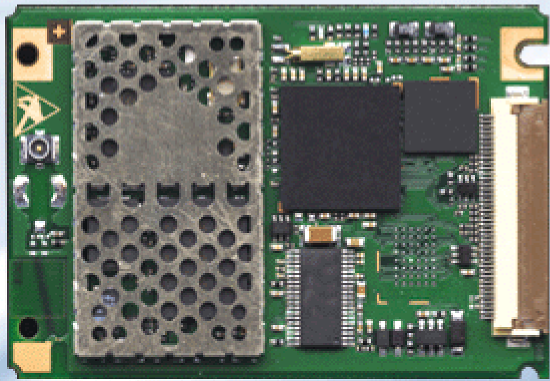
SIEMENS
mobile



Hardware Interface Description

TC35i
Siemens Cellular Engine

Version: 02.07
DocID: TC35i_HD_v02.07

Document Name: **TC35i Hardware Interface Description**

Version: **02.07**

Date: **February 03, 2004**

DocId: **TC35i_HD_v02.07**

Status: **Confidential / Released**

General Notes
Product is deemed accepted by recipient and is provided without interface to recipient's products. The documentation and/or product are provided for testing, evaluation, integration and information purposes. The documentation and/or product are provided on an "as is" basis only and may contain deficiencies or inadequacies. The documentation and/or product are provided without warranty of any kind, express or implied. To the maximum extent permitted by applicable law, Siemens further disclaims all warranties, including without limitation any implied warranties of merchantability, completeness, fitness for a particular purpose and non-infringement of third-party rights. The entire risk arising out of the use or performance of the product and documentation remains with recipient. This product is not intended for use in life support appliances, devices or systems where a malfunction of the product can reasonably be expected to result in personal injury. Applications incorporating the described product must be designed to be in accordance with the technical specifications provided in these guidelines. Failure to comply with any of the required procedures can result in malfunctions or serious discrepancies in results. Furthermore, all safety instructions regarding the use of mobile technical systems, including GSM products, which also apply to cellular phones must be followed. Siemens or its suppliers shall, regardless of any legal theory upon which the claim is based, not be liable for any consequential, incidental, direct, indirect, punitive or other damages whatsoever (including, without limitation, damages for loss of business profits, business interruption, loss of business information or data, or other pecuniary loss) arising out the use of or inability to use the documentation and/or product, even if Siemens has been advised of the possibility of such damages. The foregoing limitations of liability shall not apply in case of mandatory liability, e.g. under the German Product Liability Act, in case of intent, gross negligence, injury of life, body or health, or breach of a condition which goes to the root of the contract. However, claims for damages arising from a breach of a condition, which goes to the root of the contract, shall be limited to the foreseeable damage, which is intrinsic to the contract, unless caused by intent or gross negligence or based on liability for injury of life, body or health. The above provision does not imply a change on the burden of proof to the detriment of the recipient. Subject to change without notice at any time. The interpretation of this general note shall be governed and construed according to German law without reference to any other substantive law.

Trademark notice
MS Windows® is a registered trademark of Microsoft Corporation.

Contents

Figures

Tables

0 Document history

Preceding document: "TC35i Hardware Interface Description" Version 01.03
New document: "TC35i Hardware Interface Description" Version **02.07**

Chapter	Page	What is new
2.1	18	Added new feature "Concatenated SMS"
3.2.3	25	More detailed description of measuring periods for BATT+.
3.3.1.3, 3.3.1.4, 3.4.4, 3.5.6	28, 28, 38 44	Charging can be started while TC35i is in Alarm mode.
3.3.2.1	29	More detailed description of turn off procedure, added new URC ^SHUTDOWN
3.3.2.2	29	Deleted statement on timing of turn-on / turn-off cycles
3.5	40	Revised chapter: Note regarding PIN authentication. No power saving during Alarm mode. New LED mode. More detailed description of CYCLIC SLEEP modes. Described the improved timing of the /CTS signal during CYCLIC SLEEP mode.
3.5.5	43	Added recommendations regarding /RTS signal and setting an RTC alarm
3.7	47ff	Modified information on parity settings.
5.3	65	Table 23 – EMERGOFF pin and output pins of serial interface: To keep output pins from floating when in high impedance state use additional resistors.
5.4	69	IDLE current consumption reduced from 25mA to 15mA, Table 24 – added footnote regarding maximum current at BATT+ line, antenna performance and average supply current
5.4.1	70	More detailed description if current consumption during transmit burst. Added new Smith chart.
5.5.3	73	Table 26 – Changed EP output signal to 895mV, added footnote regarding activating the compressor and audio mode 5 and 6.
3.10.2.1, 3.10.2.2	54ff	Added information regarding new LED mode 2: LED signalization is enabled in SLEEP mode. Table 15 – Added new LED functions.

Preceding document: "TC35i Hardware Interface Description" Version 00.02
New document: "TC35i Hardware Interface Description" Version 01.03

Chapter	Page	What is new
1.3	13	Updated list of standards. Added CE conformity mark and GCF-CC certification.
3.3.2.1	29	Revised chapter, added detailed information regarding the power down procedure
3.3.2.2	29	Added information on timing and maximum number of turn-on / turn-off cycles
3.8	49	Revised chapter
5.4.1	70	Revised text, figure and references to this chapter

Preceding document: "TC35i Hardware Interface Description" Version 00.01
New document: "TC35i Hardware Interface Description" Version 00.02

Chapter	Page	What is new
3.3.3.3	32	Added new feature: Monitoring the board temperature of TC35i
3.4	34ff	Modified Chapter: Charging control Battery pack, added new Xwoda address
3.8	49	Added Table 30: Local oscillator and intermediate frequencies used by TC35i
3.9	51ff	Added information regarding CCIN pin and SIM card removal during operation. Modified Figure 18

1 Introduction

This document describes the hardware of the Siemens TC35i module that connects to the cellular device application and the air interface. As TC35i is intended to integrate with a wide range of application platforms, all functional components are described fully detailed.

So this guide covers all information you need to design and set up cellular applications incorporating the TC35i module. It helps you to quickly retrieve interface specifications, electrical and mechanical details and information on the requirements to be considered for integrating further components.

1.1 Related documents

[1] AT Command Set for TC35i, Version 02.07
[2] Release Note, Version 02.07
[3] DSB35 Support Box - Evaluation Kit for Siemens Cellular Engines
[4] Multiplexer User's Guide
[5] Application Note 02: Audio Interface Design
[6] Application Note 07: Li-Ion Batteries in GSM Applications
[7] Application Note 14: Audio and Battery Parameter Download
[8] Application Note 16: Updating TC35i Firmware
[9] Application Note 24: Application Developer's Guide
[10] Multiplexer User's Guide
[11] Multiplex Driver Developer's Guide for Windows 2000 and Windows XP
[12] Multiplexer Driver Installation Guide for Windows 2000 and Windows XP
[13] Remote SAT User's Guide

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
AFC	Automatic Frequency Control
AGC	Automatic Gain Control
ARFCN	Absolute Radio Frequency Channel Number
ARP	Antenna Reference Point
ASIC	Application Specific Integrated Circuit
BER	Bit Error Rate
BTS	Base Transceiver Station
CB or CBM	Cell Broadcast Message
CS	Coding Scheme
CSD	Circuit Switched Data
CPU	Central Processing Unit
CE	Conformité Européene (European Conformity)
DAI	Digital Audio Interface
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
DSB	Development Support Box
DSP	Digital Signal Processor
DSR	Data Set Ready
DTE	Data Terminal Equipment (typically computer, terminal, printer or, for example, GSM application)
DTR	Data Terminal Ready
DTX	Discontinuous Transmission
EFR	Enhanced Full Rate
EGSM	Enhanced GSM
EMC	Electromagnetic Compatibility
ESD	Electrostatic Discharge
ETS	European Telecommunication Standard
FDMA	Frequency Division Multiple Access
FFC	Flat Flexible Cable
FR	Full Rate
GMSK	Gaussian Minimum Shift Keying
GSM	Global Standard for Mobile Communications

Abbreviation	Description
HiZ	High Impedance
HR	Half Rate
IC	Integrated Circuit
IMEI	International Mobile Equipment Identity
I/O	Input/Output
ISO	International Standards Organization
ITU	International Telecommunications Union
kbps	kbits per second
LED	Light Emitting Diode
Li-Ion	Lithium-Ion
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
PCB	Printed Circuit Board
PCL	Power Control Level
PCN	Personal Communications Network, also referred to as DCS 1800
PCS	Personal Communication System
PD	Power Down
PDU	Protocol Data Unit
PLL	Phase Locked Loop
PPP	Point-to-point protocol
PSU	Power Supply Unit
R&TTE	Radio and Telecommunication Terminal Equipment
RAM	Random Access Memory
RF	Radio Frequency
ROM	Read-only Memory
RMS	Root Mean Square (value)
RTC	Real Time Clock
Rx	Receive Direction
SAR	Specific Absorption Rate
SELV	Safety Extra Low Voltage
SIM	Subscriber Identification Module
SMS	Short Message Service

Abbreviation	Description
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
USSD	Unstructured Supplementary Service Data
VSWR	Voltage Standing Wave Ratio
ZIF	Zero Insertion Force
Phonebook abbreviations	
FD	SIM fixdialing phonebook
LD	Last dialing phonebook (list of numbers most recently dialled)
MC	Mobile Equipment list of unanswered MT calls (missed calls)
ME	Mobile Equipment phonebook
ON	Own numbers (MSISDNs)
RC	Mobile Equipment list of received calls
SM	SIM phonebook

1.3 Standards

TC35i has been approved to comply with the directives and standards listed below and is labeled with the CE conformity mark.

Directives

99/05/EC	Directive of the European Parliament and of the council of 9 March 1999 on radio equipment and telecommunications terminal equipment and the mutual recognition of their conformity, in short referred to as R&TTE Directive 1999/5/EC The product is labeled with the CE conformity mark CE 0682
89/336/EC	Directive on electromagnetic compatibility
73/23/EC	Directive on electrical equipment designed for use within certain voltage limits (Low Voltage Directive)

Standards of type approval

ETS 300 607-1	Digital cellular telecommunications system (Phase 2); Mobile Station (MS) conformance specification; (equal GSM 11.10-1=>equal 3GPP TS 51.010-1)
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)"
ETSI EN 301 489-7	"V1.1.1 (2000-09) Candidate Harmonized European Standard (Telecommunications series) Electro Magnetic Compatibility and Radio spectrum Matters (ERM); Electro Magnetic Compatibility (EMC) standard for radio equipment and services; Part 7: Specific conditions for mobile and portable radio and ancillary equipment of digital cellular radio telecommunications systems (GSM and DCS)"
EN 60 950	Safety of information technology equipment (2000)

Requirements of quality

IEC 60068	Environmental testing
DIN EN 60529	IP codes

SAR requirements specific to handheld mobiles

Mobile phones, PDAs or other handheld 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 handheld TC35i 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 handheld operation. 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 (300 MHz - 3 GHz)

1.4 Safety Precautions

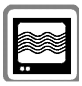
The following safety precautions must be observed during all phases of the operation, usage, service or repair of any cellular terminal or mobile incorporating TC35i. Manufacturers of the cellular terminal are advised to convey the following safety information to users and operating personnel and to incorporate these guidelines into all manuals supplied with the product. Failure to comply with these precautions violates safety standards of design, manufacture and intended use of the product. Siemens AG assumes no liability for customer failure to comply with these precautions.

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

Handsfree devices 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 cannot be guaranteed to connect in all conditions. Therefore, you should never rely solely upon any wireless device for essential communications, for example emergency calls.

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

Some networks do not allow for emergency calls if certain network services or phone features are in use (e.g. lock functions, fixed 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 overview

The TC35i GSM engine operating in the GSM 900 MHz and GSM 1800 MHz frequency band is an extremely compact and super slim communication module especially designed for telemetry, telematic and telephony such as: metering, fleet management, security systems, POS terminals or vending machines. It is compatible with the predecessor engine TC35 and offers additional features such as SIM application tool kit and extended AT commands for the industrial environment. Please note that the upper voltage limit has been changed from 5.5V to 4.8V.

The physical interface to the cellular application is made through a ZIF connector. It consists of 40 pins, required for controlling the unit, transferring data and audio signals and providing power supply lines.

The cellular device application forms the Man-Machine Interface (MMI). The serial interface allows for access to the GSM engine.

For battery powered applications, TC35i features a charging control which can be used to charge a Li-Ion battery.

2.1 TC35i key features at a glance

Table 1: TC35i key features

Feature	Implementation
Power supply (typical)	Single supply voltage 3.3V – 4.8V
Power saving	Current power consumption while remaining in SLEEP mode: 3mA
Charging	TC35i comprises an internal charging circuit
GSM class	Small MS
Frequency bands	Dual Band EGSM 900 and GSM 1800 Compliant to GSM Phase 2/2+
Transmit power	Class 4 (2W) at EGSM 900 Class 1 (1W) at GSM 1800
SMS	MT, MO, CB, Text and PDU mode, Concatenated SMS SMS storage: SIM card and in addition 25 SMS locations in the mobile equipment
DATA	Transmission rates: 2.400, 4.800, 9.600, 14.400 bps, non-transparent, USSD
FAX	Group 3: Class 1, Class 2
SIM interface	• Supported SIM card: 3V • External SIM card reader has to be connected via interface connector (note that card reader is not part of TC35i)
Antenna interface	50Ω antenna connector
Audio interface	Two analog audio interfaces (balanced microphone inputs and balanced outputs)
Speech codec	Triple rate codec: • Half Rate (ETS 06.20) • Full Rate (ETS 06.10) • Enhanced Full Rate (ETS 06.50 / 06.60 / 06.80) • Enhanced handsfree operation with echo cancellation and noise reduction
Serial interface	• 2.65V level bi-directional bus for commands / data using AT commands • Supports RTS/CTS hardware handshake and software XON/XOFF flow control. • Multiplex ability according to GSM 07.10 Multiplexer protocol • Baud rates from 300bps to 230.400 bps • Autobauding supports baud rates: 1.200, 2.400, 4.800, 9.600, 19.200, 38.400, 57.600, 115.200 and 230.400 bps
Phonebook management	Supported phonebook types: SM, FD, LD, MC, RC, ON, ME
SIM Application Toolkit	Supports SAT class 3, GSM 11.14 Release 98, support of letter class "c“
Ringing tones	Offers a choice of 7 different ringing tones / melodies, easily selectable with AT commands

Feature	**Implementation**
Real time clock	Implemented
Timer function	Programmable via AT command
Environmental	Temperature: • Normal operation: -20°C to +55°C • Restricted operation: -25°C to -20°C and +55°C to +70°C • Auto switch-off >+70°C and <-25°C When an emergency call is in progress the automatic temperature shutdown functionality is deactivated. Humidity: • max. 90 % relative humidity
Physical characteristics	Size: 54.5 x 36.0 x 3.60 mm Weight: 9g
Evaluation kit	The DSB35 support box is an evaluation kit designed to test and type approve Siemens cellular engines and provide a sample configuration for application engineering. For ordering information see Chapter 8.

2.2 Circuit concept

Figure 1 shows a block diagram of the TC35i module and illustrates the major functional components:

GSM Baseband Block:
- GSM Controller operating at 26MHz
- Power supply ASIC
- DSP operating at 78MHz
- Memory
- Application interface (ZIF connector)
- Charging circuit

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

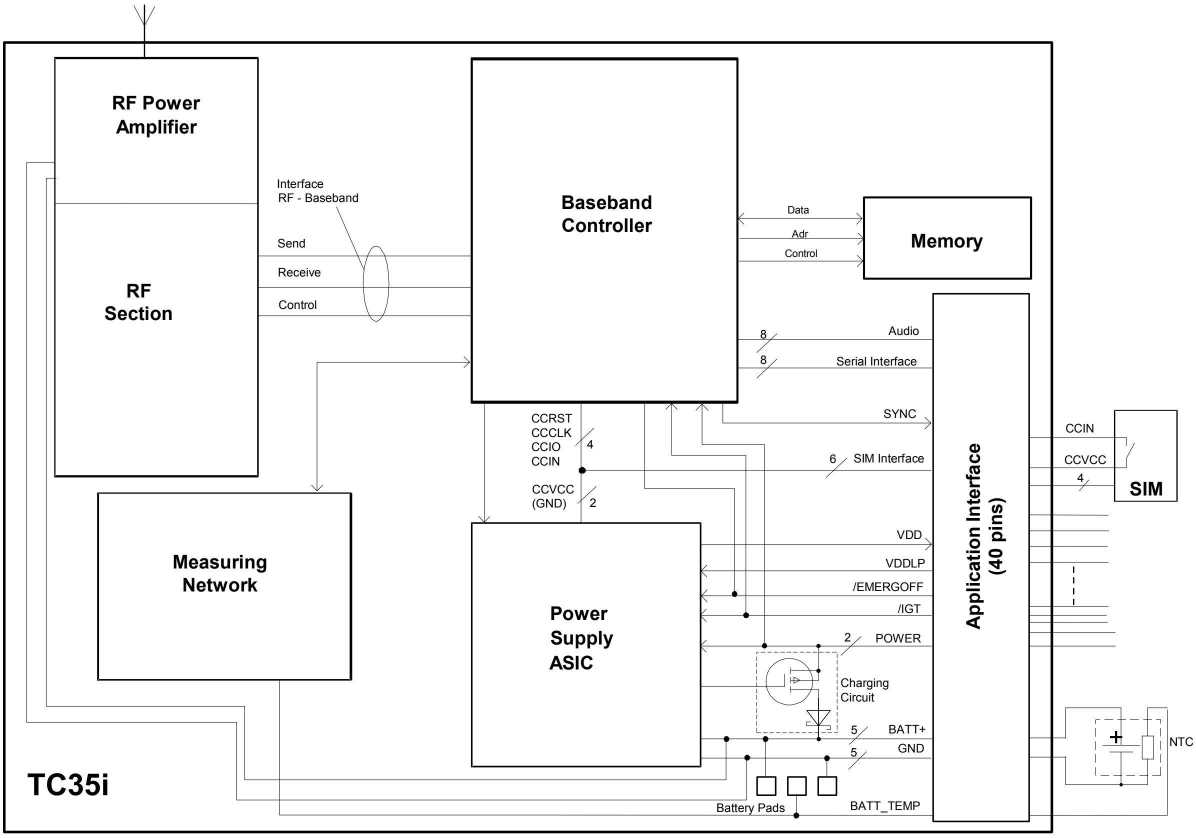


Figure 1: Block diagram of TC35i

3 Application Interface

TC35i is equipped with a 40-pin 0.5mm pitch ZIF connector that connects to the cellular application platform. The host interface incorporates several sub-interfaces described in the following chapters:

- Power supply and charging (see Chapters 3.2 and 3.3)
- Serial interface (see Chapter 3.7)
- Two audio interfaces (see Chapter 3.8)
- SIM interface (see Chapter 3.9)

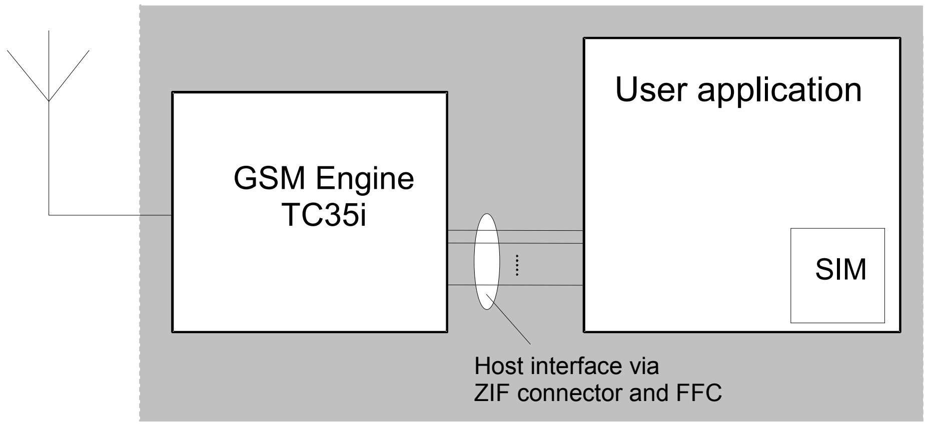


Figure 2: Block diagram of a cellular application

Electrical and mechanical characteristics of the ZIF connector are specified in Chapter 6.3. Ordering information for the ZIF connector and the required cables are listed in Chapter 8.

3.1 Operating modes

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

Table 2: Overview of operating modes

Mode	Function	
Normal operation	SLEEP	Various power saving modes set with AT+CFUN command. Software is active to a minimum extent. If the module was registered to a GSM network in IDLE mode, it remains, in SLEEP mode, registered and pageable from the BTS. Power saving can be chosen at different levels. The NON-CYCLIC SLEEP mode (AT+CFUN=0) disables the AT interface. The CYCLIC SLEEP mode AT+CFUN=5, 6, 7 and 8 alternatingly activate and deactivate the AT interface to allow permanent access to all AT commands.
	IDLE	Software is active. Once registered to the GSM network, paging with BTS is carried out. The engine is ready to send and receive.
	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.
Power Down	Normal shutdown after sending AT^SMSO command or emergency power off via /EMERGOFF pin. The Power Supply ASIC (PSU_ASIC) disconnects the supply voltage from the baseband part of the circuit. Only a voltage regulator in the PSU-ASIC is active for powering the RTC. Software is not active. The serial interface is not accessible. Operating voltage (connected to BATT+) remains applied.	
Alarm mode	Restricted operation launched by RTC alert function while GSM engine is in Power Down mode. GSM engine will not be registered to GSM network. Limited number of AT commands are accessible. Charging is possible.	
Charge-only mode	Limited operation for battery powered applications. Enables charging while engine is detached from GSM network. Limited number of AT commands is accessible. There are several ways to launch Charge-only mode: • From Power Down mode: Connect charger to POWER lines when engine was powered down by AT^SMSO. • From Normal mode: Connect charger to POWER lines, then enter AT^SMSO.	
Charge mode during normal operation	Normal operation (SLEEP, IDLE, TALK, DATA) and charging running in parallel. Charge mode changes to Charge-only mode when GSM engine is powered down before charging has been completed.	

See also Table 9 and Table 10 for the various options of waking up the GSM engine and proceeding from one mode to another.

3.2 Power supply

The power supply of the GSM engine has to be a single voltage source in the range of V_{BATT+} = 3.3V...4.8V. It must be able to withstand a sufficient current in a transmission burst which typically rises to 2A (see Chapter 5.4.1). Beyond that, the power supply must be able to account for increased current consumption if the module is exposed to inappropriate conditions, for example antenna mismatch.

5 BATT+ pins and 5 GND pins are available on the ZIF connector. The RF power amplifier is driven directly from BATT+.

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

- Stabilizes the supply voltages for the GSM baseband processor and for the RF part using linear voltage regulators.
- Controls the module's power up and power down procedures.
- A watchdog logic implemented in the baseband processor periodically sends signals to the ASIC, allowing it to maintain the supply voltage for all TC35i components. Whenever the watchdog pulses fail to arrive constantly, the module is turned off.
- Controls the charging circuit
- Delivers a regulated voltage of 2.9V across the VDD pin. The output voltage VDD may be used to supply your application, for example, an external LED or level shifter. However, the external circuitry must not cause any spikes or glitches on voltage VDD. This voltage is not available in POWER DOWN mode. Therefore, the VDD pin can be used to indicate whether or not TC35i is in POWER DOWN mode.
- Provides power to the SIM interface.

Please refer to Table 3 for a description of the power supply pins and their electrical specifications.

3.2.1 Power supply pins on the ZIF connector

10 pins of the ZIF connector are dedicated to connect the supply voltage (BATT+) and ground (GND). The values stated below must be measured directly at the reference points on the TC35i board (BATT+ pad and GND pad as shown in Figure 34).

The POWER pins signalize a connected charger to the module and serve as current input for charging of a Li-Ion battery.
VDDLP can be used to back up the RTC.

Table 3: Power supply pins of ZIF connector

Signal name	Pin	I/O	Description	Parameter
BATT+	1-5	I/O	Positive operating voltage	3.3 V...4.8 V, I_{typ} ~2 A during transmit burst (see Chapter 5.4.1) The minimum operating voltage should never fall below 3.3 V, not even in case of voltage drop.
GND	6-10	X	Ground	0 V
POWER	11-12	I	Positive charging voltage	I_{max} = 500 mA (provided by external source, e.g. charger) U = 5.5...8 V recommended internal Pull Down R=100kΩ
VDDLP	30	I/O	Buffering of RTC (see Chapter 3.3.1.4)	$U_{OUT,max} = V_{BATT+}$ U_{IN} = 2.0 V...5.5 V R_i = 1kΩ $I_{in,max}$ = 30µA

3.2.2 Minimizing power losses

When designing the power supply for your application please pay specific attention to power losses. Ensure that the input voltage measured on the TC35i never drops below the specified minimum (3.3V at BATT+), not even in a transmit burst where current consumption can rise to typical peaks of 2A at BATT+. It should be noted that TC35i switches off when exceeding these limits. Any voltage drops that may occur in a transmit burst should not exceed 400mV. For further details see Chapter 5.4.

Note: In order to minimize power losses, use a FFC cable as short as possible. The resistance of the power supply lines on the host board and a battery pack should also be considered.

Example: The ZIF-FFC-ZIF connection causes a resistance of 50mΩ in the BATT+ line and 50mΩ in the GND line, if the FFC reaches the maximum length of 200mm. As a result, a 2A transmit burst would add up to a total voltage drop of 200mV. In addition, if a battery pack is involved, further losses may occur due to the resistance across the battery lines.

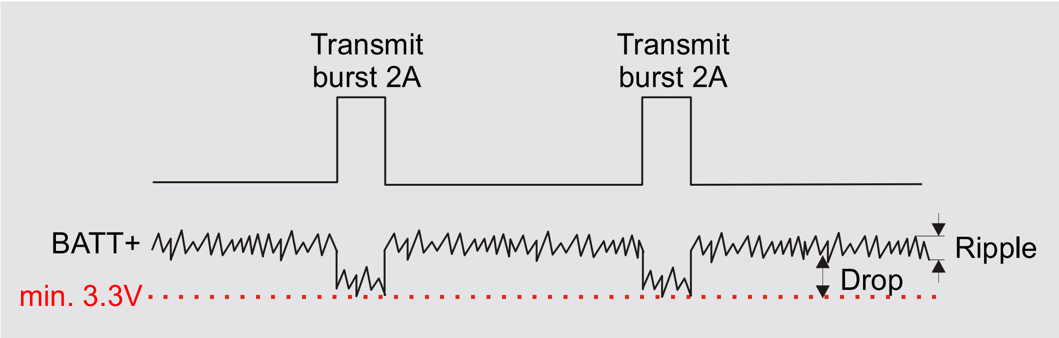


Figure 3: Power supply limits during transmit burst

The input voltage V_{BATT+} must be measured directly at the test pads on the TC35i board. For detailed information see Figure 34.

3.2.3 Monitoring power supply

To help you monitor the supply voltage you can use the AT^SBV command which returns the voltage measured at reference points BATT+ pad and GND pad.

The voltage is continuously measured at intervals depending on the operating mode on the RF interface. The duration of measuring ranges from 0.5s in TALK/DATA mode up to 50s when the module 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.

For details please refer to [1]

3.3 Power up / down scenarios

3.3.1 Turn on TC35i

TC35i can be activated in a variety of ways which are described in the following chapters:

- via ignition line IGT: starts normal operating state (see Chapters 3.3.1.1 and 3.3.1.2)
- via POWER lines: starts charging algorithm (see Chapters 3.3.1.2 and 3.3.1.3)
- via RTC interrupt: starts Alarm mode (see Chapter 3.3.1.4)

3.3.1.1 Turn on TC35i using the ignition line IGT (Power on)

To switch on TC35i the /IGT (Ignition) signal needs to be driven to ground level for at least 100ms. This can be accomplished using an open drain/collector driver in order to avoid current flowing into this pin.

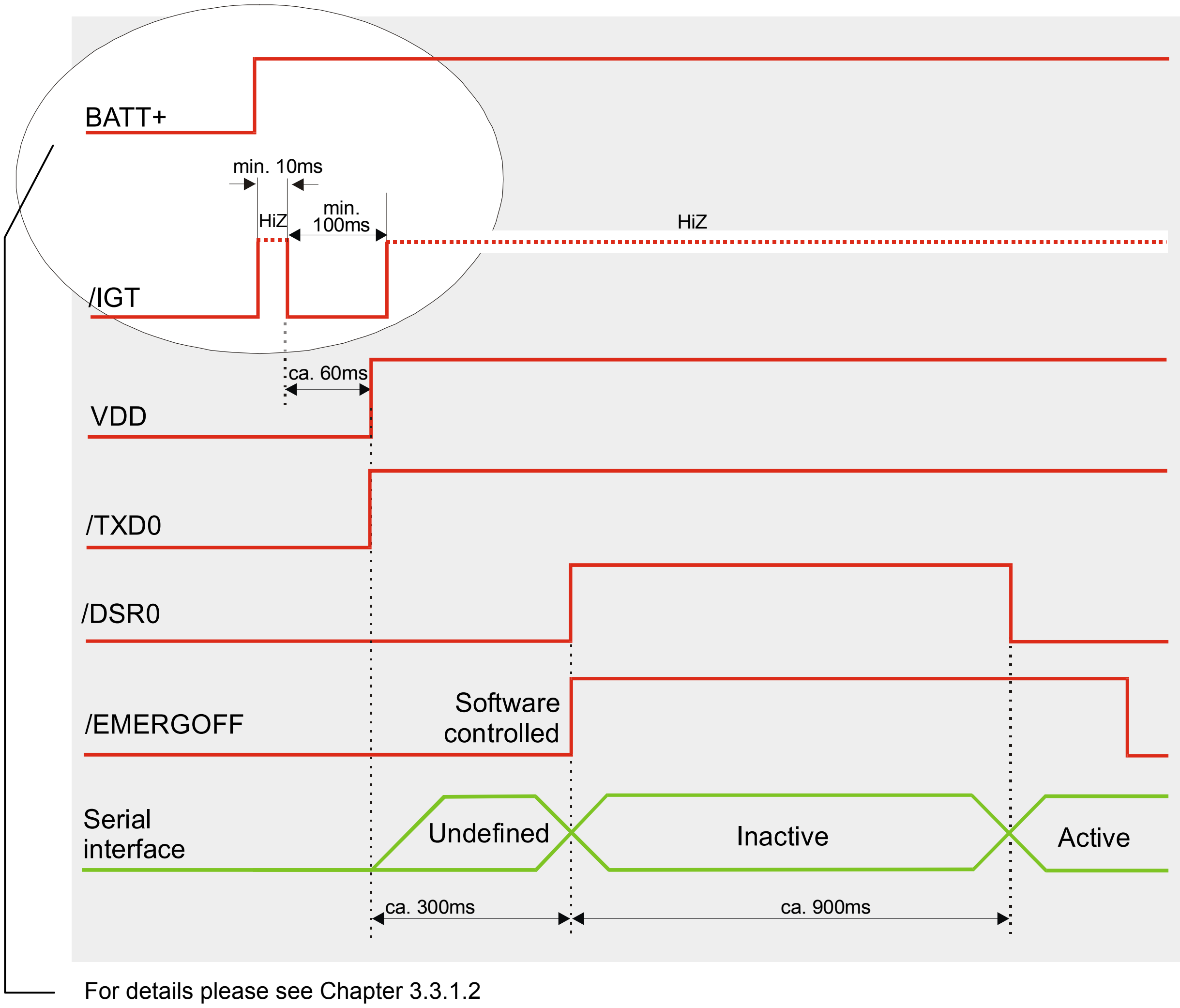


Figure 4: Power on by ignition signal

In a battery operated TC35i application, the duration of the /IGT signal must be 1s minimum when the charger is connected and you may want to go from charging to Normal mode.

3.3.1.2 Timing of the ignition process

When designing your application platform take into account that powering up TC35i requires the following steps.

- The ignition line cannot be operated until V_{BATT+} passes the level of 3.0V.
- 10ms after V_{BATT+} has reached 3.0V the ignition line can be switched low. The duration of the falling edge must not exceed 1ms.
- Another 100ms are required to power up the module.
- Ensure that V_{BATT+} does not fall below 3.0V while the ignition line is driven. Otherwise the module cannot be activated. If the VDDLP line is fed from an external power supply, the /IGT line is HiZ before the rising edge of V_{BATT+}.
- If the VDDLP line is fed from an external power supply as explained in Chapter 3.6, the /IGT line is HiZ before the rising edge of V_{BATT+}.

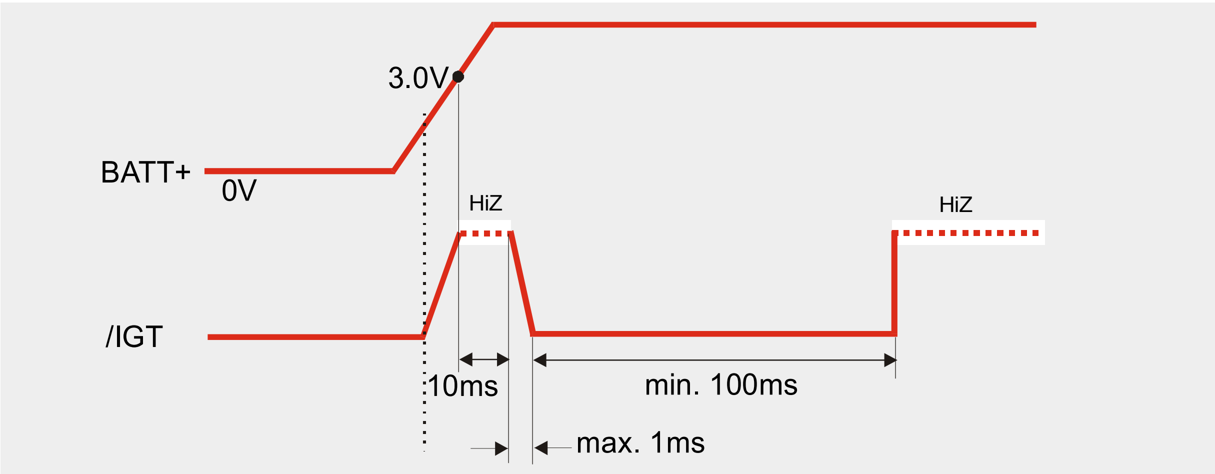


Figure 5: Timing of power-on process if VDDLP is not used

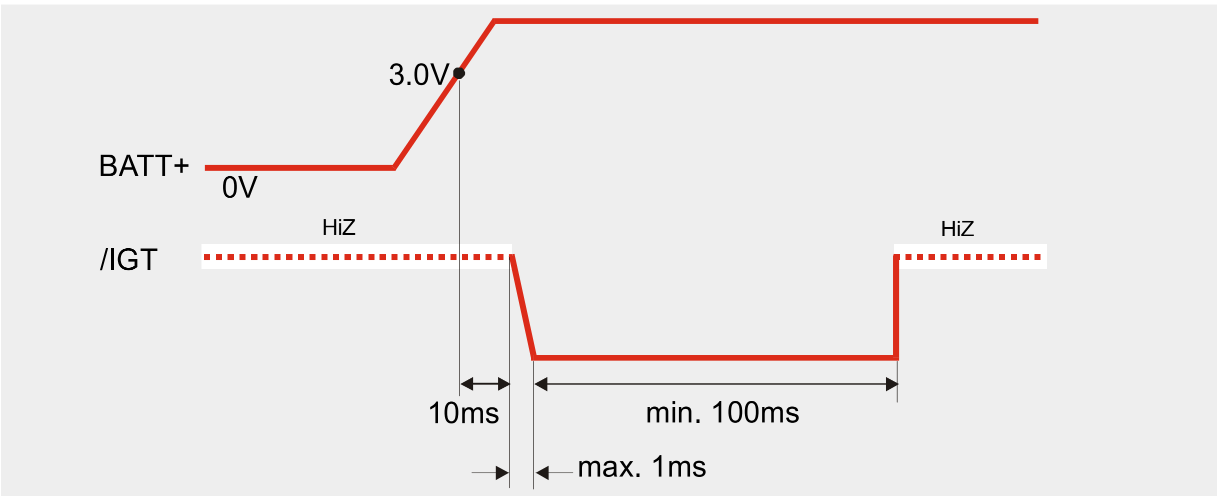


Figure 6: Timing of power-on process if VDDLP is fed from external source

3.3.1.3 Turn on TC35i using the POWER lines

As detailed in Chapter 3.4.4, the charging adapter can be connected regardless of the GSM engine's operating mode.

If the charger is connected to the POWER lines while the GSM engine is off, TC35i enters a restricted mode, referred to as Charge-only mode where only the charging algorithm will be launched.

In Charge-only mode the GSM engine is neither logged on to the GSM network nor is the serial interface fully accessible. When the minimum voltage of 3.2V is achieved within 60 minutes the charging process proceeds to software controlled charging. To switch to normal operation and log on to the GSM network, the /IGT line needs to be activated.

3.3.1.4 Turn on TC35i using the RTC (Alarm mode)

Another power-on approach is to use the RTC, which is constantly supplied with power from a separate voltage regulator in the power supply ASIC. The RTC provides an alert function which allows to wake TC35i while power is off. To prevent the engine from unintentionally logging into the GSM network, this procedure only enables restricted operation, referred to as Alarm mode. It must not be confused with a wake-up or alarm message that can be activated by using the same AT command, but without switching off power.

Use the *AT+CALA* command to set the alarm time. The RTC retains the alarm time if TC35i was powered down by AT^SMSO. Once the alarm is timed out and executed, TC35i enters the Alarm mode. This is indicated by an Unsolicited Result Code (URC) which reads:

    ^SYSSTART ALARM MODE

In Alarm mode only a limited number of AT commands is available. For further instructions refer to [1].

Table 4: AT commands available in Alarm mode

AT command	Use
AT+CALA	Set alarm time
AT+CCLK	Set date and time of RTC
AT^SBC	In Alarm mode, you can only query the present current consumption and check whether or not a charger is connected. The battery capacity is returned as 0, regardless of the actual voltage (since the values measured directly on the cell are not delivered to the module).
AT^SCTM	Query temperature of GSM engine
AT^SMSO	Power down GSM engine

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

If the charger is connected to the POWER lines when TC35i is in ALARM mode charging will start, while TC35i stays in ALARM mode.

If your host application uses the SYNC pin to control a status LED as described in Chapter 3.10.2.2, please note that the LED is off while TC35i is in Alarm mode.

3.3.2 Turn off TC35i

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

- *Normal procedure*: Software controlled by sending AT^SMSO command over the serial application interface. See Chapter 3.3.2.1.
- *Emergency shutdown*: Hardware driven by switching the /EMERGOFF line of the ZIF connector to ground = immediate shutdown of supply voltages, only applicable if the software controlled procedure fails! See Chapter 3.3.2.3.
- *Automatic shutdown*: Takes effect if undervoltage / overvoltage is detected or if battery or board (engine) temperature exceeds critical limit. See Chapter 3.3.3.

3.3.2.1 Turn off TC35i using the AT^SMSO command

The best and safest approach to powering down TC35i is to issue the *AT^SMSO* command. This procedure lets TC35i log off from the network and allows the software to enter into a secure state and safe data before disconnecting the power supply. The mode is referred to as POWER DOWN mode. In this mode, only the RTC stays active.

Before switching off the device sends the following response:

```
^SMSO: MS OFF

OK
^SHUTDOWN
```

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

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

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

While TC35i is in POWER DOWN mode the application interface is switched off and must not be fed from any other source. Therefore, your application must be designed to avoid any current flow into any digital pins of the application interface.

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

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

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

3.3.2.3 Emergency shutdown using /EMERGOFF pin

Caution: *Use the /EMERGOFF pin only when, due to serious problems, the software is not responding for more than 5 seconds. Pulling the /EMERGOFF pin causes the loss of all information stored in the volatile memory since power is cut off immediately. Therefore, this procedure is intended only for use in case of emergency, e.g. if TC35i fails to shut down properly.*

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

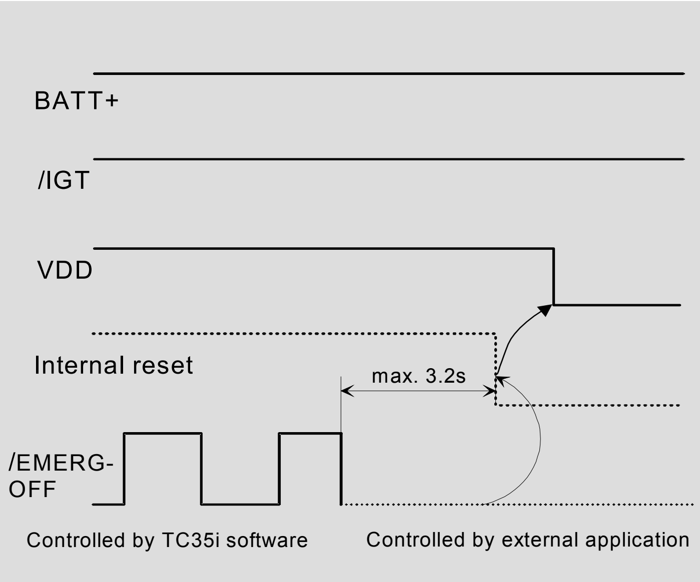


Figure 7: Deactivating GSM engine by Power Down signal

How does it work:

- Voltage V_{BATT+} is permanently applied to the module.
- The module is active while the internal reset signal is kept at high potential.
  During operation, the baseband controller generates watchdog pulses at regular intervals.
  When the /EMERGOFF pin is grounded these watchdog pulses are cut off from the power supply ASIC. The power supply ASIC shuts down the internal supply voltages of TC35i after max. 3.2s and the module turns off. Consequently the output voltage at VDD is switched off.

3.3.3 Automatic shutdown

Automatic shutdown takes effect if
- the TC35i board is exceeding the critical limits of overtemperature or undertemperature
- the battery is exceeding the critical limits of overtemperature or undertemperature.
- undervoltage is detected
- overvoltage is detected.

The automatic shutdown procedure is equivalent to the power-down initiated with the AT^SMSO command, i.e. TC35i logs off from the network and the software enters a secure state avoiding loss of data. When the module is in IDLE mode it takes typically one minute to deregister from the network and to switch off.

Alert messages transmitted before the device switches off are implemented as Unsolicited Result codes (URCs). For details see the following chapters and the description of the two commands AT^SCTM and AT^SBC provided in [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 Chapter 3.4. The values detected by either NTC resistor are measured directly on the board and the battery and, therefore, are not fully identical with the ambient temperature. The maximum ratings are stated in Table 22.

Each time the board or battery temperature goes out of range or back to normal, TC35i 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 TC35i. 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.

Table 5 summarizes the temperature ratings and the associated URCs.

Table 5: Temperature dependent behavior

Sending temperature warning (15 s after TC35i 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.
^SBCTM_A: 0	Battery returns from critical to normal temperature range.
^SBCTM_B: 0	Board returns from critical to normal temperature range.
Automatic shutdown (URC appears no matter whether presentation was enabled)	
^SCTM_A: 2	Alert: T_{amb} of battery $\geq$ 60°C. TC35i switches off.
^SCTM_B: 2	Alert: T_{amb} of board $\geq$70°C. TC35i switches off.
^SCTM_A: -2	Alert: T_{amb} of battery < -18°C. TC35i switches off.
^SCTM_B: -2	Alert: T_{amb} of board $\leq$-25°C. TC35i switches off.

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

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 and to deliver alert messages, 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 Monitoring the board temperature of TC35i

The AT^SCTM command can also be used to check the present status of the board. Depending on the selected mode, the read command returns the current board temperature in degrees Celsius or only a value that indicates whether the board is within the safe or critical temperature range. See [1] for further instructions.

3.3.3.4 Shutdown in the event of undervoltage

Undervoltage protection is the same, regardless of whether or not an NTC connects to the BATT_TEMP terminal as described in Chapter 3.4.3. This means, it makes no difference whether the application is battery powered or operated from a fixed supply voltage.

Whenever the supply voltage falls below the specified value (see Table 24) TC35i will automatically send the URC
^SBC: Undervoltage

The message will be reported, for example, when the user attempts to set up a call while the voltage is close to the critical limit and further power loss may be expected during a transmit burst. To remind the user that the battery needs to be charged soon, the URC appears several times in a minute before the module performs an orderly shutdown.

If the voltage drops quickly down to a value which is 50mV below the minimum threshold, then only one URC will be presented.

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

3.3.3.5 Shutdown in the event of overvoltage

There are two types of overvoltage URCs that may be reported as explained below:

^SBC: Overvoltage warning
This URC type is only intended for applications which are operated from a fixed supply source. It is an alarm indicator displayed if the voltage reaches the specified maximum value (see Table 24). The URC appears only once.

^SBC: Overvoltage shutdown
In the event of the voltage rising above the maximum voltage (see Table 24) the module sends one URC and then performs an orderly shutdown.
In applications powered from Li-Ion batteries the incorporated protection circuit typically prevents overcharging and thus eliminates the risk that V_{BATT+} ever reaches the maximum value specified in Table 24. The battery pack recommended in Table 6, for example, will stop charging at 4.325V ± 0.025V. Therefore, in a battery operated application, overvoltage conditions are likely to occur only if no protection circuit is present or if, due to an error caused by a bad battery, charging is not properly terminated and overcharging needs to be prevented.

Both types of URCs do not need to be activated by the user. They will be output automatically when fault conditions occur.

3.4 Charging control

3.4.1 Battery pack

For some applications the use of a battery pack may be required. TC35i can be powered from a Li-Ion battery pack which must be specified for a typical nominal voltage of 3.6 V and a maximum charging voltage of 4.2 V. The recommended capacity may be at least 600mAh.

It is strongly recommended that the battery pack you want to integrate into your TC35i 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 (see [1] for details). A battery pack especially designed to operate with TC35i is specified in Chapter 3.4.2.

- 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. Required NTC characteristics are: 10kΩ ± 5% @ 25°C, B (25/85)=3435K ± 3% (alternatively acceptable: *10 kΩ ±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. The circuit must be insensitive to pulsed current.
- On the TC35i module, a built-in measuring circuit constantly monitors the battery voltage. In the event of undervoltage, the module performs an orderly shutdown. 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 TC35i 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 gasing 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.
- The battery pack must 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.

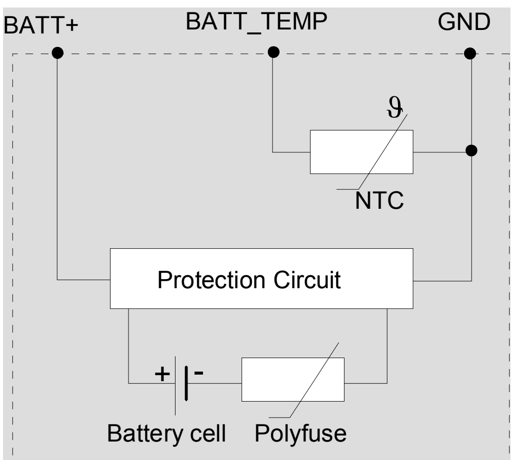


Figure 8: Battery pack circuit diagram

3.4.2 Recommended battery pack

The following battery pack has been especially designed to operate with TC35i modules.

Table 6: Specifications of XWODA battery pack

Product name, type	XWODA, Li-Ion, 3.6V, 800mAh
Vendor To place orders or obtain more information please contact:	Shenzhen Xwoda Electronic Co., Ltd Building C, Tongfukang Industrial Zone Shiyan Town Bao'an District Shenzen P.R.China Contact: Waichard Tsui Phone: +86-755-27623789 ext. 370 Fax: +86-755-27623078 Email: waichard@xwoda.com.cn
Nominal voltage	3.6V
Capacity	800mAh
NTC	10kΩ ± 5% @ 25°C, B (25/85)=3435K ± 3%
Overcharge detection voltage	4.325 ± 0.025V
Overcharge release voltage	4.075 ± 0.025V
Overdischarge detection voltage	2.5 ± 0.05V
Overdischarge release voltage	2.9 ± 0.5V
Overcurrent detection	3 ± 0.5A
Nominal working current	<5µA
Current of low voltage detection	0.5µA
Overcurrent detection delay time	8~16ms
Short detection delay time	50µs
Overdischarge detection delay time	31~125ms
Overcharge detection delay time	1s
Internal resistance	<130mΩ

3.4.3 Implemented charging technique

Charging can be accomplished in a temperature range from 0°C to +45°C. The charging process supports trickle charging and processor controlled fast charging. The trickle charge current passes the 470Ω resistor path as shown in Figure 9.

For this solution, the fast charging current provided by the charger or any other external source must be limited to 500mA.

Note: Do not connect the charger to the BATT+ lines. Only the POWER lines are intended as input for charging! The battery manufacturer must guarantee that the battery complies with the described charging technique.

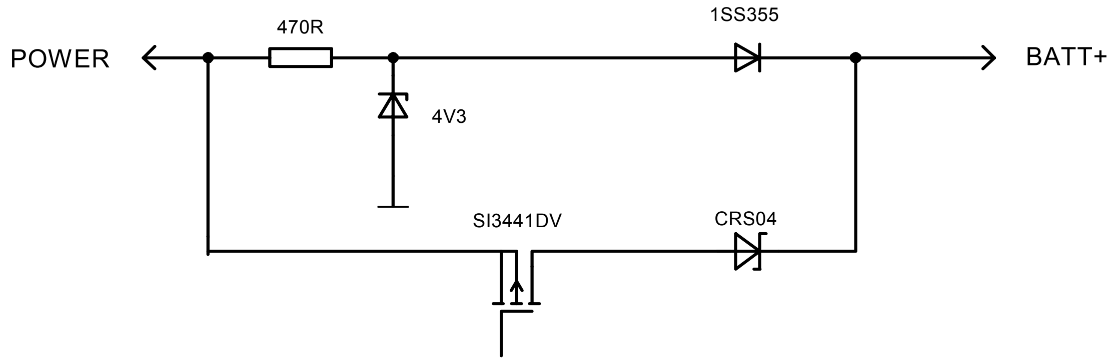


Figure 9: Internal charging circuit

Trickle charging

- Trickle charging starts when the charger is connected to the POWER pins and if the battery is deeply discharged (<3.2V). In trickle mode, the battery is charged with a current of less than 10mA.
- Trickle charging stops when the battery voltage reaches 3.6V.

Fast charging

- After trickle charging has raised the battery voltage to 3.2V within 60 minutes ±10% from connecting the charger, the power ASIC turns on and wakes up the baseband processor. Now, processor controlled fast charging begins.
  If the battery voltage was already above 3.2V, processor controlled fast charging starts just after the charger was connected to the POWER pins. Please note that the fast charging current passes the SI3441 transistor path, see Figure 9.
  If TC35i was in POWER DOWN mode, it turns on and enters the Charge-only mode along with fast charging (see also Chapter 3.3.1.3.).
  Fast charging delivers a constant current until the battery voltage reaches 4.2V and then proceeds with varying charge pulses. As shown in Figure 10, the pulse duty cycle is reduced to adjust the charging procedure and prevent the voltage from overshooting beyond 4.2V. Once the pulse width reaches the minimum of 100ms and the duty cycle does not change for 2 minutes, fast charging is completed.
- Fast charging can only be accomplished in a temperature range from 0°C to +45°C.

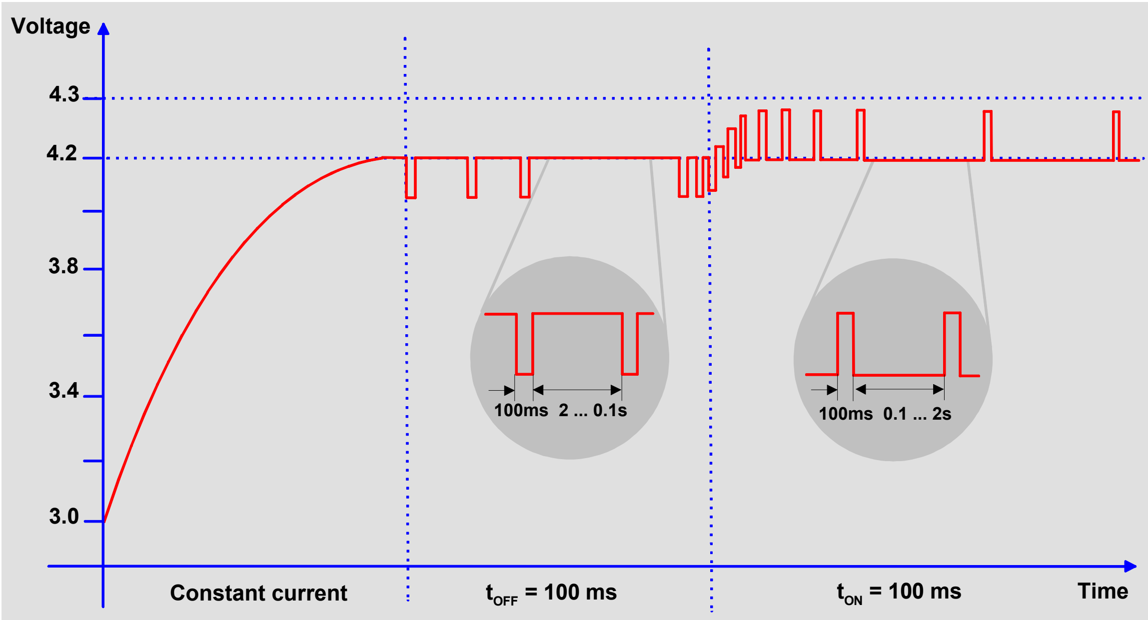


Figure 10: Charging process

Please keep in mind that if trickle charging fails to raise the battery voltage to 3.2V within 60 minutes ± 10%, processor controlled charging does not begin. If the voltage is still below 3.2V the internal timer switches off. Shortly disconnecting and reconnecting the charger restarts the timer and the entire charging process.

Apart from this, trickle charging continues whenever the charger connects to the POWER lines.

3.4.4 Operating modes during charging

Of course, the battery can be charged regardless of the engine's operating mode.

When TC35i is in Normal mode (SLEEP, IDLE or TALK 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 POWER lines when the engine is in Power Down mode (caused by AT^SMSO), the GSM engine goes into *Charge-only mode*.

If the charger is connected to the POWER lines when TC35i is in ALARM mode, charging will start, while TC35i stays in ALARM mode.

Table 7: Comparison Charge mode and Charge-only mode

	How to activate mode	**Advantages**
Charge mode	Connecting charger to the POWER lines of TC35i while TC35i engine is operating, e.g. • in IDLE or TALK mode • in SLEEP mode	• Battery can be charged while GSM engine remains operational and registered to the GSM network. • In IDLE and TALK mode, the serial interface is accessible. AT command set can be used to full extent. • In NON-CYCLIC SLEEP mode, the serial interface is not accessible at all. During the CYCLIC SLEEP mode it can be used as described in Chapter 3.5.2.
Charge-only mode	Connecting charger to the POWER lines while GSM engine is • in Power Down mode (e.g. powered down by AT^SMSO) • in Normal mode: Connect charger to POWER lines, then enter AT^SMSO. If V_{BATT+} < 3.0V the module does not automatically go into Charge-only mode. In this case, it is necessary to activate IGT for at least 100ms. If VBATT+ > 3.0V, Charge-only mode starts up without the need to activate IGT. IMPORTANT: While trickle charging is in progress, be sure that the 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.

Features of the Charge-only mode
Once the GSM engine enters the Charge-only mode, the AT command interface presents an Unsolicited Result Code which reads:
^SYSSTART CHARGE-ONLY MODE
Note that this URC will not appear when autobauding was activated (due to the missing synchronization between DTE and DCE upon start-up). Therefore, it is recommended to select a fixed baudrate before using the Charge-only mode.

While the Charge-only mode is in progress, you can take advantage of the AT commands listed in Table 8. For further instructions refer to [1].

Table 8: AT commands available in Charge-only mode

AT command	Use
AT+CALA	Set alarm time
AT+CCLK	Set date and time of RTC
AT^SBC	Monitor charging process Note: While charging is in progress, no battery parameters are available. To query the battery capacity disconnect the charger. If the charger connects *externally* to the host device no charging parameters are transferred to the module. In this case, the command cannot be used.
AT^SCTM	Query temperature of GSM engine
AT^SMSO	Power down GSM engine

To proceed from Charge-only mode to normal operation, it is necessary to drive the ignition line to ground. This must be implemented in your host application as described in Chapter 3.3.1.1. See also Chapter 3.5.6 which summarizes the various options of changing the mode of operation.
If your host application uses the SYNC pin to control a status LED as described in Chapter 3.10.2.2, please note that the LED is off while the GSM engine is in Charge-only mode.

3.4.5 Charger requirements

The charger must be designed to meet the following requirements:

a) Simple transformer power plug
- Output voltage: 5.5V...8V (under load)
- The charge current must be limited to 500mA
- Voltage spikes that may occur while you connect or disconnect the charger must be limited to a maximum of 15V and must not exceed 1ms
- There must not be any capacitor on the secondary side of the power plug (avoidance of current spikes at the beginning of charging)

b) Supplementary requirements for a) to ensure a regulated power supply
- When current is switched off a voltage peak of 10V is allowed for a maximum 1ms
- When current is switched on a spike of 1.6A for 1ms is allowed

Note: To detect extreme thermal conditions while charging is in progress, connect an NTC (10kΩ @ 25°C, B=3435 Kelvin ±3%) from BATT_TEMP to GND.

3.5 Power saving

SLEEP mode reduces the functionality of the TC35i module to a minimum and, thus, minimizes the current consumption to the lowest level. SLEEP mode is set with the AT+CFUN command which provides the choice of the functionality levels <fun> between 0 and 8, all explained below. Further instructions of how to use AT+CFUN can be found in [1].

IMPORTANT: Please keep in mind that power saving works properly only when PIN authentication has been done. If you attempt to activate power saving while the SIM card is not inserted or the PIN not correctly entered, the selected <fun> level will be set, though power saving does not take effect. For the same reason, power saving cannot be used if TC35i operates in Alarm mode.

To check whether power saving is on, you can query the status of AT+CFUN if you have chosen CYCLIC SLEEP mode. If available, you can take advantage of the status LED controlled by the SYNC pin (see Chapter 3.10.2.2). In mode 1 the LED stops flashing once the module starts power saving. In mode 2 the LED flashes if the TC35i module is in SLEEP mode but not registered to the GSM network. If the module is registered to the GSM network, the LED blinks shortly. Please note that only mode 2 enables the LED signalization during SLEEP mode. For more details see Table 15.

The wake-up procedures are quite different depending on the selected SLEEP mode. Table 9 compares the wake-up events that can occur in NON-CYCLIC SLEEP mode and in the four CYCLIC SLEEP modes.

3.5.1 No power saving (AT+CFUN=1)

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

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

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

The first wake-up event fully activates the module, enables the serial interface and terminates the power saving mode. In short, it takes TC35i back to the highest level of functionality <fun>=1.

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

The functionality levels AT+CFUN=5, AT+CFUN=6, AT+CFUN=7 and AT+CFUN=8 are referred to as CYCLIC SLEEP modes.

The major benefit of all CYCLIC SLEEP modes is that the serial interface remains accessible, and that, in intermittent wake-up periods, characters can be sent or received without terminating the selected mode. The best choice is using AT+CFUN=7 or 8, since in these modes TC35i automatically resumes power saving, after you have sent or received a short message or made a call. CFUN=5 and 6 do not offer this feature, and therefore, are only supported for compatibility with earlier releases. In all CYCLIC SLEEP modes, you can enter AT+CFUN=1 to permanently wake up TC35i and take it back to full functionality. Please refer to Table 9 for a summary of all SLEEP modes and the different ways of waking up the module.

For CYCLIC SLEEP mode, both the application and the module must be configured to use hardware flow control (RTS/CTS handshake). This is necessary since by activating the /CTS signal, the module indicates to the application when the UART is active (see Chapter 3.5.4 for details). The default setting of TC35i is AT\Q0 (no flow control) which must be altered to AT\Q3. See [1] for details.

3.5.4 Timing of the /CTS signal in CYCLIC SLEEP modes

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

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

DRX (Discontinuous Reception) is a value from 2 to 9, resulting in paging intervals from 0.47 to 2.12 seconds. The DRX value of the base station is assigned by the network operator.

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

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

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

After the last character was sent or received the interface will remain active for another

- 2 seconds, if AT+CFUN=5 or 7 or
- 10 minutes, if AT+CFUN=6 or 8.

In the pauses between listening to paging messages, while /CTS is high, the module resumes power saving and the AT interface is not accessible. See Figure 11 and Figure 12 for details.

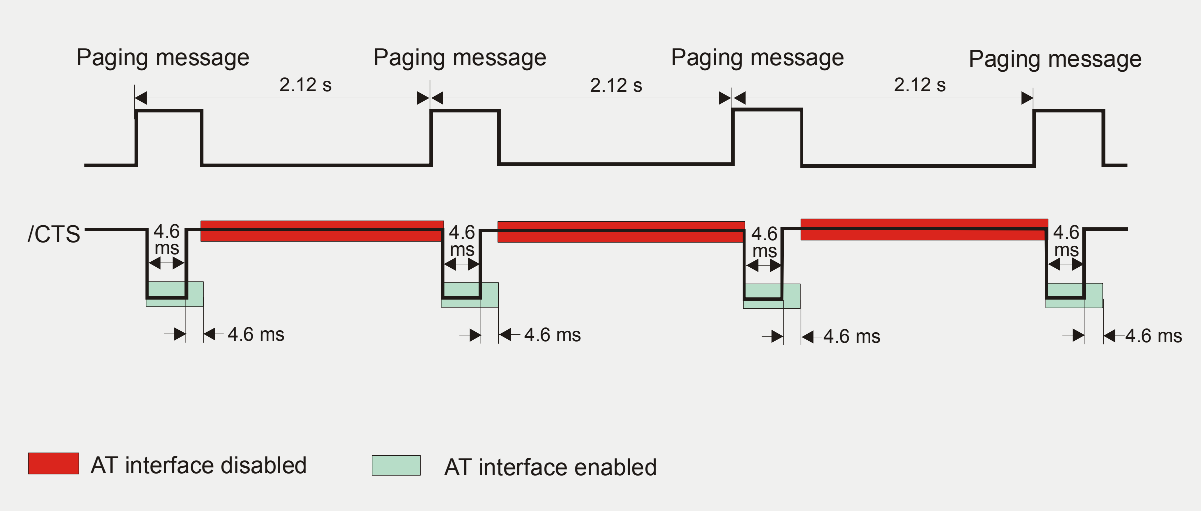


Figure 11: Timing of /CTS signal (example for a 2.12 s paging cycle)

Figure 12 illustrates the CFUN=5 mode, which resets the /CTS signal 2 seconds after the last character was sent or received.

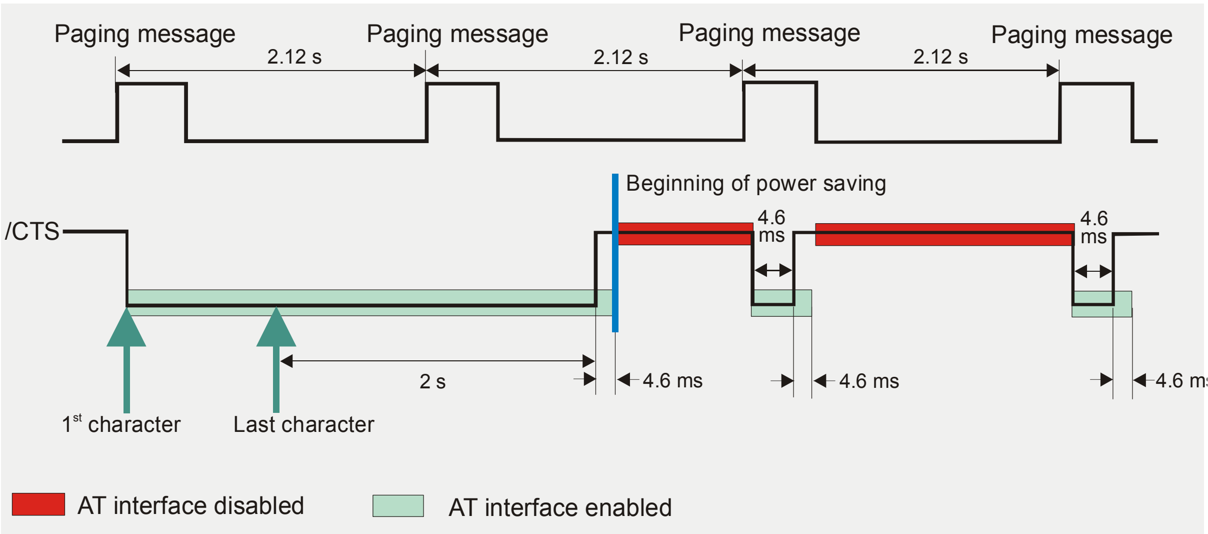


Figure 12: Beginning of power saving if CFUN=5

3.5.5 Wake up TC35i from SLEEP mode

A wake up event is any event that switches off the SLEEP mode and causes TC35i to return to full functionality. In short, it takes TC35i back to AT+CFUN=1.

Definitions of the state transitions described in Table 9:
Yes = TC35i exits SLEEP mode.
No = TC35i does not exit SLEEP mode.

Table 9: Wake-up events in NON-CYCLIC and CYCLIC SLEEP modes

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

Recommendation:

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

2) Recommendation: In NON-CYCLIC SLEEP mode, you can set an RTC alarm to wake up TC35i and return to full functionality. This is a useful approach because, in this mode, the AT interface is not accessible.

3.5.6 Summary of state transitions (except SLEEP mode)

Table 10: State transitions of TC35i (except SLEEP mode)

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

Further mode →→→ Present mode	Power Down	Normal mode**)	Charge-only mode*)	Charging in normal mode*)**)	Alarm mode
Power Down mode <u>without</u> charger	---	/IGT >100 ms at low level	Connect charger to POWER (high level at POWER)	No direct transition, but via “Charge-only mode” or “Normal mode”	Wake-up from Power Down mode (if activated with AT+CALA)
Power Down mode with charger (high level at POWER pins)	---	/IGT > 1 s at low level, if battery is fully charged	100ms < /IGT < 500ms at low level	/IGT >1 s at low level	Wake-up from Power Down mode (if activated with AT+CALA)
Normal mode**)	AT^SMSO <u>or</u> exceptionally /EMERGOFF pin > 3.2 s at low level	---	No automatic transition, but via “Power Down”	Connect charger to POWER (high level at POWER)	AT+CALA followed by AT^SMSO. TC35i enters Alarm mode when specified time is reached.
Charge-only mode *)	Disconnect charger (POWER at low level) <u>or</u> AT^SMSO <u>or</u> exceptionally /EMERGOFF >3.2 s at low level	No automatic transition, but via “Charge in Normal mode”	---	/IGT >1 s at low level	No direct transition
Charging in normal mode*) **)	Via “Charge-only mode” <u>or</u> exceptionally /EMERGOFF > 3.2 s at low level	Disconnect charger from POWER pins at TC35i	AT^SMSO	---	No direct transition
Alarm mode	AT^SMSO <u>or</u> exceptionally /EMERGOFF > 3.2 s at low level	/IGT >100 ms at low level	AT^SMSO if charger is connected	/IGT >100 ms at low level	---

*) See Chapter 3.4.3 for details on the charging mode **) Normal mode covers TALK, IDLE and SLEEP modes

3.6 RTC backup

The internal Real Time Clock of TC35i is supplied from a dedicated voltage regulator in the power supply ASIC which is also active when TC35i is in POWER DOWN status. An alarm function is included that allows to wake up TC35i without logging on to the GSM network.

In addition, you can use the VDDLP pin on the ZIF connector (pin no. 30) to backup the RTC from an external capacitor or a battery (chargeable or non-chargeable). The capacitor is charged by the BATT+ line of TC35i. 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 the module, i.e. the greater capacitor the longer TC35i will save the date and time.
If you need to adjust the date and time use the AT+CCLK command. To set the alarm time enter AT+CALA. For further instructions please refer to Chapter 3.3.1.4 and to the AT Command Set.

A serial resistor placed on the board next to the VDDLP line limits the input current of an empty capacitor. This eliminates the need of adding a resistor as required in applications based on the earlier TC35 module.

The following figures show various sample configurations. The voltage applied at VDDLP can be in the range from 2 to 5.5V. Please refer to Table 23 for the parameters required.

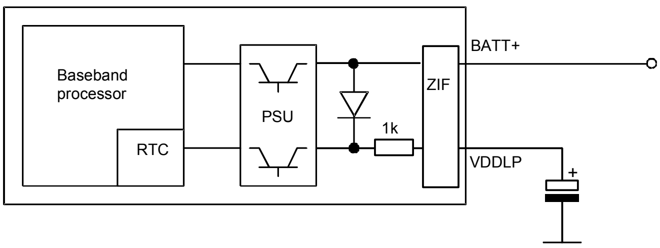


Figure 13: RTC supply from capacitor

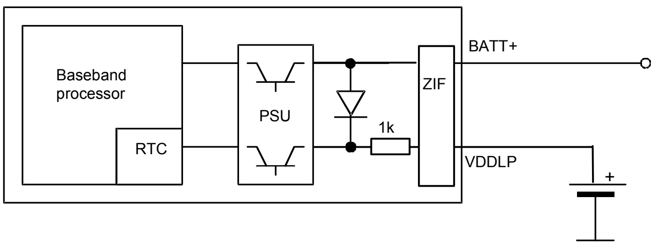


Figure 14: RTC supply from rechargeable battery

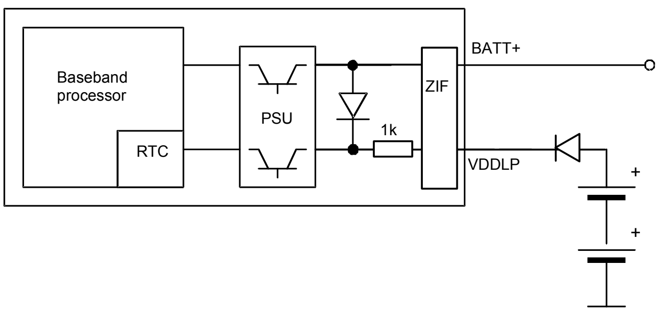


Figure 15: RTC supply from non-chargeable battery (e.g. a coin cell)

Note: In battery powered applications (Figure 14 and Figure 15), ensure that the voltage supplied from the batteries is $V_{BATTERY} \leq V_{BATT+}$.

The VDDLP voltage should be kept below the minimum BATT+. voltage. This is significant to prevent the GSM engine from being powered over the RTC backup battery. Please refer to Chapter 5.3. for more information.
The reference voltage listed in Table 23 are values measured directly on the TC35i GSM engine. They do not apply to the accessories connected.

3.7 Serial interface

TC35i offers an 8-wire, unbalanced, asynchronous serial interface conforming to ITU-T V.24 protocol DCE signaling. The electrical characteristics do not comply with ITU-T V.28. The significant levels are 0V (for low data bit or ON condition) and 2.65V (for high data bit or OFF condition). For electrical characteristics please refer to Table 23.

TC35i is designed for use as a DCE. Based on the conventions for DCE-DTE connections it communicates with the customer application (DTE) using the following signals:

- Port /TXD @ application sends data to the module's /TXD0 signal line
- Port /RXD @ application receives data from the module's /RXD0 signal line

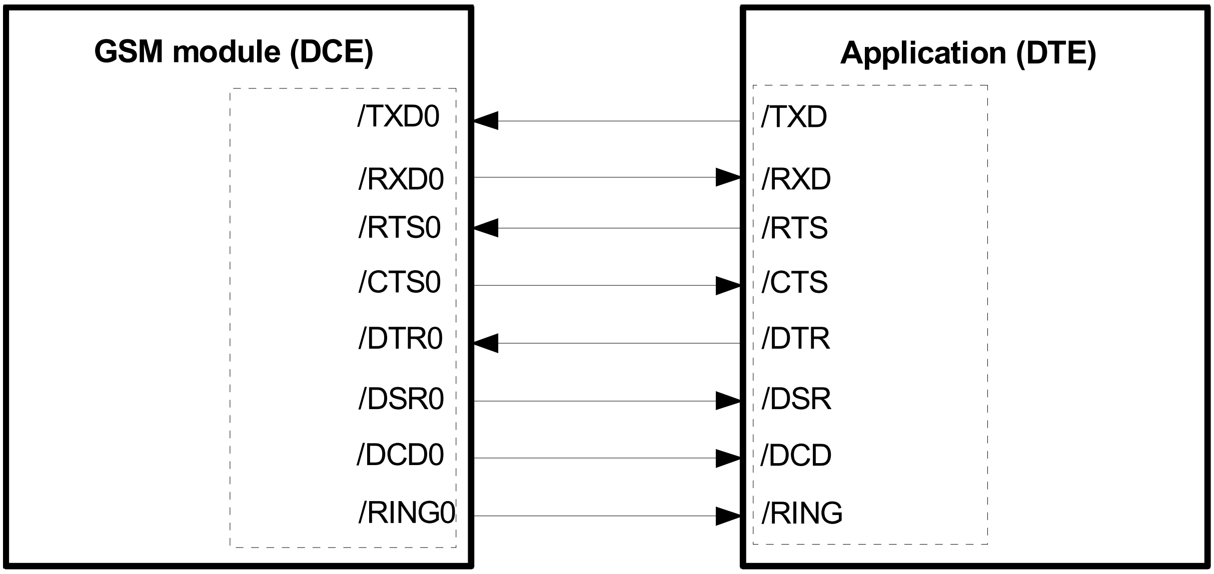


Figure 16: Serial interface

Table 11: DCE-DTE wiring

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

Features of the serial interface:

- Designed for voice, CSD, fax and for controlling the GSM engine with AT commands.
- Full Multiplex capability allows the interface to be partitioned into three virtual channels, yet with CSD and fax services only available on the first logical channel.
- Includes the data lines /TXD0 and /RXD0, the status lines /RTS0 and /CTS0 and, in addition, the modem control lines /DTR0, /DSR0, /DCD0 and /RING0.
- The /DTR0 signal will only be polled once per second from the internal firmware of TC35i. The /RING0 signal serves to indicate incoming calls and other types of URCs (Unsolicited Result Code).
- 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 se [1].
- Can be operated at bit rates from 300bps to 230400 bps.
- Autobauding supports the following bit rates: 4800, 9600, 19200, 38400, 57600, 115200, 230400 bps.
- Supports hardware handshake using RTS0/CTS0 and XON/XOFF software flow control.

3.8 Audio interface

TC35i comprises two analog audio interfaces each with a balanced anlog microphone input and a balanced analog earpiece output. The second analog interface provides a supply circuit to feed an active microphone.

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

TC35i offers six audio modes which can be selected with the AT^SNFS command. There is a default assignment of the audio interface for each audio mode (see Table 26) which can be temporarily changed with AT^SAIC and also saved with AT^SNFW within the currently selected audio mode (except audio mode 1). The electrical characteristics of the voiceband part vary with the audio mode. For example, sending and receiving amplification, sidetone paths, noise suppression etc. depend on the selected mode and can be altered with the AT commands (except for mode 1).

Please refer to Chapter 5.5 for specifications of the audio interface and an overview of the audio parameters. Detailed instructions on using AT commands are presented in [1].
Table 26 summarizes the characteristics of the various audio modes and shows what parameters are supported in each mode.

When shipped from factory, interface 1 and audio mode 1 are activated. This is the default configuration optimized for the Votronic HH-SI-30.3/1.1/0 handset and used for type approving the Siemens reference configuration. Audio mode 1 has fix parameters which cannot be modified. To adjust the settings of the Votronic handset simply change to another audio mode.

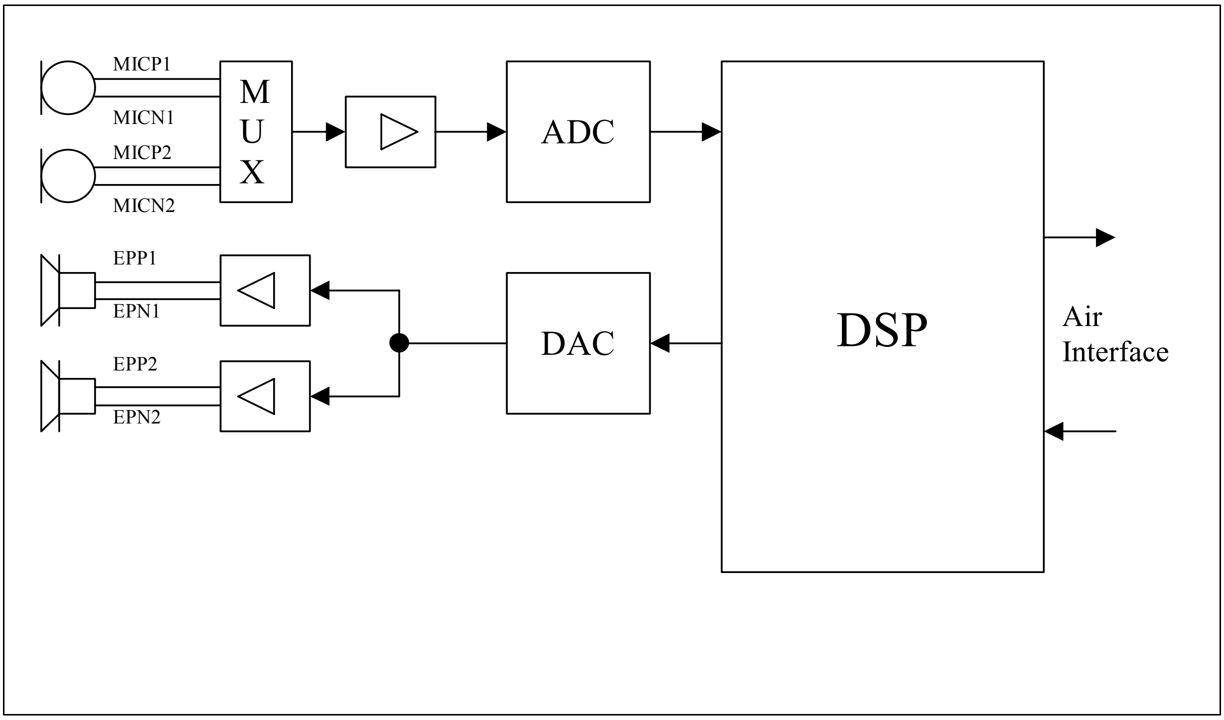


Figure 17: Audio block diagram

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

Customer specific audio parameters can be evaluated by Siemens on customer request. These parameters can be downloaded to TC35i using the appropriate AT command. For further details refer to [7] or contact your local Siemens dealer.

3.9 SIM interface

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

The CCIN pin serves to detect whether a tray (with SIM card) is present in the card holder. Using the CCIN pin is mandatory for compliance with the GSM 11.11 recommendation if the mechanical design of the host application allows the user to remove the SIM card during operation. See Chapter 3.9.1 for details.

It is recommended that the total cable length between the ZIF connector pins on TC35i and the pins of the SIM card holder does not exceed 200 mm in order to meet the specifications of 3GPP TS 51.010-1 and to satisfy the requirements of EMC compliance.

Table 12: Signals of the SIM interface (ZIF connector)

Signal	Description
CCGND	Separate ground connection for SIM card to improve EMC.
CCCLK	Chipcard clock, various clock rates can be set in the baseband processor.
CCVCC	SIM supply voltage from PSU-ASIC
CCIO	Serial data line, input and output.
CCRST	Chipcard reset, provided by baseband processor.
CCIN	Input on the baseband processor for detecting a SIM card tray in the holder. The CCIN pin is mandatory for applications that allow the user to remove the SIM card during operation. The CCIN pin is solely intended for use with a SIM card. It must not be used for any other purposes. Failure to comply with this requirement may invalidate the type approval of TC35i.

3.9.1 Requirements for using the CCIN pin

According to ISO/IEC 7816-3 the SIM interface must be immediately shut down once the SIM card is removed during operation. Therefore, the signal at the CCIN pin must go low *before* the SIM card contacts are mechanically detached from the SIM interface contacts. This shut-down procedure is particularly required to protect the SIM card as well as the SIM interface of TC35i from damage.

An appropriate SIM card detect switch is required on the card holder. For example, this is true for the model supplied by Molex, which has been tested to operate with TC35i and is part of the Siemens reference equipment submitted for type approval. Ordering information can be found in Chapter 8.

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

a) If, during startup of TC35i, the CCIN signal on the SIM interface is high, then the status of the SIM card holder can be recognized each time the card is inserted or ejected.
   A low level of CCIN indicates that no SIM card tray is inserted into the holder. In this case, the module keeps searching, at regular intervals, for the SIM card. Once the SIM card tray with a SIM card is inserted, CCIN is taken high again.
b) If, during startup of TC35i, the CCIN signal is low, the module will also attempt to initialize the SIM card. In this case, the initialization will only be successful when the card is present.
   If the SIM card initialization has been done, but the card is no more operational or removed, then the module will never search again for a SIM card and only emergency calls can be made.

Removing and inserting the SIM card during operation requires the software to be reinitialized. Therefore, after reinserting the SIM card it is necessary to restart TC35i.
It is strongly recommended to connect the contacts of the SIM card detect switch to the CCIN input and to the CCVCC output of the module as illustrated in the sample diagram in Figure 18.

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 TC35i.

3.9.2 Design considerations for SIM card holder

The schematic below is a sample configuration that illustrates the Molex SIM card holder located on the DSB35 Support Box (evaluation kit used for type approval of the Siemens TC35i reference setup, see [3] for technical details). X1201 is the designation used in [3] to refer to the SIM card holder.

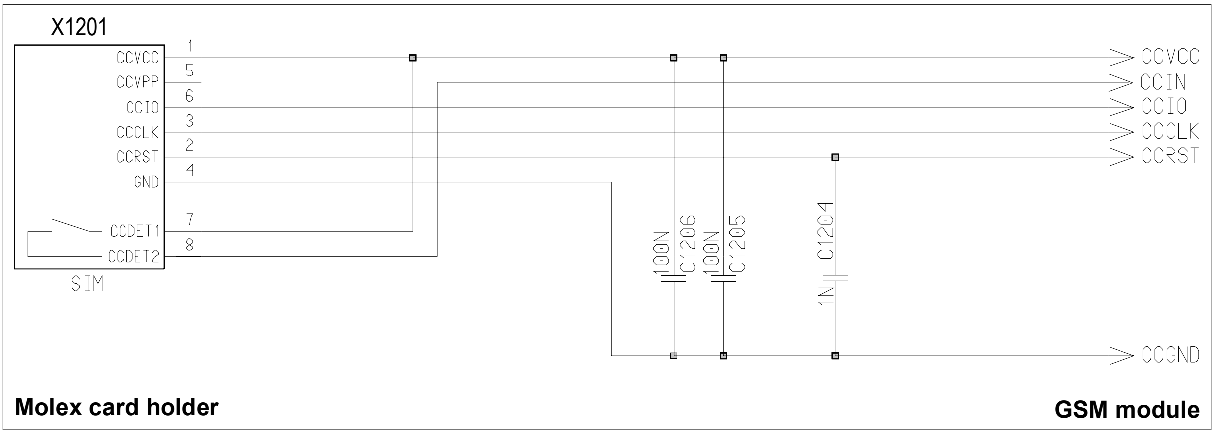


Figure 18: SIM card holder of DSB35 Support Box

Table 13: Pin assignment of Molex SIM card holder on DSB35 Support Box

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

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

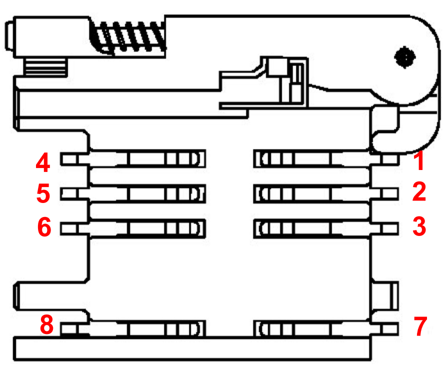


Figure 19: Pin numbers of Molex SIM card holder on DSB35 Support Box

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

3.10 Control signals

3.10.1 Inputs

Table 14: Input control signals of the TC35i module

Signal	Pin	Pin status	Function	Remarks
Ignition	/IGT	= falling edge	Power up TC35i	Active low ≥ 100ms (open drain/collector driver required in cellular device application) Note: If a charger and a battery is connected to the customer application the /IGT signal must be 1s minimum (see description in Chapter 3.3.1)
		= 1	Hi-Z	
Emergency shutdown	/EMERG-OFF	= 0	Power down TC35i	Active low ≥ 3.2s (Open drain/collector driver required in cellular device application). At the /EMERGOFF signal the watchdog signal of the GSM engine can be traced (see description in Table 23 and Chapter 3.3.1).
		= 1	Hi-Z	

(HiZ = high impedance)

3.10.2 Outputs

3.10.2.1 Synchronization signal

The synchronization signal serves to indicate growing power consumption during the transmit burst. The signal is generated by the SYNC pin (pin number 32). Please note that this pin can adopt three different operating modes which you can select by using the AT^SSYNC command: the SYNC mode 0 described below, and the two LED modes 1 and 2 described in [1] and Chapter 3.10.2.2.

SYNC mode 0 (default)
To generate the synchronization signal the pin needs to be configured to mode 0 (= default). This setting is recommended if you want your application to use the synchronization signal for better power supply control. Your application design must be such that the incoming signal accommodates sufficient power supply to the TC35i module if required. This can be achieved by lowering the current drawn from other components installed in your application.

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

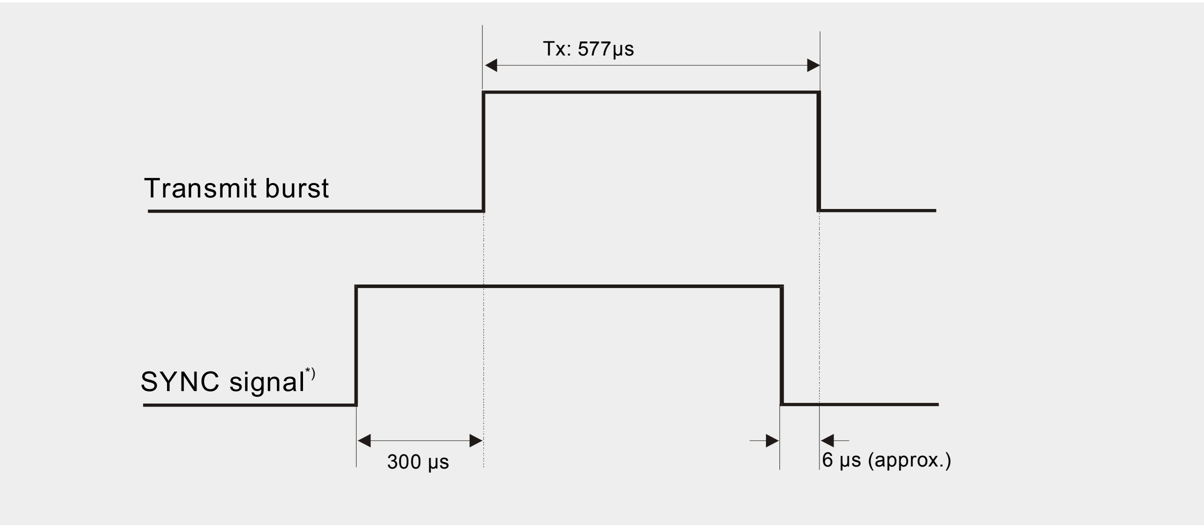


Figure 20: TC35i output control signals

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

3.10.2.2 Using the SYNC pin to control a status LED

As an alternative to generating the synchronization signal, the SYNC pin can be used to control a status LED on your application platform. Especially in the development and test phase of an application, system integrators are advised to use the LED mode of the SYNC pin in order to evaluate their product design and identify the source of errors.

To avail of this feature you need to set the SYNC pin to mode 1 or 2 by using the AT^SSYNC command. For details see [1].

When controlled from the SYNC pin the LED can display the functions listed in Table 15. For better control of power saving LED mode 2 should be given priority. See also Chapter 3.5 for details on power saving.

Table 15: Modes of the LED and associated functions

<table>
<tr><th>LED behavior</th><th>LED mode 1</th><th>LED mode 2</th></tr>
<tr><td>Off</td><td>TC35i is off or runs in SLEEP, Alarm or Charge-only mode.</td><td>TC35i is off or runs in Alarm or Charge-only mode</td></tr>
<tr><td>600 ms on / 600ms off</td><td colspan="2">No SIM card inserted or no PIN entered, or network search in progress, or ongoing user authentication, or network login in progress.</td></tr>
<tr><td>75ms on / 3s off</td><td colspan="2">Logged to network (monitoring control channels and user interactions). No call in progress. TC35i is in full functionality mode (AT+CFUN=1) or in a “temporary wake-up state” after characters have been detected on the serial interface in CYCLIC SLEEP mode. The AT interface is fully accessible.</td></tr>
<tr><td>On</td><td colspan="2">Depending on type of call:
Voice call: Connected to remote party.
Data call: Connected to remote party or exchange of parameters while setting up or disconnecting a call.</td></tr>
<tr><td><n> ms on / <n> ms off</td><td>Not possible
LED signalization is disabled in SLEEP mode</td><td>SLEEP mode is activated, but power saving does not work because the mobile is not registered to the GSM network (e.g. SIM not inserted or PIN not entered, therefore either no network service or only “Limited network service” is available).</td></tr>
<tr><td>Approx. 15ms on / <m> ms off</td><td>Not possible
LED signalization is disabled in SLEEP mode</td><td>SLEEP mode is activated while the mobile is registered to the GSM network. Power saving is properly enabled.</td></tr>
</table>

The duration of <n> and <m> depends on the network. In SLEEP mode, TC35i can only change its LED status during wake-up phases when listening to paging information from the base station. Therefore the values of <n> and <m> vary as follows:
<n> = value from 1410ms to 2360ms
<m> = value from 2110ms to 3770ms

To operate the LED a buffer, e.g. a transistor or gate, must be included in your application. A sample configuration can be gathered from Figure 21. Power consumption in the LED mode is the same as for the synchronization signal mode. For details see Table 23 pin number 32.

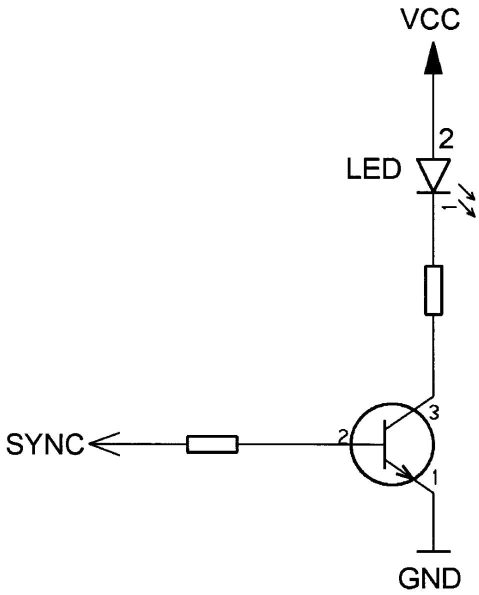


Figure 21: LED Circuit (Example)

3.10.2.3 Behavior of the /RING0 line

The /RING0 line is available on the serial interface (see also Chapter 3.7). The signal serves to indicate incoming calls and other types of URCs (Unsolicited Result Code).

Although not mandatory for use in a host application, it is strongly suggested that you connect the /RING0 line to an interrupt line of your application. In this case, the application can be designed to receive an interrupt when a falling edge on /RING0 occurs. This solution is most effective, particularly, for waking up an application from power saving. Note that if the /RING0 line is not wired, the application would be required to permanently poll the data and status lines of the serial interface at the expense of a higher current consumption. Therefore, utilizing the /RING0 line provides an option to significantly reduce the overall current consumption of your application.

The behavior of the /RING0 line varies with the type of event:

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

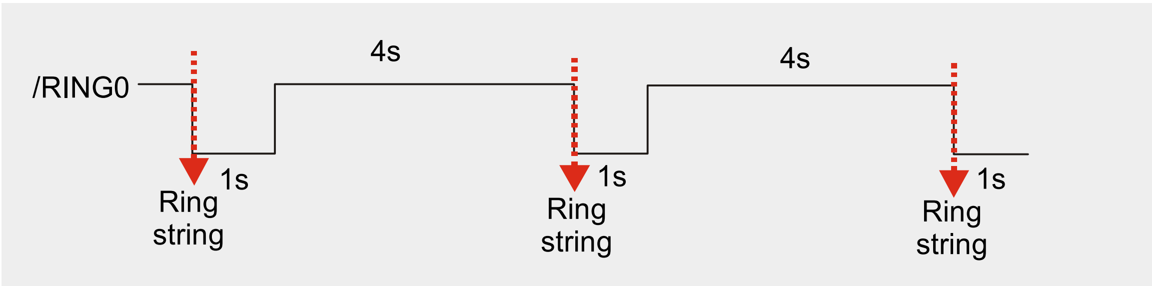


Figure 22: Incoming voice call

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

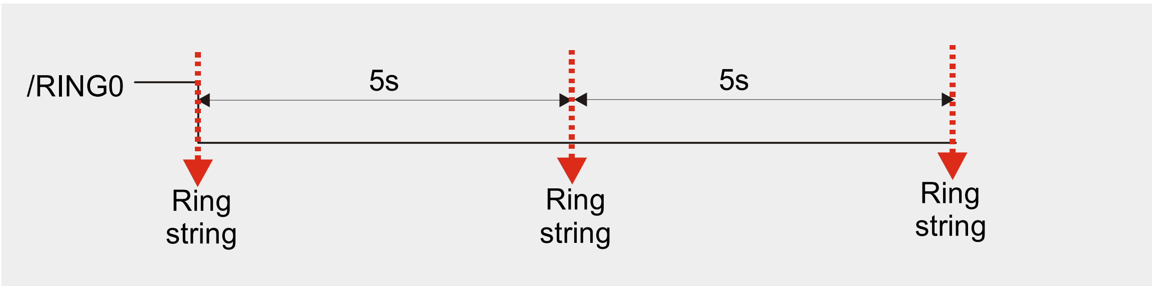


Figure 23: Incoming data call

- All types of Unsolicited Result Codes (URCs) also cause the /RING0 line to go low, however for 1 second only.
  For example, TC35i may be configured to output a URC upon the receipt of an SMS. As a result, if this URC type was activated with AT+CNMI=1,1, each incoming SMS causes the /RING0 line to go low. See [1] for detailed information on URCs.

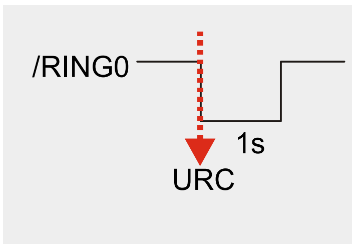


Figure 24: URC transmission

Table 16: TC35i ring signal

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

4 RF interface

The RF interface has an impedance of 50Ω. TC35i is capable of sustaining a total mismatch at the antenna connector without any damage, even when transmitting at maximum power level. The antenna jack located on the TC35i PCB is a MuRata GSC coaxial connector (see Figure 25).

The external antenna must be matched properly at least to achieve best performance regarding radiated power, DC-power consumption and harmonic suppression. Please note that the receiver is designed to use the direct conversion concept.

Regarding the return loss TC35i provides the following values.

Table 17: Return loss

State of module	Return loss of module	Recommended return loss of application
Receive	$\geq$ 8dB	$\geq$ 12dB
Transmit	not applicable	$\geq$ 12dB
Idle	$\leq$ 5dB	not applicable

A 27nH inductor to ground provides additional ESD protection for the antenna connector. To protect the inductor from damage no DC voltage must be applied to the antenna circuit.

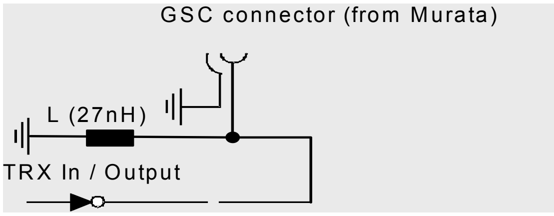


Figure 25: Antenna connector circuit on TC35i

4.1 Antenna connector

TC35i uses a GSC connector to establish the RF connection to the host application. Below please find brief ordering information to help you retrieve further details from the manufacturer MuRata, e.g. under http://www.murata.com.

Table 18: MuRata ordering information

Description	MuRata part number
Male connector mounted on TC35i	MM9329-2700
Matching female connectors suited for individual cable assembly • Right-angle flexible cable • Right-angle flexible cable • Right-angle semirigid cable	 MXTK88xxxx MXTK92xxxx MXTK91xxxx

The physical dimensions and maximum mechanical stress limits can be gathered from the table and the figures below. To securely fasten or remove the antenna cable MuRata recommends to use the P/N M22001 engagement/disengagement tool.

Table 19: Ratings and characteristics of the GSC antenna connector

Item	Specification
Frequency range	DC to 6GHz
VSWR	1.2 max. (DC to 3 GHz), 1.3 max. 3GHz to 6GHz)
Nominal impedance	50Ω
Temperature range	-40°C to +90°C
Contact resistance	15mΩ max.
Withstanding voltage	AC300V
Insulation resistance	500MΩ min.
Material and finish • Center contact: • Outer contact: • Insulator:	Material: Finish: • Copper alloy Gold plated • Copper alloy Silver plated • Engineering plasticNone

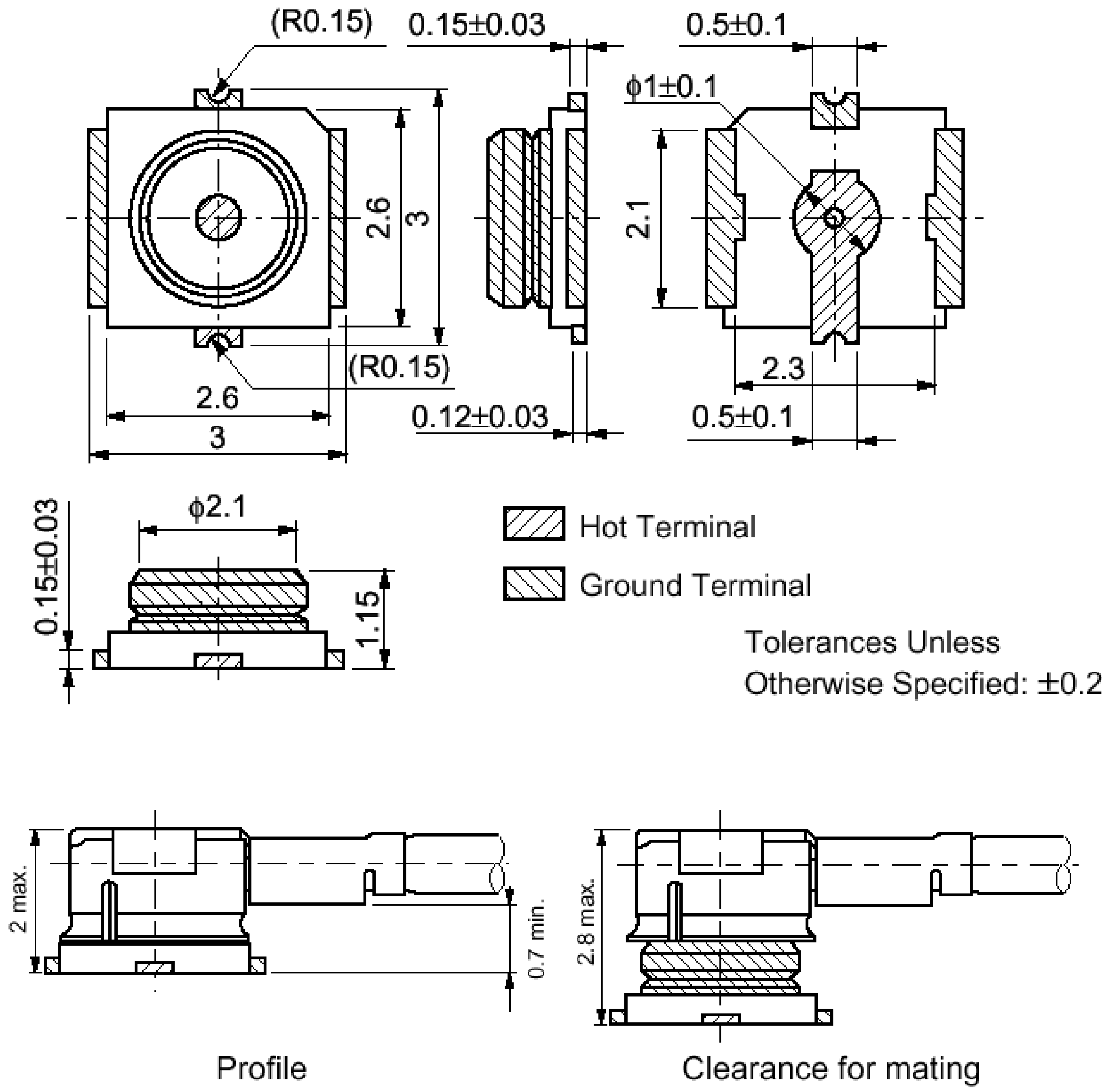


Figure 26: Mechanical dimensions of MuRata GSC connector (in mm)

Table 20: Stress characteristics of the GSC antenna connector

Parameter	Specification
Connector durability	100 cycles of mating and withdrawal with a jig at 12 cycles/minute maximum
Engage force	30N max
Disengage force	3N min, 30N max
Angle of engagement	15 degree max
Mechanical stress to connector • Stress to the housing: • Stress to outer sleeve: • Cable pull strength:	See Table 19 for details A and B: 4.9N max. C: 2.94N max and D: 1.96N max E: 4.9N max

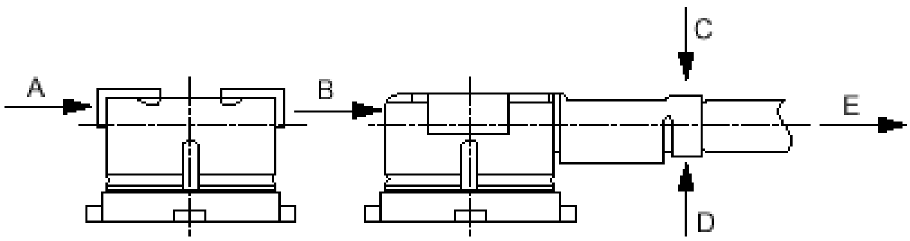


Figure 27: Maximum mechanical stress to the connector

The following figure illustrates the engagement/disengagement tool type P/N M22001 recommended by MuRata and provides instructions for proper use.

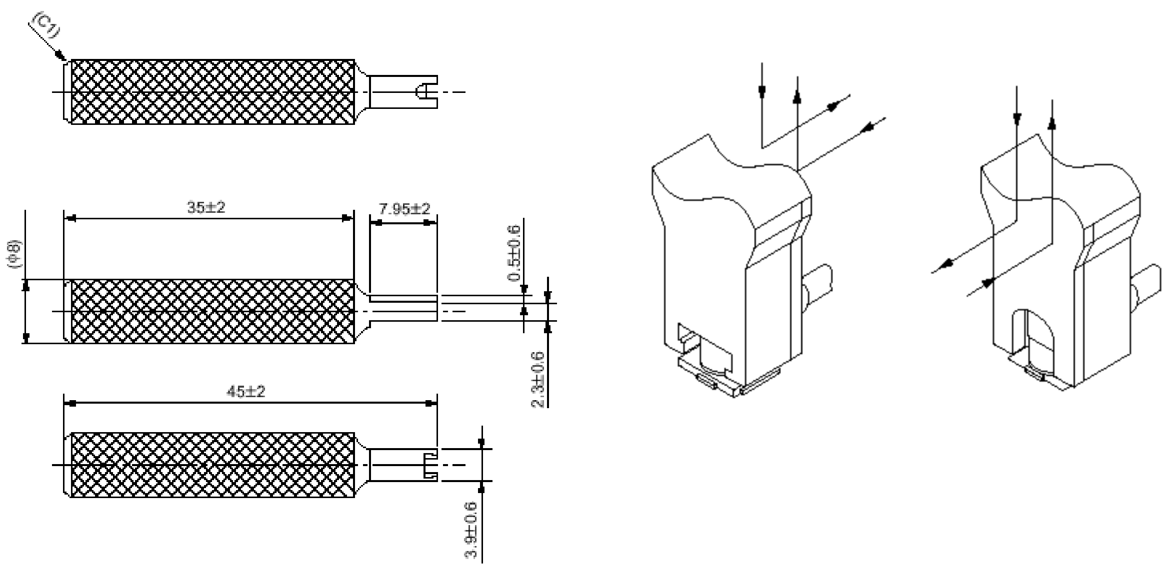


Figure 28: How to use MuRata tool

5 Electrical, reliability and radio characteristics

5.1 Absolute maximum ratings

The absolute maximum ratings stated in Table 21 are stress ratings under non-operating conditions. Stresses beyond any of these limits will cause permanent damage to TC35i.

Table 21: Absolute maximum ratings

Parameter	**Min**	**Max**	**Unit**
Voltage at digital pins	-0.3	3.3	V
Voltage at analog pins	-0.3	3.0	V
Voltage at POWER pins		20	V
Current at POWER pins		800	mA
Voltage at digital / analog pins in POWER DOWN mode	-0.25	+0.25	V
BATT+	-0.3	5.5	V

5.2 Operating conditions

5.2.1 Temperature conditions

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

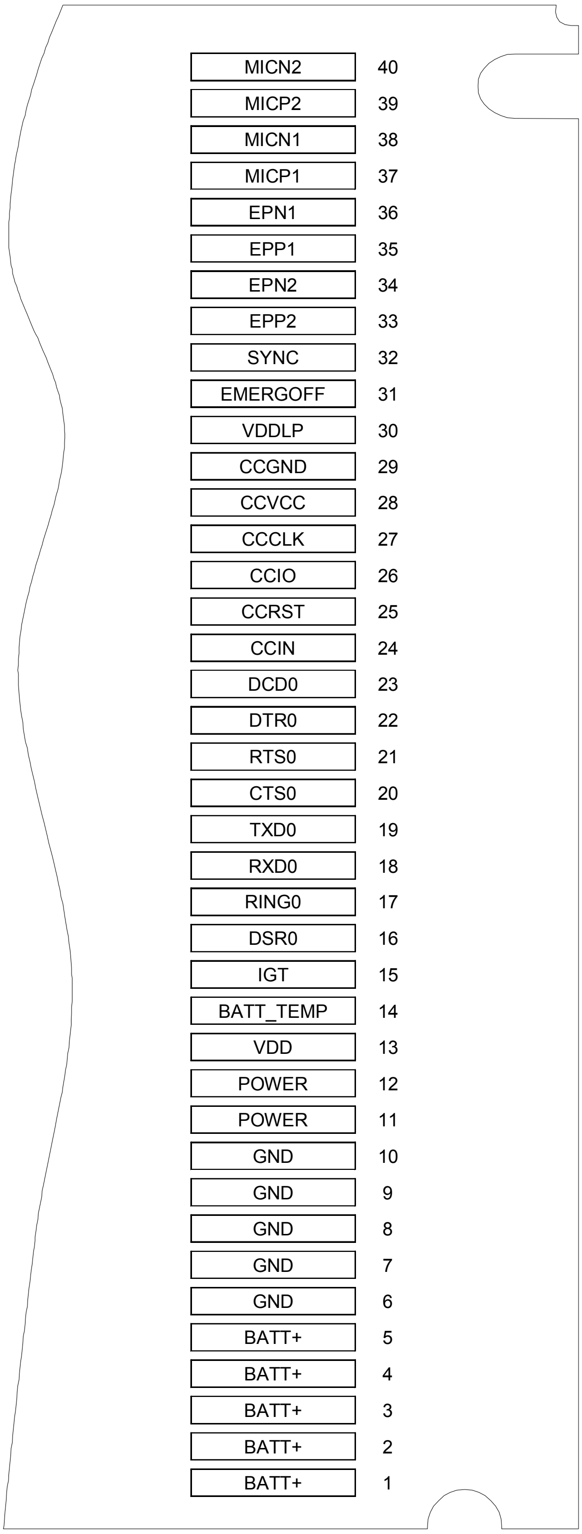
Table 22: Temperature conditions

Parameter	**Min**	**Typ**	**Max**	**Unit**
Ambient temperature (according to GSM 11.10)	-20	25	55	°C
Restricted operation *)	-25 to –20		55 to 70	°C
Automatic shutdown**): if application is not battery powered if application is battery powered	≤-25 ≤-18		≥70 ≥60	°C °C
Charging temperature (software controlled fast charging)	0		+45	°C

*) TC35i operates, but deviations from the GSM specification may occur.
**) Due to temperature measurement uncertainty, a tolerance of ±3°C on these switching thresholds max occur.

5.3 Electrical specifications of the application interface

Please note that the reference voltages listed in Table 23 are the values measured directly on the TC35i module. They do not apply to the accessories connected.
If an input pin is specified for $V_{i,h\ max}$=3.3V, ensure never to exceed the stated voltage. The value 3.3V is an absolute maximum rating.



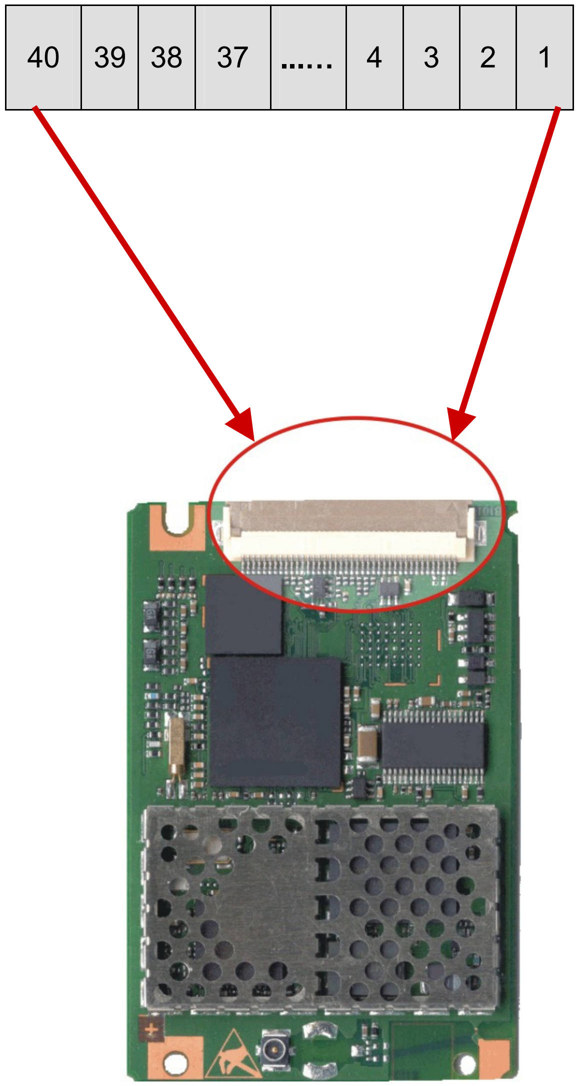
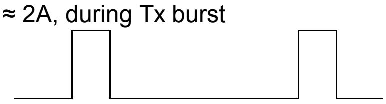


Figure 29: Pin assignment (top view on TC35i)

Table 23: Pin assignment and electrical description of application interface

Function	Signal name	IO	Signal form and level	Comment
Power supply	BATT+	I	V_I = 3.3V to 4.8V $V_{I,typ}$ = 4.2V I_{nom} ≈ 2A, during Tx burst  1 Tx, Peak current 577µs every 4.615ms	Five pins of BATT+ and GND must be connected in parallel for supply purposes because higher peak current may occur, see Chapter 5.4.
Power supply	GND		Ground	Application Ground
Charge Interface	POWER	I	$V_I$min = 3.0V $V_I$max = 15V Imax = 500mA	This line signalizes to the processor that the charger is connected. If unused keep pin open.
	BATT_TEMP	I	Connect NTC with R_{NTC} ≈ 10kΩ @ 25°C to ground.	Battery temperature measurement via NTC resistance. NTC should be installed inside or near battery pack to enable the charging algorithm and deliver temperature values. If unused keep pin open.
External supply voltage	VDD	O	IDLE / TALK mode: V_{out} = 2.9V; ±3% @ 70mA; V_{BATT+} = 4.2V and $T_{amb,typ}$ = 25°C V_{out} = 2.9V; ±3% @ 20mA; V_{BATT+} = 4.8V and $T_{amb,typ}$ = 25°C I_{max} = 70mA Power Down mode: V_{out} = 0V $C_{load,max,extern}$ = 1µF	Can be used, for example, to connect a level converter or a pull-up resistor. Not recommended for components operated by pulse current. Not available in power down mode. The external digital logic must not cause any spikes or glitches on voltage VDD. VDD signals "ON" state of module. Voltage is applied ca. 60ms after IGT was driven low If unused keep pin open.
Ignition	/IGT	I	R_I ≈ 100kΩ, C_I ≈ 1nF V_{IL}max = 0.5V at Imax = -20µA V_{Open}max = 2.3V ON ~~~|____|~~~ Active Low ≥ 100ms	This signal switches the mobile ON. This line must be driven low by an Open Drain or Open Collector driver.

Function	Signal name	IO	Signal form and level	Comment
Emergency shutdown	/EMERGOFF	I	R_I ≈22kΩ V_{IL}max = 0.45V at Imax = -100µA V_{Open}max = 2.25V Signal Active Low ≥ 3.2s Watchdog: V_{OL}max = 0.35V at I = 10µA V_{OH}min= 2.25V at I = -10µA $f_O$min = 0.16Hz $f_O$max = 1.55Hz	This line must be driven by an Open Drain or Open Collector driver. Emergency shutdown deactivates the modules power supply. A reset can be done with a following IGT. /EMERGOFF also indicates the internal watchdog function. To avoid floating if pin is high impedance, use pull-down resistor tied to GND. See Chapter 3.3.2.1 If unused keep pin open.
Synchroni-zation	SYNC	O	V_{OL}max = 0.3V at I = 0.1mA V_{OH}min = 2.25V at I = -0.1mA V_{OH}max = 2.73V	Indication of increased current consumption during uplink transmission burst, however, the timing is different during handover. Alternatively used to control status LED. Please note that the timing behavior is different in SYNC and LED mode, refer to Chapter 3.10.2.1 and 3.10.2.2 for details. If unused keep pin open.
SIM Interface	CCIN	I	R_I ≈ 100kΩ V_{IL}max = 0.5V V_{IH}min = 2.15V at I = 20µA, V_{IH}max=3.3V at I = 30µA	CCIN = high, SIM card holder closed (no card recognition) Maximum cable length or copper track 200mm to SIM card holder. All signals of SIM interface are protected against ESD with a special diode array. Usage of CCGND is mandatory.
	CCRST	O	R_O ≈47Ω V_{OL}max = 0.25V at I = 1mA V_{OH}min = 2.3V at I = -1mA V_{OH}max = 2.73V	
	CCIO	IO	R_I ≈10kΩ V_{IL}max = 0.5V V_{IH}min = 1.95V, V_{IH}max=3.3V R_O ≈220Ω V_{OL}max = 0.4V at I = 1mA V_{OH}min = 2.15V at I = -1mA V_{OH}min = 2.55V at I = -20µA V_{OH}max = 2.96V	
	CCCLK	O	R_O ≈220Ω V_{OL}max = 0.4V at I = 1mA V_{OH}min = 2.15V at I = -1mA V_{OH}max = 2.73V	
	CCVCC	O	$R_O$max = 5Ω CCVCCmin = 2.84V, CCVCCmax = 2.96V Imax = 20mA	
	CCGND		Ground	

Function	Signal name	IO	Signal form and level	Comment
RTC backup	VDDLP	O I	If V_{BATT+} is connected (IDLE/ TALK/ DATA/ POWER DOWN): Vout < V_{BATT+} is disconnected Ri = 1kΩ (serial resistor) If BATT+ disconnected (POWER DOWN mode): Vin = 2.0V…5.5V Iin,max = 30 µA	If unused, keep pin open.
Serial interface	/RXD0 /TXD0 /CTS0 /RTS0 /DTR0 /DCD0 /DSR0 /RING0	O I 0 I I O O O	V_{OL}max = 0.3V @ I = 0.1mA V_{OH}min = 2.25V @ I = -0.1mA V_{OH}max = 2.73V Vilmax = 0.4V V_{IH}min = 1.95V, V_{IH}max = 3.45V /RTS0, /DTR0:Imax = -90µA @ V_{IN} = 0V /TXD0:Imax = -30µA @ V_{IN} = 0V V_{IL} = 0.25V	Serial interface for AT commands or data stream. To avoid floating if output pins are high-impedance, use pull-up resistors tied to VDD or pull-down resistors tied to GND. See chapter 3.3.2.1. If lines are unused keep pins open.
Analog Audio interface	EPP2 EPN2	O O	R_i ≈ 15Ω, (30kΩ if not active) gain range -18...0dB in 6 dB steps Max. output differential DC offset 100mV V_{Out} = 3.7V_{pp} typical, V_{Out} = 4.07V_{pp} max, V_{Out} = 3.03V_{pp} min, measurement conditions: sine signal, 3.14 dBm0, 1024Hz, load resistance = 200kΩ audio mode = 6, outBbcGain = 0, outCalibrate = 16384	The audio output is balanced and can directly operate an earpiece. If unused keep pins open.
	EPP1 EPN1	O O	R_i ≈ 15Ω, (30kΩ if not active) gain range -18...0dB in 6 dB steps Max. output differential DC offset 100mV V_{Out} = 3.7V_{pp} typical, V_{Out} = 4.07V_{pp} max, V_{Out} = 3.03V_{pp} min, @ measurement conditions: sine signal, 3.14 dBm0, 1024Hz, load resistance = 200kΩ audio mode = 5, outBbcGain = 0, outCalibrate = 16384	The audio output is balanced and can directly operate an earpiece. If unused keep pins open.
	MICP1 MICN1	I I	R_I = 2kΩ differential $V_I$max = 1.03Vpp V_{supply} = 2.65V at R_{supply} = 4kΩ analog amplification range = 0...42dB in 6dB steps	This microphone input is balanced and can feed an active microphone. If unused keep pins open.
Explanation of signal names: P = positive, N = negative	MICP2 MICN2	I I	R_I = 2kΩ differential $V_I$max = 1.03Vpp V_{supply} = 2.65V at R_{supply} = 4kΩ analog amplification range = 0...42dB in 6dB steps	This microphone input is balanced and can feed an active microphone. If unused keep pins open.

5.4 Power supply ratings

Table 24: Power supply ratings

Parameter	Description	Conditions	Min	Typ	Max	Unit
V_{BATT+}	Supply voltage	Directly measured at the reference point (pad) BATT+ Voltage must stay within the min/max values, including voltage drop, ripple, spikes.	3.3 [5)]	4.2	4.8	V
	Voltage drop during transmit burst [1)]	Normal condition, power control level for $P_{out\ max}$			400	mV
	Voltage ripple [1)]	Normal condition, power control level for $P_{out\ max}$ @ f<200kHz @ f>200kHz			 50 2	mV
I_{BATT+}	Average supply current [4)]	Power Down mode		50	100	µA
		SLEEP mode @ DRX=6		3		mA
		IDLE mode EGSM 900 [1)] GSM 1800		15		mA
		TALK mode EGSM 900 [1)] GSM 1800		300 [6)]	450	mA
	Peak supply current (during 577µs trans-mission slot every 4.6ms)	Power control level for $P_{out\ max}$ I_{max}		2	3.5 [3)]	A
I_{CHARGE}	Charging current	Li-Ion battery pack			500	mA
	Trickle charging [2)]	$U_{battery}$ 0...3.6V			9.0	mA

1) Power control level PCL 5
2) See Chapter 3.4.3
3) The maximum current at the BATT+ line during transmit operation strongly depends on the antenna performance. See Figure 30 for details.
4) All average supply currents values @ I_{VDD}= 0mA
5) During transmit burst, the voltage at the BATT+ reference point (pad) may drop to min. 3.3V (due to the source resistance of the supply voltage and cable losses). Note that this minimum voltage must be measured against the GND reference point (pad) on TC35i. See Chapter 3.2.2.
6) Stated values applies to an average antenna performance.

5.4.1 Burst peak current during transmit burst

A Smith chart shows the complex impedance plane. The Smith chart in Figure 30 illustrates the dependence between the typical peak current consumption of the application during a transmit burst and an impedance connected to the antenna jack / GSC connector.
As shown in Figure 30, the typical current consumption is about 2A, but the current is maximized when the minimum supply voltage is used together with a total reflection at the RF interface.

The Smith chart in Figure 30 shows the current consumption at the following conditions:
- Channel with the highest current consumption: 881 MHz (Channel 979)
- T_{amb}= 25°C
- Minimum supply voltage during burst = 3.3V

This measurement case was performed with a total resistance of about 100mΩ in the current path.

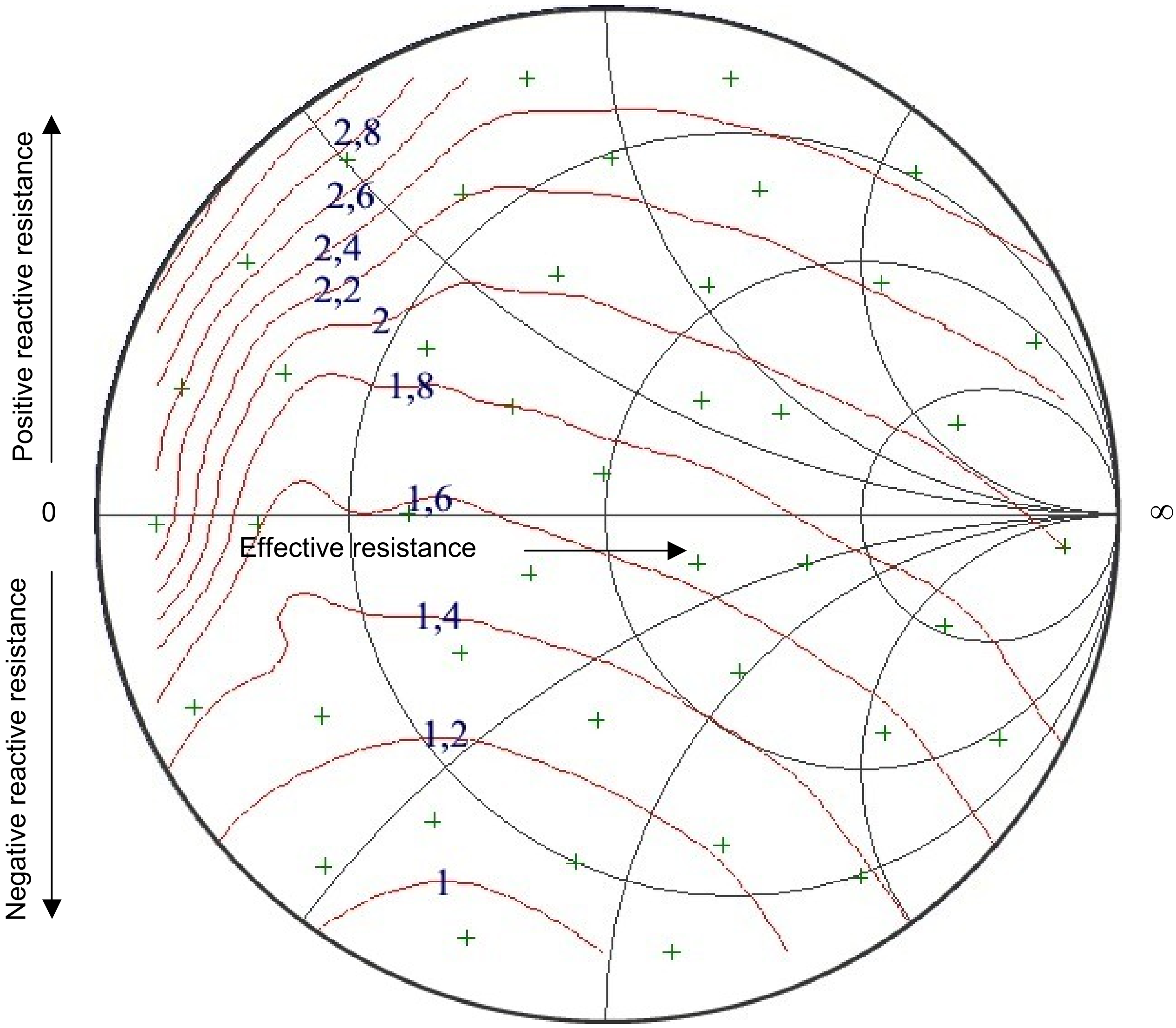


Figure 30: Peak current during transmit burst in A vs. antenna impedance

5.5 Electrical characteristics of the voiceband part

5.5.1 Setting audio parameters by AT command

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

Table 25: Audio parameters adjustable by AT command

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

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

5.5.2 Audio programming model

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

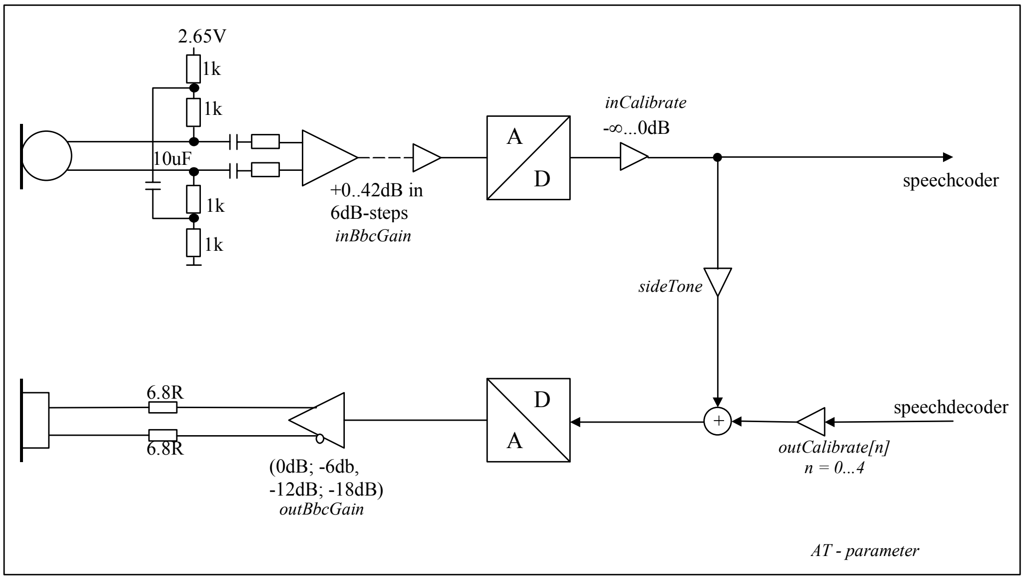


Figure 31: AT audio programming model

5.5.3 Characteristics of audio modes

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

Table 26: Voiceband characteristics (typical)

Audio mode no. AT^SNFS=	**1** (Default settings, not adjustable)	**2**	**3**	**4**	**5**	**6**
Name	Default Handset	Basic Handsfree	Headset	User Handset	Plain Codec 1	Plain Codec 2
Purpose	DSB with Votronic handset	Siemens Car Kit Portable	Siemens Headset	DSB with individual handset	Direct access to speech coder	Direct access to speech coder
Gain settting via AT command. Defaults:	Fix	Adjustable	Adjustable	Adjustable	Adjustable	Adjustable
inBbcGain	5 (30dB)	1 (6dB)	5 (30dB)	5 (30dB)	0 (0dB)	0 (0dB)
outBbcGain	1 (-6dB)	1 (-6dB)	2 (-12dB)	1 (-6dB)	0 (0dB)	0 (0dB)
MICPn/MICNn EPPn/EPNn	n=1	n=2	n=2	n=1	n=1	n=2 4)
Power supply	ON	ON	ON	ON	OFF	OFF
Sidetone	ON	---	Adjustable	Adjustable	Adjustable	Adjustable
Volume control	OFF	Adjustable	Adjustable	Adjustable	Adjustable	Adjustable
Limiter (receive)	ON	ON	ON	ON	---	---
Compressor (receive)	---	OFF 1)	---	---	---	---
AGC (send)	OFF	---	ON	---	---	---
Echo control (send)	Suppression	Cancellation + suppression	---	Suppres-sion	---	---
Noise suppression 2)	---	up to 10dB	10dB	---	---	---
MIC input signal for 0dBm0 @ 1024 Hz (default gain)	12.5mV	98mV	11mV @ -3dBm0 due to AGC	12.5mV	315mV	315mV
EP output signal in mV rms. @ 0dBm0, 1024 Hz, no load (default gain); @ 3.14 dBm0	275mV	120 mV default @ max volume	270mV default @ max volume	275 mV default @ max volume	895mV 3.7 Vpp	895mV 3.7 Vpp
Sidetone gain at default settings	27.7dB	-∞ dB	Affected by AGC, 9.3dB @ 11mV (MIC)	27.7 dB	-2.7dB @ sideTone = 8192 3)	-2.7dB @ sideTone = 8192 3)

1) Adaptive, receive volume increases with higher ambient noise level. The compressor can be activated by loading an application specific audio parameter set (see [7]).

2) In audio modes with noise reduction, the microphone input signal for 0dBm0 shall be measured with a sine burst signal for a tone duration of 5 seconds and a pause of 2 sec. The sine signal appears as noise and, after approx. 12 sec, is attenuated by the noise reduction by up to 10dB.
3) See AT^SNFO command in [1].
4) Audio mode 5 and 6 are identical. With AT^SAIC, you can easily switch mode 5 to the second interface. Therefore, audio mode 6 is only kept for compatibility to earlier GSM products.

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

5.5.4 Voiceband receive path

The values specified below were tested to 1kHz and 0dB gain stage, unless otherwise stated.

gs = 0dB means audio mode = 5 for EPP1 to EPN1 and 6 for EPP2 to EPN2, inBbcGain= 0, inCalibrate = 32767, outBbcGain = 0, OutCalibrate = 16384, sideTone = 0.

Table 27: Voiceband receive path

Parameter	**Min**	**Typ**	**Max**	**Unit**	**Test condition / remark**
Differential output voltage (peak to peak)	3.33	3.7	4.07	V	from EPPx to EPNx *gs* = 0dB @ 3.14 dBm0
Differential output gain settings (*gs*) at 6dB stages (outBbcGain)	-18		0	dB	
fine scaling by DSP (outCalibrate)	-∞		0	dB	
Output differential DC offset			100	mV	*gs* = 0dB, outBbcGain = 0 and -6dB
Differential output resistance	13	15		Ω	from EPPx to EPNx
Absolute gain accuracy			0.8	dB	Variation due to change in VDD, temperature and life time
Attenuation distortion			1	dB	for 300...3900Hz, @ EPPx/EPNx (333Hz) / @ EPPx/EPNx (3.66kHz)
Out-of-band discrimination	60			dB	for *f* > 4kHz with in-band test signal @ 1kHz and 1kHz RBW

gs = gain setting

5.5.5 Voiceband transmit path

The values specified below were tested to 1kHz and 0dB gain stage, unless otherwise stated.

Audio mode = 5 for MICP1 to MICN1 and 6 for MICP2 to MICN2, inBbcGain= 0, inCalibrate = 32767, outBbcGain = 0, OutCalibrate = 16384, sideTone = 0

Table 28: Voiceband transmit path

Parameter	Min	Typ	Max	Unit	Test condition/Remark
Input voltage (peak to peak) MICP1 to MICN1, MICP2 to MICN2			1.03	V	
Input amplifier gain in 6dB steps (inBbcGain)	0		42	dB	
Fine scaling by DSP (inCalibrate)	-∞		0	dB	
Input impedance		2.0		kΩ	
Microphone supply voltage ON Ri = 4kΩ	2.57 2.17 1.77	2.65 2.25 1.85	2.73 2.33 1.93	V V V	no supply current @ 100µA @ 200µA
Microphone supply voltage OFF Ri = 4kΩ		0		V	
Microphone supply in power down mode					see Figure 32

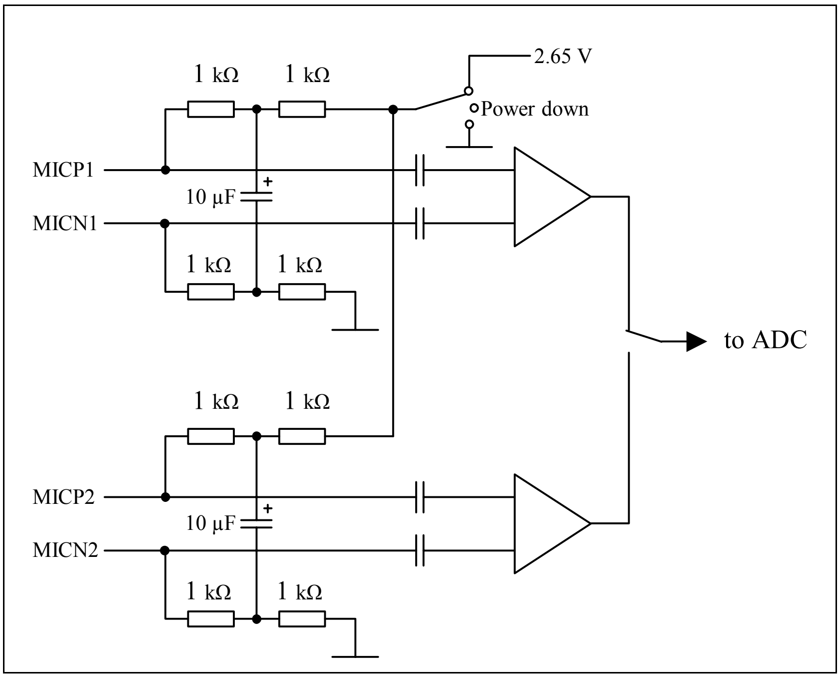


Figure 32: Structure of audio inputs

5.6 Air interface

Table 29: Air Interface

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

[1)] At power level 5
[2)] At power level 0
[3)] At 50Ω load impedance. The output power depends on the BATT+ voltage during transmit burst and the measured board temperature. The given values are valid for room temperature and nominal operating voltage.

Table 30: Local oscillator and intermediate frequencies used by TC35i

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

5.7 Electrostatic discharge

The GSM engine is not protected against Electrostatic Discharge (ESD) in general. Consequently, it is subject to ESD handling precautions that typically apply to ESD sensitive components. Proper ESD handling and packaging procedures must be applied throughout the processing, handling and operation of any application that incorporates a TC35i module.

Despite of this, the antenna port, the SIM interface, the BATT_TEMP port, the POWER port and the Battery lines are equipped with spark gaps and clamp diodes to protect these lines from overvoltage. For all the other ports, ESD protection must be implemented on the application platform that incorporates the GSM engine.

TC35i has been tested accordingly to the EN 61000-4-2 directive. The measured values verified for the Siemens reference configuration can be gathered from the following table.

Table 31: Measured electrostatic values

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

Please note that the values may vary with the individual application design. For example, it matters whether or not the application platform is grounded over external devices like a computer or other equipment, such as the Siemens reference application described in Chapter 7.

5.8 Reliability characteristics

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

Table 32: Summary of reliability test conditions

Type of test	Conditions	Standard
Vibration	Frequency range: 10-20 Hz; acceleration: 3.1mm amplitude Frequency range: 20-500 Hz; acceleration: 5g Duration: 2h per axis = 10 cycles; 3 axes	DIN IEC 68-2-6
Shock half-sinus	Acceleration: 500g Shock duration: 1msec 1 shock per axis 6 positions (± x, y and z)	DIN IEC 68-2-27
Dry heat	Temperature: +70 ±2°C Test duration: 16 h Humidity in the test chamber: < 50%	EN 60068-2-2 Bb ETS 300019-2-7
Temperature change (shock)	Low temperature: -40°C ±2°C High temperature: +85°C ±2°C Changeover time: < 30s (dual chamber system) Test duration: 1 h Number of repetitions: 100	DIN IEC 68-2-14 Na ETS 300019-2-7
Damp heat cyclic	High temperature: +55°C ±2°C Low temperature: +25°C ±2°C Humidity: 93% ±3% Number of repetitions: 6 Test duration: 12h + 12h	DIN IEC 68-2-30 Db ETS 300019-2-5
Cold (constant exposure)	Temperature: -40 ±2°C Test duration: 16 h	DIN IEC 68-2-1

6 Mechanics

6.1 Mechanical dimensions of TC35i

Figure 33 shows the RF part of TC35i and provides an overview of the board's mechanical dimensions. For further details see Figure 34.

Size: 54.5±0.2 x 36±0.2 x 3.6±0.2 mm (height of antenna connector not considered)
Weight: 9g

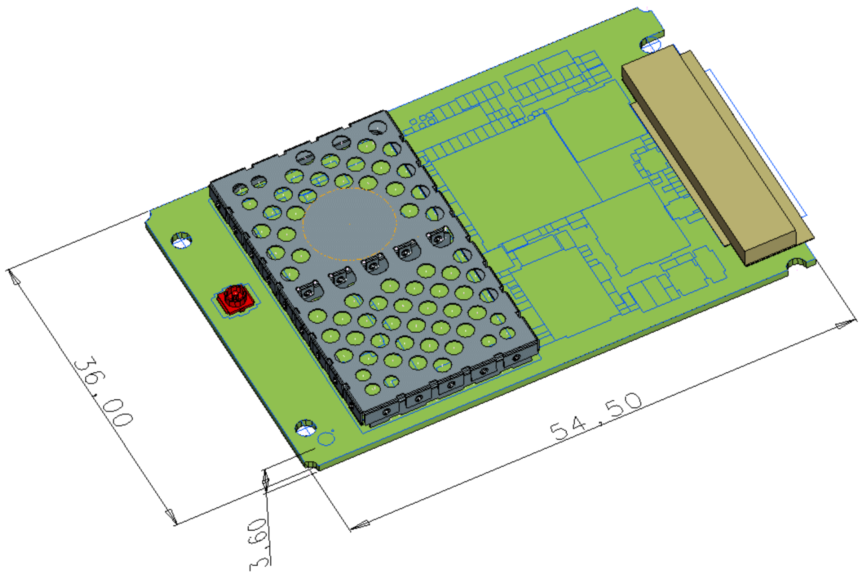
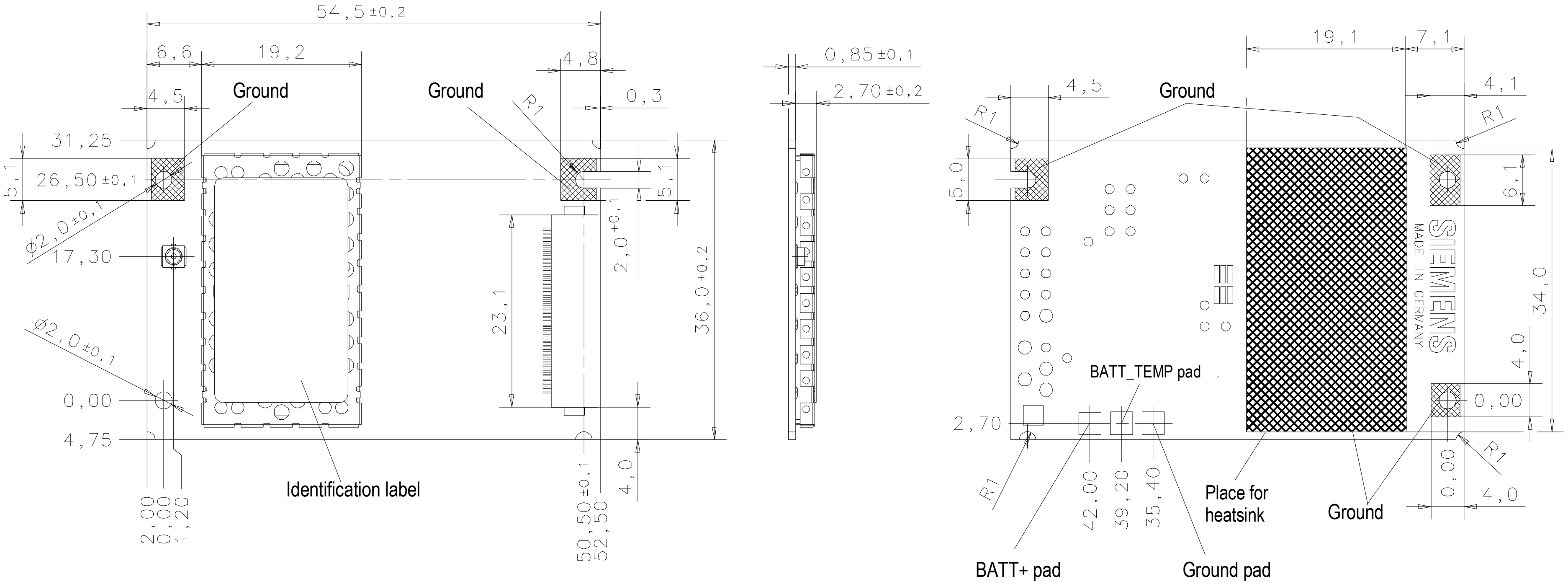


Figure 33: TC35i – top view



All dimensions in millimeter

Figure 34: Mechanical dimensions of TC35i

6.2 Mounting TC35i onto the application platform

For the cellular application to operate reliably it is essential that the GSM engine is securely attached to the host housing.

The TC35i board provides three mounting holes, see Figure 35 for details. To properly mount it to the host device you can use M1.6 or M1.8 screws plus suitable washers. The maximum diameter of the screw head incl. the washer must not exceed 4 mm.

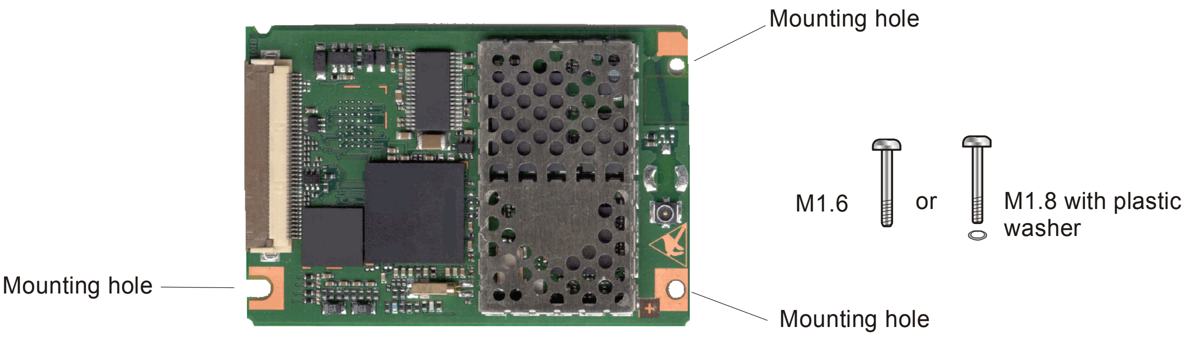


Figure 35: Mounting TC35i

Avoid placing the TC35i board tightly to the host device. Instead, it is recommended to set spacers between the module and the host device. If your design approach does not allow for spacers make sure the host device provides an opening for the RF part.

A number of ground planes are provided on the bottom of the TC35i module, all of them illustrated in Figure 34. For proper grounding it is strongly recommended to use these ground planes in addition to the five GND pins of the ZIF connector and the GND pad. To avoid short circuits ensure that the remaining sections of the TC35i PCB do not come into contact with the host device since there are a number of test points.

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

6.3 ZIF connector (application interface)

This chapter provides specifications for the 40-pin ZIF connector which serves as physical interface to the host application. The connector assembled on the TC35i PCB is type Hirose FH12-40S 0.5 SH.

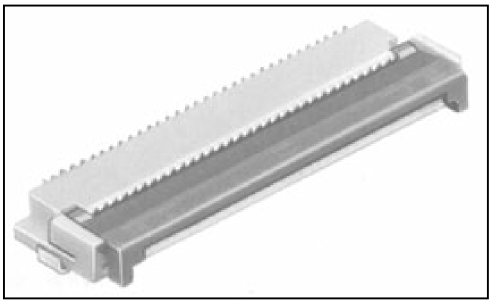


Figure 36: Hirose FH12 connector

The ZIF (zero insertion force) design allows to easily fasten or remove the cable without the need for special tools. Simply insert the FFC into the open socket without using any pressure. Then carefully close the socket lid until the contacts of the socket grip the cable contacts.

Table 33: Ordering information

Item	Part number	Pitch (mm)	HRS number
ZIF connector	FH12-40S 0.5 SH	0.5	CL586-0527-7

Table 34: Electrical and mechanical characteristics of Hirose FH12-40S 0.5 SH connector

Parameter	Specification (40 pin ZIF connector)
Number of Contacts	40
Quantity delivered	2000 Connectors per Tape & Reel
Voltage	50V
Current Rating	0.4A max per contact
Resistance	0.05Ω per contact
Dielectric Withstanding Voltage	150V RMS AC for 1min
Operating Temperature	-40°C...+85°C
Contact Material	phosphor bronze finish: solder plating
Insulator Material	PPS, deep brown / Polyamide, beige
FFC/FPC Thickness	0.3mm ±0.05mm (0.012" ±0.002"), see Chapter 6.3.1
Maximum connection cycles	20 (@ 50mΩ max)

6.3.1 FFC

As stated in Chapter 3.9 the total cable length between the ZIF connector pins on TC35i and the pins of the SIM card holder must not exceed 200 mm in order to meet the specifications of 3GPP TS 51.010-1 and to satisfy the requirements of EMC compliance.

6.3.2 Mechanical dimensions of Hirose FH12-40S 0.5 SH connector

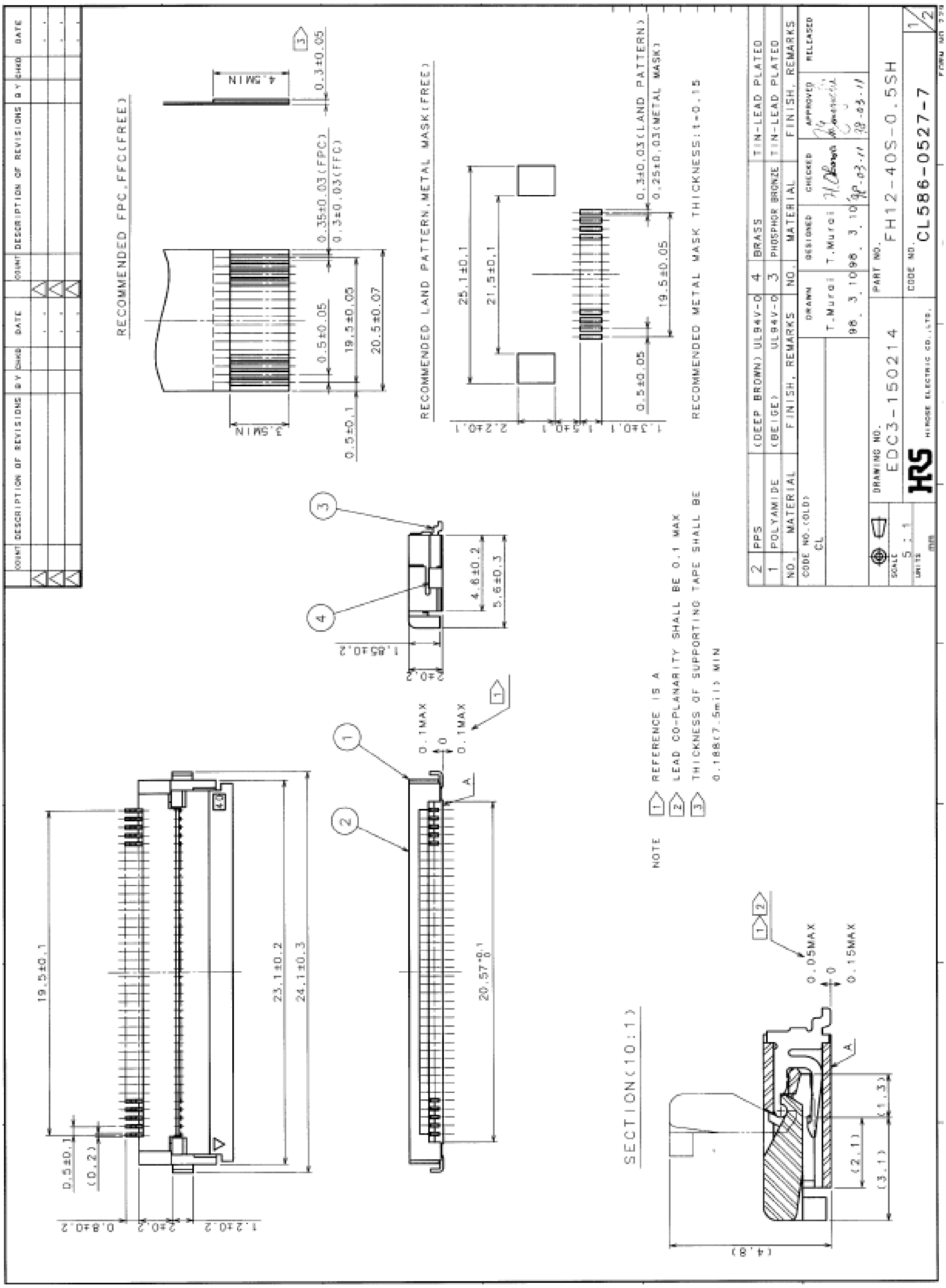


Figure 37: Description of Hirose FH12 connector

7 Reference equipment

The Siemens reference setup that will be submitted to type approve TC35i consists of the following components:

- Siemens TC35i cellular engine
- Development Support Box (DSB35)
- FFC from ZIF connector on TC35i to application interface on DSB35.
- SIM card holder integrated on the DSB35
- Handset type Votronic HH-SI-30.3/V1.1/0
- PC as MMI

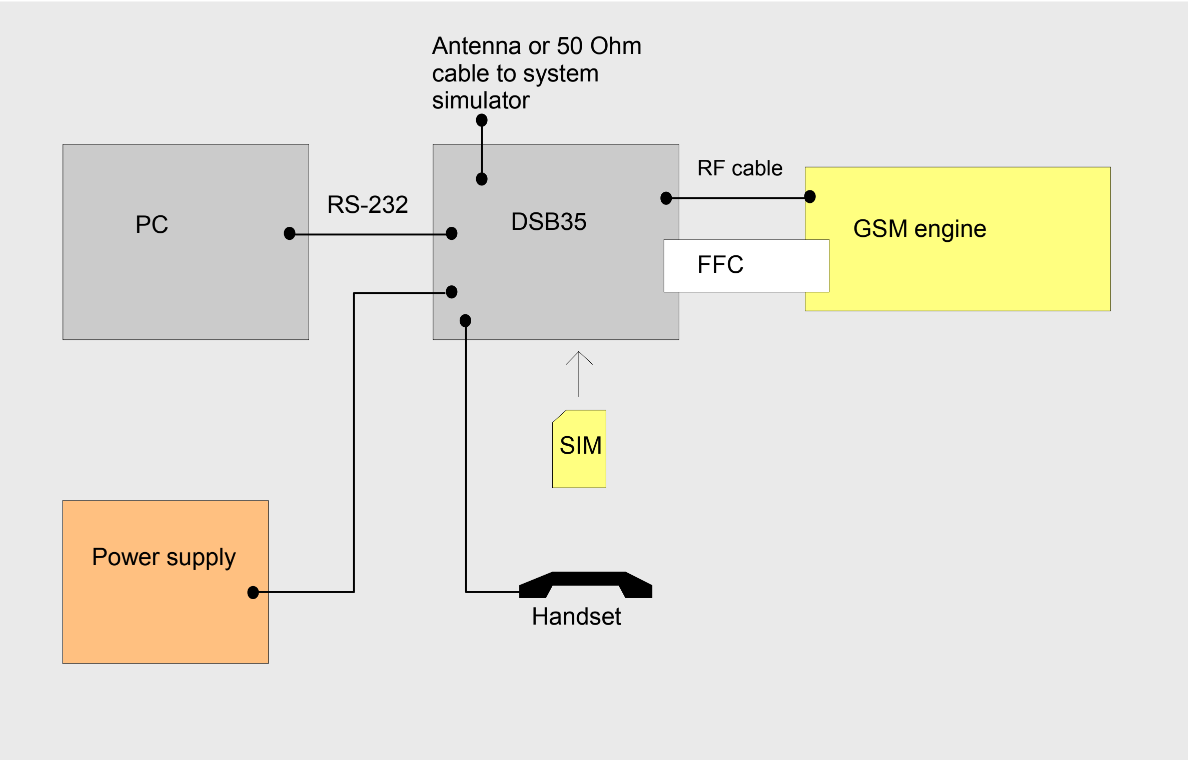


Figure 38: Reference equipment for approval

8 APPENDIX: List of parts and accessories

Table 35: List of accessories

Description	Supplier	Ordering information
TC35i engine	Siemens	Siemens ordering number L36880-N8110-A200
SIM card holder incl. push button ejector Slide-in tray	Molex	Ordering number: 91228-001 Ordering number: 91236-001 Molex Deutschland GmbH Felix-Wankel-Str. 11 74078 Heilbronn-Biberach Germany Phone: +49 (0)-7066-9555 0 Fax: +49 (0)-7066-9555 29 Email: mxgermany@molex.com Web site: http://www.molex.com/ American Headquarters Lisle, Illinois 60532, U.S.A. Phone: +1-800-78MOLEX Fax: +1-630-969-1352 Molex Japan Co. Ltd. Yamato, Kanagawa, Japan Phone: +81-462-65-2324 Fax: +81-462-65-2366 Far East Headquarters Jurong, Singapore Phone: +65-268-6868 Fax: +65-265-6044 Molex China Distributors Beijing, Room 1319, Tower B, COFCO Plaza No. 8, Jian Guo Men Nei Street, 100005 Beijing People's Republic of China Phone: +86-10-6526-9628 Phone: +86-10-6526-9728 Phone: +86-10-6526-9731 Fax: +86-10-6526-9730
ZIF connector	Hirose	See Chapter 6.3 for specifications of FH12-40S 0.5 SH connector and mating cables http://www.hirose.com

Description	Supplier	Ordering information
Flat cable for ZIF connector cable 160 mm cable 80 mm	Axon	Ordering numbers: FFC 0.50 A 40 / 0160 K4.0-4.0-08.0-08.0SABB FFC 0.50 A 40 / 0080 K4.0-4.0-08.0-08.0SABB
RF cable GSC-GSC cable 50 mm cable 100 mm	MuRata	Ordering numbers: MXTK 88 TK 0500 MXTK 88 TK 1000
GSC connector	MuRata	MM9329-2700 TB2
P/N M22001 tool (recommended for GSC antenna installation)	MuRata	Please use product name: P/N M22001
Battery cell XWODA	Shenzhen Xwoda Electronic Co., Ltd	To place orders or obtain more information please contact: Shenzhen Xwoda Electronic Co., Ltd Building C, Tongfukang Industrial Zone Shiyan Town Bao'an District Shenzen P.R.China Contact: Waichard Tsui Phone: +86-755-27623789 ext. 370 Fax: +86-755-27623078 Email: waichard@xwoda.com.cn Info: Http://xwoda.com.cn
Handset	Votronic	HH-SI-30.3/V1.1/0
Siemens Car Kit Portable	Siemens	Siemens ordering number L36880-N3015-A117
DSB35 Support Box	Siemens	Siemens ordering number L36880-N8101-A100-3
BB35 Bootbox	Siemens	Siemens ordering number L36880-N8102-A100-1