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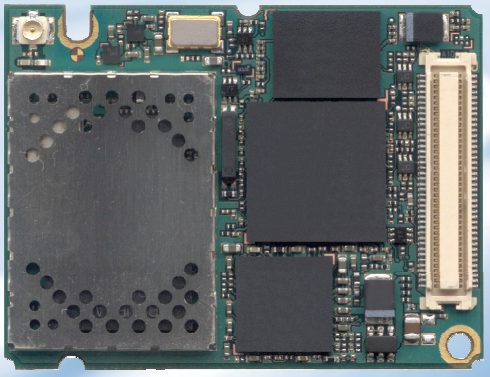

TC65
Siemens Cellular Engine

Version: 00.450
DocID: TC65_HD_V00.450

Hardware Interface Description

Document Name:	**TC65 Hardware Interface Description**
Version:	**00.450**
Date:	**April 20, 2005**
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New document: "TC65 Hardware Interface Description" Version **00.450**

Chapter	What is new
Throughout manual	IGT line needs to be driven low for at least 400ms
2.1	Updated description of I^2C and SPI.
3.1	New chapter: Operating Modes
3.3.1	Added remarks on different operating modes.
3.3.3.3	Added remark on shutdown threshold in IDLE mode.
3.5.2	New chapter to describe requirements to control end of charging.
3.5.4	Updated recommended battery specifications.
3.5.7	Added remark on how to switch the module off when in Charging-only mode.
3.6	New chapter: Summary of State Transitions (Except SLEEP Mode)
3.12	More detailed description of AT^SSPI.
3.14.1	Updated forward time of SYNC signal during transmit burst.
5.2	Added remark on temperature tolerances.
5.3	Renamed pins of I2C and SPI.
5.4	Changed table “Current consumption during transmit burst”

1 Introduction

This document describes the hardware of the Siemens TC65 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] TC65 AT Command Set
[2] TC65 Release Notes 00.450
[3] DSB75 Support Box - Evaluation Kit for Siemens Cellular Engines
[4] Application 07: Rechargeable Lithium Batteries in GSM Applications (not yet available)
[5] Multiplexer User's Guide (not yet available)

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 TC65
B	Thermistor Constant
B2B	Board-to-board connector
BER	Bit Error Rate
BTS	Base Transceiver Station
CB or CBM	Cell Broadcast Message
CE	Conformité Européene (European Conformity)
CHAP	Challenge Handshake Authentication Protocol
CPU	Central Processing Unit
CS	Coding Scheme
CSD	Circuit Switched Data
CTS	Clear to Send
DAC	Digital-to-Analog Converter
DAI	Digital Audio Interface
dBm0	Digital level, 3.14dBm0 corresponds to full scale, see ITU G.711, A-law
DCE	Data Communication Equipment (typically modems, e.g. Siemens GSM engine)
DCS 1800	Digital Cellular System, also referred to as PCN
DRX	Discontinuous Reception
DSB	Development Support Box
DSP	Digital Signal Processor
DSR	Data Set Ready
DTE	Data Terminal Equipment (typically computer, terminal, printer or, for example, GSM application)
DTR	Data Terminal Ready
DTX	Discontinuous Transmission
EFR	Enhanced Full Rate
EGSM	Enhanced GSM
EIRP	Equivalent Isotropic Radiated Power
EMC	Electromagnetic Compatibility
ERP	Effective Radiated Power

Abbreviation	Description
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
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 engine), 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

Abbreviation	Description
PPP	Point-to-point protocol
PSK	Phase Shift Keying
PSU	Power Supply Unit
R&TTE	Radio and Telecommunication Terminal Equipment
RAM	Random Access Memory
RF	Radio Frequency
RMS	Root Mean Square (value)
ROM	Read-only Memory
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 engine)
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
Phonebook abbreviations	
FD	SIM fixdialing phonebook
LD	SIM last dialing phonebook (list of numbers most recently dialed)
MC	Mobile Equipment list of unanswered MT calls (missed calls)
ME	Mobile Equipment phonebook
ON	Own numbers (MSISDNs) stored on SIM or ME
RC	Mobile Equipment list of received calls
SM	SIM phonebook

1.3 Type Approval

TC65 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)

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	"Overview of PCS Type certification review board Mobile Equipment Type Certification and IMEI control" PCS Type Certification Review board (PTCRB), Version 3.1.0
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"
ETSI EN 301 511	"V7.0.1 (2000-12) Candidate Harmonized European Standard (Telecommunications series) Global System for Mobile communications (GSM); Harmonized standard for mobile stations in the GSM 900 and DCS 1800 bands covering essential requirements under article 3.2 of the R&TTE directive (1999/5/EC) (GSM 13.11 version 7.0.1 Release 1998)"
GCF-CC	"Global Certification Forum - Certification Criteria" V3.16.0
ETSI EN 301 489-1	"V1.2.1 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	"V1.1.1 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)"
EN 60 950	Safety of information technology equipment (2000)

Requirements of quality

IEC 60068 Environmental testing

DIN EN 60529 IP codes

Compliance with international rules and regulations

Manufacturers of mobile or fixed devices incorporating TC65 modules are advised to have their completed product tested and approved for compliance with all applicable national and international regulations. As a quad-band GSM/GPRS engine designed for use on any GSM network in the world, TC65 is required to pass all approvals relevant to operation on the European and North American markets. For the North American market this includes the Rules and Regulations of the Federal Communications Commission (FCC) and PTCRB, for the European market the R&TTE Directives and GCF Certification Criteria must be fully satisfied.

The FCC Equipment Authorization granted to the TC65 Siemens reference application is valid *only* for the equipment described in Section 8.1.

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 TC65 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)

Note: Usage of TC65 in a fixed, mobile or portable application is not allowed without a new FCC certification.

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. 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.

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, 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	3.2V to 4.5V
Power consumption	Sleep mode: max. TBD Power down mode: typically 50µA
Java platform	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.
Operating temperature	-30°C to +65°C ambient temperature Auto switch-off at +90°C board temperature (preliminary)
Physical	Dimensions: 33.9mm x 44.6mm x max. 3.5mm Weight: approx. 7.5g
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

Feature	Implementation
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 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
SIM Application Toolkit	SAT Release 99
TCP/IP stack	Access by AT commands
IP addresses	IP version 6
Remote SIM Access	TC65 supports Remote SIM Access. RSA enables TC65 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	Download over serial interface ASC0 Download over SIM interface Download over USB
Interfaces	
2 serial interfaces	ASC0 • 8-wire modem interface with status and control lines, unbalanced, asynchronous • 1.2kbps to 460kbps • Autobauding TBD • Supports RTS0/CTS0 hardware handshake and software XON/XOFF flow control. • Multiplex ability according to GSM 07.10 Multiplexer Protocol.

Feature	Implementation
	ASC1 • 4-wire, unbalanced asynchronous interface • 1.2kbps to 460kbps • Autobauding TBD • 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 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	• 2 analog interfaces • 1 digital interface (PCM)
SIM interface	Supported SIM cards: 3V, 1.8V
Antenna	50Ohms. External antenna can be connected via antenna connector or solderable pad.
Module interface	80-pin board-to-board connector
Power on/off, Reset	
Power on/off	• Switch-on by hardware pin 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 pin EMERG_RST
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 pins of the application interface programmable as GPIO. Programming is done via AT commands.
Phonebook	SIM and phone
Evaluation kit	
DSB75	DSB75 Evaluation Board designed to test and type approve Siemens cellular engines and provide a sample configuration for application engineering.

2.2 TC65 System Overview

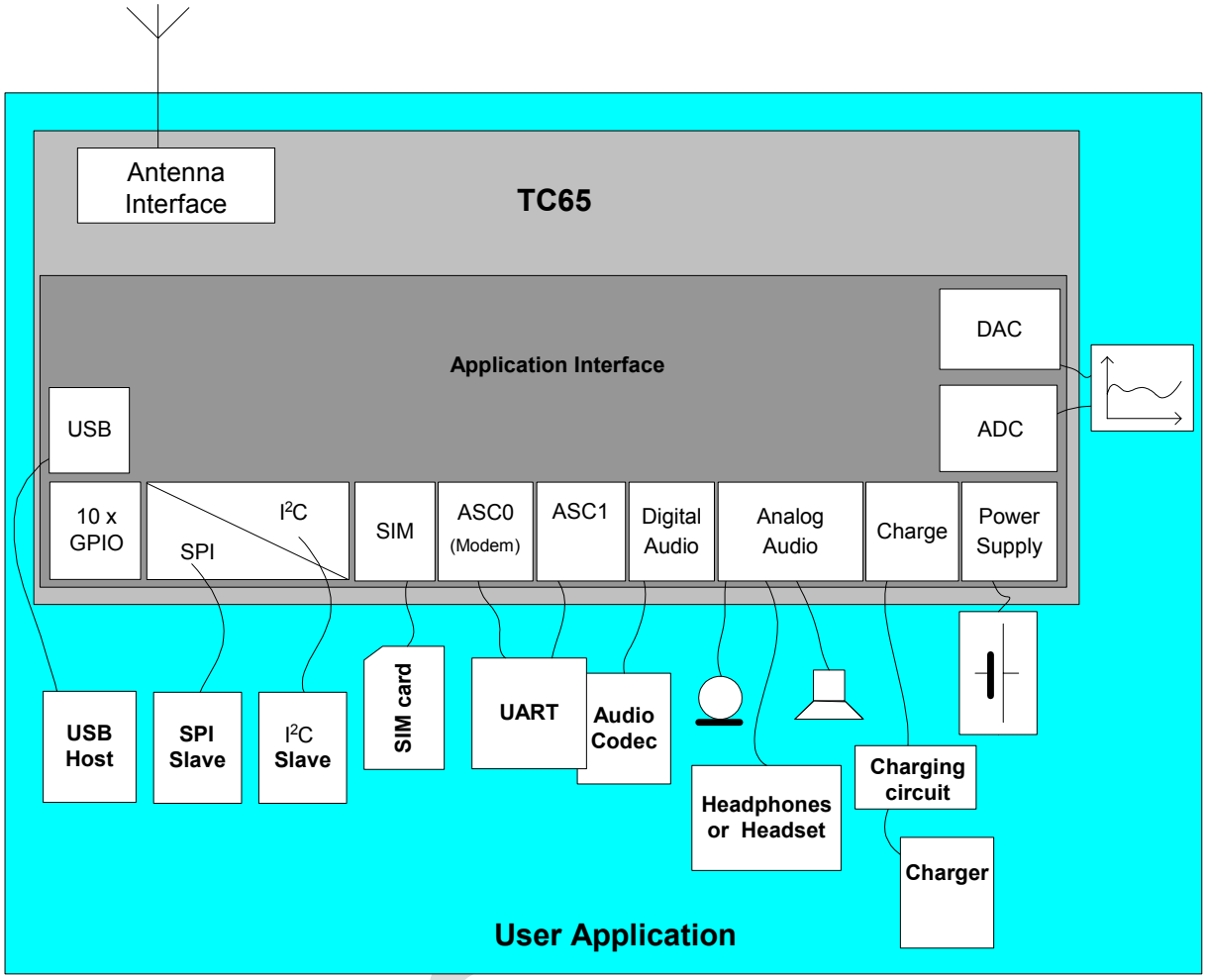

Figure 1: TC65 system overview

2.3 Circuit Concept

Figure 2 shows a block diagram of the TC65 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

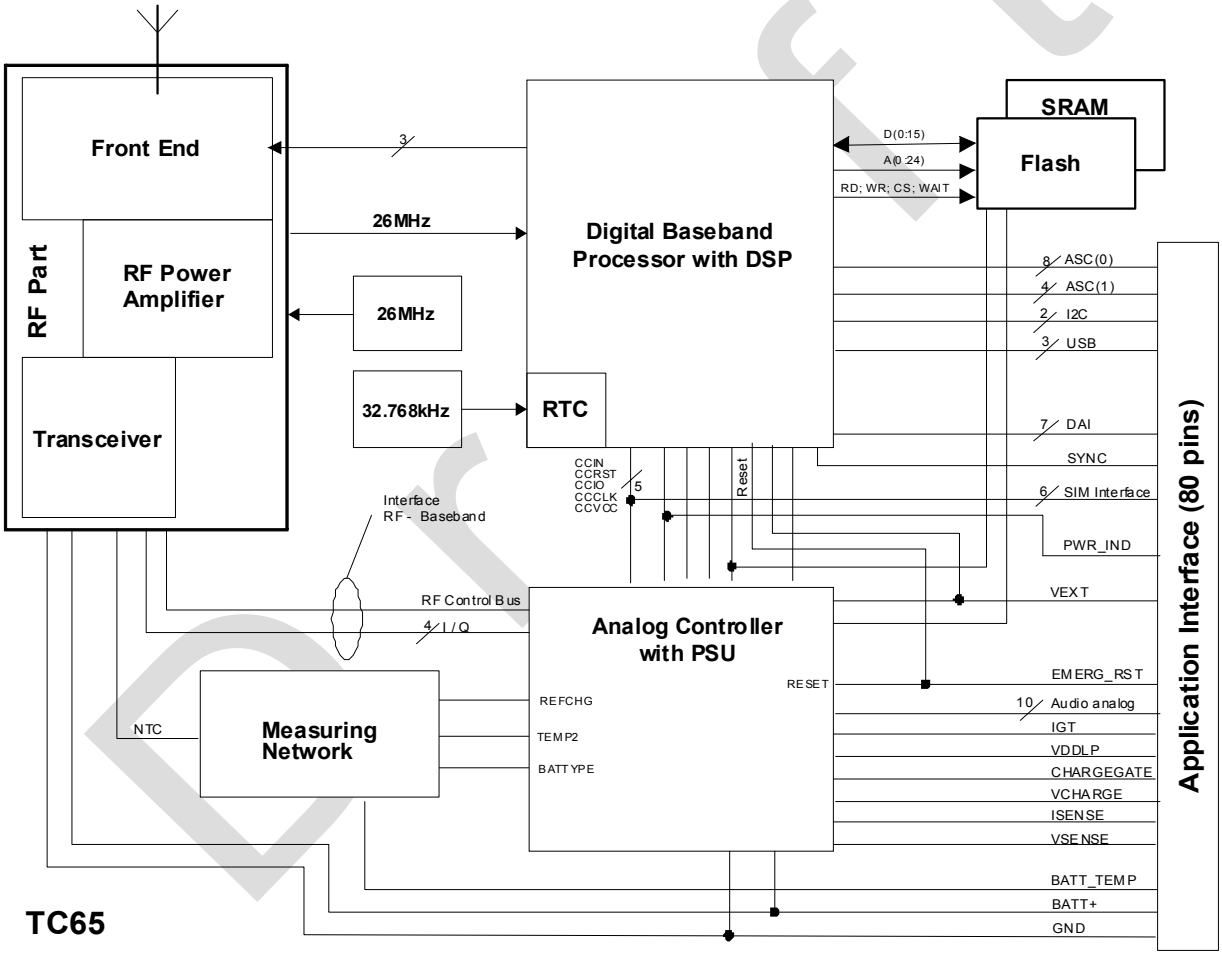

Figure 2: TC65 block diagram

3 Application Interface

TC65 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 chapters:

- Power supply - see Section 3.1
- Charger interface – see Section 3.5
- SIM interface - see Section 3.8
- Serial interface ASC0 - see Section 3.9
- Serial interface ASC1 - see Section 3.10
- Serial interface USB - see Section 3.11
- Serial interface I²C - see Section 3.12
- Two analog audio interfaces - see Section 3.13
- Digital audio interface (DAI) - see Section 3.13 and 3.13.4
- Status and control lines: IGT, EMERG_RST, PWR_IND, SYNC - see Table 17

3.1 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 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 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 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 EGPRS IDLE	Module is ready for GPRS/EGPRS data transfer, but no data is currently sent or received. Power consumption depends on network settings and GPRS/EGPRS configuration (e.g. multislot settings).
	GPRS DATA EGPRS DATA	GPRS/EGPRS data transfer in progress. Power consumption depends on network settings (e.g. power control level), uplink / downlink data rates, GPRS/EGPRS 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 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/EGPRS 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 6 for the various options proceeding from one mode to another.

3.2 Power Supply

TC65 needs to be connected to a power supply at the B2B connector (5 pins each BATT+ and GND).

The power supply of TC65 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.
- Switches the module's power voltages for the power up and down procedures.
- Delivers, across the VEXT pin, 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 TC65 board, not even in a transmit burst where current consumption can rise to typical peaks of 2A. It should be noted that TC65 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 = 0.35V

V_{batt}min = $V_I$min + Dmax
V_{batt}min = 3.2V + 0.35V = 3.55V

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.

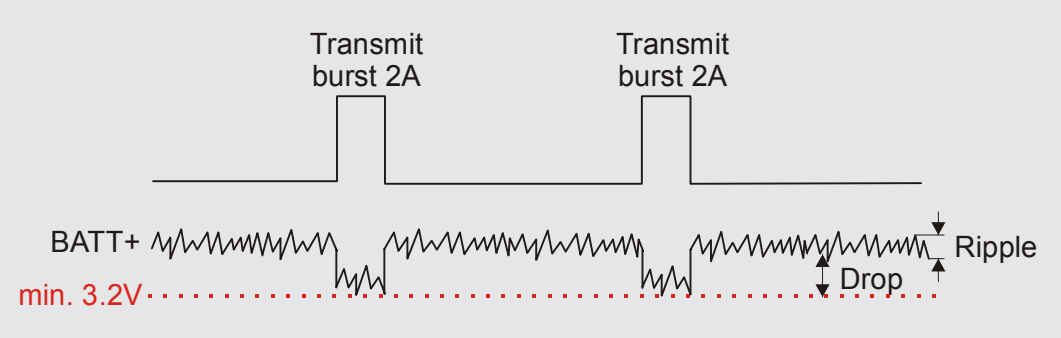

Figure 3: Power supply limits during transmit burst

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, both accessible at a capacitor located close to the board-to-board connector of the module.

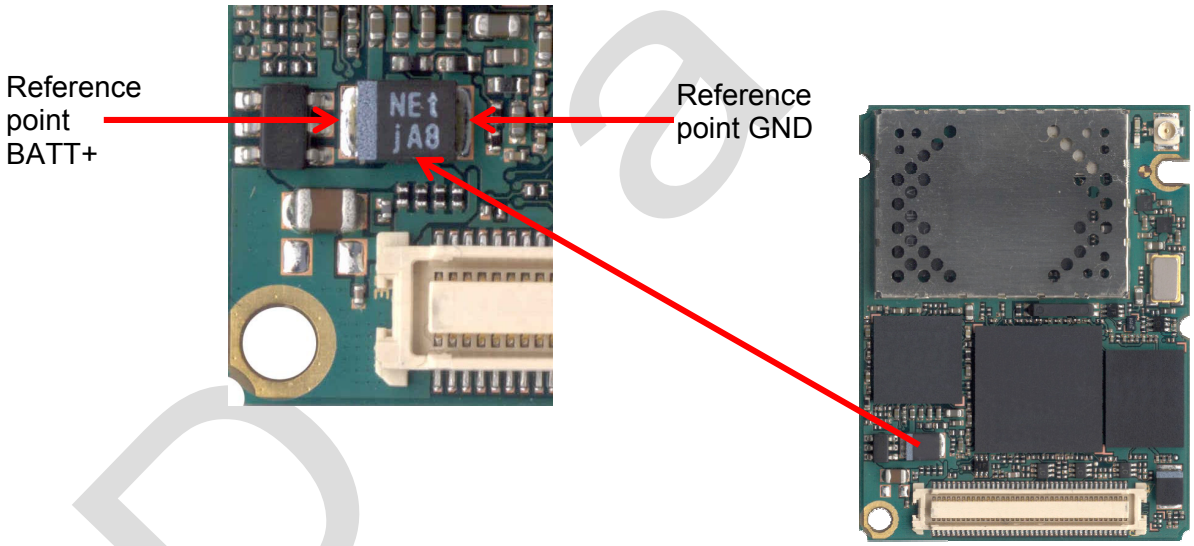

Figure 4: Position of the reference points BATT+ and GND

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 TC65 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 TC65 while it is beyond the safety limits of voltage and temperature stated in Chapter 5. TC65 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 TC65

TC65 can be started in a variety of ways as described in the following sections:
- 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 3.3.1.3)
- Hardware driven start-up by VCHARGE line: starts charging algorithm and charge-only mode (see Section 3.3.1.2)
- 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.

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

3.3.1.1 Turn on TC65 Using Ignition Line IGT

When the TC65 module is in Power-down 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 pin.

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.

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 from the moment the voltage at BATT+ is available.

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.

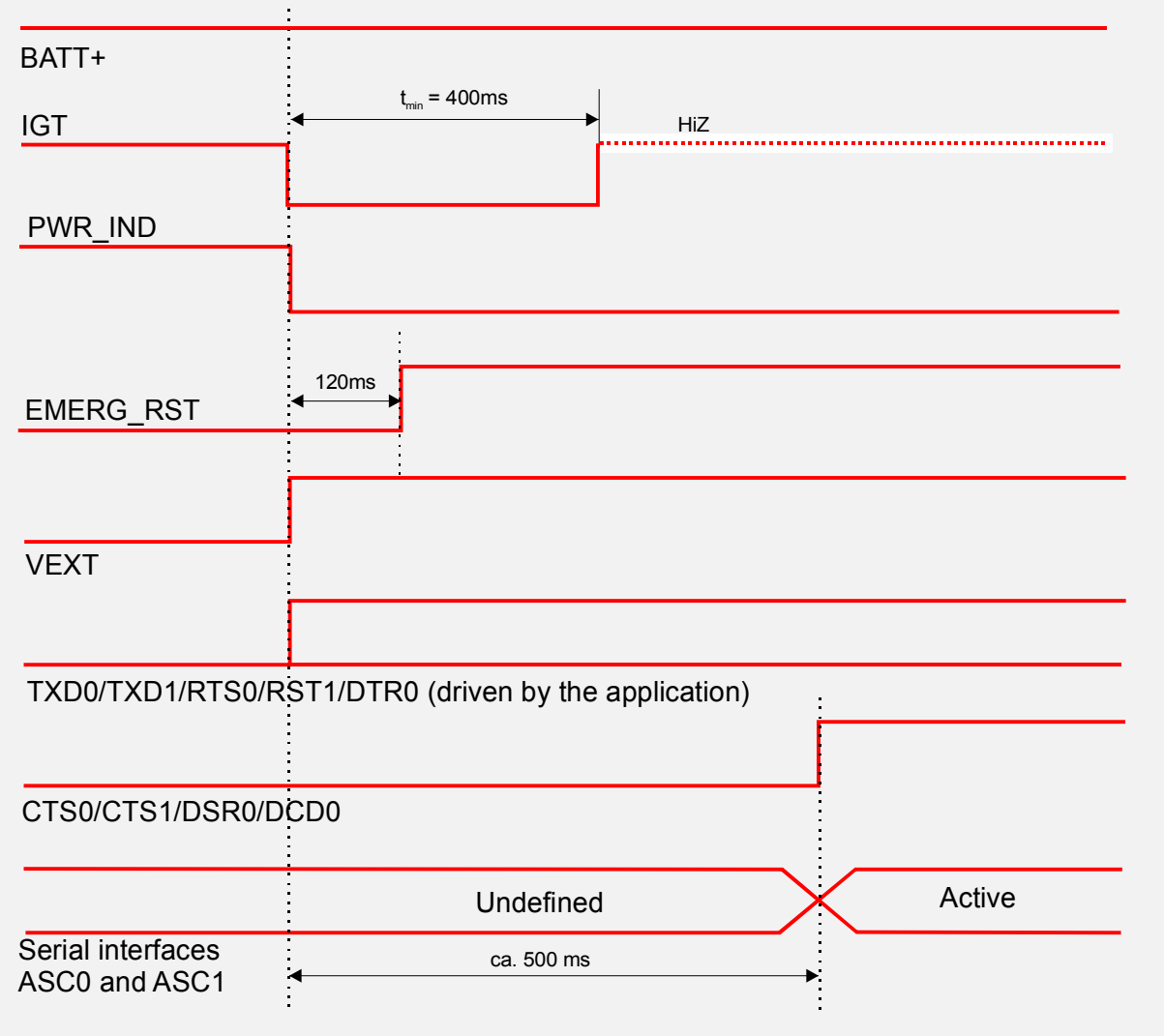

Figure 5: Power-on with operating voltage at BATT+ applied before activating IGT

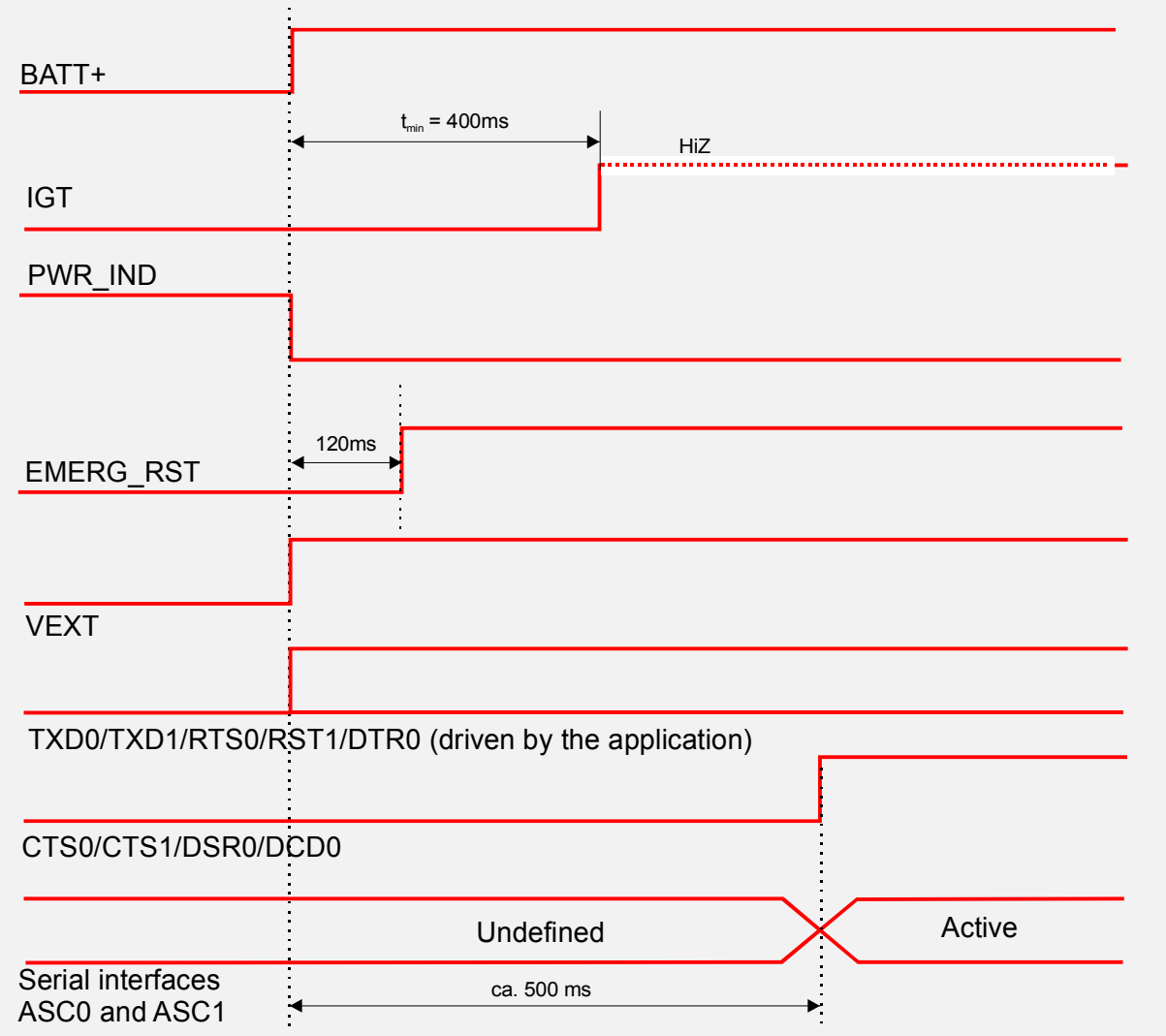

Figure 6: Power-on with IGT held low before switching on operating voltage at BATT+

3.3.1.2 Turn on TC65 Using the VCHARGE Signal

As detailed in Section 3.5.7, 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 pin while TC65 is off, and the battery voltage is above the undervoltage lockout threshold, processor controlled fast charging starts (see Section 3.5.6). TC65 enters a restricted mode, referred to as Charge-only mode where only the charging algorithm will be launched.

During the Charge-only mode TC65 is neither logged on to the GSM network nor are the serial interfaces fully accessible. To switch to normal operation and log on to the GSM network, the IGT line needs to be activated as described in Section 3.3.1.

3.3.1.3 Reset TC65 via AT+CFUN Command

To reset and restart the TC65 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.

3.3.1.4 Reset TC65 in Case of Emergency via EMERG_RST

Caution: Use the EMERG_RST pin only when, due to serious problems, the software is not responding for more than 5 seconds. Pulling the EMERG_RST pin causes the loss of all information stored in the volatile memory since the processor restarts immediately. Therefore, this procedure is intended only for use in case of emergency, e.g. if TC65 does not respond, if reset or shutdown via AT command fails.

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

To actually reset the TC65 module, the EMERG_RST line must be pulled to ground for ≥10ms. After releasing the line TC65 will start again.

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.

3.3.2 Turn off TC65

TC65 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.

3.3.2.1 Turn off TC65 Using AT Command

The best and safest approach to powering down TC65 is to issue the AT^SMSO command. This procedure lets TC65 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 pin. 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 7.

While TC65 is in Power-down mode the application interface is switched off and must not be fed from any other source. Therefore, your application must be designed to avoid any current flow into any digital pins of the application interface, especially of the serial interfaces. No special care is required for the USB interface which is protected from reverse current.

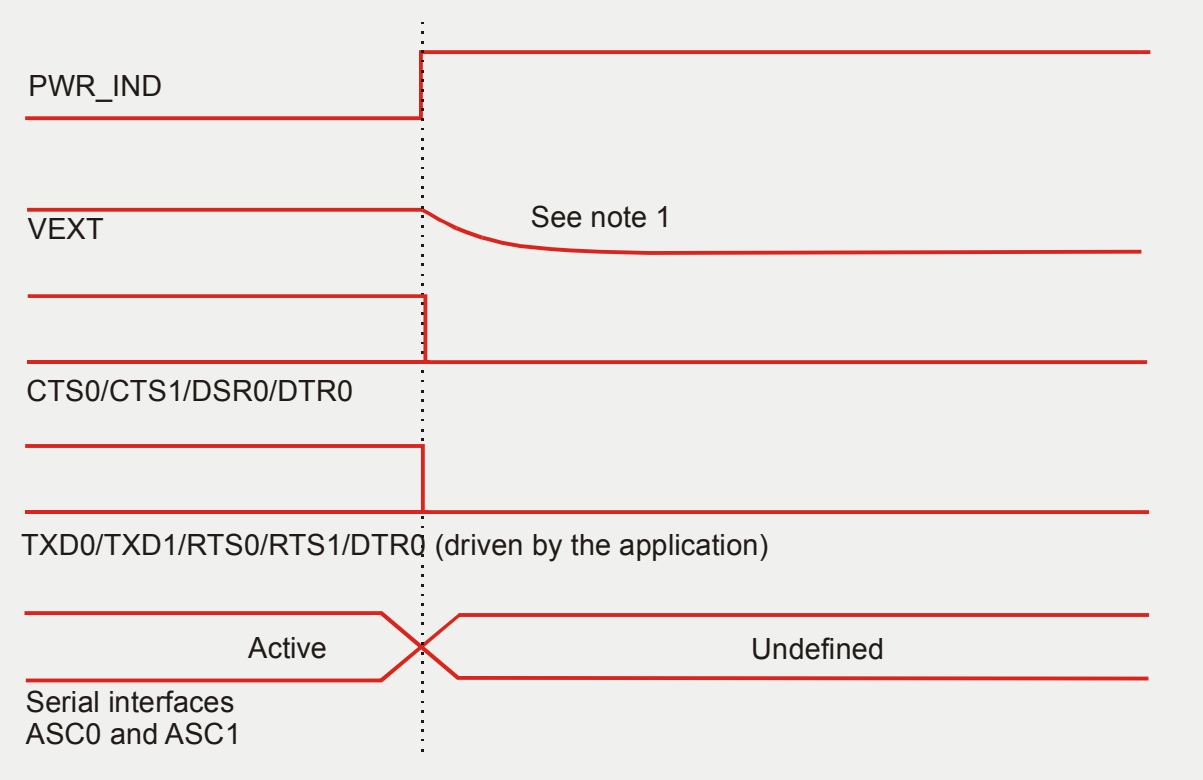

Figure 7: Signal states during turn-off procedure

Note 1: Depending on capacitance load from host application

3.3.2.2 Leakage Current in Power Down Mode

The leakage current in Power Down mode varies depending on the following conditions:

- If the supply voltage at BATT+ was disconnected and then applied again without starting up the TC65 module, the leakage current ranges between 90µA and 100µA.
- If the TC65 module is started and afterwards powered down with AT^SMSO, then the leakage current is only 50µA.

Therefore, in order to minimize the leakage current take care to start up the module at least once before it is powered down.

3.3.3 Automatic Shutdown

Automatic shutdown takes effect if:
- the TC65 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 3.5.7 for exceptions.

The automatic shutdown procedure is equivalent to the Power-down initiated with the AT^SMSO command, i.e. TC65 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 Chapters 3.3.3.1 to 3.3.3.4 for details. For further instructions on AT commands refer to [1].

3.3.3.1 Temperature Dependent 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 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, TC65 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 for 15 seconds time after start-up of TC65. After 15 seconds operation, the presentation will be disabled, i.e. no alert messages can be generated.
- URCs indicating the level "2" or "-2" are instantly followed by an orderly shutdown. The presentation of these URCs is always enabled, i.e. they will be output even though the factory setting AT^SCTM=0 was never changed.

The maximum temperature ratings are stated in Table 16. Refer to Table 2 for the associated URCs. All statements are based on test conditions according to IEC 60068-2-2 (still air).

Table 2: Temperature dependent behavior

Sending temperature alert (15s after TC65 start-up, otherwise only if URC presentation enabled)	
^SCTM_A: 1	Caution: T_{amb} of battery close to overtemperature limit.
^SCTM_B: 1	Caution: T_{amb} of board close to overtemperature limit.
^SCTM_A: -1	Caution: T_{amb} of battery close to undertemperature limit.
^SCTM_B: -1	Caution: T_{amb} of board close to undertemperature limit.
^SCTM_A: 0	Battery back to uncritical temperature range.
^SCTM_B: 0	Board back to uncritical temperature range.
Automatic shutdown (URC appears no matter whether or not presentation was enabled)	
^SCTM_A: 2	Alert: T_{amb} of battery equal or beyond overtemperature limit. TC65 switches off.
^SCTM_B: 2	Alert: T_{amb} of board equal or beyond overtemperature limit. TC65 switches off.
^SCTM_A: -2	Alert: T_{amb} of battery equal or below undertemperature limit. TC65 switches off.
^SCTM_B: -2	Alert: T_{amb} of board equal or below undertemperature limit. TC65 switches off.

3.3.3.2 Temperature Control during Emergency call

If the temperature limit is exceeded while an emergency call is in progress the engine continues to measure the temperature, but deactivates the shutdown functionality. If the temperature is still out of range when the call ends, the module switches off immediately (without another alert message).

3.3.3.3 Undervoltage Shutdown if Battery NTC is Present

In applications where the module's charging technique is used and an NTC is connected to the BATT_TEMP terminal, the software constantly monitors the applied voltage. If 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.

To enable or disable the URC use the AT^SBC command. The URC will be enabled when you enter the write command and specify the current consumption of your host application. Step by step instructions are provided in [1].

3.3.3.4 Undervoltage Shutdown if no Battery NTC is Present

The undervoltage protection is also effective in applications, where no NTC connects to the BATT_TEMP terminal. Thus, you can take advantage of this feature even though the application handles the charging process or TC65 is fed by a fixed supply voltage. All you need to do is executing the write command AT^SBC=<current> which automatically enables the presentation of URCs. You do not need to specify <current>.

Whenever the supply voltage falls below the value of 3.2V the URC
^SBC: Undervoltage
appears several times before the module switches off.

3.3.3.5 Overvoltage Shutdown

In the event of the maximum voltage of 4.6V is reached the module sends a URC and then performs an orderly shutdown. Further details: TBD

Keep in mind that several TC65 components are directly linked to BATT+ and, therefore, the supply voltage remains applied at major parts of TC65, 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 increases to the limit specified for restricted operation[1)] 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 to a value of 5 degrees below the limit of restricted operation, TC65 returns to the higher Multislot Class. If the temperature stays at the critical level or even continues to rise, TC65 will not switch back to the higher class.

After a transition from GPRS Multislot Class 12 or 10 to GPRS Multislot Class 8 a possible switchback to GPRS Multislot Class 12 or 10 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 3.3.3.1.

[1)] See Table 16 for temperature limits known as restricted operation.

3.5 Charging Control

TC65 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 battery specifications. Please refer to [4] 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

TC65 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 38.

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 TC65 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: final charge current (50mA) plus current consumption of the external application. If used the current flowing over the VEXT pin of the application interface (typically 2.9V) must be added, too.

The parameter <current> is volatile, meaning that the factory default (0mA) 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 3. It is recommended that the battery pack you want to integrate into your TC65 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 recommended capacity of 1000 to 1200mAh.
- 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 ±5% @ 25°C, $B_{25/85}$* = 3423K to B =3435K ± 3% (alternatively acceptable: *10kΩ ±2% @ 25°C, $B_{25/50}$ = 3370K ±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 TC65 module, a built-in measuring circuit constantly monitors the supply voltage. In the event of undervoltage, it causes TC65 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 TC65 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 8 shows the circuit diagram of a typical battery pack design that includes the protection elements described above.

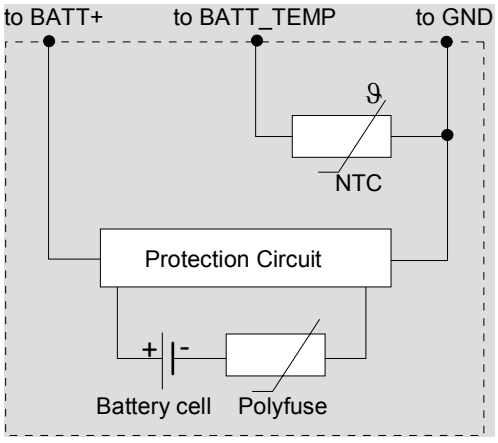

Figure 8: Battery pack circuit diagram

Table 3: Specifications of battery packs suitable for use with TC65

Battery type	Rechargeable Lithium Ion or Lithium Polymer battery
Nominal voltage	3.6V / 3.7V
Capacity	Recommended: 1000mAh to 1200mAh Minimum: 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	2.5 ± 0.05V
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 Batteries Recommended for Use with TC65

When you choose a battery for your TC65 application you can take advantage of one of the following two batteries offered by VARTA Microbattery GmbH. Both batteries meet all requirements listed above. They have been thoroughly tested by Siemens, proved to be suited for TC65, and are CE approved.

- LIP 633450A1B PCM.STB, type Lithium Ion
  This battery is listed in the standard product range of VARTA. It is incorporated in a shrink sleeve and has been chosen for integration into the reference setup submitted for Type Approval of Siemens GSM modules.
- LPP 503759CA PCM.NTC.LT50, type Lithium Polymer
  This battery has been especially designed by VARTA for use with Siemens GSM modules. It has the same properties as the above Li-Ion battery, except that it is type Polymer, is smaller and comes without casing.

Specifications, construction drawings and sales contacts for both VARTA batteries can be found in Section 9.3.

3.5.5 Charger Requirements

For using the implemented charging algorithm and the reference charging circuit recommended in [4] and in Figure 38, the charger has to meet the following requirements:

Output voltage: 5.2Volts ±0.2V (stabilized voltage)

Output current: 500mA
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 [4] for further details.

3.5.6 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.
- 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 5mA, in case of undervoltage (Undervoltage Lockout at V_{BATT+}= 2.5…3.2V) it is charged with 30mA

Software controlled charging:

- Controlled over the CHARGEGATE.
- Temperature conditions: 0°C to 45°C
- 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. 500mA) until the battery voltage reaches 4.2V (approx. 80% of the battery capacity).
  - Top-up charging: The battery is charged with constant voltage of 4.2V at stepwise reducing charge current until full battery capacity is reached.
- The duration of software controlled charging depends on the battery capacity and the level of discharge.

3.5.7 Operating Modes during Charging

Of course, the battery can be charged regardless of the engine'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 pin while TC65 is in Power-down mode, TC65 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:

- To switch from Charge-only mode to Normal mode drive the ignition line (IGT) to ground for 1 second.
- To switch from Charge-only mode to Airplane mode enter the command *AT^SCFG=MEopMode/Airplane,on*.
- If *AT^SCFG=MEopMode/Airplane/OnStart,on* is set, driving the ignition line (IGT) activates the Airplane mode.

Table 4: Comparison Charge-only and Charge mode

	How to activate mode	Description of mode
Charge mode	Connect charger to charger input of host application charging circuit and module's VCHARGE pin while TC65 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 pin while TC65 is • in Power-down mode • in Normal mode: Connect charger to the VCHARGE pin, 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 engine 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.

Table 5: 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. Enable / disable "^SBC" URCs.
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

3.6 Summary of State Transitions (Except SLEEP Mode)

Table 6: State transitions of TC65 (except SLEEP mode)
The table shows how to proceed from one mode to another (grey column = present mode, white columns = intended modes)

Further mode ➔➔➔ Present mode	POWER DOWN	Normal mode**)	Charge-only mode*)	Airplane mode
POWER DOWN mode	---	If AT^SCFG=MeOpMode/ Airplane/OnStart,off: IGT >400 ms at low level	Connect charger to VCHARGE	If AT^SCFG=MeOpMode/ Airplane/OnStart,on: IGT >400 ms at low level 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: AT+CFUN=x,1 or EMERG_RST.
Charge-only mode *)	Disconnect charger	If AT^SCFG=MeOpMode/ Airplane/OnStart,off: IGT >1s at low level	---	AT^SCFG=MeOpMode/ Airplane,on. If AT^SCFG=MeOpMode/ Airplane/OnStart,on: IGT >1s at low level
Airplane mode	AT^SMSO	AT^SCFG=MeOpMode/ Airplane,off	AT^SMSO if charger is connected	---

*) See section 3.5.7 for details on the charging mode

**) Normal mode covers TALK, DATA, GPRS, EGPRS, IDLE and SLEEP modes

3.7 RTC Backup

The internal Real Time Clock of TC65 is supplied from a separate voltage regulator in the analog controller which is also active when TC65 is in POWER DOWN status. An alarm function is provided that allows to wake up TC65 to Airplane mode without logging on to the GSM network.

In addition, you can use the VDDLP pin on the board-to-board connector to backup the RTC from an external capacitor or a battery (rechargeable or non-chargeable). The capacitor is charged by the BATT+ line of TC65. 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 TC65, i.e. the larger the capacitor the longer TC65 will save the date and time.

A serial 1kΩ 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 17 for the parameters required.

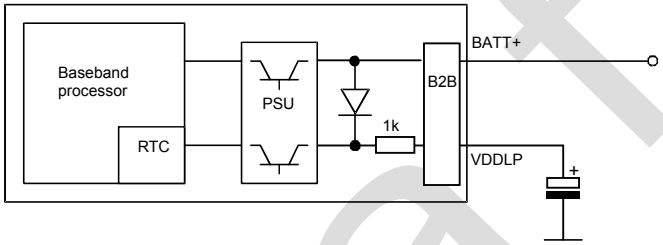

Figure 9: RTC supply from capacitor

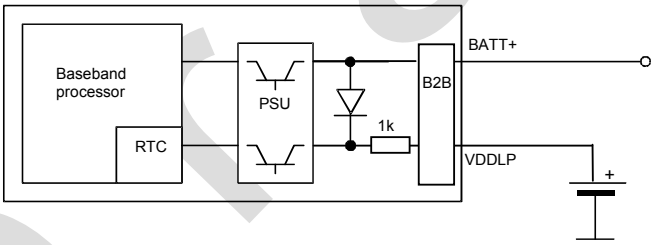

Figure 10: RTC supply from rechargeable battery

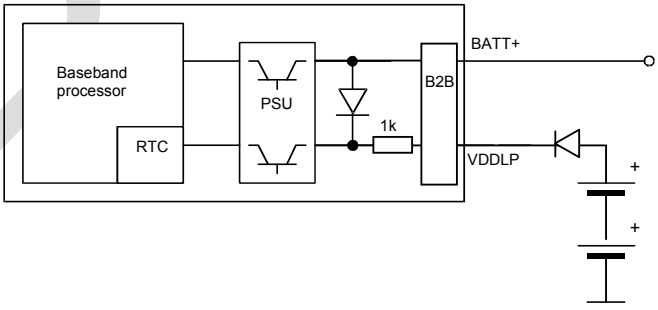

Figure 11: RTC supply from non-chargeable battery

3.8 SIM Interface

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

The SIM interface supports 3V and 1.8V SIM cards. Please refer to Table 17 for electrical specifications of the SIM interface lines depending on whether a 3V or 1.8V SIM card is used.

The CCIN pin serves to detect whether a tray (with SIM card) is present in the card holder. Using the CCIN pin is mandatory for compliance with the GSM 11.11 recommendation if the mechanical design of the host application allows the user to remove the SIM card during operation. 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 TC65 and is part of the Siemens reference equipment submitted for type approval. See Chapter 8 for Molex ordering numbers.

Table 7: 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 pin or plane on the module. A design example for grounding the SIM interface is shown in Figure 38.
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 pin is active low. The CCIN pin is mandatory for applications that allow the user to remove the SIM card during operation. The CCIN pin is solely intended for use with a SIM card. It must not be used for any other purposes. Failure to comply with this requirement may invalidate the type approval of TC65.

The total cable length between the board-to-board connector pins on TC65 and the pins 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 TC65.

3.9 Serial Interface ASC0

TC65 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 17.

TC65 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

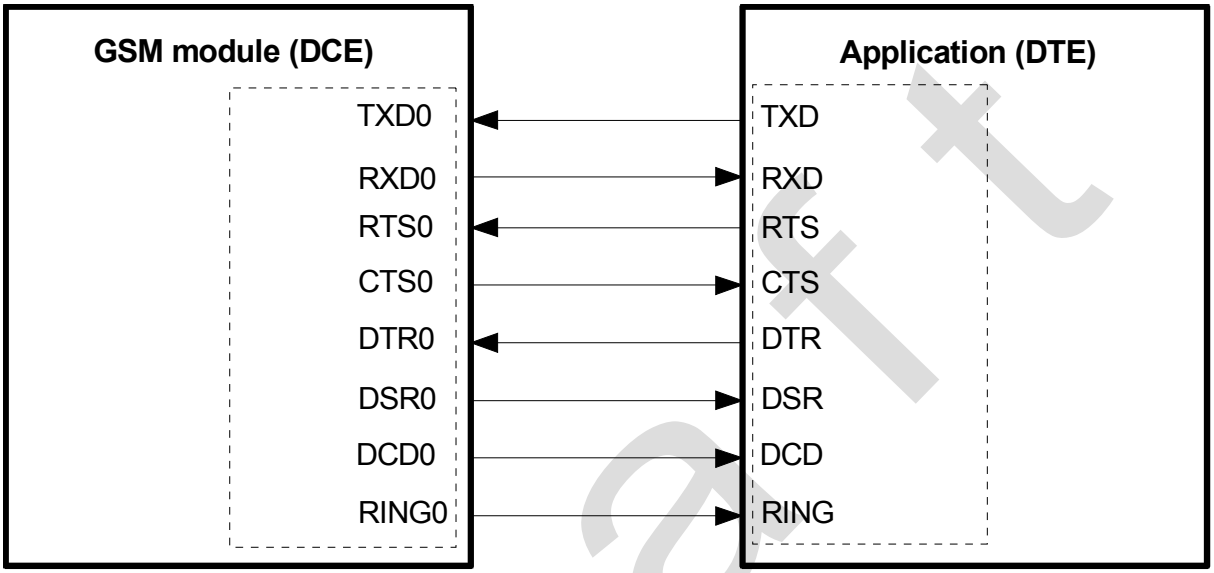

Figure 12: Serial interface ASC0

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 engine with AT commands.
- Full Multiplex capability allows the interface to be partitioned into three virtual channels, yet with CSD and fax services only available on the first logical channel. Please note that when the ASC0 interface runs in Multiplex mode, ASC1 cannot be used. For more details on Multiplex mode see [5].
- The DTR0 signal will only be polled once per second from the internal firmware of TC65.
- 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 bit rates from 300bps to 460800bps.
- Autobauding supports the following bit rates: TBD.
- Autobauding is not compatible with multiplex mode.
- Supports RTS0/CTS0 hardware flow control and XON/XOFF software flow control.

Table 8: DCE-DTE wiring of ASC0

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

3.10 Serial Interface ASC1

TC65 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 17.

TC65 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

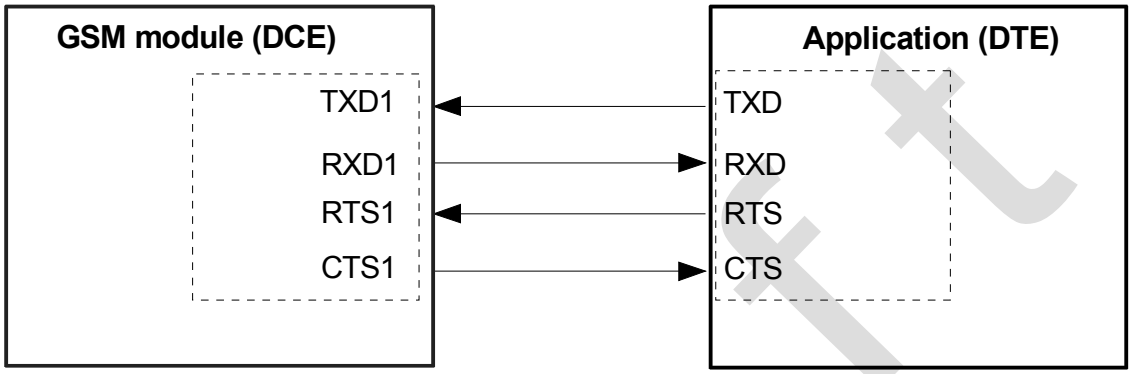

Figure 13: Serial interface ASC1

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 bit rates from 300bps to 460800bps.
- Autobauding TBD.
- Supports RTS1/CTS1 hardware flow control and XON/XOFF software flow control.

Table 9: DCE-DTE wiring of ASC1

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

3.11 USB Interface

TC65 supports a USB 2.0 Full Speed (12Mbit/s) device interface. It is primarily intended for use as command and data interface and for downloading firmware.

The USB I/O-pins are capable of driving the signal at min 3.0V. They are 5V I/O compliant.

To properly connect the module's USB interface to the host a USB 2.0 compatible connector is required. Furthermore, the USB modem driver delivered with TC65 must be installed as described below.

The USB host is responsible for supplying, across the VUSB_IN line, power to the module's USB interface, but not to other TC65 interfaces. This is because TC65 is designed as a self-powered device compliant with the "Universal Serial Bus Specification Revision 2.0"[1].

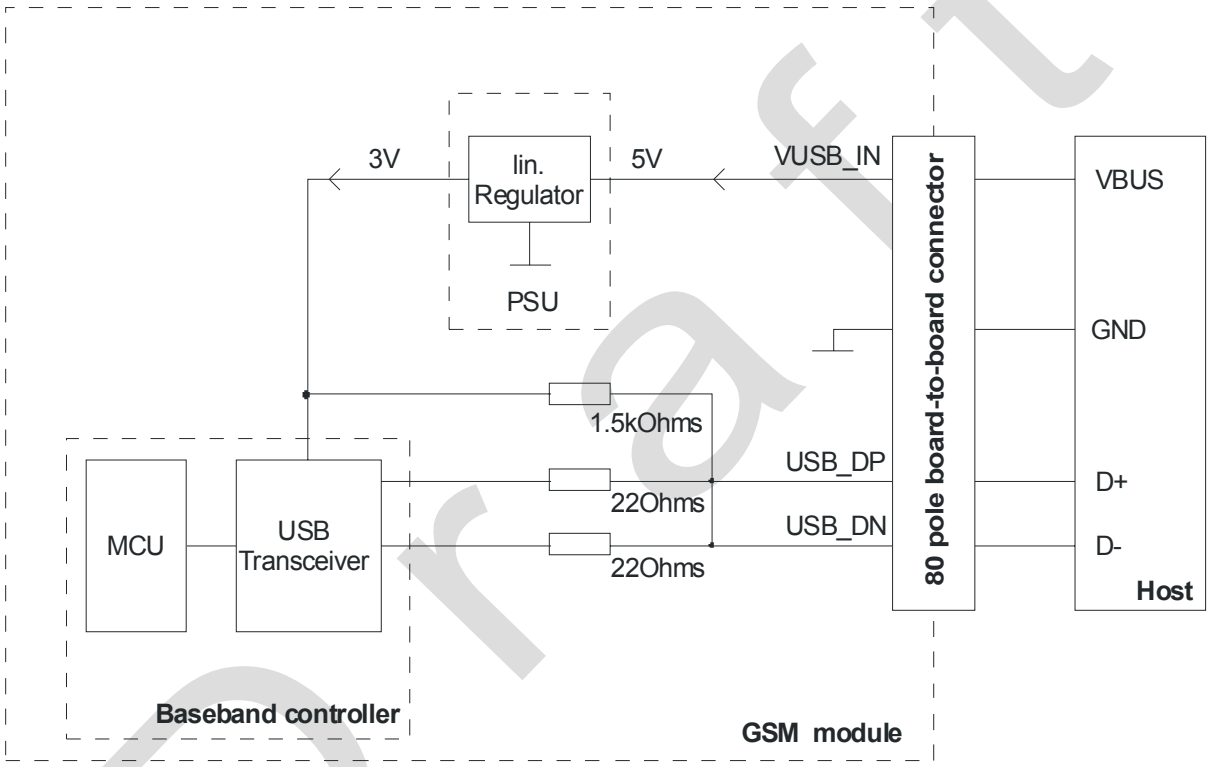

Figure 14: USB circuit

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