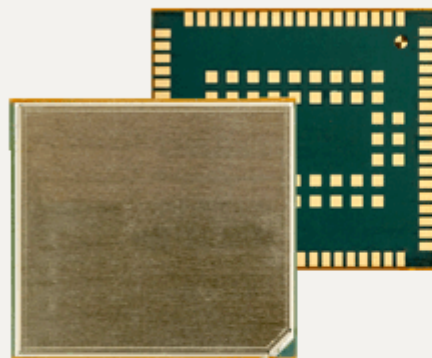**gemalto**
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Cinterion® EHS6

Hardware Interface Description

Version: 02.000
DocId: EHS6_HID_v02.000

Document Name:	**Cinterion® EHS6 Hardware Interface Description**
Version:	**02.000**
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1 Introduction

This document[1] describes the hardware of the Cinterion® EHS6 module. It helps you quickly retrieve interface specifications, electrical and mechanical details and information on the requirements to be considered for integrating further components.

1.1 Key Features at a Glance

Feature	Implementation
General	
Frequency bands	GSM/GPRS/EDGE: Quad band 850/900/1800/1900MHz UMTS/HSPA+: Five band 800/850/900/1900/2100MHz
GSM class	Small MS
Output power	Class 4 (+33dBm ±2dB) for EGSM850 Class 4 (+33dBm ±2dB) for EGSM900 Class 1 (+30dBm ±2dB) for GSM1800 Class 1 (+30dBm ±2dB) for GSM1900 Class E2 (+27dBm ± 3dB) for GSM 850 8-PSK Class E2 (+27dBm ± 3dB) for GSM 900 8-PSK Class E2 (+26dBm +3 /-4dB) for GSM 1800 8-PSK Class E2 (+26dBm +3 /-4dB) for GSM 1900 8-PSK Class 3 (+24dBm +1/-3dB) for UMTS 2100, WCDMA FDD BdI Class 3 (+24dBm +1/-3dB) for UMTS 1900,WCDMA FDD BdII Class 3 (+24dBm +1/-3dB) for UMTS 900, WCDMA FDD BdVIII Class 3 (+24dBm +1/-3dB) for UMTS 850, WCDMA FDD BdV Class 3 (+24dBm +1/-3dB) for UMTS 800, WCDMA FDD BdVI
Power supply	3.3V to 4.5V
Operating temperature (board temperature)	Normal operation: -30°C to +85°C Extended operation: -40°C to +90°C
Physical	Dimensions: 27.6mm x 25.4mm x 2.2mm Weight: approx. 3.5g
RoHS	All hardware components fully compliant with EU RoHS Directive
HSPA features	
3GPP Release 6, 7	DL 7.2Mbps, UL 5.7Mbps HSDPA Cat.8 / HSUPA Cat.6 data rates Compressed mode (CM) supported according to 3GPP TS25.212
UMTS features	
3GPP Release 4	PS data rate – 384 kbps DL / 384 kbps UL CS data rate – 64 kbps DL / 64 kbps UL

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1. The document is effective only if listed in the appropriate Release Notes as part of the technical documentation delivered with your Gemalto M2M product.

Feature	Implementation
GSM/GPRS/EGPRS features	
Data transfer	GPRS: • Multislot Class 12 • Full PBCCH support • Mobile Station Class B • Coding Scheme 1 – 4 EGPRS: • Multislot Class 12 • EDGE E2 power class for 8 PSK • Downlink coding schemes – CS 1-4, MCS 1-9 • Uplink coding schemes – CS 1-4, MCS 1-9 • SRB loopback and test mode B • 8-bit, 11-bit RACH • PBCCH support • 1 phase/2 phase access procedures • Link adaptation and IR • NACC, extended UL TBF • Mobile Station Class B CSD: • V.110, RLP, non-transparent • 9.6kbps • USSD
SMS	Point-to-point MT and MO Cell broadcast Text and PDU mode Storage: SIM card plus SMS locations in mobile equipment
Software	
AT commands	Hayes 3GPP TS 27.007, TS 27.005, Gemalto M2M AT commands for RIL compatibility
Java™ Open Platform	Java™ Open Platform with • Java™ profile IMP-NG & CLDC 1.1 HI • Secure data transmission via HTTPS/SSL • Multi-threading programming and multi-application execution Major benefits: seamless integration into Java applications, ease of programming, no need for application microcontroller, extremely cost-efficient hardware and software design – ideal platform for industrial GSM applications. The memory space available for Java programs is around 8 MB in the flash file system and around 6MB RAM. Application code and data share the space in the flash file system and in RAM.
Microsoft™ compatibility	RIL for Pocket PC and Smartphone
SIM Application Toolkit	SAT Release 99
Firmware update	Generic update from host application over ASC0 or USB modem.

Feature	Implementation
Interfaces	
Module interface	Surface mount device with solderable connection pads (SMT application interface). Land grid array (LGA) technology ensures high solder joint reliability and provides the possibility to use an optional module mounting socket. For more information on how to integrate SMT modules see also [3]. This application note comprises chapters on module mounting and application layout issues as well as on additional SMT application development equipment.
USB	USB 2.0 High Speed (480Mbit/s) device interface, Full Speed (12Mbit/s) compliant
2 serial interfaces	ASC0 (shared with GPIO lines): • 8-wire modem interface with status and control lines, unbalanced, asynchronous • Adjustable baud rates: 1,200bps to 921,600bps • Autobauding: 1,200bps to 230,400bps • Supports RTS0/CTS0 hardware flow control. • Multiplex ability according to GSM 07.10 Multiplexer Protocol. ASC1 (shared with GPIO lines): • 4-wire, unbalanced asynchronous interface • Adjustable baud rates: 1,200bps to 921,60bps • Autobauding: 1,200bps to 230,400bps • Supports RTS1/CTS1 hardware flow control
Audio	1 digital interface (PCM), shared with GPIO lines
UICC interface	Supported SIM/USIM cards: 3V, 1.8V
GPIO interface	14 GPIO lines shared with ASC0 lines, LED signalling, PWM functionality, fast shutdown and pulse counter 4 GPIO lines shared with PCM interface 4 GPIO lines shared with ASC1, SPI and HSIC interfaces
I^2C interface	Supports I^2C serial interface
HSIC interface	High-Speed Inter-Chip (HSIC) interface for USB chip-to-chip interconnect including Link Power Management (LPM) lines shared with GPIO lines
SPI interface	Serial peripheral interface, shared with GPIO lines
Antenna interface pads	50Ω
Power on/off, Reset	
Power on/off	Switch-on by hardware signal AUTO_ON and ON Switch-off by AT command Switch off by hardware signal FST_SHDN instead of AT command Automatic switch-off in case of critical temperature and voltage conditions
Reset	Orderly shutdown and reset by AT command Emergency reset by hardware signal EMERG_RST
Special features	
Real time clock	Timer functions via AT commands
Phonebook	SIM and phone
TTY/CTM support	Integrated CTM modem

Feature	Implementation
Evaluation kit	
Evaluation module	EHS6 module soldered onto a dedicated PCB that can be connected to an adapter in order to be mounted onto the DSB75.
DSB75	DSB75 Development Support Board designed to test and type approve Gemalto M2M modules and provide a sample configuration for application engineering. A special adapter is required to connect the EHS6 evaluation module to the DSB75.

1.2 EHS6 System Overview
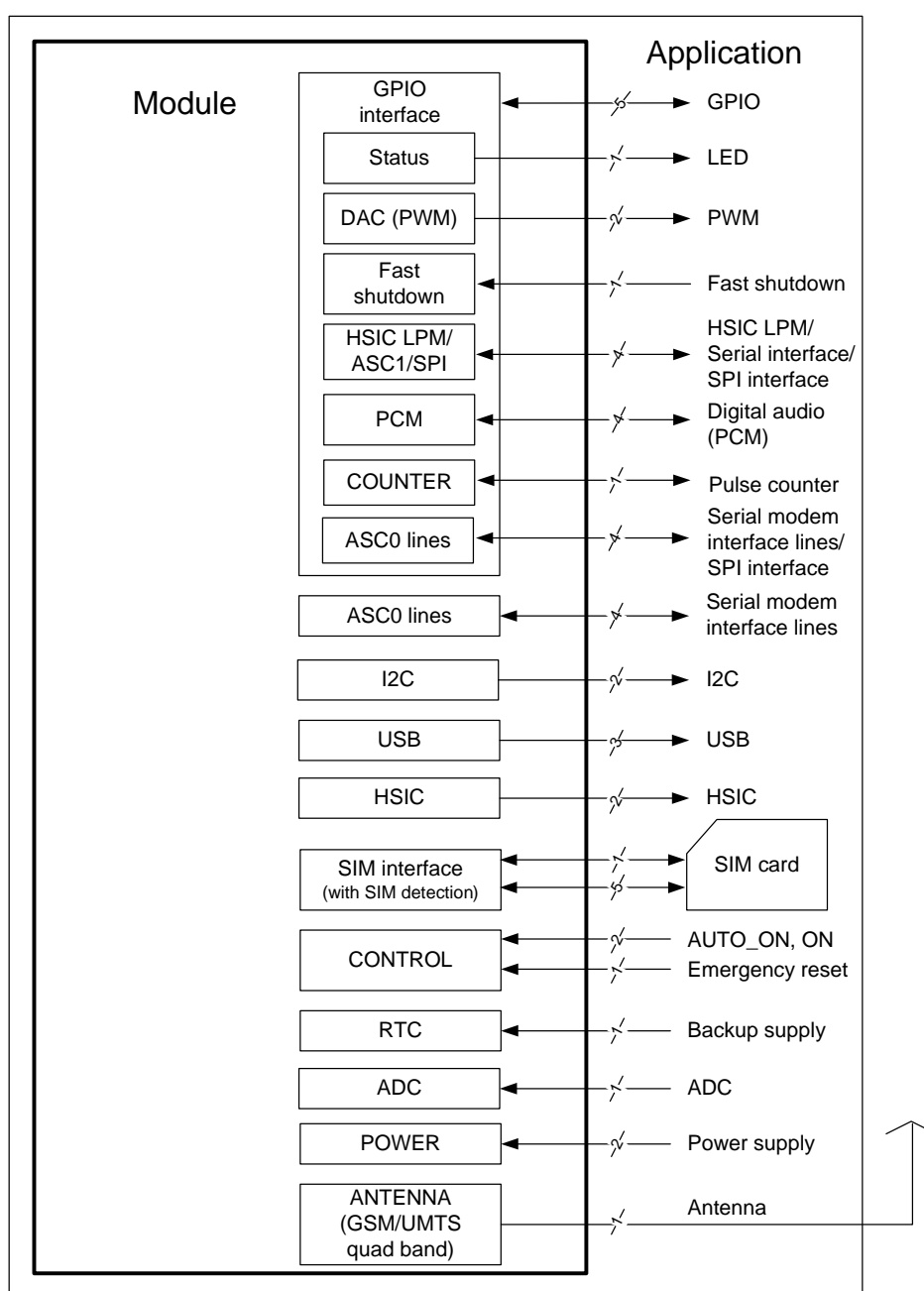
Figure 1: EHS6 system overview

1.3 Circuit Concept

Figure 2 shows a block diagram of the EHS6 module and illustrates the major functional components:
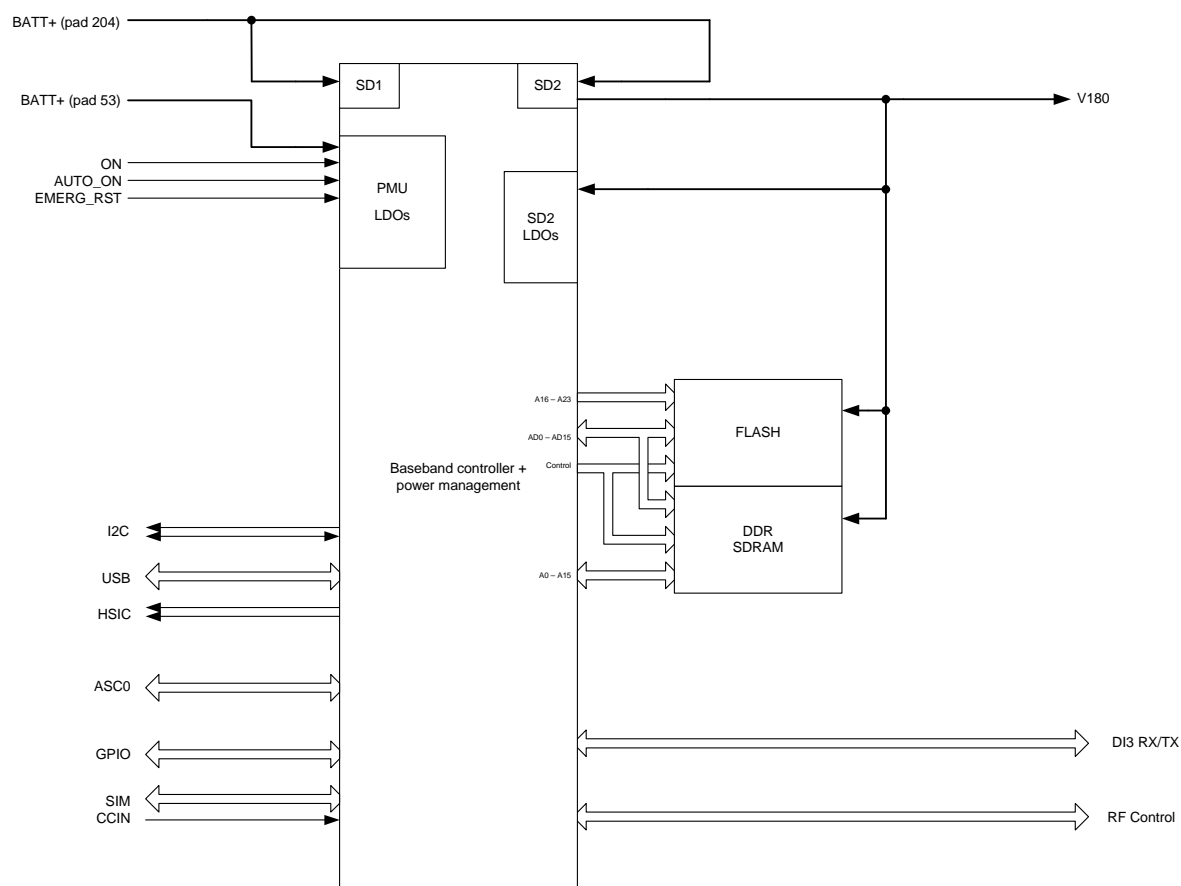
Figure 2: EHS6 baseband block diagram

1.3 Circuit Concept
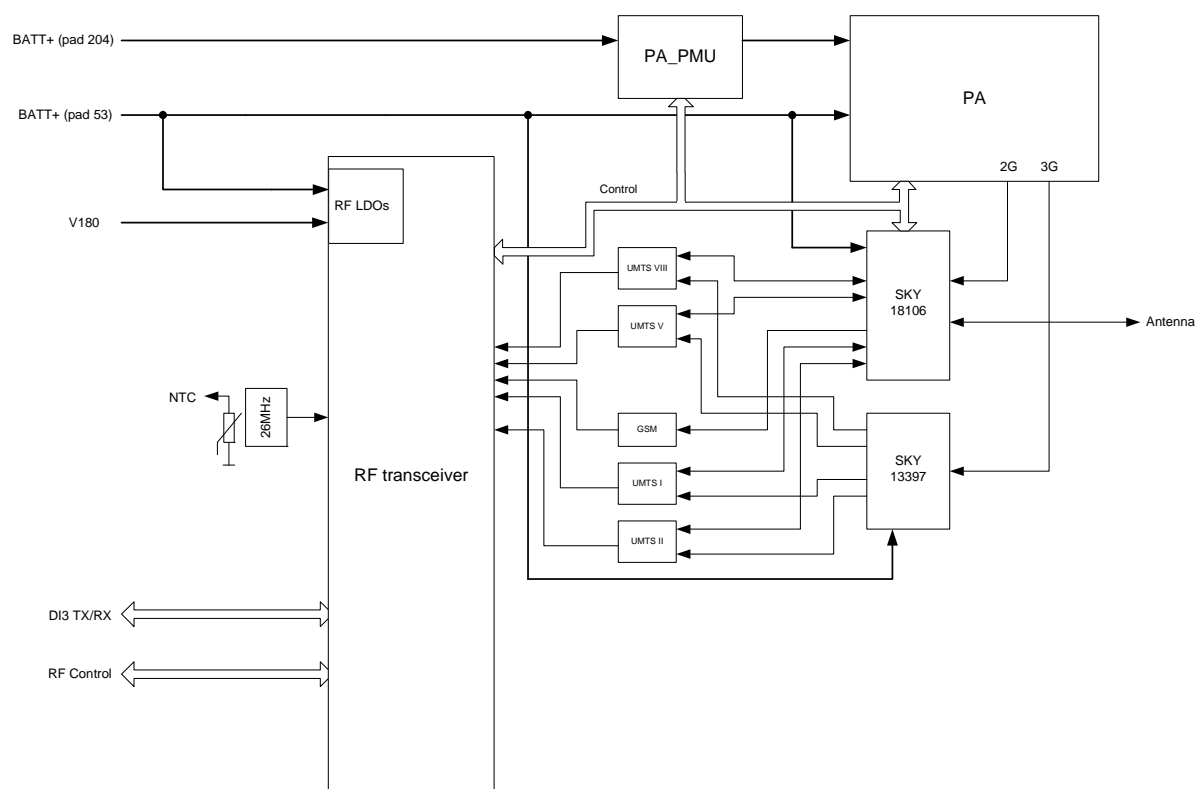
Figure 3: EHS6 GSM/UMTS RF section block diagram

2 Interface Characteristics

EHS6 is equipped with an SMT application interface that connects to the external application. The SMT application interface incorporates the various application interfaces as well as the RF antenna interface.

2.1 Application Interface

2.1.1 Pad Assignment

The SMT application interface on the EHS6 provides connecting pads to integrate the module into external applications. Figure 4 shows the connecting pads' numbering plan, the following Table 1 lists the pads' assignments.
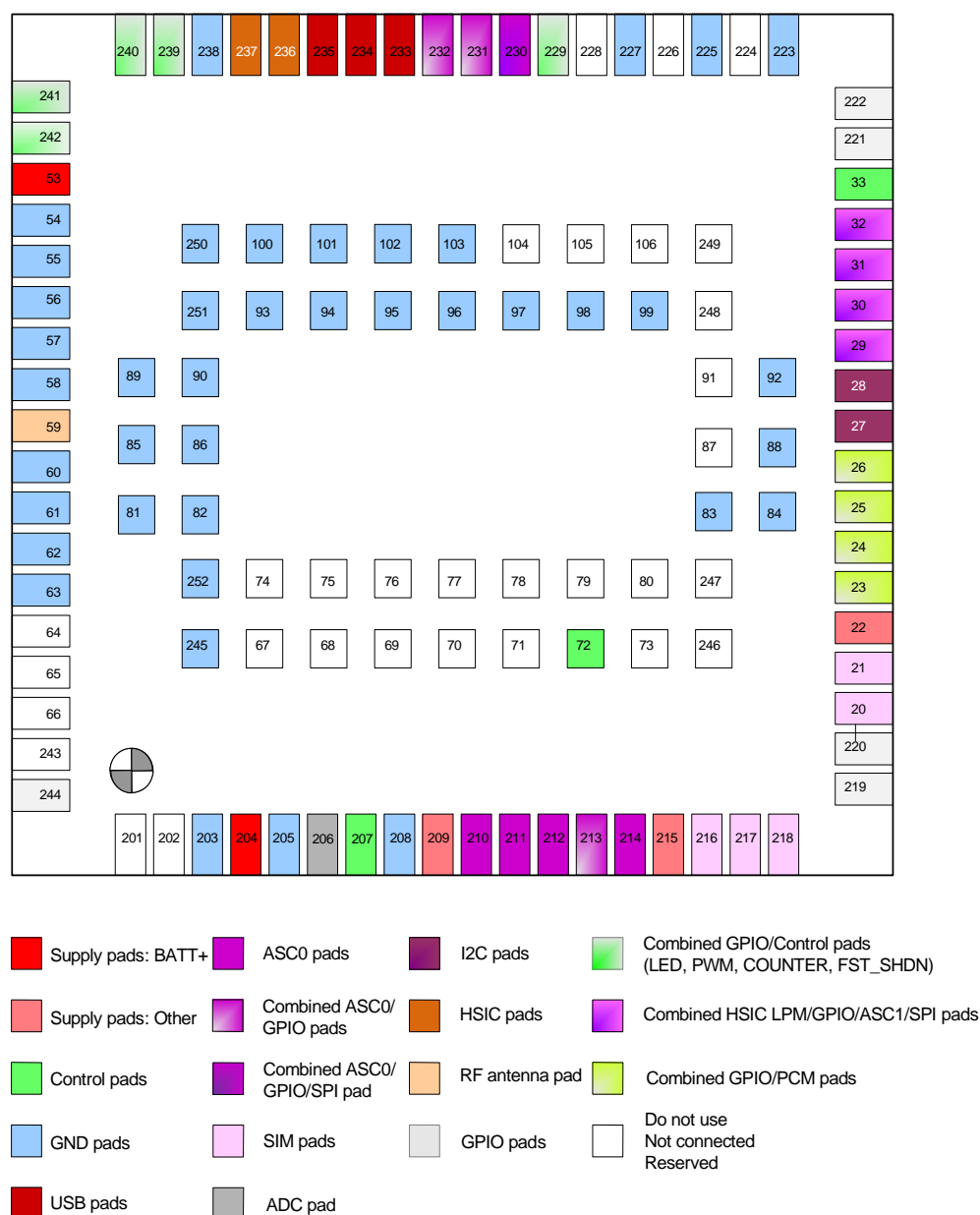
Figure 4: Numbering plan for connecting pads (bottom view)

Table 1: Pad assignments

Pad no.	Signal name	Pad no.	Signal name	Pad no.	Signal name
201	Reserved	24	GPIO22/TFSDAI	235	USB_DN
202	Reserved	25	GPIO21/RXDDAI	236	HSIC_DATA
203	GND	26	GPIO23/SCLK	237	HSIC_STRB
204	BATT+	27	I2CDAT	238	GND
205	GND	28	I2CCLK	239	GPIO5/LED
206	ADC1	29	HOST_ACTIVE/ GPIO17/TXD1/MISO	240	GPIO6/PWM2
207	ON	30	AP_WAKEUP/ GPIO16/RXD1/MOSI	241	GPIO7/PWM1
208	GND	31	CP_WAKEUP/ GPIO18/RTS1	242	GPIO8/COUNTER
209	V180	32	SUSPEND/ GPIO19/CTS1/SPI_CS	53	BATT+
210	RXD0	33	EMERG_RST	54	GND
211	CTS0	221	GPIO12	55	GND
212	TXD0	222	GPIO11	56	GND
213	RING0/GPIO24	223	GND	57	GND
214	RTS0	224	Reserved	58	GND
215	VDDLP	225	GND	59	RF_OUT
216	CCRST	226	Reserved	60	GND
217	CCIN	227	GND	61	GND
218	CCIO	228	Reserved	62	GND
219	GPIO14	229	GPIO4/FST_SHDN	63	GND
220	GPIO13	230	DSR0/GPIO3/SPI_CLK	64	Reserved
20	CCVCC	231	DCD0/GPIO2	65	Reserved
21	CCCLK	232	DTR0/GPIO1	66	Reserved
22	VCORE	233	VUSB	243	Reserved
23	GPIO20/TXDDAI	234	USB_DP	244	GPIO15
Centrally located pads					
67	Do not use	83	GND	99	GND
68	Do not use	84	GND	100	GND
69	Do not use	85	GND	101	GND
70	Do not use	86	GND	102	GND
71	Do not use	87	Do not use	103	GND
72	AUTO_ON	88	GND	104	Do not use
73	Do not use	89	GND	105	Do not use
74	Not connected	90	GND	106	Reserved
75	Not connected	91	Not connected	245	GND
76	Not connected	92	GND	246	Reserved
77	Not connected	93	GND	247	Reserved
78	Not connected	94	GND	248	Reserved
79	Not connected	95	GND	249	Reserved
80	Not connected	96	GND	250	GND
81	GND	97	GND	251	GND
82	GND	98	GND	252	GND

Signal pads that are not used should not be connected to an external application.

Please note that the reference voltages listed in Table 2 are the values measured directly on the EHS6 module. They do not apply to the accessories connected.

2.1.2   Signal Properties

Table 2: Signal properties
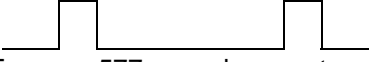
Function	Signal name	IO	Signal form and level	Comment
Power supply	BATT+ GSM activated	I	$V_I$max = 4.5V $V_I$norm = 3.8V $V_I$min = 3.3V during Tx burst on board I ≈ 2.3A, during Tx burst (GSM) n Tx = n x 577µs peak current every 4.616ms	Lines of BATT+ and GND must be connected in parallel for supply purposes because higher peak currents may occur. Minimum voltage must not fall below 3.3V including drop, ripple, spikes.
	BATT+ WCDMA activated	I	$V_I$max = 4.5V $V_I$norm = 3.8V $V_I$min = 3.3V during Transmit active. Imax=700mA during Tx	BATT+ assigned to pad 204 requires an additional ultra low ESR 150µF capacitor. If using Multilayer Ceramic Chip Capacitors (MLCC) please take DC-bias into account.
Power supply	GND		Ground	Application Ground
External supply voltage	V180	O	Normal operation: $V_O$norm = 1.80V ±3% $I_O$max = -10mA SLEEP mode Operation: V_OSleep = 1.80V ±5% $I_O$max = -10mA CLmax = 100nF	V180 may be used to supply level shifters at the interfaces or to supply external application circuits. VCORE and V180 should be used for the power indication circuit.
	VCORE	O	$V_O$norm = 1.2V $I_O$max = -10mA CLmax = 100nF	If unused keep lines open.
Ignition	ON	I	V_{IH}max = VDDLP + 0.3V V_{IH}min = 1.2V V_{IL}max = 0.5V Min low time before rising edge <=100µs ON __|‾‾‾|__ high pulse 50µs...80µs	This signal switches the module on. Set this signal low before and after the startup impulse.
	AUTO_ON	I	V_{OH}max = VDDLP max V_{IH}min = 1.2V V_{IL}max = 0.5V Low level time >= 50µs AUTO_ON ‾‾‾‾‾‾|___ low level signal	This signal switches the module on. For more information and requirements see also Section 3.2.1. This line is low level sensitive triggered. If unused keep line open.

Table 2: Signal properties

Function	Signal name	IO	Signal form and level	Comment
Emer-gency restart	EMERG_RST	I	$R_I \approx 1k\Omega$, $C_I \approx 1nF$ $V_{OH}max = VDDLP\ max$ $V_{IH}min = 1.35V$ $V_{IL}max = 0.3V$ at ~200µA ~~|___|~~ low impulse width > 10ms	This line must be driven low by an open drain or open collector driver connected to GND. If unused keep line open.
Fast shutdown	GPIO4	I	$V_{IL}max = 0.35V$ $V_{IH}min = 1.30V$ $V_{IH}max = 1.85V$ ~~|___|~~ low impulse width > 10ms	This line must be driven low. If unused keep line open. Note that if configured as fast shutdown line the listed GPIO line is identical to the following signal: GPIO4 --> FST_SHDN
RTC backup	VDDLP	I/O	$V_{O}norm = 1.8V$ $I_{O}max = -25mA$ $V_{I}max = 1.9V$ $V_{I}min = 1.0V$ $I_{I}typ < 1µA$	It is recommended to use a serial resistor between VDDLP and a possible capacitor. If unused keep line open.
USB	VUSB_IN	I	$V_{I}min = 3V$ $V_{I}max = 5.25V$ Active and suspend current: $I_{max} < 100µA$	All electrical characteristics according to USB Implementers' Forum, USB 2.0 Specification. If unused keep lines open.
	USB_DN	I/O	Full and high speed signal characteristics according USB 2.0 Specification.	
	USB_DP			

Table 2: Signal properties

Function	Signal name	IO	Signal form and level	Comment
High Speed Inter Chip	HSIC_STRB	I/O	$F_o = 240MHz$ CL min = 3pF, CL max = 14pF Z_o min = 40Ω, Z_o max = 60Ω Z_I min = 100kΩ Data falling edge hold time min=300ps Data rising edge hold time min=300ps Data rising edge setup time min=300ps STRB frequency = 4.166ns ±500ppm V_{OL}max = 0.30V at I = 2mA V_{OH}min = 0.88V at I = -2mA V_{OH}max = 1.23V V_{IL}max = 0.40V V_{IH}min = 0.80V V_{IH}max = 1.45	If unused keep lines open. Note that the HSIC LPM signals are shared with GPIO lines as follows: AP_WAKEUP --> GPIO16 HOST_ACTIVE --> GPIO17 CP_WAKEUP --> GPIO18 SUSPEND --> GPIO19
	HSIC_DATA	I/O		
High Speed Inter Chip Link Power Management (LPM)	AP_WAKEUP	I/O	V_{OL}max = 0.25V at I = 1mA V_{OH}min = 1.55V at I = -1mA V_{OH}max = 1.85V V_{IL}max = 0.35V V_{IH}min = 1.30V V_{IH}max = 1.85V	
	HOST_ACTIVE	I/O		
	CP_WAKEUP	I/O		
	SUSPEND	I/O		
Serial Interface ASC0	RXD0	O	V_{OL}max = 0.25V at I = 1mA V_{OH}min = 1.55V at I = -1mA V_{OH}max = 1.85V	If unused keep lines open. Note that some ASC0 lines are shared with the following GPIO lines: DTR0 --> GPIO1 DCD0 --> GPIO2 DSR0 --> GPIO3 RING0 --> GPIO24 The DSR0 line is also shared with the SPI interface's SPI_CLK signal. DSR0, DCD0 and RING0 signal lines are driven by a pull up or pull down resistor only.
	CTS0	O		
	DSR0	O	Pull down resistor active V_{OL}max = 0.5V at I > 50µA Pull up resistor active V_{OH}min = 1.3V at I > -50µA	
	DCD0	O		
	RING0	O		
	TXD0	I	V_{IL}max = 0.35V V_{IH}min = 1.30V V_{IH}max = 1.85V	
	RTS0	I	Pull down resistor active V_{IL}max = 0.35V at > 50µA V_{IH}min = 1.30V at < 240µA V_{IH}max = 1.85V at < 240µA	
	DTR0	I	Pull up resistor active V_{IL}max = 0.35V at < -200µA V_{IH}min = 1.30V at > -50µA V_{IH}max = 1.85V	

Table 2: Signal properties

Function	Signal name	IO	Signal form and level	Comment
Serial Interface ASC1	GPIO16	O	V_{OL}max = 0.25V at I = 1mA V_{OH}min = 1.55V at I = -1mA V_{OH}max = 1.85V V_{IL}max = 0.35V V_{IH}min = 1.30V V_{IH}max = 1.85V	If unused keep line open. Note that if configured as ASC1 interface the listed GPIO lines are identical to below ASC1 signals: GPIO16 --> RXD1 GPIO17 --> TXD1 GPIO18 --> RTS1 GPIO19 --> CTS1
	GPIO17	I		
	GPIO18	I		
	GPIO19	O		
SIM card detection	CCIN	I	$R_I \approx 110k\Omega$ V_{IH}min = 1.45V at I = 15µA, V_{IH}max= 1.9V V_{IL}max = 0.3V	CCIN = High, SIM card inserted. For details please refer to Section 2.1.6. If unused keep line open.
3V SIM Card Interface	CCRST	O	V_{OL}max = 0.30V at I = 1mA V_{OH}min = 2.45V at I = -1mA V_{OH}max = 2.90V	Maximum cable length or copper track to SIM card holder should not exceed 100mm.
	CCIO	I/O	V_{IL}max = 0.50V V_{IH}min = 2.05V V_{IH}max = 2.90V V_{OL}max = 0.25V at I = 1mA V_{OH}min = 2.50V at I = -1mA V_{OH}max = 2.90V	
	CCCLK	O	V_{OL}max = 0.25V at I = 1mA V_{OH}min = 2.40V at I = -1mA V_{OH}max = 2.90V	
	CCVCC	O	$V_O$min = 2.80V $V_O$typ = 2.85V $V_O$max = 2.90V $I_O$max = -30mA	

Table 2: Signal properties

Function	Signal name	IO	Signal form and level	Comment
1.8V SIM Card Interface	CCRST	O	V_{OL}max = 0.25V at I = 1mA V_{OH}min = 1.45V at I = -1mA V_{OH}max = 1.90V	Maximum cable length or copper track to SIM card holder should not exceed 100mm.
	CCIO	I/O	V_{IL}max = 0.35V V_{IH}min = 1.25V V_{IH}max = 1.85V V_{OL}max = 0.25V at I = 1mA V_{OH}min = 1.50V at I = -1mA V_{OH}max = 1.85V	
	CCCLK	O	V_{OL}max = 0.25V at I = 1mA V_{OH}min = 1.50V at I = -1mA V_{OH}max = 1.85V	
	CCVCC	O	V_{O}min = 1.75V V_{O}typ = 1.80V V_{O}max = 1.85V I_{O}max = -30mA	
I²C	I2CCLK	IO	Open drain IO V_{OL}min = 0.35V at I = -3mA V_{OH}max = 1.85V R external pull up min = 560Ohm V_{IL}max = 0.35V V_{IH}min = 1.3V V_{IH}max = 1.85V	According to the I²C Bus Specification Version 2.1 for the fast mode a rise time of max. 300ns is permitted. There is also a maximum V_{OL}=0.4V at 3mA specified. The value of the pull-up depends on the capacitive load of the whole system (I²C Slave + lines). The maximum sink current of I2CDAT and I2CCLK is 4mA. If lines are unused keep lines open.
	I2CDAT	IO		
SPI	GPIO3	O	V_{OL}max = 0.25V at I = 1mA V_{OH}min = 1.55V at I = -1mA V_{OH}max = 1.85V V_{IL}max = 0.335V V_{IH}min = 1.30V V_{IH}max = 1.85V	If lines are unused keep lines open. Note that if configured as SPI interface the listed GPIO lines are identical to following SPI signals: GPIO3 --> SPI_CLK GPIO16 --> MOSI GPIO17 --> MISO GPIO19 --> SPI_CS
	GPIO16	O		
	GPIO17	I		
	GPIO19	O		

Table 2: Signal properties

Function	Signal name	IO	Signal form and level	Comment
GPIO interface	GPIO1-GPIO3	IO	V_{OL}max = 0.25V at I = 1mA V_{OH}min = 1.55V at I = -1mA V_{OH}max = 1.85V V_{IL}max = 0.335V V_{IH}min = 1.30V V_{IH}max = 1.85V	If unused keep line open. Please note that some GPIO lines are or can be configured for functions other than GPIO: GPIO1-GPIO3: ASC0 control lines DTR0, DCD0 and DSR0 GPIO4: Fast shutdown GPIO5: Status LED line GPIO6/GPIO7: PWM GPIO8: Pulse Counter GPIO16-GPIO19: HSIC LPM or ASC1 or SPI GPIO20-GPIO23: PCM GPIO24: ASC0 control line RING0
	GPIO4	IO		
	GPIO5	IO		
	GPIO6	IO		
	GPIO7	IO		
	GPIO8	IO		
	GPIO11-GPIO15	IO		
	GPIO16-GPIO19	IO		
	GPIO20-GPIO23	IO		
	GPIO24	IO		
Digital audio interface (PCM)	GPIO22	O	V_{OL}max = 0.25V at I = 1mA V_{OH}min = 1.55V at I = -1mA V_{OH}max = 1.85V	If unused keep line open. Note that if configured as PCM interface the listed GPIO lines are identical to following PCM signals: GPIO22 --> TFSDAI GPIO23 --> SCLK GPIO20 --> TXDDAI GPIO21 --> RXDDAI
	GPIO23	O		
	GPIO20	O		
	GPIO21	I	V_{IL}max = 0.35V V_{IH}min = 1.30V V_{IH}max = 1.85V	
Status LED	GPIO5	O	V_{OL}max = 0.25V at I = 1mA V_{OH}min = 1.55V at I = -1mA V_{OH}max = 1.85V	If unused keep line open.
PWM	GPIO6	O	V_{OL}max = 0.25V at I = 1mA V_{OH}min = 1.55V at I = -1mA V_{OH}max = 1.85V	If unused keep lines open.
	GPIO7	O		
Pulse counter	GPIO8	I	Internal up resistor acive V_{IL}max = 0.35V at < -200µA V_{IH}min = 1.30V at > -50µA V_{IH}max = 1.85V	If unused keep line open.
ADC	ADC1	I	R_I = 1MΩ V_I = 0V ... 1.2V (valid range) V_{IH} max = 1.2V	If unused keep line open.

2.1.2.1   Absolute Maximum Ratings

The absolute maximum ratings stated in Table 3 are stress ratings under any conditions. Stresses beyond any of these limits will cause permanent damage to EHS6.

Table 3: Absolute maximum ratings

Parameter	Min	Max	Unit
Supply voltage BATT+ (no service)	-0.5	+5.5	V
Voltage at all digital lines in POWER DOWN mode	-0.3	+0.3	V
Voltage at digital lines in normal operation	-0.2	V180 + 0.2	V
Voltage at SIM/USIM interface, CCVCC in normal operation	-0.5	+3.3	V
VDDLP input voltage	-0.15	2.0	V
Voltage at ADC line in normal operation	0	1.2	V
Voltage at analog lines in POWER DOWN mode	-0.3	+0.3	V
V180 in normal operation	+1.7	+1.9	V
Current at V180 in normal operation		-50	mA
VCORE in normal operation	+0.85	+1.25	V
Current at VCORE in normal operation		-50	

2.1.3   USB Interface

EHS6 supports a USB 2.0 High Speed (480Mbit/s) device interface that is Full Speed (12Mbit/s) compliant. The USB interface is primarily intended for use as command and data interface and for downloading firmware.

The USB host is responsible for supplying the VUSB_IN line. This line is for voltage detection only. The USB part (driver and transceiver) is supplied by means of BATT+. This is because EHS6 is designed as a self-powered device compliant with the "Universal Serial Bus Specification Revision 2.0"[1].
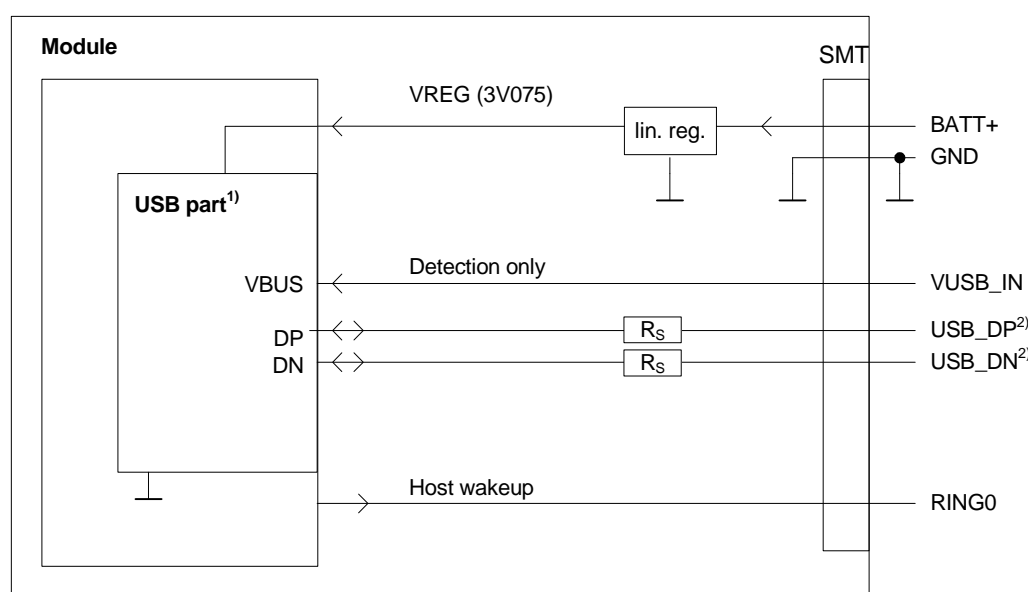
[1] All serial (including R_S) and pull-up resistors for data lines are implemented.
[2] If the USB interface is operated in High Speed mode (480MHz), it is recommended to take special care routing the data lines USB_DP and USB_DN. Application layout should in this case implement a differential impedance of 90Ohm for proper signal integrity.

Figure 5: USB circuit

To properly connect the module's USB interface to the host a USB 2.0 compatible connector is required. For more information on the USB related signals see Table 2. Furthermore, the USB modem driver distributed with EHS6 needs to be installed.

While the USB connection is active, the module will not change into SLEEP Mode. To enable switching into SLEEP mode the USB host must bring its USB interface into Suspend state. Also, VUSB_IN should always be kept enabled for this functionality. See "Universal Serial Bus Specification Revision 2.0"[1] for a description of the Suspend state. On incoming calls EHS6 will then generate a remote wake up request to resume the USB connection (active low).

As an alternative to the regular USB remote wakeup mechanism it is possible to employ the RING0 line to wake up the host application. The benefit is that the RING0 line can wake up the host application in case of incoming calls or other events signalized by URCs while the USB interface is suspended or shut down. For details on this host wakeup interface see Section 2.1.15.3.

1. The specification is ready for download on http://www.usb.org/developers/docs/

2.1.4   Serial Interface ASC0

EHS6 offers an 8-wire unbalanced, asynchronous modem interface ASC0 conforming to ITU-T V.24 protocol DCE signalling. The electrical characteristics do not comply with ITU-T V.28. The significant levels are 0V (for low data bit or active state) and 1.8V (for high data bit or inactive state). For electrical characteristics please refer to Table 2. For an illustration of the interface line's startup behavior see Figure 7.

EHS6 is designed for use as a DCE. Based on the conventions for DCE-DTE connections it communicates with the customer application (DTE) using the following signals:
• Port TXD @ application sends data to the module's TXD0 signal line
• Port RXD @ application receives data from the module's RXD0 signal line
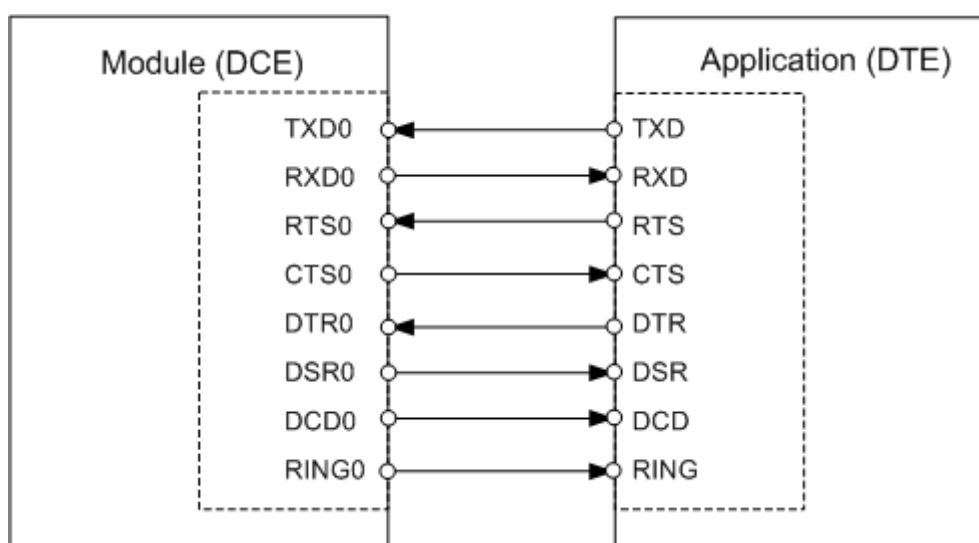
Figure 6: Serial interface ASC0

Features:
• Includes the data lines TXD0 and RXD0, the status lines RTS0 and CTS0 and, in addition, the modem control lines DTR0, DSR0, DCD0 and RING0.
• ASC0 is designed for controlling GSM/UMTS voice calls, transferring data and for controlling the module with AT commands.
• Full multiplexing capability allows the interface to be partitioned into virtual channels.
• The RING0 signal serves to indicate incoming calls and other types of URCs (Unsolicited Result Code). It can also be used to send pulses to the host application, for example to wake up the application from power saving state.
• Configured for 8 data bits, no parity and 1 stop bit.
• ASC0 can be operated at fixed bit rates from 1,200bps up to 921,600bps.
• Autobauding supports bit rates from 1,200bps up to 230,400bps.
• Supports RTS0/CTS0 hardware flow control. The hardware hand shake line RTS0 has an internal pull down resistor causing a low level signal, if the line is not used and open. Although hardware flow control is recommended, this allows communication by using only RXD and TXD lines.
• Wake up from SLEEP mode by RTS0 activation (high to low transition).

Note: Initially, the ASC0 modem control lines are available as serial interface lines. However, these lines can alternatively be configured as GPIO1 (DTR0), GPIO2 (DCD0), GPIO3 (DSR0) and GPIO24 (RING0) lines. Also, the DSR0 is shared with the SPI_CLK line of the SPI interface

and may be configured as such. Configuration is done by AT command (see [1]). The configuration is non-volatile and becomes active after a module restart.

Also note that the DSR0, DCD0 and RING0 modem control lines are driven only with an internal pull-up or pull-down resistor to change the modem signal state.

The following figure shows the startup behavior of the asynchronous serial interface ASC0.
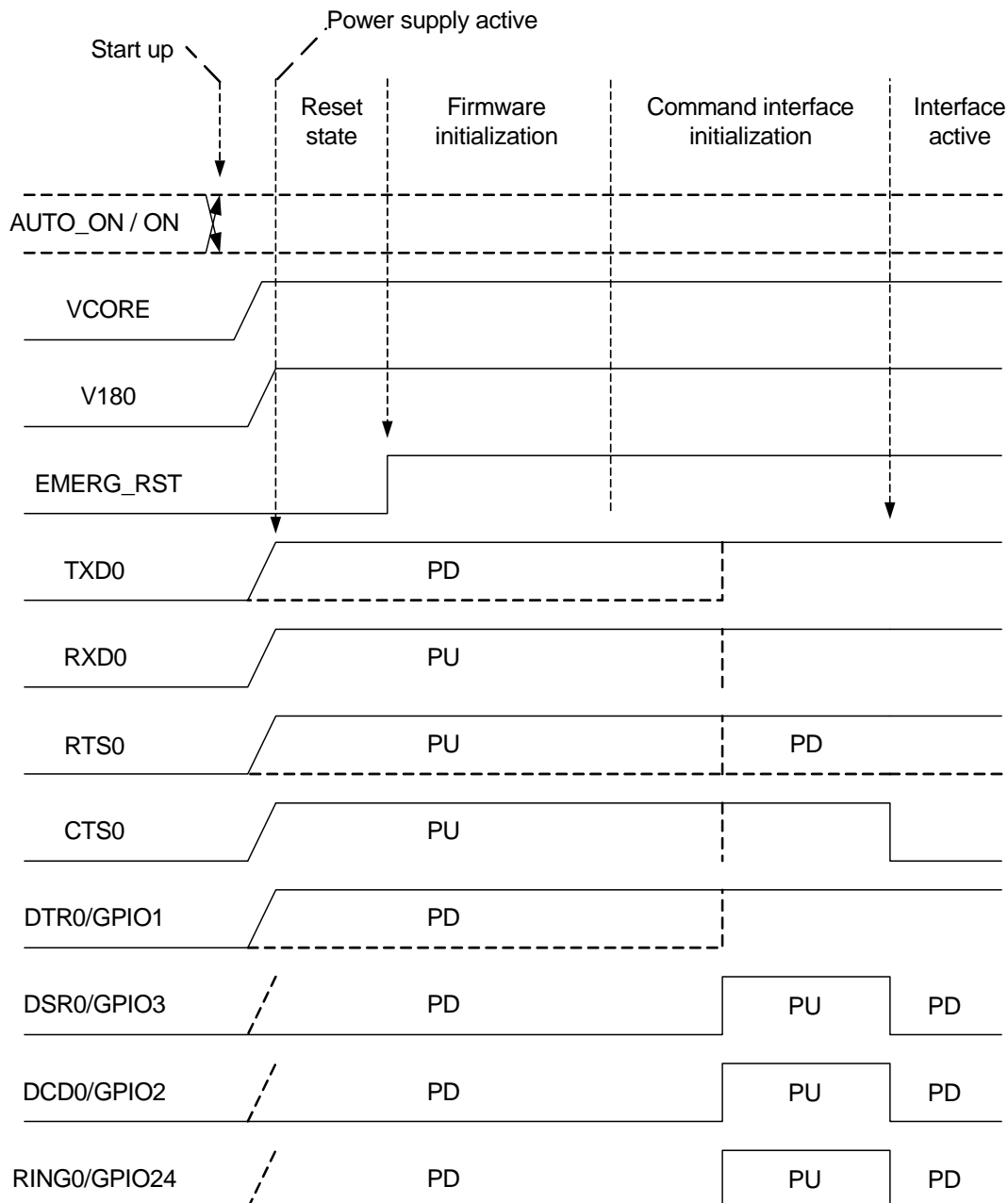
*) For pull-up and pull-down values see Table 11.

Figure 7: ASC0 startup behavior

Please note that during startup the DTR0 signal is driven active low for 500µs. It is recommended to provide a 470 Ohm serial resistor for the DTR0 line to prevent shorts.

Also note that no data must be sent over the ASC0 interface before the interface is active and ready to receive data (see Section 3.2.1).

2.1.5 Serial Interface ASC1

Four EHS6 GPIO lines can be configured as ASC1 interface signals to provide a 4-wire unbalanced, asynchronous modem interface ASC1 conforming to ITU-T V.24 protocol DCE signalling. The electrical characteristics do not comply with ITU-T V.28. The significant levels are 0V (for low data bit or active state) and 1.8V (for high data bit or inactive state). For electrical characteristics please refer to Table 2. For an illustration of the interface line's startup behavior see Figure 9.

The four GPIO lines can be configured as ASC1 interface signals as follows: GPIO16 --> RXD1, GPIO17 --> TXD1, GPIO18 --> RTS1 and GPIO19 --> CTS1. The configuration is done by AT command (see [1]). It is non-volatile and becomes active after a module restart.

EHS6 is designed for use as a DCE. Based on the conventions for DCE-DTE connections it communicates with the customer application (DTE) using the following signals:
• Port TXD @ application sends data to module's TXD1 signal line
• Port RXD @ application receives data from the module's RXD1 signal line
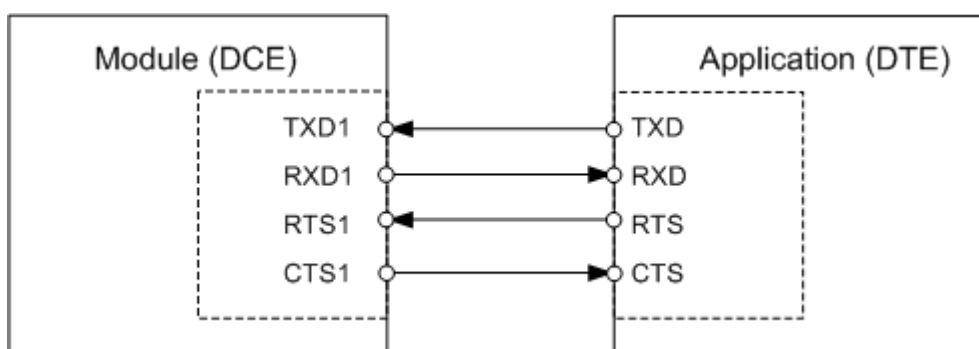
Figure 8: Serial interface ASC1

Features
• Includes only the data lines TXD1 and RXD1 plus RTS1 and CTS1 for hardware handshake.
• On ASC1 no RING line is available.
• Configured for 8 data bits, no parity and 1 or 2 stop bits.
• ASC1 can be operated at fixed bit rates from 1,200 bps to 921,600 bps.
• Autobauding supports bit rates from 1,200bps up to 230,400bps.
• Supports RTS1/CTS1 hardware flow. The hardware hand shake line RTS0 has an internal pull down resistor causing a low level signal, if the line is not used and open. Although hardware flow control is recommended, this allows communication by using only RXD and TXD lines.

The following figure shows the startup behavior of the asynchronous serial interface ASC1.
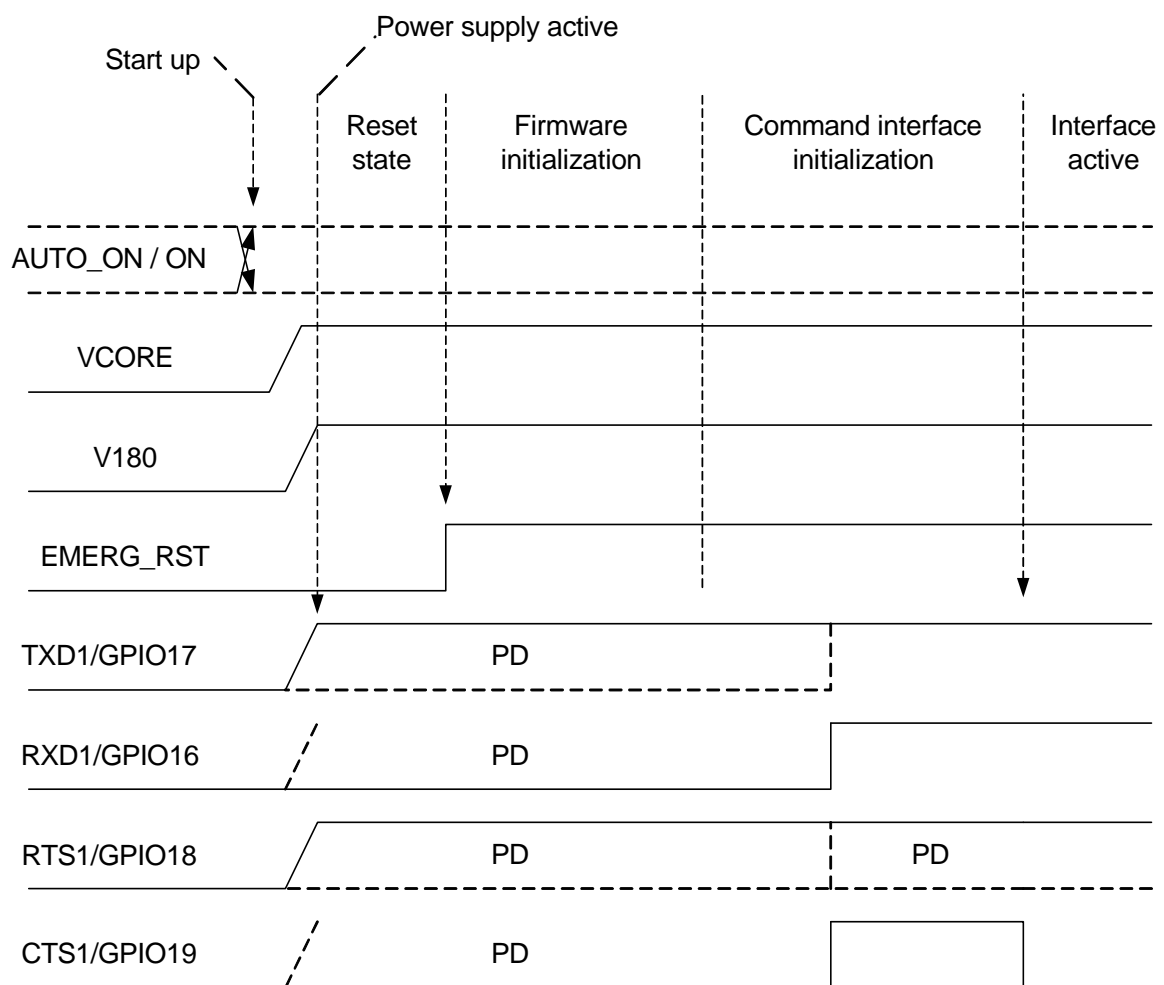
*) For pull-down values see Table 11.

Figure 9: ASC1 startup behavior

2.1.6   UICC/SIM/USIM Interface

EHS6 has an integrated UICC/SIM/USIM interface compatible with the 3GPP 31.102 and ETSI 102 221. This is wired to the host interface in order to be connected to an external SIM card holder. Five pads on the SMT application interface are reserved for the SIM interface.

The UICC/SIM/USIM interface supports 3V and 1.8V SIM cards. Please refer to Table 2 for electrical specifications of the UICC/SIM/USIM interface lines depending on whether a 3V or 1.8V SIM card is used.

The CCIN signal serves to detect whether a tray (with SIM card) is present in the card holder. Using the CCIN signal is mandatory for compliance with the GSM 11.11 recommendation if the mechanical design of the host application allows the user to remove the SIM card during operation. To take advantage of this feature, an appropriate SIM card detect switch is required on the card holder. For example, this is true for the model supplied by Molex, which has been tested to operate with EHS6 and is part of the Gemalto M2M reference equipment submitted for type approval. See Section 7.1 for Molex ordering numbers.

Table 4: Signals of the SIM interface (SMT application interface)

Signal	Description
GND	Separate ground connection for SIM card to improve EMC.
CCCLK	Chipcard clock
CCVCC	SIM supply voltage.
CCIO	Serial data line, input and output.
CCRST	Chipcard reset
CCIN	Input on the baseband processor for detecting a SIM card tray in the holder. If the SIM is removed during operation the SIM interface is shut down immediately to prevent destruction of the SIM. The CCIN signal is by default low and will change to high level if a SIM card is inserted. The CCIN signal is mandatory for applications that allow the user to remove the SIM card during operation. The CCIN signal is solely intended for use with a SIM card. It must not be used for any other purposes. Failure to comply with this requirement may invalidate the type approval of EHS6.

Note: No guarantee can be given, nor any liability accepted, if loss of data is encountered after removing the SIM card during operation. Also, no guarantee can be given for properly initializing any SIM card that the user inserts after having removed the SIM card during operation. In this case, the application must restart EHS6.

The figure below shows a circuit to connect an external SIM card holder.
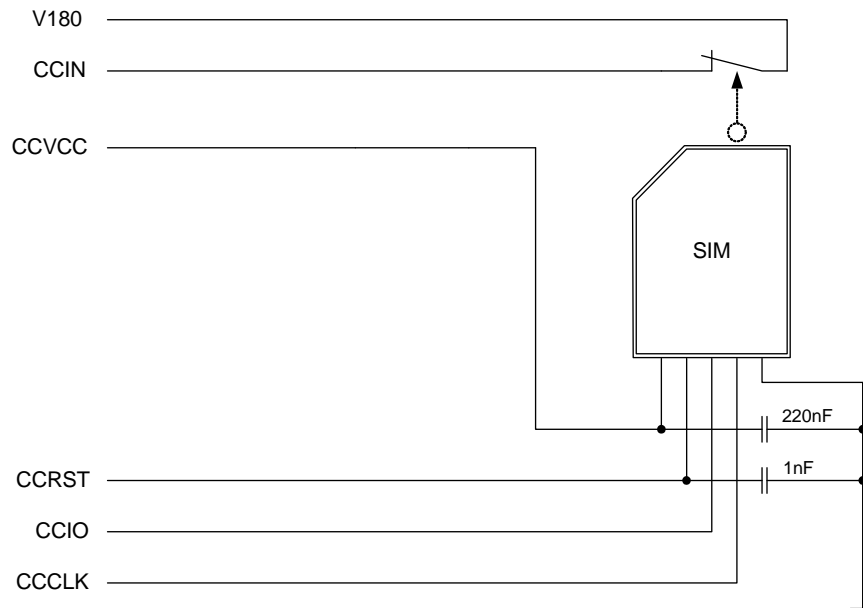
Figure 10: External UICC/SIM/USIM card holder circuit

The total cable length between the SMT application interface pads on EHS6 and the pads of the external SIM card holder must not exceed 100mm in order to meet the specifications of 3GPP TS 51.010-1 and to satisfy the requirements of EMC compliance.

To avoid possible cross-talk from the CCCLK signal to the CCIO signal be careful that both lines are not placed closely next to each other. A useful approach is using a GND line to shield the CCIO line from the CCCLK line.

An example for an optimized ESD protection for the SIM interface is shown in Section 2.1.6.1.

2.1.6.1 Enhanced ESD Protection for SIM Interface

To optimize ESD protection for the SIM interface it is possible to add ESD diodes to the SIM interface lines as shown in the example given in Figure 11.

The example was designed to meet ESD protection according ETSI EN 301 489-1/7: Contact discharge: ± 4kV, air discharge: ± 8kV.
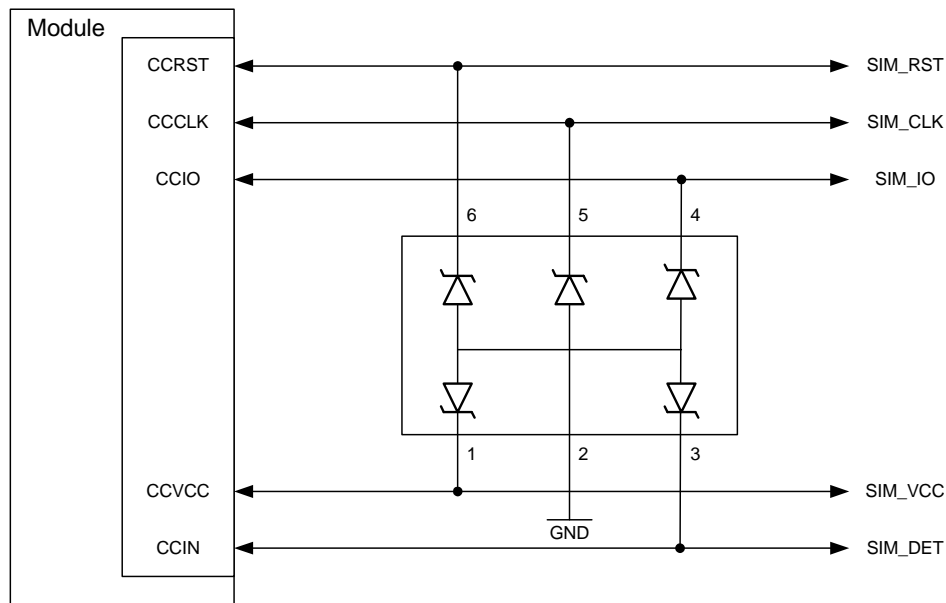
Figure 11: SIM interface - enhanced ESD protection

2.1.7 Digital Audio Interface

Four EHS6 GPIO lines can be configured as digital audio interface (DAI). The DAI can be used to connect audio devices capable of pulse code modulation (PCM). The PCM functionality allows for the use of an external codec like the W681360.

The DAI interface supports a 256kHz, long frame synchronization master mode with the following features:
- 16 Bit linear
- 8kHz sample rate
- The most significant bit MSB is transferred first
- 125µs frame duration
- Common frame sync signal for transmit and receive

The four GPIO lines can be configured as DAI/PCM interface signals as follows: GPIO20 --> TXDDAI, GPIO21--> RXDDAI, GPIO22 --> TFSDAI and GPIO23 --> SCLK. The configuration is done by AT command (see [1]). It is non-volatile and becomes active after a module restart. Table 5 describes the available DAI/PCM lines at the digital audio interface. For electrical details see Section 2.1.2.

Table 5: Overview of DAI/PCM lines

Signal name	Input/Output	Description
TXDDAI	O	PCM data from EHS6 to external codec.
RXDDAI	I	PCM data from external codec to EHS6.
TFSDAI	O	Frame synchronization signal to external codec: Long frame (8kHz)
SCLK	O	Bit clock to external codec: 256kHz

Figure 12 shows the PCM timing for the master mode available with EHS6.
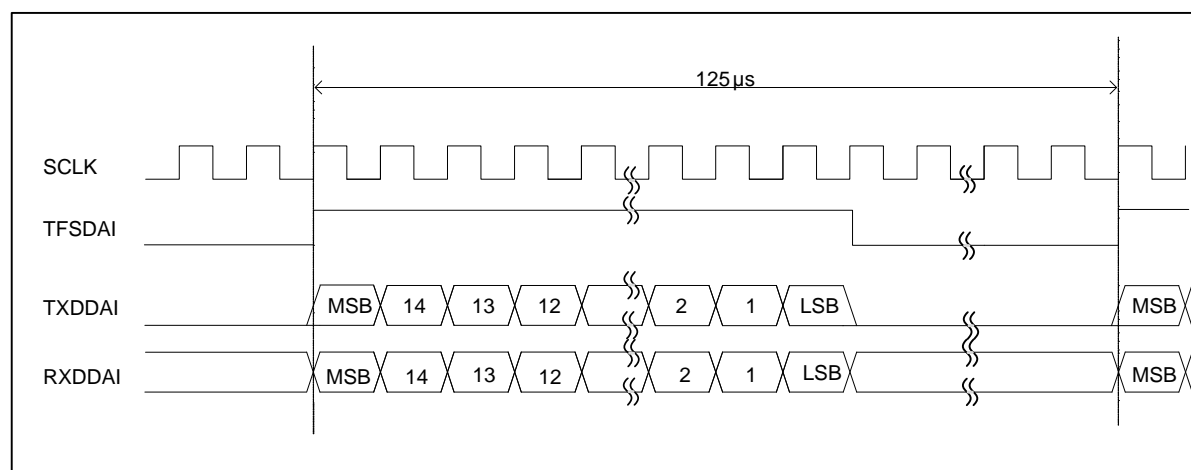
Figure 12: Long frame PCM timing, 256kHz

The following figure shows the start up behaviour of the DAI interface. The start up configuration of functions will be activated after the software initialization of the command interface. With an active state of RING0, CTS0 or CTS1 (low level) the initialization of the DAI interface is finished.
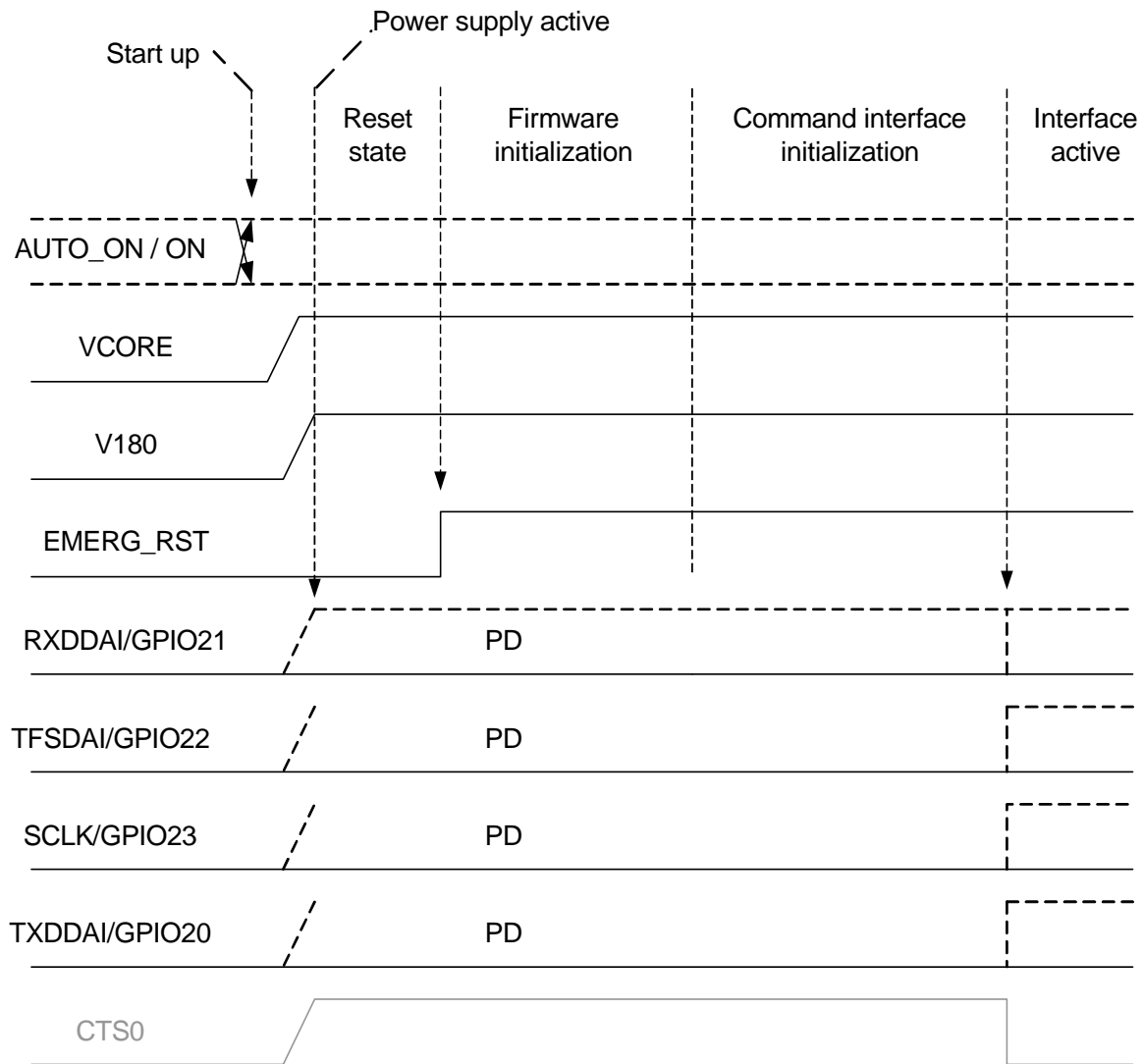
Figure 13: DAI startup timing

2.1.8   RTC Backup

The internal Real Time Clock of EHS6 is supplied from a separate voltage regulator in the power supply component which is also active when EHS6 is in Power Down mode and BATT+ is available. An alarm function is provided that allows to wake up EHS6 without logging on to the GSM/UMTS network.

In addition, you can use the VDDLP pad to backup the RTC from an external capacitor. The capacitor is charged from the internal LDO of EHS6. If the voltage supply at BATT+ is disconnected the RTC can be powered by the capacitor. The size of the capacitor determines the duration of buffering when no voltage is applied to EHS6, i.e. the greater the capacitor the longer EHS6 will save the date and time. The RTC can also be supplied from an external battery (rechargeable or non-chargeable). In this case the electrical specification of the VDDLP pad (see Section 2.1.2) has to be taken in to account.

Figure 14 shows an RTC backup configuration. A serial 1kOhm resistor has to be placed on the application next to VDDLP. It limits the input current of an empty capacitor or battery.
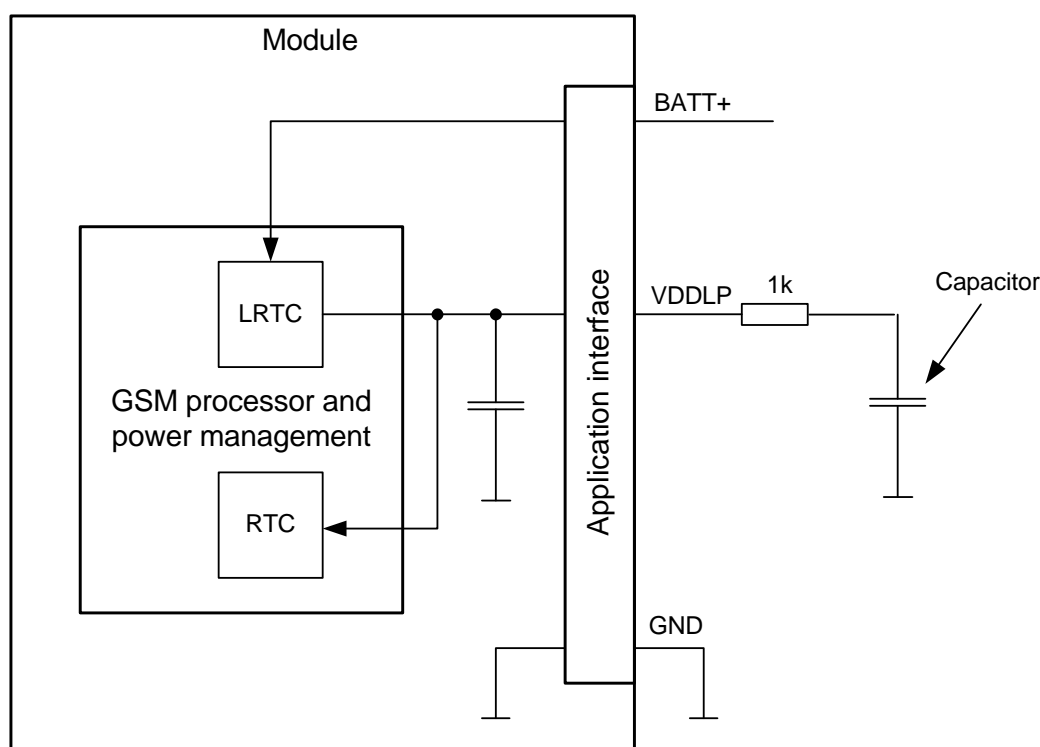
Figure 14: RTC supply variants

2.1.9   GPIO Interface

EHS6 offers a GPIO interface with 22 GPIO lines. The GPIO lines are shared with other interfaces resp. functions: Fast shutdown (see Section 2.1.15.4), status LED (see Section 2.1.15.1), the PWM functionality (see Section 2.1.13), an pulse counter (see Section 2.1.14), ASC0 (see Section 2.1.4), ASC1 (see Section 2.1.5), an SPI interface (see Section 2.1.11), an HSIC interface (see Section 2.1.12) and a PCM interface (see Section 2.1.13)

The following table shows the configuration variants for the GPIO pads. All variants are mutually exclusive, i.e. a pad configured for instance as Status LED is locked for alternative usage.

Table 6: GPIO lines and possible alternative assignment

GPIO	Fast Shutdown	Status LED	PWM	Pulse Counter	ASC0	ASC1	SPI	HSIC	PCM
GPIO1					DTR0				
GPIO2					DCD0				
GPIO3					DSR0		SPI_CLK		
GPIO4	FST_SHDN								
GPIO5		Status LED							
GPIO6			PWM2						
GPIO7			PWM1						
GPIO8				COUNTER					
GPIO11									
GPIO12									
GPIO13									
GPIO14									
GPIO15									
GPIO16						RXD1	MOSI	AP_WAKEUP	
GPIO17						TXD1	MISO	HOST_ACTIVE	
GPIO18						RTS1		CP_WAKEUP	
GPIO19						CTS1	SPI_CS	SUSPEND	
GPIO20									TXDDAI
GPIO21									RXDDAI
GPIO22									TFSDAI
GPIO23									SCLK
GPIO24					RING0				

When the EHS6 starts up, all GPIO lines (except GPIO1-GPIO3 and GPIO24) are set to high-impedance state after initializing, as described in Section 3.2.3. Therefore, it is recommended to connect external pull-up or pull-down resistors to those GPIO lines that are to be used as output. This is necessary to keep these lines from floating or driving any external devices.

After startup, the above mentioned alternative GPIO line assignments can be configured using AT commands (see [1]). The configuration is non-volatile and available after module restart.

The following figure shows the startup behavior of the GPIO interface. With an active state of the ASC0 interface (i.e. RING0, CTS0 or CTS1 are at low level) the initialization of the GPIO interface lines is also finished.
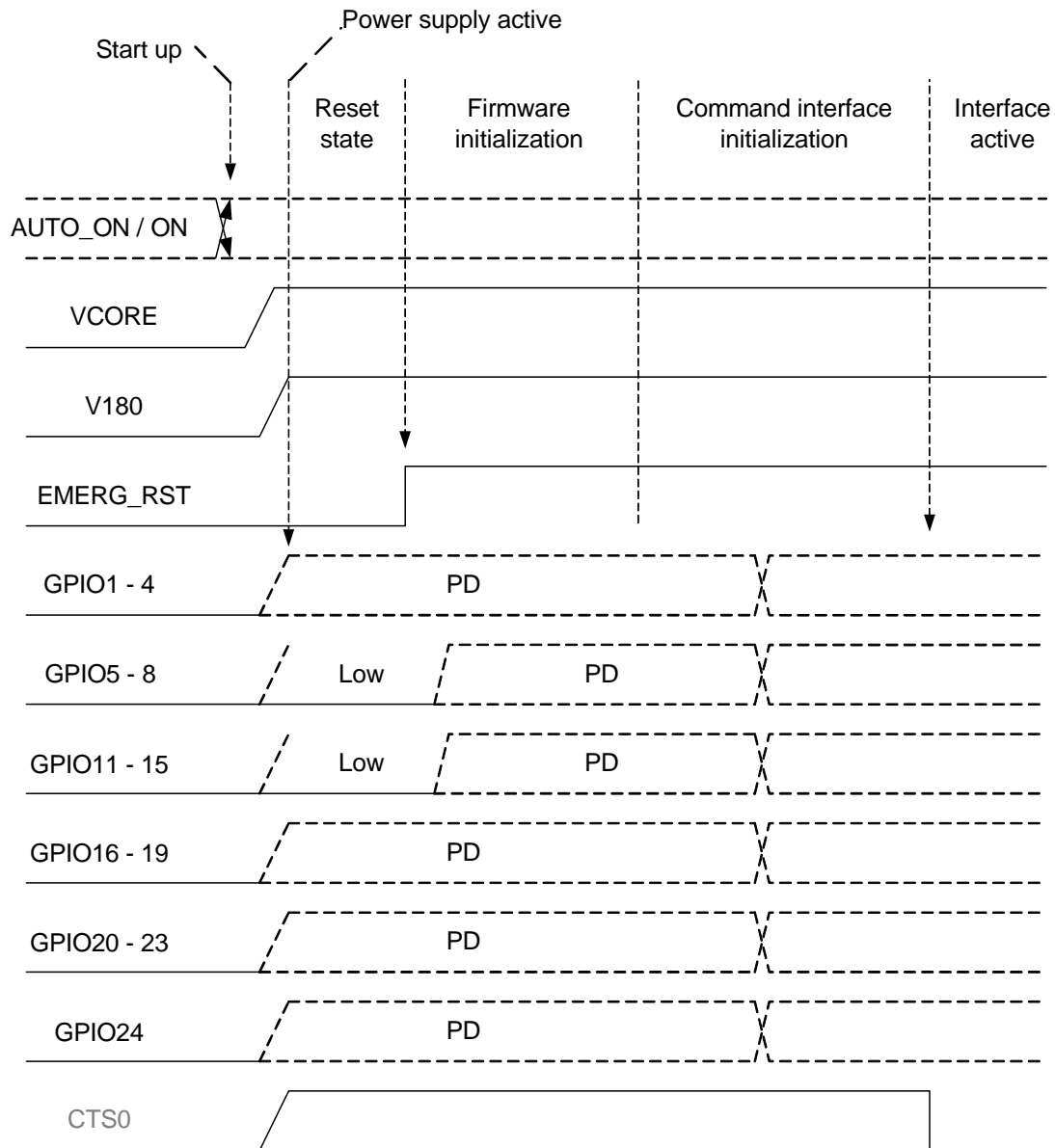
*) For pull down values see Table 11.

Figure 15: GPIO startup behavior

2.1.10   I²C Interface

I²C is a serial, 8-bit oriented data transfer bus for bit rates up to 400kbps in Fast mode. It consists of two lines, the serial data line I2CDAT and the serial clock line I2CCLK. The module acts as a single master device, e.g. the clock I2CCLK is driven by the module. I2CDAT is a bi-directional line. Each device connected to the bus is software addressable by a unique 7-bit address, and simple master/slave relationships exist at all times. The module operates as master-transmitter or as master-receiver. The customer application transmits or receives data only on request of the module.

To configure and activate the I2C bus use the AT^SSPI command. Detailed information on the AT^SSPI command as well explanations on the protocol and syntax required for data transmission can be found in [1].

The I²C interface can be powered via the V180 line of EHS6. If connected to the V180 line, the I²C interface will properly shut down when the module enters the Power Down mode.

In the application I2CDAT and I2CCLK lines need to be connected to a positive supply voltage via a pull-up resistor. For electrical characteristics please refer to Table 2.
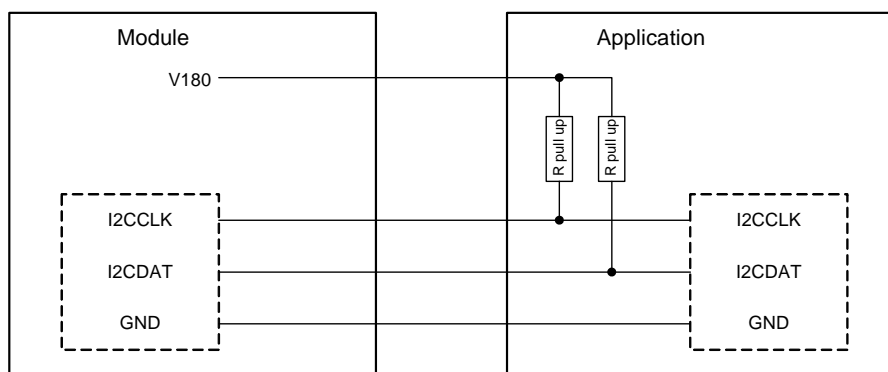
Figure 16: I²C interface connected to V180

Note: Good care should be taken when creating the PCB layout of the host application: The traces of I2CCLK and I2CDAT should be equal in length and as short as possible.

2.1 Application Interface

The following figure shows the startup behavior of the I²C interface. With an active state of the ASC0 interface (i.e. RING0, CTS0 or CTS1 are at low level) the initialization of the I²C interface is also finished.
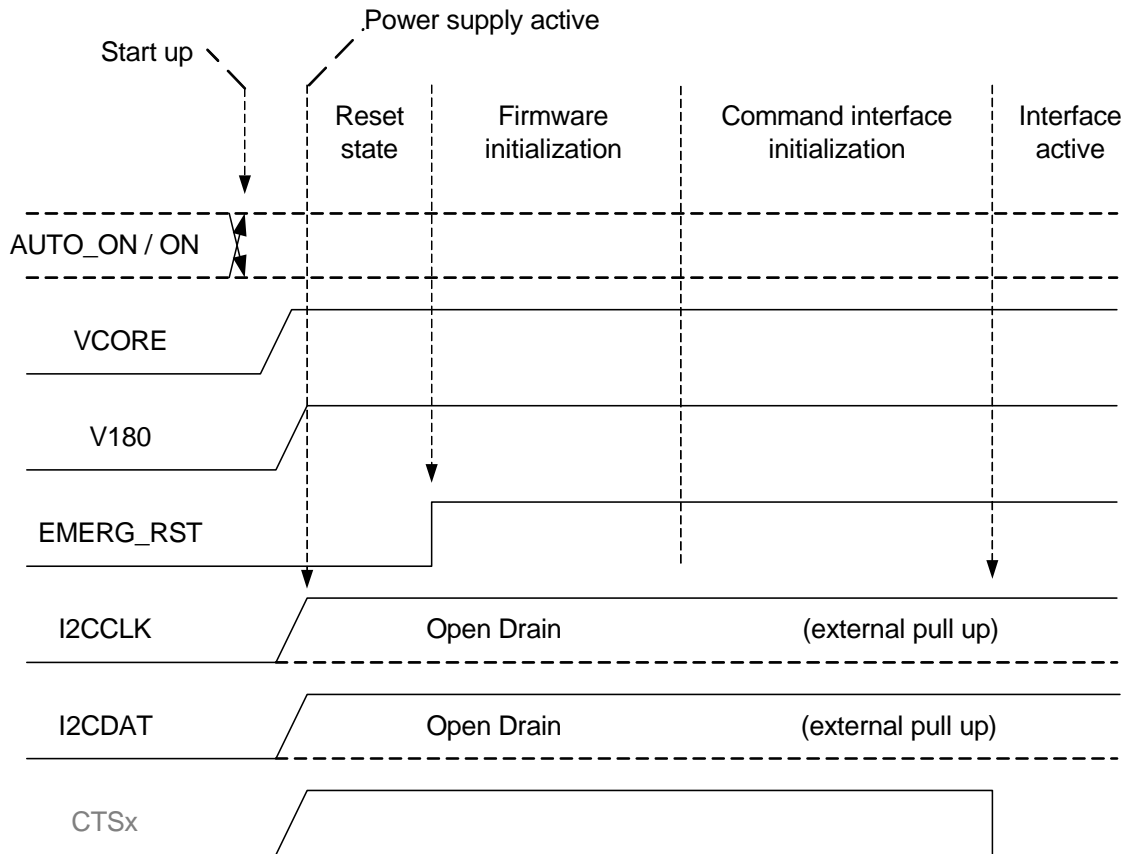
Figure 17: I²C startup behavior

2.1.11 SPI Interface

Four EHS6 GPIO interface lines can be configured as Serial Peripheral Interface (SPI). The SPI is a synchronous serial interface for control and data transfer between EHS6 and the external application. Only one application can be connected to the SPI and the interface supports only master mode. The transmission rates are up to 26Mbit/s. The SPI interface comprises the two data lines MOSI and MISO, the clock line SPI_CLK a well as the chip select line SPI_CS.

The four GPIO lines can be configured as SPI interface signals as follows: GPIO3 --> SPI_CLK, GPIO16 --> MOSI, GPIO17 --> MISO and GPIO19 --> SPI_CS. The configuration is done by AT command (see [1]). It is non-volatile and becomes active after a module restart.

The GPIO lines are also shared with the ASC1 signal lines and the ASC0 modem status signal line DSR0.

To configure and activate the SPI interface use the AT^SSPI command. Detailed information on the AT^SSPI command as well explanations on the SPI modes required for data transmission can be found in [1].

In general, SPI supports four operation modes. The modes are different in clock phase and clock polarity. The module's SPI mode can be configured by using the AT command AT^SSPI. Make sure the module and the connected slave device works with the same SPI mode.

Figure 18 shows the characteristics of the four SPI modes. The SPI modes 0 and 3 are the most common used modes. For electrical characteristics please refer to Table 2.
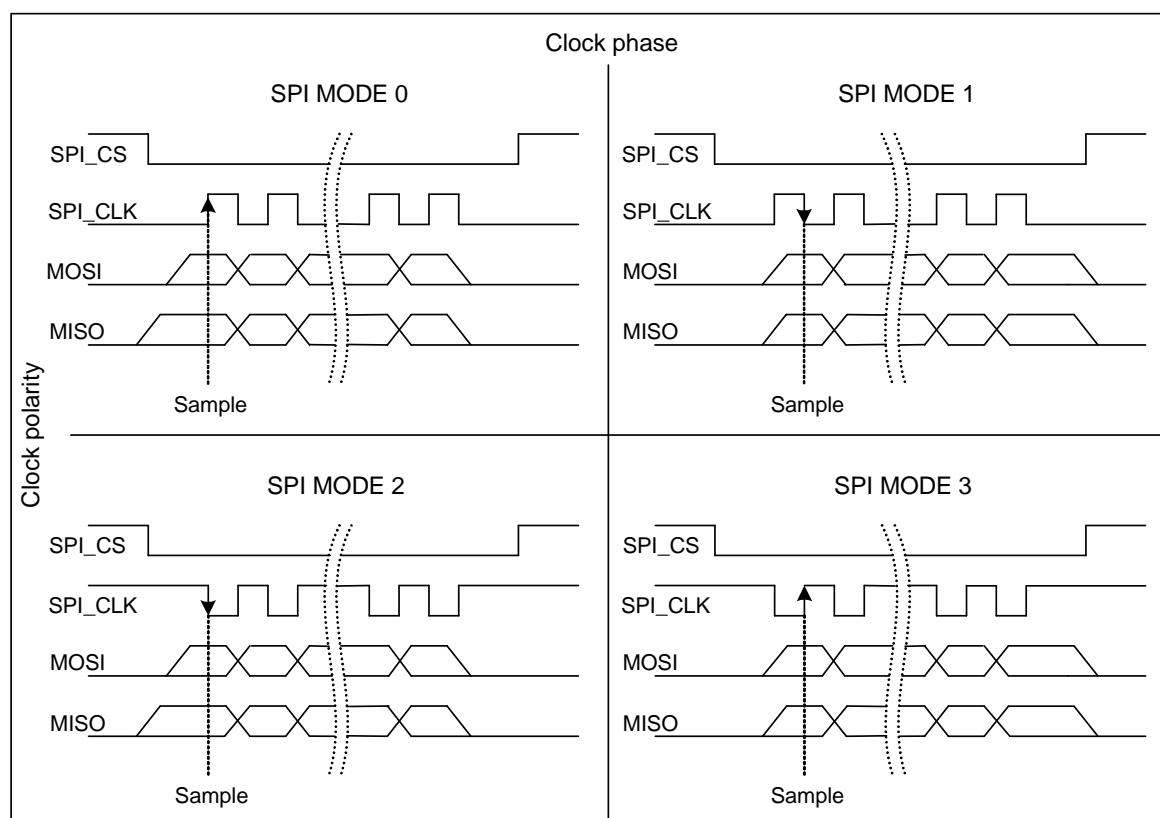
Figure 18: Characteristics of SPI modes

2.1.12   HSIC Interface

The (USB) High Speed Inter Chip Interface can be used between the module and an external application processor and is compliant to the High Speed USB 2.0 interface with 480Mbit/s. The maximum distance between module processor and external application processor should not exceed 100mm.

The HSIC interface comprises 6 lines:

- Two signal lines (strobe - HSIC_STRB - and data - HSIC_DATA) are used in a source synchronous serial interface with a 240MHz clock to provide a 480Mbps USB interface.
  The HSIC_STRB and HSIC_DATA lines are high-speed signals and should be routed as 50Ohm impedance traces. The trace length of these signals should be balanced to minimize timing skew and no longer as 100mm.
- Four signal lines for Link Power Management (LPM). For further power reduction, the USB HSIC interface supports LPM according to the USB 2.0 standard. The LPM defines power management states and mechanisms to affect state changes that are used by the AP_WAKEUP and CP_WAKEUP signal lines to efficiently manage bus and system power. To take advantage of the LPM feature, two further signals are needed to support power management state transitions - the SUSPEND and HOST_ACTIVE signals.
  The following four EHS6 GPIO interface lines are by default configured as LPM lines: GPIO16 --> AP_WAKEUP, GPIO17 --> HOST_ACTIVE, GPIO18 --> CP_WAKEUP and GPIO19 --> SUSPEND (see also Section 2.1.9).

  The default GPIO configuration as HSIC LPM signals can be changed by AT command (see [1]). A change is non-volatile and becomes active after a module restart.

2.1.13   PWM Interfaces

The GPIO6 and GPIO7 interface lines can be configured as Pulse Width Modulation interface lines PWM1 and PWM2. The PWM interface lines can be used, for example, to connect buzzers. The PWM1 line is shared with GPIO7 and the PWM2 line is shared with GPIO6 (for GPIOs see Section 2.1.9). GPIO and PWM functionality are mutually exclusive.

The startup behavior of the lines is shown in Figure 15.

2.1.14   Pulse Counter

The GPIO8 line can be configured as pulse counter line COUNTER. The pulse counter interface can be used, for example, as a clock (for GPIOs see Section 2.1.9).

2.1.15   Control Signals

2.1.15.1   Status LED

The GPIO5 interface line can be configured to drive a status LED that indicates different operating modes of the module (for GPIOs see Section 2.1.9). GPIO and LED functionality are mutually exclusive.

To take advantage of this function connect an LED to the GPIO5/LED line as shown in Figure 19.
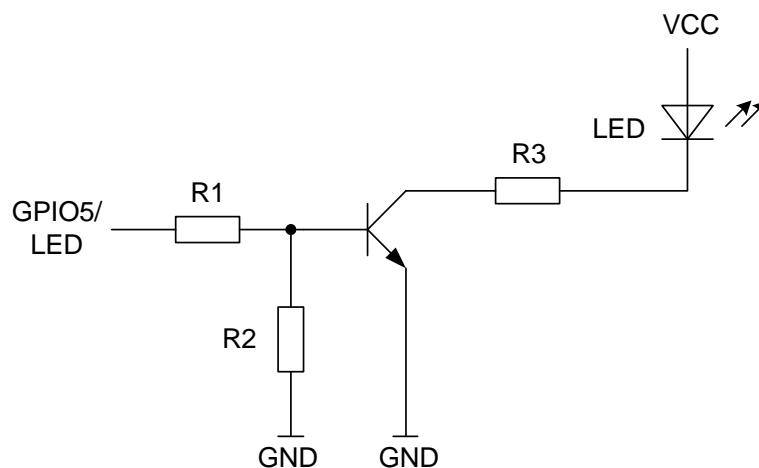
Figure 19: Status signalling with LED driver

2.1.15.2 Power Indication Circuit

In Power Down mode the maximum voltage at any digital or analog interface line must not exceed +0.3V (see also Section 2.1.2.1). Exceeding this limit for any length of time might cause permanent damage to the module.

It is therefore recommended to implement a power indication signal that reports the module's power state and shows whether it is active or in Power Down mode. While the module is in Power Down mode all signals with a high level from an external application need to be set to low state or high impedance state. The sample power indication circuit illustrated in Figure 20 denotes the module's active state with a low signal and the module's Power Down mode with a high signal or high impedance state.
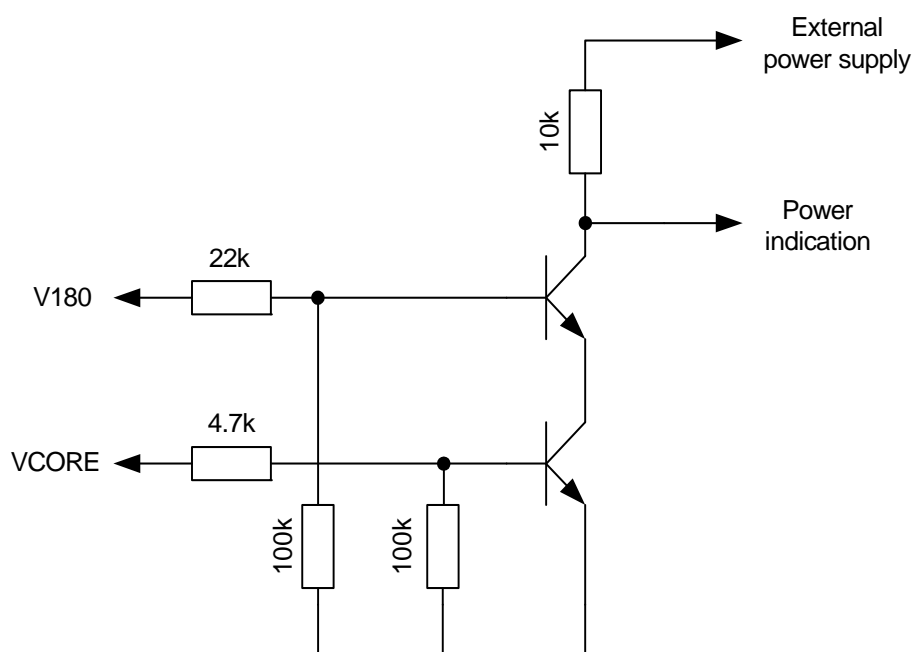
Figure 20: Power indication circuit

2.1.15.3 Host Wakeup

If no call, data or message transfer is in progress, the host may shut down its own USB interface to save power. If a call or other request (URC's, messages) arrives, the host can be notified of these events and be woken up again by a state transition of the ASC0 interface's RING0 line.

Possible RING0 line states are listed in Table 7.

Table 7: Host wakeup lines

Signal	I/O	Description
RING0	O	Inactive to active low transition: 0 = The host shall wake up 1 = No wake up request

2.1.15.4 Fast Shutdown

The GPIO4 interface line can be configured as fast shutdown signal line FST_SHDN. The configured FST_SHDN line is an active low control signal and must be applied for at least 10ms. If unused this line can be left open because of a configured internal pull-up resistor. Before setting the FST_SHDN line to low, the ON signal should be set to low (see Figure 21). Otherwise there might be back powering at the ON line in power down mode.

By default, the fast shutdown feature is disabled. It has to be enabled using the AT command AT^SCFG "MEShutdown/Fso". For details see [1].

If enabled, a low impulse >10ms on the FST_SHDN line starts the fast shutdown. The fast shutdown procedure still finishes any data activities on the module's flash file system, thus ensuring data integrity, but will no longer deregister gracefully from the network, thus saving the time required for network deregistration.
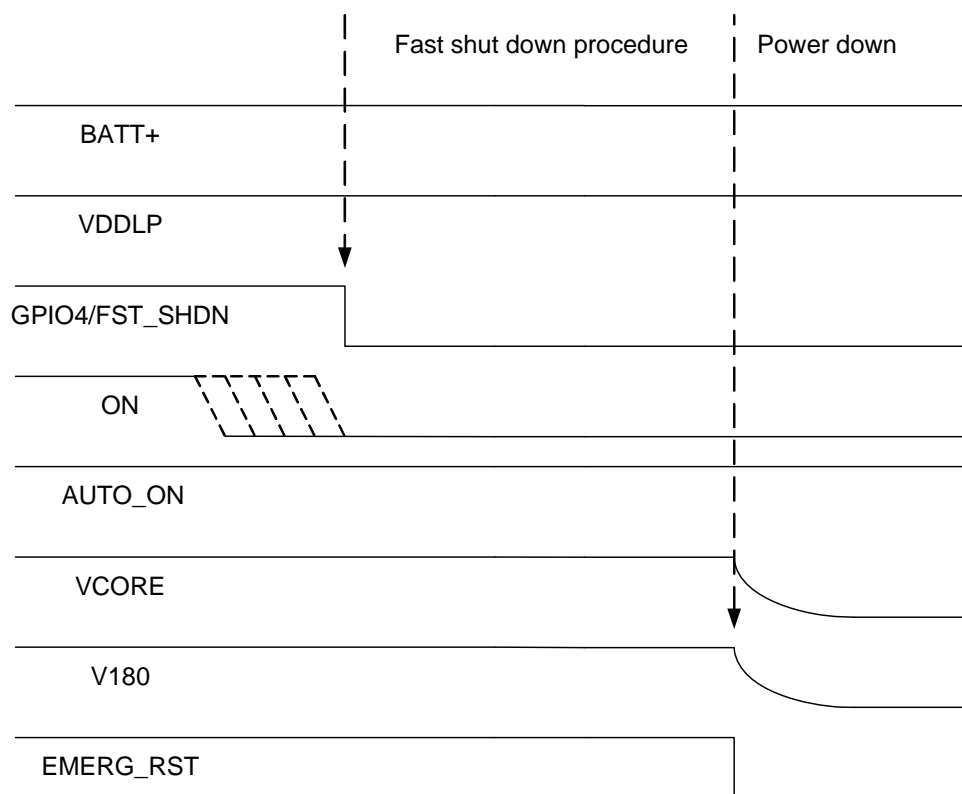
Figure 21: Fast shutdown timing

Please note that if enabled, the normal software controlled shutdown using AT^SMSO will also be a fast shutdown, i.e., without network deregistration. However, in this case no URCs including shutdown URCs will be provided by the AT^SMSO command.

2.2   RF Antenna Interface

The RF interface has an impedance of 50Ω. EHS6 is capable of sustaining a total mismatch at the antenna line without any damage, even when transmitting at maximum RF power.

The external antenna must be matched properly to achieve best performance regarding radiated power, modulation accuracy and harmonic suppression. Antenna matching networks are not included on the EHS6 module and should be placed in the host application if the antenna does not have an impedance of 50Ω.

Regarding the return loss EHS6 provides the following values in the active band:

Table 8: Return loss in the active band

State of module	Return loss of module	Recommended return loss of application
Receive	≥ 8dB	≥ 12dB
Transmit	not applicable	≥ 12dB

2.2.1   Antenna Interface Specifications

Table 9: RF Antenna interface GSM / UMTS

Parameter	Conditions	Min.	Typical	Max.	Unit
UMTS/HSPA connectivity	Band I, II, V, VI, VIII				
Receiver Input Sensitivity @ ARP	UMTS 800/850 Band VI/V	-104.7/ -106.7	-110		dBm
	UMTS 900 Band VIII	-103.7	-110		dBm
	UMTS 1900 Band II	-104.7	-109		dBm
	UMTS 2100 Band I	-106.7	-110		dBm
RF Power @ ARP with 50Ohm Load Board temperature <85°C	UMTS 800/850 Band VI/V	+21	+24	+25	dBm
	UMTS 900 Band VIII	+21	+24	+25	dBm
	UMTS 1900 Band II	+21	+24	+25	dBm
	UMTS 2100 Band I	+21	+24	+25	dBm
GPRS coding schemes	Class 12, CS1 to CS4				
EGPRS	Class 12, MCS1 to MCS9				
GSM Class	Small MS				
Static Receiver input Sensitivity @ ARP	GSM 850 / E-GSM 900	-102	-109		dBm
	GSM 1800 / GSM 1900	-102	-108		dBm
RF Power @ ARP with 50Ohm Load	GSM	GSM 850 / E-GSM 900		33		dBm
		GSM 1800 / GSM 1900		30		dBm

Table 9: RF Antenna interface GSM / UMTS

Parameter		Conditions	Min.	Typical	Max.	Unit
RF Power @ ARP with 50Ohm Load, (**ROPR = 4**, i.e. no reduction)	GPRS, 1 TX	GSM 850 / E-GSM 900		33		dBm
		GSM 1800 / GSM 1900		30		dBm
	EDGE, 1 TX	GSM 850 / E-GSM 900		27		dBm
		GSM 1800 / GSM 1900		26		dBm
	GPRS, 2 TX	GSM 850 / E-GSM 900		33		dBm
		GSM 1800 / GSM 1900		30		dBm
	EDGE, 2 TX	GSM 850 / E-GSM 900		27		dBm
		GSM 1800 / GSM 1900		26		dBm
	GPRS, 3 TX	GSM 850 / E-GSM 900		33		dBm
		GSM 1800 / GSM 1900		30.		dBm
	EDGE, 3 TX	GSM 850 / E-GSM 900		27		dBm
		GSM 1800 / GSM 1900		26		dBm
	GPRS, 4 TX	GSM 850 / E-GSM 900		33		dBm
		GSM 1800 / GSM 1900		30.		dBm
	EDGE, 4 TX	GSM 850 / E-GSM 900		27		dBm
		GSM 1800 / GSM 1900		26		dBm
RF Power @ ARP with 50Ohm Load, (**ROPR = 5**)	GPRS, 1 TX	GSM 850 / E-GSM 900		33		dBm
		GSM 1800 / GSM 1900		30		dBm
	EDGE, 1 TX	GSM 850 / E-GSM 900		27		dBm
		GSM 1800 / GSM 1900		26		dBm
	GPRS, 2 TX	GSM 850 / E-GSM 900		33		dBm
		GSM 1800 / GSM 1900		30		dBm
	EDGE, 2 TX	GSM 850 / E-GSM 900		27		dBm
		GSM 1800 / GSM 1900		26		dBm
	GPRS, 3 TX	GSM 850 / E-GSM 900		33		dBm
		GSM 1800 / GSM 1900		30.		dBm
	EDGE, 3 TX	GSM 850 / E-GSM 900		27		dBm
		GSM 1800 / GSM 1900		26		dBm
	GPRS, 4 TX	GSM 850 / E-GSM 900		31		dBm
		GSM 1800 / GSM 1900		28		dBm
	EDGE, 4 TX	GSM 850 / E-GSM 900		27		dBm
		GSM 1800 / GSM 1900		26		dBm

Table 9: RF Antenna interface GSM / UMTS

Parameter		Conditions	Min.	Typical	Max.	Unit
RF Power @ ARP with 50Ohm Load, (**ROPR = 6**)	GPRS, 1 TX	GSM 850 / E-GSM 900		33		dBm
		GSM 1800 / GSM 1900		30		dBm
	EDGE, 1 TX	GSM 850 / E-GSM 900		27		dBm
		GSM 1800 / GSM 1900		26		dBm
	GPRS, 2 TX	GSM 850 / E-GSM 900		33		dBm
		GSM 1800 / GSM 1900		30		dBm
	EDGE, 2 TX	GSM 850 / E-GSM 900		27		dBm
		GSM 1800 / GSM 1900		26		dBm
	GPRS, 3 TX	GSM 850 / E-GSM 900		33		dBm
		GSM 1800 / GSM 1900		30.		dBm
	EDGE, 3 TX	GSM 850 / E-GSM 900		27		dBm
		GSM 1800 / GSM 1900		26		dBm
	GPRS, 4 TX	GSM 850 / E-GSM 900		29		dBm
		GSM 1800 / GSM 1900		26		dBm
	EDGE, 4 TX	GSM 850 / E-GSM 900		27		dBm
		GSM 1800 / GSM 1900		26		dBm
RF Power @ ARP with 50Ohm Load, (**ROPR = 7**)	GPRS, 1 TX	GSM 850 / E-GSM 900		33		dBm
		GSM 1800 / GSM 1900		30		dBm
	EDGE, 1 TX	GSM 850 / E-GSM 900		27		dBm
		GSM 1800 / GSM 1900		26		dBm
	GPRS, 2 TX	GSM 850 / E-GSM 900		33		dBm
		GSM 1800 / GSM 1900		30		dBm
	EDGE, 2 TX	GSM 850 / E-GSM 900		27		dBm
		GSM 1800 / GSM 1900		26		dBm
	GPRS, 3 TX	GSM 850 / E-GSM 900		33		dBm
		GSM 1800 / GSM 1900		30.		dBm
	EDGE, 3 TX	GSM 850 / E-GSM 900		27		dBm
		GSM 1800 / GSM 1900		26		dBm
	GPRS, 4 TX	GSM 850 / E-GSM 900		27		dBm
		GSM 1800 / GSM 1900		24		dBm
	EDGE, 4 TX	GSM 850 / E-GSM 900		27		dBm
		GSM 1800 / GSM 1900		24		dBm

Table 9: RF Antenna interface GSM / UMTS

Parameter		Conditions	Min.	Typical	Max.	Unit
RF Power @ ARP with 50Ohm Load, (**ROPR = 8**, i.e. maximum reduction)	GPRS, 1 TX	GSM 850 / E-GSM 900		33		dBm
		GSM 1800 / GSM 1900		30		dBm
	EDGE, 1 TX	GSM 850 / E-GSM 900		27		dBm
		GSM 1800 / GSM 1900		26		dBm
	GPRS, 2 TX	GSM 850 / E-GSM 900		33		dBm
		GSM 1800 / GSM 1900		30		dBm
	EDGE, 2 TX	GSM 850 / E-GSM 900		27		dBm
		GSM 1800 / GSM 1900		26		dBm
	GPRS, 3 TX	GSM 850 / E-GSM 900		33		dBm
		GSM 1800 / GSM 1900		30.		dBm
	EDGE, 3 TX	GSM 850 / E-GSM 900		27		dBm
		GSM 1800 / GSM 1900		26		dBm
	GPRS, 4 TX	GSM 850 / E-GSM 900		27		dBm
		GSM 1800 / GSM 1900		24		dBm
	EDGE, 4 TX	GSM 850 / E-GSM 900		21		dBm
		GSM 1800 / GSM 1900		20		dBm

2.2.2   Antenna Installation

The antenna is connected by soldering the antenna pad (RF_OUT, i.e., pad #59) and its neighboring ground pads (GND, i.e., pads #58 and #60) directly to the application's PCB. The antenna pad is the antenna reference point (ARP) for EHS6. All RF data specified throughout this document is related to the ARP.
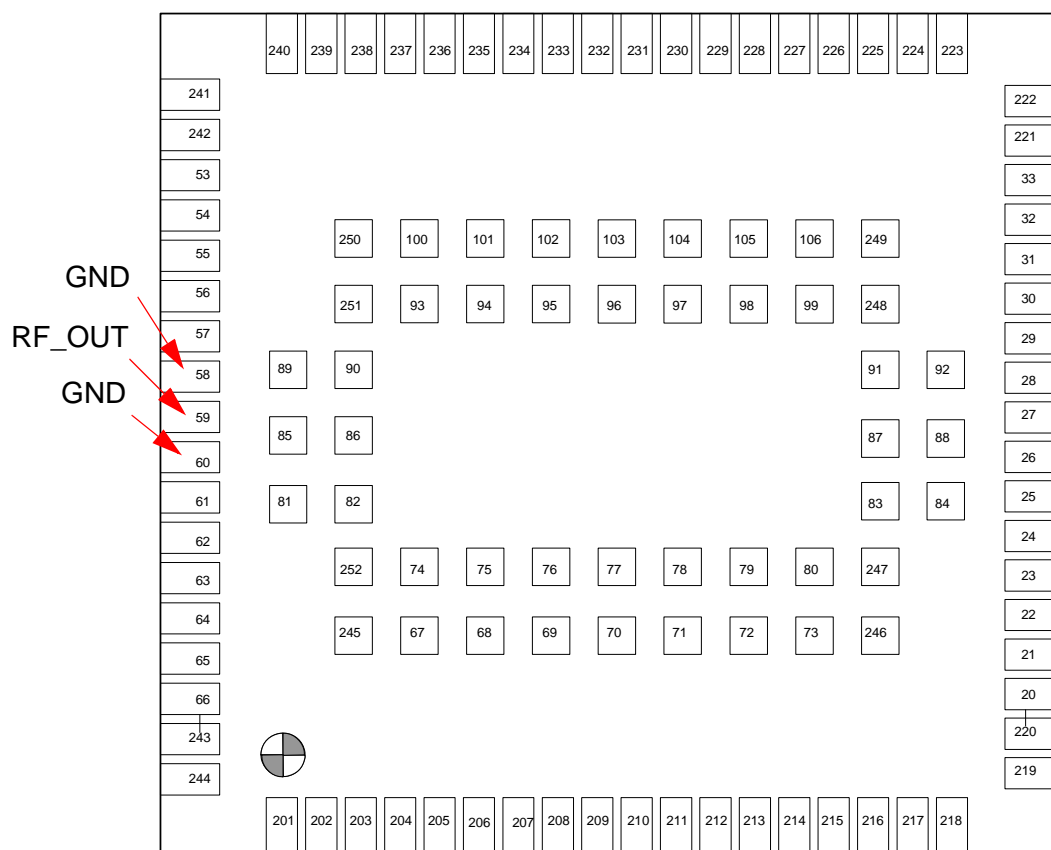
Figure 22: Antenna pads (bottom view)

The distance between the antenna RF_OUT pad (#59) and its neighboring GND pads (#58, #60) has been optimized for best possible impedance. On the application PCB, special attention should be paid to these 3 pads, in order to prevent mismatch.

The wiring of the antenna connection line, starting from the antenna pad to the application antenna should result in a 50Ω line impedance. Line width and distance to the GND plane needs to be optimized with regard to the PCB's layer stack. Some examples are given in Section 2.2.3.

To prevent receiver desensitization due to interferences generated by fast transients like high speed clocks on the application PCB, it is recommended to realize the antenna connection line using embedded Stripline rather than Micro-Stripline technology. Please see Section 2.2.3.1 for an example.

For type approval purposes, the use of a 50Ω coaxial antenna connector (U.FL-R-SMT) might be necessary. In this case the U.FL-R-SMT connector should be placed as close as possible to EHS6's antenna pad.

2.2.3 RF Line Routing Design

2.2.3.1 Line Arrangement Examples

Several dedicated tools are available to calculate line arrangements for specific applications and PCB materials - for example from http://www.polarinstruments.com/ (commercial software) or from http://web.awrcorp.com/Usa/Products/Optional-Products/TX-Line/ (free software).

Embedded Stripline
This figure below shows a line arrangement example for embedded stripline with 65µm FR4 prepreg (type: 1080) and 710µm FR4 core (4-layer PCB).
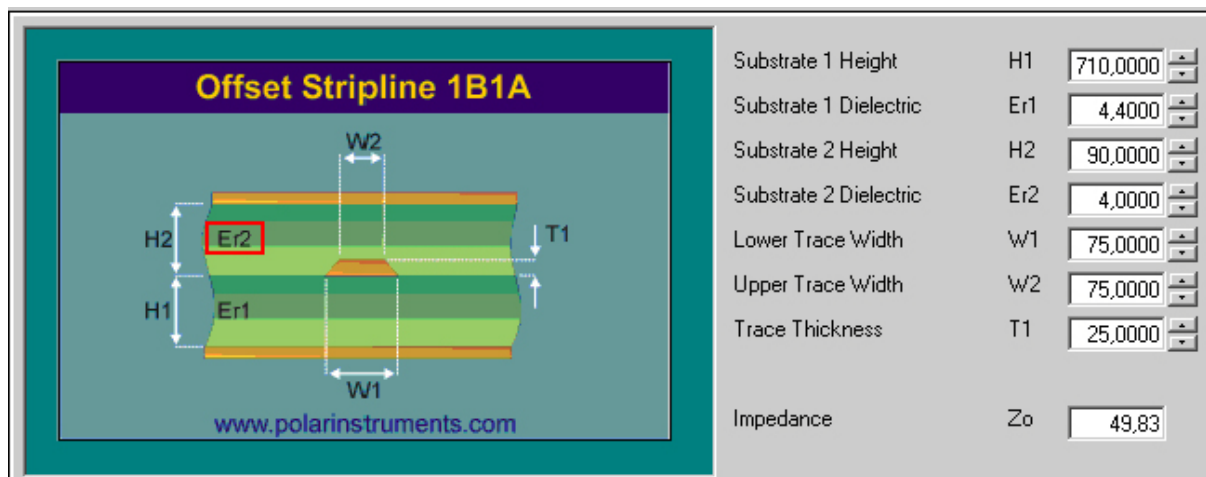
Figure 23: Embedded Stripline with 65µm prepreg (1080) and 710µm core

Micro-Stripline

This section gives two line arrangement examples for micro-stripline.

• Micro-Stripline on 1.0mm Standard FR4 2-Layer PCB
The following two figures show examples with different values for D1 (ground strip separation).

Substrate 1 Height	H1	1000,000
Substrate 1 Dielectric	Er1	4,4000
Lower Trace Width	W1	800,0000
Upper Trace Width	W2	800,0000
Ground Strip Separation	D1	185,0000
Trace Thickness	T1	25,0000
Coating Above Substrate	C1	15,0000
Coating Above Trace	C2	15,0000
Coating Dielectric	CEr	4,0000
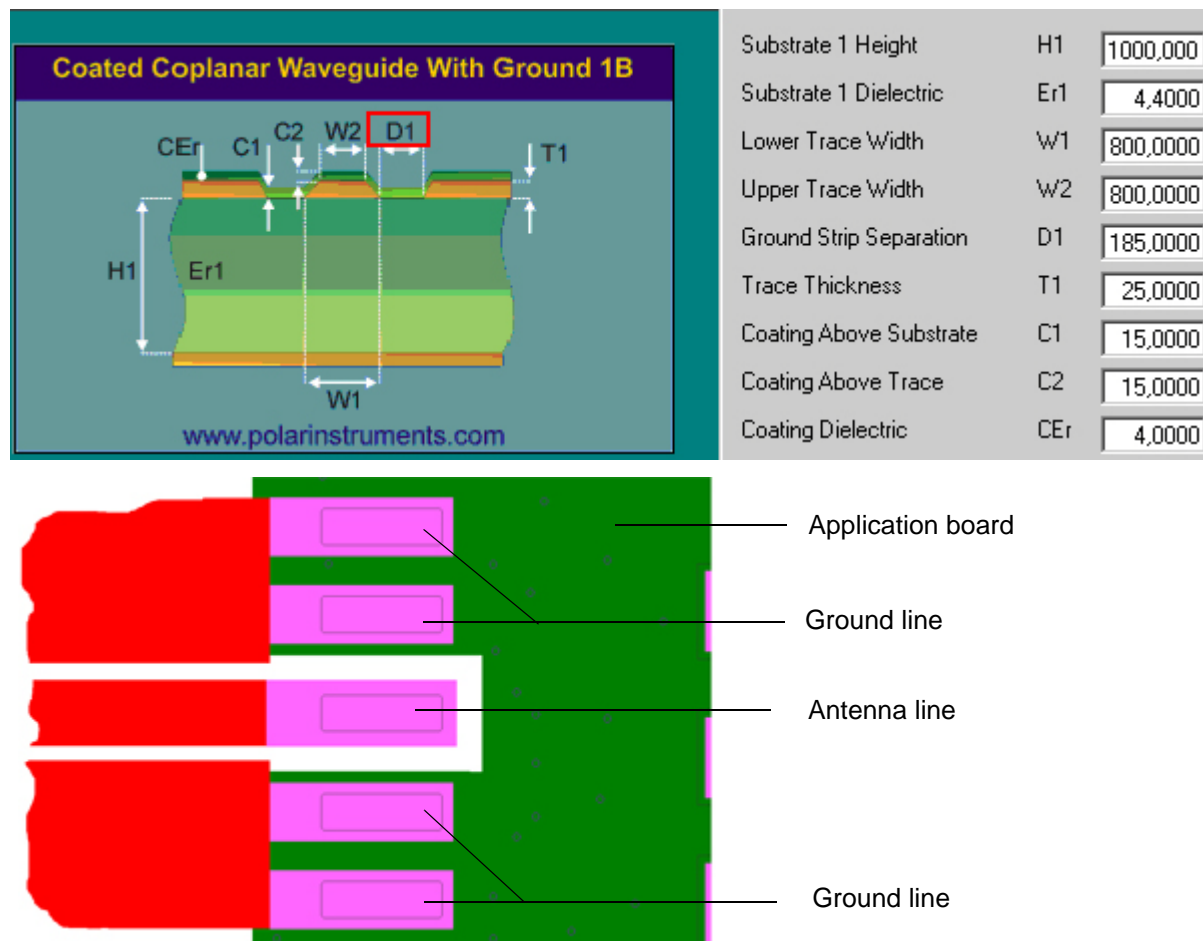
Figure 24: Micro-Stripline on 1.0mm standard FR4 2-layer PCB - example 1

Coated Coplanar Waveguide With Ground 1B

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Substrate 1 Height	H1	1000,000
Substrate 1 Dielectric	Er1	4,4000
Lower Trace Width	W1	1050,000
Upper Trace Width	W2	1050,000
Ground Strip Separation	D1	275,0000
Trace Thickness	T1	25,0000
Coating Above Substrate	C1	15,0000
Coating Above Trace	C2	15,0000
Coating Dielectric	CEr	4,0000

Application board

Ground line

Antenna line

Ground line
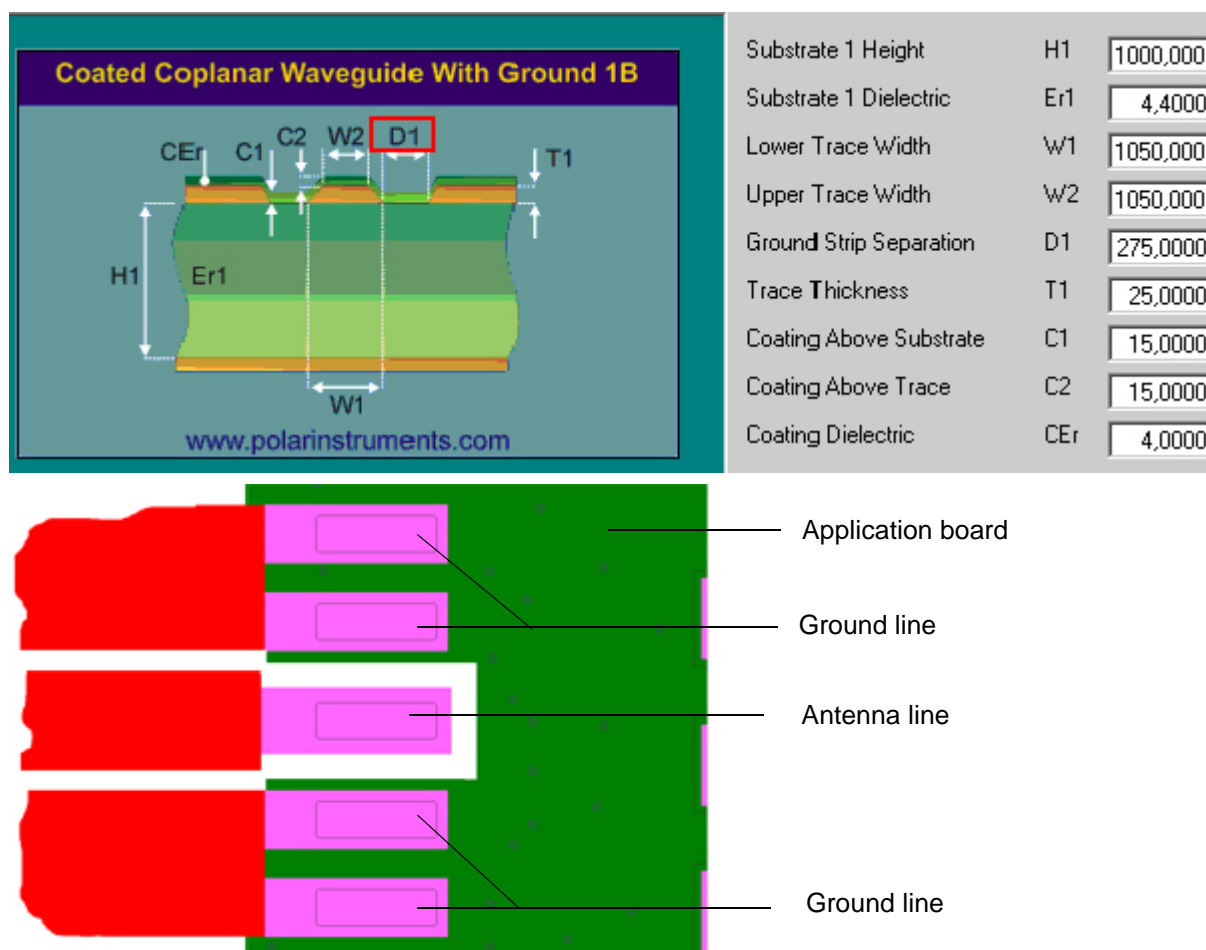
Figure 25: Micro-Stripline on 1.0mm Standard FR4 PCB - example 2

- Micro-Stripline on 1.5mm Standard FR4 2-Layer PCB
  The following two figures show examples with different values for D1 (ground strip separation).
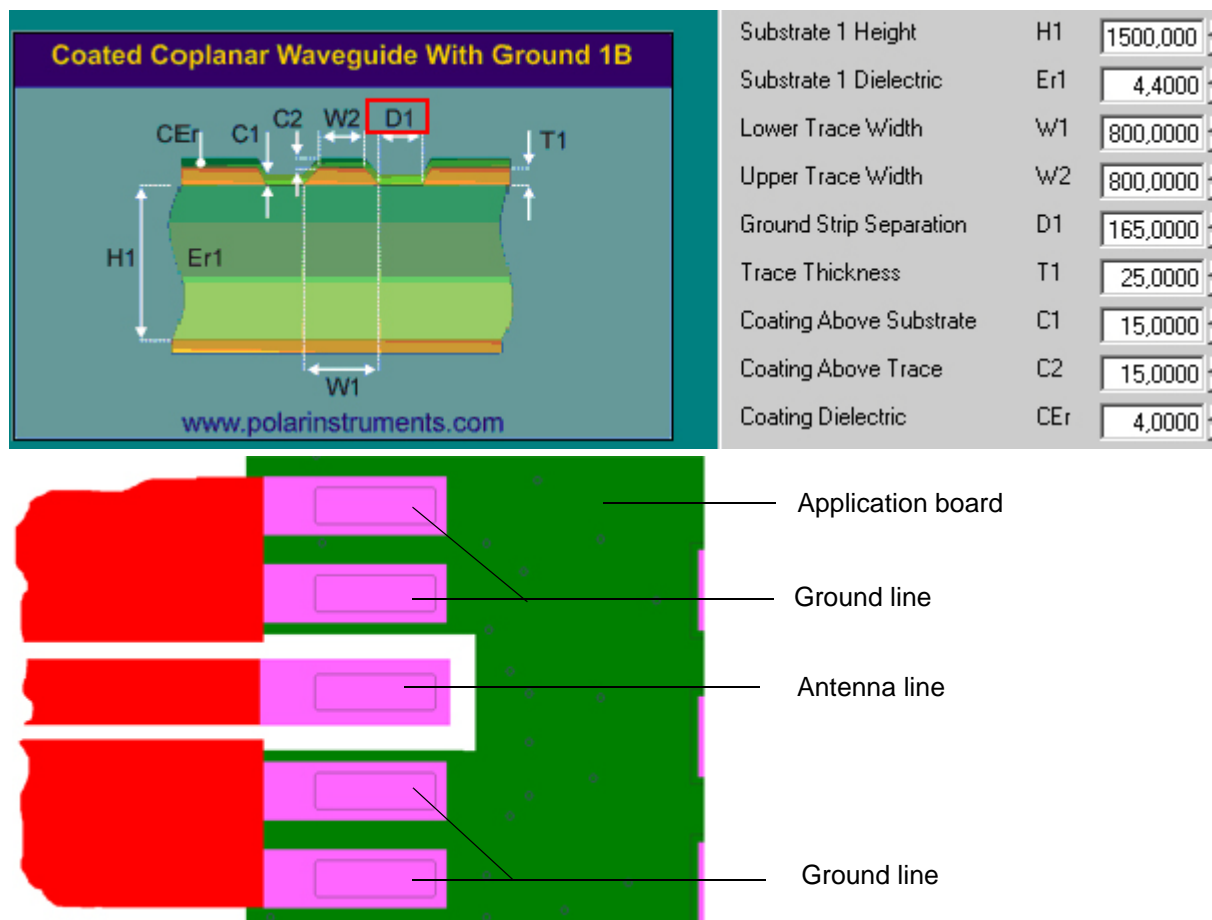
Figure 26: Micro-Stripline on 1.5mm Standard FR4 PCB - example 1

Coated Coplanar Waveguide With Ground 1B

Substrate 1 Height	H1	1500,000
Substrate 1 Dielectric	Er1	4,4000
Lower Trace Width	W1	1150,000
Upper Trace Width	W2	1150,000
Ground Strip Separation	D1	225,0000
Trace Thickness	T1	25,0000
Coating Above Substrate	C1	15,0000
Coating Above Trace	C2	15,0000
Coating Dielectric	CEr	4,0000

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Application board

Ground line

Antenna line

Ground line
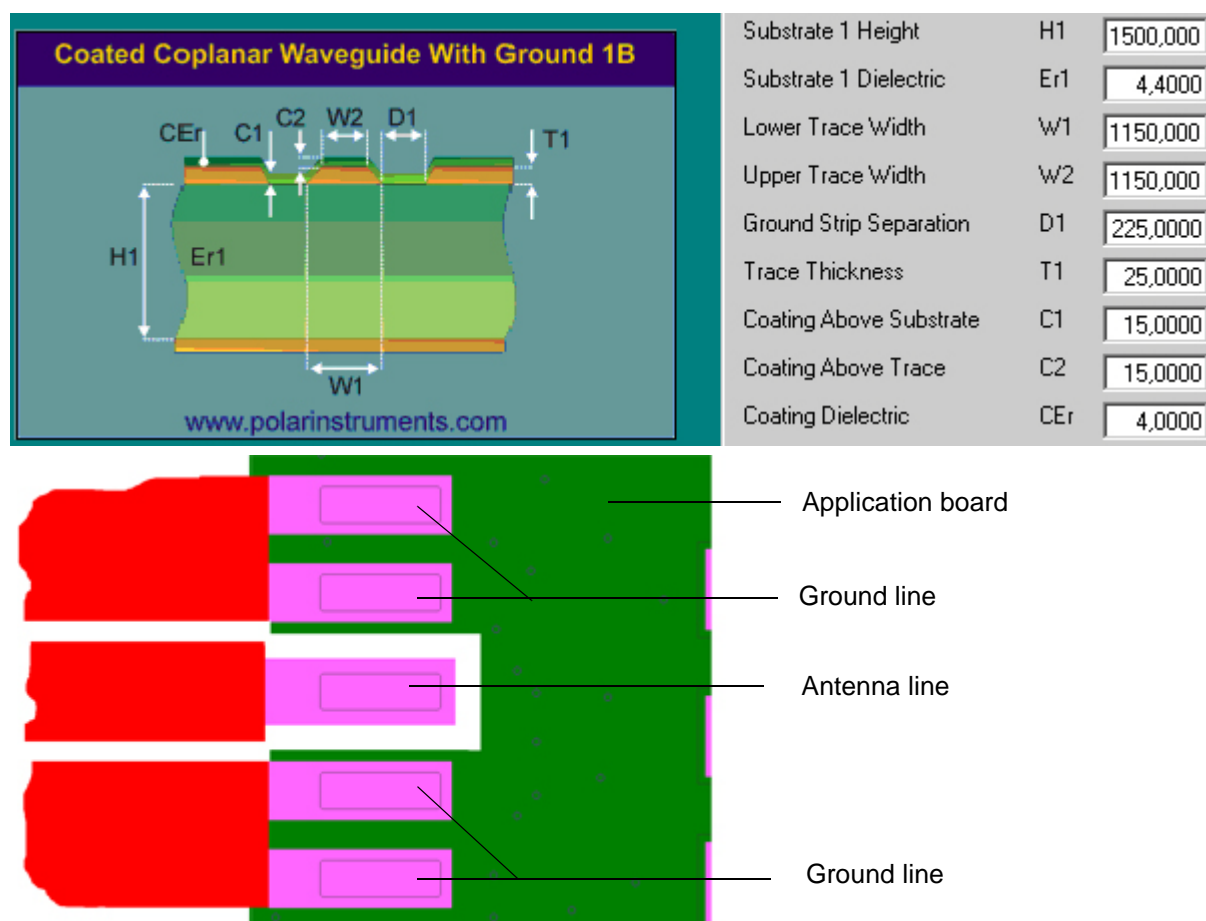
Figure 27: Micro-Stripline on 1.5mm Standard FR4 PCB - example 2

2.2.3.2   Routing Example

Interface to RF Connector
Figure 28 shows the connection of the module's antenna pad with an application PCB's coaxial antenna connector. Please note that the EHS6 bottom plane appears mirrored, since it is viewed from EHS6 top side. By definition the top of customer's board shall mate with the bottom of the EHS6 module.

TBD.

Figure 28: Routing to application's RF connector - top view

2.3 Sample Application

Figure 29 shows a typical example of how to integrate a EHS6 module with an application. Usage of the various host interfaces depends on the desired features of the application.

Because of the very low power consumption design, current flowing from any other source into the module circuit must be avoided, for example reverse current from high state external control lines. Therefore, the controlling application must be designed to prevent reverse current flow. Otherwise there is the risk of undefined states of the module during startup and shutdown or even of damaging the module.

Because of the high RF field density inside the module, it cannot be guaranteed that no self interference might occur, depending on frequency and the applications grounding concept. The potential interferers may be minimized by placing small capacitors (47pF) at suspected lines (e.g. RXD0, RXT0, VDDLP, and ON).

While developing SMT applications it is strongly recommended to provide test points for certain signals resp. lines to and from the module - for debug and/or test purposes. The SMT application should allow for an easy access to these signals. For details on how to implement test points see [3].

The EMC measures are best practice recommendations. In fact, an adequate EMC strategy for an individual application is very much determined by the overall layout and, especially, the position of components. For example, mounting the internal acoustic transducers directly on the PCB eliminates the need to use the ferrite beads shown in the sample schematic.

Please note that EHS6 is not intended for use with cables longer than 3m.

Disclaimer
No warranty, either stated or implied, is provided on the sample schematic diagram shown in Figure 29 and the information detailed in this section. As functionality and compliance with national regulations depend to a great amount on the used electronic components and the individual application layout manufacturers are required to ensure adequate design and operating safeguards for their products using EHS6 modules.
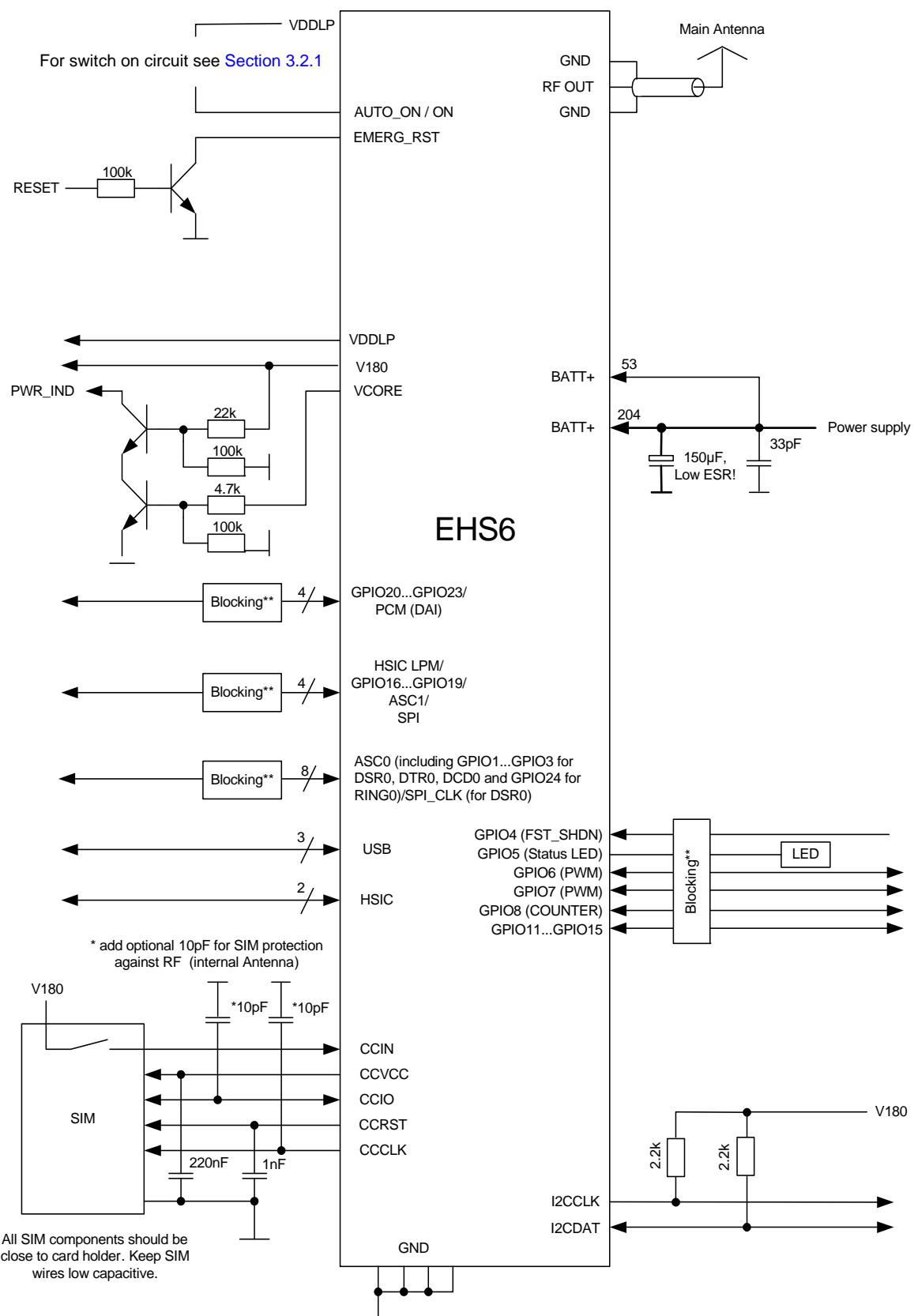
Figure 29: Schematic diagram of EHS6 sample application

Blocking** = For more details see Section 3.6.2

3 Operating Characteristics

3.1 Operating Modes

The table below briefly summarizes the various operating modes referred to throughout the document.

Table 10: Overview of operating modes

Mode	Function	
Normal operation	GSM / GPRS / UMTS / HSPA SLEEP	Power saving set automatically when no call is in progress and the USB connection is suspended by host or not present and no active communication via ASC0.
	GSM / GPRS / UMTS / HSPA IDLE	Power saving disabled or an USB connection not suspended, but no call in progress.
	GSM TALK/ GSM DATA	Connection between two subscribers is in progress. Power consumption depends on the GSM network coverage and several connection settings (e.g. DTX off/on, FR/EFR/HR, hopping sequences and antenna connection). The following applies when power is to be measured in TALK_GSM mode: DTX off, FR and no frequency hopping.
	GPRS DATA	GPRS data transfer in progress. Power consumption depends on network settings (e.g. power control level), uplink / downlink data rates and GPRS configuration (e.g. used multislot settings).
	EGPRS DATA	EGPRS data transfer in progress. Power consumption depends on network settings (e.g. power control level), uplink / downlink data rates and EGPRS configuration (e.g. used multislot settings).
	UMTS TALK/ UMTS DATA	UMTS data transfer in progress. Power consumption depends on network settings (e.g. TPC Pattern) and data transfer rate.
	HSPA DATA	HSPA data transfer in progress. Power consumption depends on network settings (e.g. TPC Pattern) and data transfer rate.
Power Down	Normal shutdown after sending the power down command. Only a voltage regulator is active for powering the RTC. Software is not active. Interfaces are not accessible. Operating voltage (connected to BATT+) remains applied.	
Airplane mode	Airplane mode shuts down the radio part of the module, causes the module to log off from the GSM/GPRS network and disables all AT commands whose execution requires a radio connection. Airplane mode can be controlled by AT command (see [1]).	

3.2   Power Up/Power Down Scenarios

In general, be sure not to turn on EHS6 while it is beyond the safety limits of voltage and temperature stated in Section 2.1.2.1. EHS6 would immediately switch off after having started and detected these inappropriate conditions. In extreme cases this can cause permanent damage to the module.

3.2.1   Turn on EHS6

EHS6 can be started as described in the following sections:
- Hardware driven switch on by (continuous) AUTO_ON line: Starts Normal mode (see Section 3.2.1.1 and Section 3.2.1.2). It is recommended to employ the AUTO_ON line as module startup signal.
- Hardware driven switch on by ON line: Starts Normal mode (see Section 3.2.1.3).

After startup or restart, the module will send the URC ^SYSSTART that notifies the host application that the first AT command can be sent to the module (see also [1]).

3.2.1.1 Switch on EHS6 Using AUTO_ON Signal

When the operating voltage BATT+ is applied, EHS6 can also be switched on by means of the AUTO_ON signal.

The AUTO_ON signal is a low level sensitive signal and only allows the input voltage level of the VDDLP signal. The module starts into normal mode with AUTO_ON at a continuously low level. Please note that BATT+ should be active and stable before the low level at the AUTO_ON signal is applied.

The following Figure 30 shows an example for a switch-on circuit, Figure 31 shows the AUTO_ON signal timing.
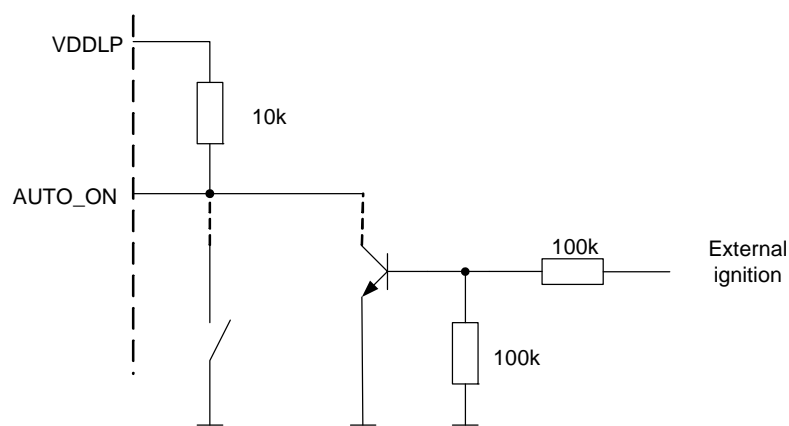
Figure 30: AUTO_ON circuit sample

It is recommended to use a 10k Ohm pull up resistor at the AUTO_ON pad.The 10kOhm pull up resistor may be required in an electrically noisy environment.
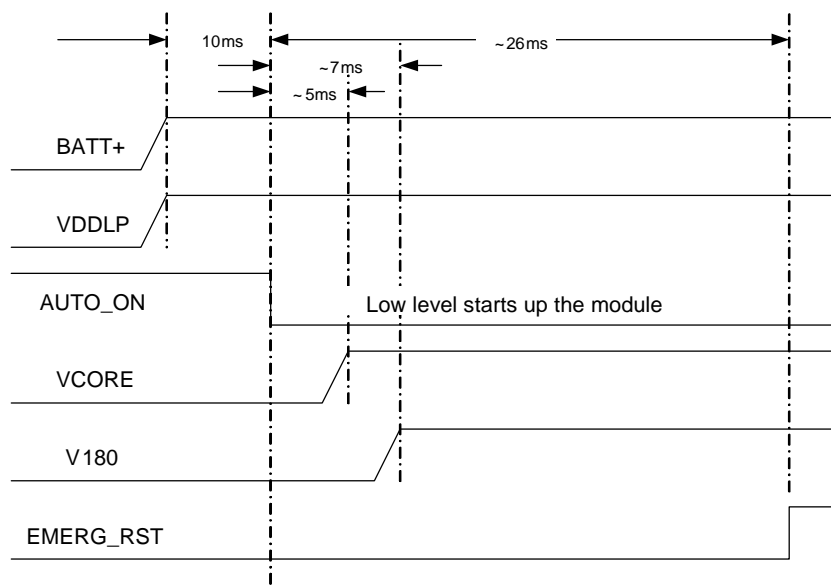
Figure 31: AUTO_ON signal timing

3.2.1.2   Switch on EHS6 Using a Continuous AUTO_ON Signal

In case the AUTO_ON signal is permanently connected to ground (i.e., low level) the module will start up if the operating voltage BATT+ is applied with a rise time of less than 1ms between 2.5V to 3.2V.

The following Figure 32 shows this startup behavior if employing the AUTO_ON signal.
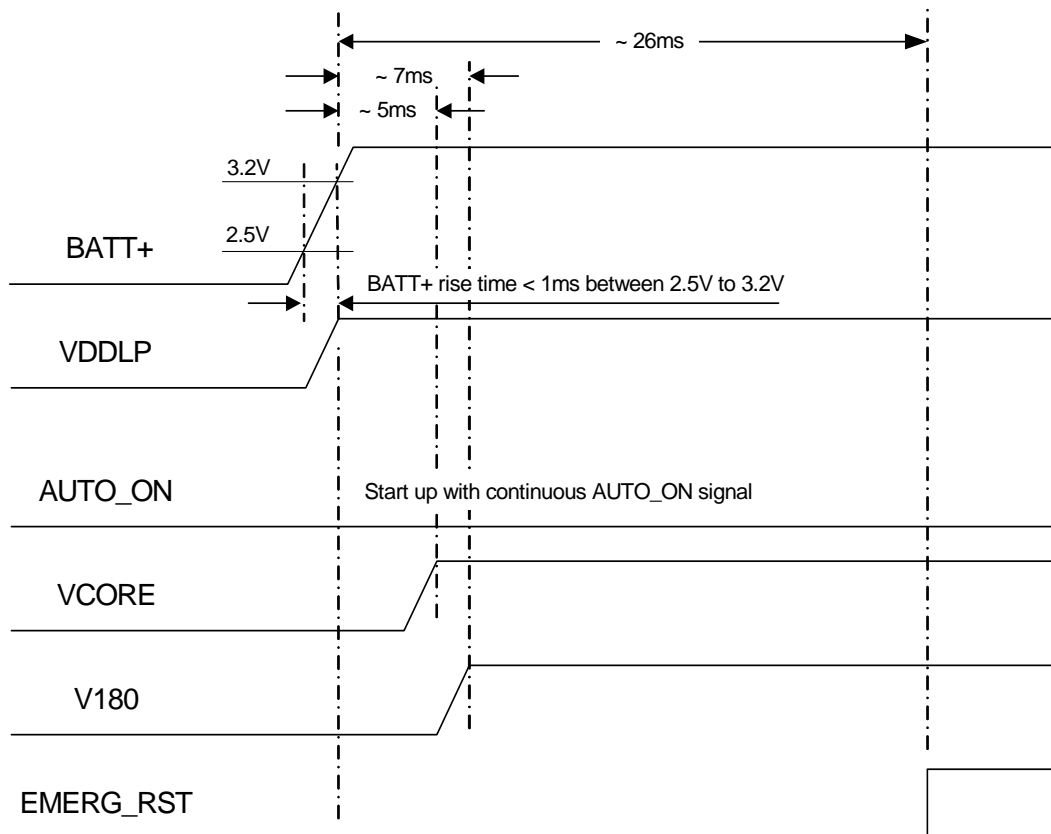
Figure 32: AUTO_ON timing

3.2.1.3 Switch on EHS6 Using ON Signal

When the operating voltage BATT+ is applied, EHS6 can be switched on by means of the ON signal.

The ON signal is a level, i.e., high pulse triggered signal and only allows the input voltage level of the VDDLP signal. The module starts into normal mode on detecting a high pulse at the ON signal. The high pulse width should be between a minimum of 50μs and a maximum of 80μs.

The following Figure 33 shows recommendations for a possible switch-on circuit.
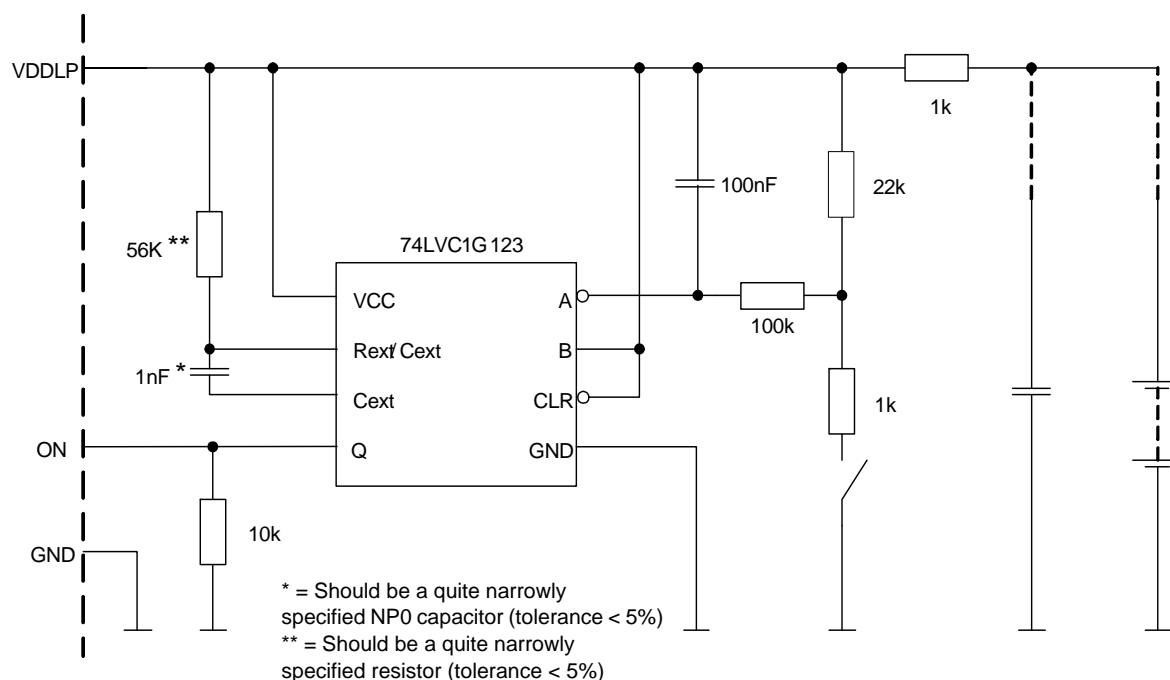
Figure 33: ON circuit options

It is recommended to set a serial 1kOhm resistor between the ON circuit and the external capacitor or battery at the VDDLP power supply. This serial resistor protection is necessary in case the capacitor or battery has low power (is empty).

The above ON circuit with the monostable multivibrator 74LVC1G123 as component generates a high pulse with a pulse width of typically 60μs.

Please note that BATT+ and VDDLP should be active at least 10ms before the high pulse at the ON signal is applied to start up the module. After module startup the ON signal should always be set to low to prevent possible back powering at this line.
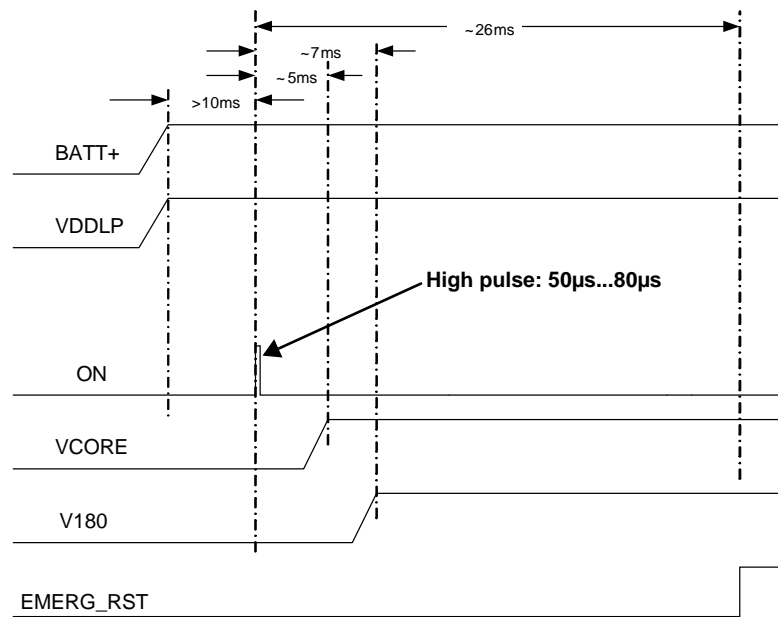
Figure 34: ON timing

3.2.2 Restart EHS6

After startup EHS6 can be re-started as described in the following sections:
- Software controlled reset by AT+CFUN command: Starts Normal mode (see Section 3.2.2.1).
- Hardware controlled reset by EMERG_RST line: Starts Normal mode (see Section 3.2.2.2)

3.2.2.1 Restart EHS6 via AT+CFUN Command

To reset and restart the EHS6 module use the command AT+CFUN. See [1] for details.

3.2.2.2 Restart EHS6 Using EMERG_RST

The EMERG_RST signal is internally connected to the central GSM processor. A low level for more than 10ms sets the processor and with it all the other signal pads to their respective reset state. The reset state is described in Section 3.2.3 as well as in the figures showing the startup behavior of an interface.

After releasing the EMERG-RST line, i.e., with a change of the signal level from low to high, the module restarts. The other signals continue from their reset state as if the module was switched on by the AUTO_ON or ON signal.
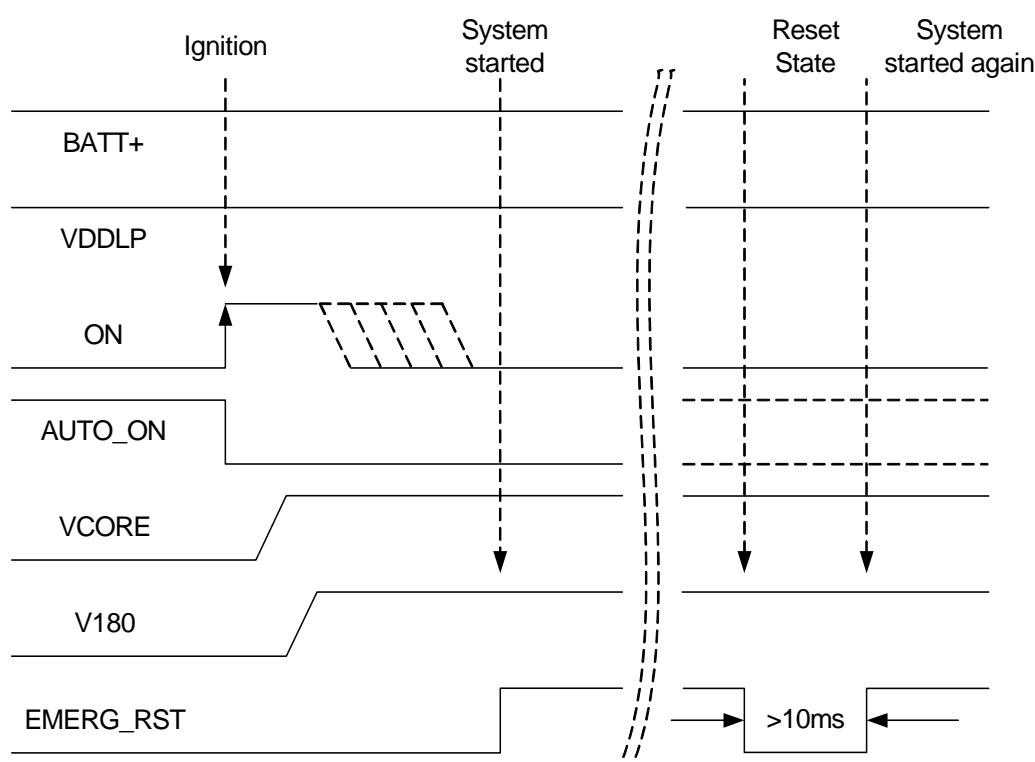
Figure 35: Emergency restart timing

It is recommended to control this EMERG_RST line with an open collector transistor or an open drain field-effect transistor.

Caution: Use the EMERG_RST line only when, due to serious problems, the software is not responding for more than 5 seconds. Pulling the EMERG_RST line causes the loss of all information stored in the volatile memory. Therefore, this procedure is intended only for use in case of emergency, e.g. if EHS6 does not respond, if reset or shutdown via AT command fails.

3.2.3   Signal States after Startup

Table 11 lists the states each interface signal passes through during reset and the firmware's first startup initialization. For further firmware startup initializations the values may differ because of different GPIO line configurations.

The reset state is reached with the rising edge of the EMERG_RST signal - either after a normal module startup (see Section 3.2.1.3) or after a reset (see Section 3.2.2.2). After the reset state has been reached the firmware initialization state begins. The firmware initialization is completed as soon as the ASC0 interface line CTS0 has turned low (see Section 2.1.4). Now, the module is ready to receive and transmit data.

Table 11: Signal states

Signal name	Reset state	First start up configuration
CCIO	L	O / L
CCRST	L	O / L
CCCLK	L	O / L
CCIN	T / 100k PD	I / 100k PD
RXD0	T / PU	O / H
TXD0	T / PD	I
CTS0	T / PU	O / H
RTS0	T / PU	I / PD
DTR0 / GPIO1	T / PD	I
DCD0 / GPIO2	T / PD	O / PU
DSR0 / GPIO3 / SPI_CLK	T / PD	O / PU
GPIO4 / FST_SHDN	T / PD	T / H
GPIO5 / Status LED	O / L	T / PD
GPIO6 / PWM2	O / L	T / PD
GPIO7 / PWM1	O / L	T / PD
GPIO8	O / L	T / PD
GPIO11-GPIO15	O / L	T / PD
AP_WAKEUP / GPIO16 / RXD1 / MOSI	T / PD	T / PD
HOST_ACTIVE / GPIO17 / TXD1 / MISO	T / PD	T / PD
CP_WAKEUP / GPIO18 / RTS1	T / PD	T / PD
SUSPEND / GPIO19 / CTS1 / SPI_CS	T / PD	T / PD
GPIO20 / TXDDAI	T / PD	T / PD
GPIO21 / RXDDAI	T / PD	T / PD
GPIO22 / TFSDAI	T / PD	T / PD
GPIO23 / SCLK	T / PD	T / PD
RING0 / GPIO24	T / PD	O / PU
I2CCLK	T	T / OD
I2CDAT	T	T / OD

Abbreviations used in above Table 11:

L = Low level H = High level T = Tristate I = Input	O = Output OD = Open Drain PD = Pull down, 200µA at 1.9V PU = Pull up, -240µA at 0V

3.2.4   Turn off EHS6

To switch the module off the following procedures may be used:
- *Software controlled shutdown procedure*: Software controlled by sending an AT command over the serial application interface. See Section 3.2.4.1.
- *Hardware controlled shutdown procedure*: Hardware controlled by disconnecting the module's power supply lines BATT+. See Section 3.2.4.2.
- *Automatic shutdown (software controlled)*: See Section 3.2.5
  - Takes effect if EHS6 board temperature exceeds a critical limit.

3.2.4.1   Switch off EHS6 Using AT Command

The best and safest approach to powering down EHS6 is to issue the appropriate AT command. This procedure lets EHS6 log off from the network and allows the software to enter into a secure state and safe data before disconnecting the power supply. The mode is referred to as Power Down mode. In this mode, only the RTC stays active.

Be sure not to disconnect the operating voltage V_{BATT+} before V180 pad has gone low. Otherwise you run the risk of losing data.

While EHS6 is in Power Down mode the application interface is switched off and must not be fed from any other voltage source. Therefore, your application must be designed to avoid any current flow into any digital pads of the application interface.
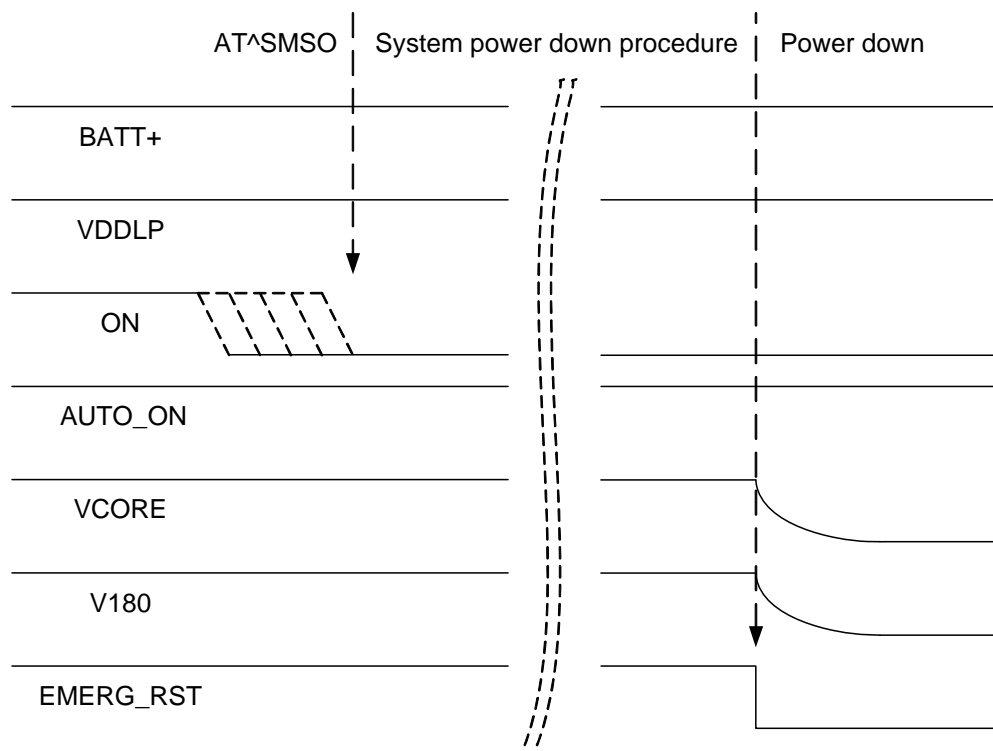
Figure 36: Switch off behavior

3.2.4.2 Disconnect EHS6 BATT+ Lines

Figure 37 shows an external application circuit that provides the possibility to temporarily (>100ms) disconnect the module's BATT+ lines from the external application's power supply. The mentioned MOSFET transistor (T8) should have an R_{DS_ON} value ≤ 50mOhm in order to minimize voltage drops. Such a circuit could be useful to maximize power savings for battery driven applications or to completely switch off and restart the module after a firmware update.

Afterwards the module can be restarted as described in Section 3.2.1.
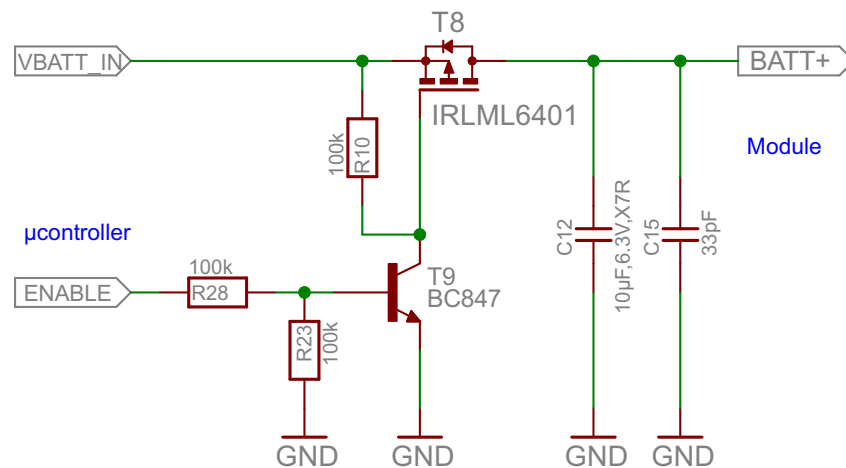
Figure 37: Restart circuit using BATT+ line

3.2.5 Automatic Shutdown

Automatic shutdown takes effect if the following event occurs:
- EHS6 board is exceeding the critical limits of overtemperature or undertemperature (see Section 3.2.5.1)

The automatic shutdown procedure is equivalent to the power-down initiated with an AT command, i.e. EHS6 logs off from the network and the software enters a secure state avoiding loss of data.

3.2.5.1 Thermal Shutdown

The board temperature is constantly monitored by an internal NTC resistor located on the PCB. The values detected by the NTC resistor are measured directly on the board and therefore, are not fully identical with the ambient temperature.

Each time the board temperature goes out of range or back to normal, EHS6 instantly displays an alert (if enabled).
- URCs indicating the level "1" or "-1" allow the user to take appropriate precautions, such as protecting the module from exposure to extreme conditions. The presentation of the URCs depends on the settings selected with the AT^SCTM write command (for details see [1]):
  AT^SCTM=1: Presentation of URCs is always enabled.
  AT^SCTM=0 (default): Presentation of URCs is enabled during the 2 minute guard period after start-up of EHS6. After expiry of the 2 minute guard period, the presentation of URCs will be disabled, i.e. no URCs with alert levels "1" or "-1" will be generated.
- URCs indicating the level "2" or "-2" are instantly followed by an orderly shutdown. The presentation of these URCs is always enabled, i.e. they will be output even though the factory setting AT^SCTM=0 was never changed.

The maximum temperature ratings are stated in Section 3.5. Refer to Table 12 for the associated URCs.

Table 12: Temperature dependent behavior

Sending temperature alert (2min after EHS6 start-up, otherwise only if URC presentation enabled)	
^SCTM_B: 1	Board close to overtemperature limit.
^SCTM_B: -1	Board close to undertemperature limit.
^SCTM_B: 0	Board back to non-critical temperature range.
Automatic shutdown (URC appears no matter whether or not presentation was enabled)	
^SCTM_B: 2	Alert: Board equal or beyond overtemperature limit. EHS6 switches off.
^SCTM_B: -2	Alert: Board equal or below undertemperature limit. EHS6 switches off.

3.3 Power Saving

EHS6 can be configured in two ways to control power consumption:

- Using the AT command AT^SPOW it is possible to specify a so-called power saving mode for the module (<mode> = 2; for details on the command see [1]). The module's UART interfaces (ASC0 and ASC1) are then deactivated and will only periodically be activated to be able to listen to network paging messages as described in Section 3.3.1 and Section 3.3.2.

  Please note that the AT^SPOW setting has no effect on the USB interface. As long as the USB connection is active, the module will not change into its SLEEP state to reduce its functionality to a minimum and thus minimizing its current consumption. To enable switching into SLEEP mode, the USB connection must therefore either not be present at all or the USB host must bring its USB interface into Suspend state. Also, VUSB_IN should always be kept enabled for this functionality. See "Universal Serial Bus Specification Revision 2.0"[1] for a description of the Suspend state.

- Using the AT command AT^SCFG="Radio/OutputPowerReduction" it is possible for the module in GPRS and EGPRS multislot scenarios to reduce its output power according to 3GPP 45.005 section. By default a maximum power reduction is enabled. For details on the command see [1].

3.3.1 Power Saving while Attached to GSM Networks

The power saving possibilities while attached to a GSM network depend on the paging timing cycle of the base station. The duration of a power saving interval can be calculated using the following formula:

t = 4.615 ms (TDMA frame duration) * 51 (number of frames) * DRX value.

DRX (Discontinuous Reception) is a value from 2 to 9, resulting in paging intervals between 0.47 and 2.12 seconds. The DRX value of the base station is assigned by the GSM network operator.

In the pauses between listening to paging messages, the module resumes power saving, as shown in Figure 38.

Figure 38: Power saving and paging in GSM networks

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1. The specification is ready for download on http://www.usb.org/developers/docs/

The varying pauses explain the different potential for power saving. The longer the pause the less power is consumed.

Generally, power saving depends on the module's application scenario and may differ from the above mentioned normal operation. The power saving interval may be shorter than 0.47 seconds or longer than 2.12 seconds.

3.3.2 Power Saving while Attached to WCDMA Networks

The power saving possibilities while attached to a WCDMA network depend on the paging timing cycle of the base station.

During normal WCDMA operation, i.e., the module is connected to a WCDMA network, the duration of a power saving period varies. It may be calculated using the following formula:

$t = 2^{DRX\ value} * 10$ ms (WCDMA frame duration).

DRX (Discontinuous Reception) in WCDMA networks is a value between 6 and 9, thus resulting in power saving intervals between 0.64 and 5.12 seconds. The DRX value of the base station is assigned by the WCDMA network operator.

In the pauses between listening to paging messages, the module resumes power saving, as shown in Figure 39.
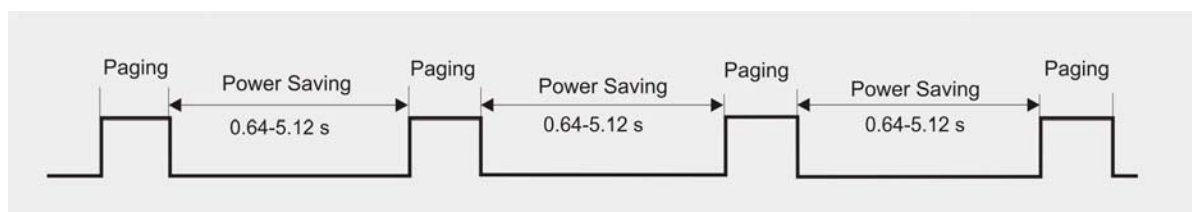
Figure 39: Power saving and paging in WCDMA networks

The varying pauses explain the different potential for power saving. The longer the pause the less power is consumed.

Generally, power saving depends on the module's application scenario and may differ from the above mentioned normal operation. The power saving interval may be shorter than 0.64 seconds or longer than 5.12 seconds.

3.4 Power Supply

EHS6 needs to be connected to a power supply at the SMT application interface (2 lines each BATT+ and GND).

The power supply of EHS6 has to be a single voltage source at BATT+. It must be able to provide the peak current during the uplink transmission.

All the key functions for supplying power to the device are handled by the power management section of the analog controller. This IC provides the following features:

- Stabilizes the supply voltages for the baseband using low drop linear voltage regulators and a DC-DC step down switching regulator.
- Switches the module's power voltages for the power-up and -down procedures.
- SIM switch to provide SIM power supply.

3.4.1 Power Supply Ratings

Table 13 and Table 14 assemble various voltage supply and current consumption ratings of the module.

Table 13: Voltage supply ratings

	Description	Conditions	Min	Typ	Max	Unit
BATT+	Supply voltage	Directly measured at Module. Voltage must stay within the min/max values, including voltage drop, ripple, spikes	3.3		4.5	V
	Maximum allowed voltage drop during transmit burst	Normal condition, power control level for Pout max			400	mV
	Voltage ripple	Normal condition, power control level for Pout max @ f <= 250 kHz @ f > 250 kHz			190 30	mV_{pp} mV_{pp}

3.4 Power Supply

Table 14: Current consumption ratings

	Description	Conditions		Typical rating	Unit
I_{VDDLP} @ 3V	OFF State supply current	RTC backup @ BATT+ = 0V		2	µA
I_{BATT+}[1]	OFF State supply current	POWER DOWN		60	µA
	Average GSM / GPRS supply current	SLEEP[2] @ DRX=9 (UART deactivated)	USB disconnected	1.1	mA
			USB suspended	1.1	mA
		SLEEP[2] @ DRX=5 (UART deactivated)	USB disconnected	1.3	mA
			USB suspended	1.3	mA
		SLEEP[2] @ DRX=2 (UART deactivated)	USB disconnected	1.6	mA
			USB suspended	1.6	mA
		IDLE @ DRX=2 (UART activated, but no communication)	USB disconnected	14	mA
			USB active	36	mA
		Voice Call GSM850/900; PCL=5		245	mA
		GPRS Data transfer GSM850/900; PCL=5; 1Tx/4Rx	ROPR=4 (max. reduction)	240	mA
			ROPR=0 (no reduction)		
		GPRS Data transfer GSM850/900; PCL=5; 2Tx/3Rx	ROPR=4 (max. reduction)	310	mA
			ROPR=0 (no reduction)	430	mA
		GPRS Data transfer GSM850/900; PCL=5; 4Tx/1Rx	ROPR=4 (max. reduction)	330	mA
			ROPR=0 (no reduction)	790	mA

3.4 Power Supply

Table 14: Current consumption ratings

	Description	Conditions		Typical rating	Unit
I_{BATT+} [1]	Average GSM / GPRS supply current	EDGE Data transfer GSM850/900; PCL=5; 1Tx/4Rx	ROPR=4 (max. reduction)	170	mA
			ROPR=0 (no reduction)		
		EDGE Data transfer GSM850/900; PCL=5; 2Tx/3Rx	ROPR=4 (max. reduction)	230	mA
			ROPR=0 (no reduction)	295	mA
		EDGE Data transfer GSM850/900; PCL=5; 4Tx/1Rx	ROPR=4 (max. reduction)	360	mA
			ROPR=0 (no reduction)	515	mA
		Voice Call GSM1800/1900; PCL=0		180	mA
		GPRS Data transfer GSM1800/1900; PCL=0; 1Tx/4Rx	ROPR=4 (max. reduction)	180	mA
			ROPR=0 (no reduction)		
		GPRS Data transfer GSM1800/1900; PCL=0; 2Tx/3Rx	ROPR=4 (max. reduction)	200	mA
			ROPR=0 (no reduction)	310	mA
		GPRS Data transfer GSM1800/1900; PCL=0; 4Tx/1Rx	ROPR=4 (max. reduction)	240	mA
			ROPR=0 (no reduction)	550	mA
		EDGE Data transfer GSM1800/1900; PCL=0; 1Tx/4Rx	ROPR=4 (max. reduction)	150	mA
			ROPR=0 (no reduction)		
		EDGE Data transfer GSM1800/1900; PCL=0; 2Tx/3Rx	ROPR=4 (max. reduction)	220	mA
			ROPR=0 (no reduction)	250	mA
		EDGE Data transfer GSM1800/1900; PCL=0; 4Tx/1Rx	ROPR=4 (max. reduction)	350	mA
			ROPR=0 (no reduction)	430	mA
	Peak current during GSM transmit burst	VOICE Call GSM850/900; PCL=5	@ 50Ohm	1.6	A
			@ total mismatch	2.3	A
		VOICE Call GSM1800/1900; PCL=0	@ 50Ohm	1.1	A
			@ total mismatch	1.4	A

Table 14: Current consumption ratings

	Description	Conditions		Typical rating	Unit
I_{BATT+}[1]	Average WCDMA supply current	SLEEP[2] @ DRX=9 (UART deactivated)	USB disconnected	1.3	mA
			USB suspended	1.4	mA
		SLEEP[2] @ DRX=8 (UART deactivated)	USB disconnected	1.3	mA
			USB suspended	1.4	mA
		SLEEP[2] @ DRX=6 (UART deactivated)	USB disconnected	1.9	mA
			USB suspended	2.0	mA
		IDLE @ DRX=6 (UART active, but no communication)	USB disconnected	13	mA
			USB active	35	mA
		Voice Call Band I; 24dBm		570	mA
		Voice Call Band II; 24dBm		620	mA
		Voice Call Band V/VI; 24dBm		590	mA
		Voice Call Band VIII; 24dBm		600	mA
		UMTS Data transfer Band I @+24dBm		500	mA
		UMTS Data transfer Band II @+24dBm		550	mA
		UMTS Data transfer Band V/VI @+24dBm		550	mA
		UMTS Data transfer Band VIII @+24dBm		580	mA
		HSPA Data transfer Band I @+24dBm		500	mA
		HSPA Data transfer Band II @+24dBm		550	mA
		HSPA Data transfer Band V/VI @+24dBm		550	mA
		HSPA Data transfer Band VIII @+24dBm		580	mA

1. With an impedance of Z_{LOAD}=50Ohm at the antenna connector.
2. Measurements start 6 minutes after switching ON the module,
   Averaging times: SLEEP mode - 3 minutes, transfer modes - 1.5 minutes
   Communication tester settings: no neighbour cells, no cell reselection etc., RMC (reference measurement channel)

3.4.2   Minimizing Power Losses

When designing the power supply for your application please pay specific attention to power losses. Ensure that the input voltage V_{BATT+} never drops below 3.3V on the EHS6 board, not even in a GSM transmit burst where current consumption can rise (for peaks values see the power supply ratings listed in Section 3.4.1). It should be noted that EHS6 switches off when exceeding these limits. Any voltage drops that may occur in a transmit burst should not exceed 400mV.

The module switches off if the minimum battery voltage ($V_{BattMin}$) is reached.

Example:
$V_{BattLowLimit}$ = 3.3V
$D_{DropMax}$ = 0.4V

$V_{BattMin}$ = $V_{BattLowLimit}$ + $D_{DropMax}$
$V_{BattMin}$ = 3.3V + 0.4V = 3.7V
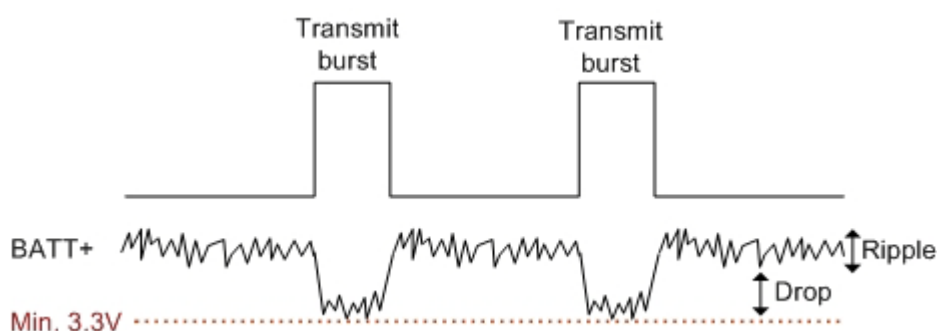
Figure 40: Power supply limits during transmit burst

3.4.3   Measuring the Supply Voltage (V_{BATT+})

To measure the supply voltage V_{BATT+} it is possible to define two reference points GND and BATT+. GND should be the module's shielding, while BATT+ should be a test pad on the external application the module is mounted on. The external BATT+ reference point has to be connected to and positioned close to the SMT application interface's BATT+ pads 53 or 204 as shown in Figure 41.
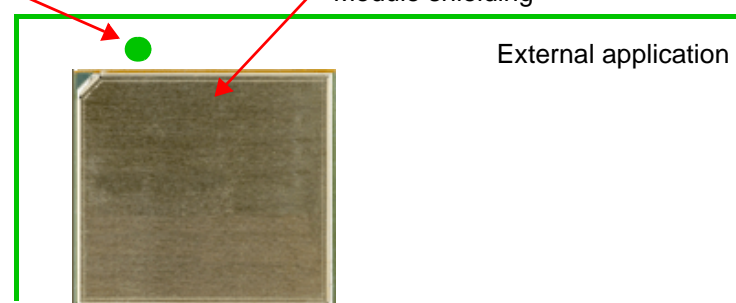
Figure 41: Position of reference points BATT+and GND

3.5   Operating Temperatures

Please note that the module's lifetime, i.e., the MTTF (mean time to failure) may be reduced, if operated outside the extended temperature range.

Table 15: Board temperature

Parameter	Min	Typ	Max	Unit
Normal operation	-30	+25	+85	°C
Extended operation[1]	-40		+90	°C

Automatic shutdown[2]
    Temperature measured on EHS6
    board
	<-40	---	>+90	°C

1. Extended operation allows normal mode speech calls or data transmission for limited time until automatic thermal shutdown takes effect. Within the extended temperature range (outside the normal operating temperature range) the specified electrical characteristics may be in- or decreased.
2. Due to temperature measurement uncertainty, a tolerance of ±3°C on the thresholds may occur.

See also Section 3.3 for information about the NTC for on-board temperature measurement, automatic thermal shutdown and alert messages.

Note that within the specified operating temperature ranges the board temperature may vary to a great extent depending on operating mode, used frequency band, radio output power and current supply voltage.

For more information regarding the module's thermal behavior please refer to [4].

3.6 Electrostatic Discharge

The GSM module is not protected against Electrostatic Discharge (ESD) in general. Consequently, it is subject to ESD handling precautions that typically apply to ESD sensitive components. Proper ESD handling and packaging procedures must be applied throughout the processing, handling and operation of any application that incorporates a EHS6 module.

An example for an enhanced ESD protection for the SIM interface is given in Section 2.1.6.1.

EHS6 has been tested according to group standard ETSI EN 301 489-1 (see Table 23) and test standard EN 61000-4-2. Electrostatic values can be gathered from the following table.

Table 16: Electrostatic values

Specification/Requirements	Contact discharge	Air discharge
EN 61000-4-2		
Antenna interface	± 1kV	n.a.
Antenna interface with ESD protection (see Section 3.6.1)	± 4kV	± 8kV
JEDEC JESD22-A114D (Human Body Model, Test conditions: 1.5 kΩ, 100 pF)		
All other interfaces	± 1kV	n.a.

Note: Please note that the values may vary with the individual application design. For example, it matters whether or not the application platform is grounded over external devices like a computer or other equipment, such as the Gemalto reference application described in Chapter 5.

3.6.1 ESD Protection for Antenna Interface

The following Figure 42 shows how to implement an external ESD protection for the RF antenna interface with either a T pad or PI pad attenuator circuit (for RF line routing design see also Section 2.2.3).
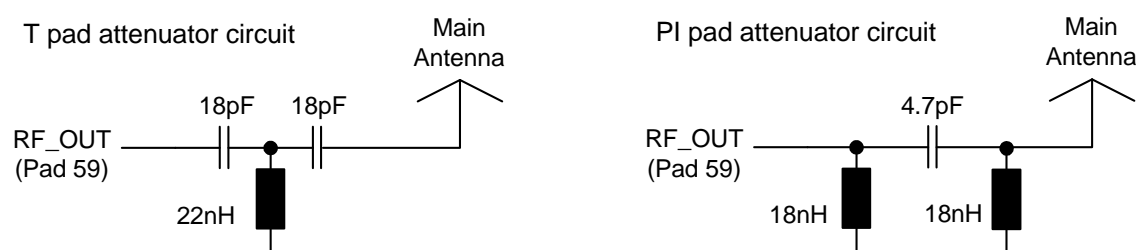

Figure 42: ESD protection for RF antenna interface

Recommended inductor types for the above sample circuits: Size 0402 SMD from Panasonic ELJRF series (22nH and 18nH inductors) or Murata LQW15AN18NJ00 (18nH inductors only).

3.6.2   Blocking against RF on Interface Lines

To reduce EMI issues there are serial resistors, or capacitors to GND, implemented on the module for the ignition, emergency restart, and SIM interface lines (cp. Section 2.3). However, all other signal lines have no EMI measures on the module and there are no blocking measures at the module's interface to an external application.

Dependent on the specific application design, it might be useful to implement further EMI measures on some signal lines at the interface between module and application. These measures are described below.

There are five possible variants of EMI measures (A-E) that may be implemented between module and external application depending on the signal line (see Figure 43 and Table 17). Pay attention not to exceed the maximum input voltages and prevent voltage overshots if using inductive EMC measures.

The maximum value of the serial resistor should be lower than 1kOhm on the signal line. The maximum value of the capacitor should be lower than 50pF on the signal line. Please observe the electrical specification of the module's SMT application interface and the external application's interface.
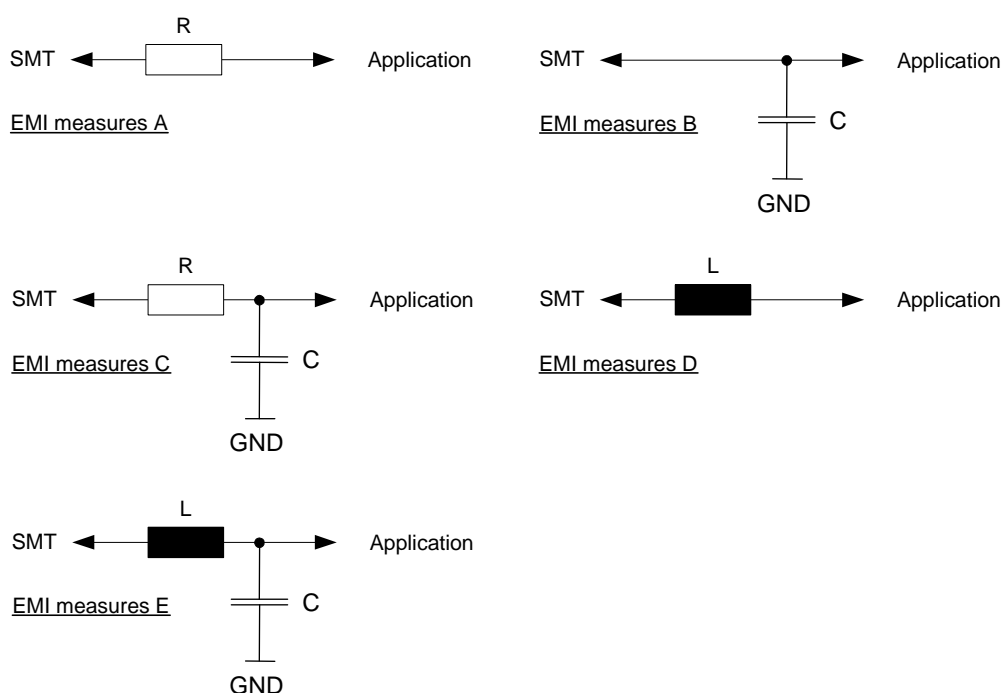
Figure 43: EMI circuits

The following table lists for each signal line at the module's SMT application interface the EMI measures that may be implemented.

Table 17: EMI measures on the application interface

Signal name	EMI measures					Remark
	A	B	C	D	E	
CCIN	x			x		
CCRST		x				The external capacitor should be not higher than 30pF. The value of the capacitor depends on the external application.
CCIO		x				
CCCLK		x				
RXD0	x	x	x	x	x	
TXD0	x	x	x	x	x	
CTS0	x	x	x	x	x	
RTS0				x		
DTR0/GPIO1	x	x	x	x	x	
DCD0/GPIO2	x	x	x	x	x	
DSR0/GPIO3/SPI_CLK	x	x	x	x	x	
GPIO4/FST_SHDN	x	x	x	x	x	
GPIO5/LED	x	x	x	x	x	
GPIO6/PWM2	x	x	x	x	x	
GPIO7/PWM1	x	x	x	x	x	
GPIO8/COUNTER	x	x	x	x	x	
GPIO11-GPIO15	x	x	x	x	x	
AP_WAKEUP/ GPIO16/RXD1/MOSI	x	x	x	x	x	
HOST_ACTIVE/ GPIO17/TXD1/MISO	x	x	x	x	x	
CP_WAKEUP/ GPIO18/RTS1	x	x	x	x	x	
SUSPEND/ GPIO19/CTS1/SPI_CS	x	x	x	x	x	
GPIO20/TXDDAI	x	x	x	x	x	
GPIO21/RXDDAI	x	x	x	x	x	
GPIO22/TFSDAI	x	x	x	x	x	
GPIO23/SCLK	x	x	x	x	x	
GPIO24/RING0	x	x	x	x	x	
I2CDAT		x		x		The rising signal edge is reduced with an additional capacitor.
I2CCLK		x		x		
V180		x		x	x	
VCORE		x		x	x	

3.7 Reliability Characteristics

The test conditions stated below are an extract of the complete test specifications.

Table 18: Summary of reliability test conditions

Type of test	Conditions	Standard
Vibration	Frequency range: 10-20Hz; acceleration: 5g Frequency range: 20-500Hz; acceleration: 20g Duration: 20h per axis; 3 axes	DIN IEC 60068-2-6[1]
Shock half-sinus	Acceleration: 500g Shock duration: 1msec 1 shock per axis 6 positions (± x, y and z)	DIN IEC 60068-2-27
Dry heat	Temperature: +70 ±2°C Test duration: 16h Humidity in the test chamber: < 50%	EN 60068-2-2 Bb ETS 300 019-2-7
Temperature change (shock)	Low temperature: -40°C ±2°C High temperature: +85°C ±2°C Changeover time: < 30s (dual chamber system) Test duration: 1h Number of repetitions: 100	DIN IEC 60068-2-14 Na ETS 300 019-2-7
Damp heat cyclic	High temperature: +55°C ±2°C Low temperature: +25°C ±2°C Humidity: 93% ±3% Number of repetitions: 6 Test duration: 12h + 12h	DIN IEC 60068-2-30 Db ETS 300 019-2-5
Cold (constant exposure)	Temperature: -40 ±2°C Test duration: 16h	DIN IEC 60068-2-1

1. For reliability tests in the frequency range 20-500Hz the Standard's acceleration reference value was increased to 20g.

4 Mechanical Dimensions, Mounting and Packaging

4.1 Mechanical Dimensions of EHS6

Figure 44 shows the top and bottom view of EHS6 and provides an overview of the board's mechanical dimensions. For further details see Figure 45.
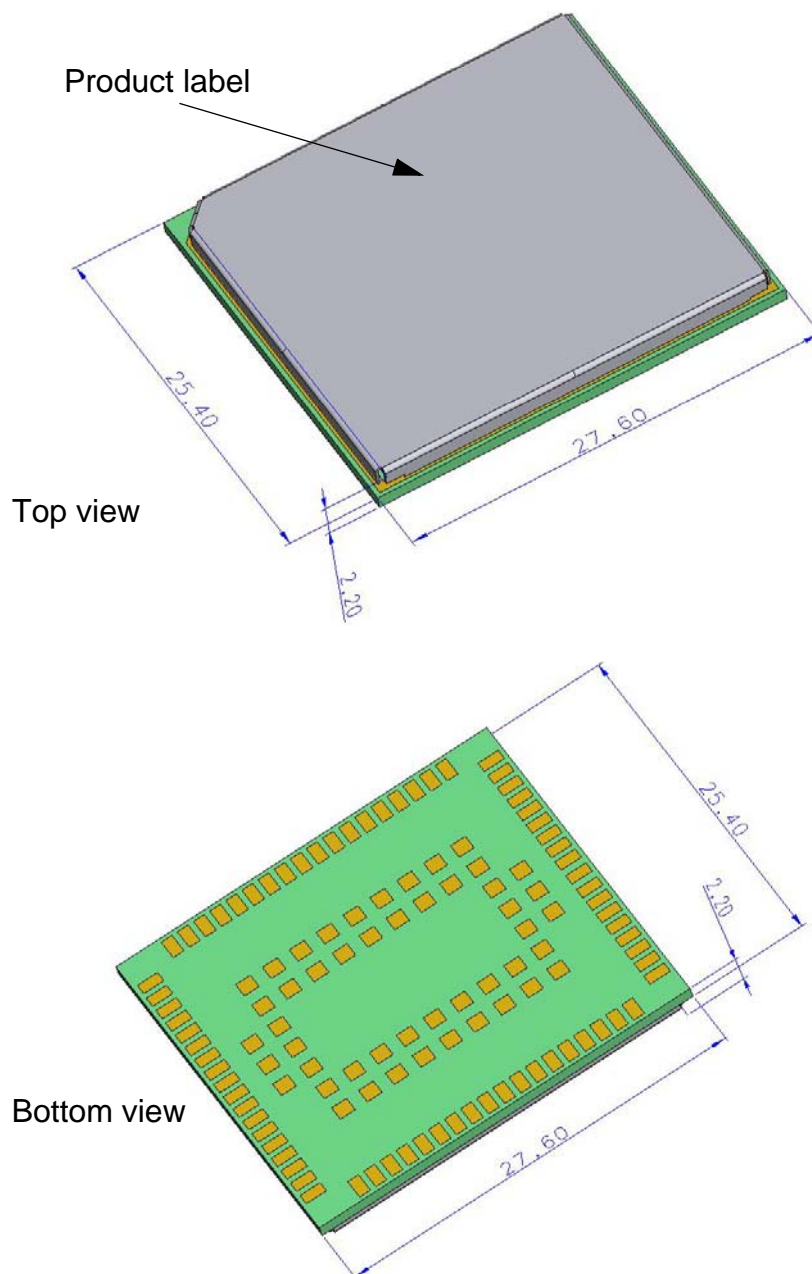
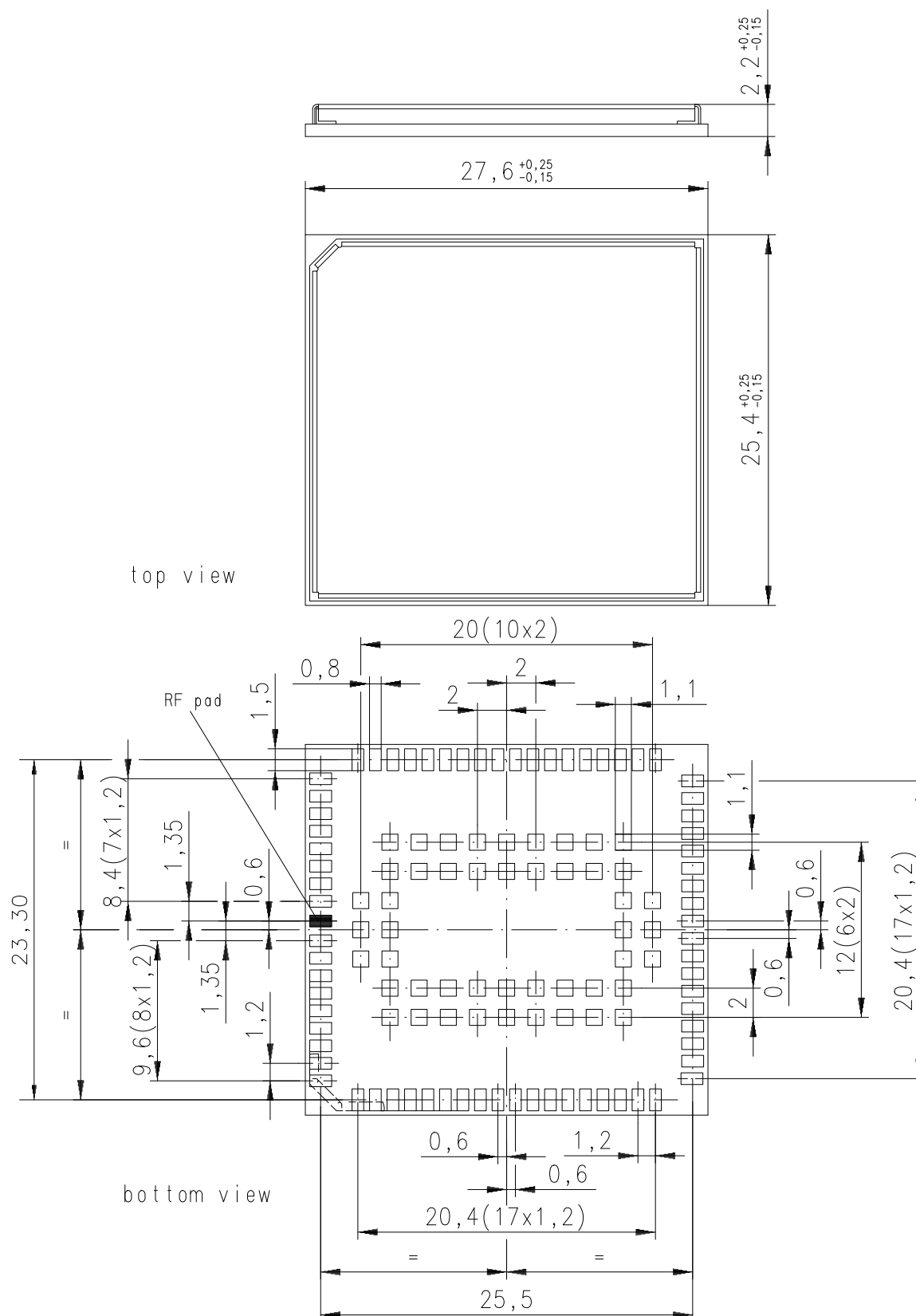**Figure 44:** EHS6– top and bottom view

Figure 45: Dimensions of EHS6 (all dimensions in mm)

4.2 Mounting EHS6 onto the Application Platform

This section describes how to mount EHS6 onto the PCBs (=printed circuit boards), including land pattern and stencil design, board-level characterization, soldering conditions, durability and mechanical handling. For more information on issues related to SMT module integration see also [3].

Note: To avoid short circuits between signal tracks on an external application's PCB and various markings at the bottom side of the module, it is recommended not to route the signal tracks on the top layer of an external PCB directly under the module, or at least to ensure that signal track routes are sufficiently covered with solder resist.

4.2.1 SMT PCB Assembly

4.2.1.1 Land Pattern and Stencil

The land pattern and stencil design as shown below is based on Gemalto characterizations for lead-free solder paste on a four-layer test PCB and a 110 respectively 150 micron thick stencil.

The land pattern given in Figure 46 reflects the module's pad layout, including signal pads and ground pads (for pad assignment see Section 2.1.1).

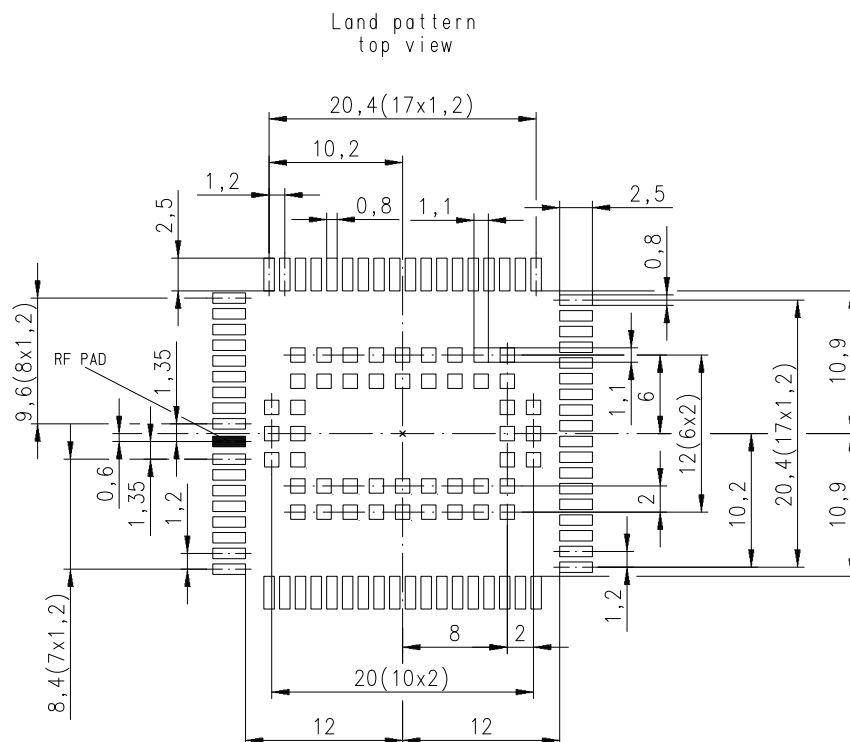**Figure 46:** Land pattern (top view)

The stencil design illustrated in Figure 47 and Figure 48 is recommended by Gemalto M2M as a result of extensive tests with Gemalto M2M Daisy Chain modules.

The central ground pads are primarily intended for stabilizing purposes, and may show some more voids than the application interface pads at the module's rim. This is acceptable, since they are electrically irrelevant.

Note that depending on coplanarity or other properties of the external PCB, it could be that all of the central ground pads may have to be soldered. For this reason the land pattern design shown in Figure 46 provides for both of these alternatives and only a modification of the stencil may be needed.
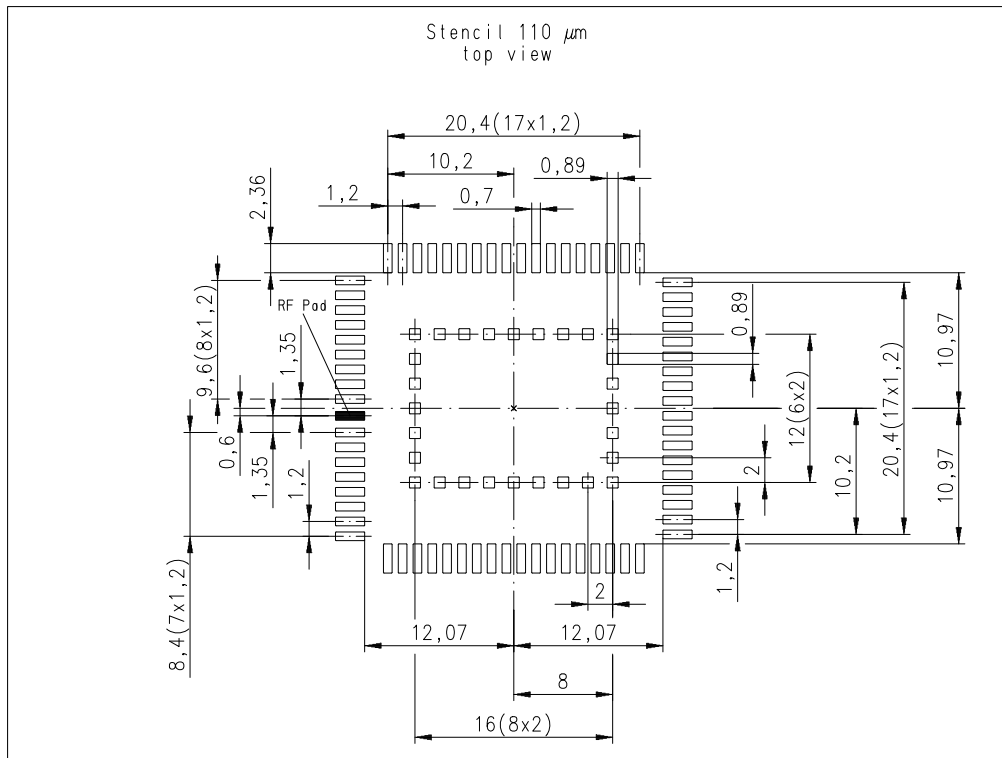

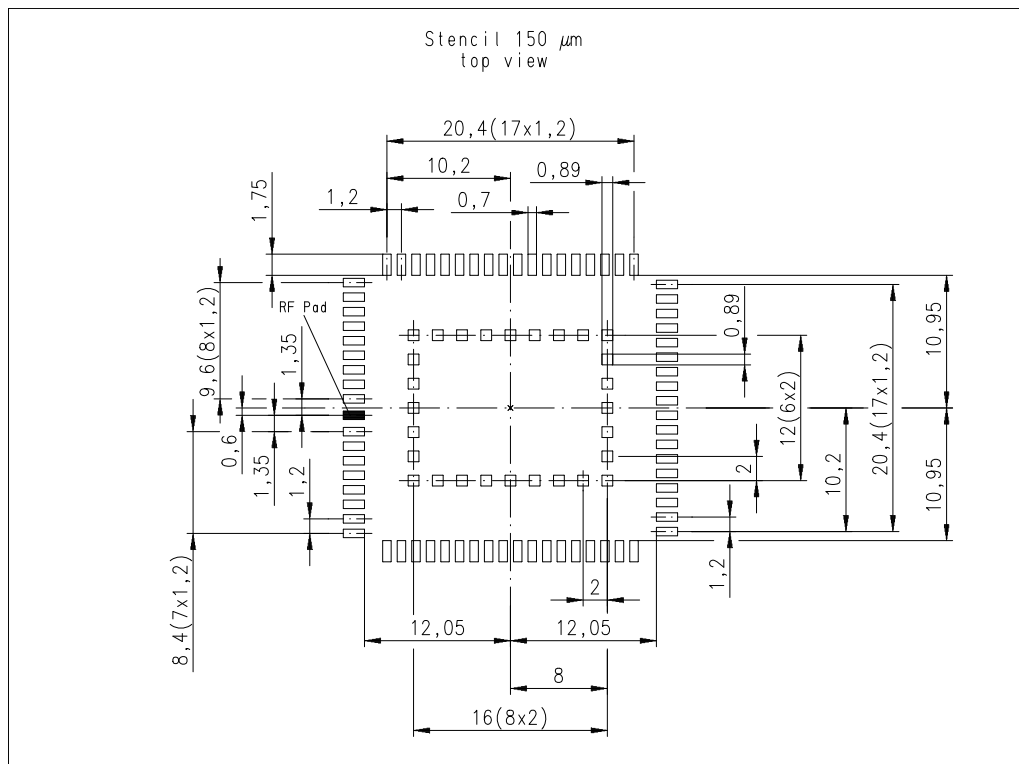**Figure 47:** Recommended design for 110µm micron thick stencil (top view)

Figure 48: Recommended design for 150µm micron thick stencil (top view)

4.2.1.2 Board Level Characterization

Board level characterization issues should also be taken into account if devising an SMT process.

Characterization tests should attempt to optimize the SMT process with regard to board level reliability. This can be done by performing the following physical tests on sample boards: Peel test, bend test, tensile pull test, drop shock test and temperature cycling. Sample surface mount checks are described in [3].

It is recommended to characterize land patterns before an actual PCB production, taking individual processes, materials, equipment, stencil design, and reflow profile into account. For land and stencil pattern design recommendations see also Section 4.2.1.1. Optimizing the solder stencil pattern design and print process is necessary to ensure print uniformity, to decrease solder voids, and to increase board level reliability.

Daisy chain modules for SMT characterization are available on request. For details refer to [3].

Generally, solder paste manufacturer recommendations for screen printing process parameters and reflow profile conditions should be followed. Maximum ratings are described in Section 4.2.3.

4.2.2 Moisture Sensitivity Level

EHS6 comprises components that are susceptible to damage induced by absorbed moisture.

Gemalto M2M's EHS6 module complies with the latest revision of the IPC/JEDEC J-STD-020 Standard for moisture sensitive surface mount devices and is classified as MSL 4.

For additional MSL (=moisture sensitivity level) related information see Section 4.2.4 and Section 4.3.2.

4.2.3 Soldering Conditions and Temperature

4.2.3.1 Reflow Profile
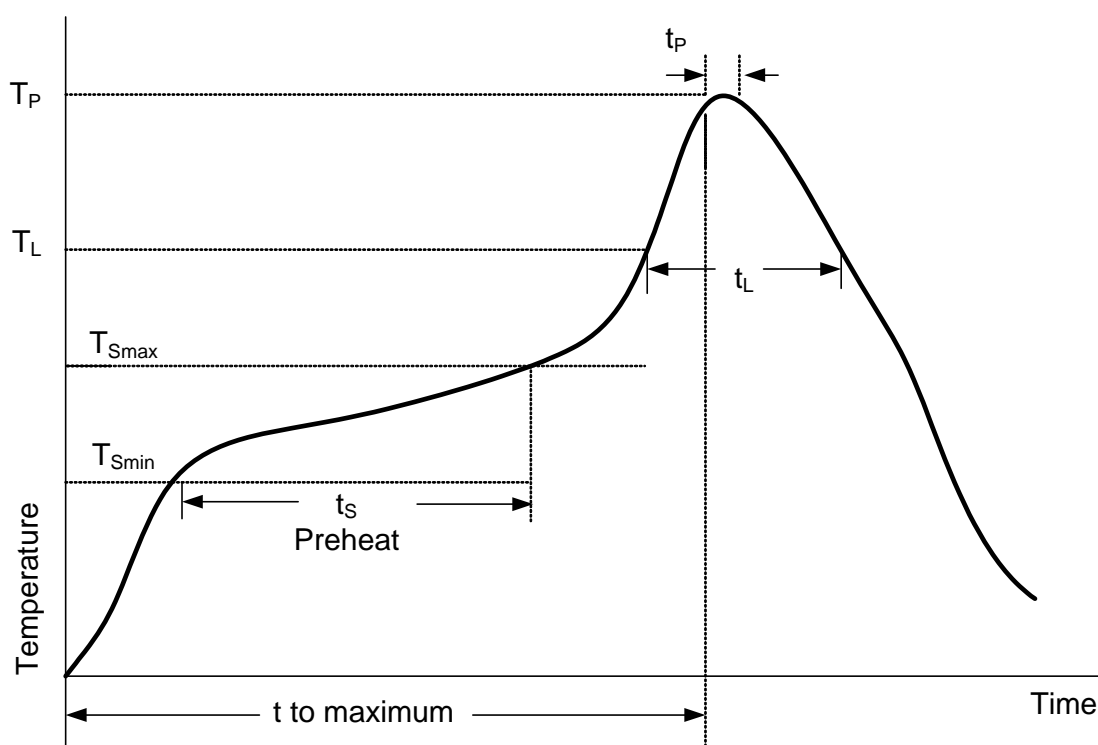
Figure 49: Reflow Profile

Table 19: Reflow temperature ratings

Profile Feature	Pb-Free Assembly
Preheat & Soak Temperature Minimum (T_{Smin}) Temperature Maximum (T_{Smax}) Time (t_{Smin} to t_{Smax}) (t_S)	150°C 200°C 60-120 seconds
Average ramp up rate (T_{Smax} to T_P)	3K/second max.
Liquidous temperature (T_L) Time at liquidous (t_L)	217°C 60-90 seconds
Peak package body temperature (T_P)	245°C +0/-5°C
Time (t_P) within 5 °C of the peak package body temperature (T_P)	30 seconds max.
Average ramp-down rate (T_P to T_{Smax})	6 K/second max.
Time 25°C to maximum temperature	8 minutes max.

4.2.3.2   Maximum Temperature and Duration

The following limits are recommended for the SMT board-level soldering process to attach the module:

- A maximum module temperature of 245°C. This specifies the temperature as measured at the module's top side.
- A maximum duration of 30 seconds at this temperature.

Please note that while the solder paste manufacturers' recommendations for best temperature and duration for solder reflow should generally be followed, the limits listed above must not be exceeded.

EHS6 is specified for one soldering cycle only. Once EHS6 is removed from the application, the module will very likely be destroyed and cannot be soldered onto another application.

4.2.4   Durability and Mechanical Handling

4.2.4.1   Storage Conditions

EHS6 modules, as delivered in tape and reel carriers, must be stored in sealed, moisture barrier anti-static bags. The conditions stated below are only valid for modules in their original packed state in weather protected, non-temperature-controlled storage locations. Normal storage time under these conditions is 12 months maximum.

Table 20: Storage conditions

Type	Condition	Unit	Reference
Air temperature: Low High	-25 +40	°C	IPC/JEDEC J-STD-033A
Humidity relative: Low High	10 90 at 40°C	%	IPC/JEDEC J-STD-033A
Air pressure: Low High	70 106	kPa	IEC TR 60271-3-1: 1K4 IEC TR 60271-3-1: 1K4
Movement of surrounding air	1.0	m/s	IEC TR 60271-3-1: 1K4
Water: rain, dripping, icing and frosting	Not allowed	---	---
Radiation: Solar Heat	1120 600	W/m^2	ETS 300 019-2-1: T1.2, IEC 60068-2-2 Bb ETS 300 019-2-1: T1.2, IEC 60068-2-2 Bb
Chemically active substances	Not recommended		IEC TR 60271-3-1: 1C1L
Mechanically active substances	Not recommended		IEC TR 60271-3-1: 1S1
Vibration sinusoidal: Displacement Acceleration Frequency range	1.5 5 2-9 9-200	mm m/s^2 Hz	IEC TR 60271-3-1: 1M2
Shocks: Shock spectrum Duration Acceleration	semi-sinusoidal 1 50	ms m/s^2	IEC 60068-2-27 Ea

4.2.4.2   Processing Life

EHS6 must be soldered to an application within 72 hours after opening the MBB (=moisture barrier bag) it was stored in.

As specified in the IPC/JEDEC J-STD-033 Standard, the manufacturing site processing the modules should have ambient temperatures below 30°C and a relative humidity below 60%.

4.2.4.3   Baking

Baking conditions are specified on the moisture sensitivity label attached to each MBB (see Figure 54 for details):
- It is *not necessary* to bake EHS6, if the conditions specified in Section 4.2.4.1 and Section 4.2.4.2 were not exceeded.
- It is *necessary* to bake EHS6, if any condition specified in Section 4.2.4.1 and Section 4.2.4.2 was exceeded.

If baking is necessary, the modules must be put into trays that can be baked to at least 125°C. Devices should not be baked in tape and reel carriers at any temperature.

4.2.4.4   Electrostatic Discharge

ESD (=electrostatic discharge) may lead to irreversable damage for the module. It is therefore advisable to develop measures and methods to counter ESD and to use these to control the electrostatic environment at manufacturing sites.

Please refer to Section 3.6 for further information on electrostatic discharge.

4.3 Packaging

4.3.1 Tape and Reel

The single-feed tape carrier for EHS6 is illustrated in Figure 50. The figure also shows the proper part orientation. The tape width is TBD. mm and the EHS6 modules are placed on the tape with a 28-mm pitch. The reels are TBD. mm in diameter with a core diameter of TBD. mm. Each reel contains 500 modules.

4.3.1.1 Orientation

TBD.

Figure 50: Carrier tape

TBD.

Figure 51: Reel direction

4.3.1.2   Barcode Label

A barcode label provides detailed information on the tape and its contents. It is attached to the reel.
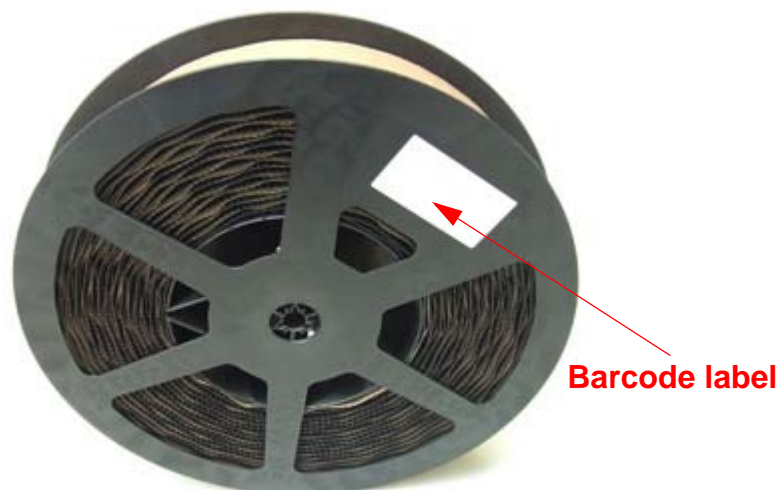

Figure 52: Barcode label on tape reel

4.3.2 Shipping Materials

EHS6 is distributed in tape and reel carriers. The tape and reel carriers used to distribute EHS6 are packed as described below, including the following required shipping materials:

• Moisture barrier bag, including desiccant and humidity indicator card
• Transportation box

4.3.2.1 Moisture Barrier Bag

The tape reels are stored inside an MBB (=moisture barrier bag), together with a humidity indicator card and desiccant pouches - see Figure 53. The bag is ESD protected and delimits moisture transmission. It is vacuum-sealed and should be handled carefully to avoid puncturing or tearing. The bag protects the EHS6 modules from moisture exposure. It should not be opened until the devices are ready to be soldered onto the application.
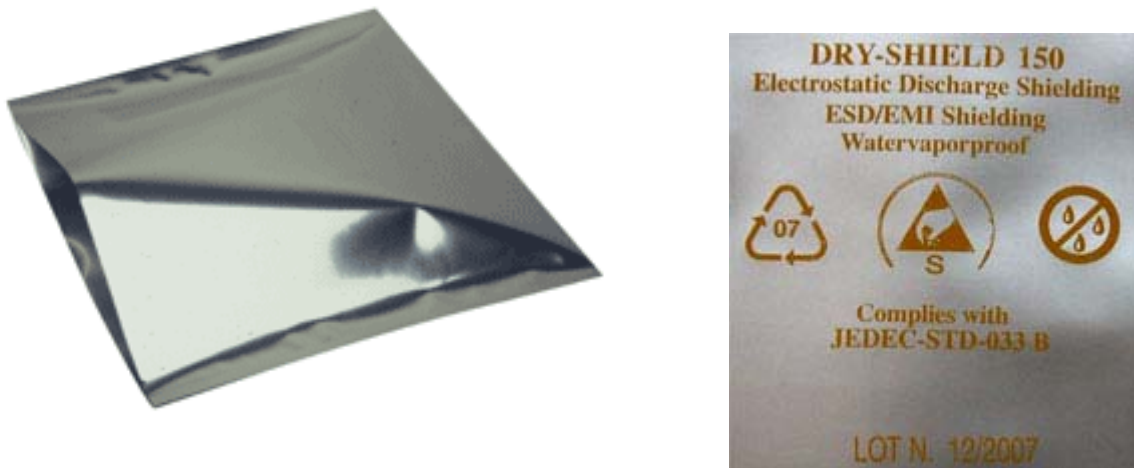

Figure 53: Moisture barrier bag (MBB) with imprint

The label shown in Figure 54 summarizes requirements regarding moisture sensitivity, including shelf life and baking requirements. It is attached to the outside of the moisture barrier bag.

Figure 54: Moisture Sensitivity Label

MBBs contain one or more desiccant pouches to absorb moisture that may be in the bag. The humidity indicator card described below should be used to determine whether the enclosed components have absorbed an excessive amount of moisture.

The desiccant pouches should not be baked or reused once removed from the MBB.

The humidity indicator card is a moisture indicator and is included in the MBB to show the approximate relative humidity level within the bag. Sample humidity cards are shown in Figure 55. If the components have been exposed to moisture above the recommended limits, the units will have to be rebaked.
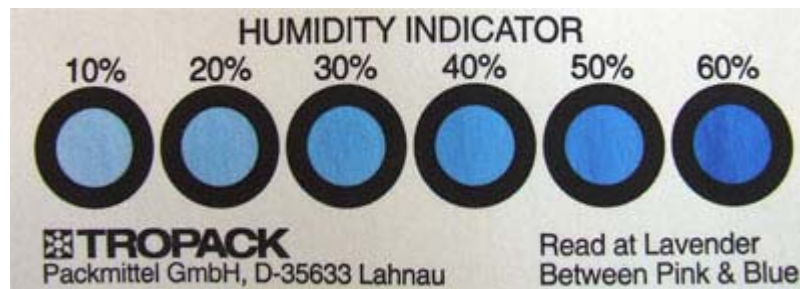
Figure 55: Humidity Indicator Card - HIC

A baking is required if the humidity indicator inside the bag indicates 10% RH or more.

4.3.2.2   Transportation Box

Tape and reel carriers are distributed in a box, marked with a barcode label for identification purposes. A box contains two reels with 500 modules each.

4.3.3   Trays

If small module quantities are required, e.g., for test and evaluation purposes, EHS6 may be distributed in trays (for dimensions see Figure 56). The small quantity trays are an alternative to the single-feed tape carriers normally used. However, the trays are not designed for machine processing. They contain modules to be (hand) soldered onto an external application (for information on hand soldering see [4]).

Trays are packed and shipped in the same way as tape carriers, including a moisture barrier bag with desiccant and humidity indicator card as well as a transportation box (see also Section 4.3.2).

TBD.

Figure 56: Tray dimensions

5 Regulatory and Type Approval Information

5.1 Directives and Standards

EHS6 is designed to comply with the directives and standards listed below.

It is the responsibility of the application manufacturer to ensure compliance of the final product with all provisions of the applicable directives and standards as well as with the technical specifications provided in the "EHS6 Hardware Interface Description".[1]

Table 21: Directives

1999/05/EC	Directive of the European Parliament and of the council of 9 March 1999 on radio equipment and telecommunications terminal equipment and the mutual recognition of their conformity (in short referred to as R&TTE Directive 1999/5/EC). The product is labeled with the CE conformity mark **C E 0682**
2002/95/EC (RoHS 1) 2011/65/EC (RoHS 2)	Directive of the European Parliament and of the Council of 27 January 2003 (and revised on 8 June 2011) on the restriction of the use of certain hazardous substances in electrical and electronic equipment (RoHS)

Table 22: Standards of North American type approval

CFR Title 47	Code of Federal Regulations, Part 22 and Part 24 (Telecommunications, PCS); US Equipment Authorization FCC
OET Bulletin 65 (Edition 97-01)	Evaluating Compliance with FCC Guidelines for Human Exposure to Radiofrequency Electromagnetic Fields
UL 60 950-1	Product Safety Certification (Safety requirements)
NAPRD.03 V5.15	Overview of PCS Type certification review board Mobile Equipment Type Certification and IMEI control PCS Type Certification Review board (PTCRB)
RSS132 (Issue2) RSS133 (Issue5)	Canadian Standard

Table 23: Standards of European type approval

3GPP TS 51.010-1	Digital cellular telecommunications system (Release 7); Mobile Station (MS) conformance specification;
ETSI EN 301 511 V9.0.2	Global System for Mobile communications (GSM); Harmonized standard for mobile stations in the GSM 900 and DCS 1800 bands covering essential requirements under article 3.2 of the R&TTE directive (1999/5/EC)
GCF-CC V3.49	Global Certification Forum - Certification Criteria
ETSI EN 301 489-01 V1.9.2	Electromagnetic Compatibility and Radio spectrum Matters (ERM); Electromagnetic Compatibility (EMC) standard for radio equipment and services; Part 1: Common Technical Requirements

1. Manufacturers of applications which can be used in the US shall ensure that their applications have a PTCRB approval. For this purpose they can refer to the PTCRB approval of the respective module.

Table 23: Standards of European type approval

ETSI EN 301 489-07 V1.3.1	Electromagnetic Compatibility and Radio spectrum Matters (ERM); Electromagnetic Compatibility (EMC) standard for radio equipment and services; Part 7: Specific conditions for mobile and portable radio and ancillary equipment of digital cellular radio telecommunications systems (GSM and DCS)
ETSI EN 301 489-24 V1.5.1	Electromagnetic Compatibility and Radio spectrum Matters (ERM); Electromagnetic Compatibility (EMC) standard for radio equipment and services; Part 24: Specific conditions for IMT-2000 CDMA Direct Spread (UTRA) for Mobile and portable (UE) radio and ancillary equipment
ETSI EN 301 908-01 V5.2.1	Electromagnetic compatibility and Radio spectrum Matters (ERM); Base Stations (BS) and User Equipment (UE) for IMT-2000 Third Generation cellular networks; Part 1: Harmonized EN for IMT-2000, introduction and common requirements of article 3.2 of the R&TTE Directive
ETSI EN 301 908-02 V5.2.1	Electromagnetic compatibility and Radio spectrum Matters (ERM); Base Stations (BS) and User Equipment (UE) for IMT-2000 Third Generation cellular networks; Part 2: Harmonized EN for IMT-2000, CDMA Direct Spread (UTRA FDD) (UE) covering essential requirements of article 3.2 of the R&TTE Directive
EN 62311:2008	Assessment of electronic and electrical equipment related to human exposure restrictions for electromagnetic fields (0 Hz - 300 GHz)
IEC/EN 60950-1:2006/ A1:2010+A12:2011 IEC 60950-1:2005/ A1:2009 (second edition)	Safety of information technology equipment

Table 24: Requirements of quality

IEC 60068	Environmental testing
DIN EN 60529	IP codes

Table 25: Standards of the Ministry of Information Industry of the People's Republic of China

SJ/T 11363-2006	"Requirements for Concentration Limits for Certain Hazardous Substances in Electronic Information Products" (2006-06).
SJ/T 11364-2006	"Marking for Control of Pollution Caused by Electronic Information Products" (2006-06). According to the "Chinese Administration on the Control of Pollution caused by Electronic Information Products" (ACPEIP) the EPUP, i.e., Environmental Protection Use Period, of this product is 20 years as per the symbol shown here, unless otherwise marked. The EPUP is valid only as long as the product is operated within the operating limits described in the Gemalto M2M Hardware Interface Description. Please see Table 26 for an overview of toxic or hazardous substances or elements that might be contained in product parts in concentrations above the limits defined by SJ/T 11363-2006.

Table 26: Toxic or hazardous substances or elements with defined concentration limits

部件名称 Name of the part	有毒有害物质或元素 Hazardous substances					
	铅 (Pb)	汞 (Hg)	镉 (Cd)	六价铬 (Cr(VI))	多溴联苯 (PBB)	多溴二苯醚 (PBDE)
金属部件 (Metal Parts)	O	O	O	O	O	O
电路模块 (Circuit Modules)	X	O	O	O	O	O
电缆及电缆组件 (Cables and Cable Assemblies)	O	O	O	O	O	O
塑料和聚合物部件 (Plastic and Polymeric parts)	O	O	O	O	O	O

O:

表示该有毒有害物质在该部件所有均质材料中的含量均在SJ/T11363-2006 标准规定的限量要求以下。

Indicates that this toxic or hazardous substance contained in all of the homogeneous materials for this part is below the limit requirement in SJ/T11363-2006.

X:

表示该有毒有害物质至少在该部件的某一均质材料中的含量超出SJ/T11363-2006标准规定的限量要求。

Indicates that this toxic or hazardous substance contained in at least one of the homogeneous materials used for this part *might exceed* the limit requirement in SJ/T11363-2006.

5.2 SAR requirements specific to portable mobiles

Mobile phones, PDAs or other portable transmitters and receivers incorporating a GSM module must be in accordance with the guidelines for human exposure to radio frequency energy. This requires the Specific Absorption Rate (SAR) of portable EHS6 based applications to be evaluated and approved for compliance with national and/or international regulations.

Since the SAR value varies significantly with the individual product design manufacturers are advised to submit their product for approval if designed for portable use. For European and US markets the relevant directives are mentioned below. It is the responsibility of the manufacturer of the final product to verify whether or not further standards, recommendations or directives are in force outside these areas.

Products intended for sale on US markets

ES 59005/ANSI C95.1 Considerations for evaluation of human exposure to Electromagnetic Fields (EMFs) from Mobile Telecommunication Equipment (MTE) in the frequency range 30MHz - 6GHz

Products intended for sale on European markets

EN 50360 Product standard to demonstrate the compliance of mobile phones with the basic restrictions related to human exposure to electromagnetic fields (300MHz - 3GHz)

Please note that SAR requirements are specific only for portable devices and not for mobile devices as defined below:
• Portable device:
  A portable device is defined as a transmitting device designed to be used so that the radiating structure(s) of the device is/are within 20 centimeters of the body of the user.
• Mobile device:
  A mobile device is defined as a transmitting device designed to be used in other than fixed locations and to generally be used in such a way that a separation distance of at least 20 centimeters is normally maintained between the transmitter's radiating structure(s) and the body of the user or nearby persons. In this context, the term "fixed location" means that the device is physically secured at one location and is not able to be easily moved to another location.

5.3 Reference Equipment for Type Approval

The Gemalto M2M reference setup submitted to type approve EHS6 (including a special approval adapter for the DSB75) is shown in the following figure[1]:
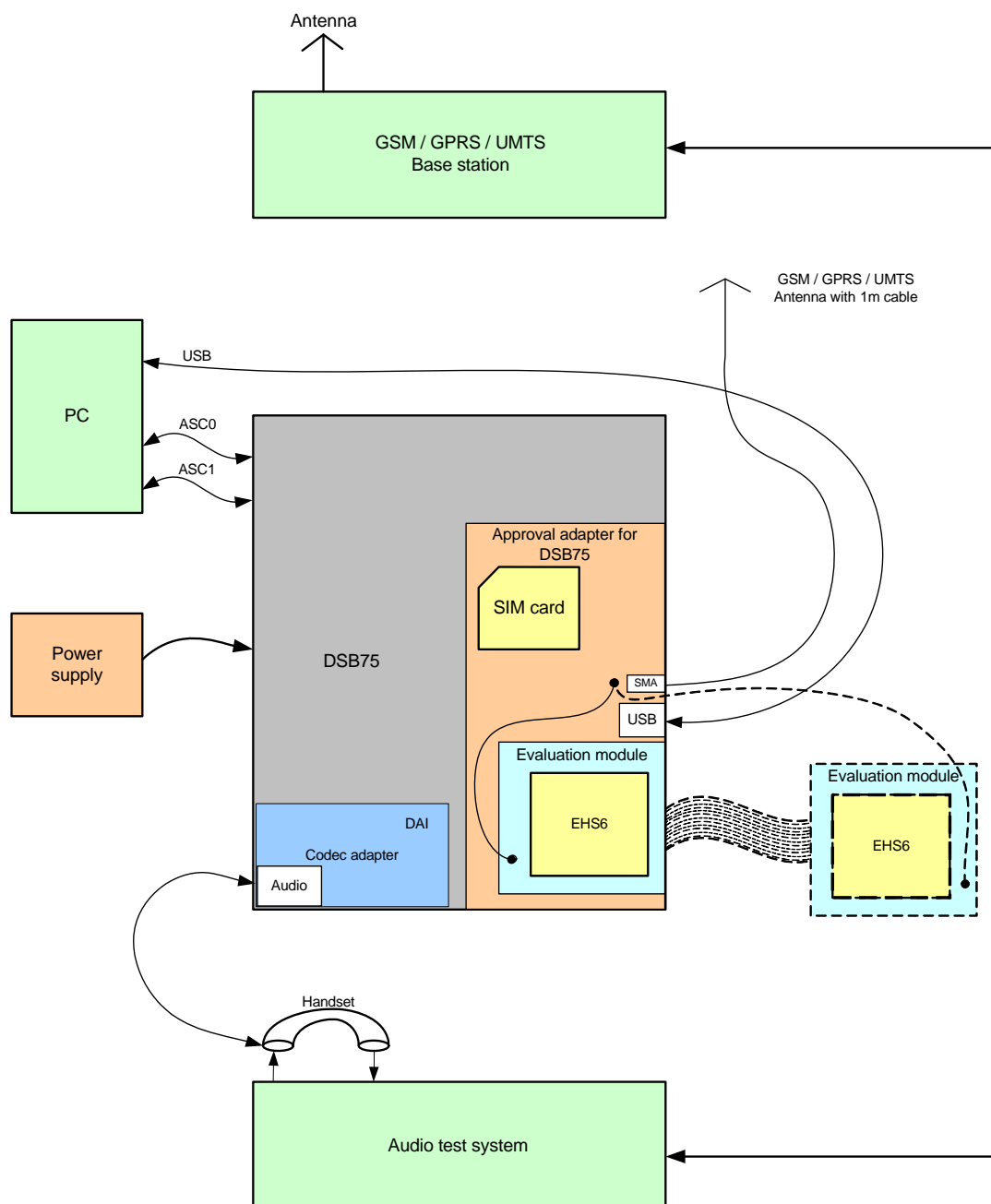
Figure 57: Reference equipment for Type Approval

1. For RF performance tests a mini-SMT/U.FL to SMA adapter with attached 6dB coaxial attenuator is chosen to connect the evaluation module directly to the GSM/UMTS test equipment instead of employing the SMA antenna connectors on the EHS6-DSB75 adapter as shown in Figure 57. The following products are recommended:
Hirose® SMA-Jack/U.FL-Plug conversion adapter HRMJ-U.FLP(40)
(for details see http://www.hirose-connectors.com/ or http://www.farnell.com/
Aeroflex Weinschel Fixed Coaxial Attenuator Model 3T/4T
(for details see http://www.aeroflex.com/ams/weinschel/pdfiles/wmod3&4T.pdf)

5.4 Compliance with FCC and IC Rules and Regulations

The Equipment Authorization Certification for the Gemalto M2M reference application described in Section 5.3 will be registered under the following identifiers:

FCC Identifier: QIPEHS6
Industry Canada Certification Number: 7830A-EHS6
Granted to Gemalto M2M GmbH

Manufacturers of mobile or fixed devices incorporating EHS6 modules are authorized to use the FCC Grants and Industry Canada Certificates of the EHS6 modules for their own final products according to the conditions referenced in these documents. In this case, an FCC/ IC label of the module shall be visible from the outside, or the host device shall bear a second label stating "Contains FCC ID QIPEHS6", and accordingly "Contains IC 7830A-EHS6". The integration is limited to fixed or mobile categorised host devices, where a separation distance between the antenna and any person of min. 20cm can be assured during normal operating conditions. For mobile and fixed operation configurations the antenna gain, including cable loss, must not exceed the limits 4.02 dBi (850 MHz) and 2.81 dBi (1900 MHz).

IMPORTANT:
Manufacturers of portable applications incorporating EHS6 modules are required to have their final product certified and apply for their own FCC Grant and Industry Canada Certificate related to the specific portable mobile. This is mandatory to meet the SAR requirements for portable mobiles (see Section 5.2 for detail).

Changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

Note: This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to part 15 of the FCC Rules and with Industry Canada licence-exempt RSS standard(s). 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/TV technician for help.

This Class B digital apparatus complies with Canadian ICES-003.

If Canadian approval is requested for devices incorporating EHS6 modules the above note will have to be provided in the English and French language in the final user documentation. Manufacturers/OEM Integrators must ensure that the final user documentation does not contain any information on how to install or remove the module from the final product.

6 Document Information

6.1 Revision History

Preceding document: "EHS6 Hardware Interface Description" Version 01.441
New document: "EHS6 Hardware Interface Description" Version **02.000**

Chapter	What is new
1.1, 3.5	Added operating temperatures.
2.1.2	Updated signal description for BATT+, VDDLP, VUSB_IN and HSIC interface.
2.1.7	Updated name of external codec for use with PCM functionality.
2.1.10	Revised section to include AT configuration command.
2.1.11	Revised section to include AT configuration command and figure showing SPI modes.
2.2.1	Completed Table 9 listing RF antenna interface characteristics.
2.3	Revised sample circuit for SIM interface in Figure 29.
3.2.1.1, 3.2.1.2	Removed note that AUTO_ON only works once after the BATT+ has been applied.
3.2.4.2	New section Disconnect EHS6 BATT+ Lines.
3.4.1	Added power supply ratings.
3.4.3	New section Measuring the Supply Voltage (VBATT+).
4.2.3.1	Completed Table 19 listing reflow temperature ratings.
4.2.3.2	Added limits for maximum temperature and duration.
4.2	Added note regarding routing of signal tracks.
4.3	New section Packaging.

Preceding document: "EHS6 Hardware Interface Description" Version 01.304b
New document: "EHS6 Hardware Interface Description" Version 01.441

Chapter	What is new
3.2.1	Revised sections describing hardware driven module switch on.

Preceding document: "EHS6 Hardware Interface Description" Version 01.304
New document: "EHS6 Hardware Interface Description" Version 01.304b

Chapter	What is new
Throughout document	Replaced "impulse counter" with "pulse counter".
3.2.1.3	Revised recommended options for possible switch-on circuits.
3.2.5.1	Added remark on 2 minute guard period for temperature URCs of level 1/-1.

Preceding document: "EHS6 Hardware Interface Description" Version 00.256
New document: "EHS6 Hardware Interface Description" Version 01.304

Chapter	What is new
Throughout document	Renamed ON2 signal to AUTO_ON. Revised GPIO interface: Amount and assignment of GPIO lines. GPIO4 shared with fast shutdown line (renamed to FST_SHDN). Added new features SPI interface and pulse counter. Both interfaces share signal lines with the GPIO interface.
1.1	Revised list of firmware update interfaces. Revised data transfer rates for CSD. Added Java^{TM} Open Platform.
2.1.2	AUTO_ON: Added comment to leave line open if not used.
2.1.2.1	Extended absolute maximum ratings listed in Table 3.
2.1.4, 2.1.5	Extended remark on hardware flow control. Added note for DTR0 line. Added note on DSR0 line being shared with SPI_CLK line of SPI interface.
2.1.6	Revised description for CCIN signal states in Table 4.
2.1.9	Revised complete section.
2.1.12	New section HSIC Interface.
2.1.11	New section SPI Interface.
2.1.15.2	Revised resistor values for power indication circuit; see also Figure 29.
2.1.15.4	Added Figure 21 showing fast shutdown timing.
2.1.14	New section Pulse Counter.
2.3	Added Figure 29.
3.2.1.3	Added serial 100Ohm resistor to switch on Option 1 shown in Figure 33.
3.2.1.1	Revised section; see also Figure 29.
3.2.1.2	New section Switch on EHS6 Using a Continuous AUTO_ON Signal.
3.2.4.1	Revised Figure 36.
3.2.5.1	Completed section Thermal Shutdown.
3.3	Completed section Power Saving. Split up table listing power supply ratings.
3.6.1	Added PI pad attenuator circuit to Figure 42.
4.1	Added tolerances to Figure 45 showing mechanical dimensions.
4.2.1.1	Completed Figure 46, Figure 47 and Figure 48.
5.2, 5.4	Revised sections.
7.1	Added module label number.

Preceding document: "EHS6 Hardware Interface Description" Version 00.000
New document: "EHS6 Hardware Interface Description" Version 00.256

Chapter	What is new
3.2.1.3	Revised Figure 34. Added note that ON signal should always be set to low after module startup.
3.6.1	New section ESD Protection for Antenna Interface.
7.1	Added ordering number.

New document: "EHS6 Hardware Interface Description" Version 00.000

Chapter	What is new
--	Initial document setup.

6.2   Related Documents

[1]   EHS6 AT Command Set
[2]   EHS6 Release Note
[3]   Application Note 48: SMT Module Integration
[4]   Application Note 40: Thermal Solutions

6.3   Terms and Abbreviations

Abbreviation	Description
ADC	Analog-to-digital converter
AGC	Automatic Gain Control
ANSI	American National Standards Institute
ARFCN	Absolute Radio Frequency Channel Number
ARP	Antenna Reference Point
ASC0/ASC1	Asynchronous Controller. Abbreviations used for first and second serial interface of EHS6
B	Thermistor Constant
BER	Bit Error Rate
BTS	Base Transceiver Station
CB or CBM	Cell Broadcast Message
CE	Conformité Européene (European Conformity)
CHAP	Challenge Handshake Authentication Protocol
CPU	Central Processing Unit

| Abbreviation	Description
CS	Coding Scheme
CSD	Circuit Switched Data
CTS	Clear to Send
DAC	Digital-to-Analog Converter
DAI	Digital Audio Interface
dBm0	Digital level, 3.14dBm0 corresponds to full scale, see ITU G.711, A-law
DCE	Data Communication Equipment (typically modems, e.g. Gemalto M2M module)
DCS 1800	Digital Cellular System, also referred to as PCN
DRX	Discontinuous Reception
DSB	Development Support Box
DSP	Digital Signal Processor
DSR	Data Set Ready
DTE	Data Terminal Equipment (typically computer, terminal, printer or, for example, GSM application)
DTR	Data Terminal Ready
DTX	Discontinuous Transmission
EFR	Enhanced Full Rate
EGSM	Enhanced GSM
EIRP	Equivalent Isotropic Radiated Power
EMC	Electromagnetic Compatibility
ERP	Effective Radiated Power
ESD	Electrostatic Discharge
ETS	European Telecommunication Standard
FCC	Federal Communications Commission (U.S.)
FDMA	Frequency Division Multiple Access
FR	Full Rate
GMSK	Gaussian Minimum Shift Keying
GPIO	General Purpose Input/Output
GPRS	General Packet Radio Service
GSM	Global Standard for Mobile Communications
HiZ	High Impedance
HR	Half Rate
I/O	Input/Output
IC	Integrated Circuit
IMEI	International Mobile Equipment Identity
ISO	International Standards Organization
ITU	International Telecommunications Union
kbps	kbits per second

Abbreviation	Description
LED	Light Emitting Diode
Li-Ion/Li+	Lithium-Ion
Li battery	Rechargeable Lithium Ion or Lithium Polymer battery
LPM	Link Power Management
Mbps	Mbits per second
MMI	Man Machine Interface
MO	Mobile Originated
MS	Mobile Station (GSM module), also referred to as TE
MSISDN	Mobile Station International ISDN number
MT	Mobile Terminated
NTC	Negative Temperature Coefficient
OEM	Original Equipment Manufacturer
PA	Power Amplifier
PAP	Password Authentication Protocol
PBCCH	Packet Switched Broadcast Control Channel
PCB	Printed Circuit Board
PCL	Power Control Level
PCM	Pulse Code Modulation
PCN	Personal Communications Network, also referred to as DCS 1800
PCS	Personal Communication System, also referred to as GSM 1900
PDU	Protocol Data Unit
PLL	Phase Locked Loop
PPP	Point-to-point protocol
PSK	Phase Shift Keying
PSU	Power Supply Unit
PWM	Pulse Width Modulation
R&TTE	Radio and Telecommunication Terminal Equipment
RAM	Random Access Memory
RF	Radio Frequency
RLS	Radio Link Stability
RMS	Root Mean Square (value)
RoHS	Restriction of the use of certain hazardous substances in electrical and electronic equipment.
ROM	Read-only Memory
RTC	Real Time Clock
RTS	Request to Send
Rx	Receive Direction
SAR	Specific Absorption Rate

Abbreviation	Description
SAW	Surface Accoustic Wave
SELV	Safety Extra Low Voltage
SIM	Subscriber Identification Module
SMD	Surface Mount Device
SMS	Short Message Service
SMT	Surface Mount Technology
SPI	Serial Peripheral Interface
SRAM	Static Random Access Memory
TA	Terminal adapter (e.g. GSM module)
TDMA	Time Division Multiple Access
TE	Terminal Equipment, also referred to as DTE
TLS	Transport Layer Security
Tx	Transmit Direction
UART	Universal asynchronous receiver-transmitter
URC	Unsolicited Result Code
USSD	Unstructured Supplementary Service Data
VSWR	Voltage Standing Wave Ratio

6.4   Safety Precaution Notes

The following safety precautions must be observed during all phases of the operation, usage, service or repair of any cellular terminal or mobile incorporating EHS6. Manufacturers of the cellular terminal are advised to convey the following safety information to users and operating personnel and to incorporate these guidelines into all manuals supplied with the product. Failure to comply with these precautions violates safety standards of design, manufacture and intended use of the product. Gemalto M2M assumes no liability for customer's failure to comply with these precautions.

	When in a hospital or other health care facility, observe the restrictions on the use of mobiles. Switch the cellular terminal or mobile off, if instructed to do so by the guidelines posted in sensitive areas. Medical equipment may be sensitive to RF energy. The operation of cardiac pacemakers, other implanted medical equipment and hearing aids can be affected by interference from cellular terminals or mobiles placed close to the device. If in doubt about potential danger, contact the physician or the manufacturer of the device to verify that the equipment is properly shielded. Pacemaker patients are advised to keep their hand-held mobile away from the pacemaker, while it is on.
	Switch off the cellular terminal or mobile before boarding an aircraft. Make sure it cannot be switched on inadvertently. The operation of wireless appliances in an aircraft is forbidden to prevent interference with communications systems. Failure to observe these instructions may lead to the suspension or denial of cellular services to the offender, legal action, or both.
	Do not operate the cellular terminal or mobile in the presence of flammable gases or fumes. Switch off the cellular terminal when you are near petrol stations, fuel depots, chemical plants or where blasting operations are in progress. Operation of any electrical equipment in potentially explosive atmospheres can constitute a safety hazard.
	Your cellular terminal or mobile receives and transmits radio frequency energy while switched on. Remember that interference can occur if it is used close to TV sets, radios, computers or inadequately shielded equipment. Follow any special regulations and always switch off the cellular terminal or mobile wherever forbidden, or when you suspect that it may cause interference or danger.
	Road safety comes first! Do not use a hand-held cellular terminal or mobile when driving a vehicle, unless it is securely mounted in a holder for speakerphone operation. Before making a call with a hand-held terminal or mobile, park the vehicle. Speakerphones must be installed by qualified personnel. Faulty installation or operation can constitute a safety hazard.
	IMPORTANT! Cellular terminals or mobiles operate using radio signals and cellular networks. Because of this, connection cannot be guaranteed at all times under all conditions. Therefore, you should never rely solely upon any wireless device for essential communications, for example emergency calls. Remember, in order to make or receive calls, the cellular terminal or mobile must be switched on and in a service area with adequate cellular signal strength. Some networks do not allow for emergency calls if certain network services or phone features are in use (e.g. lock functions, fixed dialing etc.). You may need to deactivate those features before you can make an emergency call. Some networks require that a valid SIM card be properly inserted in the cellular terminal or mobile.

7 Appendix

7.1 List of Parts and Accessories

Table 27: List of parts and accessories

Description	Supplier	Ordering information
EHS6	Gemalto M2M	Standard module Gemalto M2M IMEI: Packaging unit (ordering) number: L30960-N2950-A100 Module label number: S30960-S2950-A100-1 Customer IMEI mode: Packaging unit (ordering) number: L30960-N2955-A100 Module label number: S30960-S2955-A100-1
DSB75 Evaluation Kit	Gemalto M2M	Ordering number: L36880-N8811-A100
Multi-Adapter R1 for mounting EHS6 evaluation modules onto DSB75	Gemalto M2M	Ordering number: L30960-N0010-A100
Approval adapter for mounting EHS6 evaluation modules onto DSB75	Gemalto M2M	Ordering number: L30960-N2301-A100
Evaluation Module	Gemalto M2M	Ordering number: L30960-N2951-A100 (EHS6)
Votronic Handset	Votronic / Gemalto M2M	Gemalto M2M ordering number: L36880-N8301-A107 Votronic ordering number: HH-SI-30.3/V1.1/0 Votronic Entwicklungs- und Produktionsgesellschaft für elektronische Geräte mbH Saarbrücker Str. 8 66386 St. Ingbert Germany Phone: +49-(0)6 89 4 / 92 55-0 Fax: +49-(0)6 89 4 / 92 55-88 Email: contact@votronic.com
SIM card holder incl. push button ejector and slide-in tray	Molex	Ordering numbers: 91228 91236 Sales contacts are listed in Table 28.

Table 28: Molex sales contacts (subject to change)

Molex For further information please click: http://www.molex.com	Molex Deutschland GmbH Otto-Hahn-Str. 1b 69190 Walldorf Germany Phone: +49-6227-3091-0 Fax: +49-6227-3091-8100 Email: mxgermany@molex.com	American Headquarters Lisle, Illinois 60532 U.S.A. Phone: +1-800-78MOLEX Fax: +1-630-969-1352
Molex China Distributors Beijing, Room 1311, Tower B, COFCO Plaza No. 8, Jian Guo Men Nei Street, 100005 Beijing P.R. China Phone: +86-10-6526-9628 Fax: +86-10-6526-9730	Molex Singapore Pte. Ltd. 110, International Road Jurong Town, Singapore 629174 Phone: +65-6-268-6868 Fax: +65-6-265-6044	Molex Japan Co. Ltd. 1-5-4 Fukami-Higashi, Yamato-City, Kanagawa, 242-8585 Japan Phone: +81-46-265-2325 Fax: +81-46-265-2365

About Gemalto

Gemalto (Euronext NL0000400653 GTO) is the world leader in digital security with 2011 annual revenues of €2 billion and more than 10,000 employees operating out of 74 offices and 14 Research & Development centers, located in 43 countries.

We are at the heart of the rapidly evolving digital society. Billions of people worldwide increasingly want the freedom to communicate, travel, shop, bank, entertain and work - anytime, everywhere - in ways that are enjoyable and safe. Gemalto delivers on their expanding needs for personal mobile services, payment security, authenticated cloud access, identity and privacy protection, eHealthcare and eGovernment efficiency, convenient ticketing and dependable machine-to-machine (M2M) applications.

Gemalto develops secure embedded software and secure products which we design and personalize. Our platforms and services manage these secure products, the confidential data they contain and the trusted end-user services they enable. Our inovations enable our clients to offer trusted and convenient digital services to billions of individuals.

Gemalto thrives with the growing number of people using its solutions to interact with the digital and wireless world.

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