I56/I56i

Hardware description

Preliminary

Version 1.00

Contents

Version history

Version number	Author	Changes
1.00	Fadil Beqiri	Initial version

Cautions

Information furnished herein by FALCOM is believed to be accurate and reliable. However, no responsibility is assumed for its use. Also the information contained herein is subject to change without notice.

Please, read carefully the safety precautions.
If you have any technical questions regarding this document or the product described in it, please contact your vendor.
General information about FALCOM and its range of products is available at the following internet address: http://www.falcom.de/

Trademarks

Some mentioned products are registered trademarks of their respective companies.

Copyright

FALCOM GmbH.

No patent liability is assumed with respect to the use of the information contained herein.

0 Introduction

0.1 General

The I56/I56i is designed for use on any GSM network in the world. The I56/I56i is a tri band GSM/GPRS engine that works on three frequencies GSM 850 MHz, DCS 1800 MHz and PCS 1900 MHz.
This full type approved integrated modem constitutes a self contained, fully integrated implementation of the GSM/GPRS. I56/I56i features GPRS class B, class 10 (making download at speeds up to 85 kbps) and supports the GPRS coding schemes CS-1, CS-2, CS-3 and CS-4.
The I56/I56i module incorporates all you need to create high-performance GSM/GPRS solutions; base band processor, power supply ASIC, complete radio frequency circuit including a power amplifier, internal and external SIM interfaces and an antenna interface as well.
The physical interface to the cellular application is made through a board-to-board connector. It consists of 50 pins, required for controlling the unit, transferring data and audio signals and providing power supply lines.
The external dual band or triple band antenna can directly be connected to the integrated 50 Ω connector on the side of module.
The I56/I56i is a mobile station for transmission of voice, data calls and FAX as well as short messages (SMS - **S**hort **M**essage **S**ervice) in GSM Network.
For battery powered applications, I56/I56i features a charging control which can be used to charge a Li-Ion battery. The charging circuit must be implemented external the module on your application platform.
To control the GSM module there is an advanced set of AT commands according to GSM ETSI (**E**uropean **T**elecommunications **S**tandards **I**nstitute) 07.07 and 07.05 implemented.

Figure 1: Views (front and back side) of I56/I56i

Users are advised to proceed quickly to the „Security“ chapter and read the hints carefully.

0.2 The difference between I56 and I56i modules

I56 The **I56** is a Tri-band device which operates in three frequencies GSM 850 MHz, DCS 1800 MHz and PCS 1900 MHz, and is available to use in the American Networks. However, the I56 module contains 1800 MHz GSM functions that is not operational (must not be used) in U.S. Territories. This filing is only applicable for 850MHz GSM/1900 MHz PCS operations, whereby only these frequencies (850MHz GSM/1900 MHz PCS) are possible to be used in U.S. Territories.

I56i The **I56i** is also a Tri-band device which operates on three frequencies GSM 850 MHz, DCS 1800 MHz and PCS 1900 MHz, and is available to use in the American Networks. However, the I56i module contains 1800 MHz GSM functions that is not operational (must not be used) in U.S. Territories. This filing is only applicable for 850MHz GSM/1900 MHz PCS operations, whereby only these frequencies (850MHz GSM/1900 MHz PCS) are possible to be used in U.S. Territories. The I56i provides a specific soft- and hardware (internal TCP/IP stack software with hardware extension) which has been internally implemented for using the embedded TCP/IP stack software. The **I56i** module comes without modification regarding to the 50-pin board-to-board connector.
The integration of TCP/IP stack with hardware extension (*a TCP/IP-module added*) into the equipment converts it to a stand-alone client that can be connected to the internet through any GSM 850/1800/1900 network. The module can also send and receive data by GSM and GPRS network using TCP/IP stack. It supports SMS, DATA and FAX calls. The **I56i** module can be easily controlled by using AT or TCP commands. The "TCP Command Set" manual is also issued as separate document and is available on the distributed CD for the I56i's users.

Please note that, according to your requirement you can choose the desired device.

0.3 Used abbreviations

Abbreviation	Description
AD	Analogue/Digital
ADC	Analogue-to-Digital Converter
AFC	Automatic Frequency Control
AGC	Automatic Gain Control
AMP	Advanced Power Management
ANSI	American National Standards Institute
ARFCN	Absolute Radio Frequency Channel Number
ARP	Antenna Reference Point
ASC0	Asynchronous Controller. Abbreviations used for serial interface of I56/I56i
ASIC	Application Specific Integrated Circuit

Abbreviation	Description
B2B	Board-to-board connector
BER	Bit Error Rate
BTS	Base Transceiver Station
CB or CBM	Cell Broadcast Message
CE	Conformité Européene (European Conformity)
CHAP	Challenge Handshake Authentication Protocol
CPU	Central Processing Unit
CS	Coding Scheme
CSD	Circuit Switched Data
CTS	Clear to Send
DAC	Digital-to-Analogue Converter
dBW	Decibel per Watt
dBm0	Digital level, 3.14 dBm0 corresponds to full scale, see ITU G.711, A-law
DCE	Data Communication Equipment
DRX	Discontinuous Reception
DSP	Digital Signal Processor
DSR	Data Set Ready
DTE	Data Terminal Equipment (typically computer, terminal, printer or, for example, GSM application)
DTR	Data Terminal Ready
DTX	Discontinuous Transmission
EFR	Enhanced Full Rate
EGSM	Enhanced GSM
EMC	Electromagnetic Compatibility
ESD	Electrostatic Discharge
ETS	European Telecommunication Standard
FCC	Federal Communications Commission (U.S.)
FDMA	Frequency Division Multiple Access
FR	Full Rate
GMSK	Gaussian Minimum Shift Keying
GPRS	General Packet Radio Service
GSM	Global Standard for Mobile Communications
HiZ	High Impedance
HR	Half Rate
I/O	Input/Output
IC	Integrated Circuit
IF	Intermediate Frequency
IMEI	International Mobile Equipment Identity
ISO	International Standards Organization
ITU	International Telecommunications Union
kbps	kbits per second
LED	Light Emitting Diode
LNA	Low Noise Amplifier
Mbps	Mbits per second
MMI	Man Machine Interface
MO	Mobile Originated
MS	Mobile Station (GSM engine), also referred to as TE

Abbreviation	Description
MSISDN	Mobile Station International ISDN number
MSK	Minimum Shift Key
MT	Mobile Terminated
NC	Not Connected
PA	Power Amplifier
PAP	Password Authentication Protocol
PBCCH	Packet Switched Broadcast Control Channel
PCB	Printed Circuit Board
PCL	Power Control Level
PCM	Pulse Code Modulation
PCN	Personal Communications Network, also referred to as DCS 1800
PCS	Personal Communication System, also referred to as GSM 1900
PDU	Protocol Data Unit
PLL	Phase Locked Loop
PPP	Point-to-point protocol
PSU	Power Supply Unit
R&TTE	Radio and Telecommunication Terminal Equipment
RAM	Random Access Memory
RF	Radio Frequency
RMS	Root Mean Square (value)
ROM	Read-only Memory
RP	Receive Protocol
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
URC	Unsolicited Result Code
USSD	Unstructured Supplementary Service Data
VSWR	Voltage Standing Wave Ratio
WAAS	Wide Area Augmentation System
FD	SIM fix dialing phonebook
LD	SIM last dialing phonebook (list of numbers most recently dialed)
MC	Mobile Equipment list of unanswered MT calls (missed calls)
ME	Mobile Equipment phonebook
ON	Own numbers (MSISDNs) stored on SIM or ME
RC	Mobile Equipment list of received calls
SM	SIM phonebook

Table 1: Used abbreviations

0.4 Related documents

1. ETSI GSM 07.05: “Use of Data Terminal Equipment-Data Circuit terminating Equipment interface for Short Message Service and Cell Broadcast Service”
2. ETSI GSM 07.07 “AT command set for GSM Mobile Equipment”
3. ITU-T V.25ter “Serial asynchronous automatic dialling and control”
4. I56/I56i AT Command Set
5. gprs_startup_user_guide_rev_1.00_preliminary
6. I56i TCP Command Set

1 Security

IMPORTANT FOR THE EFFICIENT AND SAFE OPERATION OF YOUR GSM MODEM, READ THIS INFORMATION BEFORE USE!
Your cellular engine I56/I56i is one of the most exciting and innovative electronic products ever developed. With it you can stay in contact with your office, your home, emergency services and others, wherever service is provided.
This chapter contains important information for the safe and reliable use of the I56/I56i. Please read this chapter carefully before starting to use the cellular engine I56/I56i.

1.1 General information

Your I56/I56i modem utilises the GSM standard for cellular technology. GSM is a newer radio frequency („RF“) technology than the current FM technology that has been used for radio communications for decades. The GSM standard has been established for use in the European community and elsewhere.
Your modem is actually a low power radio transmitter and receiver. It sends out and receives radio frequency energy. When you use your modem, the cellular system handling your calls controls both the radio frequency and the power level of your cellular modem.

1.2 Exposure to RF energy

There has been some public concern about possible health effects of using GSM modem. Although research on health effects from RF energy has focused for many years on the current RF technology, scientists have begun research regarding newer radio technologies, such as GSM. After existing research had been reviewed, and after compliance to all applicable safety standards had been tested, it has been concluded that the product is fit for use.
If you are concerned about exposure to RF energy there are things you can do to minimise exposure. Obviously, limiting the duration of your calls will reduce your exposure to RF energy. In addition, you can reduce RF exposure by operating your cellular modem efficiently by following the guidelines below.

1.3 Efficient modem operation

In order to operate your modem at the lowest power level, consistent with satisfactory call quality please take note of the following hints.

- If your modem has an extendible antenna, extend it fully. Some models allow you to place a call with the antenna retracted. However, your modem operates more efficiently with the antenna fully extended.
- Do not hold the antenna when the modem is „IN USE“. Holding the antenna affects call quality and may cause the modem to operate at a higher power level than needed.

1.4 Antenna care and replacement

Do not use the modem with a damaged antenna. If a damaged antenna comes into contact with the skin, a minor burn may result. Replace a damaged antenna immediately. Consult your manual to see if you may change the antenna yourself. If so, use only a manufacturer-approved antenna. Otherwise, have your antenna repaired by a qualified technician.
Use only the supplied or approved antenna. Unauthorised antennas, modifications or attachments could damage the modem and may contravene local RF emission regulations or invalidate type approval.

1.5 Driving

Check the laws and regulations on the use of cellular devices in the area where you drive. Always obey them. Also, when using your modem while driving, please pay full attention to driving, pull off the road and park before making or answering a call if driving conditions so require. When applications are prepared for mobile use they should fulfil road-safety instructions of the current law!

1.6 Electronic devices

Most electronic equipment, for example in hospitals and motor vehicles is shielded from RF energy. However, RF energy may affect some malfunctioning or improperly shielded electronic equipment.

1.7 Vehicle electronic equipment

Check your vehicle manufacturer's representative to determine if any on board electronic equipment is adequately shielded from RF energy.

1.8 Medical electronic equipment

Consult the manufacturer of any personal medical devices (such as pacemakers, hearing aids, etc.) to determine if they are adequately shielded from external RF energy.
Turn your I56/I56i modem OFF in health care facilities when any regulations posted in the area instruct you to do so. Hospitals or health care facilities may be using RF monitoring equipment.

1.9 Aircraft

Turn your I56/I56i OFF before boarding any aircraft.
Use it on the ground only with crew permission.
Do not use it in the air.
To prevent possible interference with aircraft systems, Federal Aviation Administration (FAA) regulations require you to have permission from a crew member to use your modem while the plane is on the ground. To prevent interference with cellular systems, local RF regulations prohibit using your modem whilst airborne.

1.10 Children

Do not allow children to play with your I56/I56i modem. It is not a toy. Children could hurt themselves or others (by poking themselves or others in the eye with the antenna, for example). Children could damage the modem or make calls that increase your modem bills.

1.11 Blasting areas

To avoid interfering with blasting operations, turn your unit OFF when in a "blasting area" or in areas posted: „turn off two-way radio". Construction crew often use remote control RF devices to set off explosives.

1.12 Potentially explosive atmospheres

Turn your I56/I56i modem OFF when in any area with a potentially explosive atmosphere. It is rare, but your modem or its accessories could generate sparks. Sparks in such areas could cause an explosion or fire resulting in bodily injury or even death.
Areas with a potentially explosive atmosphere are often, but not always, clearly marked. They include fuelling areas such as petrol stations; below decks on boats; fuel or chemical transfer or storage facilities; and areas where the air contains chemicals or particles, such as grain, dust or metal powders.
Do not transport or store flammable gas, liquid or explosives, in the compartment of your vehicle which contains your modem or accessories.
Before using your modem in a vehicle powered by liquefied petroleum gas (such as propane or butane) ensure that the vehicle complies with the relevant fire and safety regulations of the country in which the vehicle is to be used.

1.13 Non-ionising radiation

As with other mobile radio transmitting equipment users are advised that for satisfactory operation and for the safety of personnel, it is recommended that no part of the human body be allowed to come too close to the antenna during operation of the equipment.
The radio equipment shall be connected to the antenna via a non-radiating 50 Ohm coaxial cable.
The antenna shall be mounted in such a position that no part of the human body will normally rest close to any part of the antenna. It is also recommended to use the equipment not close to medical devices as for example hearing aids and pacemakers.

2 Safety standards

This GSM modem complies with all applicable RF safety standards.
The embedded GMS modem meets the safety standards for RF receivers and the standards and recommendations for the protection of public exposure to RF electromagnetic energy established by government bodies and professional organisations, such as directives of the European Community, Directorate General V in matters of radio frequency electromagnetic energy.

3 Technical data

3.1 Technical specifications of GSM/GPRS engine

- ***Power supply:***
  - ***S***upply voltage +5 V DC ±10 % (see chapter 3.2 for further details)
- ***Power saving (GSM):***
  - ***M***inimizes power consumption in SLEEP mode to 13 mA
- ***Charging:***
  - ***S***upports charging control for Li-Ion battery for the GSM/GPRS engine of the module
- ***Temperature range:***
  - ***N***ormal operation: -20 °C to +55 °C (see chapter 3.3 for further details)
- ***Evaluation kit:***
  - ***T***he I56/I56i Evaluation Kit is designed to test consider it as a Reference-Design for your HW-application, thus, you can save time and money. In this way you can reduce the Time-To-Market (see chapter 11).
- ***Physical characteristics:***
  - ***S***ize: 60.1 ± 0.15 mm x 40.0 ± 0.15 mm x 9.4 ± 0.15 mm (for more details see chapter 5. Housing)
  - ***W***eight: 40 ± 2 g
- ***I56i firmware upgrade:***
  - ***I56i*** firmware upgradeable over serial interface
- ***Frequency bands:***
  - ***T***ri-band: GSM 850, GSM 1800, GSM 1900
  - ***C***ompliant to GSM Phase 2/2+
- ***GSM class:***
  - ***S***mall MS
- ***Transmit power:***
  - ***C***lass 4 (2 W) at GSM850
  - ***C***lass 1 (1 W) at GSM 1800 and GSM 1900

- ***GPRS connectivity:***
  - ***G***PRS multi-slot class 10
  - ***G***PRS mobile station class B
- ***DATA:***

  GPRS ⇒
  - ***G***PRS data downlink transfer: max. 85.6 kbps (see table 3).
  - ***G***PRS data uplink transfer: max. 42.8 kbps (see table 3).
  - ***C***oding scheme: CS-1, CS-2, CS-3 and CS-4.
  - ***I56/I56i*** supports the two protocols PAP (Password Authentication Protocol) and CHAP (Challenge Handshake Authentication Protocol) commonly used for PPP connections.
  - ***S***upport of Packet Switched Broadcast Control Channel (PBCCH) allows you to benefit from enhanced GPRS performance when offered by the network operators.

  CSD ⇒
  - ***C***SD transmission rates: 2.4, 4.8, 9.6, 14.4 kbps, non-transparent, V.110.
  - ***U***nstructured Supplementary Services Data (USSD) support.

  WAP ⇒
  - ***W***AP compliant.
- ***SMS:***
  - ***M***T, MO, CB, Text and PDU mode
  - ***S***MS storage: SIM card plus 25 SMS locations in the mobile equipment
  - ***T***ransmission of SMS alternatively over CSD or GPRS. Preferred mode can be user-defined.
- ***MMS:***
  - ***M***MS compliant
- ***FAX:***
  - ***G***roup 3: class 1, class 2
- ***SIM interface:***
  - ***S***upported SIM card: 3 V
  - ***I***ntegrated SIM card slot (for small SIM card, only)
  - ***E***xternal SIM interface, which can be connected via provided pins on the 40-pin board-to-board connector (note that extra card reader is not part of I56/I56i)
- ***Casing:***
  - ***F***ully shield

- ***Temperature control and auto switch-off:***
  - Constant temperature control prevents damage to I56/I56i when the specified temperature is exceeded. When an emergency call is in progress the automatic temperature shutdown functionality is deactivated. (see chapter **3.3** for further details)
- ***External antenna:***
  - ***C***onnected via 50 Ohm antenna connector.
- ***Audio interfaces:***
  - ***A***n analogue audio interface
- ***Audio features:***

  Speech code modes:
  - ***H***alf Rate (ETS 06.20)
  - ***F***ull Rate (ETS 06.10)
  - ***E***nhanced Full Rate (ETS 06.50/06.60/06.80)
  - ***A***daptive Multi Rate (AMR)

  Handsfree operation
  - ***E***cho cancellation
  - ***N***oise reduction
- ***One serial interface (ASC0):***
  - ***2***.65V level, bi-directional bus for AT commands and data
  - ***A***SC0↔full-featured 8-wire serial interface. Supports RTS0/CTS0 hardware handshake and software XON/XOFF flow control. Multiplex ability according to GSM 07.10 Multiplexer Protocol.
  - ***B***aud rate: 300 bps ... 230 kbps on ASC0
  - ***A***utobauding detects 1200, 2400, 4800, 9600, 19200, 38400, 57600, 115200, 230400 bps
- ***Phonebook management:***
  - ***S***upported phonebook types: SM, FD, LD, MC, RC, ON, ME
- ***SIM Application Toolkit:***
  - ***S***upports SAT class 3, GSM 11.14 Release 98
- ***Ringing tones:***
  - ***O***ffers a choice of 7 different ringing tones/melodies, easily selectable with AT command
- ***Real time clock:***
  - ***I***mplemented

- ***Timer function:***
  - ***P***rogrammable via AT command
- ***Support of TTY/CTM:***
  - ***T***o benefit from TTY communication via GSM, CTM equipment can be connected to one of the three audio interfaces.
- ***Internal memory for I56i, only:***
  - ***C***ombo-Memory (**2 MB Flash–512 KB SRAM**)
- ***Software for I56i, only:***
  - ***T***CP/IP stack (Internet protocols stack which handles the Internet's link, network, transport and application layers). The embedded software interface that runs on I56i module for establishing an internet connectivity using IP commands. TCP/IP software description is also available.

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

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

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

3.2 Power consumption for I56, only

POWER CONSUMPTION						
	Min	**Typ.**	**Max**	**Unit**	**Description**	
GSM/GPRS engine						
Supply voltage	4.7	5	5.2	V	Voltage must stay within the min/max values, including voltage drop, ripple and spikes.	
Average supply current						
		50	100	µA	POWER DOWN mode	
GSM		9		mA	SLEEP mode @ DRX = 6	
					MODE	**BAND (I56/I56I)**
		15		mA	IDLE mode	GSM 850
		15				GSM 1800/1900
		250		mA	TALK mode	GSM 850*)
		170				GSM 1800/1900**)
GPRS		15		mA	IDLE GPRS	GSM 850
		15				GSM 1800/1900
		290		mA	DATA mode GPRS, (4 Rx, 1 Tx)	GSM 850*)
		220				GSM 1800/1900**)
		440		mA	DATA mode GPRS, (3 Rx, 2 Tx)	GSM 850*)
		310				GSM 1800/1900**)
Peak supply current.		1.6		A	Power control level During transmission slot every 4.6 ms.	

Table 3: Power supply

*) Power Control Level (PCL 5).
**) Power Control Level (PCL 0).

3.3 Operating temperatures

Parameter	Min	Typ.	Max	Unit
Ambient temperature (according to GSM 11.10)	-20	25	50	°C
Restricted operation *)	-25 to -20		55 to 70	°C
Automatic shutdown I56/I56i board temperature	-29 °C		>70	°C

Table 4: Operating temperature

*) I56/I56i works, but deviations from the GSM specification may occur.

3.4 Air interface of the I56 GSM/GPRS engine, only

Test conditions:

All measurements have been performed at T_{amb} = 25 °C, V_{VC5} typ. = 5 V.

Parameter		Min	Typ.	Max	Unit
Frequency range Uplink (MS → BTS)	GSM 850	824		849	MHz
	GSM 1800	1710		1785	MHz
Frequency range Downlink (BTS → MS)	GSM 1900	1850		1910	MHz
	GSM 850	869		894	MHz
	GSM 1800	1805		1880	MHz
	GSM 1900	1930		1990	MHz
RF power @ ARP with 50 Ω load	GSM 850	31	33	35	dBm
	GSM 1800	28	30	32	dBm
	GSM 1900	28	30	32	dBm
Number of carriers	GSM 850		124		
	GSM 1800		374		
	GSM 1900		299		dBm
Duplex spacing	GSM 850		45		MHz
	GSM 1800		95		MHz
	GSM 1900		80		MHz
Carrier spacing			200		kHz
Multiplex, Duplex		TDMA/FTDMA, FDD			
Time slots per TDMA frame			8		
Frame duration			4.615		ms
Time slot duration			577		µs
Modulation		GMSK			
Receiver input sensitivity @ ARP	GSM 850	-102	-107		dBm
	GSM 1800	-102	-106		dBm
BER Class II < 2.4 %	GSM 1900	-102	-105.5		dBm

Table 5: Air Interface

4 GSM/GPRS application interface

4.1 Description of operating modes

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

Definition of the GPRS class B mode of operation:

The definition of GPRS class B mode is, that the MS can be attached to both GPRS and other GSM services, but the MS can only operate one set of services at a time. Class B enables making or receiving a voice call, or sending/receiving an SMS during a GPRS connection. During voice calls or SMS, GPRS services are suspended and then resumed automatically after the call or SMS session has ended.

4.1.1 Normal mode operation

4.1.1.1 GSM/GPRS SLEEP

Various power save modes set with `AT+CFUN` command. Software is active to minimum extent. If the module was registered to the GSM network in IDLE mode, it is registered and paging with the BTS in SLEEP mode, too. Power saving can be chosen at different levels: The NON-CYCLIC SLEEP mode (`AT+CFUN=0`) disables the AT interface. The CYCLIC SLEEP modes `AT+CFUN=5,6,7,8` and `9` alternatively activate and deactivate the AT interfaces to allow permanent access to all AT commands.

4.1.1.2 GSM IDLE

Software is active. Once registered to the GSM network, paging with BTS is carried out. The module is ready to send and receive.

4.1.1.3 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.

4.1.1.4 GPRS IDLE

Module is ready for GPRS data transfer, but no data is currently sent or received. Power consumption depends on network settings and GPRS configuration (e.g. multislot settings).

4.1.1.5 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).

4.1.2 Power down

Normal shutdown after sending the AT^SMSO command. The Power Supply ASIC (PSU-ASIC) disconnects the supply voltage from the base band part of the circuit. Only a voltage regulator in the PSU-ASIC is active for powering the RTC. Software is not active. The serial interfaces are not accessible. Operating voltage (connected to VC5) remains applied.

4.1.3 Alarm mode

Alarm mode restricted operation launched by RTC alert function while the module is in POWER DOWN mode. Module will not be registered to GSM network. Limited number of AT commands is accessible.

4.1.4 Charge-only mode

Limited operation for battery powered applications. Enables charging while module is detached from GSM network. Limited number of AT commands is accessible. There are several ways to launch Charge-only mode:

- From POWER DOWN mode: Connect charger to the charger input pin of the external charging circuit and the POWER pin of module when I56/I56i was powered down by AT^SMSO.
- From Normal mode: Connect charger to the charger input pin of the external charging circuit and the POWER pin of module, then enter AT^SMSO.

4.1.5 Charge mode during normal operation

Normal operation (SLEEP, IDLE, TALK, GPRS IDLE, and GPRS DATA) and charging are running in parallel. Charge mode changes to Charge-only mode when the module is powered down before charging has been completed.

5 Hardware interfaces

5.1 Interfaces on the I56/I56i

In figure 2 the interfaces of the I56/I56i module are to be seen

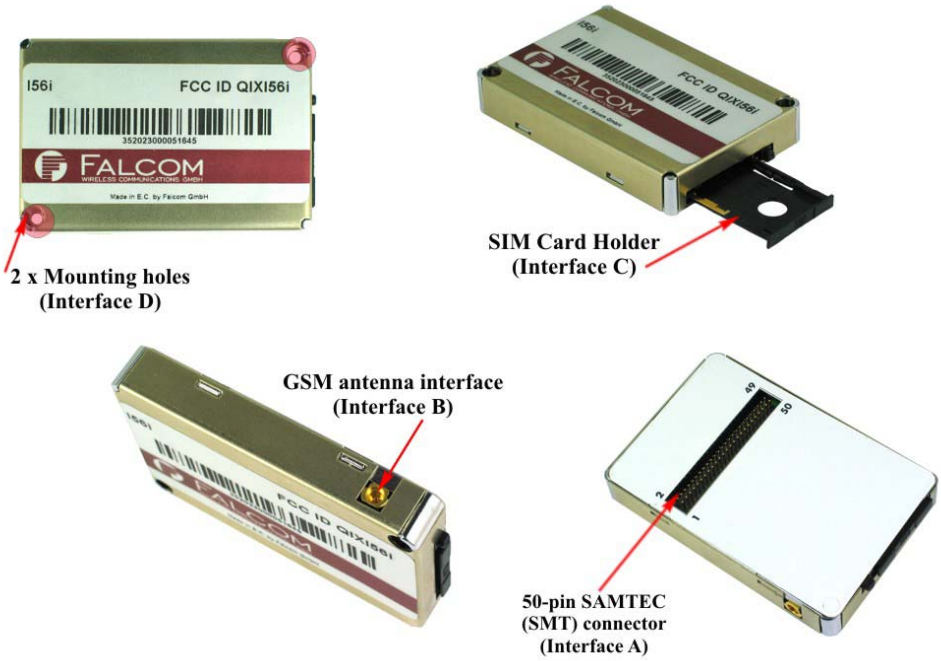


Figure 2: Provided interfaces on the I56/I56i module

Interface specifications	
Interface A	50 pin connector Samtec (SMT)
Interface B	GSM 50 Ω, MCCX connector
Interface C	card reader for small SIM cards (3 V)
Interface D	holes for fixing after mounting recommended screws: 2.2 x 16 mm The screw could be longer and it depends on the customer's application.

Table 6: Interface specifications

5.2 Description of the 50-pin double-row connector

Please note that the reference voltages listed in table 7 are the values measured directly on the I56/I56i module. I56/I56i module is equipped with a 50-pin board-to-board connector that connects to the cellular application platform.
The Samtec (SMT) board-to-board connector is a 50-pin double-row receptacle. The names and the positions of the pins can be seen from figure 3 below which shows the bottom view of I56/I56i.
This interface incorporates several sub-interfaces described in chapters below.
To avoid any mistake on structured table below, note that, all sub-interfaces included on the board-to-board connector are grouped, sequencing is not taken into account.

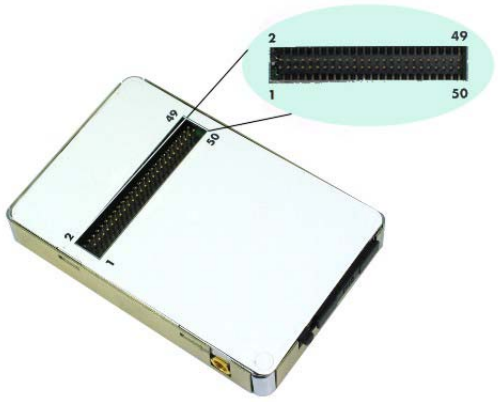


Figure 3: Pin assignment on the 50-pin connector (bottom view on I56/I56i)

PIN	GSM Modem	I/O	DESCRIPTION	LEVEL
1	GND	-	Negative operating voltage (grounds). One of these pins can also be used as SIMGND pin for an external SIM interface.	0 V
2				
6				
21				
24				
3	VC5	I	Power supply input. 5 VC5 pins to be connected in parallel. 5 GND pins to be connected in parallel. The power supply must be able to meet the requirements of current consumption in a Tx burst (up to 2 A). Sending with two Timeslots doubles the duration of current pulses to 1154 µs (every 4.616 ms)!	V_I = +5 V ±10 % I_{max} < 2 A (during Tx burst) 1 x Tx, peak current 577 µs every 4.616 ms 2 x Tx, peak current 1154 µs every 4.616 ms
4				

28	RX_O	O	The serial interface (ASC0) for AT commands or data stream. To avoid floating if output pins are high-impedance, use pull-up resistors tied to external power source (V_{min}< 2.2 and V_{max} = 3.3 V, I_{max} = 10 mA) or pull-down resistors tied to GND. See chapter 5.4.3.5. If not used leave it open.	V_{OLmax} = 0.2 V at I = 1 mA V_{OHmin} = 2.35V at I = -1mA V_{OHmax} = 2.73V V_{ILmax} = 0.5 V V_{IHmin} = 1.95 V, V_{Ihmax} = 3.3 V DTR_0, RTS_0: I_{max} = -90 µA at V_{IN} = 0 V TX_0: I_{max} = -30 µA at V_{IN} = 0 V
25	TX_O	I		
27	DSR_O	O		
9	RING_O	O		
30	RTS_O	I		
29	DTR_O	I		
13	CTS_O	O		
5	DCD_O	O		
12	SPK1P	O(+)	Analogue audio interfaces Balanced audio output. Can be used to directly operate an earpiece. If not used leave it open.	V_{Omax} = 1.3 Vpp
14	SPK1N	O(-)		
20	MIC1P	I(+)	Balanced microphone input. Can be used to directly feed an active microphone. If not used leave it open.	R_I ≈ 50 kΩ differential V_{Imax} = 20 mVpp
22	MIC1N	I(-)		
10	SPK2P	O(+)	Analogue audio interfaces Balanced audio output. Can be used to directly operate an earpiece. If not used leave it open.	V_{Omax} = 1.3 Vpp
8	SPK2N	O(-)		
16	MIC2P	I(+)	Balanced microphone input. Can be used to directly feed an active microphone. If not used leave it open.	R_I ≈ 50 kΩ differential V_{Imax} = 20 mVpp
18	MIC2N	I(-)		
48	SIMPRES	I	**SIM interface** SIMPRES = high, SIM card holder closed (no card recognition). Maximum cable length 200 mm to SIM card holder.	V_{ILmax} = 0.5 V V_{IHmin} = 2.15 V at I = 20µA, V_{IHmax}= 3.3 V at I = 30 µA
46	SIMRST	O		V_{OLmax} = 0.25 V at I = 1 mA V_{OHmin} = 2.3 V at I = -1 mA V_{OHmax} = 2.73 V

49	SIMDATA	I/O	All signals of SIM interface are protected against ESD with a special diode array. One of GND's (pins 1,2,6,21 and 24) can also be used as SIMGND pin).	V_{ILmax} = 0.5 V V_{IHmin} = 1.95 V, V_{Ihmax} = 3.3 V V_{OLmax} = 0.4 V at I = 1 mA V_{OHmin} = 2.15V at I = -1mA V_{OHmin} = 2.55V at I = -20 µA V_{OHmax} = 2.96 V
45	SIMCLK	O		V_{OLmax} = 0.4 V at I = 1 mA V_{OHmin} = 2.15V at I = -1mA V_{OHmax} = 2.73 V
47	SIMVCC	O		$SIMVCC_{min}$ = 2.84 V, $SIMVCC_{max}$ = 2.96 V I_{max} = -20 mA
41	PWRSET	I	Power set input to charge the battery set it to high level, else set it to low level. If not used leave it open.	"H" = VC5 "L" = 0 - 0.8 V DC
50	POWER	**I**	This line signals to the processor that the charger is connected. If not used leave it open.	**VImin = 3.0 V** **VImax = 15 V**
17	BAT-Temp	I	Input to measure the battery temperature over NTC resistor. NTC should be installed inside or near battery pack to enable the charging algorithm and deliver temperature values. If not used leave it open.	Connect NTC with $R_{NTC} \approx$ 10 kΩ @ 25 °C to ground.
11	GPIO1	O	Indicates increased current consumption during uplink transmission burst. Note that timing is different during handover. Alternatively used to control status LED (see chapter 5.8.2). If not used leave it open.	V_{OLmax} = 0.2 V at I = 1 mA V_{OHmin} = 2.35V at I = -1mA V_{OHmax} = 2.73 V 1 Tx, 877 µs impulse each 4.616 ms and 2 Tx, 1454 µs impulse each 4.616 ms, with 300 µs forward time.
7	GPIO2**	-	NC	--
26	GPIO0	-	NC	--

23	BOOT*	I	Set this pin to high level for reprogramming the flash of the TCP-chip (for instance updating a new firmware TCP/IP stack).	
19	RESET	I	Reset - active Low	input V_{RESET} = 0 V
15	SOFT-ON	I	Input to switch the module ON. The line must be SET to HIGH for ≥ 100 ms.	$V_{Openmin}$ = 2.5 V $V_{Openmax}$ = VC5 ON ‾‾|‾‾‾‾|‾‾ Active HIGH ≥ 100 ms
31	COL3	-	NC (Not Connected)	-
32	COL4			
33	COL1			
34	COL2			
35	ROW4			
36	COL0			
37	ROW2			
38	ROW3			
39	ROW0			
40	ROW1			
42	SPI_EN			
43	SPI_IO			
44	SPI_CLK			

- **This pin is to be used if you have purchased the option with TCP/IP stack (available upon request), else this pin has no function, so it has to be left open.**

Table 7: Description of the 50-pin connector (interface A)

5.3 Determining the External Equipment Type

Before you connect the provided serial interface on the I56/I56i board-to-board connectors to external host application, you need to determine if its external hardware serial ports are configured as DTE or DCE.
The terms DTE (Data Terminal Equipment) and DCE (Data Communications Equipment) are typically used to describe serial ports on devices. Computers (PCs) generally use DTE connectors and communication devices such as

modems and DSU/CSU devices generally use DCE connectors. As a general rule, DTE ports connect to DCE ports via straight through pinned cables. In other words, a DTE port never connects directly to another DTE port. In a similar manner, a DCE port never connects directly to another DCE port. The signalling definitions were written from the perspective of the DTE device; therefore, a Receive Data signal becomes an input to DTE but an output from DCE.

The I56/I56i is designed for use as a DCE. Based on the aforementioned conventions for DCE-DTE connections it communicates with the customer application (DTE) using the following signals:

I56/I56i (DCE)	to	Application (DTE)
TX_0	◄----------	TXD
RX_0	----------►	RXD
RTS_0	◄----------	RTS
CTS_0	----------►	CTS
DTR_0	◄----------	DTR
DSR_0	----------►	DSR
DCD_0	----------►	DCD
RING_0	----------►	RING

Table 8: Definitions between DTE and DCE ports.

5.4 Special functionality pins

5.4.1 Power supply

The power supply for the GSM/GPRS engine of the I56/I56i module has to be a single voltage source of V_{VC5+} = 4.5 … 5,5 V. It must be able to provide sufficient current in a transmit burst which typically rises to 1.6 A.
All the key functions for supplying power to the device are handled by an ASIC power supply. The ASIC0 provides the following features:

- ❖ Stabilizes the supply voltages for the GSM base band using low drop linear voltage regulators.
- ❖ Controls the module's power up and power down procedures.
- ❖ A watchdog logic implemented in the base band processor periodically sends signals to the ASIC, allowing it to maintain the supply voltage for all digital I56/I56i components. Whenever the watchdog pulses fail to arrive constantly, the module is turned off.

5.4.2 Power supply pins (3 and 4) on the board-to-board connector

Two VC5 pins of the board-to-board connector are dedicated to connect the supply voltage, five GND pins are recommended for grounding.

The values stated below are measured directly at the reference points on the I56/I56i board.
The POWER and (CRG option) pins serve as control signals for charging a Li-Ion battery.

Signal name	I/O	Parameter	Description
VC5+	I	4.5 V...5,5 V, $I_{typ} \leq 1.6$ A during transmit burst. The minimum operating voltage must not fall below 4.5 V, not even in case of voltage drop.	Positive operating voltage.
GND	-	0 V	Ground
POWER	I		This line signals to the processor that the charger is connected.

Table 9: Pin description of 50-pin board-to-board connector

5.4.3 Power up/down scenarios

In general, be sure not to turn on GSM/GPRS part of the I56/I56i module while it is out of the operating range of voltage and temperature stated in chapters 5.2 and 3.3. The GSM/GPRS part of the I56/I56i would immediately switch off after having started and detected these inappropriate conditions.

5.4.3.1 Turn on the GSM/GPRS part of I56/I56i

The GSM/GPRS part of the I56/I56i can be activated in a variety of ways, which are described in the following chapters:

- via SOFT_ON line: starts normal operating state (see chapter 5.4.3.2)
- via POWER line: starts charging algorithm (see chapter 5.4.3.3)

5.4.3.2 Turn on the I56/I56i module using the SOFT_ON line

To switch on the I56/I56i module the SOFT_ON signal needs to be set to HIGH level for at least 100 ms. On open collector is also internally integrated on this line, which manage the turn on procedure.

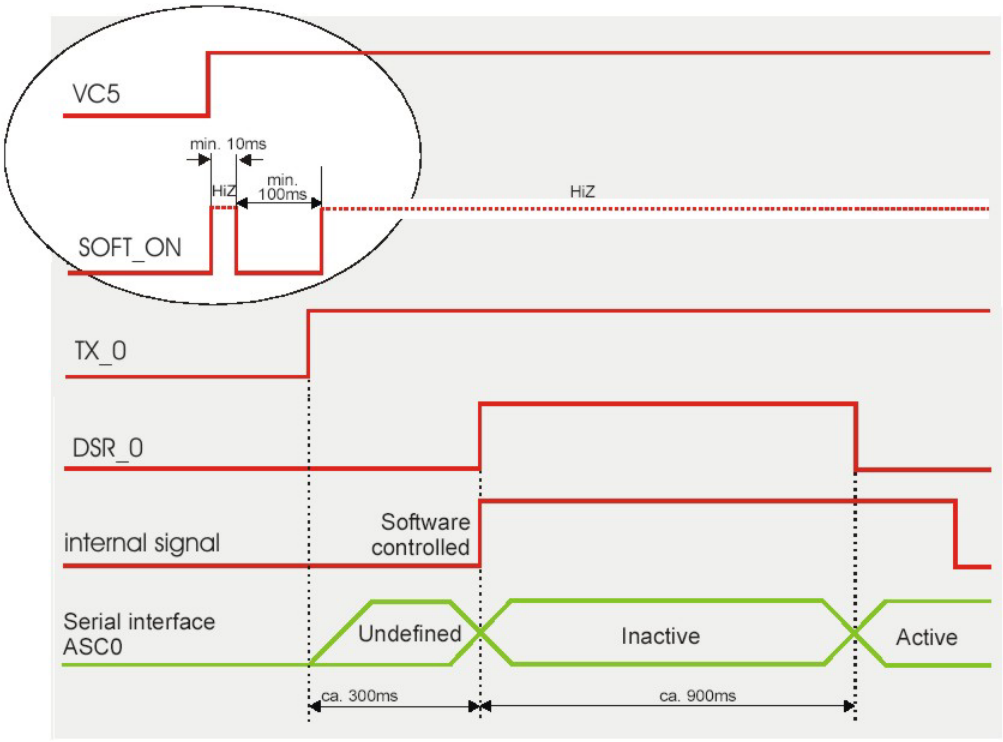


Figure 4: Power-on by ignition signal

If the module is configured to a fix baud rate, the GSM/GPRS engine of the I56/I56i will send the result code ^SYSSTART to indicate that it is ready to operate. This result code does not appear when autobauding is active.
Ensure that V_{VC5} does not fall below 4,7 V while the SOFT_ON line is driven. Otherwise the module cannot be activated.

- To switch on the I56/I56i module the SOFT_ON signal needs to be set to HIGH level for at least 100 ms.
- For switching the module off refer to the next section 5.4.3.4.

It is not recommended to switch the module on and off by means of the power supply (e.g. by tying the SOFT_ON constantly to HIGH). The module will so have no possibility to log-off correctly from the network and this will cause problems at the next attempt to register.

5.4.3.3 Turn on the GSM/GPRS engine of I56/I56i using the POWER signal

As detailed in chapter 5.6.5, the charging adapter can be connected regardless of the module's operating mode (except for Alarm mode).
If the charger is connected to the charger input of the external charging circuit and the module's POWER pin while I56/I56i is off, processor controlled fast charging starts (see chapter 5.6.4). The I56/I56i enters a restricted mode, referred to as Charge-only mode where only the charging algorithm will be launched. During the Charge-only mode I56/I56i is neither logged on to the GSM network nor are the serial interfaces fully accessible. To switch to normal operation and log on to the GSM network, the SOFT_ON line needs to be activated.

5.4.3.4 Turn off the GSM/GPRS engine of I56/I56i module

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

- *Normal shutdown procedure*: Software controlled by sending the `AT^SMSO` command over the serial application interface. See chapter 5.4.3.5.
- *Emergency shutdown*: Hardware driven by switching the RESET line (Pin 26) of the board-to-board connector to ground = immediate shutdown of supply voltages.
- *Automatic shutdown*: See chapter 5.4.4
  a) Takes effect if under voltage is detected.
  b) Takes effect if I56/I56i board temperature exceeds critical limit.

5.4.3.5 Turn off GSM/GPRS engine of the I56/I56i module using AT command

The best and safest approach to powering down the I56/I56i GSM/GPRS engine is to issue the `AT^SMSO` command. This procedure lets GSM engine log off from the network and allows the software to enter into a secure state and safe data before disconnecting the power supply. The mode is referred to as POWER DOWN mode. In this mode, only the RTC stays active.
Before switching off the device sends the following response:

```
^SMSO: MS OFF

OK

^SHUTDOWN
```

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

- Wait for the URC "SHUTDOWN". It indicates that data have been stored non-volatile and the module turns off in less than 1 second.

Be sure not to disconnect the operating voltage V_{VC5+} before the URC "SHUTDOWN" has been issued. Otherwise you run the risk of losing data.
While the GSM engine 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 output pins of the ASC0 interface RX_0, CTS_0, DCD_0, DSR_0, RING_0 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 serial interface pins you can either connect pull-up resistors to an external power source (V_{min}< 2.2 and V_{max} = 3.3 V, I_{max}= 10 mA), or pull down resistors to GND.

5.4.3.6 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.

5.4.3.7 Emergency shutdown using RESET line

!!!Caution: *Use the RESET pin only when, due to serious problems, the software is not responding for more than 5 seconds. Pulling the*

RESET 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 I56/I56i fails to shut down properly.

This signal is used to force a reset procedure by providing low level (driven to ground) during at least 3.2 s. This signal has to be considered as an emergency reset only. A reset procedure is already driven by an internal hardware during the power-up sequence.
If no external reset is necessary, this input can be left open. If used (emergency reset), the RESET signal is available on the board-to-board connectors.

5.4.3.7.1 How does it work?

a) Voltage V_{VC5+} is permanently applied to the module.
b) The module is active while the internal reset signal is kept at high level. During operation of I56/I56i the base band controller generates watchdog pulses at regular intervals. Once the RESET 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 I56/I56i after max. 3.2 s and the module turns off.

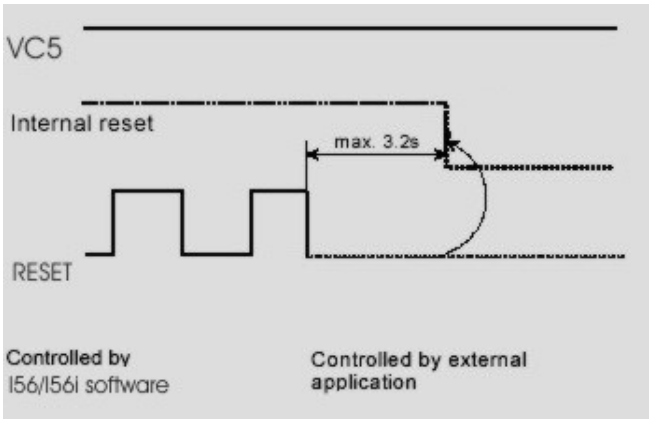


Figure 5: Deactivating GSM engine by RESET signal

5.4.4 Automatic shutdown

Automatic shutdown takes effect if

- the I56/I56i board is exceeding the critical limits of over temperature or under temperature.
- the battery is exceeding the critical limits of over temperature or under temperature.
- under voltage is detected.

The automatic shutdown procedure is equivalent to the power-down initiated with the `AT^SMSO` command, i.e. I56/I56i logs off from the network and the software enters a secure state avoiding loss of data.
NOTE: This does not apply if over voltage conditions or unrecoverable hardware or software errors occur (see below for details).
Alert messages transmitted before the device switches off are implemented as Unsolicited Result Codes (URCs). The presentation of these URCs can be enabled or disabled with the two AT commands `AT^SBC` and `AT^SCTM`. The URC presentation mode varies with the condition, please see chapters 5.4.4.1 to 5.4.4.3 for details. For further instructions on AT commands refer to [4].

5.4.4.1 Temperature dependent shutdown

The board temperature is constantly monitored by an internal NTC resistor located on the PCB. The NTC that detects the battery temperature must be part of the battery pack circuit as described in chapter **5.6**. The values detected by either NTC resistor are measured directly on the board or the battery and therefore, are not fully identical with the ambient temperature.
Each time the board or battery temperature goes out of range or back to normal, I56/I56i instantly displays an alert (if enabled).

- URCs indicating the level "1" or "-1" allow the user to take appropriate precautions, such as protecting the module from exposure to extreme conditions. The presentation of the URCs depends on the settings selected with the `AT^SCTM` write command:
  `AT^SCTM=1`: Presentation of URCs is always enabled.
  `AT^SCTM=0` (default): Presentation of URCs is enabled for 15 seconds time after start-up of I56/I56i. After 15 seconds operation, the presentation will be disabled, i.e. no alert messages can be generated.
- URCs indicating the level "2" or "-2" are instantly followed by an orderly shutdown. The presentation of these URCs is always enabled, i.e. they will be output even though the factory setting `AT^SCTM=0` was never changed.

The maximum temperature ratings are stated in chapter 3.3. Refer to tables 10 and 11 below for the associated URCs. All statements are based on test conditions according to IEC 60068-2-2 (still air).
Sending temperature alert (15 s after start-up, otherwise only if URC presentation enabled).

^SCTM_A: 1	Caution: T_{amb} of battery close to over temperature limit.
^SCTM_B: 1	Caution: T_{amb} of board close to over temperature limit.
^SCTM_A: -1	Caution: T_{amb} of battery close to under temperature limit.
^SCTM_B: -1	Caution: T_{amb} of board close to under temperature limit.
^SCTM_A: 0	Battery back to uncritical temperature range.
^SCTM_B: 0	Board back to uncritical temperature range.

Table 10: Temperature dependent behaviour

Automatic shutdown (URC appears no matter whether or not presentation was enabled).

^SCTM_A: 2	Alert: T_{amb} of battery equal or beyond over temperature limit. I56/I56i switches off.
^SCTM_B: 2	Alert: T_{amb} of board equal or beyond over temperature limit. I56/I56i switches off.
^SCTM_A: -2	Alert: T_{amb} of battery equal or below under temperature limit. I56/I56i switches off.

	I56/I56i switches off.
^SCTM_B: -2	Alert: T_{amb} of board equal or below under temperature limit. I56/I56i switches off.

Table 11: Automatic shutdown

5.4.4.2 Temperature control during emergency call

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

5.4.4.3 Under voltage shutdown if battery NTC is present

In applications where the charging technique of module is used and an NTC is connected to the BAT_TEMP terminal, the software constantly monitors the applied voltage. If the measured battery voltage is no more sufficient to set up a call the following URC will be presented:

^SBC: Under voltage.

The message will be reported, for example, when you attempt to make a call while the voltage is close to the critical limit and further power loss is caused during the transmit burst. To remind you that the battery needs to be charged soon, the URC appears several times before the module switches off. To enable or disable the URC use the `AT^SBC` command. The URC will be enabled when you enter the write command and specify the power consumption of your GSM application. Step by step instructions are provided in [4].

5.4.4.4 Under voltage shutdown if no battery NTC is present

The under voltage protection is also effective in applications, where no NTC connects to BAT_TEMP terminal. Thus, you can take advantage of this feature even though the application handles the charging process or I56/ I56i is fed by a fixed supply voltage. All you need to do is executing the write command `AT^SBC=<current>` which automatically enables the presentation of URCs. You do not need to specify <current>.
Whenever the supply voltage falls below the specified value (see **Table 4**) the URC

^SBC: Under voltage

appears several times before the module switches off.

5.4.4.5 Over voltage shutdown

For over voltage conditions, no software controlled shutdown is implemented. If the supply voltage exceeds the maximum value specified in **Table 4**, loss of data and even unrecoverable hardware damage can occur.

5.5 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 (*see 3.3 for temperature limits known as restricted operating*) while data are transmitted over GPRS, the module automatically reverts from GPRS Multislot class 10 (3 RX x 2 TX) to class 8 (4 RX x 1 TX). This reduces the power consumption and, consequently, causes the temperature of board to decrease. Once the temperature drops to a value of 5 degrees below the limit of restricted operation, I56/I56i returns to the higher Multislot class. If the temperature stays at the critical level or even continues to rise, I56/I56i 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 5.4.4.1. For GPRS connection see related document [5].

5.6 GSM charging control

The GSM/GPRS part of the I56/I56i module integrates a charging management for Li-Ion batteries. You can skip this chapter if charging is not your concern, or if you are not using the implemented charging algorithm.
To benefit from the implemented charging management you are required to build a charging circuit within your application. In this case, I56/I56i needs to be powered from a Li-Ion battery pack, e.g. as specified in chapter 5.6.3.
The module only delivers, via its POWER line, the control signal needed to start and stop the charging process. The charging circuit should include a transistor and should be designed as illustrated in figure 6. A list of parts recommended for the external circuit is given in table 12 below.

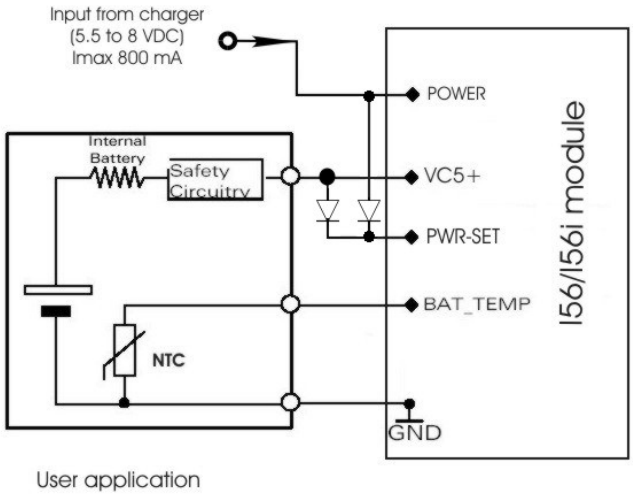


Figure 6: Schematic of charging/discharging process.

5.6.1 Power-Set-Input

This input pin has to be used if a rechargeable Li-Ion battery is connected to the module. The circuit diagram how to connect a Li-Ion battery to the module is shown in chapter 5.6. If the PWR-SET pin is kept open (low level), the internal regulator is active which drops internally the input voltage down to 3.7 V DC and supplies the GSM/GPRS core with 3.7 V DC (see figure below, the PWR-SET pin is low "L" and the regulator is active).
As above, usage of the PWR-SET pin is mandatory, if a rechargeable battery is connected to the VC5 pin, BAT_TEMP and to the one of provided Grounds. In this case the PWR-SET pin has to be set to the high level e.g. connect it to the VC5 and POWER pins (see figures 11 and below, the PWR-SET pin is set to high "H"). The input voltage on the POWER pin is monitored internally from the GSM/GPRS core and provided on the VC5 pin for charging/discharging of connected battery. Set the PWR-SET pin of High level enables the VC5 pin to alert its state from input to the input/output which is required for battery applications. In order to make a proper charging procedure, note that the POWER pin has to be supplied with 5.5 to 8 V DC, and limited current to 800 mA from external power source.

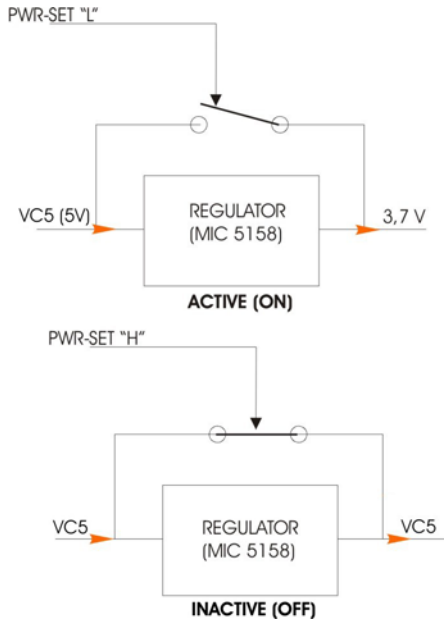


Figure 7: power set input

5.6.2 Battery pack characteristics

The charging algorithm has been optimized for a Li-Ion battery pack that meets the characteristics listed below. It is recommended that the battery pack you want to integrate into your I56/I56i application is compliant with these specifications. This ensures reliable operation, proper charging and, particularly, allows you to monitor the battery capacity using the `AT^SBC` command (see [4] for details). Failure to comply with these specifications might cause `AT^SBC` to deliver incorrect battery capacity values. A battery pack especially designed to operate with I56/I56i module is specified in chapter 5.6.3.

- Li-Ion battery pack specified for a maximum charging voltage of 4.2 V and a capacity of 800 mAh. Battery packs with a capacity down to 600 mAh or more than 800 mAh are allowed, too.
- Since charging and discharging largely depend on the battery temperature, the battery pack should include a NTC resistor. If the NTC is not inside the battery it must be in thermal contact with the battery. The NTC resistor must be connected between BAT_TEMP and GND.
  Required NTC characteristics are: *10 kΩ + 5 % @ 25 °C, B25/85 = 3435 K + 3 %* (alternatively acceptable: *10 kΩ + 2 % @ 25 °C, B25/50 = 3370 K + 3 %)*.
- Please note that the NTC is indispensable for proper charging, i.e. the charging process will not start if no NTC is present.
- Ensure that the pack incorporates a protection circuit capable of detecting over voltage (protection against overcharging), under voltage (protection against deep discharging) and over current. The circuit must be insensitive to pulsed current.
- On the I56/I56i module, a built-in measuring circuit constantly monitors the supply voltage. In the event of under voltage, it causes I56/I56i to power down. Under voltage thresholds are specific to the battery pack and must be evaluated for the intended model. When you evaluate under voltage thresholds, consider both the current consumption of I56/I56i and of the application circuit.
- The internal resistance of the battery and the protection should be as low as possible. It is recommended not to exceed 150 mΩ, even in extreme conditions at low temperature. The battery cell must be insensitive to rupture, fire and gassing under extreme conditions of temperature and charging (voltage, current).
- The battery pack must be protected from reverse pole connection. For example, the casing should be designed to prevent the user from mounting the battery in reverse orientation.
- The battery pack must be approved to satisfy the requirements of CE conformity.

Figure 8 below shows the circuit diagram of a typical battery pack design that includes the protection elements described above.

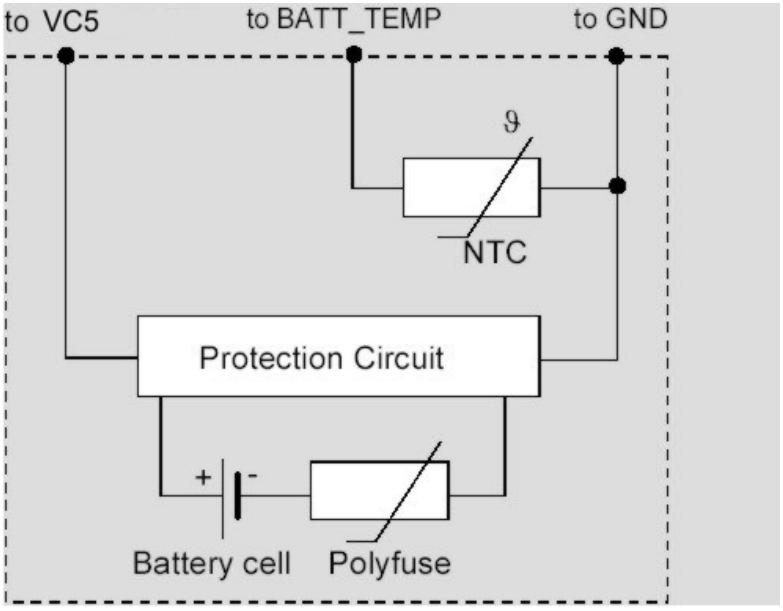


Figure 8: Battery pack circuit diagram

5.6.3 Recommended battery pack specification

Nominal voltage	3.6 V
Capacity	800 mAh
NTC	10 kΩ ± 5 % @ 25 °C, B (25/85) = 3435K ± 3 %
Overcharge detection voltage	4.325 ± 0.025 V
Overcharge release voltage	4.075 ± 0.025 V
Over discharge detection voltage	2.5 ± 0.05 V
Over discharge release voltage	2.9 ± 0.5 V
Over correct detection	3 ± 0.5 A
Nominal working current	<5 µA
Current of low voltage detection	0.5 µA
Over current detection delay time	8 ~ 16 ms
Short detection delay time	50 µs
Over discharge detection delay time	31 ~ 125 ms
Overcharge detection delay time	1 s
Internal resistance	<130 mΩ

Table 12: Battery pack specifications

5.6.4 Implemented charging technique

If the external charging circuit follows the recommendation of **Figure 6**, the charging process consists of trickle charging and processor controlled fast charging. For this solution, the fast charging current provided by the charger or any other external source must be limited to 500 mA.

5.6.4.1 Trickle charging

- Trickle charging starts when the charger is connected to the charger input of the external charging circuit and the module's POWER pin. The charging current depends on the voltage difference between the charger input of the external charging circuit and VC5+ of the module.
- Trickle charging stops when the battery voltage reaches 3.6 V.

5.6.4.2 Fast charging

- After trickle charging has raised the battery voltage to 3.2 V within 60 minutes ±10 % from connecting the charger, the power ASIC turns on and wakes up the base band processor. Now, processor controlled fast charging begins. If the battery voltage was already above 3.2 V, processor controlled fast charging starts just after the charger was connected to the charger input of the external charging circuit and the POWER pin of module. If the GSM/GPRS part of the I56/I56i was in POWER DOWN mode, it turns on and enters the Charge-only mode along with fast charging (see also chapter 5.4.3.3).
- Fast charging delivers a constant current until the battery voltage reaches 4.2 V and then it proceeds with varying charge pulses. As shown in **Figure 9**, the pulse duty cycle is reduced to adjust the charging procedure

and prevent the voltage from overshooting beyond 4.2 V. Once the pulse width reaches the minimum of 100 ms and the duty cycle does not change for 2 minutes, fast charging is completed.

- Fast charging can only be accomplished in a temperature range from 0 °C to +45 °C.

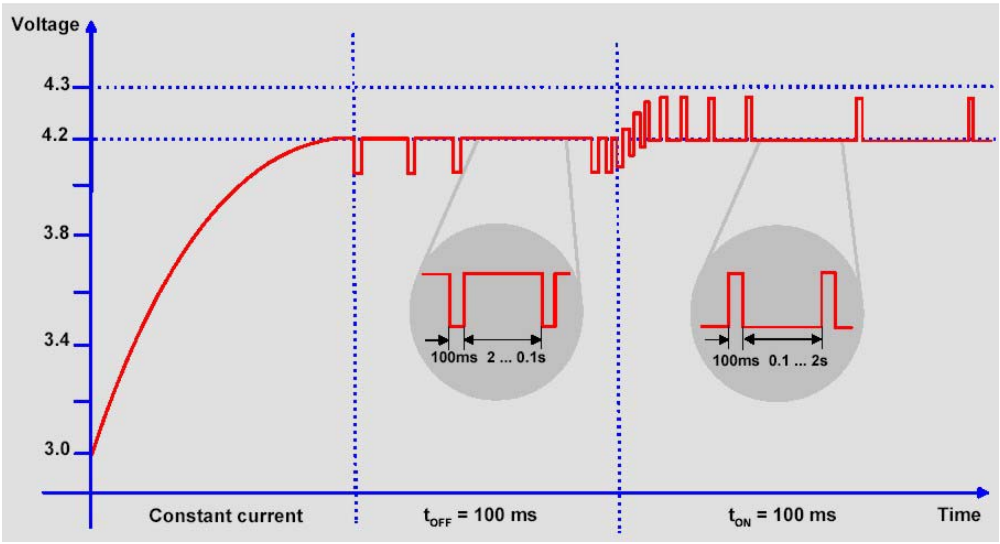


Figure 9: Charging process

Note: *Do not connect the charger to the VC+ lines. Only the charger input of the external charging circuit is intended as input for charging current! The POWER pin of I56/I56i is the input only for indicating a connected charger! The battery manufacturer must guarantee that the battery complies with the described charging technique.*

What to do if software controlled charging does not start up?

If trickle charging fails to raise the battery voltage to 3.2 V within 60 minutes +10 %, processor controlled charging does not begin. To start fast charging you can do one of the following:

- Once the voltage has risen above its minimum of 3 V, you can try to start software controlled charging by pulling the SOFT_ON line to HIGH.
- If the voltage is still below 3 V, driving the SOFT_ON line to HIGH switches the timer off. Without the timer running, the GSM/GPRS part of the I56/I56i module will not proceed to software controlled charging. To restart the timer you are required to shortly disconnect and reconnect the charger.

5.6.5 Operating modes during charging

Of course, the battery can be charged regardless of the engine's operating mode. When the GSM engine is in Normal mode (SLEEP, IDLE, TALK, GPRS IDLE or GPRS DATA mode), it remains operational while charging is in progress (provided that sufficient voltage is applied). The charging process during the Normal mode is referred to as *Charge mode*. If the charger is connected to the charger input of the external charging circuit and the POWER pin of module while GSM/GPRS part of I56/I56i is in POWER DOWN mode, the GSM/GPRS part of the I56/I56i goes into *Charge-only* mode.

5.6.5.1 Comparison Charge-only and Charge mode

5.6.5.1.1 Charge mode

In order to activate the charge mode, connect charger to charger input of external charging circuit and the POWER pin of module while the GSM/GPRS part of the I56/I56i is in the following modes:

- ✓ operating, e.g. in IDLE or TALK mode
- ✓ in SLEEP mode

The features while the charge mode is:

- ➢ Battery can be charged while GSM engine remains operational and registered to the GSM network.
- ➢ In IDLE and TALK mode, the serial interfaces are accessible. AT command set can be used to full extent.
- ➢ In the NON-CYCLIC SLEEP mode, the serial interfaces are not accessible at all. During the CYCLIC SLEEP mode they can be used as described in chapter 5.9.3.

5.6.5.1.2 Charge-only mode

In order to activate the charge-only mode, connect charger to charger input of external charging circuit and the POWER pin of module while the GSM/GPRS part of the I56/I56i is:

- ✓ in POWER DOWN mode
- ✓ in Normal mode: Connect charger to the POWER pin, then enter AT^SMSO.

IMPORTANT: While trickle charging is in progress, be sure that the application is switched off. If the application is fed from the trickle charge current the module might be prevented from proceeding to software controlled charging since the current would not be sufficient.

The features while the charge-only mode is:

- ➢ Battery can be charged while GSM engine is deregistered from GSM network.
- ➢ Charging runs smoothly due to constant current consumption.
- ➢ The AT interface is accessible and allows to use the commands listed below.

Features of Charge-only mode

Once the GSM engine enters the Charge-only mode, the AT command interface presents an Unsolicited Result Code (URC) which reads:

^SYSSTART CHARGE-ONLY MODE

Note that this URC will not appear when autobauding was activated (due to the missing synchronization between DTE and DCE upon start-up). Therefore, it is recommended to select a fixed baud rate before using the Charge-only mode. While the Charge-only mode is in progress, you can only use the AT commands listed in table 13 below. For further instructions refer to the AT Command Set supplied with your GSM engine.

AT command	Function
AT+CALA	Set alarm time
AT+CCLK	Set date and time of RTC

AT^SBC	Monitor charging process Note: While charging is in progress, no battery capacity value is available. To query the battery capacity disconnects the charger. If the charger connects *externally* to the host device no charging parameters are transferred to the module. In this case, the command cannot be used.
AT^SCTM	Query temperature range, enable/disable URCs to report critical temperature ranges.
AT^SMSO	Power down GSM engine

Table 13: AT commands for charge-only

To proceed from Charge-only mode to normal operation, it is necessary to drive the ignition line to ground. This must be implemented in your host application as described in chapter 5.4.3.3. See also chapter 5.10 which summarizes the various options of changing the mode of operation.
If your host application uses the GPIO1 pin to control a status LED as described in chapter 5.8.2, please note that the LED is off while the GSM engine is in Charge-only mode.

5.6.6 Charger requirements

If you are using the implemented charging technique and the charging circuit recommended in **Figure 66**, the charger must be designed to meet the following requirements:

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

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

When current is switched on a spike of 1.6 A for 1 ms is allowed.

5.6.7 Features supported on the first and second serial interfaces of GSM/GPRS engine

The GSM/GPRS engine of the I56/I56i module offers an unbalanced, asynchronous serial interfaces conforming to ITU-T V.24 protocol DCE signaling. The electrical characteristics do not comply with ITU-T V.28. The significant levels are 0 V (for low data bit or ON condition) and 2.65 V (for high data bit or OFF condition). See chapter 5.3 to determinate the DTE-DCE connection.

ASC0:

↔ 8-wire serial interface

- ↔ Includes the data lines TX_0 and RX_0, the status lines RTS_0 and CTS_0 and, in addition, the modem control lines DTR_0, GSM_DSR0, DCD_0 and RING_0.
- ↔ It is designed for voice calls, CSD calls, fax calls and 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.
- ↔ The DTR_0 signal will only be polled once per second from the internal firmware of I56/I56i.
- ↔ The RING_0 signal serves to indicate incoming calls and other types of URCs (Unsolicited Result Code). It can also be used to send pulses to the host application, for example to wake up the application from power saving state (if required).
- ↔ Autobauding is selectable on this interface and supports the following bit rates: 1200, 2400, 4800, 9600, 19200, 38400, 57600, 115200, 230400 bps.
- ↔ ASC0 interface is intended for firmware upgrade of the GSM/GPRS engine.
- ↔ This interface is configured for 8 data bits, no parity and 1 stop bit, and can be operated at bit rates from 300 bps to 230400 bps.
- ↔ XON/XOFF software flow control can be used on this interfaces (except if power saving is active).

5.6.8 SIM interface

The I56/I56i module includes two SIM interfaces which could not concurrently be used:

- an integrated SIM card holder, part of I56/I56i module, for small SIM cards (only 3 V).
- and an integrated 5-pin interface on board-to-board connector for user application. This SIM circuit can be implemented outside the module on the application platform. See section 5.6.8.1 “SIM Interface on board-to-board connector”.

5.6.8.1 SIM Interface on board-to-board connector

The base band 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 SIMPRES pin serves to detect whether a tray (with SIM card) is present in the card holder. Using the SIMPRES 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 5.6.8.2 for details. It is recommended that the total cable length between the board-to-board connector pins on I56/I56i 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.

Signal	Description
GND	Ground connection for SIM card.

SIMCLK	Chip card clock, various clock rates can be set in the base band processor.
SIMVCC	SIM supply voltage from PSU-ASIC
SIMDATA	Serial data line, input and output.
SIMRST	Chip card reset, provided by base band processor.
SIMPRES	Input on the base band processor for detecting a SIM card tray in the holder. The SIMPRES pin is mandatory for applications that allow the user to remove the SIM card during operation. The SIMPRES 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 I56/I56i.

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

5.6.8.2 Requirements for using the SIMPRES 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 SIMPRES 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 I56/I56i 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 I56/I56i and is part of the FALCOM reference equipment submitted for type approval. Molex ordering number is 91228-0001.

The start-up procedure of module 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 SIMPRES signal:

a) If, during start-up of I56/I56i, the SIMPRES 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 SIMPRES 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, SIMPRES is taken high again.

b) If, during start-up of I56/I56i, the SIMPRES signal is low, the module will also attempt to initialize the SIM card. In this case, the initialization will only be successful when the card is present. If the SIM card initialization has been done, but the card is no more operational or removed, then the module will never search again for a SIM card and only emergency calls can be made. Removing and inserting the SIM card during operation requires the software to be reinitialized. Therefore, after reinserting the SIM card it is necessary to restart I56/I56i. It is strongly recommended to connect the contacts of the SIM card detect switch to the SIMPRES input and to the SIMVCC output of the module as illustrated in the sample diagram in figure 6 below.

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 I56/I56i.

5.6.8.3 Design considerations for SIM card holder

The schematic below is a sample configuration that illustrates the Molex SIM card holder. X503 is the designation used for the SIM card holder.

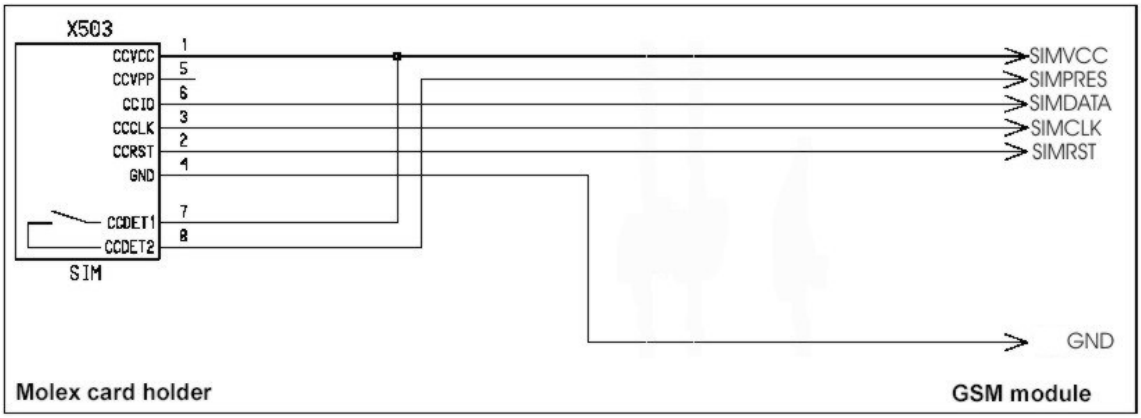


Figure 14: SIM card holder

Pin	Signal name	I/O	Function
1	SIMVCC	I	Supply voltage for SIM card, generated by the GSM engine
2	SIMRST	I	Chip card reset, prompted by the GSM engine
3	SIMCLK	I	Chip card clock
4	GND	-	Ground line for the SIM card
5	CCVPP	-	Not connected
6	SIMDATA	I/O	Serial data line, bi-directional
7	CCDET1	-	Connect to SIMVCC
8	CCDET2	-	Connects to the SIMPRES input of the GSM engine. Serves to recognize whether a SIM card is in the holder.

Table 15: Pin assignment of Molex SIM card holder on DSB45 Support Box

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 SIMPRES pin.

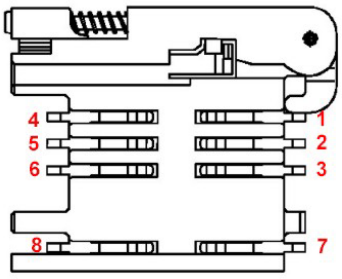


Figure 15: Pin numbers of Molex SIM card holder

5.7 Audio interface

The I56/I56i comprises an audio interface available on the 40-pin board-to-board connector:

- ❖ An analogue audio interface, with a balanced analogue microphone input and a balanced analogue earpiece output.

5.7.1 Microphone circuit

This interface with a microphone supply circuit and can be used to feed an active microphone. It has an impedance of 50 kΩ.

5.8 Control signals

5.8.1 Synchronization signal

The synchronization signal serves to indicate growing power consumption during the transmit burst. The signal is generated by the GPIO1 pin. Please note that this pin can adopt two different operating modes which you can select by using the `AT^SGPIO1` command (mode 0 and 1). For details refer to the following chapter and to [4]. 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 I56/I56i module if required. This can be achieved by lowering the current drawn from other components installed in your application. The timing of the synchronization signal is shown below. High level of the GPIO1 pin indicates increased power consumption during transmission.

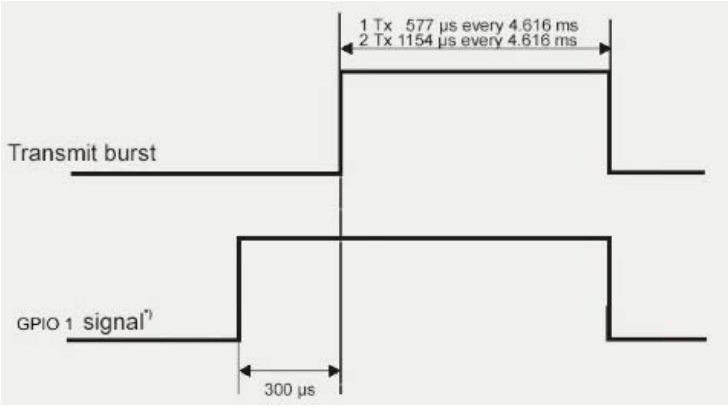


Figure 16: GPIO1 signal during transmit burst

*) The duration of the GPIO1 signal is always equal, no matter whether the traffic or the access burst are active.

5.8.2 Using the GPIO1 pin to control a status LED

As an alternative to generating the synchronization signal, the GPIO1 pin can be used to control a status LED on your application platform.

To avail of this feature you need to set the GPIO1 pin to mode 1 by using the `AT^SGPIO1` command. For details see [4].
When controlled from the GPIO1 pin the LED can display the functions listed in table 16 below.

LED mode	Operating status
Off	I56/I56i is off or run in SLEEP or Alarm mode
600 ms On/600 ms	Off No SIM card inserted or no PIN entered, or network search in progress, or ongoing user authentication, or network login in progress.
75 ms On/3 s	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 approximately 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.

Table 16: Coding of the status LED

LED Off = GPIO1 pin low.
LED On = GPIO1 pin high (if LED is connected as illustrated in figure 12)

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 17. Power consumption in the LED mode is the same as for the synchronization signal mode. For details see 7, GPIO1 pin.

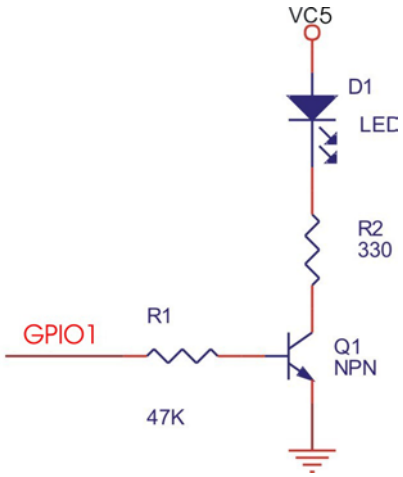


Figure 17: LED Circuit (Example)

5.8.3 Behaviour of the RING_0 line (ASC0 interface)

The RING_0 line is available on the first serial interface (ASC0). 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 RING_0 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 RING_0 occurs. This solution is most effective, particularly, for waking up an application from power saving. Note that if the RI_ 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 RING_0 line provides an option to significantly reduce the overall current consumption of your application.
The behaviour of the RING_0 line varies with the type of event:

- ✓ When a *voice call* comes in the RING_0 line goes low for 1 s and high for another 4 s. Every 5 seconds the ring string is generated and sent over the RX_0 line. If there is a call in progress and call waiting is activated for a connected handset or handsfree device, the RING_0 line switches to ground in order to generate acoustic signals that indicate the waiting call.

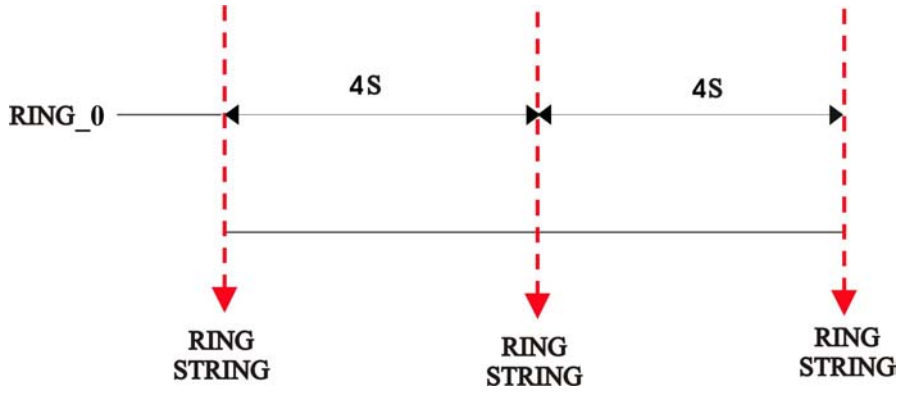


Figure 18: Incoming voice call

- ✓ Likewise, when a *fax* or *data call* is received, RING_0 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.

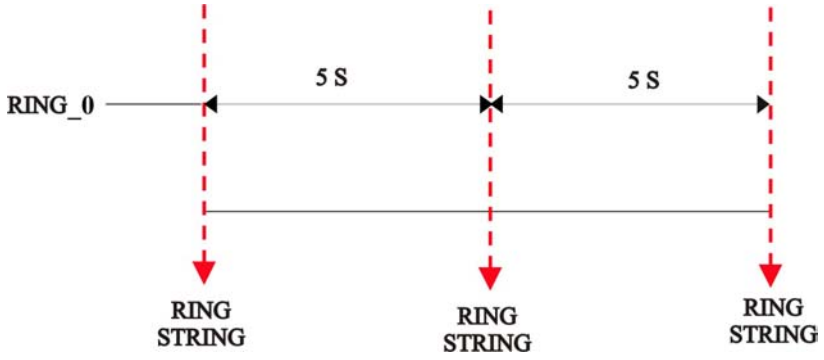


Figure 19: Incoming data call

- ✓ All types of Unsolicited Result Codes (URCs) also cause the RING_0 line to go low, however for 1 second only. For example, I56/I56i 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 RING_0 line to go low. See [4] for detailed information on URCs.

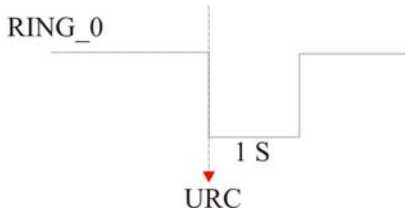


Figure 20: URC transmission

Function	Pin	Status	Description
Ring indication	RING_0	0	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

Table 17: ASC0 ring signal

5.9 Power saving

SLEEP mode reduces the functionality of the GSM/GPRS engine of the I56/I56i module to a minimum and, thus, minimizes the current consumption to the lowest level. Settings can be made using the `AT+CFUN` command. For details see below and [4]. SLEEP mode falls into two categories:

- ✓ NON-CYCLIC SLEEP mode `AT+CFUN=0`
- ✓ CYCLIC SLEEP modes, selectable with `AT+CFUN=5,6,7,8` or `9`.

IMPORTANT: Please keep in mind that power saving works properly only when PIN authentication has been done. If you attempt to activate power saving while the SIM card is not inserted or the PIN not correctly entered, the selected <fun> level will be set, though power saving does not take effect. For the same reason, power saving cannot be used if the GSM/GPRS engine of the I56/I56i 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 GPIO1 pin (see chapter 5.8.2). The LED stops flashing once the module starts power saving. The wake-up procedures are quite different depending on the selected SLEEP mode. **Table 18** compares the wake-up events that can occur in NON-CYCLIC and CYCLIC SLEEP modes.

5.9.1 No power saving (AT+CFUN=1)

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

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

If level 0 has been selected (`AT+CFUN=0`), the serial interface is blocked. The module shortly deactivates power saving to listen to a paging message sent

from the base station and then immediately resumes power saving. 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 the GSM/GPRS engine of the I56/I56i back to the highest level of functionality <fun>=1. RTS_0 is not used for flow control, but to wake up the module.

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

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 the GSM/GPRS engine of the I56/I56i to become active, for example to perform a GPRS data transfer, and to resume power saving after the GPRS data transfer is completed.

The 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. In modes CFUN=7 and 8, the GSM/GPRS engine of the I56/I56i 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 18** 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 whether or not the UART is active. The timing of CTS is described below.

Both the application and the module must be configured to use hardware flow control (RTS/CTS handshake). The default setting of the GSM/GPRS engine of the I56/I56i is AT\Q0 (no flow control) which must be altered to AT\Q3. See [4] for details.

5.9.4 CYCLIC SLEEP mode AT+CFUN=9

Mode `AT+CFUN=9` is similar to `AT+CFUN=7` or `8`, but provides two additional features:

- RTS_0 is not intended for flow control (as in modes `AT+CFUN=5,6,7` or `8`), but can be used to temporarily wake up the module. This way, the module can quickly wake up and resume power saving, regardless of the CTS timing controlled by the paging cycle.
- The time the module stays active after RTS was asserted or after the last character was sent or received, can be configured individually using the command `AT^SCFG`. Default setting is 2 seconds like in `AT+CFUN=7`. The entire range is from 0.5 seconds to 1 hour, selectable in tenths of seconds. For details see [4].

5.9.5 Timing of the CTS signal in CYCLIC SLEEP modes

The CTS signal is enabled in synchrony with the paging cycle of module. 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.
After the last character was sent or received the interface will remain active for:

- ✓ another 2 seconds, if `AT+CFUN=5` or `7`,
- ✓ another 10 minutes, if `AT+CFUN=6` or `8`,
- ✓ or for an individual time defined with `AT^SCFG`, if `AT+CFUN=9`. Assertion of RTS has the same effect.

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 21 and figure 22.

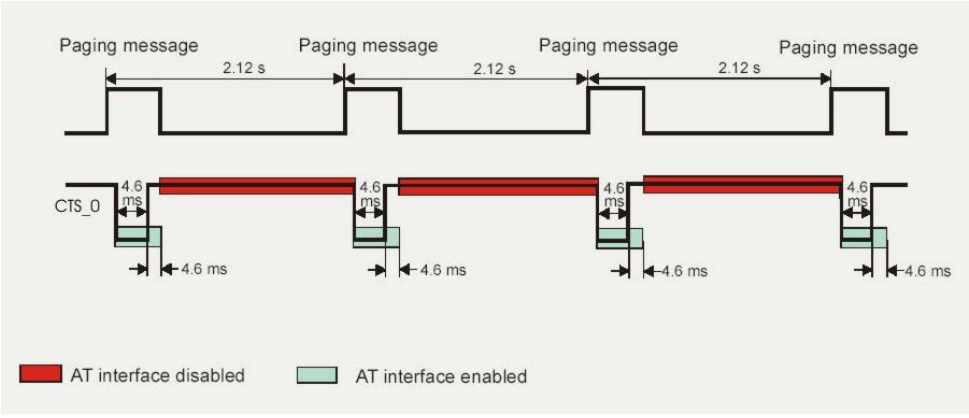


Figure 21: Timing of CTS signal (example for a 2.12 s paging cycle)

Figure 22 illustrates the CFUN=5 and CFUN=7 modes, which reset the CTS signal 2 seconds after the last character was sent or received.

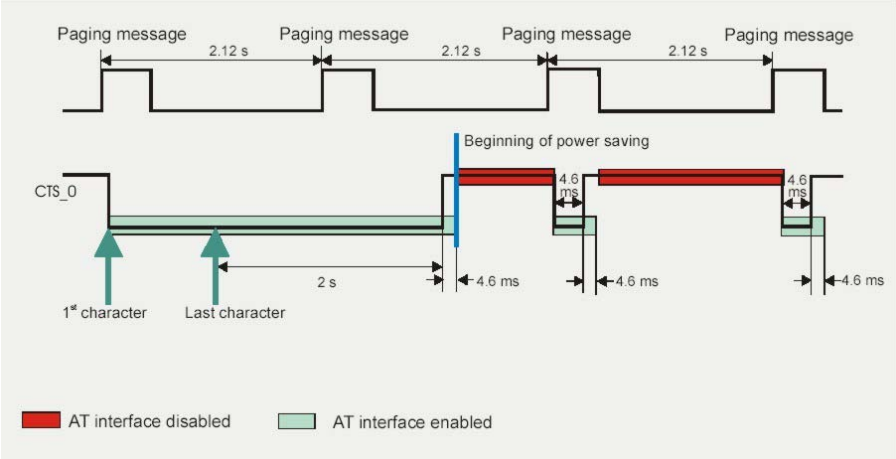


Figure 22: Beginning of power saving if CFUN=5 or 7

5.9.6 Wake up I56/I56i from SLEEP mode

A wake-up event is any event that causes the module to draw current. Depending on the selected mode the wake-up event either switches SLEEP mode off and takes I56/I56i back to `AT+CFUN=1`, or activates I56/I56i temporarily without leaving the current SLEEP mode.
Definitions of the state transitions described in table 18 below:

Quit = I56/I56i exits SLEEP mode and returns to `AT+CFUN=1`.

Temporary = I56/I56i becomes active temporarily for the duration of the event and the mode-specific follow-up time after the last character was sent or received on the serial interface.

No effect = Event is not relevant in the selected SLEEP mode. I56/I56i does not wake up.

Event	**Selected mode** `AT+CFUN=0`	**Selected mode** `AT+CFUN=5` **or 6**	**Selected mode** `AT+CFUN=7,8,9`
Ignition line	**No effect**	**No effect**	**No effect**
RTS0 [1] **(falling edge)**	**Quit**	**No effect (RTS is only used for flow control)**	**Mode 7 and 8: No effect (RTS is only used for flow control)** **Mode 9: Temporary**
Unsolicited Result Code (URC)	**Quit**	**Quit**	**Temporary**
Incoming voice or data call	**Quit**	**Quit**	**Temporary**
Any AT command (incl. outgoing voice or data call, outgoing SMS)	**Not possible (UART disabled)**	**Temporary**	**Temporary**
Incoming SMS depending on mode selected by AT+CNMI: **AT+CNMI=0,0 (= default, no indication of received SMS)** **AT+CNMI=1,1 (= displays URC upon receipt of SMS)**	**No effect** **Quit**	**No effect** **Quit**	**No effect** **Temporary**
GPRS data transfer	**Not possible (UART**	**Temporary**	**Temporary**

	disabled)		
RTC alarm[2)]	**Quit**	**Quit**	**Temporary**
AT+CFUN=1	**Not possible (UART disabled)**	**Quit**	**Quit**

Table 18: Wake-up events in NON-CYCLIC and CYCLIC SLEEP modes

[1)] During the CYCLIC SLEEP modes 5, 6, 7, and 8, RTS0 is conventionally used for flow control: The assertion of RTS_0 signal that the application is ready to receive data - without waking up the module. If the module is in CFUN=0 mode the assertion of RTS0 serves as a wake-up event, giving the application the possibility to intentionally terminate power saving. If the module is in CFUN=9 mode, the assertion of RTS_0 can be used to temporarily wake up I56/I56i for the time specified with the AT^SCFG command (default = 2 s).

[2)] Recommendation: In NON-CYCLIC SLEEP mode, you can set an RTC alarm to wake up I56/I56i and return to full functionality. This is a useful approach because, in this mode, the AT interface is not accessible.

5.10 Summary of state transitions (except SLEEP mode)

5.10.1 Summary of POWER DONE and Normal Mode

Further mode / **Present mode**	**POWER DOWN**	**Normal mode[*)]**
POWER DOWN mode	**--**	**SOFT_ON >100 ms at low level**
Normal mode[*)]	**AT^SMSO or exceptionally RESET pin >3.2 s at low level**	**--**
Alarm mode	**Alarm mode** `AT^SMSO` **or exceptionally RESET pin >3.2 s at low level**	**SOFT_ON >100 ms at low level**

Table 19: Summary of state transitions

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

5.10.2 Summary of Alarm Mode

Further mode / **Present mode**	**Alarm mode**
POWER DOWN mode	**Wake-up from POWER DOWN mode (if activated with** `AT+CALA`**)**
Normal mode[*)]	`AT+CALA` **followed by** `AT^SMSO`**. I56/I56i enters Alarm mode when specified time is reached**
Alarm mode	**--**

Table 20: Summary of state transitions

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

5.10.3 Resetting the GSM module by AT+CFUN=1,1

This command can only be used if the serial interface is enabled.
If the GSM software is still running, while the user feels the need to reset the module, AT+CFUN=1,1 can be used. The module will properly be logged-off from the registered network, resets and restarts the module to full functionality. After reset and restart, PIN authentication is necessary (AT+CPIN). If autobauding is enabled, it is recommended to wait 3 to 5 seconds before entering the first AT command.
The control status LED on SING pin (see section 5.8.2) shortly toggle to OFF and back to ON again to show the progress.
Keep in mind that, the reset command described above, does not change the level of I56/I56i functionality but only restarts the I56/I56i module.

5.11 GSM 07.05 and 07.07 commands

The GSM modem of the I56/I56i is controlled by an advanced set of AT commands. For further information it is recommended to read the ETSI GSM recommendation. See also related documents [4].

6 EMC and ESD requirements

The **ETS 300342-1** standard applies to the I56/I56i with regard to EMC and ESD requirements.
Additional requirements in relation to EMC/ESD:
If the I56/I56i is being used in cars, the requirements regarding power supply as defined in section 9.6 of the ETS 300342-1 (6/97) standard must be fulfilled.
The connecting cable between the chip card reader and the socket on the I56/I56i must be shielded in compliance with EMC requirements.
When using the I56/I56i cellular engine with individual handsfree equipment, noise interference may occur.
The I56/I56i cellular engine must be connected directly to the ground of the base device.

Note:

The device should only be handled in compliance with ESD regulations (grounded, ESD chain, trained personnel).

7 RF Exposures

This device contains 850/1800/1900 MHz GSM/GPRS functions that are operational on these frequencies.
The external antennas used for this mobile transmitter must provide a separation distance of at least 20 cm from all persons and must not be co-located or operating in conjunction with any other antenna or transmitter.

The following statements according to the FCCs are only applied for the I56i module. However, the I56i module contains 1800 MHz GSM functions that is not operational (must not be used) in U.S. Territories. This filing is only applicable for 850MHz GSM/1900 MHz PCS operations, whereby only these frequencies (850MHz GSM/1900 MHz PCS) are possible to be used in U.S. Territories.

Statement according to FCC part 15.19:

This device complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions:

(1) this device may not cause harmful interference, and
(2) this device must accept any interference received, including interference that may cause undesired operation.

Statement according to FCC part 15.21:

Modifications not expressly approved by this company could void the user's authority to operate the equipment.

Statement according to FCC part 15.105:

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

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

8 First steps to make it works

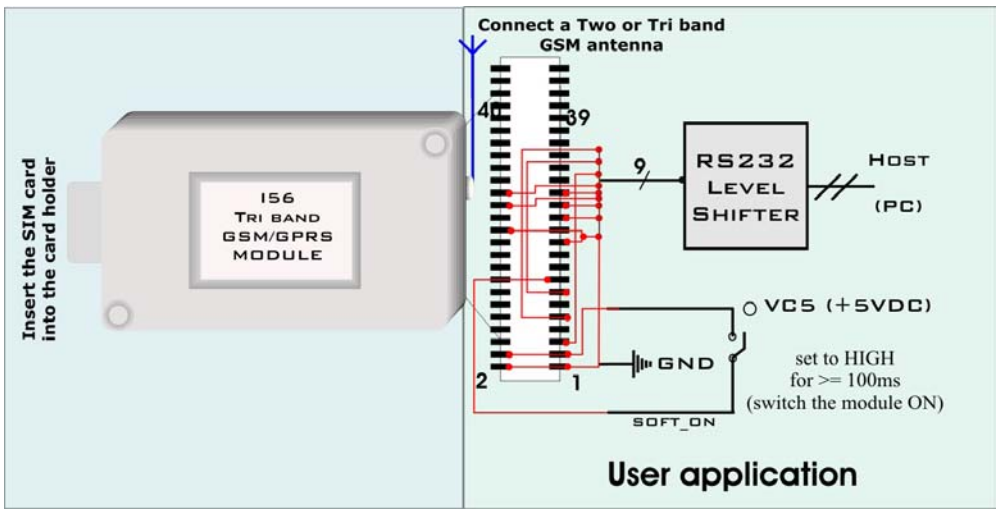
The quickest way to get first results with the I56/I56i embedded GSM/GPRS module is to operate with the GSM-EVAL-KIT which is available by FALCOM upon request. It saves design, time and reduces "Time-to-Market" period. For more details about the FALCOM GSM-EVAL-KIT, refer to the chapter "**GSM Evaluation Kit (GSM EVAL-KIT)**".

NOTE: The GSM/GPRS module I56/I56i are compatible to the I2D module as far as the pin-out on the 50-pin board-to-board connector is concerned. By evaluating the I56/I56i, an I2D adapter board is required to perform the connection between the I56/I56i and GSM-EVAL-KIT. This applies for the users who already have an adapter and a GSM-EVAL-KIT. For other users they have to purchase one.

8.1 Minimum set-up connection

This section and subsections below describes the minimum hardware connection of I56/I56i module to get started if the users do not use the GSM-EVAL-KIT.

As a minimum, to set-up a connection between your PC and the I56/I56i, it is necessary to connect the following interfaces to operate the I56/I56i properly. Please follow step-by-step the instructions below. The figure below shows in a visual form the connection of the I56/I56i hardware interfaces.



8.1.1 Mounting the I56/I56i

The I56/I56i contains two holes for mounting screws. The module can also be assembled to various applications without using the screws.

8.1.2 Antenna interface

The antenna must be located on the places where the signal strength is sufficient. Maybe a mobile phone is required to be used to verify the best location for the I56/I56i connected antenna.

Electronic devices can cause interference, which affects the performance of the I56/I56i. Do not locate the antenna nearby electric devices or other antennas.
The I56/I56i uses a MMCX antenna connector. The GSM RF connector has impedance 50 Ω. A dual- or tri band GSM antenna can be directly connected to this connector. Mating plugs and cables can also be chosen from the FALCOM GmbH. In addition to the GSM antenna, FALCOM GmbH provides antenna cable sets which connects a MMCX connector to the FME connector (if you are using a GSM antenna with FME connector, only) through 20 cm RG.174 antenna cable. The ordering number of this antenna adapter is KA07. See chapter 10.2 for more details.

8.1.3 SIM interface

The integrated SIM interface in the I56/I56i module controls a 3 V SIM card. This interface is fully compliant with GSM 11.11 recommendations concerning SIM functions.
The I56/I56i requires a small SIM card, which is provided by your mobile phone service provider. This contains the telephone number of I56/I56i you will use, as well as other customer information.
If your SIM is larger credit-card size, it may have a snap-out area that allows the small SIM to be removed by gentle twisting. Otherwise apply to your service provider for a small SIM.
The SIM card must be enabled for all services that you want to use – VOICE, DATA, and/or FAX; if in doubt contact your service provider.
Via pushing the eject button on the right side of the card holder, the card holder can be taken off. Put the SIM card into the card holder. The bevelled corner of SIM card has to be on the same side to bevelled corner of card holder and the golden contact area is facing upwards. Make sure that the SIM card is sitting firmly in the SIM card holder slot. Then insert the tray (with SIM card) into the card reader, and push it forwards till it snaps in.

8.1.4 Serial communication signals

The physical interface to the integrated I56/I56i is performed through available lines on the 40-pin board-to-board connector. The I56/I56i supports an unbalanced, asynchronous serial channel conforming to ITU-T V.24 protocol DCE signaling. The electrical characteristics do not comply with ITU-T V.28. The significant levels are 0 V (for low data bit or ON condition) and 2.65 V (for high data bit or OFF condition). This interface is provided with 8-wire support lines and ground. In order to use different voltage levels, a appropriate level shifters has to be connected. See also subsection “Level Shifter” follow.
E.g. in order to provide RS232 compatible levels use the 3 V compatible MAX3232 transceiver from Maxim (see figure 23) or others based on the required levels. If a RS232 compatible serial level is obtained, then you can directly communicate with a host device serial port. All supported variable baud rates can be controlled from the appropriate screens in the application software (e.g. HyperTerminal).
Refer also on the section 5.3 to determinate the DTE-DCE connection.

8.1.4.1 Level Shifter

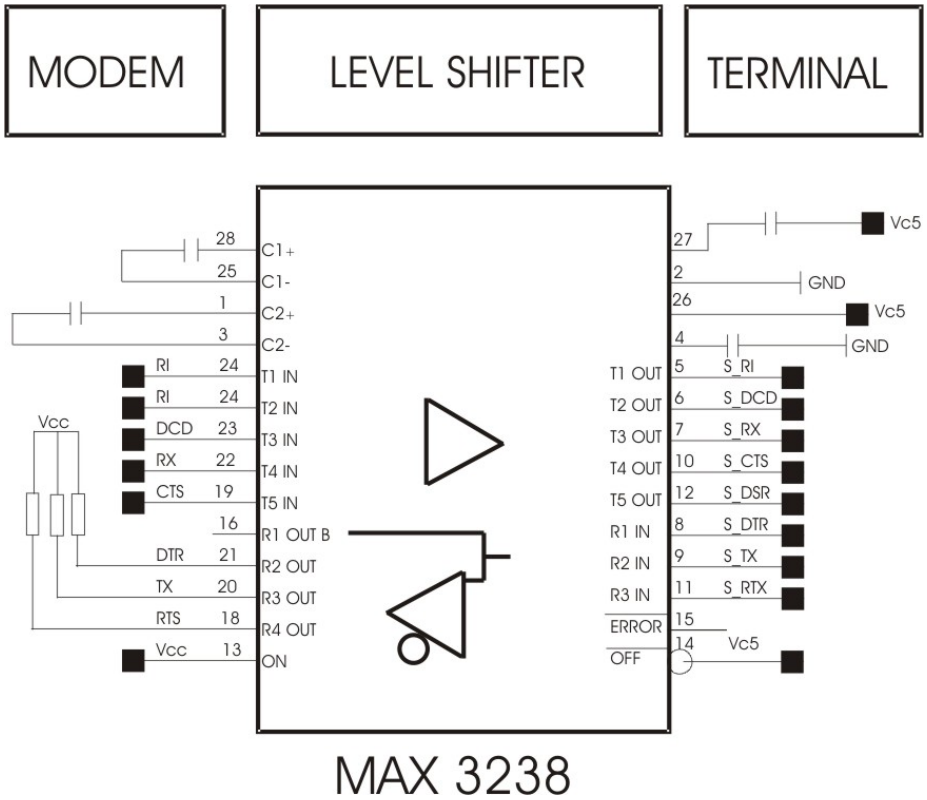


Figure 23* : level shifter application diagram for serial link

***This application note is valid for VCC ≥ 3.0 Volt (see MAX3238 specifications). Auto shut down mode is not used in this example.**

8.1.5 Power supply

Two VC5 pins of the board-to-board connector are provided to connect the supply voltage, five GND pins are recommended for grounding.

The power supply for the I56/I56i module has to be a single voltage source of V_{VC5+}= 4,75 … 5,25 V. It must be able to provide sufficient current in a transmit burst which typically rises to 1.6 A.

Before you connect the module to the external supply voltage, please, start the application software (HyperTerminal) which is to be found in the following directory:

- ✓ Go to Start > Program > Accessories > Communication and click the HyperTerminal program.
- ✓ On the appeared screen assign the name for the current connection (e.g. “I56_I56i”) and click OK.
- ✓ Then choose the correct COM Port on which the module is connected as well select the baud rate of (57000 bps, 8 bit, no parity bit, 1 stop bit) and click OK.

Now, connect GND pins to the ground, and VC5 lines of the module to the external source (+5 V DC) properly.

Once the module is connected to the supply voltage, a string “STARTING” is responded from the module and it is also displayed on the terminal screen. That signifies the module is operational, and it is waiting for switching on. The serial interface of the module is inaccessible yet.

8.1.6 Turn on the GSM/GPRS engine of I56/I56i

In general, be sure not to turn on GSM/GPRS engine of the I56/I56i module while it is out of the operating range of voltage and temperature stated described in **Table 4**. The GSM/GPRS engine of the I56/I56i would immediately switch off after having started and detected these inappropriate conditions.

To switch on the I56/I56i GSM/GPRS engine the SOFT_ON signal needs to be driven to HIGH level for at least 100 ms. To make it in a properly manner just use externally a user application switch (see also figure attached in chapter 8.1). Now the module is ready for operation and the serial interface of the module is accessible. Just type AT and then “ENTER” key the module responds OK.

9 Housing

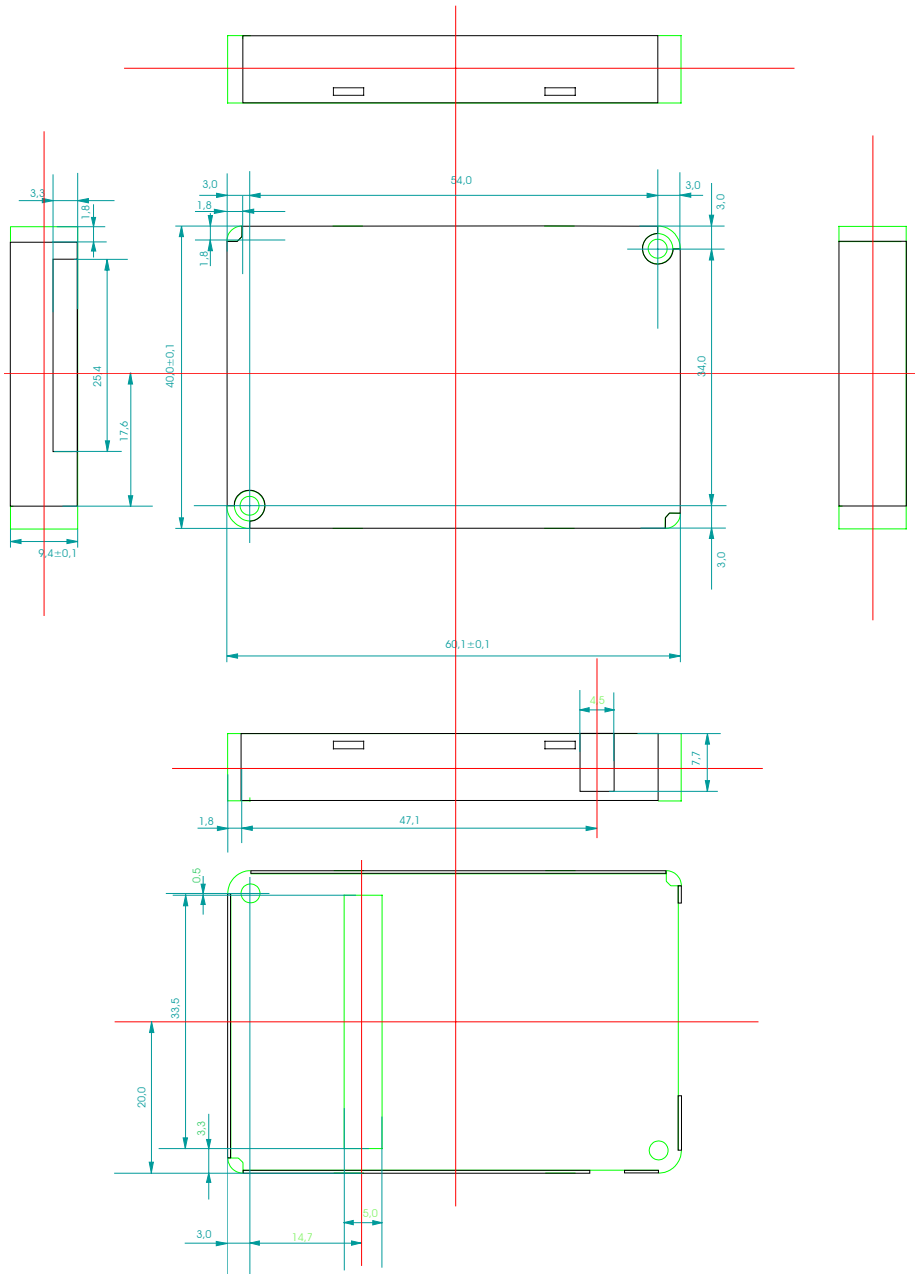


Figure 24: Housing of I56/I56i

10 Connector Supplier and Peripheral devices

10.1 50-pin connector

The 50-pin connector used in the integrated module is a Samtec SMT connector.
Part number of 50-pin connector : FTS-125-01-F-DV-P-TR.
Counterpart number of connector : CLP-125-02-G-D-PA.
For more information about this connector : http://www.samtec.com/

10.2 GSM Antenna

The integrated modem antenna connector is a MMCX connector. The MMCX connector incorporates a 'Snap On' latching action in order to make the connection easier with an excellent RF performance. An additional advantage is its small physical size which is 50% of the standard MCX connector. This type of connector is suitable for the standard ranges of flexible and semi-rigid cables. The characteristic impedance of the MMCX coaxial connector is 50 ohm. The antenna manufacturer must guarantee that the antenna will be working according to the following radio characteristics:

	EGSM 850	**GSM 1800**	**GSM 1900**
Frequency RX	869 to 894 MHz	1805 to 1880 MHz	1850 to 1910 MHz
Frequency TX	824 to 849 MHz	1710 to 1785 MHZ	1930 – 1990 MHz
RF power stand	2 W at 12.5 % duty cycle	1 W at 12.5 % duty cycle	1 W at 12.5 % duty cycle
Impedance	50 Ω		
VSWR	< 2		
Typical radiated gain	0 dBi on azimuth plane		

Table 21: radio characteristics

The I56/I56i requires a MMCX (Miniature Micro Connector) plug to connect a GSM antenna. To connect a GSM antenna (e. g ANT010 850/1900 MHz) to the I56/I56i modem, the FALCOM offers a antenna cable product called KA07 (MOQ-set of 10 pieces). Figure 25 shows the KA07 antenna cable with MMCX and FME-female connectors.

Figure 25: MMCX connector example (right angled)

Figure 26: View of the KA07 antenna cable (right angled)

10.3 The SIM card holder

The SIM card holder used in the integrated module is a MOLEX connector.
Part number connector: 99228-0002
Part number holder : 91236-0002
For more information about this connector : http://www.molex.com/
It is possible to use an external SIM card holder through the 50-pin connector (the length of the SIM line must not exceed 15 cm).

11 GSM Evaluation Kit (GSM EVAL-KIT)

The quickest way to get first results with the embedded GSM module is the activation by the GSM-EVAL-KIT by means of a terminal program.
The FALCOM GSM-EVAL-KIT provides design engineers with all necessary hard- and software information for the creation of embedded applications based on FALCOM GSM/DCS embedded modules. It saves design, time and reduces "Time-to-Market" period.

The GSM EVAL-KIT set contains:

- EVAL-Board
- Adapter PCB for A2D/F35/C2D/C55 (I56) modules called FALCOM adapter
- Adapter PCB for I56 module called CM adapter
- Wall mount power adapter
- 9-pin serial cable (pin to pin direct, male to female)
- GSM antenna (900/1800/1900) and cable (30 cm) with coaxial plug
- Coaxial adapter MMCX-FME
- Headset with RJ45 plug
- Set of connectors:
  - 2 pieces 40-pin stacking connector (plug and socket)
  - 2 pieces coaxial antenna plug (plug and socket)
  - 2 pieces 15-pin cable connector (plug and socket)
  - 2 pieces external SIM card reader
  - 3 pieces short circuit bridges
  - 4 pieces mounting clamps
  - 4 pieces dowel
- CD
  - "A2D-Testsoftware"
  - Layout data (PROTEL/GERBER format) of module
  - Evaluation board user manual
  - AT command set
  - I56 GPRS start up guide
  - I56/I56i hardware manual
  - I56i TCP/IP command set

Schematics of the evaluation platform and adapter PCB's (power supply, external SIM card, serial interface).