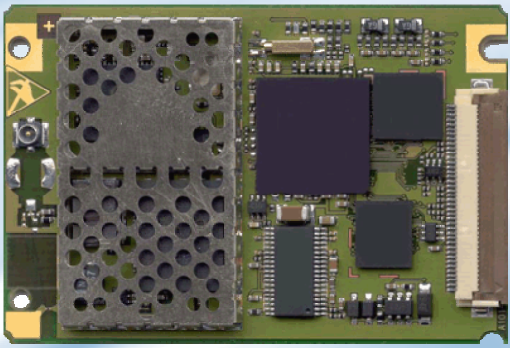
SIEMENS
mobile



Hardware Interface Description

MC39i
Siemens Cellular Engine

Version: 01.02
DocID: MC39i_HD_V01.02

SIEMENS mobile

Document Name:	**MC39i Hardware Interface Description**
Version:	**01.02**
Date:	**November 12, 2003**
DocId:	**MC39i_HD_V01.02**
Status:	**Confidential / Released**

Contents

Figures

Tables

1 Introduction

This document describes the hardware of the Siemens MC39i module that connects to the cellular device application and the air interface. As MC39i 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 MC39i 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 MC39i, Version 01.02
[2] MC39i Release Notes, Version 01.02
[3] GPRS Startup User's Guide
[4] DSB35 Support Box - Evaluation Kit for Siemens Cellular Engines
[5] Remote Sat User’s Guide
[6] Multiplexer User's Guide
[7] Multiplex Driver Developer’s Guide for Windows 2000 and Windows XP
[8] Multiplex Driver Installation Guide for Windows 2000 and Windows XP
[9] Application Note 14: Audio and Battery Parameter Download
[10] Application Note 16: Updating MC39i Firmware
[11] Application Note 24: Application Developers’ Guide
[12] Application Note 02: Audio Interface Design

Prior to using the MC39i engine, be sure to carefully read the latest product information.

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
AGC	Automatic Gain Control
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
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
GPRS	General Packet Radio Service
GSM	Global Standard for Mobile Communications
HiZ	High Impedance
HR	Half Rate
IC	Integrated Circuit

Abbreviation	Description
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
Mbps	Mbits per second
MMI	Man Machine Interface
MO	Mobile Originated
MS	Mobile Station (GSM engine), also referred to as TE
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
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
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

Abbreviation	Description
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 dialed)
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

MC39i 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

3GPP TS 51.010-1	"Digital cellular telecommunications system (Phase 2); Mobile Station (MS) conformance specification"
ETSI EN 301 511	V7.0.1 (2000-12) Candidate Harmonized European Standard (Telecommunications series) Global System for Mobile communications (GSM); Harmonized standard for mobile stations in the GSM 900 and DCS 1800 bands covering essential requirements under article 3.2 of the R&TTE directive (1999/5/EC) (GSM 13.11 version 7.0.1 Release 1998)
GCF-CC	"Global Certification Forum - Certification Criteria"
ETSI EN 301 489-7	V1.1.1 (2000-09) Candidate Harmonized European Standard (Telecommunications series) Electro Magnetic Compatibility and Radio spectrum Matters (ERM); Electro Magnetic Compatibility (EMC) standard for radio equipment and services; Part 7: Specific conditions for mobile and portable radio and ancillary equipment of digital cellular radio telecommunications systems (GSM and DCS)
EN 60 950	Safety of information technology equipment (2000)

Requirements of quality

IEC 60068	Environmental testing
DIN EN 60529	IP codes

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 MC39i 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 of 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

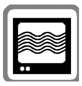
The following safety precautions must be observed during all phases of the operation, usage, service or repair of any cellular terminal or mobile incorporating MC39i. Manufacturers of the cellular terminal are advised to convey the following safety information to users and operating personnel and to 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

Designed for operation on GSM 900 MHz and GSM 1800 MHz networks, MC39i supports GPRS multislot class 10 and the GPRS coding schemes CS-1, CS-2, CS-3 and CS-4.

To save space on the application platform, MC39i comes as an extremely slim and compact module. This makes it ideally suited for a broad range of mobile computing devices, such as laptops, notebooks, multimedia appliances, and particularly offers easy integration with PDAs, pocket organizers or miniature mobile phones.

The tiny MC39i module incorporates all you need to create high-performance GSM/GPRS solutions: baseband processor, power supply ASIC, complete radio frequency circuit including a power amplifier and antenna interface. The power amplifier is directly fed from the supply voltage BATT+. The MC39i software is residing in a flash memory device. An additional SRAM enables MC39i to meet the demanding requirements of GPRS connectivity.

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

2.1 MC39i key features at a glance

Table 1: MC39i 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
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
GPRS connectivity	• GPRS multi-slot class 10 • GPRS mobile station class B
DATA *GPRS:*	• GPRS data downlink transfer: max. 85.6 kbps (see Table 2) • GPRS data uplink transfer: max. 42.8 kbps (see Table 2) • Coding scheme: CS-1, CS-2, CS-3 and CS-4 • MC39i supports the two protocols PAP (Password Authentication Protocol) and CHAP (Challenge Handshake Authentication Protocol) commonly used for PPP connections. • Support of Packet Switched Broadcast Control Channel (PBCCH) allows you to benefit from enhanced GPRS performance when offered by the network operators.
CSD:	• CSD transmission rates: 2.4, 4.8, 9.6, 14.4 kbps, non-transparent, V.110 • Unstructured Supplementary Services Data (USSD) support
SMS	• MT, MO, CB, Text and PDU mode • SMS storage: SIM card plus 25 SMS locations in the mobile equipment • Transmission of SMS alternatively over CSD or GPRS. Preferred mode can be user-defined.
FAX	Group 3: Class 1, Class 2
SIM interface	• Supported SIM card: 3V • External SIM card reader has to be connected via interface connector (note that card reader is not part of MC39i)
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

Feature	Implementation
	• 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
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 or a call to a predefined phone number is in progress automatic temperature shutdown is deferred. Humidity: • max. 90 % relative humidity
Physical characteristics	Size: 54.5± 02. x 36.0± 0.2 x 3.55± 0.3mm 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.

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

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

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

2.2 Circuit concept

Figure 1 shows a block diagram of the MC39i module and illustrates the major functional components:

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

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

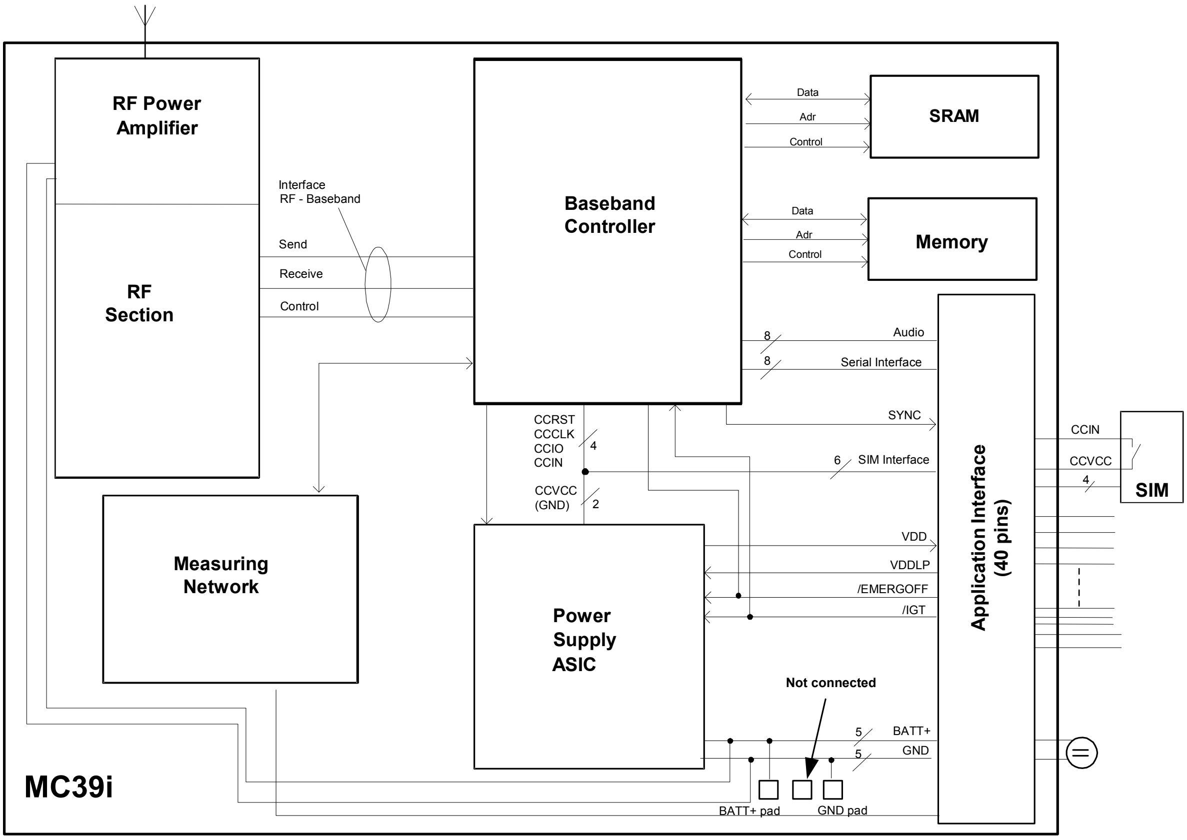


Figure 1: Block diagram of MC39i

3 Application interface

MC39i 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 (see Chapters 3.2)
- Serial interface (see Chapter 3.7)
- Two audio interfaces (see Chapter 3.8)
- SIM interface (see Chapter 3.9)

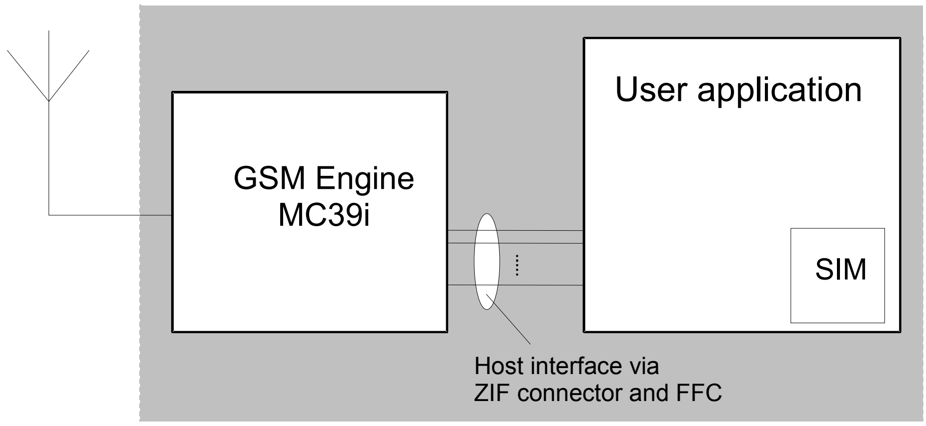


Figure 2: Block diagram of a cellular application

Electrical and mechanical characteristics of the ZIF connector are specified in Chapter 5.3. 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 3: Overview of operating modes

Mode	Function	
Normal operation	GSM / GPRS SLEEP	Various powersave modes set with AT+CFUN command. Software is active to minimum extent. If the module was registered to the GSM network in IDLE mode, it remains, in SLEEP mode, registered and pageable from the BTS. Power saving can be chosen at different levels: The NON-CYCLIC SLEEP mode (AT+CFUN=0) disables the AT interface. The CYCLIC SLEEP modes AT+CFUN=5, 6, 7 and 8 alternatingly activate and deactivate the AT interfaces to allow permanent access to all AT commands.
	GSM IDLE	Software is active. Once registered to the GSM network, the module can be paged from the BTS and is ready to send and receive.
	GSM TALK	Connection between two subscribers is in progress. Power consumption depends on network coverage individual settings, such as DTX off/on, FR/EFR/HR, hopping sequences, antenna.
	GPRS IDLE	Module is ready for GPRS data transfer, but no data is currently sent or received. Power consumption depends on network settings and GPRS configuration (e.g. DRX settings)
	GPRS DATA	GPRS data transfer in progress. Power consumption depends on network settings (e.g. power control level), uplink / downlink data rates and GPRS configuration (e.g. used multislot settings).
Power Down	Normal shutdown after sending 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 the module is in Power Down mode. In Alarm mode, the module remains deregistered from the GSM network. Limited number of AT commands are accessible.	

See also Table 7 and Table 8 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 MC39i 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 MC39i components. Whenever the watchdog pulses fail to arrive constantly, the module is turned off.
- 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 MC39i is in POWER DOWN mode.
- Provides power to the SIM interface.

Please refer to Table 4 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 MC39i board (reference point BATT+ pad and reference point GND pad as shown in Figure 29)

VDDLP can be used to back up the RTC.

Table 4: 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, $I_{typ} \leq 2$ A during transmit burst (see Chapter 5.4.1) The minimum operating voltage must not fall below 3.3 V, not even in case of voltage drop.
GND	6-10	X	Ground	0 V
VDDLP	30	I/O	Buffering of RTC (see Chapter 3.3.1.3)	$U_{OUT,max} = V_{BATT+}$ U_{IN} = 2.0 V...5.5 V $R_i = 1k\Omega$ $I_{in,max} = 30\mu A$

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 MC39i 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 MC39i 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 should also be considered.

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

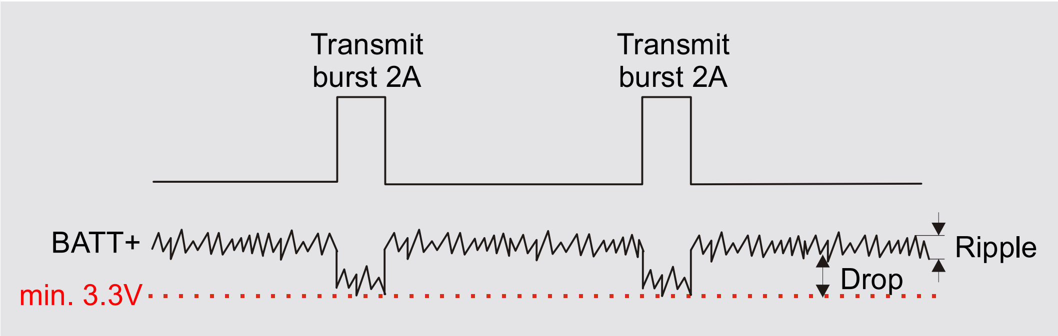


Figure 3: Power supply limits during transmit burst

The input voltage V_{BATT+} must be measured directly at the reference points on the MC39i board. For detailed information see Figure 29.

3.3 Power up / down scenarios

3.3.1 Turn on MC39i

Your MC39i GSM / GPRS engine 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 RTC interrupt: starts Alarm mode (see Chapter 3.3.1.3)

3.3.1.1 Turn on GSM engine using the ignition line IGT (Power on)

To switch on MC39i 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.

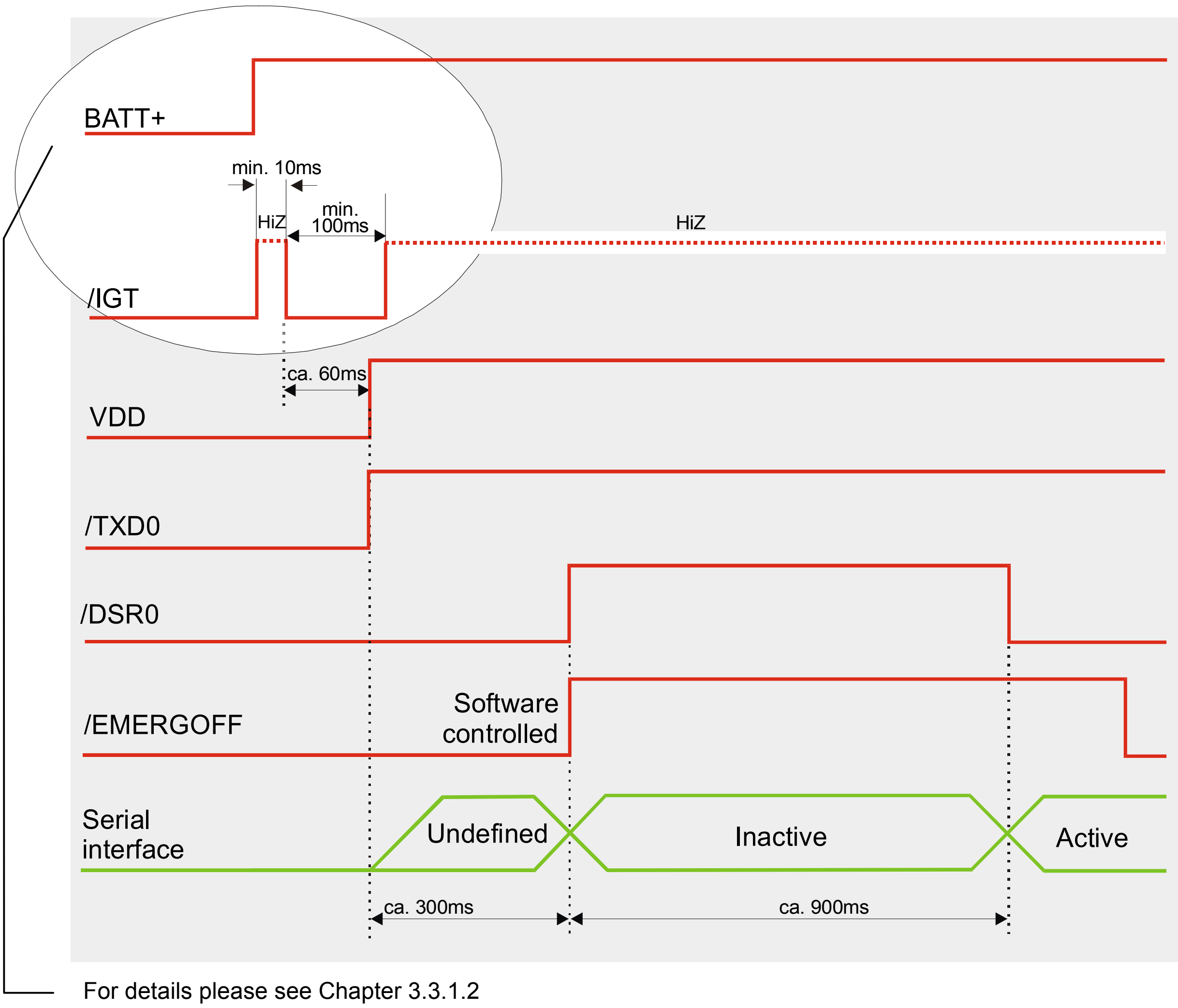


Figure 4: Power-on by ignition signal

If configured to a fix baud rate, MC39i will send the result code ^SYSSTART to indicate that it is ready to operate. This result code does not appear when autobauding is active. See chapter AT+IPR in [1].

3.3.1.2 Timing of the ignition process

When designing your application platform take into account that powering up MC39i 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+}.

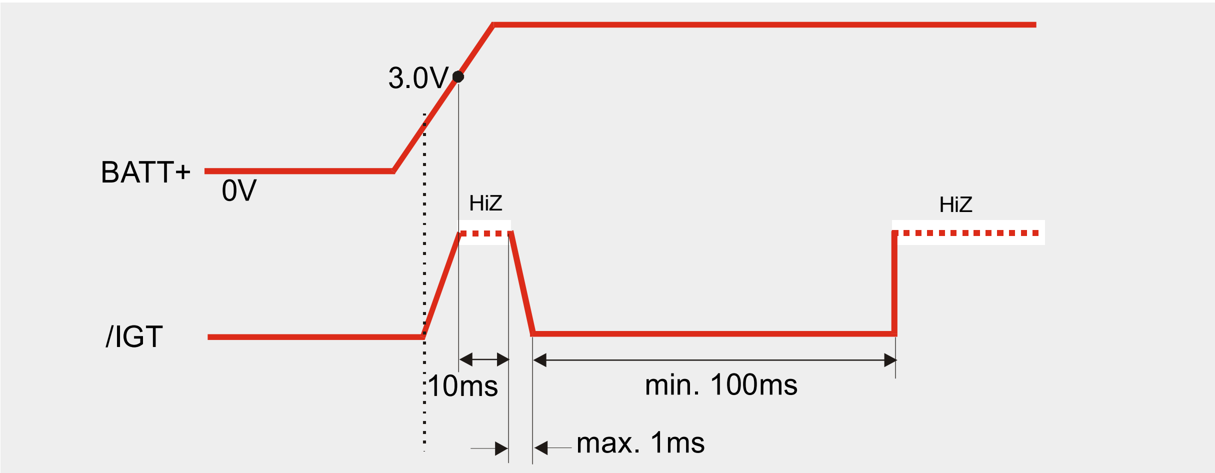


Figure 5: Timing of power-on process if VDDLP is not used

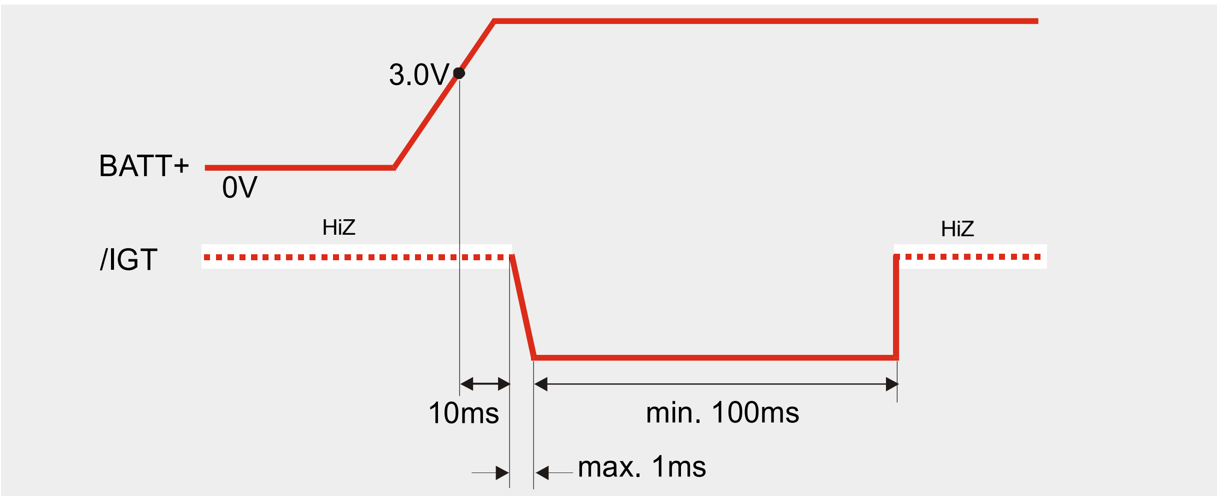


Figure 6: Timing of power-on process if VDDLP is fed from external source

3.3.1.3 Turn on GSM engine using the RTC (Alarm mode)

Another power-on approach is to use the RTC, which is constantly supplied with power from a separate voltage regulator in the power supply ASIC. The RTC provides an alert function which allows to wake up MC39i from POWER DOWN mode. 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 call that can be activated by using the same AT command, but without switching off power.

Use the *AT+CALA* command to set the alarm time. The RTC retains the alarm time if the GSM engine was powered down by AT^SMSO. Once the alarm is timed out and executed, MC39i enters into the Alarm mode. This is indicated by an Unsolicited Result Code (URC) which reads:

^SYSSTART ALARM MODE

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

Table 5: AT commands available in Alarm mode

AT command	Use
AT+CALA	Set alarm time
AT+CCLK	Set date and time of RTC
AT^SBC	Query average current consumption of MC39i, enable / disable undervoltage URCs (see Chapter 3.3.3.1)
AT^SCTM	Query temperature range, enable/disable URCs to report critical temperature ranges
AT^SMSO	Power down GSM engine

For the 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 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 Alarm mode.

3.3.2 Turn off MC39i

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*: See Chapter 3.3.3.
  Takes effect if undervoltage is detected
  Takes effect if MC35i board temperature exceeds critical limit

3.3.2.1 Turn off GSM engine using the AT^SMSO command

The best and safest approach to powering down MC39i is to issue the *AT^SMSO* command. This procedure lets MC39i 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 MC39i 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 the host controller experienced a watchdog reset and afterwards MC39i fails to shut down properly or fails to respond.*

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.

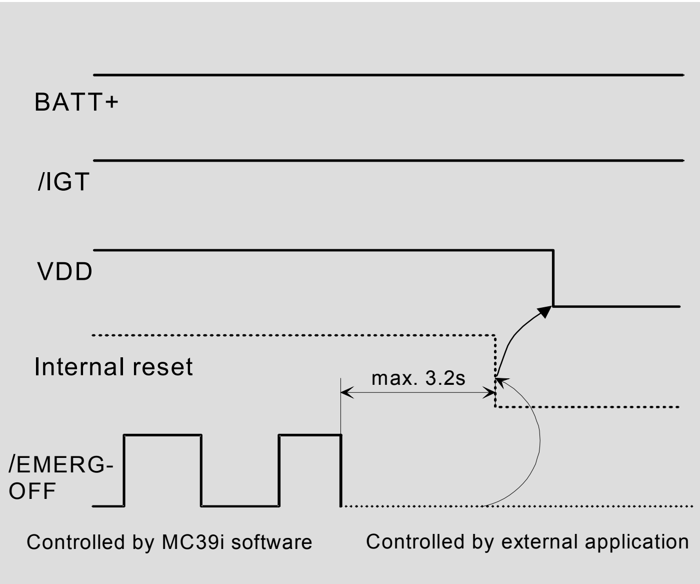


Figure 7: Deactivating GSM engine by Power Down signal

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 MC39i after max. 3.2s and the module turns off. Consequently the output voltage at VDD is switched off.

3.3.3 Automatic shutdown

Automatic shutdown takes effect if the supply voltage or the temperature of MC39i are exceeding critical limits. The shutdown procedure is equivalent to the power-down initiated with the AT^SMSO command: MC39i logs off from the network and the software enters a secure state avoiding loss of data.

3.3.3.1 Undervoltage shutdown

If the supply voltage falls below the range specified in Chapters 5.3 and 5.4, MC39i ceases to operate. This avoids that the module violates GSM specifications. Undervoltage conditions may be reported by the Unsolicited Result Code

AT^SBC: Undervoltage.

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

3.3.3.2 Temperature dependent shutdown

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

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

Each time the board temperature goes out of range or back to normal, MC39i instantly displays an alert in the form of a URC (if enabled).

- URCs indicating the level "1" or "-1" allow the user to take appropriate precautions, such as protecting the module from exposure to extreme conditions. The presentation of the URCs depends on the settings selected with the AT^SCTM write command:
  AT^SCTM=0 (default): Presentation of URCs is enabled during the two minute guard period after start-up of MC39i. After expiry of the two minute guard period, the presentation will be disabled, i.e. no URCs with alert levels “1” or “-1” will be generated.
  AT^SCTM=1: Presentation of URCs is always enabled.
- URCs indicating the level "2" or "-2" are instantly followed by an orderly shutdown, except in the cases described in Chapter 3.3.3.3. The presentation of these URCs is always enabled, i.e. they will be output even though the default setting AT^SCTM=0 was never changed.

Table 6: Temperature dependent behavior

Sending temperature warning (15 s after MC39i start-up, otherwise only if URC presentation enabled)	
^SCTM_B: 1	Caution: T_{amb} of board close to overtemperature limit.
^SCTM_B: -1	Caution: T_{amb} of board close to undertemperature limit.
^SBCTM_B: 0	Board back to uncritical temperature range.
Automatic shutdown (URC appears no matter whether presentation was enabled)	
^SCTM_B: 2	Alert: T_{amb} of board $\geq$70°C. MC39i switches off.
^SCTM_B: -2	Alert: T_{amb} of board $\leq$-25°C. MC39i switches off.

The values stated in Table 6 are based on test conditions according to IEC 60068-2-2 (still air).

3.3.3.3 Deferred shutdown at extreme temperature conditions

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

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

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

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

3.3.3.4 Monitoring the board temperature of MC39i

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.

3.4 Automatic GPRS Multislot Class change

Temperature control is also effective for operation in GPRS Multislot Class 10. If the board temperature increases to the limit specified for restricted operation[1)] while data are transmitted over GPRS, the module automatically reverts from GPRS Multislot Class 10 (2 Tx) to Class 8 (1 Tx). This reduces the power consumption and, consequently, causes the board's temperature to decrease. Once the temperature drops to a value of 5 degrees below the limit of restricted operation, MC39i returns to the higher Multislot Class. If the temperature stays at the critical level or even continues to rise, MC39i will not switch back to the higher class.

After a transition from Multislot Class 10 to Multislot Class 8 a possible switchback to Multislot Class 10 is blocked for one minute.

Please note that there is not one single cause of switching over to a lower GPRS Multislot Class. Rather it is the result of an interaction of several factors, such as the board temperature that depends largely on the ambient temperature, the operating mode and the transmit power. Furthermore, take into account that there is a delay until the network proceeds to a lower or, accordingly, higher Multislot Class. The delay time is network dependent. In extreme cases, if it takes too much time for the network and the temperature cannot drop due to this delay, the module may even switch off as described in chapter 3.3.3.2

[1)] See Table 21 for temperature limits known as restricted operation.

3.5 Power saving

SLEEP mode reduces the functionality of the MC39i module to a minimum and, thus, minimizes the current consumption to the lowest level. SLEEP mode is set with the AT+CFUN command which provides the choice of the functionality levels <fun>=0, 1, 5, 6, 7 or 8, all explained below. Further instructions of how to use AT+CFUN can be found in [1].

IMPORTANT: The AT+CFUN command can be executed before or after entering PIN1. Nevertheless, please keep in mind *that power saving works properly only when the module is registered to the GSM network*. If you attempt to activate power saving while the module is detached, the selected <fun> level will be set, though power saving does not take effect. For the same reason, power saving cannot be used if MC39i 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). The LED stops flashing once the module starts power saving.

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

3.5.1 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 MC39i back to the highest level of functionality <fun>=1.

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

3.5.3 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 over the NON-CYCLIC SLEEP mode is that the serial interface is not permanently blocked and that packet switched calls may go on without terminating the selected CYCLIC SLEEP mode. This allows MC39i to become active, for example to perform a GPRS data transfer, and to resume power saving after the GPRS data transfer is completed.

The four CYCLIC SLEEP modes give you greater flexibility regarding the wake-up procedures: For example, in all CYCLIC SLEEP modes, you can enter AT+CFUN=1 to permanently wake up the module. The best choice is using CFUN=7 or 8, since in these modes MC39i automatically resumes power saving, after you have sent or received a short message or made a call. CFUN=5 and 6 do not offer this feature, and therefore, are only supported for compatibility with earlier releases. Please refer to Table 7 for a summary of all modes.

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

Both the application and the module must be configured to use hardware flow control (RTS/CTS handshake). The default setting of MC39i 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 8 and Figure 9.

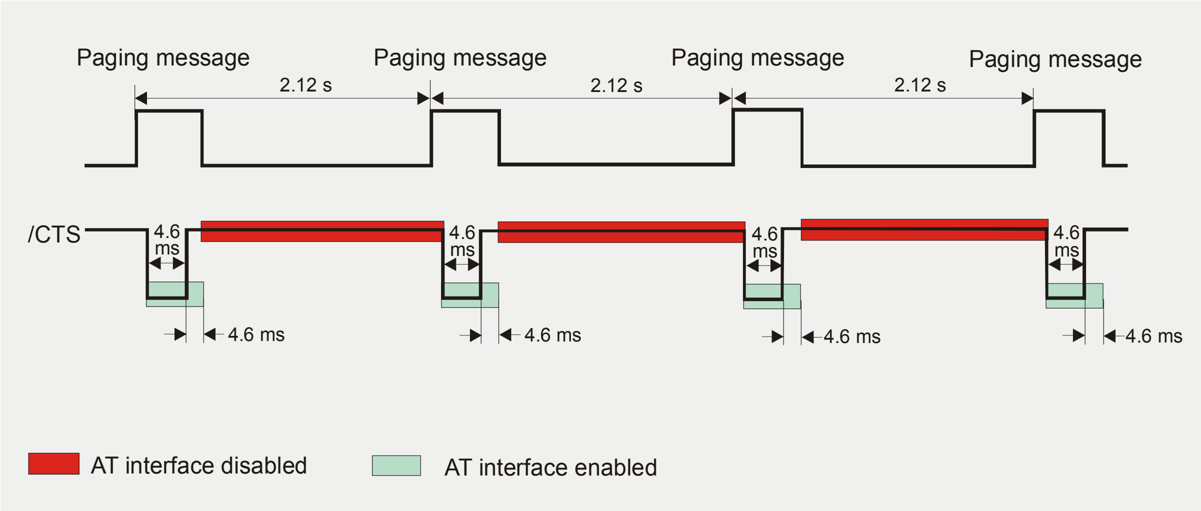


Figure 8: Timing of /CTS signal (example for a 2.12 s paging cycle)

Figure 9 illustrates the CFUN=5 mode, which resets the /CTS signal 2 seconds after the last character was sent or received.

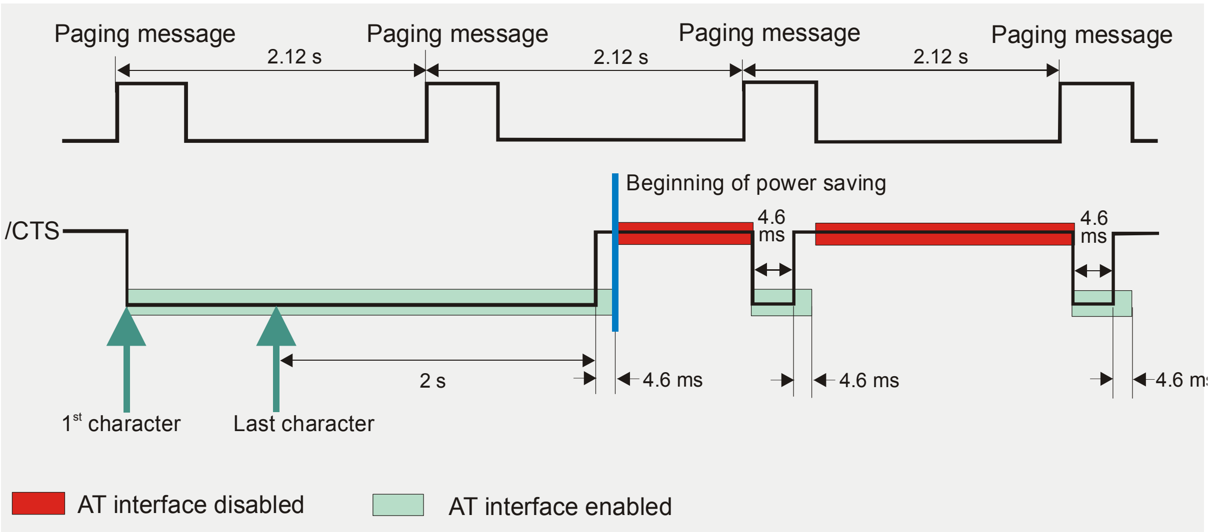


Figure 9: Beginning of power saving if CFUN=5

3.5.5 Wake up MC39i from SLEEP mode

A wake up event is any event that switches off the SLEEP mode and causes MC39i to return to full functionality. In short, it takes MC39i back to AT+CFUN=1.

Definitions of the state transitions described in Table 7:
Yes = MC39i exits SLEEP mode.
No = MC39i does not exit SLEEP mode.

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

Event	From SLEEP mode AT+CFUN=0 to AT+CFUN=1	From SLEEP mode AT+CFUN=5 or 6 to AT+CFUN=1	From SLEEP mode AT+CFUN=7 or 8 to AT+CFUN=1
Ignition line	No effect at all	No effect at all	No effect at all
/RTS0 or /RTS1 (falling edge)	Yes[1)]	No effect at all	No effect at all[1)]
Unsolicited Result Code (URC)	Yes	Yes	No
Incoming voice or data call	Yes	Yes	No
Any AT command (incl. outgoing voice or data call, outgoing SMS)	Not possible (UART disabled)	No	No
Incoming SMS depending on mode selected by AT+CNMI:			
AT+CNMI=0,0 (= default, no indication of received SMS)	No	No	No
AT+CNMI=1,1 (= displays URC upon receipt of SMS)	Yes	Yes	No
GPRS data transfer	Not possible (UART disabled)	No	No
RTC alarm[2)]	Yes	Yes	No
AT+CFUN=1	Not possible (UART disabled)	Yes	Yes

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 MC39i 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 8 shows how to proceed from one mode to another (gray column = present mode, white columns = intended modes)

Table 8: State transitions of MC39i

Further mode ➔➔➔ / Present mode	Power Down	Normal mode**)	Alarm mode
Power Down mode	---	/IGT >100 ms at low level	Wake-up from Power Down mode (if activated with AT+CALA)
Normal mode**)	AT^SMSO or exceptionally /EMERGOFF pin > 3.2 s at low level	---	AT+CALA followed by AT^SMSO. MC39i enters Alarm mode when specified time is reached.
Alarm mode	AT^SMSO or exceptionally /EMERGOFF > 3.2 s at low level	/IGT >100 ms at low level	---

*) Normal mode covers TALK, IDLE and SLEEP modes

3.6 RTC backup

The internal Real Time Clock of MC39i is supplied from a dedicated voltage regulator in the power supply ASIC which is also active when MC39i is in POWER DOWN status. An alarm function is included that allows to wake up MC39i 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. 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 MC39i 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 3.3.1.3 and to [1].
A serial resistor placed on the board next to the VDDLP line limits the input current of an empty capacitor.
The voltage applied at VDDLP can be in the range from 2 to 5.5V. Please refer to Table 22 for the parameters required.

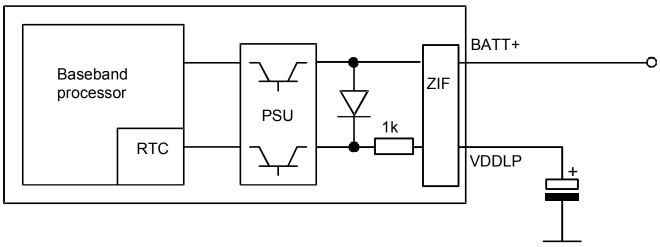


Figure 10: RTC supply from capacitor

Note: 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 22 are values measured directly on the MC39i GSM / GPRS engine. They do not apply to the accessories connected.

3.7 Serial interface

MC39i 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 22.

MC39i 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

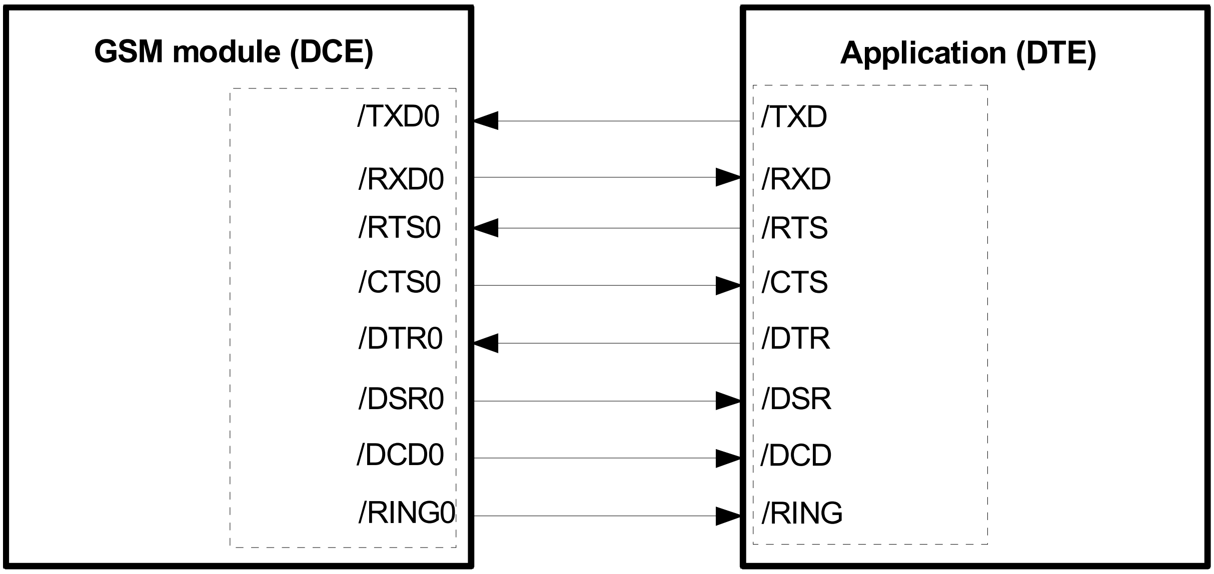


Figure 11: Serial interface

Table 9: 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, GPRS services and for controlling the GSM engine with AT commands.
- Full Multiplex capability allows the interface to be partitioned into three virtual channels, yet with CSD and fax services only available on the first logical channel.
- Includes the data lines /TXD0 and /RXD0, the status lines /RTS0 and /CTS0 and, in addition, the modem control lines /DTR0, /DSR0, /DCD0 and /RING0.
- The /DTR0 signal will only be polled once per second from the internal firmware of MC39i. The /RING0 signal serves to indicate incoming calls and other types of URCs (Unsolicited Result Code).
- Configured for 8 data bits, no parity and 1 stop bit.
- Can be operated at bit rates from 300bps to 230400 bps.
- Autobauding supports the following bit rates: 4800, 9600, 19200, 38400, 57600, 115200, 230400 bps.
- Supports hardware handshake using RTS0/CTS0 and XON/XOFF software flow control.

3.8 Audio interface

MC39i comprises two analog audio interfaces each with a balanced analog microphone input and a balanced analog earpiece output. The second analog interface provides a supply circuit to feed an active microphone.

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

MC39i 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 25) 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 25 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.

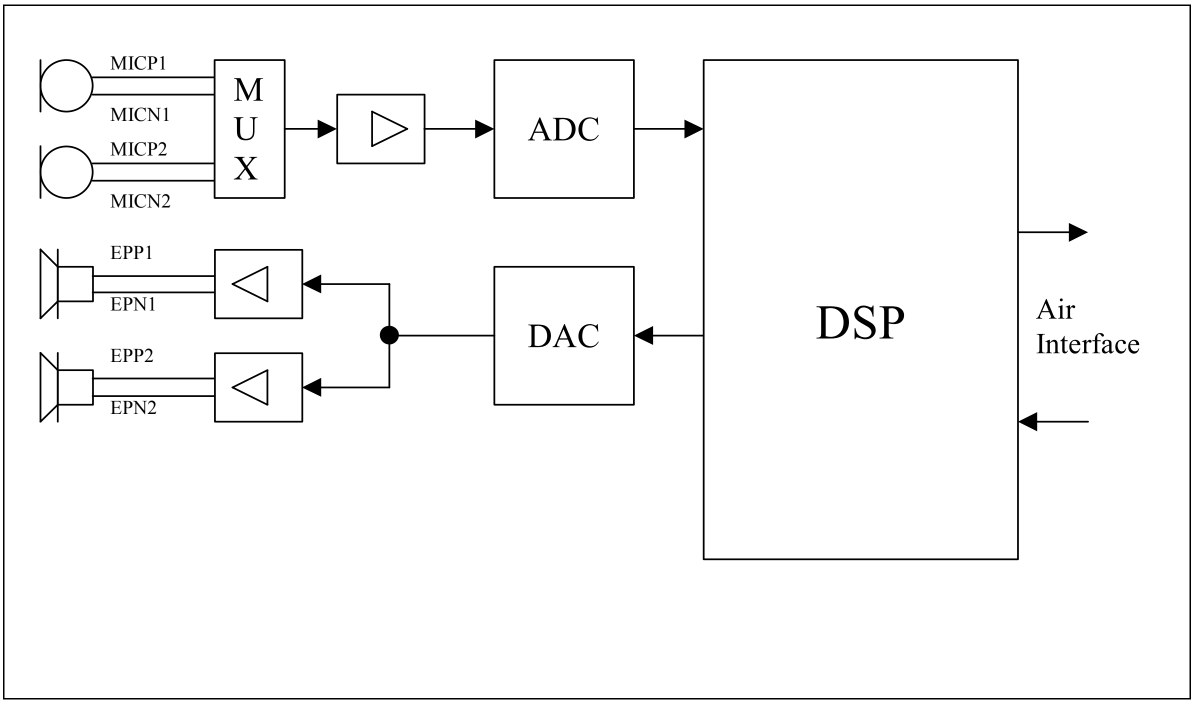


Figure 12: Audio block diagram

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 MC39i using the appropriate AT command. For further details refer to [9] 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 (board-to-board connector) in order to be connected to an external SIM card holder. Six pins on the board-to-board connector are reserved for the SIM interface.

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

It is recommended that the total cable length between the board-to-board connector pins on MC39i 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 10: Signals of the SIM interface (board-to-board connector)

Signal	Description
CCGND	Separate ground connection for SIM card to improve EMC.
CCCLK	Chipcard clock, various clock rates can be set in the baseband processor.
CCVCC	SIM supply voltage from PSU-ASIC
CCIO	Serial data line, input and output.
CCRST	Chipcard reset, provided by baseband processor.
CCIN	Input on the baseband processor for detecting a SIM card tray in the holder. The CCIN pin is mandatory for applications that allow the user to remove the SIM card during operation. The CCIN pin is solely intended for use with a SIM card. It must not be used for any other purposes. Failure to comply with this requirement may invalidate the type approval of MC39i.

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 MC39i 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 MC39i and is part of the Siemens reference equipment submitted for type approval. Molex ordering number is 91228-0001, see also Chapter 8.

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

a) If, during startup of MC39i, 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 MC39i, the CCIN signal is low, the module will also attempt to initialize the SIM card. In this case, the initializing will only be successful when the card is present.
   If the SIM card initializing 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 MC39i.
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 13.

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 MC39i.

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 MC39i reference setup, see [4] for technical details). X1201 is the designation used in [4] to refer to the SIM card holder.

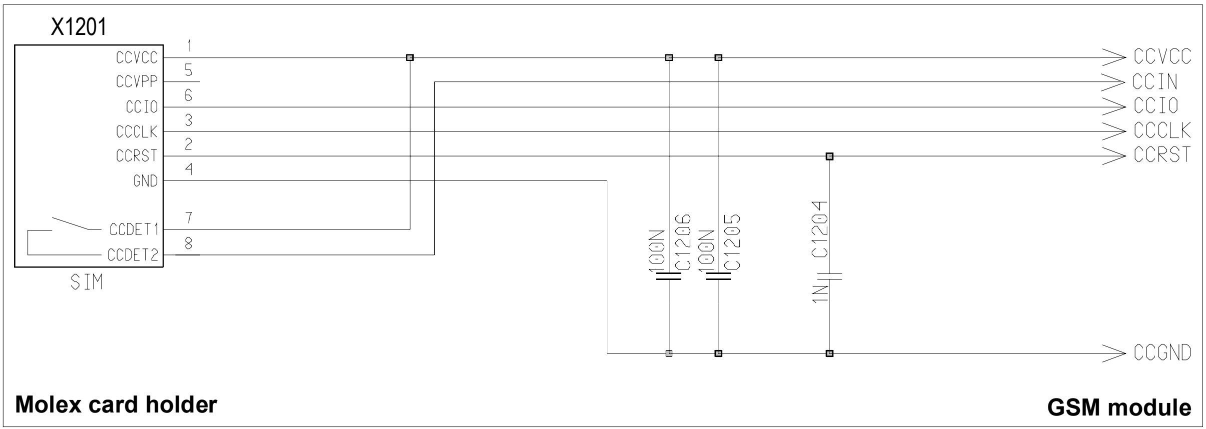


Figure 13: SIM card holder of DSB35 Support Box

Table 11: 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.

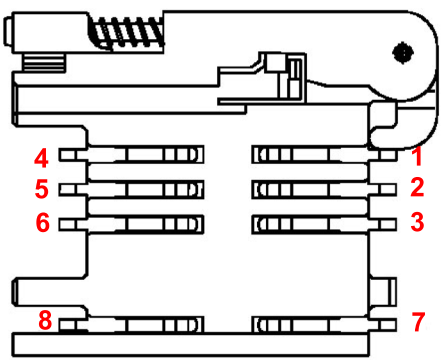


Figure 14: Pin numbers of Molex SIM card holder on DSB35 Support Box

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 12: Input control signals of the MC39i module

Signal	Pin	Pin status	Function	Remarks
Ignition	/IGT	= falling edge	Power up MC39i	Active low ≥ 100ms (open drain/collector driver required in cellular device application)
		= 1	Hi-Z	
Emergency shutdown	/EMERG-OFF	= 0	Power down MC39i	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 22 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 two different operating modes which you can select by using the AT^SSYNC command (mode 0 and 1). For details refer to the “AT Command Set”.

To generate the synchronization signal the pin needs to be configured to mode 0 (= default). This setting is recommended if you want your application to use the synchronization signal for better power supply control. Your platform design must be such that the incoming signal accommodates sufficient power supply to the MC39i module if required. This can be achieved by lowering the current drawn from other components installed in your application. The characteristics of the synchronization signal are explained below.

Table 13: MC39i synchronization signal (if SYNC pin is set to mode 0 via AT^SSYNC)

Function	Pin	Status	Description
Synchronization	SYNC	= 0	No operation
		= 1	Indicates increased power consumption during transmission.

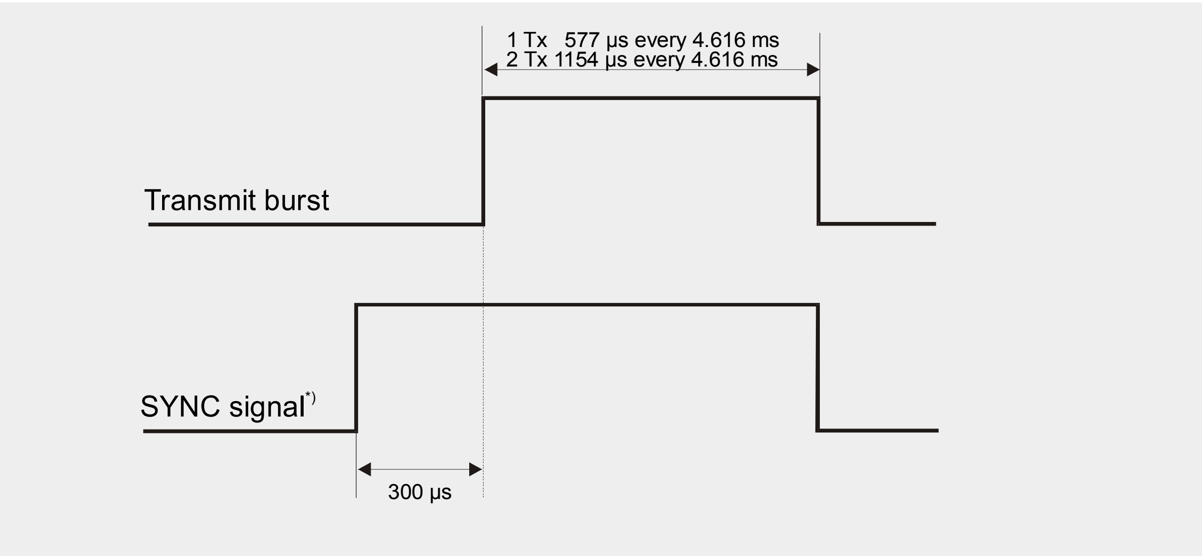


Figure 15: MC39i output control signals

*) 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.

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

When controlled from the SYNC pin the LED can display the functions listed in Table 14. Especially in the development and test phase of an application, system integrators are advised to use the LED mode of the SYNC pin in order to evaluate their product design and identify the source of errors.

Table 14: Coding of the status LED

LED mode	Operating status
Off	MC39i is off or run in SLEEP, Alarm mode
600 ms On / 600ms Off	No SIM card inserted or no PIN entered, or network search in progress, or ongoing user authentication, or network login in progress.
75ms On / 3s Off	Logged to network (monitoring control channels and user interactions). No call in progress.
75 ms on / 75 ms Off / 75 ms On / 3 s Off	One or more GPRS contexts activated.
Flashing	Indicates GPRS data transfer: When a GPRS transfer is in progress, the LED goes on within 1 second after data packets were exchanged. Flash duration is approx. 0.5 s
On	Depending on type of call: *Voice call:* Connected to remote party. *Data call:* Connected to remote party or exchange of parameters while setting up or disconnecting a call.

LED Off = SYNC pin low. LED On = SYNC pin high (if LED is connected as illustrated in Figure 16)

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 16. Power consumption in the LED mode is the same as for the synchronization signal mode.
For details see Table 22 pin number 32.

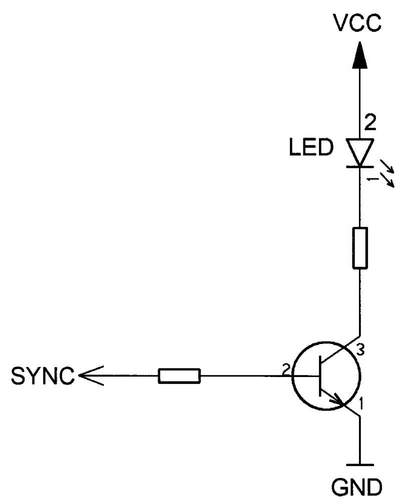


Figure 16: LED Circuit (Example)

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.

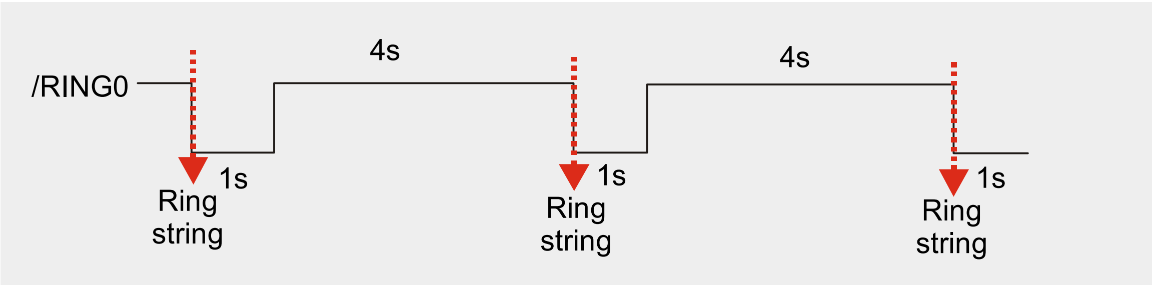


Figure 17: Incoming voice call

- 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.

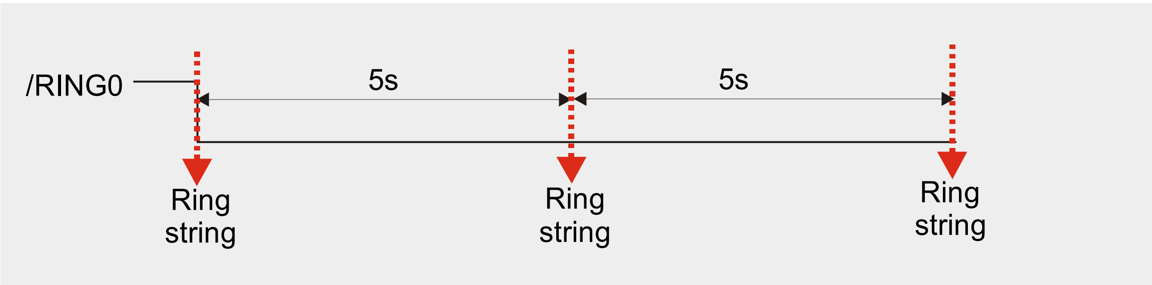


Figure 18: Incoming data call

- All types of Unsolicited Result Codes (URCs) also cause the /RING0 line to go low, however for 1 second only.
  For example, MC39i 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.

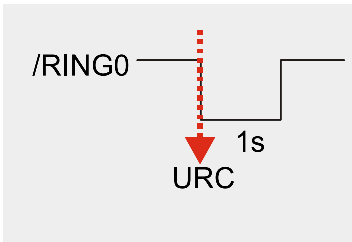


Figure 19: URC transmission

Table 15: MC39i 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. MC39i 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 MC39i PCB is a MuRata GSC coaxial connector (see Figure 20).

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 MC39i provides the following values.

Table 16: Return loss

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

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.

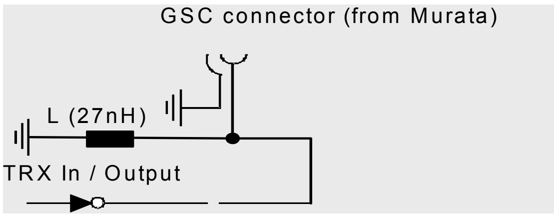


Figure 20: Antenna connector circuit on MC39i

4.1 Antenna connector

MC39i 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 17: MuRata ordering information

Description	MuRata part number
Male connector mounted on MC39i	MM9329-2700
Matching female connectors suited for individual cable assembly • Right-angle flexible cable • Right-angle flexible cable • Right-angle semi rigid 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 18: 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: • Copper alloy • Copper alloy • Engineering plastic	Finish: Gold plated Silver plated None

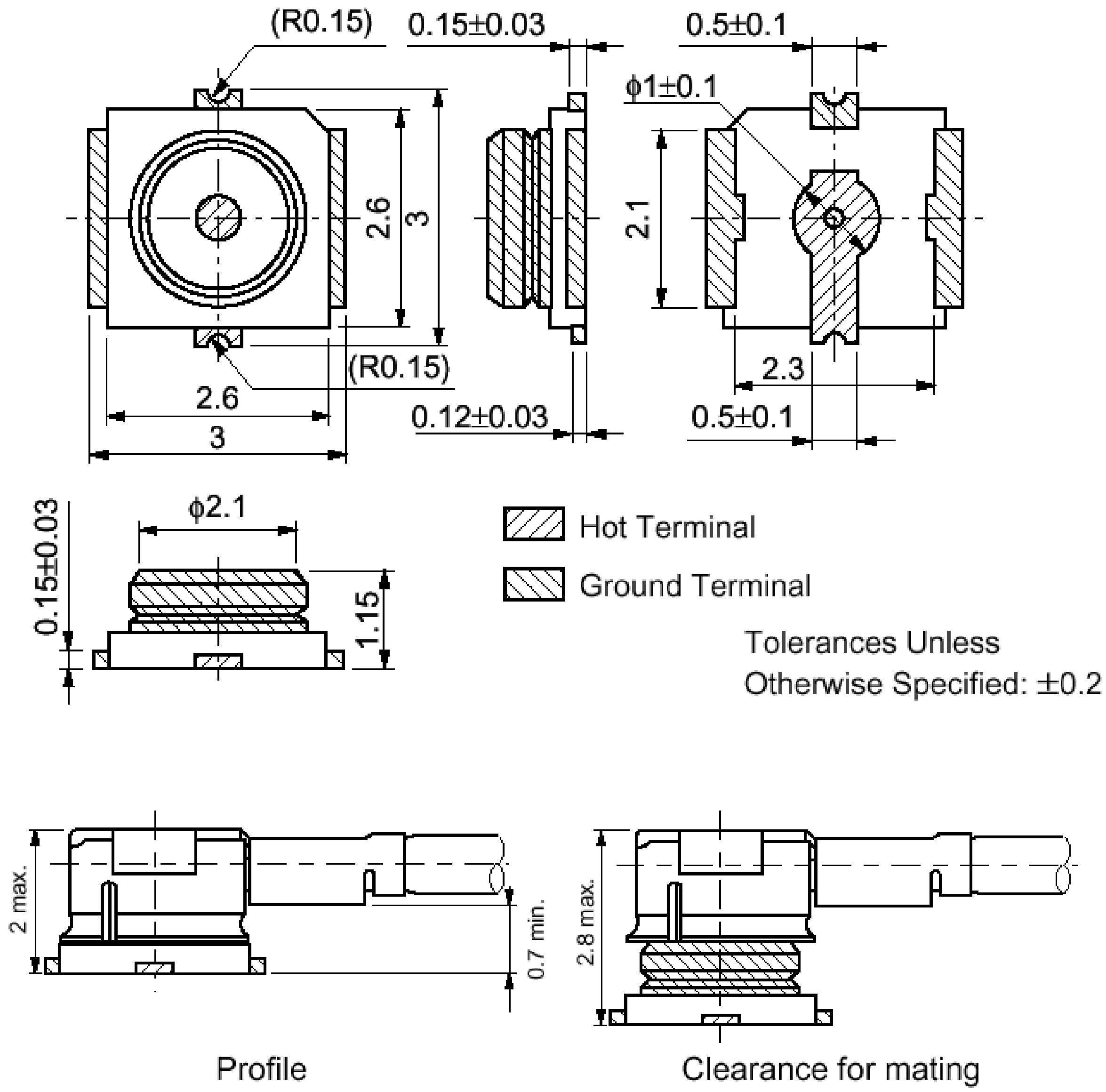


Figure 21: Mechanical dimensions of MuRata GSC connector (in mm)

Table 19: 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 18 for details A and B: 4.9N max. C: 2.94N max and D: 1.96N max E: 4.9N max

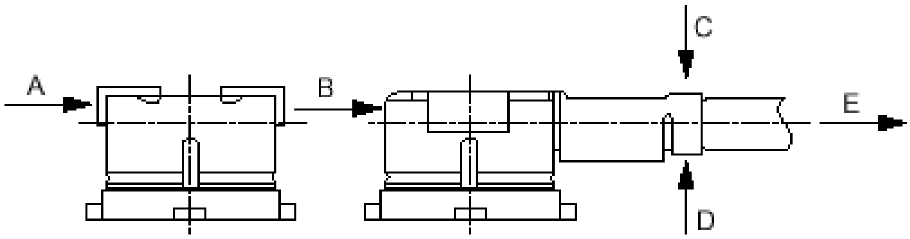


Figure 22: Maximum mechanical stress to the connector

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

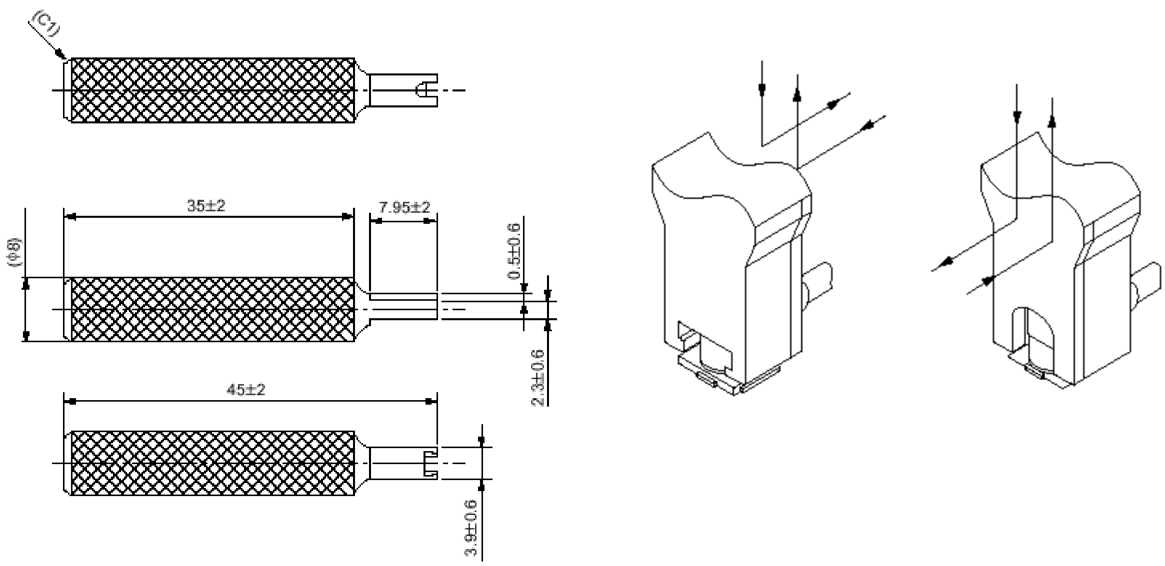


Figure 23: How to use MuRata tool

5 Electrical, reliability and radio characteristics

5.1 Absolute maximum ratings

The absolute maximum ratings stated in Table 20 are stress ratings under non-operating conditions. Stresses beyond any of these limits will cause permanent damage to MC39i.

Table 20: 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 digital / analog pins in POWER DOWN mode	-0.25	+0.25	V
BATT+	-0.3	4.9	V
Differential load resistance between EPN1 and EPP1	15		Ω
Differential load resistance between EPN2 and EPP1	15		Ω

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 21: Operating temperatures

Parameter	Min	Typ	Max	Unit
Ambient temperature (according to GSM 11.10)	-20	25	55	°C
Restricted operation [1)]	-25 to –20		55 to 70	°C
Automatic shutdown[2)]	≤-25		≥70	°C

1) MC39i operates, but deviations from the GSM specification may occur.
2) Due to temperature measurement uncertainty, a tolerance of ±3°C on these switching thresholds may occur.

5.3 Electrical specifications of the application interface

Please note that the reference voltages listed in Table 22 are the values measured directly on the MC39i 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.

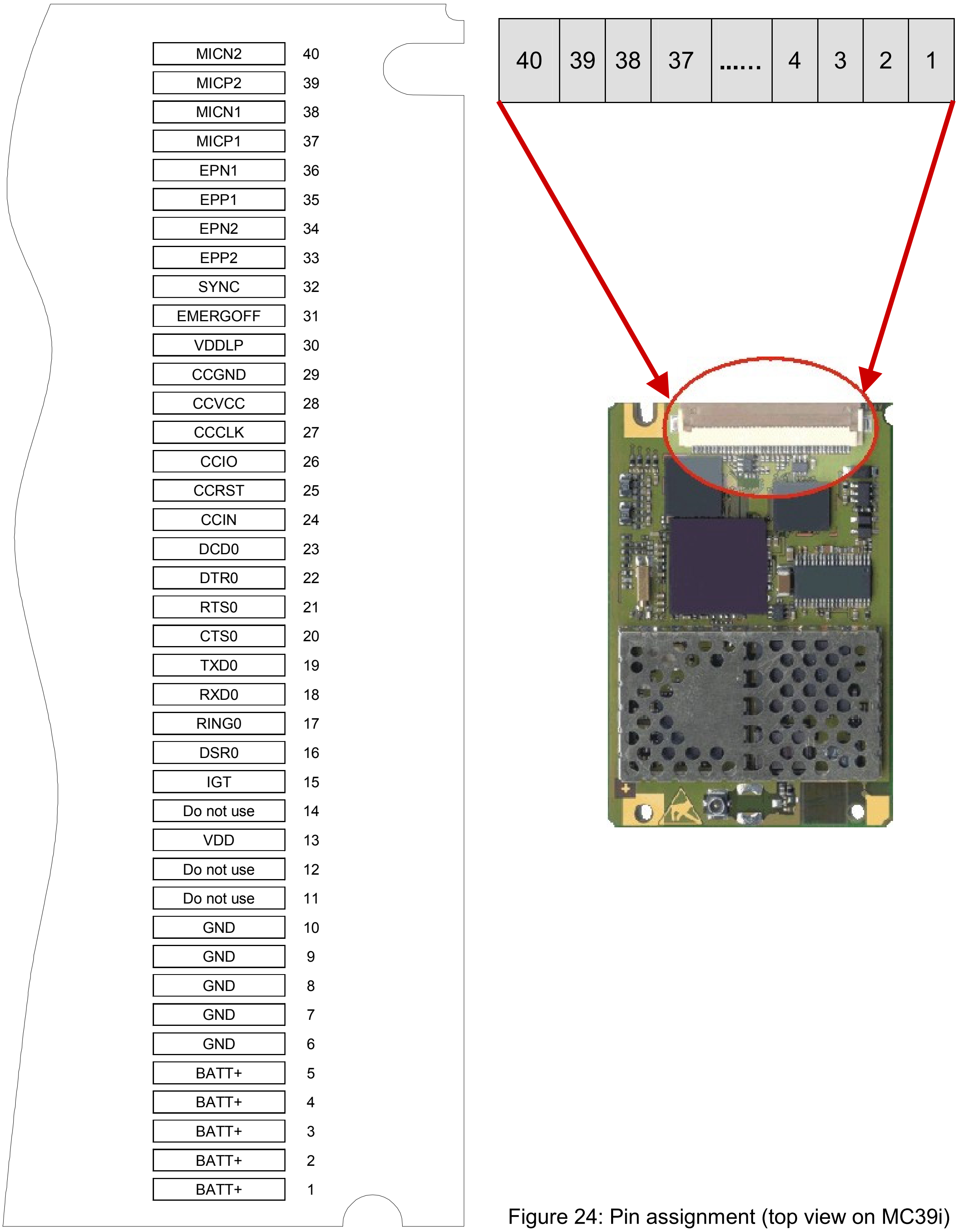


Figure 24: Pin assignment (top view on MC39i)

Table 22: 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, in Burst  1 Tx: Peak current 577µs every 4.615ms 2 Tx: Peak current 1154µs 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 Sending with two timeslots doubles the duration of current pulses to 1154µs (every 4.615ms)!
Power supply	GND		Ground	Application Ground
External supply voltage	VDD	O	IDLE / TALK mode: V_{out} = 2.9V; ±3% @ 70mA; V_{BATT+} = 4.2V and $T_{amb,typ}$ = 25°C Vout = 2.9V; ±3% @ 20mA; V_{BATT+} = 4.8V and $T_{amb,typ}$ = 25°C I_{max} = 70mA Power Down mode: Vout = 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.
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.

Function	Signal name	IO	Signal form and level	Comment
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  1 Tx: 877µs impulse each 4.615ms and 2 Tx: 1454µs impulse each 4.615ms, with 300µs forward time.	Indication of increased current consumption during uplink transmission burst, however, the timing is different during handover. Alternatively used to control status LED. If unused keep pin open.
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	
RTC backup	VDDLP	I/O	IDLE / TALK / DATA / Power down mode if BATT+ connected: Vout <V_{BATT+} is disconnected Ri = 1kΩ (serial resistor) Power Down mode if BATT+ disconnected Vin = 2.0V…5.5V Iin,max = 30 µA	If unused, keep pin open.

Function	Signal name	IO	Signal form and level	Comment
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. If lines are unused keep pins open.
Analog Audio interface	EPP2 EPN2	O O	$R_i \approx 15\Omega$, (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.
	EPP1 EPN1	O O	$R_i \approx 15\Omega$, (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. Short circuit may damage the outputs
Explanation of signal names: P = positive, N = negative	MICP1 MICN1	O O	$R_I = 2k\Omega$ differential $V_I max = 1.03Vpp$ $V_{supply} = 2.65V$ at $R_{supply} = 4k\Omega$ analog amplification range = 0...42dB in 6dB steps	This microphone input is balanced and can feed an active microphone. If unused keep pins open.
	MICP2 MICN2	O I	$R_I = 2k\Omega$ differential $V_I max = 1.03Vpp$ $V_{supply} = 2.65V$ at $R_{supply} = 4k\Omega$ 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 23: Power supply ratings

Parameter	Description	Conditions	Min	Typ	Max	Unit
V_{BATT+}	Supply voltage	Directly measured at the reference point BATT+ pad (see Figure 29) 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[2)]		15		mA
		TALK mode EGSM 900[1)] GSM 1800		300[6)] 270[6)]	450	mA
		IDLE mode GPRS EGSM 900[1)] GSM 1800[2)]		15		
		DATA mode GPRS, (4 Rx, 1 Tx) EGSM 900[1)] GSM 1800[2)]		360[6)] 330[6)]	540	mA
		DATA mode GPRS, (3 Rx, 2 Tx) EGSM 900[1)] GSM 1800[2)]		590[6)] 540[6)]	950	mA
	Peak supply current (during 577µs transmission slot every 4.6ms)	Power level PCL 5		2	[3)]	A

1) Power control level PCL 5
2) Power control level PCL 0
3) The maximum current at the BATT+ line during transmit operation strongly depends on the antenna performance. See Figure 25 for details.
4) All average supply currents values @ I_{VDD} = 0mA
5) During transmit bursts, the voltage at the BATT+ reference point 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 on MC39i. 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 25 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 in Figure 25 shown, 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 25 shows the current consumption at the following conditions:

- Channel with the highest current consumption: 881MHz (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.

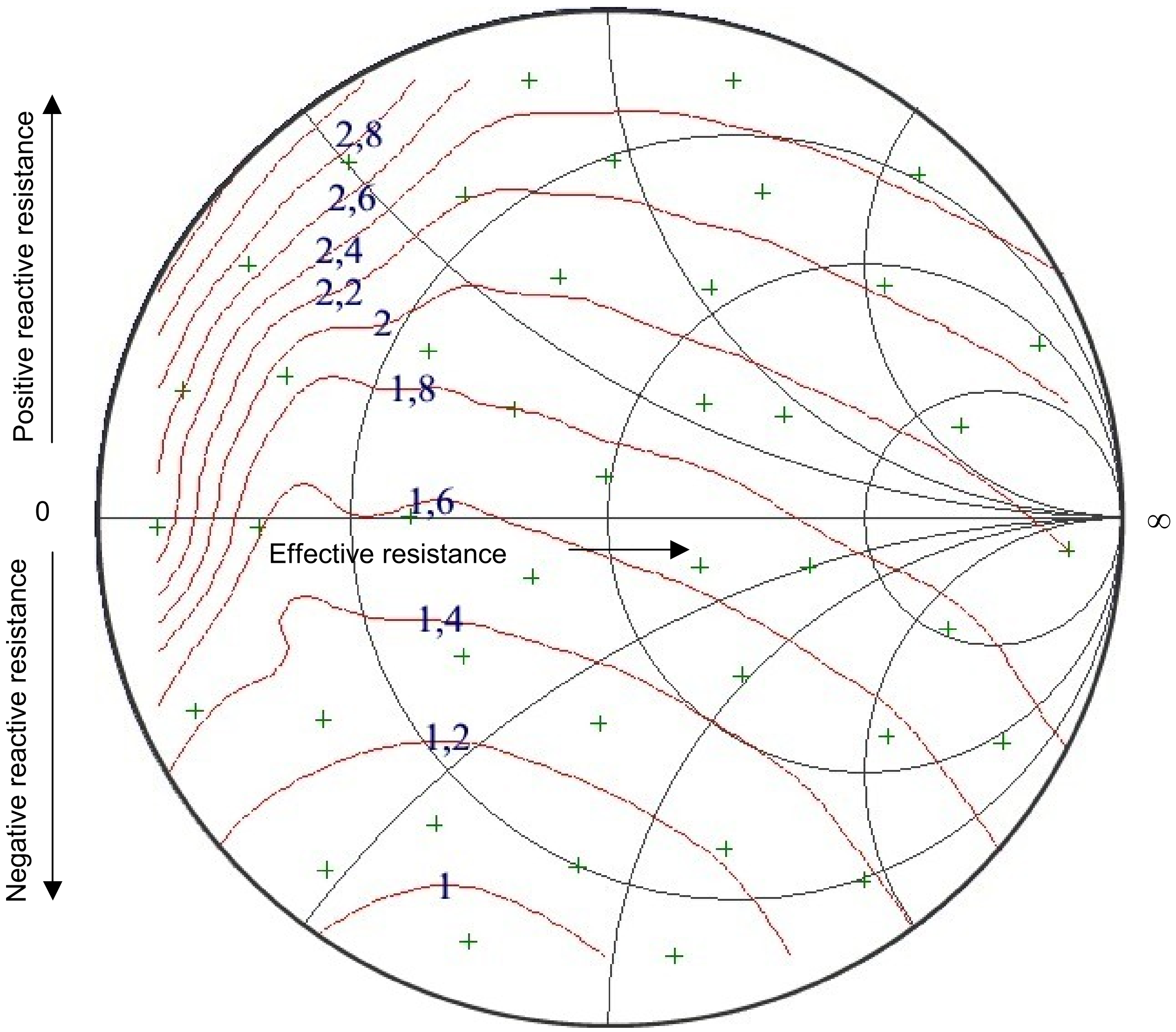


Figure 25: Peak current during transmit burst in A vs. antenna impedance

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 24: 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.

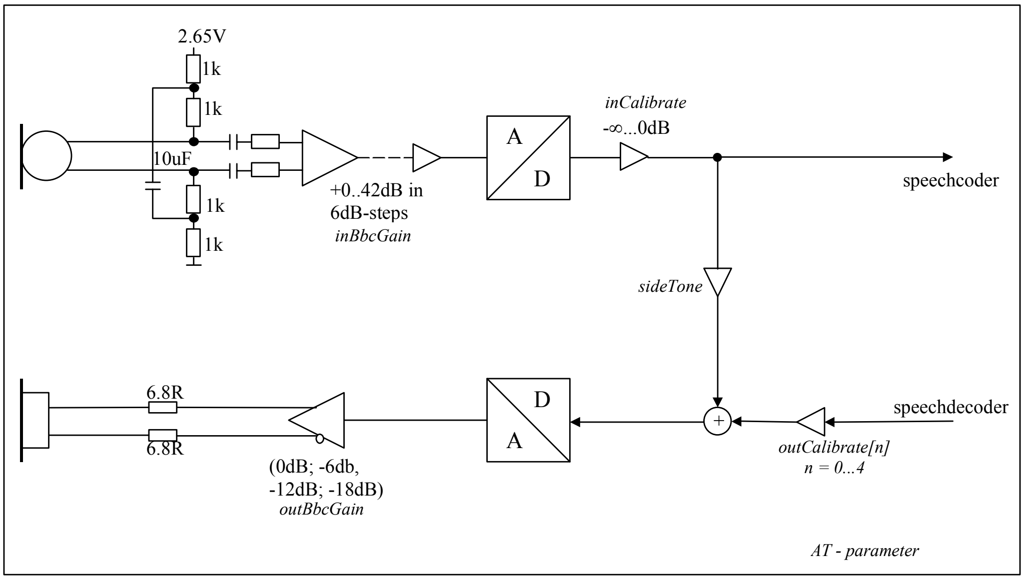


Figure 26: AT audio programming model

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 25: Voiceband characteristics (typical)

Audio mode no. AT^SNFS=	**1** (Default settings, not adjustable)	**2**	**3**	**4**	**5**	**6**
Name	Default Handset	Basic Handsfree	Headset	User Handset	Plain Codec 1	Plain Codec 2
Purpose	DSB with Votronic handset	Siemens Car Kit Portable	Siemens Headset	DSB with individual handset	Direct access to speech coder	Direct access to speech coder
Gain setting via AT command. Defaults: inBbcGain outBbcGain	Fix 5 (30dB) 1 (-6dB)	Adjustable 2 (12dB) 1 (-6dB)	Adjustable 5 (30dB) 2 (-12dB)	Adjustable 5 (30dB) 1 (-6dB)	Adjustable 0 (0dB) 0 (0dB)	Adjustable 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	48mV	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 between MIC and EP	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 [9])

2) In audio modes with noise reduction, the microphone input signal for 0dBm0 shall be measured with a sine burst signal for the 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 26: 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 27: 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 27

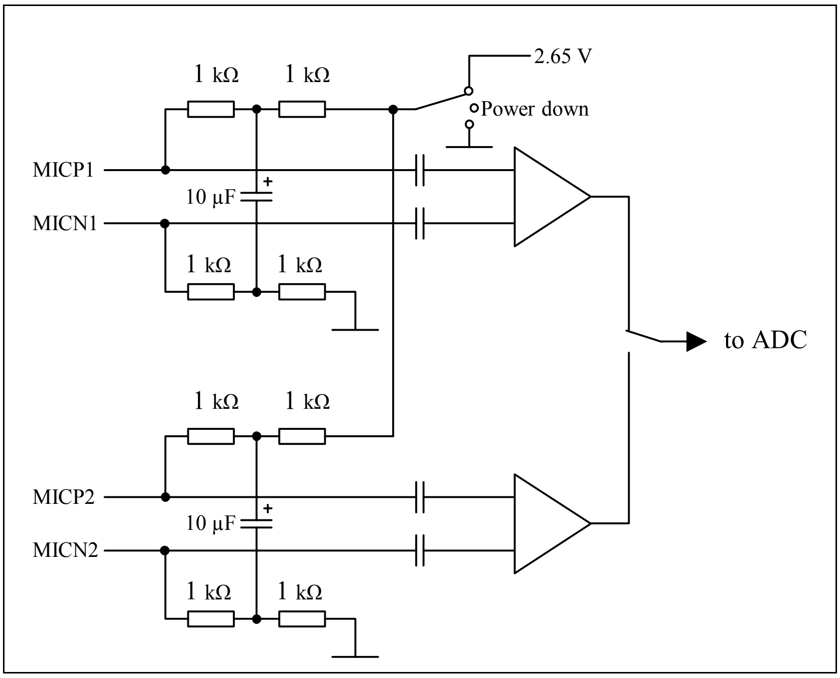


Figure 27: Structure of audio inputs

5.6 Air interface

Table 28: Air interface

Parameter		Min	Typ[3]	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 with 50Ω load	E-GSM 900 [1]	31	32.5		dBm
	GSM 1800 [2]	28	29.5		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%	GSM 1800		-106		dBm

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

Table 29: Local oscillator and intermediate frequencies used by MC39i

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 MC39i module.

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

MC39i has been tested according to the EN 61000-4-2 directive. The measured values verified for the Siemens reference configuration can be gathered from the following table.

Table 30: 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	± 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 31: 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 MC39i

Figure 28 shows the RF part of MC39i and provides an overview of the board's mechanical dimensions. For further details see Figure 29.

Size: 54.5±0.2 x 36±0.2 x 3.55±0.3 mm (height of antenna connector not considered)
Weight: 9g

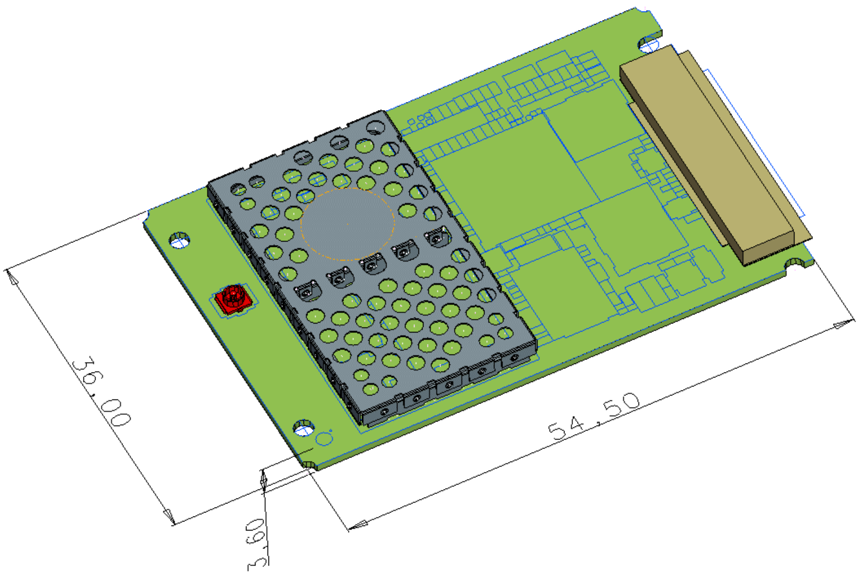
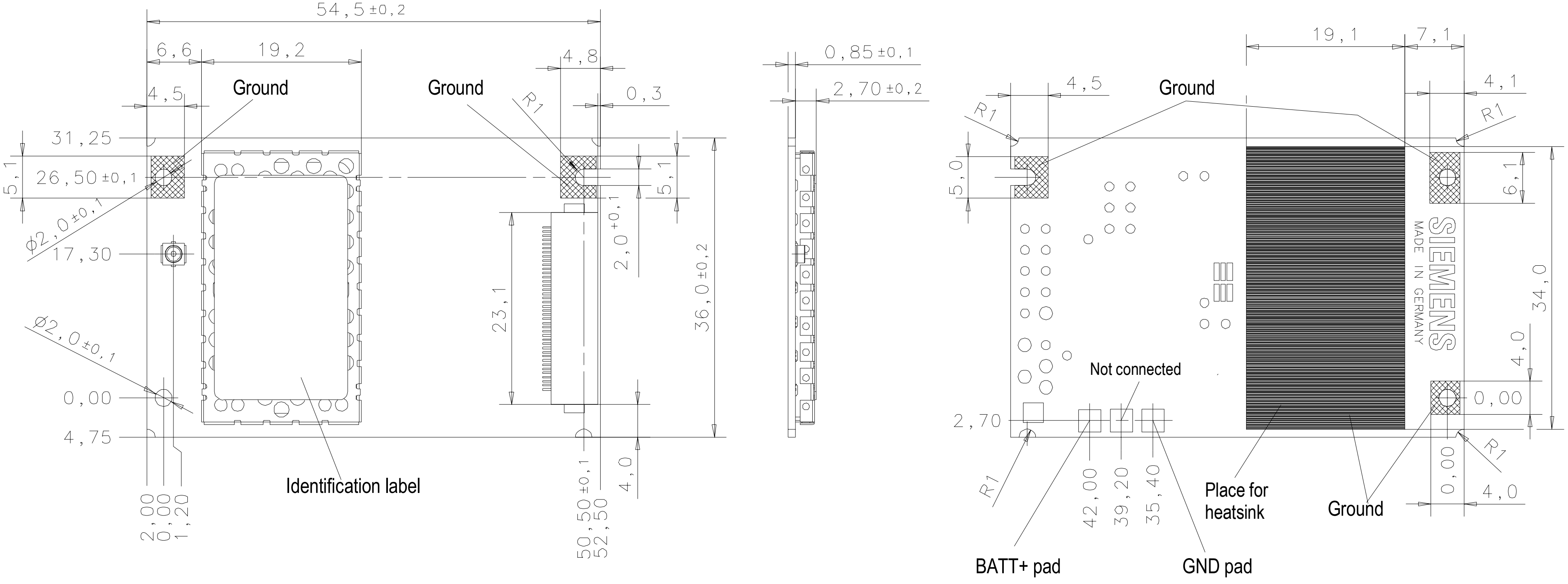


Figure 28: MC39i – top view



All dimensions in millimeter

Figure 29: Mechanical dimensions of MC39i

6.2 Mounting MC39i 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 MC39i board provides three mounting holes. 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.

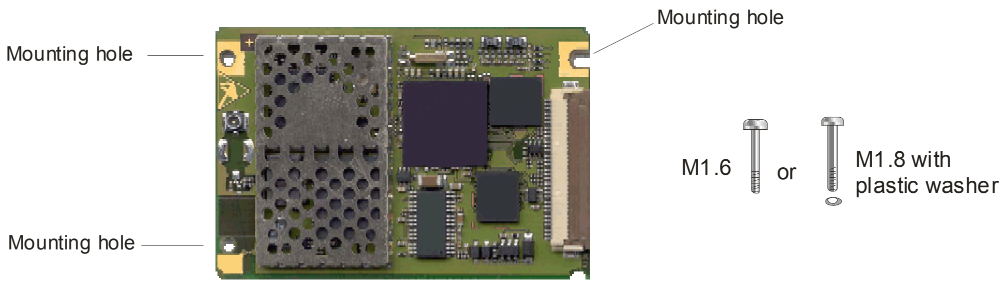


Figure 30: Recommended screws

Avoid placing the MC39i 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.

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 MC39i PCB is type Hirose FH12-40S 0.5 SH.

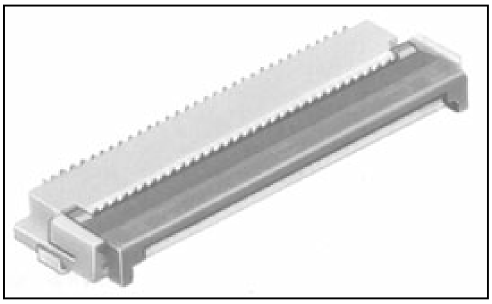


Figure 31: Hirose FH12 connector

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 32: Ordering information

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

Table 33: 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")
Maximum connection cycles	20 (@ 50mΩ max)
Cable	FFC (Flat Flexible Cable), max. length 200mm from SIM interface (see Chapter 6.3.1)

6.3.1 FFC

As stated in Chapter 3.9 the total cable length between the ZIF connector pins on MC39i 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

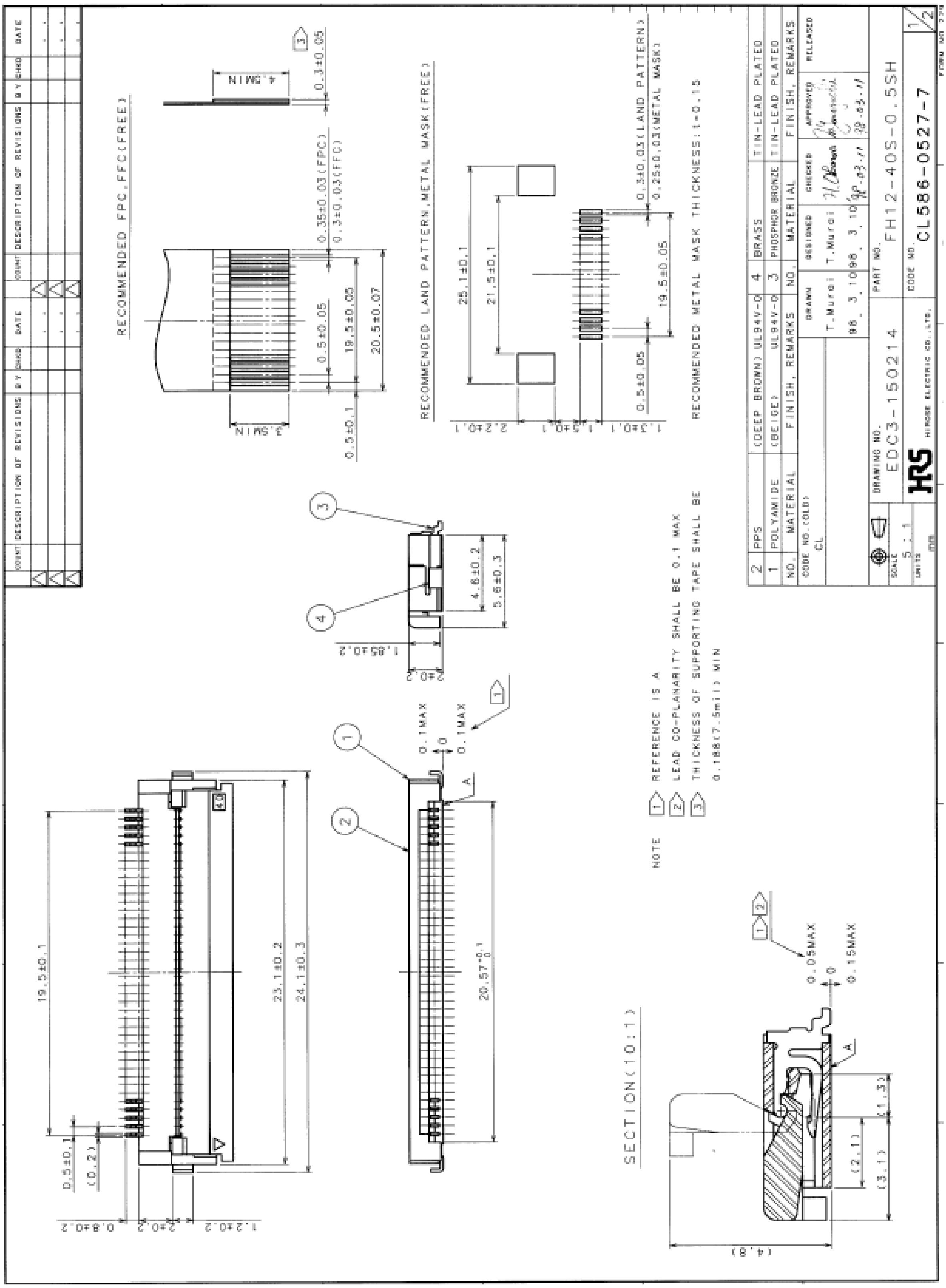


Figure 32: Description of Hirose FH12 connector

7 Reference approval

7.1 Reference equipment

The Siemens reference setup submitted to type approve MC39i consists of the following components:

- Siemens MC39i cellular engine
- Development Support Box (DSB35)
- FFC from ZIF connector on MC39i 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

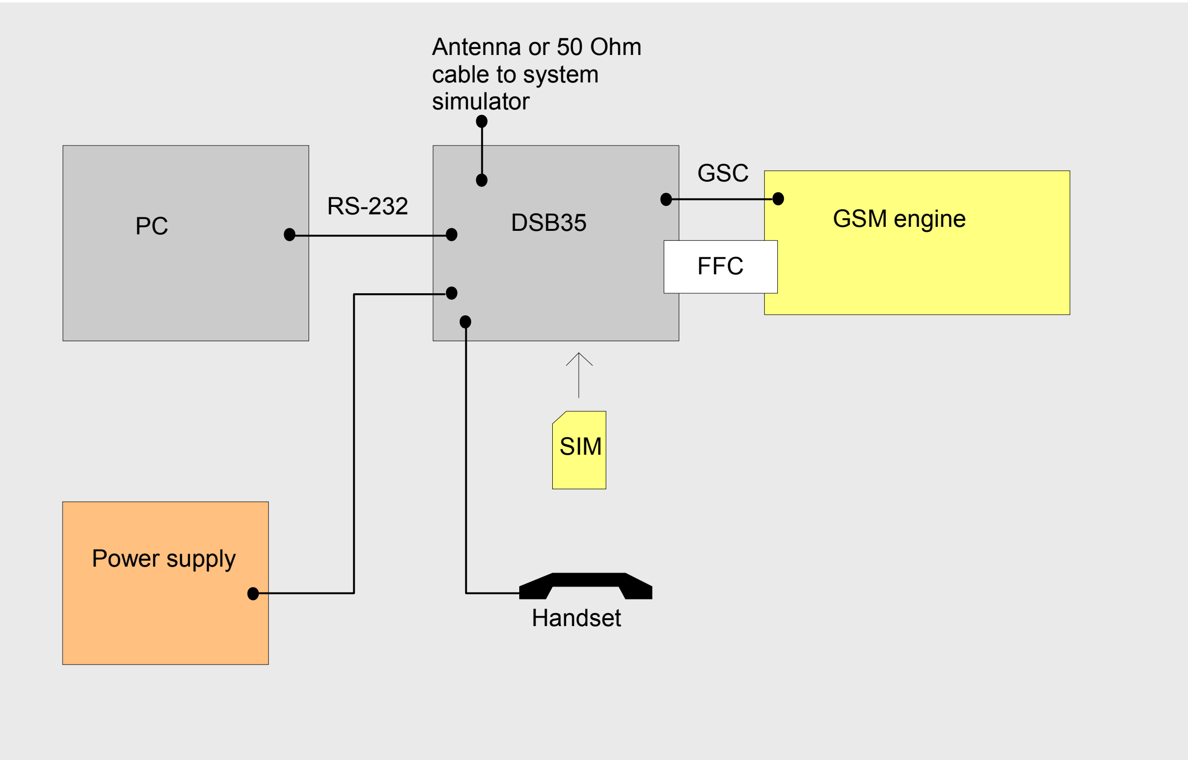


Figure 33: Reference equipment for approval

8 APPENDIX: List of parts and recommended accessories

Table 34: List of accessories

Description	Supplier	Ordering information
MC39i engine	Siemens	Siemens ordering number L36880-N8530-C100
SIM card holder incl. push button ejector and slide-in tray	Molex	Ordering numbers: 91228 91236 Molex Deutschland GmbH Felix-Wankel-Str. 11 D-74078 Heilbronn-Biberach Phone: +49(7066)9555 0 Fax: +49(7066)9555 29 Email: mxgermany@molex.com Web site: http://www.molex.com/ American Headquarters Lisle, Illinois 60532 U.S.A. Phone: +1-800-78MOLEX Fax: +1-630-969-1352 Far East Headquarters Yamato, Kanagawa, Japan Phone: +81-462-65-2324 Fax: +81-462 Far East Headquarters Jurong, Singapore Phone: +65-268-6868 Fax: +65-265-6044
ZIF connector	Hirose	See Chapter 6.3 for specifications of FH12-40S 0.5 SH connector and mating cables http://www.hirose.com
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
Handset	Votronic	HH-SI-30.3/V1.1/0

Description	Supplier	Ordering information
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