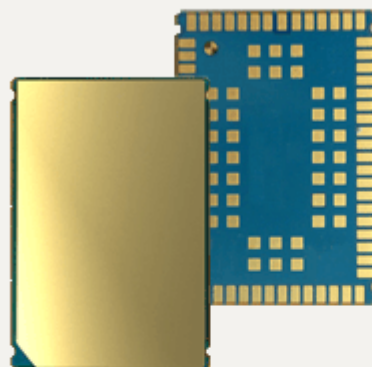


Cinterion[®] EHS5-E/EHS5-US

Hardware Interface Description

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1 Introduction

This document¹ describes the hardware of the Cinterion® EHS5-E/EHS5-US 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 |
|--|---|
| <i>General</i> | |
| Frequency bands | EHS5-E: GSM/GPRS/EDGE: Dual band GSM 900/1800MHz UMTS/HSPA+: Dual band UMTS 900/2100MHz EHS5-US: GSM/GPRS/EDGE: Dual band GSM 850/1900MHz UMTS/HSPA+: Dual band UMTS 850/1900MHz |
| GSM class | Small MS |
| Output power (according to Release 99, V5) | EHS5-E: Class 4 (+33dBm ±2dB) for EGSM900 Class 1 (+30dBm ±2dB) for GSM1800 Class E2 (+27dBm ± 3dB) for GSM 900 8-PSK Class E2 (+26dBm +3 /-4dB) for GSM 1800 8-PSK Class 3 (+24dBm +1/-3dB) for UMTS 2100, WCDMA FDD BdI Class 3 (+24dBm +1/-3dB) for UMTS 900, WCDMA FDD BdVIII EHS5-US: Class 4 (+33dBm ±2dB) for EGSM850 Class 1 (+30dBm ±2dB) for GSM1900 Class E2 (+27dBm ± 3dB) for GSM 850 8-PSK Class E2 (+26dBm +3 /-4dB) for GSM 1900 8-PSK Class 3 (+24dBm +1/-3dB) for UMTS 1900, WCDMA FDD BdII Class 3 (+24dBm +1/-3dB) for UMTS 850, WCDMA FDD BdV |
| 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 18.8mm x 2.2mm Weight: approx. 3g |
| RoHS | All hardware components fully compliant with EU RoHS Directive |

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.

1.1 Key Features at a Glance

| Feature | Implementation |
|--------------------------------|--|
| <i>HSPA features</i> | |
| 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 |
| <i>UMTS features</i> | |
| 3GPP Release 4 | PS data rate – 384 kbps DL / 384 kbps UL CS data rate – 64 kbps DL / 64 kbps UL |
| <i>GSM/GPRS/EGPRS features</i> | |
| Data transfer | <p>GPRS:</p> <ul style="list-style-type: none"> • Multislot Class 12 • Full PBCCH support • Mobile Station Class B • Coding Scheme 1 – 4 <p>EGPRS:</p> <ul style="list-style-type: none"> • 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 <p>CSD:</p> <ul style="list-style-type: none"> • 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 |
| <i>Software</i> | |
| AT commands | Hayes 3GPP TS 27.007, TS 27.005, Gemalto M2M AT commands for RIL compatibility |
| Java™ Open Platform | <p>Java™ Open Platform with</p> <ul style="list-style-type: none"> • Java™ profile IMP-NG & CLDC 1.1 HI • Secure data transmission via HTTPS/SSL • Multi-threading programming and multi-application execution <p>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.</p> <p>The memory space available for Java programs is around 10MB in the flash file system and around 10MB RAM. Application code and data share the space in the flash file system and in RAM.</p> |

1.1 Key Features at a Glance

| Feature | Implementation |
|----------------------------|---|
| 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. |
| <i>Interfaces</i> | |
| Module interface | Surface mount device with solderable connection pads (SMT application interface). Land grid array (LGA) technology ensures high solder joint reliability and allows the use of an optional module mounting socket. For more information on how to integrate SMT modules see also [4]. This application note comprises chapters on module mounting and application layout issues as well as on 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): <ul style="list-style-type: none"> 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. ASC1 (shared with GPIO lines): <ul style="list-style-type: none"> 4-wire, unbalanced asynchronous interface Adjustable baud rates: 1,200bps to 921,600bps 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 | 9 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 and SPI interfaces |
| I ² C interface | Supports I ² C serial interface |
| SPI interface | Serial peripheral interface, shared with GPIO lines |
| Antenna interface pads | 50Ω |
| <i>Power on/off, Reset</i> | |
| Power on/off | Switch-on by hardware signal AUTO_ON and ON Switch-off by AT command Switch off by hardware signal GPIO4/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 |
| <i>Special features</i> | |
| Real time clock | Timer functions via AT commands |
| Phonebook | SIM and phone |
| TTY/CTM support | Integrated CTM modem |

1.2 EHS5-E/EHS5-US System Overview

| Feature | Implementation |
|-----------------------|---|
| <i>Evaluation kit</i> | |
| Evaluation module | EHS5-E/EHS5-US 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 EHS5-E/EHS5-US evaluation module to the DSB75. |

1.2 EHS5-E/EHS5-US System Overview

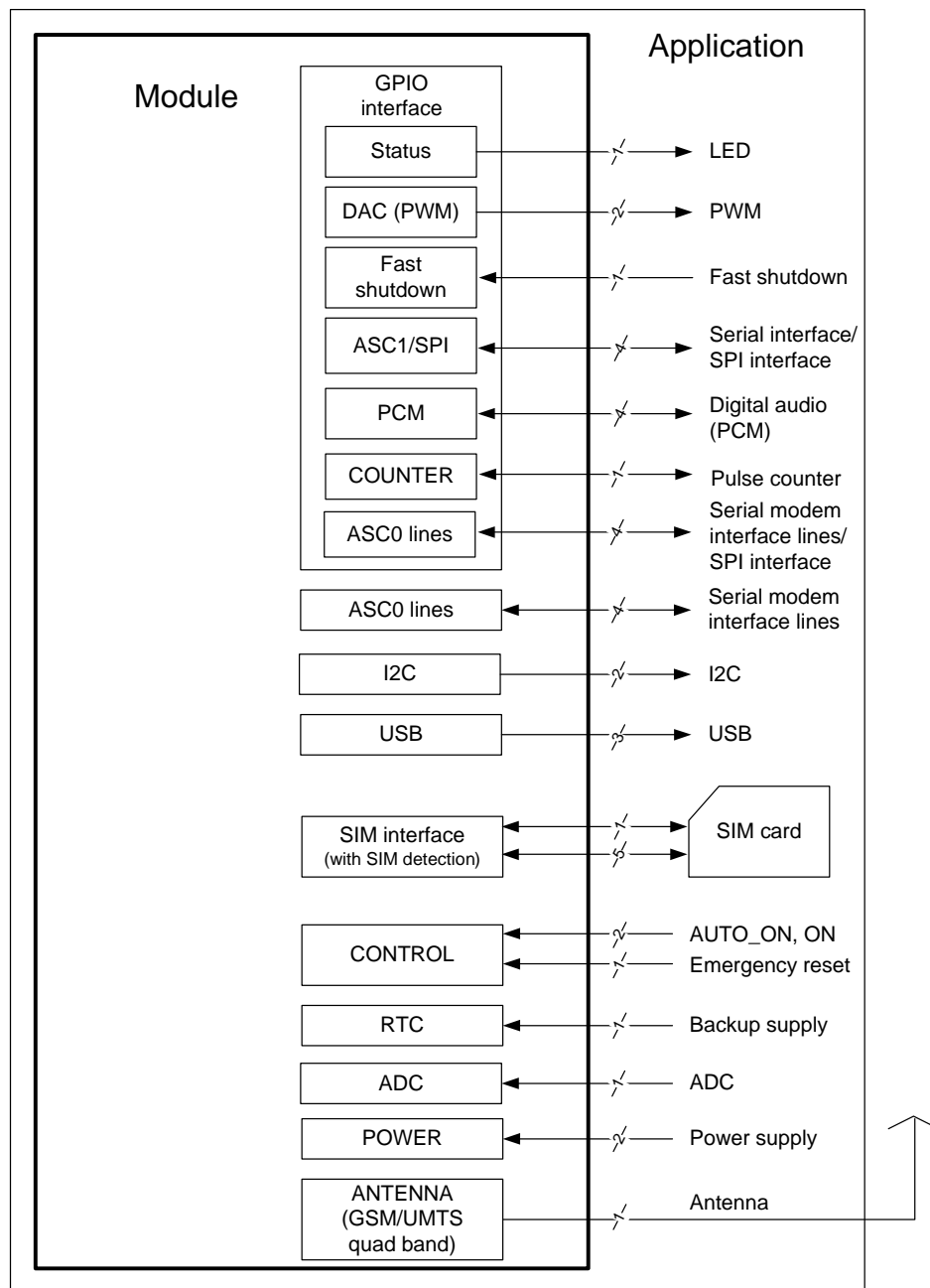


Figure 1: EHS5-E/EHS5-US system overview

1.3 Circuit Concept

1.3 Circuit Concept

The following figures show block diagrams of the EHS5-E/EHS5-US module and illustrate the major functional components:

Baseband block (see [Figure 2](#)):

- GSM baseband processor and power management
- Stacked flash/PSRAM memory
- Application interface (SMT with connecting pads)

GSM/UMTS RF section (see [Figure 3](#)):

- RF transceiver (part of baseband processor IC)
- RF power amplifier/front-end module inc. harmonics filtering
- Receive SAW filters

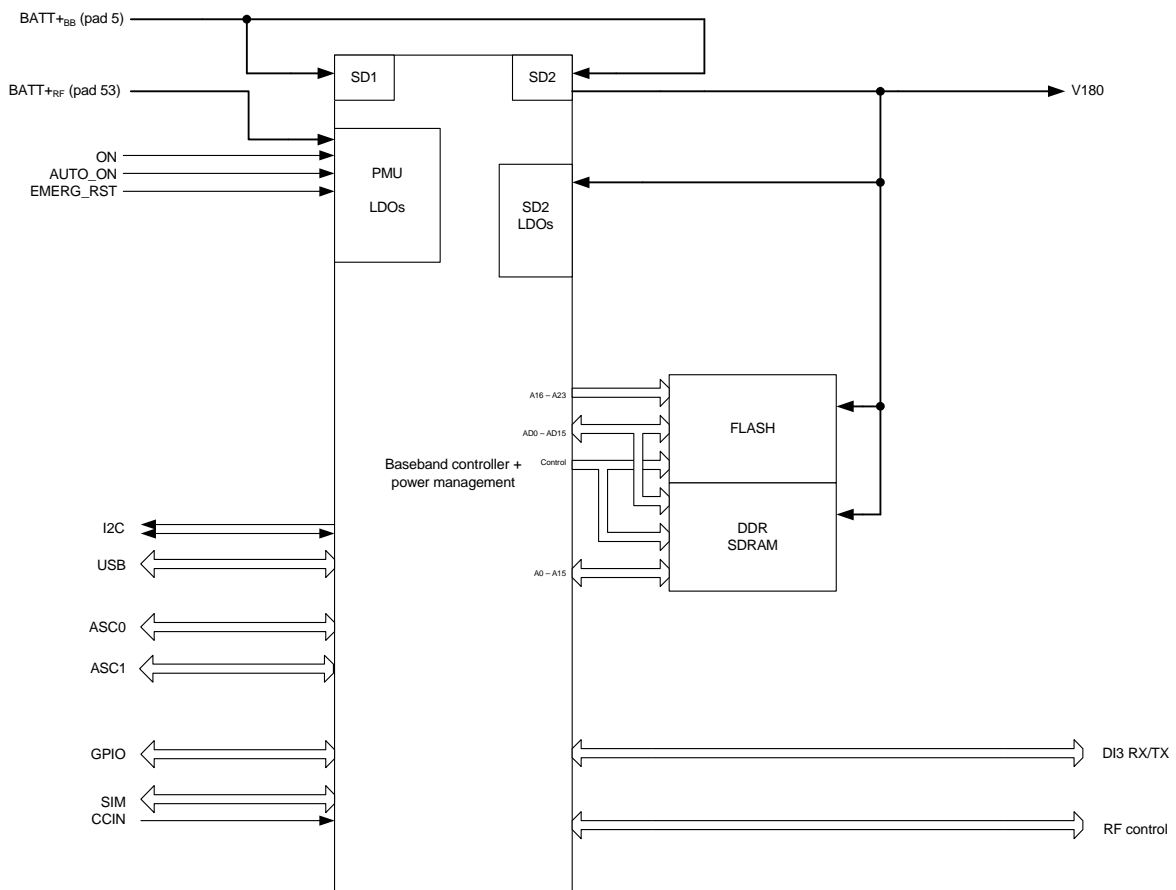


Figure 2: EHS5-E/EHS5-US baseband block diagram

1.3 Circuit Concept

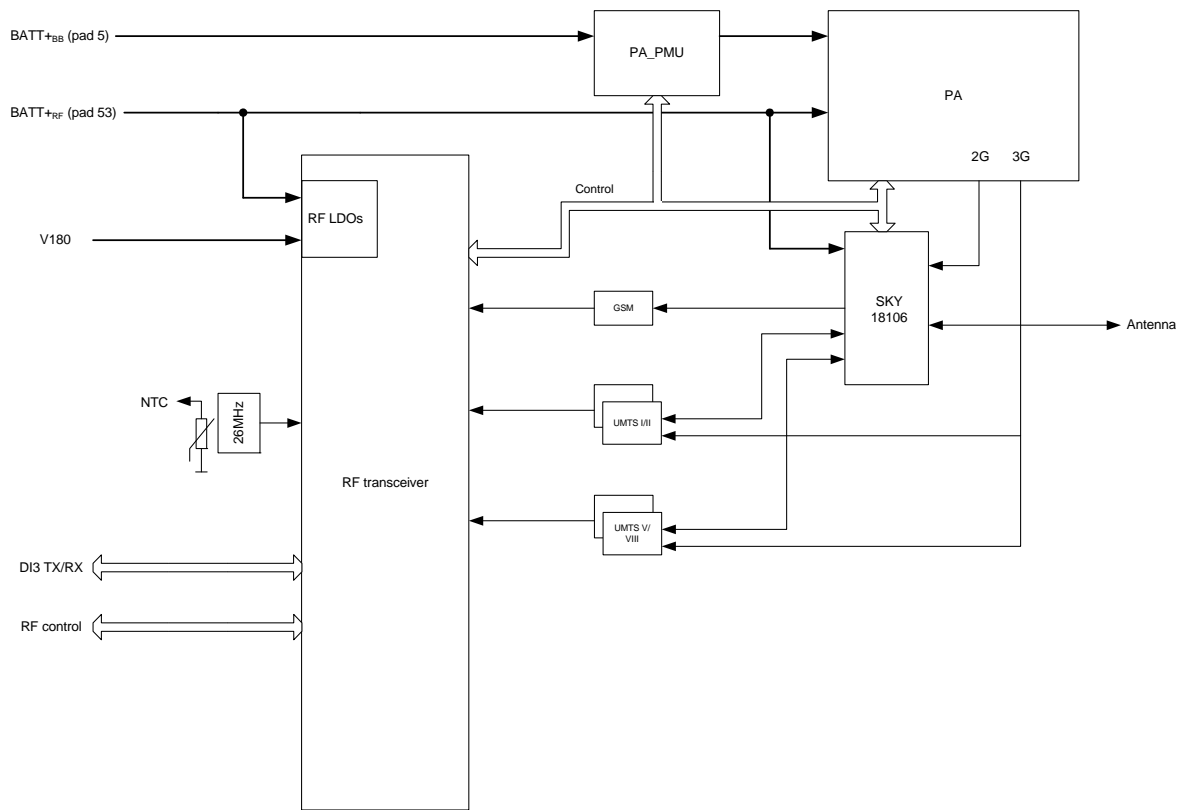


Figure 3: EHS5-E/EHS5-US GSM/UMTS RF section block diagram

2 Interface Characteristics

EHS5-E/EHS5-US 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 EHS5-E/EHS5-US 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.

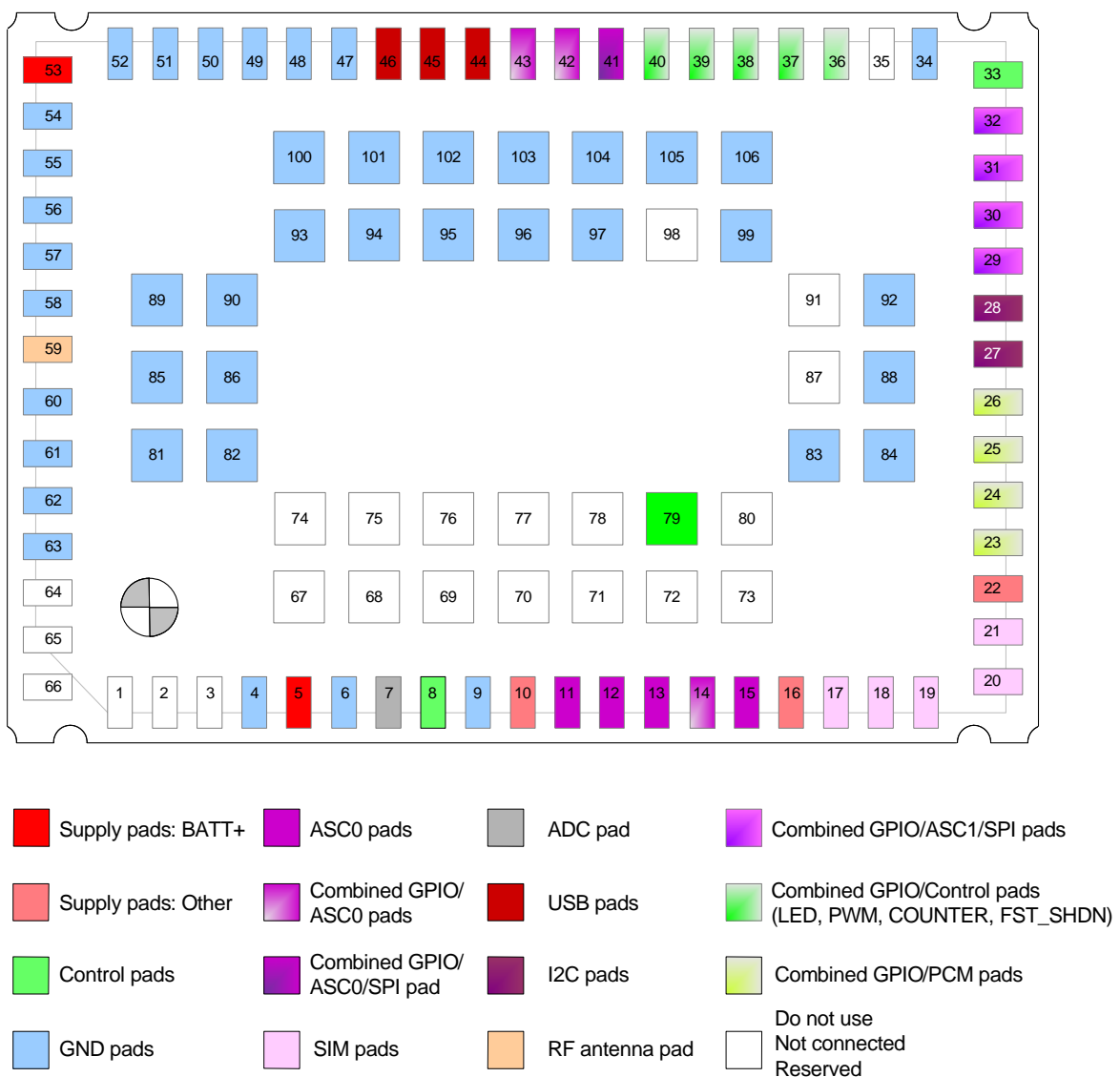


Figure 4: Numbering plan for connecting pads (bottom view)

2.1 Application Interface

Table 1: Pad assignments

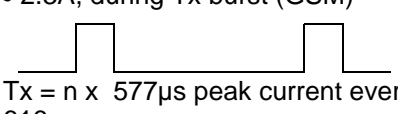
| Pad no. | Signal name | Pad no. | Signal name | Pad no. | Signal name |
|------------------------|---------------------------------|---------|--------------------|---------|---------------------------------|
| 1 | Reserved | 23 | GPIO20/TXD0 | 45 | USB_DP |
| 2 | Reserved | 24 | GPIO22/TFSDAI | 46 | USB_DN |
| 3 | Reserved | 25 | GPIO21/RXD0 | 47 | GND |
| 4 | GND | 26 | GPIO23/SCLK | 48 | GND |
| 5 | BATT ₊ _{BB} | 27 | I2CDAT | 49 | GND |
| 6 | GND | 28 | I2CCLK | 50 | GND |
| 7 | ADC1 | 29 | GPIO17/TXD1/MISO | 51 | GND |
| 8 | ON | 30 | GPIO16/RXD1/MOSI | 52 | GND |
| 9 | GND | 31 | GPIO18/RTS1 | 53 | BATT ₊ _{RF} |
| 10 | V180 | 32 | GPIO19/CTS1/SPI_CS | 54 | GND |
| 11 | RXD0 | 33 | EMERG_RST | 55 | GND |
| 12 | CTS0 | 34 | GND | 56 | GND |
| 13 | TXD0 | 35 | Not connected | 57 | GND |
| 14 | GPIO24/RING0 | 36 | GPIO8/COUNTER | 58 | GND |
| 15 | RTS0 | 37 | GPIO7/PWM1 | 59 | RF_OUT |
| 16 | VDDL | 38 | GPIO6/PWM2 | 60 | GND |
| 17 | CCRST | 39 | GPIO5/LED | 61 | GND |
| 18 | CCIN | 40 | GPIO4/FST_SHDN | 62 | GND |
| 19 | CCIO | 41 | GPIO3/DSR0/SPI_CLK | 63 | GND |
| 20 | CCVCC | 42 | GPIO2/DCD0 | 64 | Reserved |
| 21 | CCCLK | 43 | GPIO1/DTR0 | 65 | Reserved |
| 22 | VCORE | 44 | VUSB | 66 | Reserved |
| Centrally located pads | | | | | |
| 67 | Not connected | 81 | GND | 95 | GND |
| 68 | Not connected | 82 | GND | 96 | GND |
| 69 | Not connected | 83 | GND | 97 | GND |
| 70 | Not connected | 84 | GND | 98 | Do not use |
| 71 | Not connected | 85 | GND | 99 | GND |
| 72 | Not connected | 86 | GND | 100 | GND |
| 73 | Not connected | 87 | Do not use | 101 | GND |
| 74 | Do not use | 88 | GND | 102 | GND |
| 75 | Do not use | 89 | GND | 103 | GND |
| 76 | Do not use | 90 | GND | 104 | GND |
| 77 | Do not use | 91 | Not connected | 105 | GND |
| 78 | Do not use | 92 | GND | 106 | GND |
| 79 | AUTO_ON | 93 | GND | | |
| 80 | Do not use | 94 | 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 EHS5-E/EHS5-US module. They do not apply to the accessories connected.

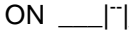

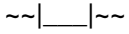
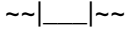
2.1.2 Signal Properties

Table 2: Signal properties

| Function | Signal name | IO | Signal form and level | Comment |
|-------------------------|--|----|--|---|
| Power supply | BATT+ _{BB} BATT+ _{RF} | I | <p><u>GSM activated:</u> $V_{I\max} = 4.5V$ $V_{Inorm} = 3.8V$ $V_{I\min} = 3.3V$ during Tx burst on board</p> <p>$I \approx 2.3A$, during Tx burst (GSM)</p>  <p>$n \text{ Tx} = n \times 577\mu\text{s}$ peak current every 4.616ms</p> <p><u>WCDMA activated:</u> $V_{I\max} = 4.5V$ $V_{Inorm} = 3.8V$ $V_{I\min} = 3.3V$ during Transmit active. $I_{\max} = 700mA$ during Tx</p> | <p>Lines of BATT+ and GND must be connected in parallel for supply purposes because higher peak currents may occur.</p> <p>Minimum voltage must not fall below 3.3V including drop, ripple, spikes and not rise above 4.5V.</p> <p>BATT+_{BB} and BATT+_{RF} require an ultra low ESR capacitor: BATT+_{BB} --> 150µF BATT+_{RF} --> 50µF If using Multilayer Ceramic Chip Capacitors (MLCC) please take DC-bias into account.</p> |
| Power supply | GND | | Ground | Application Ground |
| External supply voltage | V180 | O | <p>Normal operation: $V_{O\text{norm}} = 1.80V \pm 3\%$ $I_{O\text{max}} = -10mA$</p> <p>SLEEP mode Operation: $V_{O\text{Sleep}} = 1.80V \pm 5\%$ $I_{O\text{max}} = -10mA$</p> <p>$CL_{\text{max}} = 2\mu F$</p> | <p>V180 may be used to supply level shifters at the interfaces or to supply external application circuits.</p> <p>VCORE and V180 should be used for the power indication circuit.</p> |
| | VCORE | O | <p>Full power mode (speed stepping): $V_{O\text{full}} = 1.2V \pm 2.5\%$ $I_{O\text{max}} = -10mA$ Reduced pwr. mode (speed stepping): $V_{O\text{reduced}} = 0.9V..1.2V \pm 4\%$ $I_{O\text{max}} = -10mA$</p> <p>$CL_{\text{max}} = 100nF$</p> | If unused keep line open. |

2.1 Application Interface

Table 2: Signal properties

| Function | Signal name | IO | Signal form and level | Comment |
|-------------------|-------------|-----|---|--|
| Ignition | ON | I | $V_{IHmax} = V_{DDL P} + 0.3V$ $V_{IHmin} = 1.2V$ $V_{ILmax} = 0.5V$ Min low time before rising edge $\leq 100\mu s$ ON  high pulse $50\mu s \dots 80\mu s$ | This signal switches the module on. Set this signal low before and after the startup impulse. If unused pull to GND using $10k\Omega$. |
| | AUTO_ON | I | $V_{OHmax} = V_{DDL P} \text{ max}$ $V_{IHmin} = 1.2V$ $V_{ILmax} = 0.5V$ Low level time $\geq 50\mu s$ 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. |
| Emergency restart | EMERG_RST | I | $R_1 \approx 1k\Omega$, $C_1 \approx 1nF$ $V_{OHmax} = V_{DDL P} \text{ max}$ $V_{IHmin} = 1.35V$ $V_{ILmax} = 0.3V$ at $\sim 200\mu A$  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 | FST_SHDN | I | $V_{ILmax} = 0.35V$ $V_{IHmin} = 1.30V$ $V_{IHmax} = 1.85V$  low impulse width $> 10ms$ | This line must be driven low. If unused keep line open. Note that the fast shutdown line is originally available as GPIO line. If configured as fast shutdown, the GPIO line is assigned as follows: GPIO4 --> FST_SHDN |
| RTC backup | VDDL P | I/O | $V_{Onorm} = 1.8V$ $I_{Omax} = -25mA$ $V_1max = 1.9V$ $V_1min = 1.0V$ $I_{1typ} < 1\mu A$ | It is recommended to use a serial resistor between VDDL P and a possible capacitor. If unused keep line open. |
| USB | VUSB_IN | I | $V_1min = 3V$ $V_1max = 5.25V$ Active and suspend current: $I_{max} < 100\mu A$ | 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 | I/O | | |

2.1 Application Interface

Table 2: Signal properties

| Function | Signal name | IO | Signal form and level | Comment |
|-----------------------|-------------|---|---|--|
| Serial Interface ASC0 | RXD0 | O | $V_{OLmax} = 0.25V$ at $I = 1mA$ $V_{OHmin} = 1.55V$ at $I = -1mA$ $V_{OHmax} = 1.85V$ | If unused keep lines open. |
| | CTS0 | O | | |
| | DSR0 | O | Pull down resistor active $V_{OLmax} = 0.5V$ at $I > 50\mu A$ | Note that some ASC0 lines are originally available as GPIO lines. If configured as ASC0 lines, the GPIO lines are assigned as follows: GPIO1 --> DTR0 GPIO2 --> DCD0 GPIO3 --> DSR0 GPIO24 --> RING0 |
| | DCD0 | O | | |
| | RING0 | O | Pull up resistor active $V_{OHmin} = 1.3V$ at $I > -50\mu A$ | |
| | TXD0 | I | $V_{ILmax} = 0.35V$ $V_{IHmin} = 1.30V$ $V_{IHmax} = 1.85V$ | |
| | RTS0 | I | Pull down resistor active $V_{ILmax} = 0.35V$ at $> 50\mu A$ $V_{IHmin} = 1.30V$ at $< 240\mu A$ $V_{IHmax} = 1.85V$ at $< 240\mu A$ | |
| DTR0 | I | Pull up resistor active $V_{ILmax} = 0.35V$ at $< -200\mu A$ $V_{IHmin} = 1.30V$ at $> -50\mu A$ $V_{IHmax} = 1.85V$ | DSR0, DCD0 and RING0 signal lines are driven by a pull up or pull down resistor only. | |
| Serial Interface ASC1 | RXD1 | O | $V_{OLmax} = 0.25V$ at $I = 1mA$ $V_{OHmin} = 1.55V$ at $I = -1mA$ $V_{OHmax} = 1.85V$ | If unused keep line open. Note that the ASC1 interface lines are originally available as GPIO lines. If configured as ASC1 lines, the GPIO lines are assigned as follows: GPIO16 --> RXD1 GPIO17 --> TXD1 GPIO18 --> RTS1 GPIO19 --> CTS1 |
| | TXD1 | I | | |
| | RTS1 | I | | |
| | CTS1 | O | $V_{ILmax} = 0.35V$ $V_{IHmin} = 1.30V$ $V_{IHmax} = 1.85V$ | |
| I ² C | I2CCLK | IO | Open drain IO $V_{OLmin} = 0.35V$ at $I = -3mA$ $V_{OHmax} = 1.85V$ $R_{external\ pull\ up\ min} = 560\Omega$ | According to the I ² C 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 (I ² C Slave + lines). The maximum sink current of I2CDAT and I2CCLK is 4mA. If lines are unused keep lines open. |
| | I2CDAT | IO | $V_{ILmax} = 0.35V$ $V_{IHmin} = 1.3V$ $V_{IHmax} = 1.85V$ | |

2.1 Application Interface

Table 2: Signal properties

| Function | Signal name | IO | Signal form and level | Comment |
|-------------------------------|---------------|----|---|--|
| SPI | SPI_CLK | O | $V_{OLmax} = 0.25V$ at $I = 1mA$ $V_{OHmin} = 1.55V$ at $I = -1mA$ $V_{OHmax} = 1.85V$ $V_{ILmax} = 0.35V$ $V_{IHmin} = 1.30V$ $V_{IHmax} = 1.85V$ | If lines are unused keep lines open. Note that the SPI interface lines are originally available as GPIO lines. If configured as SPI lines, the GPIO lines are assigned as follows: GPIO3 --> SPI_CLK GPIO16 --> MOSI GPIO17 --> MISO GPIO19 --> SPI_CS |
| | MOSI | O | | |
| | MISO | I | | |
| | SPI_CS | O | | |
| GPIO interface | GPIO1-GPIO3 | IO | $V_{OLmax} = 0.25V$ at $I = 1mA$ $V_{OHmin} = 1.55V$ at $I = -1mA$ $V_{OHmax} = 1.85V$ $V_{ILmax} = 0.35V$ $V_{IHmin} = 1.30V$ $V_{IHmax} = 1.85V$ | If unused keep line open. Please note that some GPIO lines can be configured by AT command for alternative functions: GPIO1-GPIO3: ASC0 control lines DTR0, DCD0 and DSR0 GPIO4: Fast shutdown GPIO5: Status LED line GPIO6/GPIO7: PWM GPIO8: Pulse Counter GPIO16-GPIO19: ASC1 or SPI GPIO20-GPIO23: PCM GPIO24: ASC0 control line RING0 |
| | GPIO4 | IO | | |
| | GPIO5 | IO | | |
| | GPIO6 | IO | | |
| | GPIO7 | IO | | |
| | GPIO8 | IO | | |
| | GPIO16-GPIO19 | IO | | |
| | GPIO20-GPIO23 | IO | | |
| | GPIO24 | IO | | |
| Digital audio interface (PCM) | TFSDAI | O | $V_{OLmax} = 0.25V$ at $I = 1mA$ $V_{OHmin} = 1.55V$ at $I = -1mA$ $V_{OHmax} = 1.85V$ $V_{ILmax} = 0.35V$ $V_{IHmin} = 1.30V$ $V_{IHmax} = 1.85V$ | If unused keep line open. Note that the PCM interface lines are originally available as GPIO lines. If configured as PCM lines, the GPIO lines are assigned as follows: GPIO22 --> TFSDAI GPIO23 --> SCLK GPIO20 --> TXDDAI GPIO21 --> RXDDAI |
| | SCLK | O | | |
| | TXDDAI | O | | |
| | RXDDAI | I | | |
| Status LED | LED | O | $V_{OLmax} = 0.25V$ at $I = 1mA$ $V_{OHmin} = 1.55V$ at $I = -1mA$ $V_{OHmax} = 1.85V$ | If unused keep line open. Note that the LED line is originally available as GPIO line. If configured as LED line, the GPIO line is assigned as follows: GPIO5 --> LED |

2.1 Application Interface

Table 2: Signal properties

| Function | Signal name | IO | Signal form and level | Comment |
|--------------------------------------|-------------|----|---|---|
| PWM | PWM1 | O | $V_{OLmax} = 0.25V$ at $I = 1mA$ $V_{OHmin} = 1.55V$ at $I = -1mA$ $V_{OHmax} = 1.85V$ | If unused keep lines open. Note that the PWM lines are originally available as GPIO lines. If configured as PWM lines, the GPIO lines are assigned as follows: GPIO7 --> PWM1 GPIO6 --> PWM2 |
| | PWM2 | O | | |
| Pulse counter | COUNTER | I | Internal up resistor active $V_{ILmax} = 0.35V$ at $< -200\mu A$ $V_{IHmin} = 1.30V$ at $> -50\mu A$ $V_{IHmax} = 1.85V$ | If unused keep line open. Note that the COUNTER line is originally available as GPIO line. If configured as COUNTER line, the GPIO line is assigned as follows: GPIO8 --> COUNTER |
| ADC (Analog-to-Digital converter) | ADC1 | I | $R_I = 1M\Omega$ $V_I = 0V \dots 1.2V$ (valid range) $V_{IHmax} = 1.2V$ Resolution 1024 steps Tolerance 0.3% | ADC1 can be used as input for external measurements. If unused keep line open. |

2.1 Application Interface

Table 2: Signal properties

| Function | Signal name | IO | Signal form and level | Comment |
|-------------------------|-------------|-----|---|---|
| SIM card detection | CCIN | I | $R_I \approx 110k\Omega$ $V_{IHmin} = 1.45V$ at $I = 15\mu A$, $V_{IHmax} = 1.9V$ $V_{ILmax} = 0.3V$ | 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 | $V_{OLmax} = 0.30V$ at $I = 1mA$ $V_{OHmin} = 2.45V$ at $I = -1mA$ $V_{OHmax} = 2.90V$ | Maximum cable length or copper track to SIM card holder should not exceed 100mm. |
| | CCIO | I/O | $V_{ILmax} = 0.50V$ $V_{IHmin} = 2.05V$ $V_{IHmax} = 2.90V$ $V_{OLmax} = 0.25V$ at $I = 1mA$ $V_{OHmin} = 2.50V$ at $I = -1mA$ $V_{OHmax} = 2.90V$ | |
| | CCCLK | O | $V_{OLmax} = 0.25V$ at $I = 1mA$ $V_{OHmin} = 2.40V$ at $I = -1mA$ $V_{OHmax} = 2.90V$ | |
| | CCVCC | O | $V_{Omin} = 2.80V$ $V_{Otyp} = 2.85V$ $V_{Omax} = 2.90V$ $I_{Omax} = -30mA$ | |
| 1.8V SIM Card Interface | CCRST | O | $V_{OLmax} = 0.25V$ at $I = 1mA$ $V_{OHmin} = 1.45V$ at $I = -1mA$ $V_{OHmax} = 1.90V$ | |
| | CCIO | I/O | $V_{ILmax} = 0.35V$ $V_{IHmin} = 1.25V$ $V_{IHmax} = 1.85V$ $V_{OLmax} = 0.25V$ at $I = 1mA$ $V_{OHmin} = 1.50V$ at $I = -1mA$ $V_{OHmax} = 1.85V$ | |
| | CCCLK | O | $V_{OLmax} = 0.25V$ at $I = 1mA$ $V_{OHmin} = 1.50V$ at $I = -1mA$ $V_{OHmax} = 1.85V$ | |
| | CCVCC | O | $V_{Omin} = 1.75V$ $V_{Otyp} = 1.80V$ $V_{Omax} = 1.85V$ $I_{Omax} = -30mA$ | |

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 EHS5-E/EHS5-US.

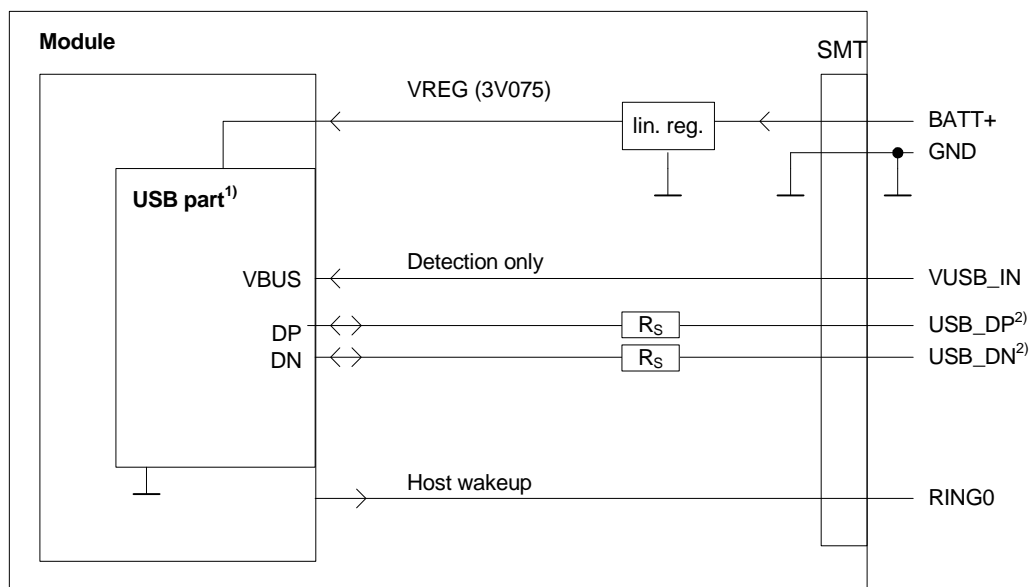
Table 3: Absolute maximum ratings

| Parameter | Min | Max | Unit |
|--|-------|------------|------|
| Supply voltage BATT _{BB} , BATT _{RF} | -0.3 | +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 | +3.3 | V |
| VDDL 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 | mA |

2.1.3 USB Interface

EHS5-E/EHS5-US 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 external application is responsible for supplying the VUSB_IN line. This line is used for cable detection only. The USB part (driver and transceiver) is supplied by means of BATT+. This is because EHS5-E/EHS5-US 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 external application, a USB 2.0 compatible connector and cable or hardware design is required. For more information on the USB related signals see [Table 2](#). Furthermore, the USB modem driver distributed with EHS5-E/EHS5-US needs to be installed.

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

2.1.3.1 Reducing Power Consumption

While a USB connection is active, the module will never switch into SLEEP mode. Only if the USB interface is in Suspended state or Detached (i.e., VUSB_IN = 0) is the module able to switch into SLEEP mode thereby saving power. There are two possibilities to enable power reduction mechanisms:

- **Recommended implementation of USB Suspend/Resume/Remote Wakeup:**

The USB host should be able to bring its USB interface into the Suspended state as described in the "Universal Serial Bus Specification Revision 2.0"¹. For this functionality to work, the VUSB_IN line should always be kept enabled. On incoming calls and other events EHS5-E/EHS5-US will then generate a Remote Wakeup request to resume the USB host controller.

See also [5] (USB Specification Revision 2.0, Section 10.2.7, p.282):

"If USB System wishes to place the bus in the Suspended state, it commands the Host Controller to stop all bus traffic, including SOFs. This causes all USB devices to enter the Suspended state. In this state, the USB System may enable the Host Controller to respond to bus wakeup events. This allows the Host Controller to respond to bus wakeup signaling to restart the host system."

- **Implementation for legacy USB applications not supporting USB Suspend/Resume:**

As an alternative to the regular USB suspend and resume mechanism it is possible to employ the RING0 line to wake up the host application in case of incoming calls or events signaled by URCs while the USB interface is in Detached state (i.e., VUSB_IN = 0). Every wakeup event will force a new USB enumeration. Therefore, the external application has to carefully consider the enumeration timings to avoid losing any signalled events. For details on this host wakeup functionality see [Section 2.1.14.3](#). To prevent existing data call connections from being disconnected while the USB interface is in detached state (i.e., VUSB_IN=0) it is possible to call AT&D0, thus ignoring the status of the DTR line (see also [1]).

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

2.1.4 Serial Interface ASC0

EHS5-E/EHS5-US 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](#).

EHS5-E/EHS5-US 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

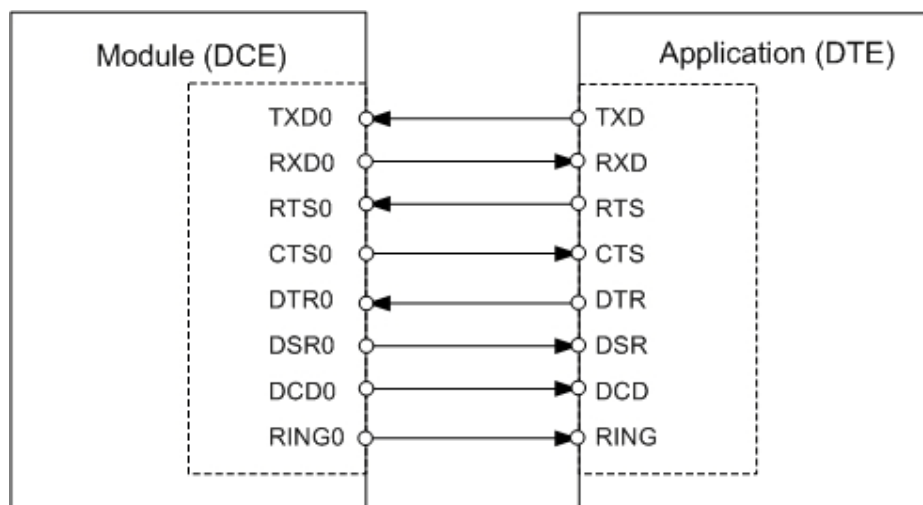


Figure 6: Serial interface ASC0

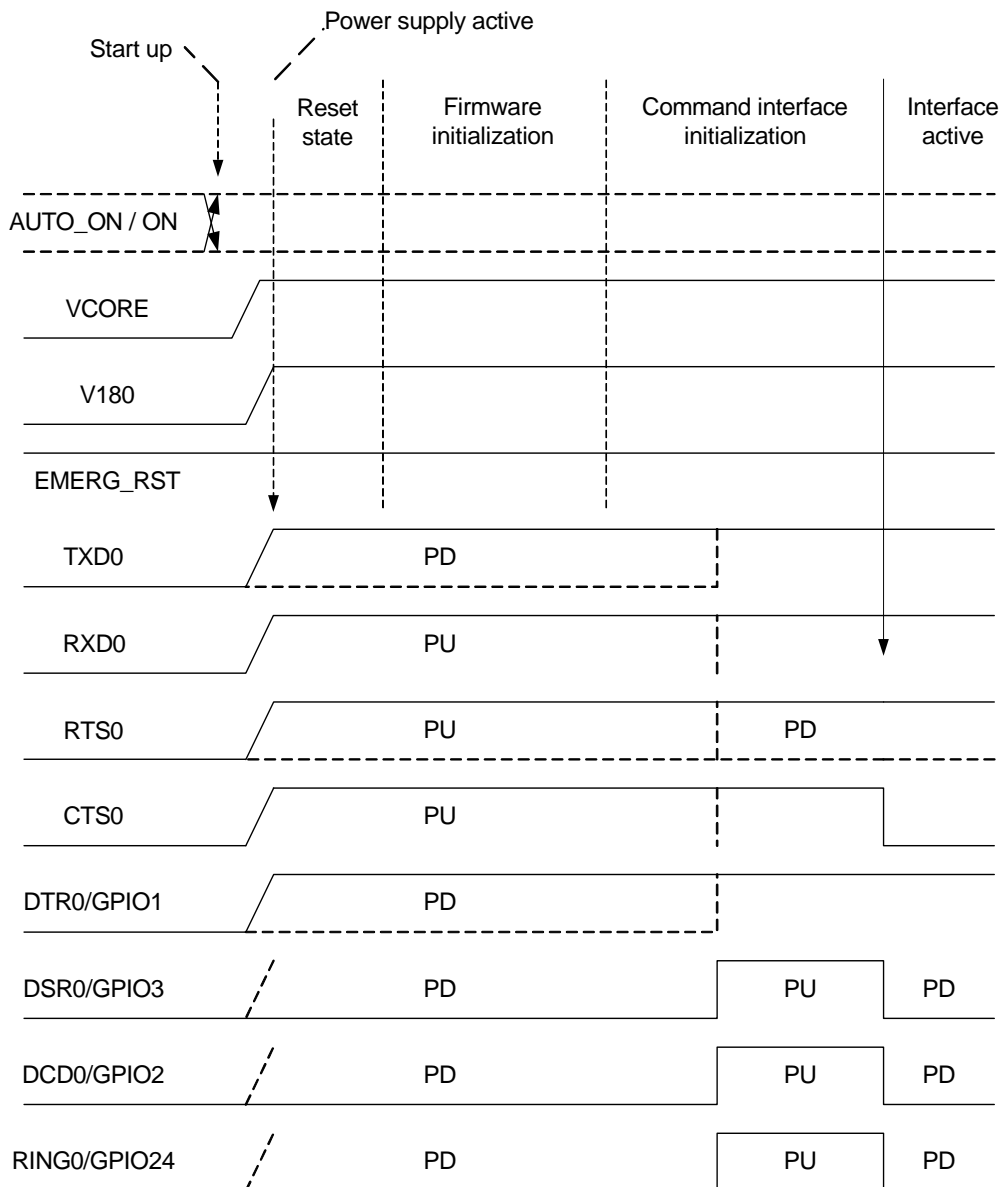
Features:

- 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.
- 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 1200bps up to 921600bps.
- Autobauding supports bit rates from 1200bps up to 230400bps.
- 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; see [Section 3.4.3](#)).

Note: The ASC0 modem control lines DTR0, DCD0, DSR0 and RING0 are originally available as GPIO lines. If configured as ASC0 lines, these GPIO lines are assigned as follows: GPIO1 --> DTR0, GPIO2 --> DCD0, GPIO3 --> DSR0 and GPIO24 --> RING0. Also, 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 [\[1\]](#): AT^SCFG). 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

Notes:

During startup the DTR0 signal is driven active low for 500µs. It is recommended to provide a 470Ω serial resistor for the DTR0 line to prevent shorts.

No data must be sent over the ASC0 interface before the interface is active and ready to receive data (see [Section 3.2.1](#)).

An external pull down to ground on the DCD0 line during the startup phase activates a special mode for EHS5-E/EHS5-US. In this special mode the AT command interface is not available and the module may therefore no longer behave as expected.

2.1.5 Serial Interface ASC1

EHS5-E/EHS5-US provides 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 ASC1 interface lines are originally available as GPIO lines. If configured as ASC1 lines, the GPIO lines are assigned as follows: GPIO16 --> RXD1, GPIO17 --> TXD1, GPIO18 --> RTS1 and GPIO19 --> CTS1. Configuration is done by AT command (see [\[1\]](#): AT^SCFG). The configuration is non-volatile and becomes active after a module restart.

EHS5-E/EHS5-US 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

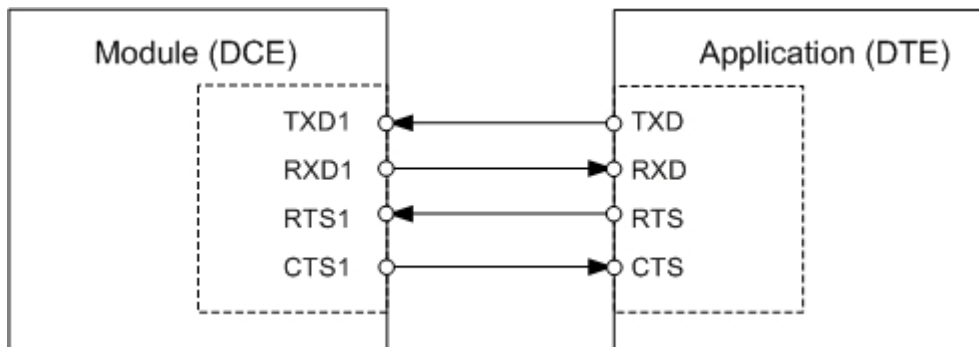
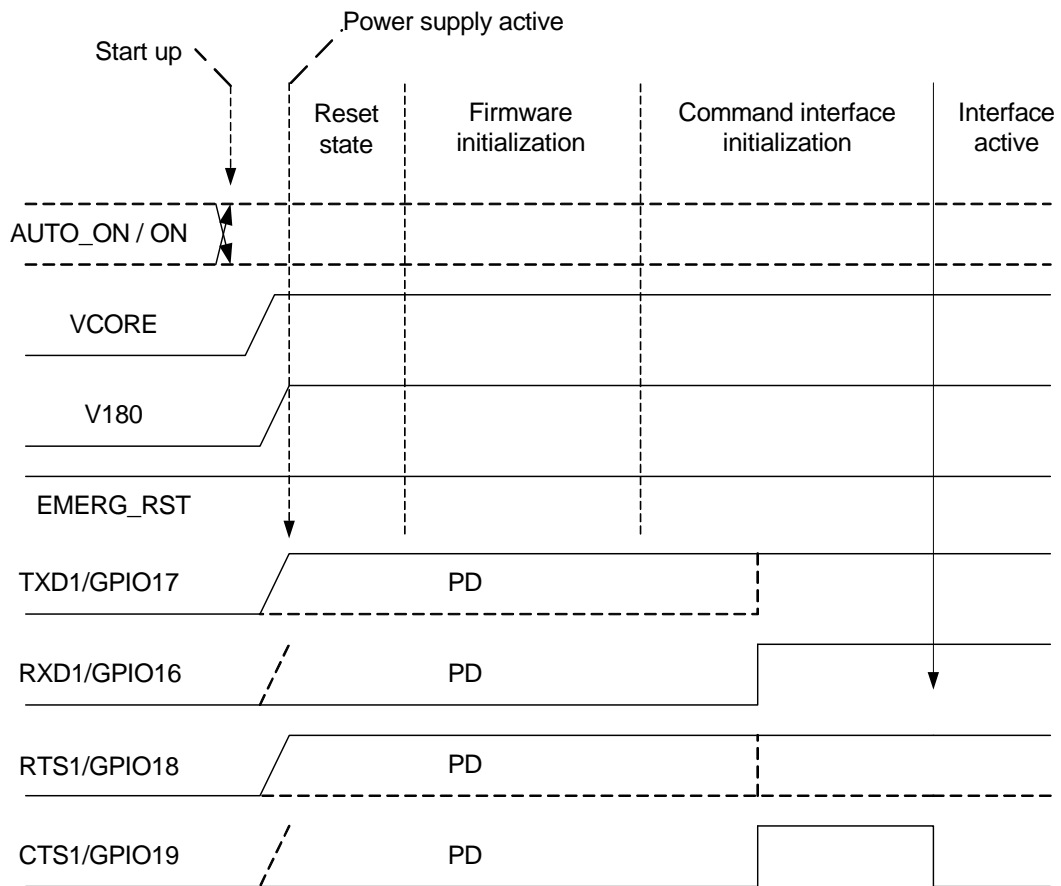


Figure 8: Serial interface ASC1

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 921600 bps.
- Autobauding supports bit rates from 1200bps up to 230400bps.
- Supports RTS1/CTS1 hardware flow control. Communication is possible by using only RXD and TXD lines, if RTS1 is pulled low.

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

EHS5-E/EHS5-US 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 EHS5-E/EHS5-US 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 EHS5-E/EHS5-US. |

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 EHS5-E/EHS5-US.

The figure below shows a circuit to connect an external SIM card holder.

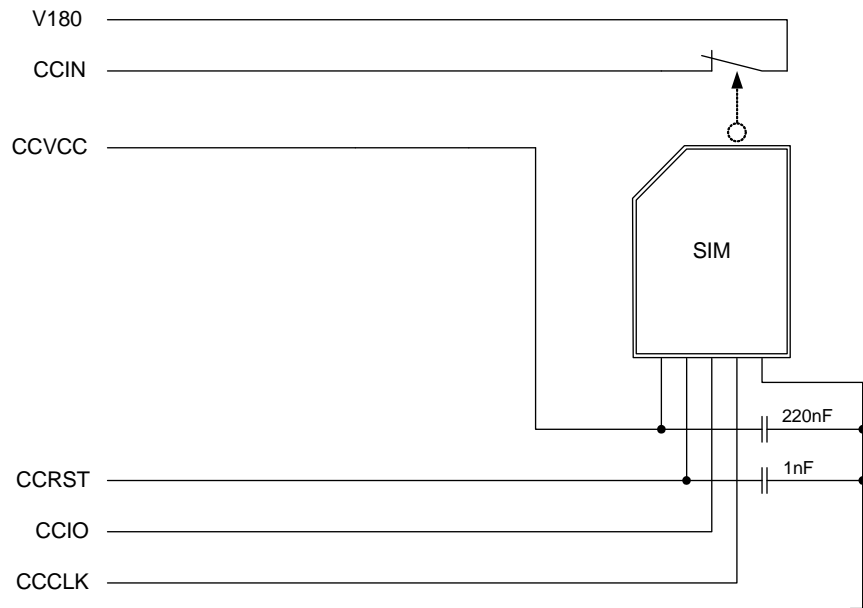


Figure 10: External UICC/SIM/USIM card holder circuit

The total cable length between the SMT application interface pads on EHS5-E/EHS5-US 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: $\pm 4\text{kV}$, air discharge: $\pm 8\text{kV}$.

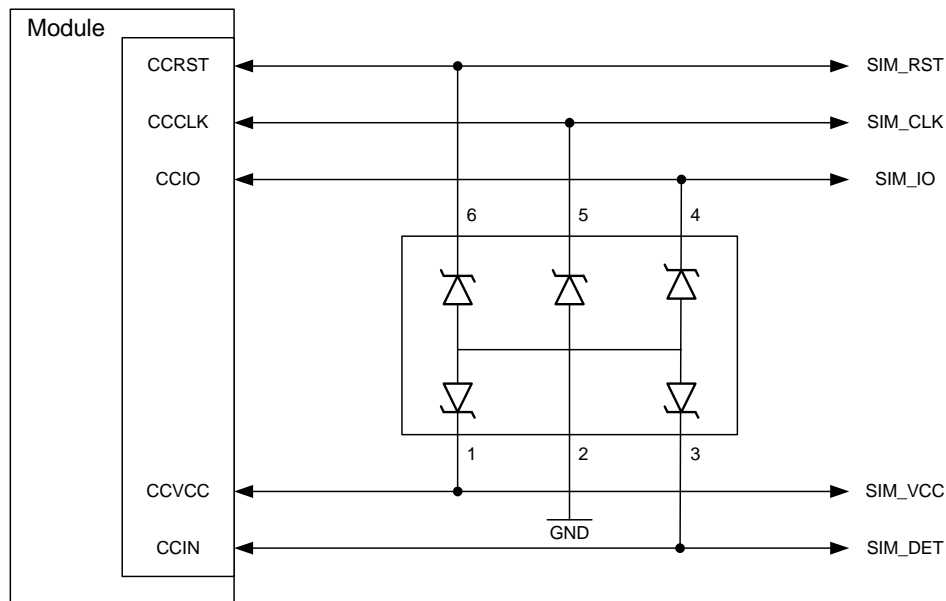


Figure 11: SIM interface - enhanced ESD protection

2.1.7 Digital Audio Interface

Four EHS5-E/EHS5-US 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 / 125µs frame duration
- The most significant bit MSB is transferred first
- Data write at rising edge / data read at falling edge
- 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 EHS5-E/EHS5-US to external codec. |
| RXDDAI | I | PCM data from external codec to EHS5-E/EHS5-US. |
| TFSDAI | O | Frame synchronization signal to external codec: Long frame @ 256kHz |
| SCLK | O | Bit clock to external codec: 256kHz |

Figure 12 shows the PCM timing for the master mode available with EHS5-E/EHS5-US.

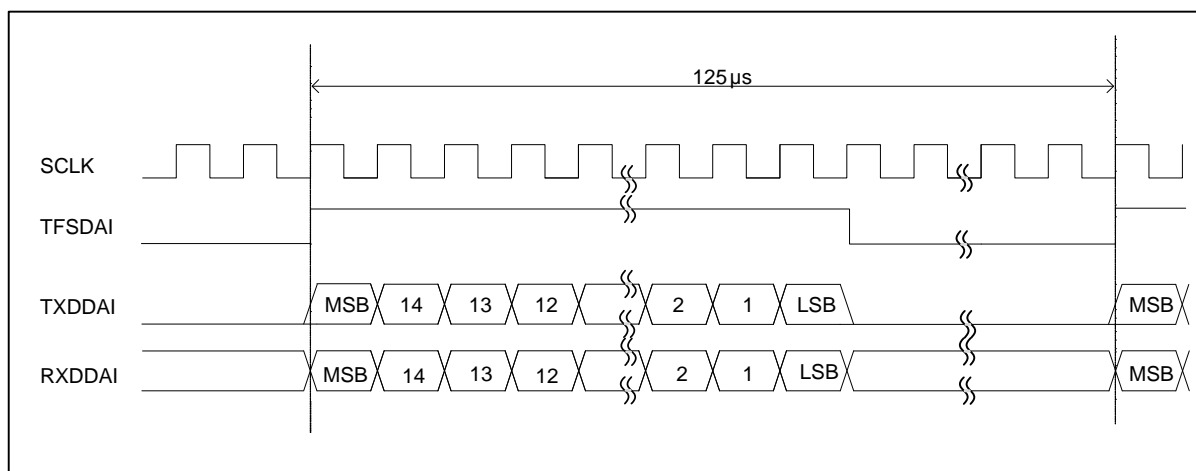


Figure 12: Long frame PCM timing, 256kHz

2.1 Application Interface

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 CTS0 (low level) the initialization of the DAI interface is finished.

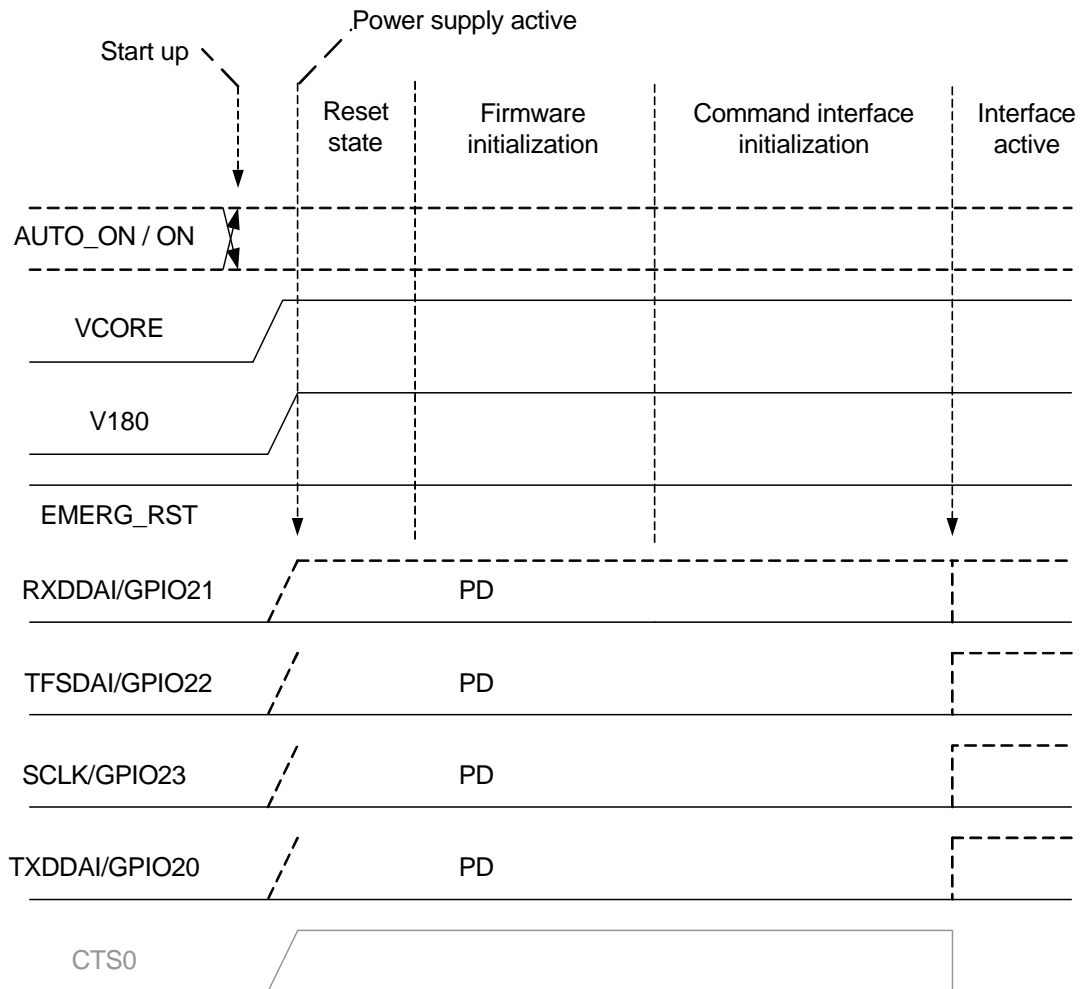


Figure 13: DAI startup timing

2.1.7.1 Solutions for the Digital Audio Interface (DAI/PCM)

Figure 14 and Figure 15 show an example of using the digital audio interface of the module. The below mentioned sample Nuvoton codec W681360 can be replaced with a DSP. In the example, framesync and clock master is the module (TFSDAI line) and thus the GSM network.

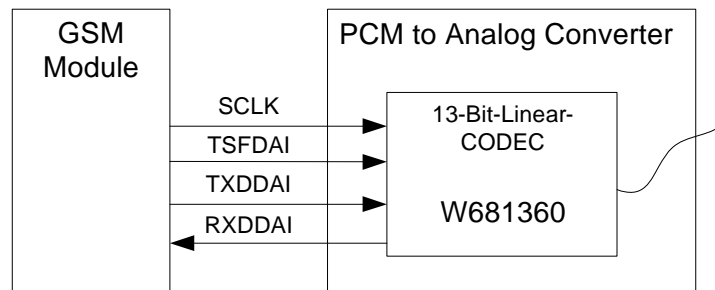


Figure 14: Block circuit for DAI/PCM to analog converter

This DAI/PCM analog converter is well suited for evaluating and testing a telephone handset and can be used instead of the headset interface of the DSB75.

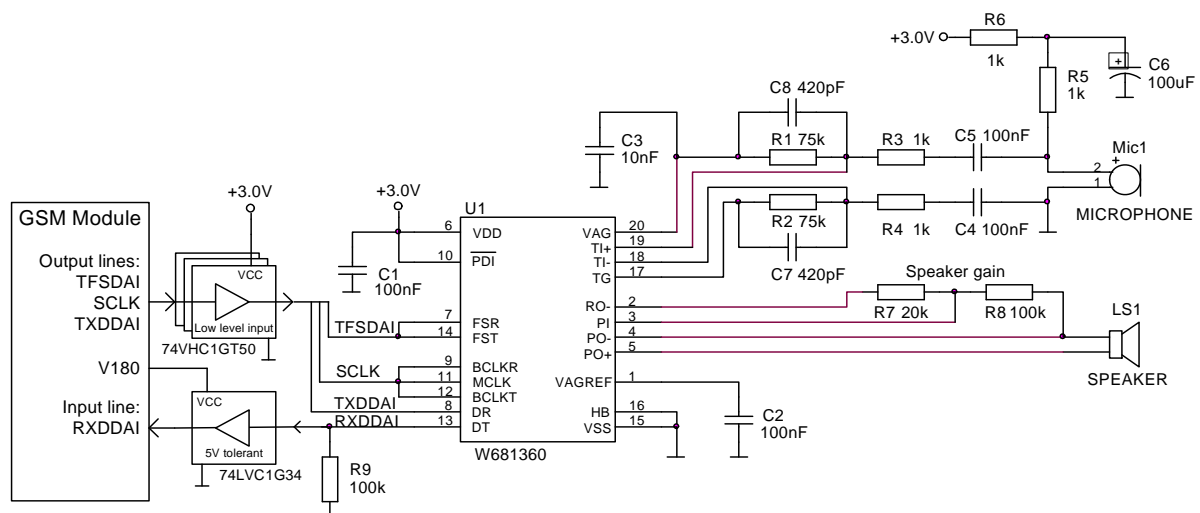


Figure 15: Sample circuit for analog to DAI/PCM box

The logical levels and the interface at connector J1 are compatible to the DSB75 PCM interface. On the module side, the PCM interface has to be enabled. This can be done by using the following AT command: `AT^SCFG="GPIO/mode/DAI", "std"`.

Please note that level converters are required between the module's 1.8V digital audio lines and the 3.0V audio codec interface lines. Possible level converters are for example 74VHC1GT50 (up) and 74LVC1G34 (down). See Figure 15 and refer to Section 2.3.1 for more information on a possible sample level conversion circuit.

2.1.8 RTC Backup

The internal Real Time Clock of EHS5-E/EHS5-US is supplied from a separate voltage regulator in the power supply component which is also active when EHS5-E/EHS5-US is in Power Down mode and BATT+ is available. An alarm function is provided that allows to wake up EHS5-E/EHS5-US without logging on to the GSM/UMTS network.

In addition, you can use the VDDL P pad to backup the RTC from an external capacitor. The capacitor is charged from the internal LDO of EHS5-E/EHS5-US. 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 EHS5-E/EHS5-US, i.e. the greater the capacitor the longer EHS5-E/EHS5-US 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 VDDL P pad (see [Section 2.1.2](#)) has to be taken in to account.

[Figure 16](#) shows an RTC backup configuration. A serial 1kΩ resistor has to be placed on the application next to VDDL P. It limits the input current of an empty capacitor or battery.

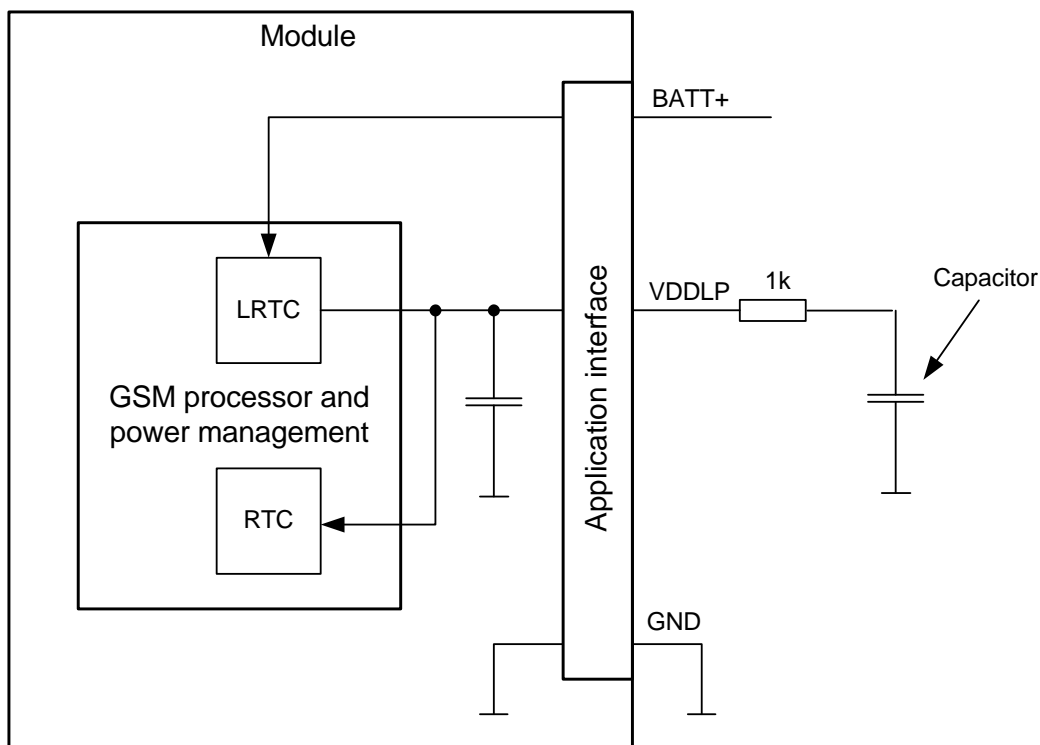


Figure 16: RTC supply variants

2.1.9 GPIO Interface

EHS5-E/EHS5-US offers a GPIO interface with 17 GPIO lines. The GPIO lines are shared with other interfaces or functions: Fast shutdown (see [Section 2.1.14.4](#)), status LED (see [Section 2.1.14.1](#)), the PWM functionality (see [Section 2.1.12](#)), an pulse counter (see [Section 2.1.13](#)), ASC0 (see [Section 2.1.4](#)), ASC1 (see [Section 2.1.5](#)), an SPI interface (see [Section 2.1.11](#)) and a PCM interface (see [Section 2.1.7](#))

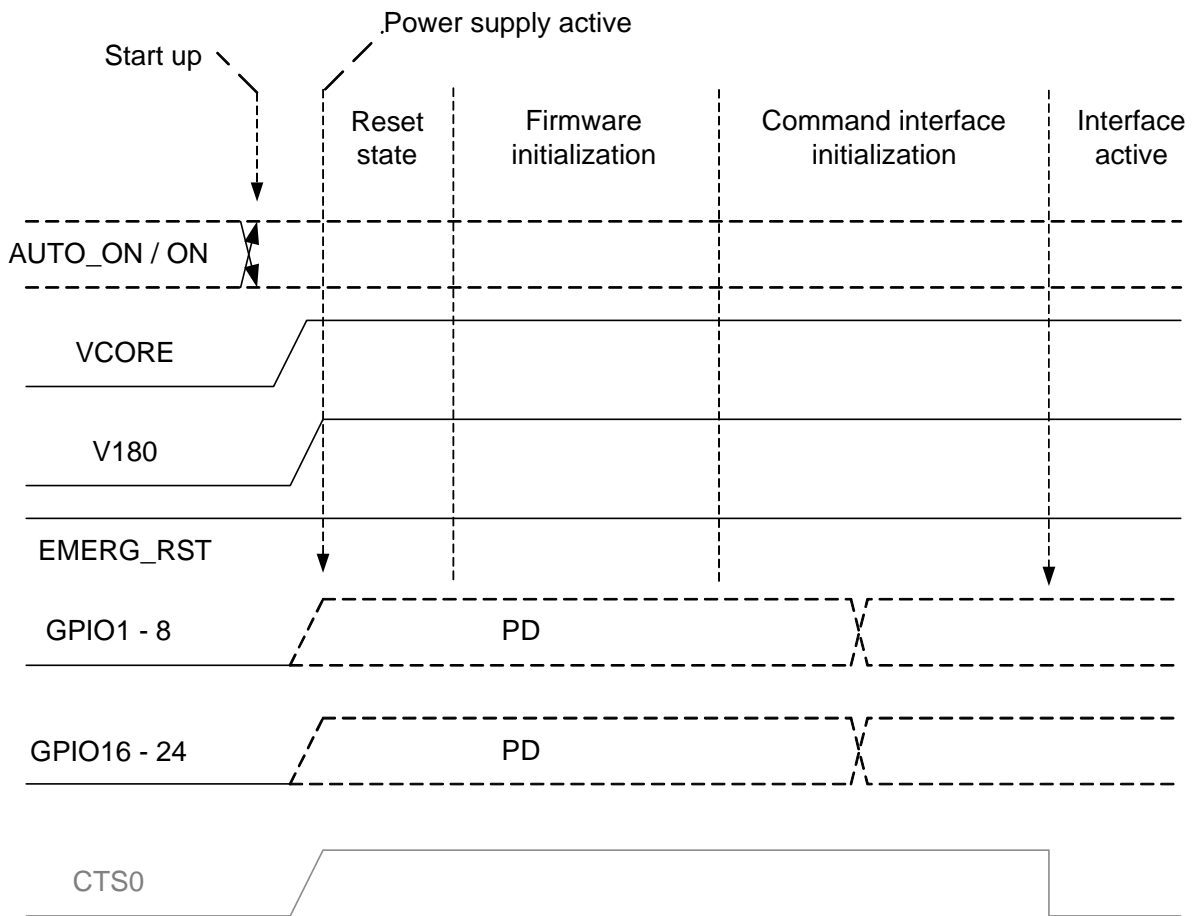
The following table shows the configuration variants for the GPIO pads. All variants are mutually exclusive, i.e. a pad configured for instance as Status LED is locked for alternative usage.

Table 6: GPIO lines and possible alternative assignment

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

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 line CTS0, the initialization of the GPIO interface lines is also finished.



*) For pull down values see [Table 11](#).

Figure 17: 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 EHS5-E/EHS5-US. 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.

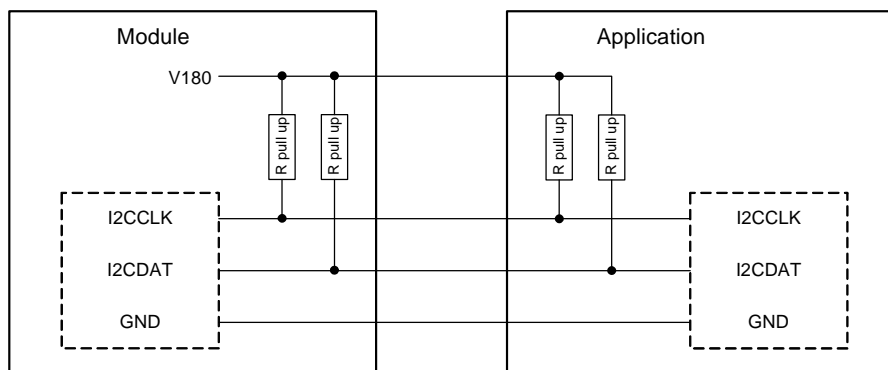


Figure 18: I²C interface connected to V180

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.

The following figure shows the startup behavior of the I²C interface. With an active state of the ASC0 interface (i.e. CTS0 is at low level) the initialization of the I²C interface is also finished.

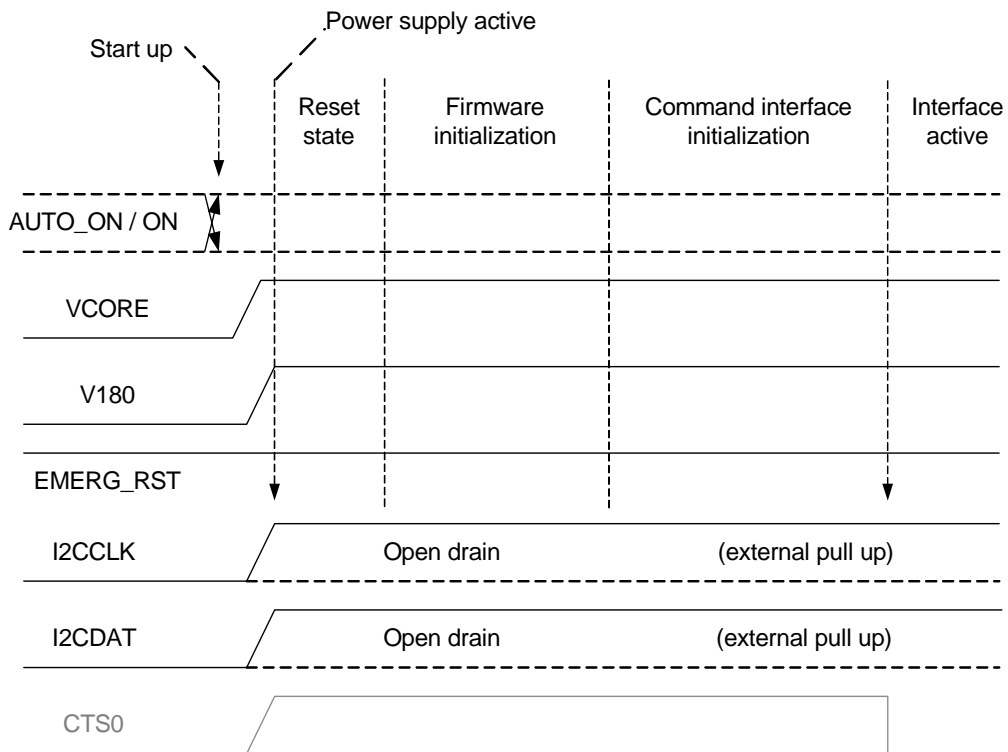


Figure 19: I²C startup behavior

2.1.11 SPI Interface

Four EHS5-E/EHS5-US GPIO interface lines can be configured as Serial Peripheral Interface (SPI). The SPI is a synchronous serial interface for control and data transfer between EHS5-E/EHS5-US 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 6.5Mbit/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 20 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.

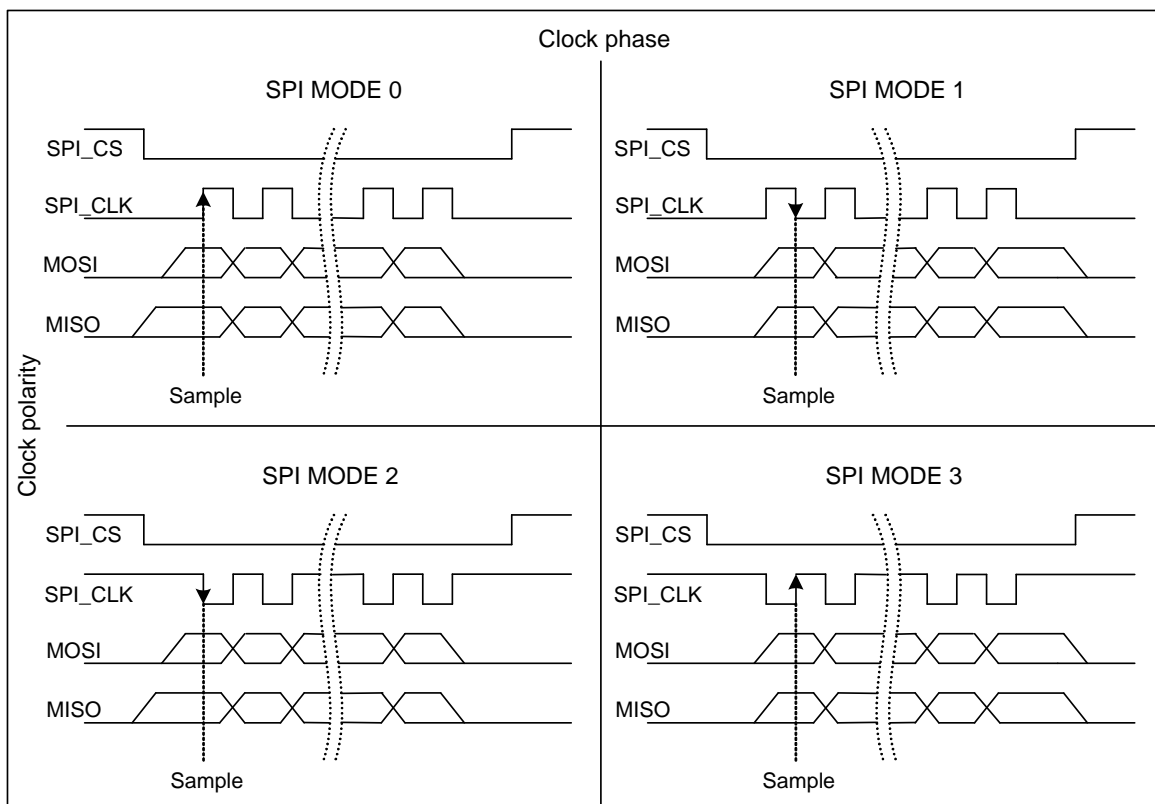


Figure 20: Characteristics of SPI modes

2.1.12 PWM Interfaces

The GPIO6 and GPIO7 interface lines can be configured as Pulse Width Modulation (PWM) 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 17](#).

2.1.13 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](#)).

2.1.14 Control Signals

2.1.14.1 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 21](#).

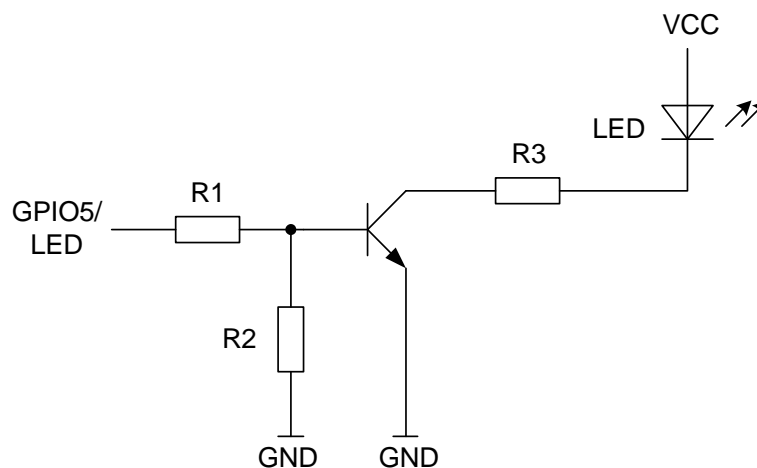


Figure 21: Status signalling with LED driver

2.1.14.2 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 22](#) 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.

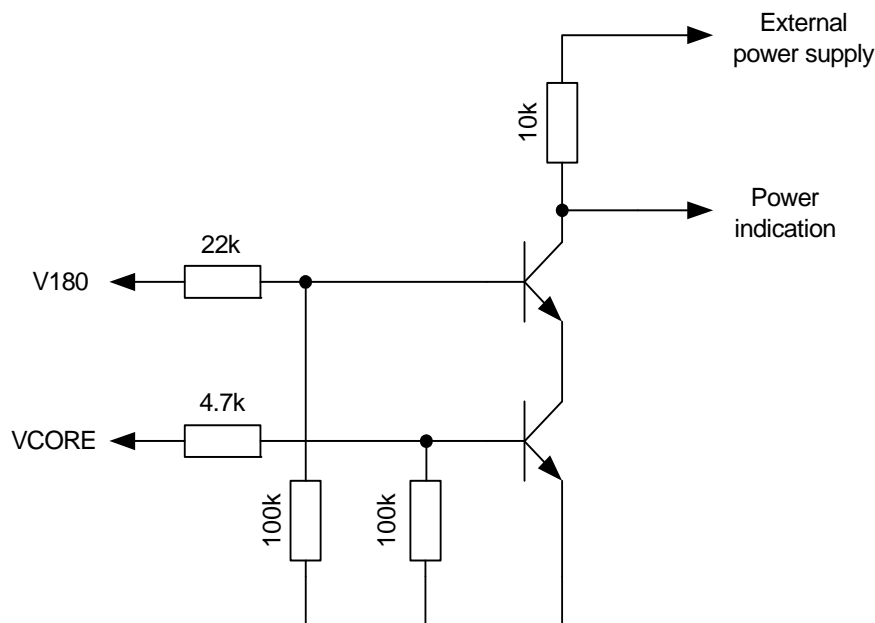


Figure 22: Power indication circuit

2.1.14.3 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. This functionality should only be used with legacy USB applications not supporting the recommended USB suspend and resume mechanism as described in [\[5\]](#) (see also [Section 2.1.3.1](#)). For more information on how to configure the RING0 line by AT^SCFG command see [\[1\]](#).

Possible RING0 line states are listed in [Table 7](#).

Table 7: Host wakeup line

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

2.1.14.4 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 10 milliseconds. 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 23](#)). 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 >10 milliseconds on the GPIO4/FST_SHDN line starts the fast shutdown (see [Figure 23](#)). 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.

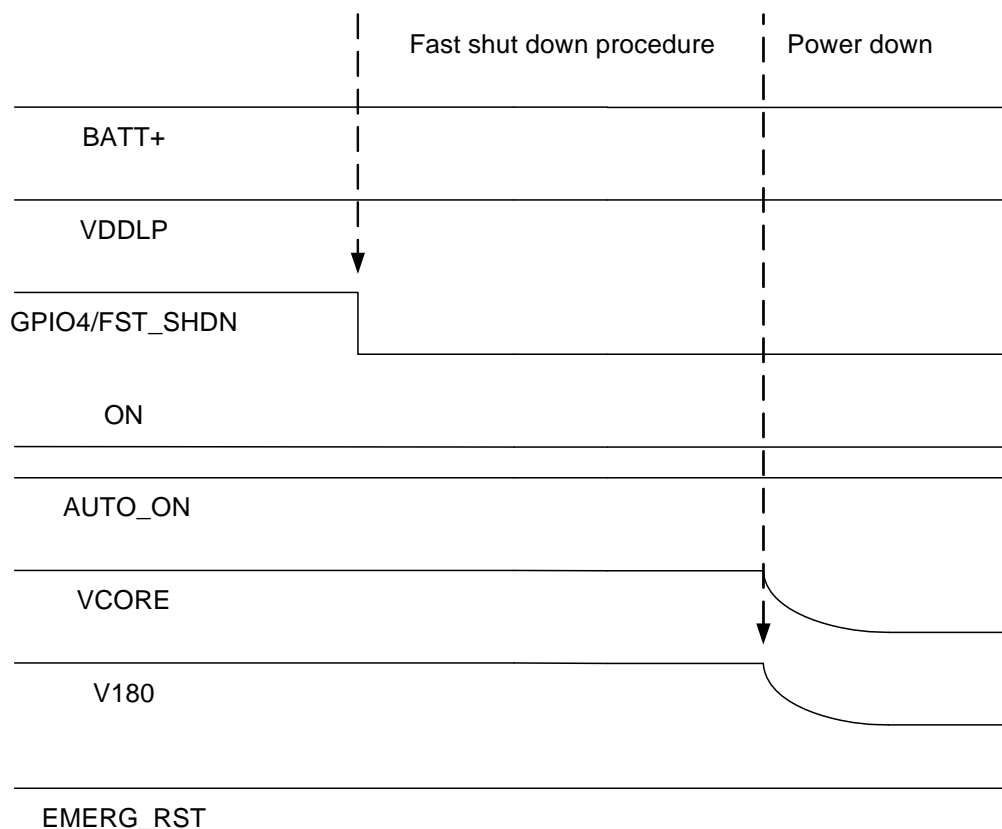


Figure 23: Fast shutdown timing

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. EHS5-E/EHS5-US 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 EHS5-E/EHS5-US module and should be placed in the host application if the antenna does not have an impedance of 50Ω.

Regarding the return loss EHS5-E/EHS5-US 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 / UMTS¹

| Parameter | Conditions | Min. | Typical | Max. | Unit |
|---|------------------------|---------------------|---------|------|------|
| UMTS/HSPA connectivity | Band I, II, V, VIII | | | | |
| Receiver Input Sensitivity @ ARP | UMTS 850 Band 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 50Ω Load Board temperature <85°C | UMTS 850 Band 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 50Ω Load | GSM | GSM 850 / E-GSM 900 | 33 | | dBm |
| | | GSM 1800 / GSM 1900 | 30 | | dBm |

2.2 RF Antenna Interface

Table 9: RF Antenna interface GSM / UMTS¹

| Parameter | | Conditions | Min. | Typical | Max. | Unit |
|---|------------|---------------------|------|---------|------|------|
| RF Power @ ARP with 50Ω Load, (ROPR = 0, 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 50Ω Load, (ROPR = 1) | 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 |

2.2 RF Antenna Interface

Table 9: RF Antenna interface GSM / UMTS¹

| Parameter | | Conditions | Min. | Typical | Max. | Unit | |
|--|--|---------------------|---------------------|---------|------|------|-----|
| RF Power @ ARP with 50Ω Load, (ROPR = 2) | 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 50Ω Load, (ROPR = 3) | 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 | |

2.2 RF Antenna Interface

Table 9: RF Antenna interface GSM / UMTS¹

| Parameter | Conditions | Min. | Typical | Max. | Unit | |
|--|------------|---------------------|---------|------|------|-----|
| RF Power @ ARP with 50Ω Load, (ROPR = 4, 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 | | 30 | | dBm |
| | | GSM 1800 / GSM 1900 | | 27 | | dBm |
| | EDGE, 2 TX | GSM 850 / E-GSM 900 | | 24 | | dBm |
| | | GSM 1800 / GSM 1900 | | 23 | | dBm |
| | GPRS, 3 TX | GSM 850 / E-GSM 900 | | 28.2 | | dBm |
| | | GSM 1800 / GSM 1900 | | 25.2 | | dBm |
| | EDGE, 3 TX | GSM 850 / E-GSM 900 | | 22.2 | | dBm |
| | | GSM 1800 / GSM 1900 | | 21.2 | | 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 |

1. Please note that the listed frequency bands apply as follows:

- EHS5-E: GSM/GPRS 900/1800MHz; UMTS/HSPA+: 900/2100MHz (Band I / VIII)
- EHS5-US: GSM/GPRS: 850/1900MHz; UMTS/HSPA+: 850/1900MHz (Band II / V)

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 EHS5-E/EHS5-US. All RF data specified throughout this document is related to the ARP.

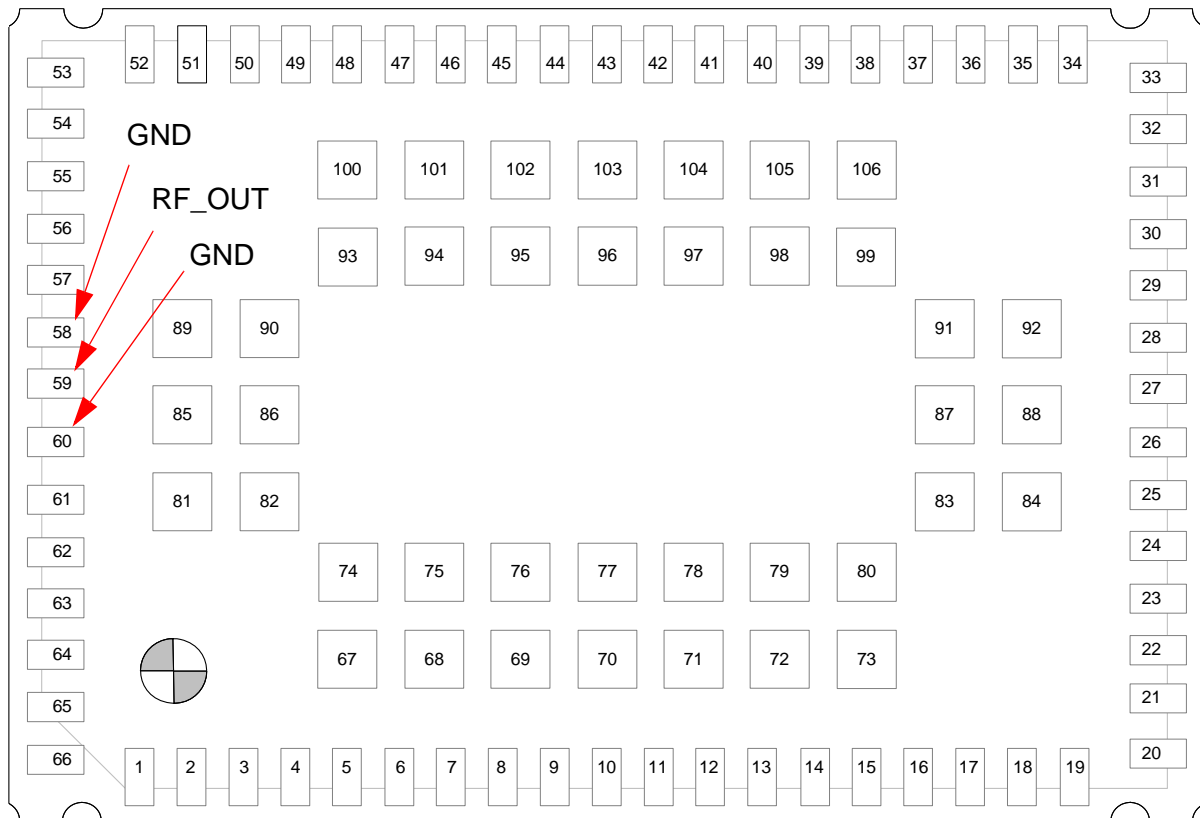


Figure 24: Antenna pads (bottom view)

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 EHS5-E/EHS5-US'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 65 μ m FR4 prepreg (type: 1080) and 710 μ m FR4 core (4-layer PCB).

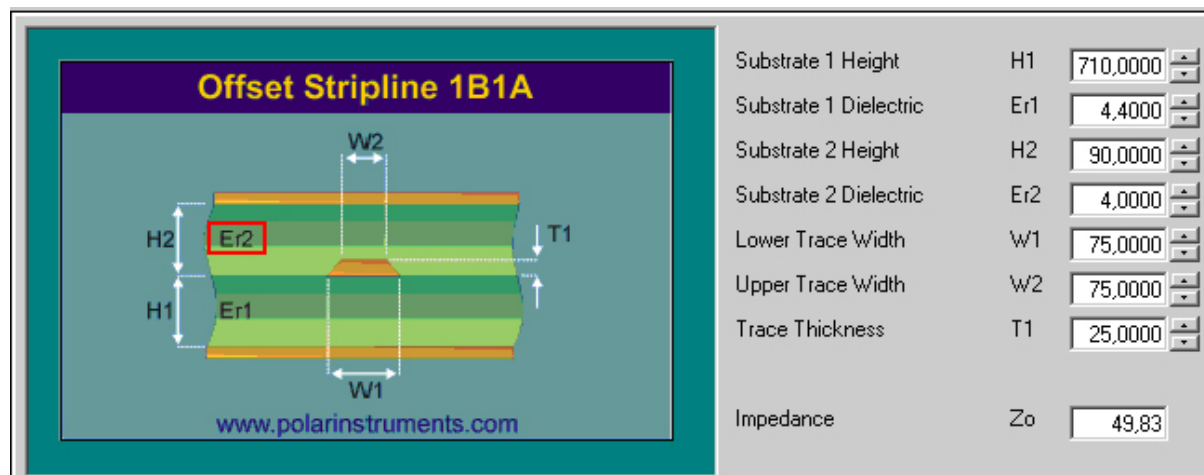


Figure 25: Embedded Stripline with 65 μ m prepreg (1080) and 710 μ m core

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).

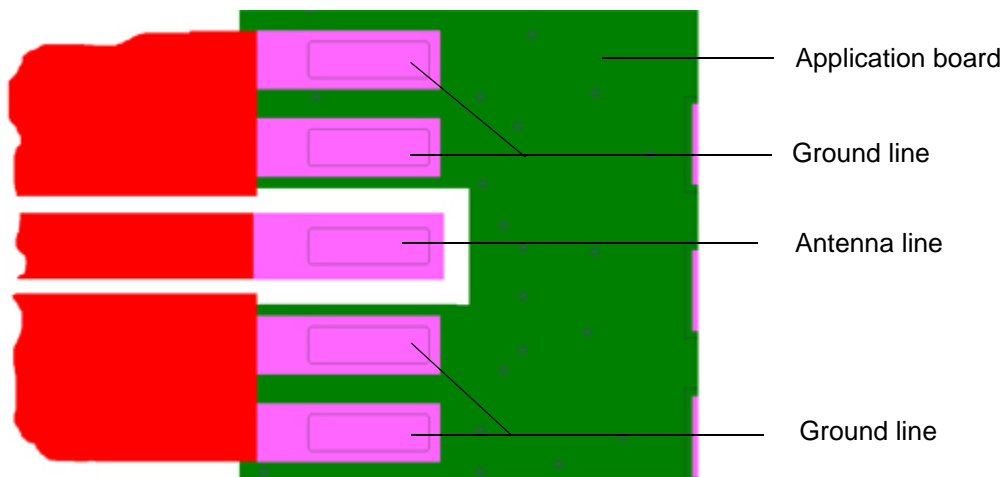
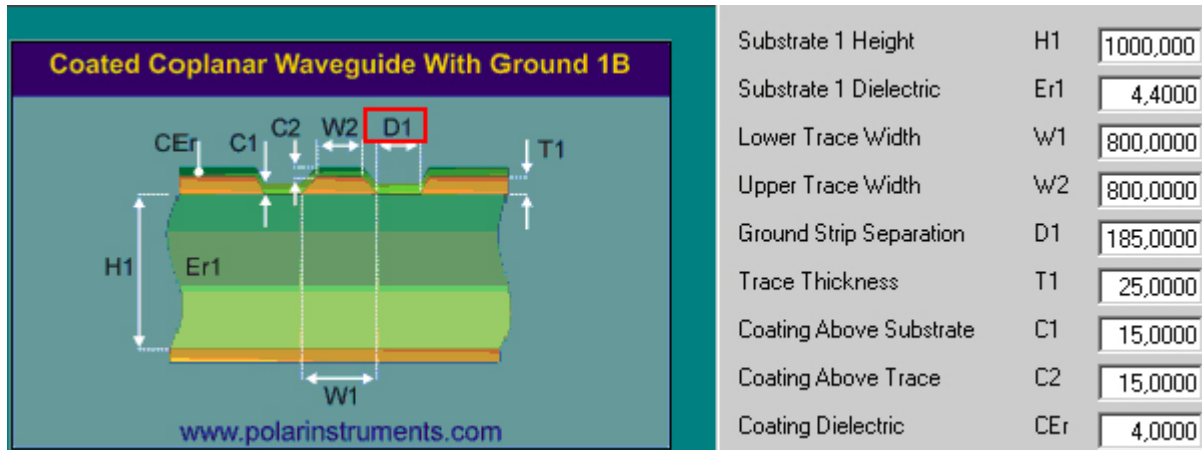


Figure 26: Micro-Stripline on 1.0mm standard FR4 2-layer PCB - example 1

2.2 RF Antenna Interface

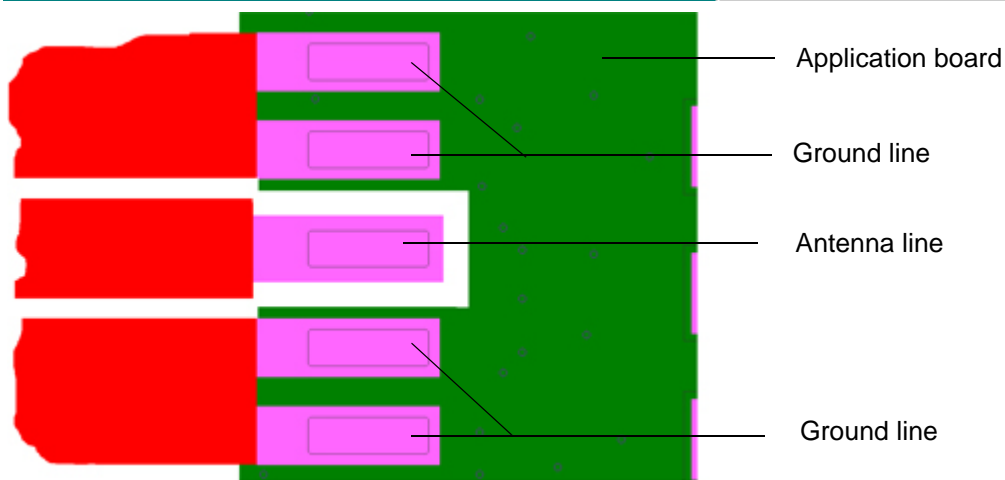
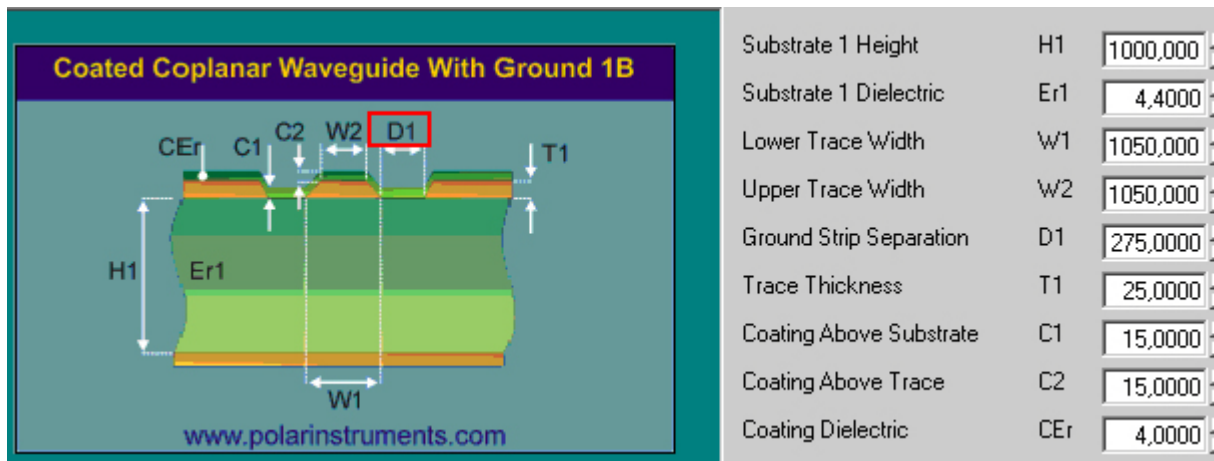


Figure 27: Micro-Stripline on 1.0mm Standard FR4 PCB - example 2

2.2 RF Antenna Interface

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

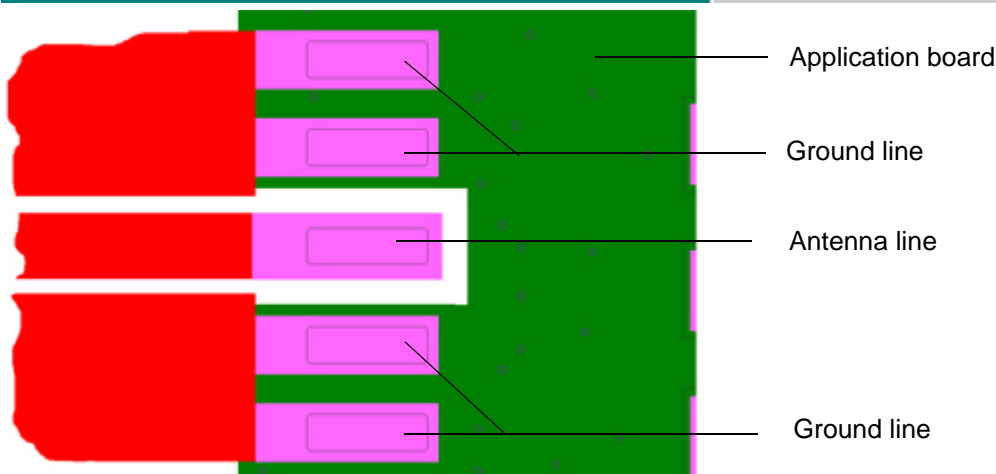
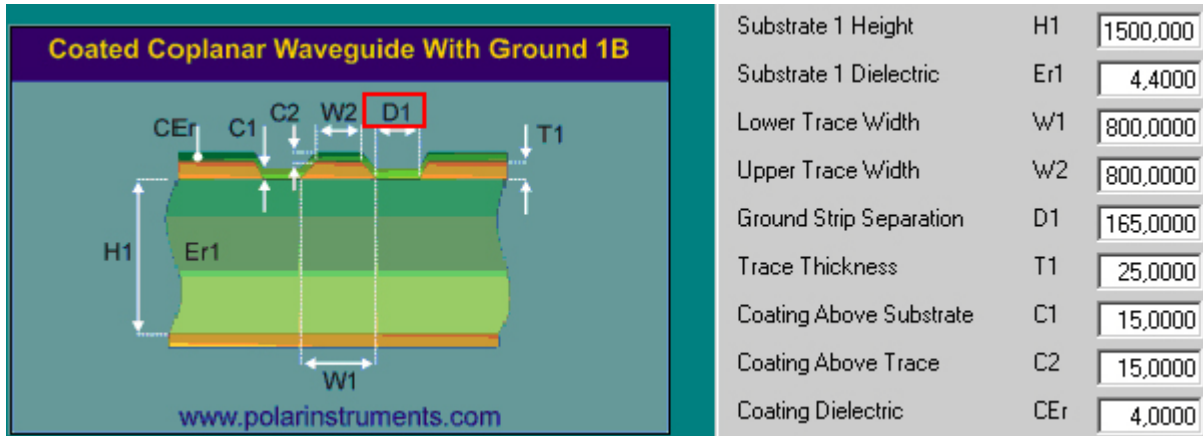


Figure 28: Micro-Stripline on 1.5mm Standard FR4 PCB - example 1

2.2 RF Antenna Interface

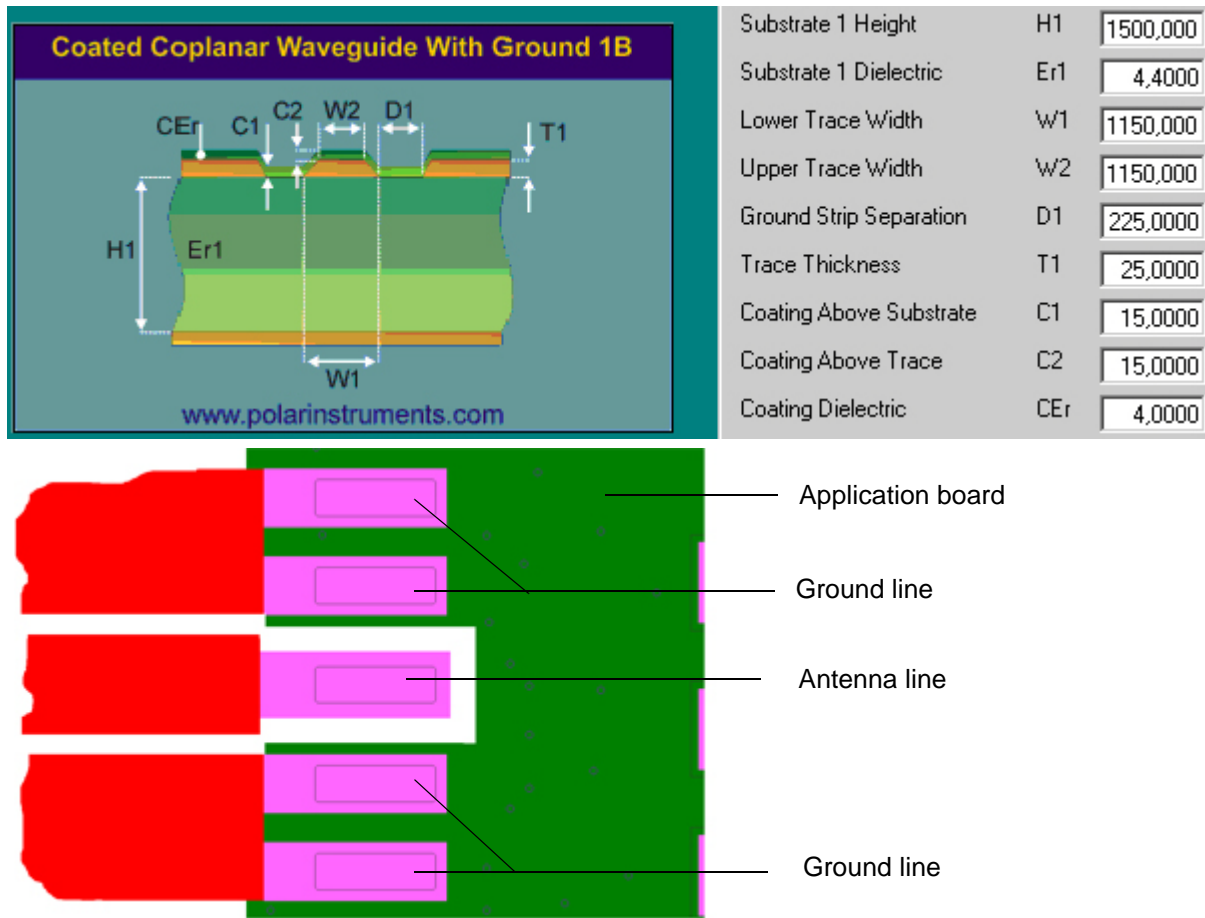


Figure 29: Micro-Stripline on 1.5mm Standard FR4 PCB - example 2

2.2.3.2 Routing Example

Interface to RF Connector

Figure 30 shows the connection of the module's antenna pad with an application PCB's coaxial antenna connector. Please note that the EHS5-E/EHS5-US bottom plane appears mirrored, since it is viewed from EHS5-E/EHS5-US top side. By definition the top of customer's board shall mate with the bottom of the EHS5-E/EHS5-US module.

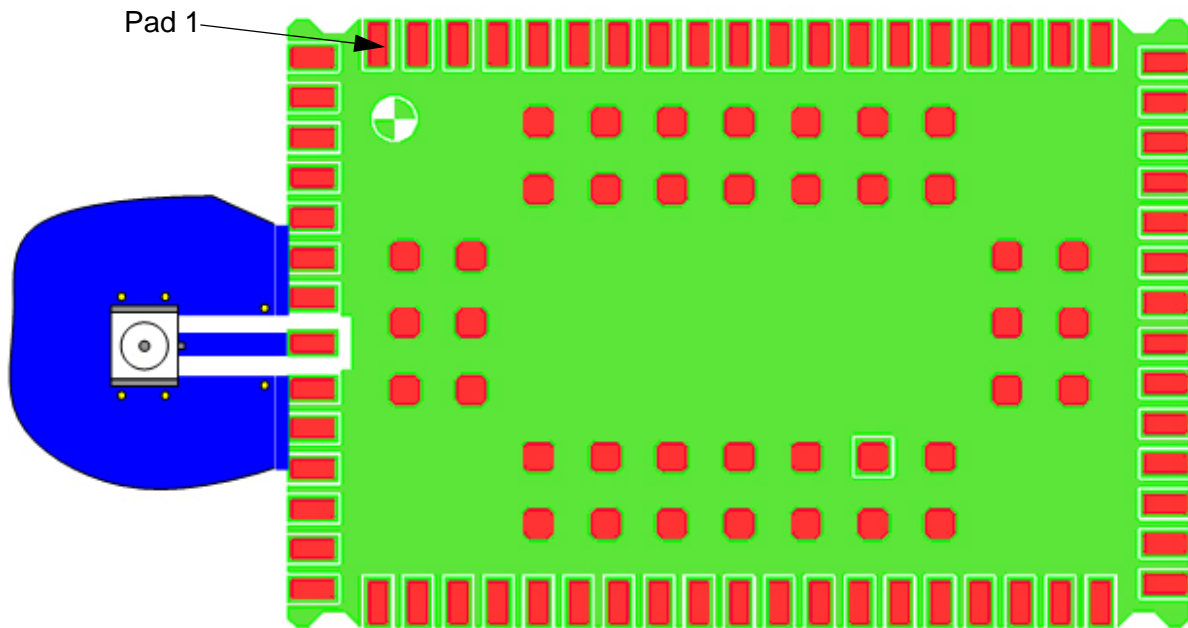


Figure 30: Routing to application's RF connector - top view

2.3 Sample Application

[Figure 31](#) shows a typical example of how to integrate a EHS5-E/EHS5-US 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, VDDL, and ON).

While developing SMT applications it is strongly recommended to provide test points for certain signals, i.e., 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 [\[4\]](#).

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.

Depending on the micro controller used by an external application EHS5-E/EHS5-US's digital input and output lines may require level conversion. [Section 2.3.1](#) shows a possible sample level conversion circuit.

Note: EHS5-E/EHS5-US 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 31](#) 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 EHS5-E/EHS5-US modules.

2.3 Sample Application

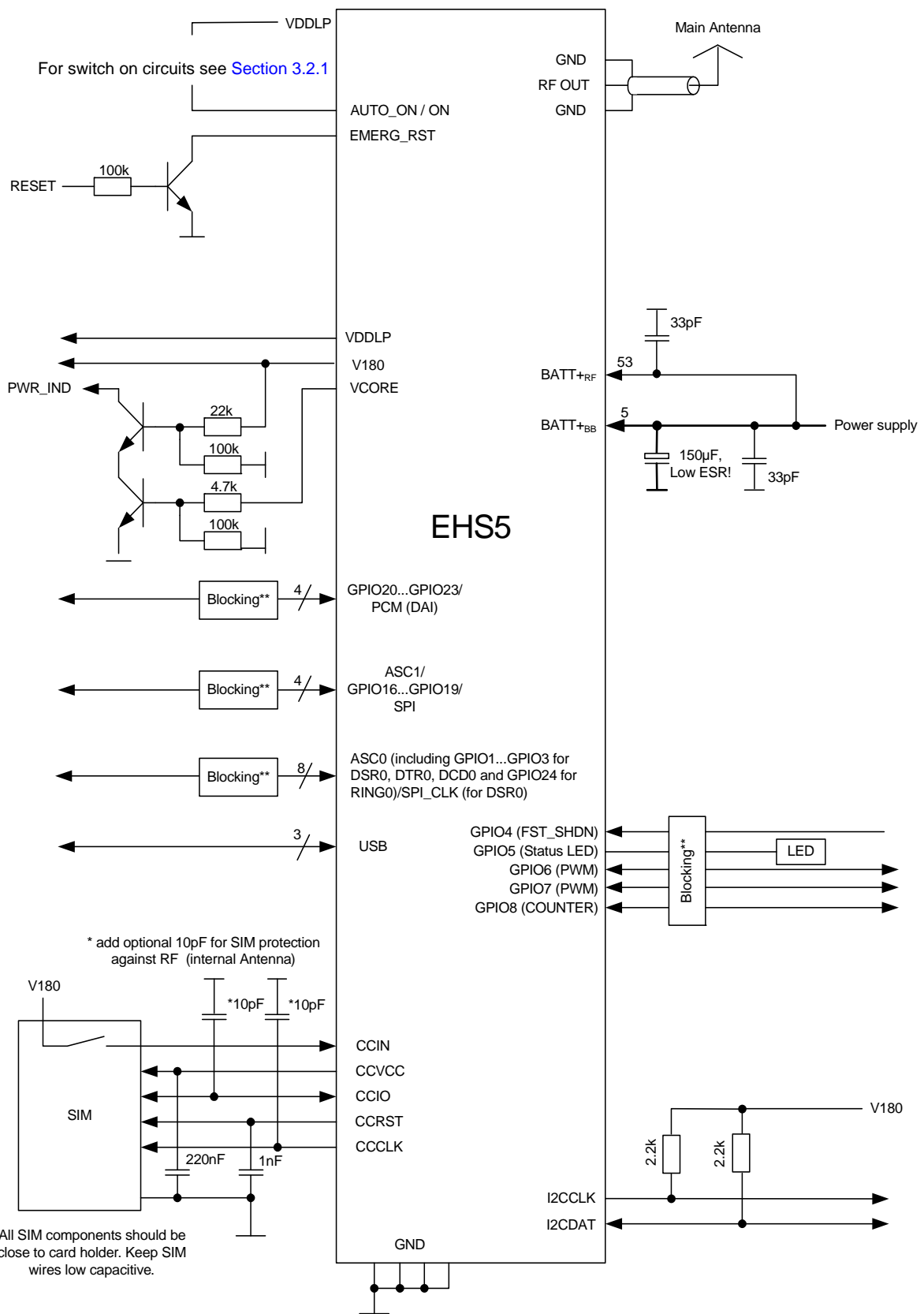


Figure 31: Schematic diagram of EHS5-E/EHS5-US sample application

2.3.1 Sample Level Conversion Circuit

Depending on the micro controller used by an external application EHS5-E/EHS5-US's digital input and output lines (i.e., ASC0, ASC1 or GPIO lines) may require level conversion. The following [Figure 32](#) shows a sample circuit with recommended level shifters for an external application's micro controller (with VLOGIC between 3.0V...3.6V). The level shifters can be used for digital input and output lines with $V_{OH,max}=1.85V$ or $V_{IH,max}=1.85V$.

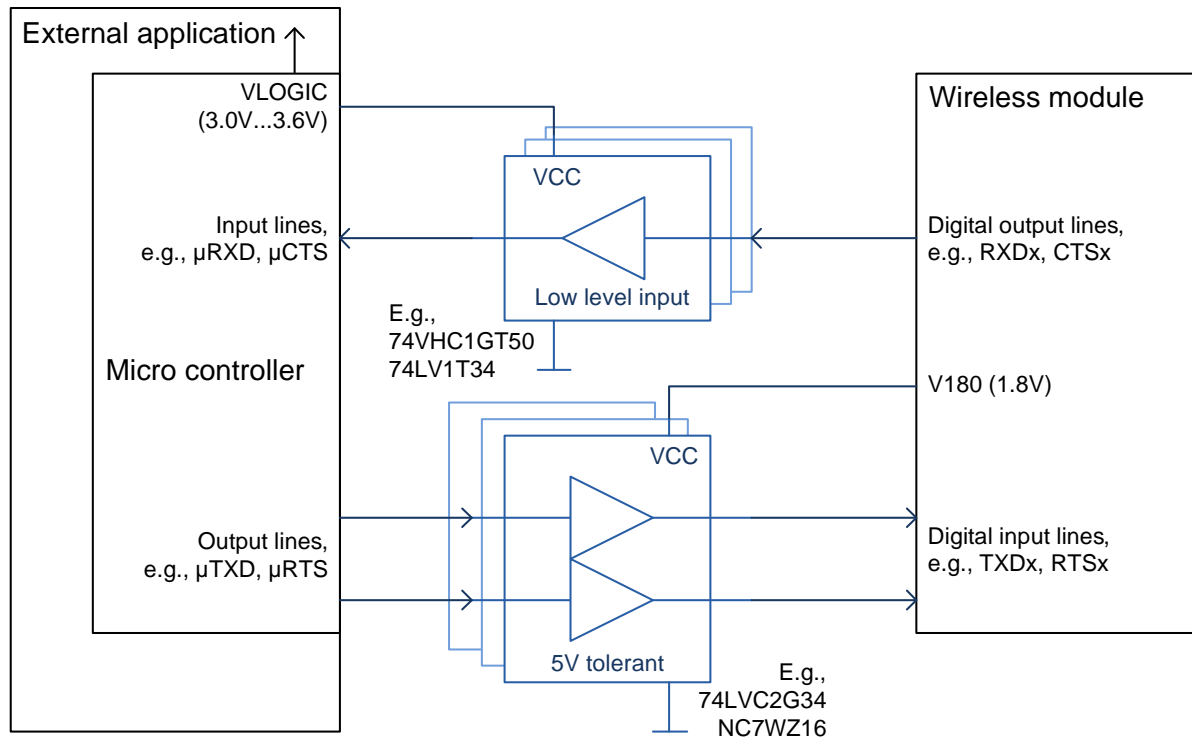


Figure 32: Sample level conversion circuit

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 | No call is in progress and the USB connection is suspended by host (or is not present) and no active communication via ASC0. For power saving issues see Section 3.4 . |
| | GSM / GPRS / UMTS / HSPA IDLE | No call is in progress and the USB connection is not suspended by host (or is not present) and no active communication via ASC0. For power saving issues see Section 3.4 . |
| | 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 EHS5-E/EHS5-US while it is beyond the safety limits of voltage and temperature stated in [Section 2.1.2.1](#). EHS5-E/EHS5-US immediately switches 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 EHS5-E/EHS5-US

EHS5-E/EHS5-US can be turned on as described in the following sections:

- Connecting the operating voltage BATT+ (see [Section 3.2.1.1](#)).
- Hardware driven switch on by (continuous) AUTO_ON line: Starts Normal mode (see [Section 3.2.1.2](#) and [Section 3.2.1.3](#)). 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 3.2.1.4](#)).

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 Connecting EHS5-E/EHS5-US BATT+ Lines

[Figure 33](#) and [Figure 34](#) show sample external application circuits that allow to connect (and also to temporarily disconnect) the module's BATT+ lines from the external application's power supply.

[Figure 33](#) illustrates the application of power employing an externally controlled microcontroller. [Figure 34](#) as an alternative shows the power application with an external voltage supervisory circuit instead of a microcontroller. The voltage supervisory circuit ensures that the power is disconnected and applied again depending on given thresholds.

The transistor T2 mentioned in [Figure 33](#) and [Figure 34](#) should have an R_{DS_ON} value $\leq 50m\Omega$ in order to minimize voltage drops.

Such circuits could be useful to maximize power savings for battery driven applications or to completely switch off and restart the module after a firmware update.

After connecting the BATT+ lines the module can then be (re-)started as described in [Section 3.2.1.2](#), [Section 3.2.1.3](#) and [Section 3.2.1.4](#).

3.2 Power Up/Power Down Scenarios

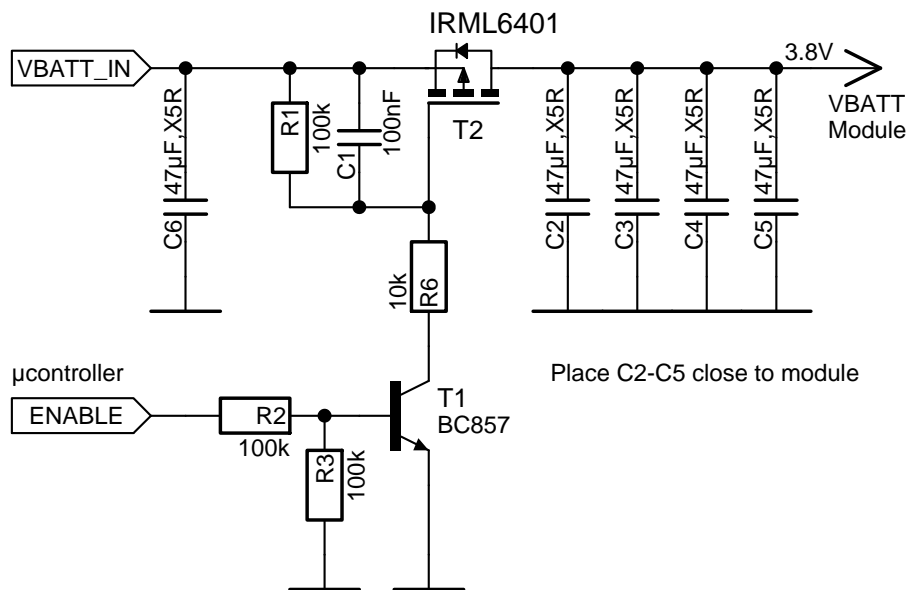


Figure 33: Sample circuit for applying power using an external μ C

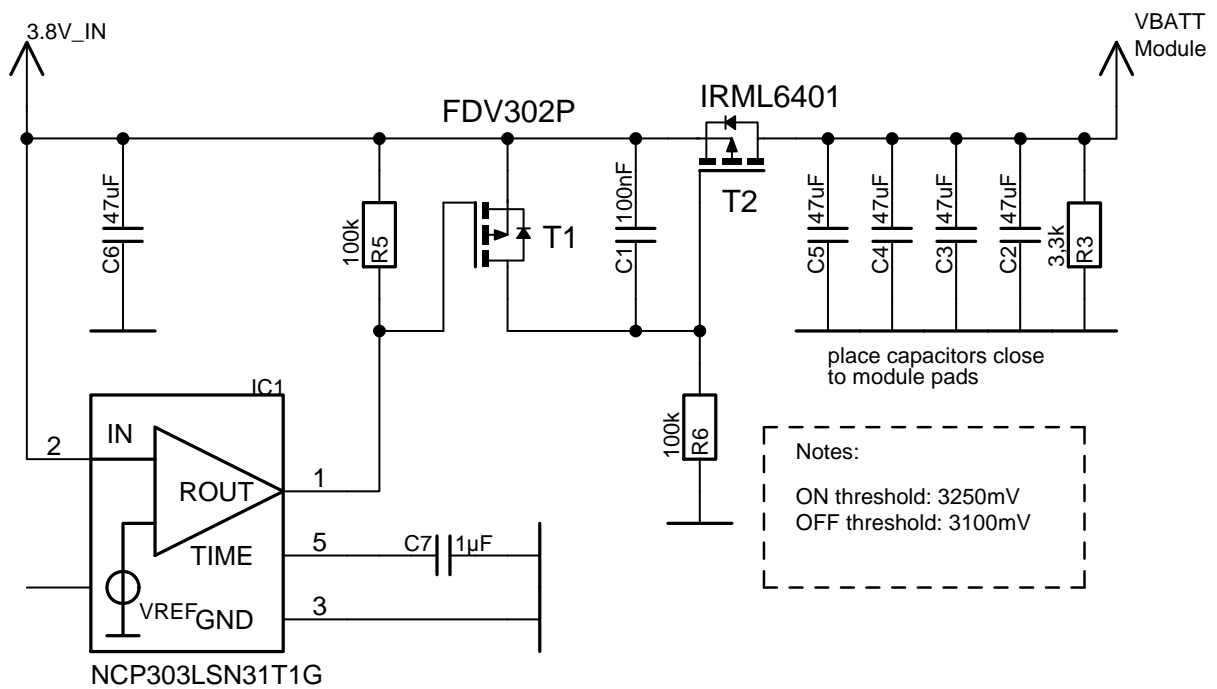


Figure 34: Sample circuit for applying power using an external voltage supervisory circuit

3.2 Power Up/Power Down Scenarios

3.2.1.2 Switch on EHS5-E/EHS5-US Using AUTO_ON Signal

When the operating voltage BATT+ is applied, EHS5-E/EHS5-US can 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 VDDL P 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 figures show examples for a module switch-on circuit:

- [Figure 35](#) for a controlled module switch on. Here, it is recommended to use a 10kΩ pull up resistor at the AUTO_ON pad. The 10kΩ pull up resistor may be required in an electrically noisy environment.
- [Figure 36](#) for an automatic module switch on. The circuit shown in [Figure 37](#) is a recommended circuit for an automatic module switch-on in applications where no external micro-controller is present to control the switch-on otherwise. This circuit will allow a software controlled shutdown of module, e.g., by regular AT^SMSO command or a temperature shutdown, before disconnecting power.

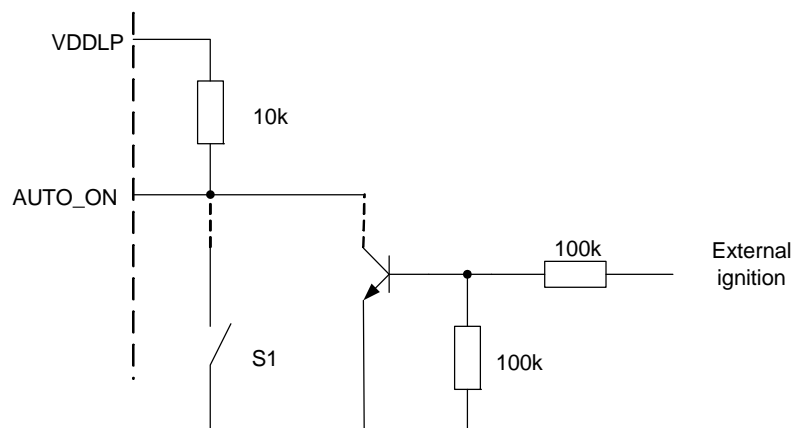


Figure 35: AUTO_ON circuit sample for controlled module switch-on

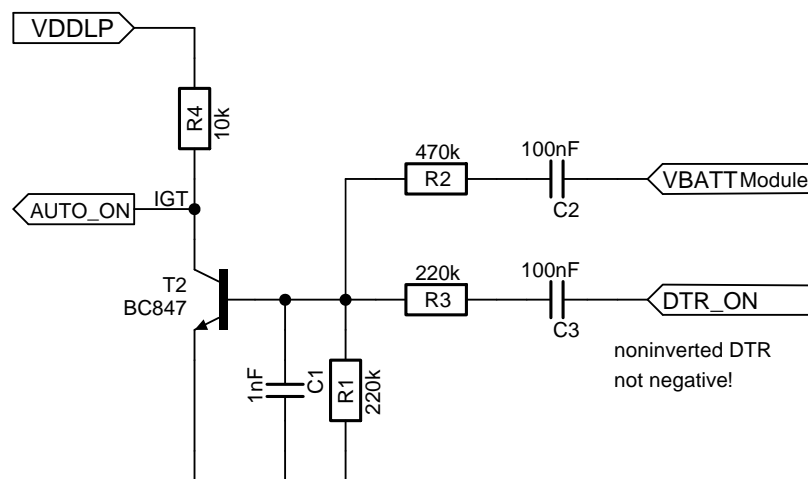


Figure 36: AUTO_ON circuit sample for automatic module switch on

3.2 Power Up/Power Down Scenarios

Figure 37 shows the AUTO_ON signal timing.

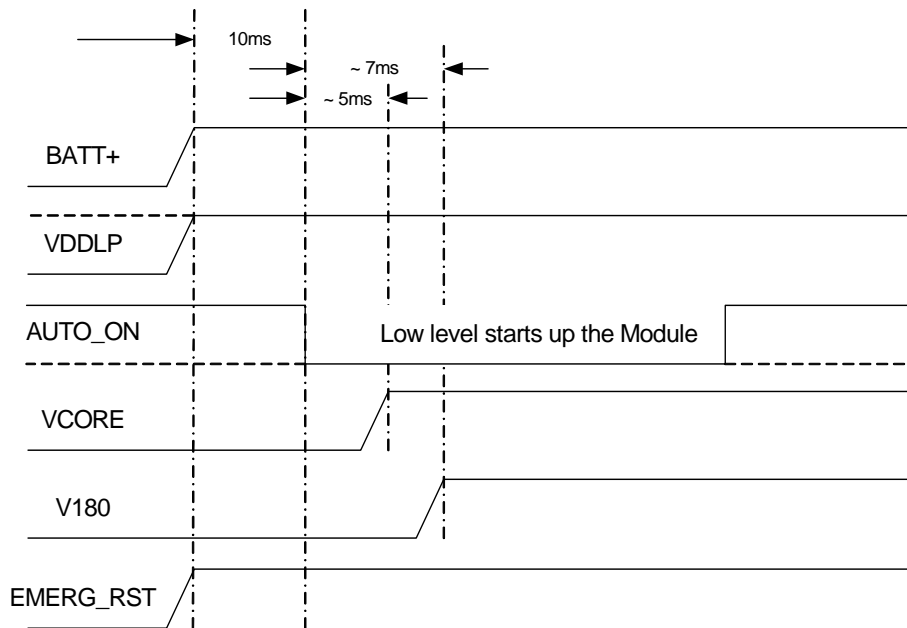


Figure 37: AUTO_ON signal timing

3.2.1.3 Switch on EHS5-E/EHS5-US Using a Continuous AUTO_ON Signal

In case the AUTO_ON signal is permanently connected to ground (see [Figure 35](#), S1 set to low level) the module will start up if the operating voltage BATT+ is applied with a rise time of less than 1 millisecond between 2.5V to 3.2V.

The following [Figure 38](#) shows this startup behavior if employing the AUTO_ON signal.

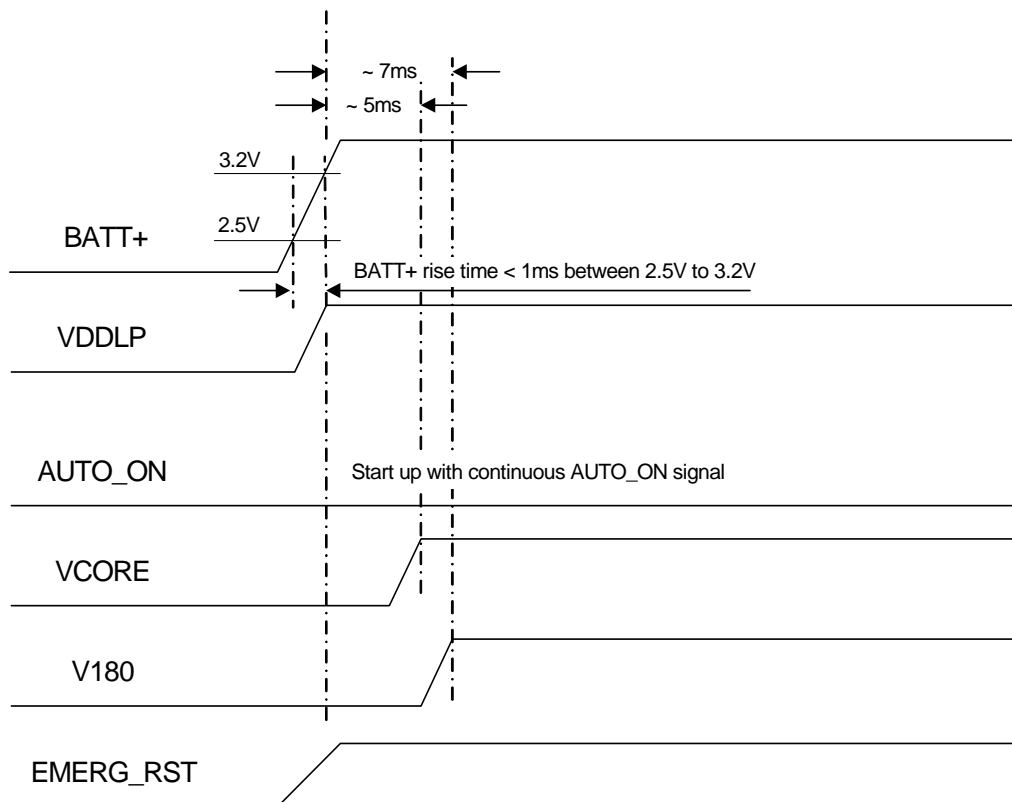


Figure 38: AUTO_ON signal timing using continuous AUTO_ON

3.2 Power Up/Power Down Scenarios

3.2.1.4 Switch on EHS5-E/EHS5-US Using ON Signal

When the operating voltage BATT+ is applied, EHS5-E/EHS5-US can also 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 VDDL P 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 50 μ s and a maximum of 80 μ s.

The following [Figure 39](#) shows recommendations for a possible switch-on circuit.

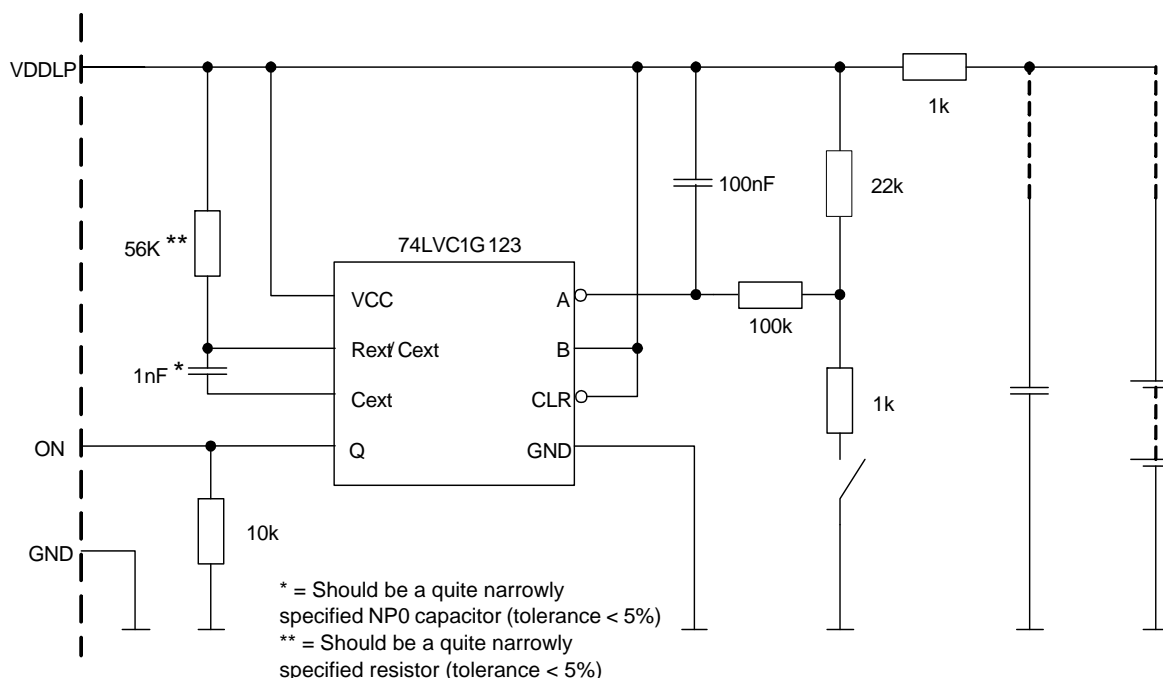


Figure 39: ON circuit options

It is recommended to set a serial 1k Ω resistor between the ON circuit and the external capacitor or battery at the VDDL P 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 60 μ s.

Please note that BATT+ and VDDL P should be active at least 10 milliseconds 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.

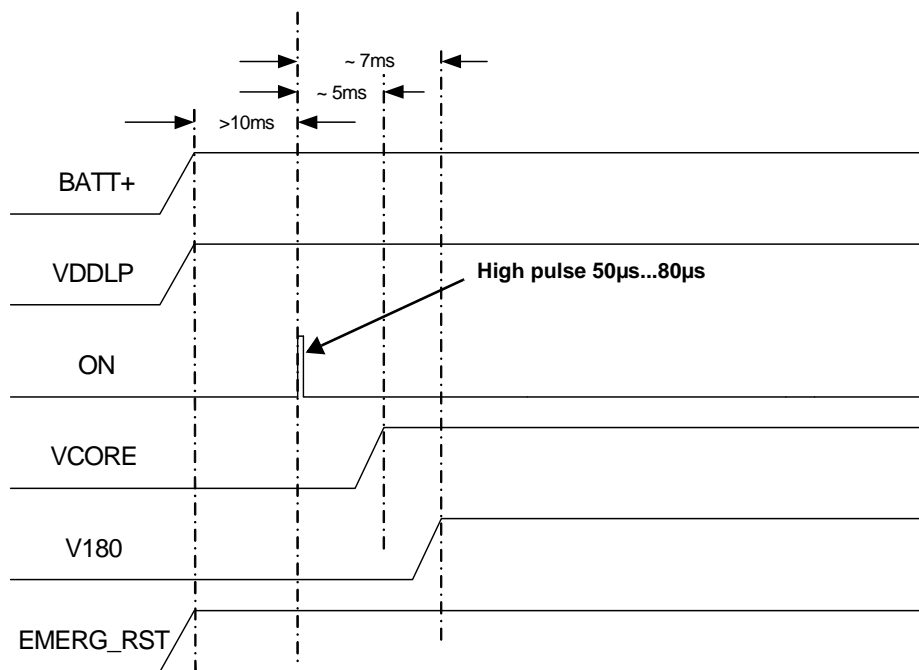


Figure 40: ON timing

3.2.2 Restart EHS5-E/EHS5-US

After startup EHS5-E/EHS5-US 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 EHS5-E/EHS5-US via AT+CFUN Command

To reset and restart the EHS5-E/EHS5-US module use the command AT+CFUN. See [\[1\]](#) for details.

3.2.2.2 Restart EHS5-E/EHS5-US Using EMERG_RST

The EMERG_RST signal is internally connected to the central GSM processor. A low level for more than 10 milliseconds 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. Please note that if restarting the module using EMERG_RST, the SIM PIN will not have to be (re-)entered.

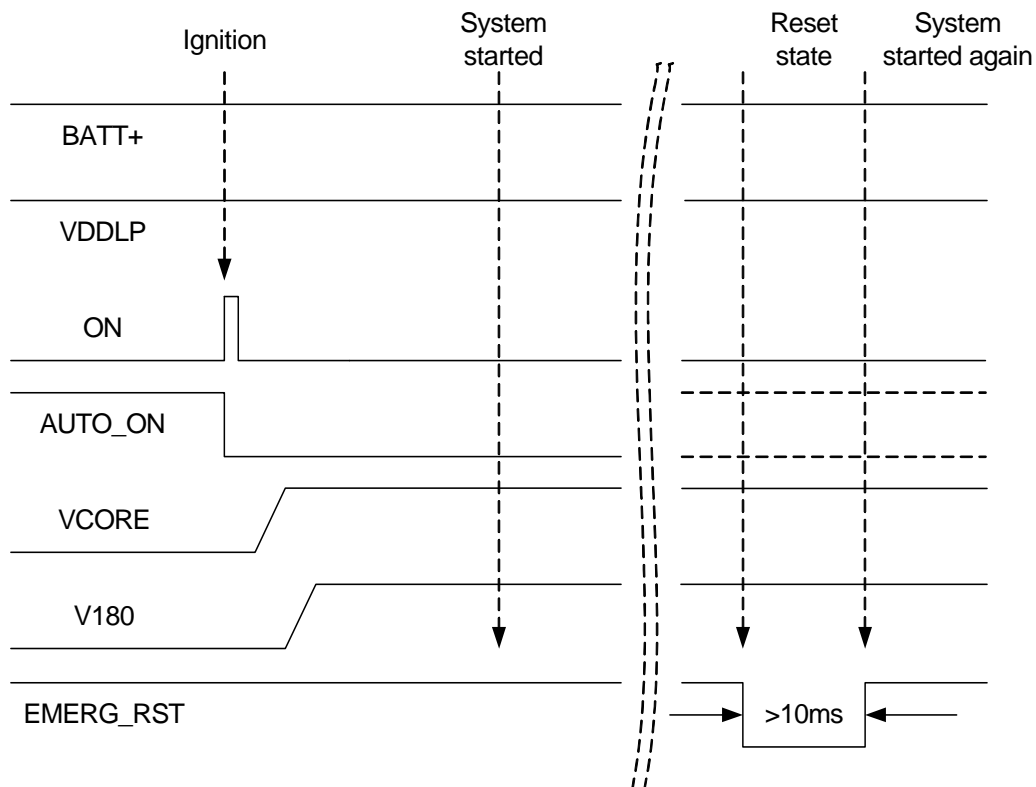


Figure 41: Emergency restart timing

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 EHS5-E/EHS5-US does not respond, if restart or shutdown via AT command fails.

3.2.3 Signal States after First Startup

Table 11 lists the states each interface signal passes through during reset and first firmware 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 an internal reset line - either with a normal module startup after about 26 milliseconds (see Section 3.2.1) or after a restart (see Section 3.2.2). After the reset state has been reached the firmware initialization state begins. The firmware and command interface 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 |
| GPIO1 | T / PD | T / PD |
| GPIO2 | T / PD | T / PD |
| GPIO3 | T / PD | T / PD |
| GPIO4 | T / PD | T / PD |
| GPIO5 | T / PD | T / PD |
| GPIO6 | T / PD | T / PD |
| GPIO7 | T / PD | T / PD |
| GPIO8 | T / PD | T / PD |
| GPIO16 | T / PD | T / PD |
| GPIO17 | T / PD | T / PD |
| GPIO18 | T / PD | T / PD |
| GPIO19 | T / PD | T / PD |
| GPIO20 | T / PD | T / PD |
| GPIO21 | T / PD | T / PD |
| GPIO22 | T / PD | T / PD |
| GPIO23 | T / PD | T / PD |
| GPIO24 | T / PD | T / PD |
| 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 EHS5-E/EHS5-US

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](#).
- *Automatic shutdown (software controlled)*: See [Section 3.2.5](#)
 - Takes effect if EHS5-E/EHS5-US board temperature exceeds a critical limit.

3.2.4.1 Switch off EHS5-E/EHS5-US Using AT Command

The best and safest approach to powering down EHS5-E/EHS5-US is to issue the appropriate AT command. This procedure lets EHS5-E/EHS5-US log off from the network and allows the software to enter into a secure state and save data before disconnecting the power supply. The mode is referred to as Power Down mode. In this mode, only the RTC stays active. Before issuing the switch off AT command, the ON signal should be set to low (see [Figure 42](#)). Otherwise there might be back powering at the ON line in Power Down mode.

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 EHS5-E/EHS5-US 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.

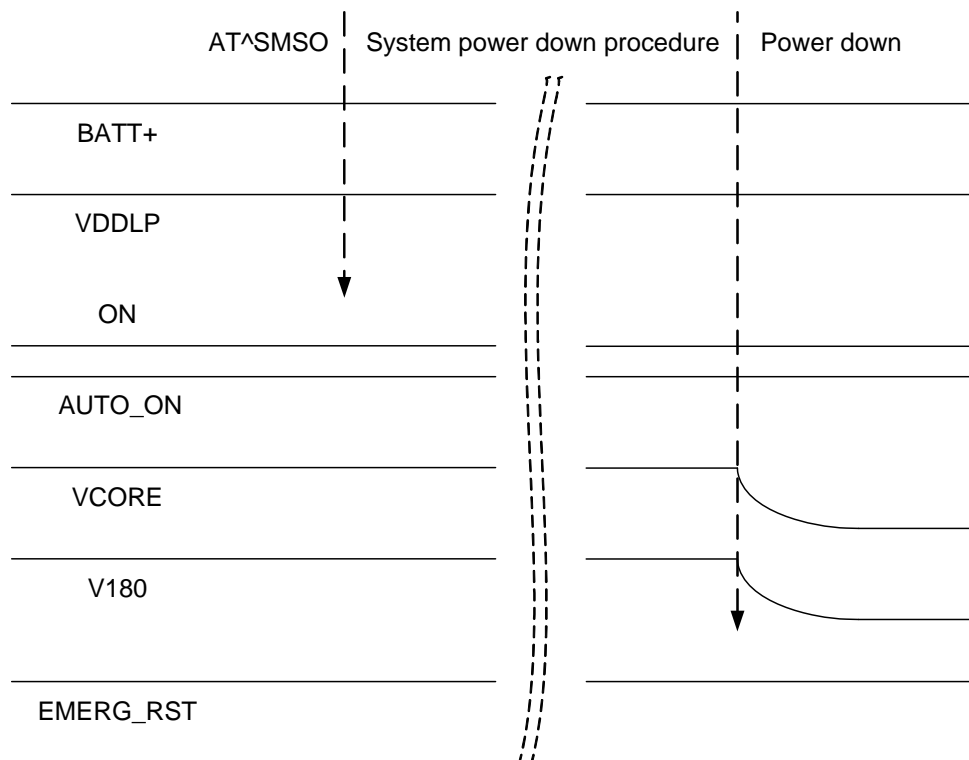


Figure 42: Switch off behavior

3.2.5 Automatic Shutdown

Automatic shutdown takes effect if the following event occurs:

- The EHS5-E/EHS5-US board is exceeding the critical limits of overtemperature or undertemperature (see [Section 3.2.5.1](#))
- Undervoltage or overvoltage is detected (see [Section 3.2.5.2](#) and [Section 3.2.5.3](#))

The automatic shutdown procedure is equivalent to the power-down initiated with an AT command, i.e. EHS5-E/EHS5-US 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, EHS5-E/EHS5-US 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 EHS5-E/EHS5-US. 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 5.2](#). Refer to [Table 12](#) for the associated URCs.

Table 12: Temperature dependent behavior

| Sending temperature alert (2min after module 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. EHS5-E/EHS5-US switches off. |
| ^SCTM_B: -2 | Alert: Board equal or below undertemperature limit. EHS5-E/EHS5-US switches off. |

3.2.5.2 Undervoltage Shutdown

The undervoltage shutdown threshold is the specified minimum supply voltage $V_{\text{BATT+}}$ given in [Table 2](#). When the average supply voltage measured by EHS5-E/EHS5-US approaches the undervoltage shutdown threshold (i.e., 0.05V offset) the module will send the following URC:

^SBC: Undervoltage Warning

The undervoltage warning is sent only once - until the next time the module is close to the undervoltage shutdown threshold.

If the voltage continues to drop below the specified undervoltage shutdown threshold, the module will send the following URC:

^SBC: Undervoltage Shutdown

This alert is sent only once before the module shuts down cleanly without sending any further messages.

This type of URC does not need to be activated by the user. It will be output automatically when fault conditions occur.

Note: For battery powered applications it is strongly recommended to implement a BATT+ connecting circuit as described in [Section 3.2.1.1](#) in order to not only be able save power, but also to restart the module after an undervoltage shutdown where the battery is deeply discharged. Also note that the undervoltage threshold is calculated for max. 400mV voltage drops during transmit burst. Power supply sources for external applications should be designed to tolerate 400mV voltage drops without crossing the lower limit of 3.3 V. For external applications operating at the limit of the allowed tolerance the default undervoltage threshold may be adapted by subtracting an offset. For details see [1]: AT^SCFG= "MEShutdown/sVsup/threshold".

3.2.5.3 Overvoltage Shutdown

The overvoltage shutdown threshold is the specified maximum supply voltage $V_{\text{BATT+}}$ given in [Table 2](#). When the average supply voltage measured by EHS5-E/EHS5-US approaches the overvoltage shutdown threshold (i.e., 0.05V offset) the module will send the following URC:

^SBC: Overvoltage Warning

The overvoltage warning is sent only once - until the next time the module is close to the overvoltage shutdown threshold.

If the voltage continues to rise above the specified overvoltage shutdown threshold, the module will send the following URC:

^SBC: Overvoltage Shutdown

This alert is sent only once before the module shuts down cleanly without sending any further messages.

This type of URC does not need to be activated by the user. It will be output automatically when fault conditions occur.

Note that several EHS5-E/EHS5-US components are directly linked to BATT+ and, therefore, the supply voltage remains applied at major parts of EHS5-E/EHS5-US. Especially the power amplifier linked to BATT+_{RF} is very sensitive to high voltage and might even be destroyed.

3.3 Automatic GPRS Multislot Class Change

Temperature control is also effective for operation in GPRS Multislot Class 10 or 12. If the board temperature increases to 75°C while data is transmitted over GPRS, the module automatically reverts from GPRS Multislot Class 12 (4Tx) or Class 10 (2Tx) to Class 8 (1Tx). This reduces the power consumption and, consequently, causes the board's temperature to decrease. Once the temperature drops to a 70°C, EHS5-E/EHS5-US returns to the higher Multislot Class. If the temperature stays at the critical level or even continues to rise, EHS5-E/EHS5-US will not switch back to the higher class.

After a transition from Multislot Class 12 or 10 to Multislot 8 a possible switchback to Multislot Class 12 or 10 is blocked for one minute.

Please note that there is not one single cause of switching over to a lower GPRS Multislot Class. Rather it is the result of an interaction of several factors, such as the board temperature that depends largely on the ambient temperature, the operating mode and the transmit power. Furthermore, take into account that there is a delay until the network proceeds to a lower or, accordingly, higher Multislot Class. The delay time is network dependent. In extreme cases, if it takes too much time for the network and the temperature cannot drop due to this delay, the module may even switch off as described in [Section 3.2.5.1](#).

3.4 Power Saving

EHS5-E/EHS5-US 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 3.4.1 and Section 3.4.2. See Section 3.4.3 for a description on how to immediately wake up EHS5-E/EHS5-US again using RTS0.

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].

3.4.1 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:

$$t = 4.615 \text{ ms (TDMA frame duration)} * 51 \text{ (number of frames)} * \text{DRX value.}$$

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 43.



Figure 43: Power saving and paging in GSM networks

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

3.4 Power Saving

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.

3.4.2 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:

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

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 44](#).

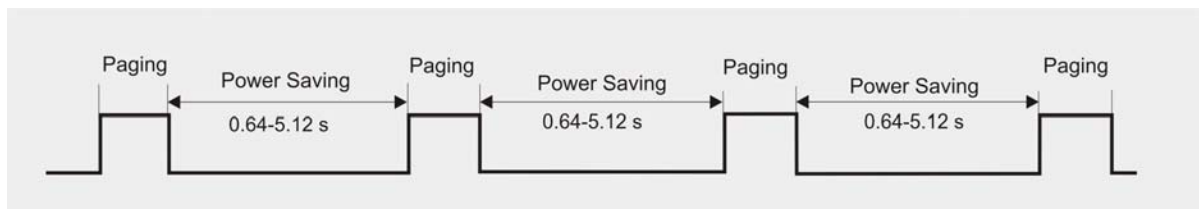


Figure 44: Power saving and paging in WCDMA networks

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.

3.4.3 Wake-up via RTS0

RTS0 can be used to wake up EHS5-E/EHS5-US from SLEEP mode configured with AT[^]SPOW. Assertion of RTS0 (i.e., toggle from inactive high to active low) serves as wake up event, thus allowing an external application to almost immediately terminate power saving. After RTS0 assertion, the CTS0 line signals module wake up, i.e., readiness of the AT command interface. It is therefore recommended to enable RTS/CTS flow control (default setting).

Figure 45 shows the described RTS0 wake up mechanism.

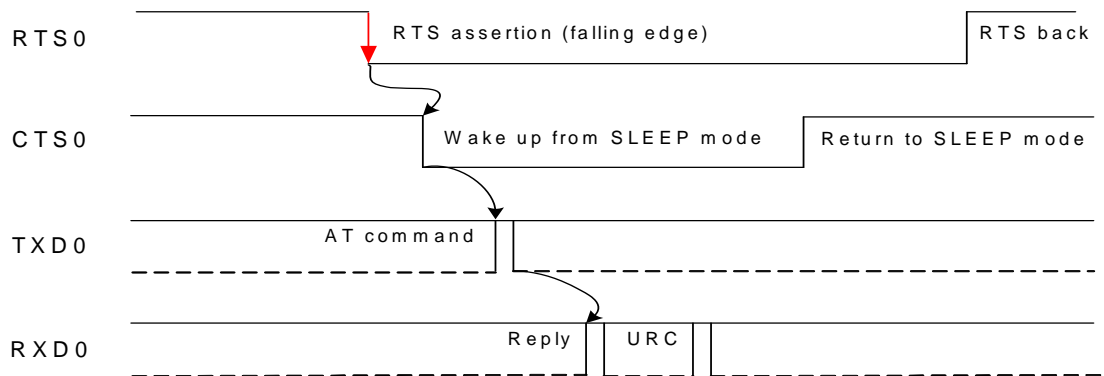


Figure 45: Wake-up via RTS0

3.5 Power Supply

EHS5-E/EHS5-US needs to be connected to a power supply at the SMT application interface - 2 lines BATT+, and GND. There are two separate voltage domains for BATT+:

- BATT+_{BB} with a line mainly for the baseband power supply.
- BATT+_{RF} with a line for the GSM power amplifier supply.

Please note that throughout the document BATT+ refers to both voltage domains and power supply lines - BATT+_{BB} and BATT+_{RF}.

The power supply of EHS5-E/EHS5-US has to be a single voltage source at BATT+_{BB} and BATT+_{RF}. 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.

3.5 Power Supply

3.5.1 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} |

Table 14: Current consumption ratings¹

| | Description | Conditions | Typical rating | Unit | |
|--|----------------------------|---|-------------------------|------|----|
| I _{VDDL} @ 1.8V | OFF State supply current | RTC backup @ BATT+ = 0V | 2 | µA | |
| I _{BATT+} ² (i.e., sum of BATT+ _{BB} and BATT+ _{RF}) | OFF State supply current | Power Down | 60 | µA | |
| | Average GSM supply current | SLEEP ³ @ DRX=9 (UART deactivated) | USB disconnected | 0.9 | mA |
| | | | USB suspended | 1.1 | mA |
| | | SLEEP ³ @ DRX=5 (UART deactivated) | USB disconnected | 1.1 | mA |
| | | | USB suspended | 1.3 | mA |
| | | SLEEP ³ @ DRX=2 (UART deactivated) | USB disconnected | 1.4 | 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 | | |

3.5 Power Supply

Table 14: Current consumption ratings¹

| | Description | Conditions | | Typical rating | Unit |
|--|--|---|----------------------------|----------------|------|
| I _{BATT+} ² (i.e., sum of BATT _{+BB} and BATT _{+RF}) | Average GSM supply current | GPRS Data transfer GSM850/900; PCL=5; 4Tx/1Rx | ROPR=4 (max. reduction) | 330 | mA |
| | | | ROPR=0 (no reduction) | 790 | mA |
| | | 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 dur- ing GSM transmit burst | VOICE Call GSM850/ 900; PCL=5 | @ 50Ω | 1.6 | A |
| | | | @ total mismatch | 2.3 | |
| | | VOICE Call GSM1800/1900; PCL=0 | @ 50Ω | 1.1 | A |
| @ total mismatch | | | 1.4 | | |

3.5 Power Supply

Table 14: Current consumption ratings¹

| | Description | Conditions | Typical rating | Unit | | |
|--|---------------------------------|---|------------------|------|-----|----|
| I _{BATT+} ² (i.e., sum of BATT _{BB} and BATT _{RF}) | Average WCDMA supply current | SLEEP ³ @ DRX=9 (UART deactivated) | USB disconnected | 1.2 | mA | |
| | | | USB suspended | 1.4 | mA | |
| | | SLEEP ³ @ DRX=8 (UART deactivated) | USB disconnected | 1.2 | mA | |
| | | | USB suspended | 1.4 | mA | |
| | | SLEEP ³ @ DRX=6 (UART deactivated) | USB disconnected | 1.8 | mA | |
| | | | USB suspended | 2.0 | mA | |
| | | IDLE @ DRX=6 (UART activated, but no communication) | USB disconnected | 13 | mA | |
| | | | USB active | 35 | mA | |
| | | Voice Call Band I; 24dBm | | | 520 | mA |
| | | Voice Call Band II; 24dBm | | | 560 | mA |
| | | Voice Call Band V; 24dBm | | | 460 | mA |
| | | Voice Call Band VIII; 24dBm | | | 530 | mA |
| | | UMTS Data transfer Band I @+23dBm | | | 440 | mA |
| | | UMTS Data transfer Band II @+23dBm | | | 490 | mA |
| | | UMTS Data transfer Band V @+23dBm | | | 410 | mA |
| | | UMTS Data transfer Band VIII @+23dBm | | | 470 | mA |
| | | HSDPA Data transfer Band I @+23dBm | | | 440 | mA |
| | | HSDPA Data transfer Band II @+23dBm | | | 490 | mA |
| | | HSDPA Data transfer Band V @+23dBm | | | 410 | mA |
| HSDPA Data transfer Band VIII @+23dBm | | | 470 | mA | | |

- Please note that the listed frequency bands apply as follows:
 - EHS5-E: GSM/GPRS 900/1800MHz; UMTS/HSPA+: 900/2100MHz (Band I / VIII)
 - EHS5-US: GSM/GPRS: 850/1900MHz; UMTS/HSPA+: 850/1900MHz (Band II / V)
- With an impedance of Z_{LOAD}=50Ω at the antenna connector. Measured at 4.5V - except for Power Down ratings that were measured at 3.4V.
- 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)

3.5.2 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 EHS5-E/EHS5-US board, not even in a GSM transmit burst where current consumption can rise (for peaks values see the power supply ratings listed in [Section 3.5.1](#)).

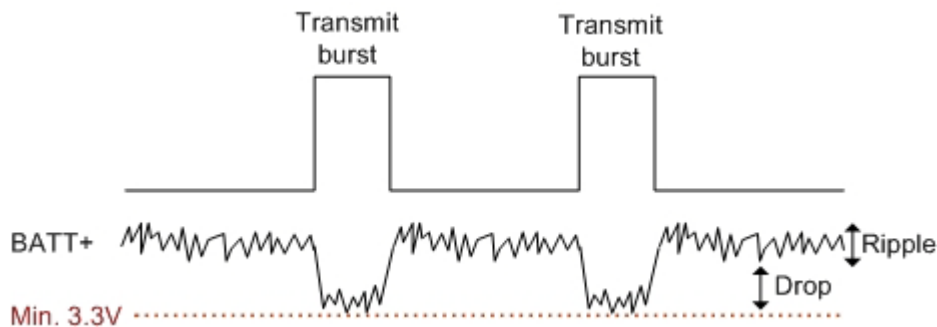


Figure 46: Power supply limits during transmit burst

3.5.3 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 5 ($BATT+_{BB}$) or 53 ($BATT+_{RF}$) as shown in [Figure 47](#).

Reference point BATT+:
External test pad connected to and positioned closely to BATT+ pad 5 or 53.

Reference point GND:
Module shielding

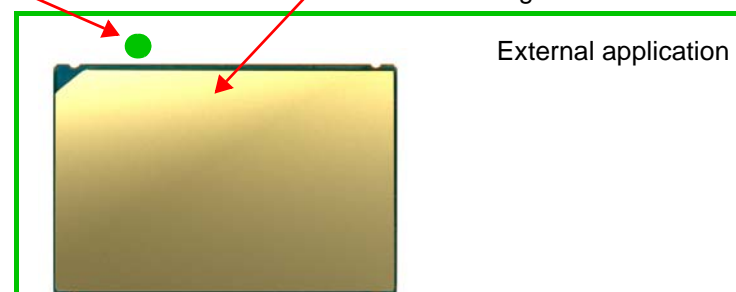


Figure 47: Position of reference points BATT+ and GND

3.5.4 Monitoring Power Supply by AT Command

To monitor the supply voltage you can also use the `AT^SBV` command which returns the value related to the reference points BATT+ and GND.

The module continuously measures the voltage at intervals depending on the operating mode of the RF interface. The duration of measuring ranges from 0.5 seconds in TALK/DATA mode to 50 seconds when EHS5-E/EHS5-US is in IDLE mode or Limited Service (deregistered). The displayed voltage (in mV) is averaged over the last measuring period before the `AT^SBV` command was executed.

If the measured voltage drops below or rises above the voltage shutdown thresholds, the module will send an `^SBC` URC and shut down (for details see [Section 3.2.5](#)).

3.6 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 EHS5-E/EHS5-US 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 $\pm 3^{\circ}\text{C}$ on the thresholds may occur.

See also [Section 3.2.5](#) for information about the NTC for on-board temperature measurement, automatic thermal shutdown and alert messages.

Note: 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 [\[3\]](#).

3.7 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 EHS5-E/EHS5-US module.

An example for an enhanced ESD protection for the SIM interface is given in [Section 2.1.6.1](#).

EHS5-E/EHS5-US 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 | $\pm 1\text{kV}$ | n.a. |
| Antenna interface with ESD protection (see Section 3.7.1) | $\pm 4\text{kV}$ | $\pm 8\text{kV}$ |
| JEDEC JESD22-A114D (Human Body Model, Test conditions: 1.5 k Ω , 100 pF) | | |
| All other interfaces | $\pm 1\text{kV}$ | n.a. |

Note: 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](#).

3.7.1 ESD Protection for Antenna Interface

The following [Figure 48](#) 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](#)).

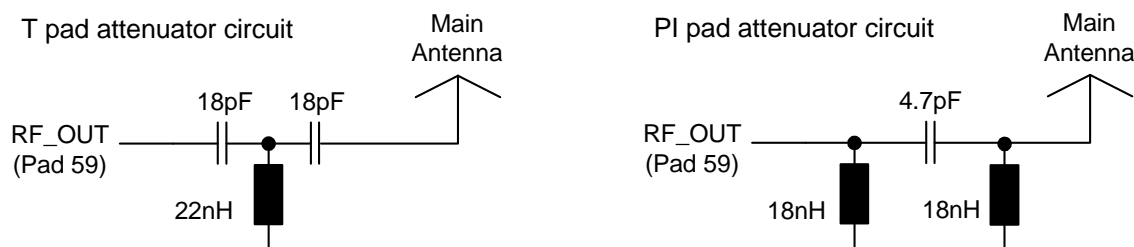


Figure 48: ESD protection for RF antenna interface

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).

3.8 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 49](#) 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 $1\text{k}\Omega$ 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.

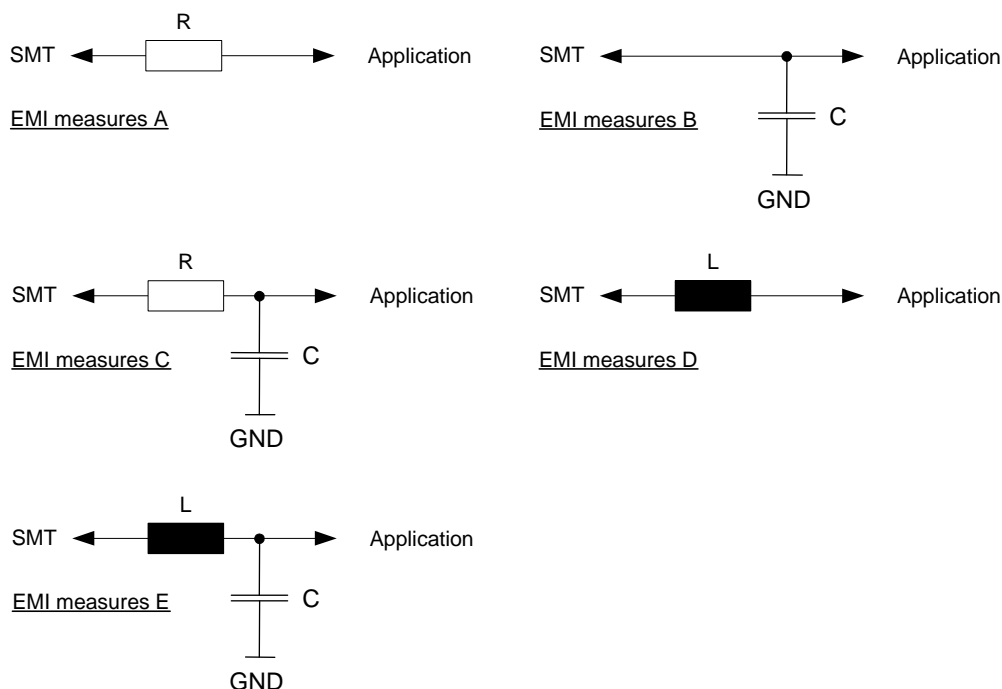


Figure 49: EMI circuits

Note: In case the application uses an internal GSM antenna that is implemented close to the EHS5-E/EHS5-US module, Gemalto strongly recommends sufficient EMI measures, e.g. of type B or C, for each digital input or output.

3.8 Blocking against RF on Interface Lines

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 10pF. 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 | x | x | x | x | |
| GPIO1/DTR0 | x | x | x | x | x | |
| GPIO2/DCD0 | x | x | x | x | x | |
| GPIO3/DSR0/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 | |
| GPIO16/RXD1/MOSI | x | x | x | x | x | |
| GPIO17/TXD1/MISO | x | x | x | x | x | |
| GPIO18/RTS1 | x | x | x | x | x | |
| 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 | |
| BATT+ _{RF} (pad 53) | | x | x | | | Measures required if BATT+ _{RF} is close to internal GSM antenna - e.g., 39pF blocking capacitor to ground |
| BATT+ _{BB} (pad 5) | | x | x | | | |

3.9 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: 1ms 1 shock per axis 6 positions (\pm x, y and z) | DIN IEC 60068-2-27 |
| Dry heat | Temperature: +70 \pm 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 \pm 2°C High temperature: +85°C \pm 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 \pm 2°C Low temperature: +25°C \pm 2°C Humidity: 93% \pm 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 \pm 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.

3.9 Reliability Characteristics

4 Mechanical Dimensions, Mounting and Packaging

The following sections describe the mechanical dimensions of EHS5-E/EHS5-US and give recommendations for integrating EHS5-E/EHS5-US into the host application.

Additional information can be found in a number of files containing Gerber data for the external application footprint and product model data in STEP format. These data are zipped in an extra file package supplied along with the EHS5-E/EHS5-US documentation package. To open these files commonly used Gerber and STEP viewers may be employed. The file package is named ehs5_gerber_stp_v01.7z.

4.1 Mechanical Dimensions of EHS5-E/EHS5-US

Figure 50 shows the top and bottom view of EHS5-E/EHS5-US and provides an overview of the board's mechanical dimensions. For further details see Figure 51.

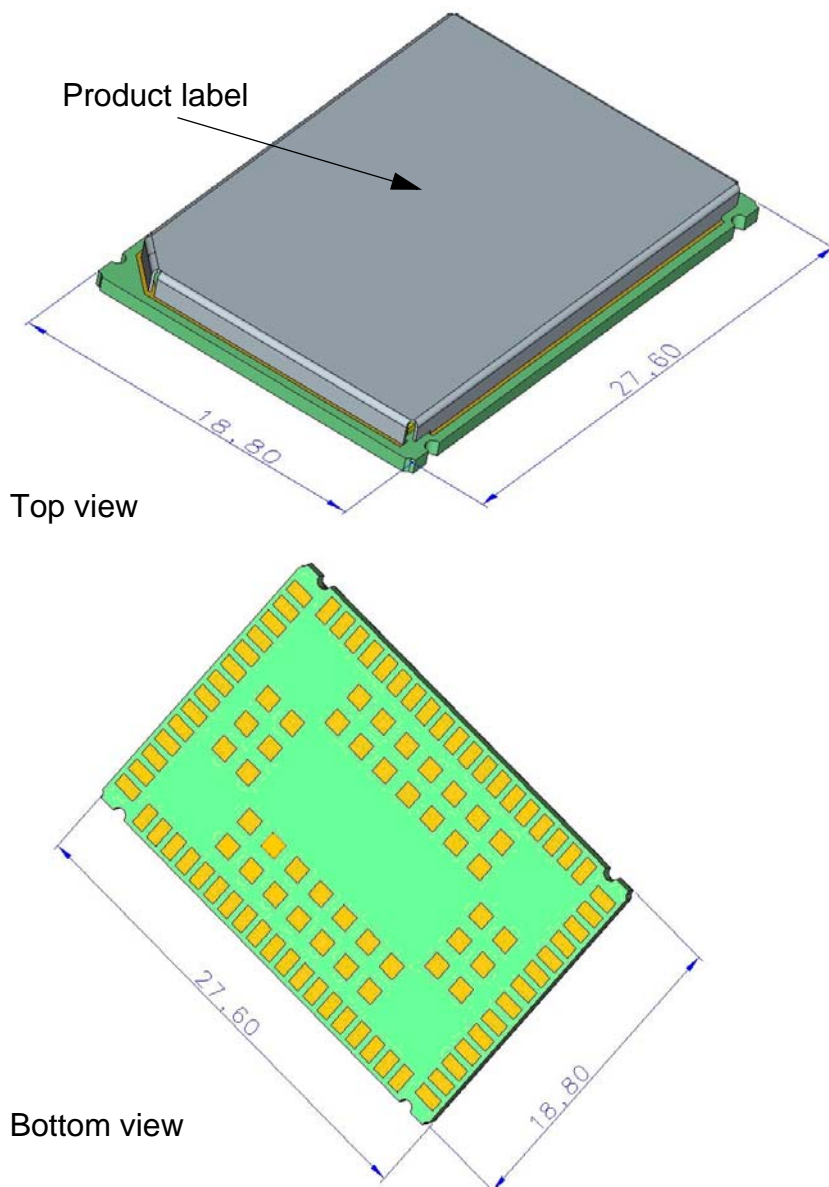


Figure 50: EHS5-E/EHS5-US– top and bottom view

4.1 Mechanical Dimensions of EHS5-E/EHS5-US

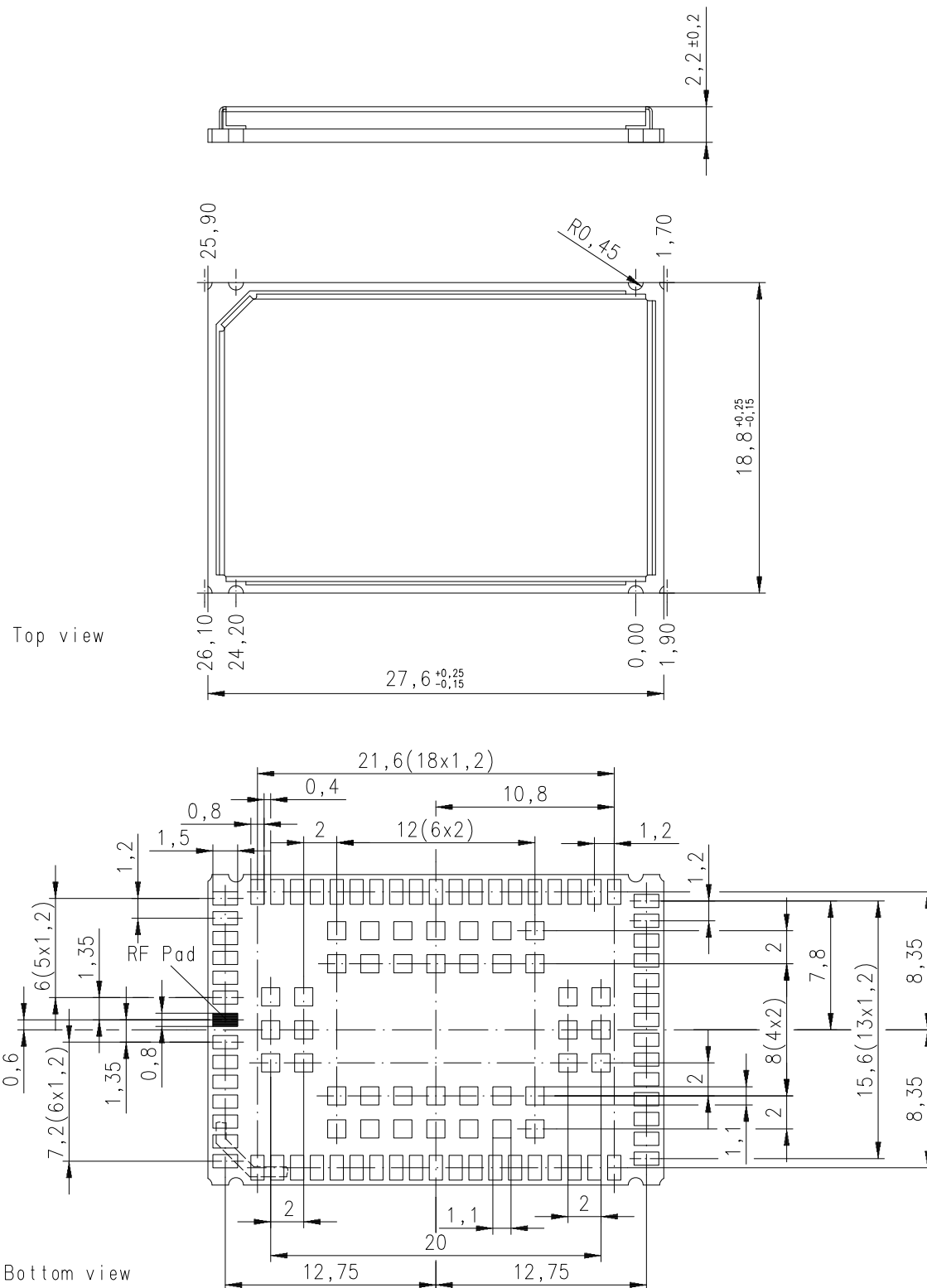


Figure 51: Dimensions of EHS5-E/EHS5-US (all dimensions in mm)

4.2 Mounting EHS5-E/EHS5-US onto the Application Platform

This section describes how to mount EHS5-E/EHS5-US 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 [4].

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 52](#) reflects the module's pad layout, including signal pads and ground pads (for pad assignment see [Section 2.1.1](#)).

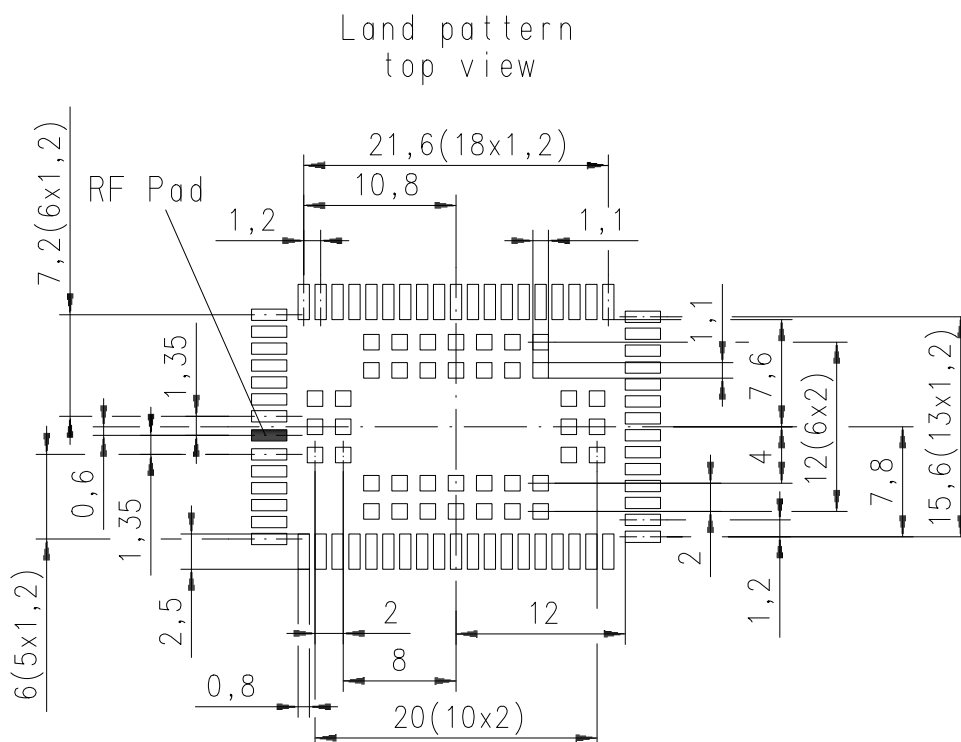


Figure 52: Land pattern (top view)

The stencil design illustrated in [Figure 53](#) and [Figure 54](#) 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.

4.2 Mounting EHS5-E/EHS5-US onto the Application Platform

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 52](#) provides for both of these alternatives and only a modification of the stencil may be needed.

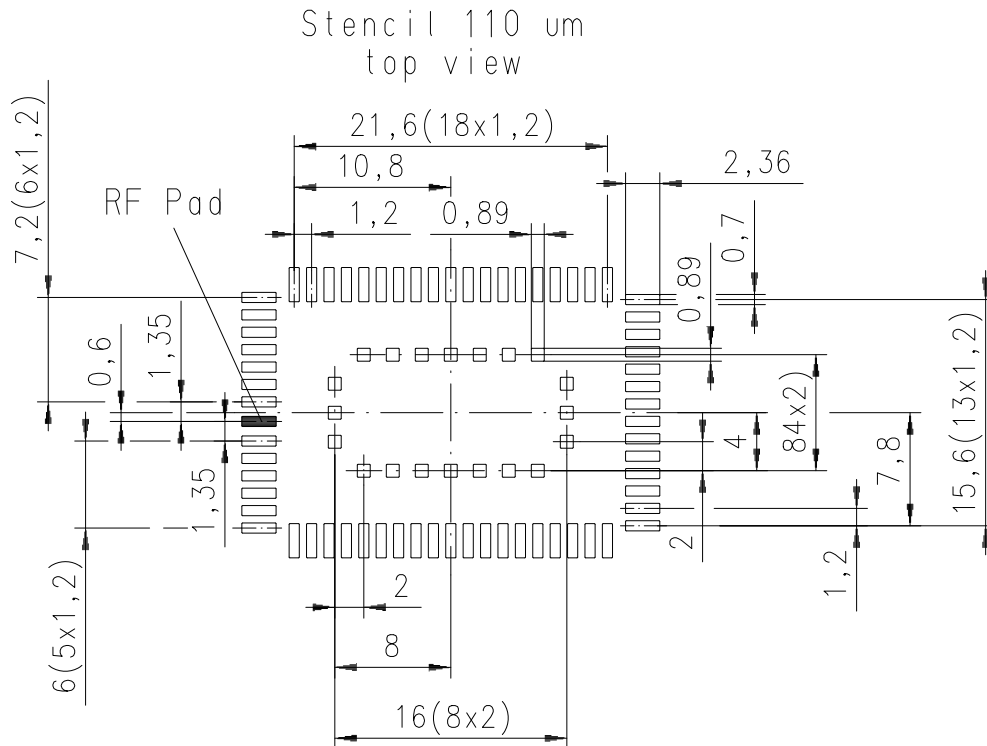


Figure 53: Recommended design for 110 micron thick stencil (top view)

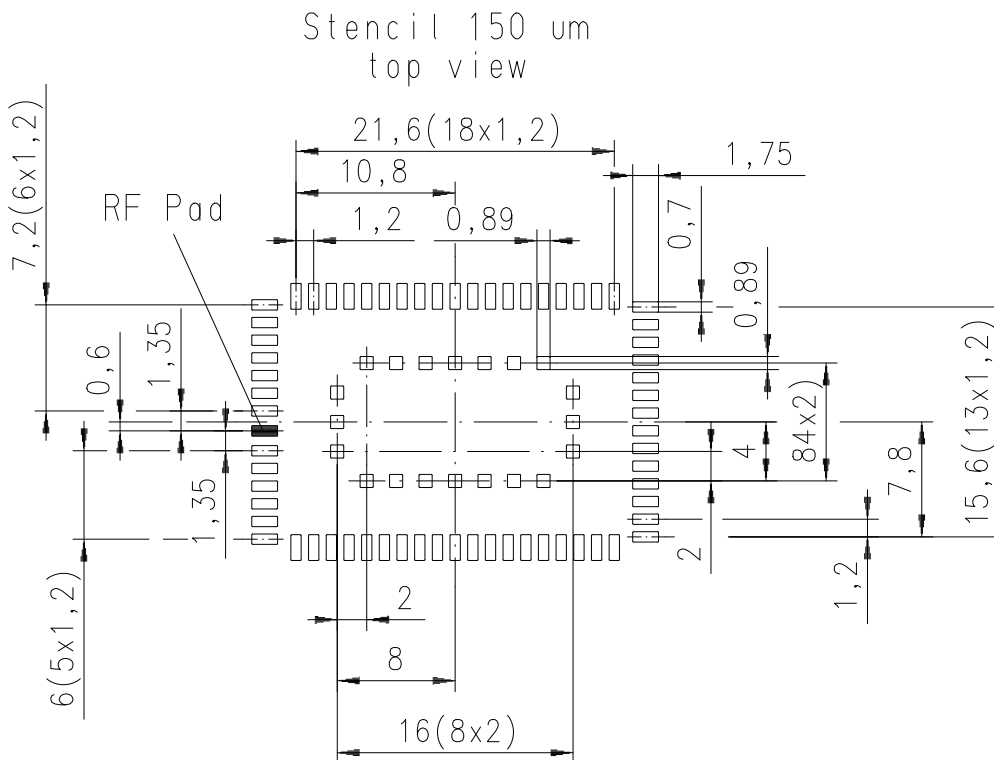


Figure 54: Recommended design for 150 micron thick stencil (top view)

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 [\[4\]](#).

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 [\[4\]](#).

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

EHS5-E/EHS5-US comprises components that are susceptible to damage induced by absorbed moisture.

Gemalto M2M's EHS5-E/EHS5-US 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

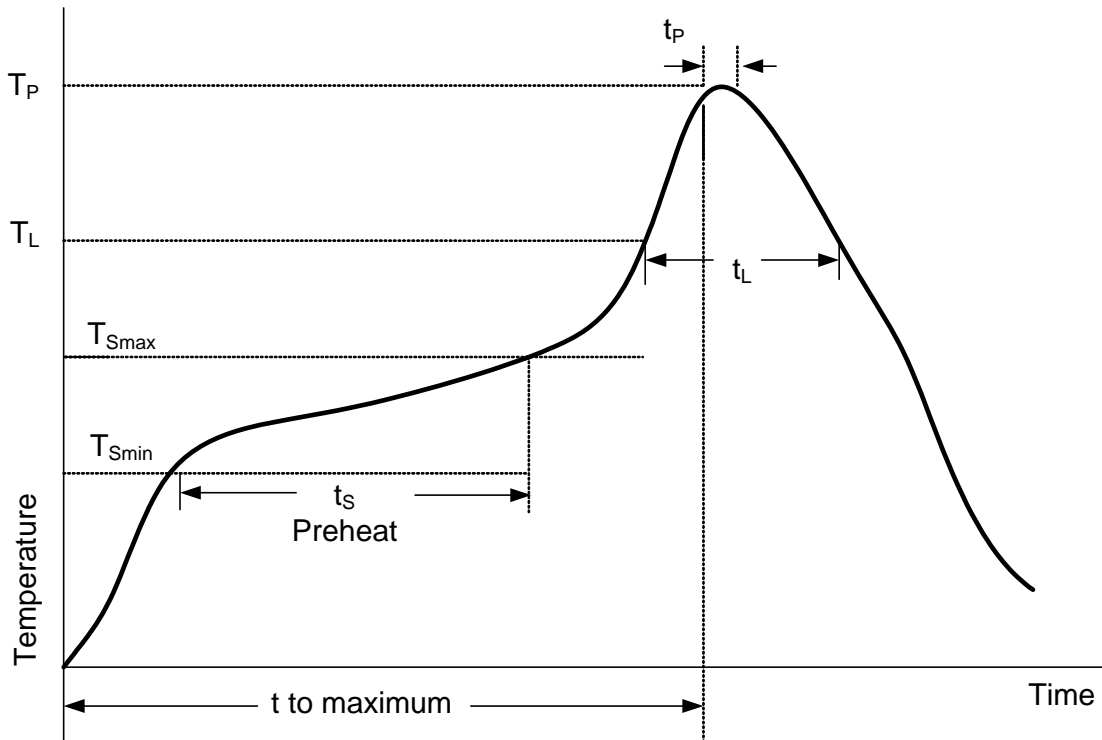


Figure 55: Reflow Profile

Table 19: Reflow temperature ratings¹

| 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}) | 3 K/second max. |
| Time 25°C to maximum temperature | 8 minutes max. |

1. Please note that the reflow profile features and ratings listed above are based on the joint industry standard IPC/JEDEC J-STD-020D.1, and are as such meant as a general guideline. For more information on reflow profiles and their optimization please refer to [4].

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 240°C. This specifies the temperature as measured at the module's top side.
- A maximum duration of 15 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.

EHS5-E/EHS5-US is specified for one soldering cycle only. Once EHS5-US 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

EHS5-E/EHS5-US 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

EHS5-E/EHS5-US 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 60](#) for details):

- It is *not necessary* to bake EHS5-E/EHS5-US, if the conditions specified in [Section 4.2.4.1](#) and [Section 4.2.4.2](#) were not exceeded.
- It is *necessary* to bake EHS5-E/EHS5-US, 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 irreversible 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 3.7](#) for further information on electrostatic discharge.

4.3 Packaging

4.3 Packaging

4.3.1 Tape and Reel

The single-feed tape carrier for EHS5-E/EHS5-US is illustrated in Figure 56. The figure also shows the proper part orientation. The tape width is 44 mm and the EHS5-US modules are placed on the tape with a 28-mm pitch. The reels are 330 mm in diameter with a core diameter of 100 mm. Each reel contains 500 modules.

4.3.1.1 Orientation

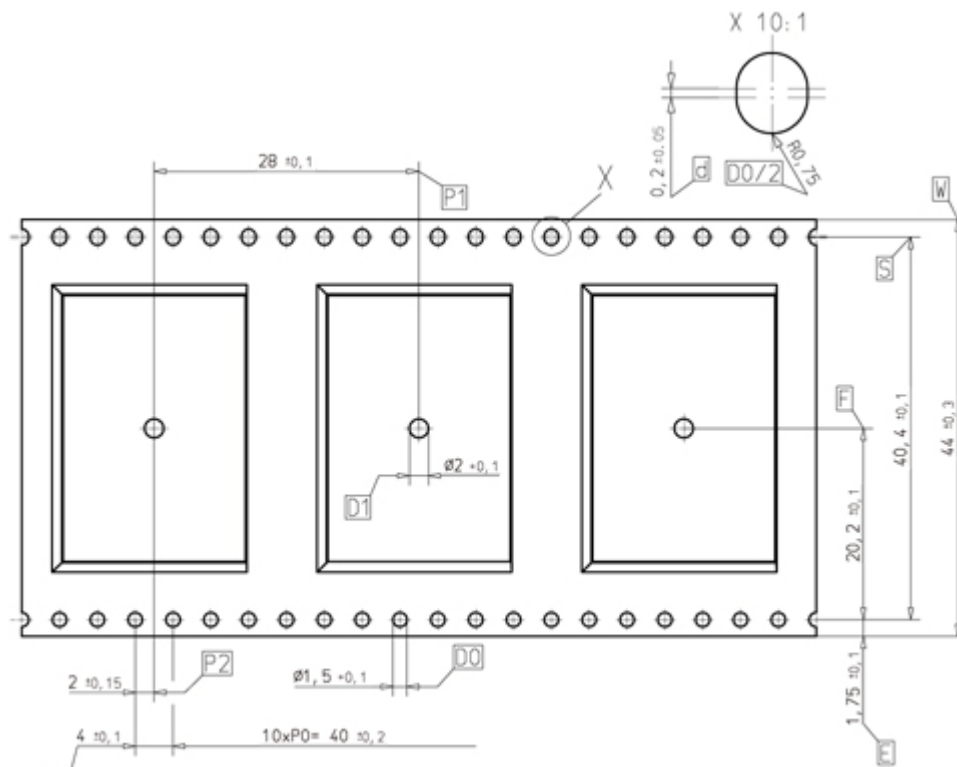


Figure 56: Carrier tape

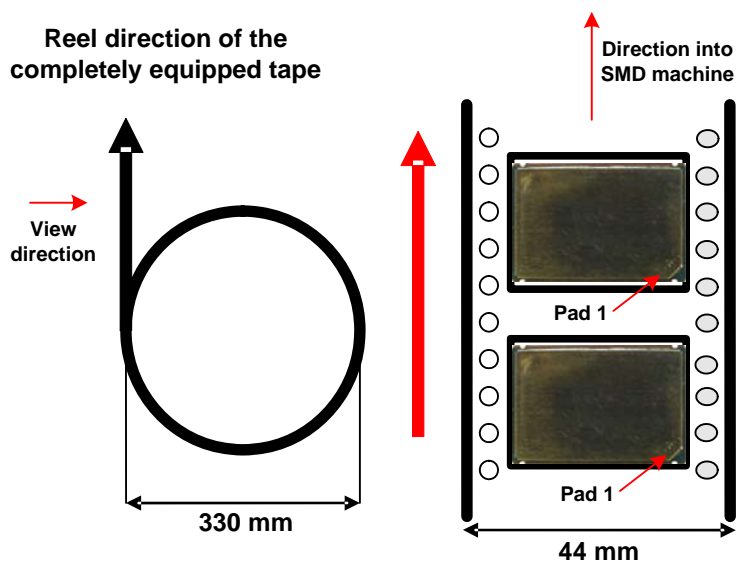


Figure 57: Reel direction

4.3.1.2 Barcode Label

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

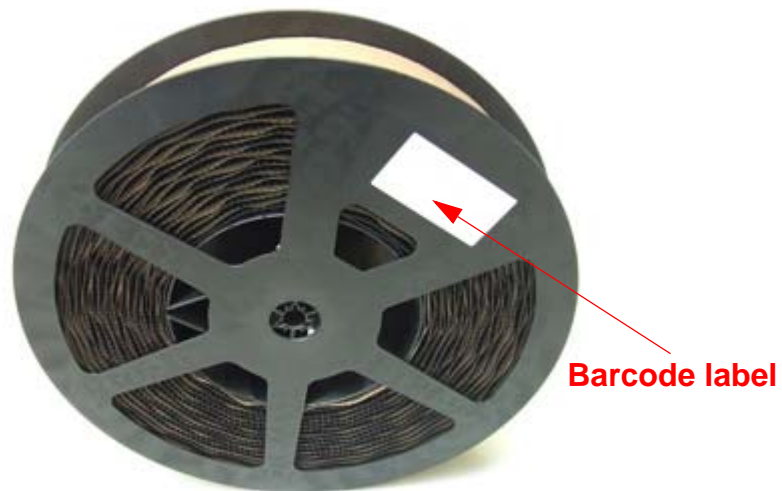


Figure 58: Barcode label on tape reel

4.3 Packaging

4.3.2 Shipping Materials

EHS5-E/EHS5-US is distributed in tape and reel carriers. The tape and reel carriers used to distribute EHS5-E/EHS5-US 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 59](#). 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 EHS5-E/EHS5-US modules from moisture exposure. It should not be opened until the devices are ready to be soldered onto the application.

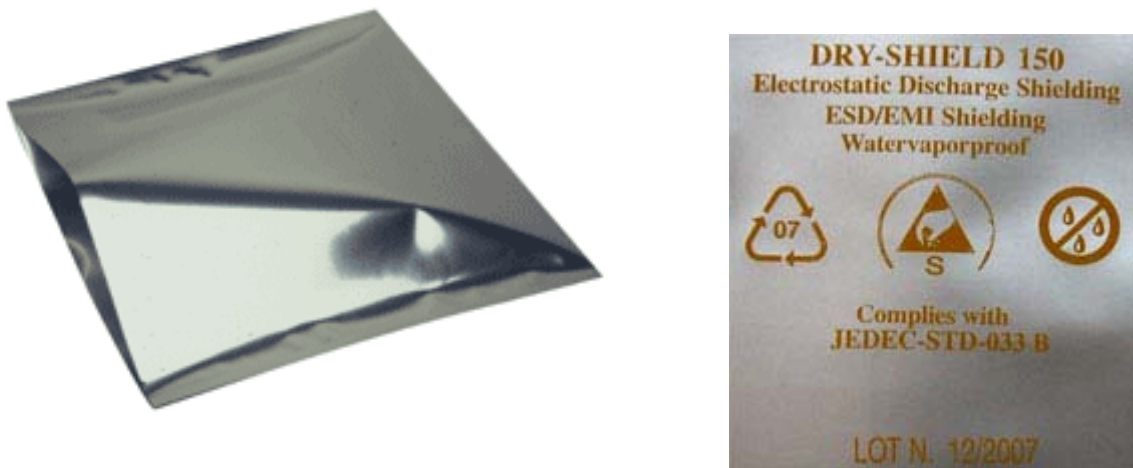


Figure 59: Moisture barrier bag (MBB) with imprint

The label shown in [Figure 60](#) summarizes requirements regarding moisture sensitivity, including shelf life and baking requirements. It is attached to the outside of the moisture barrier bag.

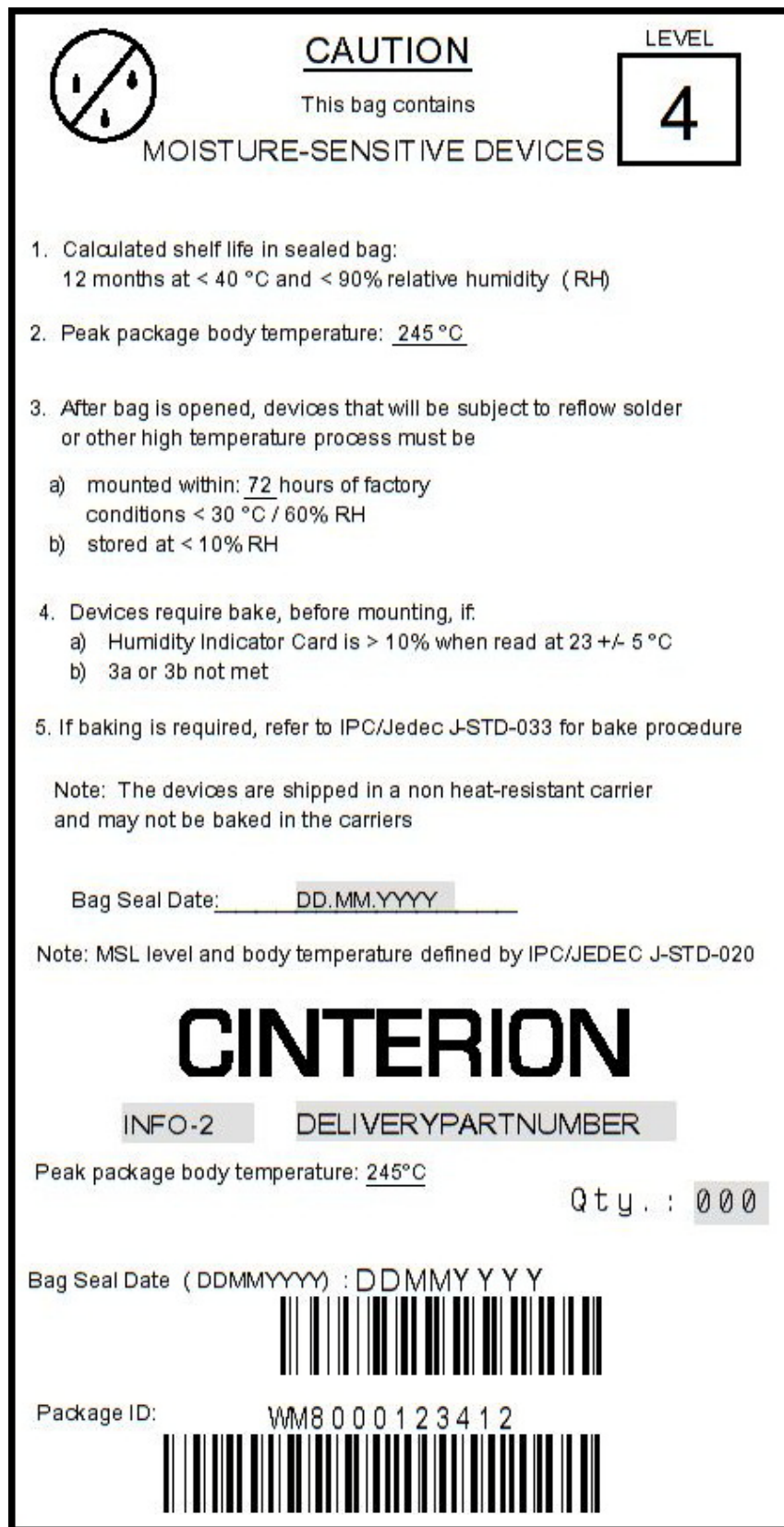


Figure 60: Moisture Sensitivity Label

4.3 Packaging

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 61](#). If the components have been exposed to moisture above the recommended limits, the units will have to be rebaked.

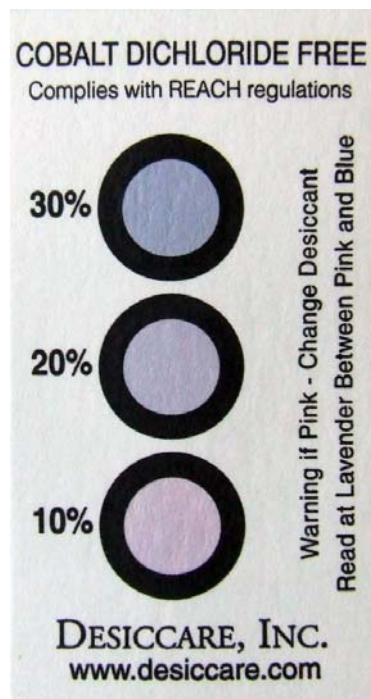


Figure 61: Humidity Indicator Card - HIC

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 Packaging

4.3.3 Trays

If small module quantities are required, e.g., for test and evaluation purposes, EHS5-E/EHS5-US may be distributed in trays (for dimensions see [Figure 65](#)). 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 [\[4\]](#)).

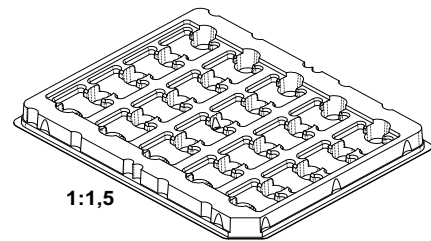


Figure 62: Small quantity tray

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](#)).



Figure 63: Tray to ship odd module amounts



Figure 64: Trays with packaging materials

4.3 Packaging

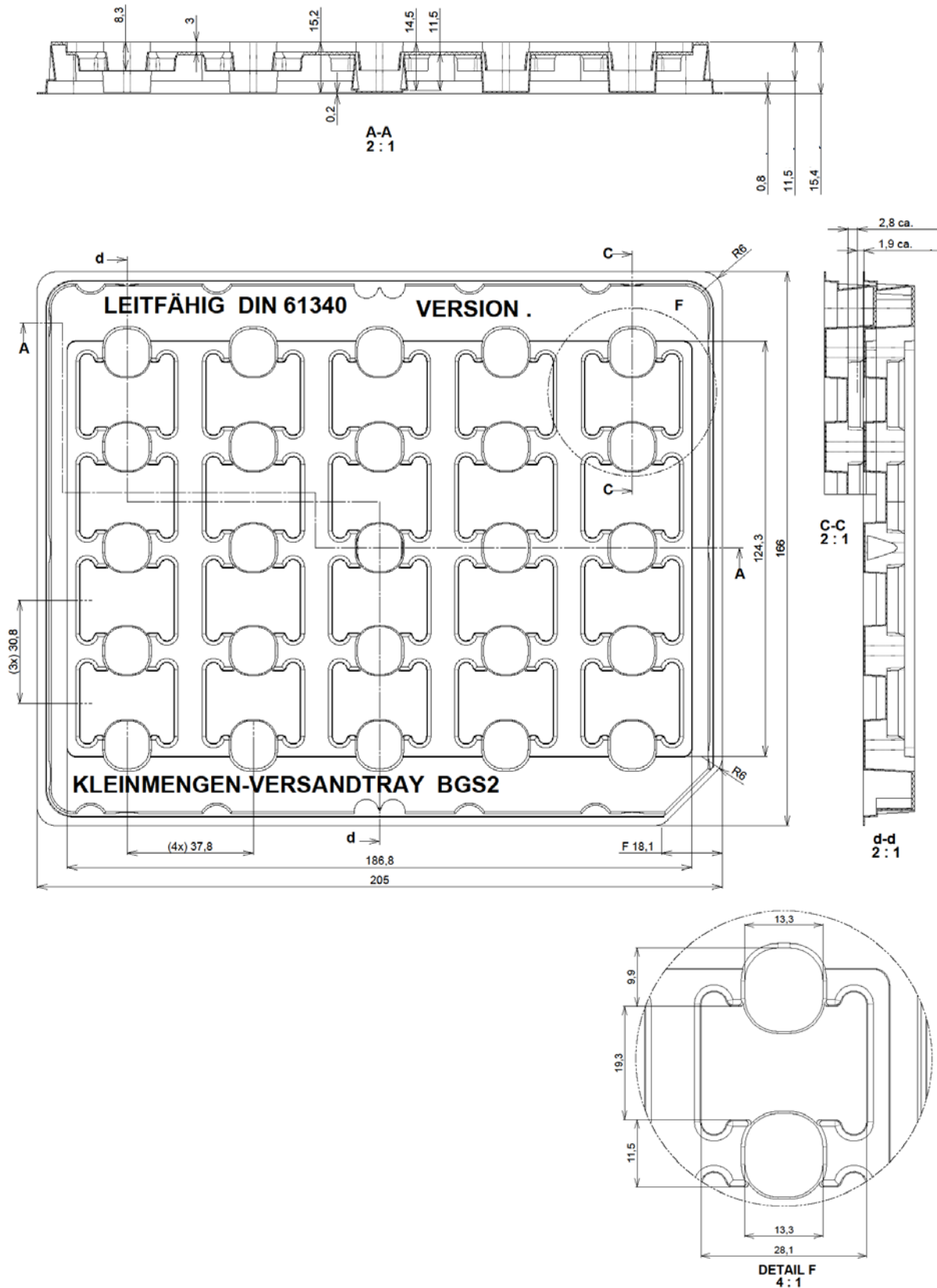


Figure 65: Tray dimensions

5 Regulatory and Type Approval Information

5.1 Directives and Standards

EHS5-E/EHS5-US 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 "EHS5-E/EHS5-US 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 CE 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 approval¹

| | |
|------------------------------------|---|
| 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 |

1. Applies to the module variant EHS5-US only.

Table 23: Standards of European type approval¹

| | |
|------------------------|---|
| 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 |

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.

5.1 Directives and Standards

Table 23: Standards of European type approval¹

| | |
|---|--|
| 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 |
| 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) |
| EN 60950-1:2006+ A12:2011+A11:2009+ A1:2010 IEC 60950-1:2005/ A1:2009 (second edition) | Safety of information technology equipment |

1. Applies to the module variant EHS5-E only.

Table 24: Requirements of quality

| | |
|--------------|-----------------------|
| IEC 60068 | Environmental testing |
| DIN EN 60529 | IP codes |

5.1 Directives and Standards

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 | <p>“Marking for Control of Pollution Caused by Electronic Information Products” (2006-06).</p> <p>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.</p> <p>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.</p>  |

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) | ○ | ○ | ○ | ○ | ○ | ○ |
| 电路模块 (Circuit Modules) | X | ○ | ○ | ○ | ○ | ○ |
| 电缆及电缆组件 (Cables and Cable Assemblies) | ○ | ○ | ○ | ○ | ○ | ○ |
| 塑料和聚合物部件 (Plastic and Polymeric parts) | ○ | ○ | ○ | ○ | ○ | ○ |

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 EHS5-E/EHS5-US 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 markets¹

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.

1. Applies for the quad band module variant EHS5-US only.

5.3 Reference Equipment for Type Approval

5.3 Reference Equipment for Type Approval

The Gemalto M2M reference setup submitted to type approve EHS5-E/EHS5-US (including a special approval adapter for the DSB75) is shown in the following figure¹:

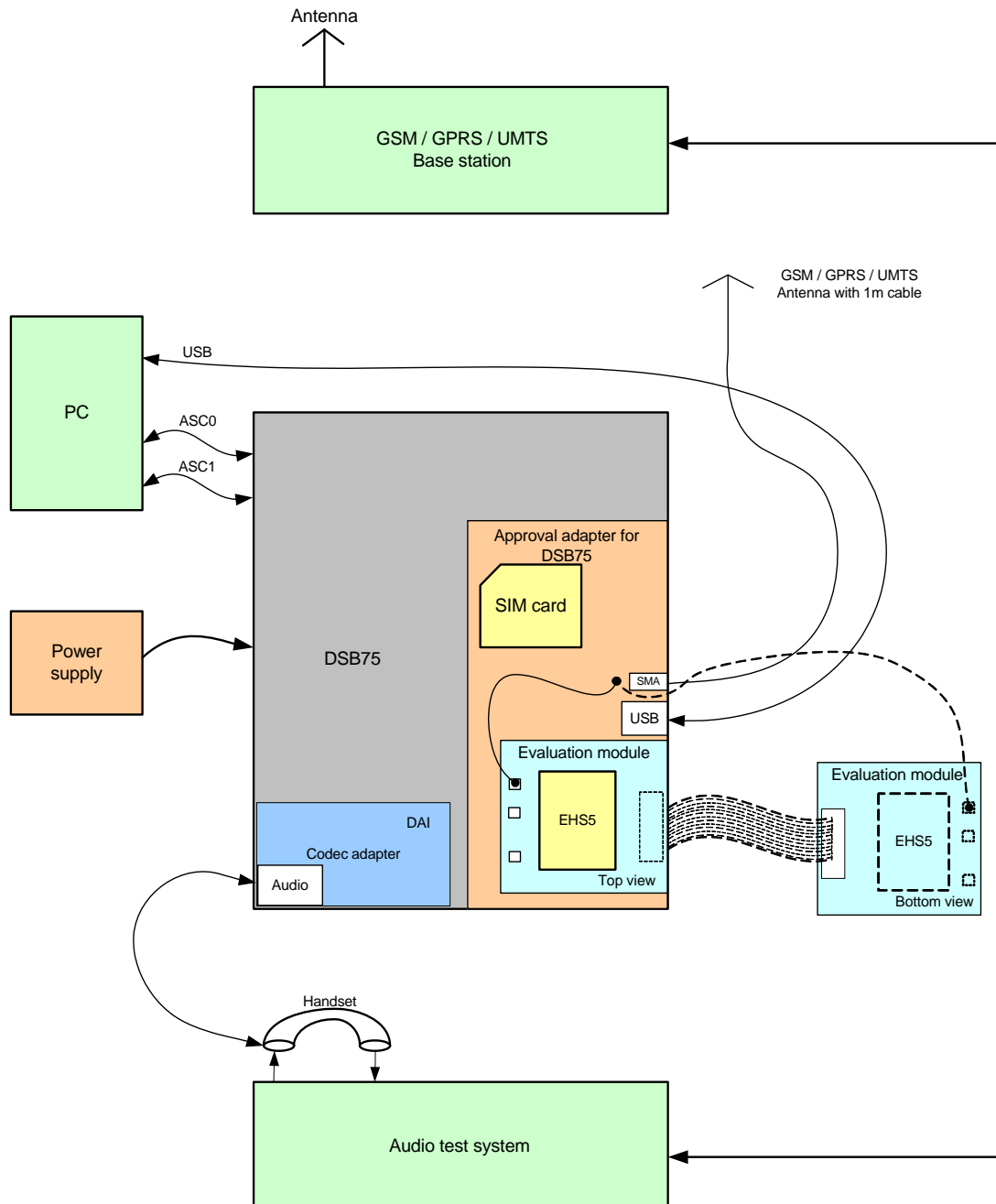


Figure 66: Reference equipment for Type Approval

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 EHS5-E/EHS5-US-DSB75 adapter as shown in Figure 66. The following products are recommended:
 Hirose SMA-Jack/U.FL-Plug conversion adapter HRMJ-U.FLP(40)
 (for details see 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/pdfs/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 identifiers¹:

FCC Identifier: QIPEHS5-US

Industry Canada Certification Number: 7830A-EHS5US

Granted to Gemalto M2M GmbH

Manufacturers of mobile or fixed devices incorporating EHS5-US modules are authorized to use the FCC Grants and Industry Canada Certificates of the EHS5-US 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: QIPEHS5-US", and accordingly "Contains IC: 7830A-EHS5US". 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 3.10 dBi (850 MHz) and 2.50 dBi (1900 MHz).

IMPORTANT:

Manufacturers of portable applications incorporating EHS5-US 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 EHS5-US 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.

1. Applies only for the quad band module variant EHS5-US.

6 Document Information

6.1 Revision History

Preceding document: "EHS5-E/EHS5-US Hardware Interface Description" Version 02.782

New document: "EHS5-E/EHS5-US Hardware Interface Description" Version **03.001**

| Chapter | What is new |
|---------------------|---|
| Throughout document | Revised GPIO startup behavior: All GPIO lines will initially start up as GPIOs, and may then be configured for an alternative functionality (see Section 2.1.9). |
| 1.1 | Revised memory space available for Java programs. |
| 2.1.2 | Revised requirement for ESR capacitor on BATT+ lines. |
| 3.2.2.2 | Added remark on SIM PIN not being required after EMERG_RST restart. |
| 3.2.5.2 | Added note on configurable undervoltage threshold. |
| 3.4.3 | New section Wake-up via RTS0 . |
| 4.2.3.1 | Added note regarding reflow profile features and ratings listed in Table 19 . Revised average ramp-down rate listed in Table 19 . |
| 7.1 | Added DSB Mini and Start Kit B80 to Table 27 . |

Preceding document: "EHS5-E/EHS5-US Hardware Interface Description" Version 02.000c

New document: "EHS5-E/EHS5-US Hardware Interface Description" Version 02.782

| Chapter | What is new |
|---------------------|--|
| Throughout document | Renamed RF_OUT to ANT_GSM to be consistent with other products. Introduced BATT+ _{BB} and BATT+ _{RF} as distinct names for the BATT+ power supply lines for general power management (BB) and the GSM power amplifier (RF). |
| 2.1.2 | Revised CLmax value for V180. Added comment for ON line in Table 2 . Revised V _{IL} max values for GPIOs. |
| 2.1.10 | Added internal pull-up resistor to Figure 18 . |
| 3.2.1 | Revised section. |
| 3.2.1.1 | New section Connecting EHS5-E/EHS5-US BATT+ Lines (i.e., the revised previous section 3.2.4.2). |
| 3.2.5.2 | New section Undervoltage Shutdown . |
| 3.2.5.3 | New section Overvoltage Shutdown . |
| 3.3 | New section Automatic GPRS Multislot Class Change . |
| 3.5.4 | New section Monitoring Power Supply by AT Command . |
| 4.2.3.2 | Revised maximum temperature and duration during SMT board-level soldering process. |
| 7.1 | Revised ordering number for evaluation module. |

6.1 Revision History

Preceding document: "EHS5-E/EHS5-US Hardware Interface Description" Version 02.000b
 New document: "EHS5-E/EHS5-US Hardware Interface Description" Version 02.000c

| Chapter | What is new |
|-------------------------|--|
| 2.1.4 | Added note that an external pull down to ground on the DCD0 line during the startup phase will activate a special mode for the module. |
| 2.1.7.1 | New section Solutions for the Digital Audio Interface (DAI/PCM) . |
| 3.8 | Added note on recommended EMI measures. |
| 7.1 | Revised ordering number for evaluation module. |

Preceding document: "EHS5-E/EHS5-US Hardware Interface Description" Version 02.000a
 New document: "EHS5-E/EHS5-US Hardware Interface Description" Version 02.000b

| Chapter | What is new |
|-------------------------|---|
| 4.3.2.1 | Replaced humidity indicator card shown in Figure 61 . |

Preceding document: "EHS5-E/EHS5-US Hardware Interface Description" Version 02.000
 New document: "EHS5-E/EHS5-US Hardware Interface Description" Version 02.000a

| Chapter | What is new |
|------------------------|---|
| Throughout document | Revised EMERG_RST signal state while module is switched off (Low --> High), including clarification of reset state description. |
| 2.1.1 | Revised table showing pad assignments. |
| 2.1.2 | Added resolution and tolerance to ADC signal properties. |
| 2.1.3 | Introduced new subsection to emphasize information on Reducing Power Consumption . |
| 2.1.9 | Removed note on GPIO high-impedance state after module startup. |
| 2.1.11 | Revised maximum transmission rate for SPI interface. |
| 2.3.1 | New section Sample Level Conversion Circuit . |
| 3.5.1 | Updated table listing power supply ratings. |

Preceding document: "EHS5-E/EHS5-US Hardware Interface Description" Version 01.441
 New document: "EHS5-E/EHS5-US Hardware Interface Description" Version 02.000

| Chapter | What is new |
|--|---|
| 2.1.7 | Updated name of sample external codec that may be used 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. |
| 2.3 | Revised sample circuit for SIM interface in Figure 31 . |
| 3.2.1.2 , 3.2.1.3 | Removed note that AUTO_ON only works once after the BATT+ has been applied. |
| 3.2.4.2 | New section Disconnect EHS5-E/EHS5-US BATT+ Lines. |
| 4.2 | Added note regarding routing of signal tracks. |

6.2 Related Documents

Preceding document: "EHS5-E/EHS5-US Hardware Interface Description" Version 01.304a
 New document: "EHS5-E/EHS5-US Hardware Interface Description" Version 01.441

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

Preceding document: "EHS5-E/EHS5-US Hardware Interface Description" Version 01.304
 New document: "EHS5-E/EHS5-US Hardware Interface Description" Version 01.304a

| Chapter | What is new |
|-------------------------|---|
| Throughout document | Replaced "impulse counter" with "pulse counter". |
| 3.2.1.1 | 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. |

New document: "EHS5-E/EHS5-US Hardware Interface Description" Version 01.304

| Chapter | What is new |
|---------|-------------------------|
| -- | Initial document setup. |

6.2 Related Documents

- [1] EHS5-E/EHS5-US AT Command Set
- [2] EHS5-E/EHS5-US Release Note
- [3] Application Note 40: Thermal Solutions
- [4] Application Note 48: SMT Module Integration
- [5] Universal Serial Bus Specification Revision 2.0, April 27, 2000

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 EHS5-E/EHS5-US |
| B | Thermistor Constant |

6.3 Terms and Abbreviations

| Abbreviation | Description |
|--------------|--|
| 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 |
| 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 |

6.3 Terms and Abbreviations







| Abbreviation | Description |
|--------------|--|
| I/O | Input/Output |
| IC | Integrated Circuit |
| IMEI | International Mobile Equipment Identity |
| ISO | International Standards Organization |
| ITU | International Telecommunications Union |
| kbps | kbits per second |
| LED | Light Emitting Diode |
| Li-Ion/Li+ | Lithium-Ion |
| Li battery | Rechargeable Lithium Ion or Lithium Polymer battery |
| 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. |

6.3 Terms and Abbreviations

| Abbreviation | Description |
|--------------|---|
| ROM | Read-only Memory |
| RTC | Real Time Clock |
| RTS | Request to Send |
| Rx | Receive Direction |
| SAR | Specific Absorption Rate |
| 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 |
| 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 EHS5-E/EHS5-US. 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.

| | |
|---|---|
|  | <p>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.</p> |
|  | <p>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.</p> |
|  | <p>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.</p> |
|  | <p>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.</p> |
|  | <p>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.</p> |
|  | <p>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.</p> |

7 Appendix

7.1 List of Parts and Accessories

Table 27: List of parts and accessories

| Description | Supplier | Ordering information |
|--|---------------------------|---|
| EHS5-E/EHS5-US | Gemalto M2M | Standard module Gemalto M2M IMEI: Packaging unit (ordering) number: L30960-N2800-A300 (EHS5-E) L30960-N2810-A300 (EHS5-US) Module label number: S30960-S2800-A300-1 (EHS5-E) S30960-S2810-A300-1 (EHS5-US) Customer IMEI mode: Packaging unit (ordering) number: L30960-N2805-A300 (EHS5-E) L30960-N2815-A300 (EHS5-US) Module label number: S30960-S2805-A300-1 (EHS5-E) S30960-S2815-A300-1 (EHS5-US) |
| DSB75 Evaluation Kit | Gemalto M2M | Ordering number: L36880-N8811-A100 |
| DSB Mini Compact Evaluation Board | Gemalto M2M | Ordering number: L30960-N0030-A100 |
| Starter Kit B80 | Gemalto M2M | Ordering Number L30960-N0040-A100 |
| Multi-Adapter R1 for mounting EHS5-E/EHS5-US evaluation modules onto DSB75 | Gemalto M2M | Ordering number: L30960-N0010-A100 |
| Approval adapter for mounting EHS5-E/EHS5-US evaluation modules onto DSB75 | Gemalto M2M | Ordering number: L30960-N2301-A100 |
| Evaluation Module | Gemalto M2M | Ordering number: L30960-N2801-A300 (EHS5-E) Ordering number: L30960-N2811-A300 (EHS5-US) |
| 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 . |

7.1 List of Parts and Accessories

Table 28: Molex sales contacts (subject to change)

| | | |
|--|---|--|
| <p>Molex For further information please click: http://www.molex.com</p> | <p>Molex Deutschland GmbH Otto-Hahn-Str. 1b 69190 Walldorf Germany Phone: +49-6227-3091-0 Fax: +49-6227-3091-8100 Email: mxgermany@molex.com</p> | <p>American Headquarters Lisle, Illinois 60532 U.S.A. Phone: +1-800-78MOLEX Fax: +1-630-969-1352</p> |
| <p>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</p> | <p>Molex Singapore Pte. Ltd. 110, International Road Jurong Town, Singapore 629174 Phone: +65-6-268-6868 Fax: +65-6-265-6044</p> | <p>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</p> |

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 innovations 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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