

User Manual

TM3 GSM/GPRS/EDGE Module

History

Company was established on 15th of April 1998. Main residence is based in Vilnius.

Company started with production of telecommunication devices.

In 2001 company expanded its fields of activity by starting design and manufacturing of electronical systems for wireless data transfer.

In 2002 contract of partnership and collaboration was signed with company Pro-Sign GmbH (Germany), considering design and representation of graphic programming interface iCon-L in Eastern Europe.

In 2003 Teltonika and NOKIA became partners and started integration of NOKIA M2M technology using NOKIA N12 module. It was the beginning of wireless technology development process.

In 2004, NOKIA invited Teltonika to join presentation of M2M technology innovations in CeBIT 2004. It was very high evaluation of a small Lithuanian company and its possibilities, which helped to feel peculiarities of international business.

In 2004 Teltonika produced more than 10 new products and solutions using EDGE technology. It was a condition that made Teltonika a leader of M2M integration solutions using EDGE not only in Lithuania, but also in Europe.

2005 was the year of two successful international exhibitions: CEBIT 2005 and HANNOVER MESSE 2005. These shows opened new possibilities for offering our products and solutions for all world.

In the year 2005 Teltonika became an international company. We became Lithuanian - Finnish Company. A few employees from NOKIA joined Teltonika's staff. Presently they successfully develop activity of new companies: Teltonika International GmbH (Düsseldorf) and Teltonika International Oy (Helsinki).

About US

Our vision is to provide added value for people and companies by creating electronical devices and solutions, which are based on the latest achievements of science and technology.

We aim to help people to integrate the latest technologies in real life, what would bring more cosiness, comfort, freedom of mobility and security to their everyday life.

We seek to make all our solutions an inconceivable part of people lives.

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1 Document Mission

TM3 User Manual contains the information necessary for a successful integration of the system into the application of the customer. Additionally, the customer uses the information described in the User Manual to compare different systems and to finally select the appropriate system for his application. Therefore TM3 User Manual is an important customer document. A particular attention has to be paid while writing the document from the customer point of view.

2 Glossary

Acronym	Meaning
3GPP	3rd Generation Partnership Project
ADC	Analog to Digital Converter
AFC	Automatic Frequency Correction
APN	Access Point Name
ASC	Asynchronous Serial Interface Controller
AT	AT Command Interpreter Software Subsystem, or attention
B2B	Board to board
CB	Cell Broadcast
CBCH	Cell Broadcast Channel
CSD	Circuit Switched Data
CS	Coding Scheme
CTS	Clear To Send
DAI	Digital Audio Interface
DCE	Data Communication Equipment
DCS	Digital Communications System
DL	Reception
DTA	Data Terminal Adaptation
DTE	Data Terminal Equipment
EDGE	Enhanced Data rates for GSM Evolution
EGPRS	Enhanced GPRS
EGSM	Extended - Global System for Mobile Communication
EMC	ElectroMagnetic Compatibility
ESD	Electro Static Discharge
FFS	Flash File System
GPIO	General Purpose Input Output
GPRS	General Packet Radio Service
GSM	Global System for Mobile communications

Acronym	Meaning
IMEI	International Mobile Equipment Identity
IP	Internet Protocol
ISDN	Integrated Services Digital Network
JTAG	Join Test Action Group
LVD	Low Voltage Directive
M2M	Machine to Machine
ME	Mobile Equipment
MIDI	Musical Instrument Digital Interface
MS	Mobile Station
MSC	Multi Slot Class
MO	Mobile Originated
MS	Mobile Station
MT	Mobile Terminated
OTG	On The Go
PA	Power Amplifier
PBCCH	Packet Broadcast Control Channel
PCCCH	Packet Common Control Channel
PCM	Pulse Code Modulation
PCS	Personal Communications Service
PDN	Packet Data Network
PDU	Protocol Data Unit
PPS	Protocol and Parameter Selection
QoS	Quality of Service
RAM	Random Access Memory
RF	Radio Frequency
RFU	Reserved for Future Use
RLP	Radio Link Protocol
R&TTED	Radio and Telecommunications Terminal Equipment Directive
ROM	Read Only Memory
RTC	Real Time Clock
RTS	Request To Send
RX	Reception
SAW	Surface Acoustic Wave
SIM	Subscriber Identifier Module
SMS	Short Message Service

Acronym	Meaning
SW	Software
TA	Terminal Adapter
TCP	Transfer Control Protocol
TS	Technical Specification
TX	Transmission
UART	Universal Asynchronous Receiver/Transmitter
UL	Transmission
USB	Universal Serial Bus

3 Scope of Product

TM3 is a small, light weight and low power consumption module that enables digital communications services on GSM/GPRS/EDGE networks for machine to machine or user to user or user to machine wireless applications.

These GSM/GPRS/EDGE data modules are developed in compliance with internal and normative certification requirements. In particular, they are certified by CE approval report (99/5/EC) and Radio & Tele Terminal Equipment Directive (R&TTED) report following the following standard regulations:

- 3GPP TS 51.010-1 Mobile Station (MS) conformance specification; Part 1: Conformance specification (Radio spectrum);
- EN 301 489-1 and EN 301 489-7 (EMC directive - 89/336/CEE);
- EN 60950 (LVD Directive - 73/23/CEE)

Requirements for lead-free components are imposed and satisfied.

The product implements a quad-band MS able to operate in the frequency bands GSM 850 MHz, EGSM 900 MHz, and DCS 1800 MHz and PCS 1900 MHz; the dynamic behavior can be configured dynamically by disabling/enabling a specific band.

The operative temperature range goes from -20 to +85 °C. The supported power classes for both voice and data services are:

- Class 4 (2W) for GSM/EGSM bands;
- Class 1 (1W) for DCS/PCS bands;
- Class ES2 (27 dBm) for 8-PSK modulation (EDGE) for GSM/EGSM bands;
- Class ES2 (26 dBm) for 8-PSK modulation (EDGE) for DCS/PCS bands.

The product implements a Class B Mobile Station; this means the data module can be attached to both EGPRS and GSM services, using one service at a time. Network operation modes I to III are supported, with user-definable preferred service between GSM and EGPRS.

Further functionalities that are implemented on the data module are Mux protocol (27.010) and USB interface (2.0 OTG) for Modem profiles and Mass Storage (optional).

3.1 Certification Requirements

TM3 GSM/GPRS/EDGE Data Module is certified by CE approval report and Radio & Telecommunications Terminal Equipment Directive (R&TTED) report. The directives that are followed for this data module are described below:

3GPP TS11.10-1 rel.99

Technical Specification Group GSM/EDGE Radio Access Network and Mobile Station (MS) conformance specification;

EN 301 489-01 V1.4.1

Electromagnetic compatibility and Radio spectrum Matters (ERM); ElectroMagnetic Compatibility (EMC) standard for radio equipment and services; Part 1: Common technical requirements

EN 301 489-07 V1.2.1

Electromagnetic compatibility and Radio spectrum Matters (ERM); ElectroMagnetic Compatibility (EMC) standard for radio equipment and services; Part 7: Specific conditions for mobile and portable radio and ancillary equipment of digital cellular radio telecommunications systems (GSM and DCS)

EN60950

Standard for safety of information technology equipment: to protect against excessive current, short circuits and earth faults in primary circuits protective devices shall be included either as integral parts of the equipment or as parts of the building installation.

73/23/EEC (Low Voltage Directive)

The Low Voltage Directive (LVD) 73/23/EEC seeks to ensure that electrical equipment within certain voltage limits both provides a high level of protection for European citizens and enjoys a Single Market in the European Union.

4 Product environment

4.1 Interface

- SIM card supporting 1.8 V and 3 V cards type via B2B connector and optionally via on board holder (Suyin 254038MA006G505ZL);
- MMCX Interface connector for RF output (50 Ohm connector MMCX Edge Mount SMD J01341A0081 (Telegartner));
- 80 pin board-to-board connector (**CBRB080PA2000R0**);

5 Product functions

The features that are implemented on TM3 GSM/GPRS/EDGE Data Module are reported in TM3 Features List. In the following sections will be described the functionalities integrated in the data module.

5.1 Modem

5.1.1 GSM/EGPRS modem functionalities

TM3 GSM/GPRS/EDGE module integrates a full-featured R4 GSM-EGPRS Protocol Stack, whose main characteristics are listed in the following.

The product implements a quad-band MS able to operate in the frequency bands GSM 850 MHz, EGSM 900 MHz, DCS 1800 MHz and PCS 1900 MHz; the dynamic behavior can be configured dynamically by disabling/enabling a specific band.

The supported power classes for both voice and data services are:

- Class 4 for GSM band;
- Class 1 for DCS bands.
- Class ES2 (27 dBm) for 8-PSK modulation (EDGE) for GSM/EGSM bands;
- Class ES2 (26 dBm) for 8-PSK modulation (EDGE) for DCS/PCS bands.

The product implements a Class B Mobile Station; this means the data module can be attached to both EGPRS and GSM services, using one service at a time. Network operation modes I to III are supported, with user-definable preferred service between GSM and EGPRS.

Optionally paging messages for GSM calls can be monitored during EGPRS data transfer in not-coordinating network operation mode NOM II-III.

PBCCH/PCCCH logical channels are supported, as well as CBCH reception. CBCH reception when on PBCCH is supported.

EGPRS multislot 12 is implemented, implying a maximum of 4 slots in DL (reception) and 4 slots in UL (transmission) and 5 slots on the whole.

Finally TM3 GSM/GPRS/EDGE module supports:

- All coding schemes from CS1 to CS4;
- Encryption algorithms A5/1 and A5/3 for GSM for GPRS are supported;
- CS Data calls are supported in transparent/non transparent mode up to 9.6 kbps;
- Bearer service fax Group 3 Class 2.0 is supported.

Among access interfaces to DTE, both V.32 and V.110 are provided.

5.1.2 E-GPRS Features

TM3 implements an EDGE terminal class B. The modulation coding schemes that are implemented are MCS 1-9. Incremental redundancy is supported.

5.1.3 Supplementary services

The following supplementary services are provided:

- Call Hold/Resume (CH);
- Call Waiting (CW);
- Multi-Party (MTPY);
- Call Forwarding (CF);
- Call Divert;
- Explicit Call Transfer (ECT);
- Call Barring (CB);
- CCBS;
- Advice of Charge (AoC);
- Calling Line Identification Presentation (CLIP);
- Calling Line Identification Restriction (CLIR);
- Connected Line Identification Presentation (COLP);
- Connected Line Identification Restriction (COLR);
- Unstructured Supplementary Services Data (USSD);
- Alternate Line Services (ALS);
- Network Identify and Time Zone (NITZ).

5.1.4 AT-command support

The modem functionalities and services are provided through a rich serial AT-command interface. Standards of AT commands that are supported on the module are:

- 3GPP TS 27.005;
- 3GPP TS 27.007;
- Proprietary AT commands.

For more details on the commands list and their syntax refer to AT commands Manual [1].

5.1.5 Other basic features

The following indications and functionalities are supported through the interface of AT Commands:

- Display of Called Number;
- Indication of Call Progress Signals;
- Country/PLMN Indication;
- Short Message Indication and Acknowledgement;
- International Access Function;
- Service Indicator;
- Dual Tone Multi Frequency (DTMF);
- Subscription Identity Management;
- Service Provider Indication;
- Abbreviated Dialing;
- Power on (external input).

5.2 Baseband

TM3 base band system provides all necessary interfaces for hardware/software designing and debugging. Data module includes the following interfaces:

- SIM card supporting 1.8 and 3V card type;
- Board to board connector on the data module with serial data I/O with handshake signals.

Via Board-to-Board connector there are the following interfaces:

- 2 UART: ASC0 with hardware handshake signals and ASC1 without flow control. Both of them are accessible on board-to-board connector and supports high speed dataflow. Only UART_0 support HW flow control;
- A SIM card holder: through the board-to-board connector it's possible to handle an external SIM card holder and optionally an on board SIM holder; cards type supported by the data module are 1.8 V and 3 V;
- USB interface (V. 2.0 OTG): it's provided via Board-to-Board connector.

5.3 Voiceband

To realize a phone call with TM3 Data Module the following devices can be used:

- Handset;
- Headset;

Moreover there is the possibility to realize phone call in hands free mode (through a loudspeaker). All these devices (handset, headset and loudspeaker) are connected to the data module via Board-to-Board connector (and Mother Board).

5.3.1 Audio Power Amplifier

The audio power amplifier can be used as a voice amplifier for the hands-free functionality and as a melody player amplifier for ringer functionality (see the next sections). The melody player could be the Midi synthesizer or the tone generator.

In order to minimize the clipping of the audio signal, the polarization voltage can be adapted to the voltage supply (battery voltage).

5.3.2 Handset Mode

A handset is supported for normal handset operation on the default audio path.

The normal voiceband functional mode of the data module is completely handled by baseband chipset:

- Microphone bias current is provided by internal regulator VMIC;
- Microphone signal is directly connected to input MIC_BIAS1/MIC_GND1;
- Earpiece is directly connected to Board-to-Board connector with EPPA1B and EPPA2A.

5.3.3 Headset Mode

One earpiece headset is supported and may be used for voice during calls.

In headset mode, the microphone signal comes from the head-set device and is connected to MIC_BIAS2/ MIC_GND2 inputs. Voice output from Board-to-Board connector with EPPA1B and EPPA2A; and then to the external audio device.

The audio path switching from handset to headset is automatic when a rising edge is detected from line CAP22_EX3XIN (Pin 70 of Board-to-Board connector; see "Pinout description" section); the audio path returning to the headset when line CAP22_EX3XIN (Pin 70) return to 0 level.

5.3.4 Microphone

The uplink path can be switched between the handset and the headset microphone. The path switching is driven automatically as described above for the earpiece.

The uplink path can be muted.

5.3.5 Hands free

A true hands-free functionality is implemented using high power loudspeaker, MS microphone and appropriate DSP algorithms for voice band handling (Echo canceller and Automatic Gain control). This functionality is managed via Software.

The product is equipped with a power audio amplifier that can drive (with a gain of +2.7dB) an external 8 ohm speaker with 400mW peak.

With viva voice operation is intended the possibility to realize a phone call with a loudspeaker and a microphone.

The audio signal on the loudspeaker is a mono signal.

In viva voice mode of operation, the output signal of EPP1/EPN1 is amplified by the built-in Audio amplifier, and then applied to the Loudspeaker output (outputs are AUON and AUOP: in this case EPPA1B and EPPA2A are disabled). The microphone signal is the signal that comes from the input MIC_BIAS1/ MIC_GND1.

5.3.6 Ringer Mode

The data module support 40 tones polyphonic ring tones. The ringer tones are generated by built-in generator and then they are amplified by amplifier before being applied to loudspeaker through the pin of Board-to-Board connector AUON and AUOP. For ringing the gain of the audio amplifier is -1.2 dB.

Polyphonic ring-tones can be generated by an internal MIDI synthesizer, which runs at 16 or 32 KHz sample frequency and can sum up to 40 voices at 16 kHz sampling rate.

The synthesizer output is only mono and cannot be mixed with TCH voice path (the two are mutually exclusive). To perform in-band alerting during TCH with voice path open, only Tone Generator can be used.

The output samples of the synthesizer are post processed by two modules:

- High Frequency Shelving Filter: This module is implemented as a first order IIR Filter, which is mainly used for high frequency boost in audio signals. Its transfer function can be controlled by 4 filter coefficients.
- Audio Compressor: The audio compressor is a device for manipulating the dynamic range of mono or stereo audio signals. The audio compressor can be controlled by 14 configuration parameters.

Polyphonic standard format supported.

The MIDI driver can play:

- MIDI files conforming to:
 - General Midi Level 1.0 with file-format 0 and 1;
 - General Midi Lite 1.0.
- SPMidi (Scalable Polyphony MIDI) files conforming to:
 - SPMidi 1.0.
- iMelody files conforming to:
 - iMelody v.1.2 specifications.

5.3.7 DAI Interface

For certification testing of audio and vocoder functions the mobile phone has to be connected to the system simulator. The Digital Audio Interface between the system simulator and the MS is supported as described in GSM 04.14 specifications.

Supported modalities are:

- Normal mode;
- Vocoder test;
- Acoustic test;
- Voiceband test.

To be noticed that TM3 Data Module is hardware compliant to DAI interface and optionally the software can be customized to enable the interface.

The table below shows the pin number related to the DAI signals.

Name	PIN #	I/O	Type	Description
CLK0_DAI	41	I/O	Generic digital signal	DAI clock
RXD_DAI	43	I	Generic digital signal	DAI receive
TXD_DAI	45	O	Generic digital signal	DAI Transmit
WA0_DAI	47	I/O	Generic digital signal	DAI Reset

5.3.8 Audio Codecs

The following speech codecs are supported in firmware on the DSP:

- GSM Half Rate (TCH/HS);
- GSM Full Rate (TCH/FS);
- GSM Enhanced Full Rate (TCH/EFER);
- 3GPP Adaptive Multi Rate (AMR) (TCH/AFS+TCH/AHS).

5.3.9 Echo canceller/Noise Reduction

For better handling of speech calls and audio functionalities, the product supports algorithms for echo cancellation, noise suppression and automatic gain control.

5.3.10 Circuit Description

The output signal of EPP1/EPN1 is amplified by the built-in Audio amplifier, and then applied to the Board-to-Board Connector:

The table below shows the pin number related to the analog audio signals.

Name	PIN #	I/O	I/O type	Description
MIC_GND1	51	I	Analog	Handset microphone reference (-)
MIC_BIAS1	53	I	Analog	Handset microphone bias (+)
EPPA1B	55	O	Analog	Balanced audio out
EPPA2A	57	O	Analog	Balanced audio out
MIC_GND2	59	I	Analog	Headset microphone reference (-)
MIC_BIAS2	61	I	Analog	Headset microphone bias (+)
AUOP	63	O	Analog	Balanced power audio out
AUON	65	O	Analog	Balanced power audio out

In the following are reported the input impedance of the audio interface:

- Input impedance between MICP1 and MICN1: 50 KOhm (typical value);
- Input impedance between MICP2 and MICN2: 50 KOhm (typical value);
- Input impedance between MIC_BIAS and MIC_GND: 1.7 KOhm

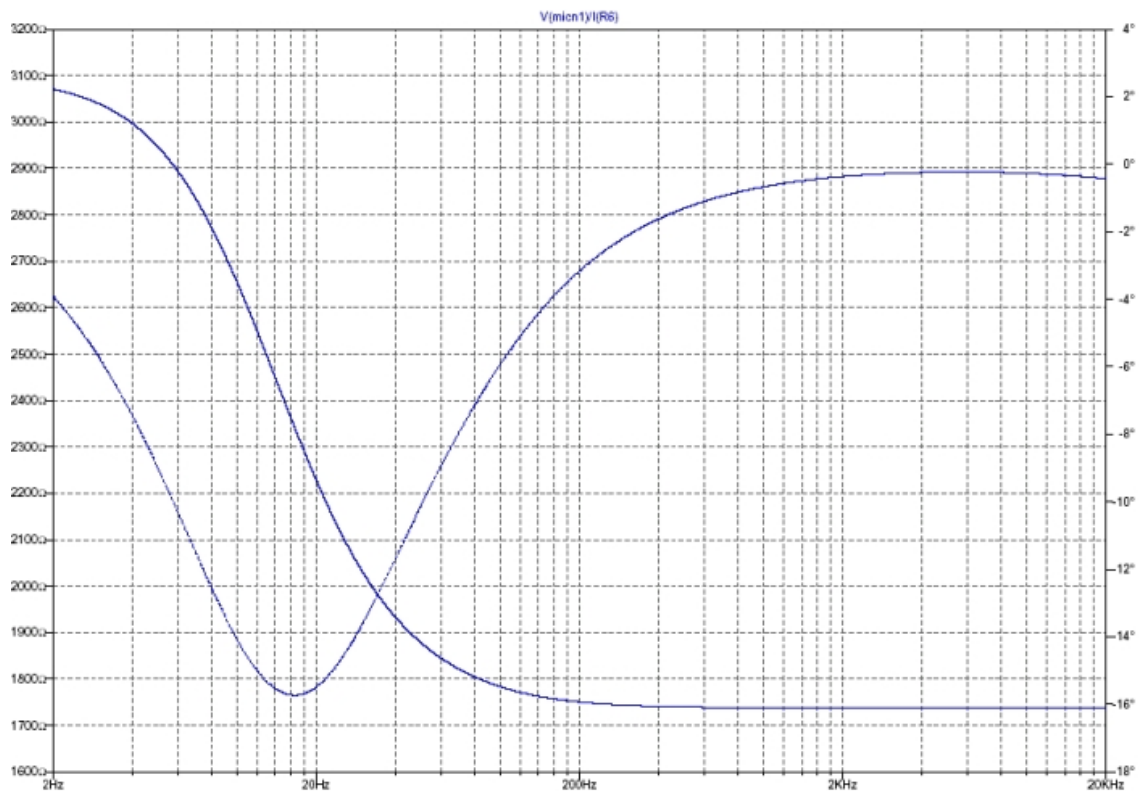
EPPA1B and EPPA2A Output Features:

- Internal Output Resistance: 4 Ohm;
- Max differential output between EPPA1B and EPPA2A: 4.1 Volts and 200 mA;
- Loads that can be applied to the data module must have an impedance of 16 Ohm or more;

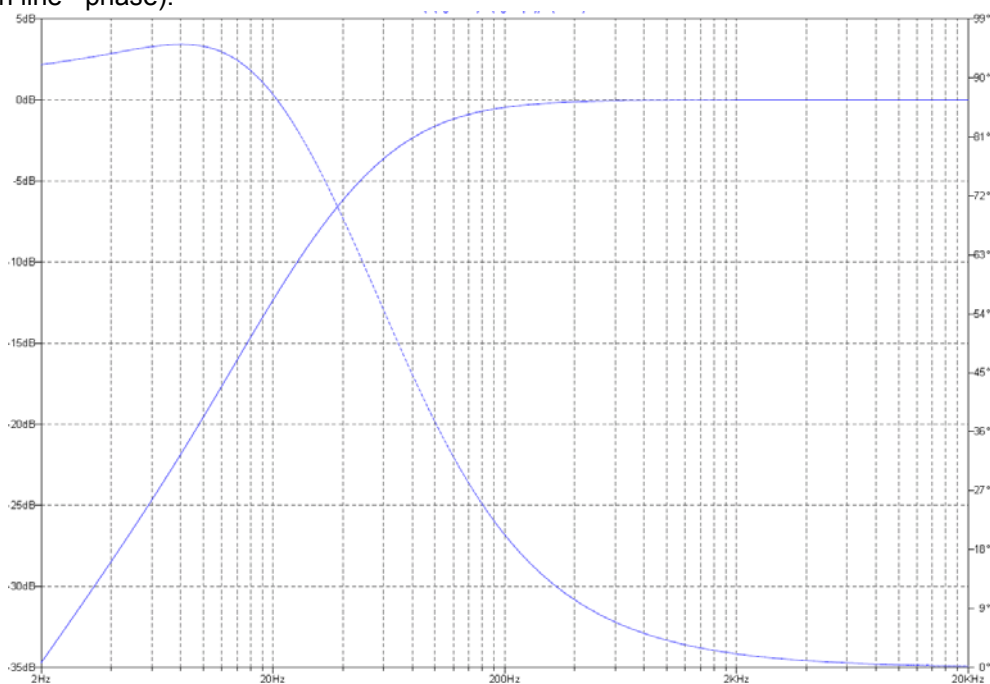
AUON and AUOP Output Features:

- Max differential output: 5.06 Volts (typical value) and 529 mA;
- Loads that can be applied to the data module must have an impedance either of 8 Ohm or 16 Ohm;

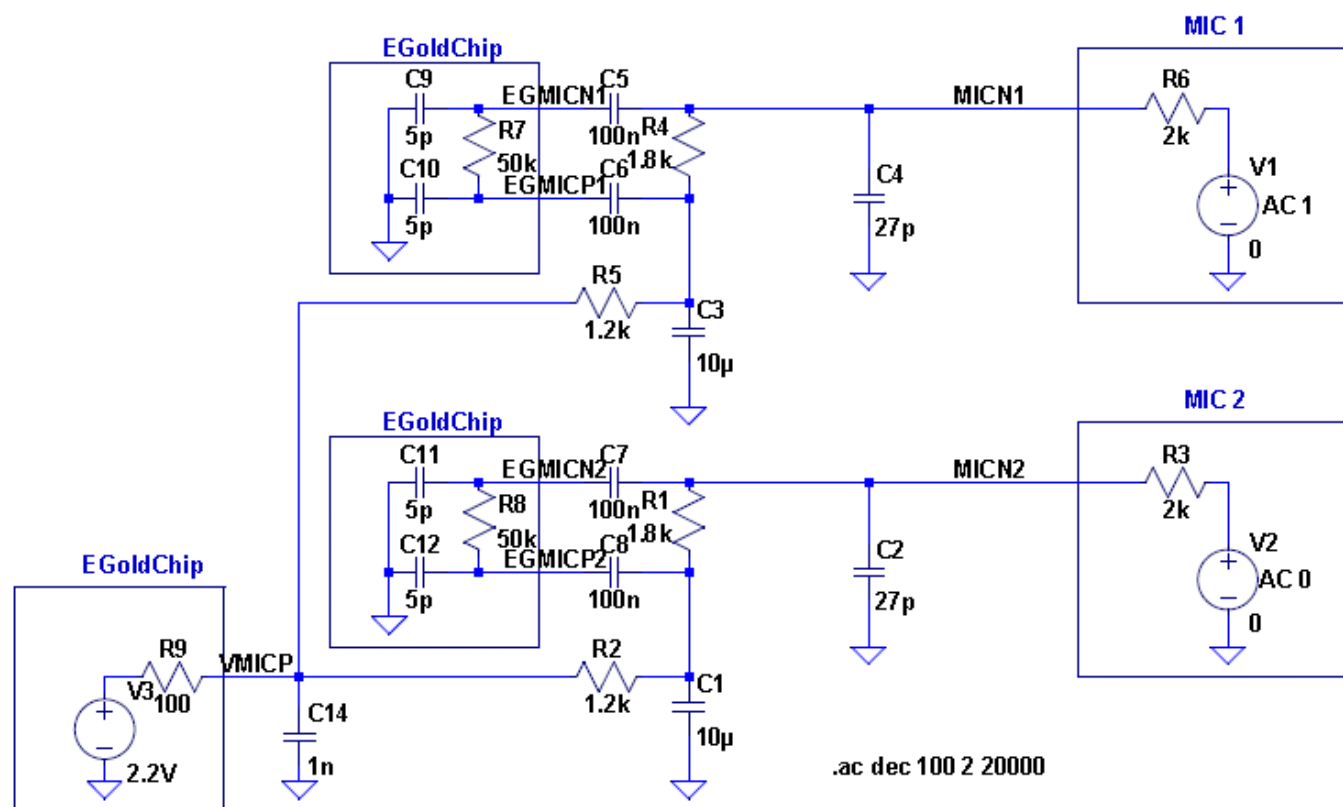
In the following is reported the input impedance on MICN1 pin (continuous line: magnitude; dash line= phase).



In the following is reported the transfer function between the input MICN1 and the chip input (continuous line: magnitude; dash line= phase).



In the following is reported the model of the audio interface related to the microphones and S-GOLD2 chipset



5.4 Mechanical characteristics

The dimensions of the data module without shields are reported in the following:

- 36.5 mm x 38.6 mm x 3.3 mm (without SIM Holder);
- 36.5 mm x 38.6 mm x 5.6 mm (with SIM Holder).

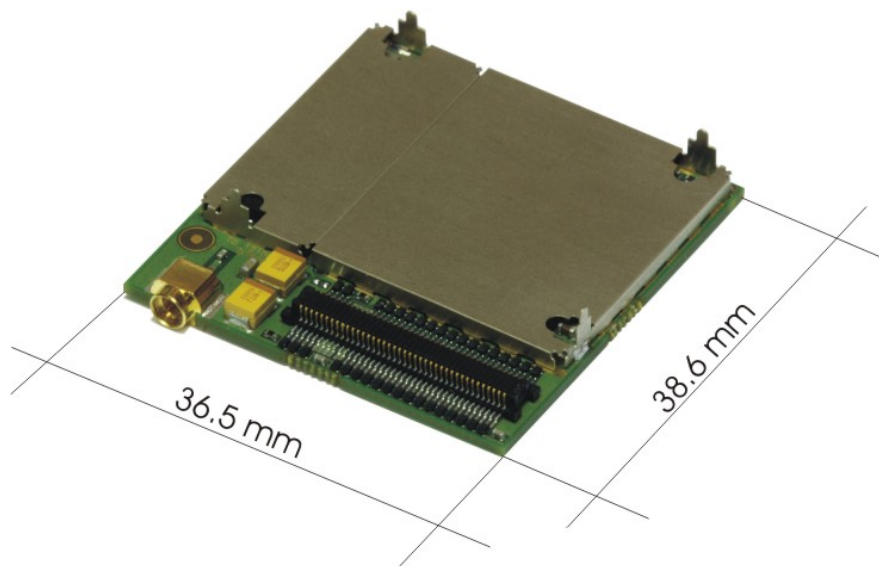


Figure 5-1: mechanical dimensions

The weight is less than 10 g.

5.5 Power supply

TM3 Data Module can be supplied by a power supplier connected with the mother board. The voltage is provided to the Data Module through the Board-to-Board connector that provides a voltage value VBAT on pins 11, 13, 15, 17. The range of VBAT is between 3.5 V and 4.2 V, while typically its value is 3.8 V. The current that must be provided to the data module through the power supplier is about 2 A (peak value).

Description	Min	Typ	Max
Supply voltage	3.5 V	3.8 V	4.2 V

The VBAT voltage is connected with the power management that supplies all components of the data module and derives all needed voltage levels to supply the different circuit parts. Power Amplifier is supplied directly by VBAT voltage.

Alternatively TM3 data Module can be supplied through a battery. The supported type for the battery is Li-Ion and Li-Polymer rechargeable only; default system will support 650 mAh nominal. Protection circuitry must be integrated in the battery package. Through a customization (Hardware and Software) it's possible to change the charging current in a range that goes by 400 to 1100 mA.

The Battery/Charger functionality provides:

- Battery charging control:
 - Precharge functionality: a limited current to bringing up a deeply discharged battery;
 - Constant current charging: the current limitation can be activated and pre-programmed by SW;
 - Constant voltage charging: current is regulated to maintain constant the battery voltage;
 - Tickling of charging in order to maintain the full capacity of the battery;
 - Optionally it's possible to implement the pulse charging mode.
- Capacity estimation during charging, no charging, ongoing calls, etc., constantly considering the different load parameters of the phone;
- Measurements of battery voltage, RF and battery temperature, equipment status, etc.

Charging of deeply discharged battery as well as charging during phone call is possible.

A description of pins of Board-to-Board Connector that are enabled to supply the Data Module and charge the battery connected with TM3 is reported below.

Name	PIN #	I/O	I/O type	Description
VBAT	11	PWR	From 3.5 to 4.2 V (Typ: 3.8 V)	Should be connected with pins 13, 15, 17
GND	12	PWR	Ground	Should be connected with pins 14, 16, 18
VBAT	13	PWR	From 3.5 to 4.2 V (Typ: 3.8 V)	Should be connected with pins 11, 15, 17
GND	14	PWR	Ground	Should be connected with pins 12, 16, 18
VBAT	15	PWR	From 3.5 to 4.2 V (Typ: 3.8 V)	Should be connected with pins 11, 15, 17
GND	16	PWR	Ground	Should be connected with pins 12, 14, 18
VBAT	17	PWR	From 3.5 to 4.2 V (Typ: 3.8 V)	Should be connected with pins 11, 15, 17
GND	18	PWR	Ground	Should be connected with pins 12, 14, 16
VCHARGE	19	PWR	From 0 to 12 V (Typ: 6V) Current limited to 700 mA	Should be connected with pin 21
VCHARGE	21	PWR	From 0 to 12 V (Typ: 6V) Current limited to 700 mA	Should be connected with pin 19

5.5.1 Current consumptions

Current consumptions of TM3 module are reported in the following pages.

Status	Average Current
Power OFF	< 30 μ A
Idle Mode	< 3 mA
Telephony GSM	< 330 mA
Telephony DCS/PCS	< 250 mA
GPRS (4+1) attach mode	< 3 mA
GPRS (4+1) TBF mode @ 850 / 900 MHz	< 770 mA
GPRS (4+1) TBF mode @ 1800 / 1900 MHz	< 650 mA
EDGE (4+1) attach mode	< 3 mA
EDGE (4+1) TBF mode @ 850 / 900 MHz	< 530 mA
EDGE (4+1) TBF mode @ 1800 / 1900 MHz	< 500 mA

5.6 Power Saving

Power saving is a special function that allows the reducing of power consumption during the idle time. If the clock increases, required power increases too. Therefore a solution for minimizing the power is the reducing of the master clock frequency when there aren't activities. In this period the system doesn't work with a clock of 26 MHz ("fast clock") but with a clock of 32 KHz (RTC clock or "slow clock"). This switching between 26 MHz and 32 KHz clock is performed by SCCU (Standby Clock Control Unit).

Main priorities of power saving are the following:

1. Reduce base (min) current consumption;
2. Minimize full-speed running periods, minimize power saving on/off switching;
3. Reduce max current consumption.

These points are reported in the following figure:

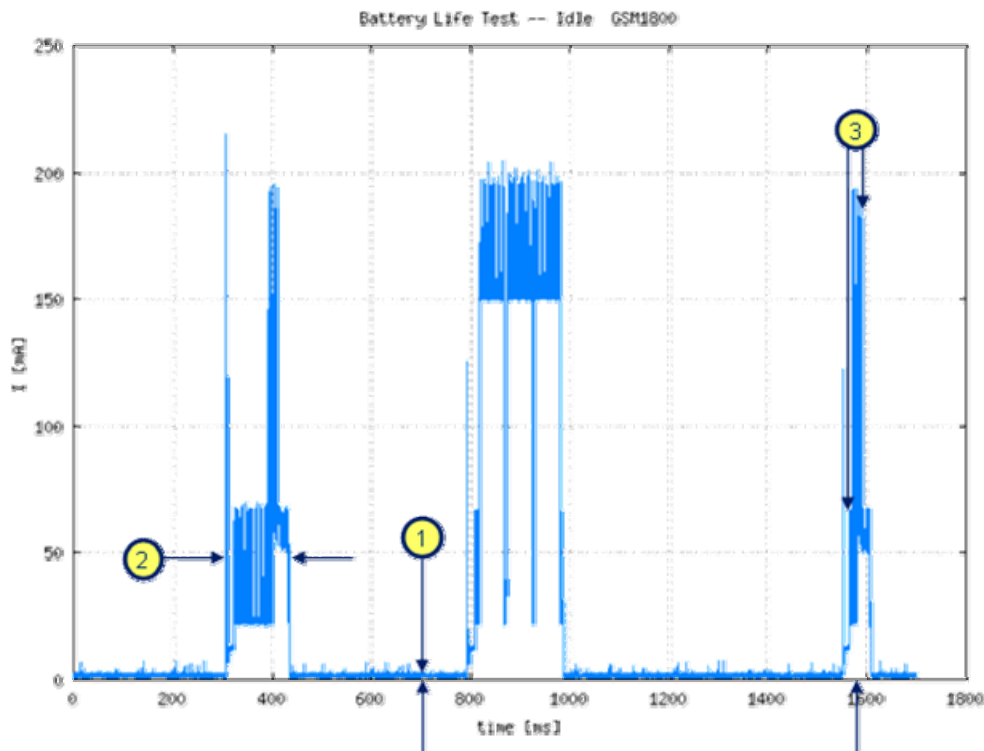


Figure 5-2: Power saving priorities

This functionality can be disabled by the user through an AT command [1].

2 areas of power management tasks are to be distinguished:

- System sleep mode handling (PSV driver):
- Dynamic power management (POW driver):

With System Sleep Mode Handling is possible to control sleep–awake transitions of the system (or parts of the system) and implements the power optimized idle loop of the ARM core. Aim of dynamic power management is to reduce the power consumption of awake system by applying only minimum clocks to the busses and peripherals.

5.6.1 System Sleep Mode Handling

The Power Saving Driver (PSV) orders the system to enter sleep mode, if

- Enough TDMA frames without scheduled air interface activity
- System sleep is not disabled by any driver

Wake-up will occur after programmed sleep time elapsed or at external wake-up event

Events that happen during sleep phase are:

- DSP is ordered to enter idle mode;
- Parts of the system are powered down;
- ARM CPU is brought into wait-for-interrupt mode;
- Base band chip is clocked with 32 kHz standby clock.

ARM idle loop enters whenever the operating system gets idle. In this state the following events happens:

- Reduces CPU frequency to 6.5 MHz, 52 MHz or 104 MHz:
 - CPU frequency setting depends on pending DMA transfers that require a minimum clock frequency on the AHB bus (clk_ahb and clk_arm are derived from same clock source);
- If no DMA transfer is ongoing the SDRAM is put into self-refresh and the EBU clock is switched off;
- ARM is ordered into Wait-For-Interrupt State;
- Wake up will occur on any interrupt.

5.7 SMS

SMS Classes that are supported by TM3 Data Module are 0, 1, 2 and 3. Mobile-originated as well as mobile-terminated SMS are supported. Others SMS features that are implemented in TM3 Data Module are reported in the following:

- SMS-CB Cell Broadcast (SMS CB);
- Concatenated SMS;
- Text and PDU mode are supported.
- Reception of SMS during circuit-switched calls;
- Reception of SMS via GSM or EGPRS;
- Voice Message;
- Sending of message delivery report;
- Message validity period support;
- Support of Reply Path (MT+MO);
- SMS SIM storage is provided.

6 User Interfaces

6.1 RF Antenna Connector

A 50 Ohm MMCX connector is provided as antenna connector for GSM/EGPRS functionalities. To connect the Data Module with an antenna with a SMA connector an antenna adapter MMCX/SMA is provided with the Deliverable Package. The two types of connector mounted on antenna adapter are MMCX male and SMA female.

6.2 Board-to-Board Connector

A 80-pin connector is provided to interface of TM3 module for the power supply, SIM interface, audio interface (2 x analog, 1x digital), I2C bus, SPI bus, 2 x analog in (ADC), 2 UART serial ports, and 30 GPIOs (maximum number).

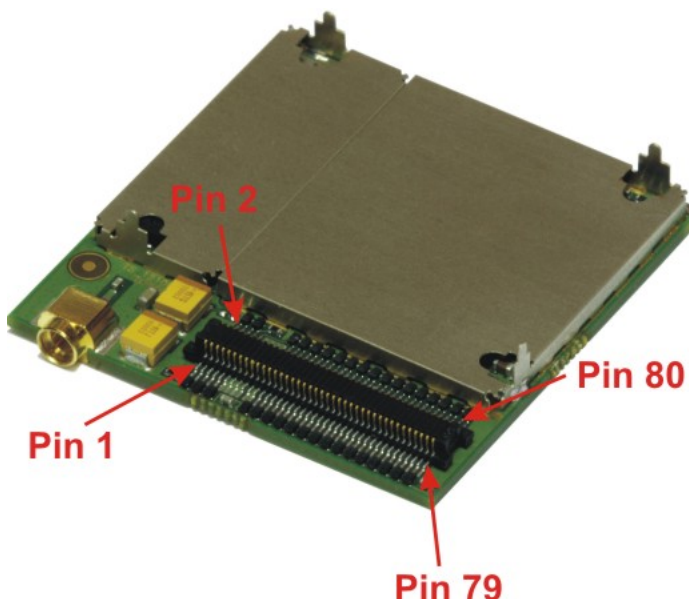


Figure 6-1: B2B connector pin localization

PIN #	Name	I/O	Function	I/O type	Description
1	GPIO_27	I/O	GPIO	Generic digital signal	GPIO 27
2	GPIO_35	I/O	I2S1_CLKO	Generic digital signal	AP_RESET
3	GPIO_25	I/O	GPIO	Generic digital signal	GPIO 25
4	GPIO_102	I/O	GPIO	Generic digital signal	None
5	GPIO_93	I/O	GPIO	Generic digital signal	GPIO 93
6	GPIO_36	I/O	I2S1_RX	Generic digital signal	I2S1_RX
7	GPIO_94	I/O	GPIO	Generic digital signal	GPIO 94
8	GPIO_37	I/O	I2S1_TX	Generic digital signal	I2S1_TX
9	GPIO_95	I/O	GPIO	Generic digital signal	GPIO 95
10	GPIO_38	I/O	I2S1_WAO	Generic digital signal	I2S1_WAO
11	VBAT	PWR	GSM Power Supply	Module Supply	Should be connected with pins 13, 15, 17
12	GND	PWR	GSM Power Supply	Ground	Should be connected with pins 14, 16, 18
13	VBAT	PWR	GSM Power Supply	Module Supply	Should be connected with pins 11, 15, 17
14	GND	PWR	GSM Power Supply	Ground	Should be connected with pins 12, 16, 18

PIN #	Name	I/O	Function	I/O type	Description
15	VBAT	PWR	GSM Power Supply	Module Supply	Should be connected with pins 11, 13, 17
16	GND	PWR	GSM Power Supply	Ground	Should be connected with pins 12, 14, 18
17	VBAT	PWR	GSM Power Supply	Module Supply	Should be connected with pins 11, 13, 15
18	GND	PWR	GSM Power Supply	Ground	Should be connected with pins 12, 14, 16
19	VCHARGE	PWR	GSM Power Supply	Module Charge	Should be connected with pin 21
20	DCD	O	Asynchronous Serial Interface 0	Generic digital signal	Data Carrier Detect
21	VCHARGE	PWR	GSM Power Supply	Module Charge	Should be connected with pin 19
22	DTR	I	Asynchronous Serial Interface 0	Generic digital signal	Data Terminal Ready
23	SIM_VCC	PWR	SIM interface	SIM Supply	SIM power supply
24	CTS_0	I	Asynchronous Serial Interface 0	Generic digital signal	RTS (DCE)
25	SIM_IO	I/O	SIM interface	SIM interface signal	SIM I/O serial data
26	RTS_0	O	Asynchronous Serial Interface 0	Generic digital signal	CTS (DCE)
27	SIM_CLK	O	SIM interface	SIM interface signal	SIM clock signal
28	RXD_0	I	Asynchronous Serial Interface 0	Generic digital signal	RX (DCE)
29	SIM_RST	O	SIM interface	SIM interface signal	SIM reset signal
30	TXD_0	O	Asynchronous Serial Interface 0	Generic digital signal	TX (DCE)
31	MRST0	I/O	Synchronous Serial Interface (SPI compatible)	Generic digital signal	Master Receive Slave Transmit
32	RI	O	Asynchronous Serial Interface 0	Generic digital signal	Ring Indicator
33	MTSR0	I/O	Synchronous Serial Interface (SPI compatible)	Generic digital signal	Master Transmit Slave Receive
34	DSR	O	Asynchronous Serial Interface 0	Generic digital signal	Data Set Ready
35	SCLK0	I/O	Synchronous Serial Interface (SPI compatible)	Generic digital signal	Shift Clock
36	RXD_1	I	Asynchronous Serial Interface 1	Generic digital signal	RX (DCE)
37	SCL	O	I2C bus interface	Generic digital signal	Serial Clock Line
38	TXD_1	O	Asynchronous Serial Interface 1	Generic digital signal	TX (DCE)
39	SDA	I/O	I2C bus interface	Generic digital signal	Serial Data Line
40	KEYOUT0	I/O	Keypad interface / GPIO	Generic digital signal	Keypad output pin 0 / GPIO 07
41	CLK0_DAI	I/O	Digital Audio Interface	Generic digital signal	DAI Clock
42	KEYOUT1	I/O	Keypad interface / GPIO	Generic digital signal	Keypad output pin 1 / GPIO 08
43	RXD_DAI	I	Digital Audio Interface	Generic digital signal	DAI Receive
44	KEYOUT2	I/O	Keypad interface / GPIO	Generic digital signal	Keypad output pin 2 / GPIO 09
45	TXD_DAI	O	Digital Audio Interface	Generic digital signal	DAI Transmit
46	KEYOUT3	I/O	GPIO	Generic digital signal	GPIO 10

PIN #	Name	I/O	Function	I/O type	Description
47	WA0_DAI	I/O	Digital Audio Interface	Generic digital signal	DAI Reset
48	KEYOUT4	I/O	USART1_RTS	Generic digital signal	GPIO 18
49	EXTRSTn	I	External reset	Generic digital signal	External HW reset
50	KEYOUT5	I/O	USART1_CTS	Generic digital signal	GPIO 19
51	MIC_GND1	I	Audio Interface	Analog signal	Handset microphone reference (-)
52	KEYIN0	I/O	Keypad interface / GPIO	Generic digital signal	Keypad input pin 0 / GPIO 00
53	MIC_BIAS1	I	Audio Interface	Analog signal	Handset microphone bias (+)
54	KEYIN1	I/O	Keypad interface / GPIO	Generic digital signal	Keypad input pin 1 / GPIO 01
55	EPPA1B	O	Audio Interface	Analog signal	Balanced audio out
56	KEYIN2	I	Keypad interface / GPIO	Generic digital signal	GPIO 02
57	EPPA2A	O	Audio Interface	Analog signal	Balanced audio out
58	KEYIN3	I/O	Keypad interface / GPIO	Generic digital signal	Keypad input pin 3 / GPIO 03
59	MIC_GND2	I	Audio Interface	Analog signal	Headset microphone reference (-)
60	CAP19	I/O	GPIO	Generic digital signal	GPIO 53
61	MIC_BIAS2	I	Audio Interface	Analog signal	Headset microphone bias (+)
62	CAP02	I/O	GPIO	Generic digital signal	GPIO 50
63	AUOP	O	Audio Interface	Analog signal	Balanced power audio out
64	CAP05	I/O	GPIO	Generic digital signal	GPIO 90
65	AUON	O	Audio Interface	Analog signal	Balanced power audio out
66	CAP06	I/O	GPIO	Generic digital signal	GPIO 88
67	ADC1	I	Measurement interface	ADC 12bits 0-2 V	Analog to Digital Converter
68	CAP00_EX5IN	I	External Interrupt	Generic digital signal	Ext Int 5B
69	ADC2	I	Measurement interface	ADC 12bits 0-2.5 V	Analog to Digital Converter
70	CAP22_EX3IN	I	Headset Detect	Generic digital signal	Headset Detect
71	USB_D+	I/O	USB interface signal	USB interface signal	D+ pin of USB interface
72	GPIO_24	I/O	GPIO	Generic digital signal	GPIO 24
73	USB_D-	I/O	USB interface signal	USB interface signal	D- pin of USB interface
74	GPIO_30	I/O	GPIO	Generic digital signal	GPIO 30
75	VBUS	PWR	USB interface supply	USB supply	Supply of USB interface
76	GPIO_23	I/O	GPIO	Generic digital signal	GPIO 23
77	GPIO_26	I/O	GPIO	Generic digital signal	GPIO 26
78	GPIO_91	I/O	GPIO	Generic digital signal	GPIO 91
79	GPIO_96	I/O	GPIO	Generic digital signal	GPIO 96
80	GPIO_92	I/O	GPIO	Generic digital signal	GPIO 92

TM3 Data Module is mechanical compatible with 60-pin Board-to-Board Connector CBRB060PA2000R0. In this case pin numbers that are available goes from 11 to 70 and USB interface is not available.

Note!! If the pin is unconnected it can be left floating.

6.2.1 Switching on of the data module

To switch on the data module the pin 56 KEYIN2/ON must be used; this pin must be connected. This pin is connected with the ON button of the mother board.

Name	PIN #	I/O	I/O type	Description
KEYIN2	56	I	Generic digital signal	Power on button

Pin 56 has the electrical characteristics of a generic digital signal and TM3 Data Module has a tolerant circuit against voltages greater than 3.3 Volts.

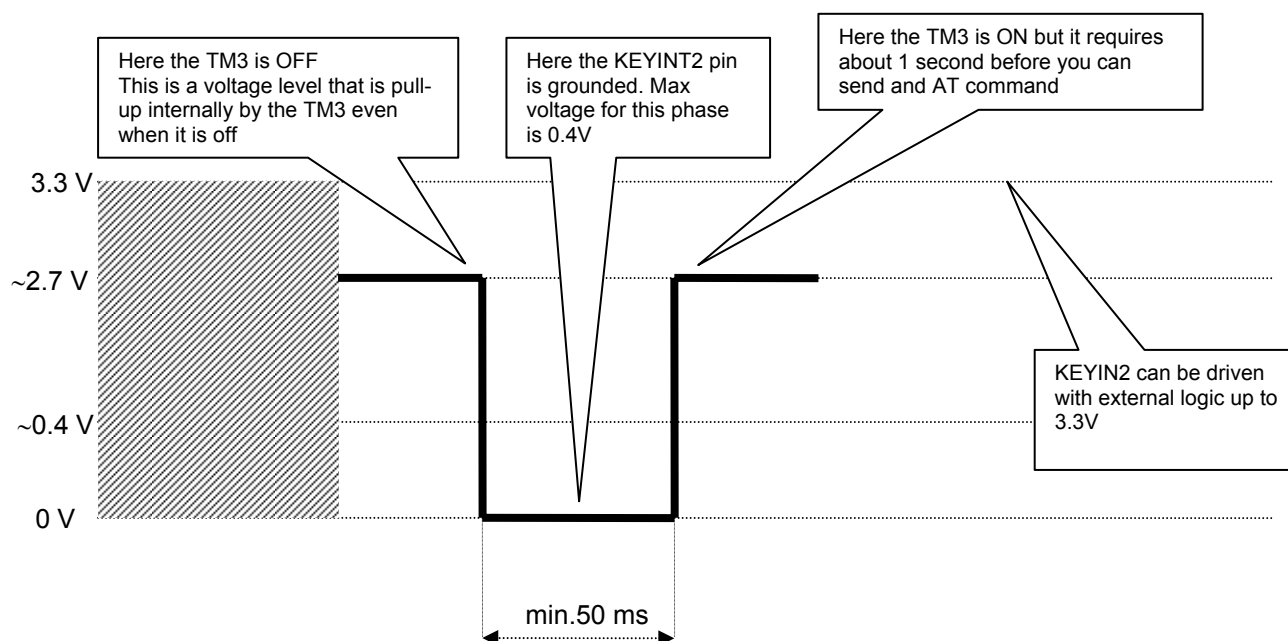


Figure 6-2: Power-on KEYIN2 timings

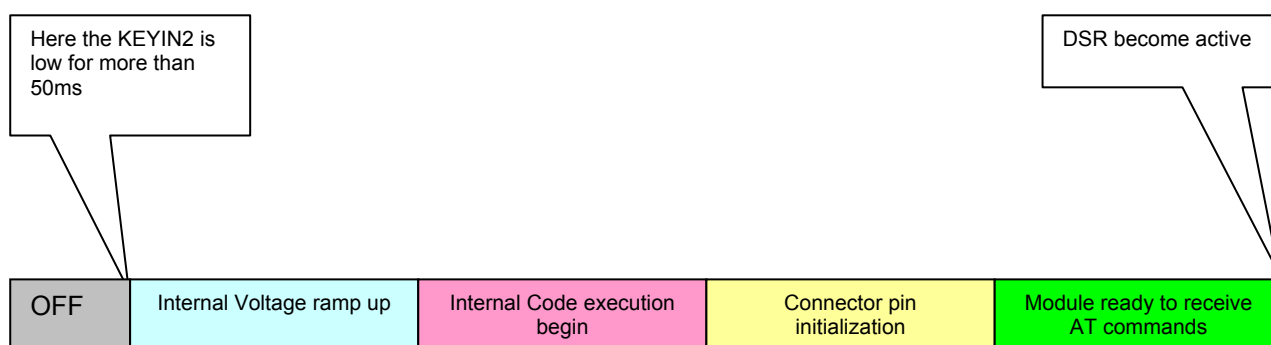


Figure 6-3: Power on phases

6.2.2 SIM Interface

TM3 Data Module can handle a SIM Card; the module can be used with an on-board SIM connector or an external SIM connector. High-speed SIM/ME interface is implemented as well as the automatic detection of the required SIM supporting voltage.

Both 1.8V and 3V SIM type are supported (1.8/3V ME); activation and deactivation with automatic voltage switch from 1.8V to 3V are implemented, according to ISO-IEC 78-16-e Specifications. The SIM driver supports the PPS (Protocol and Parameter Selection) procedure for baud-rate selection, according to the values proposed by the SIM Card. Clock stop is supported at both high and low level.

Finally, external SIM ESD protection is required.

The description of pins of the Board-to-Board connector related to SIM interface is reported in the following:

Name	PIN #	I/O	I/O type	Description
SIM_VCC	23	PWR	SIM Supply	SIM Power Supply
SIM_IO	25	I/O	SIM interface signal	SIM I/O Serial Data
SIM_CLK	27	O	SIM interface signal	SIM Clock Signal
SIM_RST	29	O	SIM interface signal	SIM Reset Signal

6.2.2.1 SIM Functionality

Among SIM functionalities, the following services of the SIM are supported:

- Abbreviated Dialing Numbers (ADN);
- Fixed Dialing Numbers (FDN);
- Last Dialed Numbers (LDN);
- Service Dialing Numbers (SDN);
- ME Personalization (SIM Lock).

ME Personalization handling is a mechanism to tie the ME operation to one specific SIM card or to a limited range of SIM cards from a given Network Operator or Service Provider. The ME will only accept the SIM if there is a positive match between the personalization code group(s) stored in the ME and the code group(s) belonging to the inserted SIM.

The SIM Lock feature supported by TM3 GSM/GPRS/EDGE module enables ME personalization through the following personalization categories:

- Network lock;
- Network subset lock;
- Service provider lock;
- Corporate lock;
- Operator lock.

SIM Toolkit R 99 is supported.

6.2.3 Serial Interfaces

TM3 Data Module offers to the user the possibility to use two serial ports (through the mother board) complying with ITU V.24 protocol Default baud rate is 115.2 Kbps; data rate maximum is 920 Kbps.

The serial ports differ for the following features:

- ASC0:
 - Complete 9-pin serial port;
 - Mux protocol (3GPP TS 27.010);
 - Power saving available;
 - Interface (present on the mother board) is fully RS232 9-pin compliant;
 - HW flow control supported;
 - Used for AT interface.
- ASC1:
 - 2 available lines (RXD and TXD);
 - Used for debug and tracing;
 - No Hardware flow control supported;
 - Optionally can be provided RTS and CTS signal together with RXD and TXD.

The available signals for ASC0 are:

- TX Data (TXD_0);

- RX Data (RXD_0);
- Request to Send (RTS_0);
- Clear to Send (CTS_0);
- Data Terminal Ready (DTR);
- Data Set Ready (DSR).

The design of the data module is done to use the data module as a DCE, while the application will be a DTE. Hence with the signal RXD_0 and RXD_1 the data module will receive the data send by the DTE, while with TXD_0 and TXD_1 the data module will transmit the data to the DTE.

In the table reported below are described the pins of the board-to-board connector of the serial ports:

Name	PIN #	I/O	I/O type	Description	Serial interface #
DCD	20	O	Generic digital signal	Data Carrier Detect	Asynchronous Serial Interface 0
DTR	22	I	Generic digital signal	Data Terminal Ready	
CTS_0	24	I	Generic digital signal	RTS (DCE)	
RTS_0	26	O	Generic digital signal	CTS (DCE)	
RXD_0	28	I	Generic digital signal	RX (DCE)	
TXD_0	30	O	Generic digital signal	TX (DCE)	
RI	32	O	Generic digital signal	Ring Indicator	
DSR	34	O	Generic digital signal	Data Set Ready	Asynchronous Serial Interface 1
RXD_1	36	I	Generic digital signal	RX (DCE)	
TXD_1	38	O	Generic digital signal	TX (DCE)	

For more details on serial port refer to chapter A.2.

6.2.3.1 Mux

TM3 has integrated the MUX functionality supported by 3GPP TS 27.010 multiplexer protocol. It is a data link protocol (layer 2 of OSI model) which uses HDLC-like framing, virtual data channels and channels' control procedures. The MUX protocol can run over a physical link (e.g. UART) existing between the wireless modem and an application processor (embedded system or PC). This functionality allows user applications to access the GSM/GPRS modem stack in concurrent way by emulating virtual communication channels.

The MUX process is responsible for:

- Control of virtual channels;
- Conveying user data over virtual channels.

Mux protocol 3GPP TS 27.010 is implemented only on ASC0 serial port.

6.2.4 USB interface

TM3 Data Module supports USB interface that fulfills USB V. 2.0 specification for full-speed (12 Mbps) devices. Moreover USB interface supports also the USB OTG standard. The profile that is supported is Modem profile while Mass Storage profile is optional.

Name	PIN #	I/O	I/O type	Description
USB_D+	71	I/O	USB interface signal	D+ pin of USB interface
USB_D-	73	I/O	USB interface signal	D- pin of USB interface
VBUS	75	I/O	USB interface supply	Supply of USB interface

6.2.5 GPIO

All General Purpose I/O (GPIOs) shall be initialized to proper direction / output logic level as soon as possible. If supply is removed from external device, relevant GPIOs should be placed at low logic level, or decoupled.

Name	PIN #	I/O	I/O type	Description
GPIO_27	1	I/O	Generic digital signal	GPIO 27
I2S1_CLK0	2	I/O	Generic digital signal	I2S1_CLK0
GPIO_25	3	I/O	Generic digital signal	GPIO 25
GPIO_102	4	I/O	Generic digital signal	None
GPIO_93	5	I/O	Generic digital signal	GPIO 93
I2S1_RX	6	I/O	Generic digital signal	I2S1_RX
GPIO_94	7	I/O	Generic digital signal	GPIO 94
I2S1_TX	8	I/O	Generic digital signal	I2S1_TX
GPIO_95	9	I/O	Generic digital signal	GPIO 95
I2S1_WAO	10	I/O	Generic digital signal	I2S1_WAO
KEYOUT0	40	I/O	Generic digital signal	Keypad output pin 0 / GPIO 07
KEYOUT1	42	I/O	Generic digital signal	Keypad output pin 1 / GPIO 08
KEYOUT2	44	I/O	Generic digital signal	Keypad output pin 2 / GPIO 09
KEYOUT3	46	I/O	Generic digital signal	GPIO 10
KEYOUT4	48	I/O	Generic digital signal	GPIO 18
KEYOUT5	50	I/O	Generic digital signal	GPIO 19
KEYIN0	52	I/O	Generic digital signal	Keypad input pin 0 / GPIO 00
KEYIN1	54	I/O	Generic digital signal	Keypad input pin 1 / GPIO 01
KEYIN2	56	I/O	Generic digital signal	GPIO 02
KEYIN3	58	I/O	Generic digital signal	Keypad input pin 3 / GPIO 03
CAP19	60	I/O	Generic digital signal	GPIO 53
CAP02	62	I/O	Generic digital signal	GPIO 50
CAP05	64	I/O	Generic digital signal	GPIO 90
CAP06	66	I/O	Generic digital signal	GPIO 88
GPIO_24	72	I/O	Generic digital signal	GPIO 24
GPIO_30	74	I/O	Generic digital signal	GPIO 30
GPIO_23	76	I/O	Generic digital signal	GPIO 23
GPIO_26	77	I/O	Generic digital signal	GPIO 26
GPIO_91	78	I/O	Generic digital signal	GPIO 91
GPIO_96	79	I/O	Generic digital signal	GPIO 96
GPIO_92	80	I/O	Generic digital signal	GPIO 92

In the case that 60-pin board-to-board connector is mounted the number of available GPIOs interfaces is 13.
In the case that USB port is not supported then the number of GPIO interface will be 33. In this case pins usually dedicated to USB port are used as GPIO interfaces.

6.2.6 ADC interface / Measurement interface

2 inputs for Analog-to-Digital Converter are supported. The resolution of these converters is of 12-bit with a range of:

- 0 - 2.5 Volts ADC2 converter;
- 0 - 2 Volts for ADC1 converter.

Name	PIN #	I/O	I/O type	Description
ADC1	67	I	ADC 12 bits 0 – 2 Volts	Analog to Digital Converter
ADC2	69	I	ADC 12 bits 0 – 2.5 Volts	Analog to Digital Converter

6.2.7 SPI

The SPI bus includes a clock signal, and two signals for the transmissions of the master and the slave.

Name	PIN #	I/O	I/O type	Description
MRST0	31	I/O	Generic digital signal	Master Receive Slave Transmit
MTSR0	33	I/O	Generic digital signal	Master Transmit Slave Receive
SCLK0	35	I/O	Generic digital signal	Shift Clock

SPI interface are available to the user only if M2M Software Package is integrated on the data module.

6.2.8 I2C bus interface

The I2C bus interface includes a serial clock and a serial data line.

Name	PIN #	I/O	I/O type	Description
SCL	37	O	Generic digital signal	Serial Clock Line
SDA	39	I/O	Generic digital signal	Serial Data Line

I2C bus interface are available to the user only if M2M Software Package is integrated on the data module.

6.2.9 Electrical Characteristics of Board-to-Board connector pins

6.2.9.1 Absolute maximum ratings for input supply/power voltages

I/O type	Name	Min	Max
Module Supply	VBAT	-0.3 V	5.5 V
Module Charge	VCHARGE		12.5 V
USB Supply	VBUS		5.5 V

Stresses above those listed here may cause permanent damage to the device. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

6.2.9.2 Absolute maximum ratings for input signal voltages

I/O type	Min	Max
Generic digital signals	-0.3 V	3.6 V
SIM interface signals	-0.3 V	3.6 V
USB interface signals	-1.0 V	7.25 V
Analog signals	-0.15 V	3.0 V

Stresses above those listed here may cause permanent damage to the device. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

6.2.9.3 Operating range for input supply/power voltages

I/O type	Name	Min	Typ	Max
Module Supply	VBAT	3.5 V	3.8 V	4.2 V
Module Charge	VCHARGE	0.0 V	6.0 V	12.0 V
USB Supply	VBUS	2.0 V	5.0 V	5.5 V

6.2.9.4 Operating range for output supply/power voltages

I/O type	Name	Min	Typ	Max	Test condition
USB Supply	VBUS	4.4 V	5.0 V	5.25 V	
SIM Supply	SIM_VCC		1.80 V		VSIM = 1.80 V
			2.85 V		VSIM = 2.85 V

6.2.9.5 Operating range for input signal voltages

I/O type	Parameter	Min	Typ	Max	Test condition
Generic digital signals	L-level	-0.20 V		0.54 V	
	H-level	1.90 V		3.30 V	
SIM interface signals	L-level	0.00 V		0.36 V	VSIM = 1.80 V
		0.00 V		0.57 V	VSIM = 2.85 V
	H-level	1.26 V		3.30 V	VSIM = 1.80 V
		2.00 V		3.30 V	VSIM = 2.85 V
USB interface signals	Differential Input Sensitivity	0.20 V			$ V(USB_D+) - V(USB_D-) $
	Differential Common Mode Range	0.80 V		2.50 V	Range of Sensitivity
	Single Ended Receiver Threshold	low < 0.8 V		high > 2.0 V	

6.2.9.6 Operating range for output signal voltages

I/O type	Parameter	Min	Typ	Max	Test condition
Generic digital signals	L-level		0.00 V	0.35 V	High I_{OL}
	H-level	2.37 V	2.72 V		High I_{OH}
SIM interface signals	L-level	0.00 V		0.36 V	VSIM = 1.80 V
		0.00 V		0.57 V	VSIM = 2.85 V
	H-level	1.26 V	1.80 V	3.30 V	VSIM = 1.80 V
		2.00 V	2.85 V	3.30 V	VSIM = 2.85 V
USB interface signals	Static Output Low	0.0 V		0.3 V	
	Static Output High	2.8 V		5.0 V	

7 Reference

7.1 *Internal*

Title
[1] TM3 AT Commands Manual
[2] TM3 Features List

A.1 AT Commands examples

For more details on the syntax of AT commands refer to TM3 AT commands Manual [1]. In the following are reported more examples with AT commands; in *italic* are highlighted the commands that are written by the user.

A.1.1 Register on the Network

```

AT
OK
AT+CPIN="1234"
                                ← Insert the PIN number, if needed (you should insert the PIN of
                                your SIM card – 1234 is written as example)
OK
AT+COPS=0
                                ← Register the phone on the network
OK
AT+CREG?
                                ← Verify registration
+CREG: 0, 1

OK
AT+CSQ
                                ← Check signal intensity
+CSQ: 18,99

OK
AT+COPS?
                                ← Read operator name
+COPS: 0,0,"LT BITE GSM"

OK

```

A.1.2 Incoming Voice Call

```

AT
OK
AT+CLIP = 1
                                ← Activation of Caller line ID presentation
OK

```

Call the phone number of the SIM in the TM3 data module.

```

RING
                                ← Incoming Call

+CLIP: "+xxxxxxxxxxxxx",145,,,0
                                ← Presentation of Caller ID

RING

+CLIP: "+xxxxxxxxxxxxx ",145,,,0
ATA
                                ← Answer to Voice Call
OK

```

Talk to your caller using the headset.

```

ATH
                                ← Hang up
OK

```

A.1.3 Outgoing Voce Call

```

AT
OK
AT+CLIP = 1                                ← Activation of Caller line ID presentation
OK

ATD"+xxxxxxxxxxxxxxxxx;                   ← Outgoing voice call
OK                                           ← Voice call is accept from network

ATH                                         ← Hang up
OK

```

A.1.4 Data Call (CSD Mode)

```

AT+CBST=7,0,1                              ← set data call to 9600 RLP analog
OK
ATD"+xxxxxxxxxxxxxxxxx                     ← outgoing data call
CONNECT 9600                               ← Connect to remote analog modem
~ }#À!;!1} }4}"& }* } }%}&ú...}<□}"")({"/Ë~~ }#À!;!2} }4}"& }* } }%}&ú...}<□}"")({ "Áv~~ }#À!;!3} }4}"& }* } }%}&ú...}<□}"")({ "Œâ~ +++
OK
ATH                                         ← Hang up
OK
AT+CBST=71,0,1                            ← set data call to 9600 RLP V.110 ISDN
OK
ATD"+xxxxxxxxxxxxxxxxx                     ← outgoing data call
CONNECT 9600                               ← Connect to remote ISDN modem
~ }#À!;!Œ }4}"& }* } }%}&ú„Ej}"")({ "Kì~~ }#À!;!□ }4}"& }* } }%}&ú„Ej}"")({ " _~~ }#À!;!Ž }4}"& }* } }%}&ú„Ej}"")({ "Éâ~ +++
OK
ATH                                         ← Hang up
OK

```

A.1.5 Internet Connection in GPRS Mode

```

AT+CGATT?                                  ← Check if the module is registered to GPRS service
+CGATT: 1

OK
AT+CGDCONT=1,"IP","apn"                   ← Define the PDP context parameters
OK
AT+CGDCONT?
+CGDCONT: 1,"IP","apn","0.0.0.0",0,0

OK

```

ATD*99***1#	← Initiate the GPRS connection
CONNECT	
~ }#Ä!}!} } }2}!}\$}%Ü"}&} }*} } }#}\$Ä#kZ~ +++	← Disconnect with +++ sequence
NO CARRIER	

A.1.6 SMS Management

AT+CMGF=1	← Set the text mode as the format that will be used. To be set before of the first operation
AT+CMGS=""+xxxxxxxxxxxxxx "	← send 1st SMS
> SMS TEXT MESSAGE 0123456789<CTRL-Z>	
+CMGS: 0	
OK	
AT+CMGS=""+xxxxxxxxxxxxxx "	← send 2nd SMS
> SMS TEXT MESSAGE 0123456789<CTRL-Z>	
+CMGS: 1	
OK	
AT+CMGL	← list all incoming SMS
+CMGL:302,"REC UNREAD","",+xxxxxxxxxxxxxx ",,"05/09/27,16:40:36+08"	
SMS TEXT MESSAGE 0123456789	
OK	

A.1.7 Phonebook Management

AT+CPBR=?	← Check the available position in SIM Phonebook
+CPBR: (1-250),40,0	
OK	
AT+CPBR=1,250	← List phonebook from position 1 to 250 record
OK	
AT+CPBW=1,""+xxxxxxxxxxxxxx ",145,"RECORD 1"	← Write phonebook record to position 1
OK	
AT+CPBW=3,""+xxxxxxxxxxxxxx ",145,"RECORD 3"	← Write phonebook record to position 3
OK	
AT+CPBR=1,250	← List phonebook from position 1 to 250
+CPBR: 1,""+xxxxxxxxxxxxxx ",145,"RECORD 1"	
+CPBR: 3,""+xxxxxxxxxxxxxx ",145,"RECORD 3"	
OK	
AT+CPBR=3	← Read phonebook record 3
+CPBR: 3,""+xxxxxxxxxxxxxx ",145,"RECORD 3"	
OK	

A.2 Serial Port and Data Traffic Behavior

A.2.1 Introduction

This chapter contains explanations of the procedures performed by TM3 data module needed to establish and terminate:

- GPRS data traffic, so called IP relaying in context activation;
- GSM Circuit Switched data traffic.

The chapter focuses about the behaviour of the serial port (UART) in the previous two scenarios both like character data traffic and signal lines status.

Another behaviour of serial signal lines is described for power saving conditions and software reset.

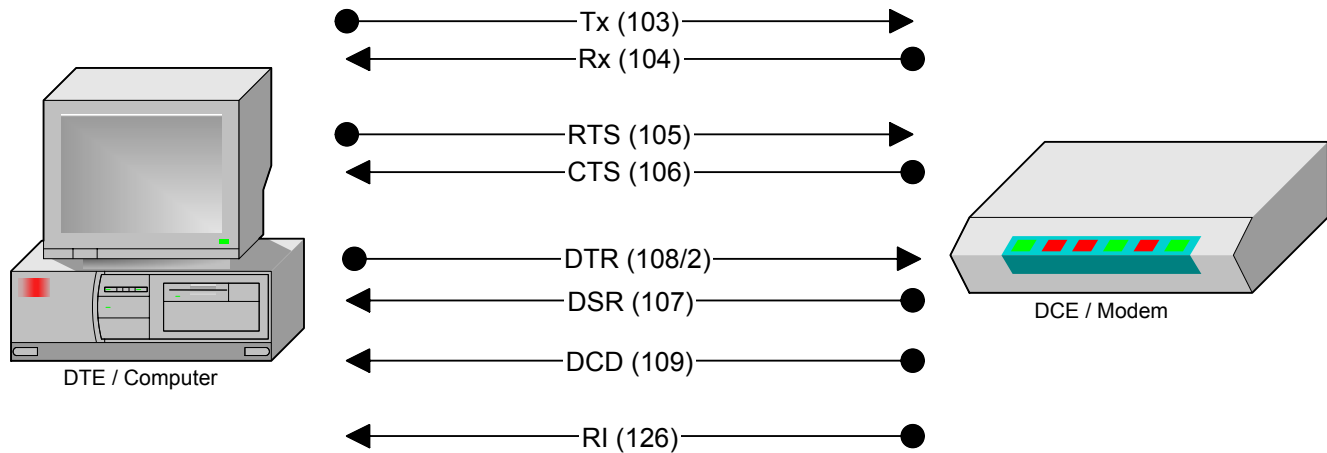
In order to establish a data communication between the module, attached to an external Data Terminal Equipment (like a PC or an application processor for embedded systems), and a remote server, different operations are involved as reported in ETSI/3GPP specifications 03.60, 07.07, 07.60, 09.61. Since any specification looks at its own scope, in this document is reported an overview of all of the interacting operations necessary to establish a data communication, both GPRS and GSM Circuit Switched, with the behaviour of the serial port (UART) in the different stages. The GPRS traffic is Internet Protocol IP based i.e. it is a packet traffic. The CSD traffic is byte raw over a dedicated GSM channel.

A.2.2 AT command mode at the startup

As default, the module starts with the serial port 0 in AT command mode (the behavior can be software configured with different services at the serial port, this is out of the scope of this document).

The user can provide AT commands in conformance with in the internal document [11] and ETSI/3GPP [3,7] specifications.

The module is a Data Communication Equipment (DCE), a modem, in conformance with the [8,9,10] specifications i.e in this document the next serial line convention is used:



Serial lines at the startup are:

Circuit 107, DSR: ON

Circuit 106, CTS: ON

Circuit 109, DCD: OFF

Circuit 126, RI: OFF

Circuit 108/2 DTR is relevant when the module is in data traffic only

Circuit 105 RTS is continuously monitored i.e. the flow control is usually hardware like default (AT&K3).

Please note:

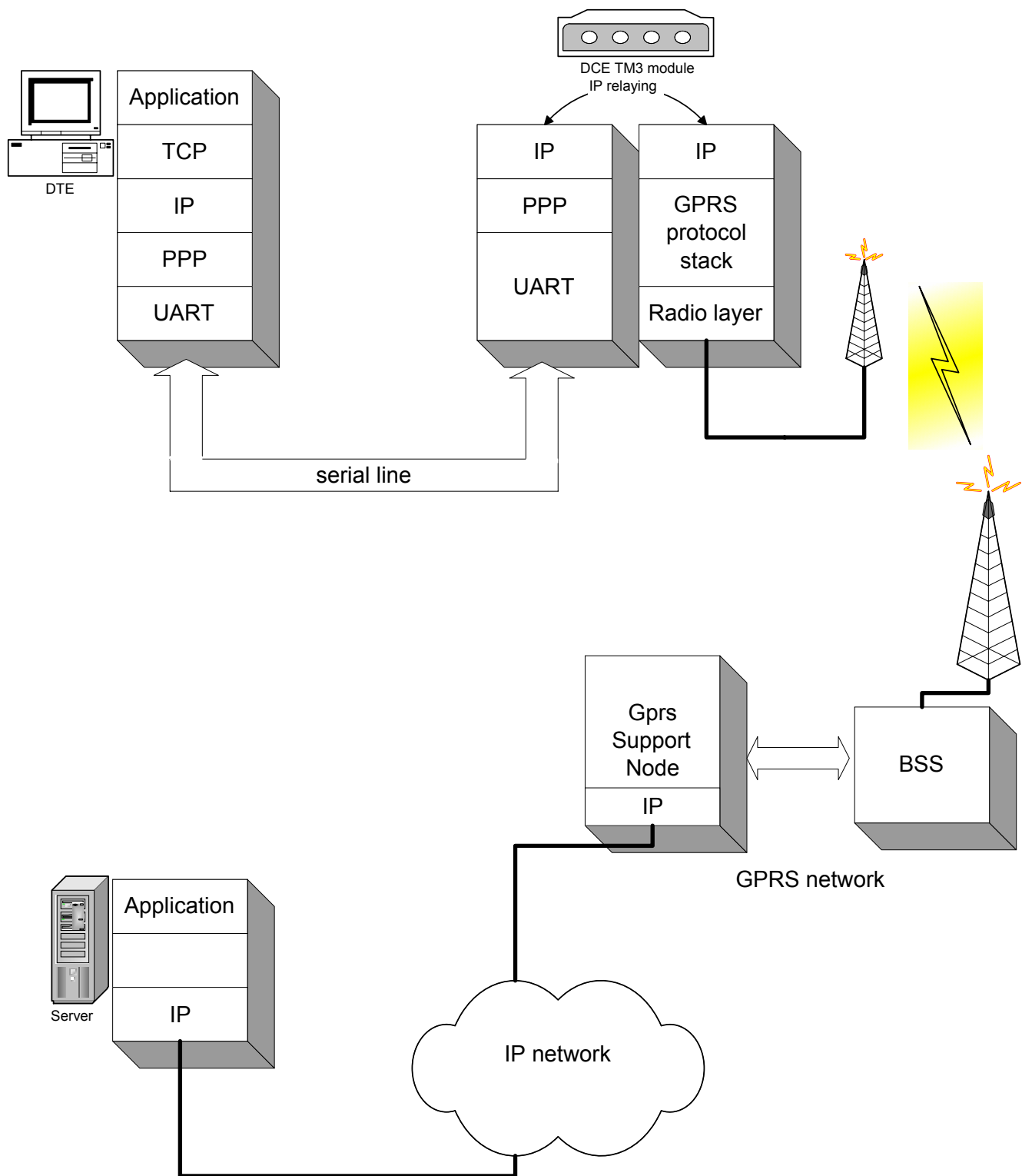
- The CTS line is synchronized with the module power saving to prevent the DTE to deliver characters if the module cannot receive them. If the power saving is let enabled without the hardware flow control, the chars delivered by the DTE can be lost.

A.2.3 GPRS data communication

A.2.3.1 Introduction to the GPRS IP relaying architecture

A GPRS data communication is done in the IP-relaying mode as described in [2,4,5] i.e. the data sent to the module through the serial port by a DTE, have to be IP packets put into PPP frames. IP packets are generated by an application on the DTE and should follow rules of a TCP/IP stack; in order to understand TCP/IP architecture and application sockets, a complete discussion can be found in [1].

The module extracts IP fragments from the PPP frames and delivers them through the GPRS infrastructure as the next diagram reports:



IP Packets are delivered to an Application Server which is attached to a Packet Data Network IP based. To establish the IP packet transfer the module requires context activation to the GPRS network [2]

A.2.3.2 Context activation

In order to perform context activation, context info should be stored by the module. Context info are managed by the module with the AT+CGDCONT, AT+CGQMIN, AT+CGQREQ commands, see [11] for a detail reference. Usually the AT+CGDCONT=1,"IP","provider.apn.xx" is sufficient but be sure to have all of the necessary context info from the GPRS provider.

A DTE application like the Windows "dial-up" (or Linux pppd) establishes the PPP traffic, and let the Windows TCP/IP stack to be able to prepare IP packets over PPP.

Before activating the PPP protocol (data plane) a dial-up application has to provide the ATD*99***<context_number># to the module: with this command the module switches from the AT command plane to the PPP data plane and can accept PPP packets. The module puts the DCD line to the ON state, then answer with a *CONNECT* to confirm the ATD*99 command. Please note that the DCD ON is not in relationship with the context activation but with the PPP data plane.

It is then **mandatory for the DTE to start the PPP negotiation** with the module; context is not active after the *CONNECT* string! During the PPP negotiation the context activation through the network is done by the module which follows ETSI/3GPP GPRS specifications in [2,4,5]. Note: the PPP has a local scope, DTE-DCE only; DCE-network traffic is GPRS protocol based with IP packets!

When the PPP link is established the IP data traffic can be done if the DTE properly delivers IP packets to the module (in PPP frames through the serial line). Pay attention! It is not possible for a DTE to deliver raw info without the IP/PPP envelope... this way of functionality is different to the GSM data traffic which will be described in next sections.

Summary of the context activation operations:

- DTE sends context info with AT+CGDCONT=<context_number>...
- DTE sends ATD*99***<context_number>#
- DCE sets the serial line DCD ON
- DCE answer with *CONNECT* (or *ERROR* if something goes wrong)
- DTE starts PPP negotiation
- DCE deals with DTE PPP
- DCE requires context activation to the network
- Network activates the context and assign an IP address to the module
- DCE sends the IP network address to the DTE in order to make the DTE part of the IP network
- DTE acknowledges the IP address and consider PPP link UP
- DCE PPP link is UP
- DTE sends IP packets to the DCE in order to be delivered to a remote IP server
- DCE sends to the DTE packets received from the network (from remote IP servers)
- This DTE-DCE communication can continue indefinitely

A.2.3.3 Context deactivation

Deactivation of the context permits to switch off the IP relaying phase (the IP data traffic) and the module can return to the AT command mode.

When the IP data traffic is established the deactivation is possible:

1. from user, the DTE follows at least one of the next actions:
 - a. sends a PPP packet called LCP termination request (Windows O.S. and Linux pppd follows this strategy);
 - b. sends a +++ after a complete PPP packet (where complete means that it is terminated with the ~ char, 0x7e);
 - c. puts the circuit 108/2, DTR from ON to OFF;
2. from the network, the module takes the next actions in sequence:
 - a. sends the PPP packet LCP termination request;
 - b. puts the CD to the OFF state after the LCP termination acknowledge from the DTE or after a timeout if the DTE does not take actions;
 - c. sends *NO CARRIER* string to the DTE;

Please note:

1. The smart way to perform a context deactivation by the user DTE is through the PPP LCP termination packet. The DTR ON to OFF transition usually is the last chance if the PPP daemon in the DTE blocks for different reasons.
2. O.S. like Windows ignores the CD line if it does not switch from OFF to ON (or it is ON from the poweup) i.e. the context activation can be done anyway without this line too. Other O.S. like Linux can ignore this line anyway.

A.2.4 GPRS On line command mode

A special meaning of the &D value is provided in the module for the ~+++ sequence during a GPRS data transfer (this is outside the specification [4,8,9] scope). The ~+++ lead to a context deactivation during a GPRS data transfer session for the AT&D0, AT&D1 values (please note that the +++ return to on-line command mode is provided for each &D value during a CSD data call [8,9]).

A different implementation for the ~+++ is done with the &D2 value: GPRS data transfer is escaped and system returns in the on-line command state. The ~ character is mandatory before the +++ sequence for the GPRS data transfer escaping, please note the slight difference in comparison with the CSD data call escaping.

Please note that the ~+++ command can be used when the PPP is established, unpredictable result are reported if it is used after the *CONNECT* string before the PPP is established. The ATO command is used to resume the GPRS data transfer session.

During the on-line command mode different AT commands can be sent but some limitations are present:

- data calls in GPRS on-line command mode cannot be granted (please activate the AT+CRC=1 mode in order to identify the kind of call and reject data incoming calls if GPRS is in the on-line command mode);
- the MUX functionalities cannot be used in cooperation with the GPRS on-line command mode.

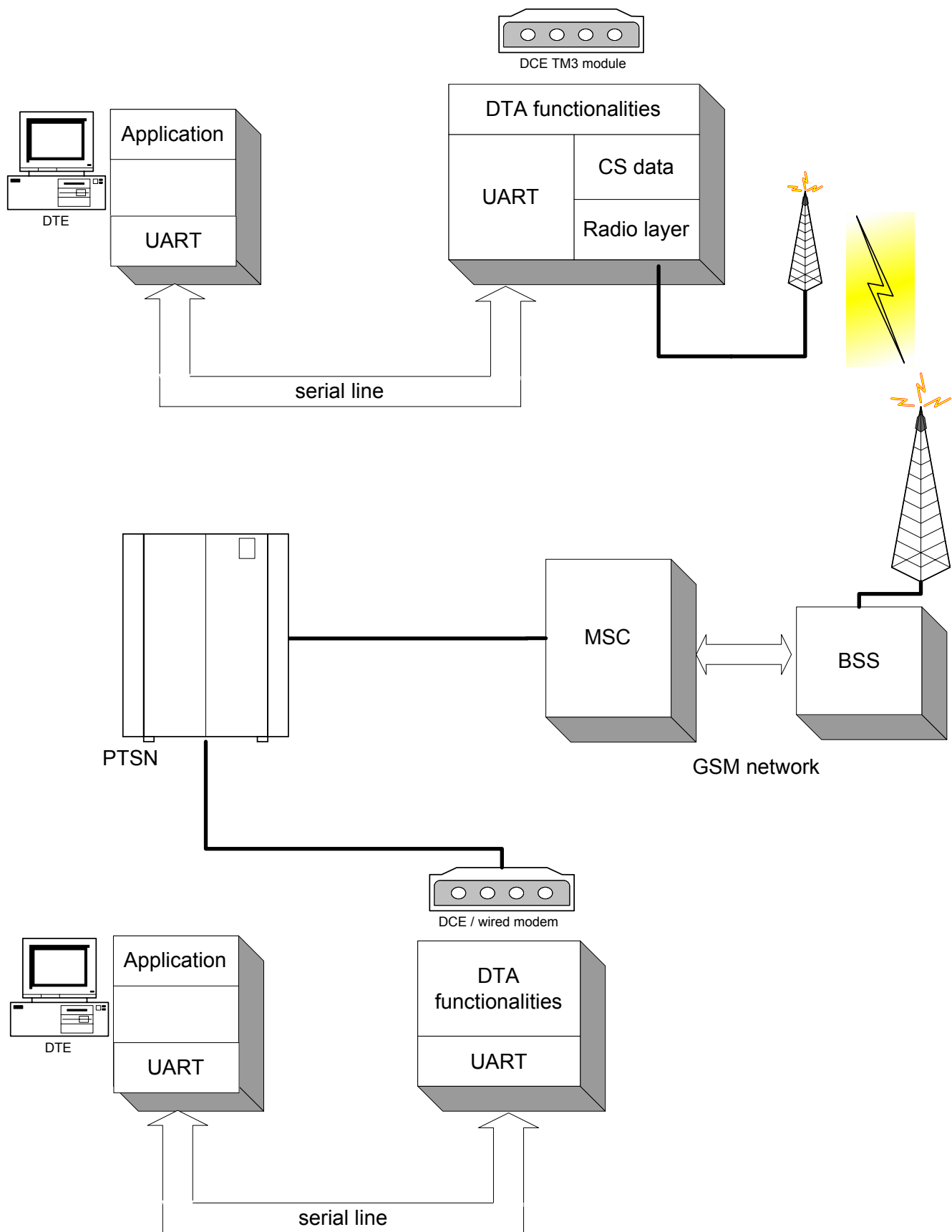
An important note about how to use this feature. A Windows dial-up application which is using a DTE serial port cannot send by itself a ~+++ sequence i.e. this kind of feature has not been thought for standard usage. Please note that some customers provide specific implementations (not necessary in the Windows environment) to send ~+++ at the same serial port of the dial-up application or they use an external hardware to multiplex two different DTE serial ports attached to the same module port!

Anyway for experimental purposes, to check this behaviour with a DTE, an hyperterminal application can send a ~+++ on a different serial port than the dial-up one. Switch by hand the cable from the dial-up associated serial port to the hyperterminal port. Send the ~+++ , an OK is the module answer, then AT commands can be delivered to do different operations. At the end type ATO, a *CONNECT* is received, switch back again to the dial-up port and the Internet data traffic can be resumed by the DTE.

A.2.5 CSD data calls

A.2.5.1 Outgoing data calls

To establish a data call the DTE can send the ATD<number> command to the module which sets an outgoing data call to a remote modem (or another data module). Data can be transparent (non reliable) or non transparent (with the reliable RLP protocol). The settings for the two kinds of data are outside the scope of this guide, see internal reference [11]. The next diagram represents the architecture for a CSD data call.



When the remote DCE accepts the data call, the module DCD line is set to ON and the *CONNECT <communication baudrate>* string is returned by the module. At this stage the DTE can send characters through the serial line to the data module which sends them through the network to the remote DCE attached to a remote DTE. The remote DTE application can take the characters and reply. The communication can proceed indefinitely.

If the remote DCE is an entry point of an internet provider, PPP packets are expected from the DTE attached to the module. Please note that PPP packets are delivered like a raw char stream from DTE through the data module to the remote DCE i.e. the data architecture is totally different than the GPRS one, in which the data module extracts the IP packets from the DTE PPP and forwards them through the GPRS IP network to a remote IP server.

The CS data plane can be escaped through the +++ sequence as requested by [8,9] spec. The AT command plane is resumed without cleardown call; we can refer to it as AT on-line command mode. Please note that the DCD line is ON both in the AT on-line command plane and data plane.

In the AT on-line command mode the user can clear the call with an ATH command (DCD changes from ON to OFF) or resume the data plane through an ATO command, the module answers with *CONNECT* again.

If the remote peer closes the call the DCD changes from ON to OFF and the *NO CARRIER* string is put on the serial port.

Summary of a CSD outgoing data call:

- DTE sets the type of data requested to the DCE (through specific AT commands like AT+RLP, see [11])
- DTE sends ATD<remote DCE number>
- DCE establishes a call with the remote DCE through the GSM network
- Remote DCE accepts the call
- DCE sets serial line DCD ON
- DCE sends *CONNECT* <communication baudrate> to the DTE
- DTE sends any character
- Remote DCE receives characters through the GSM network and delivers them to the remote DTE
- Remote DTE receives characters and delivers its characters to the remote DCE
- Remote DCE sends character through the GSM network to the DCE
- DCE sends characters to the DTE
- DTE- remote DTE communication raw character based can continue indefinitely

Raw character stream can be a PPP packet stream i.e. IP network traffic is possible from a DTE to a remote Internet provider equipped with a DCE (which deals with the local module attached to the DTE). The provider forwards the IP packets of the DTE to the Internet to a remote IP server.

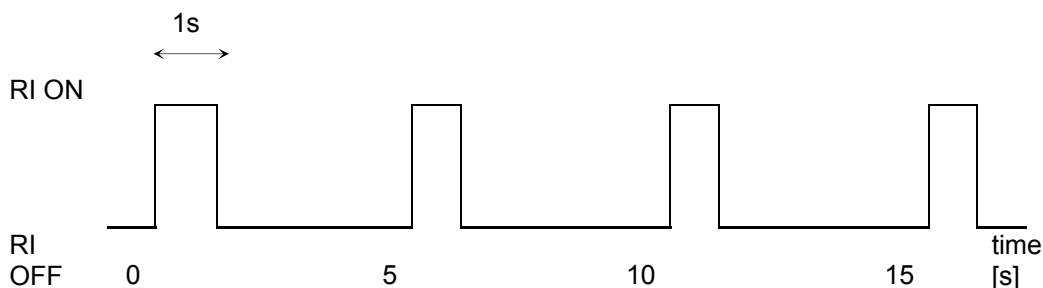
The CS call can be hang up from:

1. the user, the DTE makes one of the next operations:
 - sends ATH to the DCE in AT on-line command mode;
 - DTR transition ON to OFF with AT&D2 status (see reference [8,9] and annex 1 for a summary of the AT&D behaviour);
2. the network (or remote DCE), the DCE takes the next actions in sequence:
 - puts serial line DCD to OFF;
 - sends *NO CARRIER* string to the DTE;

A.2.5.2 Incoming data calls

The data module can accept an incoming call through the ATA command [3] (please note, commands like the AT+CRC=1 can be used to decide about the kind of call, voice or data; this is out of the scope of this document). Next operations are relevant to accept an incoming call:

1. During the incoming call the module RI line switches from OFF to ON and from ON to OFF with a duty cycle 4:1 as reported by the next figure.



2. The module sends the *RING* string to the serial port at constant time intervals not correlated with the RI ON action.
3. The DTE attached to the module sends the *ATA* string and the module accepts the incoming data call.
4. The DCE sets the serial line DCD ON.
5. The DCE sends the *CONNECT<communication baudrate>* to the DTE
6. DTE sends characters through the DCE and the GSM network to the remote DCE-DTE system and the data communication can be done like for outgoing data calls

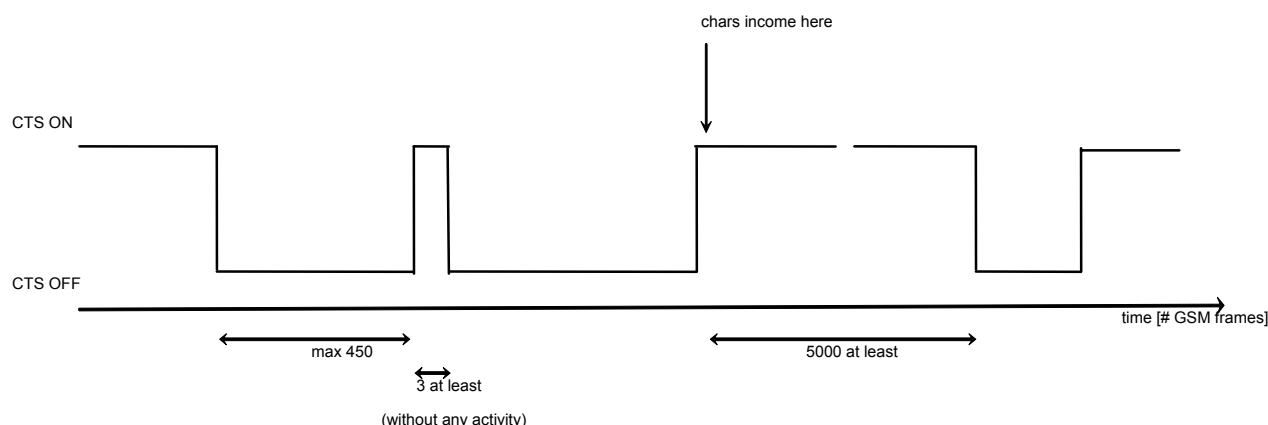
The data plane can be escaped with a +++ sequence in order to put the DCE in AT on-line command mode. AT commands can be delivered from the DTE. The ATH command is sent by the DTE to clear down call. The DTR rule is the same as for outgoing calls.

A.2.6 Power saving and CTS handshake

The CTS line is used during power saving periods in order to prevent a remote DTE to send chars to the DCE when it cannot receive. During the power saving phase the module activity is reduced and the reference clock of the system is reduced too. Under these conditions the UART cannot receive chars and the CTS line is switched to the OFF state. When the module is network attached, it periodically wakes up in order to be synchronized with the network activity; the power saving state time is in relationship with the network parameters and can be up to 450 GSM time frames (~2 s). Please note that this time is not constant, this is only a maximum time given as reference and valid when the module is attached to the network. When the module wakes-up, the CTS line is switched ON and it persists in this state at least for 3 GSM time frames (~14 ms). If the module has some network activity to do or chars are delivered at the UART port, the module remains in the operative state otherwise it comes back to the power saving conditions. When the module is outside the power saving conditions, the time amount before entering in the power saving mode is variable and it depends on parameters like:

- the kind of activity with regards to the network;
- task activity of the M2M software;
- time elapsed from the last character received at the serial port: after 5000 GSM frames (~23 s) without serial activity (chars transmitted or received), the serial drivers lets the module to go into power saving if there aren't other activities;

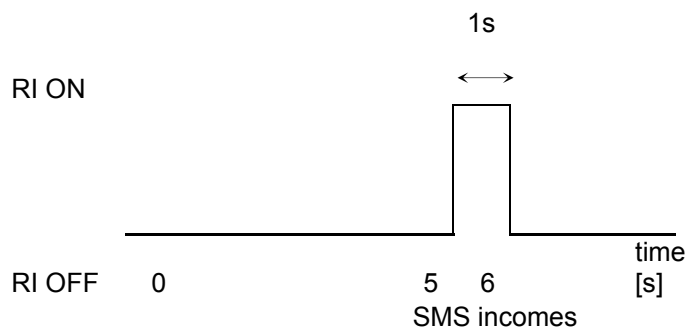
Next figure refers to the CTS line activity inside and outside the power saving in different scenarios. It can be considered like an example, most scenarios have an unpredictable power saving time line because they are in relationship with external events and network activity.



A.2.7 DSR and RI activity

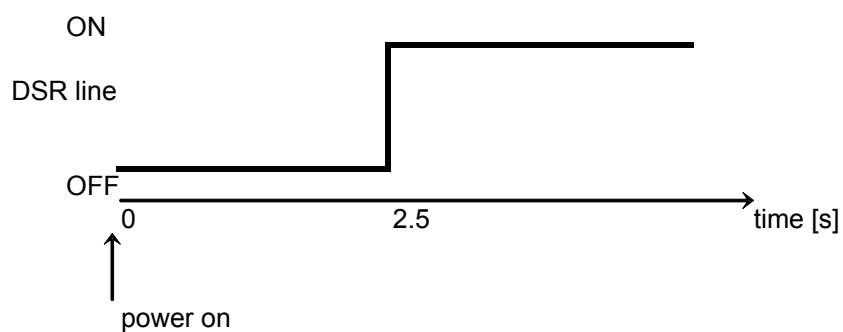
A.2.7.1 Incoming SMS

The RI line is used to notify an SMS arrival too. The RI switches from OFF to ON for 1 second as reported by the next figure.



A.2.7.2 DSR at power on

The DSR line follows the rule in the next figure after the power on:



A.3 Circuit 108/2, +++ behavior for the different &D: summarizing table

	CSD		GPRS	
	+++	DTR On to Off in data state	~+++	DTR On to Off in data state
&D0	Command mode	Data state	Context deactivation	Context deactivation
&D1	Command mode	Command mode	Context deactivation	Context deactivation
&D2	Command mode	Cleardown call	Command mode (with limitations)	Context deactivation

A.4 Incoming GPRS context activation

The 3GPP specification theoretically provides context activation from the network (something like a CSD incoming call) but most of the GPRS providers do not implement this service. Currently the module does not allow network context activation too and the protocol stack rejects any network activation request.