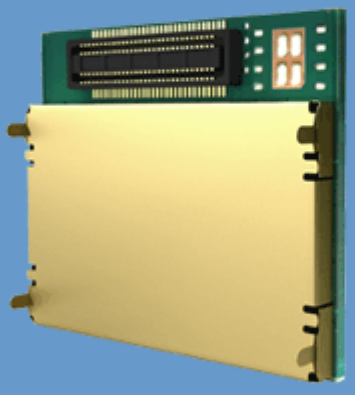
CINTERION
a Gemalto company

Hardware Interface Description

BG2-E/BG2-W



Version: 01.002
DocId: BG2_HD_v01.002

Document Name:	**BG2-E/BG2-W Hardware Interface Description**
Version:	**01.002**
Date:	**2010-11-23**
DocId:	**BG2_HD_v01.002**
Status	**Confidential / Released**
Supported Products:	**BG2-E, BG2-W**

Contents

Tables

Figures

0 Document History

Preceding document: "BG2-E/BG2-W Hardware Interface Description" Version 01.001
New document: "BG2-E/BG2-W Hardware Interface Description" Version **01.002**

Chapter	What is new
3.3.5.3	Updated description of URC behavior before overvoltage shutdown
4.2	Added note on available tools to calculate RF line arrangments.
6	Replaced Figure 42 and Figure 43. Attached archive containing zipped STEP file to the PDF.
6.2	Revised section and modified Figure 44 to include round mounting holes.
9.2	Revised section to include mounting clip data sheet.

Preceding document: "BG2-E/BG2-W Hardware Interface Description" Version 01.000
New document: "BG2-E/BG2-W Hardware Interface Description" Version 01.001

Chapter	What is new
3.3.1.2	Modified Figure 7.

Preceding document: "BG2-E/BG2-W Hardware Interface Description" Version 00.790a
New document: "BG2-E/BG2-W Hardware Interface Description" Version 01.000

Chapter	What is new
1.3.1	Updated RSS and GCF issues.

Preceding document: "BG2-E/BG2-W Hardware Interface Description" Version 00.790
New document: "BG2-E/BG2-W Hardware Interface Description" Version 00.790a

Chapter	What is new
5.6	Updated values for average supply current for SLEEP mode GSM/GPRS @ DRX = 9.
6.2	Revised section: Mounting BG2-E/BG2-W onto the Application Platform.
9.2	New section: Mounting Clip.

Preceding document: "BG2-E/BG2-W Hardware Interface Description" Version 00.781
New document: "BG2-E/BG2-W Hardware Interface Description" Version 00.790

Chapter	What is new
2.1, 5.2	Added new maximum operating temperatures.
3.3.1	Revised structure: Restart behavior is now included in a separate section 3.3.2, removed previous section on startup using BATT+ (now included in 3.3.1.1).

Chapter	What is new
3.3.1.1	Figure 6: Removed ON timing period of 400ms to start up module. Revised introductory remarks. Added note on ON signal remaining active high after module switch on. Added note that no data must be send via ASC0 until the interface is ready to receive information.
3.3.2.1	New section Restart BG2-E/BG2-W via AT+CFUN Command.
3.3.1.3	Changed description of Alarm mode.
3.3.5.3	Revised description since overvoltage URCs are available.
3.6	Transition from Alarm mode to Normal mode to be done with AT+CFUN=x,1.
3.11.2	Added recommendation for low pass filter for line output connection.
3.12	Added note that GPIO9/I2CDAT requires external pull-up resistor.
5.5	Table 28: Additional electrical characteristics for VDDLP line.
5.6	Updated Table 29: Power supply ratings.
6.3	Changed ordering number for mating B2B header on application: Molex 53885-0608.
7	Added note on maximum cable length to be used with BG2-E/BG2-W. Revised figure showing sample application.
7.1	Added new section on EMI measures.

Preceding document: "BG2-E/BG2-W Hardware Interface Description" Version 00.654
New document: "BG2-E/BG2-W Hardware Interface Description" Version 00.781

Chapter	What is new
5.5	Revised electrical characteristics for EPP/EPN. Revised electrical characteristics and comment for GPIO9 and GPIO10.
5.7.3	Updated voiceband characteristics listed in Table 31.
5.7.4	Updated voiceband receive path characteristics listed in Table 32.
5.7.5	Updated voiceband transmit path characteristics listed in Table 33.
8.2	Added FCC and IC identifiers.

Preceding document: "BG2-E Hardware Interface Description" Version 00.250
New document: "BG2-E/BG2-W Hardware Interface Description" Version 00.654

Chapter	What is new
--	Updated document identifier and version number.

Preceding document: "BG2-E Hardware Interface Description" Version 00.110
New document: "BG2-E/BG2-W Hardware Interface Description" Version 00.250

Chapter	What is new
3.5	Added remarks on power saving.
3.7	Revised remarks on usage of batteries to backup RTC.
3.8	Updated Figure 13. Only V180 can be used for CCIN.

Chapter	What is new
5.5	Updated electrical charcteristics for GPIO9 and GPIO10 lines.
5.7.3	Set TBD. for audio mode characteristics listed in Table 31.
6.1	Updated Figure 43 illustrating module dimensions.
6.2	New section describing how to mount module onto external application's PCB.
6.3	Updated serial number for board-to-board connector on module PCB.

Preceding document: "BG2-E Hardware Interface Description" Version 00.001
New document: "BG2-E/BG2-W Hardware Interface Description" Version 00.110

Chapter	What is new
Throughout document	Added new quad band product variant: BG2-W.
2.1	Updated list of key featues.
2.3	Updated Figure 2.
3	Improved figures showing timing for application interfaces.
3.2	Added switching regulator.
3.2.1	Changed remark about when the module switches off. Changed example.
3.3.2	Corrected signal names.
3.3.1.2	New section on how to suppress unintentional pulses on ON signal line.
3.3.5.2	Removed remark on battery.
3.3.5.3	Changed description on overvoltage shutdown.
3.8	Figure 13: Replaced 100nF condensator with 220nF condensator. Cable length between B2B and SIM card holder changed to 100mm.
3.9, 3.10	Changed description of pull-up and pull down in startup behavior diagrams.
3.12	Revised description of GPIOs. Changed startup behavior diagram.
3.13	Changed description of startup behavior for I^2C.
3.14	More detailed description of PWM interfaces.
3.15	Revised description on how to connect and configure status LED.
3.17	New section on how to implement a power indication circuit.
4.2	Revised section to clarify antenna line arrangements.
5.2	Added typical temperature +25°C. Removed battery NTC.
5.5	Mapped pin 41 to AGND. Improved descriptions.
7	Corrected mapping of several GPIOs.
8.1	Updated reference setup.

New document: "BG2-E Hardware Interface Description" Version 00.001

Chapter	What is new
--	Initial document setup.

1 Introduction

This document[1] describes the hardware of the BG2-E/BG2-W module that connects to the cellular device application and the air interface. It helps you quickly retrieve interface specifications, electrical and mechanical details and information on the requirements to be considered for integrating further components.

1.1 Related documents

[1] BG2-E/BG2-W AT Command Set
[2] BG2-E/BG2-W Release Notes

Prior to using the BG2-E/BG2-W modules or upgrading to a new firmware release, please carefully read the latest product information.

For further information visit the Cinterion Wireless Modules Website:
http://www.cinterion.com

[1] The document is effective only if listed in the appropriate Release Notes as part of the technical documentation delivered with your Cinterion Wireless Modules product.

1.2 Terms and Abbreviations

Abbreviation	Description
ADC	Analog-to-Digital Converter
ANSI	American National Standards Institute
ARP	Antenna Reference Point
ASC0/ASC1	Asynchronous Serial Controller. Abbreviations used for first and second serial interface of BG2-E/BG2-W
ASIC	Application Specific Integrated Circuit
B	Thermistor Constant
B2B	Board-to-board connector
BER	Bit Error Rate
BTS	Base Transceiver Station
CB or CBM	Cell Broadcast Message
CE	Conformité Européene (European Conformity)
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. GSM module)
DCS 1800	Digital Cellular System, also referred to as PCN
DRX	Discontinuous Reception
DSB	Development Support Box
DSP	Digital Signal Processor
DSR	Data Set Ready
DTE	Data Terminal Equipment (typically computer, terminal, printer or, for example, GSM application)
DTR	Data Terminal Ready
DTX	Discontinuous Transmission
EFR	Enhanced Full Rate
EGSM	Enhanced GSM
EMC	Electromagnetic Compatibility
ESD	Electrostatic Discharge
ETS	European Telecommunication Standard
FCC	Federal Communications Commission (U.S.)

Abbreviation	Description
FDMA	Frequency Division Multiple Access
FR	Full Rate
GMSK	Gaussian Minimum Shift Keying
GPRS	General Packet Radio Service
GSM	Global Standard for Mobile Communications
HiZ	High Impedance
HR	Half Rate
I/O	Input/Output
IC	Integrated Circuit
IMEI	International Mobile Equipment Identity
ISO	International Standards Organization
ITU	International Telecommunications Union
kbps	kbits per second
LED	Light Emitting Diode
Li-Ion	Lithium-Ion
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
MTTF	Mean time to failure
NTC	Negative Temperature Coefficient
OEM	Original Equipment Manufacturer
PA	Power Amplifier
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
PPP	Point-to-point protocol
PSU	Power Supply Unit
R&TTE	Radio and Telecommunication Terminal Equipment
RAM	Random Access Memory

Abbreviation	Description
RF	Radio Frequency
RMS	Root Mean Square (value)
ROM	Read-only Memory
RTC	Real Time Clock
Rx	Receive Direction
SAR	Specific Absorption Rate
SAW	Surface Accoustic Wave
SELV	Safety Extra Low Voltage
SIM	Subscriber Identification Module
SMS	Short Message Service
SRAM	Static Random Access Memory
TA	Terminal adapter (e.g. GSM module)
TDMA	Time Division Multiple Access
TE	Terminal Equipment, also referred to as DTE
Tx	Transmit Direction
UART	Universal asynchronous receiver-transmitter
URC	Unsolicited Result Code
USSD	Unstructured Supplementary Service Data
VSWR	Voltage Standing Wave Ratio

1.3 Regulatory and Type Approval Information

1.3.1 Directives and Standards

BG2-E/BG2-W has been 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 "BG2-E/BG2-W Hardware Interface Description".[2]

Table 1: 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	Directive of the European Parliament and of the Council of 27 January 2003 on the restriction of the use of certain hazardous substances in electrical and electronic equipment (RoHS)

Table 2: Standards of North American type approval[1]

CFR Title 47	Code of Federal Regulations, Part 22 and Part 24 (Telecommunications, PCS); US Equipment Authorization FCC
UL 60 950-1	Product Safety Certification (Safety requirements)
NAPRD.03 V5.1	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 Standards

1. Applies for the quad band module variant BG2-W only.

Table 3: Standards of European type approval

3GPP TS 51.010-1	Digital cellular telecommunications system (Phase 2); Mobile Station (MS) conformance specification
ETSI EN 301 511 V9.0.2	Candidate Harmonized European Standard (Telecommunications series) Global System for Mobile communications (GSM); Harmonized standard for mobile stations in the GSM 900 and DCS 1800 bands covering essential requirements under article 3.2 of the R&TTE directive (1999/5/EC) (GSM 13.11 version 7.0.1 Release 1998)
GCF-CC V3.39	Global Certification Forum - Certification Criteria
ETSI EN 301 489-1 V1.8.1	Candidate Harmonized European Standard (Telecommunications series) Electro Magnetic Compatibility and Radio spectrum Matters (ERM); Electro Magnetic Compatibility (EMC) standard for radio equipment and services; Part 1: Common Technical Requirements

2. 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 3: Standards of European type approval

ETSI EN 301 489-7 V1.3.1	Candidate Harmonized European Standard (Telecommunications series) Electro Magnetic Compatibility and Radio spectrum Matters (ERM); Electro Magnetic Compatibility (EMC) standard for radio equipment and services; Part 7: Specific conditions for mobile and portable radio and ancillary equipment of digital cellular radio telecommunications systems (GSM and DCS)
EN 60950-1:2006	Safety of information technology equipment

Table 4: Requirements of quality

IEC 60068	Environmental testing
DIN EN 60529	IP codes

Table 5: 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 Cinterion Wireless Modules Hardware Interface Description. Please see Table 6 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 6: 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.

1.3.2 SAR Requirements Specific to Portable Mobiles

Mobile phones, PDAs or other portable transmitters and receivers incorporating a GSM module must be in accordance with the guidelines for human exposure to radio frequency energy. This requires the Specific Absorption Rate (SAR) of portable BG2-E/BG2-W 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[3] 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[3]

ES 59005/ANSI C95.1	Considerations for evaluation of human exposure to Electro-magnetic 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 electro-magnetic fields (300MHz - 3GHz)

1.3.3 SELV Requirements

The power supply connected to the BG2-E/BG2-W module shall be in compliance with the SELV requirements defined in EN 60950-1.

[3] Applies for the quad band module variant BG2-W only.

1.3.4 Safety Precautions

The following safety precautions must be observed during all phases of the operation, usage, service or repair of any cellular terminal or mobile incorporating BG2-E/BG2-W. 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. Cinterion Wireless Modules GmbH assumes no liability for customer failure to comply with these precautions.

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

2 Product Concept

2.1 BG2-E/BG2-W Key Features at a Glance

Feature	Implementation
General	
Frequency bands	Dual band (BG2-E): GSM 900/1800MHz Quad band (BG2-W): GSM 850/900/1800/1900MHz
GSM class	Small MS
Output power (according to Release 99, V5)	Class 4 (+33dBm ±2dB) for EGSM850 (quad band only) Class 4 (+33dBm ±2dB) for EGSM900 Class 1 (+30dBm ±2dB) for GSM1800 Class 1 (+30dBm ±2dB) for GSM1900 (quad band only)
Power supply	$3.3V \leq V_{BATT+} \leq 4.5V$
Operating temperature (board temperature)	Normal operation: -30°C to +85°C Restricted operation: -40°C to -30°C and +85°C to +90°C
Physical	Dimensions: 31mm x 26.7mm x 3mm (5.4mm with soldering tags) Weight: approx. 5g
RoHS	All hardware components fully compliant with EU RoHS Directive
GSM/GPRS features	
Data transfer	GPRS: • Multislot Class 8 (dual band) or 10 (quad band) • Full PBCCH support • Mobile Station Class B • Coding Scheme 1 – 4 CSD: • V.110, RLP, non-transparent • 2.4, 4.8, 9.6kbps • USSD PPP-stack for GPRS data transfer
SMS	Point-to-point MT and MO Cell broadcast Text and PDU mode Storage: SIM card plus 25 SMS locations in mobile equipment Transmission of SMS alternatively over CSD or GPRS. Preferred mode can be user defined.
Fax	Group 3; Class 1
Audio	Speech codecs: • Half Rate (ETS 06.20) • Full Rate (ETS 06.10) • Enhanced Full Rate (ETS 06.50 / 06.60 / 06.80) • Adaptive Multi Rate AMR Handsfree operation, echo cancellation, noise reduction, 7 different ringing tones/melodies

Feature	Implementation
Software	
AT commands	Hayes 3GPP TS 27.007, TS 27.005, Cinterion Wireless Modules
SIM Application Toolkit	Supports SAT class 3, GSM 11.14 Release 99, support of letter class “c”
Firmware update	Windows executable for update over serial interface ASC0
Interfaces	
2 serial interfaces	ASC0: • 8-wire modem interface with status and control lines, unbalanced, asynchronous • Fixed bit rates: 1,200bps to 230,400bps • Autobauding: 1,200bps to 230,400bps • Supports RTS0/CTS0 hardware handshake and software XON/XOFF flow control. ASC1: • 4-wire, unbalanced asynchronous interface • Fixed bit rates: 1,200bps to 230,000bps • Supports RTS1/CTS1 hardware handshake and software XON/XOFF flow control
Audio	1 analog interface, with microphone feeding
SIM interface	Supported SIM cards: 3V, 1.8V External SIM card reader has to be connected via interface connector (note that card reader is not part of BG2-E/BG2-W)
GPIO interface	GPIO interface with 10 GPIO lines. The GPIO interface is shared with an I^2C interface, LED signalling and PWM functionality.
Antenna	50Ω. External antenna can be connected via board-to-board connector
Module interface	60-pin board-to-board connector
Power on/off, Reset	
Power on/off	Switch-on by hardware pin ON Switch-off by AT command (AT^SMSO) Automatic switch-off in case of critical temperature and voltage conditions
Reset	Orderly shutdown and reset by AT command
Special features	
Real time clock	Timer functions via AT commands
Phonebook	SIM and phone
TTY/CTM support	Integrated CTM modem
Evaluation kit	
DSB75	DSB75 Evaluation board designed to test and type approve Cinterion Wireless Module and provide a sample configuration for application engineering. A special adapter is required to connect the module to the DSB75.

2.2 BG2-E/BG2-W System Overview

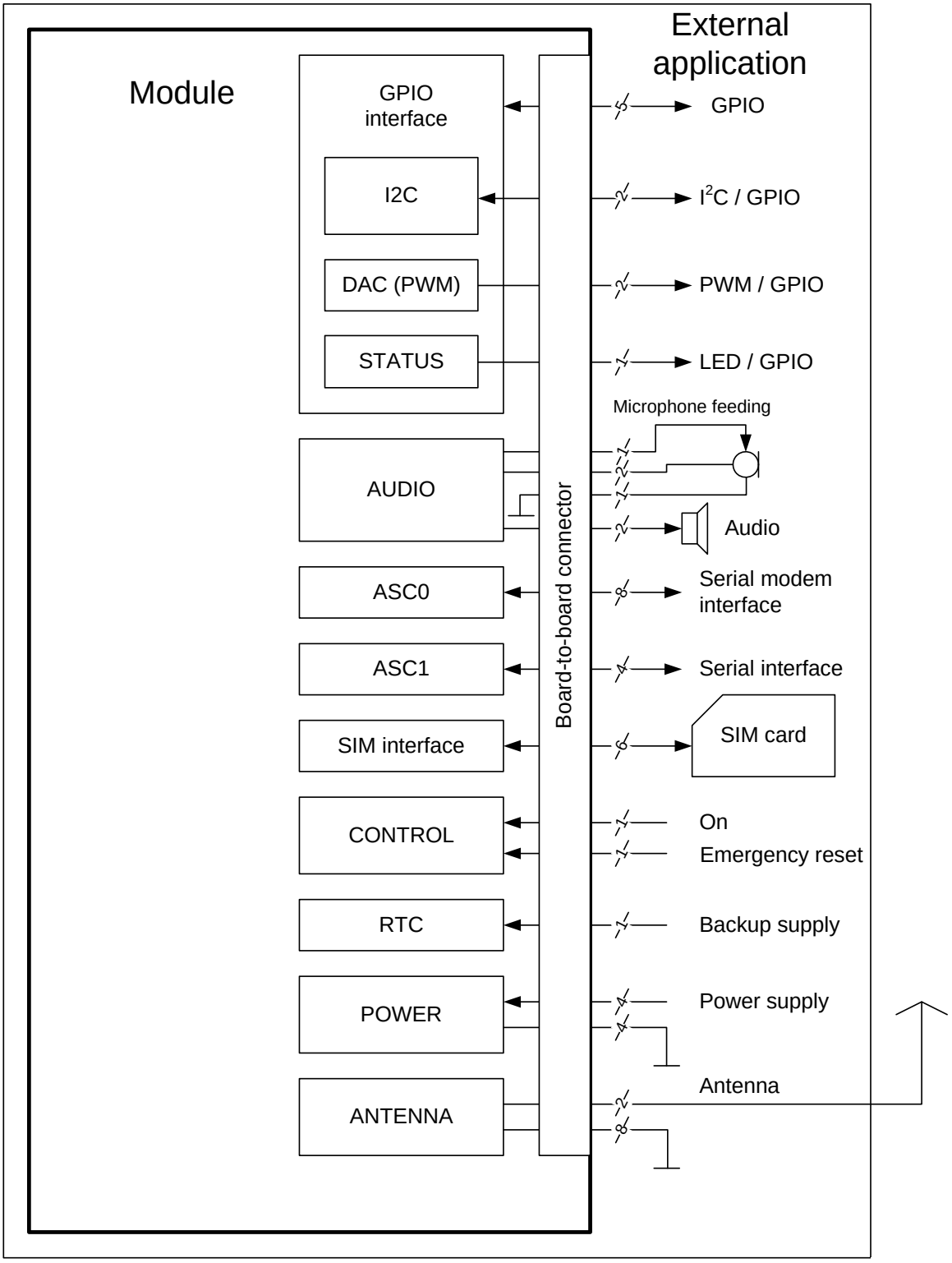


Figure 1: BG2-E/BG2-W system overview

2.3 Circuit Concept

Figure 2 shows a block diagram of the BG2-E/BG2-W module and illustrates the major functional components:

The baseband block consists of the following parts:
- GSM baseband processor and power mangement
- Stacked flash/PSRAM memory
- Application interface (60-pin board-to-board connector)

GSM RF block:
- RF transceiver (part of baseband processor)
- RF Power amplifier/front-end module inc. harmonics filtering
- Receive SAW filters

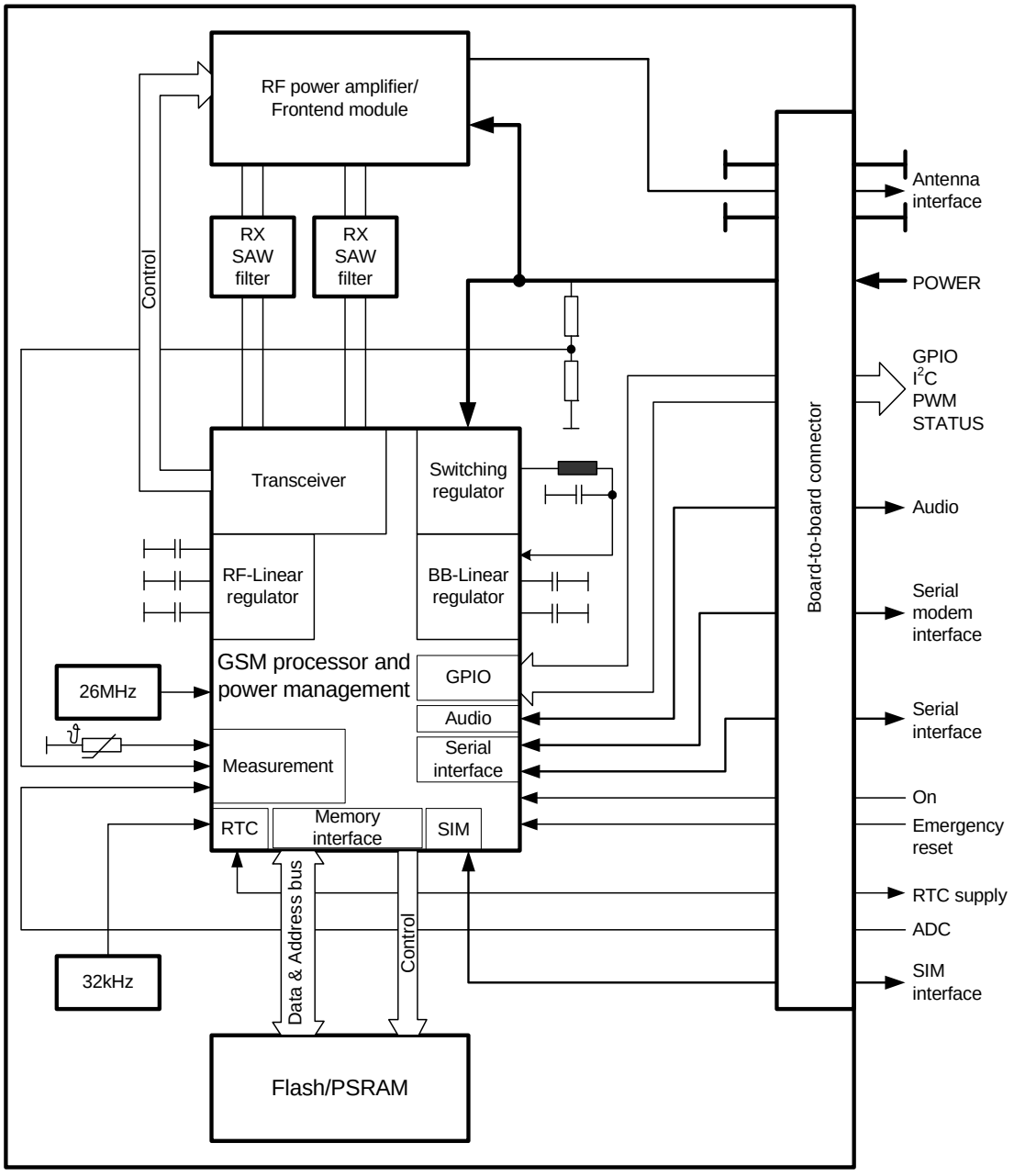


Figure 2: BG2-E/BG2-W block diagram

3 Application Interface

BG2-E/BG2-W is equipped with a 60-pin board-to-board connector that connects to the external application. The host interface incorporates several sub-interfaces described in the following sections:

- Power supply - see Section 3.2
- RTC backup - see Section 3.7
- SIM interface - see Section 3.8
- Serial interface ASC0 - see Section 3.9
- Serial interface ASC1 - see Section 3.10
- Analog audio interface - see Section 3.11
- GPIO interface - see Section 3.12
- I^2C interface - see Section 3.13
- PWM interfaces - see Section 3.14

Electrical and mechanical characteristics of the board-to-board connector are specified in Section 6.3. Information for mating connectors is included.

3.1 Operating Modes

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

Table 7: Overview of operating modes

Mode	Function	
Normal operation	GSM/GPRS SLEEP	Various powersave modes set with AT+CFUN command. Software is active to minimum extent. If the module was registered to the GSM network in IDLE mode, it 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=7and 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 and GPRS configuration (e.g. used multislot settings).
Power Down	Normal shutdown after sending the AT^SMSO command. Only a voltage regulator is active for powering the RTC. Software is not active. Interfaces are not accessible. Operating voltage (connected to BATT+) remains applied.	
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.	

See the following sections for the various options of waking up BG2-E/BG2-W and proceeding from one mode to another.

3.2 Power Supply

BG2-E/BG2-W needs to be connected to a power supply at the board-to-board connector (4 pins each BATT+ and GND).

The power supply of BG2-E/BG2-W has to be a single voltage source at BATT+. 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 GSM processor and power mangement component. This component provides the following features:

- Stabilizes the supply voltages for the GSM baseband using a switching regulator and low drop linear voltage regulators.
- Controls the power-up and -down procedures.
- Delivers, across the V180/V285 pins, a regulated voltage for an external application. This voltage is not available in Power-down mode.
- SIM switch to provide SIM power supply.

3.2.1 Minimizing Power Losses

When designing the power supply for your application please pay specific attention to power losses. Ensure that the input voltage VBATT+ never drops below 3.3V on the BG2-E/BG2-W board, not even in a GSM transmit burst where current consumption can rise (for peak values see the power supply ratings listed in Section 5.6). It should be noted that BG2-E/BG2-W switches off when exceeding this limit. Any voltage drops that may occur in a transmit burst should not exceed 400mV.

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

Example:
$V_{BattLowLimit}$ = 3.3V
$V_{DropMax}$ = 0.4V

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

The best approach to reducing voltage drops is to use a board-to-board connection as recommended, and a low impedance power source. The resistance of the power supply lines on the host board and of a battery pack (if used) should also be considered.

Note: If the application design requires an adapter cable between both board-to-board connectors, use a cable as short as possible in order to minimize power losses.

If the length of the flex cable reaches the maximum length of 100mm, this connection may cause, for example, a resistance of 30mΩ in the BATT+ line and 30mΩ in the GND line. As a result, a 1.3A transmit burst would add up to a total voltage drop of 80mV. Plus, if a battery pack is involved, further losses may occur due to the resistance across the battery lines and the internal resistance of the battery including its protection circuit.

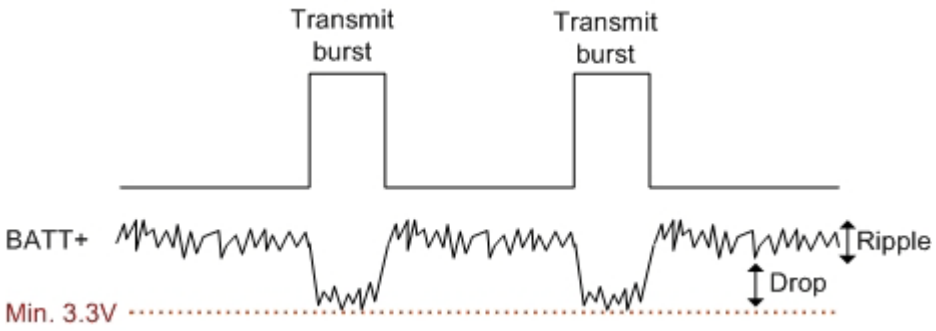


Figure 3: Power supply limits during transmit burst

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

The reference points for measuring the supply voltage V_{BATT+} on the module are BATT+ and GND as illustrated in the figure below. BATT+ can be any of the four contacts for the BATT+ pins on the board-to-board connector. GND can be the module shielding.

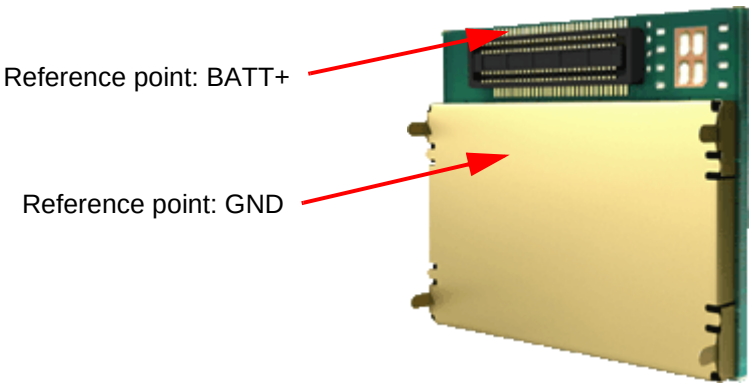


Figure 4: Position of the reference points BATT+ and GND

3.3 Power Up/Power Down Scenarios

In general, be sure not to turn on BG2-E/BG2-W while it is out of the operating range of voltage and temperature stated in Section 5.2 and Section 5.6. BG2-E/BG2-W would immediately switch off after having started and detected these inappropriate conditions.

3.3.1 Turn on BG2-E/BG2-W

BG2-E/BG2-W can be started as described in the following sections:
- Hardware driven switch on by ON line: Starts Normal mode (see Section 3.3.1.1).
- Wake-up from Power Down mode by using RTC interrupt: Starts Alarm mode (see Section 3.3.1.3).

3.3.1.1 Switch on BG2-E/BG2-W Using ON Signal

When the operating voltage BATT+ is applied, BG2-E/BG2-W can be switched on by means of the ON signal.

If the operating voltage BATT+ is applied while the ON signal is present, BG2- E/BG2-W will be switched on automatically. Please note that if the rise time for the operating voltage BATT+ is longer than 12ms, the module startup will be delayed by about 1 second.

Please also note that if there is no ON signal present right after applying BATT+, BG2-E/BG2-W will instead of switching on perform a very short switch on/off sequence (approx. 120ms) that cannot be avoided.

The ON signal is a high active signal and only allows the input voltage level of the VDDLP signal. The following Figure 5 shows an example for a switch-on circuit (an alternative switch-on possibility is shown in Figure 47).

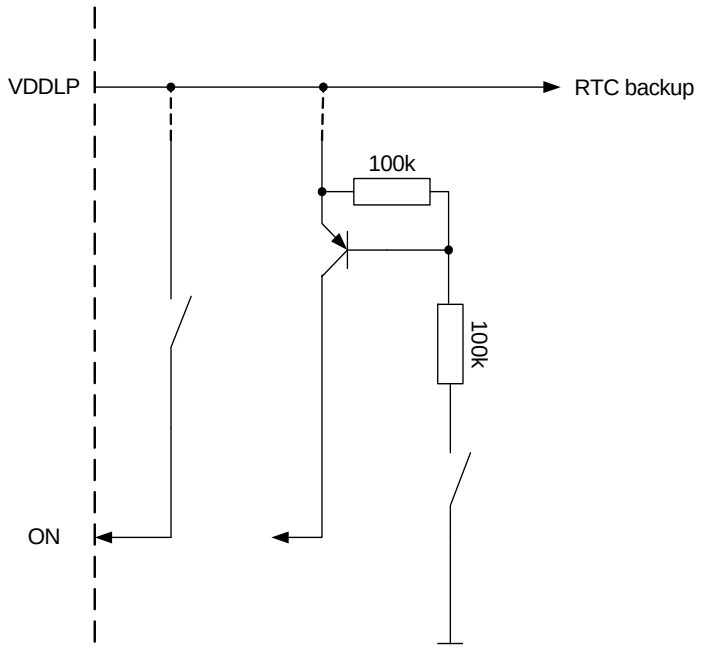


Figure 5: ON circuit sample

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

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

Please also note that if the state of the ON signal is coupled to the state of the VDDLP line or that if the ON signal otherwise remains active high after switch on, it is no longer possible to switch off BG2-E/BG2-W using the AT command AT^SMSO. Using this command will instead automatically restart the module.

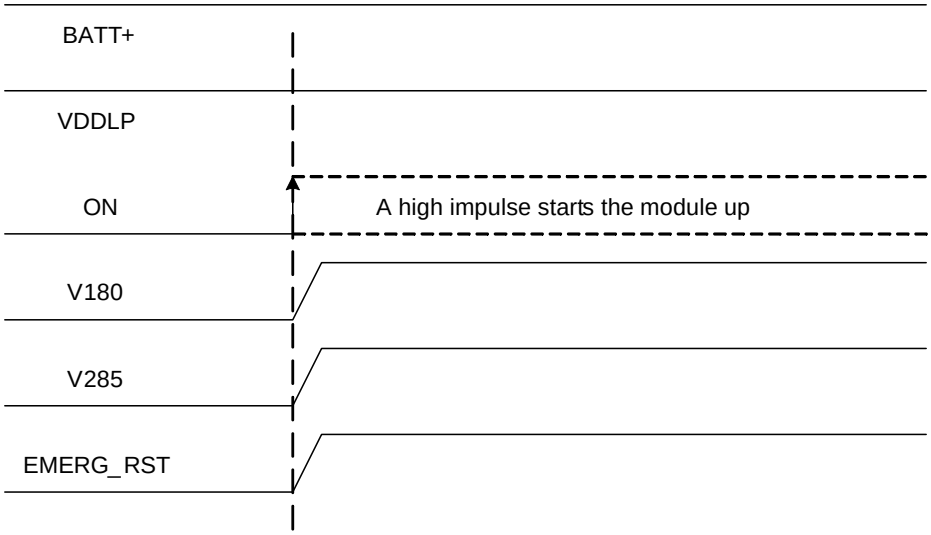


Figure 6: ON timing

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

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

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

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

3.3.1.2 Suppressing Unintentional Pulses on ON Signal Line

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

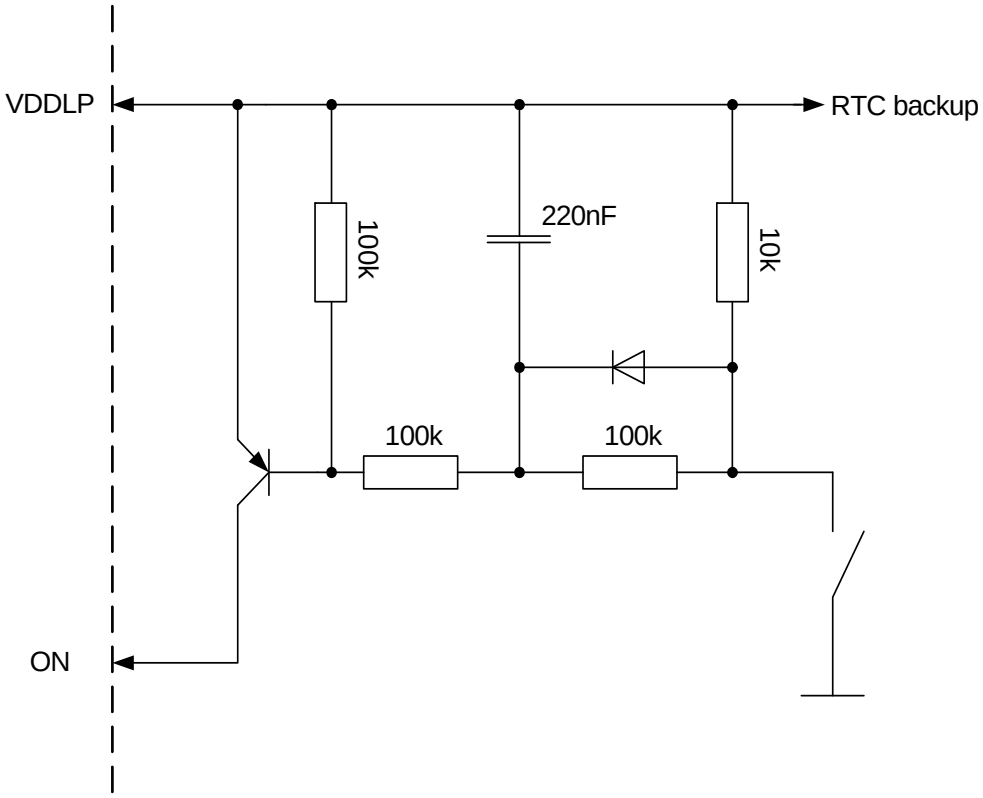


Figure 7: Sample circuit to suppress spikes or glitches on ON signal line

3.3.1.3 Turn on BG2-E/BG2-W 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 BG2-E/BG2-W 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 BG2-E/BG2-W was powered down by AT^SMSO. Once the alarm is timed out and executed, BG2-E/BG2-W enters Alarm mode. This is indicated by an Unsolicited Result Code (URC) which reads:

^SYSSTART ALARM MODE

Note that 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 the two AT commands AT+CFUN and AT^SMSO are available. A 30 seconds Power Down timer starts instantly after the alarm event occurred. Hence, you can either switch off the module with AT^SMSO (as described in Section 3.3.4.1) or restart the module into Normal mode with AT+CFUN=x,1 (as described in Section 3.3.2.1). Transition to Normal mode will be notified by the "^SYSSTART" URC (if autobauding is disabled). If not reset or switched off within the 30 seconds timeout, the module will automatically shut down when the timer expires.

Table 8: AT commands available in Alarm mode

AT command	Functions available in Alarm mode
AT+CFUN	Query status with AT+CFUN? Reset the module with one of the following commands: AT+CFUN=,1 or AT+CFUN=1,1 or AT+CFUN=7,1 or AT+CFUN=9,1 .
AT^SMSO	Power down the module

3.3.2 Restart BG2-E/BG2-W

After startup BG2-E/BG2-W can be re-started as described in the following sections:

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

3.3.2.1 Restart BG2-E/BG2-W via AT+CFUN Command

To reset and restart the BG2-E/BG2-W module use the command AT+CFUN. You can enter the command AT+CFUN=,1 or 1,1 or 7,1 or 9,1. See [1] for details.

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

3.3.2.2 Restart BG2-E/BG2-W Using EMERG_RST

The EMERG_RST signal is internally connected to the central GSM processor. A low level for more than 10ms sets the processor and with it all the other signals at the board-to-board connector to their respective reset state. The reset state is described in Section 3.3.3 as well as in the figures showing the startup behavior of an interface.

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

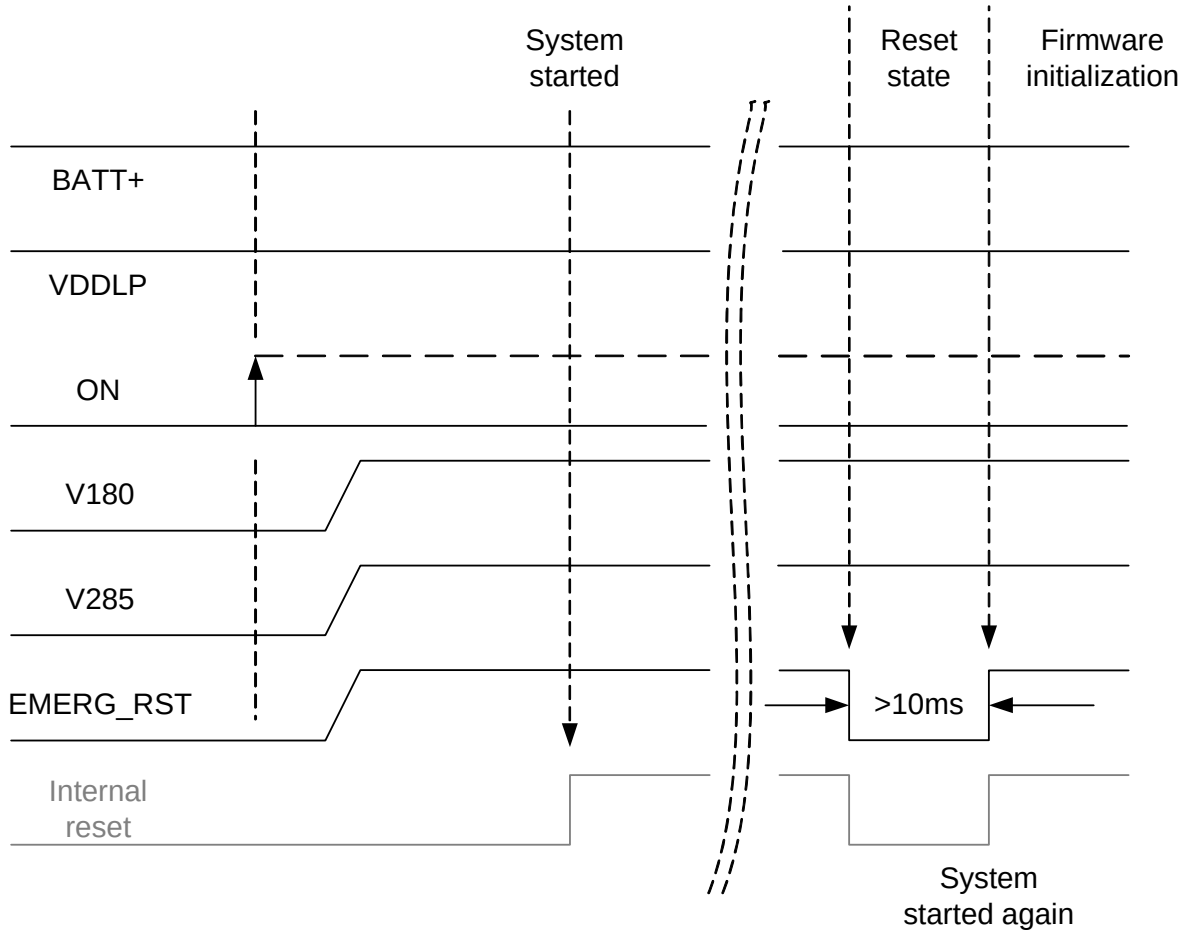


Figure 8: Emergency restart timing

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 BG2-E/BG2-W does not respond, if reset or shutdown via AT command fails.

3.3.3 Signal States after Startup

Table 9 lists the states each interface signal passes through during reset and firmware initialization.

The reset state is reached with the rising edge of the EMERG_RST signal - either after a normal module startup (see Section 3.3.1.1) or after a reset (see Section 3.3.2.2). After the reset state has been reached the firmware initialization state begins. The firmware initialization is completed as soon as the ASC0 interface lines CTS0, DSR0 and RING0 as well as the ASC1 interface line CTS1 have turned low (see Section 3.9 and Section 3.10). Now, the module is ready to receive and transmit data.

Table 9: 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	T / PU_B	O / L
RXD0	T / 2 x PU_A	O / H
TXD0	T / 2 x PU_A	I
CTS0	PD_B	O / H
RTS0	T / 10k PU	I / 10k PU
RING0	T / 10k PU	O / H, 10k PU
DTR0	T / PD_A	T / PD_A
DCD0	T / PU_A	T / PU_A
DSR0	T / PD_C	T / PD_C
RXD1	T / PD_B	O / H
TXD1	T / PD_B	I
CTS1	T / PD_B	O / H
RTS1	T / PU_A	I / PU_A
GPIO1	T / PU_B	T / PU_B
GPIO2	T / PU_B	T / PU_B
GPIO3	T / PU_B	T / PU_B
GPIO4	T / PU_A	T / PU_A
GPIO5 / LED	T / PU_A	T / PU_A
GPIO6 / PWM2	T / PU_B	T / PU_B
GPIO7 / PWM1	T / PU_B	T / PU_B
GPIO8	T / PU_B	T / PU_B
GPIO9 / I2CDAT	T / OD	T / OD
GPIO10 / I2CCLK	T / 5k PU / OD	T / 5k PU / OD

Abbreviations used in above Table 9:

L = Low level H = High level L/H = Low or 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 PD_C = Pull down, 27µA at 1.75V PU_A = Pull up -102µA at 0.05V PU_B = Pull up -55µA at 0.05V PU_C = Pull up -31µA at 0.05V

3.3.4 Turn off BG2-E/BG2-W

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

- *Normal shutdown procedure*: Software controlled by sending the AT^SMSO command over the serial application interface. See Section 3.3.4.1.
- *Automatic shutdown*: See Section 3.3.5
  - Takes effect if under- or overvoltage is detected.
  - Takes effect if BG2-E/BG2-W board temperature exceeds a critical limit.

3.3.4.1 Switch off BG2-E/BG2-W Using AT Command

The best and safest approach to powering down BG2-E/BG2-W is to issue the *AT^SMSO* command. This procedure lets BG2-E/BG2-W 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/V285 pins. The low state of these pins 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/V285 pins have gone low. Otherwise you run the risk of losing data.

While BG2-E/BG2-W 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 pins of the application interface.

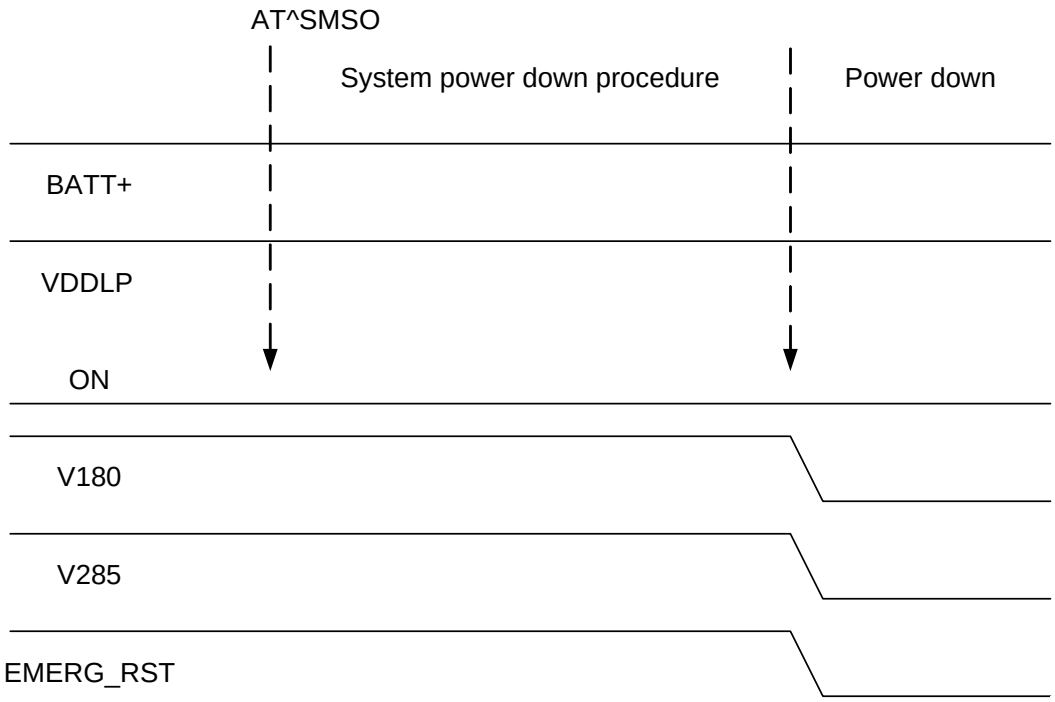


Figure 9: Switch off behavior

3.3.5 Automatic Shutdown

Automatic shutdown takes effect if any of the following events occurs:
- The BG2-E/BG2-W board exceeds the critical limits of overtemperature or undertemperature
- Undervoltage or overvoltage is detected

The automatic shutdown procedure is equivalent to the power-down initiated with the AT^SMSO command, i.e. BG2-E/BG2-W logs off from the network and the software enters a secure state avoiding loss of data.

3.3.5.1 Thermal Shutdown

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

Each time the board temperature goes out of range or back to normal, BG2-E/BG2-W instantly displays an alert (if enabled).
- URCs indicating the level "1" or "-1" allow the user to take appropriate precautions, such as protecting the module from exposure to extreme conditions. The presentation of the URCs depends on the settings selected with the AT^SCTM write command (for details see [1]):
  AT^SCTM=1: Presentation of URCs is always enabled.
  AT^SCTM=0 (default): Presentation of URCs is enabled during the 15 second guard period after start-up of BG2-E/BG2-W. After expiry of the 15 second guard period, the presentation will be disabled, i.e. no URCs with alert levels "1" or "-1" will be generated.
- URCs indicating the level "2" or "-2" are instantly followed by an orderly shutdown. The presentation of these URCs is always enabled, i.e. they will be output even though the factory setting AT^SCTM=0 was never changed.

The maximum temperature ratings are stated in Section 5.2. Refer to Table 10 for the associated URCs.

Table 10: Temperature dependent behavior

Sending temperature alert (15s after BG2-E/BG2-W 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. BG2-E/BG2-W switches off.
^SCTM_B: -2	Alert: Board equal or below undertemperature limit. BG2-E/BG2-W switches off.

3.3.5.2 Undervoltage Shutdown

If the measured supply voltage is no more sufficient to set up a call the following URC will be presented:

^SBC: Undervoltage.

The message will be reported, for example, when you attempt to make a call while the voltage is close to the shutdown threshold of 3.3V and further power loss is caused during the transmit burst. In an idle state, the shutdown threshold is the sum of the module's minimum supply voltage (3.3V) and the value of the maximum voltage drop resulting from earlier calls. This means that in an idle state the actual shutdown threshold may be higher than 3.3V. Therefore, to properly calculate the actual shutdown threshold application manufacturers are advised to measure the maximum voltage drops that may occur during transmit bursts.

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

3.3.5.3 Overvoltage Shutdown

The overvoltage shutdown threshold is 100mV above the maximum supply voltage V_{BATT+} specified in Table 28.

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

^SBC: Overvoltage

This alert is sent once.

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

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

Keep in mind that several BG2-E/BG2-W components are directly linked to BATT+ and, therefore, the supply voltage remains applied at major parts of BG2-E/BG2-W. Especially the power amplifier is very sensitive to high voltage and might even be destroyed.

3.4 Automatic GPRS Multislot Class Change

Please note that automatic GPRS multislot class change applies only for the quad band module variant BG2-W:

Temperature control is also effective for operation in GPRS Multislot Class 10. If the board temperature increases to the limit specified for restricted operation (see Section 5.2 for temperature limits) 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 a value of 5 degrees below the limit of restricted operation, BG2-W returns to the higher Multislot Class. If the temperature stays at the critical level or even continues to rise, BG2-W 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.

Please note that there is not one single cause of switching over to a lower GPRS Multislot Class. Rather it is the result of an interaction of several factors, such as the board temperature that depends largely on the ambient temperature, the operating mode and the transmit power. Furthermore, take into account that there is a delay until the network proceeds to a lower or, accordingly, higher Multislot Class. The delay time is network dependent. In extreme cases, if it takes too much time for the network and the temperature cannot drop due to this delay, the module may even switch off as described in Section 3.3.4.

3.5 Power Saving

SLEEP mode reduces the functionality of the BG2-E/BG2-W 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 BG2-E/BG2-W 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 11 compares the wake-up events that can occur in NON-CYCLIC and CYCLIC SLEEP modes.

3.5.1 No Power Saving (AT+CFUN=1)

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

3.5.2 NON-CYCLIC SLEEP Mode (AT+CFUN=0)

If level 0 has been selected (AT+CFUN=0), the serial interface is blocked. 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 BG2-E/BG2-W back to the highest level of functionality <fun>=1.

In NON-CYCLIC mode, the falling edge of the RTS0 or RTS1 lines wakes up the module to <fun>=1. To efficiently use this feature it is recommended to enable hardware flow control (RTS/CTS handshake) as in this case the CTS line notifies the application when the module is ready to send or receive characters. See Section 3.5.6.1 for details.

3.5.3 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, BG2-E/BG2-W automatically resumes power saving, after you have sent or received a short message, made a call or completed a GPRS transfer. Please refer to Table 11 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 BG2-E/BG2-W is AT\Q0 (no flow control) which must be altered to AT\Q3. See [1] for details.

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

3.5.4 CYCLIC SLEEP Mode AT+CFUN=9

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

- The time the module stays active after RTS was asserted or after the last character was sent or received, can be configured individually using the command AT^SCFG. Default setting is 2 seconds like in AT+CFUN=7. The entire range is from 0.5 seconds to 1 hour, selectable in tenths of seconds. For details see [1].
- RTS0 and RTS1 are not only used for flow control (as in mode AT+CFUN=7), but also cause the module to wake up temporarily. See Section 3.5.6.1 for details.

3.5.5 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 10 and Figure 11.

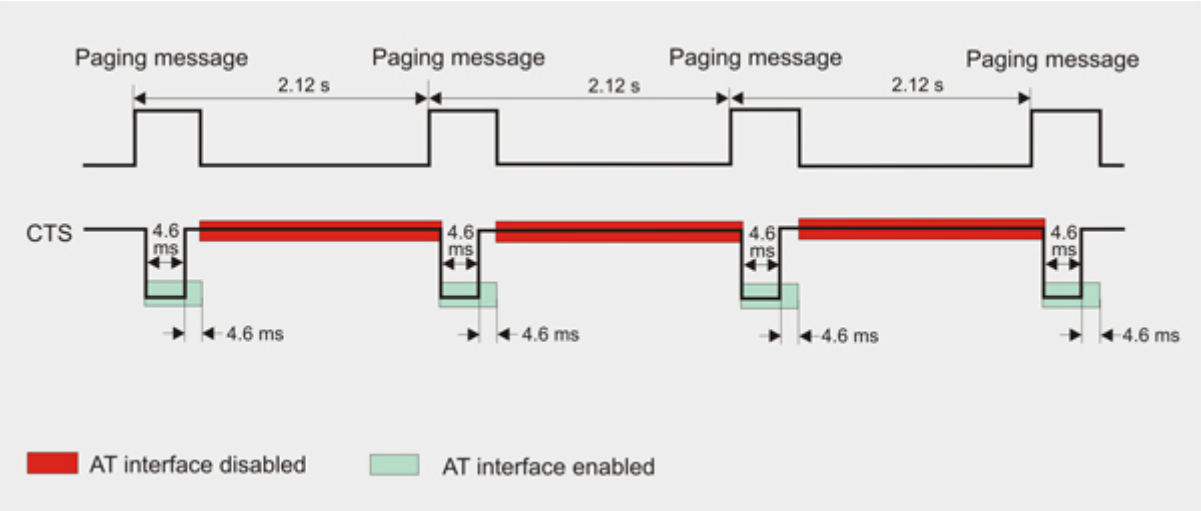


Figure 10: Timing of CTS signal (example for a 2.12 s paging cycle)

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

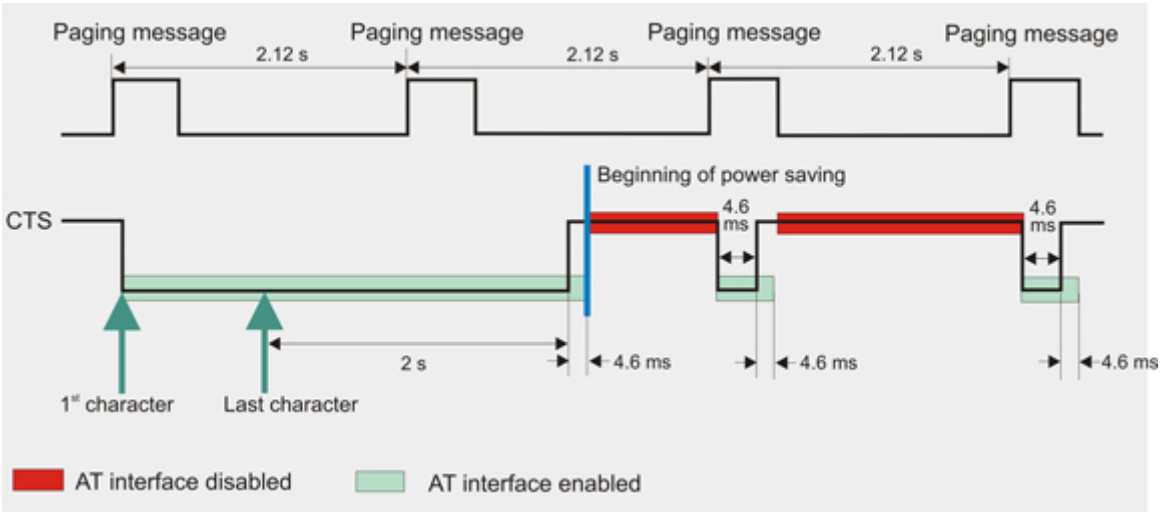


Figure 11: Beginning of power saving if CFUN=7

3.5.6 Wake up BG2-E/BG2-W 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 BG2-E/BG2-W back to AT+CFUN=1, or activates BG2-E/BG2-W temporarily without leaving the current SLEEP mode.

Definitions of the state transitions described in Table 11:

Quit = BG2-E/BG2-W exits SLEEP mode and returns to AT+CFUN=1.

Temporary = BG2-E/BG2-W 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. BG2-E/BG2-W does not wake up.

Table 11: Wake-up events in NON-CYCLIC and CYCLIC SLEEP modes

Event	Selected mode AT+CFUN=0	Selected mode AT+CFUN=7 or 9
Ignition line	No effect	No effect
RTS0 or RTS1[1)] (falling edge)	Quit + flow control	Mode 7: No effect, RTS is only used for flow control Mode 9: Temporary + flow control
Unsolicited Result Code (URC)	Quit	Temporary
Incoming voice or data call	Quit	Temporary
Any AT command (incl. outgoing voice or data call, outgoing SMS)	Not possible (UART disabled)	Temporary
Incoming SMS depending on mode selected by AT+CNMI: AT+CNMI=0,0 (= default, no indication of received SMS) AT+CNMI=1,1 (= displays URC upon receipt of SMS)	No effect Quit	No effect Temporary
GPRS data transfer	Not possible (UART disabled)	Temporary
RTC alarm[2]	Quit	Temporary
AT+CFUN=1	Not possible (UART disabled)	Quit

1. See Section 3.5.6.1 on wake-up via RTS.
2. Recommendation: In NON-CYCLIC SLEEP mode, you can set an RTC alarm to wake up BG2-E/BG2-W and return to full functionality. This is a useful approach because, in this mode, the AT interface is not accessible.

3.5.6.1 Wake-up via RTS0 and RTS1 (if AT+CFUN=0 or AT+CFUN=9)

During the CYCLIC SLEEP mode 7, the RTS0 and RTS1 lines are conventionally used for flow control: The assertion of RTS0 or RTS1 indicates that the application is ready to receive data - without waking up the module.

If the module is in CFUN=0 mode the assertion of RTS0 and RTS1 serves as a wake-up event, giving the application the possibility to intentionally terminate power saving. If the module is in CFUN=9 mode, the assertion of RTS0 or RTS1 can be used to temporarily wake up BG2-E/ BG2-W for the time specified with the AT^SCFG command (default = 2s). In both cases, if RTS0 or RTS1 is asserted while AT+CFUN=0 or AT+CFUN=9 is set, there may be a short delay until the module is able to receive data again. This delay depends on the current module activities (e.g. paging cycle) and may be up to 60ms. The ability to receive data is signalized by CTS0 and CTS1. It is therefore recommended to enable RTS/CTS flow control, not only in CYCLIC SLEEP mode, but also in NON-CYCLIC SLEEP mode.

3.6 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 12: State transitions of BG2-E/BG2-W (except SLEEP mode)

Further mode →→ Present mode	**Power Down**	**Normal mode**	**Alarm mode**
Power Down mode	---	ON >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. BG2-E/BG2-W enters Alarm mode when specified time is reached.
Alarm mode	AT^SMSO	AT+CFUN=x,1	---

3.7 RTC Backup

The internal Real Time Clock of BG2-E/BG2-W is supplied from a separate voltage regulator in the power supply component which is also active when BG2-E/BG2-W is in Power Down mode and BATT+ is available. An alarm function is provided that allows to wake up BG2-E/BG2-W without logging on to the GSM network.

In addition, you can use the VDDLP pin on the board-to-board connector to backup the RTC from an external capacitor. The capacitor is charged from the internal LDO of BG2-E/BG2-W. If the voltage supply at BATT+ is disconnected the RTC can be powered by the capacitor. The size of the capacitor determines the duration of buffering when no voltage is applied to BG2-E/BG2-W, i.e. the greater the capacitor the longer BG2-E/BG2-W will save the date and time. A serial 1kOhm resistor has to be placed on the application next to VDDLP. It limits the input current of an empty capacitor. The RTC can also be supplied from an external battery (rechargeable or non-chargeable). In this case the electrical specification of the VDDLP pin (see Section 5.5) has to be taken in to account.

Figure 12 shows an RTC backup configuration.

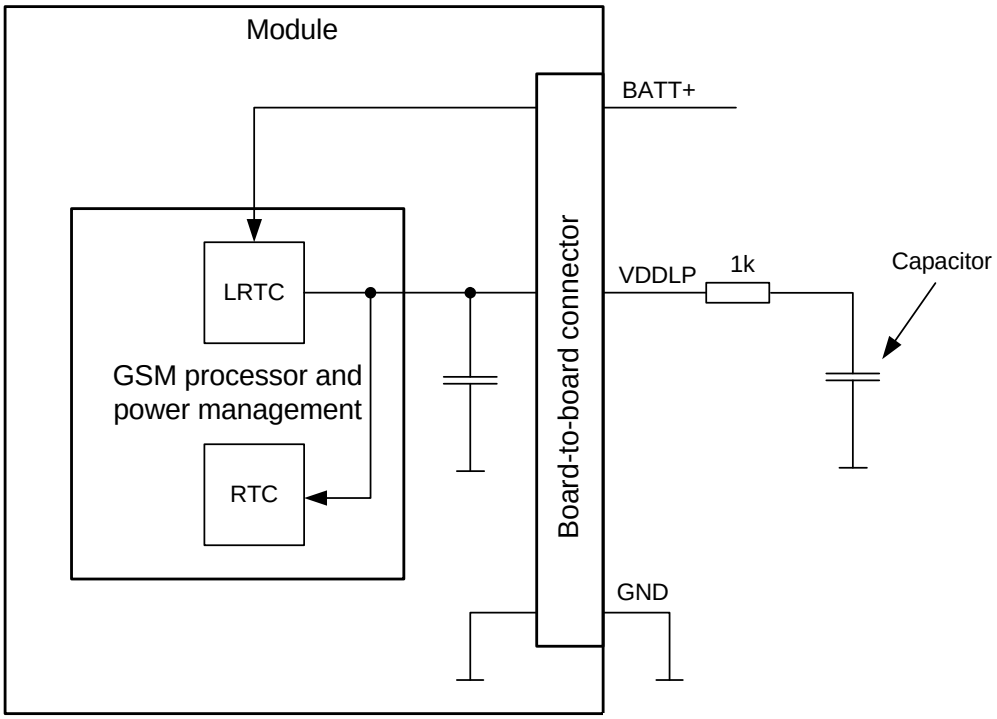


Figure 12: RTC supply variants

3.8 SIM Interface

The baseband processor has an integrated SIM card interface compatible with the ISO 7816 IC Card standard. This is wired to the host interface (board-to-board connector) in order to be connected to an external SIM card holder. Five pins on the board-to-board connector are reserved for the SIM interface. BG2-E/BG2-W supports and automatically detects 3.0V as well as 1.8V SIM cards.

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

Table 13: Signals of the SIM interface (board-to-board connector)

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 pin is mandatory for applications that allow the user to remove the SIM card during operation. The CCIN pin is solely intended for use with a SIM card. It must not be used for any other purposes. Failure to comply with this requirement may invalidate the type approval of BG2-E/BG2-W.

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

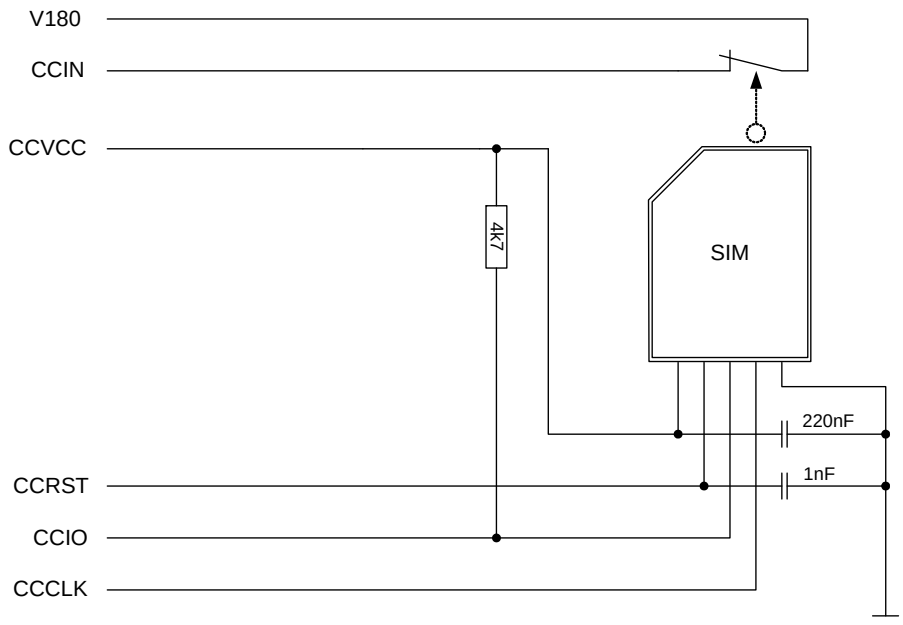


Figure 13: External SIM card holder circuit

It is recommended that the total cable length between the board-to-board connector pins on BG2-E/BG2-W and the pins of the SIM card holder does 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 (pin 2) may be employed for such a case.

Notes: 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 BG2-E/ BG2-W.
If using a SIM card holder without detecting contact please be sure to switch off the module before removing the SIM Card or inserting a new one.

3.9 Serial Interface ASC0

BG2-E/BG2-W 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 voltage level of the ASC0 interface can be configured to either 1.8V or 2.85V:

- If the VDIG signal (i.e., board-to-board connector pin 14) is connected to the V180 pin (i.e., board-to-board connector pin 16) the ASC0 interface starts up with a 1.8V signal level.
- If the VDIG signal (i.e., board-to-board connector pin 14) is connected to the V285 pin (i.e., board-to-board connector pin 15), the ASC0 interface runs with a 2.85V signal level.

The voltage level configuration of the ASC0 interface also has an impact on the I^2C interface. The I^2C interface is also in the power supply domain configured by the VDIG signal (see Section 3.13).

For electrical characteristics of the interface signals please refer to Section 5.5.

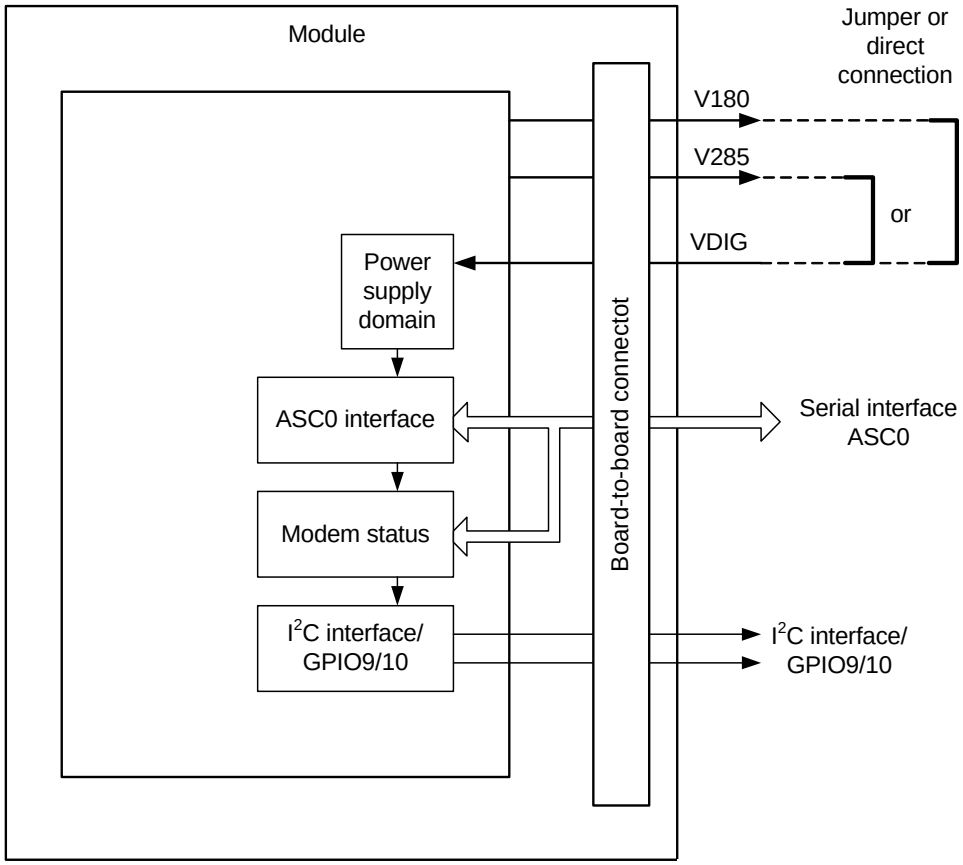


Figure 14: VDIG controlled power supply domain

BG2-E/BG2-W is designed for use as a DCE. Based on the conventions for DCE-DTE connections it communicates with the customer application (DTE) using the following signals:

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

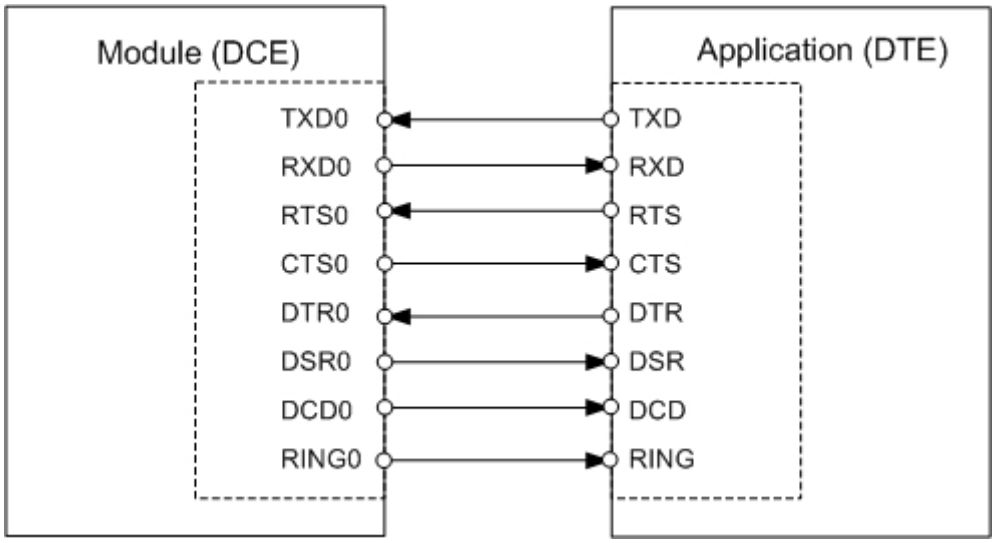


Figure 15: Serial interface ASC0

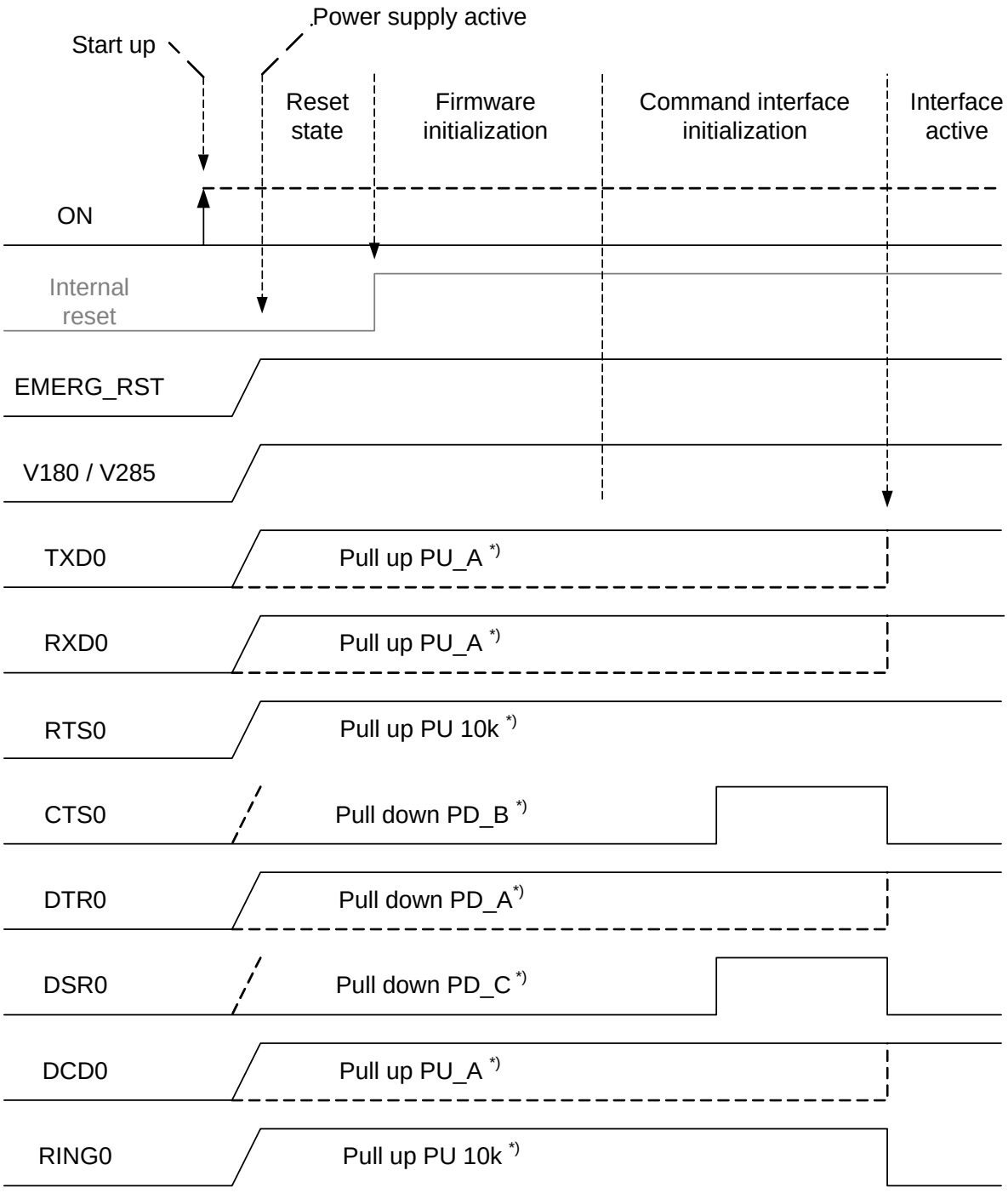
Features:

- Includes the data lines TXD0 and RXD0, the status lines RTS0 and CTS0 and, in addition, the modem control lines DTR0, DSR0, DCD0 and RING0.
- ASC0 is primarily designed for controlling voice calls, transferring CSD, fax and GPRS data and for controlling the GSM module with AT commands.
- The DTR0 signal will only be polled once per second from the internal firmware of BG2-E/ BG2-W.
- The RING0 signal serves to indicate incoming calls and other types of URCs (Unsolicited Result Code). It can also be used to send pulses to the host application, for example to wake up the application from power saving state. See [1] for details on how to configure the RING0 line by AT^SCFG.
- Configured for 8 data bits, no parity and 1 stop bit.
- ASC0 can be operated at fixed bit rates from 1,200 bps to 230,400 bps.
- Autobauding supports bit rates from 1,200 bps to 230,400 bps.
- Supports RTS0/CTS0 hardware flow control and XON/XOFF software flow control.

Table 14: DCE-DTE wiring of ASC0

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

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



*) For pull-up and pull-down values see Table 9.

Figure 16: ASC0 startup behavior

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

3.10 Serial Interface ASC1

BG2-E/BG2-W offers a 4-wire unbalanced, asynchronous modem interface ASC1 conforming to ITU-T V.24 protocol DCE signalling. The electrical characteristics do not comply with ITU-T V.28. The electrical level of the ASC1 interface is set to 1.8V. For electrical characteristics please refer to Table 28.

BG2-E/BG2-W is designed for use as a DCE. Based on the conventions for DCE-DTE connections it communicates with the customer application (DTE) using the following signals:
- Port TXD @ application sends data to module's TXD1 signal line
- Port RXD @ application receives data from the module's RXD1 signal line

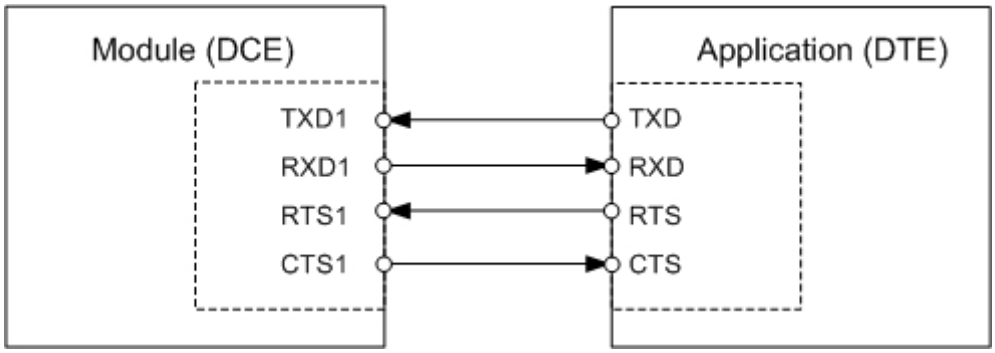


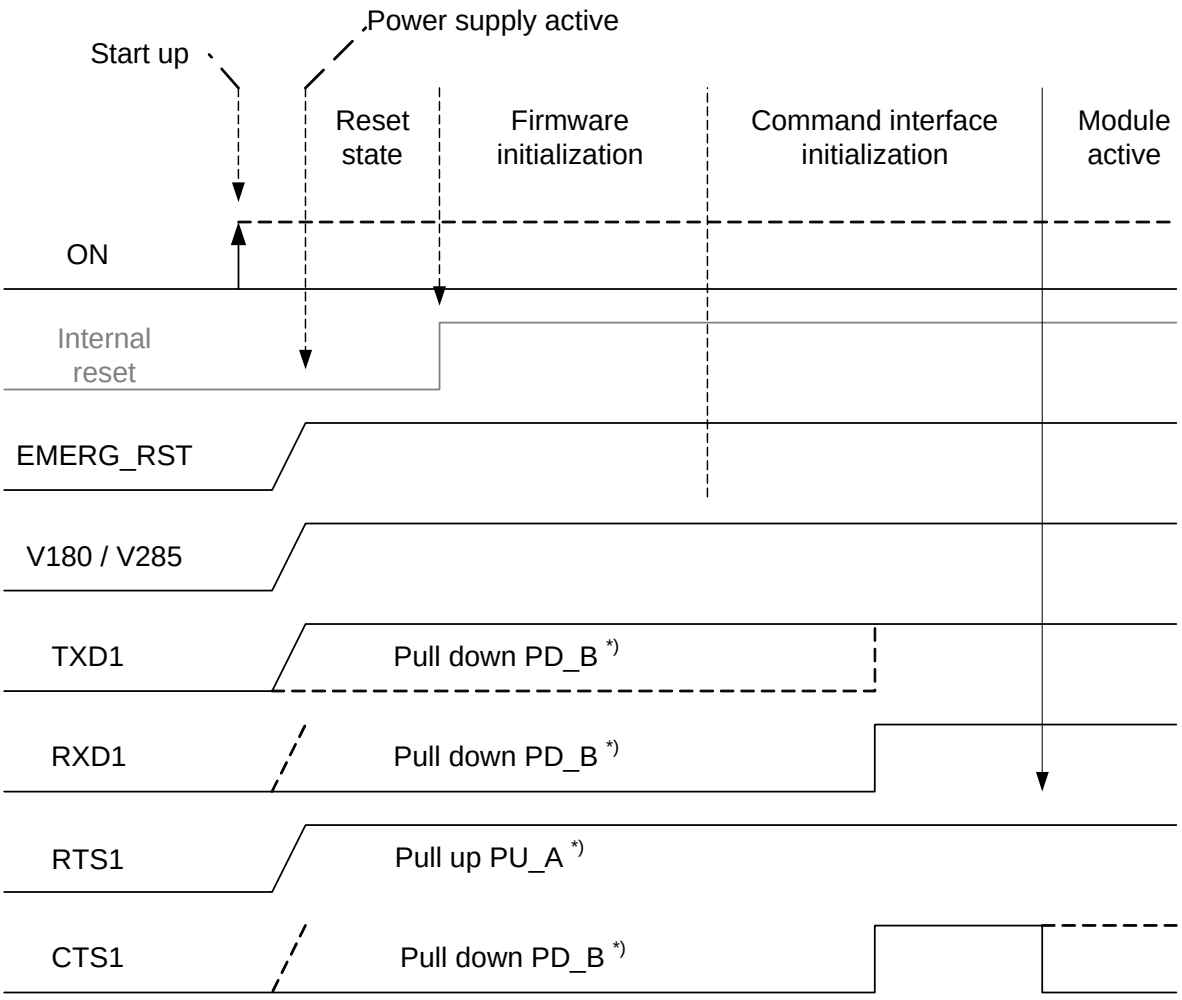
Figure 17: Serial interface ASC1

Features
- Includes only the data lines TXD1 and RXD1 plus RTS1 and CTS1 for hardware handshake.
- On ASC1 no RING line is available. The indication of URCs on the second interface depends on the settings made with the AT^SCFG command. For details refer to [1].
- Configured for 8 data bits, no parity and 1 or 2 stop bits.
- ASC1 can be operated at fixed bit rates from 1,200 bps to 230,400 bps. Autobauding is not supported on ASC1.
- Supports RTS1/CTS1 hardware flow control and XON/XOFF software flow control.

Table 15: DCE-DTE wiring of ASC1

V.24 circuit	DCE		DTE	
	Pin function	Signal direction	Pin function	Signal direction
103	TXD1	Input	TXD	Output
104	RXD1	Output	RXD	Input
105	RTS1	Input	RTS	Output
106	CTS1	Output	CTS	Input

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



*) For pull-up and pull-down values see Table 9.

Figure 18: ASC1 startup behavior

3.11 Analog Audio Interface

BG2-E/BG2-W 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 pins.

BG2-E/BG2-W offers six audio modes which can be selected with the AT^SNFS command. The electrical characteristics of the voiceband part vary with the audio mode. For example, sending and receiving amplification, sidetone paths, noise suppression etc. depend on the selected mode and can be altered with AT commands (except for mode 1).

Please refer to Section 5.7 for specifications of the audio interface and an overview of the audio parameters. Detailed instructions on using AT commands are presented in [1]. Table 31 summarizes the characteristics of the various audio modes and shows what parameters are supported in each mode.

When shipped from factory, all audio parameters of BG2-E/BG2-W are set to audio mode 1. This is the default configuration optimised for the Votronic HH-SI-30.3/V1.1/0 handset and used for type approving the Cinterion Wireless Modules reference configuration. Audio mode 1 has fix parameters which cannot be modified. To adjust the settings of the Votronic handset simply change to another audio mode.

In transmit direction, all audio modes contain internal scaling factors (digital amplification) that are not accessible.

3.11.1 Microphone Inputs and Supply

The differential microphone inputs MICP and MICN present an impedance of 50kOhm 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. AGND must not be connected to the system GND anywhere. Otherwise high GSM burst peak currents will flow across the AGND line causing GSM humming in the uplink audio signal.

The following figures show possible microphone and line connections.

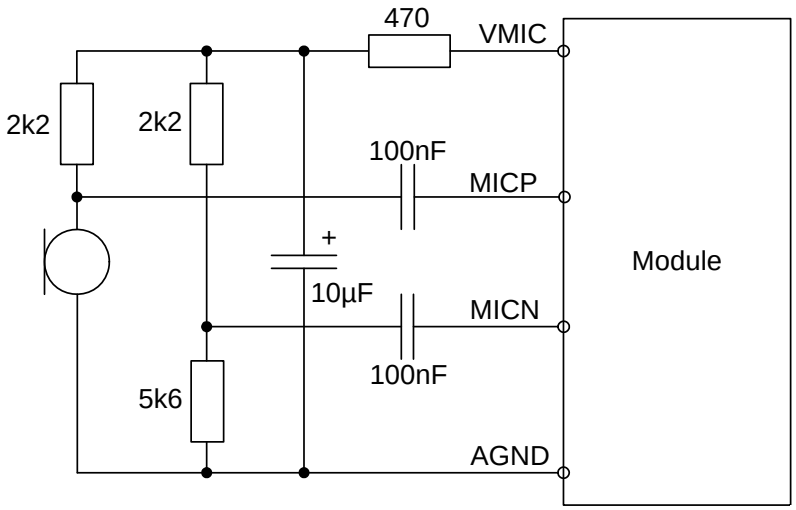


Figure 19: Single ended microphone connection

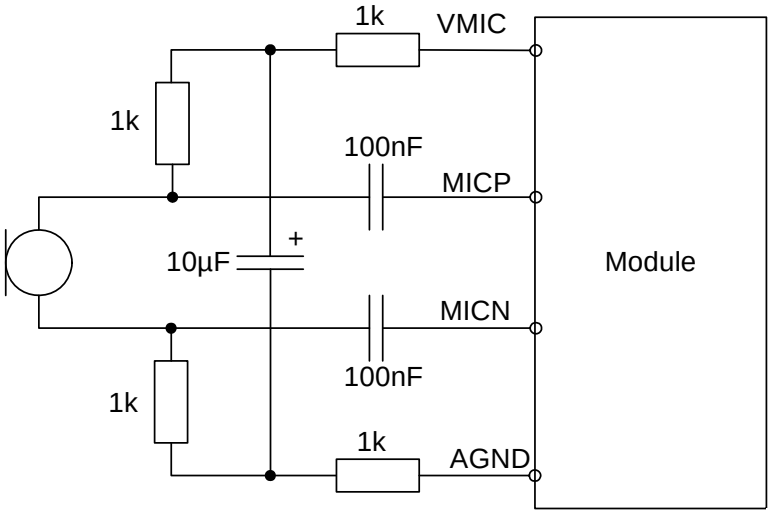


Figure 20: Differential Microphone connection

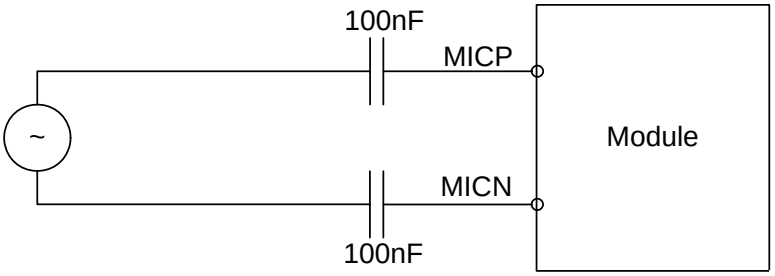


Figure 21: Line Input

3.11.2 Loudspeaker Output

BG2-E/BG2-W provides a differential loudspeaker output EPP/EPN. The output is able to deliver a voltage of 3.2Vpp at a load resistance of 16Ohm. If it is used as line output (see Figure 23), 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.

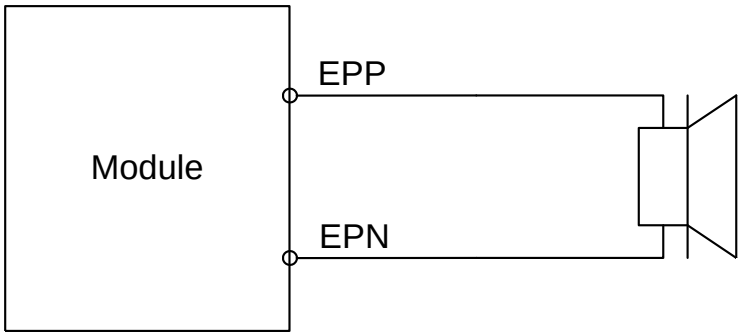


Figure 22: Differential loudspeaker connection

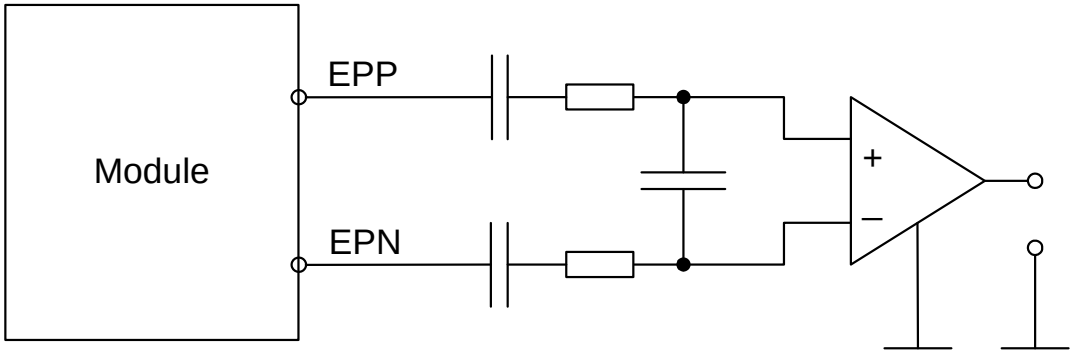


Figure 23: Line output connection

3.12 GPIO Interface

BG2-E/BG2-W offers a GPIO interface with 10 GPIO lines. Some GPIO lines are shared with other interfaces, such as I^2C interface (see Section 3.13), Status LED (see Section 3.15) and the PWM functionality (see Section 3.14). All functions are controlled by dedicated AT commands.

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

Table 16: GPIO assignment

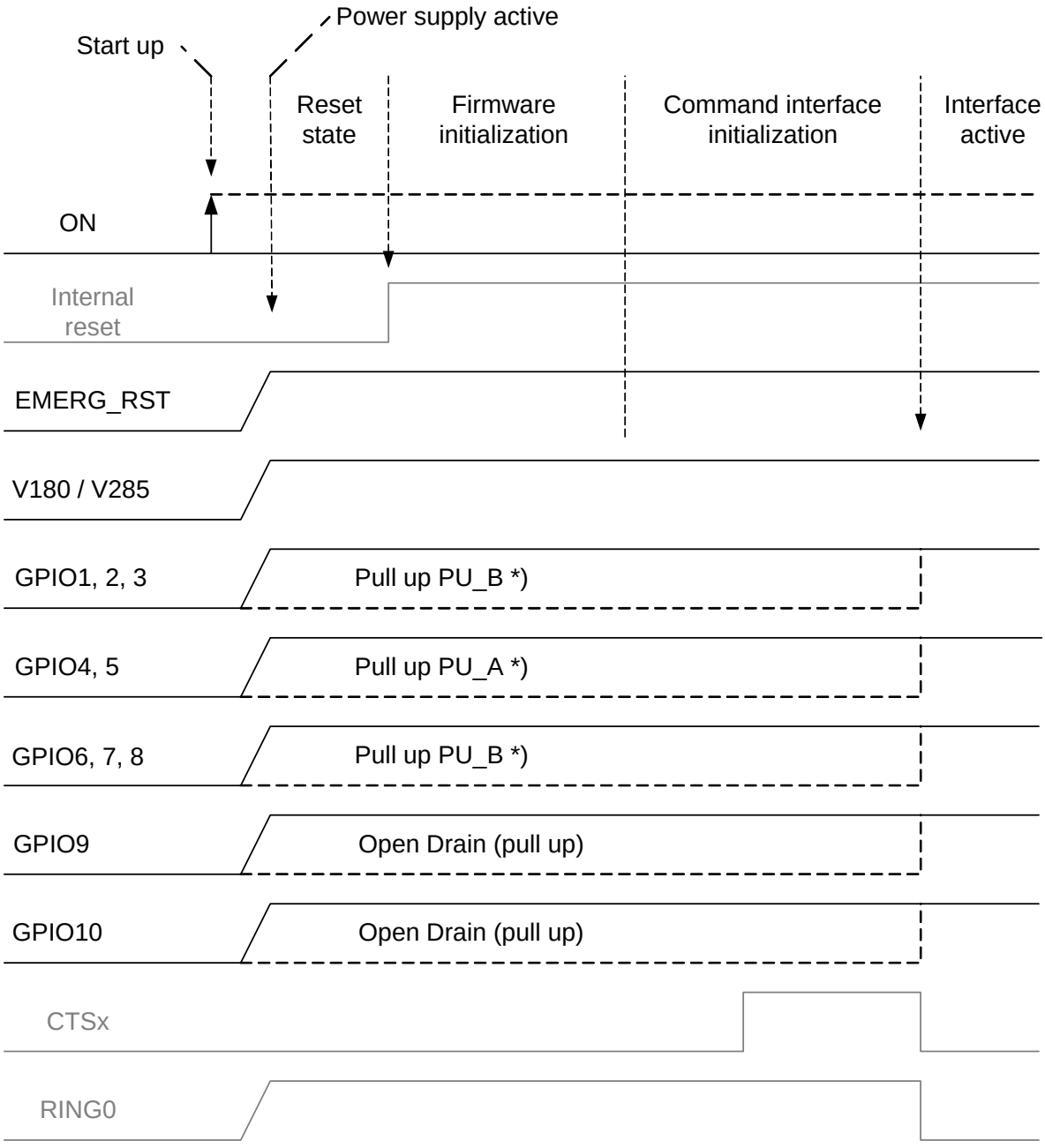
GPIO	I2C	PWM	Status LED	Voltage domain
GPIO1				V180
GPIO2				V180
GPIO3				V180
GPIO4				V180
GPIO5			Status LED	V180
GPIO6		PWM2		V180
GPIO7		PWM1		V180
GPIO8				V180
GPIO9	I2CDAT			VDIG
GPIO10	I2CCLK			VDIG

Each GPIO line can be configured for use as input or output. The GPIO related AT commands are the following: AT^SPIO, AT^SCPIN, AT^SGIO, AT^SSIO. A detailed description can be found in [1].

When the BG2-E/BG2-W starts up, all GPIO lines are set to high-impedance state after initializing, as described in Section 3.3.3. Therefore, it is recommended to connect external pull-up or pull-down resistors to all GPIO lines you want to use as output. This is necessary to keep these lines from floating or driving any external devices before all settings are done by AT command (at least AT^SPIO, AT^SCPIN), and after closing the GPIOs again.

The power supply domain voltage level for GPIO1 to GPIO8 is 1.8V. GPIO9 and GPIO10 are in the VDIG power supply domain which can be configured to either a 1.8V or a 2.85V voltage level (for details see Section 3.9; Figure 14). I2CCLK (GPIO10) has an internal 5kOhm pull-up resitor, I2CDAT (GPIO9) requires an external pull-up resistor.

The following figure shows the startup behavior of the GPIO interface. With an active state of the ASC0 interface (i.e. RING0, CTS0 or CTS1 are at low level) the initialization of the GPIO interface lines is also finished.



*) For pull-up values see Table 9.

Figure 24: GPIO startup behavior

3.13 I²C Interface

The signal lines of the I²C interface are shared with the GPIO9 and GPIO10 signal pins and are activated by means of AT command.

The voltage level configuration for the ASC0 interface has an impact on the I²C interface since the I²C interface is in the same VDIG controlled power supply domain. If the ASC0 voltage level is set to 1.8V, the I²C interface pins have the same voltage level (see Figure 14).

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 (GPIO9) and the serial clock line I2CCLK (GPIO10). 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.

The I²C interface can be powered from an external supply or via the V180/V285 line of BG2-E/BG2-W. If connected to the V180/V285 line, the I²C interface will be properly shut down when the module enters the Power Down mode. If you prefer to connect the I²C interface to an external power supply, take care that VCC of the application is in the range of V180/V285 and that the interface is shut down when the EMERG_RST signal goes low.

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 28.

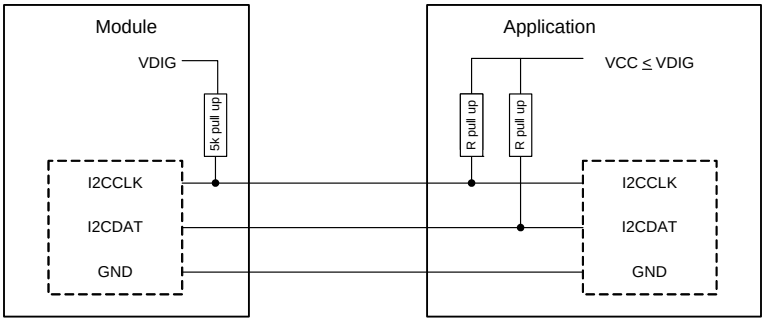


Figure 25: I²C interface connected to VCC of application

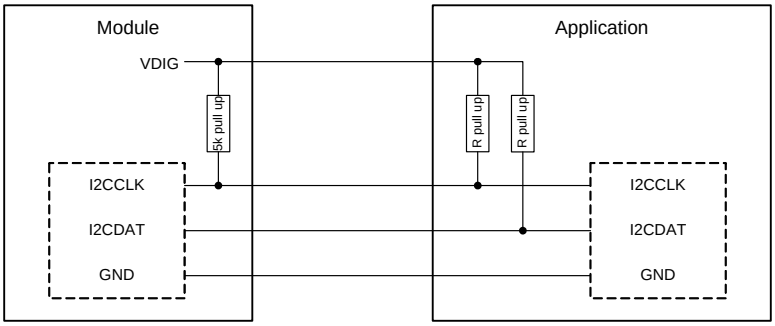


Figure 26: I²C interface connected to V180 or V285

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 I²C interface. With an active state of the ASC0 interface (i.e. RING0, CTS0 or CTS1 are at low level) the initialization of the I²C interface is also finished.

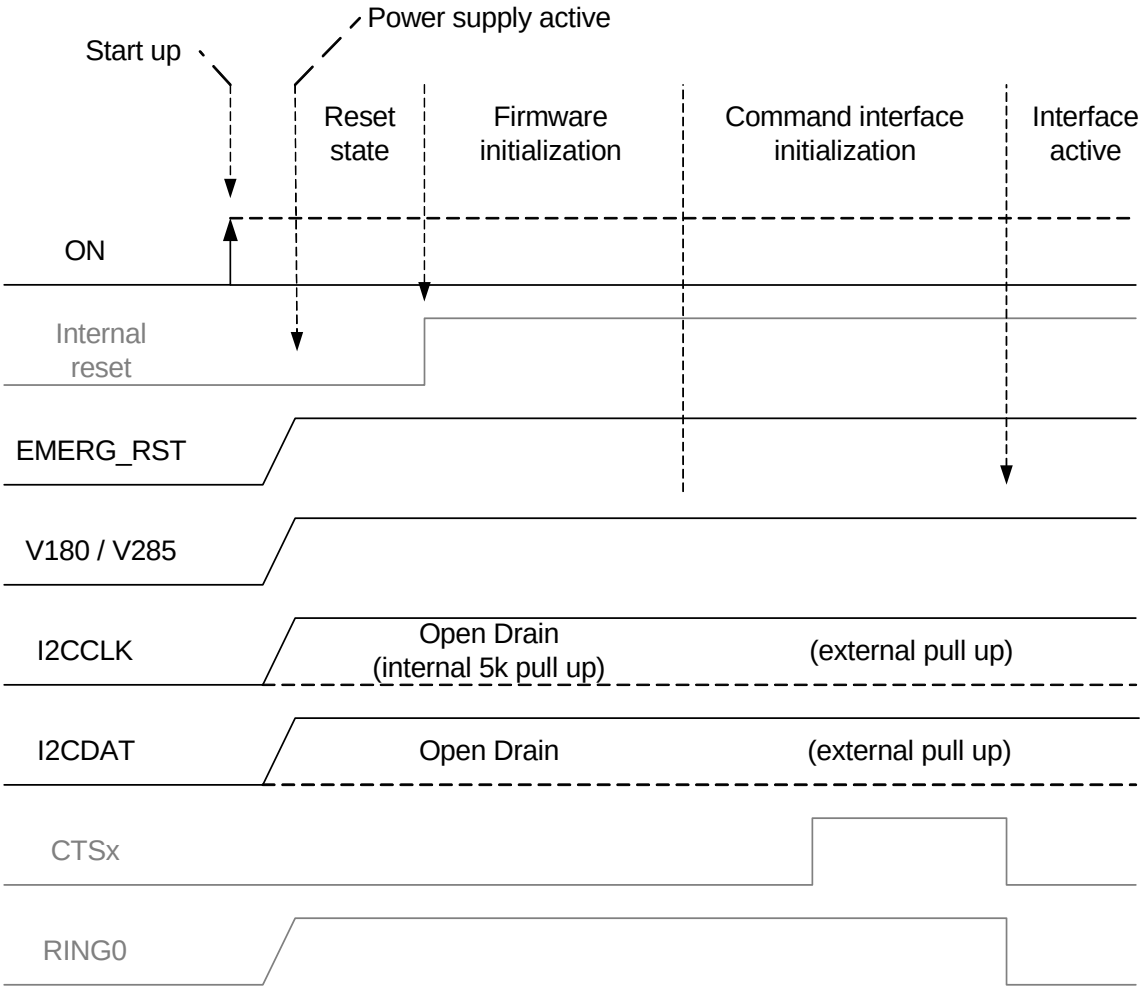


Figure 27: I²C startup behavior

3.14 PWM Interfaces

BG2-E/BG2-W offers two PWM (Pulse Width Modulation) interfaces, which can be used, for example, to connect buzzers. The PWM1 line is shared with GPIO7 and the PWM2 line is shared with GPIO6 (for GPIOs see Section 3.12). GPIO and PWM functionality are mutually exclusive.

The startup behavior of the pins is shown in Figure 24.

To open and configure a PWM output use the AT^SWDAC command. For details refer to [1].

3.15 Status LED

The GPIO5 line of the board-to-board connector can be configured to drive a status LED that indicates different operating modes of the module (for GPIOs see Section 3.12). GPIO and LED functionality are mutually exclusive.

To take advantage of this function connect an LED to the GPIO5/LED line as shown in Figure 28. The LED can be enabled/disabled by AT command. For details refer to [1].

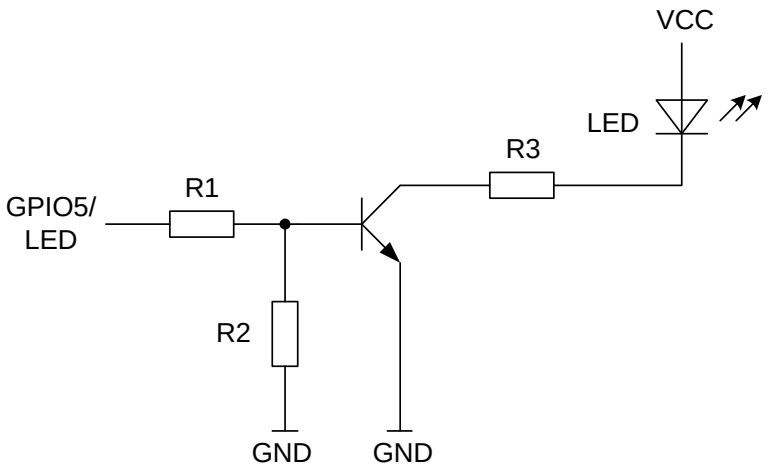


Figure 28: Status signalling with LED driver

3.16 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:

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

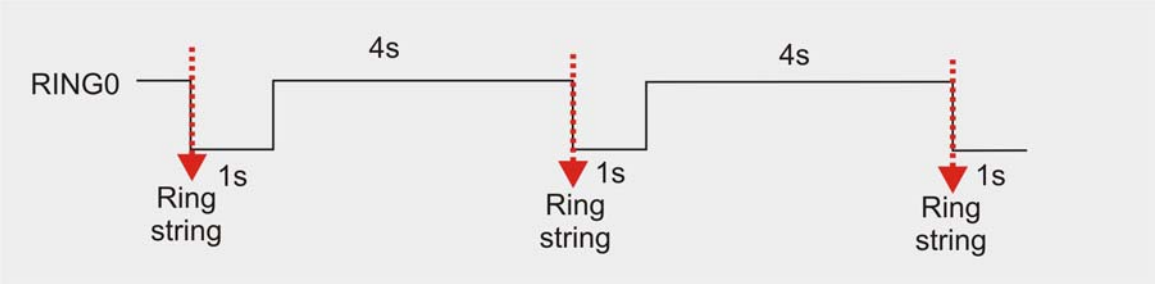


Figure 29: Incoming voice call

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

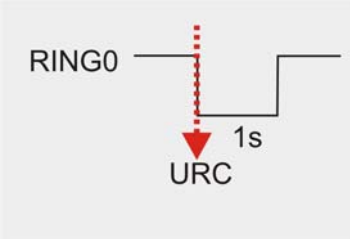


Figure 30: URC transmission

3.17 Power Indication Circuit

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

It is therefore recommended to implement a power indication signal that reports the module's power state and shows whether it is active or in Power Down mode. While the module is in Power Down mode all signals with a high level from an external application need to be set to low state or high impedance state. The sample power indication circuit illustrated in Figure 31 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.

The following Table 17 lists two different configurations for the module's interfaces, depending on the power supply domain specified with VDIG. The cases differ in the power supply voltage level configured for the ASC0, ASC1, I^2C and GPIO interface lines and the possibility of back powering through the used interface lines from an external application:

- If all interface lines operate within the V180 power supply domain (i.e., VDIG connected to V180), the V285 power supply voltage line is not prone to back powering. The power indication circuit is therefore controlled by the power supply voltage line V285.
- If the ASC0 and I^2C interface lines operate within the V285 power supply domain (i.e., VDIG connected to V285), the V180 power supply voltage line is not prone to back powering. The power indication circuit is therefore controlled by the power supply voltage line V180.

Table 17: Power indication circuit

Interface	VDIG = V180	VDIG = V285
	Voltage level at interface	Voltage level at interface
ASC0 lines	1.8V	2.85V
ASC1 lines	1.8V	1.8V
I^2C lines	1.8V	2.85V
GPIO lines	1.8V	1.8V
Voltage control for power indication circuit	V285 controlled	V180 controlled

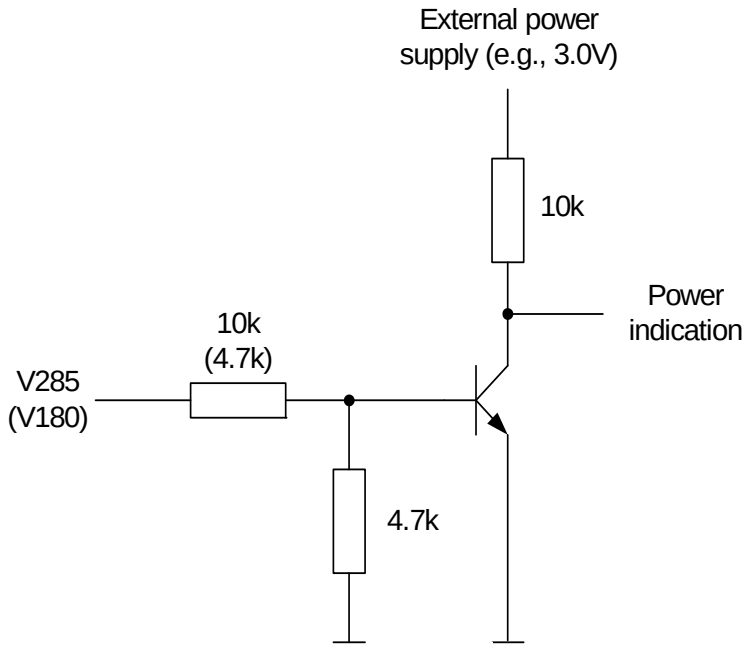


Figure 31: Power indication circuit

4 Antenna Interface

The RF interface has an impedance of 50Ω. BG2-E/BG2-W is capable of sustaining a total mismatch at the antenna lines without any damage, even when transmitting at maximum RF power.

The external antenna must be matched properly to achieve best performance regarding radiated power, DC-power consumption and harmonic suppression. Matching networks are not included on the BG2-E/BG2-W PCB and should be placed in the host application if the antenna does not have an impendance of 50Ω.

Regarding the return loss BG2-E/BG2-W provides the following values:

Table 18: Return loss

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

The connection of the antenna or other equipment must be decoupled from DC voltage. This is necessary because the antenna connector is DC coupled to ground via an inductor for ESD protection.

4.1 Antenna Installation

The BG2-E/BG2-W antenna interface comprises two pins on the board-to-board connector (pin 27 and pin 28). These pins need to be properly connected to an external antenna or a directly connected PCB antenna. Since RF line impedance is affected by physical dimensions and material characteristics, the line width as well as the distance to the surrounding ground area must be designed carefully to achieve an accurate 50Ohms matching. For line arrangement examples see Section 4.2.

Another example that prevents possible matching deviations would be a surface mount antenna connector (e.g., Hirose U.FL-R-SMT; for details see Section 4.3) right oppposite the board-to-board connector using plated via holes as shown in the figure below.

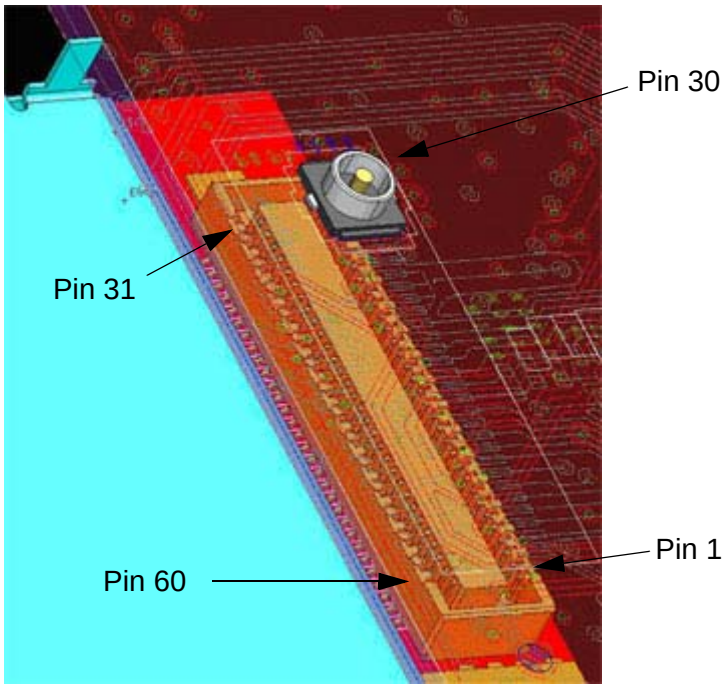


Figure 32: Antenna connector opposing the module's board-to-board connector

The antenna reference point, e.g., for type approval, is realized by the pins 27 and 28 that carry the RF signals, and the pins 25, 26 as well as 29 to 36 that are used as RF ground. The nominal impedance of that interface is defined to be 50Ω.

By definition: BG2-E/BG2-W module's top side mates with external PCB's bottom side.

4.2 Line Arrangement Examples for External PCB

The first line arrangement example is a standard double plated FR-4 PCB material with a core thickness of *1.5mm*, a metallization thickness of t = 35µm and a dielectric constant (permittivity) of ε_r = 4.8, an RF line width of 0.82mm and a gap to surrounding ground area of 0.190mm. The example would be a good starting point for impedance optimization. Some metalized via holes shall be used to connect the solid ground plane required on the layer opposing the RF line with the ground plane surrounding the RF line. The arrangement on the external application is shown in Figure 33 (through view on external application's bottom side, see also Figure 35).

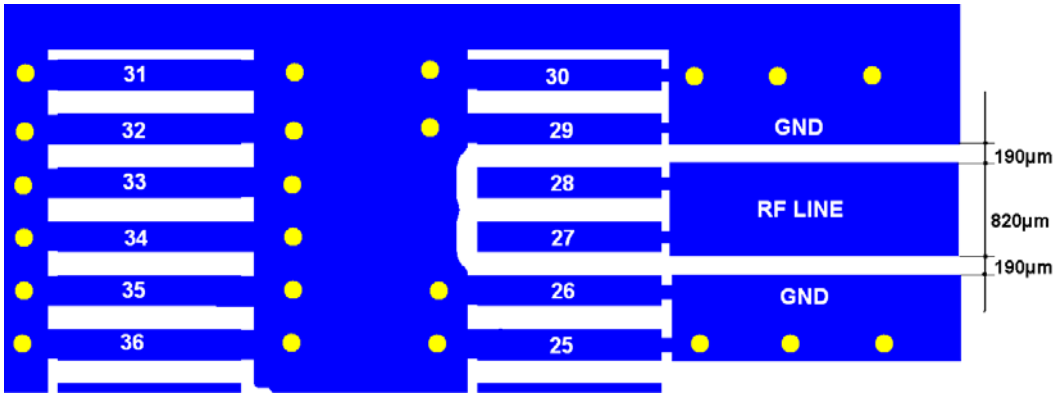


Figure 33: RF-Line PCB routing example for 1.5mm FR4

Note: Please take the pin numbering into account. Depending on the view onto the external application's PCB Figure 33 and Figure 34 may differ and appear rotated, flipped or mirrored. The numbering of the external application's mating connector has to match the numbering on BG2-E/BG2-W as shown in Figure 40 and Figure 42.

The second line arrangment example is a standard double plated FR-4 PCB material with a core thickness of *1.0mm*, a metallization thickness of t = 35µm and a dielectric constant (permittivity) of ε_r = 4.8, an RF line width of 0.80mm and a gap to surrounding ground area of 0.21mm which might also be a good start-point for impedance optimization. The arrangement on the external application is shown in Figure 34 (through view on external application's bottom side, see also Figure 35).

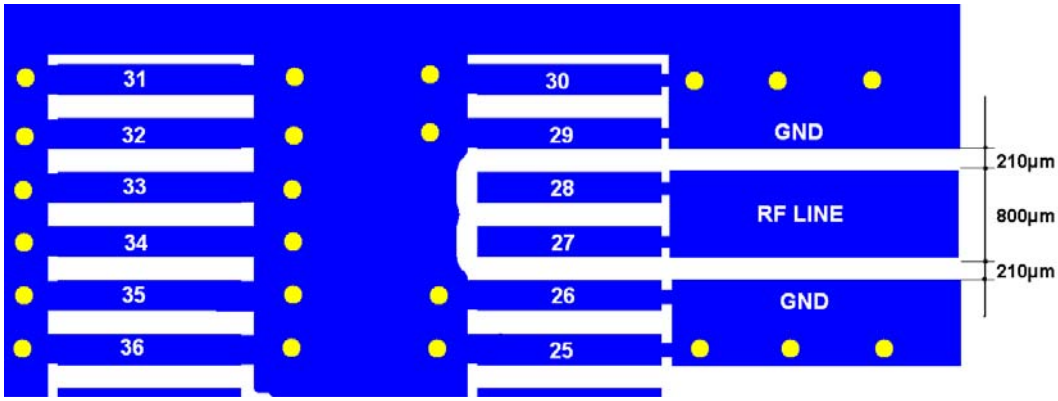
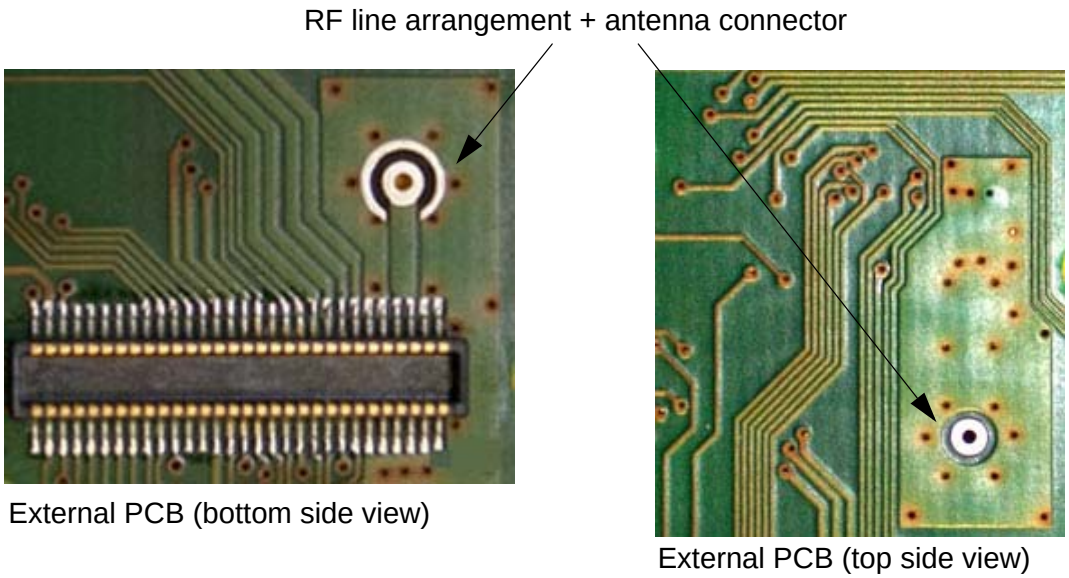


Figure 34: RF-Line PCB routing example for 1.0mm FR4

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).

The following details illustrate how an external PCB, in this case an external adapter board with an RF line arrangement for an antenna, is connected to the module's board-to-board connector.



External PCB (bottom side view)

External PCB (top side view)

External PCB connected to module

External PCB unplugged

Figure 35: External PCB with RF line arrangement connected to module

4.3 Antenna Connector Sample

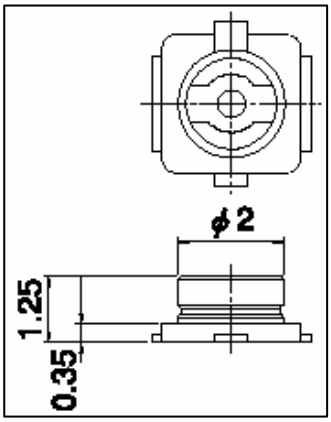


Figure 36: Mechanical dimensions of Hirose U.FL-R-SMT connector

Table 19: Product specifications of U.FL-R-SMT connector

Item	Specification	Conditions
Ratings		
Nominal impedance	50Ω	Operating temp: -40°C to +90°C Operating humidity: max. 90%
Rated frequency	DC to 6 GHz	
Mechanical characteristics		
Female contact holding force	0.15 N_{min}	Measured with a ∅ 0.475 pin gauge
Repetitive operation	Contact resistance: Centre 25 mΩ Outside 15 mΩ	30 cycles of insertion and disengagement
Vibration	No momentary disconnections of 1 µs; No damage, cracks and looseness of parts	Frequency of 10 to 100 Hz, single amplitude of 1.5 mm, acceleration of 59 m/s^2, for 5 cycles in the direction of each of the 3 axes
Shock	No momentary disconnections of 1 µs. No damage, cracks and looseness of parts.	Acceleration of 735 m/s^2, 11 ms duration for 6 cycles in the direction of each of the 3 axes
Environmental characteristics		
Humidity resistance	No damage, cracks and looseness of parts. Insulation resistance: 100 MΩ min. at high humidity 500 MΩ min when dry	Exposure to 40°C, humidity of 95% for a total of 96 hours
Temperature cycle	No damage, cracks and looseness of parts. Contact resistance: Centre 25 mΩ Outside 15 mΩ	Temperature: +40°C → 5 to 35°C → +90°C → 5 to 35°C Time: 30 min. → within 5 min. → 30 min. → within 5 min
Salt spray test	No excessive corrosion	48 hours continuous exposure to 5% salt water

Table 20: Material and finish of U.FL-R-SMT connector and recommended plugs

Part	Material	Finish
Shell	Phosphor bronze	Silver plating
Male centre contact	Brass	Gold plating
Female centre contact	Phosphor bronze	Gold plating
Insulator	Plug: PBT Receptacle: LCP	Black Beige

Mating plugs and cables can be chosen from the Hirose U.FL Series. Examples are shown below and listed in Table 21. For latest product information please contact your Hirose dealer or visit the Hirose home page, for example http://www.hirose.com.

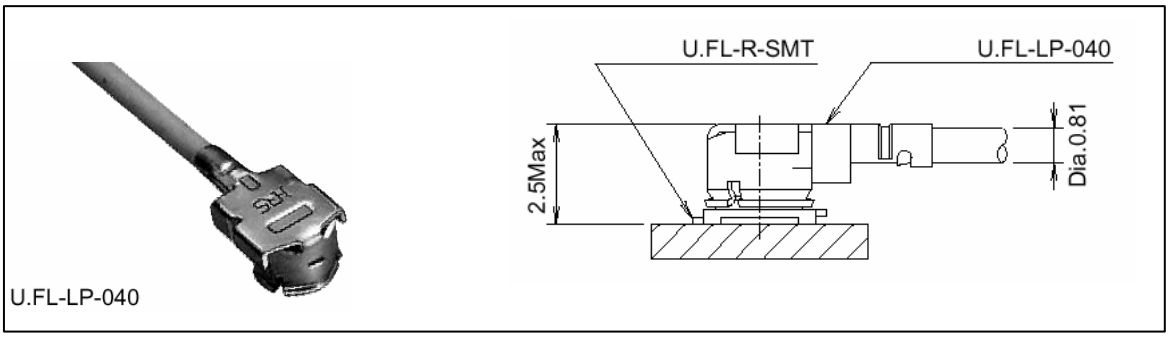


Figure 37: U.FL-R-SMT connector with U.FL-LP-040 plug

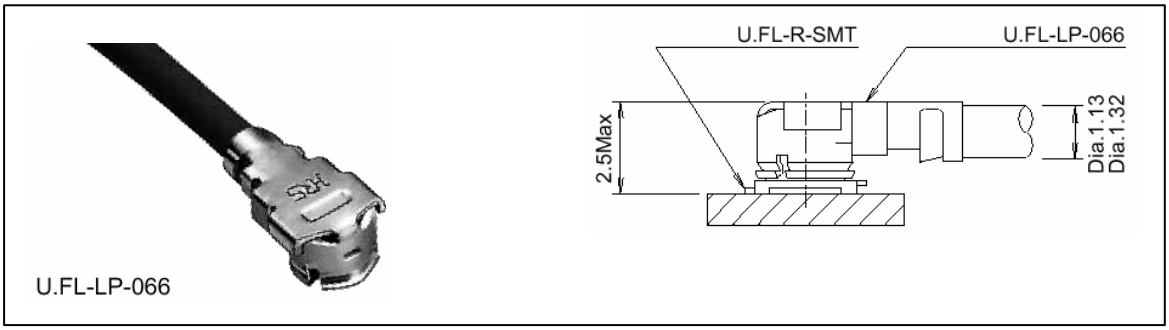


Figure 38: U.FL-R-SMT connector with U.FL-LP-066 plug

In addition to the connectors illustrated above, the U.FL-LP-(V)-040(01) version is offered as an extremely space saving solution. This plug is intended for use with extra fine cable (up to ∅ 0.81 mm) and minimizes the mating height to 2 mm. See Figure 39 which shows the Hirose datasheet.

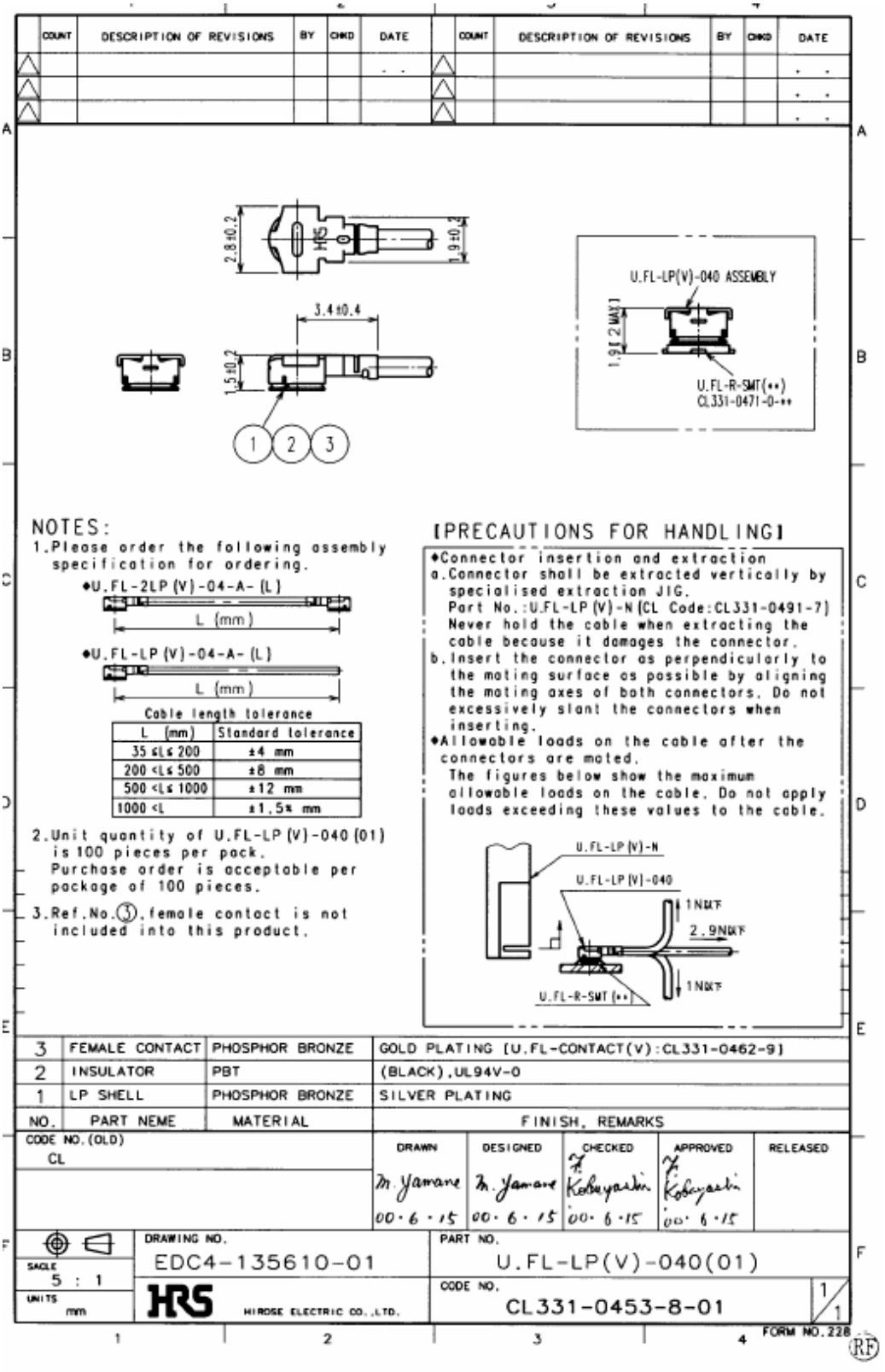


Figure 39: Specifications of U.FL-LP-(V)-040(01) plug

Table 21: Ordering information for Hirose U.FL Series

Item	Part number	HRS number
Connector on BG2-E/BG2-W	U.FL-R-SMT	CL331-0471-0-10
Right-angle plug shell for ∅ 0.81 mm cable	U.FL-LP-040	CL331-0451-2
Right-angle plug for ∅ 0.81 mm cable	U.FL-LP(V)-040 (01)	CL331-053-8-01
Right-angle plug for ∅ 1.13 mm cable	U.FL-LP-066	CL331-0452-5
Right-angle plug for ∅ 1.32 mm cable	U.FL-LP-066	CL331-0452-5
Extraction jig	E.FL-LP-N	CL331-0441-9

5 Electrical, Reliability and Radio Characteristics

5.1 Absolute Maximum Ratings

Absolute maximum ratings for supply voltage and voltages on digital and analog pins of BG2-E/BG2-W are listed in Table 22. Exceeding these values will cause permanent damage to BG2-E/BG2-W.

Table 22: Absolute maximum ratings

Parameter	Min	Max	Unit
Supply voltage BATT+	-0.3	+6.0	V
Voltage at all digital pins in Power Down mode	-0.3	+0.3	V
Voltage at digital pins 1.8V domain in normal operation	-0.3	+2.2	V
Voltage at digital pins VDIG domain (1.8V) in normal operation	-0.3	+2.2	V
Voltage at digital pins VDIG domain (2.85V) in normal operation	-0.3	+3.3	V
Voltage at SIM interface, CCVCC 1.8V in normal Operation	-0.3	+2.2	V
Voltage at SIM interface, CCVCC 2.85V in normal Operation	-0.3	+3.3	V
Voltage at analog pins in normal operation	-0.3	+3.0	V
Voltage at analog pins in Power Down mode	-0.3	+0.3	V
VDDLP	-0.3	+2.5	V

5.2 Operating Temperatures

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

Table 23: Board temperature

Parameter	Min	Typ	Max	Unit
Normal operation	-30	+25	+85	°C
Restricted operation	-40 to -30		+85 to +90	°C
Automatic shutdown[1] Temperature measured on BG2-E/BG2-W board	<-40	---	>+90	°C

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

Table 24: Ambient temperature according to IEC 60068-2 (w/o forced air circulation)

Parameter	Min	Typ	Max	Unit
GSM Call @ max. RF-Power	-40		+75	°C
GPRS Class 8 @ max. RF-Power	-40		+75	°C
GPRS Class 10 @ max. RF-Power (quad band only)	-40		+60	°C

Table 25: Ambient temperature with forced air circulation (air speed 0.9m/s)

Parameter	Min	Typ	Max	Unit
GSM Call @ max. RF-Power	-40		+80	°C
GPRS Class 8 @ max. RF-Power	-40		+80	°C
GPRS Class 10 @ max. RF-Power (quad band only)	-40		+70	°C

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

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

When data are transmitted over GPRS the quad band module variant automatically reverts to a lower Multislot Class if the temperature rises to the limit specified for normal operation and, vice versa, returns to the higher Multislot Class if the temperature is back to normal. For details see Section 3.4.

5.3 Storage Conditions

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 26: Storage conditions

Type	Condition	Unit	Reference
Air temperature: Low High	 -40 +85	 °C	 ETS 300 019-2-1: T1.2, IEC 60068-2-1 Ab ETS 300 019-2-1: T1.2, IEC 60068-2-2 Bb
Humidity relative: Low High Condens.	 10 90 at 30°C 90-100 at 30°C	 %	--- ETS 300 019-2-1: T1.2, IEC 60068-2-56 Cb ETS 300 019-2-1: T1.2, IEC 60068-2-30 Db
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

5.4 Reliability Characteristics

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

Table 27: Summary of reliability test conditions

Type of test	Conditions	Standard
Vibration	Frequency range: 10-20 Hz; acceleration: 3.1mm amplitude Frequency range: 20-500 Hz; acceleration: 5g Duration: 2h per axis = 10 cycles; 3 axes	DIN IEC 60068-2-6
Shock half-sinus	Acceleration: 500g Shock duration: 1msec 1 shock per axis 6 positions (± x, y and z)	DIN IEC 60068-2-27
Dry heat	Temperature: +70 ±2°C Test duration: 16 h Humidity in the test chamber: < 50%	EN 60068-2-2 Bb ETS 300019-2-7
Temperature change (shock)	Low temperature: -40°C ±2°C High temperature: +85°C ±2°C Changeover time: < 30s (dual chamber system) Test duration: 1 h Number of repetitions: 100	DIN IEC 60068-2-14 Na ETS 300019-2-7
Damp heat cyclic	High temperature: +55°C ±2°C Low temperature: +25°C ±2°C Humidity: 93% ±3% Number of repetitions: 6 Test duration: 12h + 12h	DIN IEC 60068-2-30 Db ETS 300019-2-5
Cold (constant exposure)	Temperature: -40 ±2°C Test duration: 16 h	DIN IEC 60068-2-1

5.5 Electrical Specifications of the Application Interface

Please note that the reference voltages listed in Table 28 are the values measured directly on the BG2-E/BG2-W module. They do not apply to the accessories connected.

If an input pin is specified for $V_{i,h,max}$ = 3.3V, be sure never to exceed the stated voltage. The value 3.3V is an absolute maximum rating.

The Molex board-to-board connector on BG2-E/BG2-W is a 60-pin double-row receptacle. The names of the pins are listed in the following Figure 40, the board-to-board connector and position of pins are shown in Figure 42.

31	GND	GND	30
32	GND	GND	29
33	GND	ANT	28
34	GND	ANT	27
35	GND	GND	26
36	GND	GND	25
37	RTS1	BATT+	24
38	CTS1	BATT+	23
39	RXD1	BATT+	22
40	TXD1	BATT+	21
41	AGND	DTR0	20
42	MICN	DCD0	19
43	MICP	Do not use	18
44	VMIC	DSR0	17
45	EPN	V180	16
46	EPP	V285	15
47	GND	VDIG	14
48	ADC1	RXD0	13
49	ON	TXD0	12
50	GPIO1	CTS0	11
51	GPIO2	RTS0	10
52	GPIO3	RING0	9
53	GPIO4	CCCLK	8
54	GPIO5 / LED	CCVCC	7
55	GPIO6 / PWM2	CCIO	6
56	GPIO7 / PWM1	CCIN	5
57	GPIO8	CCRST	4
58	GPIO9 / I2CDAT	Do not use	3
59	GPIO10 / I2CCLK	GND	2
60	VDDLP	EMERG_RST	1

Figure 40: Pin assignment

Table 28: Electrical description of application interface

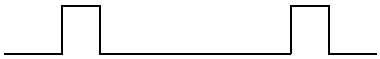
Function	Signal name	IO	Signal form and level	Comment
Power supply	BATT+	I	$V_I$max = 4.5V $V_I$norm = 4.0V $V_I$min = 3.3V during Tx burst on board I ≈ 1.35A, during Tx burst (GSM)  n Tx = n x 577µs peak current every 4.616ms	Pins of BATT+ and GND must be connected in parallel for supply purposes because higher peak currents may occur. Minimum voltage must not fall below 3.3V including drop, ripple, spikes.
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 or V285 may be used for application circuits. If unused keep pin open. Not available in Power Down mode. The external digital logic must not cause any spikes or glitches on voltage V180 or V285.
	V285	O	$V_O$norm = 2.85V +1.5%, -2% $I_O$max = -10mA CLmax = 100nF	
Ignition	ON	I	R_I ≈ 32kΩ ±15%, C_I ≈ 1nF V_{IH}max = VDDLP + 0.5V V_{IH}min = 1.2V at ~40µA V_{IL}max = 0.4V ___|‾_ _ _ _ high impulse	This signal switches the module ON. This line must be driven high by an open drain or open collector driver connected to VDDLP. See Section 3.3.
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 ~~|___|~~ low impulse width > 10ms	This line must be driven low by an open drain or open collector driver connected to GND. If unused keep pin open.
RTC backup	VDDLP	I/O	$V_O$norm = 2.3V ±5% $I_O$max = 2mA $V_I$max = 2.4V $V_I$min = 1.0V $I_I$typ = 8µA	It is recommended to use a serial resistor between VDDLP and a possible capacitor. See 3.3.1.1. If unused keep pin open.
SIM card detection	CCIN	I	R_I ≈ 110kΩ V_{IH}min = 1.45V at I = 15µA, V_{IH}max= 1.9V V_{IL}max = 0.3V	CCIN = High, SIM card inserted. If unused keep pin open.

Table 28: Electrical description of application interface

Function	Signal name	IO	Signal form and level	Comment
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	
	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 28: Electrical description of application interface

Function	Signal name	IO	Signal form and level	Comment
Digital Power Supply	VDIG	I	$V_I$min = 1.75V $V_I$max = 2.90V $I_I$max = 50mA	ASC0 and I^2C power supply input. Connect this pin to the external power supply voltage V180 or V285. See also Section 3.9.
Serial Interface ASC0	*VDIG connected to V180, i.e., VDIG = 1.80V*			If unused keep pin open.
	RXD0	O	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	
	TXD0	I		
	CTS0	O		
	DTR0	I		
	DSR0	O		
	DCD0	O		
	RTS0	I	V_{IL}max = 0.20V at I = -280µA V_{IH}min = 1.20V at I = -160µA V_{IH}max = 1.90V	
	RING0	O	V_{OL}max = 0.30V at I = 2mA V_{OH}min = 1.40V at I = -40µA V_{OH}max = 1.90V	
	VDIG connected to V285, i.e., VDIG = 2.85V			
	RXD0	O	V_{OL}max = 0.20V at I = 2mA V_{OH}min = 2.40V at I = -2mA V_{OH}max = 2.90V V_{IL}max = 0.56V V_{IH}min = 2.05V V_{IH}max = 2.90V	
	TXD0	I		
	CTS0	O		
	DTR0	I		
	DSR0	O		
	DCD0	O		
	RTS0	I	V_{IL}max = 0.30V at I = -380µA V_{IH}min = 1.96V at I = -80µA V_{IH}max = 2.90V	
	RING0	O	V_{OL}max = 0.30V at I = 2mA V_{OH}min = 2.40V at I = -40µA V_{OH}max = 2.90V	
Serial Interface ASC1	RXD1	O	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 pin open.
	TXD1	I		
	RTS1	I		
	CTS1	O		

Table 28: Electrical description of application interface

Function	Signal name	IO	Signal form and level	Comment
I^2C	*VDIG connected to V180, i.e., VDIG = 1.80V*			I2CCLK is configured as Open Drain with an internal 5kOhm 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 for the fast mode a rise time of max. 300ns is permitted. 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 lines are unused keep pins open.
	I2CCLK	O	Input, Open Drain Output $R_I \approx$ 5kOhm (internal Pull up) V_{OL}min = 0.4V at I = -3mA V_{OH}max = 1.90V	
	I2CDAT	IO	Input, Open Drain Output (no Pull up) V_{IL}max = 0.5V V_{IH}min = 1.3V V_{IH}max = 2.20V V_{OL}min = 0.4V at I = -3mA	
	VDIG connected to V285, i.e., VDIG = 2.85V			
	I2CCLK	O	Open Drain Output $R_I \approx$ 5kOhm (internal Pull up) V_{OL}min = 0.4V at I = -3mA V_{OH}max = 2.90V	
	I2CDAT	IO	Input, Open Drain Output (no Pull up) V_{IL}max = 0.8V V_{IH}min = 2.1V V_{IH}max = 3.3V V_{OL}min = 0.4V at I = -3mA	

Table 28: Electrical description of application interface

Function	Signal name	IO	Signal form and level	Comment
GPIO interface	GPIO1	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 pin open. Please note that some GPIO lines can be used for functions other than GPIO: Status LED line: GPIO5, PWM: GPIO6 / GPIO7, I^2C: GPIO9 / GPIO10. GPIO9 has an open drain output functionality only and will need an external pull-up resistor. With VDIG connected to V180 the minimum value of this external resistor should be 750Ohm. With VDIG connected to V285 the minimum value should be 1.1kOhm. GPIO10 also has an open drain output functionality only, but with an internal 5kOhm pull up. With VDIG connected to V180 the minimum value of this external resistor should be 860Ohm. With VDIG connected to V285 the minimum value should be 1.5kOhm. For further details see Section 3.12, Section 3.13, Section 3.15, Section 3.14.
	GPIO2	IO		
	GPIO3	IO		
	GPIO4	IO		
	GPIO5	IO		
	GPIO6	IO		
	GPIO7	IO		
	GPIO8	IO		
	VDIG connected to V180, i.e., VDIG = 1.80V			
	GPIO9, i.e., I2CDAT	IO	Input, Open Drain Output (no Pull up) V_{IL}max = 0.5V V_{IH}min = 1.3V V_{IH}max = 2.20V V_{OL}min = 0.4V at I = -3mA	
	GPIO10, i.e., I2CCLK	IO	Input, Open Drain Output R_I ≈ 5kOhm (internal Pull up) V_{OL}min = 0.4V at I = -3mA V_{OH}max = 1.90V	
	VDIG connected to V285, i.e., VDIG = 2.85V			
	GPIO9, i.e., I2CDAT	IO	Input, Open Drain Output (no Pull up) V_{IL}max = 0.8V V_{IH}min = 2.1V V_{IH}max = 3.3V V_{OL}min = 0.4V at I = -3mA	
	GPIO10, i.e., I2CCLK	IO	Open Drain Output R_I ≈ 5kOhm (internal Pull up) V_{OL}min = 0.4V at I = -3mA V_{OH}max = 2.90V	

Table 28: Electrical description of application interface

Function	Signal name	IO	Signal form and level	Comment
Analog audio interface	VMIC	O	$V_O$typ = 2.2V I_{max} = 4 mA	Microphone supply for customer feeding circuits If unused keep pin open.
	EPP	O	Differential, Typ. 3.4Vpp at 16Ω load Typ. 4.5Vpp at no load PCM level = +3dBm0, 1.02 kHz sine wave	Balanced output for ear-phone or balance output for line out If unused keep pin open.
	EPN	O		
	MICP	I	$Z_I$typ = 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 pins open.
	MICN	I		
	AGND		Analog Ground	GND level for external audio circuits. If unused keep pin open.
ADC	ADC1	I	R_I = 1MΩ V_I = 0V ... 1.2V V_{IH} max = 3.3V	If unused keep pin open.

5.6 Power Supply Ratings

Table 29: Power supply ratings[1]

Parame-ter	Description	Conditions	Min	Typ	Max	Unit
BATT+	Supply voltage	Voltage must stay within the min/ max values, including voltage drop, ripple and spikes.	3.3	4.0	4.5	V
	Voltage drop during transmit burst	Normal condition, power control level for $P_{out\ max}$			400	mV
	Voltage ripple	Normal condition, power control level for $P_{out\ max}$ @ f≤250kHz @ f>250kHz			 85 25	mVpp
I_{VDDLP}	OFF state supply current	RTC backup @ BATT+ = 0V @ VDDLP = 2.3V		8.0		µA
		Power Down mode		45		µA
I_{BATT+}	Average supply cur-rent	SLEEP mode, GSM[2] @ DRX = 2 @ DRX = 5 @ DRX = 9		 2.1 1.5 1.1		mA
		SLEEP mode, GPRS[2] @ DRX = 2 @ DRX = 5 @ DRX = 9		 2.2 1.5 1.2		mA
		IDLE mode [2]		8.6		mA
		TALK mode GSM GSM850/EGSM 900[3] GSM 1800/1900[4]		 200 150		mA
		DATA mode GPRS 1 TX, 4 Rx GSM 850/EGSM 900[3] GSM 1800/1900[4]		 180 145		mA
		DATA mode GPRS 2 Tx, 3 Rx GSM 850/EGSM 900[3] GSM 1800/1900[4]		 330 260		mA
	Peak supply current (during transmission slot every 4.6ms)	Power Control Level GSM 850/EGSM 900[3] GSM 1800/1900[4]		 1.30 0.95	 1.35 0.97	A

1. GSM850 and GSM1900 bands are applicable for the quad band module variant BG2-W only.
2. Measurements start 3 minutes after the module was switched ON,
   Averaging times: SLEEP mode - 3 minutes; IDLE mode - 1.5 minutes,
   Communication tester settings: no neighbour cells, no cell reselection etc.
3. Power control level PCL 5
4. Power control level PCL 0

5.7 Electrical Characteristics of the Voiceband Part

5.7.1 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 30: 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.

5.7.2 Audio Programming Model

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

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

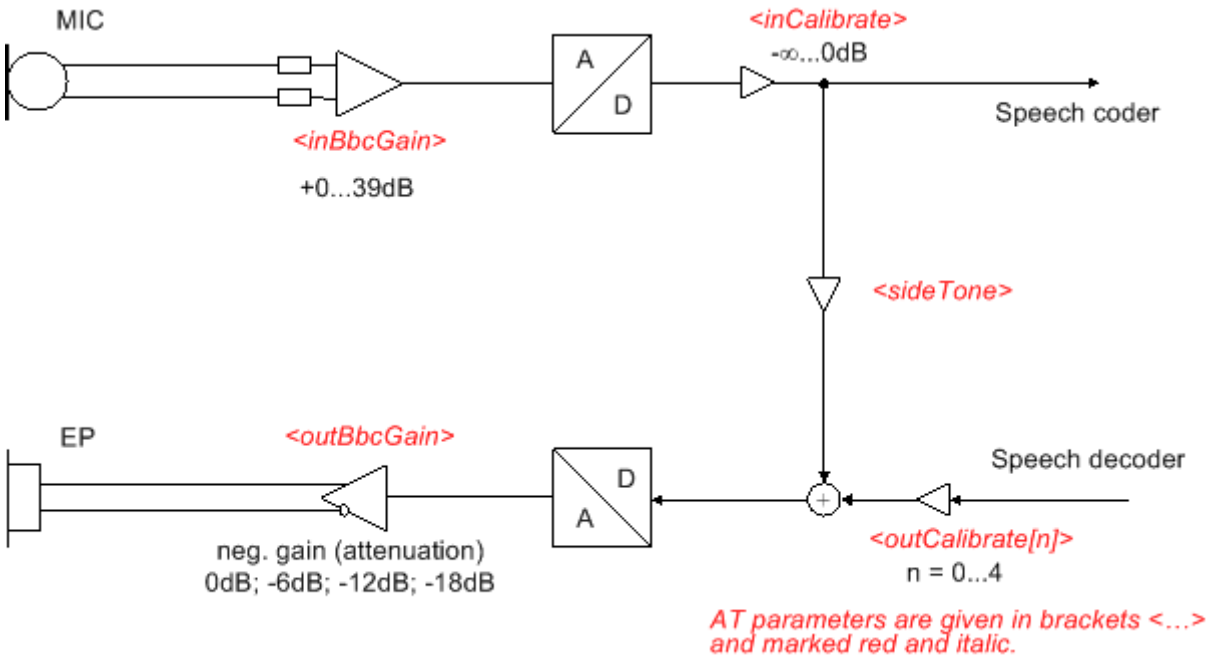


Figure 41: Audio programming model

5.7.3 Characteristics of Audio Modes

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

Table 31: Voiceband characteristics (typical)

Audio mode no. AT^SNFS=	**1** (Default settings, not adjustable)	**2**	**3**	**4**	**5**	**6**
Name	Default Handset	Basic Handsfree	Headset	User Handset	Plain Codec 1	Plain Codec 2
Purpose	DSB with Votronic handset	Car Kit	Headset	DSB with individual handset	Direct access to speech coder	Direct access to speech coder
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) 0 (0dB)
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	Cancella-tion	Cancella-tion
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	1160mV 4.5Vpp
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.

5.7.4 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 32: Voiceband receive path

Parameter	Min	Typ	Max	Unit	Test condition/remark
Differential output voltage (peak to peak)		3.4 4.5		Vpp	16Ohm, 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

5.7.5 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 33: 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.

5.8 Antenna Interface Specification

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

Table 34: Antenna interface specifications [1]

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

[1] GSM850 and GSM1900 bands are applicable for the quad band module variant BG2-W only.

5.9 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 BG2-E/BG2-W module.

Special ESD protection provided on BG2-E/BG2-W:
- SIM interface: Serial resistor and ESD protection diode

BG2-E/BG2-W has been tested according to group standard ETSI EN 301 489-1 (see Table 3) and test standard EN 61000-4-2. The measured values can be gathered from the following table.

Table 35: Measured electrostatic values

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

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

6 Mechanics

The following sections describe the mechanical dimensions of BG2-E/BG2-W and give recommendations for integrating BG2-E/BG2-W into the host application. Also, a file containing product model data in STEP format is attached to this PDF. Please open the Attachments navigation panel to view and save the STEP file.

6.1 Mechanical Dimensions of BG2-E/BG2-W

Figure 42 shows the top view on BG2-E/BG2-W and provides an overview of the mechanical dimensions of the board. For further details see Figure 43.

Length: 31.00mm
Width: 26.70mm
Height: 3.05mm (5.37mm with soldering tags)

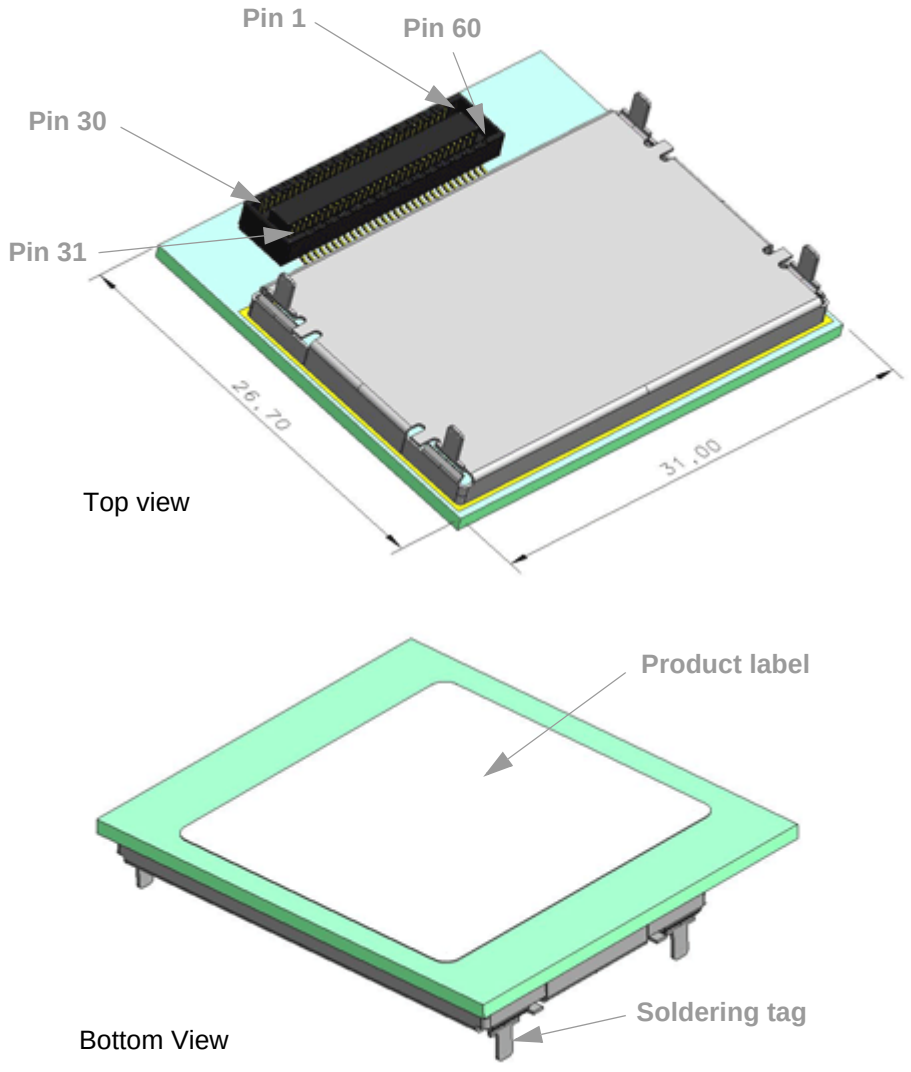


Figure 42: BG2-E/BG2-W – top and bottom view

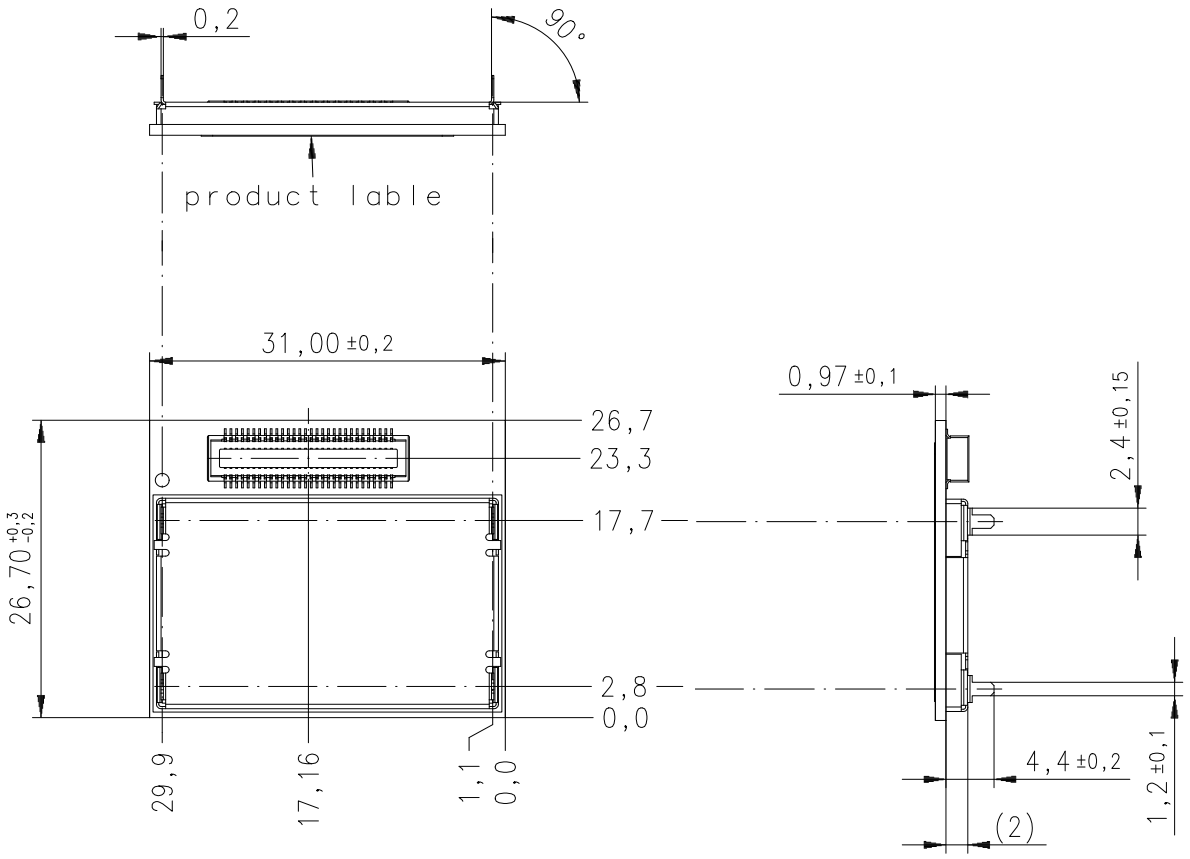


Figure 43: Mechanical dimensions of BG2-E/BG2-W (all dimensions in millimeters)

6.2 Mounting BG2-E/BG2-W onto the Application Platform

There are various ways to mount, i.e., to connect and fasten, BG2-E/BG2-W onto an external application:

The connection can be realized by the module's board-to-board connector alone. However, as a more efficient approach it is strongly recommended to additionally implement a reliable electrical ground connection from the module's shielding to the external application. Especially for applications with integrated antenna this ensures an optimal antenna performance.

In order to ground connect the module's shielding to an external application, the signal level of the shielding (including tags) must be GROUND.

Possible types of shielding ground connection are:
- Contact springs between shielding and application ground
- Conductive materials between shielding and application ground (conductive gauze or mesh)
- Soldering the solder tags (to application ground).
  For soldering the external application's PCB should not be thicker than 1.6mm.
  For best results with single soldering (i.e., with desoldering being no requirement) Cinterion recommends plated oblong holes with a size of 1.5mm x 0.4mm. The copper boundary of the oblong holes should be circular 0.5mm. The solder mask should have a circular size of 0.55mm around the holes. It is also advised to use thermal ties on both sides to connect the shielding to ground. Please refer to Figure 43 and Figure 44 for more details on the module's solder tags and an external application's matching mounting holes.
  For best results with multiple soldering (i.e., with desoldering being a requirement) Cinterion recommends to use unplated oblong holes with a size of 1.5mm x 0.4mm. The copper is withdrawn with a size of 0.3mm around the hole. The solder mask has a circular size of 1mm around the hole on both sides.

The fastening can be realized by any of the following options:
- Soldering as described above
- Glue or adhesive tape
- Mounting clip. For more information see Section 9.2.

The oblong holes on the application's PCB and their position are illustrated in Figure 44 showing a (phantom) view through the application's PCB to the board-to-board connector side, i.e., to the side the module is connected. Measurement base is the geometric mean of the board-to-board connector.

Cinterion recommends oblong holes for best soldering - and desoldering - results (see above). However, for an easier and quicker mounting it is possible to use round holes with a 1.4mm diameter instead as shown in Figure 44.

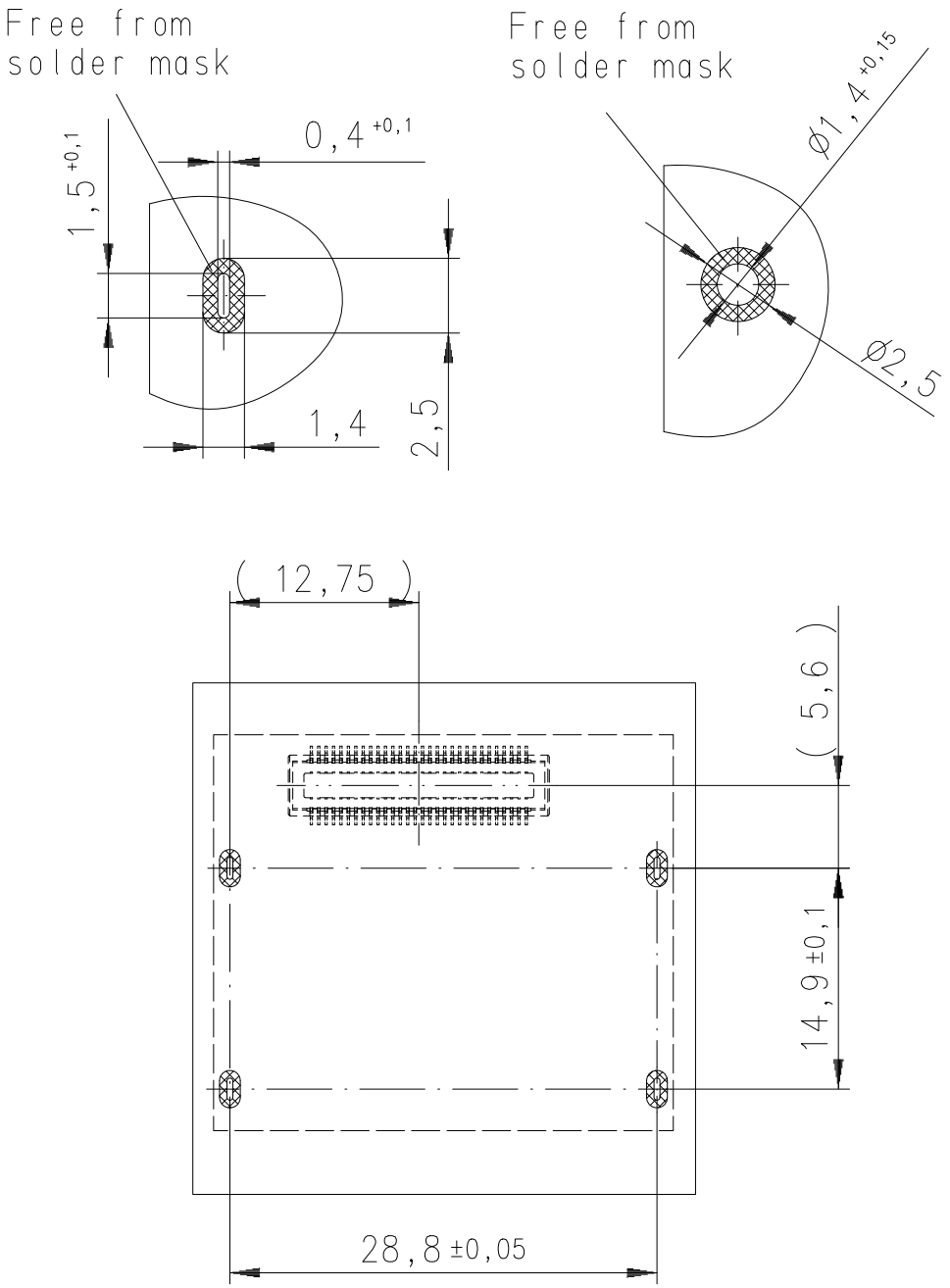
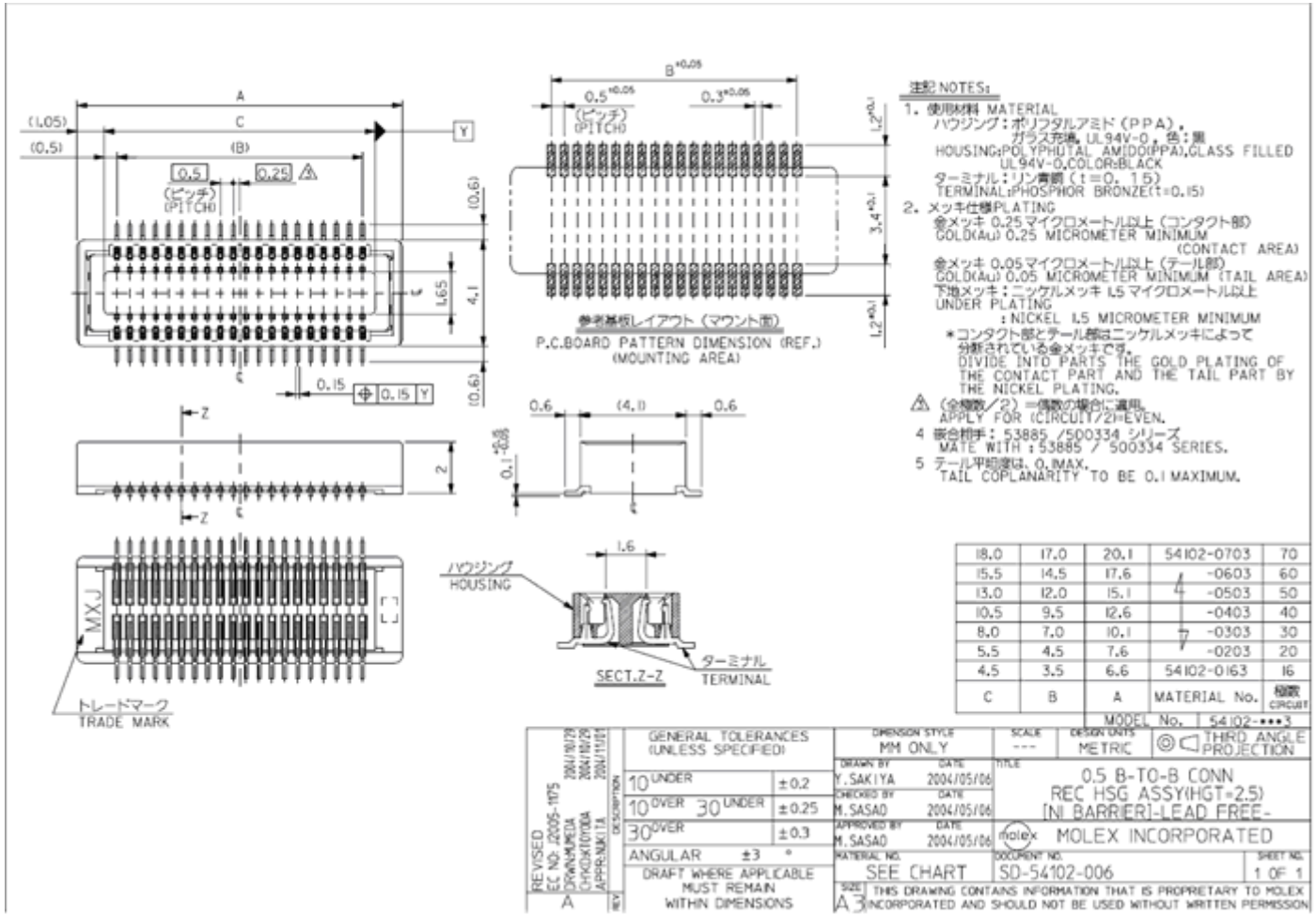


Figure 44: Layouts for mounting holes

6.3 Board-to-Board Connector

This section provides specifications for the 60-pin board-to-board connector which serves as physical interface to the host application. The receptacle assembled on the BG2-E/BG2-W PCB is of type Molex 54102-0604 (for dimensions see Figure 45). A mating header would be the Molex type 53885-0608 (see Figure 46)



18.0	17.0	20.1	54102-0703	70
15.5	14.5	17.6	-0603	60
13.0	12.0	15.1	-0503	50
10.5	9.5	12.6	-0403	40
8.0	7.0	10.1	-0303	30
5.5	4.5	7.6	-0203	20
4.5	3.5	6.6	54102-0163	16
C	B	A	MATERIAL No.	極数 CIRCUIT

Figure 45: Mechanical dimensions of Molex 54102-0604 connector on BG2-E/BG2-W

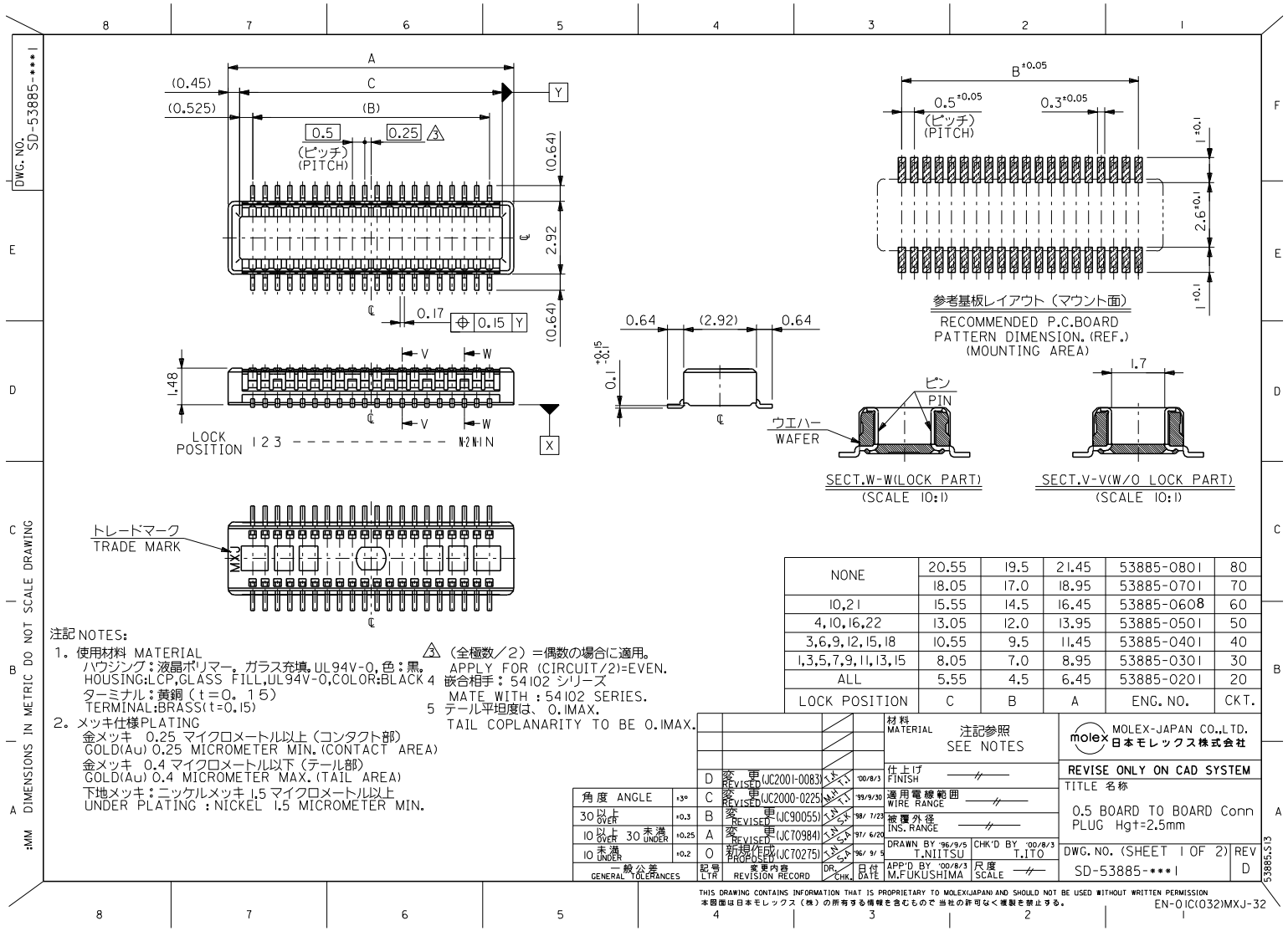


Figure 46: Mechanical dimensions of Molex 53885-0608 connector on application

7 Sample Application

Figure 47 shows a typical example of how to integrate an BG2-E/BG2-W module with an application.

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

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

Because of the high RF field density inside the module, it cannot be guaranteed that no self interference might occur, depending on frequency and the applications grounding concept. 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, RXT0, VDDLP, and ON).

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

Please note that BG2-E/BG2-W 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 47 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 BG2-E/BG2-W modules.

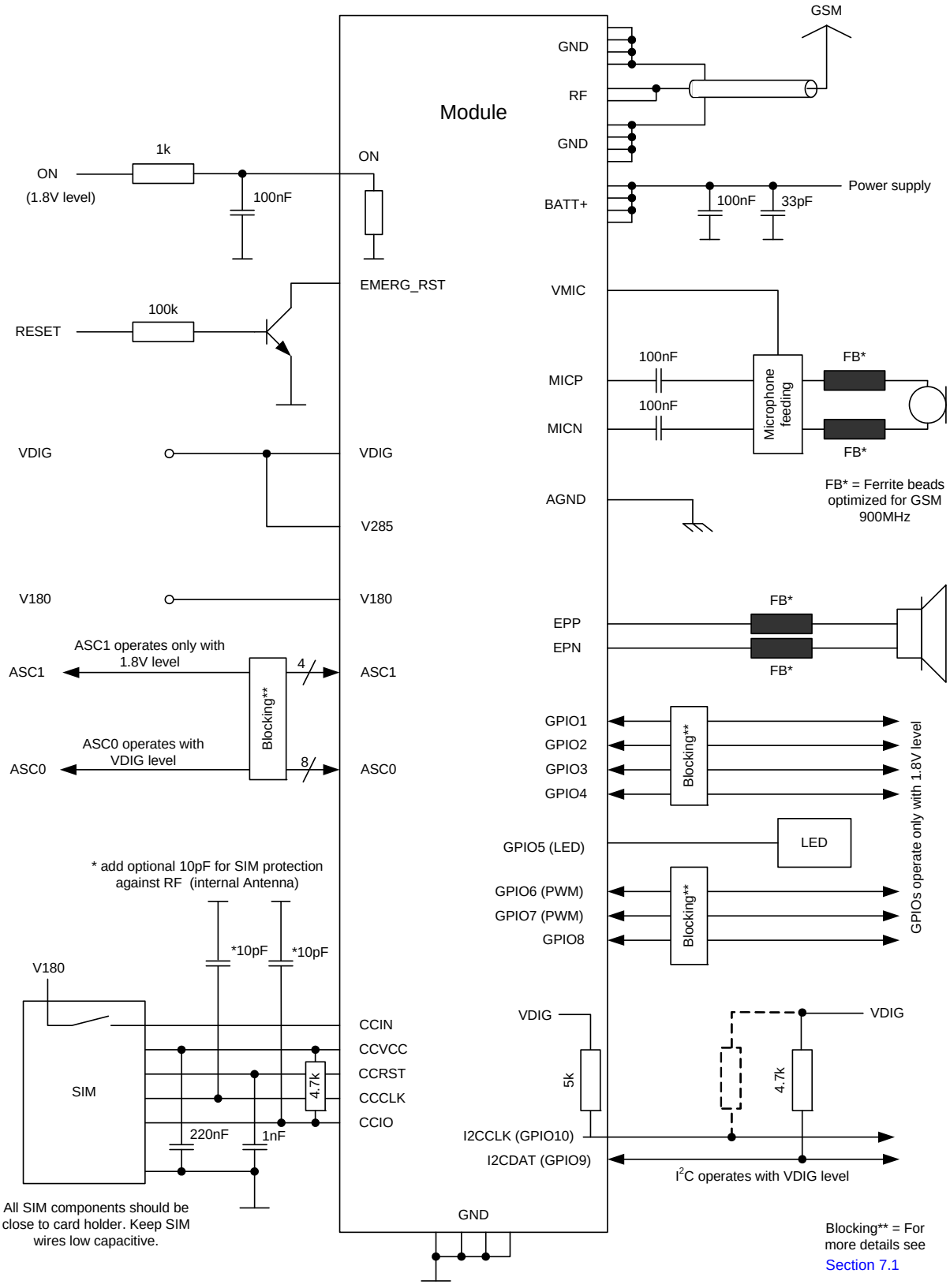


Figure 47: Schematic diagram of BG2-E/BG2-W sample application

7.1 Blocking against RF Interference

To reduce EMI resp. ESD issues there are serial resistors, or capacitors to GND, implemented on the module for the ignition, emergency restart, and SIM interface lines (cp. Section 5.9). However, all other signal lines have no EMI measures on the module and there are no blocking measures at the module's 60-pin board-to-board connector 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 48 and Table 36). Pay attention not to exceed the maximum input voltages and prevent voltage overshots if using inductive EMC measures.

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

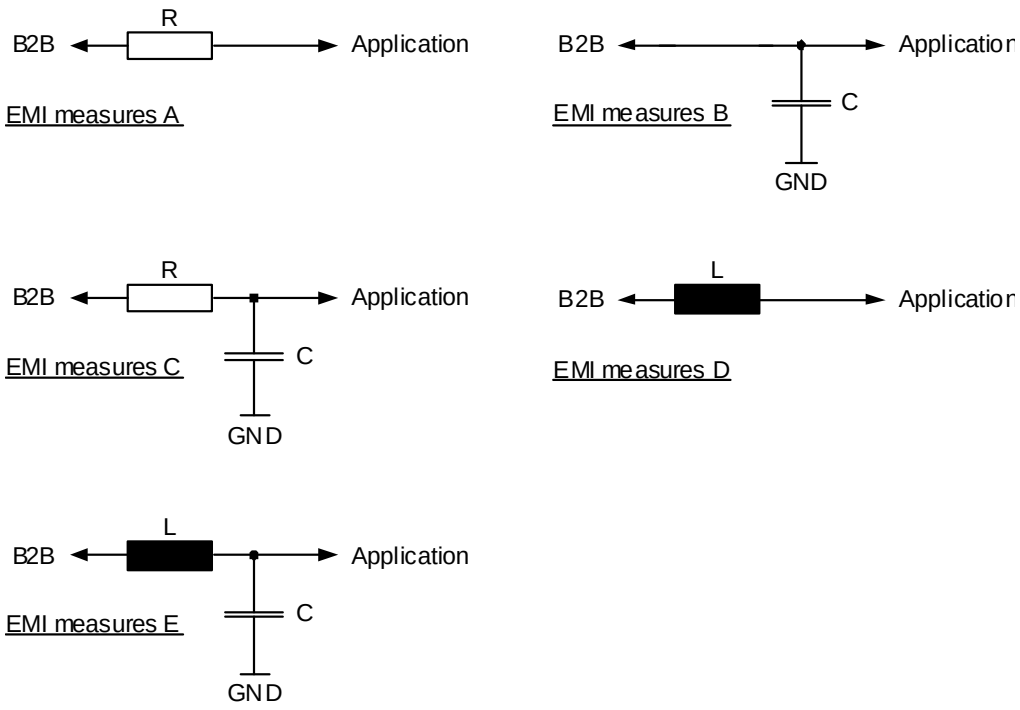


Figure 48: EMI circuits

The following table lists for each signal line at the board-to-board connector the EMI measures that may be implemented.

Table 36: EMI measures on the board-to-board connector

Signal name	EMI measures					Remark
	A	B	C	D	E	
CCIN	x			x		
CCRST		x				The external capacitor should be not higher than 30pF. 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		
RING0				x		
DTR0	x	x	x	x	x	
DCD0	x	x	x	x	x	
DSR0	x	x	x	x	x	
RXD1	x	x	x	x	x	
TXD1	x	x	x	x	x	
CTS1	x	x	x	x	x	
RTS1	x	x	x	x	x	
GPIO1	x	x	x	x	x	
GPIO2	x	x	x	x	x	
GPIO3	x	x	x	x	x	
GPIO4	x	x	x	x	x	
GPIO5/Status	x	x	x	x	x	
GPIO6/PWM2	x	x	x	x	x	
GPIO7/PWM1	x	x	x	x	x	
GPIO8	x	x	x	x	x	
GPIO9/I2CDAT		x		x		The rising signal edge is reduced with an additional capacitor.
GPIO10/I2CCLK		x		x		
V180		x		x	x	
V285		x		x	x	
VDIG		x		x	x	

8 Reference Approval

8.1 Reference Equipment for Type Approval

The Cinterion Wireless Modules reference setup submitted to type approve BG2-E/BG2-W is shown in the following figure.

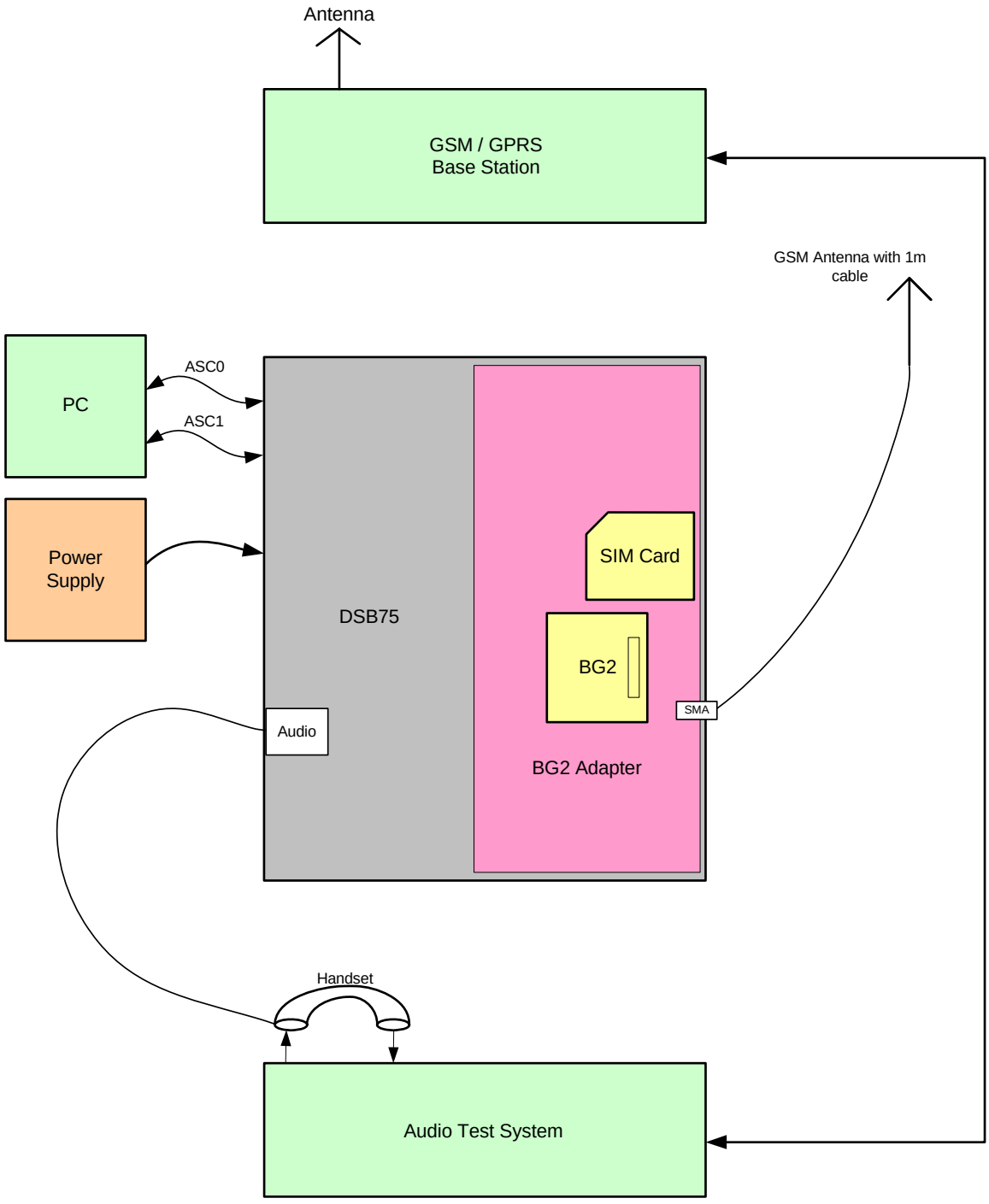


Figure 49: Reference equipment for approval

8.2 Compliance with FCC Rules and Regulations

The Equipment Authorization Certification for the Cinterion Wireless Modules reference application described in Section 8.1 will be registered under the following identifiers[4]:

FCC Identifier: QIPBG2
Industry Canada Certification Number: 7830A-BG2
Granted to Cinterion Wireless Modules GmbH

Manufacturers of mobile or fixed devices incorporating BG2-W modules are authorized to use the FCC Grants and Industry Canada Certificates of the BG2-W modules for their own final products according to the conditions referenced in these documents. In this case, the FCC label of the module shall be visible from the outside, or the host device shall bear a second label stating "Contains FCC ID QIPBG2", and accordingly "Contains IC 7830A-BG2".

IMPORTANT:
Manufacturers of portable applications incorporating BG2-W 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 1.3.2 for detail).

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

4. Applies only for the quad band module variant BG2-W.

9 Appendix

9.1 List of Parts and Accessories

Table 37: List of parts and accessories

Description	Supplier	Ordering information
BG2-E/BG2-W	Cinterion	Standard module Cinterion Wireless Modules IMEI: Ordering number: L30960-N1800-A100 (BG2-E) Ordering number: L30960-N1810-A100 (BG2-W) Customer IMEI mode: Ordering number: L30960-N1805-A100 (BG2-E) Ordering number: L30960-N1815-A100 (BG2-W)
DSB75 Support Box	Cinterion	Ordering number: L36880-N8811-A100
BG2-E/BG2-W mounting clip	GTT	Please ask Cinterion for ordering details.
DSB75-Adapter for mounting the BG2-E/BG2-W module	Cinterion	Ordering number: L30960-N1801-A100
Votronic Handset	VOTRONIC	Votronic 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 38.
Board-to-board connector	Molex	Sales contacts are listed in Table 38.

Table 38: Molex sales contacts (subject to change)

Molex For further information please click: http://www.molex.com	Molex Deutschland GmbH Felix-Wankel-Str. 11 4078 Heilbronn-Biberach Germany Phone: +49-7066-9555 0 Fax: +49-7066-9555 29 Email: mxgermany@molex.com	American Headquarters Lisle, Illinois 60532 U.S.A. Phone: +1-800-78MOLEX Fax: +1-630-969-1352
Molex China Distributors Beijing, Room 1319, Tower B, COFCO Plaza No. 8, Jian Guo Men Nei Street, 100005 Beijing P.R. China Phone: +86-10-6526-9628 Phone: +86-10-6526-972 Phone: +86-10-6526-9731 Fax: +86-10-6526-9730	Molex Singapore Pte. Ltd. Jurong, Singapore Phone: +65-268-6868 Fax: +65-265-6044	Molex Japan Co. Ltd. Yamato, Kanagawa, Japan Phone: +81-462-65-2324 Fax: +81-462-65-2366

9.2 Mounting Clip

An optional mounting clip is available to connect BG2-E/BG2-W to an external application. The mounting clip provides for an easy module exchange or replacement.

Mounting Clip for Cinterion BG2 module

GTT P/N : GT-BG2-CLIP **V1 Release 29th/Sep 2010**

PCB Mounting Clip Design for Cinterion Wireless Module : BG2

enquiries@gtteurope.co.uk ;: www.gtteurope.co.uk

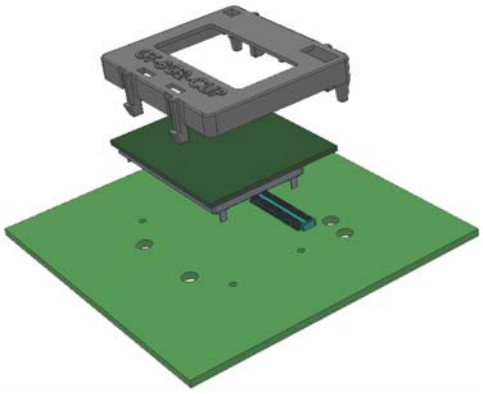
FEATURES AND APPLICATION

Board to Board connector information

Cinterion module board side connector by Molex : 54102-0604
PCB mating board side connector by Molex : 53885-0608
Size : 60 pins
Stacking height : 2.5mm

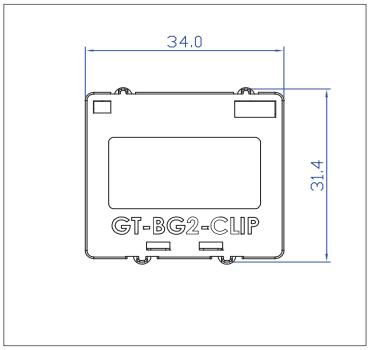
PCB mating board thickness : 1.6mm
Pulling force (Module Clip on PCB) : Minimum 10N
Maximum 150N

Reference information
Packaging information : TBD



CLIP SPECIFICATIONS

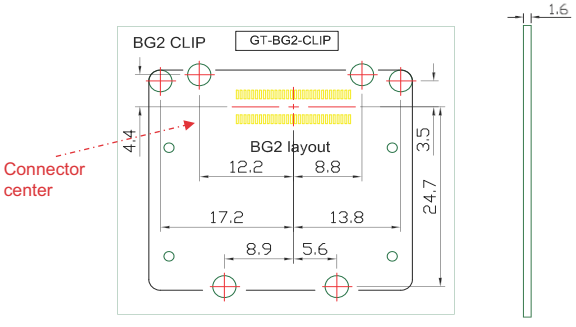
Physical



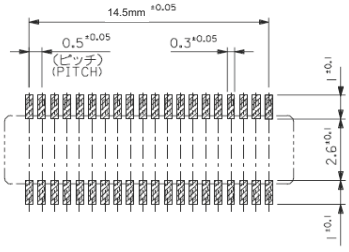
Assembled dimensions *(in millimeters)*

Stacking height 2.5mm

MODULE CLIP PCB FOOTPRINT AND CONNECTOR RECEPTACLE DIMENSIONS



Module Clip PCB Footprint



PCB Connector Receptable dimensions