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NORA-W10 series

Standalone, multiradio modules with Wi-Fi 4 (802.11b/g/n) and Bluetooth Low Energy 5.0

System integration manual

Abstract

This manual provides a functional overview combined with best-practice design guidelines for integrating ANNA-B4 stand-alone Wi-Fi and Bluetooth Low Energy v5.0 modules in customer applications. Including a powerful microcontroller, MCU, NORA-W10 is intended for custom application software. The module has several important embedded security features, including secure boot, which ensures the module boots with authenticated software only.

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Objective Specification	Target values. Revised and supplementary data will be published later.
Advance Information	Data based on early testing. Revised and supplementary data will be published later.
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This document applies to the following products:

Product name	**Document status**
NORA-W101	Early product information
NORA-W106	Early product information

☞ For information about the related hardware, software, and status of listed product types, see also the data sheet [2].

Contents

1 Module overview

The NORA-W10 series comprises small, stand-alone, multiradio modules that integrate a powerful microcontroller, MCU, and a radio for wireless Bluetooth and Wi-Fi communication. With the open CPU architecture, customers can develop advanced applications running on the dual core 32-bit MCU. The radio provides support for Wi-Fi 802.11b/g/n in the 2.4 GHz ISM band and Bluetooth Low Energy (LE) v5.0 communications.

Supporting integrated cryptographic hardware accelerators, NORA-W10 series modules are ideal for Internet of Things (IoT) devices, telematics, low power sensors, connected factories, connected buildings (appliances and surveillance), point-of-sales, health devices, Artificial intelligence (AI), facial recognition, and other design solutions that demand top-grade security.

NORA-W10 modules are compliant with the Radio Equipment Directive (RED) and are to be certified as modular transmitters in the: Europe (RED), Great Britain (UKCA), US (FCC), Canada (IC / ISED RSS), Japan (MIC), Taiwan (NCC), South Korea (KCC), Australia / New Zealand (ACMA), Brazil (Anatel), and South Africa (ICASA). For the current approval status of certification in each country, see also Country approvals.

NORA-W10 series modules are professional grade products and support an extended temperature range of 40 °C to +85 °C.

1.1 Module architecture

Based on the Espressif ESP32-S3 chip, NORA-W10 modules allow developers to choose either an arbitrary external antenna with NORA-W101 or the internal antenna supported in NORA-W106 for their application design.

These compact modules include the MCU, flash memory, crystal, and other components for matching, filtering, antenna, decoupling, and antenna operation.

Two versions of NORA-W10 are available: NORA-W101 with antenna RF pad for the connection of an external antenna and NORA-W106 that supports an internal PCB trace antenna.

Variant / Ordering code	Antenna configuration	Antenna type
NORA-W101-00B	RF_ANT0: 2.4 GHz Wi-Fi and Bluetooth LE	Antenna pad
NORA-W106-00B	Switched 2.4 GHz Wi-Fi and Bluetooth LE	Single embedded PCB antenna

Table 1: Supported configurations of the NORA-W10 module series

1.1.1 Block diagram

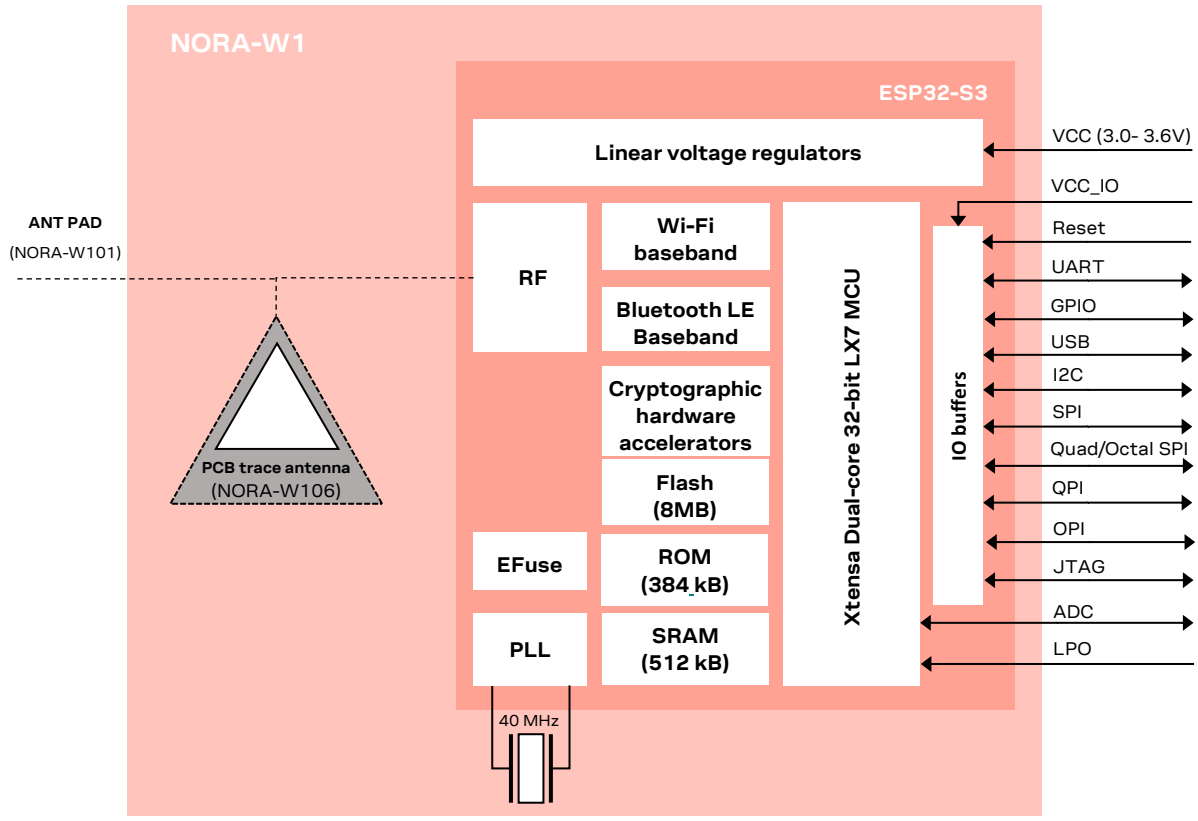


Figure 1: NORA-W10 series block diagram

1.2 Pin definition

1.2.1 General Purpose Input and Output, GPIO pins

NORA-W101/NORA-W106 modules have 82 pins. 38 pins can be used for either input or output. 4 pins are for input only.

1.3 Pin assignment

Figure 2 shows the multiplexed pinout for NORA-W101 and NORA-W106 Open CPU modules. These, and several additional interfaces not shown here, are described in

Although it is also possible to multiplex all interfaces through an IO MUX using any pin, the maximum speed is limited. See also “Digital pins” in the NORA-W10 data sheet [2].

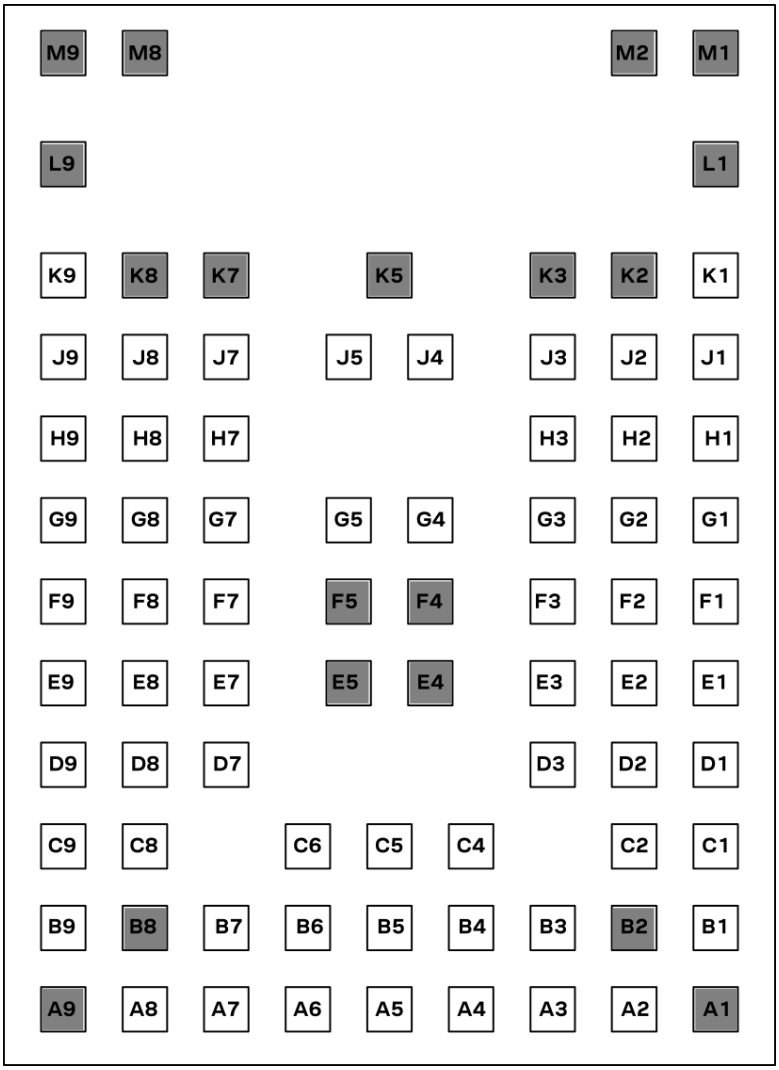


Figure 2: NORA-W101/W106 pin assignment (top view)

☞ All grey pins are GND.

☞ Pins A7, A8, B7, and J3 can only be used as (GPI) input signals – regardless of the selected function/interface.

☞ Several pins are used for bootstrap settings. It is important that these signals, shown in Table 2, have the correct state during startup. See also Boot strap pins.

1.4 Pin list

Table 2 describes the common pinout for all NORA-W10 series modules.

No.	NORA function	I/O[1]	Description	ESP32-S3 function	Remarks
A2	FSPIWP / GPIO38	I/O	SPI2 Write Protect / General Purpose I/O	FSPIWP / GPIO38	
A3	GPIO17	I/O	General Purpose I/O	GPIO17	Analog-capable pin
A4		NC			
A5	FSPIDQS / GPIO14	I/O		FSPIDQS / GPIO14	Analog-capable pin, Touch button input
A6	FSPIIO7 / GPIO13	I/O	SPI2 IO7 / General Purpose I/O	FSPIIO7 / GPIO13	Analog-capable pin, Touch button input
A7	VCCIO	I	Module I/O level voltage input		VIO voltage supply.
A8	VCC	I	Module supply voltage input		3.0-3.6 V module voltage supply.
B1	FSPICLK / GPIO36	I/O	SPI2 clock / General Purpose I/O	FSPICLK / GPIO36	
B3	FSPICS0 / GPIO34	I/O	SPI2 Chip select / General Purpose I/O	FSPICS0 / GPIO34	
B4	GPIO18	I/O	General Purpose I/O	GPIO18	Analog-capable pin
B5		NC			
B6	XTAL_32K_N /LPO_IN GPIO16	I/O	32KHz external clock input / Low Power Oscillator Input / General Purpose I/O	GPIO16	Analog-capable pin
B7	VCCIO	I	Module I/O level voltage input		VIO voltage supply.
B9		NC			
C1	FSPIQ / GPIO37	I/O	SPI2 Controller Input Peripheral Output / General Purpose I/O	FSPIQ / GPIO37	
C2	FSPID / GPIO35	I/O	SPI2 Controller Output Peripheral Input / General Purpose I/O	FSPID / GPIO35	
C4	SPICS0	I/O	SPI0 Chip select	SPICS0 / GPIO29	Connected to internal flash. Do not connect
C5		NC			
C6	XTAL_32K_P / GPIO15	I/O	32KHz external clock input / General Purpose I/O	GPIO15	Analog-capable pin. If external LPO is used at LPO_IN, put decoupling capacitor >2F to GND on this pin only.
C8	GPIO21	I/O	General Purpose I/O	GPIO21	
C9	USB_P / GPIO20	I/O	USB differential data signal / General Purpose I/O	USB_D+ / GPIO20	Analog-capable pin. Default drive capability of this pin is ~40mA
D1	SPIWP	I/O	SPI0 Write Protect	SPIWP / GPIO28	Connected to internal flash. Connect only for PSRAM else do not connect
D2	SPID	I/O	SPI0 Controller Output Peripheral Input	SPID / GPIO32	Connected to internal flash. Connect only for PSRAM else do not connect
D3	FSPIHD / GPIO33	I/O	SPI2 Hold / General Purpose I/O	FSPIHD / GPIO33	
D7		NC			
D8	GPIO4	I/O	General Purpose I/O	GPIO4	Analog-capable pin, Touch button input

[1] I/O notations: I=Input, O=Output, I/O=Input or Output, PU=Pull Up, PD=Pull Down, D=Default, PP=Push-Pull, OD=Open Drain, AI/AO=Analog Input/Output, NC=Not Connected

No.	NORA function	I/O[1]	Description	ESP32-S3 function	Remarks
D9	USB_N / GPIO19	I/O	USB differential data signal / General Purpose I/O	USB_D- / GPIO19	Analog-capable pin. Default drive capability of this pin is ~40mA
E1	SPICS1	I/O	SPI Chip select / General Purpose I/O	SPICS1 / GPIO26	PSRAM chip select.
E2	SPIQ	I/O	SPI0 Controller Input Peripheral Output	SPIQ / GPIO31	Connected to internal flash. Connect only for PSRAM else do not connect
E3	SPICLK_N / GPIO48	I/O	SPI Differential clock / General Purpose I/O	SPICLK_N / GPIO48	
E7	GPIO9	I/O	General Purpose I/O	GPIO9	Analog-capable pin, Touch button input
E8	GPIO1	I/O	General Purpose I/O	GPIO1	Analog-capable pin, Touch button input
E9	GPIO7	I/O	General Purpose I/O	GPIO7	Analog-capable pin, Touch button input
F1	SPICLK	I/O	SPI0 clock	SPICLK / GPIO30	Connected to internal flash. Connect only for PSRAM else do not connect
F2	SPIHD	I/O	SPI0 Hold	SPIHD / GPIO27	Connected to internal flash. Connect only for PSRAM else do not connect
F3	SPICLK_P / GPIO47	I/O	SPI Differential clock / General Purpose I/O	SPICLK_P / GPIO47	
F7	GPIO0/ Boot	I/O	General Purpose I/O	GPIO0/ Boot	
F8	GPIO45	I/O	General Purpose I/O	GPIO45	
F9	GPIO6	I/O	General Purpose I/O	GPIO6	Analog-capable pin, Touch button input
G1	MTDO / GPIO40	I/O	JTAG Test Data Out /	MTDO / GPIO40	
G2	FSPIIO6 / GPIO12	I/O	SPI2 IO6 / General Purpose I/O	FSPIIO6 / GPIO12	Analog-capable pin, Touch button input
G3	FSPIIO5 / GPIO11	I/O	SPI2 IO5 / General Purpose I/O	FSPIIO5 / GPIO11	Analog-capable pin, Touch button input
G4		NC			
G5		NC			
G7		NC			
G8	U0TXD / GPIO43	I/O	UART data output / General Purpose I/O	U0TXD / GPIO43	
G9	U0RXD / GPIO44	I/O	UART data input / General Purpose I/O	U0RXD / GPIO44	
H1	JTAG_TDI / GPIO41	I/O	JTAG Test Data In (debug interface) / General Purpose I/O	MTDI / GPIO41	
H2	JTAG_TMS / GPIO42	I/O	JTAG Test Mode Select / General Purpose I/O	MTMS / GPIO42	
H3	FSPII04 / GPIO10	I/O	SPI2 IO5 / General Purpose I/O	FSPII04 / GPIO10	Analog-capable pin, Touch button input
H7	GPIO46	I/O	General Purpose I/O	GPIO46	
H8	GPIO2	I/O	General Purpose I/O	GPIO2	Analog-capable pin, Touch button input
H9	GPIO8	I/O	General Purpose I/O	GPIO8	Analog-capable pin, Touch button input
J1	VDD_SPI	O	SPI power supply: 3.3 V	VDD_SPI	
J2	JTAG_TCK / GPIO39	I/O	JTAG Test clock / General Purpose I/O	MTCK / GPIO39	
J3	RESET_N	I	External system reset input.	RESET	Active low
J4		NC			

No.	NORA function	I/O[1]	Description	ESP32-S3 function	Remarks
J5		NC			
J7		NC			
J8	GPIO5	I/O	General Purpose I/O	GPIO5	Analog-capable pin, Touch button input
J9	GPIO3	I/O	General Purpose I/O	GPIO3	Analog-capable pin, Touch button input
K1		NC			
K9	ANT	I/O	Antenna Tx/Rx interface	LNA_IN	50 Ω nominal characteristic impedance, only used with NORA-W101 modules. NC for NORA-W106
	EGP	-	Exposed Ground Pins		Exposed scattered grey pins on the module should be connected to GND
L1-M9	EAGP	-	Exposed Antenna Ground Pins		Exposed pins underneath the antenna area should be connected to GND

Table 2: NORA-W10 pinout

2 Module integration

2.1 CPU

NORA-W10 series modules includes a Harvard Architecture Xtensa LX7 dual core CPU operating at an internal clock frequency of up to 240 MHz. The Open CPU architecture allows custom advanced applications running on the CPU.

The NORA-W10 architecture includes the following memories:

- 384 KByte ROM for booting and core functions
- 512 KByte SRAM for data and instruction
- 8 Mbyte FLASH for code storage, including hardware encryption to protect programs.
- 4 kbit EFUSE (non-erasable memory) for MAC addresses, module configuration, flash encryption, and chip ID

2.2 Power modes

NORA-W10 series modules are power efficient devices capable of operating in different power saving modes and configurations. Different sections of the module can be powered off when they are not needed, and complex wake up events can be generated from different external and internal inputs.

For more information about power modes, see the Espressif ESP32-S3 Datasheet [2].

2.2.1 Low Power mode with Low Frequency Clock

NORA-W10 series modules do not have an internal low power oscillator (LPO) or low frequency crystal (LFXTAL), which is required for low power modes. If low power mode is required, an external high precision, +/- 20 ppm, 32.768 kHz crystal must be connected between pins **XTAL_32K_N (Pin B6)** and **XTAL_32K_P (Pin C6)**.

On EVK-NORA-W10, the crystal is connected to **XTAL_32K_N (Pin B6)** and **XTAL_32K_P (Pin C6)** using a jumper configuration in order to use these as GPIOs when Low Power Mode is not in use, as shown in Figure 3.

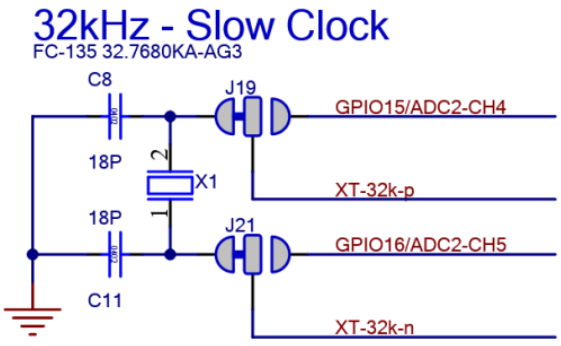


Figure 3: Low Frequency Clock

2.3 Power supply

The power for NORA-W10 series modules is supplied through **VCC** and **VCC_IO** pins by DC voltage.

⚠ The power supply circuit must be able to source the peak current of the power modes consuming highest power. Note that the current drawn from **VCC** and **VCC_IO** can vary significantly based on Wi-Fi power consumption profiles.

2.3.1 Module supply input (VCC)

NORA-W10 series modules use an integrated Linear Voltage converter to transform and stabilize the supply voltage applied to the **VCC** pin. Typical Input voltage at **VCC** and **VCC_IO** pins is 3.3V with an operating voltage range between 3.3 V and 3.6 V.

⚠ NORA-W10 must be supplied with a Class-1 PS1 (reg. IEC 62368-1) power supply.

2.3.2 Digital I/O interfaces reference voltage (VCC_IO)

NORA-W10 modules currently support 3.0–3.6 V IO voltage level only.

2.3.3 VCC application circuits

The power for NORA-W10 series modules is applied through the **VCC** pins. These supplies are taken from either of the following sources:

- Switching Mode Power Supply (SMPS)
- Low Drop Out (LDO) regulator

An SMPS is the ideal design choice when the available primary supply source is significantly higher than the operating supply voltage of the module. This offers the best power efficiency for the application design and minimizes the amount of current drawn from the main supply source.

⚠ When taking VCC supplies from an SMPS make sure that the AC ripple voltage is kept as low as possible at the switching frequency. Design layouts should focus on minimizing the impact of any high-frequency ringing.

Use an LDO linear regulator for primary VCC supplies that have a relatively low voltage. As LDO regulators dissipate power linearly related to the step-down voltage, LDOs are not recommended for step down of high voltages.

DC/DC efficiency should be regarded as a trade-off between the active and idle duty cycles of an application. Although some DC/DC devices achieve high efficiency at light loads, these efficiencies typically degrade as soon as the idle current drops below a few milliamps. This can have a negative impact on the life of the battery.

If decoupling capacitors are needed on the supply rails, it is best practice to position these as close as possible to the NORA-W10 series module. The power routing of some host system designs makes decoupling capacitance unnecessary.

For electrical specifications, see also the appropriate NORA-W10 series data sheet [2].

2.4 Module reset

NORA-W1 is reset (rebooted) by setting the **RESET_N** pin to low. **RESET_N** has an internal pull-up resistor setting its default state to high. The low-level input triggers a “hardware reset” of the module. The **RESET_N** signal should be driven by an open drain, open collector, or contact switch. The chip works at the minimum power when **RESET_N** is low (off).

2.5 Bootstrap pins

Several module pins related to the boot configuration must be strapped correctly using either pull-up or pull-down resistors, as shown in Table 3.

⚠ Boot strap pins should be avoided if other GPIO pins can be used instead. Note that all module pins shown in bold are configured to their default state internally in the ESP32-S3 chip and must NOT be configured externally.

Pin	ESP32-S3 GPIO	State during boot	Default	Behavior	Description
F7, H7	GPIO0, GPIO46	00		Download Boot	Booting mode
		01		Invalid, do not use	
		10	Pull-up*, Pull-down*	Normal Boot from internal Flash	
		11		Normal Boot from internal Flash	
J9	GPIO3	0	N/A	*EFUSE_DIS_USB_JTAG = 0,* *EFUSE_DIS_PAD_JTAG = 0,* *EFUSE_STRAP_JTAG_SEL=1* JTAG signal from on-chip JTAG pins	JTAG signal selection
		1		*EFUSE_DIS_USB_JTAG = 0,* *EFUSE_DIS_PAD_JTAG = 0,* *EFUSE_STRAP_JTAG_SEL=1* JTAG signal from USB Serial/JTAG controller	
		D/C		*EFUSE_DIS_USB_JTAG = 0,* *EFUSE_DIS_PAD_JTAG = 0,* *EFUSE_STRAP_JTAG_SEL=0* JTAG signal from USB Serial/JTAG controller	

*About 45 kΩ.

Table 3: NORA-W10 series boot strapping pins

Pin **F7** is used to enter the ESP bootloader. Consequently, this pin must be exposed on a pin header (or similar) to flash the module. To enter bootloader mode, hold down the Boot pin **F7** during the power on. To enter the programming mode, assert a reset in bootloader mode. See Figure 4.

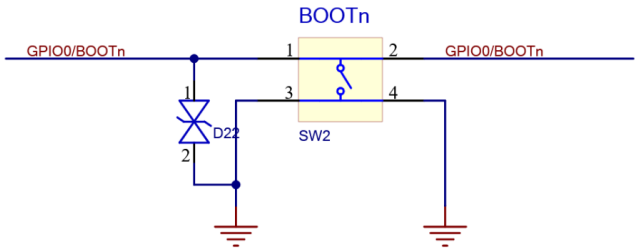


Figure 4: Button on Boot pin

2.6 Antenna integration

Antenna interfaces are different for each module variant in the NORA-W10 series. The modules support either an internal antenna (NORA-W106) or external antennas connected through a dedicated antenna pin (NORA-W101).

2.6.1 External RF antenna interface

NORA-W101 is equipped with an antenna signal (**ANT**) pin. The pin has a nominal characteristic impedance of 50 Ω and must be connected to the antenna through a 50 Ω transmission line.

Choose an antenna with optimal radiating characteristics for the best electrical performance and overall module functionality. An internal antenna, integrated on the application board or an external antenna connected to the application board through a proper 50 Ω connector, can be used.

When using an external antenna, the PCB-to-RF-cable transition must be implemented using either a suitable 50 Ω connector, or an RF-signal solder pad (including GND) that is optimized for 50 Ω characteristic impedance.

2.6.1.1 Antenna matching

The antenna return loss should be as low as possible across the entire band to provide optimal performance. The enclosure, shields, other components, and surrounding environment might impact the return loss that is seen at the antenna port. Matching components are often required to retune the antenna to 50 Ω characteristic impedance.

It is difficult to predict the actual matching values for the antenna in the final form factor. Therefore, it is good practice to have a placeholder in the circuit with a "pi" network, with two shunt components and a series component in the middle. This allows maximum flexibility while tuning the matching to the antenna feed.

2.6.1.2 Approved antenna designs

NORA-W10 modules come with a pre-certified design that can be used to save costs and time during the certification process. To take full advantage of this service, you must implement the antenna layout in accordance with u-blox reference designs. Reference designs are available on request from u-blox.

The designer integrating a u-blox reference design into an end-product is solely responsible for any unintentional RF emission generated by the end product.

The module may be integrated with other antennas. In which case, the OEM installer must certify the design with respective regulatory agencies.

2.6.2 Internal antenna

NORA-W106 module have an internal antenna that are specifically designed and optimized for u-blox Wi-Fi, Bluetooth Basic Rate/Enhanced Data Rate (BR/EDR), and Bluetooth LE modules. With NORA-W106, designers only need to consider the module placement and GND clearance in antenna area.

2.7 Data interfaces

2.7.1 Universal asynchronous serial interface (UART)

NORA-W10 modules have three UART interfaces, UART0 to UART2, for data communication and firmware upgrade. Each interface provides asynchronous communication support for RS232, RS485, and IrDA standards (with external drivers). Each UART supports the following signals:

- Data lines (**RXD** as input, **TXD** as output)
- Hardware flow control lines (**CTS** as input, **RTS** as output)

You can use the UARTs in 4-wire mode with hardware flow control, or in 2-wire mode with **TXD** and **RXD** only.

☞ 2-wire mode is not recommended, because it is prone to buffer overruns.

The **UART0** interface is used for firmware upgrade. See also Software.

It is recommended that the **UART0** is either connected to a header for firmware upgrade or made available for test points.

The IO level of the UART follows **VCC_IO**.

2.7.2 Serial peripheral interface (SPI)

Four SPI interfaces are available for the application. SPI0 is configured to internal flash storage, can be controlled with chip select CS0. Additional flash cannot be connected to SPI0 interface, but an external PSRAM can be connected. CS1 will become chip select for PSRAM.

It is possible to connect the remaining SPI interfaces to other pins via the IO MUX but the maximum speed will be reduced. It is also possible to configure the SPI interface as a dual or quad SPI (2 or 4-bit bidirectional data signals). See also Dual/Quad SPI. The module can be configured as both SPI master and slave.

⚠ External flash cannot be used for code execution.

2.7.3 Dual/Quad SPI

The dual/quad SPI (2 or 4 bi-bidirectional data signals) can be used for connecting an additional external PSRAM. The SPI to dual/quad SPI signal mappings is shown in Table 4.

SPI signal	Dual SPI signal	Quad SPI signal
MOSI	IO0	IO0
MISO	IO1	IO1
WP	-	IO2
HD	-	IO3
CS	CS	CS
CLK	CLK	CLK

Table 4: SPI to dual/quad SPI signal mapping

2.7.4 TWAI

NORA-W10 modules support the Two-Wire Automotive Interface TWAI) communication protocol, with inherited with message priorities and arbitration. It provides multi-master and multi-cast communication with error detection and signaling. The TWAI controller can operate at bit rates of 1 Kbit/s to 1 Mbit/s with 64-byte receive FIFO. It also supports CAN specification 2.0

2.8 Analog interfaces

2.8.1 Analog to digital converters

NORA-W10 modules support two 12-bit SAR Analog to Digital Converters (ADC). Any analog-capable pin can be used for ADC application. All appropriate analog pins are shown in the Pinout.

For lower power consumption, NORA-W101, NORA-W106 modules can measure voltages in sleep mode and threshold settings can be used to wake the CPU.

☞ Analog pins cannot be re-routed to other pins through the IO MUX.

2.9 No-connect pins (NC)

Do not connect the **NC** pin. No-Connect pins are allocated for future interfaces and functionality.

3 Design-in

Follow the design guidelines stated in this chapter to optimize the integration of NORA-W10 series modules in the final application board.

3.1 Overview

Although all application circuits must be properly designed, there are several points that require special attention during application design. A list of these points, in order of importance, follows:

- Module antenna connection: **ANT** Pad
  Antenna circuits affect the RF compliance of all applications that include the certification schemes related to the module. To maintain compliance and subsequent certification of the application design, it is important to observe the applicable parts of antenna schematic and layout design described in Antenna interface.
- Module supply: **VCC**, **VCC_IO**, and **GND** pins.
  Supply circuits can affect the RF performance. It is important to observe the schematic and layout design for these supplies. See also VCC application circuits. Modules normally include several supply pins described in the pin out of the NORA-W10 data sheet [2].
- High-speed interfaces: **UART** pins.
  High-speed interfaces are a potential source of radiated noise that can affect the regulatory compliance standards for radiated emissions. It is important to follow the schematic and layout design recommendations described in the General high-speed layout guidelines.
- System functions: **RESET_N**, GPIO and other System input and output pins
  Careful utilization of these pins in the application design is required to ensure correct boot up and system operation. Ensure that the voltage level is correctly defined during module boot. It is important to follow the schematic and layout design recommendations described in the General high-speed layout guidelines.
- Other pins: **ADC**, **CAN,** and NC pins.
  Careful utilization of these pins is required to guarantee proper functionality. It is important to follow the schematic and layout design recommendations described in the General high-speed layout guidelines.

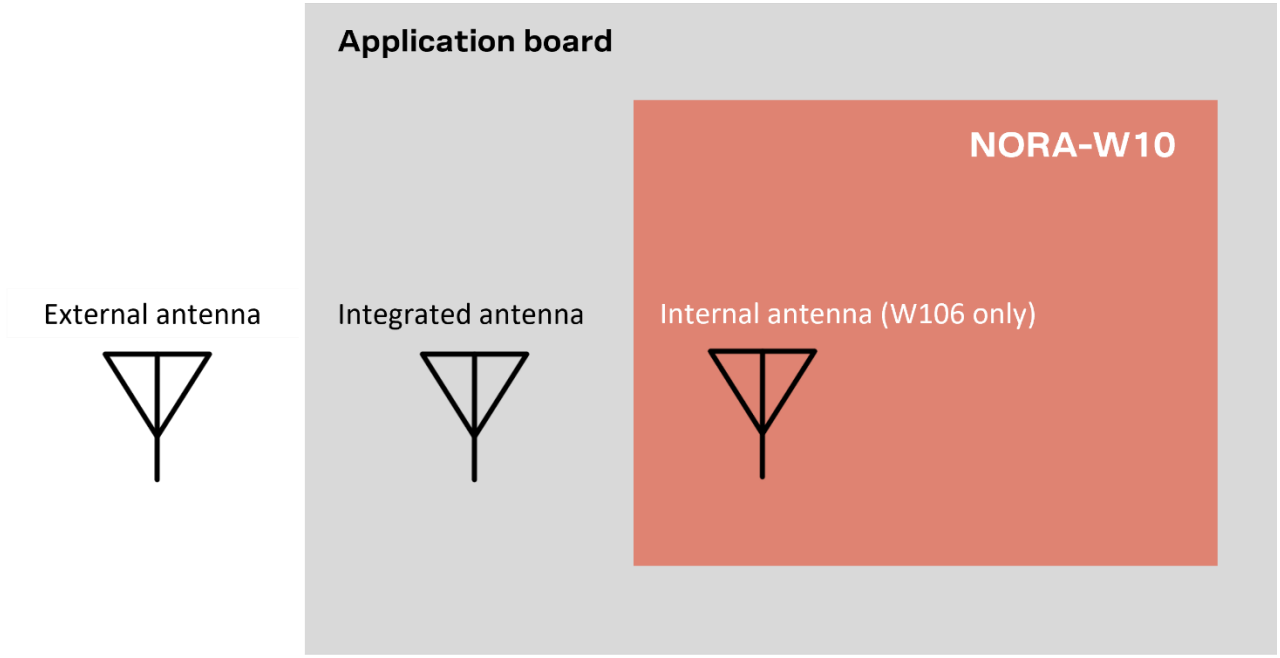
  UART_TX, UART_RXD and **SYS_BOOT** pins should be made accessible in order to flash regulatory compliance testing firmware.

3.2 Antenna interface

NORA-W10 modules support the following antenna types:

- Internal antenna included on the NORA-W106 module.
- Integrated antenna on the main application PCB. Typically, a patch antenna mounted on the main PCB or application housing, which is then connected to the NORA-W101 RF pin through a transmission line.
- External Antenna. Typically, a monopole antenna connected to the NORA-W101 RF pin through a coaxial cable and U.FL connector on the main PCB.

Figure 5 summarizes each of the available antenna options.



External antenna

An external antenna of choice connects to the application board through the RF antenna pin, U.FL, or Reverse Polarity SMA connector on the module. Typically, a dipole antenna is connected to the module RF pin through a coaxial cable and U.FL connector on the main PCB.

Integrated antenna

A permanent antenna included into the PCB application design. Ideally, patch antenna mounted on the main application PCB that connects to the module RF pin (or U.FL connectors) through the RF transmission lines.

Internal antenna

NORA-W106 uses and embedded trace antenna. For proper antenna performance the module must be placed on the main PCB, such that the edge containing the antenna is facing the main PCB edge.

Figure 5: Antenna options

Table 5 describes how the related pins shall be connected for each antenna solution

Table 5: ANNA-B4 antenna options

As NORA-W10 modules cannot be mounted arbitrarily, the placement should be chosen with consideration so that it does not interfere with radio communication. NORA-W106 modules include an internal PCB trace antenna that cannot be mounted in a metal enclosure. No metal casing or plastics using metal flakes should be used. Avoid metallic based paint or lacquer as well. NORA-W101 modules offer more freedom as an external antenna can be mounted further away from the module.

⚠ When integrating the u-blox reference design into an end-product, the application designer is solely responsible for any unintentional emission levels produced by the end-product.

⚠ According to the FCC regulations, the transmission line from the module's antenna pin to the antenna or antenna connector on the host PCB is considered part of the approved antenna design. Therefore, module integrators must either follow exactly one of the antenna reference designs used in the module's FCC type approval or certify their own designs.

3.2.1 RF transmission line design (NORA-W101)

RF transmission lines, such as the ones from the **ANT** pad up to the related antenna connector or up to the related internal antenna pad, must be designed so that the characteristic impedance is as close as possible to 50 Ω.

Design options and the most important parameters for implementing a transmission line on a PCB are described below:

- Microstrip: track separated with dielectric material and coupled to a single ground plane.
- Coplanar microstrip: track separated with dielectric material and coupled to both the ground plane and side conductor.
- Stripline: track separated by dielectric material and sandwiched between two parallel ground planes.

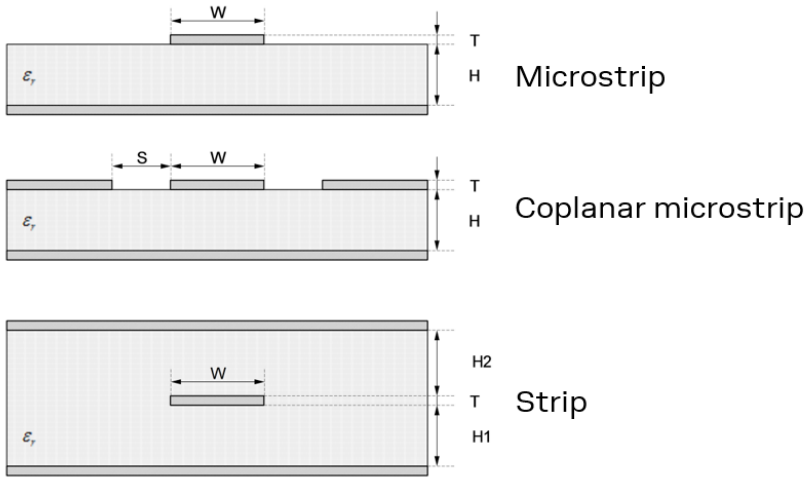


Figure 6: Transmission line trace design

Follow these recommendations to design a 50 Ω transmission line correctly:

- The designer should provide enough clearance from surrounding traces and ground in the same layer; in general, a trace to ground clearance of at least two times the trace width should be considered. The transmission line should also be “guarded” by ground plane area on each side.
- The characteristic impedance can be calculated as first iteration using tools provided by the layout software. It is advisable to ask the PCB manufacturer to provide the final values that are usually calculated using dedicated software and available stack-ups from production. It could also be possible to request an impedance coupon on panel’s side to measure the real impedance of the traces.
- FR-4 dielectric material, although its high losses at high frequencies can be considered in RF designs provided that:
  - RF trace length must be minimized to reduce dielectric losses.
  - If traces longer than few centimeters are needed, it is recommended to use a coaxial connector and cable to reduce losses
  - Stack-up should allow for thick 50 Ω traces and at least 200 µm trace width is recommended to assure good impedance control over the PCB manufacturing process.
  - FR-4 material exhibits poor thickness stability and thus less control of impedance over the trace length. Contact the PCB manufacturer for specific tolerance of controlled impedance traces.
- The transmission lines width and spacing to the GND must be uniform and routed as smoothly as possible: route RF lines in 45 °C angle or in arcs.

- Add GND stitching vias around transmission lines.
- Ensure solid metal connection of the adjacent metal layer on the PCB stack-up to main ground layer, providing enough vias on the adjacent metal layer.
- Route RF transmission lines far from any noise source (as switching supplies and digital lines) and from any sensitive circuit to avoid crosstalk between RF traces and Hi-impedance or analog signals.
- Avoid stubs on the transmission lines, any component on the transmission line should be placed with the connected pad over the trace. Also avoid any unnecessary component on RF traces.

3.2.2 Antenna design (NORA-W101)

NORA-W101 is suited for designs when an external antenna is needed due to mechanical integration or placement of the module.

Designers must take care of the antennas from all perspective at the beginning of the design phase when the physical dimensions of the application board are under analysis/decision, as the RF compliance of the device integrating NORA-W101 module with all the applicable required certification schemes heavily depends on the radiating performance of the antennas. The designer is encouraged to consider one of the u-blox suggested antenna part numbers and follow the layout requirements.

- External antennas such as linear monopole:
  - External antennas basically do not imply physical restriction to the design of the PCB where the module is mounted.
  - The radiation performance mainly depends on the antennas. It is required to select antennas with optimal radiating performance in the operating bands.
  - RF cables should carefully be selected with minimum insertion losses. Additional insertion loss will be introduced by low quality or long cable. Large insertion loss reduces radiation performance.
  - A high quality 50 Ω coaxial connector provides proper PCB-to-RF-cable transition.
- Integrated antennas such as patch-like antennas:
  - Internal integrated antennas imply physical restriction to the PCB design:
    Integrated antenna excites RF currents on its counterpoise, typically the PCB ground plane of the device that becomes part of the antenna; its dimension defines the minimum frequency that can be radiated. Therefore, the ground plane can be reduced to a minimum size that should be similar to the quarter of the wavelength of the minimum frequency that has to be radiated, given that the orientation of the ground plane related to the antenna element must be considered.
    The RF isolation between antennas in the system must be as high as possible and the correlation between the 3D radiation patterns of the two antennas has to be as low as possible. In general, an RF separation of at least a quarter wavelength between the two antennas is required to achieve a maximum isolation and low pattern correlation; increased separation should be considered, if possible, to maximize the performance and fulfil the requirements described in Table 6. As a numerical example, the physical restriction to the PCB design can be considered as shown below:
    Frequency = 2.4 GHz → Wavelength = 12.5 cm → Quarter wavelength = 3.125 cm[2]
  - Radiation performance depends on the whole product and antenna system design, including product mechanical design and usage. Antennas should be selected with optimal radiating performance in the operating bands according to the mechanical specifications of the PCB and the whole product.

[2] Wavelength referred to a signal propagating over the air.

Table 6 summarizes the requirements for the antenna RF interface:

Item	Requirements	Remarks
Impedance	50 Ω nominal characteristic impedance	The impedance of the antenna RF connection must match the 50 Ω impedance of the **ANT** pin.
Frequency Range	2400 - 2500 MHz	Wi-Fi and Bluetooth.
Return Loss	S_{11} < -10 dB (VSWR < 2:1) recommended S_{11} < -6 dB (VSWR < 3:1) acceptable	The Return loss or the S_{11}, as the VSWR, refers to the amount of reflected power, measuring how well the primary antenna RF connection matches the 50 Ω characteristic impedance of the **ANT** pin. The impedance of the antenna termination must match as much as possible the 50 Ω nominal impedance of the **ANT** pin over the operating frequency range, thus maximizing the amount of the power transferred to the antenna.
Efficiency	> -1.5 dB (> 70%) recommended > -3.0 dB (> 50%) acceptable	The radiation efficiency is the ratio of the radiated power to the power delivered to the antenna input; the efficiency is a measure of how well an antenna receives or transmits.
Maximum Gain	Refer to Data sheet	The maximum antenna gain must not exceed the value specified in type approval documentation to comply with the radiation exposure limits specified by regulatory agencies.

Table 6: Summary of antenna interface (ANT) requirements for NORA-W101

Observe the following recommendations while selecting external or internal antennas:

- Select antennas that provide optimal return loss or Voltage Standing Wave Ratio (VSWR) over all the operating frequencies.
- Select antennas that provide optimal efficiency over all operating frequencies.
- Select antennas with the appropriate gain and that provide the appropriate gain (antenna efficiency x directivity) characteristics so the electromagnetic field radiation intensity does not exceed the regulatory limits specified in some countries. For example, the limits defined by the FCC in the United States..

3.2.2.1 RF connector design

If an external antenna is required, the designer should consider using a proper RF connector. It is the responsibility of the designer to verify the compatibility between plugs and receptacles used in the design.

Table 7 suggests several RF connector plugs that can be used by the designers to connect RF coaxial cables based on the declaration of the respective manufacturers. The Hirose U.FL-R-SMT RF receptacles (or similar parts) require a suitable mated RF plug from the same connector series. Due to wide usage of this connector, several manufacturers offer compatible equivalents.

Manufacturer	Series	Remarks
Hirose	U.FL® Ultra Small Surface Mount Coaxial Connector	Recommended
I-PEX	MHF® Micro Coaxial Connector	
Tyco	UMCC® Ultra-Miniature Coax Connector	
Amphenol RF	AMC® Amphenol Micro Coaxial	

Table 7: U.FL compatible plug connector

Typically, the RF plug is available as a cable assembly. Different types of cable assembly are available; the user should select the cable assembly best suited to the application. The key characteristics are:

- RF plug type: select U.FL or equivalent
- Nominal impedance: 50 Ω
- Cable thickness: Typically, from 0.8 mm to 1.37 mm. Select thicker cables to minimize insertion loss.
- Cable length: Standard length is typically 100 mm or 200 mm; custom lengths may be available on request. Select shorter cables to minimize insertion loss.
- RF connector on the other side of the cable: For example, another U.FL. (for board-to-board connection) or SMA (for panel mounting)

Consider that SMT connectors are typically rated for a limited number of insertion cycles. Additionally, the RF coaxial cable may be relatively fragile compared to other types of cables. To increase application ruggedness, connect U.FL connector to a more robust connector such as SMA fixed on panel.

☞ A de-facto standard for SMA connectors implies the usage of reverse polarity connectors (RP-SMA) on Wi-Fi and Bluetooth® end products to increase the difficulty for the end user to replace the antenna with higher gain versions and exceed regulatory limits.

The following recommendations apply for proper layout of the connector:

- Strictly follow the connector manufacturer's recommended layout:
  - SMA Pin-Through-Hole connectors require GND keep-out (that is, clearance, a void area) on all the layers around the central pin up to annular pads of the four GND posts.
  - U.FL. surface mounted connectors require no conductive traces (that is, clearance, a void area) in the area below the connector between the GND land pads.

If the connector's RF pad size is wider than the micro strip, remove the GND layer beneath the RF connector to minimize the stray capacitance thus keeping the RF line 50 Ω. For example, the active pad of the U.FL. connector must have a GND keep-out (that is, clearance, a void area) at least on the first inner layer to reduce parasitic capacitance to ground.

3.2.2.2 Integrated antenna design

If integrated antennas are used, the transmission line is terminated by the integrated antennas themselves. Follow the guidelines mentioned below:

- The antenna design process should begin at the start of the whole product design process. Self-made PCBs and antenna assembly are useful in estimating overall efficiency and radiation path of the intended design.
- Use antennas designed by an antenna manufacturer providing the best possible return loss (or VSWR).
- Provide a ground plane large enough according to the related integrated antenna requirements. The ground plane of the application PCB may be reduced to a minimum size that must be similar to one quarter of wavelength of the minimum frequency that has to be radiated; however overall antenna efficiency may benefit from larger ground planes.
- Proper placement of the antenna and its surroundings is also critical for antenna performance. Avoid placing the antenna close to conductive or RF-absorbing parts such as metal objects, ferrite sheets and so on as they may absorb part of the radiated power or shift the resonant frequency of the antenna or affect the antenna radiation pattern.
- It is highly recommended to strictly follow the detailed and specific guidelines provided by the antenna manufacturer regarding correct installation and deployment of the antenna system, including PCB layout and matching circuitry.

- Further to the custom PCB and product restrictions, antennas may require tuning/matching to comply with all the applicable required certification schemes. It is recommended to consult the antenna manufacturer for the design-in guidelines and plan the validation activities on the final prototypes like tuning/matching and performance measures. See also Table 6.
- RF section may be affected by noise sources like hi-speed digital buses. Avoid placing the antenna close to buses such as DDR or consider taking specific countermeasures like metal shields or ferrite sheets to reduce the interference.

⚠ Take care of the interaction between co-located RF systems like LTE sidebands on 2.4 GHz band. Transmitted power may interact or disturb the performance of NORA-W10 modules.

3.2.3 On-board antenna design

If a plastic enclosure is used, it is possible to use NORA-W10 with the embedded antenna. To reach optimum operating performance, follow the instructions in this section.

3.2.3.1 NORA-W106 – PCB trace antenna

- The module shall be placed in the center of an edge of the host PCB.
  A large ground plane on the host PCB is a prerequisite for good antenna performance. It is recommended to have the ground plane extending at least 10 mm on the three non-edge sides of the module. See also Figure 7.
- The host PCB shall include a full GND plane underneath the entire module, with a ground cut out under the PCB trace antenna according to the description in Figure 8.
- The NORA-W106 has six extra GND pads under the antenna that need to be connected for a good antenna performance. Detailed measurements of the footprint including this extra GND pads can be found in the NORA-W10 series datasheet [2].
- High / large parts including metal shall not be placed closer than 10 mm to the module's antenna.
- At least 10 mm clearance between the antenna and the casing is recommended. If the clearance is less than 10 mm, the antenna performance can be adversely affected.
- The module shall be placed such that the antenna faces outwards from the product and is not obstructed by any external items in close vicinity of the products intended use case.

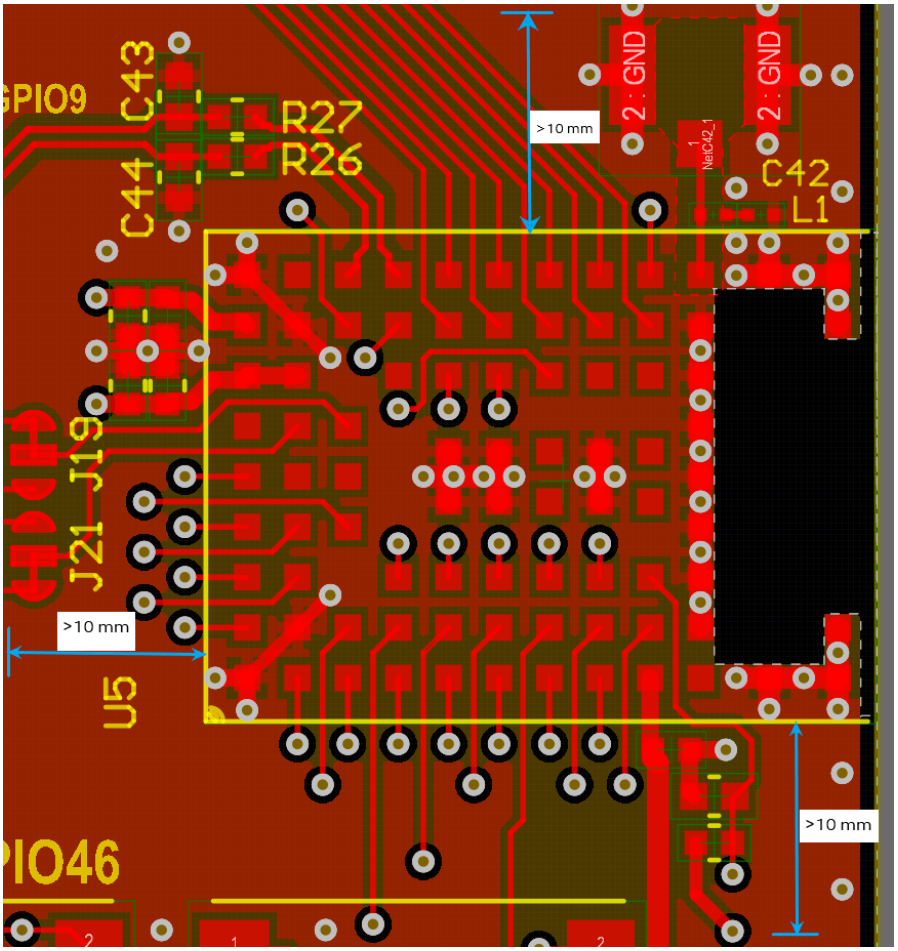


Figure 7: GND plane guard area enclosing NORA-W106

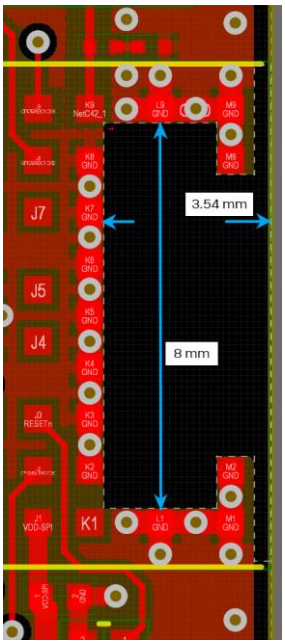


Figure 8: Size of the GND cut out for the NORA-W106 PCB trace antenna

3.3 Data communication interfaces

3.3.1 Asynchronous serial interface (UART) design

The layout of the UART bus should be done so that noise injection and cross talk are avoided. It is advisable to use the hardware flow control with RTS/CTS to prevent temporary UART buffer overrun.

The flow control signals **RTS/CTS** are active low. Consequently, 0 (ON state =low level) allows the UART to transmit.

- **CTS** is an input to the NORA-W10 module. If the host sets this input to 0 (ON state = low level) the module can transmit.
- **RTS** is an output off the NORA-W10 module. The module sets the output to 0 (ON state = low level) when it is ready to receive transmission.

3.4 General high-speed layout guidelines

These guidelines describe the best schematic and layout practices for integrating the module on a host PCB. Designers should prioritize the layout of higher speed busses. Low frequency signals, other than those with high-impedance traces, are generally not layout critical.

⚠ Low frequency signals with high-impedance traces (such as signals driven by weak pull resistors) may be affected by crosstalk. For these high-impedance traces, a supplementary isolation of 4*W from other busses is recommended.

3.4.1 Considerations for schematic design and PCB floor-planning

- Verify which signal bus requires termination and add series resistor terminations to the schematics.
- Carefully consider the placement of the module with respect to antenna position and host processor.
- Verify with PCB manufacturer allowable stack-ups and controlled impedance dimensioning.
- Verify that the power supply design and power sequence are compliant with the specification of NORA-W10 series module.

3.4.2 Component placement

- Accessory parts like bypass capacitors should be placed as close as possible to the module to improve filtering capability, prioritizing the placement of the smallest size capacitor close to module pads.
- Do not place components close to the antenna area. Follow the recommendations of the antenna manufacturer to determine distance of the antenna in relation to other parts of the system. Designers should also maximize the distance of the antenna to High-frequency busses, like DDRs and related components. Alternatively, consider an optional metal shield to reduce interference that might otherwise be picked up by the antenna and subsequently reduce module sensitivity.
- An optimized module placement allows better RF performance. For more information about the module placement and other antenna considerations, see also Antenna requirements.

3.4.3 Layout and manufacturing

- Avoid stubs on high-speed signals. Test points or component pads should be placed over the PCB trace.
- Verify the recommended maximum signal skew for differential pairs and length matching of buses.
- Minimize the routing length; longer traces degrade signal performance. Ensure that maximum allowable length for high-speed busses is not exceeded.

- Ensure to track your impedance matched traces. Consult early with your PCB manufacturer for proper stack-up definition.
- RF, analog, and digital sections should have dedicated and clearly separated areas on the board.
- No digital routing is allowed in the GND reference plane area of RF traces (ANT pins and Antenna).
- Designers are strongly recommended to avoid digital routing beneath all layers of RF traces.
- Ground cuts or separation are not allowed below the module.
- As a first priority, minimize the length of the RF traces. Then, minimize bus length to reduce potential EMI issues related to the radiation of digital busses.
- All traces (Including low speed or DC traces) must couple with a reference plane (GND or power). High-speed busses should be referenced to the ground plane. If designers need to change the ground reference, some capacitors should be added and an adequate number of GND vias must be added in the area of transition. This facilitates a low-impedance path between the two GND layers for the return current.
- Trace routing should maintain a distance that is greater than 3*W from the edge of the ground plane routing.
- Do not route power planes or traces in loops.
- Route the power traces through both the bypass capacitor and bulk capacitor before connecting to the module's pin.
- Power planes should maintain a safe distance from the edge of the PCB. The distance must be sufficient to route a ground ring around the PCB, and the ground ring must then be stitched to other layers through vias.

3.5 Module footprint and paste mask

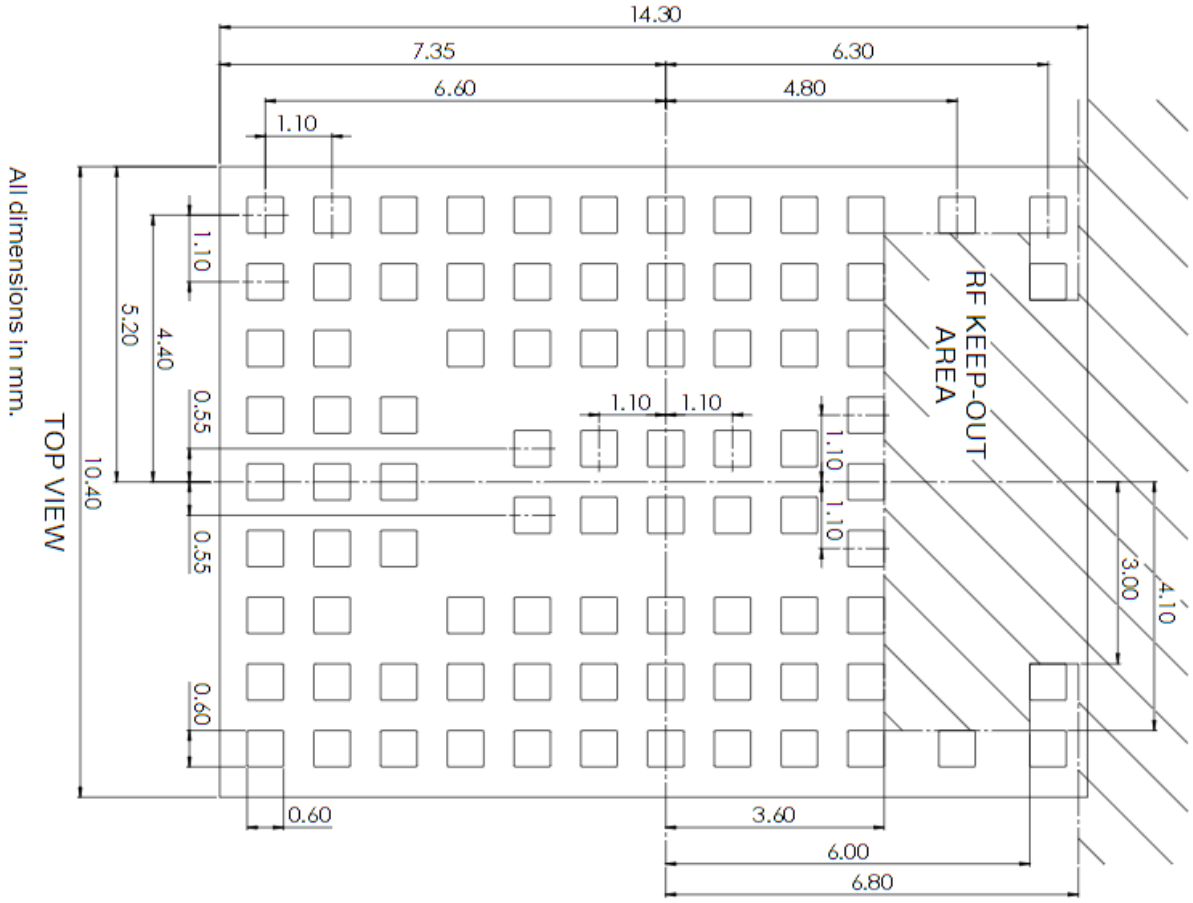


Figure 9: NORA-W10 mechanical outline

Figure 9 shows the pin layout of NORA-W10 series modules. The proposed land pattern layout complements the pin layout of the module. Both Solder Mask Defined (SMD) and Non Solder Mask Defined (NSMD) pins can be used with adherence to the following considerations:

- All pins should be Non-Solder Mask Defined (NSMD)
- To help with the dissipation of the heat generated by the module, GND pads must have good thermal bonding to PCB ground planes.

The suggested stencil layout for the NORA-W10 module should follow the copper pad layout, as shown in Figure 9.

3.6 Thermal guidelines

The NORA-W10 series modules have been successfully tested in -40 °C to +85 °C. A good grounding should be observed for temperature relief during high ambient temperature.

3.7 ESD guidelines

The immunity of devices integrating NORA-W10 modules to Electro-Static Discharge (ESD) is part of the Electro-Magnetic Compatibility (EMC) conformity, which is required for products bearing the CE marking, compliant with the R&TTE Directive (99/5/EC), the EMC Directive (89/336/EEC) and the Low Voltage Directive (73/23/EEC) issued by the Commission of the European Community.

Compliance with these directives implies conformity to the following European Norms for device ESD immunity: ESD testing standard *CENELEC EN 61000-4-2* and the radio equipment standards *ETSI EN 301 489-1*, *ETSI EN 301 489-7*, *ETSI EN 301 489-24*, the requirements of which are summarized in Table 8.

The ESD immunity test is performed at the enclosure port, defined by *ETSI EN 301 489-1* as the physical boundary through which the electromagnetic field radiates. If the device implements an integral antenna, the enclosure port is seen as all insulating and conductive surfaces housing the device. If the device implements a removable antenna, the antenna port can be separated from the enclosure port. The antenna port includes the antenna element and its interconnecting cable surfaces.

The applicability of ESD immunity test to the whole device depends on the device classification as defined by *ETSI EN 301 489-1*. Applicability of ESD immunity test to the related device ports or the related interconnecting cables to auxiliary equipment, depends on the device accessible interfaces and manufacturer requirements, as defined by the *ETSI EN 301 489-1*.

Contact discharges are performed at conductive surfaces, while air discharges are performed at insulating surfaces. Indirect contact discharges are performed on the measurement setup horizontal and vertical coupling planes as defined in the *CENELEC EN 61000-4-2*.

For the definition of integral antenna, removable antenna, antenna port, and device classification, refer to the *ETSI EN 301 489-1*. For the contact and air discharges definitions, refer to *CENELEC EN 61000-4-2*.

Parameter	Min.	Typical	Max.	Unit	Remarks
ESD immunity. All exposed surfaces of the radio equipment and ancillary equipment in a representative configuration			8	kV	Indirect discharge according to IEC 61000-4-2
ESD sensitivity, tested for all pins except ANT and RSVD pins #11, #15, #33			2.0	kV	Human body model according to JEDEC JS001

Table 8: Electro-Magnetic Compatibility ESD immunity requirements as defined by CENELEC EN 61000-4-2, ETSI EN 301 489-1, ETSI EN 301 489-7, ETSI EN 301 489-24

NORA-W10 is manufactured with consideration to the specific standards for minimizing the occurrence of ESD events. The highly automated process complies with the IEC61340-5-1 (STM5.2-1999 Class M1 devices) standard. Consequently, the designer should implement proper measures to protect from ESD events on any pin that may be exposed to the end user.

Compliance with standard protection level specified in the EN61000-4-2 can be achieved by including the ESD protections in parallel to the line, close to areas accessible by the end user.

3.8 Design-in checklists

3.8.1 Schematic checklist

- ☐ All module pins have been properly numbered and designated in the schematic (including thermal pins).
- ☐ Power supply design complies with the specification.
- ☐ The power sequence has been properly implemented.
- ☐ Adequate bypassing has been included in front of each power pin.
- ☐ Each signal group is consistent with its own power rail supply or proper signal translation has been provided.
- ☐ Configuration pins are properly set at bootstrap.
- ☐ SDIO bus includes series resistors and pull-ups, if needed.
- ☐ Unused pins are properly terminated.
- ☐ A pi-filter is provided in front of each antenna for final matching.
- ☐ Additional RF co-location filters have been considered in the design.

3.8.2 Layout checklist

- ☐ PCB stack-up and controlled impedance traces follow the recommendations given by the PCB manufacturer.
- ☐ All pins are properly connected, and the footprint follows u-blox pin design recommendations.
- ☐ Proper clearance has been provided between the RF and digital sections of the design.
- ☐ Proper isolation has been provided between antennas (RF co-location, diversity, or multi-antenna design).
- ☐ Bypass capacitors have been placed close to the module.
- ☐ Low impedance power path has been provided to the module.
- ☐ Controlled impedance traces have been properly implemented in the layout (both RF and digital) and the recommendations provided by the PCB manufacturer have been followed.
- ☐ 50 Ω RF traces and connectors follow the rules described in RF connector design.
- ☐ Antenna design has been reviewed by the antenna manufacturer.
- ☐ Proper grounding has been provided to the module for the low impedance return path and heat sink.
- ☐ Reference plane skipping has been minimized for high frequency busses.
- ☐ All traces and planes are routed inside the area defined by the main ground plane.
- ☐ u-blox has reviewed and approved the PCB[3].

[3] This is applicable only for end-products based on u-blox reference designs.

4 Software

4.1 SDK for Open CPU modules

As NORA-W10 Open CPU modules are delivered without flashed software, you develop your application design using the utilities and device-level APIs supported by the module chipset supplier. The ESP-IDF Software Development Kit [6] is available from the Espressif website. It bundles the Wi-Fi stack and the broad range of drivers and libraries necessary for building your development environment.

Figure 10 shows the architecture of NORA-W10 Open CPU software in relation to the MCU, transceiver and ESP-IDF SDK.

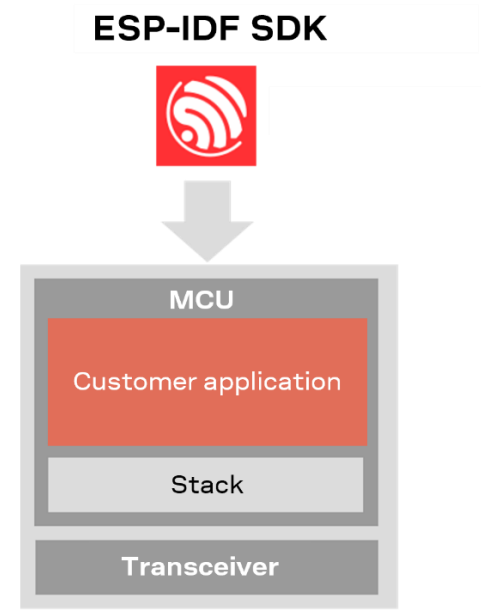


Figure 10: NORA-W10 open CPU software

4.2 Developing and flashing NORA-W10 Open CPU software

It is recommended to make following pins available through a header or similar connector:

- RESET_N
- U0TXD
- U0RXD
- GPIO0
- MTDO
- MTDI
- MTMS
- MTCK
- USB_D+
- USB_D-

For the Espressif SDK documentation, see also reference [7]. This URL provides information on how to set up the software environment using the hardware based on the Espressif ESP32-S3. This resource also describes how to use the latest ESP-IDF (Espressif IoT Development Framework) – which might have been changed since the publication of this document.

Use the following workflow setup to compile, flash, and execute a program on NORA-W10:

1. Set up Toolchain and ESP-IDF v4.4 source files Windows, Mac, and Linux are supported.
2. Get ESP-IDF. Download the GIT repository provided by Espressif
3. Setup path to ESP-IDF. The toolchain program can access the ESP-IDF using the `IDF_PATH` environment variable
4. Build and flash. Start a Project, Connect, Configure, Build and Flash a program.

See also the ESP-IDF Programming Guide [6].

4.2.1 Set up Toolchain and ESP-IDF v4.4 source files

☞ ESP-IDF v4.4+ is mandatory for NORA-W101 and NORA-W106.

Follow the appropriate toolchain instructions to use ESP-IDF v4.4 for your development environment:

- Windows
- Linux and macOS

After installing the appropriate toolchain, install ESP-IDF using the Get ESP-IDF instructions on the Espressif web site. The toolchain for the ESP-IDF uses the `IDF_PATH` environment variable, which must be set up to build the toolchain projects.

☞ The source files for Espressif ESP-IDF repository are located on github at: https://github.com/espressif/esp-idf.

4.2.2 Setup path to ESP-IDF

The Set up Toolchain and ESP-IDF v4.4 source files include the resources to install all the required tools. If you want to install the tools without the help of ESP-IDF Tools Installer, open the Command Prompt in Windows and use the following commands. The toolchain for the ESP-IDF uses the `IDF_PATH` environment variable. This variable must be set up for building the projects.

```
%userprofile%\esp\esp-idf\export.bat

cd %userprofile%\esp\esp-idf\install.bat esp32s3
```

4.2.3 Build and flash

The environment is now ready to build and flash a project. Use the following procedure to build a sample project. This project prints out “Hello World” ten times on the UART and then reboots.

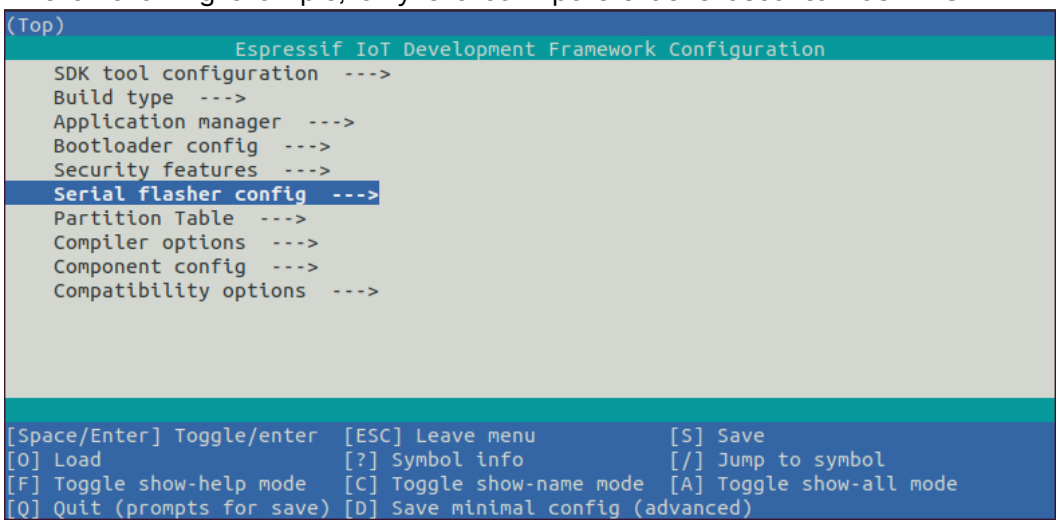
1. Build the sample project. Go to the “hello world” folder using the following command:

```
cd examples/get-started/hello_world
```

2. Plug in NORA-W10 to the PC and note down the com port number with which it is connected. In this example, the com port number is assumed to be “COM10”.
3. Enter “`idf.py menuconfig`” to open the ESP-IDF configuration window.
4. In the ESP-IDF configuration window, select and modify the configuration options to suit your environment.

```
idf.py set-target esp32s3
idf.py menuconfig
```

5. In the following example, only the com port that is used to flash NORA-W10 is modified.



6. Exit the configuration window by pressing "Q" and confirm save the configuration. Now the project is ready to build.
7. Before building and flashing, prepare NORA-W10 to accept the downloaded file. Hold the **GPIO0** low while resetting or powering on the board.
8. Use the following command to compile the application and all ESP-IDF components and generate the bootloader, partition table, and application binaries. After all files are compiled, the application is flashed to the port defined by "-p" and the series monitor starts.

```
Idf.py -p COM10 flash monitor
```

☞ The `idf.py` command can be used on different variations with different arguments. For the full options list, enter `idf.py --help`.

4.2.4 ESP-IDF partition table

NORA-W10 flash can contain multiple apps, as well as different kinds of data (calibration data, file systems, bootloader, OTA, and so on). To specify the module flash size as well as which data is allocated in a specific section of the flash, the partition table is used.

When running "menuconfig" under "Partition Table" or `CONFIG_PARTITION_TABLE_TYPE`, few predefined options are available when configuring the project.

For example, "Single factory app, no OTA":

```
# ESP-IDF Partition Table
# Name,   Type, SubType, Offset,  Size,         Flags
nvs,      data, nvs,     0x9000,  0x6000,
phy_init, data, phy,     0xf000,  0x1000,
factory,  app,  factory, 0x10000, 1M,
```

At a 0x10000 (64 KB) offset in the flash is the app labelled "factory". The bootloader runs this app by default.

There are also two data regions defined in the partition table for storing NVS library partition and PHY init data.

If the preconfigured options do not include the suitable configuration for the project a custom partition scheme can also be set, where addresses and data type are defined. See also "Creating Custom Tables" in the Espressif ESP-IDF Programming Guide [6].

4.2.5 Automatic bootloader on NORA-W10 EVK

The "`esptool.py`" flash tool supports automatic entry to the bootloader on the NORA-W10 EVK without pressing the BOOT button and RESET the module. To use this functionality, you need to connect the following pins:

- **RESET** to IO19 (**CTS**)
- **IO0** (IO zero) to IO26 (**DSR**)

The jumpers **CTS** (J14-8) and **DSR** (J14-7) should also be removed so that they do not interfere.

☞ It is not possible to use the Hardware Flow control or the **DSR** signals on the UART while using this setup.

More information about `esptool` is available at https://github.com/espressif/esptool

4.3 Output power configuration

4.3.1 NORA-W10 series

To operate within the regulatory output power limits, the integrator must configure the module using the instructions given in this section.

The following power configurations for Wi-Fi and Bluetooth low energy are only valid for the official `esp-idf` git repositories.

4.3.1.1 Wi-Fi output power configuration for version v4.4

The components required to perform the output power configuration and RF calibration are included (with examples) under the product subfolder in the u-blox SHO-OpenCPU GitHub repository [9].

4.3.1.2 Bluetooth low energy output power configuration

No output power configuration for Bluetooth low energy is required. Using the default settings, the module operates at ~6 dBm, which is within the regulatory limit for NORA-W10.

5 Handling and soldering

No natural rubbers, hygroscopic materials or materials containing asbestos are employed.

⚠ NORA-W10 series modules are Electrostatic Sensitive Devices that demand the observance of special handling precautions against static damage. Failure to observe these precautions can result in severe damage to the product.

5.1 ESD handling precautions

As the risk of electrostatic discharge in the RF transceivers and patch antennas of the module is of particular concern, standard ESD safety practices are prerequisite. See also Figure 11.

Consider also:

- When connecting test equipment or any other electronics to the module (as a standalone or PCB-mounted device), the first point of contact must always be to local GND.
- Before mounting an antenna patch, connect the device to ground.
- When handling the RF pin, do not touch any charged capacitors. Be especially careful when handling materials like patch antennas (~10 pF), coaxial cables (~50-80 pF/m), soldering irons, or any other materials that can develop charges.
- To prevent electrostatic discharge through the RF input, do not touch any exposed antenna area. If there is any risk of the exposed antenna being touched in an unprotected ESD work area, be sure to implement proper ESD protection measures in the design.
- When soldering RF connectors and patch antennas to the RF pin on the receiver, be sure to use an ESD-safe soldering iron (tip).

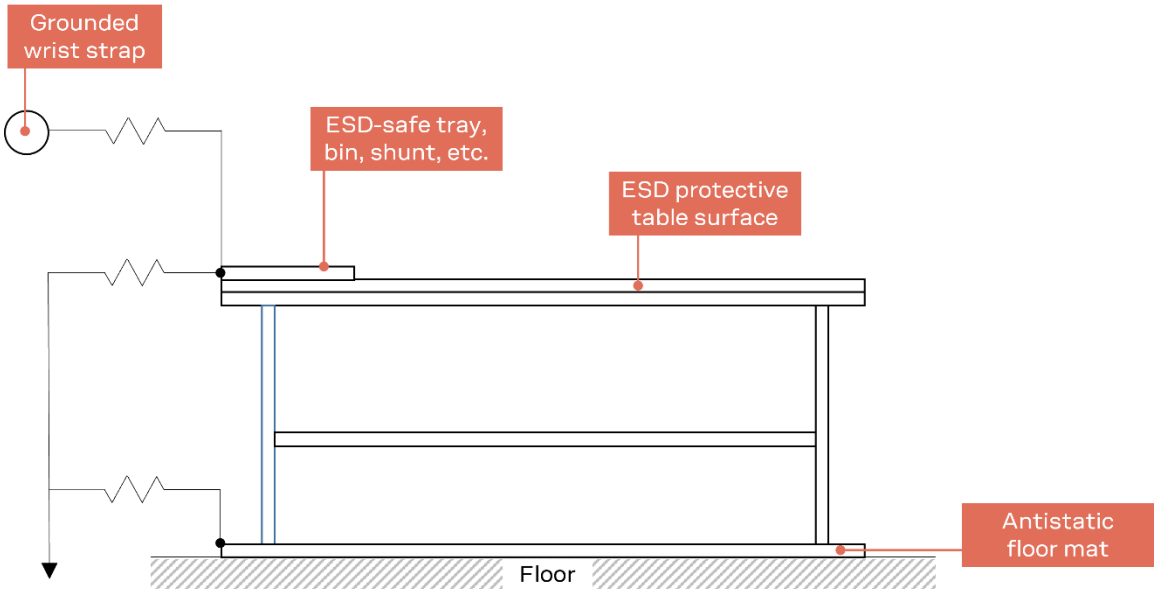


Figure 11: Standard workstation setup for safe handling of ESD-sensitive devices

5.2 Packaging, shipping, storage, and moisture preconditioning

For information pertaining to reels, tapes, or trays, moisture sensitivity levels (MSL), storage, shipment, and drying preconditioning, see the NORA-W10 series data sheet [2] and Packaging information guide [7].

5.3 Reflow soldering process

NORA-W10 series modules are surface mount modules supplied on a FR4-type PCB with gold plated connection pads and are produced in a lead-free process with a lead-free soldering paste. The thickness of solder resist between the host PCB top side and the bottom side of the NORA-W10 series module must be considered for the soldering process.

The module is compatible with industrial reflow profile for RoHS solders. Use of "No Clean" soldering paste is strongly recommended.

The reflow profile used is dependent on the thermal mass of the entire populated PCB, heat transfer efficiency of the oven, and particular type of solder paste used. The optimal soldering profile used has to be trimmed for each case depending on the specific process and PCB layout.

⚠ The target values given in Table 9 and Figure 12 are given as general guidelines for a Pb-free process only. For further information, see also the JEDEC J-STD-020E standard [8].

Process parameter		Unit	Value
Pre-heat	Ramp up rate to T_{SMIN}	K/s	3
	T_{SMIN}	°C	150
	T_{SMAX}	°C	200
	t_S (from +25 °C)	s	150
	t_S (Pre-heat)	s	60 to 120
Peak	T_L	°C	217
	t_L (time above T_L)	s	40 to 60
	T_P (absolute max)	°C	245
Cooling	Ramp-down from T_L	K/s	4
	Allowed soldering cycles	-	2

Table 9: Recommended reflow profile

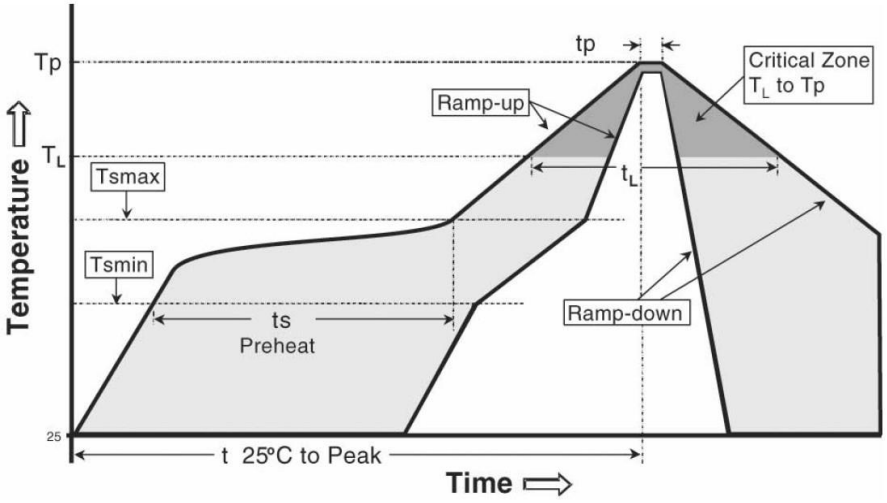


Figure 12: Reflow profile

Lower value of T_P and slower ramp down rate (2 – 3 °C/sec) is preferred.

5.3.1 Cleaning

Cleaning the modules is not recommended. Residues underneath the modules cannot be easily removed with a washing process.

- Cleaning with water will lead to capillary effects where water is absorbed in the gap between the baseboard and the module. The combination of residues of soldering flux and encapsulated water leads to short circuits or resistor-like interconnections between neighboring pads. Water will also damage the sticker and the ink-jet printed text.
- Cleaning with alcohol or other organic solvents can result in soldering flux residues flooding into the two housings areas that are not accessible for post-wash inspections. The solvent will also damage the sticker and the ink-jet printed text.
- Ultrasonic cleaning will permanently damage the module and crystal oscillators in particular.

For best results use a "no clean" soldering paste and circumvent the need for a cleaning stage after the soldering process.

5.3.2 Other remarks

- Two reflow soldering processes are allowed for boards with a module soldered on it.
- Boards with combined through-hole technology (THT) components and surface-mount technology (SMT) devices may require wave soldering to solder the THT components. Only a single, wave-soldering process is allowed for boards populated with the modules. Miniature Wave Selective Solder processes are preferred over traditional wave soldering processes.
- Hand soldering is not recommended.
- Rework is not recommended.
- Conformal coating may affect the performance of the module, it is important to prevent the liquid from flowing into the module. The RF shields do not provide protection for the module from coating liquids with low viscosity; therefore, care is required when applying the coating. Conformal coating of the module will void the warranty.
- Grounding metal covers: Attempts to improve grounding by soldering ground cables, wick, or other forms of metal strips directly onto the EMI covers is done at the customer's own risk and will void the module warranty. The numerous ground pins on the module are adequate to provide optimal immunity to interferences.
- The modules contain components that are sensitive to Ultrasonic Waves. Use of any ultrasonic processes, such as cleaning, welding, etc., may damage the module. The use of ultrasonic processes during the integration of the module into an end product will void the warranty.

6 Regulatory compliance

This chapter describes the current approval status of certification in each country and the regulatory requirements that must be met when using NORA-W10 modules in an end product.

6.1 General requirements

NORA-W10 series modules are designed to comply with the regulatory demands of Federal Communications Commission (FCC), Innovation, Science and Economic Development Canada (ISED)[4] and the CE mark[5]. This chapter contains instructions on the process needed for an integrator when including the NORA-W1 module into an end-product.

- Any deviation from the process described may cause the NORA-W10 series module not to comply with the regulatory authorizations of the module and thus void the user's authority to operate the equipment.
- Any changes to hardware, hosts or co-location configuration may require new radiated emission and SAR evaluation and/or testing.
- The regulatory compliance of NORA-W1 does not exempt the end-product from being evaluated against applicable regulatory demands; for example, FCC Part 15B criteria for unintentional radiators [15].
- The end-product manufacturer must follow all the engineering and operating guidelines as specified by the grantee (u-blox).
- The NORA-W1 is for OEM integrators only.
- Only authorized antenna(s) may be used, refer to Pre-approved antennas list. for the list of authorized antennas. In the end-product, the NORA-W1 module must be installed in such a way that only authorized antennas can be used.
- The end-product must use the specified antenna trace reference design, as described.
- Any notification to the end user about how to install or remove the integrated radio module is NOT allowed.

⚠ If these conditions cannot be met or any of the operating instructions are violated, the u-blox regulatory authorization will be considered invalid. Under these circumstances, the integrator is responsible to re-evaluate the end-product including the NORA-W10 series module and obtain their own regulatory authorization, or u-blox may be able to support updates of the u-blox regulatory authorization.

6.2 European Union regulatory compliance

⚠ Approvals are pending for NORA-W101 and NORA-W106.

For information about the regulatory compliance of NORA-W10 series modules against requirements and provisions in the European Union, see the NORA-W10 Declaration of Conformity [11].

6.2.1 Radio Equipment Directive (RED) 2014/53/EU

NORA-W10 series modules comply with the essential requirements and other relevant provisions of Radio Equipment Directive (RED) 2014/53/EU.

[4] Formerly known as IC (Industry Canada).
[5] All approvals are still pending

6.2.2 Compliance with the RoHS directive

NORA-W10 series modules comply with the Directive 2011/65/EU (EU RoHS 2) and its amendment Directive (EU) 2015/863 (EU RoHS 3).

6.3 Great Britain regulatory compliance

⚠ Approvals are pending for NORA-W101 and NORA-W106.

For information about the regulatory compliance of NORA-W10 series modules against requirements and provisions in Great Britain, see also the NORA-W10 UKCA Declaration of Conformity [12].

6.3.1 UK Conformity Assessed (UKCA)

☞ The United Kingdom is made up of the Great Britain (including England, Scotland, and Wales) and the Northern Ireland. Northern Ireland continues to accept the CE marking. The following notice is applicable to Great Britain only.

NORA-W10 series modules have been evaluated against the essential requirements of the Radio Equipment Regulations 2017 (SI 2017 No. 1206, as amended by SI 2019 No. 696).

Guidance about using the UKCA marking: https://www.gov.uk/guidance/using-the-ukca-marking

6.4 FCC/ISED End-product regulatory compliance

u-blox represents that the modular transmitter fulfills the FCC/ISED regulations when operating in authorized modes on any host product given that the integrator follows the instructions as described in this document. Accordingly, the host product manufacturer acknowledges that all host products referring to the FCC ID or ISED certification number of the modular transmitter and placed on the market by the host product manufacturer need to fulfil all of the requirements mentioned below. Non-compliance with these requirements may result in revocation of the FCC approval and removal of the host products from the market. These requirements correspond to questions featured in the FCC guidance for software security requirements for U-NII devices, FCC OET KDB 594280 D02 [14].

⚠ The modular transmitter approval of NORA-W1, or any other radio module, does not exempt the end product from being evaluated against applicable regulatory demands.

The evaluation of the end product shall be performed with the NORA-W1 module installed and operating in a way that reflects the intended end product use case.

The following requirements apply to all products that integrate a radio module:

- Subpart B - UNINTENTIONAL RADIATORS
  To verify that the composite device of host and module comply with the requirements of FCC part 15B, the integrator shall perform sufficient measurements using ANSI 63.4-2014.
- Subpart C - INTENTIONAL RADIATORS
  It is required that the integrator carries out sufficient verification measurements using ANSI 63.10-2013 to validate that the fundamental and out of band emissions of the transmitter part of the composite device complies with the requirements of FCC part 15C.

When the items listed above are fulfilled, the end product manufacturer can use the authorization procedures as mentioned in Table 1 of 47 CFR Part 15.101, before marketing the end product. This means the customer has to either market the end product under a Suppliers Declaration of Conformity (SDoC) or to certify the product using an accredited test lab.

The description is a subset of the information found in applicable publications of FCC Office of Engineering and Technology (OET) Knowledge Database (KDB). We recommend the integrator to read the complete document of the referenced OET KDB's.

- KDB 178919 D01 Permissive Change Policy
- KDB 447498 D01 General RF Exposure Guidance
- KDB 594280 D01 Configuration Control
- KDB 594280 D02 U-NII Device Security
- KDB 784748 D01 Labelling Part 15 18 Guidelines
- KDB 996369 D01 Module certification Guide
- KDB 996369 D02 Module Q&A
- KDB 996369 D04 Module Integration Guide

6.4.1 Referring to the u-blox FCC/ISED certification ID

If the General requirements, FCC/ISED End-product regulatory compliance and all Antenna requirements are met, the u-blox modular FCC/ISED regulatory authorization is valid and the end-product may refer to the u-blox FCC ID and ISED certification number. u-blox may be able to support updates to the u-blox regulatory authorization by adding new antennas to the u-blox authorization for example. See also Antenna requirements.

⚠ To use the u-blox FCC / ISED grant and refer to the u-blox FCC ID / ISED certification ID, the integrator must confirm with u-blox that all requirements associated with the Configuration control and software security of end-products are fulfilled.

6.4.2 Obtaining own FCC/ISED certification ID

Integrators who do not want to refer to the u-blox FCC/ISED certification ID, or who do not fulfil all requirements to do so may instead obtain their own certification. With their own certification, the integrator has full control of the grant to make changes.

Integrators who want to base their own certification on the u-blox certification can do so via a process called "Change in ID" (FCC) / "Multiple listing" (ISED). With this, the integrator becomes the grantee of a copy of the u-blox FCC/ISED certification. u-blox will support with an approval letter that shall be filed as a Cover Letter exhibit with the application.

☞ For modules where the FCC ID / ISED certification ID is printed on the label, the integrator must replace the module label with a new label containing the new FCC/ISED ID. For a description of the labeling requirements, see also the NORA-W10 series data sheet [13][2].

⚠ It is the responsibility of the integrator to comply with any upcoming regulatory requirements.

6.4.3 Configuration control and software security of end-products

☞ "Modular transmitter" hereafter refers to FCC ID XPYNORAW1W2.

As the end-product must comply with the requirements addressed by the OET KDB 594280 [13], the host product integrating the NORA-W1 must comply with the following requirements:

- Upon request from u-blox, the host product manufacturer will provide all of the necessary information and documentation to demonstrate how the requirements listed below are met.
- The host product manufacturer will not modify the modular transmitter hardware.

- The configuration of the modular transmitter when installed into the host product must be within the authorization of the modular transmitter at all times and cannot be changed to include unauthorized modes of operation through accessible interfaces of the host product. The Wi-Fi Tx output power limits approved by FCC grant must be followed. In particular, the modular transmitter installed in the host product will not have the capability to operate on the operating channels/frequencies referred to in the section(s) below, namely one or several of the following channels: 12 (2467 MHz), 13 (2472 MHz). The channels 12 (2467 MHz), 13 (2472 MHz), are allowed to be used only for modules that are certified for the usage ("modular transmitter"). Customers must verify that the module in use is certified as supporting DFS client/master functionality.
- The host product uses only authorized firmware images provided by u-blox and/or by the manufacturer of the RF chipset used inside the modular transmitter.
- The configuration of the modular transmitter must always follow the requirements specified in Operating frequencies and cannot be changed to include unauthorized modes of operation through accessible interfaces of the host product.
- The modular transmitter must when installed into the host product have a regional setting that is compliant with authorized US modes and the host product is protected from being modified by third parties to configure unauthorized modes of operation for the modular transmitter, including the country code.
- The host product into which the modular transmitter is installed does not provide any interface for the installer to enter configuration parameters into the end product that exceeds those authorized.
- The host product into which the modular transmitter is installed does not provide any interface to third parties to upload any unauthorized firmware images into the modular transmitter and prevents third parties from making unauthorized changes to all or parts of the modular transmitter device driver software and configuration.

☞ OET KDB 594280 D01 [13] lists the topics that must be addressed to ensure that the end-product specific host meets the Configuration Control requirements.

☞ OET KDB 594280 D02 [13] lists the topics that must be addressed to ensure that the end-product specific host meets the Software Security Requirements for U-NII Devices.

6.4.4 Operating frequencies

NORA-W1 802.11b/g/n operation outside the 2412–2462 MHz band is prohibited in the US and Canada. Configuration of the module to operate on channels 12–13 must be prevented accordingly. The channels allowed while operating under the definition of a master or client device[6] are described in Table 10.

Channel number	Channel center frequency [MHz]	Allowed channels	Remarks
1 – 11	2412 – 2462	Yes	
12 – 13	2467 – 2472	No	

Table 10: Allowed channel usage under FCC/ISED regulation

[6] 47 CFR §15.202

6.4.5 RF exposure statement

6.4.5.1 ISED compliance

All transmitters regulated by ISED must comply with the RF exposure requirements listed in RSS-102 - Radio Frequency (RF) Exposure Compliance of Radiocommunication Apparatus (All Frequency Bands). This module is approved for installation into mobile and/or portable host platforms and must not be co-located or operating in conjunction with any other antenna or transmitter except in accordance with Industry Canada's multi-transmitter guidelines.

To fulfil the requirements of the SAR evaluation Exemption limits defined in RSS-102 issue 5, must an OEM integrator implementing NORA-W10 WLAN capability into an end-product ensure a separation distance of at least 50 mm between the user (or bystander) and the antenna (or radiating element). For applications where the WLAN capability is turned off and only the Bluetooth LE capability of NORA-W10 is utilized the separation distance may be reduced to 35 mm.

6.4.5.2 FCC compliance

All transmitters regulated by FCC must comply with RF exposure requirements. KDB 447498 General RF Exposure Guidance provides guidance in determining whether proposed or existing transmitting facilities, operations or devices comply with limits for human exposure to Radio Frequency (RF) fields adopted by the Federal Communications Commission (FCC).

NORA-W10 modules are approved for installation into mobile and/or portable host platforms and must not be co-located or operating in conjunction with any other antenna or transmitter – except in accordance with FCC multi-transmitter guidelines.

To ensure that the max output power of NORA-W10 remains below the SAR Test Exclusion Threshold defined in KDB 447498 D01v06, must an OEM integrator implementing NORA-W10 WLAN capability into an end-product ensure a separation distance of at least 63 mm between the user (or bystander) and the antenna (or radiating element). For applications where the WLAN capability is turned off and only the Bluetooth LE capability of NORA-W10 is utilized the separation distance may be reduced to 34 mm.

6.4.6 End-product user manual instructions

6.4.6.1 ISED compliance

The NORA-W10 modules is certified for use in Canada under Innovation, Science and Economic Development Canada (ISED) Radio Standards Specification (RSS) RSS-247 Issue 2 and RSSGen. The host product shall be properly labelled to identify the modules within the host product.

☞ The final host device, into which this RF Module is integrated" has to be labeled with an auxiliary label stating the IC of the RF Module, such as" Contains transmitter module IC: 8595A-NORAW1W2

☞ Le périphériquehôte final, danslequelce module RF estintégré "doitêtreétiqueté avec uneétiquetteauxiliaireindiquant le CI du module RF, tel que" Contient le module émetteur IC: 8595A-NORAW1W2

☞ This device contains license-exempt transmitter(s)/receiver(s) that comply with Innovation, Science and Economic Development Canada's license-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 licencecontenudans le présentappareilestconforme aux CNR d'Innovation, Sciences et Développementéconomique Canada applicables aux appareils radio exempts de licence. L'exploitationestautorisée aux deux conditions suivantes:

(1) L' appareil ne doit pas produire de brouillage.

(2) L' appareildoit accepter tout brouillageradioélectriquesubi, mêmesi le brouillageest susceptible d' encompromettre le fonctionnement.

6.4.7 End-product labeling requirements

6.4.7.1 ISED Compliance

The host product shall be properly labelled to identify the modules within the host product.

The Innovation, Science and Economic Development Canada certification label of a module shall be clearly visible at all times when installed in the host product; otherwise, the host product must be labelled to display the Innovation, Science and Economic Development Canada certification number for the module, preceded by the word "contains" or similar wording expressing the same meaning, as shown in Figure 13.

Le produit hôte devra être correctement étiqueté, de façon à permettre l'identification des modules qui s'y trouvent.

L'étiquette d'homologation d'un module d'Innovation, Sciences et Développement économique Canada devra être posée sur le produit hôte à un endroit bien en vue, en tout temps. En l'absence d'étiquette, le produit hôte doit porter une 25ecessair sur laquelle figure le numéro d'homologation du module d'Innovation, Sciences et Développement économique Canada, précédé du mot « contient », ou d'une formulation similaire allant dans le même sens et qui va comme suit:

This device contains FCC ID: XPYNORAW1W2 IC: 8595A-NORAW1W2

Figure 13: Example of an end product label

6.4.7.2 FCC Compliance

For an end product that uses the NORA-W10 modules, there must be a label containing, at least, the information shown in Figure 13.
The label must be affixed on an exterior surface of the end product such that it will be visible upon inspection in compliance with the modular approval guidelines developed by the FCC.

☞ In accordance with 47 CFR § 15.19, the end product shall bear the following statement in a conspicuous location on the device:

"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."

The label must be affixed on an exterior surface of the end product such that it will be visible upon inspection in compliance with the modular approval guidelines developed by the FCC.

When the device is so small or for such use that it is not practicable to place the statement above on it, the information shall be placed in a prominent location in the instruction manual or pamphlet supplied to the user or, alternatively, shall be placed on the container in which the device is marketed.

In case, where the final product will be installed in locations where the end-user is not able to see the FCC ID and/or this statement, the FCC ID and the statement shall also be included in the end-product manual.

6.4.8 End-product compliance

6.4.8.1 Co-location (simultaneous transmission)

If the module is to be co-located with another transmitter, additional measurements for simultaneous transmission is required. The results must be added to the grant file as a Class II Permissive Change.

6.4.8.2 Adding a new antenna for authorization

If the authorized antennas and/or antenna trace design cannot be used, the new antenna and/or antenna trace designs must be added to the grant file. This is done by a Class I Permissive Change or a Class II Permissive Change, depending on the specific antenna and antenna trace design.

- Antennas of the same type and with less or same gain as an already approved antenna can be added under a Class I Permissive Change.
- Antenna trace designs deviating from the u-blox reference design and new antenna types are added under a Class II Permissive Change.

⚠ Integrators who want to refer to the u-blox FCC ID / IC certification ID should contact their local support team to discuss the Permissive Change Process. Class II Permissive Changes will be subject to NRE costs.

6.5 Japan radio equipment compliance

⚠ Approvals are pending for NORA-W101 and NORA-W106.

6.5.1 Compliance statement

NORA-W10 series modules comply with the Japanese Technical Regulation Conformity Certification of Specified Radio Equipment (ordinance of MPT N°. 37, 1981), Article 2, Paragraph 1:

Item 19 "2.4 GHz band wide band low power data communication system".

6.5.2 End product labelling requirement

End products based on NORA-W10 series modules and targeted for distribution in Japan must be affixed with a label with the “Giteki” marking, as shown in Figure 14. The marking must be visible for inspection.

Figure 14: Giteki mark R and NORA-W10 MIC certification number

6.5.3 End product user manual requirement

As the MIC ID is not included on the NORA-W10 marking, the end product manufacturer must include a copy of the NORA-W10 Japan Radio Certificate in the end product technical documentation.

6.6 NCC Taiwan compliance

⚠ Approvals are pending for NORA-W101 and NORA-W106.

6.6.1 Taiwan NCC Warning Statement

取得審驗證明之低功率射頻器材，非經核准，公司、商號或使用者均不得擅自變更頻率、加大功率或變更原設計之特性及功能。
低功率射頻器材之使用不得影響飛航安全及干擾合法通信；經發現有干擾現象時，應立即停用，並改善至無干擾時方得繼續使用。前述合法通信，指依電信管理法規定作業之無線電通信。低功率射頻器材須忍受合法通信或工業、科學及醫療用電波輻射性電機設備之干擾。應避免影響附近雷達系統之操作。
系統廠商應於平台上標示「本產品內含射頻模組：XXXyyyLPDzzzz-x」字樣

Statement translation:

- Without permission granted by the NCC, any company, enterprise, or user is not allowed to change frequency, enhance transmitting power, or alter original characteristic as well as performance to an approved low power radio-frequency device.
- The low power radio-frequency devices shall not influence aircraft security and interfere legal communications; If any interference is found or suspected, the user shall immediately cease operating the equipment until the interference has been prevented. The said legal communications means radio communications is operated in compliance with the Telecommunications Act. The low power radio-frequency devices must be susceptible with the interference from legal communications or ISM radio wave radiated devices.

6.6.2 Labeling requirements for end product

End products based on NORA-W1 series modules and targeted for distribution in Taiwan must carry labels with the textual and graphical elements shown below.

Contains Transmitter Module

內含發射器模組: **xxxxxxxyyyyyyy**

Other wording can be used, but only if the meaning of original messaging remains unchanged. The label must be physically attached to the product and made clearly visible for inspection.

6.7 KCC South Korea compliance

⚠ Approvals are pending for NORA-W101 and NORA-W106.

NORA-W10 series modules are certified by the Korea Communications Commission (KCC).

End products based on NORA-W10 series modules and targeted for distribution in South Korea must carry labels containing the KCC logo and certification number, as shown below. This information must also be included in the product user manuals.

x-x-xx-x

☞ The height of the KCC logo must be at least 5 mm.

6.8 Brazil compliance

⚠ Approvals are pending for NORA-W101 and NORA-W106.

End products based on NORA-W10 series modules and targeted for distribution in Brazil must carry labels that include the Anatel logo, NORA/W10 Homologation number: xxxxx-yy-zzzzz and a statement claiming that the device may not cause harmful interference but must accept it (Resolution No 506).

"Este equipamento opera em caráter secundário, isto é, não tem direito a proteção contra interferência prejudicial, mesmo de estações do mesmo tipo, e não pode causar interferência a sistemas operando em caráter primário."

Statement translation:

"This equipment operates on a secondary basis and, consequently, must accept harmful interference, including from stations of the same kind, and may not cause harmful interference to systems operating on a primary basis."

When the device is so small or for such use that it is not practicable to place the statement above on the label, the information shall be placed in a prominent location in the instruction manual or pamphlet supplied to the user or, alternatively, shall be placed on the container in which the device is marketed.

In cases where the final product is to be installed in locations where the end user is unable to see the Anatel logo, NORA-W10 Homologation number and/or statement, these graphical and textual elements must be included in the end product manual.

6.9 Australia and New Zealand regulatory compliance

⚠ Approvals are pending for NORA-W101 and NORA-W106.

The NORA-W10 modules are compliant with the standards made by the Australian Communications and Media Authority (ACMA).

The modules are compliant with AS/NZS 4268:2012 standard – Radio equipment and systems – Short range devices – Limits and methods of standard measurement. The test reports for NORA-W10 modules can be used as part of the product certification and compliance folder. For more information on the test reports, email the respective support team at the local mail address in your region. See Contact

For further support and contact information, visit us at www.u-blox.com/support.

To meet the overall Australian and/or New Zealand end product compliance standards, the integrator must create a compliance folder containing all the relevant compliance test reports such as RF, EMC, electrical safety and DoC (Declaration of Conformity). It is the responsibility of the integrator to know what is required in the compliance folder for ACMA compliance.

For more information on Australia compliance, refer to the Australian Communications and Media Authority web site http://www.acma.gov.au/.

For more information on New Zealand compliance, refer to the New Zealand Radio Spectrum Management Group web site www.rsm.govt.nz.

6.10 South Africa regulatory compliance

⚠ Approvals are pending for NORA-W101 and NORA-W106.

NORA-W10 series modules are compliant and certified by the Independent Communications Authority of South Africa (ICASA). End products that are made available for sale or lease or supplied in any other manner in South Africa shall have a legible label permanently affixed to its exterior surface. The label shall include the ICASA logo and the ICASA issued license number, as shown in the figure below. The minimum width and height of the ICASA logo shall be 3 mm. The approval labels must be purchased by the customer's local representative directly from the approval authority ICASA. A sample of a NORA-W10 ICASA label is shown below:

More information on registration as a Responsible Integrator and labeling requirements can be found at the Independent Communications Authority of South Africa (ICASA) web site: https://www.icasa.org.za

6.11 Bluetooth qualification

⚠ Approvals are pending for NORA-W101 and NORA-W106.

End products must be qualified and listed with the Bluetooth Special Interest Group (SIG).

Product declarations are submitted through the SIG Bluetooth Launch Studio website.

The NORA-W10 module series are qualified as a Controller Subsystem in accordance with the Bluetooth 5.1 specification and are registered with the SIG Qualified Design IDs (QDID) shown in Table 11.

To list your product that integrates NORA-W10 as an End product (with no additional testing required), combine the QDID for the Bluetooth stack implemented in the Host Subsystem with the QDID of the pre-qualified Controller Subsystem shown in Table 11.

Product type	QDID	Listing date
Controller Subsystem	198070	2022-11-14

Table 11: NORA-W10 series Bluetooth qualified design ID

7 Pre-approved antennas list

This chapter provides s an overview of the different external antennas that can be used together with the modules.

⚠ This radio transmitter IC: 8595A-NORAW1W2 has been approved by Innovation, Science and Economic Development Canada to operate 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: 8595A-NORAW1W2 été approuvé par Innovation, Sciences et Développement économique Canada pour fonctionner avec les types d'antenne énumérés ci-dessous avec le gain maximum autorisé et l'impédance ecessaire pour chaque type d'antenne indiqué. Les types d'antenne ne figurant pas dans cette liste et ayant un gain supérieur au gain maximum indiqué pour ce type-là sont strictement interdits d'utilisation avec cet appareil.

☞ Note that not all antennas are approved for use in all markets/regions.

7.1 Antenna accessories

Name	U.FL to SMA adapter cable	
Connector	U.FL and SMA jack (outer thread and pin receptacle)	
Impedance	50 Ω	
Minimum cable loss	0.5 dB, The cable loss must be above the minimum cable loss to meet the regulatory requirements. Minimum cable length 100 mm.	
Comment	The SMA connector can be mounted in a panel. See NORA-W1 Series system integration manual [2] for information how to integrate the U.FL connector.	
Approval	RED, UKCA, MIC, NCC, KCC, ANATEL, ACMA and ICASA	

Name	U.FL to Reverse Polarity SMA adapter cable	
Connector	U.FL and Reverse Polarity SMA jack (outer thread and pin)	
Impedance	50 Ω	
Minimum cable loss	0.5 dB. The cable loss must be above the minimum cable loss to meet the regulatory requirements. Minimum cable length 100 mm.	
Comment	The Reverse Polarity SMA connector can be mounted in a panel. See NORA-W1 Series system integration manual [2] for information about how to integrate the U.FL connector. This reference design must be followed to comply with the NORA-W1 FCC/IC modular approvals.	
Approval	FCC, IC, RED, UKCA, MIC, NCC, KCC, ANATEL, ACMA and ICASA	

7.2 Single band antennas

NORA-W106	
Manufacturer	Abracon
Gain	+3 dBi
Impedance	N/A
Size (HxWxL)	1.1 x 3.4 x 10 mm
Type	PCB trace
Comment	PCB antenna on NORA-W106. The antenna should not be mounted inside a metal enclosure.
Approval	FCC, IC, RED, UKCA, MIC, NCC, KCC, ANATEL, ACMA and ICASA

GW.26.0111	
Manufacturer	Taoglas
Polarization	Vertical
Gain	+2.0 dBi
Impedance	50 Ω
Size	Ø 7.9 x 30.0 mm
Type	Monopole
Connector	SMA (M) .
Comment	To be mounted with a U.FL to SMA adapter cable.
Approval	RED, UKCA, MIC, NCC, KCC, ANATEL, ACMA and ICASA

ANT-2.4-CW-RH-RPS	
Manufacturer	Linx
Polarization	Vertical
Gain	-1.0 dBi
Impedance	50 Ω
Size	Ø 7.4 x 27.0 mm
Type	Monopole
Connector	Reverse Polarity SMA plug (inner thread and pin receptacle).
Comment	To be mounted with a U.FL to SMA adapter cable. An SMA version antenna is also available but not recommended for use (ANT-2.4-CW-RH-SMA).
Approval	FCC, IC, RED, UKCA, MIC, NCC, KCC, ANATEL, ACMA and ICASA

Wi-Fi external antenna, PN PRO-EX-348	
Manufacturer	Abracon
Polarization	Vertical
Gain	+3.0 dBi
Impedance	50 Ω
Size	Ø 12.0 x 28.0 mm
Type	Monopole
Connector	Reverse Polarity SMA plug (inner thread and pin receptacle).
Comment	The antenna adapter cable UF.L part must be mounted on a metal ground plane for best performance. To be mounted with a U.FL to SMA adapter cable. SMA version antenna is also available but is not recommended for use (Ex-It 2400 28 SMA).
Approval	FCC, IC, RED, UKCA, MIC, NCC, KCC, ANATEL, ACMA, and ICASA

Wi-Fi / Bluetooth external antenna, PN PRO-EX-296	
Manufacturer	Abracon
Polarization	Vertical
Gain	+2.0 dBi
Impedance	50 Ω
Size	Ø 12.0 x 28.0 mm
Type	Monopole
Cable length	100 mm
Connector	U.FL. connector
Comment	This antenna requires to be mounted on a metal ground plane for best performance. To be mounted with a U.FL connector. For information on how to integrate the U.FL connector, see RF connector design. This reference design must be followed to comply with the NORA-W1 FCC/IC modular approvals.
Approval	FCC, IC, RED, UKCA, MIC, NCC, KCC, ANATEL, ACMA and ICASA

Wi-Fi / Bluetooth / Bluetooth LE external whip antenna, PN PRO-EX-333	
Manufacturer	Abracon
Polarization	Vertical
Gain	+3.0 dBi
Impedance	50 Ω
Size	Ø 10 x 83 mm
Type	Monopole
Connector	Reverse Polarity SMA plug (inner thread and pin receptacle)
Comment	To be mounted with a U.FL to Reverse Polarity SMA adapter cable. An SMA version antenna is also available but not recommended for use (PN PRO-EX-332).
Approval	FCC, IC, RED, UKCA, MIC, NCC, KCC, ANATEL, ACMA and ICASA

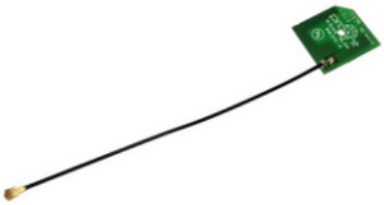
Wi-Fi / Bluetooth external whip antenna, PN PRO-EX-327	
Manufacturer	Abracon
Polarization	Vertical
Gain	+3.0 dBi
Impedance	50 Ω
Size	Ø 9.4 x 70.5 mm
Type	Monopole
Cable length	100 mm
Connector	U.FL. connector
Comment	To be mounted with a U.FL connector. For information on how to integrate the U.FL connector, see RF connector design. Ths reference design must be followed this reference design to comply with the NORA-W1 FCC/IC modular approvals.
Approval	FCC, IC, RED, UKCA, MIC, NCC, KCC, ANATEL, ACMA and ICASA

Wi-Fi / Bluetooth / Bluetooth LE board antenna, PN PRO-IS-237	
Manufacturer	Abracon
Gain	+3.0 dBi
Impedance	50 Ω
Size	27 x 12 mm (triangular)
Type	Patch
Cable length	100 mm
Connector	U.FL. connector
Comment	Should be attached to a plastic enclosure or part for best performance. To be mounted with a U.FL connector. For information on how to integrate the U.FL connector, see RF connector design. This reference design must be followed to comply with the NORA–W1 FCC/IC modular approvals.
Approval	FCC, IC, RED, UKCA, MIC, NCC, KCC, ANATEL, ACMA and ICASA

7.2.1 Dual-band antennas

Wi-Fi / Bluetooth / Bluetooth LE board antenna, PN PRO-IS-299	
Manufacturer	Abracon
Gain	+3.0 dBi
Impedance	50 Ω
Size	27 x 12 mm (triangular)
Type	Patch
Cable length	100 mm
Connector	U.FL. connector
Comment	Should be attached to a plastic enclosure or part for best performance. Dual-band (2.4 GHz / 5 GHz) antenna to be mounted with a U.FL connector. For information on how to integrate the U.FL connector, see RF connector design. This reference design must be followed to comply with the NORA–W1 FCC/IC modular approvals.
Approval	FCC, IC, RED, UKCA, MIC, NCC, KCC, ANATEL, ACMA and ICASA

Wi-Fi / Bluetooth / Bluetooth LE board antenna, PN PRO-IS-432	
Manufacturer	Abracon
Gain	+3.0 dBi
Impedance	50 Ω
Size	24x22x1 mm with mounting hole
Type	Patch
Cable length	100 mm
Connector	U.FL. connector
Comment	Should be attached to a plastic enclosure or part for best performance. Dual-band (2.4 GHz / 5 GHz) antenna to be mounted with a U.FL connector. For information on how to integrate the U.FL connector, see RF connector design. This reference design must be followed to comply with the NORA-W1 FCC/IC modular approvals.
Approval	FCC, IC, RED, UKCA, MIC, NCC, KCC, ANATEL, ACMA and ICASA



Wi-Fi / Bluetooth exernal whip antenna, PN PRO-EX-286	
Manufacturer	Abracon
Polarization	Vertical
Gain	+3 dBi
Impedance	50 Ω
Size	107 mm (Straight)
Type	Monopole
Connector	Reverse Polarity SMA plug (inner thread and pin receptacle)
Comment	To be mounted with a U.FL to Reverse Polarity SMA adapter cable.
Approval	FCC, IC, RED, UKCA, MIC, NCC, KCC, ANATEL, ACMA and ICASA

8 Product testing

8.1 u-blox in-line production test

As part of our focus on high quality products, u-blox maintain stringent quality controls throughout the production process. This means that all units in our manufacturing facilities are fully tested and that any identified defects are carefully analyzed to improve future production quality.

The Automatic test equipment (ATE) deployed in u-blox production lines logs all production and measurement data – from which a detailed test report for each unit can be generated.
Figure 15 shows the ATE typically used during u-blox production.

u-blox in-line production testing includes:

- Digital self-tests (firmware download, MAC address programming)
- Measurement of voltages and currents
- Functional tests (host interface communication)
- Digital I/O tests
- Measurement and calibration of RF characteristics in all supported bands, including RSSI calibration, frequency tuning of reference clock, calibration of transmitter power levels, etc.
- Verification of Wi-Fi and Bluetooth RF characteristics after calibration, like modulation accuracy, power levels, and spectrum, are checked to ensure that all characteristics are within tolerance when the calibration parameters are applied.

Figure 15: Automatic test equipment for module test

8.2 OEM manufacturer production test

As all u-blox products undergo thorough in-series production testing prior to delivery, OEM manufacturers do not need to repeat any firmware tests or measurements that might otherwise be necessary to confirm RF performance. Testing over analog and digital interfaces is also unnecessary during an OEM production test.

OEM manufacturer testing should ideally focus on:

- Module assembly on the device; it should be verified that:
  - Soldering and handling process did not damage the module components
  - All module pins are well soldered on device board
  - There are no short circuits between pins
- Component assembly on the device; it should be verified that:
  - Communication with host controller can be established
  - The interfaces between module and device are working
  - Overall RF performance test of the device including antenna

In addition to this testing, OEMs can also perform other dedicated tests to check the device. For example, the measurement of module current consumption in a specified operating state can identify a short circuit if the test result deviates from that taken against a "Golden Device".

The standard operational module firmware and test software on the host can be used to perform functional tests (communication with the host controller, check interfaces) and perform basic RF performance testing. Special manufacturing firmware can also be used to perform more advanced RF performance tests.

8.2.1 "Go/No go" tests for integrated devices

A "Go/No go" test compares the signal quality of the Device under Test (DUT) with that of "Golden Device" in a location with a known signal quality. This test can be performed after establishing a connection with an external device.

A very simple test can be performed by just scanning for a known Bluetooth low energy device and checking that the signal level (Received Signal Strength Indicator (RSSI) is acceptable.

☞ Tests of this kind may be useful as a "go/no go" test but are not appropriate for RF performance measurements.

Go/No go tests are suitable for checking communication between the host controller and the power supply. The tests can also confirm that all components on the DUT are well soldered.

A basic RF functional test of the device that includes the antenna can be performed with standard Bluetooth low energy devices configured as remote stations. In this scenario, the device containing NORA-W10 and the antennas should be arranged in a fixed position inside an RF shield box. The shielding prevents interference from other possible radio devices to ensure stable test results.

Appendix

A Glossary

Abbreviation	Definition
AEC	Automotive Electronics Council
AP	Access Point
API	Application Programming Interface
ATE	Automatic Test Equipment
CDM	Charged Device Model
CE	European Conformity
CTS	Clear to Send
D/C	Don't Care
DC	Direct Current
DDR	Double Data Rate
DFS	Dynamic Frequency Selection
DHCP	Dynamic Host Configuration Interface
EDR	Enhanced Data Rate
EEPROM	Electrically Erasable Programmable Read-Only Memory
EIRP	Equivalent Isotropic Radiated Power
EMI	Electromagnetic Interference
ESD	Electro Static Discharge
ESL	
FCC	Federal Communications Commission
GND	Ground
GPIO	General Purpose Input/Output
HBM	Human Body Model
HS	High-Speed
HCI	Host Controller Interface
ISED	Innovation, Science and Economic Development Canada
I2C	Inter-Integrated Circuit
KDB	Knowledge Database
LAN	Local Area Network
LDO	Low Drop Out
LED	Light-Emitting Diode
LPO	Low Power Oscillator
LTE	Long Term Evolution
MAC	Medium Access Control
MMC	Multi Media Card
MWS	Mobile Wireless Standards
NRE	Non-recurring engineering
NSMD	Non Solder Mask Defined
OEM	Original equipment manufacturer
OET	Office of Engineering and Technology
OS	Operating System
PCB	Printed Circuit Board

Abbreviation	Definition
PCI	Peripheral Component Interconnect
PCIe	PCI Express
PCM	Pulse-code modulation
PHY	Physical layer (of the OSI model)
PMU	Power Management Unit
RF	Radio Frequency
RSDB	Real Simultaneous Dual Band
RST	Request to Send
SDIO	Secure Digital Input Output
SMD	Solder Mask Defined
SMPS	Switching Mode Power Supply
SMT	Surface-Mount Technology
SSID	Service Set Identifier
STA	Station
TBD	To be Decided
THT	Through-Hole Technology
UART	Universal Asynchronous Receiver-Transmitter
VCC	IC power-supply pin
VIO	Input offset voltage
VSDB	Virtual Simultaneous Dual Band
VSWR	Voltage Standing Wave Ratio
WFD	Wi-Fi Direct
WLAN	Wireless local area network
WPA	Wi-Fi Protected Access

Table 12: Explanation of the abbreviations and terms used

Related documentation

[1] NORA-W10 series product summary, UBX-17051775
[2] NORA-W10 series Datasheet, UBX-21036702
[3] Espressif System ESP32-S3 Series Datasheet v1.1 https://www.espressif.com/sites/default/files/documentation/esp32-s3_datasheet_en.pdf
[4] u-connectXpress AT commands manual, UBX-14044127
[5] u-connectXpress SPI peripheral protocol specification, UBX-20028725
[6] Espressif ESP32-S3 v4.4 SDK Get Started
[7] ESP-IDF Programming Guide
[8] Packaging information reference, UBX-14001652
[9] JEDEC J-STD-020E - Moisture/Reflow Sensitivity Classification for Non-hermetic Surface Mount Devices
[10] u-blox SHO-OpenCPU GitHub repository
[11] NORA-W10 EU Declaration of Conformity, UBX-22023925
[12] NORA-W10 UKCA Declaration of Conformity, UBX-22040049
[13] FCC guidance 594280 D01 Configuration Control v02 r01,
[14] FCC guidance 594280 D02 U-NII Device Security v01r03
[15] FCC Regulatory Information, Title 47 – Telecommunication

☞ For product change notifications and regular updates of u-blox documentation, register on our website, www.u-blox.com.

Revision history

Revision	Date	Name	Comments
R01	02-May-2022	lkis	Initial release
R02	24-Aug-2022	fkru	Added Pre-approved antennas list and Regulatory compliance chapter. Updated disclaimer and contact information.
R03	23-Dec-2022	lkis	Updated product status in Document information and bootstrap pin table in Bootstrap pins. Updated Analog to digital converters and added low power mode implementation in Low Power mode with Low Frequency Clock. Added Great Britain regulatory compliance and updated certification status in Country approvals. Revised and restructured Antenna interface. Added QD ID and listing date in Bluetooth qualification.
R04	24-Feb-2023	ovik	Updated RF exposure statements in section 6.4

Contact

For further support and contact information, visit us at www.u-blox.com/support.