7 - Baseband

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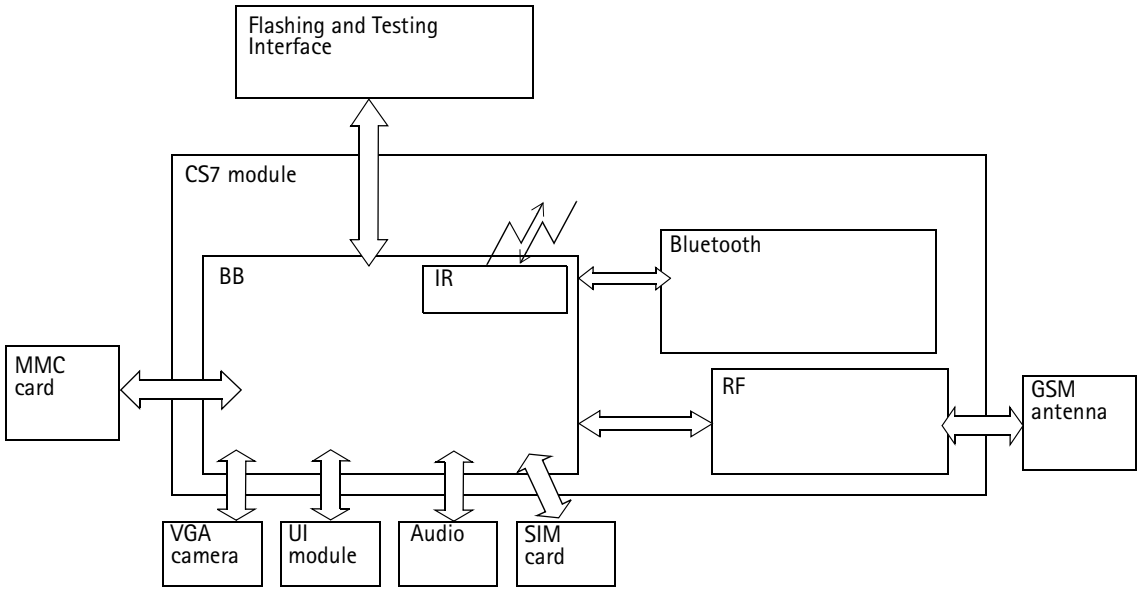
List of abbreviations:

ASIC	Application Specific Integrated Circuit
BB	Baseband
BLUETOOTH, BT	Bluetooth
BSI	Battery Size Indicator
CBus	Control Bus connecting UPP_WD2 with UEM
CCP	Compact Camera Port
CPU	Central Processing Unit
DBUS	Data Bus
DSP	Digital Signal Processor
EGSM	Extended – GSM
GPRS	General Packet Radio Service
GSM	Group Special Mobile/Global system mobile
HF	Hands free
HFCM	Handsfree Common
HS	Handset
I/O	Input/Output
IHF	Integrated hands free
IR	Infra red
IrDA	Infrared Association
LCD	Liquid Crystal Display
MCU	Micro Controller Unit
MIC, mic	Microphone
PDA	Pocket Data Application
PWB	Printed Wiring Board
RF	Radio Frequency
RFBUS	Control Bus For RF
SDRAM	Synchronous Dynamic Random Access Memory
SIM	Subscriber Identity Module
UI	User Interface
UEM	Universal Energy Management
VCXO	Voltage Controlled Crystal Oscillator
VGA	Video Graphics Array

CS7 System Module block diagram

The CS7 System module is the engine board of the NHL-8 phone. It includes the baseband and RF functions of the phone and Bluetooth and camera modules, fig. 1 below. External interfaces are drawn as arrows crossing CS7 border.

Figure 1: CS7 module block diagram



The Accessory interface is provided by Bluetooth and 115k bit IR. Only the Headset & Charger are galvanic interfaces.

Baseband Technical Summary

The heart of the BB is UPP_WD2, which includes the MCU, DSP and Digital Control Logic. Power is supplied by the UEMK ASIC and a number of discrete regulators. Memory comprises of 3 x 64Mbit Flash Memory Devices and 64 Mbit (8 Mbytes) SDRAM.

There are two audio transducers (Earpiece 8 mm and IHF Speaker 16 mm) and External Galvanic Headset (DCT4) interface. IHF Speaker is also used to handle the ring tone. The IHF Speaker is driven by a discrete audio amplifier. In NHL-8 there is only one microphone for both HS and IHF modes.

For Data connectivity there is 115k bit IR Module (IrDA compatible), Bluetooth and MMC card.

The Display is an MD2 type Colour Display with 4096 Colours and 176x208 pixels with backlighting. The UI module features a round keymat and a navigation key.

For imaging purposes BB supports a VGA camera via the CCP interface, which is integrated in to UPP_WD2.

Functional Description

BB Description

The BB Core is based on UPP_WD2 CPU, which is a PDA version of the DCT4 UPP ASIC. UPP_WD2 takes care of all the signal processing and operation controlling tasks of the phone as well as all PDA tasks.

For power management there is one main ASIC for controlling charging and supplying power UEM plus some discrete power supplies. The main reset for the system is generated by the UEM.

The interface to the RF and audio sections is also handled by the UEM. This ASIC provides A/D and D/A conversion of the in-phase and quadrature receive and transmit signal paths and also A/D and D/A conversions of received and transmitted audio signals. Data transmission between UEM and RF and the UPP_WD2 is implemented using different serial connections (CBUS, DBUS and RFBUS). Digital speech processing is handled by UPP_WD2 ASIC.

A real time clock function is integrated into UEM, which utilizes the same 32kHz-clock source as the sleep clock. A rechargeable battery provides backup power to run the RTC when the main battery is removed. Backup time is 20 Hours.

Memory Configuration

NHL-8 uses two kinds of memories, Flash and SDRAM. These Memories have their own dedicated bus interfaces to UPP_WD2.

Synchronous DRAM is used as working memory. Interface is 16 bit wide data and 14 bit Address. Memory clocking speed is 104 MHz. The SDRAM size 64Mbits (4Mx16).

SDRAM I/O is 1.8 V and core 2.78 V supplied by UEM regulator VIO and discrete regulator VMEMA respectively. All memory contents are lost if the supply voltage is switched off.

Multiplexed Flash Memory Interface is used to store the MCU program code and User Data. The memory interface is a burst type FLASH with multiplexed address/data bus, running at 104/3MHz.

Both Flash I/O and core voltage are 1.8 V supplied by UEM's VIO.

Energy Management

The master of EM control is UEM and with SW this has the main control of the system voltages and operating modes.

Modes of Operation

NHL-8 employs several hardware & SW controlled operation modes. Main Modes are described below.

- NO_SUPPLY mode means that the main battery is not present or its voltage is

too low (below UEM master reset threshold) and back-up battery voltage is too low.

- In BACK_UP mode the main battery is not present or its voltage is too low but back-up battery has sufficient charge in it.
- In PWR_OFF mode the main battery is present and its voltage is over UEM master reset threshold. All regulators are disabled.
- RESET mode is a synonym for start-up sequence and contains in fact several modes. In this mode regulators and oscillators are enabled and after they have stabilized system reset is released and PWR_ON mode entered.
- In PWR_ON mode SW is running and controlling the system.
- SLEEP mode is entered from PWR_ON mode when the system's activity is low (SLEEPX controlled by SW).
- FLASHING mode is for production SW download.

Voltage limits

In the following the voltage limits of the system are listed. These are also controlling system states.:

Parameter	Description	Value
V_{MSTR+}	Master reset threshold (rising)	2.1 V (typ.)
V_{MSTR-}	Master reset threshold (falling)	1.9 V (typ.)
V_{COFF+}	Hardware cutoff (rising)	3.1 V (typ.)
V_{COFF-}	Hardware cutoff (falling)	2.8 V (typ.)
V_BU_{COFF+}	Back-up battery cutoff (rising)	2.1 V (typ.)
V_BU_{COFF-}	Back-up battery cutoff (falling)	2.0 V (typ.)
SW_{COFF}	SW cutoff limit (> regulator drop-out limit) MIN!	3.4 V SW changeable

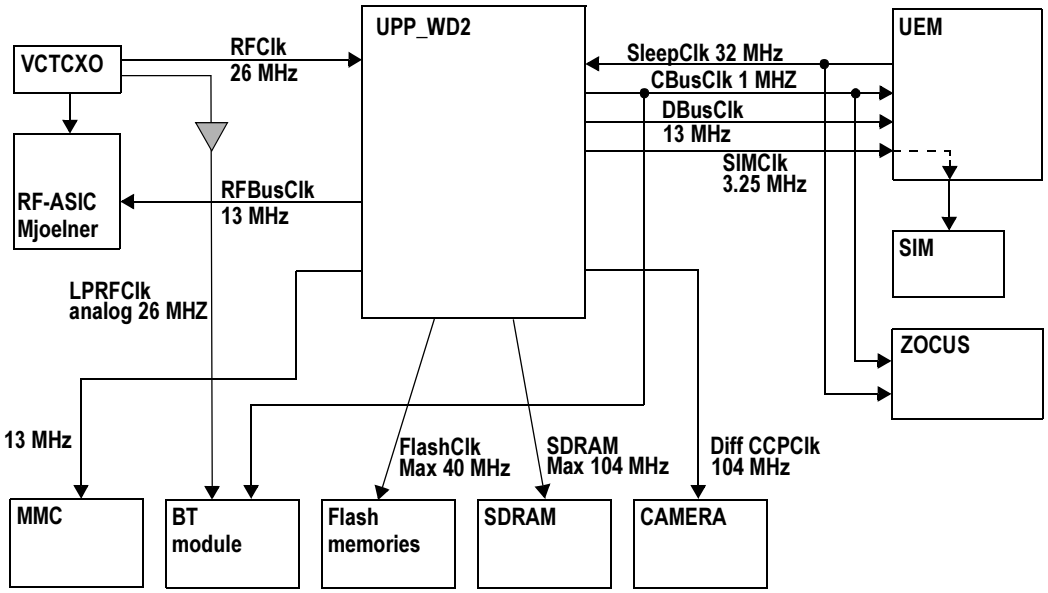
The master reset threshold controls the internal reset of UEM. If battery voltage is above V_{MSTR}, UEM's charging control logic is alive. Also, RTC is active and supplied from the main battery. Above V_{MSTR} UEM allows the system to be powered on although this may not succeed due to voltage drops during start-up. SW can also consider battery voltage too low for operation and power down the system.

Clocking Scheme

A 26 MHz VCXO is used as system clock generator in GSM. During the system start-up, UEM RC-oscillators generate timing for state machines. All clock signals of the engine are illustrated in following figure.

Bluetooth uses 26 MHz clock.

Figure 2: NHL-8 Clocking.



In SLEEP mode the VCXO is off. UEM generates low frequency clock signal (32.768 kHz) that is fed to UPP_WD2, Bluetooth and ZOCUS.

UPP_WD2 voltage/clock frequency adjusting

No external clock is available for UPP_WD2 before VCXO starts. As reset is released, the VCXO is running and MCU uses the 26 MHz clock while DSP is in reset. There are three identical DPLL's, for MCU, for DSP and for accessory interfaces, which can be controlled independently. The clock for MCU can be up to 104 MHz and 117 MHz is maximum clock Frequency for the DSP. These clock signals are used either directly (SDRAM IF) or divided down for the interfaces (e.g. flash IF).

Power Distribution, Control and Reset

All power (except backup battery power) is drawn from BL5-C Li-Ion battery located in the B cover. Current flows through ZOCUS current sense resister which is used for current measurement by ZOCUS and thus for remaining operating time estimation.

CS7 board contains one power ASIC, UEM and discrete regulators needed for generating the different operating voltages. The discrete regulators consist of an SMPS to power UPPWD2 voltage core and two linear regulators. The first linear regulator provides 2.8V to the SDRAM, LCD and IR module. This regulator and the SMPS regulator are powered at all times and feature low quiescent current consumption modes for sleep mode. The second linear regulator supplies 2.8V to the camera and hardware accelerator only. In addition there is a SMPS in CS7 generating the operating voltage for display module backlighting. In CS7 the keyboard backlight is powered with a charge pump

Power-up sequence (Reset mode)

RESET mode can be entered in four ways: by inserting the battery or charger, by RTC alarm or by pressing the power key. The VCXO is Powered by UEM. After a 220 ms delay regulators are configured and UEM enters PWR_ON mode and system reset PURX is released.

During system start-up, in RESET state, the regulators are enabled, and each regulator charges the capacitor(s) at the output with the maximum current (short circuit current) it can deliver. This results in battery voltage dropping during start-up. When a battery with voltage level just above the hardware cutoff limit is inserted, the system may not start due to excessive voltage dipping. Dropping below 2.8 V for longer than 5 us forces the system to PWR_OFF state.

Powering off

Controlled powering off is done when the user requests it by pressing the power-key or when the battery voltage falls too low. Uncontrolled powering off happens when the battery is suddenly removed or if over-temperature condition is detected in regulator block while in RESET mode. Then all UEM's regulators are disabled immediately and discrete regulators are disabled as Vbat supply disappears.

Controlled powering off

For NHL-8 powering off is initiated by pressing the power key and Power off sequence is activated in UEM and SW. Basically Power key cause UEM Interrupt to UPP_WD2 and SW sets Watchdog time value to zero and as this happens, PURX is forced low and all regulators are disabled.

If the battery voltage falls below the very last SW-cutoff level, SW will power off the system by letting the UEM's watchdog elapse.

If thermal shutdown limit in UEM regulator block is exceeded, the system is powered off. System reset PURX is forced low.

Uncontrolled powering off

This happens when the battery is suddenly removed. UEM's state machine notices battery removal after battery voltage has been below V_{COFF-} for 5 us and enters PWR_OFF mode. PURX is set low and all UEM's regulators are disabled.

Watchdogs

There are three watchdogs in UEM. The first one is for controlling system power-on and power-down sequences. The initial time for this watchdog after reset is 32 s and the watchdog can not be disabled. The time can be set using a register. This watchdog is used for powering the system off in a controlled manner. The other one is for security block and is used during IMEI code setting. The third one is a power key watchdog. It is used to power off the system in case SW is stuck and the user presses the power key. This WD is SW configurable.

There is also a "soft watchdog" in UPP_WD2. It is used to reset the chip in case software gets stuck for any reason. The Bluetooth module also contains a watchdog.

Charging

Charging control and charge switch is in UEM. There are two different charging modes; charging empty battery (start-up charge mode), and SW controlled charging.

UEM digital part takes care of charger detection (generates interrupt to UPP_WD2), pulse width modulated charging control (for internal charge switch) and over voltage and current detection. SW using registers controls all these.

Chargers

NHL-8 BB supports a standard charger (two wires), Chargers ACP-8 and ACP-12, Cigarette Charger LCH-8 and LCH-12 are supported.

Battery

NHL-8 Battery is a detachable, semi-fixed Lithium-Ion BL5-C battery. Nominal voltage is thus 3.7 V (max charging voltage 4.2 V).

The interface consists of three pins: VBAT, GND and BSI. Pull-down resistor inside of the batteries (BSI signal) recognizes the battery types. Voltage level at BSI line is measured using UEM's AD-converter.

Back-up battery and real time clock

Real time clock (RTC), crystal oscillator and back-up battery circuitry reside in UEM. A register in UEM controls back-up battery charging and charging is possible only in POWER_ON State.

Baseband Measurement A/D Converter

UEM contains 11 channels A/D converter, which is used for different Baseband measurement purposes. The resolution of A/D converter is 10 bits. Converter uses the CBUS interface clock signal for the conversion. An interrupt will be given to the MCU at the end of the measurements. The Converter is used for following purposes.

- Battery Voltage Measurement A/D Channel (Internal)
- Charger Voltage Measurement A/D Channel (Internal)
- Charger Current Measurement A/D Channel (Internal)
- Battery Temperature Measurement A/D Channel (External)
- Battery Size Measurement A/D Channel (External)
- LED Temperature measurement A/D Channel (External)

There is also auxiliary AD converter in UEM, which is used to monitor RF functions.

ZOCUS

The ZOCUS device is a current sensor used for the battery bar display and for determining whether the phone is in a high current consuming mode. The ZOCUS device measures the voltage drop across a sense resistor in the battery voltage line. This sense resistor is formed from a PWB track and is on an internal layer of the PWB. The sense resistor must be located close to the battery terminals so that all of the phones current flow through it. The nominal value of the sense resistor is 3.3 mohm. ZOCUS reports the current measurement to UPP_WD2 via the Cbus interface.

NHL-8 BB Features & HW interfaces

NHL-8 BB User interface

UI-Module Interface

The UI-Module consists of the LCD and keymat. The Colour Display resolution is 176 x 208 and backlighting is via 4 white LED's with lightguide. The display is connected to the CS7 module via an 18 pin plug and socket. The keymat is connected to CS7 by 20-pin Board-to-Board connector. Interface also includes power rails for keypad backlight. The keymat interface uses GPIO pins of UPP_WD2.

Bluetooth

Bluetooth provides a fully digital link for communication between a master unit and one or more slave units. The system provides a radio link that offers a high degree of flexibility to support various applications and product scenarios. Data and control interface for a low power RF module is provided. Data rate is regulated between the master and the slave.

IR

NHL-8 BB uses TDFU5102 1Mbit IrDA 1.1 compatible module. Module interface signals are Tx (Transmitted Data), Rx (Received Data) and SD (ShutDown). IR transmission data speed can be from 9.6 kbit/s to 115k bit/s. The communication over the IR is always started using bit rate 9.6 kbit/s.

Digital part is powered with 2.78 V by VMEMA (discrete regulator) and the LED by VBAT.

SIM Interface

The SIM interface is located in two chips (UPP_WD2 and UEM). In UEM there is only support for one SIM card. The interfaces support both 1.8 V and 3 V SIM cards. Adjustable SIM regulator (1.8V/3.0V) is located in UEM and can be controlled by SW.

The data communication between the card and the phone is asynchronous half duplex. The clock supplied to the card is 3.25 MHz. The data baudrate is SIM card clock frequency divided by 372 (by default), 64, 32 or 16.

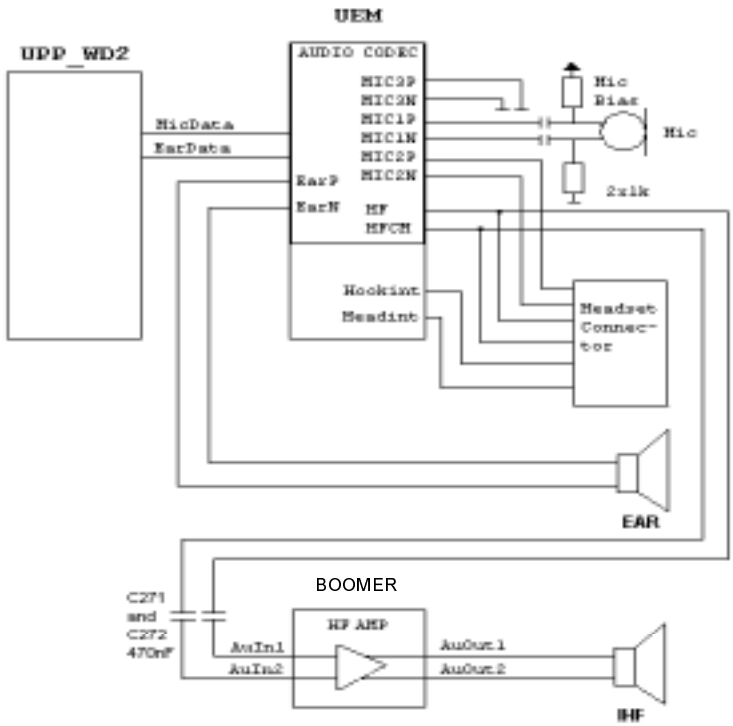
MMC Interface

The MMC interface consists of a block in UPP_WD2 plus a level shifting device known as "Lester" and an EMC protection ASIP. The MMC interface comprises 3 lines -clock, data and command and runs at 8.66 MHz. The Lester device also incorporates a 2.85V regulator to power the MMC card.

NHL-8 Audio Concept

NHL-8 Audio includes earpiece, microphone, and headset connector and Integrated Handsfree (IHF). Audio is based on ASIC's UPP_WD2, UEM and a discrete amplifier for the handsfree speaker known as "boomer".

Figure 3: NHL-8 Audio Blocks



Between UPP_WD2 and UEM the audio signals are transferred in digital format using signals MICDATA and EARDATA. The headset output of UEM is also fed to boomer i.e. the handsfree speaker and the headset share the same output lines from UEM. Ringing tones and warning/info tones are to be produced with the IHF speaker also.

Earpiece

The earpiece to be used in NHL-8 is an 8-mm Pico earpiece produced by Philips Speaker Systems. It has 32Ω continuous impedance and continuous power 8 mWatts. It's driven by differential signals from UEM (EARP & EARN). It makes contact with the PWB via spring contacts.

Microphone

The microphone capsule for NHL-8 is a WM_EZZ CY327 capsule. Its sensitivity is -42db Nominal. Contacts are done by springs.

Two inputs are used from UEM, one for normal internal microphone and a second for headset. The third microphone input is not used, so it is connected to ground via capacitors. Microphone bias block in UEM generates bias voltages for handportable and hands-Free/headset microphones. For both microphone bias outputs (MICB1 & MICB2) the minimum output voltage is 2.0 Volts and maximum output current is 600 µA. Microphone bias block also includes a low pass filter for the reference voltage used as an input for the MICB1&2 amplifiers.

IHF Amplifier and Speaker

The speaker to be used in NHL-8 is a 16mm 8Ω speaker. It can handle 0.2 Watts nominal Power and Peak power 0.3 Watts. The component is housed in the antenna housing and connects to the PWB via spring contacts.

HF and HFCM lines of UEM are use to drive Boomer IHF amplifier.

Power amplifier is a differential opamp. The differential output drives the HandsFree speaker. HandsFree amplifier load impedance is 8 ohm.

The outputs go into a high impedance state when powered down. The amplifier can be enabled and shut down using a GENIO line from UPP_WD2.

SW controls IHF and earpiece volume via UEM. Gain setting can be done in 2 dB steps, from –40 to +6 dB. Output sound pressure level of the internal HandsFree speaker is controlled by SW (CBus is used for controlling).

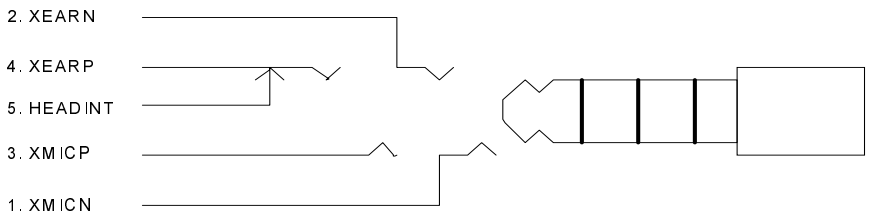
The schematic around the Boomer IHF amplifier is presented in NHL-8 schematics. The schematic shows all the filtering needed and also protection components against ESD and EMC.EMC and ESD Filtering component must be as near as possible to earphone pads of the phone.

The supply voltage for the IHF amplifier is taken directly from the battery voltage.

External Audio interface

In NHL-8 there is Headset Connector which is fully differential 4–wire connection.

Figure 4: External Audio Connector



The Handsfree (HF) driver in UEM is meant for headset. In NHL-8 case the output is driven in fully differential mode. In the fully differential mode HF pin is the negative output and HFCM pin is the positive output. The gain of the Handsfree driver in the differential mode is 6 dB. The earpiece (EARP, EARN) and headset (HF, HFCM) signals are multiplexed so that the outputs can not be used simultaneously. The HF and HFCM

amplifiers include a transient suppression circuitry, which prevents unwanted spikes in HF and HFCM outputs when switching on and off the amplifiers.

The plug will open a mechanical switch inside the connector between HF and HeadInt lines. The HeadInt line will be pulled up to 2.7V by internal resistor when the switch is open. When not having the plug inserted the voltage in the HeadInt line will be <0.8 V caused by internal pull down resistor in the HF line.

Camera Interface

The NHL-8 camera solution comprises both a camera and the Hardware Accelerator. The NHL-8 camera is a still camera with viewfinder option. Camera resolution is VGA. The Camera module is connected by means of a soldered on connector to the PWB. The Hardware Accelerator provides post-processing of the image to remove noise and defects and to perform the conversion to Jpeg.

Both the camera and hardware accelerator interface is serial CCP, which is a unidirectional interface; the control information to camera is transmitted through I2C bus. The I2C is implemented purely by SW using general purpose I/Os.

CCP interface consists of differential clock data signal. CCP enables the use of high data rates with low EMI; maximum transfer capacity is 104 Mbit/s, which means that transferring VGA (640 x 480) images at 15 fps is possible.

There is one discrete 2.78V regulator for logic and sensor and 1.8V is provided by UEM's Vcore for I/O. These power supplies power both the camera and hardware accelerator

Flashing

SW download in service is implemented by custom tools and SW, kindly refer to Service Software Instructions and Service Tool section of the manual.

Testing interfaces

Testing interface Electrical Specifications

Pin	Name	Dir	Parameter	Min	Typ	Max	Unit	Notes
1	MBUS	<->	Vol	0	0.2	0.3*VFlash1	V	
			Vil (From Prommer)	0	0.2	0.3*VFlash1	V	
			Voh	0.7*VFlash1	2.7	0.7*VFlash1	V	
			Vih(From Prommer)	0.7*VFlash1	2.7	VFlash1	V	
2	FBusTx	->	Vol	0	2.7	0.3*VFlash1	V	
			Voh	0.7*VFlash1	2.7	VFlash1	V	
3	FBusRx	<-	Vil (From Prommer)	0	2.7	0.3*VFlash1	V	
			Vih(FromPrommer)	1.89	2.7	VFlash1	V	
			Abs. Max. Voltage to Test Pad Referenced to GND	-0.3V		3.0	V	Absolute Max Voltage limits to MBUS/FBUS
4	VPP		To Phone	0 / 2.8 / 12 +/-3%	V	Prommer Select	4	VPP

Pin	Name	Dir	Parameter	Min	Typ	Max	Unit	Notes
4	VPP		To Phone	0 / 2.8 / 12 +/-3%	V	Prommer Select	4	VPP
5	GND				0		V	VBAT GROUND

Note1: VFlash1 is 2.78 +/- 3%

Electrical Specifications for Power Supply Interface in Prod Testing

Pin	Name	Min	Typ	Max	Unit	Notes
1	VBAT	0	3.6	5.1	V	
2	BSI	0	2.78	VFlash1	V	Internal pullup
3	GND	0			V	

Note 1: VAna & VFlash1 = 2.78 +/-3%

Extreme Voltages

Lithium-Ion battery BL5-C (1 cell):

Nominal voltage is 3.7V

Lower extreme voltage is 2.8V (cut off voltage)

Higher extreme voltage is 4.2V (charging high limit voltage)

Temperature Conditions

Specifications are met within range of –10C to +55C ambient temperature. Reduced operation between [-30] and [+60]. Storage temperature range is of –40C to +85C.

Humidity and Water Resistance

Relative humidity range is 5 ... 95%. Condensed or dripping water may cause intermittent malfunctions. Protection against dripping water have to be implemented in (enclosure) mechanics. Continuous dampness will cause permanent damage to the module.