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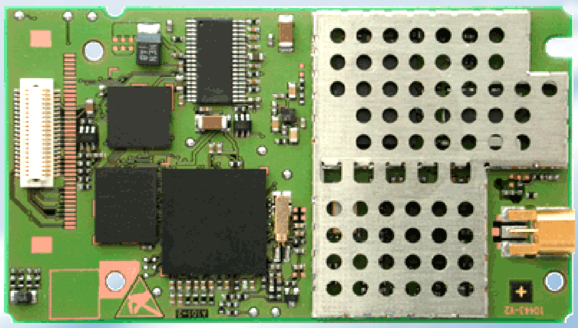

Hardware Interface Description

AC45
Siemens Cellular Engine

Version: 02.02
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0 Document history

Preceding document: "AC45 Hardware Interface Description" Version 01.07
New document: "AC45 Hardware Interface Description" Version **02.02**

Chapter	Page	What is new
2nd front page		New version of General Notes.
6.2	70	Deleted note regarding contact springs and soldering on shielding cover.

Preceding document: "AC45 Hardware Interface Description" Version 01.03
New document: "AC45 Hardware Interface Description" Version **01.07**

Chapter	Page	What is new
3.3.2.1	28	Added new URC ^SHUTDOWN
3.4.2	33	After receiving AT+CFUN=0 the module waits 2s before entering the power saving mode.
5.1	52	Modified description of absolute maximum ratings. Supply voltage BATT+ and 3V3 changed from 4.8 to 5.0
5.4	57	Added footnote regarding antenna performance.

Preceding document: "AC45 Hardware Interface Description" Version 01.01a
New document: "AC45 Hardware Interface Description" Version **01.03**

Chapter	Page	What is new
2.1	17	Added new features: Remote SIM access. Further options of deferred shutdown at extreme temperature conditions.
3.3.2.1	28	To keep /EMERGOFF pin and output pins of serial interface from floating when in high impedance state use additional resistors.
3.3.2.4	29	Added example when /EMERGOFF might be needed.
3.3.3.2	30	Enhanced functionality of temperature control: Deferred shutdown now also during a call to a predefined phone number and during a 2-minute guard period after AC45 powerup. Presentation of all URCs enabled for 2 minutes after powerup.
3.4.3	34	CYCLIC SLEEP mode requires hardware flow control set with AT\Q3.
3.4.4	34	Described the improved timing of the /CTS signal during CYCLIC SLEEP mode. Revised figures.
3.4.5	36	Added note on /RTS0 signal.
3.8.2.2	46	LED mode of the SYNC pin recommended for testing and evaluating product design.
3.8.2.3	47	Recommendations for utilizing /RING0 line added.
5.3	53ff	Table 20 - /EMERGOFF pin and output pins of serial interface: To keep output pins from floating when in high impedance state use additional resistors.
6.2	70	BATT+ line and soldering pad of board-to-board connector are placed close to one of the mounting holes. Added further mounting instructions.

Preceding document: "AC45 Hardware Interface Description" Version 01.01
New document: "AC45 Hardware Interface Description" Version **01.01a**

Chapter	Page	What is new
5.4	57	Max values of TALK and DATA mode revised back to 00.80 data; footnote 6 moved to Peak supply current
6.3.1	72	Corrected Figure 30: Mechanical dimensions of Hirose DF12 connector

Preceding document: "AC45 Hardware Interface Description" Version 00.80
New document: "AC45 Hardware Interface Description" Version **01.01**

Chapter	Page	What is new
2nd cover page		New version of General Note.
1.3	14	Updated list of standards. Added CE conformity mark and GCF-CC certification.
2.1	17f	Added information regarding firmware upgrade and humidity.
3.3.2.3	29	Added information on maximum number of turn-on / turn-off cycles.
3.3.2.1	28	More detailed description of power-down procedure.
4.1	49	Modified value of resistor. More detailed description of parameter <diag>.
5.4	57	Added footnote in Table 23 regarding maximum current at BATT+ line.
5.4.1	59	Revised Figure 22 and Figure 23.
5.6	65	Updated Table 26 including footnotes.
6.4	73	New chapter: “Recommended thermal solutions and heat sinks”.

Preceding document: "AC45 Hardware Interface Description" Version 00.50
New document: "AC45 Hardware Interface Description" Version **00.80**

Chapter	Page	What is new
3.7	41ff	Added Figure 12 (pin assignment of SIM card holder).
6.1	68ff	Modified Figure 26 (corrected position of TP BATT+).
6.2	70	Added note and figure regarding recommended screw types.

Preceding document: "AC45 Hardware Interface Description" Version 00.20
New document: "AC45 Hardware Interface Description" Version **00.50**

Chapter	Page	What is new
2.2	20	Added: baseband controller operates at 26MHz, transceiver supports Direct Conversion.
4.1	49	Added note: Free use of the technology in view of intellectual property rights is not guaranteed.
3.7	41ff	Revised information regarding CCIN pin and SIM card removal during operation.
5.3	53ff	Serial interface: Corrected /TXD0: Imax = -30µA at V_{IN} = 0V (earlier stated as 30µA)
5.6	65	Added Table 26.

Preceding document: "AC45 Hardware Interface Description" Version 00.01
New document: "AC45 Hardware Interface Description" Version **00.20**

Chapter	Page	What is new
New version of General Note. Throughout this manual: Rearranged the sequence of chapters.		
2.1	17f	Added new features: Ringing tones, Antenna detection.
2.2	20	Added antenna detection in Figure 1: AC45 block diagram
3.2.1	24	Added Chapter Minimizing power losses
3.3.1.1	25	Timing of power-up procedure modified.
3.3.3.1	30	Added instructions for activating / deactivating undervoltage URC.
3.4	33	Added new types of SLEEP mode: AT+CFUN=7 and 8.
3.5	37	Modified description of serial interface.
3.6	39	Added AT^SAIC command.
3.7	41	Added information regarding CCIN pin and SIM card removal during operation.
4.1	49	Added new feature: Antenna detection.
4.2	50	Added product specifications of Rosenberger SMP connector
5.4	57	Extended power supply range: BATT+ now 3.5V – 4.5V (earlier statement: 4.0V – 4.3V) 3V3 now 3.17V – 4.5V (earlier statement: 3.17V – 4.3V) Updated I_{BATT+} values in several operation modes.
5.4.1	59f	Added current consumption curves.
5.5.3	62	Changed sidetone gain in audio modes 5 and 6 from 0dB to –2.5dB.
6.1	68f	Updated AC45 drawing.
6.3	71	Rated current per contact corrected: max. 0.3A.

1 Introduction

This document describes the hardware interface of the Siemens AC45 module that connects to the cellular device application and the air interface. As AC45 is intended to integrate with a wide range of application platforms, all functional components are described in great detail.

So this guide covers all information you need to design and set up cellular applications incorporating the AC45 module. It helps you quickly retrieve interface specifications, electrical and mechanical details and, last but not least, information on the requirements to be considered for integrating further components.

1.1 Related documents

[1] AC45 AT Command Set, Version 02.02
[2] GPRS Startup User's Guide
[3] Remote-SAT User's Guide
[4] Multiplexer User's Guide
[5] Multiplex Driver Developer's Guide for Windows 2000 and Windows XP
[6] Multiplex Driver Installation Guide for Windows 2000 and Windows XP
[7] DSB45 Support Box - Evaluation Kit for Siemens Cellular Engines
[8] Application Note 23: Installing AC45 on DSB45
[9] Application Note 16: Updating AC45 Firmware
[10] Application Note 14: Audio and Battery Parameter Download
[11] Application Note 02: Audio Interface Design
[12] Application Note 24: Application Developer's Guide
[13] AC45 Release Notes, Release 02.02
[14] AC45 Remote SIM Access User's Guide

Prior to using the AC45 engines be sure to carefully read the latest product information provided in the Release Notes.

To visit the Siemens Website you can use the following link:
http://www.siemens.com/wm

1.2 Terms and abbreviations

Abbreviation	Description
ADC	Analog-to-Digital Converter
AFC	Automatic Frequency Control
AGC	Automatic Gain Control
ARFCN	Absolute Radio Frequency Channel Number
ARP	Antenna Reference Point
ASIC	Application Specific Integrated Circuit
B2B	Board-to-Board Connector
BER	Bit Error Rate
BTS	Base Transceiver Station
CB or CBM	Cell Broadcast Message
CE	Conformité Européene (European Conformity)
CHAP	Challenge Handshake Authentication Protocol
CPU	Central Processing Unit
CS	Coding Scheme
CSD	Circuit Switched Data
CTS	Clear to Send
DAC	Digital-to-Analog Converter
DAI	Digital Audio Interface
dBm0	Digital level, 3.14dBm0 corresponds to full scale, see ITU G.711, A-law
DCE	Data Communication Equipment (typically modems, e.g. Siemens GSM engine)
DCS 1800	Digital Cellular System, also referred to as PCN
DRX	Discontinuous Reception
DSB	Development Support Box
DSP	Digital Signal Processor
DSR	Data Set Ready
DTE	Data Terminal Equipment (typically computer, terminal, printer or, for example, GSM application)
DTR	Data Terminal Ready
DTX	Discontinuous Transmission
EFR	Enhanced Full Rate
EGSM	Enhanced GSM
EMC	Electromagnetic Compatibility
ESD	Electrostatic Discharge
ETS	European Telecommunication Standard
FDMA	Frequency Division Multiple Access

Abbreviation	Description
FR	Full Rate
GMSK	Gaussian Minimum Shift Keying
GPRS	General Packet Radio Service
GSM	Global Standard for Mobile Communications
HiZ	High Impedance
HR	Half Rate
I/O	Input/Output
IC	Integrated Circuit
IMEI	International Mobile Equipment Identity
ISO	International Standards Organization
ITU	International Telecommunications Union
kbps	kbits per second
LED	Light Emitting Diode
Mbps	Mbits per second
MMI	Man Machine Interface
MO	Mobile Originated
MS	Mobile Station (GSM engine), also referred to as TE
MSISDN	Mobile Station International ISDN number
MT	Mobile Terminated
N.C.	Not connected
NTC	Negative Temperature Coefficient
PA	Power Amplifier
PAP	Password Authentication Protocol
PBCCH	Packet Switched Broadcast Control Channel
PCB	Printed Circuit Board
PCL	Power Control Level
PCM	Pulse Code Modulation
PCN	Personal Communications Network, also referred to as DCS 1800
PDU	Protocol Data Unit
PLL	Phase Locked Loop
PPP	Point-to-point protocol
PSU	Power Supply Unit
R&TTE	Radio and Telecommunication Terminal Equipment
RAM	Random Access Memory
RF	Radio Frequency
RMS	Root Mean Square (value)
ROM	Read-only Memory

Abbreviation	Description
RTC	Real Time Clock
Rx	Receive Direction
SAT	SIM Application Toolkit
SELV	Safety Extra Low Voltage
SIM	Subscriber Identification Module
SMS	Short Message Service
SRAM	Static Random Access Memory
TA	Terminal Adapter (e.g. GSM engine)
TBD	To be defined
TDMA	Time Division Multiple Access
TE	Terminal Equipment, also referred to as DTE
Tx	Transmit Direction
UART	Universal Asynchronous Receiver-Transmitter
URC	Unsolicited Result Code
USSD	Unstructured Supplementary Service Data
Phonebook abbreviations	
FD	SIM fixdialling phonebook
LD	Last dialling phonebook (list of numbers most recently dialled)
MC	Mobile Equipment list of unanswered MT calls (missed calls)
ME	Mobile Equipment phonebook
ON	List of own numbers (MSISDNs)
RC	Mobile Equipment list of received calls
SM	SIM phonebook

1.3 Standards

This product has been approved to comply with the directives and standards listed below:

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
89/336/EC	Directive on electromagnetic compatibility
73/23/EC	"Directive on electrical equipment designed for use within certain voltage limits" (Low Voltage Directive)
95/94/EC	Automotive EMC Directive

Standards of type approval

3GPP TS 51.010-1	"Digital cellular telecommunications system (Phase 2); Mobile Station (MS) conformance specification"
ETSI EN 301 511	"V7.0.1 (2000-12) Candidate Harmonized European Standard (Telecommunications series) 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) (GSM 13.11 version 7.0.1 Release 1998)"
GCF-CC	"Global Certification Forum - Certification Criteria"
ETSI EN 301 489-7	"V1.1.1 (2000-09) Candidate Harmonized European Standard (Telecommunications series) Electro Magnetic Compatibility and Radio spectrum Matters (ERM); Electro Magnetic 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)"
EN 60 950	Safety of information technology equipment (2000)

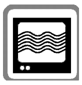
Requirements of quality

IEC 60068	Environmental testing
DIN EN 60529	IP codes

1.4 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 AC45. 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. Siemens AG assumes no liability for customer failure to comply with these precautions.

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 handsfree operation. Before making a call with a hand-held terminal or mobile, park the vehicle.

IMPORTANT!
Cellular terminals or mobiles operate using radio signals and cellular networks cannot be guaranteed to connect in 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 dialling etc.). You may need to deactivate those features before you can make an emergency call.

Some networks require that a valid SIM card be properly inserted in the cellular terminal or mobile.

2 Product concept

Designed for operation on GSM 900 MHz and GSM 1800 MHz networks, AC45 supports GPRS multislot class 8 (1 Tx, up to 4 Rx timeslots) and the GPRS coding schemes CS-1, CS-2, CS-3 and CS-4.

AC45 is specified for an operational temperature from –25°C to +65°C and, thus, combines high and low temperature capabilities with the full functionality of the GSM/GPRS engine. This makes it ideally suited for a multitude of vehicle mounted wireless applications and heavy-duty solutions in rugged environments.

A built-in NTC resistor constantly monitors the temperature on the board. The automatic shutdown functionality prevents damage to the module if the measured temperature is out of range. When an emergency call is in progress the automatic shutdown functionality is deactivated.

The slim AC45 module incorporates all you need to create high-performance GSM/GPRS appliances: baseband processor, power supply ASIC, complete radio frequency circuit including a power amplifier and antenna interface. The RF power amplifier is directly fed from the supply voltage BATT+. The AC45 software is residing in a flash memory device. An additional SRAM and FLASH enables AC45 to meet the demanding requirements of GPRS connectivity.

The physical interface to the cellular application is made through a board-to-board connector. It consists of 40 pins, required for controlling the unit, transferring data and audio signals and providing power supply lines. To optimize RF power output, minimize power losses and reduce heat generation it is recommended to apply a separate power supply for the RF power amplifier and the baseband section including the RF transceiver.

The serial interface offers easy integration with the Man-Machine Interface (MMI), remote control by AT commands and supports baud rates up to 230 kbps.

Two analog audio interfaces are available, each with a balanced microphone input and earpiece output. Both interfaces can be operated in a variety of audio modes which can be easily controlled by AT commands. Superior sound quality and the convenience of handsfree or headset operation meet the demanding requirements of vehicle mounted audio equipment.

AC45 uses a 50 Ω antenna connector fully qualified for automotive applications. A diagnostic functionality helps you verify that the antenna is properly connected. Control is made using the AT^SAD command.

2.1 AC45 key features at a glance

Table 1: AC45 key features

Feature	Implementation
Power supply (typical)	Recommended approach: Separate power supply sources, 4.2V for the RF power amplifier and 3.3 V for the baseband and RF section (except for power amplifier) Alternative approach: Single power supply source 4.2V
Power saving	Minimizes power consumption in SLEEP mode to 3mA
GSM class	Small MS
Frequency bands	• Dual-band EGSM 900, GSM1800 • Compliant to GSM Phase 2/2+
Transmit power	• Class 4 (2W) at EGSM900 • Class 1 (1W) at GSM1800
GPRS connectivity	• GPRS multi-slot class 8 • GPRS mobile station class B
DATA *GPRS:*	• GPRS data downlink transfer: max. 85.6 kbps (see Table 2) • GPRS data uplink transfer: max. 21.4 kbps (see Table 2) • Coding scheme: CS-1, CS-2, CS-3 and CS-4 • AC45 supports the two protocols PAP (Password Authentication Protocol) and CHAP (Challenge Handshake Authentication Protocol) commonly used for PPP connections. • Support of Packet Switched Broadcast Control Channel (PBCCH) allows you to benefit from enhanced GPRS performance when offered by the network operators.
CSD:	• CSD transmission rates: 2.4, 4.8, 9.6, 14.4 kbps, non-transparent, V.110 • Unstructured Supplementary Services Data (USSD) support
SMS	• MT, MO, CB, Text and PDU mode • SMS storage: SIM card plus 25 SMS locations in the mobile equipment • Transmission of SMS alternatively over CSD or GPRS. Preferred mode can be user-defined.
FAX	Group 3: Class 1, Class 2
SIM interface	• Supported SIM card: 3V • External SIM card holder has to be connected via interface connector (note that card holder is not part of AC45)
Audio interfaces	Two analog audio interfaces (balanced microphone inputs, one with feeding, balanced outputs)
Speech codec	Triple rate codec: • Half Rate (ETS 06.20) • Full Rate (ETS 06.10) • Enhanced Full Rate (ETS 06.50 / 06.60 / 06.80) Enhanced handsfree operation with echo cancellation and noise reduction

Feature	Implementation
Serial interface	• 2.65 V level, bi-directional bus for AT commands and data • Supports RTS/CTS hardware handshake and software XON/XOFF flow control. • Multiplex ability according to GSM 07.10 Multiplexer Protocol. • Baud rates from 300 bps to 230400 bps • Autobauding supports 4800, 9600, 19200, 38400, 57600, 115200, 230400 bps
Phonebook management	Supported phonebook types: SM, FD, LD, MC, RC, ON, ME
SIM Application Toolkit	Supports SAT class 3, GSM 11.14 Release 98, support of letter class "c"
Remote SIM access (RSA)	AC45 supports Remote SIM Access. RSA enables AC45 to use a remote SIM card via its serial interface, in addition to the SIM card locally attached to the dedicated lines of the application interface. In a vehicle mounted scenario, for example, this allows the driver to access a mobile phone brought into the car from a car-embedded phone. The connection between both phones can be a Bluetooth wireless link or a serial link, e.g. via the car cradle. The necessary protocols and procedures are implemented according to the "SIM Access Profile Interoperability Specification of the Bluetooth Special Interest Group".
Ringing tones	Offers a choice of 7 ringing tones / melodies, including the option of assigning different tones / melodies and volumes to incoming calls and short messages.
Real time clock	Implemented
Timer function	Programmable via AT command
Firmware upgrade	Upgradable via serial interface or SIM interface.
Environmental	Temperature: • Normal operation: -25°C to +65°C • Restricted operation: -29°C to -25°C and +65°C to +75°C • Auto switch-off >+75°C and <-29°C When an emergency call or a call to a predefined phone number is in progress automatic temperature shutdown is deferred. Humidity: • max. 90 % relative humidity
Physical characteristics	Single component side. Slim board size for tight integration into miniature product design. • Size (mm): 65 x 36 x 4.3 • Weight: 11g
Evaluation kit	The DSB45 Support Box is an evaluation kit designed to test and type approve Siemens cellular engines and provide a sample configuration for application engineering. See Chapter 8 for ordering information.

Table 2: Coding schemes and maximum net data rates over air interface

Coding scheme	1 Timeslot	2 Timeslots	4 Timeslots
CS-1:	9.05 kbps	18.1 kbps	36.2 kbps
CS-2:	13.4 kbps	26.8 kbps	53.6 kbps
CS-3:	15.6 kbps	31.2 kbps	62.4 kbps
CS-4:	21.4 kbps	42.8 kbps	85.6 kbps

Please note that the values stated above are maximum ratings which, in practice, are influenced by a great variety of factors, primarily, for example, traffic variations and network coverage.

2.2 Circuit concept

Figure 1 shows a block diagram of the AC45 module and illustrates the major functional components:

GSM / GPRS Baseband Block:
- GSM controller operating at 26MHz
- Power supply ASIC
- Flash
- SRAM
- Application interface (board-to-board connector)

GSM RF section:
- RF transceiver
- RF power amplifier
- RF frontend
- Antenna connector

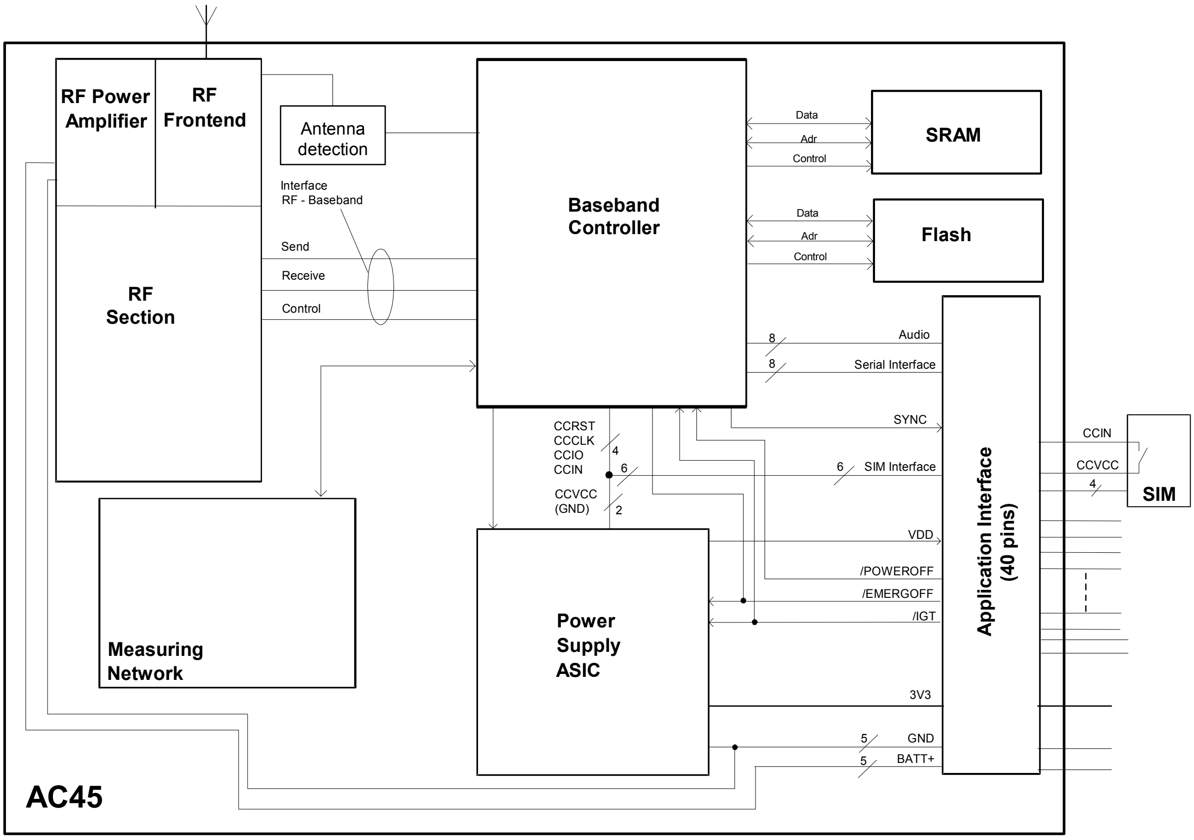


Figure 1: AC45 block diagram

3 Application Interface

AC45 is equipped with a 40-pin 0.5mm pitch board-to-board connector that connects to the cellular application platform. The host interface incorporates several sub-interfaces described in the following chapters:

- Power supply (see Chapter 3.2)
- Serial interface (see Chapter 3.5)
- Two analog audio interfaces (see Chapter 3.6)
- SIM interface (see Chapter 3.7)

Electrical and mechanical characteristics of the board-to-board connector are specified in Chapter 6.3. Ordering information can be found in Chapter 8.

3.1 Operating modes

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

Table 3: Overview of operating modes

Mode	Function	
Normal operation	GSM / GPRS SLEEP	Various powersave modes set with AT+CFUN command. Software is active to minimum extent. If the module was registered to the GSM network in IDLE mode, it remains, in SLEEP mode, registered and pageable from the BTS. Power saving can be chosen at different levels: The NON-CYCLIC SLEEP mode (AT+CFUN=0) disables the AT interface. The CYCLIC SLEEP modes AT+CFUN=5, 6, 7 and 8 alternatingly activate and deactivate the AT interfaces to allow permanent access to all AT commands.
	GSM IDLE	Software is active. Once registered to the GSM network, the module can be paged from the BTS and is ready to send and receive.
	GSM TALK	Connection between two subscribers is in progress. Power consumption depends on network coverage individual settings, such as DTX off/on, FR/EFR/HR, hopping sequences, antenna.
	GPRS IDLE	Module is ready for GPRS data transfer, but no data is currently sent or received. Power consumption depends on network settings and GPRS configuration (e.g. DRX settings).
	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).
POWER DOWN	Normal shutdown after sending the AT^SMSO command or after /POWEROFF pin has gone low. The Power Supply ASIC (PSU-ASIC) disconnects the supply voltage from the baseband part of the circuit. Software is not active. The serial interface is not accessible. Operating voltages (BATT+ and 3V3) remain applied.	
ALARM mode	Restricted operation launched by RTC alert function when the module is in POWER DOWN mode. In Alarm mode, the module remains deregistered from the GSM network. Limited number of AT commands is accessible.	

3.2 Power supply

You have two different options to connect the power supply.

1. The recommended approach is to apply separate supply sources: 4.2V for the RF power amplifier, and 3.3V for the baseband section plus the RF transceiver without power amplifier. This solution delivers maximum RF power output by minimizing losses caused in the baseband section and reduces the heat generation on the AC45 board.
2. As an alternative, a single power supply source may be applied, where VBATT+ needs to be 4.2V. In this case the 3V3 and BATT+ pins must be connected externally.

The power supply must be able to provide sufficient current in a transmit burst which typically rises to 2A. Beyond that, the power supply must be able to account for increased current consumption if the module is exposed to inappropriate conditions, for example antenna mismatch. For further details see Table 21 and Chapter 5.4.1.

5 BATT+ pins and 5 GND pins are available on the board-to-board connector. The RF power amplifier is driven directly from BATT+. The additional power supply for the baseband section and the RF transceiver connects to the 3V3 pin of the board-to-board connector.

All the key functions for supplying power to the device are handled by an ASIC power supply. The ASIC provides the following features:

- Stabilizes the supply voltages for the GSM baseband using low drop linear voltage regulators.
- Controls the module's power up and power down procedures.
  A watchdog logic implemented in the baseband processor periodically sends signals to the ASIC, allowing it to maintain the supply voltage for all digital AC45 components. Whenever the watchdog pulses fail to arrive constantly, the module is turned off.
- Delivers, across the VDD pin, a regulated voltage of 2.9V/10mA. The output voltage VDD may be used, for example, to supply an external LED or level shifter. However, the external circuitry must not cause any spikes or glitches on voltage VDD. This voltage is not available in POWER DOWN mode.
- Provides power to the SIM interface.

Please refer to Table 20 for a description of the power supply pins and their electrical specifications.

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 measured on the AC45 never drops below the specified minimum (3.5V at BATT+ and 3.17V at 3V3), not even in a transmit burst where current consumption can rise to typical peaks of 2A at BATT+ and 0.3A at 3V3. It should be noted that AC45 switches off when exceeding these limits. Any voltage drops that may occur in a transmit burst should not exceed 400mV. For further details see Chapter 5.4.

The best approach to reduce voltage drops is to use a board-to-board connection as recommended, and a low impedance power source. The resistance of the power supply lines on the host board should also be considered.

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

Example: If the length of the flex cable reaches the maximum length of 200mm, this connection may cause, for example, a resistance of 50mΩ in the BATT+ line and 50mΩ in the GND line. As a result, a 2A transmit burst would add up to a total voltage drop of 200mV.

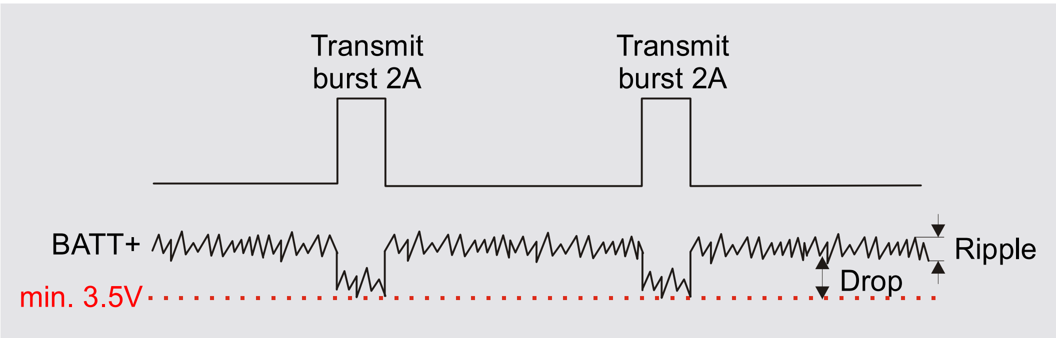


Figure 2: Power supply limits during transmit burst

The input voltage V_{BATT+} must be measured directly at the test points on the AC45 board (TP BATT+ and TP GND illustrated in Figure 26).

3.3 Power up / down scenarios

3.3.1 Turn on AC45

There are two ways to activate AC45:
- via ignition line /IGT: starts normal operating state (see Chapters 3.3.1.1 and 3.3.1.2)
- via RTC interrupt: starts Alarm mode (see Chapter 3.3.1.3)

3.3.1.1 Turn on AC45 using the ignition line /IGT (Power on)

To switch on AC45 the /IGT (Ignition) signal needs to be driven to ground level for at least 100ms. This can be accomplished using an open drain/collector driver in order to avoid current flowing into this pin.

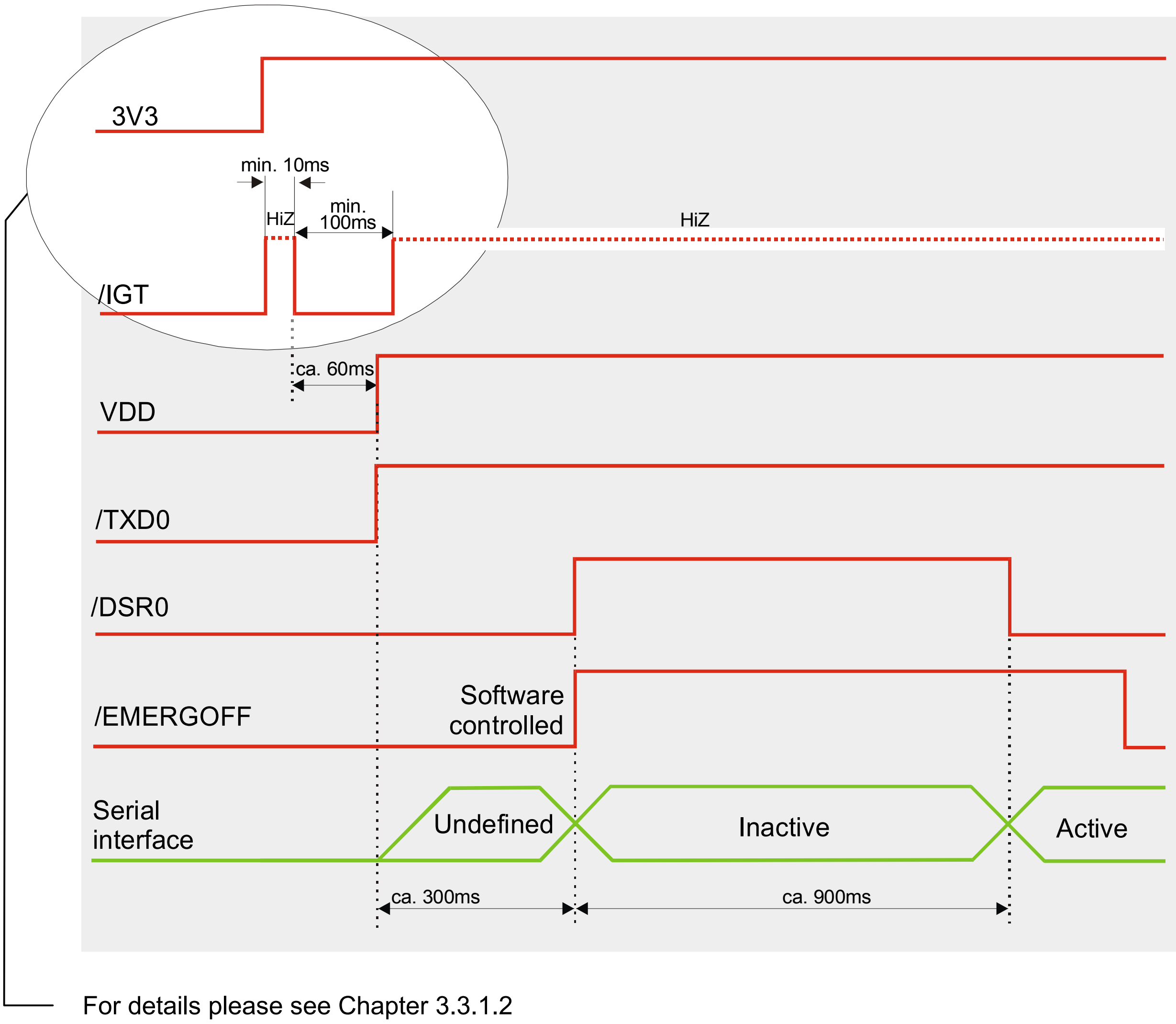


Figure 3: Power-on by ignition signal

If configured to a fix baud rate, AC45 will send the result code ^SYSSTART to indicate that it is ready to operate. This result code does not appear when autobauding is active. See chapter AT+IPR in [1].

3.3.1.2 Timing of the ignition process

When designing your application platform take into account that powering up AC45 requires the following steps.

- The ignition line cannot be operated until V_{3V3} passes the level of 3.0V.
- 10ms after the voltage V_{3V3} has reached 3.0V the ignition line can be switched low. The fall time must not exceed 1ms.
- Another 100ms are required to power up the module.
- Ensure that V_{3V3} does not fall below 3.0V while the ignition line is driven. Otherwise the module cannot be activated.

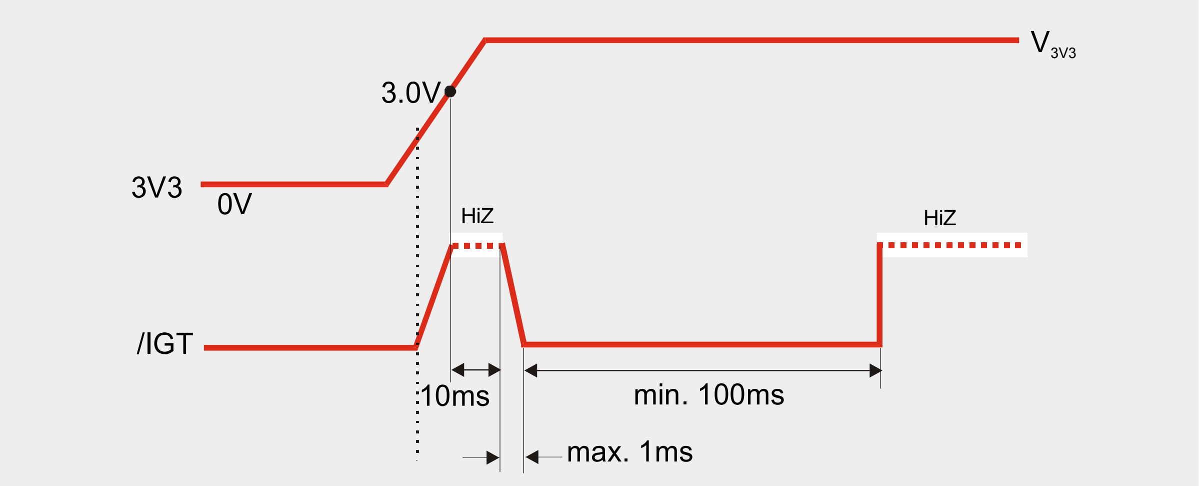


Figure 4: Timing of power-on process

3.3.1.3 Turn on AC45 using the RTC (Alarm mode)

Another power-on approach is to use the RTC, which is constantly supplied with power from a separate voltage regulator in the power supply ASIC. The RTC provides an alert function which allows to wake up the GSM engine from POWER DOWN mode (if the 3V3 pin is supplied). To prevent AC45 from unintentionally logging into the GSM network, this procedure only enables restricted operation, referred to as Alarm mode. It must not be confused with a wake-up, alarm or reminder message that can be activated by using the same AT command, but without switching off power.

Use the AT+CALA command to set the alarm time. The RTC retains the alarm time if the GSM engine was powered down by AT^SMSO. Once the alarm is timed out and executed, the GSM engine enters into the Alarm mode. This is indicated by an Unsolicited Result Code (URC) which reads:

^SYSSTART ALARM MODE

In Alarm mode only a limited number of AT commands is available. For further instructions refer to the AT Command Set.

Table 4: AT commands available in Alarm mode

AT command	Use
AT+CALA	Set alarm time
AT+CCLK	Set date and time of RTC
AT^SBC	Query average current consumption of AC45, enable / disable undervoltage URCs (see Chapter 3.3.3.1)
AT^SCTM	Query temperature range, enable/disable URCs to report critical temperature ranges
AT^SMSO	Power down GSM engine

For AC45 engine to change from the Alarm mode to full operation (normal operating mode) it is necessary to drive the ignition line to ground. This must be implemented in your host application as described in Chapter 3.3.1.1.

If your host application uses the SYNC pin to control a status LED as described in Chapter 3.8.2.2, please note that the LED is off while the GSM engine is in Alarm mode.

3.3.2 Turn off AC45

To switch the module off the following procedures may be used:

- *Normal shutdown procedure*:
  a) Software controlled by sending the AT^SMSO command over the serial application interface. See Chapter 3.3.2.1.
  b) Hardware driven by /POWEROFF pin. See Chapter 3.3.2.2.
- *Emergency shutdown*: Hardware driven by switching the /EMERGOFF line of the board-to-board connector to ground = immediate shutdown of supply voltages, only applicable if the software controlled procedure fails! See Chapter 3.3.2.4.
- *Automatic shutdown*: See Chapter 3.3.3
  a) Takes effect if undervoltage is detected.
  b) Takes effect if AC45 board temperature exceeds critical limit.

3.3.2.1 Turn off AC45 using the AT^SMSO command

The best and safest approach to powering down AC45 is to issue the *AT^SMSO* command. This procedure lets AC45 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.

Before switching off the device sends the following response:

```
^SMSO: MS OFF

OK
^SHUTDOWN
```

After sending AT^SMSO do not enter any other AT commands. There are two ways to verify when the module turns off:

- Wait for the URC "^SHUTDOWN". It indicates that all important data have been stored to the Flash and that the complete system turns off in less than 1 second.
- Also, you can monitor the VDD pin. The low state of VDD definitely indicates that the module is switched off.

Be sure not to disconnect the operating voltage V_{BATT+} before the URC "^SHUTDOWN" has been issued and the VDD signal has gone low. Otherwise you run the risk of losing data.

While AC45 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 pins of the application interface.

Note: In POWER DOWN mode, the /EMERGOFF pin and the output pins of the serial interface /RXD0, /CTS0, /DCD0, /DSR0 and /RING0 are switched to high impedance state.
If this causes the associated input pins of your application to float, you are advised to integrate an additional resistor (100 kΩ – 1 MΩ) at each line. In the case of the /EMERGOFF pin use a pull-down resistor tied to GND. In the case of the serial interface pins you can either connect pull-up resistors to the VDD line, or pull-down resistors to GND.

3.3.2.2 Turn off AC45 using the /POWEROFF pin

The same software controlled power down procedure which is gone through after sending AT^SMSO can be initiated by driving the /POWEROFF pin of the application interface LOW for at least 100ms.

3.3.2.3 Maximum number of turn-on / turn-off cycles

Each time the module is shut down, data will be written from volatile memory to flash memory. The guaranteed maximum number of write cycles is limited to 100.000.

3.3.2.4 Emergency shutdown using /EMERGOFF pin

Caution: *Use the /EMERGOFF pin only when, due to serious problems, the software is not responding for more than 5 seconds. Pulling the /EMERGOFF pin causes the loss of all information stored in the volatile memory since power is cut off immediately. Therefore, this procedure is intended only for use in case of emergency, e.g. if the host controller experienced a watchdog reset and afterwards AC45 fails to shut down properly or fails to respond.*

The /EMERGOFF signal is available on the board-to-board connector. To control the /EMERGOFF line it is recommended to use an open drain / collector driver. To turn the GSM engine off, the /EMERGOFF line has to be driven to ground for ≥ 3.2s.

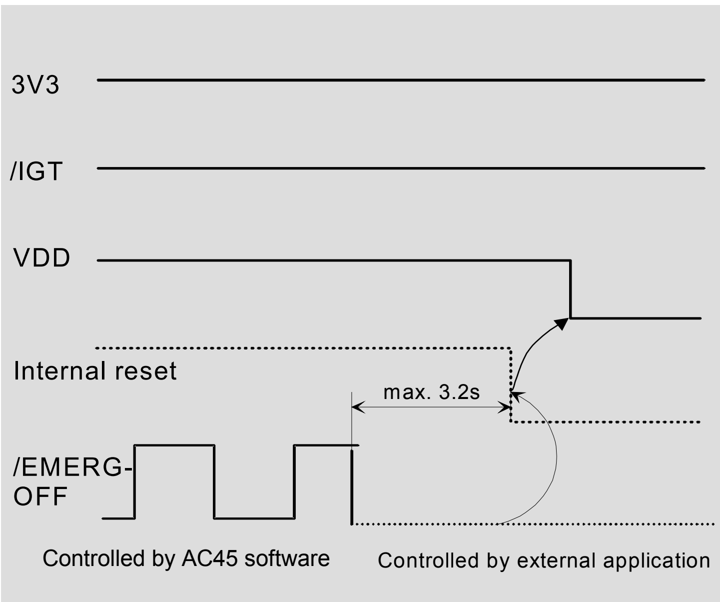


Figure 5: Deactivating GSM engine by /EMERGOFF signal

How does it work:

- Voltage V_{3V3} is permanently applied to the module.
- The module is active while the internal reset signal is kept at high level.
  During operation of AC45 the baseband controller generates watchdog pulses at regular intervals.
  Once the /EMERGOFF pin is grounded these watchdog pulses are cut off from the power supply ASIC. The power supply ASIC shuts down the internal supply voltages of AC45 after max. 3.2s and the module turns off. Consequently, the output voltage at VDD is switched off.

3.3.3 Automatic shutdown

Automatic shutdown takes effect if the supply voltage or the temperature of AC45 are exceeding critical limits. The shutdown procedure is equivalent to the power-down initiated with the AT^SMSO command or the POWEROFF pin: AC45 logs off from the network and the software enters a secure state avoiding loss of data.

3.3.3.1 Undervoltage shutdown

If the supply voltage falls below the range specified in Chapters 5.3 and 5.4, AC45 ceases to operate. This avoids that the module violates GSM specifications. Undervoltage conditions may be reported by the Unsolicited Result Code

AT^SBC: Undervoltage.

To activate or deactivate the presentation of the URC use the AT^SBC command described in [1].

3.3.3.2 Temperature dependent shutdown

The board temperature is constantly monitored by an internal NTC resistor located on the PCB. The values are measured directly on the board and therefore, are not fully identical with the ambient temperature.

During a guard period of two minutes after power-up, the module will not switch off, even if the critical temperature is exceeded. This allows the user to make an emergency call or a call to a predefined phone number, before the module switches off. See Chapter 3.3.3.3 for details.

Each time the board temperature goes out of range or back to normal, AC45 instantly displays an alert in the form of a URC (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=0 (default): Presentation of URCs is enabled during the two minute guard period after start-up of AC45. After expiry of the two minute guard period, the presentation will be disabled, i.e. no URCs with alert levels “1” or “-1” will be generated.
  AT^SCTM=1: Presentation of URCs is always enabled.
- URCs indicating the level "2" or "-2" are instantly followed by an orderly shutdown, except in the cases described in Chapter 3.3.3.3. The presentation of these URCs is always enabled, i.e. they will be output even though the default setting AT^SCTM=0 was never changed.

Table 5: Maximum temperature ratings and associated URCs

Sending temperature alert (15 s after AC45 start-up, otherwise only if URC presentation enabled)	
^SCTM_B: 1	Caution: T_{amb} of board between +65°C and +75°C.
^SCTM_B: -1	Caution: T_{amb} of board between –25°C and –29°C.
^SCTM_B: 0	Board back to uncritical temperature range.
Automatic shutdown (URC appears no matter whether or not presentation was enabled)	
^SCTM_B: 2	Alert: T_{amb} of board $\geq$75°C. AC45 switches off immediately.
^SCTM_B: -2	Alert: T_{amb} of board $\leq$-29°C. AC45 switches off immediately.

The values stated in Table 5 are based on test conditions according to IEC 60068-2-2 (still air).

3.3.3.3 Deferred shutdown at extreme temperature conditions

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

- while an emergency call is in progress
- while a call to a predefined phone number is in progress
- during a two minute guard period after powerup. This guard period has been introduced in order to allow the user to make an emergency call or a call to a phone number predefined with the AT^SCTM command (see [1] for details). The start of any of these calls extends the guard period until the end of the call. Any other network activity may be terminated by shutdown upon expiry of the guard time.

If the temperature is still out of range after the guard period expires or the call ends, the module switches off immediately (without another alert message).

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

3.3.3.4 Monitoring the board temperature of AC45

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.

3.3.4 Summary of state transitions

Table 6 shows how to proceed from one mode to another (gray column = present mode, white columns = intended modes)

Table 6: State transitions of AC45

Further mode →→→ Present mode	POWER DOWN	Normal mode	ALARM mode
POWER DOWN mode	---	/IGT >100 ms at low level	RTC alarm (if activated with AT+CALA before powering down AC45).
Normal mode	AT^SMSO or /POWEROFF >100 ms at low level or exceptionally /EMERGOFF pin ≥3.2s at low level	---	AT+CALA followed by AT^SMSO command or low state of /POWEROFF pin. AC45 enters Alarm mode when specified time is reached.
ALARM mode	AT^SMSO or /POWEROFF >100 ms at low level or exceptionally /EMERGOFF pin ≥3.2s at low level	/IGT > 100 ms at low level	---

3.4 Power saving

SLEEP mode reduces the functionality of the AC45 module to a minimum and, thus, minimizes the current consumption to the lowest level. SLEEP mode is set with the AT+CFUN command which provides the choice of the functionality levels <fun>=0, 1, 5, 6, 7 or 8, all explained below. Further instructions of how to use AT+CFUN can be found in [1].

IMPORTANT: The AT+CFUN command can be executed before or after entering PIN1. Nevertheless, please keep in mind *that power saving works properly only when the module is registered to the GSM network*. If you attempt to activate power saving while the module is detached, the selected <fun> level will be set, though power saving does not take effect. For the same reason, power saving cannot be used if AC45 operates in Alarm mode.

To check whether power saving is on, you can query the status of AT+CFUN if you have chosen CYCLIC SLEEP mode. If available, you can take advantage of the status LED controlled by the SYNC pin (see Chapter 3.8.2.2). The LED stops flashing once the module starts power saving.

The wake-up procedures are quite different depending on the selected SLEEP mode. Table 7 compares the wake-up events that can occur in NON-CYCLIC SLEEP mode and in the four CYCLIC SLEEP modes.

3.4.1 No power saving (AT+CFUN=1)

The functionality level <fun>=1 is where power saving is switched off. This is the default after startup.

3.4.2 NON-CYCLIC SLEEP mode (AT+CFUN=0)

If level 0 has been selected (AT+CFUN=0), the serial interface is blocked. Level 0 is called NON-CYCLIC SLEEP mode, since the serial interface is not alternatingly made accessible as in CYCLIC SLEEP mode.

The first wake-up event fully activates the module, enables the serial interface and terminates the power saving mode. In short, it takes AC45 back to the highest level of functionality <fun>=1.

To activate NON-CYCLIC SLEEP mode, enter the command AT+CFUN=0. Please note that after receiving AT+CFUN=0 the module waits 2 seconds before entering the power saving mode.

3.4.3 CYCLIC SLEEP mode (AT+CFUN=5, 6, 7 and 8)

The functionality levels AT+CFUN=5, AT+CFUN=6, AT+CFUN=7 and AT+CFUN=8 are referred to as CYCLIC SLEEP modes. The major benefit over the NON-CYCLIC SLEEP mode is that the serial interface is not permanently blocked and that packet switched calls may go on without terminating the selected CYCLIC SLEEP mode. This allows AC45 to become active, for example to perform a GPRS data transfer, and to resume power saving after the GPRS data transfer is completed.

The four CYCLIC SLEEP modes give you greater flexibility regarding the wake-up procedures: For example, in all CYCLIC SLEEP modes, you can enter AT+CFUN=1 to permanently wake up the module. The best choice is using CFUN=7 or 8, since in these modes AC45 automatically resumes power saving, after you have sent or received a short message or made a call. CFUN=5 and 6 do not offer this feature, and therefore, are only supported for compatibility with earlier releases. Please refer to Table 7 for a summary of all modes.

The CYCLIC SLEEP mode is a dynamic process which alternatingly enables and disables the serial interface. By setting/resetting the /CTS signal, the module indicates to the application when the UART is active. The timing of the /CTS signal is described below.

Both the application and the module must be configured to use hardware flow control (RTS/CTS handshake). The default setting of AC45 is AT\Q0 (no flow control) which must be altered to AT\Q3. See [1] for details.

3.4.4 Timing of the /CTS signal in CYCLIC SLEEP modes

The /CTS signal is enabled in synchrony with the module's paging cycle. It goes active low each time when the module starts listening to a paging message block from the base station. The timing of the paging cycle varies with the base station. The duration of a paging interval can be calculated from the following formula:

*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 from 0.47 to 2.12 seconds. The DRX value of the base station is assigned by the network operator.

Each listening period causes the /CTS signal to go active low: If DRX is 2, the /CTS signal is activated every 0.47 seconds, if DRX is 3, the /CTS signal is activated every 0.71 seconds and if DRX is 9, the /CTS signal is activated every 2.1 seconds.

The /CTS signal is active low for 4.6 ms. This is followed by another 4.6 ms UART activity. If the start bit of a received character is detected within these 9.2 ms, /CTS will be activated and the proper reception of the character will be guaranteed.

/CTS will also be activated if any character is to be sent from the module to the application.

After the last character was sent or received the interface will remain active for another
- 2 seconds, if AT+CFUN=5 or 7 or
- 10 minutes, if AT+CFUN=6 or 8.

In the pauses between listening to paging messages, while /CTS is high, the module resumes power saving and the AT interface is not accessible. See Figure 6 and Figure 7.

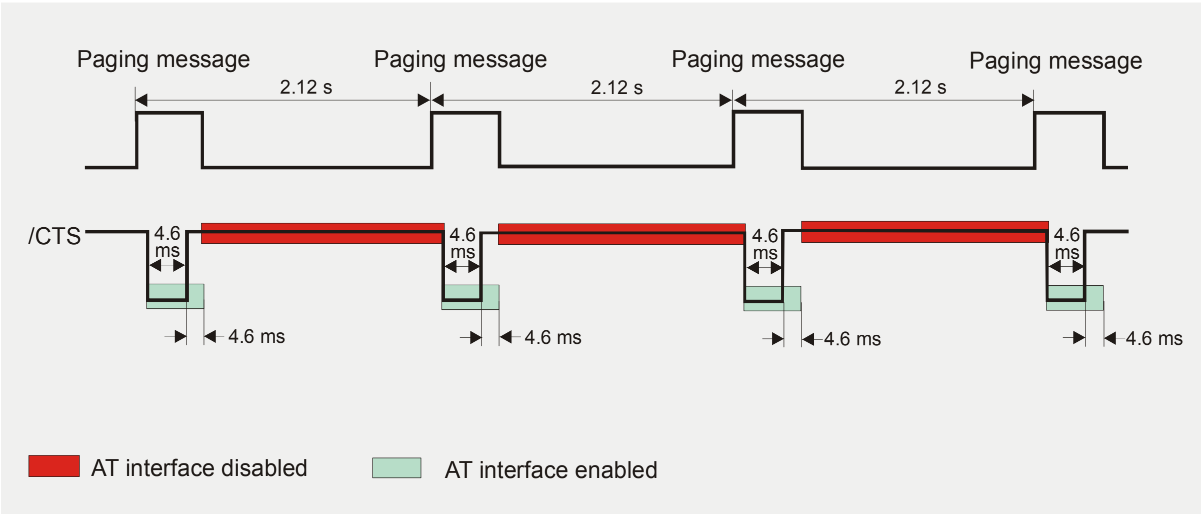


Figure 6: Timing of /CTS signal (example for a 2.12 s paging cycle)

Figure 7 illustrates the CFUN=5 and CFUN=7 modes, which reset the /CTS signal 2 seconds after the last character was sent or received.

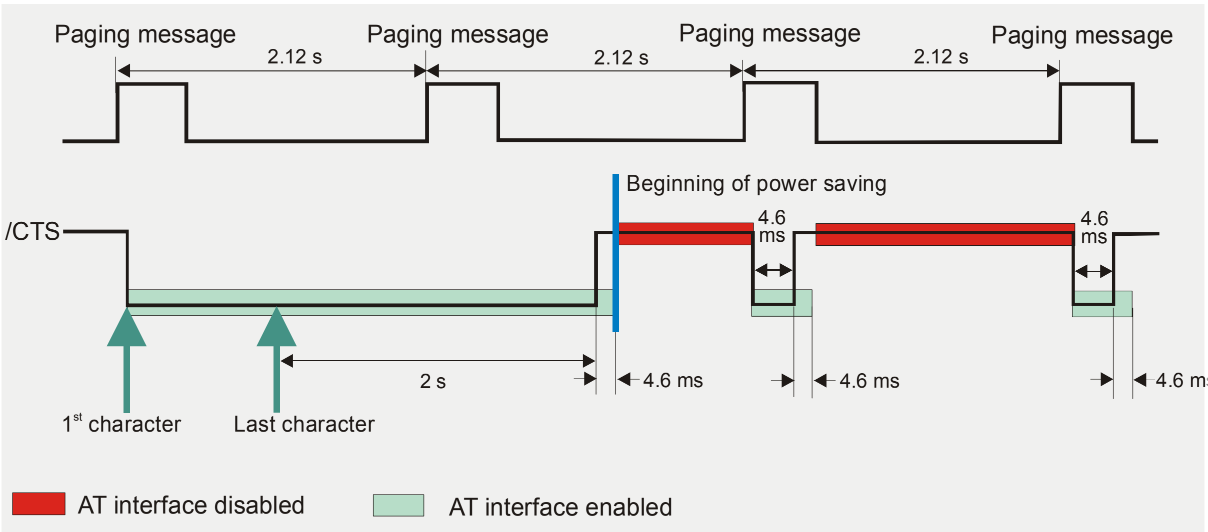


Figure 7: Beginning of power saving if CFUN=5 or 7

3.4.5 Wake up AC45 from SLEEP mode

A wake-up event is any event that switches off the SLEEP mode and causes AC45 to return to full functionality. In short, it takes AC45 back to AT+CFUN=1.

Definitions of the state transitions described in Table 7:
Yes = AC45 exits SLEEP mode.
No = AC45 does not exit SLEEP mode.

Table 7: Wake-up events in NON-CYCLIC and CYCLIC SLEEP modes

Event	**From SLEEP mode AT+CFUN=0 to AT+CFUN=1**	**From SLEEP mode AT+CFUN=5 or 6 to AT+CFUN=1**	**From SLEEP mode AT+CFUN=7 or 8 to AT+CFUN=1**
Ignition line	No	No	No
/RTS0 (falling edge)	Yes[1)]	No[1)]	No[1)]
Unsolicited Result Code (URC)	Yes	Yes	No
Incoming voice or data call	Yes	Yes	No
Any AT command (incl. outgoing voice or data call, outgoing SMS)	Not possible (UART disabled)	No	No
Incoming SMS depending on mode selected by AT+CNMI:			
AT+CNMI=0,0 (= default, no indication of received SMS)	No	No	No
AT+CNMI=1,1 (= displays URC upon receipt of SMS)	Yes	Yes	No
GPRS data transfer	Not possible (UART disabled)	No	No
RTC alarm[2)]	Yes	Yes	No
AT+CFUN=1	Not possible (UART disabled)	Yes	Yes

1) During all CYCLIC SLEEP modes, /RTS0 is conventionally used for flow control: The assertion of /RTS0 signals that the application is ready to receive data - without waking up the module. Be aware that this behavior is different if CFUN=0: In this case, the assertion of /RTS0 serves as a wake-up event, giving the application the possibility to intentionally terminate power saving.

2) Recommendation: In NON-CYCLIC SLEEP mode, you can set an RTC alarm to wake up AC45 and return to full functionality. This is a useful approach because, in this mode, the AT interface is not accessible.

3.5 Serial interface

AC45 offers an 8-wire, unbalanced, asynchronous serial interface conforming to ITU-T V.24 protocol DCE signaling. The electrical characteristics do not comply with ITU-T V.28. The significant levels are 0V (for low data bit or ON condition) and 2.65V (for high data bit or OFF condition). For electrical characteristics please refer to Table 20.

AC45 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

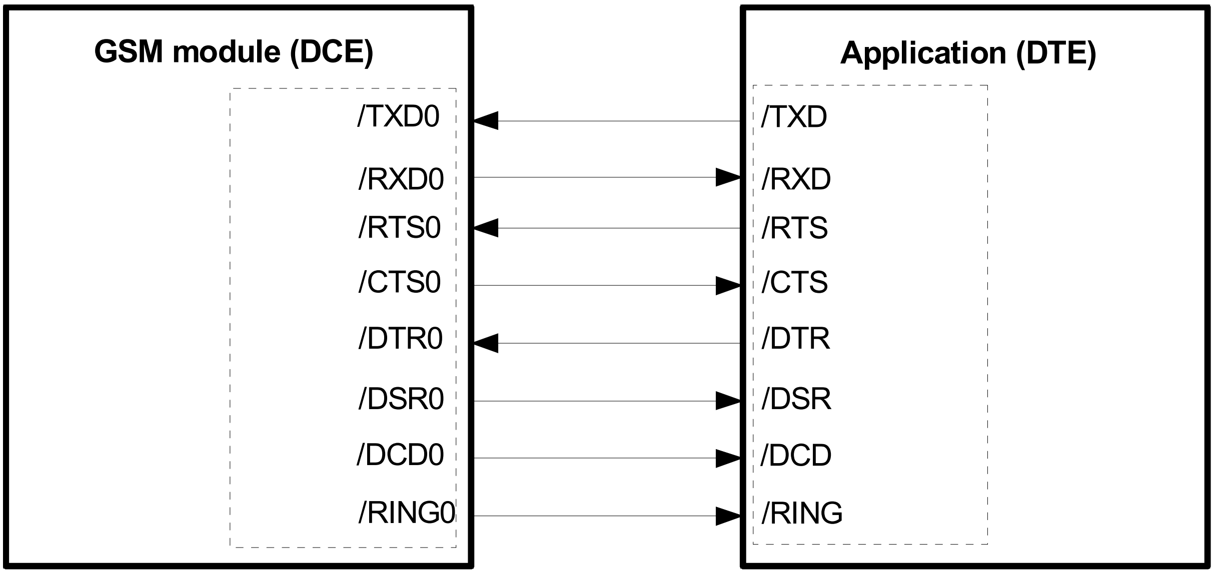


Figure 8: Serial interface

Table 8: DCE-DTE wiring

V.24 circuit	DCE		DTE	
	Pin function	Signal direction	Pin 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

Features of the serial interface:

- Designed for voice, CSD, fax and GPRS services and for controlling the GSM engine with AT commands.
- Full Multiplex capability allows the interface to be partitioned into three virtual channels, yet with CSD and fax services only available on the first logical channel.
- Includes the data lines /TXD0 and /RXD0, the status lines /RTS0 and /CTS0 and, in addition, the modem control lines /DTR0, /DSR0, /DCD0 and /RING0.
- The /DTR0 signal will only be polled once per second from the internal firmware of AC45. The /RING0 signal serves to indicate incoming calls and other types of URCs (Unsolicited Result Code).
- Configured for 8 data bits, no parity and 1 stop bit.
- Can be operated at bit rates from 300bps to 230400 bps.
- Autobauding supports the following bit rates: 4800, 9600, 19200, 38400, 57600, 115200, 230400 bps.
- Supports hardware handshake using RTS0/CTS0 and XON/XOFF software flow control.

3.6 Audio interfaces

AC45 comprises two analog audio interfaces each with a balanced analog microphone input and a balanced analog earpiece output. The second analog interface provides a supply circuit to feed an active microphone.

This means you can connect two audio devices in any combination, both at the same time. Using the AT^SAIC command you can easily switch back and forth between both audio interfaces.

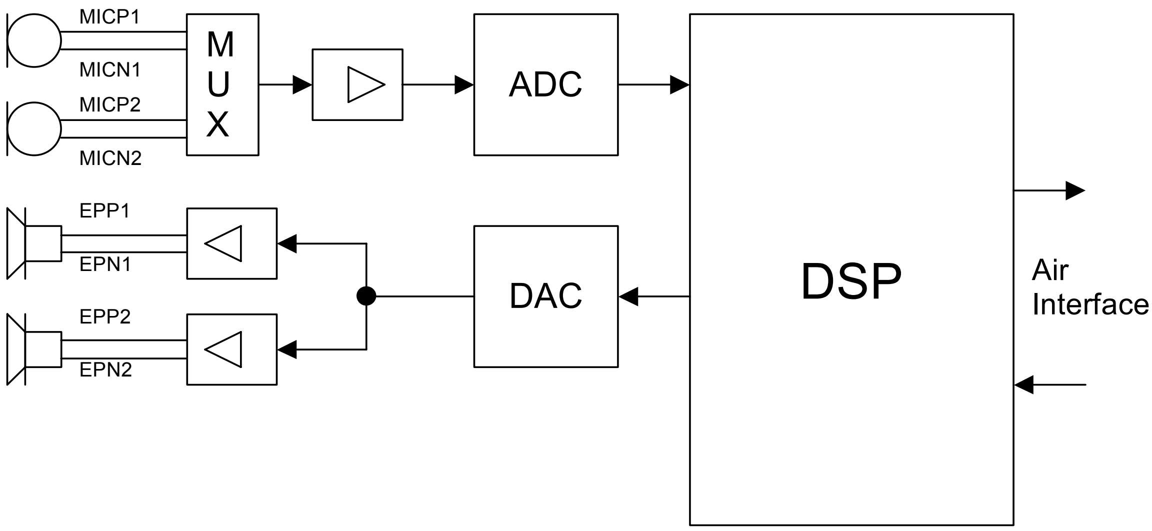


Figure 9: Audio block diagram

AC45 offers six audio modes which can be selected with the AT^SNFS command. There is a default setting of the audio interface for each audio mode (see Table 22), which can be temporarily changed with AT^SAIC and also saved with AT^SNFW within the currently selected audio mode (except mode 1). 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 be altered with AT commands (except for mode 1).

Please refer to Chapter 5.5 for specifications of the audio interface and an overview of the audio parameters. Detailed instructions on using AT commands are presented in the "AC45 AT Command Set" [1]. Table 23 on page 62 summarizes the characteristics of the various audio modes and shows what parameters are supported in each mode.

When shipped from factory, interface 1 and audio mode 1 are activated. This is the default configuration optimized for the Votronic HH-SI-30.3/V1.1/0 handset and used for type approving the Siemens 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.

3.6.1 Microphone circuit

Interface 1 (MICP1, MICN1)
This interface has no microphone supply circuit and therefore, has an impedance of 50 kΩ. When a microphone or another signal source is connected to the inputs, two 100 nF decoupling capacitors are required, both placed in series.

Interface 2 (MICP2, MICN2)
This interface comes with a microphone supply circuit and can be used to feed an active microphone. It has an impedance of 2kΩ. If you do not use it or if you want to connect another type of signal source, for example, an op amp or a dynamic microphone, it needs to be decoupled with capacitors.

Figure 10 shows the microphone inputs at both analog interfaces of AC45.

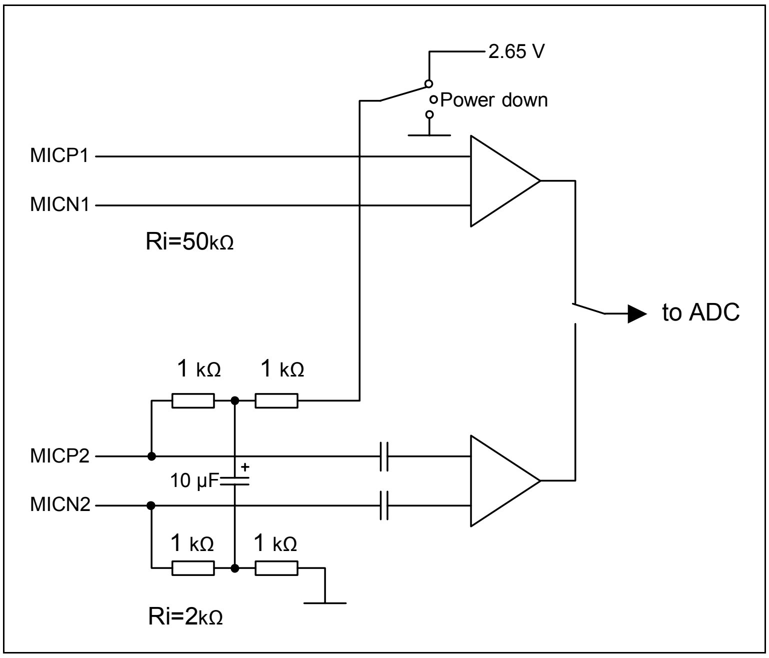


Figure 10: Schematic of microphone inputs

3.6.2 Speech processing

The speech samples from the ADC are handled by the DSP of the baseband controller to calculate e.g. amplifications, sidetone, echo cancellation or noise suppression depending on the configuration of the selected audio mode. These processed samples are passed to the speech encoder. Received samples from the speech decoder are passed to the DAC after post processing (frequency response correction, adding sidetone etc.).

Full rate, half rate, enhanced full rate, speech and channel encoding including voice activity detection (VAD) and discontinuous transmission (DTX) and digital GMSK modulation are also performed on the GSM baseband processor.

Customer specific audio parameters can be evaluated and supplied by Siemens on request. These parameters can be downloaded into AC45 using an AT command. For further information refer to [10] or contact your Siemens distributor.

3.7 SIM interface

The baseband processor has an integrated SIM interface compatible with the ISO 7816 IC Card standard. This is wired to the host interface (board-to-board connector) in order to be connected to an external SIM card holder. Six pins on the board-to-board connector are reserved for the SIM interface.

The CCIN pin serves to detect whether a tray (with SIM card) is present in the card holder. Using the CCIN pin 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. See Chapter 3.7.1 for details.

It is recommended that the total cable length between the board-to-board connector pins on AC45 and the pins of the SIM card holder does not exceed 200 mm in order to meet the specifications of 3GPP TS 51.010-1 and to satisfy the requirements of EMC compliance.

Table 9: Signals of the SIM interface (board-to-board connector)

Signal	Description
CCGND	Separate ground connection for SIM card to improve EMC.
CCCLK	Chipcard clock, various clock rates can be set in the baseband processor.
CCVCC	SIM supply voltage from PSU-ASIC
CCIO	Serial data line, input and output.
CCRST	Chipcard reset, provided by baseband processor.
CCIN	Input on the baseband processor for detecting a SIM card tray in the holder. The CCIN pin is mandatory for applications that allow the user to remove the SIM card during operation. The CCIN pin 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 AC45.

3.7.1 Requirements for using the CCIN pin

According to ISO/IEC 7816-3 the SIM interface must be immediately shut down once the SIM card is removed during operation. Therefore, the signal at the CCIN pin must go low *before* the SIM card contacts are mechanically detached from the SIM interface contacts. This shut-down procedure is particularly required to protect the SIM card as well as the SIM interface of AC45 from damage.

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 AC45 and is part of the Siemens reference equipment submitted for type approval. Molex ordering number is 91228-0001, see also Chapter 8.

The module's startup procedure involves a SIM card initialization performed within 1 second after getting started. An important issue is whether the initialization procedure ends up with a high or low level of the CCIN signal:

a) If, during startup of AC45, the CCIN signal on the SIM interface is high, then the status of the SIM card holder can be recognized each time the card is inserted or ejected.
   A low level of CCIN indicates that no SIM card tray is inserted into the holder. In this case, the module keeps searching, at regular intervals, for the SIM card. Once the SIM card tray with a SIM card is inserted, CCIN is taken high again.
b) If, during startup of AC45, the CCIN signal is low, the module will also attempt to initialize the SIM card. In this case, the initialization will only be successful when the card is present.
   If the SIM card initialization has been done, but the card is no more operational or removed, then the module will never search again for a SIM card and only emergency calls can be made.

Removing and inserting the SIM card during operation requires the software to be reinitialized. Therefore, after reinserting the SIM card it is necessary to restart AC45.
It is strongly recommended to connect the contacts of the SIM card detect switch to the CCIN input and to the CCVCC output of the module as illustrated in the sample diagram in Figure 11.

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 a SIM card during operation. In this case, the application must restart AC45.

3.7.2 Design considerations for SIM card holder

The schematic below is a sample configuration that illustrates the Molex SIM card holder located on the DSB45 Support Box (evaluation kit used for type approval of the Siemens AC45 reference setup, see [7]). X503 is the designation used for the SIM card holder in [7].

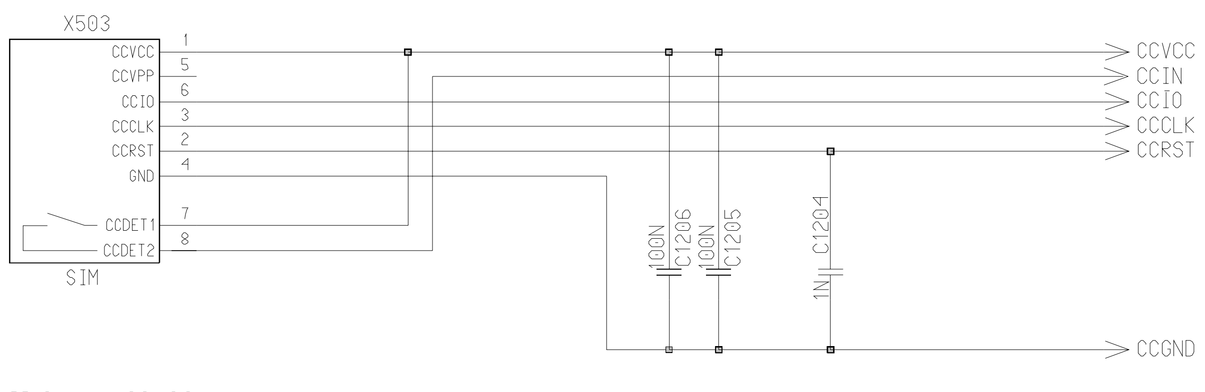


Figure 11: SIM card holder of DSB45 Support Box

Table 10 : Pin assignment of Molex SIM card holder on DSB45 Support Box

Pin no.	Signal name	I/O	Function
1	CCVCC	I	Supply voltage for SIM card, generated by the GSM engine
2	CCRST	I	Chip card reset, prompted by the GSM engine
3	CCCLK	I	Chip card clock
4	CCGND	-	Individual ground line for the SIM card to improve EMC
5	CCVPP	-	Not connected
6	CCIO	I/O	Serial data line, bi-directional
7	CCDET1	-	Connect to CCVCC
8	CCDET2		Connects to the CCIN input of the GSM engine. Serves to signalize whether a SIM card tray (with SIM card) is in the holder.

Pins 1 through 8 (except for 5) are the minimum requirement according to the GSM Recommendations, where pins 7 and 8 are needed for SIM card tray detection through the CCIN pin.

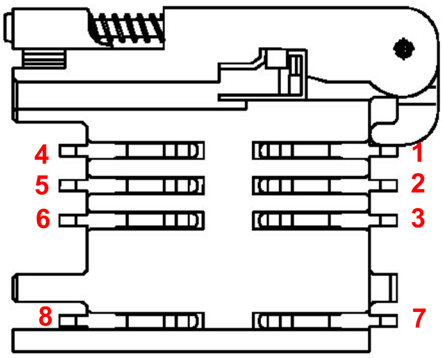


Figure 12: Pin numbers of Molex SIM card holder on DSB45 Support Box

Place the capacitors C1205 and C1206 (or instead one capacitor of 200nF) as close as possible to the pins 1 (CCVCC) and 4 (GND) of the card holder. Connect the capacitors to the pins via low resistance tracks.

3.8 Control signals

3.8.1 Inputs

Table 11: Input control signals of the AC45 module

Function	Pin	Status	Description
Ignition	/IGT	= falling edge	Power up AC45
		= 1	Hi-Z
	Active low ≥100ms (Open drain/collector driver required in cellular device application)		
Shutdown	/POWEROFF	= low	Power down AC45
		= 1	
	Active low ≥100ms		
Emergency shutdown	/EMERGOFF	= 0	Power down AC45
		= 1	Hi-Z
	Active low ≥3.2s (Open drain/collector driver required in cellular device application). At the /EMERGOFF signal the watchdog signal of AC45 can be traced (see description in Table 20).		

(HiZ = high impedance)

3.8.2 Outputs

3.8.2.1 Synchronization signal

The synchronization signal serves to indicate growing power consumption during the transmit burst. The signal is generated by the SYNC pin. Please note that this pin can adopt two different operating modes which you can select by using the AT^SSYNC command (mode 0 and 1). For details refer to the following chapter and to the "AT Command Set".

To generate the synchronization signal the pin needs to be configured to mode 0 (= default). This setting is recommended if you want your application to use the synchronization signal for better power supply control. Your platform design must be such that the incoming signal accommodates sufficient power supply to the AC45 module if required. This can be achieved by lowering the current drawn from other components installed in your application. The characteristics of the synchronization signal are explained below.

Table 12: AC45 synchronization signal (if SYNC pin is set to mode 0 via AT^SSYNC)

Function	Pin	Pin status	Description
Synchronization	SYNC	Low	No operation
		High	Indicates increased power consumption during transmission.

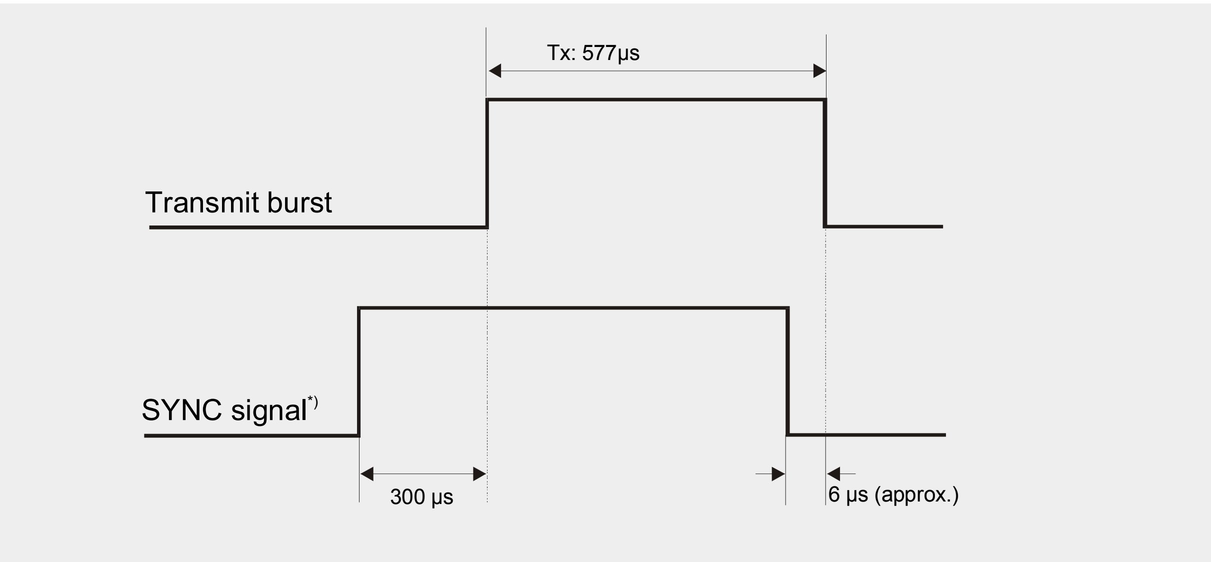


Figure 13: SYNC signal during transmit burst

*) The duration of the SYNC signal is always equal, no matter whether the traffic or the access burst are active.

3.8.2.2 Using the SYNC pin to control a status LED

As an alternative to generating the synchronization signal, the SYNC pin can be used to control a status LED on your application platform.

To avail of this feature you need to set the SYNC pin to mode 1 by using the AT^SSYNC command. For details see [1].

When controlled from the SYNC pin the LED can display the functions listed in Table 13. Especially in the development and test phase of an application, system integrators are advised to use the LED mode of the SYNC pin in order to evaluate their product design and identify the source of errors.

Table 13: Coding of the status LED

LED mode	Operating status
Off	AC45 is off or runs in SLEEP, Alarm mode
600 ms On / 600ms Off	No SIM card inserted or no PIN entered, or network search in progress, or ongoing user authentication, or network login in progress.
75 ms On / 3 s Off	Logged to network (monitoring control channels and user interactions). No call in progress.
75 ms on / 75 ms Off / 75 ms On / 3 s Off	One or more GPRS contexts activated.
Flashing	Indicates GPRS data transfer: When a GPRS transfer is in progress, the LED goes on within 1 second after data packets were exchanged. Flash duration is approximately 0.5 s.
On	Depending on type of call: *Voice call:* Connected to remote party. *Data call:* Connected to remote party or exchange of parameters while setting up or disconnecting a call.

LED Off = SYNC pin low. LED On = SYNC pin high (if LED is connected as illustrated in Figure 14)

To operate the LED, a buffer, e.g. a transistor or gate, must be included in your application. A sample configuration can be gathered from Figure 14. Power consumption in the LED mode is the same as for the synchronization signal mode. For details refer to Table 20, SYNC pin.

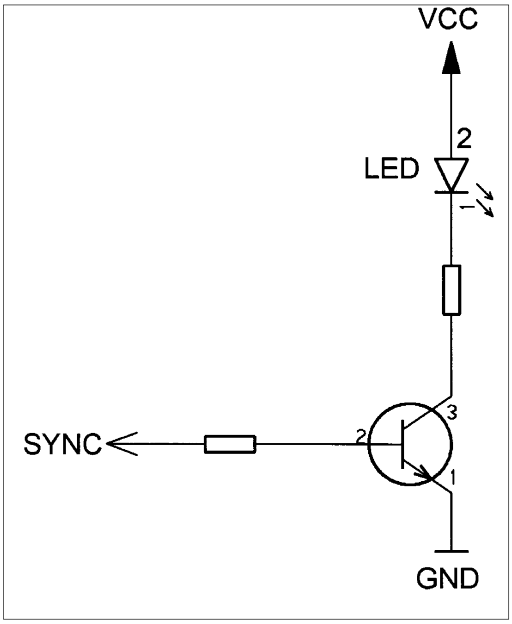


Figure 14: LED Circuit (Example)

3.8.2.3 Behavior of the /RING0 line

The /RING0 line is available on the serial interface (see also Chapter 3.5). 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 behavior of the /RING0 line varies with the type of event:

- When a *voice call* comes in the /RING0 line goes low for 1s and high for another 4s. Every 5 seconds the ring string is generated and sent over the /RXD0 line.
  If there is a call in progress and call waiting is activated for a connected handset or handsfree device, the /RING0 line switches to ground in order to generate acoustic signals that indicate the waiting call.

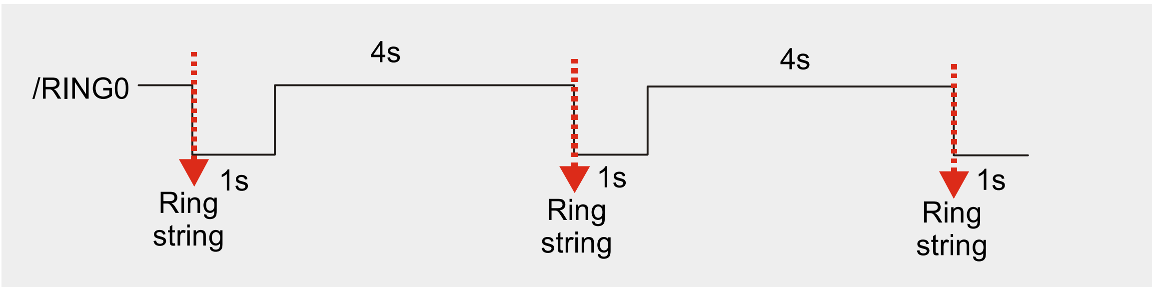


Figure 16: Incoming voice call

- Likewise, when a *Fax* or *data call* is received, /RING0 goes low. However, in contrast to voice calls, the line remains low. Every 5 seconds the ring string is generated and sent over the /RXD0 line.

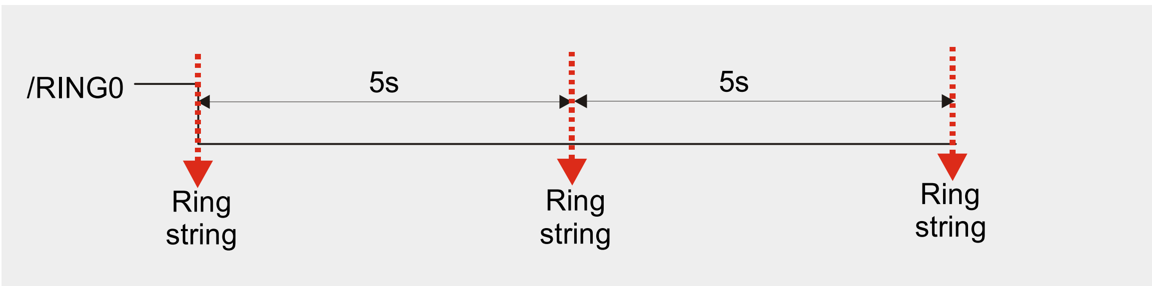


Figure 17: Incoming data call

- All types of Unsolicited Result Codes (URCs) also cause the /RING0 line to go low, however for 1 second only.
  For example, AC45 may be configured to output a URC upon the receipt of an SMS. As a result, if this URC type was activated with AT+CNMI=1,1, each incoming SMS causes the /RING0 line to go low. See [1] for detailed information on URCs.

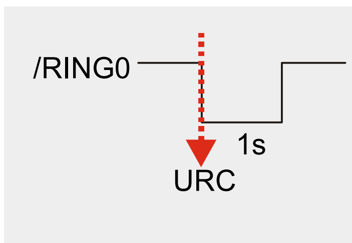


Figure 18: URC transmission

Table 14: AC45 ring signal

Function	Pin	Status	Description
Ring indication	/RING0	0	Indicates an incoming call or URC. If in NON-CYCLIC SLEEP mode CFUN=0 or CYCLIC SLEEP mode CFUN=5 or 6, the module is caused to wake up to full functionality. If CFUN=7 or 8, power saving is resumed after URC transmission or end of call.
		1	No operation

4 Antenna interface (antenna reference point – ARP)

The RF interface has an impedance of 50Ω. AC45 is capable of sustaining a total mismatch at the antenna connector without any damage, even when transmitting at maximum power level. The antenna jack located on the AC45 PCB is a Rosenberger SMP coaxial connector particularly proven to meet the requirements of vehicle mounted applications.
The external antenna must be matched properly at least to achieve best performance regarding radiated power, DC-power consumption and harmonic suppression.

Regarding the return loss AC45 provides the following values.

Table 15: Return loss

State of module	Return loss of module	Recommended return loss of application
Receive	≥ 8dB	≥ 12dB
Transmit	not applicable	≥ 12dB
Idle	≤ 5dB	not applicable

4.1 Antenna detection

AC45 offers an antenna diagnosis functionality. This allows the customer to check that the antenna is properly connected, simply by using the AT^SAD command. A description of the command can be found in [1]. Free use of the technology in view of intellectual property rights is not guaranteed.

To benefit from this feature you are required to add a resistor R_{ANT} = 10kΩ (±20%). The resistor must be placed close to the antenna connector or integrated into the antenna. Please note that the resistance ranges 5k...8kΩ and 12k...15kΩ at the antenna connector are undefined ranges.

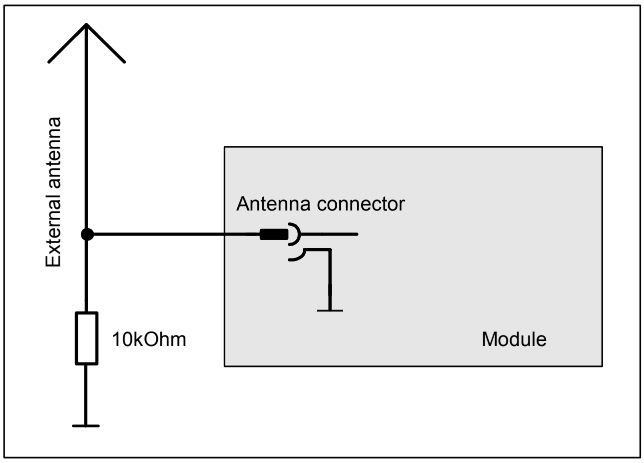


Figure 19: Resistor measurement used for antenna detection

Table 16: Antenna detection

The following four states can be verified with AT^SAD:	<diag>	equivalent to:
Antenna connected (resistor available)	<diag>=0	8k…12kΩ
Antenna connector short-circuited to GND	<diag>=1	0...5kΩ
Antenna connector short-circuited to 12V/24V	<diag>=2	>+2.5V*)
No antenna connected resp. no resistor available at antenna connector or inside antenna.	<diag>=3	15k...∞Ω

*) Any external applied voltage higher than +2.5V

4.2 Antenna connector

AC45 uses a subminiature coaxial antenna connector type SMP MIL-Std 348-A supplied from Rosenberger.

Table 17: Product specifications of Rosenberger SMP connector

Item	Specification	Conditions
Material and finish		
Center contact	Brass 0.8 µm gold plating over 2-4 µm NiP plating	
Outer contact	Brass 0.8 µm gold plating over 2-4 µm NiP plating	
Dielectric	PTFE	
Electrical ratings		
Nominal Impedance	50 Ω	
Operating frequency	DC – 2 GHz	
VSWR	1.10	DC to 2 GHz
Insertion loss	$\leq$ 0.1 dB x $\sqrt{}$ f/GHz	
Center contact resistance	max. 6 mΩ	
Outer contact resistance	max. 2 mΩ	
Insulation resistance	5 GΩ	
Working voltage	335 V rms	at sea level
Dielectric withstanding voltage	500 V rms	at sea level
Mechanical ratings		
Durability	30 mating cycles	
Engagement force	20-35 N	
Disengagement force	30-50 N	
Center contact captivation Axial retention force	7 N min.	
Environmental ratings		
Operating temperature	-65°C to +155°C	
Manufacturer		
Rosenberger Hochfrequenztechnik GmbH & Co. POB 1260 D-84526 Tittmoning http://www.rosenberger.de		

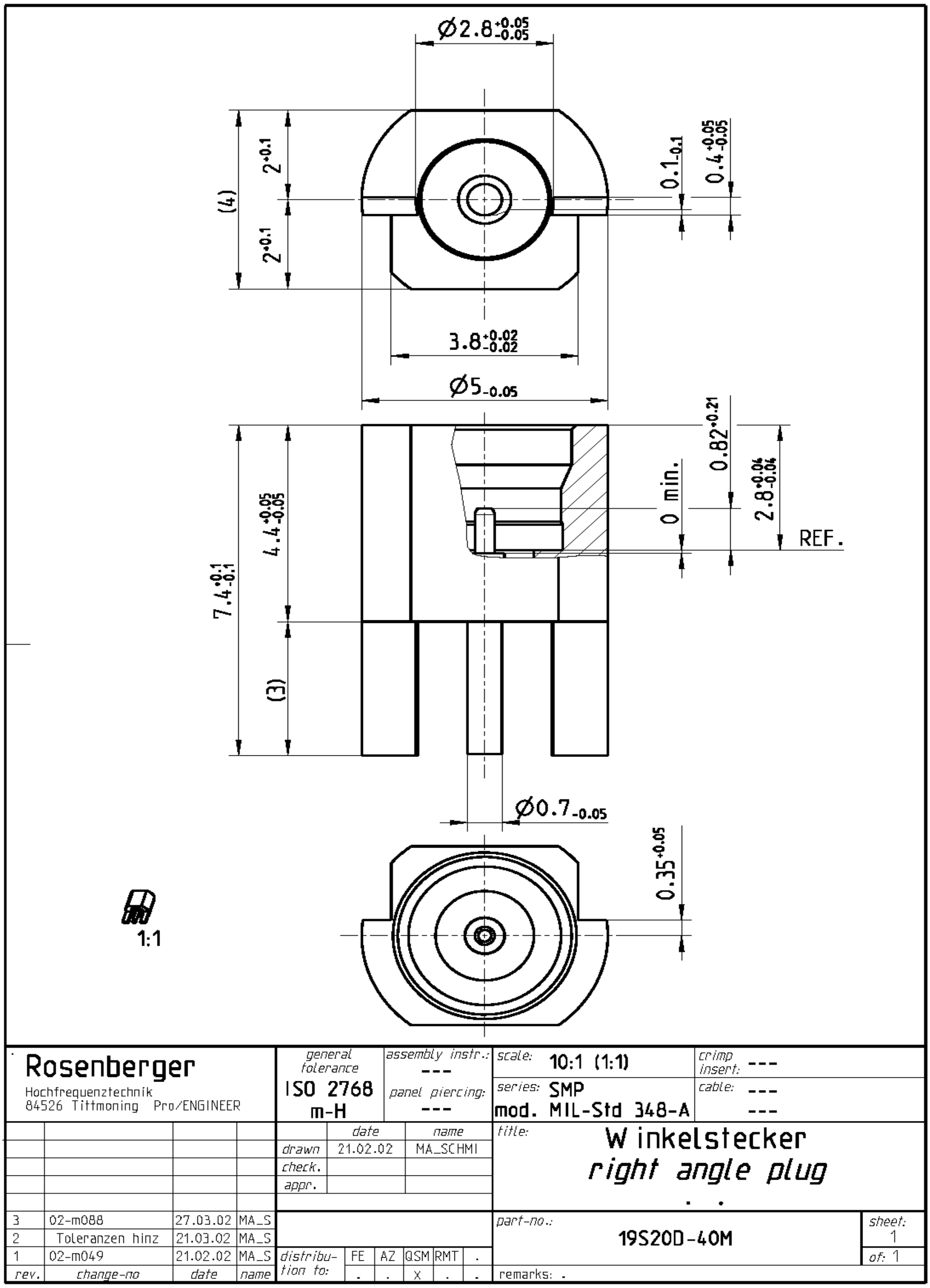


Figure 20: Datasheet of Rosenberger SMP MIL-Std 348-A connector

5 Electrical, reliability and radio characteristics

5.1 Absolute maximum ratings

The absolute maximum ratings stated in Table 18 are stress ratings under non-operating conditions. Stresses beyond any of these limits will cause permanent damage to AC45.

Table 18: Absolute maximum ratings

Parameter	Min	Max	Unit
Supply voltage BATT+	-0.3	5.0	V
Supply voltage 3V3	-0.3	5.0	V
Voltage at digital pins	-0.3	3.3	V
Voltage at analog pins	-0.3	3.0	V
Voltage at digital / analog pins in POWER DOWN mode	-0.25	+0.25	V
Differential load resistance between EPN1 and EPP1	15		Ω
Differential load resistance between EPN2 and EPP1	15		Ω

5.2 Operating temperature

Test conditions were specified in accordance with IEC 60068-2 (still air). The values stated below are in compliance with GSM recommendation TS 51.010-1.

Table 19: Temperature conditions

Parameter	Min	Typ	Max	Unit
Ambient temperature (according to GSM 11.10)	-25	25	65	°C
Restricted operation [1)]	-29 to -25		65 to 75	°C
Automatic shutdown	$\leq$-29 [2)]		$\geq$75 [2)]	°C

1) AC45 operates, but deviations from the GSM specification may occur.
2) Due to temperature measurement uncertainty, a tolerance of +/- 3°C on these switching thresholds may occur.

5.3 Electrical specifications of the application interface

Please note that the reference voltages listed in Table 20 are the values measured directly on the AC45 module. They do not apply to the accessories connected.

If an input pin is specified for $V_{i,h,max}$ = 3.3V, be sure never to exceed the stated voltage. The value 3.3V is an absolute maximum rating.

The Hirose DF12C board-to-board connector on AC45 is a 40-pin double-row receptacle. The numbers and the position of the pins can be seen from Figure 21 which shows the top view of AC45.

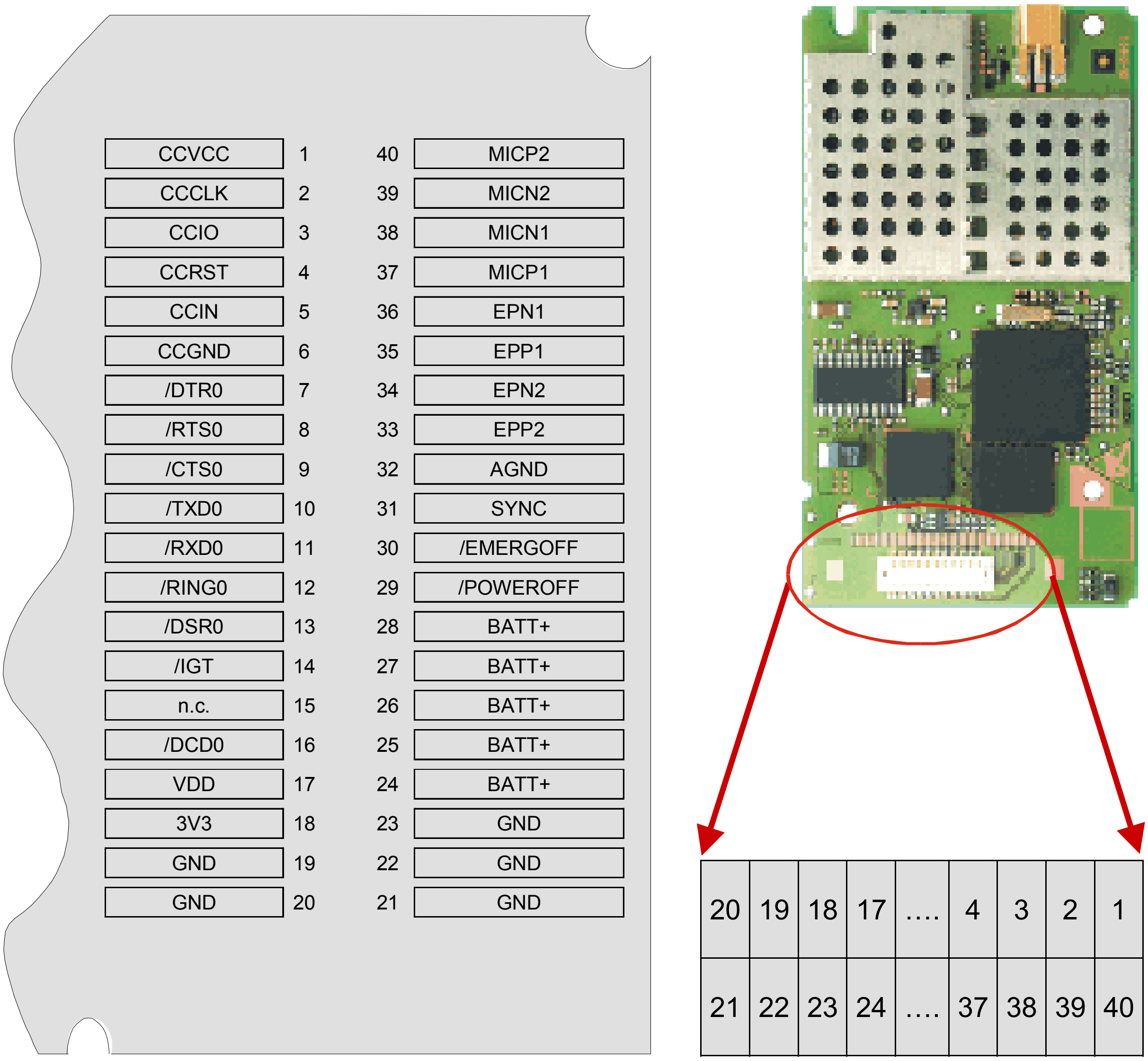


Figure 21: Pin assignment (top view on AC45)

Table 20: Electrical description of application interface

<table>
<tr><th>Function</th><th>Signal name</th><th>IO</th><th>Signal form and level</th><th>Comments</th></tr>
<tr><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Power supply (RF-PA)</td><td>BATT+</td><td>I</td><td>V_I = 3.5 to 4.5V
$V_I$nom = 4.2V
$V_I$min = 3.5V
Ityp ≈ 2A during transmit burst

1 Tx, Peak current 577µs every 4.615ms</td><td>Five BATT+ pins, all to be connected in parallel.</td></tr>
<tr><td>Power supply (baseband and RF transceiver)</td><td>3V3</td><td>I</td><td>$V_I$min = 3.17V
$V_I$nom = 3.3V
$V_I$max = 4.5V
Imax = 200mA</td><td>It is allowed to connect this pin to BATT+ externally to supply the AC45 with only one voltage.</td></tr>
<tr><td>Power supply</td><td>GND</td><td></td><td>Application ground</td><td>Five GND pins, all to be connected in parallel.</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>External supply voltage</td><td>VDD</td><td>O</td><td>VDDmin = 2.84V
VDDnom = 2.9V
VDDmax = 2.96V
Imax = -10mA
$C_L$max = 1µF</td><td>Supply voltage, e.g. for external LED or level shifter. Not available in power down mode. The external digital logic must not cause any spikes or glitches on voltage VDD.
VDD is required to monitor the POWER DOWN state.
If unused keep pin open.</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Ignition</td><td>/IGT</td><td>I</td><td>R_I ≈ 100kΩ, C_I ≈ 1nF
V_{IL}max = 0.5V at Imax = -20µA
V_{Open}max = 2.3V
ON ~~~|____|~~~ Active Low ≥ 100ms</td><td>This signal switches the module ON.
This line must be driven low by an Open Drain or Open Collector driver.</td></tr>
<tr><td>Emergency shutdown
(Watchdog)</td><td>/EMERGOFF</td><td>I</td><td>R_I ≈22kΩ
V_{IL}max = 0.45V at Imax = -100µA
V_{Open}max = 2.73V
Signal ~~~|______|~~~ Active Low ≥ 3.2s

Watchdog:
V_{OL}max = 0.35V at I = 10µA
V_{OH}min= 2.25V at I = -10µA
$f_O$min = 0.16Hz
$f_O$max = 1.55Hz</td><td>This line must be driven by an Open Drain or Open Collector driver. Emergency shutdown deactivates the module's power supply. A reset can be done with a following /IGT.
To switch off AC45 use the AT^SMSO command or /POWEROFF.
/EMERGOFF also indicates the internal watchdog function.
To avoid floating if pin is high impedance, use pull-down resistor tied to GND. See chapter 3.3.2.1.
If unused keep pin open.</td></tr>
</table>

Function	Signal name	IO	Signal form and level	Comments
SW controlled shutdown	/POWEROFF	I	$V_{IL}max = 0.5V$ $V_{IH}min = 1.95V$, $V_{IH}max=3.3V$ Imax = -90µA at V_{IN} = 0V ON ~~~|_____|~~~ Active Low ≥ 100ms	If LOW then shutdown procedure is started (similar to AT^SMSO). If unused keep pin open.
Synchronization	SYNC	O	$V_{OL}max = 0.2V$ at I = 1mA $V_{OH}min = 2.35V$ at I = -1mA $V_{OH}max = 2.73V$  1 Tx, 877µs impulse each 4.615ms, with 300µs forward time.	Indication of increased current consumption during uplink transmission burst, however, the timing is different during handover. Alternatively used to control status LED. If unused keep pin open. See Chapter 3.8.2.2.
Serial Interface	/RXD0	O	$V_{OL}max = 0.2V$ at I = 1mA $V_{OH}min = 2.35V$ at I = -1mA $V_{OH}max = 2.73V$ $V_{IL}max = 0.5V$ $V_{IH}min = 1.95V$, $V_{IH}max=3.3V$ /RTS0, /DTR0: Imax = -90µA at V_{IN} = 0V /TXD0: Imax =-30µA at V_{IN} = 0V	Serial interface for AT commands or data stream. To avoid floating if output pins are high-impedance, use pull-up resistors tied to VDD or pull-down resistors tied to GND. See chapter 3.3.2.1. If lines are unused keep pins open.
	/TXD0	I		
	/CTS0	O		
	/RTS0	I		
	/DTR0	I		
	/DCD0	O		
	/DSR0	O		
	/RING0	O		
SIM Interface	CCIN	I	R_I ≈ 100kΩ $V_{IL}max = 0.5V$ $V_{IH}min = 2.15V$ at I = 20µA, $V_{IH}max=3.3V$ at I = 30µA	CCIN = high, SIM card holder closed (no card recognition)
	CCRST	O	R_O ≈47Ω $V_{OL}max = 0.25V$ at I = 1mA $V_{OH}min = 2.3V$ at I = -1mA $V_{OH}max = 2.73V$	Maximum cable length or copper track 200mm to SIM card holder.
	CCIO	IO	R_I ≈10kΩ $V_{IL}max = 0.5V$ $V_{IH}min = 1.95V$, $V_{IH}max=3.3V$ R_O ≈220Ω $V_{OL}max = 0.4V$ at I = 1mA $V_{OH}min = 2.15V$ at I = -1mA $V_{OH}min = 2.55V$ at I = -20µA $V_{OH}max = 2.96V$	All signals of SIM interface are protected against ESD with a special diode array. Usage of CCGND is mandatory.
	CCCLK	O	R_O ≈220Ω $V_{OL}max = 0.4V$ at I = 1mA $V_{OH}min = 2.15V$ at I = -1mA $V_{OH}max = 2.73V$	
	CCVCC	O	R_Omax = 5Ω CCVCCmin = 2.84V, CCVCCmax = 2.96V Imax = 20mA	
	CCGND		Ground	

Function	Signal name	IO	Signal form and level	Comments
Analog audio interface	EPP2	O	$V_O max$ = 4.07Vpp See also Table 24.	The audio output is balanced and can directly operate an earpiece. If unused keep pins open. Short circuit may damage the outputs.
	EPN2	O		
	EPP1	O	$V_O max$ = 4.07Vpp See also Table 24.	The audio output is balanced and can directly operate an earpiece. If unused keep pins open. Short circuit may damage the outputs.
	EPN1	O		
	MICP1	I	$R_I \approx 50k\Omega$ differential $V_I max$ = 1.03Vpp See also Table 25.	This microphone input is balanced and must be decoupled with capacitors (C_K = 100nF). If unused keep pins open.
	MICN1	I		
	MICP2	I	$R_I = 2k\Omega$ differential $V_I max$ = 1.03Vpp See also Table 25.	The microphone input is balanced and can feed an active microphone. If unused keep pins open.
Explanation of signal names: P = positive, N = negative	MICN2	I		
	AGND		Ground	Ground for audio interfaces

5.4 Power supply ratings

Table 21: Power supply ratings

Parameter	Description	Conditions	Min	Typ	Max	Unit
BATT+	Supply voltage depending on application design either for RF PA only or for baseband + RF transceiver + RF PA	Directly measured at the reference points TP BATT+ and TP GND. See Figure 26 for position of test points. Voltage must stay within the min/max values, including voltage drop, ripple, spikes.	3.5[4)]	4.2	4.5	V
	Voltage drop during transmit burst	Normal condition, power control level for $P_{out\ max}$			400mV	
	Voltage ripple	Normal condition, power control level for $P_{out\ max}$ @ f<200kHz @ f>200kHz			50 2	mV
3V3	Additional supply voltage for baseband section and RF transceiver	Directly measured at the reference point TP 3V3. See Figure 26 for position of test points. Voltage must stay within the min/max values, including voltage drop, ripple, spikes.	3.17	3.3	4.5[5)]	V
I_{BATT+}	Average supply current[3)] Values are listed separately for BATT+ and 3V3	POWER DOWN mode BATT+: 3V3:		30 20	60 40	µA
		SLEEP mode (DRX = 6) BATT+: 3V3:		0.15 2.85		mA
		IDLE mode BATT+: 3V3:		0.15 25		mA
		TALK mode EGSM 900[1)] BATT+: 3V3: GSM 1800[2)] BATT+: 3V3:		185[6)] 115[6)] 135[6)] 135[6)]	250 150	mA
		DATA mode GPRS, multi-slot class 8 EGSM 900[1)] BATT+: 3V3: GSM 1800[2)] BATT+: 3V3:		190[6)] 170[6)] 130[6)] 200[6)]	240 220	mA
	Peak supply current (577µs transmission slot every 4.6ms)	Power level PCL 5 BATT+: 3V3:		1.7 0.3	7)	A A

1) Power control level PCL 5
2) Power control level PCL 0
3) All average supply current values @ I_{VDD} = 0mA
4) During transmit bursts, the voltage at the BATT+ test point may drop to min. 3.5V (due to the source resistance of the supply voltage and cable losses). Note that this minimum voltage must be

measured against the GND test point on AC45. See Chapter 3.2.1

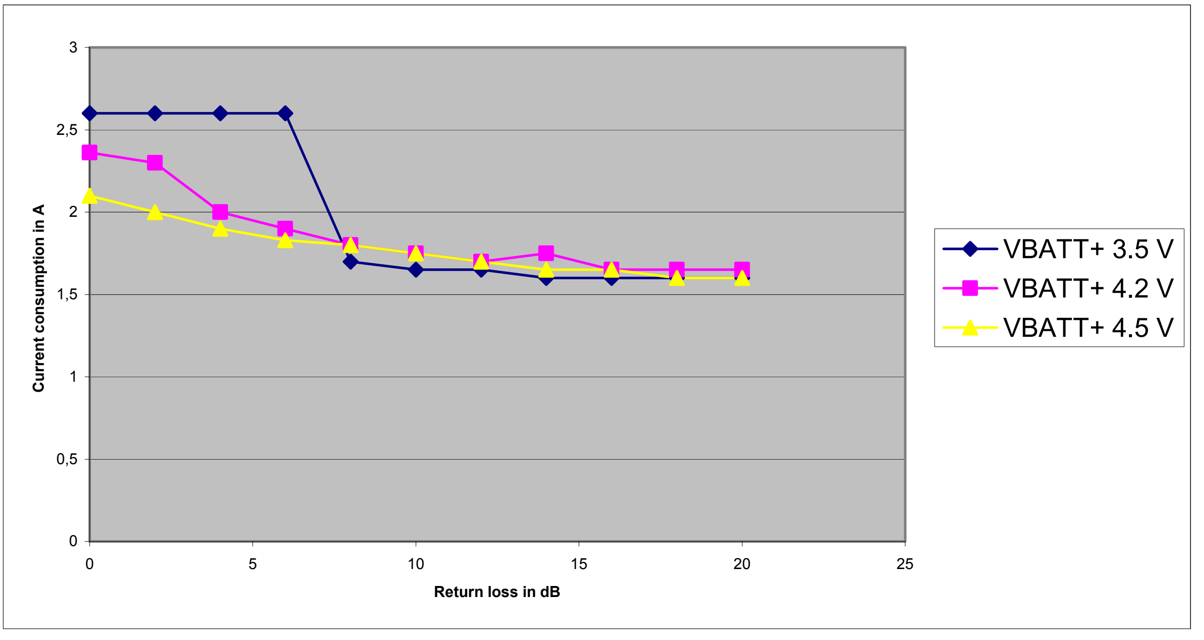
5) Takes into account the option of supplying the 3V3 input from the BATT+ source.

6) Stated value applies to an average antenna performance.

7) The maximum current at the BATT+ line during transmit operation strongly depends on the antenna performance. Data curves typically measured for mismatched antennas are given in Figure 22 and Figure 23.

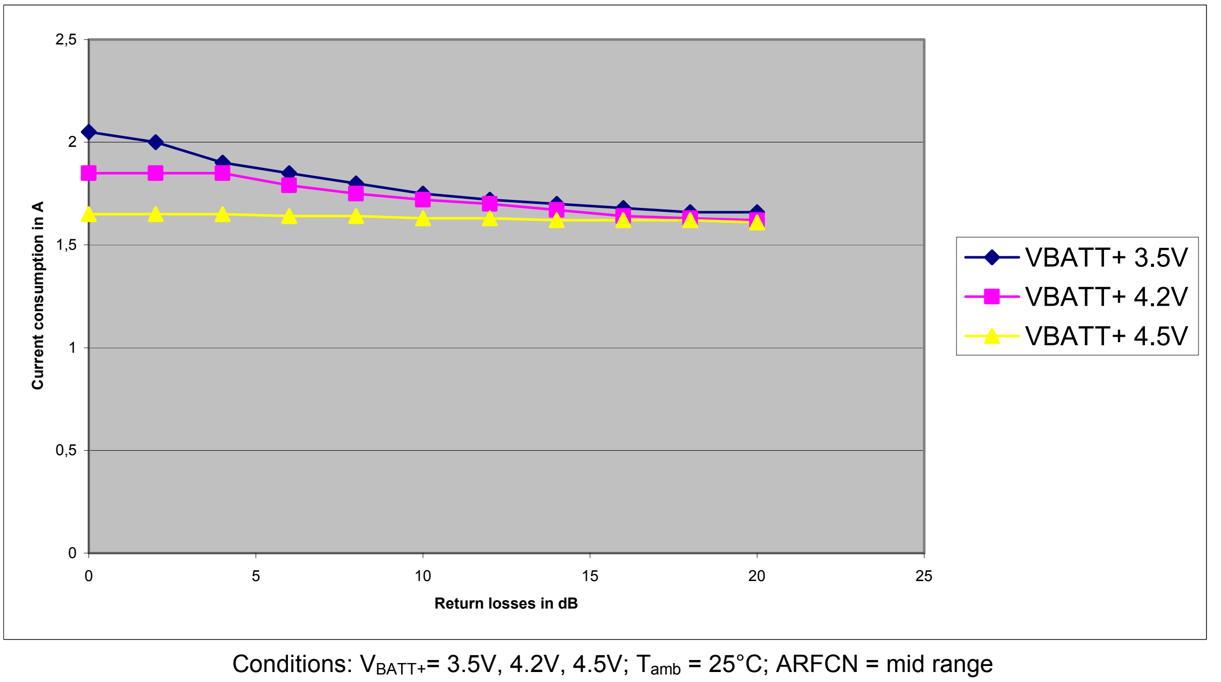
5.4.1 Current consumption during transmit burst

The diagrams provided in Figure 22 and Figure 23 illustrate the peak current consumption of the application caused during a transmit burst. The peak current is shown for GSM 900 and GSM 1800 vs. the return loss of the antenna.
All measurements have been performed at 25°C and different supply voltages. The reference points used on AC45 are the BATT+ and GND contacts.
Changing the conditions, e.g. in terms of temperature or voltage, will cause different results. The current consumption will be maximized when the minimum supply voltage is used together with a total reflection at the RF interface.



Conditions: V_{BATT+} = 3.5V, 4.2V, 4.5V; T_{amb} = 25°C; ARFCN = mid range

Figure 22: Typical current consumption vs. return loss in EGSM 900 network



Conditions: V_{BATT+}= 3.5V, 4.2V, 4.5V; T_{amb} = 25°C; ARFCN = mid range

Figure 23: Typical consumption current vs. return loss in GSM 1800 network

5.5 Electrical characteristics of the voiceband part

5.5.1 Setting audio parameters by AT commands

The audio modes 2 to 6 can be adjusted according to the parameters listed below. Each audio mode is assigned a separate set of parameters.

Table 22: Audio parameters adjustable by AT command

Parameter	Influence to	Range	Gain range	Calculation
inBbcGain	MICP/MICN analogue amplifier gain of baseband controller before ADC	0...7	0...42dB	6dB steps
inCalibrate	Digital attenuation of input signal after ADC	0...32767	-∞...0dB	20 * log (inCalibrate/ 32768)
outBbcGain	EPP/EPN analogue output gain of baseband controller after DAC	0...3	0...-18dB	6dB steps
outCalibrate[n] n = 0...4	Digital attenuation of output signal after speech decoder, before summation of sidetone and DAC present for each volume step[n]	0...32767	-∞...+6dB	20 * log (2 * outCalibrate[n]/ 32768)
sideTone	Digital attenuation of sidetone Is corrected internally by outBbcGain to obtain a constant sidetone independent of output volume	0...32767	-∞...0dB	20 * log (sideTone/ 32768)

Note: The parameters outCalibrate and sideTone accept also values from 32768 to 65535. These values are internally truncated to 32767. If inCalibrate exceeds the value of 32767, the AT^SNFI command responds with ERROR.

5.5.2 Audio programming model

The audio programming model shows how the signal path can be influenced by varying the AT command parameters. The parameters inBbcGain and inCalibrate can be set with AT^SNFI. All the other parameters are adjusted with AT^SNFO.

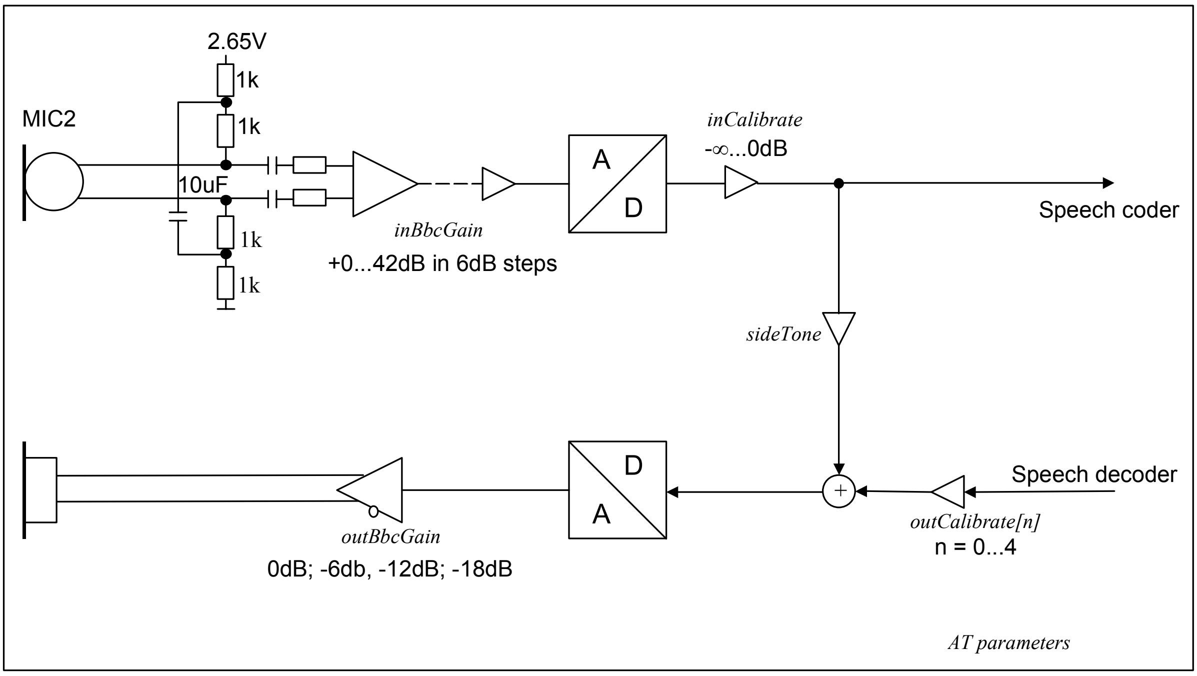


Figure 24: Audio programming model

5.5.3 Characteristics of audio modes

The electrical characteristics of the voiceband part depend on the current audio mode set with the AT^SNFS command.

Table 23: Voiceband characteristics (typical)

Audio mode no. AT^SNFS=	**1** (Default settings, not adjustable)	**2**	**3**	**4**	**5**	**6**
Name	Default Handset	Basic Handsfree	Headset	User Handset	Plain Codec 1	Plain Codec 2
Purpose	DSB with Votronic handset	Siemens Car Kit Portable	Siemens Headset	DSB with individual handset	Direct access to speech coder	Direct access to speech coder
Gain setting via AT command. Defaults: inBbcGain outBbcGain	Fix 4 (24dB) 1 (-6dB)	Adjustable 2 (12dB) 1 (-6dB)	Adjustable 5 (30dB) 2 (-12dB)	Adjustable 4 (24dB) 1 (-6dB)	Adjustable 0 (0dB) 0 (0dB)	Adjustable 0 (0dB) 0 (0dB)
Default audio interface	1	2	2	1	1	2 [4)]
Power supply	ON (2.65V)	ON (2.65V)	ON (2.65V)	ON (2.65V)	OFF (GND)	OFF (GND)
Sidetone	ON	---	Adjustable	Adjustable	Adjustable	Adjustable
Volume control	OFF	Adjustable	Adjustable	Adjustable	Adjustable	Adjustable
Limiter (receive)	ON	ON	ON	ON	---	---
Compressor (receive)	---	OFF [1)]	---	---	---	---
AGC (send)	---	---	ON	---	---	---
Echo control (send)	Suppression	Cancellation + suppression	---	Suppres-sion	---	---
Noise suppression [2)]	---	up to 12dB	12dB	---	---	---
MIC input signal for 0dBm0 @ 1024 Hz (default gain)	23mV	58mV	7.5mV @ -3dBm0 due to AGC	23mV	315mV	315mV
EP output signal in mV rms. @ 0dBm0, 1024 Hz, no load (default gain); @ 3.14 dBm0	284mV	120mV default @ max volume	300mV default @ max volume	284mV default @ max volume	895mV 3.7 Vpp	895mV 3.7 Vpp
Sidetone gain at default settings	22.8dB	-∞ dB	Affected by AGC, 13dB @ 7.5mV (MIC)	22.8dB	-2.5dB @ sideTone = 8192 [3)]	-2.5dB @ sideTone = 8192 [3)]

1) Adaptive, receive volume increases with higher ambient noise level. The compressor can be activated by loading an application specific audio parameter set (see [10]).

2) In audio modes with noise reduction, the microphone input signal for 0dBm0 shall be measured with a sine burst signal for a tone duration of 5 seconds and a pause of 2 sec. The sine signal appears as noise and, after approx. 24 sec, is attenuated by the noise reduction by up to 12dB.

3) See AT^SNFO command in [1].

4) Audio mode 5 and 6 are identical. With AT^SAIC, you can easily switch mode 5 to the second interface. Therefore, audio mode 6 is only kept for compatibility to earlier Siemens GSM products.

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 high sensitive earpiece. A protection circuit should be implemented in the cellular application.

5.5.4 Voiceband receive path

Test conditions:

- The values specified below were tested to 1kHz and 0dB gain stage, unless otherwise stated.
- Parameter setup: gs = 0dB means audio mode = 5 for EPP1 to EPN1 and 6 for EPP2 to EPN2, inBbcGain= 0, inCalibrate = 32767, outBbcGain = 0, OutCalibrate = 16384, sideTone = 0.

Table 24: Voiceband receive path

Parameter	Min	Typ	Max	Unit	Test condition / remark
Differential output voltage (peak to peak)	3.33	3.7	4.07	V	from EPPx to EPNx *gs* = 0dB @ 3.14 dBm0 no load
Differential output gain settings (*gs*) at 6dB stages (outBbcGain)	-18		0	dB	Set with AT^SNFO
Fine scaling by DSP (outCalibrate)	-∞		0	dB	Set with AT^SNFO
Output differential DC offset			100	mV	*gs* = 0dB, outBbcGain = 0 and -6dB
Differential output resistance		2		Ω	from EPPx to EPNx
Differential load capacitance			1000	pF	from EPPx to EPNx
Absolute gain accuracy			0.8	dB	Variation due to change in temperature and life time
Attenuation distortion			1	dB	for 300...3900Hz, @ EPPx/EPNx (333Hz) / @ EPPx/EPNx (3.66kHz)
Out-of-band discrimination	60			dB	for *f* > 4kHz with in-band test signal@ 1kHz and 1kHz RBW

gs = gain setting

5.5.5 Voiceband transmit path

Test conditions:

- The values specified below were tested to 1kHz and 0dB gain stage, unless otherwise stated.
- Parameter setup: Audio mode = 5 for MICP1 to MICN1 and 6 for MICP2 to MICN2, inBbcGain= 0, inCalibrate = 32767, outBbcGain = 0, OutCalibrate = 16384, sideTone = 0

Table 25: Voiceband transmit path

Parameter	Min	Typ	Max	Unit	Test condition / Remark
Input voltage (peak to peak) MICP1 to MICN1, MICP2 to MICN2			1.03	V	
Input amplifier gain in 6dB steps (inBbcGain)	0		42	dB	Set with AT^SNFI
fine scaling by DSP (inCalibrate)	-∞		0	dB	Set with AT^SNFI
Input impedance MIC1		50		kΩ	
Input impedance MIC2		2.0		kΩ	
Microphone supply voltage ON Ri = 4kΩ (MIC2 only)	2.57 2.17 1.77	2.65 2.25 1.85	2.73 2.33 .93	V V V	no supply current @ 100µA @ 200µA
Microphone supply voltage OFF; Ri = 4kΩ (MIC2 only)		0		V	
Microphone supply in POWER DOWN mode					See Figure 10

5.6 Air interface

Table 26: Air Interface

Parameter		Min	Typ	Max	Unit
Frequency range	E-GSM 900	880		915	MHz
Uplink (MS → BTS)	GSM 1800	1710		1785	MHz
Frequency range	E-GSM 900	925		960	MHz
Downlink (BTS → MS)	GSM 1800	1805		1880	MHz
RF power @ ARP at 50Ω load	E-GSM 900[1)]	31	33 [3)]	35	dBm
	GSM 1800[2)]	28	30 [3)]	32	dBm
Number of carriers	E-GSM 900		174		
	GSM 1800		374		
Duplex spacing	E-GSM 900		45		MHz
	GSM 1800		95		MHz
Carrier spacing			200		kHz
Multiplex, Duplex		TDMA / FDMA, FDD			
Time slots per TDMA frame			8		
Frame duration			4.615		ms
Time slot duration			577		µs
Modulation		GMSK			
Receiver input sensitivity @ ARP	E-GSM 900	-102			dBm
Under all propagation conditions according to GSM specification	GSM 1800	-102			dBm
Receiver input sensitivity @ ARP	E-GSM 900		-107		dBm
BER class II <2.4% @ static input level (no fading)	GSM 1800		-106		dBm

1) Power control level PCL 5
2) Power control level PCL 0
3) at 50Ω load impedance. The output power depends on the BATT+ voltage during transmit bursts and the measured board temperature. The given values are valid for room temperature and nominal operating voltage.

Table 27: Local oscillator and intermediate frequencies used by AC45

All frequencies in MHz		Frequency band	Local oscillator	Intermediate frequency
E-GSM 900	TX	880 - 915	1470 - 1550	90 - 115
	RX	925 - 960	1385 - 1440	0
GSM 1800	TX	1710 - 1785	1350 - 1415	90 - 115
	RX	1805 - 1880	1350 - 1415	0

5.7 Electrostatic discharge

The GSM engine 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 an AC45 module.

ESD protection is provided on the antenna interface, the SIM interface and the power pins. The remaining ports of AC45 are not accessible to the user of the final product (since they are installed within the device) and therefore, are only protected according to the "Human Body Model" requirements.

AC45 has been tested according to the EN 61000-4-2 standard. The measured values can be gathered from the following table.

Table 28: Measured electrostatic values

Specification / Requirements	Contact discharge	Air discharge
ETSI EN 301 489-7		
ESD at SIM port	± 4kV	± 8kV
ESD at antenna port	± 4kV	± 8kV
ESD at power pins: BATT+, 3V3, GND	± 4kV	± 8kV
Human Body Model – IEC / PAS 62179 (test conditions: 1.5 kΩ, 100 pF)		
ESD at the module	± 1kV	

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 Siemens reference application described in Chapter 7.

5.8 Reliability characteristics

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

Table 29: Summary of reliability test conditions

Type of test	Conditions	Standard
Vibration	Frequency range: 10-20 Hz; amplitude: 3.1mm Frequency range: 20-500 Hz; acceleration: 5g Duration: 2h per axis = 10 cycles; 3 axes	DIN IEC 68-2-6
Shock half-sinus	Acceleration: 500g Shock duration: 1msec 1 shock per axis 6 positions (± x, y and z)	DIN IEC 68-2-27
Dry heat	Temperature: +70 ±2°C Test duration: 16 h Humidity in the test chamber: < 50%	EN 60068-2-2 Bb ETS 300019-2-7
Temperature change (shock)	Low temperature: -40°C ±2°C High temperature: +85°C ±2°C Changeover time: < 30s (dual chamber system) Test duration: 1 h Number of repetitions: 100	DIN IEC 68-2-14 Na ETS 300019-2-7
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 68-2-30 Db ETS 300019-2-5
Cold (constant exposure)	Temperature: -40 ±2°C Test duration: 16 h	DIN IEC 68-2-1

6 Mechanics

6.1 Mechanical dimensions of AC45

Figure 25 shows the top view on AC45 and provides an overview of the mechanical dimensions of the board. For further details see Figure 26.

Size (mm): 65 ±0.2 x 36 ±0.2 x 4.3 ±0.3

Weight: 11g

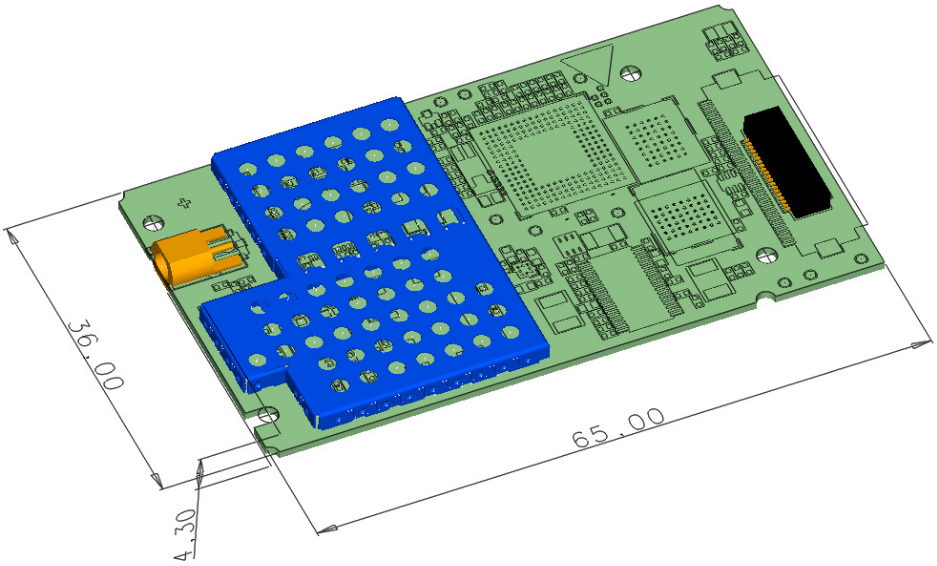
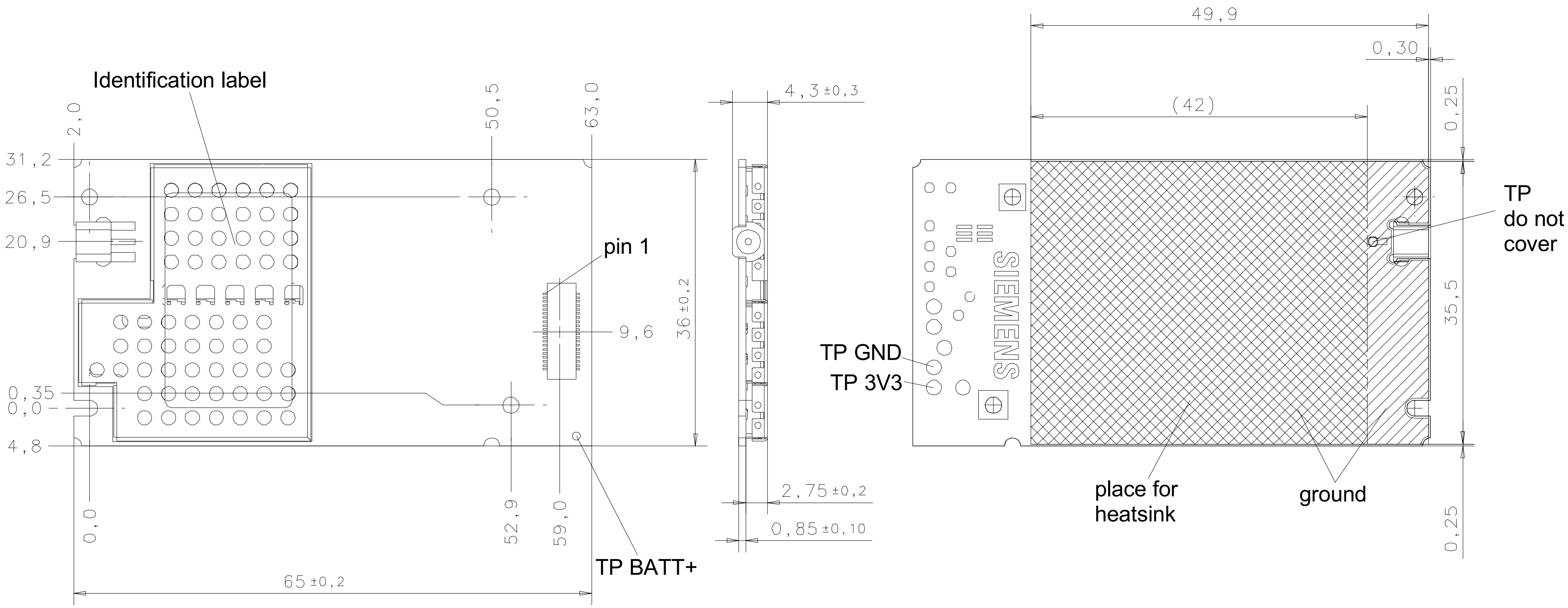


Figure 25: AC45 – top view



All dimensions in millimeter.

Figure 26: Mechanical dimensions of AC45 (left top view, right bottom view)

6.2 Mounting AC45 onto the application platform

There are many ways to properly install AC45 in the host device. An efficient approach is to mount the AC45 PCB to a frame, plate, rack or chassis.

Fasteners can be M1.6 or M1.8 screws plus suitable washers, or preferably, expandable mandrels or arbors.

Particular attention must be paid to the hole next to the board-to-board connector.

- The BATT+ power supply line is placed only 0.3 mm from the hole in a buried layer. Please take care that the mounting screw does not cut into the PCB.
- The board-to-board connector soldering pattern is placed close to the mounting hole. To avoid that the screw comes into contact with the connector or the BATT+ power supply line, screw in either an M1.6 screw or, if you use an M1.8 screw, add a plastic washer. See Figure 27.

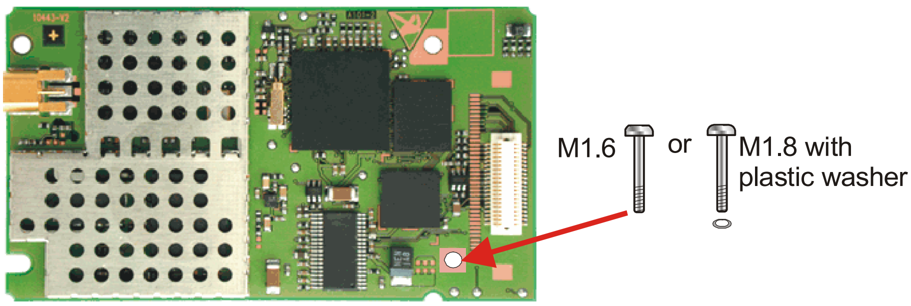


Figure 27: Recommended screws

In addition, the board-to-board connection can also be utilized to achieve better support.

To achieve optimum mechanical stability, it is mandatory to use the 3 holes and the additional slotted hole to mount AC45 to your application.

It is recommended to add cooling elements, e.g. a heatsink, which should be preferably attached to the ground pad on the bottom of AC45. The position and dimensions of the ground pad can be seen in Figure 26.

To prevent mechanical damage, be careful not to force, bend or twist the module. Be sure it is positioned flat against the host device. Avoid exerting pressure on the shielding cover to prevent degradation of shielding performance.

6.3 Board-to-board connector (application interface)

This chapter provides specifications for the 40-pin board-to-board connector which serves as physical interface to the host application. The receptacle assembled on the AC45 PCB is type Hirose DF12C. Mating headers from Hirose are available in different stacking heights.

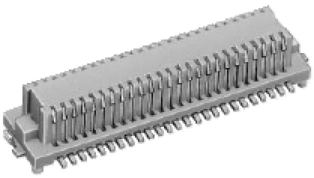


Figure 28: Hirose DF12C receptacle on AC45

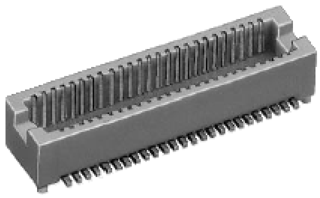


Figure 29: Header Hirose DF12 series

Table 30: Ordering information

Item	Part number	Stacking height (mm)	HRS number
Receptacle on AC45	DF12C(3.0)-40DS-0.5V(81)	3 - 5	537-0692-3-81
Headers DF12 series	DF12E(3.0)-40DP-0.5V(81)	3.0	537-0832-0-81
	DF12E(3.5)-40DP-0.5V(81	3.5	537-0532-7-81
	DF12E(4.0)-40DP-0.5V(81)	4.0	537-0557-8-81
	DF12E(5.0)-40DP-0.5V(81)	5.0	537-0582-5-81

Note: The headers listed above are without boss and metal fitting. Please contact Hirose for details on other types of mating headers.

Table 31: Electrical and mechanical characteristics of the Hirose DF12C connector

Parameter	Specifications
Number of contacts	40
Quantity delivered	2000 connectors per tape & reel
Voltage	50V
Rated current	0.3A max per contact
Resistance	0.05 Ω per contact
Dielectric withstanding voltage	500V RMS min
Operating temperature	-45°C...+125°C
Contact material	phosphor bronze (surface: gold plated)
Insulator material	PA , beige natural
Stacking height	3.0mm ; 3.5mm ; 4.0mm ; 5.0mm
Insertion force	21.8N
Withdrawal force 1st	10N
Withdrawal force 50th	10N
Maximum connection cycles	50

6.3.1 Mechanical dimensions of the Hirose DF12 connector

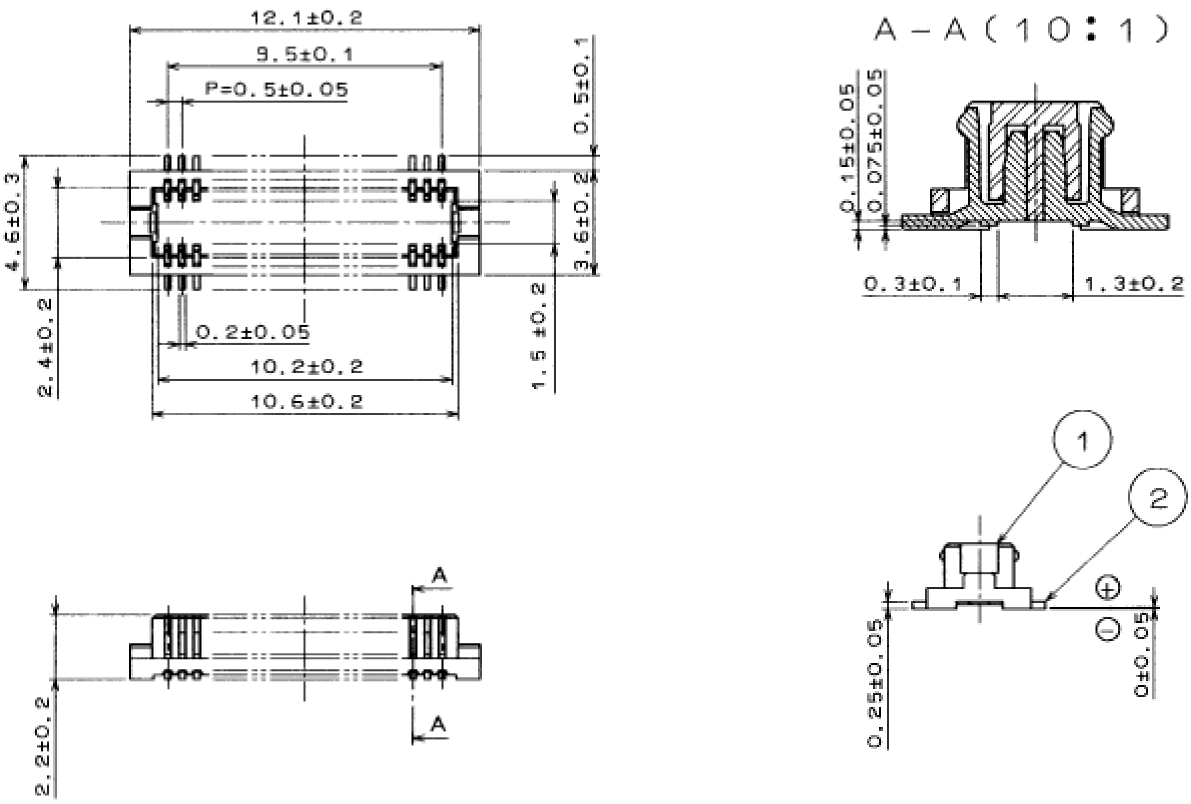


Figure 30: Mechanical dimensions of Hirose DF12 connector

6.3.2 Adapter cabling

The board-to-board connection is primarily intended for direct contact between both connectors. If this assembly solution does not fit into your application design ensure that the used adapter cable meets the following requirements:

- Maximum length: 200 mm.
  As stated in Chapter 3.7 the total cable length between the board-to-board connector pins on AC45 and the pins of the SIM card holder must not exceed 200 mm in order to meet the specifications of 3GPP TS 51.010-1 and to satisfy the requirements of EMC compliance.
- Type of cable: Flexible cable or flexible printed circuit board designed to mate with the Hirose receptacle and headers specified above.

The equipment submitted for type approving the Siemens reference setup of AC45 uses a 160mm adapter cable (not included in the scope of delivery of the DSB45 Box). See Chapter 7.1.

6.4 Recommended thermal solutions and heat sinks

Thermal management solutions vary largely according to the usage of the final product and the design of the host device. Therefore, the focus of this chapter is on a brief overview of heat sinks and thermally conductive tapes that have been successfully tested with AC45.

Table 32: Tested heat sinks and thermally conductive tapes

Product name	**Description**	**Dimensions** (mm)	R_{th} (K/W)	**Manufacturer**	**Web**
Heat sinks					
SK 18	Surface: black anodised (SA)	65 x 37.5	3.5	Fischerelektronik	www.fischerelektronik.de
SK 180	Surface: black anodised (SA)	53.3 x 37.5	5.7	Fischerelektronik	www.fischerelektronik.de
SK 99	Surface: black anodised (SA)	54 x 37.5	4.4	Fischerelektronik	www.fischerelektronik.de
SFP 060 - 50	Standard aluminium profile, flat	80 x 40, height: 8	Not specified	Fischerelektronik	www.fischerelektronik.de
Conductive tapes		**Thickness** (µm)			
TP1500 - 10	Adhesive on both sides, green, siliconfree. Successor product to TP2022	250	0.23	Balkhausen	www.balkhausen.com
TAP 005	Adhesive on both sides, yellow, siliconfree.	125	< 0.30	Balkhausen	www.balkhausen.com
Keratherm 95/15	Adhesive on both sides, yellow, Kapton carrier.	85	0.62	Kerafol	www.kerafol.de or via www.alfatec.de
BondPly™ 100-5	Adhesive on both sides, white, Fiberglass reinforcement carrier	127	Not specified	Bergquist	www.bergquistcompany.com
BondPly® 400	Adhesive on both sides, white, unreinforced	127	Not specified	Bergquist	www.bergquistcompany.com

6.4.1 Test conditions and results

The following tables show the results of extensive testing based on different combinations of heat sinks and thermally conductive tapes. The heat sinks were attached to the ground pad on the bottom of the module. A hole for the antenna connector was cut out of the heat sink to ensure that it sits perfectly flat and tight to the surface of the board. Another small hole was drilled through the heat sink to pick up the temperature sensor soldered to the test point on the bottom. Please note that the heat sink should not cover the antenna test point enclosed by the dashed line as shown in Figure 32. This area shows the test point on the antenna feeding line which would otherwise be shorted to ground.
On the top of AC45, a temperature sensor was soldered to the shield cover.

All measurements were performed under the same test conditions:

- GPRS connection, Power Level 5, GSM Band: 900MHz
- GPRS Class 8 (4x downlink, 1x uplink), Coding Scheme CS-4
- $V_{BATT+\ nom}$ = 4.2V
- Ambient temperatures: 65°C and 75°C
- Two temperature measuring points on the module: TP on top (shield cover) and TP on the bottom. See Figure 31 and Figure 32.

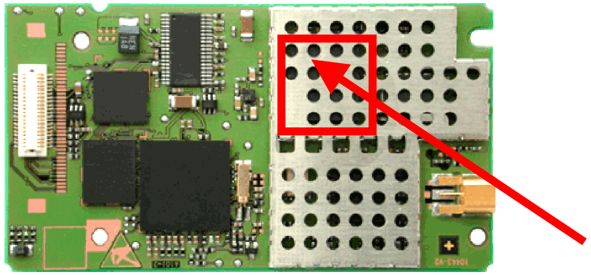


Figure 31: Temperature measuring point on AC45 shield cover

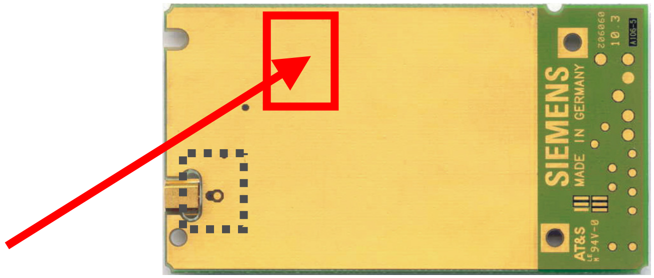


Figure 32: Temperature measuring point and antenna test point on AC45 bottom

Table 33: Temperature on board if no cooling elements are used (in °C)

Heat sink	---	---
Thermally conductive tape	---	---
Ambient temperature	T_{amb} = 65	T_{amb} = 75
Temperature @ TP bottom	84	93
Temperature @ TP top	81	90

Table 34: Temperature reduction on AC45 with SK 18 (in °C)

Used heat sink	SK 18									
Used tape	TP2022	TAP005	Keratherm 95/15	Bond Ply™ 100-5	Bond Ply® 400	TP2022	TAP005	Keratherm 95/15	Bond Ply™ 100-5	Bond Ply® 400
Ambient temperature	T_{amb} = 65					T_{amb} = 75				
Temp. @ TP bottom	73	73	73	74	73	83	83	83	84	82
Temp. @ TP top	73	73	74	74	74	83	84	84	84	82

Table 35: Temperature reduction on AC45 with SK 180 (in °C)

Used heat sink	SK 180			
Used tape	TP2022	TAP005	TP2022	TAP005
Ambient temperature	T_{amb} = 65		T_{amb} = 75	
Temp. @ TP bottom	72	74	83	84
Temp. @ TP top	72	74	83	84

Table 36: Temperature reduction on AC45 with SK 99 and SFP-060-50 (in °C)

Used heat sink	SK 99		SFP 060-50	
Used tape	TP2022			
Ambient temperature	T_{amb} = 65	T_{amb} = 75	T_{amb} = 65	T_{amb} = 75
Temp. @ TP bottom	75	85	77	87
Temp. @ TP top	75	84	77	87

7 Reference approval

7.1 Reference equipment

The Siemens reference setup that will be submitted to type approve AC45 consists of the following components:

- Siemens AC45 cellular engine
- Development Support Box (DSB45). Refer to [7] for technical specifications.
- Flex cable (160 mm) from Hirose DF12C receptacle on AC45 to Hirose DF12 connector on DSB45. Please note that this cable is not included in the scope of delivery of DSB45. For the purpose of testing customer applications, the DSB45 box is delivered with an adapter board especially designed to easily install AC45 to the DSB45 board. Installation instructions are provided in [8].
- SIM card holder integrated on the DSB45
- Handset type Votronic HH-SI-30.3/V1.1/0
- PC as MMI

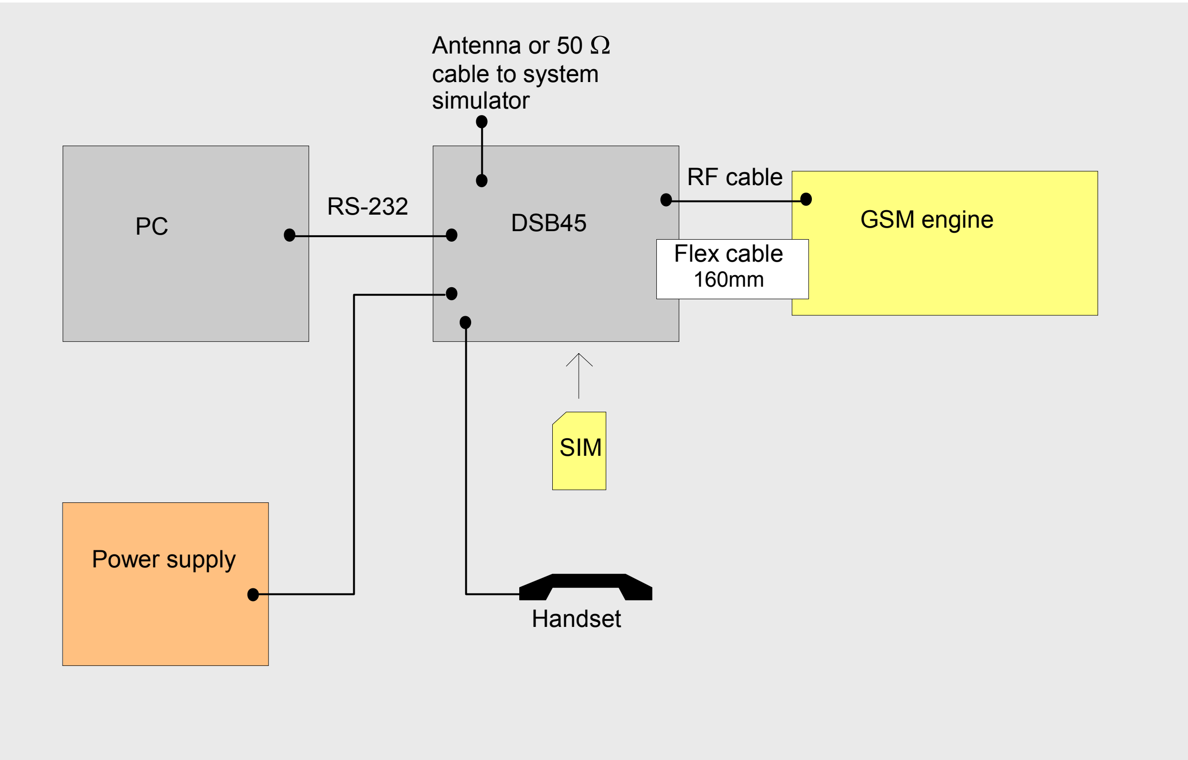


Figure 33: Reference equipment for approval

8 List of parts and accessories

Table 37: List of parts and accessories

Description	Supplier	Ordering information
AC45	Siemens	Siemens ordering number: L36880-N8310-A100
Siemens Car Kit Portable	Siemens	Siemens ordering number: L36880-N3015-A117
DSB45 Support Box	Siemens	Siemens ordering number: L36880-N8311-A100
BB35 Bootbox	Siemens	Siemens ordering number: L36880-N8102-A100-1
Votronic Handset	VOTRONIC	Votronic HH-SI-30.3/V1.1 VOTRONIC Entwicklungs- und Produktionsgesellschaft für elektronische Geräte mbH Saarbrücker Str. 8 D-66386 St. Ingbert Phone: 06 89 4 / 92 55-0 Fax: 06 89 4 / 92 55-88 e-mail: 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 38
DF12C board-to-board connector	Hirose	See Chapter 6.3 for details on the receptacle on AC45 and mating headers Sales contacts are listed in Table 39
SMP antenna connector	Rosenberger	Rosenberger Hochfrequenztechnik GmbH & Co. POB 1260 D-84526 Tittmoning http://www.rosenberger.de

Table 38: Molex sales contacts (subject to change)

Molex For further information please click: http://www.molex.com/	Molex Deutschland GmbH Felix-Wankel-Str. 11 D-74078 Heilbronn-Biberach Phone: +49(7066)9555 0 Fax: +49(7066)9555 29 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 1319, Tower B, COFCO Plaza No. 8, Jian Guo Men Nei Street, 100005 Beijing People's Republic of China Phone: +86-10-6526-9628 Phone: +86-10-6526-9728 Phone: +86-10-6526-9731 Fax: +86-10-6526-9730	Molex Singapore Pte. Ltd. Jurong, Singapore Phone: +65-268-6868 Fax: +65-265-6044	Molex Japan Co. Ltd. Yamato, Kanagawa, Japan Phone: +81-462-65-2324 Fax: +81-462-65-2366

Table 39: 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 Phone: +1-805-522-7958 Fax: +1-805-522-3217	Hirose Electric GmbH Zeppelinstrasse 42 73760 Ostfildern Kemnat 4 Phone: +49 711 4560-021 Fax +49 711 4560-729 E-mail info@hirose.de
Hirose Electric UK, Ltd Crownhill Business Centre 22 Vincent Avenue, Crownhill Milton Keynes, MK8 OAB Phone: +44-1908-305400 Fax: +44-1908-305401	Hirose Electric Co., Ltd. 5-23, Osaki 5 Chome, Shinagawa-Ku Tokyo 141, Japan Phone: +81-3-3491-9741 Fax: +81-3-3493-2933	Hirose Electric Co., Ltd. European Branch First class Building 4F Beech Avenue 46 1119PV Schiphol-Rijk Netherlands Phone: +31-20-6557-460 Fax: +31-20-6557-469