X7F202 Datasheet

Multichannel Ultra Wideband (UWB) Impulse Radar Sensor

Rev. 3.1 - Advance Information - 2024-10-21

Key Features

- Complete multichannel Ultra Wideband (UWB) radar transceiver sensor.
- Two integrated Tx/Rx transceivers and antennas allowing digital beamforming.
- Low power transmitter targeting world wide regulatory compliance.
- I2C / SPI-XIP / QSPI-XIP serial communication interface.
- Low power operation - less than 100 uW in some use cases.
- Industrial operating temperature range, from -40°C to 85°C.
- Wide supply voltage range, 1.8 V - 3.3 V.
- No external components required.

Product Description

The X7F202 is an Ultra Wideband (UWB) impulse radar transceiver sensor module designed for unlicensed operation in worldwide markets. The X7F202 includes all required circuitry, such as antennas, clocks and de-coupling capacitors and can be connected directly to existing systems through I2C or SPI interface.

Applications

- Low power robust presence detection for consumer electronics and smart buildings.

Table of Contents

1. Electrical Characteristics

1.1. Absolute Maximum Ratings

Stresses beyond those listed in this section may cause permanent damage to the device. These are stress ratings only, which do not imply functional operation of the device at these or any other conditions beyond those indicated under Recommended Operating Conditions. Exposure to absolute-maximum-rated conditions for extended periods may reduce device reliability.

Parameter		Min	Typ	Max	Unit
VDD	Supply voltage, all domains	-0.3		3.6	V
VDD_{IO}	Input voltage, digital I/O	-0.3		VDD + 0.3	V
JESD22-A103C	Storage temperature			150	°C
J-STD-020	Reflow soldering temperature			260	°C
JEDEC JS-002	ESD, CDM			500	V
JEDEC JS-001	ESD, HBM			1000	V

Table 1.1. Absolute maximum ratings

1.2. General Operating Conditions

Parameter		Min	Typ	Max	Unit
VDD	Supply voltage, all domains	1.8		3.3	V
T_A	Ambient operating temperature	-40		85	°C

Table 1.2. General operating conditions

1.3. Transceiver Parameters

Tc = 25°C, VDD = 1.8 V, unless otherwise noted.

Parameter	Min	Typ	Max	Unit
Radar receiver frame length		192 91.0 13.6		bins ns meters
Sampling rate		2100		MS/s
RX bandwidth (-3dB)		460		MHz
RX maximum input	-40	-36		dBm
RX noise figure		8	10	dB
RX S11		< -10		dB
TX center frequency		7875		MHz
TX bandwidth (-10 dB)		750		MHz
Maximum pulse repetition frequency		65.625		MHz
Peak pulse output power at max trim		2.5		dBm

Table 1.3. RX parameters summary

1.4. Current Consumption

1.4.1. Power Modes

Tc = 25°C, VDD = 1.8 V, unless otherwise noted.

Parameter		Min	Typ	Max	Unit
Power-down (reset)	RESET_N pin low		7		µA
Standby	CPU off, 64 kB RAM retention		11		µA
Standby	CPU off, 256 kB RAM retention		250		µA
Idle	CPU sleep, 64 kB RAM retention				µA
Idle	CPU sleep, 256 kB RAM retention				µA
Active	CPU on				mA

Table 1.4. Current consumption power modes

1.4.2. Radar Modes

Radar transceiver current.

Tc = 25°C, VDD = 1.8 V, unless otherwise noted.

Parameter		Min	Typ	Max	Unit
I_{TRX}	Beamforming Master, 1 TX + 2 RX + 2 x LVDS TX		165		mA
I_{TRX}	Beamforming Standalone, 1 TX + 2 RX		135		mA
I_{TRX}	Single channel radar, 1 TX + 1 RX		85		mA

Table 1.5. Current consumption radar modes

1.5. Specification of Clock Sources

1.5.1. Internal Low Power Oscillator (LPOSC)

Parameter		Min	Typ	Max	Unit
F_{tol}	Absolute frequency accuracy			35	%
F_{LPOSC}	Output frequency		50		MHz

Table 1.6. Low power oscillator (LPOSC) specification

1.5.2. Crystal Oscillator (XOSC)

Parameter		Min	Typ	Max	Unit
$F_{fundamental}$	Crystal frequency		30		MHz
F_{tol}	Frequency accuracy			100	ppm
$T_{startup}$			1.0		ms

Table 1.7. Crystal oscillator specification

2. Serial Peripheral Interface (SPI)

The Serial Peripheral Interface (SPI) enables communication between the X7 and a host device for transfer of configuration- and radar data. The SPI features:

- Two different modes of operation:
  - **SPI**: Single bit SPI using 4 wires and transfers data in full duplex with input and output from the device on dedicated pins.
  - **QSPI**: Quad SPI using 6 wires and transfers data in half duplex with input and output on bidirectional pins.
- Up to 50 MHz operation.

2.1. SPI Low Level Interface

The SPI clock is expected to have its resting state low (CPOL = 0). The output data is driven on the rising edge and the inbound data is sampled on the falling edge of the SPI clock (CPHA =1).

All transfers are 32-bit and take place with the Least Significant Bit (LSB) first.

The chip select (nCS) is active low.

The System Controller clock should be at least twice as fast as the SPI clock in quad mode. Therefore the practical maximum frequency of the SPI clock will depend on the clocking configuration of the System Controller.

2.2. SPI Protocol

For both reads and writes, each transaction begins with a 32-bit command word and is followed by N data phases, where N is an integer greater than 0. All 32-bit transfers are transmitted LSB first over the interface.

	[31:27]	**[26]**	**[25:24]**	**[23:2]**	**[1]**	**[0]**
		Mode	**Burst length**	**Address**		
Read	Dont't care	0: Single 1: Quad	0: 1 words 1: 4 words 2: 8 words 3: N words	22-bit base address	0	0
Write						1

Table 2.1. SPI command word coding

The first 32-bit transfer after nCS changes from inactive to active is always interpreted as the command, and is always decoded as a single bit SPI transfer. After the command, subsequent transfers may be single-mode or quad-mode, depending on the Mode bit.

During single bit SPI commands data is transferred from the controller to the peripheral on the SPIO0/COPI pin and from the peripheral to the controller on the SPIO1/CIPO pin.

QSPI commands use four bidirectional pins for half-duplex data transfer between controller and peripheral. Data is transferred as nibbles (four bits at a time) in both directions.

All transfers begin with the least significant bit and ends with the most significant bit. In quad-mode transfers the following applies:

- The least significant nibble is transferred on the first clock cycle and the most significant nibble on the last (8th) clock cycle of a 32-bit transfer.
- The least significant bit of each nibble is transferred on SPIO0 and the most significant bit of each nibble is transferred on SPIO3.

3. Inter-Integrated Circuit (I2C)

The Inter-Integrated Circuit (I2C) enables communication between the X7 and a host device for transfer of configuration- and radar data.

3.1. I2C Specification

Parameter	Min	Max	Unit
Maximum I2C clock frequency		400	kHz
7-bit I2C slave address	0x5A		

Table 3.1. I2C Specification

4. Implementation and Layout

NOTE: Design is subject to change

The X7F202 module is in development and some aspects of the design is subject to change. The figures in this section are updated for revision 1.1 of the X7F202 module. Exception is Figure 4.8 which is for an older revision.

Altium library files are available for all versions of the module. For more information contact Novelda.

Figure 4.1 and Figure 4.2 show the front- and backside of the X7F202 module.

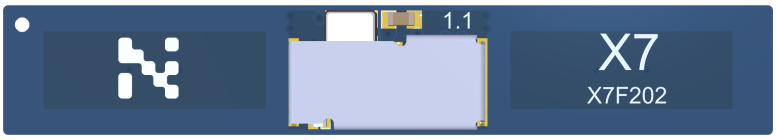

Figure 4.1. X7F202 Frontside

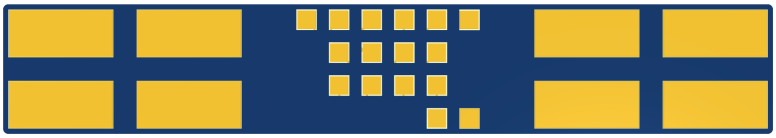

Figure 4.2. X7F202 Backside

4.1. Module Pinout

For physical pin placement see Figure 4.5.

Connector Pad	Signal Name	Typical Function
1A, 1B, 1C, 1D	GND	Ground
2	VDD	Supply Voltage
3	IO2/SPI SDIO0	SPI - PICO
4	IO5/SPI SDIO3	Not used
5	BM0	Boot Mode 0
6	IO10/LVDS_P	Not used
7	IO11/LVDS_N	IRQ - interrupt out
8A, 8B, 8C, 8D	GND	Ground
9	IO1/SPI CS0	SPI Chip Select
10	IO4/SPI SDIO2	Not used
11	BM1	Boot Mode 1
12	IO6/I2C SDA	I2C Data
13	IO0/SPI SCLK	SPI Clock
14	IO3/SPI SDIO1	SPI POCI
15	RESET_N	Reset, active low
16	IO7/I2C SCK	I2C CLock
17	GND	Ground
18	Prog	Do not connect

Table 4.1. Pinout

4.1.1. Unused Pins

Unused pins should be left unconnected.

4.1.2. Boot Mode Pin Configuration

BM1	BM0	Mode
0	0	Boot from external host using SPI.
0	1	Not supported
1	0	Boot from external host using I2C.
1	1	Not supported

Table 4.2. Bootmode Pin Configuration

Boot mode pins must be firmly pulled to either GND or VDD.

4.2. Typical Application Circuit

Figure 4.3 shows the X7F202 in typical application circuit.

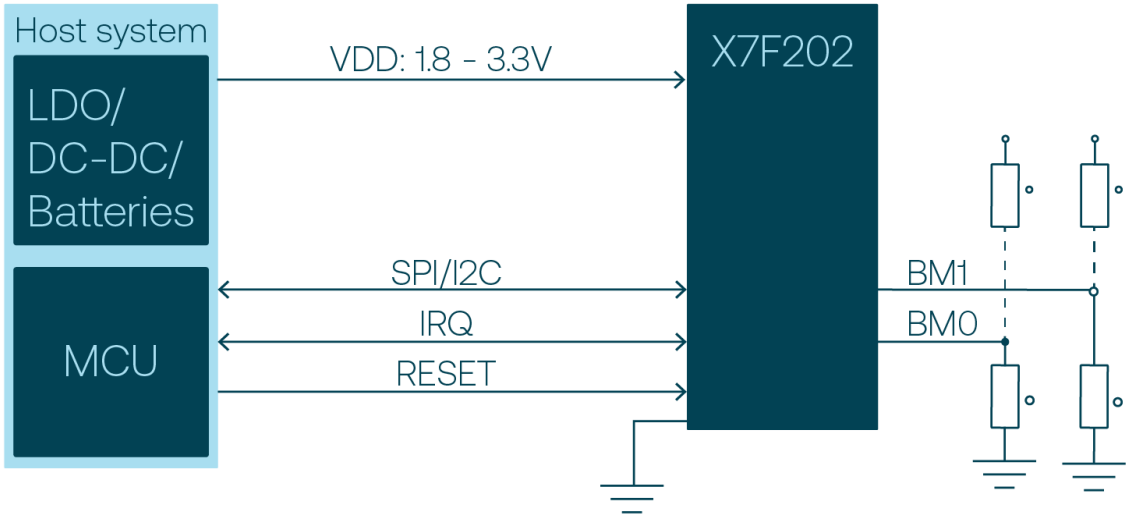

Figure 4.3. Application Circuit

4.3. Mechanical Specifications

The final version of the module will have RF shielding over the components. This will increase the total thickness of the module.

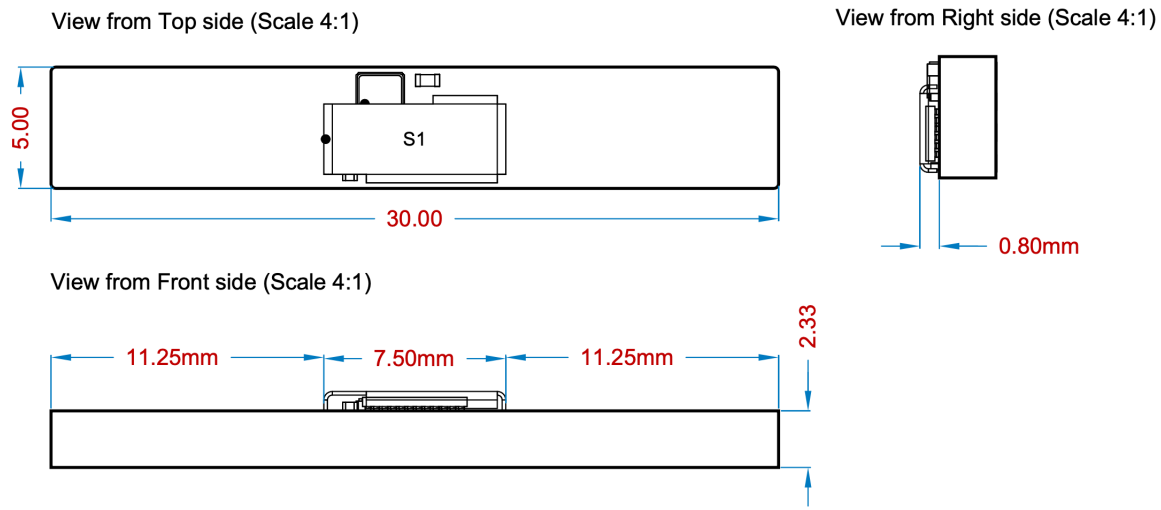

Figure 4.4. Physical Dimensions

4.4. Recommended Footprint

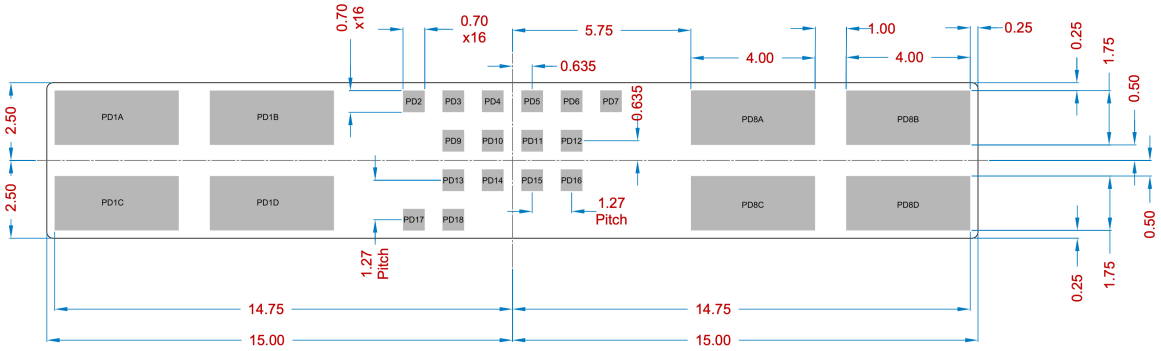

Figure 4.5. Recommended Land Pattern

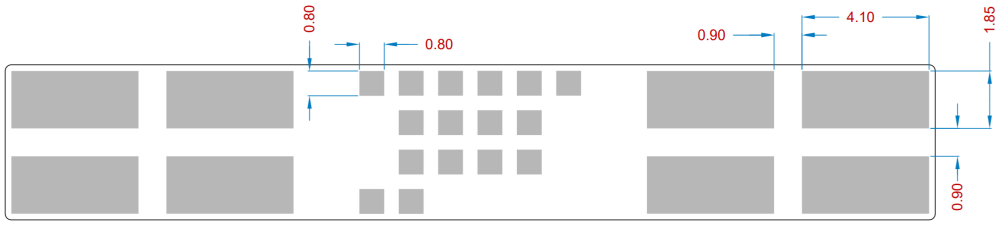

Figure 4.6. Recommended Soldermask

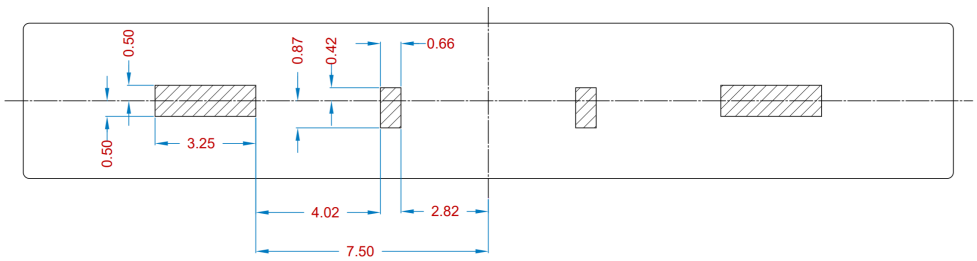

Figure 4.7. Copper Keep-Out Area

4.5. Layout

Guidelines:

- Red hatched areas are copper keep-out zones on the top PCB layer.
- The sensor can be placed directly on PCBs with solid ground planes, including aluminium PCBs.
- Signal routing underneath the sensor is allowed.
- Ground pads must be connected to a solid ground plane.

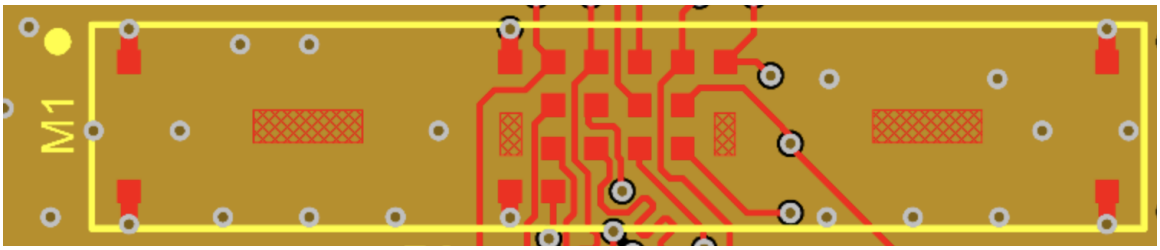

Figure 4.8. Layout Example

- Sensor outline in yellow.
- Ground plane on inner layer 1 in brown.
- Top copper (pads and traces) in red.

4.6. Light Sensitivity

The X7 IC is using Wafer-Level Chip Scale Packaging (WLCSP) which is sensitive to visible and near infrared light. Strong light sources such as direct sunlight and powerful incandescent lamps may lead to unintentional sensor operation. If the sensor is intended to be used in environments where it can be exposed to strong light, it should be properly covered by a non-transparent material. Typically, this will be ensured by the housing of the end product.

5. Antennas

The X7F202 contains two PCB antennas connected to each RF port on the X7 IC. RFIO0 is connected to the left antenna and RFIO1 is connected to the right antenna when looking into the top side of the module as shown in Figure 4.1.

The figures below show the simulated antenna patterns for the various combinations of transmitter and receiver ports.

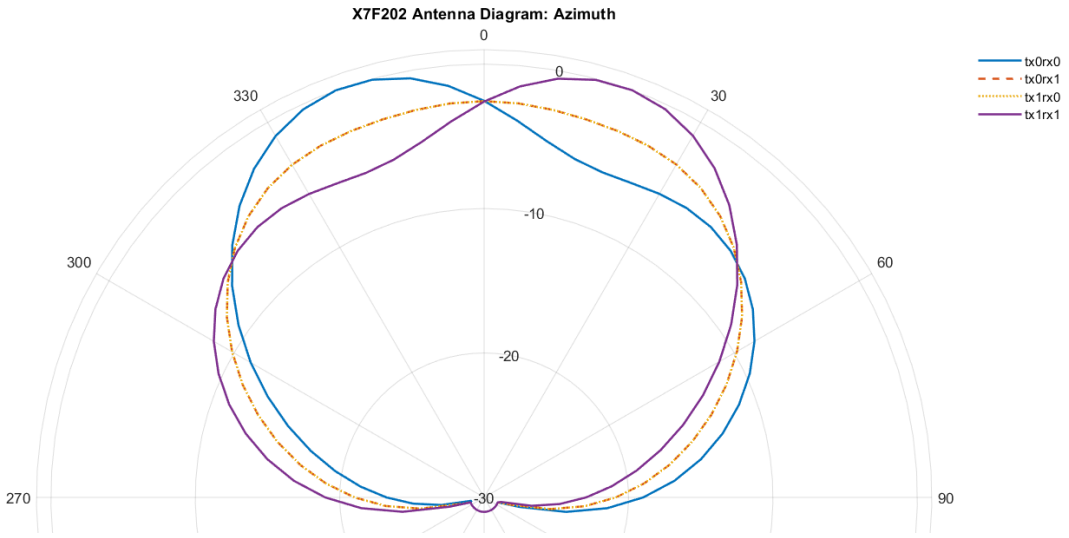

Figure 5.1. Antenna Pattern Azimuth

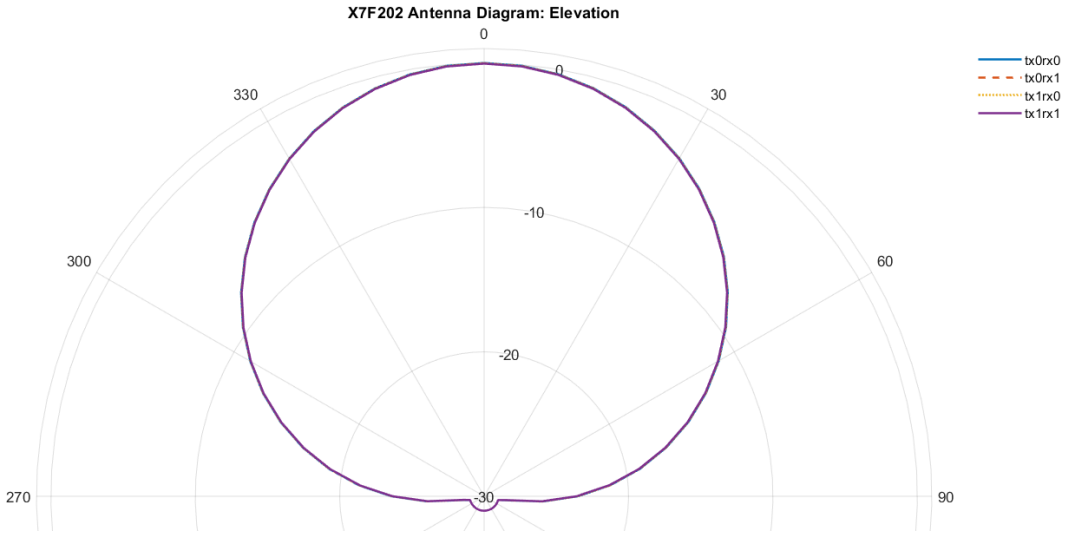

Figure 5.2. Antenna Pattern Elevation

6. Regulatory Compliance Notices

NOTE: Pending Regulatory Certification

The X7F202 module is currently not certified for regulatory compliance. All information in this section is pending official compliance testing.

This section outlines the various regulatory notices applicable for operation in certain regions.

6.1. United States (FCC) Regulatory Notices

6.1.1. UWB Device Notice

UWB devices may not be employed for the operation of toys. Operation onboard an aircraft, a ship or a satellite is prohibited.

6.1.2. Modification Statement

Changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

6.1.3. Interference Statement

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

1. This device may not cause harmful interference, and
2. This device must accept any interference, including interference that may cause undesired operation of the device.

6.1.4. RF Exposure

This device complies with the FCC RF exposure limits and has been evaluated in compliance with portable exposure condition.

There is no limitation as to which distance can be used from the human body.

6.1.5. 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.

6.1.6. Compliance of Host Devices

The module has been evaluated in portable stand-alone conditions. For different operational conditions from a stand-alone modular transmitter in a host (multiple, simultaneously transmitting modules or other transmitters in a host), additional testing may be required (collocation, retesting…).

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

product as being Part 15 Subpart B compliant (when it also contains unintentional-radiator digital circuity), then the grantee shall provide a notice stating that the final host product still requires Part 15 Subpart B compliance testing with the modular transmitter installed. The end product with an embedded module may also need to pass the FCC Part 15 unintentional emission testing requirements and be properly authorized per FCC Part 15.

6.1.7. Labelling Requirements for the Host Device

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

Contains FCC ID: TBD

6.2. Canada (ISED) Regulatory Notices

6.2.1. Modification Statement

Changes or modifications not expressly approved by the party responsible for compliance could void the user’s authority to operate the equipment.

Les changements ou modifications non expressément approuvés par la partie responsable de la conformité pourraient annuler l'autorisation de l'utilisateur d'utiliser l'équipement.

6.2.2. Interference Statement

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; and
2. This device must accept any interference, including interference that may cause undesired operation.

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.

6.2.3. RF Exposure

This device complies with the ISED RF exposure limits and has been evaluated in compliance with portable exposure condition.

There is no limitation as to which distance can be used from the human body.

Cet appareil est conforme aux limites d'exposition RF d'ISDE et a été évalué conformément aux conditions d'exposition portable.

Il n'y a aucune limitation quant à la distance qui peut être utilisée par rapport au corps humain.

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

Contains TBD

L’équipement hôte doit être correctement étiqueté pour identifier les modules dans l’équipement. L'étiquette de certification du module doit être clairement visible en tout temps lorsqu'il est installé dans l'hôte, l’équipement hôte doit être étiqueté pour afficher l'IC du module, précédé des mots "Contient le module émetteur", ou le mot "Contient", ou un libellé similaire exprimant la même signification, comme suit:

Contient TBD

6.2.5. CAN ICES-003(B)

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

Cet appareil numérique de Classe B est conforme à la norme NMB-003 du Canada.

7. Disclaimer

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8. Datasheet Status

Document status	Product status	Description
Advance Datasheet	Development	Applies to data sheet versions 0.x. This version of the data sheet contains target specifications for product development.
Preliminary Datasheet	Qualification	This version of the data sheet contains preliminary data. Supplementary and updated data may be published at a later time.
Product Datasheet	Production	This version of the data sheet contains final product specification. Novelda reserves the right to make changes at any time without notice as described in the Disclaimer.

Table 8.1. Datasheet status

Document History

Rev.	Release date	Change description
3.1 - Advance Information	2024-10-21	Updated boot mode pin description. Updated typical application circuit description. Updated pinout function table to reflect typical SW usage. Added I2C chapter.
3.0 - Advance Information	2024-05-03	Mechanical design updated to rev. 1.1.
2.0 - Advance Information	2024-02-09	Mechanical design updated to rev. 0.4. Added simulated antenna patterns.
0.1 - Advance Information	2023-08-25	First advance information release.