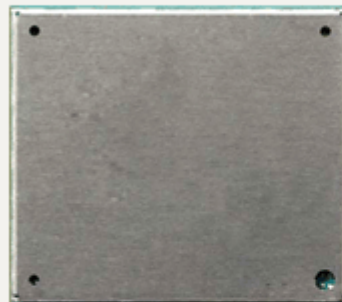


Cinterion[®] PLS8-E

Hardware Interface Description

Version: 04.001

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0 Document History

Preceding document: "Cinterion® PLS8-E Hardware Interface Description" v03.915

New document: "Cinterion® PLS8-E Hardware Interface Description" v04.001

Chapter	What is new
Throughout document	Revised names for digital audio lines, and replaced names as follows: PCM_I2S_IN --> DIN, PCM_I2S_OUT --> DOUT, PCM_I2S_FSC --> FSC, PCM_I2S_CLK --> BCLK, I2S_MCLKOUT --> MCLK
1.4.1 , 1.4.2	Revised information with regard to the new Radio Equipment Directive (RED).
3.6	Added remark about maximum USB cable length.
5.1.3	New section ESD Protection for Antenna Interfaces .
6.7	New section Electrical Characteristics of the Voiceband Part .
10.1	Added note for manufacturing information.

Preceding document: "Cinterion® PLS8-E Hardware Interface Description" v03.017

New document: "Cinterion® PLS8-E Hardware Interface Description" v03.915

Chapter	What is new
Throughout document	Added Galileo as supported GNSS.
1.4.1	Revised tables listing directives and standards.
2.1	Added VoLTE support for multiple operators as new feature.
3.3.5.1	Removed undertemperature shutdown URC.
6.10	Revised CDM rating in Table 30 .
7.3.2.1	Revised MSL label shown in Figure 48 .
10.1	Updated ordering information.

Preceding document: "Cinterion® PLS8-US Hardware Interface Description" v03.016

New document: "Cinterion® PLS8-US Hardware Interface Description" v03.017

Chapter	What is new
3.4	Revised description of power saving configuration and added Section 3.4.1 , Section 3.4.2 and Section 3.4.3 again.
3.6.1	Revised section to include remark about data connections.
6.5	Added comment for CCIN.
7.2.3.1	Revised Table 31 listing reflow temperature ratings.
7.2.3.2	Added remark on ramp-down rate.
10.1	Added note for module label information.

Preceding document: "Cinterion® PLS8-US Hardware Interface Description" v03.012

New document: "Cinterion® PLS8-US Hardware Interface Description" v03.016

Chapter	What is new
3.12.1	Revised section to mention VCC μ C in PWR_IND circuit.
6.2.1	Revised temperature allocation model given in Table 18 .

Preceding document: "Cinterion® PLS8-E Hardware Interface Description" v02.011c
 New document: "Cinterion® PLS8-US Hardware Interface Description" v03.012

Chapter	What is new
Throughout document	Added second USIM interface. Added real time clock (RTC) information. Added VDDL P line information. Added information on dead reckoning synchronization line.
1.4.1	Updated section on directives and standards.
2.1	Added WB-AMR and USAT as supported features.
3.3.4	Revised section including Figure 7 .
3.4	Revised description of power save mode and removed previous sections 3.4.1, 3.4.2 and 3.4.2.
3.5	New section RTC Backup .
3.7	Added further fixed baud rates at which ASC0 can be operated.
3.12.3	Revised description of remote host wakeup functionality. Updated other sections accordingly.
3.12.4	Revised LCI_IND to be configurable for all GPIOs.
5.2	Revised ratings for VGNSS in Figure 31 .
6.5	Added characteristics for VDDL P line (RTC backup) in Table 22 . Host wakeup functionality added for GPIOs in Table 22 .
6.6	Added current consumption rating for GPRS data transfer (4Tx/1Rx @ total mismatch). Revised average GSM/UMTS/LTE current consumption ratings while GNSS is ON. Revised current consumption ratings for IDLE mode listed in Table 29 .
7.2.3.1	Revised ramp down rate given in Table 31 .
10.1	Updated ordering information.

Preceding document: "Cinterion® PLS8-E Hardware Interface Description" v02.011b
 New document: "Cinterion® PLS8-E Hardware Interface Description" v02.011c

Chapter	What is new
7.2.3.1	Revised description for average ramp up and ramp down rates given in Table 31 .

Preceding document: "Cinterion® PLS8-E Hardware Interface Description" v02.011
 New document: "Cinterion® PLS8-E Hardware Interface Description" v02.011a

Chapter	What is new
3.4	Added reference to AT commands used to configure power saving behavior.
3.4.4	New section Wake-up via RTS0 .

Preceding document: "PLS8-E Hardware Interface Description" v01.460
 New document: "Cinterion® PLS8-E Hardware Interface Description" v02.011

Chapter	What is new
---	Version update.

Preceding document: "PLS8-E Hardware Interface Description" Version 01.460

New document: "PLS8-E Hardware Interface Description" Version 01.460a

Chapter	What is new
Throughout document	Added LTE 2100MHz (Bd1).
7.2.3.1	Added note regarding reflow profile features and ratings listed in Table 31 .

Preceding document: "PLS8-E Hardware Interface Description" v01.438

New document: "PLS8-E Hardware Interface Description" v01.460

Chapter	What is new
7.2.3.1	Revised average ramp-down rate listed in Table 31 .
8.1	New section Sample Level Conversion Circuit .

Preceding document: "PLS8-E Hardware Interface Description" v01.000c

New document: "PLS8-E Hardware Interface Description" v01.438

Chapter	What is new
Throughout document	Added power saving (SLEEP mode). See particularly Section 3.4.1 , Section 3.4.3 . Added ASC0 interface. See particularly Section 3.7 . Added PCM / I ² S interface. See particularly Section 3.9 . Added ADC3_IN line. See particularly Section 3.10 . Added host wakeup via RING0 line. See particularly Section 3.12.2 . Added Low Current indicator. See particularly Section 3.12.4 . Added STATUS line. See particularly Section 3.12.5 . Added GNSS receiver description. See particularly Section 4 . Added GNSS interface. See particularly Section 5.2 .
3.3.1	Added information on " ^SYSSTART " and " ^SYSSTART AIRPLANE " URCs.
3.3.5.2	New section Deferred Shutdown at Extreme Temperature Conditions .
3.11	Added: GPIOs can be used to wake up the module from SLEEP mode.
3.12.3	New section Remote Wakeup .
6.6	Completed Table 24 showing current consumption ratings.
10.1	Updated ordering numbers.

1 Introduction

The document¹ 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] AT Command Set for your Gemalto M2M product
- [2] Release Notes for your Gemalto M2M product
- [3] Application Note 48: SMT Module Integration
- [4] Universal Serial Bus Specification Revision 2.0, April 27, 2000

1.3 Terms and Abbreviations

Abbreviation	Description
AMR	Adaptive Multirate
ANSI	American National Standards Institute
ARP	Antenna Reference Point
BIP	Bearer Independent Protocol
CE	Conformité Européene (European Conformity)
CS	Coding Scheme
CS	Circuit Switched
CSD	Circuit Switched Data
CSFB	Circuit Switched Fallback
DCS	Digital Cellular System
DL	Download
dnu	Do not use
DRX	Discontinuous Reception
DSB	Development Support Board

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

1.3 Terms and Abbreviations

Abbreviation	Description
DTX	Discontinuous Transmission
EDGE	Enhanced Data rates for GSM Evolution
EFR	Enhanced Full Rate
EGSM	Extended GSM
EMC	Electromagnetic Compatibility
ESD	Electrostatic Discharge
ETS	European Telecommunication Standard
ETSI	European Telecommunications Standards Institute
FDD	Frequency Division Duplex
FR	Full Rate
GPRS	General Packet Radio Service
GSM	Global Standard for Mobile Communications
HiZ	High Impedance
HR	Half Rate
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
PCB	Printed Circuit Board
PCL	Power Control Level

1.3 Terms and Abbreviations

Abbreviation	Description
PCS	Personal Communication System, also referred to as GSM 1900
PD	Pull Down resistor
PDU	Protocol Data Unit
PS	Packet Switched
PSK	Phase Shift Keying
PU	Pull Up resistor
QAM	Quadrature Amplitude Modulation
R&TTE	Radio and Telecommunication Terminal Equipment
RF	Radio Frequency
rfu	Reserved for future use
ROPR	Radio Output Power Reduction
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	Signaling 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
USAT	U/SIM Application Toolkit
WB-AMR	Wideband Adaptive Multirate
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



2014/53/EU	<p>Directive of the European Parliament and of the council of 16 April 2014 on the harmonization of the laws of the Member States relating to the making available on the market of radio equipment and repealing Directive 1999/05/EC.</p> <p>The product is labeled with the CE conformity mark.</p> 
2002/95/EC (RoHS 1) 2011/65/EC (RoHS 2)	<p>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)</p> 

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 V12.5.1	Global System for Mobile communications (GSM); Mobile Stations (MS) equipment; Harmonized Standard covering the essential requirements of article 3.2 of Directive 2014/53/EU
GCF-CC V3.64	Global Certification Forum - Certification Criteria
Draft ETSI EN 301 489-01 V2.1.1	Electromagnetic Compatibility (EMC) standard for radio equipment and services; Part 1: Common technical requirements; Harmonized Standard covering the essential requirements of article 3.1(b) of Directive 2014/53/EU and the essential requirements of article 6 of Directive 2014/30/EU
Draft ETSI EN 301 489-19 V2.1.0	Electromagnetic Compatibility (EMC) standard for radio equipment and services; Part 19: Specific conditions for Receive Only Mobile Earth Stations (ROMES) operating in the 1,5 GHz band providing data communications and GNSS receivers operating in the RNSS band (ROGNSS) providing positioning, navigation, and timing data; Harmonized Standard covering the essential requirements of article 3.1(b) of Directive 2014/53/EU
Draft ETSI EN 301 489-52 V1.1.0	Electromagnetic Compatibility (EMC) standard for radio equipment and services; Part 52: Specific conditions for Cellular Communication Mobile and portable (UE) radio and ancillary equipment; Harmonized Standard covering the essential requirements of article 3.1(b) of Directive 2014/53/EU
ETSI EN 301 908-01 V11.1.1	IMT cellular networks; Harmonized Standard covering the essential requirements of article 3.2 of the Directive 2014/53/EU; Part 1: Introduction and common requirements
ETSI EN 301 908-02 V11.1.1	IMT cellular networks; Harmonized Standard covering the essential requirements of article 3.2 of the Directive 2014/53/EU; Part 2: CDMA Direct Spread (UTRA FDD) User Equipment (UE)

1.4 Regulatory and Type Approval Information

Table 2: Standards of European type approval

ETSI EN 301 908-13 V11.1.1	IMT cellular networks; Harmonized Standard covering the essential requirements of article 3.2 of the Directive 2014/53/EU; Part 13: Evolved Universal Terrestrial Radio Access (E-UTRA) User Equipment (UE)
ETSI EN 300 440 V2.1.1	Short Range Devices (SRD); Radio equipment to be used in the 1 GHz to 40 GHz frequency range; Harmonized Standard covering the essential requirements of article 3.2 of the Directive 2014/53/EU
IEC/EN 60950-1:2006+ A11:2009+A1:2010+ A12:2011+A2:2013	Safety of information technology equipment

Table 3: Requirements of quality

IEC 60068	Environmental testing
DIN EN 60529	IP codes

1.4 Regulatory and Type Approval Information

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	<p>“Marking for Control of Pollution Caused by Electronic Information Products” (2006-06).</p> <p>According to the “Chinese Administration on the Control of Pollution caused by Electronic Information Products” (ACPEIP) the EPUP, i.e., Environmental Protection Use Period, of this product is 20 years as per the symbol shown here, unless otherwise marked. The EPUP is valid only as long as the product is operated within the operating limits described in the Hardware Interface Description.</p> <p>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.</p>



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

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

O:
表示该有毒有害物质在该部件所有均质材料中的含量均在SJ/T11363-2006 标准规定的限量要求以下。
Indicates that this toxic or hazardous substance contained in all of the homogeneous materials for this part is below the limit requirement in SJ/T11363-2006.

X:
表示该有毒有害物质至少在该部件的某一均质材料中的含量超出SJ/T11363-2006标准规定的限量要求。
Indicates that this toxic or hazardous substance contained in at least one of the homogeneous materials used for this part *might exceed* the limit requirement in SJ/T11363-2006.

1.4.2 SAR requirements specific to portable mobiles

Mobile phones, PDAs or other portable transmitters and receivers incorporating a GSM/UMTS/LTE 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)
EN 62311:2008	Assessment of electronic and electrical equipment related to human exposure restrictions for electromagnetic fields (0 Hz - 300 GHz)






1.4 Regulatory and Type Approval Information

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.

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

2 Product Concept

2.1 Key Features at a Glance

Feature	Implementation
General	
Frequency bands	GSM/GPRS/EDGE: Dual band, 900/1800MHz UMTS/HSPA+: Triple band, 900 (BdVIII) / 1800 (BdIII) / 2100MHz (BdI) LTE: Five band, 800 (Bd20) / 900 (Bd8) / 1800 (Bd3) / 2100 (Bd1) / 2600MHz (Bd7)
GSM class	Small MS
Output power (according to Release 99)	Class 4 (+33dBm ±2dB) for EGSM900 Class 1 (+30dBm ±2dB) for GSM1800 Class E2 (+27dBm ± 3dB) for GSM 900 8-PSK Class 2 (+26dBm +3 /-4dB) for GSM 1800 8-PSK Class 3 (+24dBm +1/-3dB) for UMTS 2100, WCDMA FDD BdI Class 3 (+24dBm +1/-3dB) for UMTS 1800, WCDMA FDD BdIII 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 Class 3 (+23dBm +-2dB) for LTE 2100, LTE FDD Bd1 Class 3 (+23dBm +-2dB) for LTE 1800, LTE FDD Bd3 Class 3 (+23dBm +-2dB) for LTE 900, LTE FDD Bd8 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 Extended operation: -40°C to +95°C
Physical	Dimensions: 33mm x 29mm x 2.2mm Weight: approx. 4.5g
RoHS	All hardware components fully compliant with EU RoHS Directive
LTE features	
3GPP Release 9	UE CAT 3 supported DL 100Mbps, UL 50Mbps 2x2 MIMO in DL direction
HSPA features	
3GPP Release 8	UE CAT. 14, 24 DC-HSPA+ – DL 42Mbps HSUPA – UL 5.76Mbps Compressed mode (CM) supported according to 3GPP TS25.212
UMTS features	
3GPP Release 8	PS data rate – 384 kbps DL / 384 kbps UL

2.1 Key Features at a Glance

Feature	Implementation
GSM / GPRS / EGPRS features	
Data transfer	GPRS: <ul style="list-style-type: none"> • Multislot Class 12 • Mobile Station Class B • Coding Scheme 1 – 4 EGPRS: <ul style="list-style-type: none"> • Multislot Class 12 • EDGE E2 power class for 8 PSK • Downlink coding schemes – CS 1-4, MCS 1-9 • Uplink coding schemes – CS 1-4, MCS 1-9 • SRB loopback and test mode B • 8-bit, 11-bit RACH • 1 phase/2 phase access procedures • Link adaptation and IR • NACC, extended UL TBF • Mobile Station Class B
SMS	Point-to-point MT and MO Cell broadcast Text and PDU mode
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 and ASC0
U/SIM application toolkit	USAT letter c; with BIP
Audio	Audio speech codecs GSM: WB-AMR, AMR, EFR, FR, HR 3GPP: WB-AMR, AMR Speakerphone operation, echo cancellation, noise suppression, 9 ringing tones VoLTE support for multiple operators, with CSFB
GNSS Features	
Protocol	NMEA (for GPS, GLONASS and Galileo related sentences)
Modes	Standalone GNSS Assisted GNSS - Control plane - E911 - User plane - gpsOneXTRA™
General	Power saving modes Power supply for active antenna
Interfaces	
Module interface	Surface mount device with solderable connection pads (SMT application interface). Land grid array (LGA) technology ensures high solder joint reliability and provides the possibility to use an optional module mounting socket. For more information on how to integrate SMT modules see also [3]. This application note comprises chapters on module mounting and application layout issues as well as on additional SMT application development equipment.

2.1 Key Features at a Glance

Feature	Implementation
Antenna	50Ω. GSM/UMTS/LTE main antenna, UMTS/LTE Diversity/MIMO antenna, (active/passive) GNSS antenna
USB	USB 2.0 High Speed (480Mbit/s) device interface
Serial interface	ASC0: <ul style="list-style-type: none"> 8-wire modem interface with status and control lines, unbalanced, asynchronous Adjustable baud rates: 115,200bps to 921,600bps Supports RTS0/CTS0 hardware flow control
UICC interface	2 UICC interfaces (switchable) Supported chip cards: UICC/SIM/USIM 3V, 1.8V
Audio	1 digital interface (PCM or I ² S)
Status	Signal line to indicate network connectivity state
RING0	Signal line to indicate incoming calls and other types of URCs
Power on/off, Reset	
Power on/off	Switch-on by hardware signal IGT Switch-off by AT command (AT^SMSO) or IGT 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) Rx Diversity (receiver type 3i - 64-QAM) / MIMO
GPIO	10 I/O pins of the application interface programmable as GPIO. GPIOs can be configured as low current indicator (LCI). GPIO1 can be configured as dead reckoning synchronization signal. GPIOs can be configured as remote host wakeup lines. Programming is done via AT commands.
ADC inputs	Analog-to-Digital Converter with three unbalanced analog inputs.
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 modules 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

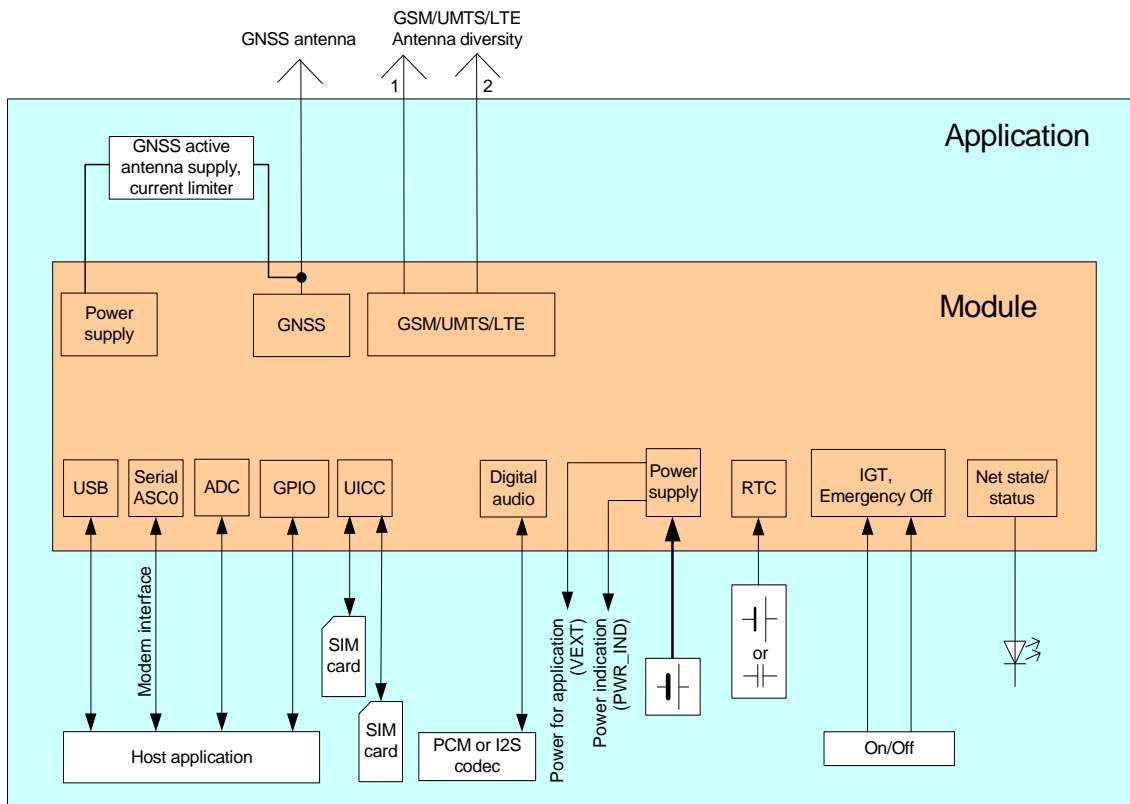


Figure 1: PLS8-E system overview

2.3 Circuit Concept

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/LTE 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
- GNSS receiver/Front end
- Antenna pad

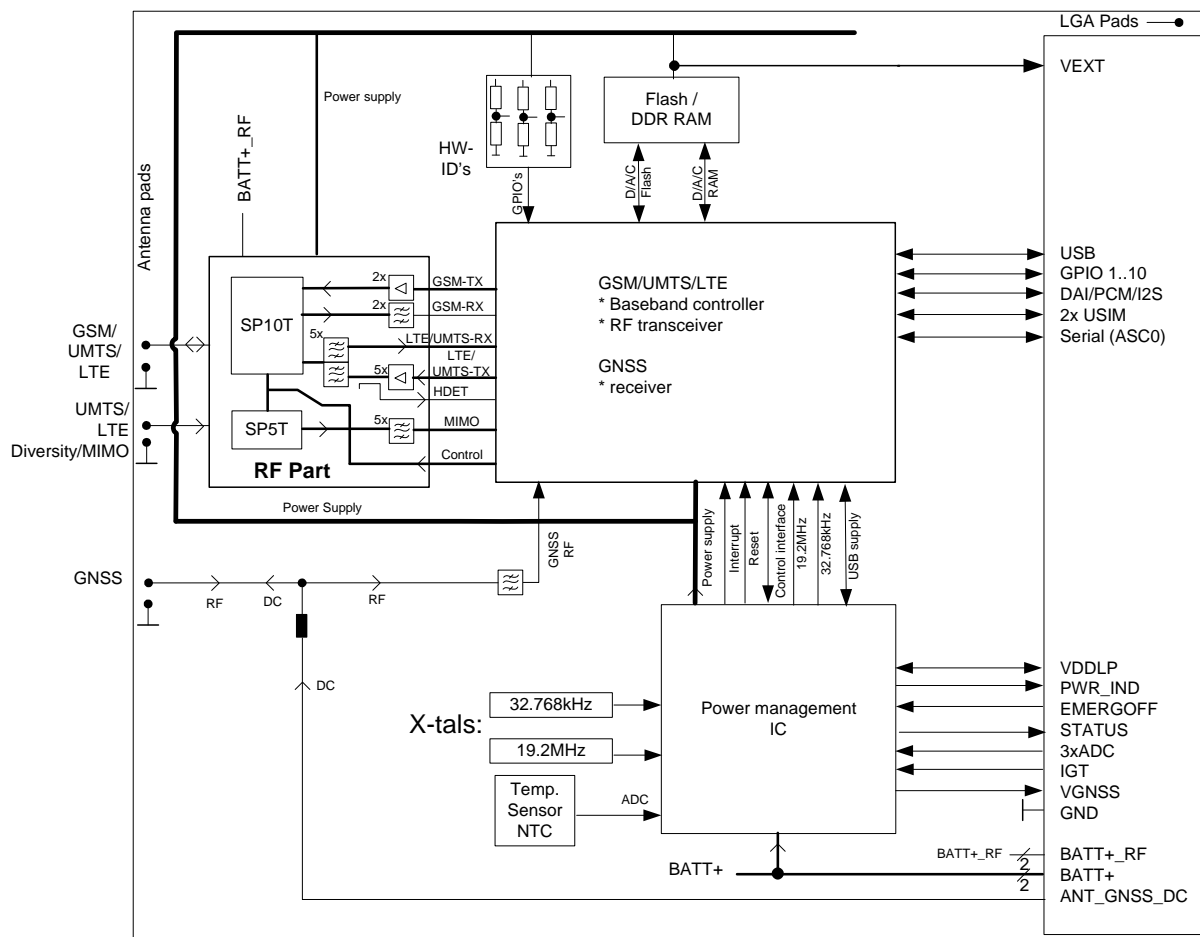


Figure 2: PLS8-E block diagram

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](#)
- RTC backup - see [Section 3.5](#)
- Serial interface USB - see [Section 3.6](#)
- Serial interface ASC0 - [Section 3.7](#)
- UICC/SIM/USIM interface - see [Section 3.8](#)
- Digital audio interface (PCM or I²S) - see [Section 3.9](#)
- ADC interface - [Section 3.10](#)
- GPIO interface - [Section 3.11](#)
- Control and status lines: PWR_IND, STATUS, RING0, STATUS, LCI - see [Section 3.12](#)

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 SLEEP Power saving set automatically when no call is in progress and the USB connection is detached and no active communication via ASC0. Also, the GNSS active antenna mode has to be turned off or set to "auto".
	GSM / GPRS / UMTS / HSPA / LTE IDLE Power saving disabled or an USB connection active, but 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. Only a voltage regulator is active for powering the RTC. Software is not active. Interfaces are not accessible. Operating voltage (connected to BATT+) remains applied.
Airplane mode	Airplane mode shuts down the radio part of the module, causes the module to log off from the GSM/GPRS network and disables all AT commands whose execution requires a radio connection. Airplane mode can be controlled by AT command (see [1]).

3.2 Power Supply

PLS8-E needs to be connected to a power supply at the SMT application interface - 4 lines 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 ($\geq 47\mu\text{F}$ MLCC @ BATT+; $\geq 4 \times 47\mu\text{F}$ MLCC @ BATT+_RF) as close as possible to LGA pads. [Figure 3](#) shows a sample circuit for decoupling capacitors for BATT+.

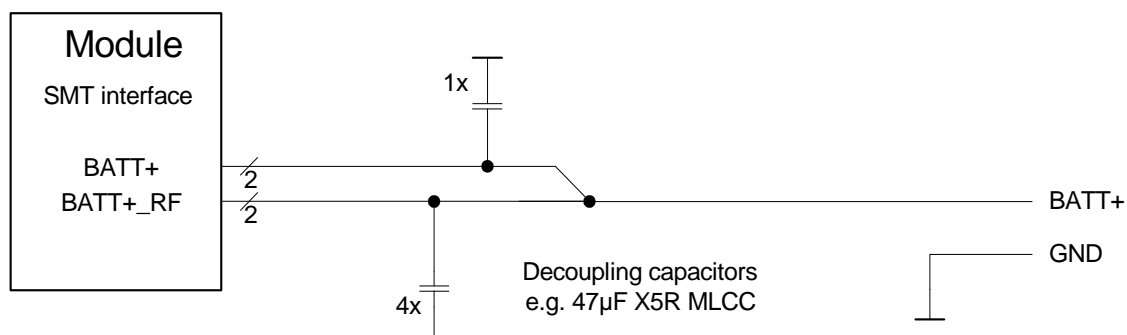


Figure 3: Decoupling capacitor(s) for BATT+

In addition, the VDDL P pad may be connected to an external capacitor or a battery to backup the RTC (see [Section 3.5](#)). Please note that for proper module startup the voltage at BATT+ should be higher than at VDDL P.

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 $V_{\text{BATT}+}$ 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 ($V_{\text{BATT} \text{ min}}$) is reached.

Example:

$V_{\text{I min}} = 3.3\text{V}$

$D_{\text{max}} = 0.4\text{V}$

$V_{\text{BATT min}} = V_{\text{I min}} + D_{\text{max}}$

$V_{\text{BATT min}} = 3.3\text{V} + 0.4\text{V} = 3.7\text{V}$

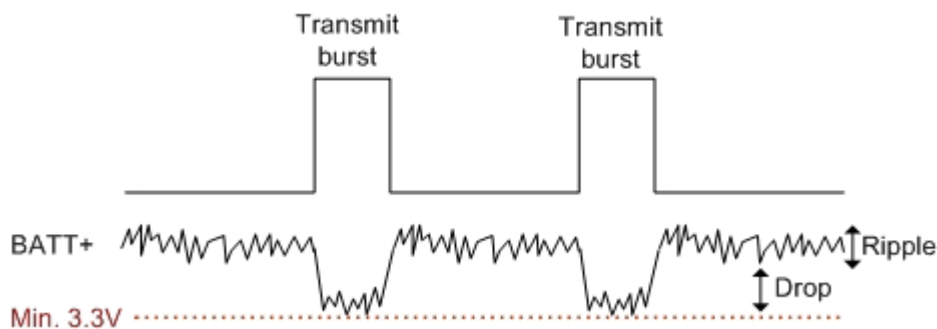


Figure 4: Power supply limits during transmit burst

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 0.5 seconds in DATA mode to 50 seconds 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 6.1](#). PLS8-E immediately switches 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 100 milliseconds. 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](#).

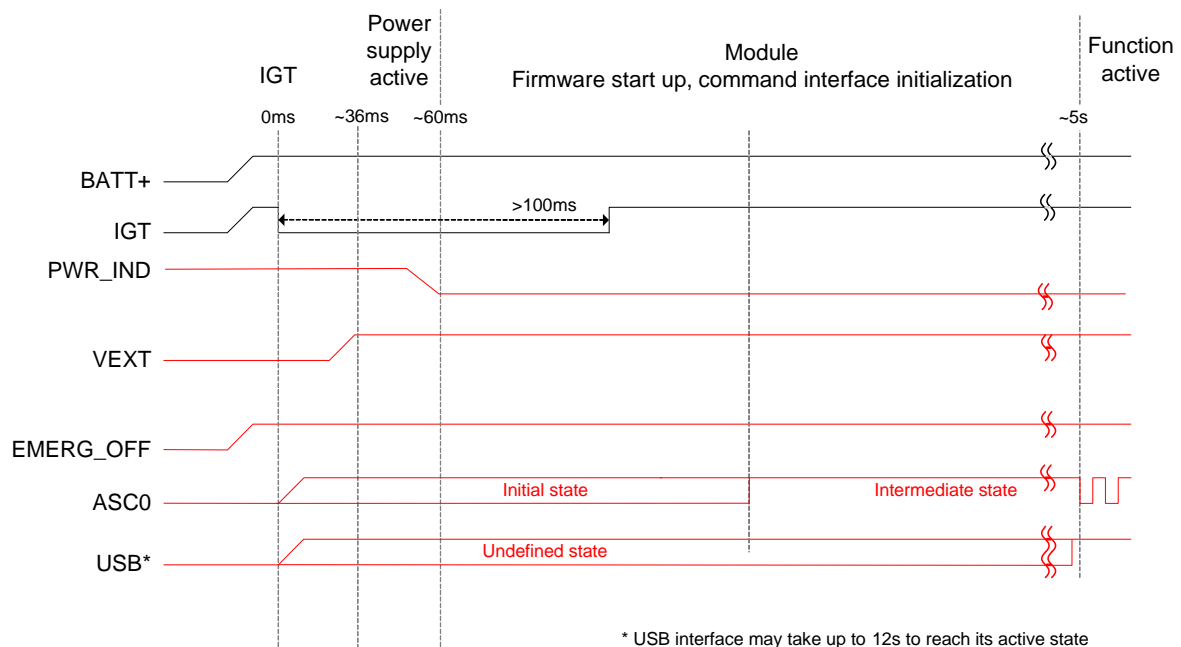


Figure 5: Power-on with IGT

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.

After startup or mode change the following URCs are sent to every port able to receive AT commands indicating the module's ready state:

- "`^SYSSTART`" indicates that the module has entered Normal mode.
- "`^SYSSTART AIRPLANE MODE`" indicates that the module has entered Airplane mode.

These URCs notify the external application that the first AT command can be sent to the module. If these URCs are not used to detect then the only way of checking the module's ready state is 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	Startup phase	State after first firmware initialization
	Duration appr. 60ms	Duration appr. 4s	After 4-5s
CCINx	PD and PU (24k)	PU(24k)	I, PU(24k)
CCRSTx	Not driven (similar PD)	Not driven (similar PD)	O, L ¹ O, H ²
CCIOx	PD(10k)	PD(10k)	PD(10k) ¹ PU(10k) ²
CCCLKx	Not driven (similar PD)	Not driven (similar PD)	O, L ¹ Clock ²
CCVCCx	Off	Off	Off ¹ 1.8V/3V ²
RXD0	PD	PU	PU
TXD0	PD	PD	PD
CTS0	PD	PD	PD
RTS0	PU and PD	PD	PD
DTR0	PD	PD	PD
DCD0	PD	PU ³	PD
DSR0	PD	PD	PD
RING0	PD	O, H	O, H
DIN	PU	PD	PD
BCLK	PD	PD	PD
FSC	PD	PD	PD
DOUT	PD	PD	PD
MCLK	PD	PD	PD
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 ⁴	PD	PD	PD

1. If CCIN = High level

2. If CCIN = Low level

3. No external pull down allowed during this phase.

4. Please note that during its startup phase the GPIO8 signal will be in an active low state for approx. 80ms.

L = Low level H = High level I = Input O = Output	PD = Pull down resistor with approx. 100k ¹ PD(...k) = Pull down resistor with ...k PU = Pull up resistor with approx. 100k PU(...k) = Pull up resistor with ...k, Z = High impedance
--	--

¹: 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 save data before disconnecting the power supply. The mode is referred to as Power Down mode. In this mode, only the RTC stays active. After sending AT^SMSO do not enter any other AT commands. While powering down the module may still send some URCs. 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.

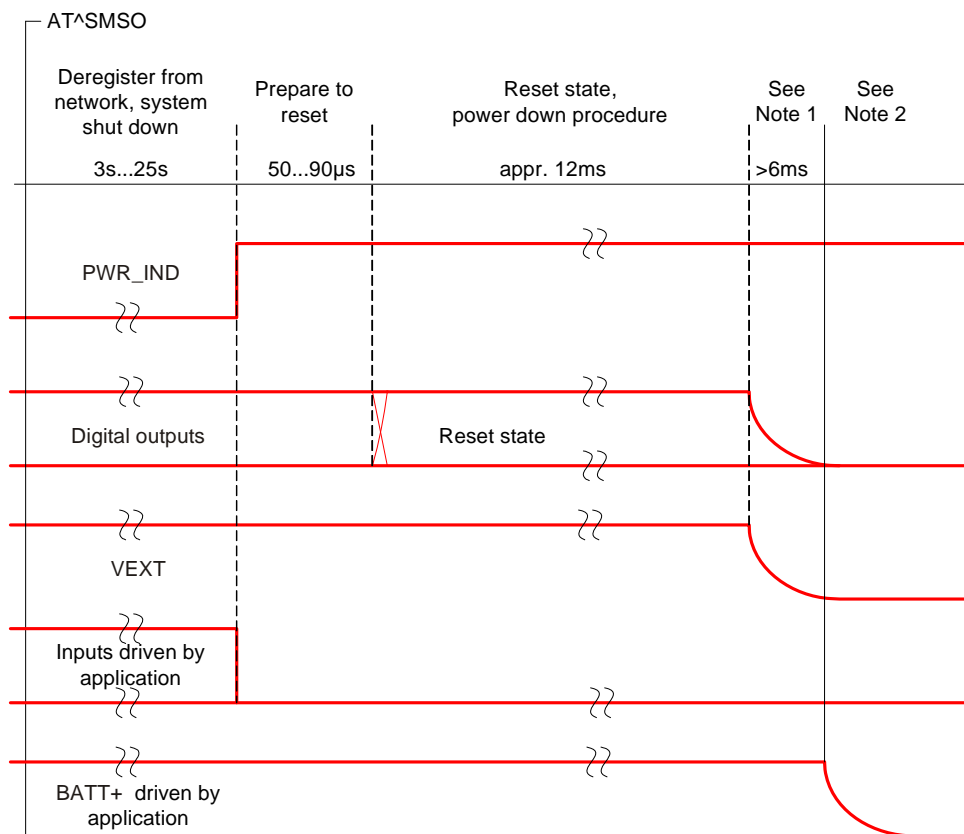


Figure 6: Signal states during turn-off procedure

Note 1: Depending on capacitance load from host application

Note 2: The power supply voltage (BATT+) may be disconnected or 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 1 second before restarting the module.

3.3.4 Turn off PLS8-E Using IGT Line

The IGT line can be configured for use in two different switching modes: You can set the IGT line to switch on the module only, or to switch it on and off. The switching mode is determined by the parameter "MEShutdown/OnIgnition" of the AT^SCFG command. This approach is useful for external application manufacturers who wish to have an ON/OFF switch installed on the host device.

By factory default, the ON/OFF switch mode of IGT is disabled:

```
at^scfg=meshutdown/onignition          # Query the current status of IGT.
^SCFG: "MEShutdown/OnIgnition","off"   # IGT can be used only to switch on PLS8-E.
OK                                       IGT works as described in Section 3.3.1.
```

To configure IGT for use as ON/OFF switch:

```
at^scfg=meshutdown/onignition          # Enable the ON/OFF switch mode of IGT.
^SCFG: "MEShutdown/OnIgnition","on"    # IGT can be used to switch on and off PLS8-E.
OK
```

Take great care before changing the switching mode of the IGT line. To ensure that the IGT line works properly as ON/OFF switch it is of vital importance that the following conditions are met:

Switch-on condition: If the PLS8-E is off, the IGT line must be asserted for at least 100 milliseconds before being released.

Switch-off condition: If the PLS8-E is on, the IGT line must be asserted for at least 2.15 seconds 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 5 seconds after startup.

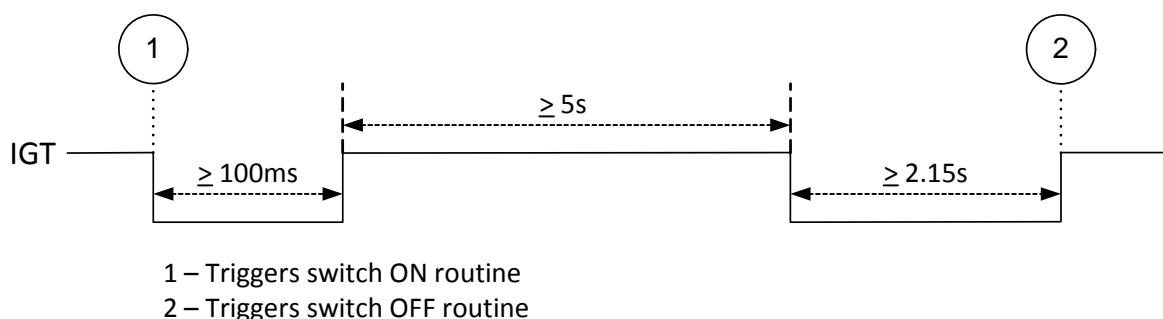


Figure 7: Timing of IGT if used as ON/OFF switch

3.3.5 Automatic Shutdown

Automatic shutdown takes effect if:

- The PLS8-E board exceeds the critical limits of overtemperature
- 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 3.3.5.4](#) for details. For further instructions on AT commands refer to [\[1\]](#).

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 2 minutes guard period after start-up of PLS8-E. After expiry of the 2 minutes 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" 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.

3.3 Power-Up / Power-Down Scenarios

The maximum temperature ratings are stated in [Section 6.2](#). Refer to [Table 8](#) for the associated URCs.

Table 8: Temperature dependent behavior

Sending temperature alert (2 minutes 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.

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.

3.3.5.2 Deferred Shutdown at Extreme Temperature Conditions

In the following cases, automatic shutdown will be deferred if a critical temperature limit is exceeded:

- While an emergency call is in progress.
- During a two minute guard period after power-up. This guard period has been introduced in order to allow for the user to make an emergency call. The start of any one of these calls extends the guard period until the end of the call. Any other network activity may be terminated by shutdown upon expiry of the guard time.

While in a "deferred shutdown" situation, PLS8-E continues to measure the temperature and to deliver alert messages, but deactivates the shutdown functionality. Once the 2 minute guard period is expired or the call is terminated, full temperature control will be resumed. If the temperature is still out of range, PLS8-E switches off immediately (without another alert message).

CAUTION! Automatic shutdown is a safety feature intended to prevent damage to the module. Extended usage of the deferred shutdown facilities provided may result in damage to the module, and possibly other severe consequences.

3.3.5.3 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.

3.3.5.4 Overvoltage Shutdown

The overvoltage shutdown threshold is 100mV above the maximum supply voltage V_{BATT+} specified in [Table 22](#).

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 40 milliseconds. After the 40 milliseconds and an additional delay period of 500 milliseconds the module shuts down as shown in [Figure 8](#).

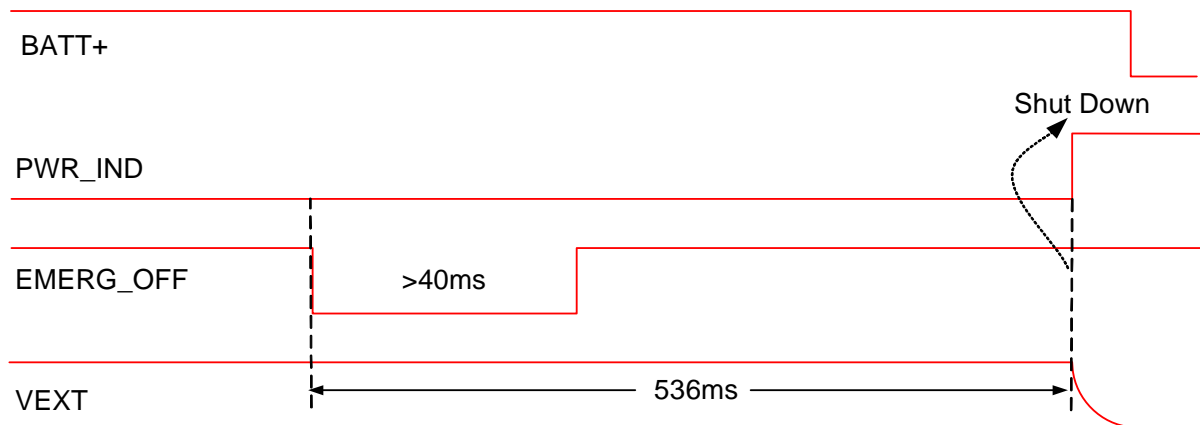


Figure 8: Shutdown by EMERG_OFF signal

Note: The power supply voltage (BATT+) may be disconnected or 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 Power Saving

PLS8-E is able to reduce its functionality to a minimum (during the so-called SLEEP mode) in order to minimize its current consumption. The following sections explain the module's network dependent power saving behavior. The power saving behavior is further configurable by AT command:

- AT^SCFG= "MEopMode/PwrSave": The power save mode is by default enabled. While inactive, the module stays in power save (SLEEP) state, waking up only upon any of the following events:
 - Cyclically to meet basic technical demands, e.g. network requirements (such as regularly listening to paging messages from the base station as described in [Section 3.4.1](#), [Section 3.4.2](#) and [Section 3.4.3](#).
 - Cyclically after expiry of a configured power saving period.
 - Data at any interface port, e.g., URCs for incoming calls.
 - A level state transition at GPIO1, GPIO3, GPIO4, GPIO5 and GPIO9.
- AT^SCFG= "MEopMode/ExpectDTR": Power saving will take effect only if there is no transmission data pending on any of the module's USB ports. The expect DTR AT command ensures that data becoming pending on any USB port before an external application has signaled its readiness to receive the data is discarded. By default this behavior is enabled for all available USB CDC ACM and CDC ECM ports.
- AT^SCFG="Radio/OutputPowerReduction": Output power reduction is possible for the module in GPRS multislots scenarios to reduce its output power according to 3GPP 45.005 section.

Please refer to [\[1\]](#) for more information on the above AT commands used to configure the module's power saving behavior.

The implementation of the USB host interface also influences the module's power saving behavior and therefore its current consumption. For more information see [Section 3.6](#). Another feature influencing the current consumption is the configuration of the GNSS antenna interface. For details see [Section 6.9](#). Also note that the command AT^SBV, which allows to monitor the module's power supply, is only available if the module is not in SLEEP mode. This means, the shorter the power saving periods, the faster and more precise the module's power supply monitoring is going to be (see also [Section 3.2.2](#)).

3.4.1 Power Saving while Attached to GSM Networks

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

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

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

Now, a paging timing cycle consists of the actual fixed length paging plus a variable length pause before the next paging. In the pauses between listening to paging messages, the module resumes power saving, as shown in [Figure 9](#).

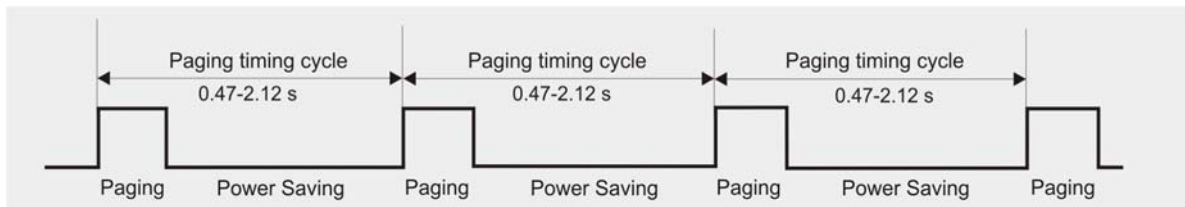


Figure 9: Power saving and paging in GSM networks

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

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

3.4.2 Power Saving while Attached to WCDMA Networks

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

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

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

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

Now, a paging timing cycle consists of the actual fixed length paging plus a variable length pause before the next paging. In the pauses between listening to paging messages, the module resumes power saving, as shown in [Figure 10](#).

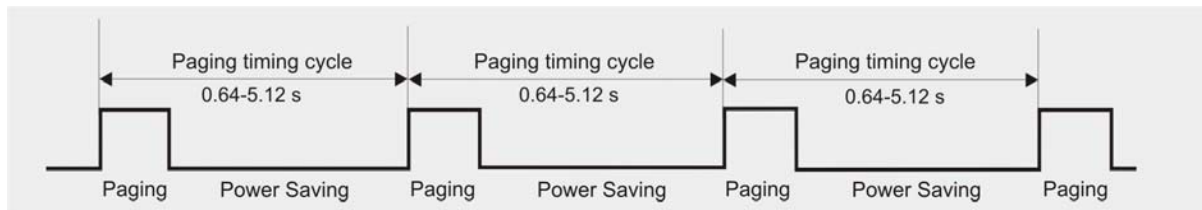


Figure 10: Power saving and paging in WCDMA networks

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

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

3.4.3 Power Saving while Attached to LTE Networks

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

During normal LTE operation, i.e., the module is connected to an LTE network, the duration of a paging timing cycle varies. It may be calculated using the following formula:

$$t = \text{DRX Cycle Value} * 10 \text{ ms}$$

DRX cycle value in LTE networks is any of the four values: 32, 64, 128 and 256, thus resulting in paging timing cycles between 0.32 and 2.56 seconds. The DRX cycle value of the base station is assigned by the LTE network operator.

Now, a paging timing cycle consists of the actual fixed length paging plus a variable length pause before the next paging. In the pauses between listening to paging messages, the module resumes power saving, as shown in [Figure 11](#).

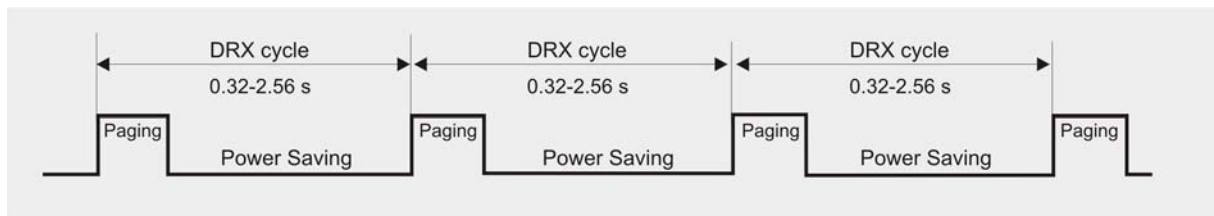


Figure 11: Power saving and paging in LTE networks

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

Generally, power saving depends on the module's application scenario and may differ from the above mentioned normal operation. The power saving interval may be shorter than 0.32 seconds or longer than 2.56 seconds.

3.4.4 Wake-up via RTS0

RTS0 can be used to wake up PLS8-E from SLEEP mode. Assertion of RTS0 (i.e., toggle from inactive high to active low) serves as wake up event, thus allowing an external application to almost immediately terminate power saving. After RTS0 assertion, the CTS0 line signals module wake up, i.e., readiness of the AT command interface. It is therefore recommended to enable RTS/CTS flow control (default setting).

Figure 12 shows the described RTS0 wake up mechanism.

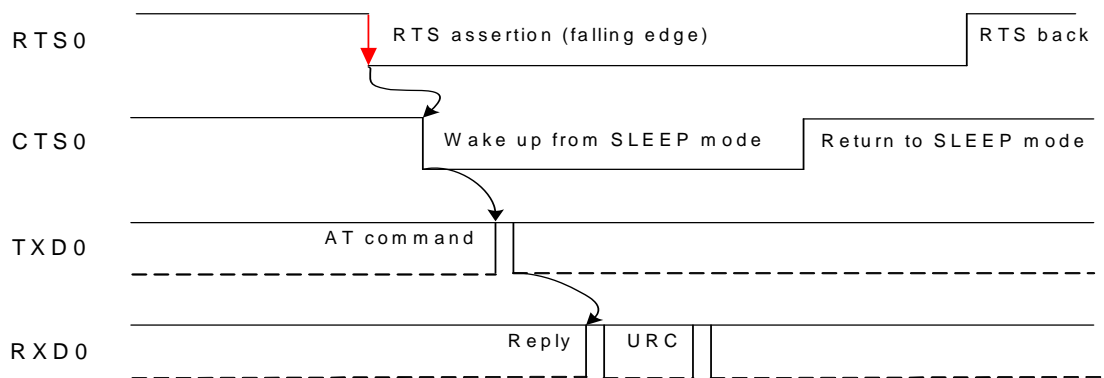


Figure 12: Wake-up via RTS0

3.5 RTC Backup

The internal Real Time Clock of PLS8-E is supplied from a separate voltage regulator in the power supply component which is also active when PLS8-E is in Power Down mode and BATT+ is available. An alarm function is provided that allows to wake up PLS8-E. When the alarm time is reached the module wakes up to the functionality level (AT+CFUN) that was valid before power down. For example, if the module was in Airplane mode before power down, the module will wake up without logging on to the GSM/UMTS/LTE network.

In addition, you can use the VDDLp pad on the SMT interface to backup the RTC from an external capacitor or a battery (rechargeable or non-chargeable). The capacitor is charged from the internal LDO of PLS8-E. If the voltage supply at BATT+ is disconnected the RTC can be powered by the capacitor. The size of the capacitor determines the duration of buffering when no voltage is applied to PLS8-E, i.e. the greater the capacitor the longer PLS8-E will save the date and time. It limits the output current of an empty capacitor or battery.

Figure 13 show various sample configurations.

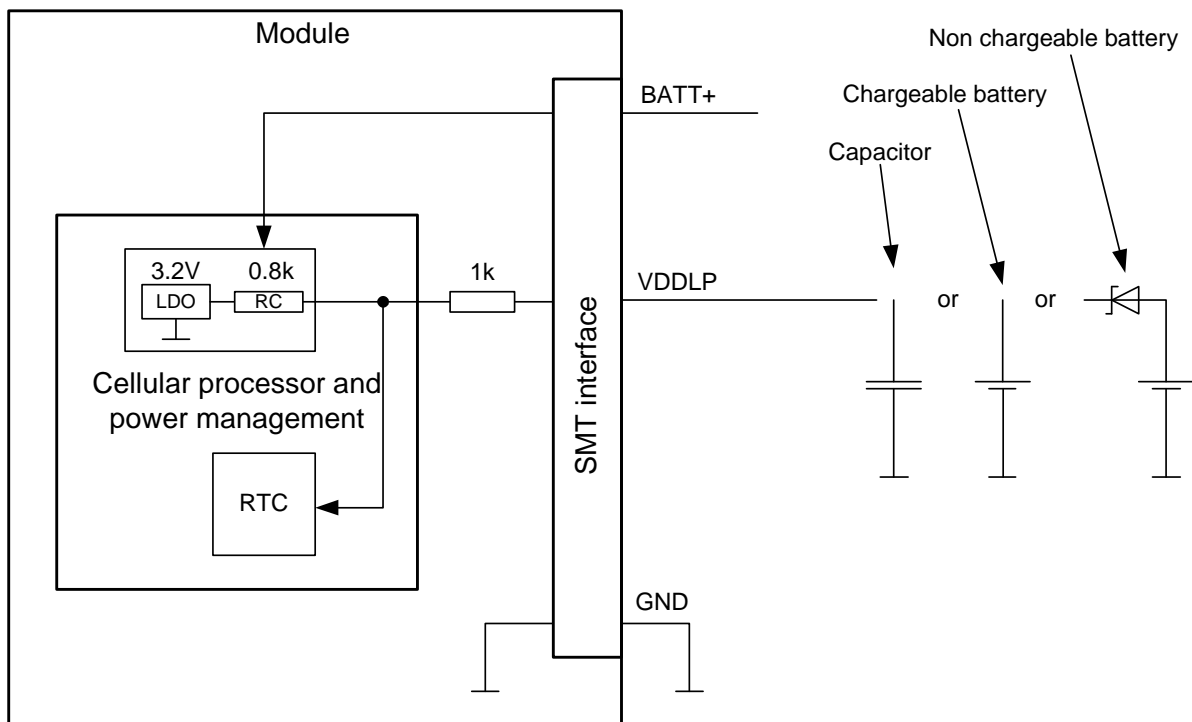
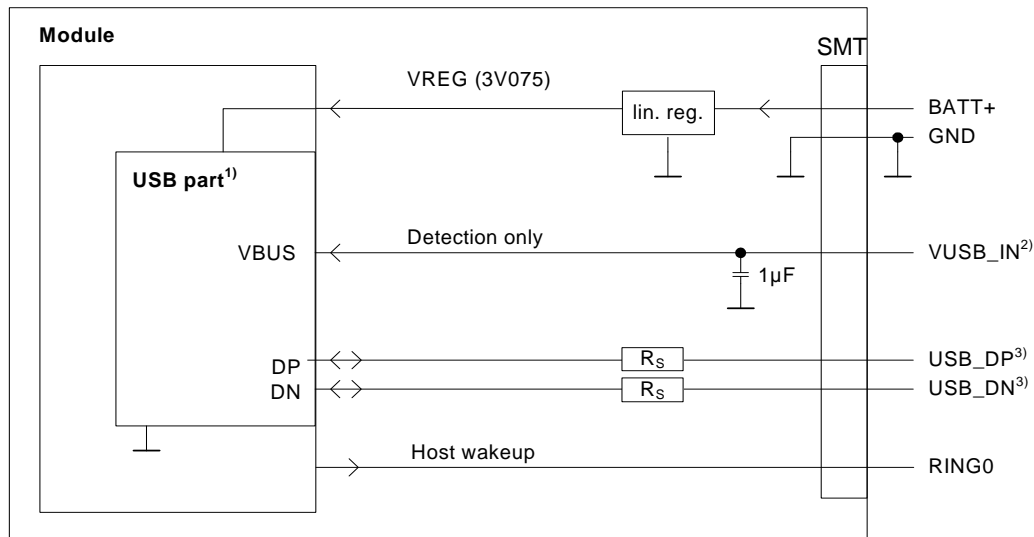


Figure 13: RTC supply variants

3.6 USB Interface

PLS8-E supports a USB 2.0 High Speed (480Mbps) device interface. 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 90 ohms for proper signal integrity.

Figure 14: USB circuit

To properly connect the module's USB interface to the external application, a USB 2.0 compatible connector and cable or hardware design is required. If all connections and impedances are within the USB 2.0 specification range, a USB cable can be up to 5m long. For more information on the USB related signals see also [Table 22](#). 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/usb20_docs/

3.6.1 Reducing Power Consumption

While a USB connection is active, the module will never switch into SLEEP mode. Only if the USB interface is in Suspended state or Detached (i.e., VUSB_IN = 0) is the module able to switch into SLEEP mode thereby saving power¹. There are two possibilities to enable power reduction mechanisms:

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

The USB host should be able to bring its USB interface into the Suspended state as described in the "Universal Serial Bus Specification Revision 2.0"². For this functionality to work, the VUSB_IN line should always be kept enabled. On incoming calls and other events PLS8-E will then generate a Remote Wakeup request to resume the USB host controller.

See also [4] (USB Specification Revision 2.0, Section 10.2.7, p.282):

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

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

As an alternative to the regular USB suspend and resume mechanism it is possible to employ a remote wakeup line (e.g., the RING0 line) to wake up the host application in case of incoming calls or events signaled by URCs while the USB interface is in Detached state (i.e., VUSB_IN = 0). Every wakeup event will force a new USB enumeration. Therefore, the external application has to carefully consider the enumeration timings to avoid losing any signaled events. For details on this remote wakeup functionality see [Section 3.12.3](#).

It is possible to prevent existing data connections from being disconnected while the USB interface is in detached state (i.e., VUSB_IN=0) by configuring at least one of the module's USB ports to contribute to a host wakeup, i.e., configuring the port to try to wake up a connected host in case an appropriate event occurs (see [1]: AT^SCFG="RemoteWakeUp/Ports"), and by configuring a GPIO as USB wakeup GPIO (see [1]: AT^SCFG="RemoteWakeUp/Event/USB").

¹. Please note that if the USB interface is employed, and a USB cable is connected, there should also be a terminal program linked to the USB port in order to receive and process the initial SYSSTART URC after module startup. Otherwise, the SYSSTART URC remains pending in the USB driver's output buffer and this unprocessed data prevents the module from power saving.

². The specification is ready for download on http://www.usb.org/developers/docs/usb20_docs/

3.7 Serial Interface ASC0

PLS8-E offers an 8-wire unbalanced, asynchronous modem interface ASC0 conforming to ITU-T V.24 protocol DCE signaling. The electrical characteristics do not comply with ITU-T V.28. The significant levels are 0V (for low data bit or active state) and 1.8V (for high data bit or inactive state). For electrical characteristics please refer to [Table 22](#).

PLS8-E is designed for use as a DCE. Based on the conventions for DCE-DTE connections it communicates with the customer application (DTE) using the following signals:

- Port TXD @ application sends data to the module's TXD0 signal line
- Port RXD @ application receives data from the module's RXD0 signal line

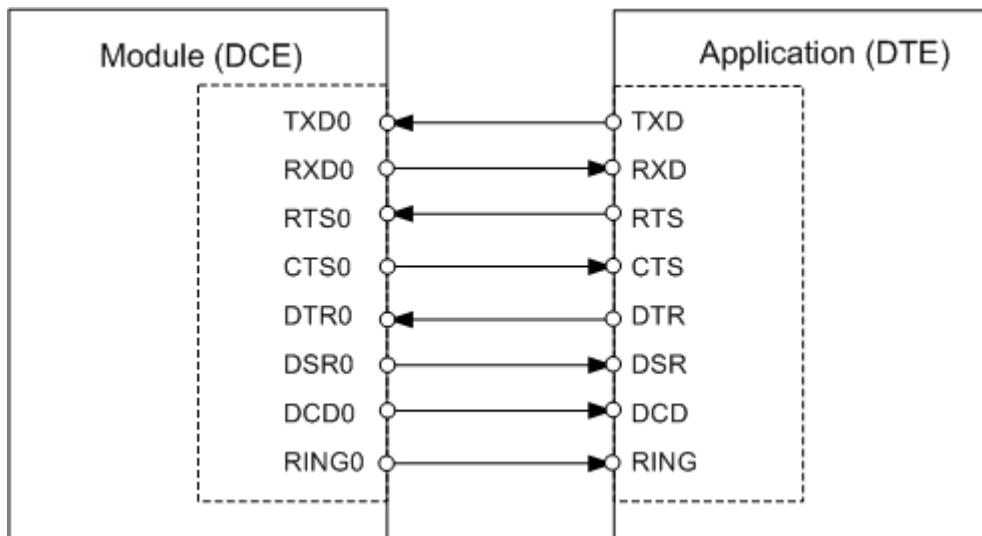


Figure 15: Serial interface ASC0

Features:

- Includes the data lines TXD0 and RXD0, the status lines RTS0 and CTS0 and, in addition, the modem control lines DTR0, DSR0, DCD0 and RING0.
- The RING0 signal serves to indicate incoming calls and other types of URCs (Unsolicited Result Code). It can also be configured to send pulses to the host application, for example to remotely wake up the application from power saving state. See [Section 3.12.3](#) and [1] for details on how to configure the RING0 line by AT^SCFG.
- Configured for 8 data bits, no parity and 1 stop bit.
- ASC0 can be operated at fixed bit rates from 115200bps up to 921600bps.
- Supports RTS0/CTS0 hardware flow control.
- Wake up from SLEEP mode by RTS0 activation (high to low transition; see [Section 3.4.4](#)).

Note: If the ASC0 serial interface is the application's only interface, it is suggested to connect test points on the USB signal lines as a potential tracing possibility.

3.7 Serial Interface ASC0

Table 9: DCE-DTE wiring of ASC0

V.24 circuit	DCE		DTE	
	Line function	Signal direction	Line function	Signal direction
103	TXD0	Input	TXD	Output
104	RXD0	Output	RXD	Input
105	RTS0	Input	RTS	Output
106	CTS0	Output	CTS	Input
108/2	DTR0	Input	DTR	Output
107	DSR0	Output	DSR	Input
109	DCD0	Output	DCD	Input
125	RING0	Output	RING	Input

3.8 UICC/SIM/USIM Interface

PLS8-E has two integrated UICC/SIM/USIM interfaces compatible with the 3GPP 31.102 and ETSI 102 221. These are wired to the host interface in order to be connected to an external SIM card holder. Five pads on the SMT application interface are reserved for each of the SIM two interfaces. An AT command allows to enable either the first or the second SIM interface (for details see [1]: AT^SCFG="Sim/CS").

The UICC/SIM/USIM interfaces support 3V and 1.8V SIM cards. Please refer to [Table 22](#) for electrical specifications of the UICC/SIM/USIM interface lines depending on whether a 3V or 1.8V SIM card is used.

The CCINx signal serves to detect whether a tray (with SIM card) is present in the card holder. Using the CCINx 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 10](#) for Molex ordering numbers.

Table 10: Signals of the SIM interface (SMT application interface)

Signal	Description
GND	Ground connection for SIM interfaces. Optionally a separate SIM ground line using e.g., pad N11 may be used to improve EMC.
CCCLK1 CCCLK2	Chipcard clock lines for 1 st and 2 nd SIM interface.
CCVCC1 CCVCC2	SIM supply voltage lines for 1 st and 2 nd SIM interface.
CCIO1 CCIO2	Serial data lines for 1 st and 2 nd SIM interface, input and output.
CCRST1 CCRST2	Chipcard reset lines for 1 st and 2 nd SIM interface.
CCIN1 CCIN2	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 CCINx signal is active low. The CCINx signal is mandatory for applications that allow the user to remove the SIM card during operation. The CCINx 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.

3.8 UICC/SIM/USIM Interface

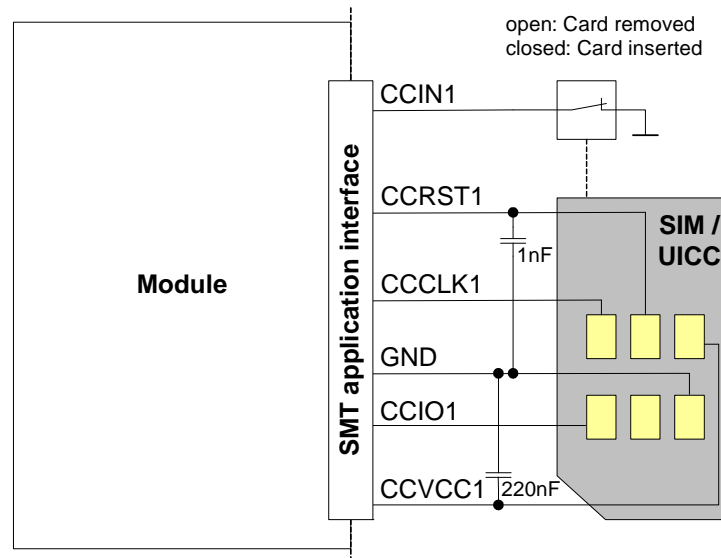


Figure 16: First UICC/SIM/USIM interface

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 CCCLKx signal to the CCIOx 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 CCIOx line from the CCCLKx line.

An example for an optimized ESD protection for the SIM interface is shown in [Section 3.8.1](#).

Note: [Figure 16](#) shows how to connect a SIM card holder to the first SIM interface. With the second SIM interface some internally integrated components on the SIM circuit will have to be externally integrated as shown for the second SIM interface in [Figure 17](#).

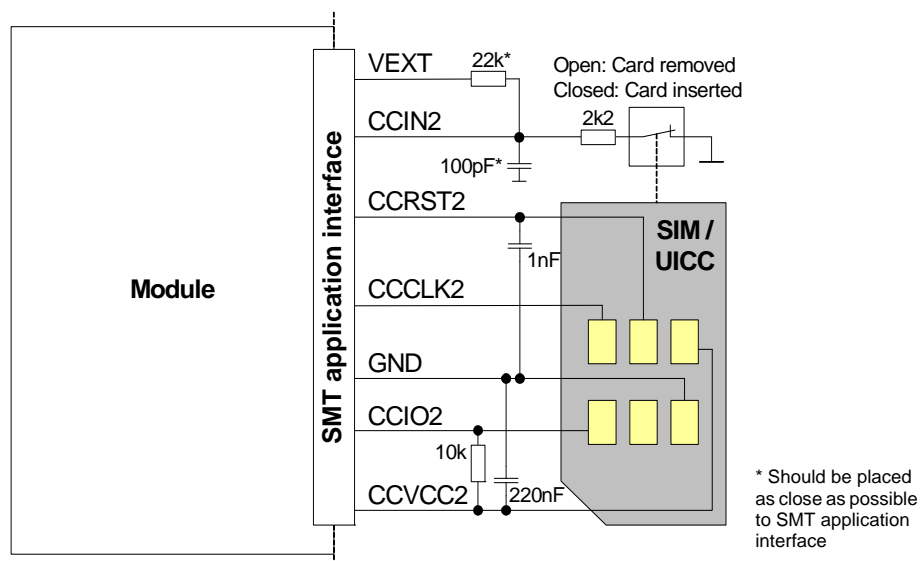


Figure 17: Second UICC/SIM/USIM interface

3.8.1 Enhanced ESD Protection for SIM Interface

To optimize ESD protection for the SIM interfaces it is possible to add ESD diodes to the interface lines of the first and second SIM interface as shown in the example given in [Figure 18](#).

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

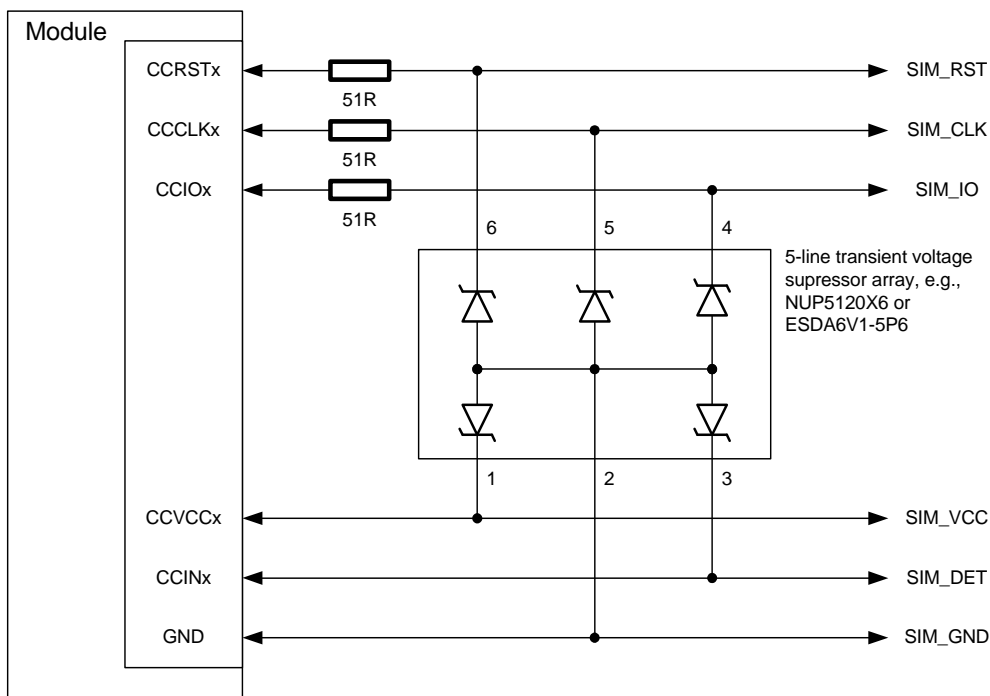


Figure 18: SIM interface - enhanced ESD protection

3.9 Digital Audio Interface

PLS8-E supports a digital audio interface that can be employed either as pulse code modulation interface (see [Section 3.9.1](#)) or as inter IC sound interface (see [Section 3.9.2](#)). Operation of these interface variants is mutually exclusive, and can be configured by AT command (see [\[1\]](#)). Default setting is pulse code modulation.

3.9.1 Pulse Code Modulation Interface (PCM)

PLS8-E's PCM interface can be used to connect audio devices capable of pulse code modulation. The PCM functionality covers the use of narrowband codecs with 8kHz sample rate and wideband codecs with 16kHz sample rate as well. Configured for wideband the PCM interface runs at 16 kHz sample rate (62.5µs frame length), while the signal processing maintains this rate in a wideband AMR call or samples automatically down to 8kHz in a narrowband call. Therefore, the PCM sample rate is independent of the audio bandwidth of the call.

The PCM interface has the following implementation:

- Master mode, slave mode
- Short frame synchronization, long frame synchronization
- 8kHz and 16kHz sample rate
- 128kHz, 256kHz, 512kHz, 2048kHz bit clock at 8kHz sample rate
- 256kHz, 512kHz, 1024kHz, 4096kHz bit clock at 16kHz sample rate
- Permanent clock option

For the PCM interface configuration the parameters <clock>, <mode>, <frame_mode>, <ext_clk_mode> and <sample_rate> of the AT^SAIC command can be configured in any combination (for details on AT^SAIC see [\[1\]](#)). But the following hints should be considered while configuring the PCM interface:

The external clock mode should be switched off in slave mode.

In Slave Mode <clock>, <frame_mode> and <sample_rate> must be set according to the characteristics of the external master. There is no automatic detection of the received clock frequency, frame length and sample rate.

[Table 11](#) lists the available PCM interface signals.

Table 11: Overview of PCM pin functions

Signal name on SMT application interface	Signal configuration inactive	Signal direction: Master	Signal direction: Slave	Description
DOUT	PD	O	O	PCM data from PLS8-E to external codec
DIN	PD	I	I	PCM data from external codec to PLS8-E
FSC	PD	O	I	Frame synchronization signal to/from external codec
BCLK	PD	O	I	Bit clock to/from external codec

Note: PCM data is always formatted as 16-bit uncompressed two's complement. Also, all PCM data and frame synchronization signals are written to the PCM bus on the rising clock edge and read on the falling edge.

The timing of a PCM short frame is shown in [Figure 19](#).

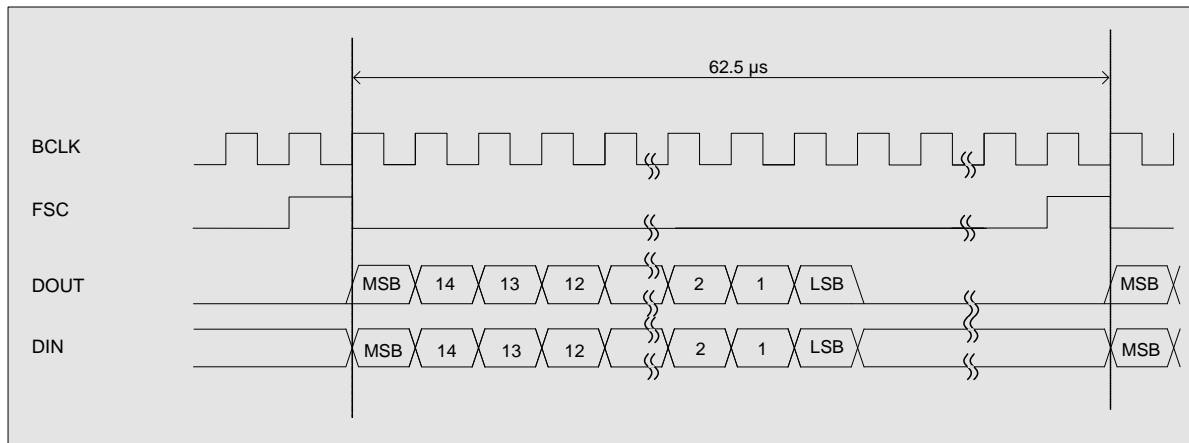


Figure 19: PCM timing short frame (master, 4096KHz, 16kHz sample rate)

Configured to short frame synchronization, the pulse on FSC is one clock period wide and occurs one clock before the data, using long frame the pulse has a duty cycle of 50% starting with the first data bit.

The timing of a PCM long frame is shown in [Figure 20](#).

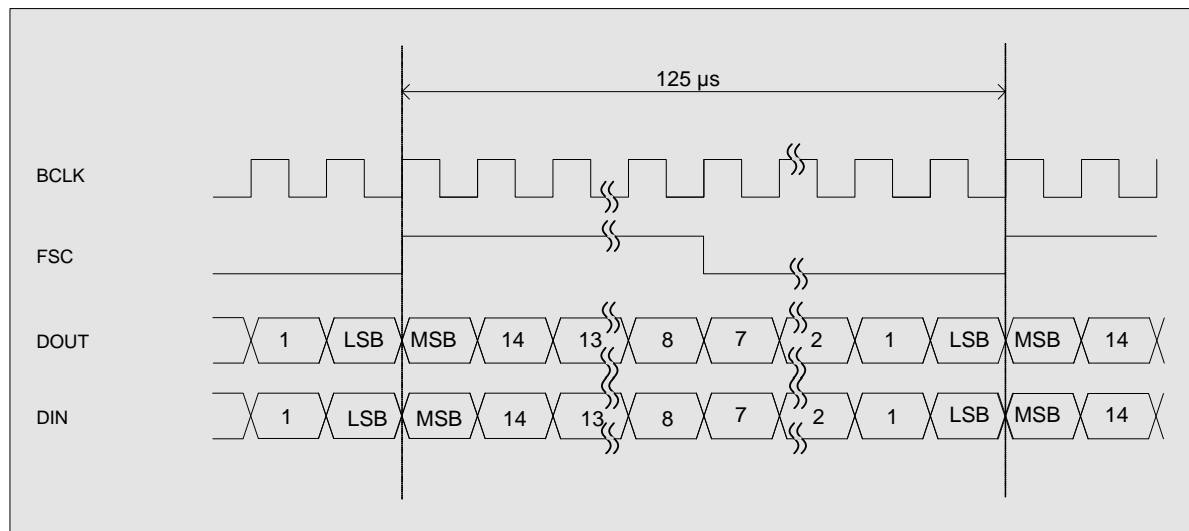


Figure 20: PCM timing long frame (master, 128kHz, 8kHz sample rate)

Characteristics of Audio Modes

PLS8-E has various audio modes selectable with AT^SNFS (for details on AT^SNFS see [\[1\]](#)).

Audio mode 1 is used for type approval with the Votronic handset via the DSB75 codec adapter. The handset is adjusted for the type 3.2 low-leakage ear simulator for narrowband and wideband calls.

Audio mode 6 is used for transparent access to the narrowband or wideband speech coders without any signal processing (except for sample rate converters in case of narrowband calls). The full scale level of the PCM interface is mapped to the full scale level of the speech coders.

3.9.2 Inter IC Sound Interface (I²S)

The I²S Interface is a standardized bidirectional I²S ("Inter-IC Sound Interface") based digital audio interface for transmission of mono voice signals for telephony services.

The I²S interface can be enabled and configured using the AT command AT^SAIC (see [1]). An activation is possible only out of call and out of tone presentation. The I²S properties and capabilities comply with the requirements laid out in the Phillips I2S Bus Specifications, revised June 5, 1996.

The I²S interface has the following characteristics:

- Bit clock mode: Master, optional master clock output
- Sampling rate: 8KHz (narrowband), 16KHz (wideband)
- 256kHz bit clock at 8kHz sample rate
- 512kHz bit clock at 16kHz sample rate
- Frame length: 32 bit stereo voice signal (16 bit word length)
- Optional Master clock: 2048KHz (8KHz sample rate) or 4096KHz (16KHz sample rate)

The digital audio interface pads available for the PCM interface are also available for the I²S interface. In I²S mode they have the same electrical characteristics. For the master clock option there is a separate line (see Section 6.5 for more information on these lines).

Table 12 lists the available I²S interface signals, Figure 21 shows the I²S timing.

Table 12: Overview of I²S pin functions

Signal name on SMT application interface	Signal configuration inactive	Signal direction: Master	Description
DOUT	PD	O	I ² S data from PLS8-E to external codec
DIN	PD	I	I ² S data from external codec to PLS8-E
FSC	PD	O	Frame synchronization signal to/from external codec Word alignment (WS)
BCLK	PD	O	Bit clock to external codec
MCLK	PD	O	I ² S Master clock to supply external codecs without PLL.

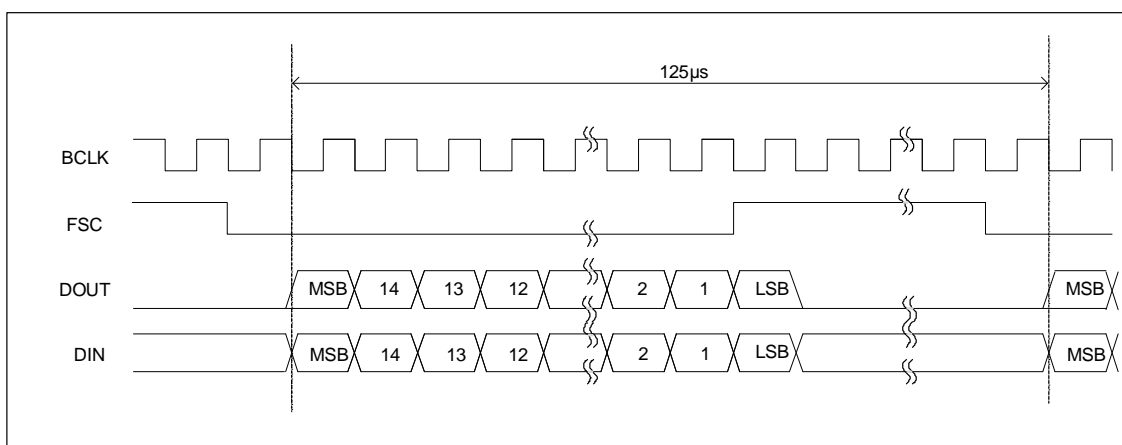


Figure 21: I²S timing (master mode)

3.10 Analog-to-Digital Converter (ADC)

PLS8-E provides three unbalanced ADC input lines: ADC1_IN, ADC2_IN and ADC3_IN. They can be used to measure three independent, externally connected DC voltages in the range of 0.3V to 3.075V.

The AT^SRADC command can be employed to select the ADC line, set the measurement mode and read out the measurement results.

3.11 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.

GPIO1 can be configured as dead reckoning synchronization line (see [Chapter 4](#)), GPIO6 may be configured as low current indicator signal (see [Section 3.12.4](#)), and GPIOs may be set as remote host wakeup lines (see [Section 3.12.3](#)).

If the PLS8-E is in power save (SLEEP) mode a level state transition at GPIO1, GPIO3, GPIO4, GPIO5 and GPIO9 will wake up the module. To query the level state the AT^SCPOL command may be used.

3.12 Control Signals

3.12.1 PWR_IND Signal

PWR_IND notifies the on/off state of the module. For state detection an external pull-up resistor is required (cp. R1 in below [Figure 22](#)). As long as the feeding voltage is applied at the pull-up resistor, a high state of PWR_IND indicates that the module is switched off.

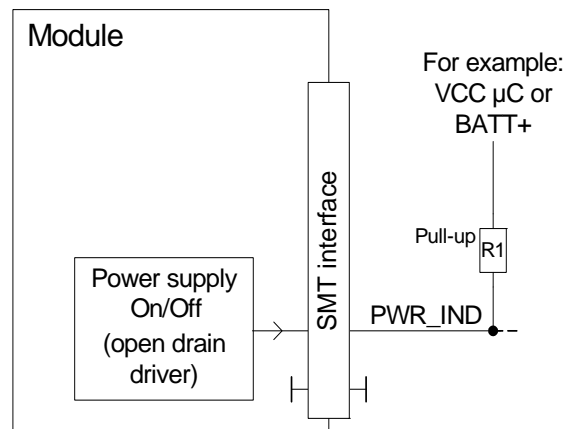


Figure 22: PWR_IND signal

3.12.2 Behavior of the RING0 Line

The RING0 line serves to indicate incoming calls and other types of URCs (Unsolicited Result Code).

Although not mandatory for use in an external host application, it is recommended that you connect the RING0 line to an interrupt line of your application. In this case, the application can be designed to receive an interrupt when a falling edge on RING0 occurs. This solution is most effective, particularly, for waking up an application from power saving (see also [Section 3.12.3](#)). Therefore, utilizing the RING0 line provides an option to significantly reduce the overall current consumption of your application.

The RING0 line behavior and usage can be configured by AT command. For details see [\[1\]](#): AT^SCFG.

3.12.3 Remote Wakeup

If no call, data or message transfer is in progress, the external host application may shut down its own module interfaces or other components in order to save power. If a call, data, or other request (URC) arrives, the external application can be notified of this event and be woken up again by a state transition of a configurable remote wakeup line. Available as remote wakeup lines are all GPIO signals as well as the RING0 line. Please refer to [1]: AT^SCFG: "RemoteWakeUp/..." for details on how to configure these lines for defined wakeup events on specified device interfaces. Possible states are listed in Table 13.

If no line is specifically configured as remote wakeup signal, the remote USB suspend and resume mechanism as specified in the "Universal Serial Bus Specification Revision 2.0"¹ applies for the USB interface (see Section 3.6), or the RING0 line may be employed with USB applications not supporting this mechanism (see also Section 3.6.1). This legacy behavior of the RING0 line as remote host wakeup line has to be enabled and configured by AT command (see [1]: AT^SCFG: "URC/Ringline"). Possible states are listed in Table 13.

Table 13: Host wakeup lines

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

¹. The specification is ready for download on http://www.usb.org/developers/docs/usb20_docs/

3.12.4 Low Current Indicator

A low current indication is optionally available over a GPIO line. By default, low current indication is disabled and the GPIO pads can be configured and employed as usual.

For a GPIO pad to work as a low current indicator the feature has to be enabled by AT command (see [1]: AT^SCFG: MEopMode/PowerMgmt/LCI). By default, the GPIO6 pad is configured as LCI_IND signal.

If enabled, the GPIOx/LCI_IND signal is high when the module is sleeping. During its sleep the module will for the most part be slow clocked with 32kHz RTC.

Table 14: Low current indicator line

Signal	I/O/P	Description
GPIOx/LCI_IND	O	Inactive to active high transition: 0 = High current consumption The module draws its power via BATT+ 1 = Low current consumption (only reached during SLEEP mode) The module draws only a low current via BATT+

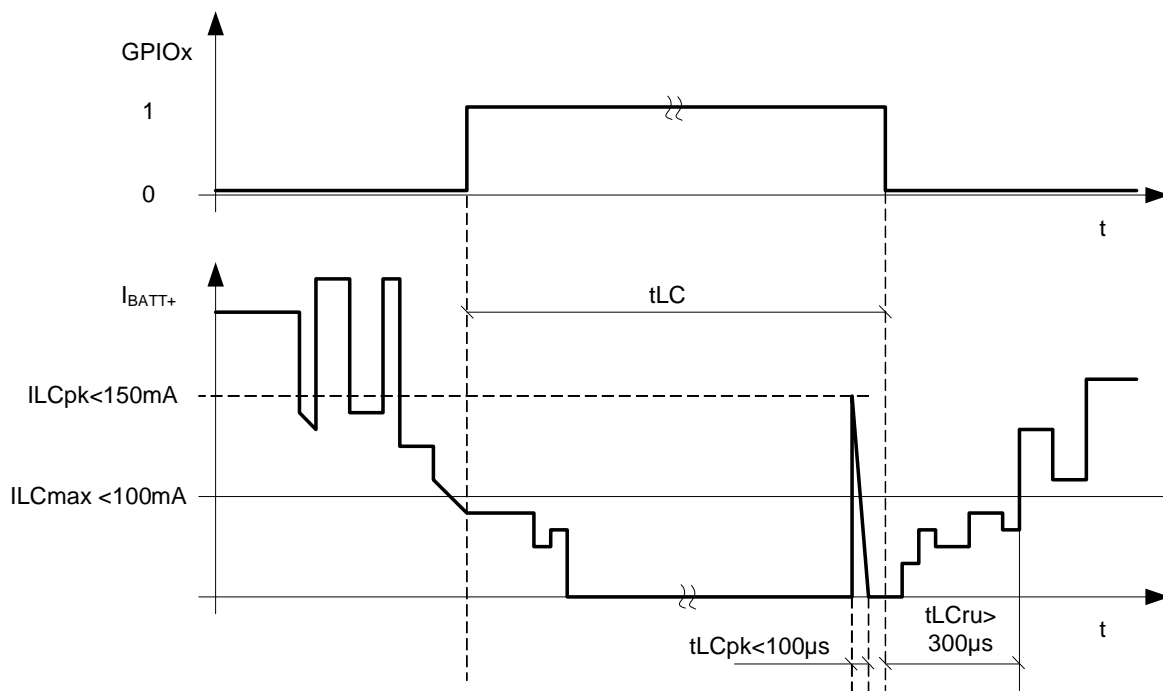


Figure 23: Low current indication timing (still to be confirmed)

- t_{LC} Time for the I_{BATT+} current consumption: $I_{LCmax} < 100mA$.
- t_{LCpk} Max. time duration for the inrush current peak at the end of the low current period.
- t_{LCru} When the GPIOx signal becomes inactive (low) the current ramps up to the maximum low current value within t_{LCru}.
- I_{LCpk} When the module turns from sleep to normal operation some internal supply voltages will be switched on. That causes a small inrush current peak.
- I_{LCmax} During the low current period t_{LC} the current consumption does not exceed the I_{LCmax} value.

3.12.5 Network Connectivity and Technology Status Signals

The STATUS line serves to indicate the module's network connectivity state or the underlying network technology (2G or 3G/4G) and can be used to control an externally connected LED as shown in [Figure 24](#). To operate the LED a buffer, e.g. a transistor or gate, must be included in the external application.

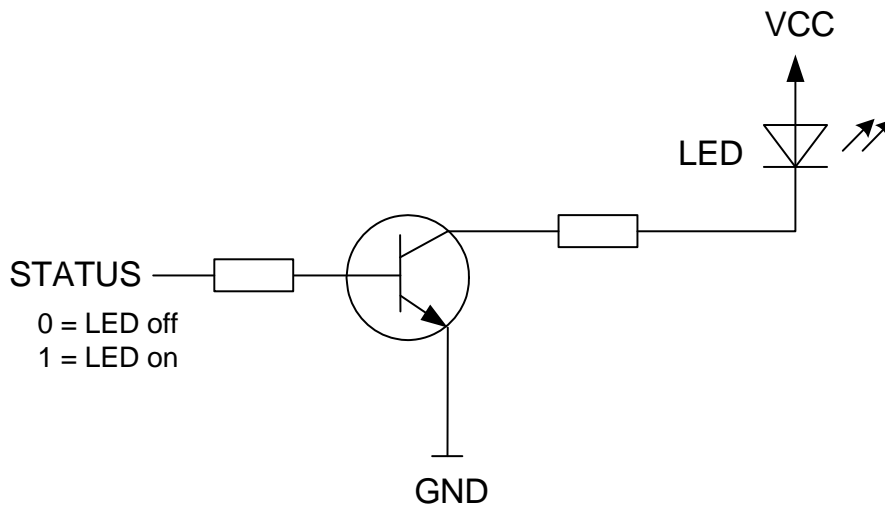


Figure 24: LED circuit (example)

For electrical characteristics of the STATUS line see [Table 22](#). The network connectivity and technology signal function is volatile and has to be activated after module startup with AT^SLED. For details on the command as well as status and mode indications through blinking intervals see [\[1\]](#).

4 GNSS Receiver

PLS8-E integrates a GNSS receiver that offers the full performance of GPS/GLONASS/Galileo technology. The GNSS receiver is able to continuously track all satellites in view, thus providing accurate satellite position data.

The integrated GNSS receiver supports the NMEA protocol via USB or ASC0 interface. NMEA is a combined electrical and data specification for communication between various (marine) electronic devices including GNSS receivers. It has been defined and controlled by the US based National Marine Electronics Association. For more information on the NMEA Standard please refer to <http://www.nmea.org>.

Depending on the receiver's knowledge of last position, current time and ephemeris data, the receiver's startup time (i.e., TTFF = Time-To-First-Fix) may vary: If the receiver has no knowledge of its last position or time, a startup takes considerably longer than if the receiver has still knowledge of its last position, time and almanac or has still access to valid ephemeris data and the precise time. For more information see [Section 6.9](#).

By default, the GNSS receiver is switched off. It has to be switched on and configured using AT commands. For more information on how to control the GNSS interface via the AT commands see [\[1\]](#).

Dead Reckoning Sync Line:

Dead reckoning solutions are used in (automotive) platforms to determine the (vehicles) location even when there is no GPS signal available (e.g. in tunnels, basement garages or even between high buildings in cities).

In addition to dead reckoning related NMEA sentences (for details see [\[1\]](#): GNSS sentences), PLS8-E provides a dead reckoning synchronization line (DR_SYNC line) to be employed in external dead reckoning applications. DR_SYNC is derived from the GPS signal clock as 1 pulse per second (1PPS) signal, with a frequency of 1Hz, an accuracy of +/-5 ms, and a high state pulse of 1ms. The DR_SYNC signal is provided as long as synchronized with the GPS satellite clock, and continues after GPS signal loss. DR_SYNC can be configured for the GPIO1 pad.

DR_SYNC can be activated using the AT command `AT^SGPSC`. For more information on the command please refer to [\[1\]](#), for electrical characteristics see [Table 22](#).

5 Antenna Interfaces

5.1 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 quality¹. 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 15: 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

¹. By delivery default the UMTS/LTE Rx diversity/MIMO antenna is configured as available for the module since its usage is mandatory for LTE. Please refer to [1] for details on how to configure antenna settings.

5.1.1 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.

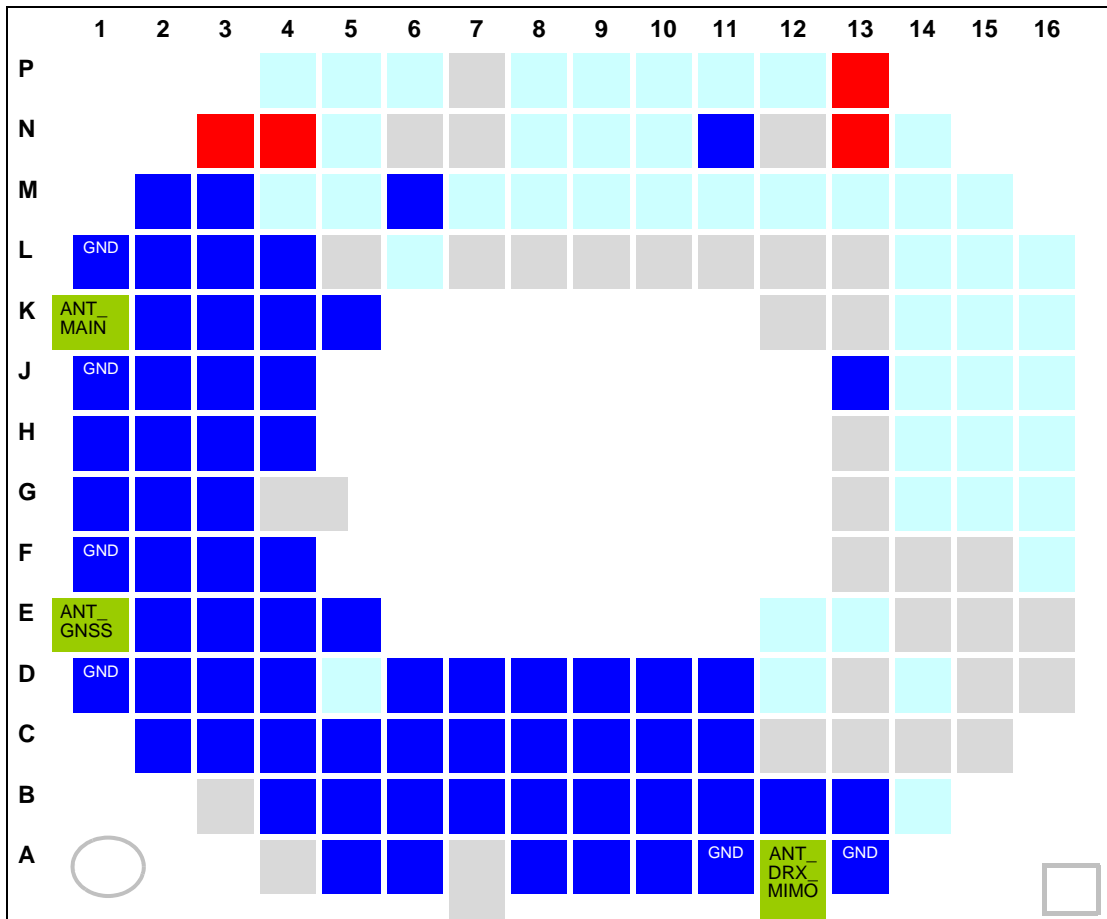


Figure 25: Antenna pads (bottom view)

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's 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 5.1.2](#).

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 5.1.2](#) 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.

5.1.2 RF Line Routing Design

5.1.2.1 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.

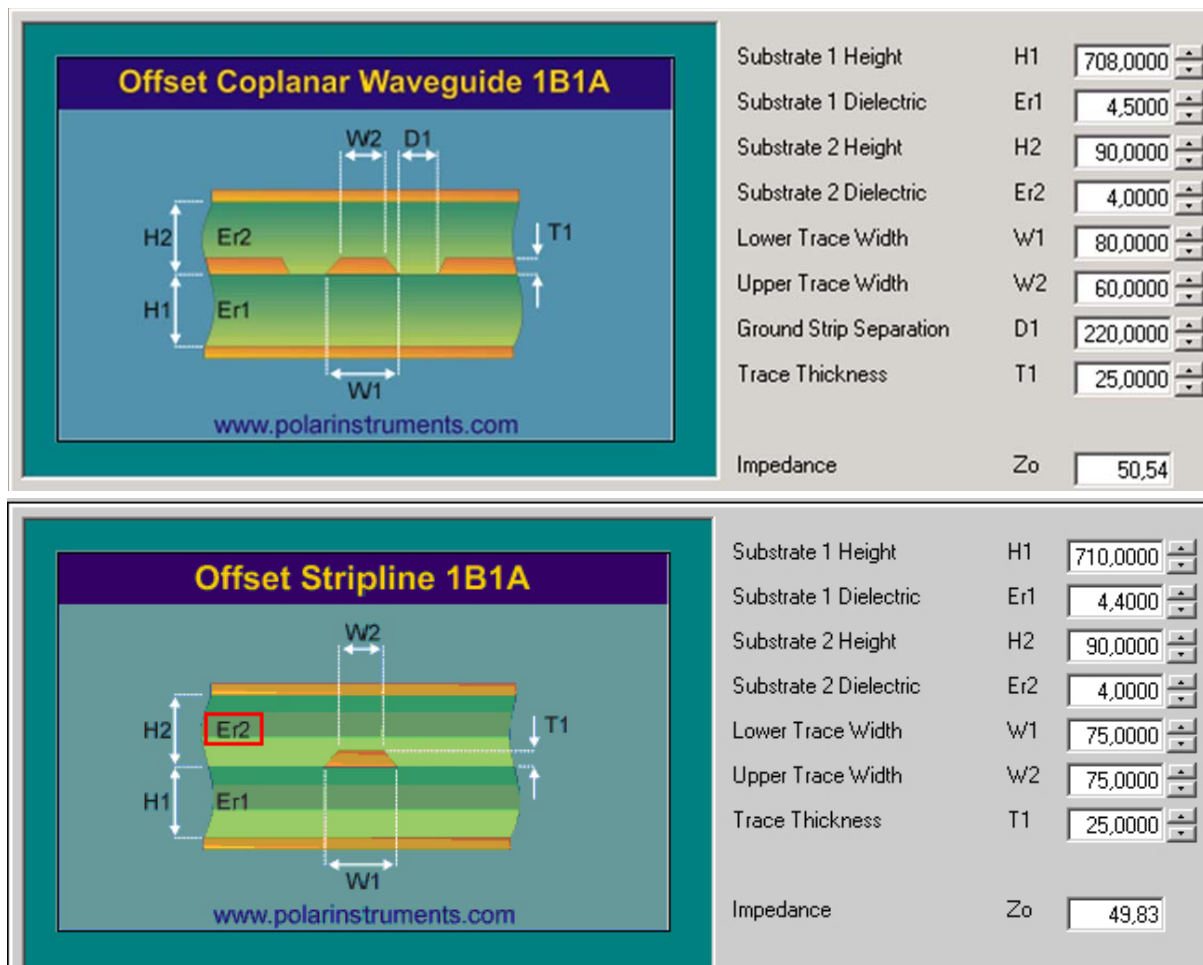


Figure 26: Embedded Stripline line arrangement

Micro-Stripline

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



Figure 27: Micro-Stripline line arrangement samples

5.1.2.2 Routing Example

Interface to RF Connector

Figure 28 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 29. For different layer stacks the stripline width will have to be adapted accordingly.

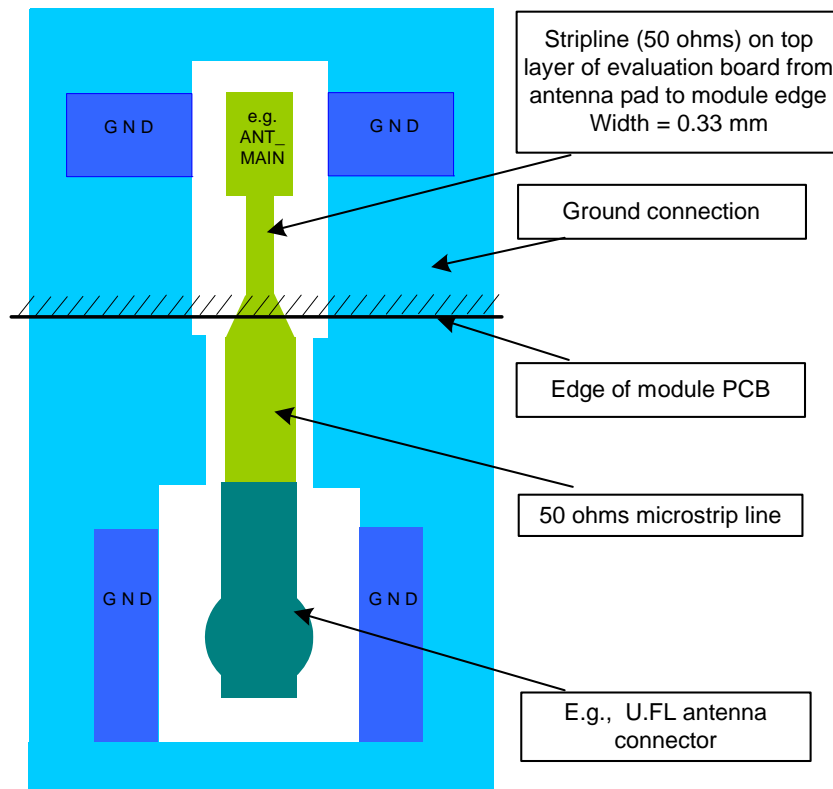


Figure 28: Routing to application's RF connector

Layer No.	Construction	Finished thknss (um)
s/m		15
1		25
	Prepreg :1080X1 RC:64%	65
2		25
	CORE:28mil H/Hoz 7628x4	708
3		25
	Prepreg :1080X1 RC:64%	65
4		25
s/m		15
	Total thickness (including S/M):	968

Figure 29: PLS8-E evaluation board layer table

5.1.3 ESD Protection for Antenna Interfaces

The following [Figure 30](#) shows how to implement an external ESD protection for the RF antenna interfaces (ANT_MAIN and ANT_DRX_MIMO) with either a T pad or PI pad network circuit (for RF line routing design see also [Section 5.1.2](#)).

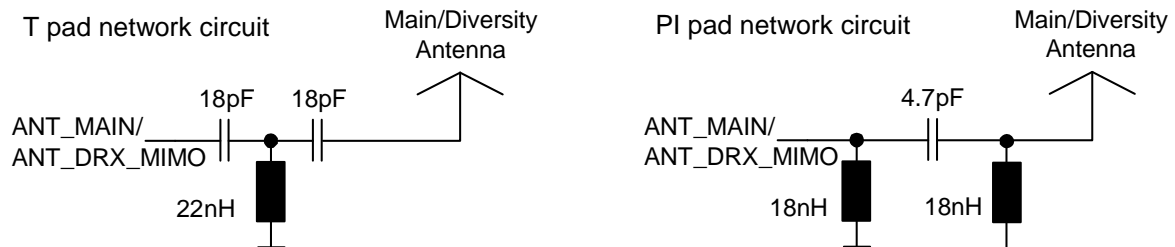


Figure 30: ESD protection for RF antenna interface

Recommended for the above sample circuits is the use of SMD 0402 chip components, e.g., Size 0402 SMD inductors from the Panasonic ELJRF series (22nH and 18nH inductors) or Murata LQW15AN18NJ00 (18nH inductors only).

5.2 GNSS Antenna Interface

In addition to the RF antenna interface PLS8-E also has a GNSS antenna interface. See [Section 6.5](#) to find out where the GNSS antenna pad is located. The GNSS pad itself is the same as for the RF antenna interface (see [Section 5.1.1](#)).

It is possible to connect active or passive GNSS antennas. In either case they must have 50Ω impedance. The simultaneous operation of GSM/UMTS/LTE and GNSS is implemented. For electrical characteristics see [Section 6.9](#).

PLS8-E provides the supply voltage VGNSS for the GNSS active antenna (3.05V). It has to be enabled by software when the GNSS receiver becomes active, otherwise VGNSS should be off (power saving). VGNSS is not short circuit protected. This will have to be provided for by an external application. The DC voltage should be fed back via ANT_GNSS_DC for coupling into the GNSS antenna path. [Figure 31](#) shows the flexibility in realizing the power supply for an active GNSS antenna by giving two sample circuits realizing the supply voltage for an active GNSS antenna - one with short circuit protection and one with an external LDO employed.

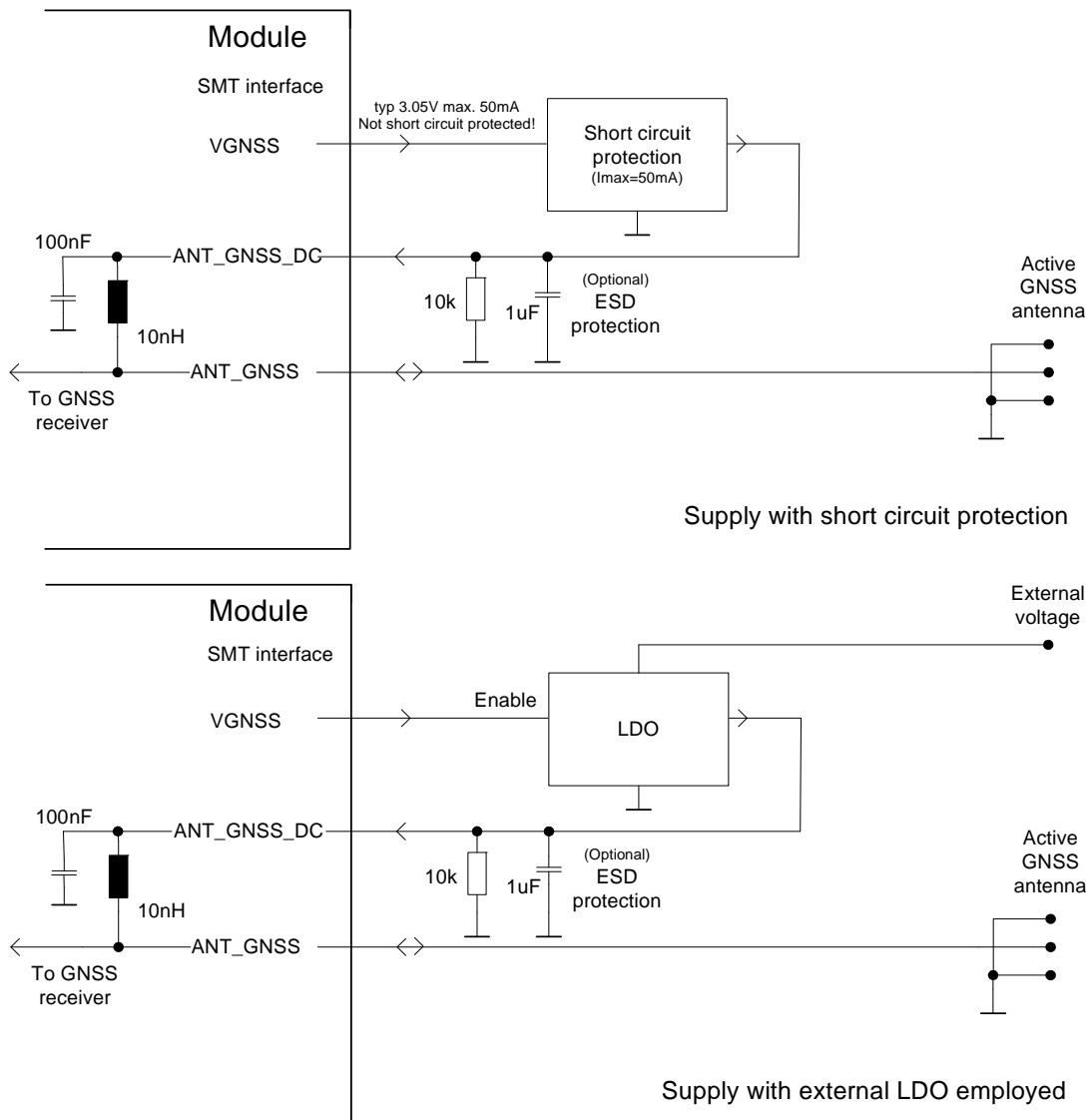


Figure 31: Supply voltage for active GNSS antenna

Figure 32 shows sample circuits realizing ESD protection for a passive GNSS antenna.

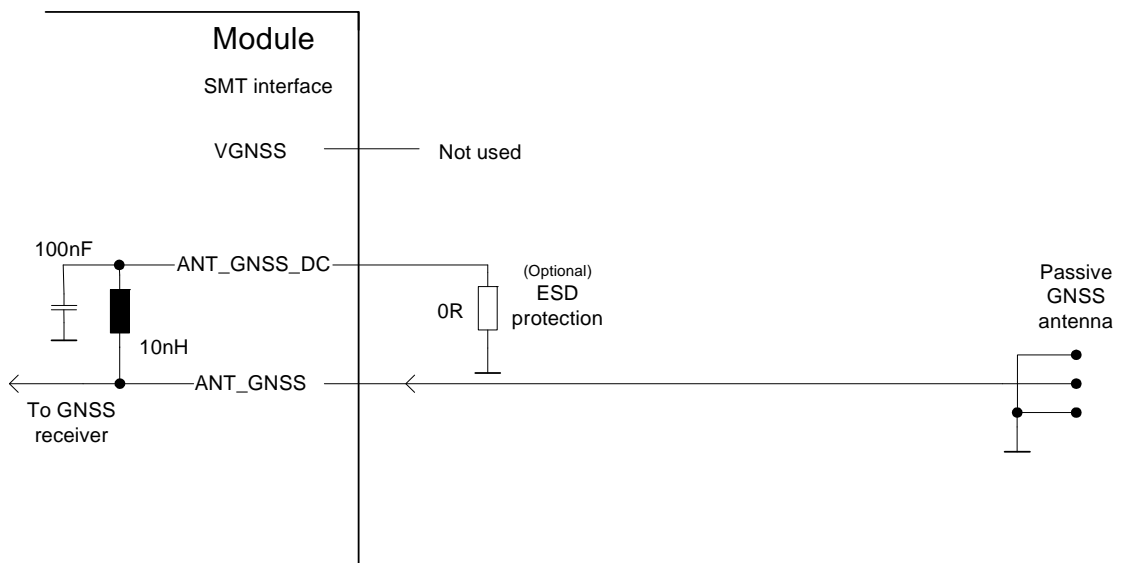


Figure 32: ESD protection for passive GNSS antenna

6 Electrical, Reliability and Radio Characteristics

6.1 Absolute Maximum Ratings

The absolute maximum ratings stated in [Table 16](#) are stress ratings under any conditions. Stresses beyond any of these limits will cause permanent damage to PLS8-E.

Table 16: 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, CCVCCx 1.8V in normal operation	-0.5	+2.3	V
Voltage at SIM/USIM interface, CCVCCx 3.0V in normal operation	-0.5	+3.4	V
VDDL input voltage	-0,3	+3.5	V
Voltage at ADC lines if the module is powered by BATT+	-0.5	+3.5	V
Voltage at ADC lines 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
GNSS antenna supply VGNSS		300	mA

6.2 Operating Temperatures

Table 17: Board temperature

Parameter	Min	Typ	Max	Unit
Operating temperature range ¹				
Normal temperature range	+15	+25	+55	°C
Extreme temperature range	-30		+85	°C
Extended temperature range ²	-40		+95	°C
Automatic shutdown ³				
Temperature measured on PLS8-E board	---	---	>+95	°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 shut-down takes effect.
Within the extended temperature range (outside the operating temperature range) 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 6.2.1](#)).
- 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 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 33](#). 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.

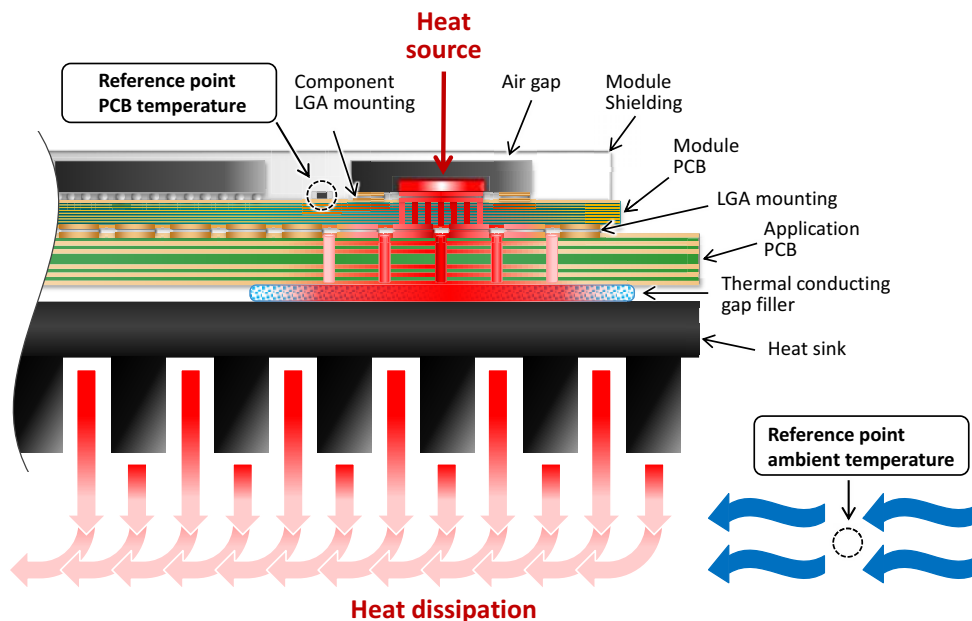


Figure 33: Board and ambient temperature differences

6.3 Storage Conditions

6.2.1 Temperature Allocation Model

The temperature allocation model shown in [Table 18](#) assumes shares of a module's average lifetime of 10 years (given in %) during which the module is operated at certain temperatures.

Table 18: Temperature allocation model

Module lifetime share (in %) ¹	1	1	5	53	35	3	1	1
Module Temperature (in °C)	-40	-30	-10	20	40	70	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.

6.3 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 19: Storage conditions

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

6.4 Reliability Characteristics

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

Table 20: Summary of reliability test conditions

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

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

6.4.1 Bending Tests

From experience with other modules an elongation of up to $200\mu\text{m}/\text{m}$ 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 34](#), the possible elongation is clearly below the value of $200\mu\text{m}/\text{m}$. 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.

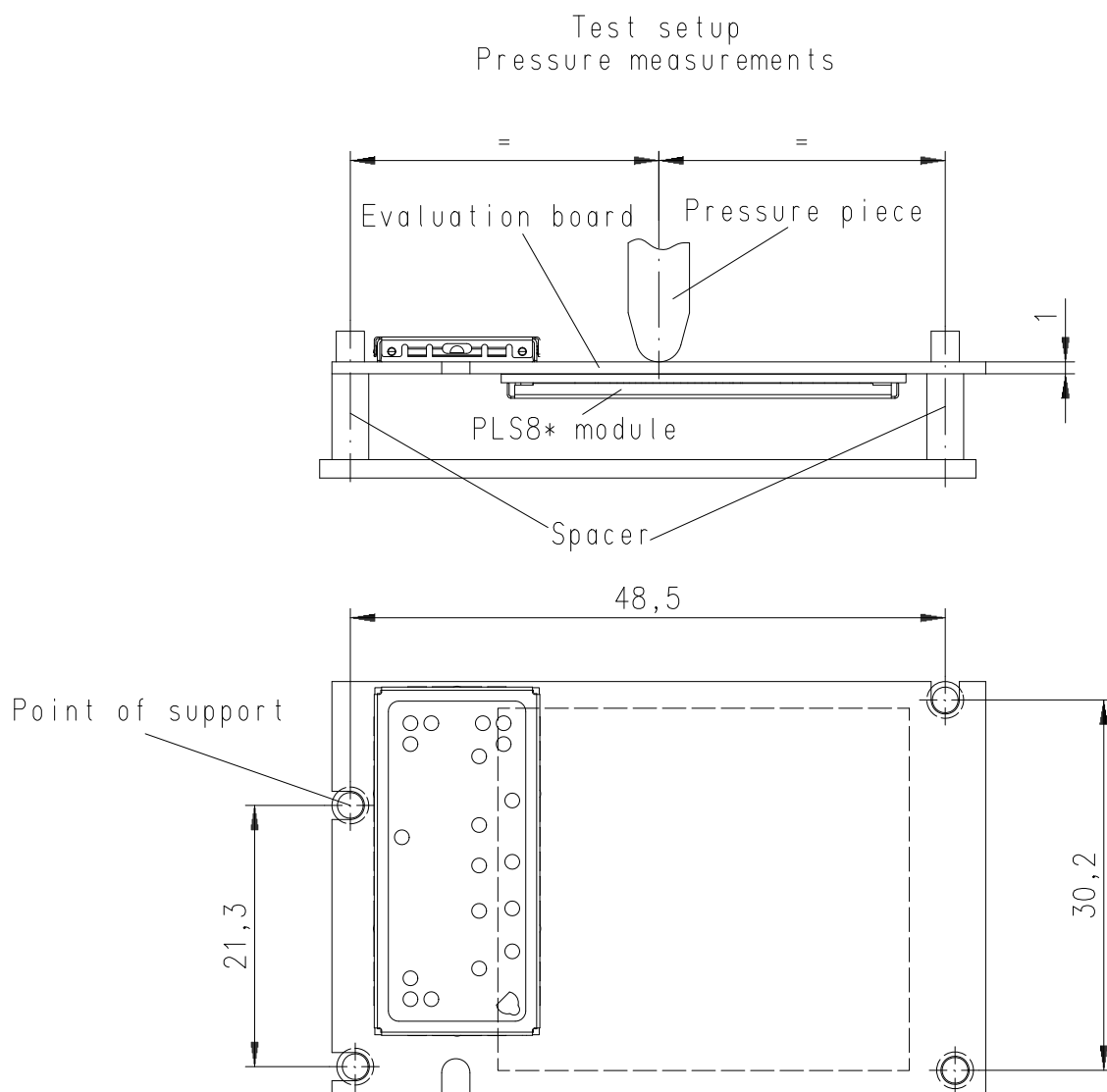


Figure 34: Bending test setup

6.5 Pad Assignment and Signal Description

The SMT application interface on the PLS8-E provides connecting pads to integrate the module into external applications. [Table 21](#) lists the pads' assignments. [Figure 35](#) (bottom view) and [Figure 36](#) (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. Pads marked "rfu" and qualified as "GND" (ground) are assigned to ground with PLS8-E modules, but may have different assignments with future Gemalto M2M products using the same pad layout.

Gemalto strongly recommends to solder all connecting pads for mechanical stability and heat dissipation.

6.5 Pad Assignment and Signal Description

Table 21: Overview: Pad assignments¹

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	CCIO2	L6	CCVCC2
A9	GND	E13	CCRST2	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	CCRST1
B6	GND	F13	rfu (dnu)	L15	CCCLK1
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	DIN
B14	STATUS	G13	rfu (dnu)	M8	BCLK
C2	GND	G14	GPIO7	M9	FSC
C3	GND	G15	GPIO8	M10	DOUT
C4	GND	G16	GPIO9	M11	ADC3_IN
C5	GND	H1	GND	M12	ADC2_IN
C6	GND	H2	GND	M13	ADC1_IN
C7	GND	H3	GND	M14	CCIN1
C8	GND	H4	GND	M15	VDDL
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	CTS0
C15	rfu (GND)	J3	GND	N9	DCD0
D1	GND	J4	GND	N10	RTS0
D2	GND	J13	GND	N11	GND
D3	GND	J14	GPIO1	N12	rfu (dnu)
D4	GND	J15	GPIO2	N13	BATT+
D5	ANT_GNSS_DC	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	MCLK
D9	GND	K4	GND	P7	rfu (dnu)
D10	GND	K5	GND	P8	DTR0
D11	GND	K12	rfu (dnu)	P9	DSR0
D12	CCIN2	K13	rfu (dnu)	P10	RING0
D13	rfu (dnu)	K14	CCIO1	P11	RXD0
D14	CCCLK2	K15	CCVCC1	P12	TXD0
D15	rfu (dnu)	K16	VGNSS	P13	BATT+
D16	rfu (dnu)	L1	GND		
E1	ANT_GNSS				

¹: nc = not connected; rfu = reserved for future use; dnu = do not use

6.5 Pad Assignment and Signal Description

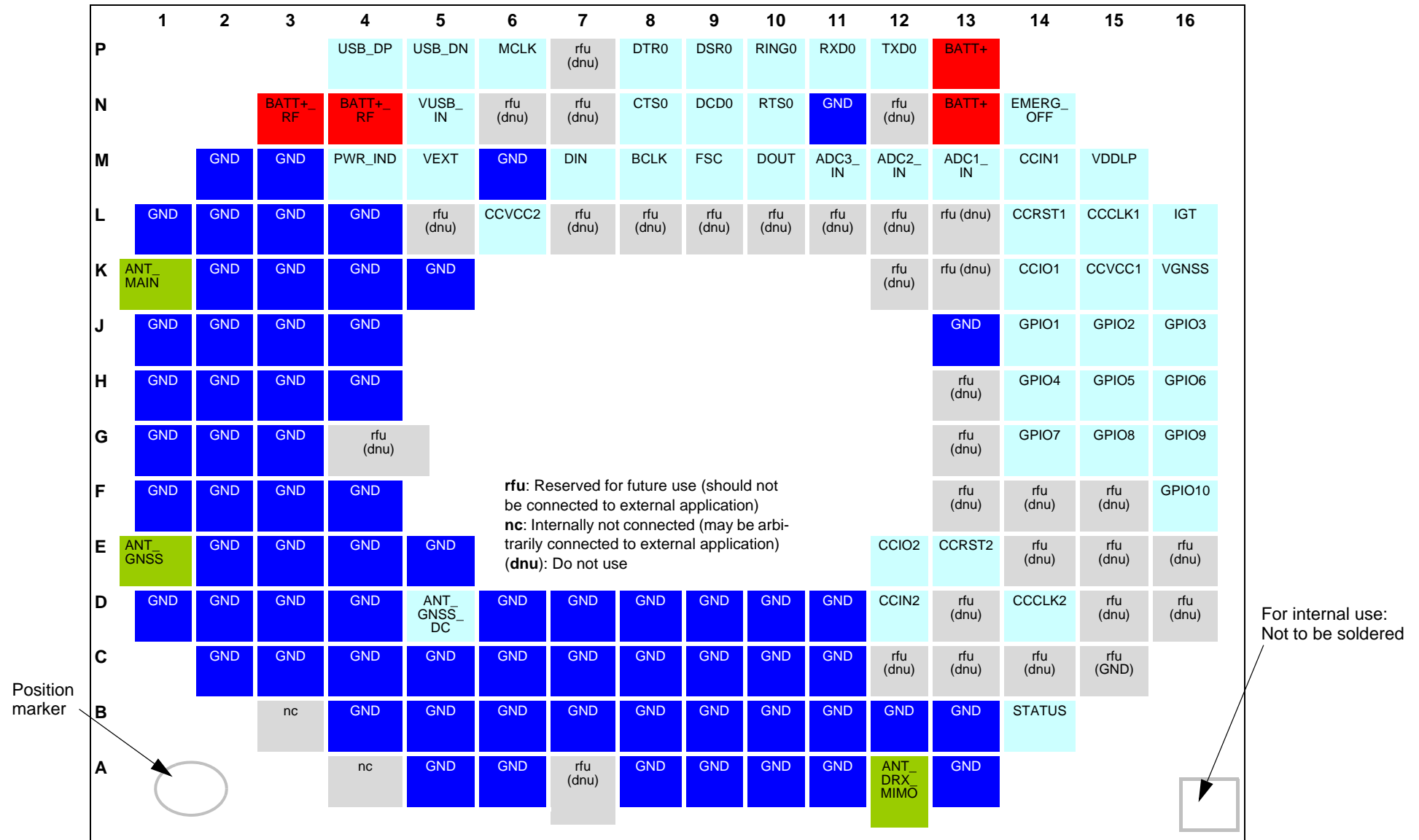


Figure 35: PLS8-E bottom view: Pad assignments

6.5 Pad Assignment and Signal Description

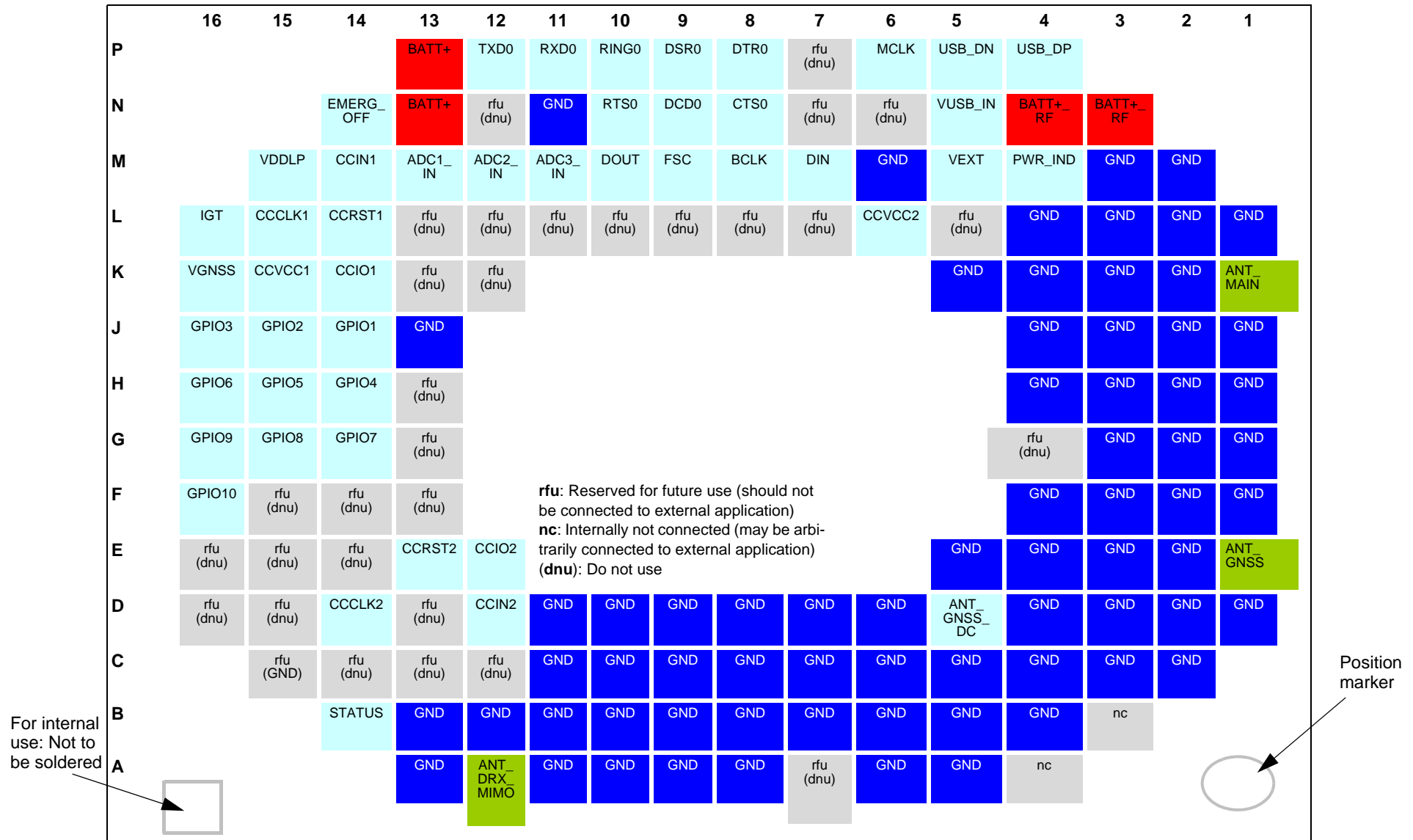



Figure 36: PLS8-E top view: Pad assignments

6.5 Pad Assignment and Signal Description

Please note that the reference voltages listed in [Table 22](#) are the values measured directly on the PLS8-E module. They do not apply to the accessories connected.

Table 22: Signal description

Function	Signal name	IO	Signal form and level	Comment
Power supply	BATT+_RF	I	$V_{I,max} = 4.2V$ $V_{I,norm} = 3.8V$ $V_{I,min} = 3.3V$ during Tx burst on board $I_{max} \approx 2A$, during Tx burst (GSM)  $n \text{ Tx} = n \times 577\mu s$ peak current every 4.615ms	<p>Lines of BATT+ and GND must be connected in parallel for supply purposes because higher peak currents may occur.</p> <p>Minimum voltage must not fall below 3.3V including drop, ripple, spikes.</p> <p>For proper module power up the voltage at BATT+ must be greater than at VDDL P.</p>
	BATT+	I	$V_{I,max} = 4.2V$ $V_{I,norm} = 3.8V$ $V_{I,min} = 3.3V$ during Tx burst on board $I_{max} = 350mA$	
Power supply	GND		Ground	Application Ground
External supply voltage	VEXT	O	$CL_{max} = 1\mu F$ $V_O = 1.80V +1\% -5\%$ $I_{O,max} = -50mA$	<p>VEXT may be used for application circuits.</p> <p>If unused keep line open.</p> <p>The external digital logic must not cause any spikes or glitches on voltage VEXT.</p> <p>Do not exceed IOmax</p>
Supply voltage for active GNSS antenna (Output)	VGNSS	O	$CL_{max} = 2.2\mu$ $V_O = 3.05V \pm 1\%$ $@I_O = -20mA$ $I_{O,max} = -50mA$	Available if GNSS antenna DC power is enabled (configurable by AT command; see Section 6.9).
Supply voltage for active GNSS antenna (Input)	ANT_GNSS_DC	I	$V_{I,max} = 6V$ The input current has to be limited at 50mA (antenna short circuit protection)	If unused connect to GND.
Ignition	IGT	I	$R_{PU} \approx 200k\Omega$ $V_{OH,max} = 1.8V$ $V_{IH,max} = 2.1V$ $V_{IH,min} = 1.17V$ $V_{IL,max} = 300mV$ Low impulse width > 100ms	<p>This signal switches the module ON.</p> <p>It is required to drive this line low by an open drain or open collector driver connected to GND.</p>

6.5 Pad Assignment and Signal Description

Table 22: Signal description

Function	Signal name	IO	Signal form and level	Comment
Emergency off	EMERG_OFF	I	$R_{PU} \approx 40k\Omega$ $V_{OHmax} = 1.8V$ $V_{IHmax} = 2.1V$ $V_{IHmin} = 1.17V$ $V_{ILmax} = 300mV$ ~ __ ~ low impulse width > 40ms	It is required to drive this line low by an open drain or open collector driver connected to GND. If unused keep line open.
RTC Back up	VDDL	O	$V_Omax = 3.20V$ while BATT+ =>3.3V $R_I = 1.8k\Omega$	If unused keep line open.
		I	$V_I = 1.5V \dots 3.25V$ at $I_{max} = 10\mu A$ while BATT+ = 0V	
Connectivity status	STATUS	O	$V_{OLmax} = 0.45V$ at $I = 2mA$ $V_{OHmin} = 1.35V$ at $I = -2mA$ $V_{OHmax} = 1.85V$	Status signalling e.g. with ext. LED circuit
SIM card detection (2x)	CCIN1	I	$R_{PU} \approx 24.2k\Omega$ $V_{OHmax} = 2.0V$ $V_{IHmin} = 1.15V$ $V_{IHmax} = 1.9V$ $V_{ILmax} = 0.4V$	CCINx = Low, SIM card inserted. If SIM card holder does not support CCIN, connect to GND.
	CCIN2	I	$V_{IHmin} = 1.20V$ at $-30\mu A$ $V_{IHmax} = 2V$ $V_{ILmax} = 0.6V$ at $30\mu A$	CCIN2: External pull-up required - for details please refer to Section 3.8 . If 2 nd SIM interface not used, keep line open.
3V SIM card interface	CCRST1 CCRST2	O	$V_{OLmax} = 0.45V$ at $I = 2mA$ $V_{OHmin} = 2.57V$ at $I = -2mA$ $V_{OHmax} = 3.08V$	Maximum cable length or copper track should be not longer than 100mm to SIM card holder. CCIO2: External 10k Ω pull-up required - for details please refer to Section 3.8 . If 2 nd SIM interface not used, keep lines open.
	CCIO1 CCIO2	I/O	CCIO1: $R_{PU} \approx 4.8 \dots 9.5k\Omega$ CCIO2: $R_{PU} \approx 9.2 \dots 190k\Omega$ $V_{ILmax} = 0.76V$ $V_{ILmin} = -0.3V$ $V_{IHmin} = 1.98V$ $V_{IHmax} = 3.35V$ $V_{OLmax} = 0.45V$ at $I = 2mA$ $V_{OHmin} = 2.57V$ at $I = -0.05mA$ $V_{OHmax} = 3.08V$	
	CCCLK1 CCCLK2	O	$V_{OLmax} = 0.45V$ at $I = 2mA$ $V_{OHmin} = 2.57V$ at $I = -2mA$ $V_{OHmax} = 3.08V$	
	CCVCC1 CCVCC2	O	$V_Omin = 3.0V$ $V_Otyp = 3.05V$ $V_Omax = 3.08V$ $I_Omax = -50mA$	

6.5 Pad Assignment and Signal Description

Table 22: Signal description

Function	Signal name	IO	Signal form and level	Comment
1.8V SIM card interface	CCRST1 CCRST2	O	$V_{OLmax} = 0.45V$ at $I = 2mA$ $V_{OHmin} = 1.35V$ at $I = -2mA$ $V_{OHmax} = 1.85V$	Maximum cable length or copper track should be not longer than 100mm to SIM card holder. CCIO2: External 10k Ω pull-up required - for details please refer to Section 3.8 . If 2 nd SIM interface not used, keep lines open.
	CCIO1 CCIO2	I/O	CCIO1: $R_{PU} \approx 4.8...9.5k\Omega$ CCIO2: $R_{PU} \approx 9.2...190k\Omega$ $V_{ILmax} = 0.62V$ $V_{ILmin} = -0.3V$ $V_{IHmin} = 1.20V$ $V_{IHmax} = 2.1V$ $V_{OLmax} = 0.45V$ at $I = 2mA$ $V_{OHmin} = 1.32V$ at $I = -0.05mA$ $V_{OHmax} = 1.82V$	
	CCCLK1 CCCLK2	O	$V_{OLmax} = 0.45V$ at $I = 2mA$ $V_{OHmin} = 1.32V$ at $I = -2mA$ $V_{OHmax} = 1.82V$	
	CCVCC1 CCVCC2	O	$V_{Omin} = 1.75V$ $V_{Otyp} = 1.80V$ $V_{Omax} = 1.82V$ $I_{Omax} = -50mA$	
Serial Modem Interface ASC0	RXD0	O	$V_{OLmax} = 0.45V$ at $I = 2mA$ $V_{OHmin} = 1.35V$ at $I = -2mA$ $V_{OHmax} = 1.85V$	If unused keep line open.
	CTS0	O		
	DSR0	O		
	DCD0	O		
	RING0	O		
	TXD0	I	$V_{ILmax} = 0.6V$ at $30\mu A$ $V_{IHmin} = 1.20V$ at $-30\mu A$ $V_{IHmax} = 2V$	
	RTS0	I		
DTR0	I			
Power indicator	PWR_IND	O	$V_{IHmax} = 5.5V$ $V_{OLmax} = 0.4V$ at $I_{max} = 1mA$	PWR_IND (Power Indicator) notifies the module's on/off state. 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. Therefore, signal may be used to enable external voltage regulators that supply an external logic for communication with the module, e.g. level converters.
Host wakeup	RING0	O	$V_{OLmax} = 0.45V$ at $I = 2mA$ $V_{OHmin} = 1.35V$ at $I = -2mA$ $V_{OHmax} = 1.85V$	If unused keep line open.

6.5 Pad Assignment and Signal Description

Table 22: Signal description

Function	Signal name	IO	Signal form and level	Comment
USB	VUSB_IN	I	$V_{INmin} = 3.0V$ $V_{INmax} = 5.25V$ $I_{typ} = 150\mu A$ $I_{max} = 200\mu A$ $C_{in} = 1\mu F$ In case of $V_{ripple} \geq 10mV_{pp}$ (with $f > 300kHz$), and V_{BUS_IN} driven in the voltage range 4.08V...4.11V, use of an RC filter 1k Ω /100nF is required.	If the USB interface is not used please connect this line to GND. 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 High Speed Specification.	Keep lines open if VUSB_IN connects to GND. USB High Speed mode operation requires a differential impedance of 90 Ω .
	USB_DP	I/O		
Digital audio interface (PCM or I ² S)	DIN	I	$V_{ILmax} = 0.6V$ at 30 μA $V_{IHmin} = 1.20V$ at -30 μA $V_{IHmax} = 2V$ $V_{OLmax} = 0.45V$ at $I = 2mA$ $V_{OHmin} = 1.35V$ at $I = -2mA$ $V_{OHmax} = 1.85V$	PCM Master/Slave mode. I ² S Master mode. If unused keep lines open.
	BCLK	I/O		
	FSC	I/O		
	DOUT	O		
	MCLK	O	$V_{OLmax} = 0.45V$ at $I = 2mA$ $V_{OHmin} = 1.35V$ at $I = -2mA$ $V_{OHmax} = 1.85V$ $F = 2048KHz$ (at 8KHz sample rate) $F = 4096KHz$ (at 16KHz sample rate)	Master clock option for audio codecs without PLL. If unused keep line open.
GPIO interface	GPIO1	I/O	$V_{ILmax} = 0.6V$ at 30 μA $V_{IHmin} = 1.20V$ at -30 μA $V_{IHmax} = 2V$ $V_{OLmax} = 0.45V$ at $I = 2mA$ $V_{OHmin} = 1.35V$ at $I = -2mA$ $V_{OHmax} = 1.85V$	If unused keep lines open. Following functions can be configured for GPIOs using AT commands: GPIO1 --> Dead reckoning synchronization Any GPIO --> Low current indication. By default GPIO6 is configured as LCI line. Any GPIO --> Remote host wakeup line
	GPIO2			
	GPIO3			
	GPIO4			
	GPIO5			
	GPIO6			
	GPIO7			
	GPIO8			
	GPIO9			
	GPIO10			
Dead reckoning synchronization	GPIO1 (DR_SYNC)	O	$V_{OLmax} = 0.45V$ at $I = 2mA$ $V_{OHmin} = 1.35V$ at $I = -2mA$ $V_{OHmax} = 1.85V$	1 pulse per second dead reckoning synchronization signal for usage in external dead reckoning applications (see Chapter 4).
Low Current Indication	GPIOx (LCI_IND)	O	$V_{OLmax} = 0.45V$ at $I = 2mA$ $V_{OHmin} = 1.35V$ at $I = -2mA$ $V_{OHmax} = 1.85V$	If the feature is enabled (see Section 3.12.4).
		I	$V_{IHmax} = 2V$ $R_{PD} = \text{appr. } 100k\Omega$	If the feature is disabled (see Section 3.12.4).

6.5 Pad Assignment and Signal Description

Table 22: Signal description

Function	Signal name	IO	Signal form and level	Comment
Remote host wakeup	GPIOx	O	$V_{OLmax} = 0.45V$ at $I = 2mA$ $V_{OHmin} = 1.35V$ at $I = -2mA$ $V_{OHmax} = 1.85V$	If feature is enabled (see- Section 3.12.3).
ADC interface	ADC1_IN, ADC2_IN, ADC3_IN	I	Full specification compliance range $V_{Imin} \geq 0.3V$ $V_{Imax} \leq 3.075V$ Degraded accuracy range $V_{Imin} 0.05V \dots 0.3V$ $R_{idc} > 1M\Omega$ Resolution: 12 Bit Offset error: $< \pm 10mV$ Gain error: $< 1\%$ analog bandwidth: $< 16kHz$ conversation time: $853\mu s$	If unused keep line open.

6.6 Power Supply Ratings

6.6 Power Supply Ratings

Table 23 and Table 24 assemble various voltage supply and current consumption ratings of the module.

Table 23: 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 24: Current consumption ratings

	Description	Conditions	Typical rating	Unit	
$I_{VDDL P}$ @ 3V	OFF state supply current	Power Down	4	μ A	
I_{BATT+}^1	OFF State supply current	Power Down	40	μ A	
	Average GSM / GPRS supply current	SLEEP ² @ DRX=9 (no communication via UART)	USB disconnected	2.0	mA
		SLEEP ² @ DRX=5 (no communication via UART)	USB disconnected	2.5	mA
		SLEEP ² @ DRX=2 (no communication via UART)	USB disconnected	3.7	mA
		IDLE @ DRX=2 UART active, but no communication	USB disconnected	40	mA
			USB active	50	mA
		Voice call GSM900; PCL=5	@50 Ω	330	mA
		GPRS Data transfer GSM900; PCL=5; 1Tx/4Rx	ROPR=8 (max. reduction)	320	mA
			ROPR=4 (no reduction)		
		GPRS Data transfer GSM900; PCL=5; 2Tx/3Rx	ROPR=8 (max. reduction)	430	mA
			ROPR=4 (no reduction)	540	
GPRS Data transfer GSM900; PCL=5; 4Tx/1Rx	ROPR=8 (max. reduction)	600	mA		
	ROPR=4 (no reduction)	930			
	@ total mismatch	990			

6.6 Power Supply Ratings

Table 24: Current consumption ratings

	Description	Conditions		Typical rating	Unit
I _{BATT+} ¹	Average GSM / GPRS supply current	EDGE Data transfer GSM900; PCL=5; 1Tx/4Rx	ROPR=8 (max. reduction)	220	mA
			ROPR=4 (no reduction)		
		EDGE Data transfer GSM900; PCL=5; 2Tx/3Rx	ROPR=8 (max. reduction)	300	mA
			ROPR=4 (no reduction)	340	
		EDGE Data transfer GSM900; PCL=5; 4Tx/1Rx	ROPR=8 (max. reduction)	490	mA
			ROPR=4 (no reduction)	570	
		Voice call GSM1800; PCL=0	@50Ω	240	mA
		GPRS Data transfer GSM1800; PCL=0; 1Tx/ 4Rx	ROPR=8 (max. reduction)	230	mA
			ROPR=4 (no reduction)		
		GPRS Data transfer GSM1800; PCL=0; 2Tx/ 3Rx	ROPR=8 (max. reduction)	300	mA
			ROPR=4 (no reduction)	360	
		GPRS Data transfer GSM1800; PCL=0; 4Tx/ 1Rx	ROPR=8 (max. reduction)	410	mA
			ROPR=4 (no reduction)	590	
		EDGE Data transfer GSM1800; PCL=0; 1Tx/ 4Rx	ROPR=8 (max. reduction)	190	mA
			ROPR=4 (no reduction)		
		EDGE Data transfer GSM1800; PCL=0; 2Tx/ 3Rx	ROPR=8 (max. reduction)	250	mA
			ROPR=4 (no reduction)	290	
EDGE Data transfer GSM1800; PCL=0; 4Tx/ 1Rx	ROPR=8 (max. reduction)	380	mA		
	ROPR=4 (no reduction)	460			
Peak current during GSM transmit burst	Voice call GSM900; PCL=5	@50Ω	2.1	A	
		@total mismatch	2.4		
	Voice call GSM1800; PCL=0	@50Ω	1.3	A	
		@total mismatch	1.6		

6.6 Power Supply Ratings

Table 24: Current consumption ratings

	Description	Conditions	Typical rating	Unit	
I_{BATT+}^1	Average GSM supply current (GNSS on)	GSM active (UART/USB active); @DRX=2 & GNSS NMEA output off	65	mA	
		GSM active (UART/USB active); @DRX=2 & GNSS NMEA output on ³	85	mA	
I_{BATT+}^1	Average UMTS supply current	SLEEP ² @ DRX=9	USB disconnected	1.8	mA
		SLEEP ² @ DRX=8	USB disconnected	2.1	mA
	Voice calls and Data transfers measured @maximum Pout	SLEEP ² @ DRX=6	USB disconnected	3.3	mA
		IDLE @ DRX=6	USB disconnected	30	mA
		USB active	40	mA	
	Voice call Band I		540	mA	
	Voice call Band III	@50Ω	600	mA	
		@total mismatch	780		
	Voice call Band VIII		460	mA	
	UMTS Data transfer Band I		560	mA	
	UMTS Data transfer Band III		620	mA	
	UMTS Data transfer Band VIII		500	mA	
	HSDPA Data transfer Band I		590	mA	
	HSDPA Data transfer Band III		620	mA	
	HSDPA Data transfer Band VIII		510	mA	
	Average UMTS supply current (GNSS on)	WCDMA active (UART / USB active); @DRX=6 & GNSS NMEA output off		65	mA
		WCDMA active (UART / USB active); @DRX=6 & GNSS NMEA output on ³		85	mA
	Average LTE supply current ⁴	SLEEP ² @ "Paging Occasions" = 256	USB disconnected	2.3	mA
		SLEEP ² @ "Paging Occasions" = 128	USB disconnected	2.7	mA
	Data transfers measured @maximum Pout	SLEEP ² @ "Paging Occasions" = 64	USB disconnected	3.5	mA
		SLEEP ² @ "Paging Occasions" = 32	USB disconnected	5.4	mA
		IDLE	USB disconnected	35	mA
			USB active	45	mA
LTE Data transfer Band 1			570	mA	
LTE Data transfer Band 3		@ 50Ω	650	mA	
		@ total mismatch	830	mA	
LTE Data transfer Band 7			640	mA	
LTE Data transfer Band 8			520	mA	
LTE Data transfer Band 20			520	mA	

6.6 Power Supply Ratings

Table 24: Current consumption ratings

	Description	Conditions	Typical rating	Unit
I _{BATT+} ¹	Average LTE supply current (GNSS on)	LTE active (UART / USB active); @DRX=6 & GNSS NMEA output off	65	mA
		LTE active (UART / USB active); @DRX=6 & GNSS NMEA output on ³	85	mA
I _{VUSB_IN}	USB typical and maximum ratings are mentioned in Table 22: VUSB_IN .			

¹. With an impedance of $Z_{LOAD}=50\Omega$ at the antenna pads. Measured at 25°C and 4.2V - except for Power Down ratings that were measured at 3.4V.

². Measurements start 6 minutes after switching ON the module,
Averaging times: SLEEP mode - 3 minutes, transfer modes - 1.5 minutes
Communication tester settings: no neighbour cells, no cell reselection etc,
RMC (Reference Measurement Channel)

³. One fix per second.

⁴. Communication tester settings:
- Channel Bandwidth: 5MHz
- Number of Resource Blocks: 25 (DL), 1 (UL)
- Modulation: QPSK

6.7 Electrical Characteristics of the Voiceband Part

6.7.1 Setting Audio Parameters by AT Commands

The audio modes 1 to 6 can be temporarily adjusted according to the AT command parameters listed in the table below. The audio parameters are set with the AT command AT^SNFO and the audio mode is changed by AT^SNFS (see [1]). For a model of how the parameters influence the audio signal path see Section 6.7.2.

Table 25: Audio parameters adjustable by AT command

Parameter ¹	Influence to	Range	Gain range	Calculation
AT^SNFO=				
rxVolStep	Digital volume of output signal after speech decoder, before summation of sidetone and DAC.	0...5	-0...-15dB	3dB steps

¹. See [1] for command syntax and further parameter descriptions.

6.7.2 Audio Programming Model

The audio programming model shows how the signal path can be influenced by varying AT command parameters: AT^SNFO allows to set the parameter <rxVolStep>. For more information on the AT commands and parameters see Section 6.7.1 and [1].

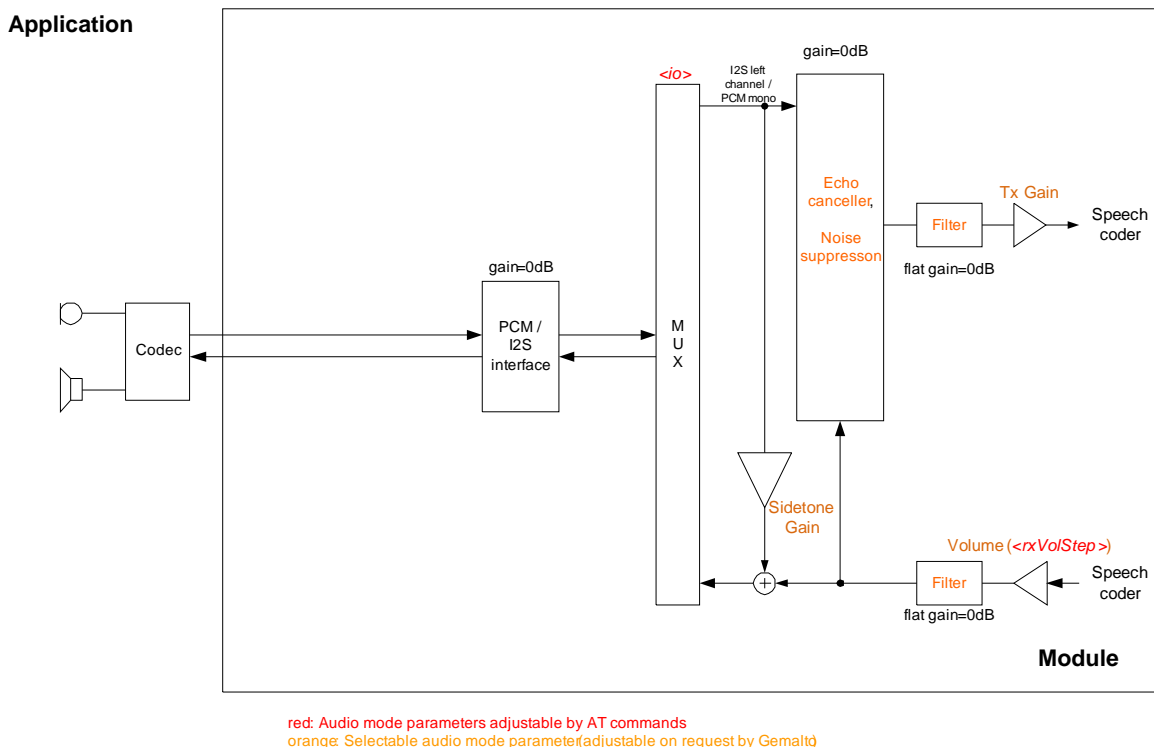


Figure 37: Audio programming model

6.7 Electrical Characteristics of the Voiceband Part

6.7.3 Characteristics of Audio Modes

The electrical characteristics of the voiceband part depend on the current audio mode set with AT command. All values are noted for default gains, e.g. the default parameters are left unchanged.

Table 26: Voiceband characteristics

Audio mode no. AT^SNFS=	1	2	3	4	5	6
Name	Default Handset	Router	User Handset	Headset	Speaker phone	Transparent
Purpose	DSB with Votronic handset	Analog phone interface	Same as audio mode 1	Mono Headset	Handheld speaker-phone	Direct access to speech coder
TX-Filters	Adjusted	Flat	Adjusted	Flat	Flat	Flat
RX-Filters	Adjusted to fit artificial ear type 3.2 low leakage	Flat	Adjusted to fit artificial ear type 3.2 low leakage	800Hz HP	800Hz HP	Flat
Echo canceller Behaviour optimized for	ON low echo	ON low echo	ON low echo	ON moderate echo	ON high echo	OFF
Residual echo suppression with comfort noise generator	ON	ON	ON	ON	ON	OFF
Noise Reduction (Tx)	-12dB	-15dB	-12dB	-15dB	-15dB	OFF
Sidetone gain at default settings	19.4dB	-∞ dB	19.4dB	17.8dB	-∞ dB	-∞ dB
Uplink gain at 1024Hz	-1dB	0dB	-1dB	0dB	0dB	0dB
Downlink gain at 1024Hz	-12dB	0dB	-12dB	-2dB	-2dB	0dB
Sidetone Gain	-21.5dB	Mute	-21.5dB	-15dB	Mute	Mute

Note: With regard to acoustic shock, the cellular application must be designed to avoid sending false AT commands that might increase amplification, e.g. for a highly sensitive earpiece. A protection circuit should be implemented in the cellular application.

6.8 RF Antenna Interface Characteristics

Table 27: RF Antenna interface GSM/UMTS/LTE (at operating temperature range¹)

Parameter	Conditions	Min.	Typical	Max.	Unit
LTE connectivity ²	Band 1, 3, 7, 8, 20				
Receiver Input Sensitivity @ ARP (ch. bandwidth 5MHz)	LTE 800 Band 20	-97	-103		dBm
	LTE 900 Band 8	-97	-104		dBm
	LTE 1800 Band 3	-97	-103		dBm
	LTE 2100 Band 1	-100	-103		dBm
	LTE 2600 Band 7	-98	-102		dBm
RF Power @ ARP with 50Ω Load	LTE 800 Band 20	+21	+23	+25	dBm
	LTE 900 Band 8	+21	+23	+25	dBm
	LTE 1800 Band 3	+21	+23	+25	dBm
	LTE 2100 Band 1	+21	+23	+25	dBm
	LTE 2600 Band 7	+21	+23	+25	dBm
UMTS/HSPA connectivity ²	Band I, III, VIII				
Receiver Input Sensitivity @ ARP	UMTS 900 Band VIII	-103.7	-111		dBm
	UMTS 1800 Band III	-103.7	-110		dBm
	UMTS 2100 Band I	-106.7	-110		dBm
RF Power @ ARP with 50Ω Load	UMTS 900 Band VIII	+21	+24	+25	dBm
	UMTS 1800 Band III	+21	+24	+25	dBm
	UMTS 2100 Band I	+21	+24	+25	dBm
Tx noise @ ARP with max. RF power for UMTS: Band 1 channel 9777 Band 2 channel 9477	GNSS band		-170		dBm/Hz
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	-102	-111		dBm
	GSM 1800	-102	-110		dBm
RF Power @ ARP with 50Ω Load GSM	E-GSM 900		33		dBm
	GSM 1800		30		dBm

6.8 RF Antenna Interface Characteristics

Table 27: RF Antenna interface GSM/UMTS/LTE (at operating temperature range¹)

Parameter	Conditions	Min.	Typical	Max.	Unit		
RF Power @ ARP with 50Ω Load (ROPR=4, i.e., no reduction)	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	
	RF Power @ ARP with 50Ω Load (ROPR=5)	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		32.2		dBm	
		GSM 1800		29.2		dBm	
EDGE, 3 TX		E-GSM 900		27		dBm	
		GSM 1800		26		dBm	
GPRS, 4 TX		E-GSM 900		31		dBm	
		GSM 1800		28		dBm	
EDGE, 4 TX		E-GSM 900		27		dBm	
		GSM 1800		26		dBm	

6.8 RF Antenna Interface Characteristics

Table 27: RF Antenna interface GSM/UMTS/LTE (at operating temperature range¹)

Parameter	Conditions	Min.	Typical	Max.	Unit		
RF Power @ ARP with 50Ω Load (ROPR=6)	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		31		dBm	
		GSM 1800		28		dBm	
	EDGE, 2 TX	E-GSM 900		27		dBm	
		GSM 1800		26		dBm	
	GPRS, 3 TX	E-GSM 900		30.2		dBm	
		GSM 1800		27.2		dBm	
	EDGE, 3 TX	E-GSM 900		27		dBm	
		GSM 1800		26		dBm	
	GPRS, 4 TX	E-GSM 900		29		dBm	
		GSM 1800		26		dBm	
	EDGE, 4 TX	E-GSM 900		27		dBm	
		GSM 1800		26		dBm	
	RF Power @ ARP with 50Ω Load (ROPR=7)	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		30		dBm	
		GSM 1800		27		dBm	
EDGE, 2 TX		E-GSM 900		27		dBm	
		GSM 1800		26		dBm	
GPRS, 3 TX		E-GSM 900		28.2		dBm	
		GSM 1800		25.2		dBm	
EDGE, 3 TX		E-GSM 900		27		dBm	
		GSM 1800		26		dBm	
GPRS, 4 TX		E-GSM 900		27		dBm	
		GSM 1800		24		dBm	
EDGE, 4 TX		E-GSM 900		27		dBm	
		GSM 1800		26		dBm	

6.8 RF Antenna Interface Characteristics

Table 27: RF Antenna interface GSM/UMTS/LTE (at operating temperature range¹)

Parameter	Conditions	Min.	Typical	Max.	Unit	
RF Power @ ARP with 50Ω Load (ROPR=8, i.e., max. reduction)	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		30		dBm
		GSM 1800		27		dBm
	EDGE, 2 TX	E-GSM 900		24		dBm
		GSM 1800		23		dBm
	GPRS, 3 TX	E-GSM 900		28.2		dBm
		GSM 1800		25.2		dBm
	EDGE, 3 TX	E-GSM 900		22.2		dBm
		GSM 1800		21.2		dBm
	GPRS, 4 TX	E-GSM 900		27		dBm
		GSM 1800		24		dBm
	EDGE, 4 TX	E-GSM 900		21		dBm
		GSM 1800		20		dBm

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

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

6.9 GNSS Interface Characteristics

The following tables list general characteristics of the GNSS interface.

Table 28: GNSS properties

Parameter	Conditions	Min.	Typical	Max.	Unit
Frequency	GPS GLONASS Galileo	1597.551	1575.42 1575.42	1605.886	MHz
Tracking Sensitivity	Open sky Active antenna or LNA Passive antenna		-159 -156		dBm
Acquisition Sensitivity	Open sky Active antenna or LNA Passive antenna		-149 -145		dBm
Cold Start sensitivity ¹			-145		dBm
Time-to-First-Fix (TTFF) ²	Cold ³		25	32	s
	Warm ⁴		10	29	s

¹. Test condition: Assumes 300 seconds timeout, QoS=1000m, and 50% yield.



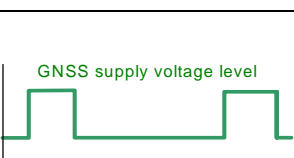
². Test condition: TTFF is defined for an open sky environment, i.e., with a clear view to the sky and a minimum signal level of -130dBm at the antenna for at least 3...4 satellites. This signal level represents C/No=42dB in an NMEA \$GPGSV message.

³. For test purposes a cold start may be triggered by AT command: AT^SBNW="agps",-1 - see also [1]

⁴. To optimize GPS start-up behavior, it is recommended to backup the module's internal real time clock via VDDL P line as described in Section 3.5.

Through the external GNSS antenna DC feeding the module is able to supply an active GNSS antenna. The supply voltage level at the GNSS antenna interface depends on the GNSS configuration done with AT command as shown in Table 29.

Table 29: Power supply for active GNSS antenna

Function	Setting samples	IO	Signal form and level
GNSS active antenna supply	Supply voltage with: GNSS receiver off Active antenna off	O	
	Supply voltage with: GNSS receiver on Active antenna on SLEEP mode	O	
	Supply voltage with: GNSS receiver on Active antenna auto	O	

6.10 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 3.8.1](#).

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 30: Electrostatic values

Specification / Requirements	Contact discharge	Air discharge
ANSI/ESDA/JEDEC JS-001-2011		
All SMT interfaces	± 1kV Human Body Model	n.a.
JESD22-C101-F (Class C1)		
All SMT interfaces	± 500V Charged Device Model (CDM)	n.a.
ETSI EN 301 489-1/7		
BATT+	± 4kV	± 8kV

Note: The values may vary with the individual application design. For example, it matters whether or not the application platform is grounded over external devices like a computer or other equipment, such as the Gemalto M2M reference application described in [Chapter 9](#).

7 Mechanics, Mounting and Packaging

7.1 Mechanical Dimensions of PLS8-E

Figure 38 shows a 3D view¹ of PLS8-E and provides an overview of the board's mechanical dimensions. For further details see Figure 39.

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

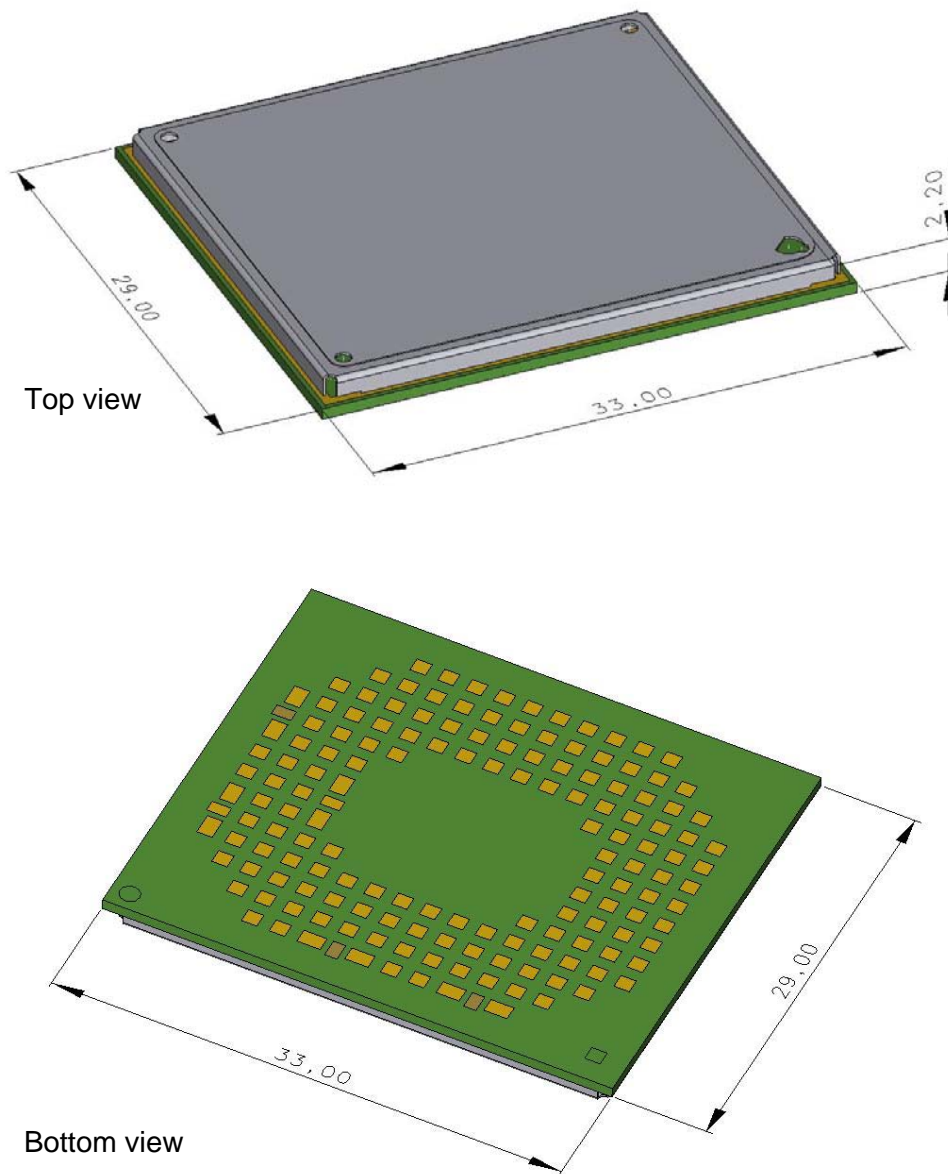


Figure 38: PLS8-E – top and bottom view

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

7.1 Mechanical Dimensions of PLS8-E

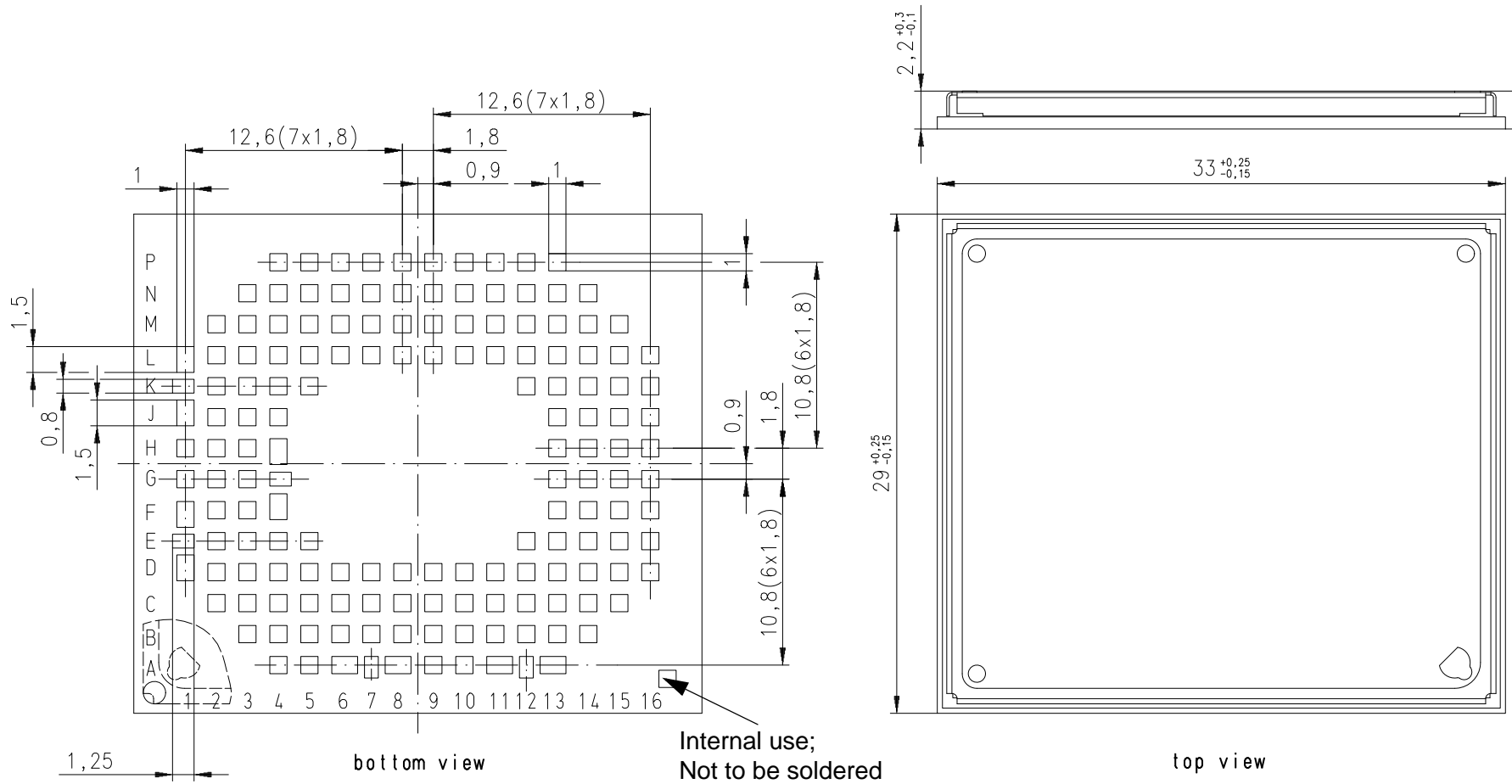


Figure 39: Dimensions of PLS8-E (all dimensions in mm)

7.2 Mounting PLS8-E onto the Application Platform

This section describes how to mount PLS8-E onto the PCBs, 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: Gemalto strongly recommends to solder all connecting pads for mechanical stability and heat dissipation. Not only must all supply pads and signals be connected appropriately, but all pads denoted as “Do not use” should also be soldered (but not electrically connected). 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.

7.2.1 SMT PCB Assembly

7.2.1.1 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 as well as a 150 micron-thick stencil.

The land pattern given in Figure 40 reflects the module’s pad layout, including signal pads and ground pads (for pad assignment see Section 6.5). 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.

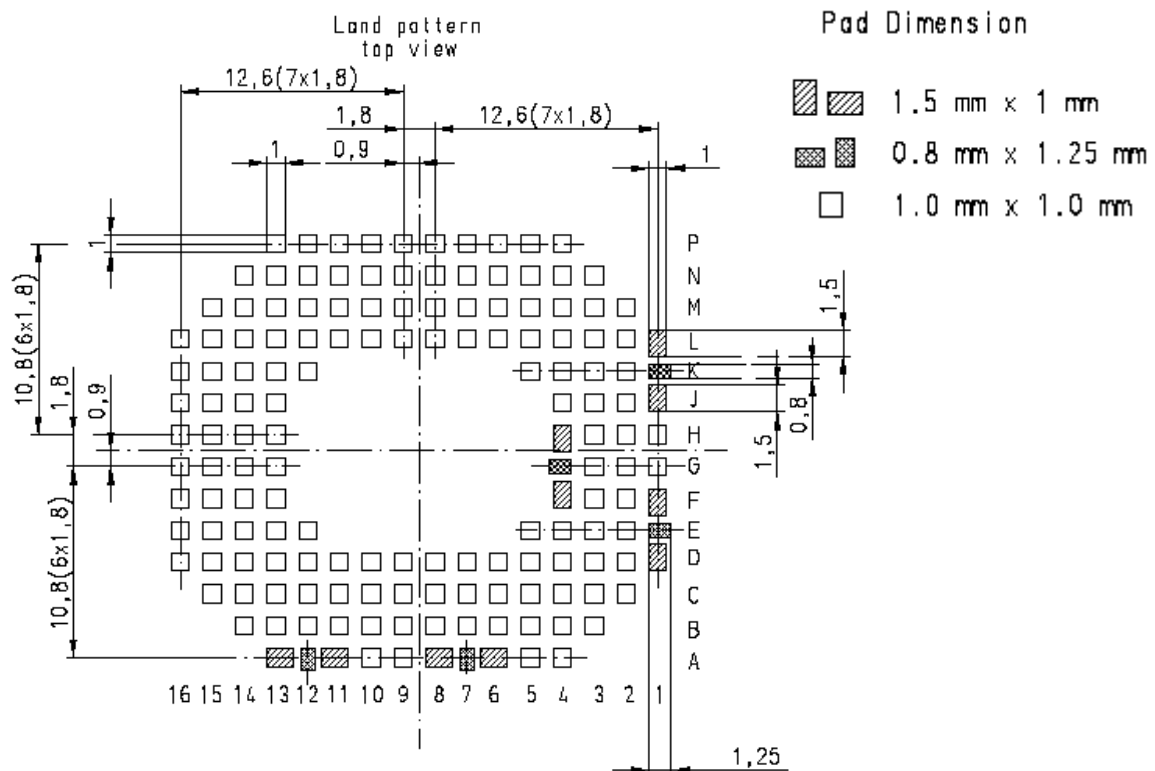


Figure 40: Land pattern (top layer)

7.2 Mounting PLS8-E onto the Application Platform

The stencil design illustrated in [Figure 41](#) and [Figure 42](#) is recommended by Gemalto M2M as a result of extensive tests with Gemalto M2M Daisy Chain modules.

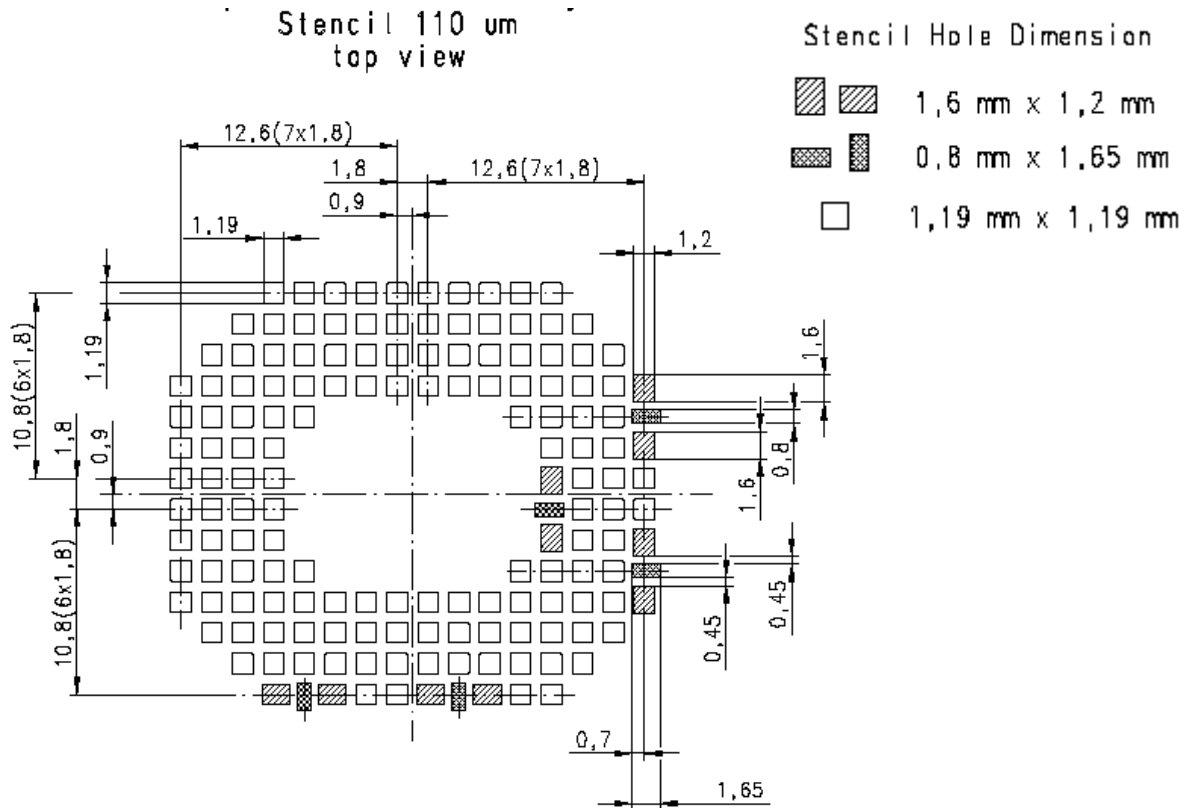


Figure 41: Recommended design for 110 micron thick stencil (top layer)

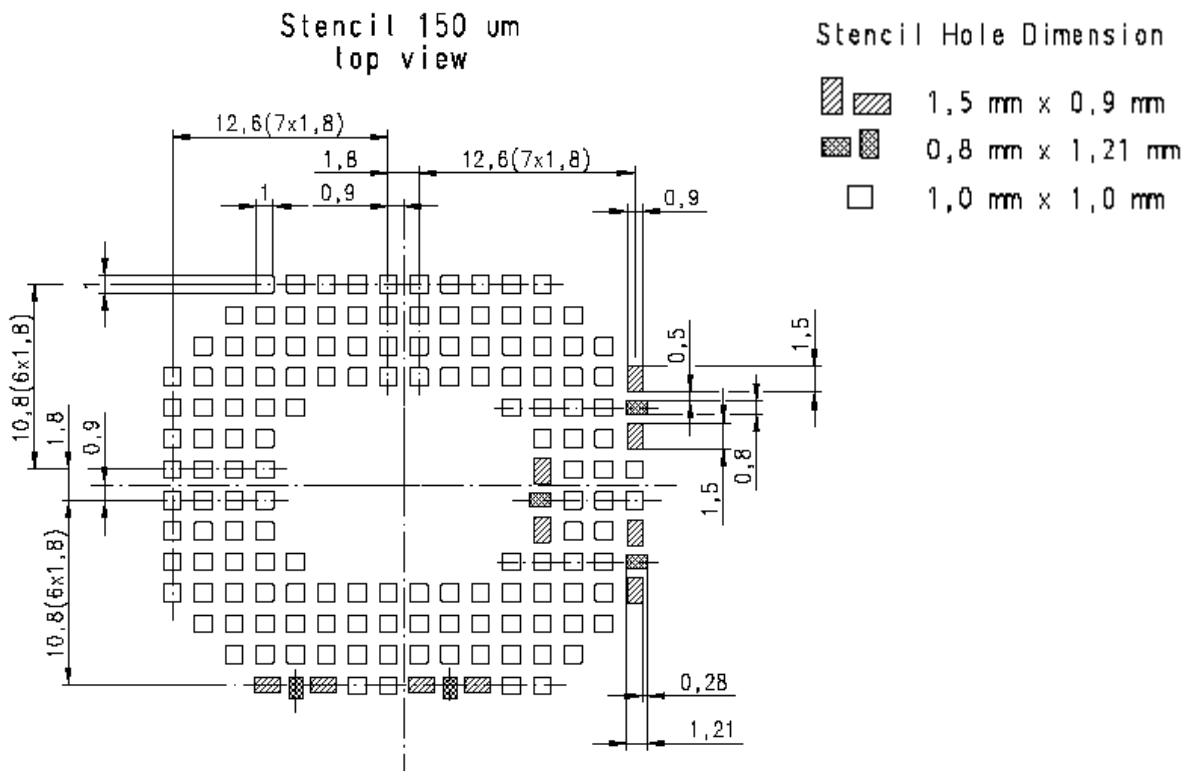


Figure 42: Recommended design for 150 micron thick stencil (top layer)

7.2.1.2 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 7.2.1.1](#). 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 7.2.3](#).

7.2.2 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 moisture sensitivity level (MSL) related information see [Section 7.2.4](#) and [Section 7.3.2](#).

7.2.3 Soldering Conditions and Temperature

7.2.3.1 Reflow Profile

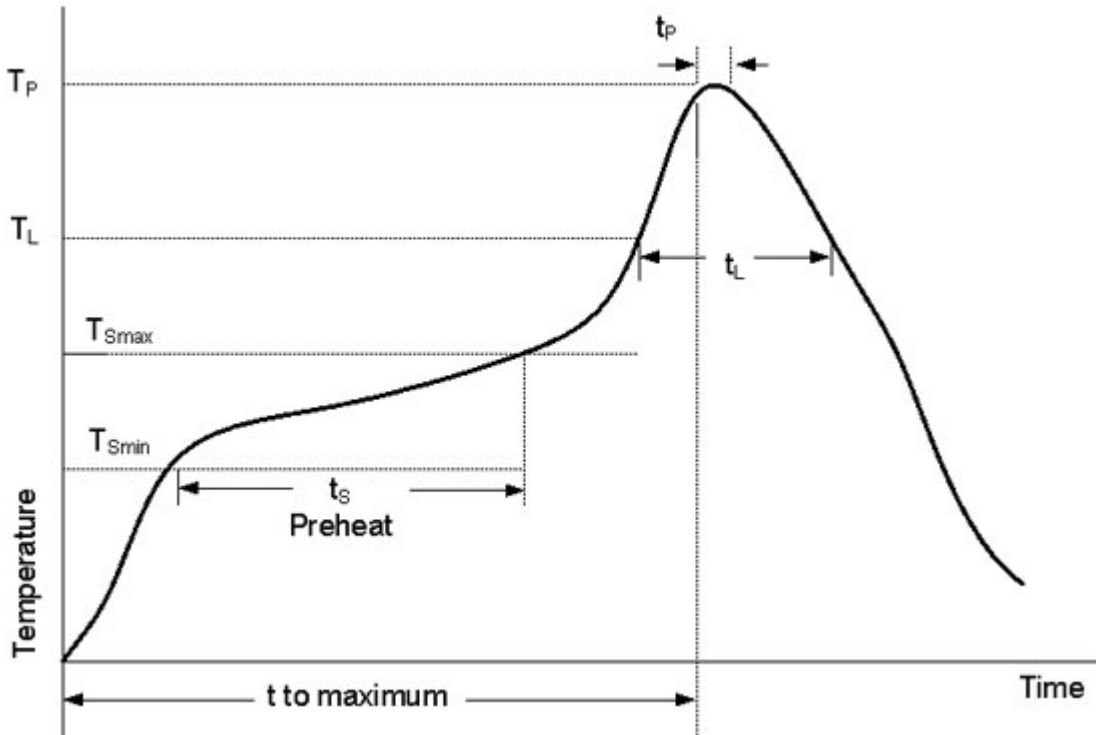


Figure 43: Reflow Profile

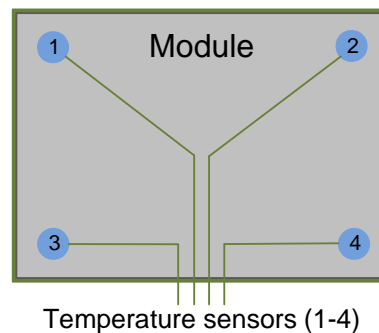
7.2 Mounting PLS8-E onto the Application Platform

Table 31: Reflow temperature recommendations¹

Profile Feature	Pb-Free Assembly
Preheat & Soak Temperature Minimum (T_{Smin}) Temperature Maximum (T_{Smax}) Time (t_{Smin} to t_{Smax}) (t_S)	150°C 200°C 60-120 seconds
Average ramp up rate (T_L to T_p)	3K/second max. ²
Liquidous temperature (T_L) Time at liquidous (t_L)	217°C 60-90 seconds
Peak package body temperature (T_p)	245°C +0/-5°C
Time (t_p) within 5 °C of the peak package body temperature (T_p)	30 seconds max.
Average ramp-down rate - Limited ramp-down rate between 225°C and 200°C	6K/second max. ² 3K/second max. ²
Time 25°C to maximum temperature	8 minutes max.

¹ Please note that the listed reflow profile features and ratings are based on the joint industry standard IPC/ JEDEC J-STD-020D.1, and are as such meant as a general guideline. For more information on reflow profiles and their optimization please refer to [3].

² Temperatures measured on shielding at each corner. See also [3].



7.2.3.2 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.
- Ramp-down rate from T_p to 200°C should be controlled in order to reduce thermally induced stress during the solder solidification phase (see Table 31 - limited ramp-down rate). Therefore, a cool-down step in the oven's temperature program between 200°C and 180°C should be considered. For more information on reflow profiles and their optimization see [3].

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.

7.2.4 Durability and Mechanical Handling

7.2.4.1 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 months. 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 22](#).

7.2.4.2 Processing Life

PLS8-E must be soldered to an application within 72 hours after opening the moisture barrier bag (MBB) 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%.

7.2.4.3 Baking

Baking conditions are specified on the moisture sensitivity label attached to each MBB (see [Figure 48](#) for details):

- It is *not necessary* to bake PLS8-E, if the conditions specified in [Section 7.2.4.1](#) and [Section 7.2.4.2](#) were not exceeded.
- It is *necessary* to bake PLS8-E, if any condition specified in [Section 7.2.4.1](#) and [Section 7.2.4.2](#) 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.

7.2.4.4 Electrostatic Discharge

Electrostatic discharge (ESD) 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 6.10](#) for further information on electrostatic discharge.

7.3 Packaging

7.3 Packaging

7.3.1 Tape and Reel

The single-feed tape carrier for PLS8-E is illustrated in Figure 44. 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.

7.3.1.1 Orientation

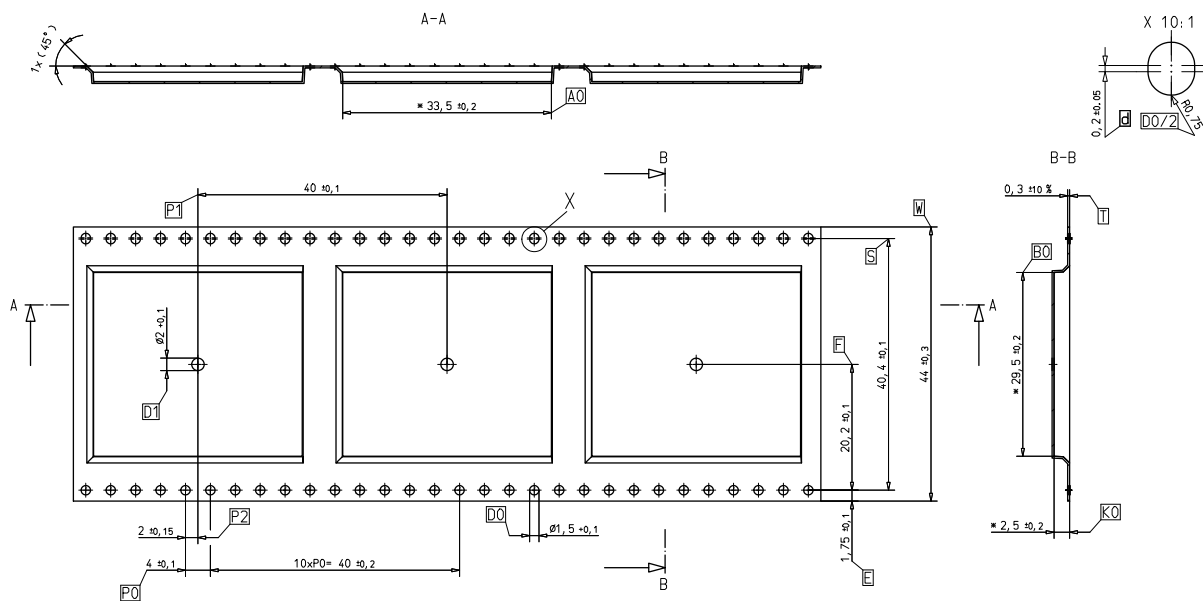


Figure 44: Carrier tape

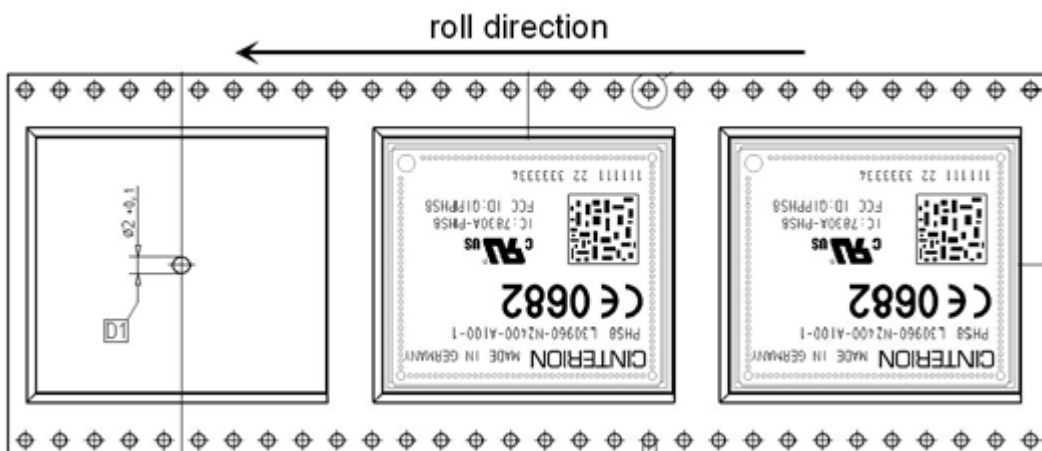


Figure 45: Roll direction

7.3.1.2 Barcode Label

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

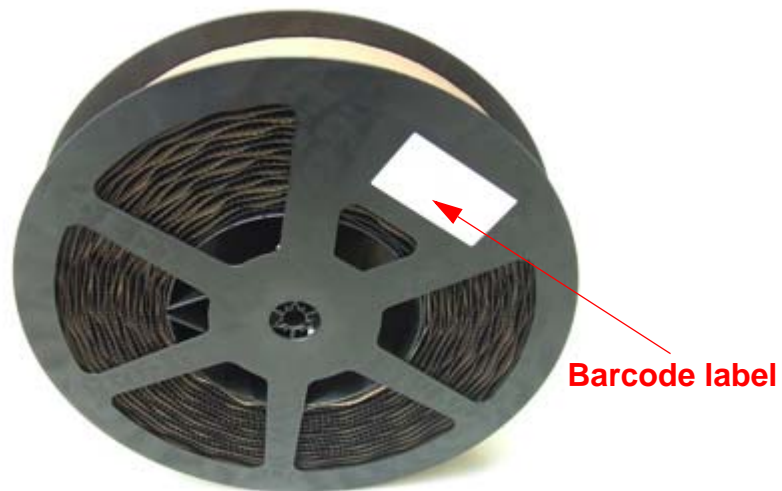


Figure 46: Barcode label on tape reel

7.3.2 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

7.3.2.1 Moisture Barrier Bag

The tape reels are stored inside a moisture barrier bag (MBB), together with a humidity indicator card and desiccant pouches - see [Figure 47](#). 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.

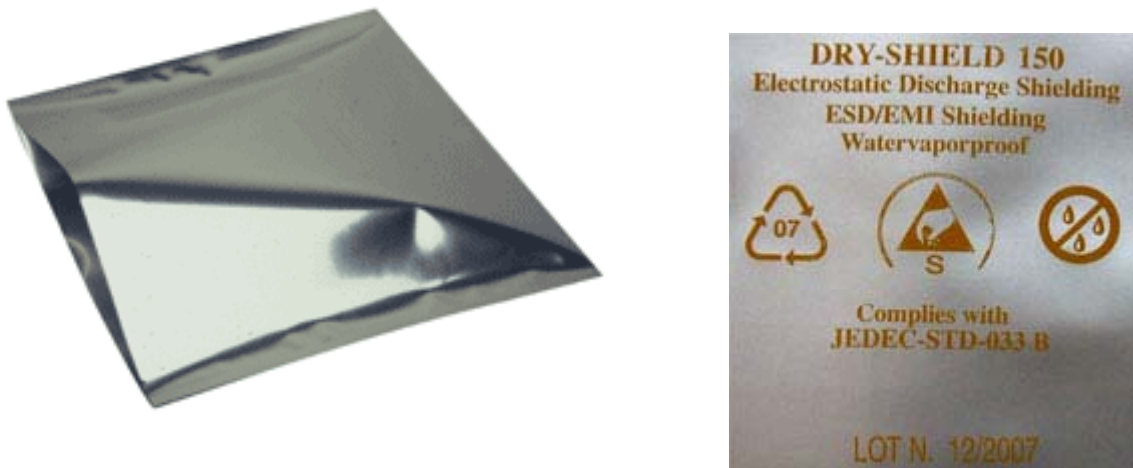



Figure 47: Moisture barrier bag (MBB) with imprint

The label shown in [Figure 48](#) summarizes requirements regarding moisture sensitivity, including shelf life and baking requirements. It is attached to the outside of the moisture barrier bag.

 **CAUTION** LEVEL
This bag contains 4
MOISTURE-SENSITIVE DEVICES

1. Calculated shelf life in sealed bag:
12 months at < 40 °C and < 90% relative humidity (RH)
2. Peak package body temperature: 245 °C
3. After bag is opened, devices that will be subject to reflow solder or other high temperature process must be
 - a) mounted within: 72 hours of factory conditions < 30 °C / 60% RH
 - b) stored at < 10% RH
4. Devices require bake, before mounting, if:
 - a) Humidity Indicator Card is > 10% when read at 23 +/- 5 °C
 - b) 3a or 3b not met
5. If baking is required, refer to IPC/Jedec J-STD-033 for bake procedure
Note: The devices are shipped in a non heat-resistant carrier and may not be baked in the carriers
6. The maximum guaranteed soldering cycle of the module is limited to 1 cycle

Bag Seal Date: DD.MM.YYYY


Note: MSL level and body temperature defined by IPC/JEDEC J-STD-020

CINTERION

INFO-2 **DELIVERYPARTNUMBER**

Peak package body temperature: 245°C Qty. : **000**

Bag Seal Date (DDMMYYYY) : DDMMYYYY



Package ID: WM8000123412




Figure 48: 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. A sample humidity card is shown in [Figure 49](#). If the components have been exposed to moisture above the recommended limits, the units will have to be rebaked.

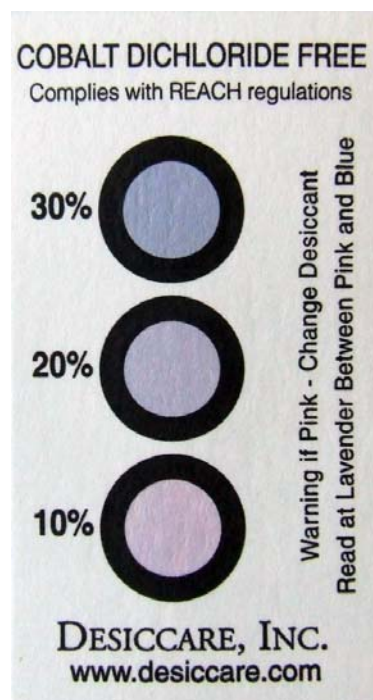


Figure 49: Humidity Indicator Card - HIC

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

7.3.2.2 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.

8 Sample Application

Figure 50 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 μ C 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, i.e., lines to and from the module - for debug and/or test purposes. The SMT application should allow for an easy access to these signals. For details on how to implement test points see [3].

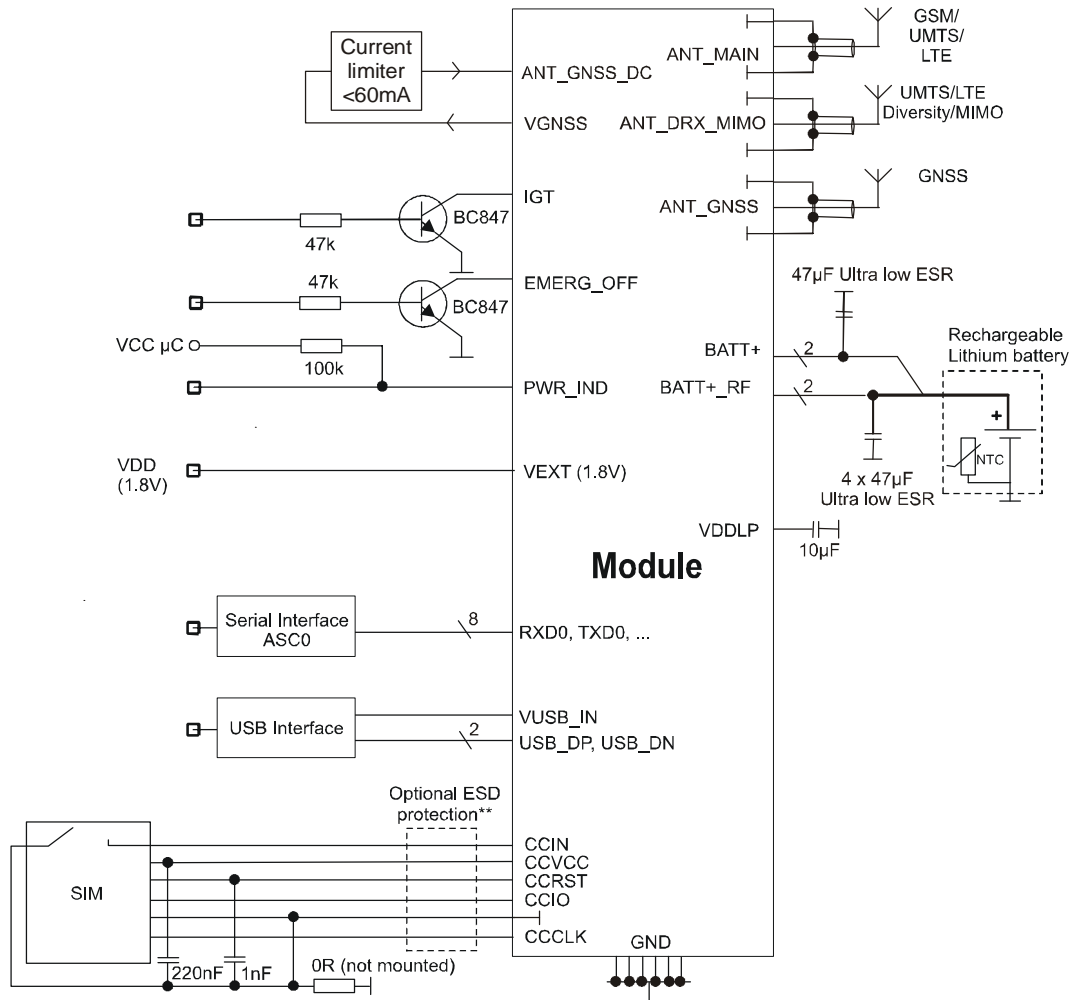
The EMC measures are best practice recommendations. In fact, an adequate EMC strategy for an individual application is very much determined by the overall layout and, especially, the position of components.

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.

Depending on the micro controller used by an external application PLS8-E's digital input and output lines may require level conversion. Section 8.1 shows a possible sample level conversion circuit.

Disclaimer:

No warranty, either stated or implied, is provided on the sample schematic diagram shown in Figure 50 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.



All SIM components shall be close to card holder.
Keep SIM wires low capacitive.

** See Section 3.8.1 for details on enhanced ESD protection

Figure 50: PLS8-E sample application

8.1 Sample Level Conversion Circuit

Depending on the micro controller used by an external application PLS8-E's digital input and output lines (i.e., ASC0 lines) may require level conversion. The following [Figure 51](#) shows a sample circuit with recommended level shifters for an external application's micro controller (with VLOGIC between 3.0V...3.6V). The level shifters can be used for digital input and output lines with $V_{OH,max}=1.85V$ or $V_{IH,max}=1.85V$.

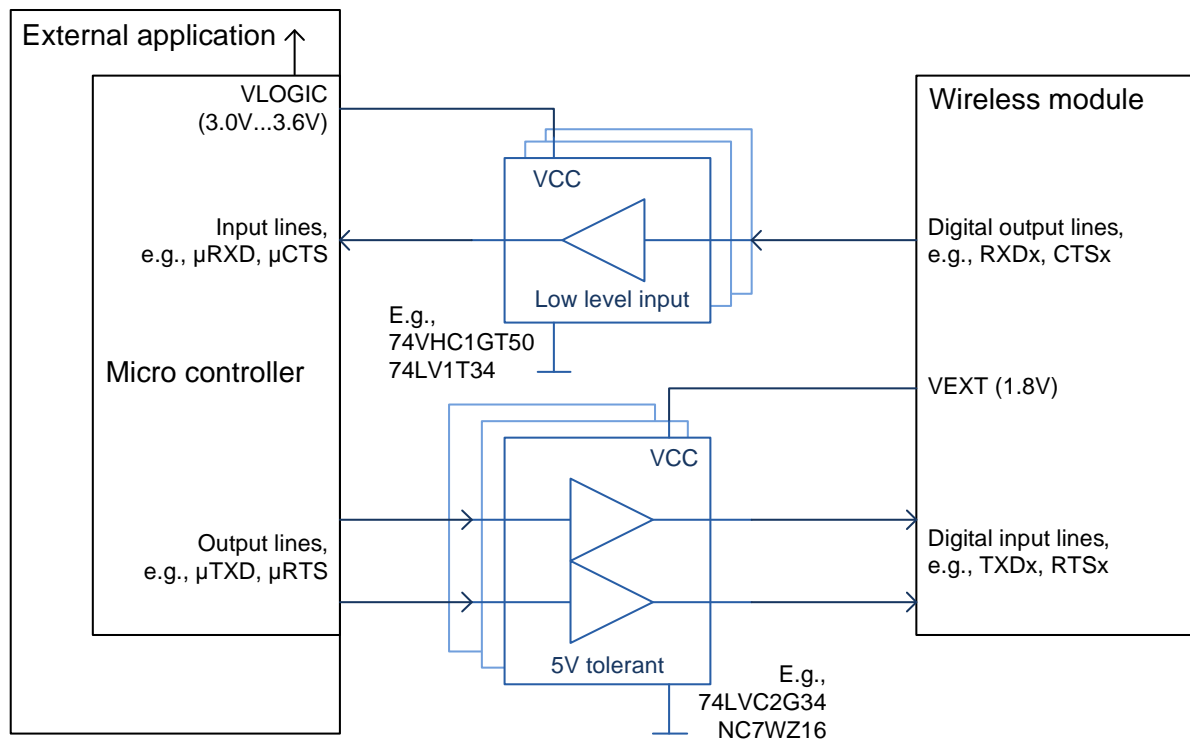


Figure 51: Sample level conversion circuit

9 Reference Approval

9.1 Reference Equipment for Type Approval

The Gemalto M2M reference setup submitted to type approve PLS8-E is shown in [Figure 52](#). 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.

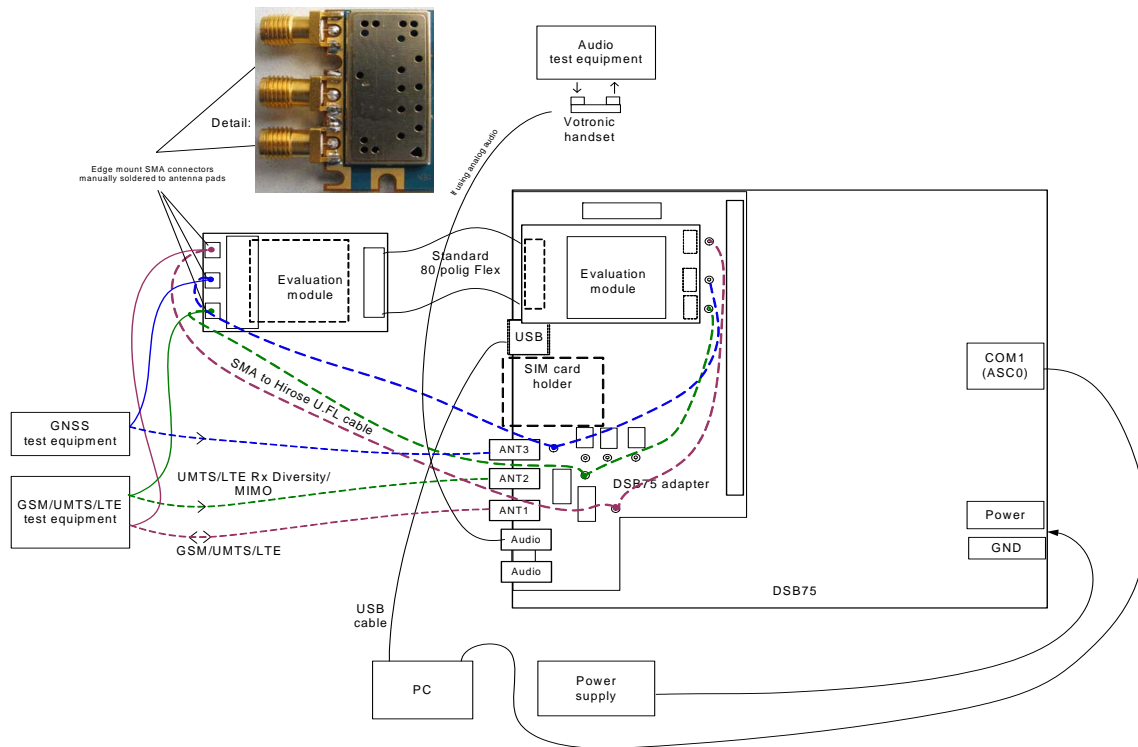


Figure 52: Reference equipment for type approval

10 Appendix

10.1 List of Parts and Accessories

Table 32: List of parts and accessories

Description	Supplier	Ordering information
PLS8-E ¹	Gemalto M2M	Standard module Gemalto M2M IMEI: Packaging unit (ordering) number: L30960-N3400-A400 Module label number: S30960-S3400-A400-1 ²
PLS8-E Evaluation Module ¹	Gemalto M2M	Packaging unit (ordering) number: L30960-N3401-A400
DSB75 Support Box	Gemalto M2M	Ordering number: L36880-N8811-A100
DSB75 adapter for mounting the evaluation module	Gemalto M2M	Ordering number: L30960-N2301-A100
Votronic handset for approval purposes	Votronic / Gemalto M2M	Gemalto M2M ordering number: L36880-N8301-A107 Votronic ordering number: HH-SI-30.3/V1.1/0 Votronic Entwicklungs- und Produktionsgesellschaft für elektronische Geräte mbH Saarbrücker Str. 8 66386 St. Ingbert Germany Phone: +49-(0)6 89 4 / 92 55-0 Fax: +49-(0)6 89 4 / 92 55-88 Email: contact@votronic.com
SIM card holder incl. push button ejector and slide-in tray	Molex	Ordering numbers: 91228 91236 Sales contacts are listed in Table 33 .
U.FL antenna connector	Hirose or Molex	Sales contacts are listed in Table 33 and Table 34 .

¹: Note: At the discretion of Gemalto M2M, modules can be made either in Germany or in China.

²: Note: At the discretion of Gemalto M2M, module label information can either be laser engraved on the module's shielding or be printed on a label adhered to the module's shielding.

10.1 List of Parts and Accessories

Table 33: Molex sales contacts (subject to change)

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

Table 34: Hirose sales contacts (subject to change)

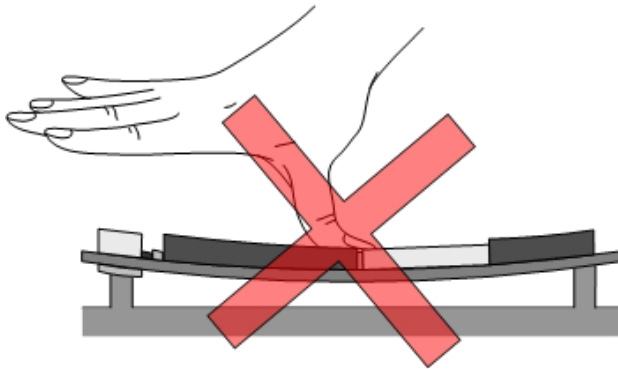
Hirose Ltd. For further information please click: http://www.hirose.com	Hirose Electric (U.S.A.) Inc 2688 Westhills Court Simi Valley, CA 93065 U.S.A. Phone: +1-805-522-7958 Fax: +1-805-522-3217	Hirose Electric Europe B.V. German Branch: Herzog-Carl-Strasse 4 73760 Ostfildern Germany Phone: +49-711-456002-1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

10.2 Mounting Advice Sheet

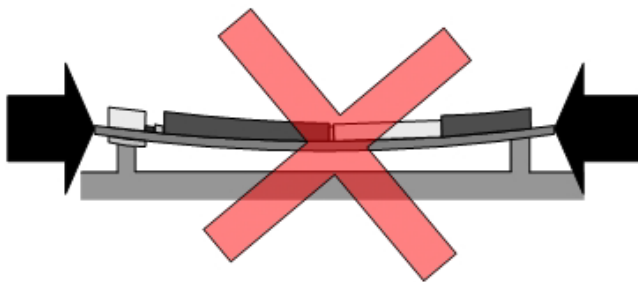
To prevent mechanical damage, be careful not to force, bend or twist the module. Be sure it is soldered flat against the host device (see also [Section 7.2](#)). The advice sheet on the next page shows a number of examples for the kind of bending that may lead to mechanical damage of the module (the module as part of an external application is integrated into a housing).

Mounting Advice

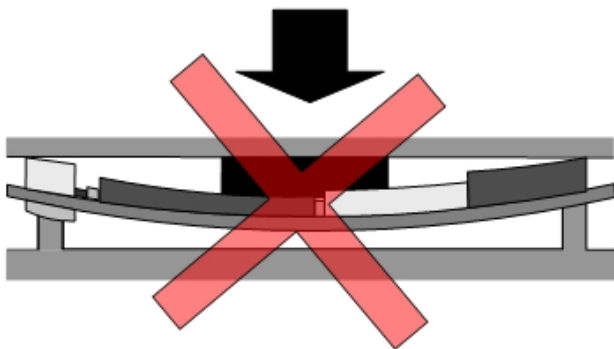
Do **NOT BEND** the Module



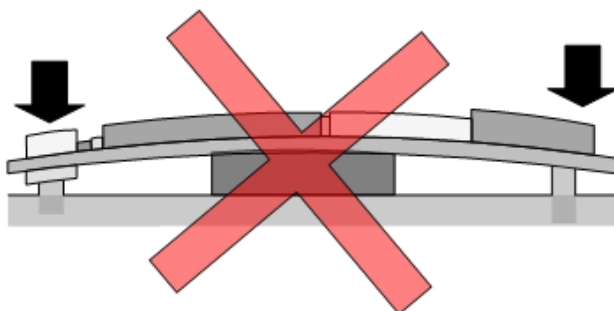
- By pressing from above



- By mounting under pressure



- By putting objects on top



- By putting objects below

About Gemalto

Since 1996, Gemalto has been pioneering groundbreaking M2M and IoT products that keep our customers on the leading edge of innovation.

We work closely with global mobile network operators to ensure that Cinterion[®] modules evolve in sync with wireless networks, providing a seamless migration path to protect your IoT technology investment.

Cinterion products integrate seamlessly with Gemalto identity modules, security solutions and licensing and monetization solutions, to streamline development timelines and provide cost efficiencies that improve the bottom line.

As an experienced software provider, we help customers manage connectivity, security and quality of service for the long lifecycle of IoT solutions.

For more information please visit

www.gemalto.com/m2m, www.facebook.com/gemalto, or Follow @gemaltoIoT on Twitter.

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