Getting started with the X-NUCLEO-S2915A1 Sub-1 GHz 915 MHz RF expansion board based on S2-LP radio for STM32 Nucleo

**Introduction**

The X-NUCLEO-S2915A1 expansion board is based on the S2-LP radio and operates in the 915 MHz ISM frequency band. The expansion board is compatible with ST morpho and Arduino UNO R3 connectors. The X-NUCLEO-S2915A1 interfaces with the STM32 Nucleo microcontroller via SPI connections and GPIO pins. You can change some of the GPIOs by mounting or removing the resistors.

![Figure 1. X-NUCLEO-S2915A1 expansion board](image-url)
## Acronyms and abbreviations

### Table 1. List of acronyms

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>AMR</td>
<td>Automatic meter reading</td>
</tr>
<tr>
<td>EEPROM</td>
<td>Electrically erasable programmable read only memory</td>
</tr>
<tr>
<td>GHz</td>
<td>Giga Hertz</td>
</tr>
<tr>
<td>GUI</td>
<td>Graphical user interface</td>
</tr>
<tr>
<td>LED</td>
<td>Light emitting diode</td>
</tr>
<tr>
<td>MCU</td>
<td>Microcontroller unit</td>
</tr>
<tr>
<td>P2P</td>
<td>Point-to-point communication</td>
</tr>
<tr>
<td>RF</td>
<td>Radio frequency communication</td>
</tr>
<tr>
<td>SPI</td>
<td>Serial peripheral interface</td>
</tr>
<tr>
<td>USB</td>
<td>Universal serial bus</td>
</tr>
<tr>
<td>wM-Bus</td>
<td>Wireless metering bus</td>
</tr>
<tr>
<td>WSN</td>
<td>Wireless sensors network</td>
</tr>
</tbody>
</table>
2 Getting started

2.1 Overview

The X-NUCLEO-S2915A1 main features are:

- Based on S2-LP radio
- S2-LP narrow band ultra-low power sub-1 GHz transceiver tuned for 860-940 MHz frequency band
- Programmable RF output power up to +27 dBm
- Modulation schemes: 2-FSK, 2-GFSK, 4-FSK, 4-GFSK, OOK and ASK
- Air data rate from 0.1 to 500 kbps
- Ultra-low power consumption: 7 mA RX and 10 mA TX at +10 dBm
- IEEE 802.15.4g hardware packet support with whitening, FEC, CRC and dual SYNC word detection
- RX and TX 128 byte FIFO buffers
- Support to wireless M-Bus
- Excellent performance of receiver sensitivity (up to -130 dBm)
- Automatic acknowledgement, retransmission and timeout protocol engine
- Compatible with STM32 Nucleo boards
- Compatible with Arduino UNO R3 connectors
- Sigfox compatible
- Sample firmware for P2P communication
- 6LoWPAN compatible thanks to STM32Cube
- FCC ID: S9NS2915A
- IC ID: 8976C-S2915A1
- RoHS and WEEE compliant

2.2 Typical applications

The X-NUCLEO-S2915A1 expansion board can be used for the evaluation of the S2-LP device in multiple applications:

- wM-Bus application
- Point-to-point communication protocol
- 6LoWPAN applications
- SigFox communication

You can develop other applications for evaluating the devices, such as:

- Automatic meter reading
- Home and building automation
- WSN
- Industrial monitoring and control
- Wireless fire and security alarm systems
2.3 Hardware and software requirements

To use STM32 Nucleo development boards with the X-NUCLEO-S2915A1 expansion board, connect the boards as shown below.

**Figure 2.** X-NUCLEO-S2915A1 expansion board connected to an STM32 Nucleo development board

The interconnection between the STM32 Nucleo and the X-NUCLEO-S2915A1 has been designed to allow using any STM32 Nucleo board, although complete testing has been performed using NUCLEO-L053R8, NUCLEO-F401RE and NUCLEO-L152RE boards hosting the ultra-low power STM32.

The following software and hardware specifications are required:

- a PC/laptop with Microsoft Windows (7 and above) to install the software package (X-CUBE-SUBG1)
- a type A USB to mini-B USB cable to connect the STM32 Nucleo board to the PC/laptop
- 128 MB of RAM
- Approximately 40 MB of hard disk space for the firmware
- Approximately 15 MB of hard disk space for the wM-Bus GUI

The use of the wM-Bus concentrator with the GUI requires additional boards to be connected to the PC. The GUI can be used to check the wM-Bus communication protocol.

2.4 Board setup

**Step 1.** Check that the jumper on JP1 connector is connected to provide the required voltage to the board devices.

**Step 2.** Connect the X-NUCLEO-S2915A1 to the STM32 Nucleo board.

**Step 3.** Power the Nucleo development board using the Mini-B USB cable.

**Step 4.** Program the firmware in the STM32 on the Nucleo development board using the firmware sample provided.

**Step 5.** Reset the MCU board using the reset button on the Nucleo development board.

The evaluation kit is ready-to-use.
3 Hardware description and configuration

3.1 Interconnection details

The X-NUCLEO-S2915A1 expansion board and the NUCLEO-F401RE or NUCLEO-L152RE board connection details are listed in the table below.

Table 2. X-NUCLEO-S2915A1 and NUCLEO-L152RE connection details (left connector)

<table>
<thead>
<tr>
<th>Signal name</th>
<th>NC</th>
<th>IOREF</th>
<th>RESET</th>
<th>3V3</th>
<th>5V</th>
<th>GND</th>
<th>GND</th>
<th>VIN</th>
<th>A0</th>
<th>A1</th>
<th>A2</th>
<th>A3</th>
<th>A4</th>
<th>A5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Connector name</td>
<td>CN6 Power</td>
<td>CN8 Analog</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pin number</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>7</td>
<td>8</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>NUCLEO-L152RE MCU port</td>
<td>PA0</td>
<td>PA1</td>
<td>PA4</td>
<td>PB0</td>
<td>PC1</td>
<td>PC0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>X-NUCLEO-S2915A1 expansion board signals</td>
<td>3V3</td>
<td>GND</td>
<td>GND</td>
<td>GPIO0</td>
<td>CSN</td>
<td>GPIO1</td>
<td>GPIO2</td>
<td>GPIO0(1)</td>
<td>GPIO3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1. Optional connection.

Table 3. X-NUCLEO-S2915A1 and NUCLEO-L152RE connection details (right connector)

<table>
<thead>
<tr>
<th>Signal name</th>
<th>D15</th>
<th>D14</th>
<th>AREF</th>
<th>GND</th>
<th>D13</th>
<th>D12</th>
<th>D11</th>
<th>D10</th>
<th>D9</th>
<th>D8</th>
<th>D7</th>
<th>D6</th>
<th>D5</th>
<th>D4</th>
<th>D3</th>
<th>D2</th>
<th>D1</th>
<th>D0</th>
</tr>
</thead>
<tbody>
<tr>
<td>Connector name</td>
<td>CN5 Digital</td>
<td>CN9 Digital</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pin number</td>
<td>10</td>
<td>9</td>
<td>8</td>
<td>7</td>
<td>6</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>8</td>
<td>7</td>
<td>6</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>NUCLEO-L152RE MCU port</td>
<td>PB8</td>
<td>PB9</td>
<td>PA5</td>
<td>PA6</td>
<td>PA7</td>
<td>PB6</td>
<td>PC7</td>
<td>PA9</td>
<td>PA8</td>
<td>PB10</td>
<td>PB4</td>
<td>PB5</td>
<td>PB3</td>
<td>PA10</td>
<td>PA2</td>
<td>PA3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>X-NUCLEO-S2915A1 expansion board signals</td>
<td>SCL</td>
<td>SDA</td>
<td>GND</td>
<td>SPI_CLK(1)</td>
<td>SPI_MISO</td>
<td>SPI_MOSI</td>
<td>SPI_CS(1)</td>
<td>nS(1)</td>
<td>SDN</td>
<td>SDN(1)</td>
<td>nS</td>
<td>SPI_CLK</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1. Optional connection.

3.2 SPI and GPIO connection options

The SPI and GPIO connection options between the STM32 Nucleo and S2-LP can be used to enable different configurations in case a signal conflict occurs when using other expansion boards.

Table 4. S2-LP interface with STM32 Nucleo board

<table>
<thead>
<tr>
<th>S2-LP signal</th>
<th>Default STM32 port</th>
<th>Optional STM32 port</th>
</tr>
</thead>
<tbody>
<tr>
<td>CSn</td>
<td>PA1</td>
<td>PB6</td>
</tr>
<tr>
<td></td>
<td>To use the optional connection, mount R9, unmount R13</td>
<td></td>
</tr>
</tbody>
</table>
To use the optional connections, modify the firmware on the basis of the STM32 resources used.

### Table 5. SKY66420 power amplifier settings

<table>
<thead>
<tr>
<th>SKY66420</th>
<th>SW1</th>
<th>SW2</th>
</tr>
</thead>
<tbody>
<tr>
<td>LNA ON (default)</td>
<td>100 pF capacitor between pin1 and pin2 (pin1 and pin3 open)</td>
<td>100 pF capacitor between pin1 and pin3 (pin1 and pin2 open)</td>
</tr>
<tr>
<td>LNA OFF</td>
<td>100 pF capacitor between pin1 and pin3 (pin1 and pin2 open)</td>
<td>100 pF capacitor between pin1 and pin2 (pin1 and pin3 open)</td>
</tr>
</tbody>
</table>

### Table 6. SKY66420 interface with STM32 Nucleo board

<table>
<thead>
<tr>
<th>SKY66420 signal</th>
<th>Default STM32 port</th>
<th>Optional STM32 port</th>
</tr>
</thead>
<tbody>
<tr>
<td>GPIO0</td>
<td>PA0</td>
<td>PC1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>To use optional connection mount R25, unmount R12</td>
</tr>
<tr>
<td>GPIO1</td>
<td>PA4</td>
<td>N.A.</td>
</tr>
<tr>
<td>GPIO2</td>
<td>PB0</td>
<td>N.A.</td>
</tr>
</tbody>
</table>

### 3.3 Current measurement

To monitor the X-NUCLEO-S2915A1 expansion board power consumption, use jumper J1: connect an ammeter probe between the connector pins 1 and 2 for measurements.

### 3.4 X-NUCLEO-S2915A1 component placement details

The figure below shows the component placement on the X-NUCLEO-S2915A1 expansion board.
Figure 3. X-NUCLEO-S2915A1 on-board device placement

1. Arduino UNO R3 left connector
2. Arduino UNO R3 right connector
3. S2-LP
4. SKY66420
4 X-NUCLEO-S2915A1 on-board device description

4.1 S2-LP radio

The X-NUCLEO-S2915A1 expansion board is based on the S2-LP standalone RF transceiver. It operates in the 915 MHz ISM frequency band and wireless M-Bus.

S2-LP narrow band ultra-low power sub-1 GHz transceiver is tuned for 430-470 MHz and 860 - 940 MHz, frequency bands and programmable RF output power up to +16 dBm.

<table>
<thead>
<tr>
<th>Features</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Order code</td>
<td>S2-LPQTR</td>
</tr>
<tr>
<td>Package</td>
<td>QFN24 4x4x1</td>
</tr>
<tr>
<td>Operating voltage</td>
<td>1.8 to 3.6 V</td>
</tr>
</tbody>
</table>

4.2 SPI EEPROM

The M95640-R is a 64 Kbit serial SPI bus EEPROM with high-speed clock interface. The device can be used to store the configuration parameters related to S2-LP RF device application or settings.

<table>
<thead>
<tr>
<th>Features</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Order code</td>
<td>M95640-RMC6TG</td>
</tr>
<tr>
<td>Package</td>
<td>MLP8</td>
</tr>
<tr>
<td>Operating voltage</td>
<td>1.8 to 5.5 V</td>
</tr>
</tbody>
</table>
Figure 4. X-NUCLEO-S2915A1 circuit schematic

LNA OFF: SW1 soldered a 100 pF cap between 1 - 2
LNA ON: SW1 soldered a 100 pF cap between 1 - 2
SW2 soldered a 100 pF cap between 1 - 3
SW2 soldered a 100 pF cap between 1 - 3
Figure 5. X-NUCLEO-S2915A1 circuit schematic - Arduino connectors

Figure 6. X-NUCLEO-S2915A1 circuit schematic - ST morpho connectors
## Table 8. X-NUCLEO-S2915A1 bill of materials

<table>
<thead>
<tr>
<th>Item</th>
<th>Qty</th>
<th>Ref.</th>
<th>Part/Value</th>
<th>Description</th>
<th>Manufacturer</th>
<th>Order code</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>CN5</td>
<td>CON10 550 V$_{AC}$ 2.54 mm pitch</td>
<td>Connector</td>
<td>SAMTEC</td>
<td>SSQ-110-03-F-S</td>
</tr>
<tr>
<td>2</td>
<td>2</td>
<td>CN6, CN9</td>
<td>CON8 550 V$_{AC}$ 2.54 mm pitch</td>
<td>Connectors</td>
<td>SAMTEC</td>
<td>SSQ-108-03-F-S</td>
</tr>
<tr>
<td>3</td>
<td>2</td>
<td>CN7, CN10</td>
<td>2.54 mm pitch</td>
<td>Header 19x2 (not mounted)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>1</td>
<td>CN8</td>
<td>CON 550 V$_{AC}$</td>
<td>Connector</td>
<td>SAMTEC</td>
<td>SSQ-106-03-F-S</td>
</tr>
<tr>
<td>5</td>
<td>9</td>
<td>C2, C5, C10, C11, C22, C30, C32, C36, C7</td>
<td>220 nF 16 V -20%, +80%. SMD-0402</td>
<td>Capacitors</td>
<td>Yageo</td>
<td>CC0402ZRY5V7BB224</td>
</tr>
<tr>
<td>6</td>
<td>12</td>
<td>C3, C4, C6, C8, C13, C24, C41, C46, C47, C51, C62, C17</td>
<td>100 pF 25 V ±5%. SMD-0402</td>
<td>VBAT bypass capacitors</td>
<td>KEMET</td>
<td>C0402C101J3GACTU</td>
</tr>
<tr>
<td>7</td>
<td>2</td>
<td>C9, C52</td>
<td>100 nF 16 V ±5%. SMD-0402</td>
<td>Decoupling capacitors</td>
<td>Murata</td>
<td>GRM155R71C104KA88D</td>
</tr>
<tr>
<td>8</td>
<td>1</td>
<td>C12</td>
<td>1 µF 25 V ±5%. SMD-0402</td>
<td>Capacitor</td>
<td>Taiyo Yuden</td>
<td>TMK105BJ105MV-F</td>
</tr>
<tr>
<td>9</td>
<td>6</td>
<td>C16, C33, C38, C42, C60, C61</td>
<td>SMD-0402</td>
<td>Capacitors (not mounted)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>7</td>
<td>R6, R7, R9, R17, R18, C18, R25</td>
<td>SMD-0402</td>
<td>Resistors (not mounted)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>1</td>
<td>C25</td>
<td>470 pF 50 V ±10%. SMD-0402</td>
<td>VREFVCO filter</td>
<td>Taiyo Yuden</td>
<td>UM105B7471KV</td>
</tr>
<tr>
<td>12</td>
<td>1</td>
<td>C31</td>
<td>2.2 pF 25 V ±5 % SMD-0402</td>
<td>Capacitors</td>
<td>Wurth Electronics</td>
<td>8.85012E+11</td>
</tr>
<tr>
<td>13</td>
<td>1</td>
<td>C34</td>
<td>3.3 pF 16 V ±5%. SMD-0402</td>
<td>Capacitors</td>
<td>Taiyo Yuden</td>
<td>EVK105CH3R3JW-F</td>
</tr>
<tr>
<td>14</td>
<td>1</td>
<td>C35</td>
<td>5.6 pF 16 V ±5%. SMD-0402</td>
<td>Capacitors</td>
<td>AVX</td>
<td>0402YA5R6JAT2A</td>
</tr>
<tr>
<td>15</td>
<td>1</td>
<td>C37</td>
<td>2.4 pF 25 V SMD-0402</td>
<td>Capacitors</td>
<td>AVX</td>
<td>MP023J2R4BBSGTR500</td>
</tr>
<tr>
<td>16</td>
<td>2</td>
<td>C39, C40</td>
<td>12 pF 16 V ±10%. SMD-0402</td>
<td>Capacitors</td>
<td>Vishay</td>
<td>VJ0402A120KXJCW1BC</td>
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<tr>
<td>17</td>
<td>1</td>
<td>C48</td>
<td>1.2 pF 16 V ±0.5%. SMD-0402</td>
<td>Capacitors</td>
<td>KEMET</td>
<td>C0402C129D4GACTU</td>
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<td>18</td>
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<td>C44</td>
<td>2.7 pF 16 V ±25%. SMD-0402</td>
<td>Capacitors</td>
<td>KEMET</td>
<td>C0402C279C4GACTU</td>
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<tr>
<td>19</td>
<td>4</td>
<td>C23, C43, C49, C50</td>
<td>1.5 pF 10 V ±5%. SMD-0402</td>
<td>Capacitors</td>
<td>Wurth Electronics</td>
<td>88501200502</td>
</tr>
<tr>
<td>20</td>
<td>1</td>
<td>C53</td>
<td>10 pF 16 V ±10%. SMD-0805</td>
<td>Capacitors</td>
<td>Samsung Electro-Mechanics</td>
<td>CL21A106KOQNNG</td>
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<tr>
<td>21</td>
<td>1</td>
<td>C54</td>
<td>10 pF 50 V ±5%. SMD-0402</td>
<td>Capacitors</td>
<td>Yageo</td>
<td>311-1014-1-ND</td>
</tr>
<tr>
<td>22</td>
<td>1</td>
<td>C55</td>
<td>33 pF 50 V ±5%. SMD-0402</td>
<td>Capacitors</td>
<td>Murata</td>
<td>GCM1555C1H330JA16D</td>
</tr>
<tr>
<td>Item</td>
<td>Qty</td>
<td>Ref.</td>
<td>Part/Value</td>
<td>Description</td>
<td>Manufacturer</td>
<td>Order code</td>
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<tr>
<td>23</td>
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<td>C56</td>
<td>1 nF 50 V ±10% SMD-0402</td>
<td>Capacitors</td>
<td>Murata</td>
<td>GCM155R71H102KA37D</td>
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<tr>
<td>24</td>
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<td>C57, C1</td>
<td>4.7 µF 10 V ±10% SMD-0402</td>
<td>Capacitors</td>
<td>Murata</td>
<td>ZRB15XR61A475KE01D</td>
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<tr>
<td>25</td>
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<td>C58</td>
<td>120 pF 50 V ±2% SMD-0402</td>
<td>Capacitors</td>
<td>Murata</td>
<td>GRM1555C1H121GA01D</td>
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<tr>
<td>26</td>
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<td>C59</td>
<td>10 nF 16 V ±10% SMD-0402</td>
<td>Capacitors</td>
<td>Taiyo Yuden</td>
<td>EMK105B7103KV-F</td>
</tr>
<tr>
<td>27</td>
<td>1</td>
<td>D1</td>
<td>20 mA SMD-0603</td>
<td>Red LED</td>
<td>OSRAM</td>
<td>LS Q976-NR-1</td>
</tr>
<tr>
<td>28</td>
<td>1</td>
<td>E1</td>
<td>AM11DG-ST01</td>
<td>SMD antenna (not mounted)</td>
<td>Mitsubishi</td>
<td>AM11DG-ST01B</td>
</tr>
<tr>
<td>29</td>
<td>1</td>
<td>JP1</td>
<td>WALCON.100/VH/T M2OE/W.325/10/ MOD</td>
<td>Jumper</td>
<td>Any</td>
<td>Any</td>
</tr>
<tr>
<td>30</td>
<td>1</td>
<td>J1</td>
<td>SMA antenna</td>
<td>LPRS</td>
<td>ANT-900M</td>
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<td>R2</td>
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<td>SW1, SW2</td>
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7 Formal notices required by the U.S. Federal Communications Commission ("FCC")

FCC NOTICE: This device complies with part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) This device may cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

Changes or modifications not expressly approved by the manufacturer could void the user’s authority to operate the equipment.

Additional warnings for FCC

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’s by one or more of the following measures:

• Reorient or relocate the receiving antenna.
• Increase the separation between the equipment and the 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.
8 Formal product notice required by the Industry Canada ("IC")

Innovation, Science and Economic Development Canada Compliance - This device complies with Innovation, Science and Economic Development RSS standards. 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 not expressly approved by the manufacturer could void the user's authority to operate the equipment.

Conformité à Innovation, Sciences et Développement Économique Canada - Cet appareil est conforme aux normes RSS d’Innovation, Science et Développement économique. L’utilisation est soumise aux deux conditions suivantes: (1) cet appareil ne doit pas causer d’interférences nuisibles, et (2) cet appareil doit accepter de recevoir tous les types d’interférence, y comprises les interférences susceptibles d’entraîner un fonctionnement indésirable. Les changements ou les modifications non expressément approuvés par le fabricant pourraient annuler le permis d’utiliser l’équipement.
Revison history

<table>
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<th>Date</th>
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