LM960
HW Design Guide

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DOCUMENTATION

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Applicability Table

PRODUCTS

- LM960

Contents

1. INTRODUCTION

1.1. Scope

This document introduces the Telit LM960 module and presents possible and recommended hardware solutions for developing a product based on the LM960 module. All the features and solutions detailed in this document are applicable to all LM960 variants, where “LM960” 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.

Information – LM960 refers to all modules listed in the Applicability Table.

This document takes into account all the basic functions of a wireless module; a valid hardware solution is suggested for each function, and incorrect solutions and common errors to be avoided are pointed out.

Obviously, this document cannot embrace every hardware solution or every product that can be designed. Where the suggested hardware configurations need not be considered mandatory, the information given should be used as a guide and a starting point for properly developing your product with the Telit LM960 module.

Information – The integration of the WCDMA/HSPA+/LTE LM960 cellular module within a user application must be done according to the design rules described in this manual.

1.2. Audience

This document is intended for Telit customers, especially system integrators, about to implement their applications using the Telit LM960 module.

1.3. Contact Information, Support

For general contact, technical support services, technical questions and report documentation errors contact Telit Technical Support at:

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

For detailed information about where you can buy the Telit modules or for recommendations on accessories and components visit:

http://www.telit.com

To register for product news and announcements or for product questions contact Telit's Technical Support Center (TTSC).

Our aim is to make this guide as helpful as possible. Keep us informed of your comments and suggestions for improvements.

Telit appreciates feedback from the users of our information.

1.4. Text Conventions

Danger – This information MUST be followed or catastrophic equipment failure or bodily injury may occur.

Caution or Warning – Alerts the user to important points about integrating the module, if these points are not followed, the module and end user equipment may fail or malfunction.

Tip or Information – Provides advice and suggestions that may be useful when integrating the module.

All dates are in ISO 8601 format, i.e. YYYY-MM-DD.

1.5. Related Documents

- LM960 SW User Guide, 1VV0301477
- LM960 AT Commands Reference Guide, 80568ST10869A
- Generic EVB HW User Guide, 1VV0301249
- LM960 Interface Board HW User Guide, 1VV0301502
- SIM Integration Design Guide Application Note Rev10, 80000NT10001A

2. GENERAL PRODUCT DESCRIPTION

2.1. Overview

The aim of this document is to present possible and recommended hardware solutions useful for developing a product with the Telit LM960 Mini PCIe module.

LM960 is Telit's platform for Mini PCIe module for applications, such as M2M applications and industrial IoT device platforms, based on the following technologies:

- LTE / WCDMA networks for data communication
- Designed for industrial grade quality

In its most basic use case, LM960 can be applied as a wireless communication front-end for mobile products, offering mobile communication features to an external host CPU through its rich interfaces.

LM960 can further support customer software applications and security features. LM960 provides a software application development environment with sufficient system resources for creating rich on-board applications. Thanks to a dedicated application processor and embedded security resources, product developers and manufacturers can create products that guarantee fraud prevention and tamper evidence without extra effort for additional security precautions.

LM960 is available in hardware variants as listed in Applicability Table
The designated RF band sets per each variant are detailed in Section 2.2, Product Variants and Frequency Bands.

2.2. Product Variants and Frequency Bands

The operating frequencies in LTE & WCDMA modes conform to the 3GPP specifications.

2.2.1. RF Bands per Regional Variant

This table summarizes the LM960, showing the supported band sets and the supported band pairs and triple for carrier aggregation.

RF Bands and Carrier Aggregation

	LTE FDD	LTE TDD	HSPA+
Bands	1, 2, 3, 4, 5, 7, 8, 12, 13, 14, 17, 18, 19, 20, 25, 26, 28, 29, 30, 32, 66, 71	38, 39, 40, 41, 42, 43, 46, 48	1, 2, 4, 5, 8, 9, 19
GNSS	GPS, GLONASS, BeiDou, Galileo		
LTE 2DL carrier aggregation combinations			
AT & T	CA_[2A]-[2A], CA_[2A]-[4A], CA_2A-5A, CA_2A-12A, CA_2A-14A, CA_2A-29A, CA_2A-30A, CA_[2A]-46A, CA_[2A]-[66A], CA_2C, CA_[4A]-[4A], CA_4A-5A, CA_4A-12A, CA_4A-29A, CA_4A-30A, CA_[4A]-46A, CA_5A-30A , CA_5A-66A, CA_5B, CA_12A-30A, CA_12A-66A, CA_12B, CA_14A-30A, CA_14A-66A, CA_29A-30A, CA_29A-66A, CA_30A-66A, CA_[66A]-[66A], CA_66B, CA_66C		

Verizon	CA_[2A]-[2A], CA_[2A]-[4A], CA_[2A]-5A, CA_[2A]-13A, CA_[2A]-[66A], CA_[4A]-[4A], CA_[4A]-5A, CA_[4A]-13A, CA_5A-[66A], CA_5B, CA_13A-[66A], CA_[66A]-[66A], CA_[66B], CA_[66C], CA_[2A]-48A, CA_13A-48A, CA_48A-[66A]
Sprint	CA_[25A]-[25A], CA_[25A]-26A, CA_25A-41A, CA_26A-[41A], CA_[41A]-[41A], CA_[41C]
Generic	CA_1C, CA_[2C], CA_3C, CA_7C, CA_12B, CA_38C, CA_39C, CA_40C, CA_[41C], CA_42C, CA_48C, CA_[66B], CA_[66C], CA_[2A]-[2A], CA_3A-3A, CA_[4A]-[4A], CA_7A-7A, CA_48A-48A, CA_[66A]-[66A], CA_1A-3A, CA_1A-5A, CA_1A-7A, CA_1A-18A, CA_1A-19A, CA_1A-20A, CA_1A-26A, CA_1A-28A, CA_1A-41A, CA_[2A]-[4A], CA_[2A]-5A, CA_2A-7A, CA_[2A]-12A, CA_[2A]-28A, CA_[2A]-46A, CA_[2A]-48A, CA_[2A]-[66A], CA_[2A]-71A, CA_3A-5A, CA_3A-7A, CA_3A-8A, CA_3A-19A, CA_3A-20A, CA_3A-26A, CA_3A-28A, CA_3A-38A, CA_[4A]-5A, CA_4A-7A, CA_[4A]-12A, CA_[4A]-28A, CA_[4A]-46A, CA_5A-7A, CA_7A-12A, CA_7A-20A, CA_7A-28A, CA_12A-[66A], CA_20A-32A, CA_26A-[41A], CA_39A-41A, CA_46A-[66A], CA_48A-[66A], CA_[66A]-71A
LTE 2UL carrier aggregation combinations	
AT & T	CA_2A-12A, CA_2A-5A, CA_4A-12A, CA_5A-66A, CA_5B, CA_12A-66A
Verizon	CA_2A-13A, CA_4A-13A
Sprint	CA_41C
Generic	CA_3C, CA_7C, CA_38C, CA_40C, CA_42C, CA_1A-7A, CA_1A-8A, CA_1A-28A, CA_3A-7A, CA_3A-8A, CA_3A-20A, CA_3A-28A
LTE 3DL carrier aggregation combinations	
AT & T	CA_2A-2A-5A, CA_[2A]-2A-12A, CA_2A-2A-14A, CA_2A-2A-30A, CA_2A-2A-66A, CA_[2A]-4A-4A, CA_2A-[4A]-[4A], CA_[2A]-4A-5A, CA_2A-[4A]-5A, CA_[2A]-4A-12A, CA_2A-[4A]-12A, CA_2A-4A-30A, CA_2A-5A-30A, CA_[2A]-5A-66A, CA_2A-5A-[66A], CA_2A-12A-30A, CA_[2A]-12A-66A, CA_2A-12A-[66A], CA_2A-14A-30A, CA_2A-14A-66A, CA_2A-29A-30A, CA_2A-30A-66A, CA_2A-46C, CA_2A-66A-66A, CA_[4A]-4A-5A, CA_[4A]-4A-12A, CA_4A-4A-30A, CA_4A-5A-30A, CA_4A-12A-30A, CA_4A-12B, CA_4A-29A-30A, CA_5A-30A-66A, CA_5A-66A-66A, CA_5A-66C, CA_12A-30A-66A, CA_12A-[66A]-66A, CA_14A-30A-66A, CA_14A-66A-66A, CA_29A-30A-66A, CA_29A-66A-66A, CA_30A-66A-66A
Verizon	CA_[2A]-2A-5A, CA_[2A]-2A-13A, CA_[2A]-2A-66A, CA_2A-2A-[66A], CA_[2A]-4A-5A, CA_2A-[4A]-5A, CA_[2A]-4A-13A, CA_2A-[4A]-13A, CA_[2A]-5A-66A, CA_2A-5A-[66A], CA_[2A]-13A-66A, CA_2A-13A-[66A], CA_[2A]-66A-66A, CA_2A-[66A]-66A, CA_[2A]-[66B], CA_[2A]-[66C], CA_[4A]-4A-5A, CA_[4A]-4A-13A, CA_5A-[66A]-66A, CA_5A-[66B], CA_5A-[66C], CA_13A-[66A]-66A, CA_13A-[66B], CA_13A-[66C], CA_[66A]-[66C], CA_[66D], CA_[2A]-48A-48A, CA_[2A]-48A-66A, CA_2A-48A-[66A], CA_[2A]-48C, CA_13A-48A-48A, CA_13A-48A-[66A], CA_13A-48C, CA_48A-48A-[66A], CA_48A-[66A]-66A, CA_48A-[66B], CA_48C-[66A]
Sprint	CA_[25A]-25A-26A, CA_26A-[41C], CA_[41A]-[41C], CA_[41D], CA_25A-41C

Generic	CA_1A-3A-7A, CA_1A-3A-19A, CA_1A-3A-20A, CA_1A-3A-28A, CA_1A-3A-38A, CA_1A-7A-20A, CA_1A-7A-28A, CA_1A-7C, CA_1A-40C, CA_1A-41C, CA_1A-42C, CA_1A-46C, CA_[2A]-2A-12A, CA_2A-[2A]-12A, CA_[2A]-2A-66A, CA_2A-[2A]-66A, CA_2A-2A-[66A], CA_[2A]-2A-71A, CA_2A-[2A]-71A, CA_[2A]-4A-4A, CA_2A-[4A]-4A, CA_2A-4A-[4A], CA_[2A]-4A-5A, CA_2A-[4A]-5A, CA_[2A]-4A-12A, CA_2A-[4A]-12A, CA_[2A]-4A-29A, CA_2A-[4A]-29A, CA_[2A]-4A-71A, CA_2A-[4A]-71A, CA_2A-7A-12A, CA_[2A]-12A-66A, CA_2A-12A-[66A], CA_[2A]-12B, CA_[2A]-46A-46A, CA_[2A]-46A-66A, CA_2A-46A-[66A], CA_[2A]-46C, CA_[2A]-48A-48A, CA_[2A]-48A-66A, CA_2A-48A-[66A], CA_[2A]-48C, CA_[2A]-66A-66A, CA_2A-[66A]-66A, CA_2A-66A-[66A], CA_[2A]-66A-71A, CA_2A-[66A]-71A, CA_[2A]-[66C], CA_[2A]-66C, CA_2A-[66C], CA_3A-7A-20A, CA_3A-7A-28A, CA_3A-7C, CA_3A-40C, CA_3A-42C, CA_3A-46C, CA_3C-5A, CA_3C-7A, CA_3C-20A, CA_3C-28A, CA_4A-4A-7A, CA_[4A]-4A-12A, CA_4A-[4A]-12A, CA_[4A]-4A-71A, CA_4A-[4A]-71A, CA_4A-7A-12A, CA_[4A]-12B, CA_[4A]-46A-46A, CA_[4A]-46C, CA_7A-46C, CA_7C-28A, CA_12A-[66A]-66A, CA_12A-66A-[66A], CA_12A-[66C], CA_19A-42C, CA_28A-40C, CA_40D, CA_46C-[66A], CA_48A-48A-[66A], CA_48A-48C, CA_48C-[66A], CA_48D, CA_[66A]-66A-71A, CA_66A-[66A]-71A
LTE 4DL carrier aggregation combinations	
AT & T	CA_2A-2A-5A-30A, CA_2A-2A-5A-66A, CA_2A-2A-12A-30A, CA_2A-2A-12A-66A, CA_2A-2A-14A-66A, CA_2A-2A-29A-30A, CA_2A-2A-66A-66A, CA_2A-4A-4A-12A, CA_2A-4A-5A-30A, CA_2A-4A-12A-30A, CA_2A-5A-30A-66A, CA_2A-5A-66A-66A, CA_2A-5B-30A, CA_2A-5B-66A, CA_2A-12A-30A-66A, CA_2A-12A-66A-66A, CA_2A-14A-30A-66A, CA_2A-14A-66A-66A, CA_2A-29A-30A-66A, CA_[2A]-46D, CA_[4A]-46D, CA_4A-4A-12A-30A, CA_5A-30A-66A-66A, CA_5B-30A-66A, CA_5B-66A-66A, CA_12A-30A-66A-66A, CA_14A-30A-66A-66A, CA_29A-30A-66A-66A, CA_46D-[66A]
Verizon	CA_2A-48A-48A-66A, CA_[2A]-48D, CA_13A-48A-48A-66A, CA_13A-48A-48C, CA_13A-48C-[66A], CA_13A-48D, CA_48A-48A-66A-66A, CA_48A-48A-[66B], CA_48A-48A-[66C], CA_48A-48C-[66A], CA_48D-[66A]
Sprint	CA_25A-41D, CA_25A-41D, CA_[41C]-41C, CA_[41A]-41D, CA_41E
Generic	CA_1A-3A-7A-20A, CA_1A-3A-7A-28A, CA_1A-3A-7C, CA_1A-3A-42C, CA_1A-3C-5A, CA_1A-3C-7A, CA_1A-46D, CA_2A-2A-12A-66A, CA_2A-2A-66A-66A, CA_[2A]-2A-66C, CA_2A-[2A]-66C, CA_2A-2A-[66C], CA_2A-4A-7A-12A, CA_2A-12A-66A-66A, CA_2A-46A-46A-66A, CA_[2A]-46A-46C, CA_[2A]-46C-66A, CA_2A-46C-[66A], CA_[2A]-46D, CA_[2C]-66A-66A, CA_2C-[66A]-66A, CA_2C-66A-[66A], CA_3A-5A-7A-7A, CA_3C-7A-20A, CA_3C-7A-28A, CA_3A-7C-28A, CA_3A-28A-40C, CA_3A-40D, CA_3A-46D, CA_3C-7C, CA_[4A]-46A-46C, CA_[4A]-46D, CA_7A-46D, CA_28A-46D, CA_40E, CA_[41C]-42C, CA_46A-46C-[66A], CA_46D-[66A], CA_48D-[66A], CA_48E
LTE 5DL carrier aggregation combinations	
AT & T	CA_2A-2A-46D, CA_2A-5B-30A-66A, CA_2A-5B-66A-66A, CA_2A-46D-66A, CA_5B-30A-66A-66A, CA_46D-66A-66A
Verizon	CA_2A-48E, CA_13A-48A-48C-66A, CA_13A-48C-48C, CA_13A-48D-66A, CA_13A-48E, CA_48A-48C-66B, CA_48A-48C-66C, CA_48C-48C-66A, CA_48E-66A
Sprint	-
Generic	CA_1A-3A-7C-28A, CA_1A-3C-7C, CA_2A-46A-46C-66A, CA_2A-46D-66A, CA_3A-28A-40D, CA_3A-40E, CA_3C-7C-28A

- [ ] mean that 4*4 MIMO is supported

Refer to Chapter 14 for details information about frequencies and bands.

2.3. Target market

LM960 can be used for telematics applications where tamper-resistance, confidentiality, integrity, and authenticity of end-user information are required, for example:

- Industrial equipment
- Home network
- Internet connectivity

2.4. Main features

The LM960 family of industrial grade cellular modules features LTE and multi-RAT module together with an on-chip powerful application processor and a rich set of interfaces.

The major functions and features are listed below.

Main Features

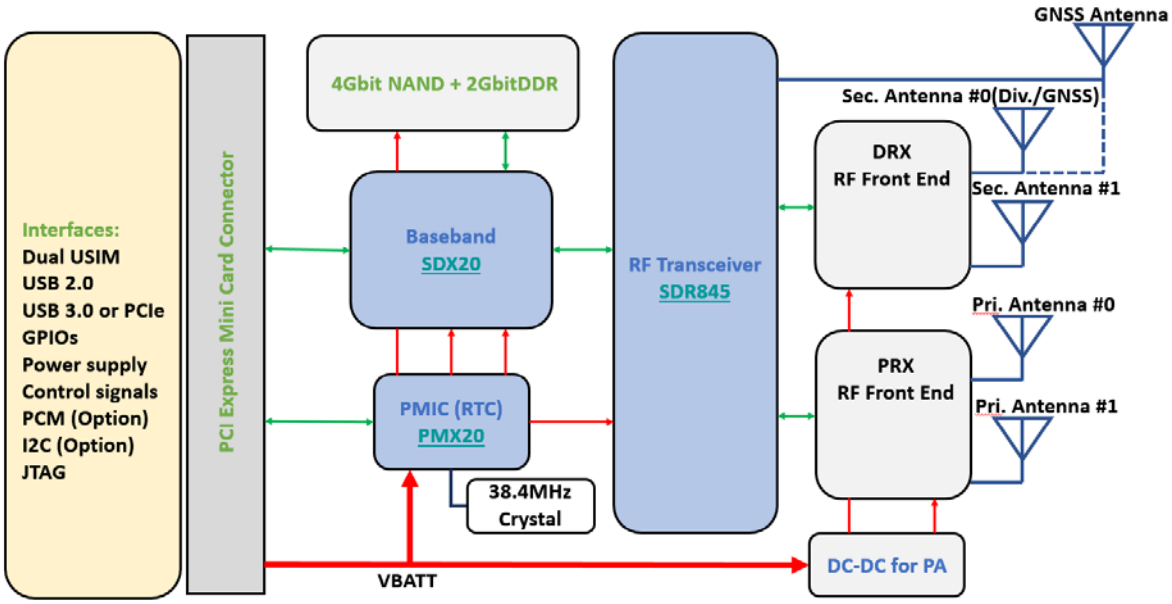
Function	Features
Module	• Multi-RAT cellular module for data communication o LTE FDD/TDD Cat18(DL)/13(UL) (1.2 Gbps/150 Mbps) o WCDMA up to DC HSPA+, Rel.10 • Support for GPS, GLONASS, BeiDou and Galileo
Audio subsystem	• Support digital audio interface (optional)
Two USIM ports – dual voltage	• Support for dual SIM • Class B and Class C support • Clock rates up to 4 MHz
Application processor	Application processor to run customer application code • 32 bit ARM Cortex-A7 up to 1.4 GHz running the Linux operating system • 4Gbit NAND Flash + 2Gbit LPDDR2 MCP is supported to allow for customer's own software applications
Interfaces	Rich set of interfaces, including: • USB3.0 – USB port is typically used for: o Flashing of firmware and module configuration o Production testing

Function	Features
	o Accessing the Application Processor's file system o AT command access o High-speed WWAN access to external host o Diagnostic monitoring and debugging o Communication between Java application environment and an external host CPU o NMEA data to an external host CPU • PCIe(Optional) • Peripheral Ports – GPIOs
Major software features	• Advanced security features o Boot integrity of firmware up to customer applications o Disable/secure re-enable of debug o Embedded security • FOTA (optional) • Telit Unified AT command set
Form factor	Mini PCIe Form factor (50.95x30x2.7mm), accommodating the multiple RF bands
Environment and quality requirements	The entire module is designed and qualified by Telit for satisfying the environment and quality requirements for use in applications.
Single supply module	The module generates all its internal supply voltages.
RTC	The real-time clock is supported.
Operating temperature	Range -40 °C to +85 °C (conditions as defined in Section 2.9.1, Temperature Range)

2.5. Block Diagram

Below figure shows an overview of the internal architecture of the LM960 module.

LM960 Block Diagram



It includes the following sub-functions:

- Application processor, Module subsystem and Location processing with their external interfaces. These three functions are contained in a single SOC.
- RF front end
- Rich IO interfaces. Depending on which LM960 software features are enabled, some of its interfaces that are exported through multiplexing may be used internally and thus may not be usable by the application.
- PMIC with the RTC function inside

2.6. TX Output Power

Band	Power class
3G WCDMA	Class 3 (0.2W)
LTE All Bands	Class 3 (0.2W)
LTE Band 41 supports HPUE	Class 2 (0.4W)

2.7. RX Sensitivity

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

Technology	3GPP Compliance
4G LTE	Throughput >95% 10MHz Dual Receiver
3G WCDMA	BER <0.1% 12.2 Kbps Dual Receiver

Product	Band	Typical Rx Sensitivity (dBm) * / ** (BW = 10 MHz / B46 BW = 20 MHz)
LM960	LTE FDD B1	-100.0 dBm
	LTE FDD B2	-100.0 dBm
	LTE FDD B3	-100.0 dBm
	LTE FDD B4	-100.5 dBm
	LTE FDD B5	-101.0 dBm
	LTE FDD B7	-100.0 dBm
	LTE FDD B8	-100.5 dBm
	LTE FDD B12	-101.0 dBm
	LTE FDD B13	-100.5 dBm
	LTE FDD B14	-100.0 dBm
	LTE FDD B17	-101.0 dBm
	LTE FDD B18	-101.0 dBm
	LTE FDD B19	-100.0 dBm
	LTE FDD B20	-100.5 dBm
	LTE FDD B25	-100.0 dBm
	LTE FDD B26	-100.0 dBm
	LTE FDD B28	-100.5 dBm
	LTE FDD B29 (DL Only)	-100.0 dBm
	LTE FDD B30	-100.0 dBm
	LTE FDD B32	-100.0 dBm
	LTE FDD B66	-100.0 dBm
	LTE TDD B38	-99.0 dBm
	LTE TDD B39	-100.0 dBm
	LTE TDD B40	-100.0 dBm

	LTE TDD B41	-99.0 dBm
	LTE TDD B42	-100.0 dBm
	LTE TDD B43	-100.0 dBm
	LTE TDD B46 (DL Only)	-95.0 dBm
	LTE TDD B48	-100.0 dBm
	LTE FDD B71	-99.5 dBm
LM960	WCDMA FDD B1	-111.0 dBm
	WCDMA FDD B2	-110.0 dBm
	WCDMA FDD B4	-111.0 dBm
	WCDMA FDD B5	-111.0 dBm
	WCDMA FDD B8	-110.0 dBm
	WCDMA FDD B9	-110.0 dBm
	WCDMA FDD B19	-111.0 dBm

* LTE Rx Sensitivity shall be verified by using both (all) antenna ports simultaneously.

** 3.3 Voltage / Room temperature

2.8. Mechanical specifications

2.8.1. Dimensions

The LM960 module's overall dimensions are:

- Length: 50.95 mm, +/- 0.15 mm tolerance
- Width: 30.00 mm, +/- 0.15 mm tolerance
- Thickness: 2.70 mm, +/- 0.15 mm tolerance

2.8.2. Weight

The nominal weight of the LM960 module is 10.1 grams.

2.9. Environmental Requirements

2.9.1. Temperature Range

		Note
Operating Temperature Range	–20°C ~ +55°C	This range is defined by 3GPP (the global standard for wireless mobile communication). Telit guarantees its modules to comply with all the 3GPP requirements and to have full functionality of the module with in this range.
	–40°C ~ +85°C	Telit guarantees full functionality within this range as well. However, there may possibly be some performance deviations in this extended range relative to 3GPP requirements, which means that some RF parameters may deviate from the 3GPP specification in the order of a few dB. For example: receiver sensitivity or maximum output power may be slightly degraded. Even so, all the functionalities, such as call connection, SMS, USB communication, UART activation etc., will be maintained, and the effect of such degradations will not lead to malfunction.
Storage and non-operating Temperature Range	–40°C ~ +85°C	

2.9.2. RoHS Compliance

As a part of the Telit corporate policy of environmental protection, the LM960 complies with the RoHS (Restriction of Hazardous Substances) directive of the European Union (EU directive 2011/65/EU).

3. PINS ALLOCATION

3.1. Pin-out

LM960 Pin-out

Pin	Signal	I/O	Function	Type	Comment
USB HS 2.0 Communication Port					
38	USB_D+	I/O	USB 2.0 Data Plus	Analog	
36	USB_D-	I/O	USB 2.0 Data Minus	Analog	
USB SS 3.0 Communication and PCIe Port					
25	USB_TX_P PCIE_TX_P	O	USB 3.0 super-speed/PCIe transmit – plus	Analog	
23	USB_TX_M PCIE_TX_M	O	USB 3.0 super-speed/PCIe transmit – minus	Analog	
33	USB_RX_P PCIE_RX_P	I	USB 3.0 super-speed/PCIe receive – plus	Analog	
31	USB_RX_M PCIE_RX_M	I	USB 3.0 super-speed/PCIe receive – minus	Analog	
Peripheral Component Interconnect Express					
7	PCIE_CLKREQ_N	I/O	PCIE reference clock request signal.	1.8V	
11	PCIE_REFCLK_M	I	PCI Express differential reference clock – minus		
13	PCIE_REFCLK_P	I	PCI Express differential reference clock – plus		

22	PCIE_RESET_N	I	Functional reset to the PCIe bus	1.8V	
SIM Card Interface 1					
8	SIMVCC1	O	Supply output for an external UIM1 card	1.8V / 2.85V	Power
10	SIMIO1	I/O	Data connection with an external UIM1 card	1.8V / 2.85V	
12	SIMCLK1	O	Clock output to an external UIM1 card	1.8V / 2.85V	
14	SIMRST1	O	Reset output to an external UIM1 card	1.8V / 2.85V	
SIM Card Interface 2					
16	SIMVCC2	O	Supply output for an external UIM2 card	1.8 / 2.85V	Power
19	SIMIO2	I/O	Data connection with an external UIM2 card	1.8 / 2.85V	
17	SIMCLK2	O	Clock output to an external UIM2 card	1.8 / 2.85V	
6	SIMRST2	O	Reset output to an external UIM2 card	1.8 / 2.85V	
Digital I/O (GPIOs)					
3	SIMIN1/GPIO_01	I/O	General purpose I/O Can be used as SIMIN1	1.8V	
5	SIMIN2/GPIO_02	I/O	General purpose I/O Can be used as SIMIN2	1.8V	
44	GPIO_03	I/O	General purpose I/O	1.8V	

46	GPIO_04	I/O	General purpose I/O	1.8V	
Control Signal					
1	PCIE_WAKE_N	O	PCIe wake-up	1.8V	
20	W_DISABLE_N	I	RF disable	Open-drain	Internal VBATT Pull-up
42	WAN_LED_N	O	LED control	Open-drain	
Miscellaneous Functions					
28	VREG_L6_1P8	O	Reference Voltage	1.8V	Power
48	SYSTEM_RESET_N	I	Reset Input	1.8V	
Digital Audio Interface					
45	DVI _CLK	O	PCM Clock	1.8V	
47	DVI _TX	O	PCM Data Out	1.8V	
49	DVI _RX	I	PCM Data In	1.8V	
51	DVI _WAO	O	PCM Frame Sync	1.8V	
I2C Interface					
30	I2C_SCL	O	I2C Clock	1.8V	
32	I2C_SDA	I/O	I2C Data	1.8V	
Power Supply					
2	VBATT	I	Power supply	Power	
24	VBATT	I	Power supply	Power	
39	VBATT	I	Power supply	Power	

41	VBATT	I	Power supply	Power
52	VBATT	I	Power supply	Power
GROUND				
4	GND	-	Ground	Ground
9	GND	-	Ground	Ground
15	GND	-	Ground	Ground
18	GND	-	Ground	Ground
21	GND	-	Ground	Ground
26	GND	-	Ground	Ground
27	GND	-	Ground	Ground
29	GND	-	Ground	Ground
34	GND	-	Ground	Ground
35	GND	-	Ground	Ground
37	GND	-	Ground	Ground
40	GND	-	Ground	Ground
43	GND	-	Ground	Ground
50	GND	-	Ground	Ground

Information – If the DVI and I2C interface are not used, the signals can be left floating.

Information – Unless otherwise specified, RESERVED pins must be left unconnected (Floating).

3.2. LM960 Signals That Must Be Connected

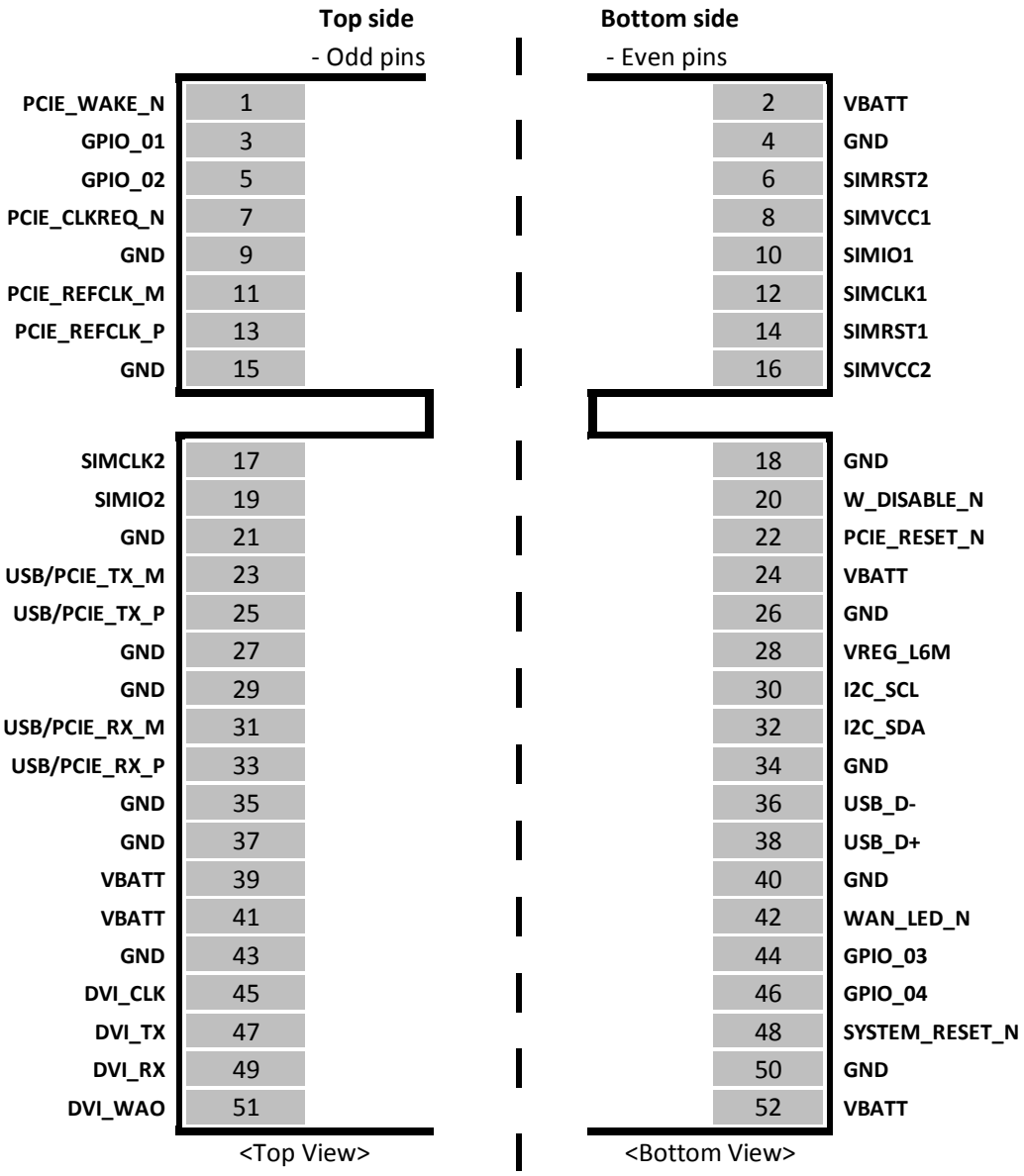
Below table specifies the LM960 signals that must be connected for a debugging purpose even if not used by the end application:

Mandatory Signals

Pin	Signal	Notes
2, 24, 39, 41, 52	VBATT	
4, 9, 15, 18, 21, 26, 27, 29, 34, 35, 37, 40, 43, 50	GND	
38	USB_D+	If not used, connect to a test point or an USB connector
36	USB_D-	If not used, connect to a test point or an USB connector

3.3. Pin Layout

LM960 Pin Layout



4. POWER SUPPLY

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

4.1. Power Supply Requirements

The LM960 power requirements are as follows:

Power Supply Requirements

Nominal supply voltage	3.3V
Supply voltage range	3.10V – 3.6V
Maximum ripple on module input supply	30 mV

4.2. Power Consumption

Below table provides typical current consumption values of LM960 for various operation modes.

LM960 Current Consumption

Mode	Average [Typ.]	Mode Description
IDLE Mode		
CFUN=1	20mA	No call connection USB3.0 is connected to a host
Power Saving Mode (PSMWDISACFG=1, W_DISABLE_N:Low)		
CFUN=4	2.5mA	Tx and Rx are disabled; module is not registered on the network (Flight mode)
WCDMA	3mA	DRx7 (1.28 sec DRx cycle)
LTE	3.3mA	Paging cycle #128 frames (1.28 sec DRx cycle)
Operative Mode (LTE)		
Non-CA mode (1DL / 1UL)	600mA	Non-CA, Band 2, Single carrier, BW 5MHz, 23dBm, 1RB
2DL CA with 2x2 MIMO / 2UL CA	900mA	CA_2A-5A, 2x2 MIMO, Full RB, 256QAM DL / 64QAM UL (FDD 300Mbps DL / 150Mbps UL)
5DL CA with 2x2 MIMO / 1UL	1000mA	CA_2A-5B-66A-66A, 2x2 MIMO, Full RB, 256QAM DL / 64QAM UL (FDD 1Gbps DL / 75Mbps UL)

Mode	Average [Typ.]	Mode Description
3DL CA with 4x4 MIMO / 1UL	1200mA	CA_2A-66C, 4x4 MIMO, Full RB, 256QAM DL / 64QAM UL (FDD 1.2Gbps DL / 75Mbps UL)
Operative Mode (WCDMA)		
WCDMA Voice	750 mA	WCDMA voice call (Tx = 23 dBm)
WCDMA HSPA (22 dBm)	650 mA	WCDMA data call (DC-HSDPA up to 42 Mbps, Max Throughput)

* Worst/best case current values depend on network configuration - not under module control.

** Loop-back mode in call equipment

*** 3.3 voltage / room temperature

Information – The electrical design for the power supply must ensure a peak current output of at least 2A.

4.3. General Design Rules

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

- Electrical design
- Thermal design
- PCB layout

4.3.1. Electrical Design Guidelines

The electrical design of the power supply depends strongly on the power source where this power is drained.

4.3.1.1. + 5V Input Source Power Supply – Design Guidelines

- The desired output for the power supply is 3.3V. So, the difference between the input source and the desired output is not big, and therefore a linear regulator can be used. A switching power supply is preferred to reduce power consumption.
- When using a linear regulator, a proper heat sink must be provided to dissipate the power generated.
- A bypass low ESR capacitor of adequate capacity must be provided to cut the current absorption peaks close to the LM960 module. A 100 µF tantalum capacitor is usually suitable on VBATT.
- Make sure that the low ESR capacitor on the power supply output (usually a tantalum one) is rated at least 10V.
- A protection diode must be inserted close to the power input to protect the LM960 module from power polarity inversion.

4.3.2. Thermal Design Guidelines

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

- Average current consumption during RF transmission @PWR level max in LM960 as shown in Section 4.2, Power Consumption table.

Information – The average consumption during transmission depends on the power level at which the device is requested to transmit via the network.

Therefore, the average current consumption varies significantly.

Information – The thermal design for the power supply must be made keeping an average consumption at the maximum transmitting level during calls of LTE/HSPA.

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 Data session.

In LTE/WCDMA/HSPA mode, the LM960 emits RF signals continuously during transmission. Therefore, you must pay special attention how to dissipate the heat generated.

While designing the application board, the designer must make sure that the LM960 module is located on a large ground area of the application board for effective heat dissipation.

Information – The LM960 must be connected to the ground and metal chassis of the host board for best RF performance and thermal dispersion as well as to have module fixed.

- The two holes at the top of the module and the main ground of the host board must be fastened together.
- The shield cover of the module and the main board of the host board or the metal chassis of the host device should be connected with conductive materials.

4.3.3. Power Supply PCB layout Guidelines

As seen in the electrical design 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 power supply performances.

- The bypass low ESR capacitor must be placed close to the LM960 power input pins, or if the power supply is of a switching type, it can be placed close to the inductor to cut the ripple, as long as the PCB trace from the capacitor to LM960 is wide enough to ensure a drop-less connection even during the 2A 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 2A current peaks.
- The PCB traces to LM960 and the bypass capacitor must be wide enough to ensure that no significant voltage drops occur when the 2A current peaks are absorbed. This is needed for the same above-mentioned reasons. Try to keep these traces as short as possible.
- The PCB traces connecting the switching output to the inductor and the switching diode must be kept as short as possible by placing the inductor and the diode very close to the power switching IC (only for the switching power supply). This is done to reduce the radiated field (noise) at the switching frequency (usually 100-500 kHz).
- Use a good common ground plane.
- Place the power supply on the board in a way to guarantee that the high current return paths in the ground plane do not overlap any noise sensitive circuitry, such as the microphone amplifier/buffer or earphone amplifier.
- The power supply input cables must be kept separate from noise sensitive lines, such as microphone/earphone cables.

4.4. RTC

The RTC within the LM960 module does not have a dedicated RTC supply pin. The RTC block is supplied by the VBATT supply.

If VBATT power is removed, RTC is not maintained so if maintaining an internal RTC is needed, VBATT must be supplied continuously.

4.5. Reference Voltage

1.8V regulated power supply output is provided as the reference voltage to a host board. This output is active when the module is ON and goes OFF when the module is shut down.

This table lists the VREG_L6_1P8 signal of LM960.

LM960 Reference Voltage

PIN	Signal	I/O	Function	Type	Comment
28	VREG_L6_1P8	O	Reference Voltage	power	1.8V

4.6. Internal LDO for GNSS bias

The LDO for GNSS bias is applied inside the LM960 model.

The voltage supply come from LM960's LDO to GNSS active antenna.

This table lists the LDO for GNSS bias of LM960.

LM960 Reference Voltage when VBATT is 3.3

Symbol	Parameter	Min	Typ	Max	Unit
$V_{GNSS\ DC\ bias}$	Voltage of Internal LDO for GNSS bias	2.9	3.1	3.15	[V]
$I_{GNSS\ DC\ bias}$	Current of Internal LDO for GNSS bias	-	-	100	[mA]

5. ELECTRICAL SPECIFICATIONS

5.1. Absolute Maximum Ratings – Not Operational

Caution – A deviation from the value ranges listed below may harm the LM960 module.

Absolute Maximum Ratings – Not Operational

Symbol	Parameter	Min	Max	Unit
VBATT	Battery supply voltage on pin VBATT	-0.5	+4.2	[V]

5.2. Recommended Operating Conditions

Recommended Operating Conditions

Symbol	Parameter	Min	Typ	Max	Unit
T_{amb}	Ambient temperature	-40	+25	+85	[°C]
VBATT	Battery supply voltage on pin VBATT	3.1	3.3	3.6	[V]
I_{VBATT+} I_{VBATT_PA}	Peak current to be used to dimension decoupling capacitors on pin VBATT	-	80	2500	[mA]

6. DIGITAL SECTION

6.1. Logic Levels

Unless otherwise specified, all the interface circuits of the LM960 are 1.8V CMOS logic.

Only USIM interfaces are capable of dual voltage I/O.

The following tables show the logic level specifications used in the LM960 interface circuits. The data specified in the tables below is valid throughout all drive strengths and the entire temperature ranges.

Caution – Do not connect LM960's digital logic signal directly to OEM's digital logic signal with a level higher than 2.3V for 1.8V CMOS signals.

6.1.1. 1.8V Pins – Absolute Maximum Ratings

Absolute Maximum Ratings – Not Functional

Parameter	Min	Max
Input level on any digital pin when on	--	+2.16V
Input voltage on analog pins when on	--	+2.16 V

6.1.2. 1.8V Standard GPIOs

Operating Range – Interface Levels (1.8V CMOS)

Parameter		Min	Max	Unit	Comment
VIH	Input high level	1.17V	2.1V	[V]	
VIL	Input low level	-0.3V	0.63V	[V]	
VOH	Output high level	1.35V	1.8V	[V]	
VOL	Output low level	0V	0.45V	[V]	
IIL	Low-level input leakage current	-1	--	[uA]	No pull-up
IIH	High-level input leakage current	--	1	[uA]	No pull-down
IILPU	Low-level input leakage current	-97.5	-27.5	[uA]	With pull-up

Parameter		Min	Max	Unit	Comment
IIHPD	High-level input leakage current	27.5	97.5	[uA]	With pull-down
CI/o	I/O capacitance	--	5	[pF]	

6.1.3. 1.8V SIM Card Pins

Operating Range – SIM Pins Working at 1.8V

Parameter		Min	Max	Unit	Comment
VIH	Input high level	1.26V	2.1V	[V]	
VIL	Input low level	-0.3V	0.36V	[V]	
VOH	Output high level	1.44V	1.8V	[V]	
VOL	Output low level	0V	0.4V	[V]	
IIL	Low-level input leakage current	--	1000	[uA]	No pull-up
IIH	High-level input leakage current	-20	20	[uA]	No pull-down

6.1.4. 2.85V Pins – Absolute Maximum Ratings

Absolute Maximum Ratings – Not Functional

Parameter	Min	Max
Input level on any digital pin when on	--	+3.42V
Input voltage on analog pins when on	--	+3.42 V

6.1.5. SIM Card Pins @2.85V

Operating Range – For SIM Pins Operating at 2.85V

Parameter		Min	Max	Unit	Comment
VIH	Input high level	1.995V	3.15V	[V]	
VIL	Input low level	-0.3V	0.57V	[V]	
VOH	Output high level	2.28V	2.85V	[V]	
VOL	Output low level	0V	0.4V	[V]	

Parameter		Min	Max	Unit	Comment
IIL	Low-level input leakage current	--	1000	[uA]	No pull-up
IIH	High-level input leakage current	-20	20	[uA]	No pull-down

6.2. Power On

The LM960 is automatically turning on when the VBATT is supplied.

Information – To turn on the LM960 module, the SYSTEM_RESET_N pin must not be asserted low.

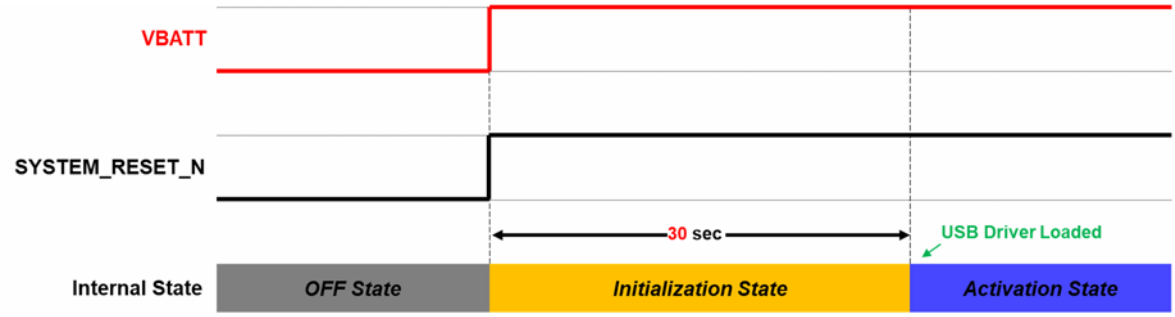
6.2.1. Initialization and Activation State

After turning on the LM960 module, the LM960 is not yet activated because the SW initialization process of the LM960 module is still in process internally. It takes some time to fully complete the HW and SW initialization of the module.

For this reason, it is impossible to access LM960 during the Initialization state.

As shown in below figure, the LM960 becomes operational (in the Activation state) at least 30 seconds after the VBATT is supplied.

LM960 Initialization and Activation



Information – To check if the LM960 has completely powered on, LM960 and the host must be connected via USB. When USB driver completely loaded, the module has completely powered on and is ready to accept AT commands.

Information – Active low signals are labeled with a name that ends with "_N"

Information – To avoid a back-powering effect, it is recommended to avoid having any HIGH logic level signal applied to the digital pins of the module when it is powered OFF or during an ON/OFF transition.

6.3. Power Off

To turn off the LM960, SYSTEM_RESET_N pad must be asserted low more than 1 seconds and then it should be kept low.

When the SYSTEM_RESET_N is asserted low more than 1 seconds, LM960 goes into the finalization state and after the end of the finalization process VREG_L6_1P8 will go to low.

Usually, it takes LM960 less than 200 milliseconds from asserting SYSTEM_RESET_N until reaching a complete shutdown. The DTE should monitor the status of VREG_L6_1P8 to observe the actual power-off.

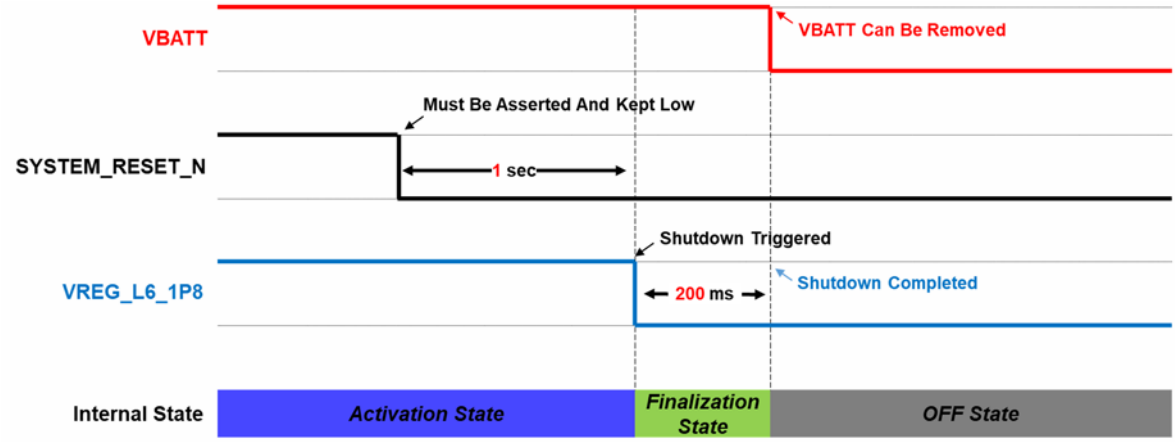
Information – To completely shut down the LM960 module, the SYSTEM_RESET_N pin must be asserted and kept low.

Otherwise, the LM960 will turn on again after shut down.

Information – To avoid a back-powering effect, it is recommended to avoid having any HIGH logic level signal applied to the digital pins of the module when it is powered OFF or during an ON/OFF transition.

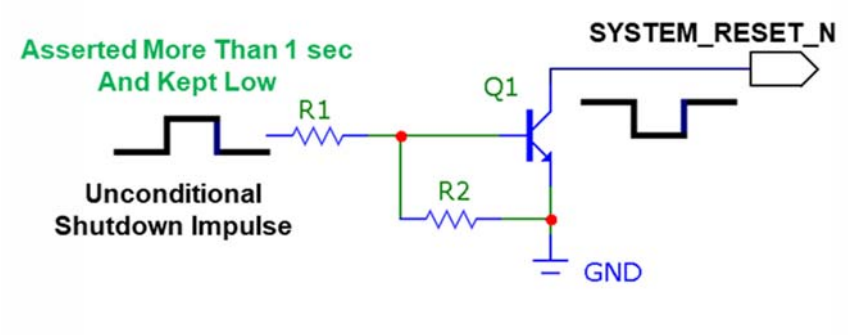
Warning – Not following the recommended shut-down procedures might damage the device and consequently void the warranty.

Shutdown by SYSTEM_RESET_N Pad



Below figure shows a simple circuit for this action.

Circuit for Shutdown by SYSTEM_RESET_N



6.4. Reset

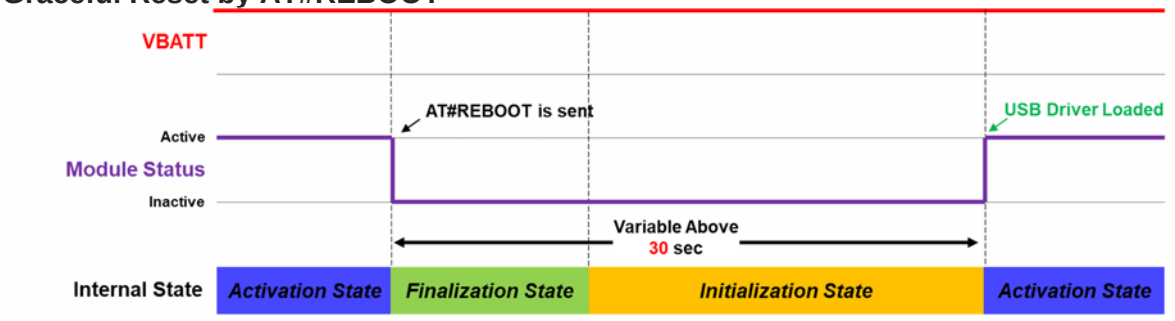
Reset the device can be done in two different ways:

- Graceful Reset by USB AT command AT#REBOOT
- Unconditional Reset using the SYSTEM_RESET_N

6.4.1. Graceful Reset

To gracefully restart the LM960 module, AT#REBOOT AT command must be sent via a USB communication.

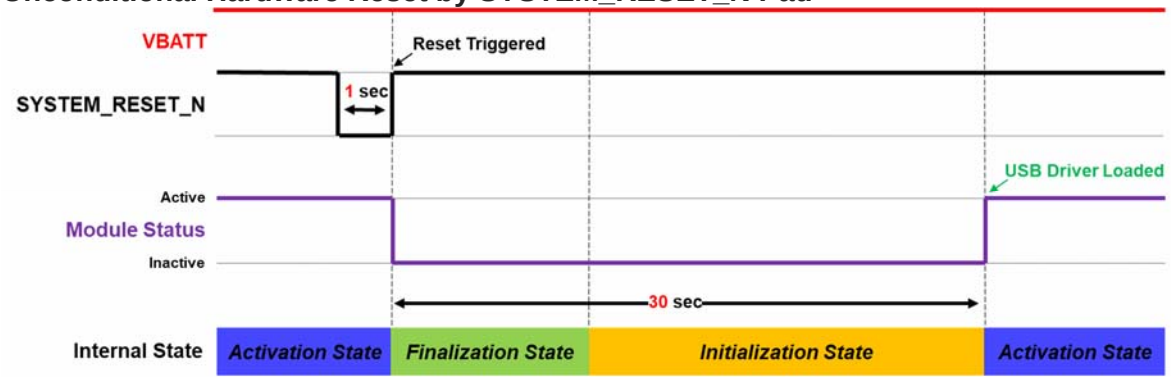
Graceful Reset by AT#REBOOT



6.4.2. Unconditional Hardware Reset

To unconditionally restart the LM960 module, the SYSTEM_RESET_N pin must be asserted low more than 1 seconds and then released.

Unconditional Hardware Reset by SYSTEM_RESET_N Pad



Information – The Unconditional Hardware Reset must be used only as an emergency exit procedure, and not as a normal power-off operation.

Information – Do not use any pull-up resistor on the RESET_N line or any totem pole digital output. Using a pull-up resistor may cause latch-up problems on the LM960 power regulator and improper functioning of the module. The RESET_N line must be connected only in an open-collector configuration.

6.5. Communication ports

Below table summarizes all the hardware interfaces of the LM960 module.

LM960 Hardware Interfaces

Interface	LM960
USB	Super-speed USB3.0 with high-speed USB2.0
PCIe	Peripheral Component Interconnect Express
USIM	x2, dual voltage each (1.8V/2.85V)
Control Signals	W_DISABLE_N, WAKE_N, WAN_LED_N
GPIO	X4, GPIO

I2C	I2C (optional)
Audio I/F	PCM (optional)
Antenna ports	4 for Cellular, 1 for GNSS

6.5.1. USB Interface

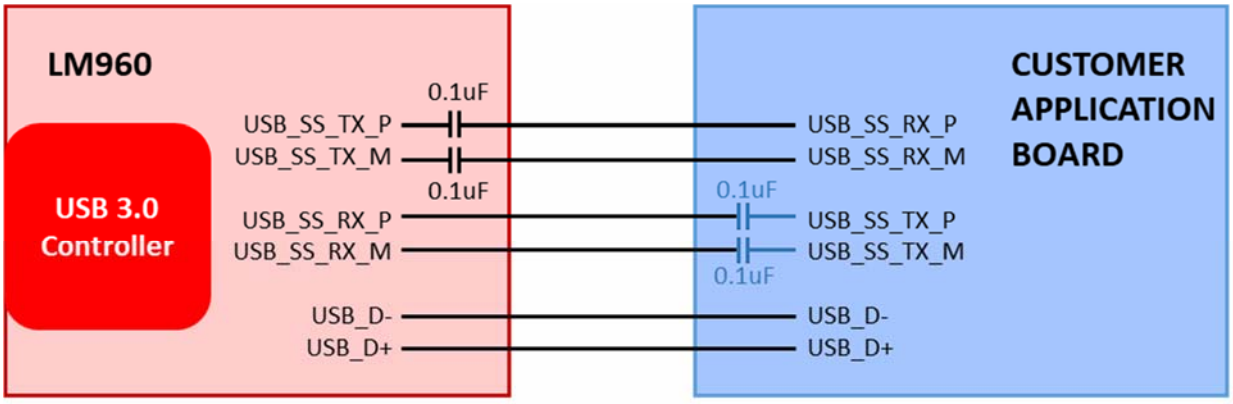
The LM960 module includes super-speed USB3.0 with high-speed USB2.0 backward compatibility. It is compliant with Universal Serial Bus Specification, Revision 3.0 and can be used for control and data transfers as well as for diagnostic monitoring and firmware update.

The USB port is typically the main interface between the LM960 module and OEM hardware.

USB 3.0 needs series capacitors on the TX lines in both directions for AC coupling. In order to interface USB3.0 with an application board of customer, 0.1uF capacitors should be installed on USB_SS_RX_P/M lines of the LM960. There are already series capacitors on USB_SS_TX_P/M lines inside LM960 module.

The USB interface suggested connection is the following:

Connection for USB Interface



*CUSTORMER : Need series capacitor (0.1uF) at USB_SS_RX_P/M Lines

Information – The USB 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.

Warning – At power-up, LM960 success to enumerate SS_USB interface. But if a hot-plug is attempted in case of SS_USB, then LM960 may fail to enumerate SS_USB.

Information – According to the mini PCIe standard, TX/RX of SS USB and PCIe share the same pin (Pin 23, 25, 31, 33) so that can not be used at the same time. Currently PCIe interface is not supported but will be enabled soon.

Below table lists the USB interface signals.

USB Interface Signals

PIN	Signal	I/O	Function	Type	Comment
38	USB_D+	I/O	USB 2.0 Data Plus	Analog	
36	USB_D-	I/O	USB 2.0 Data Minus	Analog	
33	USB_SS_RX_P	I	USB 3.0 super-speed receive – plus	Analog	
31	USB_SS_RX_M	I	USB 3.0 super-speed receive – minus	Analog	
25	USB_SS_TX_P	O	USB 3.0 super-speed transmit – plus	Analog	
23	USB_SS_TX_M	O	USB 3.0 super-speed transmit – minus	Analog	

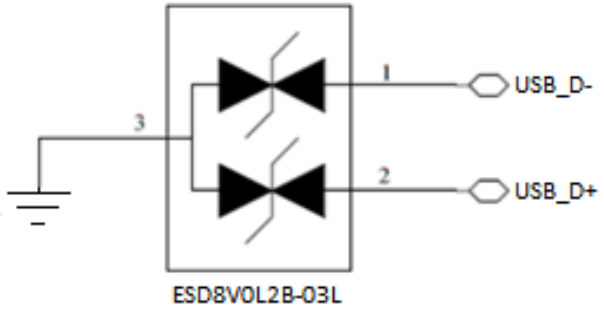
Information – Even if USB communication is not used, it is still highly recommended to place an optional USB connector on the application board.

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

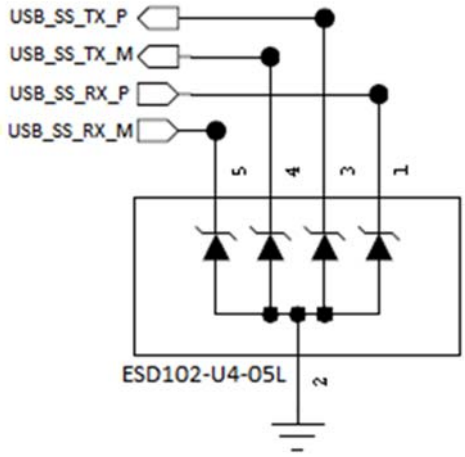
Information – Consider placing a low-capacitance ESD protection component to protect LM960 against ESD strikes

If an ESD protection should be added, the suggested connectivity is as follows:

ESD Protection for USB2.0



ESD Protection for USB3.0

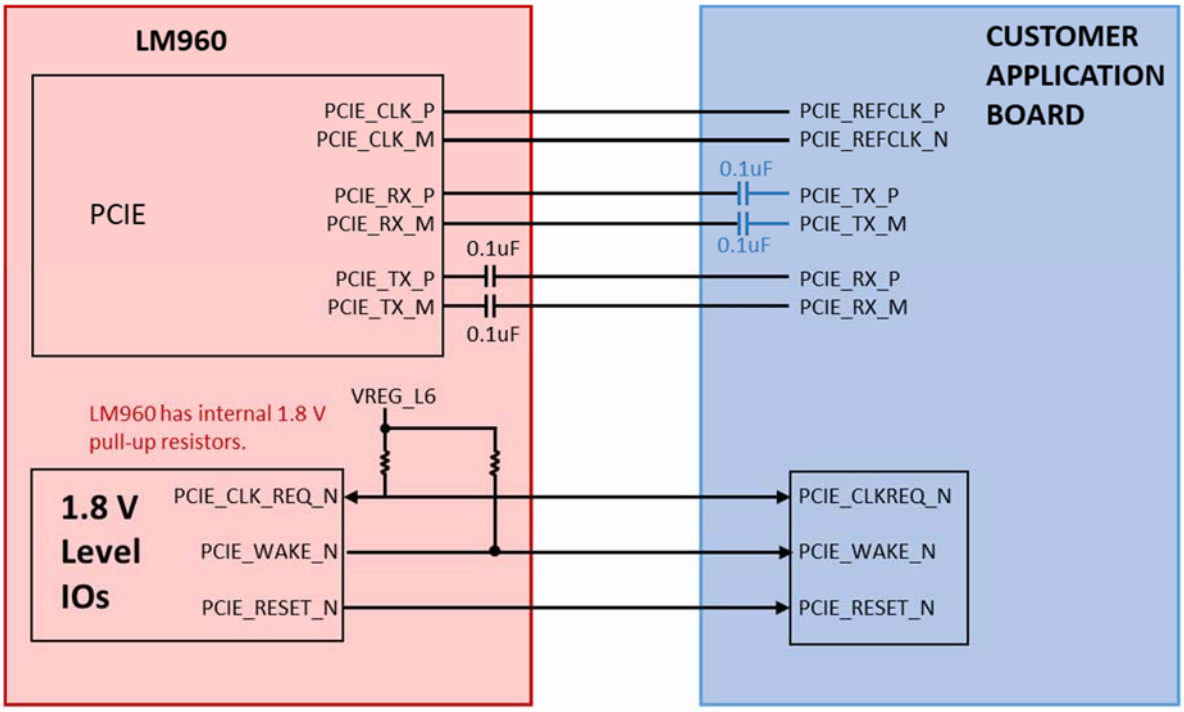


6.5.2. PCIe Interface

The LM960 will support PCIe interface

Below table lists the PCIe interface signals.

PCIe Interface Signals



*CUSTORMER : Need series capacitor (0.1uF) at PCIE_TX_P/M Lines

PIN	Signal	I/O	Function	Type	Comment
1	PCIE_WAKE_N	O	PCIe wake-up	Analog	
7	PCIE_CLKREQ_N	I/O	PCIe reference clock request signal	Analog	
11	PCIE_REFCLK_M	I	PCIe differential reference clock – minus	Analog	
13	PCIE_REFCLK_P	I	PICe differential reference colock – plus	Analog	
22	PCIE_RESET_N	I	Functional reset to the card	Analog	
23	PCIE_TX_M	O	PCIe transmit – minus	Analog	
25	PCIE_TX_P	O	PCIe transmit – plus	Analog	
31	PCIE_RX_M	I	PCIe receive – minus	Analog	
33	PCIE_RX_P	I	PCIe receive – plus	Analog	

Information – According to the mini PCIe standard, TX/RX of SS USB and PCIe share the same pin (Pin 23, 25, 31, 33) so that can not be used at the same time. Currently PCIe interface is not supported but will be enabled soon.

6.5.3. SIM Interface

The LM960 supports two external SIM interfaces (1.8V or 2.85V).

Below table lists the SIM interface signals.

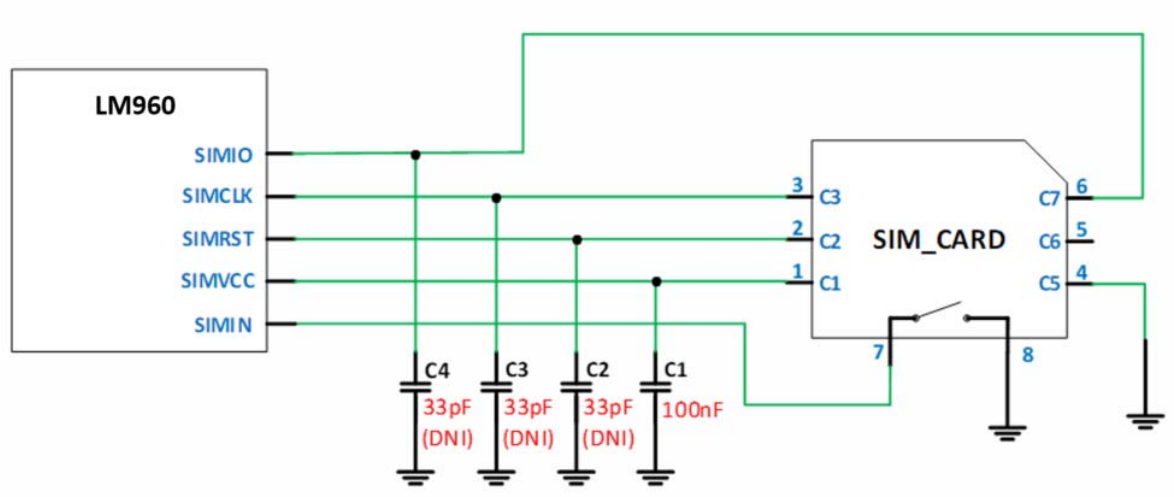
SIM Interface Signals

PIN	Signal	I/O	Function	Type	Comment
SIM Card Interface 1					
8	SIMVCC1	O	Supply output for an external UIM1 card	1.8V / 2.85V	Power
10	SIMIO1	I/O	Data connection with an external UIM1 card	1.8V / 2.85V	
12	SIMCLK1	O	Clock output to an external UIM1 card	1.8V / 2.85V	
14	SIMRST1	O	Reset output to an external UIM1 card	1.8V / 2.85V	
SIM Card Interface 2					
16	SIMVCC2	O	Supply output for an external UIM2 card	1.8 / 2.85V	Power
19	SIMIO2	I/O	Data connection with an external UIM2 card	1.8 / 2.85V	
17	SIMCLK2	O	Clock output to an external UIM2 card	1.8 / 2.85V	
6	SIMRST2	O	Reset output to an external UIM2 card	1.8 / 2.85V	
Digital I/O (GPIOs)					
3	GPIO_01	I	UIM1 Card Present Detect	1.8V	GPIO_01 can be used as SIMIN1
5	GPIO_02	I	UIM2 Card Present Detect	1.8V	GPIO_02 can be used as SIMIN2

6.5.3.1. SIM Schematic Example

The following Figures illustrate in particular how the application side should be designed.

SIM Schematics



Information – LM960 contains an internal pull-up resistor on SIMIO. It is not necessary to install external pull – up resistor.

6.5.4. Control Signals

The LM960 supports the following control signals:

- W_DISABLE_N
- PCIE_WAKE_N
- WAN_LED_N

Below table lists the control signals of LM960.

Module Control Signal

PIN	Signal	I/O	Function	Type	Comment
20	W_DISABLE_N	I	RF disable (airplane mode)	Open-drain	Internal VBATT Pull-up
1	PCIE_WAKE_N	I/O	PCIe wake-up	1.8V	
42	WAN_LED_N	O	LED control	Open-drain	

6.5.4.1. W_DISABLE_N

The W_DISABLE_N signal is provided to make the LM960 goes into the airplane mode:

- Enter into the airplane mode: Low
- Normal operating mode: High or Leave the W_DISABLE_N not connected

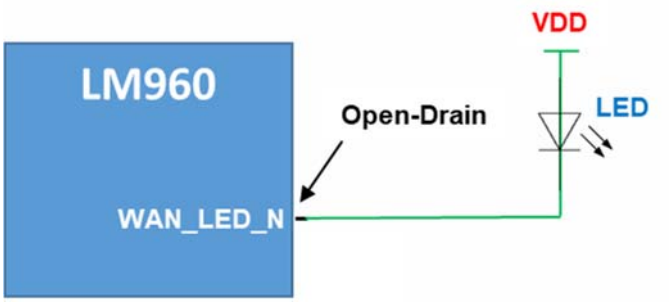
LM960 contains an internal VBATT(Nominal 3.3V) pull-up resistor on W_DISABLE_N.

6.5.4.2. WAN_LED_N

The WAN_LED_N signal drives the LED output.

The recommended WAN_LED_N connection is the following:

Recommended WAN_LED_N connection



6.5.5. General Purpose I/O

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

- Input
- Output
- Dedicate Function (Customer Requirement)

Input pins can only be read and report digital values (high or low) present on the pin at the read time. Output pins can only be written or queried and set the value of the pin output.

The following GPIOs are always available as a primary function on the LM960.

Below table lists the GPIO signals of LM960.

GPIOs

Pin no.	Signal	I/O	Function	Type	Drive Strength
3	GPIO_01	I/O	Configurable GPIO	Pull-Down 1.8V	2-16 mA
5	GPIO_02	I/O	Configurable GPIO	Pull-Down 1.8V	2-16 mA
44	GPIO_03	I/O	Configurable GPIO	Pull-Down 1.8V	2-16 mA
46	GPIO_04	I/O	Configurable GPIO	Pull-Down 1.8V	2-16 mA

6.5.5.1. Using a GPIO Pin as Input

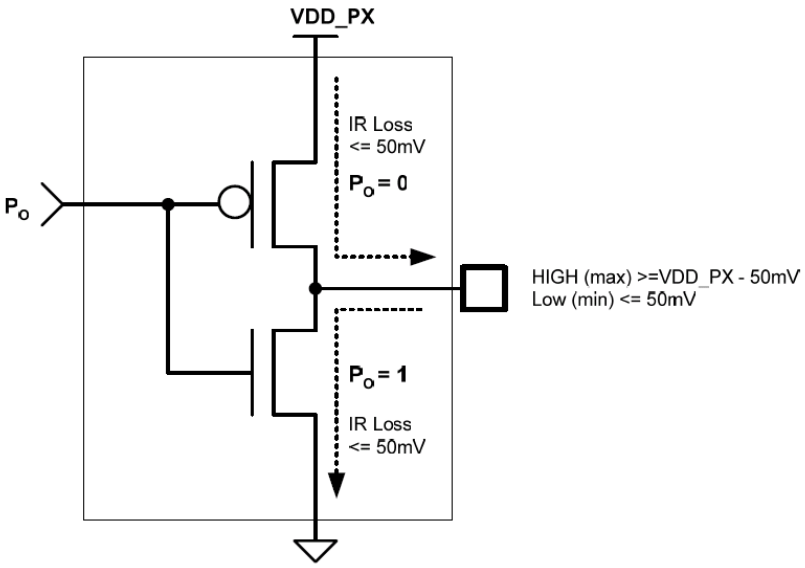
GPIO pins, when used as inputs, can be tied to a digital output of another device and report its status, provided the device interface levels are compatible with the GPIO 1.8V CMOS levels.

If a digital output of a device is tied to GPIO input, the pin has interface levels different than 1.8V CMOS. It can be buffered with an open collector transistor with a 47 kΩ pull-up resistor to 1.8V.

6.5.5.2. Using a GPIO Pin as Output

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

GPIO Output Pin Equivalent Circuit



6.5.6. I2C – Inter-integrated circuit

The LM960 supports an I2C interface on the following pins:

Below table lists the I2C signals of LM960.

Module I2C Signal

PIN	Signal	I/O	Function	Type	Comment
30	I2C_SCL	O	I2C Clock	CMOS 1.8V	
32	I2C_SDA	I/O	I2C Data	CMOS 1.8V	

The I2C interface is used for controlling peripherals inside the module (such as codec, etc.).

Information – I2C is supported only on from Modem side as SW emulation of I2C on GPIO lines.

Please contact us if you use it.

Information – If the I2C interface is not used, the signals can be left floating.

6.6. Using the Temperature Monitor Function

The Temperature Monitor permits to monitor the module's internal temperature and, if properly set (see the #TEMPSENS command in LM960 AT Commands Reference Guide), raises a GPIO to High Logic level when the maximum temperature is reached.

7. RF SECTION

7.1. Antenna requirements

The antenna connection is one of the most important aspect in the full product design as it strongly affects the product overall performance. Hence read carefully and follow the requirements and the guidelines for a proper design.

The LM960 is provided with five RF connectors.

The available connectors are:

- Primary RF antenna #0: Tx and Rx path for low bands and middle bands / 4x4 MIMO path of band41.
- Primary RF antenna #0: Tx and Rx path for high bands, ultra high bands and band32 / 4x4 MIMO path of band2(band25) and band4(band66)
- Secondary RF antenna #0: Secondary RF antenna #0: Rx Diversity path for low bands, middle bands / 4x4 MIMO path of band41 / GNSS path
- Secondary RF antenna #1: Secondary RF antenna #1: Rx Diversity path for high bands, ultra high bands and band32 / 4x4 MIMO path of band2(band25) and band4(band66)
- GNSS antena: Dedicated GNSS path

7.2. Primary Antenna Requirements

The antenna for the LM960 device must meet the following requirements:

WCDMA / LTE Antenna Requirements

Frequency range	Depending by frequency band(s) provided by the network operator, the customer shall use the most suitable antenna for that/those band(s) The bands supported by the LM960 is provided in Section 2.2, Product Variants and Frequency Bands.
Impedance	50 Ohm
Input power	> 24 dBm average power in WCDMA & LTE
VSWR absolute max	<= 10:1
VSWR recommended	<= 2:1

7.3. Secondary Antenna Requirements

This product includes an input for a second Rx antenna to improve radio sensitivity. The function is called Antenna Diversity.

Antenna Diversity Requirements

Frequency range	Depending by frequency band(s) provided by the network operator, the customer shall use the most suitable antenna for that/those band(s) The bands supported by the LM960 is provided in Section 2.2, Product Variants and Frequency Bands.
Impedance	50Ω
VSWR recommended	≤ 2:1

The second Rx antenna should not be located in the close vicinity of main antenna. In order to improve Diversity Gain, Isolation and reduce mutual interaction, the two antennas should be located at the maximum reciprocal distance possible, taking into consideration the available space into the application. For the same reason, the Rx antenna should also be cross-polarized with respect to the main antenna.
Isolation between main antenna and Rx antenna must be at least 10 dB in all uplink frequency bands.

Envelope Correlation Coefficient (ECC) value should be as close as possible to zero, for best diversity performance. ECC values below 0.5 on all frequency bands are recommended.

7.4. GNSS Receiver

The LM960 integrates a GNSS receiver that could be used in Standalone mode and in A-GPS (assisted GPS), according to the different configurations.

LM960 supports an active antenna.

Frequency range	• Wide-band GNSS: 1559–1606 MHz recommended • GPS: 2.046 MHz BW NB GPS (centered on 1575.42 MHz) • Glonass (GLO): ~ 8.3 MHz BW (1597–1606 MHz) • BeiDou (BDS): 4.092 MHz BW (1559.05 – 1563.14 MHz) • Galileo (GAL): 4.092 MHz BW (centered on 1575.42 MHz)
Gain	1.5 dBi < Gain < 3 dBi
Impedance	50 Ohm
Amplification	18 dB < Gain < 21 dB
Supply Voltage	3.1 V
Current consumption	20 mA Typical

7.4.1. GNSS RF Front End Design

The LM960 contains an integrated LNA and pre-select SAW filter.
This allows the module to work well with a passive GNSS antenna. If the antenna cannot be located near the LM960, then an active antenna (that is, an antenna with a low noise amplifier built in) can be used with an external dedicated power supply circuit.

GNSS rescive path uses either the dedicated GNSS connector or the shared Secondary #0 antenna connector.

NOTE – Please refer to the LM960 AT Commands Reference Guide, 80568ST10869A for detailed information about GNSS operating modes and GNSS Antenna selection.

7.5. Antenna connection

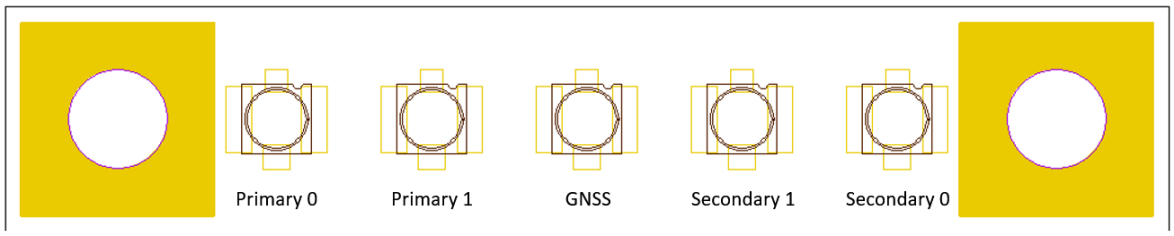
7.5.1. Support bands in antenna port

The LM960 has an assigned band depending on the antenna port.

The supported bands are:

- Primary RF antenna #0: B1, B2(B25), B3, B4(B66), B5(B26,B18,B19), B8, B12(B17), B13, B14, B20, B28, B29, B39, B71, B41 for 4 x 4 MIMO
- Primary RF antenna #1: B7, B30, B32, B38, B40, B41, B42, B43, B46, B48, B2(B25) for 4 x 4 MIMO, B4(B66) for 4 x 4 MIMO
- Secondary RF antenna #0: B1, B2(B25), B3, B4(B66), B5(B26,B18,B19), B8, B12(B17), B13, B14, B20, B28, B29, B39, B71, B41 for 4 x 4 MIMO / GNSS
- Secondary RF antenna #1: B7, B30, B32, B38, B40, B41, B42, B43, B46, B48, B25(B2) for 4 x 4 MIMO, B66(B4) for 4 x 4 MIMO
- GNSS antenna: Dedicated GNSS

See the picture on the below for their position on the interface.



7.5.2. Antenna Connector

The LM960 is equipped with a set of 50 Ω RF MHF4 connectors from I-PEX 20449-001.

For more information about mating connectors visit the website https://www.i-pex.com

7.5.3. Antenna Cable

Connecting cables between the module and the antenna must have 50 Ω impedance.
If the impedance of the module is mismatched, RF performance is reduced significantly.

If the host device is not designed to use the module's GNSS antenna, terminate the interface with a 50Ω load.

Minimize Antenna Cable Requirements

Impedance	50 Ohm
Max cable loss	Less than 0.5 dB
Avoid coupling with other signals.	

7.5.4. Antenna Installation Guidelines

- Install the antenna in a location with access to the network radio signal.
- The antenna must be installed such that it provides 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.
- The antenna must not be installed inside metal cases.
- The antenna must be installed according to the antenna manufacturer's instructions.

Furthermore, if the device is developed for the US and/or Canada market, it must comply with the FCC and/or IC approval requirements.

Information

This device is to be used only for mobile and fixed application. 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 must be provided with transmitter operation conditions for satisfying RF exposure compliance. OEM integrators must ensure that the end user has no manual instructions to remove or install the LM960 module. Antennas used for this OEM module must not exceed gain of below table for mobile and fixed operating configurations.

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

Manual Information to the End User

The OEM integrator has to be aware not to provide information to the end user regarding how to install or remove this RF module in the user's manual of the end product which integrates this module. The end user manual shall include all required regulatory information/warning as show in this manual.

8. AUDIO SECTION

8.1. Audio Interface

The LM960 module supports digital audio interfaces.

8.2. Digital Audio

The LM960 module can be connected to an external codec through the digital interface.

The product provides a single Digital Audio Interface on the following pins:

Digital Audio Interface Signals

Pin no.	Signal	I/O	Function	Type	COMMENT
51	DVI_WAO	O	PCM Frame Sync	B-PD 1.8V	
49	DVI_RX	I	PCM Data In	B-PD 1.8V	
47	DVI _TX	O	PCM Data Out	B-PD 1.8V	
45	DVI _CLK	O	PCM Clock	B-PD 1.8V	

LM960 PCM has the following characteristics:

- PCM Master mode using short or long frame sync modes
- 16 bit linear PCM format
- PCM clock rates of 256 kHz, 512 kHz, 1024 kHz and 2048 kHz (Default)
- Frame size of 8, 16, 32, 64, 128 & 256 bits per frame
- Sample rates of 8 kHz and 16 kHz

NOTE – If the Digital Audio Interface is not used, the signals can be left floating.

9. MECHANICAL DESIGN

9.1. General

The LM960 module was designed to be compliant with a standard lead-free SMT process. Moreover, it is compatible with the Mini PCIe card 52-pin card edge-type connector.

9.2. Finishing & Dimensions

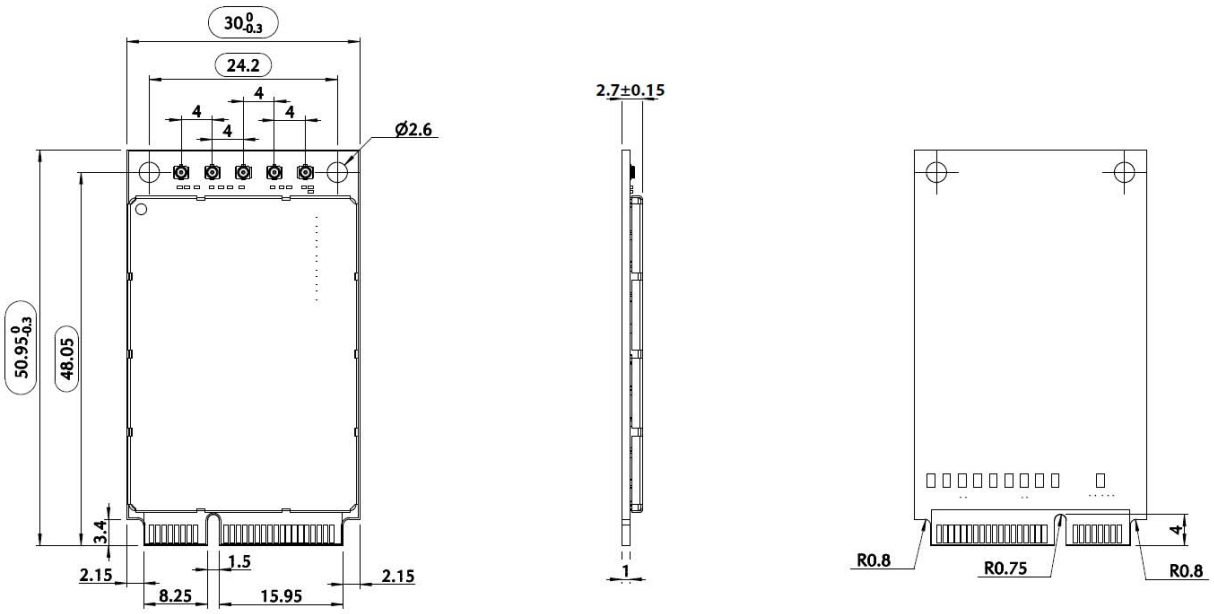
The LM960 module's overall dimensions are:

- Length: 50.95 mm
- Width: 30.00 mm
- Thickness: 2.70 mm

The module complies with the standard dimensions specified in the *PCI Express Mini Card Electromechanical Specification Revision 1.1*

9.3. Drawing

This figure shows the mechanical dimensions of the LM960 module.



10. APPLICATION GUIDE

10.1. Debug of the LM960 Module in Production

To test and debug the mounting of the LM960 module, we strongly recommend to add several test pins on the host PCB for the following purposes:

- Checking the connection between the LM960 itself and the application
- Testing the performance of the module by connecting it with an external computer

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

- SYSTEM_RESET_N, W_DISABLE_N, PCIE_WAKE_N
- VBATT, GND
- VREG_L6_1P8
- USB_D-, USB_D+
- USB_SS_TX_M, USB_SS_TX_P, USB_SS_RX_M, USB_SS_RX_P
- PCIE_TX_M, PCIE_TX_P, PCIE_RX_M, PCIE_RX_P

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

- WAN_LED_N
- GPIO_01, GPIO_02, GPIO_03, GPIO_04

10.2. Bypass Capacitor on Power Supplies

When a sudden voltage step is asserted to or a cut from the power supplies, the steep transition causes some reactions such as overshoot and undershoot. This abrupt voltage transition can affect the device causing it to not operate or to malfunction.

Bypass capacitors are needed to alleviate this behavior. The behavior can appear differently depending on the various 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 prevent ripple of the power supplies and the switching noise caused in TDMA systems such as GSM.

Especially, a suitable bypass capacitor must be mounted on the following lines on the application board:

- VBATT

Recommended values are:

- 100uF for VBATT

Customers must still consider that the capacitance mainly depends on the conditions of their application board.

Generally, more capacitance is required when the power line is longer.
And if customers use the fast power down function, then more bypass capacitors should be mounted on the application board.

10.3. EMC Recommendations

EMC protection on the pins in the table below should be designed by application side according to the customer's requirement.

EMC Recommendations

Pin	Signal	I/O	Function	Type	Comment
USB HS 2.0 Communication Port					
38	USB_D+	I/O	USB 2.0 Data Plus	Analog	
36	USB_D-	I/O	USB 2.0 Data Minus	Analog	
USB SS 3.0 Communication and PCIe Port					
33	USB/PCIE_RX_P	I	USB 3.0 super-speed/PCIe receive – plus	Analog	
31	USB/PCIE_RX_M	I	USB 3.0 super-speed/PCIe receive – minus	Analog	
25	USB/PCIE_TX_P	O	USB 3.0 super-speed/PCIe transmit – plus	Analog	
23	USB/PCIE_TX_M	O	USB 3.0 super-speed/PCIe transmit – minus	Analog	
SIM Card Interface 1					
14	SIMRST1	O	Reset output to an external UIM1 card	1.8 / 2.85V	
12	SIMCLK1	O	Clock output to an external UIM1 card	1.8 / 2.85V	

10	SIMIO1	I/O	Data connection with an external UIM1 card	1.8 / 2.85V	
8	SIMVCC1	O	Supply output for an external UIM1 card	1.8 / 2.85V	Power
SIM Card Interface 2					
6	SIMRST2	O	Reset output to an external UIM2 card	1.8 / 2.85V	
17	SIMCLK2	O	Clock output to an external UIM2 card	1.8 / 2.85V	
19	SIMIO2	I/O	Data connection with an external UIM2 card	1.8 / 2.85V	
16	SIMVCC2	O	Supply output for an external UIM2 card	1.8 / 2.85V	Power
Digital I/O (GPIOs)					
3	GPIO_01	I/O	General purpose I/O	1.8V	
5	GPIO_02	I/O	General purpose I/O	1.8V	
44	GPIO_03	I/O	General purpose I/O	1.8V	
46	GPIO_04	I/O	General purpose I/O	1.8V	
1	PCIE_WAKE_N	I/O	PCIe wake-up	1.8V	Active Low
42	WAN_LED_N	O	LED control	Open-drain	Active Low
Power ON/OFF Reset IN/OUT					
20	W_DISABLE_N	I	RF ON/OFF Control	Open-drain	Active Low (internal VBATT pull up)

22	PCIE_RESET_N	I	PCIe Reset Input	1.8V	Active Low
48	SYSTEM_RESET_N	I	Reset Input	1.8V	Active Low
1.8V Voltage Regulator					
28	VREG_L6_1P8	O	LDO out for 1.8V	Power	

All other pins have the following characteristics:

Human Body Model (HBM): ± 1000 V

Charged Device Model (CDM) JESD22-C101-C: ± 250 V

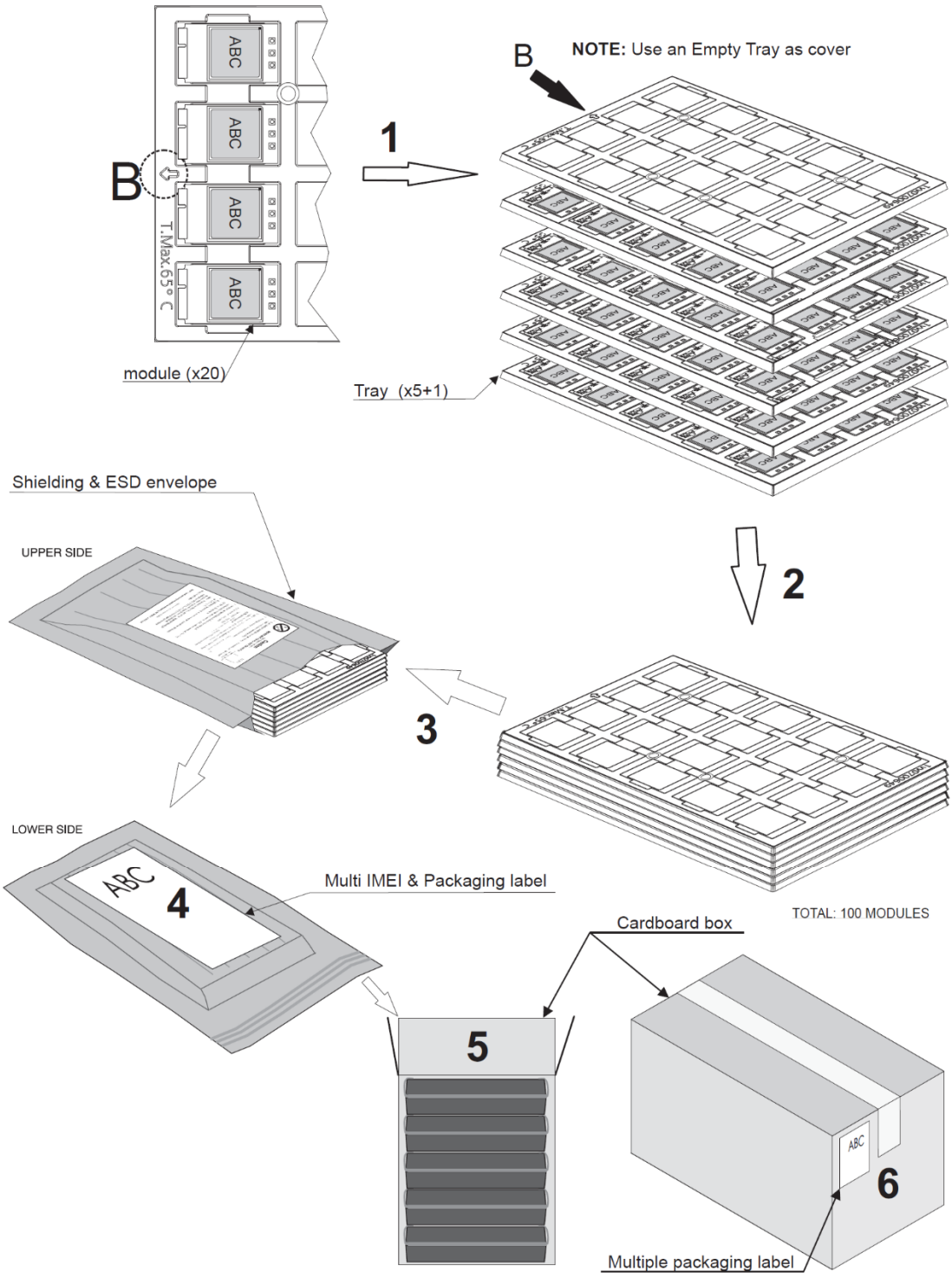
All Antenna pins up to ± 4 kV

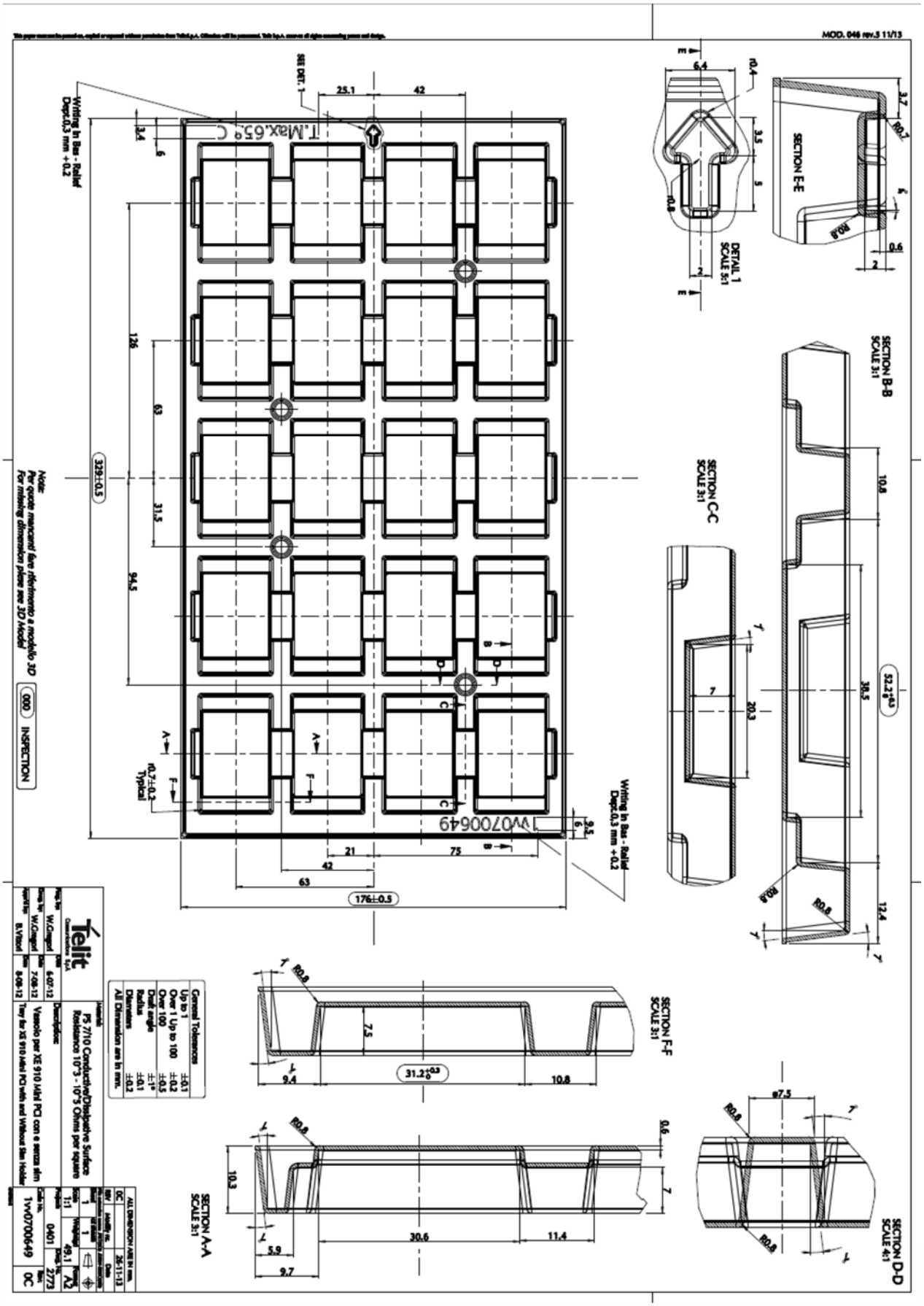
Warning – Do not touch without proper electrostatic protective equipment. The product must be handled with care, avoiding any contact with the pins because electrostatic discharge may damage the product itself.

11. PACKAGING

11.1. Tray

The LM960 modules are packaged on trays of 20 pieces each. These trays can be used in SMT processes for pick & place handling.




MOD. 046 rev.5 11/13
SEE DET. 1
Writing In Bas - Relief
Dept.0,3 mm +0.2
T.Max.65°C
1VV0700649
SECTION E-E
DETAIL 1
SCALE 5:1
SECTION B-B
SCALE 3:1
SECTION C-C
SCALE 3:1
SECTION F-F
SCALE 3:1
SECTION A-A
SCALE 3:1
SECTION D-D
SCALE 4:1
INSPECTION
Note:
Per quote mancanti fare riferimento a modello 3D
For missing dimension please see 3D Model
General Tolerances
Up to 1 ±0.1
Over 1 Up to 100 ±0.2
Over 100 ±0.3
Draft angle ±1°
Radius ±0.1
Dimensions ±0.2
All Dimension are in mm.
PS 7/10 Conductive/Dissipative Surface
Resistance 10^3 - 10^5 Ohms per square
Vassoio per XE 910 /ARM PCI con e senza slim
Tray for XE 910 /ARM PCI with and Without Slim Holder
1vv0700649
0401
2773
0C
26-11-13

12. CONFORMITY ASSESSMENT ISSUES

12.1. Approvals

- Fully type approved confirming with RE Directive (Directive 2014/53/EU)
- CE, GCF
- FCC, IC, PTCRB
- RoHS and REACH
- Approvals for major Mobile Network Operators

12.2. Declaration of Conformity

The DoC is available here: www.telit.com/RED/

12.3. FCC certificates

The FCC Certifcate is available here: www.fcc.gov/oet/ea/fccid

12.4. IC certificates

The IC Certifcate is available here:
https://sms-sgs.ic.gc.ca/equipmentSearch/searchRadioEquipments?execution=e1s1&lang=en

12.5. FCC/IC Regulatory notices

Modification statement

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.

Interference statement

This device complies with Part 15 of the FCC Rules and 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 CNR d'Industrie Canada applicables aux appareils radio exempts de licence. 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.

RF exposure

This equipment complies with FCC and ISED radiation exposure limits set forth for an uncontrolled environment. The antenna should be installed and operated with minimum distance of 20 cm between the radiator and your body. Antenna gain must be below:

Cet appareil est conforme aux limites d'exposition aux rayonnements de l'ISED pour un environnement non contrôlé. L'antenne doit être installé de façon à garder une distance minimale de 20 centimètres entre la source de rayonnements et votre corps. Gain de l'antenne doit être ci-dessous:

This radio transmitter FCCID: RI7LM960 has been approved by FCC to opeate with the antenna types listed below with the maximum permissible gain and required antenna impedance for each antenna type indicated. Antenna types not included in this list, having a gain greater than the maximum gain indicated for type, are strictly prohibited for use with this device.

This radio transmitter IC: 5131A-LM960 has been approved by Industry Canada to opeate with the antenna types listed below with the maximum permissible gain and required antenna impedance for each antenna type 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.

Cet émetteur radio IC: 5131A-LM960 a été approuvé par Industrie Canada pour fonctionner avec les types d'antennes énumérés ci-dessous avec le gain maximal admissible et impédance d'antenne requise pour chaque type d'antenne indiqué. Types d'antennes n'est pas inclus dans cette liste, ayant un gain supérieur au gain maximal indiqué pour ce type, sont strictement interdits pour une utilisation avec cet appareil.

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.

Antenna List

No.	Manufacturer	Part No.	Antenna Type	Peak Gain
1	HNS	WE14-LF-07	Dipole	1.5 dBi for 617 ~ 960 MHz
				3.5 dBi for 1420 ~ 2200 MHz
				3 dBi for 2300 ~ 2690 MHz
2	HNS	WE14-S3-1	Dipole	4 dBi for 1420 ~ 2200 MHz
				1 dBi for 2300 ~ 2400 MHz
				3 dBi for 2498 ~ 2690 MHz
				3 dBi for 5150 ~ 5928 MHz
3	HNS	WE14-S3-2	Dipole	1 dBi for CBRS(3550 ~ 3700 MHz)

Note: The antenna connector is SMA(Male) type.

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 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.

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 and ISED of the module, preceded by the words "Contains transmitter module", or the word "Contains", or similar wording expressing the same meaning, as follows:

L'appareil hôte doit être étiqueté comme il faut pour permettre l'identification des modules qui s'y trouvent. L'étiquette de certification du module donné doit être posée sur l'appareil hôte à un endroit bien en vue en tout temps. En l'absence d'étiquette, l'appareil hôte doit porter une étiquette donnant le FCC ID et l'ISED du module, précédé des mots « Contient un module d'émission », du mot « Contient » ou d'une formulation similaire exprimant le même sens, comme suit :

LM960
Contains FCC ID: RI7LM960
Contains IC: 5131A-LM960

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.

12.6. RED Regulatory notices

RF Exposure Information (MPE)

This device has been tested and meets applicable limits for Radio Frequency (RF) exposure. To comply with the RF exposure requirements, this module must be installed in a host platform that is intended to be operated in a minimum of 20 cm separation distance to the user.

OEM/Host manufacturer responsibilities

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 RED before it can be placed on the EU market. This includes reassessing the transmitter module for compliance with the Radio and EMF essential requirements of the RED. This

module must not be incorporated into any other device or system without retesting for compliance as multi-radio and combined equipment.

The allowable Antenna Specipication

In all cases assessment of the final product must be met against the Essential requirements of the RE Directive Articles 3.1(a) and (b), safety and EMC respectively, as well as any relevant Article 3.3 requirements.

1. The following antenna was verified in the conformity testing, and for compliance the antenna shall not be modified. A separate approval is required for all other operating configurations, including different antenna configurations.
2. If any other simultaneous transmission radio is installed in the host platform together with this module, or above restrictions cannot be kept, a separate RF exposure assessment and CE equipment certification is required.

Waste Electrical and Electronic Equipment (WEEE)

This symbol means that according to local laws and regulations your product and/or its battery shall be disposed of separately from household waste. When this product reaches its end of life, take it to a collection point designated by local authorities. Proper recycling of your product will protect human health and the environment.

13. SAFETY RECOMMENDATIONS

13.1. READ CAREFULLY

Be sure the use of this product is allowed in the country and in the environment required. The use of this product may be dangerous and has to be avoided in the following areas:

- Where it can interfere with other electronic devices in environments such as hospitals, airports, aircrafts, etc.
- Where there is risk of explosion such as gasoline stations, oil refineries, etc. It is the responsibility of the user to enforce the country regulation and the specific environment regulation.

Do not disassemble the product; any mark of tampering will compromise the warranty validity. We recommend following the instructions of the hardware user guides for correct wiring of the product. The product has to be supplied with a stabilized voltage source and the wiring has to be conformed to the security and fire prevention regulations. The product has to be handled with care, avoiding any contact with the pins because electrostatic discharges may damage the product itself. Same cautions have to be taken for the SIM, checking carefully the instruction for its use. Do not insert or remove the SIM when the product is in power saving mode.

The system integrator is responsible for the functioning of the final product; therefore, care has to be taken to the external components of the module, as well as any project or installation issue, because the risk of disturbing the LTE & WCDMA network or external devices or having impact on the security. Should there be any doubt, please refer to the technical documentation and the regulations in force. Every module has to be equipped with a proper antenna with specific characteristics. The antenna has to be installed with care in order to avoid any interference with other electronic devices and has to guarantee a minimum distance from the body (20 cm). In case this requirement cannot be satisfied, the system integrator has to assess the final product against the SAR regulation.

The European Community provides some Directives for the electronic equipment introduced on the market. All of the relevant information is available on the European Community website:

https://ec.europa.eu/commission/index_en

The text of the Directive 2014/35/EU regarding telecommunication equipment is available, while the applicable Directives (Low Voltage and EMC) are available at:

http://ec.europa.eu/enterprise/sectors/electrical/

14. REFERENCE TABLE OF RF BANDS CHARACTERISTICS

RF Bands Characteristics

Mode	Freq. Tx (MHz)	Freq. Rx (MHz)	Channels	Tx-Rx Offset
WCDMA 2100 – B1	1920 ~ 1980	2110 ~ 2170	Tx: 9612 ~ 9888 Rx: 10562 ~ 10838	190 MHz
WCDMA 1900 – B2	1850 ~ 1910	1930 ~ 1990	Tx: 9262 ~ 9538 Rx: 9662 ~ 9938	80 MHz
WCDMA AWS – B4	1710 ~ 1755	2110 ~ 2155	Tx: 1537 ~ 1738 Rx: 1312 ~ 1513	400 MHz
WCDMA 850 – B5	824 ~ 849	869 ~ 894	Tx: 4132 ~ 4233 Rx: 4357 ~ 4458	45 MHz
WCDMA 900 – B8	880 ~ 915	925 ~ 960	Tx: 2712 ~ 2863 Rx: 2937 ~ 3088	45 MHz
WCDMA 1800 Japan – B9	1750 ~ 1784.8	1845 ~ 1879.8	Tx: 8762 ~ 8912 Rx: 9237 ~ 9387	95 MHz
WCDMA 800 Japan – B19	830 ~ 845	875 ~ 890	Tx: 312 ~ 363 Rx: 712 ~ 763	45 MHz
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-1 – 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

Mode	Freq. Tx (MHz)	Freq. Rx (MHz)	Channels	Tx-Rx Offset
LTE 700a – B12	699 ~ 716	729 ~ 746	Tx : 23010 ~ 23179 Rx : 5010 ~ 5179	30 MHz
LTE 700c – B13	777 ~ 787	746 ~ 756	Tx : 27210 ~ 27659 Rx : 9210 ~ 9659	-31 MHz
LTE 700PS – B14	788 ~ 798	758 ~ 768	Tx : 23280 ~ 23379 Rx : 5280 ~ 5379	-30 MHz
LTE 700b – B17	704 ~ 716	734 ~ 746	Tx: 23730 ~ 23849 Rx: 5730 ~ 5849	30 MHz
LTE 800 Lower – B18	815 ~ 830	860 ~ 875	Tx: 23850 ~ 23999 Rx: 5850 ~ 5999	45 MHz
LTE 800 Upper – 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: 8040 ~ 8689 Rx: 26040 ~ 26689	80 MHz
LTE 850+ – B26	814 ~ 849	859 ~ 894	Tx: 8690 ~ 9039 Rx: 26690 ~ 27039	45 MHz
LTE 700 APT – B28	703 ~ 748	758 ~ 803	Tx: 9210 ~ 9659 Rx: 27210 ~ 27659	55 MHz
LTE 700 d – B29	Downlink only	717 ~ 728	Rx: 9660 ~ 9769	–
LTE 2300 WCS – B30	2305 ~ 2315	2350 ~ 2360	Tx: 9770 ~ 9869 Rx: 27660 ~ 27759	45 MHz
LTE 1500 L-band – B32	Downlink only	1452 ~ 1496	Rx: 9920 ~ 10359	–
LTE AWS-3 – B66	1710 ~ 1780	2110 ~ 2200	Tx: 66436 ~ 67335 Rx: 131972 ~ 132671	400 MHz
LTE 600 – B71	663 ~ 698	617 ~ 652	Tx: 133122 ~ 133471 Rx: 68586 ~ 68935	-46 MHz

Mode	Freq. Tx (MHz)	Freq. Rx (MHz)	Channels	Tx-Rx Offset
LTE TDD 2600 – B38	2570 ~ 2620		T/Rx: 37750 ~ 38250	–
LTE TDD 1900+ – B39	1880 ~ 1920		T/Rx: 38250 ~ 38649	–
LTE TDD 2300 – B40	2300 ~ 2400		T/Rx: 38650 ~ 39650	–
LTE TDD 2500 – B41	2496 ~ 2690		T/Rx: 39650 ~ 41589	–
LTE TDD 3500 – B42	3400 ~ 3600		T/Rx: 41590 ~ 43589	–
LTE TDD 3700 – B43	3600 ~ 3700		T/Rx: 43590 ~ 45589	–
LTE TDD Unlicensed – B46	Downlink only	5150 ~ 5925	Rx: 46790 ~ 54539	–
LTE TDD 3600 – B48	3550 ~ 3700		T/Rx: 55240 ~ 56739	–

15. ACRONYMS

TTSC	Telit Technical Support Centre
USB	Universal Serial Bus
HS	High Speed
DTE	Data Terminal Equipment
UMTS	Universal Mobile Telecommunication System
WCDMA	Wideband Code Division Multiple Access
HSDPA	High Speed Downlink Packet Access
HSUPA	High Speed Uplink Packet Access
UART	Universal Asynchronous Receiver Transmitter
HSIC	High Speed Inter Chip
SIM	Subscriber Identification Module
SPI	Serial Peripheral Interface
ADC	Analog – Digital Converter
DAC	Digital – Analog Converter
I/O	Input Output
GPIO	General Purpose Input Output
CMOS	Complementary Metal – Oxide Semiconductor
MOSI	Master Output – Slave Input
MISO	Master Input – Slave Output
CLK	Clock
MRDY	Master Ready

SRDY	Slave Ready
CS	Chip Select
RTC	Real Time Clock
PCB	Printed Circuit Board
ESR	Equivalent Series Resistance
VSWR	Voltage Standing Wave Radio
VNA	Vector Network Analyzer
FDD	Frequency division duplex
I2C	Inter-integrated circuit
LTE	Long term evolution
SOC	System-on-Chip

16. DOCUMENT HISTORY

Revision	Date	Changes
0	2018-2-09	First Draft
1	2018-5-30	Sec 1.5 Some of Doc's Referrence Number Is Updated Sec 3.3 Pin Layout Updated Sec 4.2 Current Consumption Updated Sec 6 Power On, Power Off, Reset Updated
2	2018-7-05	Sec 2.2.1 RF Bands per Regional Variant Updated Sec 2.6 Tx output power Updated Sec 2.7 Rx sensitivity Updated Sec 2.8.2 Weight Updated Sec 4.2 Current Consumption Updated Sec 6.5.1 USB Block Diagram Updated Sec 6.5.2 PCIe Block Diagram Updated Sec 6.5.4 PCIE_WAKE_N Section Deleted Sec 7.1 Antenna Requirements Updated Sec 9.3 Drawing Updated Sec 12.5 FCC/IC Regulatory notices Updated Sec 14 Reference Table of RF Bands Characteristic Updated
3	2018-12-14	Sec 2 General product description Updated Sec 2.2.1 RF Bands per Regional Variant Updated

SUPPORT INQUIRIES

Link to **www.telit.com** and contact our technical support team for any questions related to technical issues.

www.telit.com

Telit Communications S.p.A.
Via Stazione di Prosecco, 5/B
I-34010 Sgonico (Trieste), Italy

Telit IoT Platforms LLC
5300 Broken Sound Blvd, Suite 150
Boca Raton, FL 33487, USA

Telit Wireless Solutions Inc.
3131 RDU Center Drive, Suite 135
Morrisville, NC 27560, USA

Telit Wireless Solutions Co., Ltd.
8th Fl., Shinyoung Securities Bld.
6, Gukjegeumyung-ro8-gil, Yeongdeungpo-gu
Seoul, 150-884, Korea

Telit Wireless Solutions Ltd.
10 Habarzel St.
Tel Aviv 69710, Israel

Telit Wireless Solutions
Technologia e Servicos Ltda
Avenida Paulista, 1776, Room 10.C
01310-921 São Paulo, Brazil

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