Differences between BGSx, EHSx, ELSx, EMS31, and ENS22

Hardware Migration Guide

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0 Document History

Preceding document: " Differences between BGSx, EHSx, ELSx and EMSx", Version 06
New document: "Differences between BGSx, EHSx, ELSx, EMS31, and ENS22", Version 07

Chapter	What is new
Throughout document	Added ENS22-C and ENS22-E.
3.3.3	Added note for BGS5 (Rin).

Preceding document: "Differences between BGSx, EHSx, ELSx and EMSx", Version 05
New document: "Differences between BGSx, EHSx, ELSx and EMSx", Version 06

Chapter	What is new
Throughout document	Added ELS81-E and ELS81-US. Revised content for ELS61, EMS31.

Preceding document: " Differences between BGS2, BGS5, EHSx and ELSx", Version 04
New document: "Differences between BGSx, EHSx, ELSx and EMSx", Version 05

Chapter	What is new
Throughout document	Added ELS61-USA, ELS61-E Rel.2 and ELS31-VA and adapted content accordingly. Added BGS1 and adapted content accordingly. Removed references to ELS51/EMS51.
4.2	New section Test Points

Preceding document: " Differences between BGS2, BGS5, EHSx and ELSx", Version 03
New document: " Differences between BGS2, BGS5, EHSx and ELSx", Version 04

Chapter	What is new
Throughout document	Added further products, and adapted content accordingly.

Preceding document: " Differences between BGS2, BGS5, EHSx and ELSx", Version 02
New document: " Differences between BGS2, BGS5, EHSx and ELSx", Version 03

Chapter	What is new
Throughout document	Added further product variants, and adapted content accordingly.
3.2.4	Revised power supply ratings for ELSx, and shifted complete section.
3.3.2	Added notes for common ignition circuit and EHSx.
3.3.3	Added note for EMERG_RST with ELS31 and ELS51.

Chapter	What is new
3.3.4	Revised section to include blocking filter for ELS61.
3.3.20	Revised valid range for ADC1 input.
3.3.21	Added fast shutdown timings and AT^SMSO behavior.
3.4.3	New section Rx Diversity Antenna.
4	Revised some pad assignments for BGS2 in Table 34.

Preceding document: " Differences between BGS2, BGS5, EHSx and ELSx", Version 01
New document: " Differences between BGS2, BGS5, EHSx and ELSx", Version 02

Chapter	What is new
3.1	Added LTE band 28 (700MHz) support for ELS61-E.
3.3.1	Revised ON: V_{IH}max value for ELS61 in Table 6.
3.2.4	Revised power supply ratings for ELS61 in Table 5.
4	Revised SPI pad assignment for ELS31/ELS51: Pad 106 → SPI_MOSI, pad 249 → SPI_MISO

New document: "Differences between BGS2, BGS5, EHSx and ELSx", Version 01

Chapter	What is new
---	Initial document setup.

1 Introduction

This document[1] compares the Gemalto M2M Cinterion® modules BGS1, BGS2, BGS5, EHS5, EHS6, EHS8, ELS61, ELS81, ELS31, EMS31, and ENS22. It lists hardware related differences between these products.

The aim of the document is to provide guidance on how to migrate between any of the above products. Chapter 4 gives advice on designing one common hardware platform for smooth transition between all described products, including possible test points.

1.1 Supported Products

The following table shows the supported products including their module variants and release versions. Where necessary a note is made to differentiate between the various product variants and releases.

Product	Variant	As of Release (Revision)
BGS1	BGS1	Rel.2 (v02.000)
BGS2	BGS2-E BGS2-W	Rel.2 (v02.000) Rel.2 (v02.000)
BGS5	BGS5	Rel.1 (v01.100)
EHS5	EHS5-E EHS5-US	Rel.3 (v03.001) Rel.3 (v03.001)
EHS6	EHS6 EHS6-A	Rel.3 (v03.001) Rel.3 (v03.001)
EHS8	EHS8	Rel.3 (v03.001)
ELS61	ELS61-E ELS61-E R2 ELS61-E2 ELS61-US ELS61-USA ELS61-AUS	Rel.1 (v01.000) Rel.2 (v02.000) Rel.1 (v01.000) Rel.1 (v01.000) Rel.2 (v02.000) Rel.1 (v01.000)
ELS81	ELS81-E ELS81-US	Rel.1 (v04.000) Rel.1 (v04.000)
ELS31	ELS31-V ELS31-VA ELS31-J	Rel.2 (v4.3.3.0) Rel.2 (v4.3.4.0) Rel.2 (v4.3.2.1)
EMS31	EMS31-V EMS31-US	Rel.1 (v5.0.1.0) Rel.1 (v5.1.1.0)
ENS22	ENS22-C ENS22-E	TBD. TBD.

1.2 Related Documents

[1] Hardware Interface Description for the appropriate Cinterion® product
[2] AT Command Set for the appropriate Cinterion® product
[3] Application Note 48: SMT Module Integration for the appropriate Cinterion® product

[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.

1.3 Type Approval

BGS1, BGS2, BGS5, EHSx, ELSx, EMS31, and ENS22 comply with the same standards and directives – except for

- Standards of North American type approval that are not applicable to products not supporting PTCRB bands
- Standards of European type approval that are not applicable to products not supporting GCF bands

Because EHSx and ELS61/81 feature UMTS/HSPA (3G) functionality they also comply with standards for WCDMA. Because ELS61/81 (additionally) and EMS31 feature LTE (4G) functionality they also comply with standards for LTE, and because ENS22 features NB-IoT functionality it also complies with standards for LTE NB-IoT. For more regulatory and type approval information see [1].

2 Software Related Differences

For a complete overview of all AT command differences between BGS1, BGS2, EHSx, ELSx, EMS31, and ENS22 please refer to the respective AT Command Specifications (see [2]).

3 Hardware Related Differences

The focus of this chapter is on hardware differences between BGS1, BGS2, BGS5, EHS5, EHS6, EHS8, ELS31, ELS61, ELS81, EMS31, and ENS22.

Please note that for the current EMS31 Rel.1 the following features mentioned in this document are not yet implemented: GP(I)O, I^2C, PWM, SPI, ADC, 2^{nd} SIM/MIM and impulse counter.

3.1 Feature Overview

Table 1: Feature overview

Feature/Property	BGS1	BGS2	BGS5	EHS5	EHS6, EHS8	ELS61, ELS81	ELS31	EMS31	ENS22
General Properties									
Power supply ratings Operating temperature (board temperature)	For details see Section 3.2.4. Normal operation: -30°C to +85°C Extended operation: -40°C to +90°C (+85°C for ENS22)								
Dimensions	27.6 x 18.8 x 2.7mm	27.6 x 18.8 x 2.7mm	27.6 x 18.8 x 2.6mm	27.6 x 18.8 x 2.2mm	27.6 x 25.4 x 2.2mm	27.6 x 25.4 x 2.2mm	27.6 x 18.8 x 2.1mm	27.6 x 18.8 x 2.05mm	27.6 x 18.8 x 2.5mm
3GPP technology	2G	2G	2G	2G / 3G	2G / 3G	2G / 3G / 4G (Cat 1)	4G (Cat 1)	4G (Cat M1)	4G (Cat NB1)
Frequency bands GSM	Dual band : GSM 900/1800MHz	BGS2-W Quad band 850/900/1800/1900 BGS2-E Dual band 900/1800	Quad band 850/900/1800/1900	EHS5-US: Dual band 850/1900 EHS5-E: Dual band 900/1800	Quad band 850/900/1800/1900	ELS61-E/-E R2/-E2/ ELS81-E: Dual band: 900/1800	Not supported	Not supported	Not supported
Frequency bands UMTS	Not supported	Not supported		EHS5-US: Dual band 850/1900 EHS5-E: Dual band 900/2100	Five band 800/850/900/1900/2100	ELS61-E R2, ELS81-E: Dual Band: 900/2100 ELS61-US(A)/ELS81-US: Tri band: 850/AWS/1900 ELS61-AUS: Tri band: 850/900/2100	Not supported	Not supported	Not supported
Frequency bands LTE	Not supported	Not supported		Not supported	Not supported	ELS61-US(A): Quad band: 700/850/AWS/1900 (Bd2, Bd4, Bd5, Bd12) ELS61-E/-E R2: Quad band: 800/900/1800/2100 (Bd1, Bd3, Bd8, Bd20) ELS61-E2/ELS81-E: Penta band: 700/800/900/1800/2100 (Bd1, Bd3, Bd8, Bd20, Bd28) ELS61-AUS: Quad band: 700/850/900/1800 (Bd3, Bd5, Bd8, Bd28)	ELS31-V, ELS31-VA: Dual Band: 700/1700 (Bd4, Bd13) ELS31-J: Tri Band: 800/850/2100 (Bd1, Bd18, Bd19)	EMS31-V: Dual Band: Half-Duplex-FDD 700/AWS (Bd4, Bd13) EMS31-US: Tri Band: Half-Duplex-FDD 700/AWS/1900 (Bd2, Bd4, Bd12)	Penta band (LTE Cat NB1 - NB-IoT): 1800/850/900/800/750 (Bd3, Bd5, Bd8, Bd20, Bd28)
Output Power GSM 850/900 GSM 1800/1900 UMTS LTE NB-IoT	 +33dBm +30dBm -- -- --	 +33dBm +30dBm -- -- --	 +33dBm +30dBm -- -- --	 +33dBm +30dBm +24dBm -- --	 +33dBm +30dBm +24dBm -- --	 +33dBm +30dBm +23.5dBm +23dBm --	 -- -- -- +23dBm --	 -- -- -- +23dBm --	 -- -- -- -- +23dBm
Antenna	Single 50Ω	Single 50Ω	Single 50Ω	Single 50Ω	Single 50Ω	Dual 50Ω, Main, Rx Diversity	Dual 50Ω, Main, Rx Diversity	Single 50Ω	Single 50Ω
Interface Properties									
Module interface	For pad assignment see Chapter 4.								

Feature/Property	BGS1	BGS2	BGS5	EHS5	EHS6, EHS8	ELS61, ELS81	ELS31	EMS31	ENS22
Serial interfaces									
ASC0	8 wire, Level 1.8V Baudrate: 1200 to 230,400bps Autobauding: 1,200bps to 230,400bps Flow control: RTS0/CTS0	8 wire, Level: 1.8V Baudrate: 300 to 230,400bps Autobauding: 1,200 to 230,400bps Flow control: RTS0/CTS0 and XON/XOFF	8 wire, Level: 1.8V Baudrate: 1,200 to 921,600bps Autobauding: 1,200 to 230,400bps Flow control: RTS0/CTS0	8 wire, Level: 1.8V Baudrate: 1,200 to 921,600bps Autobauding: 1,200 to 230,400bps Flow control: RTS0/CTS0	8 wire, Level: 1.8V Baudrate: 1,200 to 921,600bps Autobauding: 1,200 to 230,400bps Flow control: RTS0/CTS0	8 wire, Level: 1.8V Baudrate: 1,200 to 3Mbit Autobauding: 1,200 to 230,400bps Flow control: RTS0/CTS0	8 wire, Level: 1.8V Baudrate: 4,800 to 921,600bps default: 115,200bps Flow control: RTS0/CTS0	8 wire, Level: 1.8V Baudrate: 4,800 to 3,686,400 bps default: 115,200bps Flow control: RTS0/CTS0	8 wire, Level: 3.0V Baudrate: 1,200 to 921,600bps default: 115,200bps Flow control: RTS0/CTS0
ASC1	4 wire, Level 1.8V Baudrate 1200 to 230,400bps Autobauding: 1,200bps to 230,400bps Flow control: RTS1/CTS1	4 wire, Level: 1.8V Baudrate: 300 to 230,000bps Flow control: RTS1/CTS1 and XON/XOFF	4 wire, Level: 1.8V Baudrate: 1,200 to 921,600bps Autobauding: 1,200 to 230,400bps Flow control: RTS1/CTS1	4 wire, Level: 1.8V Baudrate: 1,200 to 921,600bps Autobauding: 1,200 to 230,400bps Flow control: RTS1/CTS1	4 wire, Level: 1.8V Baudrate: 1,200 to 921,600bps Autobauding: 1,200 to 230,400bps Flow control: RTS1/CTS1	4 wire, Level: 1.8V Baudrate: 1,200 to 921,600bps Autobauding: 1,200 to 230,400bps Flow control: RTS1/CTS1	4 wire, Level: 1.8V Baudrate: 4,800 to 921,600bps Flow control: RTS1/CTS1	4 wire, Level: 1.8V Baudrate: 4,800 to 3,686,400 bps Flow control: RTS1/CTS1	4 wire, Level: 3.0V Baudrate: 1,200 to 921,600bps Flow control: RTS1/CTS1
USB interface	Not supported	Not supported	USB 2.0 High Speed (480Mbit/s) device interface, full speed compliant	USB 2.0 High Speed (480Mbit/s) device interface, full speed compliant	USB 2.0 High Speed (480Mbit/s) device interface, full speed compliant	USB 2.0 High Speed (480Mbit/s) device interface, full speed compliant	USB 2.0 High Speed (480Mbit/s) device interface, full speed compliant	Not supported	Not supported
UICC interface	SIM/USIM: 3V, 1.8V	SIM/USIM: 3V, 1.8V.	SIM/USIM: 3V, 1.8V.	SIM/USIM: 3V, 1.8V.	SIM/USIM: 3V, 1.8V.	SIM/USIM: 3V, 1.8V.	SIM/USIM: 3V, 1.8V.	SIM/USIM: 3V, 1.8V.	SIM/USIM: 3V, 1.8V.
Audio interfaces									
Analog audio	One balanced audio interface	One balanced audio interface	Not supported (Hardware prepared for future use)	Not supported	Not supported EHS6-A: One balanced audio interface	Not supported	Not supported	Not supported	Not supported
Digital audio	Not supported	Supported See Section 3.3.16	Supported See Section 3.3.16	Supported See Section 3.3.16	Supported See Section 3.3.16	Not supported ELS61-E R2, ELS61-USA: Supported See Section 3.3.16	Not supported (Hardware prepared for future use) ELS31-VA: supported See Section 3.3.16	Not supported	Not supported
Other interfaces									
RTC backup	Yes VDDLP 1.8V…4.2V	Yes VDDLP 1V…2.4V	Yes VDDLP 1V…1.9V	Yes VDDLP 1V…1.9V	Yes VDDLP 1V…1.9V	Yes VDDLP 1V…1.9V	Not supported	Not supported	Not supported
GPIO interface	6 GPIO: 5 GPIO shared (I2C, SIM_SWITCH, Status LED, PWM, Jamming Indicator) 1 GPIO not shared	6 GPIO: 5 GPIO shared (I^2C, LED, PWM, Jamming Indicator) 1 GPIO not shared	17 GPIO: 17 GPIO shared (ASC0, ASC1, DAI, SPI, LED, PWM, FST_SHDN, Counter)	17 GPIO: 17 GPIO shared (ASC0, ASC1, DAI, SPI, LED, PWM, FST_SHDN, Counter)	22 GPIO: 17 GPIO shared (ASC0, ASC1, DAI, SPI, LED, PWM, HSIC, FST_SHDN, Counter) 5 GPIO not shared	22 GPIO: 13 GPIO shared (ASC0, ASC1, SPI, LED, PWM, Counter, FST_SHDN) 9 GPIO not shared	20 GPIO: 17 GPIO + 3 GPO shared (ASC0, ASC1, SPI, LED, Counter, FST_SHDN) 3 GPIO not shared	20 GPIO shared with Serial Interface SPI	13 GPIO: 11 GPIO shared (I2C, ASC0, ASC1,SPI, SHTDWN) 2 GPIO not shared
SDIO	Not supported	Not supported	Not supported	Not supported	Not supported	Not supported	Not supported (only as module wakeup line)	Not supported	Not supported
ADC	10bit; 0V…1.2V	10bit, 0…1.2V	10bit, 0…1.14V	10bit, 0…1.2V	10bit, 0…1.2V	10bit, 0…1.2V	10bit, 0…2.0V	10bit, 0…1.9V	Not supported
Ignition signal	ON Rising edge (high pulse)	ON: Rising edge (high pulse)	ON: Rising edge (high pulse)	ON: High pulse ~60µs AUTO_ON: Low level	ON: High pulse ~60µs AUTO_ON: Low level	ON: Rising edge (high pulse)	ON: Rising edge (high pulse)	ON: Rising edge (high pulse)	ON: Rising edge (high pulse)

Feature/Property	BGS1	BGS2	BGS5	EHS5	EHS6, EHS8	ELS61, ELS81	ELS31	EMS31	ENS22
Reset Signal	Supported	Supported	Supported	Supported	Supported	Supported	Supported	Supported	Supported
I^2C Interface	I^2C at GPIO9 / 10	I^2C at GPIO9 / 10	I^2C at dedicated lines	I^2C at dedicated lines	I^2C at dedicated lines	I^2C at dedicated lines	I^2C at dedicated lines	Supported	Supported
SPI Interface	Not supported	Not supported	SPI shared with GPIOs	SPI shared with GPIOs	SPI shared with GPIOs	SPI shared with GPIOs	SPI at dedicated lines and shared with GPIOs	Supported	Supported
HSIC Interface	Not supported	Not supported	Not supported	Not supported	Supported	Not supported (Hardware prepared for future use)	Not supported	Not supported	Not supported
Fast shutdown	Dedicated line	Dedicated line	Fast shutdown Shared with GPIO	Fast shutdown Shared with GPIO	Fast shutdown Shared with GPIO	Fast shutdown Shared with GPIO	Fast shutdown Shared with GPIO	Fast shutdown Shared with GPIO	Not supported
GPS	Not supported	Not supported	Not supported	Not supported	EHS6: Not supported EHS8: GPS supported	Not supported	Not supported	Not supported	Not supported
UMTS/HSPA	Not supported	Not supported	Not supported	Supported	Supported	ELS61-US(A)/ELS81-E/-US: Supported ELS61-E: Not supported ELS61-E R2: Supported ELS61-E2: Not supported ELS61-AUS: Supported	Not supported	Not supported	Not supported
EGPRS	Not supported	Not supported	Not supported	Multislot class 12	Multislot class 12	ELS61-US: Not supported ELS61-E/-E R2/ELS81-E: Supported ELS61-E2: Supported ELS61-AUS: Not supported	Not supported	Not supported	Not supported
GPRS	Multislot class 12	Multislot class 10	Multislot class 12	Multislot class 12	Multislot class 12	ELS61-US: Not supported ELS61-E/-E R2/ELS81-E: Supported ELS61-E2: Supported ELS61-AUS: Not supported	Not supported	Not supported	Not supported
NB-IoT (LTE Cat NB1)	Not supported	Not supported	Not supported	Not supported	Not supported	Not supported	Not supported	Not supported	Supported
Software	For software related differences please refer to [2].								

3.2 General Properties

3.2.1 Frequency Bands

Table 2: Frequency bands

Module	Frequency bands
BGS1	GSM 900/1800MHz
BGS2	BGS2-W: GSM 850/900/1800/1900MHz BGS2-E: GSM 900/1800MHz
BGS5	GSM 850/900/1800/1900MHz
EHS5	EHS5-US: GSM 850/1900MHz, UMTS 850/1900MHz EHS5-E: GSM 900/1800MHz, UMTS 900/2100MHz
EHS6, EHS8	GSM 850/900/1800/1900MHz UMTS 800/850/900/1900/2100MHz
ELS61	ELS61-US, ELS61-USA: UMTS 850/AWS/1900, LTE 700/850/AWS/1900 ELS61-E: GSM 900/1800, LTE 800/900/1800/2100 ELS61-E R2: GSM 900/1800, UMTS 900/2100, LTE 800/900/1800/2100 ELS61-E2: GSM 900/1800, LTE 700/800/900/1800/2100 ELS61-AUS: UMTS 850/900/2100, LTE 700/850/900/1800
ELS81	ELS81-E: GSM/GPRS/EDGE: 900/1800, UMTS: 900/2100, LTE: 700/800/900/1800/2100 ELS81-US: UMTS: 850/AWS/1900, LTE: 700/850/AWS/1900
ELS31	ELS31-V: LTE: 700/1700 ELS31-VA: LTE: 700/1700 ELS31-J: LTE: 800/850/2100
EMS31	EMS31-V: LTE: 700/AWS, Half-Duplex-FDD EMS31-US: LTE: 700/AWS/1900, Half-Duplex-FDD
ENS22	ENS22: LTE Cat NB1 (NB-IoT): 700/800/850/900/1800

Reference:
“Hardware Interface Description”: Section “Key Features at a Glance”

3.2.2 Dimensions

Table 3: Dimensions

Module	Length x Width [mm]	Hight [mm]	Weight	Pad count (LGA number)
BGS1	27.6 x 18.8	2.7	~2.3g	106
BGS2	27.6 x 18.8	2.7	~3g	106
BGS5	27.6 x 18.8	2.6	~3g	114
EHS5	27.6 x 18.8	2.2	~3g	106
EHS6, EHS8	27.6 x 25.4	2.2	~3.5g	120
ELS61	27.6 x 25.4	2.2	~3.5g	120
ELS81	27.6 x 25.4	2.2	~3.5g	120
ELS31	27.6 x 18.8	2.1	~3g	114
EMS31	27.6 x 18.8	2.17	~2.2g	114
ENS22	27.6 x 18.8	2.5	TBD.	106

Reference:

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

3.2.3 Operating Temperature

Table 4: Board / battery temperatures [°C]

Parameter	BGS1	BGS2	BGS5	EHS5, EHS6, EHS8	ELS61, ELS81	ELS31	EMS31	ENS22
Operating temperature	-30°C … +85°C							
Extended temperature	-40°C … +90°C (-40°C … +85°C for ENS22)							
Automatic shutdown at board temperature	<-40°C and >+90°C (<-40°C and >+85°C for ENS22)							

Reference:

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

3.2.4 Power Supply Ratings

Power supply ratings differ between the modules. Table 5 lists some of these ratings, to highlight differences among various modules.

Please refer to the respective module's Hardware Interface Description for further power supply ratings specified with regard to additional features available with these products (i.e., LTE, UMTS, USB, GPS).

Reference:
- "Hardware Interface Description": Section "Power Supply Ratings"

Table 5: Power supply ratings[2]

Parameter	Description	Conditions	BGS1	BGS2	BGS5	EHS5	EHS6, EHS8	ELS61, ELS81[3,4]	ELS31	EMS31	ENS22	Unit
BATT+	Supply voltage	Voltage including drop, ripple and spikes.	3.3…4.5	3.3...4.5	3.3...4.5	3.3...4.5	3.3...4.5	3.0...4.5	3.3...4.5	3.2…5.5	2.8…4.2	V
	2G: Max voltage drop during transmit burst	Normal condition, max RF output power	400	400	400	400	400	400	Not applicable	Not applicable	400 (LTE Cat NB1)	mV
	Voltage ripple	Normal condition, power control level for Pout max @ f<250kHz @ f>250kHz	 -- --	 85 25	 190 30	 190 30	 190 30	 120 90	 110 30	 110 30	 120 90	mVpp
I_{VDDLP}	OFF state supply current	RTC backup @ BATT+ = 0V	47	8	2.4	2	1	1.8 0.1 for ELS81	Not applicable	Not applicable	Not applicable	µA

[2] GSM850 and GSM1900 bands are applicable for the quad band module variants only.
[3] With ELS61, power supply ratings depend to quite a degree on the current supply voltage, and may thus vary up to 30% across the voltage range. Ratings given here were measured @3.8V. With ENS22, ratings given here were measured @3.6V.
[4] Only the appropriate highest rating out of all ELS61/ELS81 product variants is mentioned. For detailed values refer to [1].

Parameter	Description	Conditions	BGS1	BGS2	BGS5	EHS5	EHS6, EHS8	ELS61, ELS81[3,4]	ELS31	EMS31	ENS22	Unit
I_{BATT+}	OFF state supply current	Power Down mode	225	45	42	60	60	90 75 for ELS81	<15	<2	<5	µA
	SLEEP current[5] GSM/GPRS UMTS LTE	 DRX=2 & 9[6] DRX=6 & 9[6] RRC=1.28s & 2.58s[6]	 2.3, 2.0 (GSM) 2.1, 1.8 (GPRS) -- --	 2.2, 1.2 -- --	 1.5, 1.0 -- --	 1.4, 0.9 1.8, 1.2 --	 1.9, 1.3[7] 2.0, 1.5[8] --	 3.0, 2.4 3.0, 2.3 3.0, 2.6	 -- -- --	 -- -- --	 -- -- --	mA
	IDLE current[5] GSM UMTS LTE LTE	 DRX=2[6] DRX=6[6] --- RRC=1.28s & 2.58s[6]	 13.5 -- -- --	 8.6 -- -- --	 21 -- -- --	 14 13 -- --	 14 16 -- --	 12.3 13[9] 17[9] --	 -- -- -- 5.5, 4.0	 -- -- -- 2.0, 1.5	 -- -- -- 6.9, 1.5	mA
I_{BATT+}	Average current Voice call @maximum Pout	GSM850/EGSM 900[10] GSM 1800/1900[11] UMTS Band II UMTS Band VIII	198.5 139.5 -- --	200 150 -- --	210 155 -- --	245 180 560 --	205 165 620 --	280 150 615 605	-- -- -- --	-- -- -- --	-- -- -- --	mA
	Average current Data @maximum Pout	GPRS 1TX, 4Rx GSM 850/900[10] GSM 1800/1900[11]	 161.1 120.2	 180 145	 188 137	 240 180	 210 150	 290 160	 -- --	 -- --	 -- --	mA
		GPRS 2Tx, 3Rx GSM 850/900[10] GSM 1800/1900[11]	 246.7 162.8	 330 260	 265 210	 310 200	 280 190	 370 220	 -- --	 -- --	 -- --	mA
		UMTS Band I Band II Band IV Band V Band VI Band VIII	 -- -- -- -- -- --	 -- -- -- -- -- --	 -- -- -- -- -- --	 440 490 -- 410 -- 470	 520 520 -- 560 560 585	 615 640 650 485 -- 580	 -- -- -- -- -- --	 -- -- -- -- -- --	 -- -- -- -- -- --	mA

[5] 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.

[6] USB disconnected

[7] EHS8: 1.4mA

[8] EHS8: 1.5mA

[9] Power save mode is disabled via AT command (AT^SPOW=1,0,0)

[10] Power control level PCL 5

[11] Power control level PCL 0

Parameter	Description	Conditions	BGS1	BGS2	BGS5	EHS5	EHS6, EHS8	ELS61, ELS81[3,4]	ELS31	EMS31	ENS22	Unit
I_{BATT+}	Average current	LTE										mA
	Data	B1	--	--	--	--	--	720	810	--	--	
	@maximum Pout	B2	--	--	--	--	--	700	--	225	--	
		B3	--	--	--	--	--	700	--	--	230 (NB-IoT)	
		B4	--	--	--	--	--	720	810	240	--	
		B5	--	--	--	--	--	580		--	205 (NB-IoT)	
		B8	--	--	--	--	--	665		--	220 (NB-IoT)	
		B12	--	--	--	--	--	670		210	--	
		B13	--	--	--	--	--		700	TBD	--	
		B18	--	--	--	--	--		700		--	
		B19	--	--	--	--	--		700		--	
		B20	--	--	--	--	--	625	--		205 (NB-IoT)	
		B28	--	--	--	--	--	620	--	--	290 (NB-IoT)	
I_{BATT+}	Peak current @maximum Pout	GSM 850/900[10] PCL=5	1.37	1.30, 1.35[12]	1.35, 1.64[12]	1.6, 2.3[12]	1.7, 2.3[12]	2.4	--	--	--	A
		GSM 1800/1900[11], PCL=0	1.03	0.95, 0.97[12]	1.1, 1.2[12]	1.1, 1.4[12]	1.2, 1.4[12]	1.6	--	--	--	

[12] Maximum current at maximum antenna mismatch.

3.3 Application Interface

3.3.1 ON (and AUTO_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 earlier EHS5, EHS6 and EHS8 firmware versions. Please refer to the Release Notes to find out whether your version supports the ON signal.

For EHS5, EHS6 and EHS8 modules, it is also possible to use an AUTO_ON line as start-up signal to avoid the dedicated ON pulse timing.

Table 6: ON signal characteristics

Signal	BGS1	BGS2	BGS5	EHS5, EHS6, EHS8	ELS61, ELS81	ELS31	EMS31	ENS22
VDDLP	2.8V	2.3V	2.3V	1.8V	1.8V	Not supported	Not supported	Not supported
ON: V_{IH}max	3.3V (VDDLP+0.5V)	2.8V (VDDLP+0.5V)	2.6V (VDDLP+0.3V)	2.1V	5V tolerant	5.5V	5.5V	4.2V
ON: V_{IH}min	1.2V	1.2V	1.2V	1.2V	1.3V	1.7V[13]	1.4V	2.8V
ON: V_{IL}max	0.2V	0.4V	0.5V	0.5V	0.5V	1.3V[13]	0.3V	0.8V
Input sensitivity	High pulse (>3s)	Rising edge triggered	Rising edge triggered	High pulse (50…80µs)	Rising edge triggered	Rising edge triggered	Rising edge triggered	Rising edge triggered
AUTO_ON (Active low signal that starts up module)[14]	Not supported	Not supported	Not supported	V_{IH}max = VDDLP+0.3V V_{IH}min = 1.2V V_{IL}max = 0.5V Input sensitivity=Level triggered		Not supported	Not supported	Not supported

Reference:

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

[13] Rating for BATT_BB voltage at 3.3V.

[14] Note: If 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.

3.3.2 Common Ignition Circuit for ON (and AUTO_ON) Signal

The common ignition circuit shown in Figure 1 can be used to switch on the module either by using the ON or – in the case of EHS5, EHS6 and EHS8 - the AUTO_ON signal.

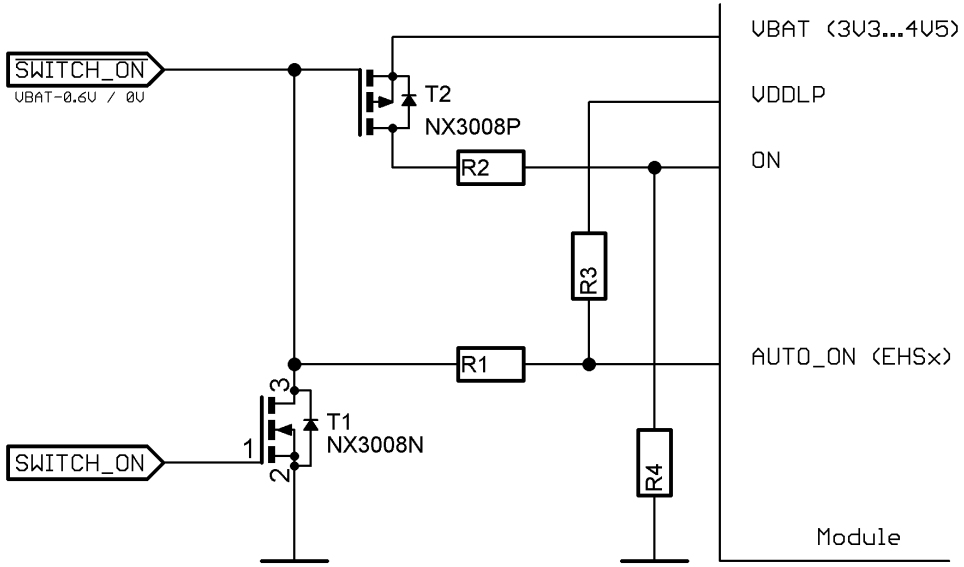

Figure 1: Common ignition circuit

Table 7: Common Ignition circuit component placement

	BGS1	BGS2	BGS5	EHS5, EHS6, EHS8[15]	ELS61, ELS81	ELS31	EMS31	ENS22		
R1	--	--	--	0Ω (--)	--	--	--	--		
R2	6.8kΩ	6.8kΩ	6.8kΩ	-- (12k)	0Ω	0Ω	0Ω	0Ω		
R3	--	--	--	10kΩ (--)	--	--	--	--		
R4	10k	10k	10k	-- (10k)	--	--	--	--		
Required transistor	T2	T2	T2	T1 (T2)	T2	T2	T2	T2		
Active signal	ON	ON	ON	AUTO_ON (ON)	ON	ON	ON	ON		

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 for different modules. Note that while EHSx can be started using AUTO_ON, it is also possible to employ the ON signal if the external application can provide a dedicated pulse timing. With ELS31 it is strongly recommended to use EMERG_RST in conjunction with the startup (see below Section 3.3.3 as well as the appropriate Hardware Interface Description ([1]).

[15] () = Alternative values in brackets apply, if EHSx application is able to employ ON signal.

3.3.3 EMERG_RST

The emergency restart signal restarts the module and 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 or level longer than 10ms. EMERG_RST should be externally driven by an open collector driver.

Table 8: EMERG_RST characteristics

EMERG_RST	BGS1	BGS2	BGS5	EHS5, EHS6, EHS8	ELS61, ELS81	ELS31	EMS31	ENS22
V_{IH}max	4.5V	1.9V	1.85V	1.9V	1.9V	5.5V	3.6V (<V_{BATT+})	3.3V
V_{IH}min	0.8V_{BAT}	1.35V	1.30V	1.35V	1.35V	0.85V	0.8V	2.1V
V_{IL}max	0.8V	0.2V I(V_{IL}max) < -150µA at V_{IL}max	0.35V I(V_{IL}max) < -105µA at V_{IL}max	0.35V I(V_{IL}max) < -130µA at V_{IL}max	0.35V I(VILmax) < -130µA at V_{IL}max	0.65	0.2V	0.6V
Rin	100kΩ // 100pF	1kΩ // 1nF	1kΩ // 1nF[16]	1kΩ // 1nF	1kΩ // 1nF	430kΩ // 1µF	27kΩ // 150pF	TBD.
Signal level @Power down	Low	Low	Low	High	Low	Low	Low	Low

Note: With ELS31, it is necessary to trigger EMERG_RST after a module turn off by a sudden (incomplete) power drop, and before using ON to restart the module. For further details see the appropriate Hardware Interface Description ([1]).

Reference:

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

[16] Additional 2.2k pull-up resistor to V180 required.

3.3.4 Power Supply BATT+

The EHSx and ELSx power supply needs an external interference suppression capacitor at the power supply $BATT+_{RF}$ and $BATT+_{BB}$. Low ESR capacitors should be connected very close to appropriate power supply pads listed below in Table 9.

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. For ELSx the 0Ohm resistor should in any case be replaced with a ferrite bead.

BGS1, BGS2, BGS5, and ENS22 do not require any additional interference suppression at both power pads.

Table 9: BATT+ power supply pads and interference suppression

BATT+	BGS1	BGS2	BGS5	EHS5	EHS6, EHS8	ELS61, ELS81	ELS31	EMS31	ENS22
Pad 5	$BATT+_{BB}$ No interference suppression	$BATT+_{BB}$ No interference suppression	BATT+ No interference suppression	$BATT+_{BB}$ Interference suppression 150µF low ESR	---	---	BATT_RF Interference suppression 150µF low ESR	BATT+ No interference suppression	$BATT+_{BB}$ No interference suppression
Pad 53	$BATT+_{RF}$ No interference suppression	$BATT+_{RF}$ No interference suppression	BATT+ No interference suppression	$BATT+_{RF}$ Interference suppression 50µF low ESR	$BATT+_{RF}$ Interference suppression 150µF low ESR	$BATT+_{RF}$ Interference suppression 150µF low ESR	BATT_BB Interference suppression 50µF low ESR	BATT+ No interference suppression	$BATT+_{RF}$ No interference suppression
Pad 204	--	---	---	---	$BATT+_{BB}$ Interference suppression 50µF low ESR	$BATT+_{BB}$ Interference suppression 50µF low ESR (150µF low ESR as of Rel.2) (plus noise blocking filter BLM18EG221/1nF/100nF)	---	---	---

The following figures show a possible sample external interference suppression circuit and its varying components.

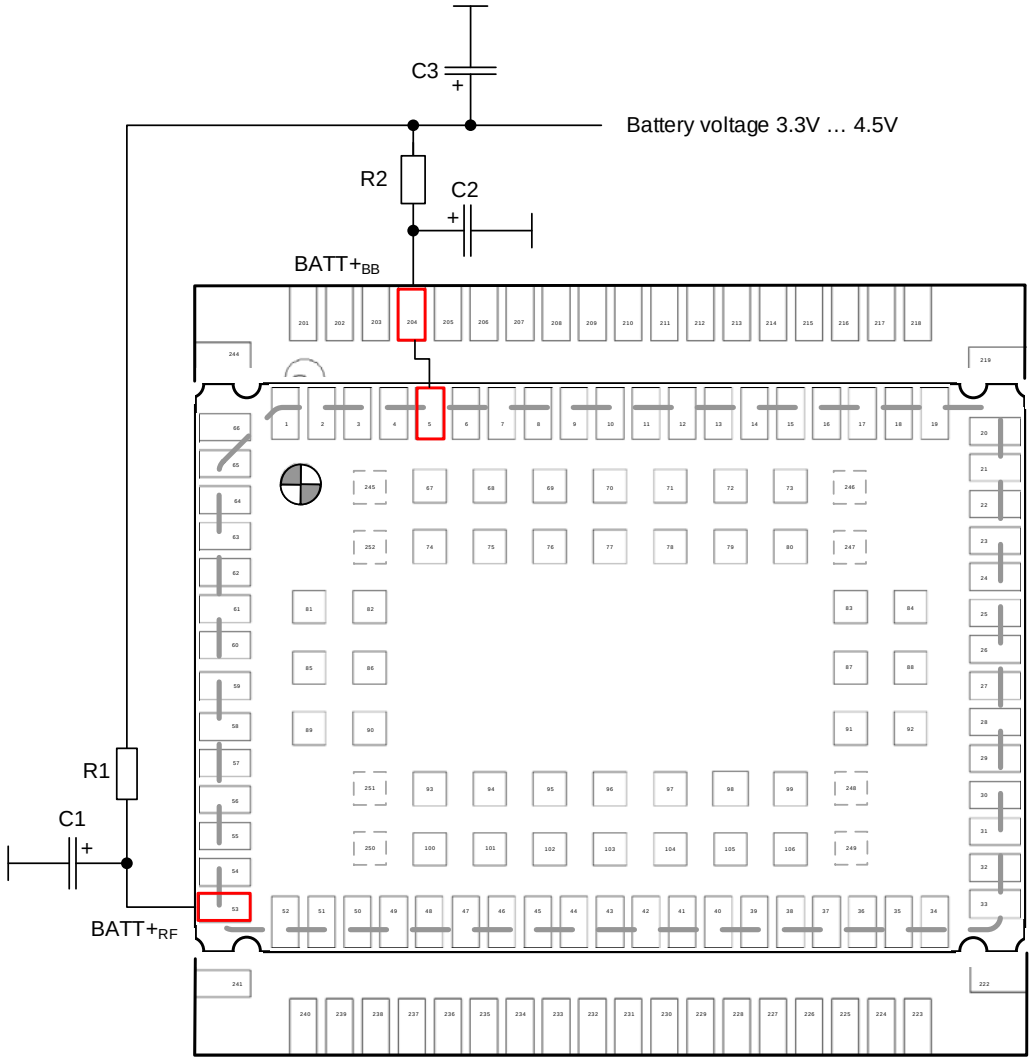

Figure 2: BATT+ and external interference suppression circuit

Table 10: Interference suppression circuit components

Item	BGS1	BGS2	BGS5	EHS5	EHS6, EHS8	ELS61	ELS31	EMS31	ENS22
C2	--	--	--	1nF low ESR	1nF low ESR	1nF low ESR	1nF low ESR	---	---
C1	--	--	--	50µF low ESR	150µF low ESR	150µF low ESR	50µF low ESR	---	---
C3	--	---	---	150µF low ESR	50µF low ESR	50µF low ESR (150µF low ESR as of Rel.2)	150µF low ESR	---	100µF(or 2x47µF) low ESR
R1	0R	0R	0R	0R	0	0R	0R	0R	
R2	0R	0R	0R	0R	0R	Ferrite bead BLM18EG221	0R	0R	

3.3.5 Voltage Domain VDIG, V180, V285/VCORE

With BGS1 and BGS2 the VDIG line is used as input reference to set the IO voltage domain for the ASC0, DAI and I^2C interfaces – and is either connected to V180 or V285. BGS5, EHSx, ELSx, and EMS31 have a fixed IO voltage domain of 1.8V, whereas ENS22 has a fixed IO voltage domain of 3.0V. The VDIG line is in these cases no longer applicable.

For compatibility reasons and migration purposes, it is recommended to configure the BGS2 IO voltage domain to 1.8V.

Table 11: Voltage domain configuration

Voltage domain	BGS1	BGS2	BGS5	EHS5, EHS6, EHS8	ELS61, ELS81	ELS31	EMS31	ENS22
VDIG	Applicable	Applicable	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable
V180 or V300 (ENS22)	1.8V ±5% $I_o$max: 10mA	1.8V ±5% $I_o$max: 10mA	1.8V ±5% $I_o$max: 10mA	1.8V ±5% $I_o$max: 10mA	1.8V ±5% $I_o$max: 10mA	1.8V ±5% $I_o$max: 50mA	3.0V ±5% $I_o$max: 10mA[17]	3.0V ±5% $I_o$max: 10mA
V285 / VCORE	V285: 2.85V	V285: 2.85V	VCORE: 0.9…1.25V	VCORE: 0.9…1.2V	VCORE: 0.9V…1.2V	VCORE: 1.09V…1.12V	Not applicable	Not applicable
IO domain	Configurable 1.8V / 2.85V	Configurable 1.8V / 2.85V	Fixed 1.8V	Fixed 1.8V	Fixed 1.8V	Fixed 1.8V	Fixed 3.0V	Fixed 3.0V

[17] Please note that with EMS31 the V180 line is switched off if the module is in SUSPEND mode (i.e. in a specific a deep sleep mode).

3.3.6 Power Indication Circuit

External level shifters or power sources need to be controlled in a safe way to prevent back feeding while the module is in Power Down mode. Generally, it is recommended to control those shifters or sources by means of the V180 line[18]. If back feeding cannot be prevented via V180 line, a more sophisticated power indication signal should be used instead.

As V180 and V285/VCORE have a slightly different start-up and shutdown timing, it is recommended to implement an external circuit to realize an optimized power indication signal (PWR_IND) if needed. 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. Please be aware that realizing a more sophisticated power indication signal will consume additional power.

Also note that ENS22 does not support V285/VCORE and has V300 instead of V180. A dedicated power indication circuit for ENS22 is show in Figure 4.

Table 12: Power indication circuit components

Voltage domain	BGS1	BGS2	BGS5	EHS5, EHS6, EHS8	ELS61, ELS81	ELS31	EMS31	ENS22
V180 or V300 (ENS22)	1.8V	1.8V	1.8V	1.8V	1.8V	1.8V	1.8V	3V
V285 / VCORE	V285: 2.85V	V285: 2.85V	VCORE: 0.9..1.25V	VCORE: 0.9..1.2V	VCORE: 0.9…1.2V	VCORE: 1.1V	VCORE: 1.045V…1.155V	--
R1	22k	22k	22k	22k	22k	22k	--	--
R2	22k…100k	22k…100k	47k…100k	47k…100k	47k…100k	47k…100k	--	--
R3	22k	22k	4.7k	4.7k	4.7k	4.7k	4.7k	--
R4	22k…47k	22k…47k	47k…100k	47k…100k	47k…100k	47k…100k	47k	--
R5	10k…100k	10k…100k	10k…100k	10k…100k	10k…100k	10k…100k	470k…1M	--
R6	--	--	--	--	--	--	--	47k
R7	--	--	--	--	--	--	--	100k
R8	--	--	--	--	--	--	--	100k

[18] Please note that with EMS31 the V180 line is switched off if the module is in SUSPEND mode (i.e. in a specific a deep sleep mode). Also, with ENS22 the V300 line is switched of if the module is in power down mode.

Voltage domain	BGS1	BGS2	BGS5	EHS5, EHS6, EHS8	ELS61, ELS81	ELS31	EMS31	ENS22
T1/T2[19]/T3	BCR148S, BCR141S R1'=0Ω	BCR148S, BCR141S R1'=0Ω	BCR116S R1'=18kΩ	BCR116S R1'=18kΩ	BCR116S R1'=18kΩ	BCR116S R1'=18kΩ	BC847	BC847

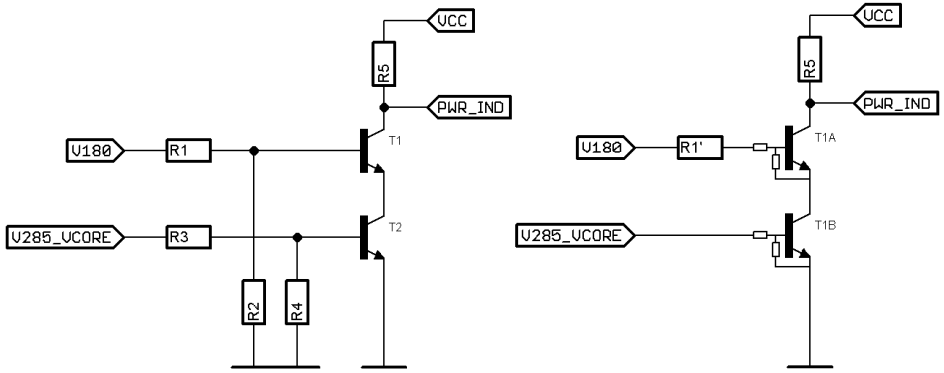

Figure 3: Power indication circuit

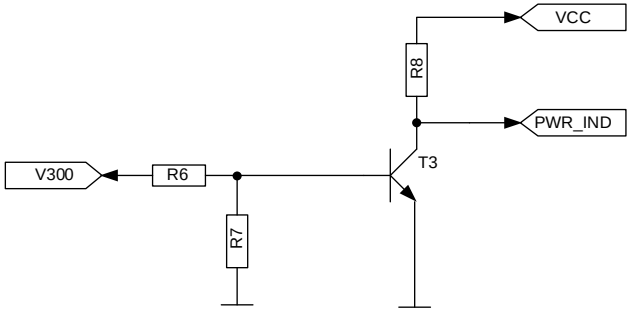

Figure 4: Power indication circuit for ENS22 only

[19] As an alternative to implementing the power indication circuit with the specified resistors and standard transistors as shown in the left circuit of Figure 3, it is possible to employ digital transistors with build in resistors as shown in the right circuit, thus saving some components and space. In such case R2 can also be connected to emitter of T1.

3.3.7 RTC Backup VDDLP

The power supply pad VDDLP can be used to back up the internal RTC from an external capacitor. Note that the voltage levels for this pad differ between BGS1, BGS2, BGS5 and EHSx/ELS61/ELS81 as shown in the following table.

Table 13: Power indication circuit components

VDDLP signal	BGS1	BGS2	BGS5	EHS5, EHS6, EHS8	ELS61, ELS81	ELS31	EMS31	ENS22
Nominal (max) level	2.8V (4.2V)	2.3V (2.4V)	2.3V	1.8V (1.9V)	1.8V (1.9V)	Not supported	Not supported	Not supported
Supply current	47µA	8µA	<2.4µA	<1µA	<1µA	--	--	--

3.3.8 SIM Interface

BGS5, EHSx, ELS61, and ENS22 have no enhanced ESD protection implemented. It is therefore recommended to implement an additional ESD protection close to the SIM card holder as shown in Figure 5.

Note to use very low capacitive protection elements, like NUP4114 or NUP4201MR6.

BGS1, BGS2, and EMS31 require a 4.7kOhm pull-up resistor at the CCIO line.

Table 14: SIM interface – enhanced ESD protection

SIM interface	BGS1	BGS2	BGS5	EHS5, EHS6, EHS8	ELS61, ELS81	ELS31	EMS31	ENS22
Enhanced Internal ESD protection	Implemented	Implemented	Not implemented	Not implemented	Not implemented	Implemented	Implemented	Not implemented
4.7kOhm pull-up resistor at CCIO line	Required	Required	Not required	Not required	Not required	Not required	Required	Not required
CCIN usage (SIM inserted)	High	High	High	High	High	High	High	Not required

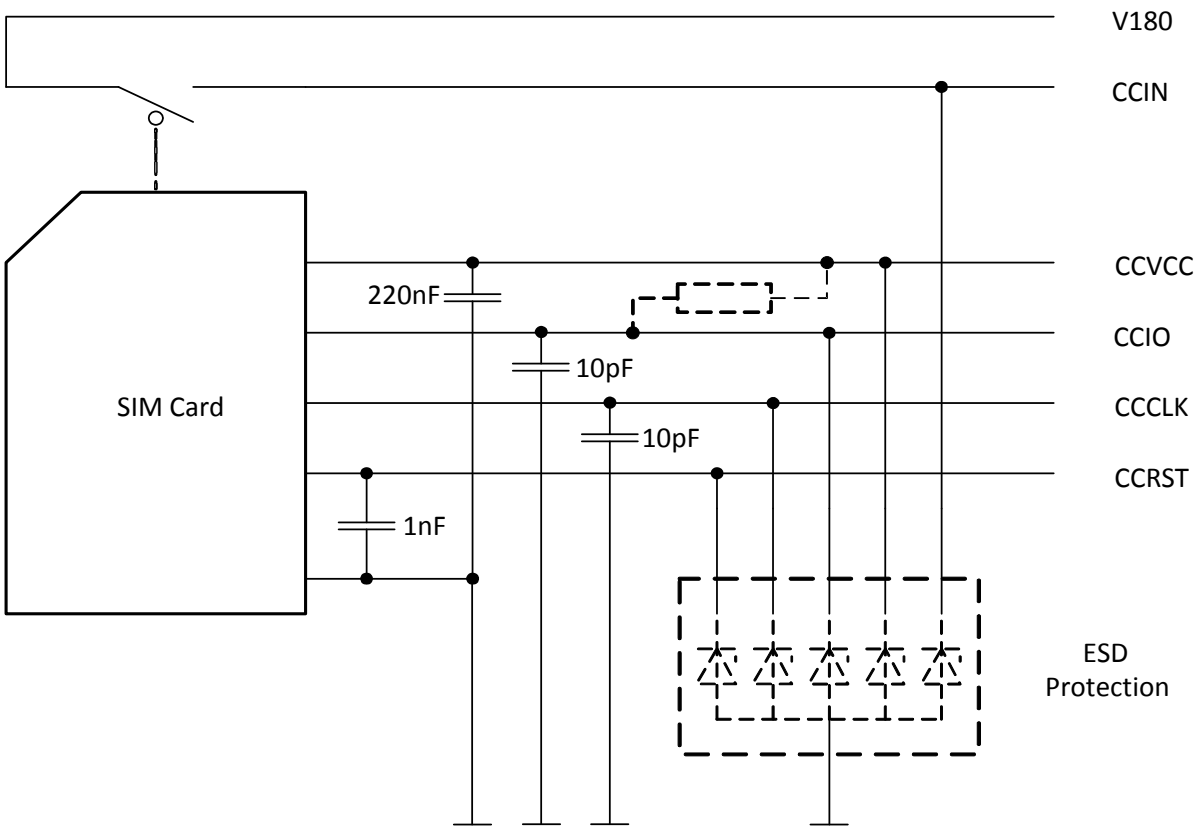

Figure 5: SIM interface - enhanced ESD protection

Reference:

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

3.3.9 Second SIM interface

EMS31 supports a second SIM interface – External SIM or embedded SIM.

Only one SIM can be operated at given time. Please note that the 2nd SIM interface is currently only hardware prepared.

3.3.10 USB Interface

BGS5 supports a full speed USB 2.0 interface, whereas EHSx and ELS61/ELS81 support a high speed 2.0 USB interface. For high speed operation, special attention should be given to USB data line routing. The external application layout should in this case implement a differential impedance of 90Ω for proper signal integrity.

The pads used as USB pads with BGS5, EHS5, ELS31 are connected to GND with BGS1 or BGS2. 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 either release of BGS1 or BGS2 is mounted, the 0Ω resistors are not equipped. Vice versa, if BGS5, EHS5, ELS31 are mounted, these resistors should be implemented.

Also, in a combined PCB layout with BGS5/EHS5/ELS31 and EHS6/EHS8/ELS61/ELS81, i.e., with pad count LGA106/114 and LGA120, is it necessary to place 0Ω serial resistors at the USB_DN and USB_DP lines to avoid the stubs in the EHS5 design by not mounting the 0Ω resistors.

Table 15: USB interface

USB interface	BGS1	BGS2	BGS5	EHS5, EHS6, EHS8	ELS61, ELS81	ELS31	EMS31	ENS22
USB	Not supported	Not supported	Supported	Supported	Supported	Supported	Not supported	Not supported

An external ESD protection should be provided for the BGS5, EHSx and ELS61/ELS81 USB interfaces.

Reference:

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

3.3.11 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. Same condition applies to BGS1. **Note:** ENS22 is an exception, because VDIG/VCORE is not supported, and the voltage level at the ASC0 lines is fixed at 3.0V.

An external application may not require and employ the ASC0 interface, however, it is highly recommended that test points are provided at all ASC0 (UART) pads for easier debugging when necessary.

The following tables show ASC0 interface differences between the modules.

Table 16: ASC0 transfer rates

ASC0 interface	BGS1	BGS2	BGS5	EHS5, EHS6, EHS8	ELS61, ELS81	ELS31	EMS31	ENS22
UART lines	8 lines	8 lines	8 lines	8 lines	8 lines	8 lines	8 lines	8 lines
Baud rate range	1200…230400	300…230400	1200…921600	1200…921600	1200…921600 (Rel.1: up to 3Mbit)	4800…921600	1200…3686400	1200…921600
Autobauding Range	Yes 1200…230400	Yes 1200…230400	Yes 1200…230400	Yes 1200…230400	Yes 1200…230400	No --	No --	No --
RTS0 wake-up	Supported	Supported	Supported	Supported	Supported	Supported	Supported[20]	Supported

Table 17: ASC0 start-up/reset signal states[21]

ASC0 lines	BGS1	BGS2	BGS5	EHS5, EHS6, EHS8	ELS61	ELS31	EMS31	ENS22
RXD0	T / 60K PU	T / PU -204µA at 0V	T / PU -220µA at 0V	T / PU -240µA at 0V	T / PU -240µA at 0V	I / PU	I / PU -36µA at 0V	TBD.
TXD0	T / 60K PU	T / PU -204µA at 0V	T / PD +150µA at 1.85V	T / PD +200µA at 1.9V	T / PD +200µA at 1.9V	I	I / PU -36µA at 0V	TBD.

[20] Please note that with EMS31, RTS0 will not wake up the module in SUSPEND mode (i.e. in a specific deep sleep mode). Instead ON signal should be used.
[21] T = Tristate; PU = Pull-up; PD = Pull-down

ASC0 lines	BGS1	BGS2	BGS5	EHS5, EHS6, EHS8	ELS61	ELS31	EMS31	ENS22
CTS0	T / 60K PD	T / PD +51µA at 1.75V	T / PD +43µA at 1.85V	T / PU -240µA at 0V	T / PU -240µA at 0V	I	I / PU -36µA at 0V	TBD.
RTS0	T / 60K PU	T / 10k PU	T / PU -55µA at 0V	T / PU -240µA at 0V	T / PU -240µA at 0V	I	I / PD +18µA at 1.8V	TBD.
DTR0	T / 60K PU	Rel1 T / PD +103µA at 1.75V Rel1 T / PU -102µA at 0V	T / PD +83µA at 1.85V	T / PD +200µA at 1.9V	T / PD +200µA at 1.9V	T / PD	I / PU -18µA at 0V	TBD.
DCD0	T / 60K PU	T / PU -102µA at 0.05V	T / PD +43µA at 1.85V	T / PD +200µA at 1.9V	T / PD +200µA at 1.9V	T / PD	I <+1µA at 1.8V	TBD.
DSR0	T / 60K PU	Rel1 T / PD +27µA at 1.75V Rel2 T / PU -102µA at 0.05V	T / PU -105µA at 0V	T / PD +200µA at 1.9V	T / PD +200µA at 1.9V	T / PD	I <+1µA at 1.8V	TBD.
RING0	T / 70K PU	T / 10k PU	T / PU -200µA at 0V	T / PD +200µA at 1.9V	T / PD +200µA at 1.9V	T / PD	I <+1µA at 1.8V	TBD.

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

3.3.12 ASC1 Interface

With BGS1 or BGS2, autobauding is not supported over the ASC1 interface. With ELS31, ASC1 is not supported as AT command interface, but only as data interface. The following tables show ASC1 interface differences between the modules.

Table 18: ASC1 transfer rates

ASC1 interface	BGS1	BGS2	BGS5	EHS5, EHS6, EHS8	ELS61, ELS81	ELS31	EMS31	ENS22
UART lines	4 lines	4 lines	4 lines	4 lines	4 lines	4 lines	4 lines	4 lines
Baud rate range	1200…230400	300…230400	1200…921600	1200…921600	1200…921600	4800…921600	1200…3686400	1200…921600
Autobauding Range	No ---	No ---	Yes 1200…230400	Yes 1200…230400	Yes 1200…230400	No --	No --	No --
RTS1 wake-up	Not supported	Not supported	Not supported	Not supported	Not supported	Supported	Supported[22]	Not supported

Table 19: ASC1 start-up/reset signal states

ASC1 lines	BGS1	BGS2	BGS5	EHS5, EHS6, EHS8	ELS61, ELS81	ELS31	EMS31	ENS22
RXD1	T / 60K PU	T / PD +51µA at 1.75V	T / PD +43µA at 1.85V	T / PU -240µA at 0V	T / PU -240µA at 0V	TBD.	I / PU -36µA at 0V	TBD.
TXD1	T / 60K PU	T / PD +51µA at 1.75V	T / PD +43µA at 1.85V	T / PD +200µA at 1.9V	T / PD +200µA at 1.9V	TBD.	I / PU -36µA at 0V	TBD.
CTS1	T / 60K PD	T / PD +51µA at 1.75V	T / PD +43µA at 1.85V	T / PD +200µA at 1.9V	T / PU -240µA at 0V	TBD.	I / PU -36µA at 0V	TBD.
RTS1	T / 60K PU	T / PU -102µA at 0V	T / PU -55µA at 0V	T / PD +200µA at 1.9V	T / PU -240µA at 0V	TBD.	I / PU -18µA at 0V	TBD.

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

[22] Please note that with EMS31, RTS1 will not wake up the module in SUSPEND mode (i.e. in a specific deep sleep mode). Instead ON signal should be used.

3.3.13 I²C Interface

With BGS1, BGS2, and ENS22 the I²C interface lines are shared with GPIO lines and may also be configured as GPIO9 and GPIO10. BGS5, EHSx, ELSx, and EMS31 have dedicated I²C interface lines[23]. For compatibility reason and migration purposes, the GPIO functionality on GPIO9 and GPIO10 should therefore not be used with BGS1, BGS2 or ENS22 modules.

The I2CDAT and I2CCLK lines have to connect via pull-up resistors to a positive supply voltage, for example from the module: V180 (EHSx and ELSx), VDIG (BGS1, BGS2) or V300 (ENS22).

With ENS22 the I²C interface lines need to be connected to external pull-up resistors. The range of allowed values for the pull-up resistors depends on the IO voltage used and the total bus capacitance. A value towards the high end of the range is recommended in order to minimize power consumption.

Table 20: I²C pull-up values (internal or external)

	BGS1	BGS2	BGS5	EHS5, EHS6, EHS8	ELS61, ELS81	ELS31	EMS31	ENS22
Internal pull-up I2CCLK	Yes	Yes	Yes	Yes	Yes	Yes	TBD	Yes
Internal pull-up I2CDAT	Yes	---	Yes	Yes	Yes	Yes	TBD	Yes
R1 (typical)	4.7kΩ	2.2kΩ	2.2kΩ	2.2kΩ	2.2kΩ	2.2kΩ	TBD	2.2kΩ
R2 (typical)	4.7kΩ	2.2kΩ	2.2kΩ	2.2kΩ	2.2kΩ	2.2kΩ	TBD	2.2kΩ
R1min	TBD.	>560Ω	>560Ω	>560Ω	>560Ω	>390Ω	TBD	TBD.
R2min	TBD.	>510Ω	>560Ω	>560Ω	>560Ω	>390Ω	TBD	TBD.

[23] Note that the I²C interface is not supported with EHS5 Release 1.

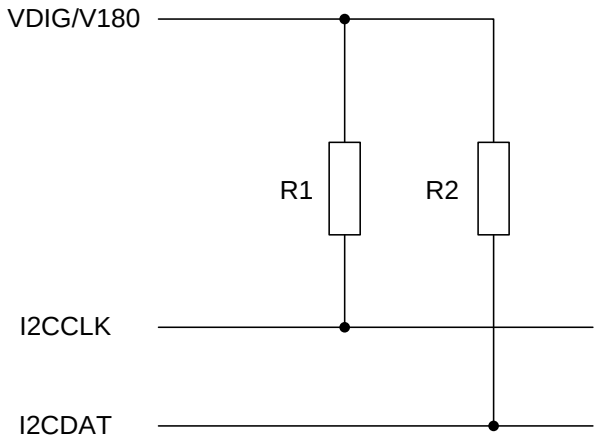

Figure 6: I2C pull-up resistors on external application

Table 21: I²C start-up/reset signal states

I²C interface lines	BGS1	BGS2	BGS5	EHS5, EHS6, EHS8	ELS61, ELS81	ELS31	EMS31	ENS22
I2CCLK	T / 60K PD	T / 5k PU	T	T	T / PU	T / PD	I / PU	TBD.
I2CDAT	T / 60K PD O/L (reset)	T	T	T	T / PU	T / PD	I / PU	TBD.

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

3.3.14 SPI Interface

BGS5, EHSx, ELSx, and ENS22 support a Serial Peripheral Interface (SPI)[24]. The SPI lines are shared with GPIO and serial interface lines, the configuration is done by AT command. ELS31 has dedicated SPI lines, but these are shared with the internal Flash memory - hence the SPI data throughput might be reduced in cases of heavy internal flash read/write processes.

Table 22: SPI interface

	BGS1	BGS2	BGS5	EHS5 EHS6, EHS8	ELS61, ELS81	ELS31	EMS31	ENS22
SPI interface - Mode	Not supported	Not supported	Supported Master	Supported Master	Supported Master	Supported Master	Supported Master	Supported Master
CS signal	--	--	1	1	1	2	2	1
Speed	--	--	< 6.5Mbit/s	< 6.5Mbit/s	< 6.5Mbit/s	< 6.5Mbit/s	< 13Mbit/s	< 800Kbit/s
Sharing	--	--	GPIO16,17,18,19	GPIO3,16,17,19	GPIO3,16,17,19	Internal Flash	GPIO 26,27	GPIO16,17,18,19

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

3.3.15 HSIC Interface

EHS6, EHS8 support a High Speed Inter-Chip (HSIC) interface.

For more information on the HSIC interface please refer to the “Hardware Interface Description”.

[24] Please note that the SPI interface is not supported with EHS5 Release 1.

3.3.16 Audio Interface

Table 23: Audio interfaces overview

BGS1	BGS2	BGS5	EHS5, EHS6, EHS8	ELS61, ELS81	ELS31	EMS31	ENS22
Analog	Analog / Digital	Digital	Analog (EHS6-A only) / Digital	Digital (ELS61-E R2 and ELS61-USA only) with VoLTE and fall back 2G	Not supported	Not supported	Not supported

3.3.17 Digital Audio Interface

BGS1, EMS31, and ENS22 do not provide a digital audio interface. With BGS2, BGS5 and EHSx, 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) and/or Inter-IC sound (I^2S) interface. Characteristics are listed in the table below.

Table 24: PCM characteristics

Characteristics	BGS1, ENS22	BGS2	BGS5	EHS5, EHS6, EHS8	ELS61, ELS81[25]	ELS31	EMS31
Digital Audio mode	Not supported	PCM master mode, 256kHz clock, long frame	PCM master mode, 256kHz clock, long frame	PCM master mode, 256kHz clock, long frame EHS6: I^2S mode (Rel.3 update)	ELS61-E Rel.2, ELS61-USA: PCM/I^2S master/slave mode, long/short frame 8 kHz sampling rate: 264 kHz (PCM short frame), 256 kHz and 520 kHz bit clock 16 kHz sampling rate: 528 kHz (PCM short frame), 512 kHz and 1040 kHz bit clock	ELS31-VA: PCM/I^2S slave mode, long/short frame 8 kHz sampling rate: 264, 256, 512, 1024, 2048, 4096 kHz bit clock 16 kHz sampling rate: 256, 512, 1024, 2048, 4096 kHz bit clock	Not supported

[25] Only ELS61-E R2 and ELS61-USA are supported.

The DAI start-up behavior differs slightly between the module variants as shown in the table below.

Table 25: DAI start-up/reset signal states

DAI interface lines	BGS1, ENS22	BGS2	BGS5	EHS5, EHS6, EHS8	ELS61, ELS81[25]	ELS31	EMS31
RXDDAI	Not supported	T / PD +51µA at 1.75V	T / PD +150µA at 1.8V	T / PD +200µA at 1.9V	T / PD (GPIO) +200µA at 1.9V	I	I / PU
TXDDAI		T / PD +51µA at 1.75V	T / PD +150µA at 1.8V	T / PD +200µA at 1.9V	T / PD (GPIO) +200µA at 1.9V	I	I / PU
TFSDAI (FSYNC0)		T / PD +51µA at 1.75V	T / PD +150µA at 1.8V	T / PD +200µA at 1.9V	T / PD (GPIO) +200µA at 1.9V	I	I / PU
SCLK (SCLK0)		T / PU -55µA at 0V	T / PD +150µA at 1.8V	T / PD +200µA at 1.9V	T / PD (GPIO) +200µA at 1.9V	I	I / PU

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

Only BGS1, BGS2 and EHS6-A support an analogue audio interface. With BGS5 an analogue audio interface is hardware prepared for future use.

Table 26: Analogue audio interface

Analogue interface	BGS1	BGS2	EHS6-A	BGS5, EHS5, EHS6, EHS8, ELS31, ELS61, ELS81, EMS31, ENS22
Analogue Audio Interface	Supported	Supported	Supported	Not supported
VMIC	2.3V max 1 mA	1.8V … 2.2V, max 4mA	2.7V±5.5% max 3mA	--
MICP1	$Z_I$typ = 20kΩ	Ri = 50kOhm Vin max 0.8Vpp	Rip = 94kOhm with 0dB gain Rin = 5.6kOhm with 30dB gain Vin max = 0.7V	--
MICN1	Ri = 20kOhm Vin max 6Vpp			
AGND	AGND	AGND	AGND	--
EPP1	4.5Vpp at 32Ω load	3.2Vpp on 16Ohm load	Max. 5Vpp at 16Ohm load	--
EPN1				

3.3.19 GPIO Interface

Table 27: GPIO lines[26, 27]

GPIOs	BGS1	BGS2	BGS5	EHS5	EHS6, EHS8	ELS61, ELS81	ELS31	EMS31	ENS22
GPIO1	-- / DTR0 (rel.2)	-- / DTR0	GPIO1 / DTR0	GPIO1 / DTR0	GPIO1 / DTR0	GPIO1 / DTR0	GPIO1 / DTR0	GPIO1 / DTR0	GPIO1 / DTR0
GPIO2	-- / DCD0 (rel.2)	-- / DCD0	GPIO2 / DCD0	GPIO2 / DCD0	GPIO2 / DCD0	GPIO2 / DCD0	GPIO2 / DCD0	GPIO2 / DCD0	GPIO2 / DCD0
GPIO3	-- / DSR0 (rel.2)	-- / DSR0	GPIO3 / DSR0	GPIO3 / DSR0 / SPI_CLK	GPIO3 / DSR0 / SPI_CLK	GPIO3 / DSR0 / SPI_CLK	GPIO3 / DSR0	GPIO3 / DSR0	GPIO3 / DSR0
GPIO4	-- / FAST_SHDN (rel.2)	-- / FAST_SHDN	GPIO4 / FST_SHDN	GPIO4 / FST_SHDN	GPIO4 / FST_SHDN	GPIO4 / FST_SHDN	GPIO4 / FST_SHDN	GPIO4 / FST_SHDN	GPIO4 / SHTDWN
GPIO5	GPIO5 / LED	GPIO5 / LED	GPIO5 / LED	GPIO5 / LED	GPIO5 / LED	GPIO5 / LED	GPO5 / LED	GPIO5 / LED	GPIO5
GPIO6	GPIO6 / PWM2	GPIO6 / PWM2	GPIO6 / PWM2	GPIO6 / PWM2	GPIO6 / PWM2	GPIO6 / PWM2	GPIO6	GPIO6 / PWM2	--
GPIO7	--	GPIO7 / PWM1	GPIO7 / PWM1	GPIO7 / PWM1	GPIO7 / PWM1	GPIO7 / PWM1	GPIO7	GPIO7 / PWM1	--
GPIO8	GPIO8 (rel.2)	GPIO8	GPIO8 / COUNTER	GPIO8 / COUNTER	GPIO8 / COUNTER	GPIO8 / COUNTER	GPIO8 / COUNTER	GPIO8 / COUNTER	GPIO8
GPIO9	GPIO9 / I2CDAT(rel.1) GPIO9 / I2CCLK(rel.2)	GPIO9 / I2CCLK	-- / I2CCLK	-- / I2CCLK	-- / I2CCLK	-- / I2CCLK	-- / I2CCLK	-- / I2CCLK	GPIO9 / I2CCLK
GPIO10	GPIO10 / I2CCLK (rel.1) GPIO10 / I2CDAT (rel.2)	GPIO10 / I2CDAT	-- / I2CDAT	-- / I2CDAT	-- / I2CDAT	-- / I2CDAT	-- / I2CDAT	-- / I2CDAT	GPIO10 / I2CDAT

[26] Please note that the GPIO interface is not supported with EHS5 Release 1.
[27] -- = Indicates that the GPIO function is not available, possible alternative functionality is given after a slash.

GPIOs	BGS1	BGS2	BGS5	EHS5	EHS6, EHS8	ELS61, ELS81	ELS31	EMS31	ENS22
GPIO11	--	--	--	--	GPIO11	GPIO11	--	--	--
GPIO12	--	--	--	--	GPIO12	GPIO12	--	--	--
GPIO13	--	--	--	--	GPIO13	GPIO13	--	--	--
GPIO14	--	--	--	--	GPIO14	GPIO14	--	--	--
GPIO15	--	--	--	--	GPIO15	GPIO15	--	--	--
GPIO16	--	--	GPIO16 / RXD1 / MOSI	GPIO16 / RXD1 / MOSI	GPIO16 / AP_WAKEUP / RXD1 / MOSI	GPIO16 / RXD1 / MOSI	GPIO16 / RXD1	GPIO16 / RXD1	GPIO16 / RXD1 / MOSI
GPIO17	--	--	GPIO17 / TXD1 / MISO	GPIO17 / TXD1 / MISO	GPIO17 / HOST_ACTIVE / TXD1 / MISO	GPIO17 / TXD1 / MISO	GPIO17 / TXD1	GPIO17 / TXD1	GPIO17 / TXD1 / MISO
GPIO18	--	--	GPIO18 / RTS1 / SPI_CLK	GPIO18 / RTS1	GPIO18 / CP_WAKEUP / RTS1	GPIO18 / RTS1	GPIO18 / RTS1	GPIO18 / RTS1	GPIO18 / RTS1 / SPI_CLK
GPIO19	--	--	GPIO19 / CTS1 / SPI_CS	GPIO19 / CTS1 / SPI_CS	GPIO19 / CTS1 / SPI_CS	GPIO19 / CTS1 / SPI_CS	GPIO19 / CTS1	GPIO19 / CTS1	GPIO19 / CTS1 / SPI_CS
GPIO20	--	--	GPIO20 / TXDDAI	GPIO20 / TXDDAI	GPIO20 / TXDDAI	GPIO20 / TXDDAI	GPIO20 / TXDDAI	GPIO20	--
GPIO21	--	--	GPIO21 / RXDDAI	GPIO21 / RXDDAI	GPIO21 / RXDDAI	GPIO21 / RXDDAI	GPIO21 / RXDDAI	GPIO21	--
GPIO22	--	--	GPIO22 / TFSDAI	GPIO22 / TFSDAI	GPIO22 / TFSDAI	GPIO22 / TFSDAI	GPIO22 / TFSDAI	GPIO22	--
GPIO23	--	--	GPIO23 / SCLK	GPIO23 / SCLK	GPIO23 / SCLK	GPIO23 / SCLK	GPO23 / SCLK	GPIO23	--
GPIO24	--	--	GPIO24 / RING0	GPIO24 / RING0	GPIO24 / RING0	GPIO24 / RING0	GPIO24 / RING0	GPIO24 / RING0	GPIO24 / RING0
GPIO25	--	--	--	--	--	--	GPIO25	GPIO25	--
GPIO26	--	--	--	--	--	--	GPO26 / SPI_CS1	GPO26 / SPI_CS1	--
GPIO27	--	--	--	--	--	--	GPIO27 / SPI_CS2	GPIO27 / SPI_CS2	--

Notes:

- With ELS31 the DAI interface is only hardware prepared, i.e., with the current firmware releases not useable as such. This means that for the time being GPIO20-23 cannot be configured as DAI signals in the same way as EHS6 or EHS8. ELS31-VA supports DAI interface.
- With ELS61 and ELS81 the HSIC interface is only hardware prepared, i.e., with the current firmware releases not useable as such. This means that for the time being GPIO16-18 cannot be configured as HSIC control signals in the same way as for EHS6 or EHS8. Also, the GPIO20-23 lines can be configured as DAI interface only for ELS61-E R2 and ELS61-USA.

Table 28: GPIO start-up/reset signal states

GPIO lines	BGS1	BGS2	BGS5	EHS5	EHS6, EHS8	ELS61, ELS81	ELS31	EMS31	ENS22
GPIO1	T / 60k PU (rel.1)	(DTR0)	T / PD	T / PD	T / PD	T / PD	T	I / PU	TBD.
GPIO2	T / 60k PU (rel.1)	(DCD0)	T / PD	T / PD	T / PD	T / PD	T	I	TBD.
GPIO3	T / 60k PU (rel.1)	(DSR0)	T / PU	T / PD	T / PD	T / PD	T	I	TBD.
GPIO4	T / 60k PU (rel.1) T/10K PU (FST_SHDN)	(FST_SHDN)	T / PD	T / PD	T / PD	T / PD	T / PD	I	TBD.
GPIO5	T / 60K PU	T / PU -102µA at 0V	T / PD	T / PD	T / PD	T / PD	T / PD (GPO5)	I	TBD.
GPIO6	T / 60K PU	T / PU -55µA at 0V	T / PD	T / PD	T / PD	L	T	I / PU	--
GPIO7	T / 60K PD (rel.1) T / 60K PU (rel.2)	T / PU -55µA at 0V	T / PU	T / PD	T / PD	T / PD	T / PU	I / PU	--
GPIO8	T / 60K PU	T / PU -55µA at 0V	T / PU	T / PD	T / PD	T / PD	T	I	TBD.
GPIO9	T / 60k PD	T / 5k PU	T / PD	T / PD	T / PD	T / PD	T / PD	--	TBD.

GPIO10	I / 60k PD	T	T / PD	T / PD	T / PD	T / PD	T / PD	--	TBD.
GPIO11	--	--	--	--	T / PD	T / PD	--	--	--
GPIO12	--	--	--	--	T / PD	T / PD	--	--	--
GPIO13	--	--	--	--	T / PD	T / PD	--	--	--
GPIO14	--	--	--	--	T / PD	T / PD	--	--	--
GPIO15	--	--	--	--	T / PD	T / PD	--	--	TBD.
GPIO16	--	--	T / PD	T / PD	T / PD	T / PU	T	I / PU	TBD.
GPIO17	--	--	T / PD	T / PD	T / PD	T / PD	T / PU	I / PU	TBD.
GPIO18	--	--	T / PU	T / PD	T / PD	T / PU	T / PU	I / PU	TBD.
GPIO19	--	--	T / PD	T / PD	T / PD	T / PU	T / PU	I / PU	TBD.
GPIO20	--	--	T / PD	T / PD	T / PD	T / PD	T	I / PU	--
GPIO21	--	--	T / PD	T / PD	T / PD	T / PD	T	I / PU	--
GPIO22	--	--	T / PD	T / PD	T / PD	T / PD	T	I / PU	--
GPIO23	--	--	T / PD	T / PD	T / PD	T / PD	T (GPO23)	I / PU	--
GPIO24	--	--	T / PU	T / PD	T / PD	T / PD	T	I	TBD.
GPIO25	--	--	--	--	--	--	T / PD	I	--
GPIO26	--	--	--	--	--	--	T (GPO26)	I / PU	--
GPIO27	--	--	--	--	--	--	T	I / PU	--

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

3.3.20 ADC1

Table 29: ADC1 characteristics

ADC1[28]	BGS1	BGS2	BGS5	EHS5, EHS6, EHS8	ELS61, ELS81	ELS31	EMS31	ENS22
Resolution	10 Bit	10 Bit	10 Bit	10 Bit	10 Bit	10 Bit	10 Bit	Not supported
R_I	1MOhm	1MOhm	1MOhm	1MOhm	1MOhm	10kΩ	10kΩ	
Valid range	0V … 1.2V	0V … 1.2V	0V … 1.14V	0V … 1.2V	0V … 1.2V	0V … 2.0V	0V … 2.0V	
V_{IH}max	3.0V	3.3V	1.14V	1.2V	1.2V	2V	TBD.	

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

[28] Please note that the ADC1 signal is not supported with EHS5 Release 1.

3.3.21 Fast Shutdown

BGS1, BGS2, BGS5, EHSx, ELSx, and EMS31 support a FST_SHDN signal[29]. If enabled by AT command, 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.

Note: With ELS61 and ELS81, a shutdown triggered by AT^SMSO can be configured by AT command either as a normal or as a fast shutdown. With BGS1, BGS2, BGS5, EHSx, ELS31, and EMS31 no such configuration is available. If fast shutdown is enabled by AT command, the AT^SMSO command triggers a fast shutdown, i.e., a shutdown without network deregistration. However, in this case no URCs including shutdown URCs will be provided by the AT^SMSO command.

Table 30: FST_SHDN characteristics

FST_SHDN	BGS1	BGS2	BGS5	EHS5, EHS6, EHS8	ELS61, ELS81	ELS31	EMS31	ENS22
V_{IH}max	1.9V	1.9V	1.85V	1.85V	1.85V	1.8V	1.8V	Not supported
V_{IH}min	1.30V	1.35V	1.3V	1.3V	1.3V	1.17V	1.17V	
V_{IL}max	0.34V I_{IH}min < -200µA at V_{IH}min	0.34V I_{IH}min < -200µA at V_{IH}min	0.35V I_{IH}min < -105µA at V_{IH}min	0.35V I_{IH}min < -200µA at V_{IH}min	0.35V I_{IH}min < -200µA at V_{IH}min	0.63V	0.63V	
Shutdown time	95ms	50ms	15ms	120ms	15ms	200ms	15ms	
FST_SHDN charges	33mAs	11mAs	8.5mAs	12mAs	13mAs	162mAs	11mAs	

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

[29] Please note that the fast shutdown signal is not supported with EHS5 Release 1.

3.4 Antenna Interface

3.4.1 RF Antenna

The BGS5, EHSx, ELSx, and EMS31 antenna interfaces have no internal ESD protection implemented. It is recommended to add an external ESD protection, an example is given in Figure 7. The additional components should be placed as close as possible to the antenna pad.

The BGS1, BGS2 and ENS22 antenna interface has 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 modules (see Figure 8). The placement options may then later be activated if required.

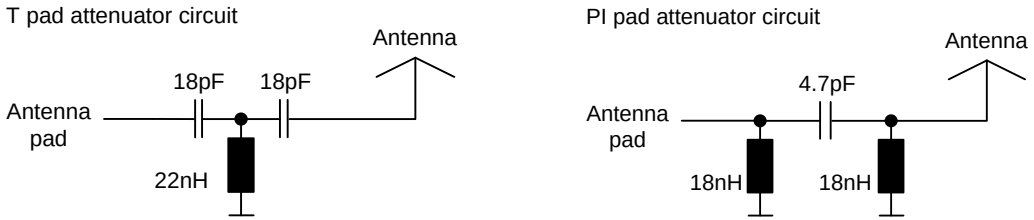

Figure 7: Possible BGS5, EHSx, ELSx, and EMS31 ESD protection circuits - T or PI pad

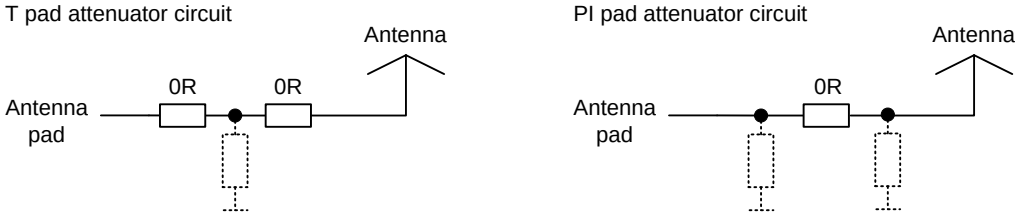

Figure 8: Possible designated ESD protection circuit - T or PI pad

Table 31: ESD protection on external application

RF antenna	BGS1	BGS2	BGS5	EHS5, EHS6, EHS8	ELS61, ELS81	ELS31	EMS31	ENS22
Internal ESD protection	Supported	Supported	Not supported	Not supported	Not supported	Not supported	Not supported	Supported
Inductors: 22nH (T pad) or 18nH (PI pad)	Not placed	Not placed	Yes	Yes	Yes	Yes	Yes	Not placed
Capacitors: 18pF (T pad) or 4.7pF (PI pad)	0 Ohm	0 Ohm	Yes	Yes	Yes	Yes	Yes	0 Ohm

Possible inductors: Murata LQG15HS22NJ02D (22nH), and LQW15AN18NJ00 (18nH)

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

3.4.2 GPS Antenna

EHS8 has a GPS receiver implemented. The GPS antenna installation is the same as for the RF antenna interface, except for pad 224 instead of pad 59, and described in the EHS8 “Hardware Interface Description”.

Table 32: GPS antenna

	BGS1, BGS2, BGS5, EHS5, EHS6, ELS61, ELS81, ELS31, EMS31, ENS22	EHS8
GPS	Not supported	Supported

An external active GPS antenna can be supplied via a dedicated ANT_GPS_PWR pad.

For more information on GPS please refer to the EHS8 “Hardware Interface Description”.

3.4.3 Rx Diversity Antenna

ELS31, ELS61 and ELS81 support an Rx diversity antenna at pad 56. The Rx diversity antenna is a receiving antenna, and as such does not transmit any RF output power.

Table 33: Rx diversity antenna

	BGS1, BGS2, BGS5, EHS5, EHS6, EHS8, EMS31, ENS22	**ELS31, ELS61, ELS81**
Rx diversity	Not supported	Supported

Note: For approval reasons it is mandatory to connect/use this Rx diversity antenna to an existing antenna. Not connecting/using the Rx diversity antenna does not necessarily impact the performance, but may result in approval failures.

For more information on Rx diversity please refer to the respective “Hardware Interface Description”.

4 Common Footprint Design

To support a possible common footprint design, this chapter assembles the pad layout and assignment for all Gemalto M2M modules mentioned in this document – BGS1, BGS2, BGS5, ENS22, EHS5, EHS6, EHS8, ELS31, EMS31, ELS61, and ELS81, thereby showing the differences between the modules. 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.

Figure 9 illustrates a common footprint for the below mentioned various pad layouts:

Module	Dimensions	Pad count	LGA number
BGS1, BGS2, EHS5, ENS22	27.6 x 18.8	106	LGA106
BGS5, ELS31, EMS31		114	LGA114
EHS6, EHS8, ELS61, ELS81	27.6 x 25.4	120	LGA120

Because of the different module dimensions and pad layouts some pads in the given common footprint are not available for all modules:

- Pads lined black are available for all modules.
- Pads lined red are available for BGS1, BGS2, BGS5, ENS22, EHS5, ELS31, and EMS31 only
- Pads lined orange are available for BGS5, EHS6, EHS8, ELS31, ELS61, ELS81, and EMS31 only
- Pads lined grey are available for EHS6, EHS8, ELS61, and ELS81 only

Table 34 lists the pad assignments for all modules, and differentiates between products with a pad count of 106 (LGA106), 114 (LGA114) and 120 (LGA120). Pads having the same functionality assigned with all modules are listed in grey. Pads varying in functionality between modules are listed in black.

With regard to pad assignment a few notes should be considered for a common footprint design:

- Pads labeled “--*”, i.e., do not use, must be left un-connected at the external application, but should be soldered.
- Pads labeled “nc”, i.e., not connected, indicate that a pad is not electrically connected on the module. For a common footprint this means that only a possible other functionality with a different module may be implemented for this pad, without having to take a transition from one pad assignment to another into account.
- BGS1 and BGS2 pads VDIG and V180 shall be connected in all cases. See also Section 3.3.5 for more detail.
- To activate or deactivate module specific functions for smooth transition, the appropriate pads should be connected via 0 Ohm resistors or assembling options. For example, the VUSB assignment at pad 44 is listed in black, indicating a pad that should be connected via 0 Ohm resistors to easily activate or deactivate the pad’s USB functionality for the appropriate module. The pad’s other “--*” (do not use) 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 “--*” functionality may also be left unconnected.
- Pads available for BGS2, BGS5, ENS22, EHS5, ELS31, and EMS31 only, and pads available for EHS6, EHS8, ELS61 and ELS81 only should be connected where possible, i.e., as far as these pads are assigned to the same signals.
- Pad assignments given in brackets are software configurable after module startup.

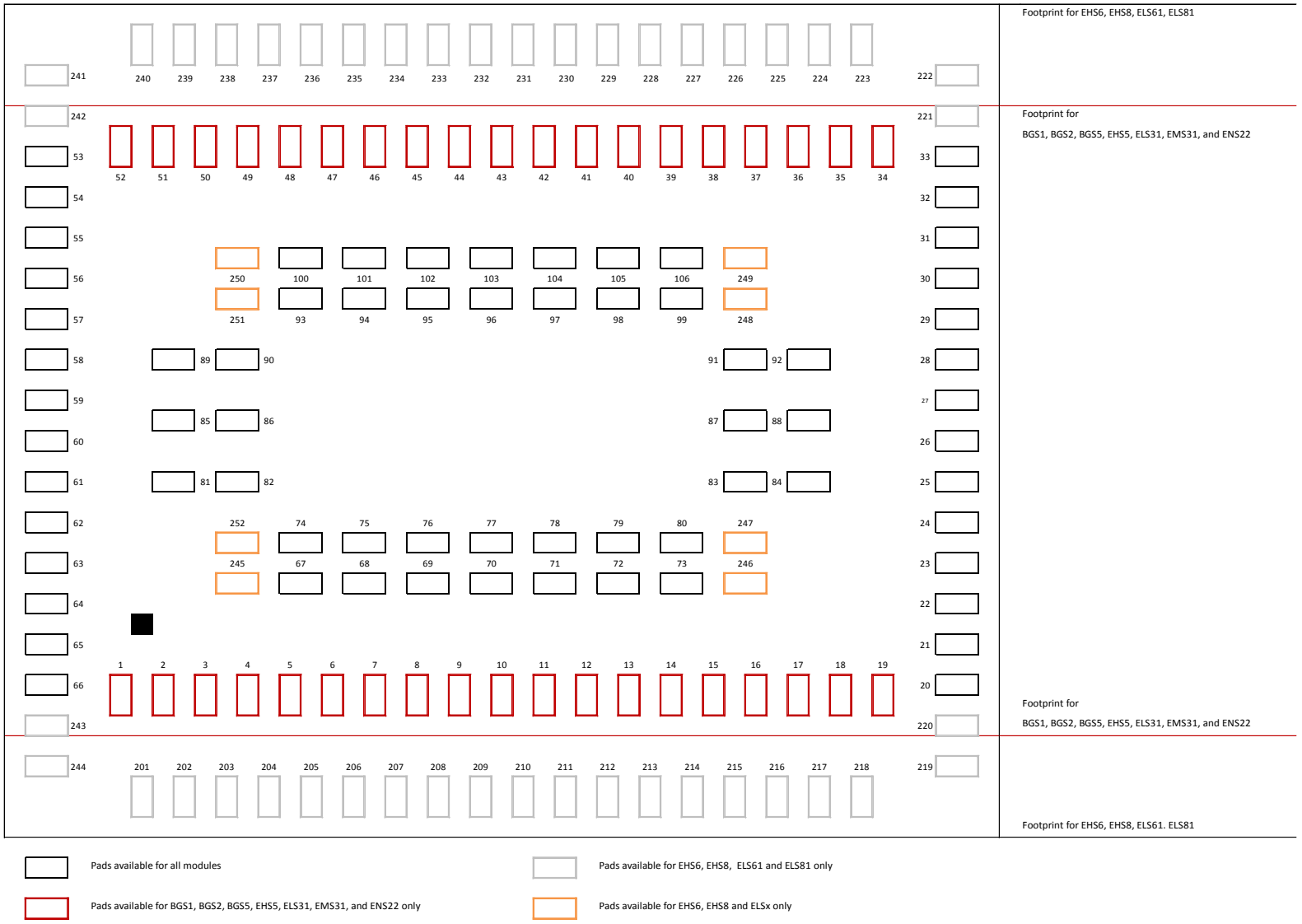

Figure 9: Common footprint for BGSx, EHSx, ELSx, EMS31, and ENS22 (bottom view)

Table 34: Pad assignments for BGS1, BGS2, EHS5x, ELSx, EMS31, and ENS22

Pad # LGA106	BGS1 LGA106	BGS2 LGA106	EHS5 LGA106	ENS22 LGA106	Pad # LGA114	BGS5 LGA114	ELS31 LGA114	EMS31 LGA114	Pad # LGA120	EHS6 LGA120	EHS6-A LGA120	EHS8 LGA120	ELS61, ELS81 LGA120
	Outer pads												
1	VMIC	VMIC	--*	nc	1	VMIC[30]	GND	GND	---				
2	EPN	EPN	--*	nc	2	EPN[30]	GND	GND	201	--*	EPN	--*	nc
3	EPP	EPP	--*	nc	3	EPP[30]	GND	GND	202	--*	EPP	--*	nc
4	GND	GND	GND	GND	4	GND	GND	GND	203	GND	GND	GND	GND
5	$BATT+_{BB}$	$BATT+_{BB}$	$BATT+_{BB}$	$BATT+_{BB}$	5	BATT+	BATT_RF	BATT+	204	$BATT+_{BB}$	$BATT+_{BB}$	$BATT+_{BB}$	$BATT+_{BB}$
6	GND	GND	GND	GND	6	GND	GND	GND	205	GND	GND	GND	GND
7	ADC1	ADC1_IN	ADC1	nc	7	ADC1	ADC1	ADC1	206	ADC1	ADC1	ADC1	ADC1
8	ON	ON	ON	ON	8	ON	ON	ON	207	ON	ON	ON	ON
9	GND	GND	GND	GND	9	GND	GND	GND	208	GND	GND	GND	GND
10	VDIG	VDIG	V180	V300	10	V180	V180	V180	209	V180	V180	V180	V180
11	RXD0	RXD0	RXD0	RXD0	11	RXD0	RXD0	RXD0	210	RXD0	RXD0	RXD0	RXD0
12	CTS0	CTS0	CTS0	CTS0	12	CTS0	CTS0	CTS0	211	CTS0	CTS0	CTS0	CTS0
13	TXD0	TXD0	TXD0	TXD0	13	TXD0	TXD0	TXD0	212	TXD0	TXD0	TXD0	TXD0
14	RING0	RING0	GPIO24 (RING0)	GPIO24 (RING0)	14	GPIO24 (RING0)	GPIO24 (RING0)	GPIO24 (RING0)	213	GPIO24 (RING0)	GPIO24 (RING0)	GPIO24 (RING0)	GPIO24 (RING0)
15	RTS0	RTS0	RTS0	RTS0	15	RTS0	RTS0	RTS0	214	RTS0	RTS0	RTS0	RTS0
16	VDDLP	VDDLP	VDDLP	nc	16	VDDLP	nc	nc	215	VDDLP	VDDLP	VDDLP	VDDLP
17	CCRST	CCRST	CCRST	CCRST	17	CCRST	CCRST	CCRST	216	CCRST	CCRST	CCRST	CCRST
18	CCIN	CCIN	CCIN	--*	18	CCIN	CCIN	CCIN	217	CCIN	CCIN	CCIN	CCIN
19	CCI0	CCIO	CCIO	CCIO	19	CCIO	CCIO	CCIO	218	CCIO	CCIO	CCIO	CCIO
									219	GPIO14	GPIO14	GPIO14	GPIO14
									220	GPIO13	GPIO13	GPIO13	GPIO13
20	CCVCC	CCVCC	CCVCC	CCVCC	20	CCVCC	CCVCC	CCVCC	20	CCVCC	CCVCC	CCVCC	CCVCC
21	CCCLK	CCCLK	CCCLK	CCCLK	21	CCCLK	CCCLK	CCCLK	21	CCCLK	CCCLK	CCCLK	CCCLK
22	V285	V285	VCORE	nc	22	VCORE	VCORE	VCORE	22	VCORE	VCORE	VCORE	VCORE
23	Do not use	TXDDAI	GPIO20 (TXDDAI)	nc	23	GPIO20 (TXDDAI)	GPIO20 (TXDDAI) [31]	GPIO20	23	GPIO20 (TXDDAI)	GPIO20 (TXDDAI)	GPIO20 (TXDDAI)	GPIO20 (TXDDAI) [31]

[30] Do not use. Hardware prepared for future use as analog audio interface.

[31] Notes:

- With ELS31 the DAI interface is only hardware prepared, i.e., with the current firmware releases not useable as such. This means that for the time being GPIO20-23 cannot

Pad # LGA106	BGS1 LGA106	BGS2 LGA106	EHS5 LGA106	ENS22 LGA106	Pad # LGA114	BGS5 LGA114	ELS31 LGA114	EMS31 LGA114	Pad # LGA120	EHS6 LGA120	EHS6-A LGA120	EHS8 LGA120	ELS61, ELS81 LGA120
24	Do not use	TFSDAI	GPIO22 (TFSDAI)	nc	24	GPIO22 (TFSDAI)	GPIO22 (TFSDAI) [31]	GPIO22	24	GPIO22 (TFSDAI)	GPIO22 (TFSDAI)	GPIO22 (TFSDAI)	GPIO22 (TFSDAI) [31]
25	Do not use	RXDDAI	GPIO21 (RXDDAI)	nc	25	GPIO21 (RXDDAI)	GPIO21 (RXDDAI) [31]	GPIO21	25	GPIO21 (RXDDAI)	GPIO21 (RXDDAI)	GPIO21 (RXDDAI)	GPIO21 (RXDDAI) [31]
26	Do not use	SCLK	GPIO23 (SCLK)	nc	26	GPIO23 (SCLK)	GPO23 (SCLK) [31]	GPOI23	26	GPIO23 (SCLK)	GPIO23 (SCLK)	GPIO23 (SCLK)	GPIO23 (SCLK) [31]
27	GPIO10 I2CDAT	GPIO10 I2CDAT	I2CDAT	GPIO10 I2CDAT	27	I2CDAT	I2CDAT	I2CDAT	27	I2CDAT	I2CDAT	I2CDAT	I2CDAT
28	GPIO9 I2CCLK	GPIO9 I2CCLK	I2CCLK	GPIO9 I2CCLK	28	I2CCLK	I2CCLK	I2CCLK	28	I2CCLK	I2CCLK	I2CCLK	I2CCLK
29	TXD1	TXD1	GPIO17 (TXD1) (MISO)	GPIO17 (TXD1) (MISO)	29	(GPIO17) TXD1 (MISO)	GPIO17 (HOST_ACTIVE) [31] (TXD1)	GPIO17 (TXD1)	29	GPIO17 (HOST_ACTIVE) (TXD1) (MISO)	GPIO17 (HOST_ACTIVE) (TXD1) (MISO)	GPIO17 (HOST_ACTIVE) (TXD1) (MISO)	GPIO17 (HOST_ACTIVE) [31] (TXD1) (MISO)
30	RXD1	RXD1	GPIO16 (RXD1) (MOSI)	GPIO16 (RXD1) (MOSI)	30	(GPIO16) RXD1 (MOSI)	GPIO16 (AP_WAKEUP) [31] (RXD1)	GPIO16 (RXD1)	30	GPIO16 (AP_WAKEUP) (RXD1) (MOSI)	GPIO16 (AP_WAKEUP) (RXD1) (MOSI)	GPIO16 (AP_WAKEUP) (RXD1) (MOSI)	GPIO16 (AP_WAKEUP) [31] (RXD1) (MOSI)
31	RTS1	RTS1	GPIO18 (RTS1)	GPIO18 (RTS1) (SPI_CLK)	31	(GPIO18) RTS1 (SPI_CLK)	GPIO18 (CP_WAKEUP) [31] (RTS1)	GPIO18 (RTS1)	31	GPIO18 (CP_WAKEUP) (RTS1)	GPIO18 (CP_WAKEUP) (RTS1)	GPIO18 (CP_WAKEUP) (RTS1)	GPIO18 (CP_WAKEUP) [31] (RTS1)
32	CTS1	CTS1	GPIO19 (CTS1) (SPI_CS)	GPIO19 (CTS1) (SPI_CS)	32	(GPIO19) CTS1 (SPI_CS)	GPIO19 (SUSPEND) [31] (CTS1)	GPIO19 (CTS1)	32	GPIO19 (SUSPEND) (CTS1) (SPI_CS)	GPIO19 (SUSPEND) (CTS1) (SPI_CS)	GPIO19 (SUSPEND) (CTS1) (SPI_CS)	GPIO19 (SUSPEND) [31] (CTS1) (SPI_CS)
33	EMERG_RST	EMERG_RST	EMERG_RST	EMERG_RST	33	EMERG_RST	EMERG_RST	EMERG_RST	33	EMERG_RST	EMERG_RST	EMERG_RST	EMERG_RST
									221	GPIO12	GPIO12	GPIO12	GPIO12
									222	GPIO11	GPIO11	GPIO11	GPIO11
34	GND	GND	GND	GND	34	GND	GND	GND	223	GND	GND	GND	GND
35	V180	V180	nc	--*	35	--*	GPIO25	GPIO25	224	--*	--*	ANT_GPS	--*

be configured as DAI signals in the same way as EHS6 or EHS8.

- With ELS61 and ELS81 the DAI interface lines GPIO20-23 are only available for the product variants ELS61-E R2 and ELS61-USA.
- With ELS61 the HSIC interface is only hardware prepared, i.e., with the current firmware releases not useable as such. This means that for the time being GPIO16-18 cannot be configured as HSIC control signals in the same way as EHS6 or EHS8. Also, with ELS61 and ELS81, the HSIC_DATA and HSIC_STRB lines (pads #236, #237) are currently not useable.

Pad # LGA106	BGS1 LGA106	BGS2 LGA106	EHS5 LGA106	ENS22 LGA106	Pad # LGA114	BGS5 LGA114	ELS31 LGA114	EMS31 LGA114	Pad # LGA120	EHS6 LGA120	EHS6-A LGA120	EHS8 LGA120	ELS61, ELS81 LGA120
36	GPIO8	GPIO8	GPIO8 (COUNTER)	GPIO8	36	GPIO8 (COUNTER)	GPIO8 (COUNTER)	GPIO8 (COUNTER)	225	GND	GND	GND	GND
37	GPIO7	GPIO7 (PWM1)	GPIO7 (PWM1)	nc	37	GPIO7 (PWM1)	GPIO7	GPIO7 (PWM1)	226	--*	--*	--*	--*
38	GPIO6 PWM2 Jamming Ind.	GPIO6 (PWM2)	GPIO6 (PWM2)	nc	38	GPIO6 (PWM2)	GPIO6	GPIO6 (PWM2)	227	GND	GND	GND	GND
39	GPIO5 (LED)	GPIO5 (LED)	GPIO5 (LED)	GPIO5	39	GPIO5 (LED)	GPO5 (LED)	GPIO5 (LED)	228	--*	--*	ANT_GPS_PWR	--*
40	FAST_SHTDWN	(FST_SHDN)	GPIO4 (FST_SHDN)	GPIO4 (SHTDWN)	40	GPIO4 (FST_SHDN)	GPIO4 (FST_SHDN)	GPIO4 (FST_SHDN)	229	GPIO4 (FST_SHDN)	GPIO4 (FST_SHDN)	GPIO4 (FST_SHDN)	GPIO4 (FST_SHDN)
41	DSR0	DSR0	GPIO3 (DSR0) (SPI_CLK)	GPIO3 (DSR0)	41	(GPIO3) DSR0	GPIO3 (DSR0)	GPIO3 (DSR0)	230	GPIO3 (DSR0) (SPI_CLK)	GPIO3 (DSR0) (SPI_CLK)	GPIO3 (DSR0) (SPI_CLK)	GPIO3 (DSR0) (SPI_CLK)
42	DCD0	DCD0	GPIO2 (DCD0)	GPIO2 (DCD0)	42	(GPIO2) DCD0	GPIO2 (DCD0)	GPIO2 (DCD0)	231	GPIO2 (DCD0)	GPIO2 (DCD0)	GPIO2 (DCD0)	GPIO2 (DCD0)
43	DTR0	DTR0	GPIO1 (DTR0)	GPIO1 (DTR0)	43	(GPIO1) DTR0	GPIO1 (DTR0)	GPIO1 (DTR0)	232	GPIO1 (DTR0)	GPIO1 (DTR0)	GPIO1 (DTR0)	GPIO1 (DTR0)
44	Do not use	GND	VUSB	nc	44	VUSB	VUSB	nc	233	VUSB	VUSB	VUSB	VUSB
45	Do not use	GND	USB_DP	nc	45	USB_DP	USB_DP	nc	234	USB_DP	USB_DP	USB_DP	USB_DP
46	Do not use	GND	USB_DN	nc	46	USB_DN	USB_DN	nc	235	USB_DN	USB_DN	USB_DN	USB_DN
47	GND	GND	GND	GND	47	GND	GND	GND	236	HSIC_DATA	HSIC_DATA	HSIC_DATA	HSIC_DATA[31]
48	GND	GND	GND	GND	48	GND	GND	--*	237	HSIC_STRB	HSIC_STRB	HSIC_STRB	HSIC_STRB[31]
49	GND	GND	GND	GND	49	GND	GND	GND	238	GND	GND	GND	GND
50	GND	GND	GND	GND	50	GND	GND	GND	239	GPIO5 (LED)	GPIO5 (LED)	GPIO5 (LED)	GPIO5 (LED)
51	GND	GND	GND	GND	51	GND	GND	GND	240	GPIO6 (PWM2)	GPIO6 (PWM2)	GPIO6 (PWM2)	GPIO6 (PWM2)
52	GND	GND	GND	GND	52	GND	GND	GND	---				
									241	GPIO7 (PWM1)	GPIO7 (PWM1)	GPIO7 (PWM1)	GPIO7 (PWM1)
									242	GPIO8 (COUNTER)	GPIO8 (COUNTER)	GPIO8 (COUNTER)	GPIO8 (COUNTER)

Pad # LGA106	BGS1 LGA106	BGS2 LGA106	EHS5 LGA106	ENS22 LGA106	Pad # LGA114	BGS5 LGA114	ELS31 LGA114	EMS31 LGA114	Pad # LGA120	EHS6 LGA120	EHS6-A LGA120	EHS8 LGA120	ELS61, ELS81 LGA120
53	$BATT+_{RF}$	$BATT+_{RF}$	$BATT+_{RF}$	$BATT+_{RF}$	53	BATT+	BATT+BB	BATT+	53	$BATT+_{RF}$	$BATT+_{RF}$	$BATT+_{RF}$	$BATT+_{RF}$
54	GND	GND	GND	GND	54	GND	GND	GND	54	GND	GND	GND	GND
55	GND	GND	GND	GND	55	GND	GND	GND	55	GND	GND	GND	GND
56	GND	GND	GND	GND	56	GND	DIV_ANT	nc	56	GND	GND	GND	ANT_DRX
57	GND	GND	GND	GND	57	GND	GND	GND	57	GND	GND	GND	GND
58	GND	GND	GND	GND	58	GND	GND	GND	58	GND	GND	GND	GND
59 [32]	RF_OUT	ANT_GSM	RF_OUT	RF_OUT	59	RF_OUT	RF_OUT	RF_OUT	59	ANT_GSM	ANT_GSM	ANT_GSM	ANT_MAIN
60	GND	GND	GND	GND	60	GND	GND	GND	60	GND	GND	GND	GND
61	GND	GND	GND	GND	61	GND	GND	GND	61	GND	GND	GND	GND
62	GND	GND	GND	GND	62	GND	GND	GND	62	GND	GND	GND	GND
63	GND	GND	GND	GND	63	GND	GND	GND	63	GND	GND	GND	GND
64	AGND	AGND	--*	GND	64	AGND[30]	GND	GND	64	--*	AGND	--*	GND
65	MICP	MICP	--*	nc	65	MICP[30]	GPIO27 (SPI_CS2)	GPIO27 (SPI_CS2)	65	--*	MICP	--*	--*
66	MICN	MICN	--*	nc	66	MICN[30]	GPO26 (SPI_CS1)	GPO26 (SPI_CS1)	66	--*	MICN	--*	--*
									243	--*	VMIC	--*	--*
									244	GPIO15	GPIO15	GPIO15	GPIO15
	Inner pads												
67	GND	GND	nc	GND	67	--*	GND	GND	67	--*	--*	--*	nc
68	GND	GND	nc	GND	68	--*	GND	GND	68	--*	--*	--*	nc
69	GND	GND	nc	GND	69	--*	GND	GND	69	--*	--*	--*	nc
70	GND	GND	nc	GND	70	--*	GND	GND	70	--*	--*	--*	nc
71	GND	GND	nc	GND	71	--*	GND	GND	71	--*	--*	--*	nc
72	GND	GND	nc	GND	72	--*	nc	nc	72	AUTO_ON	AUTO_ON	AUTO_ON	nc
73	GND	GND	nc	GND	73	--*	GND	GND	73	--*	--*	--*	nc
74	GND	GND	--*	GND	74	--*	--*	--*	74	nc	nc	nc	--*
75	GND	GND	--*	nc	75	--*	--*	--*	75	nc	nc	nc	--*
76	GND	GND	--*	nc	76	--*	--*	--*	76	nc	nc	nc	nc
77	GND	GND	--*	GND	77	--*	--*	--*	77	nc	nc	nc	nc
78	GND	GND	--*	GND	78	--*	--*	--*	78	nc	nc	nc	nc

[32] ANT_GSM, RF_OUT and ANT_MAIN all identify the main RF antenna pad, whereas DIV_ANT and ANT_DRX signify the Rx diversity antenna pad.

Pad # LGA106	**BGS1** LGA106	**BGS2** LGA106	**EHS5** LGA106	**ENS22** LGA106	**Pad #** LGA114	**BGS5** LGA114	**ELS31** LGA114	**EMS31** LGA114	**Pad #** LGA120	**EHS6** LGA120	**EHS6-A** LGA120	**EHS8** LGA120	**ELS61, ELS81** LGA120
79	GND	GND	AUTO_ON	GND	79	--*	nc	nc	79	nc	nc	nc	nc
80	GND	GND	--*	GND	80	--*	nc	nc	80	nc	nc	nc	nc
81	GND	GND	GND	GND	81	GND	GND	GND	81	GND	GND	GND	GND
82	GND	GND	GND	GND	82	GND	GND	GND	82	GND	GND	GND	GND
83	GND	GND	GND	GND	83	GND	--*	nc	83	GND	GND	GND	GND
84	GND	GND	GND	GND	84	GND	GND	GND	84	GND	GND	GND	GND
85	GND	GND	GND	GND	85	GND	GND	GND	85	GND	GND	GND	GND
86	GND	GND	GND	GND	86	GND	GND	GND	86	GND	GND	GND	GND
87	GND	GND	--*	GND	87	--*	--*	nc	87	--*	--*	--*	nc
88	GND	GND	GND	GND	88	GND	GND	GND	88	GND	GND	GND	GND
89	GND	GND	GND	GND	89	GND	GND	GND	89	GND	GND	GND	GND
90	GND	GND	GND	GND	90	GND	GND	GND	90	GND	GND	GND	GND
91	GND	GND	nc	GND	91	--*	--*	--*	91	nc	nc	nc	nc
92	GND	GND	GND	GND	92	GND	GND	GND	92	GND	GND	GND	GND
93	GND	GND	GND	GND	93	GND	--*	CCIN2	93	GND	GND	GND	GND
94	GND	GND	GND	GND	94	GND	--*	CCCLK2	94	GND	GND	GND	GND
95	GND	GND	GND	GND	95	GND	--*	--*	95	GND	GND	GND	GND
96	GND	GND	GND	GND	96	GND	--*	CCIO2	96	GND	GND	GND	GND
97	GND	GND	GND	GND	97	GND	--*	CCVCC2	97	GND	GND	GND	GND
98	TESTPIN	--*	--*	nc	98	--*	GND	GND	98	GND	GND	GND	GND
99	GND	GND	GND	GND	99	GND	GND	GND	99	GND	GND	GND	GND
100	GND	GND	GND	GND	100	GND	GND	GND	100	GND	GND	GND	GND
101	GND	GND	GND	GND	101	GND	GND	GND	101	GND	GND	GND	GND
102	GND	GND	GND	GND	102	GND	GND	GND	102	GND	GND	GND	GND
103	GND	GND	GND	GND	103	GND	GND	GND	103	GND	GND	GND	GND
104	GND	GND	GND	GND	104	GND	nc	nc	104	--*	--*	--*	--*
105	GND	GND	GND	GND	105	GND	nc	nc	105	--*	--*	--*	--*
106	GND	GND	GND	GND	106	--*	SPI_MOSI	SPI_MOSI	106	--*	--*	--*	--*

Pad # LGA106	BGS1 LGA106	BGS2 LGA106	EHS5 LGA106	ENS22 LGA106	Pad # LGA114	BGS5 LGA114	ELS31 LGA114	EMS31 LGA114	Pad # LGA120	EHS6 LGA120	EHS6-A LGA120	EHS8 LGA120	ELS61, ELS81 LGA120
					245	GND	GND	GND	245	GND	GND	GND	GND
					246	--*	--	nc	246	--*	--*	--*	nc
					247	--*	--	nc	247	--*	--*	--*	nc
					248	--*	SPI_CLK	SPI_CLK	248	--*	--*	--*	nc
					249	--*	SPI_MISO	SPI_MISO	249	--*	--*	--*	nc
					250	GND	GND	GND	250	GND	GND	GND	GND
					251	GND	--	CCRST2	251	GND	GND	GND	GND
					252	GND	GND	GND	252	GND	GND	GND	GND

Legend:
--*: Do not use
nc: internally not connected

4.1 Combined Land Pattern

Figure 10 shows a combined land pattern for BGS1/BGS2/EHS5/ELS31/EMS31/ENS22 as well as EHS6/EHS8/ELS61/ELS81. For details on the differing stencils to be used with a combined land pattern, please refer to the respective “Hardware Interface Description”.

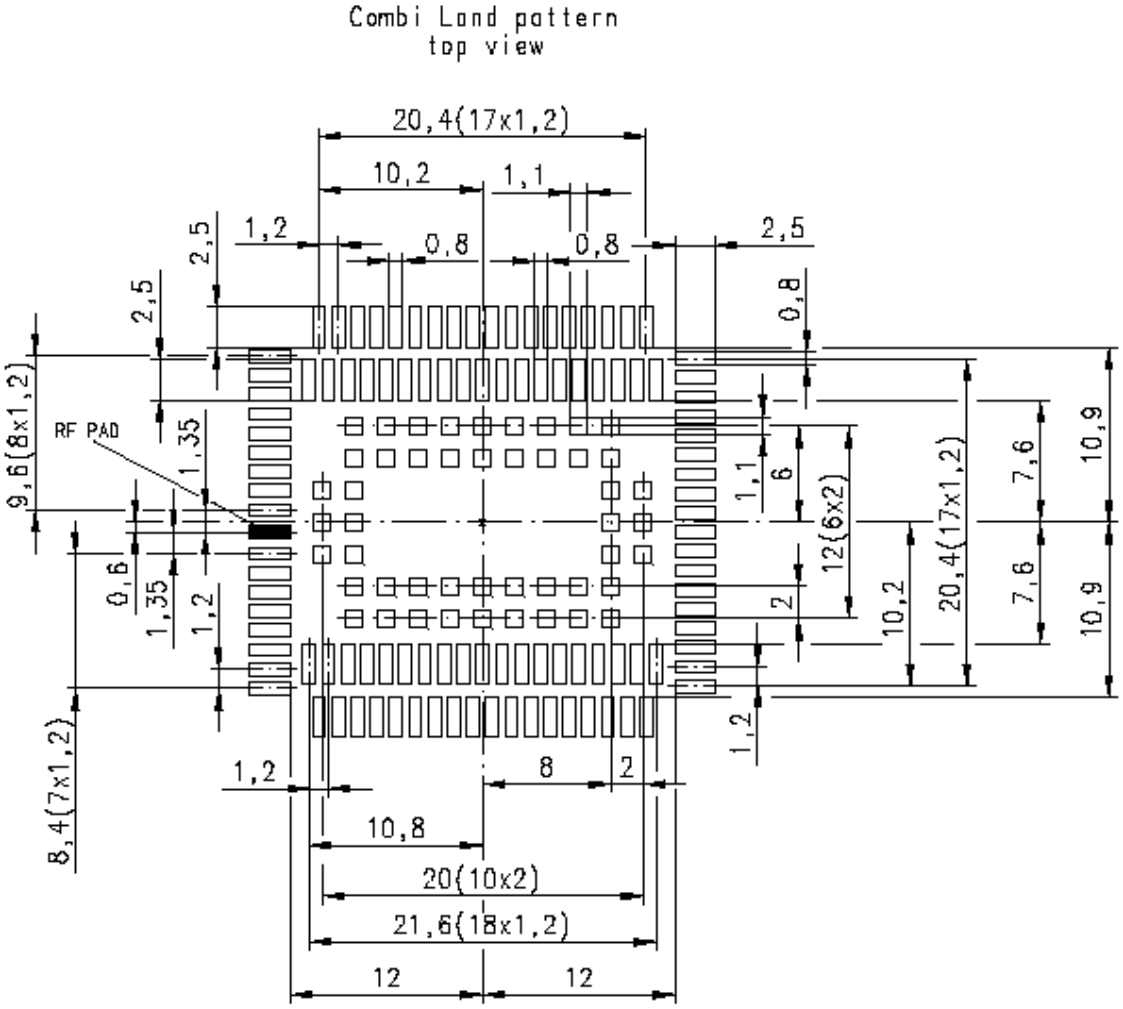

Figure 10: Combined land pattern (top view)

Please note that if soldering EHS6/EHS8/ELS61/ELS81 to an external application using a combined land pattern there should be no solder paste at those pads available for BGS2/EHS5/ELS31/EMS31/ENS22 only (i.e., pads 1-19 and 34-52) in order to avoid shorts. This is because EHS6/EHS8/ELS61/ELS81 have some areas without solder resist where the BGS1/BGS2/EHS5/ELS31/EMS31/ENS22 only pads are located in a combined land pattern.

4.2 Test Points

The below table lists mandatory signal test points that should be implemented for SMT applications (insofar as the module supports the corresponding interface lines) as well as further optional test points that might be implemented (insofar as the module employs the corresponding interface lines).

For details on test points and their implementation please refer to [3].

Table 35: Mandatory and optional test points for SMT applications

Test point	Required	Module
TP_PWR_IND	Yes	All
TP_IGT	Yes	All
TP_EMERG_RST	Yes	All
TP_V180	Yes	All except ENS22
TP_V300	Yes	ENS22
TP_V285	Yes	BGS2
TP_VCORE	Yes	BGS5, EHS5, EHS6, EHS8, ELS31, EMS31, ELS61, and ELS81 only
TP_V285_VCORE	Yes	BGS2
TP_PAD91	Yes	ELS31, EMS31
TP_PAD87	Yes	ELS31, EMS31
TP_PAD83	Yes	ELS31, EMS31
TP_RXD0	Yes	All
TP_TXD0	Yes	All
TP_RTS0	Yes	All
TP_CTS0	Yes	All
TP_RXD1	Recommended	All
TP_TXD1	Recommended	All
TP_RTS1	Recommended	All
TP_CTS1	Recommended	All
TP_VBATT	Recommended	All

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We work closely with global mobile network operators to ensure that Cinterion® modules evolve in sync with wireless networks, providing a seamless migration path to protect your IoT technology investment.

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