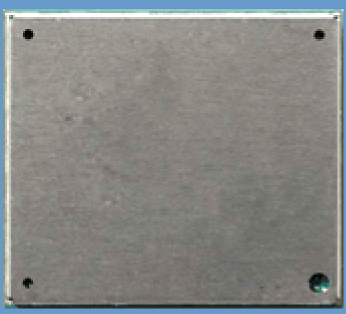
CINTERION
a Gemalto company

Hardware Interface Description

PHS8-P/PHS8-K

Version: 02.003b
DocId: PHS8-P_PHS8-K_HD_v02.003b



Document Name:	**PHS8-P/PHS8-K Hardware Interface Description**
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Contents

Tables

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0 Document History

Preceding document: "PHS8-P Hardware Interface Description" Version 02.003a
New document: "PHS8-P/PHS8-K Hardware Interface Description" Version **02.003b**

Chapter	What is new
3.8, 5.1, 6.5	Marked pad J13 as reserved for future (rfu) use and not connected (nc). Table 11: Replaced pad J13 with pad N11 for use as optional separate ground line for UICC/SIM/USIM interface.

Preceding document: "PHS8-P Hardware Interface Description" Version 02.003
New document: "PHS8-P/PHS8-K Hardware Interface Description" Version **02.003a**

Chapter	What is new
Throughout document	Added PHS8-K as new product variant.
3.6	Revised Figure 12 to include internal R_S resistors for USB lines.
3.8.1	Revised Figure 15 to include samples for 5-line transient voltage suppressor array.
5.1.2.2	Added evaluation board layer table.
6.1	Added maximum rating for VGPS.
6.5	Revised section to include pads marked as reserved for future use.
6.6	Revised maximum rating for VOICE Call GSM1800/1900. Added maximum ratings for average GSM / GPRS supply currents to Table 25.
7.1	Revised Figure 41 - Figure 44 to specify pad dimensions in more detail.
8	Revised Figure 52 by adding VDDLP line with 10µF capacitor and link to Section 3.8.1.
9.1	Revised Figure 53 illustrating reference equipment for type approval.
10.2	New section Mounting Advice Sheet.

Preceding document: "PHS8-P Hardware Interface Description" Version 02.001
New document: "PHS8-P Hardware Interface Description" Version 02.003

Chapter	What is new
3.8.1	Moved section on enhanced ESD protection, revised Figure 15.
8	Added optional ESD protection to Figure 52.
6.5	Revised description for CCIN pin in Table 24.

Preceding document: "PHS8-P Hardware Interface Description" Version 00.001
New document: "PHS8-P Hardware Interface Description" Version 02.001

Chapter	What is new
2.1	Added module weight. PHS8-P supports an Rx diversity antenna for all available UMTS bands (in contrast to PH8-P). Thus the footnote stating the non-support for the UMTS band VIII was removed.
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.
6.5	Added Figure 38 showing the module's pad assignments.
6.7.3	Revised digital logical channels for I^2S in Figure 39. See also Figure 25.
7.1	Revised position of drawings in Figure 41.
7.2.1.1	Revised Figure 42, Figure 43, Figure 44.
10.1	Revised Table 36 and Table 37 listing sales contacts for parts and accessories.

New document: "PHS8-P Hardware Interface Description" Version 02.003

Chapter	What is new
--	Initial document setup.

1 Introduction

The document[1] describes the hardware of the PHS8-P/PHS8-K 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 Cinterion product
[2] Release Notes for your Cinterion product
[3] DSB75 Support Box - Evaluation Kit for Cinterion Wireless Modules
[4] Application Note 40: Thermal Solutions
[5] Application Note 48: SMT Module Integration

1.2 Terms and Abbreviations

Abbreviation	Description
AGPS	Assisted GPS
ANSI	American National Standards Institute
AMR	Adaptive Multirate
ARP	Antenna Reference Point
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 Cinterion Wireless Modules 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
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
LGA	Land Grid Array
MBB	Moisture barrier bag
Mbps	Mbits per second
MCS	Modulation and Coding Scheme
MO	Mobile Originated
MS	Mobile Station, also referred to as TE
MSL	Moisture Sensitivity Level
MT	Mobile Terminated
nc	Not connected

Abbreviation	Description
NMEA	National Marine Electronics Association
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 (appr. 100k)
PDU	Protocol Data Unit
PS	Packet Switched
PSK	Phase Shift Keying
PU	Pull Up resistor (appr. 100k)
QAM	Quadrature Amplitude Modulation
R&TTE	Radio and Telecommunication Terminal Equipment
RF	Radio Frequency
rfu	Reserved for future use
ROPR	Radio Output Power Reduction
RTC	Real Time Clock
Rx	Receive Direction
SAR	Specific Absorption Rate
SELV	Safety Extra Low Voltage
SIM	Subscriber Identification Module
SLIC	Subscriber Line Interface Circuit
SMPL	Sudden Momentary Power Loss
SMD	Surface Mount Device
SMS	Short Message Service
SMT	Surface Mount Technology
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

Abbreviation	Description
Tx	Transmit Direction
UL	Upload
UMTS	Universal Mobile Telecommunications System
URC	Unsolicited Result Code
USB	Universal Serial Bus
UICC	USIM Integrated Circuit Card
USIM	UMTS Subscriber Identification Module
WCDMA	Wideband Code Division Multiple Access

1.3 Regulatory and Type Approval Information

1.3.1 Directives and Standards

PHS8-P/PHS8-K 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 "PHS8-P/PHS8-K Hardware Interface Description".[1]

Table 1: Directives

99/05/EC	Directive of the European Parliament and of the council of 9 March 1999 on radio equipment and telecommunications terminal equipment and the mutual recognition of their conformity (in short referred to as R&TTE Directive 1999/5/EC). The product is labeled with the CE conformity mark CE 0682
2002/95/EC	Directive of the European Parliament and of the Council of 27 January 2003 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 V5.8	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 V9.0.2	Global System for Mobile communications (GSM); Harmonized standard for mobile stations in the GSM 900 and DCS 1800 bands covering essential requirements under article 3.2 of the R&TTE directive (1999/5/EC)
GCF-CC V3.43.1	Global Certification Forum - Certification Criteria
ETSI EN 301 489-01 V1.8.1	Electromagnetic Compatibility and Radio spectrum Matters (ERM); Electromagnetic Compatibility (EMC) standard for radio equipment and services; Part 1: Common Technical Requirements

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

ETSI EN 301 489-03 V1.4.1	Electromagnetic Compatibility and Radio spectrum Matters (ERM); Electromagnetic Compatibility (EMC) standard for radio equipment and services; Part 3: Specific conditions for Short-Range Devices (SRD) operating on frequencies between 9 kHz and 40 GHz
ETSI EN 301 489-07 V1.3.1	Electromagnetic Compatibility and Radio spectrum Matters (ERM); Electromagnetic Compatibility (EMC) standard for radio equipment and services; Part 7: Specific conditions for mobile and portable radio and ancillary equipment of digital cellular radio telecommunications systems (GSM and DCS)
ETSI EN 301 489-24 V1.4.1	Electromagnetic Compatibility and Radio spectrum Matters (ERM); Electromagnetic Compatibility (EMC) standard for radio equipment and services; Part 24: Specific conditions for IMT-2000 CDMA Direct Spread (UTRA) for Mobile and portable (UE) radio and ancillary equipment
EN 301 908-01 V3.2.1	Electromagnetic compatibility and Radio spectrum Matters (ERM); Base Stations (BS) and User Equipment (UE) for IMT-2000 Third Generation cellular networks; Part 1: Harmonized EN for IMT-2000, introduction and common requirements of article 3.2 of the R&TTE Directive
EN 301 908-02 V3.2.1	Electromagnetic compatibility and Radio spectrum Matters (ERM); Base Stations (BS) and User Equipment (UE) for IMT-2000 Third Generation cellular networks; Part 2: Harmonized EN for IMT-2000, CDMA Direct Spread (UTRA FDD) (UE) covering essential requirements of article 3.2 of the R&TTE Directive
EN 300 440-02 V1.3.1	Electromagnetic compatibility and Radio spectrum Matters (ERM); Short range devices; Radio equipment to be used in the 1 GHz to 40 GHz frequency range; Part 2: Harmonized EN covering essential requirements of article 3.2 of the R&TTE Directive
EN 62311:2008	Assessment of electronic and electrical equipment related to human exposure restrictions for electromagnetic fields (0 Hz - 300 GHz)
IEC/EN 60950-1:2006	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 Cinterion 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 PHS8-P/PHS8-K 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)

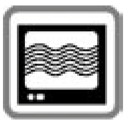
IMPORTANT:
Manufacturers of portable applications based on PHS8-P/PHS8-K modules are required to have their final product certified and apply for their own FCC Grant and Industry Canada Certificate related to the specific portable mobile.

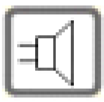
1.3.3 SELV Requirements

The power supply connected to the PHS8-P/PHS8-K 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 PHS8-P/PHS8-K. 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. Cinterion Wireless Modules 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+: Five band, 800/850/900/1900/2100MHz
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 900, WCDMA FDD BdVIII 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: 33mm x 29mm x 2mm Weight: approx. 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
GPS Features	
Protocol	NMEA
Modes	Standalone GPS Assisted GPS - Control plane - E911 - User plane - gpsOneXTRA™
General	Power saving modes
Software	
AT commands	Hayes, 3GPP TS 27.007 and 27.005, and proprietary Cinterion Wireless Modules 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

Feature	Implementation
Interfaces	
Module interface	Surface mount device with solderable connection pads (SMT application interface). Land grid array (LGA) technology ensures high solder joint reliability and provides the possibility to use an optional module mounting socket. For more information on how to integrate SMT modules see also [5]. This application note comprises chapters on module mounting and application layout issues as well as on additional SMT application development equipment.
Antenna	50Ohms. Main GSM/UMTS antenna, UMTS diversity antenna, GPS antenna (active/passive)
USB	USB 2.0 High Speed (480Mbit/s) device interface, Full Speed (12Mbit/s) 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
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
Antenna	SAIC (Single Antenna Interference Cancellation) / DARP (Downlink Advanced Receiver Performance) Rx diversity (receiver type 3i - 16-QAM)
Evaluation kit	
Evaluation module	PHS8-P/PHS8-K module soldered onto a dedicated PCB that can be connected to an adapter in order to be mounted onto the DSB75.
DSB75	DSB75 Development Support Board designed to test and type approve Cinterion Wireless Modules and provide a sample configuration for application engineering. A special adapter is required to connect the PHS8-P/PHS8-K evaluation module to the DSB75.

2.2 PHS8-P/PHS8-K System Overview

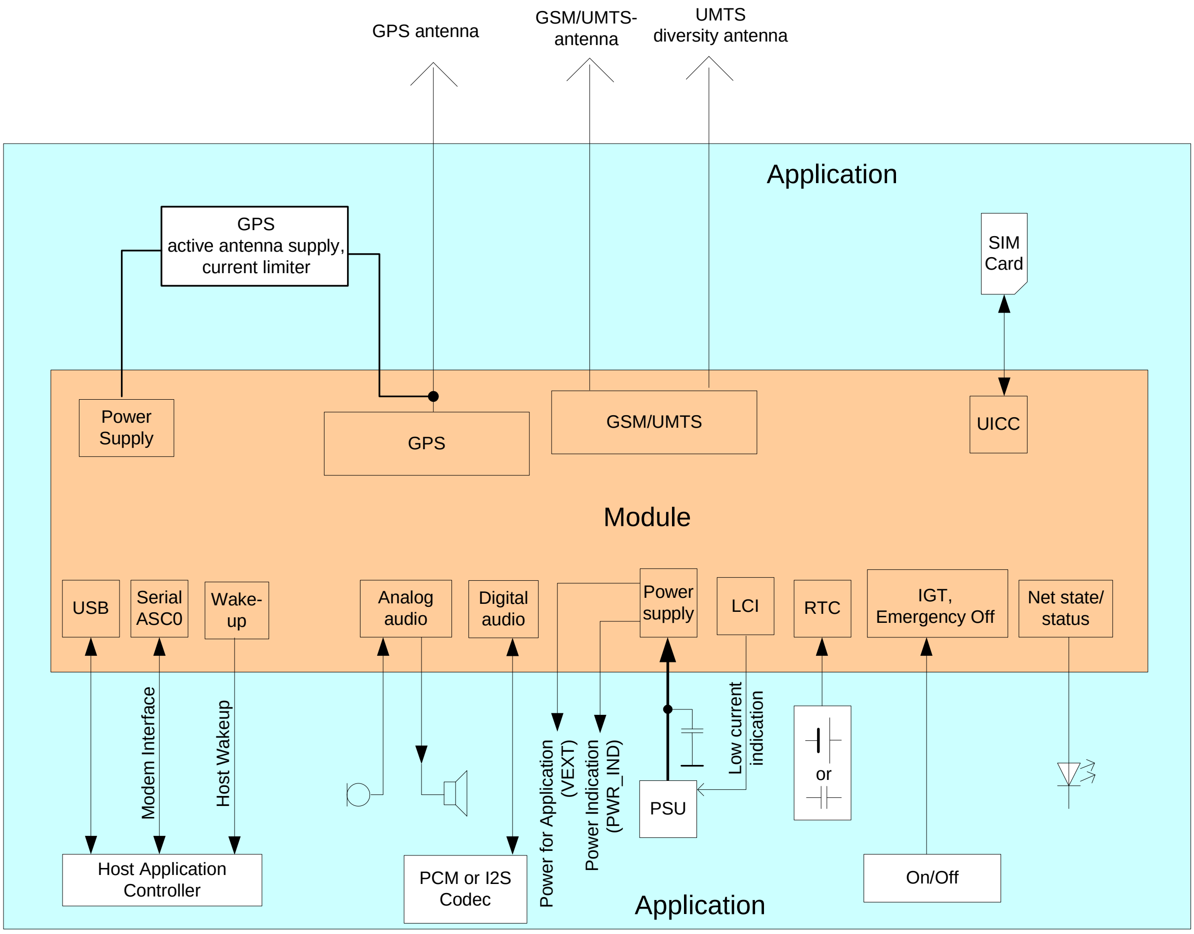


Figure 1: PHS8-P/PHS8-K system overview

2.3 Circuit Concept

Figure 2 shows a block diagram of the PHS8-P/PHS8-K 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 (SMT with connecting pads)

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

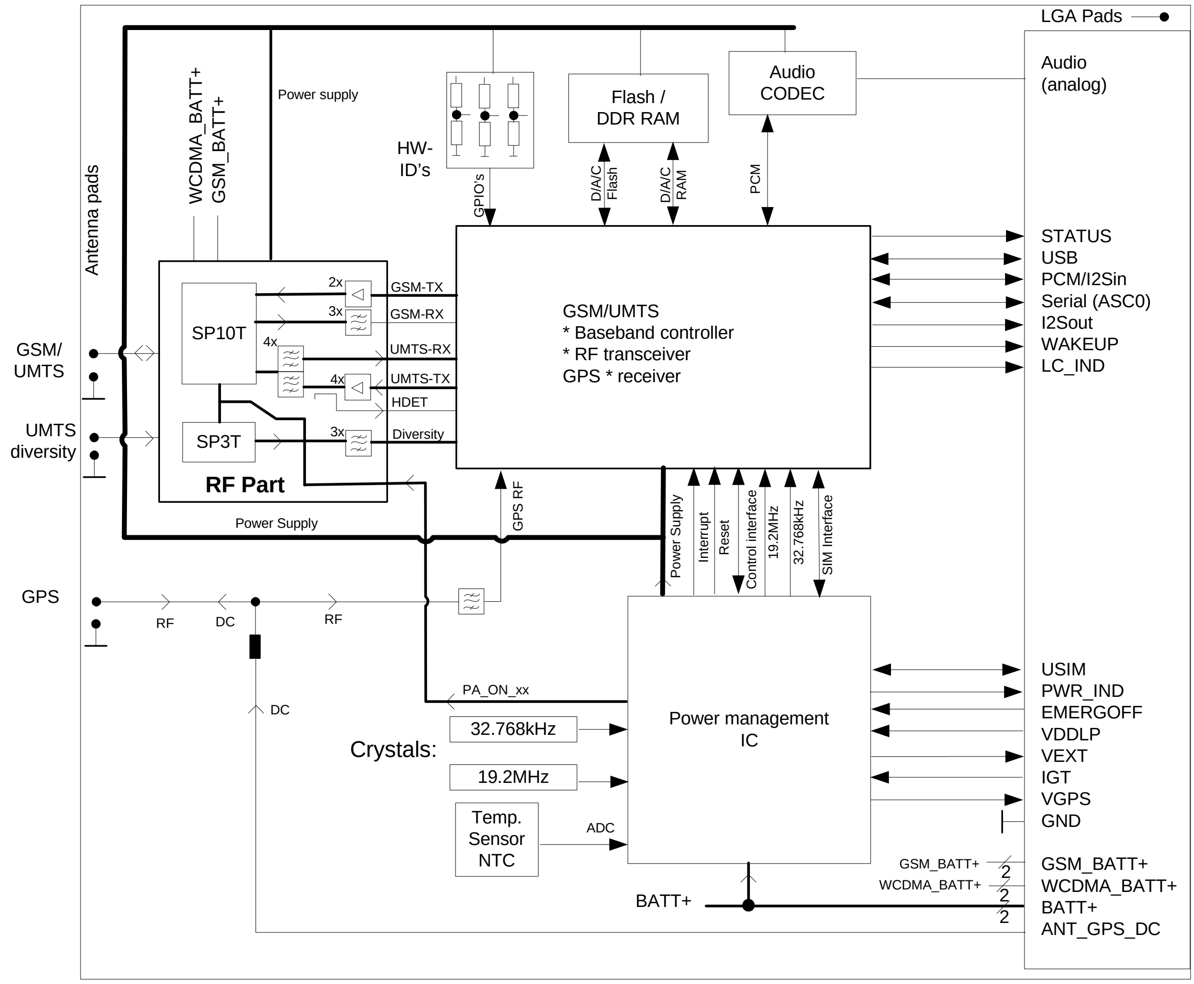


Figure 2: PHS8-P/PHS8-K block diagram

3 Application Interface

PHS8-P/PHS8-K is equipped with an SMT application interface 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
- Analog audio interface - see Section 3.9
- Digital audio interface (PCM or I^2S) - see Section 3.10
- Status and control lines: IGT, EMERG_OFF, PWR_IND, STATUS - see Table 24

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

PHS8-P/PHS8-K needs to be connected to a power supply at the SMT application interface - 6 lines each BATT+ and GND. There are three separate voltage domains for BATT+:

- BATT+_WCDMA with 2 lines for the WCDMA power amplifier supply
- BATT+_GSM with 2 lines for the GSM power amplifier supply
- BATT+ with 2 lines for the general power management.

The main power supply from an external application has to be a single voltage source and has to be expanded to three sub paths (star structure). Capacitors should be placed as close as possible to the BATT+ pads. Figure 3 shows two sample circuits (minimum requirement and recommended alternative) for decoupling capacitors for BATT+.

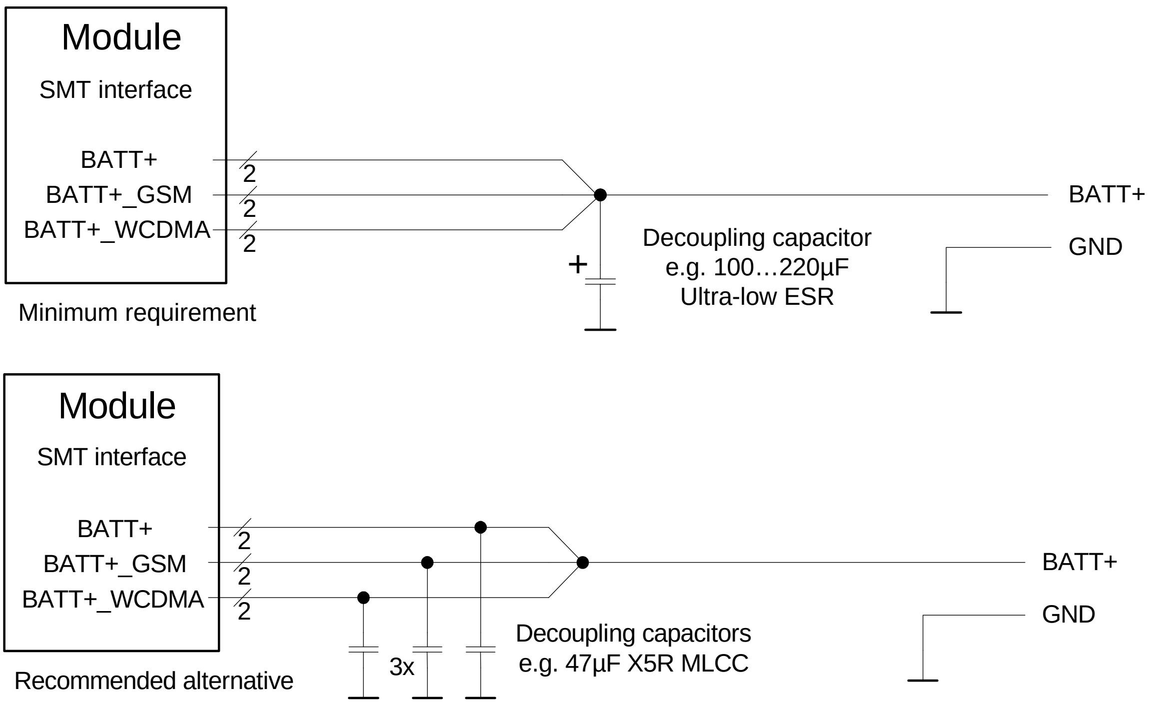


Figure 3: Decoupling capacitor(s) for BATT+

In addition, the VDDLP signal on the SMT application interface may be connected to an external capacitor or a battery to backup the RTC (see Section 3.5).

The power supply of PHS8-P/PHS8-K 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 24: 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 PHS8-P/PHS8-K board, not even in a transmit burst where current consumption can rise to typical peaks of 2A. It should be noted that PHS8-P/PHS8-K switches off when exceeding these limits. Any voltage drops that may occur in a transmit burst should not exceed 400mV to ensure the expected RF performance in 2G networks.

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

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

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

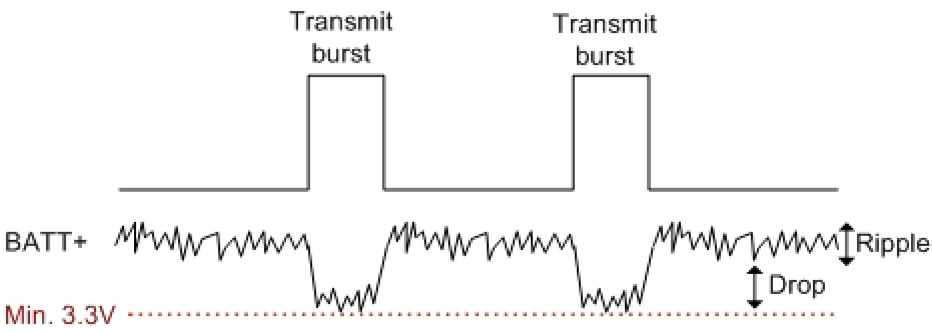


Figure 4: Power supply limits during transmit burst

3.2.2 Monitoring Power Supply by AT Command

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

The module continuously measures the voltage at intervals depending on the operating mode of the RF interface. The duration of measuring ranges from 0.5s in TALK/DATA mode to 50s when PHS8-P/PHS8-K 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 PHS8-P/PHS8-K while it is beyond the safety limits of voltage and temperature stated in Section 6.1. PHS8-P/PHS8-K would immediately switch off after having started and detected these inappropriate conditions. In extreme cases this can cause permanent damage to the module.

3.3.1 Turn on PHS8-P/PHS8-K

When the PHS8-P/PHS8-K module is in Power-down mode, it can be started to Normal mode by driving the IGT (ignition) line to ground. it is recommended to use an open drain/collector driver to avoid current flowing into this signal line. Pulling this signal low triggers a power-on sequence. To turn on PHS8-P/PHS8-K IGT has to be kept active at least 100ms. After turning on PHS8-P/PHS8-K IGT should be set inactive to prevent the module from turning on again after a shut down by AT command or EMERG_OFF. For details on signal states during startup see also Section 3.3.2 and Section 3.11.6.

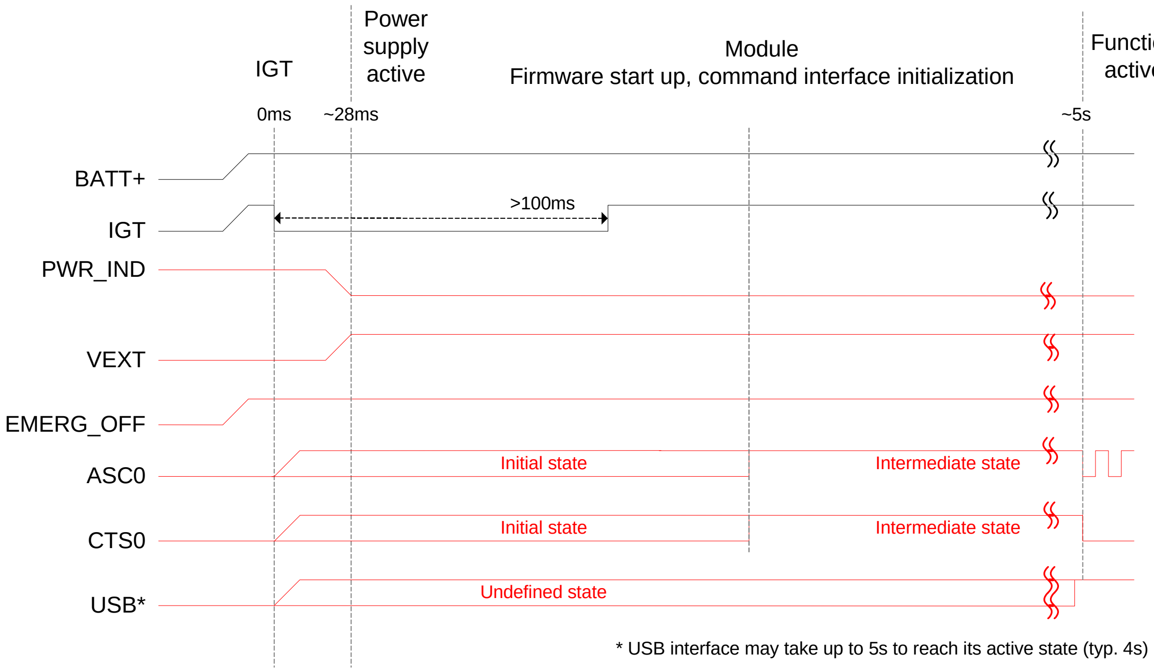


Figure 5: Power-on with IGT

Note: After power up IGT should remain high. Also note that with a USB connection the USB host may take 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. To do so, try to send characters (e.g. "at") 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 3.11.6).

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(47k)	PD(47k)	O, L
CCCLK	PD	PD	O, L
CCVCC	Off	Off	1.8V/2.85V
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 PHS8-P/PHS8-K Using AT Command

The best and safest approach to powering down PHS8-P/PHS8-K is to issue the AT^SMSO command. This procedure lets PHS8-P/PHS8-K log off from the network and allows the software to enter into a secure state and safe data before disconnecting the power supply. The mode is referred to as Power Down mode. 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 definitely 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 PHS8-P/PHS8-K 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.

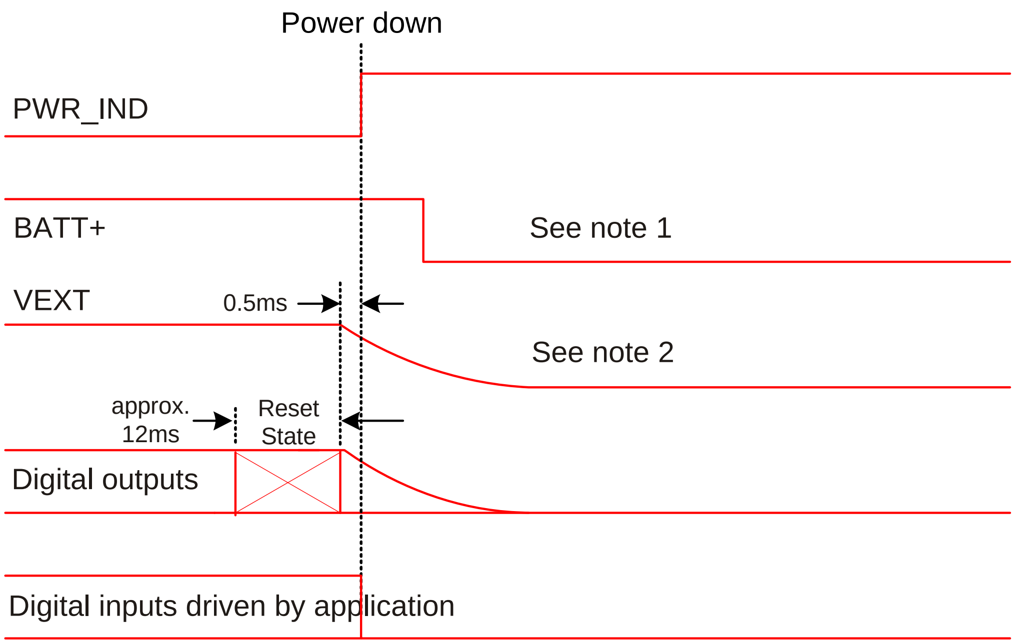


Figure 6: Signal states during turn-off procedure

Note 1: The power supply voltage (BATT+) may be disconnected resp. switched off only after having reached Power Down mode as indicated by the PWR_IND signal going high.

Note 2: Depending on capacitance load from host application

Note 3: After module shutdown by means of AT command, please allow for a time period of at least 1s before restarting the module.

3.3.4 Configuring the IGT Line for Use as ON/OFF Switch

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 ^SCFG: "MEShutdown/OnIgnition","off" OK	# Query the current status of IGT. # IGT can be used only to switch on PHS8-P/ PHS8-K. IGT works as described in Section 3.3.1.

To configure IGT for use as ON/OFF switch:

at^scfg=meshutdown/onignition ^SCFG: "MEShutdown/OnIgnition","on" OK	# Enable the ON/OFF switch mode of IGT. # IGT can be used to switch on and off PHS8-P/ PHS8-K.

We strongly recommend taking 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 PHS8-P/PHS8-K is off, the IGT line must be asserted for at least 100ms before being released.

Switch-off condition: If the PHS8-P/PHS8-K is on, the IGT line must be asserted for at least 2.1s before being released. The module switches off after the line is released. The switch-off routine is identical with the procedure initiated by AT^SMSO, i.e. the software performs an orderly shutdown as described in Section 3.3.3.
Before switching off the module wait at least 5 seconds after startup.

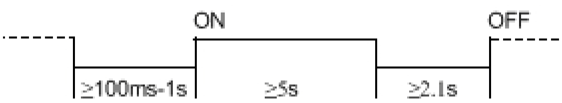


Figure 7: Timing of IGT if used as ON/OFF switch

3.3.5 Automatic Shutdown

Automatic shutdown takes effect if:

- The PHS8-P/PHS8-K 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. PHS8-P/PHS8-K logs off from the network and the software enters a secure state avoiding loss of data.

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

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, PHS8-P/PHS8-K instantly displays an alert (if enabled).

- URCs indicating the level "1" or "-1" allow the user to take appropriate precautions, such as protecting the module from exposure to extreme conditions. The presentation of the URCs depends on the settings selected with the AT^SCTM write command:
  AT^SCTM=1: Presentation of URCs is always enabled.
  AT^SCTM=0 (default): Presentation of URCs is enabled during the 15 second guard period after start-up of PHS8-P/PHS8-K. After expiry of the 15 second guard period, the presentation will be disabled, i.e. no URCs with alert levels "1" or "-1" will be generated.
- URCs indicating the level "2" or "-2" are instantly followed by an orderly shutdown. The presentation of these URCs is always enabled, i.e. they will be output even though the factory setting AT^SCTM=0 was never changed.

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

Table 9: Temperature dependent behavior

Sending temperature alert (15sec after PHS8-P/PHS8-K start-up, otherwise only if URC presentation enabled)	
^SCTM_B: 1	Caution: Board close to overtemperature limit, i.e., board is 5°C below overtemperature limit.
^SCTM_B: -1	Caution: Board close to undertemperature limit, i.e., board is 5°C above undertemperature limit.
^SCTM_B: 0	Board back to uncritical temperature range, i.e., board is 6°C below its over- or above its undertemperature limit.
Automatic shutdown (URC appears no matter whether or not presentation was enabled)	
^SCTM_B: 2	Alert: Board equal or beyond overtemperature limit. PHS8-P/PHS8-K switches off.
^SCTM_B: -2	Alert: Board equal or below undertemperature limit. PHS8-P/PHS8-K 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 Undervoltage Shutdown

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

^SBC: Undervoltage.

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

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

3.3.5.3 Overvoltage Shutdown

The overvoltage shutdown threshold is 100mV above the maximum supply voltage V_{BATT+} specified in Table 24.

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 PHS8-P/PHS8-K components are directly linked to BATT+ and, therefore, the supply voltage remains applied at major parts of PHS8-P/PHS8-K, 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 10µF capacitor).

3.3.7 Turn off PHS8-P/PHS8-K 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 PHS8-P/PHS8-K does not respond, if reset or shutdown via AT command fails.

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

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

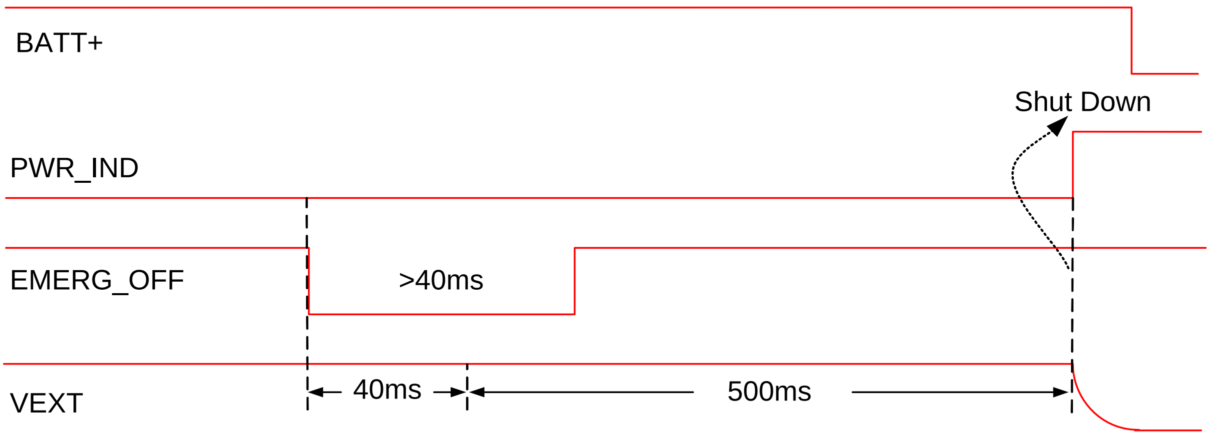


Figure 8: Shutdown by EMERG_OFF signal

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

3.4 Power Saving

PHS8-P/PHS8-K 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 dependant power saving behavior and also mention how to wake up from or disble 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 24: VEXT.

Another feature influencing the current consumption is the configuration of the GPS 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 power saving interval 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 intervals between 0.47 and 2.12 seconds. The DRX value of the base station is assigned by the GSM network operator.

In the pauses between listening to paging messages, the module resumes power saving, as shown in Figure 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 power saving period varies. It may be calculated using the following formula:

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

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

In the pauses between listening to paging messages, the module resumes power saving, as shown in Figure 10.

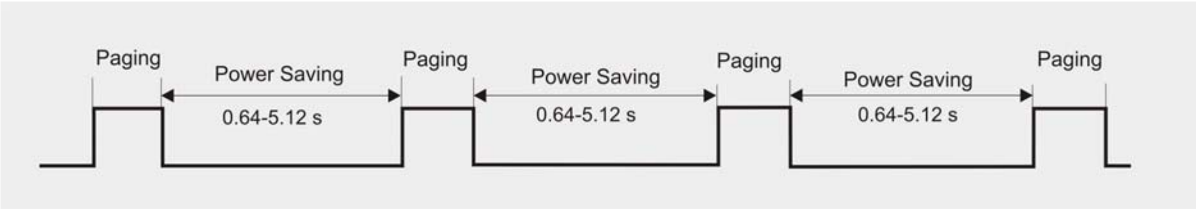


Figure 10: Power saving and paging in WCDMA networks

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 PHS8-P/PHS8-K 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 PHS8-P/PHS8-K'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 PHS8-P/PHS8-K is supplied from a separate voltage regulator in the power supply component which is also active when PHS8-P/PHS8-K is in Power Down mode and BATT+ is available.

In addition, you can use the VDDLP line on the SMT interface to backup the RTC from an external capacitor or a battery (rechargeable or non-chargeable). The capacitor is charged from the internal LDO of PHS8-P/PHS8-K. If the voltage supply at BATT+ is disconnected the RTC can be powered by the capacitor. The size of the capacitor determines the duration of buffering when no voltage is applied to PHS8-P/PHS8-K, i.e. the greater the capacitor the longer PHS8-P/PHS8-K will save the date and time. It limits the output current of an empty capacitor or battery.

Figure 11 show various sample configurations.

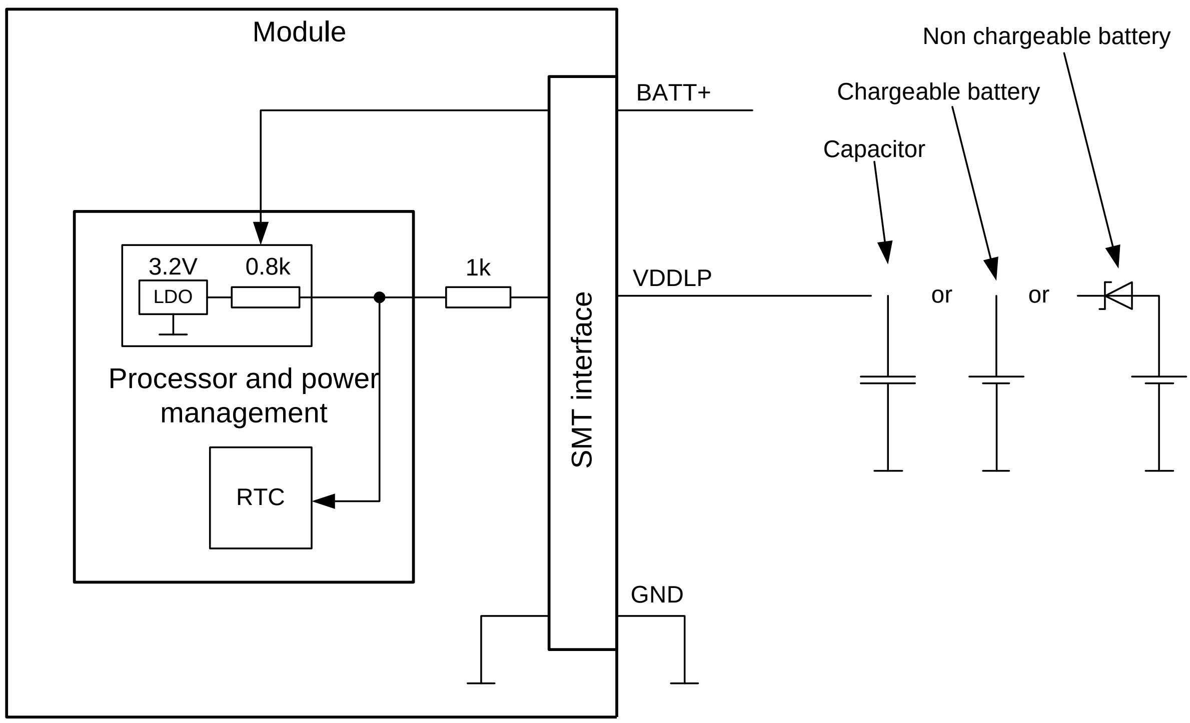
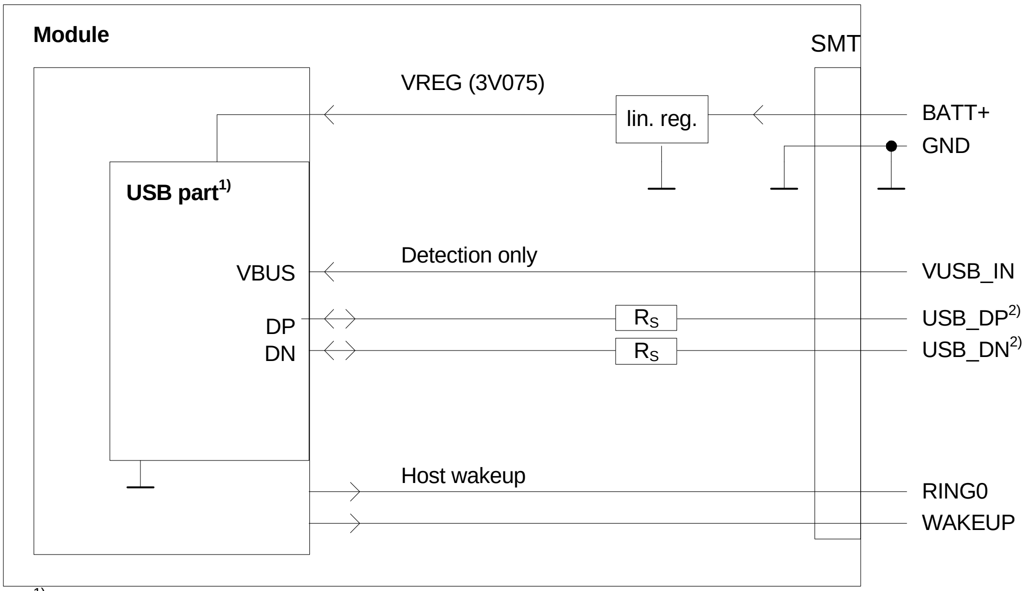


Figure 11: RTC supply variants

3.6 USB Interface

PHS8-P/PHS8-K supports a USB 2.0 High Speed (480Mbit/s) device interface that is Full Speed (12Mbit/s) compliant. The USB interface is primarily intended for use as command and data interface and for downloading firmware.

The USB host is responsible for supplying the VUSB_IN line. This line is for voltage detection only. The USB part (driver and transceiver) is supplied by means of BATT+. This is because PHS8-P/PHS8-K is designed as a self-powered device compliant with the “Universal Serial Bus Specification Revision 2.0”[1].



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

Figure 12: USB circuit

To properly connect the module's USB interface to the host a USB 2.0 compatible connector is required. For more information on the USB related signals see Table 24. Furthermore, the USB modem driver distributed with PHS8-P/PHS8-K needs to be installed.

While the USB connection is active, the module will not change into SLEEP Mode. To enable switching into SLEEP mode the USB host must bring its USB interface into Suspend state. Also, VUSB_IN should always be kept enabled for this functionality. See “Universal Serial Bus Specification Revision 2.0“[1] for a description of the Suspend state. On incoming calls PHS8-P/PHS8-K will then generate a remote wake up request to resume the USB connection (active low).

As an alternative to the regular USB remote wakeup mechanism it is possible to employ the RING0 or WAKEUP line to wake up the host application. The benefit is that the RING0 or WAKEUP lines can wake up the host application in case of incoming calls or other events signalized by URCs while the USB interface is suspended or shut down. For details on this host wakeup interface see Section 3.11.4.

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

3.7 Serial Interface ASC0

PHS8-P/PHS8-K offers an 8-wire unbalanced, asynchronous modem interface ASC0 conforming to ITU-T V.24 protocol DCE signalling. The electrical characteristics do not comply with ITU-T V.28. The significant levels are 0V (for low data bit or active state) and 1.8V (for high data bit or inactive state). For electrical characteristics please refer to Table 24. For an illustration of the interface line's startup behavior see Section 3.11.6.

PHS8-P/PHS8-K 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

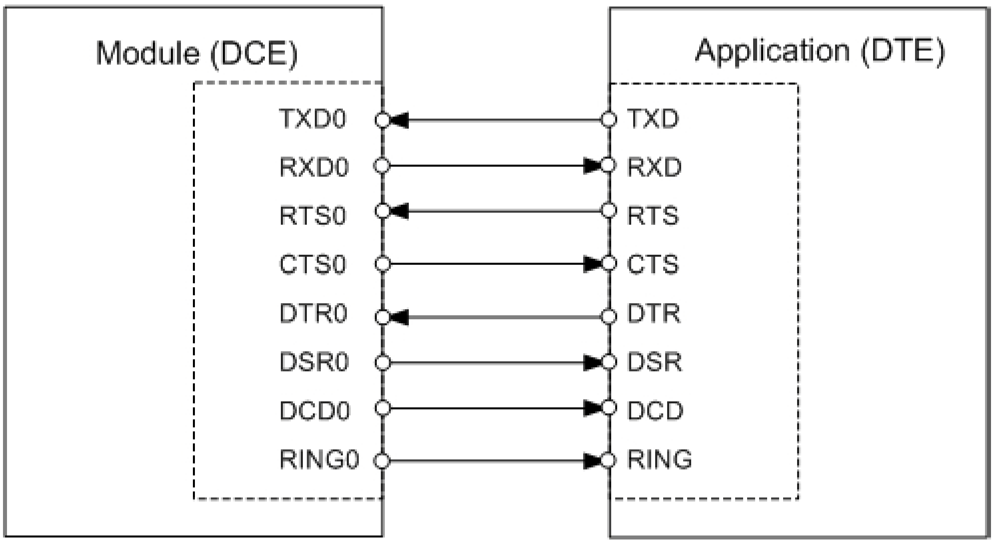


Figure 13: Serial interface ASC0

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.
- ASC0 is designed for controlling GSM/UMTS voice calls, transferring data and for controlling the module with AT commands.
- Full multiplexing capability allows the interface to be partitioned into virtual channels.
- 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

PHS8-P/PHS8-K has an integrated UICC/SIM/USIM interface compatible with the 3GPP 31.102 and ETSI 102 221. This is wired to the host interface in order to be connected to an external SIM card holder. Five pads on the SMT application interface are reserved for the SIM interface.

The UICC/SIM/USIM interface supports 3V and 1.8V SIM cards. Please refer to Table 24 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 PHS8-P/PHS8-K and is part of the Cinterion reference equipment submitted for type approval. See Chapter 10 for Molex ordering numbers.

Table 11: Signals of the SIM interface (SMT application interface)

Signal	Description
GND	Ground connection for SIM. Optionally a separate SIM ground line using e.g., pad N11 may be used to improve EMC.
CCCLK	Chipcard clock
CCVCC	SIM supply voltage.
CCIO	Serial data line, input and output.
CCRST	Chipcard reset
CCIN	Input on the baseband processor for detecting a SIM card tray in the holder. If the SIM is removed during operation the SIM interface is shut down immediately to prevent destruction of the SIM. The CCIN signal is active low. 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 PHS8-P/PHS8-K.

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 PHS8-P/PHS8-K.

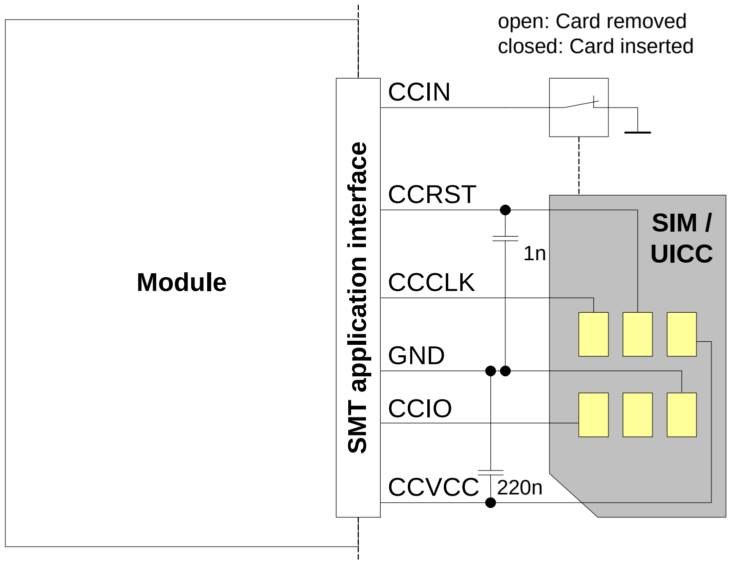


Figure 14: UICC/SIM/USIM interface

The total cable length between the SMT application interface pads on PHS8-P/PHS8-K and the pads of the external SIM card holder must not exceed 100mm in order to meet the specifications of 3GPP TS 51.010-1 and to satisfy the requirements of EMC compliance.

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

An example for an optimized ESD protection for the SIM interface is shown in Section 3.8.1.

3.8.1 Enhanced ESD Protection for SIM Interface

To optimize ESD protection for the SIM interface it is possible to add ESD diodes to the SIM interface lines as shown in the example given in Figure 15.

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

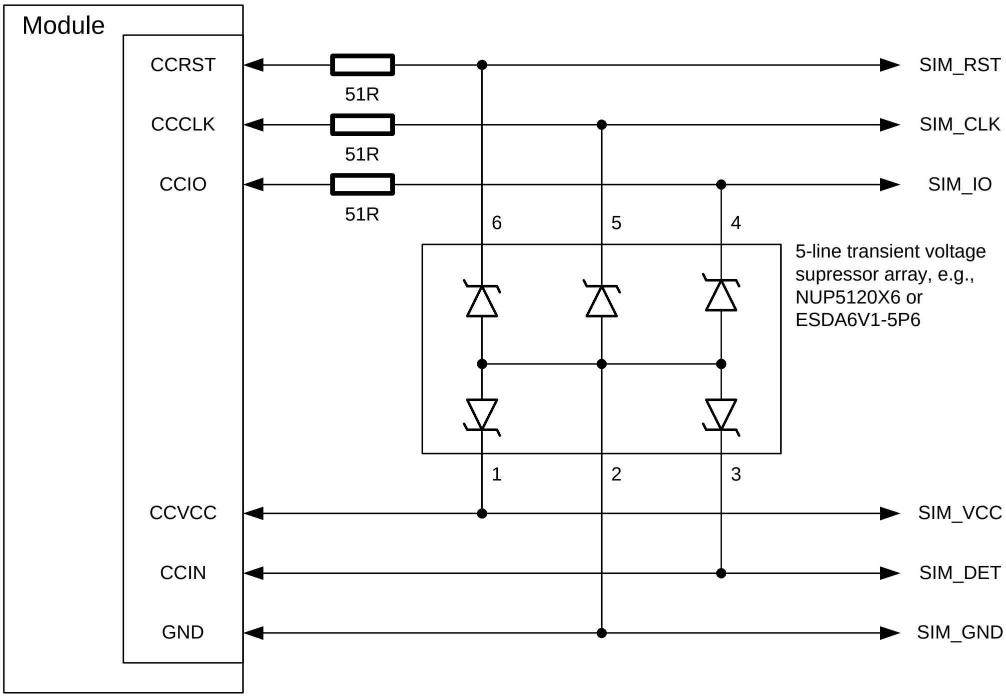


Figure 15: SIM interface - enhanced ESD protection

3.9 Analog Audio Interface

PHS8-P/PHS8-K 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.

PHS8-P/PHS8-K 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 27 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 PHS8-P/PHS8-K are set to audio mode 1. This is the default configuration optimised for the Votronic HH-SI-30.3/V1.1/0 handset and used for type approving the Cinterion Wireless Modules 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 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 16. 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].

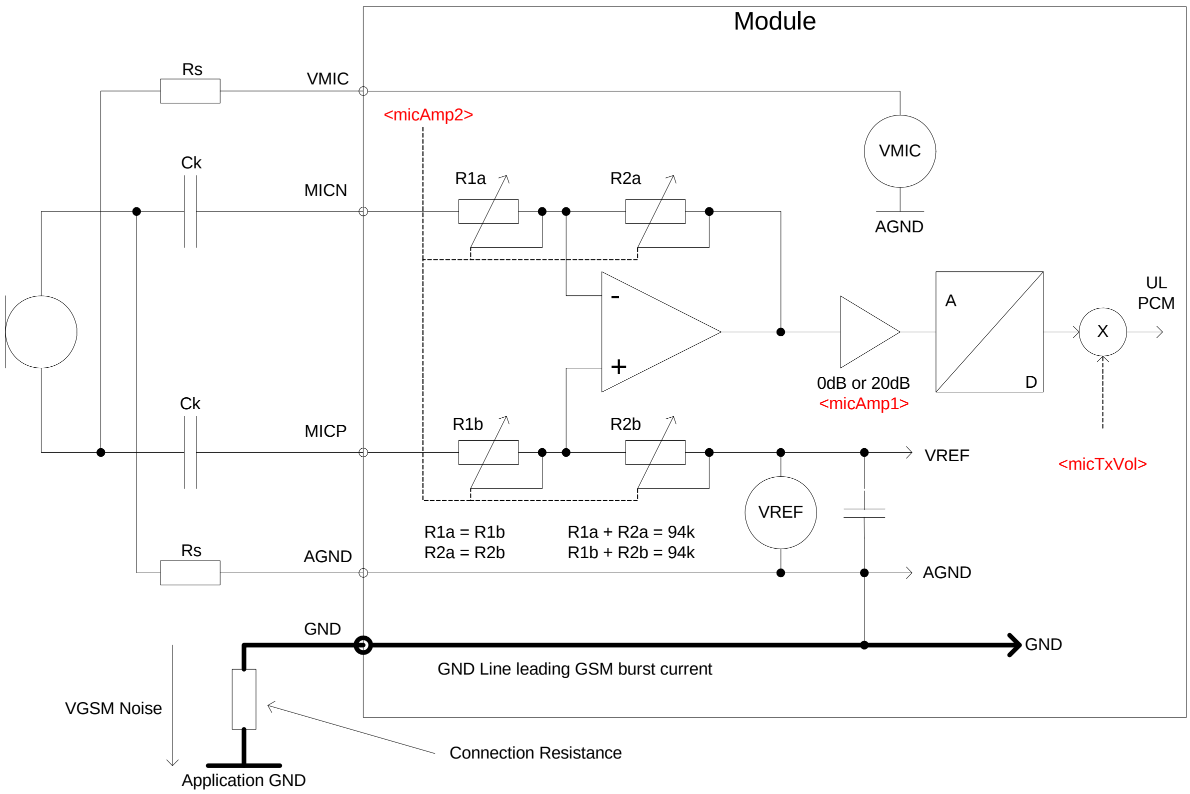


Figure 16: Structure of Audio Input and Supply

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 94kOhm. 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 [kOhm]	R2a or R2b [kOhm]
35.25	1.6	R2x = 94kOhm - R1x
30	2.9	
18	11	
12	19	
6	31	
0	47	
-12	75	

MICP presents a constant impedance of 94kOhm 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 94kOhm 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.

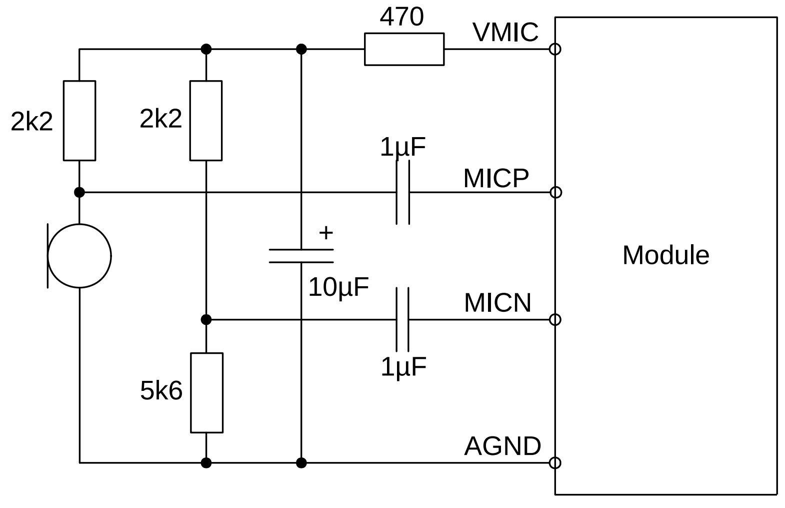


Figure 17: Single ended microphone connection

The configuration shown in Figure 17 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 470 Ohm 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 18. It is recommended to use an additional RC-filter for VMIC (for example 1kOhm, 10µF and 1kOhm as shown in the figure) in case a high microphone gain is necessary.

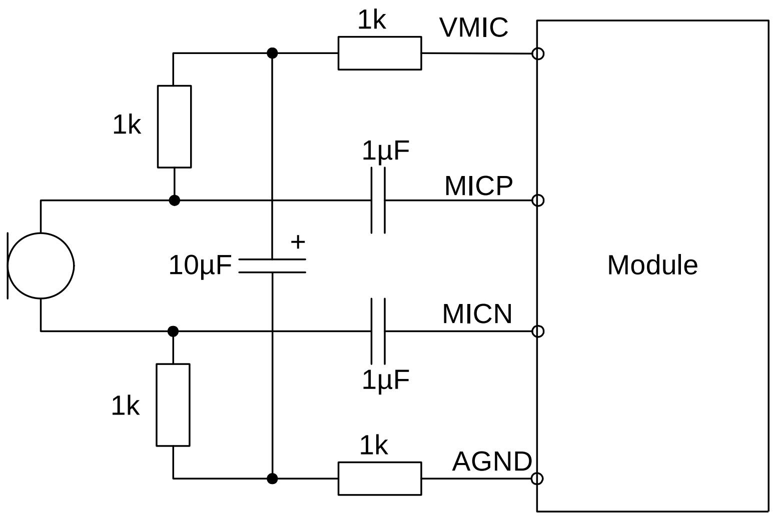


Figure 18: Differential microphone connection

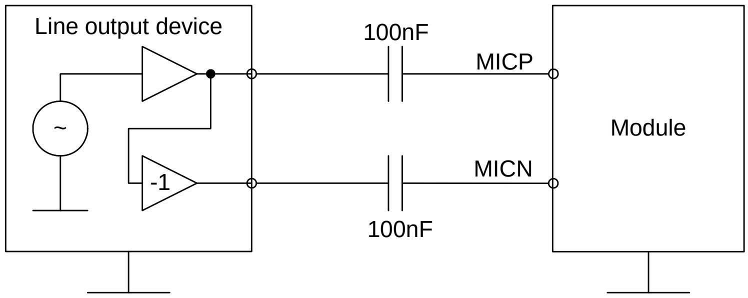


Figure 19: Line input

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 PHS8-P/PHS8-K is quite high at low gains, the coupling capacitances may be smaller.

3.9.2 Loudspeaker Output

PHS8-P/PHS8-K 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 strongly not recommended.

The following figures show the typical output configurations.

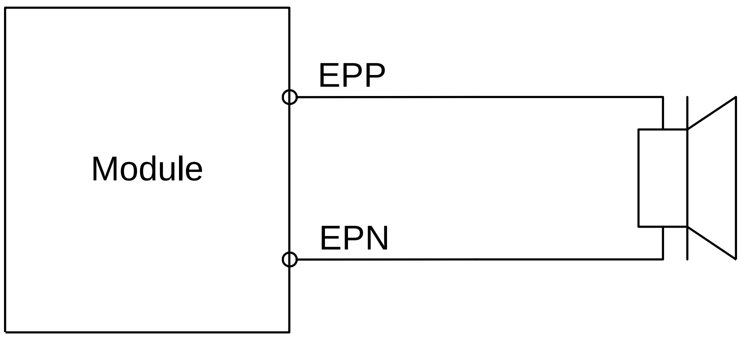


Figure 20: Differential loudspeaker connection

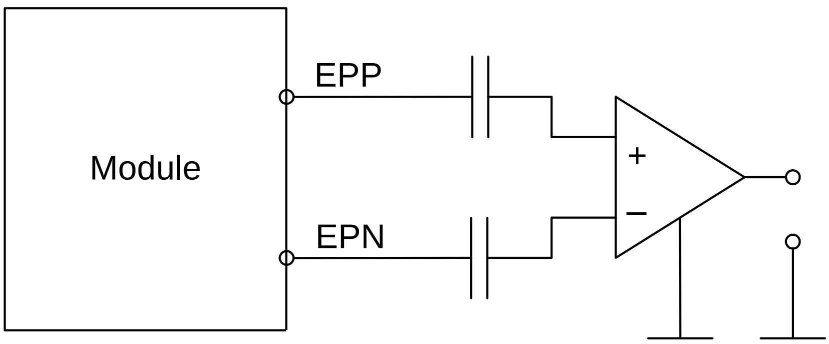


Figure 21: Line output connection

3.10 Digital Audio Interface

PHS8-P/PHS8-K supports a digital audio interface that can be employed either as pulse code modulation (see Section 3.10.1) or as inter IC sound interface (see Section 3.10.2). Operation of these interface variants is mutually exclusive.

3.10.1 Pulse Code Modulation Interface (PCM)

PHS8-P/PHS8-K'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 Freescale MC145483. 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 SMT application interface	Signal configuration inactive[1]	Signal direction: Master	Signal direction: Slave	Description
PCM_OUT	PD	O	O	PCM Data from PHS8-P/PHS8-K to external codec
PCM_IN	PD	I	I	PCM Data from external codec to PHS8-P/PHS8-K

Table 14: Overview of PCM signal functions

Signal name on SMT application interface	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 22. The timing for master and slave mode is identical, except for the PCM_FSC and PCM_CLK signal direction (see Table 14).

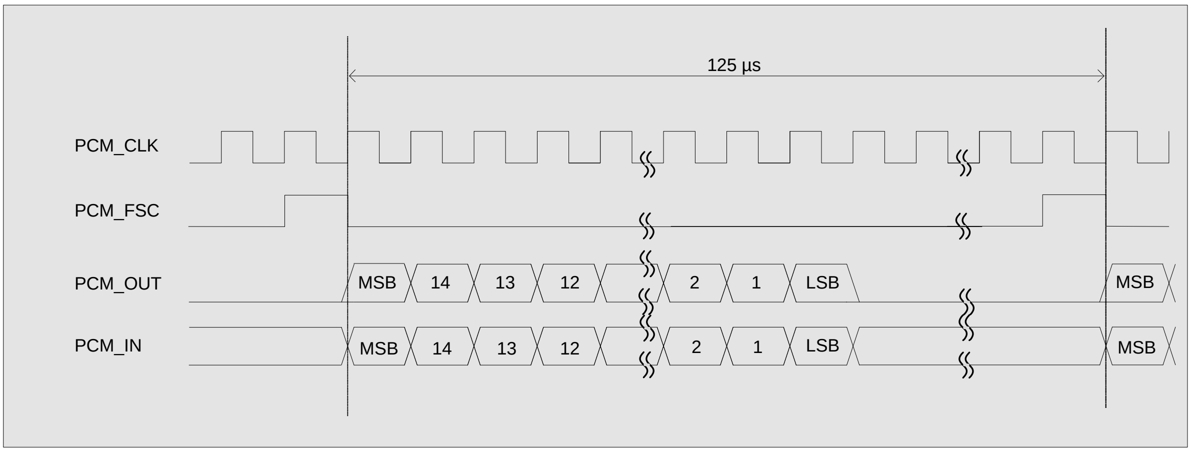


Figure 22: PCM timing short frame (master/slave, 256, 512 or 2048KHz)

The timing of a PCM long frame for the additional 128kHz master mode is shown in Figure 23.

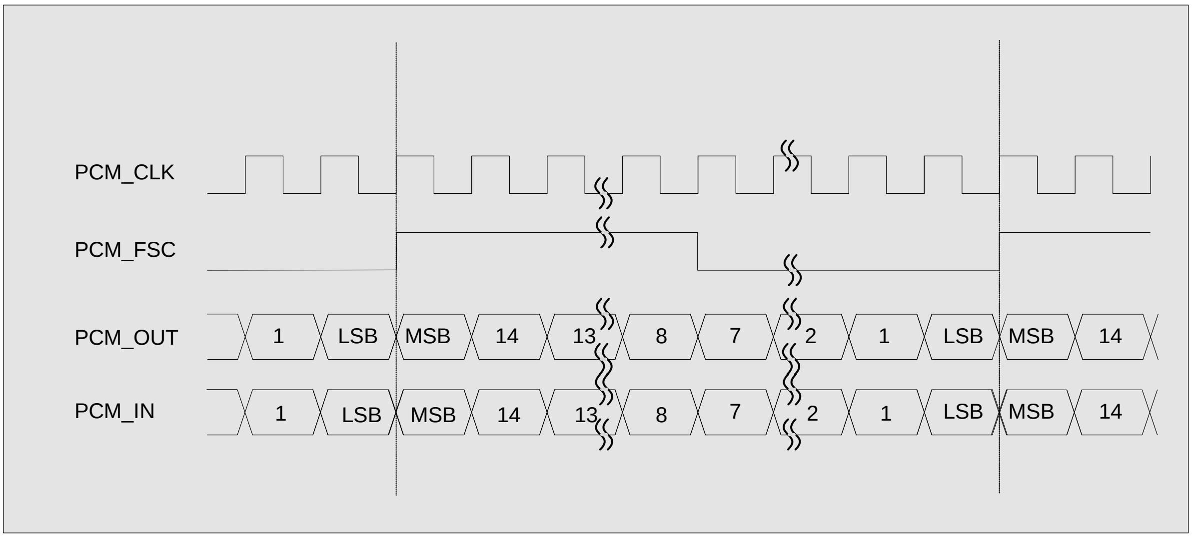


Figure 23: PCM timing long frame (master, 128kHz)

Please note that 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.

3.10.2 Inter IC Sound Interface (I^2S)

PHS8-P/PHS8-K'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 layed 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 I^{2}S interface is shown in Figure 24.

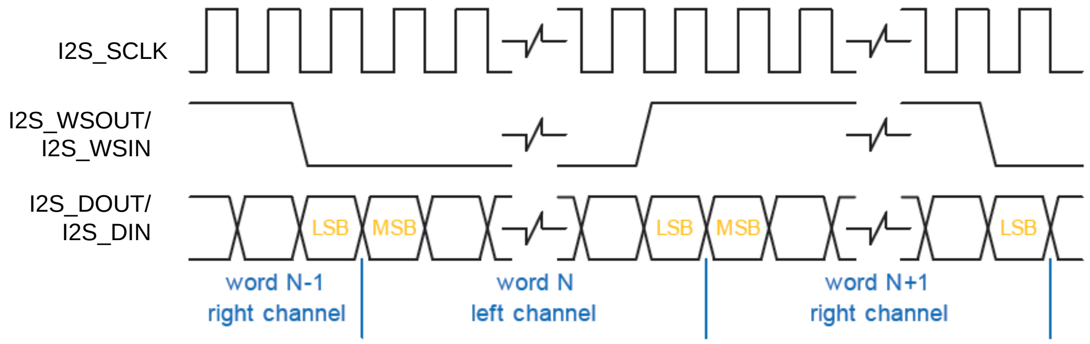


Figure 24: I^{2}S interface timing

The following signals will have to be connected by an external application, as shown in the below example of an external application with an I^{2}S codec:

- I2S_WSOUT and I2S_WSIN
- I2S_SCLKOUT and I2S_SCLKIN

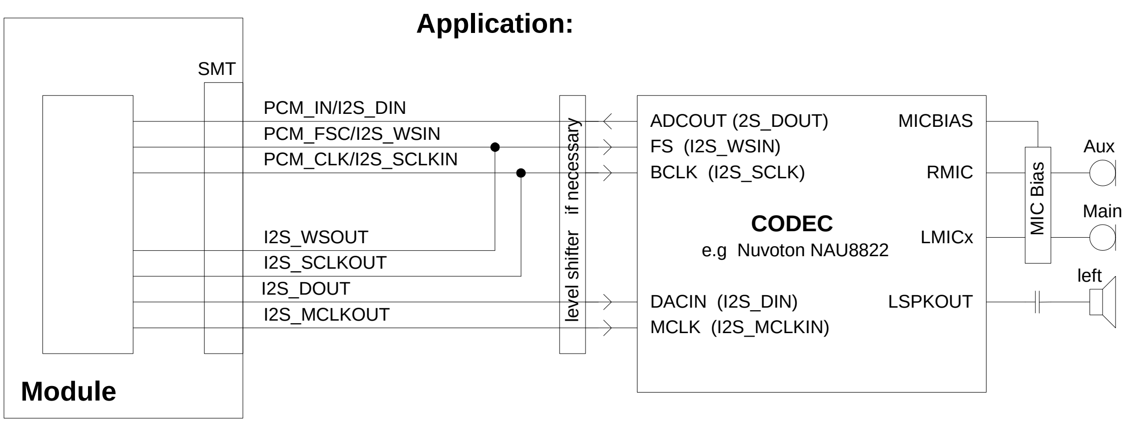


Figure 25: Dual microphone design example with I^{2}S interface

3.11 Control Signals

3.11.1 PWR_IND Signal

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

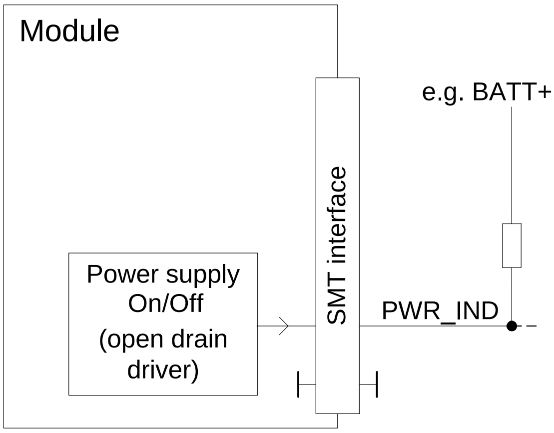


Figure 26: PWR_IND signal

3.11.2 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 27. To operate the LED a buffer, e.g. a transistor or gate, must be included in the external application.

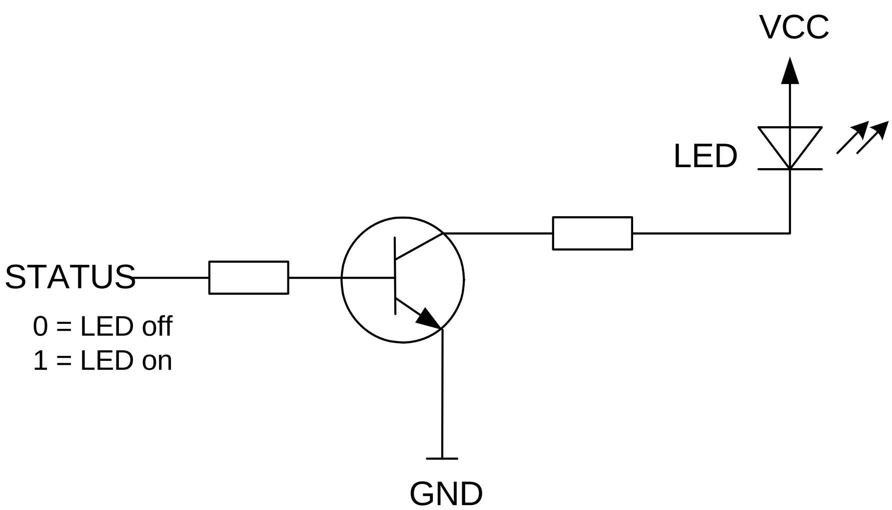


Figure 27: LED Circuit (Example)

For electrical characteristics of the STATUS line see Table 24. 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].

3.11.3 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 that if the RING0 line is not wired, the application would be 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.

3.11.4 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's, messages) arrives, the host can be notified of these events and be woken up again by a state transition of either the RING0 or the WAKEUP line.

The behaviour of these RING0 and WAKEUP lines as host wakeup lines has to be enabled and configured by AT command (see [1]: AT^SCFG). Possible states are listed in Table 16.

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 actice high transition: 0 = No wake up request 1 = The host shall wake up

3.11.5 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+

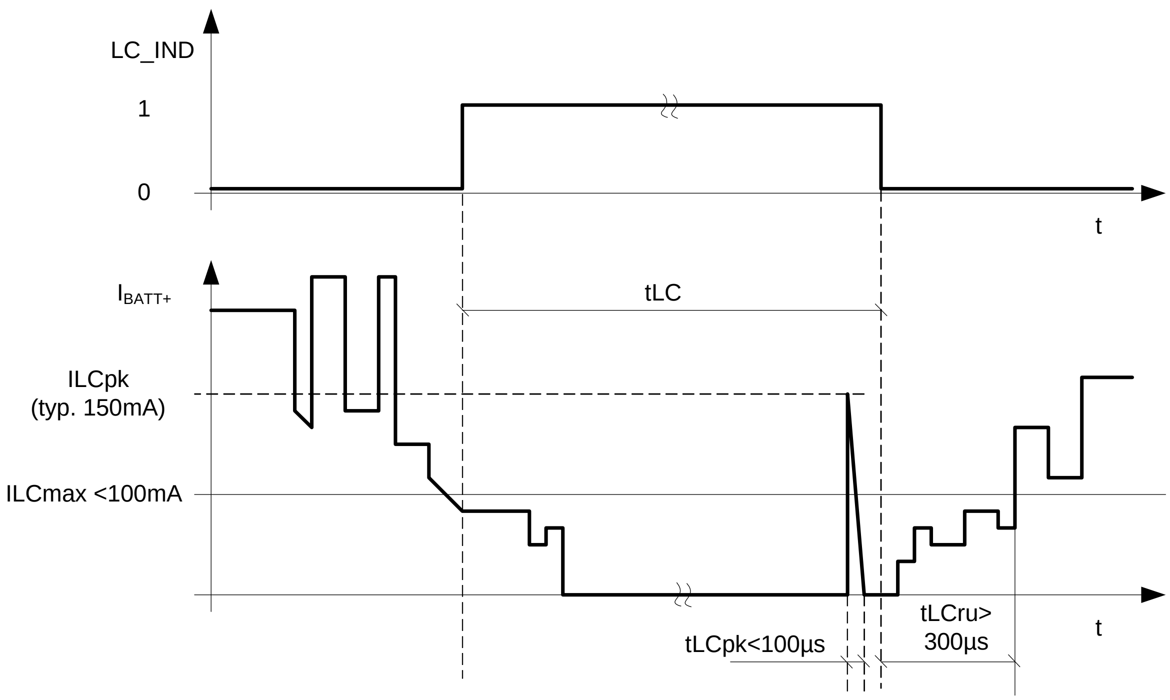
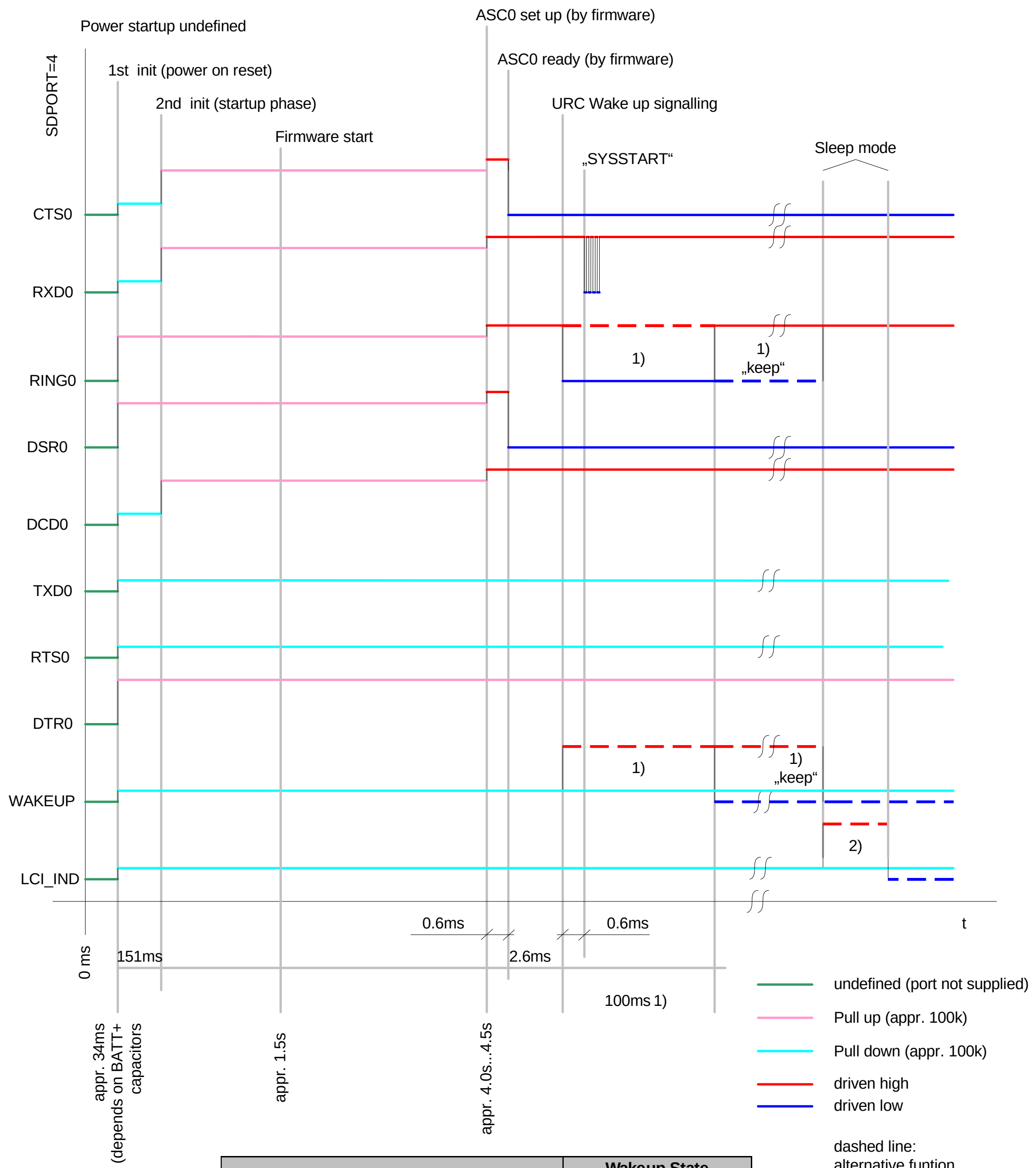


Figure 28: Low current indication timing

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.

3.11.6 RING0 (ASC0), WAKEUP and LCI_IND Startup Behavior

Table 29 shows the startup behavior of the control lines described in the above sections.



1)

Configuration		Wakeup State	
		RING0	**WAKEUP**
AT^SCFG="URC/Ringline",	"local" (P)	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" (P)	100ms
	"2"	1s
	"keep"	keeps active until 1st time enter sleep mode

(P) Power up default value

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

Figure 29: RING0 (ASC0), WAKEUP and LCI_IND startup behavior

4 GPS Receiver

PHS8-P/PHS8-K integrates a GPS receiver that offers the full performance of GPS technology. The GPS receiver is able to continuously track all satellites in view, thus providing accurate satellite position data.

The integrated GPS 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 GPS receivers. It has been defined and controlled by the US-based National Marine Electronics Association. For more information on the NMEA Standard please refer to http://www.nmea.org.

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

By default, the GPS receiver is switched off. It has to be switched on and configured using AT commands. For more information on how to control the GPS interface via the AT command AT^SGPSC see [1].

5 Antenna Interfaces

5.1 GSM/UMTS Antenna Interface

The PHS8-P/PHS8-K 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. PHS8-P/PHS8-K 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, modulation accuracy and harmonic suppression. Matching networks are not included on the PHS8-P/PHS8-K PCB and should be placed in the host application, if the antenna does not have an impedance of 50Ω.

Regarding the return loss PHS8-P/PHS8-K 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

5.1.1 Antenna Installation

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

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.

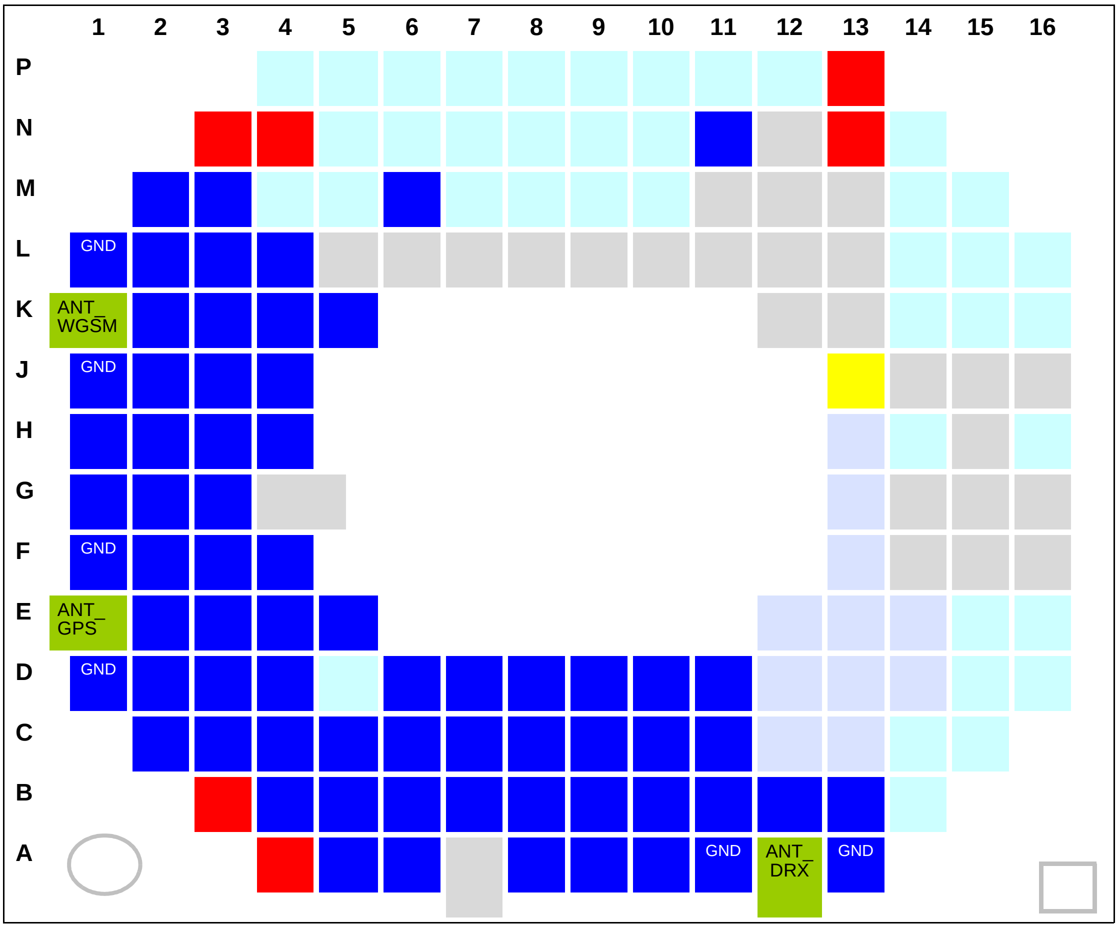


Figure 30: Antenna pads (bottom view)

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

The wiring of the antenna connection, starting from the antenna pad to the application's antenna should result in a 50Ω line impedance. Line width and distance to the GND plane need to be optimized with regard to the PCB's layer stack. Some examples are given in Section 5.1.2.

To prevent receiver desensitization due to interferences generated by fast transients like high speed clocks on the external application PCB, it is recommended to realize the antenna connection line using embedded Stripline rather than Micro-Stripline technology. Please see Section 5.1.2 for examples of how to design the antenna connection in order to achieve the required 50Ω line impedance.

For type approval purposes, the use of a 50Ω coaxial antenna connector (U.FL-R-SMT) might be necessary. In this case the U.FL-R-SMT connector should be placed as close as possible to PHS8-P/PHS8-K's antenna pad.

5.1.2 RF Line Routing Design

5.1.2.1 Line Arrangement Examples

Several dedicated tools are available to calculate line arrangements for specific applications and PCB materials - for example from http://www.polarinstruments.com/ (commercial software) or from http://web.awrcorp.com/Usa/Products/Optional-Products/TX-Line/ (free software).

Embedded Stripline
This below figure shows line arrangement examples for embedded stripline.

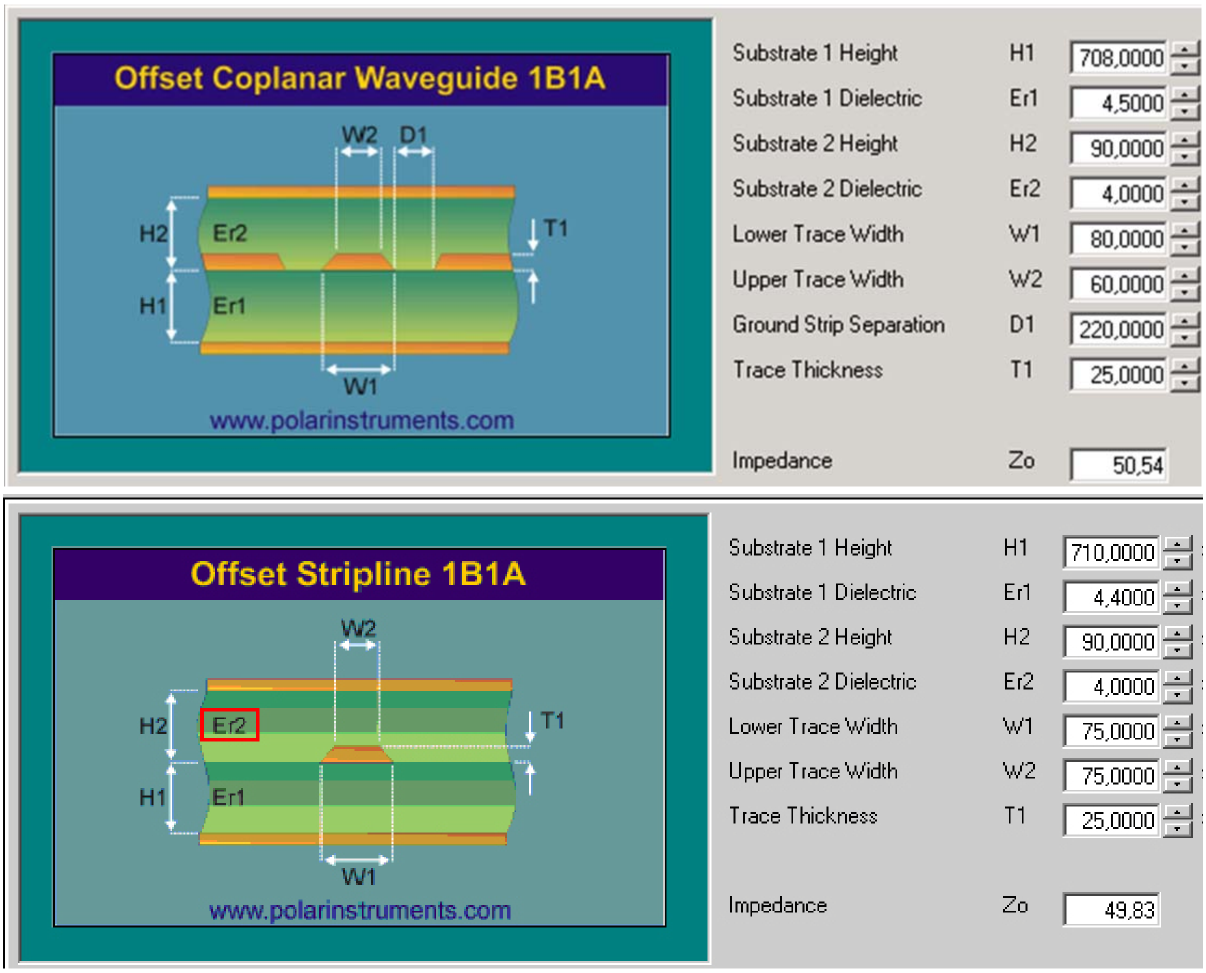


Figure 31: Embedded Stripline line arrangement

Micro-Stripline

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

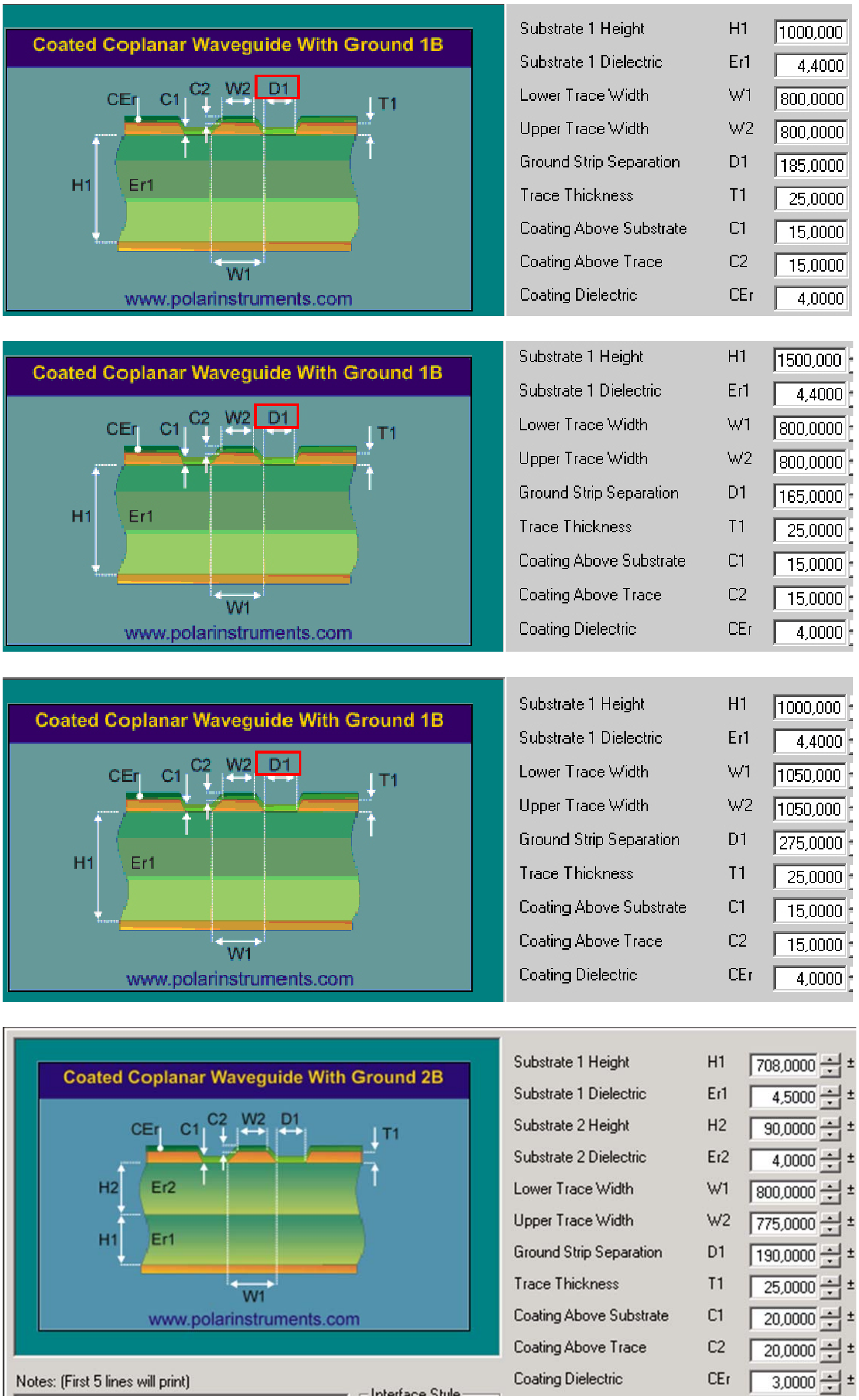


Figure 32: Micro-Stripline line arrangement samples

5.1.2.2 Routing Example

Interface to RF Connector

Figure 33 shows a sample connection of a module's antenna pad at the bottom layer of the module PCB with an application PCB's coaxial antenna connector. Line impedance depends on line width, but also on other PCB characteristics like dielectric, height and layer gap. The sample stripline width of 0.33mm is recommended for an application with a PCB layer stack resembling the one of the PHS8-P/PHS8-K evaluation board shown in Figure 34. For different layer stacks the stripline width will have to be adapted accordingly.

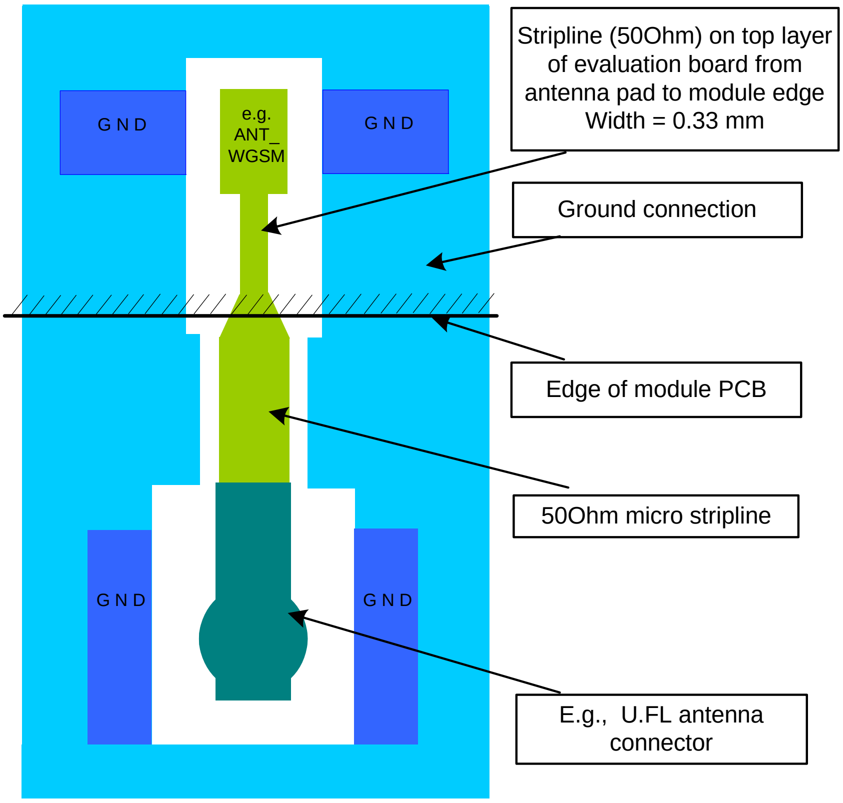


Figure 33: Routing to application's RF connector

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

Figure 34: PHS8-P/PHS8-K evaluation board layer table

5.2 GPS Antenna Interface

In addition to the RF antenna interface PHS8-P/PHS8-K also has a GPS antenna interface. The GPS antenna installation and connector are the same as for the RF antenna interface (see Section 5.1.1).

It is possible to connect active or passive GPS antennas. In either case they must have 50 Ohm impedance. The simultaneous operation of GSM and GPS has been implemented. For electrical characteristics see Section 6.9.

PHS8-P/PHS8-K provides the supply voltage VGPS for the GPS active antenna (3.05V). It has to be enabled by software when the GPS-receiver shall becomes active, otherwise VGPS should be off (power saving). VGPS is not short circuit protected. This will have to be provided for by an external application. The DC voltage should be fed back via ANT_GPS_DC for coupling into the GPS antenna path. Figure 35 shows the flexibility in realizing the power supply for an active GPS antenna by giving two sample circuits realizing the supply voltage for an active GPS antenna - one with short circuit protection and one with an external LDO employed.

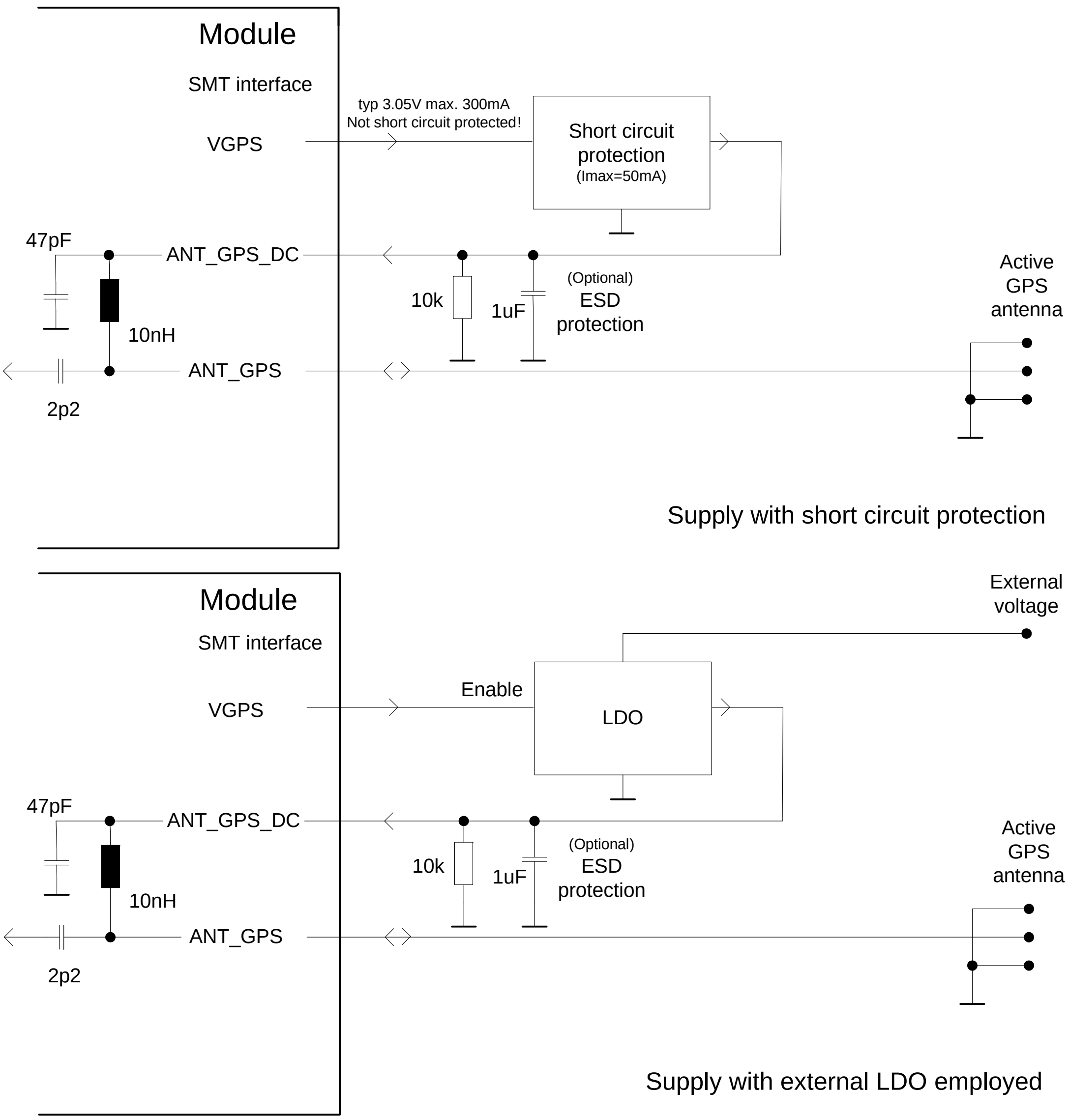


Figure 35: Supply voltage for active GPS antenna

Figure 36 shows sample circuits realizing ESD protection for a passive GPS antenna.

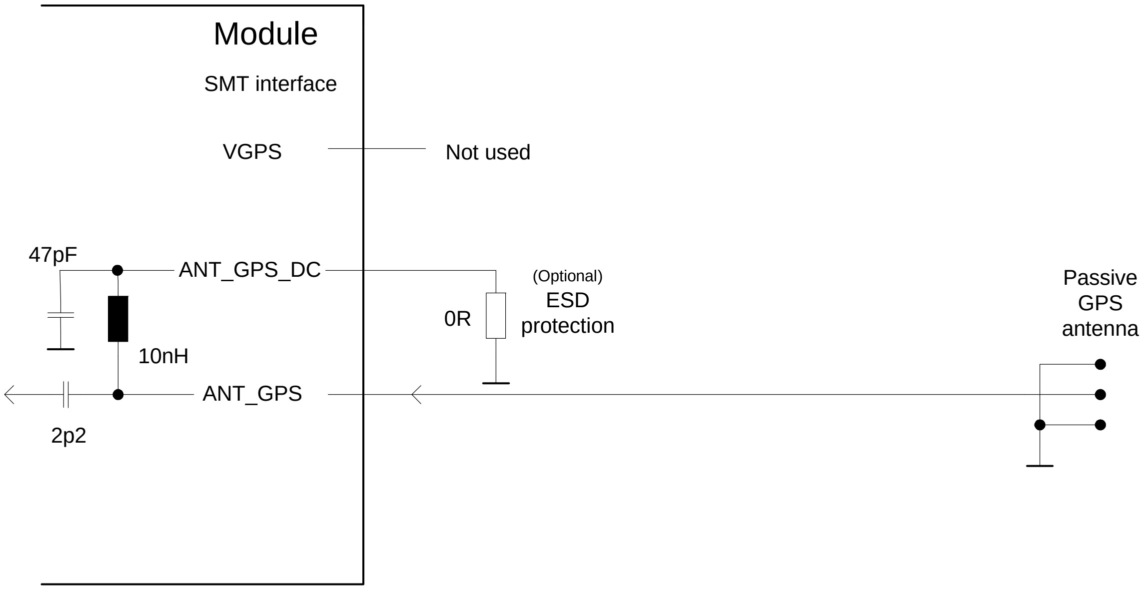


Figure 36: ESD protection for passive GPS antenna

6 Electrical, Reliability and Radio Characteristics

6.1 Absolute Maximum Ratings

The absolute maximum ratings stated in Table 19 are stress ratings under any conditions. Stresses beyond any of these limits will cause permanent damage to PHS8-P/PHS8-K.

Table 19: 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 2.85V 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	5.5	V
PWR_IND input current if PWR_IND= low		2	mA
Voltage at following signals: IGT, EMERG_OFF	-0.5	V_{BATT+}	V
GPS antenna supply VGPS		300	mA

6.2 Operating Temperatures

Table 20: 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 PHS8-P/PHS8-K 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.

For more information regarding the module's thermal behavior please refer to [4].

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 21: Storage conditions

Type	Condition	Unit	Reference
Humidity relative: Low High	10 90 at 40°C	%	IPC/JEDEC J-STD-033A
Air pressure: Low High	70 106	kPa	IEC TR 60271-3-1: 1K4 IEC TR 60271-3-1: 1K4
Movement of surrounding air	1.0	m/s	IEC TR 60271-3-1: 1K4
Water: rain, dripping, icing and frosting	Not allowed	---	---
Radiation: Solar Heat	1120 600	W/m^2	ETS 300 019-2-1: T1.2, IEC 60068-2-2 Bb ETS 300 019-2-1: T1.2, IEC 60068-2-2 Bb
Chemically active substances	Not 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 22: Summary of reliability test conditions

Type of test	Conditions	Standard
Vibration	Frequency range: 10-20Hz; acceleration: 5g Frequency range: 20-500Hz; acceleration: 20g Duration: 20h per axis; 3 axes	DIN IEC 60068-2-6[1]
Shock half-sinus	Acceleration: 500g Shock duration: 1msec 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 Pad Assignment and Signal Description

The SMT application interface on the PHS8-P/PHS8-K provides connecting pads to integrate the module into external applications. The following Table 23 lists the pads' assignments, Figure 37 (bottom view) and Figure 38 (top view) show the connecting pads' numbering plan.

Please note that a number of connecting pads are marked as reserved for future use (rfu) and further qualified as either (dnu) or (GND):
- Pads marked "rfu" and qualified as "dnu" (do not use) may be soldered but should not be connected to an external application.
- Pads marked "rfu" and qualified as "GND" (ground) are assigned to ground with PHS8-P/PHS8-K modules, but may have different assignments with future Cinterion products using the same pad layout.

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

Table 23: Overview: Pad assignments

Pad No.	Signal Name	Pad No.	Signal Name	Pad No.	Signal Name
A4	BATT+_WCDMA	E2	GND	L2	GND
A5	GND	E3	GND	L3	GND
A6	GND	E4	GND	L4	GND
A7	rfu (dnu)	E5	GND	L5	rfu (dnu)
A8	GND	E12	rfu (GND)	L6	rfu (dnu)
A9	GND	E13	rfu (GND)	L7	rfu (dnu)
A10	GND	E14	rfu (GND)	L8	rfu (dnu)
A11	GND	E15	EPP	L9	rfu (dnu)
A12	ANT_DRX	E16	EPN	L10	rfu (dnu)
A13	GND	F1	GND	L11	rfu (dnu)
B3	BATT+_WCDMA	F2	GND	L12	rfu (dnu)
B4	GND	F3	GND	L13	rfu (dnu)
B5	GND	F4	GND	L14	CCRST
B6	GND	F13	rfu (GND)	L15	CCCLK
B7	GND	F14	rfu (dnu)	L16	IGT
B8	GND	F15	rfu (dnu)	M2	GND
B9	GND	F16	rfu (dnu)	M3	GND
B10	GND	G1	GND	M4	PWR_IND
B11	GND	G2	GND	M5	VEXT
B12	GND	G3	GND	M6	GND
B13	GND	G4	rfu (dnu)	M7	PCM_IN/I2S_DIN
B14	STATUS	G13	rfu (GND)	M8	PCM_CLK/I2S_SCLKIN
C2	GND	G14	rfu (dnu)	M9	PCM_FSC/I2S_WSIN
C3	GND	G15	rfu (dnu)	M10	PCM_OUT
C4	GND	G16	rfu (dnu)	M11	rfu (dnu)
C5	GND	H1	GND	M12	rfu (dnu)
C6	GND	H2	GND	M13	rfu (dnu)
C7	GND	H3	GND	M14	CCIN
C8	GND	H4	GND	M15	VDDLP
C9	GND	H13	rfu (GND)	N3	BATT+_GSM
C10	GND	H14	WAKEUP	N4	BATT+_GSM
C11	GND	H15	rfu (dnu)	N5	VUSB_IN
C12	rfu (GND)	H16	LC_IND	N6	I2S_SCLKOUT
C13	rfu (GND)	J1	GND	N7	I2S_WSOUT
C14	VMIC	J2	GND	N8	CTS0
C15	AGND	J3	GND	N9	DCD0
D1	GND	J4	GND	N10	RTS0
D2	GND	J13	rfu (nc)	N11	GND
D3	GND	J14	rfu (dnu)	N12	rfu (dnu)
D4	GND	J15	rfu (dnu)	N13	BATT+
D5	ANT_GPS_DC	J16	rfu (dnu)	N14	EMERG_OFF
D6	GND	K1	ANT_WGSM	P4	USB_DP
D7	GND	K2	GND	P5	USB_DN
D8	GND	K3	GND	P6	I2S_MCLKOUT
D9	GND	K4	GND	P7	I2S_DOUT
D10	GND	K5	GND	P8	DTR0
D11	GND	K12	rfu (dnu)	P9	DSR0
D12	rfu (GND)	K13	rfu (dnu)	P10	RING0
D13	rfu (GND)	K14	CCIO	P11	RXD0
D14	rfu (GND)	K15	CCVCC	P12	TXD0
D15	MICP	K16	VGPS	P13	BATT+
D16	MICN	L1	GND		
E1	ANT_GPS				

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
P				USB_DP	USB_DN	I2S_ MCLK OUT	I2S_ DOUT	DTR0	DSR0	RING0	RXD0	TXD0	BATT+			
N			BATT+_ GSM	BATT+_ GSM	VUSB_I N	I2S_ SCLK- OUT	I2S_ WSOUT	CTS0	DCD0	RTS0	GND	rfu (dnu)	BATT+	EMERG_ OFF		
M		GND	GND	PWR_IND	VEXT	GND	PCM_IN / I2S_DIN	PCM_ CLK/ I2S_ SCLKIN	PCM_ FSC/ I2S_ WSIN	PCM_ OUT	rfu (dnu)	rfu (dnu)	rfu (dnu)	CCIN	VDDLP	
L	GND	GND	GND	GND	rfu (dnu)	rfu (dnu)	rfu (dnu)	rfu (dnu)	rfu (dnu)	rfu (dnu)	rfu (dnu)	rfu (dnu)	rfu (dnu)	CCRST	CCCLK	IGT
K	ANT_ WGSM	GND	GND	GND	GND							rfu (dnu)	rfu (dnu)	CCIO	CCVCC	VGPS
J	GND	GND	GND	GND									rfu (nc)	rfu (dnu)	rfu (dnu)	rfu (dnu)
H	GND	GND	GND	GND									rfu (GND)	WAKEUP	rfu (dnu)	LC_IND
G	GND	GND	GND	rfu (dnu)									rfu (GND)	rfu (dnu)	rfu (dnu)	rfu (dnu)
F	GND	GND	GND	GND									rfu (GND)	rfu (dnu)	rfu (dnu)	rfu (dnu)
E	ANT_ GPS	GND	GND	GND	GND							rfu (GND)	rfu (GND)	rfu (GND)	EPP	EPN
D	GND	GND	GND	GND	ANT_ GPS_DC	GND	GND	GND	GND	GND	GND	rfu (GND)	rfu (GND)	rfu (GND)	MICP	MICN
C		GND	GND	GND	GND	GND	GND	GND	GND	GND	GND	rfu (GND)	rfu (GND)	VMIC	AGND	
B			BATT+_ WCDMA	GND	GND	GND	GND	GND	GND	GND	GND	GND	GND	STATUS		
A				BATT+_ WCDMA	GND	GND	rfu (dnu)	GND	GND	GND	GND	ANT_ DRX	GND			

Position marker

For internal use: Not to be soldered

rfu = Reserved for future use

Figure 37: PHS8-P/PHS8-K bottom view: Pad assignments

	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
P				BATT+	TXD0	RXD0	RING0	DSR0	DTR0	I2S_ DOUT	I2S_ MCLK OUT	USB_DN	USB_DP			
N			EMERG_ OFF	BATT+	rfu (dnu)	GND	RTS0	DCD0	CTS0	I2S_ WSOUT	I2S_ SCLK- OUT	VUSB_IN	BATT+_ GSM	BATT+_ GSM		
M		VDDLP	CCIN	rfu (dnu)	rfu (dnu)	rfu (dnu)	PCM_ OUT	PCM_ FSC/ I2S_ WSIN	PCM_ CLK/ I2S_ SCLKIN	PCM_IN / I2S_DIN	GND	VEXT	PWR_IND	GND	GND	
L	IGT	CCCLK	CCRST	rfu (dnu)	rfu (dnu)	rfu (dnu)	rfu (dnu)	rfu (dnu)	rfu (dnu)	rfu (dnu)	rfu (dnu)	rfu (dnu)	GND	GND	GND	GND
K	VGPS	CCVCC	CCIO	rfu (dnu)	rfu (dnu)							GND	GND	GND	GND	ANT_ WGSM
J	rfu (dnu)	rfu (dnu)	rfu (dnu)	rfu (nc)									GND	GND	GND	GND
H	LC_IND	rfu (dnu)	WAKEUP	rfu (GND)									GND	GND	GND	GND
G	rfu (dnu)	rfu (dnu)	rfu (dnu)	rfu (GND)									rfu (dnu)	GND	GND	GND
F	rfu (dnu)	rfu (dnu)	rfu (dnu)	rfu (GND)									GND	GND	GND	GND
E	EPN	EPP	rfu (GND)	rfu (GND)	rfu (GND)							GND	GND	GND	GND	ANT_ GPS
D	MICN	MICP	rfu (GND)	rfu (GND)	rfu (GND)	GND	GND	GND	GND	GND	GND	ANT_ GPS_DC	GND	GND	GND	GND
C		AGND	VMIC	rfu (GND)	rfu (GND)	GND	GND	GND	GND	GND	GND	GND	GND	GND	GND	
B			STATUS	GND	GND	GND	GND	GND	GND	GND	GND	GND	GND	BATT+_ WCDMA		
A				GND	ANT_ DRX	GND	GND	GND	GND	rfu (dnu)	GND	GND	BATT+_ WCDMA			

For internal use: Not to be soldered

Position marker

rfu = Reserved for future use

Figure 38: PHS8-P/PHS8-K top view: Pad assignments

Please note that the reference voltages listed in Table 24 are the values measured directly on the PHS8-P/PHS8-K module. They do not apply to the accessories connected.

Table 24: Signal description

Function	Signal name	IO	Signal form and level	Comment
Power supply	BATT+_GSM	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.
	BATT+_WCDMA	I	$V_I$max = 4.2V $V_I$norm = 3.8V $V_I$min = 3.3V during Tx burst on board Imax = 800mA during Tx	
	BATT+	I	$V_I$max = 4.2V $V_I$norm = 3.8V $V_I$min = 3.3V during Tx burst on board Imax = 250mA	
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.
Supply voltage for active GPS antenna (Output)	VGPS	O	CLmax = 2.2µ V_O = 3.05V ±1% @I_O = -20mA $I_O$max = -50mA	Available if GPS antenna DC power is enabled (configurable by AT command; see Section 6.9).
Supply voltage for active GPS antenna (Input)	ANT_GPS_DC	I	$V_I$max = 6V The input curren has to be limited at 50mA (antenna short circuit protection)	If unused connect to GND.
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.

Table 24: Signal description

Function	Signal name	IO	Signal form and level	Comment
Emer-gency 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 fea-ture the VDDLP line has to supplied for at least 2 sec-onds after a possible power loss (e.g., by connecting a 10µF capacitor). See also Section 3.3.6.
		I	V_I = 1.5V…3.25V at I_{max}= 10µA while BATT+ = 0V	
Connectiv-ity 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 signalling e.g. with ext. LED circuit
SIM Card detection	CCIN	I	R_{PU} ≈ 110kΩ 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. If unused connect to GND.

Table 24: Signal description

Function	Signal name	IO	Signal form and level	Comment
3V SIM Card Interface	CCRST	O	$V_{OL}max$ = 0.45V at I = 1mA $V_{OH}min$ = 2.40V at I = -1mA $V_{OH}max$ = 2.9V	Maximum cable length or copper track should be not longer than 100mm to SIM card holder.
	CCIO	I/O	$R_{PU} \approx 47k\Omega$ $V_{IL}max$ = 1V $V_{IL}min$ = -0.3V $V_{IH}min$ = 1.85V $V_{IH}max$ = 3.2V $V_{OL}max$ = 0.45V at I = 1mA $V_{OH}min$ = 2.3V at I = -0.1mA $V_{OH}max$ = 2.9V	
	CCCLK	O	$V_{OL}max$ = 0.45V at I = 1mA $V_{OH}min$ = 2.40V at I = -1mA $V_{OH}max$ = 2.9V	
	CCVCC	O	$V_{O}min$ = 2.8V $V_{O}typ$ =2.85V $V_{O}max$ = 2.9V $I_{O}max$ = -50mA	
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	$R_{I} \approx 47k\Omega$ $V_{IL}max$ = 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	
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		

Table 24: Signal description

Function	Signal name	IO	Signal form and level	Comment
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 3.10.1. 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	VOLmax = 0.45V at I = 2mA VOHmin = 1.35V at I = -2mA VOHmax = 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 3.10.2: PCM_IN --> I2S_DIN PCM_CLK --> I2S_SCLKIN PCM_FSC --> I2S_WSIN
	I2S_DOUT	O		
	I2S_WSOUT	O		
	I2S_SCLKOUT	O		

Table 24: Signal description

Function	Signal name	IO	Signal form and level	Comment
Power Indicator	PWR_IND	O	V_{IH}max = 5.5V 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)	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 3.11.4)[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 3.11.5)[1].
		I	V_{IH}max = 2V R_{PD}= appr. 100kOhm	If the function is disabled (see Section 3.11.5)[1].

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

6.6 Power Supply Ratings

Table 25: Power 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}
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 (GPS 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			290	390[4]	mA
		GPRS Data transfer GSM850/900; PCL=5; 1Tx/4Rx	ROPR=8 (max. reduction)		285		mA
			ROPR=4 (no reduction)		285		mA
		GPRS Data transfer GSM850/900; PCL=5; 2Tx/3Rx	ROPR=8 (max. reduction)		375		mA
			ROPR=4 (no reduction)		510		mA
		GPRS Data transfer GSM850/900; PCL=5; 4Tx/1Rx	ROPR=8 (max. reduction)		490		mA
			ROPR=4 (no reduction)		860	980[4]	mA

Table 25: Power supply ratings

	Description	Conditions		Min	Typ	Max	Unit
I_{BATT+} [1]	Average GSM / GPRS supply current (GPS off)	EDGE Data transfer GSM850/900; PCL=5; 1Tx/4Rx	ROPR=8 (max. reduction)		185		mA
			ROPR=4 (no reduction)		185		mA
		EDGE Data transfer GSM850/900; PCL=5; 2Tx/3Rx	ROPR=8 (max. reduction)		240		mA
			ROPR=4 (no reduction)		290		mA
		EDGE Data transfer GSM850/900; PCL=5; 4Tx/1Rx	ROPR=8 (max. reduction)		275		mA
			ROPR=4 (no reduction)		470		mA
		Voice Call GSM1800/1900; PCL=0			205	270[4]	mA
		GPRS Data transfer GSM1800/1900; PCL=0; 1Tx/4Rx	ROPR=8 (max. reduction)		195		mA
			ROPR=4 (no reduction)		195		mA
		GPRS Data transfer GSM1800/1900; PCL=0; 2Tx/3Rx	ROPR=8 (max. reduction)		255		mA
			ROPR=4 (no reduction)		305		mA
		GPRS Data transfer GSM1800/1900; PCL=0; 4Tx/1Rx	ROPR=8 (max. reduction)		330		mA
			ROPR=4 (no reduction)		505	650[4]	mA
		EDGE Data transfer GSM1800/1900; PCL=0; 1Tx/4Rx	ROPR=8 (max. reduction)		160		mA
			ROPR=4 (no reduction)		160		mA
		EDGE Data transfer GSM1800/1900; PCL=0; 2Tx/3Rx	ROPR=8 (max. reduction)		210		mA
			ROPR=4 (no reduction)		230		mA
		EDGE Data transfer GSM1800/1900; PCL=0; 4Tx/1Rx	ROPR=8 (max. reduction)		275		mA
			ROPR=4 (no reduction)		360		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			1.1	1.8[4]	A
	Average GSM / GPS supply current (GPS on)	GSM active (UART/USB active); @DRX=2 & GPS NMEA output off			46		mA
		GSM active (UART/USB active); @DRX=2 & GPS NMEA output on[5]			75		mA

Table 25: Power supply ratings

	Description	Conditions	Min	Typ	Max	Unit
I_{BATT+}[1]	Average WCDMA supply current (GPS 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		555		mA
		Voice Call Band II; 24dBm		685	770[4]	mA
		Voice Call Band V/VI; 24dBm		580		mA
		Voice Call Band VIII; 24dBm		625	710[4]	mA
		UMTS Data transfer Band I @+24dBm		545		mA
		UMTS Data transfer Band II @+24dBm		675		mA
		UMTS Data transfer Band V/VI @+24dBm		575		mA
		UMTS Data transfer Band VIII @+24dBm		615		mA
		HSPA Data transfer Band I @+24dBm		590		mA
		HSPA Data transfer Band II @+24dBm		700	800[4]	mA
		HSPA Data transfer Band V/VI @+24dBm		600		mA
		HSPA Data transfer Band VIII @+24dBm		635	740[4]	mA
	Average WCDMA/ GPS supply current (GPS on)	WCDMA active (UART / USB active); @DRX=6 & GPS NMEA output off		46		mA
		WCDMA active (UART / USB active); @DRX=6 & GPS NMEA output on[5]		75		mA
I_{VUSB_IN}	USB suspend and active ratings are mentioned in Table 24: VUSB_IN.					

1. With an impedance of Z_{LOAD}=50Ohm 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 neighbour 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.

6.7 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 26: 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 I^{2}S) is selected, the parameters <micAmp1>, <micAmp2> and <cdcRxGain> have no influence; because they are not involved in the signal paths.

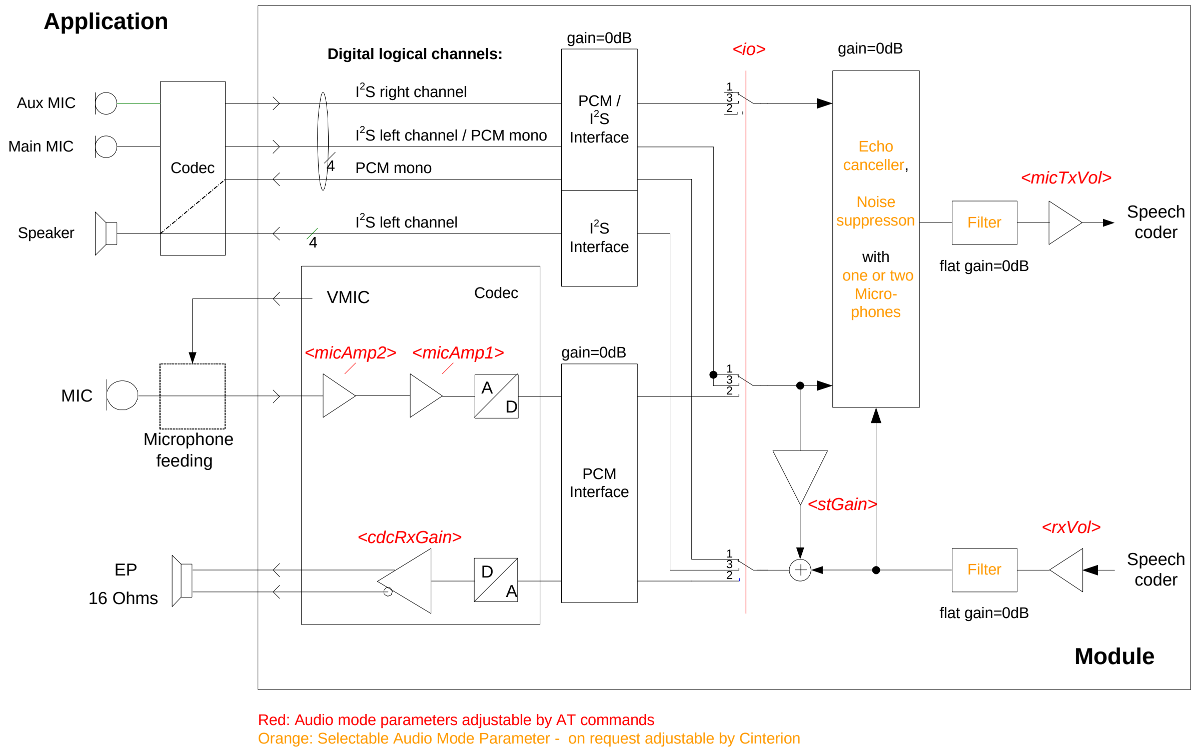


Figure 39: Audio programming model

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 27: 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 27: 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	15mV	650mV	15mV	12mV	5mV	420mV	n.a.	n.a.
EP output signal in mV rms. @ 0dBm0, 1024 Hz, no load (default gain) / @ 3.14 dBm0	465mV 2.1Vpp	512mV 2.1Vpp	465mV 2.1Vpp	370mV 1.6Vpp	1485mV 5.7Vpp	1290mV 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 28: 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 29: 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 1.5dB 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 30: RF Antenna interface GSM / UMTS

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

Table 30: RF Antenna interface GSM / UMTS

Parameter		Conditions	Min.	Typical	Max.	Unit
RF Power @ ARP with 50Ohm 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 50Ohm 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 30: RF Antenna interface GSM / UMTS

Parameter		Conditions	Min.	Typical	Max.	Unit
RF Power @ ARP with 50Ohm 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 50Ohm 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 30: RF Antenna interface GSM / UMTS

Parameter		Conditions	Min.	Typical	Max.	Unit
RF Power @ ARP with 50Ohm 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 .

6.9 GPS Interface Characteristics

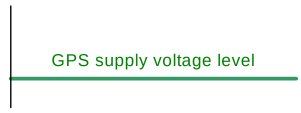
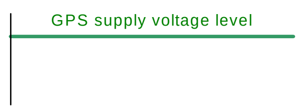
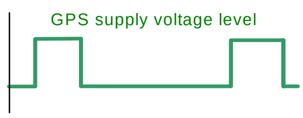
The following tables list general characteristics of the GPS interface.

Table 31: GPS properties

Parameter	Conditions	Min.	Typical	Max.	Unit
Frequency	GPS		1575.42		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			-145		dBm
Time-to-First-Fix (TTFF)	Cold		25	32	s
	Warm		10	29	s

Through the external GPS antenna DC feeding the module is able to supply an active GPS antenna. The supply voltage level at the GPS antenna interface depends on the GPS configuration done with AT^SGPSC as shown in Table 32.

Table 32: Power supply for active GPS antenna

Function	Setting samples	IO	Signal form and level
GPS active antenna supply	Supply voltage with: GPS receiver off Active antenna off	O	
	Supply voltage with[1]: GPS receiver on Active antenna on SLEEP mode	O	
	Supply voltage with[2]: GPS receiver on Active antenna auto	O	

1. Same behavior if GPS active antenna set to auto and AT^SGPSC="NMEA/Freq",x with x ≤ 4
2. 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 PHS8-P/PHS8-K module.

Special ESD protection provided on PHS8-P/PHS8-K*:*
All antenna interfaces: Inductor/capacitor
BATT+: Inductor/capacitor
An example for an enhanced ESD protection for the SIM interface is shown in Section 3.8.1.

The remaining interfaces of PHS8-P/PHS8-K 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.

PHS8-P/PHS8-K has been tested according to the following standards. Electrostatic values can be gathered from the following table.

Table 33: Electrostatic values

Specification / Requirements	Contact discharge	Air discharge
JEDEC JESD22-A114D		
All SMT interfaces	± 1kV Human Body Model	n.a.
ETSI EN 301 489-1/7		
All antenna interfaces (GSM/UMTS/GPS)	± 4kV	± 8kV
BATT+	± 4kV	± 8kV

Note: Please note that the values may vary with the individual application design. For example, it matters whether or not the application platform is grounded over external devices like a computer or other equipment, such as the Cinterion Wireless Modules reference application described in Chapter 9.

7 Mechanics, Mounting and Packaging

7.1 Mechanical Dimensions of PHS8-P/PHS8-K

Figure 40 shows a 3D view[1] of PHS8-P/PHS8-K and provides an overview of the board's mechanical dimensions. For further details see Figure 41.
Length: 33mm
Width: 29mm
Height: 2mm

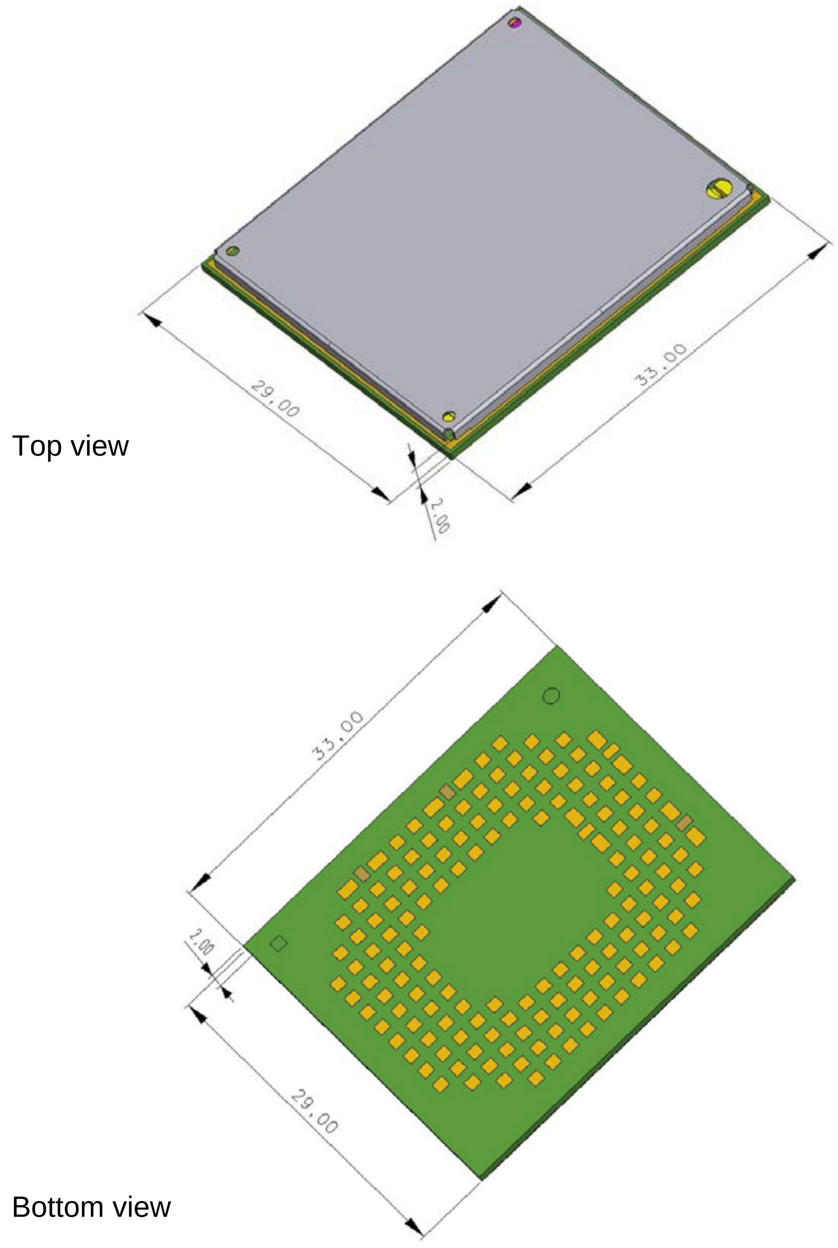


Figure 40: PHS8-P/PHS8-K – top and bottom view

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

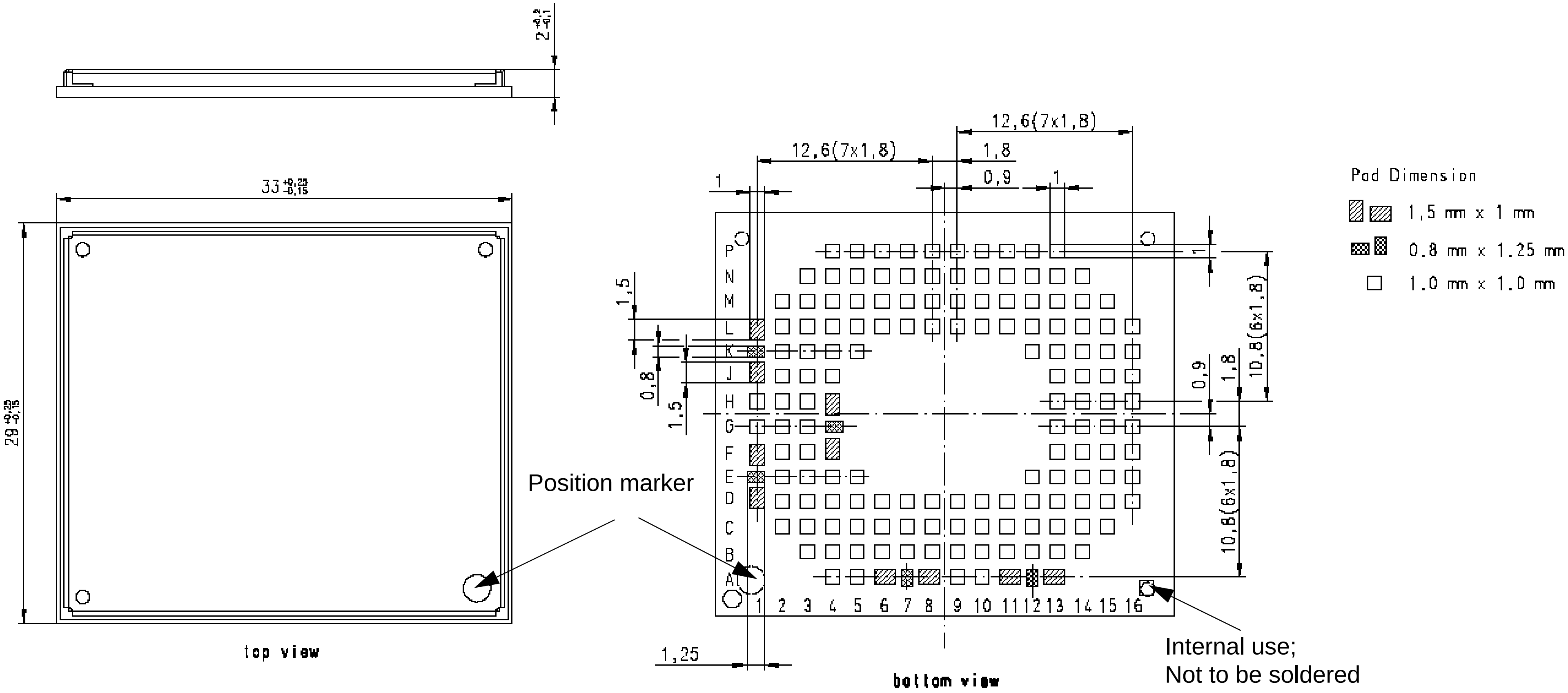


Figure 41: Dimensions of PHS8-P/PHS8-K (all dimensions in mm)

7.2 Mounting PHS8-P/PHS8-K onto the Application Platform

This section describes how to mount PHS8-P/PHS8-K onto the PCBs (=printed circuit boards), including land pattern and stencil design, board-level characterization, soldering conditions, durability and mechanical handling. For more information on issues related to SMT module integration see also [5].

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

7.2.1 SMT PCB Assembly

7.2.1.1 Land Pattern and Stencil

The land pattern and stencil design as shown below is based on Cinterion characterizations for lead-free solder paste on a four-layer test PCB and a 110 respectively 150 micron-thick stencil.

The land pattern given in Figure 42 reflects the module's pad layout, including signal pads and ground pads (for pad assignment see Section 6.5). Besides these pads there are ground areas on the module's bottom side that must not be soldered, e.g., the position marker. To prevent short circuits, it has to be ensured that there are no wires on the external application side that may connect to these module ground areas.

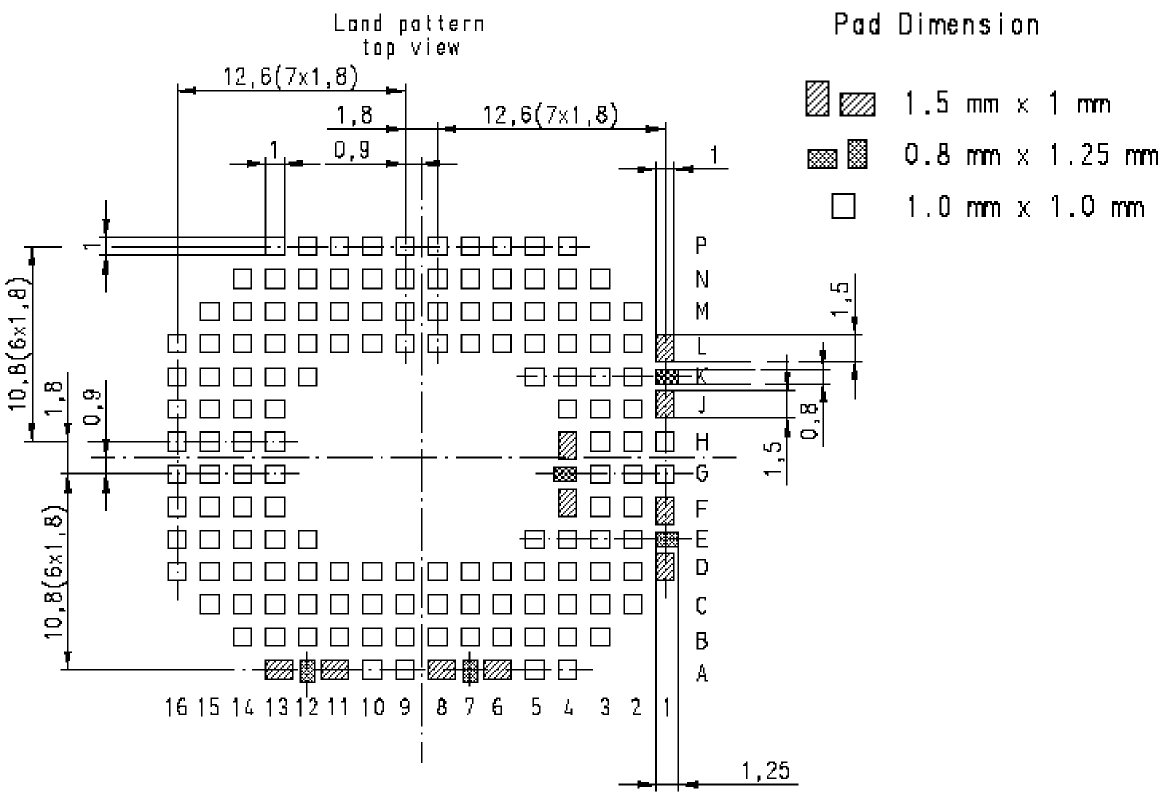


Figure 42: Land pattern (top layer)

The stencil design illustrated in Figure 43 and Figure 44 is recommended by Cinterion as a result of extensive tests with Cinterion Daisy Chain modules.

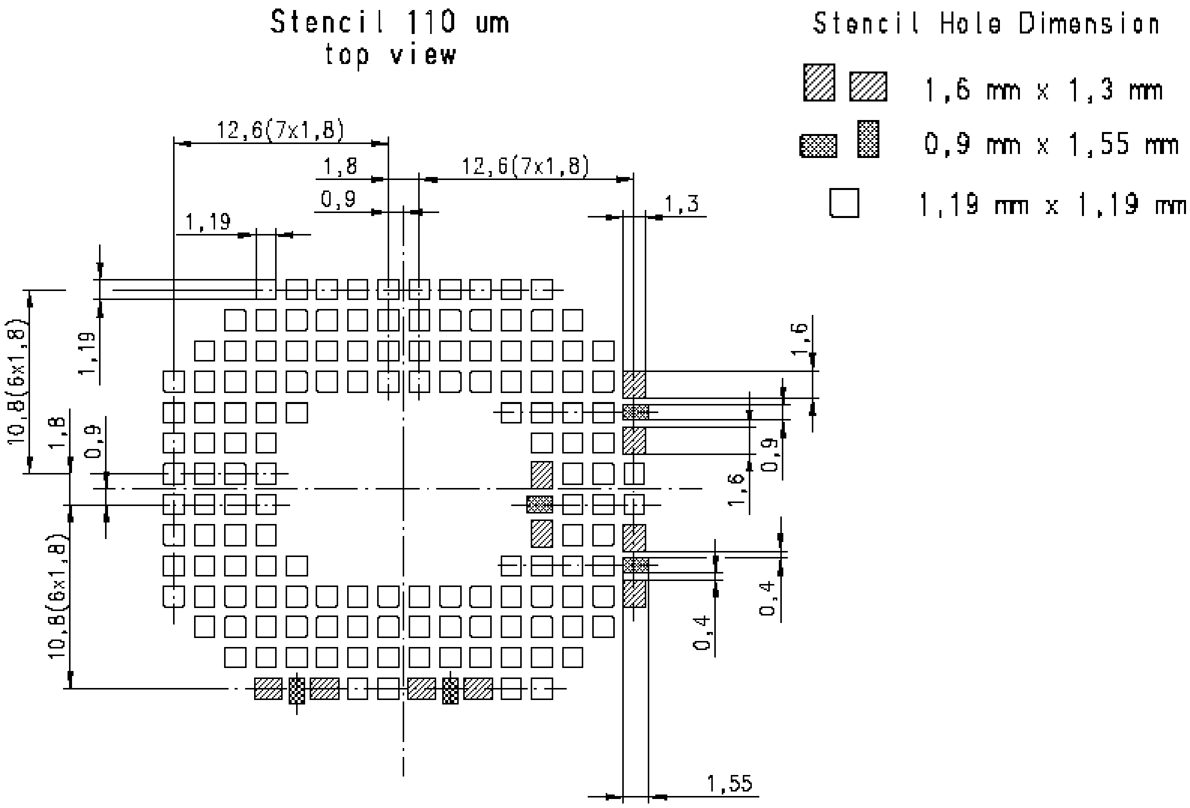


Figure 43: Recommended design for 110 micron thick stencil (top layer)

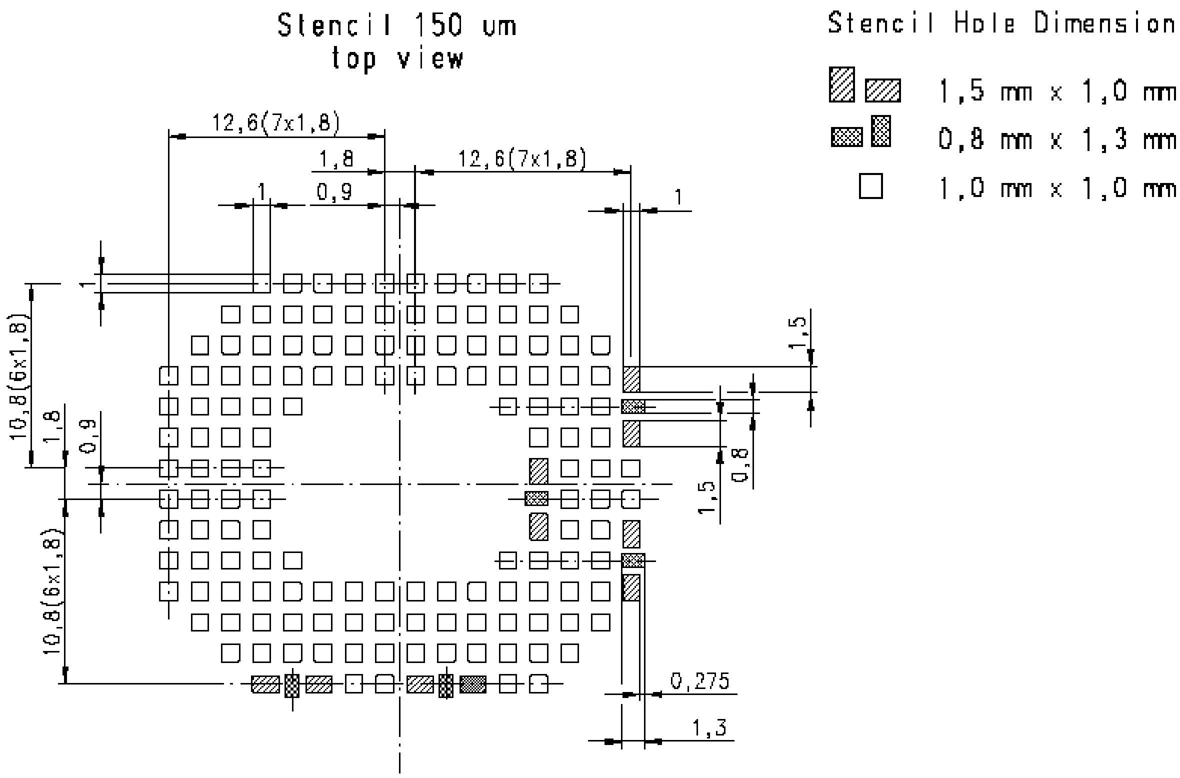


Figure 44: Recommended design for 150 micron thick stencil (top layer)

7.2.1.2 Board Level Characterization

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

Characterization tests should attempt to optimize the SMT process with regard to board level reliability. This can be done by performing the following physical tests on sample boards: Peel test, bend test, tensile pull test, drop shock test and temperature cycling. Sample surface mount checks are described in [5].

It is recommended to characterize land patterns before an actual PCB production, taking individual processes, materials, equipment, stencil design, and reflow profile into account. For land and stencil pattern design recommendations see also Section 7.2.1.1. Optimizing the solder stencil pattern design and print process is necessary to ensure print uniformity, to decrease solder voids, and to increase board level reliability.

Daisy chain modules for SMT characterization are available on request. For details refer to [5].

Generally, solder paste manufacturer recommendations for screen printing process parameters and reflow profile conditions should be followed. Maximum ratings are described in Section 7.2.3.

7.2.2 Moisture Sensitivity Level

PHS8-P/PHS8-K comprises components that are susceptible to damage induced by absorbed moisture.

Cinterion's PHS8-P/PHS8-K module complies with the latest revision of the IPC/JEDEC J-STD-020 Standard for moisture sensitive surface mount devices and is classified as MSL 4.

For additional MSL (=moisture sensitivity level) related information see Section 7.2.4 and Section 7.3.2.

7.2.3 Soldering Conditions and Temperature

7.2.3.1 Reflow Profile

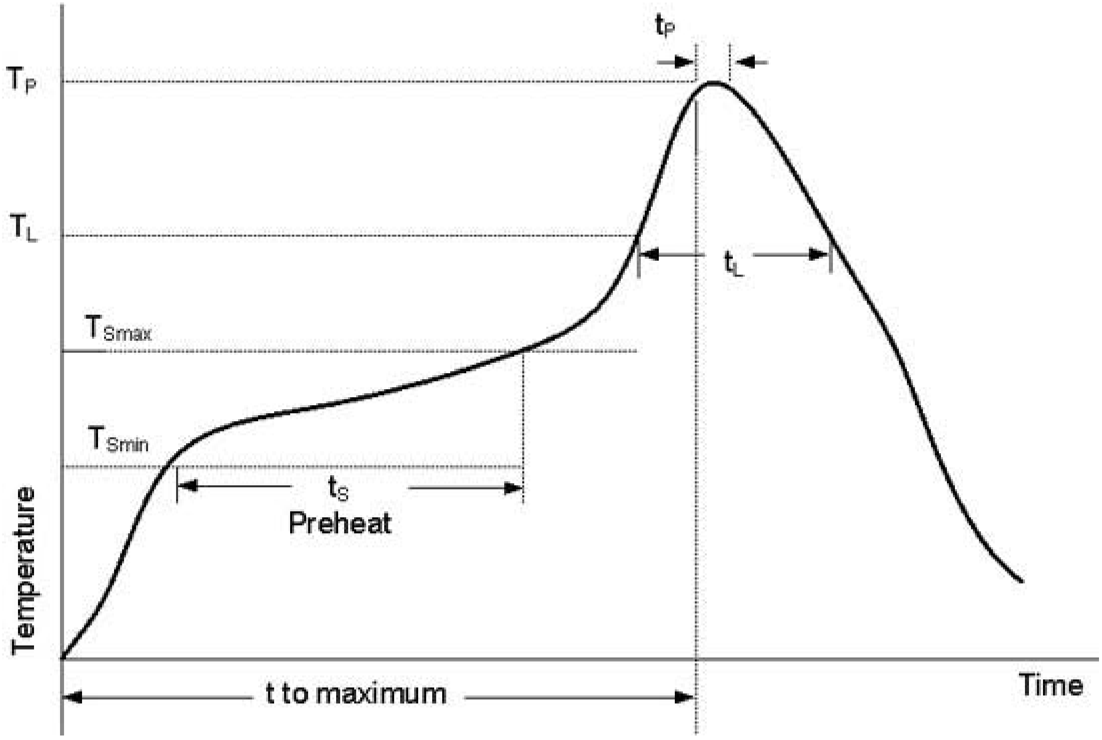


Figure 45: Reflow Profile

Table 34: Reflow temperature ratings

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

7.2.3.2 Maximum Temperature and Duration

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

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

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

PHS8-P/PHS8-K is specified for one soldering cycle only.Once PHS8-P/PHS8-K is removed from the application, the module will very likely be destroyed and cannot be soldered onto another application.

7.2.4 Durability and Mechanical Handling

7.2.4.1 Storage Life

PHS8-P/PHS8-K modules, as delivered in tape and reel carriers, must be stored in sealed, moisture barrier anti-static bags. The shelf life in a sealed moisture bag is an estimated 12 month. However, such a life span requires a non-condensing atmospheric environment, ambient temperatures below 40°C and a relative humidity below 90%. Additional storage conditions are listed in Table 24.

7.2.4.2 Processing Life

PHS8-P/PHS8-K must be soldered to an application within 72 hours after opening the MBB (=moisture barrier bag) it was stored in.

As specified in the IPC/JEDEC J-STD-033 Standard, the manufacturing site processing the modules should have ambient temperatures below 30°C and a relative humidity below 60%.

7.2.4.3 Baking

Baking conditions are specified on the moisture sensitivity label attached to each MBB (see Figure 50 for details):
- It is *not necessary* to bake PHS8-P/PHS8-K, if the conditions specified in Section 7.2.4.1 and Section 7.2.4.2 were not exceeded.
- It is *necessary* to bake PHS8-P/PHS8-K, if any condition specified in Section 7.2.4.1 and Section 7.2.4.2 was exceeded.

If baking is necessary, the modules must be put into trays that can be baked to at least 125°C. Devices should not be baked in tape and reel carriers at any temperature.

7.2.4.4 Electrostatic Discharge

ESD (=electrostatic discharge) may lead to irreversible damage for the module. It is therefore advisable to develop measures and methods to counter ESD and to use these to control the electrostatic environment at manufacturing sites.

Please refer to Section 6.10 for further information on electrostatic discharge.

7.3 Packaging

7.3.1 Tape and Reel

The single-feed tape carrier for PHS8-P/PHS8-K is illustrated in Figure 46. The figure also shows the proper part orientation. The tape width is 44mm and the PHS8-P/PHS8-K modules are placed on the tape with a 40mm pitch. The reels are 330mm in diameter with 100mm hubs. Each reel contains 500 modules.

7.3.1.1 Orientation

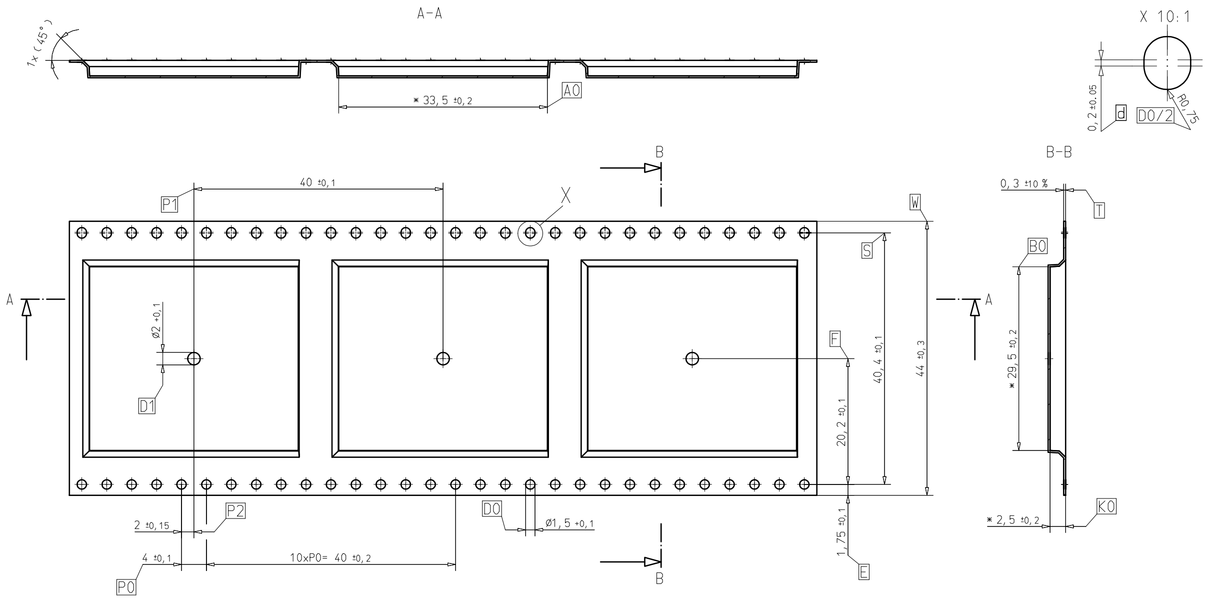


Figure 46: Carrier tape

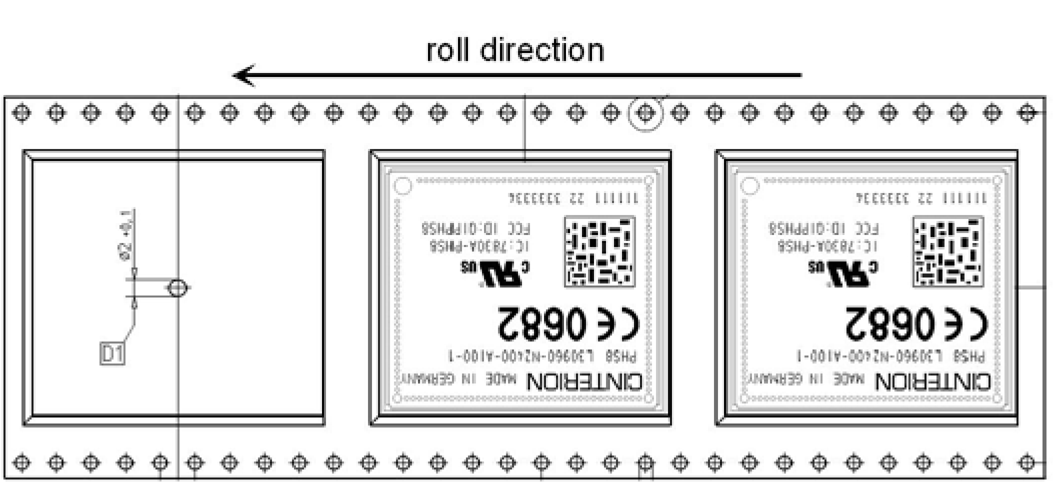


Figure 47: Roll direction

7.3.1.2 Barcode Label

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

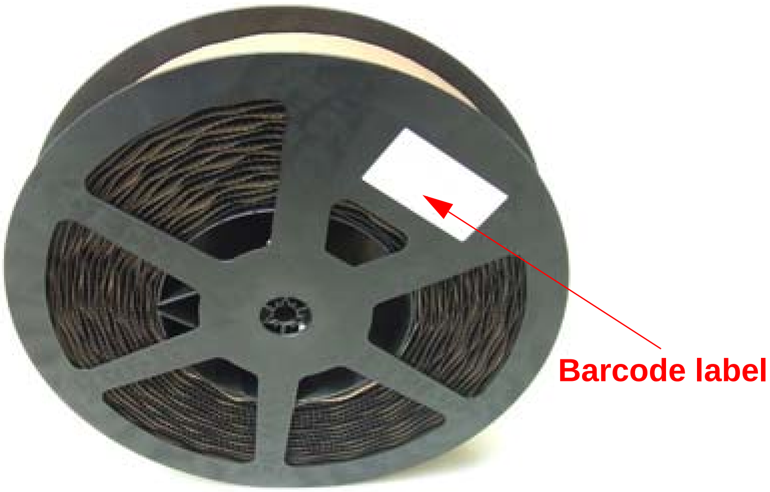


Figure 48: Barcode label on tape reel

7.3.2 Shipping Materials

PHS8-P/PHS8-K is distributed in tape and reel carriers. The tape and reel carriers used to distribute PHS8-P/PHS8-K are packed as described below, including the following required shipping materials:
- Moisture barrier bag, including desiccant and humidity indicator card
- Transportation bag

7.3.2.1 Moisture Barrier Bag

The tape reels are stored inside an MBB (=moisture barrier bag), together with a humidity indicator card and desiccant pouches - see Figure 49. The bag is ESD protected and delimits moisture transmission. It is vacuum-sealed and should be handled carefully to avoid puncturing or tearing. The bag protects the PHS8-P/PHS8-K modules from moisture exposure. It should not be opened until the devices are ready to be soldered onto the application.

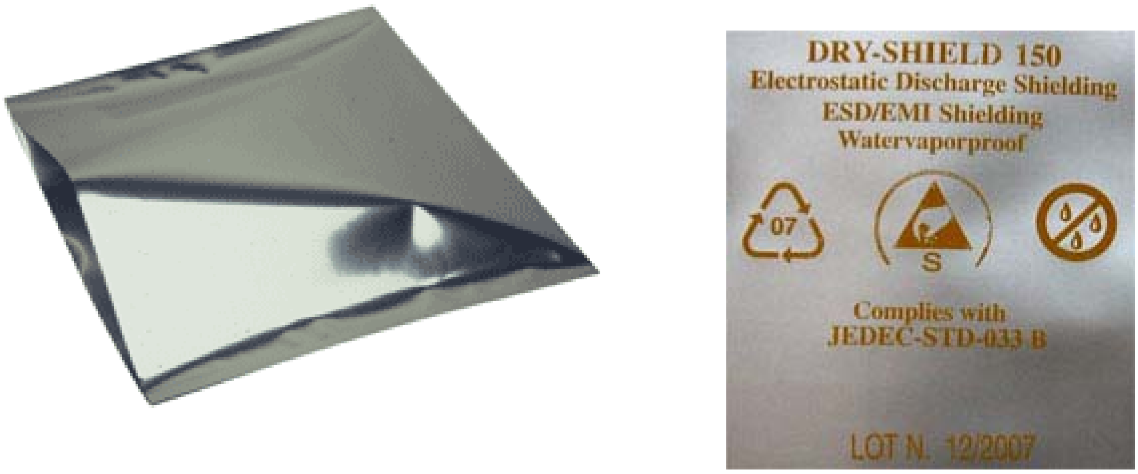
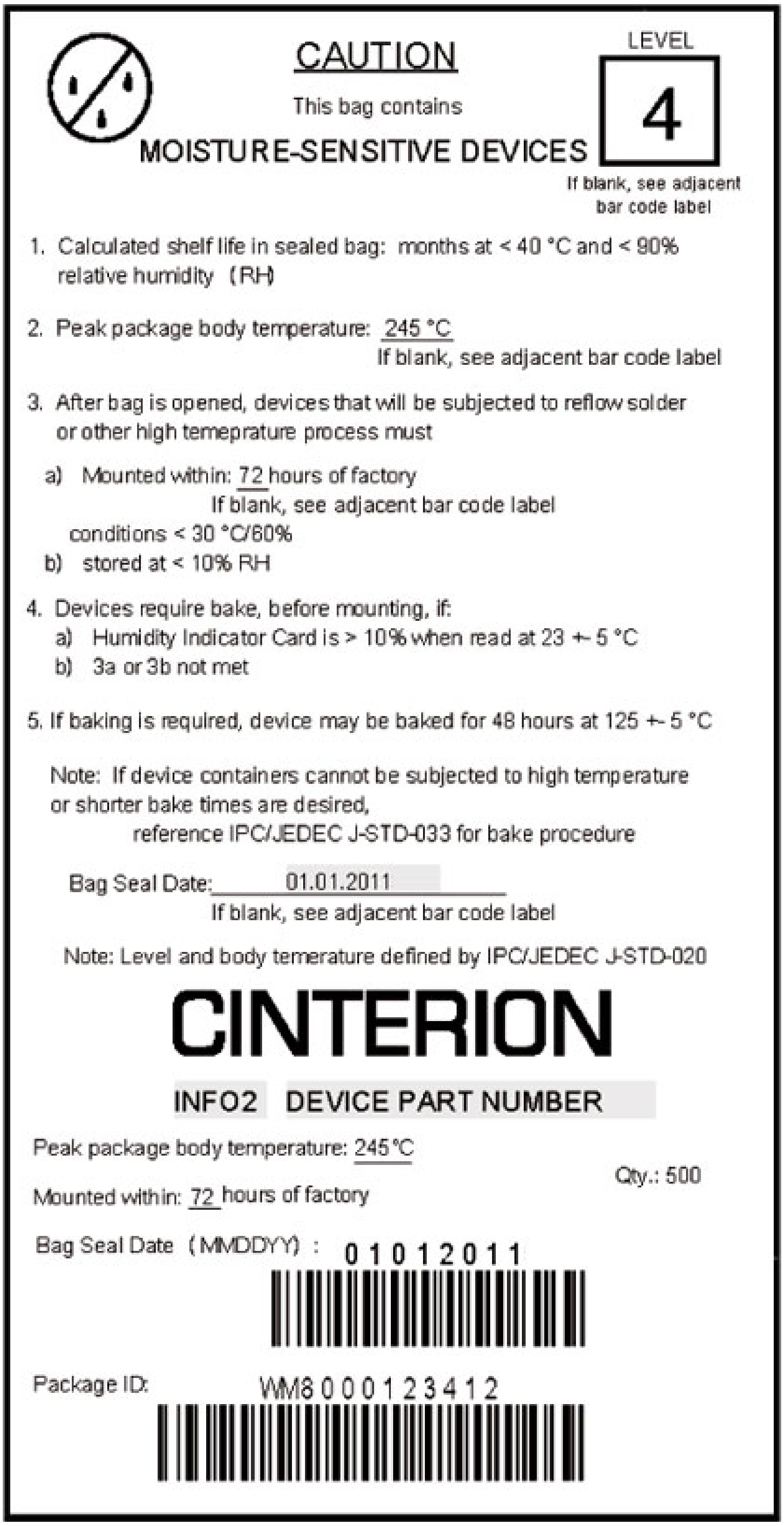


Figure 49: Moisture barrier bag (MBB) with imprint

The label shown in Figure 50 summarizes requirements regarding moisture sensitivity, including shelf life and baking requirements. It is attached to the outside of the moisture barrier bag.



CAUTION

This bag contains

MOISTURE-SENSITIVE DEVICES

LEVEL

4

If blank, see adjacent bar code label

1. Calculated shelf life in sealed bag: months at < 40 °C and < 90% relative humidity (RH)
2. Peak package body temperature: 245 °C
   If blank, see adjacent bar code label
3. After bag is opened, devices that will be subjected to reflow solder or other high temeprature process must
   a) Mounted within: 72 hours of factory
      If blank, see adjacent bar code label
      conditions < 30 °C/60%
   b) stored at < 10% RH
4. Devices require bake, before mounting, if:
   a) Humidity Indicator Card is > 10% when read at 23 +- 5 °C
   b) 3a or 3b not met
5. If baking is required, device may be baked for 48 hours at 125 +- 5 °C

Note: If device containers cannot be subjected to high temperature or shorter bake times are desired, reference IPC/JEDEC J-STD-033 for bake procedure

Bag Seal Date: 01.01.2011
If blank, see adjacent bar code label

Note: Level and body temerature defined by IPC/JEDEC J-STD-020

CINTERION

INFO2 DEVICE PART NUMBER

Peak package body temperature: 245 °C

Qty.: 500

Mounted within: 72 hours of factory

Bag Seal Date (MMDDYY) : 01012011

Package ID: WM8000123412

Figure 50: Moisture Sensitivity Label

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

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

The humidity indicator card is a moisture indicator and is included in the MBB to show the approximate relative humidity level within the bag. Sample humidity cards are shown in Figure 51. If the components have been exposed to moisture above the recommended limits, the units will have to be rebaked.

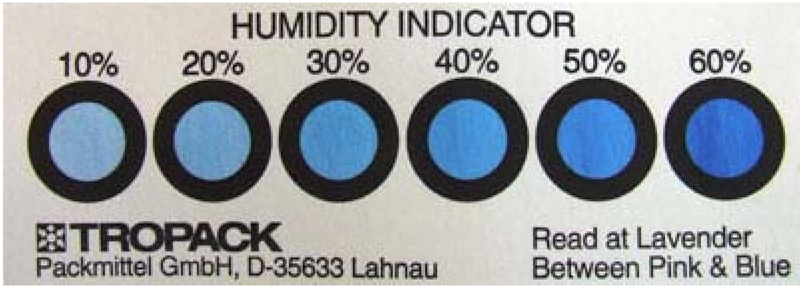


Figure 51: Humidity Indicator Card - HIC

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

7.3.2.2 Transportation Box

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

8 Sample Application

Figure 52 shows a typical example of how to integrate an PHS8-P/PHS8-K 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 PHS8-P/PHS8-K 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 $\overline{\text{OE}}$ (Output Enable) controlled by PWR_IND.

While developing SMT applications it is strongly recommended to provide test points for certain signals resp. lines to and from the module - for debug and/or test purposes. The SMT application should allow for an easy access to these signals. For details on how to implement test points see [5].

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.

Disclaimer:
No warranty, either stated or implied, is provided on the sample schematic diagram shown in Figure 52 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 PHS8-P/PHS8-K modules.

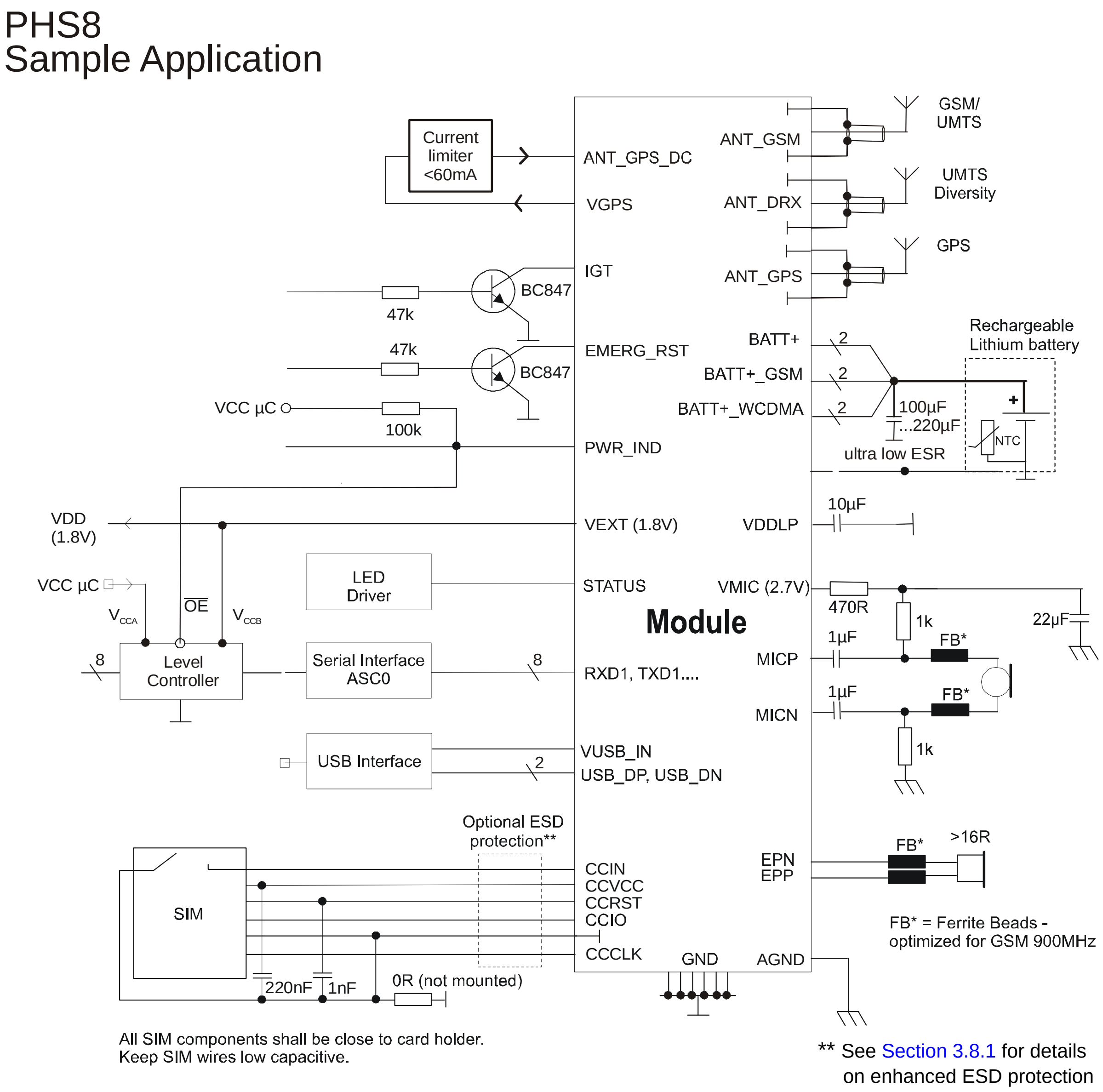


Figure 52: PHS8-P/PHS8-K sample application

9 Reference Approval

9.1 Reference Equipment for Type Approval

The Cinterion Wireless Modules reference setup submitted to type approve PHS8-P/PHS8-K is shown in Figure 53. The module (i.e., the evaluation module) is connected to the DSB75 by means of a flex cable and a special DSB75 adapter. The GSM/UMTS/GPS test equipment is connected via edge mount SMA connectors soldered to the module's antenna pads.

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

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

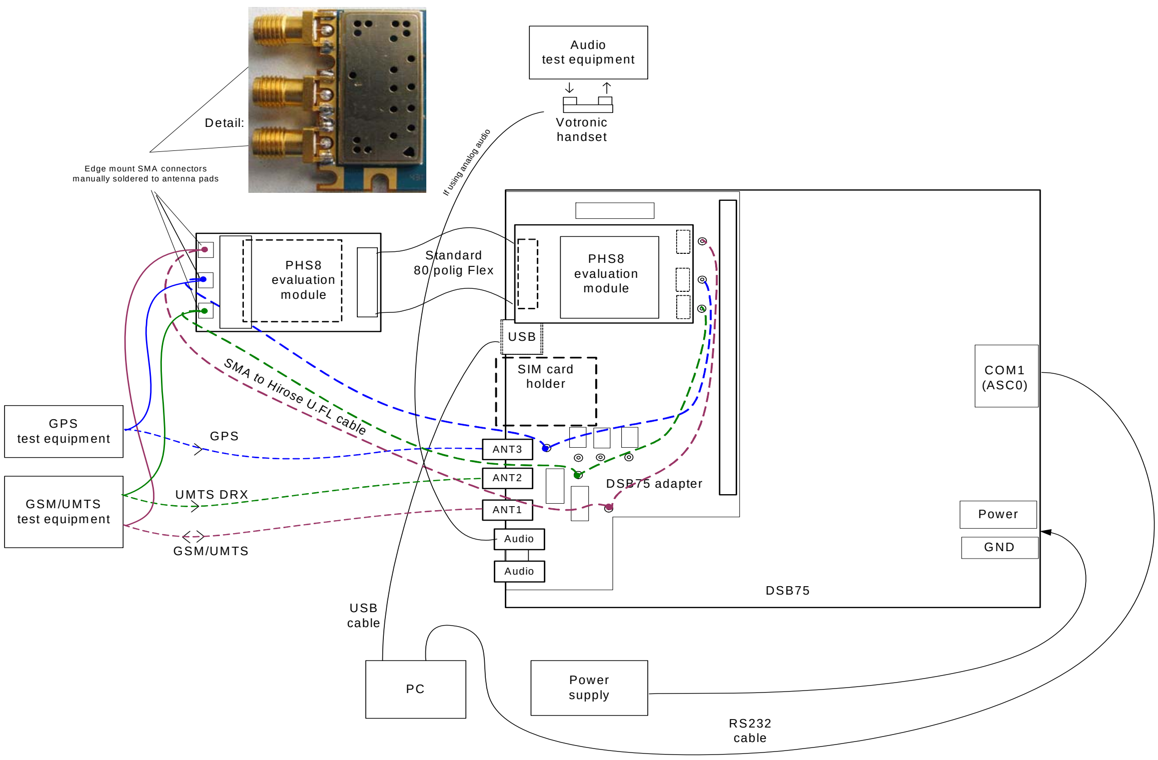


Figure 53: Reference equipment for type approval

9.2 Compliance with FCC and IC Rules and Regulations

The Equipment Authorization Certification for the Cinterion Wireless Modules reference application described in Section 9.1 will be registered under the following identifiers:

- PHS8-P:
  FCC Identifier QIPPHS8-P
  Industry Canada Certification Number: 7830A-PHS8P
  Granted to Cinterion Wireless Modules GmbH

Manufacturers of mobile or fixed devices incorporating PHS8-P/PHS8-K modules are authorized to use the FCC Grants and Industry Canada Certificates of the PHS8-P/PHS8-K 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 QIPPHS8-P", and accordingly “Contains IC 7830A-PHS8P“. The integration is limited to fixed or mobile categorised host devices, where a separation distance between the antenna and any person of min. 20cm can be assured during normal operating conditions. For mobile and fixed operation configurations the antenna gain, including cable loss, must not exceed the limits 3.92 dBi (850 MHz) and 2.51 dBi (1900 MHz).

IMPORTANT:
Manufacturers of portable applications incorporating PHS8-P/PHS8-K 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. 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.

10 Appendix

10.1 List of Parts and Accessories

Table 35: List of parts and accessories

Description	Supplier	Ordering information
PHS8-P	Cinterion	Standard module Cinterion Wireless Modules IMEI: Ordering number: L30960-N2410-A100 Customer IMEI: Ordering number: L30960-N2415-A100
PHS8-K	Cinterion	Standard module Cinterion Wireless Modules IMEI: Ordering number: L30960-N2410-C100
PHS8-P Evaluation Module	Cinterion	Ordering number: L30960-N2411-A100
DSB75 Support Box	Cinterion	Ordering number: L36880-N8811-A100
DSB75 adapter for mounting the evaluation module	Cinterion	Ordering number: L30960-N2301-A100
Votronic Handset	Cinterion, Votronic	Cinterion 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 36.
U.FL antenna connector	Hirose or Molex	Sales contacts are listed in Table 36 and Table 37.

Table 36: 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 37: Hirose sales contacts (subject to change)

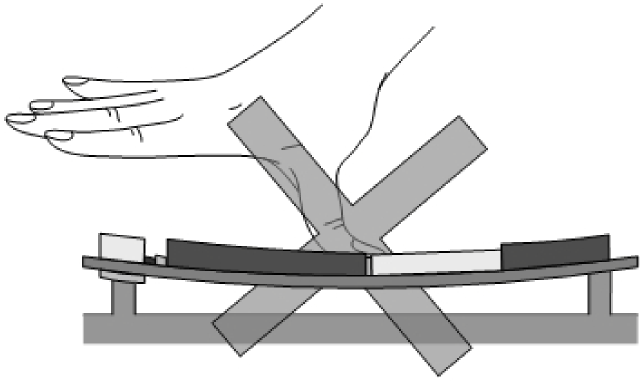
Hirose Ltd. For further information please click: http://www.hirose.com	Hirose Electric (U.S.A.) Inc 2688 Westhills Court Simi Valley, CA 93065 U.S.A. Phone: +1-805-522-7958 Fax: +1-805-522-3217	Hirose Electric Europe B.V. German Branch: Herzog-Carl-Strasse 4 73760 Ostfildern Germany Phone: +49-711-456002-1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

10.2 Mounting Advice Sheet

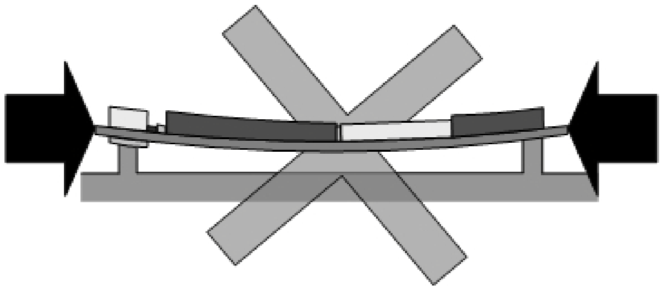
To prevent mechanical damage, be careful not to force, bend or twist the module. Be sure it is soldered flat against the host device (see also Section 7.2). The advice sheet on the next page shows a number of examples for the kind of bending that may lead to mechanical damage of the module (the module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

Mounting Advice

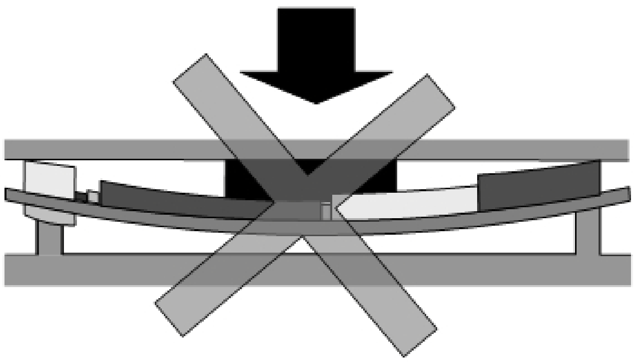
Do NOT BEND the Module



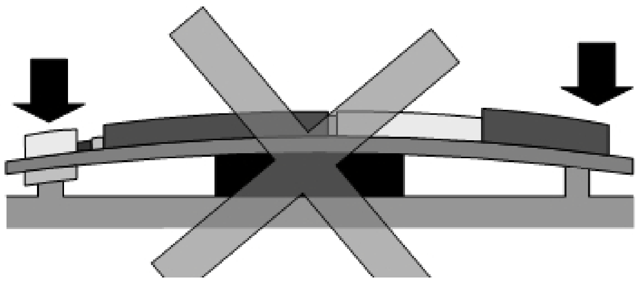
- By pressing from above



- By mounting under pressure



- By putting objects on top



- By putting objects below