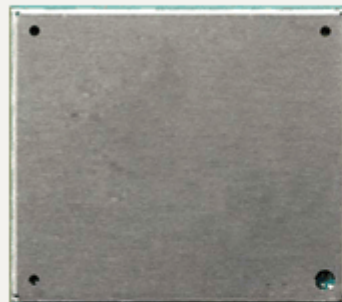# Cinterion® PLS8-X/PLS8-V

Hardware Interface Overview

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0   Document History

Preceding document: "Cinterion® PLS8-X/PLS8-V Hardware Interface Overview" v02.510
New document: "Cinterion® PLS8-X/PLS8-V Hardware Interface Overview" **v03.009**

Chapter	What is new
1.4	Removed ECE-R 10 directive from Table 1. Updated NAPRD version in Table 2.
5.2	Revised ratings for VGNSS in Figure 7.
8.2	Revised maximum antenna gain limits - added Table 9.

New document: "Cinterion® PLS8-X/PLS8-V Hardware Interface Overview" v02.510

Chapter	What is new
--	Initial document setup.

1   Introduction

The document[1] describes the hardware of the two Cinterion® modules variants PLS8-V and PLS8-X, 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.

The product variants differ in their radio access technology support:
• PLS8-X is available for operation in LTE, UMTS and GSM radio networks - for supported frequency bands please refer to Section 2.1. Connected to this, the module has two separate firmware images on board that can be activated based on the used (U)SIM card. Employing the module's two (U)SIM interfaces, it is thus possible to switch between firmware images on the fly - making PLS8-X a multi carrier/provider module.
• PLS8-V in contrast is available for operation in LTE radio networks only - for supported frequency bands please refer to Section 2.1. It has only a single firmware image on board that can be activated by (U)SIM card - making it a single carrier/provider module.

If not otherwise mentioned, this document applies to both product variants. Where necessary a note is made to differentiate between the variants.

1.1   Supported Products

This document applies to the following Gemalto M2M products:
• Cinterion® PLS8-V module
• Cinterion® PLS8-X 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
ANSI	American National Standards Institute
ARP	Antenna Reference Point
CE	Conformité Européene (European Conformity)
CS	Coding Scheme
CS	Circuit Switched
CSD	Circuit Switched Data

[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.

Abbreviation	Description
DCS	Digital Cellular System
DL	Download
dnu	Do not use
DRX	Discontinuous Reception
DSB	Development Support Board
DTX	Discontinuous Transmission
EDGE	Enhanced Data rates for GSM Evolution
EGSM	Extended GSM
EMC	Electromagnetic Compatibility
ESD	Electrostatic Discharge
ETS	European Telecommunication Standard
ETSI	European Telecommunications Standards Institute
FCC	Federal Communications Commission (U.S.)
FDD	Frequency Division Duplex
GPRS	General Packet Radio Service
GSM	Global Standard for Mobile Communications
HiZ	High Impedance
HSDPA	High Speed Downlink Packet Access
I/O	Input/Output
IMEI	International Mobile Equipment Identity
ISO	International Standards Organization
ITU	International Telecommunications Union
kbps	kbits per second
LED	Light Emitting Diode
LGA	Land Grid Array
LTE	Long term evolution
MBB	Moisture barrier bag
Mbps	Mbits per second
MCS	Modulation and Coding Scheme
MIMO	Multiple Input Multiple Output
MLCC	Multi Layer Ceramic Capacitor
MO	Mobile Originated
MS	Mobile Station, also referred to as TE
MSL	Moisture Sensitivity Level
MT	Mobile Terminated
nc	Not connected

Abbreviation	Description
NTC	Negative Temperature Coefficient
PCB	Printed Circuit Board
PCL	Power Control Level
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	Signalling Radio Bearer
TE	Terminal Equipment
TPC	Transmit Power Control
TS	Technical Specification
Tx	Transmit Direction
UL	Upload
UMTS	Universal Mobile Telecommunications System
URC	Unsolicited Result Code
USB	Universal Serial Bus
UICC	USIM Integrated Circuit Card
USIM	UMTS Subscriber Identification Module
WCDMA	Wideband Code Division Multiple Access

1.4 Regulatory and Type Approval Information

1.4.1 Directives and Standards

PLS8-X/PLS8-V 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-X/PLS8-V Hardware Interface Description".[1]

Table 1: Directives

2002/95/EC (RoHS 1) 2011/65/EC (RoHS 2)	Directive of the European Parliament and of the Council of 27 January 2003 (and revised on 8 June 2011) on the restriction of the use of certain hazardous substances in electrical and electronic equipment (RoHS)	

Table 2: Standards of North American type approval

CFR Title 47	Code of Federal Regulations, Part 22, Part 24 and Part 27; US Equipment Authorization FCC	
OET Bulletin 65 (Edition 97-01)	Evaluating Compliance with FCC Guidelines for Human Exposure to Radio-frequency Electromagnetic Fields	
UL 60 950-1	Product Safety Certification (Safety requirements)	
NAPRD.03 V5.23	Overview of PCS Type certification review board Mobile Equipment Type Certification and IMEI control PCS Type Certification Review board (PTCRB)	
RSS132, RSS133, RSS139	Canadian Standard	

Table 3: Requirements of quality

IEC 60068	Environmental testing
DIN EN 60529	IP codes

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

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

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

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

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

O:

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

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

X:

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

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

1.4.2   SAR requirements specific to portable mobiles

Mobile phones, PDAs or other portable transmitters and receivers incorporating a GSM module must be in accordance with the guidelines for human exposure to radio frequency energy. This requires the Specific Absorption Rate (SAR) of portable PLS8-X/PLS8-V 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 US markets the relevant directives are mentioned below. It is the responsibility of the manufacturer of the final product to verify whether or not further standards, recommendations or directives are in force outside these areas.

Products intended for sale on US markets
ES 59005/ANSI C95.1 Considerations for evaluation of human exposure to electromagnetic fields (EMFs) from mobile telecommunication equipment (MTE) in the frequency range 30MHz - 6GHz

IMPORTANT:
Manufacturers of portable applications based on PLS8-X/PLS8-V modules are required to have their final product certified and apply for their own FCC Grant and Industry Canada Certificate related to the specific portable mobile.

1.4.3　SELV Requirements

The power supply connected to the PLS8-X/PLS8-V 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-X/PLS8-V. Manufacturers of the cellular terminal are advised to convey the following safety information to users and operating personnel and to incorporate these guidelines into all manuals supplied with the product. Failure to comply with these precautions violates safety standards of design, manufacture and intended use of the product. Gemalto M2M assumes no liability for customer's failure to comply with these precautions.

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

2 Product Concept

2.1 Key Features at a Glance

Feature	Implementation
General	
Frequency bands	PLS8-X: GSM/GPRS/EDGE: Quad band, 850/900/1800/1900MHz UMTS/HSPA+: Triple band, 850 (BdV) / AWS (BdIV) / 1900MHz (BdII) LTE: Five band, 700 (Bd13) / 700 (Bd17) / 850 (Bd5) / AWS (Bd4) / 1900MHz (Bd2) PLS8-V: LTE: Triple band, 700 (Bd13) / AWS (Bd4) / 1900MHz (Bd2)
GSM class	Small MS
Output power (according to Release 99)	Class 4 (+33dBm ±2dB) for EGSM850 Class 4 (+33dBm ±2dB) for EGSM900 Class 1 (+30dBm ±2dB) for GSM1800 Class 1 (+30dBm ±2dB) for GSM1900 Class E2 (+27dBm ± 3dB) for GSM 850 8-PSK Class E2 (+27dBm ± 3dB) for GSM 900 8-PSK Class E2 (+26dBm +3 /-4dB) for GSM 1800 8-PSK Class E2 (+26dBm +3 /-4dB) for GSM 1900 8-PSK Class 3 (+24dBm +1/-3dB) for UMTS 1900,WCDMA FDD BdII Class 3 (+24dBm +1/-3dB) for UMTS AWS, WCDMA FDD BdIV Class 3 (+24dBm +1/-3dB) for UMTS 850, WCDMA FDD BdV
Output power (according to Release 8)	Class 3 (+23dBm +-2dB) for LTE 1900, LTE FDD Bd2 Class 3 (+23dBm +-2dB) for LTE AWS, LTE FDD Bd4 Class 3 (+23dBm +-2dB) for LTE 850, LTE FDD Bd5 Class 3 (+23dBm +-2dB) for LTE 700, LTE FDD Bd13 Class 3 (+23dBm +-2dB) for LTE 700, LTE FDD Bd17
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 2.95mm 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

Feature	Implementation
UMTS features	
3GPP Release 8	PS data rate – 384 kbps DL / 384 kbps UL
GSM / GPRS / EGPRS features	
Data transfer	GPRS: • Multislot Class 12 • Mobile Station Class B • Coding Scheme 1 – 4 EGPRS: • Multislot Class 12 • EDGE E2 power class for 8 PSK • Downlink coding schemes – CS 1-4, MCS 1-9 • Uplink coding schemes – CS 1-4, MCS 1-9 • SRB loopback and test mode B • 8-bit, 11-bit RACH • 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
GNSS Features	
Protocol	NMEA
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.
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

Feature	Implementation
Serial interface	ASC0: • 8-wire modem interface with status and control lines, unbalanced, asynchronous • Adjustable baud rate of 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 I²S)
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. GPIO6 can be configured as low current indicator (LCI). Programming is done via AT commands.
ADC inputs	Analog-to-Digital Converter with three unbalanced analog inputs.
Evaluation kit	
Evaluation module	PLS8-X/PLS8-V 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-X/PLS8-V evaluation module to the DSB75.

2.2   PLS8-X/PLS8-V System Overview
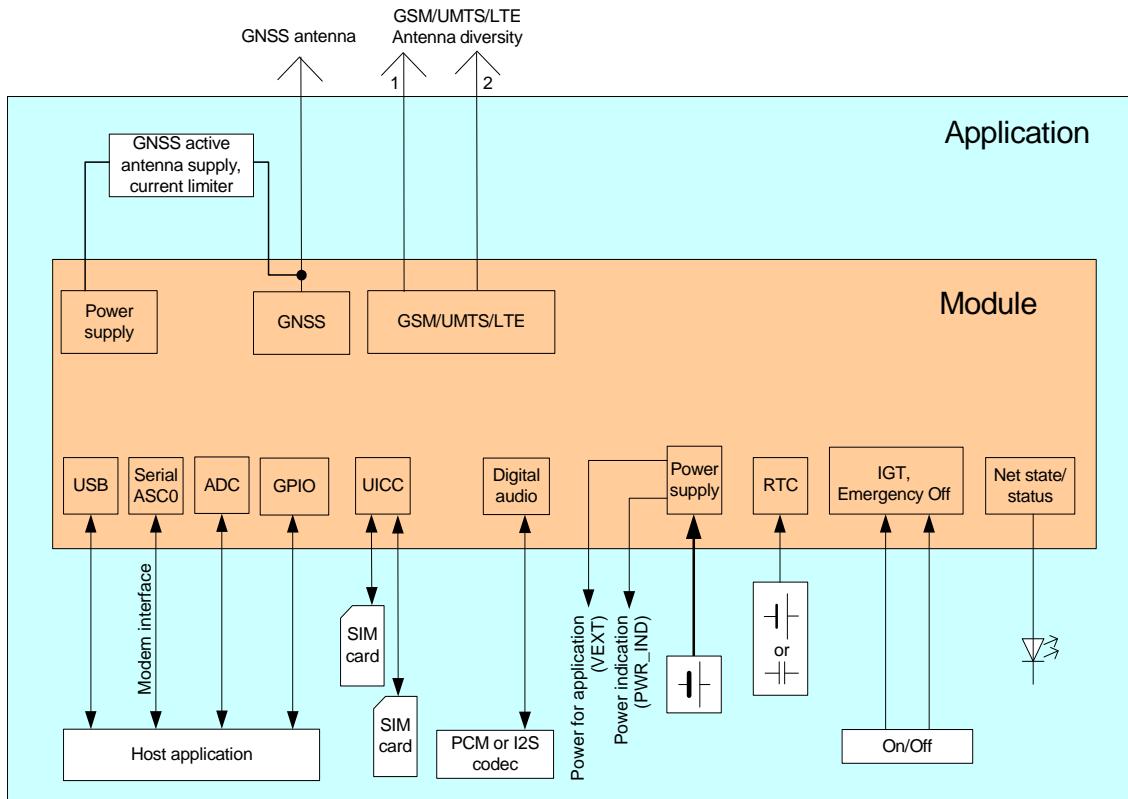
Figure 1: PLS8-X/PLS8-V system overview

3 Application Interface

PLS8-X/PLS8-V 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
- Serial interface USB - see Section 3.3
- Serial interface ASC0 - Section 3.4
- UICC/SIM/USIM interface - see Section 3.5
- Digital audio interface - see Section 3.6
- ADC interface - Section 3.7
- GPIO interface - Section 3.8

3.1   Operating Modes

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

Table 6: Overview of operating modes

Mode	Function	
Normal operation	GSM / GPRS / UMTS / HSPA / LTE 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-X/PLS8-V 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 ($\geq$ 47µF MLCC @ BATT+; $\geq$ 4x47µF MLCC @ BATT+_RF) as close as possible to LGA pads. Figure 2 shows a sample circuit for decoupling capacitors for BATT+.
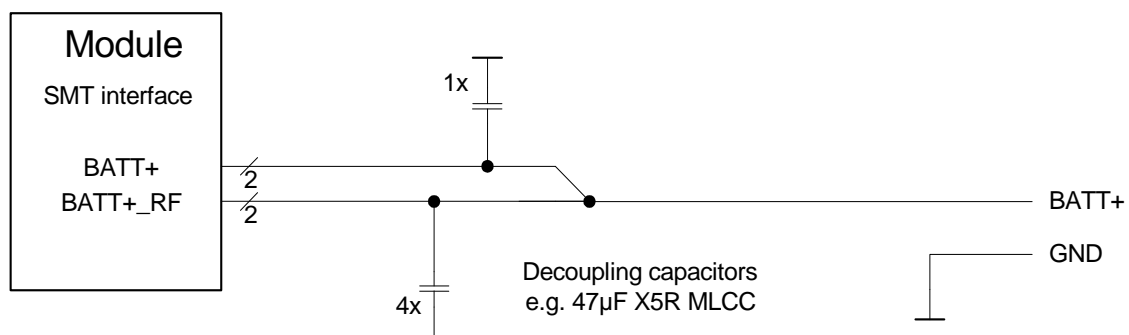
Figure 2: Decoupling capacitor(s) for BATT+

The power supply of PLS8-X/PLS8-V 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.

3.3   USB Interface

PLS8-X/PLS8-V 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-X/PLS8-V is designed as a self-powered device compliant with the "Universal Serial Bus Specification Revision 2.0"[1].
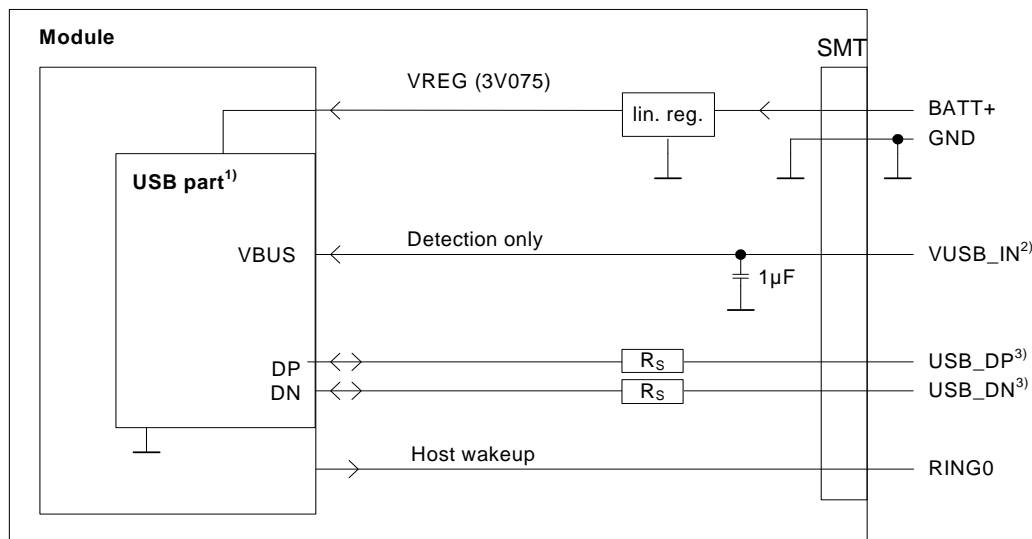
[1] All serial (including R_S) and pull-up resistors for data lines are implemented.

[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 3: 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. Furthermore, the USB modem driver distributed with PLS8-X/PLS8-V needs to be installed.

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

3.4 Serial Interface ASC0

PLS8-X/PLS8-V offers an 8-wire unbalanced, asynchronous modem interface ASC0 conforming to ITU-T V.24 protocol DCE signalling. The electrical characteristics do not comply with ITU-T V.28. The significant levels are 0V (for low data bit or active state) and 1.8V (for high data bit or inactive state).

PLS8-X/PLS8-V 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
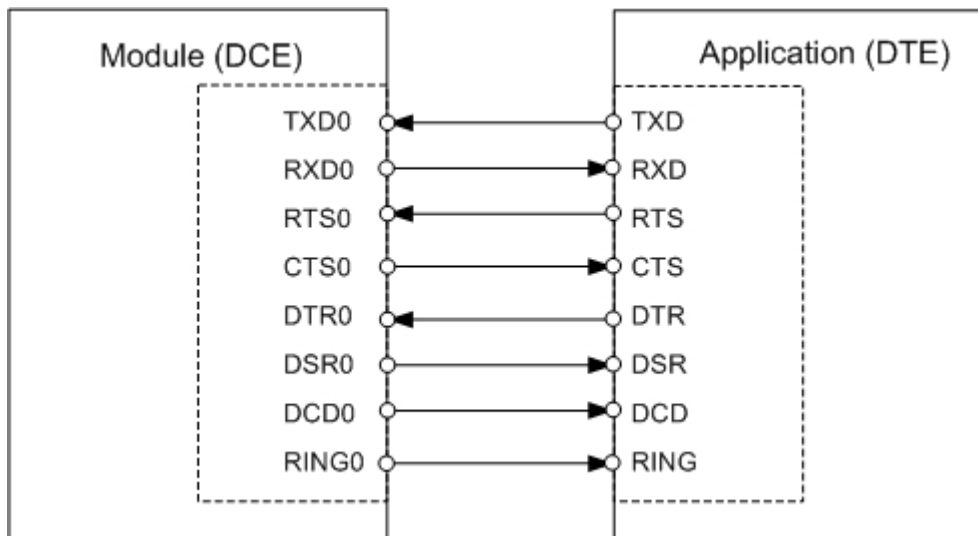
Figure 4: Serial interface ASC0

Features:
• Includes the data lines TXD0 and RXD0, the status lines RTS0 and CTS0 and, in addition, the modem control lines DTR0, DSR0, DCD0 and RING0.
• The RING0 signal serves to indicate incoming calls and other types of URCs (Unsolicited Result Code). It can also be used to send pulses to the host application, for example to wake up the application from power saving state. See [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 115,200bps up to 921,600bps.
• Supports RTS0/CTS0 hardware flow control.
• Wake up from SLEEP mode by RTS0 activation.

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.

3.5   UICC/SIM/USIM Interface

PLS8-X/PLS8-V has two 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 two SIM interfaces.

The UICC/SIM/USIM interfaces support 3V and 1.8V SIM cards.

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-X/PLS8-V and is part of the Gemalto M2M reference equipment submitted for type approval. See Chapter 9 for Molex ordering numbers.

Table 7: 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 1st and 2nd SIM interface.
CCVCC1 CCVCC2	SIM supply voltage lines for 1st and 2nd SIM interface.
CCIO1 CCIO2	Serial data lines for 1st and 2nd SIM interface, input and output.
CCRS1 CCRS2	Chipcard reset lines for 1st and 2nd 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-X/PLS8-V.

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-X/PLS8-V.
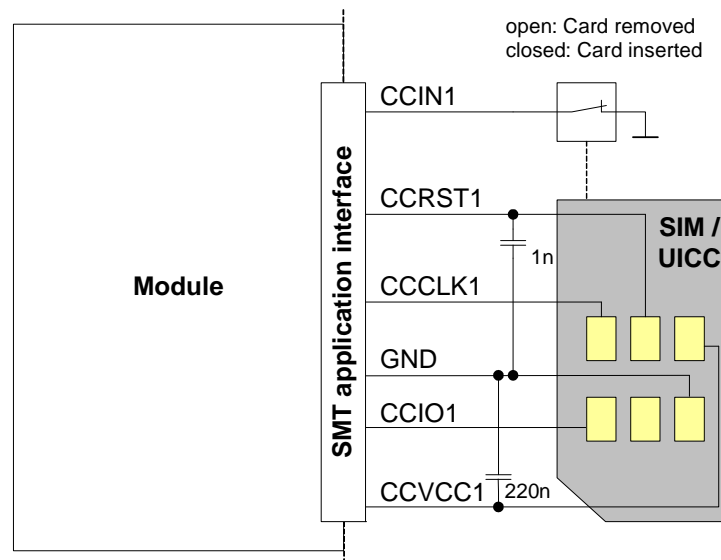
Figure 5: First UICC/SIM/USIM interface

The total cable length between the SMT application interface pads on PLS8-X/PLS8-V 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.

Note: Figure 5 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 6.
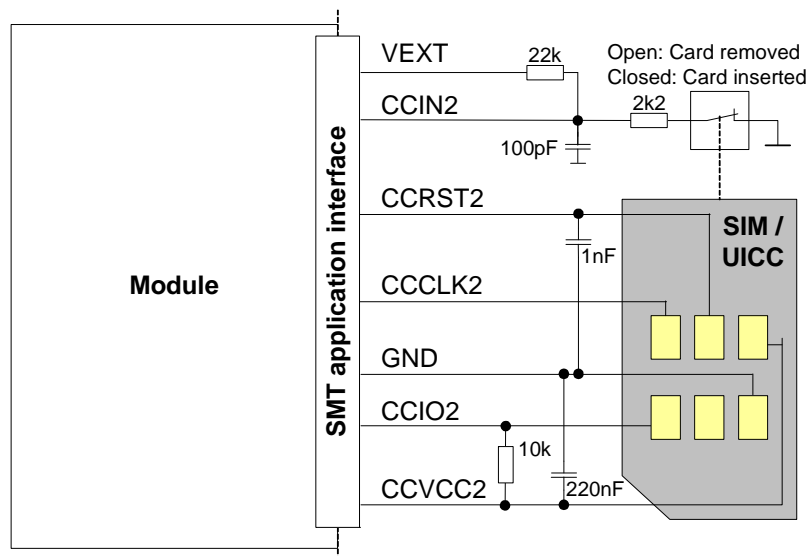
Figure 6: Second UICC/SIM/USIM interface

3.6 Digital Audio Interface

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

Note: As PLS8-X/PLS8-V is a data only module, the module's digital audio interface supports local tones only and is otherwise reserved for future use.

3.7 Analog-to-Digital Converter (ADC)

PLS8-X/PLS8-V 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.

3.8 GPIO Interface

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

4 GNSS Receiver

PLS8-X/PLS8-V integrates a GNSS receiver that offers the full performance of GPS/ GLONASS 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 ephimeris data and the precise time.

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].

5   Antenna Interfaces

5.1   GSM/UMTS/LTE Antenna Interface

The PLS8-X/PLS8-V GSM/UMTS/LTE antenna interface comprises a GSM/UMTS/LTE main antenna as well as a UMTS/LTE Rx diversity/MIMO antenna to improve signal reliability and quality[1]. The interface has an impedance of 50Ω. PLS8-X/PLS8-V 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-X/PLS8-V PCB and should be placed in the host application, if the antenna does not have an impedance of 50Ω.

Regarding the return loss PLS8-X/PLS8-V provides the following values in the active band:

Table 8: Return loss in the active band

State of module	Return loss of module	Recommended return loss of application
Receive	$\geq$ 8dB	$\geq$ 12dB
Transmit	not applicable	$\geq$ 12dB
Idle	$\leq$ 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.

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

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

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.

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-X/PLS8-V's antenna pad.

5.2 GNSS Antenna Interface

In addition to the RF antenna interface PLS8-X/PLS8-V also has a GNSS antenna interface. 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 and GNSS is implemented.

PLS8-X/PLS8-V 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 7 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.
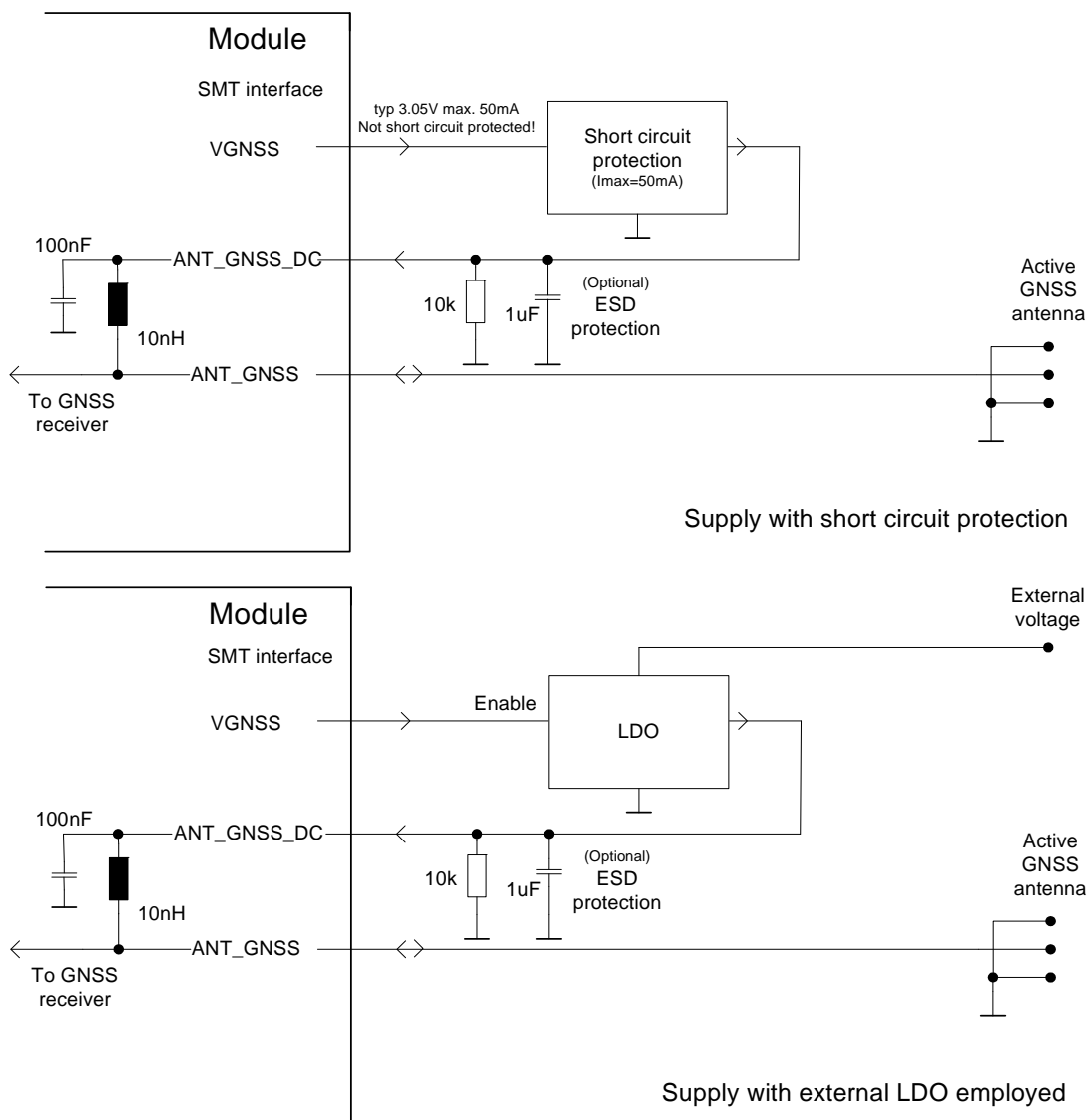
Figure 7: Supply voltage for active GNSS antenna

Figure 8 shows sample circuits realizing ESD protection for a passive GNSS antenna.
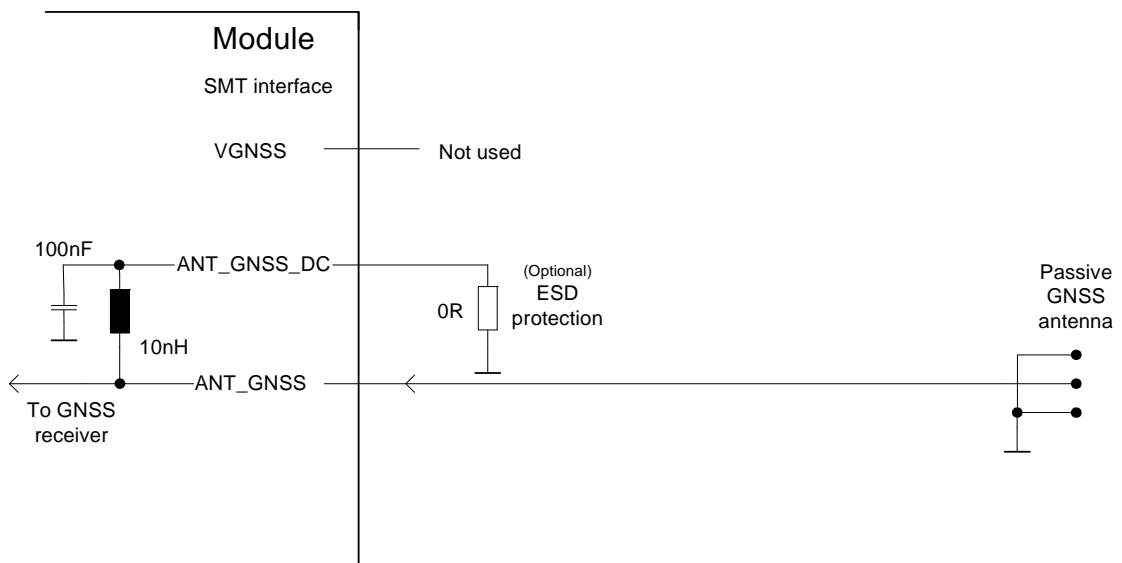
Figure 8: ESD protection for passive GNSS antenna

6 Mechanics

6.1 Mechanical Dimensions of PLS8-X/PLS8-V

Figure 9 shows a 3D view[1] of PLS8-X/PLS8-V and provides an overview of the board's mechanical dimensions. For further details see Figure 10.

Length: 33mm
Width: 29mm
Height: 2.95mm

Top view

Bottom view

Figure 9: PLS8-X/PLS8-V – top and bottom view

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

6.1 Mechanical Dimensions of PLS8-X/PLS8-V

Figure 10: Dimensions of PLS8-X/PLS8-V (all dimensions in mm)

7   Sample Application

Figure 11 shows a typical example of how to integrate an PLS8-X/PLS8-V module with an application.

The PWR_IND line is an open collector that needs an external pull-up resistor which connects to the voltage supply VCC μC of the microcontroller. Low state of the open collector pulls the PWR_IND signal low and indicates that the PLS8-X/PLS8-V module is active, high level notifies the Power Down mode.
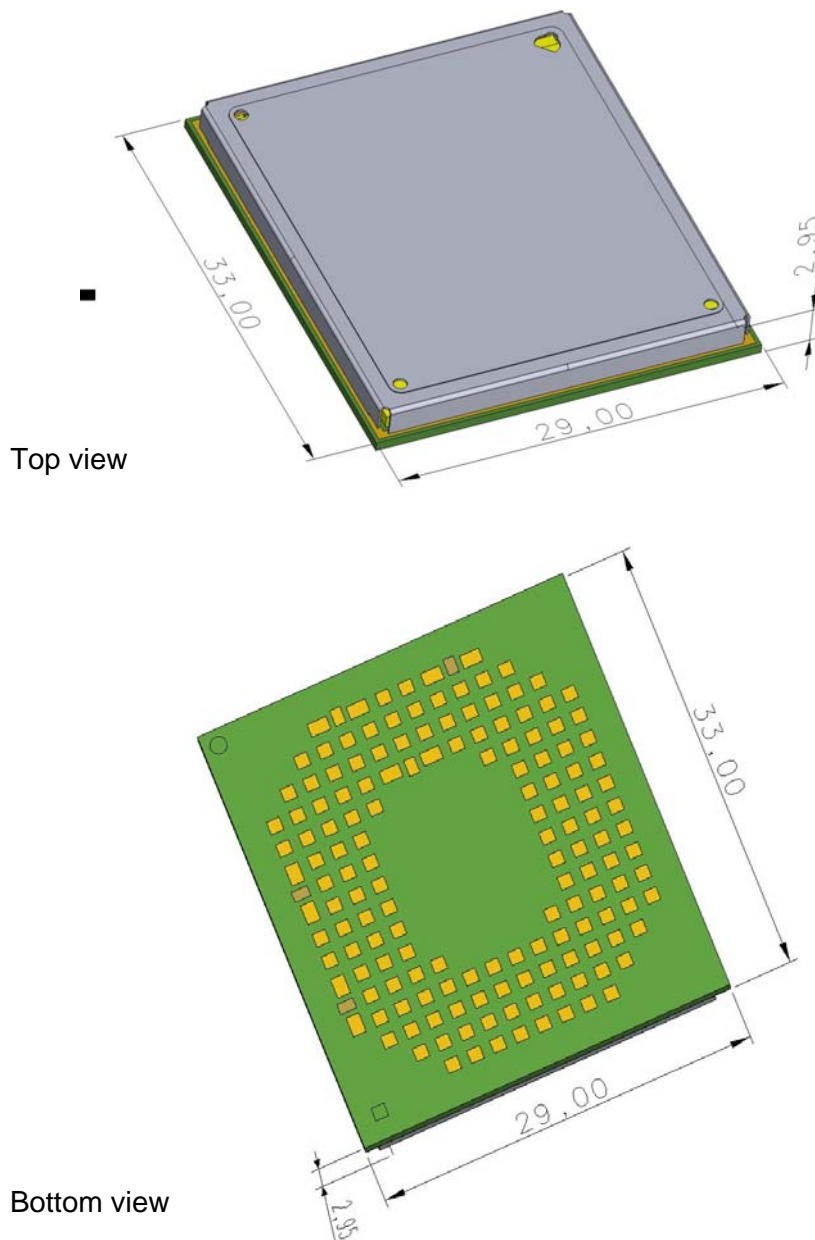
If the module is in Power Down mode avoid current flowing from any other source into the module circuit, for example reverse current from high state external control lines. Therefore, the controlling application must be designed to prevent reverse flow.

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.

Disclaimer:
No warranty, either stated or implied, is provided on the sample schematic diagram shown in Figure 11 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-X/PLS8-V modules.
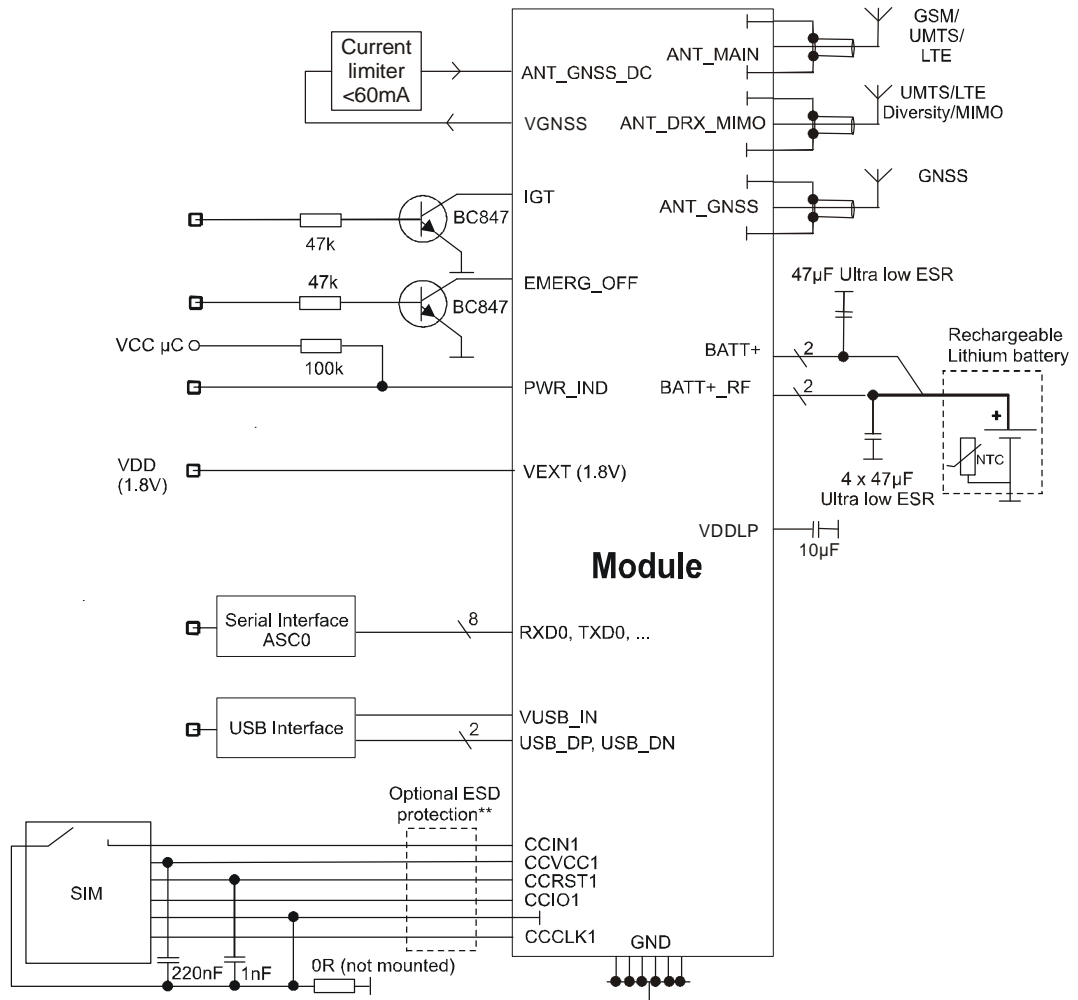
Figure 11: PLS8-X/PLS8-V sample application

8   Reference Approval

8.1   Reference Equipment for Type Approval

The Gemalto M2M reference setup submitted to type approve PLS8-X/PLS8-V is shown in Figure 12. 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.
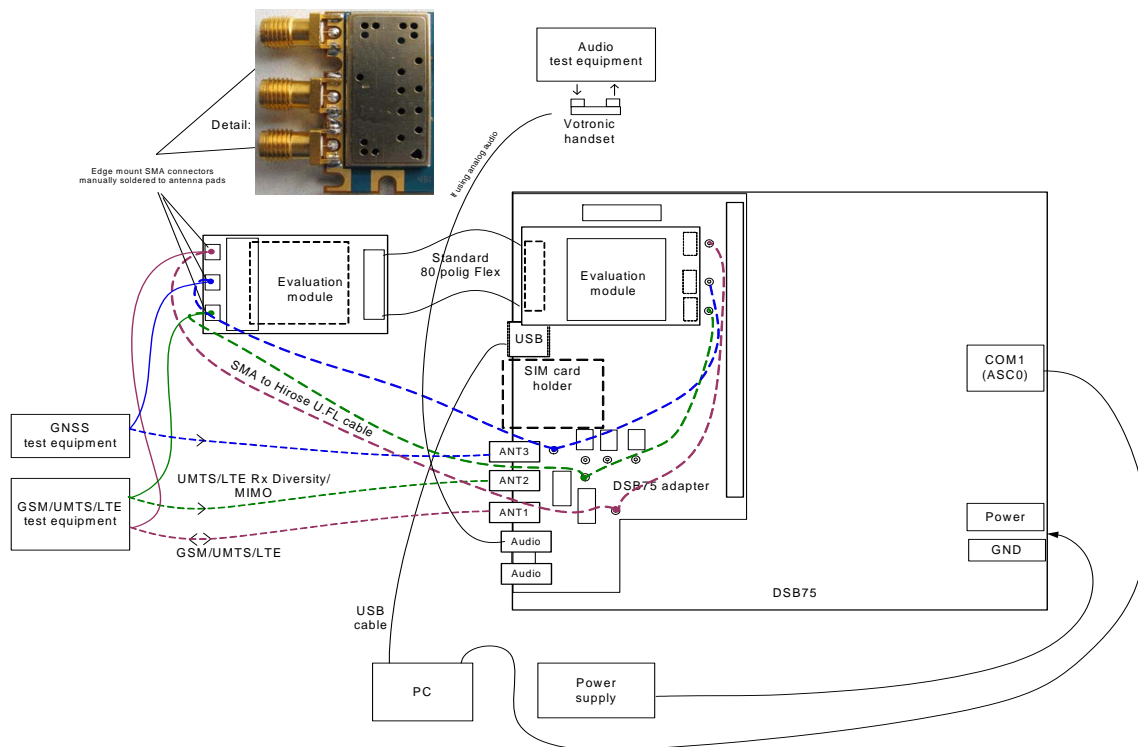

Figure 12: Reference equipment for type approval

8.2 Compliance with FCC and IC Rules and Regulations

The Equipment Authorization Certification for the Gemalto M2M modules reference application described in Section 8.1 will be registered under the following identifiers:

- PLS8-X:
  FCC Identifier QIPPLS8-X
  Industry Canada Certification Number: 7830A-PLS8X
  Granted to Gemalto M2M GmbH
- PLS8-V:
  FCC Identifier QIPPLS8-V
  Industry Canada Certification Number: 7830A-PLS8V
  Granted to Gemalto M2M GmbH

Manufacturers of mobile or fixed devices incorporating PLS8-X/PLS8-V modules are authorized to use the FCC Grants and Industry Canada Certificates of the PLS8-X/PLS8-V modules for their own final products according to the conditions referenced in these documents. In this case, the FCC label of the module shall be visible from the outside, or the host device shall bear a second label stating "Contains FCC ID: QIPPLS8-X" or "Contains FCC ID: QIPPLS8-V" and accordingly "Contains IC: 7830A-PLS8X" or "Contains IC: 7830A-PLS8V". The integration is limited to fixed or mobile categorised host devices, where a separation distance between the antenna and any person of min. 20cm can be assured during normal operating conditions.

For mobile and fixed operation configurations the antenna gain, including cable loss, must not exceed the limits listed in the following Table 9 for FCC and IC.

Table 9: Antenna gain limits for FCC and IC

Operating band[a]	FCC limit	IC limit	Unit
Maximum gain in lower operating bands with f< 1GHz (GSM850, WCDMA BdV, LTE Bd5 / Bd13 / Bd17	3.25	0.16	dBi
Maximum gain in higher operating bands with f=1700MHz (WCDMA BdIV, LTE Bd4)	5.5	5.5	dBi
Maximum gain in higher operating bands with f=1900MHz (GSM1900, WCDMA BdII, LTE Band 2)	2.51	2.51	dBi

  [a.] Please note that the listed frequency bands apply as follows:
  PLS8-X: LTE: Bd 2, 4, 5, 13 and 17; WCDMA Bd II, IV and V; GSM 850/1900MHz
  PLS8-V: LTE: Bd 2, 4 and 13

IMPORTANT:
Manufacturers of portable applications incorporating PLS8-X/PLS8-V modules are required to have their final product certified and apply for their own FCC Grant and Industry Canada Certificate related to the specific portable mobile. This is mandatory to meet the SAR requirements for portable mobiles (see Section 1.4 for detail).

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

Note: This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to part 15 of the FCC Rules and with Industry Canada licence-exempt RSS standard(s). These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- Reorient or relocate the receiving antenna.
- Increase the separation between the equipment and receiver.
- Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
- Consult the dealer or an experienced radio/TV technician for help.

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

If Canadian approval is requested for devices incorporating PLS8-X/PLS8-V modules the above note will have to be provided in the English and French language in the final user documentation. Manufacturers/OEM Integrators must ensure that the final user documentation does not contain any information on how to install or remove the module from the final product.

9 Appendix

9.1 List of Parts and Accessories

Table 10: List of parts and accessories

Description	Supplier	Ordering information
PLS8-X	Gemalto M2M	Standard module Gemalto M2M IMEI: Packaging unit (ordering) number: L30960-N3460-A300 Module label number: S30960-S3460-A300-1 Customer IMEI module: Packaging unit (ordering) number: L30960-N3465-A300 Module label number: S30960-S3465-A300-1
PLS8-X Evaluation Module	Gemalto M2M	Packaging unit (ordering) number: L30960-N3461-A300 Module label number: S30960-S3461-A300
PLS8-V	Gemalto M2M	Standard module Gemalto M2M IMEI: Packaging unit (ordering) number: L30960-N3470-A300 Module label number: S30960-S3470-A300-1
PLS8-V Evaluation Module	Gemalto M2M	Packaging unit (ordering) number: L30960-N3471-A300 Module label number: S30960-S3471-A300
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 11.
U.FL antenna connector	Hirose or Molex	Sales contacts are listed in Table 11 and Table 12.

Table 11: 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 12: 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

About Gemalto

Gemalto (Euronext NL0000400653 GTO) is the world leader in digital security with 2014 annual revenues of €2.5 billion and blue-chip customers in over 180 countries. Our 14,000 employees operate out of 99 offices, 34 personalization and data centers, and 24 research and software development centers located in 46 countries.

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

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

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

For more information please visit
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