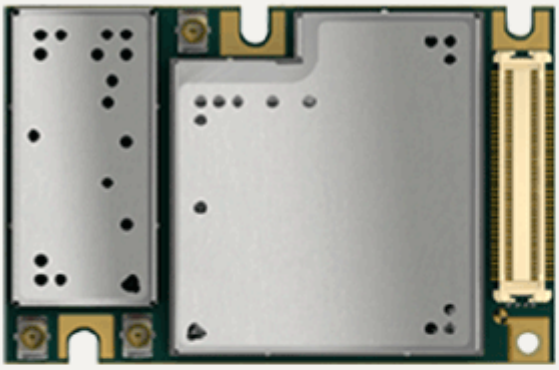
Cinterion® PH8/PH8-P

Hardware Interface Description

Version: 03.320c
DocId: PH8_PH8-P_HD_v03.320c



Document Name:	**Cinterion® PH8/PH8-P Hardware Interface Description**
Version:	**03.320c**
Date:	**2017-04-28**
DocId:	**PH8_PH8-P_HD_v03.320c**
Status	**Confidential / Released**

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0 Document History

Preceding document: "Cinterion® PH8/PH8-P Hardware Interface Description" v03.320b
New document: "Cinterion® PH8/PH8-P Hardware Interface Description" v**03.320c**

Chapter	What is new
1.3.1, 1.3.2	Revised information with regard to the new Radio Equipment Directive (RED).
10.1	Added note for module label number.

Preceding document: "Cinterion® PH8/PH8-P Hardware Interface Description" v03.320a
New document: "Cinterion® PH8/PH8-P Hardware Interface Description" v03.320b

Chapter	What is new
2.1	Added SBAS as supported feature.
9.2	Revised maximum antenna gain limits - added Table 40.

Preceding document: "Cinterion® PH8/PH8-P Hardware Interface Description" v03.320
New document: "Cinterion® PH8/PH8-P Hardware Interface Description" v03.320a

Chapter	What is new
3.5	Removed description of possible capacitor on VDDLP for RTC backup.
6.7.3	Revised units given in Table 32 for MIC input and EP output (mV --> mVpp).

Preceding document: "Cinterion® PH8/PH8-P Hardware Interface Description" v03.309
New document: "Cinterion® PH8/PH8-P Hardware Interface Description" v03.320

Chapter	What is new
3.4.1, 3.4.2	Revised description and illustration of paging timing cycles.

Preceding document: "Cinterion® PH8/PH8-P Hardware Interface Description" v03.301
New document: "Cinterion® PH8/PH8-P Hardware Interface Description" v03.309

Chapter	What is new
3.3.1	Revised section to include new Figure 5.
3.3.3	Added note regarding time period before PWR_IND goes high to Figure 6.
3.3.4	Revised section including Figure 7.
3.3.5.1	Revised section to include 2 minute guard period after startup.
3.3.5.2	New section Deferred Shutdown at Extreme Temperature Conditions.
3.5	Added remark on configurable alarm functionality.
3.6.1	Added remark on usage of AT&D0. Added footnote regarding power saving while connected via USB interface.

3.7	Slightly revised ASC0 feature description.
3.9	Revised audio section to include new subsection on USB Audio Interface.
3.10.1	Revised section to mention VCC µC in PWR_IND circuit.
3.10.6	Revised default AT command values in Figure 28.

Preceding document: "Cinterion® PH8/PH8-P Hardware Interface Description" v03.001a
New document: "Cinterion® PH8/PH8-P Hardware Interface Description" v03.301

Chapter	What is new
2.1	Added eCall, RLS and audio over USB to key feature overview.

Preceding document: "PH8/PH8-P Hardware Interface Description" Version 03.001
New document: "Cinterion® PH8/PH8-P Hardware Interface Description" v03.001a

Chapter	What is new
6.5	Revised voltage levels for 3V SIMs. Added remark to VUSB_IN signal form and level.
6.6	Revised table listing power supply ratings.
6.9	Revised frequency range for GLONASS in Table 36.
8.1	New section Sample Level Conversion Circuit.

Preceding document: "PH8/PH8-P Hardware Interface Description" Version 02.003a
New document: "PH8/PH8-P Hardware Interface Description" Version 03.001

Chapter	What is new
Throughout document	Replaced GPS with GNSS where necessary to account for added GLONASS support.
3.6.1	Added new section Reducing Power Consumption as part of USB interface description.
3.10.4	Added reference to new Section 3.6.1.

Preceding document: "PH8/PH8-P Hardware Interface Description" Version 02.003
New document: "PH8/PH8-P Hardware Interface Description" Version 02.003a

Chapter	What is new
Throughout document	Added PH8-K as new product variant.
6.6	Revised max rating for VOICE Call GSM1800/1900.

Preceding document: "PH8/PH8-P Hardware Interface Description" Version 02.002
New document: "PH8/PH8-P Hardware Interface Description" Version 02.003

Chapter	What is new
6.7.2	Revised digital logical channels for I^2S in Figure 34. See also Figure 24.

Preceding document: "PH8/PH8-P Hardware Interface Description" Version 02.001
New document: "PH8/PH8-P Hardware Interface Description" Version 02.002

Chapter	What is new
3.3.3	Revised remarks on how to verify that the module has turned off.
3.6	Revised remarks on USB host's suspend state.
10.1	Revised Table 42 and Table 43 listing sales contacts for parts and accessories.

Preceding document: "PH8/PH8-P Hardware Interface Description" Version 01.382
New document: "PH8/PH8-P Hardware Interface Description" Version 02.001

Chapter	What is new
1.3.1	Updated NAPRD and GCF version numbers in Table 2 and Table 3.
3.3.2	Revised Table 8 showing signal states after startup.
3.3.5.3	Revised section on undervoltage shutdown.
3.3.6	Added new section Automatic Reset.
3.9.2	Added column to Figure 14 and Figure 15 showing signal configuration states.
3.10	Revised structure for section Control Signals to include WAKEUP and LCI_IND lines.
3.10.6	Added new section RING0 (ASC0), WAKEUP and LCI_IND Startup Behavior.
6.5	Revised current values for the VUSB_IN line.
6.6	Revised Table 29 listing power supply ratings.
6.9	Added remark on DC decoupling the GPS antenna.
7	Added alternate top view to Figure 35.
9.2	Added remark regarding integration of fixed or mobile categorised host devices.

Preceding document: "PH8/PH8-P Hardware Interface Description" Version 01.002
New document: "PH8/PH8-P Hardware Interface Description" Version 01.382

Chapter	What is new
Througout document	Removed VSENSE signal. Added PH8-P product variant (WCDMA band VIII instead of band IV)
1.3.1	Added EN 300 440-02 V1.3.1 and EN 301 489-03 V1.4.1 to Table 3.
3.3.1	Added note on SYSSTART URCs.
3.3.3	Modified Figure 6 to include details for digital output signals.
3.3.7	Modified Figure 8 to include BATT+ signal.
3.6	Removed external pull down resistor from text and Figure 12. Added note to Figure 12 suggesting the implementation of a differential impedance for the USB data lines.
3.7	Removed incorrect note on ASC0 and USB operation being mutually exclusive. Added note on suggested test points.
3.9.2.2	Added new section Inter IC Sound Interface (I^2S) and updated document accordingly.
3.10.4	Added new section Host Wakeup and updated document accordingly.
3.10.5	Added new section Low Current Indicator and updated document accordingly.

3.10.3	Revised section to mention that RING0 line behavior is configurable by AT command.
5	Added footnote for optional UMTS Rx diversity antenna.
6.5	Changed minimum output load resistence for EPP/EPN from 8Ω to 16Ω.
6.7.2	Updated audio programming model shown in Figure 34.
6.9	Revised table showing power supply for active GPS antenna. Added remark on provisioning of supply voltage at the GPS antenna interface.
10.1	Updated module ordering number.

Preceding document: "PH8/PH8-P Hardware Interface Description" Version 01.000
New document: "PH8/PH8-P Hardware Interface Description" Version 01.002

Chapter	What is new
3.6	Added remark on CDC ACM compliant USB device drivers on host systems not necessarily supporting USB suspend mode.
3.9.2.1	Added note on PCM data format and handling.
3.10.3	Revised RING0 line timing and added note on ring on data option.
6.5	Revised IGT signal description.

Preceding document: "PH8/PH8-P Hardware Interface Description" Version 00.290
New document: "PH8/PH8-P Hardware Interface Description" Version 01.000

Chapter	What is new
3.3.1	Updated Figure 4.
3.3.2	New section: Signal States after Startup.
3.4	Revised statement on VEXT power save mode and current consumption
3.4.3	Removed section: Power Saving during Network Search, GSM/WCDMA.
3.4.4	New section: Wake up from or Disabling Power Saving.
3.6	Revised section to include note on external pull down resistor on VUSB_IN line. Modified sample application (Figure 40) and signal description (Table 28) accordingly.
3.7	Added remark on feature Wake-up from SLEEP mode by RTS0 activation.
3.9.1.1	Replaced <inCalibrate> with <micTxVol> throughout document.
3.10.3	Revised description of RING line behavior.
4	Added note on GPS receiver being by default switched off.
5	Modified chapter structure to include previous Chapter 6: GPS antenna interface
5.2	Added notes regarding active GPS antennas.
6.2	Added Table 24 and Table 25 listing temperatures for sample operating conditions.
6.6	Updated Table 29 showing power supply ratings.
6.8	Added line for Tx noise in GPS band to Table 35.
6.9	Updated section on GPS interface characteristics.
7.1	Replaced Figure 35 and Figure 36.

1 Introduction

The document[1] describes the hardware of the Cinterion® PH8/PH8-P 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 Related Documents

[1] AT Command Set for your Gemalto M2M product
[2] Release Notes for your Gemalto M2M product
[3] DSB75 Support Box - Evaluation Kit for Gemalto M2M modules
[4] Universal Serial Bus Specification Revision 2.0, April 27, 2000
[5] Application Note 39: USB Interface Description

1.2 Terms and Abbreviations

Abbreviation	Description
ANSI	American National Standards Institute
AMR	Adaptive Multirate
ARP	Antenna Reference Point
B2B	Board-to-board connector
BB	Baseband
BEP	Bit Error Probability
BTS	Base Transceiver Station
CB or CBM	Cell Broadcast Message
CE	Conformité Européene (European Conformity)
CS	Coding Scheme
CS	Circuit Switched
CSD	Circuit Switched Data
CTM	Cellular Text Modem
DAC	Digital-to-Analog Converter
DCS	Digital Cellular System
DL	Download
dnu	Do not use
DRX	Discontinuous Reception
DSB	Development Support Board
DSP	Digital Signal Processor

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
DTMF	Dual Tone Multi Frequency
DTX	Discontinuous Transmission
EDGE	Enhanced Data rates for GSM Evolution
EFR	Enhanced Full Rate
EGSM	Extended GSM
EMC	Electromagnetic Compatibility
ERP	Effective Radiated Power
ESD	Electrostatic Discharge
ETS	European Telecommunication Standard
ETSI	European Telecommunications Standards Institute
FCC	Federal Communications Commission (U.S.)
FDD	Frequency Division Duplex
FDMA	Frequency Division Multiple Access
FR	Full Rate
GLONASS	Globalnaja Nawigazionnaja Sputnikowaja Sistema
GNSS	Global Navigation Satellite System
GPRS	General Packet Radio Service
GPS	Global Positioning System
GSM	Global Standard for Mobile Communications
HiZ	High Impedance
HSDPA	High Speed Downlink Packet Access
HR	Half Rate
I/O	Input/Output
IF	Intermediate Frequency
IMEI	International Mobile Equipment Identity
ISO	International Standards Organization
ITU	International Telecommunications Union
kbps	kbits per second
LED	Light Emitting Diode
Mbps	Megabits per second
MCS	Modulation and Coding Scheme
MO	Mobile Originated
MS	Mobile Station, also referred to as TE
MT	Mobile Terminated
nc	Not connected
NMEA	National Marine Electronics Association

Abbreviation	Description
NTC	Negative Temperature Coefficient
PBCCH	Packet Switched Broadcast Control Channel
PCB	Printed Circuit Board
PCL	Power Control Level
PCM	Pulse Code Modulation
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
SBAS	Satellite-Based Augmentation Systems
SELV	Safety Extra Low Voltage
SIM	Subscriber Identification Module
SLIC	Subscriber Line Interface Circuit
SMPL	Sudden Momentary Power Loss
SMS	Short Message Service
SNR	Signal-to-Noise Ratio
SRAM	Static Random Access Memory
SRB	Signalling Radio Bearer
SUPL	Secure User Plane Location
TDMA	Time Division Multiple Access
TE	Terminal Equipment
TPC	Transmit Power Control
TS	Technical Specification
TTFF	Time To First Fix
Tx	Transmit Direction
UL	Upload

Abbreviation	Description
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

1.3 Regulatory and Type Approval Information

1.3.1 Directives and Standards

PH8/PH8-P 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 "PH8/PH8-P Hardware Interface Description".[1]

Table 1: Directives

2014/53/EU	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. The product is labeled with the CE conformity mark.
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 Radiofrequency Electromagnetic Fields
UL 60 950-1	Product Safety Certification (Safety requirements)
NAPRD.03 V5.24	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: 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 V3.58	Global Certification Forum - Certification Criteria
ETSI EN 301 489-1 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

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 3: Standards of European type approval

Draft ETSI EN 301 489-3 V2.1.1	ElectroMagnetic Compatibility (EMC) standard for radio equipment and services; Part 3: Specific conditions for Short-Range Devices (SRD) operating on frequencies between 9kHz and 246GHz; 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 301 908-1 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 301 908-2 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)
ETSI EN 300 440 V2.1.1	Short Range Devices (SRD); Radio equipment to be used in the 1GHz to 40GHz frequency range; Harmonized Standard covering the essential requirements of article 3.2 of the Directive 2014/53/EU
EN 60950-1:2006/ A11:2009+A1:2010+ A12:2011+A2:2013	Safety of information technology equipment

Table 4: Requirements of quality

IEC 60068	Environmental testing
DIN EN 60529	IP codes

Table 5: Standards of the Ministry of Information Industry of the People's Republic of China

SJ/T 11363-2006	"Requirements for Concentration Limits for Certain Hazardous Substances in Electronic Information Products" (2006-06).
SJ/T 11364-2006	"Marking for Control of Pollution Caused by Electronic Information Products" (2006-06).  According to the "Chinese Administration on the Control of Pollution caused by Electronic Information Products" (ACPEIP) the EPUP, i.e., Environmental Protection Use Period, of this product is 20 years as per the symbol shown here, unless otherwise marked. The EPUP is valid only as long as the product is operated within the operating limits described in the Gemalto M2M Hardware Interface Description. Please see Table 6 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 6: 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.

1.3.2 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 PH8/PH8-P 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 and 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 US markets

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

Products intended for sale on European markets

EN 50360	Product standard to demonstrate the compliance of mobile phones with the basic restrictions related to human exposure to electromagnetic fields (300MHz - 3GHz)
EN 62311:2008	Assessment of electronic and electrical equipment related to human exposure restrictions for electromagnetic fields (0 Hz - 300 GHz)

IMPORTANT:
Manufacturers of portable applications based on PH8/PH8-P 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.

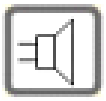
1.3.3 SELV Requirements

The power supply connected to the PH8/PH8-P module shall be in compliance with the SELV requirements defined in EN 60950-1.

1.3.4 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 PH8/PH8-P. Manufacturers of the cellular terminal are advised to convey the following safety information to users and operating personnel and to incorporate these guidelines into all manuals supplied with the product. Failure to comply with these precautions violates safety standards of design, manufacture and intended use of the product. Gemalto M2M assumes no liability for customer's failure to comply with these precautions.

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

	IMPORTANT! Cellular terminals or mobiles operate using radio signals and cellular networks. Because of this, connection cannot be guaranteed at all times under all conditions. Therefore, you should never rely solely upon any wireless device for essential communications, for example emergency calls. Remember, in order to make or receive calls, the cellular terminal or mobile must be switched on and in a service area with adequate cellular signal strength. Some networks do not allow for emergency calls if certain network services or phone features are in use (e.g. lock functions, fixed dialing etc.). You may need to deactivate those features before you can make an emergency call. Some networks require that a valid SIM card be properly inserted in the cellular terminal or mobile.
	Bear in mind that exposure to excessive levels of noise can cause physical damage to users! With regard to acoustic shock, the cellular application must be designed to avoid unintentional increase of amplification, e.g. for a highly sensitive earpiece. A protection circuit should be implemented in the cellular application.

2 Product Concept

2.1 Key Features at a Glance

Feature	Implementation
General	
Frequency bands	GSM/GPRS/EDGE: Quad band, 850/900/1800/1900MHz UMTS/HSPA+: PH8: Five band, 800/850/AWS[1]/1900/2100MHz PH8-P: Five band, 800/850/900[2]/1900/2100MHz
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 2100, WCDMA FDD BdI Class 3 (+24dBm +1/-3dB) for UMTS 1900,WCDMA FDD BdII Class 3 (+24dBm +1/-3dB) for UMTS AWS, WCDMA FDD BdIV[1] Class 3 (+24dBm +1/-3dB) for UMTS 900, WCDMA FDD BdVIII[2] Class 3 (+24dBm +1/-3dB) for UMTS 850, WCDMA FDD BdV Class 3 (+24dBm +1/-3dB) for UMTS 800, WCDMA FDD BdVI
Power supply	$3.3V \leq V_{BATT+} \leq 4.2V$
Operating temperature (board temperature)	Normal operation: -30°C to +85°C Extended operation: -40°C to +95°C
Physical	Dimensions: 33.9mm x 50mm x 3.1mm Weight: approx. 9.5g
RoHS	All hardware components fully compliant with EU RoHS Directive
HSPA features	
3GPP Release 6, 7	DL 14.4Mbps, UL 5.7Mbps UE CAT. 1-12 supported Compressed mode (CM) supported according to 3GPP TS25.212
UMTS features	
3GPP Release 4	PS data rate – 384 kbps DL / 384 kbps UL CS data rate – 64 kbps DL / 64 kbps UL

Feature	Implementation
GSM / GPRS / EGPRS features	
Data transfer	GPRS: • Multislot Class 12 • Full PBCCH support • Mobile Station Class B • Coding Scheme 1 – 4 EGPRS: • Multislot Class 12 • EDGE E2 power class for 8 PSK • Downlink coding schemes – CS 1-4, MCS 1-9 • Uplink coding schemes – CS 1-4, MCS 1-9 • SRB loopback and test mode B • 8-bit, 11-bit RACH • PBCCH support • 1 phase/2 phase access procedures • Link adaptation and IR • NACC, extended UL TBF • Mobile Station Class B CSD: • V.110, RLP, non-transparent • 14.4kbps • USSD
SMS	Point-to-point MT and MO Cell broadcast Text and PDU mode
GNSS Features	
Protocol	NMEA
Modes	Standalone GNSS Assisted GNSS - Control plane - E911 - User plane - gpsOneXTRA™
General	Power saving modes Power supply for active GNSS antenna supported SBAS support (Satellite-Based Augmentation Systems)
Software	
AT commands	Hayes, 3GPP TS 27.007 and 27.005, and proprietary Gemalto M2M commands
SIM Application Toolkit	SAT Release 99
Audio	Audio speech codecs GSM: AMR, EFR, FR, HR 3GPP: AMR Speakerphone operation, echo cancellation, noise suppression, 9 ringing tones, TTY support
Firmware update	Generic update from host application over ASC0 or USB
Interfaces	
Module interface	80-pin board-to-board connector
Antenna	50Ω. Main GSM/UMTS antenna, UMTS diversity antenna, GNSS antenna (active/passive)

Feature	Implementation
USB	USB 2.0 High Speed (480Mbps) device interface, Full Speed (12Mbps) compliant
Serial interface	ASC0: • 8-wire modem interface with status and control lines, unbalanced, asynchronous • Adjustable baud rates from 9,600bps up to 921,600bps • Supports RTS0/CTS0 hardware flow control • Multiplex ability according to GSM 07.10 Multiplexer Protocol
UICC interface	Supported chip cards: UICC/SIM/USIM 3V, 1.8V
Status	Signal line to indicate network connectivity state
Audio	1 analog interface with microphone feeding 1 digital interface: PCM or I^2S USB audio
Power on/off, Reset	
Power on/off	Switch-on by hardware signal IGT Switch-off by AT command (AT^SMSO) 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	
Phonebook	SIM and phone
TTY/CTM support	Integrated CTM modem
Emergency Call Handling	EU eCall 3GPP Release 10 compliant ERA GLONASS compliant
RLS Monitoring	Jamming Detection
Antenna	SAIC (Single Antenna Interference Cancellation) / DARP (Downlink Advanced Receiver Performance) Rx diversity (receiver type 3i - 16-QAM)
Evaluation kit	
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 module to the DSB75.

1. AWS UMTS/HSPA+ band IV supported by PH8 only.
2. 900MHz UMTS/HSPA+ band VIII supported by PH8-P only. Band VIII however, is not supported by the UMTS Rx diversity antenna.

2.2 PH8/PH8-P System Overview

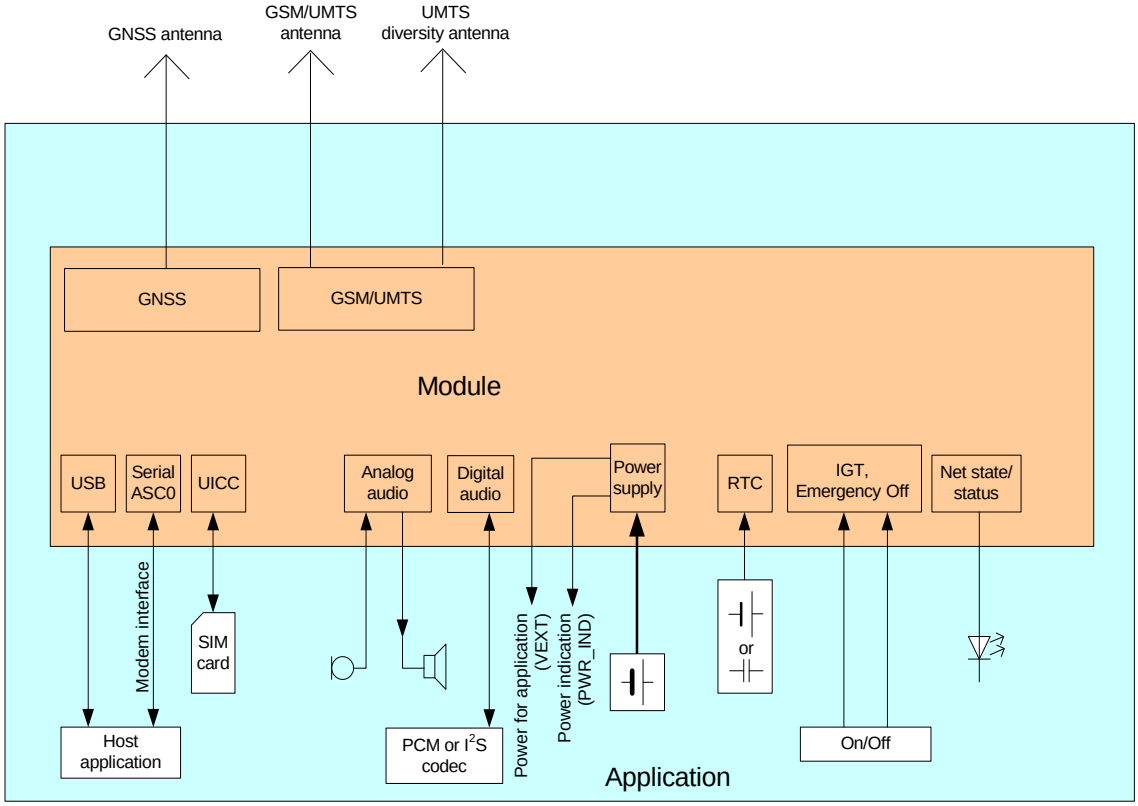


Figure 1: PH8/PH8-P system overview

2.3 Circuit Concept

Figure 2 shows a block diagram of the PH8/PH8-P module and illustrates the major functional components:

Baseband block:
- GSM/UMTS controller/transceiver/power supply
- Stacked Flash/RAM memory with multiplexed address data bus
- Audio codec
- Application interface (80-pin board-to-board connector)

RF section:
- RF transceiver
- RF power amplifier/frontend
- RF filter
- GNSS receiver/frontend
- Antenna connector

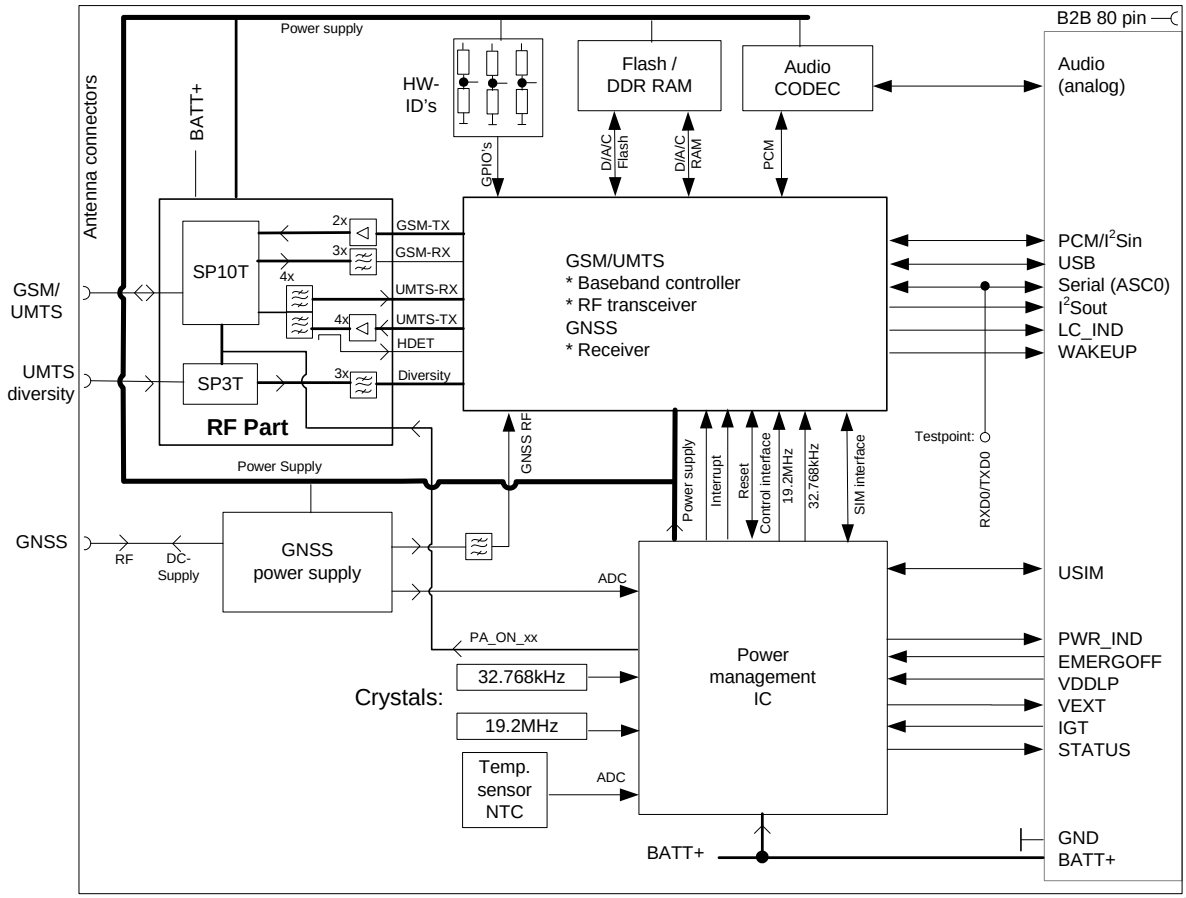


Figure 2: PH8/PH8-P block diagram

3 Application Interface

PH8/PH8-P is equipped with an 80-pin board-to-board connector 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
- Audio interfaces (analog, digital, USB) - see Section 3.9
- Status and control lines: IGT, EMERG_OFF, PWR_IND, STATUS - see Table 28

3.1 Operating Modes

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

Table 7: Overview of operating modes

Mode	Function	
Normal operation	GSM / GPRS / UMTS / HSPA SLEEP	Power saving set automatically when no call is in progress and the USB connection is suspended by host or not present and no active communication via ASC0.
	GSM / GPRS / UMTS / HSPA IDLE	Power saving disabled (see [1]: AT^SCFG "MEopMode/PwrSave",<PwrSaveMode>) or an USB connection not suspended, but no call in progress.
	GSM TALK/ GSM DATA	Connection between two subscribers is in progress. Power consumption depends on the GSM network coverage and several connection settings (e.g. DTX off/on, FR/EFR/HR, hopping sequences and antenna connection). The following applies when power is to be measured in TALK_GSM mode: DTX off, FR and no frequency hopping.
	GPRS DATA	GPRS data transfer in progress. Power consumption depends on network settings (e.g. power control level), uplink / downlink data rates and GPRS configuration (e.g. used multislot settings).
	EGPRS DATA	EGPRS data transfer in progress. Power consumption depends on network settings (e.g. power control level), uplink / downlink data rates and EGPRS configuration (e.g. used multislot settings).
	UMTS TALK/ UMTS DATA	UMTS data transfer in progress. Power consumption depends on network settings (e.g. TPC Pattern) and data transfer rate.
	HSPA DATA	HSPA data transfer in progress. Power consumption depends on network settings (e.g. TPC Pattern) and data transfer rate.
Power Down	Normal shutdown after sending the 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

PH8/PH8-P needs to be connected to a power supply at the board-to-board connector - 5 lines BATT+, and GND.

In addition, the VDDLP signal on the board-to-board connector may be connected to an external battery to backup the RTC (see Section 3.5).

The power supply of PH8/PH8-P has to be a single voltage source at BATT+. It 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. This voltage is not available in Power Down mode and can be reduced via AT command to save power (see Table 28: VEXT).
- SIM switch to provide SIM power supply.

3.2.1 Minimizing Power Losses

When designing the power supply for your application please pay specific attention to power losses. Ensure that the input voltage V_{BATT+} never drops below 3.3V on the PH8/PH8-P board, not even in a transmit burst where current consumption can rise to typical peaks of 2A. It should be noted that PH8/PH8-P switches off when exceeding these limits. Any voltage drops that may occur in a transmit burst should not exceed 400mV to ensure the expected RF performance in 2G networks.

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

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

V_{BATT}min = $V_I$min + Dmax
V_{BATT}min = 3.3V + 0.4V = 3.7V
The best approach to reducing voltage drops is to use a board-to-board connection as recommended, and a low impedance power source. The resistance of the power supply lines on the host board and of a battery pack should also be considered.

Note: If the application design requires an adapter cable between both board-to-board connectors, use a flex cable as short as possible in order to minimize power losses.

Example:
If the length of the flex cable reaches the maximum length of 100mm, this connection may cause, for example, a resistance of 30mΩ in the BATT+ line and 30mΩ in the GND line. As a result, a 2A transmit burst would add up to a total voltage drop of 120mV. Plus, if a battery pack is involved, further losses may occur due to the resistance across the battery lines and the internal resistance of the battery including its protection circuit.

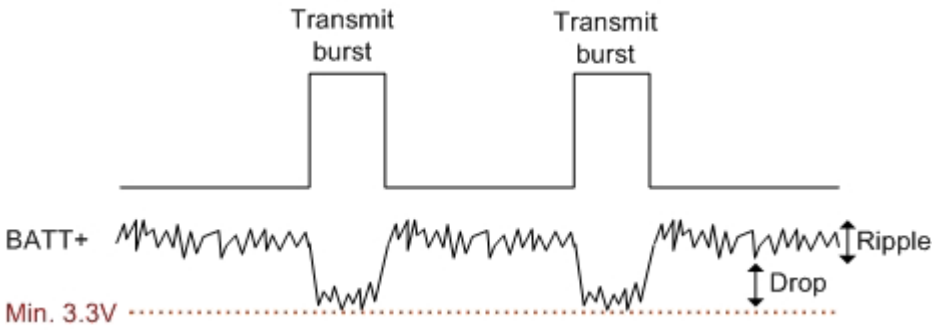


Figure 3: Power supply limits during transmit burst

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 board-to-board connector.

The module continuously measures the voltage at intervals depending on the operating mode of the RF interface. The duration of measuring ranges from 0.5 seconds in TALK/DATA mode to 50 seconds when PH8/PH8-P 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 PH8/PH8-P while it is beyond the safety limits of voltage and temperature stated in Section 6.1. PH8/PH8-P 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 PH8/PH8-P

When the PH8/PH8-P module is in Power Down mode, it can be started to Normal mode by driving the IGT (ignition) line to ground. This must be accomplished using an open drain/collector driver to avoid current flowing into this pad.

The module will start up when both of the following two conditions are met:
- The supply voltage applied at BATT+ must be within the operating range.
- The IGT line needs to be driven low for at least 100 millseconds. After turning on the module, IGT should be set inactive high to prevent the module from turning on again after a shut down by AT command or EMERG_OFF.

Considering different strategies of external application design the figures below show two approaches to meet this requirement: The example in Figure 4 assumes that IGT is activated after BATT+ has already been applied. The example in Figure 5 assumes that IGT is active low before BATT+ is switched on. In either case, to power on the module, ensure that active low state of IGT takes at least 100 milliseconds.

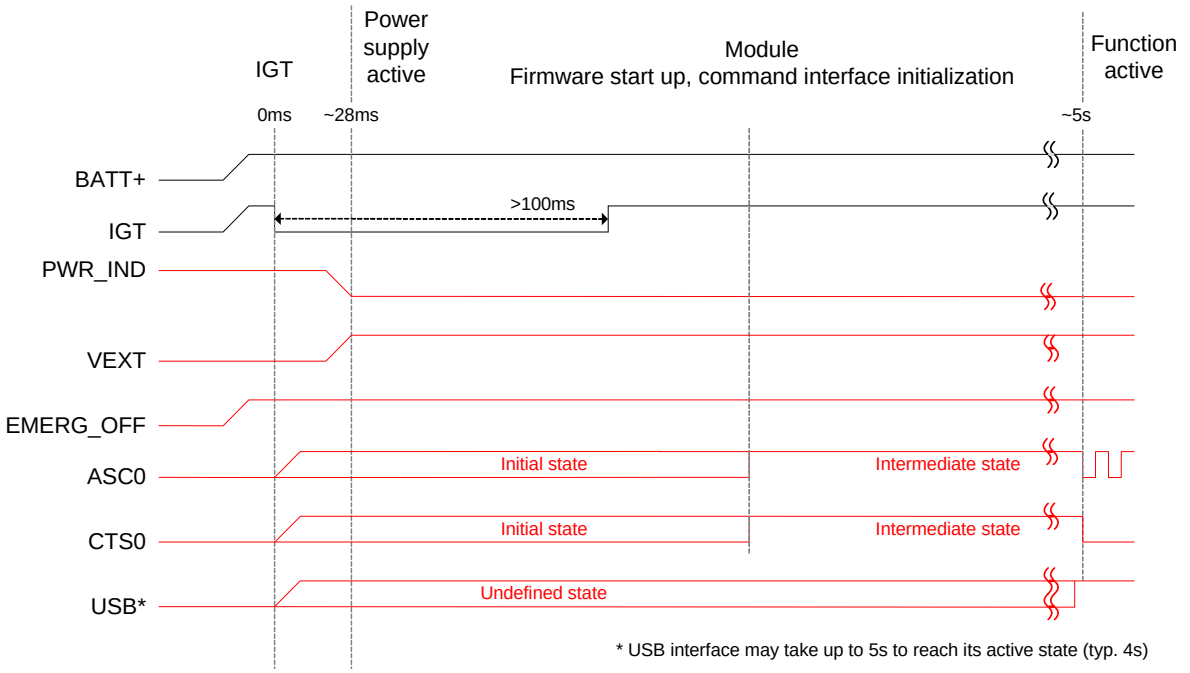


Figure 4: Power-on with operating voltage at BATT+ applied before activating IGT

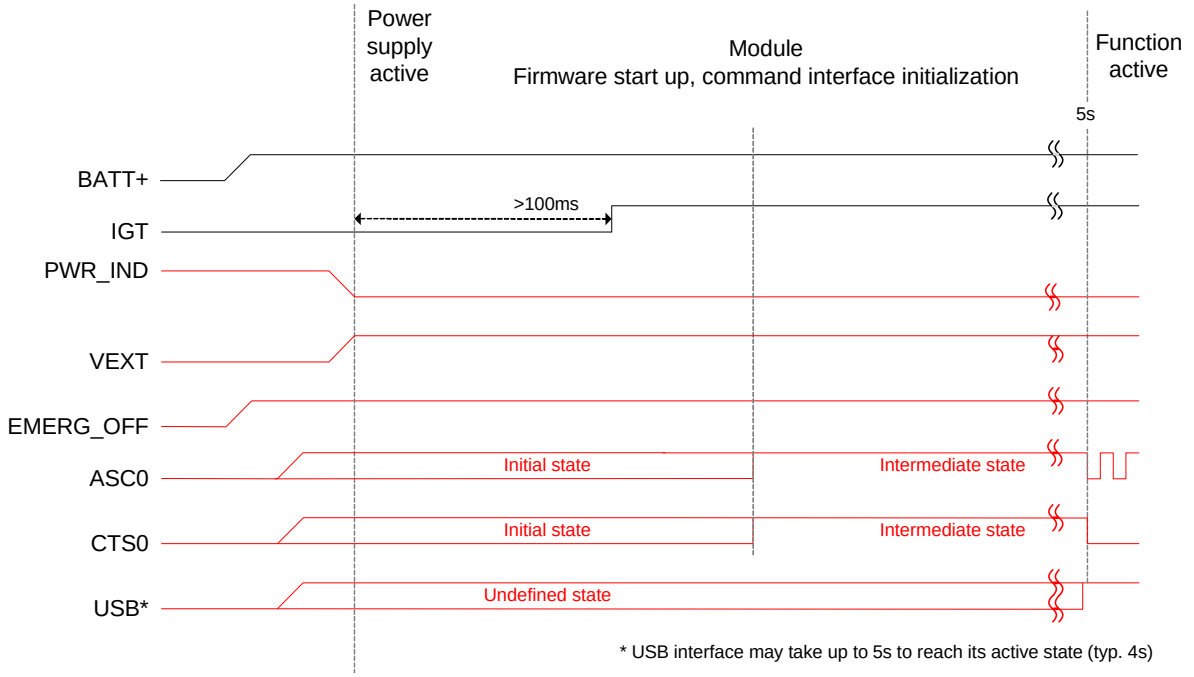


Figure 5: Power-on with IGT active low before switching on operating voltage at BATT+

Note: With a USB connection the USB host may take more than 5 seconds to set up the virtual COM port connection.

After startup or mode change the following URCs 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. try to send command characters (e.g., "AT" or "ATI") until the module is responding.

3.3.2 Signal States after Startup

Table 8 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 (for more information see also Section 3.10.6).

Table 8: Signal states

Signal name	Power on reset Duration appr. 150ms	Startup phase Duration appr. 4s	State after first firmware initialization After 4-4.5s
CCIN	PU(100k)	PU(100k)	I, PU(100k)
CCRST	PD	PD	O, L
CCIO	PD(4.7k)	PD(4.7k)	O, L
CCCLK	PD	PD	O, L
CCVCC	Off	Off	1.8V/3.0V
RXD0	PD	PU	O, H
TXD0	PD	PD	I, PD
CTS0	PD	PU	O, L
RTS0	PD	PD	I, PD
DTR0	PD	PU	I, PU
DCD0	PD	PU[1]	O, H
DSR0	PU	PU	O, L
RING0	PU	PU	O, H
WAKEUP	PD	PD	PD
LCI_IND	PD	PD	PD
PWR_IND	O, L	O, L	O, L
STATUS	PD	PD	PD
PCM/I2S lines	PD	PD	PD

1. No external pull down allowed during this phase.

L = Low level H = High level I = Input O = Output	PD = Pull down resistor with appr. 100k PD(…k) = Pull down resistor with ...k PU = Pull up resistor with appr. 100k PU(…k) = Pull up resistor with ...k

3.3.3 Turn off PH8/PH8-P Using AT Command

The best and safest approach to powering down PH8/PH8-P is to issue the AT^SMSO command. This procedure lets PH8/PH8-P 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. 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 switched off.

Be sure not to disconnect the supply voltage V_{BATT+} before the module has been switched off and the PWR_IND signal has gone high. Otherwise you run the risk of losing data.

While PH8/PH8-P 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, especially of the serial interfaces. No special care is required for the USB interface which is protected from reverse current.

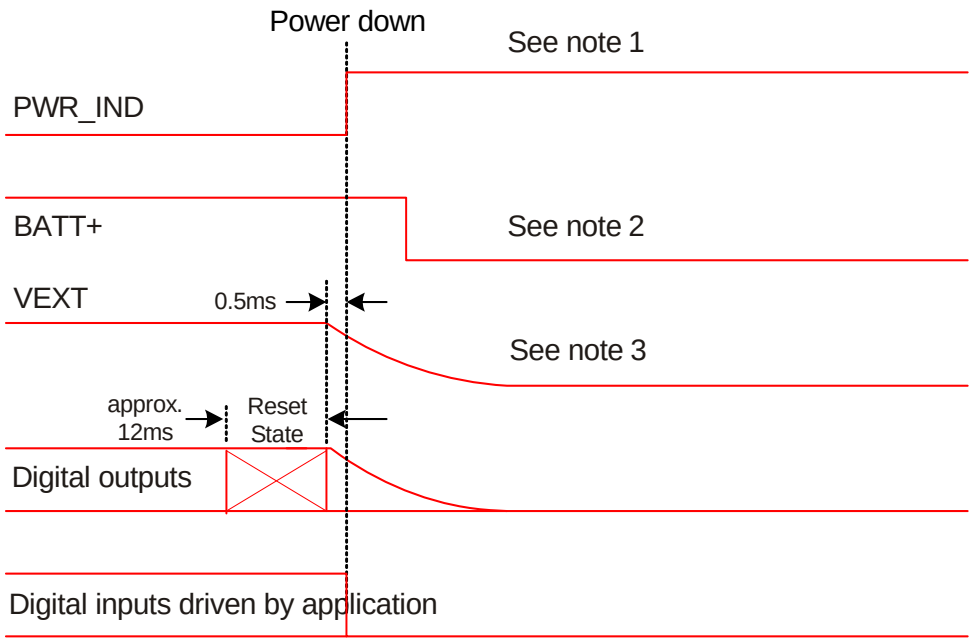


Figure 6: Signal states during turn-off procedure

Note 1: The 0.5ms time period before the PWR_IND signal goes high after a VEXT drop applies to the regular turn off procedure while the module is in idle mode. If the module is turned off while a call is being initiated, e.g., an eCall, this time period may increase.

Note 2: The power supply voltage (BATT+) may be disconnected or switched off only after having reached Power Down mode as indicated by the PWR_IND signal going high.

Note 3: Depending on capacitance load from the host application.

Note 4: After module shutdown by means of AT command, please allow for a time period of at least 1 second before restarting the module.

3.3.4 Turn off PH8/PH8-P 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 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 PH8/PH8-P.
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 PH8/PH8-P.
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 PH8/PH8-P is off, the IGT line must be asserted for at least 100 milliseconds before being released.

Switch-off condition: If the PH8/PH8-P is on, the IGT line must be asserted for at least 2.1 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.

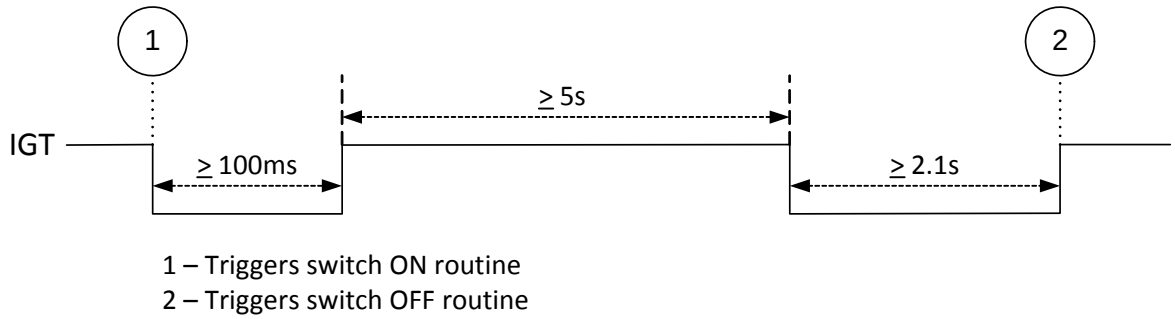


Figure 7: Timing of IGT if used as ON/OFF switch

3.3.5 Automatic Shutdown

Automatic shutdown takes effect if:
- The PH8/PH8-P board is exceeding the critical limits of overtemperature or undertemperature
- Undervoltage or overvoltage is detected

The automatic shutdown procedure is equivalent to the power down initiated with the AT^SMSO command, i.e. PH8/PH8-P 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, PH8/PH8-P 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 PH8/PH8-P. 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" or "-2" are instantly followed by an orderly shutdown, except in cases described in Section 3.3.5.2. The presentation of these URCs is always enabled, i.e. they will be output even though the factory setting AT^SCTM=0 was never changed.

The maximum temperature ratings are stated in Section 6.2. Refer to Table 9 for the associated URCs.

Table 9: Temperature dependent behavior

Sending temperature alert (2 minutes after PH8/PH8-P start-up, otherwise only if URC presentation enabled)	
^SCTM_B: 1	Caution: Board temperature close to overtemperature limit, i.e., board temperature is 5°C below overtemperature limit.
^SCTM_B: -1	Caution: Board temperature close to undertemperature limit, i.e., board temperature is 5°C above undertemperature limit.
^SCTM_B: 0	Board temperature back to uncritical temperature range, i.e., board temperature is 6°C below its over- or above its undertemperature limit.

Table 9: Temperature dependent behavior

Automatic shutdown (URC appears no matter whether or not presentation was enabled)	
^SCTM_B: 2	Alert: Board temperature equal or beyond overtemperature limit. PH8/PH8-P switches off.
^SCTM_B: -2	Alert: Board temperature equal or below undertemperature limit. PH8/PH8-P 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.
- While the eCall operation mode is active.
- 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, PH8/PH8-P 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, PH8/PH8-P 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 28.

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 PH8/PH8-P components are directly linked to BATT+ and, therefore, the supply voltage remains applied at major parts of PH8/PH8-P, 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 Automatic Reset

An automatic reset takes effect if a sudden momentary power loss (SMPL) occurs - e.g., a very brief battery disconnect - and the power returns within 2 seconds.

The SMPL feature ensures that if VBATT+ drops out-of-range (< 2.55V nominal) and then returns into range within 2 seconds, the power-on sequence is executed and the module switches on again. Thus the SMPL feature achieves immediate and automatic recovery from momentary power loss such as a brief battery disconnect.

To employ the SMPL feature the VDDLP line has to supplied for at least 2 seconds after a possible power loss (e.g., by connecting a battery).

3.3.7 Turn off PH8/PH8-P 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 PH8/PH8-P 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.

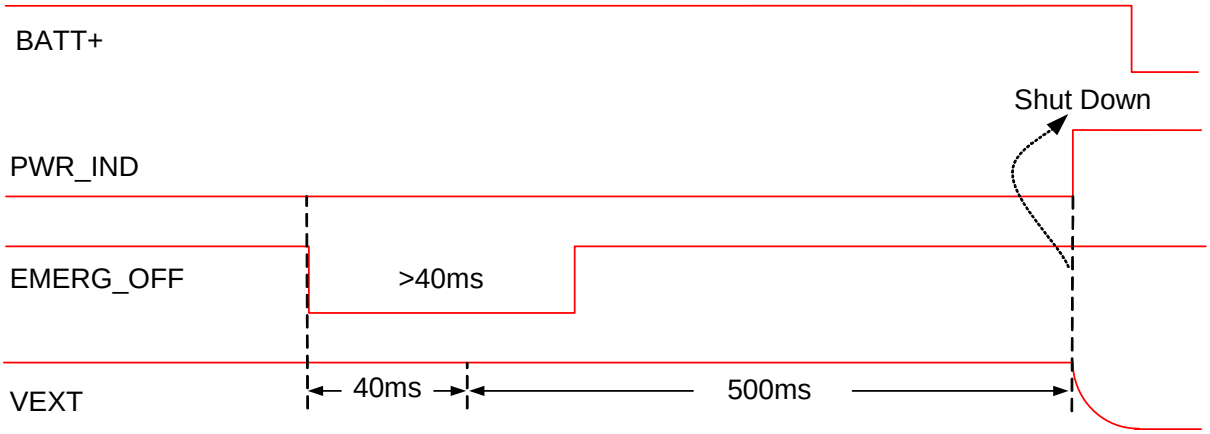


Figure 8: Shutdown by EMERG_OFF signal

Please note that 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

PH8/PH8-P 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 and also mention how to wake up from or disable the so-called SLEEP mode.

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.

Note: The module's SLEEP mode current consumption can be reduced significantly (0.6mA) by enabling the VEXT power save mode. Hence, it is recommended to enable power saving on VEXT if at all possible. For more information see Table 28: VEXT.

Another feature influencing the current consumption is the configuration of the GNSS antenna interface. For details see Section 6.9.

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 ms (TDMA frame duration) * 51 (number of frames) * 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.

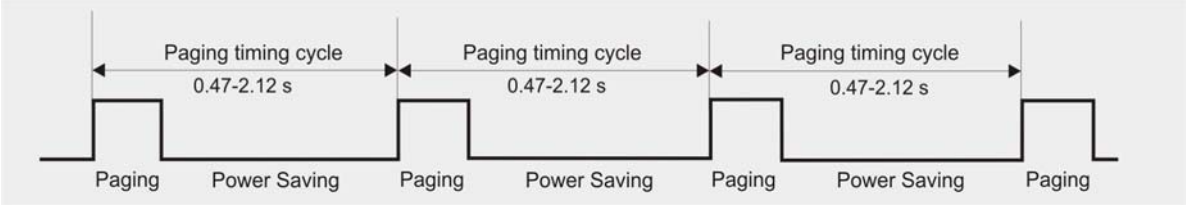


Figure 9: Power saving and paging in GSM networks

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:

$t = 2^{DRX\ value} * 10$ 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.

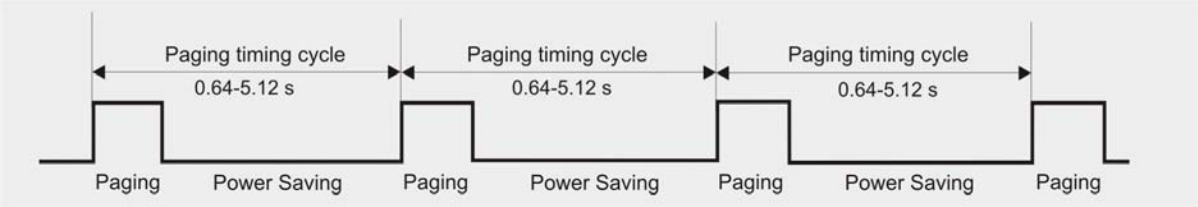


Figure 10: Power saving and paging in WCDMA networks

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 Timing of the CTS0 Signal, GSM/WCDMA

As long as PH8/PH8-P is operated via the ASC0 interface and not in power saving mode, the CTS0 line is always active. This means that while attached to a network the CTS0 signal will be temporarily active during each paging.

After a concluding activity on the serial interface ASC0 - and depending on the module's other activities - it takes by default 5 seconds before CTS0 goes inactive (again) and power saving starts (as described in Section 3.4.1 and Section 3.4.2). The 5 second delay period can be configured using the AT^SCFG parameter "MEopMode/PwrSave", <PwrSaveDelay> (see [1]).

With regard to programming or using timeouts, the UART must take the varying CTS0 inactivity periods into account.

Note: Hardware handshaking is mandatory if employing PH8/PH8-P's ASC0 interface with enabled power saving. Thus AT commands are only recognized by the module while CTS0 is active.

3.4.4 Wake up from or Disabling Power Saving

The RTS0 line can be used to wake up the module from its power saving SLEEP mode. RTS0 activation (high to low transition) may be employed to cut short pauses between listening to paging messages. Following an RTS toggle the module will return to SLEEP mode 5 seconds after the last character was sent over the interface. This default delay period can be configured using the AT^SCFG parameter "MEopMode/PwrSave", <PwrSaveDelay>.

If not regularly woken up from power saving (through network requirements or by means of RTS toggling as described above), the power saving timeout recommended for the AT^SCFG parameter "MEopMode/PwrSave", <PwrSaveTimeout> ensures that the module regularly wakes up from its power saving state (SLEEP mode). It is recommended to configure a regular module wake up, especially if the radio interface is switched off (Airplane mode) and the module is connected via serial interface (i.e., AT^SDPORT=2) to an external application without direct access to its RTS0 line (e.g., an application using standard Windows/Linux serial device drivers).

The AT^SCFG parameter "MEopMode/PwrSave", <PwrSaveMode> can be used to disable power saving completely, i.e., the module will no longer enter SLEEP mode but remain in IDLE mode instead. Please note that if this setting is used to avoid implementing hardware handshaking on ASC0, it is mandatory to have RTS0 pulled down or left open (an internal pull down is available).

For more information on power saving and the appropriate AT^SCFG parameters to configure the power save behavior see [1].

3.5 RTC Backup

The internal Real Time Clock of PH8/PH8-P is supplied from a separate voltage regulator in the power supply component which is also active when PH8/PH8-P is in Power Down mode and BATT+ is available. An alarm function is provided that allows to wake up PH8/PH8-P. 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 network.

In addition, you can use the VDDLP line on the board-to-board connector to backup the RTC from a battery (rechargeable or non-chargeable). If the voltage supply at BATT+ is disconnected the RTC can be powered by the battery. The size of the battery determines the duration of buffering when no voltage is applied to PH8/PH8-P, i.e. the greater the battery the longer PH8/PH8-P will save the date and time.

Figure 11 show various sample configurations.

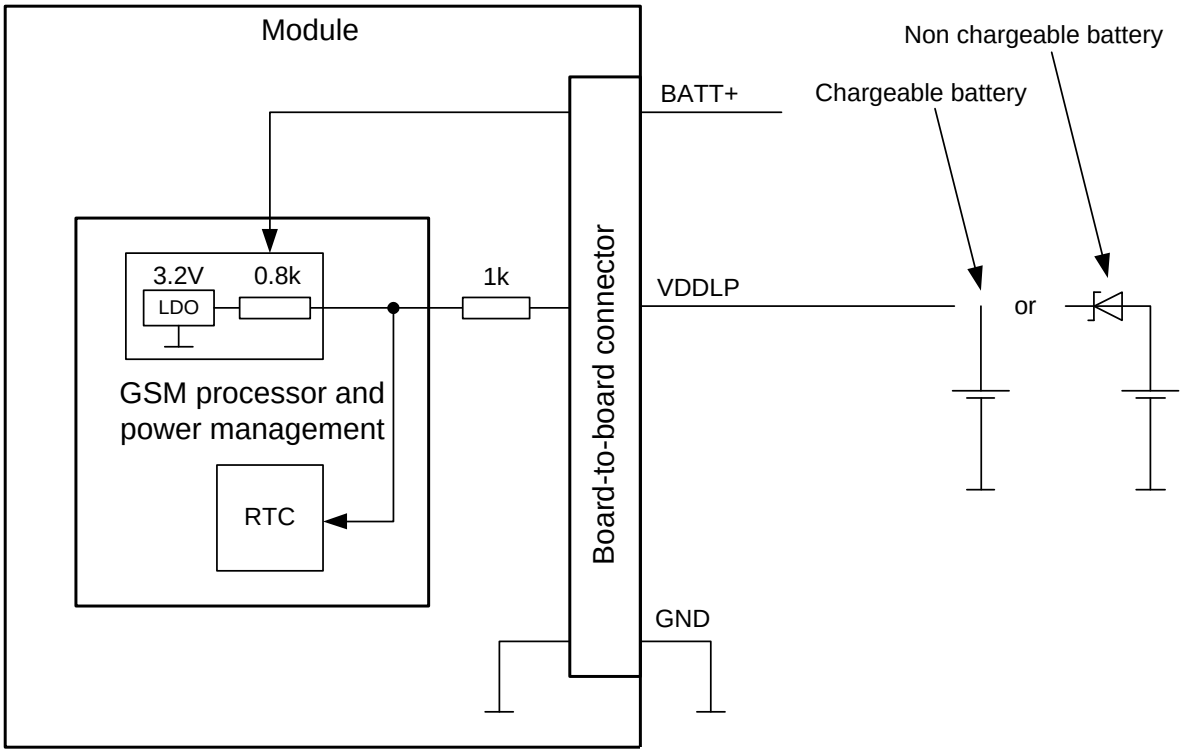
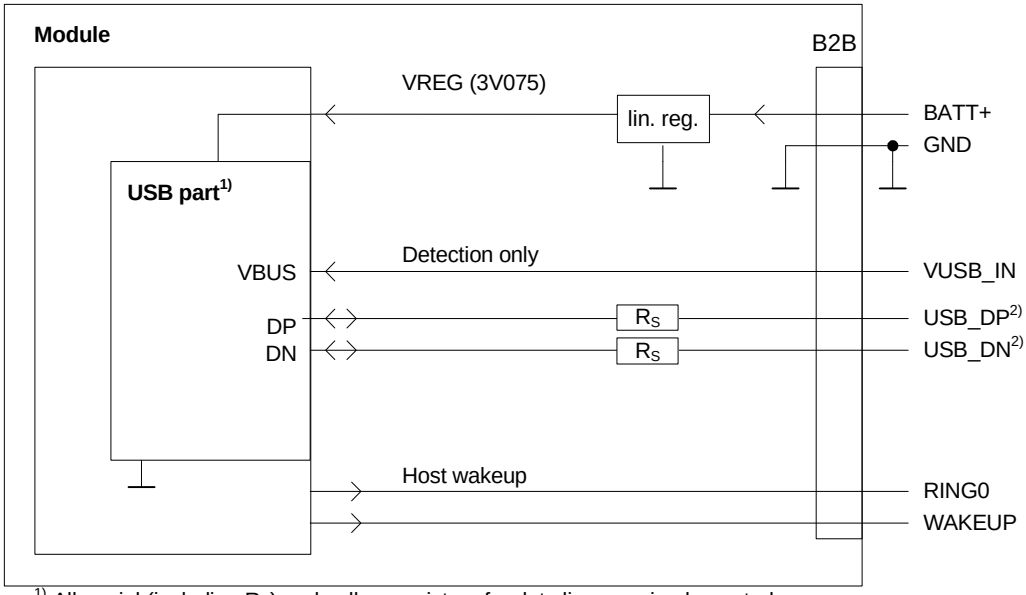


Figure 11: RTC supply variants

3.6 USB Interface

PH8/PH8-P supports a USB 2.0 High Speed (480Mbps) device interface that is Full Speed (12Mbps) compliant. The USB interface is primarily intended for use as command and data interface and for downloading firmware.

The external application is responsible for supplying the VUSB_IN line. This line is used for cable detection only. The USB part (driver and transceiver) is supplied by means of BATT+. This is because PH8/PH8-P is designed as a self-powered device compliant with the “Universal Serial Bus Specification Revision 2.0”[1].



1) All serial (including R_S) and pull-up resistors for data lines are implemented.
2) If the USB interface is operated in High Speed mode (480MHz), it is recommended to take special care routing the data lines USB_DP and USB_DN. Application layout should in this case implement a differential impedance of 90 ohms for proper signal integrity.

Figure 12: USB circuit

To properly connect the module's USB interface to the external application, a USB 2.0 compatible connector and cable or hardware design is required. For more information on the USB related electrical signals see Table 28.

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 power[1]. 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 PH8/PH8-P 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 the RING0 or WAKEUP line to wake up the host application in case of incoming calls or events signalized 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 loosing any signaled events. For details on this host wakeup functionality see Section 3.10.4. To prevent existing data call connections from being disconnected while the USB interface is in detached state (i.e., VUSB_IN=0) it is possible to call AT&D0, thus ignoring the status of the DTR line (see also [1]).

1. 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

PH8/PH8-P 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 28. For an illustration of the interface line's startup behavior see Section 3.10.6.

PH8/PH8-P 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

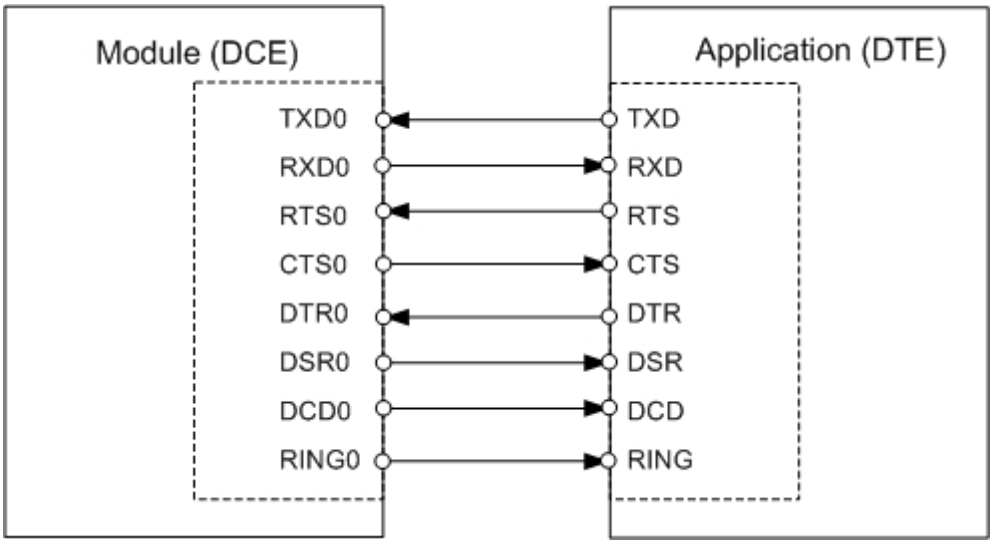


Figure 13: Serial interface ASC0

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 9600bps up to 921600bps.
- Supports RTS0/CTS0 hardware flow control.
- Wake up from SLEEP mode by RTS0 activation (high to low transition).

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.

Table 10: 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

PH8/PH8-P has an integrated UICC/SIM/USIM interface compatible with the 3GPP 31.102 and ETSI 102 221. This is wired to the host interface in order to be connected to an external SIM card holder. Six pins on the board-to-board connector are reserved for the SIM interface.

The UICC/SIM/USIM interface supports 3V and 1.8V SIM cards. Please refer to Table 28 for electrical specifications of the UICC/SIM/USIM interface lines depending on whether a 3V or 1.8V SIM card is used.

The CCIN signal serves to detect whether a tray (with SIM card) is present in the card holder. Using the CCIN signal is mandatory for compliance with the GSM 11.11 recommendation if the mechanical design of the host application allows the user to remove the SIM card during operation. To take advantage of this feature, an appropriate SIM card detect switch is required on the card holder. For example, this is true for the model supplied by Molex, which has been tested to operate with PH8/PH8-P and is part of the Gemalto M2M reference equipment submitted for type approval. See Chapter 10 for Molex ordering numbers.

Table 11: Signals of the SIM interface (board-to-board connector)

Signal	Description
CCGND	Ground connection for SIM. Be sure to use this ground line for the SIM interface rather than any other ground line or plane on the module.
CCCLK	Chipcard clock
CCVCC	SIM supply voltage.
CCIO	Serial data line, input and output.
CCRST	Chipcard reset
CCIN	Input on the baseband processor for detecting a SIM card tray in the holder. If the SIM is removed during operation the SIM interface is shut down immediately to prevent destruction of the SIM. The CCIN signal is active low. The CCIN signal is mandatory for applications that allow the user to remove the SIM card during operation. The CCIN signal is solely intended for use with a SIM card. It must not be used for any other purposes. Failure to comply with this requirement may invalidate the type approval of PH8/PH8-P.

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 PH8/PH8-P.

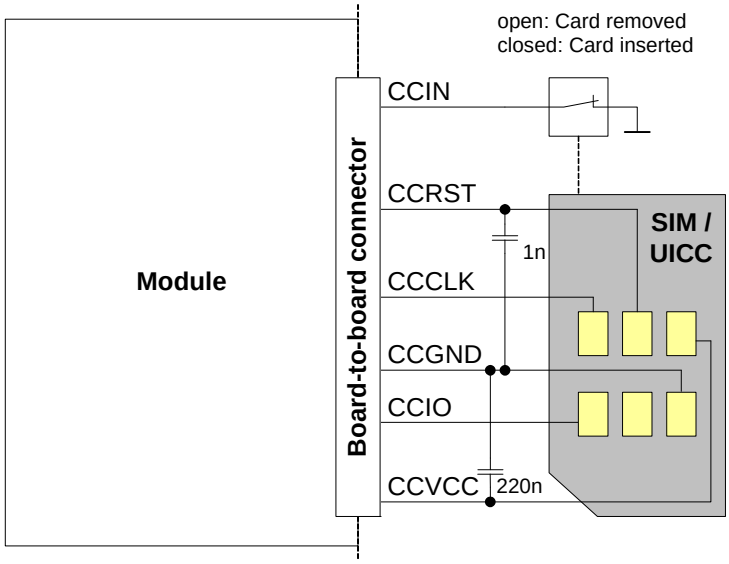


Figure 14: UICC/SIM/USIM interface

The total cable length between the board-to-board connector pins on PH8/PH8-P and the pads of the external SIM card holder must not exceed 100mm in order to meet the specifications of 3GPP TS 51.010-1 and to satisfy the requirements of EMC compliance.

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

3.9 Audio Interfaces

PH8/PH8-P supports three types of audio interface as described in the following sections:
- Analog audio interface - see Section 3.9.1
- Digital audio interface - see Section 3.9.2
- USB audio interface - see Section 3.9.3

3.9.1 Analog Audio Interface

PH8/PH8-P has an analog audio interface with a balanced analog microphone input and a balanced analog earpiece output. A supply voltage and an analog ground connection are provided at dedicated lines.

PH8/PH8-P offers eight audio modes which can be selected with the AT^SNFS command. The electrical characteristics of the voiceband part vary with the audio mode. For example, sending and receiving amplification, sidetone paths, noise suppression etc. depend on the selected mode and can in parts be altered with AT commands (except for mode 1).

Please refer to Section 6.7 for specifications of the audio interface and an overview of the audio parameters. Detailed instructions on using AT commands are presented in [1]. Table 32 summarizes the characteristics of the various audio modes and shows what parameters are supported in each mode.

When shipped from factory, all audio parameters of PH8/PH8-P are set to audio mode 1. This is the default configuration optimized for the Votronic HH-SI-30.3/V1.1/0 handset and used for type approving the Gemalto M2M reference configuration. Audio mode 1 has fix parameters which cannot be modified. To adjust the settings of the Votronic handset simply change to another audio mode.

3.9.1.1 Microphone Inputs and Supply

The differential microphone inputs MICP and MICN present variable impedances depending on the gain. The microphone inputs must be decoupled by capacitors Ck (typical 1µF). The input stage uses a differential operational amplifier circuit with programmable resistors in the input and the feedback path. The detailed structure of this stage and the following uplink path is shown in Figure 15. The input can be controlled by the AT command AT^SNFI. Command parameters with their effect are mentioned in the figure and marked in <red>. More information about audio AT commands can be found in Section 6.7 and [1].

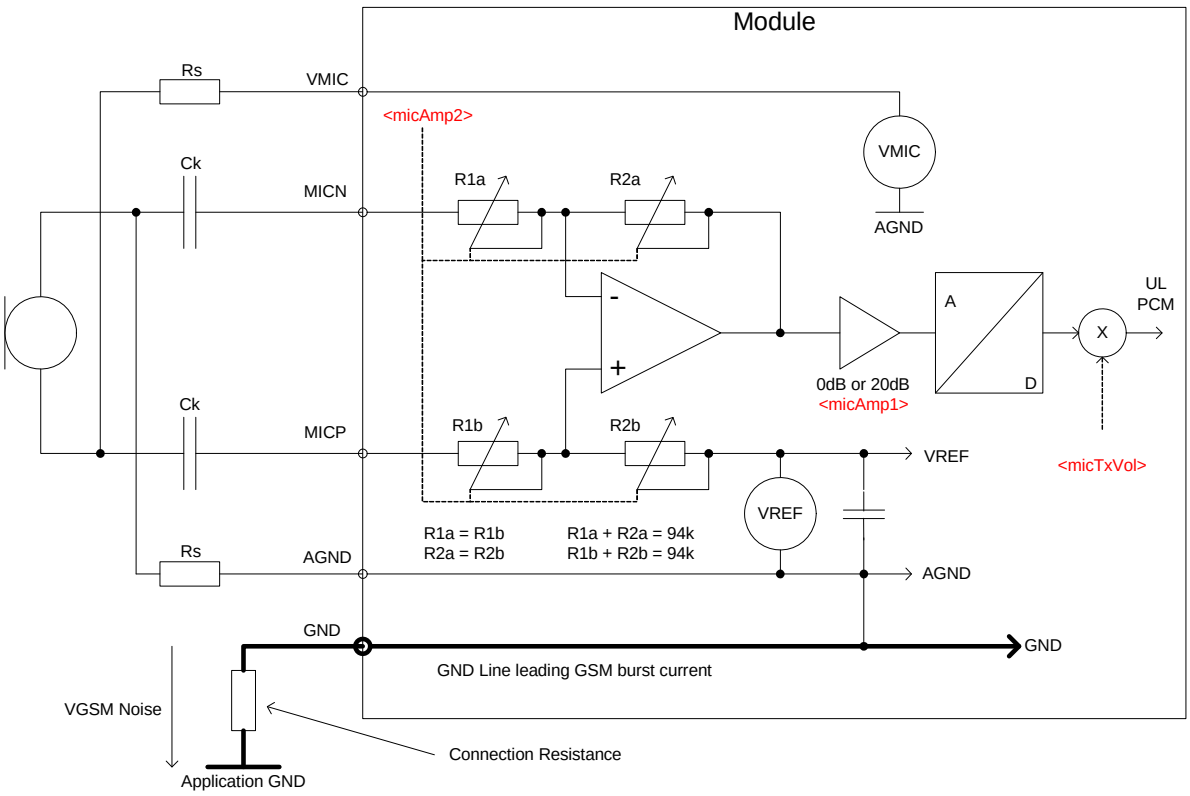


Figure 15: Structure of Audio Input and Supply

MICP leads the signal via a resistor R1b to the non-inverting input of the operational amplifier which is then connected via a resistor R2b to VREF. The inverted signal goes through MICN via a feedback path of resistors R1a and R2a to the inverting input of the opamp.

The gain of the **first** input **stage** can be programmed by the parameter <micAmp2>, in steps of 0.75dB and between -12dB and +35.25dB. R1a and R2a respective R1b and R2b are varied depending on this gain. The sum of R1a and R2a (respective R1b and R2b) is always 94kΩ. The value of R1a or R1b varies as listed in Table 12 for selected gains:

Table 12: Feedback resistor values versus input gain

Gain [dB]	R1a or R1b [kΩ]	R2a or R2b [kΩ]
35.25	1.6	R2x = 94kΩ - R1x
30	2.9	
18	11	
12	19	
6	31	
0	47	
-12	75	

MICP presents a constant impedance of 94kΩ with respect to AGND. If MICP is AC coupled held at AGND, the impedance of MICN with respect to AGND is R1a (see Table 12). A floating differential source sees an impedance of R1a + R1b. The common mode input impedance is constantly 94kΩ for each input.

The matching of these resistors has an accuracy of 0.1% resulting in a maximum common mode rejection ratio of 60dB. The typical value is around 54dB.

A **second** gain **stage** follows that can be set to 0dB or 20dB using <micAmp1>. If 20dB is specified, the common mode rejection ratio is reduced accordingly.

Finally, the uplink gain can be scaled in the PCM path by the <micTxVol> parameter.

It is recommended to use the AGND line for grounding the microphone circuit. AGND provides for the same module ground potential the analog circuits of the module refer to. AGND must not be connected to the system GND anywhere. Otherwise high GSM burst peak currents will flow across AGND causing GSM humming in the uplink audio signal.

A regulated power supply for electret microphones is available at VMIC. The voltage at VMIC is rated at 2.7V at 3mA and is available while audio is active (e.g., during a call).

The following figures show possible microphone and line connections.

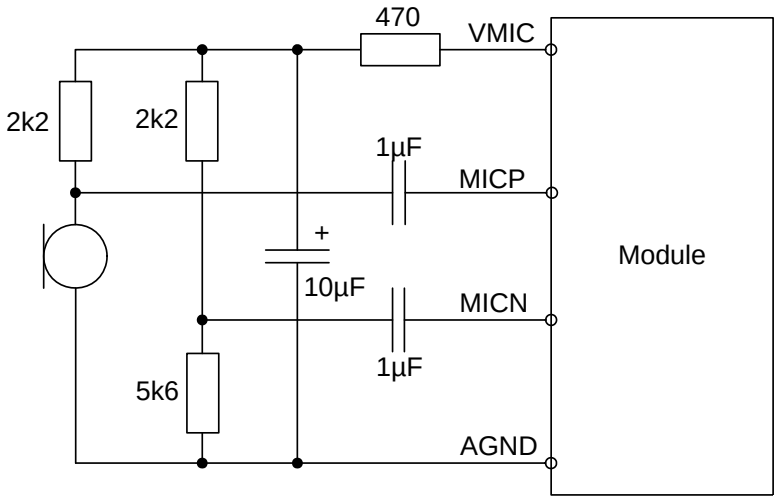


Figure 16: Single ended microphone connection

The configuration shown in Figure 16 is suitable for short distances between microphone and module. A typical electret microphone has a metal case connected to its ground pad. Since this is routed directly to AGND, electro static discharges applied to the microphone will be easily led away. It is recommended to use an additional RC-filter for VMIC (for example 470Ω and 10µF as shown in the figure) in case a high microphone gain is necessary.

If the microphone lines are longer, use the configuration shown in Figure 17. It is recommended to use an additional RC-filter for VMIC (for example 1kΩ, 10µF and 1kΩ as shown in the figure) in case a high microphone gain is necessary.

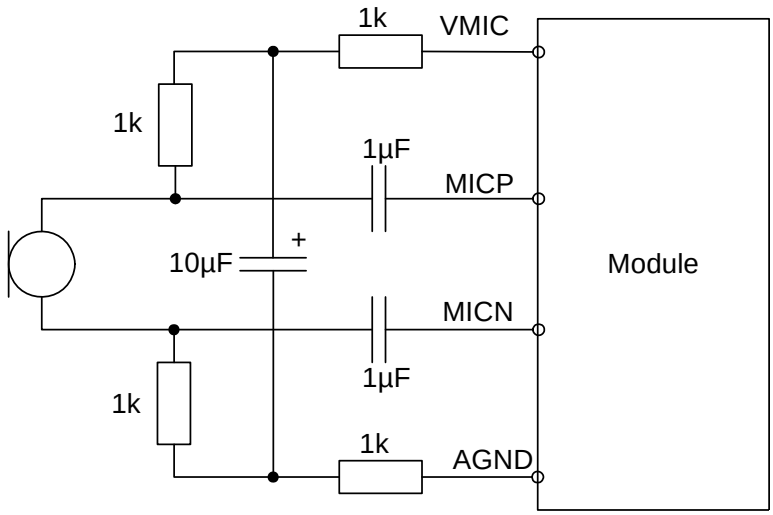


Figure 17: Differential microphone connection

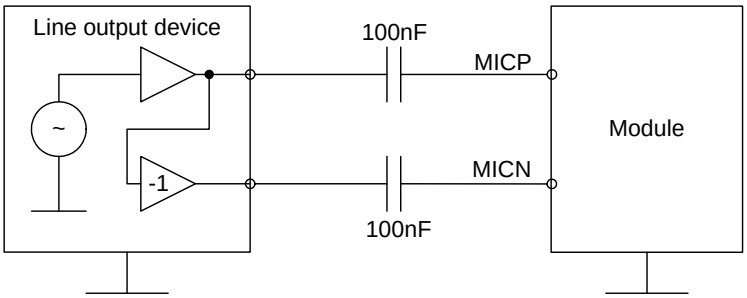


Figure 18: Line input

Using the line input configuration the output level of the ground related balanced source should be as high as possible to achieve the best SNR. Since the input impedance of PH8/PH8-P is quite high at low gains, the coupling capacitances may be smaller.

3.9.1.2 Loudspeaker Output

PH8/PH8-P provides a differential loudspeaker output EPP/EPN. If it is used as line output, the application should provide a capacitor decoupled differential input to eliminate GSM humming. A single ended connection to a speaker or a line input is not recommended.

The following figures show the typical output configurations.

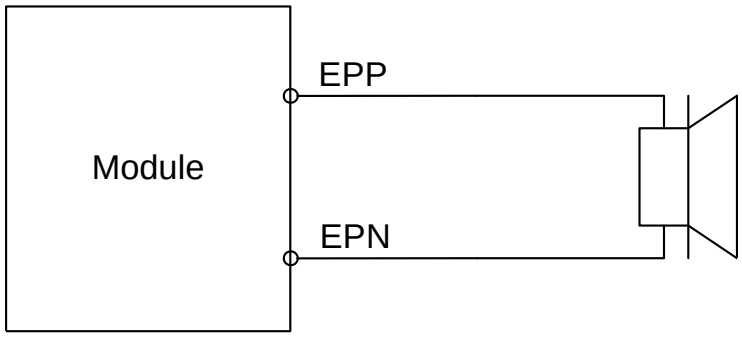


Figure 19: Differential loudspeaker connection

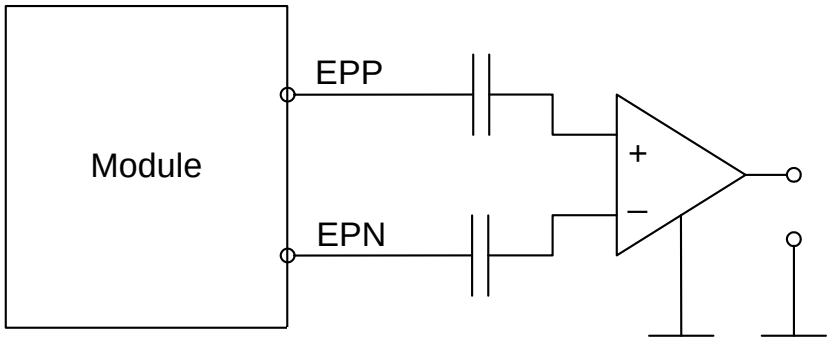


Figure 20: Line output connection

3.9.2 Digital Audio Interface

PH8/PH8-P has a digital audio interface that can be employed either as pulse code modulation (see Section 3.9.2.1) or as inter IC sound interface (see Section 3.9.2.2). Operation of these interface variants is mutually exclusive.

3.9.2.1 Pulse Code Modulation Interface (PCM)

PH8/PH8-P's PCM interface can be used to connect audio devices capable of pulse code modulation. The PCM functionality allows the use of a codec like the W681360. Using the AT^SAIC command you can activate and configure the PCM interface (see [1]).

The PCM interface supports the following modes:
- Master mode, slave mode
- Short frame synchronization
- 256kHz, 512kHz and 2048kHz bit clock
- Additional master mode with 128kHz, long frame synchronization

For the PCM interface configuration the parameters <clock>, <mode> <frame_mode> and <ext_clk_mode> of the AT^SAIC command can be configured. The following table lists possible combinations:

Table 13: Configuration combinations for the PCM interface

Configuration	<clock>	<mode>	<frame_mode>	<ext_clk_mode>
Master, 128kHz, long frame	0	0	1	0 or 1
Master, 256kHz, short frame	1	0	0	0 or 1
Master, 512kHz, short frame	2	0	0	0 or 1
Master, 2048kHz, short frame	3	0	0	0 or 1
Slave, 256kHz, short frame	1	1	0	1
Slave, 512kHz, short frame	2	1	0	1
Slave, 2048kHz, short frame	3	1	0	1

In slave mode <clock> must be set according the source clock frequency. Being in master mode clock and frame synchronization signals may be permanently switched on by <ext_clk_mode> parameter. These signals may be used for clocking digital audio periphery outside a call.

Table 14 lists the available PCM interface signals.

Table 14: Overview of PCM signal functions

Signal name on B2B connector	Signal configuration inactive[1]	Signal direction: Master	Signal direction: Slave	Description
PCM_OUT	PD	O	O	PCM Data from PH8/PH8-P to external codec
PCM_IN	PD	I	I	PCM Data from external codec to PH8/PH8-P

Table 14: Overview of PCM signal functions

Signal name on B2B connector	Signal configuration inactive[1]	Signal direction: Master	Signal direction: Slave	Description
PCM_FSC	PD	O	I	Frame synchronization signal to/from external codec
PCM_CLK	PD	O	I	Bit clock to/from external codec

1. Inactive means no call, no tone generation and no external clock mode. PD = Pull down

The timing of a PCM short frame is shown in Figure 21. The timing for master and slave mode is identical, except for the PCM_FSC and PCM_CLK signal direction (see Table 14).

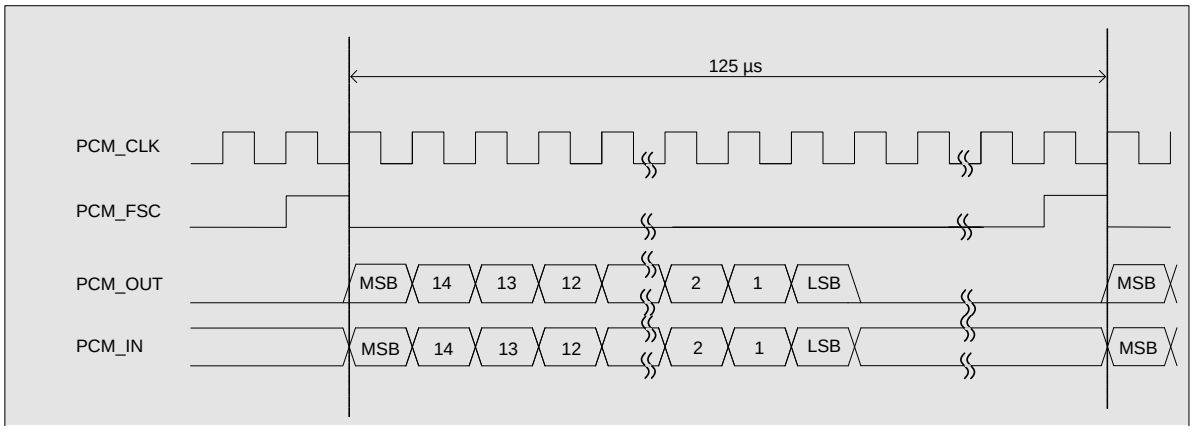


Figure 21: PCM timing short frame (master/slave, 256, 512 or 2048KHz)

The timing of a PCM long frame for the additional 128kHz master mode is shown in Figure 22.

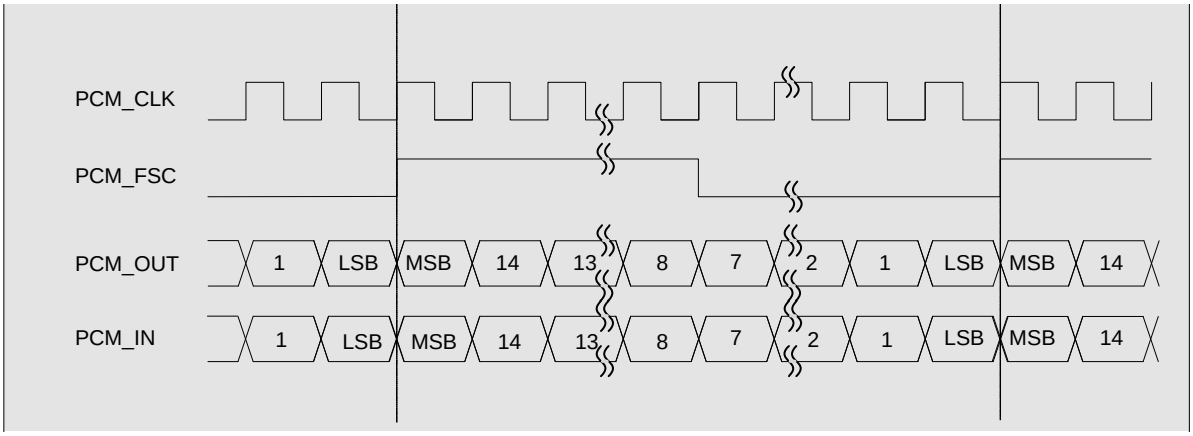


Figure 22: PCM timing long frame (master, 128kHz)

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.

3.9.2.2 Inter IC Sound Interface (I^2S)

PH8/PH8-P's digital audio interface may also be employed as an inter IC sound interface. The I^2S interface is a dedicated, optional interface for non-stationary background noise suppression with 2 microphones and one speaker for handheld handset or hands-free operation.

The I^2S interface is enabled using the AT command AT^SAIC. An activation is possible only out of call and out of tone presentation. The I^2S properties and capabilities comply with the requirements laid out in the Phillips I^2S Bus Specifications, revised June 5, 1996.

The I^2S Interface is a dual interface that provides possibility to transfer mono as well as dual/stereo audio signals in either direction.

The I^2S interface has the following characteristics:

- The I^2S Interface operates as master for the bidirectional operation and consists of 2 unidirectional single interfaces:
  - The first I^2S interface uses PCM signal lines as uplink path (PCM_IN as I2S_DIN, PCM_FSC as I2S_WSIN and PCM_CLK as I2S_SCLKIN)
  - The second I^2S interface uses separate signal lines as downlink path (I2S_MCLKOUT, I2S_DOUT, I2S_WSOUT and I2S_SCLKOUT)
- The GSM downlink signal is always available on left channel (the right channel is not used).
- For all single-mic audio modes the GSM uplink signal is the left channel.
- The sample rate is set to 8 KHz, the serial bit clock SCLK is 256kHz. The data transmission is synchronized to word-sync (WS) signals. The serial bits are transmitted on the trailing edge and received on the leading edge of the serial clock.
- For each microphone the samples are coded by 16 bit linear PCM. Signals from two microphones are transferred interleaved on the physical interface.
- Audio modes:
  Audio mode 1 does not work with the I^2S Interface whereas the audio modes 2-6 may be used with I^2S. Additional audio modes 7 and 8 are dedicated for dual microphone customer solutions for handset operation and an additional audio mode for handheld hands-free operation. If an audio mode prepared for two microphones is used with the PCM or analogue interface, the audio path is muted.

Table 15 lists the available I^2S interface signals.

Table 15: Overview of I^2S signal functions

Signal name	Alternate name	Signal configuration inactive[1]	I/O	Description
Not used	PCM_OUT	PD	I	Not used.
I2S_DIN	PCM_IN	PD	I	Data input (8kHz sample rate)
I2S_WSIN	PCM_FSC	PD	I	Word sync input
I2S_SCLKIN	PCM_CLK	PD	I	Clock input (256kHz)
I2S_MCLKOUT		PD	O	Optional master clock (2048MHz)
I2S_DOUT		PD	O	Data output (8kHz sample rate)
I2S_WSOUT		PD	O	Word sync output
I2S_SCLKOUT		PD	O	Clock output (256kHz)

1. Inactive means no call, no tone generation and no external clock mode. PD = Pull down

The timing over the I²S interface is shown in Figure 23.

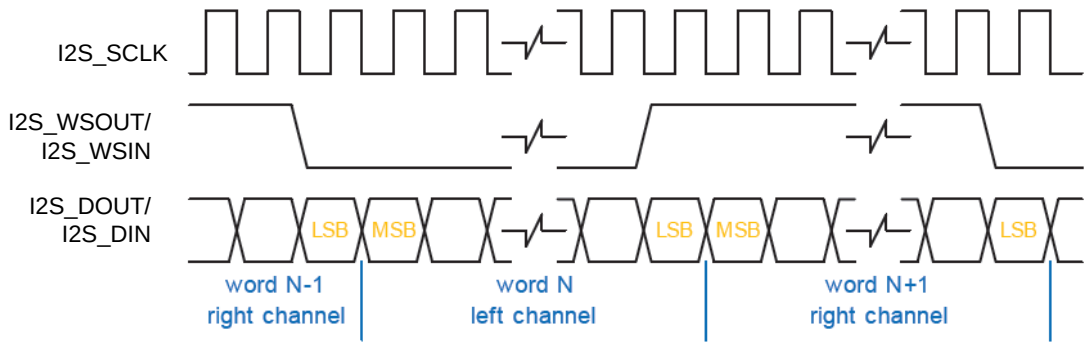


Figure 23: I²S interface timing

The following signals will have to be connected by an external application, as shown in the below example of an external application with an I²S codec:

- I2S_WSOUT and I2S_WSIN
- I2S_SCLKOUT and I2S_SCLKIN

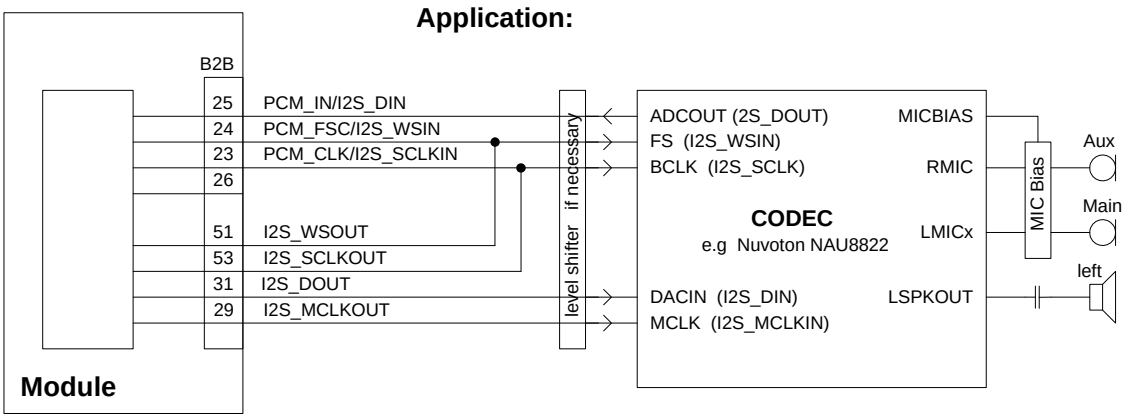


Figure 24: Dual microphone design example with I²S interface

3.9.3 USB Audio Interface

As an alternative to the above described analog and digital audio interfaces with their particular physical audio lines, PH8/PH8-P also supports USB Audio, i.e., an audio interface based on the USB Audio specification[1], and employing the USB interface lines.

The audio over USB interface is implemented as a narrowband digital audio interface, with PH8/PH8-P acting as connected USB client, featuring mono, microphone and speaker, 16 bit/sample and 8000 samples/second.

USB Audio can be enabled by AT command (see [1]: AT^SCFG="Serial/USB/Instances/Audio"), and is then available - after module restart and re-enumeration - as part of a USB composite device. With the latest PH8/PH8-P USB drivers installed, the USB Audio device is automatically detected as pair of microphone and speakers on a Windows host.

If the USB Audio interface is available, the module can be configured to use this interface (see [1]: AT^SAIC). As long as USB Audio is active, changing of USB interface assignments is locked to avoid USB re-enumeration and data transmission drop.

For more information on USB Audio see [1] and [5].

1. The specification is ready for download on http://www.usb.org/developers/docs/devclass_docs/Audio2.0_final.zip

3.10 Control Signals

3.10.1 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 25). 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.

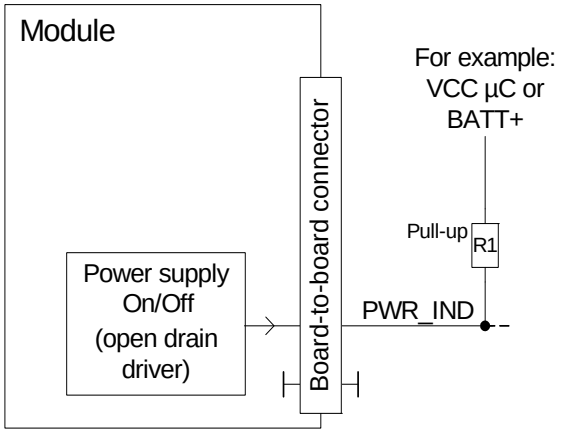


Figure 25: PWR_IND signal

3.10.2 Network Connectivity Status Signals

The STATUS line serves to indicate the module's network connectivity state and can be used to control an externally connected LED as shown in Figure 26. To operate the LED a buffer, e.g. a transistor or gate, must be included in the external application.

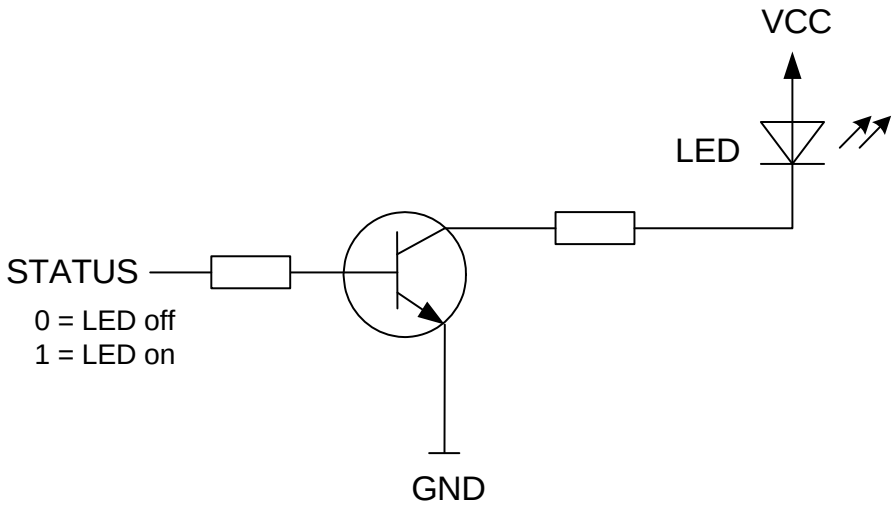


Figure 26: LED Circuit (Example)

For electrical characteristics of the STATUS line see Table 28. The network connectivity 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].

3.10.3 Behavior of the RING0 Line (ASC0 Interface only)

The RING0 line is available on the first serial interface ASC0 (see also Section 3.7). The signal serves to indicate incoming calls and other types of URCs (Unsolicited Result Code).

Although not mandatory for use in a host application, it is strongly suggested 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.

Note: If the RING0 line is not wired, the application is required to permanently poll the data and status lines of the serial interface at the expense of a higher current consumption. 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.

3.10.4 Host Wakeup

If no call, data or message transfer is in progress, the host may shut down its own USB interface to save power. If a call or other request (URC) arrives, the host can be notified of this event and be woken up again by a state transition of either the RING0 or the WAKEUP line. This functionality should only be used with legacy USB applications not supporting the recommended USB suspend and resume mechanism as described in in the “Universal Serial Bus Specification Revision 2.0“[1] (see also Section 3.6.1).

The behavior of these RING0 or WAKEUP lines as host wakeup line has to be enabled and configured by AT command (see [1]: AT^SCFG). Possible states are listed in Table 16. Please note that it is not possible to use both lines in parallel. The WAKEUP signal just inverts the RING0 signal in order to meet different application needs.

Table 16: Host wakeup lines

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

3.10.5 Low Current Indicator

A low current indication is optionally available over the LC_IND line. By default, low current indication is disabled.

For the LC_IND signal to work as a low current indicator the feature has to be enabled by AT command (see [1]: AT^SCFG: MEopMode/PowerMgmt/LCI).

If enabled, the LC_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 17: Low current indicator line

Signal	I/O/P	Description
LC_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+

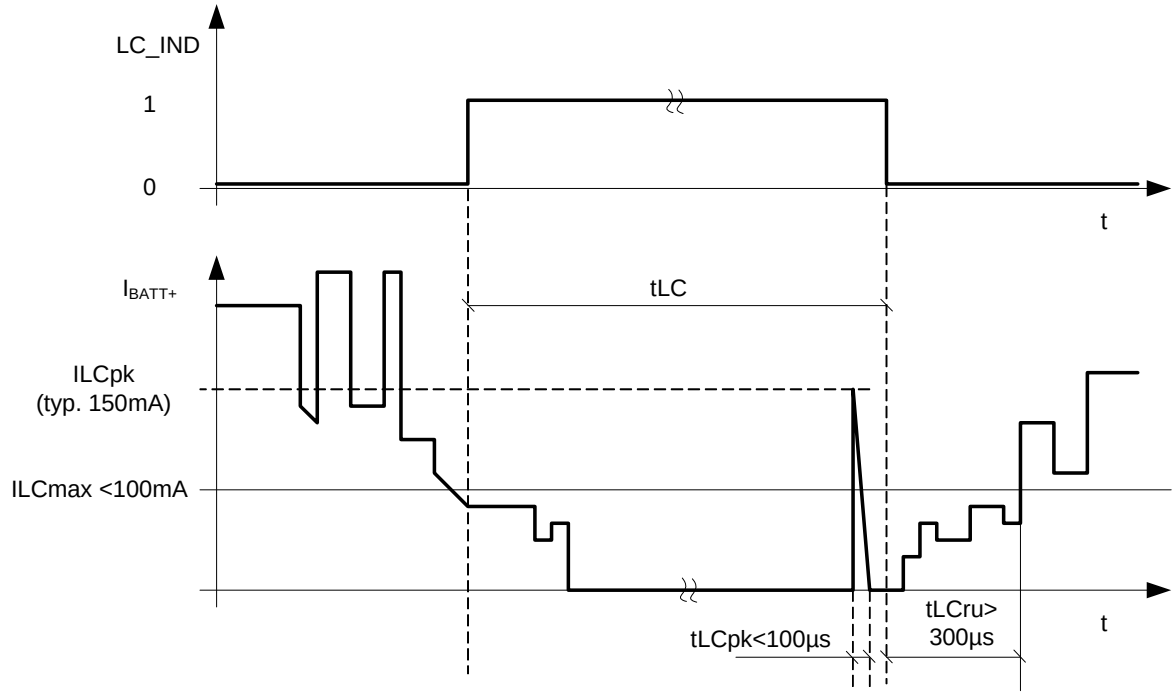
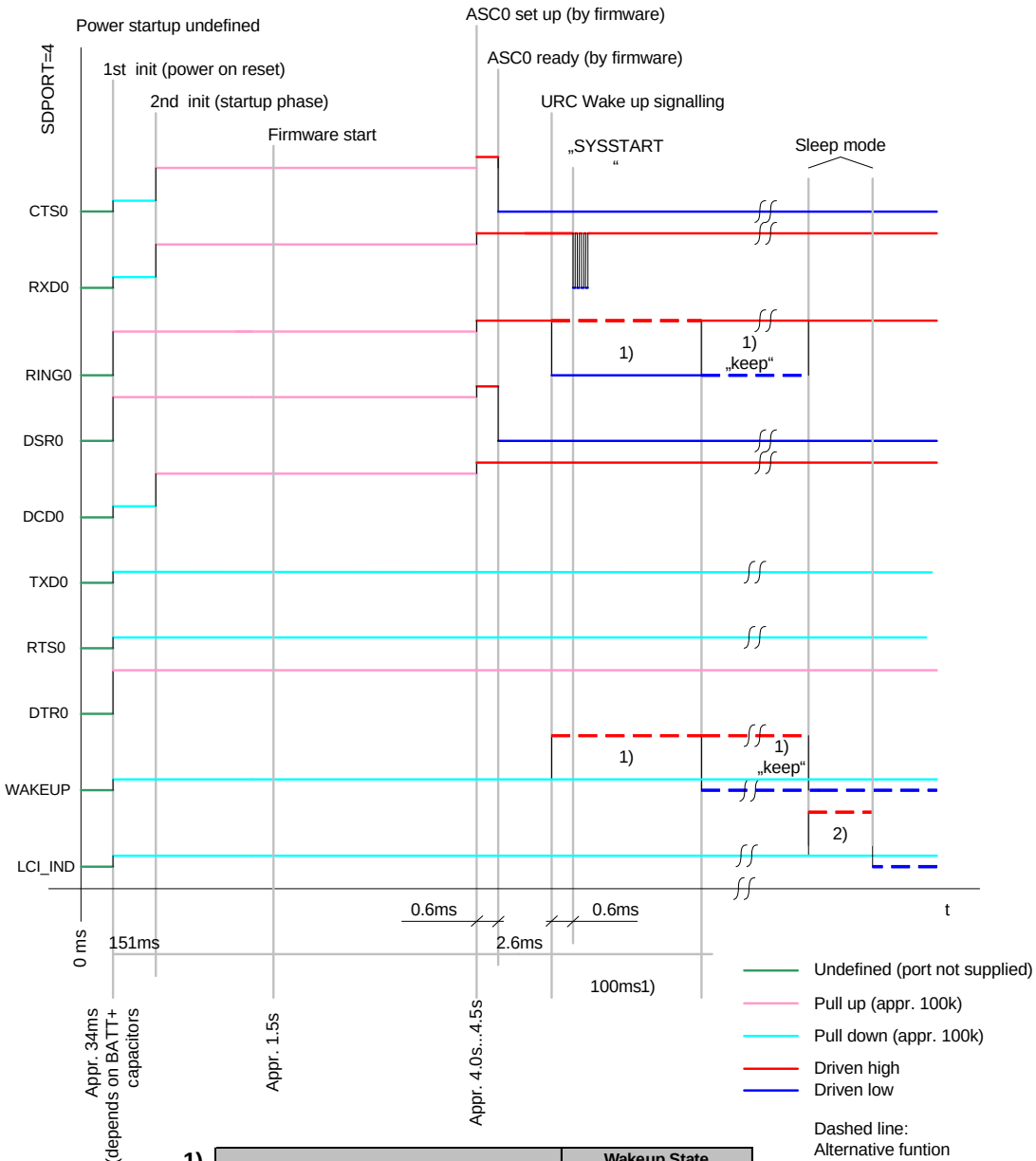


Figure 27: Low current indication timing

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

3.10.6 RING0 (ASC0), WAKEUP and LCI_IND Startup Behavior

Table 28 shows the startup behavior of the control lines described in the above sections.



1)

Configuration		Wakeup State	
		RING0	WAKEUP
AT^SCFG="URC/Ringline",	"local" (D)	low (active)	low (PD)
	"asc0"	low (active)	low (PD)
	"off"	high	low (PD)
	"wakeup"	high	high (active)

Configuration		Wakeup Active Time for RING0, WAKEUP
AT^SCFG= "URC/Ringline/ActiveTime",	"0"	4.6ms-9ms
	"1" (D)	100ms
	"2"	1s
	"keep"	keeps active until 1st time enter sleep mode

(D) Delivery default value

2) If needed: During runtime the LCI feature has to be enabled by AT^SCFG="MEopMode/PowerMgmt/LCI","enabled"

Figure 28: RING0 (ASC0), WAKEUP and LCI_IND startup behavior

4 GNSS Receiver

PH8/PH8-P integrates a GNSS receiver that offers the full performance of GPS/GLONASS technology. The GNSS receiver is able to continuously track all GPS/GLONASS 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 command AT^SGPSC see [1].

5 Antenna Interfaces

5.1 GSM/UMTS Antenna Interface

The PH8/PH8-P GSM/UMTS antenna interface comprises a main GSM/UMTS antenna as well as an optional UMTS Rx diversity antenna to improve signal reliability and quality[1]. The interface has an impedance of 50Ω. PH8/PH8-P is capable of sustaining a total mismatch at the antenna interface without any damage, even when transmitting at maximum RF power.

The external antenna must be matched properly to achieve best performance regarding radiated power, DC-power consumption, modulation accuracy and harmonic suppression. Matching networks are not included on the PH8/PH8-P PCB and should be placed in the host application, if the antenna does not have an impedance of 50Ω.

Regarding the return loss PH8/PH8-P provides the following values in the active band:

Table 18: 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

The connection of the antenna or other equipment must be decoupled from DC voltage. This is necessary because the antenna connector is DC coupled to ground via an inductor for ESD protection.

5.1.1 Antenna Installation

The U.FL antenna connector from Hirose/Molex of the main GSM/UMTS antenna has been chosen as antenna reference point (ARP) for the Gemalto M2M reference equipment submitted to type approve PH8/PH8-P. See Section 5.1.2 for details. All RF data specified throughout this manual is related to the ARP. The positions of the module's antenna connectors can be seen in Figure 35.

1. By delivery default the optional UMTS Rx diversity antenna is configured as available for the module. To avoid negative side effects and performance degradation it is recommended to disable the diversity antenna path if
   - the host application does not support a diversity antenna
   - the host application includes a diversity antenna - but a 3G network simulator is used for development and performance tests.

   Please refer to [1] for details on how to configure antenna settings.

5.1.2 Antenna Connector

PH8/PH8-P uses either an ultra-miniature SMT antenna connector from Hirose Ltd: U.FL-R-SMT, or the Molex 07341201 U.FL antenna connector. Both connectors have identical mechanical dimensions (see Figure 29). Minor differences in product specifications are mentioned in Table 19. The position of the antenna connectors on the PH8/PH8-P board can be seen in Figure 35.

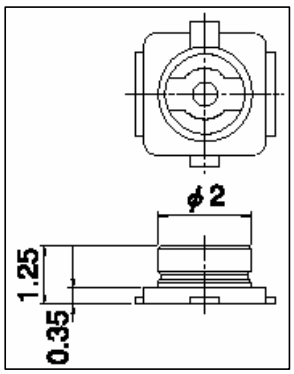


Figure 29: Mechanical dimensions of PH8/PH8-P antenna connectors

Table 19: Product specifications of PH8/PH8-P antenna connectors

Item	Specification	Conditions
Ratings		
Nominal impedance	50Ω	Operating humidity: max. 90%
Rated frequency	DC to 3GHz	
Mechanical characteristics		
Repetitive operation	Contact resistance: Center 25Ω Outside 15Ω	30 cycles of insertion and disengagement
Vibration	No momentary disconnections of 1µs. No damage, cracks and looseness of parts.	Frequency of 10 to 100Hz, single amplitude of 1.5mm, acceleration of 59m/s^2, for 5 cycles in the direction of each of the 3 axes
Shock	No momentary disconnections of 1µs. No damage, cracks and looseness of parts.	Acceleration of 735m/s^2, 11ms duration for 6 cycles in the direction of each of the 3 axes
Environmental characteristics		
Humidity resistance	No damage, cracks and looseness of parts. Insulation resistance: 100MΩ min. at high humidity 500MΩ min. when dry	Exposure to 40°C, humidity of 95% for a total of 96 hours
Temperature cycle	No damage, cracks and looseness of parts. Contact resistance: Center 25mΩ Outside 15mΩ	Temperature: +40°C → 5 to 35°C → +90°C → 5 to 35°C Time: 30min → within 5min → 30min within 5min
Salt spray test	No excessive corrosion	48 hours continuous exposure to 5% salt water

Table 20: Material and finish of PH8/PH8-P antenna connectors and recommended plugs

Part	Material	Finish
Shell	Phosphor bronze	Hirose: Silver plating Molex: Gold plating
Male center contact	Brass	Gold plating
Female center contact	Phosphor bronze	Gold plating
Insulator	Receptacle: LCP	Hirose: Beige, Molex: Ivory

Mating plugs and cables can be chosen from the Hirose U.FL Series or from other antenna equipment manufacturers like Molex or IMS. Examples from the Hirose U.FL Series are shown below and listed in Table 21. For latest product information please contact your respective antenna equipment manufacturer.

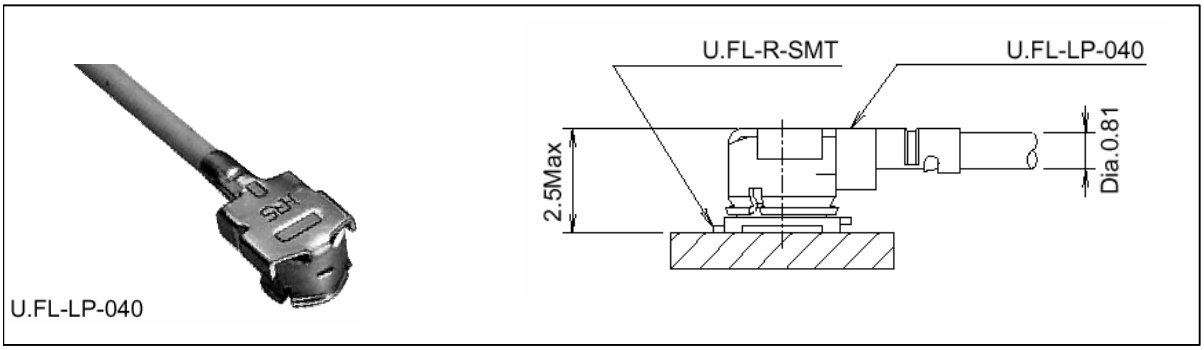


Figure 30: U.FL-R-SMT connector with U.FL-LP-040 plug

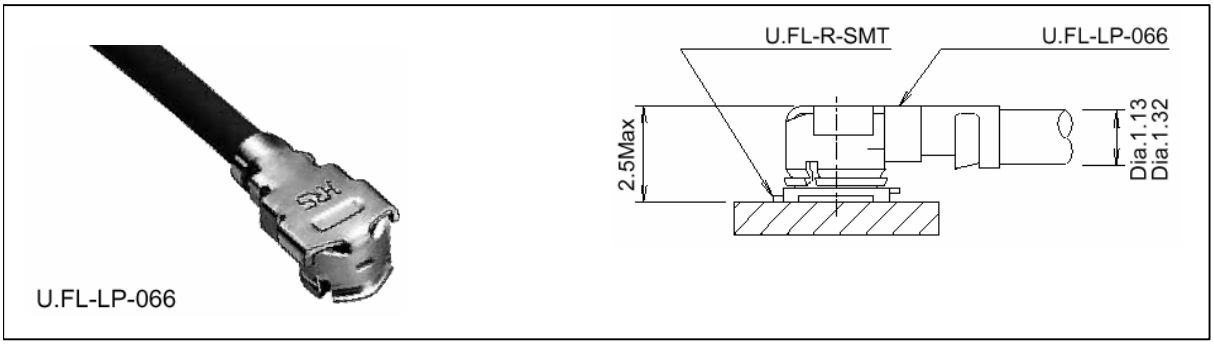


Figure 31: U.FL-R-SMT connector with U.FL-LP-066 plug

In addition to the connectors illustrated above, the U.FL-LP-(V)-040(01) version is offered as an extremely space saving solution. This plug is intended for use with extra fine cable (up to Ø 0.81mm) and minimizes the mating height to 2mm. See Figure 32 which shows the Hirose data sheet.

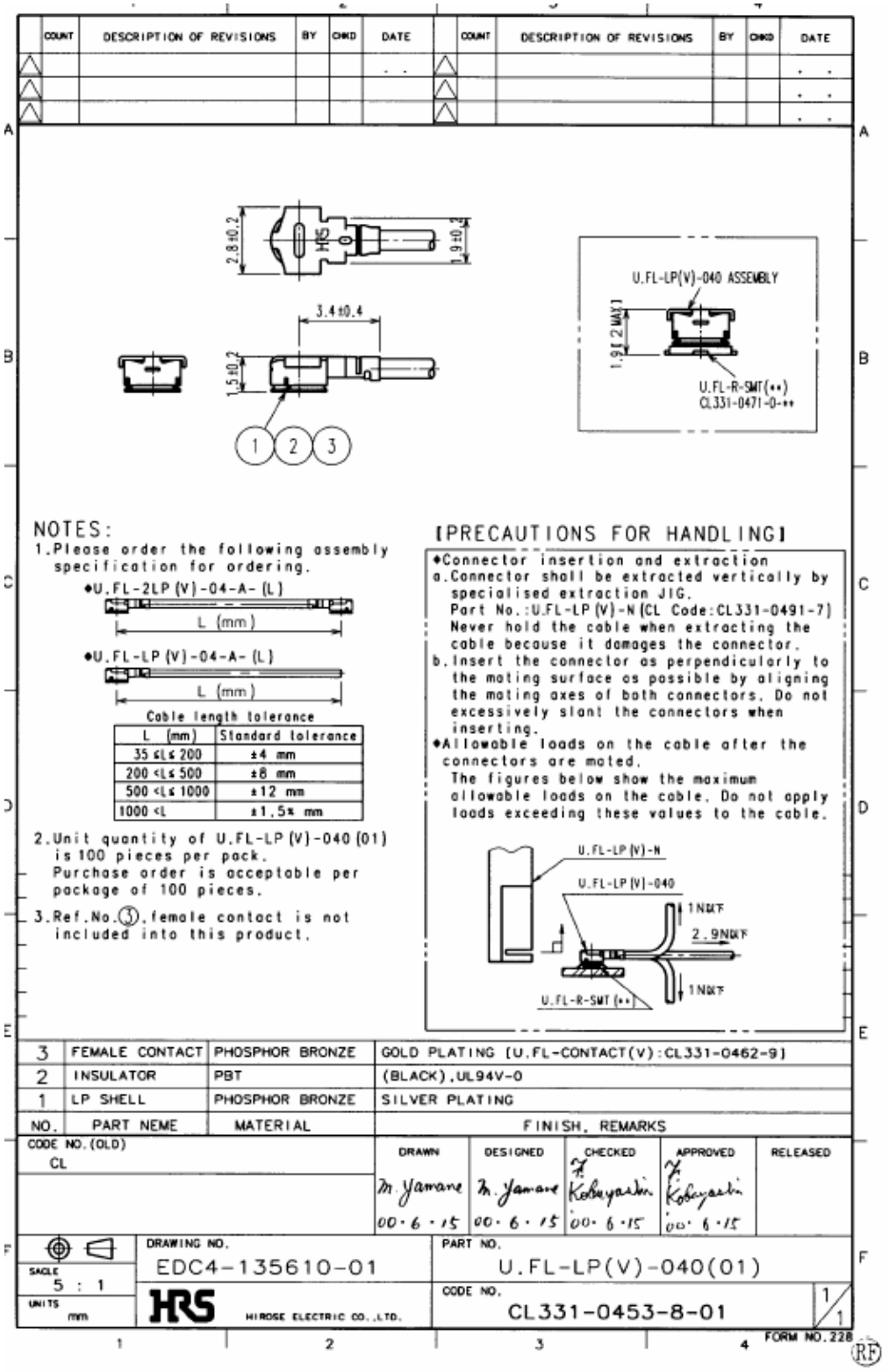


Figure 32: Specifications of U.FL-LP-(V)-040(01) plug

Table 21: Ordering information for Hirose U.FL Series

Item	Part number	HRS number
Connector on PH8/PH8-P	U.FL-R-SMT	CL331-0471-0-10
Right-angle plug shell for Ø 0.81mm cable	U.FL-LP-040	CL331-0451-2
Right-angle plug for Ø 0.81mm cable	U.FL-LP(V)-040 (01)	CL331-053-8-01
Right-angle plug for Ø 1.13mm cable	U.FL-LP-068	CL331-0452-5
Right-angle plug for Ø 1.32mm cable	U.FL-LP-066	CL331-0452-5
Extraction jig	E.FL-LP-N	CL331-04441-9

5.2 GNSS Antenna Interface

In addition to the RF antenna interface PH8/PH8-P also has a GNSS antenna interface. See Section 7.1 to find out where the GNSS antenna connector is located. The GNSS antenna installation and connector are the same as for the RF antenna interface (see Section 5.1.1 and Section 5.1.2). For use with GPS and GLONASS it is recommended to use a GPS and GLONASS capable antenna.

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. For electrical characteristics see Section 6.9.

Active 3V GNSS antennas can be supplied via the GNSS antenna interface, if the supply voltage is switched on. This is done by AT command: AT^SGPSC="Power/Antenna" to configure the use of an active GNSS antenna and AT^SGPSC="Engine" to start the GNSS receiver (for command details see [1]). The available current is limited to prevent short circuits.

6 Electrical, Reliability and Radio Characteristics

6.1 Absolute Maximum Ratings

The absolute maximum ratings stated in Table 22 are stress ratings under any conditions. Stresses beyond any of these limits will cause permanent damage to PH8/PH8-P.

Table 22: Absolute maximum ratings

Parameter	Min	Max	Unit
Supply voltage BATT+	-0.5	+5.5	V
Voltage at all digital lines in Power Down mode	-0.3	+0.3	V
Voltage at digital lines in normal operation	-0.3	+2.1	V
Voltage at SIM/USIM interface, CCVCC 1.8V in normal operation	-0.5	+2.3	V
Voltage at SIM/USIM interface, CCVCC 3.0V in normal operation	-0.5	+3.4	V
Voltage at analog audio lines in normal operation (VMIC=on)	-0.3	+3.3	V
Voltage at analog audio lines during audio off mode (VMIC=off)	-0.3	+0.3	V
VDDLP input voltage	-0.3	+3.5	V
Microphone supply (VMIC) maximum current to GND		3	mA
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	10	V
PWR_IND input current if PWR_IND= low		2	mA
Voltage at following signals: IGT, EMERG_OFF	-0.5	V_{BATT+}	V
GNSS antenna supply limited output current		-53	mA

6.2 Operating Temperatures

Table 23: Board temperature

Parameter	Min	Typ	Max	Unit
Operating temperature range	-30	+25	+85	°C
Extended temperature range[1]	-40		+95	°C
Automatic shutdown[2] Temperature measured on PH8/PH8-P board	<-40	---	>+95	°C

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

The maximum allowable ambient temperature that causes the module to shut down depends on various conditions. The following Table 24 and Table 25 show sample lab environment conditions with GNSS switched on (NMEA data output) and USB connected. Please be aware that the maximum ambient temperature may vary for your application.

Table 24: Sample operating conditions without forced air circulation (according to IEC 60068-2)[1]

Mode	Ambient Temperature	Voltage	RF Power	Operating Duration
GSM, GPRS/EDGE Class 8	+75°C	$V_{BATT+} \leq 4.2V$	Max.	∞
GPRS/EDGE Class 10 ROPR=4	+65°C	$V_{BATT+} \leq 3.8V$	Max.	∞
GPRS/EDGE Class 12 ROPR=4 ROPR=8	+55°C +65°C	$V_{BATT+} \leq 3.8V$ $V_{BATT+} \leq 3.8V$	Max. Reduced	∞ ∞
GPRS/EDGE Class 12 ROPR=4	+65°C	$V_{BATT+} \leq 3.8V$	Max.	≤ 2min
WCDMA	+55°C	$V_{BATT+} \leq 3.8V$	Max.	∞
WCDMA	+65°C	$V_{BATT+} \leq 3.8V$	≤ 10dBm	∞
WCDMA (typical transmission power)	+70°C	$V_{BATT+} \leq 3.8V$	≤ 0dBm	∞
WCDMA	+65°C	$V_{BATT+} \leq 3.8V$	Max.	≤ 3min

1. The thermal resistance of the module (board-to-ambient) was measured to be about R_{th}=20K/W

Table 25: Sample operating conditions with forced air circulation (air speed 0.9m/s)

Mode	Ambient Temperature	Voltage	RF Power	Operating Duration
GSM, GPRS/EDGE Class 8	+80°C	$V_{BATT+} \leq 4.2V$	Max.	∞
GPRS/EDGE Class 10 ROPR=4	+75°C	$V_{BATT+} \leq 3.8V$	Max.	∞
GPRS/EDGE Class 12 ROPR=4 ROPR=8	 +65°C +75°C	 $V_{BATT+} \leq 3.8V$ $V_{BATT+} \leq 3.8V$	 Max. Reduced	 ∞ ∞
WCDMA	+70°C	$V_{BATT+} \leq 3.8V$	Max.	∞
WCDMA	+75°C	$V_{BATT+} \leq 3.8V$	$\leq$ 10dBm	∞
WCDMA (typical transmission power)	+80°C	$V_{BATT+} \leq 3.8V$	$\leq$ 0dBm	∞

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 26: Storage conditions

Type	Condition	Unit	Reference
Air temperature: Low High	-40 +90	°C	ETS 300 019-2-1: T1.2, IEC 60068-2-1 Ab ETS 300 019-2-1: T1.2, IEC 60068-2-2 Bb
Humidity relative: Low High Condens.	10 90 at 30°C 90-100 at 30°C	%	--- ETS 300 019-2-1: T1.2, IEC 60068-2-56 Cb ETS 300 019-2-1: T1.2, IEC 60068-2-30 Db Cb
Air pressure: Low High	70 106	kPa	IEC TR 60271-3-1: 1K4 IEC TR 60271-3-1: 1K4
Movement of surrounding air	1.0	m/s	IEC TR 60271-3-1: 1K4
Water: rain, dripping, icing and frosting	Not allowed	---	---
Radiation: Solar Heat	1120 600	W/m^2	ETS 300 019-2-1: T1.2, IEC 60068-2-2 Bb ETS 300 019-2-1: T1.2, IEC 60068-2-2 Bb
Chemically active substances	Not recommended		IEC TR 60271-3-1: 1C1L
Mechanically active substances	Not recommended		IEC TR 60271-3-1: 1S1
Vibration sinusoidal: Displacement Acceleration Frequency range	 1.5 5 2-9 9-200	 mm m/s^2 Hz	IEC TR 60271-3-1: 1M2
Shocks: Shock spectrum Duration Acceleration	 Semi-sinusoidal 1 50	 ms m/s^2	IEC 60068-2-27 Ea

6.4 Reliability Characteristics

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

Table 27: Summary of reliability test conditions

Type of test	Conditions	Standard
Vibration	Frequency range: 10-20Hz; acceleration: 3.1mm amplitude Frequency range: 20-500Hz; acceleration: 5g Duration: 2h per axis = 10 cycles; 3 axes	DIN IEC 60068-2-6[1]
Shock half-sinus	Acceleration: 500g Shock duration: 1ms 1 shock per axis 6 positions (± x, y and z)	DIN IEC 60068-2-27
Dry heat	Temperature: +70 ±2°C Test duration: 16h Humidity in the test chamber: < 50%	EN 60068-2-2 Bb ETS 300 019-2-7
Temperature change (shock)	Low temperature: -40°C ±2°C High temperature: +85°C ±2°C Changeover time: < 30s (dual chamber system) Test duration: 1h Number of repetitions: 100	DIN IEC 60068-2-14 Na ETS 300 019-2-7
Damp heat cyclic	High temperature: +55°C ±2°C Low temperature: +25°C ±2°C Humidity: 93% ±3% Number of repetitions: 6 Test duration: 12h + 12h	DIN IEC 60068-2-30 Db ETS 300 019-2-5
Cold (constant exposure)	Temperature: -40 ±2°C Test duration: 16h	DIN IEC 60068-2-1

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

6.5 Pin Assignment and Signal Description

The Molex board-to-board connector on PH8/PH8-P is an 80-pin double-row receptacle. The position of the pins can be seen in Figure 35 that shows the top view of PH8/PH8-P.

1	GND	GND	80
2	Not connected	Not connected	79
3	Not connected	PWR_IND	78
4	GND	Not connected	77
5	Do not use (DI PD VI=1.8V)	Do not use (DI PD VI=1.8V)	76
6	Do not use (DI PD VI=1.8V)	Not connected	75
7	Not connected	WAKEUP	74
8	Do not use (DI PD VI=1.8V)	Do not use (DI PD VI=1.8V)	73
9	LC_IND	Do not use (DI PD VI=1.8V)	72
10	Do not use (DI PD VI=1.8V)	Do not use (DI PD VI=1.8V)	71
11	Not connected	Not connected	70
12	VUSB_IN	USB_DP	69
13	Not connected	USB_DN	68
14	Not connected	Not connected	67
15	Do not use (DI PD VI=1.8V)	VMIC	66
16	CCCLK	Not connected	65
17	CCVCC	Not connected	64
18	CCIO	EPP	63
19	CCRST	EPN	62
20	CCIN	Not connected	61
21	CCGND	Not connected	60
22	Not connected	MICP	59
23	PCM_CLK or I2S_SCLKIN	MICN	58
24	PCM_FSC or I2S_WSIN	AGND	57
25	PCM_IN or I2S_DIN	IGT	56
26	PCM_OUT	EMERG_OFF	55
27	Not connected	DCD0	54
28	STATUS	I2S_SCLKOUT	53
29	I2S_MCLKOUT	CTS0	52
30	RXD0	I2S_WSOUT	51
31	I2S_DOUT	DTR0	50
32	TXD0	RTS0	49
33	VDDLP	DSR0	48
34	Not connected	RING0	47
35	Not connected	VEXT	46
36	GND	BATT+	45
37	GND	BATT+	44
38	GND	BATT+	43
39	GND	BATT+	42
40	GND	BATT+	41

Figure 33: Pin assignment

DI= Digital Input
PD= Pulldown resistor appr. 250kΩ
VI= Maximum allowed high input voltage

Please note that the reference voltages listed in Table 28 are the values measured directly on the PH8/PH8-P module. They do not apply to the accessories connected.

Table 28: Signal description

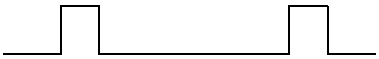
Function	Signal name	IO	Signal form and level	Comment
Power supply	BATT+	I	$V_I$max = 4.2V $V_I$norm = 3.8V $V_I$min = 3.3V during Tx burst on board Imax ≈ 2A, during Tx burst (GSM)  n Tx = n x 577µs peak current every 4.615ms	Lines of BATT+ and GND must be connected in parallel for supply purposes because higher peak currents may occur. Minimum voltage must not fall below 3.3V including drop, ripple, spikes
Power supply	GND		Ground	Application Ground
External supply voltage	VEXT	O	CLmax = 1µF High power mode: V_O = 1.80V +1% -5% $I_O$max = -50mA Power save mode: V_O = 1.80V +2% -5% $I_O$max = -10mA	VEXT may be used for application circuits.Not available in Power Down mode. If unused keep line open and enable power save mode via AT^SCFG= "MEopMode/PowerMgmt/VExt", "low" (see [1]) The external digital logic must not cause any spikes or glitches on voltage VEXT.
Ignition	IGT	I	R_{PU} ≈ 160kΩ, C_I ≈ 1nF V_{OH}max=*1.85V* V_{IH}max =*2.2V* V_{IH}min = *1.17V* V_{IL}max = *300mV* Low impulse width > 100ms	This signal switches the module ON. It is recommended to drive this line low by an open drain or open collector driver connected to GND.
Emergency Off	EMERG_OFF	I	R_{PU} ≈ 160kΩ, C_I ≈ 1nF V_{OH}max=*1.85V* V_{IH}max =*2.2V* V_{IH}min = *1.17V* V_{IL}max = *300mV* ~~|___|~~ low impulse width > 40ms	It is recommended to drive this line low by an open drain or open collector driver connected to GND. If unused keep line open.
RTC Back up	VDDLP	O	$V_O$max = 3.20V while BATT+ =>3.3V R_I = 1.8kΩ	If unused keep line open. To employ the SMPL feature the VDDLP line has to supplied for at least 2 seconds after a possible power loss (e.g., by connecting a battery). See also Section 3.3.6.
		I	V_I = 1.5V…3.25V at I_{max}= 10µA while BATT+ = 0V	
Connectivity Status	STATUS	O	V_{OL}max = 0.45V at I = 2mA V_{OH}min = 1.35V at I = -2mA V_{OH}max = 1.85V	Status signaling e.g. with ext. LED circuit

Table 28: Signal description

Function	Signal name	IO	Signal form and level	Comment
SIM Card detection	CCIN	I	$R_{PU} \approx 110k\Omega$ V_{OH}max=1.9V V_{IH}min = 1.15V V_{IH}max= 1.9V V_{IL}max = 0.6V	CCIN = Low, SIM card inserted. CCIN is protected against ESD with a special diode array. If unused connect to GND.
3V SIM Card Interface	CCRST	O	V_{OL}max = 0.45V at I = 1mA V_{OH}min = 2.55V at I = -1mA V_{OH}max = 3.05V	Maximum cable length or copper track should be not longer than 100mm to SIM card holder. The signals CCRST, CCIO, CCCLK and CCVCC are protected against ESD with a special diode array.
	CCIO	I/O	$R_{PU} \approx 4.7k\Omega$ V_{IL}max = 1V V_{IL}min = -0.3V V_{IH}min = 1.85V V_{IH}max = 3.2V V_{OL}max = 0.45V at I = 1mA V_{OH}min = 2.45V at I = -0.1mA V_{OH}max = 3.05V	
	CCCLK	O	V_{OL}max = 0.45V at I = 1mA V_{OH}min = 2.55V at I = -1mA V_{OH}max = 3.05V	
	CCVCC	O	$V_O$min = 2.95V $V_O$typ = 3.00V $V_O$max = 3.05V $I_O$max = -50mA	
	CCGND		Ground	
1.8V SIM Card Interface	CCRST	O	V_{OL}max = 0.45V at I = 1mA V_{OH}min = 1.35V at I = -1mA V_{OH}max = 1.85V	
	CCIO	I/O	$R_I \approx 4.7k\Omega$ V_{IL}max = 0.65V V_{IL}min = -0.3V V_{IH}min = 1.20V V_{IH}max = 1.85V V_{OL}max = 0.45V at I = 1mA V_{OH}min = 1.25V at I = -0.1mA V_{OH}max = 1.85V	
	CCCLK	O	V_{OL}max = 0.45V at I = 1mA V_{OH}min = 1.35V at I = -1mA V_{OH}max = 1.85V	
	CCVCC	O	$V_O$min = 1.75V $V_O$typ = 1.80V $V_O$max = 1.85V $I_O$max = -50mA	
	CCGND		Ground	

Table 28: Signal description

Function	Signal name	IO	Signal form and level	Comment
Serial Modem Interface ASC0	RXD0	O	V_{OL}max = 0.45V at I = 2mA V_{OH}min = 1.35V at I = -2mA V_{OH}max = 1.85V	If unused keep line open.
	CTS0	O		
	DSR0	O		
	DCD0	O		
	RING0	O		
	TXD0	I	V_{IL}max = 0.6V at 30µA V_{IH}min = 1.20V at -30µA V_{IH}max = 2V	
	RTS0	I		
	DTR0	I		
Analog Audio interface	VMIC	O	$V_O$typ = 2.7V I_{max} = 3 mA	Microphone supply for customer feeding circuits. If unused keep line open.
	EPP	O	Differential, Minimum load resistance 16Ω typ. 5.0Vpp at no load PCM level = +3dBm0, 1.02kHz sine wave	Balanced output for earphone or balance output for line out. See also Section 6.7.4. If unused keep line open.
	EPN	O		
	MICP	I	$Z_i$typ = 94kΩ @ 0dB gain $Z_i$typ = 5.8kΩ @ 30dB gain Vinmax = 2.57Vpp (for 3dBm0 @ 0dB gain)	Balanced differential microphone with external feeding circuit (using VMIC and AGND) or balanced differential line input. See also Section 6.7.4. Use coupling capacitors. If unused keep lines open.
	MICN	I		
	AGND		Analog ground	GND level for external audio circuits
Pulse Code Modulation (PCM)	PCM_IN	I	V_{IL}max = 0.6V at 30µA V_{IH}min = 1.20V at -30µA V_{IH}max = 2V V_{OL}max = 0.45V at I = 2mA V_{OH}min = 1.35V at I = -2mA V_{OH}max = 1.85V	In Master mode PCM_FSC and PCM_CLK are output signals[1]. In Slave mode PCM_FSC and PCM_CLK are input signals. See also Section 3.9.2.1. If unused keep line open.
	PCM_CLK	I/O		
	PCM_FSC	I/O		
	PCM_OUT	O		
Inter IC sound interface (I^2S)	I2S_MCLKOUT	O	V_{OL}max = 0.45V at I = 2mA V_{OH}min = 1.35V at I = -2mA V_{OH}max = 1.85V	As an alternative to PCM a I^2S interface can be employed. In this case PCM lines are used as input signals[1]. See also Section 3.9.2.2: PCM_IN --> I2S_DIN PCM_CLK --> I2S_SCLKIN PCM_FSC --> I2S_WSIN
	I2S_DOUT	O		
	I2S_WSOUT	O		
	I2S_SCLKOUT	O		

Table 28: Signal description

Function	Signal name	IO	Signal form and level	Comment
Power Indicator	PWR_IND	O	V_{IH}max = 10V V_{OL}max = 0.4V at Imax = 2mA	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, the signal may be used to enable external voltage regulators which supply an external logic for communication with the module, e.g. level converters.
USB	VUSB_IN	I	V_{IN}min = 3.0V V_{IN}max = 5.25V Active current $I_I$typ = 105µA (max 130µA) Suspend current $I_I$typ = 135µA (max 200µA) In case of Vripple ≥ 10mVpp (with f>300kHz), and VBUS_IN driven in the voltage range 4.08V...4.11V, use of an RC filter 1kΩ/100nF is required.	If the USB interface is not used please connect this line to GND.
	USB_DN	I/O	All electrical characteristics according to USB Implementers' Forum, USB 2.0 Full or High Speed Specification.	If lines are unused keep lines open. USB High Speed mode operation requires a differential impedance of 90Ω.
	USB_DP	I/O		
Host wakeup	WAKEUP	O	V_{OL}max = 0.45V at I = 2mA V_{OH}min = 1.35V at I = -2mA V_{OH}max = 1.85V	Can be used as a host wakeup line similar to RING0 (see Section 3.10.4)[1].
Low Current Indication	LC_IND	O	V_{OL}max = 0.45V at I = 2mA V_{OH}min = 1.35V at I = -2mA V_{OH}max = 1.85V	If the function is enabled (see Section 3.10.5)[1].
		I	V_{IH}max = 2V R_{PD}= approx. 100kΩ	If the function is disabled (see Section 3.10.5)[1].

1. Signal state if not configured: I, PD (approx. 100k)

6.6 Power Supply Ratings

Table 29: 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			 20 16	 mV_{pp} mV_{pp}

Table 30: Current consumption ratings

	Description	Conditions		Min	Typ	Max	Unit
I_{VDDLP} @ 3V	OFF State supply current	RTC backup @ BATT+ = 0V			4.0		µA
I_{BATT+} [1]	OFF State supply current	Power Down			39		µA
	Average GSM / GPRS supply current (GNSS off)	SLEEP[2] (USB Suspend or USB disconnected and no communication via ASC0) @ DRX=9			1.5		mA
		SLEEP[2] (USB Suspend or USB disconnected and no communication via ASC0) @ DRX=5			2.1		mA
		SLEEP[2] (USB Suspend or USB disconnected and no communication via ASC0) @ DRX=2			3.1		mA
		IDLE[3] (USB disconnected, UART active) @ DRX=2			39		mA
		IDLE[3] (USB active) @ DRX=2			70		mA
		Voice Call GSM850/900; PCL=5			310	390[4]	mA
		GPRS Data transfer GSM850/900; PCL=5; 1Tx/4Rx	ROPR=8 (max. reduction)		310		mA
			ROPR=4 (no reduction)		310		mA
		GPRS Data transfer GSM850/900; PCL=5; 2Tx/3Rx	ROPR=8 (max. reduction)		395		mA
			ROPR=4 (no reduction)		540		mA
		GPRS Data transfer GSM850/900; PCL=5; 4Tx/1Rx	ROPR=8 (max. reduction)		515		mA
			ROPR=4 (no reduction)		885	980[4]	mA

Table 30: Current consumption ratings

	Description	Conditions		Min	Typ	Max	Unit
I_{BATT+} [1]	Average GSM / GPRS supply current (GNSS off)	EDGE Data transfer GSM850/900; PCL=5; 1Tx/4Rx	ROPR=8 (max. reduction)		195		mA
			ROPR=4 (no reduction)		195		mA
		EDGE Data transfer GSM850/900; PCL=5; 2Tx/3Rx	ROPR=8 (max. reduction)		250		mA
			ROPR=4 (no reduction)		295		mA
		EDGE Data transfer GSM850/900; PCL=5; 4Tx/1Rx	ROPR=8 (max. reduction)		390		mA
			ROPR=4 (no reduction)		510		mA
		Voice Call GSM1800/1900; PCL=0			220	270[4]	mA
		GPRS Data transfer GSM1800/1900; PCL=0; 1Tx/4Rx	ROPR=8 (max. reduction)		220		mA
			ROPR=4 (no reduction)		220		mA
		GPRS Data transfer GSM1800/1900; PCL=0; 2Tx/3Rx	ROPR=8 (max. reduction)		265		mA
			ROPR=4 (no reduction)		335		mA
		GPRS Data transfer GSM1800/1900; PCL=0; 4Tx/1Rx	ROPR=8 (max. reduction)		345		mA
			ROPR=4 (no reduction)		550	650[4]	mA
		EDGE Data transfer GSM1800/1900; PCL=0; 1Tx/4Rx	ROPR=8 (max. reduction)		170		mA
			ROPR=4 (no reduction)		170		mA
		EDGE Data transfer GSM1800/1900; PCL=0; 2Tx/3Rx	ROPR=8 (max. reduction)		220		mA
			ROPR=4 (no reduction)		260		mA
		EDGE Data transfer GSM1800/1900; PCL=0; 4Tx/1Rx	ROPR=8 (max. reduction)		310		mA
			ROPR=4 (no reduction)		400		mA
	Peak current during GSM transmit burst	VOICE Call GSM850/900; PCL=5			1.95	2.7[4]	A
		VOICE Call GSM1800/1900; PCL=0			1.2	2.1[4]	A
	Average GSM / GNSS supply current (GNSS on)	GSM active (UART/USB active); @DRX=2 & GNSS NMEA output off			46		mA
		GSM active (UART/USB active); @DRX=2 & GNSS NMEA output on[5]			75		mA

Table 30: Current consumption ratings

	Description	Conditions	Min	Typ	Max	Unit
I_{BATT+} [1]	Average WCDMA supply current (GNSS off)	SLEEP[2] (USB Suspend or USB disconnected and no communication via ASC0) @ DRX=9		1.2		mA
		SLEEP[2] (USB Suspend or USB disconnected and no communication via ASC0) @ DRX=8		1.5		mA
		SLEEP[2] (USB Suspend or USB disconnected and no communication via ASC0) @ DRX=6		3.1		mA
		IDLE[3] (USB disconnected, UART active) @ DRX=6		26		mA
		IDLE[3] (USB active) @ DRX=6		50		mA
		Voice Call Band I; 24dBm		570		mA
		Voice Call Band II; 24dBm		635	770[4]	mA
		Voice Call Band IV; 24dBm[6]		640		mA
		Voice Call Band V/VI; 24dBm		590		mA
		Voice Call Band VIII; 24dBm[7]		640	780[4]	mA
		UMTS Data transfer Band I @+24dBm		545		mA
		UMTS Data transfer Band II @+24dBm		625		mA
		UMTS Data transfer Band IV @+24dBm[6]		635		mA
		UMTS Data transfer Band V/VI @+24dBm		575		mA
		UMTS Data transfer Band VIII @+24dBm[7]		615		mA
		HSPA Data transfer Band I @+24dBm		590		mA
		HSPA Data transfer Band II @+24dBm		650	800[4]	mA
		HSPA Data transfer Band IV @+24dBm[6]		675		mA
		HSPA Data transfer Band V/VI @+24dBm		600		mA
		HSPA Data transfer Band VIII @+24dBm[7]		635	790[4]	mA
	Average WCDMA/ GNSS supply current (GNSS on)	WCDMA active (UART / USB active); @DRX=6 & GNSS NMEA output off		46		mA
		WCDMA active (UART / USB active); @DRX=6 & GNSS NMEA output on[5]		75		mA
I_{VUSB_IN}	USB suspend and active ratings are mentioned in Table 28: VUSB_IN.					

1. With an impedance of Z_{LOAD}=50Ω at the antenna connector.
2. Measurements start 6 minutes after switching ON the module,
   Averaging times: SLEEP mode - 3 minutes, transfer modes - 1.5 minutes
   Communication tester settings: no neighbor cells, no cell reselection etc., RMC (reference measurement channel)
   The power save mode for VEXT is switched on via AT command AT^SCFG="MEopMode/PowerMgmt/VExt","low". Without this setting the listed typical SLEEP ratings are approx. 0.6mA higher.
3. The power save mode is disabled via AT command AT^SCFG="MEopMode/PwrSave","disabled"
4. At total mismatch.
5. One fix per second.
6. AWS UMTS/HSPA+ band IV supported by PH8 only.
7. 900MHz UMTS/HSPA+ band VIII supported by PH8-P only.

6.7 Electrical Characteristics of the Voiceband Part

6.7.1 Setting Audio Parameters by AT Commands

Audio mode 1 is the basic audio mode optimized for the Votronic reference handset (see Section 10.1). The default parameters are determined for type approval and are not adjustable with AT commands.

The audio modes 2 to 8 can be temporarily adjusted according to the AT command parameters listed in the table below. The audio parameters are set with the AT commands AT^SNFI as well as AT^SNFO and stored volatile for the current audio mode (see [1]). For a model of how the parameters influence the audio signal path see Section 6.7.2.

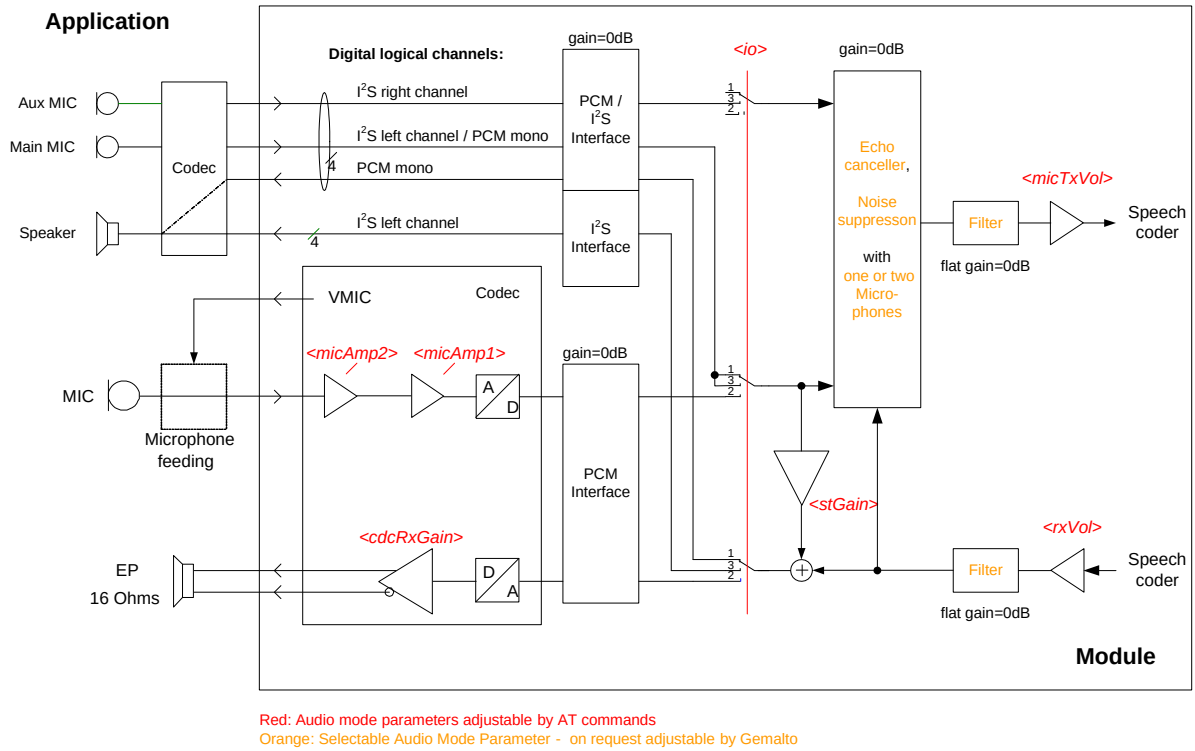
Table 31: Audio parameters adjustable by AT command

Parameter	Influence to	Range	Gain range	Calculation
AT^SNFI=				
micAmp1	MICP/MICN second analog amplifier gain of before ADC	0,1	0 or 20dB	
micAmp2	MICP/MICN first analog amplifier gain of before ADC	0…63	-12…35.25dB	0.75dB steps
micTxVol	Digital gain of input signal after ADC	0, 1...65535	Mute, -84...+12dB	20 * log (micTxVol/ 16384)
AT^SNFO=				
cdcRxGain	Analog gain of output signal after summation of sidetone	0...63	-57...+6dB	1dB steps
rxVol	Digital Volume of output signal after speech decoder, before summation of sidetone and DAC	0, 1…41	Mute, -48...+12dB	1.5dB steps
stGain	Digital attenuation of sidetone	0, 1...65535	Mute, -96...0dB	20 * log (stGain/ 16384) -12

6.7.2 Audio Programming Model

The audio programming model shows how the signal path can be influenced by varying AT command parameters: AT^SNFI allows to set the parameters <micAmp1>, <micAmp2> and <micTxVol>, whereas the parameters <cdcRxGain>, <stGain> and <rxVol> can be adjusted with AT^SNFO. For more information on the AT commands and parameters see Section 6.7.1 and [1].

If the digital audio interface (PCM or I²S) is selected, the parameters <micAmp1>, <micAmp2> and <cdcRxGain> have no influence; because they are not involved in the signal paths.



Red: Audio mode parameters adjustable by AT commands
Orange: Selectable Audio Mode Parameter - on request adjustable by Gemalto

Figure 34: Audio programming model

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 32: Voiceband characteristics

Audio mode no. AT^SNFS=	**1**[1]	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Name	Default Handset	Router	User Handset	Headset	Speaker phone	Transparent	I2S mode	I2S mode
Purpose	DSB with Votronic handset	Analog phone interface		Mono Headset	Handheld speakerphone	Direct access to speech coder	Handset with 2 micro-phones.	Speaker phone with 2 microphones
TX-Filters	Adjusted	Flat	Adjusted	Flat	Flat	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	Flat	Flat
Default SNFI Parameters <micAmp1> <micAmp2> <micTxVol>	 0 (0dB) 63 (+35.25dB) 16384 (0dB)	 0 (0dB) 18 (+1.5dB) 16384 (0dB)	 0 (0dB) 63 (+35.25dB) 16384 (0dB)	 1 (+20dB) 37 (+15.75dB) 16384 (0dB)	 1 (+20dB) 48 (+24dB) 16384 (0dB)	 0 (0dB) 21 (+3.75dB) 16384 (0dB)	 0 (0dB) 21 (+3.75dB) 16384 (0dB)	 0 (0dB) 21 (+3.75dB) 16384 (0dB)
Default SNFO Parameters <cdcRxGain> <rxVol> <stGain>	 61 (+4dB) 33 (0dB) 5514 (-21.5dB)	 50 (-7dB) 33 (0dB) 0 (Mute)	 61 (+4dB) 33 (0dB) 5514 (-21.5dB)	 49 (-8dB) 33 (0dB) 12288 (-15dB)	 61 (+4dB) 33 (0dB) 0 (Mute)	 58 (+1dB) 33 (0dB) 0 (Mute)	 58 (+1dB) 33 (0dB) 0 (Mute)	 58 (+1dB) 33 (0dB) 0 (Mute)
Echo canceller Behaviour optimized for	ON low echo	ON low echo	ON low echo	ON moderate echo	ON high echo	OFF	ON low echo	ON high echo
Residual echo suppres-sion with comfort noise generator	ON	ON	ON	ON	ON	OFF	ON	ON

Table 32: Voiceband characteristics

Audio mode no. AT^SNFS=	**1**[1]	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Noise Reduction (Tx)	OFF	OFF	-12dB	-12dB	-12dB	OFF	Up to -25dB	Up to -20dB
MIC input signal for 0dBm0, [2] f = 1024 Hz	15mVpp	650mVpp	15mVpp	12mVpp	5mVpp	420mVpp	n.a.	n.a.
EP output signal in mV rms. @ 0dBm0, 1024 Hz, no load (default gain) / @ 3.14 dBm0	465mVpp 2.1Vpp	512mVpp 2.1Vpp	465mVpp 2.1Vpp	370mVpp 1.6Vpp	1485mVpp 5.7Vpp	1290mVpp 5.5Vpp	n.a.	n.a.
Sidetone gain at default settings	20.8dB	-∞ dB	20.8dB	17.0dB	-∞ dB	-∞ dB	n.a.	n.a.
Digital audio characteristics (PCM)								
Uplink gain at 1024Hz	-1dB	0dB	-1dB	0dB	0dB	0dB	n.a.	n.a.
Downlink gain at 1024Hz	-12dB	0dB	-12dB	-2dB	-2dB	0dB	n.a.	n.a.
Sidetone gain	-21.5dB	Mute	-21.5dB	-15dB	Mute	Mute	n.a.	n.a.
Digital audio characteristics (I^2S)								
Uplink gain at 1024Hz	n.a.	0dB	-1dB	0dB	0dB	0dB	n.a.	n.a.
Downlink gain at 1024Hz	n.a.	0dB	-12dB	-2dB	-2dB	0dB	n.a.	n.a.
Sidetone gain	n.a.	Mute	-21.5dB	-15dB	Mute	Mute	n.a.	n.a.

1. Fixed audio mode. Values cannot be adapted.
2. All values measured before the noise reduction attenuates the sine wave after a few seconds.

n.a. = not applicable

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.

6.7.4 Voiceband Receive Path

Test conditions:
- The values specified below were tested to 1024Hz using AT^SNFO=57,33,0 in audio mode 6 during a GSM FR voice call unless otherwise stated.

Table 33: Voiceband receive path

Parameter	Min	Typ	Max	Unit	Test condition / remark
Maximum differential output voltage (peak to peak) EPP to EPN		4.5 5.0		V V	16Ω, No load, @ 3.14dBm0 (Full Scale)
Nominal differential output voltage (peak to peak) EPP to EPN		3.1 3.4		V V	16Ω, No load, @ 0dBm0 (Nominal level)
Output bias voltage		1.5		V	From EPP or EPN to GND
Differential output load resistance	16			Ω	

6.7.5 Voiceband Transmit Path

Test conditions:
- The values specified below were tested to 1024Hz using AT^SNFI=0,16,16384 in audio mode 6 during a GSM FR voice call unless otherwise stated.

Table 34: Voiceband transmit path

Parameter	Min	Typ	Max	Unit	Test condition / Remark
Full scale input voltage (peak to peak) for 3.14dBm0 MICP to MICN		2.57		V	Balanced
Nominal input voltage (rms) for 0dBm0 MICP to MICN		0.64		V	Balanced
Input amplifier 1 gain (micAmp1)	0		20	dB	Set with AT^SNFI
Input amplifier 2 gain in 0.75dB steps (micAmp2)	-12		35.25	dB	Set with AT^SNFI
Fine scaling by DSP (micTxVol)	-84		12	dB	Set with AT^SNFI
Microphone supply voltage VMIC		2.7		V	No load
Microphone supply voltage VMIC	2.6			V	@ 3mA

6.8 RF Antenna Interface Characteristics

Table 35: RF Antenna interface GSM / UMTS

Parameter		Conditions	Min.	Typical	Max.	Unit
UMTS/HSPA connectivity[1]		Band I, II, IV[2], V, VI, VIII[3]				
Receiver Input Sensitivity @ ARP[1]		UMTS 800/850 Band VI/V	-104.7/ -106.7	-110		dBm
		UMTS 900 Band VIII[3]	-103.7	-110		dBm
		UMTS AWS Band IV[2]	-106.7	-110		dBm
		UMTS 1900 Band II	-104.7	-109		dBm
		UMTS 2100 Band I	-106.7	-110		dBm
RF Power @ ARP with 50Ω Load		UMTS 800/850 Band VI/V	+21	+24	+25	dBm
		UMTS 900 Band VIII[3]	+21	+24	+25	dBm
		UMTS AWS Band IV[2]	+21	+24	+25	dBm
		UMTS 1900 Band II	+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		GSM 850 / E-GSM 900	-102	-109		dBm
		GSM 1800 / GSM 1900	-102	-108		dBm
RF Power @ ARP with 50Ω Load	GSM	GSM 850 / E-GSM 900		33		dBm
		GSM 1800 / GSM 1900		30		dBm

Table 35: RF Antenna interface GSM / UMTS

Parameter		Conditions	Min.	Typical	Max.	Unit
RF Power @ ARP with 50Ω Load, (**ROPR = 4**, i.e. no reduction)	GPRS, 1 TX	GSM 850 / E-GSM 900		33		dBm
		GSM 1800 / GSM 1900		30		dBm
	EDGE, 1 TX	GSM 850 / E-GSM 900		27		dBm
		GSM 1800 / GSM 1900		26		dBm
	GPRS, 2 TX	GSM 850 / E-GSM 900		33		dBm
		GSM 1800 / GSM 1900		30		dBm
	EDGE, 2 TX	GSM 850 / E-GSM 900		27		dBm
		GSM 1800 / GSM 1900		26		dBm
	GPRS, 3 TX	GSM 850 / E-GSM 900		33		dBm
		GSM 1800 / GSM 1900		30		dBm
	EDGE, 3 TX	GSM 850 / E-GSM 900		27		dBm
		GSM 1800 / GSM 1900		26		dBm
	GPRS, 4 TX	GSM 850 / E-GSM 900		33		dBm
		GSM 1800 / GSM 1900		30		dBm
	EDGE, 4 TX	GSM 850 / E-GSM 900		27		dBm
		GSM 1800 / GSM 1900		26		dBm
RF Power @ ARP with 50Ω Load, (**ROPR = 5**)	GPRS, 1 TX	GSM 850 / E-GSM 900		33		dBm
		GSM 1800 / GSM 1900		30		dBm
	EDGE, 1 TX	GSM 850 / E-GSM 900		27		dBm
		GSM 1800 / GSM 1900		26		dBm
	GPRS, 2 TX	GSM 850 / E-GSM 900		33		dBm
		GSM 1800 / GSM 1900		30		dBm
	EDGE, 2 TX	GSM 850 / E-GSM 900		27		dBm
		GSM 1800 / GSM 1900		26		dBm
	GPRS, 3 TX	GSM 850 / E-GSM 900		32,2		dBm
		GSM 1800 / GSM 1900		29,2		dBm
	EDGE, 3 TX	GSM 850 / E-GSM 900		27		dBm
		GSM 1800 / GSM 1900		26		dBm
	GPRS, 4 TX	GSM 850 / E-GSM 900		31		dBm
		GSM 1800 / GSM 1900		28		dBm
	EDGE, 4 TX	GSM 850 / E-GSM 900		27		dBm
		GSM 1800 / GSM 1900		26		dBm

Table 35: RF Antenna interface GSM / UMTS

Parameter		Conditions	Min.	Typical	Max.	Unit
RF Power @ ARP with 50Ω Load, (**ROPR = 6**)	GPRS, 1 TX	GSM 850 / E-GSM 900		33		dBm
		GSM 1800 / GSM 1900		30		dBm
	EDGE, 1 TX	GSM 850 / E-GSM 900		27		dBm
		GSM 1800 / GSM 1900		26		dBm
	GPRS, 2 TX	GSM 850 / E-GSM 900		31		dBm
		GSM 1800 / GSM 1900		28		dBm
	EDGE, 2 TX	GSM 850 / E-GSM 900		27		dBm
		GSM 1800 / GSM 1900		26		dBm
	GPRS, 3 TX	GSM 850 / E-GSM 900		30,2		dBm
		GSM 1800 / GSM 1900		27,2		dBm
	EDGE, 3 TX	GSM 850 / E-GSM 900		27		dBm
		GSM 1800 / GSM 1900		26		dBm
	GPRS, 4 TX	GSM 850 / E-GSM 900		29		dBm
		GSM 1800 / GSM 1900		26		dBm
	EDGE, 4 TX	GSM 850 / E-GSM 900		27		dBm
		GSM 1800 / GSM 1900		26		dBm
RF Power @ ARP with 50Ω Load, (**ROPR = 7**)	GPRS, 1 TX	GSM 850 / E-GSM 900		33		dBm
		GSM 1800 / GSM 1900		30		dBm
	EDGE, 1 TX	GSM 850 / E-GSM 900		27		dBm
		GSM 1800 / GSM 1900		26		dBm
	GPRS, 2 TX	GSM 850 / E-GSM 900		30		dBm
		GSM 1800 / GSM 1900		27		dBm
	EDGE, 2 TX	GSM 850 / E-GSM 900		27		dBm
		GSM 1800 / GSM 1900		26		dBm
	GPRS, 3 TX	GSM 850 / E-GSM 900		28,2		dBm
		GSM 1800 / GSM 1900		25,2		dBm
	EDGE, 3 TX	GSM 850 / E-GSM 900		27		dBm
		GSM 1800 / GSM 1900		26		dBm
	GPRS, 4 TX	GSM 850 / E-GSM 900		27		dBm
		GSM 1800 / GSM 1900		24		dBm
	EDGE, 4 TX	GSM 850 / E-GSM 900		27		dBm
		GSM 1800 / GSM 1900		26		dBm

Table 35: RF Antenna interface GSM / UMTS

Parameter		Conditions	Min.	Typical	Max.	Unit
RF Power @ ARP with 50Ω Load, (**ROPR = 8**, i.e. maximum reduction)	GPRS, 1 TX	GSM 850 / E-GSM 900		33		dBm
		GSM 1800 / GSM 1900		30		dBm
	EDGE, 1 TX	GSM 850 / E-GSM 900		27		dBm
		GSM 1800 / GSM 1900		26		dBm
	GPRS, 2 TX	GSM 850 / E-GSM 900		30		dBm
		GSM 1800 / GSM 1900		27		dBm
	EDGE, 2 TX	GSM 850 / E-GSM 900		24		dBm
		GSM 1800 / GSM 1900		23		dBm
	GPRS, 3 TX	GSM 850 / E-GSM 900		28,2		dBm
		GSM 1800 / GSM 1900		25,2		dBm
	EDGE, 3 TX	GSM 850 / E-GSM 900		22,2		dBm
		GSM 1800 / GSM 1900		21,2		dBm
	GPRS, 4 TX	GSM 850 / E-GSM 900		27		dBm
		GSM 1800 / GSM 1900		24		dBm
	EDGE, 4 TX	GSM 850 / E-GSM 900		21		dBm
		GSM 1800 / GSM 1900		20		dBm

1. Applies also to UMTS Rx diversity antenna .
2. AWS UMTS/HSPA+ band IV supported by PH8 only.
3. 900MHz UMTS/HSPA+ band VIII supported by PH8-P only.

6.9 GNSS Interface Characteristics

The following tables list general characteristics of the GNSS interface.

Table 36: GNSS properties

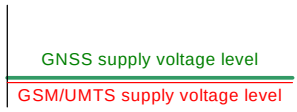
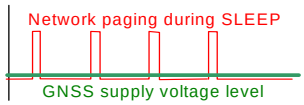
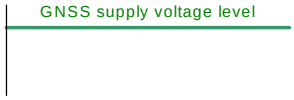
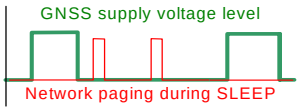
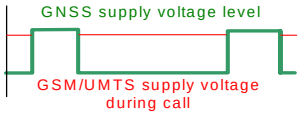
Parameter	Conditions	Min.	Typical	Max.	Unit
Frequency	GPS GLONASS	 1597.551	1575.42	 1605.886	MHz
Tracking Sensitivity	Open sky Active antenna or LNA Passive antenna		 -159 -156		dBm
Acquisition Sensitivity	Open sky Active antenna or LNA Passive antenna		 -149 -145		dBm
Cold Start sensitivity[1]			-145		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 VDDLP line as described in Section 3.5.

Through its GNSS antenna interface the module is able to supply an active GNSS antenna. The supply voltage at the GNSS antenna interface is provided by means of a linear voltage regulator (LDO with voltage ripple <1mV). The LDO is coupled to a DC bias current limiter to prevent short circuits.

The supply voltage level at the GNSS antenna interface depends on the GNSS configuration done with AT^SGPSC. Also, the GNSS antenna voltage is commonly used together with the internal GSM/UMTS RF switch supply voltage and therefore - in power saving mode - also dependant on the paging timing cycles of the GSM/GPRS or WCDMA base station as shown in Table 37 (for more information see Section 3.4). In order to DC decouple the GNSS antenna an external serial capacitor should implemented (ESD might have to be retested).

Table 37: Power supply for active GNSS antenna

Function	Setting samples	IO	Signal form and level[1]
GNSS active antenna supply	Supply voltage with: GNSS receiver off Active antenna off Airplane mode	O	
	Supply voltage with: GNSS receiver on or off Active antenna off SLEEP mode	O	
	Supply voltage with[2]: GNSS receiver on Active antenna on SLEEP mode	O	
	Supply voltage with[3]: GNSS receiver on Active antenna auto SLEEP mode	O	
	Supply voltage with: GNSS receiver on Active antenna auto GSM/UMTS call	O	

1. Green: High level approx. 3V; Red: High level 2.8V
2. Same behavior if GNSS active antenna set to auto and AT^SGPSC="NMEA/Freq",x with x ≤ 4
3. Frequency of a position request (fix) should be set with AT^SGPSC="NMEA/Freq",x with x > 4

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 PH8/PH8-P module.

Special ESD protection provided on PH8/PH8-P*:*
SIM/USIM interface: Serial resistor and clamp diodes for protection against overvoltage.
All antenna interfaces: Inductor/capacitor
BATT+: Inductor/capacitor

The remaining interfaces of PH8/PH8-P 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 JEDEC JESD22-A114D requirements.

PH8/PH8-P has been tested according to the following standards. Electrostatic values can be gathered from the following table.

Table 38: Electrostatic values

Specification / Requirements	Contact discharge	Air discharge
JEDEC JESD22-A114D		
All board-to-board interfaces	± 1kV Human Body Model	n.a.
ETSI EN 301 489-1/7		
SIM/USIM interface	± 4kV	± 8kV
All antenna interfaces (GSM/UMTS/GNSS)	± 4kV	± 8kV
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

7.1 Mechanical Dimensions of PH8/PH8-P

Figure 35 shows a 3D view[1] of PH8/PH8-P and provides an overview of the board's mechanical dimensions. For further details see Figure 36.

Length: 50.00mm
Width: 33.90mm
Height: 3.10mm

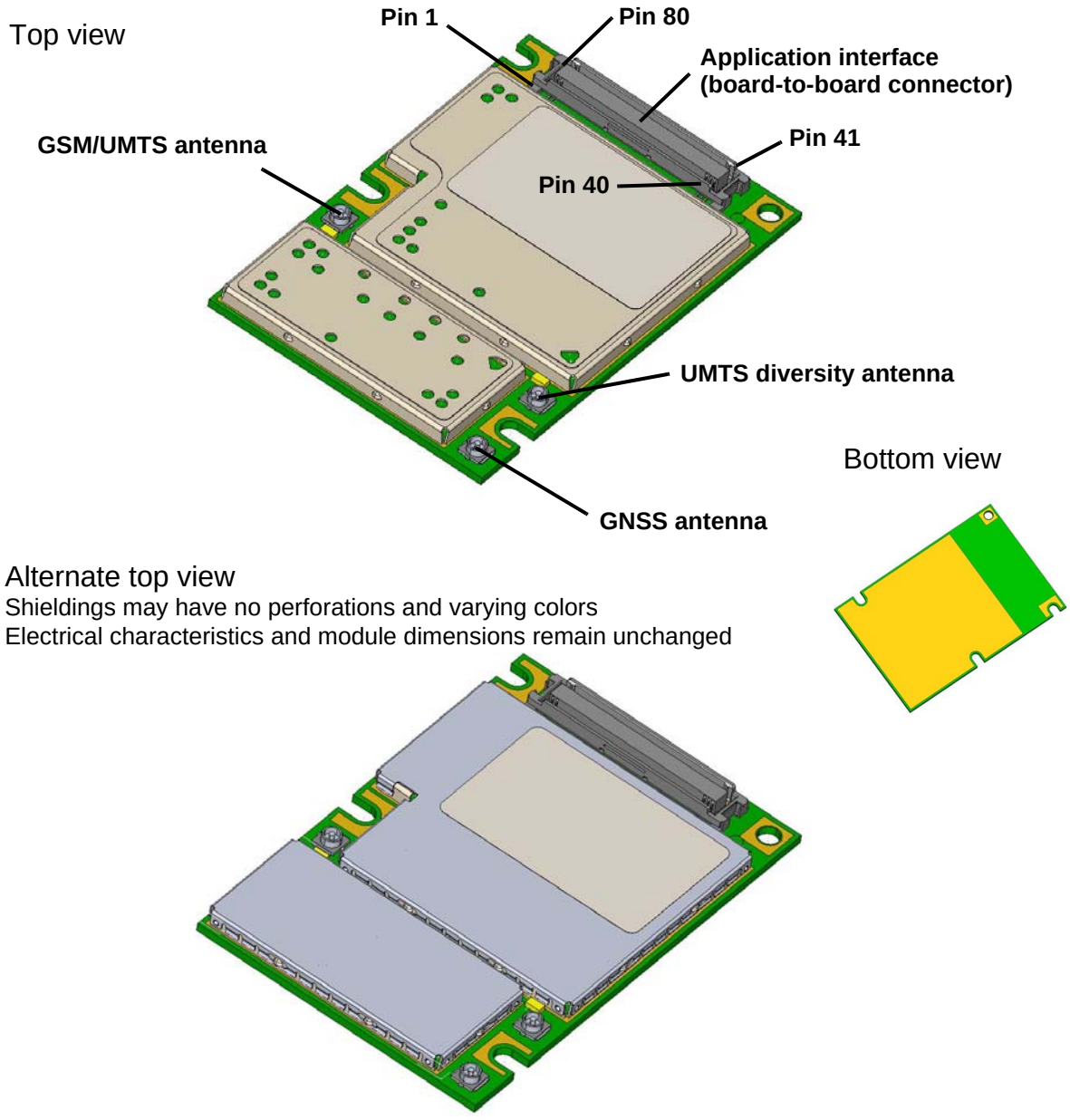


Figure 35: PH8/PH8-P – top and bottom view

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

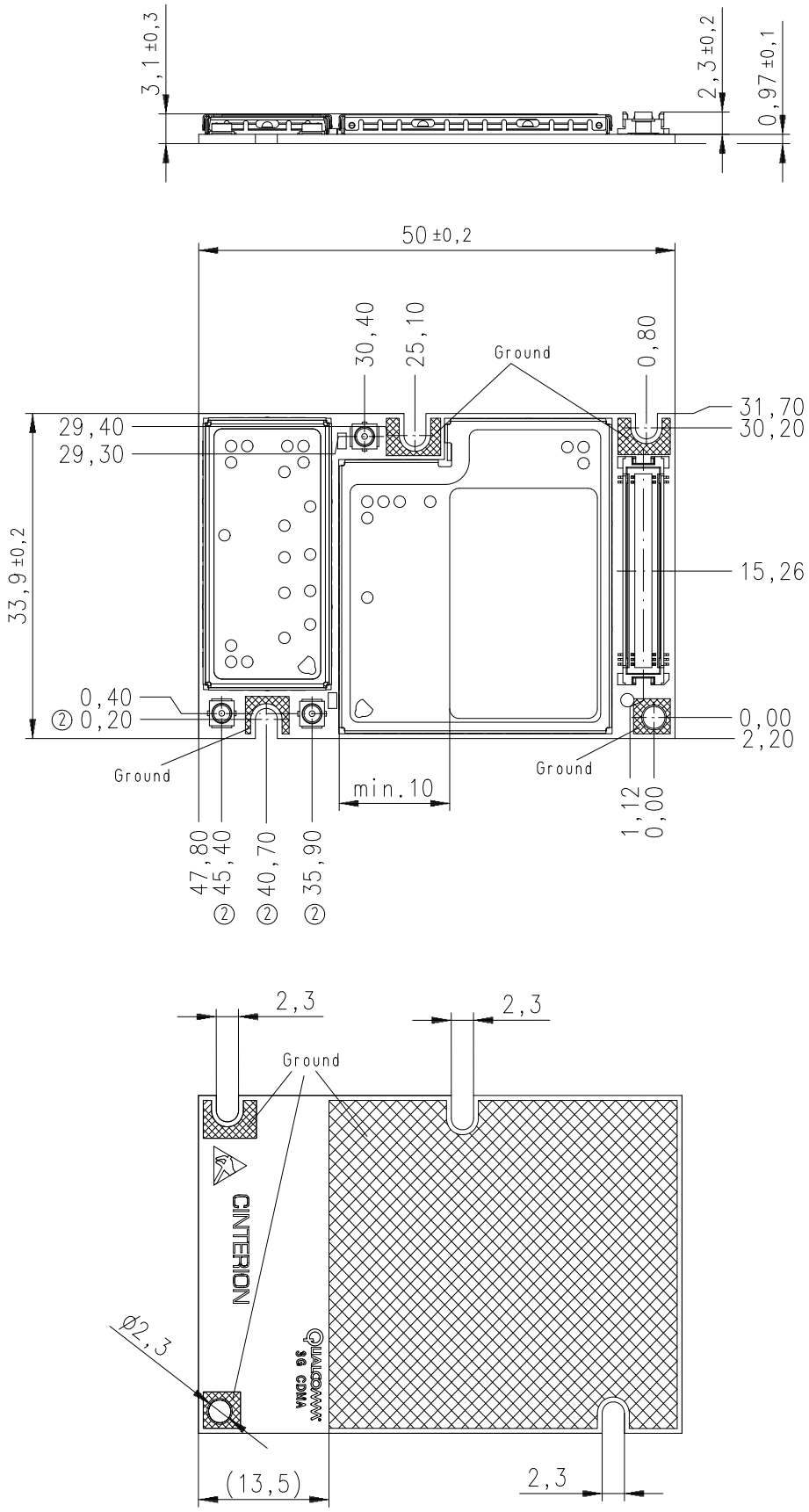


Figure 36: Dimensions of PH8/PH8-P (all dimensions in mm)

7.2 Mounting PH8/PH8-P to the Application Platform

There are many ways to properly install PH8/PH8-P in the host device. An efficient approach is to mount the PH8/PH8-P PCB to a frame, plate, rack or chassis.

Fasteners can be M2 screws plus suitable washers, circuit board spacers, or customized screws, clamps, or brackets. In addition, the board-to-board connection can also be utilized to achieve better support. To help you find appropriate spacers a list of selected screws and distance sleeves for 3mm stacking height can be found in Section 10.2.

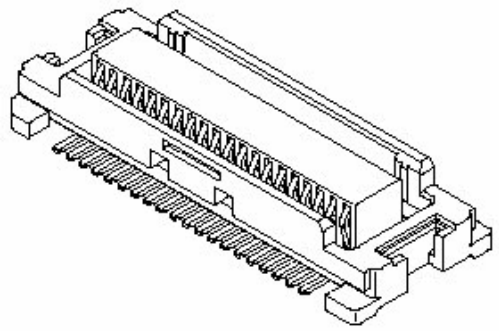
For proper grounding it is strongly recommended to use large ground plane on the bottom of board in addition to the five GND pins of the board-to-board connector. The ground plane may also be used to attach cooling elements, e.g. a heat sink or thermally conductive tape.

To prevent mechanical damage, be careful not to force, bend or twist the module. Be sure it is positioned flat against the host device. See also Section 10.3 with mounting advice sheet.

7.3 Board-to-Board Application Connector

This section provides the specifications of the 80-pin board-to-board connector used to connect PH8/PH8-P to the external application.

Connector mounted on the PH8/PH8-P module:



Type: 52991-0808 SlimStack Receptacle 80 pins, 0.50mm pitch, for stacking heights of 3.0 or 4.0mm, see Figure 38 for details.
Supplier: Molex, http//www.molex.com

Table 39: Technical specifications of Molex board-to-board connector

Parameter	Specification (80-pin B2B connector)
Electrical	
Number of Contacts	80
Contact spacing	0.5mm (.020")
Voltage	50V
Rated current	0.5A max per contact
Contact resistance	50mΩ max per contact
Insulation resistance	> 100MΩ
Dielectric Withstanding Voltage	500V AC (for 1 minute)
Physical	
Insulator material (housing)	White glass-filled LCP plastic, flammability UL 94V 0
Contact material	Plating: Gold over nickel
Insertion force 1st	< 74.4N
Insertion force 30th	< 65.6N
Withdrawal force 1st	> 10.8N
Maximum connection cycles	30 (@ 70mΩ max per contact)

Mating connector types for the customer's application offered by Molex:

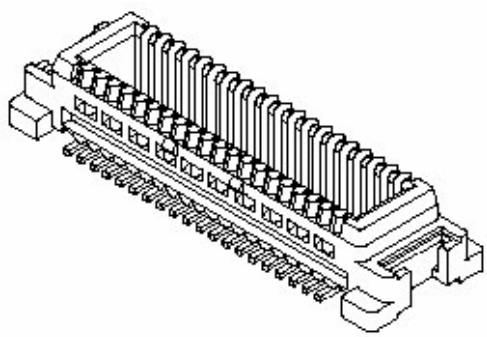


Figure 37: Mating board-to-board connector 53748-0808 on application

- 53748-0808 SlimStack Plug, 3mm stacking height,
  see Figure 39 for details.
- 53916-0808 SlimStack Plug, 4mm stacking height

Note: There is no inverse polarity protection for the board-to-board connector. It is therefore very important that the board-to-board connector is connected correctly to the host application, i.e., pin1 must be connected to pin1, pin2 to pin 2, etc. Pin assignments are listed in Section 6.5, pin locations are shown in Figure 35.

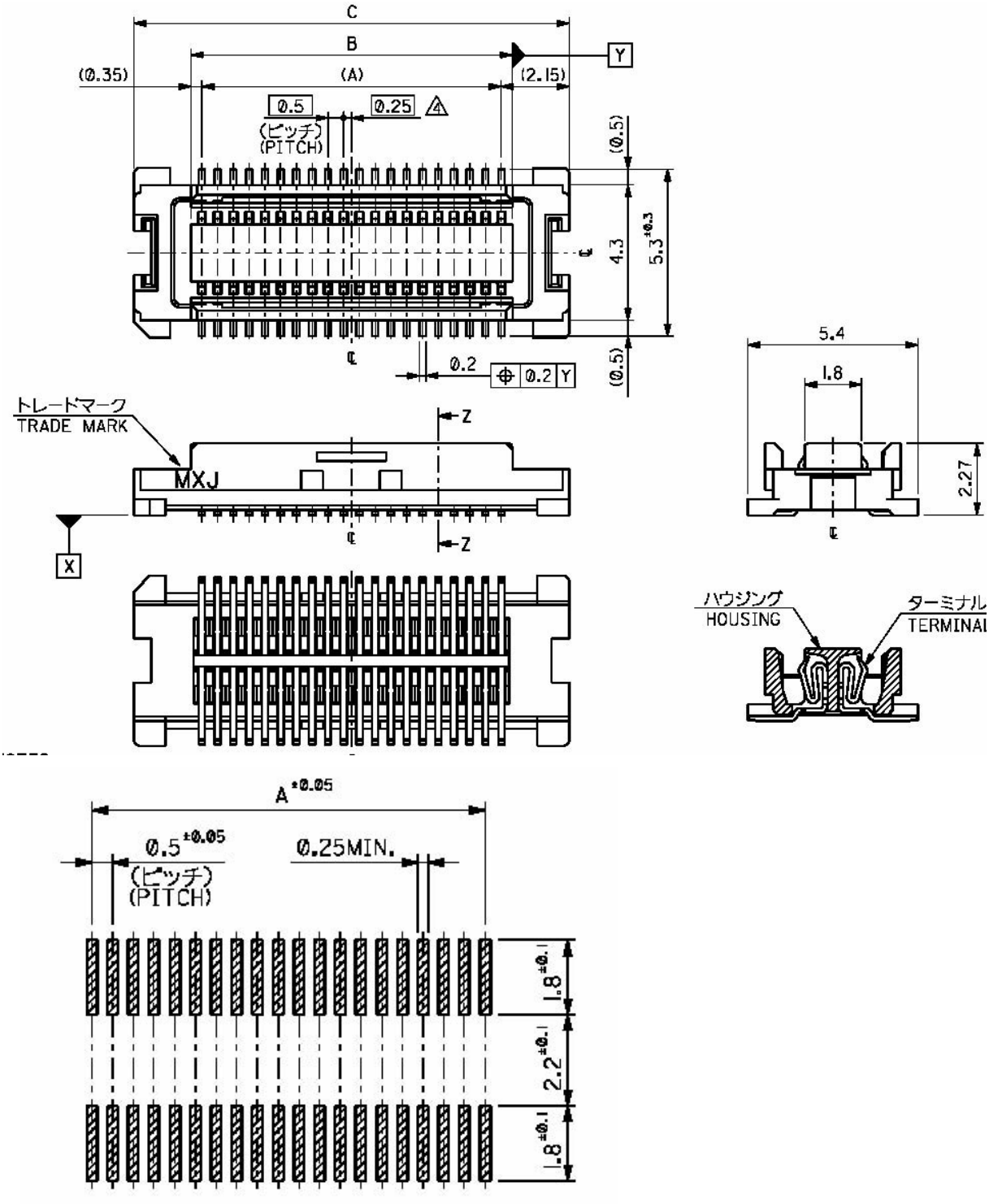


Figure 38: Molex board-to-board connector 52991-0808 on PH8/PH8-P

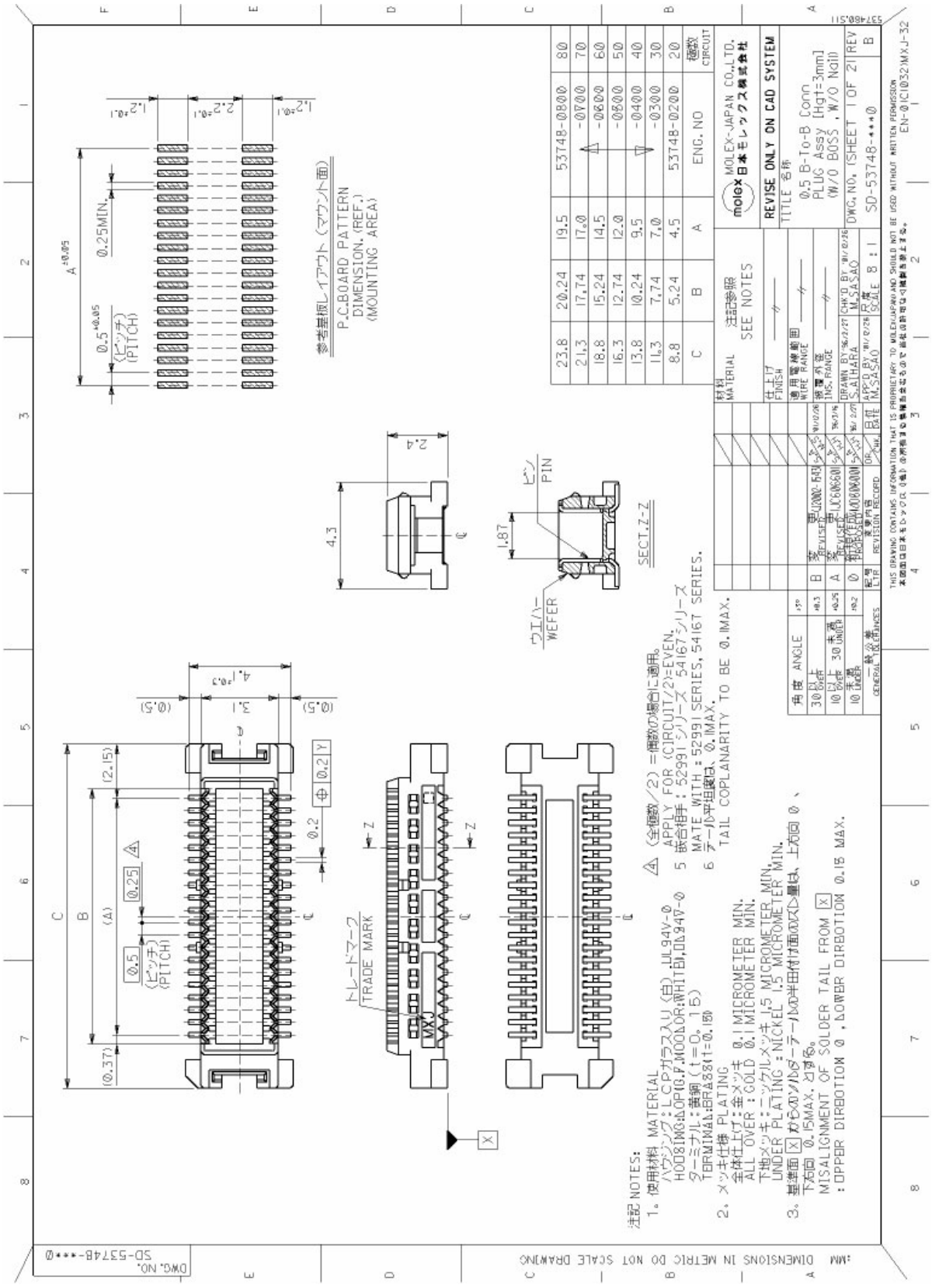


Figure 39: Mating board-to-board connector 53748-0808 on application

8 Sample Application

Figure 40 shows a typical example of how to integrate an PH8/PH8-P module with an application.

The audio interface demonstrates the balanced connection of microphone and earpiece. This solution is particularly well suited for internal transducers.

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 PH8/PH8-P 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. If an external level controller is required, this can be done by using for example a 5V I/O tolerant buffer/driver like a "74AVC4T245" with $\overline{OE}$ (Output Enable) controlled by PWR_IND.

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.

Depending on the micro controller used by an external application PH8/PH8-P'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 40 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 PH8/PH8-P modules.

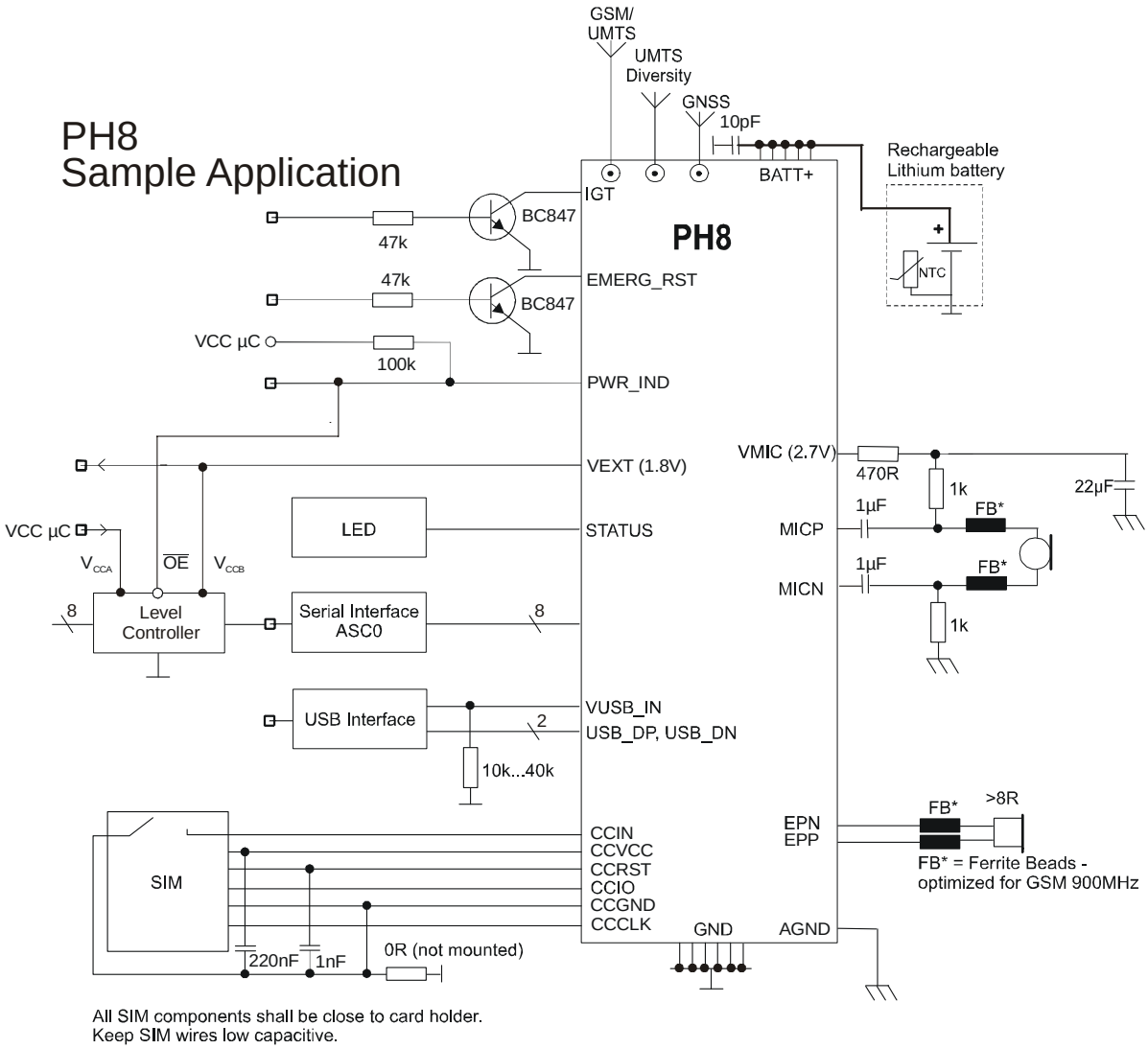


Figure 40: PH8/PH8-P sample application

8.1 Sample Level Conversion Circuit

Depending on the micro controller used by an external application PH8/PH8-P's digital input and output lines (i.e., ASC0 lines) may require level conversion. The following Figure 41 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.

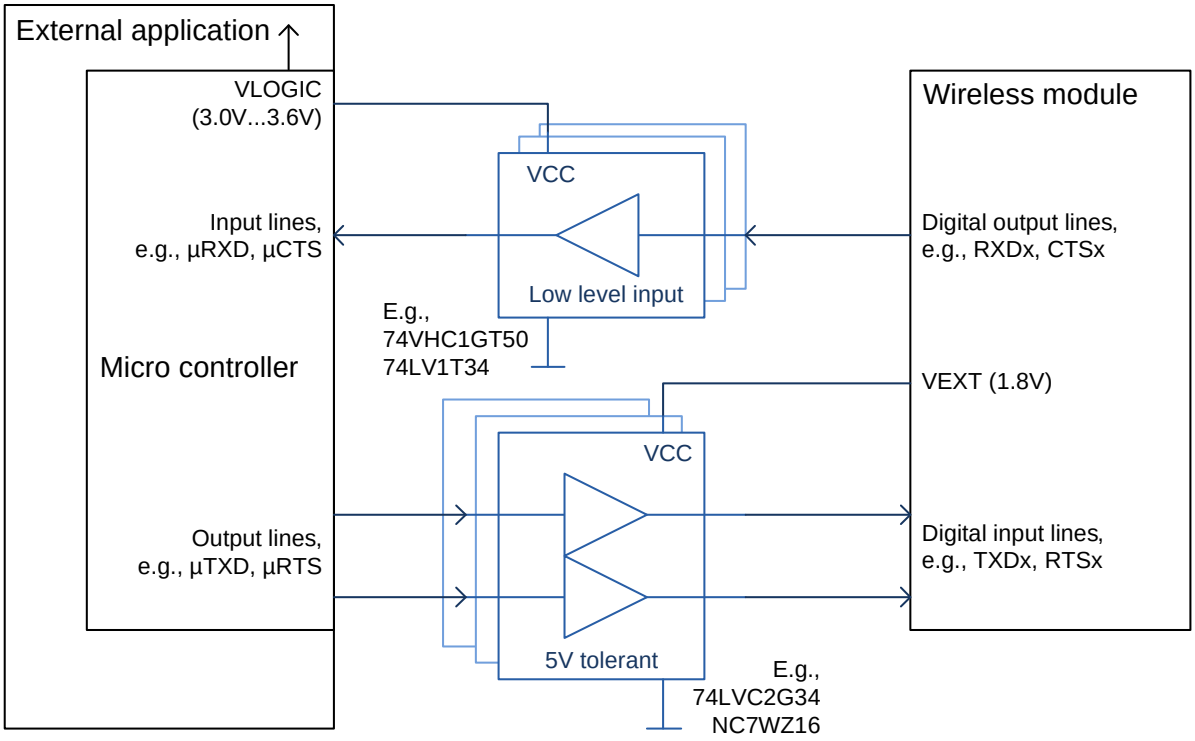


Figure 41: Sample level conversion circuit

9 Reference Approval

9.1 Reference Equipment for Type Approval

The Gemalto M2M reference setup submitted to type approve PH8/PH8-P is shown in the following figure[1]. The module is connected to the DSB75 via a special adapter and either mounted directly onto the adapter or connected using a flex cable:

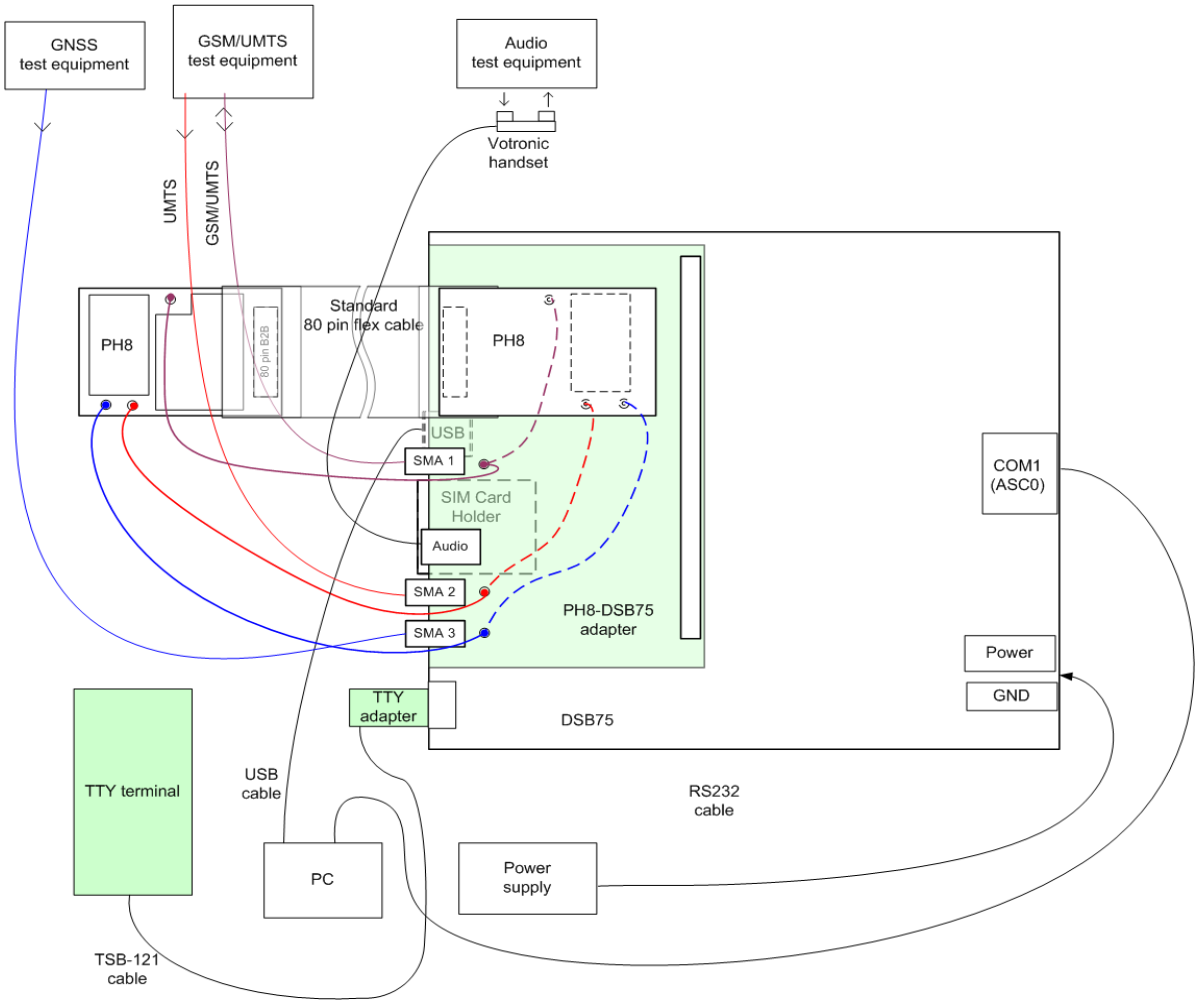


Figure 42: Reference equipment for type approval

1. For RF performance tests a mini-SMT/U.FL to SMA adapter with attached 6dB coaxial attenuator is chosen to connect the module directly to the GSM/UMTS/GNSS test equipment instead of employing the SMA antenna connectors on the PH8/PH8-P-DSB75 adapter as shown in Figure 42. The following products are recommended:
Hirose SMA-Jack/U.FL-Plug conversion adapter HRMJ-U.FLP(40)
(for details see see http://www.hirose-connectors.com/ or http://www.farnell.com/
Aeroflex Weinschel Fixed Coaxial Attenuator Model 3T/4T
(for details see http://www.aeroflex.com/ams/weinschel/pdfiles/wmod3&4T.pdf)

9.2 Compliance with FCC and IC Rules and Regulations

The Equipment Authorization Certification for the Gemalto M2M reference application described in Section 9.1 will be registered under the following identifiers:

- PH8:
  FCC Identifier: QIPPH8
  Industry Canada Certification Number: 7830A-PH8
  Granted to Gemalto M2M GmbH

- PH8-P:
  FCC Identifier: QIPPH8-P
  Industry Canada Certification Number: 7830A-PH8P
  Granted to Gemalto M2M GmbH

Manufacturers of mobile or fixed devices incorporating PH8/PH8-P modules are authorized to use the FCC Grants and Industry Canada Certificates of the PH8/PH8-P 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: QIPPH8" or "Contains FCC ID: QIPPH8-P", and accordingly “Contains IC: 7830A-PH8“ or “Contains IC: 7830A-PH8P“. The integration is limited to fixed or mobile categorized 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 40 for FCC and IC.

Table 40: Antenna gain limits for FCC and IC

Maximum gain in operating band	FCC limit	IC limit	Unit
GSM850 with f=850MHz	0.89	0.7	dBi
WCDMA BdV with f=850MHz	0.89	6.6	dBi
WCDMA BdIV (AWS) with f=1700MHz[1]	--	8.8	dBi
GSM1900 with f=1900MHz	1.60	6.0	dBi
WCDMA BdII with f=1900MHz	1.60	9.0	dBi

1. AWS band IV supported by PH8 only.

IMPORTANT:
Manufacturers of portable applications incorporating PH8/PH8-P 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 1.3.1 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 license-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 PH8/PH8-P 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.

10 Appendix

10.1 List of Parts and Accessories

Table 41: List of parts and accessories

Description	Supplier	Ordering information
PH8	Gemalto M2M	Standard module Gemalto M2M IMEI: Packaging unit (ordering) number: L30960-N1900-A330 Module label number[1]: S30960-S1900-A330-1 Customer IMEI: Packaging unit (ordering) number: L30960-N1905-A330 Module label number[1]: S30960-S1905-A330-1
PH8-P	Gemalto M2M	Standard module Gemalto M2M IMEI: Packaging unit (ordering) number: L30960-N1910-A330 Module label number[1]: S30960-S1910-A330-1 Customer IMEI: Packaging unit (ordering) number: L30960-N1915-A330 Module label number[1]: S30960-S1915-A330-1
DSB75 Support Box	Gemalto M2M	Ordering number: L36880-N8811-A100
DSB75 adapter for mounting the module	Gemalto M2M	Ordering number: L30960-N1802-A100
Votronic Handset	Gemalto M2M, Votronic	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 42.
Board-to-board connector	Molex	Sales contacts are listed in Table 42.
U.FL antenna connector	Hirose or Molex	Sales contacts are listed in Table 42 and Table 43.

1. 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.

Table 42: 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 43: 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 Fasteners and Fixings for Electronic Equipment

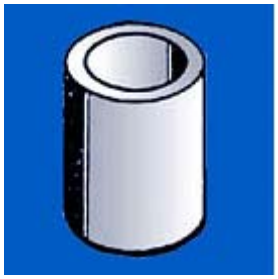
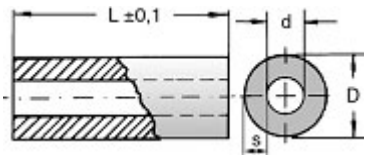
This section provides a list of suppliers and manufacturers offering fasteners and fixings for electronic equipment and PCB mounting. The content of this section is designed to offer basic guidance to various mounting solutions with no warranty on the accuracy and sufficiency of the information supplied. Please note that the list remains preliminary although it is going to be updated in later versions of this document.

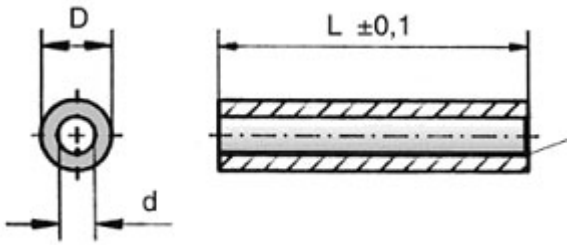
10.2.1 Fasteners from German Supplier ETTINGER GmbH

Sales contact:
ETTINGER GmbH
http://www.ettinger.de/main.cfm
Phone: +4981 04 66 23 – 0
Fax: +4981 04 66 23 – 0

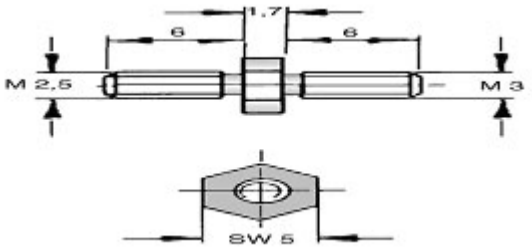
The following tables contain only article numbers and basic parameters of the listed components. For further detail and ordering information please contact Ettinger GmbH.

Please note that some of the listed screws, spacers and nuts are delivered with the DSB75 Support Board. See comments below.

Article number: 05.71.038	Spacer - Aluminum / **Wall thickness = 0.8mm**
Length	3.0mm
Material	AlMgSi-0,5
For internal diameter	M2=2.0-2.3
Internal diameter	d = 2.4mm
External diameter	4.0mm
Vogt AG No.	x40030080.10
	

Article number: 07.51.403	Insulating Spacer for M2 Self-gripping[1]
Length	3.0mm
Material	Polyamide 6.6
Surface	Black
Internal diameter	2.2mm
External diameter	4.0mm
Flammability rating	UL94-HB
	

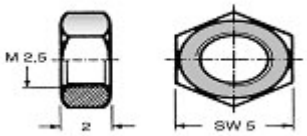
1. 2 spacers are delivered with DSB75 Support Board

Article number: 05.11.209	Threaded Stud M2.5 - M2 Type E / External thread at both ends
Length	3.0mm
Material	Stainless steel X12CrMoS17
Thread 1 / Length	M2.5 / 6.0mm
Thread 2 / Length	M2 / 8.0mm
Width across flats	5
Recess	yes
Type	External / External
	

Article number: 01.14.131	Screw M2[1] DIN 84 - ISO 1207
Length	8.0mm
Material	Steel 4.8
Surface	Zinced A2K
Thread	M2
Head diameter	D = 3.8mm
Head height	1.30mm
Type	Slotted cheese head screw
	

1. 2 screws are delivered with DSB75 Support Board

Article number: 01.14.141	Screw M2 DIN 84 - ISO 1207
Length	10.0mm
Material	Steel 4.8
Surface	Zinced A2K
Thread	M2
Head diameter	D = 3.8mm
Head height	1.30mm
Type	Slotted cheese head screw
	

Article number: 02.10.011	Hexagon Nut[1] DIN 934 - ISO 4032
Material	Steel 4.8
Surface	Zinced A2K
Thread	M2
Wrench size / Ø	4
Thickness / L	1.6mm
Type	Nut DIN/UNC, DIN934
	

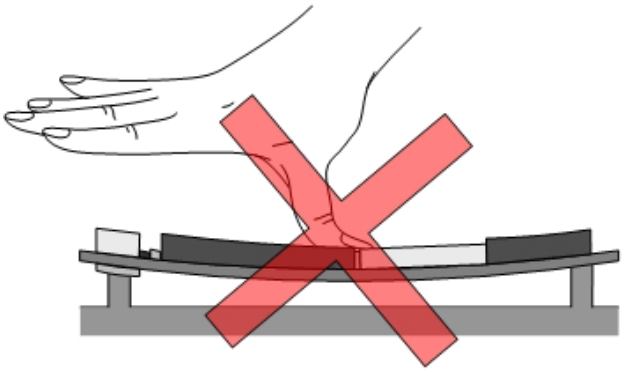
1. 2 nuts are delivered with DSB75 Support Board

10.3 Mounting Advice Sheet

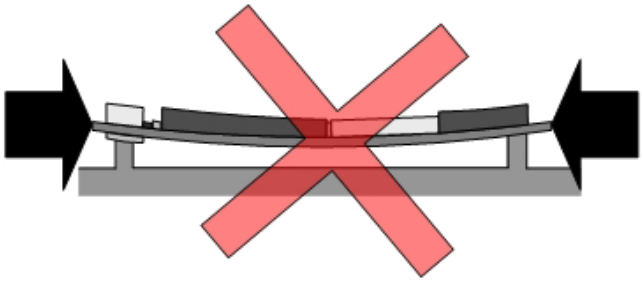
To prevent mechanical damage, be careful not to force, bend or twist the module. Be sure it is positioned flat against the host device (see also Section 7.2). The advice sheet on the next page shows a number of examples for the kind of bending that may lead to mechanical damage of the module.

Mounting Advice

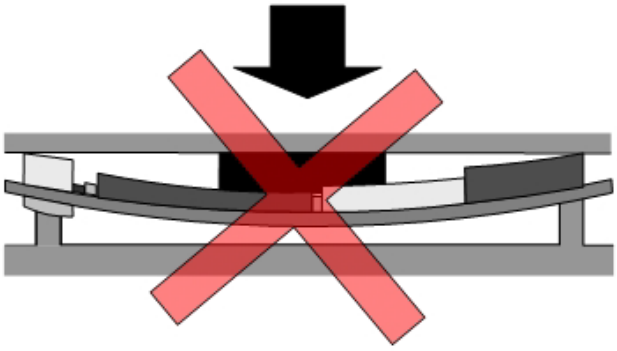
Do NOT BEND the Module



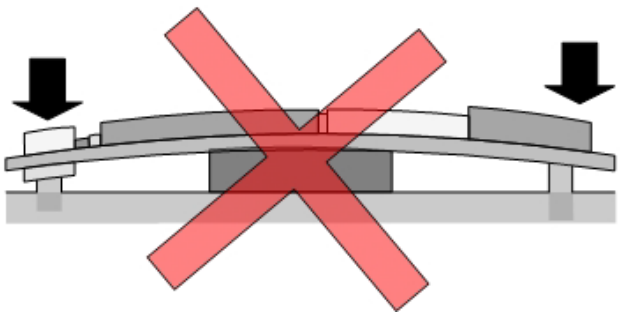
- By pressing from above



- By mounting under pressure



- By putting objects on top



- By putting objects below

About Gemalto

Gemalto (Euronext NL0000400653 GTO) is the world leader in digital security with 2015 annual revenues of €3.1 billion and blue-chip customers in over 180 countries. Our 14,000+ employees operate out of 118 offices, 45 personalization and data centers, and 27 research and software development centers located in 49 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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security to be free