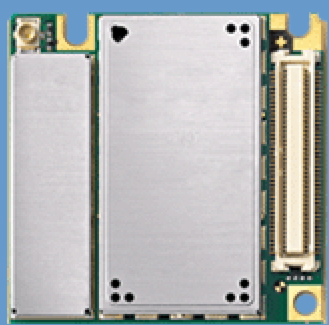
CINTERION
a Gemalto company

Hardware Interface Description

TC65i

Version: 02.004
DocId: TC65i_HD_v02.004



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Contents

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0 Document History

Preceding document: "TC65i Hardware Interface Description" Version 02.003
New document: "TC65i Hardware Interface Description" Version **02.004**

Chapter	What is new
--	Updated DocID.

Preceding document: "TC65i Hardware Interface Description" Version 01.841
New document: "TC65i Hardware Interface Description" Version 02.003

Chapter	What is new
1.3.1	Updated NAPRD and GCF versions.
2.1	Revised values for nominal reduction of maximum output power.
5.6	Updated current consumption for GSM call in Table 32.
8.2	Updated FCC and IC IDs.

Preceding document: "TC65i Hardware Interface Description" Version 01.800
New document: "TC65i Hardware Interface Description" Version 01.841

Chapter	What is new
3.12	Added remark on virtual lines of USB interface.

New document: "TC65i Hardware Interface Description" Version 01.800

Chapter	What is new
	Initial document setup.

1 Introduction

This document[1] describes the hardware of the Cinterion TC65i module that connects to the cellular device application and the air interface. It helps you quickly retrieve interface specifications, electrical and mechanical details and information on the requirements to be considered for integrating further components.

1.1 Related Documents

[1] TC65i AT Command Set
[2] TC65i Release Notes
[3] DSB75 Support Box - Evaluation Kit for Cinterion Wireless Modules
[4] Application Note 02: Audio Interface Design for GSM Applications
[5] Application Note 07: Rechargeable Lithium Batteries in GSM Applications
[6] Application Note 16: Upgrading Firmware
[7] Application Note 17: Over-The-Air Firmware Update
[8] Application Note 22: Using TTY / CTM Equipment
[9] Application Note 26: Power Supply Design for GSM Applications
[10] Application Note 32: Integrating USB into GSM Applications
[11] Multiplexer User's Guide
[12] Multiplex Driver Developer's Guide
[13] Multiplex Driver Installation Guide
[14] Java User's Guide
[15] Java doc \wtk\doc\html\index.html

1.2 Terms and Abbreviations

Abbreviation	Description
ADC	Analog-to-Digital Converter
AGC	Automatic Gain Control
ANSI	American National Standards Institute
ARFCN	Absolute Radio Frequency Channel Number
ARP	Antenna Reference Point
ASC0 / ASC1	Asynchronous Controller. Abbreviations used for first and second serial interface of TC65i
B	Thermistor Constant
B2B	Board-to-board connector
BER	Bit Error Rate
BTS	Base Transceiver Station

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

Abbreviation	Description
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. Cinterion GSM module)
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
EIRP	Equivalent Isotropic Radiated Power
EMC	Electromagnetic Compatibility
ERP	Effective Radiated Power
ESD	Electrostatic Discharge
ETS	European Telecommunication Standard
FCC	Federal Communications Commission (U.S.)
FDMA	Frequency Division Multiple Access
FR	Full Rate
GMSK	Gaussian Minimum Shift Keying
GPIO	General Purpose Input/Output
GPRS	General Packet Radio Service
GSM	Global Standard for Mobile Communications
HiZ	High Impedance
HR	Half Rate
I/O	Input/Output

Abbreviation	Description
IC	Integrated Circuit
IMEI	International Mobile Equipment Identity
ISO	International Standards Organization
ITU	International Telecommunications Union
kbps	kbits per second
LED	Light Emitting Diode
Li-Ion / Li+	Lithium-Ion
Li battery	Rechargeable Lithium Ion or Lithium Polymer battery
Mbps	Mbits per second
MMI	Man Machine Interface
MO	Mobile Originated
MS	Mobile Station (GSM module), also referred to as TE
MSISDN	Mobile Station International ISDN number
MT	Mobile Terminated
NTC	Negative Temperature Coefficient
OEM	Original Equipment Manufacturer
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
PCS	Personal Communication System, also referred to as GSM 1900
PDU	Protocol Data Unit
PLL	Phase Locked Loop
PPP	Point-to-point protocol
PSK	Phase Shift Keying
PSU	Power Supply Unit
PWM	Pulse Width Modulation
R&TTE	Radio and Telecommunication Terminal Equipment
RAM	Random Access Memory
RF	Radio Frequency
RMS	Root Mean Square (value)
RoHS	Restriction of the use of certain hazardous substances in electrical and electronic equipment.
ROM	Read-only Memory

Abbreviation	Description
RTC	Real Time Clock
RTS	Request to Send
Rx	Receive Direction
SAR	Specific Absorption Rate
SELV	Safety Extra Low Voltage
SIM	Subscriber Identification Module
SMS	Short Message Service
SPI	Serial Peripheral Interface
SRAM	Static Random Access Memory
TA	Terminal adapter (e.g. GSM module)
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
USB	Universal Serial Bus
USSD	Unstructured Supplementary Service Data
VSWR	Voltage Standing Wave Ratio

1.3 Regulatory and Type Approval Information

1.3.1 Directives and Standards

TC65i has been approved to comply with the directives and standards listed below.

It is the responsibility of the application manufacturer to ensure compliance of the final product with all provisions of the applicable directives and standards as well as with the technical specifications provided in the "TC65i Hardware Interface Description" [2].

Table 1: Directives

99/05/EC	Directive of the European Parliament and of the council of 9 March 1999 on radio equipment and telecommunications terminal equipment and the mutual recognition of their conformity (in short referred to as R&TTE Directive 1999/5/EC). The product is labeled with the CE conformity mark CE 0682
2002/95/EC	Directive of the European Parliament and of the Council of 27 January 2003 on the restriction of the use of certain hazardous substances in electrical and electronic equipment (RoHS)

Table 2: Standards of North American type approval

CFR Title 47	Code of Federal Regulations, Part 22 and Part 24 (Telecommunications, PCS); US Equipment Authorization FCC
UL 60 950	Product Safety Certification (Safety requirements)
NAPRD.03 V5.9	Overview of PCS Type certification review board Mobile Equipment Type Certification and IMEI control PCS Type Certification Review board (PTCRB)
RSS133 (Issue2)	Canadian Standard

Table 3: Standards of European type approval

3GPP TS 51.010-1	Digital cellular telecommunications system (Phase 2); Mobile Station (MS) conformance specification
ETSI EN 301 511 V9.0.2	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 V3.43	Global Certification Forum - Certification Criteria
ETSI EN 301 489-1 V1.8.1	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 1: Common Technical Requirements

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

Table 3: Standards of European type approval

ETSI EN 301 489-7 V1.3.1	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)
IEC/EN 60950-1:2006	Safety of information technology equipment

Table 4: Requirements of quality

IEC 60068	Environmental testing
DIN EN 60529	IP codes

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

SJ/T 11363-2006	"Requirements for Concentration Limits for Certain Hazardous Substances in Electronic Information Products" (2006-06).
SJ/T 11364-2006	"Marking for Control of Pollution Caused by Electronic Information Products" (2006-06).  According to the "Chinese Administration on the Control of Pollution caused by Electronic Information Products" (ACPEIP) the EPUP, i.e., Environmental Protection Use Period, of this product is 20 years as per the symbol shown here, unless otherwise marked. The EPUP is valid only as long as the product is operated within the operating limits described in the Cinterion Wireless Modules Hardware Interface Description. Please see Table 6 for an overview of toxic or hazardous substances or elements that might be contained in product parts in concentrations above the limits defined by SJ/T 11363-2006.

Table 6: Toxic or hazardous substances or elements with defined concentration limits

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

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

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

1.3.2 SAR Requirements Specific to Portable Mobiles

Mobile phones, PDAs or other portable transmitters and receivers incorporating a GSM module must be in accordance with the guidelines for human exposure to radio frequency energy. This requires the Specific Absorption Rate (SAR) of portable TC65i based applications to be evaluated and approved for compliance with national and/or international regulations.

Since the SAR value varies significantly with the individual product design manufacturers are advised to submit their product for approval if designed for portable use. For European and US markets the relevant directives are mentioned below. It is the responsibility of the manufacturer of the final product to verify whether or not further standards, recommendations or directives are in force outside these areas.

Products intended for sale on US markets

ES 59005/ANSI C95.1	Considerations for evaluation of human exposure to Electromagnetic Fields (EMFs) from Mobile Telecommunication Equipment (MTE) in the frequency range 30MHz - 6GHz

Products intended for sale on European markets

EN 50360	Product standard to demonstrate the compliance of mobile phones with the basic restrictions related to human exposure to electromagnetic fields (300MHz - 3GHz)

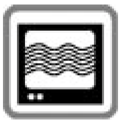
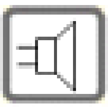
IMPORTANT:
Manufacturers of portable applications based on TC65i modules are required to have their final product certified and apply for their own FCC Grant and Industry Canada Certificate related to the specific portable mobile. See also Section 8.2.

1.3.3 SELV Requirements

The power supply connected to the TC65i module shall be in compliance with the SELV requirements defined in EN 60950-1. See also Section 5.1 for further detail.

1.3.4 Safety Precautions

The following safety precautions must be observed during all phases of the operation, usage, service or repair of any cellular terminal or mobile incorporating TC65i. Manufacturers of the cellular terminal are advised to convey the following safety information to users and operating personnel and to incorporate these guidelines into all manuals supplied with the product. Failure to comply with these precautions violates safety standards of design, manufacture and intended use of the product. Cinterion Wireless Modules GmbH assumes no liability for customer's failure to comply with these precautions.

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

2 Product Concept

2.1 Key Features at a Glance

Feature	Implementation
General	
Frequency bands	Quad band: GSM 850/900/1800/1900MHz
GSM class	Small MS
Output power (according to Release 99)	Class 4 (+33dBm ±2dB) for EGSM850 Class 4 (+33dBm ±2dB) for EGSM900 Class 1 (+30dBm ±2dB) for GSM1800 Class 1 (+30dBm ±2dB) for GSM1900 The values stated above are maximum limits. According to Release 99, the maximum output power in a multislot configuration may be lower. The nominal reduction of maximum output power varies with the number of uplink timeslots used and amounts to 2.0dB for 2Tx, 4.0dB for 3Tx and 6.0dB for 4Tx.
Power supply	3.2V to 4.5V
Ambient operating temperature according to IEC 60068-2	Normal operation: -30°C to +65°C Restricted operation: +65°C to +75°C, -30°C to -40°C
Physical	Dimensions: 35mm x 33.9mm x 3.3mm Weight: approx. 7.5g
RoHS	All hardware components fully compliant with EU RoHS Directive
GSM / GPRS features	
Data transfer	GPRS: • Multislot Class 12 • Full PBCCH support • Mobile Station Class B • Coding Scheme 1 – 4 CSD: • V.110, RLP, non-transparent • 2.4, 4.8, 9.6, 14.4kbps • USSD PPP-stack for GPRS data transfer
SMS	Point-to-point MT and MO Cell broadcast Text and PDU mode Storage: SIM card plus 25 SMS locations in mobile equipment Transmission of SMS alternatively over CSD or GPRS. Preferred mode can be user defined.
Fax	Group 3; Class 1
Audio	Speech codecs: • Half rate HR (ETS 06.20) • Full rate FR (ETS 06.10) • Enhanced full rate EFR (ETS 06.50/06.60/06.80) • Adaptive Multi Rate AMR Line echo cancellation, noise reduction, DTMF, 7 ringing tones

Feature	**Implementation**
Software	
AT commands	Hayes 3GPP TS 27.007, TS 27.005, Cinterion
Java platform	Java Virtual Machine with APIs for amongst others AT Parser, Serial Interface, FlashFileSystem and TCP/IP Stack. Major benefits: seamless integration into Java applications, ease of programming, no need for application microcontroller, extremely cost-efficient hardware and software design – ideal platform for industrial GSM applications. The memory space available for Java programs is around 1.7 MB in the flash file system and around 400k RAM. Application code and data share the space in the flash file system and in RAM.
SIM Application Toolkit	SAT Release 99
TCP/IP stack	Access by AT commands
Remote SIM Access	TC65i supports Remote SIM Access. RSA enables TC65i to use a remote SIM card via its serial interface and an external application, in addition to the SIM card locally attached to the dedicated lines of the application interface. The connection between the external application and the remote SIM card can be a Bluetooth wireless link or a serial link. The necessary protocols and procedures are implemented according to the “SIM Access Profile Interoperability Specification of the Bluetooth Special Interest Group”.
Firmware update	Generic update from host application over ASC0, ASC1 or USB. Over-the-air (OTA) firmware update is possible via SPI interface.
Interfaces	
Module interface	80-pin board-to-board connector.
2 serial interfaces	ASC0: • 8-wire modem interface with status and control lines, unbalanced, asynchronous • Adjustable baud rates: 300 bps to 921,600 bps • Autobauding: 1,200 bps to 460,800 bps • Supports RTS1/CTS1 hardware handshake and software XON/XOFF flow control • Multiplex ability according to GSM 07.10 Multiplexer Protocol. ASC1: • 4-wire, unbalanced asynchronous interface • Adjustable baud rates: 300 bps to 921,600 bps • Supports RTS1/CTS1 hardware handshake and software XON/XOFF flow control
USB	Supports a USB 2.0 Full Speed (12Mbit/s) slave interface.
I^2C	I^2C bus for 7-bit addressing and transmission rates up to 400kbps. Programmable with AT^SSPI command. Alternatively, all lines of the I^2C interface are configurable as SPI.
SPI	Serial Peripheral Interface for transmission rates up to 6.5 Mbps. Programmable with AT^SSPI command. If the SPI is active the I^2C interface is not available.
Audio	2 analog interfaces 1 digital interface (PCM)
SIM interface	Supported SIM cards: 3V, 1.8V

Feature	Implementation
Antenna	50Ohms. External antenna can be connected via antenna connector or solderable pad.
Power on/off, Reset	
Power on/off	Switch-on by hardware signal IGT Switch-off by AT command (AT^SMSO) Automatic switch-off in case of critical temperature and voltage conditions.
Reset	Orderly shutdown and reset by AT command Emergency reset by hardware signal EMERG_OFF and IGT.
Special features	
Charging	Supports management of rechargeable Lithium Ion and Lithium Polymer batteries
Real time clock	Timer functions via AT commands
GPIO	10 I/O signals of the application interface programmable as GPIO. Programming is done via AT commands. Alternatively, GPIO signal 10 is configurable as pulse counter.
Pulse counter	Pulse counter for measuring pulse rates from 0 to 1000 pulses per second. If the pulse counter is active the GPIO10 signal is not available.
ADC inputs	Analog-to-Digital Converter with two balanced analog inputs for measuring external voltages.
DAC output	Digital-to-Analog Converter which can provide a PWM signal.
Phonebook	SIM and phone
Evaluation kit	
DSB75	DSB75 Evaluation Board designed to test and type approve Cinterion Wireless Modules and provide a sample configuration for application engineering.

2.2 TC65i System Overview

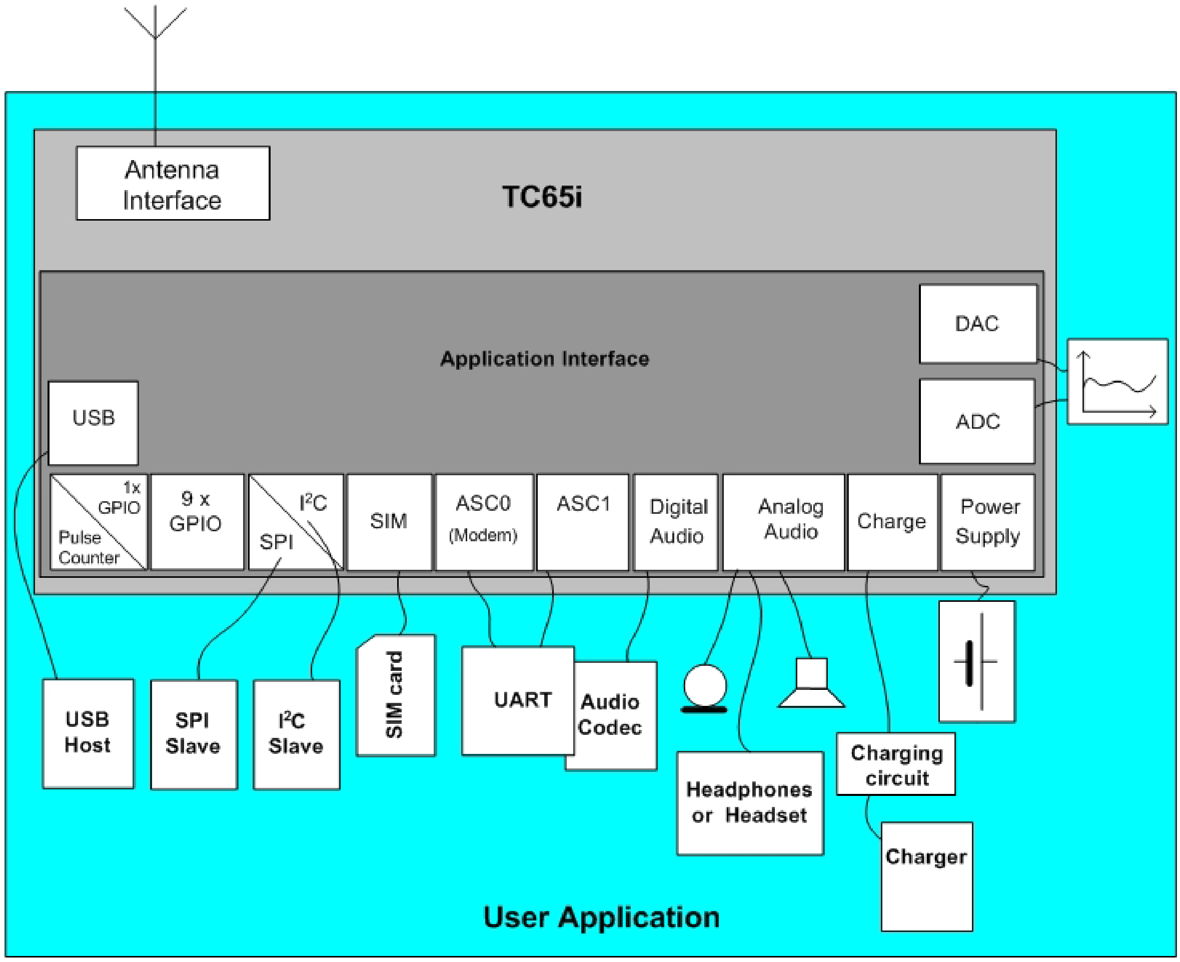


Figure 1: TC65i system overview

2.3 Circuit Concept

Figure 2 shows a block diagram of the TC65i module and illustrates the major functional components:

Baseband block:
- Digital baseband processor with DSP
- Analog processor with power supply unit (PSU)
- Flash / SRAM (stacked)
- Application interface (board-to-board connector)

RF section:
- RF transceiver
- RF power amplifier
- RF front end
- Antenna connector

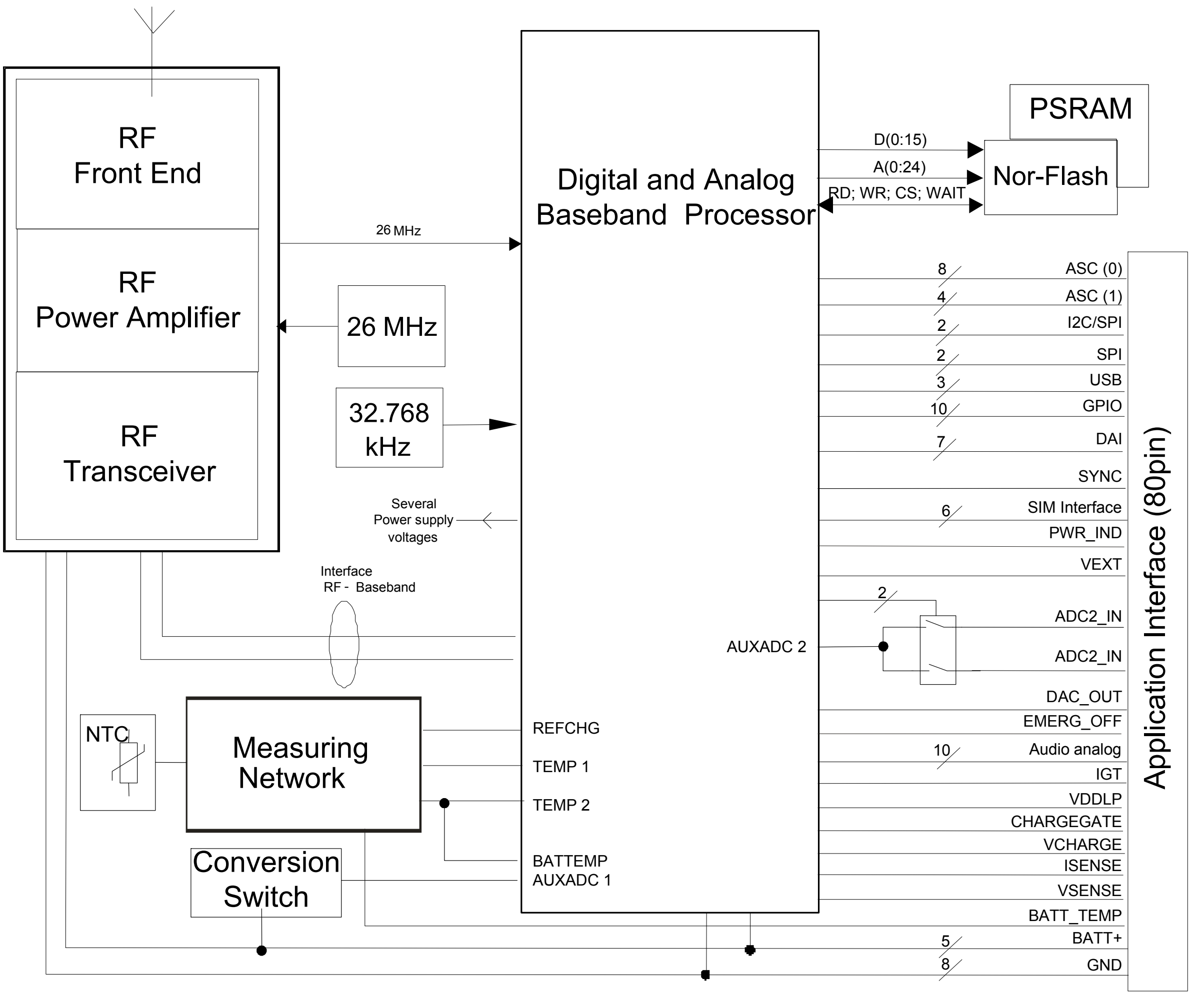


Figure 2: TC65i block diagram

3 Application Interface

TC65i is equipped with an 80-pin board-to-board connector that connects to the external application. The host interface incorporates several sub-interfaces described in the following sections:

- Power supply - see Section 3.1
- Charger interface – see Section 3.5
- SIM interface - see Section 3.9
- Serial interface ASC0 - see Section 3.10
- Serial interface ASC1 - see Section 3.11
- Serial interface USB - see Section 3.12
- Serial interface I²C/SPI - see Section 3.13 and Section 3.14
- Two analog audio interfaces - see Section 3.15
- Digital audio interface (DAI) - see Section 3.15 and Section 3.15.4
- Status and control lines: IGT, EMERG_OFF, PWR_IND, SYNC - see Table 30

3.1 Operating Modes

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

Table 7: Overview of operating modes

Normal operation	GSM / GPRS SLEEP	Various power save 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 is registered and paging with the BTS in SLEEP mode, too. 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=7 and 9 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, paging with BTS is carried out. The module 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. multislot settings).
	GPRS DATA	GPRS data transfer in progress. Power consumption depends on network settings (e.g. power control level), uplink / downlink data rates, GPRS configuration (e.g. used multislot settings) and reduction of maximum output power.
POWER DOWN	Normal shutdown after sending the AT^SMSO command. Only a voltage regulator is active for powering the RTC. Software is not active. Interfaces are not accessible. Operating voltage (connected to BATT+) remains applied.	
Airplane mode	Airplane mode shuts down the radio part of the module, causes the module to log off from the GSM/GPRS network and disables all AT commands whose execution requires a radio connection. Airplane mode can be controlled by using the AT commands AT^SCFG and AT+CALA: • With AT^SCFG=MEopMode/Airplane/OnStart the module can be configured to enter the Airplane mode each time when switched on or reset. • The parameter AT^SCFG=MEopMode/Airplane can be used to switch back and forth between Normal mode and Airplane mode any time during operation. • Setting an alarm time with AT+CALA followed by AT^SMSO wakes the module up into Airplane mode at the scheduled time.	
Charge-only mode	Limited operation for battery powered applications. Enables charging while module is detached from GSM network. Limited number of AT commands is accessible. Charge-only mode applies when the charger is connected if the module was powered down with AT^SMSO.	
Charge mode during normal operation	Normal operation (SLEEP, IDLE, TALK, GPRS IDLE, GPRS DATA) and charging running in parallel. Charge mode changes to Charge-only mode when the module is powered down before charging has been completed.	

See Table 13 for the various options proceeding from one mode to another.

3.2 Power Supply

TC65i needs to be connected to a power supply at the board-to-board connector (5 lines each BATT+ and GND).

The power supply of TC65i has to be a single voltage source at BATT+. It must be able to provide the peak current during the uplink transmission.

All the key functions for supplying power to the device are handled by the power management section of the analog controller. This IC provides the following features:

- Stabilizes the supply voltages for the GSM baseband using low drop linear voltage regulators and a DC-DC step down switching regulator.
- Switches the module's power voltages for the power-up and -down procedures.
- Delivers, across the VEXT line, a regulated voltage for an external application. This voltage is not available in Power-down mode.
- SIM switch to provide SIM power supply.

3.2.1 Minimizing Power Losses

When designing the power supply for your application please pay specific attention to power losses. Ensure that the input voltage V_{BATT+} never drops below 3.2V on the TC65i board, not even in a transmit burst where current consumption can rise to typical peaks of 1.6A. It should be noted that TC65i switches off when exceeding these limits. Any voltage drops that may occur in a transmit burst should not exceed 400mV.

The measurement network monitors outburst and inburst values. The drop is the difference of both values. The maximum drop (Dmax) since the last start of the module will be saved. In IDLE and SLEEP mode, the module switches off if the minimum battery voltage (V_{batt}min) is reached.

Example:
$V_I$min = 3.2V
Dmax = 0.4V

V_{batt}min = $V_I$min + Dmax
V_{batt}min = 3.2V + 0.4V = 3.6V

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

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

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

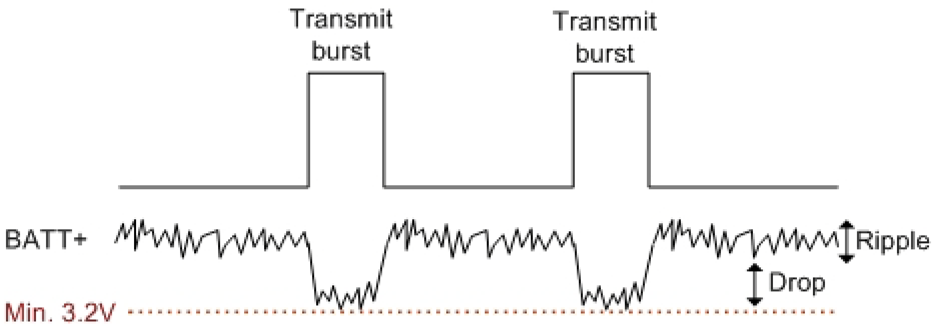


Figure 3: Power supply limits during transmit burst

3.2.2 Measuring the Supply Voltage V_{BATT+}

The reference points for measuring the supply voltage V_{BATT+} on the module are BATT+ and GND as illustrated in the figure below. BATT+ can be any of the five contacts for the BATT+ pins on the board-to-board connector.

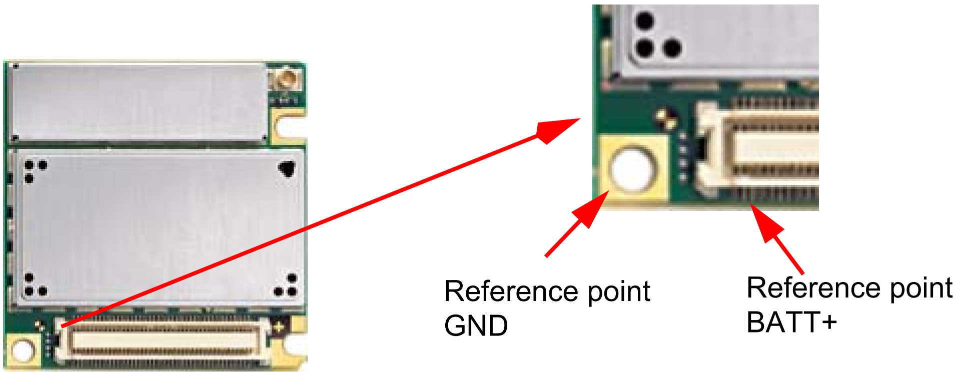


Figure 4: Position of the reference points BATT+ and GND

3.2.3 Monitoring Power Supply by AT Command

To monitor the supply voltage you can also use the AT^SBV command which returns the value related to the reference points BATT+ and GND.

The module continuously measures the voltage at intervals depending on the operating mode of the RF interface. The duration of measuring ranges from 0.5s in TALK/DATA mode to 50s when TC65i is in IDLE mode or Limited Service (deregistered). The displayed voltage (in mV) is averaged over the last measuring period before the AT^SBV command was executed.

3.3 Power Up / Power Down Scenarios

In general, be sure not to turn on TC65i while it is beyond the safety limits of voltage and temperature stated in Chapter 5. TC65i would immediately switch off after having started and detected these inappropriate conditions. In extreme cases this can cause permanent damage to the module.

3.3.1 Turn on TC65i

TC65i can be started in a variety of ways as described in the following chapters:

- Hardware driven start-up by IGT line: starts Normal mode or Airplane mode (see Section 3.3.1.1)
- Software controlled reset by AT+CFUN command: starts Normal mode or Airplane mode (see Section 3.3.1.4)
- Hardware driven start-up by VCHARGE line: starts charging algorithm and charge-only mode (see Section 3.3.1.3)
- Wake-up from Power-down mode by using RTC interrupt: starts Airplane mode

The option whether to start into Normal mode or Airplane mode depends on the settings made with the AT^SCFG command or AT+CALA. With AT+CALA, followed by AT^SMSO the module can be configured to restart into Airplane mode at a scheduled alarm time. Switching back and forth between Normal mode and Airplane mode is possible any time during operation by using the AT^SCFG command.

After startup or mode change the following URCs indicate the module's ready state:

- "SYSSTART" indicates that the module has entered Normal mode.
- "^SYSSTART AIRPLANE MODE" indicates that the module has entered Airplane mode.
- "^SYSSTART CHARGE ONLY MODE" indicates that the module has entered the Charge-only mode.

These URCs are indicated only if the module is set to a fixed bit rate, i.e. they do not appear if autobauding is enabled (AT+IPR≠0).

Detailed explanations on AT^SCFG, AT+CFUN, AT+CALA, Airplane mode and AT+IPR can be found in [1].

3.3.1.1 Turn on TC65i Using Ignition Line IGT

When the TC65i module is in Power-down mode or Charge-only mode, it can be started to Normal mode or Airplane mode by driving the IGT (ignition) line to ground. This must be accomplished with an open drain/collector driver to avoid current flowing into this line.

The module will start up when both of the following two conditions are met:
- The supply voltage applied at BATT+ must be in the operating range.
- The IGT line needs to be driven low for at least 400ms in Power-down mode or at least 2s in Charge-only mode.

Considering different strategies of host application design the figures below show two approaches to meet this requirement: The example in Figure 5 assumes that IGT is activated after BATT+ has already been applied. The example in Figure 6 assumes that IGT is held low before BATT+ is switched on. In either case, to power on the module, ensure that low state of IGT takes at least 400ms (Power-down mode) or 2s (Charge-only mode) from the moment the voltage at BATT+ is available. For Charge-only mode see also Section 3.3.1.3 and Section 3.5.6.

Assertion of CTS indicates that the module is ready to receive data from the host application. In addition, if configured to a fixed bit rate (AT+IPR≠0), the module will send the URC “^SYSSTART” or “^SYSSTART AIRPLANE MODE” which notifies the host application that the first AT command can be sent to the module. The duration until this URC is output varies with the SIM card and may take a couple of seconds.

Please note that no “^SYSSTART” or “^SYSSTART AIRPLANE MODE” URC will be generated if autobauding (AT+IPR=0) is enabled.

To allow the application to detect the ready state of the module we recommend using hardware flow control which can be set with AT\Q or AT+IFC (see [1] for details). The default setting of TC65i is AT\Q0 (no flow control) which shall be altered to AT\Q3 (RTS/CTS handshake). If the application design does not integrate RTS/CTS lines the host application shall wait at least for the “^SYSSTART” or “^SYSSTART AIRPLANE MODE” URC. However, if the URCs are neither used (due to autobauding) then the only way of checking the module’s ready state is polling. To do so, try to send characters (e.g. “at”) until the module is responding.

See also Section 3.3.2 "Signal States after Startup”.

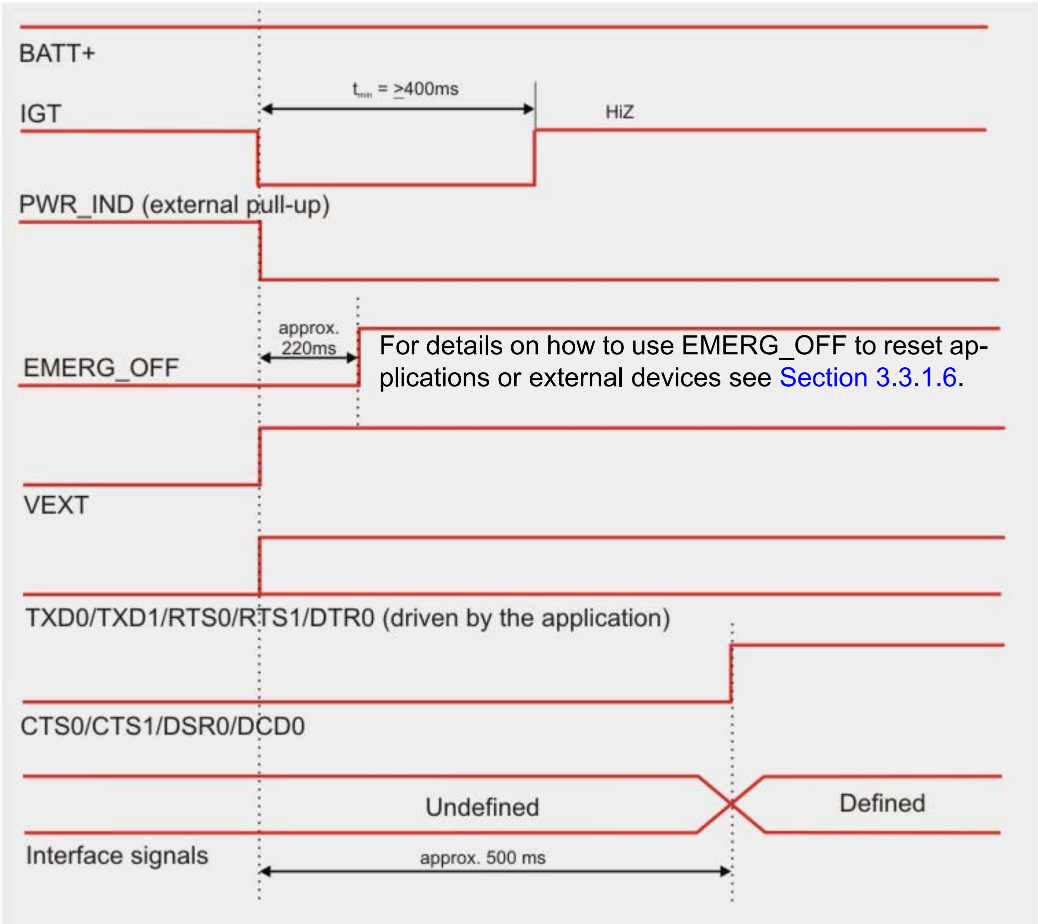


Figure 5: Power-on with operating voltage at BATT+ applied before activating IGT

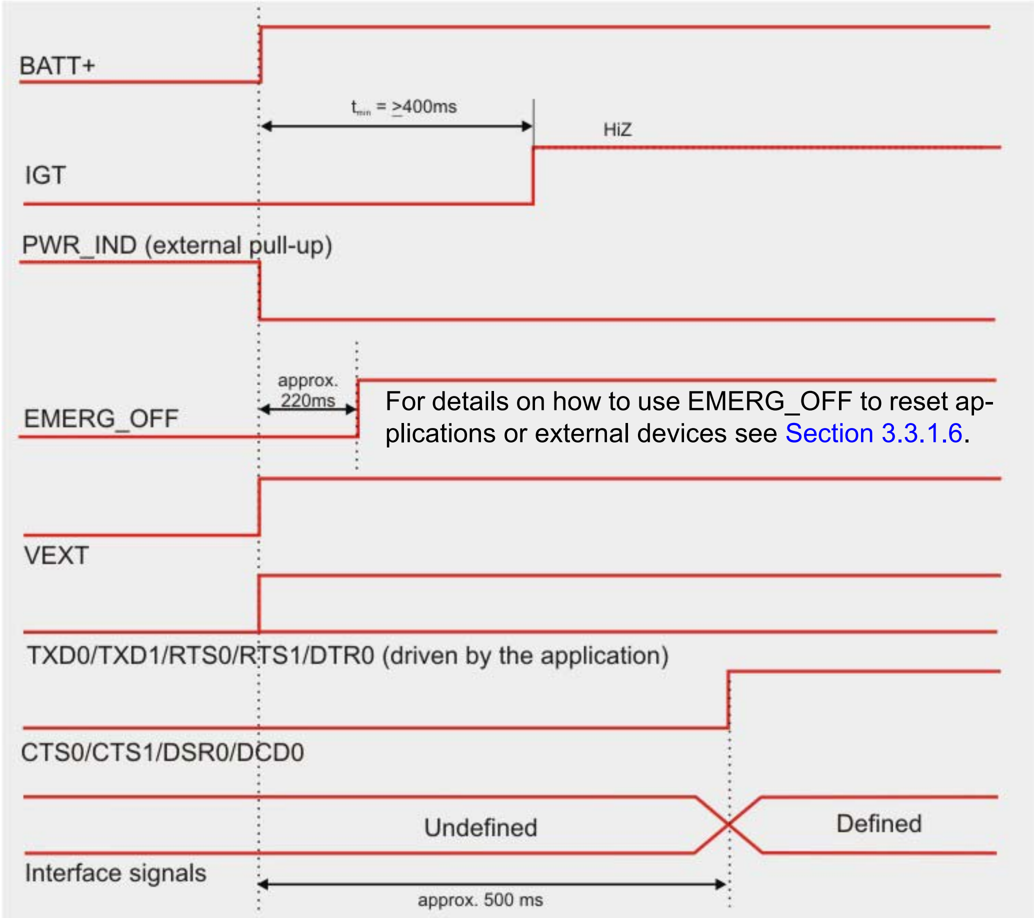


Figure 6: Power-on with IGT held low before switching on operating voltage at BATT+

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

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

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

at^scfg=meshutdown/onignition ^SCFG: "MEShutdown/OnIgnition","off" OK	# Query the current status of IGT. # IGT can be used only to switch on TC65i. IGT works as described in Section 3.3.1.1.

To configure IGT for use as ON/OFF switch:

at^scfg=meshutdown/onignition ^SCFG: "MEShutdown/OnIgnition","on" OK	# Enable the ON/OFF switch mode of IGT. # IGT can be used to switch on and off TC65i.

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

Switch-on condition: If the TC65i is off, the IGT line must be asserted for at least 400ms before being released. The module switches on after 400ms.

Switch-off condition: If the TC65i is on, the IGT line must be asserted for at least 1s before being released. The module switches off after the line is released. The switch-off routine is identical with the procedure initiated by AT^SMSO, i.e. the software performs an orderly shutdown as described in Section 3.3.3.1. Before switching off the module wait at least 2 seconds after startup.

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

3.3.1.3 Turn on TC65i Using the VCHARGE Signal

As detailed in Section 3.5.6, the charging adapter can be connected regardless of the module's operating mode.

If the charger is connected to the charger input of the external charging circuit and the module's VCHARGE line while TC65i is off, and the battery voltage is above the undervoltage lockout threshold, processor controlled fast charging starts (see Section 3.5.5). TC65i enters a restricted mode, referred to as Charge-only mode where only the charging algorithm will be launched. During the Charge-only mode TC65i is neither logged on to the GSM network nor are the serial interfaces fully accessible. To switch from Charge-only mode to Normal mode the ignition line (IGT) must be pulled low for at least 2 seconds. When released, the IGT line goes high and causes the module to enter the Normal mode. See also Section 3.3.3.1.

3.3.1.4 Reset TC65i via AT+CFUN Command

To reset and restart the TC65i module use the command AT+CFUN. You can enter AT+CFUN=,1 or AT+CFUN=x,1, where x may be in the range from 0 to 9. See [1] for details.

If configured to a fix baud rate (AT+IPR≠0), the module will send the URC "^SYSSTART" or "^SYSSTART AIRPLANE MODE" to notify that it is ready to operate. If autobauding is enabled (AT+IPR=0) there will be no notification. To register to the network SIM PIN authentication is necessary after restart.

3.3.1.5 Reset or Turn off TC65i in Case of Emergency

Note: Use the EMERG_OFF line only when, due to serious problems, the software is not responding for more than 5 seconds. Pulling the EMERG_OFF line causes the loss of all information stored in the volatile memory. Therefore, this procedure is intended only for use in case of emergency, e.g. if TC65i *does not respond, if reset or shutdown via AT command fails.*

The EMERG_OFF signal is available on the application interface. To control the EMERG_OFF line it is recommended to use an open drain / collector driver.

The EMERG_OFF line can be used to switch off or to reset the module. In any case the EMERG_OFF line must be pulled to ground for ≥10ms. Then, after releasing the EMERG_OFF line the module restarts if IGT is held low for at least 400ms. Otherwise, if IGT is not low the module switches off. In this case, it can be restarted any time as described in Section 3.3.1.1.

After hardware driven restart, notification via “^SYSSTART” or “^SYSSTART AIRPLANE” URC is the same as in case of restart by IGT or AT command. To register to the network SIM PIN authentication is necessary after restart.

3.3.1.6 Using EMERG_OFF Signal to Reset Application(s) or External Device(s)

When the module starts up, while IGT is held low for 400ms, the EMERG_OFF signal goes low for approximately 220ms as shown in Figure 5 and Figure 6. During this period, EMERG_OFF becomes an output which can be used to reset application(s) or external device(s) connected to the module.

After this period, i.e. during operation of the module, the EMERG_OFF is an input.

Specifications of the input and output mode of EMERG_OFF can be found in Table 30.

3.3.2 Signal States after Startup

Table 8 describes the various states each interface signal passes through after startup and during operation.

As shown in Figure 5 and Figure 6 signals are in an undefined state while the module is initializing. Once the startup initialization has completed, i.e. when the software is running, all signals are in defined state. The state of several signals will change again once the respective interface is activated or configured by AT command:

Table 8: Signal States

Signal name	Undefined state during startup	Defined state after initialization	Active state after configuration by AT command			
			GPIO	SPI	I^2C	DAI
SYNC	O, L	O, L				
CCIN	I, PU	I, PU				
CCRST	O, L	O, L				
CCIO	O, L	O, L				
CCCLK	O, L	O, L				
CCVCC	O, L	2.9V				
RXD0	I, PU	O, H				
TXD0	I, PU	I, PD				
CTS0	O, L	O, L[1]				
RTS0	I, PU	I, PD				
DTR0	I, PU	I, PU				
DCD0	O, L	O, H				
DSR0	O, L	O, L[1]				
RING0	I, PU	O, H[2]				
RXD1	O, H	O, H				
TXD1	I, PD	I, PD				
CTS1	L	O, L[1]				
RTS1	I, PD	I, PD				
SPIDI	I	Tristate		I	Tristate	
SPICS	I	O, H		O, L	Tristate	
I2CDAT_SPIDO	I	Tristate		O, L/H	IO	
I2CCLK_SPICLK	I	Tristate		O, L/H	O, OD	
GPIO1	I, PU	Tristate	IO			
GPIO2	I, PU	Tristate	IO			
GPIO3	I, PU	Tristate	IO			
GPIO4	I, PD	Tristate	IO			
GPIO5	O, L	Tristate	IO			

Table 8: Signal States

Signal name	Undefined state during startup	Defined state after initialization	Active state after configuration by AT command			
			GPIO	SPI	I^2C	DAI
GPIO6	I, PU	Tristate	IO			
GPIO7	I, PU	Tristate	IO			
GPIO8	O, L	Tristate	IO			
GPIO9	I	Tristate	IO			
GPIO10	I	Tristate	IO			
DAC_OUT	O, L	O, L				
DAI0	I	O, L				O, L
DAI1	I	Tristate				I
DAI2	I	O, L[3]				O, L
DAI3	I	O, L				O, L
DAI4	I	Tristate				I
DAI5	I	Tristate				I
DAI6	I	Tristate				I

1. Before reaching the defined state the signal has the intermediate state O, H for about 2s.
2. Before reaching the defined state the signal has the intermediate states O, H for about 2s and O, L for about 1s.
3. Before reaching the defined state the signal has the intermediate state O, H for about 0.5s.

Abbreviations used in Table 8:

L = Low level H = High level L/H = Low or high level I = Input O = Output	OD = Open Drain PD = Pull down with min. +15µA, max. +100µA PD(…k) = Fix pull down resistor PU = Pull up with typ. -200µA and max. -350µA PU(…k) = Fix pull up resistor

3.3.3 Turn off TC65i

TC65i can be turned off as follows:
- Normal shutdown: Software controlled by AT^SMSO command
- Automatic shutdown: Takes effect if board or battery temperature is out of range or if undervoltage or overvoltage conditions occur.

3.3.3.1 Turn off TC65i Using AT Command

The best and safest approach to powering down TC65i is to issue the AT^SMSO command. This procedure lets TC65i 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 data have been stored non-volatile and the module turns off in less than 1 second.
- Also, you can monitor the PWR_IND line. High state of PWR_IND definitely indicates that the module is switched off.

Be sure not to disconnect the supply voltage V_{BATT+} before the URC “^SHUTDOWN” has been issued and the PWR_IND signal has gone high. Otherwise you run the risk of losing data. Signal states during turn-off are shown in Figure 8.

While TC65i 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 lines of the application interface, especially of the serial interfaces. No special care is required for the USB interface which is protected from reverse current.

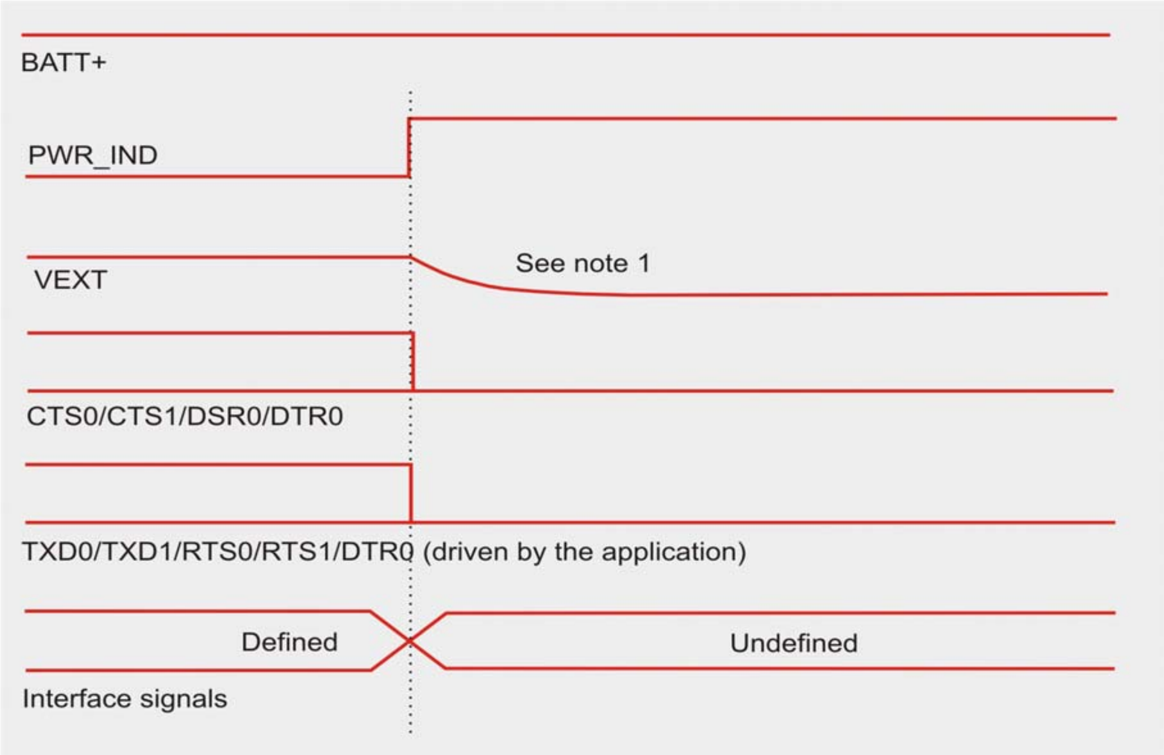


Figure 8: Signal states during turn-off procedure

Note: Depending on capacitance load from host application

3.3.3.2 Turn on/off TC65i Applications with Integrated USB

In a Windows environment, the USB COM port emulation causes the USB port of TC65i to appear as a virtual COM port (VCOM port). The VCOM port emulation is only present when Windows can communicate with the module, and is lost when the module shuts down. Therefore, the host application or Terminal program must be disconnected from the USB VCOM port each time the module is restarted.

Restart after shutdown with AT^SMSO:
After entering the power-down command AT^SMSO on one of the interfaces (ASC0, ASC1, USB) the host application or Terminal program used on the USB VCOM port must be closed before the module is restarted by activating the IGT line.

Software reset with AT+CFUN=x,1:
Likewise, when using the reset command AT+CFUN=x,1 on one of the interfaces (ASC0, ASC1, USB) ensure that the host application or Terminal program on the USB VCOM port be closed down before the module restarts.

Note that if AT+CFUN=x,1 is entered on the USB interface the application or Terminal program on the USB VCOM port must be closed immediately after the response OK is returned.

3.3.4 Automatic Shutdown

Automatic shutdown takes effect if:
- the TC65i board is exceeding the critical limits of overtemperature or undertemperature
- the battery is exceeding the critical limits of overtemperature or undertemperature
- undervoltage or overvoltage is detected

See Charge-only mode described in Section 3.5.6 for exceptions.

The automatic shutdown procedure is equivalent to the Power-down initiated with the AT^SMSO command, i.e. TC65i logs off from the network and the software enters a secure state avoiding loss of data.

Alert messages transmitted before the device switches off are implemented as Unsolicited Result Codes (URCs). The presentation of these URCs can be enabled or disabled with the two AT commands AT^SBC and AT^SCTM. The URC presentation mode varies with the condition, please see Section 3.3.4.1 to Section 3.3.4.3 for details. For further instructions on AT commands refer to [1].

3.3.4.1 Thermal Shutdown

The board temperature is constantly monitored by an internal NTC resistor located on the PCB. The NTC that detects the battery temperature must be part of the battery pack circuit as described in Section 3.5.3 The values detected by either NTC resistor are measured directly on the board or the battery and therefore, are not fully identical with the ambient temperature.

Each time the board or battery temperature goes out of range or back to normal, TC65i instantly displays an alert (if enabled).
- URCs indicating the level "1" or "-1" allow the user to take appropriate precautions, such as protecting the module from exposure to extreme conditions. The presentation of the URCs depends on the settings selected with the AT^SCTM write command:
  AT^SCTM=1: Presentation of URCs is always enabled.
  AT^SCTM=0 (default): Presentation of URCs is enabled during the 2 minute guard period after start-up of TC65i. After expiry of the 2 minute guard period, the presentation will be disabled, i.e. no URCs with alert levels "1" or "-1" will be generated.
- URCs indicating the level "2" or "-2" are instantly followed by an orderly shutdown, except in cases described in Section 3.3.4.2. The presentation of these URCs is always enabled, i.e. they will be output even though the factory setting AT^SCTM=0 was never changed.

The maximum temperature ratings are stated in Section 5.2. Refer to Table 9 for the associated URCs.

Table 9: Temperature dependent behavior

Sending temperature alert (15s after TC65i start-up, otherwise only if URC presentation enabled)	
^SCTM_A: 1	Caution: Battery close to overtemperature limit.
^SCTM_B: 1	Caution: Board close to overtemperature limit, i.e., board is 5°C below overtemperature limit.
^SCTM_A: -1	Caution: Battery close to undertemperature limit.
^SCTM_B: -1	Caution: Board close to undertemperature limit, i.e., board is 5°C above undertemperature limit.
^SCTM_A: 0	Battery back to uncritical temperature range.
^SCTM_B: 0	Board back to uncritical temperature range, i.e., board is 6°C below its over- or above its undertemperature limit.
Automatic shutdown (URC appears no matter whether or not presentation was enabled)	
^SCTM_A: 2	Alert: Battery equal or beyond overtemperature limit. TC65i switches off.
^SCTM_B: 2	Alert: Board equal or beyond overtemperature limit. TC65i switches off.
^SCTM_A: -2	Alert: Battery equal or below undertemperature limit. TC65i switches off.
^SCTM_B: -2	Alert: Board equal or below undertemperature limit. TC65i switches off.

3.3.4.2 Deferred Shutdown at Extreme Temperature Conditions

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

- While an emergency call is in progress.
- During a two minute guard period after power-up. This guard period has been introduced in order to allow for the user to make an emergency call. The start of emergency call 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. The guard period starts again when the module registers to the GSM network the first time after power-up.

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.

3.3.4.3 Undervoltage Shutdown

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

^SBC: Undervoltage.

The message will be reported, for example, when you attempt to make a call while the voltage is close to the shutdown threshold of 3.2V and further power loss is caused during the transmit burst. In IDLE mode, the shutdown threshold is the sum of the module's minimum supply voltage (3.2V) and the value of the maximum voltage drop resulting from earlier calls. This means that in IDLE mode the actual shutdown threshold may be higher than 3.2V. Therefore, to properly calculate the actual shutdown threshold application manufacturers are advised to measure the maximum voltage drops that may occur during transmit bursts.

To remind you that the battery needs to be charged soon, the URC appears several times before the module switches off.

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

3.3.4.4 Overvoltage Shutdown

The overvoltage shutdown threshold is 100mV above the maximum supply voltage V_{BATT+} specified in Figure 27.

When the supply voltage approaches the overvoltage shutdown threshold the module will send the URC

^SBC: Overvoltage warning.

This alert is sent once.

When the overvoltage shutdown threshold is exceeded the module will send the URC

^SBC: Overvoltage shutdown

before it shuts down cleanly.

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

Keep in mind that several TC65i components are directly linked to BATT+ and, therefore, the supply voltage remains applied at major parts of TC65i, even if the module is switched off. Especially the power amplifier is very sensitive to high voltage and might even be destroyed.

3.4 Automatic GPRS Multislot Class Change

Temperature control is also effective for operation in GPRS Multislot Class 10 and GPRS Multislot Class 12. If the board temperature rises close to the limit specified for normal operation (see Section 5.2 for limits) while data are transmitted over GPRS, the module automatically reverts:

- from GPRS Multislot Class 12 (4Tx slots) to GPRS Multislot Class 8 (1Tx),
- from GPRS Multislot Class 10 (2Tx slots) to GPRS Multislot Class 8 (1Tx)

This reduces the power consumption and, consequently, causes the board's temperature to decrease. Once the temperature drops by 5 degrees, TC65i returns to the higher Multislot Class. If the temperature stays at the critical level or even continues to rise, TC65i will not switch back to the higher class.

After a transition from a higher Multislot Class to a lower Multislot Class a possible switchback to the higher Multislot Class is blocked for one minute.

Please note that there is not one single cause of switching over to a lower Multislot Class. Rather it is the result of an interaction of several factors, such as the board temperature that depends largely on the ambient temperature, the operating mode and the transmit power. Furthermore, take into account that there is a delay until the network proceeds to a lower or, accordingly, higher Multislot Class. The delay time is network dependent. In extreme cases, if it takes too much time for the network and the temperature cannot drop due to this delay, the module may even switch off as described in Section 3.3.4.1.

3.5 Charging Control

TC65i integrates a charging management for rechargeable Lithium Ion and Lithium Polymer batteries. You can skip this chapter if charging is not your concern, or if you are not using the implemented charging algorithm.

The following sections contain an overview of charging and specifications. Please refer to [5] for greater detail, especially regarding requirements for batteries and chargers, appropriate charging circuits, recommended batteries and an analysis of operational issues typical of battery powered GSM/GPRS applications.

3.5.1 Hardware Requirements

TC65i has no on-board charging circuit. To benefit from the implemented charging management you are required to install a charging circuit within your application according to the Figure 50.

3.5.2 Software Requirements

Use the command AT^SBC, parameter <current>, to enter the current consumption of the host application. This information enables the TC65i module to correctly determine the end of charging and terminate charging automatically when the battery is fully charged. If the <current> value is inaccurate and the application draws a current higher than the final charge current, either charging will not be terminated or the battery fails to reach its maximum voltage. Therefore, the termination condition is defined as: current consumption dependent on operating mode of the ME plus current consumption of the external application. If used the current flowing over the VEXT line of the application interface must be added, too.

The parameter <current> is volatile, meaning that the factory default (0 mA) is restored each time the module is powered down or reset. Therefore, for better control of charging, it is recommended to enter the value every time the module is started.

See [1] for details on AT^SBC.

3.5.3 Battery Pack Requirements

The charging algorithm has been optimized for rechargeable Lithium batteries that meet the characteristics listed below and in Table 10. It is recommended that the battery pack you want to integrate into your TC65i application is compliant with these specifications. This ensures reliable operation, proper charging and, particularly, allows you to monitor the battery capacity using the AT^SBC command. Failure to comply with these specifications might cause AT^SBC to deliver incorrect battery capacity values.

- Li-Ion or Lithium Polymer battery pack specified for a maximum charging voltage of 4.2V and a capacity higher than 500 mAh.
- Since charging and discharging largely depend on the battery temperature, the battery pack should include an NTC resistor. If the NTC is not inside the battery it must be in thermal contact with the battery. The NTC resistor must be connected between BATT_TEMP and GND.
  The B value of the NTC should be in the range: *10kΩ* $\underline{+}$*5% @ 25°C,* $B_{25/85}$ = 3423K to B =3435K ± 3% (alternatively acceptable: *10kΩ* $\underline{+}$*2% @ 25°C,* $B_{25/50}$ *= 3370K* $\underline{+}$*3%)*. Please note that the NTC is indispensable for proper charging, i.e. the charging process will not start if no NTC is present.
- Ensure that the pack incorporates a protection circuit capable of detecting overvoltage (protection against overcharging), undervoltage (protection against deep discharging) and overcurrent. Due to the discharge current profile typical of GSM applications, the circuit must be insensitive to pulsed current.
- On the TC65i module, a built-in measuring circuit constantly monitors the supply voltage. In the event of undervoltage, it causes TC65i to power down. Undervoltage thresholds are specific to the battery pack and must be evaluated for the intended model. When you evaluate undervoltage thresholds, consider both the current consumption of TC65i *and* of the application circuit.
- The internal resistance of the battery and the protection should be as low as possible. It is recommended not to exceed 150mΩ, even in extreme conditions at low temperature. The battery cell must be insensitive to rupture, fire and gassing under extreme conditions of temperature and charging (voltage, current).
- The battery pack must be protected from reverse pole connection. For example, the casing should be designed to prevent the user from mounting the battery in reverse orientation.
- It is recommended that the battery pack be approved to satisfy the requirements of CE conformity.

Figure 9 shows the circuit diagram of a typical battery pack design that includes the protection elements described above.

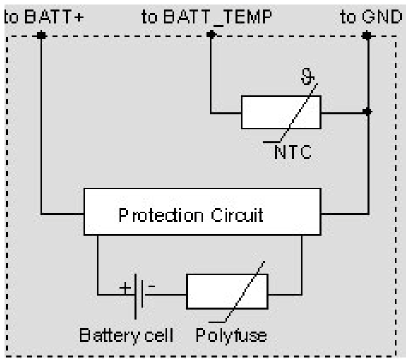


Figure 9: Battery pack circuit diagram

Table 10: Specifications of battery packs suitable for use with TC65i

Battery type	Rechargeable Lithium Ion or Lithium Polymer battery
Nominal voltage	3.6V / 3.7V
Capacity	> 500mAh
NTC	10kΩ ± 5% @ 25°C approx. 5kΩ @ 45°C approx. 26.2kΩ @ 0°C B value range: B (25/85)=3423K to B =3435K ± 3%
Overcharge detection voltage	4.325 ± 0.025V
Overdischarge detection voltage	2.4V
Overdischarge release voltage	2.6V
Overcurrent detection	3 ± 0.5A
Overcurrent detection delay time	4 ~ 16ms
Short detection delay time	50µs
Internal resistance	<130mΩ *Note: A maximum internal resistance of 150mΩ should not be exceeded even after 500 cycles and under extreme conditions.*

3.5.4 Charger Requirements

For using the implemented charging algorithm and the reference charging circuit recommended in [5] and in Figure 50, the charger has to meet the following requirements:

Output voltage: up to 7.0V (stabilized voltage)

Output current: 500 mA.
Chargers with a higher output current are acceptable, but please consider that only 500mA will be applied when a 0.3Ohms shunt resistor is connected between VSENSE and ISENSE. See [5] for further details.

3.5.5 Implemented Charging Technique

If all requirements listed above are met (appropriate external charging circuit of application, battery pack, charger, AT^SBC settings) then charging is enabled in various stages depending on the battery condition:

Trickle charging:
- Trickle charge current flows over the VCHARGE line.
- Temperature conditions: 0°C to 45°C. Outside this range no trickle charging is possible.
- Trickle charging is done when a charger is present (connected to VCHARGE) and the battery is deeply discharged or has undervoltage.
  - If deeply discharged (Deep Discharge Lockout at V_{BATT+} = 0…2.5V) the battery is charged with 30mA.
  - In case of undervoltage (Undervoltage Lockout at V_{BATT+} = 2.5…3.0V) the battery is charged at 60mA.
  - If V_{BATT+} = 3.0V... 3.2V the battery is charged at 100mA.

Software controlled charging:
- Controlled over the CHARGEGATE.
- Temperature conditions: 0°C to 45°C. Outside this range no software controlled charging is possible.
- Software controlled charging is done when the charger is present (connected to VCHARGE) and the battery voltage is at least above the undervoltage threshold. Software controlled charging passes the following stages:
  - Power ramp: Depending on the discharge level of the battery (i.e. the measured battery voltage V_{BATT+}) the software adjusts the maximum charge current for charging the battery. The duration of power ramp charging is very short (less than 30 seconds).
  - Fast charging: Battery is charged with constant current (approx. 500 mA) until the battery voltage reaches 4.2 V (approx. 80% of the battery capacity).
  - Top-up charging: The battery is charged with constant voltage of 4.2 V at stepwise reducing charge current until full battery capacity is reached.

Duration of charging:
- TC65i provides a software controlled timer set to 4 hours as a safety feature to prevent permanent charging of defective batteries. The duration of software controlled charging depends on the battery capacity and the level of discharge. Normally, charging stops when the battery is fully charged or, at the latest, when the software timer expires after 4 hours. If the software timer expires a charging error occurs, i.e., the AT^SBC's battery connecting status (<bcs>) is 4. To prevent this time out the charge current should be adjusted to the battery capacity.

3.5.6 Operating Modes during Charging

Of course, the battery can be charged regardless of the module's operating mode. When the GSM module is in Normal mode (SLEEP, IDLE, TALK, GPRS IDLE or GPRS DATA mode), it remains operational while charging is in progress (provided that sufficient voltage is applied). The charging process during the Normal mode is referred to as *Charge mode*.

If the charger is connected to the charger input of the external charging circuit and the module's VCHARGE line while TC65i is in Power-down mode, TC65i goes into *Charge-only* mode.

While the charger remains connected it is not possible to switch the module off by using the AT^SMSO command or the automatic shutdown mechanism. Instead the following applies:
- If the module is in Normal mode and the charger is connected (Charge mode) the AT^SMSO command causes the module to shut down shortly and then start into the Charge-only mode.
- In Charge-only mode the AT^SMSO command is not usable.
- In Charge-only mode the module neither switches off when the battery or the module exceeds the critical limits of overtemperature or undertemperature.

In these cases you can only switch the module off by disconnecting the charger.

To proceed from Charge-only mode to another operating mode you have the following options, provided that the battery voltage is at least above the undervoltage threshold.
- To switch from Charge-only mode to Normal mode you have two ways:
  - Hardware driven: The ignition line (IGT) must be pulled low for at least 2 seconds. When released, the IGT line goes high and causes the module to enter the Normal mode.
  - AT command driven: Set the command *AT^SCFG=MEopMode/Airplane,off* (please do so although the current status of Airplane mode is already "off"). The module will enter the Normal mode, indicated by the "^SYSSTART" URC.
- To switch from Charge-only mode to Airplane mode set the command *AT^SCFG=MEopMode/Airplane,on*. The mode is indicated by the URC "^SYSSTART AIRPLANE MODE".
- If *AT^SCFG=MEopMode/Airplane/OnStart,on* is set, driving the ignition line (IGT) activates the Airplane mode. The mode is indicated by the URC "^SYSSTART AIRPLANE MODE".

Table 11: AT commands available in Charge-only mode

AT command	Use
AT+CALA	Set alarm time, configure Airplane mode.
AT+CCLK	Set date and time of RTC.
AT^SBC	Query status of charger connection.
AT^SBV	Monitor supply voltage.
AT^SCTM	Query temperature range, enable/disable URCs to report critical temperature ranges
AT^SCFG	Enable/disable parameters MEopMode/Airplane or MEopMode/Airplane/OnStart

Table 12: Comparison Charge-only and Charge mode

Mode	How to activate mode	Description of mode
Charge mode	Connect charger to charger input of host application charging circuit and module's VCHARGE line while TC65i is • operating, e.g. in IDLE or TALK mode • in SLEEP mode	• Battery can be charged while GSM module remains operational and registered to the GSM network. • In IDLE and TALK mode, the serial interfaces are accessible. All AT commands can be used to full extent. *Note: If the module operates at maximum power level (PCL5) and GPRS Class 12 at the same time the current consumption is higher than the current supplied by the charger.*
Charge-only mode	Connect charger to charger input of host application charging circuit and module's VCHARGE line while TC65i is • in Power-down mode • in Normal mode: Connect charger to the VCHARGE line, then enter AT^SMSO. *Note: While trickle charging is in progress, be sure that the host application is switched off. If the application is fed from the trickle charge current the module might be prevented from proceeding to software controlled charging since the current would not be sufficient.*	• Battery can be charged while GSM module is deregistered from GSM network. • Charging runs smoothly due to constant current consumption. • The AT interface is accessible and allows to use the commands listed below.

3.6 Power Saving

Intended for power saving, SLEEP mode reduces the functionality of the TC65i to a minimum and thus minimizes the current consumption. Settings can be made using the AT+CFUN command. For details see [1]. SLEEP mode falls in two categories:

- NON-CYCLIC SLEEP mode: AT+CFUN = 0
- CYCLIC SLEEP modes, AT+CFUN = 7 or 9.

The functionality level AT+CFUN=1 is where power saving is switched off. This is the default after startup.

NON-CYCLIC SLEEP mode permanently blocks the serial interface. The benefit of the CYCLIC SLEEP mode is that the serial interface remains accessible and that, in intermittent wake-up periods, characters can be sent or received without terminating the selected mode. This allows the TC65i to wake up for the duration of an event and, afterwards, to resume power saving. Please refer to [1] for a summary of all SLEEP modes and the different ways of waking up the module.

For CYCLIC SLEEP mode both the TC65i and the application must be configured to use hardware flow control. This is necessary since the CTSx signal is set/reset every 0.9-2.7 seconds in order to indicate to the application when the UART is active. Please refer to [1] for details on how to configure hardware flow control for the TC65i.

Note: Although not explicitly stated, all explanations given in this section refer equally to ASC0 and ASC1, and accordingly to CTS0 and CTS1 or RTS0 and RTS1.

3.6.1 Network Dependency of SLEEP Modes

The power saving possibilities of SLEEP modes depend on the network the module is registered in. The paging timing cycle varies with the base station. The duration of a paging interval can be calculated from the following formula:

*t = 4.615 ms (TDMA frame duration) * 51 (number of frames) * DRX value*.

DRX (Discontinuous Reception) is a value from 2 to 9, resulting in paging intervals from 0.47-2.12 seconds. The DRX value of the base station is assigned by the network operator. In the pauses between listening to paging messages, the module resumes power saving, as shown in Figure 10.

Figure 10: Power saving and paging

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

3.6.2 Timing of the CTSx Signal in CYCLIC SLEEP Mode 7

Figure 11 illustrates the CTSx signal timing in CYCLIC SLEEP mode 7 (CFUN=7).

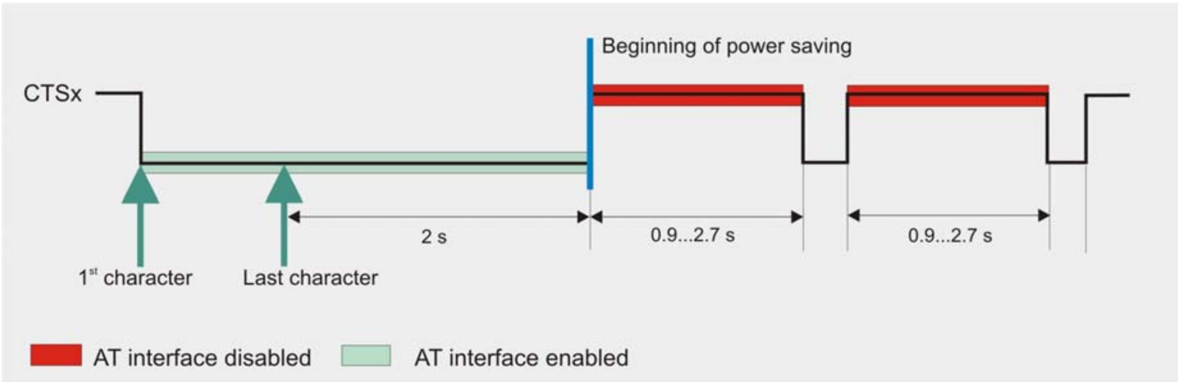


Figure 11: Timing of CTSx signal (if CFUN= 7)

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

3.6.3 Timing of the RTSx Signal in CYCLIC SLEEP Mode 9

In SLEEP mode 9 the falling edge of RTSx can be used to temporarily wake up the ME. In this case the activity time is at least the time set with AT^SCFG="PowerSaver/Mode9/ Timeout",<psm9to> (default 2 seconds). RTSx has to be asserted for at least a dedicated debounce time in order to wake up the ME. The debounce time specifies the minimum time period an RTSx signal has to remain asserted for the signal to be recognized as wake up signal and being processed. The debounce time is defined as 8*4.615 ms (TDMA frame duration) and is used to prevent bouncing or other fluctuations from being recognized as signals. Toggling RTSx while the ME is awake has no effect on the AT interface state, the regular hardware flow control via CTS/RTS is unaffected by this RTSx behaviour.

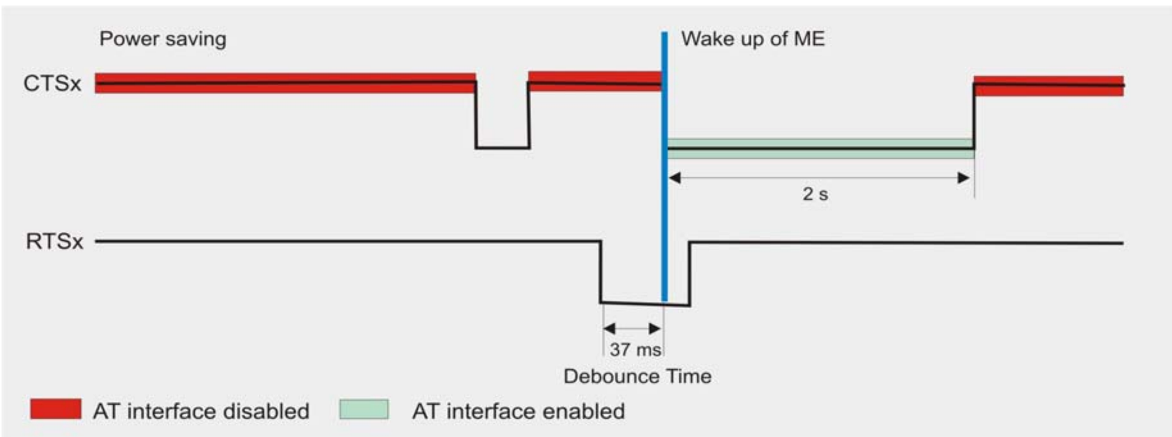


Figure 12: Timing of RTSx signal (if CFUN = 9)

3.7 Summary of State Transitions (Except SLEEP Mode)

The following table shows how to proceed from one mode to another (grey column = present mode, white columns = intended modes).

Table 13: State transitions of TC65i (except SLEEP mode)

Intended mode --> Present mode	POWER DOWN	Normal mode[1]	Charge-only mode[2]	Airplane mode
POWER DOWN mode	---	If AT^SCFG=MeOpMode/Airplane/OnStart,off: IGT >400 ms at low level, then release IGT	Connect charger to VCHARGE	If AT^SCFG=MeOpMode/Airplane/OnStart,on: IGT >400 ms at low level, then release IGT. Regardless of AT^SCFG configuration: scheduled wake-up set with AT+CALA.
Normal mode	AT^SMSO	---	AT^SMSO if charger is connected	AT^SCFG=MeOpMode/Airplane,on. If AT^SCFG=MeOpMode/Airplane/OnStart,on: IGT >2s at low level, then release IGT
Charge-only mode	Disconnect charger	Hardware driven: If AT^SCFG=MeOpMode/Airplane/OnStart,off: IGT >2s at low level, then release IGT AT command driven: AT^SCFG= MeOpMode/Airplane,off	---	AT^SCFG=MeOpMode/Airplane,on. If AT^SCFG=MeOpMode/Airplane/OnStart,on: IGT >2s at low level, then release IGT
Airplane mode	AT^SMSO	AT^SCFG=MeOpMode/Airplane,off	AT^SMSO if charger is connected	---

1. Normal mode covers TALK, DATA, GPRS, IDLE and SLEEP modes
2. See Section 3.5.6 for details on the charging mode

3.8 RTC Backup

The internal Real Time Clock of TC65i is supplied from a separate voltage regulator in the analog controller which is also active when TC65i is in POWER DOWN status. An alarm function is provided that allows to wake up TC65i to Airplane mode without logging on to the GSM network.

In addition, you can use the VDDLP line to backup the RTC from an external capacitor or a battery (rechargeable or non-chargeable). The capacitor is charged by the BATT+ line of TC65i. If the voltage supply at BATT+ is disconnected the RTC can be powered by the capacitor. The size of the capacitor determines the duration of buffering when no voltage is applied to TC65i, i.e. the larger the capacitor the longer TC65i will save the date and time.

A serial 1 kΩ resistor placed on the board next to VDDLP limits the charge current of an empty capacitor or battery.

The following figures show various sample configurations. Please refer to Table 30 for the parameters required.

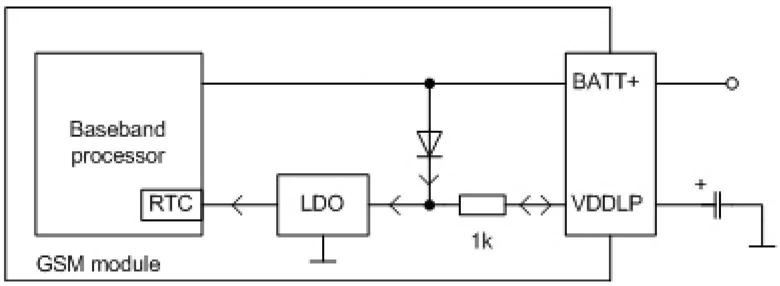


Figure 13: RTC supply from capacitor

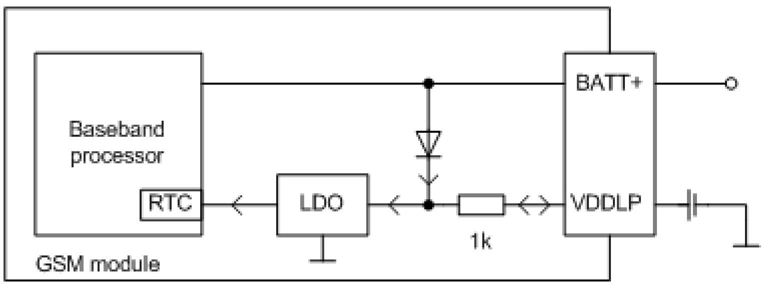


Figure 14: RTC supply from rechargeable battery

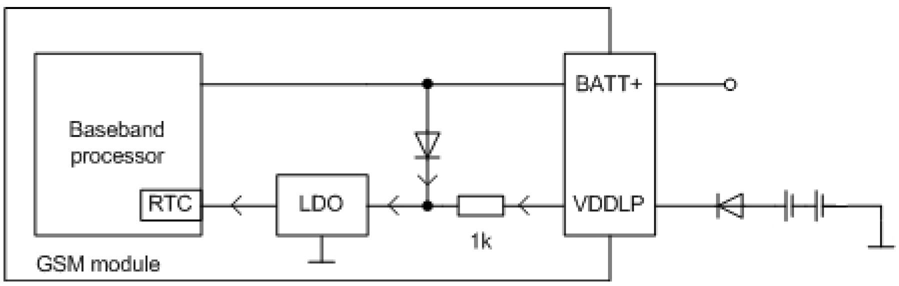


Figure 15: RTC supply from non-chargeable battery

3.9 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 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 SIM interface supports 3V and 1.8V SIM cards. Please refer to Table 30 for electrical specifications of the SIM interface lines depending on whether a 3V or 1.8V SIM card is used.

The CCIN signal serves to detect whether a tray (with SIM card) is present in the card holder. Using the CCIN signal is mandatory for compliance with the GSM 11.11 recommendation if the mechanical design of the host application allows the user to remove the SIM card during operation. To take advantage of this feature, an appropriate SIM card detect switch is required on the card holder. For example, this is true for the model supplied by Molex, which has been tested to operate with TC65i and is part of the Cinterion Wireless Modules reference equipment submitted for type approval. See Chapter 9 for Molex ordering numbers.

Table 14: Signals of the SIM interface (board-to-board connector)

Signal	Description
CCGND	Separate ground connection for SIM card to improve EMC. Be sure to use this ground line for the SIM interface rather than any other ground line or plane on the module. A design example for grounding the SIM interface is shown in Figure 50.
CCCLK	Chipcard clock, various clock rates can be set in the baseband processor.
CCVCC	SIM supply voltage.
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. If the SIM is removed during operation the SIM interface is shut down immediately to prevent destruction of the SIM. The CCIN signal is active low. The CCIN signal is mandatory for applications that allow the user to remove the SIM card during operation. The CCIN signal is solely intended for use with a SIM card. It must not be used for any other purposes. Failure to comply with this requirement may invalidate the type approval of TC65i.

The total cable length between the board-to-board connector pins on TC65i and the connector of the external SIM card holder must not exceed 100mm in order to meet the specifications of 3GPP TS 51.010-1 and to satisfy the requirements of EMC compliance.

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

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 TC65i.

3.10 Serial Interface ASC0

TC65i offers an 8-wire unbalanced, asynchronous modem interface ASC0 conforming to ITU-T V.24 protocol DCE signalling. The electrical characteristics do not comply with ITU-T V.28. The significant levels are 0V (for low data bit or active state) and 2.9V (for high data bit or inactive state). For electrical characteristics please refer to Table 30.

TC65i 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

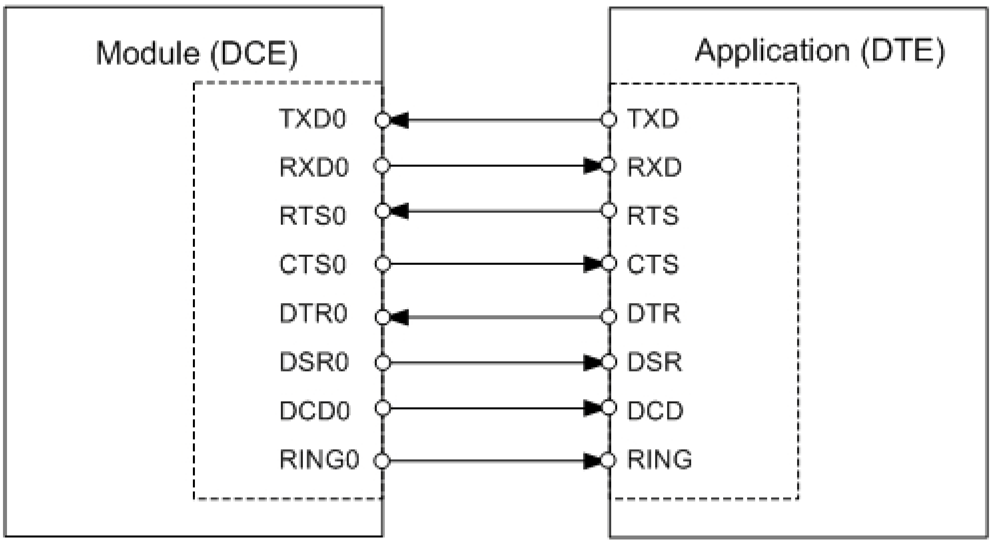


Figure 16: Serial interface ASC0

Features:
- Includes the data lines TXD0 and RXD0, the status lines RTS0 and CTS0 and, in addition, the modem control lines DTR0, DSR0, DCD0 and RING0.
- ASC0 is primarily designed for controlling voice calls, transferring CSD, fax and GPRS data and for controlling the GSM module 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. Please note that when the ASC0 interface runs in Multiplex mode, ASC1 cannot be used. For more details on Multiplex mode see [10].
- The DTR0 signal will only be polled once per second from the internal firmware of TC65i.
- The RING0 signal serves to indicate incoming calls and other types of URCs (Unsolicited Result Code). It can also be used to send pulses to the host application, for example to wake up the application from power saving state. See [1] for details on how to configure the RING0 line by AT^SCFG.
- By default, configured for 8 data bits, no parity and 1 stop bit. The setting can be changed using the AT command AT+ICF and, if required, AT^STPB. For details see [1].
- ASC0 can be operated at fixed bit rates from 300 bps to 921600 bps.
- Autobauding supports bit rates from 1200 to 460800 bps. To employ autobauding, the bit rate tolerance of the sender should - as a rule - be less than 2%. With bit rates $\leq$ 19200 bps however, the sender's bit rate tolerance must be less than 1%.
- Autobauding is not compatible with multiplex mode.
- Supports RTS0/CTS0 hardware flow control and XON/XOFF software flow control.

Table 15: DCE-DTE wiring of ASC0

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

3.11 Serial Interface ASC1

TC65i offers a 4-wire unbalanced, asynchronous modem interface ASC1 conforming to ITU-T V.24 protocol DCE signalling. The electrical characteristics do not comply with ITU-T V.28. The significant levels are 0V (for low data bit or active state) and 2.9V (for high data bit or inactive state). For electrical characteristics please refer to Table 30.

TC65i 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 module's TXD1 signal line
- Port RXD @ application receives data from the module's RXD1 signal line

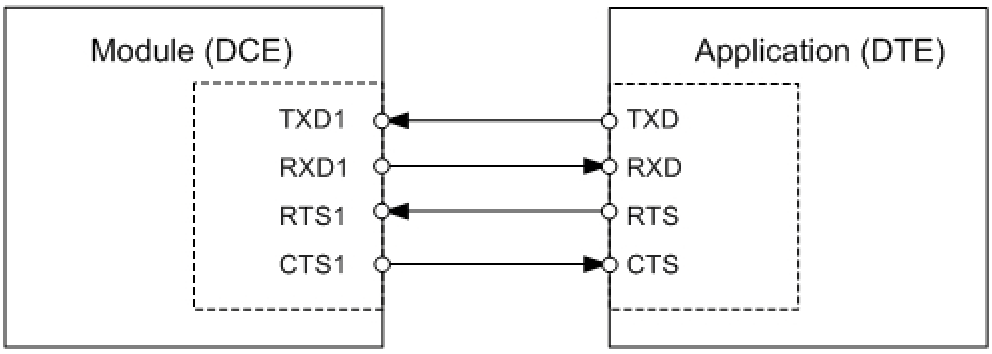


Figure 17: Serial interface ASC1

Features
- Includes only the data lines TXD1 and RXD1 plus RTS1 and CTS1 for hardware handshake.
- On ASC1 no RING line is available. The indication of URCs on the second interface depends on the settings made with the AT^SCFG command. For details refer to [1].
- Configured for 8 data bits, no parity and 1 or 2 stop bits.
- ASC1 can be operated at fixed bit rates from 300 bps to 921600 bps. Autobauding is not supported on ASC1.
- Supports RTS1/CTS1 hardware flow control and XON/XOFF software flow control.

Table 16: DCE-DTE wiring of ASC1

V.24 circuit	DCE		DTE	
	Line function	**Signal direction**	**Line function**	**Signal direction**
103	TXD1	Input	TXD	Output
104	RXD1	Output	RXD	Input
105	RTS1	Input	RTS	Output
106	CTS1	Output	CTS	Input

3.12 USB Interface

TC65i supports a USB 2.0 Full Speed (12Mbit/s) device interface. The USB interface is primarily intended for use as command and data interface and for downloading firmware. The USB I/O-lines are capable of driving the signal at min 3.0V. They are 5V I/O compliant.

The USB port has different functions depending on whether or not Java is running. Under Java, the lines may be used for debugging purposes (see [14] for further detail). If Java is not used, the USB interface is available as a command and data interface and for downloading firmware.

The USB host is responsible for supplying, across the VUSB_IN line, power to the module's USB interface, but not to other TC65i interfaces. This is because TC65i is designed as a self-powered device compliant with the "Universal Serial Bus Specification Revision 2.0"[3].

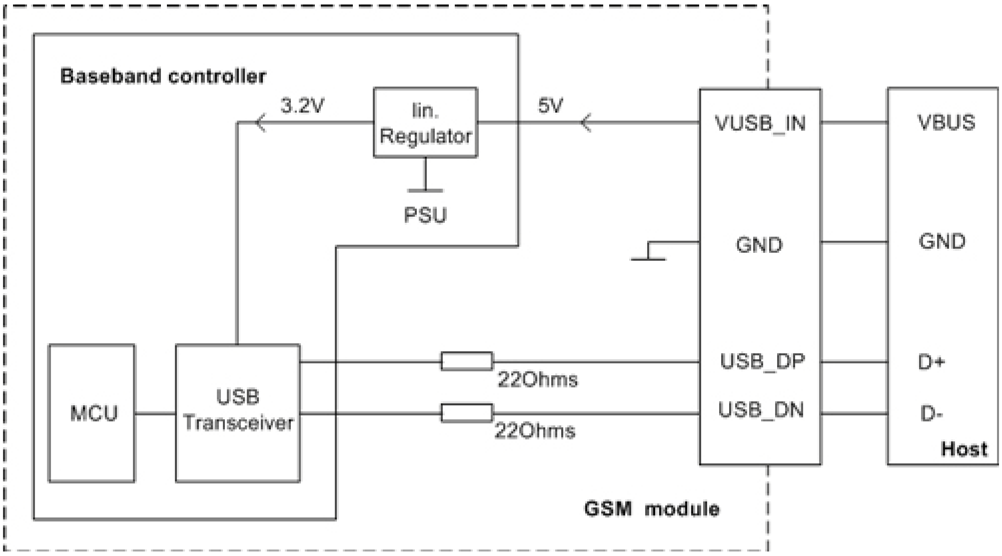


Figure 18: USB circuit

To properly connect the module's USB interface to the host a USB 2.0 compatible connector is required. For more information on how to install a USB modem driver and on how to integrate USB into TC65i applications see [10]. This Application Note also lists a selection of USB 2.0 hubs the module has been tested to operate with.

Because its USB stack is based on the Communication Device Class Abstract Control Model specification (CDC ACM v1.1), the module is integrated as a USB modem device with a virtual COM port - supporting most of the control and status lines an RS-232 serial interface would. Note that communication over the USB interface is only possible if the virtual DTR line on the virtual COM port is active.

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

3.13 I²C Interface

I²C is a serial, 8-bit oriented data transfer bus for bit rates up to 400 kbps in Fast mode. It consists of two lines, the serial data line I2CDAT and the serial clock line I2CCLK.

The TC65i module acts as a single master device, e.g. the clock I2CCLK is driven by module. I2CDAT is a bi-directional line. Each device connected to the bus is software addressable by a unique 7-bit address, and simple master/slave relationships exist at all times. The module operates as master-transmitter or as master-receiver. The customer application transmits or receives data only on request of the module.

To configure and activate the I²C bus use the AT^SSPI command. If the I²C bus is active the two lines I2CCLK and I2DAT are locked for use as SPI lines. Vice versa, the activation of the SPI locks both lines for I²C. Detailed information on the AT^SSPI command as well explanations on the protocol and syntax required for data transmission can be found in [1].

The I²C interface can be powered from an external supply or via the VEXT line of TC65i. If connected to the VEXT line the I²C interface will be properly shut down when the module enters the Power-down mode. If you prefer to connect the I²C interface to an external power supply, take care that VCC of the application is in the range of VEXT and that the interface is shut down when the PWR_IND signal goes high. See figures below as well as Chapter 7 and Figure 50.

In the application I2CDAT and I2CCLK lines need to be connected to a positive supply voltage via a pull-up resistor. For electrical characteristics please refer to Table 30.

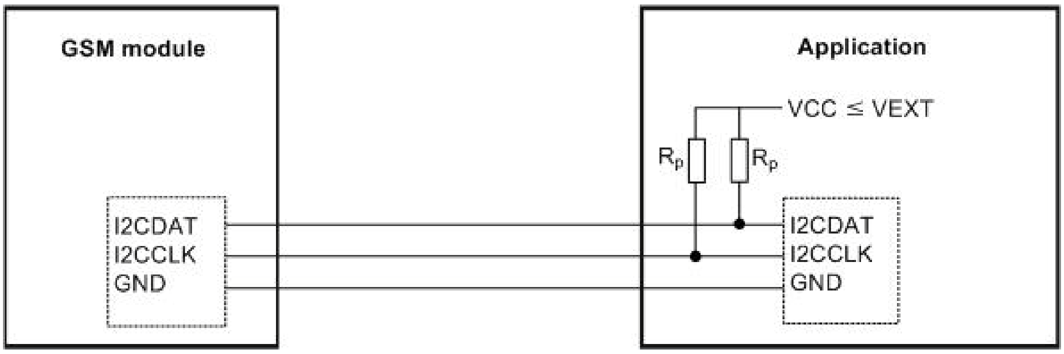


Figure 19: I²C interface connected to VCC of application

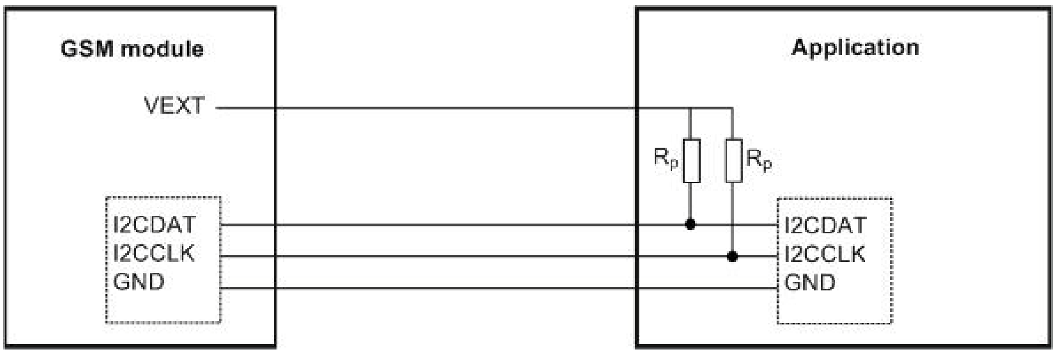


Figure 20: I²C interface connected to VEXT line of TC65i

Note: Good care should be taken when creating the PCB layout of the host application: The traces of I2CCLK and I2CDAT should be equal in length and as short as possible.

3.14 SPI Interface

The SPI (serial peripheral interface) is a synchronous serial interface for control and data transfer between the TC65i module and the connected application. Only one application can be connected to the module's SPI. The interface supports transmission rates up to 6.5 Mbit/s. It consists of four lines, the two data lines SPIDI/SPIDO, the clock line SPICLK and the chip select line SPICS.

The TC65i module acts as a single master device, e.g. the clock SPICLK is driven by module. Whenever the SPICS line is in a low state, the SPI bus is activated and data can be transferred from the module and vice versa. The SPI interface uses two independent lines for data input (SPIDI) and data output (SPIDO).

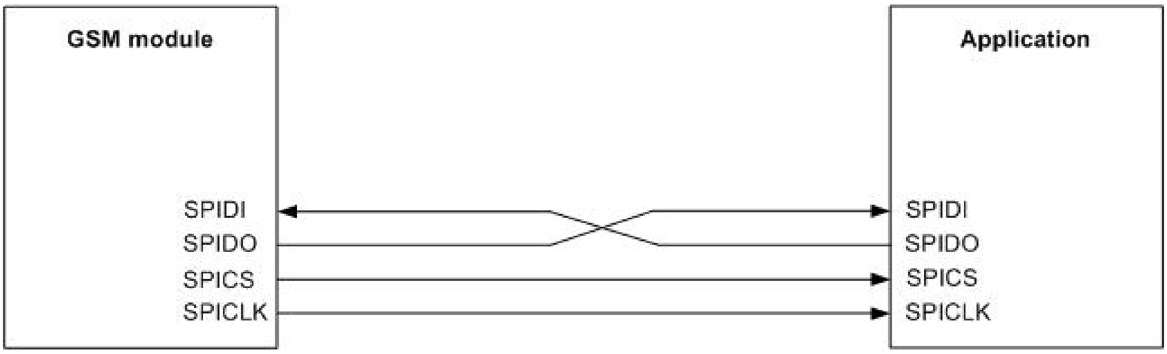


Figure 21: SPI interface

To configure and activate the SPI bus use the AT^SSPI command. If the SPI bus is active the two lines I2CCLK and I2DAT are locked for use as I2C lines. Detailed information on the AT^SSPI command as well explanations on the SPI modes required for data transmission can be found in [1].

In general, SPI supports four operation modes. The modes are different in clock phase and clock polarity. The module's SPI mode can be configured by using the AT command AT^SSPI. Make sure the module and the connected slave device works with the same SPI mode.

Figure 22 shows the characteristics of the four SPI modes. The SPI modes 0 and 3 are the most common used modes.

For electrical characteristics please refer to Table 30.

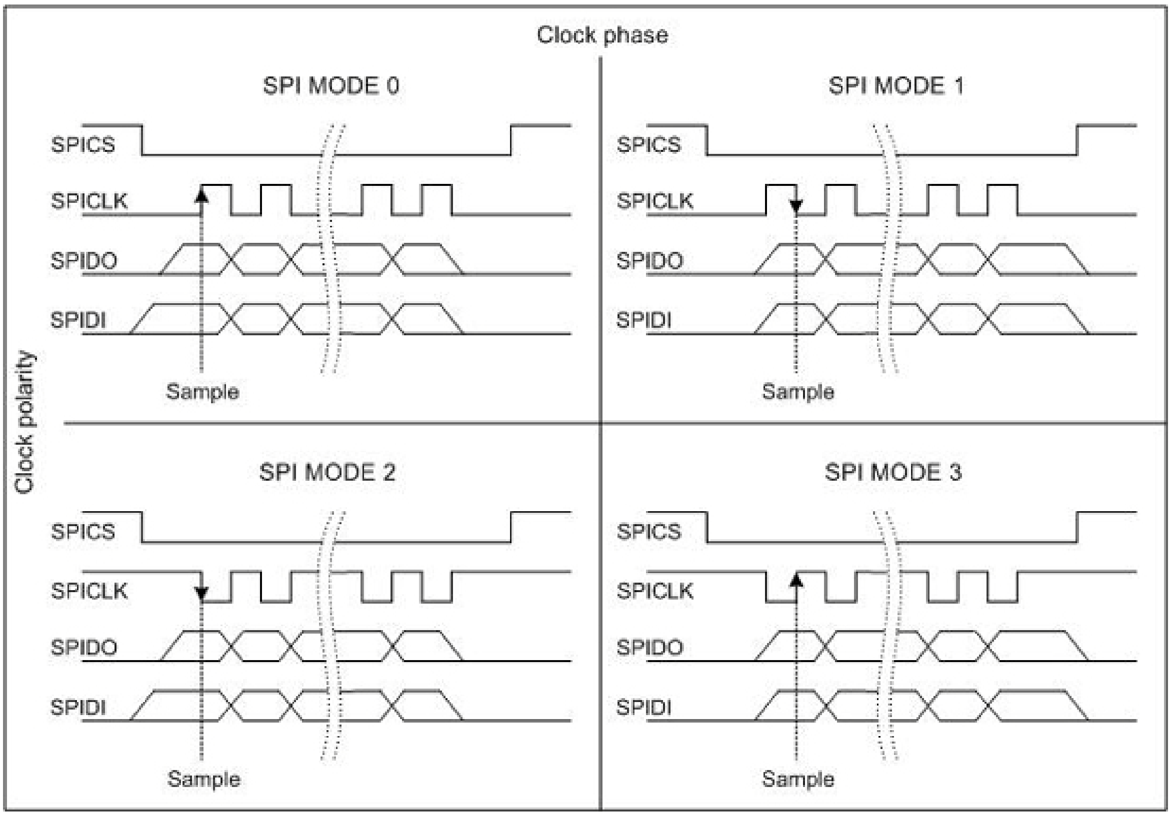


Figure 22: Characteristics of SPI modes

3.15 Audio Interfaces

TC65i comprises three audio interfaces available on the board-to-board connector:
- Two analog audio interfaces.
- Serial digital audio interface (DAI) designed for PCM (Pulse Code Modulation).

This means you can connect up to three different audio devices, although only one interface can be operated at a time. Using the AT^SAIC command you can easily switch back and forth.

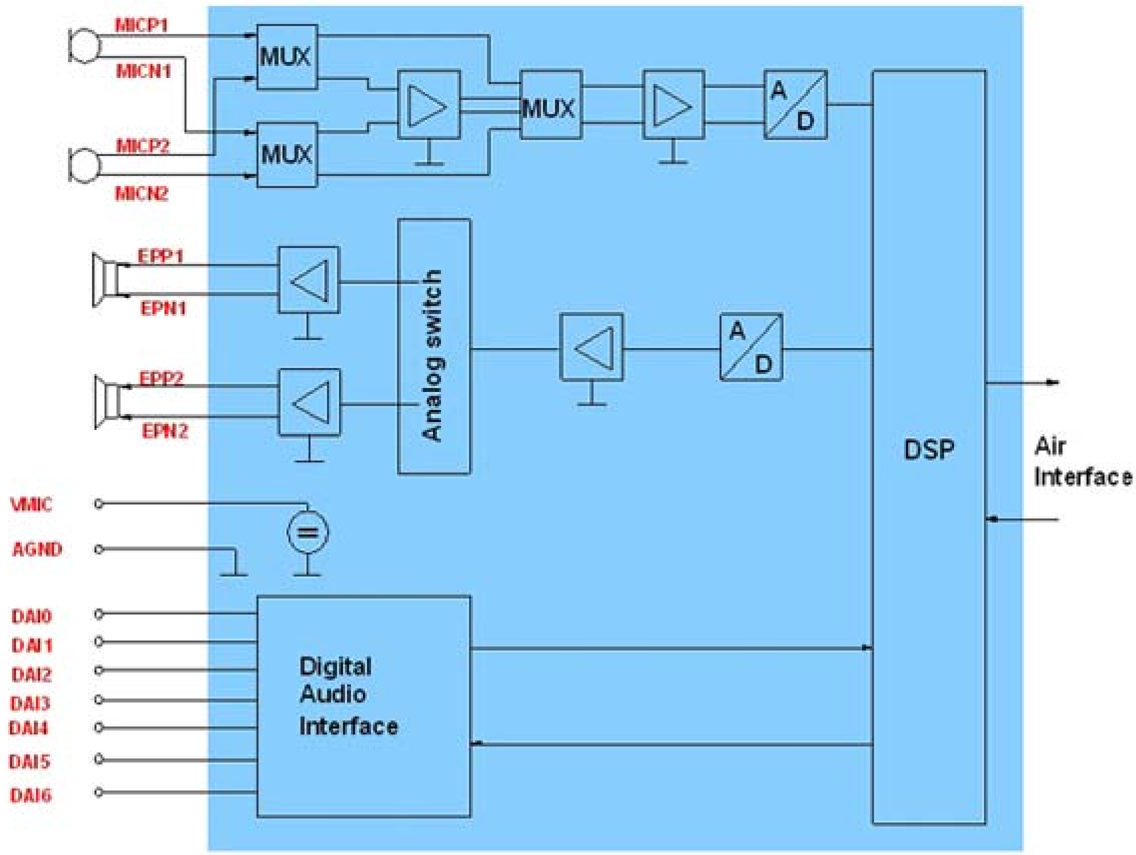


Figure 23: Audio block diagram

To suit different types of accessories the audio interfaces can be configured for different audio modes via the AT^SNFS command. The electrical characteristics of the voiceband part vary with the audio mode. For example, sending and receiving amplification, sidetone paths, noise suppression etc. depend on the selected mode and can be altered with AT commands (except for mode 1).

Both analog audio interfaces can be used to connect headsets with microphones or speaker-phones. Headsets can be operated in audio mode 3, speakerphones in audio mode 2. Audio mode 5 can be used for direct access to the speech coder without signal pre or post processing.

When shipped from factory, all audio parameters of TC65i are set to interface 1 and audio mode 1. This is the default configuration optimized for the Votronic HH-SI-30.3/V1.1/0 handset and used for type approving the Cinterion Wireless Modules reference configuration. Audio mode 1 has fix parameters which cannot be modified. To adjust the settings of the Votronic handset simply change to another audio mode.

3.15.1 Speech Processing

The speech samples from the ADC or DAI 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 active audio mode. These processed samples are passed to the speech encoder. Received samples from the speech decoder are passed to the DAC or DAI after post processing (frequency response correction, adding sidetone etc.).

Full rate, half rate, enhanced full rate, adaptive multi rate (AMR), 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.

3.15.2 Microphone Circuit

TC65i has two identical analog microphone inputs. There is no on-board microphone supply circuit, except for the internal voltage supply VMIC and the dedicated audio ground line AGND. Both lines are well suited to feed a balanced audio application or a single-ended audio application.

The AGND line on the TC65i board is especially provided to achieve best grounding conditions for your audio application. As there is less current flowing than through other GND lines of the module or the application, this solution will avoid hum and buzz problems.

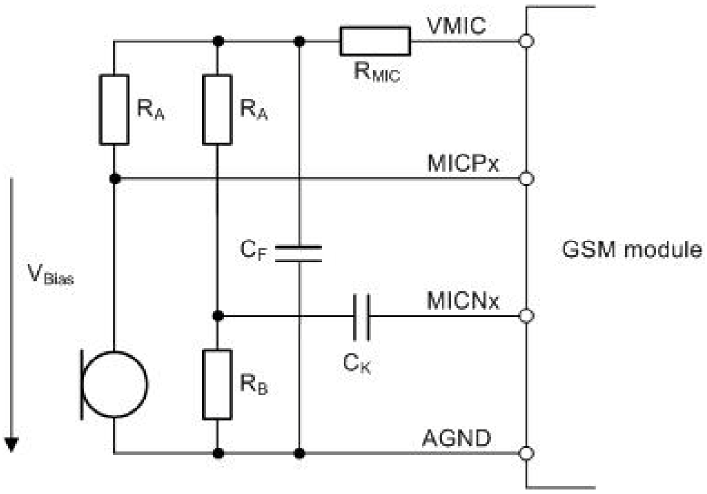
While TC65i is in Power-down mode, the input voltage at any MIC line must not exceed ±0.3 V relative to AGND (see also Section 5.1). In any other operating state the voltage applied to any MIC line must be in the range of +2.4 V to 0 V, otherwise undervoltage shutdown may be caused. Consider that the maximum full scale input voltage is V_{pp} = 1.6 V.

If VMIC is used to generate the MICP line bias voltage as shown in the following examples consider that VMIC is switched off (0V) outside a call. Audio signals applied to MICP in this case must not fall below -0.3 V.

If higher input levels are used especially in the line input configuration the signal level must be limited to 600 mV_{pp} outside a call, or AT^SNFM=1 should be used to switch on VMIC permanently.

3.15.2.1 Single-ended Microphone Input

Figure 24 as well as Figure 50 show an example of how to integrate a single-ended microphone input.



R_A = typ. 2k
R_B = typ. 5k
R_{VMIC} = typ. 470Ohm

C_k = typ. 100nF
C_F = typ. 22µF

V_{MIC} = typ. 2.5V

V_{bias} = 1.0V … 1.6V, typ. 1.5V

Figure 24: Single ended microphone input

R_A has to be chosen so that the DC voltage across the microphone falls into the bias voltage range of 1.0 V to 1.6 V and the microphone feeding current meets its specification.

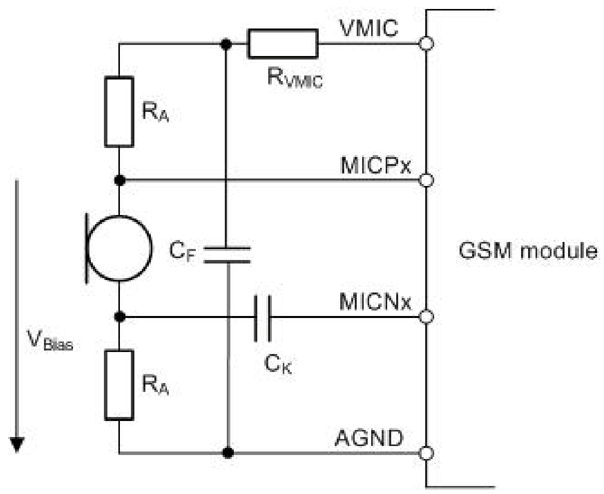
The MICNx input is automatically self biased to the MICPx DC level. It is AC coupled via C_K to a resistive divider which is used to optimize supply noise cancellation by the differential microphone amplifier in the module.

The VMIC voltage should be filtered if gains larger than 20 dB are used. The filter can be attached as a simple first order RC-network (R_{VMIC} and C_F).

This circuit is well suited if the distance between microphone and module is kept short. Due to good grounding the microphone can be easily ESD protected as its housing usually connects to the negative terminal.

3.15.2.2 Differential Microphone Input

Figure 25 shows a differential solution for connecting an electret microphone.



R_A = typ. 1 k
R_{VMIC} = 470 Ω

C_K = typ. 100 nF
C_F = typ. 22 µF

V_{MIC} = typ. 2.5 V

V_{bias} = 1.0V … 1.6 V,
typ. 1.5 V

Figure 25: Differential microphone input

The advantage of this circuit is that it can be used if the application involves longer lines between microphone and module.

While VMIC is switched off, the input voltage at any MIC line should not exceed ± 0.25 V relative to AGND (see also Section 5.1). In this case no bias voltage has to be supplied from the customer circuit to the MIC line and any signal voltage should be smaller than Vpp = 0.5 V.

VMIC can be used to generate the MICP line bias voltage as shown below. In this case the bias voltage is only applied if VMIC is switched on.

Only if VMIC is switched on, can the voltage applied to any MIC line be in the range of 2.4 V to 0V. If these limits are exceeded undervoltage shutdown may be caused.

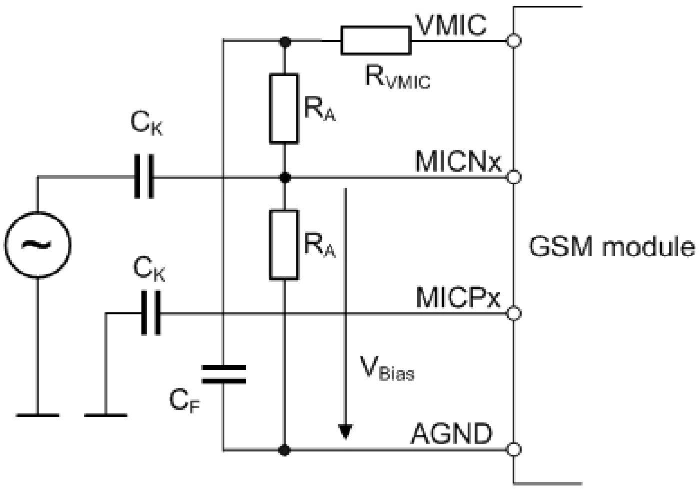
Consider that the maximum full scale input voltage is Vpp = 1.6 V.

The behavior of VMIC can be controlled with the parameter micVccCtl of the AT command AT^SNFM (see [1]):

- micVccCtl=2 (default). VMIC is controlled automatically by the module. VMIC is always switched on while the internal audio circuits of the module are active (e.g., during a call). VMIC can be used as indicator for active audio in the module.
- micVccCtl=1. VMIC is switched on continuously. This setting can be used to supply the microphone in order to use the signal in other customer circuits as well. However, this setting leads to a higher current consumption in SLEEP modes.
- micVccCtl=0. VMIC is permanently switched off.

3.15.2.3 Line Input Configuration with OpAmp

Figure 26 shows an example of how to connect an opamp into the microphone circuit.



R_A = typ. 47 k
R_{VMIC} = 470 Ω

C_k = typ. 100 nF
C_F = typ. 22 µF

V_{MIC} = typ. 2.5 V

V_{bias} = typ. ½ V_{MIC} = 1.25 V

Figure 26: Line input configuration with OpAmp

The AC source (e.g. an opamp) and its reference potential have to be AC coupled to the MICPx resp. MICNx input terminals. The voltage divider between VMIC and AGND is necessary to bias the input amplifier. MICNx is automatically self biased to the MICPx DC level.

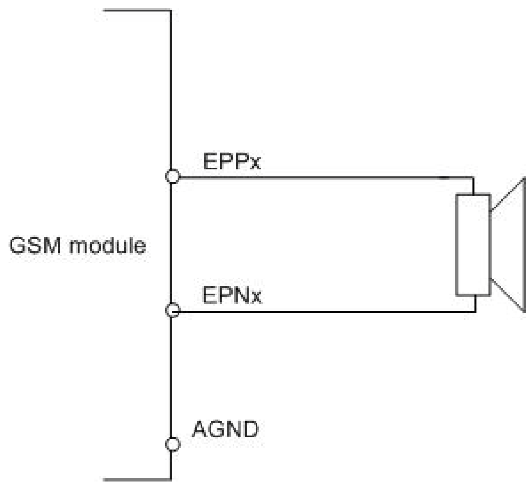
The VMIC voltage should be filtered if gains larger than 20dB are used. The filter can be attached as a simple first order RC-network (R_{VMIC} and C_F). If a high input level and a lower gain are applied the filter is not necessary.

Consider that if VMIC is switched off, the signal voltage should be limited to Vpp = 0.5V and any bias voltage must not be applied. Otherwise VMIC can be switched on permanently by using AT^SNFM=,1. In this case the current consumption in SLEEP modes is higher.

If desired, MICNx via C_K can also be connected to the inverse output of the AC source instead of connecting it to the reference potential for differential line input.

3.15.3 Loudspeaker Circuit

The GSM module comprises two analog differential speaker outputs: EP1 and EP2. Output EP1 is able to drive a load of 8Ohms while the output EP2 can drive a load of 32Ohms. Interface EP2 can also be connected in single ended configuration. Figure 27 shows an example of a differential loudspeaker configuration.



Loudspeaker impedance

EPP1/EPN1
Z_L = typ. 8 Ω

EPP2/EPN2
Z_L = typ. 32 Ω

Figure 27: Differential loudspeaker configuration

3.15.4 Digital Audio Interface (DAI)

The DAI can be used to connect audio devices capable of PCM (Pulse Code Modulation) or for type approval. The following chapters describe the PCM interface functionality.

The PCM functionality allows the use of a codec like for example the MC145483. This codec replaces the analog audio inputs and outputs during a call, if digital audio is selected by AT^SAIC.

The PCM interface is configurable with the AT^SAIC command (see [1]) and supports the following features:

- Master and slave mode
- Short frame and long frame synchronization
- 256 kHz or 512 kHz bit clock frequency

For the PCM interface configuration the parameters <clock>, <mode> and <framemode> of the AT^SAIC command are used. The following table lists possible combinations:

Table 17: Configuration combinations for the PCM interface

Configuration	<clock>	<mode>	<framemode>
Master, 256kHz, short frame	0	0	0
Master, 256kHz, long frame	0	0	1
Master, 512kHz, short frame	1	0	0
Master, 512kHz, long frame	1	0	1
Slave, 256kHz, short frame	0 or 1[1]	1	0
Slave, 256kHz, long frame	0 or 1	1	1
Slave, 512kHz, short frame	0 or 1	1	0
Slave, 512kHz, long frame	0 or 1	1	1

1. In slave mode the BCLKIN signal is directly used for data shifting. Therefore, the clock frequency setting is not evaluated and may be either 0 or 1.

In all configurations the PCM interface has the following common features:

- 16 Bit linear
- 8 kHz sample rate
- the most significant bit MSB is transferred first
- 125 µs frame duration
- common frame sync signal for transmit and receive

Table 18 shows the assignment of the DAI0...6 signals to the PCM interface signals. To avoid hardware conflicts different lines are used as inputs and outputs for frame sync and clock signals in master or slave operation. The table shows also which line is used for master or slave. The data lines (TXDAI and RXDAI) however are used in both modes. Unused inputs should be tied to GND via pull down resistors. Unused outputs must be left open.

Table 18: Overview of DAI signal functions

Signal name	Function for PCM Interface		Input/Output
DAI0	TXDAI	Master/Slave	O
DAI1	RXDAI	Master/Slave	I
DAI2	FS (Frame sync)	Master	O
DAI3	BITCLK	Master	O
DAI4	FSIN	Slave	I
DAI5	BCLKIN	Slave	I
DAI6	nc		I

3.15.4.1 Master Mode

To clock input and output PCM samples the PCM interface delivers a bit clock (BITCLK) which is synchronous to the GSM system clock. The frequency of the bit clock is 256kHz or 512kHz. Any edge of this clock deviates less than ±100ns (Jitter) from an ideal 256kHz clock respectively deviates less than ±320ns from an ideal 512kHz clock.

The frame sync signal (FS) has a frequency of 8kHz and is high for one BITCLK period before the data transmission starts if short frame is configured. If long frame is selected the frame sync signal (FS) is high during the whole transfer of the 16 data bits. Each frame has a duration of 125µs and contains 32 respective 64 clock cycles.

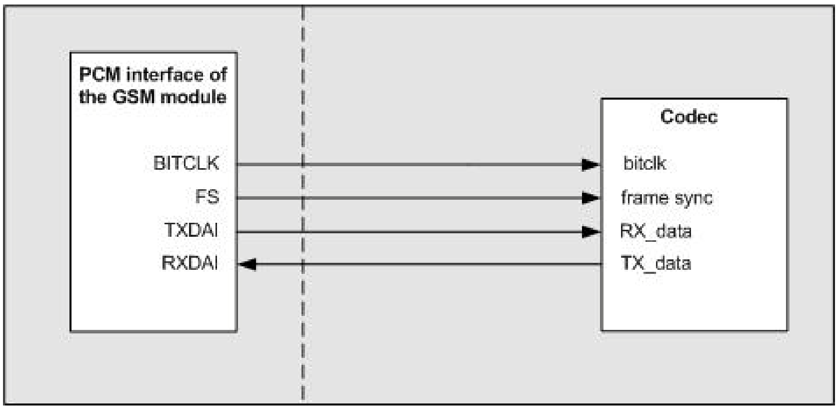


Figure 28: Master PCM interface Application

The timing of a PCM **short frame** is shown in Figure 29. The 16-bit TXDAI and RXDAI data is transferred simultaneously in both directions during the first 16 clock cycles after the frame sync pulse. The duration of a frame sync pulse is one BITCLK period, starting at the rising edge of BITCLK. TXDAI data is shifted out at the next rising edge of BITCLK. RXDAI data (i.e. data transmitted from the host application to the module's RXDAI line) is sampled at the falling edge of BITCLK.

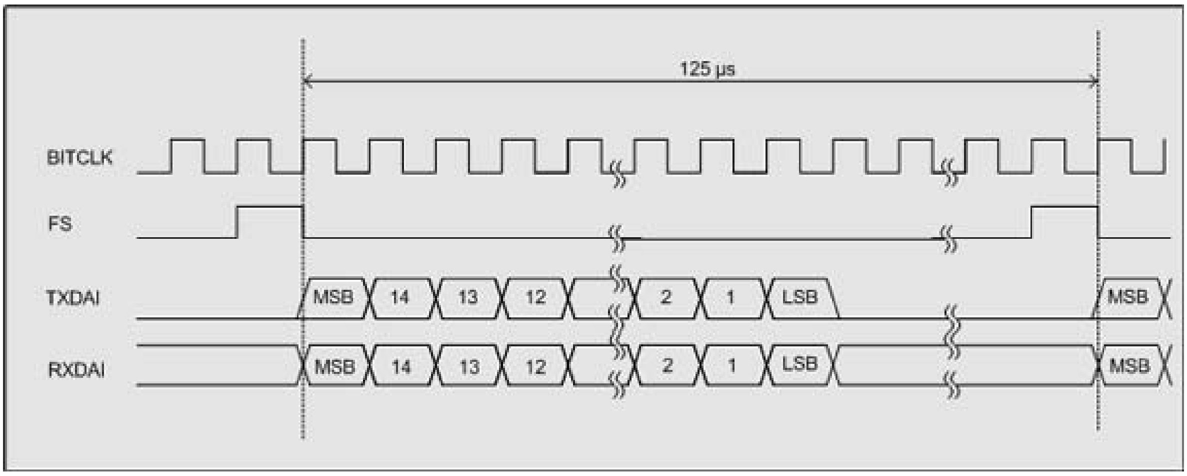


Figure 29: Short Frame PCM timing

The timing of a PCM **long frame** is shown in Figure 30. The 16-bit TXDAI and RXDAI data is transferred simultaneously in both directions while the frame sync pulse FS is high. For this reason the duration of a frame sync pulse is 16 BITCLK periods, starting at the rising edge of BITCLK. TXDAI data is shifted out at the same rising edge of BITCLK. RXDAI data (i.e. data transmitted from the host application to the module's RXDAI line) is sampled at the falling edge of BITCLK.

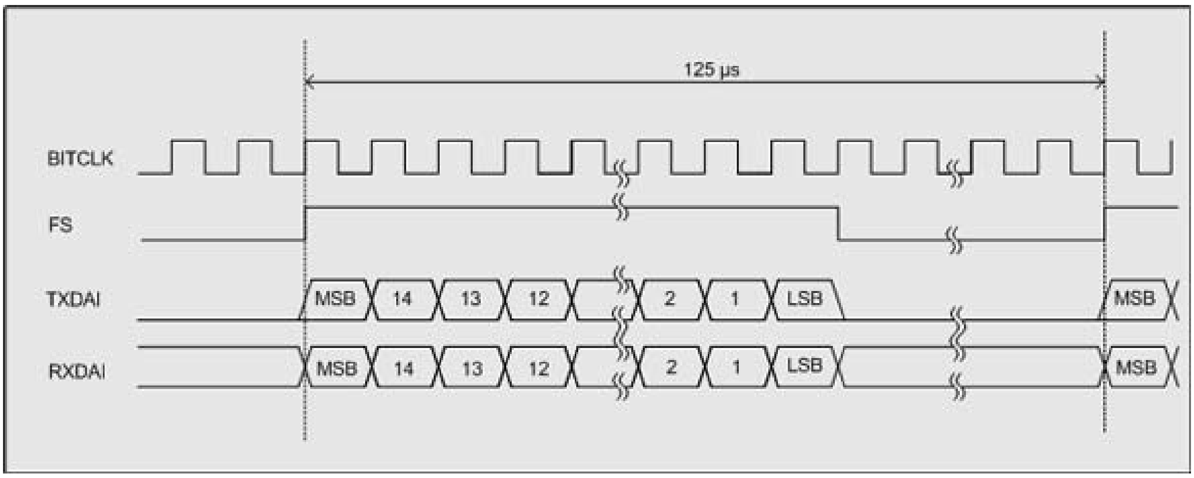


Figure 30: Long Frame PCM timing

3.15.4.2 Slave Mode

In slave mode the PCM interface is controlled by an external bit clock and an external frame sync signal applied to the BCLKIN and FSIN lines and delivered either by the connected codec or another source. The bit clock frequency has to be in the range of 256kHz -125ppm to 512kHz +125ppm.

Data transfer starts at the falling edge of FSIN if the short frame format is selected, and at the rising edge of FSIN if long frame format is selected. With this edge control the frame sync signal is independent of the frame sync pulse length.

TXDAI data is shifted out at the rising edge of BCLKIN. RXDAI data (i.e. data transmitted from the host application to the module's RXDAI line) is sampled at the falling edge of BCLKIN.

The deviation of the external frame rate from the internal frame rate must not exceed ±125ppm. The internal frame rate of nominal 8kHz is synchronized to the GSM network.

The difference between the internal and the external frame rate is equalized by doubling or skipping samples. This happens for example every second, if the difference is 125ppm.

The resulting distortion can be neglected in speech signals.

The lines BITCLK and FS remain low in slave mode.

Figure 31 shows the typical slave configuration. The external codec delivers the bit clock and the frame sync signal. If the codec itself is not able to run in master mode as for example the MC145483, a third party has to generate the clock and the frame sync signal.

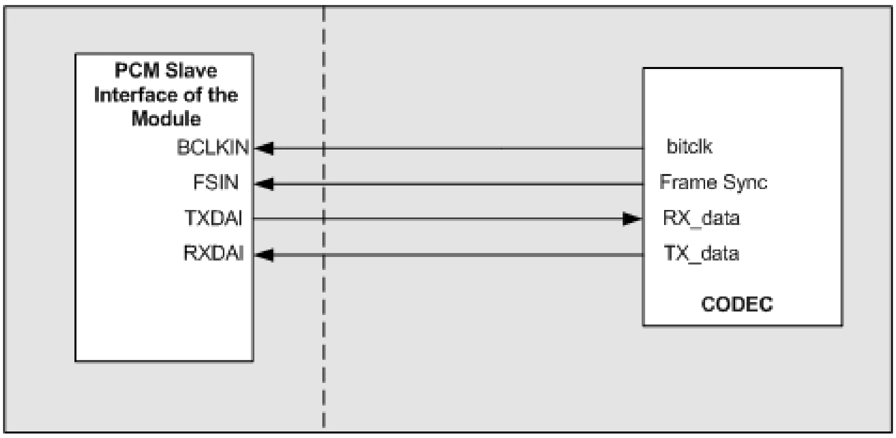


Figure 31: Slave PCM interface application

The following figures show the slave short and long frame timings. Because these are edge controlled, frame sync signals may deviate from the ideally form as shown with the dotted lines.

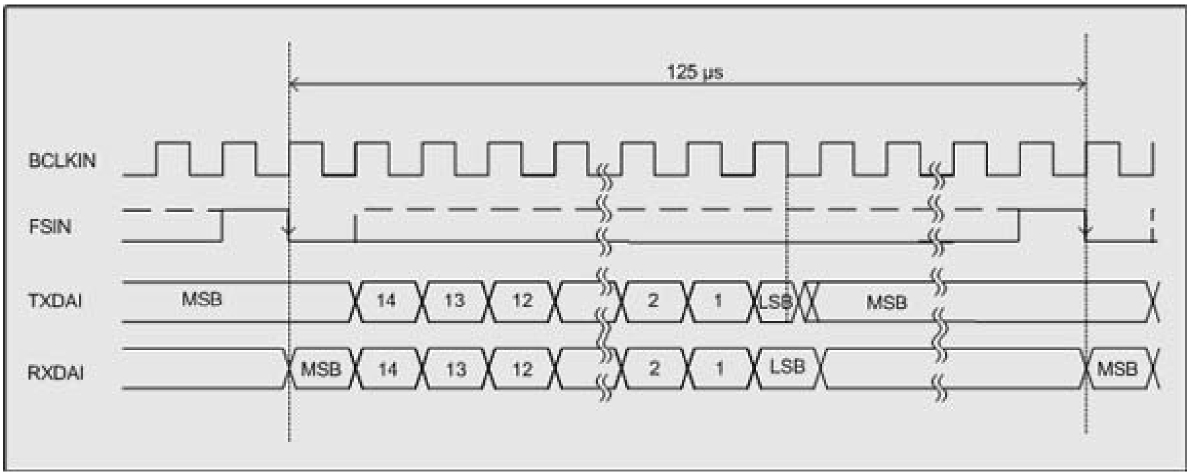


Figure 32: Slave PCM Timing, Short Frame selected

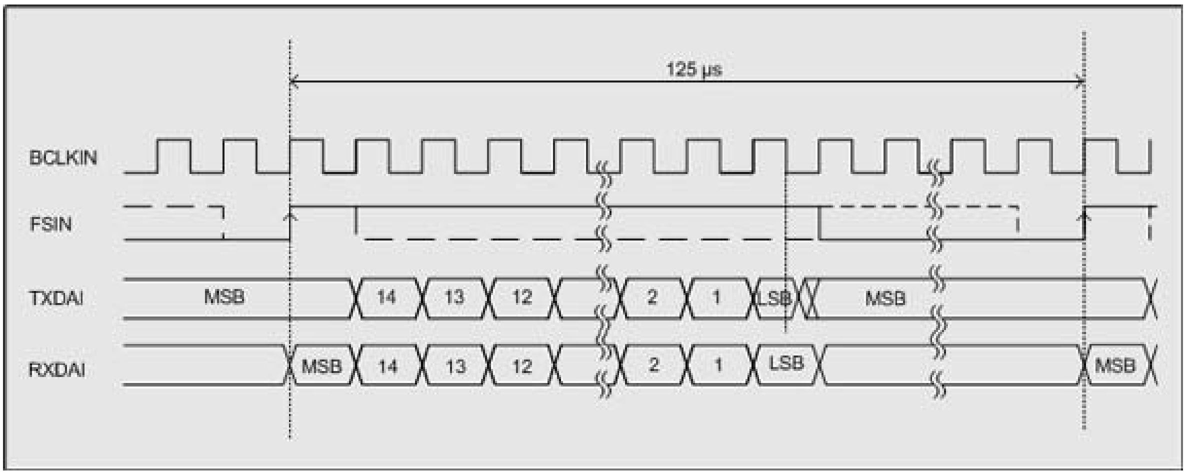


Figure 33: Slave PCM Timing, Long Frame selected

3.16 Analog-to-Digital Converter (ADC)

The ADC of the TC65i consists of 2 independent, unbalanced, multiplexed analog inputs that can be used for measuring external DC voltages in the range of 0mV…+2400 mV. The ADC has a resolution of 12 bits.

Use the command AT^SRADC described in [1] to select the analog inputs ADC1_IN or ADC2_IN, to set the measurement mode and read out the measurement results. The measured values are indicated in mV with a resolution of 1mV.

There is no out of range detection. Voltages beyond these limits cannot be measured:

- Underflow: Values < -25 mV
- Overflow: Values > 2425 mV

The measurement repetition interval is adjustable from 100ms up to 30s using AT^SRADC. When sampling is taking place (for a time ts~400ìs) the conversion switch is closed.

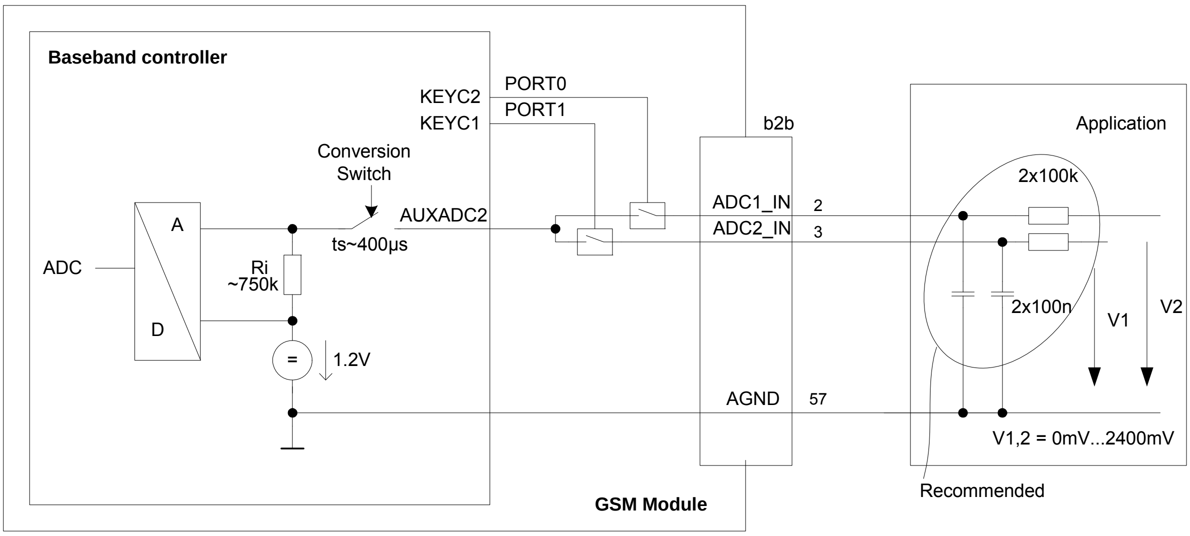


Figure 34: Analog-to-Digital Converter (ADC)

Please make sure that during Power-down mode the ADCx_IN input voltage does not exceed ±0.3V. Use a RC network as shown in Figure 34 to reduce the reverse current.

3.17 GPIO Interface

The TC65i has 10 GPIOs for external hardware devices. Each GPIO can be configured for use as input or output. All settings are AT command controlled.

The GIPO related AT commands are the following: AT^SPIO, AT^SCPIN, AT^SCPOL, AT^SCPORT, AT^SDPORT, AT^SGIO, AT^SSIO. A detailed description can be found in [1].

When the TC65i starts up, all GPIO lines are set to high-impedance state after initializing, as described in Section 3.3.2. Therefore, it is recommended to connect pull-up or pull-down resistors to all GPIO lines you want to use as output. This is necessary to keep these lines from floating or driving any external devices before all settings are done by AT command (at least AT^SPIO, AT^SCPIN), and after closing the GPIOs again.

3.17.1 Using the GPIO10 Line as Pulse Counter

The GPIO10 line can be assigned two different functions selectable by AT command:
- The AT^SCPIN command configures the line for use as GPIO.
- With AT^SCCNT and AT^SSCNT the line can be configured and operated as pulse counter.

Both functions exclude each other. The pulse counter disables the GPIO functionality, and vice versa, the GPIO functionality disables the pulse counter. Detailed AT command descriptions can be found in [1].

The pulse counter is designed to measure signals from 0 to 1000 pulses per second. It can be operated either in Limit counter mode or Start-Stop mode. Depending on the selected mode the counted value is either the number of pulses or the time (in milliseconds) taken to generate a number of pulses specified with AT^SCCNT. For reliable pulse detection a duty cycle of 50% on a pulse signal with 1000 pulses per second is required. This means, that a "low"- resp. "high"-signal duration of at least 500µs is required. Shorter signals may lead to inaccuracy of the pulse detection.

In Limit counter mode, the displayed measurement result (URC “^SSCNT: <count>”) implies an inaccuracy <5ms. In Start-Stop mode, you can achieve 100% accuracy if you take care that no pulses are transmitted before starting the pulse counter (AT^SSCNT=0 or 1) and after closing the pulse counter (AT^SSCNT=3).

3.18 Control Signals

3.18.1 Synchronization Signal

The synchronization signal serves to indicate growing power consumption during the transmit burst. The signal is generated by the SYNC line. Please note that this line can adopt three different operating modes which you can select by using the AT^SSYNC command: the mode AT^SSYNC=0 described below, and the two LED modes AT^SSYNC=1 or AT^SSYNC=2 described in [1] and Section 3.18.2.

The first function (factory default AT^SSYNC=0) 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 TC65i module if required. This can be achieved by lowering the current drawn from other components installed in your application.

The timing of the synchronization signal is shown below. High level of the SYNC line indicates increased power consumption during transmission.

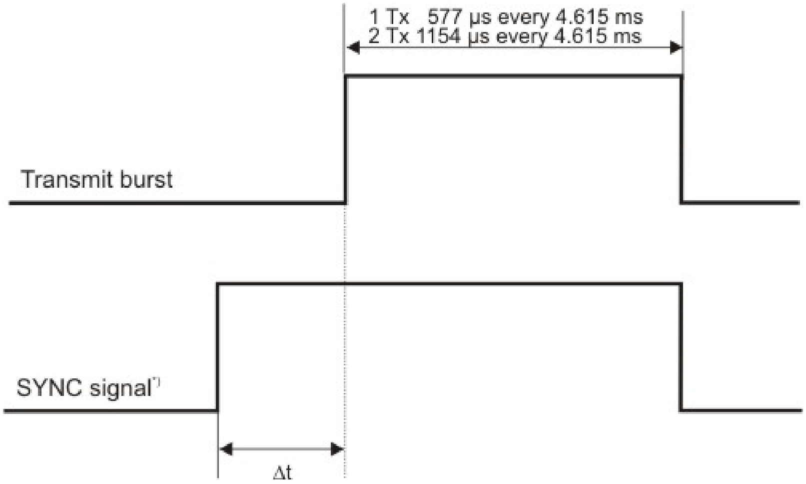


Figure 35: SYNC signal during transmit burst

*)The duration of the SYNC signal is always equal, no matter whether the traffic or the access burst are active. Δt is a fixed time in the range of 100µs...200µs.

3.18.2 Using the SYNC Line to Control a Status LED

As an alternative to generating the synchronization signal, the SYNC line can be configured to drive a status LED that indicates different operating modes of the TC65i module. To take advantage of this function the LED mode must be activated with the AT^SSYNC command and the LED must be connected to the host application. The connected LED can be operated in two different display modes (AT^SSYNC=1 or AT^SSYNC=2). For details please refer to [1].

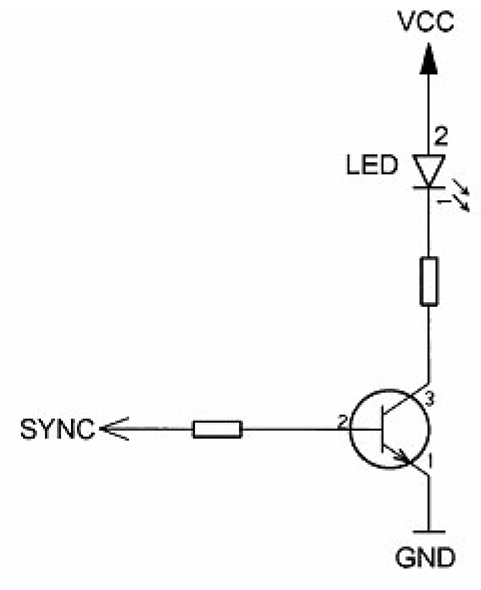


Figure 36: LED Circuit (Example)

Especially in the development and test phase of an application, system integrators are advised to use the LED mode of the SYNC line in order to evaluate their product design and identify the source of errors.

To operate the LED a buffer, e.g. a transistor or gate, must be included in your application. A sample circuit is shown in Figure 36. Power consumption in the LED mode is the same as for the synchronization signal mode. For details see Table 30, SYNC line.

3.18.3 Behavior of the RING0 Line (ASC0 Interface only)

The RING0 line is available on the first serial interface ASC0 (see also Section 3.10). 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/fax/data 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.

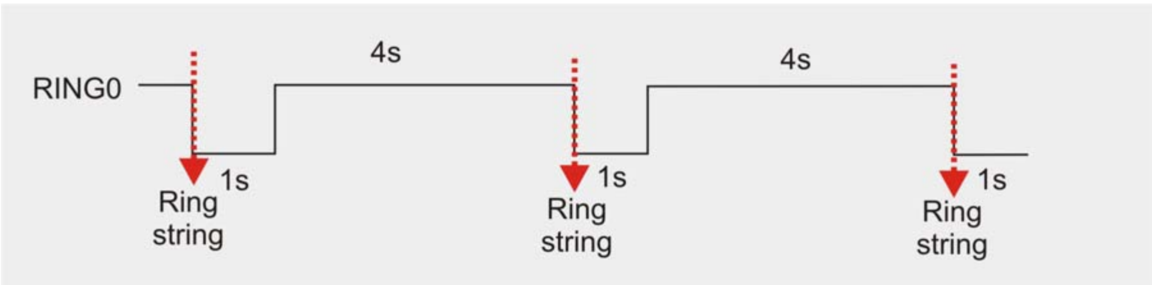


Figure 37: Incoming voice/fax/data call

- All other types of Unsolicited Result Codes (URCs) also cause the RING0 line to go low, however for 1 second only.

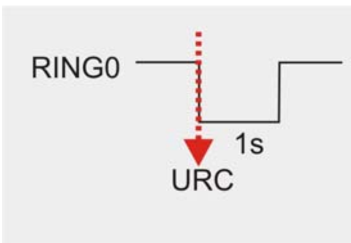


Figure 38: URC transmission

3.18.4 PWR_IND Signal

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

4 Antenna Interface

The antenna interface has an impedance of 50Ω. TC65i is capable of sustaining a total mismatch at the antenna interface without any damage, even when transmitting at maximum RF power.

The external antenna must be matched properly to achieve best performance regarding radiated power, DC-power consumption, modulation accuracy and harmonic suppression. Antenna matching networks are not included on the TC65i module and should be placed in the host application.

Regarding the return loss TC65i provides the following values in the active band:

Table 19: Return loss in the active band

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

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

4.1 Antenna Installation

To suit the physical design of individual applications TC65i offers two alternative approaches to connecting the antenna:

- Recommended approach: U.FL-R-SMT antenna connector from Hirose assembled on the component side of the PCB (top view on TC65i). See Section 4.3 for details.
- Antenna pad and grounding plane placed on the bottom side. See Section 4.2.

The U.FL-R-SMT connector has been chosen as antenna reference point (ARP) for the Cinterion Wireless Modules reference equipment submitted to type approve TC65i. All RF data specified throughout this manual are related to the ARP. For compliance with the test results of the Cinterion Wireless Modules type approval you are advised to give priority to the connector, rather than using the antenna pad.

IMPORTANT: Both solutions can only be applied alternatively. This means, whenever an antenna is plugged to the Hirose connector, the pad must not be used. Vice versa, if the antenna is connected to the pad, then the Hirose connector must be left empty.

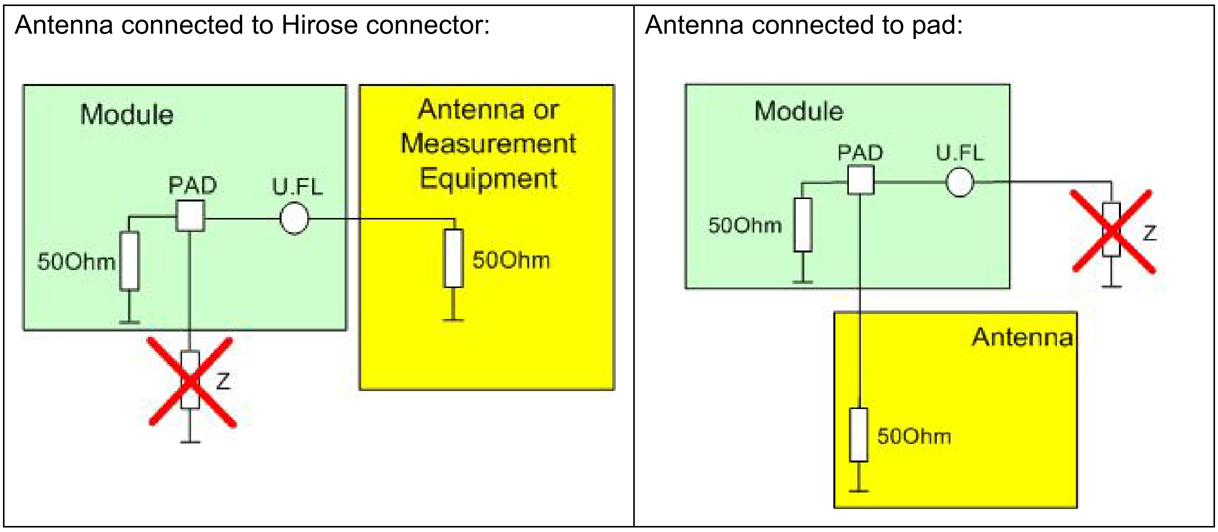


Figure 39: Never use antenna connector and antenna pad at the same time

No matter which option you choose, ensure that the antenna pad does not come into contact with the holding device or any other components of the host application. It needs to be surrounded by a restricted empty area, i.e., free space which must also be reserved 0.8mm in height.

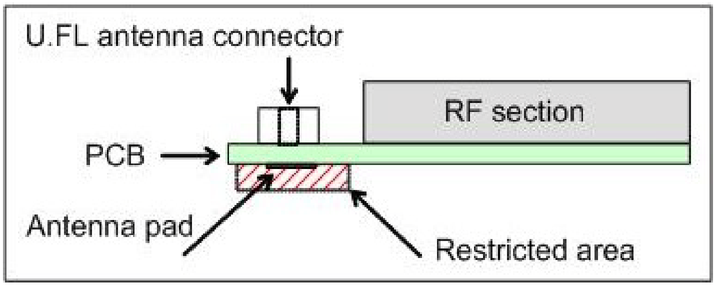


Figure 40: Restricted area around antenna pad

4.2 Antenna Pad

The antenna can be soldered to the pad, or attached via contact springs. For proper grounding connect the antenna to the ground plane on the bottom of TC65i which must be connected to the ground plane of the application.

When you decide to use the antenna pad take into account that the pad has not been intended as antenna reference point (ARP) for the Cinterion Wireless Module TC65i type approval. The antenna pad is provided only as an alternative option which can be used, for example, if the recommended Hirose connection does not fit into your antenna design.

Also, consider that according to the GSM recommendations TS 45.005 and TS 51.010-01 a 50Ω connector is mandatory for type approval measurements. This requires GSM devices with an integral antenna to be temporarily equipped with a suitable connector or a low loss RF cable with adapter.

Notes on soldering:
- To prevent damage to the module and to obtain long-term solder joint properties you are advised to maintain the standards of good engineering practice for soldering.
- Be sure to solder the antenna core to the pad and the shielding of the coax cable to the ground plane of the module next to the antenna pad. The direction of the cable is not relevant from the electrical point of view.

TC65i material properties:
TC65i PCB: FR4
Antenna pad: Gold plated pad

4.2.1 Suitable Cable Types

For direct solder attachment, we suggest to use the following cable types:
- RG316/U 50Ω coaxial cable
- 1671A 50Ω coaxial cable

Suitable cables are offered, for example, by IMS Connector Systems. For further details and other cable types please contact http://www.imscs.com.

4.3 Antenna Connector

TC65i uses either an ultra-miniature SMT antenna connector from Hirose Ltd: U.FL-R-SMT, or the Molex 07341201 U.FL antenna connector. Both connectors have identical mechanical dimensions (see Figure 41). Minor differences in product specifications are mentioned in Table 20. The position of the antenna connector on the TC65i board can be seen in Figure 46.

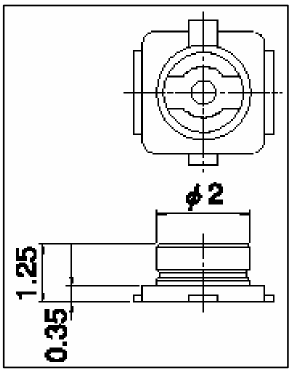


Figure 41: Mechanical dimensions of TC65i antenna connectors

Table 20: Product specifications of TC65i antenna connectors

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

Table 21: Material and finish of TC65i antenna connectors and recommended plugs

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

Mating plugs and cables can be chosen from the Hirose U.FL Series or from other antenna equipment manufacturers like Molex or IMS. Examples from the Hirose U.FL Series are shown below and listed in Table 22. For latest product information please contact your respective antenna equipment manufacturer.

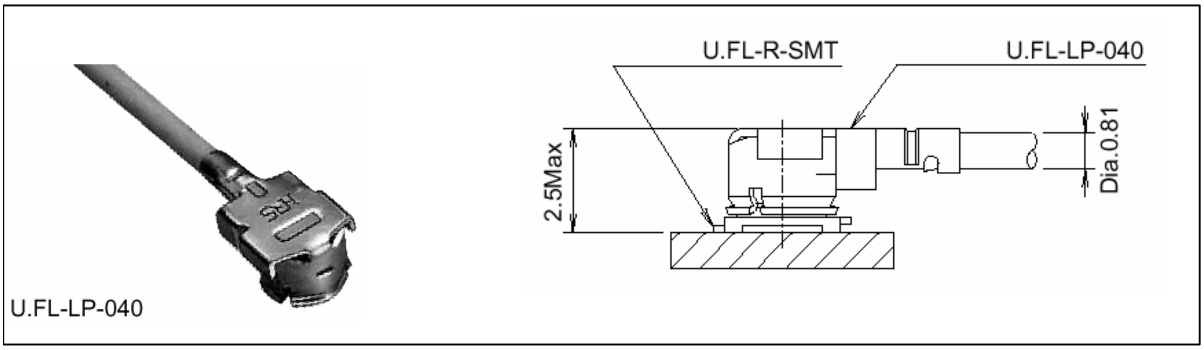


Figure 42: U.FL-R-SMT connector with U.FL-LP-040 plug

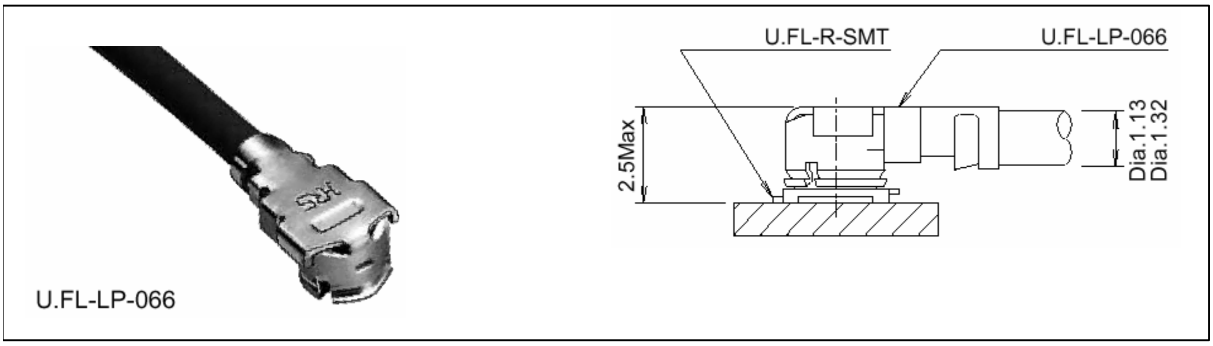


Figure 43: U.FL-R-SMT connector with U.FL-LP-066 plug

In addition to the connectors illustrated above, the U.FL-LP-(V)-040(01) version is offered as an extremely space saving solution. This plug is intended for use with extra fine cable (up to Ø 0.81mm) and minimizes the mating height to 2mm. See Figure 44 which shows the Hirose data sheet.

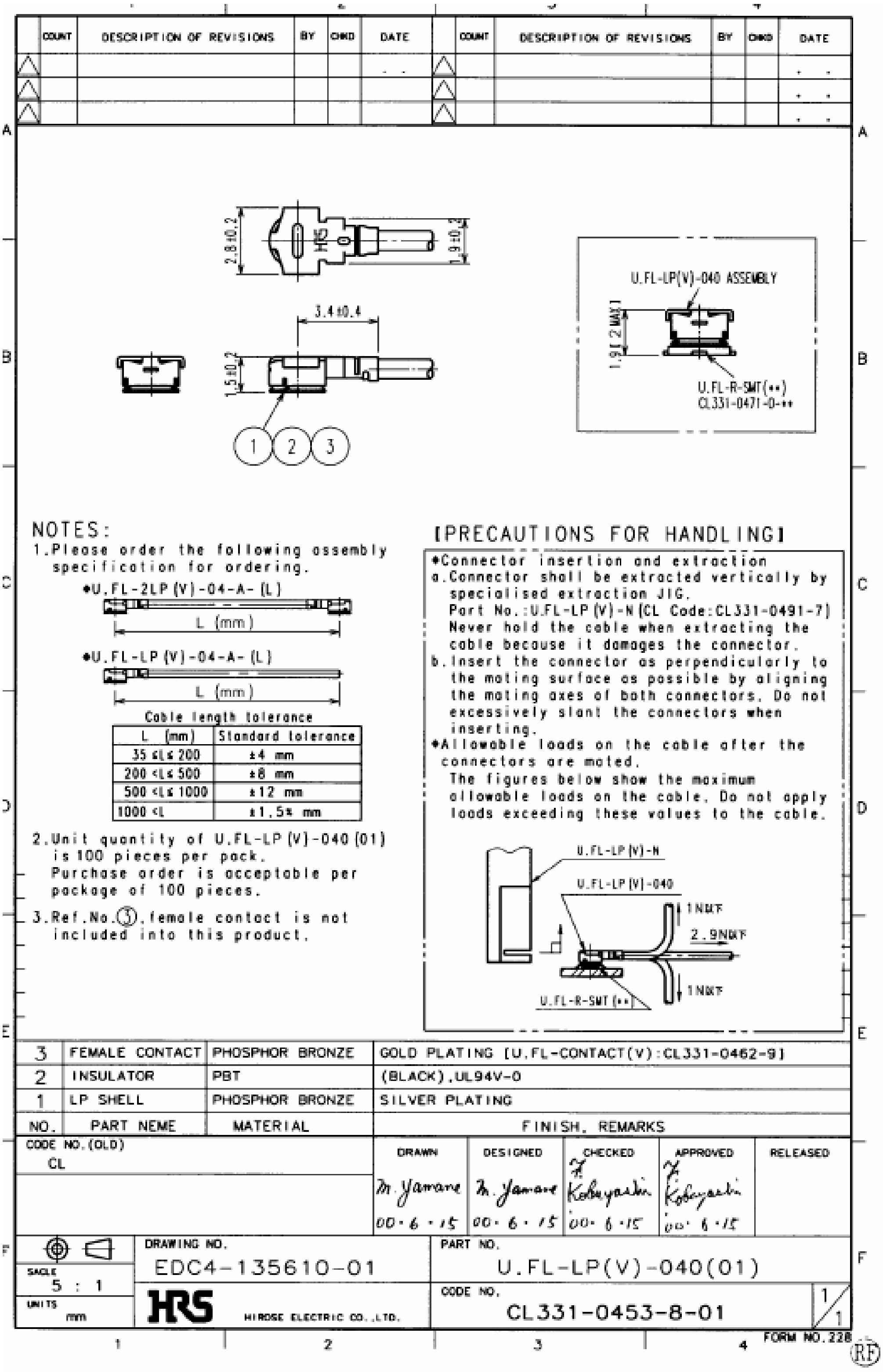


Figure 44: Specifications of U.FL-LP-(V)-040(01) plug

Table 22: Ordering information for Hirose U.FL Series

Item	Part number	HRS number
Connector on TC65i	U.FL-R-SMT	CL331-0471-0-10
Right-angle plug shell for Ø 0.81mm cable	U.FL-LP-040	CL331-0451-2
Right-angle plug for Ø 0.81mm cable	U.FL-LP(V)-040 (01)	CL331-053-8-01
Right-angle plug for Ø 1.13mm cable	U.FL-LP-068	CL331-0452-5
Right-angle plug for Ø 1.32mm cable	U.FL-LP-066	CL331-0452-5
Extraction jig	E.FL-LP-N	CL331-04441-9

5 Electrical, Reliability and Radio Characteristics

5.1 Absolute Maximum Ratings

The absolute maximum ratings stated in Table 23 are stress ratings under any conditions. Stresses beyond any of these limits will cause permanent damage to TC65i.

The power supply connected to the TC65i module shall be compliant with the SELV requirements defined in EN60950. Above all, the peak current of the power supply shall be limited according to Table 23.

Table 23: Absolute maximum ratings

Parameter	Min	Max	Unit
Peak current of power supply		1.6	A
Supply voltage BATT+	-0.3	4.9	V
Voltage at digital lines in POWER DOWN mode	-0.3	0.3	V
Voltage at digital lines in normal operation	-0.3	3.05 or VEXT+0.3	V
Voltage at analog lines in POWER DOWN mode	-0.3	0.3	V
Voltage at analog lines, VMIC on[1]	-0.3	3.0	V
Voltage at analog lines, VMIC off[1]	-0.3	0.3	V
Voltage at VCHARGE line	-0.3	7.0	V
Voltage at CHARGEGATE line	-0.3	7.0	V
VUSB_IN	-0.3	5.5	V
USB_DP, USB_DN	-0.3	3.5	V
VSENSE		5.5	V
ISENSE		5.5	V
PWR_IND	-0.3	10	V
VDDLP	-0.3	5.5	V

1. For normal operation the voltage at analog lines with *VMIC on* should be within the range of 0V to 2.4V and with *VMIC off* within the range of -0.25V to 0.25V.

5.2 Operating Temperatures

Table 24: Board / battery temperature

Parameter	Min	Typ	Max	Unit
Normal operation	-30	+25	+70	°C
Restricted operation[1]	-30 to -40	---	+70 to +75	°C
Automatic shutdown[2] Temperature measured on TC65i board Temperature measured at battery NTC	 -40 -20	 --- ---	 >+80 +60	°C

1. Restricted operation allows normal mode speech calls or data transmission for limited time until automatic thermal shutdown takes effect. The duration of emergency calls is unlimited because automatic thermal shutdown is deferred until hang up.
2. Due to temperature measurement uncertainty, a tolerance on the stated shutdown thresholds may occur. The possible deviation is in the range of ±3°C at the overtemperature limit and ±5°C at the undertemperature limit.

Table 25: Ambient temperature according to IEC 60068-2 (without forced air circulation)

Parameter	Min	Typ	Max	Unit
Normal operation	-30	+25	+65	°C
Restricted operation[1]	-30 to -40	---	+65 to +75	°C

1. Restricted operation allows normal mode speech calls or data transmission for limited time until automatic thermal shutdown takes effect. The duration of emergency calls is unlimited because automatic thermal shutdown is deferred until hang up.

Table 26: Charging temperature[1]

Parameter	Min	Typ	Max	Unit
Battery temperature for software controlled fast charging (measured at battery NTC)	0	---	+45	°C

1. Outside the given temperature range (0°C to +45°C) no charging is possible.

Note: See Section 3.3.4 for further information about the NTCs for on-board and battery temperature measurement, automatic thermal shutdown and alert messages.
When data is transmitted over GPRS the TC65i automatically reverts to a lower Multislot Class if the temperature increases to the limit specified for normal operation and, vice versa, returns to the higher Multislot Class if the temperature is back to normal. For details see Section 3.4.

5.3 Storage Conditions

The conditions stated below are only valid for modules in their original packed state in weather protected, non-temperature-controlled storage locations. Normal storage time under these conditions is 12 months maximum.

Table 27: Storage conditions

Type	Condition	Unit	Reference
Air temperature: Low High	-40 +85	°C	ETS 300 019-2-1: T1.2, IEC 68-2-1 Ab ETS 300 019-2-1: T1.2, IEC 68-2-2 Bb
Humidity relative: Low High Condens.	10 90 at 30°C 90-100 at 30°C	%	--- ETS 300 019-2-1: T1.2, IEC 68-2-56 Cb ETS 300 019-2-1: T1.2, IEC 68-2-30 Db
Air pressure: Low High	70 106	kPa	IEC TR 60271-3-1: 1K4 IEC TR 60271-3-1: 1K4
Movement of surrounding air	1.0	m/s	IEC TR 60271-3-1: 1K4
Water: rain, dripping, icing and frosting	Not allowed	---	---
Radiation: Solar Heat	1120 600	W/m^2	ETS 300 019-2-1: T1.2, IEC 60068-2-2 Bb ETS 300 019-2-1: T1.2, IEC 60068-2-2 Bb
Chemically active substances	Not recom-mended		IEC TR 60271-3-1: 1C1L
Mechanically active substances	Not recom-mended		IEC TR 60271-3-1: 1S1
Vibration sinusoidal: Displacement Acceleration Frequency range	 1.5 5 2-9 9-200	 mm m/s^2 Hz	IEC TR 60271-3-1: 1M2
Shocks: Shock spectrum Duration Acceleration	 semi-sinusoidal 1 50	 ms m/s^2	IEC 60068-2-27 Ea

5.4 Reliability Characteristics

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

Table 28: Summary of reliability test conditions

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

5.5 Pin Assignment and Signal Description

The Molex board-to-board connector on TC65i is an 80-pin double-row receptacle. Pin names and numbers are listed in Table 29. The pin positions can be gathered from Figure 46.

Table 29: Pin assignment

1	GND	GND	80
2	ADC1_IN	DAC_OUT	79
3	ADC2_IN	PWR_IND	78
4	GND	Do not use	77
5	GPIO10	GPIO9	76
6	GPIO8	SPICS	75
7	SPIDI	GPIO4	74
8	GPIO7	GPIO3	73
9	GPIO6	GPIO2	72
10	GPIO5	GPIO1	71
11	I2CCLK_SPICLK	I2CDAT_SPIDO	70
12	VUSB_IN	USB_DP	69
13	DAI5	USB_DN	68
14	ISENSE	VSENSE	67
15	DAI6	VMIC	66
16	CCCLK	EPN2	65
17	CCVCC	EPP2	64
18	CCIO	EPP1	63
19	CCRST	EPN1	62
20	CCIN	MICN2	61
21	CCGND	MICP2	60
22	DAI4	MICP1	59
23	DAI3	MICN1	58
24	DAI2	AGND	57
25	DAI1	IGT	56
26	DAI0	EMERG_OFF	55
27	BATT_TEMP	DCD0	54
28	SYNC	CTS1	53
29	RXD1	CTS0	52
30	RXD0	RTS1	51
31	TXD1	DTR0	50
32	TXD0	RTS0	49
33	VDDLP	DSR0	48
34	VCHARGE	RING0	47
35	CHARGEGATE	VEXT	46
36	GND	BATT+	45
37	GND	BATT+	44
38	GND	BATT+	43
39	GND	BATT+	42
40	GND	BATT+	41

Please note that the reference voltages listed in Table 30 are the values measured directly on the TC65i module. They do not apply to the accessories connected

.

Table 30: Signal description

Function	Signal name	IO	Signal form and level	Comment
Power supply	BATT+	I	$V_I$max = 4.5V $V_I$typ = 3.8V $V_I$min = 3.2V during Tx burst on board I ≈ 1.6A, during Tx burst  n Tx = n x 577µs peak current every 4.616ms	Five lines of BATT+ and GND must be connected in parallel for supply purposes because higher peak currents may occur. Minimum voltage must not fall below 3.2V including drop, ripple, spikes.
Power supply	GND		Ground	Application Ground
Charge Interface	VCHARGE	I	$V_I$min = 3.1V $V_I$max = 7.00V	This line signalizes to the processor that the charger is connected. If unused keep line open.
	BATT_TEMP	I	Connect NTC with R_{NTC} ≈ 10kΩ @ 25°C to ground. See Section 3.5.3 for B value of NTC.	Battery temperature measurement via NTC resistance. NTC should be installed inside or near battery pack to enable proper charging and deliver temperature values. If unused keep line open.
	ISENSE	I	$V_I$max = 4.65V ΔV_Imax to V_{BATT+} = +0.3V at normal condition	ISENSE is required for measuring the charge current. For this purpose, a shunt resistor for current measurement needs to be connected between ISENSE and VSENSE. If unused connect line to VSENSE.
	VSENSE	I	$V_I$max = 4.5V	VSENSE must be directly connected to BATT+ at battery connector or external power supply.
	CHARGE-GATE	O	$V_O$max = 7.0V $I_O$typ = 5.2mA (for fast charging @ CHARGEGATE = 1V)	Control line to the gate of charge FET or bipolar transistor. If unused keep line open.

Table 30: Signal description

Function	Signal name	IO	Signal form and level	Comment
External supply voltage	VEXT	O	Normal mode: $V_O$min = 2.75V $V_O$typ = 2.93V $V_O$max = 3.00V $I_O$max = -50mA	VEXT may be used for application circuits, for example to supply power for an I^2C If unused keep line open. Not available in Power-down mode. The external digital logic must not cause any spikes or glitches on voltage VEXT.
Power indicator	PWR_IND	O	V_{IH}max = 10V V_{OL}max = 0.4V at Imax = 2mA	PWR_IND (Power Indicator) notifies the module's on/off state. PWR_IND is an open collector that needs to be connected to an external pull-up resistor. Low state of the open collector indicates that the module is on. Vice versa, high level notifies the Power-down mode. Therefore, the line may be used to enable external voltage regulators which supply an external logic for communication with the module, e.g. level converters.
Ignition	IGT	I	Internal pull-up: $R_I \approx 30k\Omega$, $C_I \approx$ 10nF V_{IL}max = 0.8V at Imax = -150µA V_{OH}max = 4.5V (V_{BATT+}) IGT as ON switch: ˜˜˜|____|˜˜˜ Active Low ≥ 400ms IGT as ON/OFF switch: ON/OFF ~~~|_____|~~~~~|_____|~~~ ≥ 0.4s | ≥ 2s | ≥ 1s |	The IGT signal switches on the module. Depending on settings made with AT^SCFG, parameter "MeShutdown/OnIgnition", it may also be used as ON/OFF switch. This line must be driven low by an open drain or open collector driver.

Table 30: Signal description

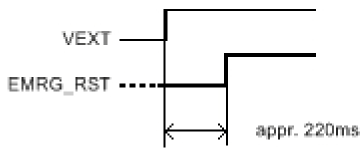
Function	Signal name	IO	Signal form and level	Comment
Emer- gency reset	EMERG_OFF	I	Internal pull-up: $R_I \approx 10k\Omega$ $V_{IL}max = 0.3V$ at $Imax = -140\mu A$ $V_{OH}min = 1.70V$ $V_{OH}max = 1.90V$ Signal ¯¯|___|¯¯ Active Low ≥10ms	Turn-off in case of emergency: Pull down and release EMERG_OFF. Falling edge turns off the module. Data stored in the volatile memory will be lost. For orderly software controlled reset rather use the AT+CFUN command (e.g. AT+CFUN=x,1). This line must be driven by open drain or open collector. If unused keep line open.
Power-on reset		O	Internal pull-up: $R_I \approx 5k\Omega$ $V_{OL}max = 0.2V$ at $I = 2mA$ $V_{OH}min = 1.75V$ $V_{OH}max = 3.00V$ Reset signal driven by the module:  (see also Figure 5 and Figure 6)	Reset signal driven by the module which can be used to reset any application or device connected to the module. Only effective for approximately 220ms during the assertion of IGT when the module is about to start (see also Section 3.3.1.6).
Syn- chroni- zation	SYNC	O	$V_{OL}max = 0.3V$ at $I = 0.1mA$ $V_{OH}min = 2.3V$ at $I = -0.1mA$ $V_{OH}max = 3.00V$  n Tx = n x 577µs impulse each 4.616ms, with 180µs forward time.	There are two alternative options for using the SYNC line: a) Indicating increased current consumption during uplink transmission burst. Note that the timing of the signal is different during handover. b) Driving a status LED to indicate different operating modes of TC65i. The LED must be installed in the host application. To select a) or b) use the AT^SSYNC command. If unused keep line open.
RTC backup	VDDLP	I/O	$R_I \approx 1k\Omega$ $V_O max = 4.5V$ $V_{BATT+} = 4.5V$: $V_O = 3.2V$ at $I_O = -500\mu A$ $V_{BATT+} = 0V$: $V_I = 2.7V...4.5V$ at $Imax = 10\mu A$	If unused keep line open.

Table 30: Signal description

Function	Signal name	IO	Signal form and level	Comment
ASC0 Serial interface	RXD0	O	V_{OL}max = 0.2V at I = 2mA V_{OH}min = 2.55V at I = -0.5mA V_{OH}max = 3.00V V_{IL}max = 0.8V V_{IH}min = 2.15V V_{IH}max = VEXTmin + 0.3V = 3.05V Internal pull-down at TXD0: R_I =330kΩ Internal pull-down at RTS0: R_I =330kΩ	Serial interface for AT commands or data stream. If lines are unused keep lines open.
	TXD0	I		
	CTS0	O		
	RTS0	I		
	DTR0	I		
	DCD0	O		
	DSR0	O		
	RING0	O		
ASC1 Serial interface	RXD1	O	V_{OL}max = 0.2V at I = 2mA V_{OH}min = 2.55V at I = -0.5mA V_{OH}max = 3.00V V_{IL}max = 0.8V V_{IH}min = 2.15V V_{IH}max = VEXTmin + 0.3V = 3.05V Internal pull-down at TXD1: R_I =330kΩ Internal pull-down at RTS1: R_I =330kΩ	4-wire serial interface for AT commands or data stream. If lines are unused keep lines open.
	TXD1	I		
	CTS1	O		
	RTS1	I		
SIM interface specified for use with 3V SIM card	CCIN	I	R_I ≈ 100kΩ V_{IL}max = 0.6V at I = -25µA V_{IH}min = 2.1V at I = -10µA $V_O$max = 3.05V	CCIN = Low, SIM card holder closed If CCIN is unused, connect to CCGND. Maximum cable length or copper track 100mm to SIM card holder. All signals of SIM interface are protected against ESD with a special diode array. Usage of CCGND is mandatory.
	CCRST	O	R_O ≈ 47Ω V_{OL}max = 0.25V at I = +1mA V_{OH}min = 2.5V at I = -0.5mA V_{OH}max = 2.95V	
	CCIO	I/O	R_I ≈ 4.7kΩ V_{IL}max = 0.75V V_{IL}min = -0.3V V_{IH}min = 2.1V V_{IH}max = CCVCCmin + 0.3V = 3.05V R_O ≈ 100Ω V_{OL}max = 0.3V at I = +1mA V_{OH}min = 2.5V at I = -0.5mA V_{OH}max = 2.95V	
	CCCLK	O	R_O ≈ 100Ω V_{OL}max = 0.3V at I = +1mA V_{OH}min = 2.5V at I = -0.5mA V_{OH}max = 2.95V	
	CCVCC	O	$V_O$min = 2.75V $V_O$typ = 2.85V $V_O$max = 2.95V $I_O$max = -20mA	
	CCGND		Ground	

Table 30: Signal description

Function	Signal name	IO	Signal form and level	Comment
SIM interface specified for use with 1.8V SIM card	CCIN	I	$R_I \approx 100k\Omega$ V_{IL}max = 0.6V at I = -25µA V_{IH}min = 2.1V at I = -10µA $V_O$max = 3.05V	CCIN = Low, SIM card holder closed If CCIN is unused, connect to CCGND. Maximum cable length or copper track 100mm to SIM card holder. All signals of SIM interface are protected against ESD with a special diode array. Usage of CCGND is mandatory.
	CCRST	O	$R_O \approx 47\Omega$ V_{OL}max = 0.25V at I = +1mA V_{OH}min = 1.45V at I = -0.5mA V_{OH}max = 1.90V	
	CCIO	I/O	$R_I \approx 4.7k\Omega$ V_{IL}max = 0.45V V_{IH}min = 1.35V V_{IH}max = CCVCCmin + 0.3V = 2.00V $R_O \approx 100\Omega$ V_{OL}max = 0.3V at I = +1mA V_{OH}min = 1.45V at I = -0.5mA V_{OH}max = 1.90V	
	CCCLK	O	$R_O \approx 100\Omega$ V_{OL}max = 0.3V at I = +1mA V_{OH}min = 1.45V at I = -0.5mA V_{OH}max = 1.90V	
	CCVCC	O	$V_O$min = 1.70V, $V_O$typ = 1.80V $V_O$max = 1.90V $I_O$max = -20mA	
	CCGND		Ground	
I^2C interface	I2CCLK_SPICLK	O	V_{OL}max = 0.2V at I = 2mA V_{OH}min = 2.55V at I = -0.5mA V_{OH}max = 3.00V	I^2C interface is only available if the two lines are not used as SPI interface. I2CDAT is configured as Open Drain and needs a pull-up resistor in the host application. According to the I^2C Bus Specification Version 2.1 for the fast mode a rise time of max. 300ns is permitted. There is also a maximum VOL=0.4V at 3mA specified. The value of the pull-up depends on the capacitive load of the whole system (I^2C Slave + lines). The maximum sink current of I2CDAT and I2CCLK is 4mA. If lines are unused keep lines open.
	I2CDAT_SPIDO	I/O	V_{OL}max = 0.2V at I = 2mA V_{IL}max = 0.8V V_{IH}min = 2.15V V_{IH}max = VEXTmin + 0.3V = 3.05V	

Table 30: Signal description

Function	Signal name	IO	Signal form and level	Comment
SPI Serial Peripheral Interface	SPIDI	I	V_{OL}max = 0.2V at I = 2mA V_{OH}min = 2.55V at I = -0.5mA V_{OH}max = 3.00V V_{IL}max = 0.8V V_{IH}min = 2.15V, V_{IH}max = VEXTmin + 0.3V = 3.05V	If the Serial Peripheral Interface is active the I^2C interface is not available. If lines are unused keep lines open.
	I2CDAT_SPIDO	O		
	I2CCLK_SPICLK	O		
	SPICS	O		
USB	VUSB_IN	I	V_{IN}min = 4.0V V_{IN}max = 5.25V	All electrical characteristics according to USB Implementers' Forum, USB 2.0 Full Speed Specification. Without Java: USB port Under Java: Debug interface for development purposes. If lines are unused keep lines open.
	USB_DN	I/O	Differential Output Crossover voltage Range V_{CRS}min = 1.5V, V_{CRS}max = 2.0V Line to GND: V_{OH}max = 3.6V V_{OH}typ = 3.3V V_{OH}min = 3.0V at I=-0.5mA V_{OL}max = 0.2V at I=2mA V_{IH}min = 2.24V V_{IL}max = 0.96V Driver Output Resistance Z_{typ} = 32Ohm Pullup at USB_DP R_{typ}=1.5kOhm	
	USB_DP	I/O		
Analog Digital Converter	ADC1_IN	I	Input voltage: VImin = 0V, VImax = 2.4V Ri ≈ 750kOhms Measurement interval: 100ms - 30s selectable by AT command Resolution: 2400 steps (1step = 1mv) Accuracy total: ±2mV Cut-off frequency: 30 Hz Underflow: ≥ -25mV Overflow: ≥ +2425 mV Accuracy: ± 0.5mV Linear error: ± 0.5mV Temperature error: ± 0.5mV Burst error: ± 0.5mV	Inputs used for measuring external voltages. ADC1_IN and ADC2_IN are internally multiplexed through analog switch.
	ADC2_IN	I		
Digital Analog Converter	DAC_OUT	O	V_{OL}max = 0.2V at I = 2mA V_{OH}min = 2.55V at I = -0.5mA V_{OH}max = 3.00V	PWM signal which can be smoothed by an external filter. Use the AT^SWDAC command to open and configure the DAC_OUT output.

Table 30: Signal description

Function	Signal name	IO	Signal form and level	Comment
General Purpose Input/ Output	GPIO1	I/O	$V_{OL}max$ = 0.2V at I = 2mA $V_{OH}min$ = 2.55V at I = -0.5mA $V_{OH}max$ = 3.00V $V_{IL}max$ = 0.8V $V_{IH}min$ = 2.15V, $V_{IH}max$ = VEXTmin + 0.3V = 3.05V Pulse counter: pulse ~|_________|~~~~~~~~~~~~~|________| ~ | ≥ 450µs | ≥ 450µs | Slew rate ≤ 1µs Pulse rate: max. 1000 pulses per second	Recommendation: Connect pull-up or pull-down resistors to all GPIO lines intended for use as output. See also Section 3.17. If lines are unused (not configured) keep lines open. Alternatively, the GPIO10 line can be configured as a pulse counter for pulse rates from 0 to 1000 pulses per second.
	GPIO2	I/O		
	GPIO3	I/O		
	GPIO4	I/O		
	GPIO5	I/O		
	GPIO6	I/O		
	GPIO7	I/O		
	GPIO8	I/O		
	GPIO9	I/O		
	GPIO10	I/O		
Digital Audio interface	DAI0	O	$V_{OL}max$ = 0.2V at I = 2mA $V_{OH}min$ = 2.55V at I = -0.5mA $V_{OH}max$ = 3.00V $V_{IL}max$ = 0.8V $V_{IH}min$ = 2.15V $V_{IH}max$ = VEXTmin + 0.3V = 3.05V	See Table 17 for details. Unused input lines should be tied to GND via pull down resistors. Unused output lines must be left open.
	DAI1	I		
	DAI2	O		
	DAI3	O		
	DAI4	I		
	DAI5	I		
	DAI6	I		

Table 30: Signal description

Function	Signal name	IO	Signal form and level	Comment
Analog Audio interface	VMIC	O	$V_O$min = 2.4V $V_O$typ = 2.5V $V_O$max = 2.6V I_{max} = 2mA	Microphone supply for customer feeding circuits
	EPP2	O	3.0Vpp differential typical @ 0dBm0 4.2Vpp differential maximal @ 3.14dBm0 Measurement conditions: Audio mode: 6 Outstep 3 No load Minimum differential resp. single ended load 27Ohms	The audio output can directly operate a 32-Ohm-loud-speaker. If unused keep lines open.
	EPN2	O		
	EPP1	O	4.2Vpp (differential) typical @ 0dBm0 6.0Vpp differential maximal @ 3.14dBm0 Measurement conditions: Audio mode: 5 Outstep 4 No load Minimum differential load 7.5Ohms	The audio output can directly operate an 8-Ohm-loud-speaker. If unused keep lines open.
	EPN1	O		
	MICP1	I	Full Scale Input Voltage: 1.6Vpp 0dBm0 Input Voltage: 1.1Vpp At MICN1, apply external bias from 1.0V to 1.6V. Measurement conditions: Audio mode: 5	Balanced or single ended microphone or line input with external feeding circuit (using VMIC and AGND). If unused keep lines open.
	MICN1	I		
	MICP2	I	Full Scale Input Voltage: 1.6Vpp 0dBm0 Input Voltage: 1.1Vpp At MICN2, apply external bias from 1.0V to 1.6V. Measurement conditions: Audio mode: 6	Balanced or single ended microphone or line input with external feeding circuit (using VMIC and AGND). If unused keep lines open.
	MICN2	I		
	AGND		Analog Ground	GND level for external audio circuits

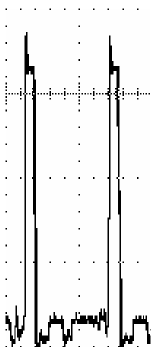
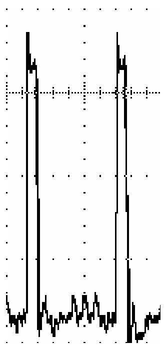
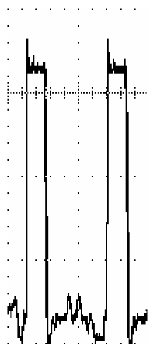
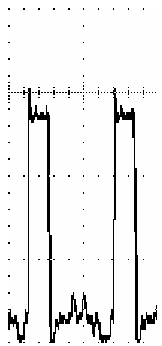
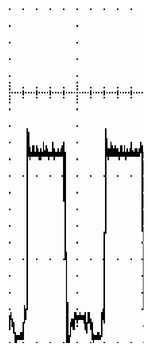
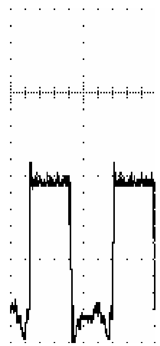
5.6 Power Supply Ratings

Table 31: Power supply ratings

Parameter	Description	Conditions	Min	Typ	Max	Unit
BATT+	Supply voltage	Directly measured at reference point TP BATT+ and TP GND, see Section 3.2.2. Voltage must stay within the min/max values, including voltage drop, ripple, spikes.	3.2	3.8	4.5	V
	Voltage drop during transmit burst	Normal condition, power control level for $P_{out\ max}$			400	mV
	Voltage ripple	Normal condition, power control level for $P_{out\ max}$ @ f<200kHz @ f>200kHz			 50 2	 mV mV
I_{VDDLP}	OFF State supply current	RTC backup @ BATT+ = 0V		6		µA
I_{BATT+}		POWER DOWN mode		50	100	µA
	Average standby supply current[1]	SLEEP mode @ DRX = 9		1.5		mA
		SLEEP mode @ DRX = 5		2.0		mA
		SLEEP mode @ DRX = 2		3.5		mA
		IDLE mode		18		mA
I_{VUSB_IN}	USB transceiver supply current (average)	USB suspend		1		mA
		USB active		5		mA

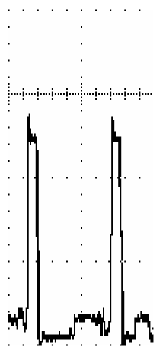
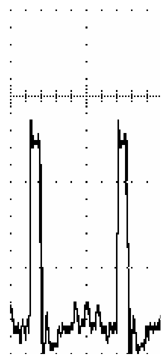
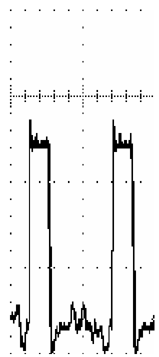
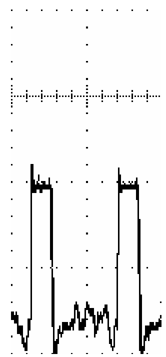
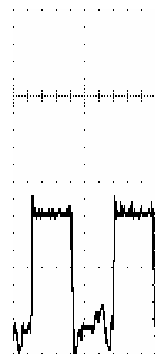
1. Additional conditions:
- SLEEP and IDLE mode measurements started 5 minutes after switching ON the module
- Averaging times: SLEEP mode - 3 minutes; IDLE mode - 1.5 minutes
- Communication tester settings: no neighbor cells, no cell reselection
- USB interface disabled

Table 32: Current consumption during Tx burst for GSM 850MHz and GSM 900MHz

Mode	**GSM call**	**GPRS Class 8**	**GPRS Class10**		**GPRS Class 12**	
Timeslot configuration	1Tx / 1Rx	1Tx / 4Rx	2Tx / 3Rx		4Tx / 1Rx	
RF power nominal	2W (33dBm)	2W (33dBm)	2W (33dBm)	1W (30dBm)	1W (30dBm)	0.5W (27dBm)
Radio output power reduction with AT^SCFG, parameter *<ropr>*	*<ropr>* = 1 ... 3	*<ropr>* = 1 ... 3	*<ropr>* = 1	*<ropr>* = 2 or 3	*<ropr>* = 1	*<ropr>* = 2 or 3
Current characteristics						
Burst current @ 50Ω antenna (typ.)	1600mA	1600mA	1600mA	1300mA	1100mA	880mA
Burst current @ total mismatch	1600mA	1600mA	1600mA	1300mA	1100mA	880mA
Average current @ 50Ω antenna (typ.)	270mA	260mA	480mA	400mA	570mA	480mA
Average current @ total mismatch	270mA	260mA	480mA	400mA	570mA	480mA

AT parameters are given in brackets <...> and marked *italic*. Test conditions: V_{BATT} = 4.5V, $T_{ambient}$ = 25°.

Table 33: Current consumption during Tx burst for GSM 1800MHz and GSM 1900MHz

Mode	**GSM call**	**GPRS Class 8**	**GPRS Class10**		**GPRS Class 12**	
Timeslot configuration	1Tx / 1Rx	1Tx / 4Rx	2Tx / 3Rx		4Tx / 1Rx	
RF power nominal	1W (30dBm)	1W (30dBm)	1W (30dBm)	0.5W (27dBm)	0.5W (27dBm)	0.25W (24dBm)
Radio output power reduction with AT^SCFG, parameter *<ropr>*	*<ropr>* = 1 ... 3	<ropr> = 1 ... 3	<ropr> = 1	<ropr> = 2 or 3	*<ropr>* = 1	*<ropr>* = 2 or 3
Current characteristics						
Burst current @ 50Ω antenna (typ.)	1000mA	1000mA	1000mA	850mA	700mA	620mA
Burst current @ total mismatch	1000mA	1000mA	1000mA	850mA	700mA	620mA
Average current @ 50Ω antenna (typ.)	200mA	200mA	320mA	280mA	400mA	370mA
Average current @ total mismatch	200mA	200mA	320mA	280mA	400mA	370mA

AT parameters are given in brackets <..> and marked *italic*. Test conditions: V_{BATT} = 4.5V, $T_{ambient}$ = 25°.

5.7 Electrical Characteristics of the Voiceband Part

5.7.1 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 34: Audio parameters adjustable by AT commands

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
outCali- brate[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 * outCali- brate[n]/ 32768)
sideTone	Digital attenuation of sidetone Is corrected internally by outBbc- Gain 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.

5.7.2 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.

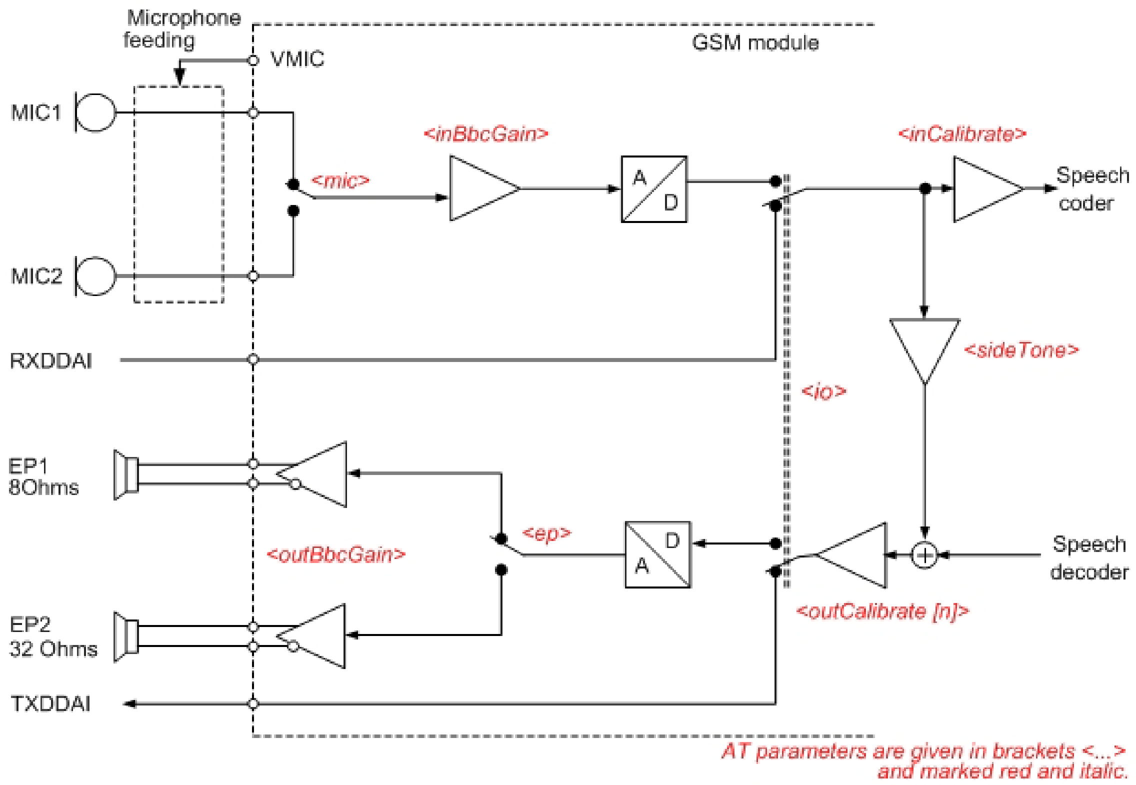


Figure 45: Audio programming model

5.7.3 Characteristics of Audio Modes

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

Table 35: 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	DTMF
Purpose	DSB with Votronic handset	Car Kit	Headset	DSB with individual handset	Direct access to speech coder	Tip and Ring interface for DTMF end-to-end transmission
Gain setting via AT command. Defaults: inBbcGain outBbcGain	Fix 5 2	Adjustable 2 2	Adjustable 5 1	Adjustable 5 2	Adjustable 0 1	Adjustable 1 1
Default audio interface	1	2	2	1	1	2
Power supply VMIC	ON	ON	ON	ON	ON	ON
Sidetone	Fix	---	Adjustable	Adjustable	Adjustable	Adjustable
Volume control	Fix	Adjustable	Adjustable	Adjustable	Adjustable	Adjustable
Echo canceller	ON	ON	ON	ON	OFF	ON
Noise reduction	6dB	12dB	12dB	6dB	OFF	OFF
MIC input signal for 0dBm0 [1] -10dBm0 f=1024 Hz	 16mV 5mV	 ---[2] 90mV	 18mV 16mV	 16mV 5mV	 400mV 126mV	 200mV 63mV
EP output signal in mV rms. @ 0dBm0, 1024 Hz, no load (default gain) / @ 3.14 dBm0	660mV	240mV default @ max volume	740mV default @ max volume	660mV default @ max volume	1.47V Vpp = 6.2V	735mV Vpp=3.1[3]V
Sidetone gain at default settings	21dB	-∞ dB	10.0dB	21dB	-∞ dB	-∞ dB

1. All values measured before the noise reduction attenuates the sine wave after a few seconds.
2. 0dBm0 cannot be achieved at 1024Hz due to attenuation of the frequency correction filter for the sending direction at this frequency.
3. Output voltage is limited to 4.2V.

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

5.7.4 Voiceband Receive Path

Test conditions:

- The values specified below were tested to 1kHz using audio mode 5.
- EPP1 to EPN1 with default settings
- EPP2 to EPN2 with AT^SAIC=2,2,2,0,0,0 at^snfi=1,32767 and at^snfo=0,4096,5792,8192, 11584,16384,4,0

Table 36: Voiceband receive path

Parameter	Min	Typ	Max	Unit	Test condition / remark
Maximum differential output voltage (peak to peak) EPP1 to EPN1		6.0 6.2		V V	8Ω , no load, Audio Mode 5, Volume 4 @ 3.14 dBm0 (Full Scale) Batt+ = 3.6V
Maximum differential output voltage (peak to peak) EPP2 to EPN2		4.0 4.2		V V	32Ω, no load Audio Mode 6, Volume 3[1] @ 3.14 dBm0 (Full Scale)
Nominal differential output voltage (peak to peak) EPP1 to EPN1		4.2 4.3		V V	8Ω, no load, Audio Mode 5, Volume 4 @ 0 dBm0 (Nominal level)
Nominal differential output voltage (peak to peak) EPP2 to EPN2		2.8 2.9		V V	32Ω, no load Audio Mode 6, Volume 3[1] @ 0 dBm0 (Nominal level)
Output bias voltage		Batt+/2		V	from EPP1 or EPN1 to AGND
Output bias voltage		1.2		V	from EPP2 or EPN2 to AGND
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
Differential output load resistance	7.5	8		Ω	From EPP1 to EPN1
Differential output load resistance	27	32		Ω	From EPP2 to EPN2
Single ended output load resistance	27	32		Ω	From EPP2 or EPN2 to AGND
Absolute gain error	-0.1		0.1	dB	outBbcGain=2
Idle channel noise[2]		-83	-75	dBm0p	outBbcGain=2
Signal to noise and distortion[3]	47			dB	outBbcGain=2

Table 36: Voiceband receive path

Parameter	Min	Typ	Max	Unit	Test condition / remark
Frequency Response[4] 0Hz - 100Hz 200Hz 300Hz - 3350Hz 3400Hz 4000Hz ≥4400Hz	 -0.2	 -1.1 -0.7 -39	 -34 0.1 -75	 dB	

1. Full scale of EPP2/EPN2 is lower than full scale of EPP1/EPN1 but the default gain is the same. 3.14dBm0 will lead to clipping if the default gain is used.
2. The idle channel noise was measured with digital zero signal fed to decoder. This can be realized by setting outCalibrate and sideTone to 0 during a call.
3. The test signal is a 1 kHz, 0 dbm0 sine wave.
4. This is the frequency response from a highpass and lowpass filter combination in the DAC of the baseband chip set. If the PCM interface is used, this filter is not involved in the audio path. Audio mode 1 to 4 incorporate additional frequency response correction filters in the digital signal processing unit and are adjusted to their dedicated audio devices (see Table 35)

gs = gain setting

5.7.5 Voiceband Transmit Path

Test conditions:
- The values specified below were tested to 1kHz using audio mode 5.
- MICP1 to MICN1 with default settings.
- MICP2 to MICN2 with at^saic=2,2,2,0,0,0 at^snfi=1,32767 and at^snfo=0,4096,5792,8192, 11584,16384,4,0

Table 37: Voiceband transmit path

Parameter	Min	Typ	Max	Unit	Test condition / Remark
Full scale input voltage (peak to peak) for 3.14dBm0 MICP1 to MICN1 or AGND, MICP2 to MICN2 or AGND		1.6		V	MICPx must be biased with 1.25V (VMIC/2)
Nominal input voltage (peak to peak) for 0dBm0 MICP1 to MICN1 or AGND, MICP2 to MICN2 or AGND		1.1		V	MICPx must be biased with 1.25V (VMIC/2)
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
Microphone supply voltage VMIC	2.4	2.5	2.6	V	
VMIC current			2	mA	
Idle channel noise		-82	-76	dBm0p	
Signal to noise and distortion	70	77		dB	
Frequency response[1]					
0Hz - 100Hz			-34	dB	
200Hz		-1.1			
300Hz - 3350Hz	-0.2		0.1		
3400Hz		-0.7			
4000Hz		-39			
≥4400Hz			-75		

1. This is the frequency response from a highpass and lowpass filter combination in the DAC of the baseband chip set. If the PCM interface is used, this filter is not involved in the audio path. Audio mode 1 to 4 incorporate additional frequency response correction filters in the digital signal processing unit and are adjusted to their dedicated audio devices (see Table 35).

5.8 Air Interface

Test conditions: All measurements have been performed at T_{amb}= 25×C, $V_{BATT+ nom}$ = 4.0V. The reference points used on TC65i are the BATT+ and GND contacts (test points are shown in Figure 4).

Table 38: Air interface

Parameter		Min	Typ	Max	Unit
Frequency range Uplink (MS → BTS)	GSM 850	824		849	MHz
	EGSM 900	880		915	MHz
	GSM 1800	1710		1785	MHz
	GSM 1900	1850		1910	MHz
Frequency range Downlink (BTS → MS)	GSM 850	869		894	MHz
	EGSM 900	925		960	MHz
	GSM 1800	1805		1880	MHz
	GSM 1900	1930		1990	MHz
RF power @ ARP with 50Ω load	GSM 850	31	33	35	dBm
	EGSM 900[1]	31	33	35	dBm
	GSM 1800[2]	28	30	32	dBm
	GSM 1900	28	30	32	dBm
Number of carriers	GSM 850		124		
	EGSM 900		174		
	GSM 1800		374		
	GSM 1900		299		
Duplex spacing	GSM 850		45		MHz
	EGSM 900		45		MHz
	GSM 1800		95		MHz
	GSM 1900		80		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 BER Class II < 2.4% (static input level)	GSM 850	-102	-108		dBm
	EGSM 900	-102	-108		dBm
	GSM 1800	-102	-107		dBm
	GSM 1900	-102	-107		dBm

1. Power control level PCL 5
2. Power control level PCL 0

5.9 Electrostatic Discharge

The GSM module is not protected against Electrostatic Discharge (ESD) in general. Consequently, it is subject to ESD handling precautions that typically apply to ESD sensitive components. Proper ESD handling and packaging procedures must be applied throughout the processing, handling and operation of any application that incorporates a TC65i module.

Special ESD protection provided on TC65i:
SIM interface: clamp diodes for protection against overvoltage.

The remaining ports of TC65i 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.

TC65i has been tested according to the EN 61000-4-2 standard. Electrostatic values can be gathered from the following table.

Table 39: Electrostatic values

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

Note: Please note that the values may vary with the individual application design. For example, it matters whether or not the application platform is grounded over external devices like a computer or other equipment, such as the Cinterion Wireless Modules reference application described in Chapter 8.

6 Mechanics

6.1 Mechanical Dimensions of TC65i

Figure 46 shows the top view of TC65i and provides an overview of the board's mechanical dimensions. For further details see Figure 47.

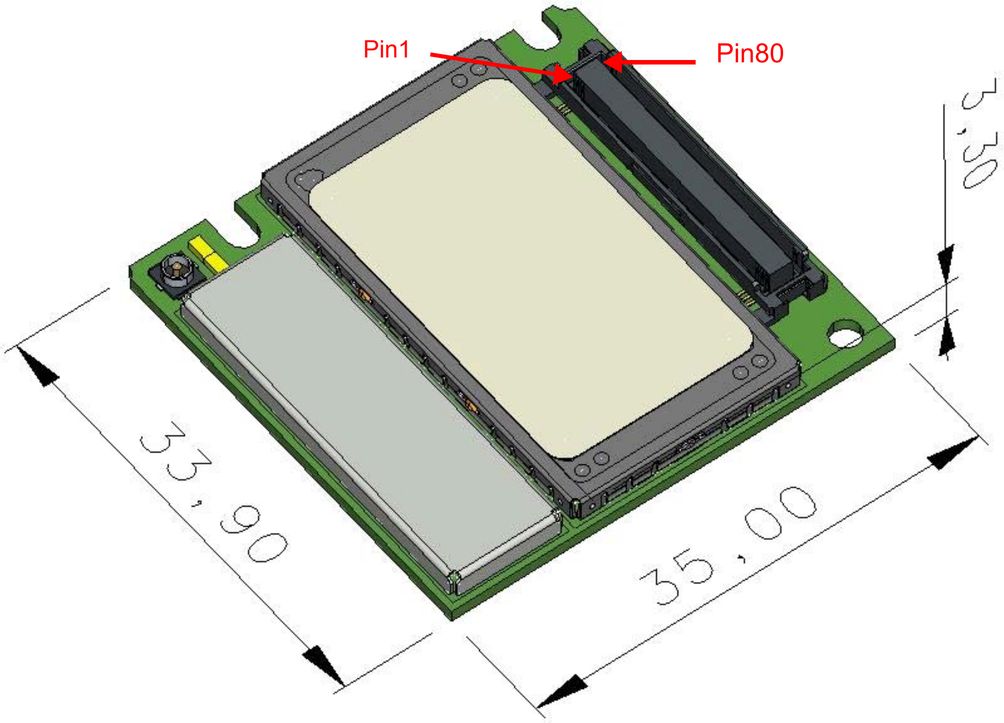


Figure 46: TC65i– top view

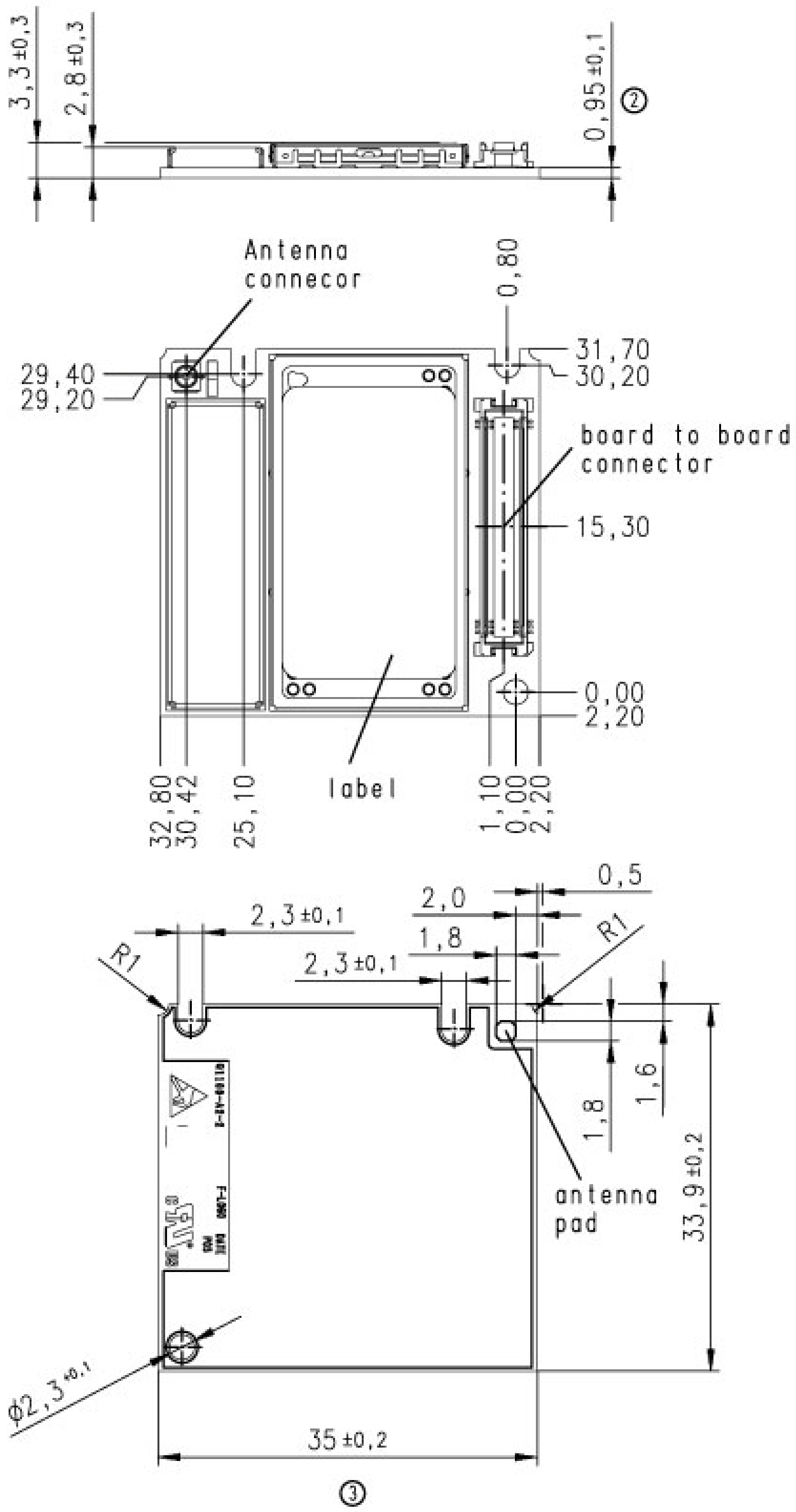


Figure 47: Dimensions of TC65i (all dimensions in mm)

6.2 Mounting TC65i to the Application Platform

There are many ways to properly install TC65i in the host device. An efficient approach is to mount the TC65i PCB to a frame, plate, rack or chassis.

Fasteners can be M2 screws plus suitable washers, circuit board spacers, or customized screws, clamps, or brackets. In addition, the board-to-board connection can also be utilized to achieve better support. To help you find appropriate spacers a list of selected screws and distance sleeves for 3mm stacking height can be found in Section 9.2.

An optional mounting clip is available to connect TC65i to the application platform. The mounting clip provides for an easy module exchange or replacement. For details see Section 9.3.

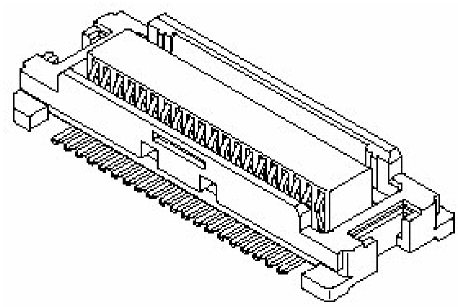
For proper grounding it is strongly recommended to use large ground plane on the bottom of board in addition to the five GND pins of the board-to-board connector. The ground plane may also be used to attach cooling elements, e.g. a heat sink or thermally conductive tape. Please take care that attached cooling elements do not touch the antenna pads on the module's bottom side, as this may lead a short-circuit.

To prevent mechanical damage, be careful not to force, bend or twist the module. Be sure it is positioned flat against the host device. See also Section 9.4 with mounting advice sheet.

6.3 Board-to-Board Application Connector

This section provides the specifications of the 80-pin board-to-board connector used to connect TC65i to the external application.

Connector mounted on the TC65i module:

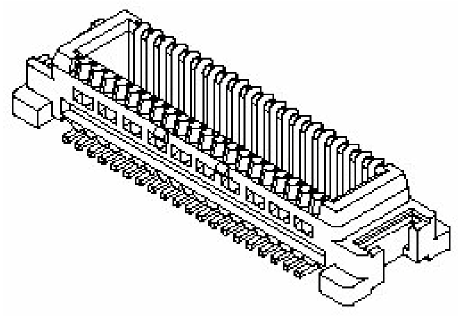


Type: 52991-0808 SlimStack Receptacle 80 pins, 0.50mm pitch, for stacking heights from 3.0 to 4.0mm, see Figure 48 for details.
Supplier:Molex, http//www.molex.com

Table 40: Technical specifications of Molex board-to-board connector

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

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



- 53748-0808 SlimStack Plug, 3mm stacking height,
  see Figure 49 for details.
- 53916-0808 SlimStack Plug, 4mm stacking height

Note: There is no inverse polarity protection for the board-to-board connector. It is therefore very important that the board-to-board connector is connected correctly to the host application, i.e., pin1 must be connected to pin1, pin2 to pin 2, etc. Pin assignments are listed in Section 5.5, pin locations are shown in Figure 46.

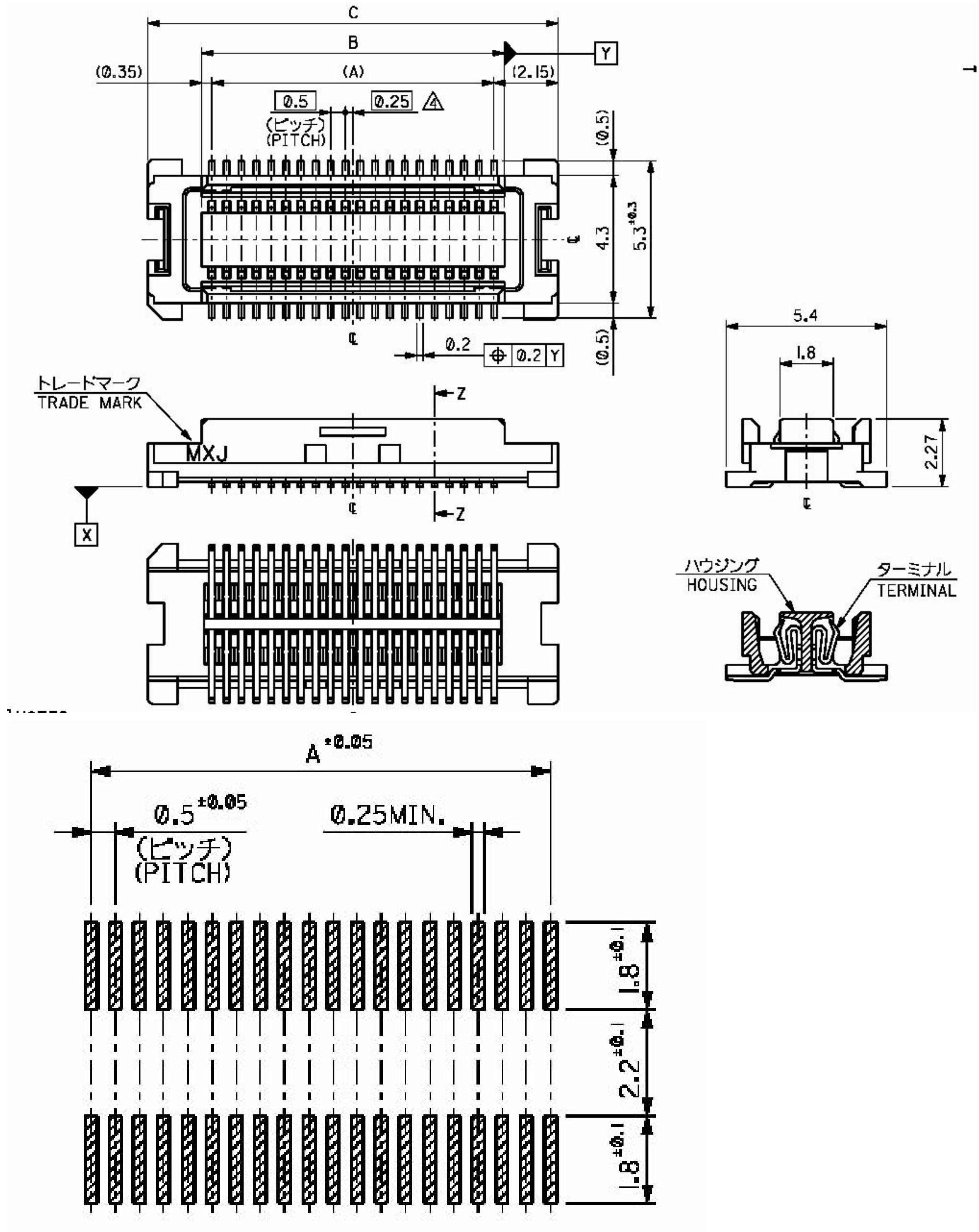


Figure 48: Molex board-to-board connector 52991-0808 on TC65i

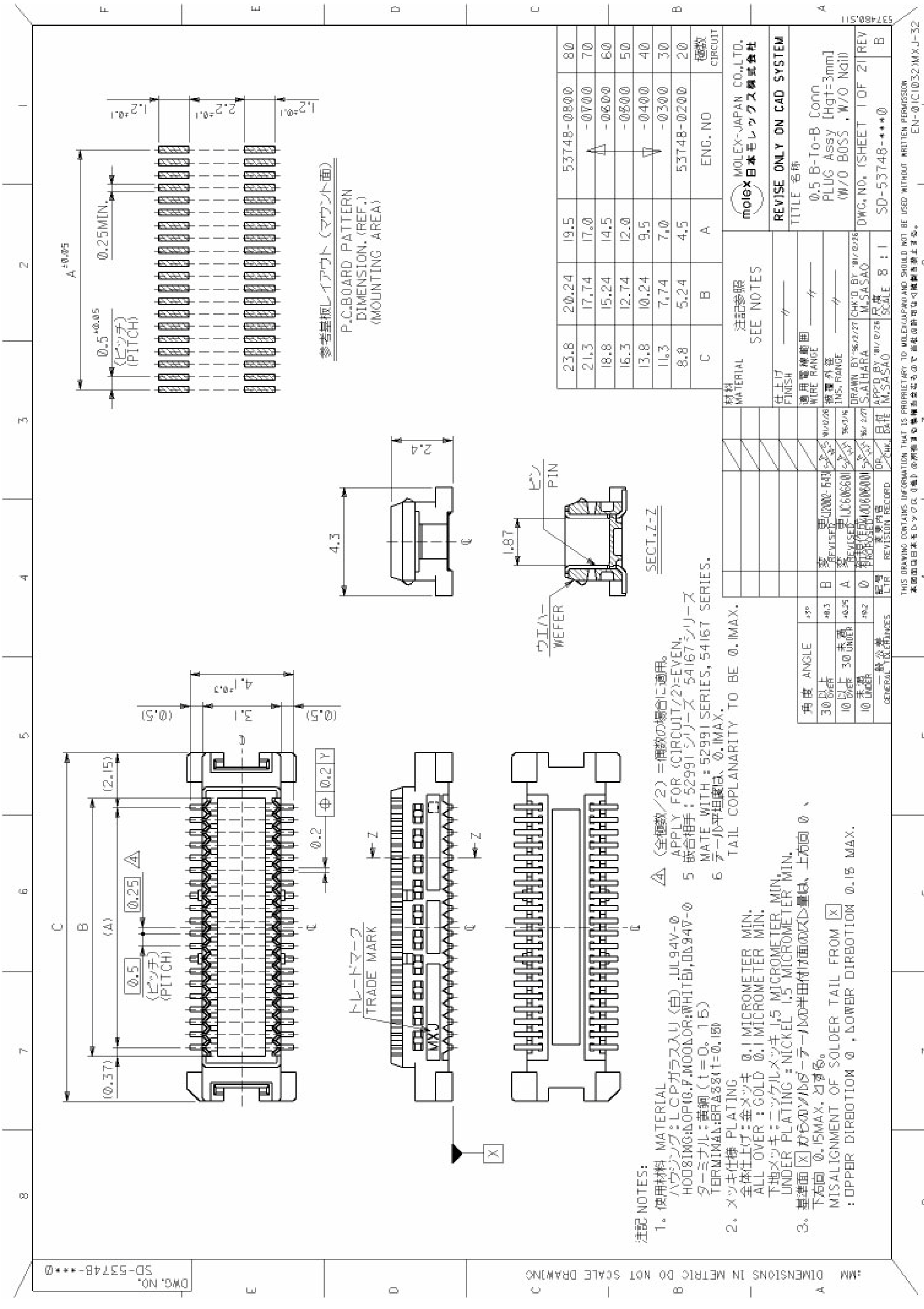


Figure 49: Mating board-to-board connector 53748-0808 on application

7 Sample Application

Figure 50 shows a typical example of how to integrate TC65i modules with a Java application. Usage of the various host interfaces depends on the desired features of the application.

Audio interface 1 demonstrates the balanced connection of microphone and earpiece. This solution is particularly well suited for internal transducers. Audio interface 2 uses an unbalanced microphone and earpiece connection typically found in headset applications.

The charging circuit is optimized for the charging stages (trickle charging and software controlled charging) as well as the battery and charger specifications described in Section 3.5.

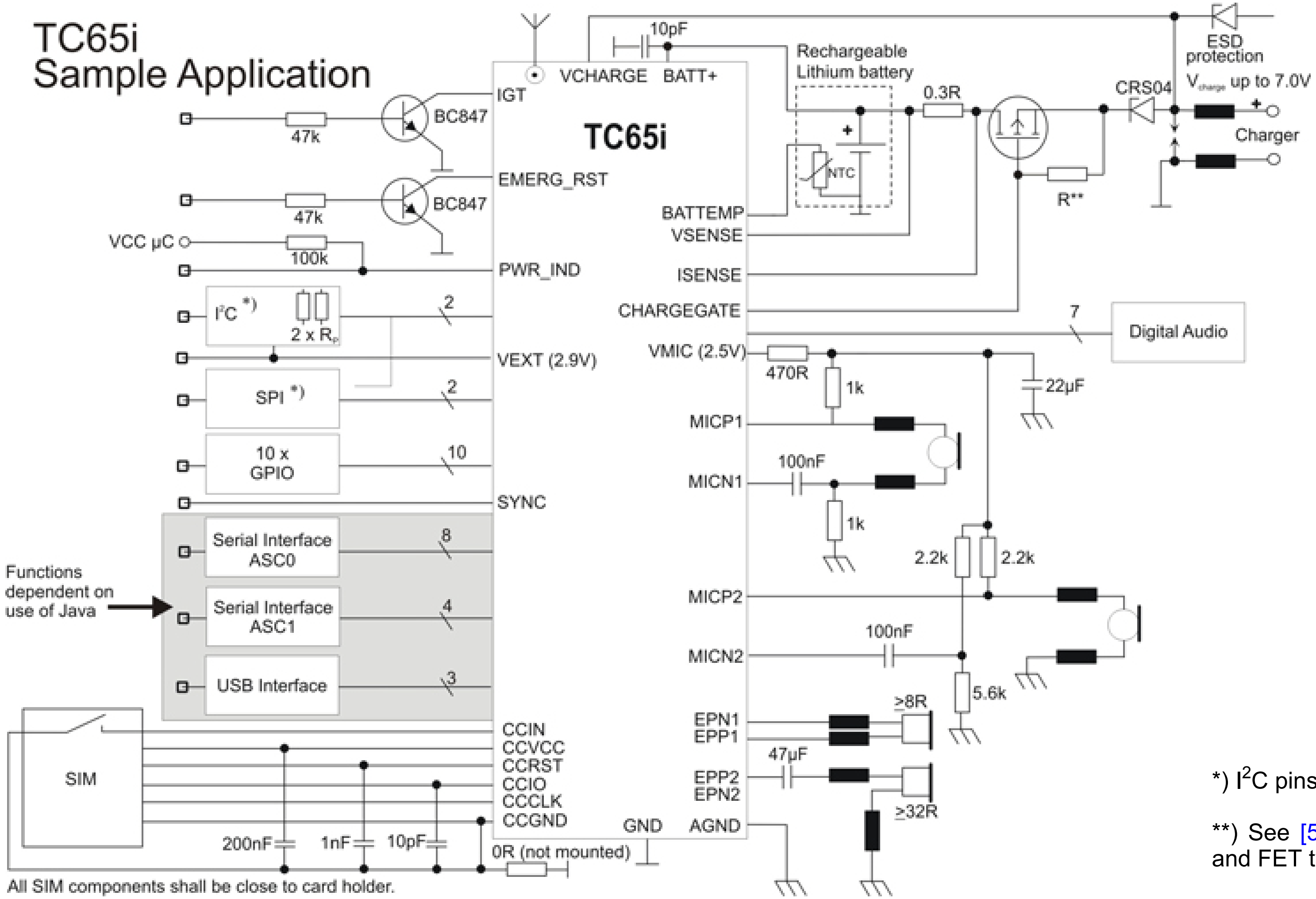
The PWR_IND line is an open collector that needs an external pull-up resistor which connects to the voltage supply VCC µC of the microcontroller. Low state of the open collector pulls the PWR_IND signal low and indicates that the TC65i module is active, high level notifies the Power-down mode. If the module is in Power-down mode avoid current flowing from any other source into the module circuit, for example reverse current from high state external control lines. Therefore, the controlling application must be designed to prevent reverse flow.

If the I2C bus is active the two lines I2CCLK and I2DAT are locked for use as SPI lines. Vice versa, the activation of the SPI locks both lines for I2C. Settings for either interface are made by using the AT^SSPI command. The internal pull-up resistors (Rp) of the I2C interface can be connected to an external power supply or to the VEXT line of TC65i. The advantage of using VEXT is that when the module enters the Power-down mode, the I2CI interface is shut down as well. If you prefer to connect the resistors to an external power supply, take care that the interface is shut down when the PWR_IND signal goes high in Power-down mode.

The interfaces ASC0, ASC1 and USB have different functions depending on whether or not Java is running. Without Java, all of them are used as AT interfaces. When a Java application is started, ASC0 and ASC1 can be used for CommConnection or/and System.out, and the USB lines can be used for debugging or System.out.

The EMC measures are best practice recommendations. In fact, an adequate EMC strategy for an individual application is very much determined by the overall layout and, especially, the position of components. For example, mounting the internal acoustic transducers directly on the PCB eliminates the need to use the ferrite beads shown in the sample schematic. However, when connecting cables to the module's interfaces it is strongly recommended to add appropriate ferrite beads for reducing RF radiation.

Disclaimer
No warranty, either stated or implied, is provided on the sample schematic diagram shown in Figure 50 and the information detailed in this chapter. As functionality and compliance with national regulations depend to a great amount on the used electronic components and the individual application layout manufacturers are required to ensure adequate design and operating safeguards for their products using TC65i modules.



*) I²C pins are shared with SPI

**) See [5] for details on size of R and FET type for charging circuit.

Figure 50: TC65i sample application

8 Reference Approval

8.1 Reference Equipment for Type Approval

The Cinterion Wireless Modules GmbH reference setup submitted to type approve TC65i consists of the following components:

- Cinterion Wireless Module TC65i
- Development Support Box DSB75
- SIM card reader integrated on DSB75
- U.FL-R-SMT antenna connector and U.FL-LP antenna cable
- Handset type Votronic HH-SI-30.3/V1.1/0
- Li-Ion battery (capacity: 1200mAh)
- PC as MMI

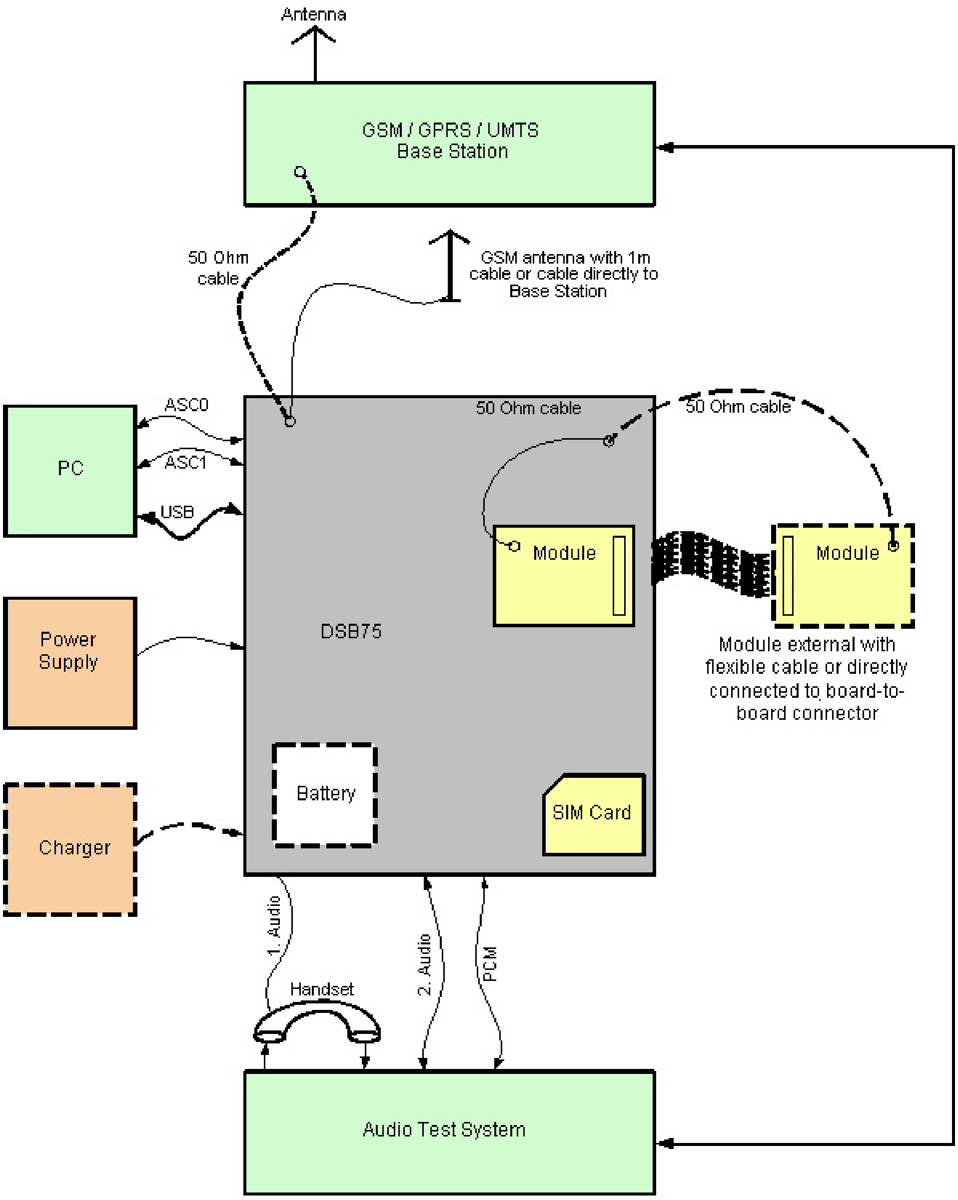


Figure 51: Reference equipment for Type Approval

8.2 Compliance with FCC and IC Rules and Regulations

The Equipment Authorization Certification for the Cinterion Wireless Modules reference application described in Section 8.1 will be registered under the following identifiers:

FCC Identifier: QIPTC65i
Industry Canada Certification Number: 7830A-TC65i
Granted to Cinterion Wireless Modules GmbH

Manufacturers of mobile or fixed devices incorporating TC65i modules are authorized to use the FCC Grants and Industry Canada Certificates of the TC65i modules for their own final products according to the conditions referenced in these documents. In this case, an FCC/ IC label of the module shall be visible from the outside, or the host device shall bear a second label stating "Contains FCC ID QIPTC65i", and accordingly “Contains IC 7830A-TC65i“.

IMPORTANT:
Manufacturers of portable applications incorporating TC65i modules are required to have their final product certified and apply for their own FCC Grant and Industry Canada Certificate related to the specific portable mobile. This is mandatory to meet the SAR requirements for portable mobiles (see Section 1.3.2 for detail).

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

The TC65i reference application registered under the above identifiers is certified to be in accordance with the following Rules and Regulations of the Federal Communications Commission (FCC) and Industry Canada Certificate (IC):

FCC Section 15.105 (b)
"This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

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

FCC Section 15.19 Labelling requirements
"This device complies with Part 15 of the FCC Rules.
Operation is subject to the following two conditions:
1. This device may not cause harmful interference, and
2. This device must accept any interference received, including interference that may cause undesired operation."

FCC RF Radiation Exposure Statement
"This equipment complies with FCC RF radiation exposure limits set forth for an uncontrolled environment. The antenna used for this transmitter must be installed to provide a separation distance of at least 20 cm from all persons and must not be co-located or operating in conjunction with any other antenna or transmitter."

IC
"This Class B digital apparatus complies with Canadian ICES-003. Cet appareil numérique de la classe B est conforme à la norme NMB-003 du Canada."

If the final product is not approved for use in U.S. territories the application manufacturer shall take care that the 850 MHz and 1900 MHz frequency bands be deactivated and that band settings be inaccessible to end users. If these demands are not met (e.g. if the AT interface is accessible to end users), it is the responsibility of the application manufacturer to always ensure that the application be FCC approved regardless of the country it is marketed in.
The frequency bands can be set using the command:

AT^SCFG="Radio/Band"[,<rbp>][, <rba>]

A detailed command description can be found in [1].

9 Appendix

9.1 List of Parts and Accessories

Table 41: List of parts and accessories

Description	Supplier	Ordering information
TC65i	Cinterion	Standard module Cinterion Wireless Module IMEI: Ordering number: L30960-N1150-A200 Customer IMEI mode: Ordering number: L30960-N1160-A200
DSB75 Support Box	Cinterion	Ordering number: L36880-N8811-A100
TC65i Mounting Clip	GTT	Please ask Cinterion for ordering details.
Votronic Handset	VOTRONIC	Votronic HH-SI-30.3/V1.1/0 VOTRONIC Entwicklungs- und Produktionsgesellschaft für elek-tronische Geräte mbH Saarbrücker Str. 8 66386 St. Ingbert Germany Phone: +49-(0)6 89 4 / 92 55-0 Fax: +49-(0)6 89 4 / 92 55-88 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 42.
Board-to-board connector	Molex	Sales contacts are listed in Table 42.
U.FL-R-SMTantenna con-nector	Hirose or Molex	See Section 4.3 for details on U.FL-R-SMT connector, mating plugs and cables. Sales contacts are listed in Table 43.

Table 42: Molex sales contacts (subject to change)

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

Table 43: Hirose sales contacts (subject to change)

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

9.2 Fasteners and Fixings for Electronic Equipment

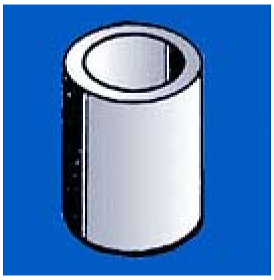
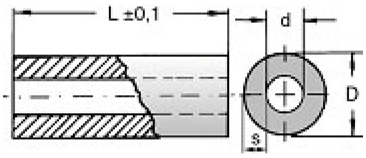
This section provides a list of suppliers and manufacturers offering fasteners and fixings for electronic equipment and PCB mounting. The content of this section is designed to offer basic guidance to various mounting solutions with no warranty on the accuracy and sufficiency of the information supplied.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

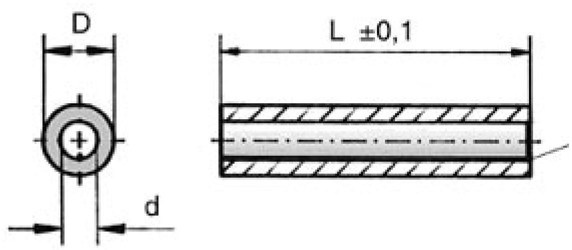
9.2.1 Fasteners from German Supplier ETTINGER GmbH

Sales contact:
ETTINGER GmbH
http://www.ettinger.de/main.cfm

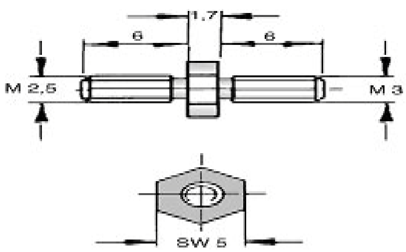
Phone: +49-81-046623-0
Fax: +49-81-046623-99

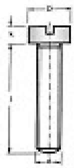
The following tables contain only article numbers and basic parameters of the listed components. For further detail and ordering information please contact Ettinger GmbH.
Please note that some of the listed screws, spacers and nuts are delivered with the DSB75 Support Board. See comments below.

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

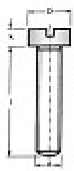
Article number: 07.51.403	Insulating Spacer for M2 Self-gripping[1]
Length	3.0mm
Material	Polyamide 6.6
Surface	Black
Internal diameter	2.2mm
External diameter	4.0mm
Flammability rating	UL94-HB
	

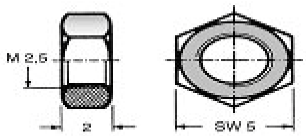
1. 2 spacers are delivered with DSB75 Support Board

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

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

1. 2 screws are delivered with DSB75 Support Board

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

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

1. 2 nuts are delivered with DSB75 Support Board

9.3 Mounting Clip

The following figure shows specifications and dimensions for the optional TC65i mounting clip.

Mounting Clip for Cinterion MC75i / TC65i / TC63i modules

GTT Europe P/N : GT-MC75i-CLIP **V1.0 Release 07th August 2008**

PCB Mounting Clip Design for Cinterion Wireless Modules : MC75i / TC65i / TC63i

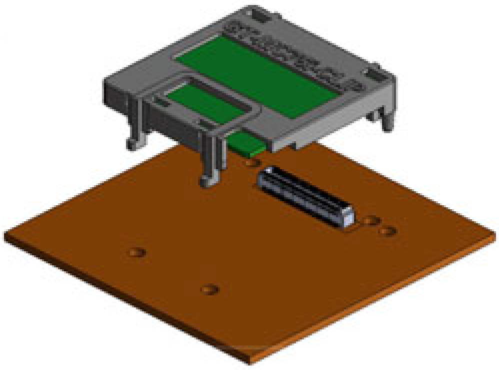
Web: www.gtteurope.co.uk
Email: enquiries@gtteurope.co.uk
Phone: + 44 (0) 1780 758 530

FEATURES AND APPLICATION

Board to Board connector information
Cinterion module board side connector by Molex : SD-53748-0800
PCB mating board side connector by Molex : SD-53916-0800
Size : 80 pins
Stacking height : 4.0mm

PCB mating board thickness : 1.6mm
Pulling force (Module Clip on PCB) : Minimum 5N

Reference information
Packaging information : TBD



CLIP SPECIFICATIONS

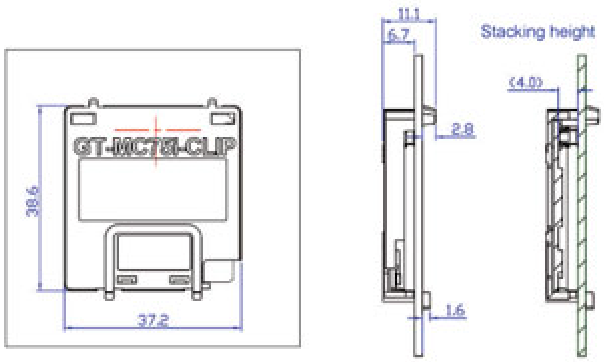
Physical

Clip material :
- PC-940A (Flame retardant PC ,UL 94V-0)
- Color : Black
- RoHS compliant

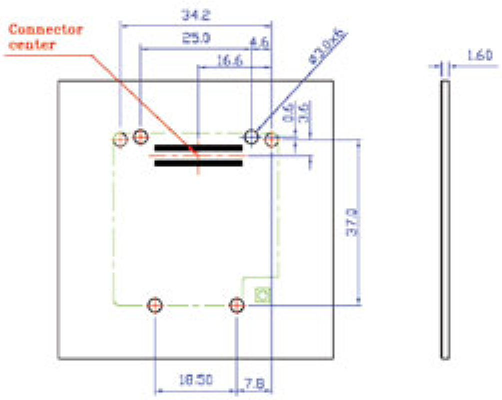
Operating Temperature : -40°C ~ +100°C

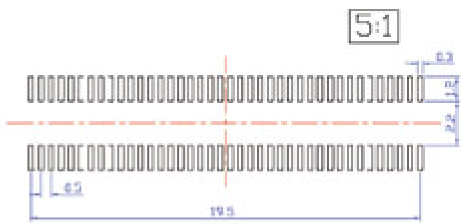
Weight : 2 g

Assembled dimensions (in millimeters)



MODULE CLIP PCB FOOTPRINT AND CONNECTOR RECEPTACLE DIMENSIONS





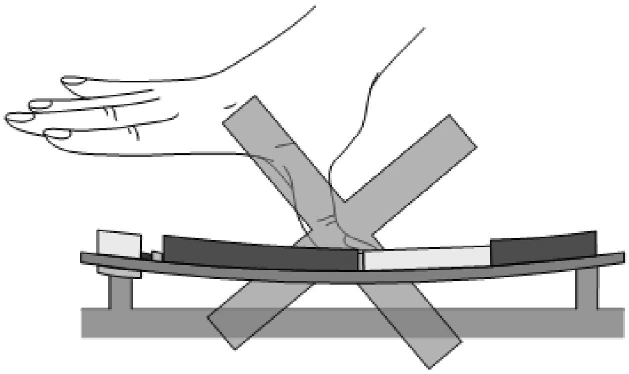
PCB Connector Receptable dimensions

9.4 Mounting Advice Sheet

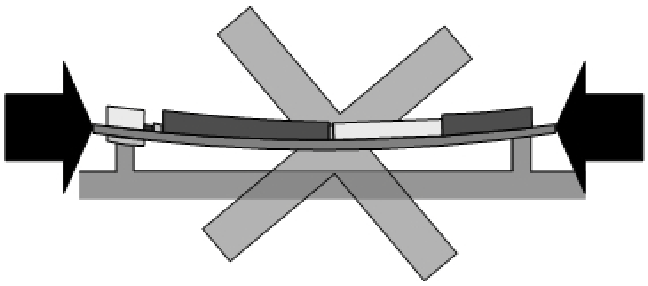
To prevent mechanical damage, be careful not to force, bend or twist the module. Be sure it is positioned flat against the host device (see also Section 6.2). The advice sheet on the next page shows a number of examples for the kind of bending that may lead to mechanical damage of the module.

Mounting Advice

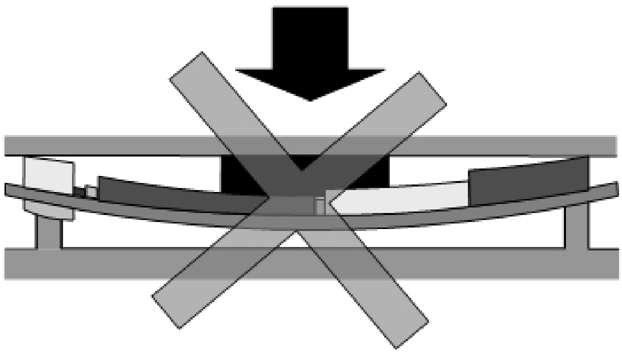
Do NOT BEND the Module



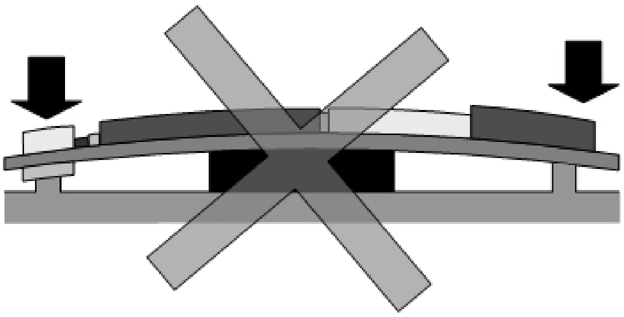
- By pressing from above



- By mounting under pressure



- By putting objects on top



- By putting objects below