LE910Q1

Hardware Design Guide

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1 Applicability Table

Table 1: Applicability Table

Products
LE910Q1-WW
LE910Q1-SN
LE910Q1-WWG
LE910Q1-SNG

2 Introduction

This document introduces the Telit LE910Q1 module and presents possible and recommended hardware solutions for the development of a product based on the LE910Q1 module. All the features and solutions described in this document are applicable to all LE910Q1 variants, where “LE910Q1” refers to the variants listed in the applicability table.

If a specific feature is applicable to a specific product only, it will be clearly marked.

> Note: LE910Q1 refers to all modules listed in the Applicability Table.

This document covers all the basic functions of a wireless module; it cannot include every hardware solution or every product that can be designed. Where the suggested hardware configurations are not to be considered mandatory, the information provided should be used as a guide and starting point to successfully develop the product with the Telit LE910Q1 module.

> Note: The integration of the LTE LE910Q1 cellular module within a user application must be done according to the design rules described in this manual.

2.1 Audience

This document is intended for system integrators that are using the Telit LE910Q1module in their products.

2.2 Contact Information, Support

For technical support and general questions, e-mail:

- TS-EMEA@telit.com
- TS-AMERICAS@telit.com
- TS-APAC@telit.com
- TS-SRD@telit.com
- TS-ONEEDGE@telit.com

Alternatively, use: https://www.telit.com/contact-us/

For Product information and technical documents, visit: https://www.telit.com

2.3 Conventions

Note:	Provide advice and suggestions that may be useful when integrating the module.
Danger:	This information MUST be followed, or catastrophic equipment failure or personal injury may occur.
Warning:	Alerts the user on important steps about the module integration.

All dates are in ISO 8601 format, that is YYYY-MM-DD.

2.4 Terms and Conditions

Refer to https://www.telit.com/hardware-terms-conditions/.

2.5 Disclaimer

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3 General Product Description

3.1 Overview

The LE910Q1 is a commercial-grade, cost-optimized LTE Cat1 Bis module series ideal for IoT applications that need data transmission. The use of a Single Antenna reduces the hardware design complexity, bringing significant cost savings compared to LTE Cat 1 modules with two antennas, and allowing for the reduction of the overall device dimensions, making it possible to serve IoT applications with stringent size requirements. The optional embedded GNSS receiver makes the LE910Q1 ideal for all-in-one tracking use cases in which more precise, faster-refreshing, satellite-based positioning and navigation must complement cellular-based positioning.

LE910Q1 is available in hardware variants as listed in Applicability Table. For differences in the designated RF band sets – refer to Section 7.1.Bands Variants.

Note:

(EN) The integration of the LE910Q1 cellular module within user application shall be done according to the design rules described in this manual.

(IT) L'integrazione del modulo cellulare LE910Q1 all'interno dell'applicazione dell'utente dovrà rispettare le indicazioni progettuali descritte in questo manuale.

(DE) Die Integration des LE910Q1 Mobilfunk-Moduls in ein Gerät muß gemäß der in diesem Dokument beschriebenen Kunstruktionsregeln erfolgen.

(SL) Integracija LE910Q1 modula v uporabniški aplikaciji bo morala upoštevati projektna navodila, opisana v tem priročniku.

(SP) La utilización del modulo LE910Q1 debe ser conforme a los usos para los cuales ha sido deseñado descritos en este manual del usuario.

(FR) L'intégration du module cellulaire LE910Q1 dans l'application de l'utilisateur sera faite selon les règles de conception décrites dans ce manuel.

(HE)

האינטגרטור מתבקש ליישם את ההנחיות המפורטות במסמך זה בתהליך האינטגרציה של המודם הסלולארי LE910Q1 עם המוצר.

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3.2 Product Variants and Frequency Bands

Table below summarizes all region variants within the LE910Q1 family, showing the band sets supported in each variant.

The following bands combinations are available:

Table 2 RF Bands Variant

Region Variant	LTE FDD	LTE TDD	GNSS
LE910Q1-WW	B1, B2, B3, B4, B5, B7, B8, B12, B13, B18, B19, B20, B25, B26, B28, B66, B8_39d*	B34, B38, B39, B40, B41	
LE910Q1-SN	B2, B4, B5, B12, B13, B66		
LE910Q1-WWG	B1, B2, B3, B4, B5, B7, B8, B12, B13, B18, B19, B20, B25, B26, B28, B66, B8_39d*	B34, B38, B39, B40, B41	GNSS (GPS-GLONASS-Galileo-BeiDou-QZSS-SBAS)
LE910Q1-SNG	B2, B4, B5, B12, B13, B66		GNSS (GPS-GLONASS-Galileo-BeiDou-QZSS-SBAS)

Refer to “RF SECTION” for details information about frequencies and bands.

Note: * “B8_39d” is not a 3GPP band, it means the following:

U.S. FCC 900MHz that employs 39MHz duplexing

UL range: 897.5-900.5MHz, DL range: 936.5-939.5

It is available only for modules where AT#BNDOPTIONS command contains the string

B8_39d. that is AT#BNDOPTIONS?

#BNDOPTIONS: 1,2,3,4,5,8,12,13,18,19,20,25,26,27,28,66,71,85, B8_39d.

Note: Cellular technologies and frequency bands that are enabled may vary based on firmware version and firmware configuration used.

3.3 Target Market

LE910Q1 can be used for applications where tamper-resistance, confidentiality, integrity, and authenticity of end-user information are required, for example:

- Road pricing
- Pay-as-you-drive insurance.
- Internet connectivity

3.4 Main Features

The LE910Q1 series of cellular modules features an LTE CAT1 Bis modem baseband and RF transceiver to cover 700MHz~2.7GHz bands for worldwide roaming.

Table 3: Functional Features

Function	Features
Modem	FDD, TDD LTE CAT1 Bis DL 10Mbps/ UL 5Mbps LTE+LTE dual-SIM single-standby supported Support for MNO profile switching. Regional variants with optimal choice of RF bands for worldwide coverage of countries and MNOs State-of-the-art GNSS solution with GPS/GLONASS/Galileo/BeiDou/QZSS/ SBAS receiver
SIM	Dual SIM/USIM card controller (optional internal eSIM)
Application processor	Application processor to run customer application code Arm Cortex-M3, support frequencies: 204 MHz/102 MHz/26 MHz Eight-entry MPU 16 KB cache > 1 MB SRAM 4 MB on-chip NOR flash
Interfaces	Rich set of interfaces, including: USB2.0 – USB port is typically used for: • Flashing of firmware and module configuration • Production testing • AT command access • Diagnostic monitoring and debugging Peripheral Ports – I2C, UART GPIOs SPI (as alternate function) ADCs Antenna ports
Form factor	Form factor (28.2mmx28.2mm), accommodating the multiple RF bands in each region variant
Environment and quality requirements	The entire module is designed and qualified by Telit for satisfying the environment and quality requirements.
Single supply module	The module generates all its internal supply voltages.
RTC	No dedicated RTC supply, RTC is supplied by VBATT
Operating temperature	Range -40 °C to +85 °C (conditions as defined in Section 3.8 Temperature Range)

3.5 Block Diagram

Figure below shows an overview of the internal architecture of the LE910Q1 module. It includes the following sub-functions:

- PMIC, Application processor and Modem subsystem with their external interfaces. These three functions are contained in a single SOC.
- RF front end and antenna ports.
- Rich IO interfaces. Depending on which LE910Q1 software features are enabled, some of its exported interfaces due to multiplexing may be used internally and therefore may not be usable by the application.

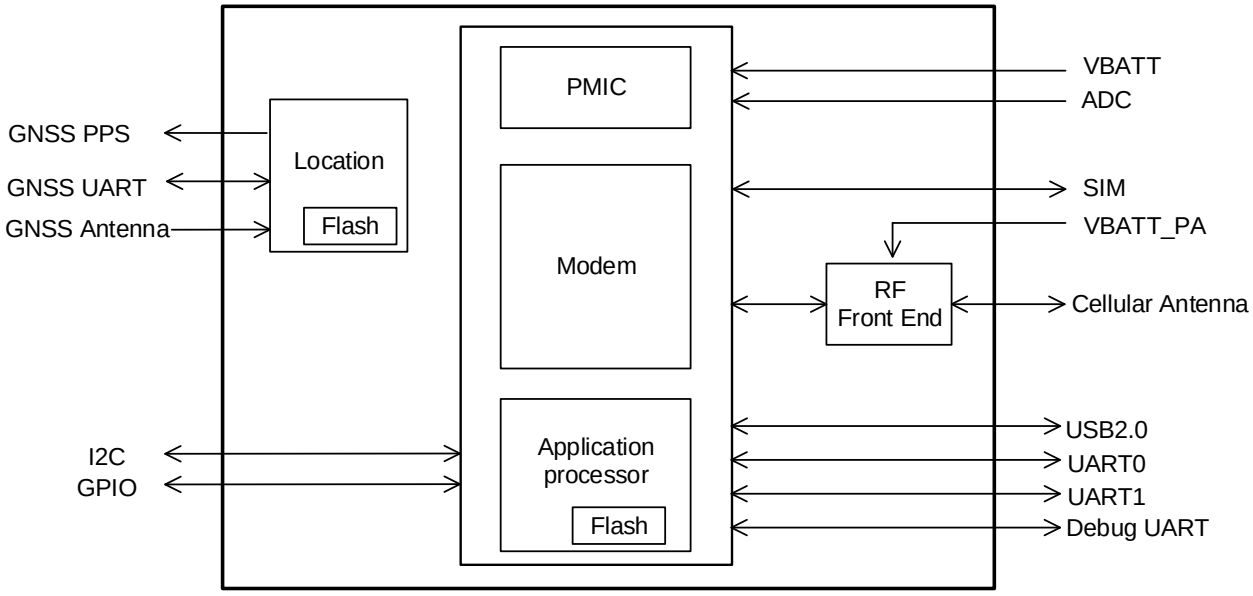

Figure 1: Block Diagram with main functions

3.6 TX Output Power

Typical values for Max output level are as follow:

Table 4: Transmission Output Power – Band

Band	Mode	Class	RF power (dBm) Nominal*
B1, B2, B3, B4, B5, B7, B8, B12, B13, B18, B19, B20, B25, B26, B28, B66, B8_39d	4G LTE FDD -CAT1bis	3	23dBm
B34, B38, B39, B40, B41	4G LTE TDD -CAT1bis	3	23dBm

* Max output power tolerance range according to 3GPP TS 36.521-1 or better

3.7 Mechanical Specifications

3.7.1 Dimensions

The overall dimensions of LE910Q1 are:

Table 5: LE910Q1 dimensions

X Y Z	mm
Length	28.2 mm, +/- 0.25 mm tolerance
Width	28.2 mm, +/- 0.25 mm tolerance
Thickness	2.6 mm, +/- 0.2 mm tolerance

3.7.2 Weight

The nominal weight of the LE910Q1 module is 4.2 grams.

3.8 Temperature Range

Table 6: Temperature Range

Mode	Temperature	Note
Operating Temperature Range	–35°C ÷ +75°C	The module is fully functional(*) in all the temperature range and it fully meets the 3GPP specifications. EU RED certification range.
	–40°C ÷ +85°C	The module is fully functional (*) in all the temperature range, might slightly deviate from the 3GPP specifications.
Storage and non-operating Temperature Range	–40°C ÷ +85°C	The module is not powered and not connected to power supply

Note: (*) Functional: if applicable, the module is able to make and receive data calls, send and receive SMS and data traffic.

4 Pins Allocation

4.1 Pin-out

Table 7: Pin-out Information

PAD	Signal	I/O	Function	Type	Power Domain	Comment
	USB HS 2.0 Communication Port					
B15	USB_D+	I/O	USB differential Data (+)			
C15	USB_D-	I/O	USB differential Data (-)			
F14	FORCED_USB_BOOT	I	FORCED_USB_BOOT	1.8V	VP1	Pull up to VAUX to enter emergency download mode. Same net on two pins.
M9	FORCED_USB_BOOT	I	FORCED_USB_BOOT	1.8V	VP1	
	Asynchronous UART					
N15	C103/TXD	I	Serial data input (TXD) from DTE	1.8V	VP1	
M15	C104/RXD	O	Serial data output to DTE	1.8V	VP1	
M14	C108/DTR	I	Input for Data Terminal Ready (DTR) from DTE	1.8V	VAON	
L14	C105/RTS	I	Input for Request to send signal (RTS) from DTE	1.8V	VP1	
P15	C106/CTS	O	Output for Clear to send signal (CTS) to DTE	1.8V	VP1	
N14	C109/DCD	O	Output for Data Carrier Detect (DCD) to DTE	1.8V	VAON	
P14	C107/DSR	O	Output for Data Set Ready (DSR) to DTE	1.8V	VP1	
R14	C125/RING	O	Output for Ring Indication (RI) to DTE	1.8V	VAON	
K4	DEBUG_UART_TXD	O	Trace UART TX	1.8V	VP1	UART_DEBUG
M6	DEBUG_UART_RXD	I	Trace UART RX‡	1.8V	VP1	
	AUX UART					
D15	TX_AUX	O	TX_AUX/ SPI_CLK	1.8V	VP1	UART for GNSS variant

PAD	Signal	I/O	Function	Type	Power Domain	Comment
E15	RX_AUX	I	RX_AUX/ SPI_MISO	1.8V	VP1	UART for GNSS variant
	SIM Card Interface 1					
A6	SIMCLK1	O	External SIM 1 signal – Clock	1.8V	VSIM	
A7	SIMRST1	O	External SIM 1 signal – Reset	1.8V	VSIM	
A5	SIMIO1	I/O	External SIM 1 signal - Data I/O	1.8V	VSIM	Internally PU 4.7 kΩ to SIMVCC1
A4	SIMIN1	I	External SIM 1 signal - Presence	1.8V	VAON	Active low
A3	SIMVCC1	-	External SIM 1 signal – Power supply for SIM 1	1.8V		
	SIM Card Interface 2					
C1	SIMCLK2	O	External SIM 2 signal – Clock	1.8V	VP1	
D1	SIMRST2	O	External SIM 2 signal – Reset	1.8V	VP1	
C2	SIMIO2	I/O	External SIM 2 signal - Data I/O	1.8V	VP1	Internally PU 10kΩ to SIMVCC2
D2	SIMVCC2		External SIM 2 signal – Power supply for SIM 2	1.8V		
	General Purpose Digital I/O					
C8	GPIO_1	I/O	STAT_LED/ GPIO_1	1.8V	VAON	
C9	GPIO_2	I/O	GPIO_2	1.8V	VP1	
C10	GPIO_3	I/O	GPIO_3	1.8V	VP1	
C11	GPIO_4	I/O	GPIO_4	1.8V	VAON	
B14	GPIO_5	I/O	GPIO_5	1.8V	VL33	
C12	GPIO_6	I/O	GPIO_6	1.8V	VAON	
C13	GPIO_7	I/O	GPIO_7/ GNSS_EN# OUT	1.8V	VL33	GNSS_EN# OUT is active in LE910Q1-xxG
K15	GPIO_8	I/O	SW_RDY/ GPIO_8	1.8V	VL33	
L15	GPIO_9	I/O	GPIO_9/ GNSS_RESET# OUT	1.8V	VL33	GNSS_RESET# OUT is active in LE910Q1-xxG
G15	GPIO_10	I/O	GPIO_10/ GNSS_VCC_DIS OUT	1.8V	VL33	GNSS_VCC_DIS OUT is active in LE910Q1-xxG
H14	GPIO_11	I/O	GPIO_11/ SPI_CS	1.8V	VP1	

PAD	Signal	I/O	Function	Type	Power Domain	Comment
J13	GPIO_12	I/O	GPIO_12	1.8V	VAON	
N13	GPIO_13	I/O	GPIO_13	1.8V	VP1	
F15	GPIO_14	I/O	GPIO_14/ SPI_MOSI	1.8V	VP1	
	RF Section					
K1	Antenna	I/O	LTE Main antenna (50 Ohm)	RF		
	GNSS Section					
R9	ANT_GNSS	I	GNSS antenna (50 Ohm)	RF		Reserved on variant without GNSS
R7	GNSS_LNA_EN	O	Enables the external regulator for GNSS LNA	1.8V	VGNSS	Reserved on variant without GNSS
N9	GNSS_PPS	O	GNNS 1PPS signal	1.8V	VGNSS	Reserved on variant without GNSS
G14	GNSS_EN#	I	GNSS ENABLE (ACTIVE LOW)	1.8V		Active low Reserved on variant without GNSS
J14	GNSS_NMEA_TX	O	GNSS NMEA TX (GNSS receiver serial port)	1.8V	VGNSS	Reserved on variant without GNSS
K14	GNSS_NMEA_RX	I	GNSS NMEA RX (GNSS receiver serial port)	1.8V	VGNSS	Reserved on variant without GNSS
J12	GNSS_RESET#	I	GNSS RESET signal (ACTIVE LOW)	1.8V		Reserved on variant without GNSS
K12	GNSS_NMEA_CTS	I	GNSS NMEA Clear to send signal (CTS)	1.8V	VGNSS	Reserved on variant without GNSS
H12	GNSS_NMEA_RTS	O	GNSS NMEA Request to send signal (RTS)	1.8V	VGNSS	Reserved on variant without GNSS
E12	GNSS_VCC_DIS	I	Disable GNSS power except RTC power.	1.8V		Active high. Reserved on variant without GNSS
	Miscellaneous Functions					
R12	ON_OFF#	I	Power ON / Power OFF input			Active low
R13	EMERG_RST#	I	RESET signal	1.8V	VAON	Active low, refer to specific

PAD	Signal	I/O	Function	Type	Power Domain	Comment
						section for details
R11	VAUX/PWRMON	O	Supply output for external accessories / Power ON monitor	1.8V		
E13	VIO_1V8	O	IO voltage for internal ICs	1.8V		
B1	ADC_IN1	AI	Analog / Digital Converter Input 1	Analog	VLA	
H4	ADC_IN2	AI	Analog / Digital Converter Input 2	Analog	VLA	
D7	ADC_IN3	AI	Analog / Digital Converter Input 3	Analog	VLA	
	I2C Interface					
B11	I2C_SCL	O	I2C clock	1.8V	VP1	Need external PU 4.7kΩ to 1.8V
B10	I2C_SDA	I/O	I2C Data	1.8V	VP1	Need external PU 4.7kΩ to 1.8V
	Power Supply					
M1	VBATT	-	Main Power Supply (Digital Section)	Power		
M2	VBATT	-	Main Power Supply (Digital Section)	Power		
N1	VBATT_PA	-	Main Power Supply (RF Section)	Power		
N2	VBATT_PA	-	Main Power Supply (RF Section)	Power		
P1	VBATT_PA	-	Main Power Supply (RF Section)	Power		
P2	VBATT_PA	-	Main Power Supply (RF Section)	Power		
A2	GND	-	Ground			
B13	GND	-	Ground			
D4	GND	-	Ground			
E1	GND	-	Ground			
E2	GND	-	Ground			
E14	GND	-	Ground			
F2	GND	-	Ground			
G1	GND	-	Ground			
G2	GND	-	Ground			

PAD	Signal	I/O	Function	Type	Power Domain	Comment
G7	GND	-	Ground			
G8	GND	-	Ground			
G9	GND	-	Ground			
H1	GND	-	Ground			
H2	GND	-	Ground			
H7	GND	-	Ground			
H8	GND	-	Ground			
H9	GND	-	Ground			
J1	GND	-	Ground			
J2	GND	-	Ground			
J7	GND	-	Ground			
J8	GND	-	Ground			
J9	GND	-	Ground			
K2	GND	-	Ground			
L1	GND	-	Ground			
L2	GND	-	Ground			
M3	GND	-	Ground			
M4	GND	-	Ground			
M12	GND	-	Ground			
N3	GND	-	Ground			
N4	GND	-	Ground			
N5	GND	-	Ground			
N6	GND	-	Ground			
P3	GND	-	Ground			
P4	GND	-	Ground			
P5	GND	-	Ground			
P6	GND	-	Ground			
P8	GND	-	Ground			
P9	GND	-	Ground			
P10	GND	-	Ground			
P13	GND	-	Ground			
R2	GND	-	Ground			
R3	GND	-	Ground			
R5	GND	-	Ground			
R6	GND	-	Ground			
R8	GND	-	Ground			
R10	GND	-	Ground			
	Reserved for Internal Use					
A13	Reserved	-	Reserved			

PAD	Signal	I/O	Function	Type	Power Domain	Comment
G4	Reserved	-	Reserved			
B2	Reserved	-	Reserved			
B3	Reserved	-	Reserved			
B4	Reserved	-	Reserved			
B5	Reserved	-	Reserved			
G13	Reserved	-	Reserved			
F13	Reserved	-	Reserved			
L13	Reserved	-	Reserved			
M13	Reserved	-	Reserved			
K13	Reserved	-	Reserved			
H13	Reserved	-	Reserved			
L12	Reserved	-	Reserved			
M11	Reserved	-	Reserved			
M10	Reserved	-	Reserved			
L4	Reserved	-	Reserved			
B9	Reserved		Reserved			
B6	Reserved		Reserved			
B7	Reserved		Reserved			
B8	Reserved		Reserved			
B12	Reserved	-	Reserved			
P7	Reserved	-	Reserved			
D12	Reserved	-	Reserved			
	Reserved					
A8	Reserved	-	Reserved			
A9	Reserved	-	Reserved			
A10	Reserved	-	Reserved			
A11	Reserved	-	Reserved			
A12	Reserved	-	Reserved			
A14	Reserved	-	Reserved			
C7	Reserved	-	Reserved			
D5	Reserved	-	Reserved			
D6	Reserved	-	Reserved			
D8	Reserved	-	Reserved			
D9	Reserved	-	Reserved			
D10	Reserved	-	Reserved			
D11	Reserved	-	Reserved			
D13	Reserved	-	Reserved			
D14	Reserved	-	Reserved			
E4	Reserved	-	Reserved			

PAD	Signal	I/O	Function	Type	Power Domain	Comment
F1	Reserved	-	Reserved			
F4	Reserved	-	Reserved			
G3	Reserved	-	Reserved			
H3	Reserved	-	Reserved			
H15	Reserved	-	Reserved			
J3	Reserved	-	Reserved			
J4	Reserved	-	Reserved			
J15	Reserved	-	Reserved			
M5	Reserved	-	Reserved			
M7	Reserved	-	Reserved			
M8	Reserved	-	Reserved			
N7	Reserved	-	Reserved			
N8	Reserved	-	Reserved			
N10	Reserved	-	Reserved			
N11	Reserved	-	Reserved			
N12	Reserved	-	Reserved			
P11	Reserved	-	Reserved			
P12	Reserved	-	Reserved			
C14	Reserved	-	Reserved			
C4	Reserved	-	Reserved			
C3	Reserved	-	Reserved			
C5	Reserved	-	Reserved			
C6	Reserved	-	Reserved			
D3	Reserved	-	Reserved			
E3	Reserved	-	Reserved			
F3	Reserved	-	Reserved			
R4	Reserved	-	Reserved			
K3	Reserved	-	Reserved			
L3	Reserved	-	Reserved			
F12	Reserved	-	Reserved			
G12	Reserved	-	Reserved			

Note: The following pins are unique for the LE910Q1 and may not be supported on other (former or future) xE910 family modules. Special care must be taken when designing the application board if future compatibility is required.

- I2C_SCL
- I2C_SDA
- ADC_IN1
- ADC_IN2
- ADC_IN3

Note: UART_AUX_RXD shall not be logic level LOW at startup.

Warning: Reserved pins must not be connected.

4.2 Signals that Must Be Connected

Table below lists the LE910Q1 signals that must be connected even if not used by the end application:

Table 8: LE910Q1 signals that must be connected.

PAD	Signal	Notes
M1, M2, N1, N2, P1, P2	VBATT & VBATT_PA	
A2, B13, D4, E1, E2, E14, F2, G1, G2, G7, G8, G9, H1, H2, H7, H8, H9, J1, J2, J7, J8, J9, K2, L1, L2, M3, M4, M12, N3, N4, N5, N6, P3, P4, P5, P6, P8, P9, P10, P13, R2, R3, R5, R6, R8, R10	GND	
R12	ON_OFF#	Main power on off signal
R13	EMERG_RST	Reset signal
B15	USB_D+	If not used, connect to a Test Point or an USB connector
C15	USB_D-	If not used, connect to a Test Point or an USB connector
F14	FORCED_USB_BOOT	If not used, connect to a Test Point
N15	C103/TXD	If not used, connect to a Test Point
M15	C104/RXD	If not used, connect to a Test Point
L14	C105/RTS	If flow control is not used, connect to GND
P15	C106/CTS	If not used, connect to a Test Point
K4	DEBUG_UART_TXD	If not used, connect to a Test Point
M6	DEBUG_UART_RXD	If not used, connect to a Test Point

PAD	Signal	Notes
C8	GPIO_1/STAT_LED	If not used, connect to a Test Point
K1	Antenna	MAIN antenna
R9	ANT_GNSS	GNSS antenna, only for LE910Q1-XXG
G14	GNSS_EN#	Internal GNSS enabling, only for LE910Q1-XXG
J14	GNSS_NMEA_TX	GNSS NMEA streaming, only for LE910Q1-XXG
K14	GNSS_NMEA_RX	GNSS NMEA streaming, only for LE910Q1-XXG

4.3 LGA Pads Layout

TOP VIEW LE910Q1-xx

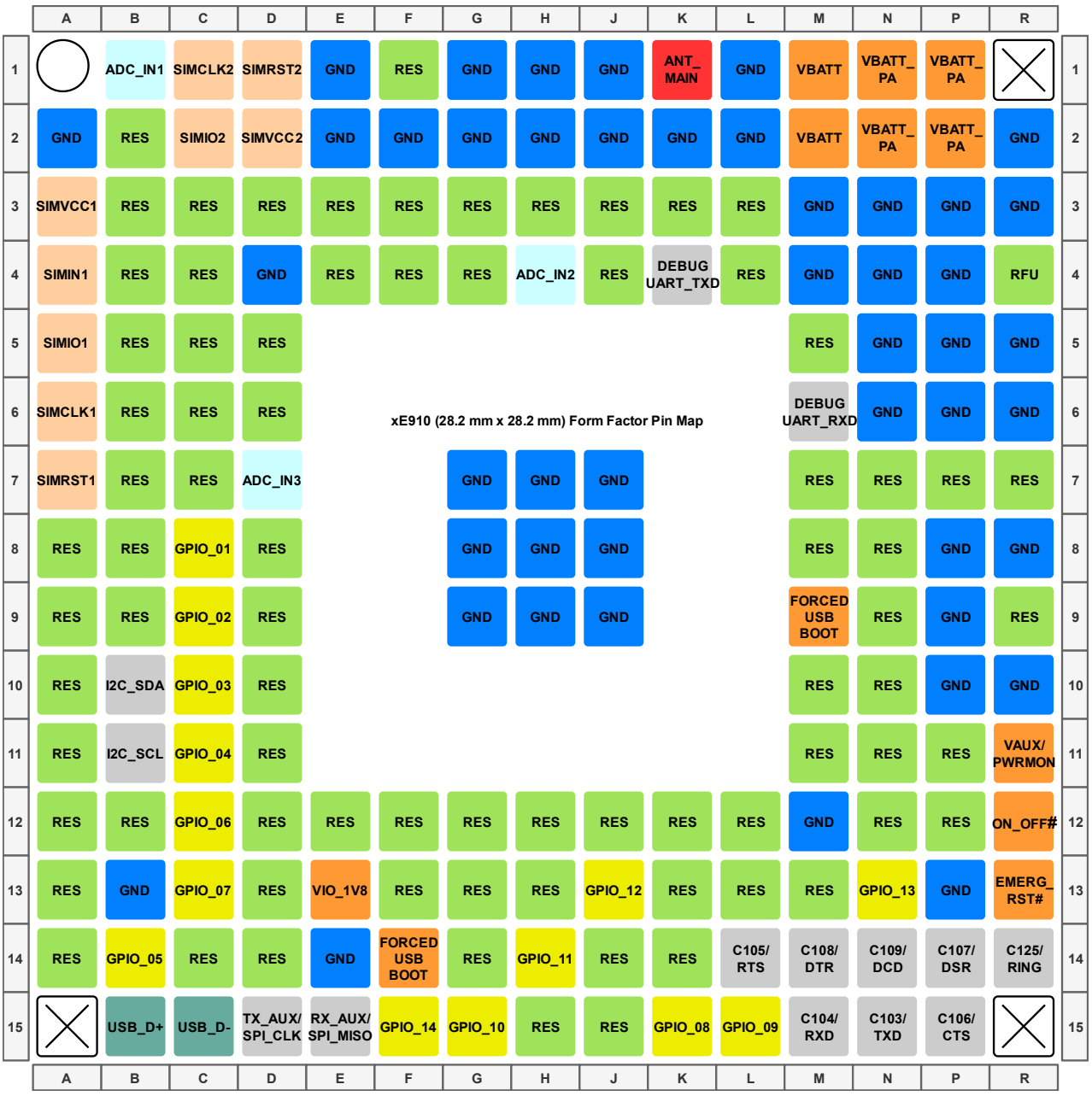

Figure 2: LGA Pads Layout LE910Q1-XX

- SUPPLY AND CONTROL
- SIM CARD
- ANALOG FUNCTIONALITY
- GROUND
- DIGITAL FUNCTIONALITY
- DIGITAL COMMUNICATION
- HIGH SPEED DIGITAL COMMUNICATION
- EXT. MEMORY INTERFACE
- RF SIGNALS
- NO CONNECT / RESERVED FOR FUTURE USE

TOP VIEW LE910Q1-xxG

Figure 3: LGA Pads Layout LE910Q1-XXG

SUPPLY AND CONTROL
SIM CARD
ANALOG FUNCTIONALITY
GROUND
DIGITAL FUNCTIONALITY
DIGITAL COMMUNICATION
HIGH SPEED DIGITAL COMMUNICATION
EXT. MEMORY INTERFACE
RF SIGNALS
NO CONNECT / RESERVED FOR FUTURE USE

4.4 Pin Characteristics by Power Domains

Table 9: VP1 and VL33 Power Domain - Electrical Characteristics

Parameter	Description	Min	Max	Units
VP1, VL33	Internal Supply Voltage	1.75	1.85	V
V_{IH}	High-level input voltage	1.26	-	V
V_{IL}	Low-level input voltage	-0.3	0.36	V
V_{OH}	High-level output voltage, CMOS	1.44	-	V
V_{OL}	Low-level output voltage, CMOS	0.0	0.27	V
V_{SHYS}	Schmitt hysteresis voltage	62	111	mV
I_{OH}		TBD		mA
I_{OL}			TBD	mA
R_{PU}	Pull-up resistance	117	331	kΩ
R_{PD}	Pull-down resistance	91	291	kΩ
C_i	Input capacitance	--	3.5	pF

Table 10: VSIM Power Domain - Electrical Characteristics

Parameter	Description	Min	Max	Units
VSIM	Internal Supply Voltage	1.75	1.85	V
V_{IH}	High-level input voltage	1.26	-	V
V_{IL}	Low-level input voltage	-0.3	0.36	V
V_{OH}	High-level output voltage	1.44	-	V
V_{OL}	Low-level output voltage	0.0	0.27	V
V_{SHYS}	Schmitt hysteresis voltage	62	111	mV
I_{OH}		TBD		mA
I_{OL}			TBD	mA

Table 11: VAON Power Domain - Electrical Characteristics

Parameter	Description	Min	Max	Units
VAON	Internal Supply Voltage	1.9	2.1	V
V_{IH}	High-level input voltage	0.7 * V_{DD}	-	
V_{IL}	Low-level input voltage	-0.3	0.2 * V_{DD}	V
V_{OH}	High-level output voltage	TBD	TBD	V
V_{OL}	Low-level output voltage	TBD	TBD	V
V_{SHYS}	Schmitt hysteresis voltage	200	-	mV
I_{OH}		TBD		mA
I_{OL}			TBD	mA
R_{PU}	Pull-up resistance	170	230	kΩ
R_{PD}	Pull-down resistance	-	-	kΩ
C_i	Input capacitance	1.5	2.0	pF

Table 12: VLA (ADC inputs) Power Domain - Electrical Characteristics

Parameter	Description	Min	Max	Units
V_{IN_ADC}	Voltage input swing	0	1.2	V
C_{IN_U}	Input Capacitance Unselected channel	0.1		pF
C_{IN_S}	Input Capacitance Selected channel	1.2		pF
R_{IN_U}	Input Resistance Unselected channel	29	-	MΩ
R_{IN_S}	Input Resistance Selected channel	0.26	0.75	MΩ

Table 13: VGNSS Power Domain - Electrical Characteristics

Parameter	Description	Min	Max	Units
VGNSS	Internal Supply Voltage	1.62	1.98	V
V_{IH}	High-level input voltage	0.75 * VGNSS	VGNSS + 0.3	V
V_{IL}	Low-level input voltage	-0.3	0.25 * VGNSS	V
V_{OH}	High-level output voltage	1.53	-	V
V_{OL}	Low-level output voltage	0.0	0.27	V
V_{SHYS}	Schmitt hysteresis voltage	62	111	mV
I_{OH}	Digital High Output Current (max drive mode)	8	-	mA
I_{OL}			TBD	mA
R_{PU}	Pull-up resistance	70	380	kΩ
R_{PD}	Pull-down resistance	70	380	kΩ

Note: VAON rail is active regardless the Power Saving Mode applied to the module. This rail is activated at first power on and remains active until VBATT is removed. GPIO pins belonging to this power domain can retain previous value if properly set up by AT command.

5 Power Supply

The power supply circuitry and board layout are very important parts of the complete product design, with a critical impact on the overall product performance. Please read the following requirements and guidelines carefully to ensure a good and proper design.

5.1 Power Supply Requirements

The LE910Q1 power requirements are as follows:

Table 14: Power Supply Requirements

Power Supply	Value
Nominal Supply Voltage	3.8V
Operating Voltage Range	normal: 3.4 - 4.2 V extended 3.1 - 4.5 V

Note: The Operating Voltage Range MUST never be exceeded; the application's power supply section must be designed with care to avoid an excessive voltage drop.

If the voltage drop exceeds the limits it may cause an unintentional module power off.

Note: For approval on the final products the power supply is required to be within the "Normal Operating Voltage Range". In the extended voltage operating range below the 3.4V the RF power could have some reduction.

5.2 Power Consumption

Table below provides typical current consumption values of LE910Q1 for the various available modes.

Table 15: Current Consumption

Mode	Average (Typ.)	Mode Description
Switched Off		
Switched off	2.7uA	Module supplied but switched Off (RTC On)
Idle Mode (Standby Mode; No data call in Progress)		
AT+CFUN = 1	8.1mA	Module full functionality with power saving disabled
AT+CFUN=4	7mA	Disabled TX and RX; module is not registered on the network

Mode	Average (Typ.)	Mode Description
AT+CFUN=5	7.2mA	Paging cycle #256 frames
AT+CFUN=14	280uA	Paging cycle #256 frames (2.56s DRx cycle)
	100uA	81.92s eDRx cycle length (PTW=2.56s, DRX=1.28s)
	89uA	327.68s eDRx cycle length (PTW=2.56s, DRX=1.28s)
	87uA	655.36s eDRx cycle length (PTW=2.56s, DRX=1.28s)
	86uA	1310.72s eDRx cycle length (PTW=2.56s, DRX=1.28s)
	85uA	2621.44s eDRx cycle length (PTW=2.56s, DRX=1.28s)
PSM Mode		
AT+CPSMS=1	56uA	No current source or sink by any connected pin
Operative Mode (GNSS)		
GNSS	24mA before fix and 22mA in tracking	

Note: Worst/best case current values depend on network configuration, not under module control.

Note: The electrical design for the power supply must ensure a peak current output of at least 1.0A.

The support of specific network wireless technology depends on the product variant configuration.

Note: The CFUN5 low power mode is retained for backward compatibility with previous Telit Cinterion modules. Entering and exiting from CFUN5 power mode is triggered by changes in the DTR signal. This mode does not provide the best power consumption because many power domains remain active, to improve power consumption the CFUN14 mode has been introduced. CFUN14 state is entered immediately after setting the mode by AT command but prior to it GPIO12 needs to be configured to wake up the module (AT#GPIO=12,0,13 or AT#GPIO=12,0,14 according to customer design needs), refer to AT Command Guide for further details.

5.3 General Design Rule

The principal guidelines for the Power Supply Design comprise three different design steps:

- the electrical design of the power supply
- the thermal design
- the PCB layout

5.3.1 Electrical Design Guidelines

TBD

5.3.2 Thermal Design Guidelines

The thermal design for the power supply heat sink should be done with the following specifications:

- Considering the very low current during Idle, especially if the Power Saving function is enabled, it is possible to consider from the thermal point of view that the device absorbs significant current only during a Data session.
- In LTE mode, the LE910Q1 emits RF signals continuously during transmission. Therefore, special attention must be paid on how to dissipate the heat generated.
- The LE910Q1 is designed to conduct the heat flow from the module IC's towards the bottom of the PCB across GND metal layers
- The generated heat is mostly conducted to the grounding plane under the LE910Q1 module. The application board should be properly designed to dissipate this heat.
- The design of the application board must ensure that the area under the LE910Q1 module is as large as possible. Make sure the LE910Q1 is mounted on the large ground area of application board and provides plenty of ground vias to dissipate heat.

Note: Make PCB design to have the best connection of GND pads to large surfaces of copper.

Note: The average consumption during transmission depends on the power level at which the device is requested to transmit over the network. Therefore, the average current consumption varies significantly.

Note: The thermal design for the power supply should be made keeping an average consumption at maximum transmission level during data transmission of LTE plus average consumption in GNSS Tracking mode.

5.3.3 Power Supply PCB Layout Guidelines

the power supply must have a low ESR capacitor on the output to cut the current peaks and a protection diode on the input to protect the supply from spikes and polarity inversion. The placement of these components is crucial for the correct operation of the circuitry. A misplaced component can be useless or can even decrease the performance of the power supply.

- The Bypass low ESR capacitor must be placed close to the Telit LE910Q1 power input pads or, in the case the power supply is a switching type it can be placed close to the inductor to cut the ripple provided the PCB trace from the capacitor to the LE910Q1 is wide enough to ensure low voltage drop even during the 1A current peaks.
- The protection diode must be placed close to the input connector where the power source is drained.
- The PCB traces from the input connector to the power regulator IC must be wide enough to ensure that no voltage drops occur during the 1A current peaks.
- The PCB traces to LE910Q1 and the bypass capacitor must be wide enough to ensure that no significant voltage drops occur when the 1A current peaks are absorbed. This is necessary for the same above-mentioned reasons. Try to keep these traces as short as possible.
- To reduce the EMI due to switching, it is important to keep the mesh involved very small; therefore, the input capacitor, the output diode (if not embodied in the IC) and the regulator shall form a very small loop. This is done to reduce the radiated and conducted noise at the switching frequency (500-1500 kHz usually).
- The insertion of EMI filter on VBATT pins is suggested for those designs where antenna is placed close to battery or supply lines. A ferrite bead like Murata BLM18EG101TN1 or Taiyo Yuden P/N FBMH1608HM101 can be used for this purpose.

The below figure shows the recommended circuit:

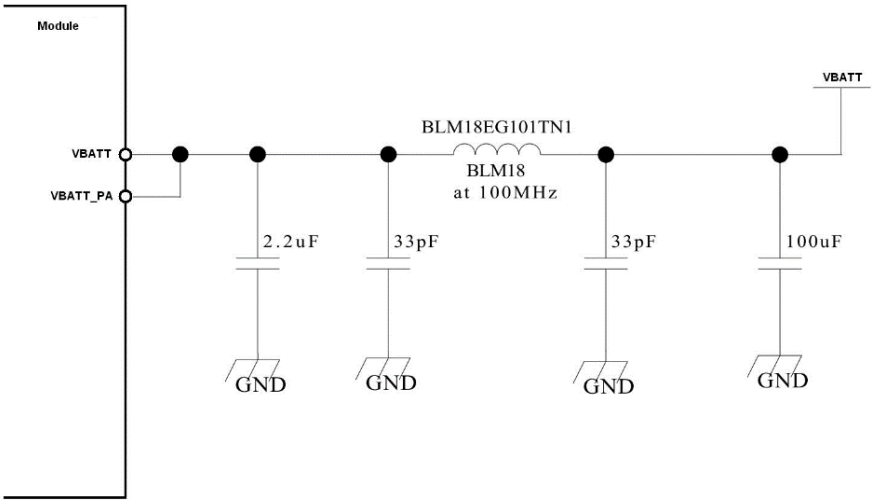

Figure 4: Recommended Circuit

5.3.4 Bypass Capacitor on Power Supplies

When a sudden current consumption step, either an increase or drop, happens, the steep transition can cause some reaction such as undershootor overshoot. This abrupt voltage transition can affect the device causing it to fail or to malfunction.

Bypass capacitors are needed to alleviate this behaviour. The behaviour may appear for different applications. Customers must pay special attention to this issue when they design their application board.

The length and width of the power lines must be considered carefully, and the capacitance of the capacitors must be selected accordingly.

The capacitor will also reduce power supplies ripple and the switching noise.

Note: In particular, a suitable bypass capacitor must be placed near the following lines on the application board:

- VBATT & VBATT_PA (M1, M2, N1, N2, P1, P2)

Recommended values are:

- 100µF for both VBATT and VBATT_PA together

However, customers should consider that the capacitance mainly depends on the conditions of their application board.

Generally, more capacitance is required when the power line is longer.

5.4 VAUX/PWRMON Power Output (pad R11)

A regulated power supply output is provided to supply small devices from the module. This output is active when the module is ON and goes OFF when the module is shut down or in specific low power modes.

Module wakeup source(s), together with the VAUX/PWRMON status, for each low power configuration is defined in the following table:

Table 16: Operating range characteristics of the supply

Power mode	VAUX/PWRMON	Wakeup Source
CFUN 1	active	N/A
CFUN 5	active	DTR
CFUN 14	disabled	GPIO12 †

Note:
- GPIO12 must be previously configured by AT command, refer to AT Command guide AT#GPIO command for further details

The operating range characteristics of the supply are as follows:

Table 17: Operating range characteristics of the supply

Item	Min	Typical	Max
Output voltage	-	1.8V	-
Output current	-	-	50mA
Output bypass capacitor (inside the module)		1µF	

5.5 RTC Supply

The RTC within the LE910Q1 module does not have a dedicated RTC supply pin. The RTC block is supplied by the VBATT supply.

When the VBATT is removed, RTC time is lost and RTC stopped; if you need to maintain the time and RTC running, VBATT must be supplied continuously.

In Power OFF mode, the average current consumption is ~3uA.

6 DIGITAL SECTION

6.1 Logic Levels

Unless otherwise specified, all the interface circuits of the LE910Q1 are 1.8V CMOS logic.

The following tables show the logic level specifications used in the LE910Q1 interface circuits.

6.1.1 1.8V Standard GPIOs

Table 18: Absolute Maximum Ratings - Not Functional

Parameter	Min	Max
Input level on any digital pin when on	-0.3V	+3.6 V

6.1.2 SIM Voltage Pads - Absolute Maximum Ratings

Table 19: Absolute Maximum Ratings - Not Functional

Parameter	Min	Max
Input level on any digital pin when on	-0.3V	+2.1 V
Input voltage on analog pins when on	-0.3V	+2.1 V

For functional characteristics refer to section “Pin Characteristics by Power Domains”. For SIM1 interface refer to VSIM power domain, for SIM2 interface refer to VP1 power domain.

6.2 Power On

To turn on the LE910Q1 module, the ON_OFF# pad must be asserted low for more than 10 milliseconds, and then released.

The maximum current that can be drained from the ON/OFF # pad is 13uA. This pin is pulled up internally; customers should expect to see VBATT at the output.

Figure below illustrates a simple circuit to power on the module using an inverted buffer output.

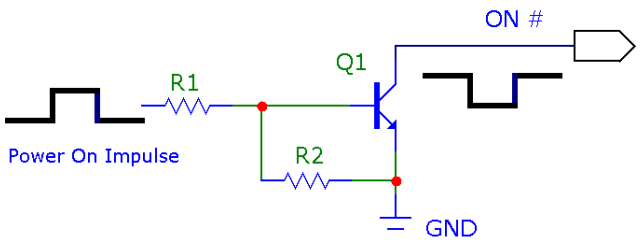

Figure 5: Power-on Circuit; illustrates a simple circuit to power on the module using an inverted buffer output.

Note: Do not use any pull up resistor on the ON_OFF# line, it is internally pulled up. Using pull up resistor may bring to latch up problems on the LE910Q1 power regulator and improper power on/off of the module. The line ON_OFF# must be connected only in open collector or open drain configuration.

Note: To avoid back powering it is recommended to prevent any HIGH logic level signal from being applied to the digital pins of LE910Q1 when the module is powered off or during an ON-OFF transition.

Note: To check if the device has powered on, the hardware line PWRMON should be monitored.

After turning on the LE910Q1 module, a predefined internal boot sequence performs the HW and SW initialization of the module, which takes some time to complete. During this process, the LE910Q1 is not accessible.

As shown in Figure 6, the LE910Q1 becomes operational in less than 4 seconds after ON_OFF is asserted.

Note: During the Initialization state, AT commands are not available. The DTE host must wait for the Activation state prior to communicating with the LE910Q1.

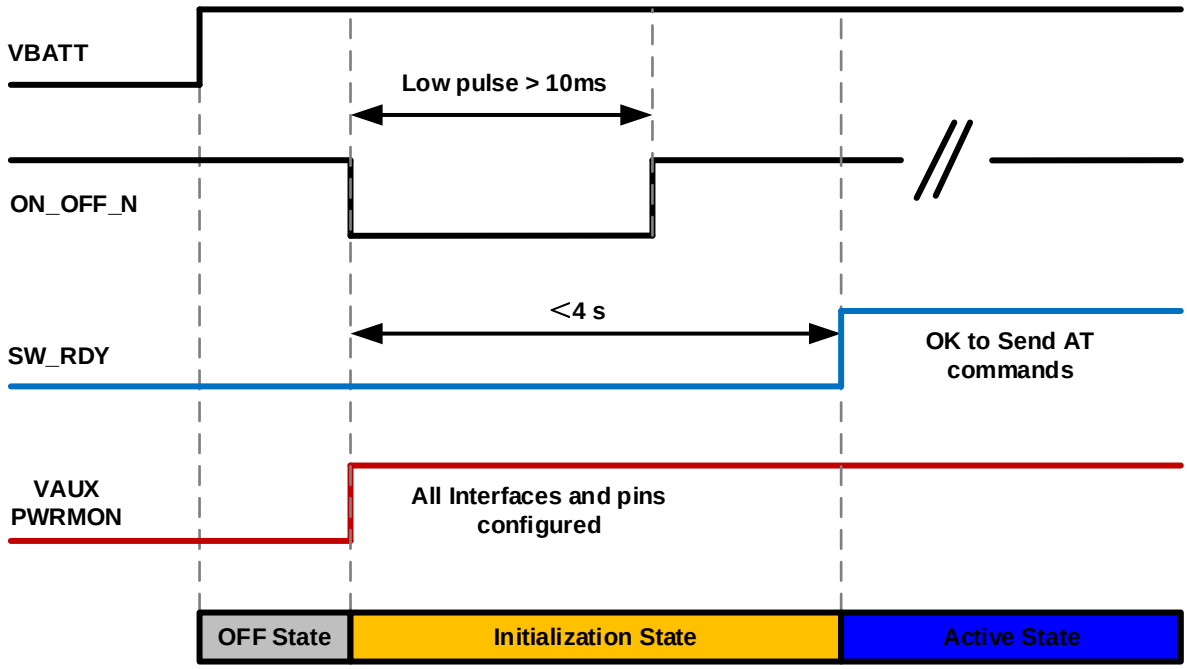

Figure 6: Power ON Sequence

Note: SW_RDY signal is available on GPIO_8 (by default GPIO_8 functions as SW_RDY).

Note: To check whether the LE910Q1 is fully operational, monitor the SW_RDY hardware line. When SW_RDY goes high, the module is fully operational and is ready to accept AT commands

Note: Active low signals are labelled with a name that ends with "#" or with "_N".

6.3 Power Off

Turning off the device can be done in the following different ways:

- Shutdown by software using related AT command
- Hardware shutdown using ON_OFF# pad
- Unconditional shutdown using EMERG_RST pad

When the device is shut down by a software command or a hardware shutdown, it sends a detach disconnection request to the network, informing the network that the device will no longer be reachable.

Note: To check if the device has turned off, monitor the PWRMON hardware line. When PWRMON goes low, this indicates that the device is turned off.

Note: To avoid back powering it is recommended to prevent any HIGH logic level signal from being applied to the digital pins of LE910Q1 when the module is powered off or during an ON-OFF transition.

Warning: Not following the recommended shut-down procedures might damage the device and consequently void the warranty.

6.3.1 Shutdown by Software Command

The LE910Q1 module can be shut down via a software command.

When a shutdown command is sent, the LE910Q1 enters the Finalization state and at the end of the finalization process shuts down PWRMON.

The duration of the Finalization state may vary depending on the current situation of the module, so it is not possible to define a value.

Usually, it will take less than 15 milliseconds from sending a shutdown command until a complete shutdown is achieved. The DTE host should monitor the PWRMON status to observe the actual power-off.

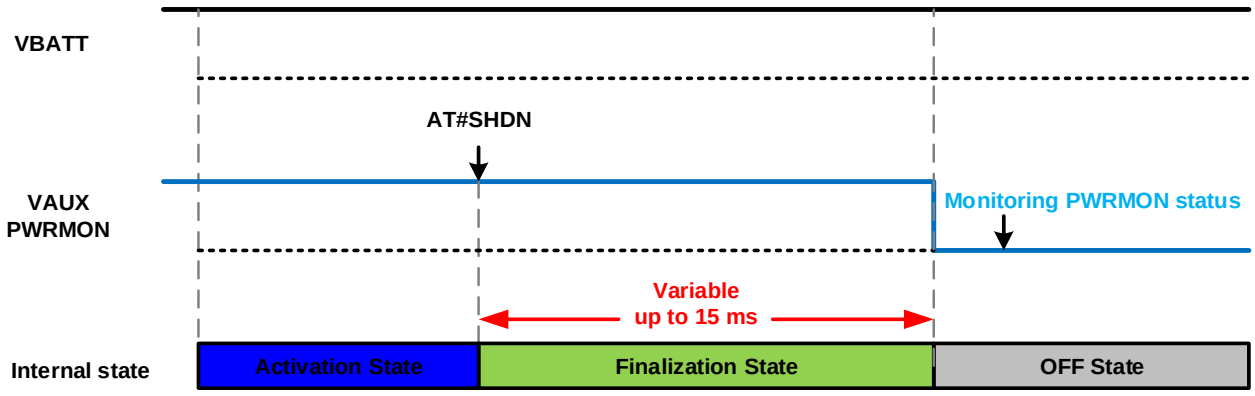

Figure 7: Shutdown by Software Command

Note: To check if the device is turned off, monitor the PWRMON hardware line. When PWRMON goes down, the device has powered off.

6.3.2 Hardware Shutdown

To turn off the LE910Q1 module, the ON_OFF# pad must be asserted low for more than 5 seconds, and then released. When the hold time of ON/OFF_N is more than 5 seconds, the LE910Q1 enters the Finalization state and finally shuts down PWRMON.

The duration of the Finalization may vary depending on the current situation of the module, so it is not possible to define a value. Usually, it will take less than 15 milliseconds issuing a shutdown command until a complete shutdown is achieved. The DTE host should monitor the PWRMON status to observe the actual power-off.

To turn off the LE910Q1 module, the ON_OFF# pad must be asserted low for more than 5 seconds and less than 25 seconds, and then released.

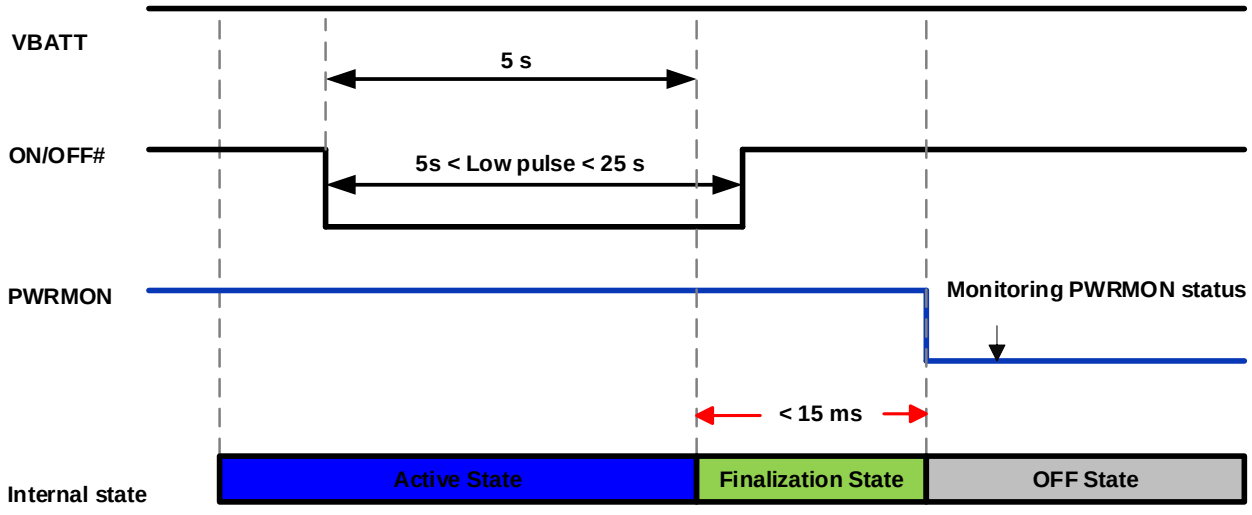

Figure 8: Hardware Shutdown

Note: To check whether the device is turned off, monitor the PWRMON hardware line. When PWRMON goes down, the device has powered off.

6.3.3 Emergency Reset

The LE910Q1 module provides an active low EMERG_RST# pin on pad R13, this signal acts as a reset of the baseband and supply section and, if held low for more than 5s, completely discharges internal power rails performing the same functionality of an unconditional shutdown. Releasing the EMERG_RST# pin will immediately initiate the power up procedure regardless of the state of the ON_OFF# signal. The module will not perform any disconnection procedure from the network and will reset regardless of its operational status.

EMERG_RST# is an active low signal whose voltage level should always be in the range 1.8V / 0V and be driven in open-drain or open-collector configuration with no required external pull-up resistor.

> **Warning:** Emergency Reset by toggling VBATT Power, must not be used during the normal shutdown operation of the device. It does not detach the device from the network and may damage the memory content. It must be performed only as an emergency exit procedure.
> INCORRECT SHUTDOWN Procedure may void the warranty.

6.4 Communication Ports

6.4.1 USB Port

The LE910Q1 module includes a Universal Serial Bus (USB) transceiver, which operates at USB high-speed (480Mbits/sec). It can also operate with USB full-speed hosts (12Mbits/sec).

It is compliant with the USB 2.0 specification and can be used for control and data transfers, as well as for diagnostic monitoring and firmware update.

The USB port is typically the main interface between the LE910Q1 module and OEM hardware.

> **Note:** The USB_D+ and USB_D- signals have a clock rate of 480 MHz. The signal traces must be routed carefully. Minimize trace lengths, number of vias, and capacitive loading. The impedance value should be as close as possible to 90 Ohms differential.

Table below lists the USB interface signals.

Table 20: USB Interface Signals

Signal	Pad No.	Usage
USB_D-	C15	Minus (-) line of the differential, bi-directional USB signal to/from the peripheral device
USB_D+	B15	Plus (+) line of the differential, bi-directional USB signal to/from the peripheral device

Signal	Pad No.	Usage
FORCED_USB_BOOT	F14	Pull up to VAUX to enter emergency download mode
FORCED_USB_BOOT	M9	Same function of Pad F14 but replicated in another Pad to keep compatibility with other LE910 modules.

Note: Even if USB communication is not used, it is still highly recommended to place an optional USB connector on the application board.

At least USB signals test points are required as the USB physical communication is needed in the case of SW update.

6.4.2 Serial Ports

The serial port is typically a secondary interface between the LE910Q1 module and OEM hardware. The following serial ports are available on the module:

- Modem Serial Port 1 (Main)
- Modem Serial Port 2 (Auxiliary, UART for GNSS variant)
- Modem Serial Port 3 (DEBUG_LOG)

Several serial port configurations can be designed for the OEM hardware. The most common are:

- RS232 PC com port
- Microcontroller UART @ 1.8V (Universal Asynchronous Receive Transmit)
- Microcontroller UART @ 3.3V/5V or other voltages different from 1.8V

Depending on the type of serial port on the OEM hardware, level translator circuits may be required to make the system operate. The only configuration that does not require level translation is the 1.8V UART. The LE910Q1 UART has CMOS levels as described in Section Logic Levels.

6.4.3 Modem Serial Port 1 Signals

On the LE910Q1, Serial Port 1 is a +1.8V UART with 7 RS232 signals. It differs from the PC-RS232 in signal polarity (RS232 is reversed) and levels.

Table 21 lists the signals of LE910Q1 Serial Port 1.

Table 21: Modem Serial Port 1 Signals

RS232 Pin#	Signal	Pad No.	Name	Usage
1	DCD - DCD_UART	N14	Data Carrier Detect	Output from LE910Q1 that indicates carrier presence
2	RXD - TX_UART	M15	Transmit line *see Note	Output transmit line of LE910Q1 UART
3	TXD -RX_UART	N15	Receive line *see Note	Input receive line of LE910Q1 UART

RS232 Pin#	Signal	Pad No.	Name	Usage
4	DTR - DTR_UART	M14	Data Terminal Ready	Input to LE910Q1 that controls the DTE READY condition
5	GND	A2, B13, D4...	Ground	Ground
6	DSR - DSR_UART	P14	Data Set Ready	Output from LE910Q1 that indicates that the module is ready
7	RTS - RTS_UART	L14	Request to Send	Input to LE910Q1 controlling the Hardware flow control
8	CTS - CTS_UART	P15	Clear to Send	Output from LE910Q1 controlling the Hardware flow control
9	RI - RI_UART	R14	Ring Indicator	Output from LE910Q1 indicating the Incoming data call condition

Note: To avoid back powering it is recommended to prevent any HIGH logic level signal from being applied to the digital pins of LE910Q1 when the VAUX/PWRMON of the module is low, this includes the following power states:

- powered off ;
- ON-OFF transitions;
- module is in CFUN 14 state.

Note: For minimum implementations, only the TXD, RXD lines need to be connected to the host, but RTS must be either grounded or connected directly to CTS. The other lines can be left open provided a software flow control is implemented.

Note: According to V.24, Rx/Tx signal names refer to the application side; therefore, on the LE910Q1 side, these signals are in the opposite direction: TXD from the application side will be connected to the reception line (here named TXD/ RX_UART) of the LE910Q1 serial port and vice versa for Rx.

Note: The DTR pin is used to control the UART and CFUN 5 system sleep.Pulling the DTR pin down prevents the UART and the entire module from entering CFUN 5 low power mode

6.4.4 Modem Serial Port 2

On the LE910Q1, Serial Port 2 is a +1.8V UART with Rx and Tx signals only.

Table 22: Modem Serial Port 2 Signals

PAD	Signal	I/O	Function	Type	Comment
D15	TXD_AUX	O	Auxiliary UART (Tx Data to DTE)	1.8V	UART for GNSS variant
E15	RXD_AUX	I	Auxiliary UART (Rx Data to DTE)	1.8V	UART for GNSS variant

Note: To avoid back powering it is recommended to prevent any HIGH logic level signal applied to the digital pins of the module when it is powered OFF or during an ON/OFF transition.

Note: Rx/Tx signal names refer to the module side.

6.4.5 Modem Serial Port 3

Table 23: Modem Serial Port 3

PAD	Signal	I/O	Function	Type	Comment
K4	DEBUG_UART_TXD	O	LOG_UART_TXD	1.8V	
M6	DEBUG_UART_RXD	I	LOG_UART_RXD	1.8V	

Note: The DEBUG_UART is used as the SW main debug console. Test points must be placed on this interface even if not used.

Note: Setting DEBUG_UART_RXD to logic level LOW before powering on will lead the module to enter download mode.

Note: Rx/Tx signal names refer to the module side.

6.4.6 RS232 Level Translation

To interface the LE910Q1 with a PC COM port or an RS232 (EIA/TIA-232) application, a level translator is required. This level translator must perform the following actions:

- Invert the electrical signal in both directions
- Change the level from 0/1.8V to +15/-15V

The RS232 UART 16450, 16550, 16650 & 16750 chipsets accept signals with lower levels on the RS232 side (EIA/TIA-562), allowing for a lower voltage-multiplying ratio on the level translator. Note that the negative signal voltage must be less than 0V and therefore some sort of level translation is always required.

The easiest way to translate the levels and invert the signal is by using a single chip-level translator. There are a multitude of them, which differ in the number of drivers and receivers and in the levels (be sure to get a real RS232 level translator, not a RS485 or other standards).

By convention, the driver is the level translator from the 0-1.8V UART to the RS232 level. The receiver is the translator from the RS232 level to 0-1.8V UART. To translate the whole set of control lines of the UART, the following is required:

- 2 drivers
- 2 receivers

Warning: The digital input lines, operating at 1.8V CMOS levels, have absolute maximum input voltage of 2.2V. The level translator IC outputs on the module side (i.e. LE910Q1 inputs) will cause damage to the module inputs if the level translator is powered with +3.8V power.
Therefore, the level translator IC must be powered from a dedicated +1.8V power supply.

As an example, RS232 level adaption circuitry could use a MAXIM transceiver (MAX218). In this case, the chipset is able to translate directly from 1.8V to the RS232 levels (example on 4 signals only).

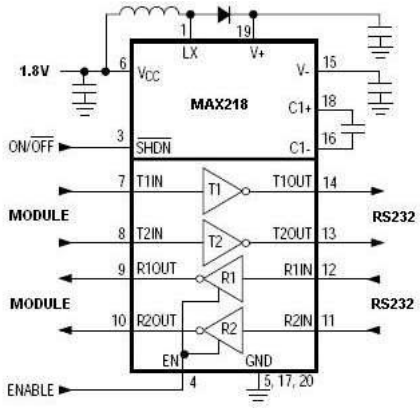

Figure 9: RS232 Level Adaption Circuitry Example

Note: In this case, it is necessary to consider the length of the lines on the application to avoid problems in the case of high-speed rates on RS232.

The RS232 serial port lines are usually connected to a DB9 connector as shown in the figure below. Signal names and directions are named and defined from the DTE perspective.

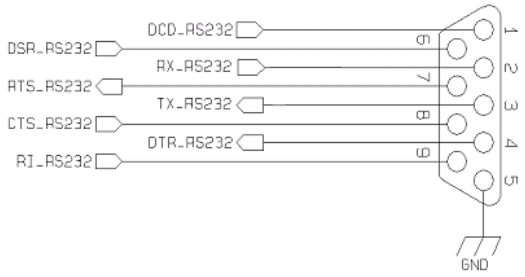

Figure 10: RS232 Serial Port Lines Connection Layout

6.4.7 I2C - Inter-integrated Circuit

The LE910Q1 supports I2C interface on the following pins:

- B11 - I2C_SCL
- B10 - I2C_SDA

The I2C can also be used externally by the end customer application. LE910Q1 supports I2C Master Mode only.

Need external PU 4.7kΩ to 1.8V.

6.4.8 General Purpose I/O

The general-purpose I/O pads can be configured to act in three different ways:

- Input
- Output
- Alternative function (internally controlled)

Input pads can only be read, reporting digital values (high / low) present on the pad at the time of reading. Output pads can be queried or written to set values on the pad output. Alternative function pads can be controlled internally by LE910Q1 firmware and act according to the implementation.

The following GPIOs are always available as a primary function on the LE910Q1.

Table 24: Primary GPIOs

PAD	Signal	I/O	Function	Type	Power Domain	Note
C8	GPIO_1	I/O	STAT_LED/ GPIO_1	1.8V	VAON	
C9	GPIO_2	I/O	GPIO_2	1.8V	VP1	
C10	GPIO_3	I/O	GPIO_3	1.8V	VP1	
C11	GPIO_4	I/O	GPIO_4	1.8V	VAON	
B14	GPIO_5	I/O	GPIO_5	1.8V	VL33	
C12	GPIO_6	I/O	GPIO_6	1.8V	VAON	

PAD	Signal	I/O	Function	Type	Power Domain	Note
C13	GPIO_7	I/O	GPIO_7/ GNSS_EN#* OUT	1.8V	VL33	GNSS_EN* # OUT is active in LE910Q1-xxG
K15	GPIO_8	I/O	SW_RDY/ GPIO_8	1.8V	VL33	
L15	GPIO_9	I/O	GPIO_9/ GNSS_RESET*# OUT	1.8V	VL33	GNSS_RESET#* OUT is active in LE910Q1-xxG
G15	GPIO_10	I/O	GPIO_10/ GNSS_VCC_DIS OUT	1.8V	VL33	GNSS_VCC_DIS OUT is active in LE910Q1-xxG
H14	GPIO_11	I/O	GPIO_11/ SPI_CS	1.8V	VP1	
J13	GPIO_12	I/O	GPIO_12	1.8V	VAON	
N13	GPIO_13	I/O	GPIO_13	1.8V	VP1	
F15	GPIO_14	I/O	GPIO_14/ SPI_MOSI	1.8V	VP1	

Note: When designing the application board for migration between xE910 modules, please pay attention that not all families provide more than 10 GPIOs. Designers should populate first the GPIOs from 1 to 10 if migration is a requirement. Please refer to the specific product Hardware Design Guide for more details on supported IOs.

6.4.9 Using a GPIO Pad as Input

GPIO pads, when used as inputs, can be connected to a digital output of another device and report its status, provided this device has interface levels compatible with the 1.8V CMOS levels of the GPIO.

If the digital output of the device is connected to the GPIO input, the pad has interface levels other than 1.8V CMOS. It can be buffered with an open collector transistor with a 10 kΩ pull-up resistor to 1.8V.

6.4.10 Using a GPIO Pad as an Interrupt / Wakeup Source

GPIO pads that are used as input can also be used as an interrupt source for the software. In general, all GPIO pads can also be used as interrupts. However, not all GPIO's can be used as a wakeup source of the module (wakeup from sleep).

Only the following GPIO can be used to wake up the system from sleep:

- GPIO_12

6.4.11 Using a GPIO Pad as Output

GPIO pads, when used as outputs, can drive 1.8V CMOS digital devices or compatible hardware. When set as outputs, the pads have a push-pull output, and therefore the pull-up resistor can be omitted.

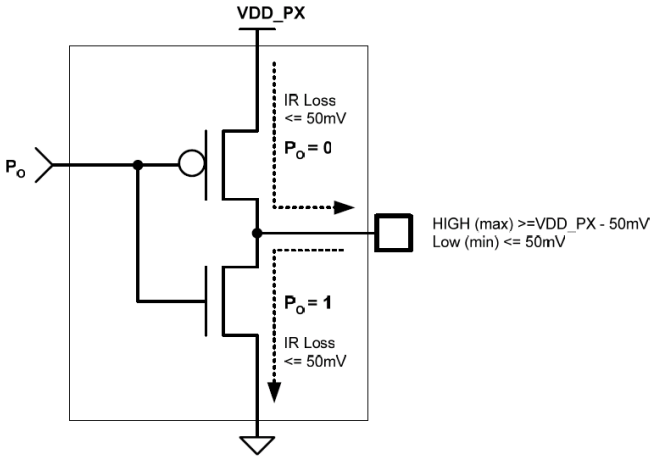

Figure 11: GPIO Output Pad Equivalent Circuit

6.5 Indication of Network Service Availability

The STAT_LED pin status shows information on the network service availability. In the LE910Q1 module, the STAT_LED usually needs an external transistor to drive an external LED. The STAT_LED does not have a dedicated pin. The STAT_LED functionality is available on GPIO_1 pin (by default GPIO_1 functions as STAT_LED)

See the AT Command User Guide for details on the related AT command.

Table 25: Network Service Availability Indication

LED Status		Device Status
Permanently off		Device off
Blinking	Blinking 1s on and 2s off	Registered in idle
	Blinking time depends on network condition in order to minimize power consumption	Registered in idle with power saving
Permanently on		Not registered

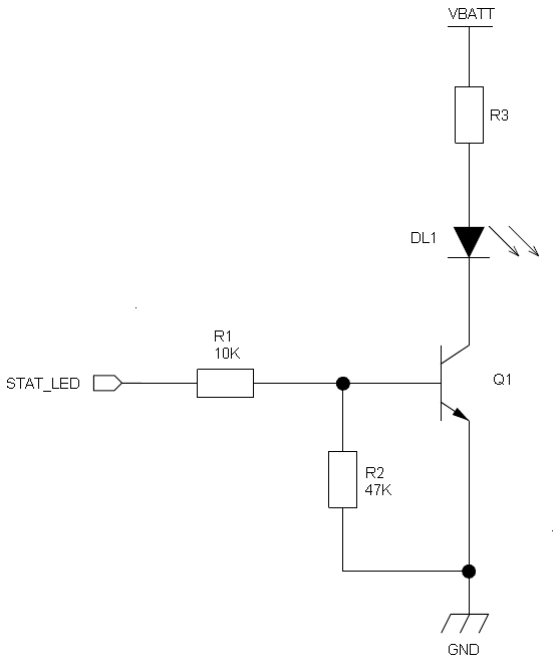

Figure 12: Status LED Circuit Example

6.6 Indication of Software Ready

The SW_RDY signal provides indication about the module' ability to receive commands. As long as the SW_RDY is asserted low, it indicates that the LE910Q1 has not finished booting yet. Once the SW_RDY is asserted high, it indicates that the LE910Q1 is ready to receive commands.

6.7 External SIM Holder

This section presents the recommended schematics for the design of SIM interfaces on the application boards. The LE910Q1 supports up to two external SIM interfaces.

6.7.1 SIM Schematic Example

Figure 13 figure shows how to design the application side and what values to assign to the components.

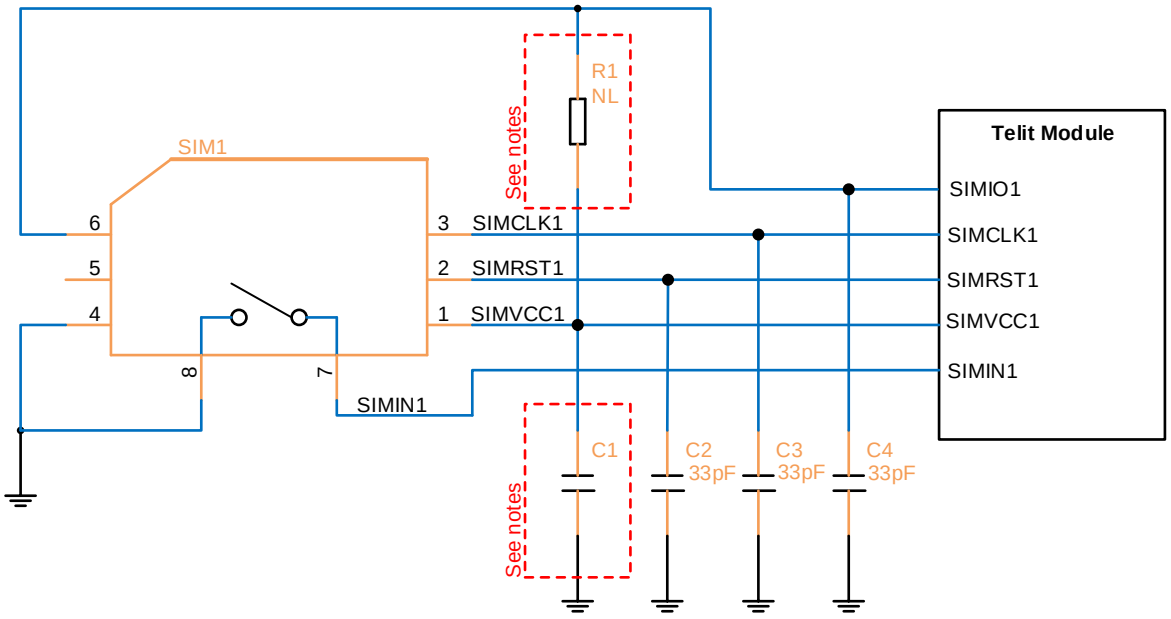

Figure 13: SIM1 Schematics

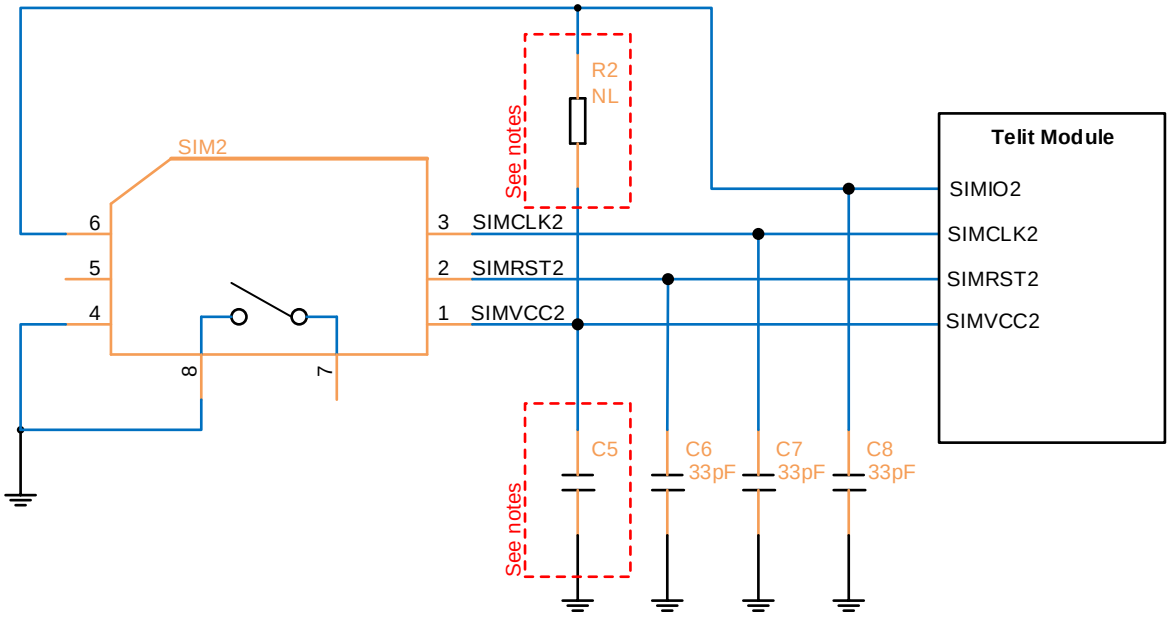

Figure 14: SIM2 schematics

Note: The resistor value on SIMIO pulled up to SIMVCC must be defined to comply with the 3GPP specification for USIM electrical testing. The LE910Q1 module contains internal pull-up resistors on SIMIO1 and SIMIO2.

The un-mounted R1 and R2 option in the application can be used to tune SIMIO1 and SIMIO2 timing if required.

Warning: SIMVCC2 rail is active whenever SIMVCC1 is.

Note: SIM 2 interface is without SIM card detection pin.

Table below lists the values of C1 and C5 to be adopted with the LE910Q1 product:

Table 26: SIM Interface – C1 and C5

Product P/N	C1 (nF)	C5 (nF)
LE910Q1	100	100

6.8 ADC Converter

6.8.1 Description

The LE910Q1 module provides two on-board Analog to Digital converters. Each ADC reads the voltage level applied to the relevant pin, the accuracy is about 30mV@1.8v.

Please refer to table VLA (ADC inputs) Power Domain - Electrical Characteristics

Table 27: ADC Parameters

Item	Min		Max	Units
Accuracy	-		TBD	mV

6.8.2 Using the ADC Converter

An AT command is available to use the ADC function.

The read value is expressed in uV.

Refer to LE910Q1 AT Command User Guide for the full description of this function.

6.9 Debug of the LE910Q1 Module in Production

To test and debug the mounting of the LE910Q1 module, it is highly recommended to add several test pads on the application board design for the following purposes:

- Check the connection between the LE910Q1 itself and the application
- Test the performance of the module by connecting it with an external computer.

Depending on the customer's application, these test pads include, but are not limited to the following signals:

- TXD
- RXD
- ON/OFF
- EMERG_RST
- GND
- VBATT
- DEBUG_UART_TXD
- DEBUG_UART_RXD
- USB_D+
- USB_D-
- FORCED_USB_BOOT

In addition, the following signals are also recommended (but not mandatory:

- SW_RDY
- PWRMON
- STAT_LED

7 RF SECTION

7.1 Bands Variants

Table below summarizes all region variants within the LE910Q1 family, showing the band sets supported in each variant.

Different bands combinations are available:

Table 28: RF Bands Variant

Region Variant	LTE FDD	LTE TDD	GNSS
LE910Q1-WW	B1, B2, B3, B4, B5, B7, B8, B12, B13, B18, B19, B20, B25, B26, B28, B66, B8_39d	B34, B38, B39, B40, B41	
LE910Q1-SN	B2, B4, B5, B12, B13, B66		
LE910Q1-WWG	B1, B2, B3, B4, B5, B7, B8, B12, B13, B18, B19, B20, B25, B26, B28, B66, B8_39d	B34, B38, B39, B40, B41	GNSS (GPS-GLONASS-Galileo-BeiDou-QZSS-SBAS)
LE910Q1-SNG	B2, B4, B5, B12, B13, B66		GNSS (GPS-GLONASS-Galileo-BeiDou-QZSS-SBAS)

Table 29: Bandwidth

Mode	Freq. Tx (MHz)	Freq. Rx (MHz)	Channels	Tx-Rx Offset
LTE 2100 – B1	1920 ~ 1980	2110 ~ 2170	Tx: 18000 ~ 18599 Rx: 0 ~ 599	190 MHz
LTE 1900 – B2	1850 ~ 1910	1930 ~ 1990	Tx: 18600 ~ 19199 Rx: 600 ~ 1199	80 MHz
LTE 1800 – B3	1710 ~ 1785	1805 ~ 1880	Tx: 19200 ~ 19949 Rx: 1200 ~ 1949	95 MHz
LTE AWS – B4	1710 ~ 1755	2110 ~ 2155	Tx: 19950 ~ 20399 Rx: 1950 ~ 2399	400 MHz
LTE 850 – B5	824 ~ 849	869 ~ 894	Tx: 20400 ~ 20649 Rx: 2400 ~ 2649	45 MHz
LTE 2600 – B7	2500 – 2570	2620 – 2690	Tx: 20750 ~ 21449 Rx: 2750~ 3449	120 MHz
LTE 900 – B8	880 ~ 915	925 ~ 960	Tx: 21450 ~ 21799 Rx: 3450 ~ 3799	45 MHz
LTE 700 – B12	699 ~ 716	729 ~ 746	Tx: 23010 ~ 23179 Rx: 5010 ~ 5179	30 MHz
LTE 750 – B13	777 ~ 787	746 ~ 756	Tx: 23180 ~ 23279 Rx: 5180 ~ 5279	-31 MHz
LTE 850 – B18	815 ~ 830	860 ~ 875	Tx: 23850 ~ 23999	45 MHz

Mode	Freq. Tx (MHz)	Freq. Rx (MHz)	Channels	Tx-Rx Offset
			Rx: 5850 ~ 5999	
LTE 850 – B19	830 ~ 845	875 ~ 890	Tx: 24000 ~ 24149 Rx: 6000 ~ 6149	45 MHz
LTE 800 – B20	832 ~ 862	791 ~ 821	Tx: 24150 ~ 24449 Rx: 6150 ~ 6449	-41 MHz
LTE 1900 – B25	1850 ~ 1915	1930 ~ 1995	Tx: 26040 ~ 26689 Rx: 8040 ~ 8689	80 MHz
LTE 850 – B26	814 ~ 849	859 ~ 894	Tx: 26690 ~ 27039 Rx: 8690 ~ 9039	45 MHz
LTE 700 – B28	703 ~ 748	758 ~ 803	Tx: 27210 ~ 27659 Rx: 9210 ~ 9659	55 MHz
LTE 2100 – B66	1710 ~ 1780	2110 ~ 2180	Tx: 131972 ~ 132671 Rx: 66436 ~ 67135	400 MHz
U.S. FCC 900MHz – B8_39d	897.5 ~ 900.5	936.5 ~ 939.5	Tx: 21625 ~ 21655 Rx: 21565 ~ 21595	39 MHz
LTE TDD 2000 – B34	2010 ~ 2025	2010 ~ 2025	Tx: 36200 ~ 36349 Rx: 36200 ~ 36349	0 MHz
LTE TDD 2600 – B38	2570 ~ 2620	2570 ~ 2620	Tx: 37750 ~ 38249 Rx: 37750 ~ 38249	0 MHz
LTE TDD 1800 – B39	1880 ~ 1920	1880 ~ 1920	Tx: 38250 ~ 38649 Rx: 38250 ~ 38649	0 MHz
LTE TDD 2300 – B40	2300 ~ 2400	2300 ~ 2400	Tx: 38650 ~ 39649 Rx: 38650 ~ 39649	0 MHz
LTE TDD 2500 – B41	2496 ~ 2690	2496 ~ 2690	Tx: 39650 ~ 41589 Rx: 39650 ~ 41589	0 MHz

7.2 TX Output Power

Typical values for Max output level are as follow:

Table 30: Transmission Output Power – Band

Band	Mode	Class	RF power (dBm)Nominal*
B1, B2, B3, B4, B5, B7, B8, B12, B13, B18, B19, B20, B25, B26, B28, B66, B8_39d	4G LTE FDD - CAT1bis	3	23dBm
B34, B38, B39, B40, B41	4G LTE TDD - CAT1bis	3	23dBm

7.3 RX Sensitivity

Below the 3GPP measurement conditions used to define the RX sensitity:

Table 31: Reception Sensitivity

Technology	3GPP Compliance
4G LTE	Throughput >95% 10MHz

Table 32: Typical Sensitivity Levels

Mode	Sensitivity	3GPP minimum requirements
LTE 2100 – B1	-97dBm	-93.3dBm
LTE 1900 – B2	-98dBm	-91.3dBm
LTE 1800 – B3	-97dBm	-90.3dBm
LTE AWS – B4	-98dBm	-93.3dBm
LTE 850 – B5	-98dBm	-91.8dBm
LTE 2600 – B7	-97dBm	-91.3dBm
LTE 900 – B8	-98dBm	-90.8dBm
LTE 700 – B12	-98dBm	-90.3dBm
LTE 750 – B13	-98dBm	-90.3dBm
LTE 850 – B18	-98dBm	-93.8dBm
LTE 850 – B19	-98dBm	-93.8dBm
LTE 800 – B20	-98dBm	-90.8dBm
LTE 1900 – B25	-98dBm	-91.3dBm
LTE 850 – B26	-98dBm	-91.3dBm
LTE 700 – B28	-98dBm	-92.3dBm
LTE 2100 – B66	-98dBm	-92.8dBm
U.S. FCC 900MHz – B8_39d	-98dBm	N/A
LTE TDD 2000 – B34	-98dBm	-93.8dBm
LTE TDD 2600 – B38	-98dBm	-91.8dBm
LTE TDD 1800 – B39	-98dBm	-93.8dBm
LTE TDD 2300 – B40	-98dBm	-93.8dBm
LTE TDD 2500 – B41	-98dBm	-91.8dBm

Note: The sensitivity level may present a deviation of approximately +/- 2dB depending on model, device and channel; the level shown is the typical value.

7.4 Antenna Requirements

The antenna connection and board layout design are the most important aspect in the full product design as they strongly affect the general performance of the product, so read carefully and follow the requirements and the guidelines for a proper design.

The antenna and antenna transmission line on PCB for a Telit LE910Q1 device shall fulfil the following paragraphs.

7.5 PCB Design Guidelines

When using the LE910Q1, since there's no antenna connector on the module, the antenna must be connected to the LE910Q1 antenna pad (K1) by means of a transmission line implemented on the PCB.

This transmission line shall fulfil the following requirements:

Table 33: Antenna Pad Requirements

Item	Value
Characteristic Impedance	50 ohm (+-10%)
Max Attenuation	0.3 dB
Coupling	Coupling with other signals shall be avoided
Ground Plane	Cold End (Ground Plane) of antenna shall be equipotential to the LE910Q1 ground pins

The transmission line should be designed according to the following guidelines:

- Make sure that the transmission line characteristic impedance is 50 ohms.
- Keep the antenna waveguide on the PCB as short as possible since the antenna line loss shall be less than about 0.3 dB.
- The geometry of the line must have uniform characteristics, constant cross section, avoid meanders and abrupt curves.
- Any kind of suitable geometry / structure (Microstrip, Stripline, Coplanar, Grounded Coplanar Waveguide...) can be used to implement the printed transmission line relating to the antenna.
- If a Ground plane is required in the geometry of the line, this plane must be continuous and sufficiently extended, so that the geometry can be as similar as possible to the related canonical model.
- Keep, if possible, at least one layer of the PCB used only for the Ground plane; If possible, use this layer as reference Ground plane for the transmission line.
- It is advisable to surround (on both sides) the PCB transmission line with Ground, avoiding that other signal tracks face directly the antenna line track.
- Avoid crossing any un-shielded transmission line footprint with other signal tracks on different layers.
- The ground surrounding the antenna line on the PCB must be tightly connected to the main Ground Plane through holes (at least once every 2mm), placed near the edges of the ground facing the line track.
- Place EM noisy devices as far as possible from LE910Q1 antenna line.

- Keep the antenna line far away from the LE910Q1 power supply lines.
- If EM noisy devices (such as fast switching ICs, LCD and so on) are present on the PCB hosting the LE910Q1, take care of the shielding of the antenna line by burying it in an inner layer of PCB and surrounding it with the Ground planes, or shield it with a metal frame cover.
- If EM noisy devices are not present around the line, the use of geometries such as Microstrip or Grounded Coplanar Waveguide is preferable since they typically ensure less attenuation if compared to a Stripline of the same length.

The following image shows the suggested layout for the Antenna pad connection:

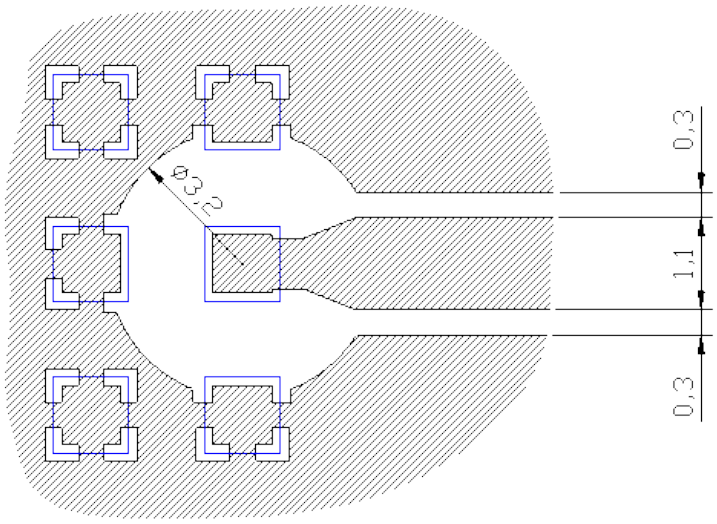

Figure 15: Layout for the Antenna pad connection

7.5.1 Transmission Line Design

When designing the LE910Q1 interface board, the placement of components was chosen properly, in order to keep the length of the line as short as possible, thus leading to the lowest possible power losses. A Grounded Coplanar Waveguide (G-CPW) line has been chosen, since this kind of transmission line ensures good impedance control and can be implemented in an outer PCB layer as needed in this case. A SMA female connector has been used to feed the line.

The interface board is made on a FR4, 4-layers PCB. The substrate material is characterized by relative permittivity εr = 4.6 ± 0.4 @ 1 GHz, TanD= 0.019 ÷ 0.026 @ 1 GHz.

A characteristic impedance of nearly 50 Ω is achieved using a track width = 1.1 mm, clearance from a coplanar ground plane = 0.3 mm each side.

The line uses the reference ground plane on layer 3, while copper is removed from layer 2 below the line. The height of the trace above ground plane is 1.335 mm. The calculated characteristic impedance is 51.6 Ω, the estimated line loss is less than 0.1 dB.

The line geometry is shown below:

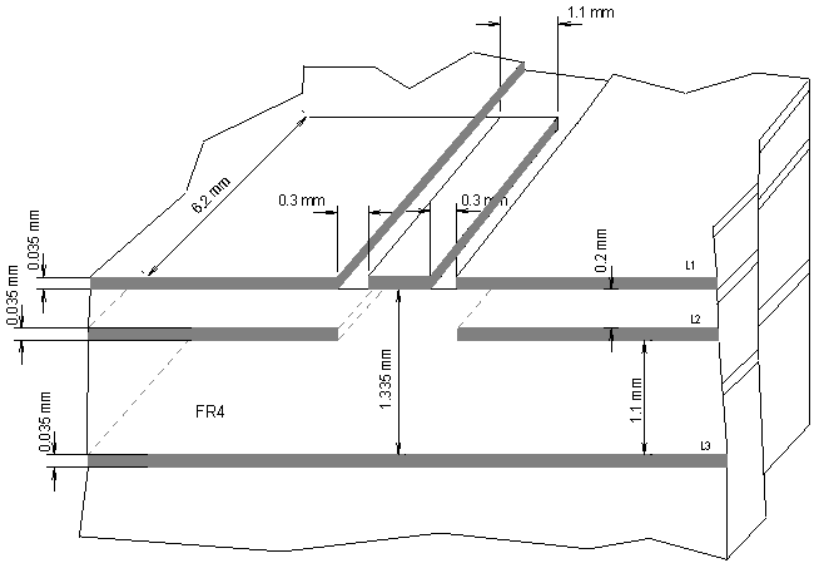

Figure 16: Line Geometry

7.5.2 Transmission Line Measurements

An HP8753E VNA (Full-2-port calibration) was used in this measurement session.

A calibrated coaxial cable was soldered to the pad corresponding to RF output; a SMA connector was soldered to the board in order to characterize the losses of the transmission line including the connector itself. During Return Loss / impedance measurements, the transmission line has been terminated to 50 Ω load.

Return Loss plot of line under test is shown below:

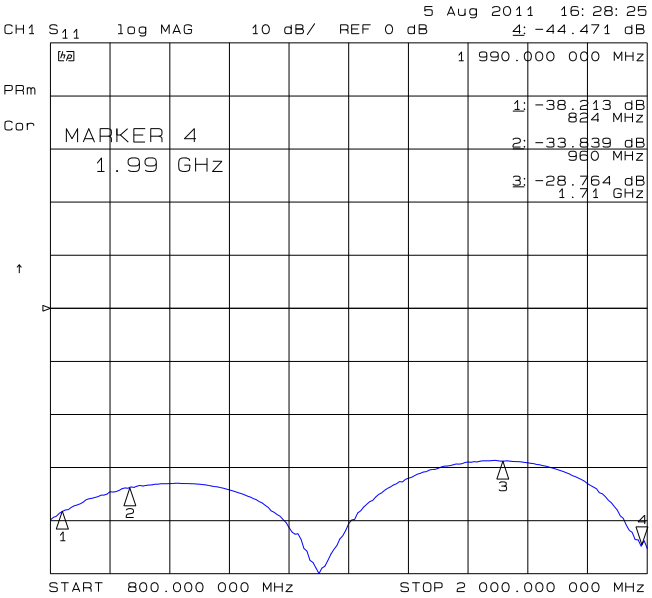

Figure 17: Return Loss plot of line under test

The input impedance of the line (in Smith Chart format, once the line has been terminated to 50 Ω load) is shown in the following figure:

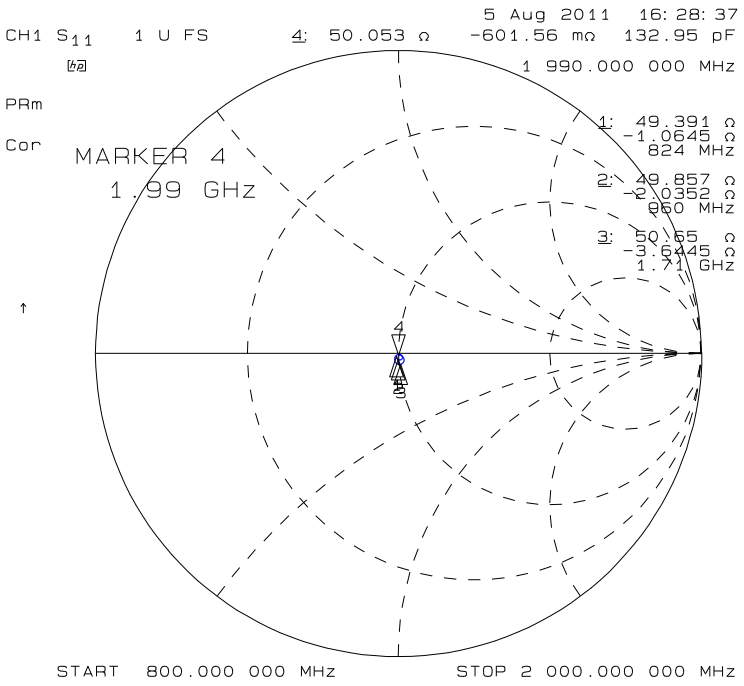

Figure 18: Line input impedance

Insertion Loss of G-CPW line plus SMA connector is shown below:

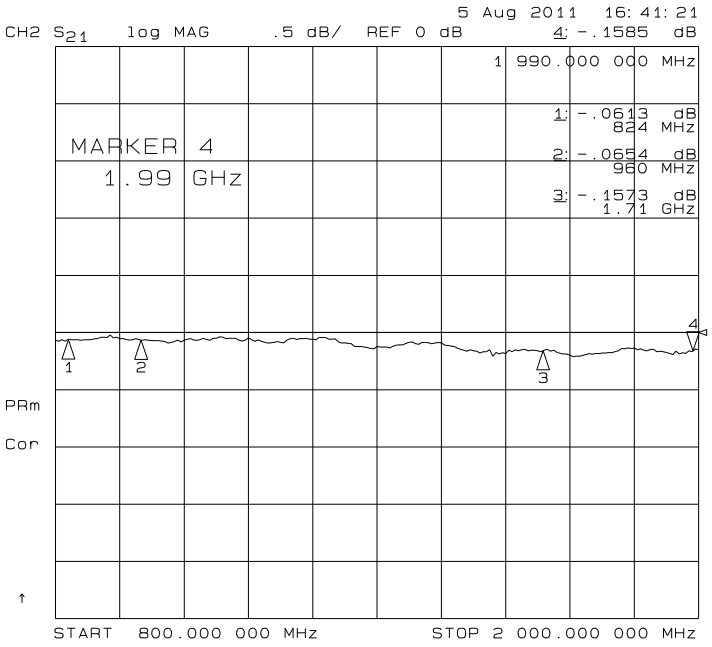

Figure 19: Insertion Loss of G-CPW line plus SMA connector

7.5.3 Antenna Installation Guidelines

Install the antenna in a place covered by the LTE signal.

- The Antenna must not be installed inside metal cases.
- The Antenna must be installed according to Antenna manufacturer instructions.
- The Antenna integration should optimize the Radiation Efficiency. Efficiency values > 50% are recommended on all frequency bands.

- The Antenna integration should not perturb the radiation pattern described in the documentation of the Antenna manufacturer.
- It is preferable to get an omnidirectional radiation pattern.
- The Antenna Gain must not exceed the values indicated in regulatory requirements, where applicable, to meet the related EIRP limitations. The Typical antenna Gain in most M2M applications does not exceed 2.1dBi.

8 GNSS Section

The LE910Q1-xxG module variant includes a state-of-art receiver that can simultaneously search and track satellite signals from multiple satellite constellations. This multi-GNSS receiver uses GPS, GLONASS, BeiDou, Galileo, QZSS, SBAS . The supported bands are listed in following Table 34.

Table 34: GNSS supported bands

Product	Constellations
LE910Q1-xxG	GPS (L1) GLONASS (L1OF) Galileo (E1) BeiDou (B1) QZSS and SBAS ranging

8.1 GNSS Characteristics

The table below specifies the GNSS characteristics and expected performance. The values are related to typical environments and conditions.

Table 35: GNSS Characteristics

Parameters		Typical Measurement	Notes
Sensitivity	Standalone or MS Based Tracking Sensitivity	-161dBm	
	Re-Acquisition	-156dBm	
	Cold Start	-144dBm	
TTFF	Hot	1s	-130dB CN0:36 Nine GPS satellites
	Cold	33s	-130dB CN0:36 Nine GPS satellites
Accuracy (CEP)		TBD	24 h static test

8.2 Block Diagram

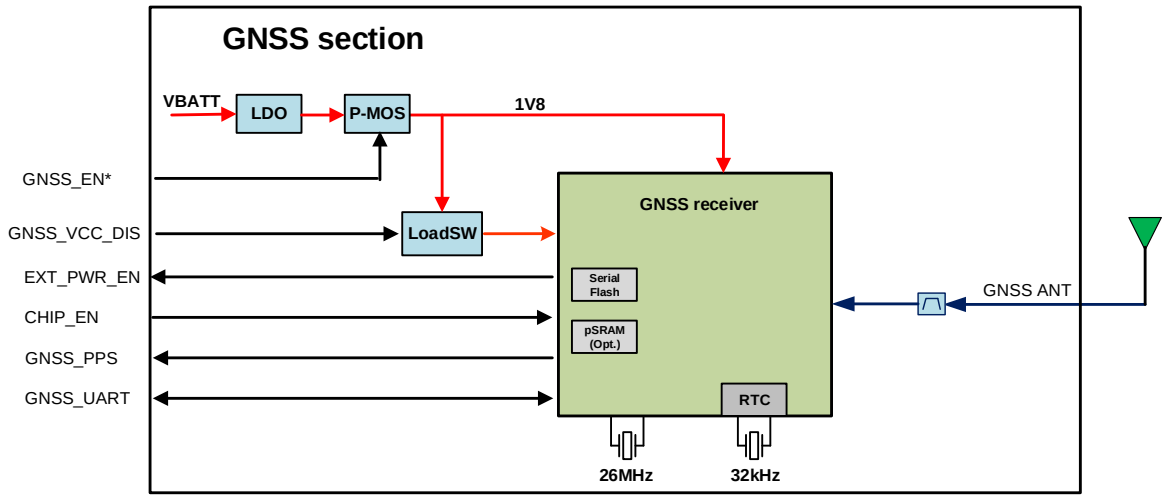

Figure 20: LE910Q1-xxG GNSS Block Diagram

8.3 GNSS Hardware Setup

The GNSS receiver of the LE910Q1-xxG module can be used in Module Controlled Mode (simply Controlled Mode) or in Standalone Mode

The circuital configurations required are shown in Figure 20 and in the following sections

8.3.1 GNSS Signals PIN-OUT

Following table contains the list of involved Pins:

Table 36: GNSS Signals PIN-OUT

PAD	Signal	I/O	Function	Type	Comment
GNSS Section					
R9	ANT_GNSS	I	GNSS antenna (50 Ohm)	RF	Reserved on variant without GNSS
R7	GNSS_LNA_EN	O	Enables the external regulator for GNSS LNA	1.8V	Reserved on variant without GNSS
N9	GNSS_PPS	O	GNNS 1PPS signal	1.8V	Reserved on variant without GNSS
G14	GNSS_EN#	I	GNSS ENABLE (ACTIVE LOW)	1.8V	Reserved on variant without GNSS
J14	GNSS_NMEA_TX	O	GNSS NMEA TX (GNSS receiver serial port)	1.8V	Reserved on variant without GNSS
K14	GNSS_NMEA_RX	I	GNSS NMEA RX (GNSS receiver serial port)	1.8V	Reserved on variant without GNSS
K12	GNSS_NMEA_CTS*				
H12	GNSS_NMEA_RTS	O	GNSS NMEA Request to send signal (RTS)	1.8V	Reserved on variant without GNSS
E12	GNSS_VCC_DIS	I	Disable GNSS power excepet for RTC power.	1.8V	Active high. Reserved on variant without GNSS
AUX UART					
D15	TX_AUX	O	TX_AUX	1.8V	UART for GNSS variant
E15	RX_AUX	I	RX_AUX	1.8V	UART for GNSS variant
General Purpose Digital I/O					
C13	GPIO_7	I/O	GPIO_7/ GNSS_EN# OUT	1.8V	Alternate Fn GNSS_EN# OUT Default value Hi-Z
L15	GPIO_9	I/O	GPIO_9/ GNSS_RESET# OUT	1.8V	Alternate Fn GNSS_RESET# OUT Default value Hi-Z
G15	GPIO_10	I/O	GPIO_10/ GNSS_VCC_DIS OUT	1.8V	Alternate Fn GNSS_VCC_DIS OUT Default value Hi-Z

8.3.2 Digital signals

8.3.2.1 GNSS_LNA_EN

This signal, exported on Pad R7, is used in Module Controlled Mode. It is an output signal generated from the Modem/App Processor section used to enable an external LNA or an active antenna.

8.3.2.2 GNSS_PPS

The GNSS receiver generates a one-pulse-per-second signal for synchronization. It is mapped on Pad N9.

8.3.2.3 GNSS_EN#

GNSS_EN#, mapped on pad G14, is an active low input signal. The GNSS_EN enables the internal supply of the GNSS section. In Module Controlled Mode the GNSS_EN* is generated by GPIO_7 (Pad C13). In standalone Mode GNSS_EN# must be generated by the external host.

Warning:	The line GNSS_EN# must be connected only in open collector configuration since it is already internally pull-up.

8.3.3 GNSS Module Controlled Mode

In Controlled Mode, the GNSS receiver can be controlled by the Cellular part through specific AT commands (refer to the Telit AT Commands Reference Guide).

The NMEA stream can be retrieved through the AT interface or USB physical port of the Module.

The UART of the GNSS section must be connected to the AUX UART of the Module.

GNSS_NMEA_RX K14 must be connected to D15 TX_AUX

GNSS_EMEA_TX J14 must be connected to E15 RX_AUX

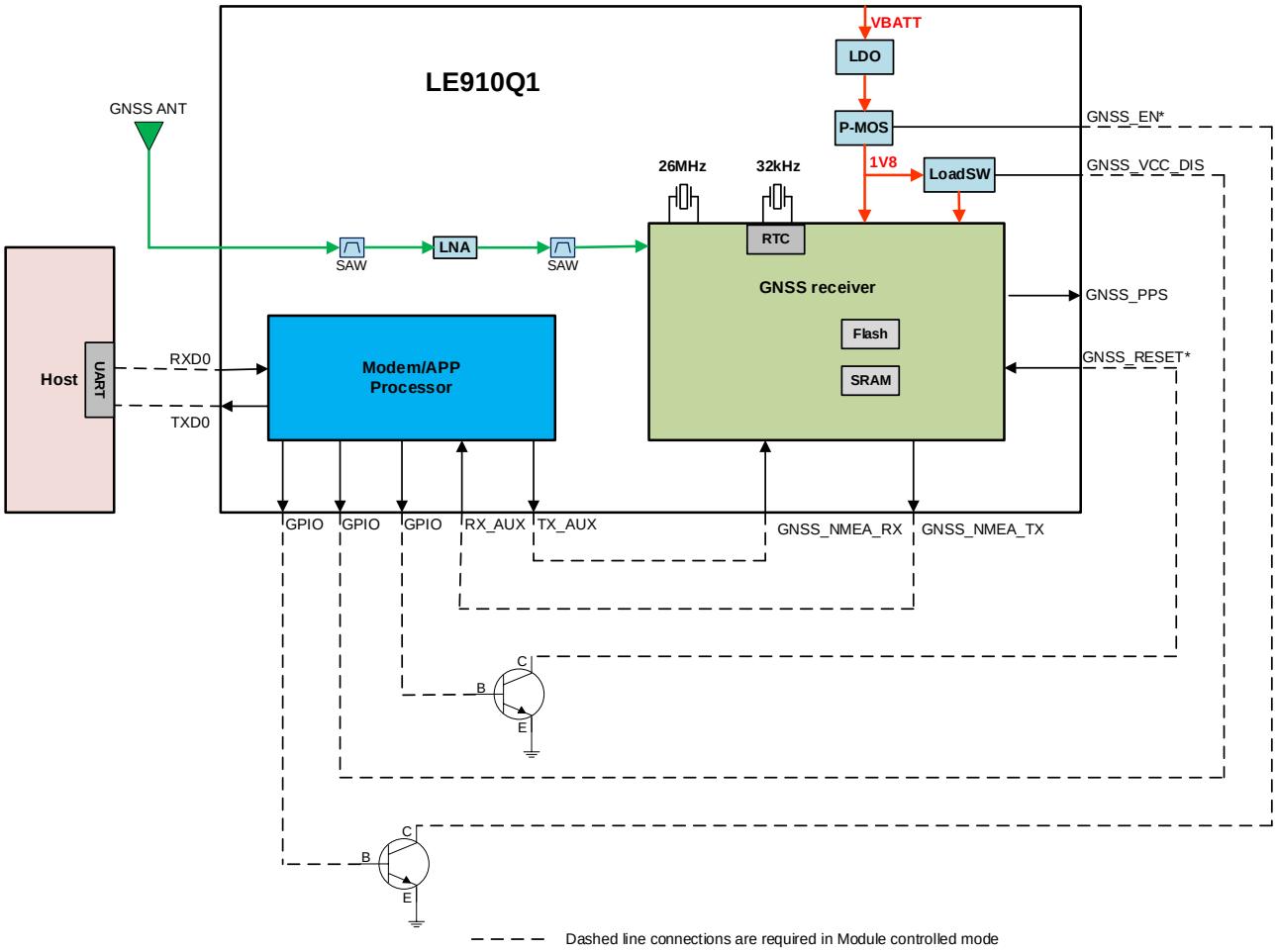

Figure 21 GNSS module controlled mode

Warning: The GNSS firmware upgrade in the Module Controlled Mode is not supported

Note: Do not use any pull-up resistor on the GNSS_EN# and GNSS_RESET# lines nor use any totem pole digital output to drive them. Using a pull-up resistor may bring latch-up problems on the Module power regulator and improper functioning of the module. The line GNSS_EN# must be connected only in open collector configuration because it already has an internal pull-up.

8.3.4 GNSS Standalone Mode

The LE910Q1 module can be also used in Standalone mode. In this case the input signal GNSS_EN# must be provided from the external host. The GNSS_LNA_EN signal will not be available in standalone mode. The UART signals: GNSS_NMEA_RX and GNSS_NMEA_TX shall be connected to the external host. The receiver can be controlled by GNSS AT commands. For more info contact Telit's technical support.

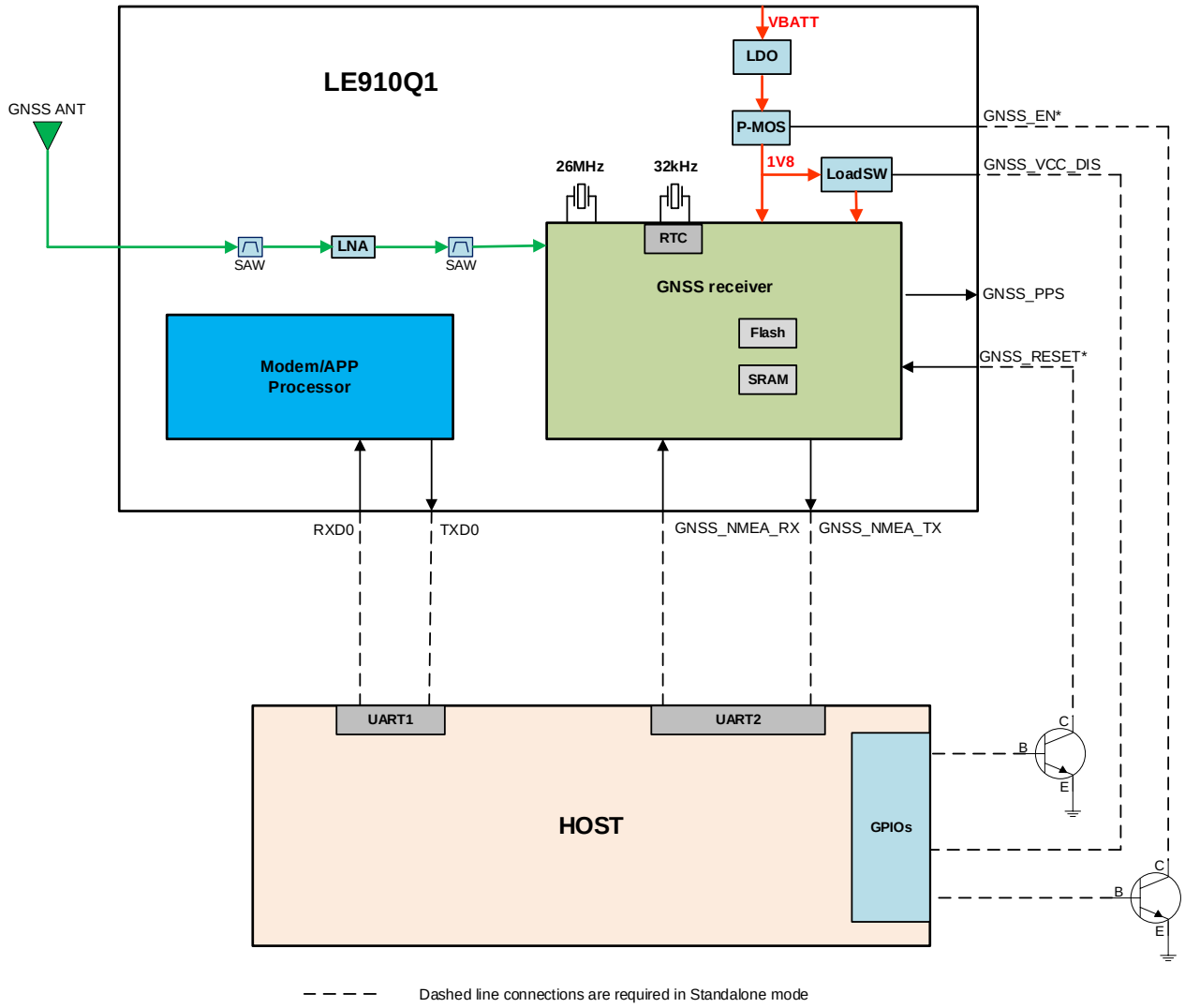

Figure 22 GNSS standalone mode

Note: Do not use any pull-up resistor on the GNSS_EN# and GNSS_RESET# lines nor use any totem pole digital output to drive them. Using a pull-up resistor may bring latch-up problems on the Module power regulator and improper functioning of the module. The line GNSS_EN# must be connected only in open collector configuration because it already has an internal pull-up.

8.4 GNSS Power supply

The GNSS Section is supplied by VBATT through a dedicated LDO and a load switch. They generate two different voltages:

- VCC_1V8: is the always on voltage that powers the RTC section
- VCC_GNSS: this rail is enabled by the GNSS_EN# and powers the IO pins, Core, RF and Memory receiver sections.

8.5 RF Front End Design

The LE910Q1 Module contains a SAW filter . An active antenna (antenna with a built-in low noise amplifier) could be used, if so it must be powered by a proper bias circuit.

8.5.1 Guidelines of PCB Line for GNSS Antenna

- Make sure that the antenna line impedance is 50ohm.
- Keep the antenna line on the PCB as short as possible to reduce losses.
- The Antenna line must have uniform characteristics, constant cross-section, and avoid meanders, and abrupt curves.
- If possible, keep one layer of the PCB used only for the Ground plane.
- Surround (on both sides, above and below) the antenna line on PCB with Ground, avoid having other signal tracks directly facing the antenna line of the track.
- The ground around the antenna line on PCB must be properly connected to the Ground Plane by placing stitching vias whose distance should be less than 2 mm from each other.
- Place EM noisy devices as far as possible from the antenna line.
- Keep the antenna line far away from power supply lines.
- If there are noisy EM devices around the PCB hosting the module, such as fast switching ICs, take care of shielding the antenna line by burying it inside the layers of the PCB and surrounding it with Ground planes, or shielding it with a metal frame cover.
- If there are no noisy EM devices around the PCB hosting the module, use a strip line on the outer copper layer for the antenna line. The line attenuation will be lower than a buried one.

8.6 GNSS Antenna Requirements

GNSS active antenna must be used or integrated into the application when the module and GNSS antenna are spaced apart.

8.6.1 GNSS Antenna Specification

Table 37: GNSS Antenna specification

Item	Value
Frequency range	1559.0 ~ 1610.0 MHz
Gain	TBD
Impedance	50 ohm
Noise Figure of LNA	< 1.5 (recommended)
DC supply voltage	DC 1.8 ~ 3.3V
VSWR	≤ 3:1 (recommended)

8.6.2 GNSS Antenna – Installation Guidelines

- To obtain the best performance from the GNSS receiver, the antenna must be installed according to the manufacturer's instructions.
- The antenna location must be carefully evaluated if operating in conjunction with any other antenna or transmitter.
- The antenna must not be installed inside metal cases or near any obstacle that may degrade features such as antenna lobes and gain.

8.6.3 Powering the External LNA (active antenna)

The LNA of the active antenna needs a power source as the 1.8V or 3V DC voltage required by the active antenna is not supplied by the LE910Q1 module but can be easily included by the host design.

The electrical characteristics of the GNSS_LNA_EN signal are:

Table 38: GNSS_LNA_EN signal characteristics (available in GNSS Module Controlled Mode only)

Level	Min	Max
Output High Level	1.6V	
Output Low Level		0.2V

Example of external antenna bias circuitry in GNSS Module Controlled Mode:

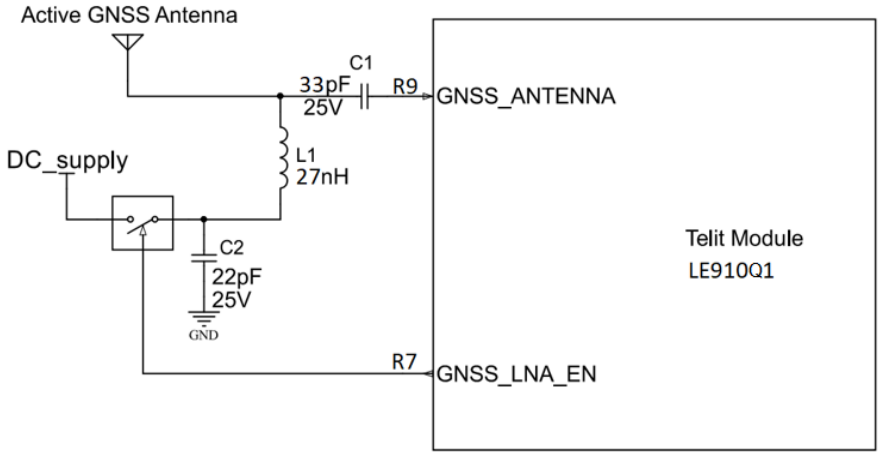

Figure 23: Antenna bias circuitry example

Be aware of the max bias current in the event of an unintentional short circuit on the antenna cable since the decoupling inductor could be damaged.

Warning: In case of GNSS standalone mode implementation, the GNSS_LNA_EN signal is not generated by the module and must be provided by the external host.

9 MECHANICAL DESIGN

9.1 General

The LE910Q1 module is designed to comply with a standard lead-free soldering process.

9.2 Finishing & Dimensions

The below figure shows the mechanical dimensions of the LE910Q1 module.

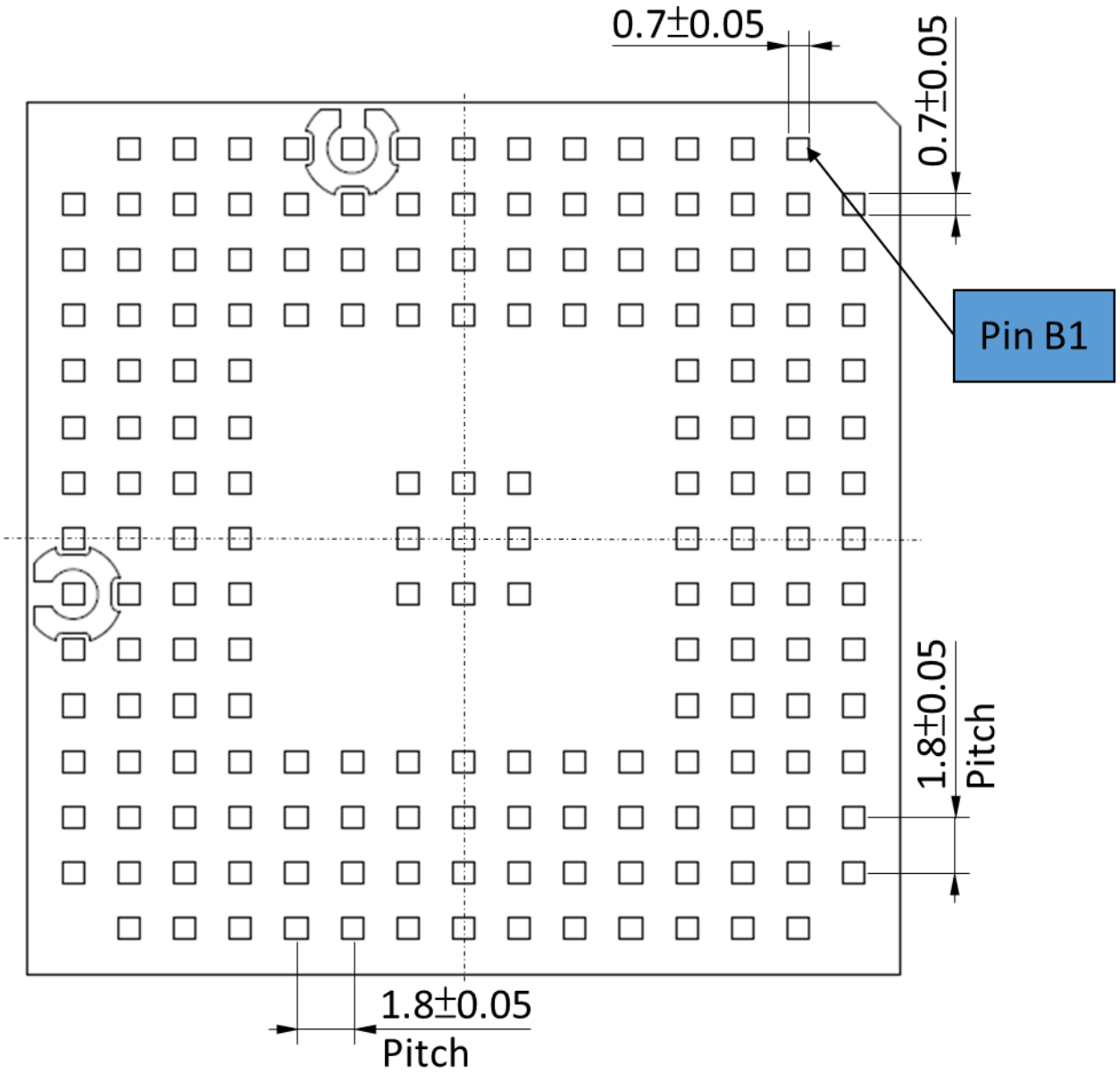

Figure 24: LE910Q1 Mechanical Dimensions (Bottom View)

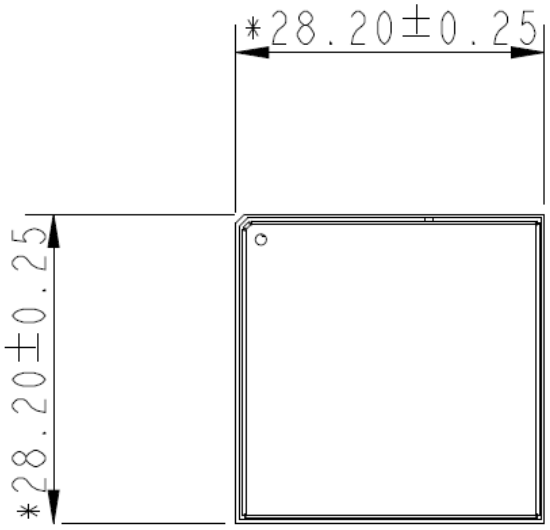

Figure 25: LE910Q1 Mechanical Dimensions (Top view)

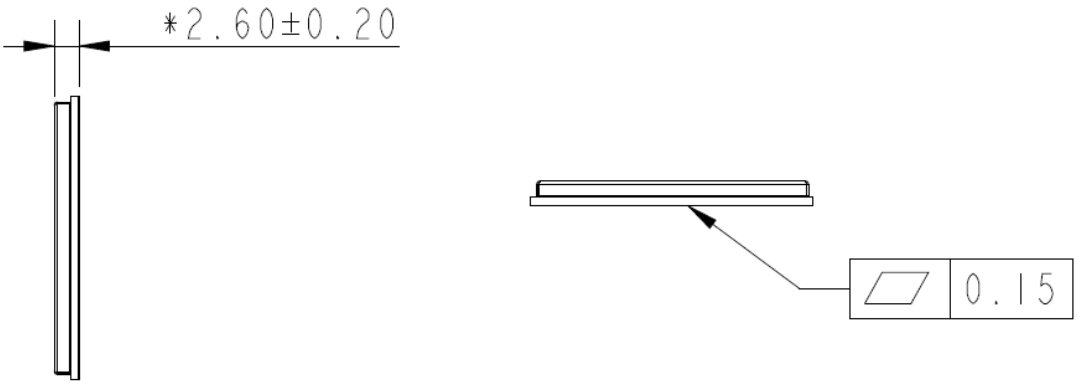

Figure 26: LE910Q1 Mechanical Dimensions (Side view)

10 APPLICATION PCB DESIGN

The LE910Q1 modules have been designed to be compliant with a standard lead-free SMT process.

10.1 CAD symbols, PCB footprints and 3D models

CAD symbols, PCB footprints and 3D models of Telit Cinterion modules are available on www.snapeda.com.

Please make sure you download only the files marked as "Created with Telit Cinterion", which follow Telit Cinterion standards and are approved by Telit Cinterion engineers.

Please contact Telit Cinterion technical support for any further information.

10.2 Recommended Footprint for the Application

TOP VIEW

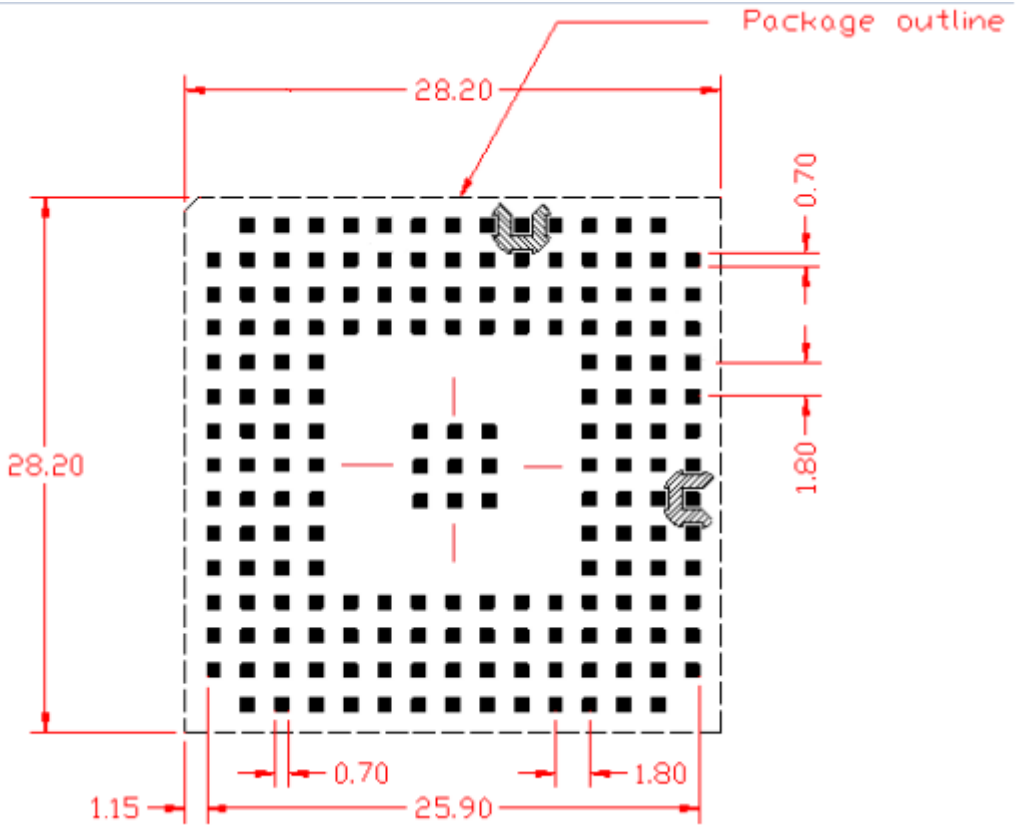

Figure 27: Footprint

INHIBIT WIRING AREA (dimensions in mm)

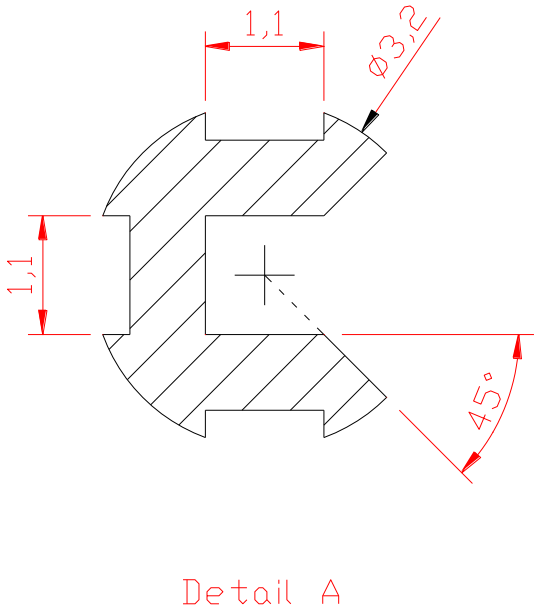

Figure 28: Inhibit Wiring Area

Top Transparent View

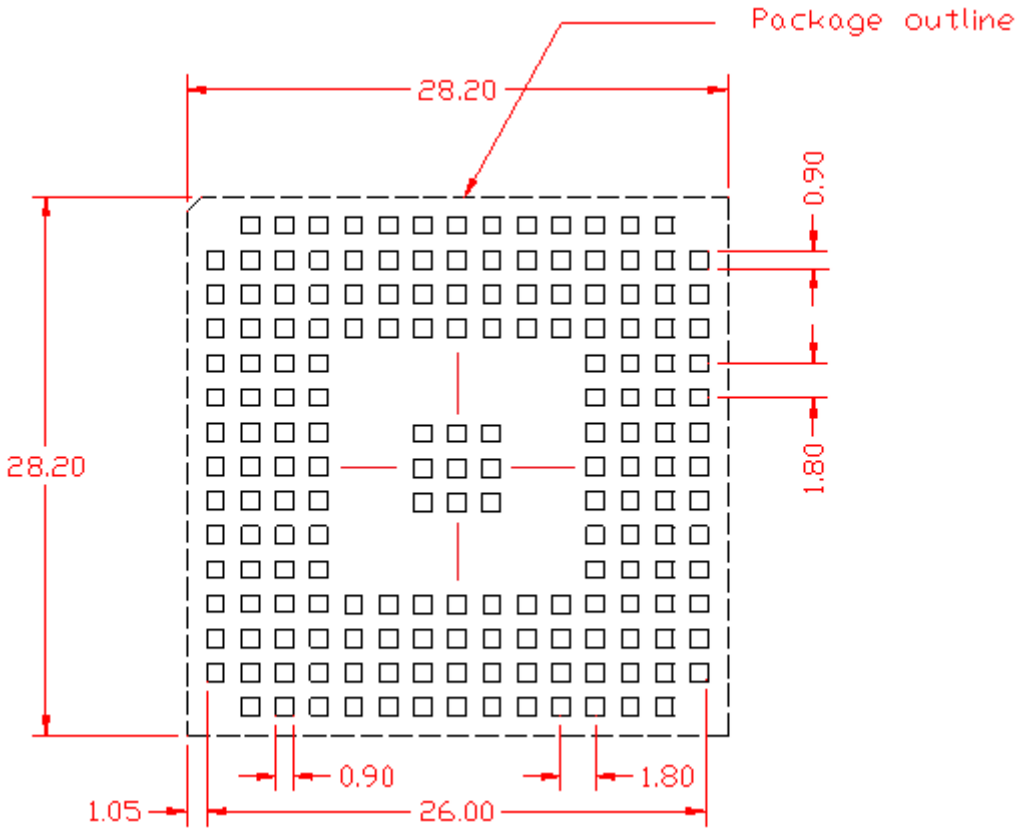

Figure 29: Top transparent view

To easily rework the LE910Q1 it is recommended to consider on the application a 1.5 mm placement inhibit area around the module.

It is also suggested, as common rule for an SMT component, to avoid having a mechanical part of the application in direct contact with the module.

Note: In the customer application, the region under WIRING INHIBIT (see figure above) must be clear from signal or ground paths.

10.3 PCB Pad Design

In PCB design, the solder pads can be defined as either Solder Mask Defined (SMD) or Non-Solder Mask Defined (NSMD). The difference between these two solder mask pad definitions, is in the closeness of the solder mask to the metal pad. In SMD pads, the solder mask opening is smaller than the metal pad and overlaps the metal on all sides. The solder mask opening defines the solderable area of the pad. In NSMD pads, the solder mask opening is larger than the metal pad and does not overlap the metal. The metal edge defines the solderable area of the pad (see Figure below).

The metal etching process in PCB manufacturing, has significantly tighter alignment and etching tolerances than the alignment of the solder masking process, which implies that a more accurate solder pad land pattern can be achieved with NSMD pads. In addition, with SMD pads, the solder mask that overlaps the metal pad introduces additional height above the metal surface that may affect solder joint adhesion and reliability. Non solder mask defined (NSMD) type is recommended for the solder pads on the PCB.

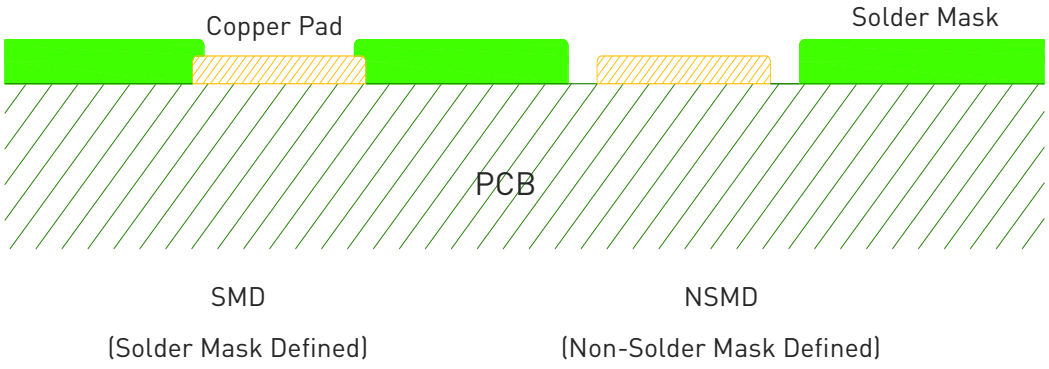

Figure 30: PCB solder pad recommendations

10.4 Recommendations for PCB Pad Dimensions

It is not recommended to place via or micro-via not covered by solder resist in an area of 0,3 mm around the pads unless it carries the same signal of the pad itself.

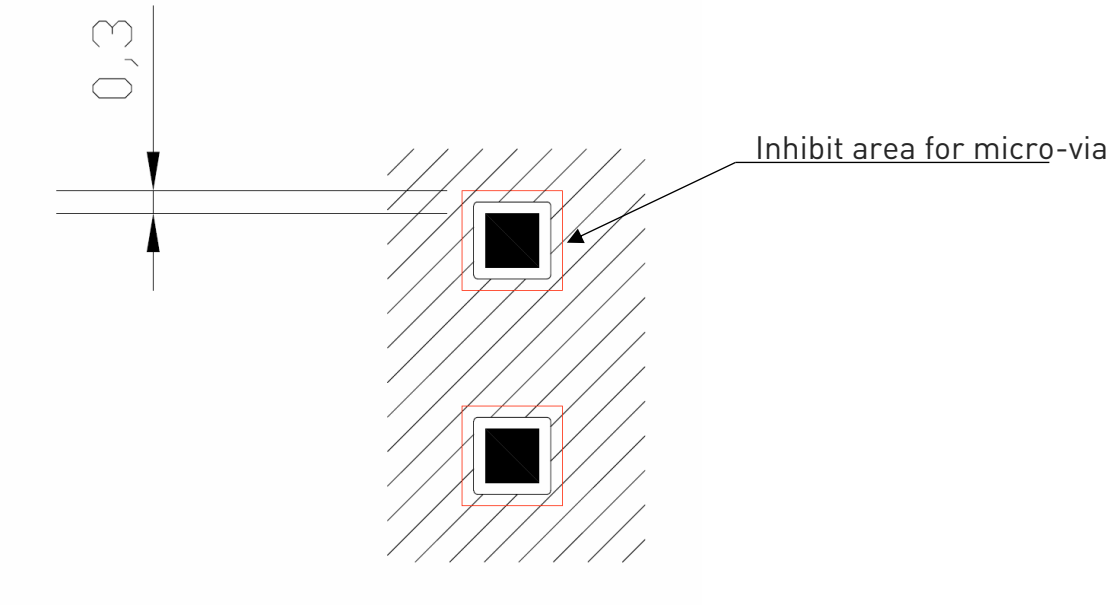

Figure 31: Pad dimensions recommendations

Holes in pad are allowed only for blind holes and not for through holes.

Recommendations for PCB pad surfaces:

Table 39: Recommendations for PCB pad surfaces

Finish	Layer Thickness (um)	Properties
Electro-less Ni / Immersion Au	3 –7 / 0.05 – 0.15	good solder ability protection, high shear force values

The PCB must be able to resist the higher temperatures which are occurring during the lead-free process. This issue should be discussed with the PCB-supplier. Generally, the wettability of tin-lead solder paste on the described surface plating is better than compared to the lead-free solder paste.

It is not necessary to panel the application's PCB, however in that case it is recommended to use milled contours and predrilled board breakouts; scoring or v-cut solutions are not recommended.

10.5 Thermal Performance

FR4 is one of the most commonly used PCB materials, it is a flame retardant composite material, composed by fiberglass-reinforced and epoxy laminate. One of the features of the FR4, is to have a very low thermal conductivity. An inexpensive way to improve thermal transfer for FR-4 PCBs is to add thermal vias - plated through-holes (PTH) between the conductive layers. Vias are created by drilling holes and copper plating them, in the same way that a PTH or via is used for electrical interconnections between layers. A series of plated through-hole thermal vias, should be located in the GND area

underneath Telit module of the PCB to provide a thermal connection from the PCB GND to additional metal layers of the PCB.

The application PCB layout should include plated through-hole thermal vias for efficient heat dissipation from the Telit module into the PCB. One of the following thermal via types should be used:

- Open plated through-hole vias that will provide lower PCB fabrication costs but may fill with solder.
- Plugged and capped plated through-hole vias that will provide higher PCB fabrication costs but will not fill with solder.

Telit recommends creating areas of 10 mil (0.254-mm) vias arranged on a 25 mil (0.635-mm) rectilinear matrix. The reason for this choice is the combination of cost, performance and manufacturability. According to several PCB manufacturers, 10-mil holes and 25-mil spacing are reasonable and repeatable production choice.

A uniform metal plating thickness on the PCB will ensure reliable, high Telit module solder assembly yield.

10.6 Stencil

A silk-screen process will be required for the deposition of solder paste to the PCB, for reflow of the Telit module to the PCB. The silk-screen process requires the use of a metal stencil based on an opening where the solder paste is transferred through the openings on the solder pads of the application PCB. To minimize solder voids and ensure maximum electrical and thermal connectivity of the module to the PCB, large pads, solder volume, and solder straining must be considered in the stencil design. The design and fabrication of the stencil determines the quality of the solder paste deposition onto the PCB and the resulting solder joint after reflow. The primary stencil parameters are aperture size, thickness, and fabrication method. The stencil should be made from stainless steel and the apertures layout can be the same of the recommended footprint (1:1). The recommended thickness shall be 127 um (5 mil). A stencil thickness of 152 µm (6 mil) can be used as well.

10.7 Solder Paste

Various types and grades of solder paste can be used for surface mounting Telit modules. For lead-free applications, a Sn-Ag (SA) or Sn-Ag-Cu (SAC) solder paste can be used. Any Type 3 solder paste that is either water-soluble or no clean is acceptable.

We recommend using only “no clean” solder paste in order to avoid the cleaning of the modules after assembly.

10.8 Solder Reflow

Recommended solder reflow profile:

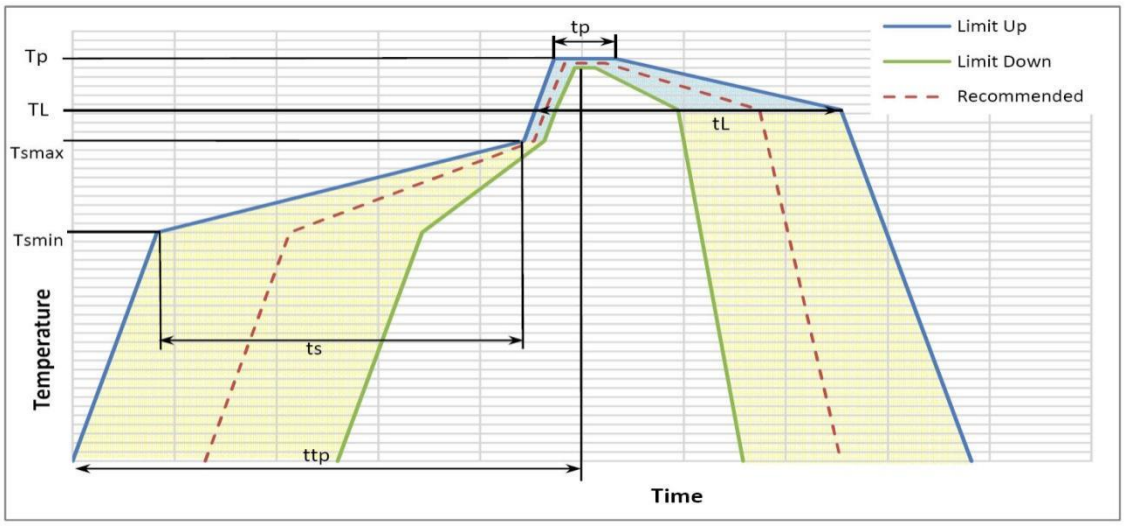

Figure 32: Recommended solder reflow profile

Table 40: Profile feature recommendations

Profile Feature	Pb-Free Assembly Free
Average ramp-up rate (T_L to T_P)	3°C/second max
Preheat – Temperature Min (Tsmin) – Temperature Max (Tsmax) – Time (min to max) (ts)	 150°C 200°C 60-180 seconds
Tsmax to TL – Ramp-up Rate	 3°C/second max
Time maintained above: – Temperature (TL) – Time (tL)	 217°C 60-150 seconds
Peak Temperature (Tp)	245 +0/-5°C
Time within 5°C of actual Peak Temperature (tp)	10-30 seconds
Ramp-down Rate	6°C/second max.
Time 25°C to Peak Temperature	8 minutes max.

Note: Please note that ramp-down rate from Tp to 200°C should be controlled in order to reduce thermally induced stress during the solder solidification phase. Therefore, a cooldown step in the oven's temperature program between 200°C and 180°C should be controlled. Typically, it is below 3°C/s.

Note:	All temperatures refer to topside of the package, measured on the package body surface.

Note:	In order to get a good overall performance the resulting voiding and the formation of intermetallics as well as other thermal induced degradations must be well balanced. As mentioned above a longer preheating phase can help gases to escape from solder joints before solidification. To not overstress the assembly, the complete reflow profile should be as short as possible. Here an optimization considering all components on the application must be performed. The optimization of a reflow profile is a gradual process. It needs to be performed for every paste, equipment and product combination. The presented profiles are only samples and valid for the used pastes, reflow machines and test application boards. Therefore a "ready to use" reflow profile cannot be given.

Warning:	The LE910Q1 module withstands one reflow process only.

Warning:	The above solder reflow profile represents the typical SAC reflow limits and does not guarantee adequate adherence of the module to the customer application throughout the temperature range. Customer must optimize the reflow profile depending on the overall system considering such factors as thermal mass and warpage.

10.9 Inspection

An inspection of the solder joint between the solder pads of the Telit module and the application PCB should be performed. The best visual inspection tool for inspection of the Telit module solder joints on the PCB is a transmission X-ray, which can identify defects such as solder bridging, shorts, opens, and large voids (Note: small voids in large solder joints are not detrimental to the reliability of the solder joint).

11 PACKAGING

11.1 Tray

The LE910Q1 modules are packaged on trays that can be used in SMT processes for pick & place handling.The first Marketing and Engineering samples of the LE910Q1 series will be shipped with the current packaging of the LE910Q1 modules. The mass production units of LE910Q1 will be shipped according to the following drawings:

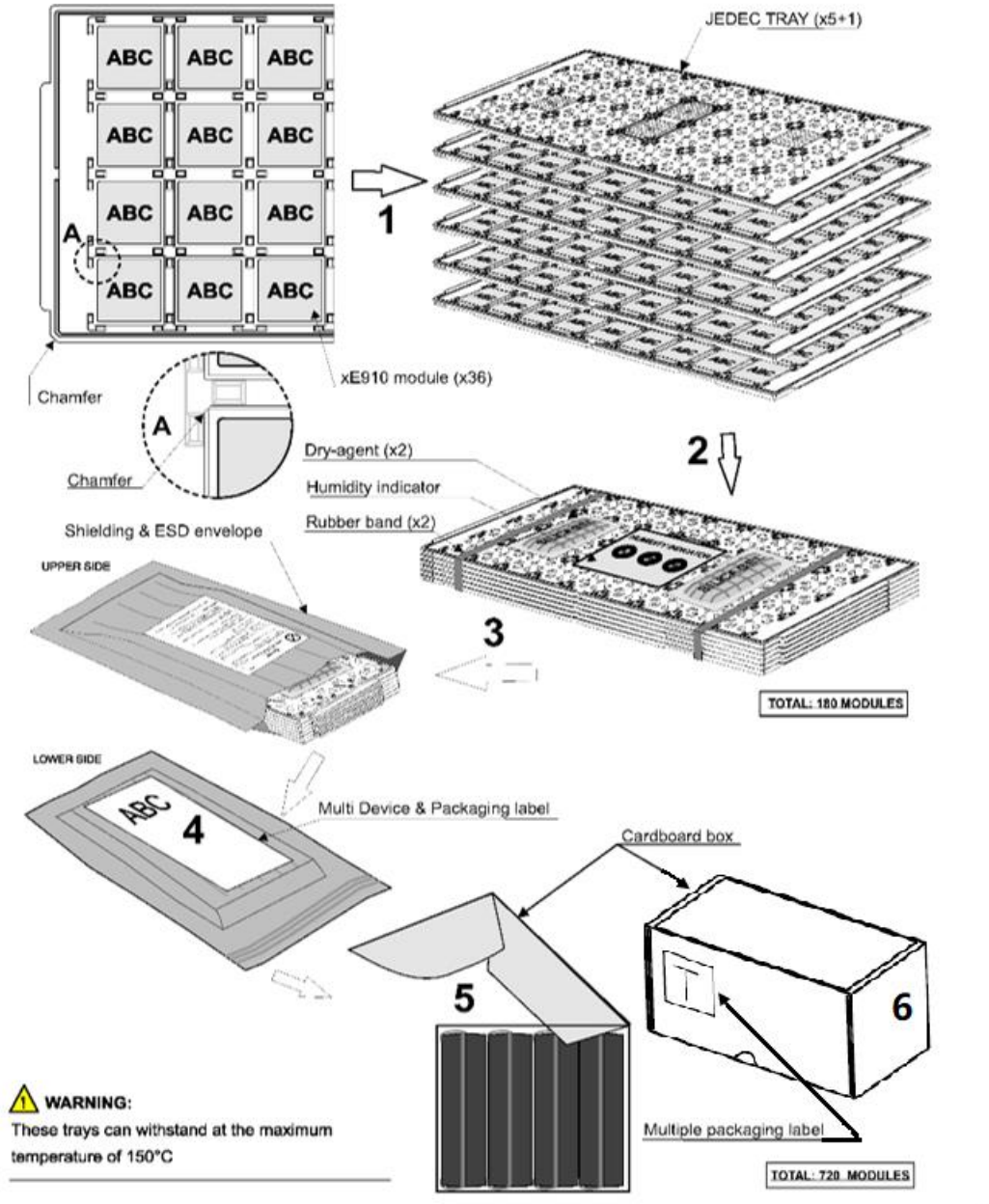

Figure 33: Tray packaging

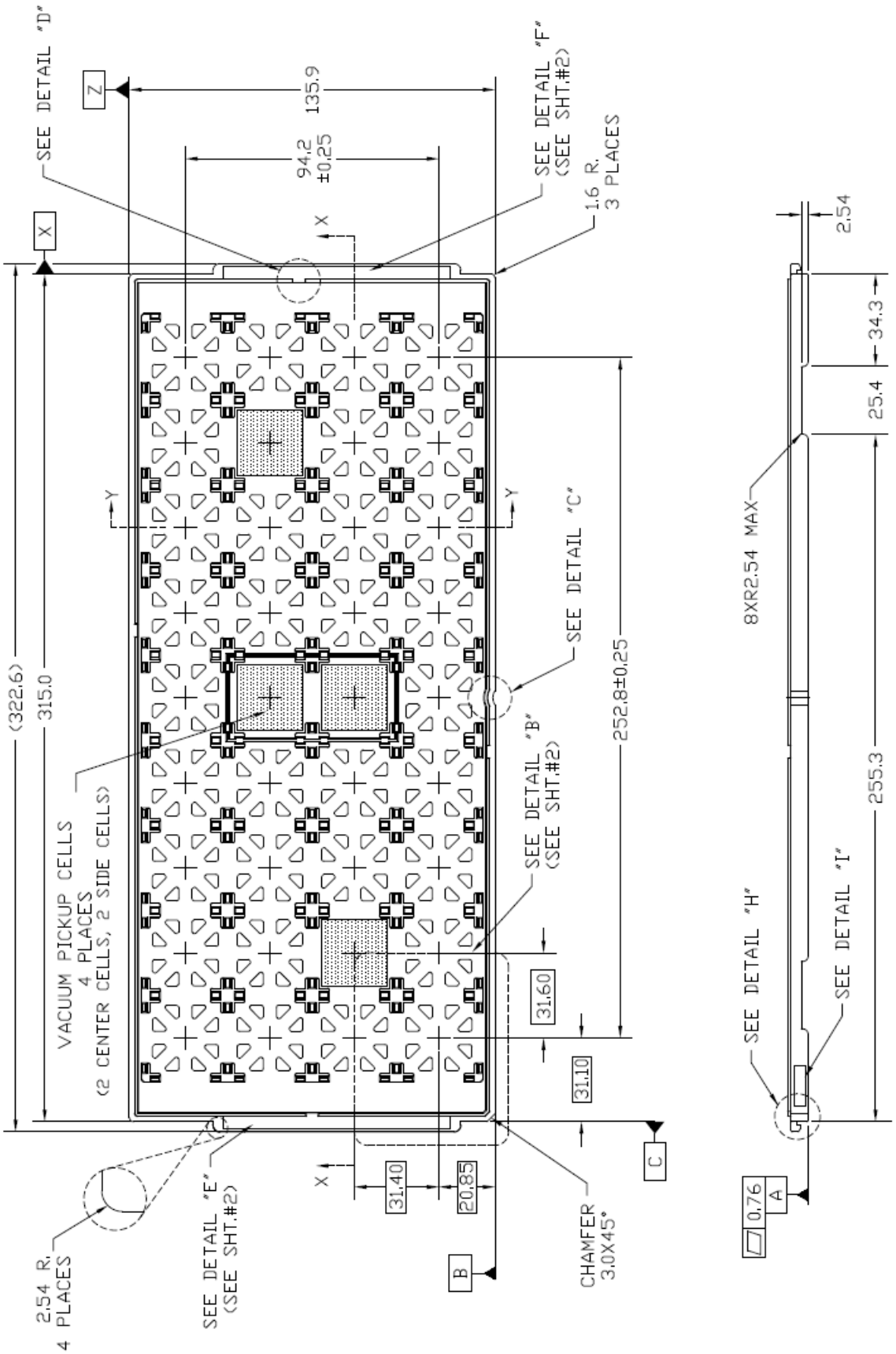

Figure 34: Tray dimensions

11.2 Moisture Sensitivity

The LE910Q1 is a Moisture Sensitive Device level 3, in according with standard IPC/JEDEC J-STD-020, take care all the relatives requirements for using this kind of components.

Moreover, the customer must take care of the following conditions:

a) Calculated shelf life in sealed bag: 12 months at <40°C and <90% relative humidity (RH).

b) Environmental condition during the production: 30°C / 60% RH according to IPC/JEDEC J-STD-033A paragraph 5.

c) The maximum time between the opening of the sealed bag and the reflow process must be 168 hours if condition b) “IPC/JEDEC J-STD-033D paragraph 5.2” is respected

d) Baking is required if conditions b) or c) are not respected

e) Baking is required if the humidity indicator inside the bag indicates 10% RHor more.

12 CONFORMITY ASSESSMENT ISSUES

12.1 Approvals Summary

Table 41: EMEA Approvals summary

Region	EMEA	
Country & Type Approval	EU RED	UK UKCA
LE910Q1-WW	●	●

Table 42: Americas Approvals summary

Region	Americas		
Country & Type Approval	US FCC	CA ISED	BR ANATEL
LE910Q1-WW	●	●	

Table 43: APAC Approvals summary

Region	APAC					
Country & Type Approval	JAP JRF / JTBL	CH CCC	KOREA KCC	AUS RCM	SG IMDA	TW NCC
LE910Q1-WW				●		

●	The equipment is compliant
●	Type approval is in progress
	The equipment is not compliant

Note: For approvals not included in the above, please contact Telit support.

12.2 EMEA Approvals

12.2.1 EU RED

12.2.1.1 EU Declaration of Conformity

In accordance with the above Approval Compliance Summary table, where applicable (green dots), hereby, Telit Communications S.p.A declares that the equipment is in compliance with the Directive 2014/53/EU.

The full text of the EU declaration of conformity is available at the following internet address: https://www.telit.com/red

Text of 2014/53/EU Directive (RED) requirements can be found here:

https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32014L0053

12.2.1.2 RED Antennas

This radio transmitter has been approved under RED to operate with the antenna types listed below with the maximum permissible gain indicated. The usage of a different antenna in the final hosting device may need a new assessment of host conformity to RED.

Table 44: RED Antenna Type

Model	Antenna Type
LE910Q1-WW	External Smarteq MiniMag 1140.24 Antenna Gain: B1/B3/B7/B34/B38/B40/B41 2.17 dBi, B8/B20 5.17dBi, B28 3.17dBi

Table 45: Max Gain for RED

Max Gain for RED (dBi)	
Band	LE910Q1-WW
B1	11.85
B3	11.35
B7	11.96
B8	8.46
B20	8.23
B28	7.49
B34	11.96
B38	11.96
B40	11.96
B41	11.96

12.2.2 UK UKCA

12.2.2.1 UKCA Declaration of Conformity

In accordance with the above Approval Compliance Summary table, where applicable (green ball), hereby, Telit Communications S.p.A declares that the equipment is in compliance with the Radio Equipment Regulations 2017 for UKCA.

The full text of the UKCA declaration of conformity is available at the following internet address: https://www.telit.com/ukca

The UKCA requirements can be found here:

https://www.gov.uk/guidance/using-the-ukca-marking

12.2.2.2 RED/UKCA Antennas

This radio transmitter has been approved under UKCA to operate with the antenna types listed below with the maximum permissible gain indicated. The usage of a different antenna in the final hosting device may need a new assessment of host conformity to UKCA.

Table 46: UKCA Antenna Type

Model	Antenna Type
LE910Q1-WW	External Smarteq MiniMag 1140.24 Antenna Gain: B1/B3/B7/B34/B38/B40/B41 2.17 dBi, B8/B20 5.17dBi, B28 3.17dBi

Table 47: Max Gain for UKCA

Max Gain for RED (dBi)	
Band	LE910Q1-WW
B1	11.85
B3	11.35
B7	11.96
B8	8.46
B20	8.23
B28	7.49
B34	11.96
B38	11.96
B40	11.96
B41	11.96

12.3 Americas Approvals

12.3.1 USA FCC

12.3.1.1 FCC Certificates

The FCC Grants can be found here: https://www.fcc.gov/oet/ea/fccid

12.3.1.2 Applicable FCC Rules

Table 48: Applicable FCC rules

Model	Applicable FCC Rules
LE910Q1-WW	47 CFR: - Part 2, 22, 24, 27, 90 - Part 15B

12.3.1.3 FCC Regulatory Notices

This module is intended for OEM integrators only. Per FCC KDB 996369 D03 OEM Manual, the following conditions must be strictly followed when using this certified module.

Modification statement

Telit has not approved any changes or modifications to this device by the user.

FCC Caution: Any changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate this equipment.

Interference statement

This device complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions:

(1) this device may not cause interference, and

(2) this device must accept any interference, including interference that may cause undesired operation of the device.

RF exposure considerations

This equipment complies with FCC mobile radiation exposure limits set forth for an uncontrolled environment. This equipment should be installed and operated with a minimum distance of 20cm between the radiator and your body. If the module is installed in a portable host, a separate SAR evaluation is required to confirm compliance with relevant FCC portable RF exposure rules.

FCC Class B digital device notice

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 taking 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.

Information for the OEMs and Integrators

1. This device is intended for OEM integrators only.
2. Please see the full Grant of Equipment document for other restrictions.

OEM/Host manufacturers are ultimately responsible for the compliance of the Host and Module. The final product must be reassessed against all the essential requirements of the FCC rule such as FCC Part 15 Subpart B before it can be placed on the US market. This includes reassessing the transmitter module for compliance with the Radio and EMF essential requirements of the FCC rules. This module must not be incorporated into any other device or system without retesting for compliance as multi-radio and combined equipment.

The final host product must comply with the requirements specified in §15.203, §15.204(b) and §15.204(c).

Manual Information to the End User

The OEM integrator should be aware not to provide information to the end user on 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/warming as shown in this manual

Information on test modes and additional testing requirement

The module is tested for standalone mobile RF exposure use condition. Any other usage conditions such as co-location with other transmitter(s) or being used in a portable condition will need a separate reassessment through a class II permissive change application or new certification.

If this module is intended for use in a portable device, you are responsible for separate approval to satisfy the SAR requirements of FCC Part 2.1093.

Limited module procedures

Not applicable.

Trace antenna designs

Please, refer to Section 8 of this document for antenna connector trace layout design and to the Gerber files attached to this document. Note that only the unique antenna connectors as indicated in this manual can be used for all transmitter ports.

Any deviation(s) from the defined parameters of the trace layout to antenna connector(s), as described by the instructions, require that the host product manufacturer must notify the module grantee that they wish to change the antenna trace design. In this case, a Class II permissive change application is required to be filed by the grantee, or the host manufacturer can take responsibility through the change in FCC ID (new application) procedure followed by a Class II permissive change application.

Unique antenna connector

For situations where the host product manufacturer is responsible for an external connector, for example with an RF pin and antenna trace design, the integration instructions shall inform the installer that unique antenna connector must be used on the Part 15 authorized transmitters used in the host product. The module manufacturers shall provide a list of acceptable unique connectors.

Additional testing, Part 15 Subpart B disclaimer

The modular transmitter is only authorized by the FCC for the specific rule parts (for example, FCC transmitter rules) listed on the grant, and that the host product manufacturer is responsible for compliance to any other FCC rules that apply to the host not covered by the modular transmitter grant of certification.

This transmitter module is tested as a subsystem and its certification does not cover the FCC Part 15 Subpart B (unintentional radiator) rule requirement applicable to the final host. The final host will still need to be reassessed for compliance to this portion of rule requirements if applicable.

As long as all 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.

IMPORTANT NOTE:

In the event that these conditions can not be met (for example certain laptop configurations or co-location with another transmitter), then the FCC authorization is no longer considered valid and the FCC 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 FCC authorization.

EMI Considerations

Please follow the guidance provided for host manufacturers in KDB publications 996369 D02 and D04.

How to make changes

Only Grantees are permitted to make permissive changes. Please contact us should the host integrator expect the module to be used differently than as granted:

Grantee code: RI7

Grantee name: Telit Communications S.p.A.

Mailing address: Viale Stazione di Prosecco 5/b, 34010 Sgonico – Trieste, Italy

Website: https://www.telit.com/

Support contact: TS-EMEA@telit.com

12.3.1.4 FCC Antenna Info

This radio transmitter has been approved by FCC to operate with the antenna types listed below with the maximum permissible gain indicated. Antennas of the same type with equal or lower gain may also be used with this module. Antennas having a gain greater than the maximum gain indicated for that type, are strictly prohibited for use with this device. The antenna must be installed such that 20 cm can be maintained between the antenna and users.

This radio module is sold without a specific antenna. Detailed electrical characteristics of the usable antenna are shown in Chapter 7

Table 49: FCC Antenna Type

Model	Antenna Type
LE910Q1-WW	External Smarteq MiniMag 1140.24 Max Antenna Gain: 617-803MHz 3.17dBi, 824-960MHz 5.17 dBi, 1710-2500 2.17dBi

Table 50: Max Gain for FCC (dBi)

Max Gain for FCC (dBi)	
Band	LE910Q1-WW
FDD 2	8.00
FDD 4	5.00
FDD 5	9.41
FDD 7	8.00
FDD 8	9.78
FDD 12	8.70
FDD 13	9.16
FDD 25	8.00
FDD 26	9.36 / 9.41
FDD 66	5.00
FDD 38	8.00
FDD 41	8.00

12.3.1.5 FCC Labelling Requirements for the Host Device

The host device shall be properly labelled to identify the modules within the host device. The certification label of the module shall be clearly visible at all times when installed in the host device, otherwise the host device must be labelled to display the FCC ID of the module, preceded by the words "Contains transmitter module", or the word "Contains", or similar wording expressing the same meaning, as in the below table.

Table 51:Host device FCC label

Model	FCC ID
LE910Q1-WW	Contains FCC ID: RI7LE910Q1WW

12.3.2 Canada ISED

12.3.2.1 ISED Database

The product ISED certified can be found here

Le certificat ISDE est disponible ici:

https://sms-sgs.ic.gc.ca/equipmentSearch/searchRadioEquipments?execution=e1s1&lang=en

Table 52: Applicable ISED rules

Model Modèle	Applicable ISED Rules Règles ISDE applicables
LE910Q1-WW	RSS-130 Issue 2, RSS-132 Issue 4, RSS-133 Issue 7, RSS-139 Issue 4, RSS-199 Issue 4; RSS-Gen Issue 5

12.3.2.2 ISED Regulatory Notices

Modification Statement */ Déclaration de modification*

Telit has not approved any changes or modifications to this device by the user. Any changes or modifications could void the user's authority to operate the equipment.

Telit n'approuve aucune modification apportée à l'appareil par l'utilisateur, quelle qu'en soit la nature. Tout changement ou modification peuvent annuler le droit d'utilisation de l'appareil par l'utilisateur.

Information for the OEMs and Integrators */ Informations pour les OEM et les intégrateurs*

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

1) The antenna must be installed and operated with greater than 20cm between the antenna and users, and

2) The transmitter module may not be co-located with any other transmitter or antenna.

As long as 2 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 installé et exploité avec plus de 20 cm entre l'antenne et les utilisateurs, et (if EUT is portable device, please delete this item)
2) Le module émetteur peut ne pas être coïmplanté avec un autre émetteur ou antenne. Tant que les 2 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.

Interference Statement */ Déclaration d'interférence*

This device complies with Industry Canada licence-exempt RSS standard(s). Operation is subject to the following two conditions: (1) this device may not cause interference, and (2) this device must accept any interference, including interference that may cause undesired operation of the device.

Le présent appareil est conforme aux applicables RSS standards d'Industrie Canada. L'exploitation est autorisée aux deux conditions suivantes : (1) l'appareil ne doit pas produire de brouillage, et (2) l'utilisateur de l'appareil doit accepter tout brouillage radioélectrique subi, même si le brouillage est susceptible d'en compromettre le fonctionnement.

Radio Exposure Notice */ Avis d'exposition radio*

This device complies with ISED radiation exposure limits set forth for an uncontrolled environment and meets the RSS-102 of the ISED radio frequency (RF) Exposure rules. Antenna gain must be less than the values reported in the following chapter.

Le présent appareil est conforme à l'exposition aux radiations FCC / ISED définies pour un environnement non contrôlé et répond aux directives d'exposition de la fréquence de la FCC radiofréquence (RF) et RSS-102 de la fréquence radio (RF) ISED règles d'exposition. Le gain de l'antenne doit être inférieur aux valeurs reportées dans le chapitre suivant.

12.3.2.3 ISED Antenna Info */ Informations sur l'antenne d'ISDE*

This radio transmitter has been approved by ISED to operate with the antenna types listed below with the maximum permissible gain indicated. Antenna types not included in this list, having a gain greater than the maximum gain indicated for that type, are strictly prohibited for use with this device. This transmitter module is authorized only for use in device where the antenna may be installed and operated with greater than 20cm between the antenna and users.

Le présent émetteur radio a été approuvé par ISDE pour fonctionner avec les types d'antenne énumérés ci-dessous et ayant un gain admissible maximal. Les types d'antenne non inclus dans cette liste, et dont le gain est supérieur au gain maximal indiqué, sont strictement interdits pour l'exploitation de l'émetteur. Ce module émetteur est autorisé uniquement pour une utilisation dans un appareil où l'antenne peut être installée et utilisée à plus de 20 cm entre l'antenne et les utilisateurs.

This radio module is sold without a specific antenna. Detailed electrical characteristics of the usable antenna are shown in Chapter 8.

Ce module radio est vendu sans antenne spécifique. Les caractéristiques électriques détaillées de l'antenne utilisable sont présentées au chapitre 8.

Table 53: ISED Antenna Type/ISDE Type d'antenne

Model Modèle	Antenna Type Type d'Antenne
LE910Q1-WW	Smarteq MiniMag 1140.24 Max Antenna Gain: 617-803MHz 3.17dBi, 824-960MHz 5.17 dBi, 1710-2500 2.17dBi

Table 54: Gain maximum for ISED (dBi) / *Gain maximum pour ISDE (dBi)*

Max Gain for ISED (dBi) /	
Band	LE910Q1-WW
FDD 2	8.00

Max Gain for ISED (dBi) /	
FDD 4	5.00
FDD 5	6.12
FDD 7	8.00
FDD 12	5.63
FDD 13	5.95
FDD 25	8.00
FDD 26	6.12
FDD 66	5.00
FDD 38	8.00
FDD 41	8.00

This transmitter must not be co-located or operating in conjunction with any other antenna or transmitter.

L'émetteur ne doit pas être colocalisé ni fonctionner conjointement avec à autre antenne ou autre émetteur.

This equipment must be installed and operated in accordance with provided instructions and the antenna(s) used for this transmitter must be installed to provide a separation distance of at least 20 cm from all persons and must not be co-located or operating in conjunction with any other antenna or transmitter. End-users and installers must be provided with antenna installation instructions and consider removing the no-collocation statement.

Cet équipement doit être installé et utilisé conformément aux instructions fournies et la ou les antennes utilisées pour cet émetteur doivent être installées pour fournir une distance de séparation d'au moins 20 cm de toutes les personnes et ne doivent pas être co-localisées ou fonctionner en conjonction avec toute autre antenne ou émetteur. Les utilisateurs finaux et les installateurs doivent recevoir les instructions d'installation de l'antenne et envisager de supprimer la déclaration de non-collocation.

Information on test modes and additional testing requirement */ Informations sur les modes de test et exigences de test supplémentaires*

The module has been evaluated in mobile stand-alone conditions. For operational conditions other than a stand-alone modular transmitter in a host (multiple, simultaneously transmitting modules or other transmitters in a host), additional testing may be required (collocation, retesting...) If this module is intended for use in a portable device, you are responsible for separate approval to satisfy the SAR requirements IC RSS-102.

Le module a été évalué dans des conditions mobiles autonomes. Pour des conditions de fonctionnement autres qu'un émetteur modulaire autonome dans un hôte (plusieurs modules transmettant simultanément ou d'autres émetteurs dans un hôte), des tests supplémentaires peuvent être nécessaires (colocalisation, retest...) Si ce module est destiné à être utilisé dans un appareil portable , vous êtes responsable de l'approbation séparée pour satisfaire aux exigences SAR IC RSS-102.

Trace antenna designs

See Chapter 7 on Antenna - PCB Line Guidelines

12.3.2.4 Voir le chapitre 7 sur l'antenne - *Directives de ligne PCB*

12.3.2.5 ISED Label and compliance information */ ISDE Étiquette et informations de conformité*

Labelling requirements for the host device */ Exigences d'étiquetage pour le périphérique hôte*

The host product shall be properly labelled to identify the modules within the host product.

The ISED certification label of a module shall be clearly visible at all times when installed in the host product; otherwise, the host product must be labelled to display the ISED certification number for the module, preceded by the word "contains" or similar wording expressing the same meaning, as follows:

Contains IC: XXXXXX-YYYYYYYYYY

In this case, XXXXXX-YYYYYYYYYY is the module's certification number.

Le produit hôte devra être correctement étiqueté, de façon à permettre l'identification des modules qui s'y trouvent.
L'étiquette d'homologation d'un module d'ISDE devra être apposée sur le produit hôte à un endroit bien en vue, en tout temps. En l'absence d'étiquette, le produit hôte doit porter une étiquette sur laquelle figure le numéro d'homologation du module d'ISDE, précédé du mot « contient », ou d'une formulation similaire allant dans le même sens et qui va comme suit :
Contient IC : XXXXXX-YYYYYYYYYY
Dans ce cas, XXXXXX-YYYYYYYYYY est le numéro d'homologation du module.

Table 55: Host device IC label / Ètiquette IC du dispositif hôte

Model HVIN	Host device IC label Ètiquette IC du dispositif hôte
LE910Q1-WW	Contains IC: 5131A-LE910Q1WW

CAN ICES-3 (B) / NMB-3 (B)

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

Cet appareil numérique de classe B est conforme à la norme canadienne ICES-003.

12.4 APAC Approvals

12.4.1 Australian RCM

12.4.1.1 RCM Regulatory Notices

In accordance with the above Approval Compliance Summary table, where applicable (green ball), hereby, Telit Communications S.p.A declares that the equipment is in compliance with Regulatory Compliance Mark (RCM) of Australia.

Module integration note

Manufacturers and suppliers of end-products that use a cellular modem cannot rely on module compliance alone. It is necessary to re-test at least the ETSI EN 301 908-1 radiated spurious emission within the context of the final end-product to ensure compliance with AS/CA S042. This testing will capture the impact of possible higher gain antenna and other changes introduced by the integration.

Note: The equipment listed may not work when main power fails.

13 REFERENCE TABLE OF RF BANDS CHARACTERISTICS

Table 56: RF Bands Characteristics

Mode	Freq. Tx (MHz)	Freq. Rx (MHz)	Channels	Tx-Rx Offset
LTE 2100 – B1	1920 ~ 1980	2110 ~ 2170	Tx: 18000 ~ 18599 Rx: 0 ~ 599	190 MHz
LTE 1900 – B2	1850 ~ 1910	1930 ~ 1990	Tx: 18600 ~ 19199 Rx: 600 ~ 1199	80 MHz
LTE 1800 – B3	1710 ~ 1785	1805 ~ 1880	Tx: 19200 ~ 19949 Rx: 1200 ~ 1949	95 MHz
LTE AWS – B4	1710 ~ 1755	2110 ~ 2155	Tx: 19950 ~ 20399 Rx: 1950 ~ 2399	400 MHz
LTE 850 – B5	824 ~ 849	869 ~ 894	Tx: 20400 ~ 20649 Rx: 2400 ~ 2649	45 MHz
LTE 2600 – B7	2500 – 2570	2620 – 2690	Tx: 20750 ~ 21449 Rx: 2750~ 3449	120 MHz
LTE 900 – B8	880 ~ 915	925 ~ 960	Tx: 21450 ~ 21799 Rx: 3450 ~ 3799	45 MHz
LTE 700 – B12	699 ~ 716	729 ~ 746	Tx: 23010 ~ 23179 Rx: 5010 ~ 5179	30 MHz
LTE 750 – B13	777 ~ 787	746 ~ 756	Tx: 23180 ~ 23279 Rx: 5180 ~ 5279	-31 MHz
LTE 850 – B18	815 ~ 830	860 ~ 875	Tx: 23850 ~ 23999 Rx: 5850 ~ 5999	45 MHz
LTE 850 – B19	830 ~ 845	875 ~ 890	Tx: 24000 ~ 24149 Rx: 6000 ~ 6149	45 MHz
LTE 800 – B20	832 ~ 862	791 ~ 821	Tx: 24150 ~ 24449 Rx: 6150 ~ 6449	-41 MHz
LTE 1900 – B25	1850 ~ 1915	1930 ~ 1995	Tx: 26040 ~ 26689 Rx: 8040 ~ 8689	80 MHz
LTE 850 – B26	814 ~ 849	859 ~ 894	Tx: 26690 ~ 27039 Rx: 8690 ~ 9039	45 MHz
LTE 700 – B28	703 ~ 748	758 ~ 803	Tx: 27210 ~ 27659 Rx: 9210 ~ 9659	55 MHz
LTE 2100 – B66	1710 ~ 1780	2110 ~ 2180	Tx: 131972 ~ 132671 Rx: 66436 ~ 67135	400 MHz
U.S. FCC 900MHz – B8_39d	897.5 ~ 900.5	936.5 ~ 939.5	Tx: 21625 ~ 21655 Rx: 21565 ~ 21595	39 MHz
LTE TDD 2000 – B34	2010 ~ 2025	2010 ~ 2025	Tx: 36200 ~ 36349 Rx: 36200 ~ 36349	0 MHz
LTE TDD 2600 – B38	2570 ~ 2620	2570 ~ 2620	Tx: 37750 ~ 38249	0 MHz

Mode	Freq. Tx (MHz)	Freq. Rx (MHz)	Channels	Tx-Rx Offset
			Rx: 37750 ~ 38249	
LTE TDD 1800 – B39	1880 ~ 1920	1880 ~ 1920	Tx: 38250 ~ 38649 Rx: 38250 ~ 38649	0 MHz
LTE TDD 2300 – B40	2300 ~ 2400	2300 ~ 2400	Tx: 38650 ~ 39649 Rx: 38650 ~ 39649	0 MHz
LTE TDD 2500 – B41	2496 ~ 2690	2496 ~ 2690	Tx: 39650 ~ 41589 Rx: 39650 ~ 41589	0 MHz

14 Acronyms and Abbreviations

Table 57: Acronyms and Abbreviations

Acronym	Definition
ADC	Analog – Digital Converter
CLK	Clock
CMOS	Complementary Metal – Oxide Semiconductor
CS	Chip Select
DAC	Digital – Analog Converter
DTE	Data Terminal Equipment
ESR	Equivalent Series Resistance
GPIO	General Purpose Input Output
HS	High Speed
HSDPA	High-Speed Downlink Packet Access
HSIC	High-Speed Inter Chip
HSUPA	High-Speed Uplink Packet Access
I/O	Input Output
MISO	Master Input – Slave Output
MOSI	Master Output – Slave Input
MRDY	Master Ready
PCB	Printed Circuit Board
RTC	Real-Time Clock
SIM	Subscriber Identification Module
SRDY	Slave Ready
TTSC	Telit Technical Support Centre
UART	Universal Asynchronous Receiver Transmitter
USB	Universal Serial Bus
VNA	Vector Network Analyzer
VSWR	Voltage Standing Wave Radio

15 Related Documents

Refer to https://dz.telit.com/ for current documentation and downloads.

Table 58: Related Documents

S.no	Book Code	Document Title
1	80798ST11194A	LE910Q1 AT Commands Reference Guide

16 Document History

Table 59: Document History

Revision	Date	Changes
2	2024-12-09	Updated: • 3.2 added B8 US • 4.1 added pinout details • 5.2 added more details and new +CFUN=14 consumptions • 5.4 added power mode details table • 6.4.3 added a note for back powering • 6.4.8. added a note about max number of GPIO • 6.7.1 added a warning about SIMVCC • 8.3.1 added details about GNSS pins • Cap7 added B8 US • 10.8 added a note for ramp-down rate during reflow Added: • 4.4 Pin Characteristics by Power Domains • 6.6.3 Emergency Reset • Added cap 12 CONFORMITY ASSESSMENT ISSUES
1	2024-08-05	Updated: • Table 1 – Applicability Table • 3.8 temperature range • 4.1 pinout information • 4.3 LGA pads layout • 5.2 power consumption • 6.2 power on section • 6.7 external SIM holder Added: • 3.7 and 7.3 typical sensitivity levels • 8.1 GNSS characteristics and block diagrams • 8.3 diagrams for GNSS controlled and standalone modes • 11 packaging
0	2024-02-13	First Issue

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