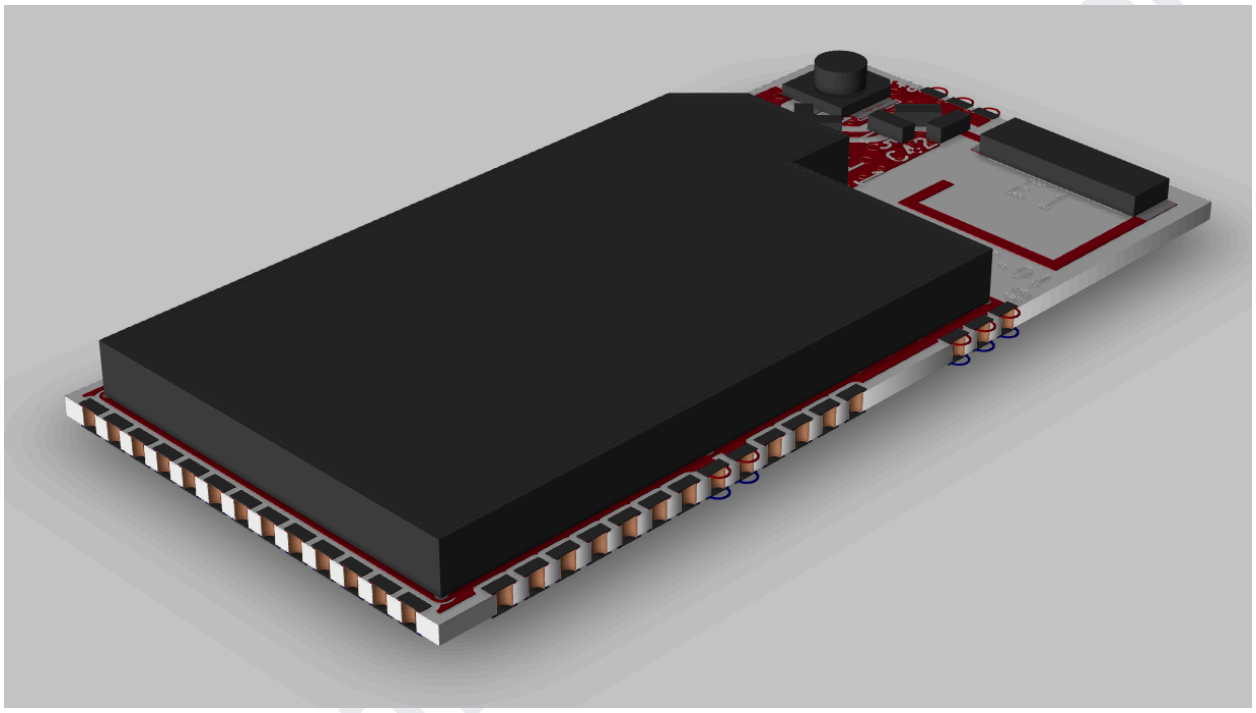
30 October 2023

MMB Gen2 Wi-SUN Module

Integration Manual Revision 0.3



1 Table of Contents

2 Revision History

Date	Revision	Comments
28 April 2022	0.1	Preliminary release
25 July 2023	0.2	Document updated per design updates
17 Oct 2023	0.3	Include FCC/ISED Regulatory Approvals Section

3 General Information

The MMB Gen2 Wi-SUN Module integrates the CC1312R7 System-on-Chip (SoC) from Texas Instruments and a high-power RF Front-End Module. The CC1312R7 contains an ARM Cortex-M4F main CPU and a software-defined radio (SDR) powered by a separate ARM Cortex-M0 CPU.

4 Memory

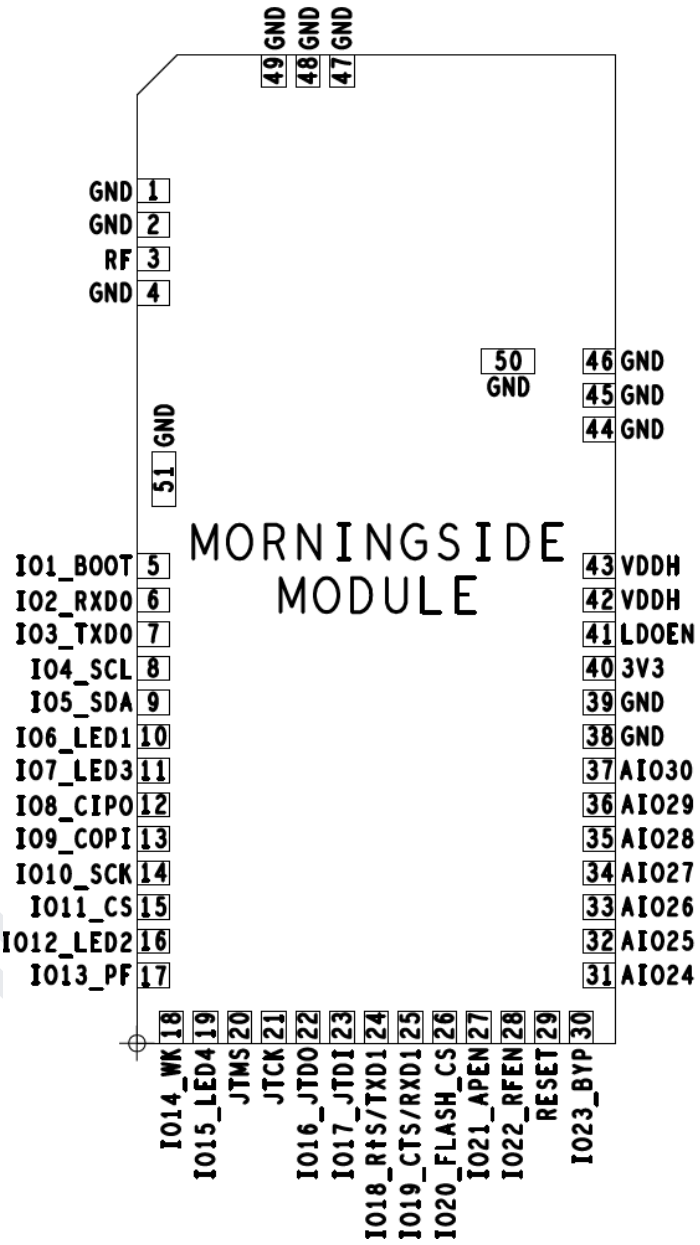
The MMB Gen2 Wi-SUN Module includes the following on-board memory resources:

RAM (kB)	ROM (kB)	On-Chip Flash (kB)
152	256	704

An additional external NOR flash memory module is also required and must be connected to DIO_8, 9, 10, and 20. The external memory is accessed via the module's SPI interface. The minimum size of the external flash is 4MB/32Mb. A suggested part number is Winbond W25Q32JV.

5 Module Pinout

5.1 Pin Diagram



5.2 Pin Function Table

Pad #	Pad name	Function	CC1312 pin name (#)
1	GND1	Ground	
2	GND2	Ground	
3	RF	RF input/output (optional)	
4	GND	Ground	
5	IO1_BOOT	Bootloader entry pin, active low. Requires pullup resistor.	DIO_1 (6)
6	IO2_RXD	Serial UART0 receive pin	DIO_2 (7)
7	IO3_TXD	Serial UART0 transmit pin	DIO_3 (8)
8	IO4_SCL	I^2C serial clock pin. Requires pullup resistor if using I^2C.	DIO_4 (9)
9	IO5_SDA	I^2C serial data pin. Requires pullup resistor if using I^2C.	DIO_5 (10)
10	IO6_LED1	SDK LED1 (red, bootloader) pin, active high.	DIO_6 (11)
11	IO7_LED3	SDK LED3 (green, network status) pin, active high.	DIO_7 (12)
12	IO8_CIPO	SPI CIPO (Central In Peripheral Out) pin	DIO_8 (14)
13	IO9_COPI	SPI COPI (Central Out Peripheral In) pin	DIO_9 (15)
14	IO10_SCK	SPI SCK (Serial Clock) pin	DIO_10 (16)
15	IO11_CS	SPI CS (Chip Select) pin for user SPI devices. Requires pullup resistor if using SPI.	DIO_11 (17)

16	IO12_LED2	SDK2 LED2 (yellow, RF transmit indicate) pin, active high.	DIO_12 (18)
17	IO13_PF	SDK Power Fail (PF) input, active low. Requires pullup resistor.	DIO_13 (19)
18	IO14_WK	SDK wake input pin, active high. Requires pulldown resistor.	DIO_14 (20)
19	IO15_LED4	SDK2 LED4 (orange, RF receive indicate) pin, active high	DIO_15 (21)
20	JTMS	JTAG TMS (Test Mode Select) pin. Requires pullup resistor.	JTAG_TMSC (24)
21	JTCK	JTAG TCK (Test Clock) pin. Requires pulldown resistor.	JTAG_TCKC (25)
22	IO16_TDO	JTAG TDO (Test Data Out) pin. Requires pullup resistor.	DIO_16 (26)
23	IO17_TDI	JTAG TDI (Test Data In) pin. Requires pullup resistor.	DIO_17 (27)
24	IO18_RTS/TXD1	UART0 RTS pin OR UART1 TXD pin	DIO_18 (28)
25	IO19_CTS/RXD1	UART0 CTS pin OR UART1 RXD pin	DIO_19 (29)
26	IO20_FLASH_CS	SPI CS (Chip Select) pin for required external SPI flash. Requires pullup resistor.	DIO_20 (30)
27	IO21_TXACT	RF front-end transmit/receive indication output pin. (Active High)	DIO_21 (31)
28	IO22_RFACT	RF front-end wake/sleep indication output pin. (Active High)	DIO_22 (32)
29	RESET	Module MCU RESET pin (active-low). Includes built-in pullup resistor.	RESET_N (35)

30	IO23_BYP	RF front-end receive LNA bypass indication output pin. (Active High)	DIO_23 (36)
31	AIO24	User GPIO or analog input pin	DIO_24 (37)
32	AIO25	User GPIO or analog input pin	DIO_25 (38)
33	AIO26	User GPIO or analog input pin	DIO_26 (39)
34	AIO27	User GPIO or analog input pin	DIO_27 (40)
35	AIO28	User GPIO or analog input pin	DIO_28 (41)
36	AIO29	User GPIO or analog input pin	DIO_29 (42)
37	AIO30	User GPIO or analog input pin	DIO_30 (43)
38	GND	Ground	
39	GND	Ground	
40	3V3 (VDD33)	Built-in 3.3V LDO output pin. *Optional: bypass interenal LDO by supplying 3.3V to this pin externally. Pull LDOEN low.*	VDDS2 (13), VDDS3 (22), VDDS_DCDC (34), VDDS (44)
41	LDOEN	Built-in 3.3V LDO enable pin, active high. *Optional: pulled low when 3V3 (VDD33) is supplied externally.*	
42	VDDH	Main supply voltage input (3.3 - 4.5 V). *Optional: supplied externally for front-end TX power amplifier. 3V3 should also be supplied externally and LDOEN is pulled low.*	
43	VDDH	Main supply voltage input (3.3 - 4.5 V) *Optional: supplied externally for front-end TX power amplifier. 3V3 should also be supplied externally and LDOEN is pulled low.*	
44	RFGND	RF ground pin, connect to PCB GND.	

45	RFGND	RF ground pin, connect to PCB GND.	
46	RFGND	RF ground pin, connect to PCB GND.	
47	RFGND	RF ground pin, connect to PCB GND.	
48	RFGND	RF ground pin, connect to PCB GND.	
49	RFGND	RF ground pin, connect to PCB GND.	
50	SHGND	Shield ground tab. Connect to PCB GND.	
51	SHGND	Shield ground tab. Connect to PCB GND.	

6 Electrical Specifications

6.1 Absolute Maximum Ratings

Parameter	Minimum	Maximum	Units
Main supply voltage (VDDH)	-0.3	5.0	V
LDO enable pin voltage (LDOEN)	-0.3	5.0	V
Optional 3.3V supply voltage (3V3)	-0.3	3.6	V
Voltage on any GPIO	-0.3	3.6	V
Ambient Operating Temperature	-40	85	℃
Storage Temperature	-40	125	℃

6.2 Recommended Operating Conditions

Parameter	Minimum	Typical	Maximum	Units
Main Supply Voltage (VDDH)	3.3	4.0	4.4	V
LDO enable pin voltage (LDOEN)	0	3.3 (Low Power) 4.0 (High Power)	4.4	V
Optional 3.3V supply voltage (3V3)[1]	3.3		3.6	V
LDO external output current (high-power mode only)[2]			120	mA
Ambient operating temperature	-40	25	85	℃

[1] When operating at VDDH ≥ 3.6 V, the internal LDO can produce the 3.3V supply rail. A separate external 3.3V supply is not required for this use case.

[2] In low-power mode (3.3V =< VDDH < 3.6 V), the module's internal LDO should be disabled as it will not operate correctly.

6.3 DC Electrical Characteristics

Note: Typical values are measured at room temperature(25C°).

Parameter	Test Condition	Min	Typical	Max	Units
Input logic high voltage (Vih)		0.8*VDD33			
Input logic low voltage (Vil)				0.2*VDD33	
Transmit current	High-power mode (HP) VDDH = 4.0 V		650	750[1]	mA
	Low-power mode (LP) VDDH = 3.3 V		550	650[1]	mA
Receive current	VDDH = 3.3 or 4 V		25		mA
Sleep current			3.5		uA

[1] Such current levels could indicate poor chip antenna performance due to enclosure proximity or PCB design around the antenna

6.4 RF Receive Specifications

Note: Conducted measurements were taken for the external U.FL antenna variant (DTX01PA10-RFC).

Parameter	Test Condition	Min	Typical	Max	Units
Frequency Range		902	915	928	MHz
Wi-SUN Sensitivity	Wi-SUN Mode 3		-104		dBm

6.5 RF Transmit Specifications

Parameter	Test Condition	Min	Typical	Max	Units
Transmit power	High-power mode, VDDH = 4.0 V		29		dBm
	Low-power mode, VDDH = 3.3 V		27		dBm

7 Functional Description

Refer to the CC1312R7 datasheet for detailed functional specifications of the various interfaces (UART, SPI, I^2C, ADC, etc.)

7.1 JTAG Debug Interface

The module includes a standard 4-wire JTAG debug interface that can be used to flash firmware images and for step debugging of the running CPU. It is suggested that pullup resistors (100 kΩ max) be provided on the TDO, TDI, and TMS pins and a pulldown resistor (100 kΩ max) be provided on the TCK pins.

7.2 Serial UART Interface

The module includes 4 serial UART interface pins (IO2, IO3, IO18, and IO19). These can be configured to act as 2 independent UARTs (UART0, UART1) or alternatively as a single UART (UART0) with RTS/CTS hardware flow control functionality.

7.3 Bootloader entry pin

The logic level of IO1_BOOT is checked by the bootloader during the power-up or reset (POR) sequence. An external pullup resistor should be provided for this. If the pin is held at a logic LOW level during boot, the module will enter into bootloader mode and SDK LED1 (red) will be activated. When in bootloader mode, the module's firmware can be upgraded via the UART0 connection.

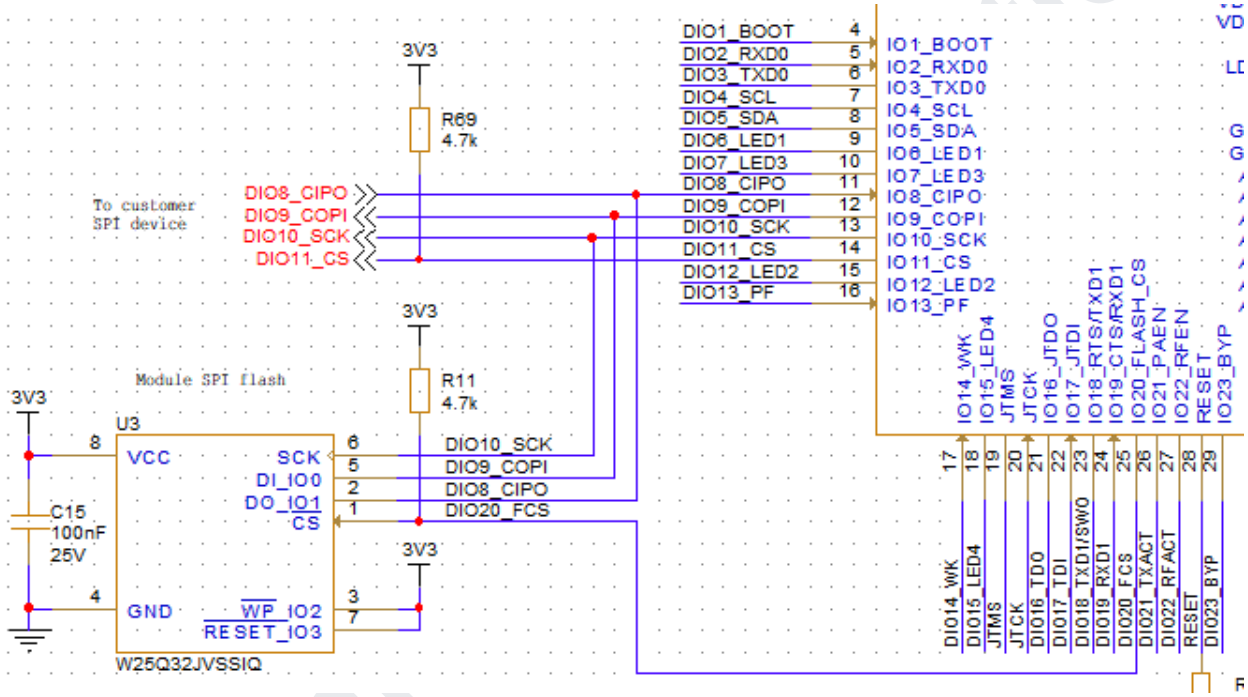
7.4 SPI Interface

The module includes a standard 4-wire SPI interface (IO8, 9, 10, and 11) for customer use. There is also an additional Chip Select signal (IO20_FLASH_CS) which is connected to the mandatory external SPI flash. Customer SPI applications must be tolerant of traffic arising on the SPI bus due to activity between the module and its SPI flash. The dual chip select pins can be used as a deconfliction mechanism.

8 Applications Information

8.1 SPI bus sharing

The MMB Gen2 Wi-SUN Module requires an external NOR SPI flash (suggested MPN W25Q32JV) connected to its SPI bus. A separate Chip Select signal (DIO20_FLASH_CS) is provided for this flash memory. Customer SPI devices should use their own separate Chip Select signal on pin DIO11_CS.



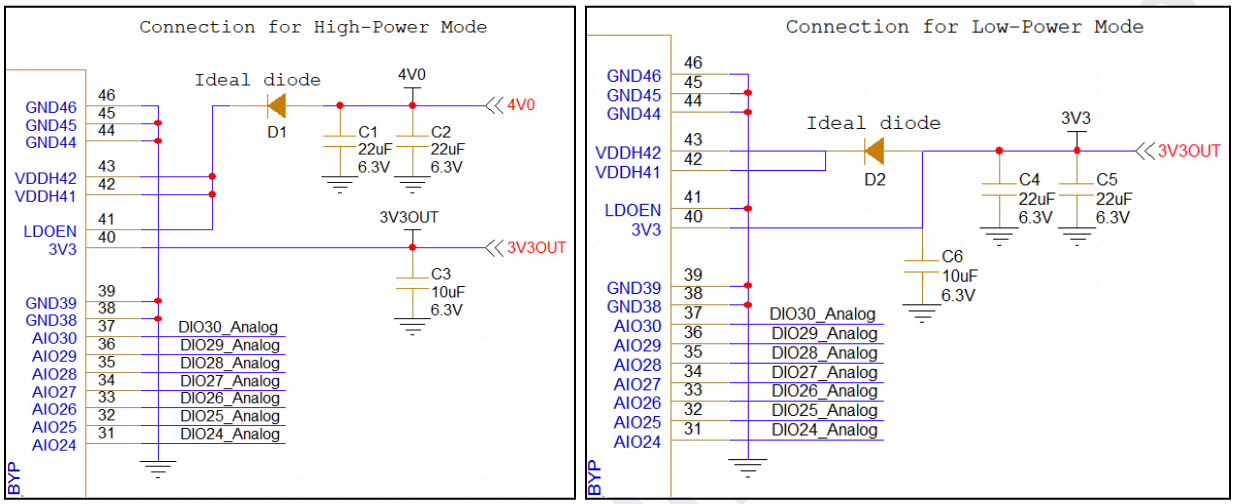
8.2 High-power and low-power modes

The MMB Gen2 Wi-SUN Module can be operated in 1 of 2 power supply configurations:

1. **High-power mode.** An external supply of typically 4.0 V is connected to the VDDH and LDOEN pins. The module's internal 3.3V LDO generates the 3V3/VDD33 supply. The customer may optionally place up to 100 mA of load on this LDO. The expected RF output power is approximately +29 dBm.
2. **Low-power mode.** An external supply of typically 3.3V is connected to the VDDH and 3V3/VDD33 pins. The LDOEN pin is grounded. The module's internal LDO is therefore disabled. The expected RF output power is approximately +27 dBm.

In general, high-power mode should be used for the longest radio range and low-power mode when reduced power consumption is required or no 4.0 V supply is available.

Regardless of which power mode is chosen, 2x 22uF decoupling capacitors should be connected at the VDDH pins and 1x 10uF at the 3V3/VDD33 pin.



Optional: The host manufacturer installing this module into their product can offer reverse protection for VDDH and 3V3 power rails. Forward voltage drop of selected diode should account for TX Current Consumption figures stated in Section 6.3. Voltage on VDDH pins should be approximately 4V during TX when operating in High Power mode for best RF performance.

8.3 RF Antenna Options

The MMB Gen2 Wi-SUN Module includes 3 options for connecting an RF antenna. The antenna option is selected when the module is ordered and is not subsequently configurable by the customer.

8.3.1 Option 1: External U.FL antenna

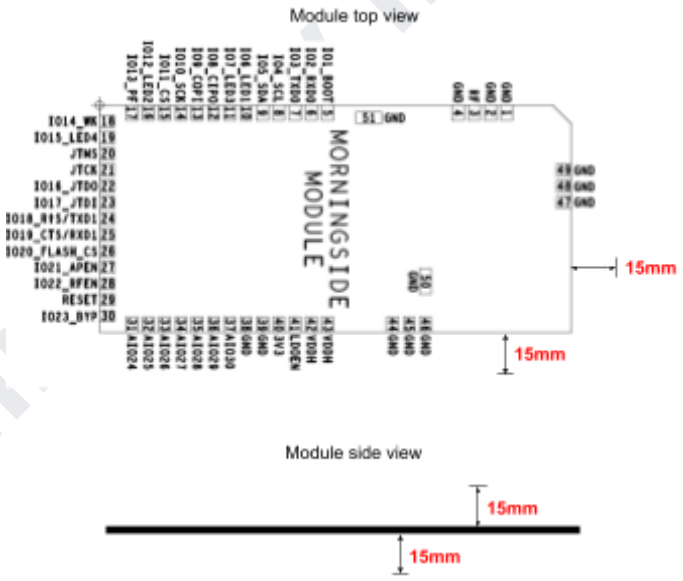
This is the preferred antenna option when not constrained by size and cost or when the antenna must be mounted outside the project enclosure. A suitable 902-928 MHz antenna (863-870 MHz for European version) with U.FL cable should be connected to the module's built-in U.FL connector. The maximum gain of the connected antenna will be subject to regional radio regulations, and the

module is intended to be FCC/IC certified with one or more pre-approved external antennas as described in section 11 Regulatory Approvals.

8.3.2 Option 2: Internal chip antenna

For applications that are subject to size constraints or where it isn't practical to assemble a separate antenna, the module's onboard chip antenna may be used. The chip antenna's gain and efficiency performance are inherently lower than their typical external counterparts available off the shelf, resulting in slightly reduced radio range. When using the chip antenna, it is required to place the module at the corner of the customer PCBA and provide an appropriate copper and keepout, shown in section 9.1 Module Physical Dimensions and Host PCB Antenna Keep-out, and enclosure clearances in order to achieve the best RF performance.

In the next figure, the minimum physical clearance of plastic enclosures from the module to maintain good performance is illustrated. Similar to the carrier PCB parameters above, maintaining these figures would ensure the best on-board antenna performance for best radio range.

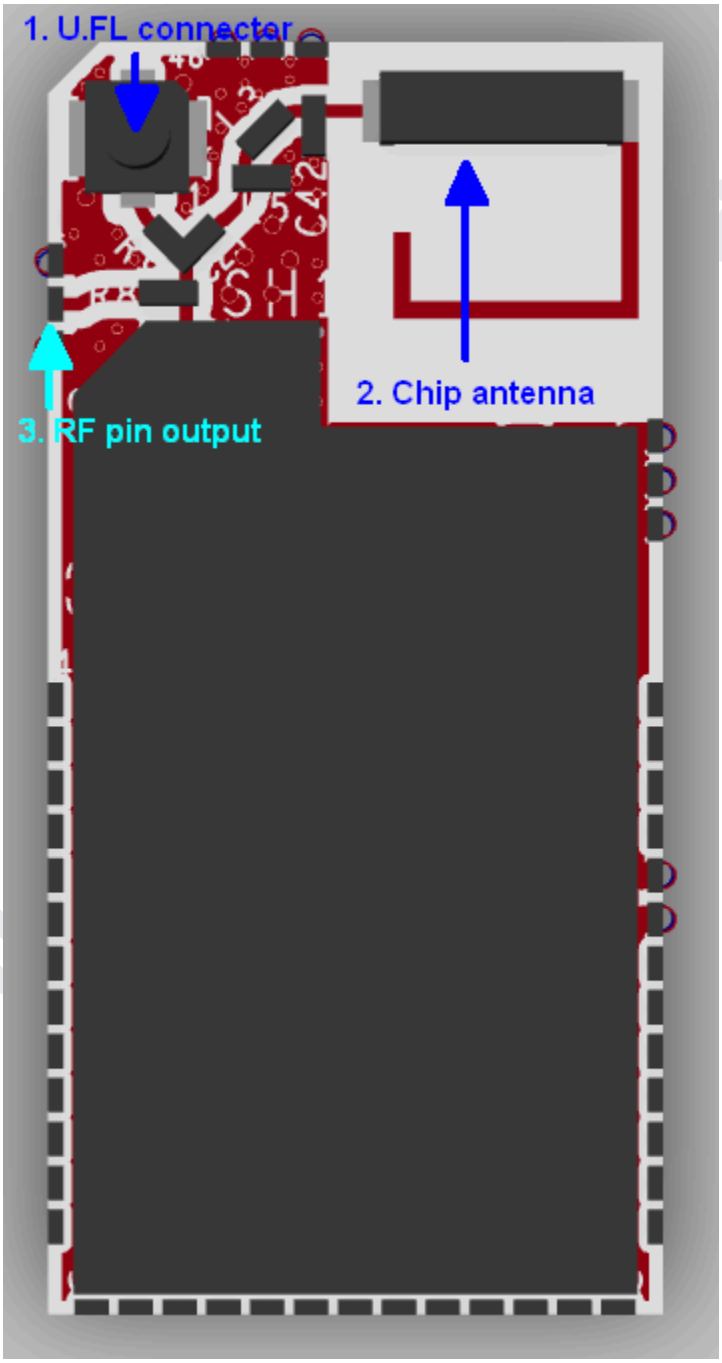


8.3.3 Option 3: RF pin output

If the application requires a specific custom antenna connector or if it is desired to use a low-cost, high-gain PCB antenna at the expense of larger PCB area, it is possible to route a coplanar waveguide with ground (CPWG) or microstrip PCB trace from the module's RF pin to an antenna

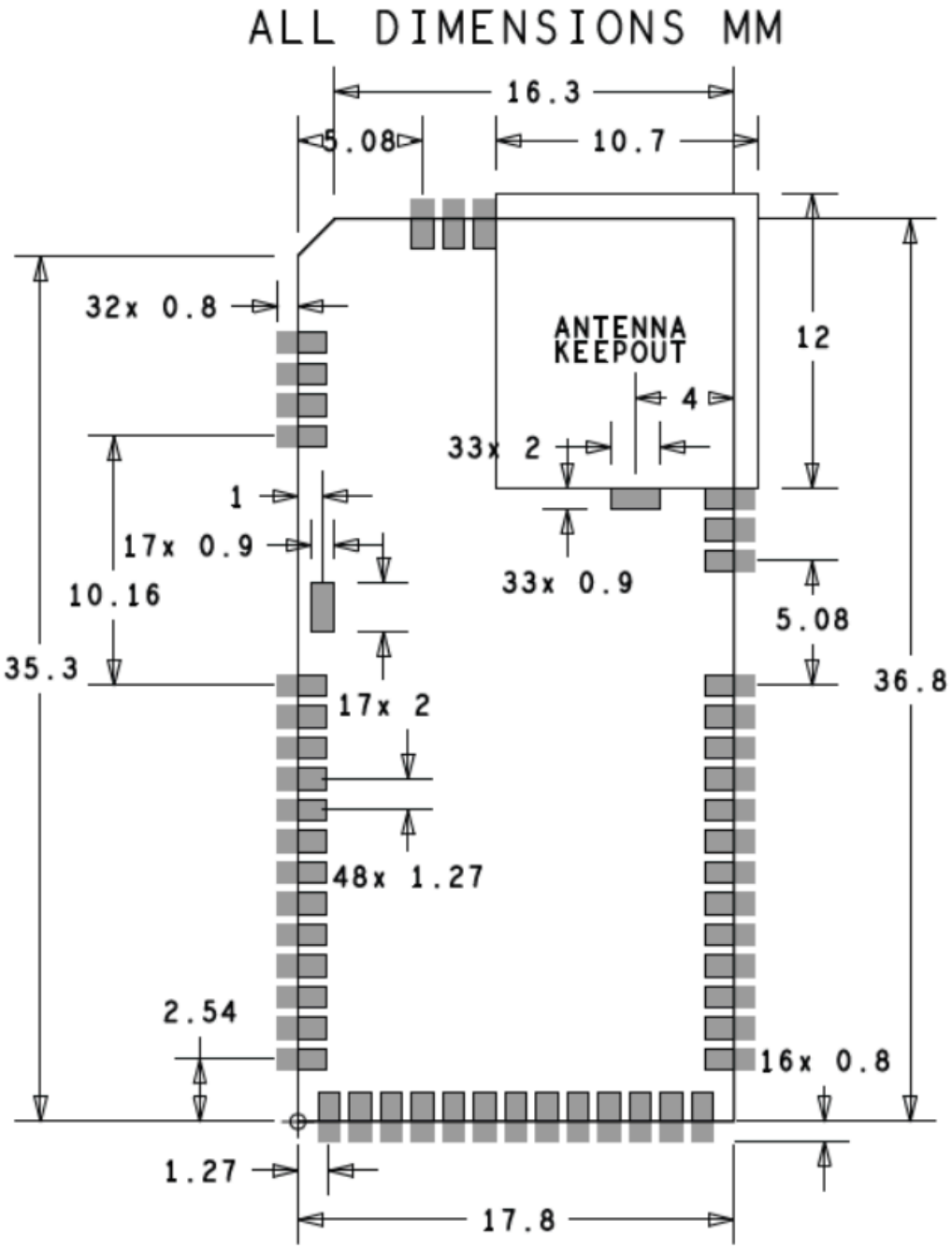
located on the customer PCB. The RF pin version of the module does not qualify for FCC/IC modular approval and customers selecting this option will be required to perform their own full certification testing.

8.3.4 Antenna Options Drawing



9 Mechanical Specifications

9.1 Module Physical Dimensions and Host PCB Antenna Keep-out

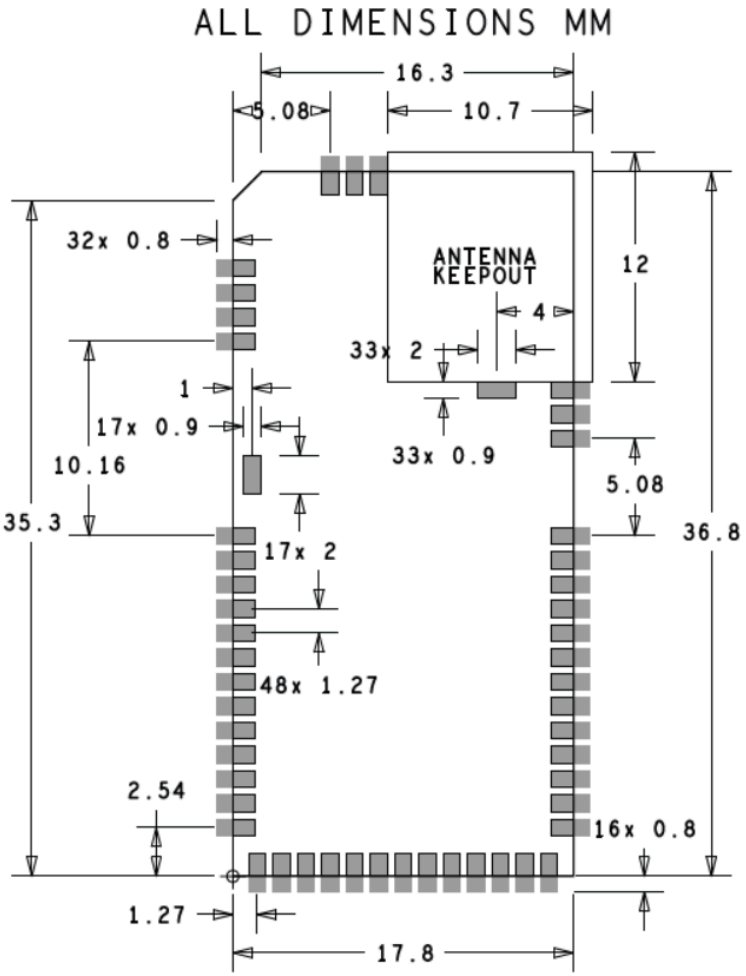


Module Height: 3mm

9.2 Recommended Land Pattern (Surface Mount)

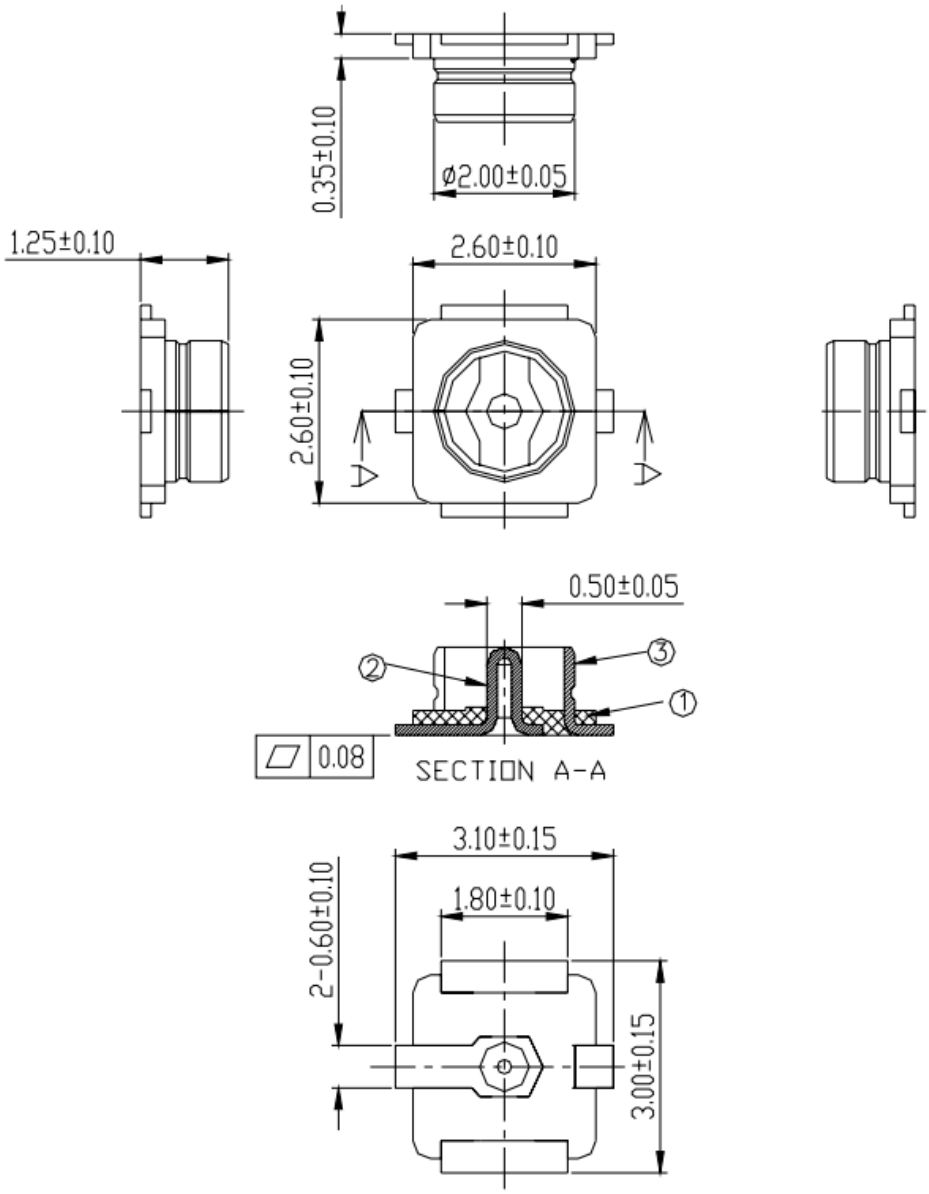
The diagram below shows the recommended dimensions and arrangement of the pads for the module. The PCB upon which the module will be mounted should not include any non-ground traces or vias on the top layer directly under the module. All copper features other than the module mounting pads, including ground vias, should be plugged and covered with soldermask to avoid coming in contact with the module's traces and producing unexpected behavior.

If it is absolutely necessary to include traces and/or vias under the module due to space constraints, then a customer can elect to do so at their own risk. MMB can provide a Hardware Designer Package to show the module's footprint and drill locations, which must not line up with the daughtercard's drill locations.



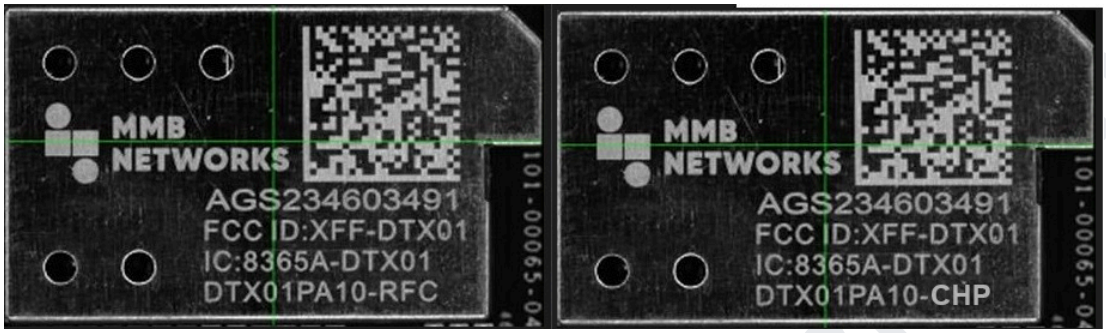
9.3 RF Connector Dimensions

The diagram below shows the dimensions for the optional RF connector. This connector appears on the TBD variants only. It is a standard U.FL-compatible connector (also known as IPEX, Ultra-Miniature Coaxial (UMC/UMCC), or MHF1).

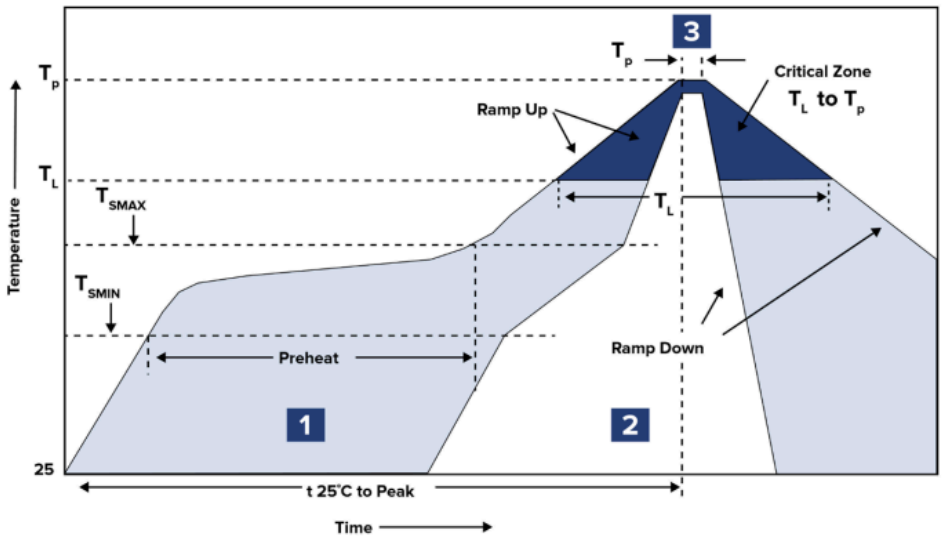


9.4 Label Drawings

Module information (including unit serial number, FCC ID, IC ID and HVIN) will be laser engraved directly on the shield can.



10 Reflow Soldering Profile



Zone	Description	Temperature	Time
1	Preheat	T_{SMIN}~T_{SMAX} 150°C~180°C	60~120 sec
2	Reflow	T_L 217°C	45~90 sec
3	Peak Heat	T_p 260°C Max	10 sec

11 Regulatory Approvals

Product is being designed for FCC/IC compliance and may be compatible with other global regions depending on frequency allocations. If it is desired for a customer design to inherit the module's FCC/IC certification, one of the approved antenna options must be used.

Because the RF pin version of the module does not include an onboard antenna or custom connector, customers selecting the RF pin variant will be unable to certify using modular approval and will be required to run their own full certification testing.

11.1 Federal Communication Commission (FCC - US)

Integration instructions for host device manufacturers can be found below and are compliant with the KDB 996369 D03 OEM Manual v01.

11.1.1 List of Applicable FCC Rules

FCC Part 15 Subpart C 15.247 & 15.209

11.1.2 Specific Operational Use Conditions

Module is tested for mobile RF exposure use conditions. Using the module for portable conditions will require additional assessment though a Class II permissive change or a change in FCC ID through a new application.

The host manufacturer installing this module into their product must ensure that the final product complies with the FCC requirements by a technical assessment or evaluation against the FCC rules. The host manufacturer 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 host's end-user manual shall include all required regulatory information/warning as shown in this manual.

11.1.3 Limited Module Procedure

Not Applicable. This device is a single-modular transmitter and complies with the requirement of FCC Part 15.212(a)(1)

11.1.4 Trace Antenna Design

Not Applicable. Any host device that will use the RF pin variant will not be able to certify using modular approval.

11.1.5 RF Exposure Conditions

A 25 cm minimum distance has to be able to be maintained between the antenna and the users for the host device this module is integrated into. Under such configuration, the FCC radiation exposure limits set forth for an uncontrolled environment can be satisfied. Further RF exposure shall be re-evaluated to the scenario of portable, and co-located use.

USER MANUAL OF THE END PRODUCT:
In the user manual of the end product, the end user has to be informed to keep at least 25 cm separation with the antenna while this end product is installed and operated. The end user has to be informed that the FCC radio-frequency exposure guidelines for an uncontrolled environment can be satisfied.
The end user has to also be informed that any changes or modifications not expressly approved by the manufacturer could void the user's authority to operate this equipment.

11.1.6 Antennas

The DTX01PA1-CHP module uses the FCC approved onboard chip antenna while the DTX01PA1-RFC modules will use one of the FCC approved external antennas. For DTX01PA1-RFC external antennas of the same type with equal or lower gain may also be used with this module

Antenna Type	Manufacturer	Model	Maximum Gain(dBi)	Nominal Impedance (Ω)
Integral Chip	Johanson Technology Inc.	0915AT43A0026	1	50
Dome	TE Connectivity Laird	TRAB9023NP	3	50
Monopole	TopPoint Technology	DD300033	3	50

11.1.7 Label and compliance information

The final end product must be labeled, in a font size of 4pt or greater, in a visible area with the following:

Contains FCC ID: XFF-DTX01

Contains IC: 8365A-DTX01

11.1.8 Information on test modes and additional testing requirements

The module supports Wi-SUN Mode 1b, Mode 2a and Mode 3

- Operational Frequency:
  - Mode 1b: 902.2 - 927.8 MHz
  - Mode 2a & 3: 902.4 MHz - 927.6 Mhz
- Number of Channels:
  - Mode 1b: 129
  - Mode 2a & 3: 64
- Modulation:
  - Mode 1b: GFSK
  - Mode 2a & 3: GFSK

Host device manufacturers must perform some investigative measurements to ensure the system does not exceed spurious emission or band edge limits. The device is tested in a standalone modular transmitter and simultaneous transmission with other transmitters will require a Class II permissive change or a new FCC ID.

11.1.9 Additional testing, Part 15 Subpart B disclaimer

This modular transmitter is only FCC authorized for FCC Part 15 Subpart C 15.247 & 15.209 and the host device manufacturer is responsible for compliance to any other FCC rules that apply to the host not covered by the modular transmitter grant certification. Although the module is compliant with Part 15 Subpart B (unintentional radiator), certification does not carry forward to host devices. The final host device will require Part 15 Subpart B compliance testing with the modular transmitter installed.

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 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.

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.

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

If the transmitter must be co-located with any other transmitter or antenna, additional testing will be required which will result in a Class II permissive change or new FCC ID.

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

Important Note: In the event that these conditions cannot be met (for example certain laptop configurations or co-location with another transmitter), then the FCC authorization for this module in combination with the host equipment is no longer considered valid and the FCC ID of the module 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 authorization.

11.1.10 Note EMI Considerations

Not Applicable. Follow the design guidelines highlighted in this document and refer to 996369 D04 Module Integration Guide V02 for “best practices”.

11.1.11 How to make changes

Instructions for expected use cases are highlighted within the document. If the module is used differently than granted as part of this certification which requires some permissive change, please contact your local MMB sales representative for additional support.

11.2 Innovation, Science and Economic Development Canada (ISED)

Note: This section applies to DTX01PA10-CHP and DTX01PA10-RFC devices only.

11.2.1 Approved Antennas

This radio transmitter IC: 8365A-DTX01 has been approved by Innovation, Science and Economic Development Canada to operate with the antenna types listed below, with the maximum permissible gain indicated. Antenna types not included in this list that have a gain greater than the maximum gain indicated for any type listed are strictly prohibited for use with this device.

Antenna Type	Manufacturer	Model	Maximum Gain(dBi)	Nominal Impedance (Ω)
Integral Chip	Johanson Technology Inc.	0915AT43A0026	1	50
Dome	TE Connectivity Laird	TRAB9023NP	3	50
Monopole	TopPoint Technology	DD300033	3	50

11.2.2 ISED Notice

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.

11.2.3 Labeling Requirement

The host device shall be properly labelled to identify the modules within the host device. The Innovation, Science and Economic Development 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 labelled to display the ISED 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: 8365A-DTX01

Contient le émetteur radio IC: 8365A-DTX01

11.2.4 Additional Notice

This module is intended for an OEM integrator. The OEM integrator is responsible for the compliance to all the rules that apply to the product into which this certified RF module is integrated. Additional testing and certification may be necessary when multiple modules are used. A 25 cm minimum distance has to be able to be maintained between the antenna and the users for the host this module is integrated into. Under such configuration, the ISED radiation exposure limits set forth for a population/ uncontrolled environment can be satisfied. Further RF exposure shall be re-evaluated to the scenario of portable, and collocated use

11.3 RoHS Compliance

The DTX01 devices do not contain any substances in excess of the maximum concentration allowed by Directive 2002/95/EC. The module is RoHS compliant.

11.4 FCC & IC Compliance

In the event that conditions as described in the manual cannot be met, then the FCC and ISED authorizations are no longer considered valid and the FCC ID and IC certification number cannot be used on the final product. In these circumstances, the integrator will be responsible for re-evaluating the end product (including the transmitter) and obtaining a separate FCC and ISED authorization.

Module is presently only certified for use in the USA and Canada.. Use in other regions will have to be coordinated with MMB for additional certification of the module.

12 Ordering Information

Hardware SKU	Regulatory Approvals	RF Output Option	Status
DTX01PA10-RFC	FCC/IC	External U.FL antenna	Engineering Samples
DTX01PA10-CHP	FCC/IC	Internal chip antenna	Engineering Samples
DTX01PA10-PIN	N/A[1]	RF output pin	Engineering Samples

[1] The PIN variant of the module has no regulatory approvals. Host manufacturers who decide to use this variant are responsible for full certification of the product.