SIEMENS

TC65 Terminal
Siemens Cellular Engine

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Hardware Interface Description

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1 Introduction

This document describes the hardware of the Siemens TC65 Terminal. The information are intended for users, developers or manufacturers who design and build cellular applications beyond the standard setup. The scope of this document includes interface specifications, electrical issues and mechanical characteristics of TC65 Terminal. It specifies standards pertaining to wireless applications and outlines requirements that must be adhered to for successful product design. The TC65 Terminal is a compact GSM modem for the transfer of data, voice, SMS and faxes in GSM networks. Industrial standard interfaces and an integrated SIM card reader allow using TC65 Terminal easily as a dual band GSM terminal. The functionality of the Terminal corresponds to the features of the TC65 module.

1.1 Related Documents

[1] TC65 AT Command Set
[2] TC65 Terminal Release Notes 00.550
[3] Application Note 16: Upgrading TC65 Firmware
[4] Multiplexer User's Guide (not yet available)
[5] TC65 JAVA User's Guide
[6] Java doc \wtk\doc\html\index.html

Prior to using the GSM engine, be sure to carefully read and understand the latest product information provided in the Release Notes.

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

1.2 Terms and Abbreviations

Abbreviation	Description
ADC	Analog-to-Digital Converter
ANSI	American National Standards Institute
ARP	Antenna Reference Point
B	Thermistor Constant
BER	Bit Error Rate
BTS	Base Transceiver Station
CE	Conformité Européene (European Conformity)
CHAP	Challenge Handshake Authentication Protocol
CS	Coding Scheme
CSD	Circuit Switched Data
CTS	Clear to Send
DAC	Digital-to-Analog Converter
dBm0	Digital level, 3.14dBm0 corresponds to full scale, see ITU G.711, A-law
DCE	Data Communication Equipment (typically modems, e.g. Siemens GSM engine)
DCS 1800	Digital Cellular System, also referred to as PCN
DSP	Digital Signal Processor
DSR	Data Set Ready
DTE	Data Terminal Equipment (typically computer, terminal, printer or, for example, GSM application)
DTR	Data Terminal Ready
DTX	Discontinuous Transmission
EFR	Enhanced Full Rate
EGSM	Enhanced GSM
EMC	Electromagnetic Compatibility
ESD	Electrostatic Discharge
ETS	European Telecommunication Standard
FCC	Federal Communications Commission (U.S.)
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
IMEI	International Mobile Equipment Identity
ISO	International Standards Organization
ITU	International Telecommunications Union
kbps	kbits per second
LED	Light Emitting Diode
Mbps	Mbits per second
MMI	Man Machine Interface
MO	Mobile Originated
MS	Mobile Station (GSM module), also referred to as TE
MT	Mobile Terminated
NTC	Negative Temperature Coefficient
PAP	Password Authentication Protocol
PBCCH	Packet Switched Broadcast Control Channel
PCB	Printed Circuit Board
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
PPP	Point-to-point protocol
PSU	Power Supply Unit
R&TTE	Radio and Telecommunication Terminal Equipment
RAM	Random Access Memory
RF	Radio Frequency
RTC	Real Time Clock
RTS	Request to Send
Rx	Receive Direction
SELV	Safety Extra Low Voltage
SIM	Subscriber Identification Module
SMS	Short Message Service
SPI	Serial Peripheral Interface
SRAM	Static Random Access Memory
TE	Terminal Equipment, also referred to as DTE
Tx	Transmit Direction
UART	Universal asynchronous receiver-transmitter
URC	Unsolicited Result Code
USSD	Unstructured Supplementary Service Data

1.3   Type Approval

TC65 Terminal is designed to comply with the directives and standards listed below. Please note that the product is still in a pre-release state and, therefore, type approval and testing procedures have not yet been completed.

European 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
89/336/EC	Directive on electromagnetic compatibility
73/23/EC	Directive on electrical equipment designed for use within certain voltage limits (Low Voltage Directive)
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 (RUHS)
2002/96/EC	Directive of the European Parliament and of the Council on waste electrical and electronic equipment (WEEE)
2003/108/EC	Directive of the European Parliament and of the Council of 8 December 2003 amending directive 2002/96/ec on waste electrical and electronic equipment (WEEE)

Standards of North American Type Approval

CFR Title 47	"Code of Federal Regulations, Part 22 and Part 24 (Telecommuni-cations, PCS)"; US Equipment Authorization FCC
UL 60 950	"Product Safety Certification" (Safety requirements)
NAPRD.03	"Overview of PCS Type certification review board Mobile Equipment Type Certification and IMEI control" PCS Type Certification Review board (PTCRB), Version 3.1.2
RSS133 (Issue2)	Canadian Standard

Standards of European Type Approval

3GPP TS 51.010-1	"Digital cellular telecommunications system (Phase 2); Mobile Station (MS) conformance specification" V5.10.0
ETSI EN 301 511	"V9.0.2 (2003-03) Candidate Harmonized European Standard (Telecommunications series) Global System for Mobile communications (GSM); Harmonized standard for mobile stations in the GSM 900 and DCS 1800 bands covering essential requirements under article 3.2 of the R&TTE directive (1999/5/EC) (GSM 13.11 version 7.0.1 Release 1998)"
GCF-CC	"Global Certification Forum - Certification Criteria" V3.18.0
ETSI EN 301 489-1	"V1.4.1 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"
ETSI EN 301 489-7	"V1.2.1 (2002-08) Candidate Harmonized European Standard (Telecommunications series) Electro Magnetic Compatibility and Radio spectrum Matters (ERM); Electro Magnetic Compatibility (EMC) standard for radio equipment and services; Part 7: Specific conditions for mobile and portable radio and ancillary equipment of digital cellular radio telecommunications systems (GSM and DCS)"
EN 60 950-1	Safety of information technology equipment (2001)

Requirements of quality

IEC 60068	Environmental testing
DIN EN 60529	IP codes

1.4 Safety Precautions

The following safety precautions must be observed during all phases of the operation, usage, service or repair of any cellular terminal or mobile incorporating TC65 Terminal. Manufacturers of the cellular terminal are advised to convey the following safety information to users and operating personnel and to incorporate these guidelines into all manuals supplied with the product. Failure to comply with these precautions violates safety standards of design, manufacture and intended use of the product. Siemens AG assumes no liability for customer'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.

SOS

IMPORTANT!
Cellular terminals or mobiles operate using radio signals and cellular networks. Because of this, connection cannot be guaranteed at all times under all conditions. Therefore, you should never rely solely upon any wireless device for essential communications, for example emergency calls.

Remember, in order to make or receive calls, the cellular terminal or mobile must be switched on and in a service area with adequate cellular signal strength.

Some networks do not allow for emergency calls if certain network services or phone features are in use (e.g. lock functions, fixed dialing etc.). You may need to deactivate those features before you can make an emergency call.

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

If a power supply unit is used to supply the device, it must meet the demands placed on SELV circuits in accordance with EN60950. The maximum permissible connection length between the device and the supply source should not exceed 3m.

According to the guidelines for human exposure to radio frequency energy, an antenna connected to the SMA jack of the device should be placed at least 20cm away from human bodies.

2 Key features of TC65 Terminal

Feature	Implementation
General	
Incorporates TC65 module	The TC65 module handles all processing for audio, signal and data within the TC65 Terminal. Internal software runs the application interface and the whole GSM protocol stack.
Frequency bands	Quad band: GSM 850/900/1800/1900MHz
GSM class	Small MS
Output power (according to Release 99, V5)	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, Version 5, 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 3.0dB for 2Tx, 4.8dB for 3Tx and 6.0dB for 4Tx.
Power supply	Single supply voltage 8V to 30V
Operating temperature	-30°C to +65°C ambient temperature
Physical	Dimensions: 130mm x 90mm x 38mm Weight: approx. 190g Hardware platform is free of lead and halogen.
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

Feature	Implementation
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 Speakerphone operation Echo cancellation, noise suppression DTMF 7 ringing tones
Software	
AT commands	AT-Hayes GSM 07.05 and 07.07, Siemens AT commands for RIL compatibility (NDIS/RIL)
Microsoft™ compatibility	RIL / NDIS for Pocket PC and Smartphone
Java platform JDK Version: 1.4.2_07	Java Virtual Machine with interfaces to 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.
SIM Application Toolkit	SAT Release 99
TCP/IP stack	Access by AT commands
IP adresses	IP version 6
Remote SIM Access	TC65 Terminal supports Remote SIM Access. RSA enables TC65 Terminal to use a remote SIM card via its serial interface, in addition to the SIM card locally attached to the dedicated lines of the application interface. In a vehicle mounted scenario, for example, this allows the driver to access a mobile phone brought into the car from a car-embedded phone. The connection between both phones can be a Bluetooth wireless link or a serial link, e.g. via the car cradle. The necessary protocols and procedures are implemented according to the "SIM Access Profile Interoperability Specification of the Bluetooth Special Interest Group".
Firmware update	Upgradeable via serial interface.
Interfaces	
1 serial interface	ASC0 • 8-wire modem interface with status and control lines, unbalanced, asynchronous • Fixed bit rates: 300 bps to 460,800 bps • Autobauding: 1,200 bps to 460,800 bps • Supports RTS0/CTS0 hardware handshake and software XON/XOFF flow control. • Multiplex ability according to GSM 07.10 Multiplexer Protocol.

I²C	I²C bus for transmission rates up to 400kbps. Programmable with AT^SSPI command. Alternatively, all pins of the I²C 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 I²C interface is not available.
Audio	Analog (Microphone, Earpiece)
SIM interface	Supported SIM cards: 3V, 1.8V
Antenna	Connected via antenna SMA connector
Power on/off, Reset	
Power on/off	• Switch on via On/Off push button, ONOFF line (GPIO), DTR line (RS232) or POWER line (Power connector) • Switch off via AT command (AT^SMSO), On/Off push button or EMERGOFF line (Power connector) • Automatic switch off in case of critical temperature and voltage conditions.
Reset	Orderly shutdown and reset by AT command
Special features	
Real time clock	Timer functions via AT commands
GPIO	10 I/O pins of the application interface programmable as GPIO. Programming is done via AT commands. Alternatively, GPIO pin 10 is configurable as pulse counter.
Pulse counter	Pulse counter for frequency range of 0Hz to 1000Hz. If the pulse counter is active the GPIO pin 10 is not available.
ADC inputs	Two balanced analog inputs for measuring external voltages.
Phonebook	SIM and phone

2.1   Technical Requirements for Using TC65 Terminal

- TC65 Terminal
- Computer running Windows 2000, Windows XP
- 1.8V or 3.0V SIM card
- 8 to 30 Volts power supply unit
- RS-232 cable (for high data rates ≤ 1.5m)
- UART capable of data rates up to 460800 bps. Usually, this requires an appropriate serial adapter to be installed on the computer.
- RF antenna
- Audio handset
- Customized mating connector for IO interfaces type Micro Mate-N-LOK.
- Terminal program to control the COM port, for example Windows Hyperterminal.
- Access to a GSM/GPRS network providing support of the authentication protocol PAP or CHAP. The GPRS settings of your service provider should be at hand. Please contact your service provider or follow the link below to obtain all required information.
  http://www.gsmworld.com/technology/gprs/operators.shtml

3   Interface Description

3.1   Overview

TC65 Terminal provides the following connectors for power supply, interfacing and antenna:

1. GPIO Micro Mate-N-LOK connector for GPIOs, I²C, SPI, ADC
2. 9-pole (female) SUB-D plug for RS-232 serial interface
3. SMA connector (female) for antenna
4. On/Off push button
5. 4-pole Western plug (female) for audio accessory, such as a handset
6. SIM card holder
7. 6-pole Western plug (female) for power supply, ignition, power down signal
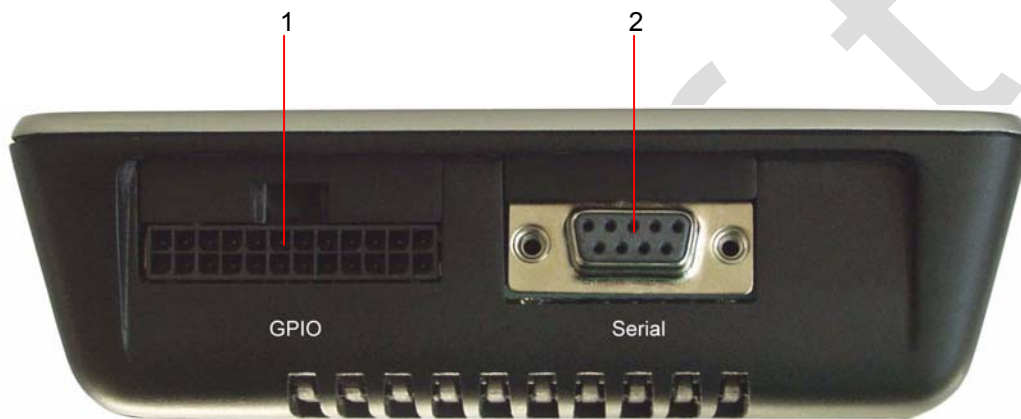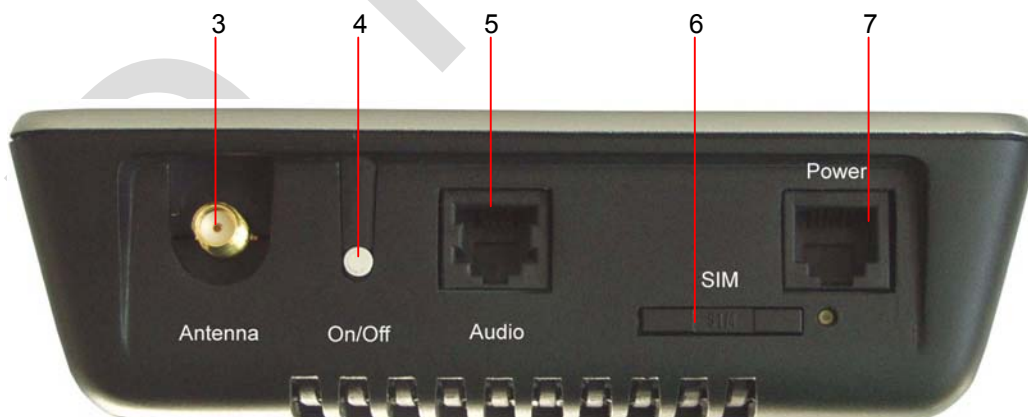

Figure 1: TC65 Terminal front view

Figure 2: TC65 Terminal rear view

3.2 Block Diagram

Figure 3 shows a block diagram of a sample configuration that incorporates a TC65 Terminal and typical accessories.

1) Fast acting fuse 1,25A , (0.9...1.3)A^{2}s is recommended for 24V vehicle supply only.
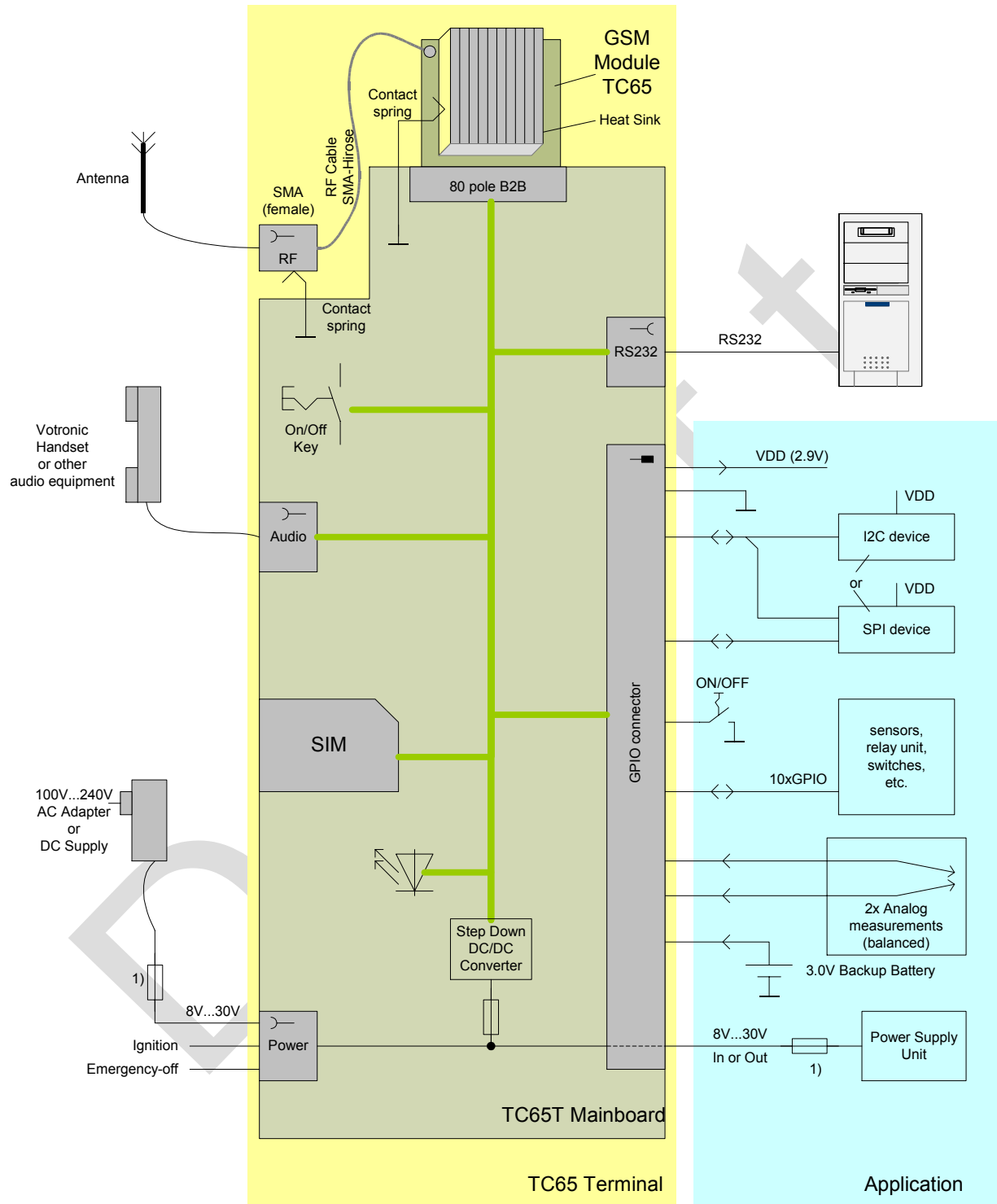
Figure 3: Block diagram

3.3 Operating Modes

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

Table 1: 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 Terminal 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 alternatively 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 Terminal 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	Terminal 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. The Power Supply disconnects the supply voltage from the baseband part of the circuit. 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 Terminal 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 Terminal 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.

3.4 Terminal circuit
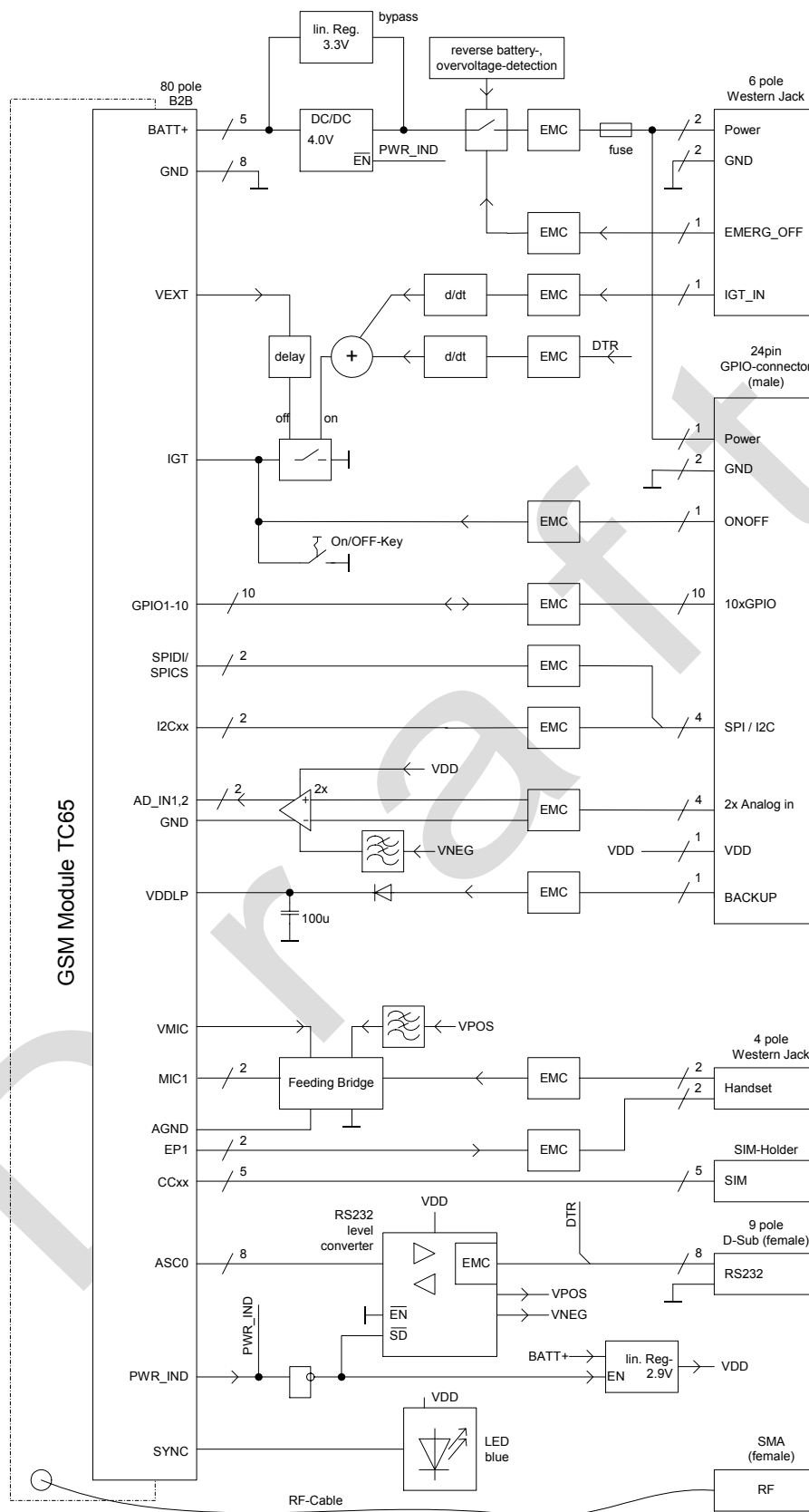
Figure 4: TC65 Terminal circuit block diagram

3.5 Power Supply

The power supply of the TC65 Terminal has to be a single voltage source of POWER=8V…30V capable of providing a peak current of about 2A at 12V during an active transmission. The uplink burst causes strong ripple (drop) on the power lines. The drop voltage should not exceed 3.2V.

The TC65 Terminal is protected from supply voltage reversal and overvoltage. An internal fuse that is not removable ensures for electrical safety according to EN60950.

A fast acting fuse 1.25A, (0.9 … 1.3) A²s is necessary to operate the TC65 Terminal at 24V vehicle power supply systems.

The power supply must be compliant with the EN60950 guidelines.

Table 2: Pin assignment of the Western plug for power supply

Pin	Signal name	Use	Parameters
1	POWER	Power supply	8V – 30V DC
2	POWER	Power supply	
3	EMERGOFF	Signal for POWER DOWN mode	Active: 4.5V – 30V Inactive: <3V
4	IGT_IN	Ignition input	Active: 4.5V – 30V Inactive: <3V
5	GND	Ground	0V
6	GND	Ground	

Pin assignment

1 - POWER
2 - POWER
3 - EMERGOFF
4 - IGT_IN
5 - GND
6 - GND
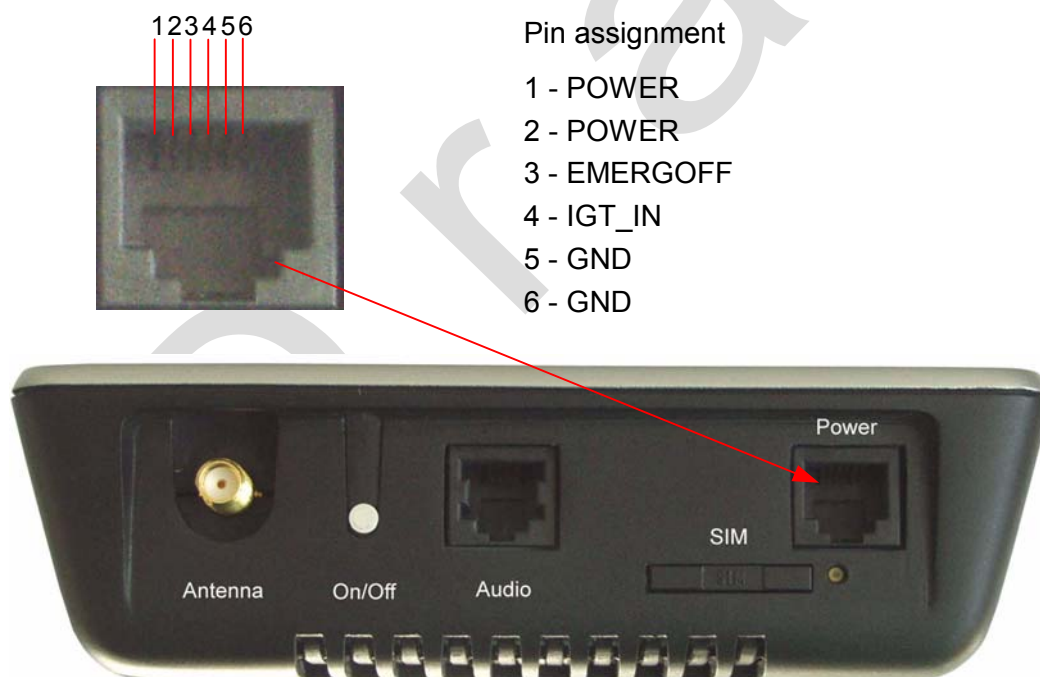
Figure 5: Female 6-pole Western plug for power supply, ignition, emergency off

3.5.1 Switch on TC65 Terminal

There are several ways to turn on the TC65 Terminal:
- *Switch on via ON/OFF push button or the ONOFF signal line (GPIO connector)*
  The major approach is to switch on the TC65 Terminal by pressing the ON/OFF key.
  The ONOFF pin of the GPIO connector connected in parallel to the ON/OFF key makes it
  possible to control the TC65 Terminal from a remote unit.
- *Switch on via IGT_IN line (power supply connector) or DTR line (serial connector)*
  The rising edge of the IGT_IN line or the DTR line voltage generates an ignition signal
  (impulse) so that it is possible to switch on the TC65 Terminal from the host or by remote
  control.

Switch on condition: If the TC65 Terminal is off the ON/OFF push button or the
corresponding signal line must be asserted for at least 400 ms and then released.

3.5.2 Reset TC65 Terminal

An easy way to reset the TC65 Terminal is entering the command AT+CFUN=x,1. For details
on AT+CFUN please see [1].

3.5.3 Switch off TC65 Terminal

TC65 Terminal can be switched off as follows:
- *Software controlled shutdown by AT^SMSO command*
  The AT^SMSO command lets TC65 Terminal 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.
- *Software controlled shutdown via ON/OFF push button, ONOFF line (GPIO connector)*
  By pressing the ON/OFF push button or by activating the ONOFF signal for >1s the TC65
  Terminal will be switched off. The shutdown behavior is identical to the behavior when
  using the AT^SMSO command.
- *Shutdown via EMEROFF line (power supply connector)*
  By activating the EMERGOFF signal for >1s the TC65 Terminal will be switched off. All
  information stored in the volatile memory get lost.
- *Automatic shutdown:*
  Takes effect if board temperature is out of range or if undervoltage or overvoltage
  conditions occur.

3.5.4 Disconnecting power supply

Before disconnecting the power supply from the POWER pin, make sure that the TC65
Terminal is in a safe condition. The best way is to wait 1s after the "^SHUTDOWN" result
code has been indicated.

3.5.5 RTC

The internal Real Time Clock (RTC) of the TC65 Terminal must be supplied from a separate voltage regulator which is also active when TC65 Terminal is in POWER DOWN status. An alarm function is provided that allows to wake up TC65 Terminal to Airplane mode without logging on to the GSM network. See [1] for details.

You can use the BACKUP pin on the GPIO connector to backup the RTC from an external battery (rechargeable or non-chargeable). If no external battery is connected, a 100µF capacitor supplies the RTC about 6s during power interruptions.

3.6   RS-232 Interface

The serial interface of the TC65 Terminal is intended for the communication between the GSM module and the host application. This RS-232 interface is a data and control interface for transmitting data, AT commands and providing multiplexed channels. EMC immunity complies with the vehicular environment requirements according to EN 301 489-7.
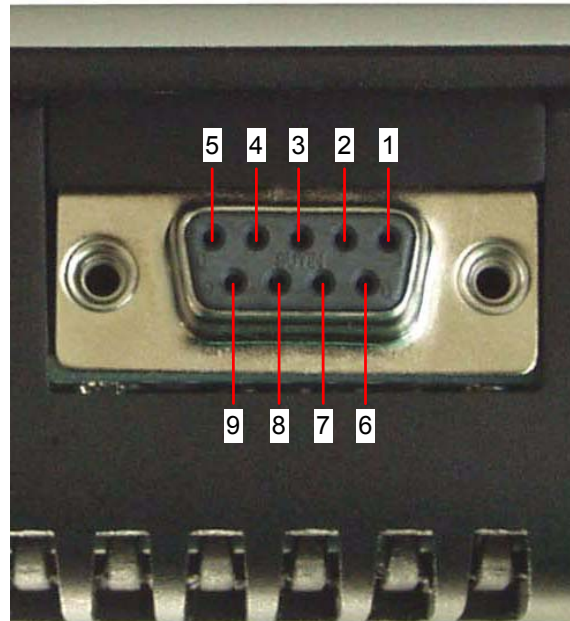
Figure 6: Pin assignment RS-232 (D-Sub 9-pole female)

Table 3: 9-pole D-Sub (female) RS-232

Pin no.	Signal name	I/O	Function
1	DCD	O	Data Carrier Detected
2	RXD	O	Receive Data
3	TXD	I	Transmit Data
4	DTR	I	Data Terminal Ready Attention: Low-to-high transition of the DTR line activates the ignition signal of the GSM module
5	GND	-	Ground
6	DSR	O	Data Set Ready
7	RTS	I	Request To Send
8	CTS	O	Clear To Send
9	RING	O	Ring Indication

TC65 Terminal 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 TXD of TC65 Terminal
- Port RxD @ application receives data from RXD of TC65 Terminal

The RS-232 interface is implemented as a serial asynchronous transmitter and receiver conforming to ITU-T V.24 Interchange Circuits DCE. It is configured for 8 data bits, no parity and 1 stop bit, and can be operated at fixed bit rates from 300bps to 460,800bps. Autobauding supports bit rates from 1,2bps to 460,800bps. Hardware handshake using the /RTS and /CTS signals and XON/XOFF software flow control are supported.

In addition, the modem control signals DTR, DSR, DCD and RING are available. The modem control signal RING (Ring Indication) can be used to indicate, to the cellular device application, that a call or Unsolicited Result Code (URC) is received.

3.7 Audio Interface

The audio interface provides one analog input for a microphone and one analog output for an earpiece.

- The microphone input and the earpiece output are balanced.
- For electret microphones a supply source is implemented.
- The microphone supply characteristics are optimized for the recommended Votronic handset. For ordering Information see Chapter 7.
- This handset has been used as the reference handset for type approval. An extra approval must be obtained for integrating other handsets or amplifiers.

The amplification of sending direction, receiving direction and sidetone depend on the current audio mode.

EMC immunity complies with the vehicular environment requirements according to EN 301 489-7.

Pin assignment

1 - MICN (Microphone -)

2 - EPN (Earpiece)

3 - EPP (Earpiece)

4 - MICP (Microphone +)
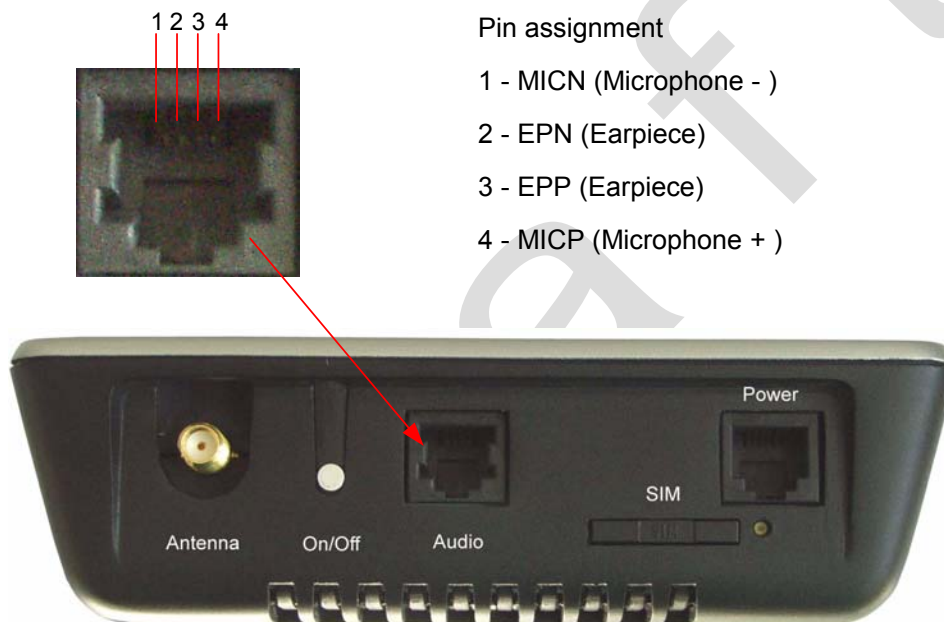
Figure 7: Audio Western plug (4-pole female)
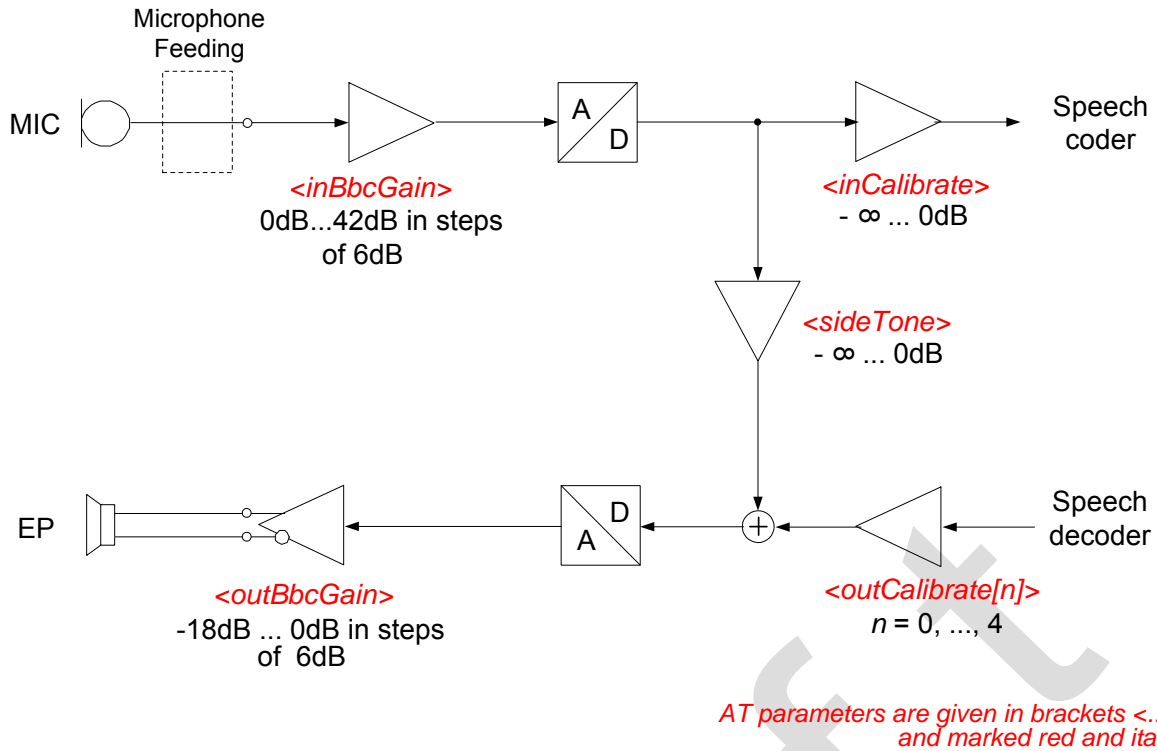
Figure 8: Audio block diagram

The audio interface can be configured by AT commands. Please note that the 2nd audio interface mentioned in [1] is not connected. Audio modes 2, 3 and 6 can be selected by setting AT^SAIC=2,1,1, for further details refer to [1].
The electrical characteristics of the voiceband part vary with the audio mode. To suit several types of audio equipment, three audio modes given by default can be selected by the AT command AT^SNFS, see [1].

Speech processing:

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

Full rate, half rate, enhanced full rate, 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.

3.8   Antenna Interface

In order to send or receive data, connect an external RF antenna to the SMA connector which is internally connected to the RF signal of the GSM module.

Please consider that the recommended antenna equipment has been chosen to achieve optimum RF performance when operating the TC65 Terminal. Siemens does not accept warranty claims for damage caused by inappropriate equipment connected to the antenna connector.

3.9   SIM Interface

The SIM interface is intended for 3V and 1.8V SIM cards. The card holder is a five wire interface according to GSM 11.11. A sixth pin has been added to detect whether or not the SIM card drawer is inserted.

Removing and inserting the SIM card during operation requires the software to be reinitialized. Therefore, after reinserting the SIM card it is necessary to restart TC65 Terminal.

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 TC65 Terminal.
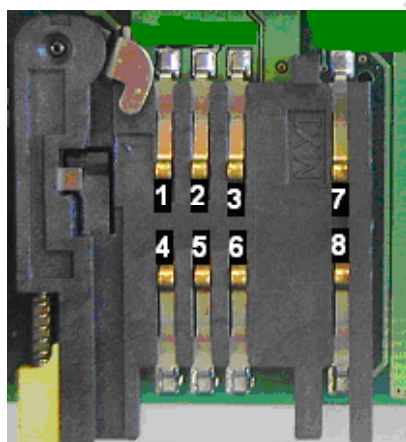
Figure 9: Pin location of the Molex SIM card holder and position

Table 5: Pin assignment – SIM card holder

Pin number on holder	Signal name	I/O	Function
1	VSIM	**O**	Supply voltage for SIM card, generated by the module (see section **Error! Reference source not found.**. for details)
2	CCRST	**O**	Chip card reset, prompted by the module
3	CCCLK	**O**	Chip card clock
4,8	GND	**-**	Ground
5	CCVPP	**-**	Not connected
6	CCIO	**I/O**	Serial data line, bi-directional
7	CCIN	**I**	Chip card drawer detection 0 = Chip card drawer inserted 1 = Chip card drawer not inserted Input on the baseband processor for detecting the chip card drawer in the holder; if the SIM is removed during operation the interface is shut down immediately to prevent destruction of the SIM.

3.10   IO Interfaces

Via the GPIO connector the following interfaces and functions are provided.
- Programmable GPIOs
- I²C bus
- SPI interface
- Two analog inputs (balanced)
- Power supply
- Backup supply
- VDD supply
- On/Off switch of the terminal

The total cable length of the digital lines for I²C and SPI interfaces should not exceed 150mm.
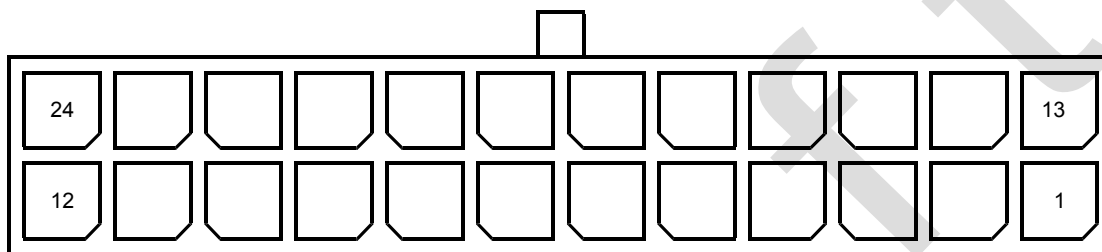
Figure 10: GPIO connector front view

Table 6: Assignment of the GPIO connector

Pin	Signal name	I/O	Description
1	I2CCLK_SPICLK	O	I2C Clock
2	I2CDAT_SPIDO	I/O	I2C Data
3	IO3	I/O	Programmable GPIO
4	IO4	I/O	Programmable GPIO
5	IO5	I/O	Programmable GPIO
6	IO6	I/O	Programmable GPIO
7	IO1	I/O	Programmable GPIO
8	IO2	I/O	Programmable GPIO
9	AD2_IN_P	I	Balanced analog 2 positive input
10	AD2_IN_N	I	Balanced analog 2 negative input
11	BACKUP	I/O	Backup battery
12	GND		Ground for power supply
13	SPICS	O	SPI Select
14	SPIDI	I	SPI Data In
15	IO9	I/O	Programmable GPIO
16	IO10	I/O	Programmable GPIO/ Pulse counter
17	IO7	I/O	Programmable GPIO
18	IO8	I/O	Programmable GPIO
19	VDD	O	Signal supply voltage
20	ONOFF	I	Ignition
21	AD1_IN_P	I	Balanced analog 1 positive input
22	AD1_IN_N	I	Balanced analog 1 negative input
23	GND		Signal ground
24	POWER	I	Power supply

3.10.1   GPIOs

The TC65 Terminal provides 10 GPIOs at the GPIO connector. Each GPIO line is ESD protected and a serial resistor of 100 Ohms is added.
This avoids short circuits and is especially important in the first stages of development, where the Java application is not yet fully implemented.

The signal direction (input/output) of the GPIO lines is selectable with AT commands.
Figure 11 shows the position of the GPIO pins at the GPIO connector.

Alternatively GPIO pin10 can be used to configure, start or stop a pulse counter for input frequency range of 0Hz to 1000Hz.

The GPIOs and the pulse counter can be configured via the following AT commands: AT^SPIO, AT^SCPIN, AT^SCPOL, AT^SCPORT, AT^SDPORT, AT^SGIO, AT^SSIO, AT^SCCNT, AT^SSCNT. For details please refer to [1].

Figure 11: Location of GPIO pins

3.10.2 I²C Interface

The I²C interface is located on the GPIO connector of the TC65 Terminal.

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

The TC65 Terminal acts as a single master device, e.g. the clock I2CCLK is driven by the Terminal. I2CDAT is a bi-directional line.
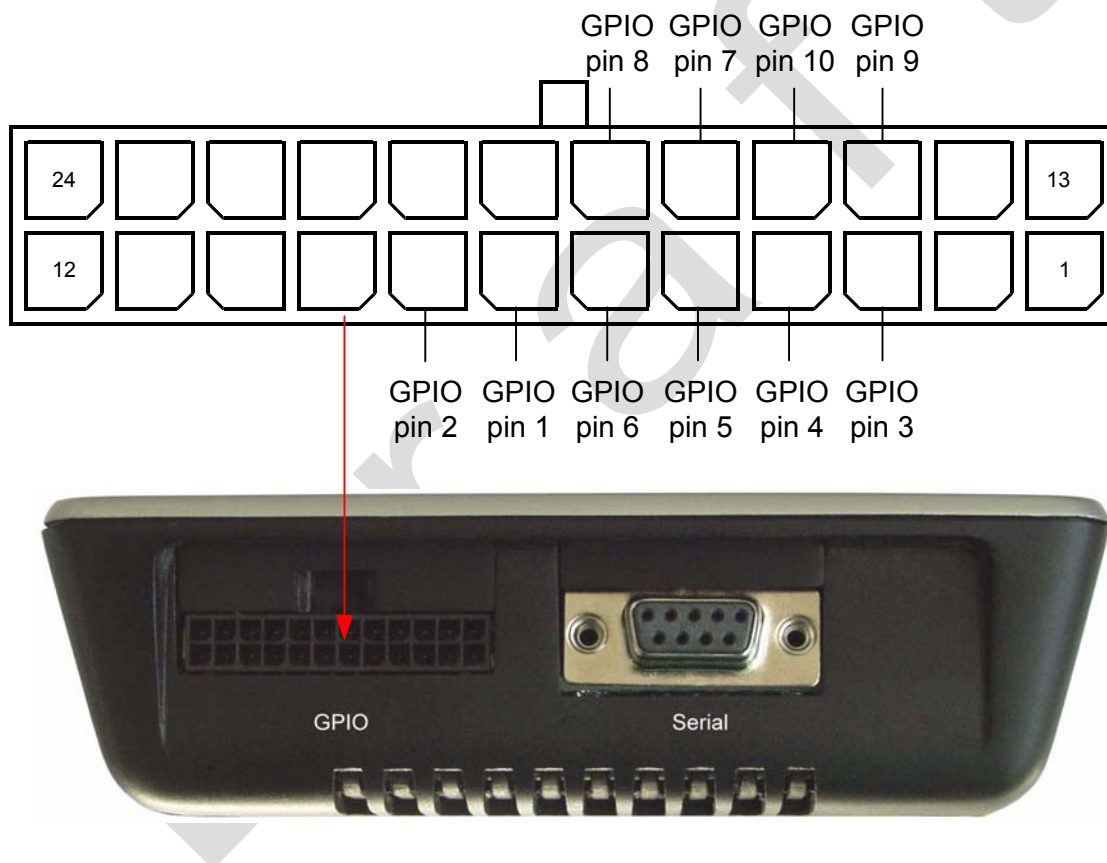
Each device connected to the bus is software addressable by a unique address, and simple master/slave relationships exist at all times. The Terminal operates as master-transmitter or as master-receiver. The customer application transmits or receives data only on request of the Terminal. To configure and activate the I²C interface use the AT^SSPI command described in [1].

The I²C interface is only available if the pins 1 and 2 of the GPIO connector are not used as SPI interface.

Table 7: I²C interface – signal description

Signal name	Pin	Description
I2CDAT_SPIDO	1	Data in/out – bidirectional serial data line
I2CCLK_SPICLK	2	Serial clock line

3.10.3 SPI Interface

The SPI interface is located on the GPIO connector of the TC65 Terminal.

The SPI (serial peripheral interface) is a synchronous serial interface for control and data transfer between the TC65 Terminal and the connected application. Only one application can be connected to the Terminal's SPI. The interface supports transmission rates up to 6.5Mbit/s. It consists of four lines, the two data lines SPIDI/SPIDO, the clock line SPICLK and the chip select line SPICS.

The TC65 Terminal acts as a single master device, e.g. the clock SPICLK is driven by Terminal. Whenever the SPICS pin is in a low state, the SPI bus is activated and data can be transferred from the Terminal and vice versa. The SPI interface uses two independent lines for data input (SPIDI) and data output (SPIDO).

The SPI interface is only available if the pins 1 and 2 of the GPIO connector are not used as I²C interface.

Table 8: SPI interface – signal description

Signal name	Pin	Description
SPICS	13	Chip select – selects and activates the external device via a low signal.
SPIDI	14	Data in – serial data input line (from the external device to the TC65 Terminal)
I2CDAT_SPIDO	1	Data out – serial data output line (from the TC65 Terminal to the external device)
I2CCLK_SPICLK	2	Serial clock line

3.10.4   Analog Inputs

The two analog inputs are used for measuring external DC voltages in range of 0V to 5.0V. To configure the analog inputs use the commands AT^SRADC and AT^SAADC described in [1].

TBD

3.10.5   Power Supply

The two power supply pins of the GPIO connector are parallel to two pins of the Western Jack for power supply. This allows supplying the TC65 Terminal by using the Power connector or via the GPIO connector.

3.10.6   VDD Supply

The VDD pin of the GPIO connector may be used for supplying external circuit devices or applications and indicates the following states of the TC65 Terminal.

- VDD output voltage = 2.9V @ max. 50mA indicates Normal Operation mode or Airplane mode
- VDD output voltage = 0V indicates Power Down mode

3.10.7   ON/OFF Switch

If the ONOFF pin of the GPIO connector is active low it may be used to switch on or switch off the TC65 Terminal.
For more information to switch on /switch off the Terminal please refer to chapter 3.5.1 and 3.5.3.

3.11   Status LED

A blue LED displays the operating status of the TC65 Terminal.

The connected LED can be operated in two different display modes (AT^SSYNC=1 or AT^SSYNC=2).
Display mode 1 (AT^SSYNC=1) is the factory default of the TC65 Terminal. For more information to the different operating states and to change the mode please refer to [1].

Status LED
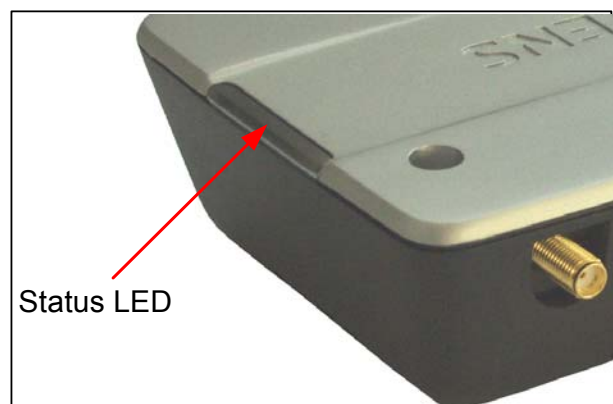
4 Mechanical Characteristics

Table 9: Mechanical characteristics

Weight	190g
Dimensions (max) L x W x H	130mm x 90mm x 38mm
Temperature range	-30°C to +65°C ambient temperature
Protection class	IP40 (Avoid exposing TC65 Terminal to liquid or moisture, for example do not use it in a shower or bath.)
Mechanical vibrations Amplitude	7.5mm at 5-200Hz sinus
Max. pulse acceleration	30g pulse with 18 ms duration time
Air humidity	5...80% (non condensing)
Class of flammability	UL94 HB
Casing material	PC/ABS Cycoloy 1200 HF
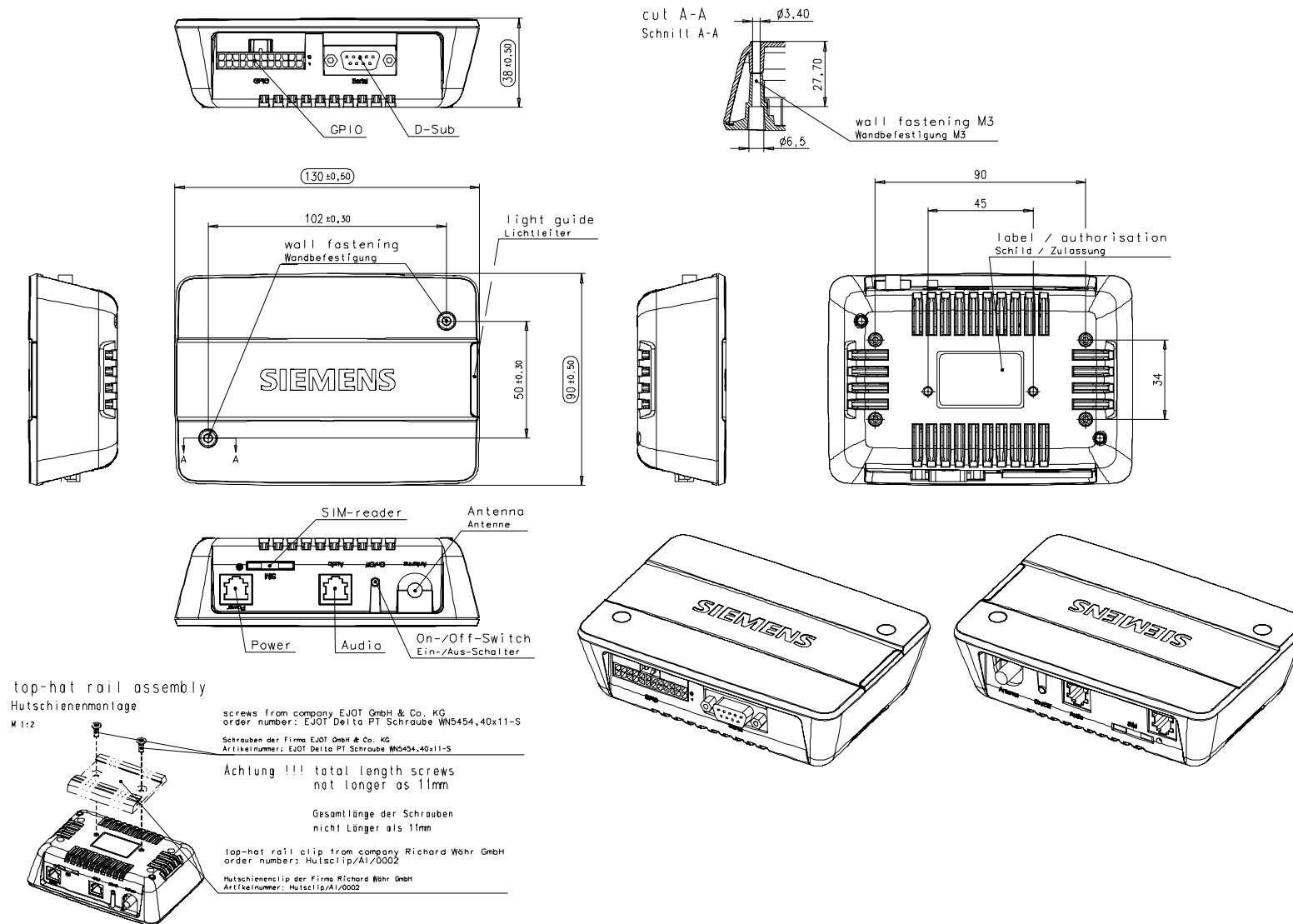
Figure 12: Mechanical dimensions

4.1   IO Interface Connector

This chapter provides specifications for the 24-pin IO interface connector which serves the I2C, SPI and GPIO interfaces of the Terminal. The receptacle assembled on the TC65 Terminal is type Micro Mate-N-LOK 3mm from Tyco Electronics. Mating headers can be chosen from the Tyco Micro Mate-N-LOK Series. For latest product information please contact your Micro Electronics dealer or visit the Tyco home page, for example http://www.tycoelectronics.com.
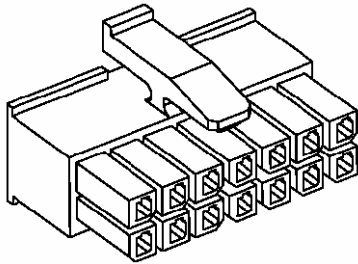
Figure 13: Receptacle connector Tyco Micro Mate-N-LOK series
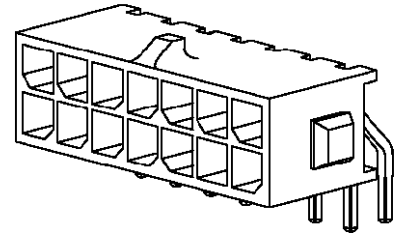
Figure 14: Header Tyco Micro Mate-N-LOK series on TC65 Terminal
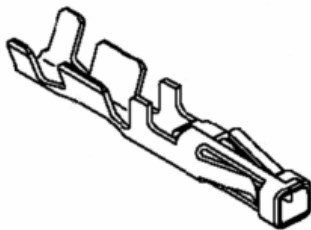
Figure 15: Receptacle contact for Tyco Micro Mate-N-LOK series

Table 10: Electrical and mechanical characteristics of the Micro Mate-N-LOK connector

Parameter	Specification
Number of contacts	24
Voltage rating	250V
Current rating	5A max.
Resistance	0.02 Ohm max. per contact
Dielectric withstanding voltage	1500VAC
Operating temperature	-40°C...+105°C
Contact centerline	3.0mm
Mating force	6.67N max. per contact
Contacts packaging method	Contacts available in strip form or loose piece (24 pieces/housing for full assembly)
Receptacle housing material	Flame-retardant black thermoplastic
Contact material	Phosphor bronze

Table 11: Ordering information Tyco Micro Mate-N-LOK

Item	Number of positions	Ordering number
Receptacle Housing Micro Mate-N-LOK 3mm	24	2-794617-4
Crimp Snap-IN Receptacle Contacts for max. $\varnothing$ 1.53mm cable		79460-1

4.1.1 Mechanical dimensions of the Mate_N_LOK Header

DIM X	DIM Y	DIM Z	Number of Positions
40.00	36.86	33.00	24
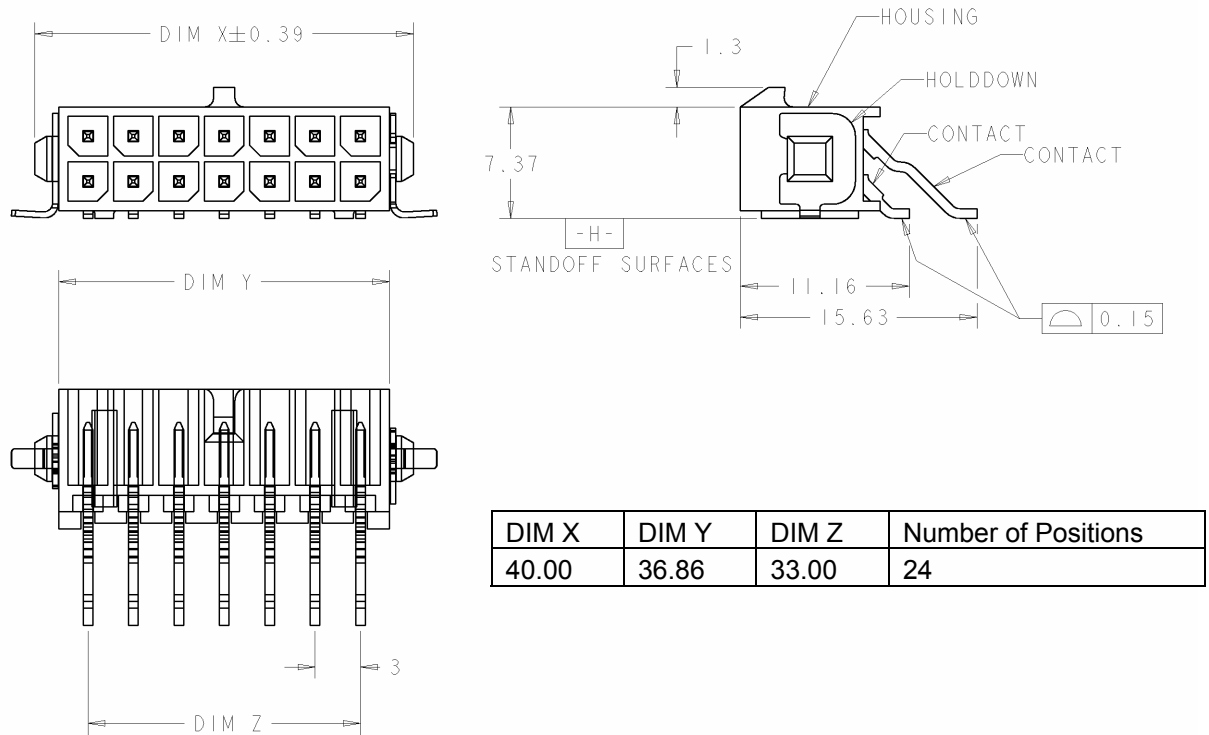
Figure 16: Mechanical dimension of Tyco Mate_N_LOK Header

5   Electrical and Environmental Characteristics

Table 12: Absolute maximum ratings

Parameter	Port / Description	Min.	Max.	Unit
Supply voltage	POWER	+8	+30	V
Overvoltage	POWER for 1min		+33	V
Revers voltage	POWER		-30	V
Input voltage for emergency off	EMERGOFF	-5	+30	V
RS-232 input voltage range	TXD0, DTR0, RTS0	-25	+25	V
	RXD0, CTS0, DSR0, DCD0, RING0	-13	+13	V
Digital GPIO	IO1 – IO10	-0.3	+3.05	V
Digital SPI	I2CCLK_SPICLK, I2CDAT_SPIDO, SPICS, SPIDI	-0.3	+3.05	V
Digital I2C	I2CCLK_SPICLK, I2CDAT_SPIDO	-0.3	+3.05	V
Analog Input	AD1_IN_P, AD1_IN_N, AD2_IN_P, AD2_IN_N	-0.3	+6	V
Microphone input line voltage	MICP1, MICN1	-0.3	+7	V
Earpiece voltage (idle, no power)	EPP1, EPN1	-0.3	+3.0	V
Earpiece voltage (idle, with power)	EPP1, EPN1		+3.6	V
Immunity against air discharge of static electricity	all connectors (lines)	-8	+8	kV
Immunity against contact discharge of static electricity	all connectors (lines)	-4	+4	kV
Protection Class	IP40 (avoid exposing to liquid or moisture, for example do not use it in a shower or bath)		IP 40	
Mechanical vibrations amplitude	@ 5-200Hz		7.5	mm
Mechanical pulse-acceleration	@ 18ms duration		30	g

Table 13: Operating conditions

Parameter	Min	Typ	Max	Unit
Ambient temperature	-30	25	65[1]	°C
Supply voltage V_{POWER} measured at (6-pole) western jack plug (1, 2 to 5,6)	7.6 lowest voltage (minimum peak) incl. all ripple and drops	12	30	V

[1]

Continuous operation at 65°C environmental temperature is not possible in every operating mode due to intrinsic heating of the TC65 Terminal.

The level of intrinsic heating depends on several factors, inter alia from the level of the supply voltage, the operating mode (GPRS/GSM) and the network coverage. The maximum possible environmental temperature in GPRS Class 12 operating mode (MS-configuration 1down/4up, PCL5/Gamma3, 12V supply voltage, 900MHz band, with power reduction) is about 45°C. When exceeding this temperature the TC65 Terminal will send a request for a Class-Mark-Change (CMC, from GPRS Class 12 to GPRS Class 8) to the base station. At a successful change of the GPRS class the intrinsic heating of the TC65 Terminal will be reduced. If the board temperature decreases for an amount of 5K the GPRS Class will be stepped up again.

Continuous operation in Talk mode is possible up to an environmental temperature of about 67°C (12V, 900MHz, PCL5). With decreasing transmit power of the TC65 Terminal, the maximum possible environmental temperature, at which a GPRS continuous operation at PCL5/Gamma3 is possible, increases.

For a short time it is also possible to establish a GPRS Class 12 connection at PCL5/Gamma3 and at an ambient temperature of 65°C. Starting a data download in GPRS Class 12 mode with power reduction at 65°C environmental temperature, the CMC will be enabled after 7 minutes.

This information concerns to 12V supply voltage. At 8V resp. 30V the intrinsic heating is higher, whereby the maximum possible environmental temperature will be lower.

Special values of maximum ratings

The following table shows the highest possible ambient temperatures, at which the temperature of the NTC will reach a final value of 81°C (GPRS Class 10,12 Temperature of Class Marc Change) or the final shut down temperature 90°C (GPRS Class 8 and Voice Call).

Terminal horizontal, normal position	Highest possible ambient temperature
GPRS Class 8 PCL5/Gamma3	67°C
GPRS Class 10 PCL5/Gamma3	48°C
GPRS Class 12 PCL5/Gamma3 with Power Reduction	45°C
GPRS Class 12 PCL5/Gamma3 without Power Reduction	34°C

The following table shows the longest possible duration of connection until 81°C (Temperature of Class Marc Change) will be reached at the NTC, when the ambient temperature is 65°C.

Terminal horizontal, normal position	Longest possible duration of connection
GPRS Class 10 PCL5/Gamma3	11 minutes
GPRS Class 12 PCL5/Gamma3 with Power Reduction	7 minutes
GPRS Class 12 PCL5/Gamma3 without Power Reduction	---

The following table shows the longest possible duration of connection when the Class Mark Change from GPRS Class 12 or 10 to GPRS Class 8 did not work proberly and 90°C (Temperature of Hardware shut off) will be reached at the NTC (ambient temperature is 65°C).

Terminal horizontal, normal position	Longest possible duration of connection
GPRS Class 8 PCL5/Gamma3	continous operation
GPRS Class 10 PCL5/Gamma3	22 minutes
GPRS Class 12 PCL5/Gamma3 with Power Reduction	14 minutes
GPRS Class 12 PCL5/Gamma3 without Power Reduction	---

Table 14: Characteristics power supply

Parameter	Description	Conditions		Min	Typ	Max	Unit
V_{POWER}	Operating Voltage			8 [1]	12	30	V
		for one minute				33	V
	Allowed voltage ripple (peak-peak), drop during transmit burst peak current	Talk mode, power control level for P_{out} max [1]				400	mV
I_{POWER}	Average supply current (average time 3 min.) @25°C @ worst case: GSM 900 max power level	Power Down mode	@8V		0.45		µA
			@12V		0.50		
			@30V		0.80		
		SLEEP mode	@8V		40		mA
			@12V		29		
			@30V		18		
		IDLE mode	@8V		50		mA
			@12V		36		
			@30V		21		
		TALK mode	@8V		277		mA
			@12V		184		
			@30V		82		
		Data GPRS 1Tx / 4Rx	@8V		260		mA
			@12V		173		
			@30V		77		
		Data GPRS 2Tx / 3Rx (Power reduction = 3dB)	@8V		378		mA
			@12V		248		
			@30V		108		
		Data GPRS 4Tx / 1Rx (Power reduction = 6dB)	@8V		500		mA
			@12V		330		
			@30V		140		
I_{POWER_P} [2]	Peak supply current during transmission slot (577µs * No. of Tx every 4.6ms)	Power control level for Pout max	@8V		TBD		A
			@12V		TBD		
			@30V		TBD		
$t_{PLUS-Fail}$	Allowed power fail time without terminal reset or power down	After this time the Terminal will be reset or switched off				1	ms
	Allowed power fail time without RTC reset	Backup Battery not connected, After this time the RTC will be reset			6		s
t_{R_PLUS}	Allowed rise time of V_{PLUS}	0% to 100%				20	ms

[1] Lowest voltage (minimum peak) incl. all ripple and drops >7.6V including voltage drop, ripple and spikes, measured at western jack (6-pole) pin (1 to 6)

[2] Typical values measured with antenna impedance = 50Ohm (return loss >20dB)
 Maximum values measured with mismatched antenna

Table 15: Characteristics On/Off control
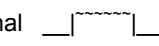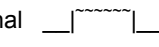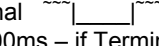
Function	Signal name	IO	Signal from and level	Comment
Emergency OFF	EMERGOFF	I	$V_L$max = 0.8V $V_L$min = -0.3V $V_H$min = 4V $V_H$max = 30V Signal __|‾‾‾‾|__ Active High ≥ 1s	Emergency off switched the power supply of the Terminal off. Data stored in the volatile memory will be lost, if used the emergency off. If unused keep pin open.
Ignition	IGT_IN	I	$V_L$max = 0.8V $V_L$min = -0.3V $V_H$min = 4V at 20µA $V_H$max = 30V at 150µA Signal __|‾‾‾‾|__ Active High ≥ 300ms	This signal switches the mobile ON. It´s possible to connect IGT_IN directly with POWER If unused keep pin open.
	ONOFF	I	R_I ≈ 30kΩ, C_I ≈ 10nF V_{IL}max = 0.5V at Imax = -150µA V_{OH}max = V_{BATT+} Signal ‾‾|____|‾‾ Active Low: ≥ 400ms – if Terminal OFF → ON ≥ 1s – if Terminal ON → OFF	This signal switches the mobile ON. This line must be driven low by an open drain or open collector driver. If unused keep pin open.

Table 16: Characteristics RS-232 interface

Function	Signal name	IO	Signal from and level	Comment
RS232	TXD RTS DTR	I I I	$R_I$min = 3kOhm V_{IL}max = 0.6V V_{IH}min = 2.4V $V_I$max = ±25V Baud rate 1.2kbps … 460kbps	If lines are unused keep pin open.
	RXD CTS DSR DCD RING	O O O O O	$V_O$min = ±5V at 3kOhm load Leakage Current max = ±25µA at Module power down.	

Table 17: Characteristics audio interface

Function	Signal name	IO	Parameter	Min.	Typ.	Max.	Unit
Microphone	MICP	I	DC (no load) at MICP	5.3	5.4	5.5	V
			DC at MICP in POWER DOWN		0		V
			DC (no load) at MICN		0		V
			DC Resistance differential MICN, MICP (balanced)	2.3	2.4	2.5	kOhm
			Impedance Z_i (balanced)	1.9	2.0	2.1	kOhm
	MICN	I	Input level U_{imax}			1.58	V_{PP}
			Gain range 6 dB steps	0		42	dB
			Frequency Range	200		3900	Hz
			fine scaling by DSP (inCalibrate)	-∞		0	dB
Earpiece	EPP	O	Impedance (balanced)	8			Ohm
			AC output level U_O *Gain* = 0dB @ 3.14 dBm0 no load		5.97		V_{PP}
			Gain range	-18		0	dB
			Gain accuracy			0.8	dB
	EPN	O	Frequency area	200		3900	Hz
			DC Offset (balanced)			100	mV
			Attenuation distortion for 200...3900Hz			1	dB
			Out-of-band discrimination		70		dB
LE_{Audio}			Length of Audio (Handset) cable			3	m

Audio Modes:

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

Table 18: AT adjustable parameters

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

Note: The parameters inCalibrate, outCalibrate and sideTone accept also values from 32768 to 65535. These values are internally truncated to 32767.

Table 19: Characteristics SIM interface for use with 3V cards

Function	Signal name	IO	Signal form and level	Comment
Reset	CCRST	O	$R_O \approx 47\Omega$ $V_{OL}max = 0.25V$ at $I = +1mA$ $V_{OH}min = 2.5V$ at $I = -0.5mA$ $V_{OH}max = 2.95V$	All signals of SIM interface are protected against ESD with a special diode array.
Data IO	CCIO	I/O	$R_I \approx 4.7k\Omega$ $V_{IL}max = 0.75V$ $V_{IL}min = -0.3V$ $V_{IH}min = 2.1V$ $V_{IH}max = CCVCCmin + 0.3V = 3.05V$ $R_O \approx 100\Omega$ $V_{OL}max = 0.3V$ at $I = +1mA$ $V_{OH}min = 2.5V$ at $I = -0.5mA$ $V_{OH}max = 2.95V$	
Clock	CCCLK	O	$R_O \approx 100\Omega$ $V_{OL}max = 0.3V$ at $I = +1mA$ $V_{OH}min = 2.5V$ at $I = -0.5mA$ $V_{OH}max = 2.95V$	
Supply	CCVCC	O	$V_O min = 2.75V$ $V_O typ = 2.85V$ $V_O max = 2.95V$ $I_O max = -20mA$	
Ground	CCGND		Ground	

Table 20: Characteristics SIM interface for use with 1.8V cards

Function	Signal name	IO	Signal form and level	Comment
Reset	CCRST	O	$R_O \approx 47\Omega$ $V_{OL}max = 0.25V$ at $I = +1mA$ $V_{OH}min = 1.45V$ at $I = -0.5mA$ $V_{OH}max = 1.90V$	All signals of SIM interface are protected against ESD with a special diode array.
Data IO	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 $I = -0.5mA$ $V_{OH}max = 1.90V$	
Clock	CCCLK	O	$R_O \approx 100\Omega$ $V_{OL}max = 0.3V$ at $I = +1mA$ $V_{OH}min = 1.45V$ at $I = -0.5mA$ $V_{OH}max = 1.90V$	
Supply	CCVCC	O	$V_O min = 1.70V$ $V_O typ = 1.80V$ $V_O max = 1.90V$ $I_O max = -20mA$	
Ground	CCGND		Ground	

Table 21: Characteristics GPIOs

Function	Signal name	IO	Signal form and level	Comment
General Purpose Input/Output	IO1 IO2 IO3 IO4 IO5 IO6 IO7 IO8 IO9 IO10	I/O I/O I/O I/O I/O I/O I/O I/O I/O I/O	$R_O \approx 100\Omega$ $V_{OL}max = 0.4V$ at $I = 2mA$ $V_{OH}min = 2.50V$ at $I = -0.5mA$ $V_{OH}max = 3.05V$ $V_{IL}max = 0.8V$ $V_{IH}min = 2.0V$ $V_{IH}max = 3.05V$	If unused keep pins with a pull up or pull down resistor while the GPIO is set to input. Alternatively IO10 can be used as pulse counter (input frequency range of 0Hz to 1000Hz).

Table 22: Characteristics I2C interface

Function	Signal name	IO	Signal form and level	Comment
I^2C interface	I2CCLK_SPICLK	O	$R_O \approx 33\Omega$ $V_{OL}max = 0.25V$ at $I = 2mA$ $V_{OH}min = 2.50V$ at $I = -0.5mA$ $V_{OH}max = 3.05V$	I2CDAT is configured as Open Drain and needs a pull-up resistor in the host application. According to the I2C Bus Specification Version 2.1 for the fast mode a rise time of max. 300ns is permitted. There is also a maximum $V_{OL}=0.4V$ at 3mA specified. The value of the pull-up depends on the capacitive load of the whole system (I2C Slave + lines). The maximum sink current of I2CDAT and I2CCLK is 4mA. If lines are unused keep pins open.
	I2CDAT_SPIDO	I/O	$R_O \approx 33\Omega$ $V_{OL}max = 0.25V$ at $I = 2mA$ $V_{IL}max = 0.8V$ $V_{IH}min = 2.0V$ $V_{IH}max = 3.05V$	

Table 23: Characteristics SPI interface

Function	Signal name	IO	Signal form and level	Comment
SPI1 Serial Peripheral Interface 1	I2CCLK_SPICLK	O	$R_O \approx 33\Omega$ $V_{OL}max = 0.25V$ at $I = 2mA$ $V_{OH}min = 2.50V$ at $I = -0.5mA$ $V_{OH}max = 3.05V$ $V_{IL}max = 0.8V$ $V_{IH}min = 2.0V$ $V_{IH}max = 3.05V$	If the Serial Peripheral Interface 1 active I^2C interface is not available. If lines are unused keep pins open.
	I2CDAT_SPIDO	O		
	SPICS	O		
	SPIDI	I		

Table 24: Characteristics ADC interface

Function	Signal name	IO	Signal form and level	Comment
Analog/ Digital Converter balanced input	Input 1: AD1_IN_P AD1_IN_N Input2: AD2_IN_P AD2_IN_N	I I I I	Single ended input voltage V_I min = 500mV, $V_I$max = 6.0V Differential Input Voltage min = 0V, $V_I$max = 5.0V Underflow: $V_i \geq 50mV$ Overflow: $V_i \geq 5050$ mV Ri single ended ≈ 600k Ri balanced ≈ 1200k Cut-off frequency: f_C= 30Hz Common-mode rejection ratio: CMRR >60dB Sensitivity, accuracy: 2400 steps @ 500mV 1step = 2.08mV Offset:+/- 2.08mV Measurement interval 100ms – 30s selectable by AT command	AD1_IN and AD2_IN are balanced lines and multiplexed with an analog switch. Both inputs are filtered by a low pass

Table 25: RF Connector

Parameter	Conditions	Min.	Typical	Max.	Unit
GPRS connectivity	GPRS multislot class 12				
	Time slots Rx			4	
GPRS coding schemes	Time slots Tx			4	
	Full implementation CS-1,CS-2,CS-3, CS-4				
GSM Class	Small MS class B				
Frequency range	EGSM 850	824		894	MHz
	GSM 900	880		1785	MHz
	GSM 1800	1710		1880	MHz
	GSM 1900	1850		1990	MHz
Receiver input Sensitivity @ antenna connector Under all propagation conditions according to GSM Spec.	EGSM 850	-102			dBm
	GSM 900	-102			dBm
	GSM 1800	-102			dBm
	GSM 1900	-102			dBm
Receiver input Sensitivity @ antenna connector BER Class II<=2.43% @ static input level (no fading)	EGSM 850	-102	-105		dBm
	GSM 900	-102	-105		dBm
	GSM 1800	-102	-105		dBm
	GSM 1900	-102	-105		dBm
RF power @ antenna connector (50Ω Load) Under normal conditions [3]	EGSM 850		31,9		dBm
	GSM 900		31,9		dBm
	GSM 1800		29,2		dBm
	GSM 1900		29,2		dBm

6   Full Type Approval

The Siemens reference setup submitted to type approve TC65 Terminal consists of the following components:

- TC65 Terminal with approved GSM module TC65
- Votronic Handset type
- PC as MMI
- Power Supply: Mains adapter Sphere Design Type 39020
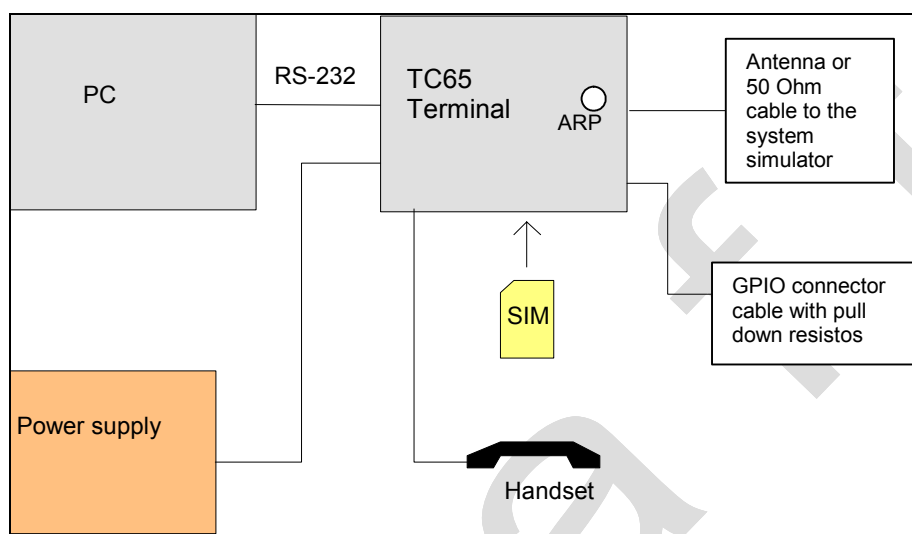- GPIO connector cable with pull down resistors. Please note that this cable is not available for customer.

Figure 17: Reference equipment for approval

For ordering information please refer to Chapter 7.

6.1   Cable Requirements

The cable length of following interfaces may not exceed the maximum of 3m:
- Serial interface (RS232)
- Audio interface
- Antenna interface
- ADC inputs
- GPIOs

It is recommended to keep the digital lines for I²C-, SPI- lines as short as possible (≤150mm).

6.2 Restrictions

Later enhancements and modifications beyond the certified configuration require extra approvals. Each supplementary approval process includes submittal of the technical documentation as well as testing of the changes made.

- No further approvals are required for customer applications that comply with the approved TC65 Terminal configuration.
- Extra approval must be obtained for applications using other accessories than those included in the approved TC65 Terminal configuration (handset, power supply, MMI implementation supported by AT commands).

6.3 CE Conformity

The TC65 Terminal meets the requirements of the EU directives listed below:

- R&TTE Directive 1999/5/EG
- LVD 73/23/EEC
- EMC conformity in accordance with Directive 89/336/EEC

6.4 Electromagnetic Compatibility (EMC)

The TC65 Terminal meets EN 301489-7 requirements of equipment for vehicular and fixed use.
(Note: V_{POWER} voltage dip or interruption corresponding to a reduction of the supply voltage of >30% for >1ms does reset or shut down the terminal.)
The TC65 Terminal does not resist against test pulse 5 according ISO 7637-2 (load dump at vehicles 24 volt supply voltage). The internal slow acting, not removable fuse will be damaged. It's recommended to use an external fast acting fuse 1.25A with melting integral I^2t (0.9…1.3)A^2s.

7 List of Parts and Recommended Accessories

Table 26: List of parts and accessories

Description	Supplier	Ordering information
TC65 Terminal	Siemens	Siemens ordering number: L36880-N8670-A100
Mounting kit for top/hat rail installation		TBD
Power supply unit Primary adapter (US)	Sphere Design	Ordering number: 39020 Ordering number: 39004 Sphere Design Saarpfalz-Park 17 D-66450 Bexbach / Saar Phone: +49-6826-5200-0 Fax: +49-6826-5200-25 E-Mail: info@spheredesign.de http://www.spheredesign.de
Handset	Votronic	Ordering number: HH-SI-30.3/V1.1/0 Votronic GmbH Saarbrücker Str. 8 D-86386 St. Ingbert Phone: +49-6894-9255-44 Fax: +49-6894-9255-88
Antenna Magnet. Mount US (GSM 850 +GSM 1900) EU (GSM 900 +GSM 1800) Direct Mount US (GSM 850 +GSM 1900) EU (GSM 900 +GSM 1800)	Smarteq Smarteq Bondale Bondale Radiall	MiniMag 1140.26 MiniMag 1140.27 E-Mail: info@smarteq.se http://www.smarteq.com TBD TBD http://www.bondale.com R380.900.307 http://www.radiall.com

Description	Supplier	Ordering information
GPIO-Connector	Tyco Electronics AMP	Ordering Numbers: Receptacle Housing Micro Mate-N_LOK 3mm: 2-794617-4 Crimp Snap_In Receptacle Contacts: 79460-1 (24 pieces/housing for full assembly) Hand Tool CERTI-CRIMP II Straight: 91501-1 http://www.tycoelectronics.com/cust.stm
Rail Clip	Firma Richard Wöhr GmbH	Ordering number: Hutsclip/AL/0002 **Richard Wöhr GmbH** Gräfenau 58-60 D-75339 Höfen/Enz Phone: +49-7081-9540-0 Fax: +49-7081-9540-90 E-Mail: info-ig@woehrgmbh.de http://www.industriegehaeuse.woehrgmbh.de
Screws for Rail Clip	EJOT GmbH & Co. KG	Ordering number: EJOT Delta PT Screw WN5454,40x11-S http://www.ejot.de