CINTERION® BGS12

Hardware Interface Description

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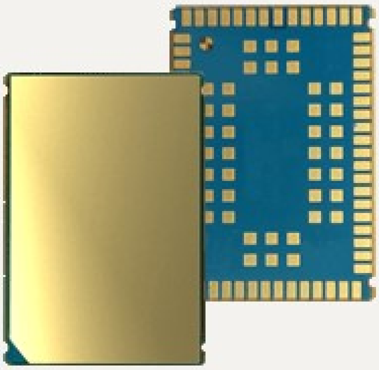

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Tables

Figures

1 Introduction

This document describes the hardware of the Cinterion® BGS12 module that connects to the cellular device application and the air interface. It helps you quickly retrieve interface specifications, electrical and mechanical details and information on the requirements to be considered for integrating further components.

1.1 Related Documents

[1] Cinterion® BGS12 AT Command Set2
[2] Cinterion® BGS12 Release Note
[3] Application Note 48: SMT Module integration for BGS12
[4] Jamming Detection
[5] Upgrading BGS12 Firmware
[6] BGS12 migration guide
[7] BGS12 Dual SIM/USIM Card Application Note

1.2 Terms and Abbreviations

Abbreviation	Description
ADC	Analog-to-digital converter
AGC	Automatic Gain Control
ANSI	American National Standards Institute
ARFCN	Absolute Radio Frequency Channel Number
ARP	Antenna Reference Point
ASC0/ASC1/ ASC2	Asynchronous Controller. Abbreviations used for first and second and third serial interface of BGS12
B	Thermistor Constant
BER	Bit Error Rate
BTS	Base Transceiver Station
CB or CBM	Cell Broadcast Message
CE	Conformité Européene (European Conformity)
CHAP	Challenge Handshake Authentication Protocol
CPU	Central Processing Unit
CS	Coding Scheme
CSD	Circuit Switched Data
CTS	Clear to Send
DAC	Digital-to-Analog Converter

Abbreviation	Description
DAI	Digital Audio Interface
dBm0	Digital level, 3.14dBm0 corresponds to full scale, see ITU G.711, A-law
DCE	Data Communication Equipment (typically modems, e.g. a Gemalto M2M module)
DCS 1800	Digital Cellular System, also referred to as PCN
DRX	Discontinuous Reception
DSB	Development Support Box
DSP	Digital Signal Processor
DSR	Data Set Ready
DTE	Data Terminal Equipment (typically computer, terminal, printer or, for example, GSM application)
DTR	Data Terminal Ready
DTX	Discontinuous Transmission
EFR	Enhanced Full Rate
EGSM	Enhanced GSM
EIRP	Equivalent Isotropic Radiated Power
EMC	Electromagnetic Compatibility
ERP	Effective Radiated Power
ESD	Electrostatic Discharge
ETS	European Telecommunication Standard
FCC	Federal Communications Commission (U.S.)
FDMA	Frequency Division Multiple Access
FR	Full Rate
GMSK	Gaussian Minimum Shift Keying
GPIO	General Purpose Input/Output
GPRS	General Packet Radio Service
GSM	Global Standard for Mobile Communications
HiZ	High Impedance
HR	Half Rate
I/O	Input/Output
IC	Integrated Circuit
IMEI	International Mobile Equipment Identity
ISO	International Standards Organization
ITU	International Telecommunications Union
kbps	kbits per second
LED	Light Emitting Diode
Li-Ion/Li+	Lithium-Ion
Li battery	Rechargeable Lithium Ion or Lithium Polymer battery
Mbps	Mbits per second

Abbreviation	Description
MMI	Man Machine Interface
MO	Mobile Originated
MS	Mobile Station (GSM module), also referred to as TE
MSISDN	Mobile Station International ISDN number
MT	Mobile Terminated
NTC	Negative Temperature Coefficient
OEM	Original Equipment Manufacturer
PA	Power Amplifier
PAP	Password Authentication Protocol
PBCCH	Packet Switched Broadcast Control Channel
PCB	Printed Circuit Board
PCL	Power Control Level
PCM	Pulse Code Modulation
PCN	Personal Communications Network, also referred to as DCS 1800
PCS	Personal Communication System, also referred to as GSM 1900
PDU	Protocol Data Unit
PLL	Phase Locked Loop
PPP	Point-to-point protocol
PSK	Phase Shift Keying
PSU	Power Supply Unit
PWM	Pulse Width Modulation
R&TTE	Radio and Telecommunication Terminal Equipment
RAM	Random Access Memory
RF	Radio Frequency
RMS	Root Mean Square (value)
RoHS	Restriction of the use of certain hazardous substances in electrical and electronic equipment.
ROM	Read-only Memory
RTC	Real Time Clock
RTS	Request to Send
Rx	Receive Direction
SAR	Specific Absorption Rate
SAW	Surface Acoustic Wave
SELV	Safety Extra Low Voltage
SIM	Subscriber Identification Module
SMD	Surface Mount Device
SMS	Short Message Service
SMT	Surface Mount Technology

Abbreviation	Description
SRAM	Static Random Access Memory
TA	Terminal adapter (e.g. GSM module)
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

1.3 Regulatory and Type Approval Information

1.3.1 Directives and Standards

BGS12 is designed to comply with the directives and standards listed below.

It is the responsibility of the application manufacturer to ensure compliance of the final product with all provisions of the applicable directives and standards as well as with the technical specifications provided in the "BGS12 Hardware Interface Description"

Table 1: Directives

RED（2014/53/EU）	Directive 2014/53/EU of the European Parliament and of the Council of 16 April 2014 on the harmonisation of the laws of the Member States relating to the making available on the market of radio equipment and repealing Directive 1999/5/EC Text with EEA relevance. Applicable as of 13 June 2016. OJ L 153, 22.5.2014 The product is labeled with the CE conformity mark. CE
2002/05/EC	Directive of the European Parliament and of the Council of 27 January 2003 on the restriction of the use of certain hazardous substances in electrical and electronic equipment (RoHS) RoHS compliant
FCC ID： QIPBGS12	US Federal Communications Commission set up according to Communications Act in 1934. The FCC control the radio, TV, telecom, satellite and cable to coordinate domestic and international communication.

NOTE: Hereby, Gemalto M2M GmbH declares that this GSM/GPRS Wireless Module (Model No.:BGS12) is in compliance with the essential requirements and other relevant provisions of RED 2014/53/EU. This product can be used across EU member states.
The full text of the EU declaration of conformity is available at the following internet address: https://www.gemalto.com/m2m

RF exposure information: The Maximum Permissible Exposure (MPE) level has been calculated based on a distance of d=20 cm between the device and the human body. To maintain compliance with RF exposure requirement, use product that maintain a 20cm distance between the device and human body.

Table 2: Standards of European type approval

3GPP TS 51.010-1	Digital cellular telecommunications system (Phase 2); Mobile Station (MS) conformance specification
ETSI EN 301 511 V12.5.1	Global System for Mobile communications (GSM); Mobile Stations (MS) equipment; Harmonised Standard covering the essential requirements of article 3.2 of Directive 2014/53/EU
GCF-CC V3.73.0	Global Certification Forum
ETSI EN 301 489-1 V.2.1.1	Electromagnetic compatibility and Radio spectrum Matters (ERM); Electro Magnetic Compatibility (EMC) standard for radio equipment and services
ETSI EN 301 489-52 V1.1.0	Candidate Harmonized European Standard (Telecommunications series) Electro Magnetic Compatibility and Radio spectrum Matters (ERM); Electro Magnetic Compatibility (EMC) standard for radio equipment and services; Part 7: Specific conditions for mobile and portable radio and ancillary equipment of digital cellular radio telecommunications systems (GSM and DCS)

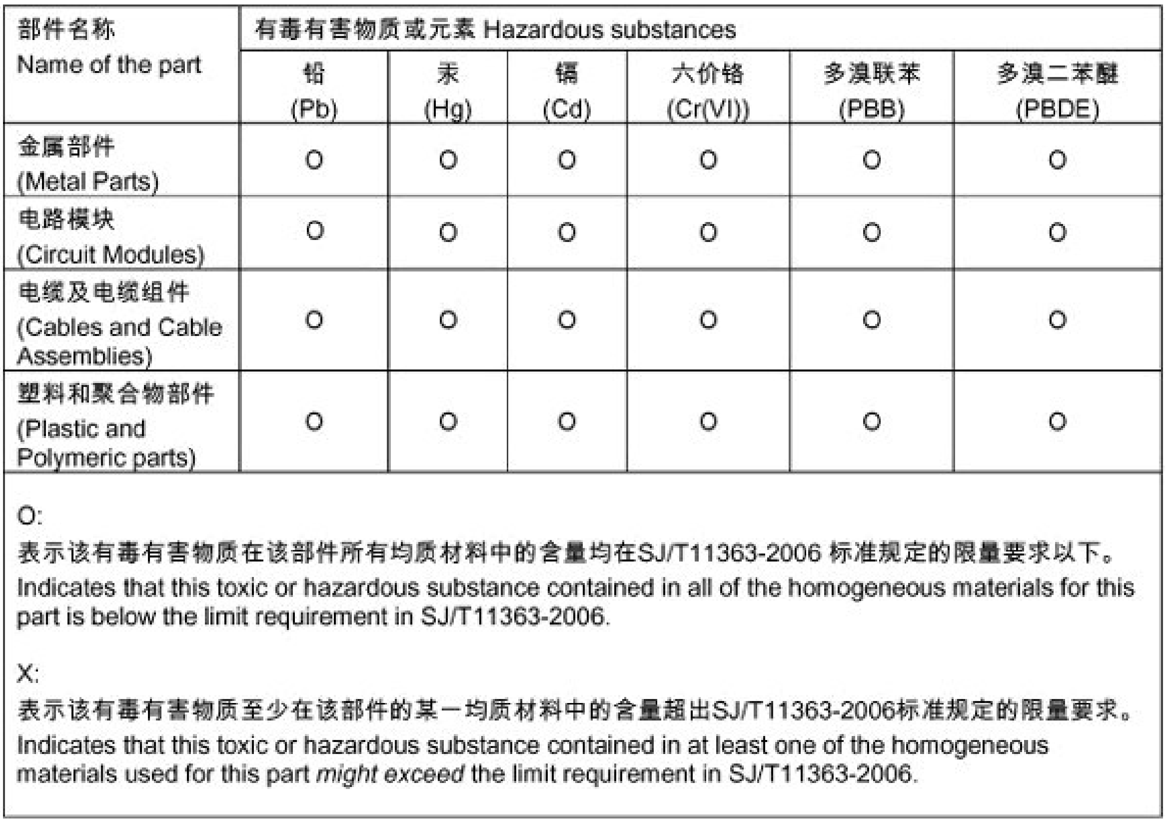
Table 3: Requirements of quality

IEC 60068	Environmental testing
DIN EN 60529	IP codes

Table 4: Standards of the Ministry of Information Industry of the People's Republic of China

SJ/T 11363-2006	"Requirements for Concentration Limits for Certain Hazardous Substances in Electronic Information Products" (2006-06).
SJ/T 11364-2006	"Marking for Control of Pollution Caused by Electronic Information Products" (2006-06).  According to the "Chinese Administration on the Control of Pollution caused by Electronic Information Products" (ACPEIP) the EPUP, i.e., Environmental Protection Use Period, of this product is 20 years as per the symbol shown here, unless otherwise marked. The EPUP is valid only as long as the product is operated within the operating limits described in the Gemalto M2M Hardware Interface Description. Please see Table5 for an overview of toxic or hazardous substances or elements that might be contained in product parts in concentrations above the limits defined by SJ/T 11363-2006.

Table 5: Toxic or hazardous substances or elements with defined concentration limits



部件名称 Name of the part	有毒有害物质或元素 Hazardous substances					
	铅 (Pb)	汞 (Hg)	镉 (Cd)	六价铬 (Cr(VI))	多溴联苯 (PBB)	多溴二苯醚 (PBDE)
金属部件 (Metal Parts)	O	O	O	O	O	O
电路模块 (Circuit Modules)	O	O	O	O	O	O
电缆及电缆组件 (Cables and Cable Assemblies)	O	O	O	O	O	O
塑料和聚合物部件 (Plastic and Polymeric parts)	O	O	O	O	O	O

O:
表示该有毒有害物质在该部件所有均质材料中的含量均在SJ/T11363-2006 标准规定的限量要求以下。
Indicates that this toxic or hazardous substance contained in all of the homogeneous materials for this part is below the limit requirement in SJ/T11363-2006.

X:
表示该有毒有害物质至少在该部件的某一均质材料中的含量超出SJ/T11363-2006标准规定的限量要求。
Indicates that this toxic or hazardous substance contained in at least one of the homogeneous materials used for this part *might exceed* the limit requirement in SJ/T11363-2006.

1.3.2 SAR requirements specific to portable mobiles

Mobile phones, PDAs or other portable transmitters and receivers incorporating a GSM module must be in accordance with the guidelines for human exposure to radio frequency energy. This requires the Specific Absorption Rate (SAR) of portable BGS12 based applications to be evaluated and approved for compliance with national and/or international regulations.

Since the SAR value varies significantly with the individual product design manufacturers are advised to submit their product for approval if designed for portable use.

For European markets the relevant directives are mentioned below. It is the responsibility of the manufacturer of the final product to verify whether or not further standards, recommendations or directives are in force outside these areas.

Products intended for sale on European markets

EN 62311:2008	Assessment of electronic and electrical equipment related to human exposure restrictions for electromagnetic fields (0 Hz - 300 Ghz)

The device complies with RF specifications when the device used at 20 cm form your body.

1.3.3 Safety Precautions

The following safety precautions must be observed during all phases of the operation, usage, service or repair of any cellular terminal or mobile incorporating BGS12. Manufacturers of the cellular terminal are advised to convey the following safety information to users and operating personnel and to incorporate these guidelines into all manuals supplied with the product. Failure to comply with these precautions violates safety standards of design, manufacture and intended use of the product. Gemalto M2M assumes no liability for customer's failure to comply with these precautions.

♥	When in a hospital or other health care facility, observe the restrictions on the use of mobiles. Switch the cellular terminal or mobile off, if instructed to do so by the guidelines posted in sensitive areas. Medical equipment may be sensitive to RF energy. The operation of cardiac pacemakers, other implanted medical equipment and hearing aids can be affected by interference from cellular terminals or mobiles placed close to the device. If in doubt about potential danger, contact the physician or the manufacturer of the device to verify that the equipment is properly shielded. Pacemaker patients are advised to keep their hand-held mobile away from the pacemaker, while it is on.
✈	Switch off the cellular terminal or mobile before boarding an aircraft. Make sure it cannot be switched on inadvertently. The operation of wireless appliances in an aircraft is forbidden to prevent interference with communications systems. Failure to observe these instructions may lead to the suspension or denial of cellular services to the offender, legal action, or both.
🔥	Do not operate the cellular terminal or mobile in the presence of flammable gases or fumes. Switch off the cellular terminal when you are near petrol stations, fuel depots, chemical plants or where blasting operations are in progress. Operation of any electrical equipment in potentially explosive atmospheres can constitute a safety hazard.
📺	Your cellular terminal or mobile receives and transmits radio frequency energy while switched on. Remember that interference can occur if it is used close to TV sets, radios, computers or inadequately shielded equipment. Follow any special regulations and always switch off the cellular terminal or mobile wherever forbidden, or when you suspect that it may cause interference or danger.
🚗	Road safety comes first! Do not use a handheld cellular terminal or mobile when driving a vehicle, unless it is securely mounted in a holder for speakerphone operation. Before making a call with a handheld terminal or mobile, park the vehicle. Speakerphones must be installed by qualified personnel. Faulty installation or operation can constitute a safety hazard.

SOS	IMPORTANT! Cellular terminals or mobiles operate using radio signals and cellular networks. Because of this, connection cannot be guaranteed at all times under all conditions. Therefore, you should never rely solely upon any wireless device for essential communications, for example emergency calls. Remember, in order to make or receive calls, the cellular terminal or mobile must be switched on and in a service area with adequate cellular signal strength. Some networks do not allow for emergency calls if certain network services or phone features are in use (e.g. lock functions, fixed dialing etc.). You may need to deactivate those features before you can make an emergency call. Some networks require that a valid SIM card be properly inserted in the cellular terminal or mobile.
⚠	Use careful with the earphone maybe possible excessive sound pressure from earphones and headphones can cause hearing loss.

2 Product Concept

2.1 Key Features at a Glance

Feature	**Implementation**
General	
Frequency bands	Quad band : GSM 850/900/1800/1900MHz
GSM class	Small MS
Output power (according to Release 99, V5)	GSM850 824.2MHz~848.8MHz GSM:31.5±1dBm GPRS:31.5±1dBm PCS1900 1850.2MHz~1909.8MHz GSM:27.5±1dBm GPRS:27.5±1dBm EGSM900:880~915MHz GSM:32.8dBm GPRS:27.3dBm DCS1800：1710MHz~1785MHz GSM:30.4dBm GPRS:24.1dBm
Power supply[1]	3.4V to 4.2V
Operating temperature (board temperature)	-10°C to +55°C
Physical	Dimensions: 27.6mm x 18.8mm x 2.7mm Weight: approx. 2.2 g
RoHS	All hardware components fully compliant with EU RoHS Directive
GSM/GPRS features	
Data transfer	GPRS: • Multislot Class 12 • Mobile Station Class B • Coding Scheme 1 – 4 PPP-stack for GPRS data transfer
SMS	Point-to-point MT and MO Cell broadcast Text and PDU mode Storage: SIM card plus 50 SMS locations in mobile equipment
Audio	Speech codecs: • Half rate HR (ETS 06.20) • Full rate FR (ETS 06.10) • Enhanced full rate EFR (ETS 06.50/06.60/06.80) Handsfree operation, echo cancellation, noise suppression, 7 different ringing tones/melodies

1. The module operates within a voltage level range from 3.4V up to 4.2V without restrictions. It is suggested to supply 3.4V to 4.35V on module.
   Please add at least 3700uF capacitor to VBAT signal line against GSM burst current while 3.2V to 3.4V supply for BGS12 module.

Feature	**Implementation**
Software	
AT commands	Hayes 3GPP TS 27.007, TS 27.005, Gemalto M2M
TCP/IP stack	Protocols: TCP server/client, UDP, HTTP, FTP Access by AT commands
Firmware update	Generic update from host application over ASC1.
Interfaces	
Module interface	Surface mount device with solderable connection pads (SMT application interface). Land grid array (LGA) technology ensures high solder joint reliability and provides the possibility to use an optional module mounting socket. For more information on how to integrate SMT modules see also [3]. This application note comprises chapters on module mounting and application layout issues as well as on additional SMT application development equipment.
3 serial interfaces	ASC0: • 8-wire modem interface with status and control lines, unbalanced, asynchronous • Adjustable baud rates: 4,800bps to 230,400bps • Autobauding: 4,800bps to 230,400bps • Supports RTS0/CTS0 hardware handshake • Multiplex ability according to GSM 07.10 Multiplexer Protocol. ASC1: • 2-wire, unbalanced asynchronous interface • ASC1 operated at Fixed Bit rate 921,600 bps For firmware upgrade and tracing purpose ASC2: • 4-wire, unbalanced asynchronous interface • ASC2 operated at Fixed Bit rates from 4,800 bps to 230,400 bps Supports RTS2/CTS2 hardware handshake
Audio	1 analog interface (with microphone feeding)
UICC interface	Supported SIM/USIM cards: 3V, 1.8V External SIM card reader has to be connected via interface connector (note that card reader is not part of BGS12)
GPIO interface	GPIO interface with 6 GPIO lines. The GPIO interface is shared with an I^{2}C interface and LED signalling functionality as well as a jamm- ing indicator.
Antenna	50Ω
Power on/off, Reset	
Power on/off	Switch-on by hardware signal ON Switch-off by AT command (AT^SMSO) Automatic switch-off in case of critical temperature and voltage conditions Fast power shutdown by GPIO Fast power shutdown by AT command
UpgradingReset	Orderly shutdown and reset by AT command
Special features	
Real time clock	Timer functions via AT commands

Feature	**Implementation**
Evaluation kit	
Phonebook	SIM and phone
SSL security	TLS 1.2
RLS monitoring	Jamming detection
Evaluation module	BGS12 module soldered onto a dedicated PCB that can be connected to an adapter in order to be mounted onto the DSB75.
DSB75	DSB75 Development Support Board designed to test and type approve Gemalto M2M modules and provide a sample configuration for application engineering. A special adapter setup is required to connect the evaluation module to the DSB75. For more information on how to setup such a connection please refer to Chapter 9.

2.2 BGS12 System Overview

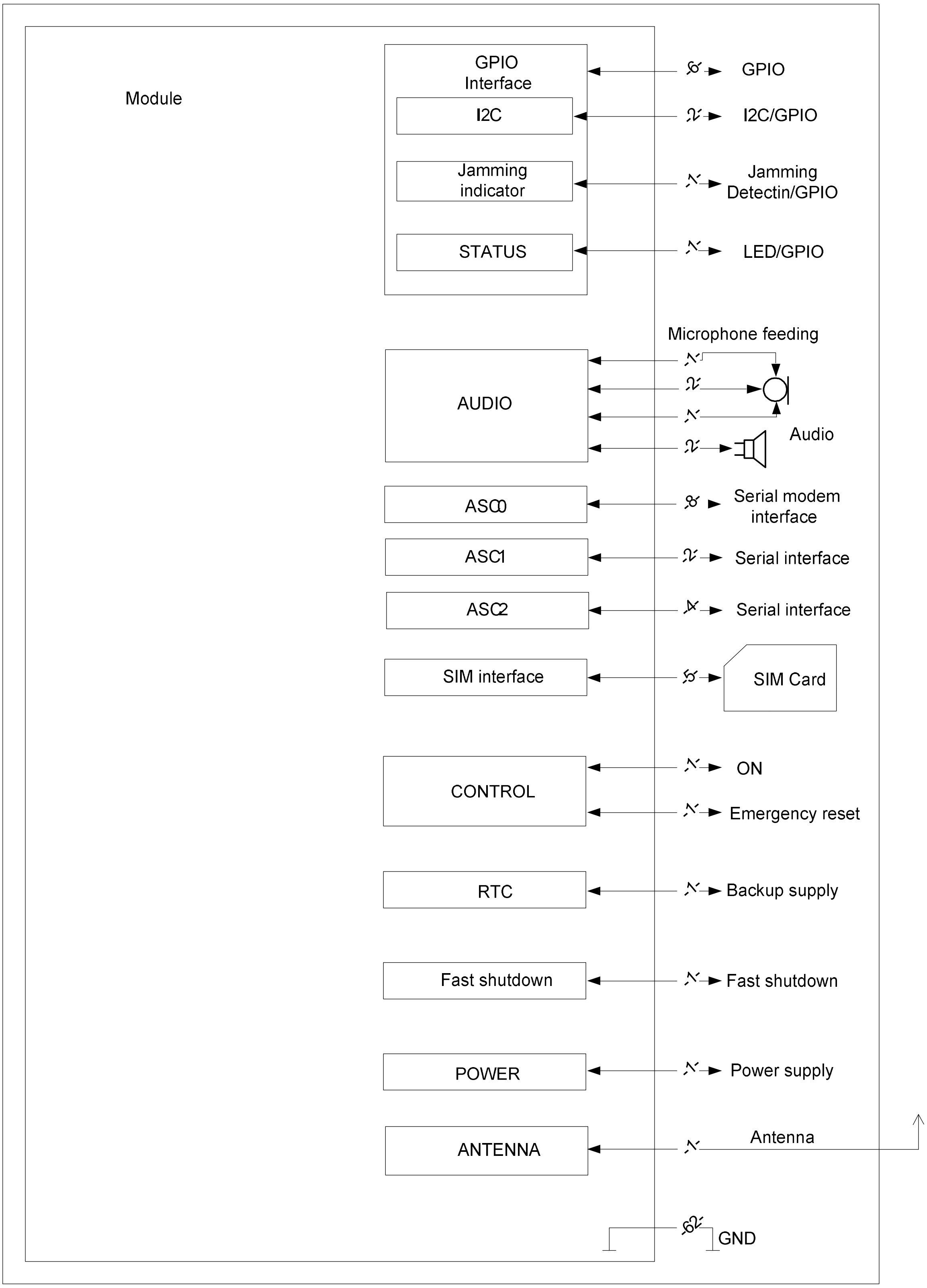


Figure 1: BGS12 system overview

2.3 Circuit Concept

Figure 2 shows a block diagram of the BGS12 module and illustrates the major functional components:
Baseband block:

- GSM baseband processor and power management
- Stacked flash/PSRAM memory
- Application interface (SMT with connecting pads)

GSM RF section:

- RF transceiver (part of baseband processor IC)
- RF power amplifier/front-end module inc. harmonics filtering
- Receive Balun

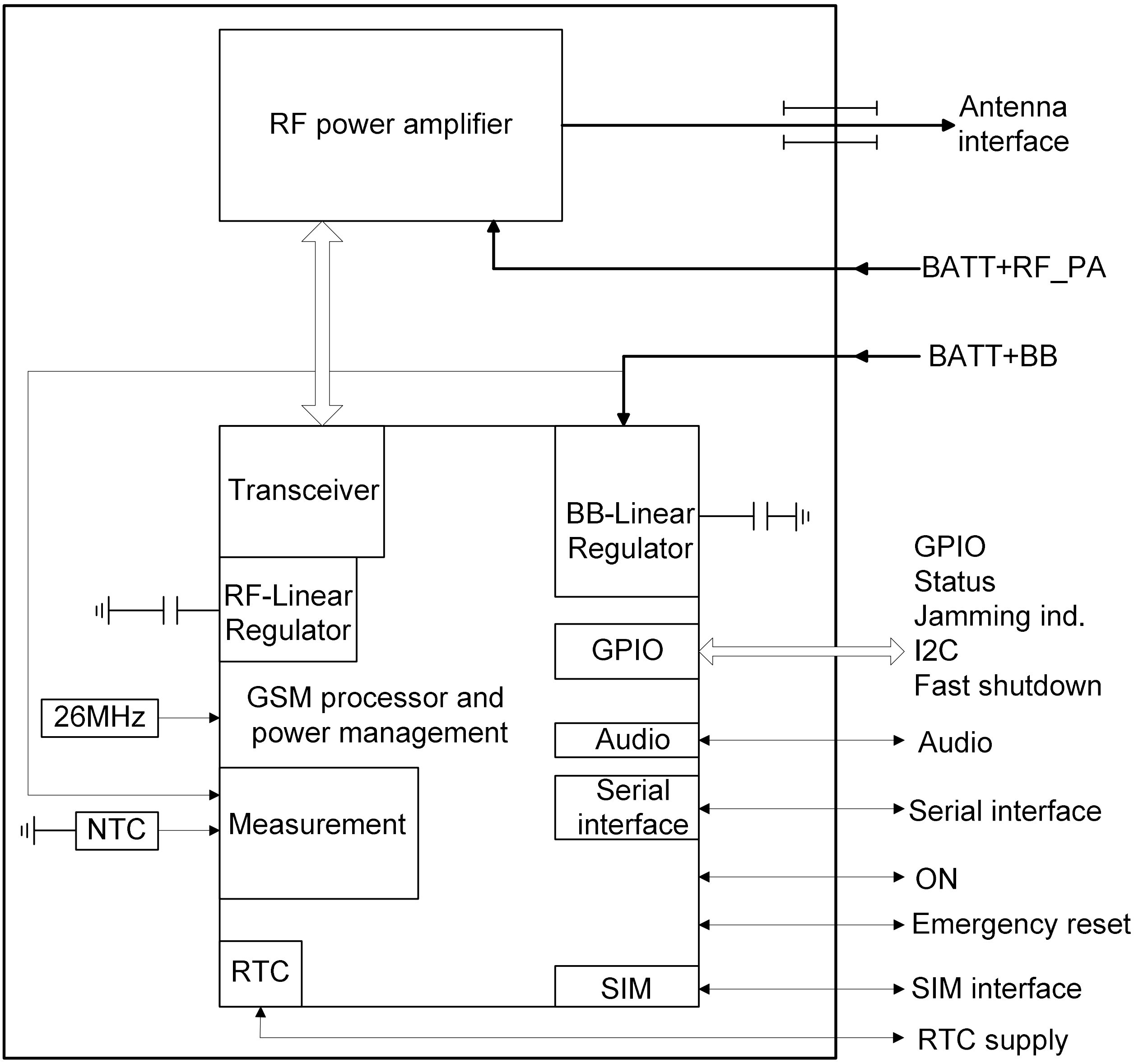


Figure 2: BGS12 block diagram

3 Application Interface

BGS12 is equipped with an SMT application interface that connects to the external application. The host interface incorporates several subinterfaces described in the following sections:

- Power supply - see Section 3.2
- SIM/USIM interface - see Section 3.7
- Serial interface ASC0 - see Section 3.8
- Serial interface ASC1 - see Section 3.9
- Serial interface ASC2 - see Section 3.10
- Analog audio interface - see Section 3.11
- Digital audio interface - see Section 3.12
- GPIO interface - see Section 3.13
- I²C interface - Section 3.14
- Jamming indicator - Section 3.15
- Status Control - LED: Section 3.16, RING line: Section 3.17, Power indication: Section 3.18
- Fast shutdown - Section 3.19

3.1 Operating Modes

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

Table 6: Overview of operating modes

Normal operation	GSM/GPRS SLEEP	Various power save modes set with AT+CFUN command. Software is active to minimum extent. If the module was registered to the GSM network in IDLE mode, it is registered and paging with the BTS in SLEEP mode, too. Power saving can be chosen at different levels: The NON-CYCLIC SLEEP mode (AT+CFUN=0) disables the AT interface. The CYCLIC SLEEP modes AT+CFUN=7 and 9 alternatingly activate and deactivate the AT interfaces to allow permanent access to all AT commands.
	GSM IDLE	Software is active. Once registered to the GSM network, paging with BTS is carried out. The module is ready to send and receive.
	GSM TALK	Connection between two subscribers is in progress. Power consumption depends on network coverage individual settings,such as DTX off/on,FR/EFR/HR, hopping sequences, antenna.
	GPRS IDLE	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. multislotsettings).
	GPRS DATA	GPRS data transfer in progress. Power consumption depends on network settings (e.g. power control level), uplink/downlink data rates, GPRS configuration (e.g. used multislot settings) and reduction of maximum output power.
Power Down	Normal shutdown after sending the AT^SMSO command. Only a voltage regulator is active for powering the RTC. Software is not active. Interfaces are not accessible. Operating voltage (connected to BATT+) remains applied.	

See the following sections for the various options of waking up BGS12 and proceeding from one mode to another.

3.2 Power Supply

BGS12 needs to be connected to a power supply at the SMT application interface - 3 lines each $BATT_{+BB}$, $BATT_{+RF}$ and GND. $BATT_{+BB}$ is for the general power management and $BATT_{+RF}$ is for the GSM power amplifier supply.

The power supply of BGS12 has to be a single voltage source at $BATT_{+BB}$ and $BATT_{+RF}$. It must be able to provide the peak current during the uplink transmission.

All the key functions for supplying power to the device are handled by the power management section of the analog controller. This IC provides the following features:

- Stabilizes the supply voltages for the GSM baseband using low drop linear voltage regulators and a DC-DC step downswitching regulator.
- Switches the module's power voltages for the power-up and -down procedures.
- SIM switch to provide SIM power supply.

When power supply is provided on $BATT_{+BB}$ and $BATT_{+RF}$ pins and BGS12 has not been powered on, please make sure to avoid that current is flowing from any other source into the module circuit (for example reverse current from high state external control lines). The controlling application must be designed to prevent reverse current flow, otherwise there is the risk of damaging the module.

3.2.1 Minimizing Power Losses

When designing the power supply for your application please pay specific attention to power losses. Ensure that the input voltage V_{BATT+} never drops below 3.3V on the BGS12 board, not even in a GSM transmit burst where current consumption can rise (for peaks values see the power supply ratings listed in Section 5.5). It should be noted that BGS12 switches off when exceeding these limits. Any voltage drops that may occur in a transmit burst should not exceed 400mV.

The module switches off if the minimum battery voltage ($V_{BattMin}$) is reached. Example:

$V_{BattLowLimit} = 3.3V$
$D_{DropMax} = 0.4V$
$V_{BattMin} = V_{BattLowLimit} + D_{DropMax}$

$V_{BattMin} = 3.3V + 0.4V = 3.7V$

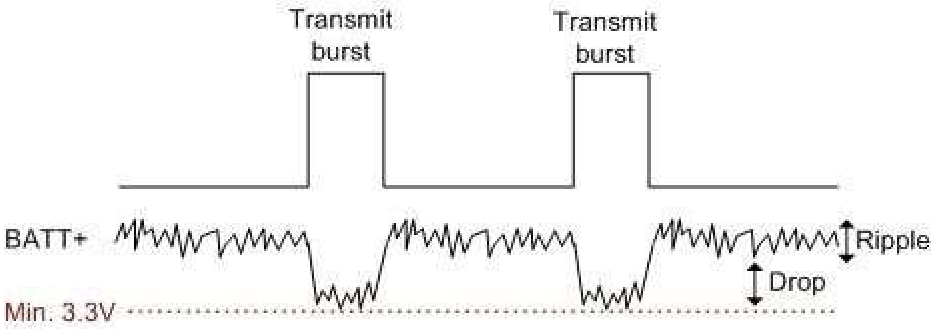


Figure 3: Power supply limits during transmit burst

3.2.2 Measuring the Supply Voltage (V_{BATT+})

To measure the supply voltage V_{BATT+} it is possible to define two reference points GND and BATT+. GND should be the module’s shielding, while BATT+ should be a test pad on the external application the module is mounted on. The external BATT+ reference point has to be connected to and positioned close to the SMT application interface’s BATT+ pads 5 or 53 as shown in Figure 4.

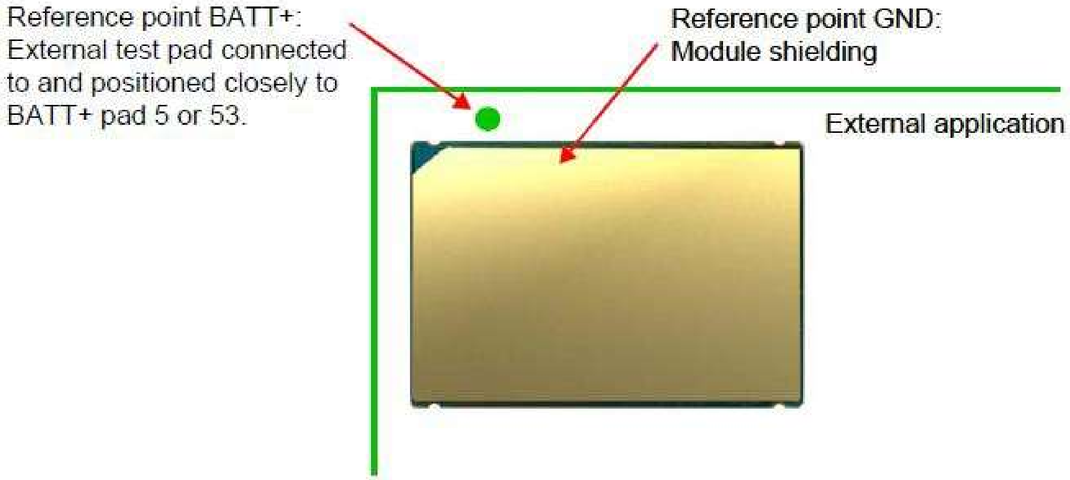


Figure 4: Position of reference points BATT+ and GND

3.2.3 Monitoring Power Supply by AT Command

To monitor the supply voltage you can also use the AT^SBV command which returns the value related to the reference points BATT+ and GND.

The module continuously measures the voltage at intervals. The displayed voltage (in mV) is averaged over the last measuring period before the AT^SBV command was executed.

If the measured average voltage drops below or rises above the specified voltage shutdown thresholds, the module will send an "^SBC" URC and shut down. (for details see Section 3.3.5)

3.3 Power Up/Power down Scenarios

In general, be sure not to turn on BGS12 while it is beyond the safety limits of voltage and temperature stated in Chapter 5. BGS12 will immediately switch off after having started and detected these inappropriate conditions. In extreme cases this can cause permanent damage to the module.

3.3.1 Turn on BGS12

BGS12 can be started as described in the following sections:
Hardware driven switch on by ON line: Starts Normal mode (see Section 3.3.1.1).

3.3.1.1 Switch on BGS12 Using ON Signal

When the operating voltage $BATT_{+BB}/BATT_{+RF}$ is applied, BGS12 can be switched on by means of the ON signal.

If the operating voltage $BATT_{+BB}/BATT_{+RF}$ is applied while the ON signal is present for at least 2s, the BGS12 will be switched on automatically. The startup time is about 4s.

Please also note that if there is no ON signal present right after applying $BATT_{+BB}/BATT_{+RF}$, BGS12 will instead of switching on perform a switch on/off sequence that cannot be avoided. The switch on/off sequence is about 3.7s.

The ON signal is a high active signal and only allows the input voltage level of the VDDLP signal. The following Figure 5 shows an example for a switch-on circuit (an alternative switch-on possibility is shown in Figure 59).

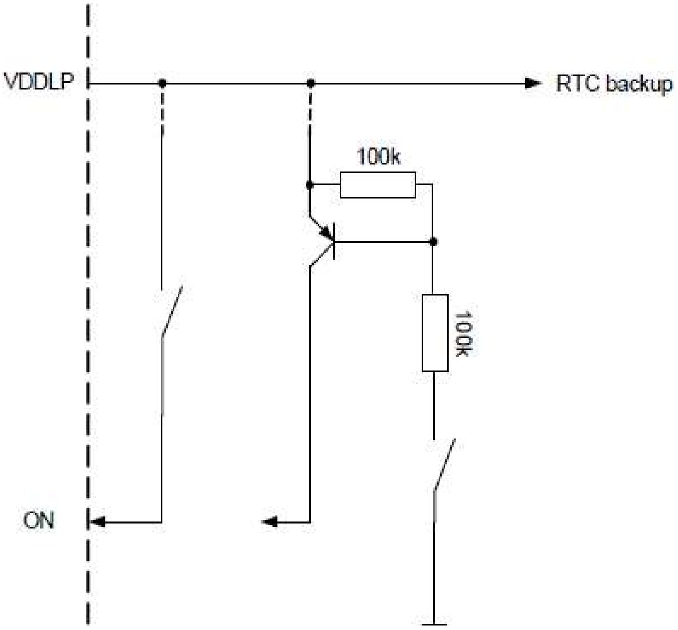


Figure 5: ON circuit sample

It is recommended to set a serial 1kOhm resistor between the ON circuit and the external capacitor or battery at the VDDLP power supply. This serial resistor protection is necessary in case the capacitor or battery has low power (is empty).

Please note that the ON signal is an edge triggered signal. This implies that a micro-second high pulse on the signal line suffices to almost immediately switch on the module, as shown in Figure 6. The following Section 3.3.1.2 describes a sample circuit that may be implemented to prevent possible spikes or glitches on the ON signal line from unintentionally switching on the module.

Please also note that if the state of the ON signal is coupled to the state of the VDDLP line or that if the ON signal otherwise remains active high after switch on, it is no longer possible to switch off BGS12 using the AT command AT^SMSO. Using this command will instead automatically restart the module.

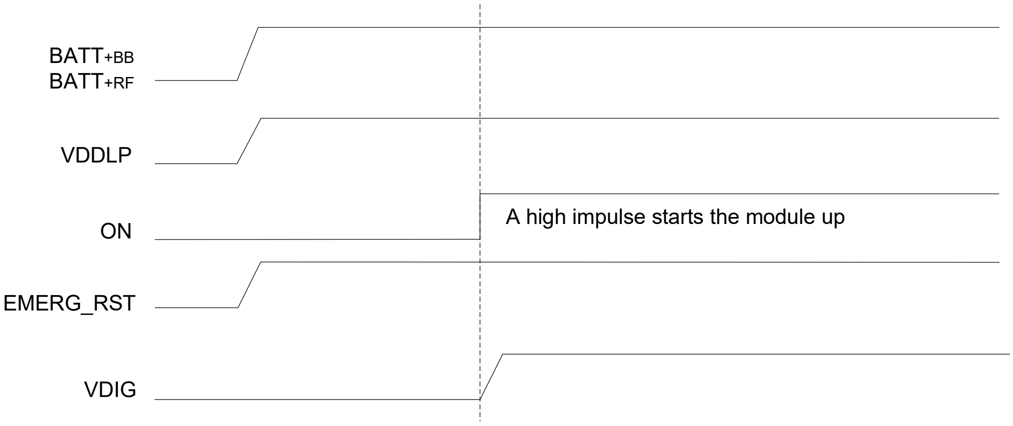


Figure 6: ON timing

If configured to a fixed bit rate (AT+IPR≠0), the module will send the URC “^SYSSTART” which notifies the host application that the first AT command can be sent to the module. The duration until this URC is output varies with the SIM card and may take a couple of seconds, particularly if the request for the SIM PIN is deactivated on the SIM card.

Please note that no “^SYSSTART” URC will be generated if autobauding (AT+IPR=0) is enabled.

To allow the application to detect the ready state of the module we recommend using hardware flow control which can be set with AT\Q (see [1] for details). The default setting is AT\Q0 (no flow control) which shall be altered to AT\Q3 (RTS/CTS handshake). If the application design does not integrate RTS/CTS lines the host application shall wait at least for the “^SYSSTART” URC. However, if the URC is not available (due to autobauding), you will simply have to wait for a period of time (at least 2 seconds) before assuming the module to be in ready state and before entering any data.

Please note that no data must be sent over the ASC0 interface before the interface is active and ready to receive data.

3.3.1.2 Suppressing Unintentional Pulses on ON Signal Line

Since the ON signal is edge triggered and a high pulse on the signal line suffices to almost immediately switch on the module, it might be necessary to implement a circuit on the external application that prevents possible spikes or glitches on the signal line from unintentionally switching on the module. Figure 7 shows an example for such a circuit.

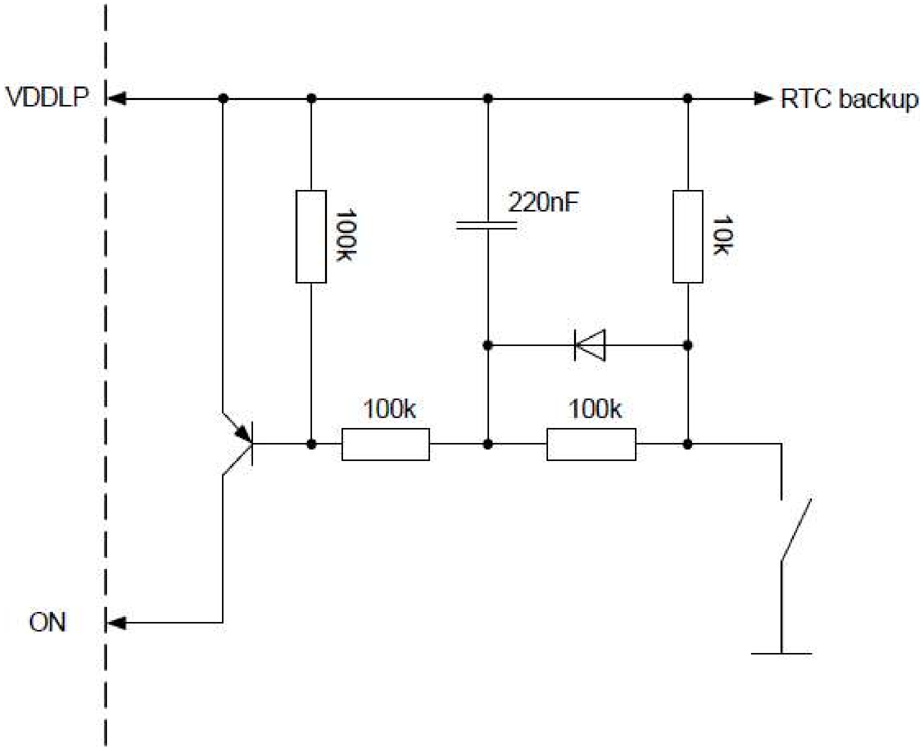


Figure 7: Sample circuit to suppress spikes or glitches on ON signal line

3.3.2 Restart BGS12

After startup BGS12 can be restarted as described in the following sections:

- Software controlled reset by AT+CFUN command: Starts Normal mode (see Section 3.3.2.1).
- Hardware controlled reset by EMERG_RST line: Starts Normal mode (see Section 3.3.2.2)

3.3.2.1 Restart BGS12 via AT+CFUN Command

To reset and restart the BGS12 module use the command AT+CFUN. You can enter the command AT+CFUN=,1 or 1,1 or 7,1 or 9,1. See [1] for details.

If configured to a fix baud rate (AT+IPR≠0) the module will send the URC "^SYSSTART" to notify that it is ready to operate. If autobauding is enabled (AT+IPR=0) there will be no notification. To register to the network SIM PIN authentication is necessary after restart.

3.3.2.2 Turn off or restart BGS12 Using EMERG_RST

The EMERG_RST signal is internally connected to the central GSM processor. Abrupt “hardware” shutdown will accur when A low level for more than 1ms is applied to EMERG_RST pin. BGS12 can be switched on by mean of ON signal after releasing EMERG_RST.

Note: EMERG_RST is controlled solely cannot restart BGS12, it can only turn BGS12 off at the hardware aspect. If want to achieve restart module like RESET behaver, it should control ON signal at the same time as described by following paragraph.

For the other solution that high level has always been applied to ON pin, triggering EMERG_RST will set the processor and with it all the other signal pads to their respective reset state. The reset state is described in Section 3.3.3 as well as in the figures showing the startup behavior of an interface.

After releasing the EMERG_RST line, i.e., with a change of the signal level from low to high, the module restarts. The other signals continue from their reset state as the module was switched on by the ON signal.

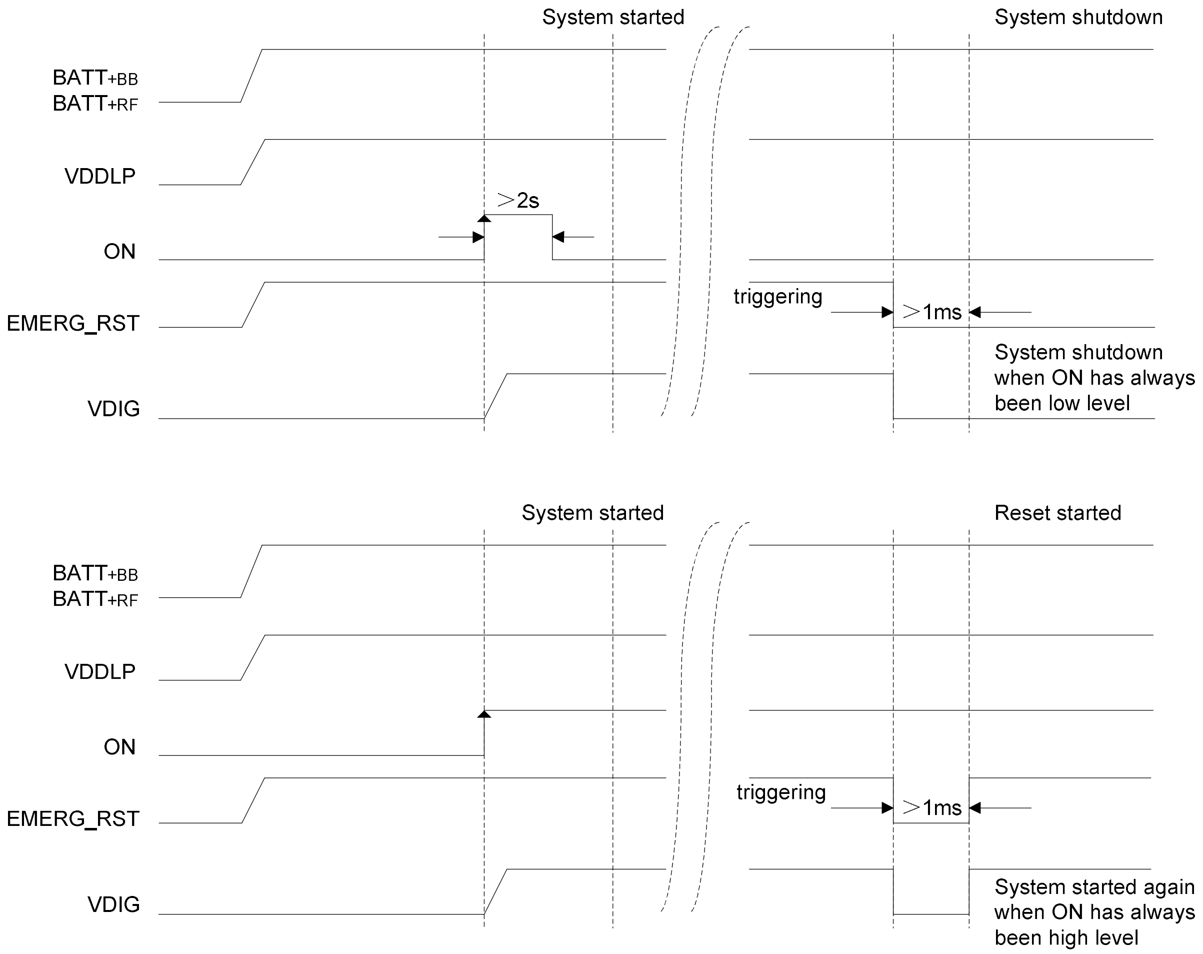


Figure 8: Emergency shutdown/restart timing

It is recommended to control this EMERG_RST line with an open collector transistor or an open drain field-effect transistor.

Caution: Use the EMERG_RST line only when, due to serious problems, the software is not responding for more than 5 seconds. Pulling the EMERG_RST line causes the loss of all information stored in the volatile memory. Therefore, this procedure is intended only for use in case of emergency, e.g. if BGS12 does not respond, if reset or shutdown via AT command fails.

3.3.3 Signal States after Startup

Table 7 lists three states each interface signal passes through during reset and firmware initialization:
1) At reset: BGS12 begins to startup and performs the reset action.

2) After reset: BGS12 has finished the reset action and has not entered the firmware initialization state.
3) Firmware initialization: The software has taken the control right of hardware, and begins to initialize the firmware.

At reset state is reached with the rising edge of the EMERG_RST signal - either after a normal module startup (see Section 3.3.1.1) or after a reset (see Section 3.3.2.2). When BGS12 passes through at reset state and after reset state, the firmware initialization state begins. The firmware initialization is completed as soon as the ASC0 interface lines CTS0, DSR0 and RING0 as well as the ASC1 interface line CTS1 have turned high (see Section 3.7 and Section 3.8). At that time, the module is ready to receive and transmit data.

Table 7: Signal states

Signal name	**At reset**	**After reset**	**Firmware initialization**
CCIN	I / 166K PD	I / 166K PD	I /166K PD
CCRST	L	L	O / L
CCIO	L	L	I O / L
CCCLK	L	L	O / L
RXD0	I / 166K PD	I / 166K PD	O / H
TXD0	I / 166K PD	I / 166K PD	I
CTS0	I / 166K PD	I / 166K PD	O / H
RTS0	I / 166K PD	I / 166K PD	I / 166K PU
RING0	I / 166K PD	I / 166K PD	O / H
DTR0	I / 166K PD	I / 166K PD	I / 166K PU
DCD0	I / 166K PD	I / 166K PD	O / 166K PU
DSR0	I / 166K PD	I / 166K PD	O / 166K PU
RXD1	O / 166K PU	O / 166K PU	O / H
TXD1	I / 166K PU	I / 166K PU	I
RXD2	I / 166K PD	I / 166K PD	O / H
TXD2	I / 166K PD	I / 166K PD	I
CTS2	I / 33K PD	I / 33K PD	O / H
RTS2	I / 33K PD	I / 33K PD	I / 33K PU
FAST_SHTDWN	I / 166K PD	I / 166K PD	I / 166K PU
GPIO5 / LED	O / L	O / L	O / 33K PU
GPIO6 / Jamming Indicator	I / 166K PD	I / 166K PD	I O / 166K PU
GPIO7	I / 166K PD	I / 166K PD	I O / 166K PU
GPIO8	I / 166K PD	I / 166K PD	I O / 166K PU
GPIO9 / I2CCLK	O / L	O / L	O / 33K PU
GPIO10 / I2CDAT	O / L	O / L	I O / 33K PU

Abbreviations used in above Table 7:

L = Low level
H =High level
L/H = Low or High level
T = Tristate
I = Input
O = Output
IO=Input or Output

OD = Open Drain
PD = Pull Down
PU = Pull Up

3.3.4 Turn off BGS12

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

- Software controlled shutdown procedure: See Section 3.3.4.1.
  Software controlled by sending the AT^SMSO command over the serial application interface.
- Automatic shutdown of BGS12 due to safety precautions: See Section 3.3.5
- Fast shutdown (Hardware line): See Section 3.19

3.3.4.1 Switch off BGS12 Using AT Command

The best and safest approach to powering down BGS12 is to issue the *AT^SMSO* command. This procedure lets BGS12 log off from the network and allows the software to enter into a secure state and safe data before disconnecting the power supply. The mode is referred to as Power Down mode. In this mode, only the RTC stays active.

Before switching off the device sends the following response:

```
^SMSO: MS OFF

OK
^SHUTDOWN
```

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

- Wait for the URC “^SHUTDOWN”. It indicates that data have been stored non-volatile and the module turns off in less than 1 second.
- Also, you can monitor the VDIG pad. The low state of this pad definitely indicates that the module is switched off.

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

While BGS12 is in Power Down mode the application interface is switched off and must not be fed from any other voltage source. Therefore, your application must be designed to avoid any current flow into any digital pads of the application interface.

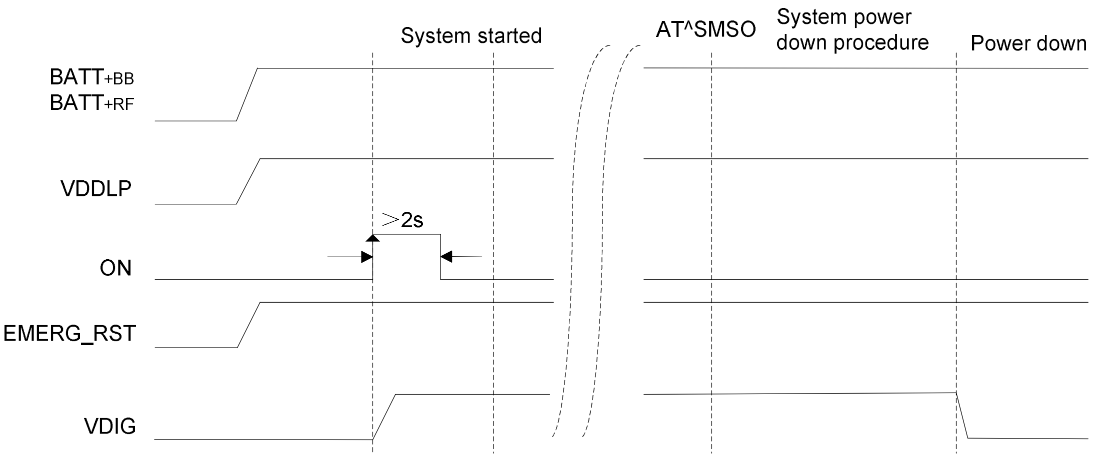


Figure 9: Switch off behavior

3.3.5 Automatic Shutdown

Automatic shutdown takes effect if any of the following events occurs:

- the BGS12 board is exceeding the critical limits of overtemperature or undertemperature (see Section 3.3.5.1)
- undervoltage or overvoltage is detected (see Section 3.3.5.2 and Section 3.3.5.3)

The automatic shutdown procedure is equivalent to the power-down initiated with the AT^SMSO command, i.e. BGS12 logs off from the network and the software enters a secure state avoiding loss of data.

3.3.5.1 Thermal Shutdown

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

Each time the board temperature goes out of range or back to normal, BGS12 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 (for details see [1]):

  AT^SCTM=1: Presentation of URCs is always enabled.
  AT^SCTM=0 (default): Presentation of URCs is enabled during the 15 second guard period after start-up of BGS12. After expiry of the 15 second guard period, the presentation will be disabled, i.e. no URCs with alert levels "1" or "-1" will 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 Section 5.2. Refer to Table 8 for the associated URCs.

Table 8: Temperature dependent behavior

Sending temperature alert (15s after BGS12 startup, otherwise only if URC presentation enabled)	
^SCTM_B: 1	Board close to overtemperature limit.
^SCTM_B: -1	Board close to undertemperature limit.
^SCTM_B: 0	Board back to non-critical temperature range.
Automatic shutdown (URC appears no matter whether or not presentation was enabled)	
^SCTM_B: 2	Alert: Board equal or beyond overtemperature limit. BGS12 switches off.
^SCTM_B: -2	Alert: Board equal or below undertemperature limit. BGS12 switches off.

3.3.5.2 Undervoltage Shutdown

The undervoltage shutdown threshold is 3.2V, i.e., it is 50mV below the specified minimum supply voltage V_{BATT+} given in Table 21

When the average supply voltage measured by BGS12 drops below the undervoltage shutdown threshold the module will send the following URC:
^SBC: Undervoltage

This alert is sent only once before the module shuts down cleanly without sending any further messages.

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

3.3.5.3 Overvoltage Shutdown

The overvoltage shutdown threshold is equal to the maximum supply voltage V_{BATT+} specified in Table 21.

When the supply voltage approaches the overvoltage shutdown threshold the module will send the following URC:
^SBC: Overvoltage

This alert is sent once.

When the overvoltage shutdown threshold is exceeded the module will shut down cleanly.

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

Keep in mind that several BGS12 components are directly linked to $BATT_{+BB}$ and $BATT_{+RF}$, therefore, the supply voltage remains applied at major parts of BGS12. Especially the power amplifier linked to $BATT_{+RF}$ is very sensitive to high voltage and might even be destroyed.

3.4 Power Saving

SLEEP mode reduces the functionality of the BGS12 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 [1]. SLEEP mode falls into two categories:

- NON-CYCLIC SLEEP mode AT+CFUN=0
- CYCLIC SLEEP modes, selectable with AT+CFUN=7 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 (Limited Service), the selected <fun> level will be set, though power saving does not take effect.

To check whether power saving is on, you can query the status of AT+CFUN if you have chosen CYCLIC SLEEP mode.

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

3.4.1 No Power Saving (AT+CFUN=1)

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

3.4.2 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 BGS12 back to the highest level of functionality <fun>=1.

In NON-CYCLIC mode, the falling edge of the RTS0 or RTS1 lines wakes up the module to <fun>=1. To efficiently use this feature it is recommended to enable hardware flow control (RTS/CTS handshake) as in this case the CTS line notifies the application when the module is ready to send or receive characters. See Section 3.4.7.1 for details.

3.4.3 CYCLIC SLEEP Mode AT+CFUN=7

The functionality level AT+CFUN=7 is referred to as CYCLIC SLEEP modes. The major benefit of all CYCLIC SLEEP modes is that the serial interface remains accessible, and that, in intermittent wake-up periods, characters can be sent or received without terminating the selected mode.

The 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 mode CFUN=7, BGS12 automatically resumes power saving, after you have sent or received a short message, made a call or completed a GPRS transfer. Please refer to

Table 9 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 BGS12 is AT\Q0 (no flow control) which must be altered to AT\Q3. See [1] for details.

Note: If both serial interfaces ASC0 and ASC1 are connected, both are synchronized. This means that SLEEP mode takes effect on both, no matter on which interface the AT command was issued. Although not explicitly stated, all explanations given in this section refer equally to ASC0 and ASC1, and accordingly to CTS0 and CTS1.

3.4.4 CYCLIC SLEEP Mode AT+CFUN=9

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

- 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 [1].
- RTS0 and RTS1 are not only used for flow control (as in mode AT+CFUN=7), but also cause the module to wake up temporarily. See Section 3.4.7.1 for details.

3.4.5 Timing of the CTS Signal in CYCLIC SLEEP Modes

The CTS signal is enabled in synchrony with the module's paging cycle. It goes active low each time when the module starts listening to a paging message block from the base station. The timing of the paging cycle varies with the base station. The duration of a paging interval can be calculated from the following formula:
*4.616 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 5ms. This is followed by another 5ms UART activity. If the start bit of a received character is detected within these 10ms, 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=7
- 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 10 and Figure 11.

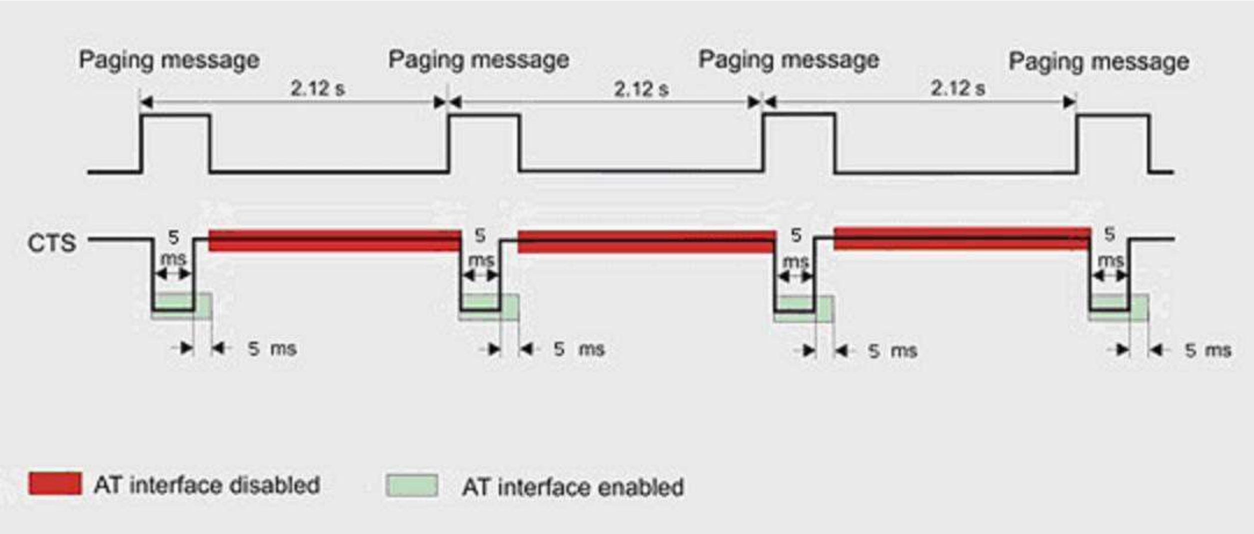


Figure 10: Timing of CTS signal (example for a 2.12 s paging cycle)

Figure 11 illustrates the CFUN=7 modes, which reset the CTS signal 2 seconds after the last character was sent or received.

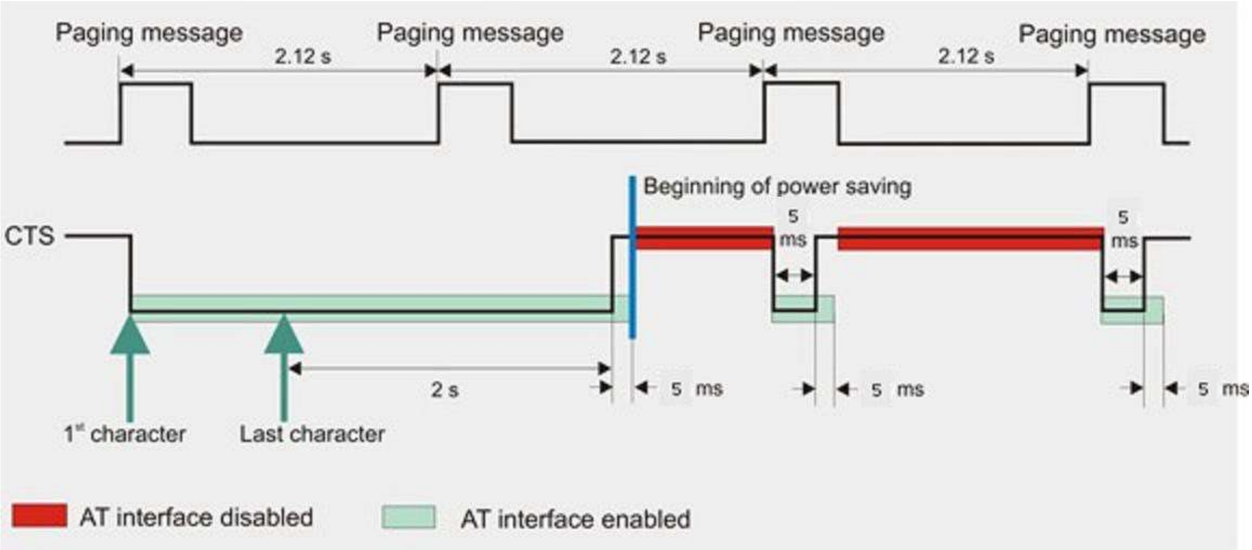


Figure 11: Beginning of power saving if CFUN=7

3.4.6 Power Saving in OFF-state

When the BGS12 is powered off, and the $BATT_{+BB}$, $BATT_{+RF}$ lines are supplied, the OFF-current can be lesser than 100uA (V_{BATT+} =4.2V). Detail power off state supply current of I_{BATT+} is shown in Table 27. If the power-off current is a concern, it is suggested to use a MOSFET as a switch to reduce the 100uA (V_{BATT+} =4.2V) current to the quiescence current of the MOS- FET.

The figure below shows an external application circuit that provides the possibility to disconnect the module‘s BATT+ lines from the external application‘s power supply. The MOSFET transistor (T8) should have an RDS_ON value < 50mΩ in order to minimize voltage drops.

This circuit can also be used to reset the module in case it becomes unresponsive, or to completely switch off and restart the module after a firmware update.

Afterwards the module can be restarted using the ON signal as described in Section 3.3.1.1.

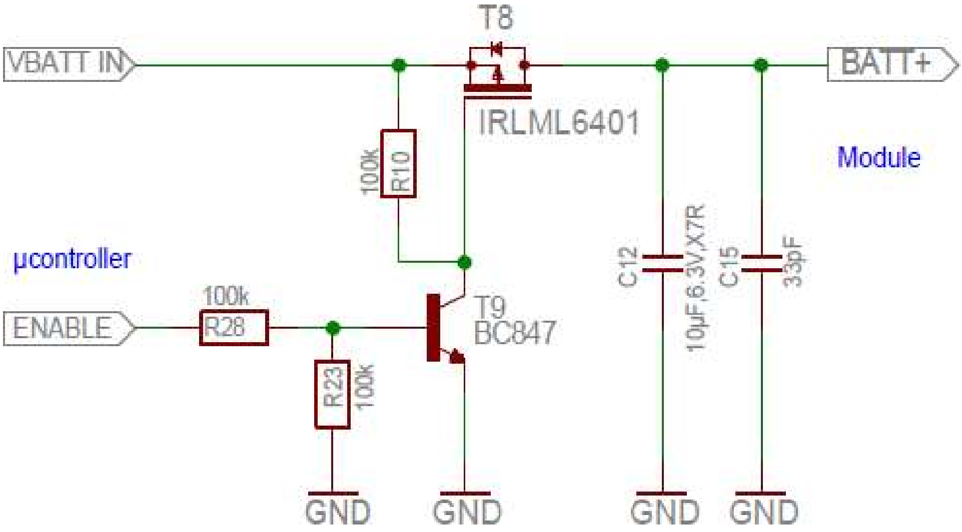


Figure 12: Power Saving in OFF-state

3.4.7 Wake up BGS12 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 BGS12 back to AT+CFUN=1, or activates BGS12 temporarily without leaving the current SLEEP mode.

Definitions of the state transitions described in Table 9:
Quit = BGS12 exits SLEEP mode and returns to AT+CFUN=1.
Temporary = BGS12 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. BGS12 does not wake up.

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

Event	**Selected mode AT+CFUN=0**	**Selected mode AT+CFUN=7 or 9**
Ignition line	No effect	No effect
RTS0 or RTS1[1)] (falling edge)	Quit + flow control	Mode 7: No effect, RTS is only used for flow control Mode 9: Temporary + flow control
Unsolicited Result Code (URC)	Quit	Temporary
Incoming voice or data call	Quit	Temporary
Any AT command (incl. outgoing voice or data call, outgoing SMS)	Not possible (UART disabled)	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 Temporary
GPRS data transfer	Not possible (UART disabled)	Temporary
AT+CFUN=1	Not possible (UART disabled)	Quit

1. See Section Section 3.4.7.1 on wake-up via RTS.

3.4.7.1 Wake-up via RTS0 and RTS2 (if AT+CFUN=0 or AT+CFUN=9)

During the CYCLIC SLEEP mode 7, the RTS0 and RTS2 lines are conventionally used for flow control: The assertion of RTS0 or RTS2 indicates 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 and RTS2 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 RTS0 or RTS2 can be used to temporarily wake up BGS12 for the time specified with the AT^SCFG command (default = 2s). In both cases, if RTS0 or RTS2 is asserted while AT+CFUN=0 or AT+CFUN=9 is set, there may be a short delay until the module is able to receive data again. This delay depends on the current module activities (e.g. paging cycle) and may be up to 60ms. The ability to receive data is signalized by CTS0 and CTS2. It is therefore recommended to enable RTS/CTS flow control, not only in CYCLIC SLEEP mode, but also in NON-CYCLIC SLEEP mode.

3.5 Summary of State Transitions (except SLEEP Mode)

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

Table 10: State transitions of BGS12 (except SLEEP mode)

Further mode →→ Present mode	**Power Down**	**Normal mode**
Power Down mode	---	ON >2s at VDDLP level
Normal mode	AT^SMSO	---
Normal mode	EMERG_RST > 1ms	EMERG_RST > 1ms And ON has always been at VDDLP level

3.6 RTC Backup

The internal Real Time Clock of BGS12 is supplied from a separate voltage regulator in the power supply component which is also active when BGS12 is in Power Down mode and BATT+ is available.

In addition, you can use the VDDLP pad to backup the RTC from an external capacitor. The capacitor is charged from the internal LDO of BGS12. If the voltage supply at BATT+ is disconnected the RTC can be powered by the capacitor. The size of the capacitor determines the duration of buffering when no voltage is applied to BGS12, i.e. the greater the capacitor the longer BGS12 will save the date and time. The RTC can also be supplied from an external battery (rechargeable or non-chargeable). In this case the electrical specification of the VDDLP pad (see Section 5.4) has to be taken in to account.

3.7 SIM/USIM Interface

The baseband processor has an integrated SIM/USIM card interface compatible with the ISO/ IEC 7816 IC Card standard. This is wired to the host interface in order to be connected to an external SIM card holder. Five pads are reserved for the SIM interface. BGS12 supports and automatically detects 3.0V as well as 1.8V SIM cards.

3.7.1 Single SIM/USIM Card Application

The CCIN pad serves to detect whether a tray is present in the card holder. Using the CCIN pad is mandatory for compliance with the 3GPP TS 11.11 (Rel.99) recommendation if the mechanical design of the host application allows the user to remove the SIM card during operation.

Table 11: Signals of the SIM interface (SMT application interface)

Signal	Description
CCCLK	Chipcard clock, various clock rates can be set in the baseband processor. The total capacitors on CCCLK should be less than 12pF. Some device which connect with CCCLK, have the equivalent capacitors, such as the ESD component and analogue switch IC. When selecting such component, one should calculate equivalent capacitors of all device, and make sure they are less than 12pF.
CCVCC	SIM supply voltage from PSU-ASIC
CCIO	Serial data line, input and output.
CCRST	Chipcard reset, provided by baseband processor
CCIN	Input on the baseband processor for detecting a SIM card tray in the holder. The default level of CCIN is low (internal pull down resistor, no card inserted). It will change to high level when the card is inserted. To take advantage of this feature, an appropriate contact is required on the cardholder. Ensure that the cardholder on your application platform is wired to output a high signal when the SIM card is present. The CCIN pad is mandatory for applications that allow the user to remove the SIM card during operation. The CCIN pad 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 BGS12.

The figure below shows a circuit to connect an external SIM card holder.

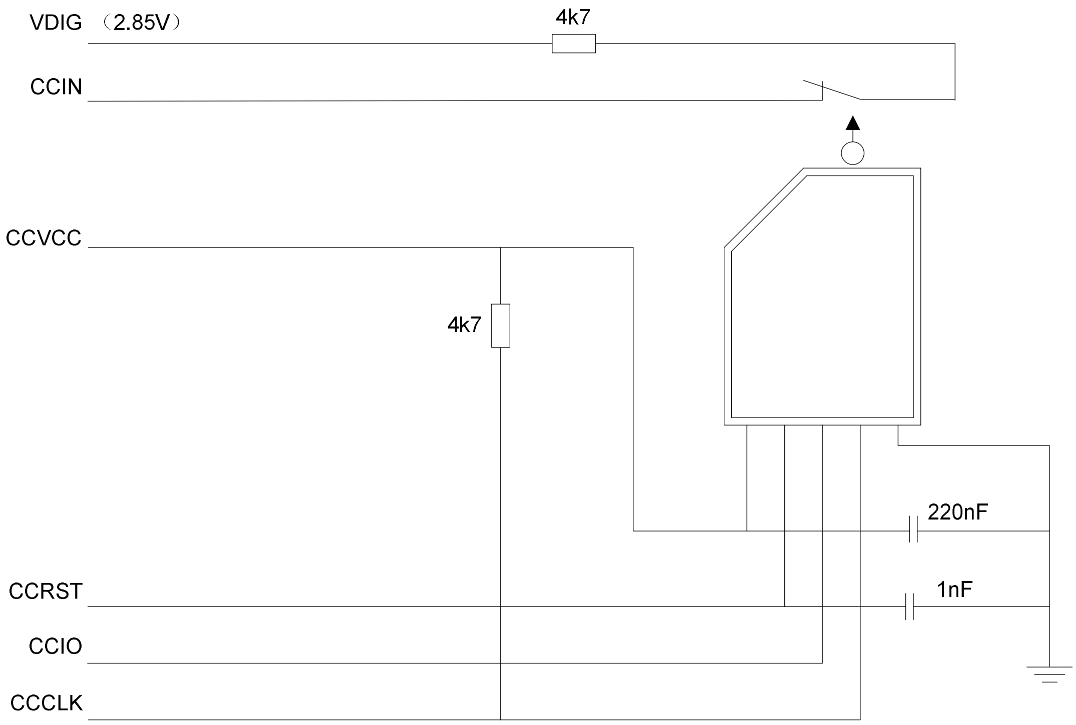


Figure 13: External SIM card holder circuit

It is recommended that the total cable length between SMT application interface pads on BGS12 and the connector of the external SIM card holder must not exceed 100mm in order to meet the specifications of 3GPP TS 51.010-1 and to satisfy the requirements of EMC com-

pliance.
To avoid possible cross-talk from the CCCLK signal to the CCIO signal be careful that both lines are not placed closely next to each other. A useful approach would be to use a separate SIM card ground connection to shield the CCIO line from the CCCLK line. A GND line may be employed for such a case.

Notes: The total capacitors on CCCLK should be less than 12pF. Some device which connect with CCCLK, have the equivalent capacitors, such as the ESD component and analogue switch IC. When selecting such component, one should calculate equivalent capacitors of all device, and make sure they are less than 12pF.

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 initialising any SIM card that the user inserts after having removed a SIM card during operation. In this case, the application must restart BGS12.

If using a SIM card holder without detecting contact please be sure to switch off the module before removing the SIM Card or inserting a new one.

3.7.2 Dual SIM/USIM Card Application

BGS12 can support dual SIM card by add a dual SIM card analog switch IC (for details see [7]).

3.8 Serial Interface ASC0

BGS12 offers an 8-wire unbalanced, asynchronous modem interface ASC0 conforming to ITUT V.24 protocol DCE signalling. The electrical characteristics do not comply with ITUT V.28. The voltage level of the ASC0 interface is at 2.8V.

As the 2.8V voltage level is not supported by Gemalto M2M 3G modules, it is recommended to use the 1.8V level convertor in case a migration to these modules is intended.

For electrical characteristics of the interface signals please refer to Section 5.4.

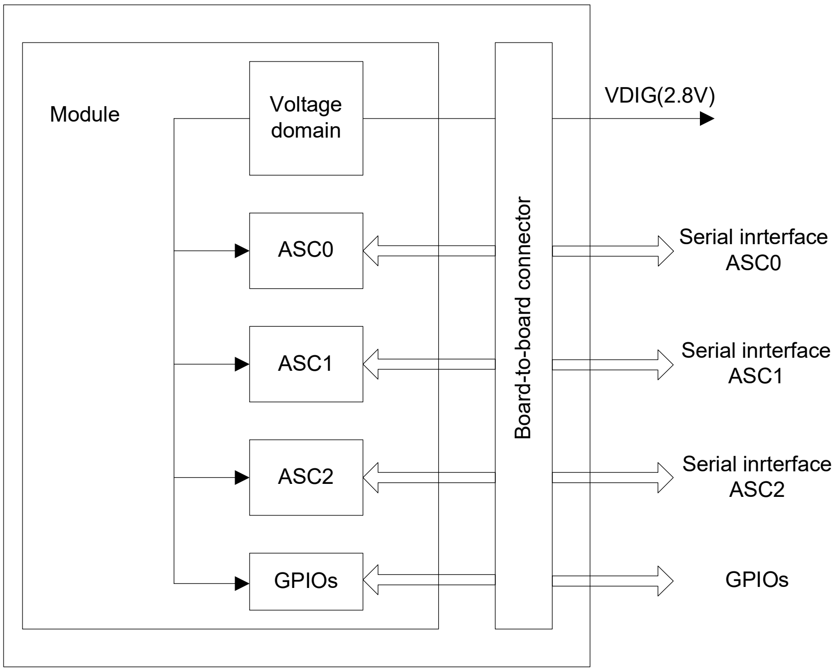


Figure 14: VDIG power supply domain

BGS12 is designed for use as a DCE. Based on the conventions for DCE-DTE connections it communicates with the customer application (DTE) using the following signals:

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

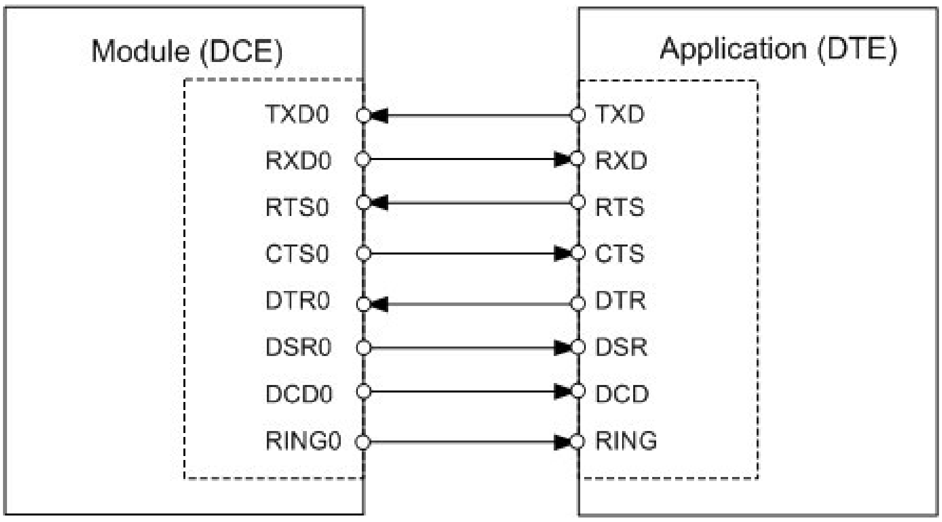


Figure 15: Serial interface ASC0

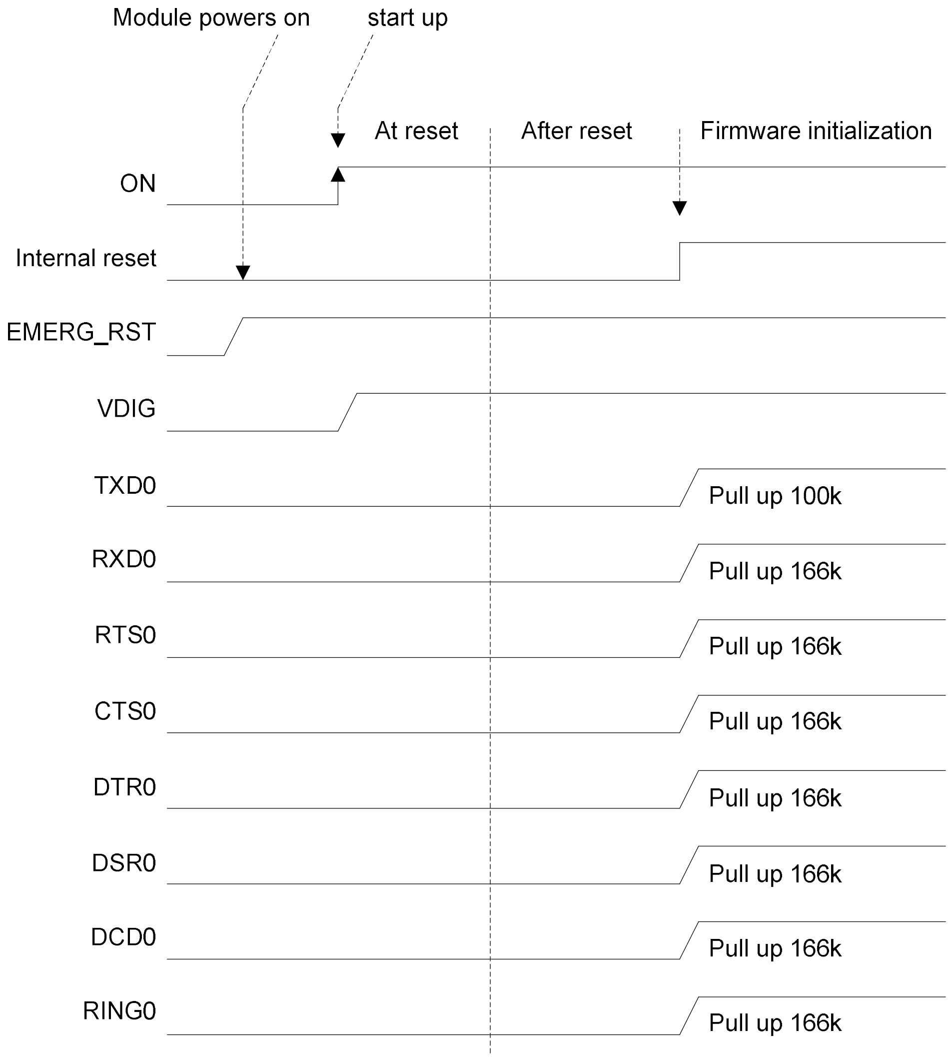
Features:

- Includes the data lines TXD0 and RXD0, the status lines RTS0 and CTS0 and, in addition, the modem control lines DTR0, DSR0, DCD0 and RING0.
- ASC0 is primarily designed for controlling voice calls, GPRS data and for controlling the GSM module with AT commands.
- The DTR0 signal will only be polled once per second from the internal firmware of BGS12.
- The RING0 signal serves to indicate incoming calls and other types of URCs (Unsolicited Result Code). It can also be used to send pulses to the host application, for example to wake up the application from power saving state. See [1] for details on how to configure the RING0 line by AT^SCFG.
- Configured for 8 data bits, no parity and 1 stop bit.
- Autobauding supports bit rates from 4,800 bps to 230,400 bps.
- Supports RTS0/CTS0 hardware flowcontrol.

Table 12: DCE-DTE wiring of ASC0

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

The following figure shows the startup behavior of the asynchronous serial interface ASC0.



For output and input states see Table 7

Figure 16: ASC0 startup behavior

Please note that no data must be sent over the ASC0 interface before the interface is active and ready to receive data (see Section 3.3.1.1).

3.9 Serial Interface ASC1

BGS12 offers a 2-wire unbalanced, asynchronous modem interface ASC1 conforming to ITU-T V.24 protocol DCE signalling. The electrical characteristics do not comply with ITUT V.28. The electrical level of the ASC1 interface is set to 2.8V. For electrical characteristics please refer to Table 20.

BGS12 is designed for use as a DCE. Based on the conventions for DCE-DTE connections it communicates with the customer application (DTE) using the following signals:

- Port TXD @ application sends data to module's TXD1 signal line
- Port RXD @ application receives data from the module's RXD1 signal line

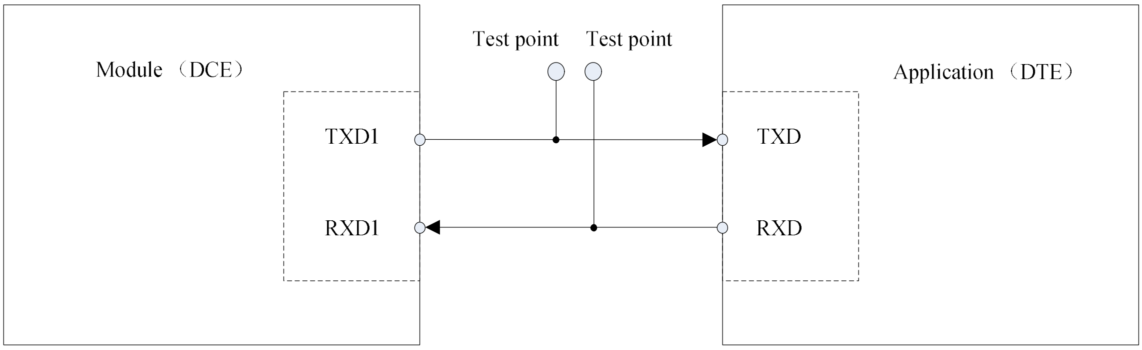


Figure 17: Serial interface ASC1

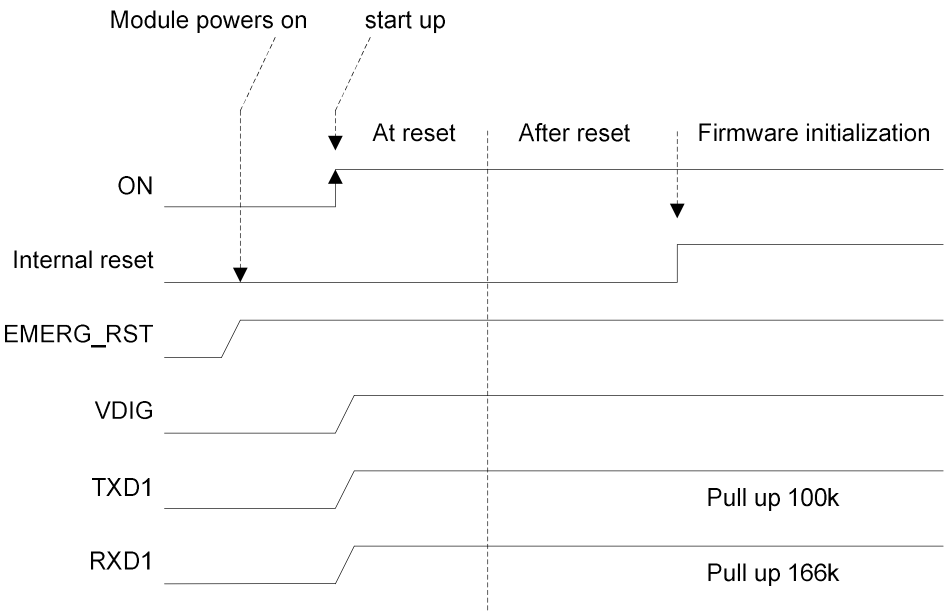
Features

- Includes only the data lines TXD1 and RXD1.
- For firmware upgrading and tracing purpose.
- Configured for 8 data bits, no parity and 1 or 2 stop bits.
- ASC1 can be operated at fixed bit rate at 921,600 bps. Autobauding is not supported on ASC1.

Table 13: DCE-DTE wiring of ASC1

V.24 circuit	**DCE**		**DTE**	
	Line function	**Signal direction**	**Line function**	**Signal direction**
103	TXD1	Input	TXD	Output
104	RXD1	Output	RXD	Input

The following figure shows the startup behavior of the asynchronous serial interface ASC1.



For output and input states see Table 7

Figure 18: ASC1 startup behavior

3.10 Serial Interface ASC2

BGS12 offers a 4-wire unbalanced, asynchronous modem interface ASC2 conforming to ITU-T V.24 protocol DCE signalling. The electrical characteristics do not comply with ITUT V.28. The electrical level of the ASC2 interface is set to 2.8V. For electrical characteristics please refer to Table 20.

BGS12 is designed for use as a DCE. Based on the conventions for DCE-DTE connections it communicates with the customer application (DTE) using the following signals:

- Port TXD @ application sends data to module’s TXD2 signal line
- Port RXD @ application receives data from the module’s RXD2 signal line

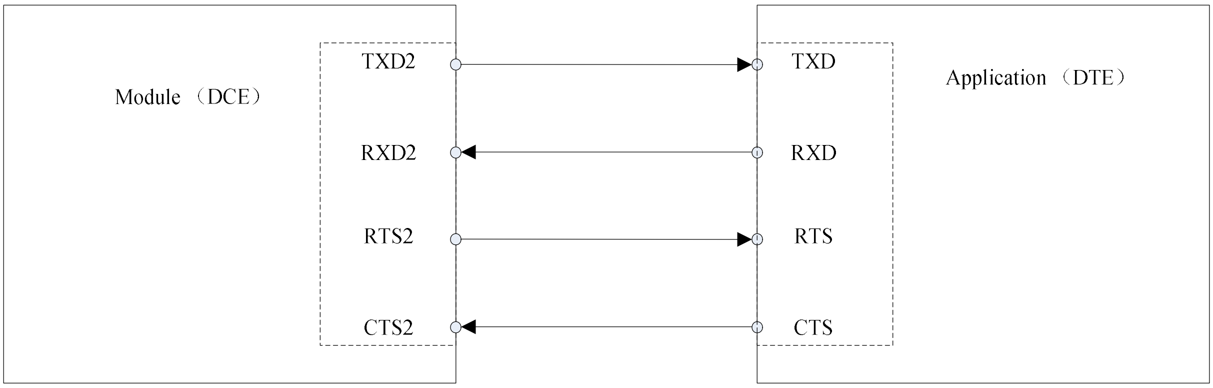


Figure 19: Serial interface ASC2

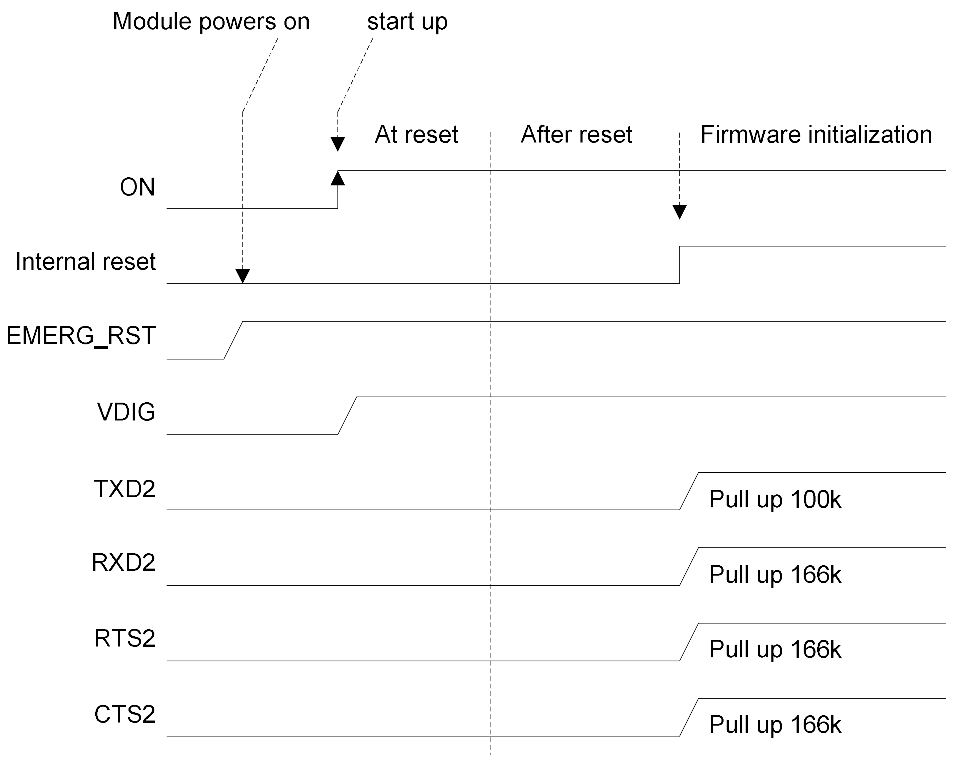
Features

- Includes only the data lines TXD2 and RXD2 plus RTS2 and CTS2 for hardware handshake.
- On ASC2 no RING line is available. The indication of URCs on the second interface depends on the settings made with the AT^SCFG command. For details refer to [1].
- Configured for 8 data bits, no parity and 1 or 2 stop bits.
- ASC2 can be operated at fixed bit rates from 4,800 bps to 230,400 bps. Autobauding is not supported on ASC2.
- Supports RTS2/CTS2 hardware flowcontrol.

Table 14: DCE-DTE wiring of ASC2

V.24 circuit	**DCE**		**DTE**	
	Line function	**Signal direction**	**Line function**	**Signal direction**
103	TXD2	Input	TXD	Output
104	RXD2	Output	RXD	Input
105	RTS2	Input	RTS	Output
106	CTS2	Output	CTS	Input

The following figure shows the startup behavior of the asynchronous serial interface ASC2.



For output and input states see Table 7

Figure 20: ASC2 startup behavior

3.11 Analog Audio Interface

BGS12 has an analog audio interface with a balanced analog microphone input and a balanced analog earpiece output. A supply voltage is provided at dedicated pad.

BGS12 offers four audio modes which can be selected with the AT^SNFS command. The electrical characteristics of the voice band part vary with the audio mode. For example, sending and receiving amplification, side tone paths, noise suppression etc. depend on the selected mode and can be altered with AT commands.

Please refer to Section 5.6 for specifications of the audio interface and an overview of the audio parameters. Detailed instructions on using AT commands are presented in [1]. Table 30 summarizes the characteristics of the various audio modes and shows what parameters are supported in each mode.

When shipped from factory, all audio parameters of BGS12 are set to default audio mode.

3.11.1 Microphone Inputs and Supply

The differential microphone inputs MICP and MICN present an impedance of 2kOhm and must be decoupled by capacitors (typical 100nF). A regulated power supply for electret microphones is available at VMIC. The voltage at VMIC is rated at 1.8V and available while audio is active (e.g., during a call). It can also be controlled by AT^SNFM. It is recommended to use an additional RC-filter if a high microphone gain is necessary.

The following figures show possible microphone and line connections.

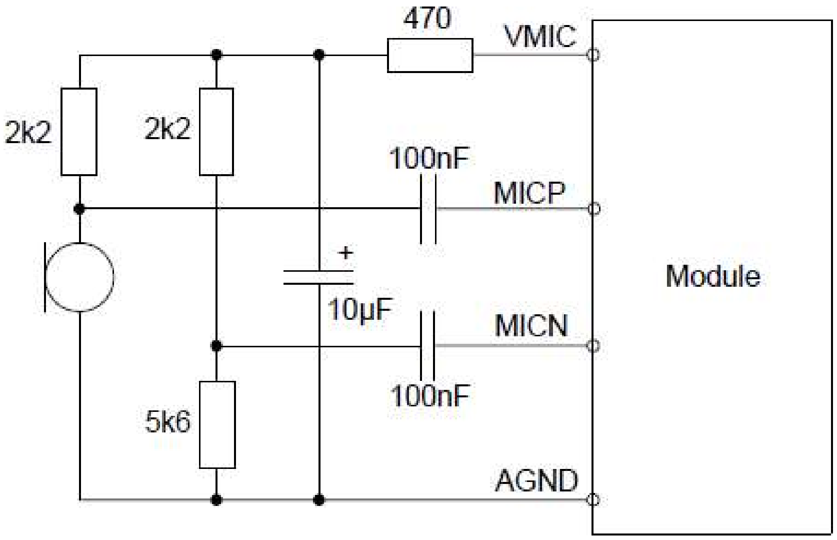


Figure 21: Single ended microphone connection

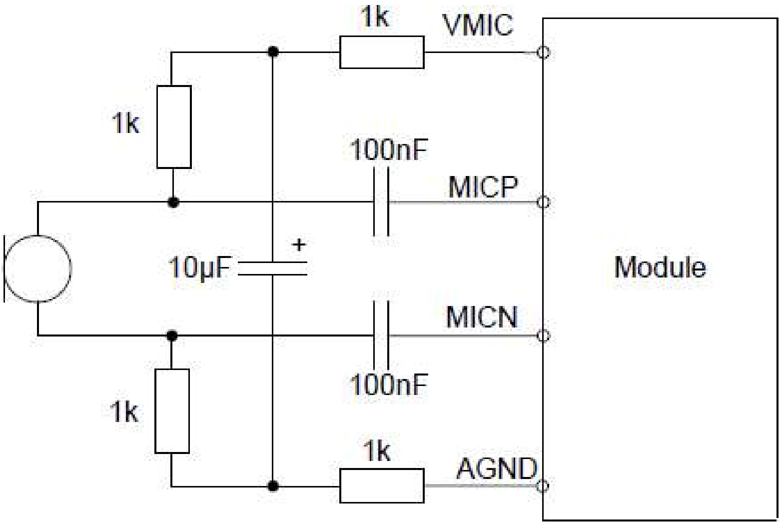


Figure 22: Differential Microphone connection

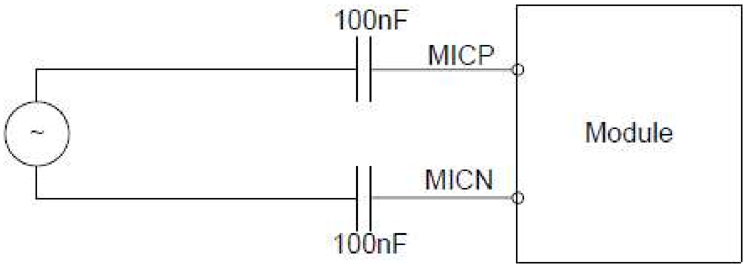


Figure 23: Line Input

3.11.2 Loudspeaker Output

BGS12 provides a differential loudspeaker output EPP/EPN. If it is used as line output (see Figure 25), the application should provide a capacitor decoupled differential input to eliminate GSM humming. A first order low pass filter above 4 kHz may be useful to improve the out-of-band signal attenuation. A single ended connection to a speaker or a line input should not be realized.

The following figures show the typical output configurations.

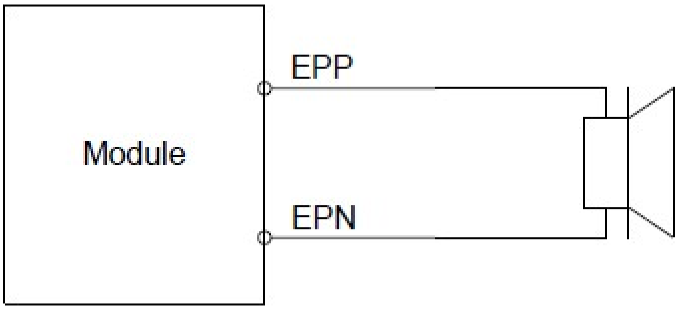


Figure 24: Differential loudspeaker connection

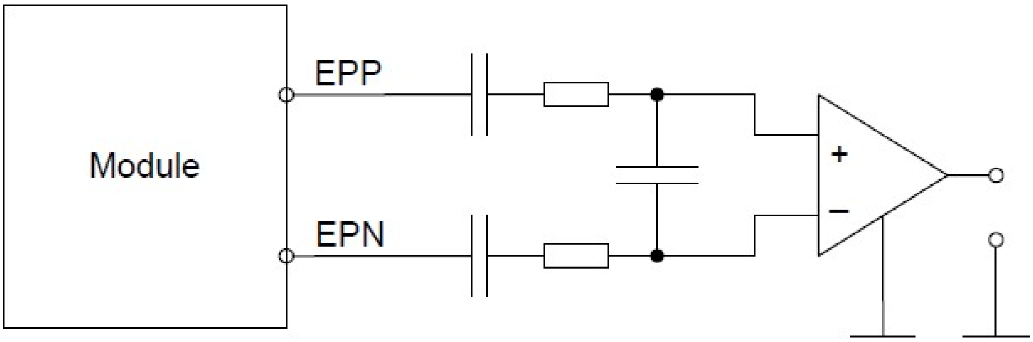


Figure 25: Line output connection

3.12 I²S Interface

BGS12 offers a I2S interface with 4 lines. These signals are shared with IISDO, IISLRCK, IISDI, IISCLK pads.

Normal I2S master mode supports:
- 16 bits word, linear.
- Mono interface.
- Sample:<I2S_sample_rate>parameter.
- I²S runs in normal I²S – long alignment mode.
- I²S word alignment signal always runs at the <I2S_sample_rate> and synchronizes 2 channel (timeslots on word alignment high, word alignment low).
- I²S transmit data is composed of 16 bit words, dual mono (the words are written on both channels). Data are in 2's complement notation. MSB is transmitted first. The bits are written on I²S clock rising or falling edge (configurable).
- I2S receive data is read as 16 bit words, mono (words are read only on the timeslot with WA high). Data is read in 2's complement notation. MSB is read first. The bits are read on the I²S clock edge opposite to I²S transmit data writing edge (configurable).
- I²S clock frequency is 16 bits x 2 channels x <I2S_sample_rate>.
- MSB can be 1 bit delayed or non-delayed on I²S word alignment edge.
- I²S transmit data can change on rising or falling edge of I²S clock signal.
- I²S receive data are read on the opposite front of I²S clock signal.

3.13 GPIO Interface

BGS12 offers a GPIO interface with 6 GPIO lines. Some GPIO lines are shared with other interfaces, such as I²C interface (see Section 3.14), Status LED (see Section 3.16), and the jamming indicator (see Section 3.15). All functions are controlled by dedicated AT commands.

The following table shows the configuration variants of the GPIO pads. All variants are mutually exclusive, i.e. a pad configured as GPIO is locked for alternative use.

Table 15: GPIO assignment

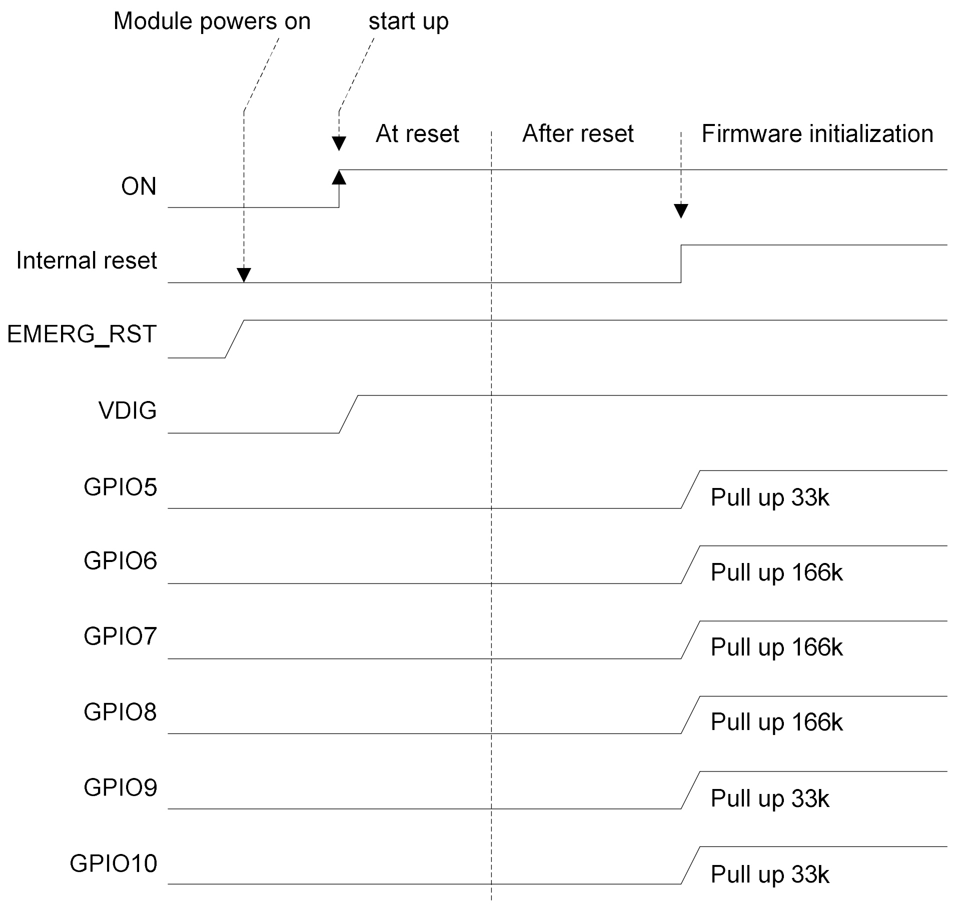
GPIO	**I2C**	**Status LED**	**Voltage domain**
GPIO5		Status LED	VDIG(=2.8V)
GPIO6		Jamming indicator	VDIG(=2.8V)
GPIO7			VDIG(=2.8V)
GPIO8			VDIG(=2.8V)
GPIO9	I2CCLK		VDIG(=2.8V)
GPIO10	I2CDAT		VDIG(=2.8V)

Each GPIO line can be configured for use as input or output. The default function is reserved in present software, the GPIO related AT commands will be developed in the future, please pay attention to the newest released note.

When the BGS12 starts up, all GPIO lines states are described in Section 3.3.3. Therefore, it is recommended to connect external pull-up or pull-down resistors to all GPIO lines you want to use as output.

The power supply domain voltage level for GPIO5 to GPIO10 is 2.8V. I2CCLK (GPIO9) and I2CDAT (GPIO10) require an external pull-up resistor.

The following figure shows the startup behavior of the GPIO interface.



For output and input states see Table 7

Figure 26: GPIO startup behavior

3.14 I²C Interface

The signal lines of the I²C interface are shared with the GPIO9 and GPIO10 signal pads.

The power supply domain voltage level for 2.8V, the I²C interface pads voltage level (see Figure 14).

I²C is a serial data transfer bus. Only normal (100kbps) and fast modes (400kbps) are supported. It consists of two lines, the serial data line I2CDAT (GPIO10) and the serial clock line I2CCLK (GPIO9). The module acts as a single master device, e.g. the clock I2CCLK is driven by the module. I2CDAT is a bidirectional line. Each device connected to the bus is software addressable by a unique 7- bit address, and simple master/slave relationships exist at all times. The module operates as master- transmitter or as master receiver. The customer application transmits or receives data only on request of the module.

In the application I2CDAT and I2CCLK lines need to be connected to a positive supply voltage via a pull-up resistor. For electrical characteristics please refer to Table 22.

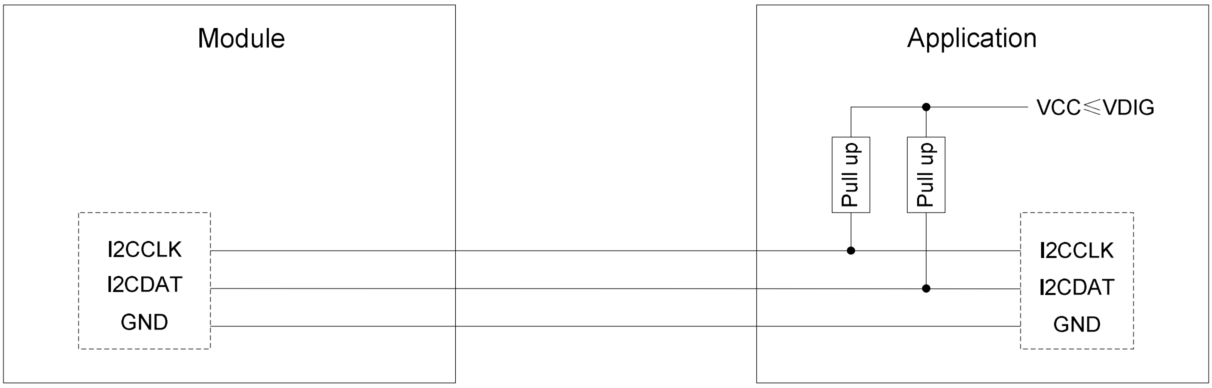


Figure 27: I2C interface connected to VCC of application

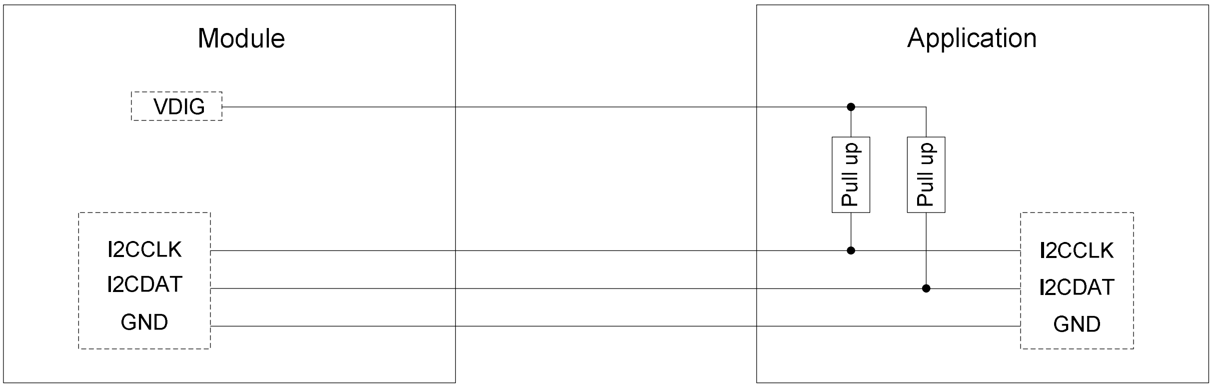


Figure 28: I2C interface connected to VDIG

Note: Good care should be taken when creating the PCB layout of the host application: The traces of I2CCLK and I2CDAT should be equal in length and as short as possible.
The timing of TSU:STO and SHD:STA has deviation from the I2C specification but the I2C interface do work properly with slave devices as verified. The deviation cannot be changed due to limitation on the chipset.

The following figure shows the startup behavior of the I2C interface.

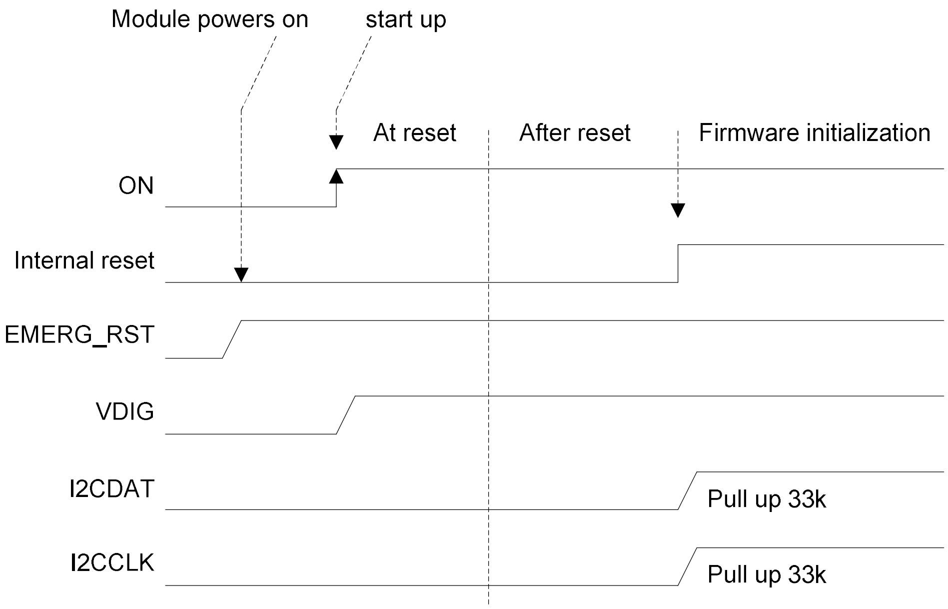


Figure 29: I2C startup behavior

3.14.1 I2C Interface on DSB75

To evaluate the I^2C interface employing the DSB75, some modifications are required on the AH6-DSB75 adapter mentioned in Section 9.1. Four components will have to be populated on the adapter: D305 (I2C EEPROM, SOIC-8, 1V8; a suitable EEPROM type would for example be "AT24C1024BN-SH-T" from ATMEL), C300 (decoupling capacitor, 0402 package), R301, R302 (I2C pull-up resistors, 0402 package). For details see Figure 30.

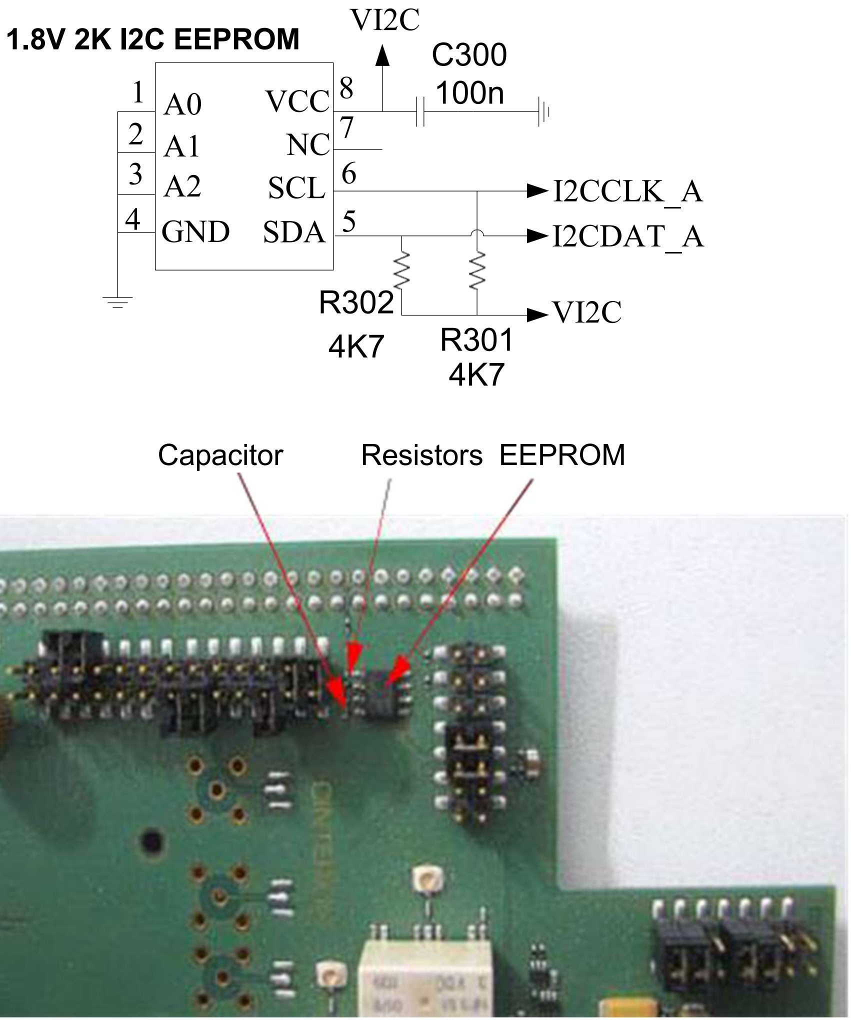
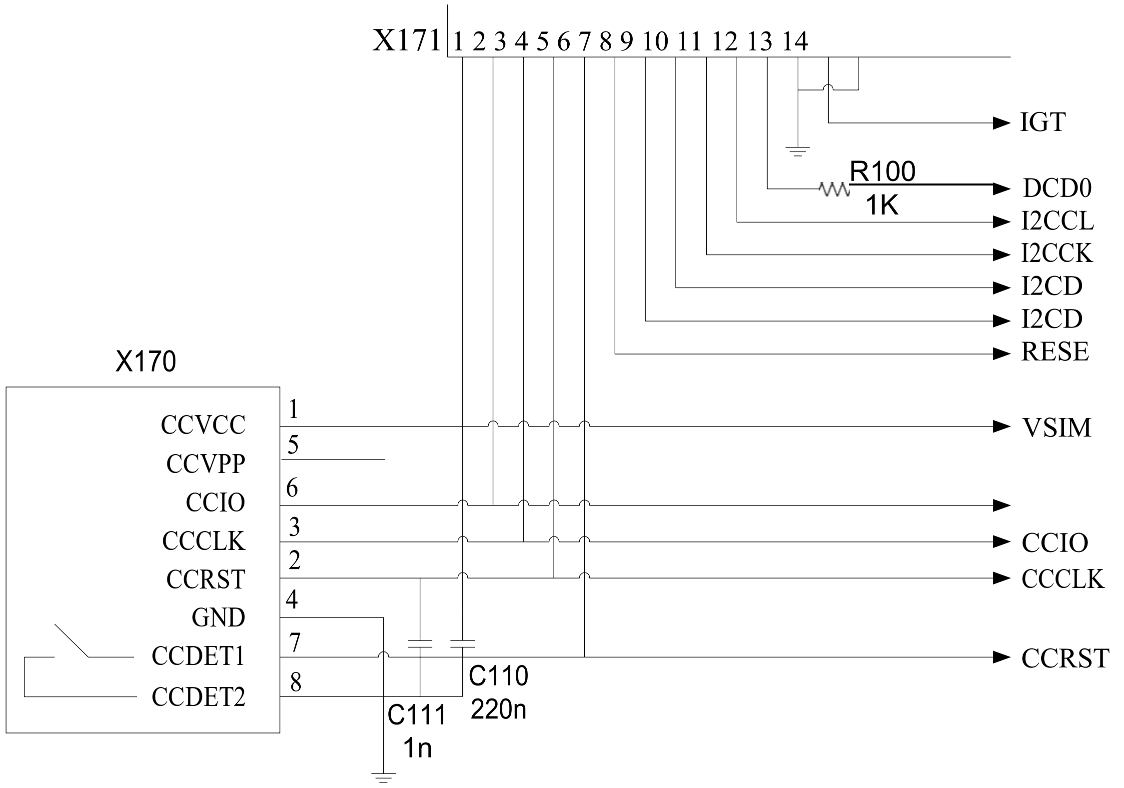


Figure 30: Additional EEPROM to enable usage of I2C interface on DSB75

Furthermore, two jumpers (X171, for pins 7&8, 9&10) must be set in order to connect the module's I^{2}C signals with the memory device's input pins. For details see Figure 31.



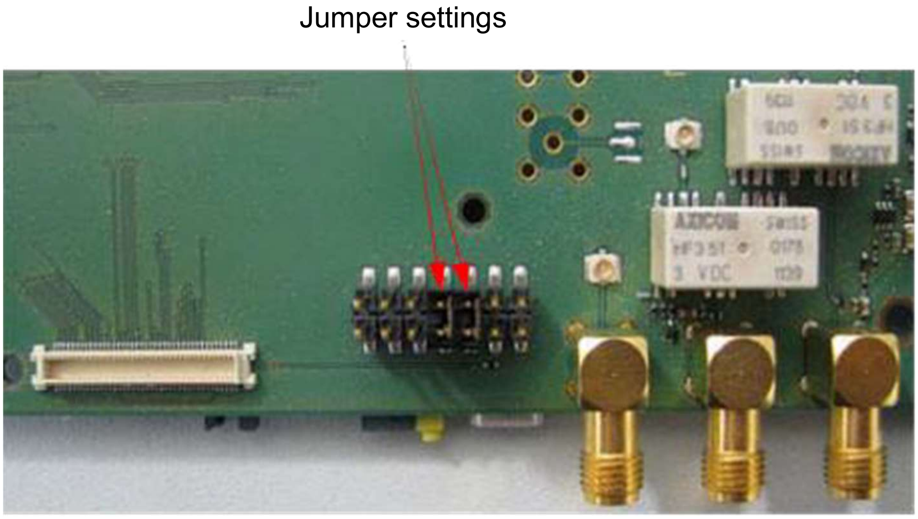


Figure 31: Jumper settings to enable usage of I2C interface on DSB75

3.15 Jamming Indicator

The GPIO6 interface line can be configured as a jamming indicator by AT command. When possible jamming is detected by the module, GPIO6 is set to high level. This state lasts as long as possible jamming is detected.

By default, the jamming indicator feature is disabled. It has to be enabled using the AT command AT^SCFG "MEopMode/JamDet/If". For details see [1].

3.16 Status LED

The GPIO5 line at the SMT application interface can be configured to drive a status LED which indicates different operating modes of the module (for GPIOs see Section 3.13). GPIO and LED functionality are mutuallyexclusive.

To take advantage of this function connect an LED to the GPIO5/LED line as shown in Figure 32. The LED can be enabled/disabled by AT command. For details refer to [1]: AT^SSYNC.

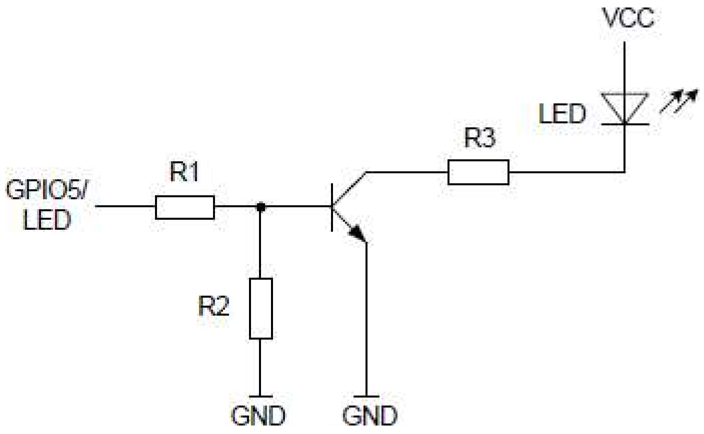


Figure 32: Status signalling with LED driver

3.17 Behavior of the RING0 Line (ASC0 Interface only)

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

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

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

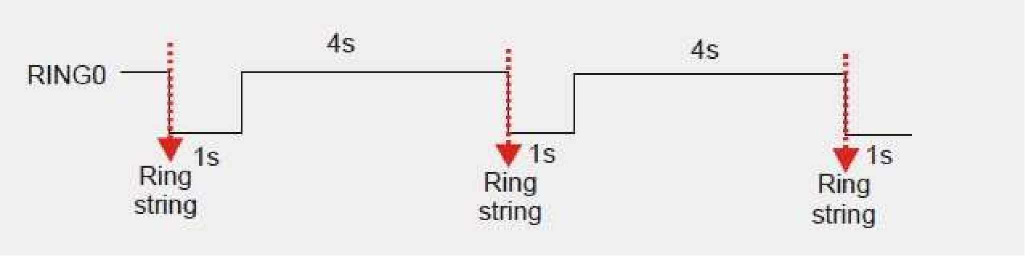


Figure 33: Incoming voice call

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

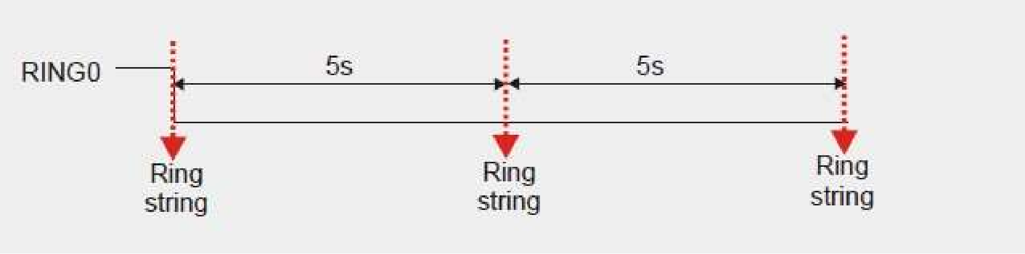


Figure 34: incoming data receive

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

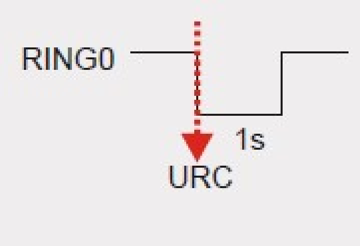


Figure 35: URC transmission

3.18 Power Indication Circuit

In Power Down mode the maximum voltage at any digital or analog interface line must not exceed +0.3V (see also Section 5.1). Exceeding this limit for any length of time might cause permanent damage to the module.

It is therefore recommended to implement a power indication signal that reports the module’s power state and shows whether it is active or in Power Down mode. While the module is in Power Down mode all signals with a high level from an external application need to be set to low state or high impedance state. The sample power indication circuit illustrated in Figure 36 denotes the module’s active state with a low signal and the module’s Power Down mode with a high signal or high impedance state.

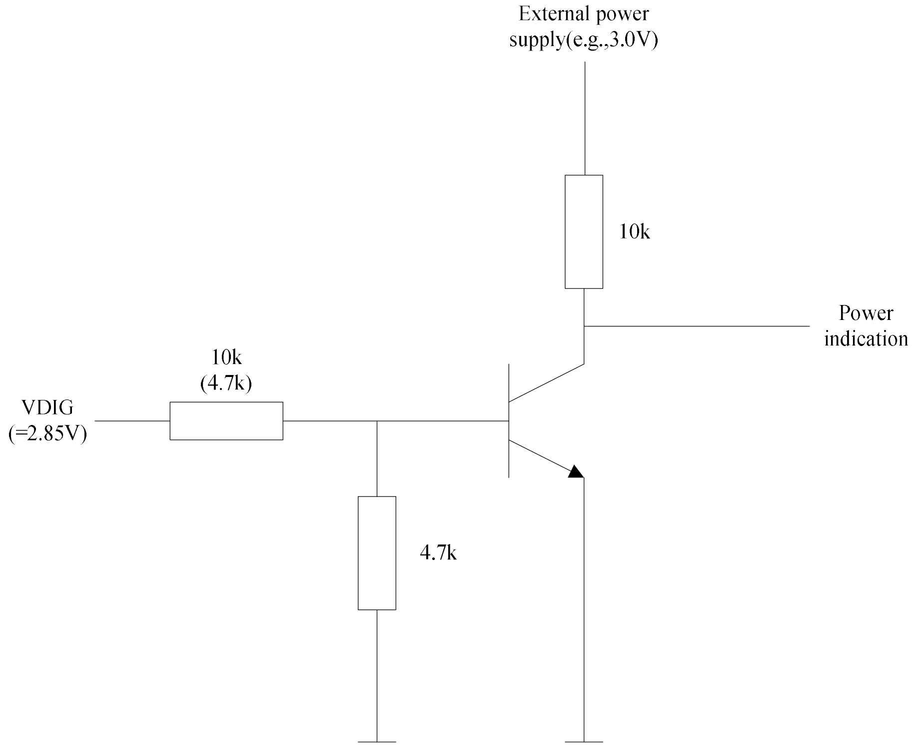


Figure 36: Power indication circuit

3.19 Fast Shutdown

BGS12 provides a dedicated fast shutdown signal. The FAST_SHTDWN line is an active low control signal and it is recommended to be applied for at least 10 milliseconds. If unused this pin can be left open because of a configured internal pull-up resistor.

By default, the fast shutdown feature is disabled. It has to be enabled using the AT command AT^SCFG "MEShutdown/Fso". For details see [1].

If enabled, a low impulse >10 milliseconds on the FAST_SHTDWN line starts the fast shutdown. The fast shutdown procedure still finishes any data activities on the module's flash file system, thus ensuring data integrity, but will no longer deregister gracefully from the network, thus saving the time required for network deregistration.

Please note that if enabled, the normal software controlled shutdown using AT^SMSO will also be a fast shutdown, i.e., without network deregistration. However, in this case no URCs including shutdown URCs will be provided by the AT^SMSO command.

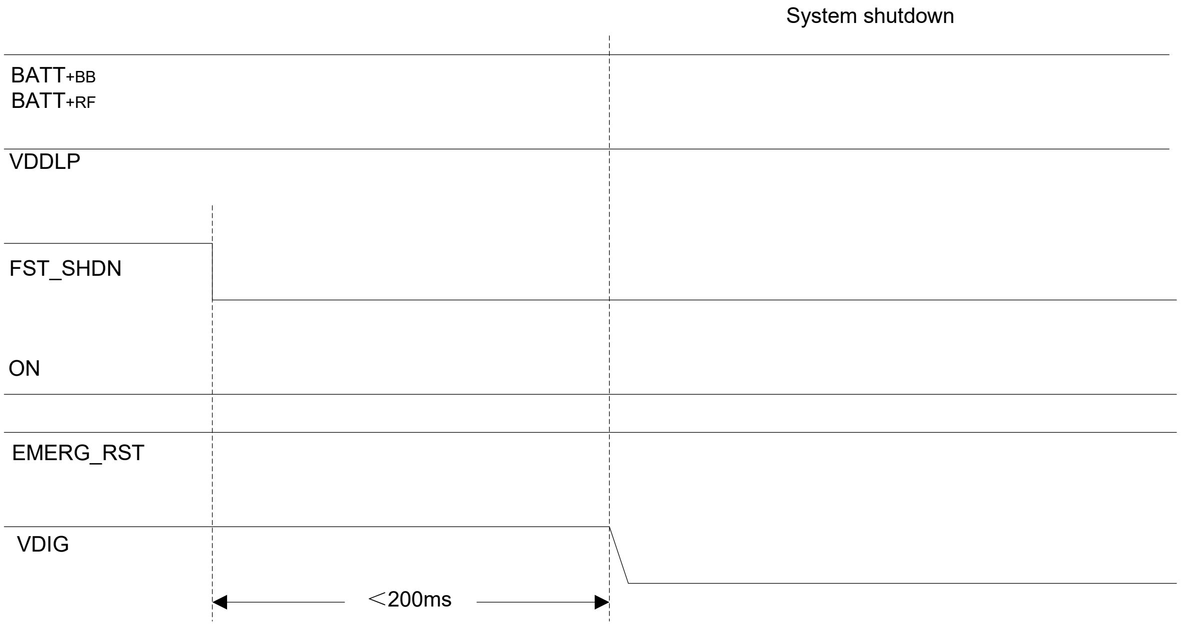


Figure 37: Fast Shutdown timing

4 Antenna Interface

The RF interface has an impedance of 50Ω. BGS12 is capable of sustaining a total mismatch at the antenna lines without any damage, even when transmitting at maximum RF power.

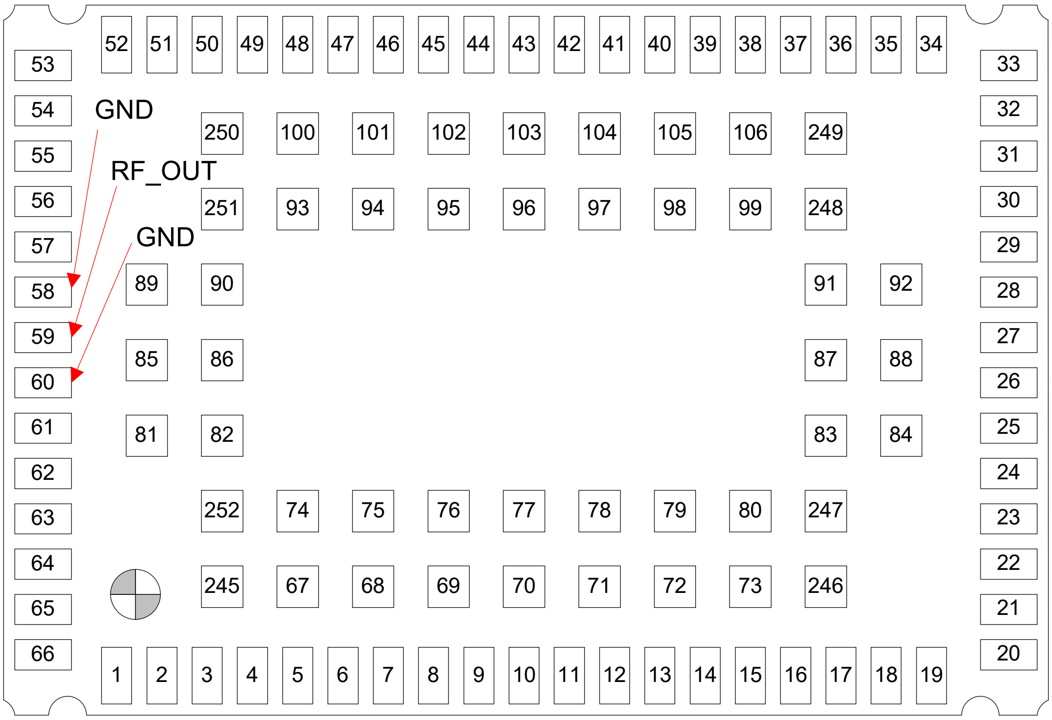
The external antenna must be matched properly to achieve best performance regarding radiated power, modulation accuracy and harmonic suppression. Antenna matching networks are not included on the BGS12 module and should be placed in the host application if the antenna does nothave an impendance of 50Ω.

Regarding the return loss BGS12 provides the following values in the active band:

Table 16: Return loss in the active band

State of module	Return loss of module	Recommended return loss of application
Receive	> 8dB	> 12dB
Transmit	not applicable	> 12dB

4.1 Antenna Installation



The antenna is connected by soldering the antenna pad (RF_OUT, i.e., pad #59) and its neighboring ground pads (GND, i.e., pads #58 and #60) directly to the application's PCB. The antenna pad is the antenna reference point (ARP) for BGS12. All RF data specified throughout this document is related to theARP.

Figure 38: Antenna pads (bottom view)

The distance between the antenna RF_OUT pad (#59) and its neighboring GND pads (#58, #60) has been optimized for best possible impedance. On the application PCB, special attention should be paid to these 3 pads, in order to prevent mismatch.

The wiring of the antenna connection line, starting from the antenna pad to the application antenna should result in a 50Ω line impedance. Line width and distance to the GND plane needs to be optimized with regard to the PCB's layer stack. Some examples are given in Section 4.2 .

To prevent receiver desensitization due to interferences generated by fast transients like high speed clocks on the application PCB, it is recommended to realize the antenna connection line using embedded Stripline rather than Micro-Stripline technology. Please see Section 4.2.1 for an example.

For type approval purposes, the use of a 50Ω coaxial antenna connector (U.FL-R-SMT) might be necessary. In this case the U.FL-R-SMT connector should be placed as close as possible to BGS12's antenna pad.

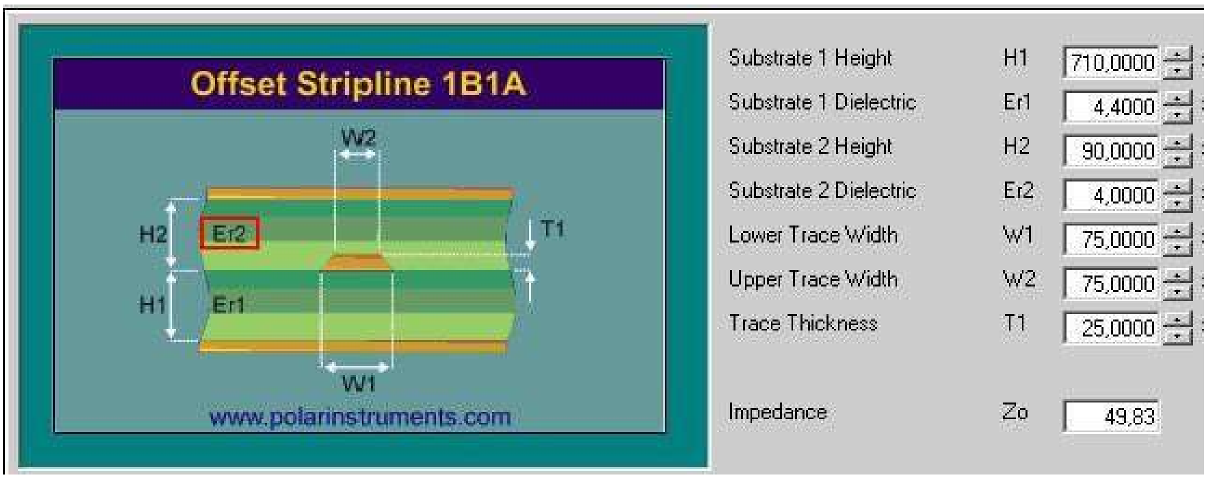
4.2 RF Line Routing Design

4.2.1 Line Arrangement Examples

Several dedicated tools are available to calculate line arrangements for specific applications and PCB materials - for example from http://www.polarinstruments.com/ (commercial software) or from http://web.awrcorp.com/Usa/Products/Optional-Products/TX-Line/ (free software).

4.2.1.1 Embedded Stripline

This below figure shows a line arrangement example for embedded stripline with 65µm FR4 prepreg (type: 1080) and 710µm FR4 core (4-layer PCB).



Substrate 1 Height	H1	710,0000
Substrate 1 Dielectric	Er1	4,4000
Substrate 2 Height	H2	90,0000
Substrate 2 Dielectric	Er2	4,0000
Lower Trace Width	W1	75,0000
Upper Trace Width	W2	75,0000
Trace Thickness	T1	25,0000
Impedance	Zo	49,83

Figure 39: Embedded Stripline with 65µm prepreg (1080) and 710µm core

4.2.1.2 Micro-Stripline

This section gives two line arrangement examples for micro-stripline.

Micro-Stripline on 1.0mm Standard FR4 2-Layer PCB

The following two figures show examples with different values for D1 (ground strip separation).

Substrate 1 Height	H1	1000,000
Substrate 1 Dielectric	Er1	4,4000
Lower Trace Width	W1	800,0000
Upper Trace Width	W2	800,0000
Ground Strip Separation	D1	185,0000
Trace Thickness	T1	25,0000
Coating Above Substrate	C1	15,0000
Coating Above Trace	C2	15,0000
Coating Dielectric	CEr	4,0000

Figure 40: Micro-Stripline on 1.0mm standard FR4 2-layer PCB - example 1

Substrate 1 Height	H1	1000,000
Substrate 1 Dielectric	Er1	4,4000
Lower Trace Width	W1	1050,000
Upper Trace Width	W2	1050,000
Ground Strip Separation	D1	275,0000
Trace Thickness	T1	25,0000
Coating Above Substrate	C1	15,0000
Coating Above Trace	C2	15,0000
Coating Dielectric	CEr	4,0000

Figure 41: Micro-Stripline on 1.0mm Standard FR4 PCB - example 2

Micro-Stripline on 1.5mm Standard FR4 2-Layer PCB

The following two figures show examples with different values for D1 (ground strip separation).

Substrate 1 Height	H1	1500,000
Substrate 1 Dielectric	Er1	4,4000
Lower Trace Width	W1	800,0000
Upper Trace Width	W2	800,0000
Ground Strip Separation	D1	165,0000
Trace Thickness	T1	25,0000
Coating Above Substrate	C1	15,0000
Coating Above Trace	C2	15,0000
Coating Dielectric	CEr	4,0000

Figure 42: Micro-Stripline on 1.5mm Standard FR4 PCB - example 1

Coated Coplanar Waveguide With Ground 1B

Substrate 1 Height	H1	1500,000
Substrate 1 Dielectric	Er1	4,4000
Lower Trace Width	W1	1150,000
Upper Trace Width	W2	1150,000
Ground Strip Separation	D1	225,0000
Trace Thickness	T1	25,0000
Coating Above Substrate	C1	15,0000
Coating Above Trace	C2	15,0000
Coating Dielectric	CEr	4,0000

Figure 43: Micro-Stripline on 1.5mm Standard FR4 PCB - example 2

4.2.2 Routing Example

4.2.2.1 Interface to RF Connector

Figure 44 shows the connection of the module‘s antenna pad with an application PCB‘s coaxial antenna connector. Please note that the BGS12 bottom plane appears mirrored, since it is viewed from BGS12 top side. By definition the top of customer's board shall mate with the bottom of the BGS12 module.

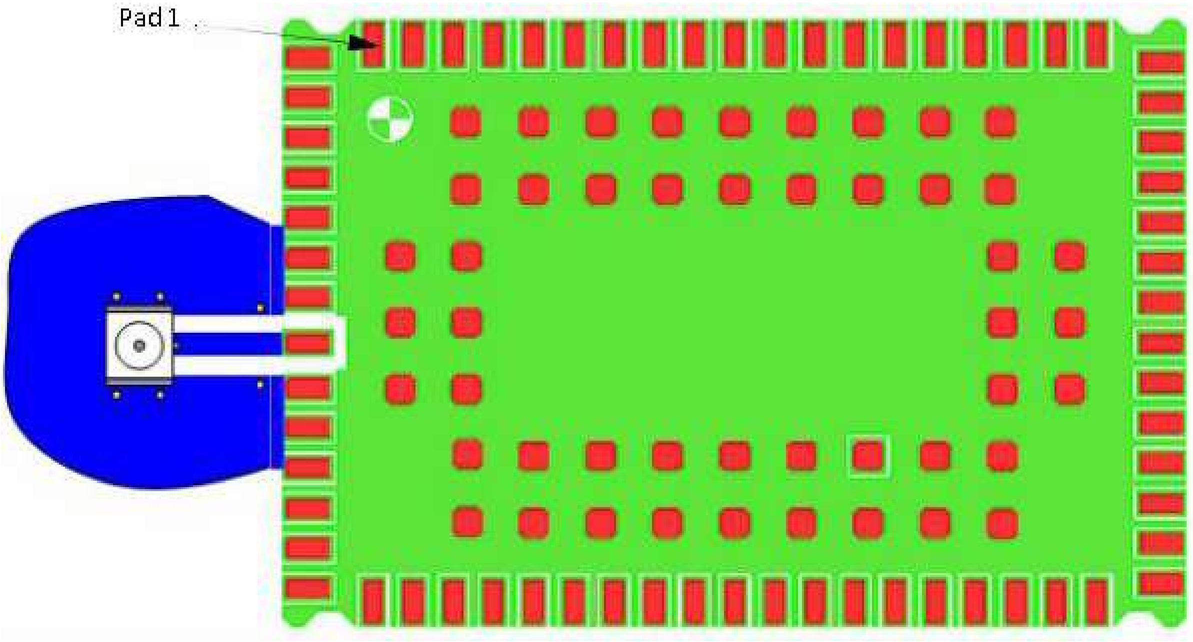


Figure 44: Pouting to application‘s RF connector - top view

5 Electrical Reliability and Radio Characteristics

5.1 Absolute Maximum Ratings

The absolute maximum ratings stated in Table 17 are stress ratings under any conditions. Stresses beyond any of these limits will cause permanent damage to BGS12.

Table 17: Absolute maximum ratings

Parameter	Min	Max	Unit
Supply voltage $BATT_{+BB}$, $BATT_{+RF}$	-0.3	+5	V
Voltage at all digital lines in Power Down mode	-0.3	+0.3	V
Voltage at digital lines VDIG domain (2.8V) in normal operation	-0.3	+3.3	V
Voltage at SIM interface, CCVCC 1.8V in normal Operation	-0.3	+2.2	V
Voltage at SIM interface, CCVCC 3.0V in normal Operation	-0.3	+3.3	V
Voltage at analog lines in normal operation	-0.3	+3.0	V
Voltage at analog lines in Power Down mode	-0.3	+0.3	V
VDDLP	-0.3	+3.6	V

5.2 Operating Temperatures

Please note that the module's lifetime, i.e., the MTTF (mean time to failure) may be reduced, if operated outside the restricted temperature range. A special URC reports whether the module enters or leaves the restricted temperature range (see [1]; AT^SCTM).

Table 18: Board temperature

Parameter	Min	Typ	Max	Unit
Normal operation	-20	+25	+85	°C
Extended operation	-40		+90	°C
Automatic shutdown[1] Temperature measured on BGS12 board	<-40	---	>+95	°C

[1] Due to temperature measurement uncertainty, a tolerance of ±3°C on the thresholds may occur.

See also Section 3.3.5.1 for information about the NTC for on-board temperature measurement, automatic thermal shutdown and alert messages.

Note that within the specified operating temperature ranges the board temperature may vary to a great extent depending on operating mode, used frequency band, radio output power and current supply voltage.

5.3 Reliability Characteristics

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

Table 19: Summary of reliability test conditions

Type of test	Conditions	Standard
Vibration	Frequency range: 10 - 20 Hz Acceleration: 5g; Frequency range: 20 - 500 Hz Acceleration: 5g; Duration:20h per axis; 3 axes	
Shock half-sinus	Acceleration: 25g Shock duration: 6msec 5 shock per axis 6 positions(±x, y and z)	
Dry heat	Temperature: +70 ±2°C Test duration: 16h Humidity in the test chamber: < 50%	EN 60068-2-2 Bb ETS 300 019-2-7
Temperature change (shock)	Low temperature: -40°C ±2°C High temperature:+85 ℃± 2°C Changeover time:< 30s(dual chamber system) Test duration: 1h Number of repetitions: 24	
Damp heat cyclic	High temperature: +55°C ±2°C Low temperature: +25°C ±2°C Humidity: 93% ±3% Number of repetitions: 6 Test duration: 12h + 12h	DIN IEC 60068-2-30 Db ETS 300 019-2-5
Cold (constant exposure)	Temperature: -40 ±2°C Test duration: 16h	DIN IEC 60068-2-1

5.4 Pad Assignment and Signal Description

The SMT application interface on the BGS12 provides connecting pads to integrate the module into external applications. Figure 45 shows the connecting pads' numbering plan, the following Table 20 lists the pads' assignments.

Figure 45: Numbering plan for connecting pads (bottom view)

Table 20: Pad assignments

Pad no.	Signal name	Pad no.	Signal name	Pad no.	Signal name
1	VMIC	27	GPIO10/I2CDAT	53	$BATT_{+RF}$
2	EPN	28	GPIO9/I2CCLK	54	GND
3	EPP	29	TXD1	55	GND
4	GND	30	RXD1	56	GND
5	$BATT_{+BB}$	31	Do not use	57	GND
6	GND	32	Do not use	58	GND
7	Do not use	33	EMERG_RST	59	RF_OUT
8	ON	34	GND	60	GND
9	GND	35	NC	61	GND
10	VDIG	36	GPIO8	62	GND
11	RXD0	37	GPIO7	63	GND
12	CTS0	38	GPIO6/ Jamming Indicator	64	AGND
13	TXD0	39	GPIO5/LED	65	MICP
14	RING0	40	FAST_SHTDWN	66	MICN
15	RTS0	41	DSR0	67-97	GND
16	VDDLP	42	DCD0	98	Do not use
17	CCRST	43	DTR0	99-106	GND
18	CCIN	44	Do not use	245	GND
19	CCIO	45	Do not use	246	RTS2
20	CCVCC	46	Do not use	247	CTS2
21	CCCLK	47	GND	248	RXD2
22	NC	48	GND	249	TXD2
23	IISDO	49	GND	250	GND
24	IISLRCK	50	GND	251	GND
25	IISDI	51	GND	252	GND
26	IISCLK	52	GND		

1. The pads 67-106 are centrally located and should be connected to Ground **except** for pad 98 that is not used. Pad 98 should not be connected to the external appli- cation, but should be left open.

Signal pads that are not used should not be connected to an external application.

Please note that the reference voltages listed in Table 21 are the values measured directly on the BGS12 module. They do not apply to the accessories connected.

Table 21: Electrical description of application interface

<table>
<tr><th>Function</th><th>Signal</th><th>IO</th><th>Signal form and level</th><th>Comment</th></tr>
<tr><td>Power supply</td><td>$BATT_{+BB}$
$BATT_{+RF}$</td><td>I</td><td>$V_I$max = 4.35V $V_I$norm = 3.8V
$V_I$min = 3.2V[1] during Tx burst on board
<table><tr><th>C</th><th>I</th></tr><tr><td>C=0</td><td>2.1A</td></tr><tr><td>C=2200uF</td><td>0.92A</td></tr><tr><td>C=4400uF</td><td>0.62A</td></tr></table>
C is the capacitor connecting with VBAT pins.
I is the peak current of Tx burst at EGSM network.</td><td>Lines of $BATT_{+BB}$ or $BATT_{+RF}$ and GND must be connected in parallel for supply purposes because higher peak currents may occur.
Minimum voltage must not fall below 3.2V including drop, ripple, spikes.</td></tr>
<tr><td>Power</td><td>GND</td><td></td><td>Ground</td><td>Application Ground</td></tr>
<tr><td>External supply voltage</td><td>VDIG</td><td>O</td><td>Normal operation: $V_O$norm = 2.80V ±3%
$I_O$max = -50mA
SLEEP mode Operation: V_OSleep = 2.80V ±5%
$I_O$max = -50mA</td><td>VDIG may be used for application circuits.
If unused keep line open.
Not available in Power Down mode. The external digital logic must not cause any spikes or glitches on VDIG.</td></tr>
<tr><td>Ignition</td><td>ON</td><td>I</td><td>$R_I \approx 1M\Omega$ ±15%
V_{IH}max = VDDLP + 0.5V
V_{IH}min = 1.2V at ~12µA
V_{IL}max = 0.2V
___|¯ _¯ _¯ _¯ _ high impulse</td><td>This signal switches the module ON.
This line must be driven high by an open drain or open collector driver connected to VDDLP. See Section 3.3.</td></tr>
<tr><td>Emergency shutdown</td><td>EMERG_RST</td><td>I</td><td>V_{IH} max = V_{BAT}
V_{IH} min =1.2V
V_{IL}max =0.2V
~~|___|~~ low impulse width > 1ms</td><td>This line must be driven low by an open drain or open collector driver connected to GND.
If unused keep line open.</td></tr>
<tr><td>Fast shutdown</td><td>FAST_SHTDWN</td><td>I</td><td>V_{IL}max = 0.84V
V_{IH}min = 1.96V
V_{IH}max = 3.1V
~~|___|~~ low impulse width = 10ms</td><td>This line must be driven low.
If unused keep line open.</td></tr>
<tr><td>RTC backup</td><td>VDDLP</td><td>I/O</td><td>$V_O$norm = 3.0V ±10%
$I_O$max = 1.6mA
$V_I$max = 3.3V
$V_I$min = 2.6V
$I_I$typ = 170µA</td><td>It is recommended to use a serial resistor between VDDLP and a possible capacitor. See 3.3.1.1.
If unused keep line open.</td></tr>
</table>

SIM card detection	CCIN	I	VIHmin = 1.96V VIHmax= 3.1V VILmax = 0.84V	CCIN = High, SIM card inserted. If unused keep line open.

1. The module operates within a voltage level range from 3.4V up to 4.2V without restrictions. It is suggested to supply 3.4V to 4.35V on module.
   Please add at least 3700uF capacitor to VBAT signal line against GSM burst current while 3.2V to 3.4V supply for BGS12 module.

Table 22: Electrical description of application interface

Function	Signal	IO	Signal form and level	Comment
3V SIM Card Interface	CCRST	O	V_{OL}max = 0.30V V_{OH}min = 2.40V V_{OH}max = 3.2V	Maximum cable length or copper track to SIM card holder should not exceed 100mm.
	CCIO	I/O	V_{IL}max = 0.60V V_{IH}min=1.95V V_{IH}max = 3.2V V_{OL}max = 0.30V V_{OH}min = 2.40V V_{OH}max = 3.2V	
	CCCLK	O	V_{OL}max = 0.30V V_{OH}min = 2.40V V_{OH}max = 3.2V	
	CCVCC	O	V_{O}min = 2.59V V_{O}typ = 3.00V V_{O}max = 3.2V I_{O}max = 150mA	
1.8V SIM Card Interface	CCRST	O	V_{OL}max = 0.19V V_{OH}min = 1.5V V_{OH}max = 2.05V	
	CCIO	I/O	V_{IL}max = 0.57V V_{IH}min = 1.33V V_{IH}max = 2.05V V_{OL}max = 0.19V V_{OH}min = 1.5V V_{OH}max = 2.05V	
	CCCLK	O	V_{OL}max = 0.19V V_{OH}min = 1.5V V_{OH}max = 2.05V	
	CCVCC	O	V_{O}min = 1.73V V_{O}typ = 1.90V V_{O}max = 2.05V I_{O}max = 110mA	

Table 23: Electrical description of application interface

Function	**Signal**	**IO**	**Signal form and level**	**Comment**
Serial Interface ASC0	RXD0	O	V_{OL}max = 0.19V V_{OH}min = 2.78V V_{OH}max = 3.1V V_{IL}max = 0.84V V_{IH}min = 1.96V V_{IH}max = 3.3V	If unused keep line open.
	TXD0	I		
	CTS0	O		
	RTS0	I		
	RING0	O		
	DTR0	I		
	DSR0	O		
	DCD0	O		
Serial Interface ASC1	RXD1	O	V_{OL}max = 0.19V V_{OH}min = 2.78V V_{OH}max = 3.1V V_{IL}max = 0.84V V_{IH}min = 1.96V V_{IH}max = 3.3V	
	TXD1	I		
Serial Interface ASC2	RXD2	O	V_{OL}max = 0.19V V_{OH}min = 2.78V V_{OH}max = 3.1V V_{IL}max = 0.84V V_{IH}min = 1.96V V_{IH}max = 3.3V	If unused keep line open.
	TXD2	I		
	RTS2	I		
	CTS2	O		

Table 24: Electrical description of application interface

Function	**Signal**	**IO**	**Signal form and level**	**Comment**
I2C	I2CCLK	O	V_{IL}max = 0.84V V_{IH}min = 1.96V V_{IH}max = 3.1V	I2C is configured as `pull-up internal` and needs a pull-up resistor in the host application. If lines are unused keep lines open.
	I2CDAT	IO		

Table 25: Electrical description of application interface

Function	**Signal**	**IO**	**Signal form and level**	**Comment**
GPIO interface	GPIO5	IO	V_{OL}max = 0.19V V_{OH}min = 1.5V V_{OH}max = 2.05V V_{IL}max = 0.57V V_{IH}min = 1.53V V_{IH}max = 2.05V	If unused keep line open. Please note that some GPIO lines can be used for functions other than GPIO: Status LED line: GPIO5 Jamming Indicator: GPIO6 I^{2}C: GPIO9/GPIO10. For further details see Section 3.14, Section 3.15, Section 3.16.
	GPIO6	IO		
	GPIO7	IO		
	GPIO8	IO		
	GPIO10, i.e., I2CDAT	IO	Input, Open Drain Output (no Pull up) V_{IL}max = 0.84V V_{IH}min = 1.96V V_{IH}max = 3.1V	
	GPIO9, i.e., I2CCLK	IO	Input, Open Drain Output (no Pull up) V_{OH}max = 3.1V	

Table 26: Electrical description of application interface

Function		Signal	IO	Signal form and level	Comment
Analog audio interface		VMIC	O	$V_O$typ = 1.8V Imax =0.5 mA	Microphone supply for customer feeding circuits If unused keep line open.
		EPP	O	Differential, max 1.3Vrms at 32 load 0.95kHz sine wave	Balanced output for earphone or balance output for line out If unused keep line open.
		EPN	O		
		MICP	I	$Z_I$typ = 2kΩ Vinmax = 0.3Vrms (@0dB gain)	Balanced differential microphone with external feeding circuit (using VMIC and AGND) or balanced differential line input. Use coupling capacitors. If unused keep lines open.
		MICN	I		

5.5 Power Supply Ratings

Table 27: Power supply ratings[1]

Parameter	Description	Conditions	Min	Typ	Max	Unit
BATT$_{+BB}$ BATT$_{+RF}$	Supply voltage	Voltage must stay within the min/ max values, including voltage drop, ripple and spikes.	3.2	3.8	4.35	V
	Voltage drop during transmit burst	Normal condition, power control level for Pout max			400	mV
I$_{VDDLP}$	OFF state supply current	RTC backup				µA
		@ BATT+ = 0V				
		@ VDDLP = 3.3V		171		
		@ VDDLP = 3.0V		170		
		@ VDDLP = 2.8V		169		
		@ VDDLP = 2.6V		169		
		@ VDDLP = 2.3V		168		
		@ VDDLP = 2.0V		167		
		@ VDDLP = 1.8V		164		
		Power Down mode				µA
		@ BATT+ =3.8V				
		@ VDDLP = 3.3V		25		
		@ VDDLP = 3.0V		-223		
		@ VDDLP = 2.8V		-3148		
		@ VDDLP = 2.6V		-3144		
		@ VDDLP = 2.3V		-3152		
		@ VDDLP = 2.0V		-3152		
		@ VDDLP = 1.8V		-3152		
I$_{BATT+}$	Average supply current	SLEEP mode, GSM[1]				mA
		@ DRX = 2		1.6		
		@ DRX = 9		0.9		
		IDLE mode[1]				
		GSM		12.6		mA
		TALK mode GSM				mA
		GSM 850[2]		211.3		
		GSM 900[2]		210.3		
		DCS 1800[3]		151.7		
		PCS 1900[3]		137.9		
		DATA mode GPRS 1 TX, 4 Rx				mA
		GSM 850[2]		201.5		
		EGSM 900[2]		196.4		
		DCS 1800[3]		140.6		
		PCS 1900[3]		127.1		
		DATA mode GPRS 4 TX, 1Rx				mA
		GSM 850[2]		408.5		
		EGSM 900[2]		412.9		
		DCS 1800[3]		300.1		
		PCS 1900[3]		267.2		

		DATA mode GPRS 3 TX, 2Rx GSM 850[2] EGSM 900[2] DCS 1800[3] PCS 1900[3]		 318.4 320.2 238.8 212.7		mA
		DATA mode GPRS 2 Tx, 3 Rx GSM 850[2] EGSM 900[2] DCS 1800[3] PCS 1900[3]		 283.1 284.2 210.8 186.5		mA

Table 28:Power supply ratings[1]

Parameter	Description	Conditions	Min	Typ	Max	Unit
I_{BATT+}	Peak supply current (during transmission slot every 4.6ms)	Power Control Level GSM 850[2] EGSM 900[2] DCS 1800[3] PCS 1900[3]		 2.10 2.06 1.18 1.24		A
	OFF state supply current	Power Down mode @ BATT+ =3.8V		38		uA

1. Measurements start 3 minutes after the module was switched ON,
   Averaging times: SLEEP mode 10minutes; TALK mode and DATA mode 5 minutes, IDLE mode 1.5 minutes.
   Communication tester settings: no neighbour cells, no cell reselection, etc.
2. Power control level PCL 5
3. Power control level PCL 0

5.6 Electrical Characteristics of the Voiceband Part

5.6.1 Setting Audio Parameters by AT Commands

The audio modes 1 to 3 can be adjusted according to the parameters listed below. Each audio mode is assigned a separate set of parameters.

Table 29: Audio parameters adjustable by AT command

Parameter	Influence to	Range	Gain	Calculation
inBbcGain	MICP/MICN analog amplifier gain of baseband controller before ADC	0...8	0...24dB	3dB steps
inCalibrate	Digital attenuation of input signal after ADC	-13...16	-13...16dB	— —
outBbcGain	EPP/EPN analog output gain of baseband controller after DAC	0...21	-6....15dB	1dB steps
outCalibrate[n] n = 0...4	Digital attenuation of output signal after speech decoder, before summation of sidetone and DAC present for each volume step[n]	-26...5	-26...5dB	— —
sideTone	Digital attenuation of sidetone is corrected internally by outBbcGain to obtain a constant sidetone independent of output volume	0...32767	-128dB	— —

5.6.2 Audio Programming Model

The audio programming model shows how the signal path can be influenced by varying the AT command parameters.

The parameters <inBbcGain> and <inCalibrate> can be set with AT^SNFI. All the other parameters are adjusted with AT^SNFO.

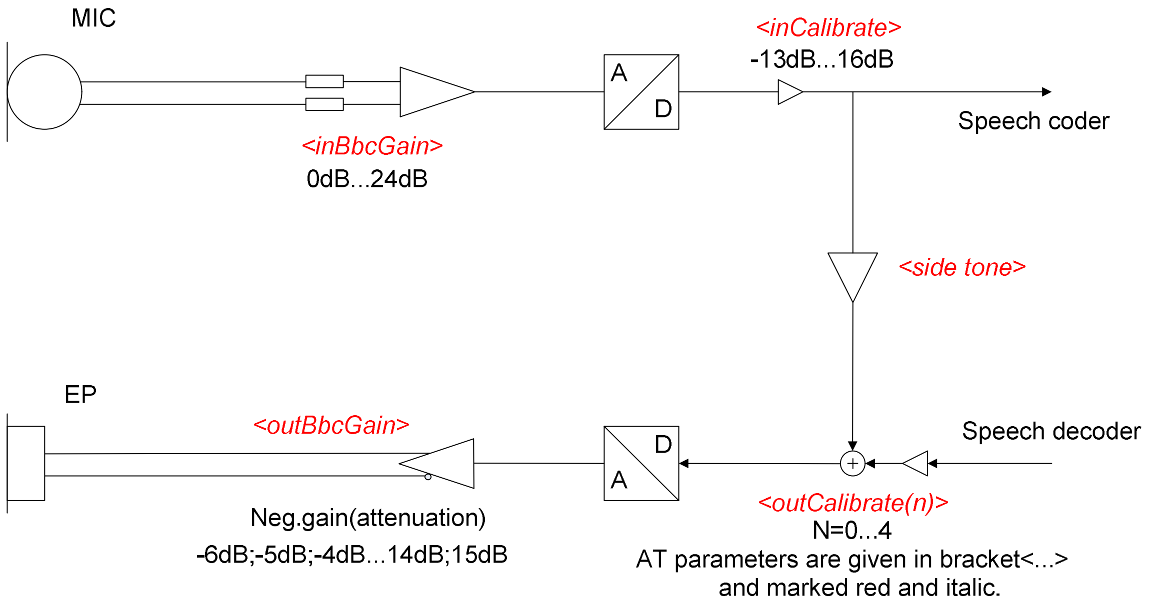


Figure 46: Audio programming model

5.6.3 Characteristics of Audio Modes

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

Table 30: Voiceband characteristics (typical)

Audio mode no. AT^SNFS=	**1**	**2**	**3**
Name	User Handset	Basic Handsfree	Headset
Purpose	DSB with individual handset	Car Kit	Headset
Gain setting via AT command. Defaults: inBbcGain outBbcGain	Adjustable 0-24dB -6-15dB	Adjustable 0-24dB -6-15dB	Adjustable 0-24dB -6-15dB
Sidetone	Adjustable	Adjustable	Adjustable
Volume control	Adjustable	Adjustable	Adjustable
Echo control (send)	Cancellation	Cancellation	Cancellation
Sidetone gain at default settings	-128dB	-128dB	-128dB

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

5.6.4 Voiceband Receive Path

Test conditions:

- The values specified below were tested to 0.95kHz and 0dB gain stage, unless otherwise stated.

Table 31: Voiceband receive path

Parameter	**Min**	**Typ**	**Max**	**Unit**	**Test condition/remark**
Differential output voltage (peak to peak)		1.3		Vrms	32Ohm, from EPPx to EPNx
Differential output gain settings (*gs*) at 6dB stages (outBbcGain)	-6		+15	dB	Set with AT^SNFO
Fine scaling by DSP (outCalibrate)	-26		+5	dB	Set with AT^SNFO
Output differential DC offset	1.2		1.2	V	*gs* = 0dB, outBbcGain = 0 and -6dB
Differential output load resistance	16	32		Ω	from EPP to EPN
Allowed single ended load capacitance			100	pF	from EPP or EPN to GND

- gs = gain setting

5.6.5 Voiceband Transmit Path

Test conditions:

- The values specified below were tested to 0.95kHz and 0dB gain stage, unless otherwise stated.

Table 32: Voiceband transmit path

Parameter	**Min**	**Typ**	**Max**	**Unit**	**Test condition/Remark**
Input voltage (peak to peak) MICP to MICN			0.3	Vrms	(@0dB gain)
Input amplifier gain in 6dB steps (inBbcGain)[1]	0		24	dB	Set with AT^SNFI
Fine scaling by DSP (inCalibrate)	-13		16	dB	Set with AT^SNFI
Input impedance MIC		2		kΩ	
Microphone supply voltage		1.8		V	
Microphone supply current		0.5		mA	

5.7 Antenna Interface Specification

Measurement conditions: T_{amb}= 25°C, $V_{BATT+ nom}$ = 4.1V.

Table 33: Antenna interface specifications

Parameter		**Min**	**Typ**	**Max**	**Unit**
Frequency range Uplink (MS →BTS)	GSM 850	824		849	MHz
	E-GSM 900	880		915	MHz
	DCS 1800	1710		1785	MHz
	PCS 1900	1850		1910	MHz
Frequency range Downlink (BTS →MS)	GSM 850	869		894	MHz
	E-GSM 900	925		960	MHz
	DCS 1800	1805		1880	MHz
	PCS 1900	1930		1990	MHz
Receiver input sensitivity @ ARP Under all propagation conditions according to GSM specification	GSM 850	-102			dBm
	E-GSM 900	-102			dBm
	DCS 1800	-102			dBm
	PCS 1900	-102			dBm
Receiver input sensitivity @ ARP BER Class II <= 2.43% @ static input level (no fading)	GSM 850		-107		dBm
	E-GSM 900		-107		dBm
	DCS 1800		-107		dBm
	PCS 1900		-107		dBm
RF power @ ARP with 50Ω load	GSM 850	31	32.5	34	dBm
	E-GSM 900	31	32.5	34	dBm
	DCS 1800	28	29.5	31	dBm
	PCS 1900	28	29.5	31	dBm
RF Gain	GSM 850		1.0		dBi
	E-GSM 900		1.2		dBi
	DCS 1800		2.1		dBi
	PCS 1900		2.7		dBi

5.8 Electrostatic Discharge

The GSM module is not protected against Electrostatic Discharge (ESD) in general. Consequently, it is subject to ESD handling precautions that typically apply to ESD sensitive components. Proper ESD handling and packaging procedures must be applied throughout the processing, handling and operation of any application that incorporates a BGS12 module.

Special ESD protection provided on BGS12:
- SIM interface: Serial resistor and ESD protection diode

BGS12 has been tested according to group standard ETSI EN 301 489-1 (see Table 2) and test standard EN 61000-4-2. The measured values can be gathered from the following table.

Table 34: Measured electrostatic values

Specification/Requirements	Contact discharge	Air discharge
EN 61000-4-2		
SIM interface	± 4kV	± 8kV
Antenna interface	± 4kV	± 8kV
JEDEC JESD22-A114D (Human Body Model, Test conditions: 1.5 kΩ, 100 pF)		
ESD at the module	± 1kV	n.a.

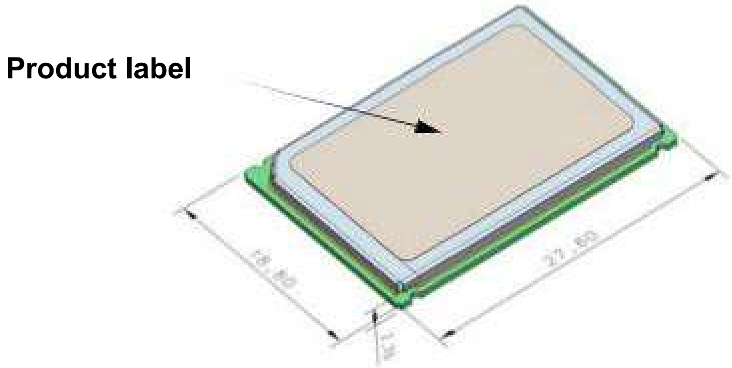
Note: Please note that the values may vary with the individual application design. For example, it matters whether or not the application platform is grounded over external devices like a computer or other equipment, such as the Gemalto M2M reference application described in Chapter 8.

6 Mechanics, Mounting and Packaging

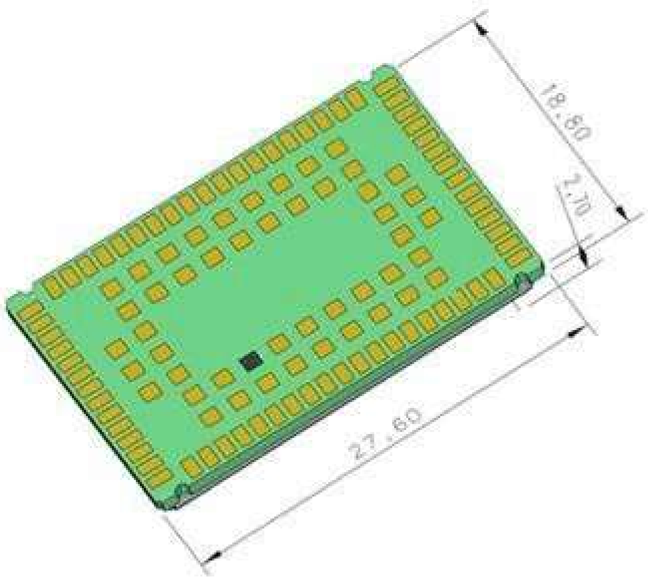
The following sections describe the mechanical dimensions of BGS12 and give recommendation for integrating BGS12 into the host application. Also, a number of files containing product model data in STEP format as well as Gerber data for the external application footprint are attached to this PDF. Please open the attachments navigation panel to view and save these files.

6.1 Mechanical Dimensions of BGS12

Figure 47 shows the top and bottom view of BGS12 and provides an overview of the board's mechanical dimensions. For further details see Figure 48.



Top view



Bottom view

Figure 47: BGS12 – top and bottom view

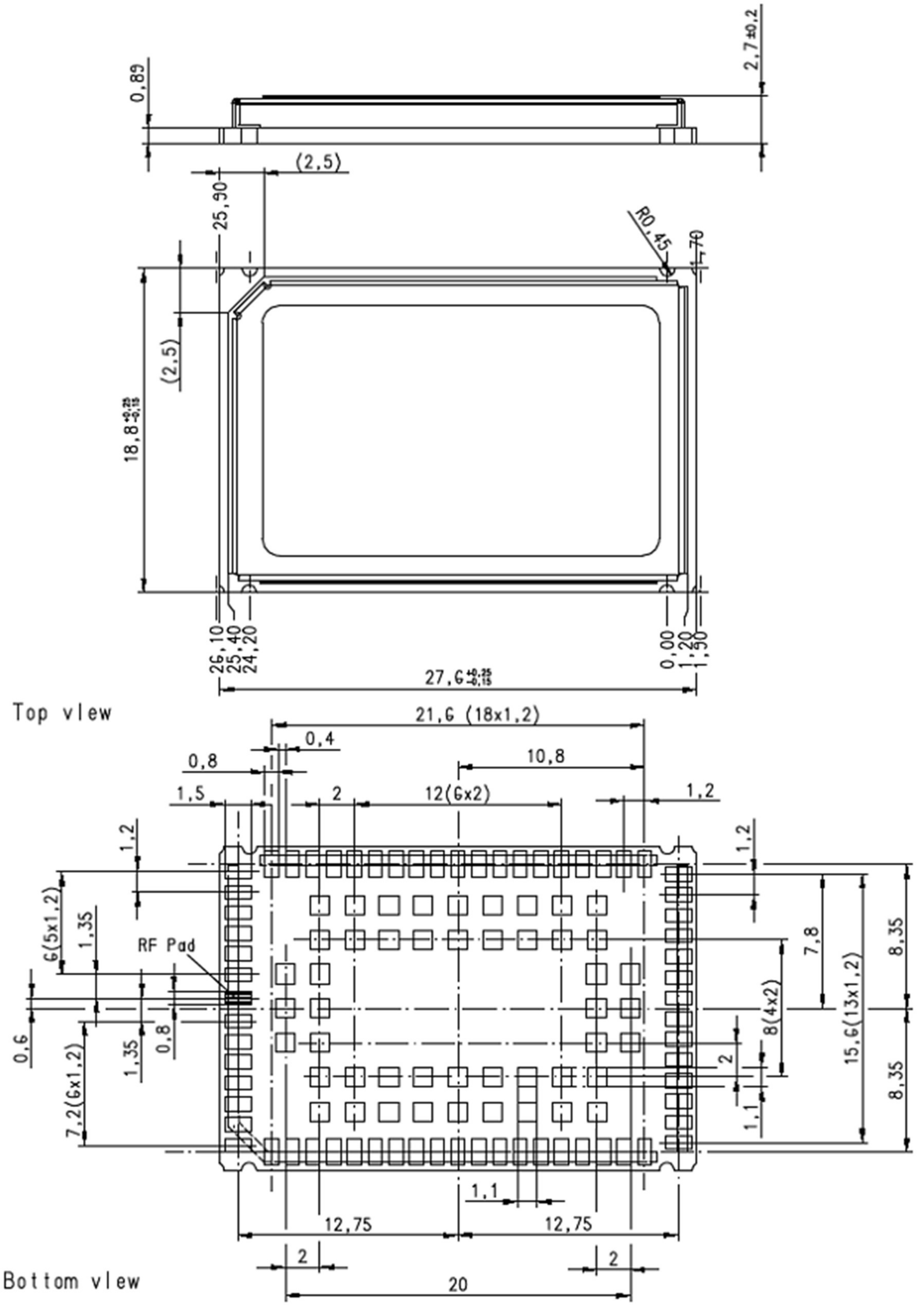


Figure 48: Dimensions of BGS12 (all dimensions in mm)

6.2 Mounting BGS12 onto the Application Platform

This section describes how to mount BGS12 onto the PCBs (=printed circuit boards), including land pattern and stencil design, board-level characterization, soldering conditions, durability and mechanical handling. For more information on issues related to SMT module integration see also [3].

6.2.1 SMT PCB Assembly

6.2.1.1 Land Pattern and Stencil

The land pattern and stencil design as shown below is based on Gemalto M2M characterizations for lead-free solder paste on a four-layer test PCB and a 120 respectively 150 micron thick stencil.

The land pattern given in Figure 49 reflects the module's pad layout, including signal pads and ground pads (for pad assignment see Section 5.4).

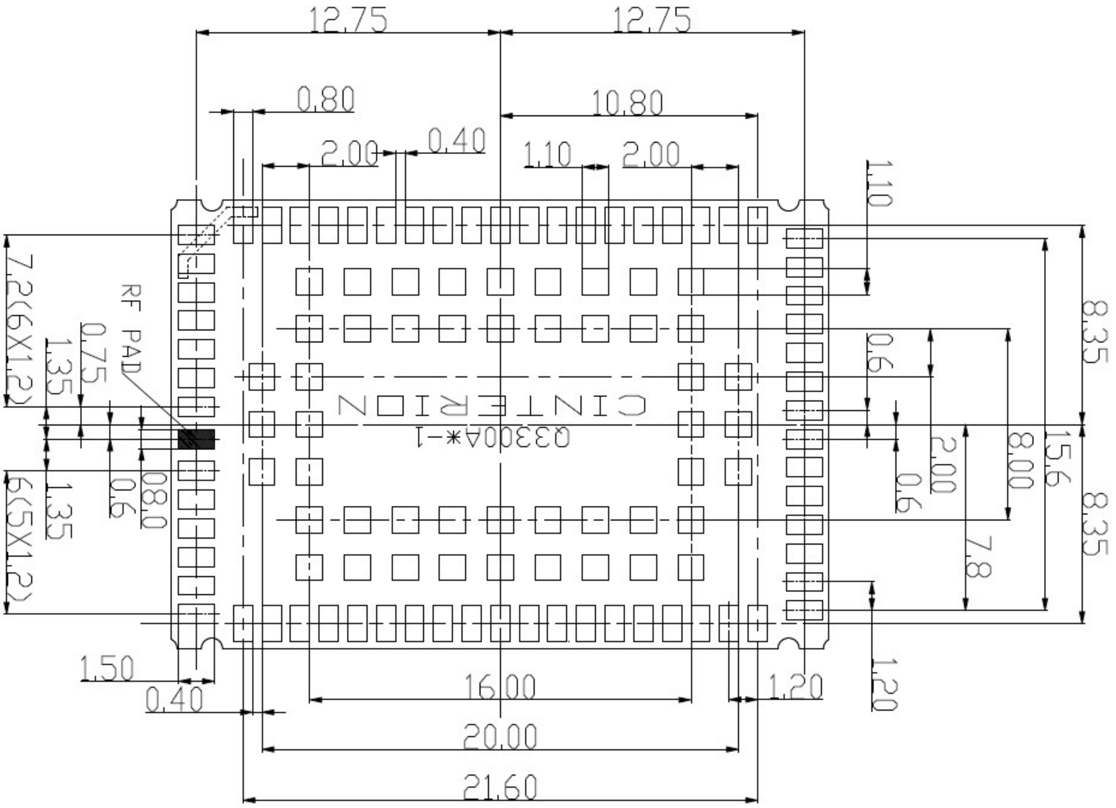


Figure 49: Land pattern (top view)

The stencil design illustrated in Figure 50 and Figure 51 is recommended by Gemalto M2M as a result of extensive tests with Gemalto M2M Daisy Chain modules.

Note that depending on coplanarity or other properties of the external PCB, it could be that all of the central ground pads may have to be soldered.

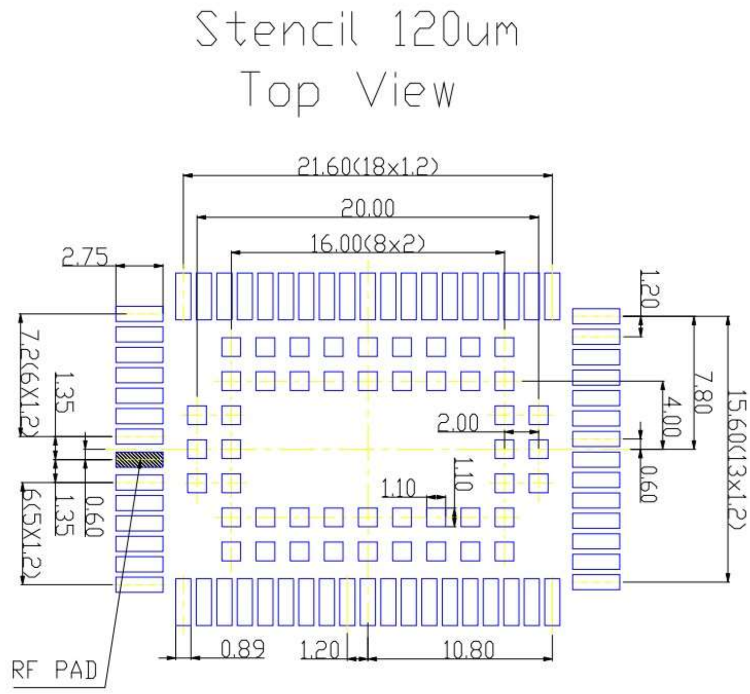


Figure 50: Recommended design for 120 micron thick stencil (top view)

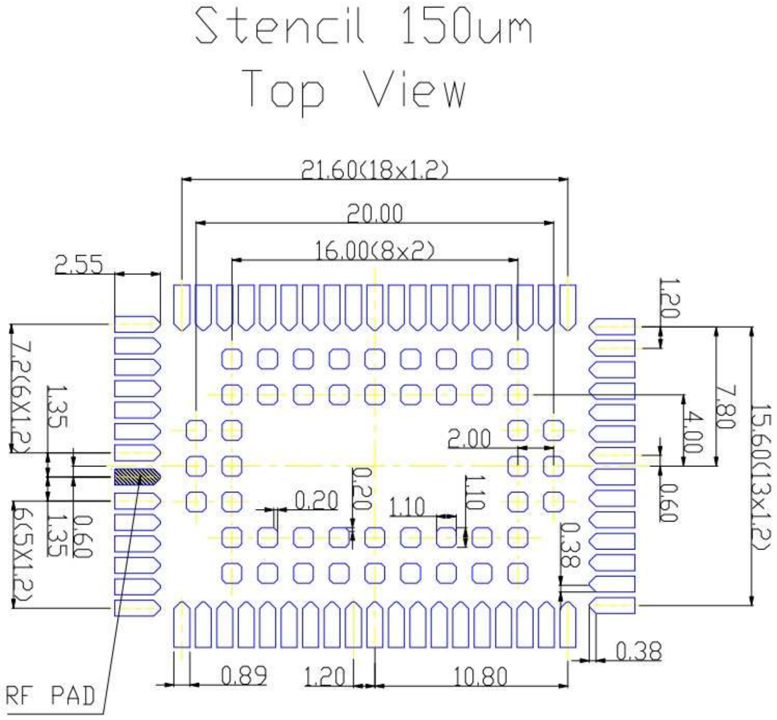


Figure 51: Recommended design for 150 micron thick stencil (top view)

6.2.1.2 Board Level Characterization

Board level characterization issues should also be taken into account if devising an SMT process.

Characterization tests should attempt to optimize the SMT process with regard to board level reliability. This can be done by performing the following physical tests on sample boards: Peel test, bend test, tensile pull test, drop shock test and temperature cycling. Sample surface mount checks are described in [3].

It is recommended to characterize land patterns before an actual PCB production, taking individual processes, materials, equipment, stencil design, and reflow profile into account. For land and stencil pattern design recommendations see also Section 6.2.1.1. Optimizing the solder stencil pattern design and print process is necessary to ensure print uniformity, to decrease solder voids, and to increase board level reliability.

Daisy chain modules for SMT characterization are available on request. For details refer to [3].

Generally, solder paste manufacturer recommendations for screen printing process parameters and reflow profile conditions should be followed. Maximum ratings are described in Section 6.2.3.

6.2.2 Moisture Sensitivity Level

BGS12 comprises components that are susceptible to damage induced by absorbed moisture.

Gemalto M2M's BGS12module complies with the latest revision of the IPC/JEDEC J-STD-020 Standard for moisture sensitive surface mount devices and is classified as MSL 4.

For additional MSL (=moisture sensitivity level) related information see Section 6.2.4 and Section 6.3.2.

6.2.3 Soldering Conditions and Temperature

6.2.3.1 Reflow Profile

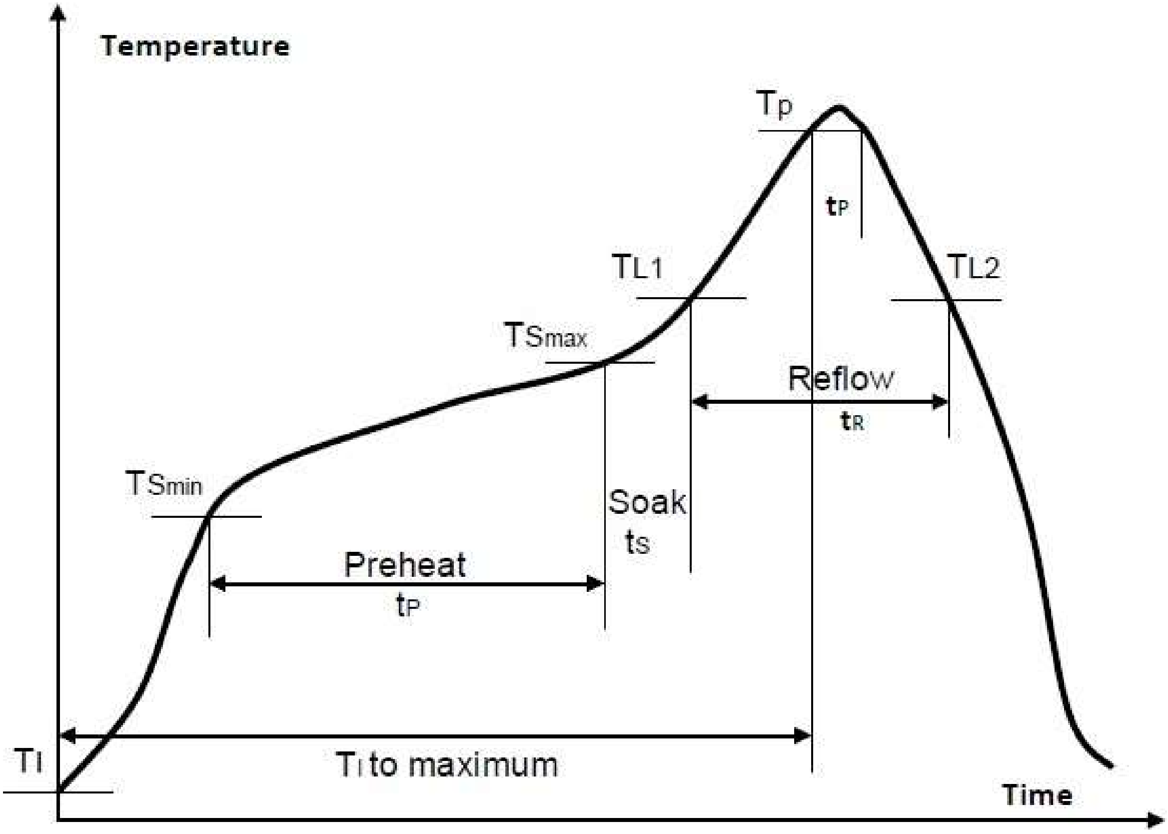


Figure 52: Reflow Profile

Table 35: Reflow temperature ratings

Profile Feature	Pb-Free Assembly
Initial temperature (T_I) Average temperature slope (T_I to T_{Smin})	25 °C 0.5-2.0 °C /second
Preheat & Soak Temperature Minimum (T_{Smin}) Temperature Maximum (T_{Smax}) Time (t_{Smin} to t_{Smax}) (t_S)	150°C 210°C 90-120 seconds
Average ramp up rate (T_{Smax} to T_P)	3K/second max.
Liquidous temperature (T_{L1}) Time at liquidous (t_R)	217°C 30-90 seconds
Peak package body temperature (T_P)	245°C +0/-5°C
Time (t_P) within 5 °C of the peak package body temperature (T_P)	30 seconds max.
Average ramp-down rate (T_P to T_{Smax})	6K/second max.
Time of cold-down (T_P to T_{L2})	0-60 seconds
Time TI to maximum (T_I to T_P)	8 min max.

6.2.3.2 Maximum Temperature and Duration

The following limits are recommended for the SMT board-level soldering process to attach the module:

- A maximum module temperature of 245°C. This specifies the temperature as measured at the module’s top side.
- A maximum duration of 30 seconds at this temperature.

Please note that while the solder paste manufacturers' recommendations for best temperature and duration for solder reflow should generally be followed, the limits listed above must not be exceeded.

BGS12 is specified for one soldering cycle only. Once BGS12 is removed from the application, the module will very likely be destroyed and cannot be soldered onto another application.

6.2.4 Durability and Mechanical Handling

6.2.4.1 Storage Conditions

BGS12 modules, as delivered in tape and reel carriers, must be stored in sealed, moisture barrier anti-static bags. The conditions stated below are only valid for modules in their original packed state in weather protected, non-temperature-controlled storage locations. Normal storage time under these conditions is 12 months maximum.

Table 36: Storage conditions

Type	Condition	Unit	Reference
Air temperature: Low High	-25 +40	°C	IPC/JEDEC J-STD-033A
Humidity relative: Low High	10 90 at 40°C	%	IPC/JEDEC J-STD-033A
Air pressure: Low High	70 106	kPa	IEC TR 60271-3-1: 1K4 IEC TR 60271-3-1: 1K4
Movement of surrounding air	1.0	m/s	IEC TR 60271-3-1: 1K4
Water: rain, dripping, icing and frosting	Not allowed	---	---
Radiation: Solar Heat	1120 600	W/m^2	ETS 300 019-2-1: T1.2, ETS 300 019-2-1: T1.2, IEC 60068-2-2 Bb
Chemically active substances	Not recommended		IEC TR 60271-3-1: 1C1L
Mechanically active substances	Not recommended		IEC TR 60271-3-1: 1S1
Vibration sinusoidal: Displacement Acceleration Frequency range	 1.5 5 2-9 9-200	 mm m/s^2 Hz	IEC TR 60271-3-1: 1M2
Shocks: Shock spectrum Duration Acceleration	 semi-sinusoidal 1 50	 ms m/s^2	IEC 60068-2-27 Ea

6.2.4.2 Processing Life

BGS12 must be soldered to an application within 72 hours after opening the MBB (=moisture barrier bag) it was stored in.

As specified in the IPC/JEDEC J-STD-033 Standard, the manufacturing site processing the modules should have ambient temperatures below 30°C and a relative humidity below 60%.

6.2.4.3 Baking

Baking conditions are specified on the moisture sensitivity label attached to each MBB (see Figure 55 for details):

- It is *not necessary* to bake BGS12, if the conditions specified in Section 6.2.4.1 and Section 6.2.4.2 were not exceeded.
- It is *necessary* to bake BGS12, if any condition specified in Section 6.2.4.1 and Section 6.2.4.2 was exceeded.

If baking is necessary, the modules must be put into trays that can be baked to at least 125°C. Devices should not be baked in tape and reel carriers at any temperature.

6.2.4.4 Electrostatic Discharge

ESD (=electrostatic discharge) may lead to irreversable damage for the module. It is therefore advisable to develop measures and methods to counter ESD and to use these to control the electrostatic environment at manufacturing sites.

Please refer to Section 5.8 for further information on electrostatic discharge.

6.3 Packaging

6.3.1 Tape and Reel

The single-feed tape carrier for BGS12 is illustrated in Figure 53. The figure also shows the proper part orientation. The tape width is 44 mm and the BGS12 modules are placed on the tape with a 28-mm pitch. The reels are 330 mm in diameter with a core diameter of 180 mm.

Each reel contains 500 modules.

6.3.1.1 Orientation

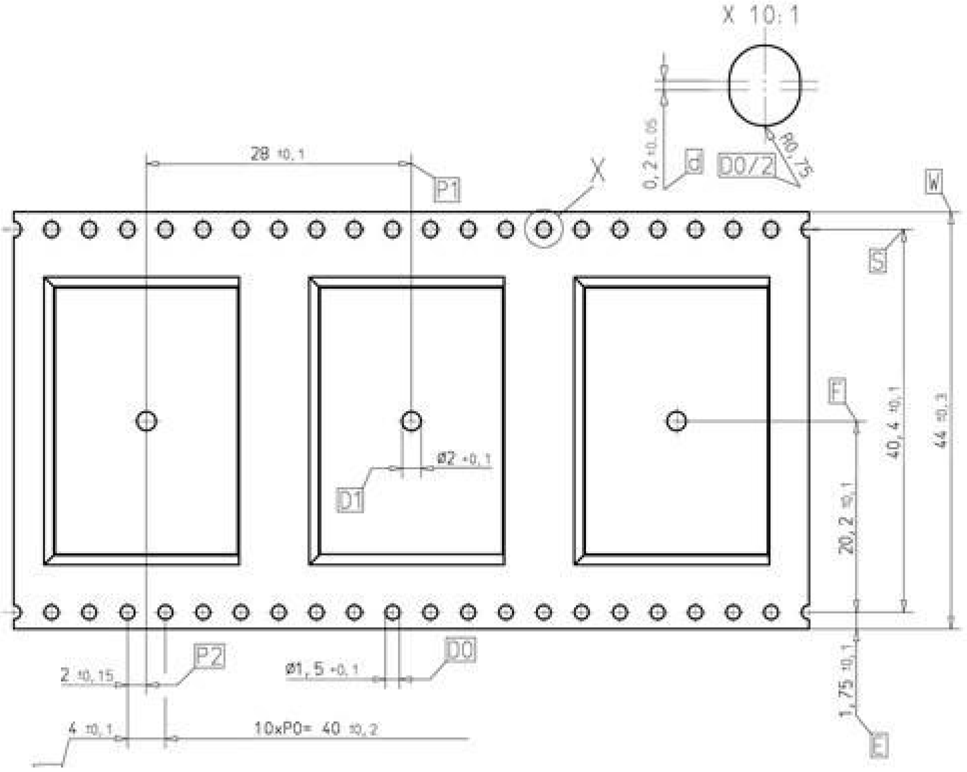


Figure 53: Carrier tape

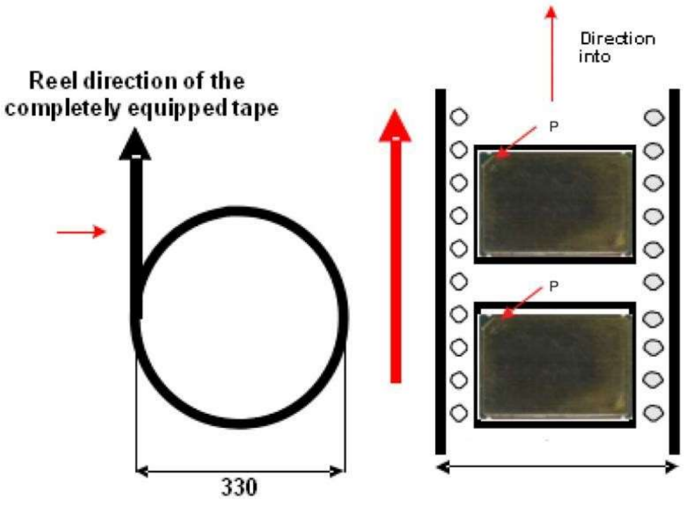


Figure 54: Reel direction

Barcode Label
A barcode label provides detailed information on the tape and its contents. It is attached to the reel.

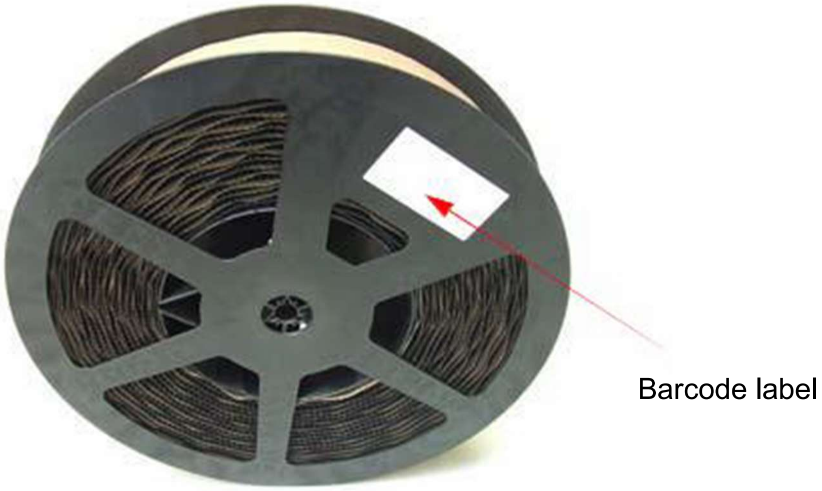


Figure 55: Barcode label on tape reel

6.3.2 Shipping Materials

BGS12 is distributed in tape and reel carriers. The tape and reel carriers used to distribute BGS12 are packed as described below, including the following required shipping materials:

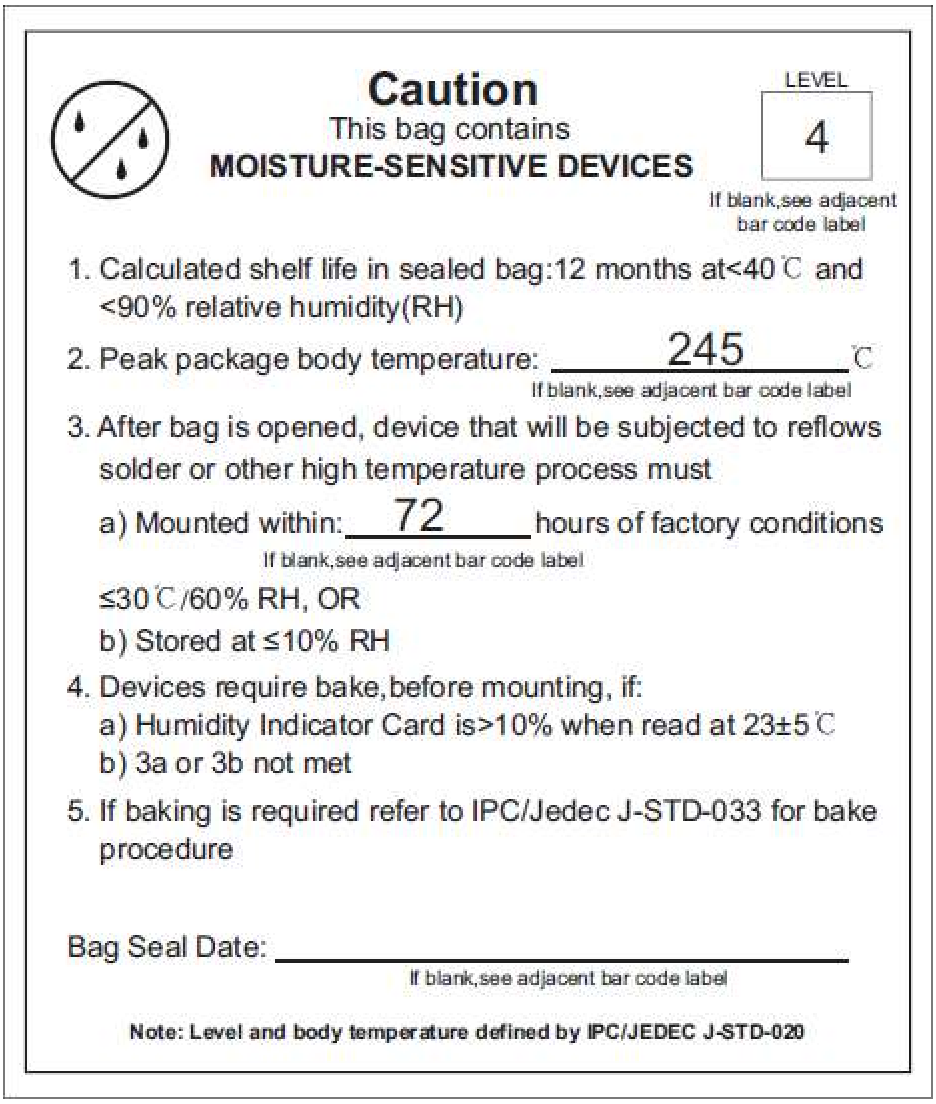
- Moisture barrier bag, including desiccant and humidity indicator card
- Transportation box

6.3.2.1 Moisture Barrier Bag

The tape reels are stored inside an MBB (=moisture barrier bag), together with a humidity indicator card and desiccant pouches - see Figure 56. The bag is ESD protected and delimits moisture transmission. It is vacuum-sealed and should be handled carefully to avoid puncturing or tearing. The bag protects the BGS12 modules from moisture exposure. It should not be opened until the devices are ready to be soldered onto the application.

Figure 56: Moisture barrier bag (MBB)

The label shown in Figure 57 summarizes requirements regarding moisture sensitivity, including shelf life and baking requirements. It is attached to the outside of the moisture barrier bag.



Caution
This bag contains
MOISTURE-SENSITIVE DEVICES

LEVEL
4
If blank,see adjacent bar code label

1. Calculated shelf life in sealed bag:12 months at<40℃ and <90% relative humidity(RH)
2. Peak package body temperature: 245 ℃
   If blank,see adjacent bar code label
3. After bag is opened, device that will be subjected to reflows solder or other high temperature process must
   a) Mounted within: 72 hours of factory conditions
   If blank,see adjacent bar code label
   ≤30℃/60% RH, OR
   b) Stored at ≤10% RH
4. Devices require bake,before mounting, if:
   a) Humidity Indicator Card is>10% when read at 23±5℃
   b) 3a or 3b not met
5. If baking is required refer to IPC/Jedec J-STD-033 for bake procedure

Bag Seal Date: ____________________________
If blank,see adjacent bar code label

Note: Level and body temperature defined by IPC/JEDEC J-STD-020

Figure 57: Moisture Sensitivity Label

MBBs contain one or more desiccant pouches to absorb moisture that may be in the bag. The humidity indicator card described below should be used to determine whether the enclosed components have absorbed an excessive amount of moisture.

The desiccant pouches should not be baked or reused once removed from the MBB.

The humidity indicator card is a moisture indicator and is included in the MBB to show the approximate relative humidity level within the bag. Sample humidity cards are shown in Figure 58. If the components have been exposed to moisture above the recommended limits, the units will have to be rebaked.

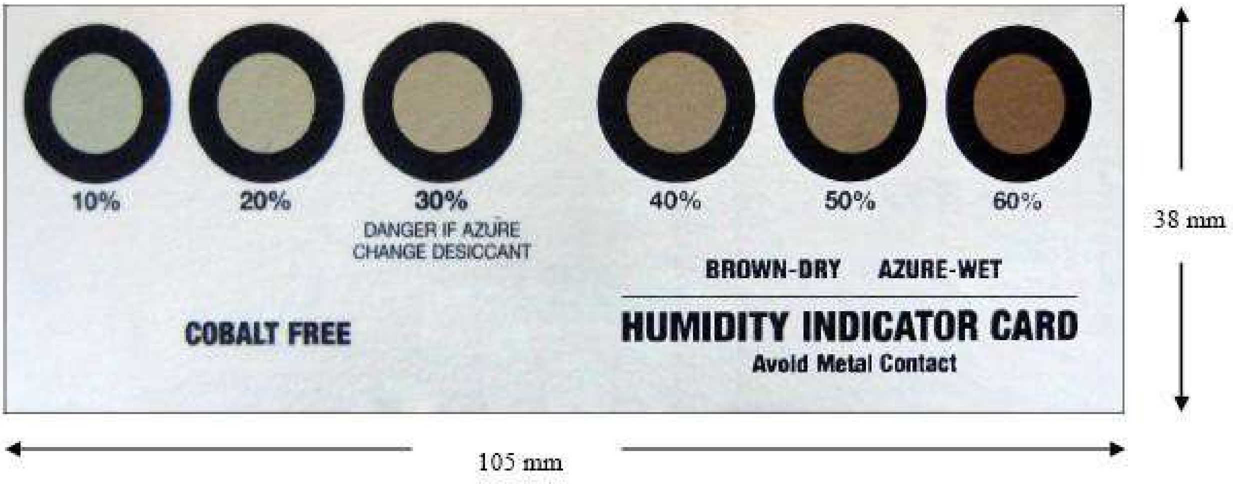


Figure 58: Humidity Indicator Card – HIC

A baking is required if the humidity indicator inside the bag indicates 10% RH or more.

6.3.2.2 Transportation Box

Tape and reel carriers are distributed in a box, marked with a barcode label for identification purposes. A box contains 4 reels with 500 modules each.

7 Sample Application

Figure 59 shows a typical example of how to integrate a BGS12 module with an application. Usage of the various host interfaces depends on the desired features of the application.

The audio interface demonstrates the balanced connection of microphone and earpiece. This solution is particularly well suited for internal transducers.

Because of the very low power consumption design, current flowing from any other source into the module circuit must be avoided, for example reverse current from high state external control lines. Therefore, the controlling application must be designed to prevent reverse current flow. Otherwise there is the risk of undefined states of the module during startup and shutdown or even of damaging the module.

Because of the high RF field density inside the module, it cannot be guaranteed that no self interference might occur, depending on frequency and the applications grounding concept. The potential interferers may be minimized by placing small capacitors (47pF) at suspected lines (e.g. RXD0, RXT0, VDDLP, and ON).

While developing SMT applications it is strongly recommended to provide test points for certain signals resp. lines to and from the module - for debug and/or test purposes. The SMT application should allow for an easy access to these signals. For details on how to implement test points see [3].

The EMC measures are best practice recommendations. In fact, an adequate EMC strategy for an individual application is very much determined by the overall layout and, especially, the position of components. For example, mounting the internal acoustic transducers directly on the PCB eliminates the need to use the ferrite beads shown in the sample schematic.

Please note that BGS12 is not intended for use with cables longer than 3m.

Disclaimer

No warranty, either stated or implied, is provided on the sample schematic diagram shown in Figure 59 and the information detailed in this section. As functionality and compliance with national regulations depend to a great amount on the used electronic components and the individual application layout manufacturers are required to ensure adequate design and operating safeguards for their products using BGS12 modules.

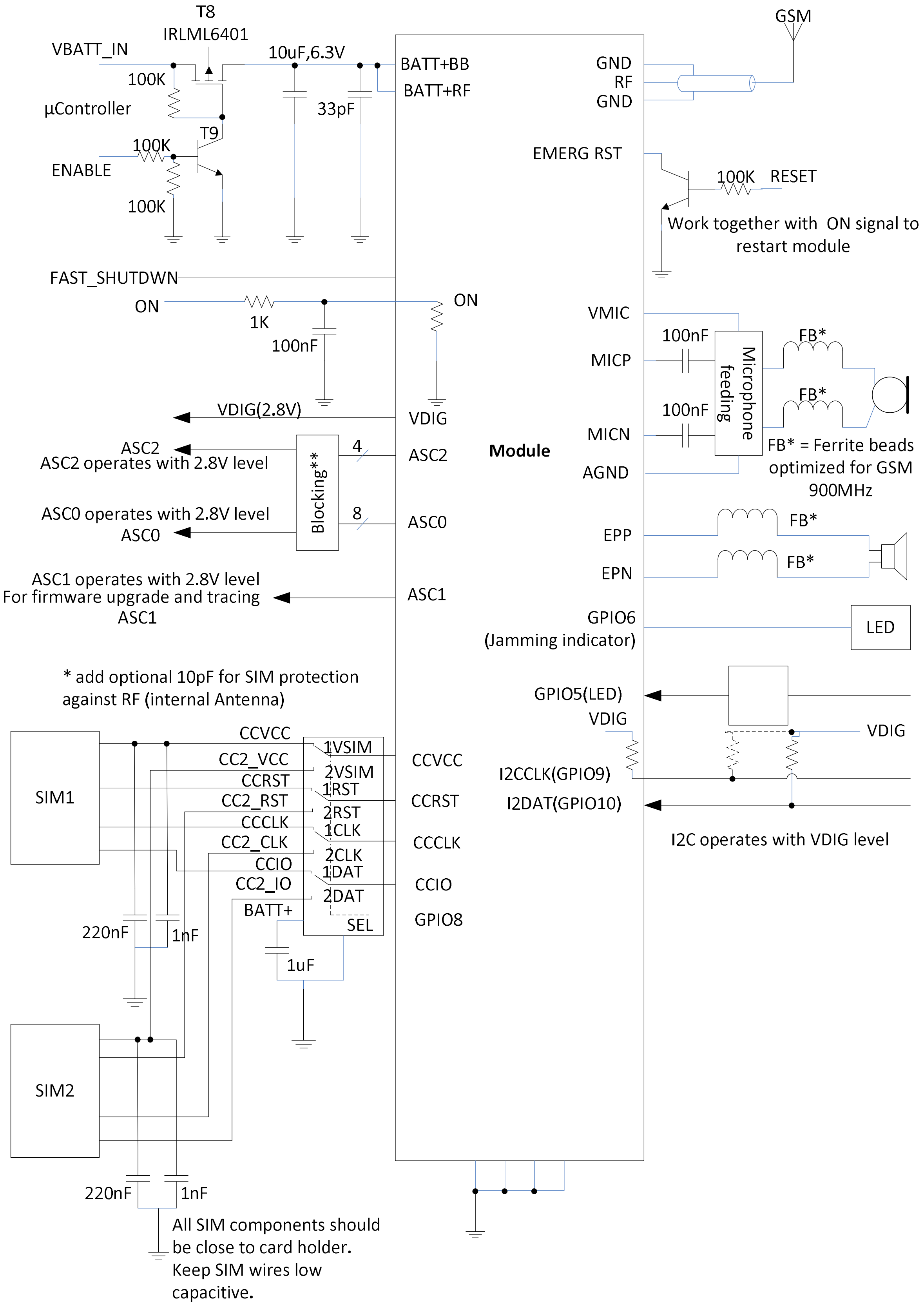


Figure 59: Schematic diagram of BGS12 sample application

7.1 Blocking against RF on Interface Lines

To reduce EMI issues there are serial resistors implemented on the module for the ignition, UART0, UART1 and UART2 lines (cp. Section 5.8). There are 560Ohm serial resist- ors on UART0, UART1 andUART2 lines. However, all other signal lines have no EMI measures on the module and there are no blocking measures at the module’s interface to an external applica- tion.

Dependent on the specific application design, it might be useful to implement further EMI measures on some signal lines at the interface between module and application. These measures are described below.

There are five possible variants of EMI measures (A-E) that may be implemented between module and external application depending on the signal line (see Figure 60 and Table 37). Pay attention not to exceed the maximum input voltages and prevent voltage overshots if using inductive EMC measures.

The maximum value of the serial resistor should be lower than 1kOhm on the signal line. The maximum value of the capacitor should be lower than 50pF on the signal line. Please observe the electrical specification of the module interface and the application interface.

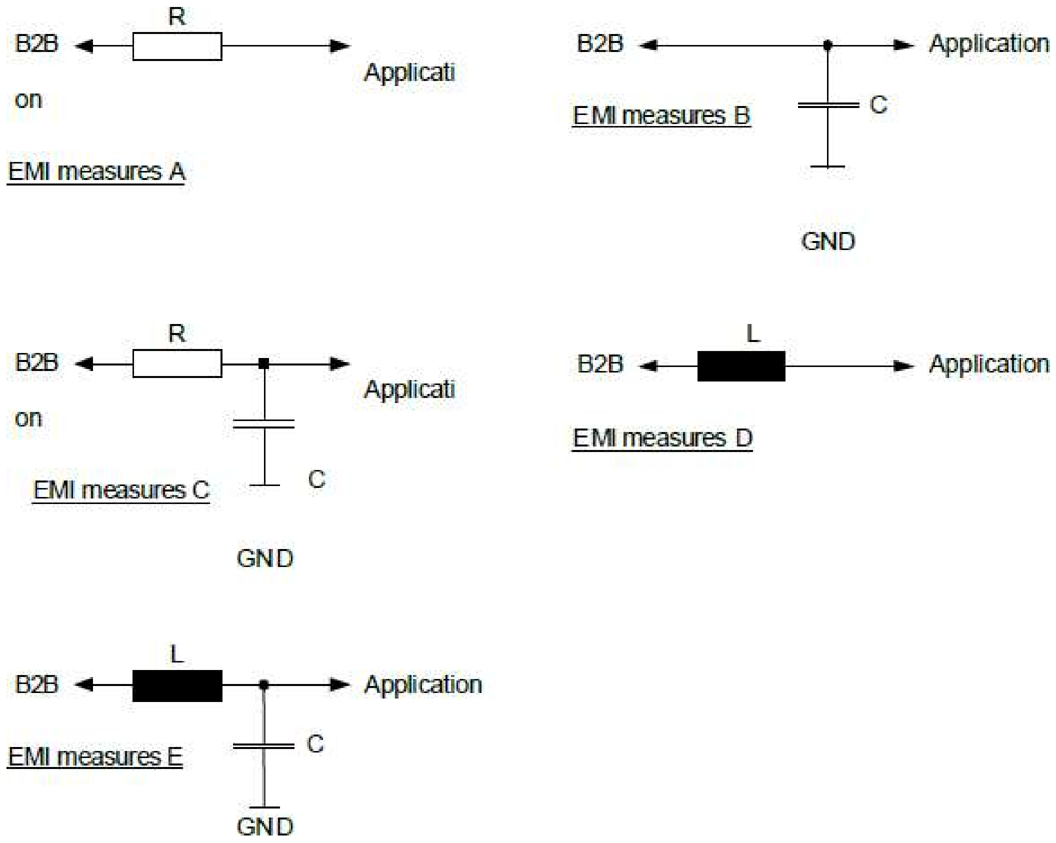


Figure 60: EMI circuits

The following table lists for each signal line at the SMT application interface the EMI measures that may be implemented.

Table 37: EMI measures on the application interface

Signal name	**EMI measures**					**Remark**
	A	**B**	**C**	**D**	**E**	
CCIN	x			x		
CCRST	x	x	x			The external capacitor should be not higher than 30pF on CCIO and CCRST signal rail. The total capacitance of external capacitor and TVS diode should be not higher than 12pF on CCCLK signal rail. The value of the capacitor depends on the external application. The serial resistor should be not higher than 33Ohm
CCIO	x	x	x			
CCCLK	x	x	x			
RXD0		x		x	x	
TXD0		x		x	x	
CTS0		x		x	x	
RTS0				x		
RING0				x		
DTR0		x		x	x	
DCD0		x		x	x	
DSR0		x		x	x	
RXD1		x		x	x	
TXD1		x		x	x	
CTS1		x		x	x	
RTS1		x		x	x	
GPIO5/LED	x	x	x	x	x	
GPIO6/PWM2	x	x	x	x	x	
GPIO7	x	x	x	x	x	
GPIO8	x	x	x	x	x	
GPIO9/I2CCLK		x		x		The rising signal edge is reduced with an additional capacitor.
GPIO10/I2CDAT		x		x		
V180		x		x	x	
V285		x		x	x	
VDIG		x		x	x	

8 Reference Approval

8.1 Reference Equipment for Type Approval

The Gemalto M2M reference setup submitted to type approve BGS12 is shown in the following figure:

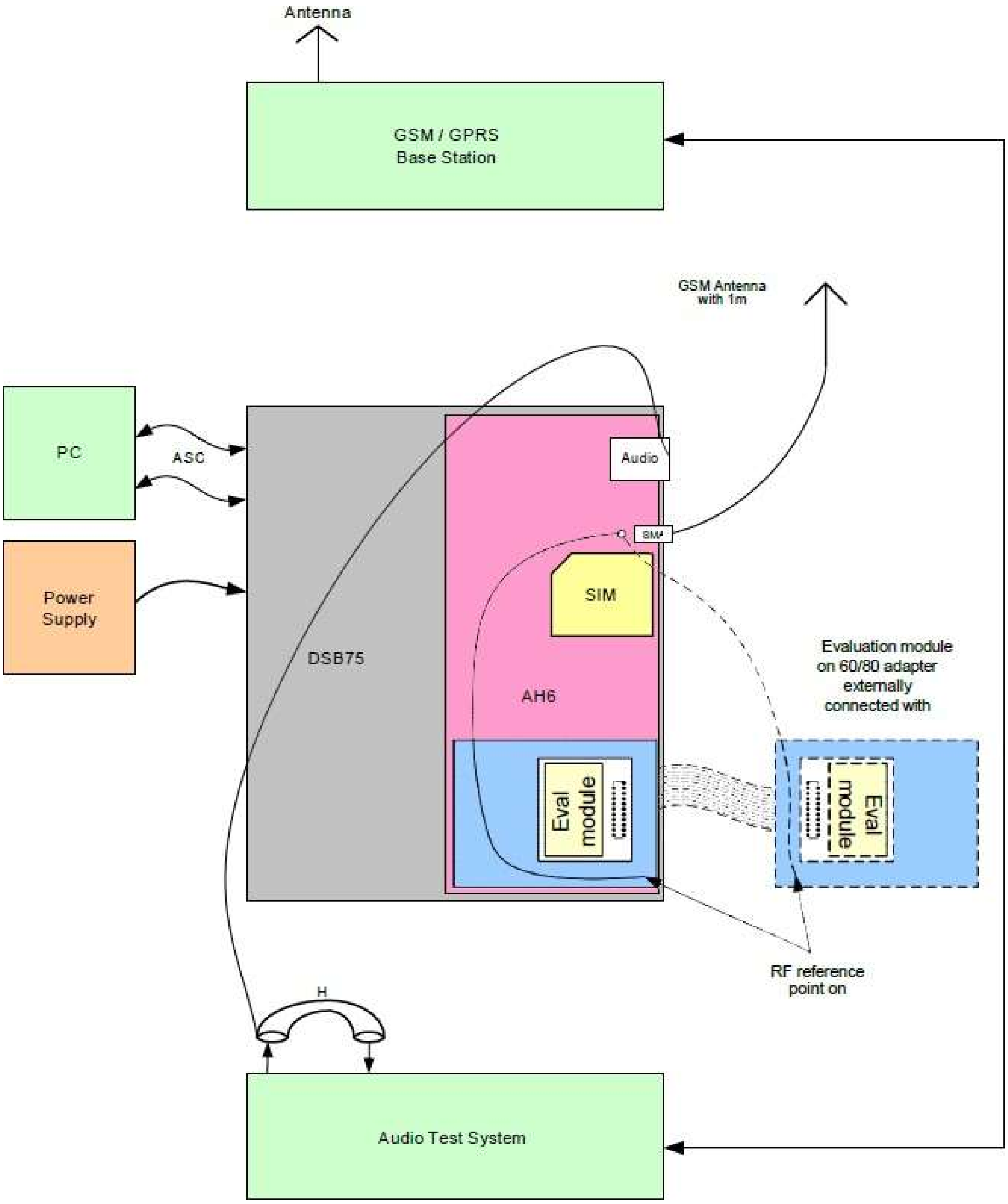


Figure 61: Reference equipment for Type Approva

9 Appendix

9.1 List of Parts and Accessories

Table 38: List of parts and accessories

Description	**Supplier**	**Ordering information**
BGS12	Gemalto M2M	Standard module Gemalto M2M IMEI: Ordering number: L30960-N4810-A200
DSB75 Evaluation Kit	Gemalto M2M	Ordering number: L36880-N8811-A100
DSB75 adapter for mounting BGS12 evaluation modules	Gemalto M2M	Ordering number: L30960-N1801-A100
BGS12 Evaluation Module	Gemalto M2M	Ordering number: L30960-N4801-A200
Votronic Handset	VOTRONIC	Votronic HH-SI-30.3/V1.1/0 VOTRONIC Entwicklungsund Produktionsgesellschaft für elektronische Geräte mbH Saarbrücker Str. 8 66386 St. Ingbert Germany Phone: +49-(0)6 89 4 / 92 55-0 Fax: +49-(0)6 89 4 / 92 55-88 Email: contact@votronic.com
SIM card holder incl. push button ejector and slide-in tray	Molex	Ordering numbers: 91228 91236 Sales contacts are listed in Table 39.

Table 39: Molex sales contacts (subject to change)

Molex For further information please click: http://www.molex.com	Molex Deutschland GmbH Felix-Wankel-Str. 11 4078 Heilbronn-Biberach Germany Phone: +49-7066-9555 0 Fax: +49-7066-9555 29 Email: mxgermany@molex.com	American Headquarters Lisle, Illinois 60532 U.S.A. Phone: +1-800-78MOLEX Fax: +1-630-969-1352
Molex China Distributors Beijing, Room 1319, Tower B, COFCO No. 8, Jian Guo Men Nei Street, 100005 Beijing P.R. China Phone: +86-10-6526-9628 Phone: +86-10-6526-9728 Phone: +86-10-6526-9731 Fax: +86-10-6526-9730	Molex Singapore Pte. Ltd. Jurong, Singapore Phone: +65-268-6868 Fax: +65-265-6044	Molex Japan Co. Ltd. Yamato, Kanagawa, Japan Phone: +81-462-65-2324 Fax: +81-462-65-2366

Table 40: Manufacturer address DBG Holdings Limited

No.5, Yongda Road, Xiangshui River Industrial Area, Daya Bay, Huizhou, Guangdong, China

9.2 FCC statement

FCC Radiation Exposure Statement

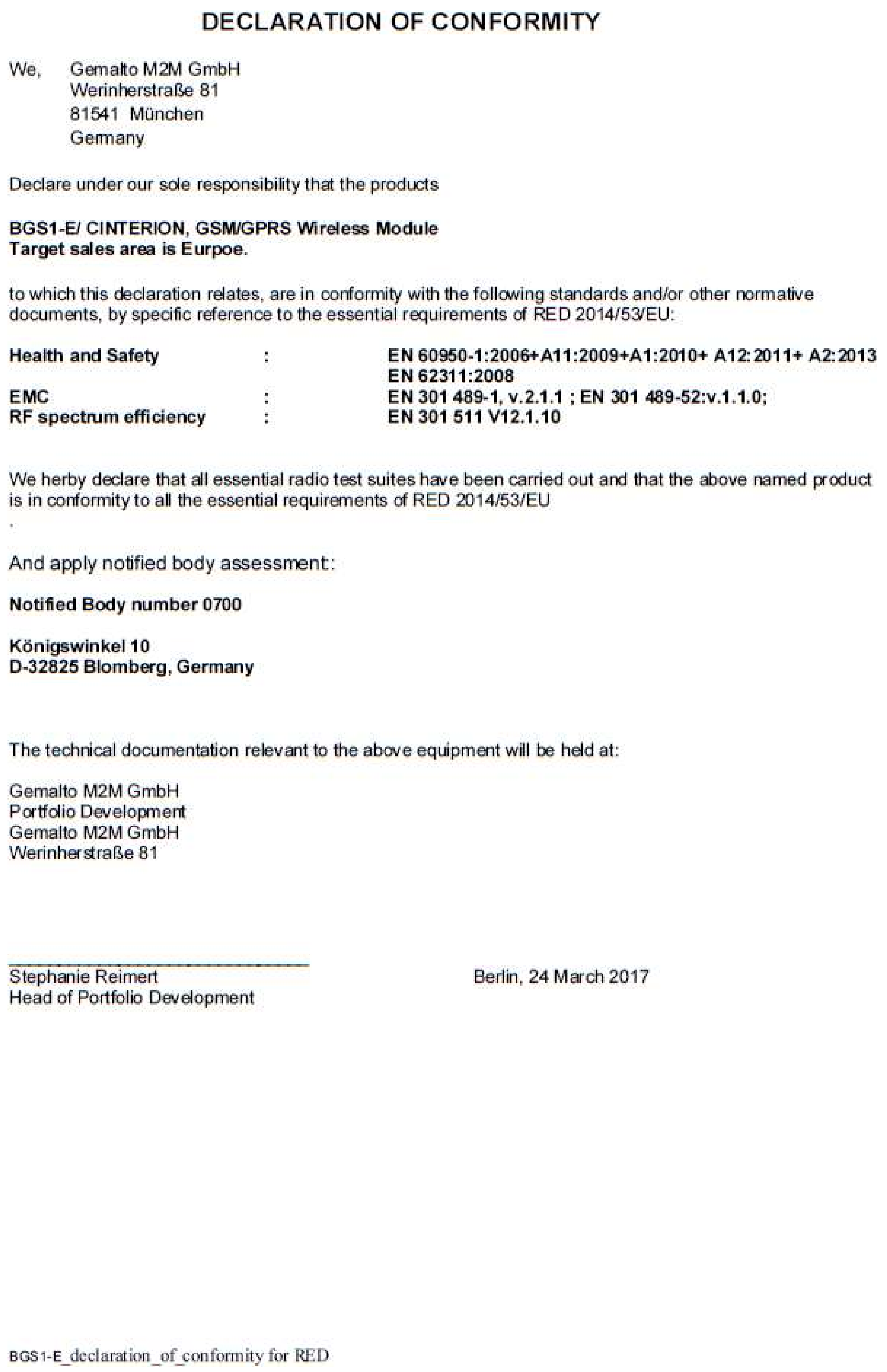
This modular complies with FCC RF radiation exposure limits set forth for an uncontrolled environment. This transmitter must not be co-located or operating in conjunction with any other antenna or transmitter.

If the FCC identification number is not visible when the module is installed inside another device, then the outside of the device into which the module is installed must also display a label referring to the enclosed module. This exterior label can use wording such as the following: “Contains Transmitter Module FCC ID: QIPBGS12 Or Contains FCC ID: QIPBGS12”

When the module is installed inside another device, the user manual of the host must contain below warning statements;

2. Changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

The devices must be installed and used in strict accordance with the manufacturer's instructions as described in the user documentation that comes with the product.



DECLARATION OF CONFORMITY

We, Gemalto M2M GmbH
Werinherstraße 81
81541 München
Germany

Declare under our sole responsibility that the products

BGS1-E/ CINTERION, GSM/GPRS Wireless Module
Target sales area is Eurpoe.

to which this declaration relates, are in conformity with the following standards and/or other normative documents, by specific reference to the essential requirements of RED 2014/53/EU:

Health and Safety : EN 60950-1:2006+A11:2009+A1:2010+ A12:2011+ A2:2013
EN 62311:2008
EMC : EN 301 489-1, v.2.1.1 ; EN 301 489-52:v.1.1.0;
RF spectrum efficiency : EN 301 511 V12.1.10

We herby declare that all essential radio test suites have been carried out and that the above named product is in conformity to all the essential requirements of RED 2014/53/EU

And apply notified body assessment:

Notified Body number 0700

Königswinkel 10
D-32825 Blomberg, Germany

The technical documentation relevant to the above equipment will be held at:

Gemalto M2M GmbH
Portfolio Development
Gemalto M2M GmbH
Werinherstraße 81

Stephanie Reimert
Head of Portfolio Development

Berlin, 24 March 2017

BGS1-E_declaration_of_conformity for RED

About Gemalto

Gemalto (Euronext NL0000400653 GTO) is the world leader in digital security with 2011 annual revenues of €2 billion and more than 10,000 employees operating out of 74 offices and 14 Research & Development centers, located in 43 countries.

We are at the heart of the rapidly evolving digital society. Billions of people worldwide increasingly want the freedom to communicate, travel, shop, bank, entertain and work - anytime, everywhere - in ways that are enjoyable and safe. Gemalto delivers on their expanding needs for personal mobile services, payment security, authenticated cloud access, identity and privacy protection, eHealthcare and eGovernment efficiency, convenient ticketing and dependable machine-to- machine (M2M) applications.

Gemalto develops secure embedded software and secure products which we design and personalize. Our platforms and services manage these secure products, the confidential data they contain and the trusted end-user services they enable. Our inovations enable our clients to offer trusted and convenient digital services to billions of individuals.

Gemalto thrives with the growing number of people using its solutions to interact with the digital and wireless world.

For more information please visit
m2m.gemalto.com, www.facebook.com/gemalto, or Follow@gemaltom2m on twitter.

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