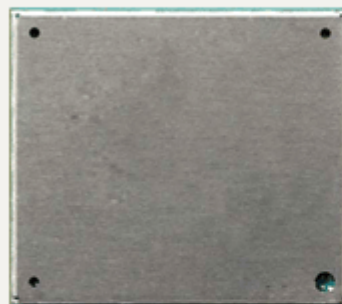security to be free

# Cinterion® PLS8-E

Hardware Interface Description

Version: 01.000c
DocId: PLS8-E_HD_v01.000c

| | |
|---|---|
| Document Name: | **Cinterion® PLS8-E Hardware Interface Description** |
| Version: | **01.000c** |
| Date: | **2013-12-13** |
| DocId: | **PLS8-E_HD_v01.000c** |
| Status | **Confidential / Released** |

**GENERAL NOTE**

**Copyright**

**Trademark Notice**

# Contents

# Tables

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# 0      Document History

Preceding document: "PLS8-E Hardware Interface Description" Version 01.000b
New document: "PLS8-E Hardware Interface Description" Version **01.000c**

| Chapter | What is new |
|---------|-------------|
| 5.2 | Added Figure 18. |

Preceding document: "PLS8-E Hardware Interface Description" Version 01.000a
New document: "PLS8-E Hardware Interface Description" Version 01.000b

| Chapter | What is new |
|---------|-------------|
| -- | Set state to "Confidential / Released". |

Preceding document: "PLS8-E Hardware Interface Description" Version 00.192
New document: "PLS8-E Hardware Interface Description" Version 01.000a

| Chapter | What is new |
|---------|-------------|
| -- | Removed LTE Bd1. |
| 1.4.1 | Revised versions of some standards and directives. |
| 3.3.2 | Revised some signal states mentioned in Table 7.<br>Added note to Table 7 on internal pulls being implemented using JFETs. |
| 3.4 | Added note to Figure 9 recommending no blocking capacitors on VUSB line. |
| 3.6 | New section Analog-to-Digital Converter (ADC). |
| 3.7 | New section GPIO Interface. |
| 5.2 | Revised section to include temperature allocation model for the module (incuding new Section 5.2.1 explaining this model). |
| 5.4.1 | New section Bending Tests. |
| 5.5 | Revised electrical characteristics for CCIN and VUSB_IN line |
| 5.6 | Revised and completed section giving power supply ratings.<br>Revised current consumption rating for POWER DOWN mode in Table 19. |
| 5.7 | Completed Table 20 listing RF antenna interface characteristics. |

Preceding document: "PLS8-E Hardware Interface Description" Version 00.130
New document: "PLS8-E Hardware Interface Description" Version 00.192

| Chapter | What is new |
|---------|-------------|
| Throughout document | Removed SLEEP mode and references to power saving |
| 3.3.1 | Added maximum startup time for USB interface. |
| 3.3.4 | New section Turn off PLS8-E Using IGT Line. |
| 3.3.6 | Revised Figure 8 showing shutdown timings for EMERG_OFF signal. |
| 3.4 | Removed section "Power Saving". |

| 3.4 | Removed remarks on USB Suspended state and power saving. |
| 5.5 | Revised some electrical characteristics for SIM interface lines. |
| 5.6 | Added some more power supply ratings. |
| 6.2.1.1 | Revised Figure 25 and Figure 26. |

New document: "PLS8-E Hardware Interface Description" Version 00.130

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

# 1        Introduction

The document[1] describes the hardware of the Cinterion® PLS8-E module, designed to connect to a cellular device application and the air interface. 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        Supported Products

This document applies to the following Gemalto M2M products:
• Cinterion® PLS8-E module

## 1.2        Related Documents

[1]    Cinterion® PLS8-E AT Command Set
[2]    Cinterion® PLS8-E Release Notes
[3]    Application Note 48: SMT Module Integration

## 1.3        Terms and Abbreviations

| Abbreviation | Description |
|---|---|
| ANSI | American National Standards Institute |
| ARP | Antenna Reference Point |
| CE | Conformité Européene (European Conformity) |
| CS | Coding Scheme |
| CS | Circuit Switched |
| CSD | Circuit Switched Data |
| DCS | Digital Cellular System |
| DL | Download |
| dnu | Do not use |
| DRX | Discontinuous Reception |
| DSB | Development Support Board |
| DTX | Discontinuous Transmission |
| EDGE | Enhanced Data rates for GSM Evolution |
| EGSM | Extended GSM |
| EMC | Electromagnetic Compatibility |

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[1.] The document is effective only if listed in the appropriate Release Notes as part of the technical documentation delivered with your Gemalto M2Mproduct.

| Abbreviation | Description |
|---|---|
| ESD | Electrostatic Discharge |
| ETS | European Telecommunication Standard |
| ETSI | European Telecommunications Standards Institute |
| FDD | Frequency Division Duplex |
| GPRS | General Packet Radio Service |
| GSM | Global Standard for Mobile Communications |
| HiZ | High Impedance |
| HSDPA | High Speed Downlink Packet Access |
| I/O | Input/Output |
| IMEI | International Mobile Equipment Identity |
| ISO | International Standards Organization |
| ITU | International Telecommunications Union |
| kbps | kbits per second |
| LED | Light Emitting Diode |
| LGA | Land Grid Array |
| LTE | Long term evolution |
| MBB | Moisture barrier bag |
| Mbps | Mbits per second |
| MCS | Modulation and Coding Scheme |
| MIMO | Multiple Input Multiple Output |
| MLCC | Multi Layer Ceramic Capacitor |
| MO | Mobile Originated |
| MS | Mobile Station, also referred to as TE |
| MSL | Moisture Sensitivity Level |
| MT | Mobile Terminated |
| nc | Not connected |
| NTC | Negative Temperature Coefficient |
| PBCCH | Packet Switched Broadcast Control Channel |
| PCB | Printed Circuit Board |
| PCL | Power Control Level |
| PCS | Personal Communication System, also referred to as GSM 1900 |
| PD | Pull Down resistor (appr. 100k) |
| PDU | Protocol Data Unit |
| PS | Packet Switched |
| PSK | Phase Shift Keying |
| PU | Pull Up resistor (appr. 100k) |

| Abbreviation | Description |
|---|---|
| QAM | Quadrature Amplitude Modulation |
| R&TTE | Radio and Telecommunication Terminal Equipment |
| RF | Radio Frequency |
| rfu | Reserved for future use |
| RTC | Real Time Clock |
| Rx | Receive Direction |
| SAR | Specific Absorption Rate |
| 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 |
| SRB | Signalling Radio Bearer |
| TE | Terminal Equipment |
| TPC | Transmit Power Control |
| TS | Technical Specification |
| Tx | Transmit Direction |
| UL | Upload |
| UMTS | Universal Mobile Telecommunications System |
| URC | Unsolicited Result Code |
| USB | Universal Serial Bus |
| UICC | USIM Integrated Circuit Card |
| USIM | UMTS Subscriber Identification Module |
| WCDMA | Wideband Code Division Multiple Access |

## 1.4 Regulatory and Type Approval Information

### 1.4.1 Directives and Standards

PLS8-E has been 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 "PLS8-E Hardware Interface Description".

**Table 1:** Directives

| 99/05/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). <br> The product is labeled with the CE conformity mark $\quad$ CE 0682 |
|---|---|
| ECE-R 10 | Economic Commission for Europe (ECE) Regulation No. 10: Uniform provisions concerning the approval of vehicles with regard to electromagnetic compatibility |
| 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 2:** Standards of European type approval

| 3GPP TS 51.010-1 | Digital cellular telecommunications system (Release 7); Mobile Station (MS) conformance specification; |
|---|---|
| ETSI EN 301 511 V9.0.2 | Global System for Mobile communications (GSM); Harmonized standard for mobile stations in the GSM 900 and DCS 1800 bands covering essential requirements under article 3.2 of the R&TTE directive (1999/5/EC) |
| GCF-CC V3.50 | Global Certification Forum - Certification Criteria |
| ETSI EN 301 489-01 V1.9.1 | 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 |
| 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 |

**Table 2:** Standards of European type approval

| | |
|---|---|
| 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 301 908-13 V5.2.1 | IMT cellular networks; Harmonized EN covering the essential requirements of article 3.2 of the R&TTE Directive; Part 13: Evolved Universal Terrestrial Radio Access (E-UTRA) User Equipment (UE) |
| EN 300 440-02 V1.3.1 | Electromagnetic compatibility and Radio spectrum Matters (ERM); Short range devices; Radio equipment to be used in the 1 GHz to 40 GHz frequency range; Part 2: Harmonized EN covering essential requirements of article 3.2 of the R&TTE Directive |
| EN 62311:2008 | Assessment of electronic and electrical equipment related to human exposure restrictions for electromagnetic fields (0 Hz - 300 GHz) |
| IEC/EN 60950-1:2006+ A11:2009+A1:2010+ A12:2011 | Safety of information technology equipment |

**Table 3:** Requirements of quality

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

**Table 4:** Standards of the Ministry of Information Industry of the People's Republic of China

| SJ/T 11363-2006 | "Requirements for Concentration Limits for Certain Hazardous Substances in Electronic Information Products" (2006-06). |
|---|---|
| SJ/T 11364-2006 | "Marking for Control of Pollution Caused by Electronic Information Products" (2006-06).<br><br>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.<br><br>Please see Table 5 for an overview of toxic or hazardous substances or elements that might be contained in product parts in concentrations above the limits defined by SJ/T 11363-2006. |

**Table 5:** Toxic or hazardous substances or elements with defined concentration limits

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

O:

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

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

X:

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

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

## 1.4.2    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 PLS8-E 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 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 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)

## 1.4.3    SELV Requirements

The power supply connected to the PLS8-E module shall be in compliance with the SELV requirements defined in EN 60950-1.

## 1.4.4    Safety Precautions

The following safety precautions must be observed during all phases of the operation, usage, service or repair of any cellular terminal or mobile incorporating PLS8-E. Manufacturers of the cellular terminal are advised to convey the following safety information to users and operating personnel and to incorporate these guidelines into all manuals supplied with the product. Failure to comply with these precautions violates safety standards of design, manufacture and intended use of the product. Gemalto M2M assumes no liability for customer's failure to comply with these precautions.

| | |
|---|---|
|  | When in a hospital or other health care facility, observe the restrictions on the use of mobiles. Switch the cellular terminal or mobile off, if instructed to do so by the guidelines posted in sensitive areas. Medical equipment may be sensitive to RF energy. The operation of cardiac pacemakers, other implanted medical equipment and hearing aids can be affected by interference from cellular terminals or mobiles placed close to the device. If in doubt about potential danger, contact the physician or the manufacturer of the device to verify that the equipment is properly shielded. Pacemaker patients are advised to keep their hand-held mobile away from the pacemaker, while it is on. |
|  | Switch off the cellular terminal or mobile before boarding an aircraft. Make sure it cannot be switched on inadvertently. The operation of wireless appliances in an aircraft is forbidden to prevent interference with communications systems. Failure to observe these instructions may lead to the suspension or denial of cellular services to the offender, legal action, or both. |
|  | Do not operate the cellular terminal or mobile in the presence of flammable gases or fumes. Switch off the cellular terminal when you are near petrol stations, fuel depots, chemical plants or where blasting operations are in progress. Operation of any electrical equipment in potentially explosive atmospheres can constitute a safety hazard. |
|  | Your cellular terminal or mobile receives and transmits radio frequency energy while switched on. Remember that interference can occur if it is used close to TV sets, radios, computers or inadequately shielded equipment. Follow any special regulations and always switch off the cellular terminal or mobile wherever forbidden, or when you suspect that it may cause interference or danger. |
|  | 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. |

# 2 Product Concept

## 2.1 Key Features at a Glance

| Feature | Implementation |
|---|---|
| General | |
| Frequency bands | GSM/GPRS/EDGE: Dual band, 900/1800MHz<br>UMTS/HSPA+: Triple band, 900 (BdVIII) / 1800 (BdIII) / 2100MHz (BdI)<br>LTE:  band, 800 (Bd20) / 900 (Bd8) / 1800 (Bd3) / 2600MHz (Bd7) |
| GSM class | Small MS |
| Output power (according to Release 99) | Class 4 (+33dBm ±2dB) for EGSM900<br>Class 1 (+30dBm ±2dB) for GSM1800<br>Class E2 (+27dBm ± 3dB) for GSM 900 8-PSK<br>Class E2 (+26dBm +3 /-4dB) for GSM 1800 8-PSK<br>Class 3 (+24dBm +1/-3dB) for UMTS 2100, WCDMA FDD BdI<br>Class 3 (+24dBm +1/-3dB) for UMTS 1800, WCDMA FDD BdIII<br>Class 3 (+24dBm +1/-3dB) for UMTS 900, WCDMA FDD BdVIII |
| Output power (according to Release 8) | Class 3 (+23dBm ±2dB) for LTE 2600, LTE FDD Bd7<br>Class 3 (+23dBm ±2dB) for LTE 1800, LTE FDD Bd3<br>Class 3 (+23dBm ±2dB) for LTE 900, LTE FDD Bd8<br>Class 3 (+23dBm ±2dB) for LTE 800, LTE FDD Bd20 |
| Power supply | $3.3V \leq V_{BATT+} \leq 4.2V$ |
| Operating temperature (board temperature) | Normal operation: -30°C to +85°C<br>Extended operation: -40°C to +95°C |
| Physical | Dimensions: 33mm x 29mm x 2.2mm<br>Weight: approx. 4.5g |
| RoHS | All hardware components fully compliant with EU RoHS Directive |
| LTE features | |
| 3GPP Release 9 | UE CAT 3 supported<br>DL 100Mbps, UL 50Mbps<br>2x2 MIMO in DL direction |
| HSPA features | |
| 3GPP Release 8 | UE CAT. 14, 24<br>DC-HSPA+ – DL 42Mbps<br>HSUPA – UL 5.76Mbps<br>Compressed mode (CM) supported according to 3GPP TS25.212 |
| UMTS features | |
| 3GPP Release 8 | PS data rate – 384 kbps DL / 384 kbps UL |

| Feature | Implementation |
|---|---|
| GSM / GPRS / EGPRS features | |
| Data transfer | GPRS:<br>• Multislot Class 12<br>• Mobile Station Class B<br>• Coding Scheme 1 – 4<br>EGPRS:<br>• Multislot Class 12<br>• EDGE E2 power class for 8 PSK<br>• Downlink coding schemes – CS 1-4, MCS 1-9<br>• Uplink coding schemes – CS 1-4, MCS 1-9<br>• SRB loopback and test mode B<br>• 8-bit, 11-bit RACH<br>• 1 phase/2 phase access procedures<br>• Link adaptation and IR<br>• NACC, extended UL TBF<br>• Mobile Station Class B |
| Software | |
| AT commands | Hayes, 3GPP TS 27.007 and 27.005, and proprietary Gemalto M2M commands |
| Firmware update | Generic update from host application over USB |
| Interfaces | |
| Module interface | Surface mount device with solderable connection pads (SMT application interface).<br>Land grid array (LGA) technology ensures high solder joint reliability and provides the possibility to use an optional module mounting socket.<br>For more information on how to integrate SMT modules see also [3]. This application note comprises chapters on module mounting and application layout issues as well as on additional SMT application development equipment. |
| Antenna | 50Ohms. GSM/UMTS/LTE main antenna, UMTS/LTE Diversity/MIMO antenna |
| USB | USB 2.0 High Speed (480Mbit/s) device interface, Full Speed (12Mbit/s) compliant |
| UICC interface | Supported chip cards: UICC/SIM/USIM 3V, 1.8V |
| Power on/off, Reset | |
| Power on/off | Switch-on by hardware signal IGT<br>Switch-off by AT command (AT^SMSO) or IGT<br>Automatic switch-off in case of critical temperature or voltage conditions |
| Reset | Orderly shutdown and reset by AT command |
| Emergency-off | Emergency-off by hardware signal EMERG_OFF if IGT is not active |
| Special Features | |
| Antenna | SAIC (Single Antenna Interference Cancellation) / DARP (Downlink Advanced Receiver Performance)<br>Rx Diversity (receiver type 3i - 64-QAM) / MIMO |

| Feature | Implementation |
|---|---|
| Evaluation kit | |
| Evaluation module | PLS8-E 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 and provide a sample configuration for application engineering. A special adapter is required to connect the PLS8-E evaluation module to the DSB75. |

## 2.2      PLS8-E System Overview
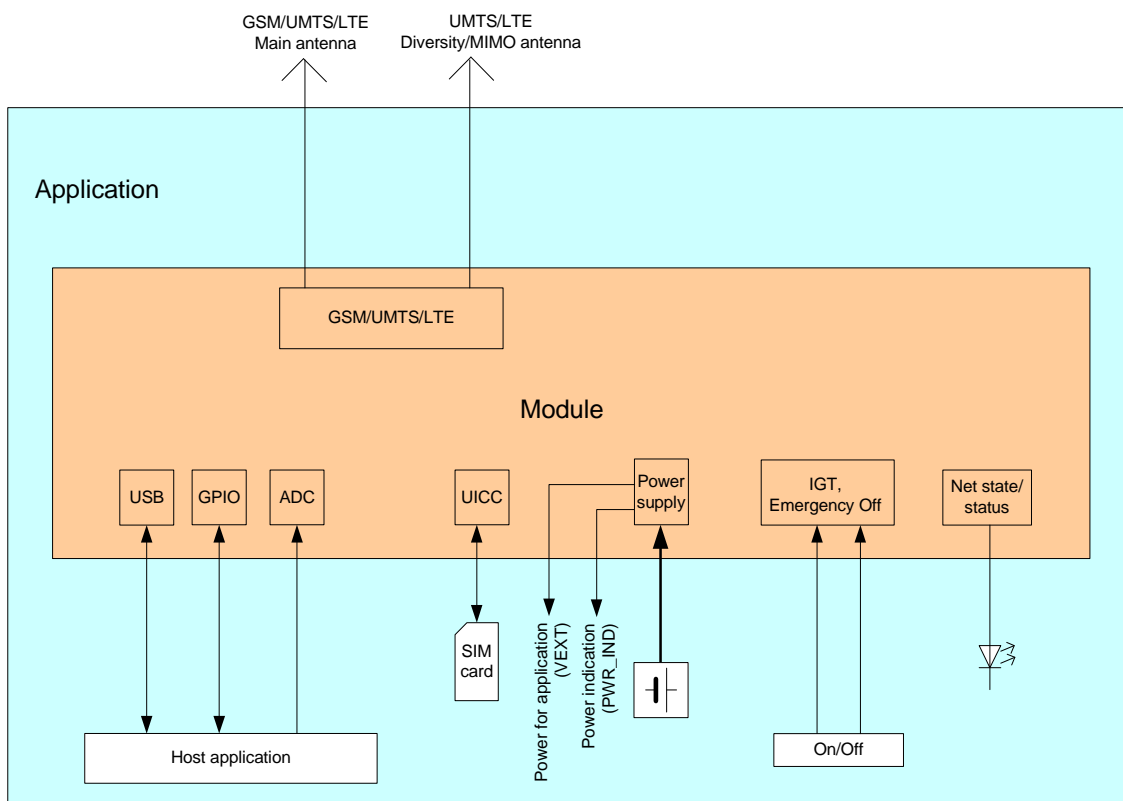


**Figure 1:**  PLS8-E  system overview

## 2.3 Circuit Concept

Figure 2 shows a block diagram of the PLS8-E module and illustrates the major functional components:

Baseband block:
- GSM/UMTS controller/transceiver/power supply
- Stacked Flash/RAM memory with multiplexed address data bus
- Application interface (SMT with connecting pads)

RF section:
- RF transceiver
- RF power amplifier/frontend
- RF filter
- Antenna pad
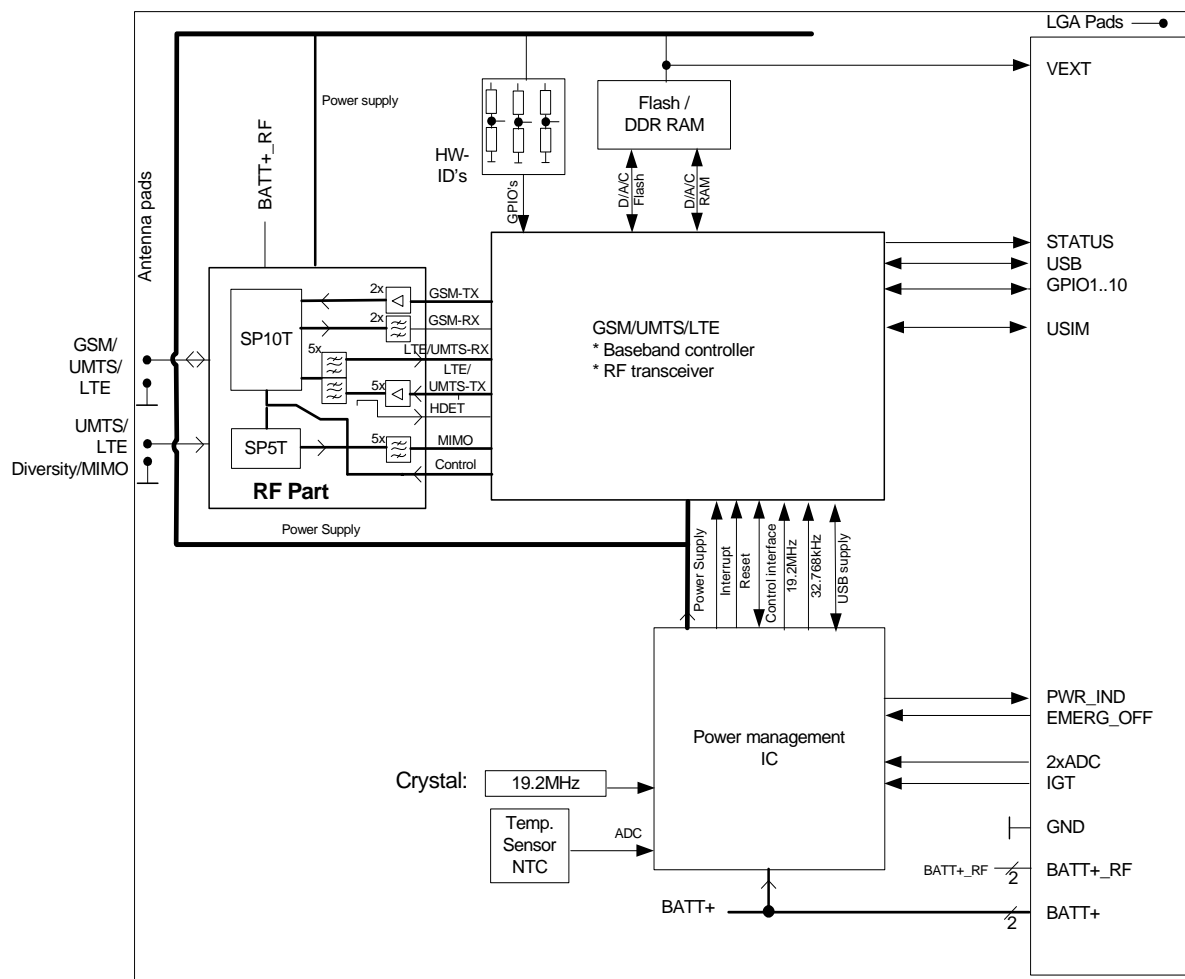


**Figure 2:** PLS8-E block diagram

# 3        Application Interface

PLS8-E is equipped with an SMT application interface (LGA pads) that connects to the external application. The host interface incorporates several sub-interfaces described in the following sections:

- Operating modes - see Section 3.1
- Power supply  - see Section 3.2
- USB interface - see Section 3.4
- UICC/SIM/USIM interface - see Section 3.5
- ADC interface - Section 3.6
- GPIO interface - Section 3.7
- Control line: PWR_IND - see Section 3.8

## 3.1     Operating Modes

The table below briefly summarizes the various operating modes referred to in the following chapters.

**Table 6:**  Overview of operating modes

| Mode | Function | |
|------|----------|---|
| Normal operation | GSM / GPRS / UMTS / HSPA / LTE IDLE | No data transfer in progress. |
| | 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 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. |
| | LTE DATA | LTE 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 AT^SMSO command. 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 Supply

PLS8-E needs to be connected to a power supply at the SMT application interface - 4 lines each BATT+ and GND. There are two separate voltage domains for BATT+:
- BATT+_RF with 2 lines for the RF power amplifier supply
- BATT+ with 2 lines for the general power management.

The main power supply from an external application has to be a single voltage source and has to be expanded to two sub paths (star structure). Each voltage domain must be decoupled by application with low ESR capacitors ($\geq$ 47µF MLCC @ BATT+; $\geq$ 4x47µF MLCC @ BATT+_RF) as close as possible to LGA pads. Figure 3 shows a sample circuit for decoupling capacitors for BATT+.
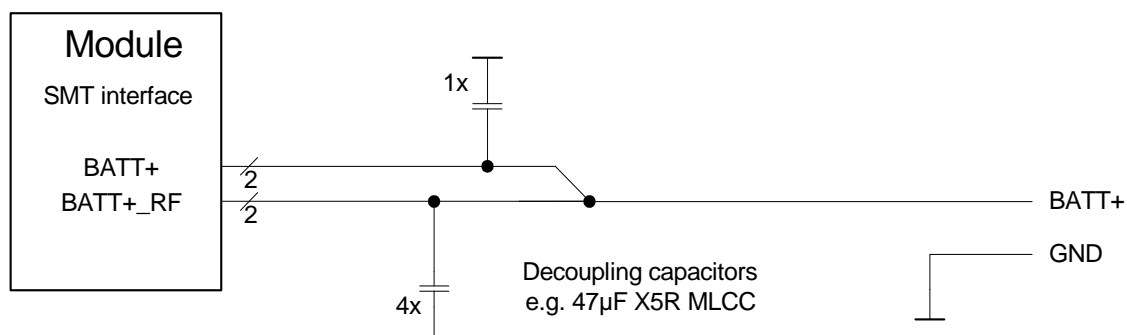


**Figure 3:**  Decoupling capacitor(s) for BATT+

The power supply of PLS8-E must be able to provide the peak current during the uplink transmission.

All key functions for supplying power to the device are handled by the power management IC. It provides the following features:
- Stabilizes the supply voltages for the baseband using switching regulators and low drop linear voltage regulators.
- Switches the module's power voltages for the power-up and -down procedures.
- Delivers, across the VEXT line, a regulated voltage for an external application.
- LDO to provide SIM power supply.

### 3.2.1    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 PLS8-E board, not even in a transmit burst where current consumption can rise to typical peaks of 2A. It should be noted that PLS8-E switches off when exceeding these limits. Any voltage drops that may occur in a transmit burst should not exceed 400mV to ensure the expected RF performance in 2G networks.

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

Example:
$V_I$min = 3.3V
Dmax = 0.4V

$V_{BATT}$min = $V_I$min + Dmax
$V_{BATT}$min = 3.3V + 0.4V = 3.7V
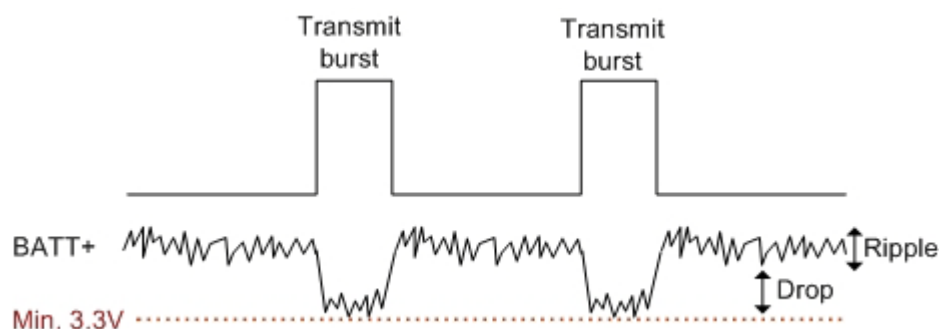


**Figure 4:**  Power supply limits during transmit burst

### 3.2.2    Monitoring Power Supply by AT Command

To monitor the supply voltage you can use the AT^SBV command which returns the averaged value related to BATT+ and GND at the SMT application interface.

The module continuously measures the voltage at intervals depending on the operating mode of the RF interface. The duration of measuring ranges from 0.5s in DATA mode to 50s when PLS8-E is in Limited Service (deregistered). The displayed voltage (in mV) is averaged over the last measuring period before the AT^SBV command was executed.

## 3.3 Power-Up / Power-Down Scenarios

In general, be sure not to turn on PLS8-E while it is beyond the safety limits of voltage and temperature stated in Section 5.1. PLS8-E would immediately switch off after having started and detected these inappropriate conditions. In extreme cases this can cause permanent damage to the module.

## 3.3.1 Turn on PLS8-E

When the PLS8-E module is in Power-down mode, it can be started to Normal mode by driving the IGT (ignition) line to ground. it is recommended to use an open drain/collector driver to avoid current flowing into this signal line. Pulling this signal low triggers a power-on sequence. To turn on PLS8-E IGT has to be kept active at least 100ms. After turning on PLS8-E IGT should be set inactive to prevent the module from turning on again after a shut down by AT command or EMERG_OFF. For details on signal states during startup see also Section 3.3.2.
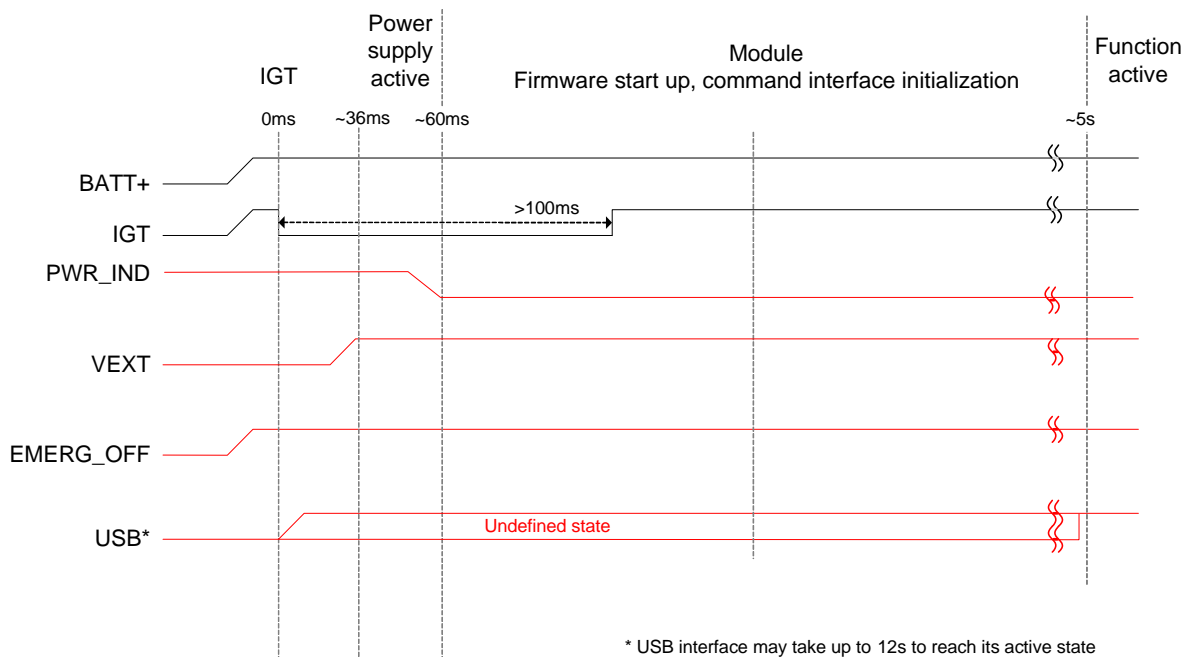


**Figure 5:** Power-on with IGT

Note: After power up IGT should remain high. Also note that with a USB connection the USB host may take up to 12 seconds to set up the virtual COM port connection.

The module's ready state can be checked by polling. To do so, try to send characters (e.g. "at") until the module is responding.

## 3.3.2    Signal States after Startup

Table 7 describes the various states each interface signal passes through after startup and during operation.

Signals are in an initial state while the module is initializing. Once the startup initialization has completed, i.e. when the software is running, all signals are in defined state. The state of several signals will change again once the respective interface is activated or configured by AT command.

**Table 7:** Signal states

| Signal name | Power on reset<br><br>Duration appr. 60ms | Startup phase<br><br>Duration appr. 4s | State after first firmware initialization<br>After 4-5s |
|---|---|---|---|
| CCIN | PD and PU (24k) | PU(24k) | I, PU(24k) |
| CCRST | Not driven (similar PD) | Not driven (similar PD) | O, L[1] |
| | | | O, H[2] |
| CCIO | PD(10k) | PD(10k) | PD(10k)[1] |
| | | | PU(10k)[2] |
| CCCLK | Not driven (similar PD) | Not driven (similar PD) | O, L[1] |
| | | | Clock[2] |
| CCVCC | Off | Off | Off[1] |
| | | | 1.8V/3V[2] |
| PWR_IND | Z | O, L | O, L |
| STATUS | PD | PD | PD |
| EMERG_OFF | PU | I, PU | I, PU |
| IGT | I, PU | I, PU | I, PU |
| GPIO1...10 | PD | PD | PD |

| | |
|---|---|
| L = Low level<br>H = High level<br>I = Input<br>O = Output | PD = Pull down resistor with appr. 100k[3]<br>PD(…k) = Pull down resistor with ...k<br>PU = Pull up resistor with appr. 100k<br>PU(…k) = Pull up resistor with ...k<br>Z = High impedance |

[1.] If CCIN = High level

[2.] If CCIN = Low level

[3.] Internal pulls are implemented using JFETs; strengths vary between devices, possible range: 55k…390k

### 3.3.3 Turn off PLS8-E Using AT Command

The best and safest approach to powering down PLS8-E is to issue the AT^SMSO command. This procedure lets PLS8-E log off from the network and allows the software to enter into a secure state and safe data before disconnecting the power supply. The mode is referred to as Power Down mode. After sending AT^SMSO do not enter any other AT commands. To verify that the module turned off it is possible to monitor the PWR_IND signal. A high state of the PWR_IND signal line indicates that the module is being switched off as shown in Figure 6.

Be sure not to disconnect the supply voltage $V_{BATT+}$ before the module's switch off procedure has been completed and the VEXT signal has gone low. Otherwise you run the risk of losing data. Signal states during switch off are shown in Figure 6.

While PLS8-E is in Power-down mode the application interface is switched off and must not be fed from any other source. Therefore, your application must be designed to avoid any current flow into any digital signal lines of the application interface. No special care is required for the USB interface which is protected from reverse current.
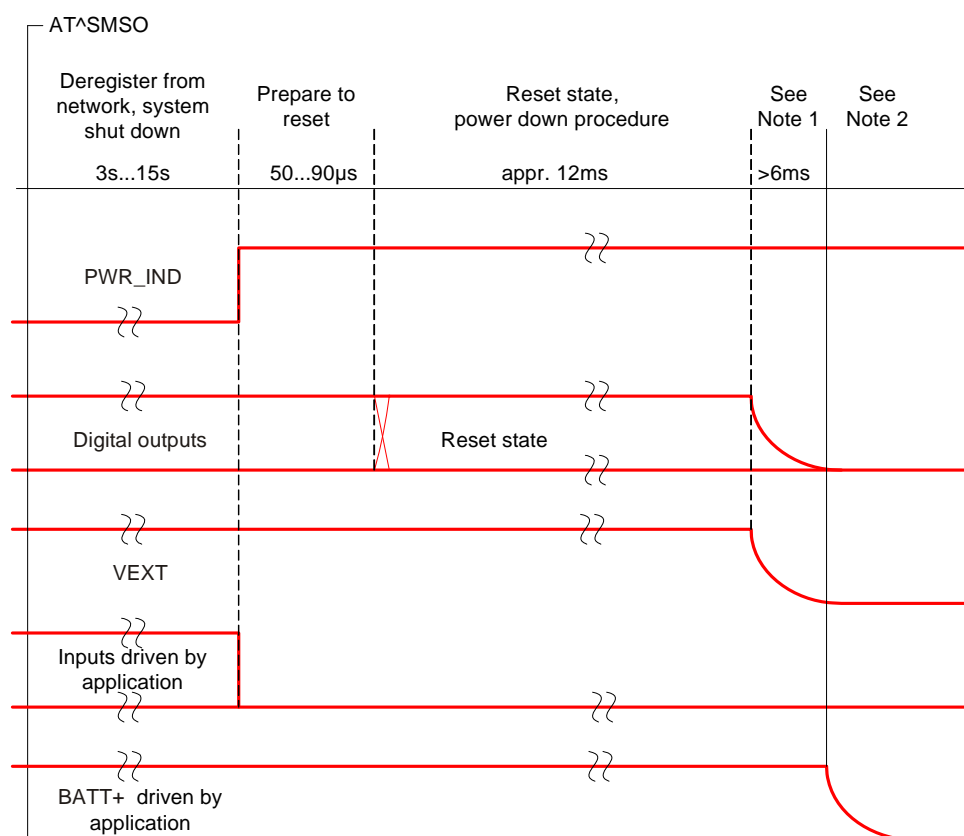


**Figure 6:** Signal states during turn-off procedure

Note 1:     Depending on capacitance load from host application
Note 2:     The power supply voltage (BATT+) may be disconnected resp. switched off only after the VEXT went low.
Note 3:     After module shutdown by means of AT command is completed, please allow for a time period of at least 1s before restarting the module.

## 3.3.4     Turn off PLS8-E Using IGT Line

The IGT line can be can be used to switch off PLS8-E. If the module is on, the IGT line must be asserted for at least 2.1s before being released. The module switches off after the line is released. The switch-off routine is identical with the procedure initiated by AT^SMSO, i.e. the software performs an orderly shutdown as described in Section 3.3.3. Before switching off the module wait at least 12 seconds after startup.



**Figure 7:**  Timing of IGT if used to switch off the module

## 3.3.5     Automatic Shutdown

Automatic shutdown takes effect if:
*   The PLS8-E board is exceeding the critical limits of overtemperature or undertemperature
*   Undervoltage or overvoltage is detected

The automatic shutdown procedure is equivalent to the power down initiated with the AT^SMSO command, i.e. PLS8-E logs off from the network and the software enters a secure state avoiding loss of data.

Alert messages transmitted before the device switches off are implemented as Unsolicited Result Codes (URCs). The presentation of the temperature URCs can be enabled or disabled with the AT commands AT^SCTM. The URC presentation mode varies with the condition, please see Section 3.3.5.1 to Section 3.3.5.3 for details. For further instructions on AT commands refer to [1].

**Cinterion® PLS8-E Hardware Interface Description**

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3.3 Power-Up / Power-Down Scenarios

## 3.3.5.1 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, PLS8-E 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:
AT^SCTM=1: Presentation of URCs is always enabled.
AT^SCTM=0 (default): Presentation of URCs is enabled during the 15 second guard period after start-up of PLS8-E. After expiry of the 15 second guard period, the presentation 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 8 for the associated URCs.

**Table 8:** Temperature dependent behavior

| Sending temperature alert (15sec after PLS8-E start-up, otherwise only if URC presentation enabled) | |
|---|---|
| ^SCTM_B: 1 | Caution: Board close to overtemperature limit, i.e., board is 5°C below overtemperature limit. |
| ^SCTM_B: -1 | Caution: Board close to undertemperature limit, i.e., board is 5°C above undertemperature limit. |
| ^SCTM_B: 0 | Board back to uncritical temperature range, i.e., board is 6°C below its over- or above its undertemperature limit. |
| Automatic shutdown (URC appears no matter whether or not presentation was enabled) | |
| ^SCTM_B: 2 | Alert: Board equal or beyond overtemperature limit. PLS8-E switches off. |
| ^SCTM_B: -2 | Alert: Board equal or below undertemperature limit. PLS8-E switches off. |

The AT^SCTM command can also be used to check the present status of the board. Depending on the selected mode, the read command returns the current board temperature in degrees Celsius or only a value that indicates whether the board is within the safe or critical temperature range. See [1] for further instructions.

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## 3.3.5.2    Undervoltage Shutdown

If the measured battery voltage is no more sufficient to set up a call the following URC will be presented:

^SBC:  Undervoltage.

The URC indicates that the module is close to the undervoltage threshold. If undervoltage persists the module keeps sending the URC several times before switching off automatically.

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

## 3.3.5.3    Overvoltage Shutdown

The overvoltage shutdown threshold is 100mV above the maximum supply voltage $V_{BATT+}$ specified in Table 17.

When the supply voltage approaches the overvoltage shutdown threshold the module will send the following URC:

^SBC:  Overvoltage warning

This alert is sent once.

When the overvoltage shutdown threshold is exceeded the module will send the following URC

^SBC:  Overvoltage shutdown

before it shuts down cleanly:

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

Keep in mind that several PLS8-E components are directly linked to BATT+ and, therefore, the supply voltage remains applied at major parts of PLS8-E, even if the module is switched off. Especially the power amplifier is very sensitive to high voltage and might even be destroyed.

## 3.3.6    Turn off PLS8-E in Case of Emergency

*Caution: Use the EMERG_OFF line only when, due to serious problems, the software is not responding for more than 5 seconds. Pulling the EMERG_OFF 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 PLS8-E does not respond, if reset or shutdown via AT command fails.*

The EMERG_OFF line is available on the application interface and can be used to switch off the module. To control the EMERG_OFF line it is recommended to use an open drain / collector driver.

To switch off, the EMERG_OFF line must be pulled to ground for longer than 40ms. After the 40ms and an additional delay period of 500ms the module shuts down as shown in Figure 8.
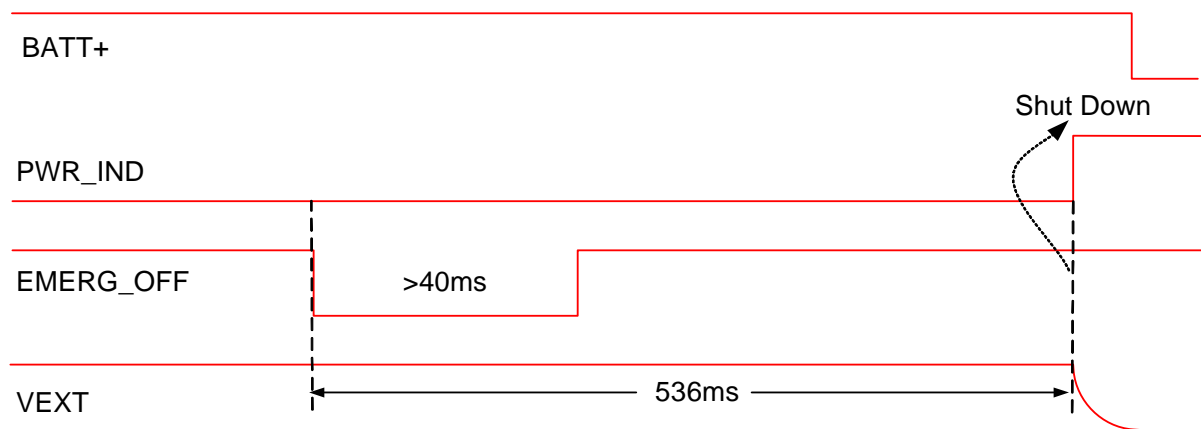


**Figure 8:**  Shutdown by EMERG_OFF signal

Please note that the power supply voltage (BATT+) may be disconnected resp. switched off only after having reached Shut Down as indicated by the PWR_IND signal going high. The power supply has to be available (again) before the module is restarted.

## 3.4    USB Interface

PLS8-E supports a USB 2.0 High Speed (480Mbit/s) device interface that is Full Speed (12Mbit/s) compliant. The USB interface is primarily intended for use as command and data interface and for downloading firmware.

The USB host is responsible for supplying the VUSB_IN line. This line is for voltage detection only. The USB part (driver and transceiver) is supplied by means of BATT+. This is because PLS8-E is designed as a self-powered device compliant with the "Universal Serial Bus Specification Revision 2.0"[1].
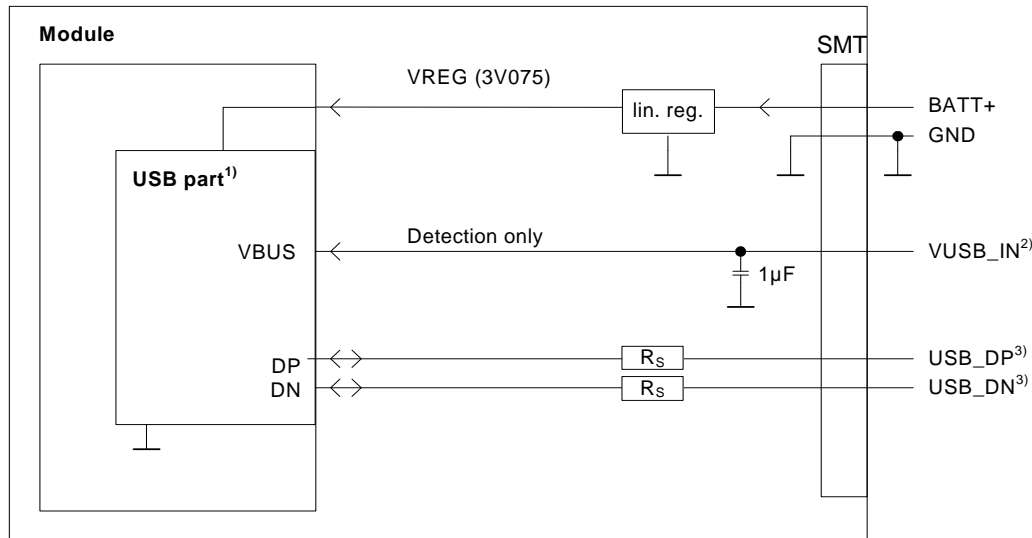


[1] All serial (including $R_S$) and pull-up resistors for data lines are implemented.

[2] Since VUSB_IN is used for detection only it is recommended not to add any further blocking capacitors on the VUSB_IN line.

[3] 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 9:**  USB circuit

To properly connect the module's USB interface to the host a USB 2.0 compatible connector is required. For more information on the USB related signals see Table 17. Furthermore, the USB modem driver distributed with PLS8-E needs to be installed.

---

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

## 3.5 UICC/SIM/USIM Interface

PLS8-E 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 interfaceare reserved for the SIM interface.

The UICC/SIM/USIM interface supports 3V and 1.8V SIM cards. Please refer to Table 17 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 PLS8-E and is part of the Gemalto M2M reference equipment submitted for type approval. See Chapter 9 for Molex ordering numbers.

**Table 9:** Signals of the SIM interface (SMT application interface)

| Signal | Description |
| --- | --- |
| GND | Ground connection for SIM. Optionally a separate SIM ground line using e.g., pad N11 may be used 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 active low. <br> The CCIN signal is mandatory for applications that allow the user to remove the SIM card during operation. <br> 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 PLS8-E. |

*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 PLS8-E.*
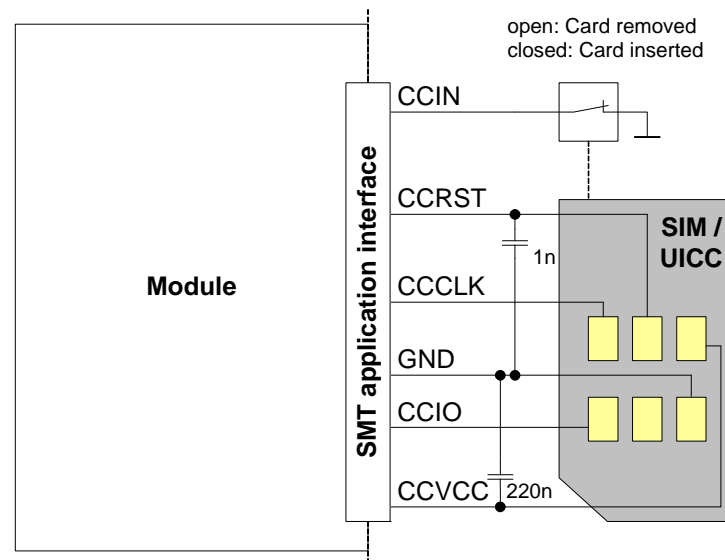
**Figure 10:** UICC/SIM/USIM interface

The total cable length between the SMT application interface pads on PLS8-E 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 the 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 3.5.1.

## 3.5.1    Enhanced ESD Protection for SIM Interface

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

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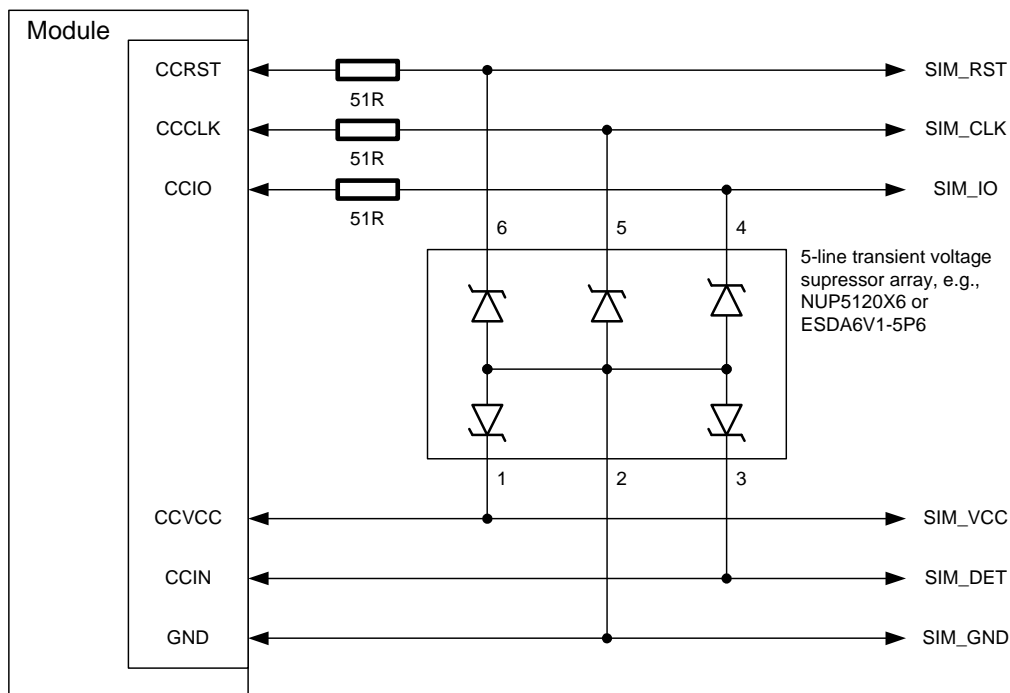


**Figure 11:**  SIM interface - enhanced ESD protection

## 3.6 Analog-to-Digital Converter (ADC)

ADC1_IN and ADC2_IN are prepared for general purpose and are designed to measure two independent voltages in the range of 0.3V to 3.075V.

## 3.7 GPIO Interface

PLS8-E has 10 GPIOs for external hardware devices. Each GPIO can be configured for use as input or output. All settings are AT command controlled.

The IO port driver has to be open before using and configuring GPIOs. Before changing the configuration of a GPIO pin (e.g. input to output) the pin has to be closed. If the GPIO pins are not configured or the pins/driver were closed, the GPIO pins are high-Z with pull down resistor. If a GPIO is configured to input, the pin has high-Z without pull resistor. Internal pulls are implemented using JFETs; strengths vary between devices, possible range: 55k…390k.

## 3.8 Control Signal

### 3.8.1 PWR_IND Signal

PWR_IND notifies the on/off state of the module. High state of PWR_IND indicates that the module is switched off. The state of PWR_IND immediately changes to low when IGT is pulled low. For state detection an external pull-up resistor is required.
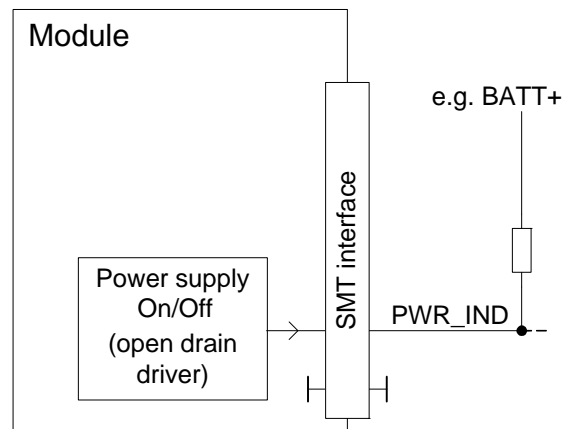


**Figure 12:** PWR_IND signal

# 4 Antenna Interfaces

## 4.1 GSM/UMTS/LTE Antenna Interface

The PLS8-E GSM/UMTS/LTE antenna interface comprises a GSM/UMTS/LTE main antenna as well as a UMTS/LTE Rx diversity/MIMO antenna to improve signal reliability and quality. The interface has an impedance of 50Ω. PLS8-E is capable of sustaining a total mismatch at the antenna interface without any damage, even when transmitting at maximum RF power.

The external antennas must be matched properly to achieve best performance regarding radiated power, modulation accuracy and harmonic suppression. Matching networks are not included on the PLS8-E PCB and should be placed in the host application, if the antenna does not have an impedance of 50Ω.

Regarding the return loss PLS8-E provides the following values in the active band:

**Table 10:** 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 |
| Idle | ≤ 5dB | not applicable |

## 4.1.1 Antenna Installation

The antenna is connected by soldering the antenna pads (ANT_MAIN; ANT_DRX_MIMO) and their neighboring ground pads directly to the application's PCB.
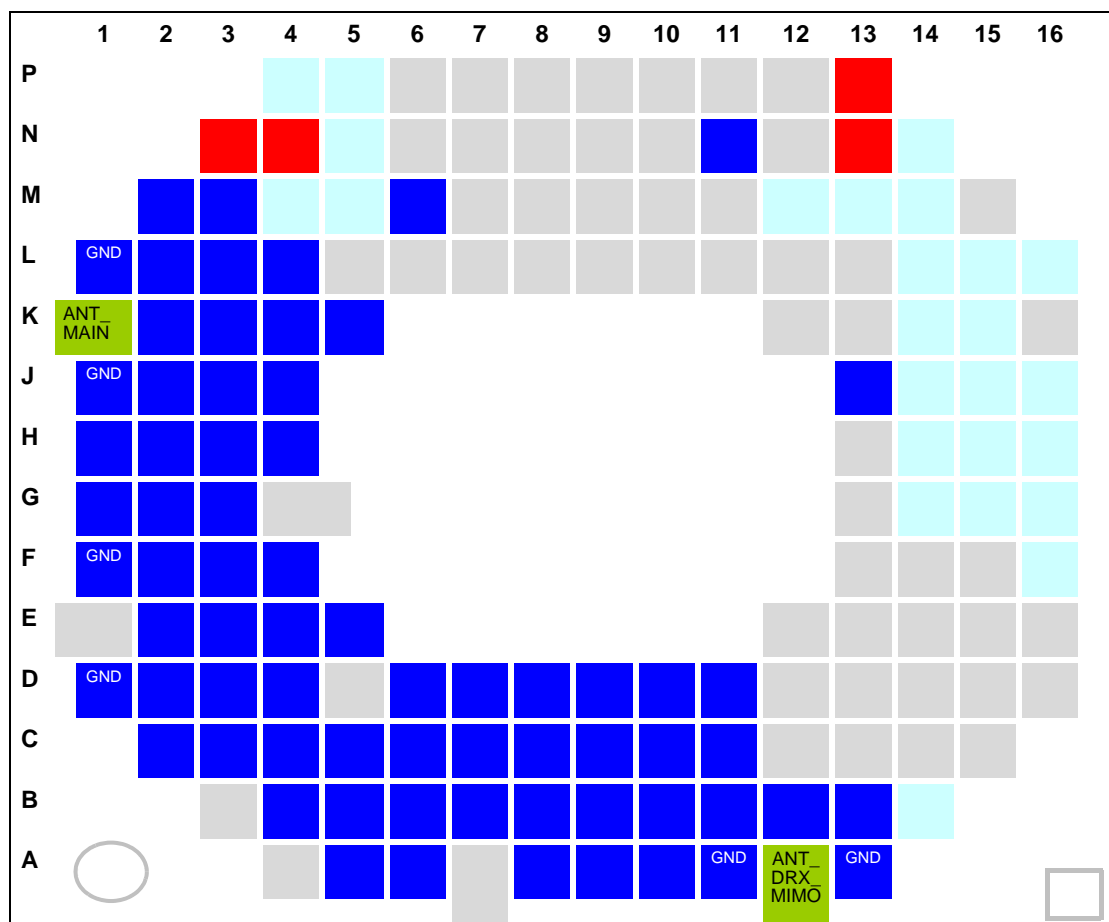


**Figure 13:** Antenna pads (bottom view)

The distance between the antenna pads and their neighboring GND pads has been optimized for best possible impedance. To prevent mismatch, special attention should be paid to these pads on the application' PCB.

The wiring of the antenna connection, starting from the antenna pad to the application's antenna should result in a 50Ω line impedance. Line width and distance to the GND plane need to be optimized with regard to the PCB's layer stack. Some examples are given in Section 4.1.2.

To prevent receiver desensitization due to interferences generated by fast transients like high speed clocks on the external application PCB, it is recommended to realize the antenna connection line using embedded Stripline rather than Micro-Stripline technology. Please see Section 4.1.2 for examples of how to design the antenna connection in order to achieve the required 50Ω line impedance.

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 PLS8-E's antenna pad.

## 4.1.2    RF Line Routing Design

## 4.1.2.1    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 below figure shows line arrangement examples for embedded stripline.
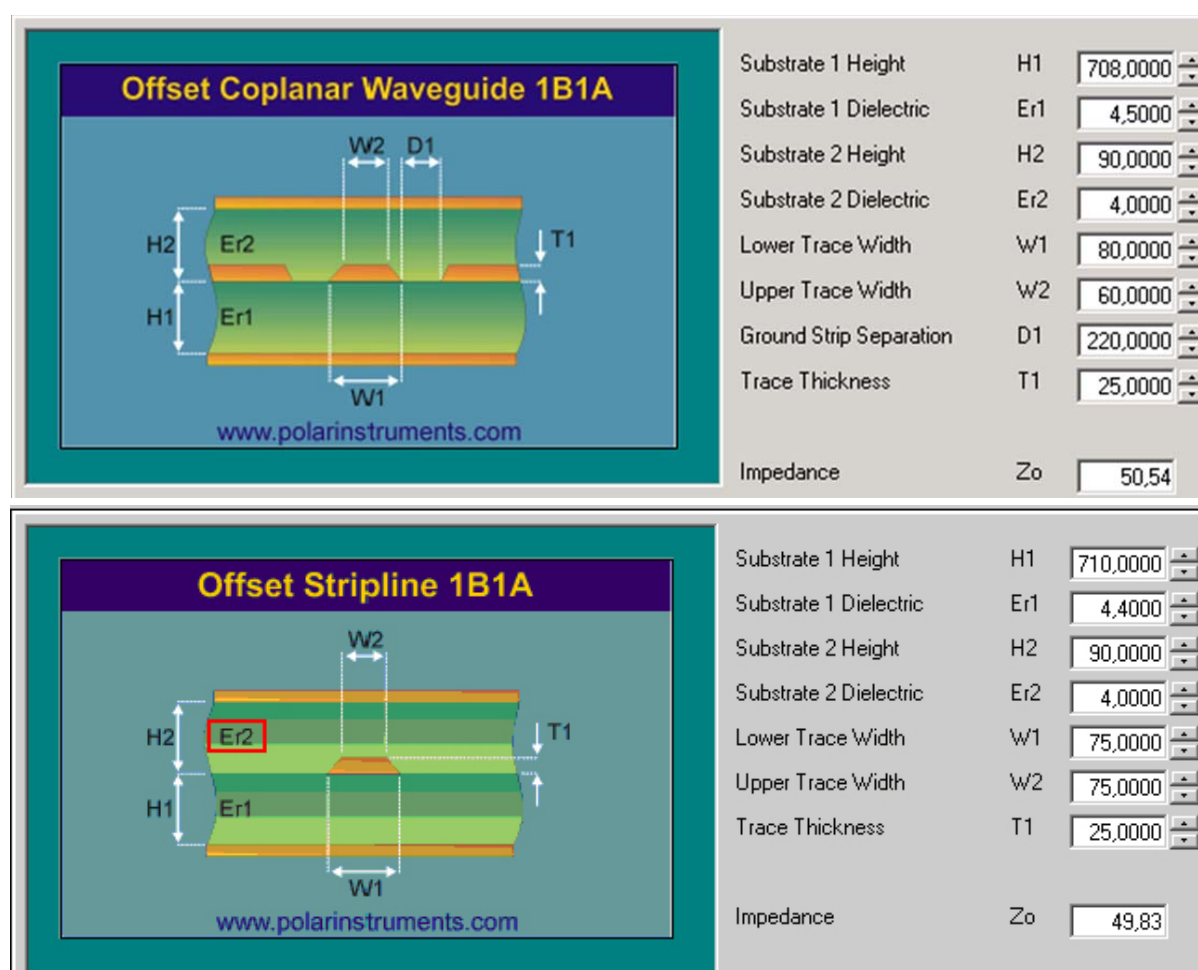


**Figure 14:**  Embedded Stripline line arrangement

## Micro-Stripline

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



| | | |
|---|---|---|
| Substrate 1 Height | H1 | 1000,000 |
| Substrate 1 Dielectric | Er1 | 4,4000 |
| Lower Trace Width | W1 | 800,0000 |
| Upper Trace Width | W2 | 800,0000 |
| Ground Strip Separation | D1 | 185,0000 |
| Trace Thickness | T1 | 25,0000 |
| Coating Above Substrate | C1 | 15,0000 |
| Coating Above Trace | C2 | 15,0000 |
| Coating Dielectric | CEr | 4,0000 |

| | | |
|---|---|---|
| Substrate 1 Height | H1 | 1500,000 |
| Substrate 1 Dielectric | Er1 | 4,4000 |
| Lower Trace Width | W1 | 800,0000 |
| Upper Trace Width | W2 | 800,0000 |
| Ground Strip Separation | D1 | 165,0000 |
| Trace Thickness | T1 | 25,0000 |
| Coating Above Substrate | C1 | 15,0000 |
| Coating Above Trace | C2 | 15,0000 |
| Coating Dielectric | CEr | 4,0000 |

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

| | | |
|---|---|---|
| Substrate 1 Height | H1 | 708,0000 ± |
| Substrate 1 Dielectric | Er1 | 4,5000 ± |
| Substrate 2 Height | H2 | 90,0000 ± |
| Substrate 2 Dielectric | Er2 | 4,0000 ± |
| Lower Trace Width | W1 | 800,0000 ± |
| Upper Trace Width | W2 | 775,0000 ± |
| Ground Strip Separation | D1 | 190,0000 ± |
| Trace Thickness | T1 | 25,0000 ± |
| Coating Above Substrate | C1 | 20,0000 ± |
| Coating Above Trace | C2 | 20,0000 ± |
| Coating Dielectric | CEr | 3,0000 ± |

Notes: (First 5 lines will print)

**Figure 15:** Micro-Stripline line arrangement samples

## 4.1.2.2    Routing Example

**Interface to RF Connector**

Figure 16 shows a sample connection of a module's antenna pad at the bottom layer of the module PCB with an application PCB's coaxial antenna connector. Line impedance depends on line width, but also on other PCB characteristics like dielectric, height and layer gap. The sample stripline width of 0.33mm is recommended for an application with a PCB layer stack resembling the one of the PLS8-E evaluation board shown in Figure 17. For different layer stacks the stripline width will have to be adapted accordingly.
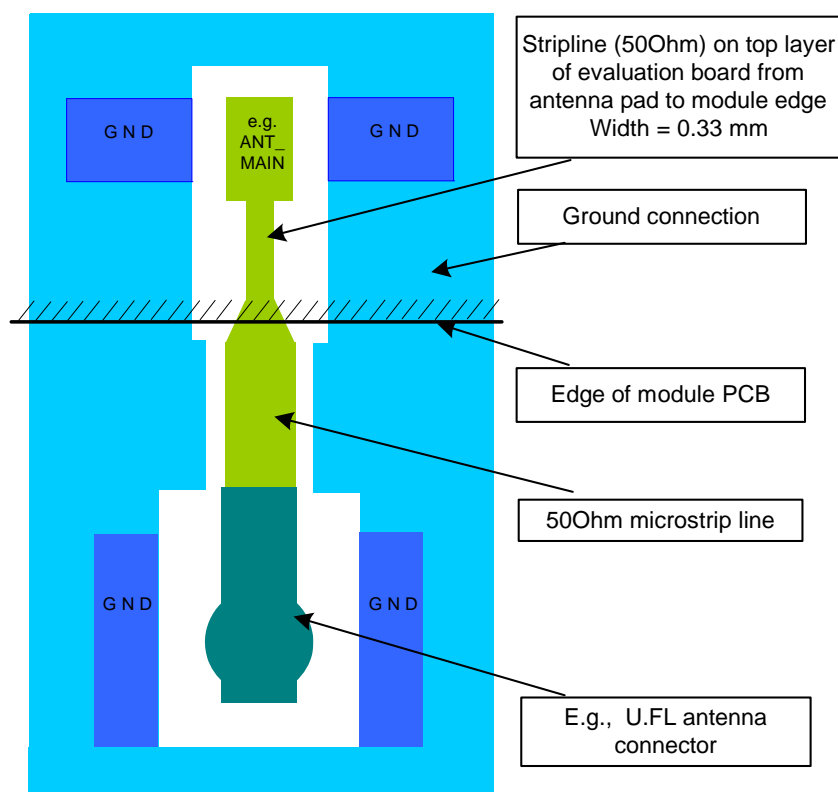


**Figure 16:** Routing to application's RF connector



**Figure 17:** PLS8-E evaluation board layer table

# 5 Electrical, Reliability and Radio Characteristics

## 5.1 Absolute Maximum Ratings

The absolute maximum ratings stated in Table 11 are stress ratings under any conditions. Stresses beyond any of these limits will cause permanent damage to PLS8-E.

**Table 11:** Absolute maximum ratings

| Parameter | Min | Max | Unit |
|---|---|---|---|
| Supply voltage BATT+ | -0.5 | +6.0 | V |
| Voltage at all digital lines in POWER DOWN mode | -0.5 | +0.5 | V |
| Voltage at digital lines in normal operation | -0.5 | +2.3 | V |
| Voltage at SIM/USIM interface, CCVCC 1.8V in normal operation | -0.5 | +2.3 | V |
| Voltage at SIM/USIM interface, CCVCC 3.0V in normal operation | -0.5 | +3.4 | V |
| Voltage at ADC pins if the module is powered by BATT+ | -0.5 | +3.5 | V |
| Voltage at ADC pins if the module is not powered | -0.5 | +0.5 | V |
| VEXT maximum current shorted to GND | | -300 | mA |
| VUSB_IN, USB_DN, USB_DP | -0.3 | 5.75 | V |
| Voltage at PWR_IND line | -0.5 | 5.5 | V |
| PWR_IND input current if PWR_IND= low | | 2 | mA |
| Voltage at following signals: IGT, EMERG_OFF | -0.5 | 2.5 | V |

## 5.2    Operating Temperatures

**Table 12:**  Board temperature

| Parameter | Min | Typ | Max | Unit |
|---|---|---|---|---|
| Operating temperature range[1]<br>    Normal temperature range<br>    Extreme temperature range | <br>+15<br>-30 | <br>+25 | <br>+55<br>+85 | <br>°C<br>°C |
| Extended temperature range[2] | -40 | | +95 | °C |
| Automatic shutdown[3]<br>    Temperature measured on PLS8-E board | <br><-40 | <br>--- | <br>>+95 | <br>°C |

[1.] Operating temperature range according to 3GPP type approval specification.

[2.] Extended operation allows normal mode data transmissions for limited time until automatic thermal shutdown takes effect.
Within the extended temperature range (outside the operating temperature range) there will be no inefficient use of the radio spectrum and no harm to the radio network. Also, there should not be any unrecoverable malfunctioning. General performance parameters like Pout or RX sensitivity however may be reduced in their values. The module's life time may also be affected, if deviating from a general temperature allocation model (for details see Section 5.2.1).

[3.] Due to temperature measurement uncertainty, a tolerance on the stated shutdown thresholds may occur. The possible deviation is in the range of ± 2°C at the overtemperature and undertemperature limit.

See also Section 3.3.5 for information about the NTC for on-board temperature measurement, automatic thermal shutdown and alert messages.

Note that within the specified operating temperature ranges the board temperature may vary to a great extent depending on operating mode, used frequency band, radio output power and current supply voltage. Note also the differences and dependencies that usually exist between board (PCB) temperature and ambient temperature as shown in the following Figure 18. The possible ambient temperature range depends on the mechanical application design including the module and the PCB with its size and layout. A thermal solution will have to take these differences into account and should therefore be an integral part of application design.
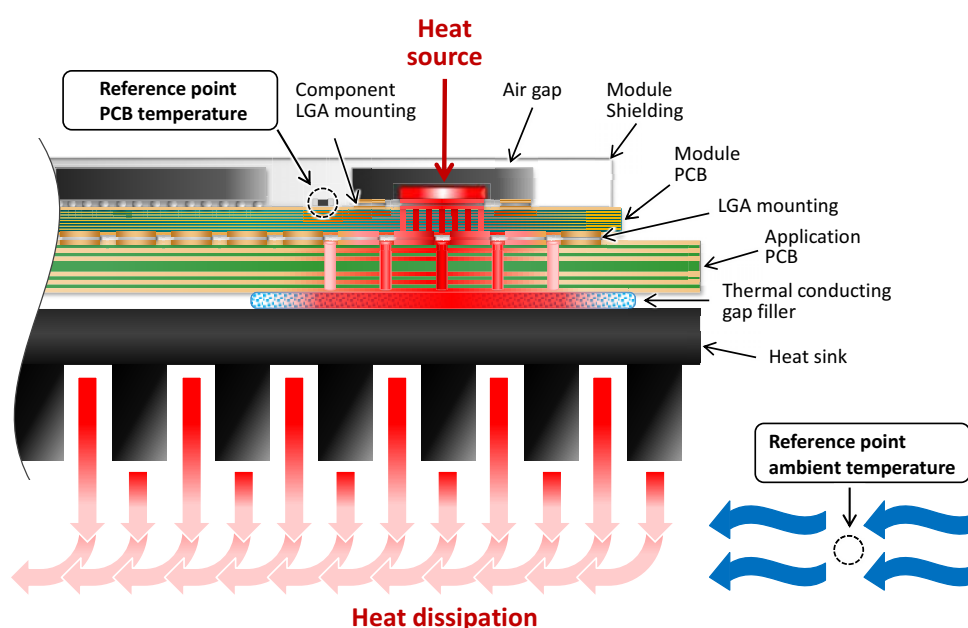


**Figure 18:**  Board and ambient temperature differences

## 5.2.1    Temperature Allocation Model

The temperature allocation model shown in Table 13 assumes shares of a module's average lifetime of 10 years (given in %) during which the module is operated at certain temperatures.

**Table 13:**  Temperature allocation model

| Module lifetime share (in %)[1] | 6 | 20 | 65 | 7 | 1 | 1 |
|---|---|---|---|---|---|---|
| Module Temperature (in °C) | -40 | 20 | 40 | 75 | 85 | 95 |

[1.] Based on an assumed average module lifetime of 10 years (=100%).

Any deviations from the above temperature allocation model may reduce the module's life span, for example if the module is operated close to the maximum automatic shutdown temperature not only for 1% but for 20% of its product life.

## 5.3       Storage Conditions

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. The modules will be delivered in a packaging that meets the requirements according "IPD/JEDEC J-STD-033B.1" for Low Temperature Carriers.

**Table 14:**  Storage conditions

| Type | Condition | Unit | Reference |
|---|---|---|---|
| Humidity relative: Low<br>                 High | 10<br>90 at 40°C | % | CbIPC/JEDEC J-STD-033A |
| Air pressure:     Low<br>                 High | 70<br>106 | kPa | IEC TR 60271-3-1: 1K4<br>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<br>                 Heat | 1120<br>600 | W/m$^2$ | ETS 300 019-2-1: T1.2, IEC 60068-2-2 Bb<br>ETS 300 019-2-1: T1.2, IEC 60068-2-2 Bb |
| Chemically active substances | Not recom-mended | | IEC TR 60271-3-1: 1C1L |
| Mechanically active substances | Not recom-mended | | IEC TR 60271-3-1: 1S1 |
| Vibration sinusoidal:<br>    Displacement<br>    Acceleration<br>    Frequency range | 1.5<br>5<br>2-9   9-200 | mm<br>m/s$^2$<br>Hz | IEC TR 60271-3-1: 1M2 |
| Shocks:<br>    Shock spectrum<br>    Duration<br>    Acceleration | semi-sinusoidal<br>1<br>50 | ms<br>m/s$^2$ | IEC 60068-2-27 Ea |

## 5.4 Reliability Characteristics

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

**Table 15:** Summary of reliability test conditions

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

## 5.4.1 Bending Tests

From experience with other modules an elongation of up to 200µm/m is acceptable for PLS8-E modules as a result of bending strains.

Tests (based on EN 60068-2-21) showed that if applying a force of 10N at the middle of the module, i.e., the evaluation module with the actual PLS8-E module soldered onto the evaluation PCB as shown in Figure 19, the possible elongation is clearly below the value of 200µm/m. Therefore, a force of 10N is recommended as maximum force.

Please note that these values only apply for a one-off short stress. The module will have to be mounted free of any strains and without being exposed to dynamic pressures.
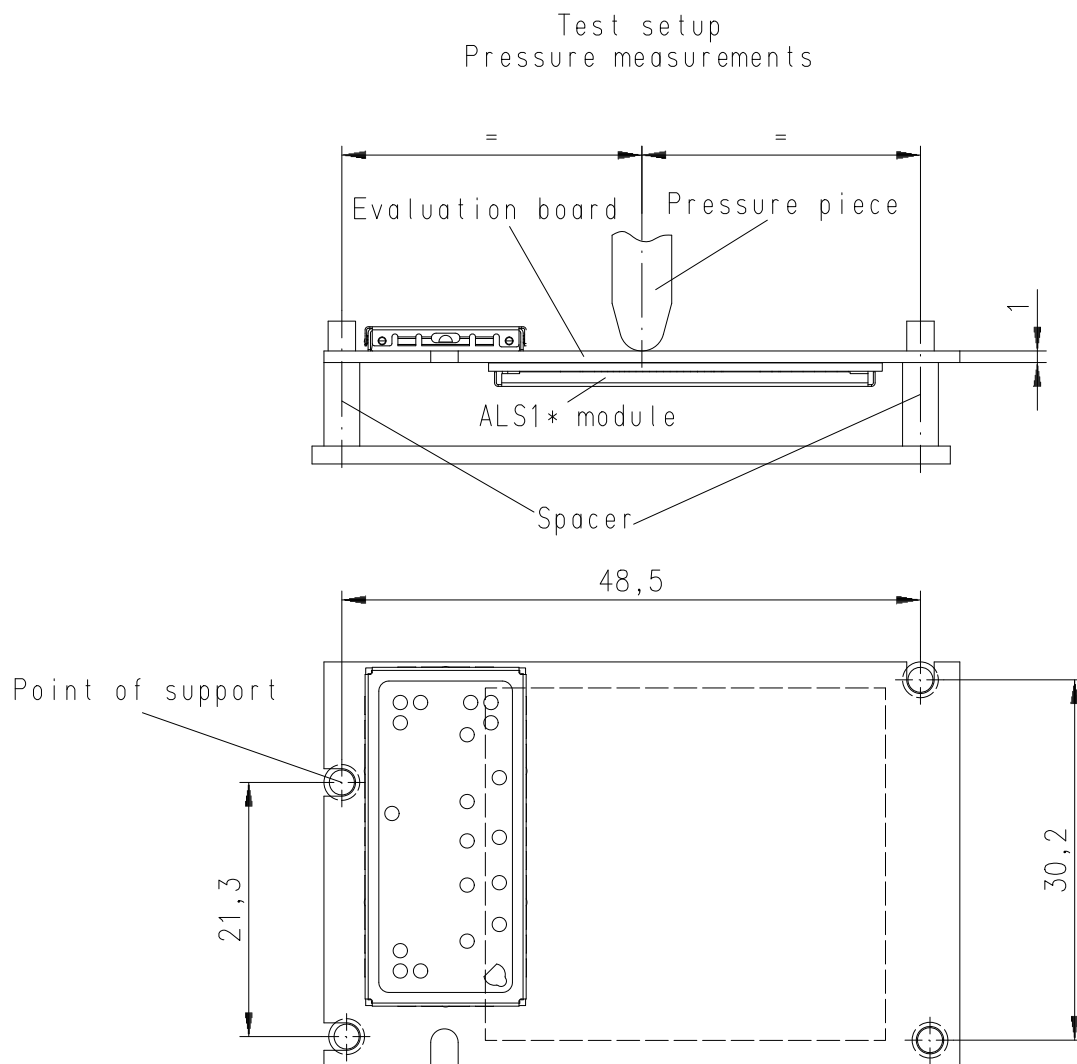
**Figure 19:** Bending test setup

## 5.5 Pad Assignment and Signal Description

The SMT application interface on the PLS8-E provides connecting pads to integrate the module into external applications. The following Table 16 lists the pads' assignments, Figure 20 (bottom view) and Figure 21 (top view) show the connecting pads' numbering plan.

Please note that pads marked "rfu" (reserved for future use) and further qualified as "dnu" (do not use) may be soldered but should not be connected to an external application.

Because with surface mount modules the heat is transported through the solder pads to the external application's PCB, it is generally recommended to solder all pads.

**Table 16:** Overview: Pad assignments[1]

| Pad No. | Signal Name | Pad No. | Signal Name | Pad No. | Signal Name |
|---|---|---|---|---|---|
| A4 | nc | E2 | GND | L2 | GND |
| A5 | GND | E3 | GND | L3 | GND |
| A6 | GND | E4 | GND | L4 | GND |
| A7 | rfu (dnu) | E5 | GND | L5 | rfu (dnu) |
| A8 | GND | E12 | rfu (dnu) | L6 | rfu (dnu) |
| A9 | GND | E13 | rfu (dnu) | L7 | rfu (dnu) |
| A10 | GND | E14 | rfu (dnu) | L8 | rfu (dnu) |
| A11 | GND | E15 | rfu (dnu) | L9 | rfu (dnu) |
| A12 | ANT_DRX_MIMO | E16 | rfu (dnu) | L10 | rfu (dnu) |
| A13 | GND | F1 | GND | L11 | rfu (dnu) |
| B3 | nc | F2 | GND | L12 | rfu (dnu) |
| B4 | GND | F3 | GND | L13 | rfu (dnu) |
| B5 | GND | F4 | GND | L14 | CCRST |
| B6 | GND | F13 | rfu (dnu) | L15 | CCCLK |
| B7 | GND | F14 | rfu (dnu) | L16 | IGT |
| B8 | GND | F15 | rfu (dnu) | M2 | GND |
| B9 | GND | F16 | GPIO10 | M3 | GND |
| B10 | GND | G1 | GND | M4 | PWR_IND |
| B11 | GND | G2 | GND | M5 | VEXT |
| B12 | GND | G3 | GND | M6 | GND |
| B13 | GND | G4 | rfu (dnu) | M7 | rfu (dnu) |
| B14 | STATUS | G13 | rfu (dnu) | M8 | rfu (dnu) |
| C2 | GND | G14 | GPIO7 | M9 | rfu (dnu) |
| C3 | GND | G15 | GPIO8 | M10 | rfu (dnu) |
| C4 | GND | G16 | GPIO9 | M11 | rfu (dnu) |
| C5 | GND | H1 | GND | M12 | ADC2_IN |
| C6 | GND | H2 | GND | M13 | ADC1_IN |
| C7 | GND | H3 | GND | M14 | CCIN |
| C8 | GND | H4 | GND | M15 | rfu (dnu) |
| C9 | GND | H13 | rfu (dnu) | N3 | BATT+_RF |
| C10 | GND | H14 | GPIO4 | N4 | BATT+_RF |
| C11 | GND | H15 | GPIO5 | N5 | VUSB_IN |
| C12 | rfu (dnu) | H16 | GPIO6 | N6 | rfu (dnu) |
| C13 | rfu (dnu) | J1 | GND | N7 | rfu (dnu) |
| C14 | rfu (dnu) | J2 | GND | N8 | rfu (dnu) |
| C15 | rfu (dnu) | J3 | GND | N9 | rfu (dnu) |
| D1 | GND | J4 | GND | N10 | rfu (dnu) |
| D2 | GND | J13 | GND | N11 | GND |
| D3 | GND | J14 | GPIO1 | N12 | rfu (dnu) |
| D4 | GND | J15 | GPIO2 | N13 | BATT+ |
| D5 | rfu (dnu) | J16 | GPIO3 | N14 | EMERG_OFF |
| D6 | GND | K1 | ANT_MAIN | P4 | USB_DP |
| D7 | GND | K2 | GND | P5 | USB_DN |
| D8 | GND | K3 | GND | P6 | rfu (dnu) |
| D9 | GND | K4 | GND | P7 | rfu (dnu) |
| D10 | GND | K5 | GND | P8 | rfu (dnu) |
| D11 | GND | K12 | rfu (dnu) | P9 | rfu (dnu) |
| D12 | rfu (dnu) | K13 | rfu (dnu) | P10 | rfu (dnu) |
| D13 | rfu (dnu) | K14 | CCIO | P11 | rfu (dnu) |
| D14 | rfu (dnu) | K15 | CCVCC | P12 | rfu (dnu) |
| D15 | rfu (dnu) | K16 | rfu (dnu) | P13 | BATT+ |
| D16 | rfu (dnu) | L1 | GND | | |
| E1 | rfu (dnu) | | | | |

[1.] nc = not connected; rfu = reserved for future use; dnu = do not use

## 5.5 Pad Assignment and Signal Description

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **P** | | | | USB_DP | USB_DN | rfu (dnu) | rfu (dnu) | rfu (dnu) | rfu (dnu) | rfu (dnu) | rfu (dnu) | rfu (dnu) | BATT+ | | | |
| **N** | | | BATT+_RF | BATT+_RF | VUSB_IN | rfu (dnu) | rfu (dnu) | rfu (dnu) | rfu (dnu) | rfu (dnu) | GND | rfu (dnu) | BATT+ | EMERG_OFF | | |
| **M** | | GND | GND | PWR_IND | VEXT | GND | rfu (dnu) | rfu (dnu) | rfu (dnu) | rfu (dnu) | rfu (dnu) | ADC2_in | ADC1_IN | CCIN | rfu (dnu) | |
| **L** | GND | GND | GND | GND | rfu (dnu) | rfu (dnu) | rfu (dnu) | rfu (dnu) | rfu (dnu) | rfu (dnu) | rfu (dnu) | rfu (dnu) | rfu (dnu) | CCRST | CCCLK | IGT |
| **K** | ANT_MAIN | GND | GND | GND | GND | | | | | | | rfu (dnu) | rfu (dnu) | CCIO | CCVCC | rfu (dnu) |
| **J** | GND | GND | GND | GND | | | | | | | | GND | | GPIO1 | GPIO2 | GPIO3 |
| **H** | GND | GND | GND | GND | | | | | | | | | rfu (dnu) | GPIO4 | GPIO5 | GPIO6 |
| **G** | GND | GND | GND | rfu (dnu) | | | | | | | | | rfu (dnu) | GPIO7 | GPIO8 | GPIO9 |
| **F** | GND | GND | GND | GND | | | | | | | | | rfu (dnu) | rfu (dnu) | rfu (dnu) | GPIO10 |
| **E** | rfu (dnu) | GND | GND | GND | GND | | | | | | | rfu (dnu) | rfu (dnu) | rfu (dnu) | rfu (dnu) | rfu (dnu) |
| **D** | GND | GND | GND | GND | rfu (dnu) | GND | GND | GND | GND | GND | GND | rfu (dnu) | rfu (dnu) | rfu (dnu) | rfu (dnu) | rfu (dnu) |
| **C** | | GND | GND | GND | GND | GND | GND | GND | GND | GND | GND | rfu (dnu) | rfu (dnu) | rfu (dnu) | rfu (dnu) | |
| **B** | | | nc | GND | GND | GND | GND | GND | GND | GND | GND | GND | GND | STATUS | | |
| **A** | | | | nc | GND | GND | rfu (dnu) | GND | GND | GND | GND | ANT_DRX_MIMO | GND | | | |

**rfu**: Reserved for future use (should not be connected to external application)
**nc**: Internally not connected (may be arbitrarily connected to external application)
**(dnu)**: Do not use

Position marker

For internal use: Not to be soldered

**Figure 20:** PLS8-E bottom view: Pad assignments
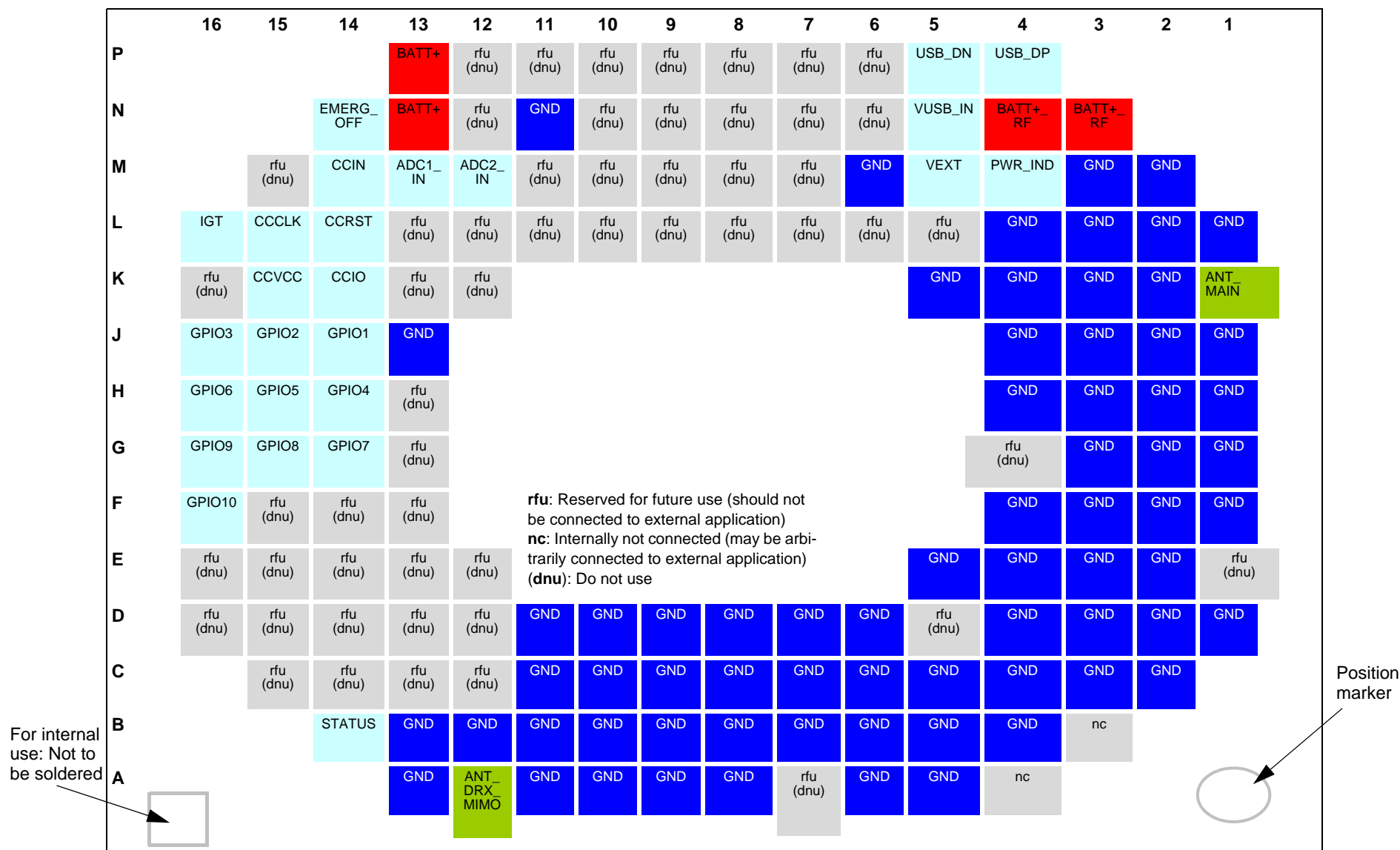
5.5 Pad Assignment and Signal Description

| | 16 | 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| P | | | | BATT+ | rfu (dnu) | rfu (dnu) | rfu (dnu) | rfu (dnu) | rfu (dnu) | rfu (dnu) | rfu (dnu) | USB_DN | USB_DP | | | |
| N | | | EMERG_OFF | BATT+ | rfu (dnu) | GND | rfu (dnu) | rfu (dnu) | rfu (dnu) | rfu (dnu) | rfu (dnu) | VUSB_IN | BATT+_RF | BATT+_RF | | |
| M | | rfu (dnu) | CCIN | ADC1_IN | ADC2_IN | rfu (dnu) | rfu (dnu) | rfu (dnu) | rfu (dnu) | rfu (dnu) | GND | VEXT | PWR_IND | GND | GND | |
| L | IGT | CCCLK | CCRST | rfu (dnu) | rfu (dnu) | rfu (dnu) | rfu (dnu) | rfu (dnu) | rfu (dnu) | rfu (dnu) | rfu (dnu) | rfu (dnu) | GND | GND | GND | GND |
| K | rfu (dnu) | CCVCC | CCIO | rfu (dnu) | rfu (dnu) | | | | | | | GND | GND | GND | GND | ANT_MAIN |
| J | GPIO3 | GPIO2 | GPIO1 | GND | | | | | | | | | GND | GND | GND | GND |
| H | GPIO6 | GPIO5 | GPIO4 | rfu (dnu) | | | | | | | | | GND | GND | GND | GND |
| G | GPIO9 | GPIO8 | GPIO7 | rfu (dnu) | | | | | | | | rfu (dnu) | GND | GND | GND | GND |
| F | GPIO10 | rfu (dnu) | rfu (dnu) | rfu (dnu) | | | | | | | | | GND | GND | GND | GND |
| E | rfu (dnu) | rfu (dnu) | rfu (dnu) | rfu (dnu) | rfu (dnu) | | | | | | | GND | GND | GND | GND | rfu (dnu) |
| D | rfu (dnu) | rfu (dnu) | rfu (dnu) | rfu (dnu) | rfu (dnu) | GND | GND | GND | GND | GND | GND | rfu (dnu) | GND | GND | GND | GND |
| C | | rfu (dnu) | rfu (dnu) | rfu (dnu) | rfu (dnu) | GND | GND | GND | GND | GND | GND | GND | GND | GND | GND | |
| B | | | STATUS | GND | GND | GND | GND | GND | GND | GND | GND | GND | GND | nc | | |
| A | | | | GND | ANT_DRX_MIMO | GND | GND | GND | GND | rfu (dnu) | GND | GND | nc | | | |

rfu: Reserved for future use (should not be connected to external application)
nc: Internally not connected (may be arbitrarily connected to external application)
(dnu): Do not use

For internal use: Not to be soldered

Position marker

**Figure 21:** PLS8-E top view: Pad assignments

Please note that the reference voltages listed in Table 17 are the values measured directly on the PLS8-E module. They do not apply to the accessories connected.

**Table 17:** Signal description

| Function | Signal name | IO | Signal form and level | Comment |
|---|---|---|---|---|
| Power supply | BATT+_RF | I | $V_I max = 4.2V$<br>$V_I norm = 3.8V$<br>$V_I min = 3.3V$ during Tx burst on board<br>$Imax \approx 2A$, during Tx burst (GSM)<br><br>n Tx = n x 577µs peak current every 4.615ms | Lines of BATT+ and GND must be connected in parallel for supply purposes because higher peak currents may occur.<br><br>Minimum voltage must not fall below 3.3V including drop, ripple, spikes. |
| | BATT+ | I | $V_I max = 4.2V$<br>$V_I norm = 3.8V$<br>$V_I min = 3.3V$ during Tx burst on board<br>$Imax = 350mA$ | |
| Power supply | GND | | Ground | Application Ground |
| External supply voltage | VEXT | O | $CLmax = 1µF$<br><br>$V_O = 1.80V$ +1% -5%<br>$I_O max = -50mA$ | VEXT may be used for application circuits.<br><br>If unused keep line open.<br><br>The external digital logic must not cause any spikes or glitches on voltage VEXT.<br><br>Do not exeed IOmax |
| Ignition | IGT | I | $R_{PU} \approx 200k\Omega$<br>$V_{OH} max = 1.8V$<br>$V_{IH} max = 2.1V$<br>$V_{IH} min = 1.17V$<br>$V_{IL} max = 300mV$<br>Low impulse width > 100ms | This signal switches the module ON.<br><br>It is recommended to drive this line low by an open drain or open collector driver connected to GND. |
| Emergency off | EMERG_OFF | I | $R_{PU} \approx 40k\Omega$<br>$V_{OH} max = 1.8V$<br>$V_{IH} max = 2.1V$<br>$V_{IH} min = 1.17V$<br>$V_{IL} max = 300mV$<br><br>~~\|___\|~~ low impulse width > 40ms | It is recommended to drive this line low by an open drain or open collector driver connected to GND.<br><br>If unused keep line open. |
| Connectivity status | STATUS | O | $V_{OL} max = 0.45V$ at I = 2mA<br>$V_{OH} min = 1.35V$ at I = -2mA<br>$V_{OH} max = 1.85V$ | Status signalling e.g. with ext. LED circuit |
| SIM card detection | CCIN | I | $R_{PU} \approx 24.2k\Omega$<br>$V_{OH} max = 1.9V$<br>$V_{IH} min = 1.15V$<br>$V_{IH} max = 1.9V$<br>$V_{IL} max = 0.4V$ | CCIN = Low, SIM card inserted.<br><br>If unused connect to GND. |

**Table 17:** Signal description

| Function | Signal name | IO | Signal form and level | Comment |
|---|---|---|---|---|
| 3V SIM card interface | CCRST | O | $V_{OL}$max = 0.45V at I = 2mA<br>$V_{OH}$min = 2.40V at I = -2mA<br>$V_{OH}$max = 2.9V | Maximum cable length or copper track should be not longer than 100mm to SIM card holder. |
| | CCIO | I/O | $R_{PU} \approx 4.8...9.5k\Omega$<br>$V_{IL}$max = 0.76V<br>$V_{IL}$min = -0.3V<br>$V_{IH}$min = 1.98V<br>$V_{IH}$max = 3.35V<br><br>$V_{OL}$max = 0.45V at I = 2mA<br>$V_{OH}$min = 2.57V at I = -0.05mA<br>$V_{OH}$max = 3.08V | |
| | CCCLK | O | $V_{OL}$max = 0.45V at I = 2mA<br>$V_{OH}$min = 2.57V at I = -2mA<br>$V_{OH}$max = 3.08V | |
| | CCVCC | O | $V_O$min = 3.0V<br>$V_O$typ =3.05V<br>$V_O$max = 3.08V<br>$I_O$max = -50mA | |
| 1.8V SIM card interface | CCRST | O | $V_{OL}$max = 0.45V at I = 2mA<br>$V_{OH}$min = 1.35V at I = -2mA<br>$V_{OH}$max = 1.85V | Maximum cable length or copper track should be not longer than 100mm to SIM card holder. |
| | CCIO | I/O | $R_I \approx 4.8...9.5k\Omega$<br>$V_{IL}$max = 0.62V<br>$V_{IL}$min = -0.3V<br>$V_{IH}$min = 1.20V<br>$V_{IH}$max = 2.1V<br><br>$V_{OL}$max = 0.45V at I = 2mA<br>$V_{OH}$min = 1.32V at I = -0.05mA<br>$V_{OH}$max = 1.82V | |
| | CCCLK | O | $V_{OL}$max = 0.45V at I = 2mA<br>$V_{OH}$min = 1.32V at I = -2mA<br>$V_{OH}$max = 1.82V | |
| | CCVCC | O | $V_O$min = 1.75V<br>$V_O$typ = 1.80V<br>$V_O$max = 1.82V<br>$I_O$max = -50mA | |

**Table 17:** Signal description

| Function | Signal name | IO | Signal form and level | Comment |
|---|---|---|---|---|
| Power indicator | PWR_IND | O | $V_{IH}max = 5.5V$<br>$V_{OL}max = 0.4V$ at Imax = 1mA | PWR_IND (Power Indicator) notifies the module's on/off state.<br><br>PWR_IND is an open collector that needs to be connected to an external pull-up resistor. Low state of the open collector indicates that the module is on. Vice versa, high level notifies the power-down mode.<br><br>Therefore, signal may be used to enable external voltage regulators that supply an external logic for communication with the module, e.g. level converters. |
| USB | VUSB_IN | I | $V_{IN}min = 3.0V$<br>$V_{IN}max = 5.75V$<br><br>$I_{I}typ = 150\mu A$<br>$I_{I}max = 200\mu A$<br>Cin=1µF | If the USB interface is not used please connect this line to GND.<br>Since VUSB_IN is used for detection only it is recommended not to add any further blocking capacitors on the VUSB_IN line. |
| | USB_DN | I/O | All electrical characteristics according to USB Implementers' Forum, USB 2.0 Full or High Speed Specification. | If lines are unused keep lines open.<br><br>USB High Speed mode operation requires a differential impedance of 90Ω. |
| | USB_DP | I/O | | |
| GPIO interface | GPIO1<br>GPIO2<br>GPIO3<br>GPIO4<br>GPIO5<br>GPIO6<br>GPIO7<br>GPIO8<br>GPIO9<br>GPIO10 | I/O | $V_{IL}max = 0.6V$ at 30µA<br>$V_{IH}min = 1.20V$ at -30µA<br>$V_{IH}max = 2V$<br><br>$V_{OL}max = 0.45V$ at I = 2mA<br>$V_{OH}min = 1.35V$ at I = -2mA<br>$V_{OH}max = 1.85V$ | If lines are unused keep lines open. |
| ADC interface | ADC1_IN,<br>ADC2_IN | I | Full specification compliance range<br>$V_{Imin}>=0.3V$<br>$V_{Imax}<=3.075V$<br><br>Degraded accuracy range<br>$V_{Imin}$ 0.05V ... 0.3V<br>Ridc>1MOhm<br>Resolution: 12 Bit<br>Offset error: <+-10mV<br>Gain error: <1%<br>analog bandwidth: <16kHz<br>conversation time: 853µs | If unused keep pin open.<br><br>Prepared for general purpose. |

## 5.6 Power Supply Ratings

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

**Table 18:** 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 | 3.8 | 4.2 | 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 | | | 120 90 | $mV_{pp}$ $mV_{pp}$ |

**Table 19:** Current consumption ratings

| | Description | Conditions | Typical rating | Unit |
|---|---|---|---|---|
| $I_{BATT+}$ [1] | OFF State supply current | POWER DOWN | 40 | µA |
| | Average GSM / GPRS supply current | IDLE (USB disconnected) @ DRX=2 | 75 | mA |
| | | IDLE (USB active) @ DRX=2 | 90 | mA |
| | | GPRS Data transfer GSM900; PCL=5; 1Tx/4Rx | 320 | mA |
| | | GPRS Data transfer GSM900; PCL=5; 2Tx/3Rx | 540 | mA |
| | | GPRS Data transfer GSM900; PCL=5; 4Tx/1Rx - @Total mismatch | 930 990 | mA |
| | | EDGE Data transfer GSM900; PCL=5; 1Tx/4Rx | 220 | mA |
| | | EDGE Data transfer GSM900; PCL=5; 2Tx/3Rx | 340 | mA |
| | | EDGE Data transfer GSM900; PCL=5; 4Tx/1Rx | 570 | mA |
| | | GPRS Data transfer GSM1800; PCL=0; 1Tx/4Rx | 230 | mA |
| | | GPRS Data transfer GSM1800; PCL=0; 2Tx/3Rx | 360 | mA |
| | | GPRS Data transfer GSM1800; PCL=0; 4Tx/1Rx | 590 | mA |
| | | EDGE Data transfer GSM1800; PCL=0; 1Tx/4Rx | 190 | mA |
| | | EDGE Data transfer GSM1800; PCL=0; 2Tx/3Rx | 290 | mA |
| | | EDGE Data transfer GSM1800; PCL=0; 4Tx/1Rx | 460 | mA |

**Table 19:** Current consumption ratings

| | Description | Conditions | Typical rating | Unit |
|---|---|---|---|---|
| $I_{BATT+}$ [1] | Average WCDMA supply current | IDLE (USB disconnected) @ DRX=6 | 50 | mA |
| | | IDLE (USB active) @ DRX=6 | 65 | mA |
| | | UMTS Data transfer Band I @+24dBm | 560 | mA |
| | | UMTS Data transfer Band III @+24dBm | 620 | mA |
| | | UMTS Data transfer Band VIII @+24dBm | 500 | mA |
| | | HSDPA Data transfer Band I @+24dBm | 590 | mA |
| | | HSDPA Data transfer Band III @+24dBm | 620 | mA |
| | | HSDPA Data transfer Band VIII @+24dBm | 510 | mA |
| | Average LTE supply current[2] | IDLE (USB disconnected) | 55 | mA |
| | | IDLE (USB active) | 70 | mA |
| | | LTE Data transfer Band 3 @+23dBm<br>- @ 50Ohm<br>- @ Total mismatch | 650<br>830 | mA |
| | | LTE Data transfer Band 7 @+23dBm | 640 | mA |
| | | LTE Data transfer Band 8 @+23dBm | 520 | mA |
| | | LTE Data transfer Band 20 @+23dBm | 520 | mA |
| $I_{VUSB\_IN}$ | USB typical and maximum ratings are mentioned in Table 17: VUSB_IN. | | | |

[1] With an impedance of $Z_{LOAD}$=50Ohm at the antenna pads. Measured at 25°C and 4.2V - except for POWER DOWN ratings that were measured at 3.4V.

[2] Communication tester settings:
   - Channel Bandwidth: 5MHz
   - Number of Resource Blocks: 25 (DL), 1 (UL)
   - Modulation: QPSK

## 5.7 RF Antenna Interface Characteristics

**Table 20:** RF Antenna interface GSM / UMTS/LTE (at operating temperature range[1])

| Parameter | Conditions | Nominal | Unit |
|---|---|---|---|
| LTE connectivity[2] | Band 3, 7, 8, 20 | | |
| Receiver Input Sensitivity @ ARP (ch. bandwidth 5MHz) | LTE 800 Band 20 | -103 | dBm |
| | LTE 900 Band 8 | -104 | dBm |
| | LTE 1800 Band 3 | -103 | dBm |
| | LTE 2600 Band 7 | -102 | dBm |
| RF Power @ ARP with 50Ohm Load | LTE 800 Band 20 | +23 | dBm |
| | LTE 900 Band 8 | +23 | dBm |
| | LTE 1800 Band 3 | +23 | dBm |
| | LTE 2600 Band 7 | +23 | dBm |
| UMTS/HSPA connectivity[2] | Band I, III, VIII | | |
| Receiver Input Sensitivity @ ARP | UMTS 900 Band VIII | -112 | dBm |
| | UMTS 1800 Band III | -111 | dBm |
| | UMTS 2100 Band I | -111 | dBm |
| RF Power @ ARP with 50Ohm Load | UMTS 900 Band VIII | +24 | dBm |
| | UMTS 1800 Band III | +24 | dBm |
| | UMTS 2100 Band I | +24 | dBm |
| GPRS coding schemes | Class 12, CS1 to CS4 | | |
| EGPRS | Class 12, MCS1 to MCS9 | | |
| GSM Class | Small MS | | |
| Static Receiver input Sensitivity @ ARP | E-GSM 900 | -111 | dBm |
| | GSM 1800 | -110 | dBm |
| RF Power @ ARP with 50Ohm Load GSM | E-GSM 900 | 33 | dBm |
| | GSM 1800 | 30 | dBm |

**Table 20:** RF Antenna interface GSM / UMTS/LTE (at operating temperature range[1])

| Parameter | | Conditions | Nominal | Unit |
|---|---|---|---|---|
| RF Power @ ARP with 50Ohm Load | GPRS, 1 TX | E-GSM 900 | 33 | dBm |
| | | GSM 1800 | 30 | dBm |
| | EDGE, 1 TX | E-GSM 900 | 27 | dBm |
| | | GSM 1800 | 26 | dBm |
| | GPRS, 2 TX | E-GSM 900 | 33 | dBm |
| | | GSM 1800 | 30 | dBm |
| | EDGE, 2 TX | E-GSM 900 | 27 | dBm |
| | | GSM 1800 | 26 | dBm |
| | GPRS, 3 TX | E-GSM 900 | 33 | dBm |
| | | GSM 1800 | 30 | dBm |
| | EDGE, 3 TX | E-GSM 900 | 27 | dBm |
| | | GSM 1800 | 26 | dBm |
| | GPRS, 4 TX | E-GSM 900 | 33 | dBm |
| | | GSM 1800 | 30 | dBm |
| | EDGE, 4 TX | E-GSM 900 | 27 | dBm |
| | | GSM 1800 | 26 | dBm |

[1.] At restricted temperature range no active power reduction is implemented - any deviations are hardware related.

[2.] Applies also to UMTS/LTE Rx diversity/MIMO antenna.

## 5.8 Electrostatic Discharge

The 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 PLS8-E module.

*Special ESD protection provided on* PLS8-E*:*
BATT+: Inductor/capacitor
An example for an enhanced ESD protection for the SIM interface is shown in Section 3.5.1.

The remaining interfaces of PLS8-E with the exception of the antenna interface are not accessible to the user of the final product (since they are installed within the device) and are therefore only protected according to the ANSI/ESDA/JEDEC JS-001-2011 requirements.

PLS8-E has been tested according to the following standards. Electrostatic values can be gathered from the following table.

**Table 21:** Electrostatic values

| Specification / Requirements | Contact discharge | Air discharge |
|---|---|---|
| **ANSI/ESDA/JEDEC JS-001-2011** | | |
| All SMT interfaces | ± 1kV Human Body Model | n.a. |
| **JESD22-A114-F** | | |
| All SMT interfaces | ± 500V Charge Device Model (CDM) | n.a. |
| **ETSI EN 301 489-1/7** | | |
| BATT+ | ± 4kV | ± 8kV |

Note: Please note that the values may vary with the individual application design. For example, it matters whether or not the application platform is grounded over external devices like a computer or other equipment, such as the Gemalto M2M reference application described in Chapter 8.

# 6      Mechanics, Mounting and Packaging

## 6.1      Mechanical Dimensions of PLS8-E

Figure 22 shows a 3D view[1] of PLS8-E and provides an overview of the board's mechanical dimensions. For further details see Figure 23.

Length:      33mm
Width:       29mm
Height:      2.2mm
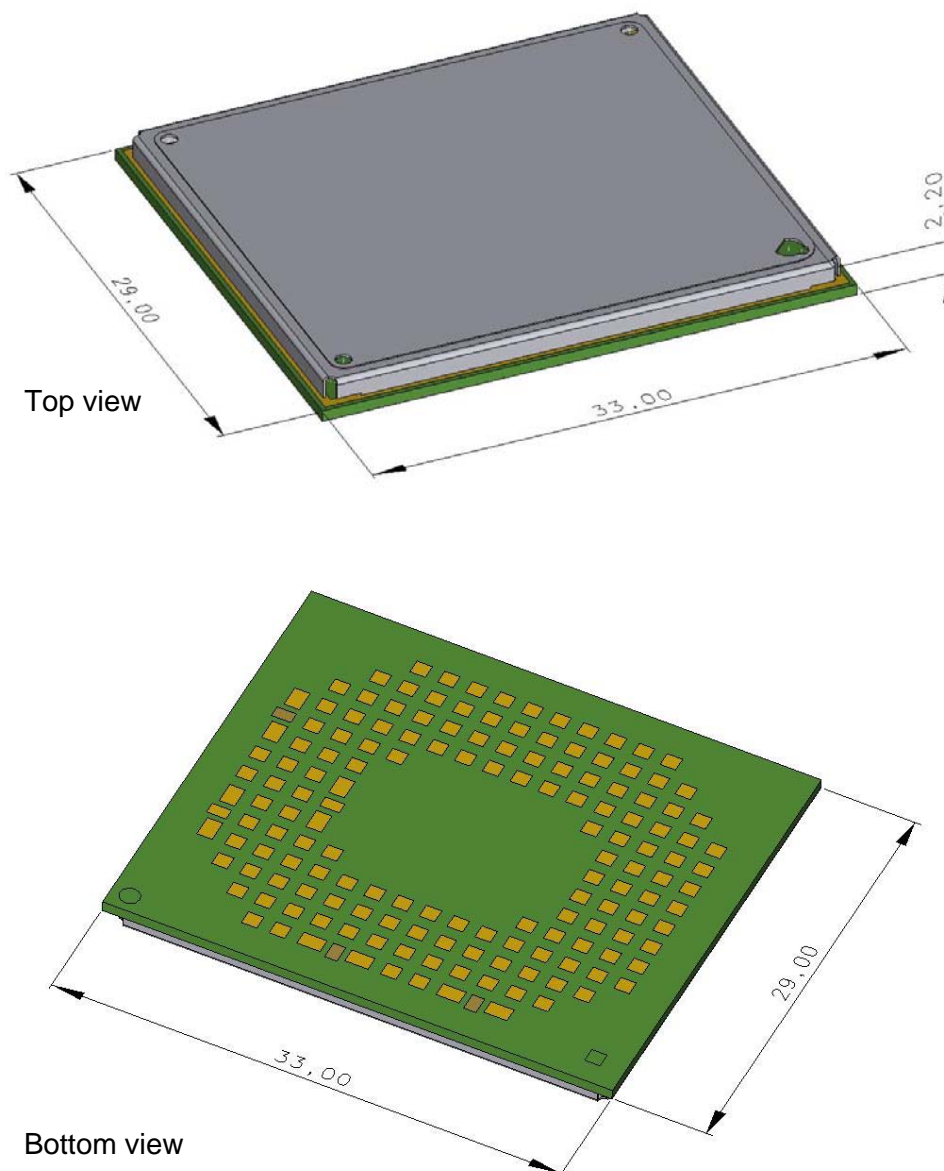


**Figure 22:**  PLS8-E – top and bottom view

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[1.] The coloring of the 3D view does not reflect the module's real color.

## 6.1 Mechanical Dimensions of PLS8-E
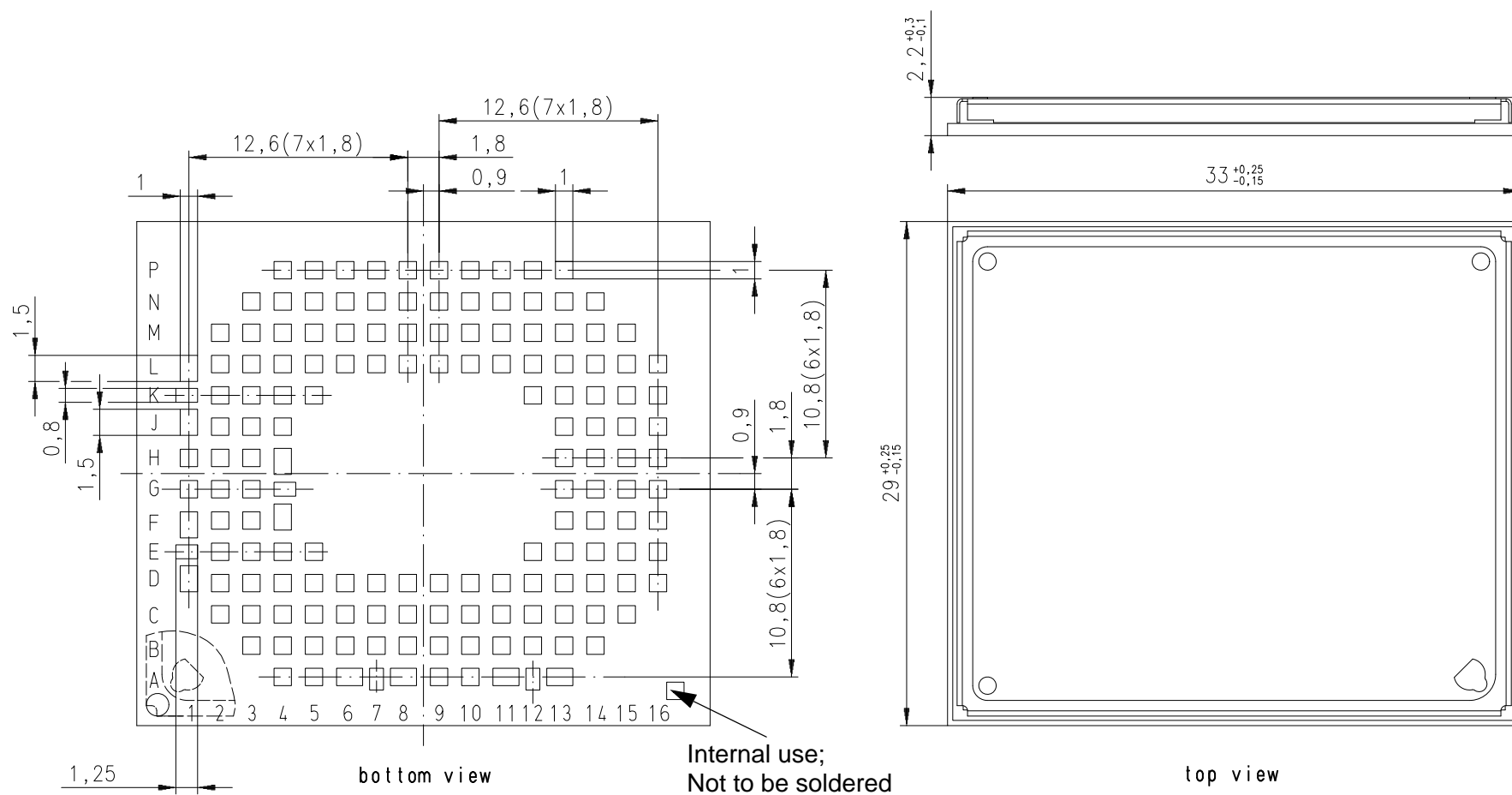
**Figure 23:** Dimensions of PLS8-E (all dimensions in mm)

## 6.2　Mounting PLS8-E onto the Application Platform

This section describes how to mount PLS8-E onto the PCBs (=printed circuit boards), including land pattern and stencil design, board-level characterization, soldering conditions, durability and mechanical handling. For more information on issues related to SMT module integration see also [3].

**Note:** All SMT module pads need to be soldered to the application's PCB. Not only must all supply pads and signals be connected appropriately, but all pads denoted as "Do not use" will also have to be soldered (but not electrically connected) in order to ensure the best possible mechanical stability. Note also that in order 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.

### 6.2.1　SMT PCB Assembly

### 6.2.1.1　Land Pattern and Stencil

The land pattern and stencil design as shown below is based on Gemalto M2M 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 24 reflects the module's pad layout, including signal pads and ground pads (for pad assignment see Section 5.5). Besides these pads there are ground areas on the module's bottom side that must not be soldered, e.g., the position marker. To prevent short circuits, it has to be ensured that there are no wires on the external application side that may connect to these module ground areas.
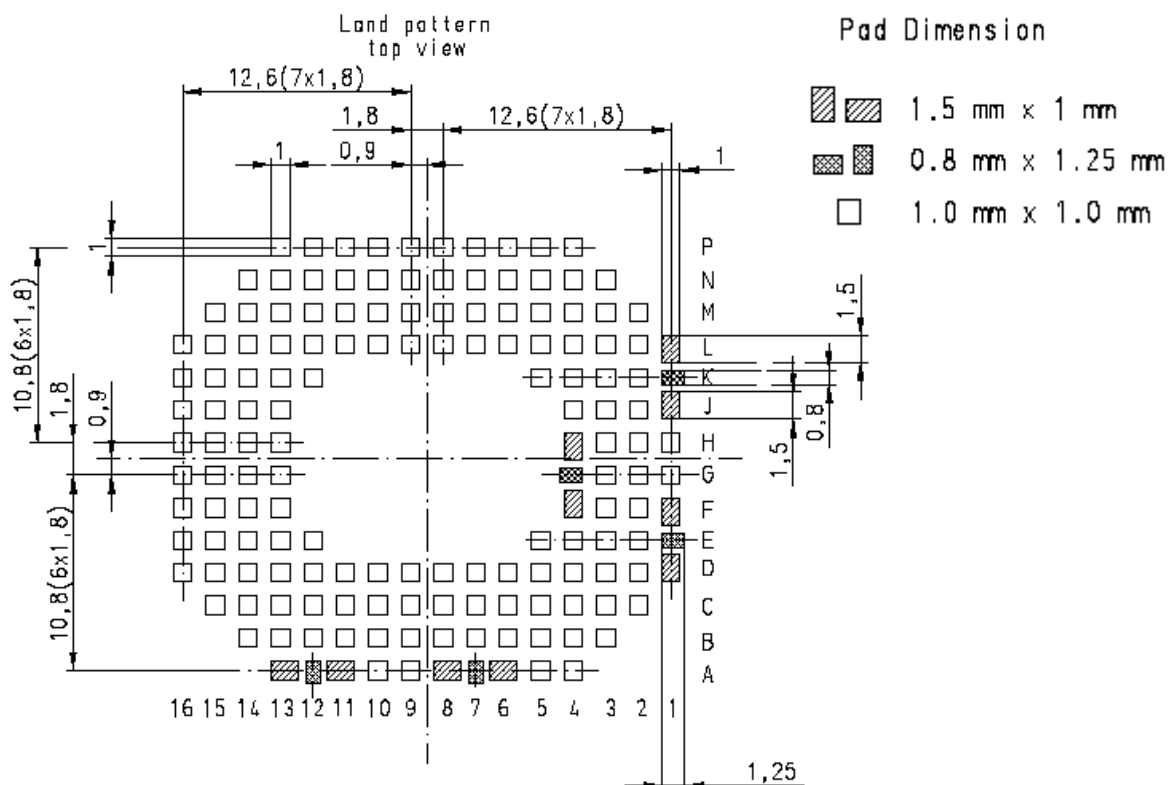


**Figure 24:** Land pattern (top layer)

The stencil design illustrated in Figure 25 and Figure 26 is recommended by Gemalto M2M as a result of extensive tests with Gemalto M2M Daisy Chain modules.
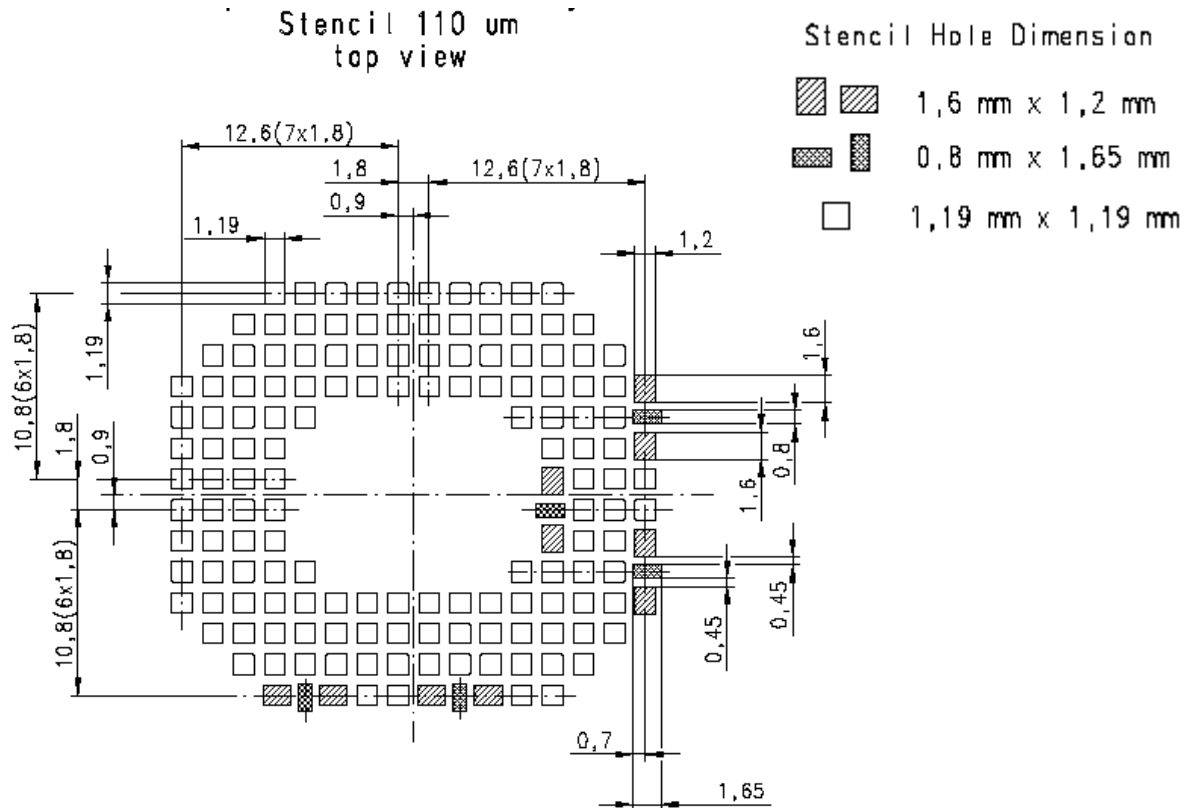
**Figure 25:** Recommended design for 110 micron thick stencil (top layer)
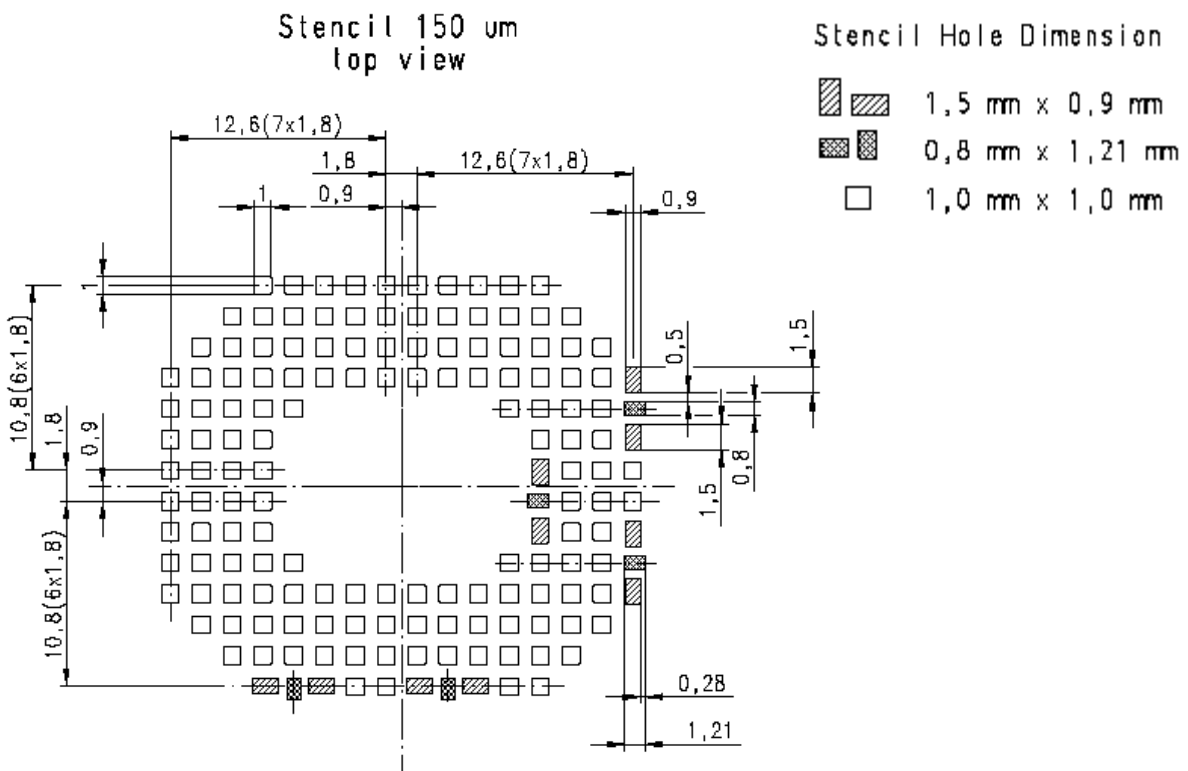
**Figure 26:** Recommended design for 150 micron thick stencil (top layer)

## 6.2.1.2    Board Level Characterization

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

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

It is recommended to characterize land patterns before an actual PCB production, taking individual processes, materials, equipment, stencil design, and reflow profile into account. For land and stencil pattern design recommendations see also Section 6.2.1.1. Optimizing the solder stencil pattern design and print process is necessary to ensure print uniformity, to decrease solder voids, and to increase board level reliability.

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

Generally, solder paste manufacturer recommendations for screen printing process parameters and reflow profile conditions should be followed. Maximum ratings are described in Section 6.2.3.

## 6.2.2    Moisture Sensitivity Level

PLS8-E comprises components that are susceptible to damage induced by absorbed moisture.

Gemalto M2M's PLS8-E 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 6.2.4 and Section 6.3.2.

## 6.2.3    Soldering Conditions and Temperature

### 6.2.3.1    Reflow Profile
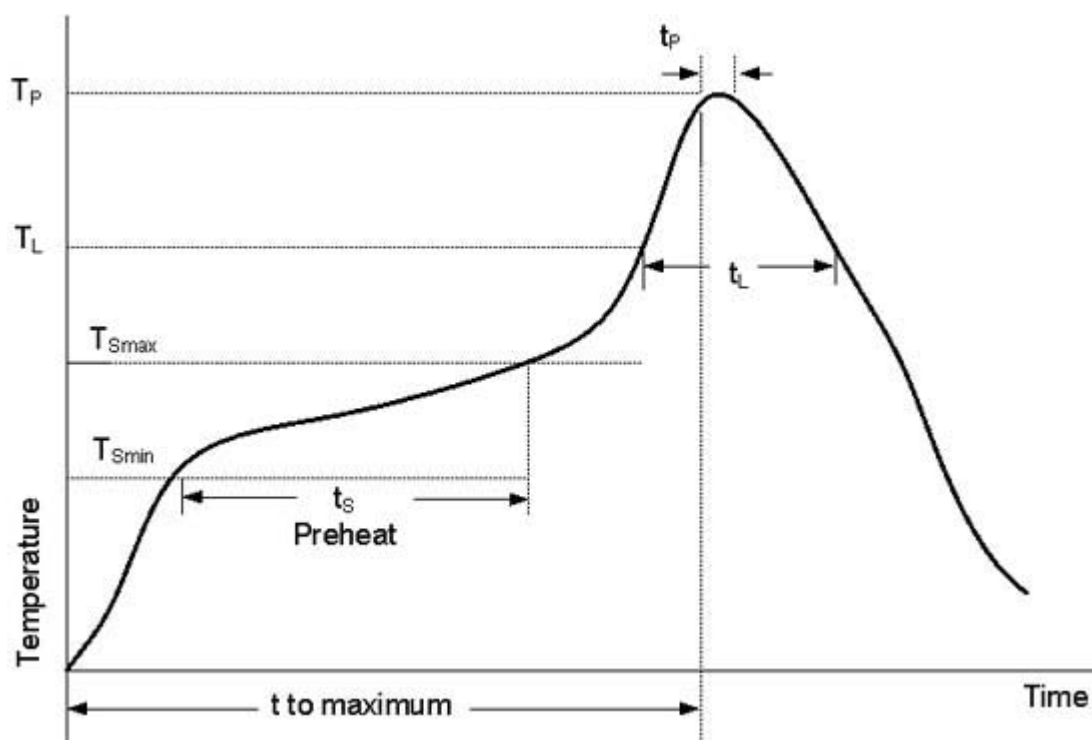


**Figure 27:**  Reflow Profile

**Table 22:** Reflow temperature ratings

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

## 6.2.3.2    Maximum Temperature and Duration

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

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

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

PLS8-E is specified for one soldering cycle only.Once PLS8-E is removed from the application, the module will very likely be destroyed and cannot be soldered onto another application.

## 6.2.4 Durability and Mechanical Handling

### 6.2.4.1 Storage Life

PLS8-E modules, as delivered in tape and reel carriers, must be stored in sealed, moisture barrier anti-static bags. The shelf life in a sealed moisture bag is an estimated 12 month. However, such a life span requires a non-condensing atmospheric environment, ambient temperatures below 40°C and a relative humidity below 90%. Additional storage conditions are listed in Table 17.

### 6.2.4.2 Processing Life

PLS8-E 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%.

### 6.2.4.3 Baking

Baking conditions are specified on the moisture sensitivity label attached to each MBB (see Figure 32 for details):
• It is *not necessary* to bake PLS8-E, if the conditions specified in Section 6.2.4.1 and Section 6.2.4.2 were not exceeded.
• It is *necessary* to bake PLS8-E, if any condition specified in Section 6.2.4.1 and Section 6.2.4.2 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.

### 6.2.4.4 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 5.8 for further information on electrostatic discharge.

## 6.3 Packaging

### 6.3.1 Tape and Reel

The single-feed tape carrier for PLS8-E is illustrated in Figure 28. The figure also shows the proper part orientation. The tape width is 44mm and the PLS8-E modules are placed on the tape with a 40mm pitch. The reels are 330mm in diameter with 100mm hubs. Each reel contains 500 modules.

### 6.3.1.1 Orientation
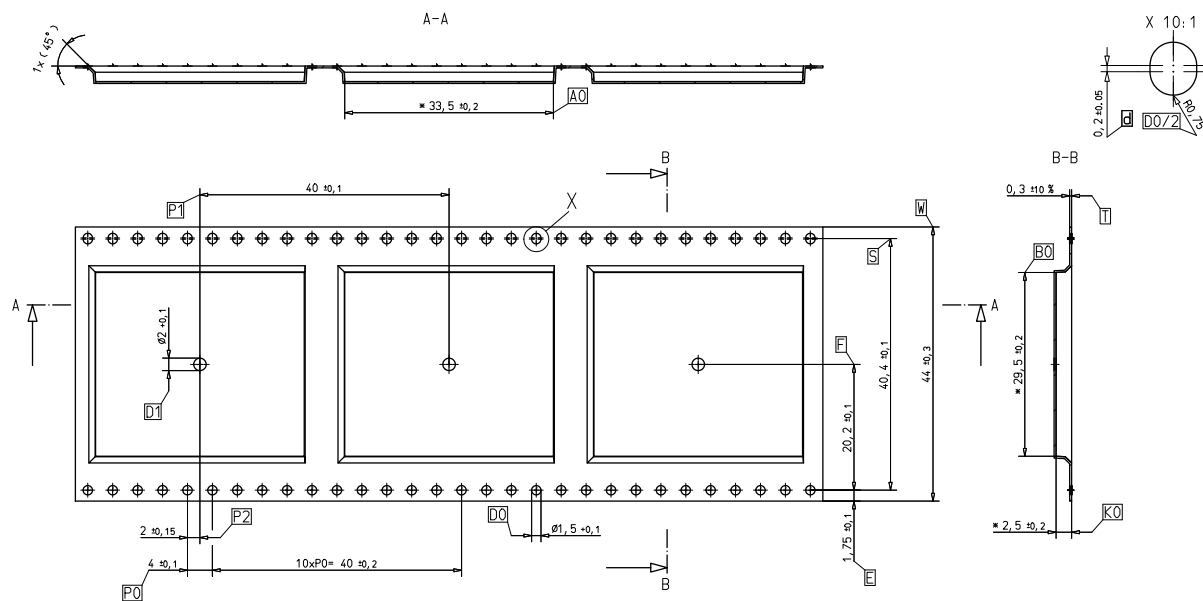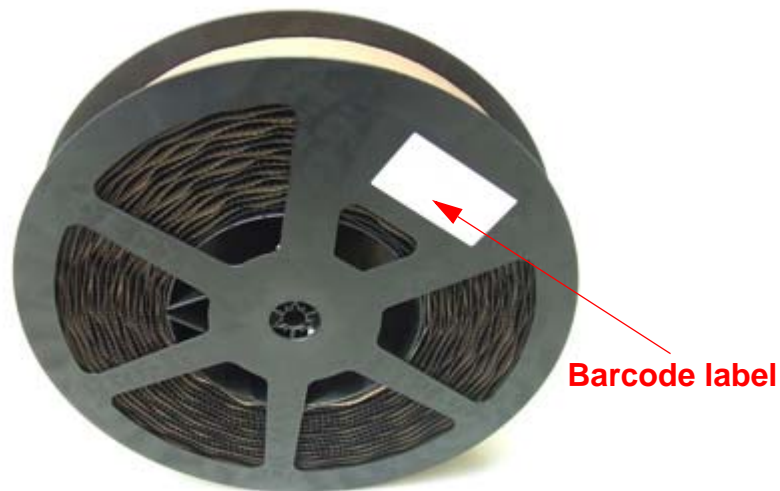


**Figure 28:** Carrier tape
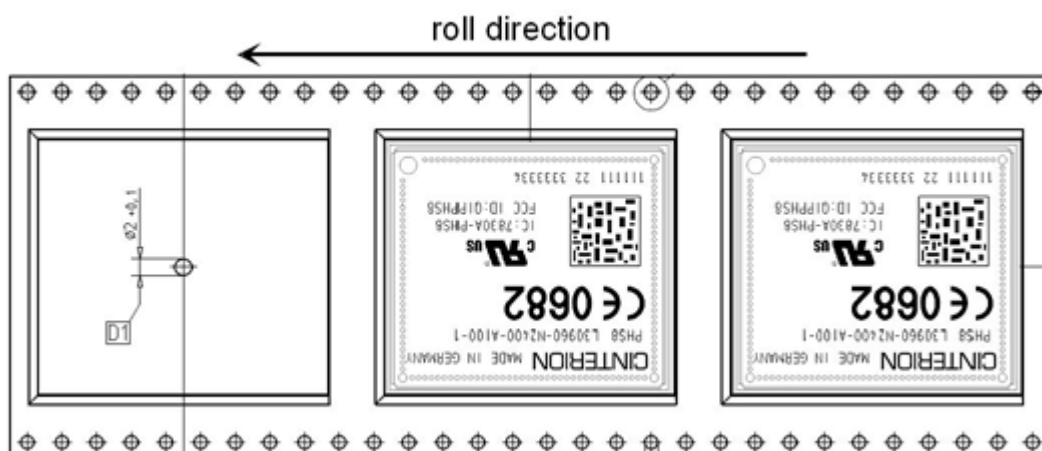


**Figure 29:** Roll direction

## 6.3.1.2    Barcode Label

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

**Figure 30:**  Barcode label on tape reel

## 6.3.2    Shipping Materials

PLS8-E is distributed in tape and reel carriers. The tape and reel carriers used to distribute PLS8-E are packed as described below, including the following required shipping materials:
- Moisture barrier bag, including desiccant and humidity indicator card
- Transportation bag

## 6.3.2.1    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 31. 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 PLS8-E modules from moisture exposure. It should not be opened until the devices are ready to be soldered onto the application.
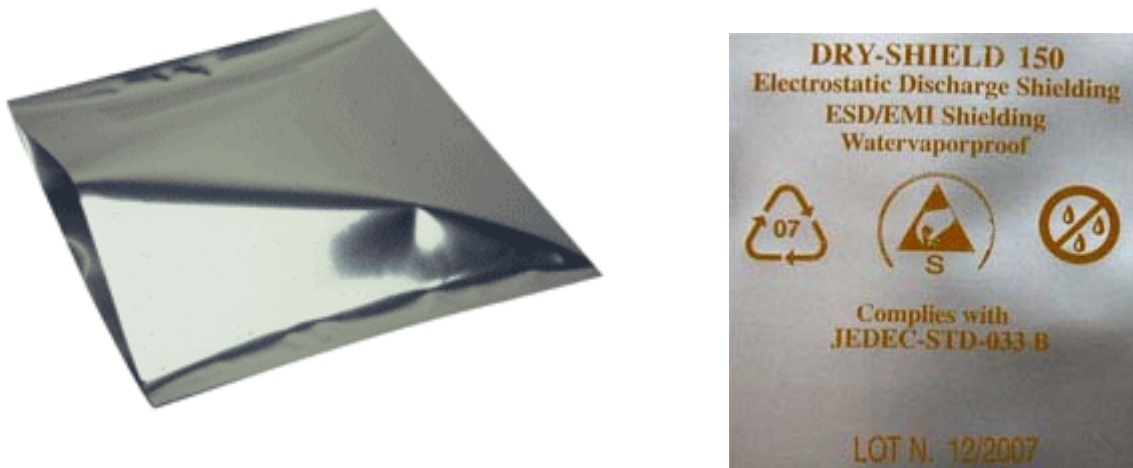


**Figure 31:**  Moisture barrier bag (MBB) with imprint

The label shown in Figure 32 summarizes requirements regarding moisture sensitivity, including shelf life and baking requirements. It is attached to the outside of the moisture barrier bag.

**Figure 32:** Moisture Sensitivity Label

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

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

The humidity indicator card is a moisture indicator and is included in the MBB to show the approximate relative humidity level within the bag. Sample humidity cards are shown in Figure 33. If the components have been exposed to moisture above the recommended limits, the units will have to be rebaked.
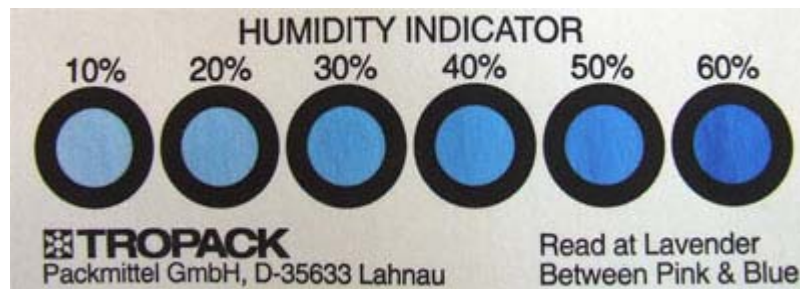


**Figure 33:** Humidity Indicator Card - HIC

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


## 6.3.2.2    Transportation Box

Tape and reel carriers are distributed in a box, marked with a barcode label for identification purposes. A box contains 2 reels with 500 modules each.

# 7 Sample Application

Figure 34 shows a typical example of how to integrate an PLS8-E module with an application.

The PWR_IND line is an open collector that needs an external pull-up resistor which connects to the voltage supply VCC µC of the microcontroller. Low state of the open collector pulls the PWR_IND signal low and indicates that the PLS8-E module is active, high level notifies the Power-down mode.

If the module is in Power-down mode avoid current flowing from any other source into the module circuit, for example reverse current from high state external control lines. Therefore, the controlling application must be designed to prevent reverse flow.

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

The EMC measures are best practice recommendations. In fact, an adequate EMC strategy for an individual application is very much determined by the overall layout and, especially, the position of components.

Some LGA pads are connected to clocks or high speed data streams that might interfere with the module's antenna. The RF receiver would then be blocked at certain frequencies (self interference). The external application's PCB tracks connected to these pads should therefore be well shielded or kept away from the antenna. This applies especially to the USB and UICC/ SIM interfaces.

Disclaimer:
No warranty, either stated or implied, is provided on the sample schematic diagram shown in Figure 34 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 PLS8-E modules.

# Sample Application
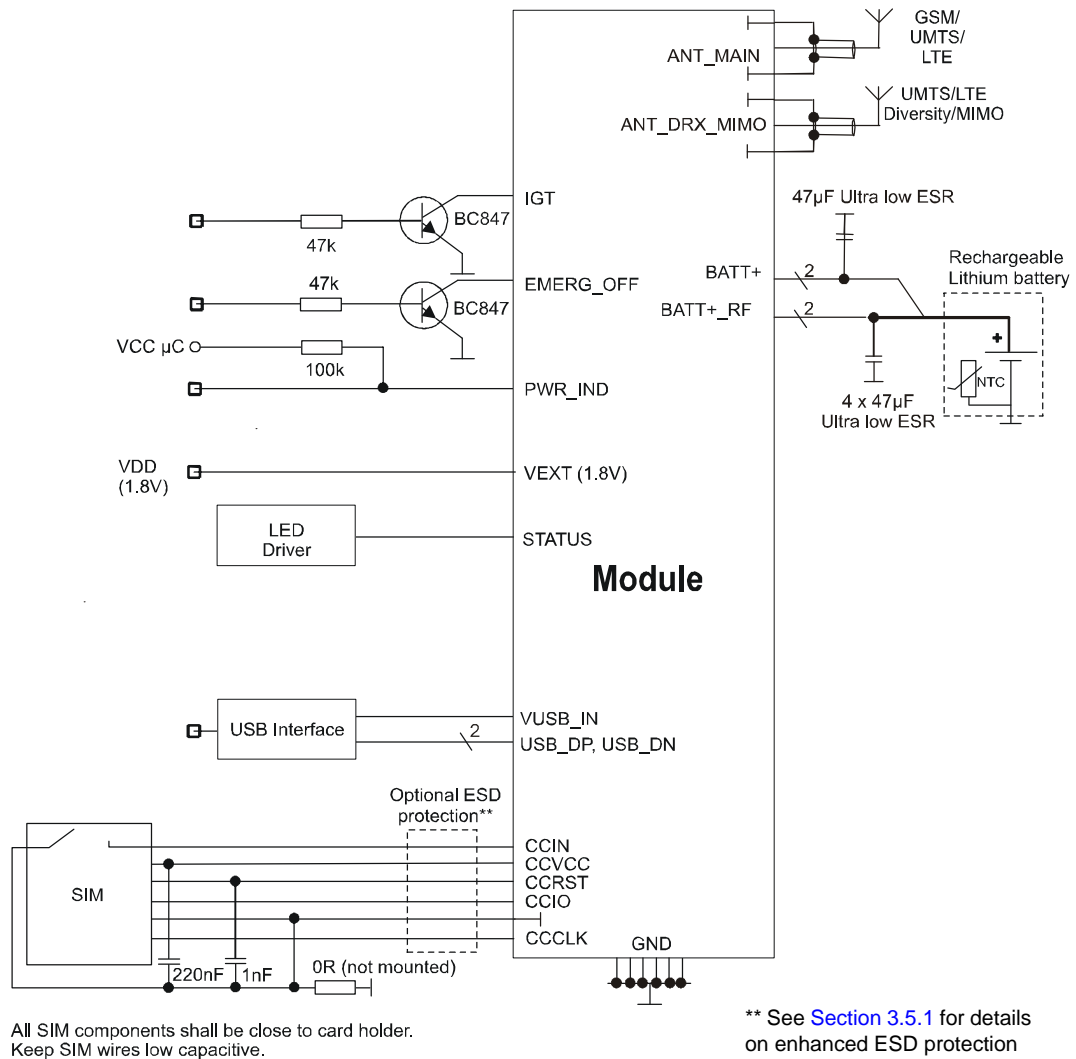


**Figure 34:** PLS8-E sample application

# 8    Reference Approval

## 8.1    Reference Equipment for Type Approval

The Gemalto M2M reference setup submitted to type approve PLS8-E is shown in Figure 35. The module (i.e., the evaluation module) is connected to the DSB75 by means of a flex cable and a special DSB75 adapter. The GSM/UMTS/LTE test equipment is connected via edge mount SMA connectors soldered to the module's antenna pads.

For ESD tests and evaluation purposes, it is also possible connect the module to the GSM/ UMTS/LTE test equipment through an SMA-to-Hirose-U.FL antenna cable and the SMA antenna connectors of the DSB75 adapter.

A further option is to mount the evaluation module directly onto the DSB75 adapter's 80-pin board-to-board connector and to connect the test equipment as shown below.
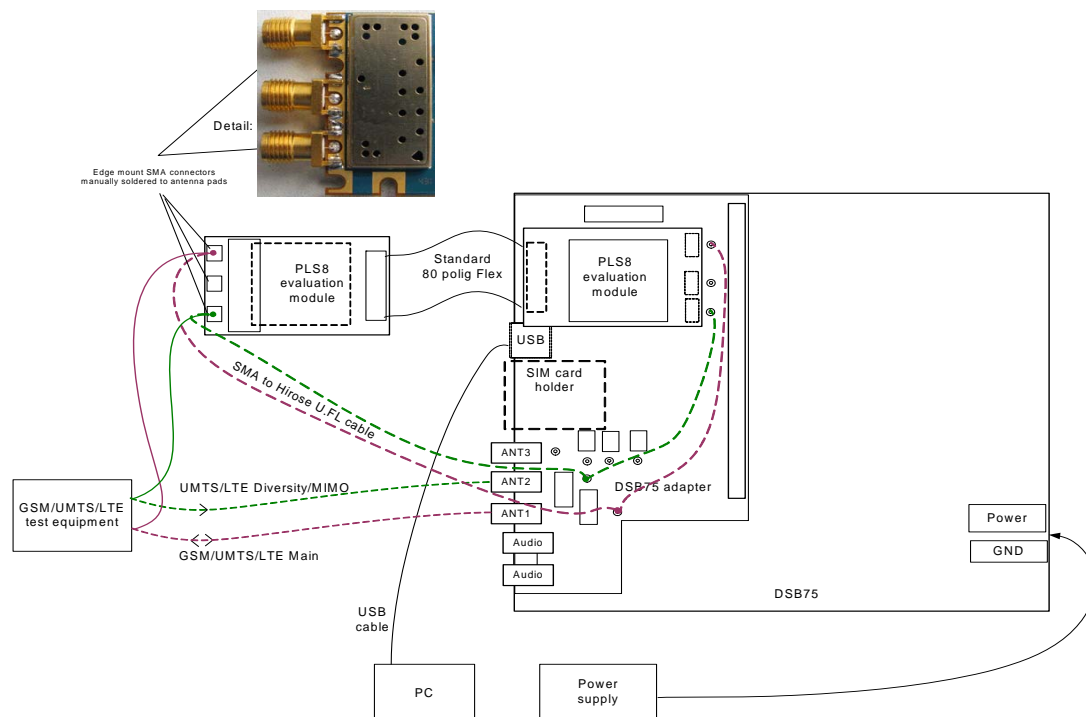


**Figure 35:**  Reference equipment for type approval

# 9      Appendix

## 9.1      List of Parts and Accessories

**Table 23:**  List of parts and accessories

| Description | Supplier | Ordering information |
|---|---|---|
| PLS8-E | Gemalto M2M | Standard module<br>Gemalto M2M IMEI:<br>Packaging unit (ordering) number: L30960-N3400-A100<br>Module label number: S30960-S3400-A100-1 |
| PLS8-E Evaluation Module | Gemalto M2M | Ordering number: L30960-N3401-A100 |
| DSB75 Support Box | Gemalto M2M | Ordering number: L36880-N8811-A100 |
| DSB75 adapter for mounting the evaluation module | Gemalto M2M | Ordering number: L30960-N2301-A100 |
| SIM card holder incl. push button ejector and slide-in tray | Molex | Ordering numbers:  91228<br>                             91236<br>Sales contacts are listed in Table 24. |
| U.FL antenna connector | Hirose or Molex | Sales contacts are listed in Table 24 and Table 25. |

9.1 List of Parts and Accessories

**Table 24:** Molex sales contacts (subject to change)

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

**Table 25:** Hirose sales contacts (subject to change)

| Hirose Ltd.<br>For further information please click:<br>http://www.hirose.com | Hirose Electric (U.S.A.) Inc<br>2688 Westhills Court<br>Simi Valley, CA 93065<br>U.S.A.<br><br>Phone: +1-805-522-7958<br>Fax: +1-805-522-3217 | Hirose Electric Europe B.V.<br>German Branch:<br>Herzog-Carl-Strasse 4<br>73760 Ostfildern<br>Germany<br><br>Phone: +49-711-456002-1<br>Fax: +49-711-456002-299<br>Email: info@hirose.de |
|---|---|---|
| Hirose Electric Europe B.V.<br>UK Branch:<br>First Floor, St. Andrews House,<br>Caldecotte Lake Business Park,<br>Milton Keynes MK7 8LE<br>Great Britain<br><br>Phone: +44-1908-369060<br>Fax: +44-1908-369078 | Hirose Electric Co., Ltd.<br>5-23, Osaki 5 Chome,<br>Shinagawa-Ku<br>Tokyo 141<br>Japan<br><br>Phone: +81-03-3491-9741<br>Fax: +81-03-3493-2933 | Hirose Electric Europe B.V.<br>Hogehillweg 8<br>1101 CC Amsterdam Z-O<br>Netherlands<br><br>Phone: +31-20-6557-460<br>Fax: +31-20-6557-469 |

## 9.2     Mounting Advice Sheet

To prevent mechanical damage, be careful not to force, bend or twist the module. Be sure it is soldered flat against the host device (see also Section 6.2). The advice sheet on the next page shows a number of examples for the kind of bending that may lead to mechanical damage of the module (the module as part of an external application is integrated into a housing).
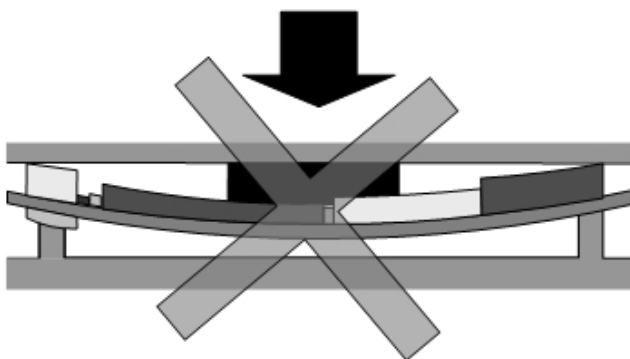
**Mounting Advice**

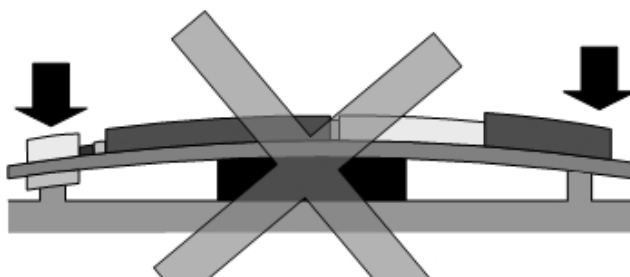# Do NOT BEND the Module
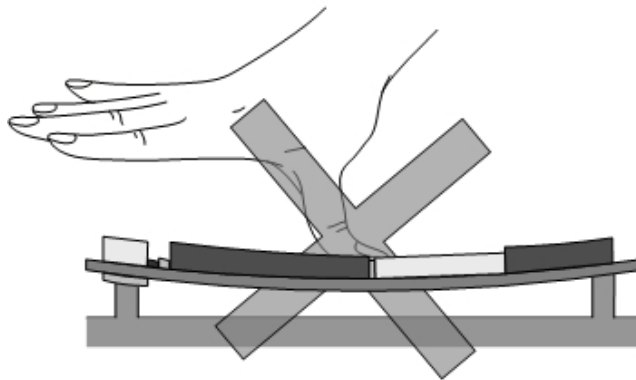
- By pressing from above
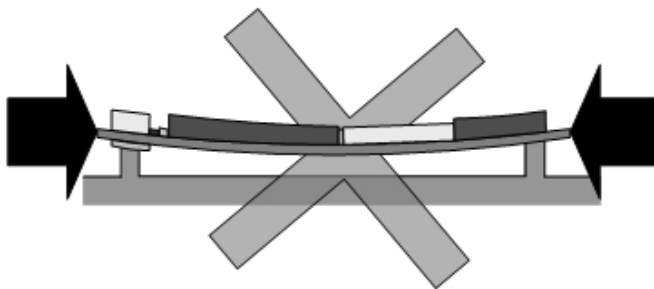
- By mounting under pressure

- By putting objects on top

- By putting objects below

## About Gemalto

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

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

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

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

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security to be free