Cinterion® BGS8

Hardware Interface Description

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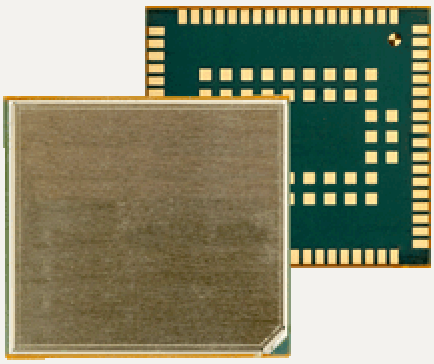

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1 Introduction

This document[1] describes the hardware of the Cinterion® BGS8 module. 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 Key Features at a Glance

Feature	Implementation
General	
Frequency bands	GSM/GPRS: Quad band 850/900/1800/1900MHz
GSM class	Small MS
Output power	Class 4 (+33dBm ±2dB) for EGSM850 Class 4 (+33dBm ±2dB) for EGSM900 Class 1 (+30dBm ±2dB) for GSM1800 Class 1 (+30dBm ±2dB) for GSM1900
Power supply	3.3V to 4.5V
Operating temperature (board temperature)	Normal operation: -30°C to +85°C Extended operation: -40°C to +90°C
Physical	Dimensions: 27.6mm x 25.4mm x 2.6mm Weight: approx. 3.5g
RoHS	All hardware components fully compliant with EU RoHS Directive
GSM/GPRS/EGPRS features	
Data transfer	GPRS: • Multislot Class 10 • Full PBCCH support • Mobile Station Class B • Coding Scheme 1 – 4 CSD: • V.110, RLP, non-transparent • 2.4, 4.8, 9.6, 14.4kbps • USSD PPP-stack for GPRS data transfer
SMS	Point-to-point MT and MO Cell broadcast Text and PDU mode Storage: SIM card plus SMS locations in mobile equipment Transmission of SMS alternatively over CSD or GPRS. Preferred mode can be user defined.Transmission of SMS over GSM.
Fax	Group 3; Class 1

1. The document is effective only if listed in the appropriate Release Notes as part of the technical documentation delivered with your Gemalto M2M product.

Feature	**Implementation**
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) • Adaptive Multi Rate AMR 7 different ringing tones/melodies
GNSS Features	
Protocol	NMEA
Modes	Standalone GNSS
General	Power saving modes Power supply for an active antenna
GPS 1pps clock	1 pulse per second synchronized with GPS time
Software	
AT commands	Hayes 3GPP TS 27.007, TS 27.005, Gemalto M2M AT commands for RIL compatibility
Microsoft™ compatibility	RIL for Pocket PC and Smartphone
SIM Application Toolkit	SAT Release 99
TCP/IP stack	Access by AT commands
Firmware update	Generic update from host application over ASC0.
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.
1 serial interface	ASC0: • 8-wire modem interface with status and control lines, unbalanced, asynchronous • Adjustable baud rates: 300bps to 230,400bps • Autobauding: 1,200bps to 230,400bps • Supports RTS0/CTS0 hardware flow control and software XON/XOFF • Multiplex ability according to GSM 07.10 Multiplexer Protocol.
Audio	1 analog interface (with microphone feeding) 1 digital interface (PCM/I^2S)
UICC interface	Supported SIM/USIM cards: 3V, 1.8V
GPIO interface	GPIO interface with 6 GPIO lines. The GPIO interface is shared with a PWM functionality as well as a fast shutdown signal, a status line and a jamming indicator.

Feature	Implementation
I^2C interface	Supports I^2C serial interface
GPS 1pps clock	High accuracy 1pps output (one pulse per second) signal
ADC input	Analog-to-digital comverter for general purpose voltage measurements
Antenna interface pads	50Ω
Power on/off, Reset	
Power on/off	Switch-on by hardware signal IGT Switch-off by AT command (AT^SMSO) Switch off by hardware signal FST_SHDN instead of AT command Automatic switch-off in case of critical temperature and voltage conditions
Reset	Orderly shutdown and reset by AT command Emergency reset by hardware signal EMERG_RST
Special features	
Real time clock	Timer functions via AT commands
Phonebook	SIM and phone
TTY/CTM support	Integrated CTM modem
TLS security	Transport layer security
RLS monitoring	Jamming detection
Evaluation kit	
Evaluation module	BGS8 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 is required to connect the BGS8 evaluation module to the DSB75.

1.2 BGS8 System Overview

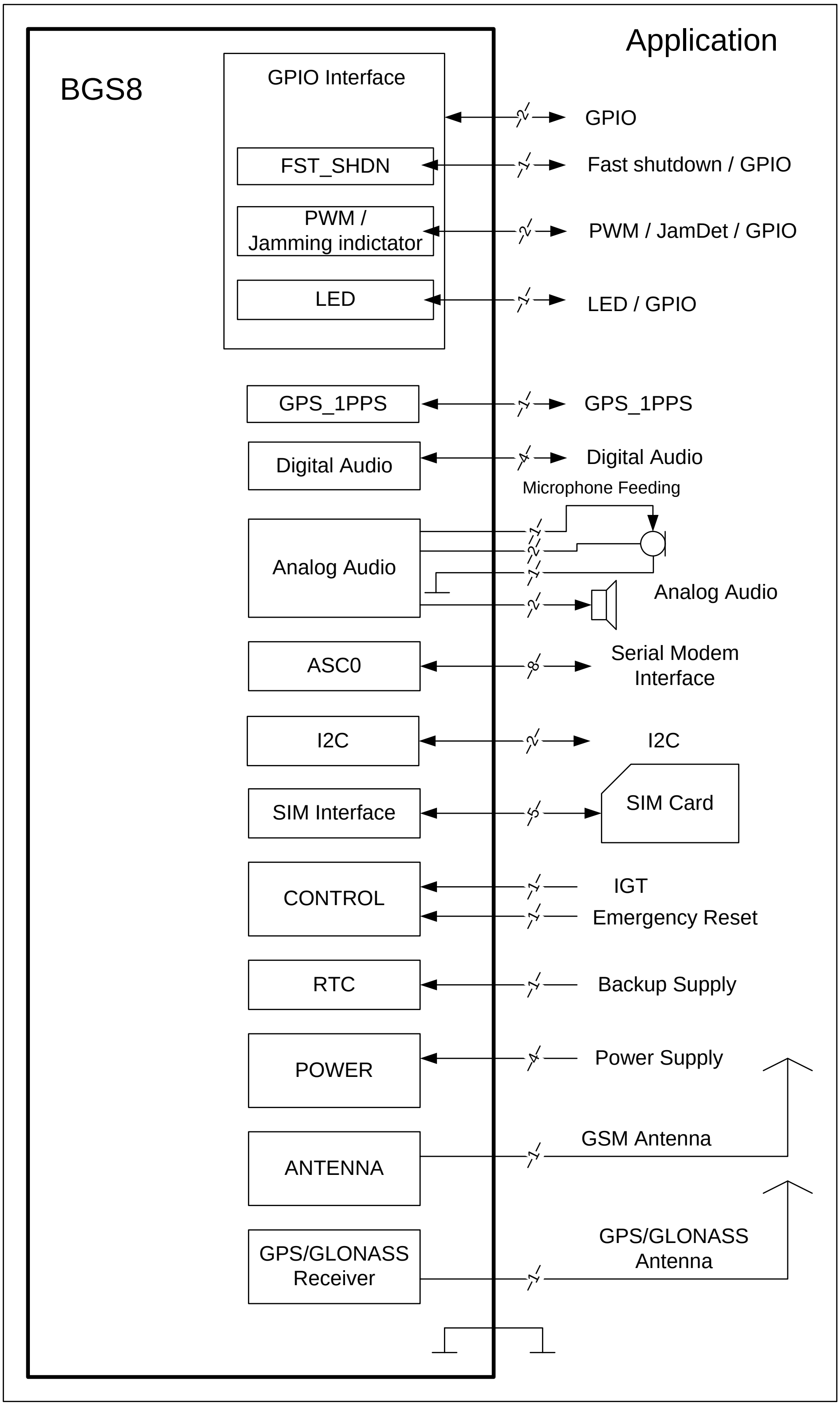


Figure 1: BGS8 system overview

1.3 Circuit Concept

Figure 2 shows a block diagram of the BGS8 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 SAW filters

GNSS RF section
- GNSS receiver

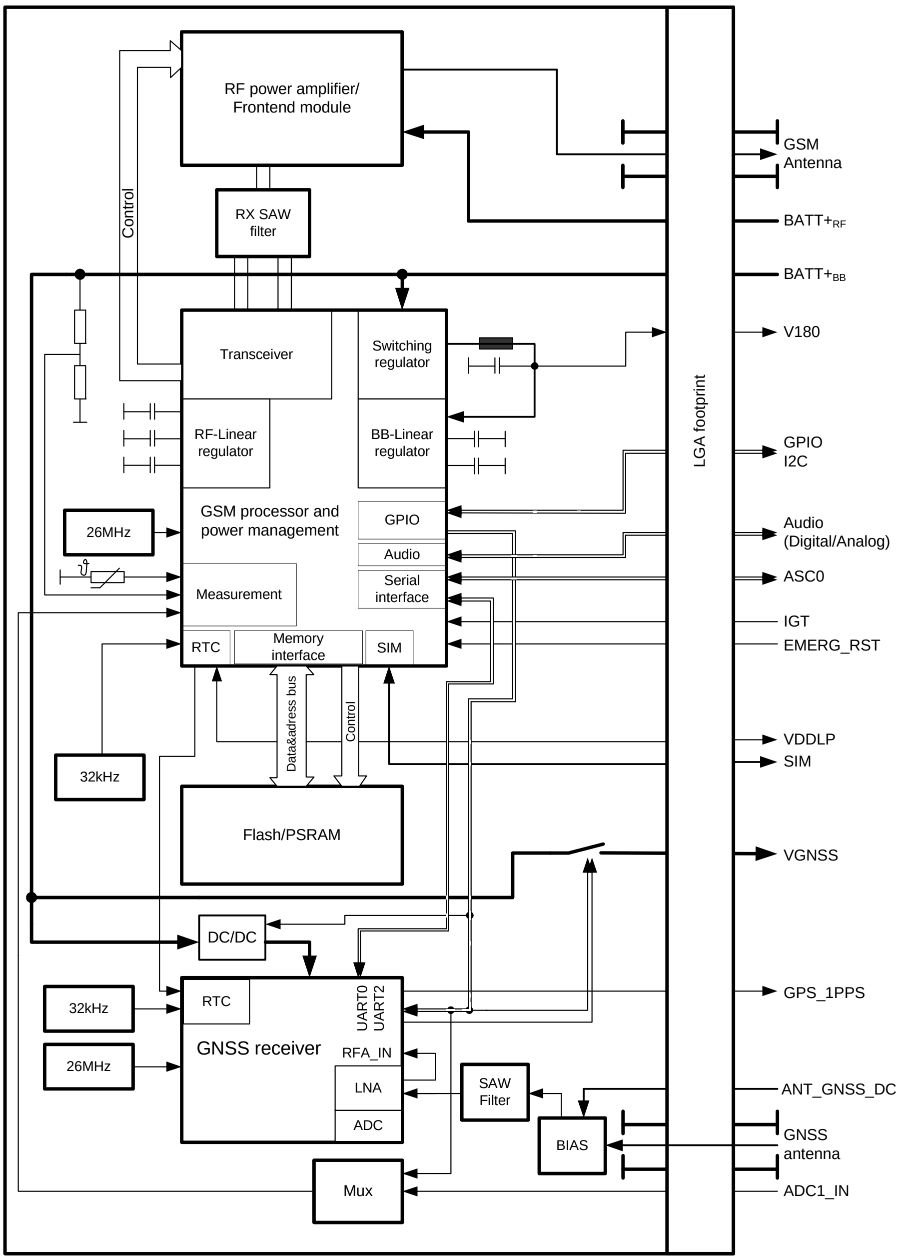


Figure 2: BGS8 baseband block diagram

2 Interface Characteristics

BGS8 is equipped with an SMT application interface that connects to the external application. The SMT application interface incorporates the various application interfaces as well as the RF antenna interface.

2.1 Application Interface

2.1.1 Pad Assignment

The SMT application interface on the BGS8 provides connecting pads to integrate the module into external applications. Figure 3 shows the connecting pads' numbering plan, the following Table 1 lists the pads' assignments.

Figure 3: Numbering plan for connecting pads (bottom view)

Table 1: Pad assignments

Pad no.	Signal name	Pad no.	Signal name	Pad no.	Signal name
201	EPN	24	TFSDAI	235	Do not use
202	EPP	25	RXDDAI	236	Do not use
203	GND	26	SCLK	237	Do not use
204	$BATT+_{BB}$	27	I2CDAT	238	GND
205	GND	28	I2CCLK	239	GPIO5/LED
206	ADC1_IN	29	Do not use	240	GPIO6/PWM2/JamDet
207	IGT	30	Do not use	241	GPIO7/PWM1
208	GND	31	Do not use	242	GPIO8 (Reserved)
209	V180	32	Do not use	53	$BATT+_{RF}$
210	RXD0	33	EMERG_RST	54	GND
211	CTS0	221	VGNSS	55	GND
212	TXD0	222	GPIO11	56	GND
213	RING0	223	GND	57	GND
214	RTS0	224	ANT_GNSS	58	GND
215	VDDLP	225	GND	59	ANT_GSM
216	CCRST	226	Do not use	60	GND
217	CCIN	227	GND	61	GND
218	CCIO	228	ANT_GNSS_DC	62	GND
219	Do not use	229	GPIO4/FST_SHDN	63	GND
220	Do not use	230	DSR0	64	AGND
20	CCVCC	231	DCD0	65	MICP
21	CCCLK	232	DTR0	66	MICN
22	VCORE	233	Do not use	243	VMIC
23	TXDDAI	234	Do not use	244	Do not use
Centrally located pads					
67	Reserved	83	GND	99	GND
68	Reserved	84	GND	100	GND
69	Reserved	85	GND	101	GND
70	GPS_1PPS	86	GND	102	GND
71	Do not use	87	Do not use	103	GND
72	Do not use	88	GND	104	Do not use
73	Do not use	89	GND	105	Do not use
74	Reserved	90	GND	106	Reserved
75	Reserved	91	Not connected	245	GND
76	Reserved	92	GND	246	Reserved
77	Reserved	93	GND	247	Reserved
78	Reserved	94	GND	248	Reserved
79	Do not use	95	GND	249	Reserved
80	Reserved	96	GND	250	GND
81	GND	97	GND	251	GND
82	GND	98	GND	252	GND

Signal pads that are not used should not be connected to an external application.
Please note that the reference voltages listed in Table 2 are the values measured directly on the BGS8 module. They do not apply to the accessories connected.

2.1.2 Signal Properties

Table 2: Signal properties

Function	Signal name	IO	Signal form and level	Comment
Power supply	$BATT+_{BB}$ $BATT+_{RF}$	I	$V_I$max = 4.5V $V_I$norm = 4.0V $V_I$min = 3.3V during Tx burst on board I ≈ 1.3A, during Tx burst (GSM)  n Tx = n x 577µs peak current every 4.616ms	Lines of BATT+ and GND must be connected in parallel for supply purposes because higher peak currents may occur. Minimum voltage must not fall below 3.3V for including drop, ripple, spikes. $BATT+_{BB}$ assigned to pad 204 requires an additional ultra low ESR 150µF capacitor. If using Multilayer Ceramic Chip Capacitors (MLCC) please take DC-bias into account.
Power supply	GND		Ground	Application Ground
External supply voltage	V180	O	Normal operation: $V_O$norm = 1.80V ±3% $I_O$max = -10mA SLEEP mode Operation: V_OSleep = 1.80V ±5% $I_O$max = -10mA CLmax = 100nF	V180 may be used to supply level shifters at the interfaces or to supply external application circuits. V180 is not available in Power Down mode. The external digital logic must not cause any spikes or glitches on V180 line. VCORE and V180 can be used for a power indication circuit. If unused keep lines open.
	VCORE	O	Normal operation: $V_O$norm =1.2V±2% Sleep mode Operation: V_OSleep=1.0V±2% CLmax = 120nF	
Ignition	IGT	I	R_I ≈ 100kΩ V_{IH}max = VDDLP + 0.5V V_{IH}min = 1.8V V_{IL}max = 0.5V at -15µA IGT ____|____ high pulse	This signal switches the module on. The IGT signal is an edge triggered signal.
Emergency restart	EMERG_RST	I	R_I ≈ 1kΩ, C_I ≈ 1nF V_{OH}max = 1.9V V_{IH}min = 1.35V V_{IL}max = 0.3V at ~200µA ~~|___|~~ low impulse width > 10ms	This line must be driven low by an open drain or open collector driver connected to GND. If unused keep line open.

Table 2: Signal properties

Function	Signal name	IO	Signal form and level	Comment
Fast shutdown	GPIO4	I	V_{IL}max = 0.34V V_{IH}min = 1.30V V_{IH}max = 1.90V ~~|___|~~ low impulse width > 10ms	This line must be driven low. If unused keep line open. Note that if configured as fast shutdown line the listed GPIO line is identical to the following signal: GPIO4 --> FST_SHDN
RTC backup	VDDLP	I/O	$V_O$norm = 2.3V ±5% $I_O$max = -2mA $V_I$max = 2.4V Low limit GSM & GNSS $V_I$min = 1.50V Low limit only GSM VImin = 1.0V IItyp = TBD.µA	It is recommended to use a serial resistor between VDDLP and a possible capacitor. If unused keep line open.
Serial Interface ASC0	RXD0	O	V_{OL}max = 0.20V at I = 2mA V_{OH}min = 1.50V at I = -2mA V_{OH}max = 1.90V	If unused keep lines open.
	CTS0	O		
	DSR0	O		
	DCD0	O		
	RING0	O		
	TXD0	I	V_{IL}max = 0.34V V_{IH}min = 1.30V V_{IH}max = 1.90V	
	RTS0	I		
	DTR0	I		

Table 2: Signal properties

Function	Signal name	IO	Signal form and level	Comment
SIM card detection	CCIN	I	$R_I \approx 100k\Omega$ V_{IH}min = 1.2V, V_{IH}max= 1.9V V_{IL}max = 0.4V at -10µA	CCIN = High, SIM card inserted. For details please refer to Section 2.1.4. If unused keep line open.
3V SIM Card Interface	CCRST	O	V_{OL}max = 0.20V at I = 2mA V_{OH}min = 2.40V at I = -2mA V_{OH}max = 2.90V	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 = 2.90V V_{OL}max = 0.20V at I = 2mA V_{OH}min = 2.40V at I = -2mA V_{OH}max = 2.90V	
	CCCLK	O	V_{OL}max = 0.20V at I = 2mA V_{OH}min = 2.40V at I = -2mA V_{OH}max = 2.90V	
	CCVCC	O	$V_O$min = 2.80V $V_O$typ = 2.85V $V_O$max = 2.90V $I_O$max = -30mA	
1.8V SIM Card Interface	CCRST	O	V_{OL}max = 0.20V at I = 2mA V_{OH}min = 1.50V at I = -2mA V_{OH}max = 1.90V	Maximum cable length or copper track to SIM card holder should not exceed 100mm.
	CCIO	I/O	V_{IL}max = 0.37V V_{IH}min = 1.22V V_{IH}max = 1.90V V_{OL}max = 0.20V at I = 2mA V_{OH}min = 1.50V at I = -2mA V_{OH}max = 1.90V	
	CCCLK	O	V_{OL}max = 0.20V at I = 2mA V_{OH}min = 1.50V at I = -2mA V_{OH}max = 1.90V	
	CCVCC	O	$V_O$min = 1.75V $V_O$typ = 1.80V $V_O$max = 1.85V $I_O$max = -30mA	

Table 2: Signal properties

Function	Signal name	IO	Signal form and level	Comment
I^2C	I2CCLK	O	Open drain Output $R_I \approx 5k\Omega$ (internal pull up) V_{OL}min = 0.4V at I = -3mA V_{OH}max = 1.90V R external pull up min = 560Ω	I2CCLK is configured as open drain with an internal 5kΩ pull up resistor. I2CDAT is configured as open drain and needs a pull-up resistor in the host application. According to the I^2C Bus Specification Version 2.1 a rise time of max. 300ns is permitted for the fast mode. There is also a maximum V_{OL}=0.4V at 3mA specified. The value of the pull-up depends on the capacitive load of the whole system (I^2C slave + lines). The maximum sink current of I2CDAT and I2CCLK is 4mA. If unused keep lines open.
	I2CDAT	IO	Open Drain IO (no internal Pull up) V_{IL}max = 0.5V V_{IH}min = 1.3V V_{IH}max = 2.25V V_{OL}min = 0.4V at Imax = -3mA R external pull up min= 500Ω	
GPIO interface	GPIO4	IO	V_{OL}max = 0.20V at I = 2mA V_{OH}min = 1.50V at I = -2mA V_{OH}max = 1.90V V_{IL}max = 0.34V V_{IH}min = 1.30V V_{IH}max = 1.90V	If unused keep lines open. Please note that some GPIO lines are or can be configured for functions other than GPIO: GPIO4: Fast shutdown GPIO5: Status LED line GPIO6: PWM and Jamming detection GPIO7: PWM GPIO8: Reserved
	GPIO5	IO		
	GPIO6	IO		
	GPIO7	IO		
	GPIO8	IO		
	GPIO11	IO		
Status LED	GPIO5	O	V_{OL}max = 0.20V at I = 2mA V_{OH}min = 1.50V at I = -2mA V_{OH}max = 1.90V	If unused keep line open. Note that if configured as Status LED line the listed GPIO line is identical to the following signal: GPIO5 --> LED
Jamming detection	GPIO6	O	V_{OL}max = 0.20V at I = 2mA V_{OH}min = 1.50V at I = -2mA V_{OH}max = 1.90V	If unused keep line open. Note that if configured as Jamming detection line the listed GPIO line is identical to the following signal: GPIO6 --> JamDet

Table 2: Signal properties

Function	Signal name	IO	Signal form and level	Comment
PWM	GPIO6 GPIO7	O	V_{OL}max = 0.20V at I = 2mA V_{OH}min = 1.50V at I = -2mA V_{OH}max = 1.90V	If unused keep lines open. Note that if configured as PWM lines the listed GPIO lines are identical to the following signal: GPIO6 --> PWM2 GPIO7 --> PWM1
Digital audio interface (PCM/I^{2}S)	TFSDAI	O	V_{OL}max = 0.20V at I = 2mA V_{OH}min = 1.50V at I = -2mA V_{OH}max = 1.90V	If unused keep line open.
	SCLK	O		
	TXDDAI	O		
	RXDDAI	I	V_{IL}max = 0.34V V_{IH}min = 1.30V V_{IH}max = 1.90V	
ADC (Analog-to-Digital Converter)	ADC1_IN	I	R_I = 1MΩ V_I = 0V ... 1.2V (valid range) V_{IH} max = 1.8V Resolution 1024 steps Tolerance 0.3%	ADC can be used as input for external measurements. If unused keep line open.
Analog audio interface	VMIC	O	$V_O$typ = 1.8V ... 2.2V I_{max} = 4 mA	Microphone supply for customer feeding circuits. If unused keep line open.
	EPP	O	Differential, typ. 3.2Vpp at 16Ω load typ. 4.1Vpp at no load PCM level = +3dBm0, 1.02 kHz sine wave CLmax <= 100pF to AGND at each line.	Balanced output for earphone or for line out. If unused keep lines open.
	EPN	O		
	MICP	I	ZItyp = 50kΩ Vinmax = 0.8Vpp (for 3dBm0 @ 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		
	AGND		Analog ground	GND level for external audio circuits.

Table 2: Signal properties

Function	Signal name	IO	Signal form and level	Comment
Supply voltage for active GNSS antenna	VGNSS	O	V_{OH}max = BATT+ V_{OH}min = BATT+ -0.1V at Ityp = -50mA V_{OL} = 0V	Available if GNSS antenna DC power is enabled.
Supply voltage for active GNSS antenna	ANT_GNSS_DC	I	V_{IH}max = 50V Imax = 50mA	If unused connect to GND.
GPS 1pps output	GPS_1PPS	O	V_{OL}max = 0.4V at I = 1mA V_{OH}min = 1.3V at I = -1mA V_{OH}max = 1.9V	Directly connected to GNSS receiver.

2.1.2.1 Absolute Maximum Ratings

The absolute maximum ratings stated in Table 3 are stress ratings under any conditions. Stresses beyond any of these limits will cause permanent damage to BGS8.

Table 3: Absolute maximum ratings

Parameter	Min	Max	Unit
Supply voltages $BATT+_{BB}$, $BATT+_{RF}$	-0.3	+5.5	V
Voltage at all digital lines in Power Down mode	-0.3	+0.3	V
Voltage at digital lines 1.8V domain in normal operation	-0.3	+2.2	V
Voltage at SIM interface, CCVCC 1.8V in normal Operation	-0.3	+2.2	V
Voltage at SIM interface, CCVCC 2.85V in normal Operation	-0.3	+3.3	V
Voltage at analog ADC lines in normal operation	-0.3	+2.0	V
Voltage at analog lines in Power Down mode	-0.3	+0.3	V
VDDLP	-0.3	+2.5	V
GPS antenna supply limited output current		100	mA

2.1.3 Serial Interface ASC0

BGS8 offers an 8-wire unbalanced, asynchronous modem interface ASC0 conforming to ITU-T V.24 protocol DCE signalling. The electrical characteristics do not comply with ITU-T V.28. The significant levels are 0V (for low data bit or active state) and 1.8V (for high data bit or inactive state). For electrical characteristics please refer to Table 2. For an illustration of the interface line's startup behavior see Figure 5.

BGS8 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

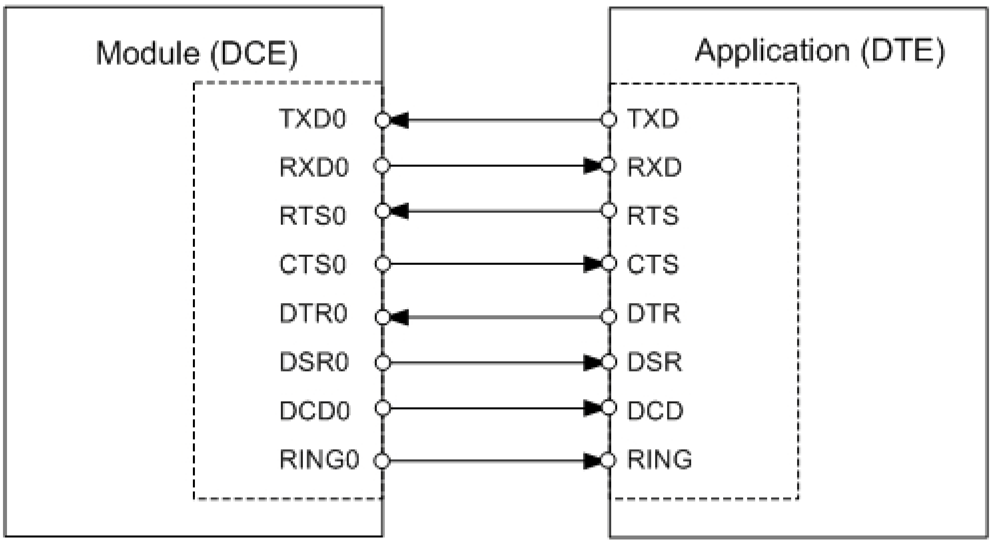


Figure 4: Serial interface ASC0

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.
- Full multiplexing capability allows the interface to be partitioned into virtual channels.
- The DTR0 signal will only be polled once per second from the internal firmware of BGS8.
- 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.
- By default configured to 8 data bits, no parity and 1 stop bit.
- ASC0 can be operated at fixed bit rates from 300bps to 230,400bps.
- Autobauding supports bit rates from 1,200bps to 230,400bps.
- Supports RTS0/CTS0 hardware flow control and XON/XOFF software flow control.

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

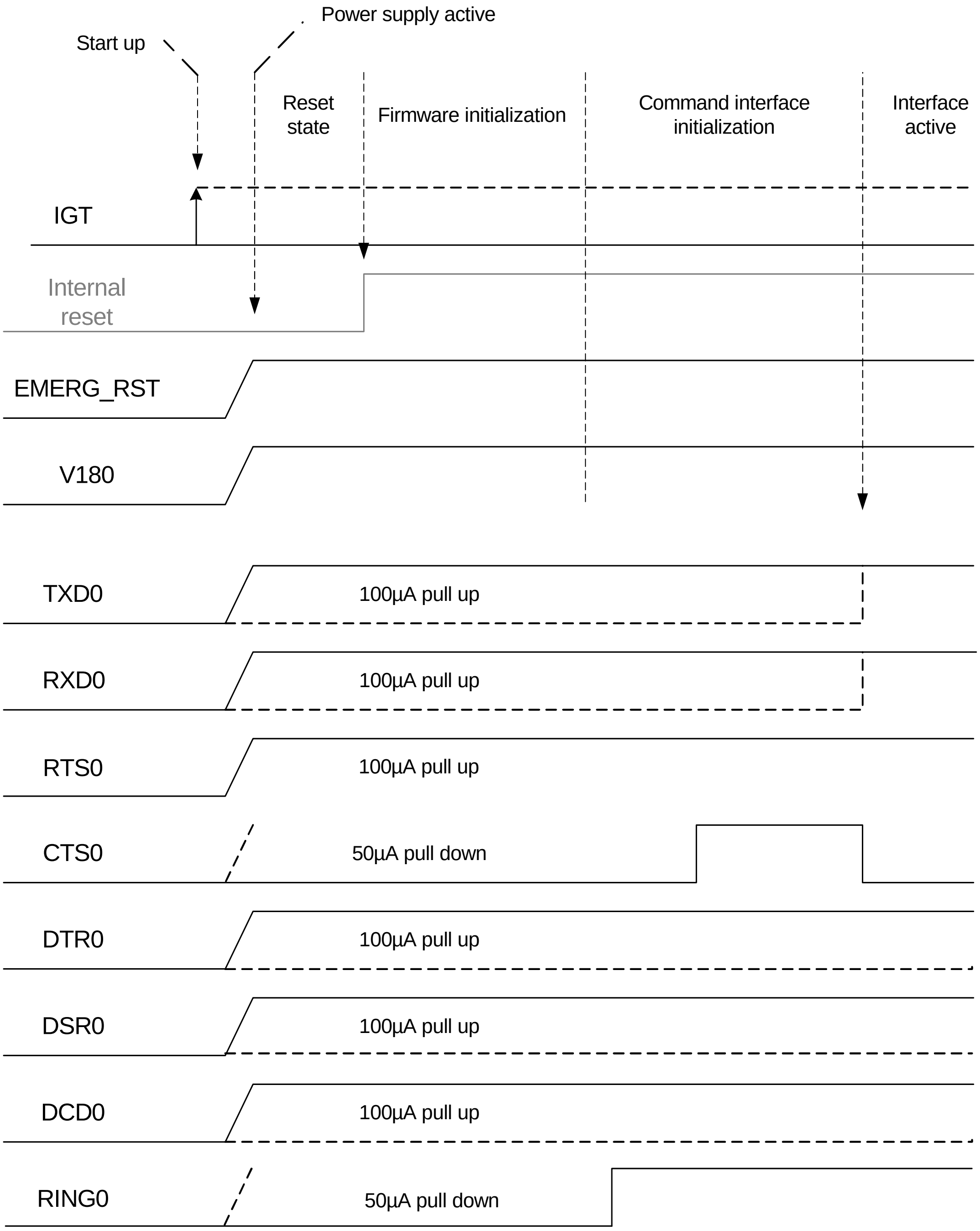


Figure 5: ASC0 startup behavior

Note: No data must be sent over the ASC0 interface before the interface is active and ready to receive data (see Section 3.2.1).

2.1.4 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. BGS8 supports and automatically detects 3.0V as well as 1.8V SIM cards. Please refer to Table 2 for electrical specifications of the SIM/USIM interface lines depending on whether a 3V or 1.8V SIM card is used.

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. To take advantage of this feature, an appropriate SIM card detect switch is required on the card holder. For example, this is true for the model supplied by Molex, which has been tested to operate with BGS8 and is part of the Gemalto M2M reference equipment submitted for type approval. See Section 7.1 for Molex ordering numbers.

Table 4: Signals of the SIM interface (SMT application interface)

Signal	Description
CCCLK	Chipcard clock, various clock rates can be set in the baseband processor.
CCVCC	SIM supply voltage from PSU-ASIC
CCIO	Serial data line, input and output.
CCRST	Chipcard reset, provided by baseband processor
CCIN	Input on the baseband processor for detecting a SIM card tray in the holder.The 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 BGS8.

The figure below shows a circuit to connect an external SIM card holder including enhanced ESD protection for the SIM interface lines.

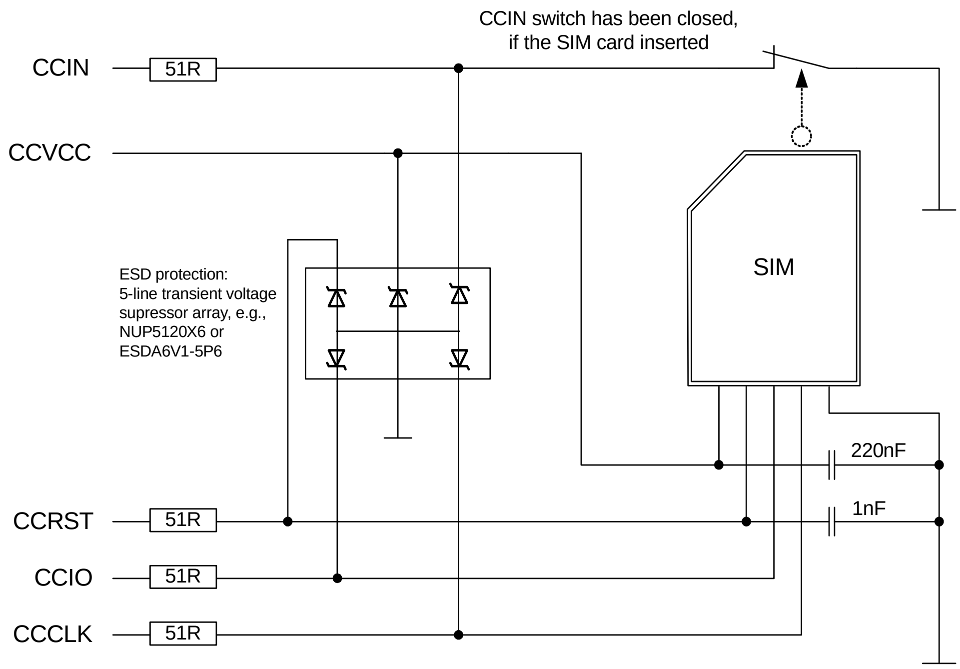


Figure 6: External SIM card holder circuit

It is recommended that the total cable length between SMT application interface pads on BGS8 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 compliance.

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.

Note: No guarantee can be given, nor any liability accepted, if loss of data is encountered after removing the SIM card during operation.
Also, no guarantee can be given for properly initialising any SIM card that the user inserts after having removed a SIM card during operation. In this case, the application must restart BGS8.
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.

2.1.5 Analog Audio Interface

BGS8 has an analog audio interface with a balanced analog microphone input and a balanced analog earpiece output. A supply voltage and an analog ground connection are provided at dedicated pads.

2.1.5.1 Microphone Inputs and Supply

The differential microphone inputs MICP and MICN present an impedance of 50kΩ 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 2.2V 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. It is also recommended to use the AGND line for grounding the microphone circuit. AGND provides for the same module ground potential the analog circuits of the module refer to.

The following figures show possible microphone and line connections.

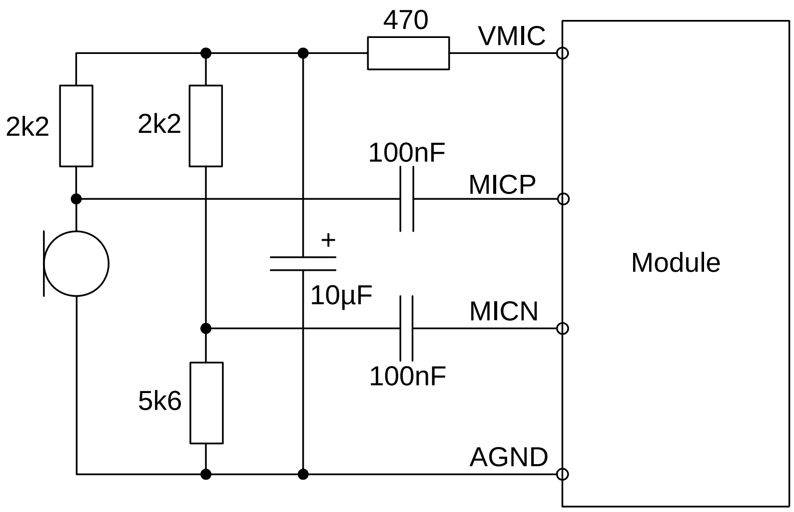


Figure 7: Single ended microphone connection

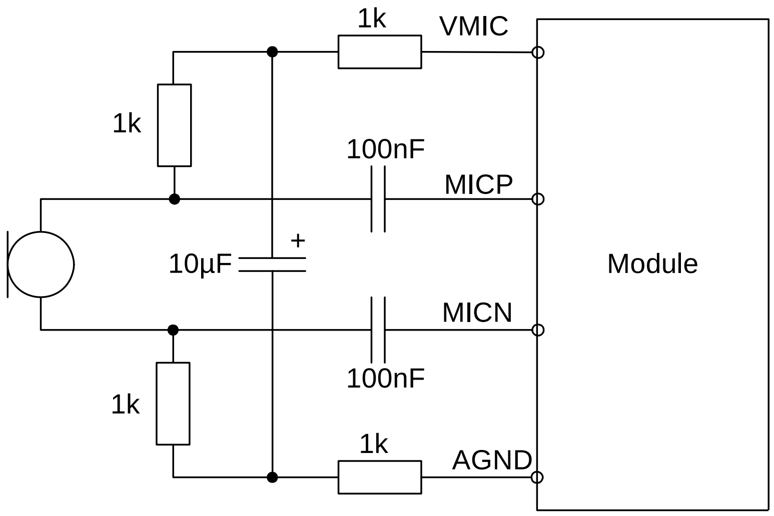


Figure 8: Differential Microphone connection

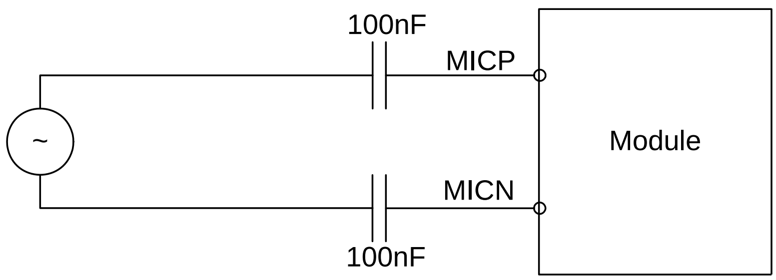


Figure 9: Line Input

2.1.5.2 Loudspeaker Output

BGS8 provides a differential loudspeaker output EPP/EPN. The output is able to deliver a voltage of 3.2Vpp at a load resistance of 16Ω. If it is used as line output (see Figure 11), the application should provide a capacitor decoupled differential input to eliminate GSM humming. A first order low pass filter above 4kHz 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.

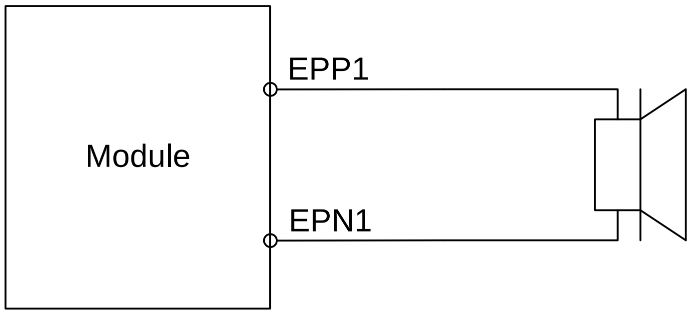


Figure 10: Differential loudspeaker connection

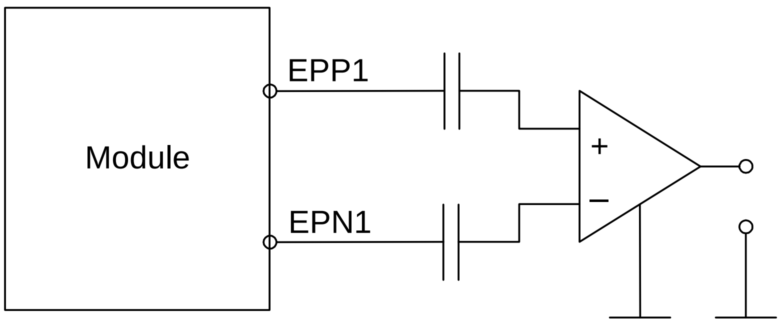


Figure 11: Line output connection

2.1.5.3 Electrical Characteristics of the Voiceband Part

Setting Audio Parameters by AT Commands

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

Table 5: Audio parameters adjustable by AT command

Parameter	Influence to	Range	Gain range	Calculation
inBbcGain	MICP/MICN analog amplifier gain of baseband controller before ADC	0...7	0...39dB	6dB steps, 3dB between step 6 and 7
inCalibrate	Digital attenuation of input signal after ADC	0...32767	-∞...0dB	20 * log (inCalibrate/ 32768)
outBbcGain	EPP/EPN analog output gain of baseband controller after DAC	0...3	0...-18dB	6dB steps
outCalibrate[n] n = 0...4	Digital attenuation of output signal after speech decoder, before summation of sidetone and DAC present for each volume step[n]	0...32767	-∞...+6dB	20 * log (2 * outCalibrate[n]/ 32768)
sideTone	Digital attenuation of sidetone is corrected internally by outBbcGain to obtain a constant sidetone independent of output volume	0...32767	-∞...0dB	20 * log (sideTone/ 32768)

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

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 and AT^SAIC.

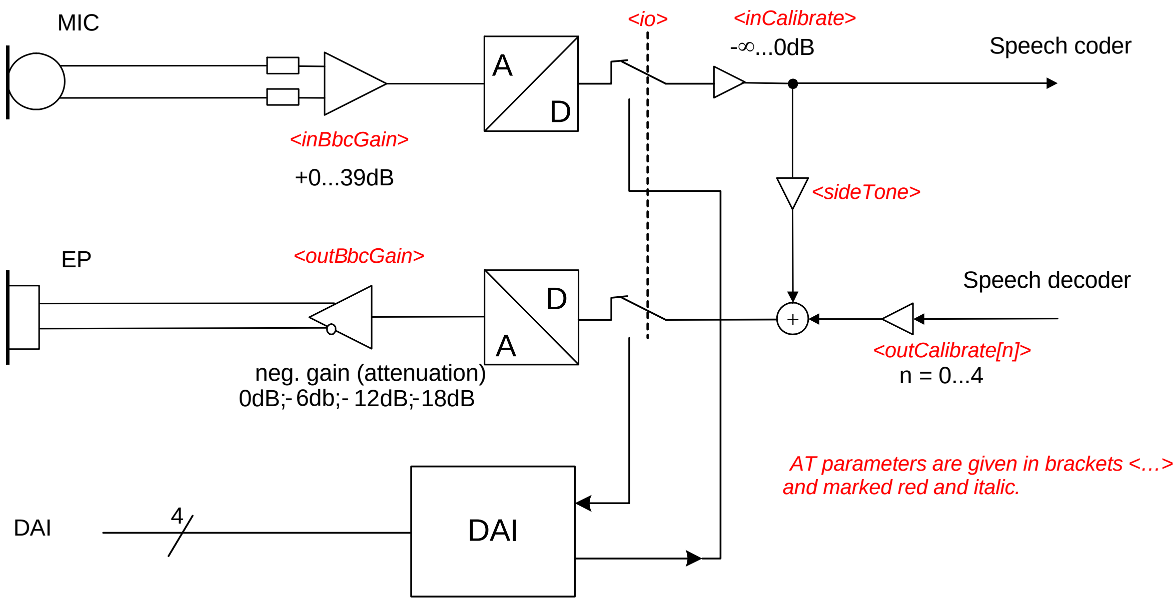


Figure 12: Audio programming model

Characteristics of Audio Modes

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

Table 6: Voiceband characteristics (typical)

Audio mode no. AT^SNFS=	**1** (Default settings, not adjustable)	**2**	**3**	**4**	**5**	**6**
Name	Default Handset	Basic Handsfree	Headset	User Handset	Plain Codec	DTMF
Purpose	DSB with Votronic handset	Car Kit	Headset	DSB with individual handset	Direct access to speech coder	Tip and Ring interface for DTMF end-to-end trans-mission
Gain setting via AT command. Defaults: inBbcGain outBbcGain	Fix 4 (24dB) 0 (0dB)	Adjustable 1 (6dB) 2 (-12dB)	Adjustable 6 (36dB) 2 (-12dB)	Adjustable 4 (24dB) 0 (0dB)	Adjustable 0 (0dB) 0 (0dB)	Adjustable 0 (0dB) 1 (-6dB)
Power supply	ON (2.2V)	ON (2.2V)	ON (2.2V)	ON (2.2V)	ON (2.2V)	ON (2.2V)
Sidetone	ON	--	Adjustable	Adjustable	Adjustable	Adjustable
Volume control	OFF	Adjustable	Adjustable	Adjustable	Adjustable	Adjustable
Echo control (send)	Cancella-tion	Cancella-tion	Cancella-tion	Cancella-tion	--	Line echo cancellation
Noise suppression[1]	12dB	12dB	12dB	12dB	--	--
MIC input signal for 0dBm0 @ 1024 Hz (default gain)	16mV	130mV	7.5mV[2]	16mV	275mV	275mV
EP output signal in mV rms. @ 0dBm0, 1024 Hz, no load (default gain); @ 3.14 dBm0	500mV	160mV	230mV	500mV	1160mV 4.5Vpp	520mV
Sidetone gain at default settings	20dB	-∞	17dB	20dB	-∞	-∞

1. In audio modes with noise reduction, the microphone input signal for 0dBm0 shall be measured with a sine burst signal for a tone duration of 5 seconds and a pause of 2 sec. The sine signal appears as noise and, after approx. 12 sec, is attenuated by the noise reduction by up to 12dB.
2. Signal for -2dBm0 (due to attenuation of uplink filter at 1kHz)

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.

Voiceband Receive Path

Test conditions:

- The values specified below were tested to 1kHz and 0dB gain stage, unless otherwise stated.
- Parameter setup: gs = 0dB means audio mode = 5 for EPP to EPN, inBbcGain= 0, inCalibrate = 32767, outBbcGain = 0, OutCalibrate = 16384, sideTone = 0.

Table 7: Voiceband receive path

Parameter	Min	Typ	Max	Unit	Test condition/remark
Differential output voltage (peak to peak)		3.4 4.5		Vpp	16Ω, no load, from EPPx to EPNx *gs* = 0dB @ 3.14dBm0
Differential output gain settings (*gs*) at 6dB stages (outBbcGain)	-18		0	dB	Set with AT^SNFO
Fine scaling by DSP (outCalibrate)	-∞		+6	dB	Set with AT^SNFO
Output differential DC offset	-50		+50	mV	*gs* = 0dB, outBbcGain = 0 and -6dB
Differential output load resistance	14			Ω	from EPP to EPN
Allowed single ended load capacitance			150	pF	from EPP or EPN to AGND
Absolute gain drift	-5		+5	%	Variation due to change in temperature and life time
Passband ripple			0.5	dB	for f < 3600 Hz
Stopband attenuation	50			dB	for f > 4600 Hz

gs = gain setting

Voiceband Transmit Path

Test conditions:

- The values specified below were tested to 1kHz and 0dB gain stage, unless otherwise stated.
- Parameter setup: Audio mode = 5 for MICP to MICN, inBbcGain= 0, inCalibrate = 32767, outBbcGain = 0, OutCalibrate = 16384, sideTone = 0

Table 8: Voiceband transmit path

Parameter	Min	Typ	Max	Unit	Test condition/Remark
Input voltage (peak to peak) MICP to MICN			0.8	V	
Input amplifier gain in 6dB steps (inBbcGain)[1]	0		39	dB	Set with AT^SNFI
Fine scaling by DSP (inCalibrate)	-∞		0	dB	Set with AT^SNFI
Input impedance MIC		50		kΩ	
Microphone supply voltage		2.2		V	
Microphone supply current			4	mA	

1. 3dB step between inBbcGain 6 and 7.

2.1.6 Digital Audio Interface

BGS8 supports a digital audio interface (DAI) that can be employed either as pulse code modulation (see Section 2.1.6.1) or as inter IC sound interface (see Section 2.1.6.2). Operation of these interface variants is mutually exclusive.

2.1.6.1 Pulse Code Modulation Interface

BGS8's DAI interface can be used to connect audio devices capable of pulse code modulation (PCM). The PCM functionality allows for the use of an external codec like the W681360. Using the AT^SAIC command you can activate the PCM interface (see [1]).

The PCM interface supports a 256kHz, long frame synchronization master mode with the following features:

- 16 Bit linear
- 8kHz sample rate
- The most significant bit MSB is transferred first
- 125µs frame duration
- Common frame sync signal for transmit and receive

Table 9 describes the available PCM lines at the digital audio interface. For electrical details see Section 2.1.2.

Table 9: Overview of DAI/PCM lines

Signal name at SMT interface	Pad direction	Input/Output
TXDDAI	O	PCM data from BGS8 to external codec.
RXDDAI	I	PCM data from external codec to BGS8.
TFSDAI	O	Frame synchronization signal to external codec: Long frame @ 256kHz
SCLK	O	Bit clock to external codec: 256kHz

Figure 13 shows the PCM timing for the master mode available with BGS8.

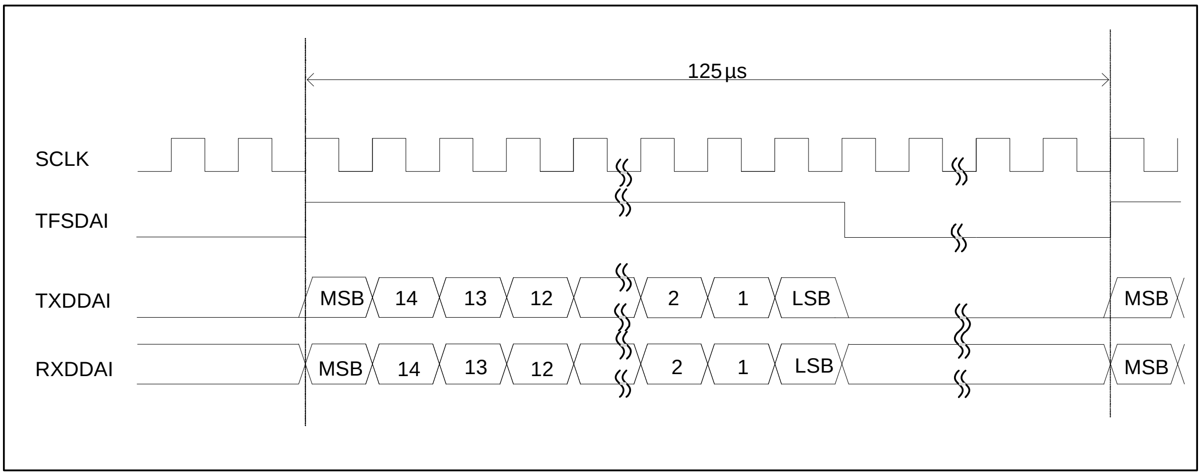


Figure 13: Long frame PCM timing, 256kHz

The following figure shows the start up behaviour of the DAI interface. It is possible to set the startup configuration of the DAI interface via AT command (see [1]). The start up configuration of functions will be activated after the software initialization of the command interface. With an active state of CTS0 (low level) the initialization of the DAI interface is finished.

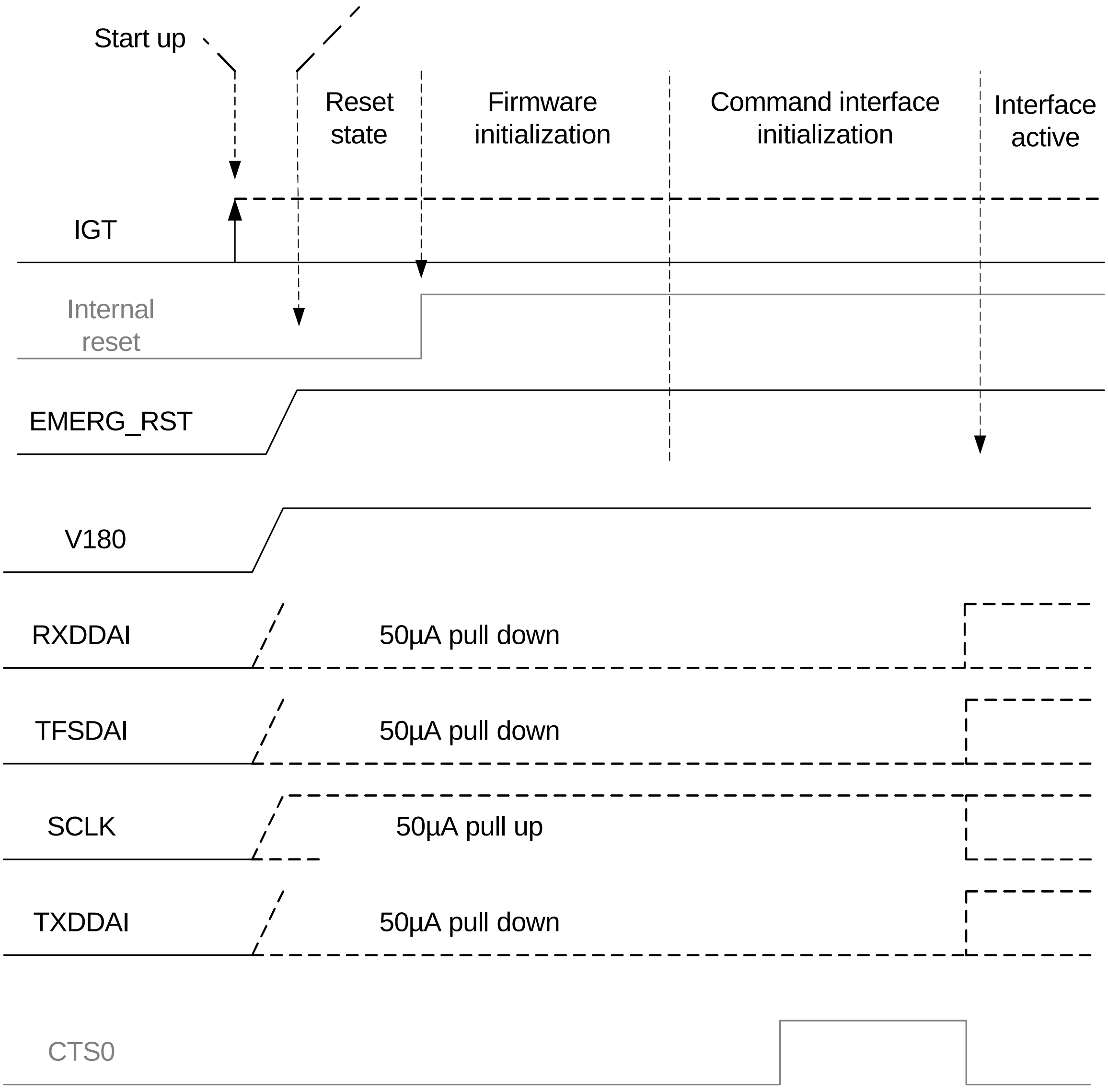


Figure 14: DAI startup timing

2.1.6.2 Inter IC Sound Interface

The Inter IC Sound interface (I2S) is enabled using the AT command AT^SAIC (see [1]). An activation is possible only out of call and out of tone presentation. The I2S properties and capabilities comply with the requirements layed out in the Phillips I2S Bus Specifications, revised June 5, 1996.

The I2S interface has the following characteristics:

- Clock Modes: Master with permanent clock option
- Sampling Rate: 8 KHz (narrowband)
- Frame Length: 16 bit mono voice signal. The mono voice signal is transferred in the left channel, the right channel is muted

The digital audio interface pads available for the PCM interface are also available for the I2S interface. In I2S mode they have the same electrical characteristics (for more information on the TXDDAI, RXDDAI, TFSDAI and SCLK pads please refer to Section 2.1.2 and Section 2.1.6.1).

The table below lists the available pads at the module`s digital audio interface.

Table 10: Overview of DAI/I2S lines

Signal name	Input/Output	Description
TXDDAI	O	I2S data from module to external codec.
RXDDAI	I	I2S data from external codec to module.
TFSDAI	O	Frame synchronization signal to external codec: Word alignment (WS)
SCLK	O	Bit clock to external codec: 256kHz

The following figure shows the I2S timing for the master mode available with the module.

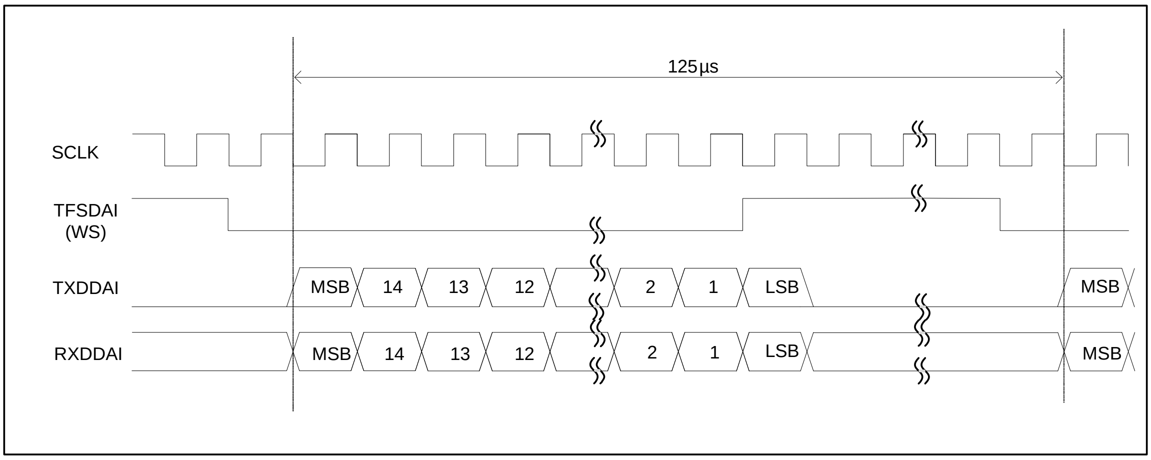


Figure 15: Long frame I2S timing, 256kHz

2.1.7 RTC Backup

The internal Real Time Clocks of BGS8 are supplied from a separate voltage regulator in the power supply component which is also active when BGS8 is in Power Down mode and BATT+ is available. An alarm function is provided that allows to wake up BGS8 without logging on to the GSM network.

In addition, you can use the VDDLP pad to backup the RTCs from an external capacitor. The capacitor is charged from the internal LDO of BGS8. If the voltage supply at BATT+ is disconnected the RTCs can be powered by the capacitor. The size of the capacitor determines the duration of buffering when no voltage is applied to BGS8, i.e. the greater the capacitor the longer BGS8 will save the date and time. The RTCs can also be supplied from an external battery (rechargeable or non-chargeable). In this case the electrical specification of the VDDLP pad (see Section 2.1.2) has to be taken in to account.

Figure 16 shows an RTC backup configuration.

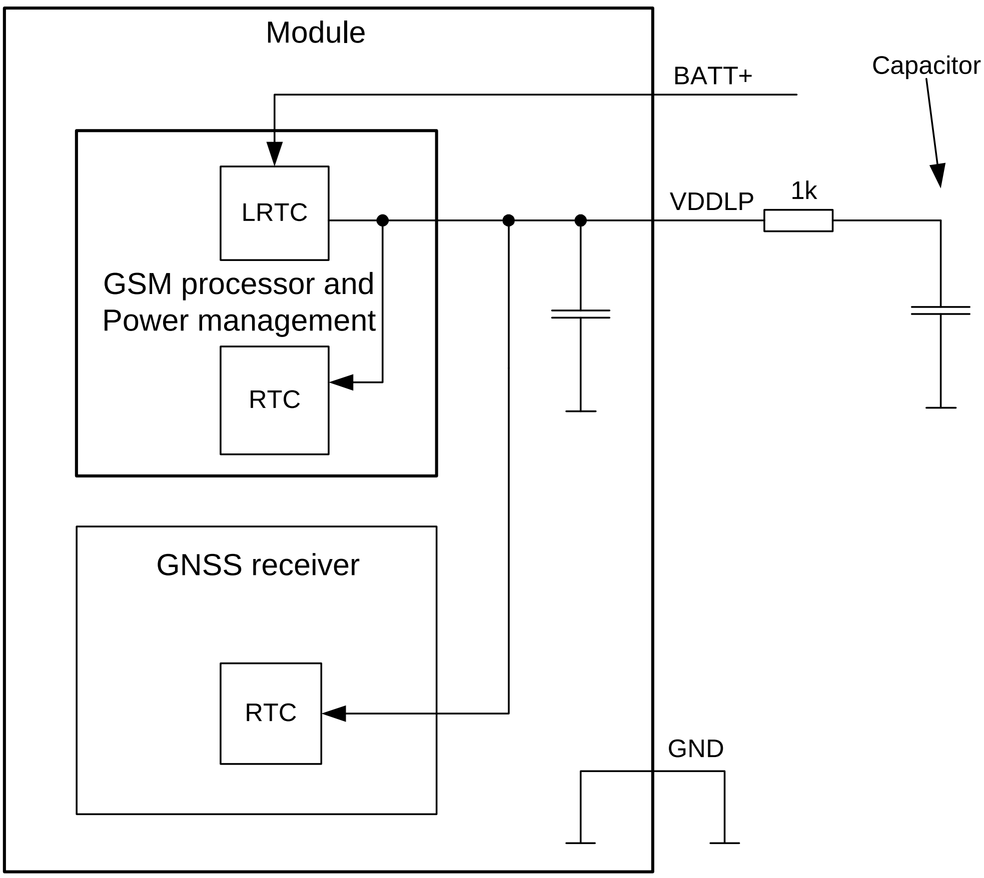


Figure 16: RTC supply variant

2.1.8 I²C Interface

I²C is a serial, 8-bit oriented data transfer bus for bit rates up to 400kbps in Fast mode. It consists of two lines, the serial data line I2CDAT and the serial clock line I2CCLK. The module acts as a single master device, e.g. the clock I2CCLK is driven by the module. I2CDAT is a bi-directional 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.

To configure and activate the I2C bus use the AT^SSPI command. Detailed information on the AT^SSPI command as well explanations on the protocol and syntax required for data transmission can be found in [1].

The I²C interface can be powered via the V180 line of BGS8. If connected to the V180 line, the I²C interface will properly shut down when the module enters the Power Down mode.

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 2.

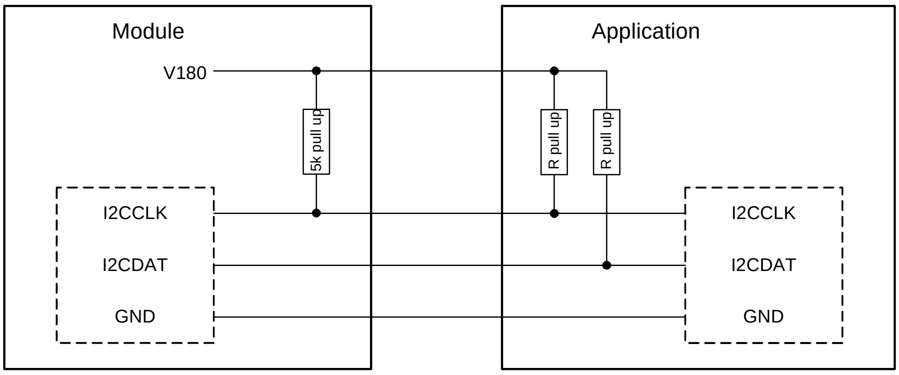


Figure 17: I²C interface connected to V180

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 following figure shows the startup behavior of the I^{2}C interface. With an active state of the ASC0 interface (i.e. CTS0 is at low level) the initialization of the I^{2}C interface is also finished.

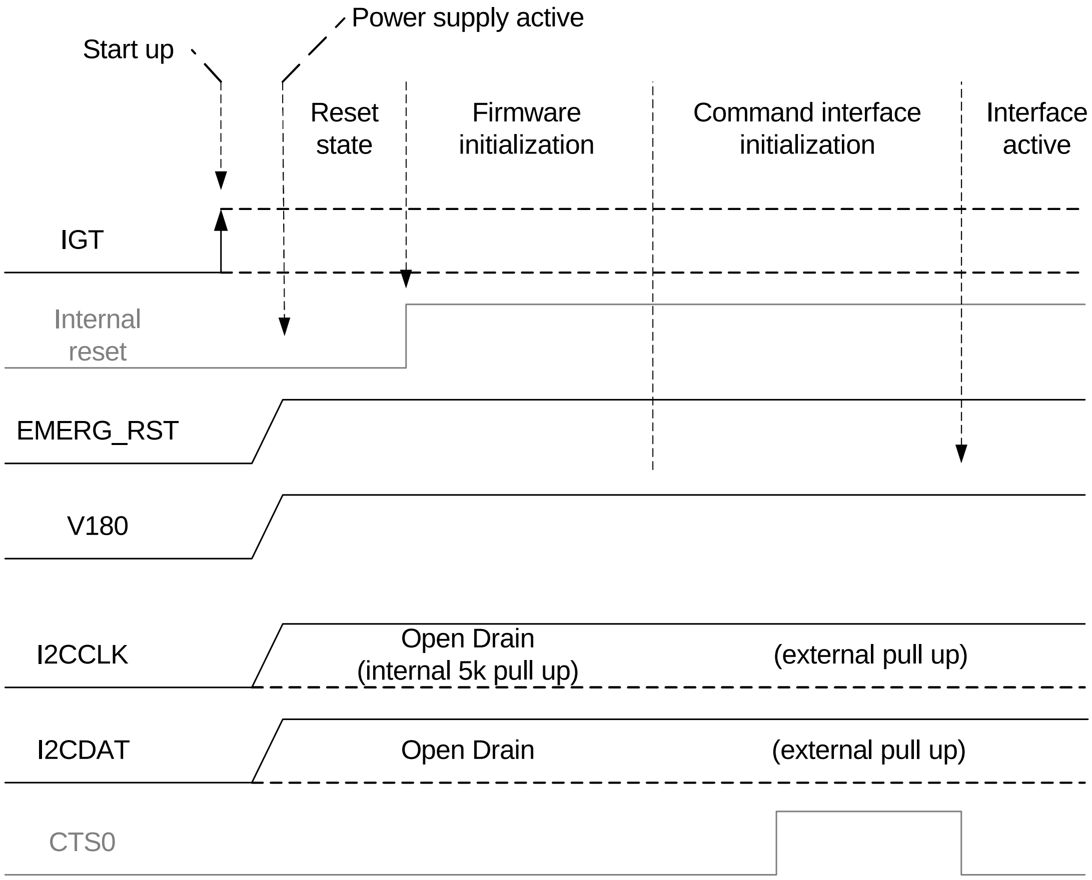


Figure 18: I^{2}C startup behavior

2.1.8.1 I²C Interface on DSB75

To evaluate the I²C interface employing the DSB75, some modifications are required on the AH6-DSB75 adapter mentioned in Section 7.1. 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 19.

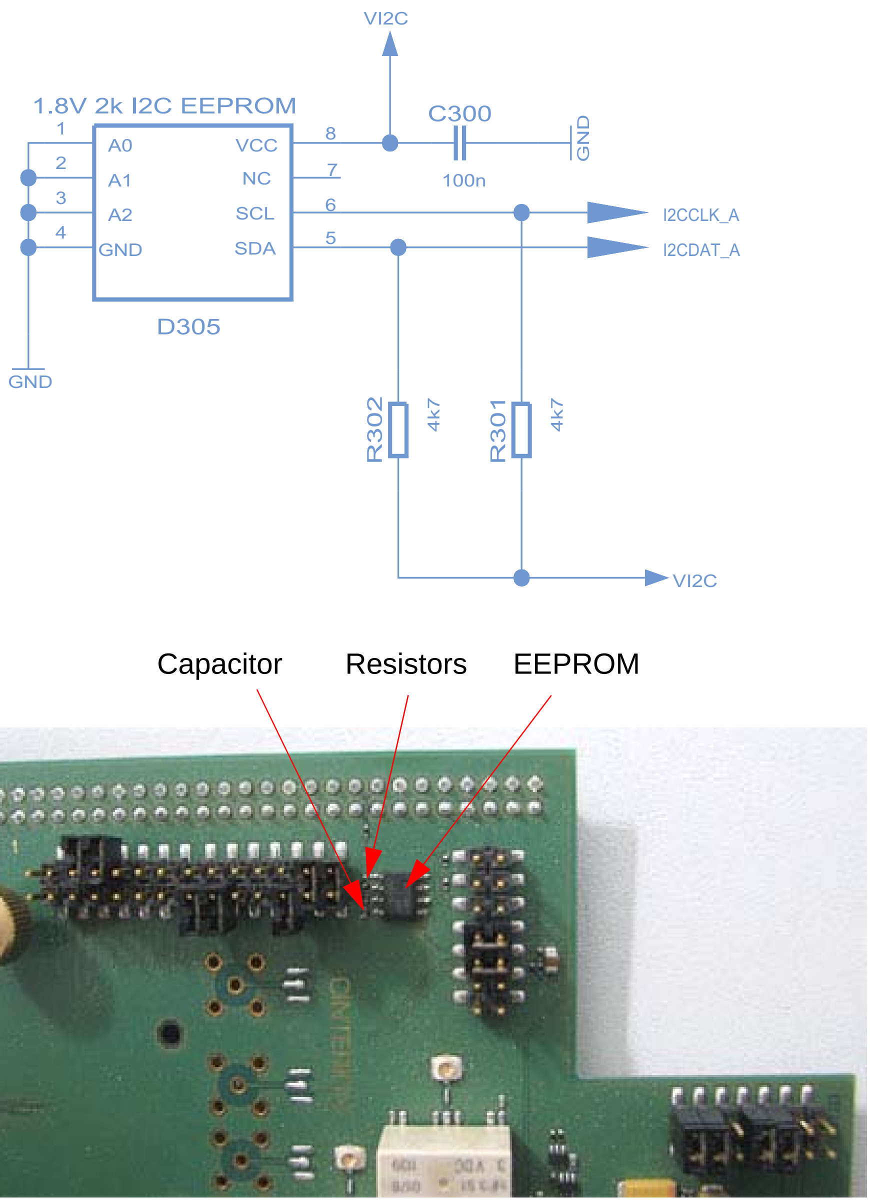


Figure 19: Additional EEPROM to enable usage of I²C interface on DSB75

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 20.

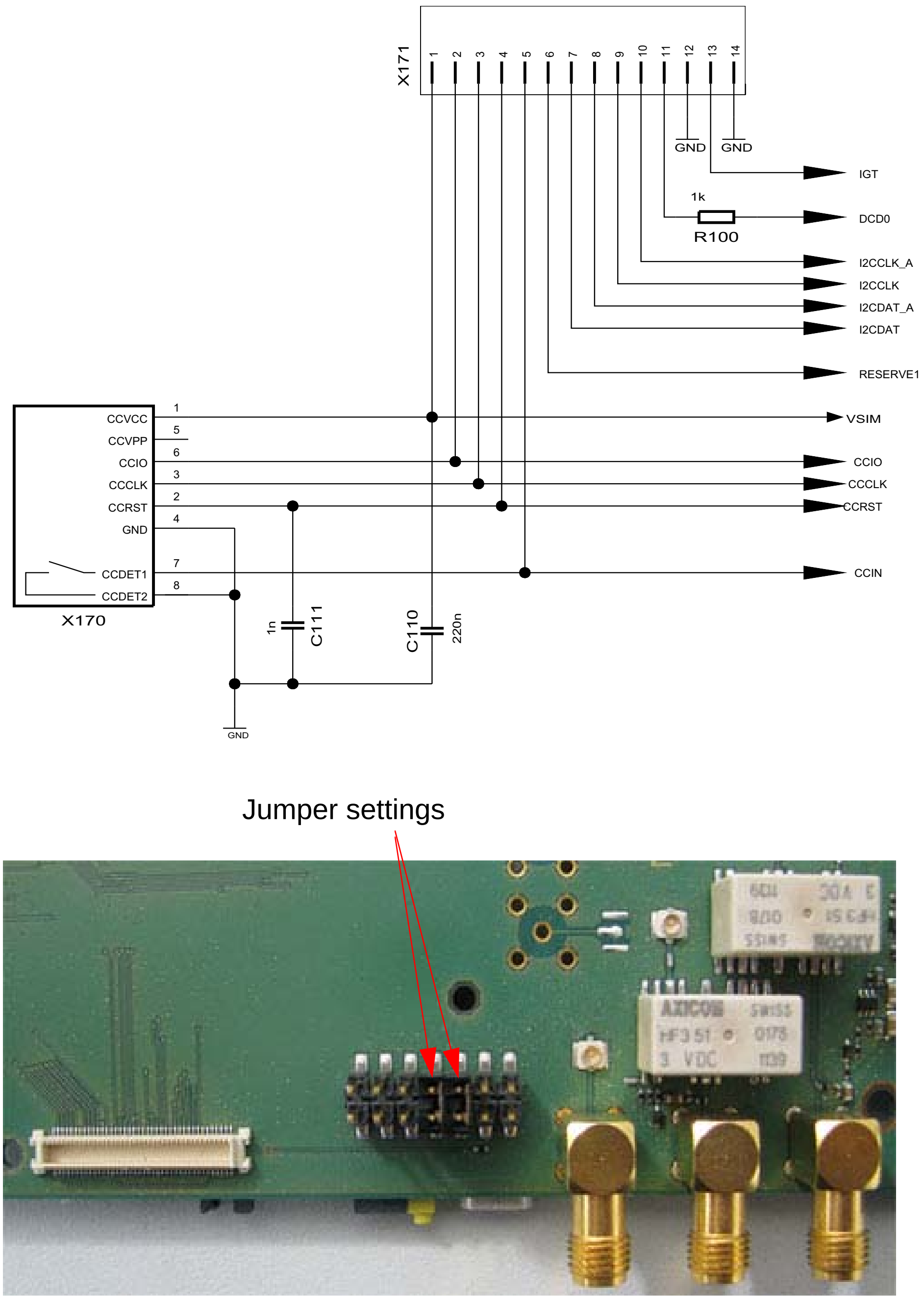


Figure 20: Jumper settings to enable usage of I^{2}C interface on DSB75

2.1.9 Analog-to-Digital Converter

ADC1_IN is used for general purpose voltage measurements. For electrical characteristics see Section 2.1.2. ADC1_IN can be configured and read by the AT^SRADC command - see [1].

2.1.10 GPIO Interface

BGS8 offers a GPIO interface with 6 GPIO lines. The GPIO lines are shared with other interfaces, such as the fast shutdown functionality (see Section 2.1.11), the PWM functionality (see Section 2.1.14), jamming indicator (see Section 2.1.13) or status LED (see Section 2.1.12). 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. GPIO11 is not shared with another interface and GPIO8 is reserved for future use.

Table 11: GPIO assignment

GPIO	FST_SHTDN	PWM	Jamming indicator	Status LED
GPIO4	Yes			
GPIO5				Yes
GPIO6		Yes	Yes	
GPIO7		Yes		
GPIO8	Reserved for future use.			
GPIO11	Not shared with another interface.			

Each GPIO line can be configured for use as input or output. The GPIO related AT commands are desribed in detail in [1].

When the BGS8 starts up, all GPIO lines are set to high-impedance state after initializing, as described in Section 3.2.3. Therefore, it is recommended to connect external pull-up or pull-down resistors to all GPIO lines you want to use as output. This is necessary to keep these lines from floating or driving any external devices before all settings are done by AT command, and after closing the GPIOs again.

The following figure shows the startup behavior of the GPIO interface. With an active state of the ASC0 interface (i.e. CTS0 is at low level) the initialization of the GPIO interface lines is also finished.

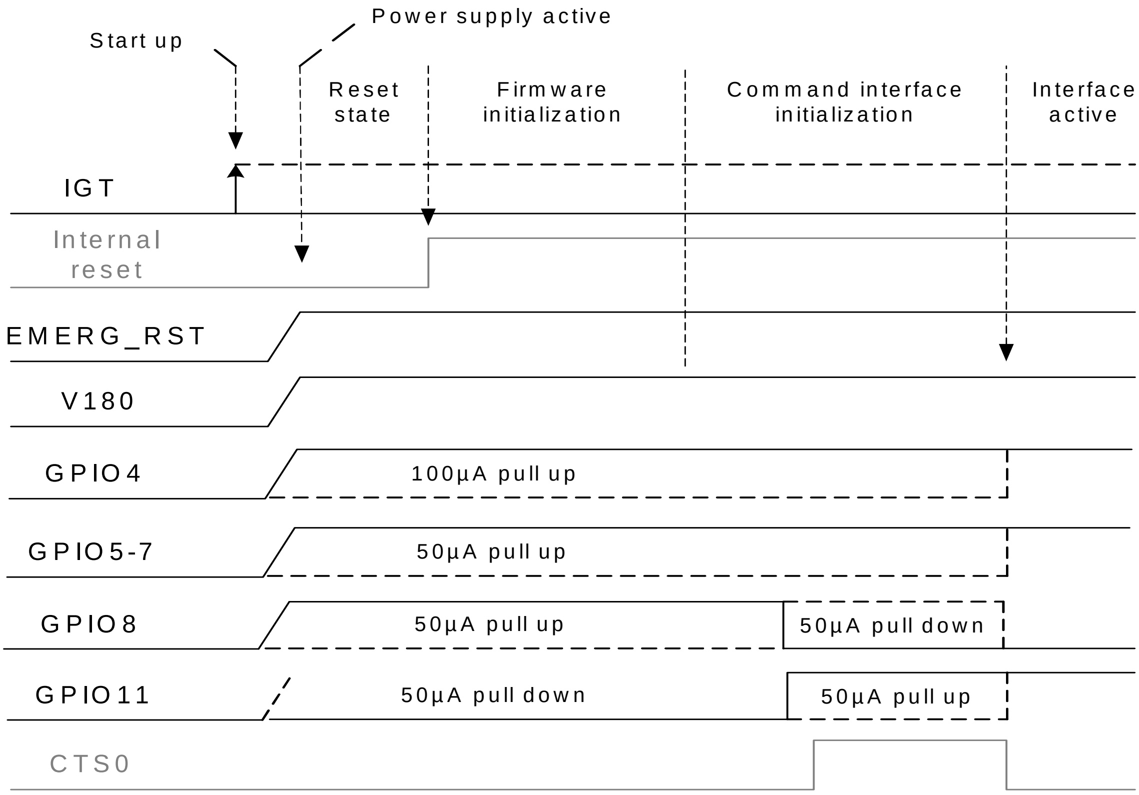


Figure 21: GPIO startup behavior

2.1.11 Fast Shutdown

The GPIO4 interface line can be configured as fast shutdown signal line FST_SHDN. The configured FST_SHDN line is an active low control signal and must be applied for at least 10 milliseconds. If unused this line 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 GPIO4/FST_SHDN line starts the fast shutdown (see Figure 22). 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.

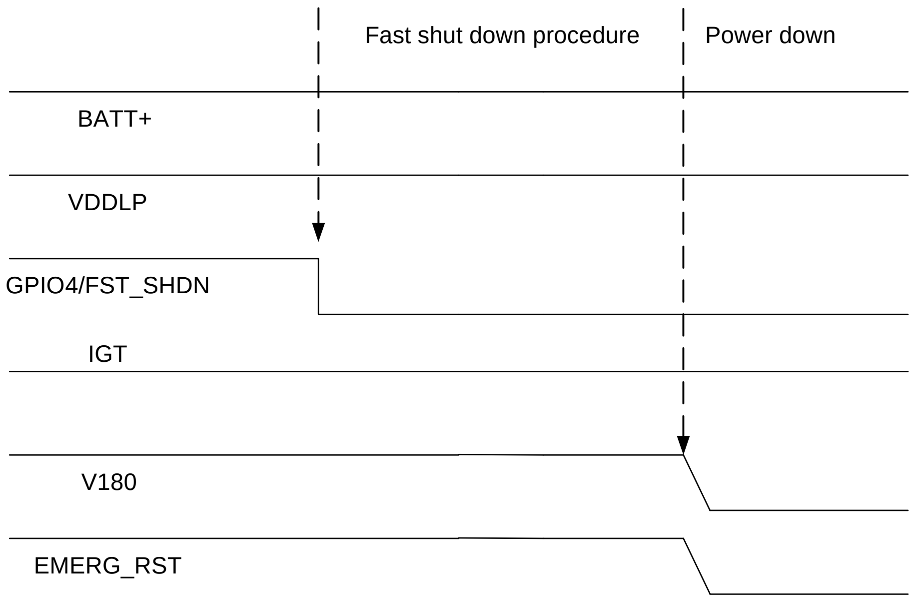


Figure 22: Fast shutdown timing

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.

2.1.12 Status LED

The GPIO5 interface line can be configured to drive a status LED that indicates different operating modes of the module (for GPIOs see Section 2.1.10). GPIO and LED functionality are mutually exclusive.

To take advantage of the function connect an LED to the GPIO5/LED line as shown in Figure 23.

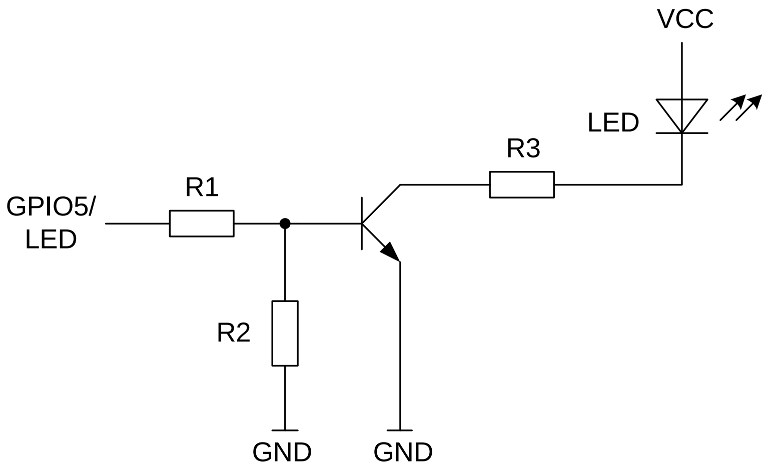


Figure 23: Status signalling with LED driver

2.1.13 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].

2.1.14 PWM Interface

The GPIO6 and GPIO7 interface lines can be configured as Pulse Width Modulation interface lines PWM1 and PWM2. The PWM interface line can be used, for example, to connect a buzzer. The PWM1 line is shared with GPIO7 and the PWM2 line is shared with GPIO6 (for GPIOs see Section 2.1.10). GPIO and PWM functionality are mutually exclusive.

The startup behavior of the line is shown in Figure 21.

2.1.15 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 2.1.2.1). 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 24 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.

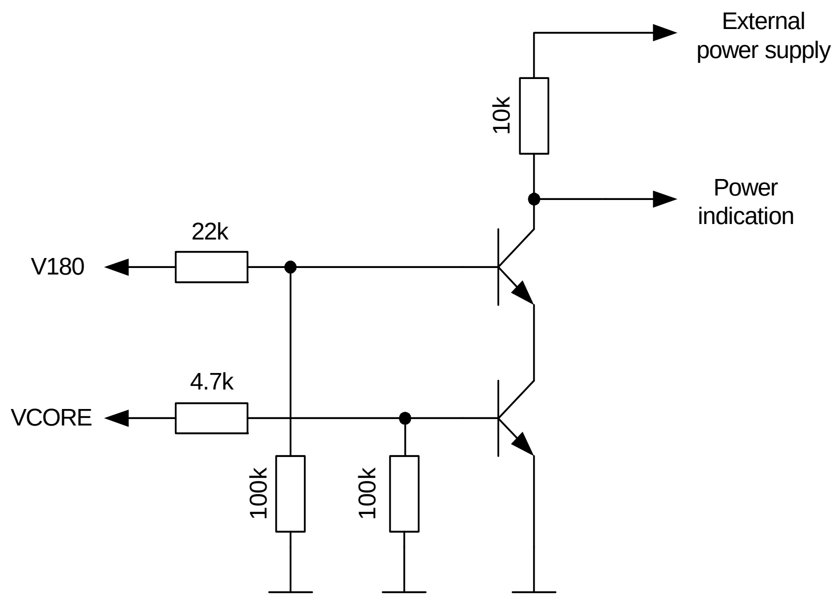


Figure 24: Power indication circuit

2.1.16 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. Note that the behavior described below is the default behavior, and may be adapted by AT command (for details see [1]):

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

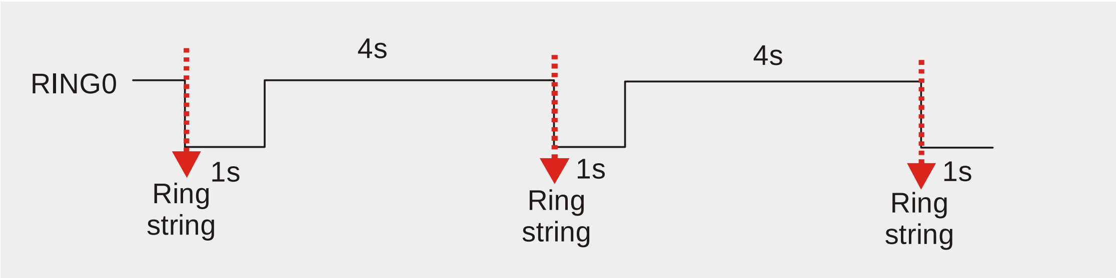


Figure 25: Incoming voice call

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

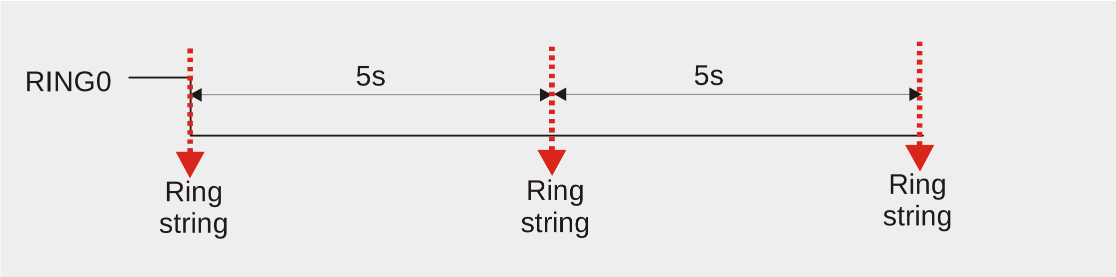


Figure 26: Incoming data or fax call

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

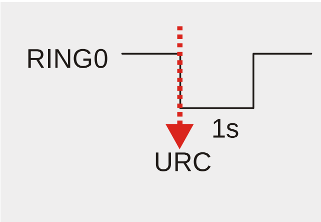


Figure 27: URC transmission

2.2 RF Antenna Interface

The RF interface has an impedance of 50Ω. BGS8 is capable of sustaining a total mismatch at the antenna line 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 BGS8 module and should be placed in the host application if the antenna does not have an impedance of 50Ω.

Regarding the return loss BGS8 provides the following values in the active band:

Table 12: 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
Idle	≤ 5dB	Not applicable

2.2.1 Antenna Interface Specifications

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

Table 13: Antenna interface specifications

Parameter		Min	Typ	Max	Unit
Frequency range Uplink (MS → BTS)	GSM 850	824		849	MHz
	E-GSM 900	880		915	MHz
	GSM 1800	1710		1785	MHz
	GSM 1900	1850		1910	MHz
Frequency range Downlink (BTS → MS)	GSM 850	869		894	MHz
	E-GSM 900	925		960	MHz
	GSM 1800	1805		1880	MHz
	GSM 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
	GSM 1800	-102			dBm
	GSM 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
	GSM 1800		-107		dBm
	GSM 1900		-107		dBm
RF power @ ARP with 50Ω load	GSM 850	31	33	35	dBm
	E-GSM 900	31	33	35	dBm
	GSM 1800	28	30	32	dBm
	GSM 1900	28	30	32	dBm

2.2.2 Antenna Installation

The antenna is connected by soldering the antenna pad (ANT_GSM, 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 BGS8. All RF data specified throughout this document is related to the ARP.

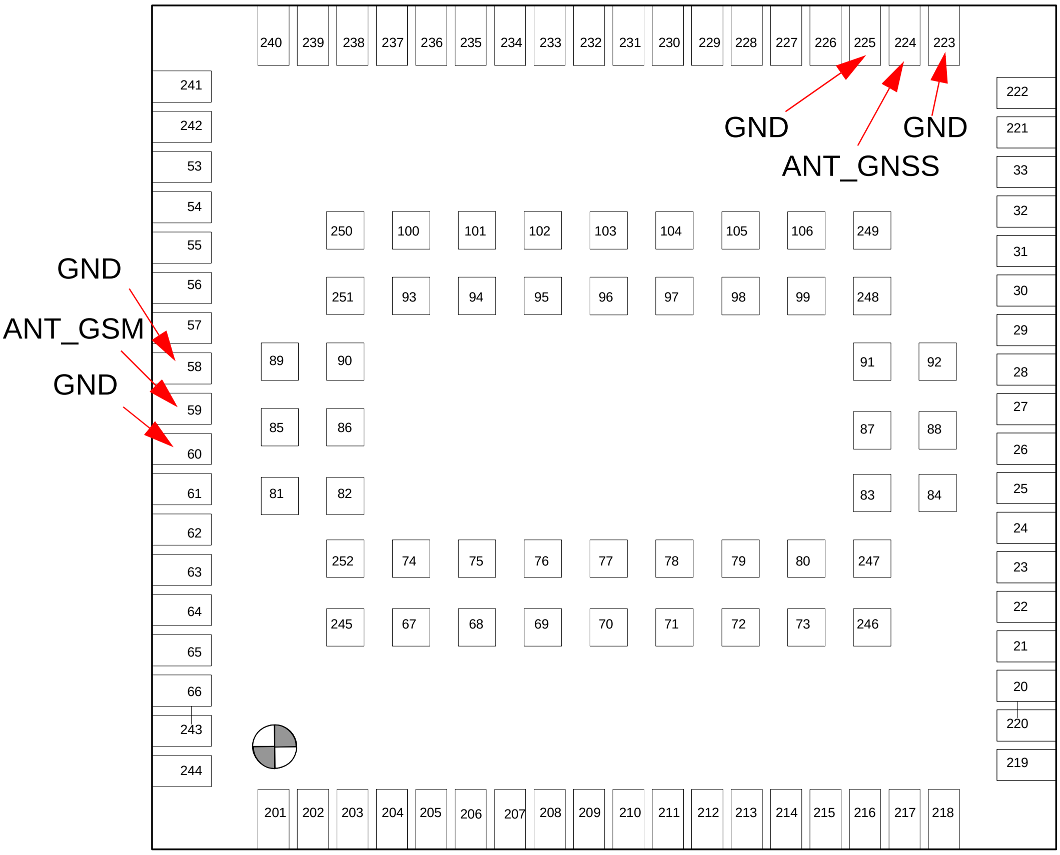


Figure 28: Antenna pads (bottom view)

The distance between the antenna ANT_GSM 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 2.2.3.

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 2.2.3.1 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 BGS8's antenna pad.

2.2.3 RF Line Routing Design

2.2.3.1 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).

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

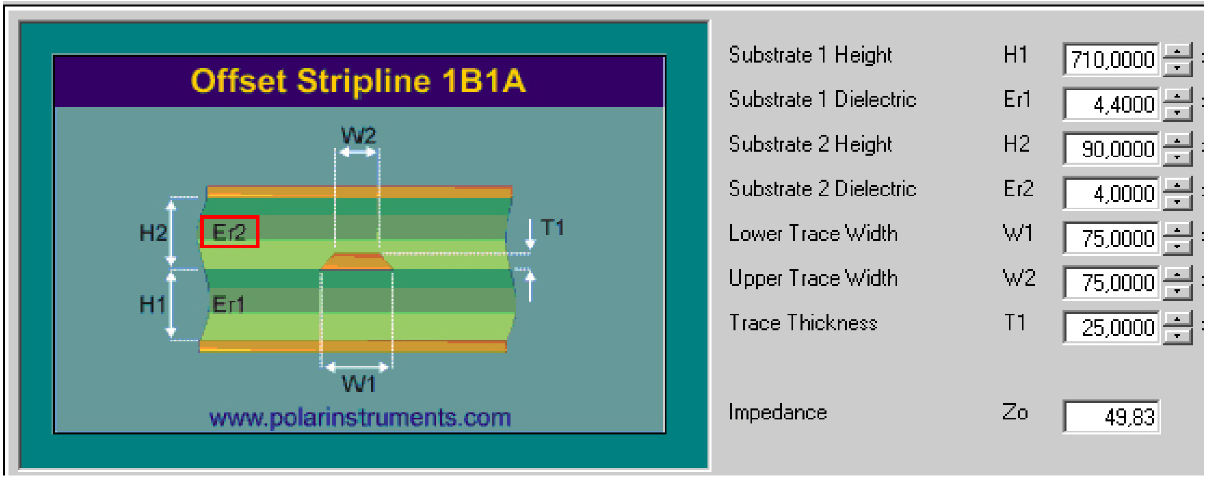


Figure 29: Embedded Stripline with 65µm prepreg (1080) and 710µm core

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).

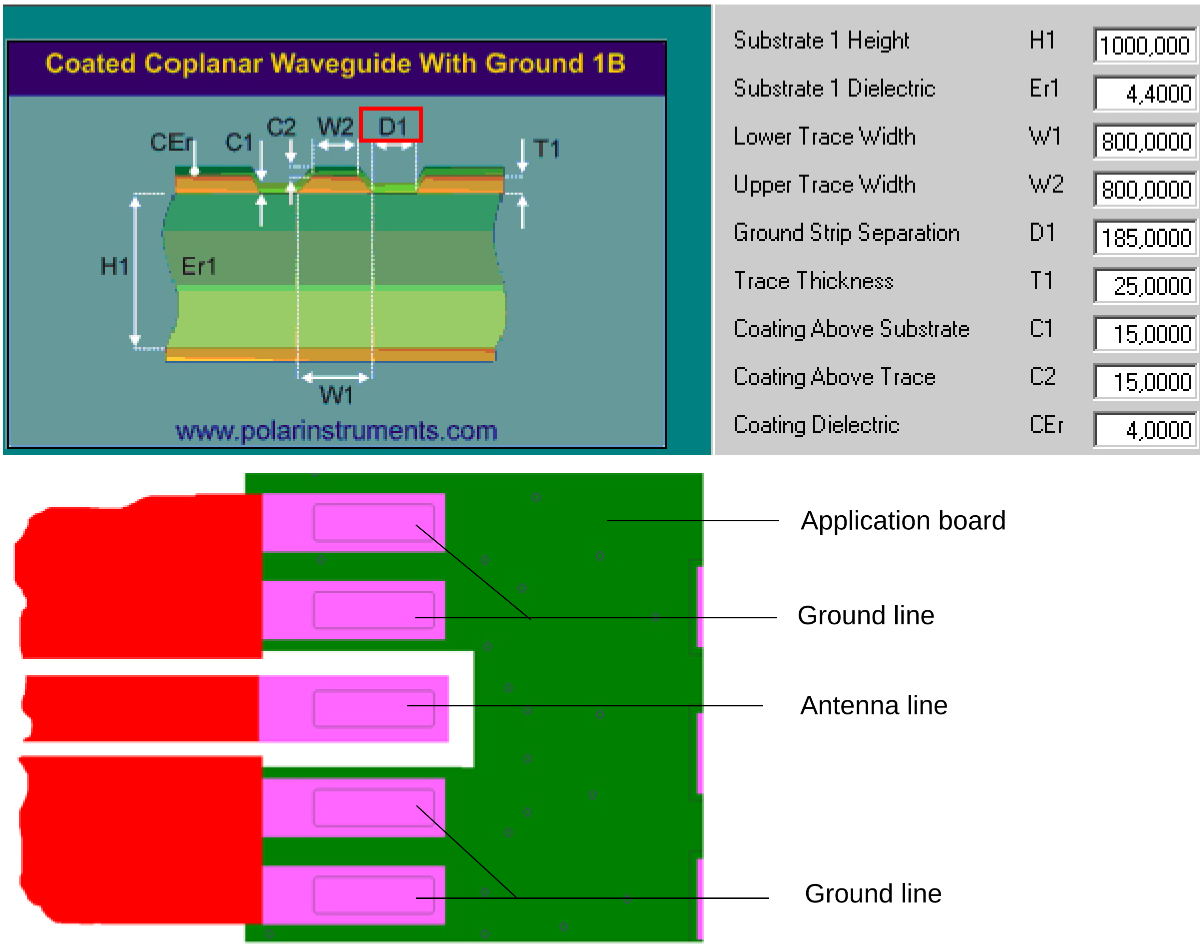


Figure 30: Micro-Stripline on 1.0mm standard FR4 2-layer PCB - example 1

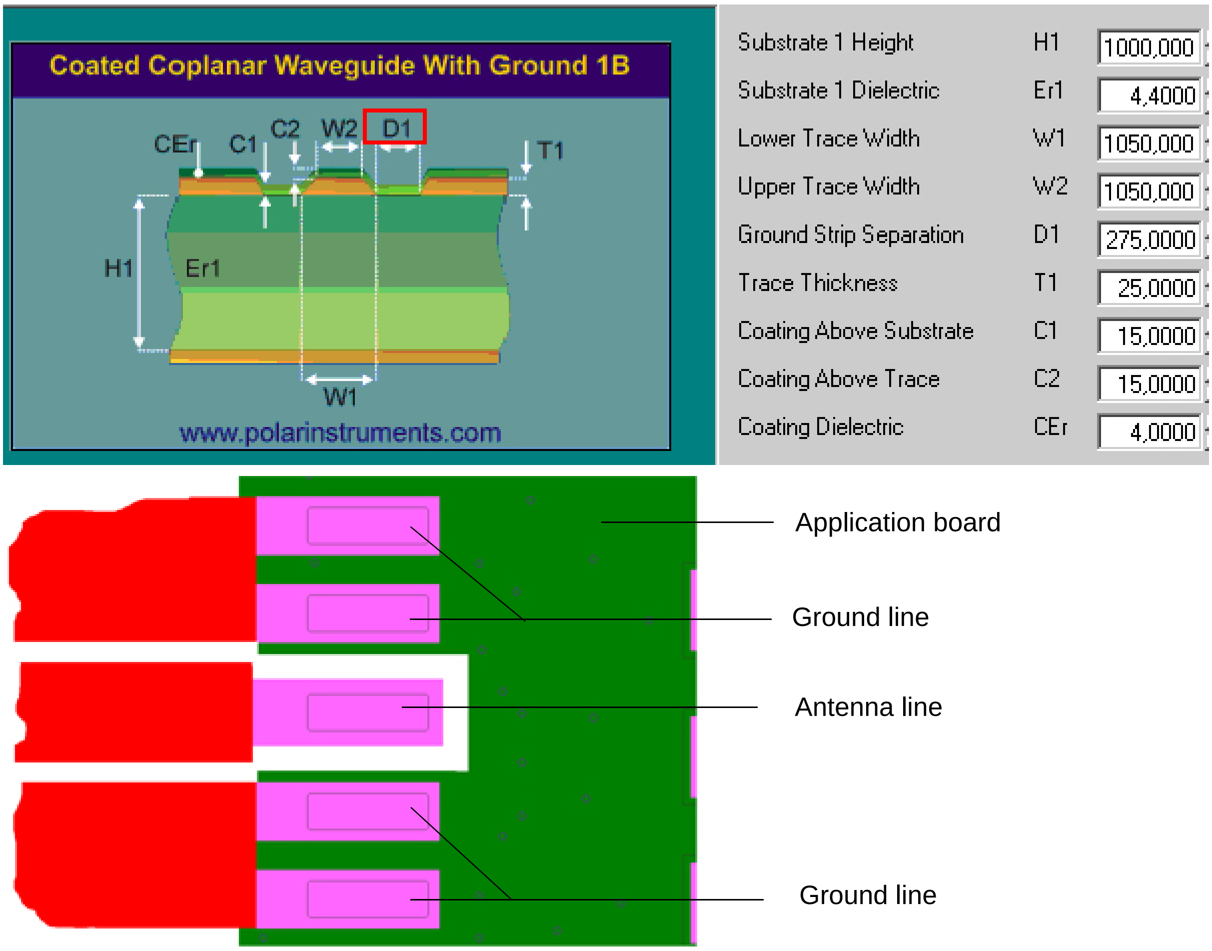


Figure 31: Micro-Stripline on 1.0mm Standard FR4 PCB - example 2

- Micro-Stripline on 1.5mm Standard FR4 2-Layer PCB
  The following two figures show examples with different values for D1 (ground strip separation).

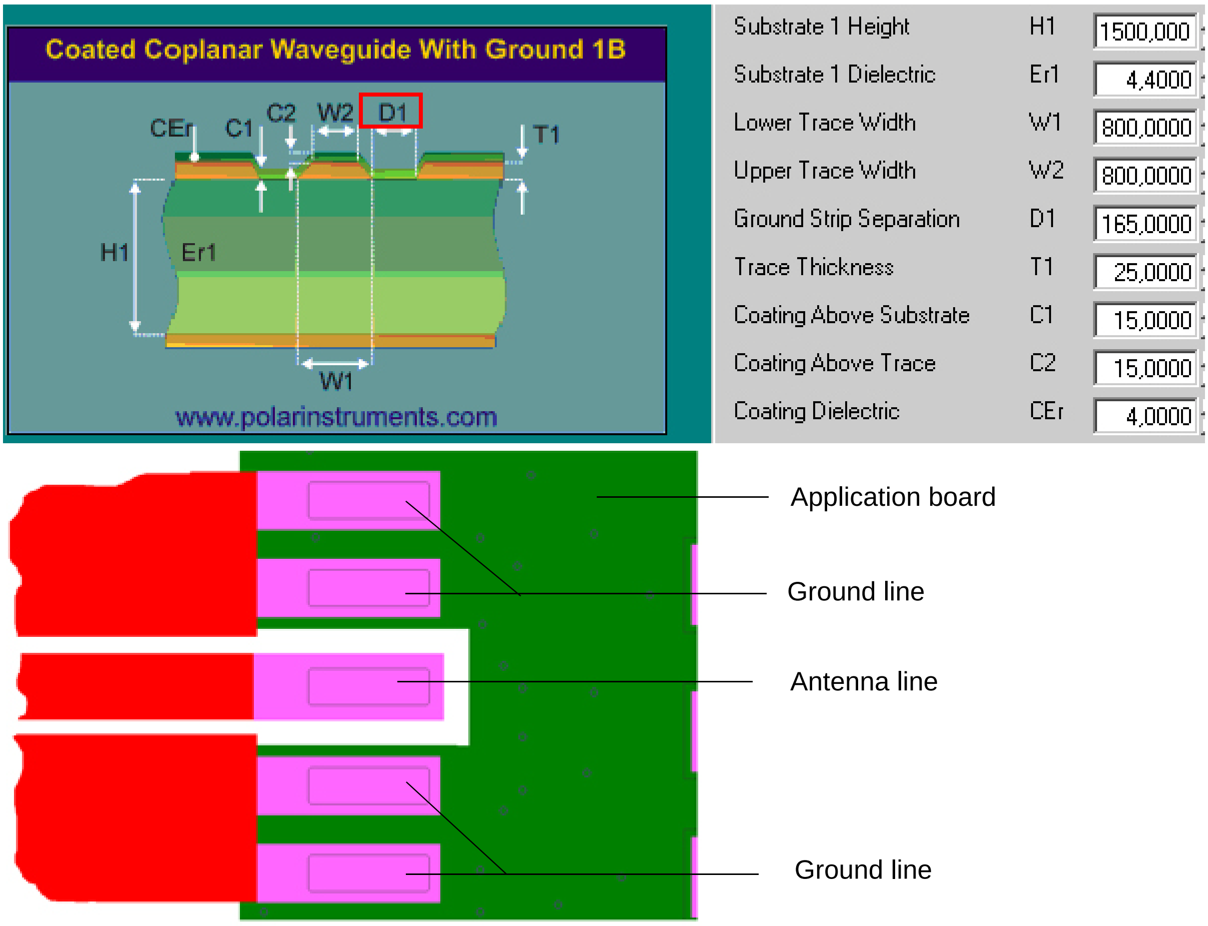


Figure 32: Micro-Stripline on 1.5mm Standard FR4 PCB - example 1

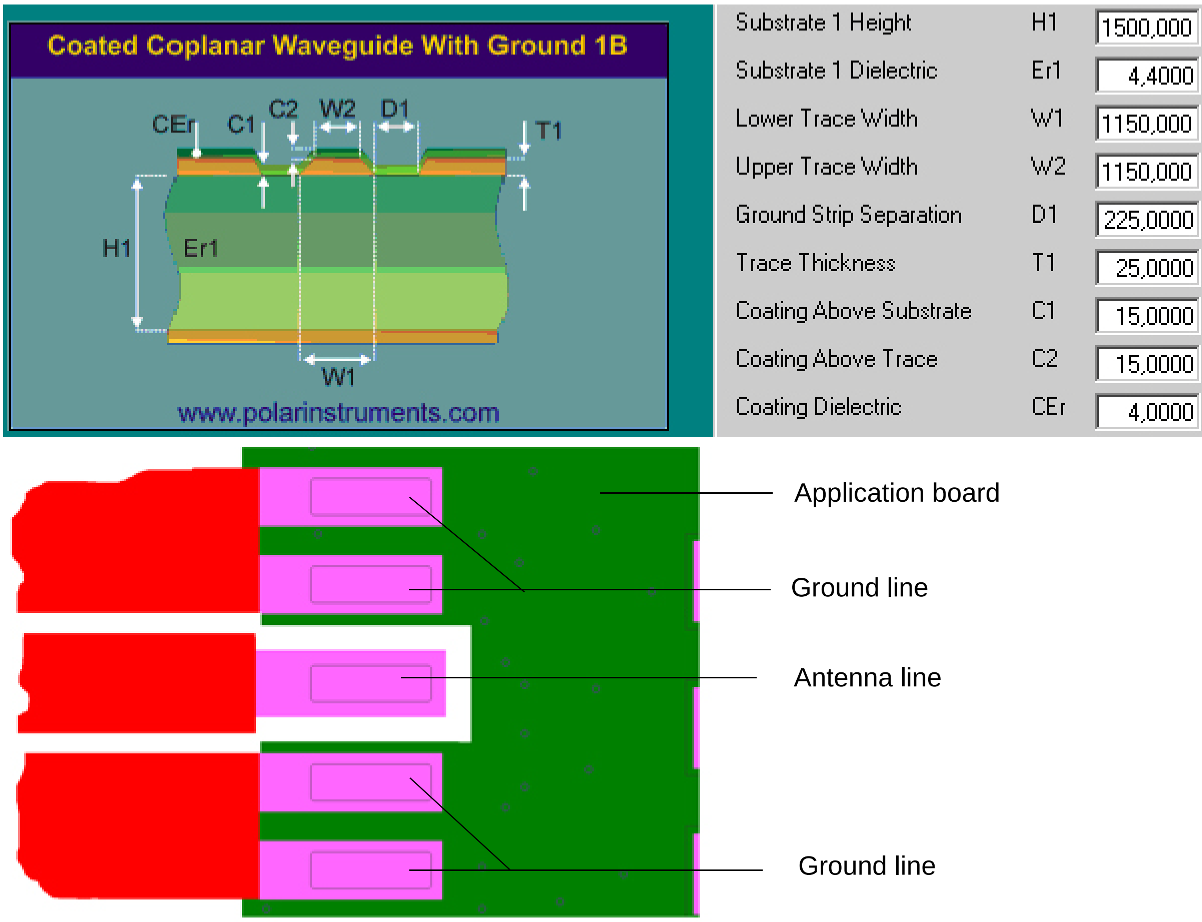


Figure 33: Micro-Stripline on 1.5mm Standard FR4 PCB - example 2

2.2.3.2 Routing Example

Interface to RF Connector

Figure 34 shows the connection of the module‘s antenna pad with an application PCB‘s coaxial antenna connector. Please note that the BGS8 bottom plane appears mirrored, since it is viewed from BGS8 top side. By definition the top of customer's board shall mate with the bottom of the BGS8 module.

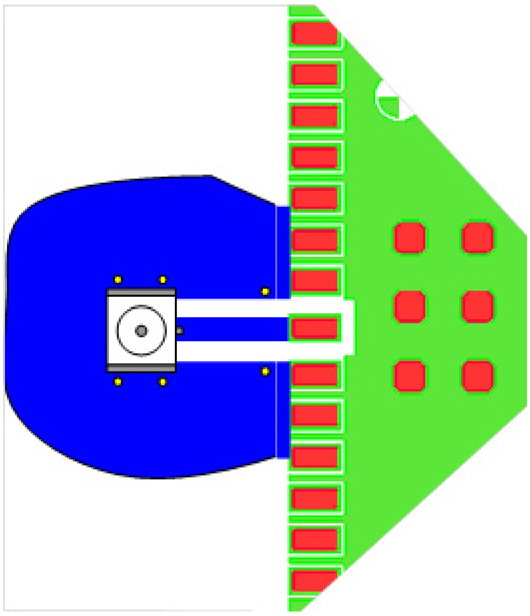


Figure 34: Routing to application‘s RF connector - top view

2.3 GNSS Interface

2.3.1 GNSS Receiver

BGS8 integrates a GPS receiver that offers the full performance of GPS technology. The GPS receiver is able to continuously track all satellites in view, thus providing accurate satellite position data.

The integrated GPS receiver supports the NMEA protocol via ASC0 interface. NMEA is a combined electrical and data specification for communication between various (marine) electronic devices including GPS receivers. It has been defined and controlled by the US based National Marine Electronics Association. For more information on the NMEA Standard please refer to http://www.nmea.org.

Depending on the receiver's knowledge of last position, current time and ephemeris data, the receiver's startup time (i.e., TTFF = Time-To-First-Fix) may vary: If the receiver has no knowledge of its last position or time, a startup takes considerably longer than if the receiver has still knowledge of its last position, time and almanac or has still access to valid ephimeris data and the precise time. For more information see Section 2.3.3.

By default, the GPS receiver is switched off. It has to be switched on and configured using AT commands (AT^SGPSC; see [1]).

GPS 1pps Clock:
BGS8 provides a high accuracy 1pps output (one pulse per second) signal, synchronized with the GPS time.

The 1pps output can be used by an external application as a reference to generate accurate high-frequency clocks. A specific design however has to address the short-term jitter affecting the 1pps signal. As a general rule, the divided system clock is synchronized with the GPS 1pps for the long-term accuracy. The deviation is less than 50ns.

The 1pps signal is based on the almost-perfect timing of the satellite. But as the satellite moves, the distance to it will increase or decrease. This change in distance will produce a change in the 1pps signal, because the light has to travel a different distance each time.

To compensate for this effect the GNSS (Global Navigation Satellite System) has to know its position. Then it is able to correct signal effects (mainly distance but there are more). Therefore, at least three satellites are required (better four).

2.3.2 GNSS Antenna

In addition to the RF antenna interface BGS8 also has a GNSS antenna interface. See Section 2.1.1 to find out where the GNSS antenna pad is located. The GNSS installation is the same as for the RF antenna interface, except for pad 224 instead of pad 59 (see Section 2.2.2).

It is possible to connect active or passive GNSS antennas. In either case they must have 50Ω impedance. The simultaneous operation of GSM and GNSS has been implemented. For electrical characteristics see Section 2.1.2.

BGS8 provides the supply voltage VGNSS for the GNSS active antenna (3.05V). It has to be enabled by software when the GNSS receiver shall becomes active, otherwise VGNSS should be off (power saving). VGNSS is not short circuit protected. This will have to be provided for by an external application. The DC voltage should be fed back via ANT_GNSS_DC for coupling into the GNSS antenna path. Figure 35 shows the flexibility in realizing the power supply for an active GNSS antenna by giving two sample circuits realizing the supply voltage for an active GNSS antenna - one with short circuit protection and one with an external LDO employed.

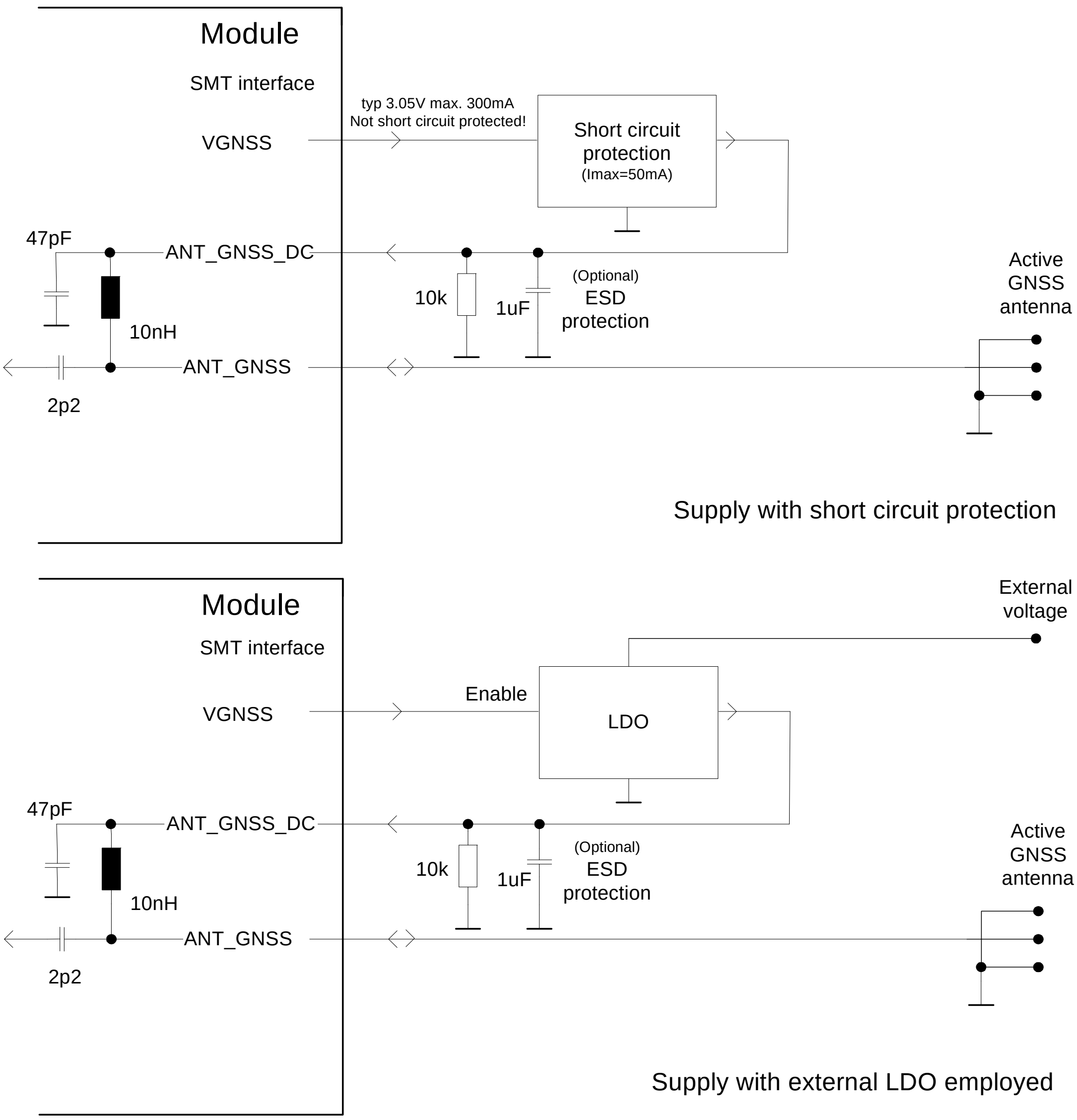


Figure 35: Supply voltage for active GNSS antenna

Figure 36 shows sample circuits realizing ESD protection for a passive GNSS antenna.

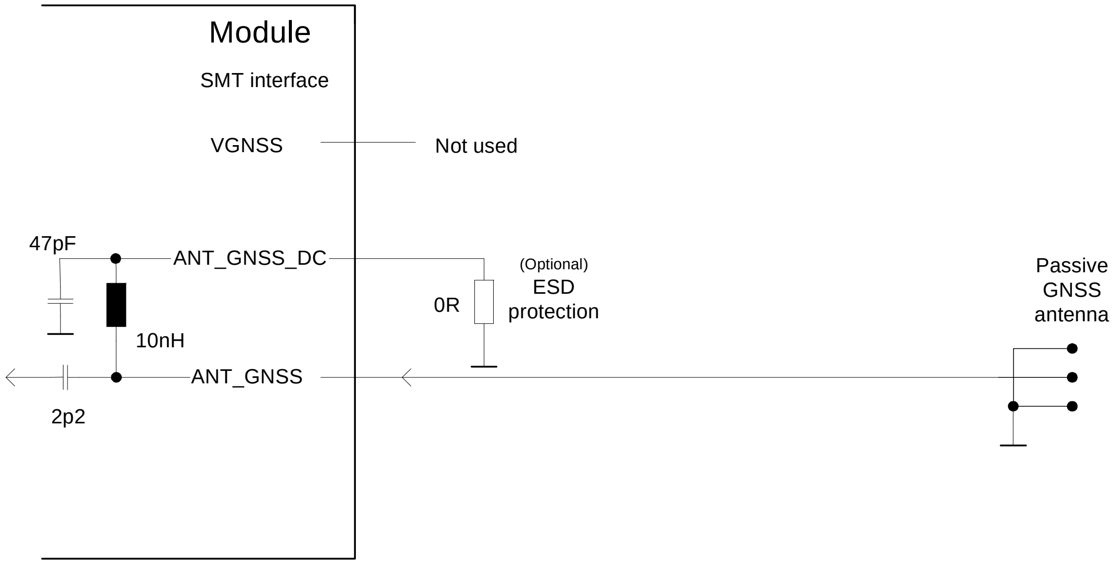


Figure 36: ESD protection for passive GNSS antenna

2.3.3 GNSS Interface Characteristics

Table 14: GNSS properties

Parameter	Conditions	GPS	GLONASS	GPS + GLONASS	Unit
Frequency	---	1575.42	1601.72		MHz
Tracking Sensitivity[1]	---	-161	-157		dBm
Acquisition Sensitivity[1]	Cold start sensitivity	-146	-142		dBm
Hot Start sensitivity[1]	GPS C/N0=18dB	-154	-150		dBm
Warm Start sensitivity[1]	GPS C/N0=25dB	-147	-143		dBm
Cold Start sensitivity[1]	GPS C/N0=26dB	-146	-142		dBm
Time-to-First-Fix (TTFF)[2]	Hot	1.3		<1	s
	Warm	32		21	s
	Cold	36		35	s

1. Full open sky with a good active GPS antenna or good LNA.
2. To optimize GPS start-up behavior, it is recommended to backup the module's internal real time clock via VDDLP line as described in Section 2.1.7.

2.4 Sample Application

Figure 37 shows a typical example of how to integrate a BGS8 module with an application. Usage of the various host interfaces depends on the desired features of the application.

The analog 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. excluded that in some applications dependant on the grounding concept of the customer. The potential interferers may be minimized by placing small capacitors (47pF) at suspected lines (e.g. RXD0, SCLK, VDDLP, and IGT).

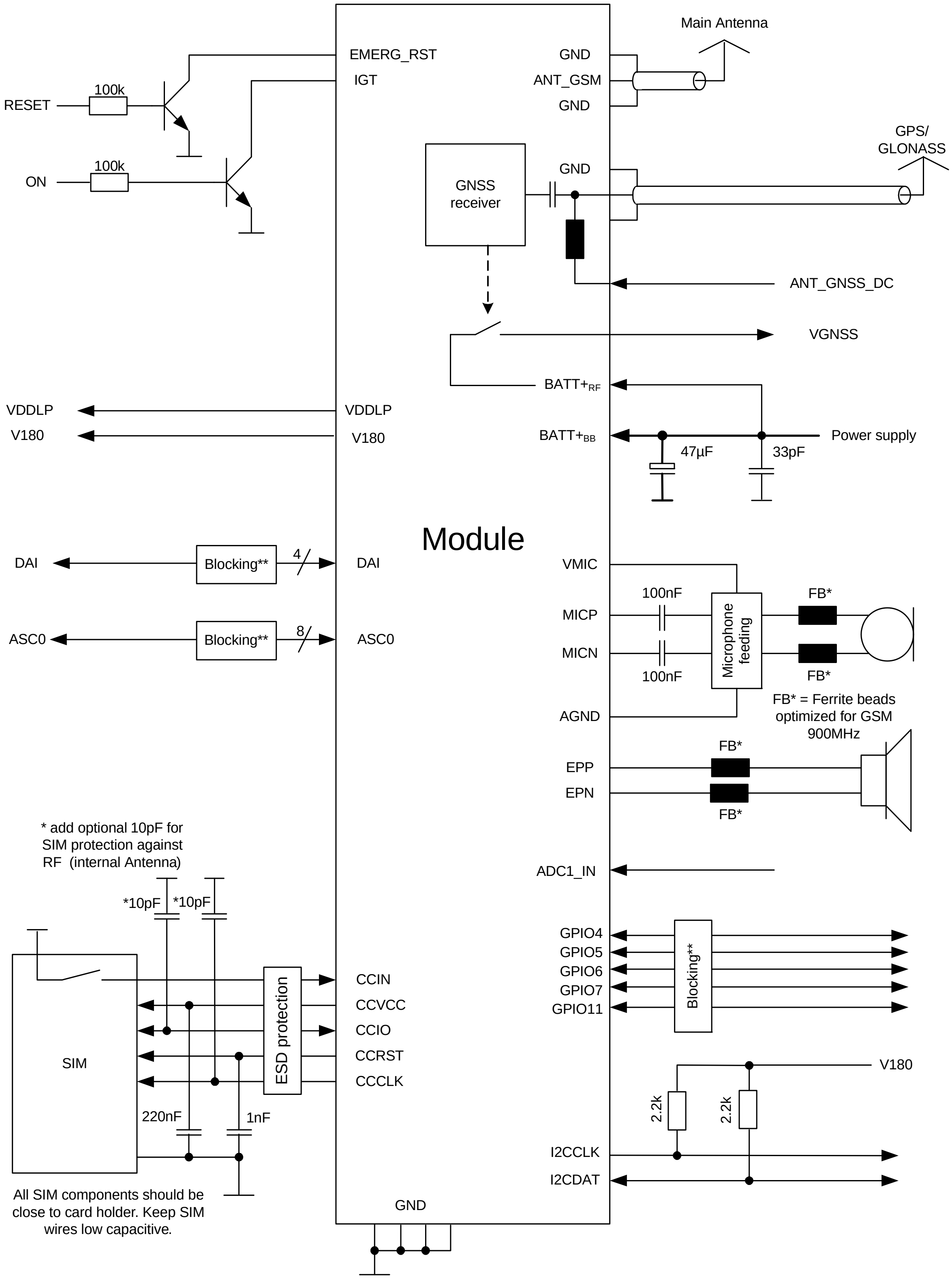
While developing SMT applications it is strongly recommended to provide test points for certain signals, i.e., lines to and from the module - for debug and/or test purposes. The SMT application should allow for an easy access to these signals. For details on how to implement test points see [3].

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.

Depending on the micro controller used by an external application EHS5-E/EHS5-US‘s digital input and output lines may require level conversion. Section 2.4.1 shows a possible sample level conversion circuit.

Please note that BGS8 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 37 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 BGS8 modules.



Blocking** = For more details see Section 3.9.

Figure 37: Schematic diagram of BGS8 sample application

2.4.1 Sample Level Conversion Circuit

Depending on the micro controller used by an external application BGS8's digital input and output lines (i.e., ASC0 lines) may require level conversion. The following Figure 38 shows a sample circuit with recommended level shifters for an external application's micro controller (with VLOGIC between 3.0V...3.6V). The level shifters can be used for digital input and output lines with V_{OH}max=1.85V or V_{IH}max =1.85V.

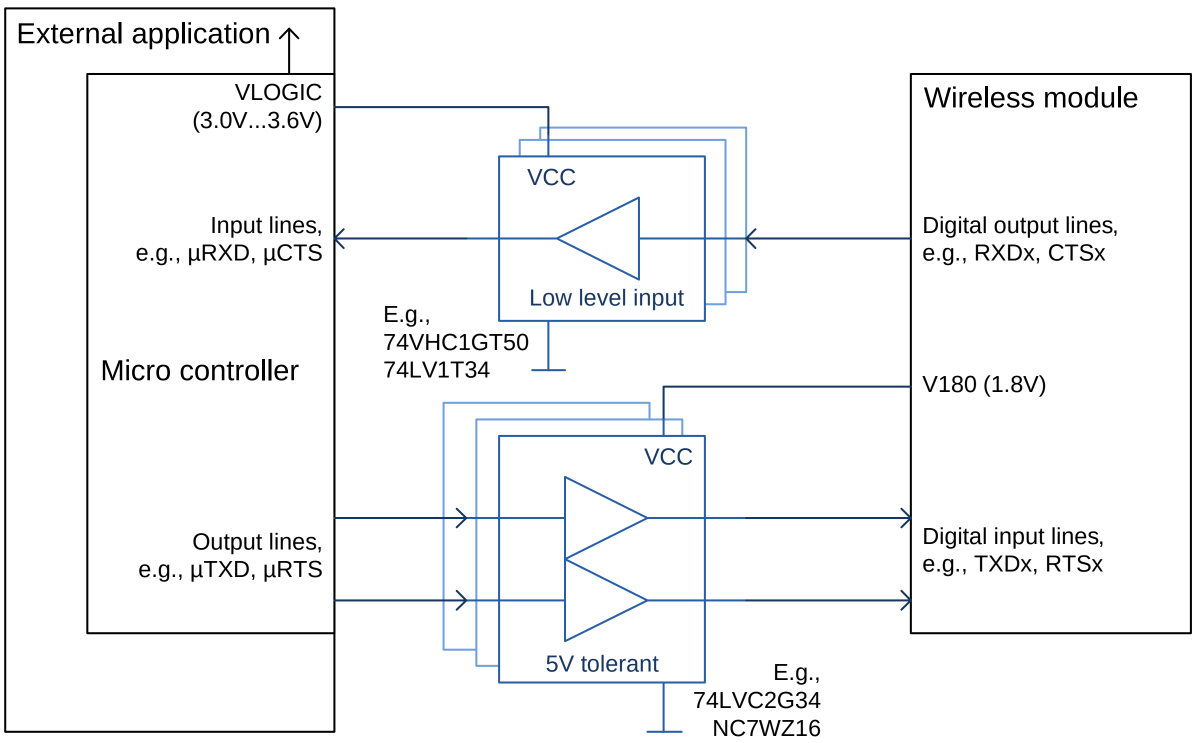


Figure 38: Sample level conversion circuit

3 Operating Characteristics

3.1 Operating Modes

The table below briefly summarizes the various operating modes referred to throughout the document.

Table 15: 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. multislot settings).
	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.
	GNSS	The GNSS NMEA data stream is internally routed to the ASC0 interface, while the baseband processor in the idle or active state. NMEA data streams are not available while the base band processor is in the SLEEP mode.
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 remains applied.	
Alarm mode	Restricted operation launched by RTC alert function while the module is in Power Down mode. Module will not be registered to GSM network. Limited number of AT commands is accessible.	

3.2 Power Up/Power Down Scenarios

In general, be sure not to turn on BGS8 while it is beyond the safety limits of voltage and temperature stated in Section 2.1.2.1. BGS8 immediately switches off after having started and detected these inappropriate conditions. In extreme cases this can cause permanent damage to the module.

3.2.1 Turn on BGS8

BGS8 can be started as described in the following sections:

- Hardware driven switch on by IGT line: Starts Normal mode (see Section 3.2.1.1 and Section 3.2.1.2).
- Wake-up from Power Down mode by using RTC interrupt: Starts Alarm mode (see Section 3.2.1.3).

3.2.1.1 Switch on BGS8 Using IGT Signal

When the operating voltage BATT+ is applied, BGS8 can be switched on by means of the IGT signal.

If the operating voltage BATT+ is applied while the IGT signal is present, BGS8 will be switched on automatically. Please note that if the rise time for the operating voltage BATT+ is longer than 12 milliseconds, the module startup will be delayed by about 1 second.

Please also note that if there is no IGT signal present right after applying BATT+, BGS8 will instead of switching on perform a very short switch on/off sequence (approx. 120 milliseconds) that cannot be avoided.

The IGT signal is a high active signal and has the same output voltage level as the VDDLP signal. The following Figure 39 shows an example for a switch-on circuit.

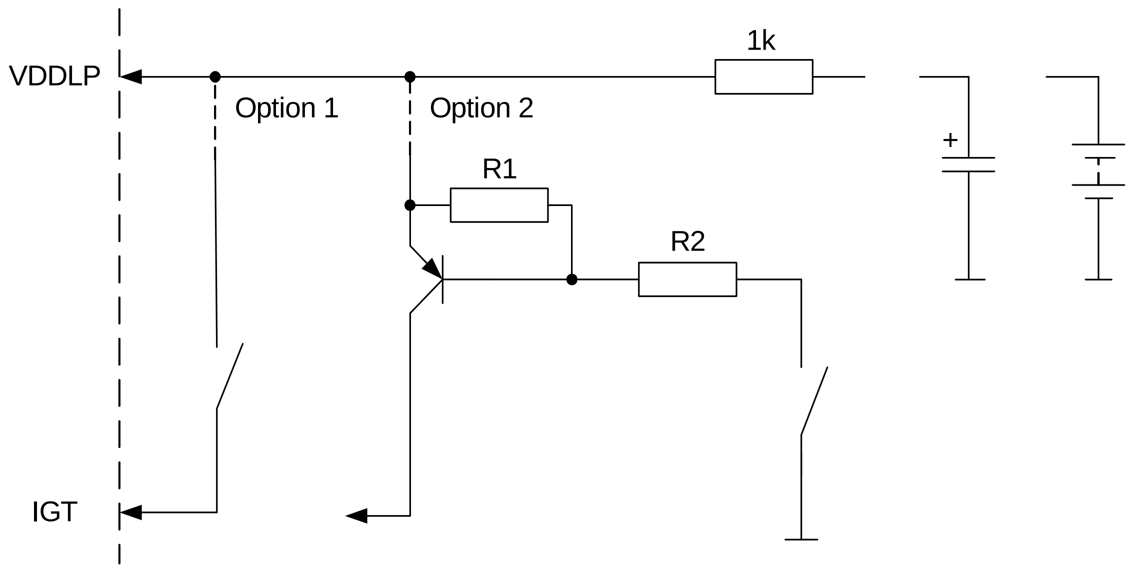


Figure 39: IGT circuit sample

It is recommended to set a serial 1kOhm resistor between the IGT 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). Typical values for the resistors shown in Figure 39 are R1=150k and R2=22k, depending on the current gain of the employed PNP transistor.

Please note that the IGT 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 40. After module startup the IGT signal should always be set to low to prevent possible back powering at this pin.

Please also note that that if the IGT signal remains active high after switch on, it is no longer possible to switch off BGS8 using the AT command AT^SMSO. Using this command will instead automatically restart the module.

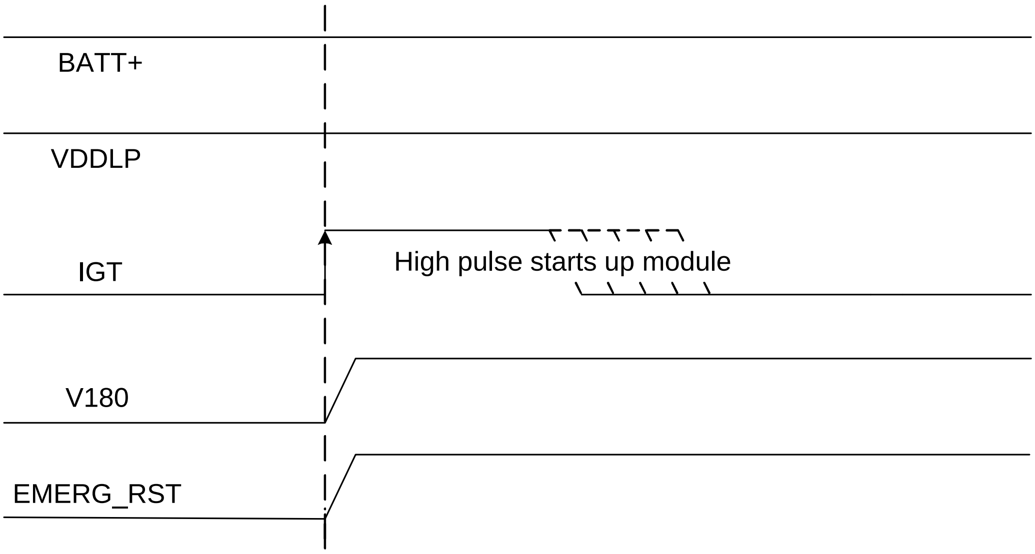


Figure 40: IGT timing

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.

3.2.1.2 Switch on BGS8 using Continuous IGT Signal

In case the IGT signal is directly connected to VDDLP, i.e., permanently at an active high level the module will start up if the operating voltage BATT+ is applied.

The following Figure 41 shows this startup behavior if employing the IGT signal.

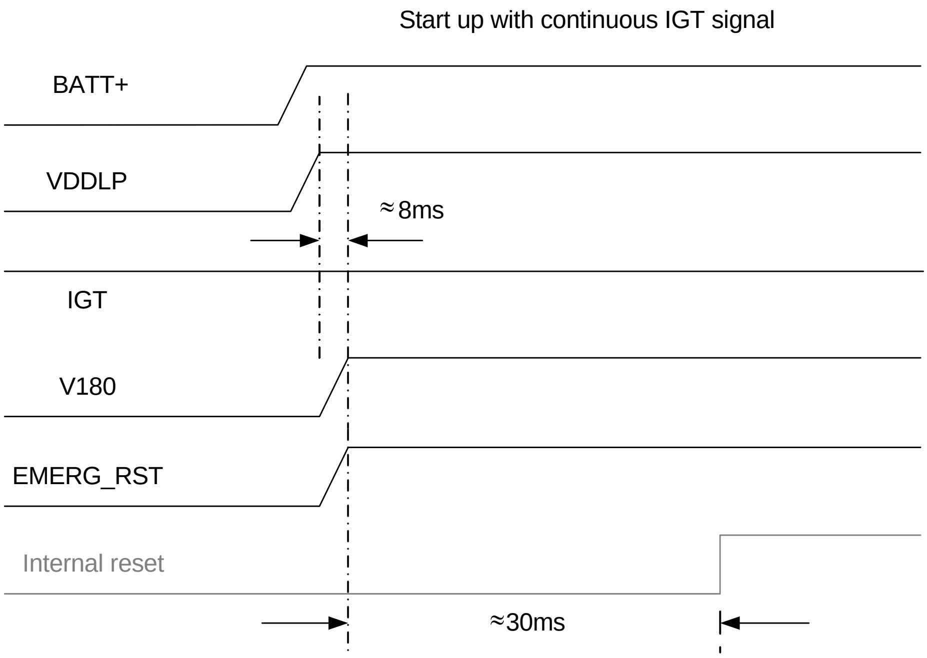


Figure 41: Switch on using continuous IGT signal

Note: While the continuous IGT signal is active, it is not possible to switch off the module using the AT command AT^SMSO. The module restarts automatically after the AT^SMSO command.

3.2.1.3 Turn on BGS8 Using the RTC (Alarm Mode)

Another power-on approach is to use the RTC, which is constantly supplied with power from a separate voltage regulator in the power supply processor. The RTC provides an alert function, which allows the BGS8 to wake up whilst the internal voltage regulators are off. This procedure only enables restricted operation, referred to as Alarm mode. It must not be confused with a reminder message that can be activated by using the same AT command, but without switching off power.

Use the AT+CALA command to set the alarm time. The RTC retains the alarm time if BGS8 was powered down by AT^SMSO. Once the alarm is timed out and executed, BGS8 enters Alarm mode. This is indicated by an Unsolicited Result Code (URC) which reads:

^SYSSTART ALARM MODE

Note: This URC is the only indication of the Alarm mode and will not appear when autobauding AT+IPR=0 was activated (due to the missing synchronization between DTE and DCE upon start-up). Therefore, it is recommended to select a fixed baudrate before using the Alarm mode.

In Alarm mode the module is deregistered from the GSM network and only a limited number of AT commands is available. For a table showing the availability of AT commands depending on the module‘s operating mode please refer to [1].

For the module to change from Alarm mode to full operation (normal operating mode) it is possible to use the AT+CFUN command or to switch on the module using the IGT signal. The latter must be implemented in your host application as described in Section 3.2.1.1.

3.2.2 Restart BGS8

After startup BGS8 can be re-started as described in the following sections:

- Software controlled reset by AT+CFUN command: Starts Normal mode (see Section 3.2.2.1).
- Hardware controlled reset by EMERG_RST line: Starts Normal mode (see Section 3.2.2.2)

3.2.2.1 Restart BGS8 via AT+CFUN Command

To reset and restart the BGS8 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.

3.2.2.2 Restart BGS8 Using EMERG_RST

The EMERG_RST signal is internally connected to the central GSM processor. A low level for more than 10 milliseconds sets the processor and with it all the other signal pads to their respective reset state. The reset state is described in Section 3.2.3 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 if the module was switched on by the IGT signal.

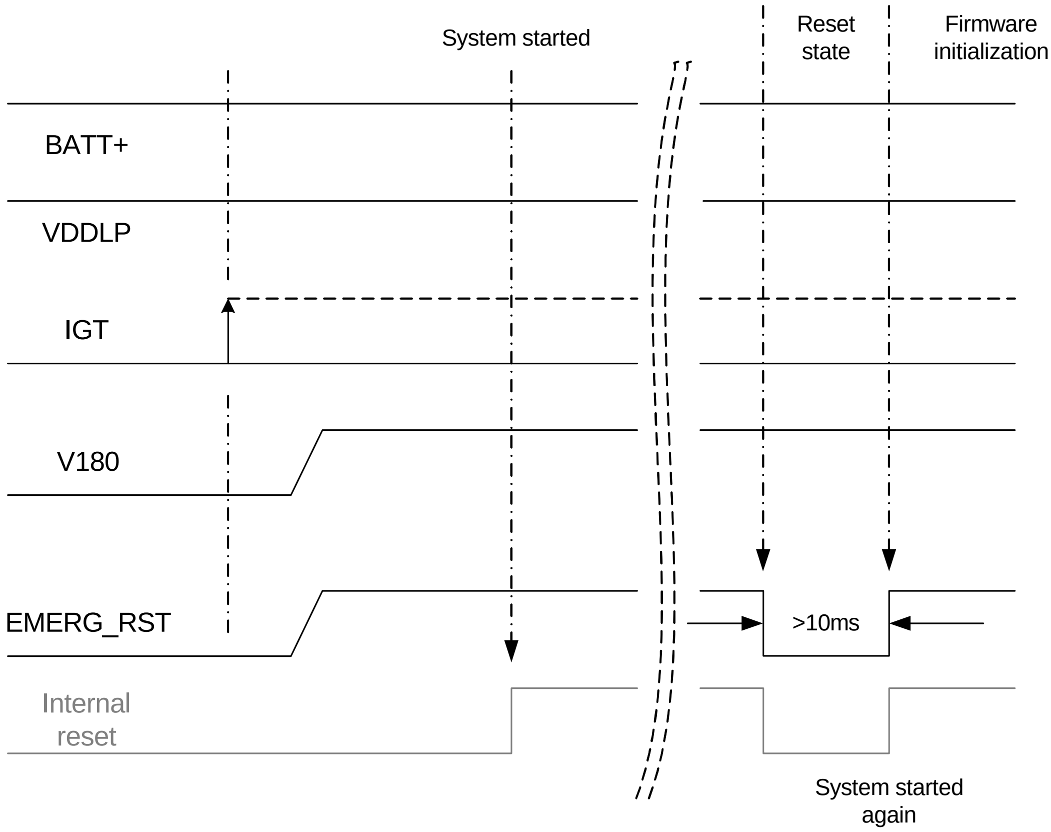


Figure 42: Emergency restart timing

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 BGS8 does not respond, if reset or shutdown via AT command fails.

3.2.3 Signal States after Startup

Table 16 lists the states each interface signal passes through during reset and the firmware‘s first startup initialization. For further firmware startup initializations the values may differ because of different GPIO line configurations.

The reset state is reached with the rising edge of an internal reset line - either after a normal module startup (see Section 3.2.1) or after a restart (see Section 3.2.2). After the reset state has been reached the firmware initialization state begins. The firmware and command interface initialization is completed as soon as the ASC0 interface line CTS0 has turned low (see Section 2.1.3). Now, the module is ready to receive and transmit data.

Table 16: Signal states

Signal name	Reset state	Firmware initialization
CCIN	T / 100k PD	I / 100k PD
CCRST	L	O / L
CCIO	L	O / L
CCCLK	L	O / L
CCVCC	L	O / L
RXD0	T / 2 x PU_B	O / H
TXD0	T / 2 x PU_B	I
CTS0	PD_B	O / H
RTS0	T / PU_A	I / PU_A
RING0	T / PD_B	O / H
DTR0	T / PU_A	T / PU_A
DCD0	T / PU_A	T / PU_A
DSR0	T / PU_A	T / PU_A
GPS_1PPS	T	T
GPIO4/FST_SHDN	T / PU_A	T / PU_A
GPIO5/LED	T / PU_B	T / PU_B
GPIO6/PWM2/JamDet	T / PU_B	T / PU_B
GPIO7/PW1	T / PU_B	T / PU_B
GPIO8 (reserved)	T / PU_B	T / PD_B
GPIO11	I / PD_B	T / PU_B
RXDDAI	T / PD_B	T / PD_B
SCLK	T / PU_B	T / PU_B
TFSDAI	T / PD_B	T / PD_B
TXDDAI	T / PD_B	T / PD_B
I2CCLK	T / 5k PU / OD	T / 5k PU / OD
I2CDAT	T / OD	T / OD

Abbreviations used in above Table 16:

L = Low level H = High level T = Tristate I = Input O = Output	OD = Open Drain PD_A = Pull down, 103µA at 1.75V PD_B = Pull down, 51µA at 1.75V PU_A = Pull up, -102µA at 0.05V PU_B = Pull up, -55µA at 0.05V

3.2.4 Turn off BGS8

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

- *Software controlled shutdown procedure*: Software controlled by sending the AT^SMSO command over the serial application interface. See Section 3.2.4.1.
- *Automatic shutdown (software controlled)*: See Section 3.2.5
  - Takes effect if under- or overvoltage is detected.
  - Takes effect if BGS8 board temperature exceeds a critical limit.
  - Takes effect if BGS8‘s hardware watchdog triggers a shutdown notification

3.2.4.1 Switch off BGS8 Using AT Command

The best and safest approach to powering down BGS8 is to issue the *AT^SMSO* command. This procedure lets BGS8 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 V180 pad. The low state of this pads 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 V180 pad has gone low. Otherwise you run the risk of losing data.

While BGS8 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.

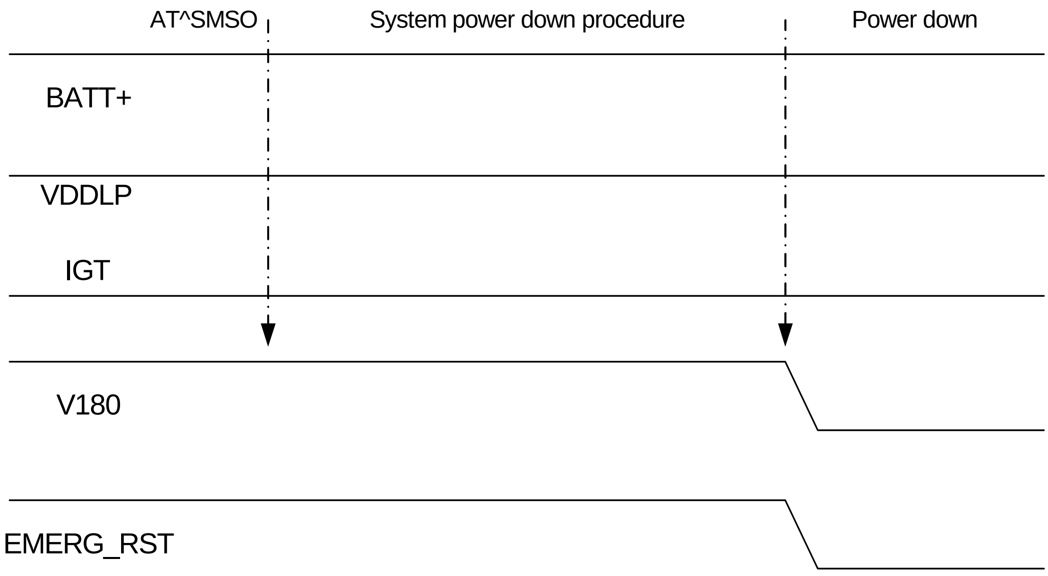


Figure 43: Switch off behavior

3.2.5 Automatic Shutdown

Automatic shutdown takes effect if any of the following events occurs:
- The BGS8 board is exceeding the critical limits of overtemperature or undertemperature (see Section 3.2.5.1)
- Undervoltage or overvoltage is detected (see Section 3.2.5.2 and Section 3.2.5.3)
- The internal BGS8 hardware watchdog registers a shutdown notification (see Section 3.2.5.4)

The automatic shutdown procedure is equivalent to the power-down initiated with the AT^SMSO command, i.e. BGS8 logs off from the network and the software enters a secure state avoiding loss of data.

3.2.5.1 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, BGS8 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 seconds guard period after start-up of BGS8. After expiry of the 15 seconds 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 3.7. Refer to Table 17 for the associated URCs.

Table 17: Temperature dependent behavior

Sending temperature alert (15 seconds after BGS8 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. BGS8 switches off.
^SCTM_B: -2	Alert: Board equal or below undertemperature limit. BGS8 switches off.

3.2.5.2 Undervoltage Shutdown

The undervoltage shutdown threshold is 3.25V, i.e., it is 50mV below the specified minimum supply voltage V_{BATT+} given in Table 2.

When the average supply voltage measured by BGS8 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.

3.2.5.3 Overvoltage Shutdown

The overvoltage shutdown threshold is 4.6V, i.e., it is 100mV above the specified maximum supply voltage V_{BATT+} given in Table 2.

When the average supply voltage measured by BGS8 rises above the overvoltage shutdown threshold the module will send the following URC:

^SBC: Overvoltage

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.

Keep in mind that several BGS8 components are directly linked to BATT+ and, therefore, the supply voltage remains applied at major parts of BGS8. Especially the power amplifier linked to $BATT+_{RF}$ is very sensitive to high voltage and might even be destroyed.

3.2.5.4 Hardware Watchdog

The BGS8 chipset features a built-in hardware watchdog. The watchdog is activated automatically after module power up during the firmware initialization phase. In case the watchdog will not be reset within 2.5 seconds, the module will send a shutdown notification on its serial interface and will shut down itself. The module's firmware is designed in such a way that all the main tasks register to the reset procedure of the watchdog. If one of these tasks is not responding, the module will be shutdown.

It is recommended to design an external application in such a way that if the module is powered on, the ignition line is permanently active. If the module then shuts off, it will be restarted automatically because of the active ignition line. On the other hand, the external application will have to take into account that if the module is meant to be powered off, the ignition line must be deactivated.

3.3 Automatic GPRS Multislot Class Change

For operation in GPRS Multislot Class 10, temperature control is effective. If the board temperature increases up to 80°C while data is transmitted over GPRS, the module automatically reverts from GPRS Multislot Class 10 (2Tx) to Class 8 (1Tx). This reduces the power consumption and, consequently, causes the board’s temperature to decrease. Once the temperature drops to 75°C, BGS8 returns to the higher Multislot Class. If the temperature stays at the critical level or even continues to rise, BGS8 will not switch back to the higher class.

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

Note: There is not one single cause of switching over to a lower GPRS Multislot Class. Rather it is the result of an interaction of several factors, such as the board temperature that depends largely on the ambient temperature, the operating mode and the transmit power. Furthermore, take into account that there is a delay until the network proceeds to a lower or, accordingly, higher Multislot Class. The delay time is network dependent. In extreme cases, if it takes too much time for the network and the temperature cannot drop due to this delay, the module may even switch off as described in Section 3.2.4.

For BGS8‘s general temperature limits please refer to Section 3.7.

3.4 Power Saving

SLEEP mode reduces the functionality of the BGS8 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. For the same reason, power saving cannot be used if BGS8 operates in Alarm mode.

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

The wake-up procedures are quite different depending on the selected SLEEP mode. Table 18 compares the wake-up events that can occur in NON-CYCLIC and CYCLIC SLEEP modes.

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 BGS8 back to the highest level of functionality <fun>=1.

In NON-CYCLIC mode, the falling edge of the RTS0 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 3.4.6.1 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, BGS8 automatically resumes power saving, after you have sent or received a short message, or made a call or completed a GPRS transfer. Please refer to Table 18 for a summary of all modes.

The CYCLIC SLEEP mode is a dynamic process which alternatingly enables and disables the serial interface. By setting/resetting the CTS signal, the module indicates to the application whether or not the UART is active. The timing of CTS is described below.

Both the application and the module must be configured to use hardware flow control (RTS/CTS handshake). The default setting of BGS8 is AT\Q0 (no flow control) which must be altered to AT\Q3. See [1] for details.

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 is not only used for flow control (as in mode AT+CFUN=7), but also causes the module to wake up temporarily. See Section 3.4.6.1 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 4.6 ms. This is followed by another 4.6 ms UART activity. If the start bit of a received character is detected within these 9.2 ms, CTS will be activated and the proper reception of the character will be guaranteed. CTS will also be activated if any character is to be sent.

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

- another 2 seconds, if AT+CFUN=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 44 and Figure 45.

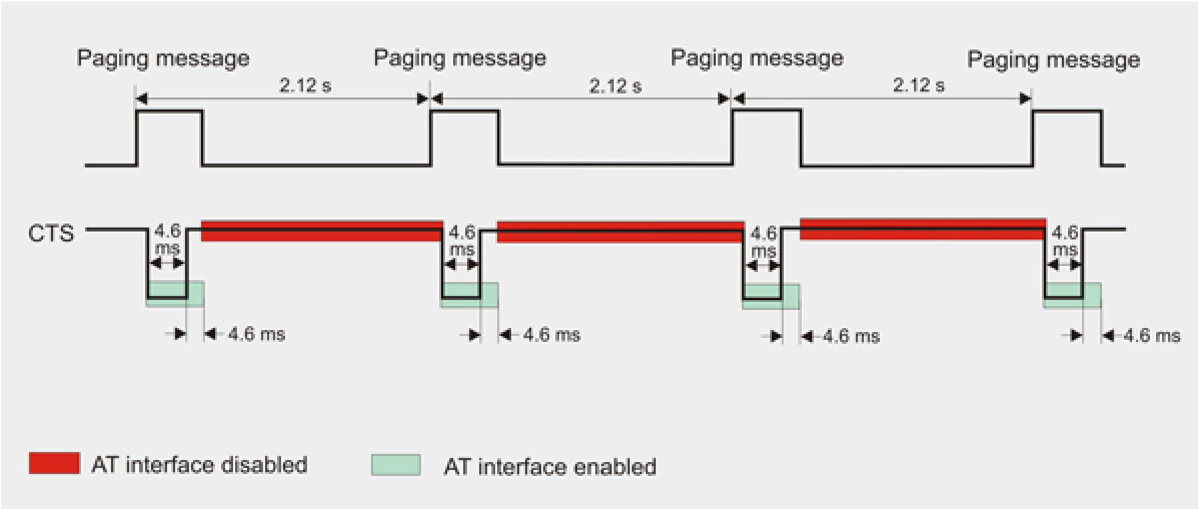


Figure 44: Timing of CTS signal (example for a 2.12 s paging cycle)

Figure 45 illustrates the CFUN=7 modes, which reset the CTS signal 2 seconds after the last character was sent or received.

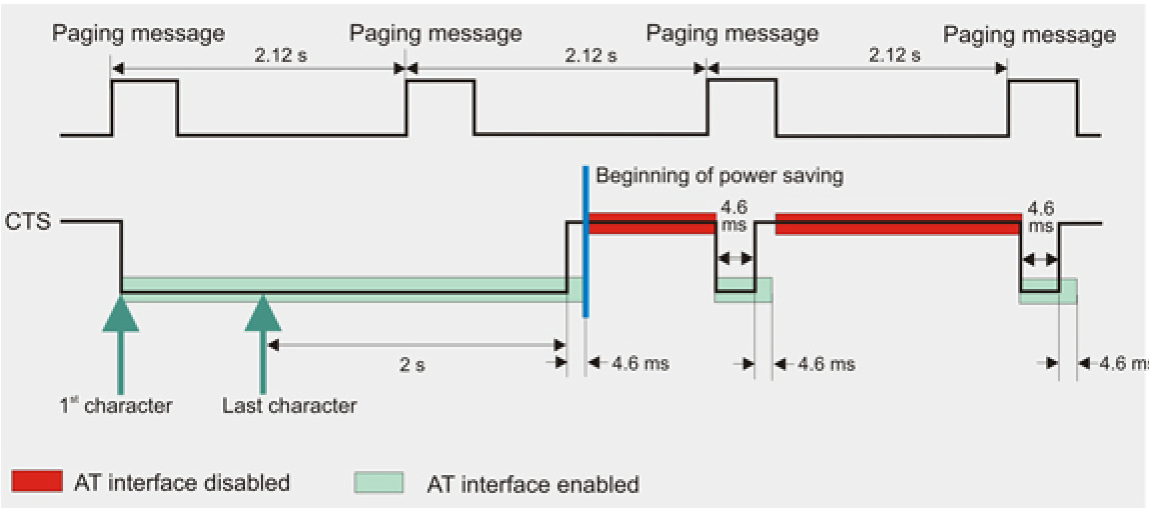


Figure 45: Beginning of power saving if CFUN=7

3.4.6 Wake up BGS8 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 BGS8 back to AT+CFUN=1, or activates BGS8 temporarily without leaving the current SLEEP mode.

Definitions of the state transitions described in Table 18:

Quit = BGS8 exits SLEEP mode and returns to AT+CFUN=1.
Temporary = BGS8 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. BGS8 does not wake up.

Table 18: 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[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
RTC alarm[2]	Quit	Temporary
AT+CFUN=1	Not possible (UART disabled)	Quit

1. See Section 3.4.6.1 on wake-up via RTS.
2. Recommendation: In NON-CYCLIC SLEEP mode, you can set an RTC alarm to wake up BGS8 and return to full functionality. This is a useful approach because, in this mode, the AT interface is not accessible.

3.4.6.1 Wake-up via RTS0 (if AT+CFUN=0 or AT+CFUN=9)

During the CYCLIC SLEEP mode 7, the RTS0 line is conventionally used for flow control: The assertion of RTS0 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 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 can be used to temporarily wake up BGS8 for the time specified with the AT^SCFG command (default = 2 seconds). In both cases, if RTS0 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 60 milliseconds. The ability to receive data is signalized by CTS0. 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 19: State transitions of BGS8 (except SLEEP mode)

Further mode →→ Present mode	**Power Down mode**	**Normal mode**	**Alarm mode**
Power Down mode	---	IGT >10ms at VDDLP level	Wake-up from Power Down mode (if activated with AT+CALA)
Normal mode	AT^SMSO	EMERG_RST > 10ms	AT+CALA followed by AT^SMSO. BGS8 enters Alarm mode when specified time is reached.
Alarm mode	AT^SMSO	AT+CFUN=x,1 or IGT >10ms at VDDLP level	---

3.6 Power Supply

BGS8 needs to be connected to a power supply at the SMT application interface - 2 lines BATT+, and GND. There are two separate voltage domains for BATT+:
- $BATT+_{BB}$ with a line for the general power management.
- $BATT+_{RF}$ with a line for the GSM power amplifier supply.

Please note that throughout the document BATT+ refers to both voltage domains and power supply lines - $BATT+_{BB}$ and $BATT+_{RF}$.

The power supply of BGS8 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 down switching regulator.
- Switches the module's power voltages for the power-up and -down procedures.
- SIM switch to provide SIM power supply.

3.6.1 Power Supply Ratings

Table 20 and Table 21 assemble various voltage supply and current consumption ratings of the module.

Table 20: Voltage supply ratings

	Description	Conditions	Min	Typ	Max	Unit
BATT+	Supply voltage[1]	Directly measured at Module. Voltage must stay within the min/max values, including voltage drop, ripple, spikes	3.3		4.5	V
	Maximum allowed voltage drop during transmit burst	Normal condition, power control level for Pout max			400	mV
	Voltage ripple	Normal condition, power control level for Pout max @ f <= 250 kHz @ f > 250 kHz			 85 25	 mV_{pp} mV_{pp}

1. Although the module`s supply voltage is defined in the range of $3.3 \leq V_{BATT+BB}$, $V_{BATT+RF} \leq 4.5V$, best performance with respect to RF output power can be achieved at a voltage level of $V_{BATT+RF} = 4.0V$.

Table 21: Current consumption ratings

Parameter	Description	Conditions	Typical rating	Unit
I_{VDDLP}	OFF state supply current	RTC backup @ BATT+ = 0V	7	µA
I_{BATT+}[1] (i.e., sum of $BATT+_{BB}$ and $BATT+_{RF}$)	OFF state supply c.	Power Down mode	115	µA
	Average GSM supply current (GNSS off)	SLEEP[2] @ DRX = 9 (UART deactivated)	1.2	mA
		SLEEP[2] @ DRX = 5 (UART deactivated)	1.4	mA
		SLEEP[2] @ DRX = 2 (UART deactivated)	2.2	mA
		SLEEP[2] GPRS @ DRX = 9 (UART deactivated)	1.2	mA
		SLEEP[2] GPRS @ DRX = 5 (UART deactivated)	1.5	mA
		SLEEP[2] GPRS@ DRX = 2 (UART deactivated)	2.2	mA
		IDLE @ DRX = 2 (no communication via UART)	8	mA
		Voice call GSM 850/900; PCL = 5	225	mA
		GPRS data transfer GSM 850/900 PCL = 5; 1Tx/4Rx	225	mA
		GPRS data transfer GSM 850/900 PCL = 5; 2Tx/3Rx	400	mA
		Voice call GSM 1800/1900; PCL = 0	150	mA
		GPRS data transfer GSM 1800/1900 PCL = 0; 1Tx/4Rx	140	mA
		GPRS data transfer GSM 1800/1900 PCL = 0; 2Tx/3Rx	255	mA
	Peak current during GSM transmit burst	Voice call GSM850/900; PCL = 5 @50Ω @Total mismatch	 1.6 1.6	A
		Voice call GSM1800/1900; PCL = 0 @50Ω @Total mismatch	 1.0 1.1	
	Average GSM supply current (GNSS on)	GSM active (UART active) @ DRX=2 GNSS NMEA output off	59	mA
		GSM active (UART active) @ DRX=2 GNSS NMEA output on[3]	55	

1. With an impedance of Z_{LOAD}=50Ω at the antenna pad.
   All measurements have been done with BATT+= 4V5, except POWERDOWN with BATT+ = 3V4.
2. Measurements start 6 minutes after the module was switched ON,
   Averaging times: SLEEP mode - 3 minutes; transfer modes - 1.5 minutes,
   Communication tester settings: no neighbour cells, no cell reselection etc. RMC (Reference Measurement Channel)
3. One fix per second.

3.6.2 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 BGS8 board, not even in a GSM transmit burst where current consumption can rise (for peaks values see the power supply ratings listed in Section 3.6.1).

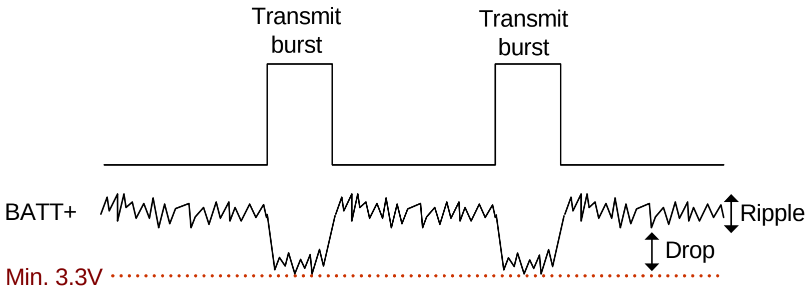


Figure 46: Power supply limits during transmit burst

3.6.3 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 53 ($BATT+_{RF}$) or 204 ($BATT+_{BB}$) as shown in Figure 47.

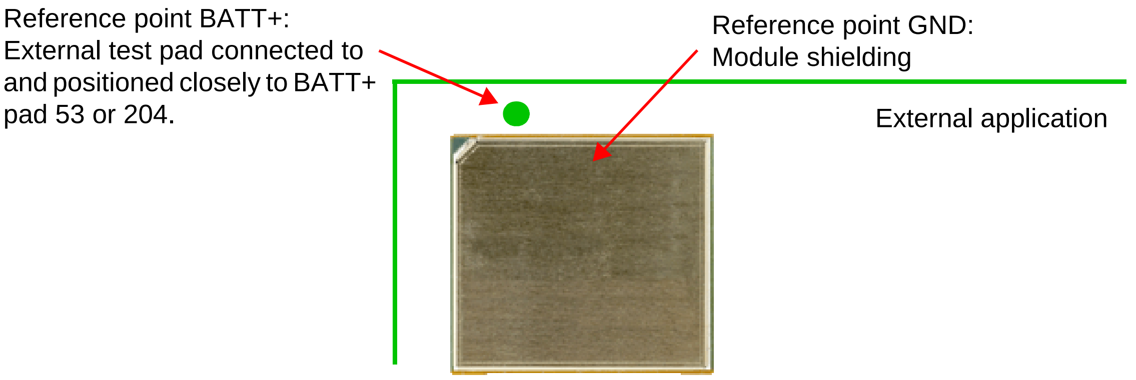


Figure 47: Position of reference points BATT+and GND

3.6.4 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 depending on the operating mode of the RF interface. The duration of measuring ranges from 0.5 seconds in TALK/DATA mode to 50 seconds when BGS8 is in IDLE mode or Limited Service (deregistered). The displayed voltage (in mV) is averaged over the last measuring period before the AT^SBV command was executed.

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 3.2.5).

3.7 Operating Temperatures

Table 22: Board temperature

Parameter	Min	Typ	Max	Unit
Operating temperature range[1] Normal temperature range Extreme temperature range	 +15 -30	 +25 	 +55 +85	 °C °C
Extended temperature range[2]	-40		+90	°C
Automatic shutdown[3] Temperature measured on BGS8 board	 <-40	 ---	 >+90	 °C

1. Operating temperature range according to 3GPP type approval specification.
2. Extended operation allows normal mode data transmissions for limited time until automatic thermal shutdown takes effect.
   Within the extended temperature range (outside the operating temperature range) there should not be any unrecoverable malfunctioning. General performance parameters like Pout or RX sensitivity however may be reduced in their values. The module's life time may also be affected, if deviating from a general temperature allocation model (for details see Section 3.7.1).
3. Due to temperature measurement uncertainty, a tolerance on the stated shutdown thresholds may occur. The possible deviation is in the range of ± 2°C at the overtemperature and undertemperature limit.

See also Section 3.2.5 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. Note also the differences and dependencies that usually exist between board (PCB) temperature and ambient temperature as shown in the following Figure 48. The possible ambient temperature range depends on the mechanical application design including the module and the PCB with its size and layout. A thermal solution will have to take these differences into account and should therefore be an integral part of application design.

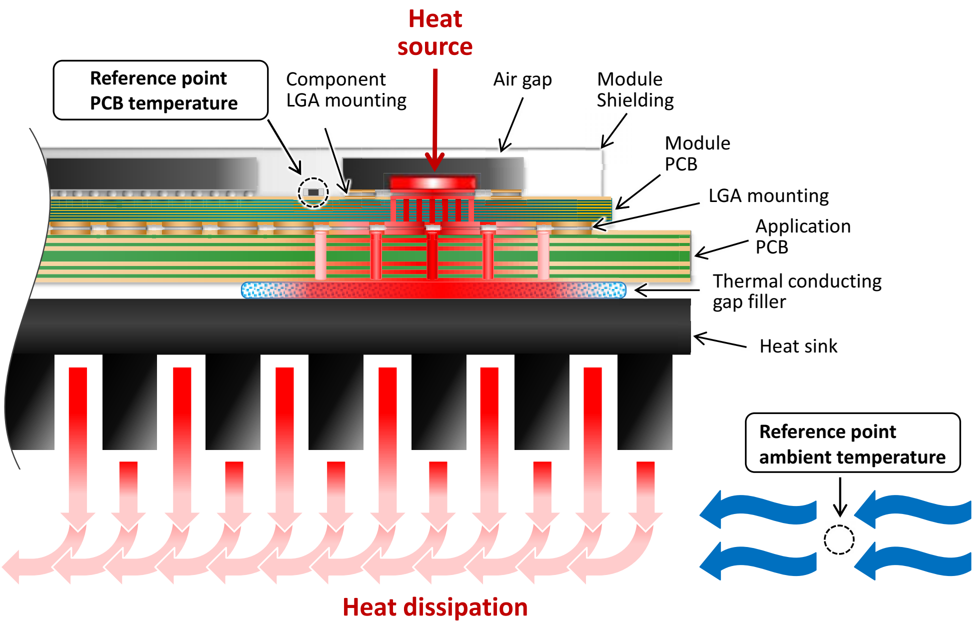


Figure 48: Board and ambient temperature differences

3.7.1 Temperature Allocation Model

The temperature allocation model shown in Table 23 assumes shares of a module's average lifetime of 10 years (given in %) during which the module is operated at certain temperatures.

Table 23: Temperature allocation model

Module lifetime share (in %)[1]	1	1	5	53	35	3	1	1
Module temperature (in °C)	-40	-30	-10	20	40	70	85	90

1. Based on an assumed average module lifetime of 10 years (=100%).

Any deviations from the above temperature allocation model may reduce the module's life span, for example if the module is operated close to the maximum automatic shutdown temperature not only for 1% but for 20% of its product life.

3.8 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 BGS8 module.

An example for an enhanced ESD protection for the SIM interface is given in Section 2.1.4.

The SIM, RF antenna and GNSS antenna interfaces, as well as all the other interfaces of BGS8 that are not accessible to the user of the final product (since they are installed within the device), are only protected according to the ANSI/ESDA/JEDEC JS-001-2011 requirements. Electrostatic values can be gathered from the following table.

Table 24: Electrostatic values

Specification/Requirements	Contact discharge	Air discharge
JEDEC JESD22-A114D (Human Body Model, Test conditions: 1.5 kΩ, 100 pF)		
ESD at the module (including SIM interface as well as RF and GNSS antenna interfaces)	± 1kV	n.a.

Note: 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 5.

3.8.1 ESD Protection for Antenna Interface

The following Figure 49 shows how to implement an external ESD protection for the RF antenna interface with either a T pad or PI pad attenuator circuit (for RF line routing design see also Section 2.2.3).

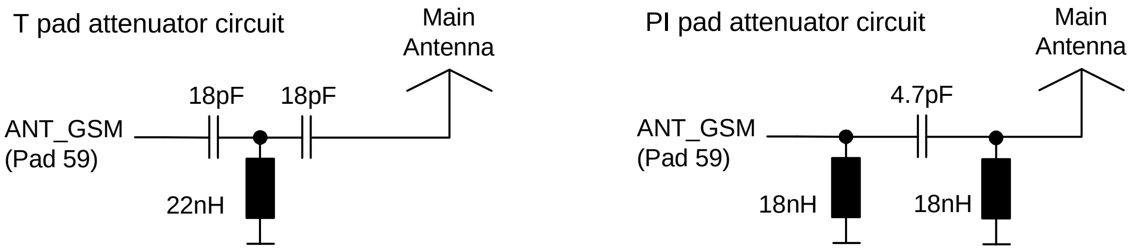


Figure 49: ESD protection for RF antenna interface

Recommended inductor types for the above sample circuits: Size 0402 SMD from Panasonic ELJRF series (22nH and 18nH inductors) or Murata LQW15AN18NJ00 (18nH inductors only).

3.9 Blocking against RF on Interface Lines

To reduce EMI issues the signal lines have no EMI measures on the module and there are no blocking measures at the module's interface to an external application.

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 50 and Table 25). 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 1kΩ 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.

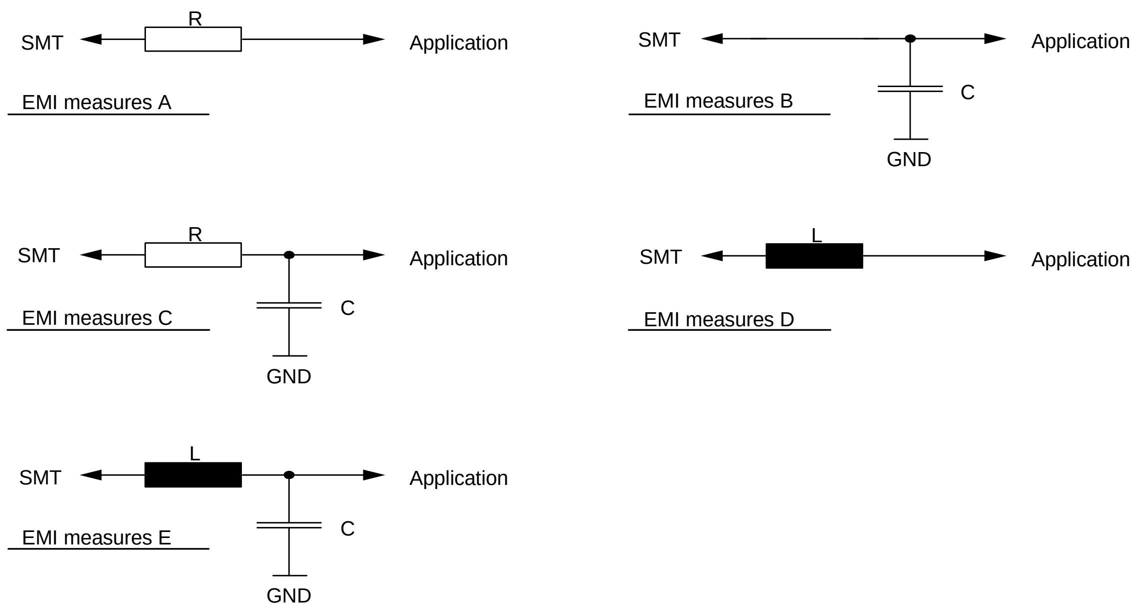


Figure 50: EMI circuits

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

Table 25: EMI measures on the application interface

Signal name	EMI measures					Remark
	A	B	C	D	E	
CCIN	x			x		
CCRST		x				The external capacitor should be not higher than 10pF. The value of the capacitor depends on the external application.
CCIO		x				
CCCLK		x				
RXD0	x	x	x	x	x	
TXD0	x	x	x	x	x	
CTS0	x	x	x	x	x	
RTS0	x	x	x	x	x	
RING0				x		
DTR0	x	x	x	x	x	
DCD0	x	x	x	x	x	
DSR0	x	x	x	x	x	
RXDDAI	x	x	x	x	x	
SCLK	x	x	x	x	x	
TFSDAI	x	x	x	x	x	
TXDDAI	x	x	x	x	x	
GPS_1PPS	x	x	x	x	x	
GPIO4	x	x	x	x	x	
GPIO5	x	x	x	x	x	
GPIO6	x	x	x	x	x	
GPIO7	x	x	x	x	x	
GPIO11	x	x	x	x	x	
I2CCLK		x		x		The rising signal edge is reduced with an additional capacitor.
I2CDAT		x		x		
V180		x		x	x	

3.10 Reliability Characteristics

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

Table 26: Summary of reliability test conditions

Type of test	Conditions	Standard
Vibration	Frequency range: 10-20Hz; acceleration: 5g Frequency range: 20-500Hz; acceleration: 20g Duration: 20h per axis; 3 axes	DIN IEC 60068-2-6[1]
Shock half-sinus	Acceleration: 500g Shock duration: 1ms 1 shock per axis 6 positions (± x, y and z)	DIN IEC 60068-2-27
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°C ±2°C Changeover time: < 30s (dual chamber system) Test duration: 1h Number of repetitions: 100	DIN IEC 60068-2-14 Na ETS 300 019-2-7
Damp heat cyclic	High temperature: +55°C ±2°C Low temperature: +25°C ±2°C Humidity: 93% ±3% Number of repetitions: 6 Test duration: 12h + 12h	DIN IEC 60068-2-30 Db ETS 300 019-2-5
Cold (constant exposure)	Temperature: -40 ±2°C Test duration: 16h	DIN IEC 60068-2-1

1. For reliability tests in the frequency range 20-500Hz the Standard's acceleration reference value was increased to 20g.

4 Mechanical Dimensions, Mounting and Packaging

4.1 Mechanical Dimensions of BGS8

Figure 51 shows the top and bottom view of BGS8 and provides an overview of the board's mechanical dimensions. For further details see Figure 52.

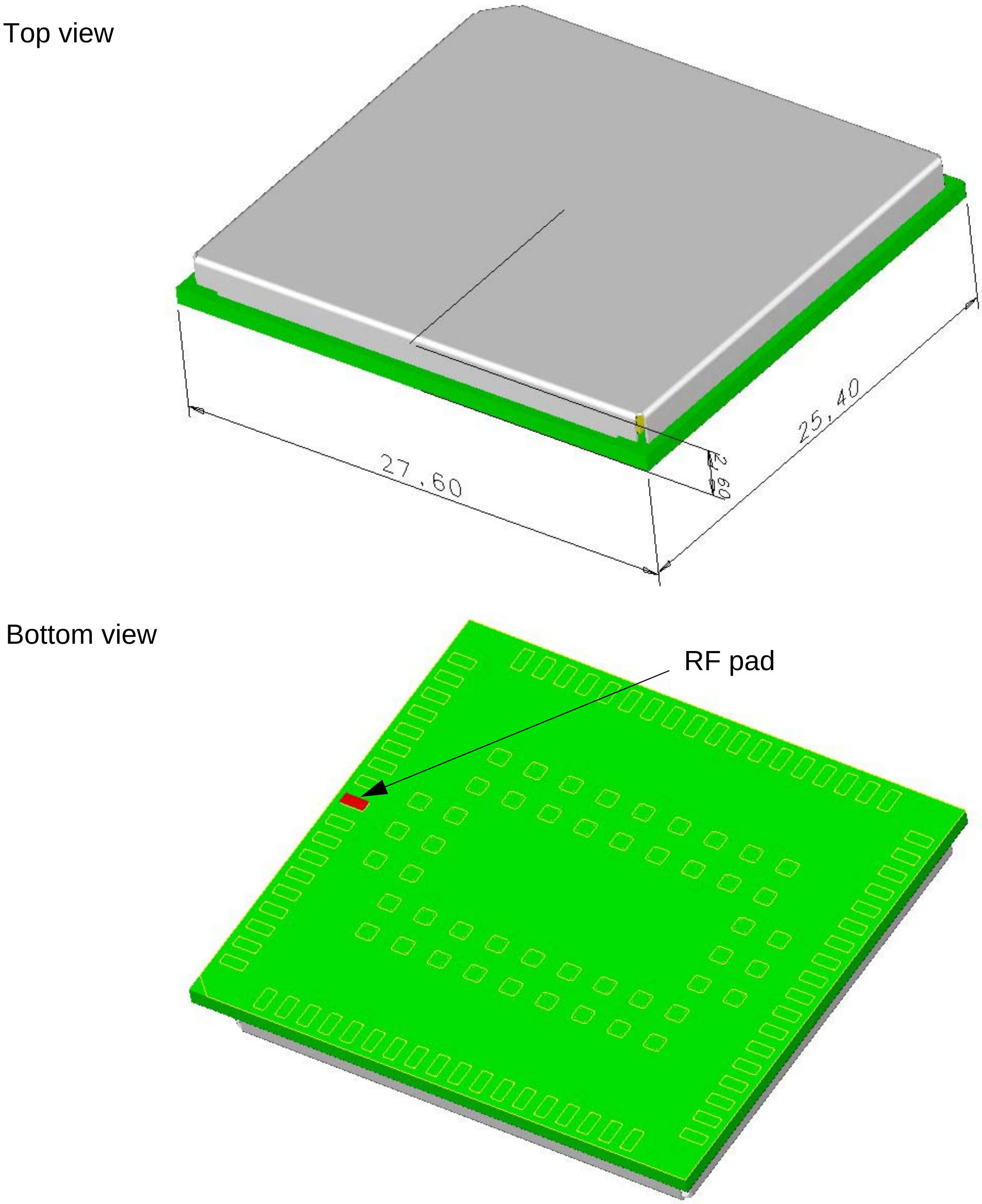


Figure 51: BGS8– top and bottom view

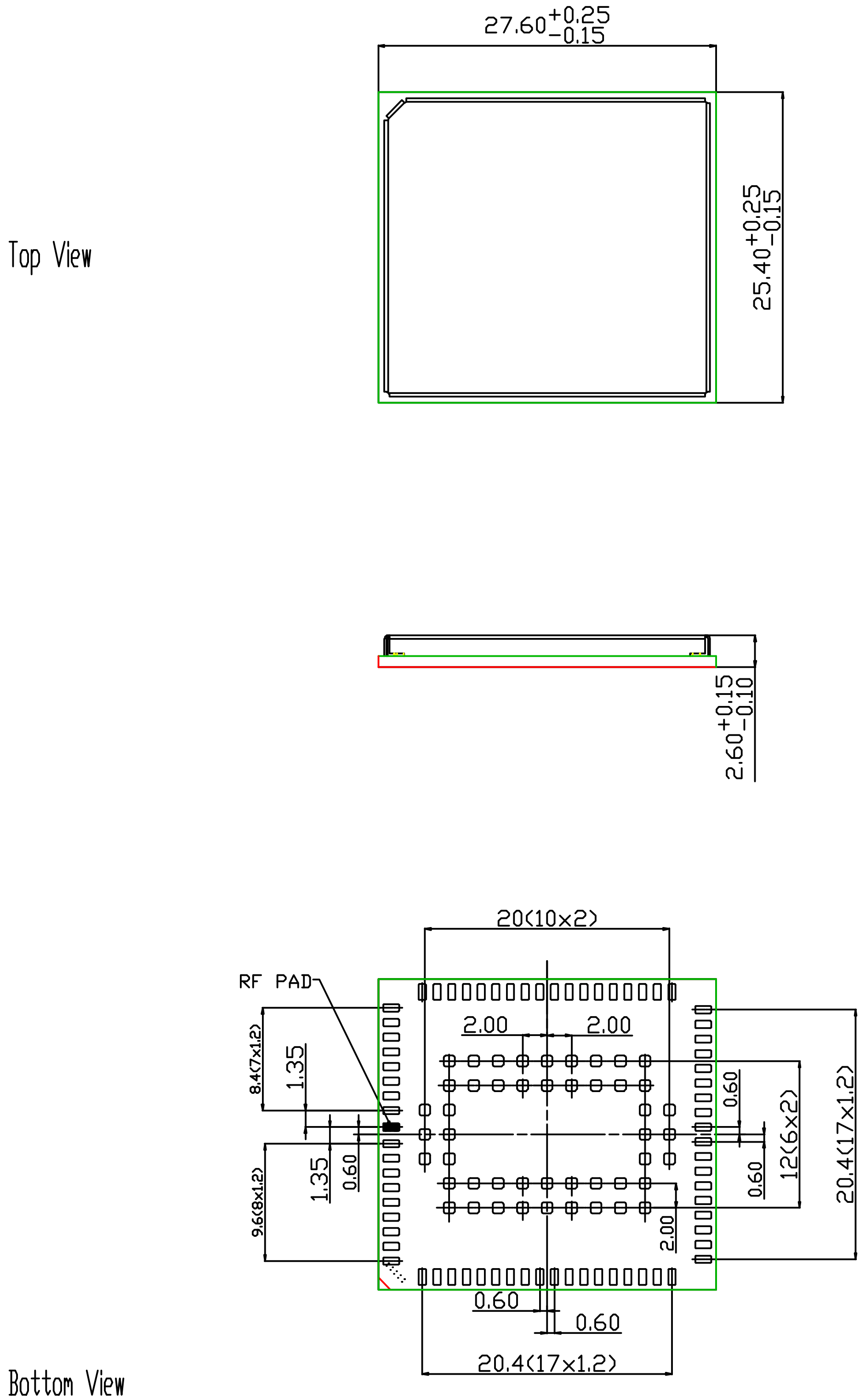


Figure 52: Dimensions of BGS8 (all dimensions in mm)

4.2 Mounting BGS8 onto the Application Platform

This section describes how to mount BGS8 onto the PCBs, 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].

Note: To avoid short circuits between signal tracks on an external application's PCB and various markings at the bottom side of the module, it is recommended not to route the signal tracks on the top layer of an external PCB directly under the module, or at least to ensure that signal track routes are sufficiently covered with solder resist.

4.2.1 SMT PCB Assembly

4.2.1.1 Land Pattern and Stencil

The land pattern and stencil design as shown below is based on Gemalto 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 53 reflects the module's pad layout, including signal pads and ground pads (for pad assignment see Section 2.1.1).

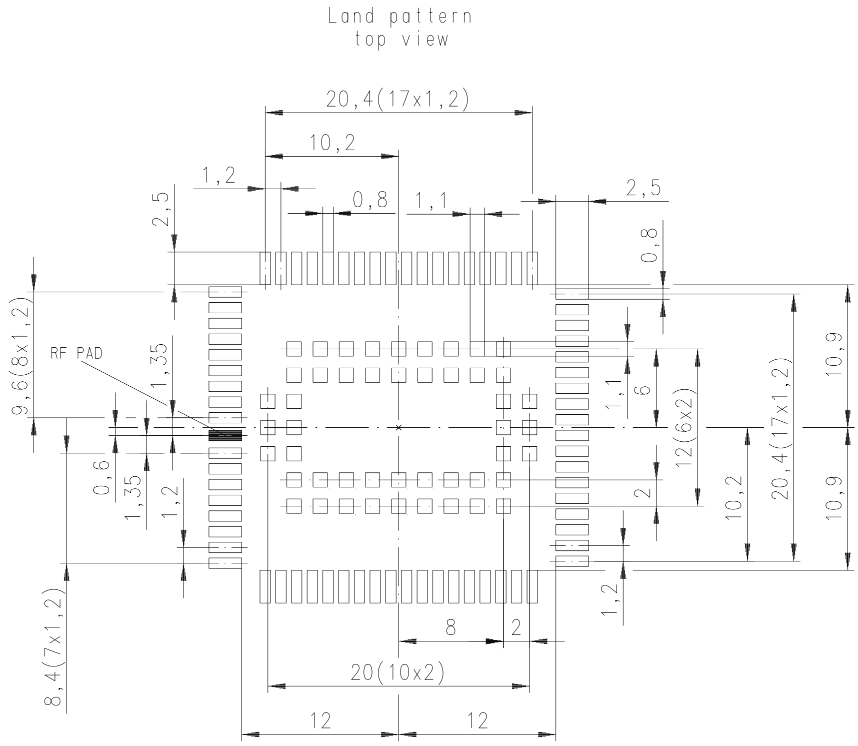


Figure 53: Land pattern (top view)

The stencil design illustrated in Figure 54 and Figure 55 is recommended by Gemalto M2M as a result of extensive tests with Gemalto M2M Daisy Chain modules.

The central ground pads are primarily intended for stabilizing purposes, and may show some more voids than the application interface pads at the module's rim. This is acceptable, since they are electrically irrelevant.

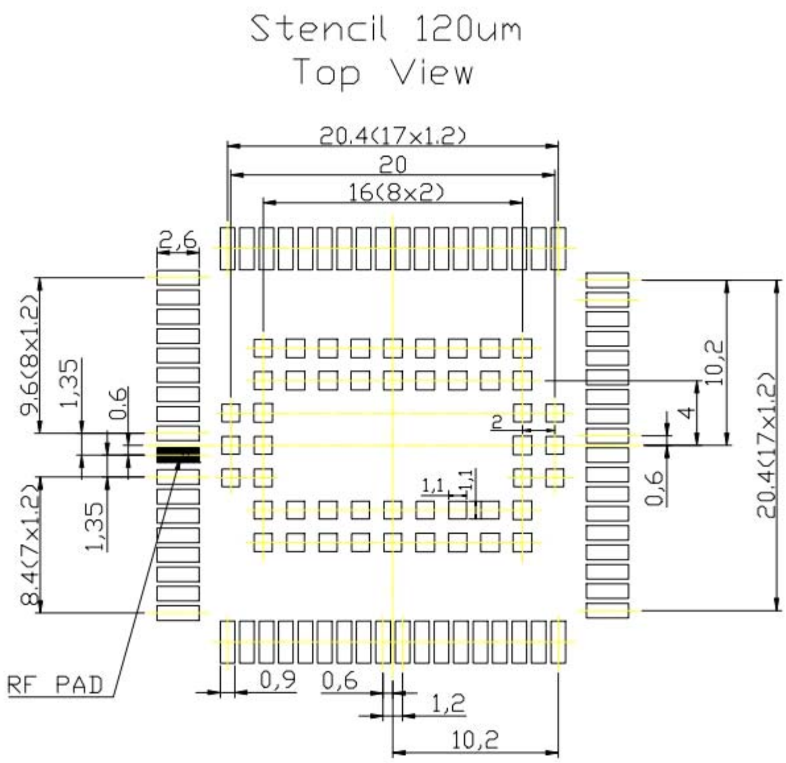


Figure 54: Recommended design for 110µm micron thick stencil (top view)

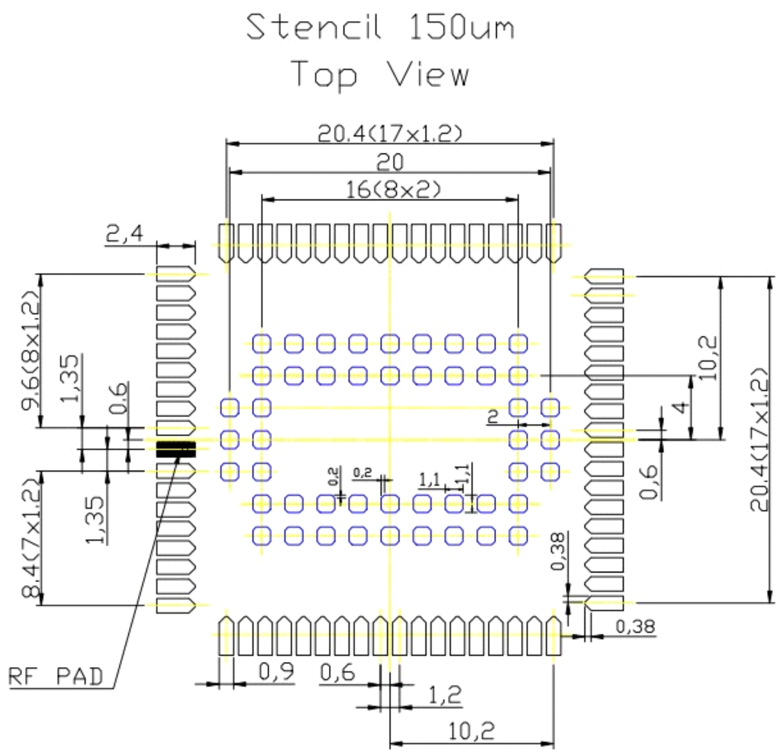


Figure 55: Recommended design for 150µm micron thick stencil (top view)

4.2.1.2 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 4.2.1.1. 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 4.2.3.

4.2.2 Moisture Sensitivity Level

BGS8 comprises components that are susceptible to damage induced by absorbed moisture.

Gemalto M2M's BGS8 module 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 moisture sensitivity level (MSL) related information see Section 4.2.4 and Section 4.3.2.

4.2.3 Soldering Conditions and Temperature

4.2.3.1 Reflow Profile

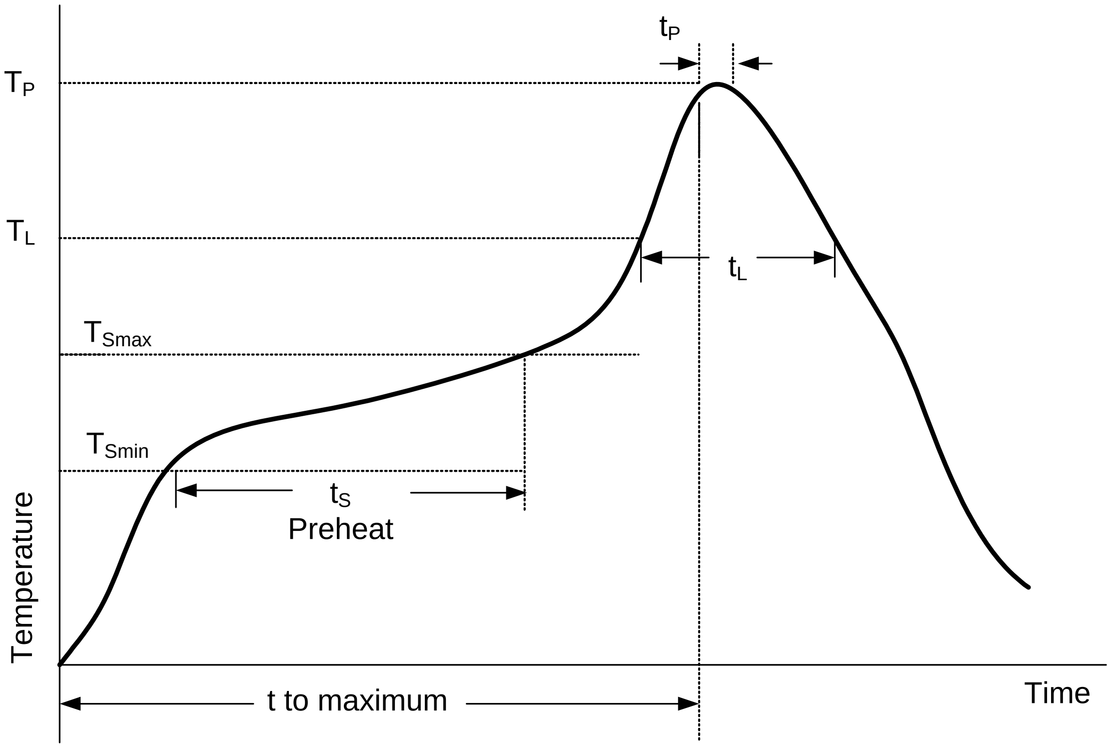


Figure 56: Reflow Profile

Table 27: Reflow temperature ratings

Profile Feature	Pb-Free Assembly
Preheat & Soak Temperature Minimum (T_{Smin}) Temperature Maximum (T_{Smax}) Time (t_{Smin} to t_{Smax}) (t_S)	 150°C 200°C 60-120 seconds
Average ramp up rate (T_{Smax} to T_P)	3K/second max.
Liquidous temperature (T_L) Time at liquidous (t_L)	217°C 60-90 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})	6 K/second max.
Time 25°C to maximum temperature	8 minutes max.

4.2.3.2 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.

BGS8 is specified for one soldering cycle only. Once BGS8 is removed from the application, the module will very likely be destroyed and cannot be soldered onto another application.

4.2.4 Durability and Mechanical Handling

4.2.4.1 Storage Conditions

BGS8 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 28: 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, IEC 60068-2-2 Bb 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

4.2.4.2 Processing Life

BGS8 must be soldered to an application within 72 hours after opening the moisture barrier bag (MBB) 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%.

4.2.4.3 Baking

Baking conditions are specified on the moisture sensitivity label attached to each MBB (see Figure 61 for details):

- It is *not necessary* to bake BGS8, if the conditions specified in Section 4.2.4.1 and Section 4.2.4.2 were not exceeded.
- It is *necessary* to bake BGS8, if any condition specified in Section 4.2.4.1 and Section 4.2.4.2 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.

4.2.4.4 Electrostatic Discharge

Electrostatic discharge (ESD) 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 3.8 for further information on electrostatic discharge.

4.3 Packaging

4.3.1 Tape and Reel

The single-feed tape carrier for BGS8 is illustrated in Figure 57. The figure also shows the proper part orientation. The tape width is 44mm and the BGS8 modules are placed on the tape with a 32-mm pitch. The reels are 330mm in diameter with a core diameter of 100mm. Each reel contains 500 modules.

4.3.1.1 Orientation

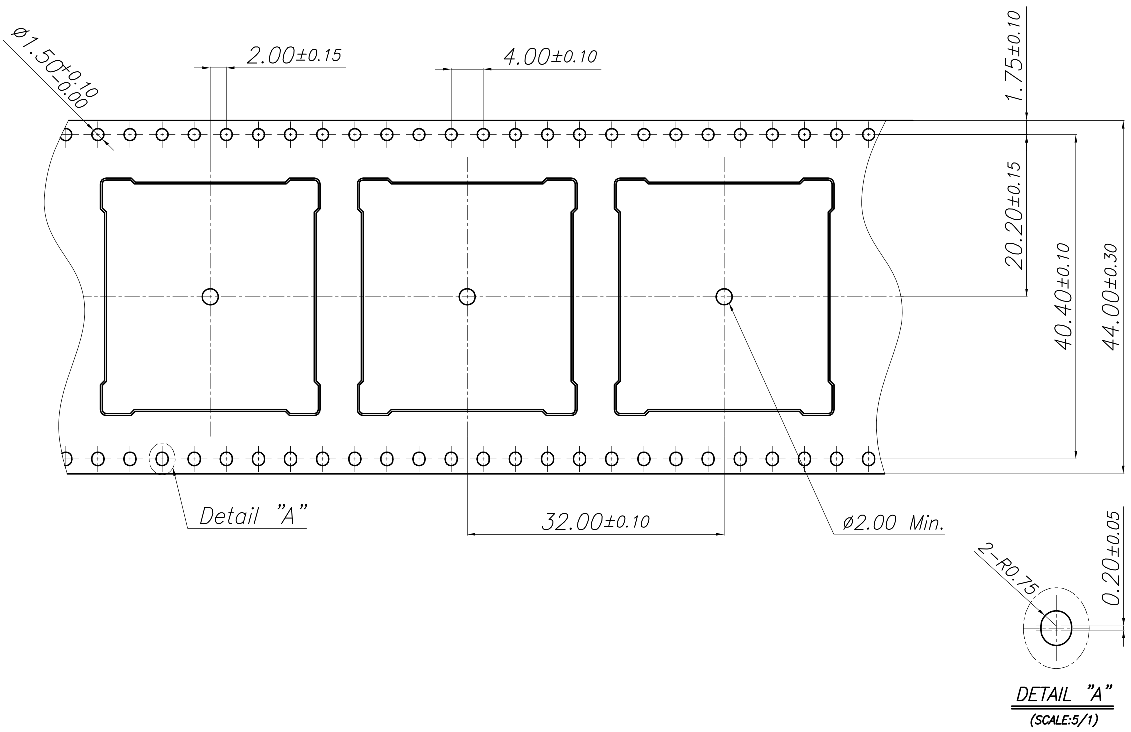


Figure 57: Carrier tape

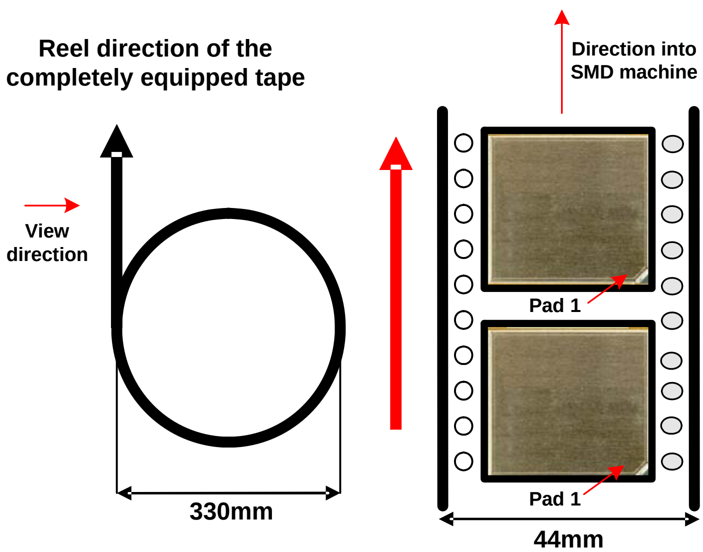


Figure 58: Reel direction

4.3.1.2 Barcode Label

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

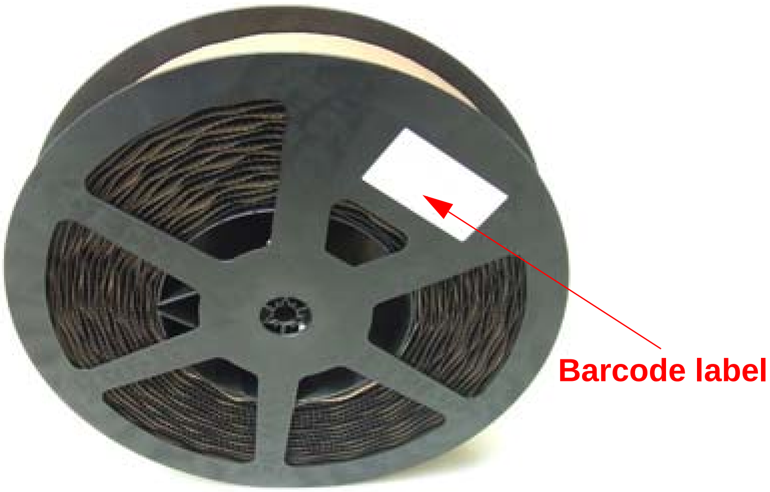


Figure 59: Barcode label on tape reel

4.3.2 Shipping Materials

BGS8 is distributed in tape and reel carriers. The tape and reel carriers used to distribute BGS8 are packed as described below, including the following required shipping materials:

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

4.3.2.1 Moisture Barrier Bag

The tape reels are stored inside a moisture barrier bag (MBB), together with a humidity indicator card and desiccant pouches - see Figure 60. 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 BGS8 modules from moisture exposure. It should not be opened until the devices are ready to be soldered onto the application.

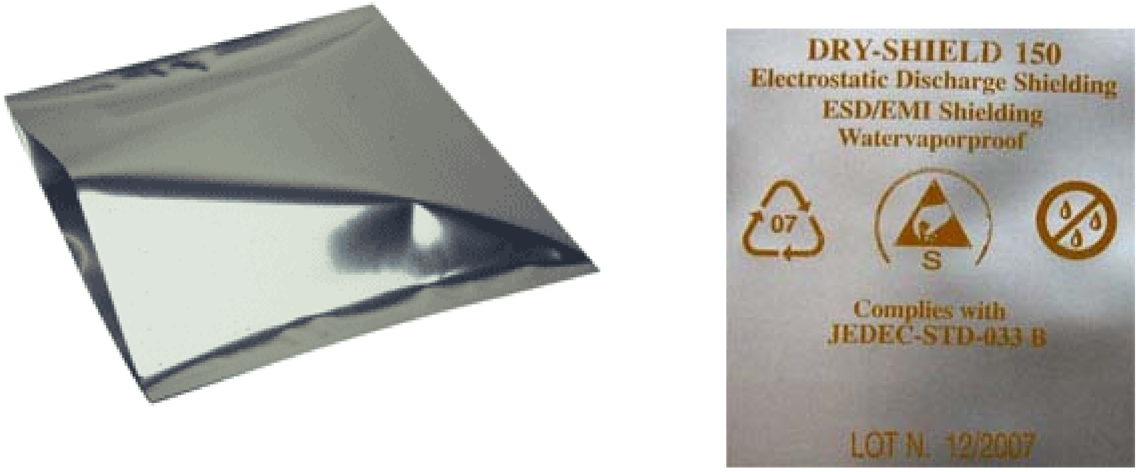


Figure 60: Moisture barrier bag (MBB) with imprint

The label shown in Figure 61 summarizes requirements regarding moisture sensitivity, including shelf life and baking requirements. It is attached to the outside of the moisture barrier bag.

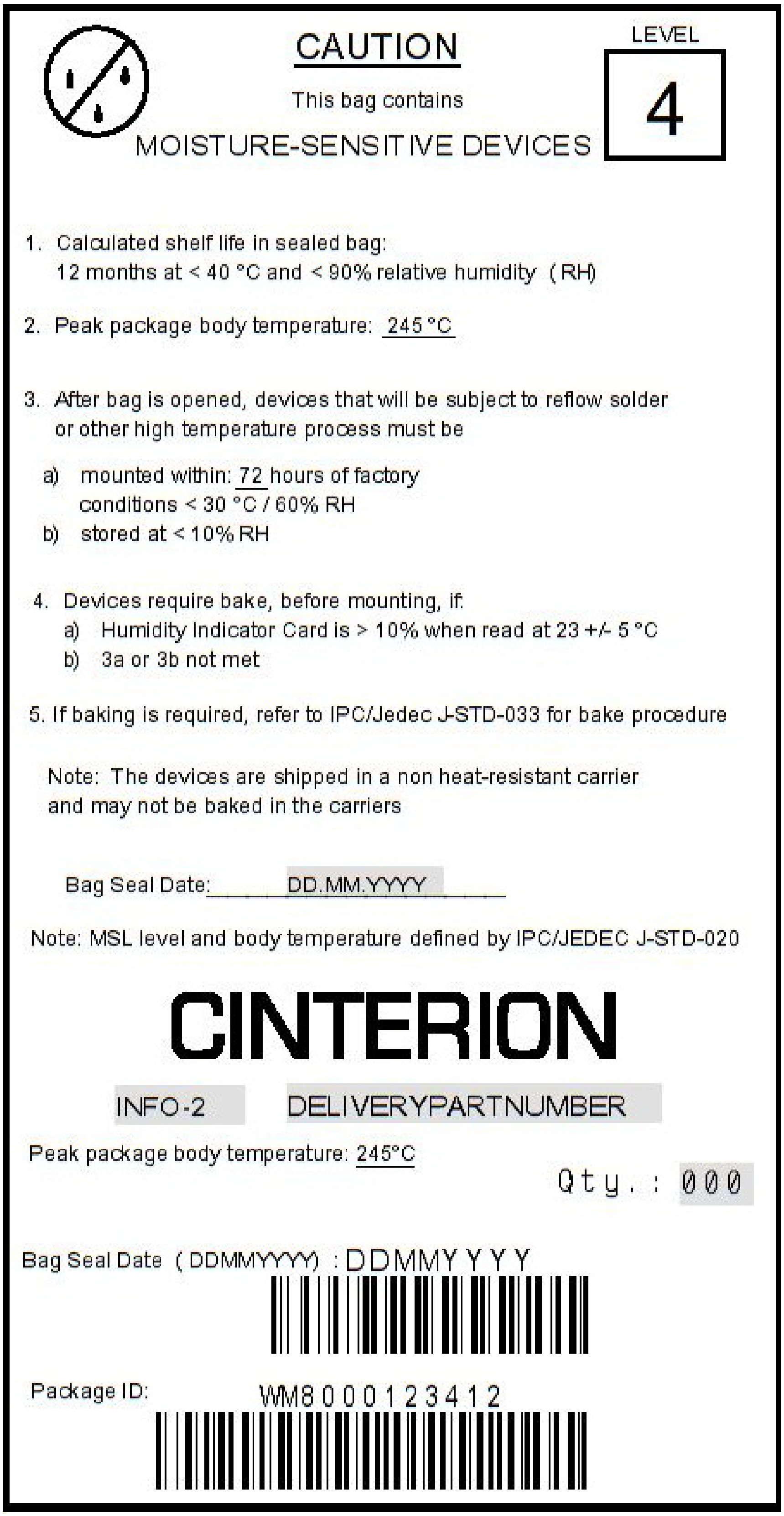


Figure 61: Moisture Sensitivity Label

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 62. If the components have been exposed to moisture above the recommended limits, the units will have to be rebaked.

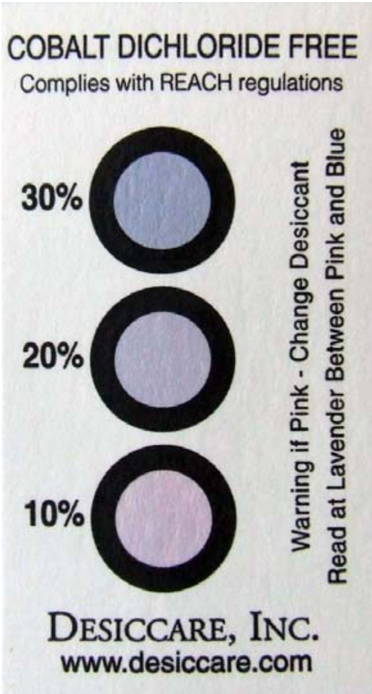


Figure 62: Humidity Indicator Card - HIC

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

4.3.2.2 Transportation Box

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

4.3.3 Trays

If small module quantities are required, e.g., for test and evaluation purposes, BGS8 may be distributed in trays (for dimensions see Figure 63). The small quantity trays are an alternative to the single-feed tape carriers normally used. However, the trays are not designed for machine processing. They contain modules to be (hand) soldered onto an external application (for information on hand soldering see [3]).

Trays are packed and shipped in the same way as tape carriers, including a moisture barrier bag with desiccant and humidity indicator card as well as a transportation box (see also Section 4.3.2).

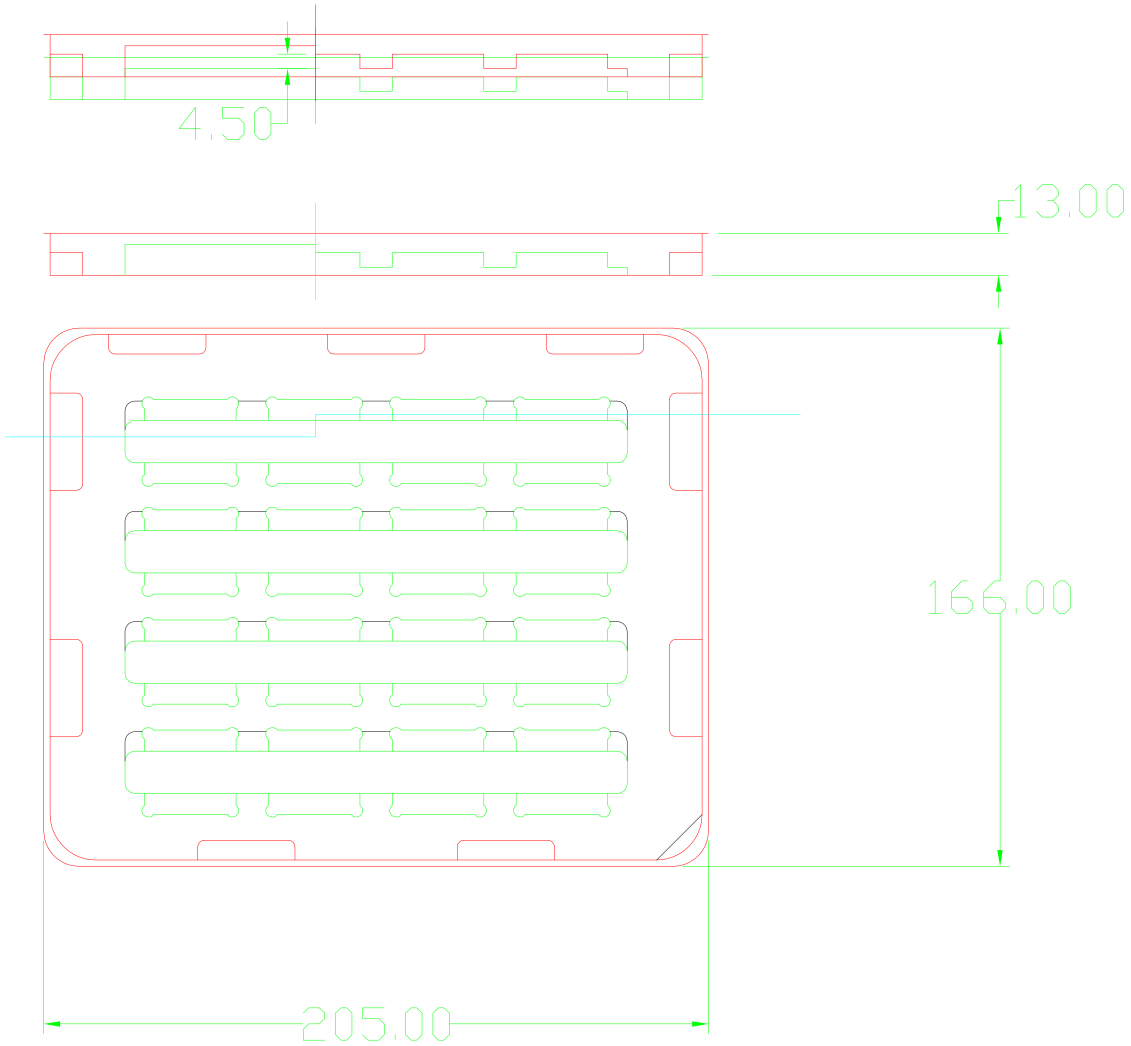


Figure 63: Tray dimensions

5 Regulatory and Type Approval Information

5.1 Directives and Standards

BGS8 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 "BGS8 Hardware Interface Description".[1]

Table 29: Directives

1999/05/EC	Directive of the European Parliament and of the council of 9 March 1999 on radio equipment and telecommunications terminal equipment and the mutual recognition of their conformity (in short referred to as R&TTE Directive 1999/5/EC). The product is labeled with the CE conformity mark CE 0682
2002/95/EC (RoHS 1) 2011/65/EC (RoHS 2)	Directive of the European Parliament and of the Council of 27 January 2003 (and revised on 8 June 2011) on the restriction of the use of certain hazardous substances in electrical and electronic equipment (RoHS)

Table 30: Standards of North American type approval

CFR Title 47	Code of Federal Regulations, Part 22 and Part 24 (Telecommunications, PCS); US Equipment Authorization FCC
OET Bulletin 65 (Edition 97-01)	Evaluating Compliance with FCC Guidelines for Human Exposure to Radiofrequency Electromagnetic Fields
UL 60 950-1	Product Safety Certification (Safety requirements)
NAPRD.03 V5.20	Overview of PCS Type certification review board Mobile Equipment Type Certification and IMEI control PCS Type Certification Review board (PTCRB)
RSS132 (Issue2) RSS133 (Issue5)	Canadian Standard

Table 31: Standards of European type approval

3GPP TS 51.010-1	Digital cellular telecommunications system (Release 7); Mobile Station (MS) conformance specification;
ETSI EN 301 511 V9.0.2	Global System for Mobile communications (GSM); Harmonized standard for mobile stations in the GSM 900 and DCS 1800 bands covering essential requirements under article 3.2 of the R&TTE directive (1999/5/EC)
GCF-CC V3.55	Global Certification Forum - Certification Criteria
ETSI EN 301 489-01 V1.9.2	Electromagnetic Compatibility and Radio spectrum Matters (ERM); Electromagnetic Compatibility (EMC) standard for radio equipment and services; Part 1: Common Technical Requirements

1. Manufacturers of applications which can be used in the US shall ensure that their applications have a PTCRB approval. For this purpose they can refer to the PTCRB approval of the respective module.

Table 31: Standards of European type approval

ETSI EN 301 489-07 V1.3.1	Electromagnetic Compatibility and Radio spectrum Matters (ERM); Electromagnetic Compatibility (EMC) standard for radio equipment and services; Part 7: Specific conditions for mobile and portable radio and ancillary equipment of digital cellular radio telecommunications systems (GSM and DCS)
EN 60950-1:2006+ A11:2009+A1_2010+ AC: 2011+A12:2011	Safety of information technology equipment

Table 32: Requirements of quality

IEC 60068	Environmental testing
DIN EN 60529	IP codes

Table 33: 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 Table 34 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 34: 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)	X	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.

5.2 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 BGS8 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 and US markets the relevant directives are mentioned below. It is the responsibility of the manufacturer of the final product to verify whether or not further standards, recommendations or directives are in force outside these areas.

Products intended for sale on US markets

ES 59005/ANSI C95.1	Considerations for evaluation of human exposure to Electromagnetic Fields (EMFs) from Mobile Telecommunication Equipment (MTE) in the frequency range 30MHz - 6GHz

Products intended for sale on European markets

EN 50360	Product standard to demonstrate the compliance of mobile phones with the basic restrictions related to human exposure to electromagnetic fields (300MHz - 3GHz)

IMPORTANT:
Manufacturers of portable applications based on BGS8 modules are required to have their final product certified and apply for their own FCC Grant and Industry Canada Certificate related to the specific portable mobile (see also Section 5.4).

5.3 Reference Equipment for Type Approval

The Gemalto M2M reference setup submitted to type approve BGS8 is shown in the following figure[1]. The module (i.e., the evaluation module) is connected to the DSB75 via a special adapter and either mounted directly onto the adapter or connected using a flex cable:

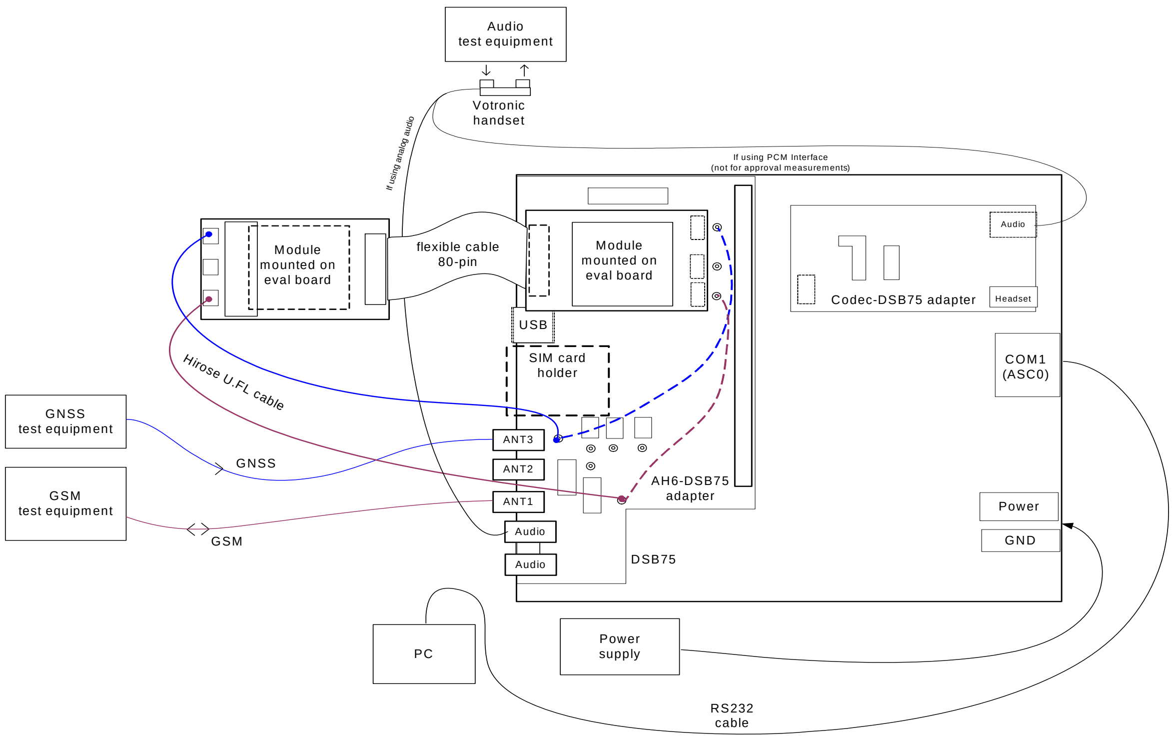


Figure 64: Reference equipment for Type Approval

1. For RF performance tests a mini-SMT/U.FL to SMA adapter with attached 6dB coaxial attenuator is chosen to connect the module directly to the GSM/UMTS/GNSS test equipment instead of employing the SMA antenna connectors on the BGS8-DSB75 adapter as shown in Figure 64. The following products are recommended:
Hirose SMA-Jack/U.FL-Plug conversion adapter HRMJ-U.FLP(40)
(for details see see http://www.hirose-connectors.com/ or http://www.farnell.com/
Aeroflex Weinschel Fixed Coaxial Attenuator Model 3T/4T
(for details see http://www.aeroflex.com/ams/weinschel/pdfiles/wmod3&4T.pdf)

5.4 Compliance with FCC and IC Rules and Regulations

The Equipment Authorization Certification for the Gemalto M2M reference application described in Section 5.3 will be registered under the following identifiers:

FCC Identifier: QIPBGS8
Industry Canada Certification Number: 7830A-BGS8
Granted to Gemalto M2M GmbH

Manufacturers of mobile or fixed devices incorporating BGS8 modules are authorized to use the FCC Grants and Industry Canada Certificates of the BGS8 modules for their own final products according to the conditions referenced in these documents. In this case, an FCC/ IC label of the module shall be visible from the outside, or the host device shall bear a second label stating "Contains FCC ID: QIPBGS8", and accordingly “Contains IC: 7830A-BGS8“.

The integration is limited to fixed or mobile categorised host devices, where a separation distance between the antenna and any person of min. 20cm can be assured during normal operating conditions. For mobile and fixed operation configurations the antenna gain, including cable loss, must not exceed the limits 6.67dBi (850MHz) and 1.41dBi (1900MHz).

IMPORTANT:
Manufacturers of portable applications incorporating BGS8 modules are required to have their final product certified and apply for their own FCC Grant and Industry Canada Certificate related to the specific portable mobile. This is mandatory to meet the SAR requirements for portable mobiles (see Section 5.2 for detail).

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

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

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

This Class B digital apparatus complies with Canadian ICES-003.

If Canadian approval is requested for devices incorporating BGS5 modules the above note will have to be provided in the English and French language in the final user documentation. Manufacturers/OEM Integrators must ensure that the final user documentation does not contain any information on how to install or remove the module from the final product.

6 Document Information

6.1 Revision History

Preceding document: "BGS8 Hardware Interface Description" Version 03.001
New document: "BGS8 Hardware Interface Description" Version **03.001a**

Chapter	What is new
5.4	Revised maximum antenna gain for 1900MHz.

Preceding document: "BGS8 Hardware Interface Description" Version 02.109a
New document: "BGS8 Hardware Interface Description" Version 03.001

Chapter	What is new
2.4.1	Added further sample level converter type to Figure 38.
3.2.1.1, 3.2.1.2	Replaced Figure 39 showing IGT circuit sample. Revised IGT active state again from low --> high; see Figure 40/Figure 41 and also Table 2).
3.6.1	Updated power supply ratings listed in Table 21.
4.2.1.1	Revised Figure 53 showing land pattern.
5.4	Added maximum antenna gain.
5.3	Revised Figure 64 showing reference approval design.

Preceding document: "BGS8 Hardware Interface Description" Version 02.109
New document: "BGS8 Hardware Interface Description" Version 02.109a

Chapter	What is new
Throughout document	Introduced $BATT+_{BB}$ and $BATT+_{RF}$ as distinct names for the BATT+ power supply lines for general power management (BB) and the GSM power amplifier (RF).
2.1.2	Added analog audio lines‘ characteristics to Table 2. Revised GPIO characteristics.
2.1.3	Revised RING0 startup behavior shown in Figure 5.
2.1.5.3	Revised audio mode 6 characteristics listed in Table 6.
2.1.8	Revised Figure 17 and Figure 18 to show internal 5k pull up for I2CCLK.
2.1.10	Revised GPIO8 and GPIO11 startup behavior shown in Figure 21.
2.3.3	Completed GNSS properties listed in Table 14.
2.4.1	Removed duplicate section “Blocking against RF on Interface Lines“.
3.2.1.1, 3.2.1.2	Replaced Figure 39 showing IGT circuit sample. Revised IGT active state from (high --> low; see Figure 40/Figure 41 and also Table 2).
3.2.3	Revised signal states for some GPIOs in Table 16. Added reserved GPIO8 line.
3.2.5.2, 3.2.5.3	Revised sections to include the actual voltage shutdown thresholds.
3.3	Revised description to mention class change threshold.

3.6.1	Completed power supply ratings listed in Table 20 and Table 21.
3.6.3	New section Measuring the Supply Voltage (VBATT+).
3.6.4	Added reference to description of voltage shutdown thresholds.

New document: "BGS8 Hardware Interface Description" Version 02.109

Chapter	What is new
--	Initial document setup.

6.2 Related Documents

[1] BGS8 AT Command Set
[2] BGS8 Release Note
[3] Application Note 48: SMT Module Integration

6.3 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	Asynchronous Controller. Abbreviation used for serial interface of BGS8
B	Thermistor Constant
BER	Bit Error Rate
BTS	Base Transceiver Station
CB or CBM	Cell Broadcast Message
CE	Conformité Européenne (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
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. Gemalto M2M module)
DCS 1800	Digital Cellular System, also referred to as PCN

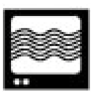
Abbreviation	Description
DRX	Discontinuous Reception
DSB	Development Support Box
DSP	Digital Signal Processor
DSR	Data Set Ready
DTE	Data Terminal Equipment (typically computer, terminal, printer or, for example, GSM application)
DTR	Data Terminal Ready
DTX	Discontinuous Transmission
EFR	Enhanced Full 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
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
Mbps	Mbits per second
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

Abbreviation	Description
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
RLS	Radio Link Stability
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 Accoustic Wave
SELV	Safety Extra Low Voltage
SIM	Subscriber Identification Module
SMD	Surface Mount Device
SMS	Short Message Service
SMT	Surface Mount Technology
SPI	Serial Peripheral Interface
SRAM	Static Random Access Memory
TDMA	Time Division Multiple Access
TE	Terminal Equipment, also referred to as DTE
TLS	Transport Layer Security
Tx	Transmit Direction

Abbreviation	Description
UART	Universal asynchronous receiver-transmitter
URC	Unsolicited Result Code
USSD	Unstructured Supplementary Service Data
VSWR	Voltage Standing Wave Ratio

6.4 Safety Precaution Notes

The following safety precautions must be observed during all phases of the operation, usage, service or repair of any cellular terminal or mobile incorporating BGS8. 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 hand-held 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 hand-held terminal or mobile, park the vehicle. Speakerphones must be installed by qualified personnel. Faulty installation or operation can constitute a safety hazard.
	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.

7 Appendix

7.1 List of Parts and Accessories

Table 35: List of parts and accessories

Description	Supplier	Ordering information
BGS8	Gemalto M2M	Standard module Gemalto M2M IMEI: Packaging unit (ordering) number: L30960-N3900-A100 Module label number: S30960-S3900-A100-1
DSB75 Evaluation Kit	Gemalto M2M	Ordering number: L36880-N8811-A100
Multi-Adapter R1 for mounting BGS8 evaluation modules onto DSB75	Gemalto M2M	Ordering number: L30960-N0010-A100
Approval adapter for mounting BGS8 evaluation modules onto DSB75	Gemalto M2M	Ordering number: L30960-N2301-A100
BGS8 Evaluation Module	Gemalto M2M	Ordering number: L30960-N3901-A100 (BGS8)
Votronic Handset	Votronic / Gemalto M2M	Gemalto M2M ordering number: L36880-N8301-A107 Votronic ordering number: HH-SI-30.3/V1.1/0 Votronic Entwicklungs- und 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 36.

Table 36: Molex sales contacts (subject to change)

Molex For further information please click: http://www.molex.com	Molex Deutschland GmbH Otto-Hahn-Str. 1b 69190 Walldorf Germany Phone: +49-6227-3091-0 Fax: +49-6227-3091-8100 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 1311, Tower B, COFCO Plaza No. 8, Jian Guo Men Nei Street, 100005 Beijing P.R. China Phone: +86-10-6526-9628 Fax: +86-10-6526-9730	Molex Singapore Pte. Ltd. 110, International Road Jurong Town, Singapore 629174 Phone: +65-6-268-6868 Fax: +65-6-265-6044	Molex Japan Co. Ltd. 1-5-4 Fukami-Higashi, Yamato-City, Kanagawa, 242-8585 Japan Phone: +81-46-265-2325 Fax: +81-46-265-2365

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 innovations 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.

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