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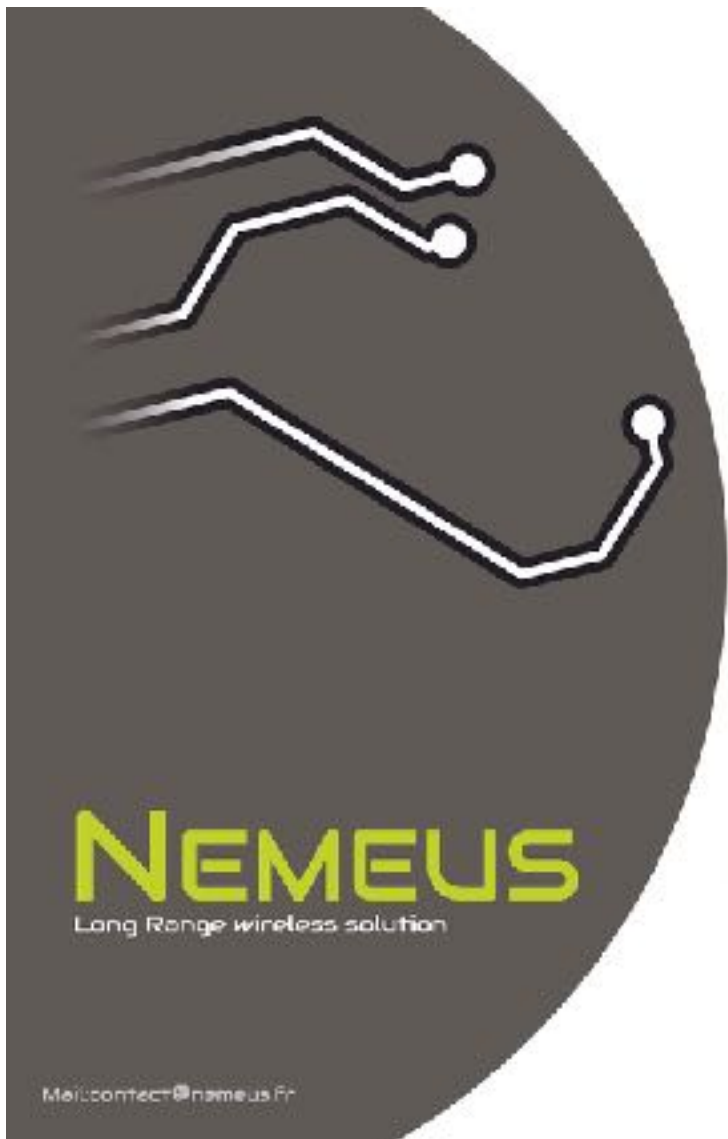
**Product** : MM002-xx-US

**Doc** : Datasheet

**Reference** : datasheet\_MM002-xx-US

**History** : V0.1

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## Document history

Version	Date	Author	Comments
V0.1	19/11/2018	Gilles Ronco	Initial

Table 1 : Document versions

## References

[1] Semtech - Datasheet SX1272

## Purpose

This document is dedicated to NEMEUS MM002-xx-US radio module.

## Certification

This module is certified for US/CANA Area with following ID :

- **FCC:** 2AKSYMM002XUS
- **IC:** 22302-MM002XUS

## Module features

The **MM002-xx-US** is a long range / low power wireless module operating in US/ CANADA ISM band (915Mhz). With interferers' robustness and low power consumption, it is the best solution for applications requiring long range, maximum battery lifetime and secure radio link. This module integrates a SX1272 LoRa™ transceiver from Semtech and a low power ARM Cortex M3 controller.



### Key product features

- ✓ Size 14,4mm x 26,4mm x 2,5mm
- ✓ Modulations : LoRa™
- ✓ Maximum output power +20 dBm
- ✓ LoRa WAN US915 Class A & C protocol stack
- ✓ Soldered like a SMD component
- ✓ Usable as Modem companion
- ✓ RoHS conform

### Applications

- ✓ Automated Meter Reading
- ✓ Home and Building Automation
- ✓ Industrial Monitoring and Control
- ✓ IoT (Internet of Things)
- ✓ Smart Cities

### Module software content

The module software is based on Contiki OS.

## General description

The MM002-xx-US module is a long range, high-performance, solution for wireless bi-directional communication using patented LoRa™ technology from Semtech company. It operates in the US/CANADA 915 MHz frequency band and includes all necessary components for an easy integration in existing systems. With high interference robustness, a max sensitivity of -137dBm, a low consumption (less than 2uA in idle mode with RTC), and this module is the best solution for low throughput application requiring a long battery lifetime and a secured radio link. Integration of this module eases fast-time to market.

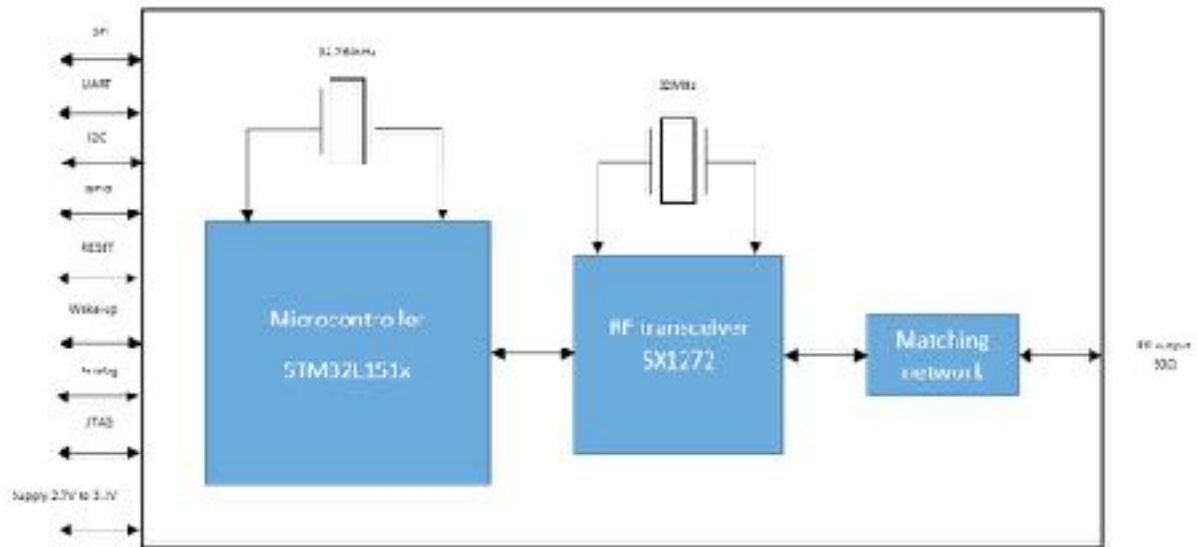
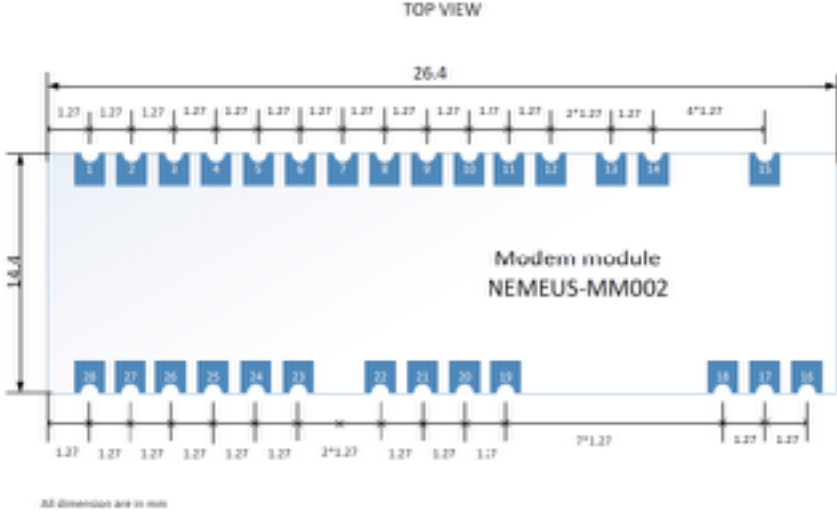


Figure 1. Simplified block diagram

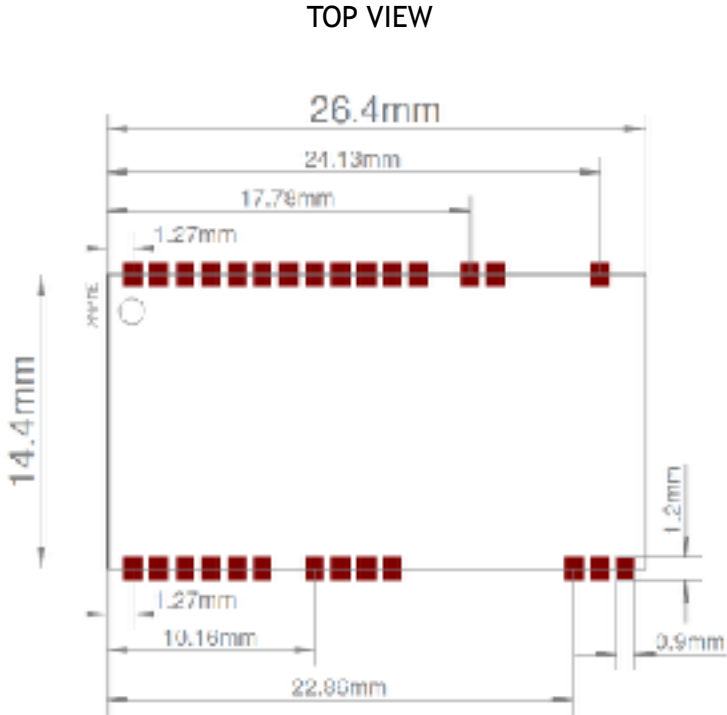
### Module pins diagram

The following figure gives the top view of the MM002-xx-EU module.



Pad size on MM002: 0.8x1mm

Footprint recommendations:



Footprint for all pads: 0.9x1.2mm



### Design recommendations

With 4 layers PCB design, it is recommended to keep the 1<sup>st</sup> layer under the module without any layout and have a full ground plane on the 2<sup>nd</sup> layer (at least under the right part of the module : under RF transceiver part).

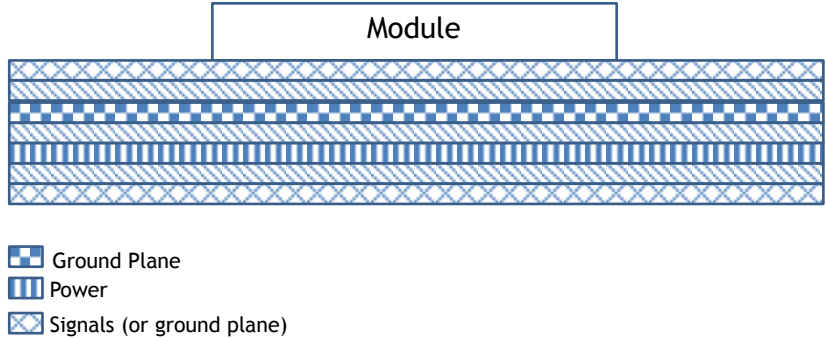


Figure 2 : 4 layer PCB design

All ground p:

In case of ground planes on different layers, these one must be connected together through via.

### Antenna path

The following figure gives an overview of a design with SMA connector for Antenna.

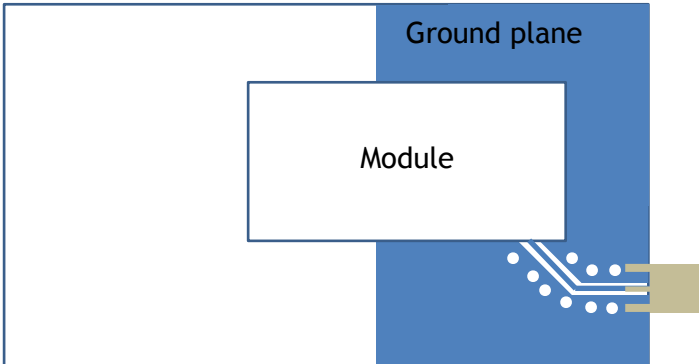


Figure 3 : Antenna path design

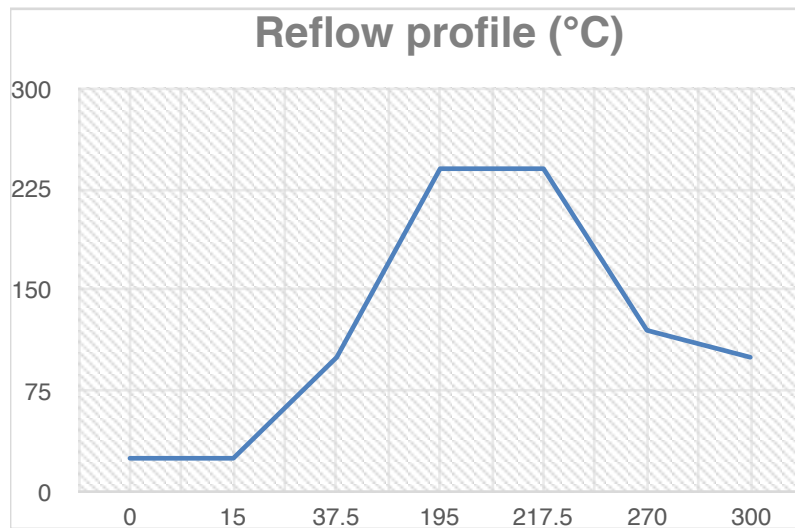
The antenna path must be designed with a 50 ohms line inserted into ground plane for better performance. 1<sup>st</sup> and 2<sup>nd</sup> layer ground planes must be connected with via.

Antenna must be kept away from any metal part like batteries, etc ... for better performances.

### Reflow temperature profile

The following figure & table give the reflow temperature profile of the MM002 module.

T(s)	0	15	37,5	195	217,5	270	300
Temp( °C )	25	25	100	240	240	120	100



### Embedded software

By default, the module is provided with AT command software version allowing to control it from an external micro-controller through an UART interface.

## Module pinning description

Module pins functions can be configured by specific software. Description of possible configurations is provided at the end of this specification for reference.

Whatever the pins configuration made by embedded software, some of them have unique functionality.

Functions class	PAD name	Function	Comment
<b>JTAG</b>	8	N J T R S T / (GPIO)	JTAG Reset
	9	J T D O / (GPIO)	JTAG Data Output
	10	J T D I / (GPIO)	JTAG Data Input
	11	JTCK-SWCLK / (GPIO)	JTAG Clock
	12	JTMS-SWDAT / (GPIO)	JTAG Mode Select
<b>PWR-UP</b>	2	/NRST	Module is automatically reset at power-up / keep unconnected if reset is not needed when module is powered On
	5	NC	Keep unconnected
<b>Ground</b>	1	GND	Ground
	15	GND	Ground
	16	GND	Ground
	18	GND	Ground
	28	GND	Ground
<b>Power supply</b>	27	VCC	Power supply of the board (3v)
<b>Antenna</b>	17	ANT	RF antenna port matched to 50Ω No DC capacitor required

Table 2 : Modem pins with unique functionality

## Default pinning configuration (modem controlled by AT command)

With AT command modem software, only few pins are configured and used. Other ones have no specific functions and are not driven by embedded software. These extra pins must be kept Unconnected.

Default modem software manages UART2 to communicate with application processor or similar. In this configuration following pins are configured.

Functions class	PAD name	Function	Comment
UART	23	USART2_RX	
	24	USART2_TX	
	25	Wake-up	Used in power saving mode to wake-up the module for UART communication

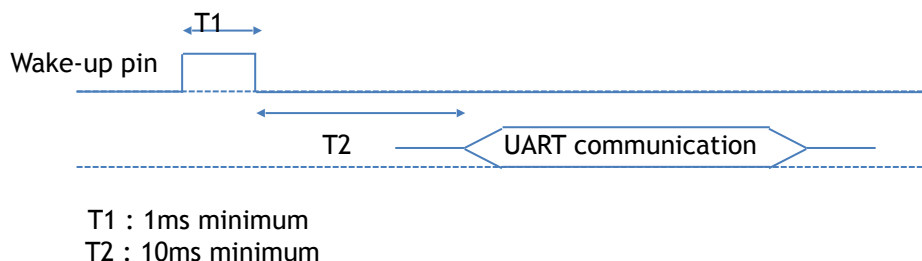
## UART

The UART configuration for Modem connection is following:

- Baud Rate : 38400
- Data : 8 bits
- Parity : None
- Stop : 1 bit
- Flow control : None
- End line character : LF

## Power saving mode

With embedded software using power saving mode, the Wake-up pin must be used to wake-up the module before any communication through UART. Find below the chronogram for this wake-up pin use.



## Electrical characteristics

### Absolute maximum rating

Symbol	Description	Min	Max	Unit
VCC	Module power supply	2.7	3.3	V
Temperature		-40	+85	°C
PwIN	RF input power	-	+10	dBm

### Operating range

Symbol	Description	Min	Typ.	Max	Unit
VCC	Module power supply	2.7	3.0	3.3	V
Temperature		-40	20	+85	°C
PwIN	RF input power	-	-	+10	dBm

### Recommended voltage operation

please use a low noise voltage regulator for VCC, in order to have a voltage ripple less than 10mV and a voltage drop less than 80mV when the TX mode is activated, at +13dBm.

## Current consumption

Three states must be considered for current consumption:

- Modem module in IDLE mode with RTC like function
- Modem module in TX mode
- Modem module in RX mode

Conditions: VCC =3V, T=25°C

Symbol	Description	Condi-tions	Min	Typ (LoRa)	Max	Unit
ICC_IDLE			-	< 2uA	-	uA
ICC_TX_20dB	Modem in TX mode	Tx power = +20dBm	-	122	-	mA
ICC_RX	Modem in RX mode	-	-	13	-	mA

## Available Pin configuration

Based on STM32L15x uC family, major part of module pins can be configured by embedded software and allow to have up to:

- 2 x UART
- 1 x SPI
- 1 x I2C
- 4 x ADC
- 19 x GPIO
- 1 Wake-up Interrupt

The configuration matrix is given in following table.

Use of such type of interface is done based on development made by Nemeus.

Functions class	1/2 lunde PAD name	Functions	Default function (modem only mode)	Name pins MCU	Reset/Boot Mode	JTAG/SW	USART1	USART2	SPI1	I2C1	ADC	WKUP	GPIO	
Modem_JTAG	12	JTMS-SWDAT	JTMS-SWDAT	PA13		JTAG/SW							GPIO #1	
	11	JTCK-SWCLK	JTCK-SWCLK	PA14										GPIO #2
	10	JTDI	JTDI	PA15										GPIO #3
	9	JTDO	JTDO	PB3										GPIO #4
	8	NJTRST	NJTRST	PB4										GPIO #5
Modem PWRUP	2	NRST	NRST	NRS T	NRE-SET									
	5	NC	NC	BOO TO	BOO TO									
Sensors pins	25	WKUP1/RTC_TAMP2/TIM2_CH1_ETR/TIM5_CH1/USART2_CTS/ADC_IN0/COMP1_INP		PA0				USAR T#2			ADC #1	WKUP #1	GPIO #6	
	26	USART2_RTS/ADC_IN1/TIM2_CH2/LCD_SEG0/COMP1_INP		PA1							ADC #2		GPIO #7	
	24	TIM2_CH3/TIM5_CH3/TIM9_CH1/USART2_TX/LCD_SEG1/ADC_IN2/COMP1_INP/OPAMP1_VINM		PA2				USAR T#2			ADC #3		GPIO #8	

Sensors pins	23	TIM2_CH4/TIM5_-CH4/ TIM9_CH2/ USART2_RX/ LCD_SEG2/ ADC_IN3/ COMP1_INP/ OPAMP1_VOUT		PA 3				USAR T#2			ADC #4		GPIO #9
	7		USART1_TX	PB 6			USAR T#1						GPIO #10
	6		USART1_RX	PB 7									GPIO #11
	4	TIM4_CH3/TIM10_-CH1/ I2C1_SCL/LCD_-SEG16	I2C1_SCL	PB 8							I2C #1		GPIO #12
	3	TIM4_CH4/TIM11_-CH1/ I2C1_SDA/LCD_-COM3	I2C1_SDA	PB 9									GPIO #13
	22		SPI1_NSS	PA 4									GPIO #14
	20		SPI1_SCK	PA 5							SPI #1*		GPIO #15
	21		SPI1_MISO	PA 6									GPIO #16
	19		SPI1_MOSI	PA 7									GPIO #17
	14	USART1_CTS/ USB_DM/ SPI1_MISO	USB	PA 11				USAR T#1					GPIO #18
	13	USART1_RTS/ USB_DP/ SPI1_MOSI	USB	PA 12									GPIO #19

Ground	1	GND	Ground										
	15	GND	Ground										
	16	GND	Ground										
	18	GND	Ground										
	28	GND	Ground										



<b>Supply</b>	27	<b>VCC</b>	Analog and digital supply										
<b>RF</b>	17	<b>ANT</b>	RF antenna input/output										

## FCC REGULATORY APPROVAL

The MM002-LS-US module has received Federal Communications Commission (FCC) CFR47 Telecommunications, Part 15 Subpart C "Intentional Radiators" modular approval in accordance with Part 15.212 Modular Transmitter approval. Modular approval allows the end user to integrate the MM002-L-US module into a finished product without obtaining subsequent and separate FCC approvals for intentional radiation, provided no changes or modifications are made to the module circuitry.

This device complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions:  
(1) this device may not cause harmful interference, and  
(2) this device must accept any interference received, including interference that may cause undesired operation.

Changes or modifications could void the user's authority to operate the equipment. The end user must comply with all of the instructions provided by the Grantee, which indicate installation and/or operating conditions necessary for compliance.

The finished product is required to comply with all applicable FCC equipment authorizations regulations, requirements and equipment functions not associated with the transmitter module portion. For example, compliance must be demonstrated to regulations for other transmitter components within the host product; to requirements for unintentional radiators (Part 15 Subpart B "Unintentional Radiators"), such as digital devices, computer peripherals, radio receivers, etc.; and to additional authorization requirements for the non-transmitter functions on the transmitter module (i.e., Verification, or Declaration of Conformity) (e.g., transmitter modules may also contain digital logic functions) as appropriate.

The module is for use with external antenna ONLY. The certified antennas include:  
- Dipole Antenna with maximum gain 2.2dBi.

### LABELING AND USER INFORMATION REQUIREMENTS

The MM002-LS-US module has been labeled with its own FCC ID number. If the FCC ID is not visible when the module is installed inside another device, then the outside of the finished product into which the module is installed must also display a label referring to the enclosed module. This exterior label can use wording as follows:

Contains Transmitter Module FCC ID: 2AKSYMM002XUS  
or  
Contains FCC ID: 2AKSYMM002XUS  
This device complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions:  
(1) this device may not cause harmful interference, and  
(2) this device must accept any interference received, including interference that may cause undesired operation.

A user's manual for the finished product should include one of the following statements:  
- For a Class A digital device or peripheral, the instructions furnished the user shall include the following or similar statement, placed in a prominent location in the text of the manual:

This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at his own expense."

- For a Class B digital device or peripheral, the instructions furnished the user shall include the following or similar statement, placed in a prominent location in the text of the manual:

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.

The user's manual for the finished product should include the following statements:

Any changes or modifications to this equipment not expressly approved by [Name\_of\_OEM/Integrator] may cause harmful interference and void the user's authority to operate this equipment.

#### RF EXPOSURE

The FCC grant is valid only when the module is sold to OEM integrators and must be installed by the OEM or OEM integrators. This transmitter is restricted for use with the specific antenna(s) tested in this application for Certification and must not be co-located or operating in conjunction with any other antenna or transmitters within a host device, except in accordance with FCC multi-transmitter product procedures.

The following statement must be included as a caution statement in manual on OEM products to alert users of FCC RF exposure compliance:

To satisfy FCC RF Exposure requirements for mobile and base station transmission devices, a separation distance of 20 cm or more should be maintained between the antenna of this device and persons during operation. To ensure compliance, operation at closer than this distance is not recommended. The antenna used for this transmitter must not be co-located or operating in conjunction with any other antenna or transmitter

If the MM002-LS-US module is used in a portable application (i.e., the antenna is less than 20 cm from persons during operation), the integrator is responsible for performing Specific Absorption Rate (SAR) exclusion evaluation or testing in accordance with FCC rules 2.1091.

## CANADA (ISED) REGULATORY APPROVAL

The MM002-LS-US module has been certified for use in Canada under Industry Canada (IC) Radio Standards Specification (RSS) RSS-247 and RSS-Gen. Modular approval permits the installation of a module in a host device without the need to recertify the device.

This device contains licence-exempt transmitter(s)/receiver(s) that comply with Innovation, Science and Economic Development Canada's licence-exempt RSS(s). Operation is subject to the following two conditions: 1. This device may not cause interference. 2. This device must accept any interference, including interference that may cause undesired operation of the device.

*L'émetteur/récepteur exempt de licence contenu dans le présent appareil est conforme aux CNR d'Innovation, Sciences et Développement économique 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; 2. L'appareil doit accepter tout brouillage radioélectrique subi, même si le brouillage est susceptible d'en compromettre le fonctionnement.*

This radio transmitter (22302-MM002xUS) has been approved by Industry Canada 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.

*Le présent émetteur radio (22302-MM002xUS) a été approuvé par Industrie Canada 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.*

The module is for use with external antenna ONLY. The certified antennas include:

- Dipole Antenna with maximum gain 2.2dBi.

### LABELING AND USER INFORMATION REQUIREMENTS

The Industry Canada certification label of a module shall be clearly visible at all times when installed in the host device, otherwise the host device must be labeled to display the Industry Canada certification number of the module, preceded by the words "Contains transmitter module", or the word "Contains", or similar wording expressing the same meaning, as follows:

Contains Transmitter Module IC: 22302-MM002XUS or Contains IC ID: 22302-MM002XUS
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User manuals for license-exempt radio apparatus shall contain the following or equivalent notice in a conspicuous location in the user manual or alternatively on the device or both:

This device complies with Industry Canada license-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. <i>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.</i>
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### RF EXPOSURE

All transmitters regulated by IC must comply with RF exposure requirements listed in RSS-102 - Radio Frequency (RF) Exposure Compliance of Radiocommunication Apparatus (All Frequency Bands).

The following statement must be included as a caution statement in manuals and OEM products to alert users of IC RF exposure compliance:

To satisfy IC RF Exposure requirements for mobile and base station transmission devices, a separation distance of 20 cm or more should be maintained between the antenna of this device and persons during operation. To ensure compliance, operation at closer than this distance is not recommended. The antenna used for this transmitter must not be co-located or operating in conjunction with any other antenna or transmitter.
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If the MM002-L-US module is used in a portable application (i.e., the antenna is less than 20 cm from persons during operation), the integrator is responsible for performing Specific Absorption Rate (SAR) exclusion evaluation or testing in accordance with RSS-102.