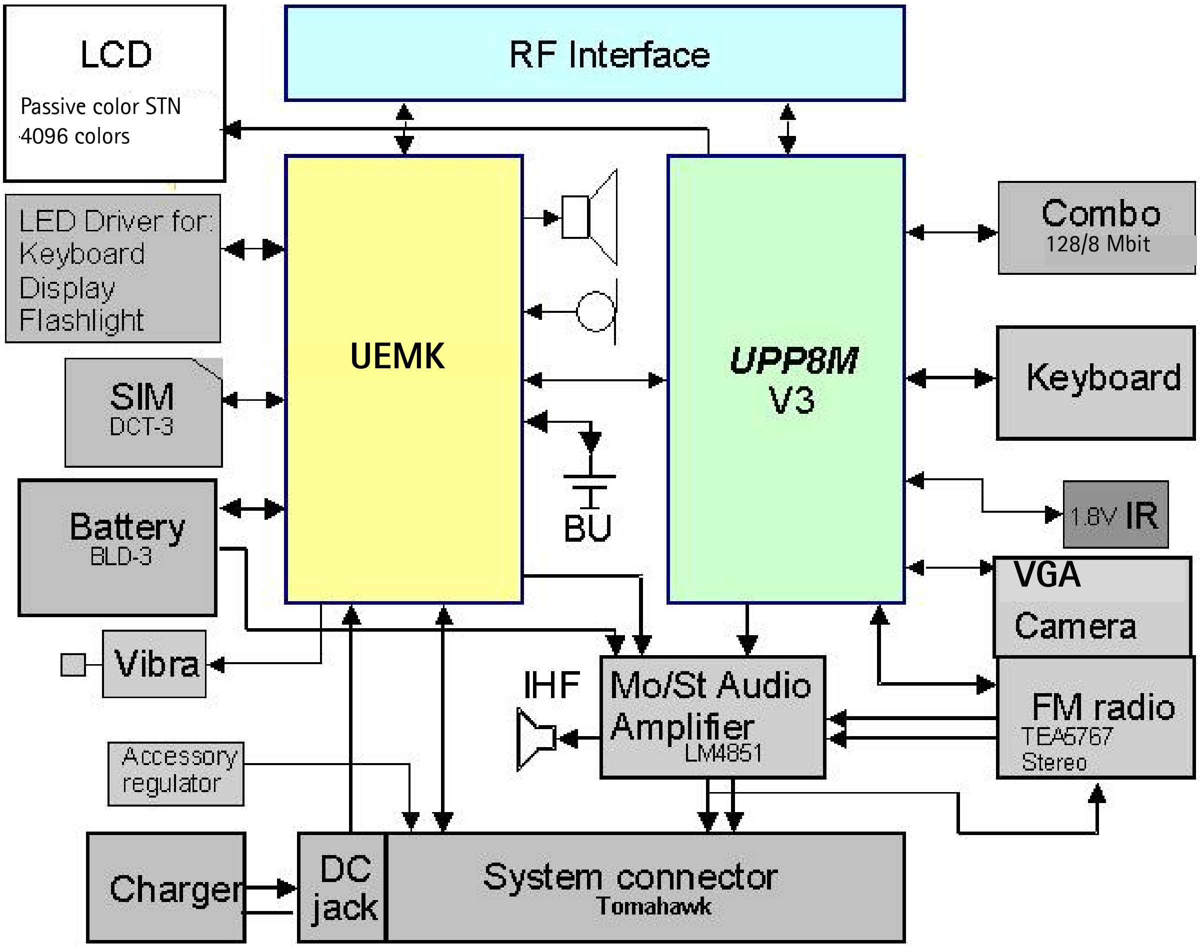

Figure 2: Baseband block assembly

RM-11 BB functional blocks are listed below:

- UEM and UPP
- Battery
- LED driver
- LCD display
- RF IF block
- Memory module
- Keyboard (UI module)
- External audio connector
- IrDa interface
- Vibra
- FM radio
- System connector (Pop-Port™)
- PWB strategy

- EMC strategy
- Test interface

UEM and UPP

The UEM contains a series of voltage regulators to supply both the baseband module and the RF module. Both the RF and baseband modules are supplied with regulated voltages of 2.78 V and 1.8 V. The UEM contains six linear LDO (low drop-out) regulators for the baseband and seven regulators for RF circuitry. The RF regulator VR1 uses two LDOs and a charge pump. The VR1 regulator is used by the RF module. The core of the UPP is supplied with a programmable voltage of 1.0 V, 1.3 V, 1.5 V, or 1.8 V. Note that with the UEMK, VCORE supply voltage is set to 1.5 V.

The UPP operates from a 19.2 MHz clock generated in the RF ASIC. The UEM contains a real-time clock, sliced down from the 32768 Hz crystal oscillator. The UPP uses the 32768 Hz clock as the sleep clock.

The communication between the UEM and the UPP is done via the bi-directional serial busses, CBUS and DBUS. The CBUS is controlled by the MCU and operates at a speed of 1.08 MHz. The DBUS is controlled by the DSP and operates at a speed of 9.6 MHz. Both processors are located in the UPP.

The interface between baseband and RF is implemented in the UEM and UPP ASIC. The UEM provides A/D and D/A conversion of the in-phase and quadrature receive and transmit signal paths. It also provides A/D and D/A conversions of received and transmitted audio signals to and from the user interface. The UEM supplies the analog signals to the RF section according to the UPP DSP digital control. The RF ASIC is controlled via the UPP RFBUS serial interface. There are also separate signals for PDM-coded audio. Digital speech processing is handled by the DSP inside the UPP ASIC. The UEM is a dual voltage circuit with the digital parts running from the baseband supply (1.8 V) and the analog parts running from the analog supply of 2.78 V. The input battery voltage (VBAT) is also used directly by some UEM blocks.

The baseband supports both internal and external microphone inputs as well as speaker outputs. Input and output signal source selection and gain control are done by the UEM according to control messages from the UPP. Keypad tones, DTMF, and other audio tones are generated and encoded by the UPP and transmitted to the UEM for decoding. The RM-11 has two external serial control interfaces: FBUS and MBUS provided by the UEM. These busses can be accessed only through production test patterns. RM-11 also uses the UPP8MV3 and UEMK.

Battery

BLD-3 Li-ion (inbox battery) is used as the main power source. The BLD-3 has a capacity of 780 mAh.

Table 1: BLD-3 characteristics

Description	Value
Nominal discharge cut-off voltage	3.1V
Nominal battery voltage	3.7V
Nominal charging voltage	4.2V
Maximum charger output current	850mA
Minimum charger output current	200mA
Cell pack impedance -20 ... 0 °C	180mΩ max
Cell pack impedance 0 ... +20 °C	150mΩ max
Cell pack impedance +20 ...+60 °C	130mΩ max
Cell pack impedance +60 ...+80 °C	250mΩ max

Table 2: Pin numbering of battery pack

Signal name	Pin number	Function
VBAT	1	Positive battery terminal
BSI	2	Battery capacity measurement (fixed resistor inside the battery pack)
BTEMP	3	Battery temperature measurement (measured by ntc resistor inside pack)
GND	4	Negative/common battery terminal

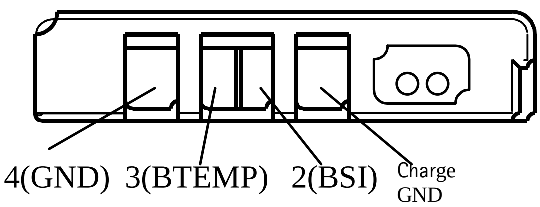

Figure 3: Battery pack contacts

The BSI fixed resistor value indicates the type and default capacity of a battery. The NTC-resistor measures the battery temperature.

Temperature and capacity information is needed for charge control. These resistors are connected to the BSI and BTEMP pins of the battery connector. The phone has 100 kW pull-up resistors for these lines so that they can be read by A/D inputs in the phone. For safety reasons, the phone software will shut the phone off if it senses a temperature of 38°C or higher on the BTEMP line.

Table 3: BSI resistor values

Parameter	Min	Typ	Max	Unit	Notes
Battery size indicator resistor BSI		75		kΩ	Battery size indicator (BLD-3) Tolerance “1%
NTC thermistor BTEMP		47 4000		kΩ K	Battery temperature indicator (NTC pulldown) 47kΩ“5% @ 25 °C Beta value (B). Tolerance “5%, 25 °C / 85 °C

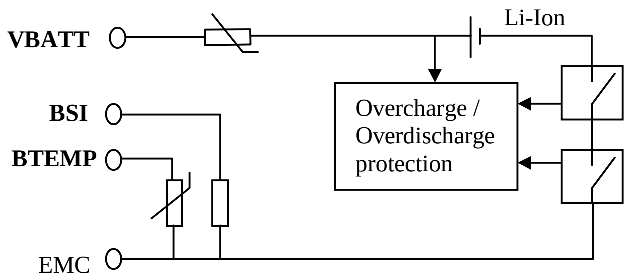

Figure 4: Interconnection diagram

Supply Voltage Regulation

The UEM ASIC controls supply voltage regulation. There are six separate regulators used by the baseband block. For a more detailed description about the regulator parameters, see the *UEM ASIC Specification* document.

Charging

The RM-11 baseband supports the NMP charger interface specified in the *Janette Charger Interface* document. SW control is specified in the *EM SW Specification, ISA EM Core SW Project* document. The UEM ASIC controls charging, and external components are used to provide EMC, reverse polarity, and transient protection of the charger input to the baseband module. The charger connection is through the system connector interface. Both 2- and 3-wire type chargers are supported. The operation of the charging circuit has been specified to limit the power dissipation across the charge switch and to ensure safe operation in all modes.

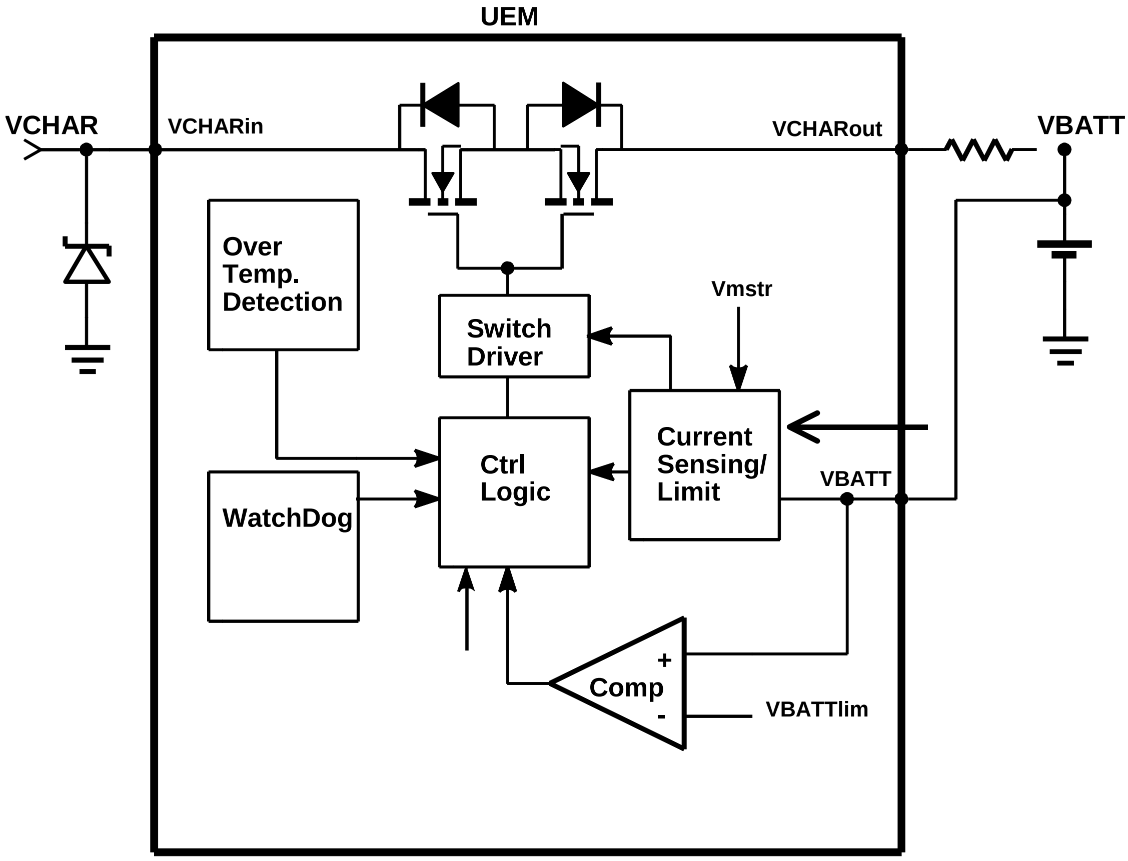

Figure 5: UEM charging circuitry

Charger Detection

Connecting a charger creates voltage on the VCHAR input to the UEM. When the VCHAR input voltage level rises above the VCHDET+ threshold, the UEM starts the charging process. The VCHARDET signal is generated to indicate the presence of the charger for the SW.

Energy Management (EM) SW controls the charger identification and acceptance. The charger recognition is initiated when the EM SW receives a "charger connected" interupt.
If the charger is identified and accepted, the appropriate charging algorithm is initiated.

Charger Interface Protection

In order to ensure safe operation with all chargers and in misuse situations, the charger interface is protected using a transient voltage suppressor (TVS) and a 1.5A fuse. The TVS device used in RM-11 is rated for 16 V@175 W.

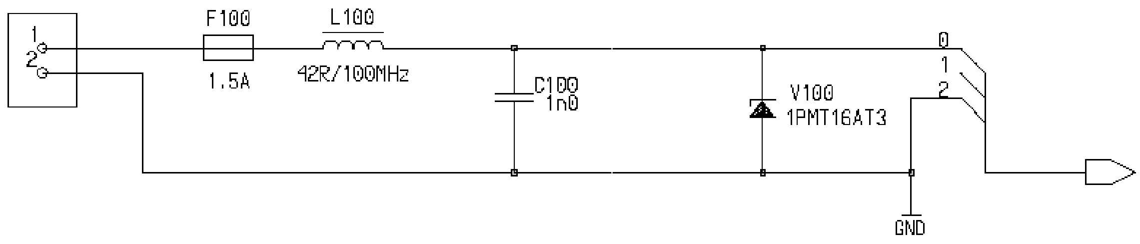

Figure 6: Charger interface diagram

Table 4 includes the values for the TVS.

Table 4: Charger interface TVS characteristics

Characteristic	Value
Breakdown voltage (VBR)	17.8Vmin (at IT 1.0mA)
Reverse standoff voltage (VR)	6V
Max reverse leakage current at VR (IR)	5uA
Max peak impulse current (Ipp)	7A (at Ta=25*C, current waveform: 10/1000us)
Max clamping voltage at Ipp (Vc)	26V

LED Driver Circuit

In RM-11, white LEDs are used for LCD and keypad lighting. Two LEDs are used for LCD lighting and six are used for the keyboard. A step-up DC-DC converter (TK11851) is used as the white LED driver.

Keyboard LEDs are driven in 2-serial/3 parallel modes.

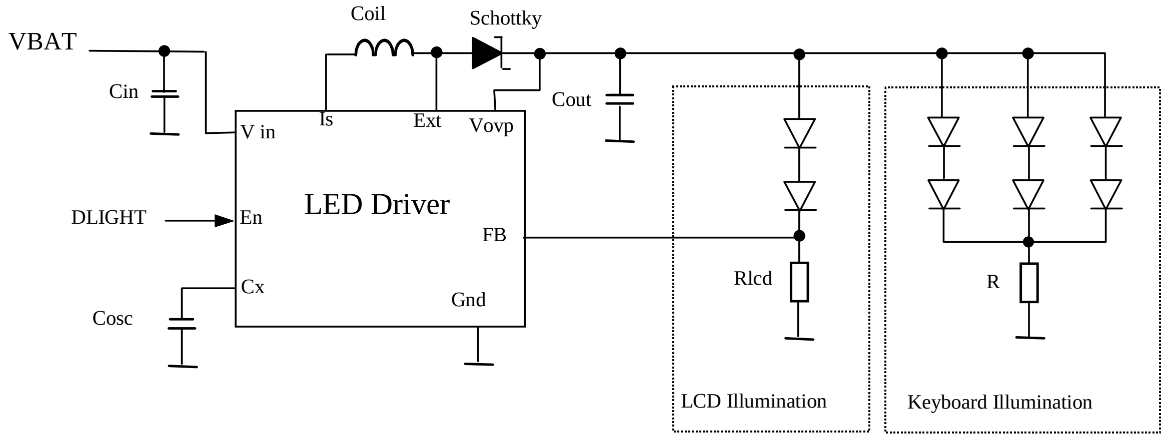

Figure 7: Shared LED driver circuit for LCD and keyboard backlight

LCD Backlight

The LCD backlight consists of two white LEDs, which are integrated with the LCD module.

Keyboard Illumination

The keyboard light consists of six white LEDs on the UI board. They are placed under the keyboard for proper illumination of the keypad.

LCD Display

The LCD is a CSTN 130 x 130, full-dot matrix display with 12bit (4096 colors) color resolution and a single pixel border area around the content area, which makes the total active area 128 x 128 pixels.

Table 5: LCD general specifications

LCD parameter	Value
Glass size, width x height x thickness	33.98 mm x 37.95 mm x 1.71 mm
Glass thickness	0.50 mm
Viewing area (width x height)	30.29 mm x 30.29 mm
Active pixel area (width x height)	27.29 mm x 27.29 mm
Number of pixels	130 x 130 pixels
Technology	CSTN (color super twisted nematic)
Operating temperature range	-25 ^{o}C to +70 ^{o}C
Main viewing direction	6 o'clock
Illumination mode	transflective
Color tone Background:	 Neutral/Black

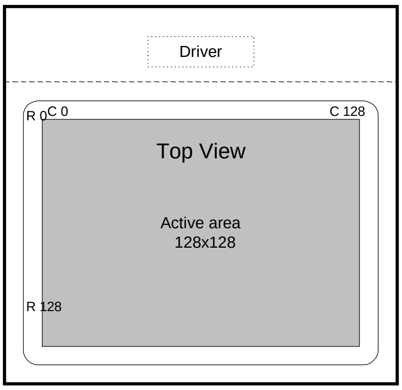

Figure 8: Color LCD module

RF Interface Block

The interface between the baseband and the RF module can be divided into two categories: the digital interface and the analog interface. The digital interface is between the UPP and the RF chip. The serial digital interface is used to control the operation of the different blocks in the RF chip. The analog interface is between the UEM and the RF.

Combo Memory Module

The RM-11 baseband memory module consists of a combo Flash/SRAM chip. It has 128 Mbit burst-type flash memory and 8Mbit of SRAM. In addition, the UPP has 8Mbits of internal RAM. The UPP RAM is part of the UPP and is not discussed here.

Combo Memory Interface

The memory interface consists of a multiplexed address/data bus MEMADDA, the MEMCONT memory control bus, and the GENIO, which is used for memory control. The purpose of the memory interface is to reduce the amount of interconnections by multiplexing the address and data signals on the same bus. The memory interface supports asynchronous read burst mode, synchronous read, and simultaneous read-while-write/erase — all controlled by the UPP.

SRAM Memory

The combo memory chip used in RM-11 has 8 Mbit of SRAM, 16-bits wide running at 1.8 V.

Flash Memory

The 128 Mbit density flash with 16-bit data access operates in both asynchronous random access and synchronous burst access (with crossing partition boundaries) and has various data protection features. Upon power up or reset, the device defaults to asynchronous read configuration.

The device supports reads and in-system erase and program operations at Vcc=1.8 V (Voltage range 1.7-1.9 V).

Keyboard (UI Module)

The RM-11 consists of a separate UI board and includes contacts for the keypad domes and LEDs for keypad lighting. The UI board is connected to the main PWB through a 16-pole, board-to-board connector with springs. A 5x4 matrix keyboard is also used. Key pressing is detected by a scanning procedure. Keypad signals are connected via the UPP keyboard interface.

Internal Audio

Internal Microphone

The internal microphone capsule is mounted to in the UI frame. The microphone is omni-directional and is connected to the UEM microphone input (MIC1P/N). The microphone input is asymmetric and the UEM (MICB1) provides bias voltage. The microphone input on the UEM is ESD protected. Spring contacts are used to connect the microphone to the main PWB.

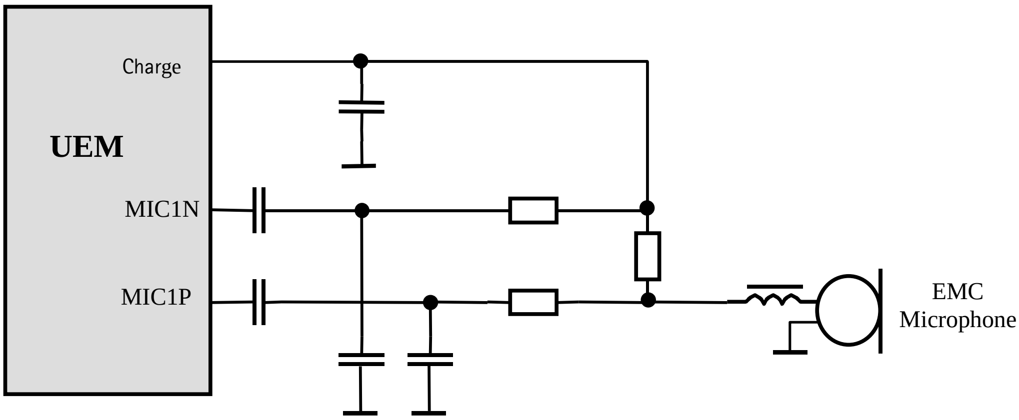

Figure 9: Internal microphone connection

Internal Speaker

The internal earpiece is a dynamic earpiece with an impedance of 32 ohms. The earpiece is low impedance because the sound pressure is to be generated using current and not voltage as the supply voltage is restricted to 2.7 V. The earpiece is driven directly by the UEM and the earpiece driver (EARP and EARN outputs) is a fully differential bridge amplifier with 6 dB gain. In RM-11, an 8 mm leak tolerant PICO earpiece is used.

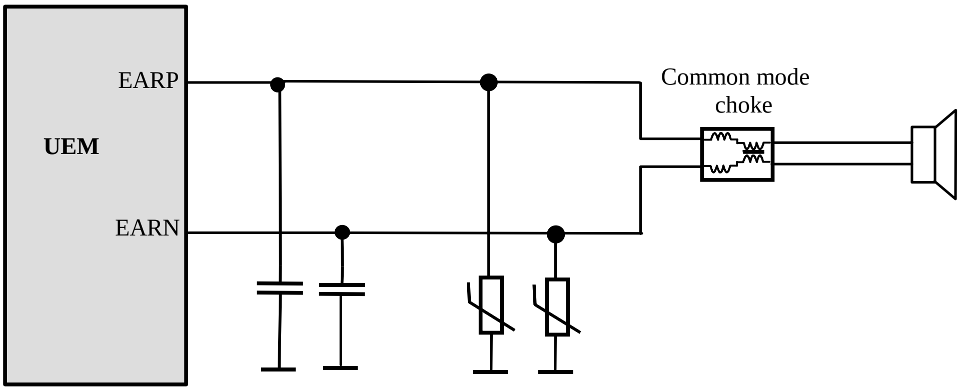

Figure 10: Speaker connection

IHF Speaker and Stereo Audio Amplifier

The Integrated Hands Free (IHF) speaker (16 mm MALT) is used to generate speech audio, ringing and warning tones. The audio amplifier is controlled by the UPP. The speaker capsule is mounted in the C-cover. Spring contacts are used to connect the IHF speaker contacts to the main PWB.

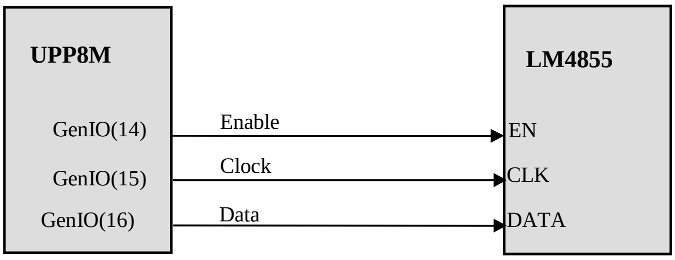

Figure 11: Digital interface of audio amplifier

The LM4855 features a 32-step, digital volume control and eight distinct output modes. The digital volume control and output modes are accessed through a 3-wire interface controlled by the UPP. Digital volume control is needed when the FM radio is activated; there is no amplifier block in the FM radio module. Output modes are needed when routing audio to different locations (i.e., headset, IHF).

External Audio Connector

The RM-11 is designed to support a fully differential external audio accessory connection by using a Pop-Port™ system connector. The Pop-Port™ connector has a serial data bus called Accessory Control Interface (ACI) for accessory insertion and removal detection, identification, and authentication. The ACI line is used for accessory control purposes and includes the following:

- 4-wire fully differential stereo audio (used also FM-radio antenna connection)
- 2-wire differential mic input

External Microphone Connection

The external microphone input is fully differential and lines are connected to the UEM microphone input (MIC2P/N). The UEM (MICB2) provides bias voltage. The microphone input lines are ESD protected.

Creating a short circuit between the headset microphone signals generates the hook signal. When the accessory is not connected, the UEM resistor pulls up the HookInt signal. When the accessory is inserted and the microphone path is biased the HookInt signal decreases to 1.8 V due to the microphone bias current flowing through the resistor. When the button is pressed, the microphone signals are connected together and the HookInt input receives half of micbias DC value 1.1 V. This change in DC level causes the HookInt comparator output to change states, in this case from 0 to 1. The button can be used for answering incoming calls but not to initiate outgoing calls.

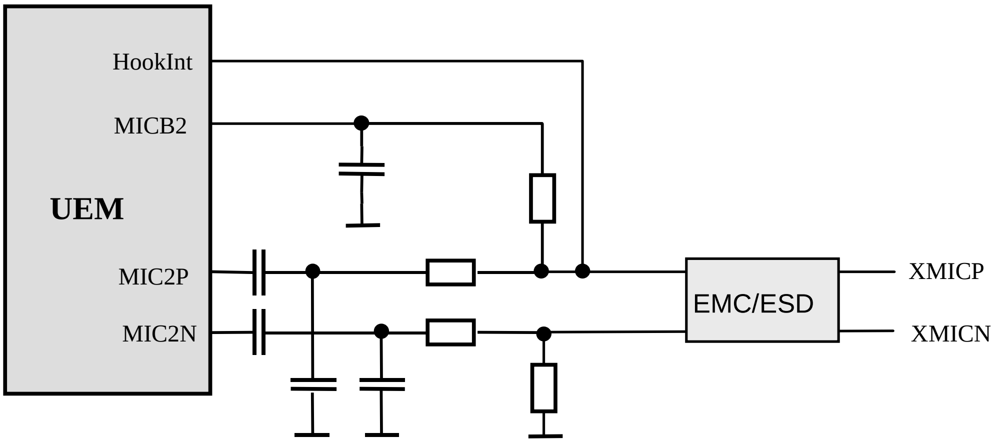

Figure 12: External microphone connection

External Earphone Connection

Headset implementation uses separate microphone and earpiece signals. The accessory is detected by the HeadInt signal when the plug is inserted.

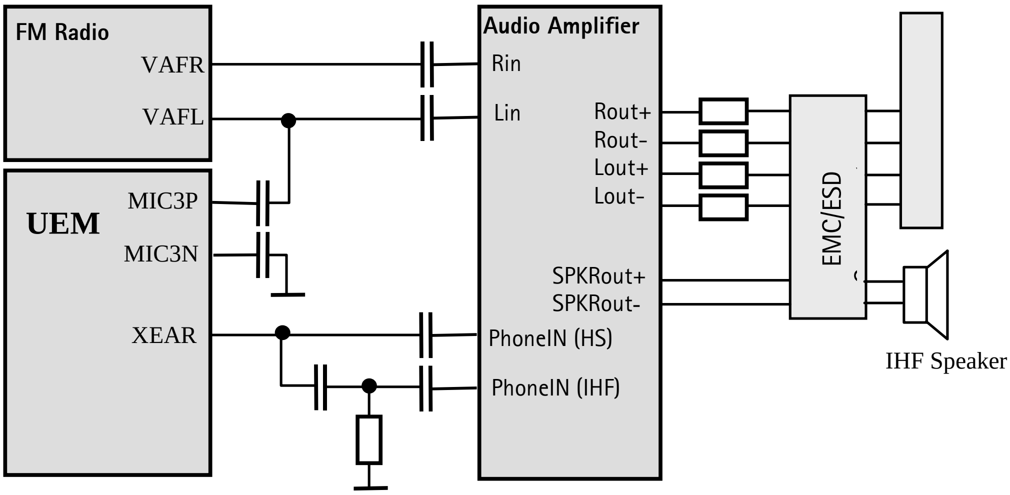

Figure 13: External earphone and IHF connections

IrDa Interface

When using transceiver with 1.8V I/O, the IrDa interface is designed into the UPP. The IR link supports speeds from 9600 bit/s to 1.152 MBit/s up to a distance of 80 cm. Transmission over the IR is half-duplex.

The IR transceiver can be set into SIR or MIR modes. In SIR mode the transceiver is capable of transmission speeds up to 115.2kbit/s. In MIR mode faster transmission speeds are used. The maximum speed is 1.152Mbit/s.

Vibra

A vibra-alerting device is used to generate a vibration signal for an incoming call. Vibra is located in the bottom end of the phone and a connection is done with spring contacts.

FM Radio

FM radio circuitry is implemented by using a highly integrated radio IC (TEA5767). TEA5767 is a single-chip, electronically tuned, FM stereo radio with fully integrated IF selectivity and demodulation. The IF frequency is 225 kHz. The radio is completely adjustment-free and only requires a minimum of small, low-cost, external components. It has signal-dependent mono/stereo blend [Stereo Noise Cancelling (SNC)]. The radio can tune the European, US, and Japan FM bands.

Channel tuning and other controls are controlled through a serial bus interface by the MCUSW. The reference clock (32kHz) is generated by the UPP CTSI block (routed from the sleep clock).

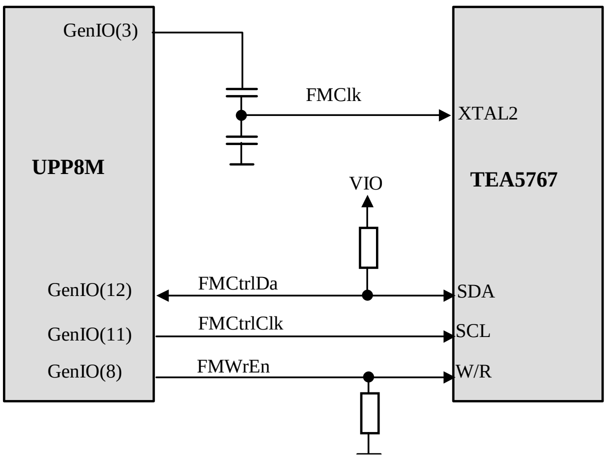

Figure 14: FM radio digital interface connections

Camera

The VGA camera module is connected to the baseband (UPP) through an HW accelerator IC. And external 1.8 V regulator is used as a power supply (VDIG) for the camera module and HW accelerator, together with VFLASH2.

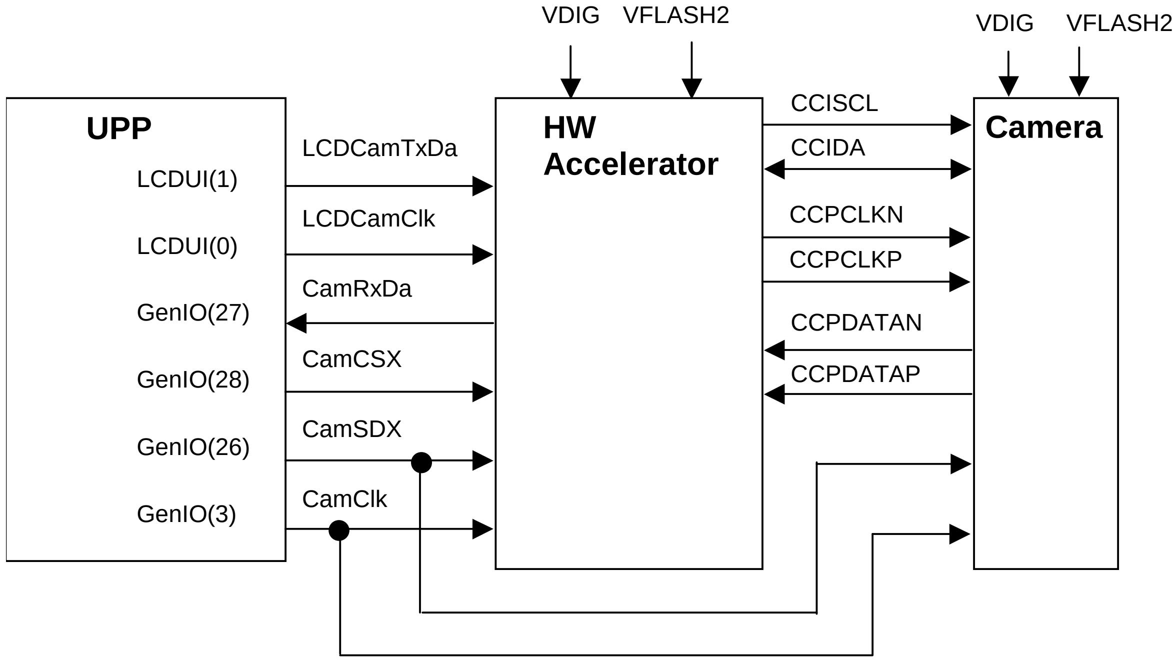

Figure 15: Camera connections to baseband

The VGA camera has a resolution of 640 x 480 with a pixel size of 5.6um x 5.6um. Both the camera and the HW accelerator support sleep functionality in order to minimize the current consumption.

Flashlight

The flashlight feature is driven by the white LED driver and is controlled by the UEM. The circuit for the flashlight is driven by TK11851TL.

System Connector (Pop-Port™)

The 14-pin Pop-Port™ bottom connector consists of charging plug socket and Pop-Port™ System Connector. The Pop-Port™ system connector includes signals for the following:

Table 6: Pop-Port™ system connector signals

Function	Notes
Charging	Pads for 2-wire charging in cradles
Audio	4-wire fully differential stereo audio output 2-wire differential microphone input FM radio antenna connection
Power supply for accessories	2.78V/70mA output to accessories
ACI (Accessory Control Interface)	Accessory detection/removal and controlling
FBUS	Standard FBUS
DKU-5 (similar to USB) (optional)	Power in 5V in from DKU-5 cable

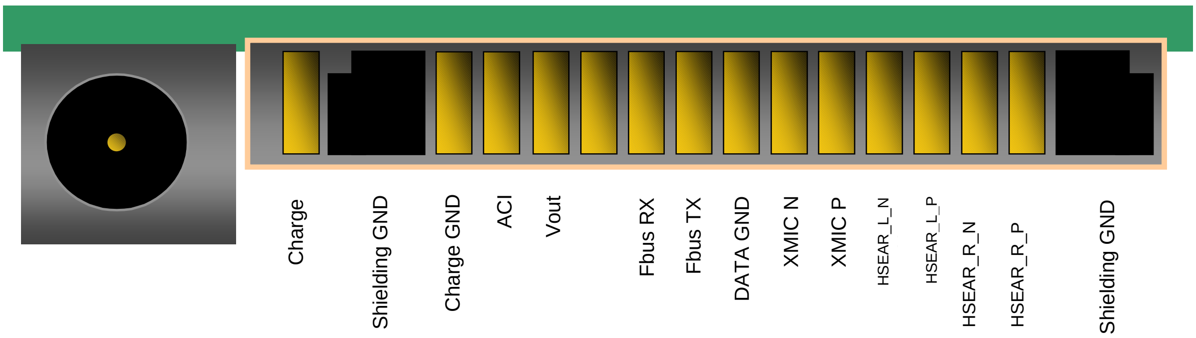

Figure 16: Pop-Port™ bottom connector (charger plug socket and Pop-Port™ system connector)

Accessory Control Interface (ACI)

The ACI is a point-to-point, bi-directional serial bus. It has three main features:

- The insertion and removal detection of an accessory device
- Acting as a data bus, intended mainly for control purposes
- The identification and authentication of accessory type which is connected

The accessories are detected by the HeadInt signal when the plug is inserted. Normally when an accessory is not present, the pull-up resistor 100k pulls up the HeadInt signal to VFLASH1. If the accessory is inserted, the external resistor (located to accessory) works as a voltage divider and decreases the voltage level below the threshold of Vhead. The comparator output is then changed to a high state, which causes an interrupt.

If the accessory is removed, the voltage level of HeadInt increases again to VFLASH1. This voltage level is higher than the threshold of the comparator and so its output is changed to low, which leads to an interrupt. These HeadInt interrupts are initiated by the accessory detection or removal sequence.

External Accessory Regulator

An external LDO Regulator is needed for accessory power supply purposes. All ACI accessories require this power supply. A regulator input is connected to the battery voltage VBAT and output is connected to the Vout pin in the Pop-Port™ connector. The regulator ON/OFF function is controlled via the UPP.

The pull-down resistor on the enable input of the regulator is needed because in the switch-off mode of the phone, the output level of the Genio(0) is not defined. If the Genio(0) is floating, the regulator may be enabled when it should not be.

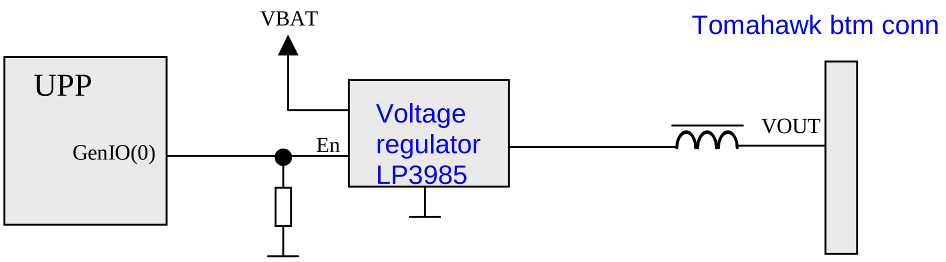

Figure 17: Accessory power supply diagram

Test Interfaces

Using the Pop-Port™ connector's FBUS connections, the phone HW can be tested by PC software (i.e., Phoenix test software). In addition, RM-11 also supports Flash programming interface via the service battery.

After Sales Interface

Test pads are placed on the engine PWB for service purposes. The same test pattern is used by the After Market Sales (AMS) group for product testing and software upgrades. The following figure shows the top view of the test pads.

RF Functional Description

Most of the RF functions are centered around the RF ASIC. Receiver IF stages, low-band LNA, PLLs, RXVHF oscillator, TX VHF VCO active part and loop filter, high-band and low-band TX up-converters, TX IF stages, IQ modulator and demodulator and reference oscillator buffering are all integrated on single chip.

Circuit Diagrams and PWB Layout

Receiver

The receiver shows a superheterodyne structure with zero 2nd IF. Low-band and high-band receivers have separate front ends from the diplexer to the first IF. Most of the receiver functions are integrated in the RF ASIC. The only functions out of the chip are the high-band LNA, duplexers, and SAW filters. Receiver characteristics are very similar on both bands.

Frequency Synthesizers

The RM-11 synthesizer consists of three synthesizers: one UHF synthesizer and two VHF synthesizers. The UHF synthesizer is based on an integrated PLL and external UHF VCO, loop filter, and VCTCXO. Its main goal is to achieve the channel selection, thus for dual-band operations associated with dual mode.

Two VHF synthesizers consist of the RX VHF synthesizer and the TX VHF synthesizer. The RX VHF synthesizer includes integrated PLL and VCO and loop filter and resonator. The output of the RX-VHF PLL is used as a LO signal for the second mixer in the receiver. The TX VHF Synthesizer and loop filter are integrated into the RF ASIC. See the depicted block diagrams.

Transmitter

The transmitter RF architecture is up-conversion type with (RF-) modulation and gain control at IF. The IF frequency is 180.54 MHz. The cellular band is 824.01-848.97 MHz and the PCS band is 1850.01-1909.95 MHz.

Common IF

The RF modulator is integrated with a Programmable Gain Amplifier (PGA) and an IF output buffer inside the RFIC chip.

Cellular Band

At operation in cellular band, the IF signal is buffered at the IF output stage that is enabled by TXP1 TX control. The maximum linear (balanced) IF signal level to 50 W load is about -8 dBm.

Before power amplifier RF signal is filter in band filter. The typical insertion loss is about -2.7dB, and the maximum is less than -3.0dB. The input and output return losses are about -10dB.

PCS Band

When operating in the PCS band, the IF signal is routed outside from RF IC to be filtered in the TX IF strip filter, and after that back to the RF IC, then to the upconverter mixer. The LO signal to the mixer is buffered and balanced inside the RF IC. The mixer output is enabled by the TXP2 TX control signal. The maximum linear (balanced) RF signal level to 50 W load is about +7dBm.

Next, the RF IC-balanced RF signal is single-ended in 1:1 balun and then filtered in the SAW filter.

Power Control

For power monitoring, there is a power detector module (PDM) build up from a dual coupler, a biased diode detector, and an NTC resistor. RF signals from both bands are routed via this PDM.

The diode output and NTC voltages are routed to the BB A/D converters for power control.

NTC voltage is used for diode temperature compensation and for thermal shut down when the radio board's temperature exceeds +85°C.

The coupler's insertion loss is -0.42dB (max) at the cellular band and -0.48dB (max) at the PCS band. Typical values for insertion losses are about -0.2dB.

Antenna Circuit

The antenna circuit stands for duplex filters and diplexer. The cellular band duplex filter is a band pass type SAW filter. The PCS band duplex filter is a band stop (for receiver band) ceramic filter.

Antenna

The RM-11 antenna solution is an internal dual resonance PIFA antenna.