Monarch 2 Platform

GM02S Module

Data Sheet

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About this Data Sheet

Purpose and Scope

The GM02S is a complete LTE Cat M1/NB1/NB2 module with baseband, RF and memory, targeted at narrow band low data rate M2M and IoT devices for wide deployment. This document provides technical information about GM02S LGA module. GM02S is based on Sequans' Monarch 2 platform.

Who Should Read this Document

This document is intended for engineers who develop User Equipment (UE) for LTE systems.

Changes in this Document

This is revision 12 of the GM02S Data Sheet.

The signal list delivered as MS-Excel companion file to this data sheet is unchanged.

The following changes were done since the previous version of this document:

- Added information about LTE-M/NB-IoT dual mode operation.

Table of Contents

1 General Description

The Monarch 2 GM02S an LTE Cat M1/NB1/NB2 module based on Sequans' second generation *Monarch 2* chip platform. The GM02S is a total module solution, including a complete, *Single-SKU*™ RF front end capable of operating on every GSM band worldwide, and an integrated EAL5+ Secure Element (SE) capable of hosting the SIM inside the module with zero compromise on security while lowering cost and reducing complexity. The GM02S is part of Sequans next generation "S" family of modules, featuring a very small and cost-effective form factor that requires no external components.

The GM02S leverages Sequans's 15-plus years of experience in 4G+ technologies and incorporates Sequans's carrier-approved LTE protocol stack and a software suite amongst the most mature in the industry. The GM02S is part of Sequans's next generation "S" family of modules, featuring a very small and cost-effective form factor which requires no external components. The GM02S inherits *Monarch's* already certified LTE-M and NB-IoT stack and delivers a significantly improved performance and lower power consumption thanks to Sequans's second generation *Monarch 2* chip and the new module architecture.

Sequans's technology, both hardware and software, is completely owned by Sequans, ensuring a fast time to market and the lowest total cost of ownership for device makers.

1.1 Frequency Bands

GM02S supports the following bands:

- B1 (2100);
- B2 (1900 PCS);
- B3 (1800+);
- B4 (AWS-1);
- B5 (850);
- B8 (900 GSM);
- B12 (700 a);
- B13 (700 c);
- B14 (700 PS);
- B17 (700 b);
- B18 (800 Lower);
- B19 (800 Upper);
- B20 (800 DD);
- B25 (1900+);
- B26 (850+);
- B28 (700 APT);
- B66 (AWS-3);
- B71 (600);
- B85 (700 a+).

1.2 Applications

GM02S is ideal for adding LTE-M and/or NB-IoT LTE connectivity to narrow band, low data rate M2M and IoT devices such as utility meters, industrial sensors, health and fitness appliances, asset trackers, and many additional devices in smart home, smart city, and wearable applications.

GM02S can also be used as a slim modem controlled by an external MCU via its UART. Alternatively, the GM02S can execute applets on its embedded MCU.

1.3 Block Diagram

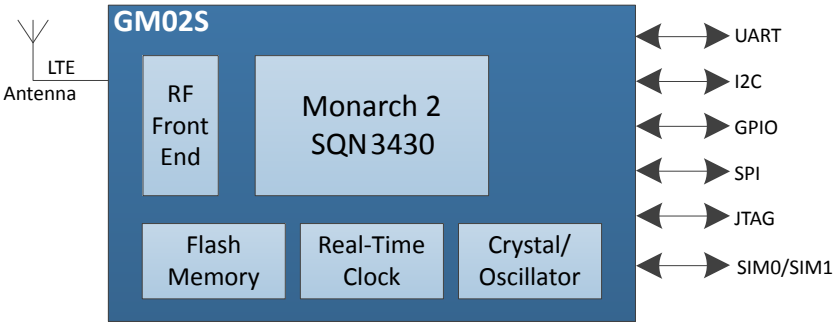


Figure 1: GM02S Block Diagram

1.4 General Features

Physical Characteristics	LGA module, 120 pads. Size: 16.3 × 17 × 1.85 mm
Temperature Range	Operation temperature range: -40 to +85 °C Storage: MSL3
Power Supply	Voltage range for RF compliance: 2.5 to 5.5 V Functional voltage range: 2.2 to 5.5 V
Tx Power	+23 dBm in each band
Interfaces	• Dual (U)SIM Card Interface: support for external, removable or fixed UICC. Support for integrated UICC (iUICC) with a dedicated p/n; • 4x High-Speed UART Interfaces with flow control, up to 921600 bauds; • GPIOs, I2C, SPI, PWM, Pulse Counter, I2S/PCM, ADC;
SMS	Text and PDU modes
Firmware Upgrade	UART interface, FOTA, support of full and differential firmware upgrade

RoHS	All hardware components are fully compliant with EU RoHS directive, bromine-free
LTE Features	• 3GPP LTE Release 13/14 Cat M1/NB1/NB2 compliant; • LTE Cat M1: 1.1 Mbps / 0.3 Mbps UL/DL throughput; • LTE Cat NB1: 62.5 kbps / 27.2 kbps UL/DL throughput; • LTE Cat NB2: 160 kbps / 120.7 kbps UL/DL throughput.

1.5 Available Part Numbers

GM02S's ECCN is 5A991.

Table 1: Available Part Numbers

Available Part Number	Hardware Version	Software Build (ATI1)	UE Version (ATI1)	PTCRB Model Name / Model	SVN	Availability Status
GM02RB6QRC	HW Rev.2 FCC/IC/ RED/ UKCA/ ACMA/ JATE/ TELEC/ PTCRB/ GCF	LR 8.0.1.2	UE 8.0.1.2	See note below	See note below	Obsolete. Not recommended for new designs.
GM02RB6QRD	HW Rev.2 FCC/IC/ RED/ UKCA/ ACMA/ NCC/ JATE/ TELEC/ PTCRB/ GCF	LR 8.0.4.3	UE 8.0.4.3	See note below	See note below	Available
GM02RB6QRE	HW Rev.2 FCC/IC/ RED/ UKCA/ ACMA/ NCC/ JATE/ TELEC/ PTCRB/ GCF	LR 8.0.5.10	UE 8.0.5.10	See note below	See note below	See note below

Note: Please contact your local technical representative to pick the appropriate part number for your project.

Note: There is still no available part number corresponding to the dual-mode version of the GM02S. Dual-mode LTE-M/NB-IoT pre-commercial software release is however available and can be activated after a software upgrade from the LTE-M single-mode module version. Please contact your local technical representative for detailed information

2 Interfaces

The GM02S provides electric interfaces connecting it to the external parts, such as communication I/O ports, GPIO and antenna RF I/O. This chapter provides information about all these interfaces.

Power supply pins and details thereof are detailed in section Electrical, RF and Thermal Characteristics.

Important: Please refer to this data sheet's companion MS-Excel file for details on each pin's:

- Default assigned function;
- State during low power modes;
- Configurability with AT commands;
- Pull status and requirements.

2.1 Pin Assignment

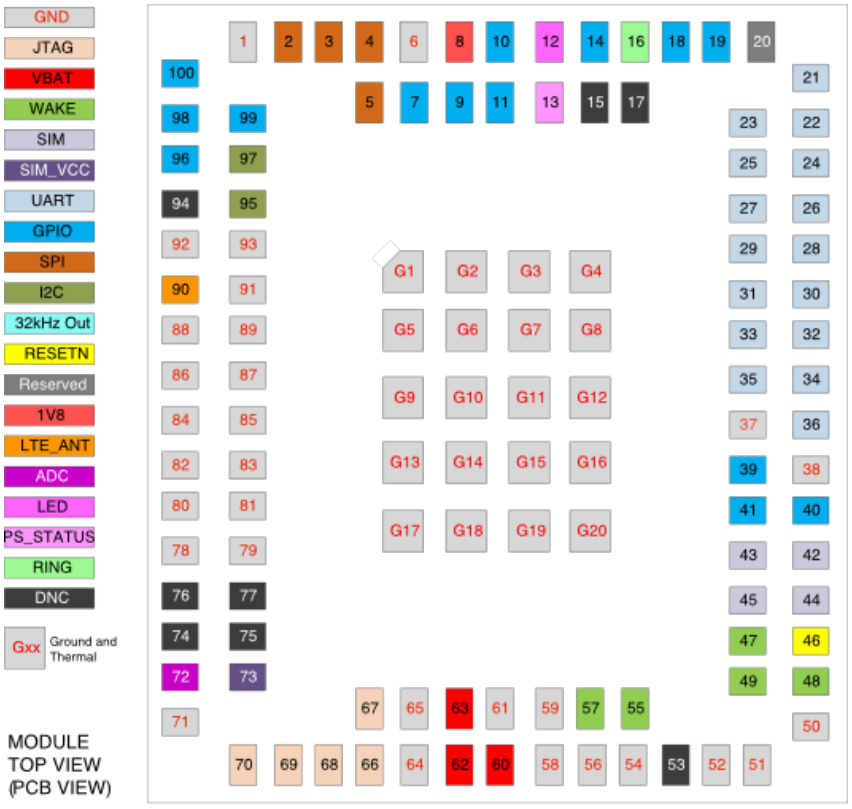


Figure 2: GM02S Module Pads Assignments

2.2 UART

When the GM02S is used as a slim modem, it has three UARTs available. The default function for each UART is as follows:

- UART0: data and control from external MCU via AT commands
- UART1: debug and upgrade
- UART2: modem console

This default configuration can be overridden. In addition, a fourth UART (UART3) is available for applications running on the GM02S .

Note: See section Power for behaviour of I/Os in `Deep Sleep` mode.

Table 2: UART Signals

Pad #	Pad Name	Primary Function	Alternate Function [1]	Power Group	Direction	Pad type [2]	Reset state
36	GPIO12/ TXD0	TXD0	GPIO12	PVDD_1V8	In/Out	BIDIR	High-Z, 2 mA
		In for primary function, UART0					
34	GPIO13/ RXD0	RXD0	GPIO13	PVDD_1V8	In/Out	BIDIR	Out-1, 2 mA
		Out for primary function, UART0					
35	GPIO14/ CTS0	CTS0	GPIO14	PVDD_1V8	In/Out	BIDIR	Out-1, 2 mA
		Out for primary function, UART0					
33	RTS0	RTS0	N/A	PMU_5V	In	IN	High-Z
		Wake signal enabled by default.					
32	TXD1	TXD1	N/A	PVDD_1V8	In	BIDIR	High-Z, 2 mA
		UART1					
30	RXD1	RXD1	N/A	PVDD_1V8	Out	BIDIR	Out-1, 2 mA
		UART1					
31	CTS1	CTS1	N/A	PVDD_1V8	Out	BIDIR	Out-1, 2 mA
		UART1					
29	RTS1	RTS1	N/A	PMU_5V	In	IN	High-Z
		Wake signal enabled by default.					
28	GPIO15/ TXD2	TXD2	GPIO15	PVDD_1V8	In/Out	BIDIR	High-Z, 2 mA
		In for primary function, UART2					
26	GPIO16/ RXD2	RXD2	GPIO16	PVDD_1V8	In/Out	BIDIR	Out-1, 2 mA
		Out for primary function, UART2					

1 Alternate functions will be available in future versions via SW upgrade.

2 UART pad types's electrical characteristics are detailed in Table 19 and Table 20.

Pad #	Pad Name	Primary Function	Alternate Function [1]	Power Group	Direction	Pad type [2]	Reset state
27	GPIO17/ CTS2/ DCD0	GPIO17	CTS2/ DCD0	PVDD_1V8	In/Out	BIDIR	Out-1, 2 mA
		UART2					
25	GPIO18/ RTS2/ DSR0	GPIO18	RTS2/ DSR0	PVDD_1V8	In/Out	BIDIR	High-Z, 2 mA
		UART2					
24	GPIO19/ TXD3	GPIO19	TXD3	PVDD_1V8	In/Out	BIDIR	HighZ, 2 mA
		In for primary function, UART3					
22	GPIO20/ RXD3	GPIO20	RXD3	PVDD_1V8	In/Out	BIDIR	Out-1, 2 mA
		Out for primary function, UART3					
21	GPIO21/ CTS3	GPIO21	CTS3	PVDD_1V8	In/Out	BIDIR	Out-1, 2 mA
		UART3					
23	GPIO22/ RTS3	GPIO22	RTS3	PVDD_1V8	In/Out	BIDIR	Out-1, 2 mA
		UART3					

High-Speed UARTs Flow Control Signals

- CTS0, CTS1, CTS2, CTS3: Clear-To-Send signals of resp. UART0, UART1, UART2, UART3 (active low). To be connected to the CTS of the remote UART device. See Figure 3.

  Leave CTS unconnected if hardware flow control is not used.

- RTS0, RTS1, RTS2, RTS3: Ready-To-Send signals of resp. UART0, UART1, UART2, UART3 (active low). To be connected to the RTS of the remote UART device. Tie to a 1 kΩ pull-down when flow control is not used. If connected to an external part (like a RS-232 driver), the user must insure that the part presents a low level to the GM02S See Figure 3.

Figure 3 represents the typical implementation for hardware flow control.

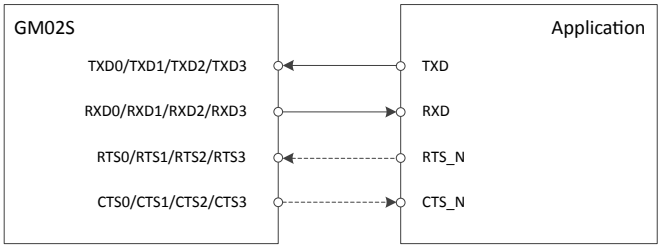


Figure 3: UART Convention and Flow Control

Note: Please refer to *Module Integration Guide* for details on UART connections.

1 Alternate functions will be available in future versions via SW upgrade.

2 UART pad types's electrical characteristics are detailed in Table 19 and Table 20.

2.3 USIM Interfaces

2.3.1 SIM0 Interface

This is the main external SIM interface. It can be used with removable or non-removable SIM cards or with soldered SIM chips. The modem manages the SIM's power supply to keep consumption as low as possible.

Note: See Section Power for behaviour of I/Os in `Deep Sleep` mode.

Table 3: SIM0 Signals

Pad #	Pad Name	Primary Function	Power Group	Direction	Pad type [3]	Reset State	Comment
42	SIM0_CLK	SIM0_CLK	PVDD_1V8	Out	BIDIR	Out-0, 2 mA	Main SIM
45	SIM0_DETECT [4]	SIM0_DETECT	PMU_5V	In	IN	High-Z	Main SIM
44	SIM0_IO	SIM0_IO	PVDD_1V8	In/Out	BIDIR	High-Z, 2 mA	Main SIM
43	SIM0_RSTN	SIM0_RSTN	PVDD_1V8	Out	BIDIR	Out-0, 2 mA	Main SIM
73	SIM0_VCC [5]	SIM0_VCC	PVDD_1V8	Out	SUPPLY	Out-0, 2 mA	Main SIM

2.3.2 SIM1 Interface

This GM02S 's interface to a second SIM is typically meant for soldered SIM chips (since it lacks SIM detect and SIM VCC). If the board makes use of a single SIM, it should be connected to the main SIM interface (see Section SIM0 Interface above).

Note: See Section Power for behaviour of I/Os in `Deep Sleep` mode.

Table 4: SIM1 Signals

Pad #	Pad Name	Primary Function	Alternate Function [6]	Power Group	Direction	Pad Type [7]	Reset state
40	GPIO26/ SIM1_CLK	GPIO26	SIM1_CLK	PVDD_1V8	Out	BIDIR	Out-0, 2 mA
41	GPIO27/ SIM1_RESETN	GPIO27	SIM1_RESETN	PVDD_1V8	Out	BIDIR	Out-0, 2 mA
39	GPIO25/ SIM1_IO	GPIO25	SIM1_IO	PVDD_1V8	In/Out	BIDIR	High-Z, 2 mA

[3] USIM pad types electrical characteristics are detailed in Table 19 and Table 20.

[4] SIM0_DETECT is active high (high when a card is present, low when no card is present). It can be configured as a `WAKE` pin via software command.

[5] See range of values in Table 13.

[6] Alternate functions will be available in future versions via SW upgrade.

[7] Pad types electrical characteristics are detailed in Table 19.

Important: Both SIM0 and SIM1 interfaces use 1.8 V signalling.

2.4 I²C

Note: See Section Power for behaviour of I/Os in `Deep Sleep` mode.

Table 5: I²C Pad Details

Pad #	Pad Name	Primary Function	Alternate Function [8]	Power Group	Direction	Pad type [9]	Reset State
95	GPIO23/ I2C_SDA	GPIO23	I2C_SDA	PVDD_1V8	In/Out	BIDIR	High-Z
97	GPIO24/ I2C_SCL	GPIO24	I2C_SCL	PVDD_1V8	In/Out	BIDIR	High-Z

2.5 PCM

Note: See section Power for behaviour of I/Os in `Deep Sleep` mode.

Table 6: PCM Pad Details

Pad #	Pad Name	Primary Function	Alternate Function [10]	Power Group	Direction	Pad type [11]	Reset State
96	GPIO4/ PCM_CLK	GPIO4	PCM_CLK	PVDD_1V8	In/Out	BIDIR	High-Z
98	GPIO3/ PCM_RXD	GPIO3	PCM_RXD	PVDD_1V8	In/Out	BIDIR	High-Z
99	GPIO5/ PCM_FS	GPIO5	PCM_FS	PVDD_1V8	In/Out	BIDIR	High-Z
100	GPIO6/ PCM_TXD	GPIO6	PCM_TXD	PVDD_1V8	In/Out	BIDIR	High-Z

2.6 SPI

Note: See section Power for behaviour of I/Os in `Deep Sleep` mode.

8 Alternate functions will be available in future versions via SW upgrade.
9 I²C pad types's electrical characteristics are detailed in Table 19.
10 Alternate functions will be available in future versions via SW upgrade.
11 PCM pad types's electrical characteristics are detailed Table 19.

Table 7: SPI Pad Details

Pad #	Pad Name	Primary Function	Alternate Function [12]	Power Group	Direction	Pad type [13]	Reset state
3	GPIO7/ SPI_SDI	GPIO7	SPI_SDI	PVDD_1V8	In/Out	BIDIR	High-Z
4	GPIO8/ SPI_SDO	GPIO8	SPI_SDO	PVDD_1V8	In/Out	BIDIR	High-Z
2	GPIO9/ SPI_CLK	GPIO9	SPI_CLK	PVDD_1V8	In/Out	BIDIR	High-Z
5	GPIO10/ SPI_CSN1	GPIO10	SPI_CSN1	PVDD_1V8	In/Out	BIDIR	High-Z
7	GPIO11/ SPI_CSN2	GPIO11	SPI_CSN2	PVDD_1V8	In/Out	BIDIR	High-Z

2.7 GPIO

33 GPIOs are available on the GM02S the first 28 are named GPIO1 to GPIO28 and the last five GPIO31 to GPIO35. The GPIOs listed in Table 8 are not enabled by default. Their states are controlled by software.

Table 8: GPIO pads detail

GPIO Range	Default State
GPIO3 to GPIO11	Disabled
GPIO17 to GPIO28	Disabled
GPIO31 to GPIO32	Disabled

The GPIOs are documented in this data sheet according to their shared or assigned function. In addition to the GPIO, five wake signals are also available (see section Other Signals).

2.8 Other Signals

Table 9: GND and DNC pads

Pads Type	Pads Number
GND	1, 6, 37, 38, 50, 51, 52, 54, 56, 58, 59, 61, 64, 65, 71,78, 79, 80, 81, 82, 83, 84, 85, 86, 87, 88, 89, 91, 92, 93
DNC (Reserved)	15, 17, 53, 74, 75, 76, 77, 94

Note: See Section Power for behaviour of I/Os in `Deep Sleep` mode.

[12] Alternate functions will be available in future versions via SW upgrade.

[13] SPI pad types' electrical characteristics are detailed in Table 19.

Table 10: Other Signals (No Interface)

Pad #	Name	Primary Function	Alternate Function [14]	Power Group	Direction	Pad Type [15]	Reset State
72	ADC1	ADC1 (see Note 14)	N/A	N/A	In	IN	N/A
		Analogue-Digital Converter (ADC, IN)					
12	GPIO1/ STATUS_LED	STATUS_LED	GPIO1	PVDD_1V8	In/Out	BIDIR	High-Z, 2 mA
		Primary Function: Status LED (STATUS_LED, OUT)					
13	GPIO2/ PS_STATUS	PS_STATUS	GPIO2	PVDD_1V8	In/Out	BIDIR	High-Z, 2 mA
		Primary Function: Power Saving status (PS_STATUS, OUT) enabled by default. Active high.					
14	GPIO28/ DTR0	GPIO28 (see Note 14)	DTR0	PVDD_1V8	In/Out	BIDIR	High-Z
19	GPIO31/ PWM0/ PULSE0/ 19M2_OUT	GPIO31 (see Note 14)	PWM0/ PULSE0/ 19M2_OUT	PVDD_1V8	In/Out	BIDIR	High-Z
18	GPIO32/ PWM1/ PULSE1	GPIO32 (see Note 14)	PWM1/ PULSE1	PVDD_1V8	In/Out	BIDIR	High-Z
9	GPIO33/ TX_IND	TX_IND	GPIO33	PVDD_1V8	In/Out	BIDIR	High-Z, 2 mA
		Primary Function: Transmission indicator (TX_IND, OUT). Active high.					
10	GPIO34/ ANT_TUNE0	ANT_TUNE0	GPIO34	PVDD_1V8	In/Out	BIDIR	High-Z, 2 mA
		Primary Function: Antenna tuning (ANT_TUNE0, OUT)					
11	GPIO35/ ANT_TUNE1	ANT_TUNE1	GPIO35	PVDD_1V8	In/Out	BIDIR	High-Z, 2 mA
		Primary Function: Antenna tuning (ANT_TUNE1, OUT)					
14	GPIO28/ LNA_ENABLE	LNA_ENABLE	GPIO28	PVDD_1V8	In/Out	BIDIR	High-Z, 2 mA
		Primary Function: External GNSS LNA enable signal					
20	RESERVED/ FFF_FFH	RESERVED	N/A	PVDD_1V8	N/A	BIDIR	High-Z, 2 mA
		Boot mode selection (FFF_FFH, IN). This pad needs a pull-down resistor by default.					
15, 17, 53, 74, 75, 76, 77, 94	RESERVED	RESERVED	N/A	PVDD_1V8	N/A	BIDIR	N/A
		Do not connect					
46	RESETN	RESETN	N/A	PMU_5V	In	IN	In, Pull-up

[14] Functions will be available in future versions via SW upgrade.

[15] Pad types's electrical characteristics are detailed in Table 19 and Table 20.

Pad #	Name	Primary Function	Alternate Function [14]	Power Group	Direction	Pad Type [15]	Reset State
		Module HW reset signal. Active low. The minimum duration of a reset pulse on the RESETN signal is 100 μs.					
16	RING0	RING0	N/A	PVDD_1V8	In/Out	BIDIR	High-Z, 2 mA
		UART0 ring line (RING0, OUT). Enabled by default with inverted polarity.					
48	WAKE0	WAKE0	N/A	PMU_5V	In	IN	High-Z
		Wake #0 input line (WAKE0, IN), disabled by default.					
47	WAKE1	WAKE1	N/A	PMU_5V	In	IN	High-Z
		Wake #1 input line (WAKE1, IN), disabled by default.					
49	WAKE2	WAKE2	N/A	PMU_5V	In	IN	High-Z
		Wake #2 input line (WAKE2, IN), disabled by default.					
55	WAKE3	WAKE3	N/A	PMU_5V	In	IN	High-Z
		Wake #3 input line (WAKE3, IN), disabled by default.					
57	WAKE4	WAKE4	N/A	PMU_5V	In	IN	High-Z
		Wake #4 input line (WAKE4, IN), disabled by default.					

2.9 JTAG

Note: See Section Power for behaviour of I/Os in `Deep Sleep` mode.

Table 11: JTAG pads Details

Pad #	Pad Name	Primary Function	Power Group	Direction	Pad type [16]	Reset State
69	JTAG_TCK	JTAG_TCK	PVDD_1V8	In	IN	In, Pull-down, Schmitt-trigger
67	JTAG_TDI	JTAG_TDI	PVDD_1V8	In	IN	In, Pull-up
68	JTAG_TDO	JTAG_TDO	PVDD_1V8	Out	BIDIR	Out, 0
66	JTAG_TMS	JTAG_TMS	PVDD_1V8	In	IN	In, Pull-up
70	JTAG_TRSTN	JTAG_TRSTN	PVDD_1V8	In	IN	In, Pull-down

Note: The GM02S does not support boundary scan (IEEE 1149.1) for production testing.

14 Functions will be available in future versions via SW upgrade.

15 Pad types's electrical characteristics are detailed in Table 19 and Table 20.

16 JTAG pad types's electrical characteristics are detailed in Table 19.

2.10 Antenna

Table 12: Antenna pad Details

Pad #	Pad Name	Direction	Comments
90	LTE_ANT	In/Out	Main Antenna, for Rx and Tx

3 Electrical, RF and Thermal Characteristics

3.1 Power

3.1.1 Power Pads Characteristics

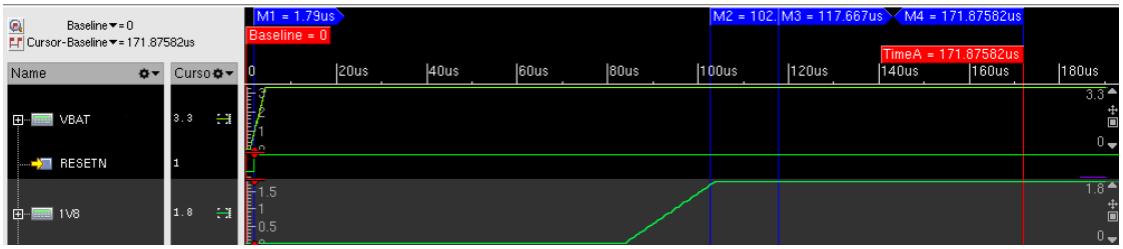
Note: Pad 1V8 is the reference voltage for I/Os. It can be used to provide power to small devices (100 mA maximum usage). This voltage is not available when the modem is in `Deep Sleep` mode. When the modem is in standby the voltage drops to 1.62 V as per Table 13.

Table 13: Power Pads

Pad #	Pad Name	Power Group	Direction	Min Value	Typical Value	Max Value
8	1V8 (see Note above)	PVDD_1V8	Out	1.62 V	1.8 V	1.98 V
73	SIM_VCC [17]	PVDD_1V8	Out	1.62 V	1.8 V	1.98 V
60, 62, 63	VBAT	N/A	In	2.2 V		5.5 V

Note: Reference VBAT voltage range is 2.5 V to 5.5 V for RF-compliant operation and 2.2 V to 5.5 V for functional operation with possible degradation of RF performances.

3.1.2 Power-Up and Reset Sequences



Important: The 1V8 power signal can remain low up to 370 µs after the VBAT rising edge

Figure 4: Typical Timing Diagram for Power-Up Sequence

[17] See also Section USIM Interfaces.

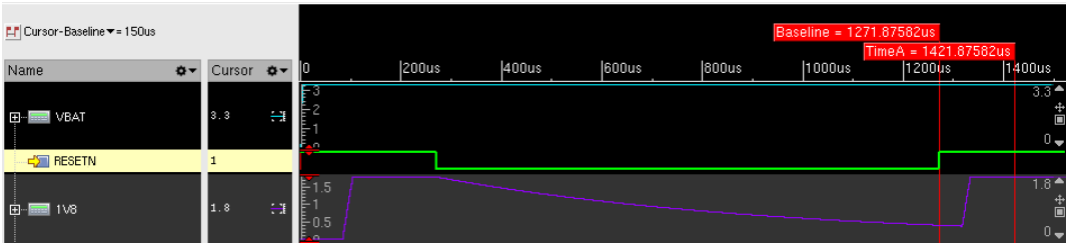


Figure 5: Typical Timing Diagram for Reset Sequence

Note: since RESETN is pulled-up internally, RESETN does not need to be held low after VBAT is established, as shown in Figure 5. There is no timing condition between RESETN and VBAT.

Note: RESETN minimum duration for reliable detection is 100 µs

3.1.3 Power States

Figure 6 represents the electrical states of the module and their transitions.

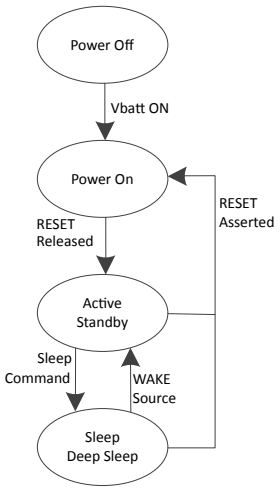


Figure 6: Electrical States and Transitions

Power modes are described in Table 14 and illustrated in Figure 6.

Table 14: Power Modes Description

Power Mode	LTE Mode	Available Interfaces
Active	Connected (RF on)	All interfaces
Standby	Connected (RF off)	All interfaces
Sleep	Short eDRX idle duration RRC Idle	WAKE pins (including RTS0/1)
Deep Sleep	PSM idle, Long eDRX idle duration, radio-off, airplane	WAKE pins (including RTS0/1)

3.1.4 PVDD_1V8 BIDIR Pads State in Deep Sleep mode

In `Deep Sleep` mode, the Digital PVDD_1V8 bi-directional I/Os are completely powered off and behave like 50 MΩ high-impedance pins.

3.1.5 PMU_5V IN Pads State in Deep Sleep mode

In `Deep Sleep` mode the digital PMU_5V inputs are completely powered off and behave like 180 MΩ high-impedance pins.

Table 15 gives the values of the measured leakage current (measurements taken on silicon) for the PMU wake inputs.

Table 15: Measured Leakage Current for the PMU Wake Inputs

Minimum	Typical	Maximum
3 nA	4 nA	12 nA

Table 16 shows values of the external pull-up/pull-down resistor to be used at the PMU wake inputs pads.

Table 16: External Pull-up/Pull-down Resistor at PMU Wake Input Pads

Minimum	Typical	Maximum
1 kΩ	10 kΩ	100 kΩ

Table 17 details the PMU wake input pulses detection mechanism timings.

Table 17: PMU Wake Input Pulses Detection Mechanism Timings

Maximum pulse width guaranteed to be ignored	Minimum pulse width guaranteed to be recognised
11.1 ns	100 μs

Table 18 provides the internal pull-up current range at RESETN.

Table 18: Internal Pull-Up Current at RESETN Pad

Minimum	Typical	Maximum
73.5 nA	100 nA	160.5 nA

3.2 Digital I/O Characteristics

This section details the voltage and current characteristics of the various I/O pads of the GM02S .

The I/Os belong either one of two power groups:

- PVDD_1V8
- PMU_5V

The operational voltage range of both power groups is described in Table 19 and Table 20.

CAUTION: Designers must ensure that the input voltage on any of the I/O pads never exceeds the V_{IH} of the power group they belong to.

See Table 19 for the digital I/O characteristics of the different I/O pads. Refer to each interface of the GM02S in chapter Interfaces for the power group and I/O pad type of each pad. Note that IN pads are inputs only whereas BIDIR can be both inputs and outputs.

Table 19: DC Ratings for Digital I/Os, PVDD_1V8 Power Group

Symbol	Minimum	Maximum	Unit
V_{IH} Input HIGH level	1.26	3.3	V
V_{IL} Input LOW level	0	0.54	V
V_{OH} Output HIGH voltage	1.44	1.8	V
V_{OL} Output LOW voltage	0	0.36	V
I_{RPU} Input pull-up resistor current	15		µA
R_{RPU} Input pull-up resistance	27	34	kΩ
I_{RPD} Input pull-down resistor current	15		µA
R_{RPD} Input pull-down resistance	27	34	kΩ
V_H Input hysteresis	0.18		V
I_{PAD} Input leakage current, non-tolerant	-1	1	µA
I_{OZ} Off-State leakage current		1	µA

Table 20: DC Ratings for Digital I/Os, PMU_5V Power Group

Symbol	Minimum	Maximum	Unit
V_{IH} Input HIGH level	0.8	VBAT + 0.6 (max. 5.5)	V
V_{IL} Input LOW level	0	0.2	V

3.3 RF Performance

Important: For proper operation, the VSWR at the antenna pad must be better than 2:1 in conducted mode and 3:1 in radiated mode. A higher value could result either in poor RF performance, reduced Tx power or increased sideband/harmonic emission levels. Very high VSWRs can permanently damage the power amplifier.

It is recommended to add a DC blocking capacitor in series with the module RF input/output pad (#90).

3.3.1 RF Sensitivity

The GM02S exhibits the following typical RF sensitivity at 2.5 V:

Table 21: RF Sensitivity

Technology	Band	Typical Sensitivity
LTE-M	Low Bands: B5, B8, B12, B13, B14, B17, B18, B19, B20, B26, B28, B71, B85	-105 dBm
	High bands: B1, B2, B3, B4, B25, B66	-106 dBm
NB-IoT	Low Bands: B5, B8, B12, B13, B17, B18, B19, B20, B26, B28, B71, B85	-108 dBm

Technology	Band	Typical Sensitivity
	High bands: B1, B2, B3, B4, B25, B66	-108 dBm

3.3.2 RF Output Power

The GM02S maximum output power within the recommended operating range (from 2.5 to 5.5 V) is given in Table 22.

Table 22: RF Max Output Power

Bands	Output Power
All Bands	23 dBm ± 1 dB

3.3.3 RF performance at 2.2 V

While it is not recommended to operate the GM02S in the range 2.2 to 2.5 V, the RF section will continue to work normally, albeit with reduced TX output power as shown in Table 23 below.

Table 23: RF Performance at 2.2 V compared to 2.5 V

Temperature	Sensitivity Loss	Output Power Loss
-30 °C	No loss	1.1 dB
25 °C	No loss	1.1 dB
85 °C	No loss	1.7 dB

3.4 Power Supply Dimensioning

This section provides guidance to designers working on the power supply or selecting a suitable battery to power the GM02S .

3.4.1 Overview

The current consumption of the GM02S peaks before every TX sub-frame as shown in Figure 7. In this figure, the time division is 50 µs. Around 150 µs from the start, two current pulses peaking 34% higher than the average current consumption during the 23 dBm TX tone which follows can be observed.

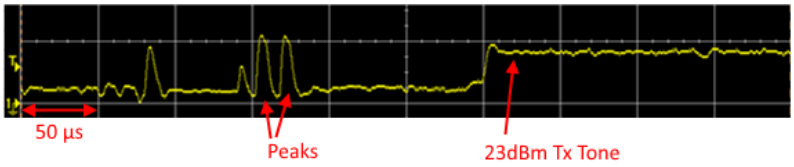


Figure 7: Current Consumption in TX Sub-Frame

3.4.2 Peak Current Measurement Method

Sequans recommends to use the setup represented in Figure 8 for peak current measuring. This setup was used to record the measurements presented in Table 24.

Note that:

1. Voltage probes are placed close to module VBAT input;
2. Voltage probes accuracy is calibrated using a current probe;
3. A large capacitance C_{batt} is placed close to the VBAT pin to simulate a battery and screen the device from the parasitic inductances of the cables and tracks;
4. 2 × 22 µF capacitors (C_{ext}) are placed between the voltage probes and the module VBAT input to soften the current peaks.

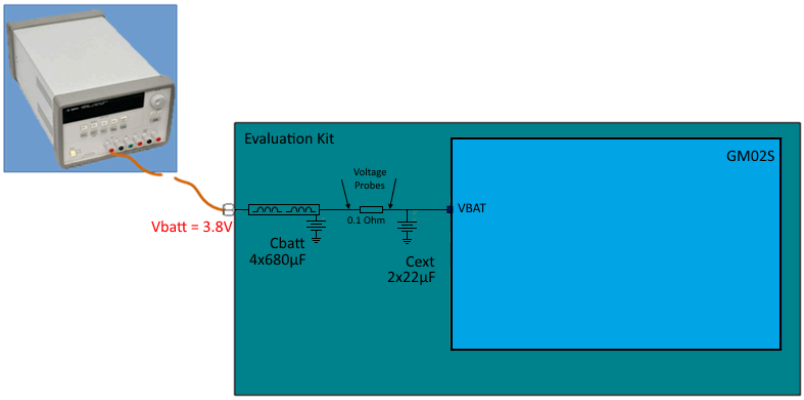


Figure 8: Setup for Current Peak Measurement

3.4.3 Peak Current Measurement

Table 24 gives the peak current values measured on the setup shown on Figure 8 for different voltages and temperatures.

Table 24: Peak Current Measurements

Input Voltage	T = -40°C	T = -30°C	T = +25°C	T = +85°C
5.5 V	328 mA	305 mA	263 mA	268 mA
3.8 V	475 mA	438 mA	444 mA	479 mA
2.5 V	705 mA	667 mA	679 mA	741 mA
2.2 V	676 mA	640 mA	652 mA	717 mA

3.4.4 Margin

Important: It is recommended that designs potentially sensitive to the current peaks described in this section use the recommended C_{ext} 2 × 22 µF and dimension the power supply with an extra 20% margin w/r to the values provided in this section.

3.5 Maximum Electrical Ratings

Table 25: Maximum Electrical Ratings

Parameter	Minimum	Maximum
Supply Voltage VBAT	-0.2 V	5.5 V
I/Os in Power Group PVDD_1V8	-0.2 V	4.125 V

Parameter	Minimum	Maximum
I/Os in Power Group PMU_5V	-0.2 V	6.0 V

3.6 Thermal Considerations

Special attention needs to be given to thermal dissipation.

The outer layers of the host board must be covered in as many wide copper areas as possible, and those must be stitched with evenly spaced ground vias. Care must be taken that no air gap exists along the thermal path from the GM02S to the dissipating copper area(s). Gaps can be filled with heat conducting materials such as *GapPad*™.

The `Gxx` pads should be tied to a large ground plane on the customer's PCB layer 1. It is also recommended to have the `Gxx` pads area on the PCB stitched with through ground vias to improve thermal dissipation.

If the host board is piggybacked over a larger board, the aforementioned heat dissipation considerations should be applied to both the main and the daughter board.

4 Mechanical Characteristics

4.1 Package Description

The package size with tolerance is (16.3 ± 0.15) mm × (17.0 ± 0.15) mm × (1.85 max) mm. Maximum warpage is 0.13 mm (as per JEITA ED7306).

The GM02S weights 0.85 g.

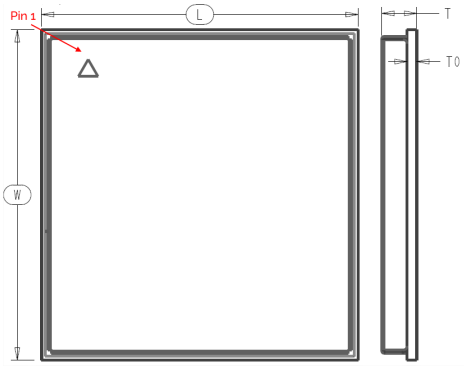


Figure 9: Module Top and Side Views

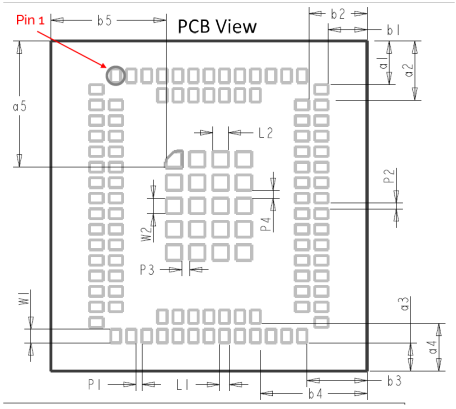


Figure 10: Module PCB View

Table 26: Module Dimensions (mm)

Dimension	Value (mm)
L	16.3 ± 0.15
W	17.0 ± 0.15
T	1.85 max
T0	0.426 max
L1	0.5 ± 0.1
W1	0.7 ± 0.1
L2	0.8 ± 0.1

Dimension	Value (mm)
W2	0.8 ± 0.1
a1	2.25 ± 0.1
a2	3.05 ± 0.1
a3	1.45 ± 0.1
a4	2.45 ± 0.1
a5	6.5 ± 0.1
b1	2.0 ± 0.1
b2	3.0 ± 0.1
b3	3.1 ± 0.1
b4	5.5 ± 0.1
b5	5.95 ± 0.1
P1	0.3 ± 0.1
P2	0.3 ± 0.1
P3	0.4 ± 0.1
P4	0.4 ± 0.1

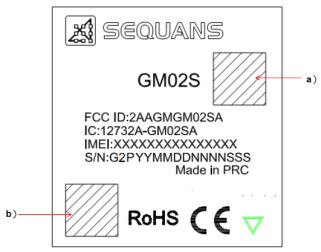


Figure 11: GM02S Laser Marking

Notes on Figure 11:

1. The triangle in the bottom-right corner provides pin #1 location.
2. FCC ID: 2AAGMGM02SA
3. IC: 12732A-GM02SA
4. IMEI:*XXXXXXXXXXXXXXX*
5. S/N:G2P*YYMMDDNNNNSSS* (16 digits)
   - G2P: reserved, value subject to change at Sequans' discretion (3 digits);
   - *YYMMDD*: Manufacturing Date (YY:Year;MM:Month,DD:Day);
   - *NNNN*: Panel counter (from 0001~9999);
   - *SSS*: Piece location on panel (from 001 to 065).
6. 2D marked "a" refer to IMEI Barcode
7. 2D marked "b" refer to S/N Barcode

4.2 Environmental Conditions

GM02S operating conditions:

- Temperature (PCB temperature as measured by on-board thermistor):
  - Operational: -40°C to +85°C;
  - RF compliant: -30°C to +85°C
- Humidity: 10% to 85% (non-condensing)

4.3 Packing

The GM02S is delivered in Tape-and-Reel. Details are provided in the figures below.

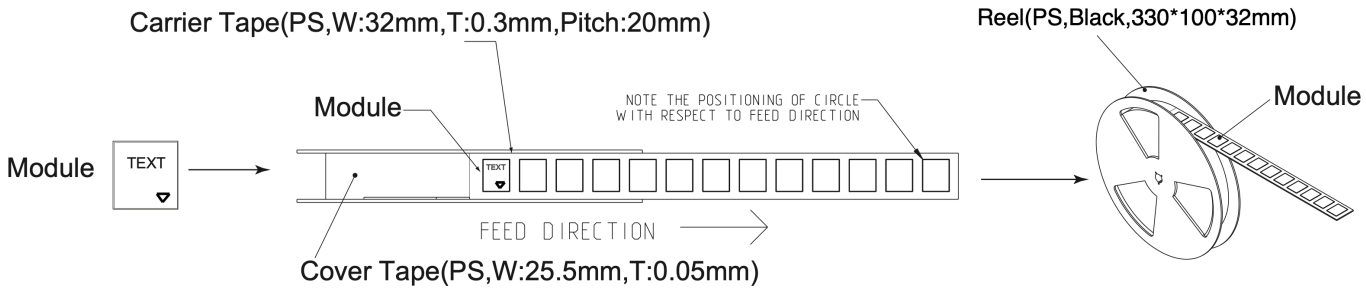


Figure 12: Packing Modules in Reels

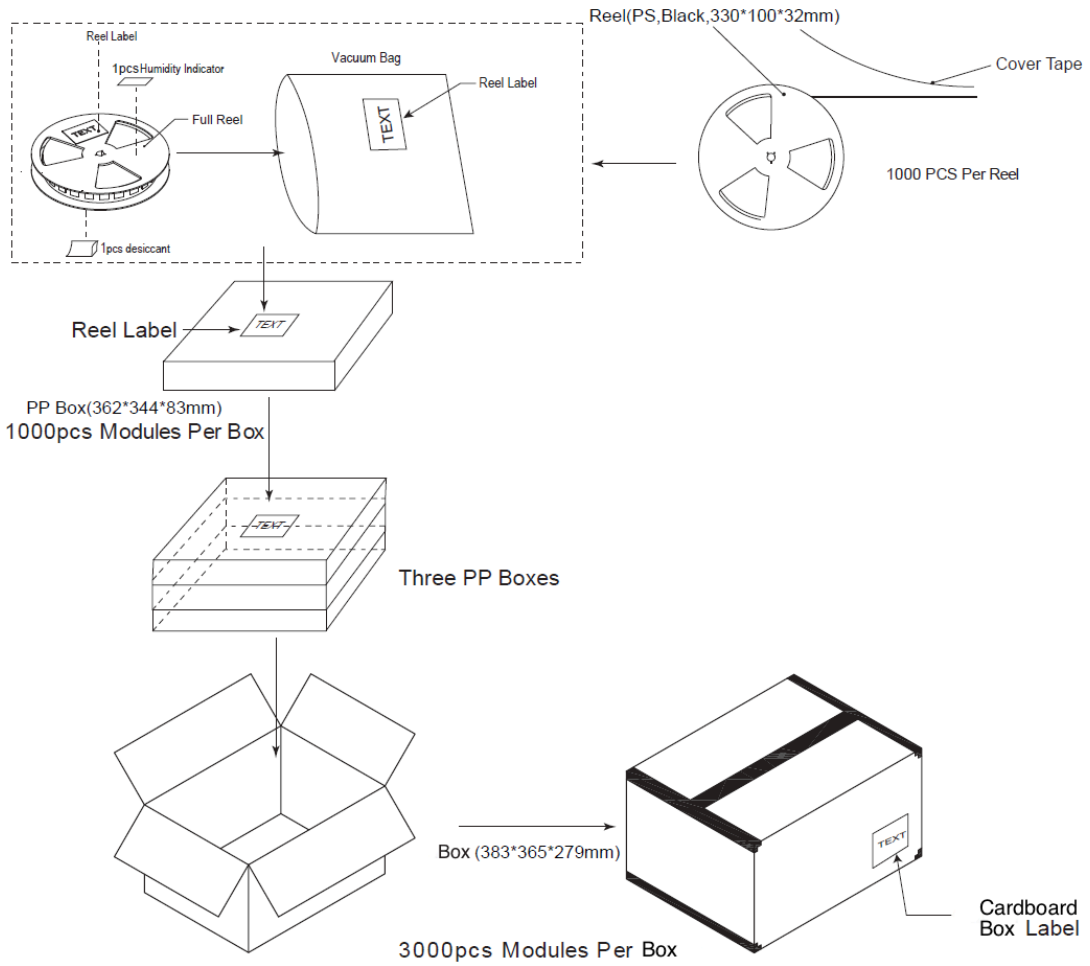


Figure 13: Packing Reels in Boxes

The full box set weights about 5.95 kg.

The label attached to reels, vacuum bags, and the PP boxes is shown in Figure 14. The label attached to the cardboard box (which contains 3 PP boxes) is shown in Figure 15.

Figure 14: Reel, Vacuum Bag and PP Box Label

Figure 15: Cardboard Box Label

4.4 Storage and Mounting

The GM02S module is Moisture Level 3 rated as per JEDEC industrial standard.

The GM02S is JEDEC J-STD-033D compliant and can be stored at T < 40 °C and relative humidity < 90%.

The GM02S can withstand up to three reflows at a maximum of 250 °C.

Table 27: Reflow Profile

Profile Feature	
Solder Paste Alloy	Sn 96.5/Ag 3.0/Cu 0.5 (Lead Free solder paste)
Peak Package Body Temperature	235 °C to 245 °C
Fusion Time	Temp: over 220°C Duration: 60 ~ 90 s
Pre-heat / Soak	Temp: 150 ~ 200 °C Time: 60 ~ 120 s
Ramp-up Rate	< 3 °C/s
Ramp-down Rate	-3 to 0 °C/s

Profile Feature	
Air composition	N_2, O_2 contents less than 1,500 ppm

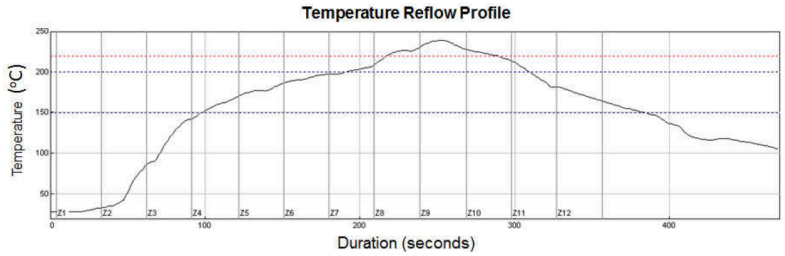


Figure 16: Reflow Profile Parameters

Recommended stencil thickness: 0.1 to 0.13 mm (prefer 0.1 mm). More detail on the PCB land pattern will be provided in a future edition of the document.

4.5 Reliability Specification

GM02S has been tested against Sequans's industrial reliability specification as described in Table 28.

Table 28: Reliability Test Plan

Item	Test conditions	Standard	#Samples	Result
Preconditioning	(a) Bake: 125°C / 24 hours (b) MSL3: 30°C/60% RH, 192 hrs (c) SAT (CSAM & TSCAN) (d) X-ray (e) Reflow 3 cycles at Tp: 250 ±2°C (f) SAT (CSAM & TSCAN)	JESD22-A113	175	PASS
TC	Temperature Shock Cycling (TC): -40°C to +85°C air to air, 20 minutes, ramp rate 20°C/minute, 1000 cycles	JESD22-A104	25	PASS
THB	Temperature Humidity Bias Test +85°C, 85 % RH, Vcc Max, Read Point at 168/500/1,000 hrs	JESD22-A101	25	168 hrs: PASS 500/1,000 hrs: see note below
Environmental Testing - A Cold	Environmental Testing Test A Cold. -40°C, 500 hrs	IEC60068-2-1 JESD22-A119	25	PASS
Environmental Testing - B Dry Heat	Environmental Testing Test B Dry Heat. +85°C, 500 hrs	IEC60068-2-2 JESD22-A103	25	PASS
HTOL	High Temperature Operating Test 75°C, Vcc max, Tx: 50% / Rx: 50%. Read Point at 283/500/1,000 hours	N/A	50	PASS

Item	Test conditions	Standard	#Samples	Result
Shock	Mechanical Shock (MS) (Half Sine, 500G, 1.0 ms, 1 shock for each ±axis)	DIN IEC 68-2-27	15	PASS
Drop	Drop Test 1. Height: 80cm; 2. Concrete or steel; 3. All surfaces and edges.	DIN IEC 68-2-31 ETS 300019-2-7	15	PASS
Vibration	Vibration Test (Vib) Sweep-Sine Vibration. Sinusoidal, 10 ~ 500 Hz, 1.0 octave/min, 10 sweep cycles for 2 hr for each axis.	DIN IEC 68-2-6 EIA/TIA 571 §4.1.1.2	15	PASS
ESD	HBM Start: ±1000V, Stop:± 1500V	JS-001JESD22-A114	12	PASS
	CDM Start: ±250V, Stop: ±500V	JS-002STM5.3.1	12	PASS
TCT	Temperature Change Test 10 cycles; 1 cycle has the following steps (roughly 7+ hrs): • Ramp from ambient (23°C) to -40°C at 3°C/min. • 3 hrs at - 40°C • Ramp to 85°C at 3°C/min • 3 hrs at 85°C • Ramp from 85°C to 23°C at 3°C/min	IEC60068-2-14	25	PASS

Note: THB test is ongoing. Results will be provided in a future edition of the document.

5 Regulatory Approval

5.1 Regulatory Approval, LTE-M Operation Only

5.1.1 FCC Regulatory Approval

`FCC-ID: 2AAGMGM02SA` (single modular approval)

This above identified LTE radio module is not intended to be provided to end-users but is for installation by OEM integrators only.

Installation/Integration

OEM integrators must follow Sequans' installation instructions to provide for and benefit from FCC compliant module integrations and must abide especially by the following provisions:

The maximum antenna gain values (accounting for cable attenuation) to comply with the FCC maximum ERP/EIRP limits and with RF Exposure rules:

- LTE band 2 (1900 PCS): 8.0 dBi
- LTE band 4 (AWS-1): 5.0 dBi
- LTE band 5 (850): 9.4 dBi
- LTE band 12 (700a): 8.6 dBi
- LTE band 13 (700c): 9.1 dBi
- LTE band 17 (700b): 8.7 dBi
- LTE band 25 (1900+): 8.0 dBi
- LTE band 66 (AWS-3): 5.0 dBi

Sequans's module integration guidelines must be closely followed.

Compliance of host integrations of the module is limited to hosts adaptation designs which are identical to Sequans' reference design.

Host integrations with adaption designs deviating from Sequans' reference design require either class 2 permissive change to this modular approval or a separate host approval with different FCC-ID;

Host integrations with co-located (simultaneously operating) radio transmitters must be evaluated in accordance with FCC multi-transmitter rules and may require either class 2 permissive change to this modular approval or a separate host approval with different FCC-ID, dependent on the result of the evaluation; Inquiry at FCC or a TCB is urgently recommended.

Integrations of the module into host products which are intended for portable use, i.e. less than 20cm distance between its radiating structures (antenna) and the body of nearby persons, or which otherwise put additional technical requirements like Hearing Aid compatibility require either class 2 permissive change to this modular approval or a separate host approval with different FCC-ID;

Compliance with Unwanted Emission Limits for Digital Device

If the OEM host integration fully complies with the above described reference design and can completely inherit and rest on compliance of the existing modular approval the OEM remains still responsible to show compliance of the overall end-product with the FCC limits for unwanted conducted and radiated emissions from the digital device (unintentional radio) portion of such end-product (commonly addressed as part 15B compliance or similar).

End-product Labelling

- The module's FCC-ID must either be visible from the exterior of the host product (e.g. per window) or per electronic display, or shall be displayed on an additional exterior label per the following or similar string: `contains FCC-ID: 2AAGMGM02SA`
- Digital Device - Unwanted Emissions Notice: If the end-product falls under part 15 of the FCC rules (it shall display the following user notice on its exterior acc. to part 15.19 (the notice may be printed in the manual in case the host is too small):

  `This device complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) This device may not cause harmful interference, and (2) This device must accept any interference received, including interference that may cause undesired operation.`
- Further Labelling Requirements may apply dependent on the FCC rule parts relevant to the host product.
- End-product User Instructions / Notices in the Manual: At a minimum, end-product users must be provided with the following notices at a prominent location of the product literature furnished with the product:
  - Product Modifications: `Modifications not expressly approved by the party responsible for compliance could void the user's authority to operate this equipment.`
  - RF Exposure Compliance: `This equipment complies with FCC radio frequency radiation exposure rules and limits set forth for an uncontrolled environment, when installed and operated with minimum distance of 20 cm between its radiating structures (antenna) and the body of nearby persons and when not operated simultaneously with other nearby radio-transmitters.`
  - Maximum Antenna Gain: `The user instructions of end-products equipped with standard external antenna connectors for the modular radio transmitter providing the option to connect other antennae than those which may or may not be bundled with the end-product must list the maximum allowed antenna gain values as derived from those given above, accounting for the cable attenuations of the actual installation.`
  - Digital Device - Unwanted Emissions Notice: If the end-product is or contains a digital device (unintentional radio portions) and is not exempted by its use case (like vehicular use) the following part 15.105 (b) user notice shall be provided at prominent location of the product literature:

    `This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to part 15 of the FCC rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is`

encouraged to try to correct the interference by one or more of the following measures:

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

– Further User Notices: May be required dependent on the FCC rule parts relevant to the host product.

– Non-allowed User Instructions: The end-product user guidance may NOT include instructions about how to install or de-install the module.

5.1.2 ISED Regulatory Approval

This device complies with ISED's licence exempt RSSs. Operation is subject to the following two conditions: (1) This device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

Le présent appareil est conforme aux CNR de l'ISED applicables aux appareils radio exempts de licence. L'exploitation est autorisée aux deux conditions suivantes : (1) le dispositif ne doit pas produire de brouillage préjudiciable, et (2) ce dispositif doit supporter tout brouillage reçu, y compris un brouillage susceptible de provoquer un fonctionnement indésirable.

This device is intended only for OEM integrators under the following conditions: (For module device use)

1. The antenna must be installed such that 20 cm is maintained between the antenna and users, and
2. The transmitter module may not be co located with any other transmitter or antenna.

As long as the two conditions above are met, further transmitter test will not be required. However, the OEM integrator is still responsible for testing their end product for any additional compliance requirements required with this module installed.

Cet appareil est conçu uniquement pour les intégrateurs OEM dans les conditions suivantes: (Pour utilisation de dispositif module)

1. L'antenne doit être installée de telle sorte qu'une distance de 20 cm est respectée entre l'antenne et les utilisateurs, et
2. Le module émetteur peut ne pas être co implanté avec un autre émetteur ou antenne.

Tant que les deux conditions ci-dessus sont remplies, des essais supplémentaires sur l'émetteur ne seront pas nécessaires. Toutefois, l'intégrateur OEM est toujours responsable des essais sur son produit final pour toutes exigences de conformité supplémentaires requis pour ce module installé.

- LTE band 2 (1900 PCS): 8.0 dBi
- LTE band 4 (AWS-1): 5.0 dBi
- LTE band 5 (850): 6.1 dBi
- LTE band 12 (700a): 5.6 dBi
- LTE band 13 (700c): 5.9 dBi
- LTE band 17 (700b): 5.6 dBi

- LTE band 25 (1900+): 8.0 dBi
- LTE band 66 (AWS-3): 5.0 dBi

IMPORTANT NOTE:

In the event that these conditions can not be met (for example certain laptop configurations or colocation with another transmitter), then the Canada authorisation is no longer considered valid and the IC ID can not be used on the final product. In these circumstances, the OEM integrator will be responsible for re-evaluating the end product (including the transmitter) and obtaining a separate Canada authorisation.

NOTE IMPORTANTE:

Dans le cas où ces conditions ne peuvent être satisfaites (par exemple pour certaines configurations d'ordinateur portable ou de certaines co-localisation avec un autre émetteur), l'autorisation du Canada n'est plus considéré comme valide et l'ID IC ne peut pas être utilisé sur le produit final. Dans ces circonstances, l'intégrateur OEM sera chargé de réévaluer le produit final (y compris l'émetteur) et l'obtention d'une autorisation distincte au Canada.

End Product Labelling

This transmitter module is authorised only for use in device where the antenna may be installed such that 20 cm may be maintained between the antenna and users. The final end product must be labeled in a visible area with the following: `"Contains IC:12732A-GM02SA"`.

Plaque signalétique du produit final

Ce module émetteur est autorisé uniquement pour une utilisation dans un dispositif où l'antenne peut être installée de telle sorte qu'une distance de 20 cm peut être maintenue entre l'antenne et les utilisateurs. Le produit final doit être étiqueté dans un endroit visible avec l'inscription suivante: `"Contient des IC: 12732A-GM02SA"`.

Manual Information To the End User

The OEM integrator has to be aware not to provide information to the end user regarding how to install or remove this RF module in the user's manual of the end product which integrates this module.

The end user manual shall include all required regulatory information/warning as show in this manual.

Manuel d'information à l'utilisateur final

L'intégrateur OEM doit être conscient de ne pas fournir des informations à l'utilisateur final quant à la façon d'installer ou de supprimer ce module RF dans le manuel de l'utilisateur du produit final qui intègre ce module.

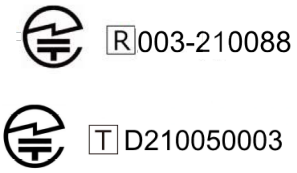
Le manuel de l'utilisateur final doit inclure toutes les informations réglementaires requises et avertissements comme indiqué dans ce manuel.

5.1.3 NCC Regulatory Approval

Installation/Integration
減少電磁波影響，請妥適使用 電波功率密度MPE 標準值：0.90 mW/ cm², 送測產品實測值：0.059 mW/cm², 建議使用時設備天線至少距離人體20公分

5.1.4 ACMA Regulatory Marking

5.1.5 JATE TELEC Regulatory Marking



5.1.6 RED Regulatory Safety Notice

CAUTION: Equipment must be supplied by ES1, PS1 circuits according to the standard EN 62368-1.

5.1.7 UKCA Regulatory Marking

5.2 Regulatory approval, NB-IoT Operation Only

Certification of NB-IoT pre-commercial software release is under way with FCC, ISED, ACMA, RED, UKCA.

A Acronyms

Acronym	Definition
ADC	Analog to Digital Converter
CPU	Central Processing Unit
DL	Downlink
ESD	Electro-static discharge
ETSI	European Telecommunications Standard Institute
GND	Ground
GPIO	General Purpose Input Output
I/O	Input/Output
I²C	Inter-Integrated Circuit interface
IMEI	International Mobile Equipment Identity
IP	Internet Protocol
JTAG	Joint Test Action Group
LGA	Large Grid Array
LNA	Low-Noise Amplifier
LTE	Long Term Evolution, or 4G. Standard is developed by the 3GPP.
MIMO	Multiple In Multiple Out
NAS	Network Access Server
OMADM	Open Mobile Alliance Device Management
PCM	Pulse-Code Modulation
PHY	Physical Layer
RED	European Radio Equipment Directive
SAW	Surface Acoustic Wave (filter)
RF	Radio Frequency
RoHS	Restriction of Hazardous Substances
Rx	Reception
S/N	or SN: Serial Number
SIM	Subscriber Identification Module
SMS	Short Message Service
SPI	Serial Peripheral Interface
Tx	Transmission
UART	Universal Asynchronous Receiver Transmitter
UE	User Equipment
UL	Uplink

Acronym	Definition
USB	Universal Serial Bus