Differences between Cinterion® BGS2 Rel. 1+2 and EHSx

Migration Guide

Version: 06
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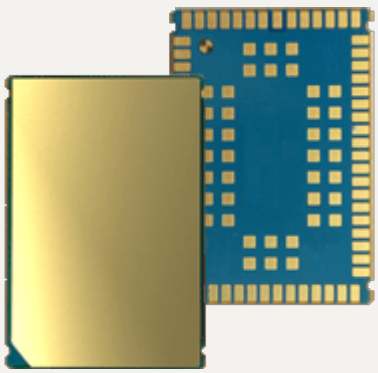

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Contents

Tables

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0 Document History

Preceding document: "Differences between BGS2 Rel.1+2 and EHSx", Version 05
New document: "Differences between BGS2 Rel.1+2 and EHSx", Version 06

Chapter	What is new
3.1	Revised GPIO interfaces for EHS5 and EHS6 Revised ignition signal for EHS5 and EHS6
3.2.3	Added temperature ratings for EHS6
3.3.3	Revised Figure 1.
3.3.4	Added note on EMERG_RST signal state.
3.3.9	Completed power supply ratings for EHS6
3.3.15	New section SPI Interface.
4	Revised Figure 11 and Figure 12 regarding AUTO_ON
4.1	Revised section and added Figure 14 and Figure 15.

Preceding document: "Differences between BGS2 Rel.1+2 and EHSx", Version 04
New document: "Differences between BGS2 Rel.1+2 and EHSx", Version 05

Chapter	What is new
3.1	Revised GPIO interfaces for EHS5 and EHS6
3.3.1, 3.3.2, 3.3.3	Revised order and contents of sections describing module startup signals.
3.3.19	Added shared GPIO for EHS5 and EHS6

Preceding document: "Differences between BGS2 Rel.1+2 and EHSx", Version 03
New document: "Differences between BGS2 Rel.1+2 and EHSx", Version 04

Chapter	What is new
3.1	Added autobauding rates for EHS6. Added weight for EHS6. Revised maximum autobauding rates for ASC0/ASC1 (230,000 → 230,400). GPIO4 line shared with fast shutdown line
3.3.5	Revised Figure 2 showing external interference suppression circuit.
3.3.7	Revised values for R1 and R3 (EHS5/EHS6) in Table 10.

Chapter	What is new
3.3.16	Added remark on HSIC interface requiring ASC1.
3.3.19	Revised characteristics for GPIO4, GPIO9, GPIO10 (EHS5, EHS6)
4	Listed further pad connections in Figure 11 and Figure 12.
4.1	New section Combined Land Pattern.

Preceding document: "Differences between BGS2 Rel.1+2 and EHSx", Version 02
New document: "Differences between BGS2 Rel.1+2 and EHSx", Version 03

Chapter	What is new
Throughout document	Removed future EHS8 module (except for Figure 17 illustrating a common footprint design still comprising EHS8). Renamed ON2 pad to AUTO_ON pad.
3.1	Added autobauding rates for EHS5. Added operating temperature range for EHS5.
3.3.3	Revised R1 value given for BGS2 ignition circuit.
3.4.1	Revised example for an external ESD protection circuit for RF antenna interface.
3.3.9	Completed section listing power supply ratings.

Preceding document: "Differences between BGS2 Rel.1+2 and EHSx", Version 01
New document: "Differences between BGS2 Rel.1+2 and EHSx", Version 02

Chapter	What is new
4	Added notes on pad assignment. Clarified some pad assignments.

New document: "Differences between BGS2 Rel.1+2 and EHSx", Version 01

Chapter	What is new
---	Initial document setup.

1 Introduction

This document[1] compares the Gemalto M2M modules BGS2 Rel.1, BGS2 Rel.2, EHS5 and EHS6. It lists hardware related differences between these modules.

The aim of the document is to provide guidance on how to migrate from BGS2 Rel.1 or BGS2 Rel.2 to EHS5 or EHS6. Chapter 4 gives advice on designing one common hardware platform for smooth transition between all described products.

BGS2 Rel.1 and BGS2 Rel.2 in this document refer to the product variants BGS2-E and BGS2-W. Where necessary a note is made to differentiate between these two product variants.

EHS5 in this document refers to the product variants EHS5-E and EHS5-US. Where necessary a note is made to differentiate between these two product variants. For EHS6 no product variants have as yet been defined.

1.1 Related Documents

[1] BGS2 Rel.1 Hardware Interface Description
[2] BGS2 Rel.2 Hardware Interface Description
[3] EHS5 Hardware Interface Description
[4] EHS6 Hardware Interface Description
[5] BGS2 Rel.1 AT Command Set
[6] BGS2 Rel.2 AT Command Set
[7] EHS5 AT Command Set
[8] EHS6 AT Command Set
[9] Migrating BGS2 Rel.2 to EHS5 Rel.1 (AT Command Set comparison)

1.2 Type Approval

BGS2 Rel.1, BGS2 Rel.2 and EHSx comply with the same standards and directives – except for

- Standards of North American type approval that are not applicable to BGS2-E and EHS5-E
- Standards of European type approval that are not applicable to EHS5-US

Because EHSx features UMTS/HSPA functionality it also complies with standards for WCDMA.

For more regulatory and type approval information see [1], [2], [3] and [4].

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

2 Software Related Differences

The EHSx firmware has no predecessor, i.e., it is not an update of the BGS2 Rel.1 or BGS2 Rel.2 firmware.

For a complete overview of all AT command differences between BGS2 Rel.1, BGS2 Rel.2 and EHSx please refer to the respective AT Command Specifications, i.e., [5] for BGS2 Rel.1, [6] for BGS2 Rel.2, [7] for EHS5 and [8] for EHS6.

For a separate software comparison guide detailing software differences between BGS2 Rel.2 and EHS5 please refer to [9].

3 Hardware Related Differences

The focus of this chapter is on hardware differences between BGS2 Rel.1, BGS2 Rel.2 and EHS5 as well as EHS6.

Please note that the GPIO, I^2C, SPI and ADC1 interfaces as well as the fast shutdown signal and an impulse counter mentioned in this document are not supported with EHS5 Release 1. These interfaces will be available as of EHS5 Release 2 as well as with EHS6.

3.1 Feature Overview

The following table compares general properties and features of BGS2 Rel.1, BGS2 Rel.2, EHS5 and EHS6.
It lists differences between the modules. Where appropriate, these differences are described in more detail in the next sections.

Table 1: Feature overview

Feature/Property	BGS2 Rel.1, BGS2 Rel.2	EHS5	EHS6
General Properties			
Power supply ratings	For details see Section 3.3.9.		
Operating temperature (board temperature)	Normal operation: -30°C to +85°C Extended operation: -40°C to +90°C	Normal operation: -30°C to +85°C Extended operation: -40°C to +90°C	Normal operation: -30°C to +85°C Extended operation: -40°C to +90°C
Dimensions	Size: 27.6 x 18.8 x 2.7mm Weight: approx. 3g	Size: 27.6 x 18.8 x 2.3mm Weight: approx. 3g	Size: 27.6 x 25.4 x 2.2mm Weight: approx. 3.5g
Frequency bands	Quad band (BGS2-W): GSM 850/900/1800/1900MHz Dual band (BGS2-E): GSM 900/1800MHz	EHS5-US: Dual band GSM 850/1900MHz Dual band UMTS 850/1900MHz EHS5-E: Dual band GSM 900/1800MHz Dual band UMTS 900/2100MHz	Quad band GSM 850/900/1800/1900MHz Five band UMTS 800/850/900/1900/2100MHz
Interface Properties			
Module interface	For pad assignment see Chapter 4.		
Serial interfaces			
ASC0	Baudrate: 300 to 230,400bps Autobauding: 1,200 to 230,400bps Flow control: RTS0/CTS0 and XON/XOFF Signal level: 1.8V	Baudrate: 1,200 to 921,600bps Autobauding: 1,200 to 230,400bps Flow control: RTS0/CTS0 Signal level: 1.8V	Baudrate: 1,200 to 921,600bps Autobauding: 1,200 to 230,400bps Flow control: RTS0/CTS0 Signal level: 1.8V

Feature/Property	BGS2 Rel.1, BGS2 Rel.2	EHS5	EHS6
ASC1	Baudrate: 300 to 230,000bps Flow control: RTS1/CTS1 and XON/XOFF Signal level: 1.8V	Baudrate: 1,200 to 921,600bps Autobauding: 1,200 to 230,400bps Flow control: RTS1/CTS1 Signal level: 1.8V	Baudrate: 1,200 to 921,600bps Autobauding: 1,200 to 230,400bps Flow control: RTS1/CTS1 Signal level: 1.8V
USB interface	Not supported	USB 2.0 High Speed (480Mbit/s) device interface	USB 2.0 High Speed (480Mbit/s) device interface
Audio interfaces			
Analog audio	One balanced audio interface	Not supported	Not supported
Digital audio	BGS2 Rel.1: Not supported BGS2 Rel.2, EHS5, EHS6: For differences see Section 3.3.17		
RTC backup	Yes. 1.0V < VDDLP < 2.4V	Yes. 1.0V < VDDLP < 1.9V	Yes. 1.0V < VDDLP < 1.9V
GPIO interface	10 GPIO lines (BGS2 Rel.1) resp. 6 GPIO lines (BGS2 Rel.2) shared with an I^2C interface, LED signaling and PWM functionality	5 GPIO lines shared with LED signaling, PWM functionality, fast shutdown and an impulse counter 12 GPIO lines shared with ASC0, ASC1, DAI and SPI	5 GPIO lines shared with LED signaling, PWM functionality, fast shutdown and an impulse counter 12 GPIO lines shared with ASC0, ASC1, DAI and SPI 5 GPIO lines not shared
Ignition signal	ON: High impulse/level switches on	ON: High pulse switches on AUTO_ON: Active low switches on	ON: High pulse switches on AUTO_ON: Active low switches on
I^2C Interface	I^2C interface at GPIO9 and GPIO10	I^2C interface at dedicated lines	I^2C interface at dedicated lines
SPI Interface	Not supported	Lines shared with GPIO	Lines shared with GPIO

Feature/Property	BGS2 Rel.1, BGS2 Rel.2	EHS5	EHS6
HSIC Interface	Not supported	Not supported	HSIC interface up to 480MBit/s supported
Fast shutdown	BGS2 Rel.1: Not supported BGS2 Rel.2: Dedicated line	Line shared with GPIO	Line shared with GPIO
Other Properties			
UMTS/HSPA	No UMTS/HSPA	Supports UMTS/HSPA	Supports UMTS/HSPA
EGPRS	Not supported	Multislot class 12	Multislot class 12
GPRS	Multislot class 10 (BGS2-E only: Multislot class 8)	Multislot class 12	Multislot class 12
For software related differences please refer to [5], [6], [7] and [8] as well as [9].			

3.2 General Properties

This section lists general properties that are different between BGS2 Rel.1, BGS2 Rel.2, EHS5 and EHS6.

3.2.1 Frequency Bands

Table 2: Frequency bands

BGS2 Rel.1, BGS2 Rel.2	EHS5	EHS6
BGS2-W: Quad band GSM 850/900/ 1800/1900MHz BGS2-E: Dual band GSM 900/1800MHz	EHS5-US: Dual band GSM 850/1900MHz Dual band UMTS 850/1900MHz EHS5-E: Dual band GSM 900/1800MHz Dual band UMTS 900/2100MHz	Quad band GSM 850/900/ 1800/1900MHz Five band UMTS 800/850/900/ 1900/2100MHz

Reference:

- "Hardware Interface Description": Section "Key Features at a Glance"

3.2.2 Dimensions

EHS5, BGS2 Rel.1 and BGS2 Rel.2 are identical in width, length and pad layout. EHS6 has slightly different dimensions.

Table 3: Dimensions

BGS2 Rel.1, BGS2 Rel.2	EHS5	EHS6
Length and width: 27.6 mm x 18.8 mm	Length and width: 27.6 mm x 18.8 mm	Length and width: 27.6 mm x 25.4 mm
Height: 2.7 mm (single sided)	Height: 2.3 mm (single sided)	Height: 2.2 mm (single sided)
Weight: approx. 3g	Weight: approx. 3g	Weight: approx. 3.5g
106 SMT pads	106 SMT pads	120 SMT pads
Identical pad layout.		Pad layout in parts identical

Reference:

- "Hardware Interface Description": Section "Mechanics" and "Pad Assignment"

3.2.3 Operating Temperature

The operating temperatures for the modules are listed in the below table.

Table 4: Board / battery temperatures

Parameter	Unit	BGS2 Rel.1, BGS2 Rel.2			EHS5, EHS6		
		Min	Typ	Max	Min	Typ	Max
Operating temperature range	°C	-30	+25	+85	-30	+25	+85
Extended temperature range	°C	-30 to -40		+85 to +90	-30 to -40		+85 to +90
Automatic shutdown Temp. measured on board	°C	<-40		>+90	<-40		>+90

Reference:

- “Hardware Interface Description”: Section “Operating Temperatures”

3.3 Application Interface

3.3.1 ON Signal

The ON signal starts the module. Differences are shown in the following table. ON switch-on circuits are shown in the respective Hardware Interface Descriptions. Note that the ON signal may not be supported by some EHS5 and EHS6 firmware versions. Please refer to the Release Notes to find out whether your firmware version supports the ON signal.

For EHS5 and EHS6 modules, it is recommended to use the AUTO_ON line as start-up signal (see Section 3.3.2).

Table 5: Electrical characteristics of ON signal

Signal	BGS2 Rel.1, BGS2 Rel.2	EHS5, EHS6
VDDLP	2.3V	1.8V
ON: V_{IH}max	2.3V	2.1V
ON: V_{IH}min	1.2V	1.2V
Input sensitivity	Level sensitive	High pulse (50…80µs)

Reference:
- "Hardware Interface Description": Section "Pad Assignment and Signal Description"

3.3.2 AUTO_ON Signal (IGT Signal)

The AUTO_ON signal is available for EHS5 and EHS6 modules only. It is an active low signal that starts up the module. BATT+ should be active and stable before the low level at the AUTO_ON signal is applied.

An AUTO_ON switch-on circuit for EHS5 and EHS6 can be found in the Hardware Interface Description. A common switch-on circuit employing either ON (BGS2) or AUTO_ON (EHS5 and EHS6) signal lines to turn on the module is illustrated below in Section 3.3.3.

Table 6: AUTO_ON signal characteristics

AUTO_ON	BGS2 Rel.1, BGS2 Rel.2	EHS5, EHS6
V_{IH}max	Not supported	VDDLP
V_{IH}min		1.2V
V_{IL}max		0.5V
Input sensitivity		Level sensitive

Please note that if the AUTO_ON signal is set permanently low (i.e., connected to GND), the module will start up automatically if BATT+ is applied with a rise time of less than 1ms between 2.5V to 3.2V. It will also restart automatically if AT^SMSO is called to switch of the module. To prevent this from happening, the AUTO_ON line should be set to inactive high after module start up.

Reference:
- "Hardware Interface Description": Section "Pad Assignment and Signal Description"

3.3.3 Common Ignition Circuit (ON and AUTO_ON Signal)

The common ignition circuit shown in Figure 1 can be used to switch on either BGS2 using the ON signal, or EHS5 and EHS6, i.e., EHSx using the AUTO_ON signal.

For BGS2 the 0Ohm resistor marked *(for BGS2 only)* will have to be equipped, for EHSx the 0Ohm resistor and 10K PU marked *(for EHSx only)* will have to be implemented.

There are two ignition options available: The module can either be powered on by a switch to ground or by a turn-on pulse.

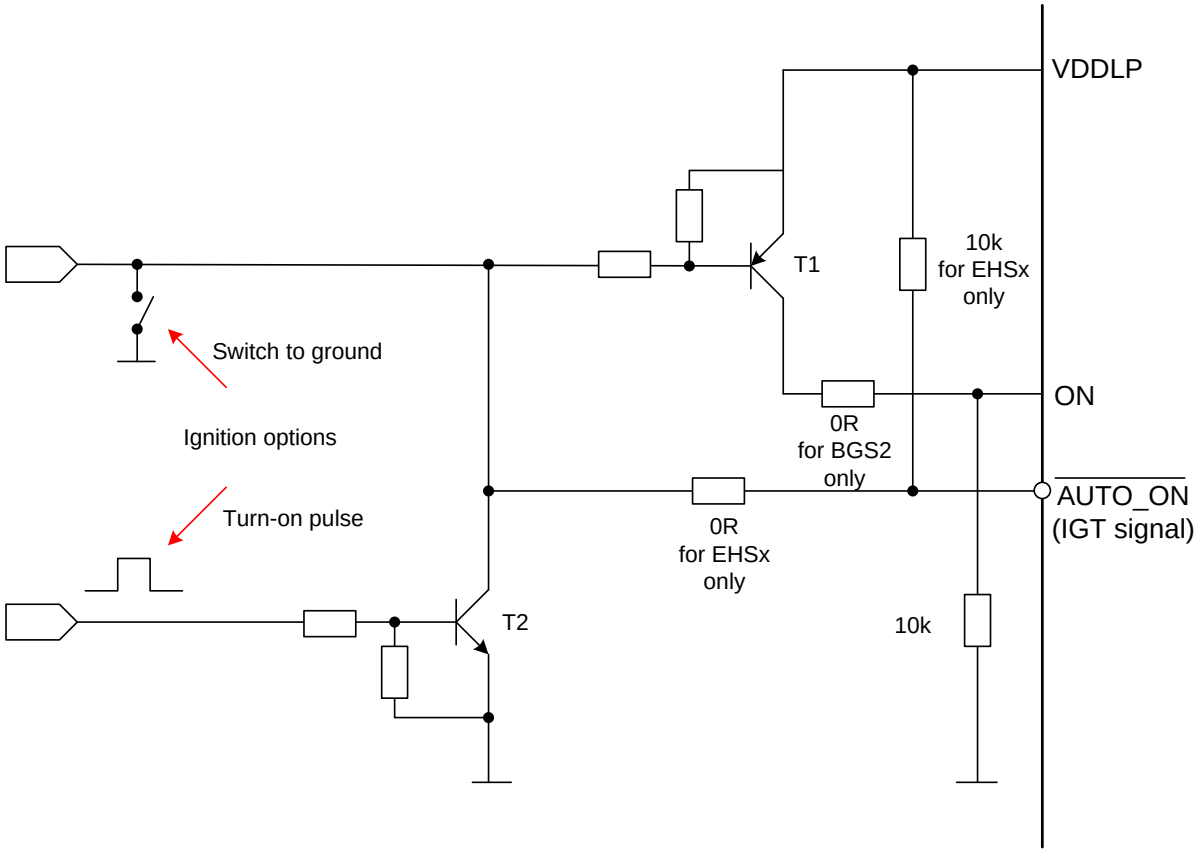


Figure 1: Common ignition circuit

Note that T1 (PNP transistor) is only required for BGS2 and T2 (NPN transistor) is only required for EHSx.

The component placement options of the common ignition circuit ensure compatibility of the power-on signal. There is therefore no need to adapt the external application software if either BGS2 or EHSx is employed.

3.3.4 EMERG_RST

The emergency restart signal restarts the module, but causes the loss of all information stored in the volatile memory. Therefore the EMERG_RST line should only be used when, due to serious problems, the software is not responding for more than 5 seconds.

EMERG_RST is triggered by an active low pulse longer than 10ms. EMERG_RST should be externally driven by an open collector driver.

Note that with BGS2 Rel.1 and BGS2 Rel.2 the EMERG_RST signal state is low if the module is switched off, with EHS5 and EHS6 the EMERG_RST signal state is high.

Table 7: EMERG_RST characteristics

EMERG_RST	BGS2 Rel.1, BGS2 Rel.2	EHS5, EHS6
V_{IH}max	1.9V	1.9V
V_{IH}min	1.35V	1.35V
V_{IL}max	0.2V $I(V_{IL}max) < -150\mu A$ at V_{IL}max	0.35V $I(V_{IL}max) < -130\mu A$ at V_{IL}max

Reference:

- “Hardware Interface Description”: Section “Pad Assignment and Signal Description”

3.3.5 Power Supply BATT+

The EHS5 and EHS6 power supply needs an external interference suppression capacitor at the high power supply BATT+ pads (EHS5: Pad 5; EHS6: Pad 204). A low ESR capacitor 150µF should be connected very close to these pads.

It is recommended to implement 0Ohm resistors for both power lines to be able to exchange the 0Ohm resistors with ferrite beads, thus improving interference suppression by reducing self interference.

BGS2 Rel.1 and BGS2 Rel.2 do not require any additional interference suppression at both power pins.

Table 8: BATT+ power supply and interference suppression

BATT+ signal	BGS2 Rel.1, BGS2 Rel.2	EHS5	EHS6
Pad 5	µC and LDOs No interference suppression	µC and PA (high power) Interference suppression (150µF low ESR)	---
Pad 53	PA (high power) No interference suppression	LDOs and Frontend Additional interference suppression by ferrite	LDOs and Frontend Additional interference suppression by ferrite
Pad 204	---	---	µC and PA (high power) Interference suppression (150µF low ESR)

The following figure shows a possible external interference suppression circuit at EHS5's pad 5 resp. at EHS6's pad 204.

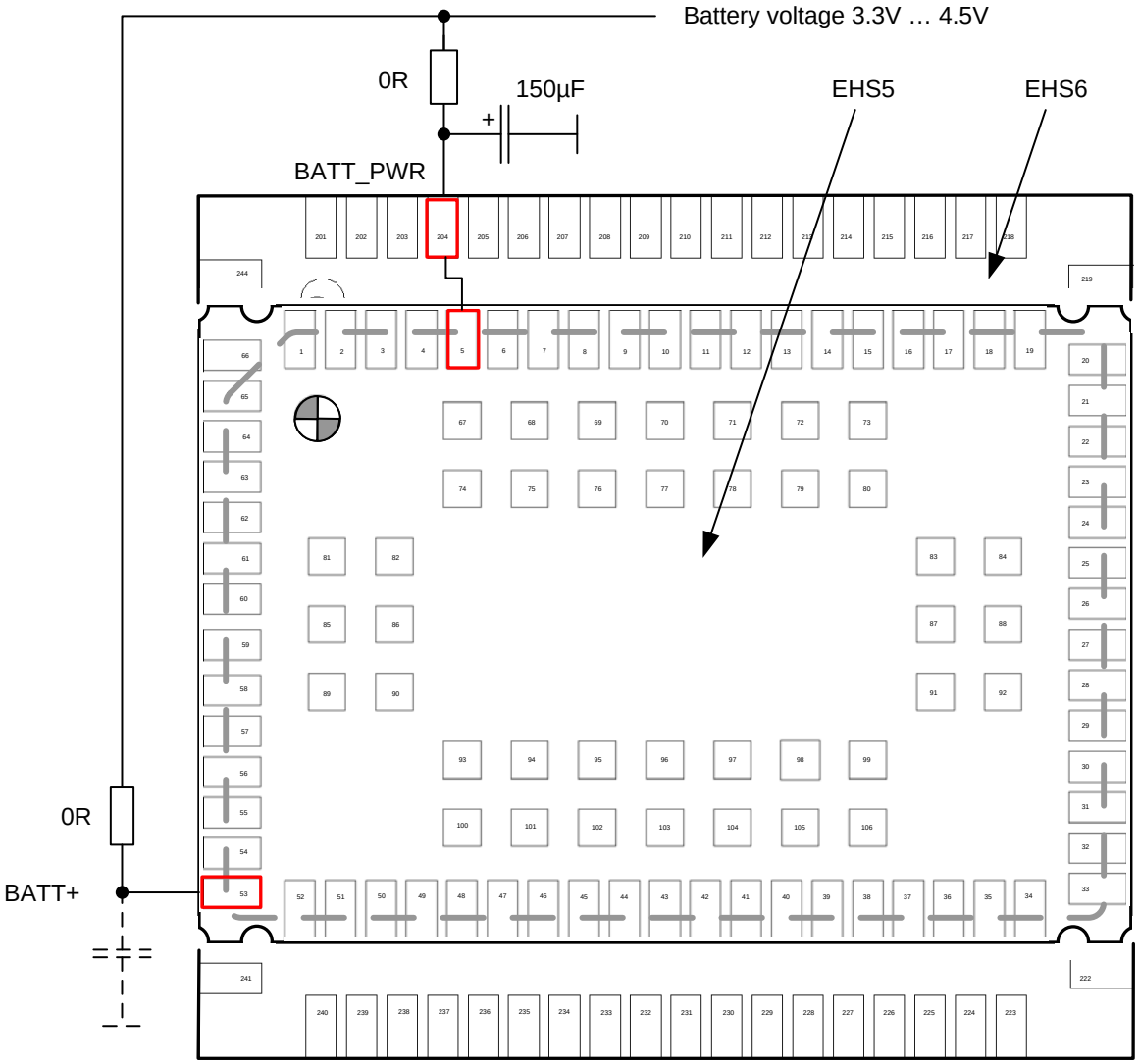


Figure 2: BATT+ and external interference suppression circuit (EHS5 and EHS6)

3.3.6 Voltage Domain VDIG, V180, V285/VCORE

With BGS2 Rel.1 and BGS2 Rel.2 the VDIG line is used to configure the interface voltage domain for the ASC0, DAI and I^2C interfaces – and either connected to V180 to set an 1.8V voltage level at the concerned interface pads or V285 to set an 2.85V voltage level. With EHS5 and EHS6 the voltage level at the interface pads is permanently set to 1.8V (V180) – the VDIG line is no longer available.

For compatibility reasons and migration purposes it is recommended to configure / connect the interface voltage VDIG of BGS2 Rel.1 or BGS2 Rel.2 to V180 in order to realize a common interface voltage level of 1.8V.

Table 9: BATT+ power supply and interference suppression

Voltage domain	BGS2 Rel.1, BGS2 Rel.2	EHS5, EHS6
VDIG	Applicable/configurable	Not applicable/configurable 1.8V connected
V180	1.8V	1.8V
V285 / VCORE	V285: 2.85V	VCORE: 0.9V…1.2V

3.3.7 Power Indication Circuit

As V180 and V285/VCORE have a slightly different start-up and shutdown timing it is recommended to implement an external circuit in order to realize a safe power indication. This circuit as illustrated in Figure 3 uses the same signals for all modules. The V285/VCORE pad is located at the same position for all modules.

Table 10: Power indication circuit components

Voltage domain	BGS2 Rel.1, BGS2 Rel.2	EHS5, EHS6
V180	1.8V	1.8V
V285 / VCORE	V285: 2.85V	VCORE: 0.9V…1.2V
R1	100k	22k
R2	100k	100k
R3	22k	4.7k
R4	22k	100k
R5	10k	10k

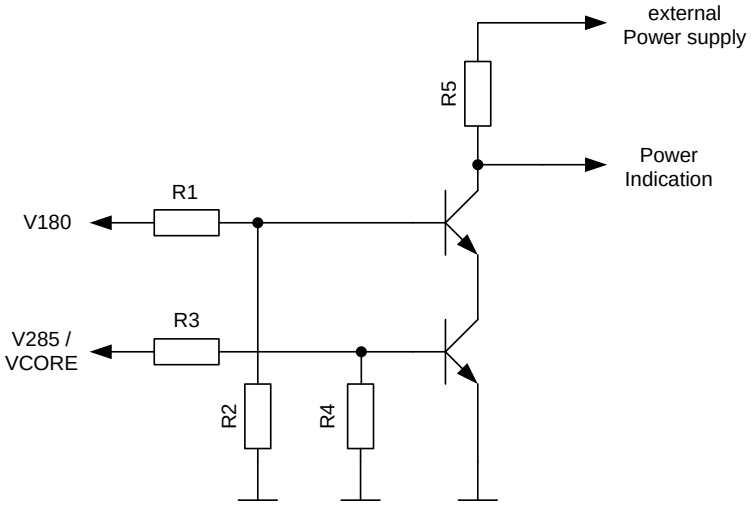


Figure 3: Power indication circuit

3.3.8 RTC Backup VDDLP

The power supply pad VDDLP can be used to backup the internal RTC from an external capacitor. Note that the voltage levels for this pad differ between BGS2 Rel.1, BGS2 Rel.2 and EHS5, EHS6 as shown in the following table.

Table 11: Power indication circuit components

VDDLP signal	BGS2 Rel.1, BGS2 Rel.2	EHS5, EHS6
Nominal (max) level	2.3V (2.4V)	1.8V (1.9V)
Supply current	8µA	<1µA

3.3.9 Power Supply Ratings

Power supply ratings differ between BGS2 Rel.1, BGS2 Rel.2 and EHS5 as well as EHS6. The following Table 12 lists these differences only for the power supply ratings specified in the BGS2 Rel.1 and BGS2 Rel.2 Hardware Interface Descriptions. Please refer to the EHS5 and EHS6 Hardware Interface Descriptions for further power supply ratings specified with regard to additional features available with these products (i.e., UMTS, USB).

Reference:

- “Hardware Interface Description”: Section “Power Supply Ratings”

Table 12: Power supply ratings[2]

Para-meter	Description	Conditions	Min			Typ			Max			Unit
			BGS2 Rel.1, BGS2 Rel.2	EHS5	EHS6	BGS2 Rel.1, BGS2 Rel.2	EHS5	EHS6	BGS2 Rel.1, BGS2 Rel.2	EHS5	EHS6	
BATT+	Supply voltage	Voltage must stay within the min/max values, including voltage drop, ripple and spikes.	3.3	3.3	3.3				4.5	4.5	4.5	V
	Voltage burst during transmit burst	Normal condition, power control level for Pout max							400	400	400	mV
	Voltage ripple	Normal condition, power control level for Pout max @ f<250kHz @ f>250kHz							 85 25	 190 30	 190 30	mVpp
I_{VDDLP}	OFF state supply current	RTC backup @ BATT+ = 0V				 8.0	 <1	 <1				µA
I_{BATT+}	OFF state supply current	Power Down mode				45	60	60				µA
	Average supply current	SLEEP, GSM[3] @ DRX = 2 @ DRX = 5 @ DRX = 9				 2.1 1.5 1.1	 1.4[4] 1.1[4] 0.9[4]	 1.6[5] 1.3[4] 1.1[4]				mA
		SLEEP, GPRS[3] @ DRX = 2 @ DRX = 5 @ DRX = 9				 2.2 1.5 1.2	 1.4[4] 1.1[4] 0.9[4]	 1.6[6] 1.3[4] 1.1[4]				mA
		IDLE @ DRX=2[3]				 8.6	 14[4]	 14[4]				mA

[2] GSM850 and GSM1900 bands are applicable for the quad band module variants only.

[3] Measurements start 6 minutes after the module was switched ON,
Averaging times: SLEEP mode - 3 minutes; IDLE mode - 1.5 minutes,
Communication tester settings: no neighbor cells, no cell reselection etc.

[4] USB disconnected

[5] USB disconnected

[6] USB disconnected

Para-meter	Description	Conditions	Min			Typ			Max			Unit
			BGS2 Rel.1, BGS2 Rel.2	EHS5	EHS6	BGS2 Rel.1, BGS2 Rel.2	EHS5	EHS6	BGS2 Rel.1, BGS2 Rel.2	EHS5	EHS6	
I_{BATT+}	Average supply current	Voice call GSM850/EGSM 900[7] GSM 1800/1900[8]				 200 150	 245 180	 245 180				mA
		GPRS data transfer 1 TX, 4 Rx GSM 850/EGSM 900[7] GSM 1800/1900[8]				 180 145	 240 180	 240 180				mA
		GPRS data transfer 2 Tx, 3 Rx GSM 850/EGSM 900[7] GSM 1800/1900[8]				 330 260	 310 200	 310 200				mA
	Peak supply current (during transmission slot every 4.6ms)	Voice call, PCL=5 GSM 850/EGSM 900[7] Voice call, PCL=0 GSM 1800/1900[8]				1.30 0.95	1.6 1.1	1.6 1.1	1.35 0.97	2.3 1.4	2.3 1.4	A

[7] Power control level PCL 5
[8] Power control level PCL 0

3.3.10 SIM Interface

EHS5 and EHS6 have no internal ESD protection implemented. Therefore, it is recommended to implement an additional ESD protection close to the SIM card holder. An example is shown in Figure 4.

BGS2 Rel.1 and BGS2 Rel.2 require a 4.7kOhm pull-up resistor at the CCIO line.

Table 13: SIM interface – enhanced ESD protection

SIM interface	BGS2 Rel.1, BGS2 Rel.2	EHS5, EHS6
Internal ESD protection	Implemented	Not implemented
4.7kOhm pull-up resistor at CCIO line	Required	Not required

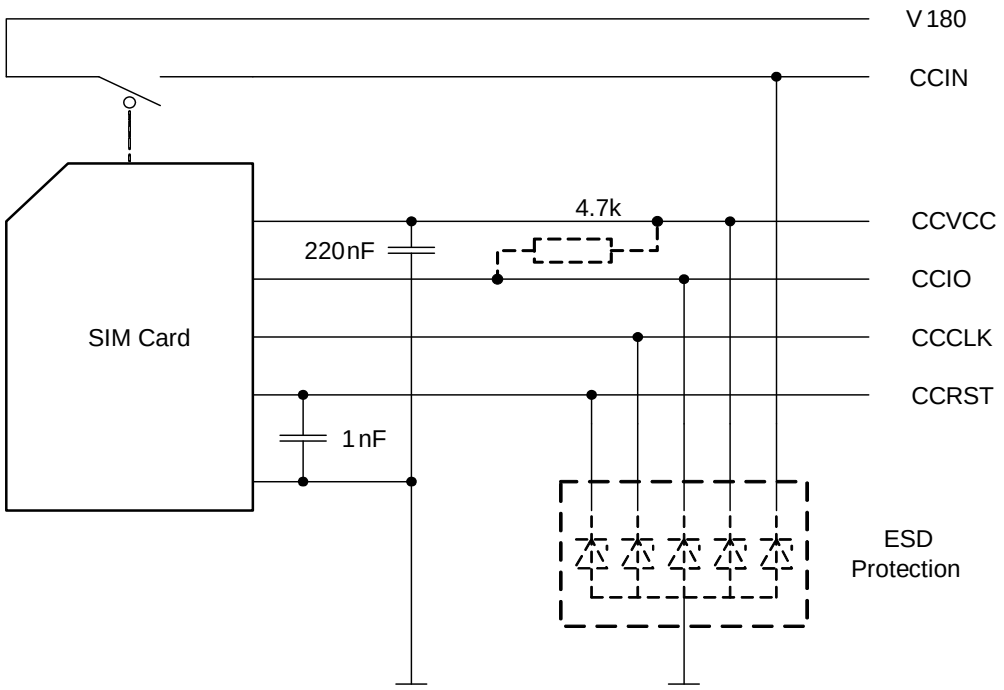


Figure 4: SIM interface - enhanced ESD protection

Reference:

- “Hardware Interface Description”: Section “SIM Interface”

3.3.11 USB Interface

EHS5 and EHS6 support a high speed 2.0 USB interface. Special care must be taken while routing the USB signal lines on the external application's PCB as differential 90Ω impedance.

The pads used as USB pads with EHS5 are connected to GND with BGS2 Rel.1 and BGS2 Rel.2. It is therefore recommended to place 0Ω resistors at the USB signal lines (USB_DN, USB_DP, VUSB) to be able to activate USB support in a combined PCB layout. If BGS2 Rel.1 or BGS2 Rel.2 is mounted, the 0Ω resistors are not equipped. Vice versa, if EHS5 is mounted, these resistors should be implemented.

Also, in a combined PCB layout with EHS5 and EHS6 is it necessary to place 0Ω serial resistors at the USB_DN and USB_DP lines. This is to avoid the stubs in the EHS5 design by not mounting the 0Ω resistors.

Table 14: USB interface

USB interface	BGS2 Rel.1, BGS2 Rel.2	EHS5, EHS6
USB	Not supported	Supported

An external ESD protection should be provided for the EHS5 and EHS6 USB interfaces.

Reference:
- "Hardware Interface Description": Section "USB Interface"

3.3.12 ASC0 Interface

The voltage levels at the ASC0 interface lines are identical for all modules as long as VDIG is connected to V180 for BGS2 Rel.1 and BGS2 Rel.2 – 1.8V. The following tables show ASC0 interface differences between the modules.

Table 15: ASC0 transfer rates

ASC0 interface	BGS2 Rel.1, BGS2 Rel.2	EHS5, EHS6
Baud rate range	300 … 230400	1200 … 921600
Autobauding	Yes	Yes
Autobauding range	1200 … 230400	1200 … 230400

Table 16: ASC0 start-up/reset signal states[9]

ASC0 interface lines	BGS2 Rel.1	BGS2 Rel.2	EHS5, EHS6
RXD0	T / PU (-204µA at 0.05V)	T / PU (-204µA at 0.05V)	T / PU (-240µA at 0V)
TXD0	T / PU (-204µA at 0.05V)	T / PU (-204µA at 0.05V)	T / PD (+200µA at 1.9V)
CTS0	T / PD (+51µA at 1.75V)	T / PD (+51µA at 1.75V)	T / PU (-240µA at 0V)
RTS0	T / 10k PU	T / 10k PU	T / PU (-240µA at 0V)
DTR0	T / PD (+103µA at 1.75V)	T / PU (-102µA at 0.05V)	T / PD (+200µA at 1.9V)
DCD0	T / PU (-102µA at 0.05V)	T / PU (-102µA at 0.05V)	T / PD (+200µA at 1.9V)
DSR0	T / PD (+27µA at 1.75V)	T / PU (-102µA at 0.05V)	T / PD (+200µA at 1.9V)
RING0	T / 10k PU	T / 10k PU	T / PD (+200µA at 1.9V)

For more information on the interface and its start-up timings please refer to the respective “Hardware Interface Description”.

[9] T = Tristate; PU = Pull-up; PD = Pull-down

3.3.13 ASC1 Interface

With BGS2 Rel.1 and BGS2 Rel.2 autobauding is not supported over the ASC1 interface. The following tables show ASC1 interface differences between the modules.

Table 17: ASC1 transfer rates

ASC1 interface	BGS2 Rel.1, BGS2 Rel.2	EHS5, EHS6
Baud rate range	300 … 230400	1200 … 921600
Autobauding	No	Yes
Autobauding range	---	1200 … 230400

Table 18: ASC1 start-up/reset signal states

ASC0 interface lines	BGS2 Rel.1, BGS2 Rel.2	EHS5, EHS6
RXD1	T / PD (+51µA at 1.75V)	T / PU (-240µA at 0V)
TXD1	T / PD (+51µA at 1.75V)	T / PD (+200µA at 1.9V)
CTS1	T / PD (+51µA at 1.75V)	T / PD (+200µA at 1.9V)
RTS1	T / PU (-102µA at 0.05V)	T / PD (+200µA at 1.9V)

For more information on the interface and its start-up timings please refer to the respective “Hardware Interface Description”.

3.3.14 I²C Interface

With BGS2 Rel.1 and BGS2 Rel.2 the I²C interface lines are shared with GPIO lines and may also be configured as GPIO9 and GPIO10.

EHS5 and EHS6 have dedicated I²C interface lines[10]. For compatibility reason and migration purposes, the GPIO functionality on GPIO9 and GPIO10 should therefore not be used with BGS2 Rel.1 and BGS2 Rel.2 modules.

The I2CDAT and I2CCLK lines have to connect to a positive supply voltage via a pull-up resistor. The following table lists the values for the internally implemented pull-up resistors and values for resistors that should be implemented for an external application. The below figure illustrates that the voltage may be supplied from the module – via VDIG for BGS2 Rel.1 and BGS2 Rel.2 or via V180 for EHS5 and EHS6.

Table 19: I²C pull-up values (internal or external)

	BGS2 Rel.1, BGS2 Rel.2	EHS5, EHS6
Internal pull-up I2CCLK	5k	---
Internal pull-up 2CDAT	---	---
R1 (typical)	2.2kΩ	2.2kΩ
R2 (typical)	2.2kΩ	2.2kΩ
R1min	560Ω	510Ω
R2min	510Ω	510Ω

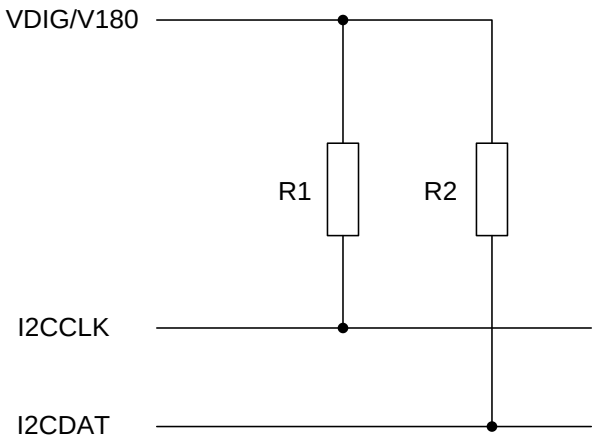


Figure 5: I²C pull-up resistors on external application

[10] Please note that the I²C interface is not supported with EHS5 Release 1. The interface will be available as of EHS5 Release 2 as well as with EHS6.

The following table shows the startup behavior of the I^2C interface lines.

Table 20: I^2C start-up/reset signal states

I^2C interface lines	**BGS2 Rel.1, BGS2 Rel.2**	**EHS5, EHS6**
I2CCLK	T / 5k PU	T
I2CDAT	T	T

For more information on the interface and its start-up timings please refer to the respective "Hardware Interface Description".

3.3.15 SPI Interface

EHS5 and EHS6 support a Serial Peripheral Interface (SPI)[11]. The SPI is a synchronous serial interface for control and data transfer between module and the external application. Only one application can be connected to the SPI and the interface supports only master mode. The transmission rates are up to 6.5Mbit/s. The SPI interface comprises the two data lines MOSI and MISO, the clock line SPI_CLK a well as the chip select line SPI_CS. The SPI lines are shared with GPIO and serial interface lines, the configuration is done by AT command.

Table 21: SPI interface

	BGS2 Rel.1, BGS2 Rel.2	**EHS5 EHS6**
SPI interface	Not supported	Supported

For more information on the interface please refer to the respective "Hardware Interface Description".

3.3.16 HSIC Interface

EHS6 supports a 2-wire High Speed Inter-Chip interface. Both signal lines have to be routed as 50 Ohm impedance on the application PCB. The HSIC interface requires ASC1 as power link management interface for power saving modes (hardware handshake signalling).

Table 22: HSIC interface

	BGS2 Rel.1, BGS2 Rel.2, EHS5	**EHS6**
HSIC interface	Not supported	Supported

For more information on the interface please refer to the respective "Hardware Interface Description".

[11] Please note that the SPI interface is not supported with EHS5 Release 1. The interface will be available as of EHS5 Release 2 as well as with EHS6.

3.3.17 Digital Audio Interface

BGS2 Rel.1 does not support a digital audio interface.

With BGS2 Rel.2, EHS5 and EHS6 there are no differences regarding the voltage level of the digital audio interface (DAI) lines. The digital audio interface is implemented as a pulse code modulation (PCM) interface. Characteristics are listed in the table below.

Table 23: PCM characteristics

Characteristics	BGS2 Rel.2	EHS5, EHS6
PCM Audio mode	Master mode, 256kHz clock, long frame	Master mode, 256kHz clock, long frame

The DAI start-up behavior differs slightly between BGS2 Rel.2 and EHSx as shown in the table below.

Table 24: DAI start-up/reset signal states

DAI interface lines	BGS2 Rel.2	EHS5, EHS6
RXDDAI	T / PD (+51µA at 1.75V)	T / PD (+200µA at 1.9V)
TXDDAI	T / PD (+51µA at 1.75V)	T / PD (+200µA at 1.9V)
TFSDAI (FSYNC0)	T / PD (+51µA at 1.75V)	T / PD (+200µA at 1.9V)
SCLK (SCLK0)	T / PU (-55µA at 0.05V)	T / PD (+200µA at 1.9V)

For more information on the interface and its start-up timings please refer to the respective “Hardware Interface Description”.

3.3.18 Analogue Audio Interface

For EHS5 and EHS6 no analogue audio interface is implemented. BGS2 Rel.1 and BGS2 Rel.2 do support an analogue audio interface. With EHS5 and EHS6 the corresponding pads should be kept open.

Table 25: Analogue audio interface

Analogue interface	BGS2 Rel.1, BGS2 Rel.2	EHS5, EHS6
Analogue Audio Interface	Supported	Not supported
VMIC	Vout 1.8V … 2.2V, max 4mA	
MICP1	Ri = 50kOhm Vin max 0.8Vpp	
MICN1		
AGND	AGND	
EPP1	3.2Vpp on 16Ohm load	
EPN1		

3.3.19 GPIO Interface

BGS2 Rel.1, BGS2 Rel.2, EHS5 and EHS6 differ in the number and assignment of their GPIO lines as listed in the table below[12].

Table 26: GPIO lines

GPIO lines	BGS2 Rel.1	BGS2 Rel.2	EHS5	EHS6
GPIO1	GPIO1	(DTR0)	DTR0 / GPIO1	DTR0 / GPIO1
GPIO2	GPIO2	(DCD0)	DCD0 / GPIO2	DCD0 / GPIO2
GPIO3	GPIO3	(DSR0)	DSR0 / GPIO3 / SPI_CLK	DSR0 / GPIO3 / SPI_CLK
GPIO4	GPIO4	(FST_SHDN)	GPIO4 / FST_SHDN	GPIO4 / FST_SHDN
GPIO5	GPIO5 / LED	GPIO5 / LED	GPIO5 / LED	GPIO5 / LED
GPIO6	GPIO6 / PWM	GPIO6 / PWM	GPIO6 / PWM	GPIO6 / PWM
GPIO7	GPIO7 / PWM	GPIO7 / PWM	GPIO7 / PWM	GPIO7 / PWM
GPIO8	GPIO8	GPIO8	GPIO8 / COUNTER	GPIO8 / COUNTER
GPIO9	GPIO9 / I2CCLK (shared)	GPIO9 / I2CCLK (shared)	I2CCLK (only)	I2CCLK (only)
GPIO10	GPIO10 / I2CDAT (shared)	GPIO10 / I2CDAT (shared)	I2CDAT (only)	I2CDAT (only)
GPIO11	n.a.	n.a.	n.a.	GPIO11
GPIO12	n.a.	n.a.	n.a.	GPIO12
GPIO13	n.a.	n.a.	n.a.	GPIO13
GPIO14	n.a.	n.a.	n.a.	GPIO14
GPIO15	n.a.	n.a.	n.a.	GPIO15
GPIO16	n.a.	n.a.	RXD1 / GPIO16 / MOSI	AP_WAKEUP / GPIO16 / RXD1 / MOSI
GPIO17	n.a.	n.a.	TXD1 / GPIO17 / MISO	HOST_ACTIVE / GPIO17 / TXD1 / MISO
GPIO18	n.a.	n.a.	RTS1 / GPIO18	CP_WAKEUP / GPIO18 / RTS1
GPIO19	n.a.	n.a.	CTS1 / GPIO19 / SPI_CS	SUSPEND / GPIO19 / CTS1 / SPI_CS
GPIO20	n.a.	n.a.	GPIO20 / TXDDAI	GPIO20 / TXDDAI
GPIO21	n.a.	n.a.	GPIO21 / RXDDAI	GPIO21 / RXDDAI
GPIO22	n.a.	n.a.	GPIO22 / TFSDAI	GPIO22 / TFSDAI
GPIO23	n.a.	n.a.	GPIO23 / SCLK	GPIO23 / SCLK
GPIO24	n.a.	n.a.	RING0 / GPIO24	RING0 / GPIO24

[12] Please note that the GPIO interface is not supported with EHS5 Release 1. The interface will be available as of EHS5 Release 2 as well as with EHS6. GPIO assignments may then be extended to include further functionalities. For details confer to the respective “Hardware Interface Description”.

Table 27: GPIO start-up/reset signal states

GPIO lines	BGS2 Rel.1	BGS2 Rel.2	EHS5	EHS6
GPIO1	T / PU (-55µA at 0.05V)	(DTR0)	(DTR0)	(DTR0)
GPIO2	T / PU (-55µA at 0.05V)	(DCD0)	(DCD0)	(DCD0)
GPIO3	T / PU (-55µA at 0.05V)	(DSR0)	(DSR0)	(DSR0)
GPIO4	T / PU (-102µA at 0.05V)	(FST_SHDN)	T / PD	T / PD
GPIO5	T / PU (-102µA at 0.05V)	T / PU (-102µA at 0.05V)	O / L	O / L
GPIO6	T / PU (-55µA at 0.05V)	T / PU (-55µA at 0.05V)	O / L	O / L
GPIO7	T / PU (-55µA at 0.05V)	T / PU (-55µA at 0.05V)	O / L	O / L
GPIO8	T / PU (-55µA at 0.05V)	T / PU (-55µA at 0.05V)	O / L	O / L
GPIO9	T / 5k PU	T / 5k PU	T	T
GPIO10	T	T	T	T
GPIO11	n.a.	n.a.	n.a.	O / L
GPIO12	n.a.	n.a.	n.a.	O / L
GPIO13	n.a.	n.a.	n.a.	O / L
GPIO14	n.a.	n.a.	n.a.	O / L
GPIO15	n.a.	n.a.	n.a.	O / L
GPIO16	n.a.	n.a.	T / PD	T / PD
GPIO17	n.a.	n.a.	T / PD	T / PD
GPIO18	n.a.	n.a.	T / PD	T / PD
GPIO19	n.a.	n.a.	T / PD	T / PD
GPIO20	n.a.	n.a.	T / PD	T / PD
GPIO21	n.a.	n.a.	T / PD	T / PD
GPIO22	n.a.	n.a.	T / PD	T / PD
GPIO23	n.a.	n.a.	T / PD	T / PD
GPIO24	n.a.	n.a.	T / PD	T / PD

For more information on the interface and its start-up timings please refer to the respective “Hardware Interface Description”.

3.3.20 ADC1

All modules support an analog-to-digital converter[13]. The ADC1 input differences are shown in the following table.

Table 28: ADC1 characteristics

ADC1	BGS2 Rel.1, BGS2 Rel.2	EHS5, EHS6
Result solution	10 Bit	10 Bit
R_I	1MOhm	1MOhm
Valid range	0V … 1.2V	0V … 1.2V
V_{IH}max	3.3V	1.2V

For more information on the ADC1 line please refer to the respective “Hardware Interface Description”.

3.3.21 Fast Shutdown

BGS2 Rel.1 does not provide a dedicated fast shutdown line.

BGS2 Rel.2 and EHS5 support such a FST_SHDN signal[14]. If enabled by using the AT command AT^SCFG "MEShutdown/Fso", a low impulse >10ms on the FST_SHDN line starts the fast shutdown. The fast shutdown procedure still finishes any data activities on the module's flash file system, thus ensuring data integrity, but will no longer deregister gracefully from the network, thus saving the time required for network deregistration.

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

Table 29: FST_SHDN characteristics

FST_SHDN	BGS2 Rel.2	EHS5	EHS6
V_{IH}max	1.9V	1.9V	1.9V
V_{IH}min	1.35V	1.3V	1.3V
V_{IL}max	0.34V I_{IH}min < -200µA at V_{IH}min	0.34V I_{IH}min < -200µA at V_{IH}min	0.45V I_{IH}min < -200µA at V_{IH}min

For more information on the fast shutdown line please refer to the respective “Hardware Interface Description” and “AT Command Set”.

[13] Please note that the ADC1 interface is not supported with EHS5 Release 1. The interface will be available as of EHS5 Release 2 as well as with EHS6.
[14] Please note that the fast shutdown signal is not supported with EHS5 Release 1. The signal will be available as of EHS5 Release 2 as well as with EHS6.

3.4 Antenna Interface

3.4.1 RF Antenna

The EHS5 and EHS6 antenna interfaces have no internal ESD protection implemented. It is therefore recommended to add an external ESD protection. An example for an additional ESD external protection circuit is given in Figure 6. The additional components should be placed as close as possible to the antenna pad.

The BGS2 Rel.1 and BGS2 Rel.2 antenna interfaces have an internal ESD protection implemented. For compatibility reasons and a possible migration however, it is advised to envisage the recommended possible ESD protection circuits (T pad or PI pad) in external applications currently using BGS2 Rel.1 or BGS2 Rel.2 modules (see Figure 7). The placement options may then later be activated if required.

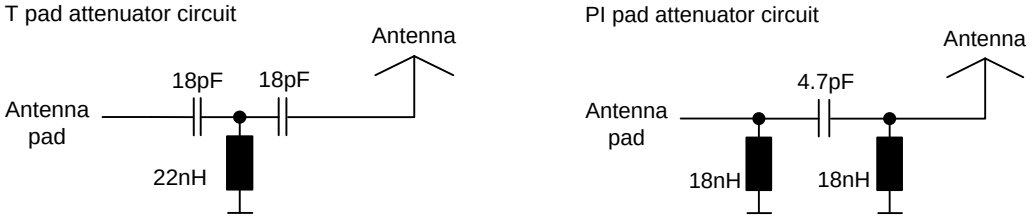


Figure 6: Possible EHS5 and EHS6 ESD protection circuits - T or PI pad

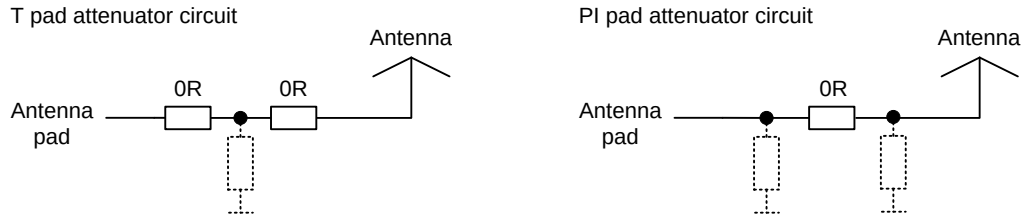


Figure 7: Possible designated ESD protection circuit - T or PI pad

Table 30: ESD protection on external application

RF antenna	BGS2 Rel.1, BGS2 Rel.2	EHS5, EHS6
Internal ESD protection	Supported	Not supported
22nH inductor placement (T pad) or 18nH inductors placement (PI pad)	No	Yes (Recommended inductor type: Size 0402 SMD from Panasonic ELJRF series (22nH and 18nH inductors) or Murata LQW15AN18NJ00 (18nH inductors only)
Value of serial capacitors (T pad) or Value of serial capacitor (PI pad)	0 Ohm 0 Ohm	18pF 4.7pF

For more information on the RF antenna interface please refer to the respective “Hardware Interface Description”.

4 Common Footprint Design

The following chapter shows the pad assignment differences between all Gemalto M2M modules described in this document. It notes the modifications a possible common footprint design will have to allow for in order to provide an easy migration path from one product to the next one.

The following figures show that only few changes are required to adapt an existing hardware platform to meet the requirements of another product.

When using the same footprint for different products take care that the following requirements be met:

- Pads marked yellow and labeled “Don’t use” must be left un-connected, but can be soldered.
- Pads VDIG and V180 shall be connected in all cases. See also Section 3.3.6 for more detail. The pads are marked blue in the figures below.
- Pads V285 and VCORE shall be used only for power-on indication. See also Section 3.3.7 for more detail. The pads are marked green in the figures below.
- Some pads should be connected via 0 Ohm resistors to easily activate or deactivate product specific functions for smooth transition.
  These pads are marked (light) pink in the figures below.

Because of the different pad layout and dimensions between BGS2 Rel.1, BGS2 Rel.2, EHS5 on the one hand and on the other hand EHS6 (and EHS8) some pads in a comprehensive footprint design are not available for all modules:

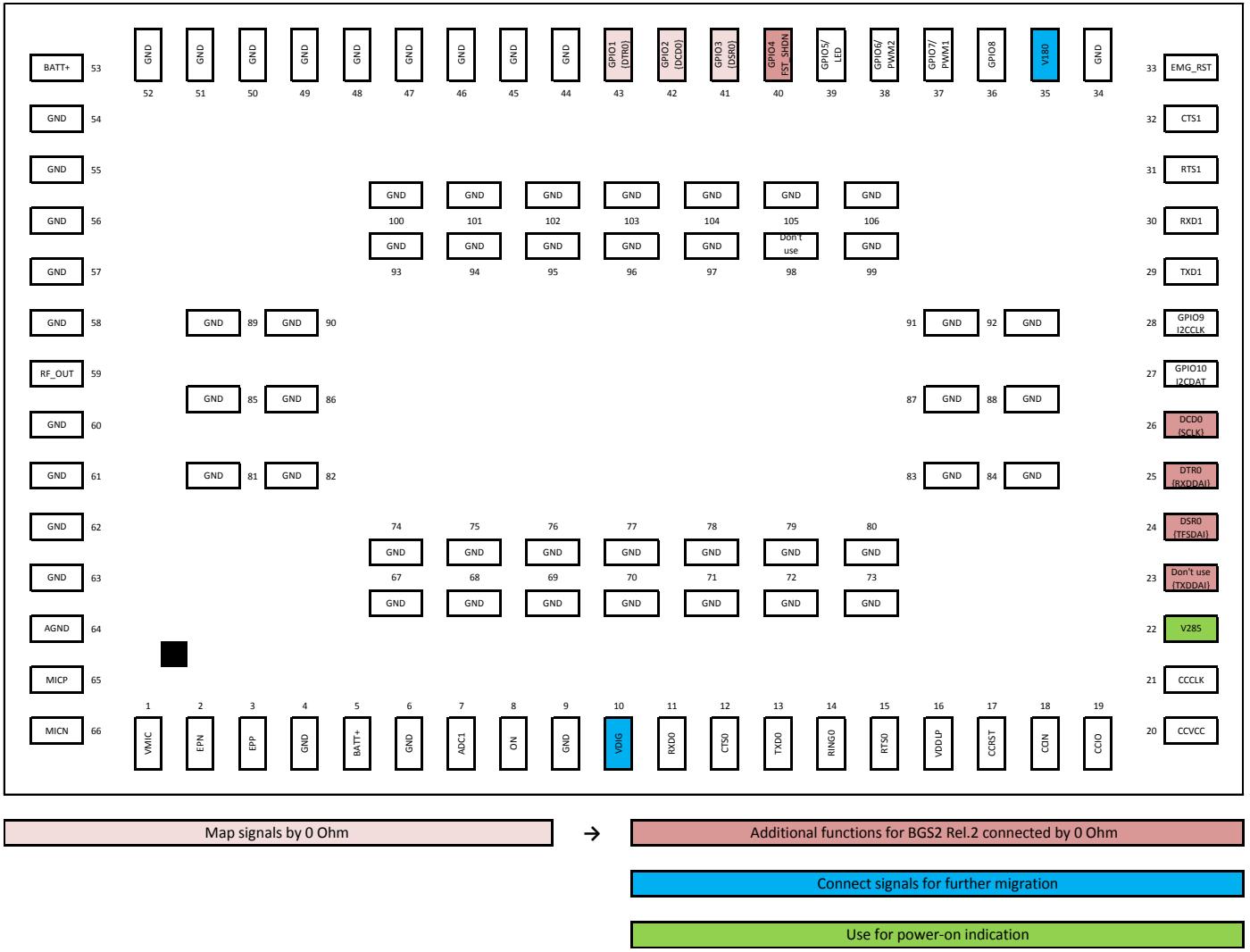
- Pads lined black are available for all modules.
- Pads lined red are available for BGS2 Rel.1, BGS2 Rel.2 and EHS5 only
- Pads lined grey are available for EHS6 (and EHS8) only

Pad assignments shown in curly brackets signify a possible alternative assignment/ functionality for a pad in a common footprint. For example {VUSB} indicates a pad that should be connected via 0 Ohm resistors to easily activate or deactivate the pad’s alternative USB functionality for the appropriate module. The pad’s other GND functionality may also be connected via 0 Ohm resistors to be able to activate or deactivate it for another module. However, in this sample case the GND functionality may also be left unconnected.

“nc” indicates a pad that is electrically not connected on the module. This means that in a common footprint only the other functionality may be implemented for the appropriate module without having to take a transition from one assignment to another into account.

Note that pads available for BGS2 Rel.1, BGS2 Rel.2, EHS5 only and pads available for EHS6 (and EHS8) only should be connected, as far as these pads are assigned to the same signals. Figure 11 and Figure 12 show a list of these pad connections.

The pad layout differences will also have to be taken into account for the stencil design. For SMT PCB assembly and recommended stencil designs please refer to the respective “Hardware Interface Description”. For a combined land pattern please see Section 4.1.



Mapping Table		
	BGS2r1	BGS2r2
DCD0	26	42
DTR0	25	43
DSR0	24	41

Figure 8: Common footprint for migration from BGS2 Rel.1 to BGS2 Rel.2 (bottom view)

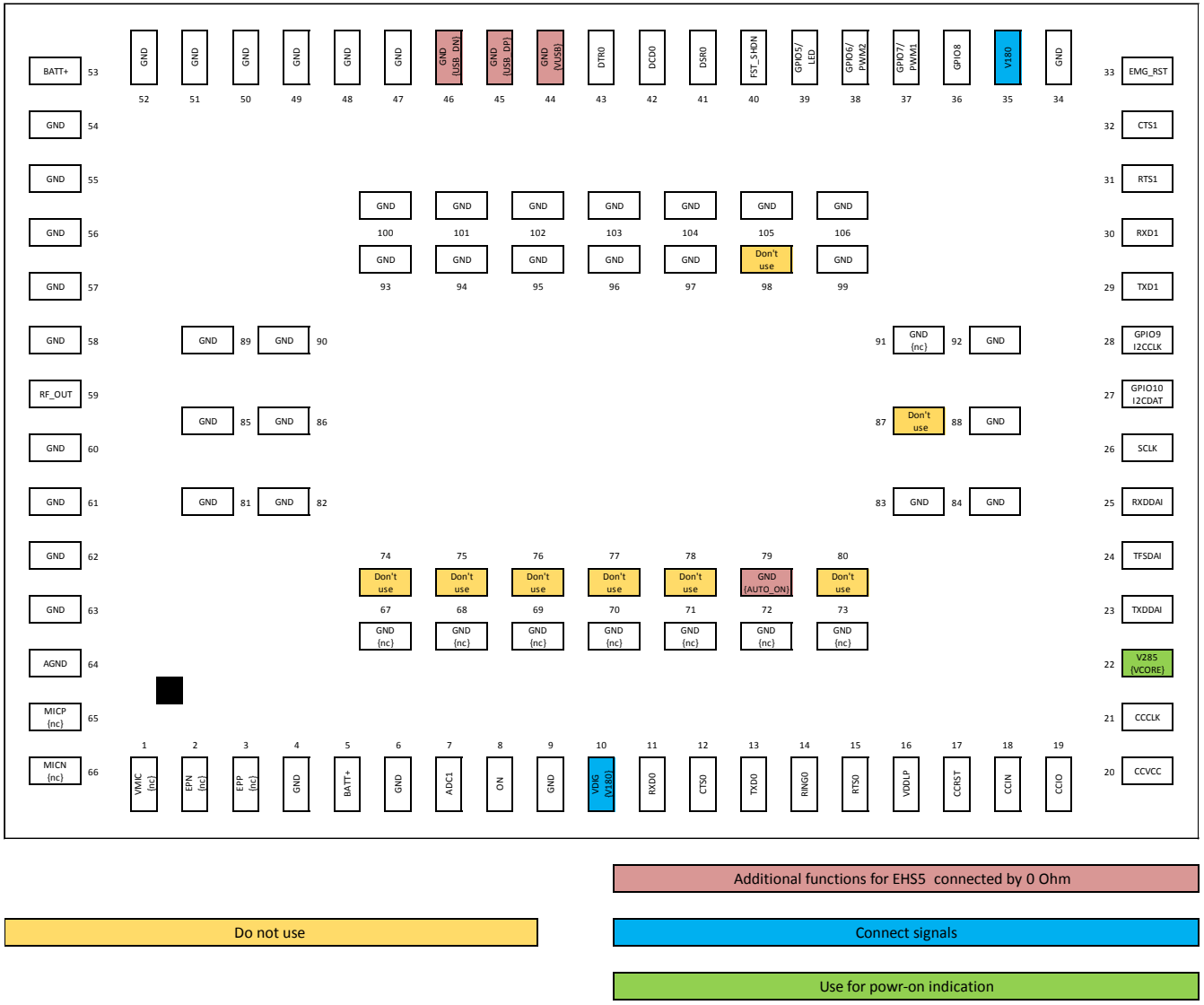
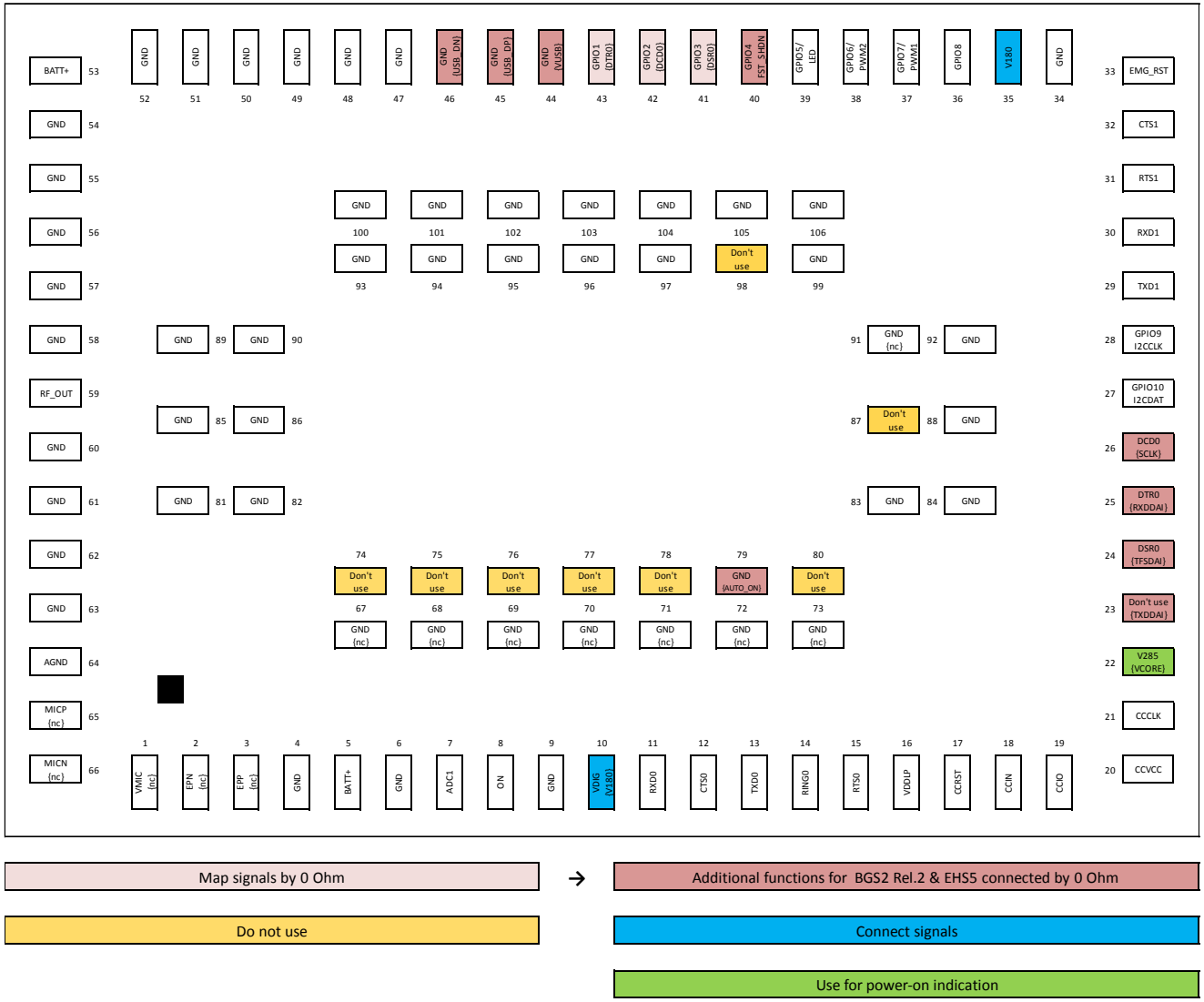


Figure 9: Common footprint for migration from BGS2 Rel.2 to EHS5 (bottom view)



Mapping Table

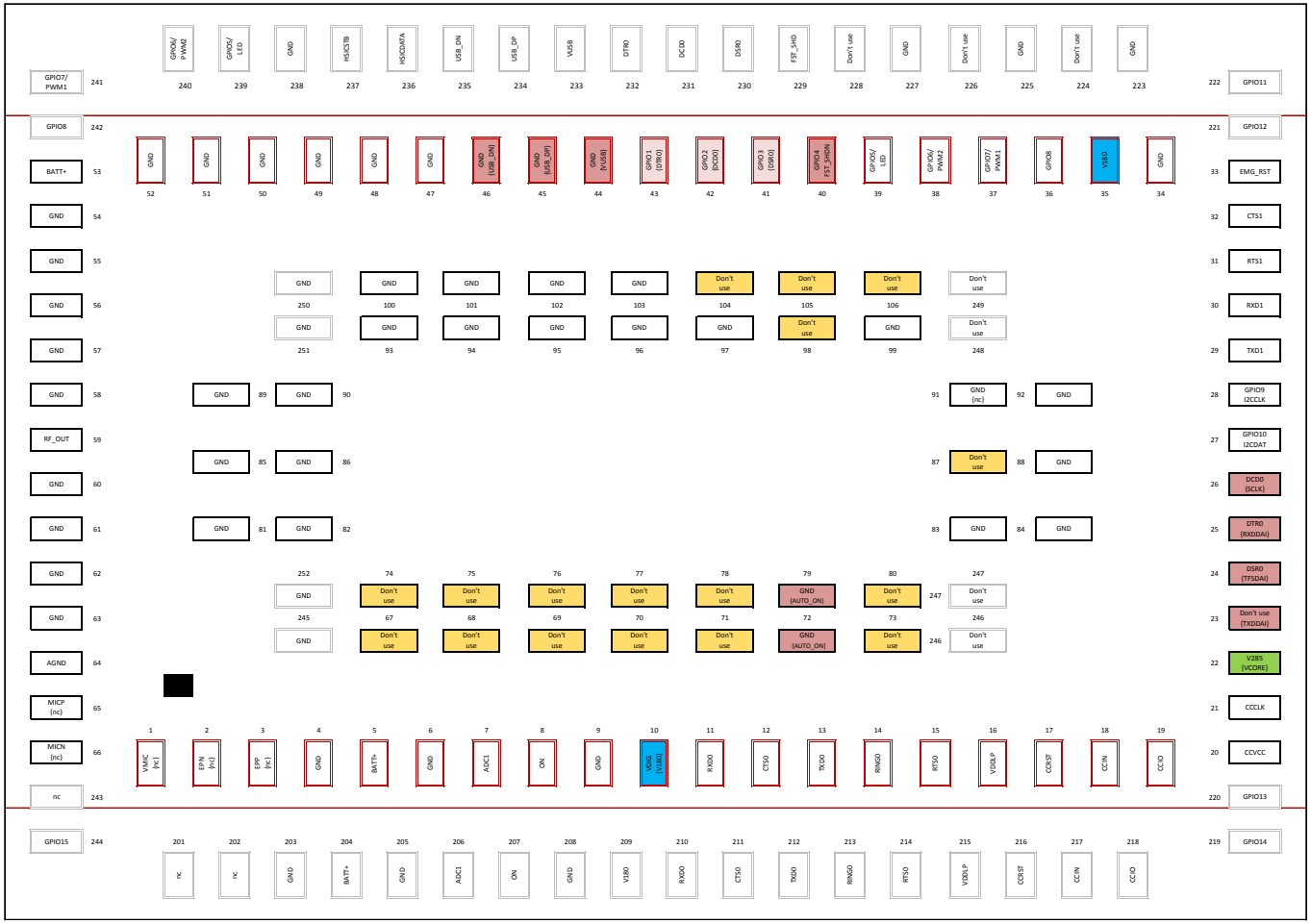
	BGS2r1	BGS2r2	EHS5
DCD0	26	42	42
DTR0	25	43	43
DSR0	24	41	41

Map signals by 0 Ohm → Additional functions for BGS2 Rel.2 & EHS5 connected by 0 Ohm

Do not use — Connect signals

Use for power-on indication

Figure 10: Common footprint for migration from BGS2 Rel.1 / BGS2 Rel.2 to EHS5 (bottom view)



Mapping BGS2 R1, BGS2 R2, EHS5

	R1	R2	EHS5
DCD0	26	42	42
DTR0	25	43	43
DSR0	24	41	41

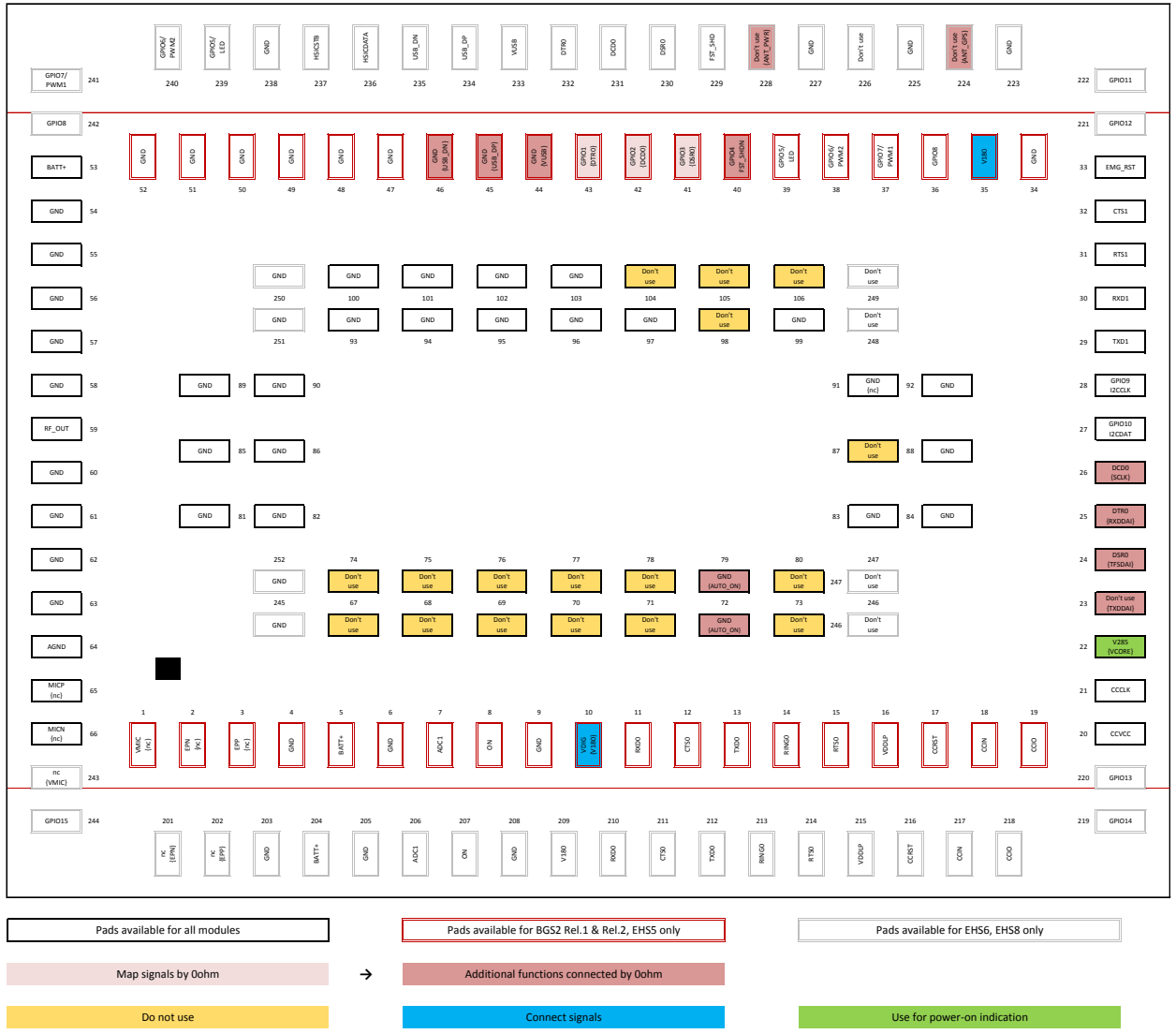
Pad connections BGS2/EHS5 to EHS6

	BGS2/EHS5	EHS6/EHS8
GND	4	203
BATT+	5	204
GND	6	205
ADC1	7	206
ON	8	207
GND	9	208
VDIG V180	10	209
RXD0	11	210
CTS0	12	211
TXD0	13	212
RING0	14	213
RTS0	15	214
VDDLP	16	215
CCRST	17	216
CCIN	18	217
CCIO	19	218
GPIO8	36	242
GPIO7 PWM	37	241
GPIO6 PWM	38	240
GPIO5 LED	39	239
GPIO4 FST_SHDN	40	229
GPIO3 DSR0	41	230
GPIO2 DCD0	42	231
GPIO1 DTR0	43	232
GND VUSB	44	233
GND USB_DP	45	234
GND USB_DN	46	235

Pad connections EHS5 to EHS6

	EHS5	EHS6/EHS8
AUTO_ON	79	72

Figure 11: Common footprint for migration from BGS2 Rel.1 / BGS2 Rel.2 / EHS5 to EHS6 (bottom view)



Mapping BGS2 R1, BGS2 R2, EHS5

	R1	R2	EHS5
DCD0	26	42	42
DTR0	25	43	43
DSR0	24	41	41

Pad connections BGS2/EHS5 to EHS6/EHS8

	BGS2/EHS5	EHS6/EHS8
VMIC*	1	243
EPN*	2	201
EPP*	3	202
GND	4	203
BATT+	5	204
GND	6	205
ADC1	7	206
ON	8	207
GND	9	208
VDIG V180	10	209
RXD0	11	210
CTS0	12	211
TXD0	13	212
RING0	14	213
RTS0	15	214
VDDLP	16	215
CCRST	17	216
CCIN	18	217
CCIO	19	218
GPIO8	36	242
GPIO7 PWM	37	241
GPIO6 PWM	38	240
GPIO5 LED	39	239
GPIO4 FST_SHDN	40	229
GPIO3	41	230
DSR0	42	231
GPIO2 DCD0	43	232
GPIO1 DTR0	44	233
GND	45	234
VUSB	46	235
GND USB_DP		
GND USB_DN		

Pad connections EHS5 to EHS6

	EHS5	EHS6/EHS8
AUTO_ON	79	72

* BGS2r2 and EHS8 only

Figure 12: Common footprint for migration from BGS2 Rel.1 / BGS2 Rel.2 / EHS5 / EHS6 to EHS8 (bottom view)

4.1 Combined Land Pattern

Figure 13 shows a combined land pattern for BGS2 Rel.1/BGS2 Rel.2/EHS5 and EHS6. For details on the differing stencils to be used with a combined land pattern – as shown in Figure 14 and Figure 15 - please refer to the respective “Hardware Interface Description”.

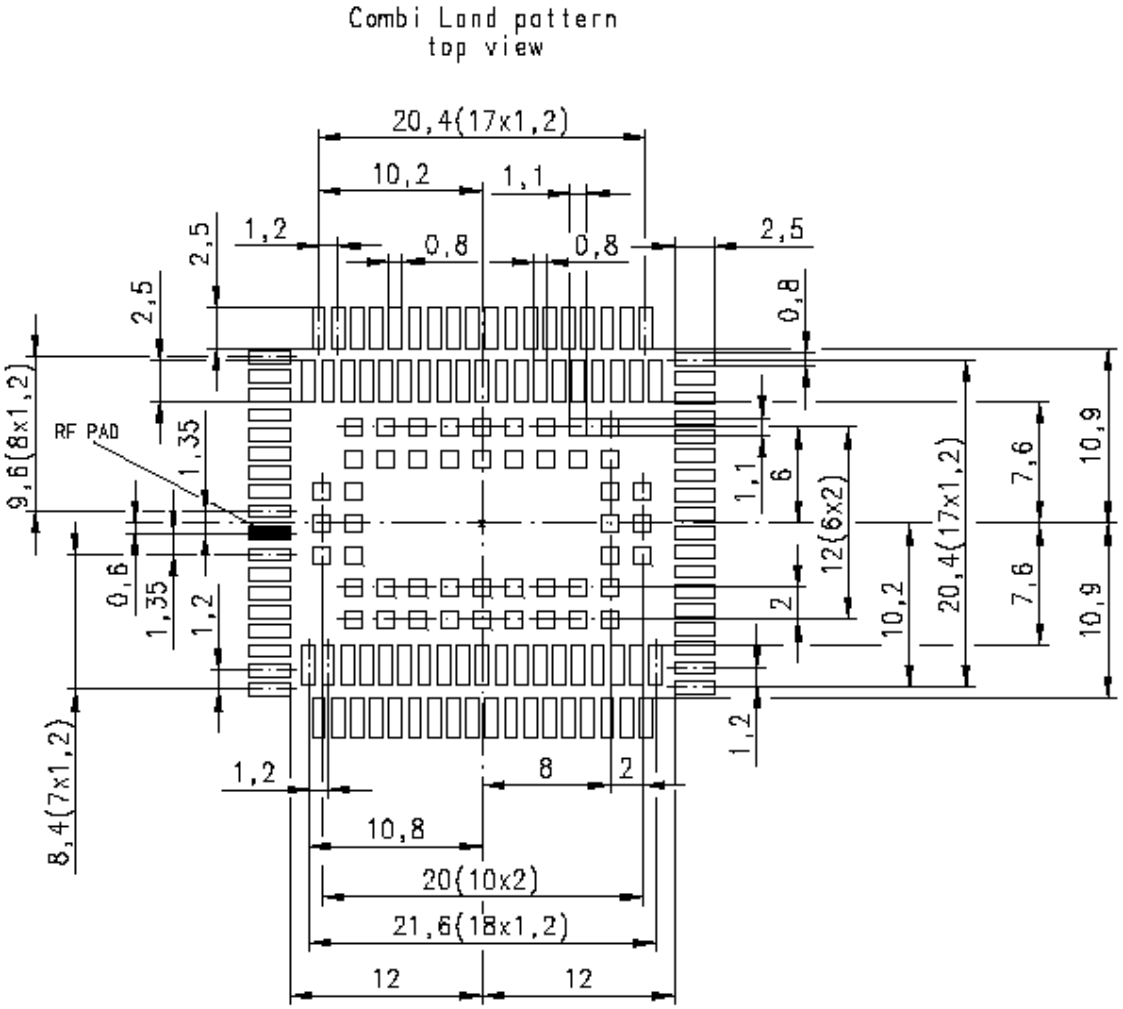


Figure 13: Combined land pattern (top view)

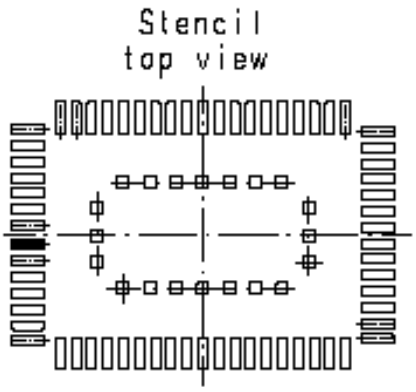


Figure 14: BGS2 Rel.1/BGS2 Rel.2/EHS5 stencil

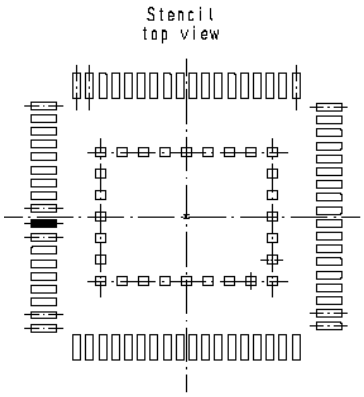


Figure 15: EHS6 stencil

Please note that if soldering EHS6 to an external application using a combined land pattern there should be no solder paste at those pads available for BGS2 Rel.1, BGS2 Rel.2 and EHS5 only (i.e., pads 1-19 and 34-52) in order to avoid shorts. This is because EHS6 has some areas without solder resist where the BGS2 Rel.1, BGS2 Rel.2 and EHS5 only pads are located in a combined land pattern.

About Gemalto

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

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

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

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

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