S

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 NORA-W10 stand-alone Wi-Fi and Bluetooth Low Energy v5.0 modules in customer applications. Including a powerful microcontroller, 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.

Document information

Title	**NORA-W10 series**
Subtitle	Standalone, multiradio modules with Wi-Fi 4 (802.11b/g/n) and Bluetooth Low Energy 5.0
Document type	System integration manual
Document number	UBX-22005601
Revision and date	R07 22-Jan-2025
Disclosure restriction	C1-Public

Product status	Document status	Corresponding content status
Functional sample	Draft	For functional testing. Revised and supplementary data will be published later.
In development / Prototype	Objective specification	Target values. Revised and supplementary data will be published later.
Engineering sample	Advance information	Data based on early testing. Revised and supplementary data will be published later.
Initial production	Early production information	Data from product verification. Revised and supplementary data may be published later.
Mass production / End of life	Production information	Document contains the final product specification.

This document applies to the following products:

Product name	Document status
NORA-W101	Early Production Information
NORA-W106	Early Production Information

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

u-blox or third parties may hold intellectual property rights in the products, names, logos and designs included in this document. Copying, reproduction, or modification of this document or any part thereof is only permitted with the express written permission of u-blox. Disclosure to third parties is permitted for clearly public documents only.
The information contained herein is provided “as is”. No warranty of any kind, either express or implied, is made in relation to the accuracy, reliability, fitness for a particular purpose, or content of this document. This document may be revised by u-blox at any time. For most recent documents and product statuses, please visit www.u-blox.com.
Copyright © u-blox AG.

Contents

1 Product 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 series modules are compliant with the Radio Equipment Directive (RED) and are also certified in the following countries: 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 support a temperature range of –40 °C to +85 °C and are qualified according to the u-blox qualification policy based on AEC-Q104 standard for professional grade operation. For further information about the module operating conditions, see the data sheet [2].

1.1 Module architecture

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

The three variants of NORA-W10 series are described in Table 1.

Model	Antenna configuration	Antenna type
NORA-W101-00B	RF_ANT0: 2.4 GHz Wi-Fi, 2.4 GHz Bluetooth LE	Antenna pad
NORA-W106-00B	2.4 GHz Wi-Fi, 2.4 GHz Bluetooth LE	Single embedded PCB antenna
NORA-W106-10B	2.4 GHz Wi-Fi, 2.4 GHz Bluetooth LE	Single embedded PCB antenna

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

2 Module integration

NORA-W10 series modules come in a host-less, open CPU configuration that allows customer applications to run on the module itself – without any need for a supporting host MCU, supporting IEEE 802.11 b/g/n single-band 2.4 GHz operation Bluetooth Low Energy (LE) v5.0 communications. NORA-W10 series modules support a wide range of IO interfaces, such as GPIO, UART, USB OTG, SPI, I2S, I2C, PWM, RMT, CAN, and SD/MMC host.

Figure 1 shows a typical integration as a host.

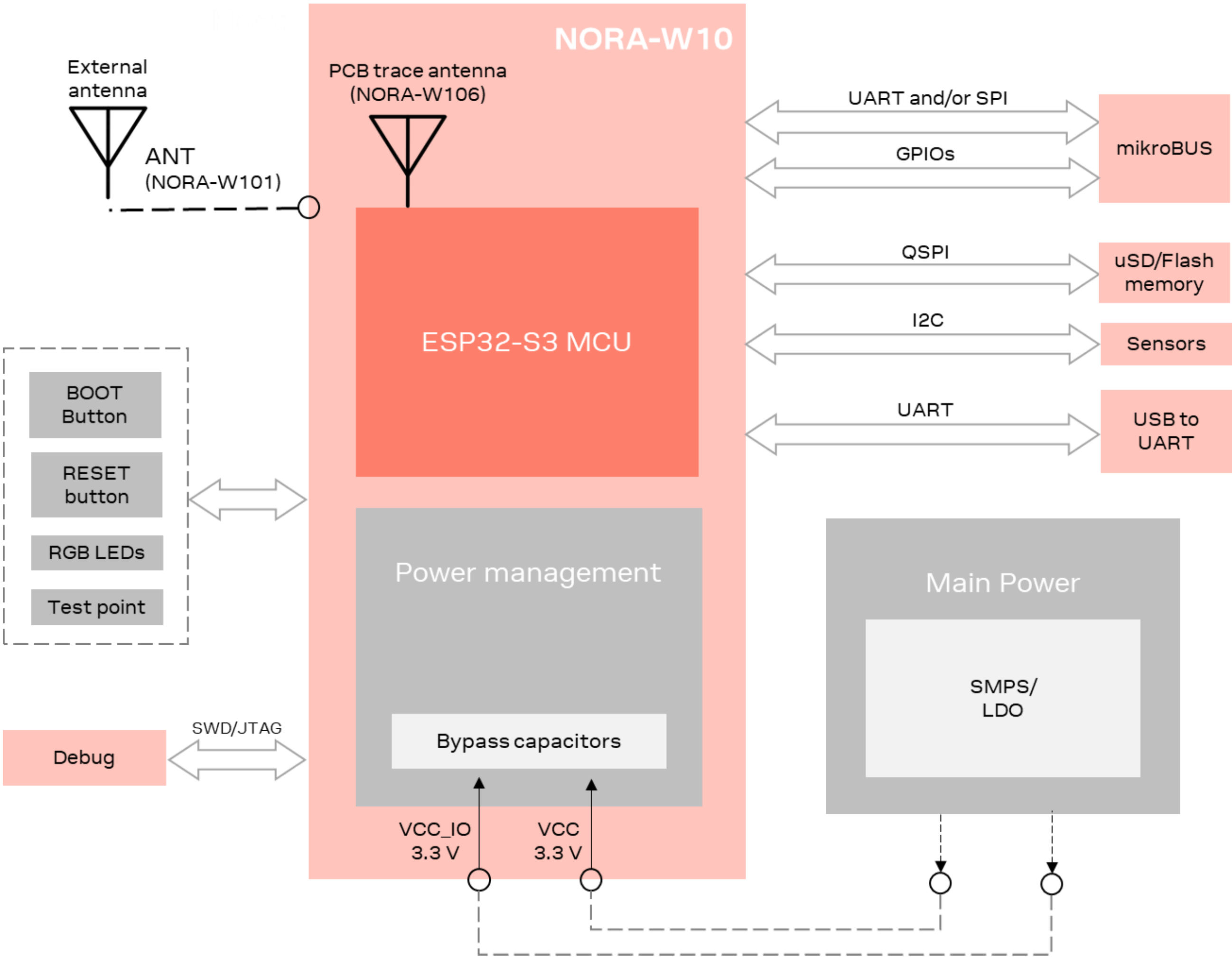


Figure 1: Example of NORA-W10 integrated as a host

Figure 2 shows an example of controlling NORA-W10 series modules through a host CPU and interface connections.

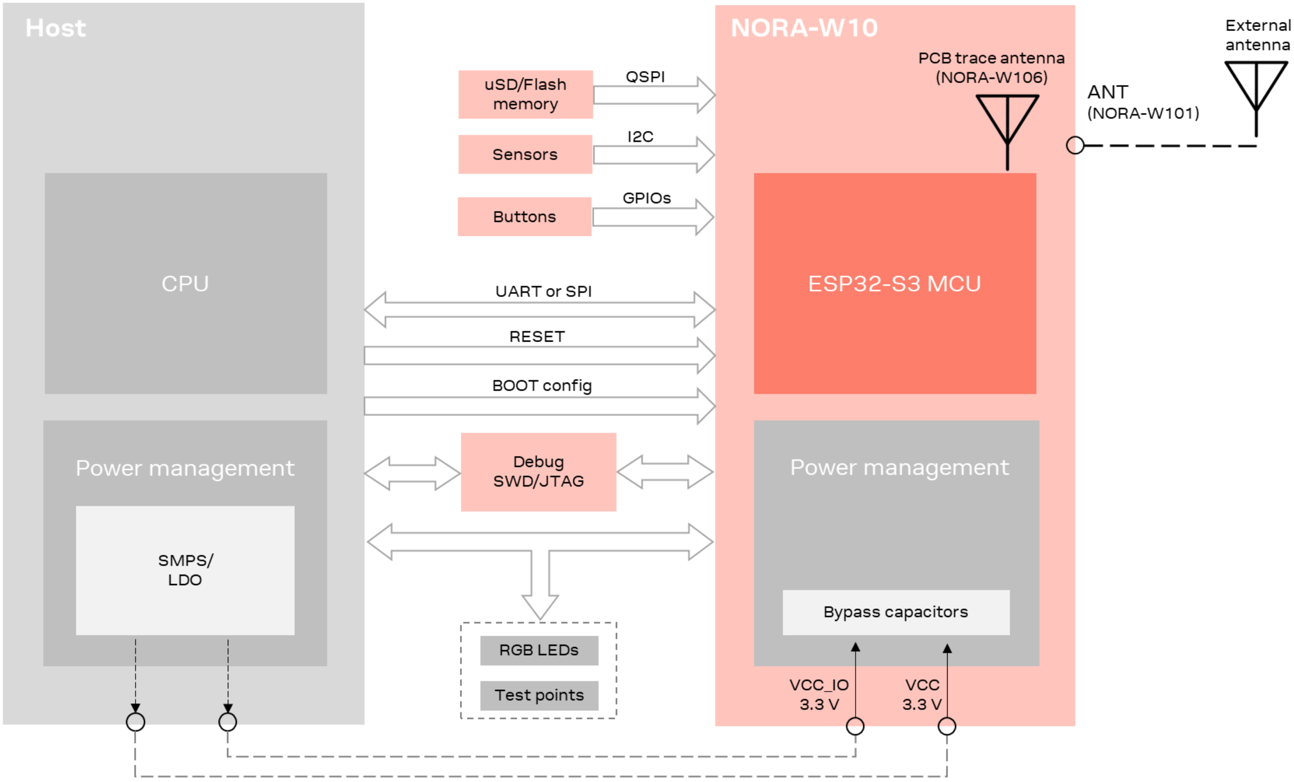


Figure 2: Example of NORA-W10 integration in a host system

Device design is simplified, as developers can choose to use an external antenna (NORA-W101) or take advantage of the internal antenna (NORA-W106). Pin-compatible with all other NORA modules, NORA-W10 also provides maximum flexibility for the development of similar devices offering different radio technologies.

2.1 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.

2.1.1 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 3.3 V 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.

2.1.2 Digital I/O interfaces reference voltage (VCC_IO)

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

2.1.3 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].

2.2 CPU and memory

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

2.3 System functions

2.3.1 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.

The following predefined power modes power up different combinations of power domains:

- Active mode: The CPU, RF circuits, and all peripherals are on. The chip can process data, receive, transmit, and listen.

- Modem-sleep mode: The CPU is operational, and the clock speed can be reduced. The wireless connections can be configured to remain active as RF circuits are periodically switched on when required.
- Low power modes:
  - Light-sleep mode : The CPU and part of peripheral are powered down. The RTC peripherals, as well as the ULP coprocessor, can be woken up periodically by the timer. The chip can be woken using all wake up mechanisms: MAC, host, RTC timer, or external interrupts. Wireless connections can remain active. Some groups of peripherals can be optionally shut down.
  - Deep-sleep mode: Only the ULP coprocessor, RTC memory, and RTC peripherals are powered up. Wireless connection data is stored in RTC memory.

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

2.3.1.1 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 a 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. This arrangement allows these pins to be used as GPIOs when a low power mode is not in use, as shown in Figure 3.

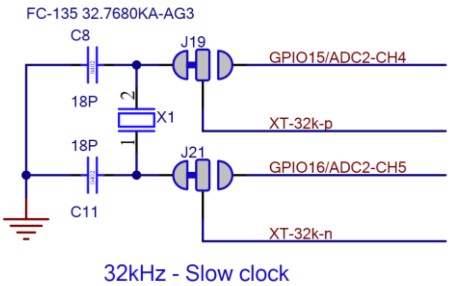


Figure 3: 32 kHz Low Frequency Clock

2.3.2 Module reset

NORA-W10 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).

2.3.3 Bootstrap pins

At each startup or reset, the module requires some initial configuration parameters, such as in which boot mode to load. These parameters are passed over via the bootstrap pins. For normal operation, the pins must have the correct settings during boot. The pins must also be in the correct state during power-up. The parameters are parsed according to the configuration of the bootstrap pins. After reset, the bootstrap pins operate as regular IO 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 2.

⚠ Utilization of the bootstrap 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 can 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	
		ignored		*EFUSE_DIS_USB_JTAG = 0, EFUSE_DIS_PAD_JTAG = 0, EFUSE_STRAP_JTAG_SEL=0* JTAG signal from USB Serial/JTAG controller	

*The configuration pin is set high by default with a weak 45 kΩ pull-up resistor and should not be directly connected to GND. To set the pin low, use a 4.7 kΩ resistor connected to GND.

Table 2: NORA-W10 series bootstrap 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, make sure that pin **F7** is driven low during power up. To enter *Normal boot from internal flash* mode, assert a reset in bootloader mode.

Consider also the timing requirements for the bootstrap pins, such as the parameters for the setup time and hold time. For more information, see the Table 3. Figure 4, and the *values referred to in the ESP32-S3 Series Datasheet [3].

Parameter	Description	Min	Max
t_{SU}	*Setup time* is the time reserved for the power rails to stabilize before the VCC pin is pulled high to activate the chip.	0 ms	-
t_H	*Hold time* is the time reserved for the chip to read the bootstrap pin values after VCC is already high and before these pins start operating as regular IO pins.	3 ms	-
*V_{IL_nRST}	Reset voltage	-0.3 V	0.825 V
*V_{IH}	High-level input voltage	2.475 V	3.6 V

* Values are referred from ESP32-S3 Series Datasheet [3]

Table 3: Timing parameters for the bootstrap pins

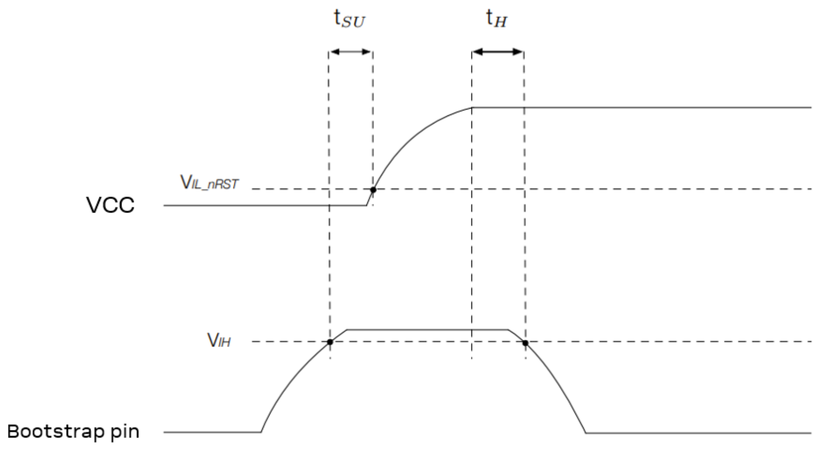


Figure 4: Timing parameters for bootstrap pins

2.4 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/integrated antennas connected through a dedicated antenna pin (NORA-W101).

2.4.1 Antenna solutions

NORA-W10 series modules support various antenna solutions:

- NORA-W101 has an antenna pin that can be used with either
  - Integrated SMD chip antenna
  - External antenna
- NORA-W106 includes an internal PCB trace antenna which is specifically designed and optimized for the NORA-W10 module. There is no need for an RF trace design on the host PCB which means less effort is required in the test lab.

Figure 5 summarizes each of the available antenna options.

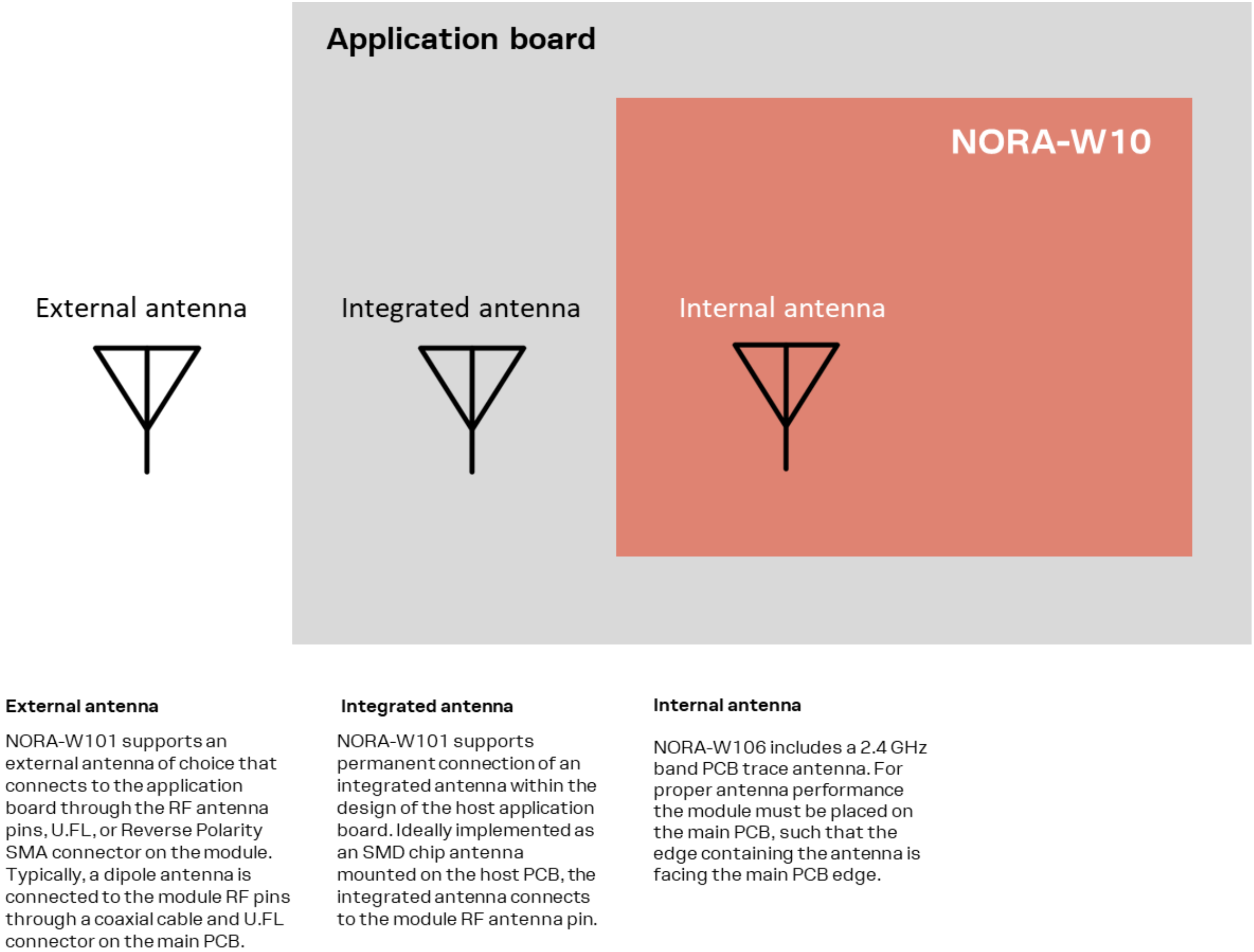


Figure 5: Antenna options

2.4.2 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 leverage this benefit, customers are required to implement an antenna layout that is fully compliant with the u-blox reference design outlined in this document. Reference design source files are available from u-blox on request.[1]

☞ 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.

For Bluetooth and Wi-Fi operation, NORA-W10 modules have been tested and approved for use with the antennas featured in the listed in the Pre-approved antennas list.

⚠ To avoid invalidating the compliance and pre-certification of u-blox modules with the various regulatory bodies, use only external antennas included on the Pre-approved antennas list. Reference design source files are available from u-blox on request.

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

[1] Reference design available only after certification

2.5 Data interfaces

2.5.1 Universal asynchronous serial interface (UART)

NORA-W10 modules have three UART interfaces, UART0, UART1, and 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)
- Frame format configuration:
  - 8 data bits
  - Even or no-parity bit
  - 1 stop bit
  - 115200 bits/s baud rate
- Default frame configuration is 8N1 means eight (8) data bits, no (N) parity bit, and one (1) stop bit.

UARTs can be implemented 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 **UART0** is made available via connector or test points for firmware upgrades, debugging and radio testing. See also Radio test and compliance.

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

2.5.2 Serial peripheral interface (SPI)

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

It is possible to connect the remaining SPI interfaces to other pins via the IO MUX, but the maximum speed is then 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 Main and Sub SPI modes.

⚠ The NORA-W106-10B module is equipped with internal PSRAM only and connected to the SPI0 interface, which can be controlled via chip select CS0. However, to enable code retention and execution, it is necessary to connect an external flash storage to the SPI0 interface as well. This external flash will be controlled using chip select CS1.

For more information, see the Espressif ESP32-S3 Datasheet [2]

⚠ External flash connected to other SPI interface on NORA-W10x-00B modules can't be used for code execution.

2.5.3 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 are 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

2.5.4 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.

2.6 Analog interfaces

2.6.1 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 applications. For more information about the analog-capable pins, see the NORA-W10 series data sheet [2].

For lower power consumption, NORA-W10 modules can measure interval voltages in all sleep modes and threshold settings can be used to wake the CPU.

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

2.7 Other remarks

2.7.1 No-connect pins (NC)

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

2.7.2 GND pins

Good electrical connection of module GND pins, using solid ground layer of the host application board, is required for correct RF performance. Firm connections provide a thermal heat sink for the module and significantly reduce EMC issues.

3 Design-in

Follow the design guidelines described in this chapter to optimize the integration of NORA-W10 series modules on host application boards.

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 RF performance. It is important to observe the schematic and layout design for these supplies. See also VCC application circuits. Select appropriate power supply source and bypass capacitors, and carefully route the power supply nets or planes. Modules normally include several supply pins described in the pinout of the NORA-W10 data sheet [2].
- High-speed interfaces: **UART**, **SPI** 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 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 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 layout guidelines.

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

3.2 RF Interface

To avoid interference with radio communication, the module must be strategically mounted and careful consideration must be given to its placement on the host PCB.

NORA-W106 modules include an internal PCB trace antenna, which makes them unsuitable for mounting in a metal enclosure. No metal casing or plastics using metal flakes should be used. Also avoid metallic based paint or lacquer.

⚠ According to FCC regulations, the transmission line from the module 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 Antenna integration

To optimize the radiated performance of the final product, the selection and placement of both the module and antenna must be chosen with due regard to the mechanical structure and electrical design of the product. To avoid later redesigns, it is important to decide the positioning of these components at an early phase of the product design.

The compliance and subsequent certification of the RF design depends heavily on the radiating performance of the antennas.

To ensure proper performance of the application product, carefully follow the guidelines outlined below. Note also that the RF certification of the module is extended through to the application design.

- External antennas, including, linear monopole classes:
  - Place the module and antenna in any convenient area on the board. External antennas do not impose any restriction on where the module is placed on the PCB.
  - Select antennas with optimal radiating performance in the operating bands. The radiation performance depends mainly on the antennas.
  - Choose RF cables that offer minimum insertion loss. Unnecessary insertion loss is introduced by low quality or long cables. Large insertion losses reduce radiation performance.
  - Use a high-quality 50 Ω coaxial connector for proper PCB-to-RF-cable transition.
- Integrated antennas, such as patch-like antennas:
  - Internal integrated antennas impose some physical restrictions on the PCB design:
    - Integrated antennas excite RF currents on its counterpoise. Typically, the PCB ground plane of the device becomes part of the antenna and its dimension defines the minimum frequency that can be radiated. Therefore, the ground plane can be reduced to a minimum size that is no smaller than a quarter of the wavelength of the minimum frequency that is to be radiated. The orientation of the ground plane related to the antenna element must also be considered.
    - Find a numerical example to estimate the physical restrictions on a PCB, where: *Frequency = 2.4 GHz → Wavelength = 12.5 cm → Quarter wavelength = 3.5 cm* in free space or 1.5 cm on a FR4 substrate PCB.
- Choose antennas with optimal radiating performance in the operating bands. Radiation performance depends on the complete product and antenna system design, including the mechanical design and usage of the product. Table 5 summarizes the requirements for the antenna RF interface.
- Make the RF isolation between the system antennas as high as possible, and the correlation between the 3D radiation patterns of the two antennas as low as possible. In general, RF separation of at least a quarter wavelength between the two antennas is required to achieve some isolation and low pattern correlation. If possible, increase the separation to maximize the performance and fulfill the requirements in Table 6.

Item	Requirements	Remarks
Impedance	50 Ω nominal characteristic impedance	The impedance of the antenna RF connection must match the 50 Ω impedance of Antenna pins.
Frequency Range	2400 - 2500 MHz	For 802.11b/g/n and Bluetooth.
Return Loss	S11 < -10 dB (VSWR < 2:1) recommended S11 < -6 dB (VSWR < 3:1) acceptable	The Return loss or S_{11} parameter (normally represented on vector network analyzers) in the voltage standing-wave ratio (VSWR) refers to reflected power. This loss is a measurement of how well the primary RF antenna connection matches the 50 Ω characteristic impedance of the antenna pins. To maximize the amount of power transferred to the antenna, the impedance of the antenna termination must match (as far as possible) the 50 Ω nominal impedance of antenna pins over the operating frequency range.

Item	Requirements	Remarks
Efficiency	> -1.5 dB (> 70%) recommended > -3.0 dB (> 50%) acceptable	Radiation efficiency is the ratio of the radiated power to the power fed to the antenna input This is a measurement of how well an antenna receives or transmits data.
Maximum Gain	+3 dBi	To comply radiation exposure limits defined by various regulatory agencies, the maximum antenna gain must not exceed the value specified in the Pre-approved antennas list. Although higher gain antennas can be used, these must be evaluated and certified. See also Regulatory compliance.

Table 5: Summary of antenna interface requirements

Table 6 specifies additional requirements for implementing a dual antenna design.

Item	Requirements	Remarks
Isolation (in-band)	S21 > 30 dB recommended	The antenna-to-antenna isolation is the S21 parameter between the two antennas in the band of operation. Lower isolation might be acceptable depending on the use-case scenario and performance requirements.
Isolation (out-of-band)	S21 > 35 dB recommended S21 > 30 dB acceptable	Out-of-band isolation is evaluated in the band of the aggressor. This ensures that the transmitting signal from the other radio is sufficiently attenuated by the receiving antenna. It also avoids any saturation and intermodulation effect on the receiver port.
Envelope Correlation Coefficient (ECC)	ECC < 0.1 recommended ECC < 0.5 acceptable	The ECC parameter correlates the far field parameters between antennas in the same system. A low ECC parameter is fundamental in improving the performance of MIMO-based systems.

Table 6: Summary of Wi-Fi/Bluetooth coexistence requirements

⚠ When operating dual antennas in the same 2.4 GHz band, sufficient isolation is critical for attaining an optimal throughput performance in Wi-Fi/Bluetooth coexistence mode.

Select antennas that provide:

- Optimal return loss (or VSWR) over all the operating frequencies.
- Optimal efficiency figure over all the operating frequencies.
- An appropriate gain that does not exceed the regulatory limits specified in some regulatory country authorities like the FCC in the United States.

A useful approach for the antenna microstrip design is to place an U.FL connector close to the embedded PCB or chip antenna. The U.FL connector only needs to be mounted on units used for verification.

3.2.2 RF transmission line design

RF transmission lines, such as those that connect from **RF_ANT** pins to their related antenna connectors or antenna, must be designed with a characteristic impedance of 50 Ω.

Figure 6 shows the design options for implementing a transmission line, namely:

- 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. This in the most common transmission line implementation.
- Stripline – track separated by dielectric material and sandwiched between two parallel ground planes.

The parameters shown in the cross-sectional area of each trace design include:

- Width (W) – shows the width of the copper layer on the top layer
- Distance (S) – shows the distance between the top copper layer and the two adjacent GND planes.
- Dielectric substrate thickness (H) – shows the distance between the GND reference on the bottom plane and the copper layer on the top layer.

- Thickness of the copper layer (T) – can also be represented by "Base Copper Weight", which is commonly used as the parameter for PCB stack-up.

Dielectric constant (ε_r) defines the ratio between the electric permeability of the material against the electric permeability of free space.

☞ The width of a 50 Ω microstrip depends on mainly "ε_r" and "H", which must be calculated for each PCB layer stack-up.

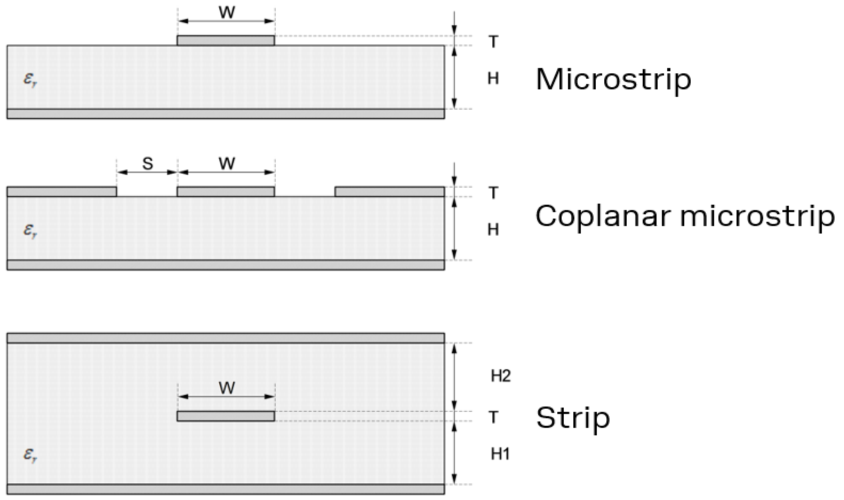


Figure 6: Transmission line trace design

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 a 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.

Figure 7 shows a typical trace and ground design for NORA-W101.

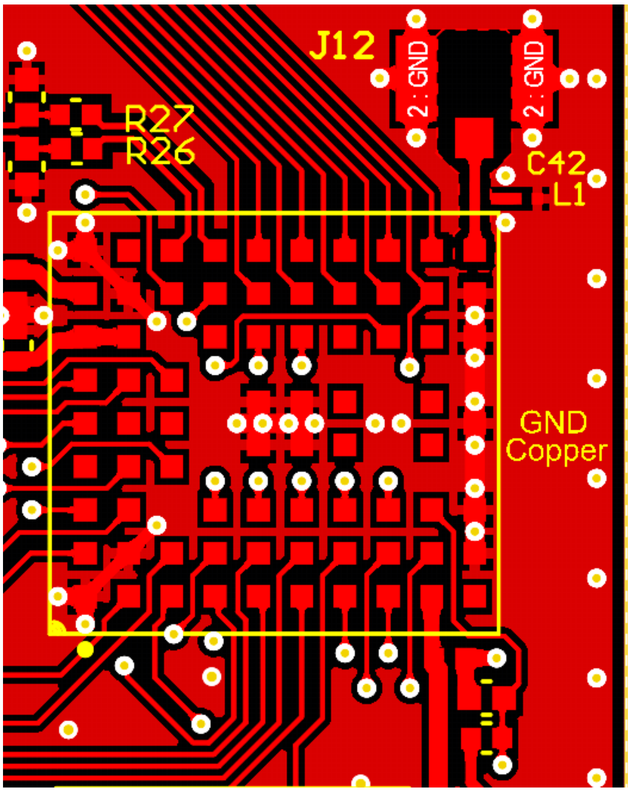


Figure 7: RF trace and ground design example for NORA-W101

3.2.3 NORA-W101

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

Designers must consider the antennas from all perspectives at the beginning of the design phase when the physical dimensions of the application board are under analysis/decision. This is important because the RF compliance of any device that integrates NORA-W101 module, with all the applicable required certification schemes that are necessary, depends heavily on the radiating performance of the antennas. Designers are encouraged to consider one of the u-blox suggested antenna part numbers from the Pre-approved antennas list and follow the layout requirements.

3.2.3.1 RF connector design

If an external antenna is necessary, designers should ensure they use an appropriate RF connector. Designers must ensure that the plugs and receptacles they choose are compatible with each other.

Table 7 suggests several RF connector plugs that designers can use 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. It is the responsibility of the designer to verify the compatibility between plugs and receptacles used in the design.

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	
Lighthorse Technologies, Inc.	IPX ultra micro-miniature RF connector	

Table 7: U.FL compatible plug connector

Typically, the RF plug is available as a cable assembly. Different types of cable assembly are available, and the user should select the cable assembly best suited to the application.

The key characteristics of the assembly include:

- RF plug type: select U.FL or equivalent
- Nominal impedance: 50 W
- 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).

Note 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 improve the ruggedness of the application, connect the U.FL connector to a more robust connector, such as an SMA fixed panel connector.

Figure 8 shows the layout of pads for U.FL connector. Consider especially the GND clearance under the signal pad.

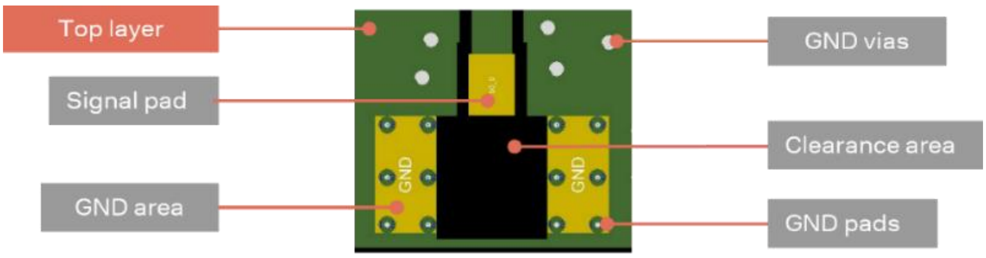


Figure 8: GND keepout on top layer under U.FL connector

☞ To make it more difficult for end users to replace the antenna with higher gain versions that exceed the regulatory limits in some countries, it is now standard industry practice to use reverse polarity connectors (RP-SMA) on Wi-Fi and Bluetooth® end products.

Strictly follow the connector manufacturer's recommended layout:

- SMA Pin-Through-Hole connectors require GND keep-out (clearance/void area) on all the layers around the central pin up to the annular pads of the four GND posts.
- SMA side-mounted connector (or similar): If the RF pad of the connector is wider than the microstrip, remove the GND layer beneath the RF connector. This minimizes stray capacitance and maintains the RF line at 50 Ω.
- U.FL. surface mounted connectors require no conductive traces in the area below the connector between the GND land pads. For instance, the active pad of the U.FL. connector must have a GND keep-out area on at least the first inner layer to reduce parasitic capacitance to ground.

3.2.3.2 Integrated antenna design

If integrated antennas are used, the transmission line is terminated by the integrated antennas themselves. Observe the following guidelines:

- The antenna design process should start at the beginning of the whole product design process. Self-made PCBs and antenna assemblies are useful in estimating overall efficiency and radiation path of the intended design.
- Use antennas designed by an antenna manufacturer to provide the best possible return loss (or VSWR).
- Provide a ground plane large enough to meet 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, larger ground planes can improve antenna efficiency.
- Proper placement of the antenna and the surrounding area 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. These objects tend to absorb part of the radiated power, shift the resonant frequency of the antenna or affect the antenna radiation pattern.
- To correctly install and deploy the antenna system, including PCB layout and matching circuitry, it is strongly advised that you adhere to the manufacturer's detailed guidelines.
- Further to the custom PCB and product restrictions, antennas may require tuning/matching to comply with all the applicable required certification schemes. It is strongly advised that you consult the antenna manufacturer for specific design-in guidelines and plan validation activities for the final prototypes, such as tuning, matching, and performance assessments.
- Avoid placing the antenna close to buses such as DDR or consider taking specific countermeasures like metal shields or ferrite sheets to reduce interference. Noise sources like hi-speed digital buses can affect the RF section.

⚠ Give due consideration to the interaction between co-located RF systems like LTE sidebands on 2.4 GHz band. Transmitted power can interact or disturb the performance of NORA-W10 series modules.

3.2.4 NORA-W106

NORA-W106 modules include an internal PCB trace antenna that is integrated on the module PCB using antenna technology from Abracon. The RF signal is completely internal and not connected to any module pin.

NORA-W106 modules can't be mounted inside a metal enclosure. Metal casings or plastics that include metal flakes should not be used. Metallic-based paints and lacquers should also be avoided.

3.2.4.1 Internal PCB trace antenna

For optimal operating performance, observe the following layout considerations when developing the antenna layout:

- 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 as shown in Figure 9.
- The host PCB shall include a full GND plane underneath the entire module, with a ground cut out under the internal PCB trace antenna on all layers as shown in Figure 9.
- NORA-W106 has six GND pads located close to the antenna that need to be connected to GND for good antenna performance. Detailed measurements of the footprint can be found in the NORA-W10 series data sheet [2].
- Include plenty of stitching vias from the module ground pads to the GND plane layer. Ensure that the impedance between the module pads and ground reference is minimal.
- 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. Polycarbonate (PC) and Acrylonitrile butadiene styrene (ABS) materials have less impact on antenna performance than other types of thermoplastics.
- 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 9 shows a typical trace and ground design for NORA-W106, including the critical dimensions between the ground plane and three non-edge sides of the module.

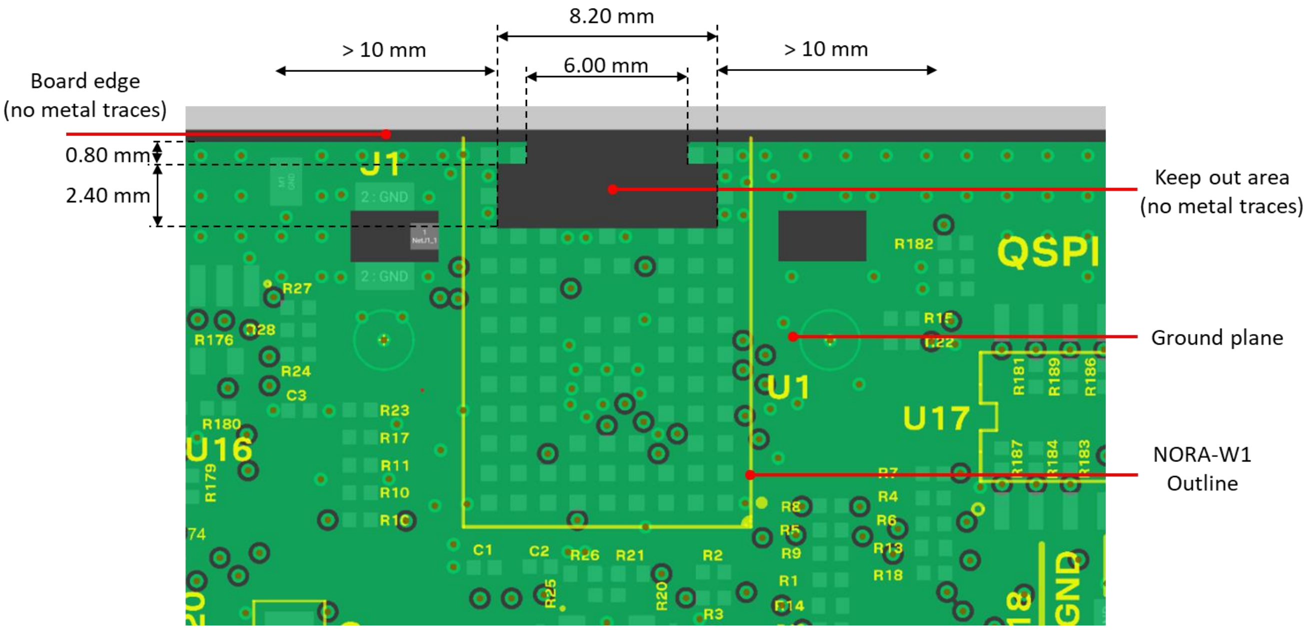


Figure 9: Antenna keepout area and GND plane design

3.3 General layout guidelines

This section describes the best practice for the schematic design and circuit layout of the application.

3.3.1 Considerations for schematic design and PCB floor-planning

- Low frequency signals are generally not critical to the layout and designers should focus on the higher speed buses. One exception to this general rule is when high impedance traces, such as signals driven by weak pull resistors, might be affected by crosstalk. For these and similar traces, a supplementary isolation of **4w** (four times the line width) from other buses is recommended.
- Verify which interface bus requires termination and add series resistor terminations to these buses.
- Carefully consider the placement of the module with respect to the antenna position and host processor.
- Verify the controlled impedance dimensions of the selected PCB stack-up. The PCB manufacturer might be able to provide test coupons.
- Verify that the power supply design and power sequence are compliant with module specifications, as described in the NORA-W10 data sheet [2].

⚠ Take particular care not to place components close to the antenna area and follow the recommendations from the antenna manufacturer to determine the safe distance between the antenna and any other part of the system. Designers should also maximize the distance between the antenna and high-frequency buses, like DDRs and related components, or consider the use of an optional metal shield to reduce the potential interference picked up by the module antenna.

3.3.2 Component placement

- Place the module such that it provides optimum RF performance. This includes short low-loss antenna connections and unobstructed antenna placement. For more information about the module placement and other antenna considerations, see also Antenna integration.
- Place accessory parts, like bypass capacitors, as close as possible to the module to improve filtering capability. Prioritize the placement of the smallest size capacitor close to module pads. The supply rails must be routed through the capacitors from the power supply to the supply pad on the module.
- 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 buses, like DDRs and related components. Alternatively, consider an optional metal shield to reduce interferences that might otherwise be picked up by the antenna and subsequently reduce module sensitivity.

3.3.3 Layout and manufacturing

- Avoid stubs on high-speed signals which might adversely affect signal quality. 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. Ensure that the maximum allowable length for high-speed buses is not exceeded. Longer traces generally degrade signal performance.
- For impedance matched traces, consult with your PCB manufacturer early in the project for proper stack-up definition.
- Separate the RF and digital sections of the board.
- Don’t split ground layers under the module.
- Couple all traces (including low speed or DC traces) with a reference plane (GND or power), and reference all hi-speed buses against the ground plane. If any ground reference needs to be

changed, add an adequate number of GND vias in the area in which the layer is switched. This is necessary to provide a low impedance path between the two GND layers for the return current.
- Don't change the reference plane for Hi-Speed buses. If changes in the reference plane are unavoidable, add capacitors in the transition area of the reference planes. This is necessary to ensure that a low impedance return path exists through the different reference planes.
- Following the "3w rule", keep traces at a distance no less than three times that of its own width from the routing edge of the ground plane.
- For EMC purposes and the need to shield against any potential radiation, it is advisable to add GND stitching vias around the edge of the PCB. Traces on the PCB peripheral are not recommended.

3.4 Module footprint and paste mask

Figure 10 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.

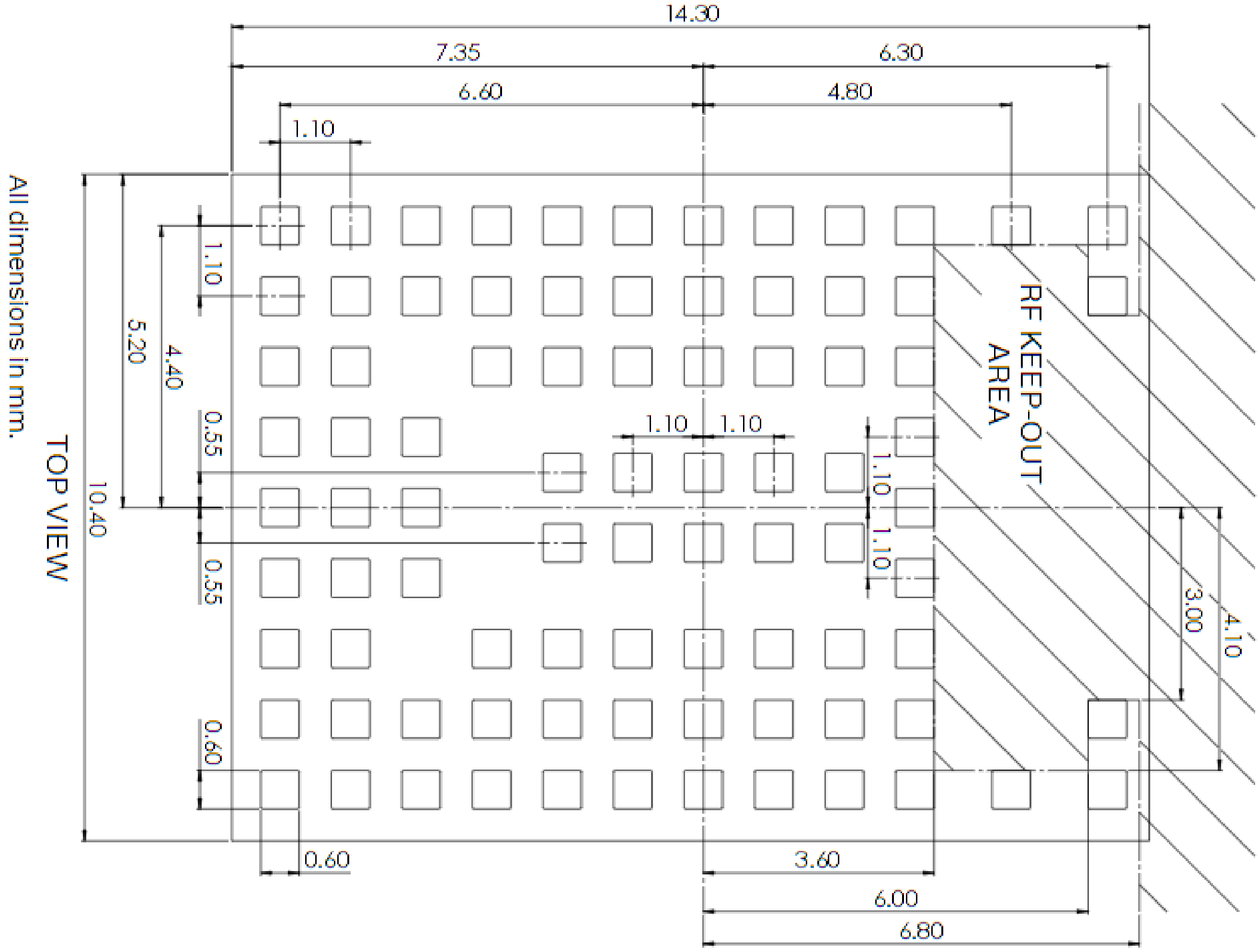


Figure 10: NORA-W10 mechanical outline

☞ The RF keep-out area is not required for NORA-W101.

The suggested stencil layout for the NORA-W10 module should follow the copper pad layout, as shown in Figure 10. The assembly house should determine the thickness of the solder paste stencil based on the entire host PCB, typically 100-120 µm.

3.5 Thermal guidelines

NORA-W10 series modules are designed to operate in a specified temperature range at an ambient temperature within the enclosure box. The PCB generates heat during high loads that must be dissipated to sustain the lifetime of the components.

The improvement of thermal dissipation in the module decreases its internal temperature and consequently increases the long-term reliability of device applications operating at high ambient temperatures.

For the best performance, layouts should adhere to the following guidelines:

- Vias specification for ground filling: $300/600\mu m$, with no thermal reliefs allowed on vias.
- Ground via densities under the module: $50\ vias/cm^2$; thermal vias can be placed in gaps between the thermal pads of the module.
- Minimum layer count and copper thickness: $4\ layers$, $35\ \mu m$.
- Minimum board size: $55x70\ mm$.
- To optimize the heat flow from the module, power planes and signal traces should not cross the layers beneath the module.

Use the following hardware techniques to further improve thermal dissipation in the module and optimize its performance in customer applications:

- Maximize the return loss of the antenna to reduce reflected RF power to the module.
- Improve the efficiency of any component that generates heat, including power supplies and processor, by dissipating it evenly throughout the application device.
- Provide sufficient ventilation in the mechanical enclosure of the application.
- For continuous operation at high temperatures, particularly in high-power density applications or smaller PCB sizes, include a heat sink on the bottom side of the main PCB. The heat sink is best connected using electrically insulated / high thermal conductivity adhesive[2].

3.6 ESD guidelines

The immunity of devices, integrating NORA-W10 modules, against Electro-Static Discharge (ESD) is part of the Electro-Magnetic Compatibility (EMC) conformity. This immunity 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.

[2] Typically, not required.

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 test measurement setup for 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 levels specified in the EN61000-4-2 can be achieved by including the ESD protection in parallel to the line, close to areas accessible by the end user.

3.7 Design-in checklists

3.7.1 Schematic checklist

☐ All module pins have been properly numbered and designated on the schematic (including thermal pins) as shown in the pin list of the data sheet [2].
☐ Power supply design complies with the supply requirements, as described in the data sheet [2].
☐ Adequate bypassing is included in front of each power pin, as described in the data sheet [2]
☐ Each signal group is consistent with its own power rail supply or proper signal translation has been provided, as described in data sheet [2].
☐ Configuration pins are properly set at bootstrap, as described in data sheet [2].
☐ SDIO bus includes series resistors and pull-ups, if needed.
☐ Unused pins are properly terminated.
☐ When using an external antenna, A pi-filter is provided in front of each antenna for final matching. See Antenna integration.

3.7.2 Layout checklist

☐ PCB stack-up and controlled impedance traces follow the recommendations given by the PCB manufacturer. See RF transmission line design.
☐ All pins are properly connected, and the footprint follows u-blox pin design recommendations. See the solder mask information in the data sheet [2].
☐ 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. See Layout and manufacturing.
☐ 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. See RF transmission line design.
☐ 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. See Layout and manufacturing.
☐ 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

The NORA-W10 modules are delivered without flashed firmware for software implementations with an open-CPU configuration. Using NORA-W10 module, customers develop their application designs using the utilities and device-level APIs provided by the module chipset supplier.

This section offers comprehensive instructions on setting up the toolchain and building and flashing a project example using the SDK provided by the module chipset supplier. It also provides the GitHub repository URL for output power configuration and RF calibration. Additionally, it includes guidance on using the Arduino integrated development environment to program the NORA-W10 module.

4.1 Espressif SDK

The ESP-IDF Software Development Kit [4] 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 11 shows the architecture of NORA-W10 Open CPU software in relation to the MCU, transceiver and ESP-IDF SDK.

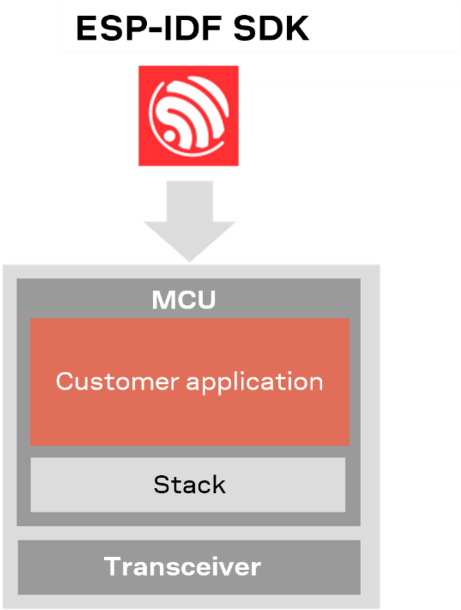


Figure 11: NORA-W10 open CPU software

4.1.1 Developing and flashing NORA-W10 Open CPU software

It is recommended that you make the 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 [5]. 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 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 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 [4].

4.1.2 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.

4.1.3 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\install.bat esp32s3

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

4.1.4 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.

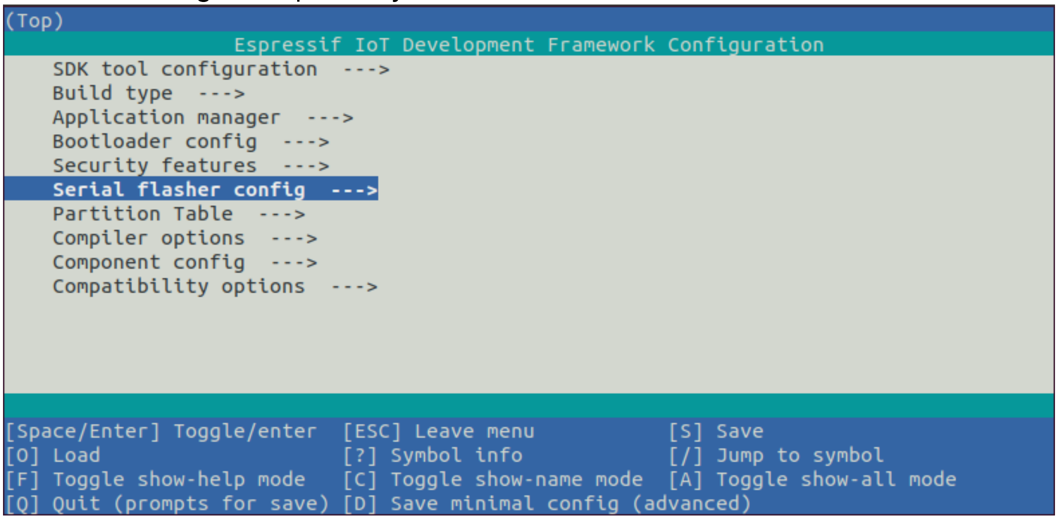
1. Build the sample project. Go to the "hello world" folder using the following command:

   ```
   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 COMPORT that is used to flash NORA-W10 is modified.



```
(Top)
                  Espressif IoT Development Framework Configuration
    SDK tool configuration  --->
    Build type  --->
    Application manager  --->
    Bootloader config  --->
    Security features  --->
    Serial flasher config  --->
    Partition Table  --->
    Compiler options  --->
    Component config  --->
    Compatibility options  --->

[Space/Enter] Toggle/enter   [ESC] Leave menu           [S] Save
[O] Load                     [?] Symbol info            [/] Jump to symbol
[F] Toggle show-help mode    [C] Toggle show-name mode  [A] Toggle show-all mode
[Q] Quit (prompts for save) [D] Save minimal config (advanced)
```

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 **GPIO0** low while resetting or powering on the board.
8. Use the following command to build 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`.

4.1.5 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 a 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 [4].

4.1.6 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

4.1.7 Output power configuration

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` SDK git repositories.

4.1.7.1 Wi-Fi output power configuration

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 [7].

4.1.7.2 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.

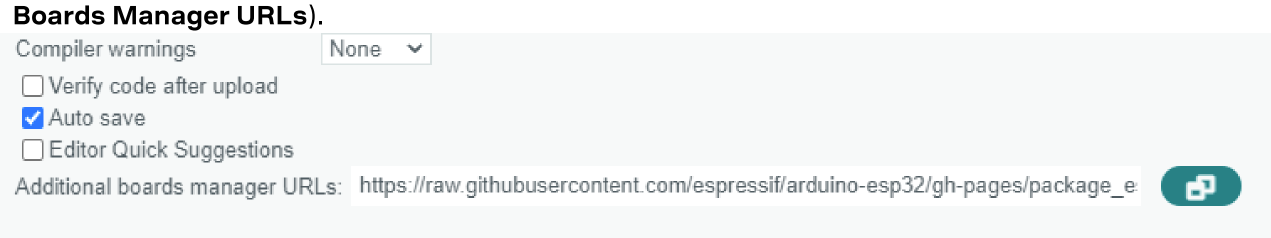
4.2 Arduino support for NORA-W10

Implemented on shields (expansion boards), NORA-W1 modules can be directly mounted on top of open-source Arduino boards to provide wireless connectivity during the development of your application project.

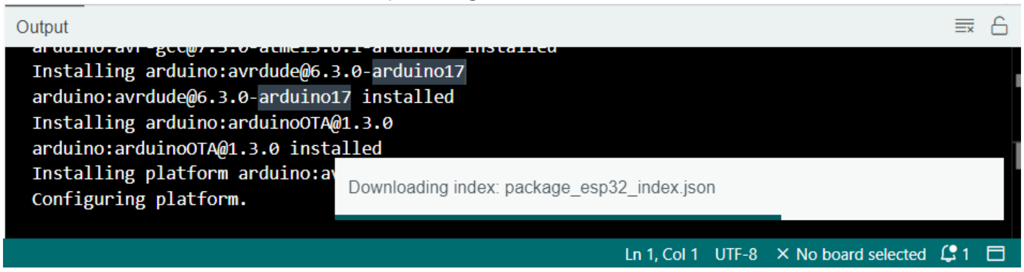
ESP32 Arduino Core documentation contains the information you need to install and set up the Arduino IDE and the ESP32 environment.

4.2.1 Quick setup of NORA-W10 in Arduino IDE

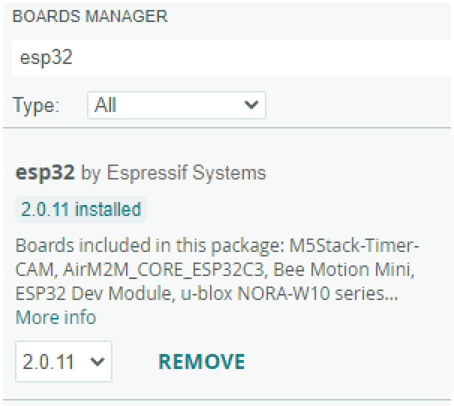
1. Download and install Arduino IDE (2.0 or higher) from the download site. See also the Arduino support documentation [15].
2. To add ESP32 ESP-IDF (Espressif IoT Development Framework), including boards and toolchains, copy the path (`https://raw.githubusercontent.com/espressif/arduino-esp32/gh-pages/package_esp32_index.json`) to the Additional Boards URL (**File > Preferences > Additional Boards Manager URLs**).



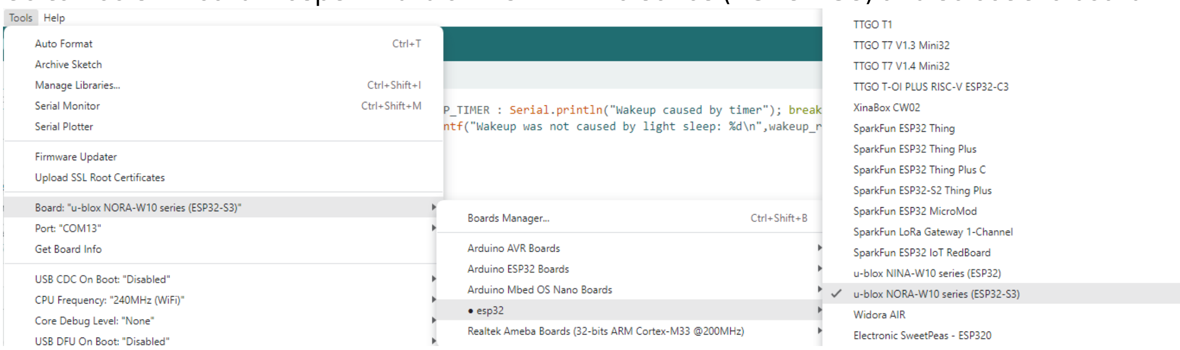
3. Select OK to start the ESP32 package download.



4. Wait for the download to complete before proceeding with the next step.
5. Open the Board Manager (**Tools > Board > Board Manager**), and type "esp32" in the search bar. Select "esp32 by Espressif Systems" and install it.



6. Go to Tools > Board > esp32 > u-blox NORA-W10 series (ESP32-S3) and select the board.



See also the public espressif/arduino-esp32 GitHub repository [14] and the Arduino support documentation [15].

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 12.

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 the 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).

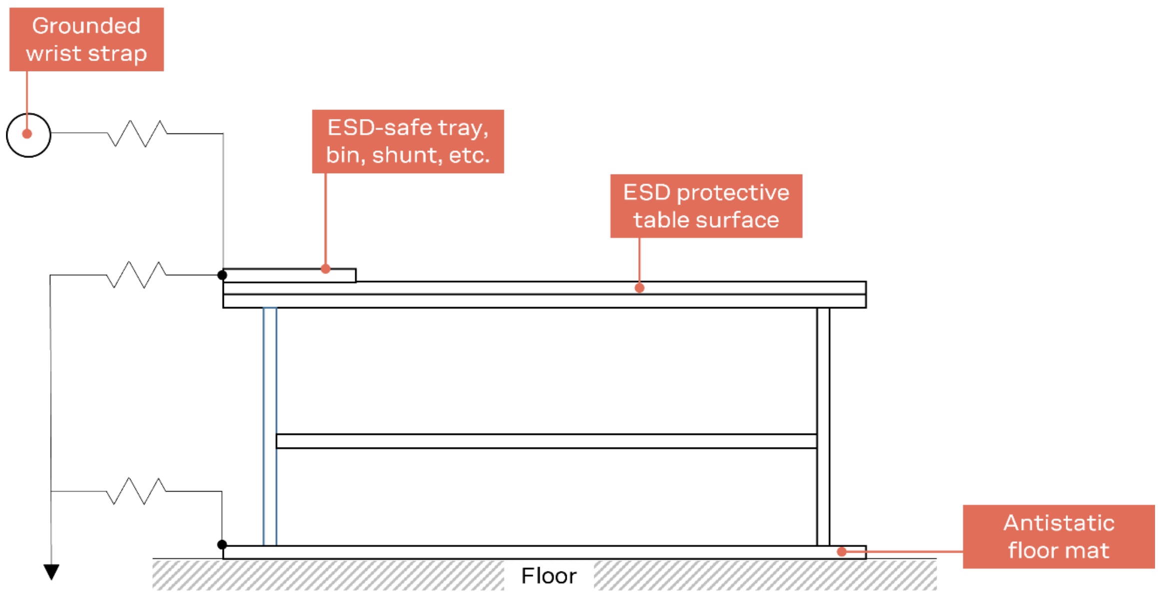


Figure 12: Standard workstation setup for safe handling of ESD-sensitive devices

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 Product packaging reference guide [5].

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.

NORA-W10 series modules are compatible with the industrial reflow profile for common SAC type RoHS solders. No-clean soldering paste is strongly recommended. The reflow profile is dependent on the thermal mass over the entire area of the fully populated host PCB, the heat transfer efficiency of the oven, and the type of solder paste that is used. The optimal soldering profile that is used must be trimmed for each case depending on the specific soldering process and PCB layout.

⚠ The target values given in Table 9 and Figure 13 are given as general guidelines for a Pb-free process only. For further information, see also the JEDEC J-STD-020E standard [6].

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

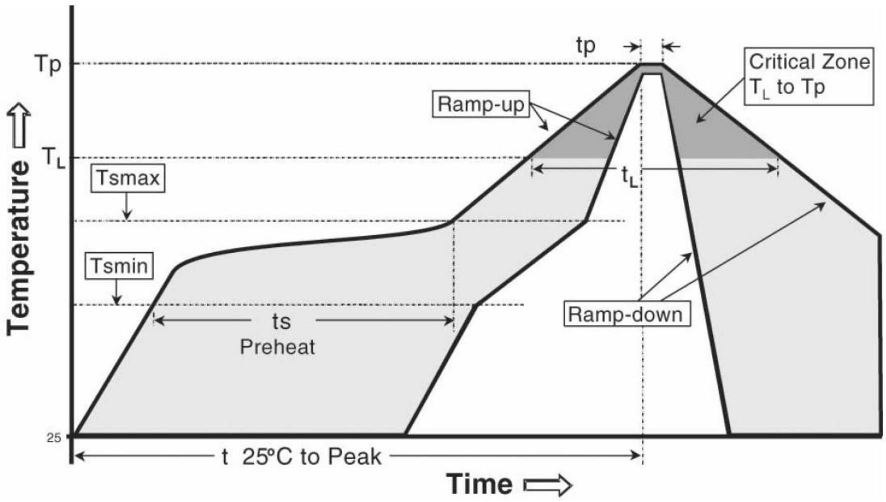


Figure 13: Reflow profile

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

5.3.1 Repeated reflow soldering

Repeated reflow soldering processes and soldering the module upside-down are not recommended.

Boards with components on both sides may require two reflow cycles. In this case, the module should always be placed on the side of the board that is submitted into the last reflow cycle. The reason for this (besides others) is the risk of the module falling off due to significantly higher weight in relation to other components.

⚠ u-blox gives no warranty against damages to the NORA-W10 modules caused by performing more than the specified reflow soldering processes (one reflow soldering process to mount the NORA-W10 module, plus one reflow soldering process to mount other parts).

5.3.2 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.

5.3.3 Other remarks

- 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 Country approvals

NORA-W10 modules are certified for use in different regions and countries, such as Europe, Great Britain, USA, and Canada. See also the NORA-W10 series data sheet [2] for a list of approved countries/regions where NORA-W10 modules are approved for use. Each market has its own regulatory requirements that must be fulfilled, and NORA-W10 series modules must comply with the requirements for a radio transmitter in each of the listed markets.

In some cases, limitations must be placed on the end-product that integrates a NORA-W10 module to comply with the regulatory requirements.

This chapter describes the limitations and requirements that a module integrator must take into consideration and is divided into different sections for each market.

⚠ This chapter reflects u-blox interpretation of different regulatory requirements of a radio device in each country/region. It does not cover all the requirements placed on an end-product that uses the radio module of u-blox or any other manufacturer.

6.2 European Union regulatory compliance

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 [9].

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.

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).

6.2.3 CE End-product regulatory compliance

For guidance concerning end product marking in accordance with RED go to: http://ec.europa.eu/.

For guidance concerning the restrictions while operating the NORA-W10 in Wi-Fi mode in European countries, see European Union regulatory compliance.

⚠ The EIRP of the NORA-W10 module must not exceed the limits of the regulatory domain that the module operates. Depending on the host platform implementation and antenna gain, integrators must limit the maximum output power of the module through the host software. For information about the corresponding maximum transmit power levels, see the Pre-approved antennas list.

6.3 Great Britain regulatory compliance

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 [10].

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 compliance

This device complies with Part 15 of the FCC Rules and with Industry Canada license-exempt RSS standard(s).

Any changes or modifications NOT explicitly APPROVED by u-blox AG may cause the module to not comply with the FCC rules part 15 thus void the user's authority to operate the equipment.

Model	FCC ID	ISED certification number
NORA-W101	XPYNORAW1W2	8595A-NORAW1W2
NORA-W106	XPYNORAW1W2	8595A-NORAW1W2

Table 10: FCC and ISED Certification Number for the NORA-W10 series modules

6.4.1 FCC compliance statements

NORA-W10 modules are for OEM integrations only. The end-product will be professionally installed in such a manner that only the authorized antennas can be used.

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.

This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that the interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- Reorient or relocate the receiving antenna
- Increase the separation between the equipment and receiver
- Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
- Consult the dealer or an experienced radio/TV technician for help.

⚠ NORA-W10 modules are for OEM integrations only. The end product has to be professionally installed in such a manner that only the authorized antennas can be used. See also Pre-approved antennas list.

⚠ Any changes to hardware, hosts or co-location configuration may require new radiated emission and SAR evaluation and/or testing. Any changes or modifications NOT explicitly APPROVED by u-blox may cause the NORA-W10 series module to cease to comply with the FCC rules part 15 thus void the user's authority to operate the equipment on the US market.

⚠ Any changes or modifications NOT explicitly APPROVED by u-blox AG may invalidate compliance with FCC rules part 15 and subsequently void the user's authority to operate the equipment.

⚠ The end-product manufacturer (OEM integrator) is responsible for verifying the end-product compliance with FCC Part 15, subpart B limits for unintentional radiators through an accredited test facility.

6.4.2 Configuration control and software security of end-products

☞ "Modular transmitter" hereafter refers to FCC ID.

As the end-product must comply with the requirements addressed by the OET KDB 594280 [11], the host product integration with NORA-W10 must comply with the following requirements:

- Upon request from u-blox, the host product manufacturer will provide all the necessary information and documentation to demonstrate how the requirements listed below are met.
- The manufacturer of the host product will not modify the modular transmitter hardware.
- The modular transmitter's configuration, when installed in the host product, must operate within its approved parameters and cannot be altered to include unauthorized modes of operation through interfaces accessible in 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 [11] lists the topics that must be addressed to ensure that the end-product specific host meets the Configuration Control requirements.

☞ OET KDB 594280 D02 [12] lists the topics that must be addressed to ensure that the end-product specific host meets the Software Security Requirements for U-NII Devices.

6.4.3 Operating frequencies

NORA-W10 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[4] are described in Table 11.

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

Table 11: Allowed channel usage under FCC/ISED regulation

6.4.4 RF exposure statement

6.4.4.1 IC compliance

All transmitters regulated by IC must comply with RF exposure requirements listed in RSS-102 - Radio Frequency (RF) Exposure Compliance of Radiocommunication Apparatus (All Frequency Bands). 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. End-users must be provided with transmitter operating conditions for satisfying RF Exposure compliance.

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

6.4.4.2 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, an OEM integrator implementing NORA-W10 WLAN capability into an end-product must ensure a separation distance of at least 63 mm between the user (or bystander) and the antenna (or radiating element). The separation distance may be reduced to 34 mm in applications where the WLAN capability is turned off and only the Bluetooth LE capability of NORA-W10 is utilized.

☞ KDB 996369 D03 section 2.4 (limited module procedures) is not applicable to NORA-W10 series modules.

☞ KDB 996369 D03 section 2.5 (trace antenna designs) is not applicable to NORA-W10 series modules.

[4] 47 CFR §15.202

6.4.5 End-product user manual instructions

6.4.5.1 ISED compliance

The NORA-W10 module 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.

6.4.6 End-product labeling requirements

6.4.6.1 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 14.

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 14: Example of an end product label

6.4.6.2 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 14: Example of an end product label

.

The label must be affixed to 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 to 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.

6.4.7 End-product compliance

6.4.7.1 General requirements

- Any changes to hardware, hosts or co-location configuration may require new radiated emission and SAR evaluation and/or testing.
- The regulatory compliance of the NORA-W10 modules does not exempt
- Only authorized antenna(s) may be used.
- Any notification to the end user about how to install or remove the integrated radio module is NOT allowed.
- The approval of the modular transmitter in NORA-W10 series modules does not exempt the end product from being evaluated against any applicable regulatory demands. The evaluation of the end product shall be performed with the NORA-W10 module installed and operating in a way that reflects the intended use case of the end product. The upper frequency measurement range for the end product evaluation is the 5th harmonic of 2.4 GHz as declared in 47 CFR Part 15.33 (b)(1).
- 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 complies with the requirements of FCC part 15B the integrator shall perform sufficient measurements using equipment compliant with ANSI 63.4-2014.
  - Subpart C - INTENTIONAL RADIATORS

    The integrator must carry out sufficient verification measurements, using compliant ANSI 63.10-2013 equipment, to validate that the fundamental and out-of-band emissions of the transmitter part of the composite device comply with the requirements of FCC part 15C.

- When the items listed above are fulfilled, the end product manufacturer can use the authorization procedures 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.

6.4.7.2 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.

6.4.7.3 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

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 15. The marking must be visible for inspection.

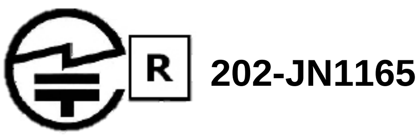


Figure 15: Giteki mark R and NORA-W10 MIC certification number

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

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 tolerate interference from legal communications or ISM radio wave radiated devices and must not cause harmful interference to them.

6.6.2 Labeling requirements for end product

End products based on NORA-W10 series modules and targeted for distribution in Taiwan must carry labels with the textual and graphical elements shown below.

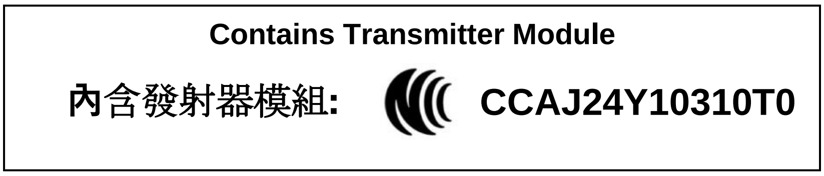


Figure 16: Example of an end product label that includes a NORA-W101 module

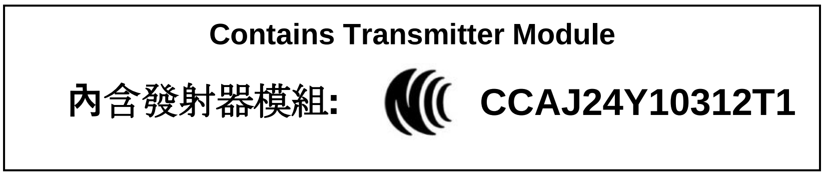


Figure 17: Example of an end product label that includes a NORA-W106 module

⚠ 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

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.

R-C-ULX-NORA-W101

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

6.8 Brazil compliance

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).

ANATEL
15817-23-01056

"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 packaging 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

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. Contact your local support team for more information.

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 SRRC China Radio Transmission Equipment Type Approval

In accordance with the provisions on the Radio Regulations of the People's Republic of China, the NORA-W106 module with the product name NORA-W106 conforms to the provisions with its CMIIT ID: 24J993CLD252.

6.11.1 NORA-W106 labeling requirements for end product statement

The following requirements apply for end products that are sold in China:

- Label with CMIIT ID number of the module is required to be placed on the end product.
- The following statement must be included in Chinese in the Chinese user manual:

本设备包含型号核准代码(分别)为: CMIIT ID: 24J993CLD252的无线电发射模块。

6.12 Safety compliance

For compliance with safety standard EN 62368-1 [13], NORA-W10 modules must be supplied with a Class-2 Limited Power Source.

6.13 Pre-approved antennas list

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

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

For each antenna, the "Approvals" field defines in which test reports the antenna is included. Definitions of the «Approvals» field are:

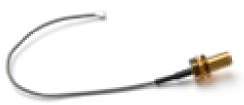
- FCC - The antenna is included in the FCC test reports and thus approved for use in countries that accept the FCC radio approvals, primarily US.
- IC - The antenna is included in the IC (Industrie Canada) test reports and thus approved for use in countries that accept the IC radio approvals, primarily Canada.

- RED - The antenna is included in the ETSI test reports and thus approved for use in countries that accept the Radio Equipment Directive, primarily the European countries.
- MIC - The antenna is included in the Japanese government affiliated MIC test reports and thus approved for use in the Japanese market.
- NCC - The antenna is included in the Taiwan NCC test reports and thus approved for use in Taiwan.
- KCC - The antenna is included in the KCC test reports and thus approved for use in South Korea.
- ANATEL – The antenna is included in the Brazil ANATEL test reports and thus approved for use in Brazil.
- ACMA – The antenna is included in the Australia and New Zealand test reports and thus approved for use in Australia and New Zealand.
- ICASA – The antenna is included in the South Africa ICASA test reports and thus approved for use in South Africa.

6.13.1 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. For information on how to integrate the U.FL connector, see RF connector design.
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. 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-W10 FCC/IC modular approvals.
Approval	FCC, IC, RED, UKCA, MIC, NCC, KCC, ANATEL, ACMA and ICASA



6.13.2 Single band antennas

NORA-W106 internal antenna	
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 2.4 GHz monopole antenna SMA, 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

RF 2.4 GHZ whip antenna, 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, NCC, KCC, ANATEL, ACMA, and ICASA *Not approved for use in Japan

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-W10 FCC/IC modular approvals.
Approval	FCC, IC, RED, UKCA, NCC, KCC, ANATEL, ACMA and ICASA *Not approved for use in Japan

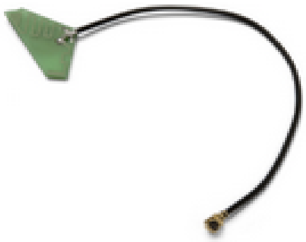
Wi-Fi / Bluetooth / Bluetooth LE external whip antenna, PN PRO-EX-333	
Manufacturer	Abracon
Polarization	Vertical
Gain	+3.0 dBi
Impedance	50 Ω
Size	Ø 10 x 83 mm
Type	Monopole
Connector	Reverse Polarity SMA plug (inner thread and pin receptacle)
Comment	To be mounted with a U.FL to Reverse Polarity SMA 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. This reference design must be followed this reference design to comply with the NORA-W10 FCC/IC modular approvals.	
Approval	FCC, IC, RED, UKCA, NCC, KCC, ANATEL, ACMA and ICASA *Not approved for use in Japan	

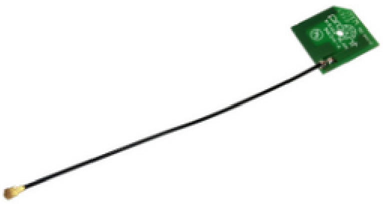
Wi-Fi / Bluetooth / Bluetooth LE board antenna, PN PRO-IS-237		
Manufacturer	Abracon	
Gain	+3.0 dBi	
Impedance	50 Ω	
Size	27 x 12 mm (triangular)	
Type	Patch	
Cable length	100 mm	
Connector	U.FL. connector	
Comment	Should be attached to a plastic enclosure or part for best performance. To be mounted 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	

6.13.3 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-W10 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, NCC, KCC, ANATEL, ACMA, and ICASA *Not approved for use in Japan

7 Product testing

7.1 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 18 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 18: Automatic test equipment for module test

7.2 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.

7.2.1 “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.

7.3 Radio performance test

Users can take full advantage of the ESP RF Test Tool, which is a specialized utility developed by Espressif Systems for conducting RF performance tests on their range of ESP series chips, including ESP32, ESP32-C3, ESP32-S3, ESP32-C6, ESP32-C2, ESP32-H2, and ESP82661. This tool is essential for ensuring that devices meet regulatory compliance and performance standards.

The ESP RF Test Tool consists of five parts: Serial Port Configuration, Download Status, Download Path Configuration, RF Test settings and Control, and Log Management as shown in Figure 19.

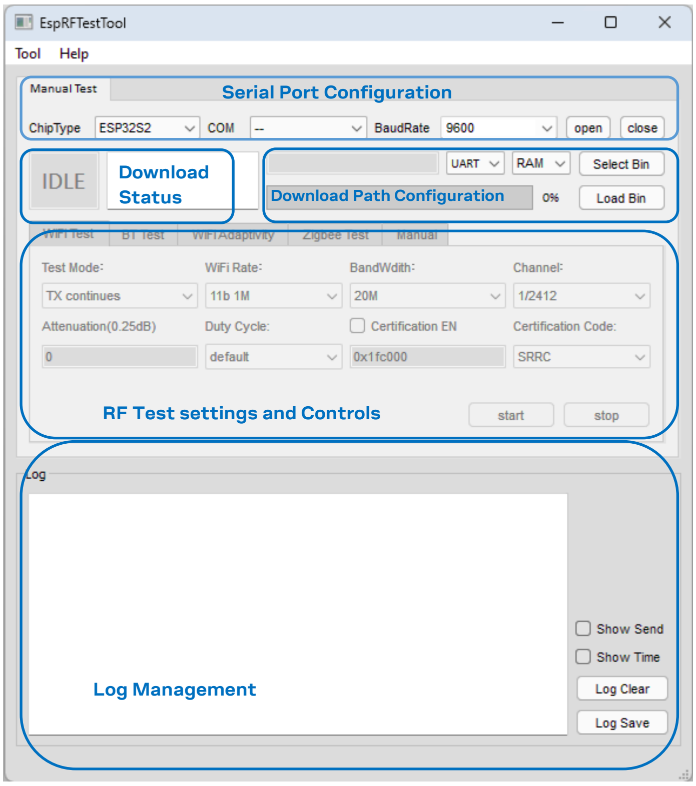


Figure 19: ESP RF performance test tool

The tool allows users to perform various RF tests to evaluate the performance of NORA-W10 modules under different conditions. It includes specific firmware designed to facilitate RF performance testing and a test guide that offers detailed instructions on setting up and conducting tests, ensuring accurate and reliable results.

This tool is invaluable for developers and engineers working with NORA-W10 modules, providing a robust framework for ensuring their applications are compliant and perform optimally in real-world scenarios.

7.3.1 Download and setup

To download and set up the ESP RF Test Tool, follow these steps:

1. Go to Espressif website for the EspRFTestTool Toolkit.
2. Follow the “Download Link” on this website to obtain the zip package with the latest version of the toolkit. This zip file includes the EspRFTestTool toolkit, necessary firmware for RF tests, and test guides. The downloaded file should be named something similar to “EspRFTestTool_v3.6_Manual.zip”.
3. Unzip the package and open the “ESP_RF_Test_Guide_EN.pdf” found in the “help” folder. Within the “RF Test” chapter, you will find “Download Instructions” on how to download firmware for RF testing to the module.

4. During the step “Select which firmware to download,” ensure you select the correct file for the ESP32-S3. The file should be named something similar to “ESP32-S3_xxxxxx_xxxx.bin.”
5. For FCC, CE, or SRRC certifications, refer to the following documents located in the “help” folder of the downloaded package:
    - FCC_Certification_Guide_EN.pdf
    - CE_Certification_Guide_EN.pdf
    - SRRC_Certification_Guide_EN.pdf

7.3.2 Wi-Fi emission test

During these tests, the radio can be configured to transmit a modulated carrier at 90% duty cycle and maximum output power. It is important to use the correct power parameter for each channel according to FCC/ETSI certifications.

The power parameter is the attenuation (higher value -> lower output power) related to maximum allowed output power and is different depending on the channel. The step size is 0.25dB -> add 4 decreases the output power by 1 dB. For example, attenuation value of Channel 1, 11b rate would be ***16 x 0.25= 4 dB***.

☞ The band edge requirement for FCC requires the output power for the band edge channels to be reduced.

Table 12 and Table 13 list the attenuation values for each channel and data rate for operation in the FCC/ISED and ETSI/Japan regulatory domains.

7.3.2.1 FCC/ISED

	b-rate		g-rate		n-rate 20/40 MHz	
Ch	**Rate**	**Value**	**Rate**	**Value**	**Rate**	**Value**
1-11	1Mb/s	16	6Mb/s	16	MCS0	16
	2Mb/s	16	9Mb/s	16	MCS1	16
	5.5Mb/s	16	12Mb/s	16	MCS2	16
	11Mb/s	16	18Mb/s	16	MCS3	16
	-	-	24Mb/s	16	MCS4	16
	-	-	36Mb/s	16	MCS5	16
	-	-	48Mb/s	16	MCS6	16
	-	-	54Mb/s	16	MCS7	16

Table 12: FCC/ISED Wi-Fi power parameters

7.3.2.2 ETSI/Japan

	b-rate		g-rate		n-rate 20/40 MHz	
Ch	**Rate**	**Value**	**Rate**	**Value**	**Rate**	**Value**
1-13	1Mb/s	16	6Mb/s	16	MCS0	16
	2Mb/s	16	9Mb/s	16	MCS1	16
	5.5Mb/s	16	12Mb/s	16	MCS2	16
	11Mb/s	16	18Mb/s	16	MCS3	16
	-	-	24Mb/s	16	MCS4	16
	-	-	36Mb/s	16	MCS5	16
	-	-	48Mb/s	16	MCS6	16
	-	-	54Mb/s	16	MCS7	16

Table 13: ETSI/Japan Wi-Fi power parameters

7.3.3 Bluetooth classic and Bluetooth LE emission test

The firmware used for Bluetooth classic/Low Energy emission tests are the same as that for Wi-Fi emission tests.

Figure 20 shows the Bluetooth Classic TX data test settings on channel 7 with power level 6, no hopping, bitrate 3M, and packet type DH3 and 1010.

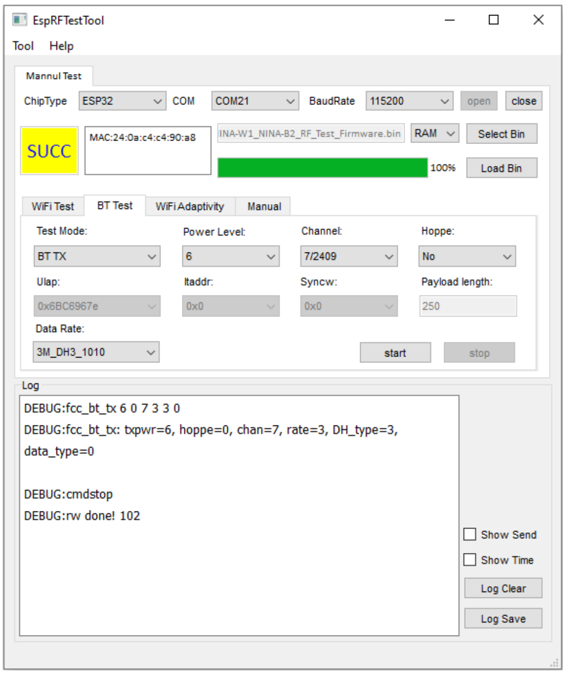


Figure 20: Bluetooth Classic TX data test

Appendix

A Antenna reference designs

Designers can take full advantage of NORA-W10's Single-Modular Transmitter certification approval by integrating the u-blox reference design into their products. This approach requires compliance with the following rules:

- Only listed antennas can be used. See also Pre-approved antennas list.
- Schematics and parts used in the design must be identical to the reference design. Use only parts validated by u-blox for antenna matching.
- PCB layout must be identical to the one provided by u-blox. Implement one of the reference designs described in this section or contact u-blox.
- The designer must use the PCB stack-up provided by u-blox. RF traces on the carrier PCB are part of the certified design.

When using the NORA-W101 with this antenna reference design, the circuit trace layout must be made in strict compliance with the antenna reference design described in this appendix.

A.1 Reference design for external antennas (U.FL connector)

The reference design uses a U.FL micro-coaxial connector to connect the external antenna via a 50 Ω coaxial cable. Figure 21 shows the placement of the connector in relation to the module footprint. The components connected to the RF trace must be kept as shown in the reference design.

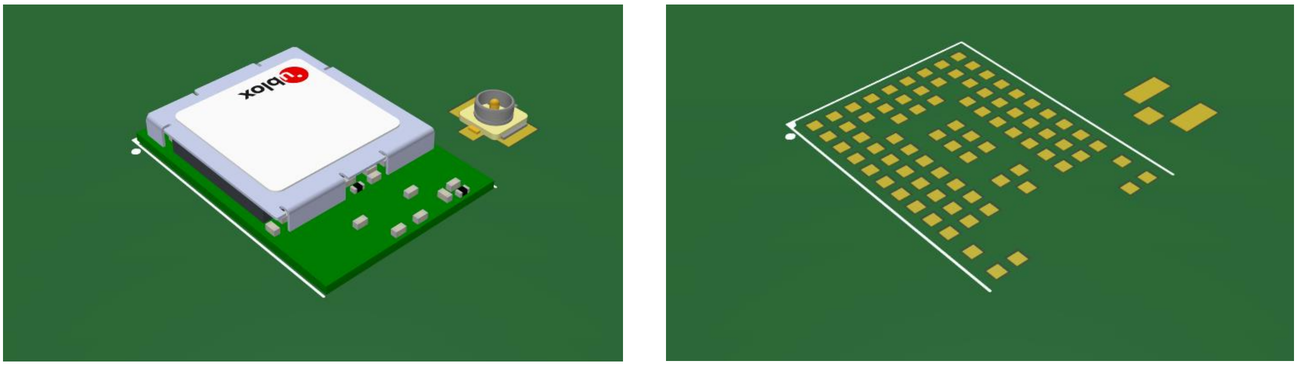


Figure 21: U.FL connector placement (left) and module footprint (right)

A.1.1 Floor plan

Figure 22 and Figure 23 show the critical components and positioning of the copper traces in the reference design. The itemized references are described in Table 14.

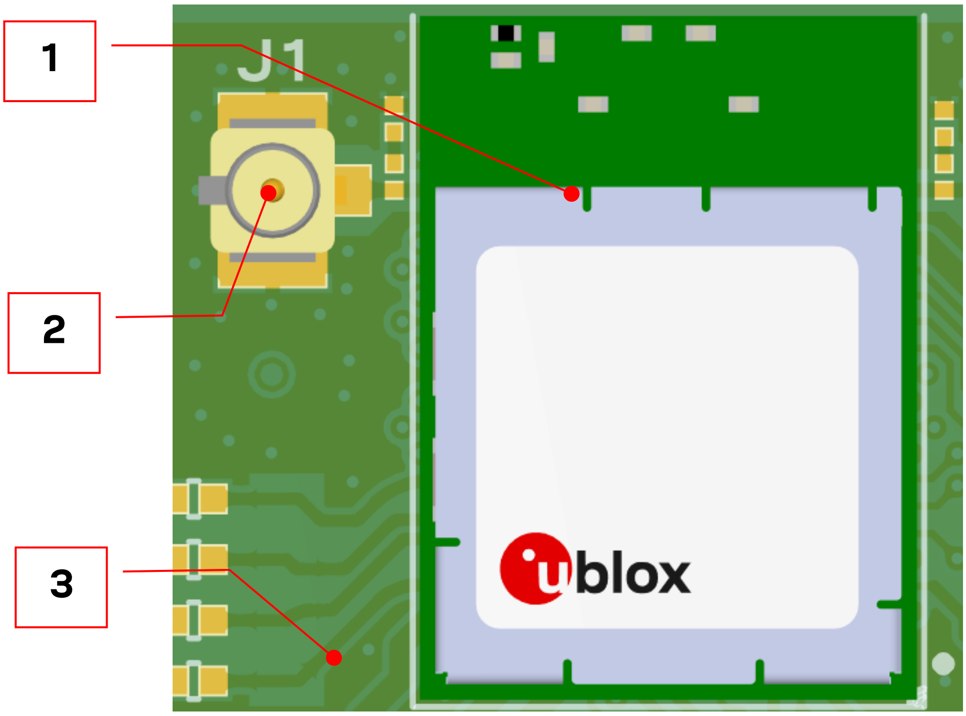


Figure 22: NORA-W101 antenna reference design 1

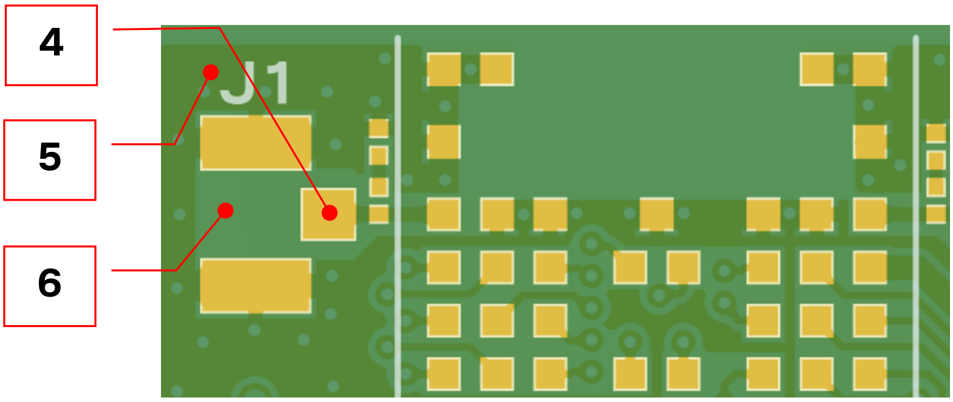


Figure 23: NORA-W101 antenna reference design 2

Reference	Part	Manufacturer	Description
1	NORA-W101	u-blox	NORA-W40 module with antenna pin
2	U.FL-R-SMT-1(10)	Hirose	Coaxial connector, 0 – 6 GHz, for external antennas
3	Carrier PCB		Should have a solid GND inner layer underneath and around the RF components (vias and small openings are allowed)
4	RF trace		Antenna coplanar microstrip, matched to 50 Ω
5	GND trace		Minimum required top layer GND-trace. See also Figure 25. All dimensions are shown in millimeters (mm).
6	Copper keep-out area		Keep this area free from any copper on the top layer

Table 14: Antenna reference design – item descriptions

A.1.2 RF trace specification

The dimensions of the 50 Ω coplanar microstrip used in the reference design are shown in Figure 24 and described in Table 15. GND stitching vias should be used around the RF trace to ensure a proper GND connection. No other components are allowed within this area.

The solid GND layer beneath the "top layer" shall surround at least the entire RF trace and connector. No signal traces are allowed to be routed on the GND layer within this area but vias and small openings are allowed.

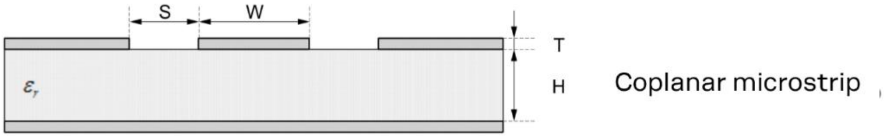


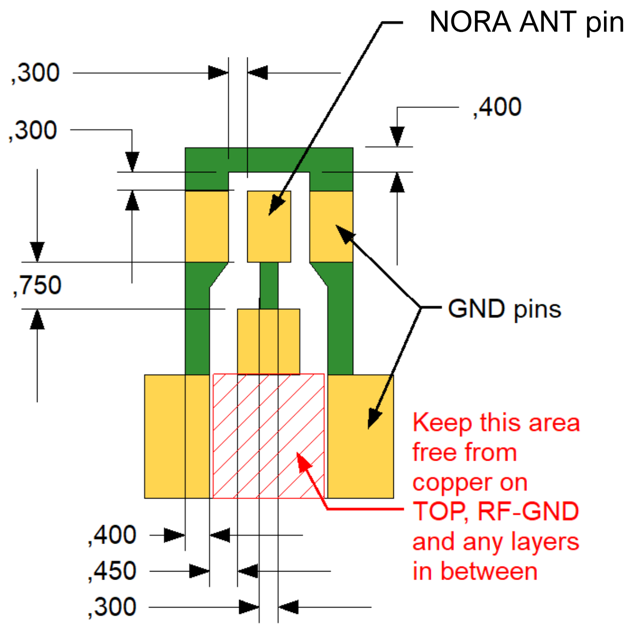
Figure 24: Coplanar microstrip dimension specification

Reference	Item	Value
S	Spacing	200 +/- 50 µm
W	Conductor width	300 +/- 30 µm (match as close to 50 Ω as possible)
T	Copper and plating/surface coating thickness	35 +/- 15 µm
H	Conductor height	150 +/- 20 µm
ε_r	Dielectric constant (relative permittivity)	3.77 +/- 0.5 @ 2 GHz

Table 15: Coplanar microstrip specification

☞ The GND spacing requirements of the IRIS ANT and U.FL connector RF pins are greater than the spacing requirement of a 50 Ω coplanar microstrip. However, when using the conductor width and height specified in Figure 25, the increased spacing to GND does not significantly affect the trace impedance for short trace lengths. Therefore, the impedance is still close to 50 Ω.

Figure 25 shows the **ANT** and **GND** pins, with the dimensions of the U.FL connector, and the copper-free area on RF-GND.



All dimensions are shown in mm

Figure 25: RF trace and minimum required GND trace of the U.FL antenna connector reference design

B 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
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
PCI	Peripheral Component Interconnect
PCIe	PCI Express
PCM	Pulse-code modulation

Abbreviation	Definition
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
SDK	Software Development Kit
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 16: Explanation of the abbreviations and terms used

Related documentation

[1] NORA-W10 series product summary, UBX-17051775
[2] NORA-W10 series data sheet, 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] Espressif ESP32-S3 v4.4 SDK Get Started
[5] ESP-IDF Programming Guide
[6] Product packaging reference guide, UBX-14001652
[7] JEDEC J-STD-020E - Moisture/Reflow Sensitivity Classification for Non-hermetic Surface Mount Devices
[8] u-blox SHO-OpenCPU GitHub repository
[9] NORA-W10 EU Declaration of Conformity, UBX-22023925
[10] NORA-W10 UKCA Declaration of Conformity, UBX-22040049
[11] FCC guidance 594280 D01 Configuration Control v02 r01
[12] FCC guidance 594280 D02 U-NII Device Security v01r03
[13] EN 62368-1 - Audio/video, information and communication technology equipment - Part 1: Safety requirements
[14] espressif/arduino-esp32 GitHub repository, espressif/arduino-esp32
[15] Arduino ESP32 support documentation, https://docs.espressif.com/projects/arduino-esp32/en/latest/getting_started.html

☞ 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	15-Mar-2023	lkis	Country approval list updated in Table 10. FCC ID and ISED certification number added in Table 11. Added descriptions for channel 12 and 13 usage restrictions in Configuration control and software security of end-products. Added Operating frequencies. SAR minimum distance updated in RF exposure statement. Updated RF transmission line design (NORA-W101). Added CE End-product regulatory compliance and Safety compliance.
R05	04-Sep-2023	lkis	Added product variant NORA-W106-10B in Document information and in Module architecture. Timing requirements of bootstrap pins added in Bootstrap pins. Added 'Not approved for use in Japan' disclaimer for antennas PRO-EX-286, PRO-EX-348, PRO-EX-327 in Pre-approved antennas list. Reorganized description of antenna options now included in Antenna solutions. Removed pin list (maintained in data sheet), Added note to highlight pre-certification limitations for external antennas in Approved antenna designs. Added frame configuration parameters in Universal asynchronous serial interface (UART). Described good practice for connecting GND pins, added summary of Wi-Fi/Bluetooth coexistence requirements in Antenna integration, added Thermal guidelines. Included minor editorial throughout the document.
R06	01-Nov-2024	lkis, ftor, lber, fkru	Minor editorial updates. Brazil approval updated in Brazil compliance. Added 'Not approved for use in Japan' disclaimer for antenna PRO-EX-296 in Pre-approved antennas list. Removed Bluetooth qualification section – now maintained in the data sheet. Restructured the Software section. Details for Wi-Fi output power configuration has been removed from chapter Wi-Fi output power configuration and added to GitHub.. Added the Arduino support for NORA-W10 section. Adjusted number of allowed reflow processes to on in Reflow soldering process. Antenna keepout area and GND plane dimensions updated. Allowed number of Soldering cycle removed and added a conditional note under Table 9. Approval information added for Giteki, NCC, SRRC and KCC. Relevant references added in Design-in checklists. Added Radio performance test and Antenna reference designs chapter.
R07	02-Dec-2024	lkis	U.FL connector layout Figure 8 added in chapter RF connector design. Several figure and table x-refs fixed. ESP RF test tool and test guide download link fixed in Download and setup.

Contact

u-blox AG

Address: Zürcherstrasse 68
8800 Thalwil
Switzerland

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