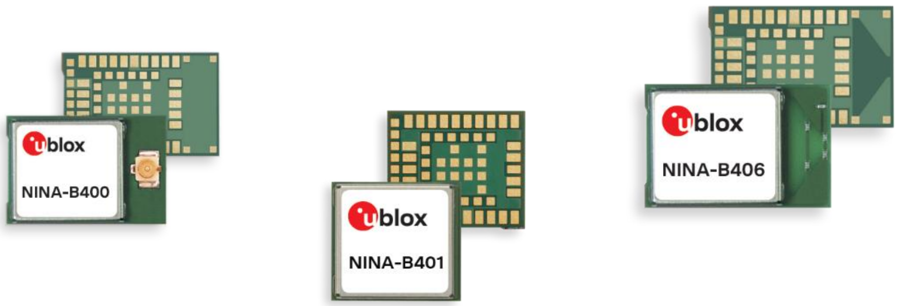
S

NINA-B4 series

Stand-alone Bluetooth 5.1 low energy modules

System integration manual



Abstract

Used together with the respective module data sheets that describe the pinout and module functions, this manual provides a functional overview combined with best-practice design guidelines for integrating the short-range module in an end product. With several supporting examples, the document explains how applications are developed for NINA-B4 open cpu solutions using the Nordic SDK. It also describes the options for flashing the u-connectXpress module software in production environments.

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Document information

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Functional sample	Draft	For functional testing. Revised and supplementary data will be published later.
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This document applies to the following products:

Product name	**Document status**
NINA-B400	Initial Production
NINA-B401	Initial Production
NINA-B406	Initial Production
NINA-B410	Initial Production
NINA-B411	Initial Production
NINA-B416	Initial Production

☞ For information about the related hardware, software, and status of listed product types, refer to the respective data sheets [2][3].

Contents

1 Functional description

1.1 Overview

The NINA-B4 series is comprised of small, standalone Bluetooth low energy wireless modules featuring full Bluetooth 5.1.

Based on the Nordic Semiconductor nRF52833 chip that includes an integrated RF core and powerful Arm® Cortex®-M4 processor with FPU, NINA-B4 modules include the S140 SoftDevice radio stack that operates as a Bluetooth 5.1 low energy central and peripheral protocol stack solution – as well as in Thread, Zigbee 802.15.4, and Nordic proprietary modes (NINA-B40 only).

For a flexible and innovative approach to application design, two conceptually different architecture solutions are available: u-connectXpress (B41) or open cpu (B40). End-user products based on either architecture are developed on pre-certified u-blox reference designs that are qualified with the regional regulatory bodies for your chosen product markets. This approach to application development provides good opportunity for less compliance testing, lower development cost, and reduced time to market.

With an operational temperature range that spans from -40 up to +105°C, NINA-B4 modules are ideal for harsh industrial or lighting applications that must operate at high ambient temperatures. NINA-B41 also caters towards applications in smart buildings, smart cities, industrial automation systems, sensor networks and asset tracking solutions.

Featuring Angle of Arrival (AoA) and Angle of Departure (AoD) transceivers, the NINA-B40 series supports the Bluetooth 5.1 Direction Finding service. The service can be used for indoor positioning, wayfinding, and asset tracking.

NINA-B4 modules integrates internal power management circuitry requiring only a single supply voltage in the range of 1.7 – 3.6 V. The broad supply range also makes the modules particularly useful in battery powered systems.

With the same pinout, physical size, and mechanical design of NINA-B3 modules, NINA-B4 offers a natural upgrade path for existing NINA applications.

Table 1 describes the various models in the NINA-B40 series.

Model	Description
NINA-B400	Bluetooth 5.1 module that includes a powerful Arm® Cortex®-M4 with FPU and delivers state-of-the-art power performance. All NINA-B40 variants are open CPU modules that enable customer applications to run on the built-in Arm® Cortex®-M4 with FPU. With 512 kB flash and 128 kB RAM, these modules offer respectable capacity for customer applications on top of the Bluetooth Low Energy stack. NINA-B400 has a U.FL connector for use with an external antenna.
NINA-B401	Bluetooth 5.1 module that includes a powerful Arm® Cortex®-M4 with FPU and delivers state-of-the-art power performance. All NINA-B40 variants are open CPU modules that enable customer applications to run on the built-in Arm® Cortex®-M4 with FPU. With 512 kB flash and 128 kB RAM, these modules offer respectable capacity for customer applications on top of the Bluetooth Low Energy stack. NINA-B401 has an RF pin for use with an external antenna.
NINA-B406	Bluetooth 5.1 module that includes a powerful Arm® Cortex®-M4 with FPU and delivers state-of-the-art power performance. All NINA-B40 variants are open CPU modules that enable customer applications to run on the built-in Arm® Cortex®-M4 with FPU. With 512 kB flash and 128 kB RAM, these modules offer respectable capacity for customer applications on top of the Bluetooth Low Energy stack. NINA-B406 has an internal PCB trace antenna with an extensive range. The antenna is specifically designed for embedded devices.

Table 1: NINA-B40 series

Table 2 describes the different models in the NINA-B41 series.

Model	Description
NINA-B410	Bluetooth 5.1 module that includes a powerful Arm® Cortex®-M4 with FPU and delivers state-of-the-art power performance. All NINA-B41 variants have u-connectXpress software pre-flashed. NINA-B410 has a U.FL connector for use with an external antenna.
NINA-B411	Bluetooth 5.1 module that includes a powerful Arm® Cortex®-M4 with FPU and delivers state-of-the-art power performance. All NINA-B41 variants have u-connectXpress software pre-flashed. NINA-B411 has an RF pin for use with an external antenna.
NINA-B416	Bluetooth 5.1 module that includes a powerful Arm® Cortex®-M4 with FPU and delivers state-of-the-art power performance. All NINA-B41 variants have u-connectXpress software pre-flashed. NINA-B416 has an internal PCB trace antenna with an extensive range. The antenna is specifically designed for embedded devices.

Table 2: NINA-B41 series

☞ Already globally certified for use with an internal antenna or range of external antennas, the time, cost, and effort spent on deploying NINA-B4 modules into customer applications is reduced significantly.

1.2 Applications

- Industrial automation
- Smart buildings and cities
- Low power sensors
- Wireless-connected and configurable equipment
- Point-of-sales
- Health devices
- Real-time Location, RTLS
- Indoor positioning
- Asset tracking

1.3 Block diagrams

Block diagrams of the NINA-B40 and NINA-B41 module designs are shown in Figure 1 and Figure 2.

1.3.1 NINA-B40

A block diagram of the NINA-B40 open-cpu module design showing the alternative U.FL connector (B400), antenna pin (B401), and PCB trace antenna (B406) solutions is shown in Figure 1.

☞ NINA-B400 modules include a U.FL connector for connecting an external antenna. The module size is 10 x 15 x 2.2 mm.

☞ NINA-B401 modules include an ANT pad on the footprint for connecting an external antenna. The module size is 10 x 11.6 x 2.2 mm.

☞ NINA-B406 module support an internal PCB trace antenna using antenna technology from Proant AB. The module size is 10 x 15 x 2.2 mm.

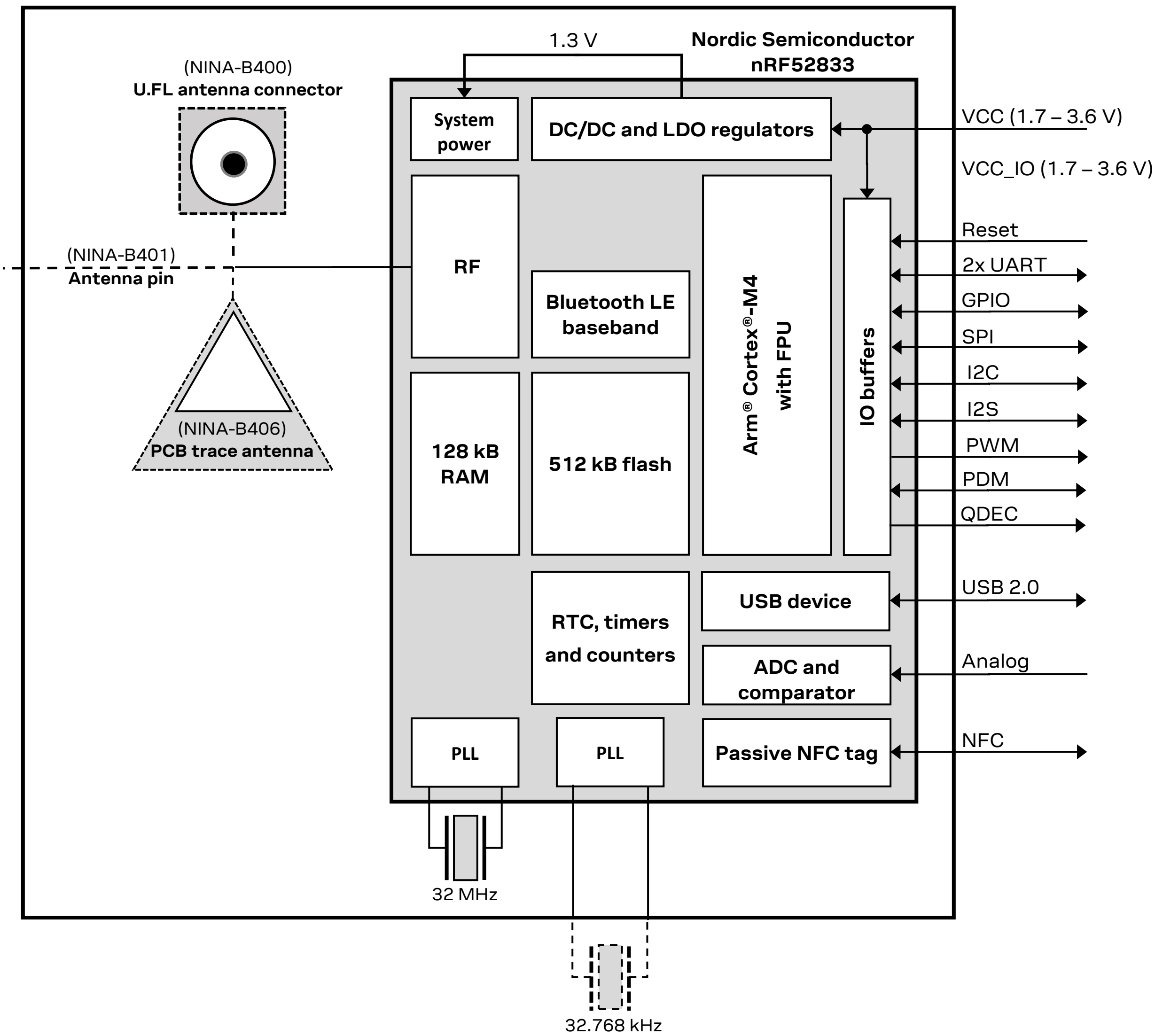


Figure 1: NINA-B40 series block diagram

1.3.2 NINA-B41

A block diagram of the NINA-B4 u-connect module design showing the alternative U.FL connector (B410), antenna pin (B411), and PCB trace antenna (B416) solutions is shown in Figure 2.

☞ NINA-B410 modules support a U.FL connector to accommodate an external antenna. The module size is 10 x 15 x 2.2 mm.

☞ NINA-B411 modules have a footprint arrangement that includes an ANT pad for connecting an external antenna. The module size is 10 x 11.6 x 2.2 mm.

☞ NINA-B416 modules support an internal PCB trace antenna using antenna technology from Proant AB. The module size is 10 x 15 x 2.2 mm.

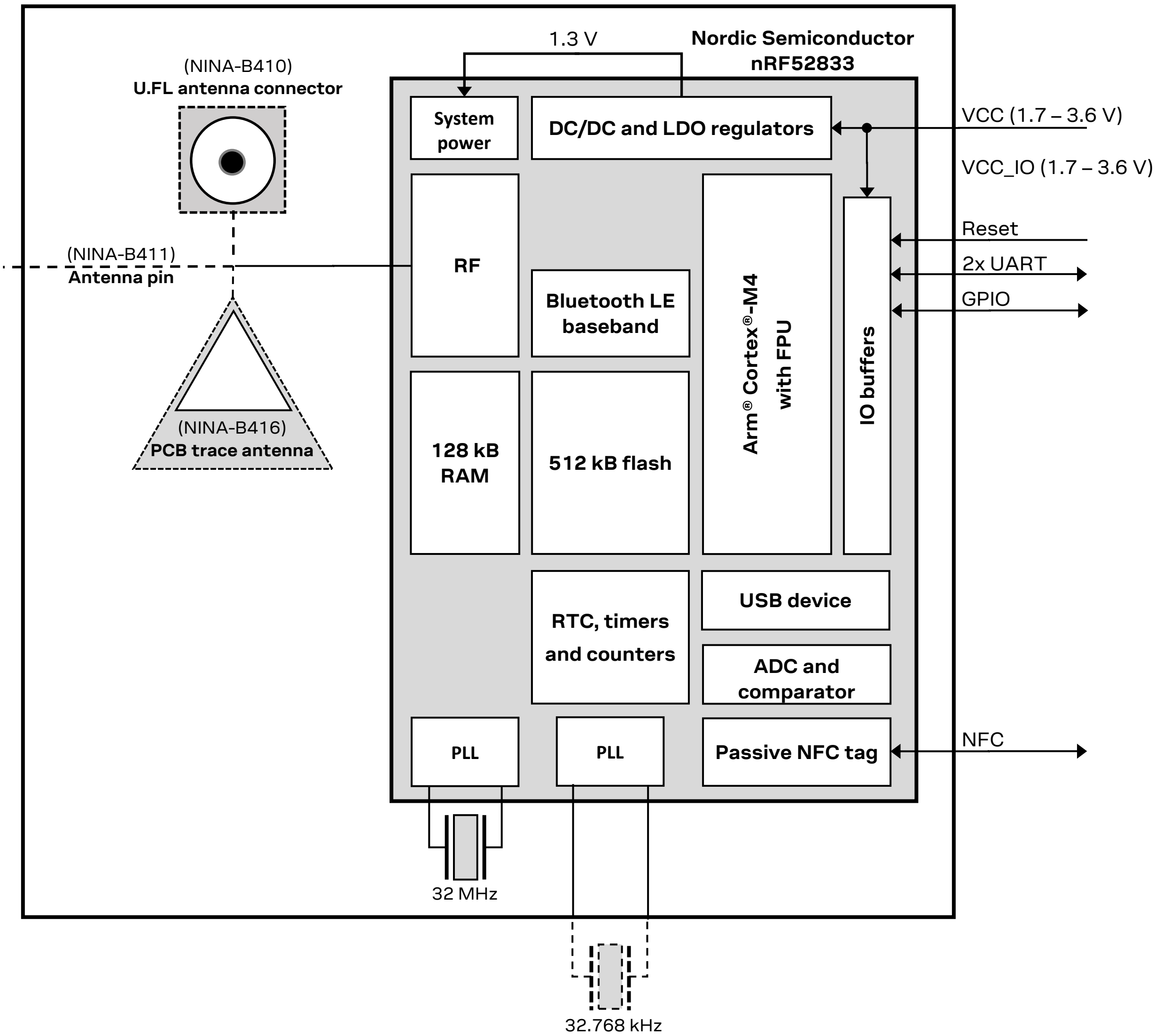


Figure 2: NINA-B41 series block diagram

1.4 Product description

Please see the data sheet for the respective product family [2] [3] for the latest data.

1.4.1 NINA-B40 series

Item	NINA-B400	NINA-B401	NINA-B406
Bluetooth version	5.1	5.1	5.1
Band support	2.4 GHz, 40 channels	2.4 GHz, 40 channels	2.4 GHz, 40 channels
Typical conducted output power	+8 dBm	+8 dBm	-
Radiated output power (EIRP)	+11 dBm (with typical antenna)	+11 dBm (with typical antenna)	+11 dBm
RX sensitivity (conducted)	-95 dBm	-95 dBm	-95 dBm
RX sensitivity, long range mode (conducted)	-102 dBm	-102 dBm	-102 dBm
Supported 2.4 GHz radio modes	Bluetooth Low Energy IEEE 802.15.4 Proprietary 2.4 GHz modes	Bluetooth Low Energy IEEE 802.15.4 Proprietary 2.4 GHz modes	Bluetooth Low Energy IEEE 802.15.4 Proprietary 2.4 GHz modes
Supported Bluetooth LE data rates	1 Mbps 2 Mbps 500 kbps 125 kbps	1 Mbps 2 Mbps 500 kbps 125 kbps	1 Mbps 2 Mbps 500 kbps 125 kbps
Module size	10.0 x 15.0 mm	10.0 x 11.6 mm	10.0 x 15.0 mm

Table 3: NINA-B4 series characteristics summary

1.4.2 NINA-B41 series

Item	NINA-B410	NINA-B411	NINA-B416
Bluetooth version	5.1	5.1	5.1
Band support	2.4 GHz, 40 channels	2.4 GHz, 40 channels	2.4 GHz, 40 channels
Typical conducted output power	+8 dBm	+8 dBm	-
Radiated output power (EIRP)	+11 dBm (with typical antenna)	+11 dBm (with typical antenna)	+11 dBm
RX sensitivity (conducted)	-95 dBm	-95 dBm	-95 dBm
RX sensitivity, long range mode (conducted)	-102 dBm	-102 dBm	-102 dBm
Supported 2.4 GHz radio modes	Bluetooth Low Energy IEEE 802.15.4 Proprietary 2.4 GHz modes	Bluetooth Low Energy IEEE 802.15.4 Proprietary 2.4 GHz modes	Bluetooth Low Energy IEEE 802.15.4 Proprietary 2.4 GHz modes
Supported Bluetooth LE data rates	1 Mbps 2 Mbps 500 kbps 125 kbps	1 Mbps 2 Mbps 500 kbps 125 kbps	1 Mbps 2 Mbps 500 kbps 125 kbps
Module size	10.0 x 15.0 mm	10.0 x 11.6 mm	10.0 x 15.0 mm

Table 4: NINA-B4 series characteristics summary

1.5 Hardware options

Except for the different antenna solutions, NINA-B4 series modules use an identical hardware architecture based on nRF52833.

1.6 Software options

NINA-B4 modules are integrated with an Arm® Cortex®-M4 application processor with FPU, 512 kB flash memory and 128 kB RAM.

The structure of any software running on either NINA-B4 module variant includes the following components:

- Radio stack
- Bootloader (optional)
- Application software

Figure 3 shows the software architecture and implementation of software components for NINA-B40 and NINA-B41 modules:

- NINA-B40 modules host the customer application and optional bootloader software, developed using the Nordic SDK, in an open-CPU configuration on the module. See also section 1.6.1.
- NINA-B41 modules are pre-flashed with bootloader and u-connectXpress software that interfaces through an AT command interpreter for control by customer application software running on host MCUs. See also section 1.6.2.
- Both module variants include the Nordic S140 SoftDevice Bluetooth low energy protocol stack that supports GATT client and server, central and peripheral roles, and multidrop connections.

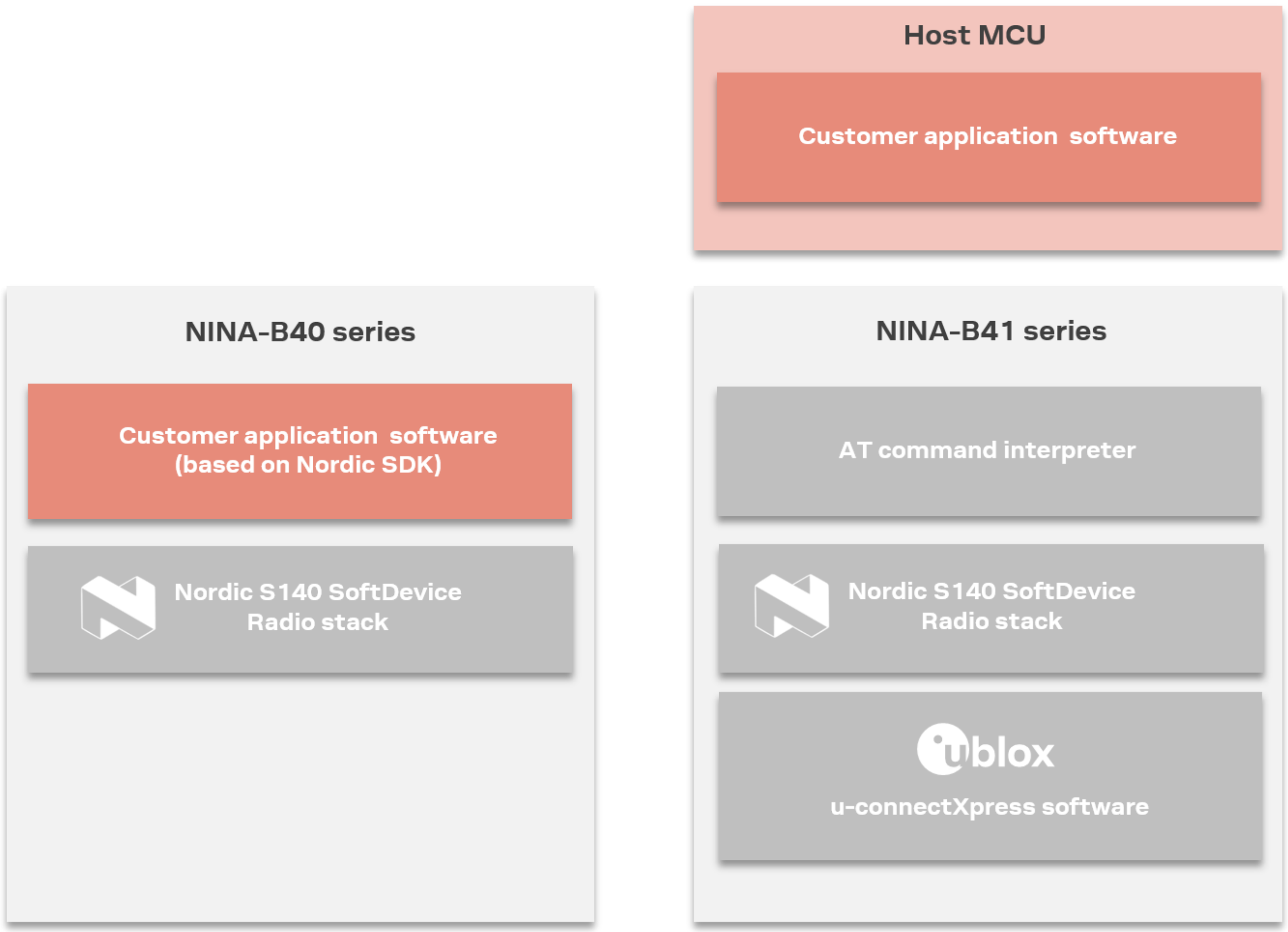


Figure 3: NINA-B4 software structure

1.6.1 Open CPU

The open CPU architecture of NINA-B40 series modules allows module integrators to build their own applications. Table 5 describes the possible connectivity and application support that is enabled with NINA-B40 hardware in the recommended Nordic SDK environment.

Feature	Support
Development environment	Nordic SDK (including Bluetooth Mesh HomeKit, AirFuel, IoT, Thread, Zigbee)
HW interfaces	2 x UART
	3 x SPI
	40 x GPIO pins
	8 x ADC channels
	1 x USB
	2 x I2C
	1 x I2S
	4 x PWM
	1 x QDEC
Security	Secure boot ready
	Secure Simple Pairing
	128-bit AES encryption
	Bluetooth low energy secure connections

Table 5: Open CPU software support

For further information about Open CPU software, see chapter 3.

1.6.2 u-connectXpress software

NINA-B41 modules are pre-flashed with u-connectXpress and bootloader software that interfaces through an AT command interpreter to control customer application software running on host MCUs. Table 6 describes the feature support in the u-connectXpress software.

Feature	Support
Bluetooth	u-blox Low Energy Serial Port Service (SPS)
	GATT server and client using AT commands
	Beacons
	2 Mbit/s modulation
	125 Kbit/s modulation long range functionality
	Advertising extensions
Configuration over air	Wireless transmission of AT commands to control the module
Extended Data Mode™	For simultaneous AT commands and data, and multiple simultaneous data streams
HW interfaces	2 x UART, GPIO
Configuration	AT commands
Support tools	s-center
Operating modes	Central role (7 simultaneous links)
	Peripheral role (6 simultaneous links)
	Simultaneous central and peripheral roles
	(8 in total, where max 4 as peripheral and max 7 as central)
	LE 1M PHY
	LE 2M PHY
	LE CODED PHY
	Advertising extensions
	LE data length extension
Security	Secure boot Secure Simple Pairing 128-bit AES encryption

Feature	Support
	Bluetooth low energy secure connections
Throughput over UART	780 Kbit/s

Table 6: u-connectXpress software support

See also u-connectXpress software.

1.6.3 u-connectLocate software

u-connectLocate is direction finding software from u-blox. The software runs on all NINA-B41x module variants that are enabled for Bluetooth Direction Finding. The ordering number for all module variants equipped with this software end with the suffix -4xB. For example, NINA-B411-4xB. See also the respective NINA data sheets [2][3].

☞ Note that modules enabled for direction finding cannot run regular u-connectXpress software. Consequently, the flashing procedure is different from that of all other u-blox modules. See also the XPLR-AOA explorer kits user guide [23].

1.7 Bluetooth device address

You can scan the data matrix barcode on the module label to retrieve the Bluetooth device address. For more information about the Bluetooth device address for NINA-B40x, see also Bluetooth device (MAC) address and other production data.

1.8 Pin configurations and functions

1.8.1 NINA-B40 pins

The pin functions of the versatile NINA-B40 open CPU should be selected with consideration to the pin-out and nRF52833 multiplexing. The pin assignments for NINA-B40 are shown in Figure 4.

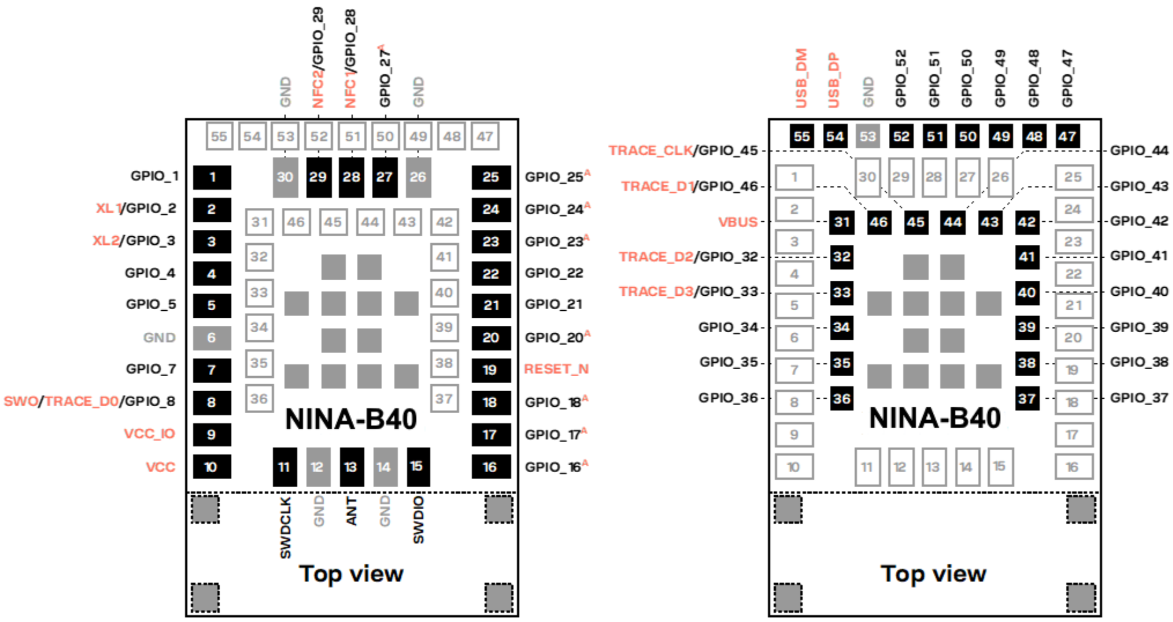


Figure 4: NINA-B40 pin assignments

☞ For more information about the pin assignments, see also the NINA-B40 series data sheet [2].

1.8.2 NINA-B41 pins

The u-connectXpress software running on NINA-B41 modules has fixed pin multiplexing that implements a given set of features, like the UART connection. The pin assignments for NINA-B41 are shown in Figure 5.

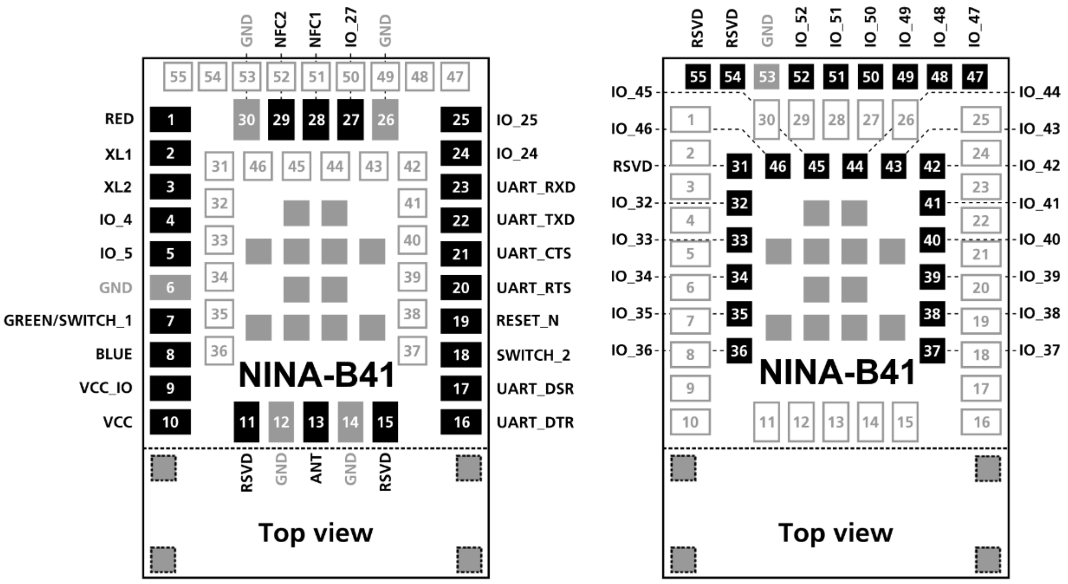


Figure 5: NINA-B41 pin assignments

☞ For more detailed information about pin assignment, see the NINA-B41 series data sheet [3].

1.9 Low power clock

NINA-B4 modules use a 32.768 kHz low power clock to enable different sleep modes.

The clock can be generated from either of the following sources:

- Internal oscillator
- External crystal (LFXO)
- External clock source such as a crystal oscillator (TCXO)

The u-connectXpress software automatically senses the clock input and uses the source from the external crystal – if one is available. Otherwise, the software uses the source from the internal oscillator. This automatic sense functionality adds some additional time delay during startup (about 1 s).

To reach the lowest sleep current consumption of the NINA-B4 module, an external crystal or external clock source shall be used. The internal oscillator gives higher sleep current but of course a leaner BOM. For more information about sleep and other power modes, see the respective data sheet [2] [3].

Sections 1.9.1 to 1.9.3 describe the different hardware options for the low power clock source and explain the implications the clock choices have on both the cost and performance of NINA-B4 modules. For practical guidance on how to configure the oscillator on nRF5 open CPU modules, see reference [21].

1.9.1 External crystal

NINA-B4 modules have two input pins for connecting an external low-frequency crystal (LXFO) as source for the low power clock. This setup enables NINA-B4 modules to run with the lowest overall power consumption.

Table 7 describes the details of the crystal used on EVK-NINA-B4.

Component	Value	Note
Crystal oscillator	32.768 kHz – 20 ppm	EPSON FC-12M used on NINA-B4 EVK

Table 7: Components used on the NINA-B4 EVK evaluation kit

☞ The specifications for external LFXO sources are described in the electrical specifications of the respective data sheet [2][3].

1.9.2 Internal oscillator

Choosing to use NINA-B4 modules with the internal oscillator makes for a leaner BOM reduces the cost to end users. This choice of oscillator adversely provides slightly higher sleep mode power consumption.

When using the internal oscillator, pins XL1 and XL2 must be connected to ground. In NINA-B40 these pins can be reassigned and used for GPIO.

⚠ To ensure that the clock is stable at +/- 250 ppm, the customer application software must check the calibration of the internal oscillator at least once every 8 seconds.

1.9.3 External clock source

As an alternative to using an external crystal, an external clock source generated from a host CPU or a TCXO can be used. The clock source can be either a low-swing or full-swing signal.

The electrical parameters are stated in the respective product data sheets [2] and [3].

Pin name	Parameter	Min	Typ	Max	Unit	Remarks
XL1	Input characteristic: Peak to Peak amplitude	200		1000	mV	Input signal must not swing outside supply rails.
XL2	-	-		-	-	Connect to GND

Table 8: Electrical parameters for a low-swing clock

Pin name	Parameter	Min	Typ	Max	Unit	Remarks
XL1	Input characteristic: Low-level input	0		0.3*VCC	V	
	Input characteristic: high-level input	0.7*VCC		VCC	V	
XL2	-	-	-	-	-	Connect to GND

Table 9: Electrical parameters for a full-swing clock

2 Design-in

2.1 NINA family migration design

NINA-B4 modules are based on the Nordic nRF52833 system on chip (SoC). The modules are compatible with the pin out of NINA-B3 modules. This means that application designs based on NINA-B3 modules can be easily upgraded for use with NINA-B4.

As the pin out supported in NINA-B1, NINA-B2, and NINA-W1 series modules share a common footprint, these modules can be positioned interchangeably in application designs. To accommodate the larger physical dimensions of NINA-B3 and NINA-B4 modules, a reserved “keep-out” of approximately 1 mm should be included in the design. In all other respects, the mechanical design of NINA-B4 modules is identical to that of other NINA modules. For more information about how to make a common design, see the Nested design application note [6].

2.2 Supply interfaces

2.2.1 Main supply input

The NINA-B4 series uses an integrated DC/DC converter to transform the supply voltage presented at the **VCC** pin into a stable system core voltage. Due to this, the NINA-B4 modules are compatible for use in battery powered designs.

While using NINA-B4 with a battery, it is important that the battery type can handle the peak power of the module. In case of battery supply, consider adding extra capacitance on the supply line to avoid capacity degradation. For information about voltage supply requirement and current consumption, see the respective datasheet [2][3].

2.2.2 Digital I/O interfaces reference voltage (VCC_IO)

On NINA-B4 series modules, the I/O voltage level is the same as the supply voltage and **VCC_IO** is internally connected to the supply input **VCC**.

When using NINA-B4 with a battery, the I/O voltage level varies with battery output voltage. The battery voltage depends on the battery “state of charge”. Level shifters might be needed to stabilize the voltage – depending on the I/O voltage of the host system and interfacing components.

2.2.3 VCC application circuits

The power for NINA-B4 series modules is provided through the VCC pins. The VCC supply can be taken from any of the following sources:

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

DC/DC efficiency should be evaluated as a tradeoff between active and idle duty cycle of the specific application. Although some DC/DC converters provide high efficiency with extremely light loads, their efficiency typically worsens when idle current drops below a few mA – greatly reducing the battery life.

2.2.3.1 Battery

The low current consumption and wide voltage range of NINA-B4 series modules means that a battery can be used as a main supply. In which case, the capacity of the battery must be selected to match the application. Ensure that the battery can deliver the peak current required by the module.

For further information about current consumption and other performance data, see also the electrical specifications in the respective product datasheet [2][3].

It is best practice to include bypass capacitors on the supply rails close to the NINA-B4 series module. Depending on the design of the power routing on the host system, capacitance might not be needed.

2.2.3.2 Switched Mode Power Supply

A Switched Mode Power Supply (SMPS) is ideal in situations where the available primary supply source has more than a moderately higher value than the operating supply voltage of the module. An SMPS minimizes the amount of current drawn from the main supply and optimizes power efficiency in the final application design.

⚠ When using an SMPS, ensure that the AC voltage ripple at switching frequency is kept as low as possible. The layout design must minimize impact of high frequency ringing.

2.2.3.3 Low Drop Out (LDO) regulator

An LDO linear regulator provides a convenient primary supply option when the voltage difference between the main supply and module VCC is reasonably small. The benefit of an LDO source over SMPS is that an LDO is simpler to integrate and does not generate switching noise. However, with a larger voltage difference, the superior efficiency of an SMPS converter provides less heat dissipation and a longer operating time in battery-powered products.

As a contingency against “latch up”, include an over-current limiter to protect the module from electrical over stress (EOS). An LDO or SMPS serves this purpose.

2.3 System function interfaces

2.3.1 Module reset

You can reset NINA-B4 modules by applying a low level on the **RESET_N** input pin, which is normally set high with an internal pull-up. This causes an “external” or “hardware” reset of the module. The current parameter settings are not saved in the non-volatile memory of the module and a proper network detach is not performed.

2.3.2 Internal temperature sensor

The radio chip in NINA-B4 contains a temperature sensor used for over and under temperature shutdown.

⚠ The temperature sensor is located inside the radio chip and should not be used if an accurate temperature reading of the surrounding environment is required.

2.4 Serial interfaces

⚠ As NINA B4 can be used with both the u-connectXpress and open CPU based applications based on the Nordic SDK, the available interfaces and pin mapping vary. See also Pin configurations and functions.

2.4.1 Universal Asynchronous Serial Interface (UART)

NINA B4 provides a Universal Asynchronous Serial Interface (UART) for data communication.

The following UART signals are available:

- Data lines (**RXD** as input, **TXD** as output)
- Hardware flow control lines (**CTS** as input, **RTS** as output)
- **DSR** and **DTS** are used to set and indicate system modes

The UART can be used as both a 4-wire UART with hardware flow control and a 2-wire UART with only **TXD** and **RXD**. If using the UART in 2-wire mode, **CTS** should be connected to GND on the NINA-B4 module.

Depending on the bootloader used, the UART interface can also be used for software upgrades. See also Software options.

The u-connectXpress software adds the **DSR** and **DTR** pins to the UART interface. These pins are not used as originally intended, but to control the state of the NINA-B4 module. Depending on the current configuration, the **DSR** can be used to:

- Enter command mode
- Disconnect and/or toggle connectable status
- Enable/disable the rest of the UART interface
- Enter/wake up from the sleep mode

For more information about the characteristics of the UART interface, see also the respective data sheets [2][3].

Interface	Default configuration
COM port	115200 baud, 8 data bits, no parity, 1 stop bit, hardware flow control

Table 10: Default settings for the COM port while using the u-connectXpress software

It is advisable to make the UART available either as test points or have them connected to a header for a software upgrade. The I/O level of the UART follows the VCC voltage, which means that it can consequently be in the range of 1.8 V and 3.6 V. Use a level shifter if you are connecting NINA-B4 to a host with a different voltage on the UART interface.

2.4.2 Serial Peripheral Interface (SPI)

NINA-B40 (only) supports up to three serial peripheral interfaces that can operate in both master and slave modes with a maximum serial clock frequency of 8 MHz in both these modes. The SPI interfaces use the following signals:

- **SCLK**
- **MOSI**
- **MISO**
- **CS**
- **DCX** (Data/Command signal). This signal is optional but is sometimes used by the SPI slaves to distinguish between SPI commands and data.

When using the SPI interface in master mode, it is possible to use GPIOs as additional Chip Select (CS) signals to allow addressing of multiple slaves.

2.4.3 I2C interface

The (NINA-B40 only) Inter-Integrated Circuit (I2C) interface can be used to transfer or receive data on a 2-wire bus network. NINA-B40 can operate as both master and slave on the I2C bus using both standard (100 kbps) and fast (400 kbps) transmission speeds. The interface uses the **SCL** signal to clock instructions and data on the **SDA** signal.

External pull-up resistors are required for the I2C interface. The value of the pull-up resistor should be selected depending on the speed and capacitance of the bus. See also the Electrical specifications in the NINA-B40 series data sheet [2] for recommended resistor values.

2.4.4 USB 2.0 interface

NINA-B40 series modules (only) include a full speed Universal Serial Bus (USB) device interface compliant with version 2.0 of the USB specification. The pin configuration of the USB interface is provided below:

- **VBUS**, 5 V supply input needed to use the interface
- **USB_DP**, **USB_DM**, differential data pair

The USB interface has a dedicated power supply that requires a 5 V supply voltage for the **VBUS** pin. This allows the USB interface to be used even though the rest of the module might be battery powered or supplied by a 1.8 V supply, etc.

2.5 GPIO pins

In an unconfigured state, NINA-B40 modules have 40 GPIO pins, 10 of which are analog-enabled pins that can be assigned to analog functions.

In an unconfigured state, NINA-B41 modules have 38 x GPIO pins, with no analog or digital interfaces.

All interfaces or functions must be allocated to a GPIO pin before use. The digital and analog functions that can be assigned to a GPIO pin, in addition to the serial interfaces, are shown in Table 12.

Function	Description	Default NINA-B4 pin	Configurable GPIOs
General purpose input	Digital input with configurable pull-up, pull-down, edge detection and interrupt generation		Any
General purpose output	Digital output with configurable drive strength, push-pull, open-collector, or open-emitter output		Any
Pin disabled	Pin is disconnected from the input and output buffers.	All*	Any
Timer/ counter	High-precision time measurement between two pulses/ Pulse counting with interrupt/event generation		Any
Interrupt/ Event trigger	Interrupt/event trigger to software application/ Wake-up event		Any
HIGH/LOW/Toggle on event	Programmable digital level triggered by internal or external events without CPU involvement		Any
ADC input	8/10/12/14-bit analog to digital converter		Any analog
Analog comparator input	Compare two voltages, capable of generating wake-up events and interrupts		Any analog
PWM output	Output simple or complex pulse width modulation waveforms		Any
Connection status indicator	Indicates if a BLE connection is maintained	BLUE**	Any

* = If left unconfigured ** = If using u-connectXpress software

Table 11: GPIO custom functions configuration

2.5.1 Analog interfaces

NINA-B40 modules have 40 GPIO pins, 10 of which can be multiplexed to analog functions. The following analog functions are available for use:

- 1x 8-channel ADC
- 1x Analog comparator*
- 1x Low-power analog comparator*

*Only one of the comparators can be used simultaneously.

NINA-B40 modules have no support for analog or digital interfaces. For further information about the support for analog interfaces, see also the NINA-B40 data sheet [2].

2.5.1.1 ADC

The Analog to Digital Converter (ADC) can sample up to 200 kHz using different inputs as sample triggers. Both one-shot conversion and continuous sampling are supported. Table 12 shows the sample speed in correlation to the maximum source impedance. It supports 8/10/12-bit resolution. The ADC includes 14-bit resolution if oversampling is used. Any of the 8 analog inputs can be used both as single-ended inputs and as differential pairs for measuring the voltage across them.

The ADC supports the full 0 V to VCC input range. If the sampled signal level is much lower than **VCC**, it is possible to lower the input range of the ADC to encompass the desired signal and obtain a higher effective resolution. Continuous sampling can be configured to sample at a configurable time interval, or at different internal or external events, without CPU involvement.

ACQ [us]	Maximum source resistance [kΩ]
3	10
5	40
10	100
15	200
20	400
40	800

Table 12: Acquisition versus source impedance

2.5.1.2 Comparator

The comparator compares voltages from any analog pin with different references as shown in Table 13. It supports the full 0 V to VCC input range and can generate different software events to the rest of the system. The comparator can operate in the one of the following two modes as explained below, this is, single-ended or differential.

- Single-ended mode: A single reference level or an upper and lower hysteresis selectable from a 64-level reference ladder with a range from 0 V to **VREF**, as described in Table 13,
- Differential mode: Two analog pin voltage levels are compared, optionally with a 50 mV hysteresis.

2.5.1.3 Low power comparator

The low-power comparator operates in the same way as the normal comparator, with reduced functionality. It can be used during system OFF modes as a wake-up source.

2.5.1.4 Analog pin options

Table 13 shows the supported connections of the analog functions.

☞ An analog pin may not be simultaneously connected to multiple functions.

Symbol	Analog function	Connects to
ADCP	ADC single-ended or differential positive input	Any analog pin or VCC
ADCN	ADC differential negative input	Any analog pin or VCC
VIN+	Comparator input	Any analog pin
VREF	Comparator single-ended mode reference ladder input	Any analog pin, VCC, 1.2 V, 1.8 V or 2.4 V
VIN-	Comparator differential mode negative input	Any analog pin
LP_VIN+	Low-power comparator IN+	Any analog pin
LP_VIN-	Low-power comparator IN-	GPIO_16 or GPIO_18, 1/16 to 15/16 VCC in steps of 1/16 VCC

Table 13: Possible uses of the analog pin

2.6 Antenna interface

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.

Carefully consider the placement of an embedded antenna in NINA-B4x6, or an external antenna (connected through SMD assembly or RF connector) in NINA-B4x0 and NINA-B4x1.

Choose a module variant that supports an external antenna if the product includes a metal product enclosure – or if any of the NINA-B4x6 antenna layout considerations for integrating an internal PCB trace antenna into the design prove impractical.

- **NINA-B4x0** modules include a U.FL connector for connecting an external antenna. Some antennas connect directly to the U.FL, while others connect through a short U.FL or reversed polarity SMA adapter cable.
    - Antennas with SMD connections, either reverse-polarity SMA connectors or U.FL connectors, are radio tested and verified against regulatory FCC, IC, RED, and MIC standards.
    - Antennas with SMA connectors are radio tested and verified against regulatory RED and MIC radio tests, but not against FCC or IC standards.
- **NINA-B4x1** modules include an ANT pad for connecting an external antenna. The antenna can be either an external SMD antenna or an antenna that is connected through an externally assembled U.FL or SMA connector. See also External RF Connector Design-in (NINA-B4x1) and External antenna design-in (NINA-B4x1).
- **NINA-B4x6** modules include an embedded PCB Niche antenna. See also NINA-B4x6 design-in.

A list of u-blox-approved external antennas, together with regulatory information for NINA-B4x0 and NINA-B4x1, can be found in the NINA-B4 series certification application note [8].

☞ Although customers are actively encouraged to add their own antennas and connector designs, all custom antenna and connector designs must be approved by u-blox and in some cases, tested. Contact your local u-blox support team for more information about this process.

2.6.1 External antenna selection

Designers are encouraged to consider one of the u-blox certified antennas and follow the layout requirements outlined below:

- External antennas, such as linear monopole antennas:
  - External antennas do not impose any physical restrictions on the design of the PCB where the module is mounted.
  - Radiation performance depends mostly on the type of antenna used in the application product. Choose antennas that provide an optimal radiating performance in each operating band.
  - RF cables must be carefully selected to keep insertion losses to an absolute minimum. Low-quality or long cables introduce additional insertion losses. Large insertion losses reduce the radiation performance.
  - A high quality 50 Ω coaxial connector provides proper PCB-to-RF-cable transition.

- Integrated antennas, such as patch-like antennas:
  - Internal integrated antennas impose physical restrictions on the PCB design:

    An integrated antenna excites RF currents on its counterpoise, typically in the PCB ground plane of the device that effectively becomes part of the antenna. Consequently, the dimensions of the ground plane define the minimum frequency that can be radiated. To optimize radiation, the ground plane can be reduced to a minimum size that should not be less than a quarter of the wavelength frequency that needs to be radiated. The orientation of the ground plane related to the antenna element must be considered.

    The RF isolation between antennas in the system must be as high as possible, and the correlation between the 3D radiation patterns of the antennas must be as low as possible. In general, an RF separation of at least a quarter wavelength between the two antennas is a minimal requirement for achieving isolation and pattern correlation. Consider increasing the separation to maximize performance – if possible.

    As a numerical example, consider the following physical restrictions of the PCB design:

    Frequency = 2.4 GHz → Wavelength = 12.5 cm → Quarter wavelength = 3.125 cm[1]
  - Radiation performance depends on the antenna system design, the mechanical design of the final product, and the application use case. Choose antennas that offer optimal radiating performance in the operating bands and meet the mechanical specifications of the PCB and entire product application.

Table 14 summarizes the RF interface requirements of the antenna.

Item	Requirements	Remarks
Impedance	50 Ω nominal characteristic impedance	The impedance of the antenna RF connection must match the 50 Ω impedance of the ANT pin.
Frequency Range	2400 - 2500 MHz	Bluetooth low energy.
Return loss	S_{11} < -10 dB (VSWR < 2:1) recommended S_{11} < -6 dB (VSWR < 3:1) acceptable	The return loss or $S_{11.}$ As a parameter of the of the standing waves ratio (VSWR) measurement, S_{11} refers to the amount of reflected power. This parameter indicates how well the primary antenna RF connection matches the 50 Ω characteristic impedance of the ANT pin. To maximize the amount of the power transferred to the antenna, the impedance of the antenna termination must match (as much as possible) the 50 Ω nominal impedance of the ANT pin over the entire operating frequency range.

[1] Wavelength referred to a signal propagating in air

Item	Requirements	Remarks
Efficiency	> -1.5 dB (> 70%) recommended > -3.0 dB (> 50%) acceptable	The radiation efficiency is the ratio of the radiated power against the power delivered to the antenna input; the efficiency is a measure of how well an antenna receives or transmits.
Maximum Gain	+3 dBi	Although higher gain antennas can be used, these must be evaluated and/or certified. See NINA-B4 certification [8] for more information on regulatory requirements.

Table 14: Summary of antenna interface (ANT) requirements for NINA-B4

When selecting external or internal antennas, the following recommendations should be observed:

- Select antennas that provide optimal return loss (or VSWR) over all operating frequencies.
- Select antennas that provide optimal efficiency over all operating frequencies.
- Select antennas that provide an appropriate gain (that is, combined antenna directivity and efficiency), so that the electromagnetic field radiation intensity does not exceed the regulatory limits specified in some countries (like the FCC in the United States for example).

2.6.1.1 External RF Connector Design-in (NINA-B4x1)

If the designer wants to implement an arbitrary external RF connector different to the U.FL connector available on NINA-B4x0 NINA-B4x1 can be used. NINA-B4x1 is smaller compared to NINA-B4x0 and can be used if a minimum size implementation is required.

Table 15 suggests some RF connector plugs that can be used by the designers to connect RF coaxial cables based on the declaration of the respective manufacturers. The Hirose U.FL-R-SMT RF receptacles (or similar parts) require a suitable mated RF plug from the same connector series. Due to wide usage of this connector, several manufacturers offer compatible equivalents. 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 15: U.FL compatible plug connector

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

- RF plug type: Select U.FL or equivalent
- Nominal impedance: 50 Ω
- Cable thickness: Select thicker cables, typically those with a thickness between 0.8 mm to 1.37 mm, to minimize insertion loss.
- Cable length: The standard cable length is typically 100 mm or 200 mm; custom lengths are available on request. Select shorter cables to minimize insertion loss.
- RF connector terminating the other side of the cable: for example another U.FL (for board-to-board connection) or SMA (for panel mounting).

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

☞ A de-facto standard for SMA connectors implies the usage of reverse polarity connectors (RP-SMA) on Wi-Fi and Bluetooth end products to make it more difficult for end users to replace the antenna with higher gain versions that exceed the regulatory limits.

The following recommendations apply for proper layout of the connector:

- Strictly follow the connector manufacturer's recommended layout:
  - SMA Pin-Through-Hole connectors require GND keep-out (that is, clearance, a void area) on all the layers around the central pin up to annular pads of the four GND posts.
  - UFL surface mounted connectors require no conductive traces (clearance or void) in the area below the connector between the GND land pads.
- If the RF pad size of the connector is wider than the micro strip, remove the GND layer beneath the RF connector to minimize the stray capacitance and retain the RF line impedance of 50 Ω. For example, the active pad of the UF.L connector must have a GND keep-out (clearance or void area) – at least on the first inner layer to reduce parasitic capacitance to ground.

2.6.1.2 External antenna design-in (NINA-B4x1)

Observe the following guidelines if the design requires an external antenna to be mounted directly on the main PCB:

- The antenna design process should begin at the start of the product design process. Prototype PCBs with antenna assembly are useful in estimating overall efficiency and radiation pattern of the intended design.
- Use antennas designed by an antenna manufacturer providing the best possible return loss (or VSWR).
- Provide a ground plane large enough according to the related integrated antenna requirements. The ground plane of the application PCB may be reduced to a minimal size that is not less than a quarter of a wavelength of the minimum frequency that shall be radiated. The overall antenna efficiency may benefit from larger ground planes.
- Proper placement of the antenna and its surroundings is also critical for antenna performance. Avoid placing the antenna close to conductive or RF-absorbing parts such as metal objects, ferrite sheets. These parts can absorb part of the radiated power, shift the resonant frequency of the antenna, or affect the antenna radiation pattern.
- Strict adherence to the antenna manufacturer's guidelines describing the installation and deployment of the antenna system, including the PCB layout and matching circuitry, is strongly advised.
- In addition to the custom PCB and product restrictions, antennas may require tuning/matching to comply with the required certification schemes. Consult the antenna manufacturer for the design-in guidelines and plan the validation activities on the final prototypes, like tuning/matching and performance measures (see also Table 14).
- The RF section may be affected by noise sources like hi-speed digital buses. Avoid placing the antenna close to buses such as DDR or consider taking specific countermeasures like metal shields or ferrite sheets to reduce the interference.

⚠ Take care of interaction between co-located RF systems like LTE sidebands on 2.4 GHz band. Transmitted power may interact or disturb the performance of NINA-B4 modules.

2.6.1.3 RF transmission line design (NINA-B4x1)

RF transmission lines connecting the **ANT** pad with the related antenna connector or antenna, must be designed with a 50 Ω impedance characteristic.

Figure 6 shows the design options for PCB transmission lines, where:

- **Microstrip** is a trace coupled to a single ground plane, separated by dielectric material.

- **Coplanar microstrip** is a trace coupled to ground plane and adjacent conductors, separated by dielectric materials).
- **Stripline** is a trace sandwiched between two parallel ground planes, separated by dielectric materials).

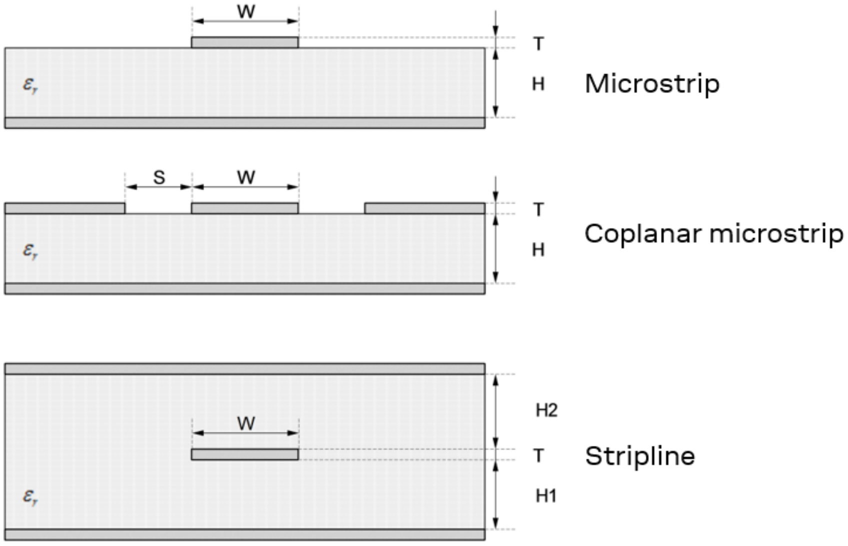


Figure 6: Transmission line trace design

Observe the following comments to design a proper 50 Ω transmission line:

- The designer shall provide enough clearance from adjacent traces and ground in the same layer. The trace-to-ground clearance should be at least twice as wide as the trace width. The transmission line should be 'guarded' with ground planes on each side.
- The characteristic impedance can be calculated as a first iteration by using tools provided by the layout software. It is advisable to ask the PCB manufacturer for the final values that are usually calculated during the PCB production process using dedicated software and the available stack-ups. To measure the real impedance of the traces, it might also be possible to request that an impedance coupon be attached to the side of the panel.
- Despite the high losses anticipated at high frequencies, an FR-4 dielectric material can be considered in the RF designs, providing that:
    - RF trace lengths are minimized to reduce dielectric losses.
    - If traces longer than a few centimeters are needed, coaxial connectors and cables are used to reduce the anticipated losses.
    - To ensure good impedance control during the PCB manufacturing process, the PCB stack-ups allow for wide 50 Ω traces of at least 200 µm.
    - FR-4 material exhibits poor thickness stability with less control of impedance over the trace length. Contact the PCB manufacturer for specific tolerance of controlled impedance traces.
- The width and spacing of the transmission lines to GND must be uniform and routed as smoothly as possible. Route RF lines in arcs or at 45° angles.
- Add GND stitching vias around transmission lines.
- Include sufficient vias to ensure that a low-impedance connection is made between the main ground layer and the adjacent metal layer on the PCB stack-up.
- To avoid crosstalk between RF traces and high-impedance or analog signals, route RF transmission lines far away from noise sources (like switching supplies and digital lines) and sensitive circuits.
- Avoid stubs on the transmission lines; impedance matching components on the transmission line should be placed with the connected pad over the trace.
- Avoid unnecessary component on RF traces.

2.6.2 NINA-B4x6 design-in

NINA-B4x6 modules include an internal PCB trace antenna that is integrated on the module PCB using antenna technology from Proant AB. The RF signal is completely internal and not connected to any module pin.

NINA-B4x6 modules cannot 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.

The pre-certification of NINA-B4 modules minimizes the effort of certification testing in the test lab.

2.6.2.1 NINA-B4x6 antenna layout considerations

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

- NINA-B4x6. To enable good antenna radiation performance, it is important to place the module on the edge of the main PCB with the antenna facing outwards.
- A ground plane extending at least 10 mm on both sides of the module is recommended, as shown in Figure 7.
- Include a non-disruptive GND plane underneath the module with a cut out underneath the antenna, as shown in Figure 8.
- Observe the antenna “keep-out” area on all layers, as shown in figures Figure 7 and Figure 8.
- NINA-B4x6 has four GND pads located close to the antenna, as shown in Figure 4. Connect these pads to GND. Detailed dimensions of the footprint, including those related to these GND pads, can be found in the NINA-B4 series data sheet [2].
- To avoid degradation of the antenna characteristics, do not place physically tall or large components closer than 10 mm to the module antenna.
- To avoid any adverse impact on antenna performance, include a 10 mm clearance between the antenna and the casing. Polycarbonate (PC) and Acrylonitrile butadiene styrene (ABS) materials have less impact on antenna performance than other types of thermoplastic.
- 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.
- Connect all ground pads to the ground plane.
- Consider the end products use case and assembly to make sure that the antenna is not obstructed by any external item.

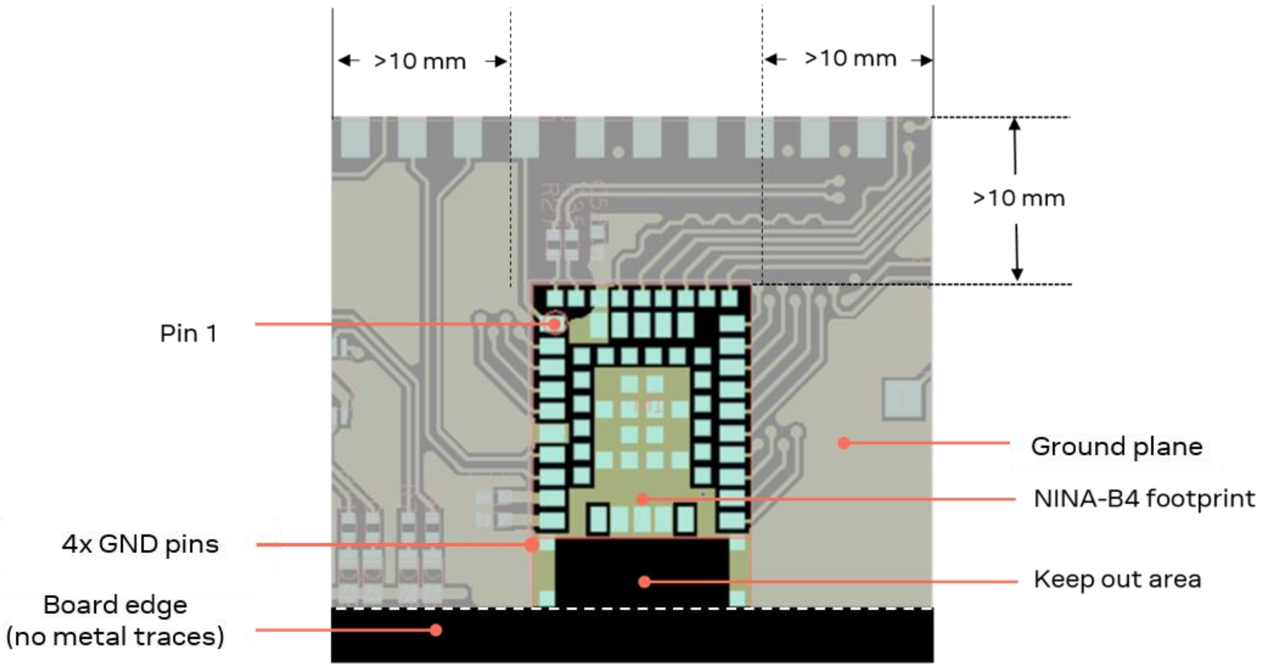


Figure 7: Extended host ground plane outside NINA-B4x6

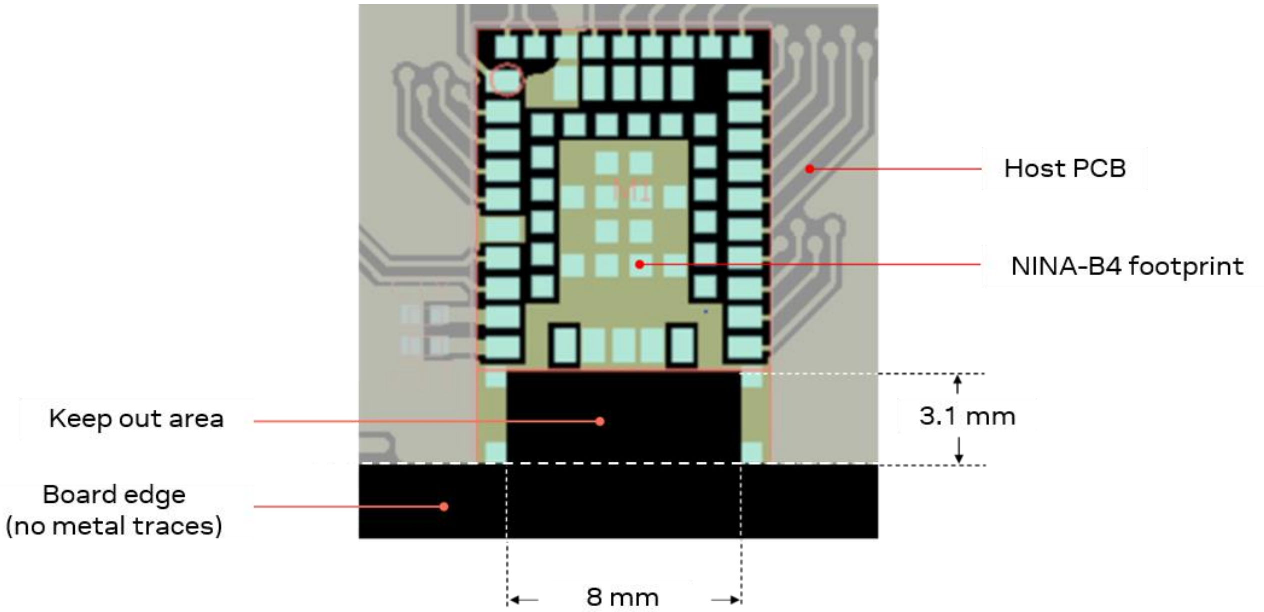


Figure 8: NINA-B4x6 keep out area

2.7 NFC interface

⚠ As the pins for the NFC interface in NINA-B40 series modules can be used as normal GPIOs, it is important that all NFC pins are correctly configured in the software. Connecting an NFC antenna to pins that are configured for GPIO can damage the module. In NINA-B41 series modules, NFC pins are always set to "NFC mode".

The NFC antenna coil must be connected differentially between the NFC1 and NFC2 pins of the device.

Two external capacitors should be used to tune the resonance of the antenna circuit to 13.56 MHz.

The required tuning capacitor value is given by the below equations: an antenna inductance of L_{ant} = 2 µH will give tuning capacitors in the range of 130 pF on each pin. For good performance, match the total capacitance on NFC1 and NFC2.

The NINA-B4 modules have been tested with a 3x3 cm PCB trace antenna, so it is recommended to keep an antenna design close to these measurements. You can still use a smaller or larger antenna as long as it is tuned to resonate at 13.56 MHz. To comply with European regulatory demands, the NFC antenna must be placed in such a way that the space between the NINA-B4 module and the remote NFC transmitter is always within 3 meters during transmission.

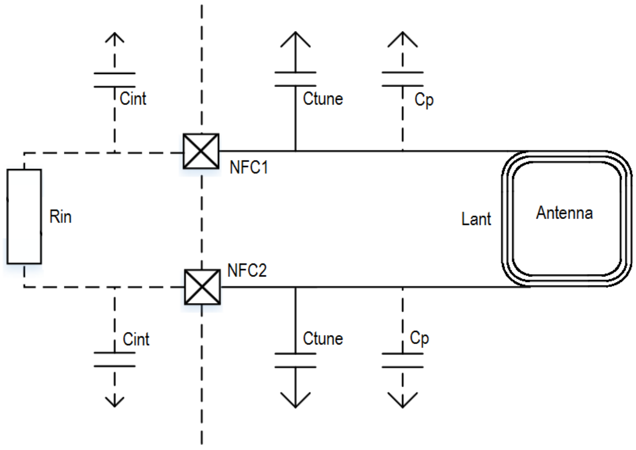


Figure 9: NFC antenna design

$$C'_{tune} = \frac{1}{(2\pi \times 13.56\ MHz)^2 L_{ant}} \quad were\ C'_{tune} = \frac{1}{2} \times \left(C_p + C_{int} + C_{tune}\right)$$

$$C_{tune} = \frac{2}{(2\pi \times 13.56\ MHz)^2 L_{ant}} - C_p - C_{int}$$

2.7.1 Battery protection

If the antenna is exposed to a strong NFC field, parasitic diodes and unintended ESD structures can cause the current to flow in the opposite direction of the supply.

If the battery used does not tolerate a return current, protect the battery with a series diode placed between the battery and the device.

2.8 Debug interface

NINA-B40x modules support Serial Wire debug (SWD) and Serial Wire Viewer, but not JTAG debug.

When designing your application with the NINA-B40x, the SWD interface (pins **SWDCLK** and **SWDIO**) to the module should ideally be made available in the application design.

To allow the module to be flashed using the UART or the SWD interface, the module is preloaded with bootloader software that is without security. A debug connector to the module is also useful during the software development.

For security reasons, the debug interface should also be disabled to prevent the upload or download insecure software – or software that has not been validated.

Figure 10 shows the pinout of the 10-pin, 50 mil pitch connector used on the EVK-NINA-B40x. This compact debug header can also be used on a host board design. Other solutions, such as test points or spring-loaded connectors (Tag-Connect-pads [19]), can be used as well. Keep in mind that the **GND** and **VDD_IO** references are needed for the SWD interface to work.

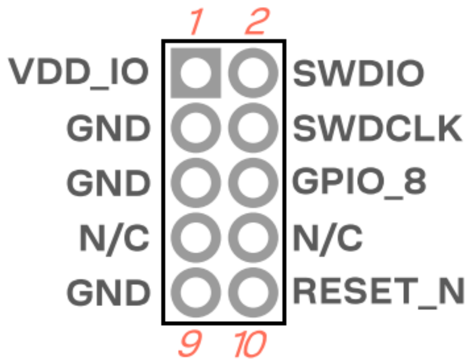


Figure 10: Cortex debug connector pin out for SWD

2.9 General layout guidelines

The best practices described in sections 2.9.1 to 2.9.4 are valid for any bus in NINA-B4 series modules.

2.9.1 General 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 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 NINA-B4 series module specifications, as described in the respective NINA-B4 data sheet [2][3].

⚠ Take particular care not to place components close to the antenna area. 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 potential interference picked up by the module antenna.

2.9.2 Layout and manufacturing

- An optimized module placement provides for better RF performance. See also NINA-B4x6 design-in.
- Bypass capacitors should be placed as close as possible to the module. Prioritize the placement of capacitors with the least capacitance so that these are closest to module pads. The supply rails must be routed through the capacitors from the power supply to the supply pad on the module.
- Avoid stubs and through-hole vias on high-speed signals which might adversely affect signal quality.
- 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.
- Track 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.
- Ground splitting is not allowed under the module.
- Minimize the bus length to reduce potential EMI issues from digital buses.
- All traces (including low speed or DC traces) must couple with a reference plane (GND or power); Hi-speed buses should be referenced against the ground plane. If any ground reference needs to be changed, an adequate number of GND vias must be added in the area that the layer is switched. This is necessary to provide a low impedance path between the two GND layers for the return current.
- Hi-Speed buses are not allowed to change reference plane. If changes in the reference plane are unavoidable, capacitors must be added 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 of 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.

2.9.3 Thermal guidelines

NINA-B4 series modules have been successfully tested from –40 °C to +105 °C. NINA-B4 modules are low-power devices that generate only a small amount of heat during operation. A good grounding should still be observed for temperature relief during high ambient temperatures.

2.9.4 ESD guidelines

Device immunity against Electrostatic Discharge (ESD) is a requirement for Electromagnetic Compatibility (EMC) conformance and use of the CE marking for products intended for sale in Europe. For any product that integrates u-blox modules to bear the CE mark it must be conformance tested in accordance with the R&TTE Directive (99/5/EC), EMC Directive (89/336/EEC), and Low Voltage Directive (73/23/EEC) issued by the Commission of the European Community.

Compliance with the above directives also implies conformity to the following European norms for device ESD immunity: ESD testing standard CENELEC EN 61000-4-2 [10] and radio equipment standards ETSI EN 301 489-1 [11], ETSI EN 301 489-7, ETSI EN 301 489-24. The ESD immunity requirements for each of these standards are summarized in Table 16.

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

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

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

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

Application	Category	Immunity level
All exposed surfaces of the radio equipment and ancillary equipment in a representative configuration	Indirect Contact Discharge	±8 kV

Table 16: Electromagnetic 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

NINA-B4 is manufactured with consideration to specific standards that minimize the occurrence of ESD events; the highly automated process complies with IEC61340-5-1 (STM5.2-1999 Class M1 devices) standard [12], and designers should subsequently implement proper measures to protect any pin that might be exposed to the end user from ESD events.

Compliance with the standard protection level specified in EN61000-4-2 is achieved by including ESD protection close to any areas accessible by the end user.

2.10 Product testing

2.10.1 u-blox in-series production tests

With strong focus on the development of high-quality products, u-blox products are produced and fully tested automatically in the production line. Stringent quality control processes are observed during production, and all modules are tested using automatic test equipment (ATE).

For the purpose of quality control and future product improvement, all test and measurement data is archived in a production database, where the results from any defective test unit is thoroughly analyzed. A detailed test report for each module can be generated from the production data.

The following tests are performed during production:

- Digital self-test (software download, MAC address programming)
- Measurement of voltages and currents
- Functional tests
- Digital I/O tests
- Measurement of RF characteristics in all supported bands (such as receiver RSSI calibration, frequency tuning of the reference clock, calibration of transmitter power levels, and so on.

Figure 11 shows the typical automatic test equipment (ATE) used in a production line.

Figure 11: Automatic test equipment for module testing

2.10.2 OEM manufacturer production test

As production testing is already performed by u-blox, OEM manufacturers do not need to take any further RF performance measurements or repeat any test of the software or interfaces during production.

Consequently, OEMs are encouraged to focus testing of end-product applications towards:

- Verification of the module assembly; check that:
  - Soldering and handling processes have not damaged the module components
  - All module pins are soldered on the device board
  - There are no short circuits between pins
- Verification of the component assembly on the device; check that:
  - Communication with host controller can be established
  - The interfaces between the module and device are working
  - Overall RF performance test of the device including the antenna

Dedicated tests can be implemented to check the device. For example, the current consumption of module when set in a specified state can detect a short circuit if compared with a “Golden Device” result.

The standard operational module firmware and test software on the host can be used to perform functional tests (tests that that check the interfaces and communication with the host controller) and perform basic RF performance tests.

2.10.2.1 “Go/No go” tests for integrated devices

Go/No Go testing is used to test overall function of the device. In a good test setup, each component and soldering joint is related to a basic functional test. If the test is successful, the assembly is considered as functionally correct.

A “Go/No go” test compares the signal quality of the antenna under test with that of a “golden device” in common location and known signal quality. Go/no go tests are normally performed after connection with the external device has been established.

Go/no go tests are suitable for checking communication with the host controller and power supply. The tests also verify that the components are well-soldered.

A simple go/no go test would typically scan and check the signal for a known Bluetooth low energy device.

☞ Although a Bluetooth scan and subsequent comparative signal test approach is appropriate for “go/no go” evaluation, this type of testing does not measure RF performance.

A basic RF functional test of the device that includes checking the antenna can be performed with standard Bluetooth low energy devices configured as remote stations. To obtain stable test results and prevent possible interference from other radio devices, the device containing the NINA-B4 series module and antenna should be arranged in a fixed position inside an RF shield box.

3 Open CPU software

NINA-B40 series modules are used in an open CPU configuration allows customer applications to be developed in a Nordic SDK environment in the NINA-B4 module.

3.1 Nordic SDK

The Nordic nRF SDK includes a broad selection of drivers and libraries that provide a rich development environment for a broad range of devices and applications. The SDK is delivered in zip container file for easy installation.

The SDK comes with support for the SEGGER Embedded Studio, Keil microcontroller development kit, IAR embedded workbench IDE, as well as a GCC compiler that supports many platforms and languages.

3.1.1 Getting started with the Nordic SDK

When working with the Nordic SDK on the NINA-B4 series module, follow the steps below to get started with the Nordic Semiconductor toolchain and examples:

1. Download and install the nRF Connect that includes an embedded Programmer app for programming over SWD.
2. Download and install the latest SEGGER embedded studio.
3. Download and extract the latest nRF5-SDK.

☞ When installing the SDK, be sure not to include any space characters in the file path. Keep the folder structure intact. The examples in the SDK use relative folder references.

4. Read SDK release notes and check the nRF5 SDK documentation available from the Nordic Semiconductor Infocenter [15].

3.1.1.1 Nordic tools

For further information and links to all Nordic tools, as well as the supported compilers, see Nordic software and tools.

3.1.1.2 Support – Nordic development forum

For support on questions related to the development of software using the Nordic SDK, check out the Nordic DevZone forum.

3.1.1.3 Create a custom board support file for Nordic SDK

The predefined hardware boards included in the Nordic SDK are for Nordic development boards only. To add support for a custom board, create a support file with the name `custom_board.h` and save this to one of the folders:

- `<SDK folder>/components/boards` to be valid for all examples, or
- `<SDK folder>/examples/<project>/pca10100/<softdevice>/config` (valid for this project only).

☞ The above-mentioned directories are according to the Nordic nRF5 SDK version 16.0.0.

An example of what a custom board support file could look like for the EVK-NINA-B4 can be found in the u-blox short range GitHub repository [20].

The custom board can then be selected by adding a define of the symbol `BOARD_CUSTOM` to your build.

You can add the `BOARD_CUSTOM` define statement in SEGGER Embedded Studio by following the instructions below:

1. Right-click the Project in "Project Explorer".
2. Select **Options**…

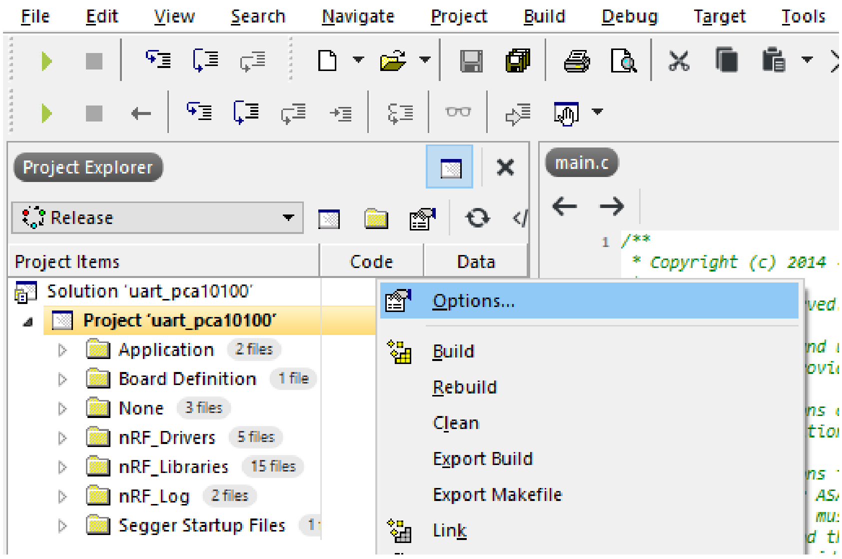


Figure 12: Selecting project options in SEGGER Embedded Studio

3. Select the **Common** configuration.
4. Select the **Code** / **Preprocessor**.
5. Select the **Preprocessor Definitions**.

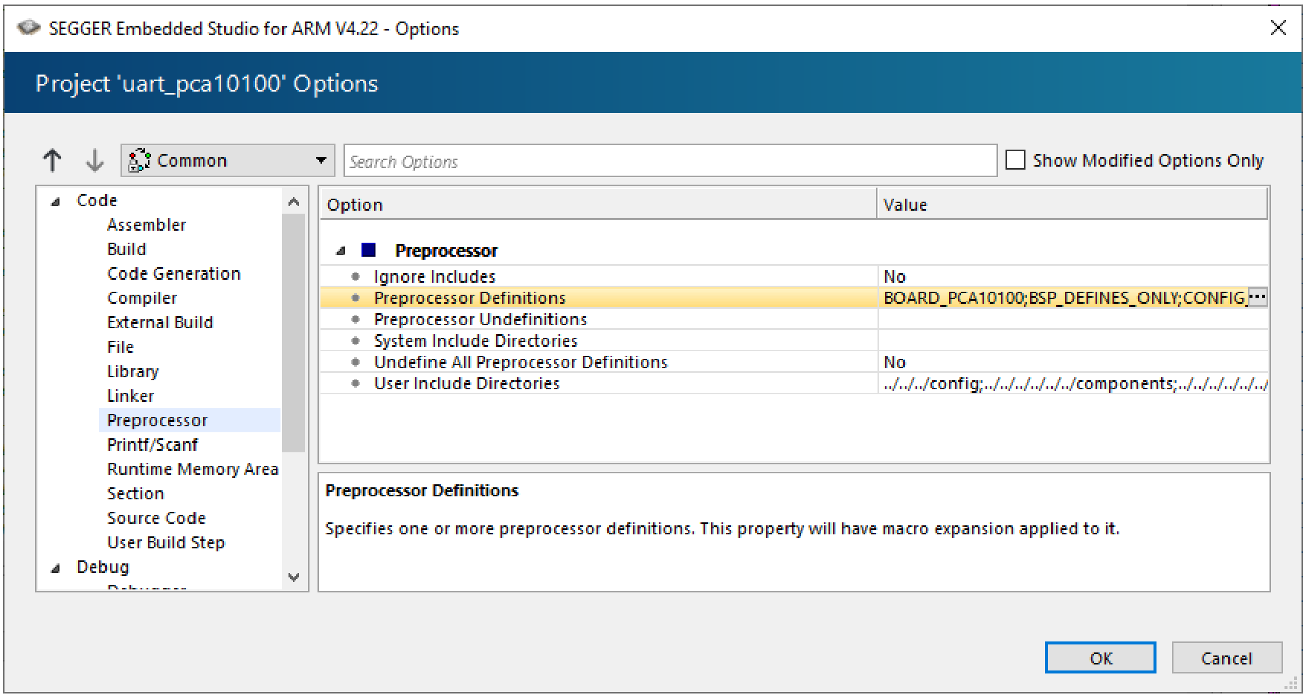


Figure 13: Selecting preprocessor definitions in SEGGER Embedded Studio

6. Modify the "BOARD_" definition to define the BOARD_CUSTOM.

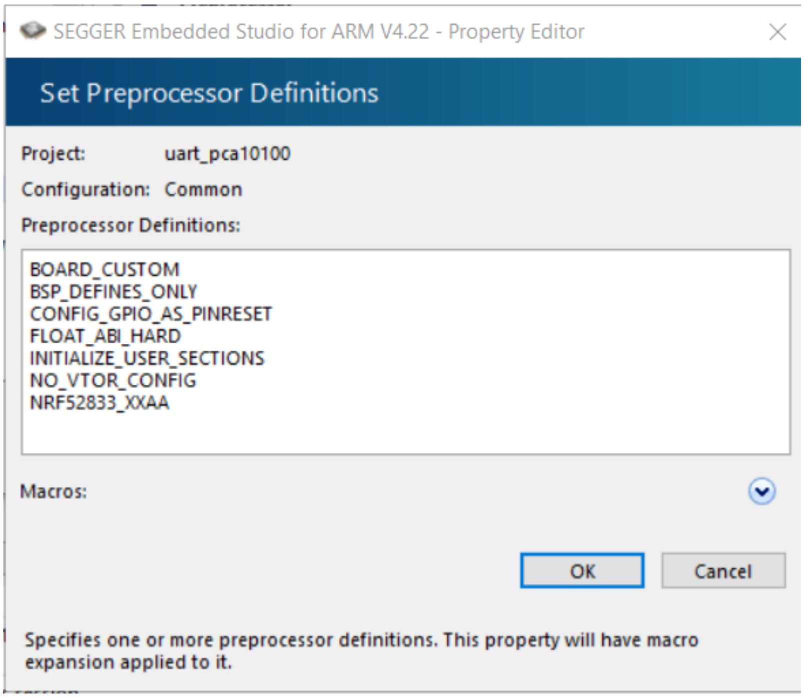


Figure 14: Modifying the board definition in SEGGER Embedded Studio

3.1.2 Bluetooth device (MAC) address and other production data

The open CPU (B40x) variants of the NINA-B4 modules are provided with a unique, public Bluetooth device (MAC) address programmed. If required, this address can be used by the customer application.

The MAC address is programmed in the `CUSTOMER[0]` and `CUSTOMER[1]` registers in the UICR of the nRF52833 chip. The address can be read and written for example, using Segger J-Link utilities or the `nrfjprog` utility from Nordic.

```
$ nrfjprog.exe --memrd 0x10001080 --n 8
```

The memory area can be saved and, if the flash is erased, written back later using the `savebin` and `loadbin` utilities in the Segger J-link tool suite.

The UICR memory area also holds serial number and other information that can be valuable to save. If you want to save the whole memory area you can use

```
$ nrfjprog.exe --readuicr uicr.hex
...
$ nrfjprog.exe --program uicr.hex
```

☞ If the bootloader supplied by u-blox is not used for the open CPU development the UICR register cannot be saved way that is described here. This is because the UICR registers that hold the bootloader start address confuse the boot process. In these instances, the MAC address has to be written separately.

For additional information and instructions on saving and using the public Bluetooth device address, see reference [18].

3.1.3 Definition of Low Frequency Clock source

NINA-B4x modules are delivered without an external low frequency crystal oscillator (LFXO). To configure the software correctly for your configuration, follow the steps in the RC oscillator configuration application note [21].

EVK NINA-B40x is delivered with an external low frequency crystal oscillator mounted.

3.2 Flashing open CPU software

Modules with open CPU configuration can be flashed using various utility programs over the SWD or UART interface.

3.2.1 Flashing over the SWD interface

To flash NINA-B4 modules over the Serial Wire Debug (SWD) interface an external debugger must be connected to the SWD interface of the module. Third-party tools like J-Link Commander, J-Flash, nRF Command Line Utilities or nRF Connect Programmer, are used to flash the module.

☞ SEGGER J-Link BASE external debugger works with NINA-B40 modules.

☞ EVK-NINA-B40 incorporates an onboard debugger, which means that it can be flashed without an external debugger.

⚠ Always make a note of your Bluetooth device address before starting the flashing procedure. As flashing the software can erase the original u-blox Bluetooth device address, this address might need to be reinstated. The Bluetooth device address can be re-written manually or with the use of a script. See also Bluetooth device (MAC) address and other production data.

In the nRF Connect Programmer, drag and drop the hex files you want to program into the GUI, as shown in Figure 15, and then write them to the module using the GUI.

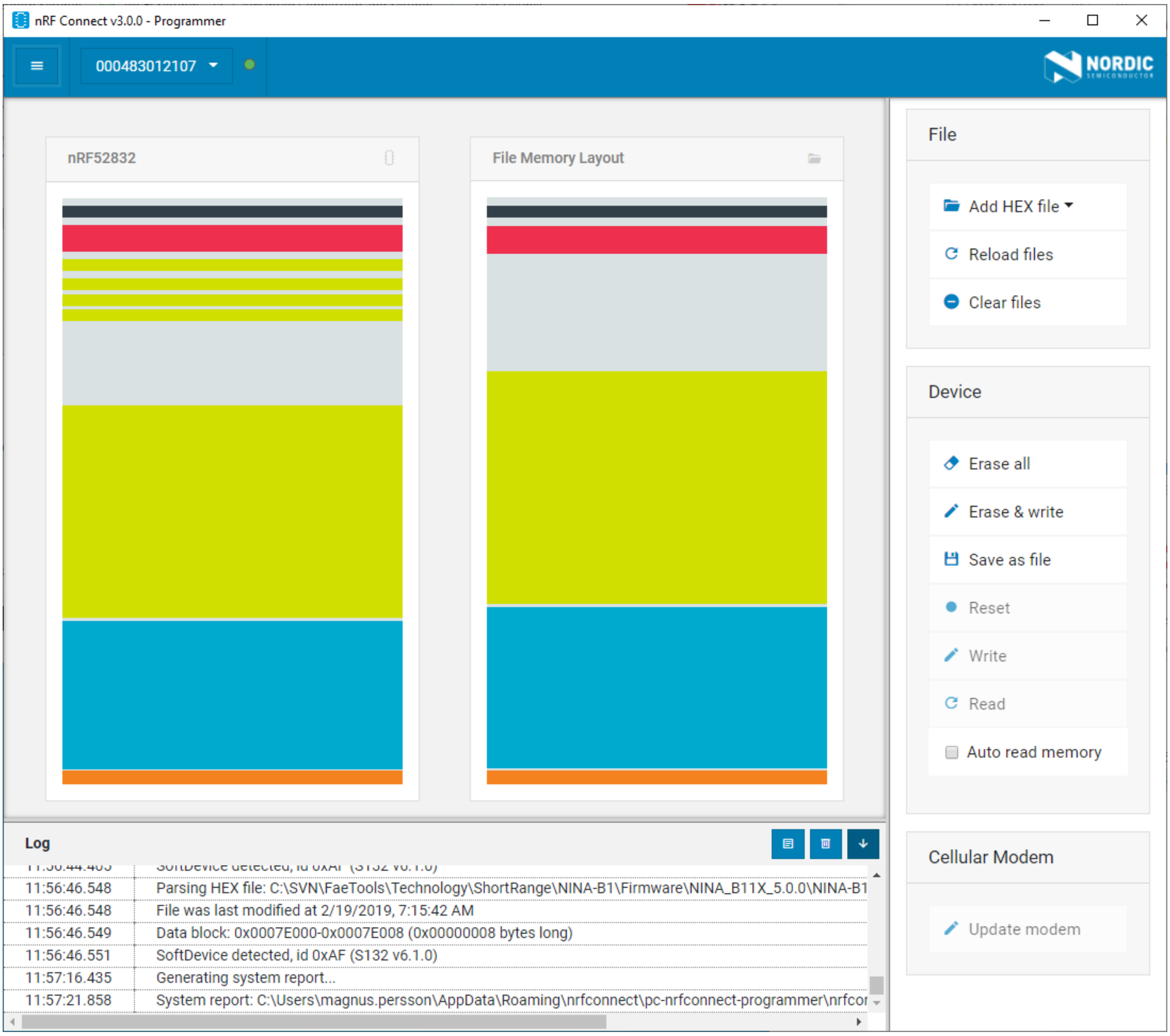


Figure 15 Selecting hex files in nRF Connect Programmer

3.2.2 Flashing over the UART interface

To flash NINA-B40 modules over the UART interface, the module must be pre-loaded with a bootloader based on DFU bootloader examples included in the Nordic Semiconductor nRF5 SDK. The bootloader is accessed using Nordic Semiconductor flash tools like nRF util.

The memory layout of the module as delivered from factory is described in Table 17. The shaded parts settings are flashed in the factory.

Usage	S140 SoftDevice version 7.0.x
Bootloader settings	0x0007F000 -0x80000
MBR parameter storage	0x7E000-0x7F000
Bootloader	0x72000-0x7E000
Application	0x27000 – 0x72000
Softdevice	0x1000 – 0x27000
MBR	0x0 – 0x1000

Table 17 NINA-B40x flash layout that includes S140 SoftDevice

☞ Note that memory sizes can vary dependent on the SoftDevice radio stack software running on the module.

3.2.2.1 Building applications to be flashed using the bootloader

To flash an application to the module without destroying the master boot record (MBR) that is preflashed in the factory, the start address in flash must be changed to `0x27000` (for applications with S140 SoftDevice) or `0x1000` (applications without SoftDevice). This change can be done in the nRF5 SDK by changing the macro `FLASH_START` – in a similar way to how the `BOARD_CUSTOM` flag was set to Create a custom board support file for Nordic SDK. The flag is set using the Property Editor in SEGER Embedded Studio: **Code > Linker > Section Placement Macros**, as shown in Figure 16.

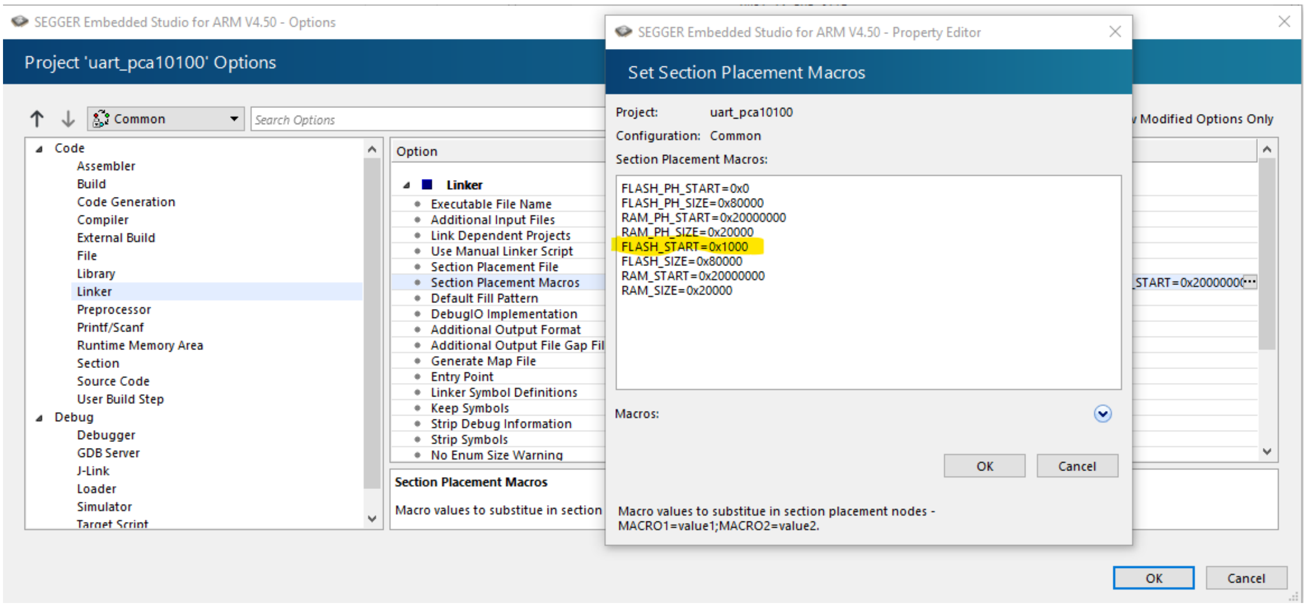


Figure 16 Setting the FLASH_START macro

3.2.2.2 Preparing the Device Firmware Update (DFU) package

The package to be flashed is in a special DFU package format. The package is generated in the following way:

An application that does not use a SoftDevice:

```
nrfutil pkg generate --hw-version 52 --sd-req 0x00 --application-version 0 --application
app.hex app.zip
```

An application with SoftDevice:

```
nrfutil pkg generate --hw-version 52 --sd-req 0xCA --sd-id 0xCA --softdevice
s140_nrf52_7.0.1_softdevice.hex --application-version 0 --application app.hex sd_app.zip
```

3.2.2.3 Flashing the DFU package

The generated DFU package can be flashed on the module using the following `nrfutil` command:

```
nrfutil dfu serial -pkg app.zip -p COM95 -b 115200 -fc 1
```

☞ As there is no application to boot, the loader automatically stops in DFU mode when flashing is done for the first time. On subsequent reboots, you need to stop the bootloader in DFU mode by driving **SWITCH_2** low during startup.

4 u-connectXpress software

NINA-B41 modules come preflashed with the u-connectXpress software and a bootloader.

To ensure that the module only boots with the original u-blox software, the secure bootloader initiates a signature verification on the flashed software binary before it is booted.

NINA-B41 u-connectXpress software can be reflashed over the UART interface using AT commands or the s-center client software available from the u-blox website.

4.1 Updating NINA-B41 software

New versions of NINA-B41 u-connectXpress software can be flashed to the module over the UART interface. See also Updating software with -center and Updating software with AT commands.

The following pins should be made available as either headers or test points to flash the module:

- **UART** (RX, TX)
- **RESET_N**
- **SWITCH_1** and **SWITCH_2**

4.1.1 Updating over UART

NINA-B4 u-connectXpress software includes the bootloader for flashing NINA-B4 over the UART interface. The software is available for download at www.u-blox.com.

Distributed in a single ZIP container, the software includes two separate binary files and one JSON file that includes the software label, software description, file name, version, flash address, image size, image id, file permissions, and signature file reference for the SoftDevice and ConnectivitySoftware applications:

- Java Script Object Notation:
  `NINA-B41X-CF-<version>.json`. For example: `NINA-B41X-CF-1.0.json`
- ConnectivitySoftware:
  `NINA-B41X-SW-x.y.z-<build>.bin`. For example: `NINA-B41X-SW-3.0.0-005.bin`
- SoftDevice:
  `NINA-S140-SD-a.b.c.bin`. For example, `NINA-S140-SD-6.1.1.bin`

Signature files (`NINA-B41X-SI-x.x.x-xxx.txt` and `NINA-S140-SI-x.x.x-xxx.txt`) for each of the binaries are also included in the container.

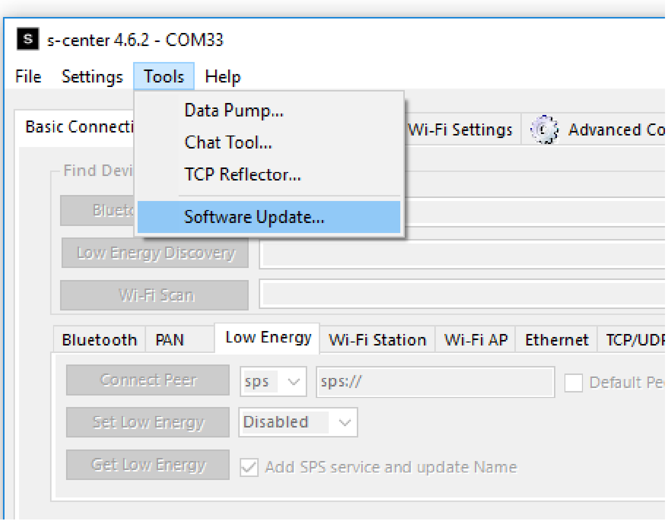
4.1.1.1 Updating software with s-center

⚠ To update NINA-B4 u-connectXpress requires s-center software version 4.6.2 or later. See also the s-center user guide [22].

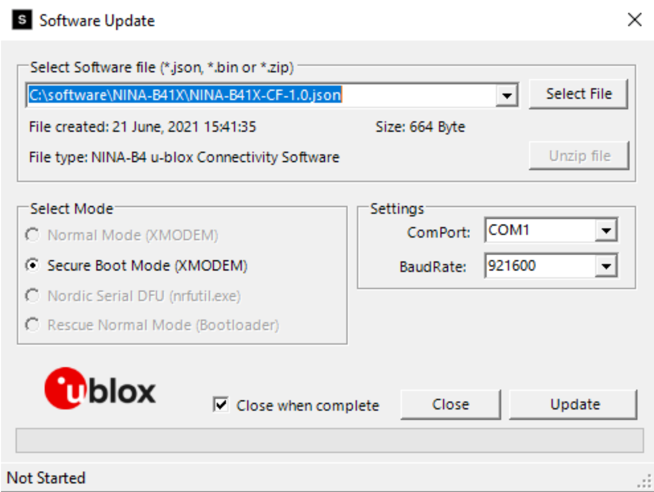
Procedure

1. Connect the supplied serial cable from the J8 connector on EVK-NINA-B4 to the USB port your computer. For further information about setting up EVK-NINA-B4, see also EVK-NINA-B4 user guide [24].
2. Download and the latest version of the s-center and u-connectXpress software from u-blox Product Resources. See also the EVK-NINA-B4 user guide [24] and s-center user guide [22].
3. Start s-center and choose "USB Serial Port (COMx)" in the drop-down “COM Port” menu. All other dialog settings are set to default.
4. Select **Open Port**. A series of AT commands and response are shown in the “Console Window”.

5. Select **Tools** > **Software Update**.



6. Check that the correct COM port is shown in "Settings". **Select File** and choose the `NINA-B41X-CF-<version>.json` file from the unzipped u-connectXpress container.



7. Select **Update**. The module then reboots using the secure bootloader and flashing of both the SoftDevice and application starts automatically.

4.1.1.2 Updating software with AT commands

☞ You can send AT commands to NINA-B4 to execute certain tasks over the serial interface, using open-source terminal emulator software that supports XMODEM, like TeraTerm or ExtraPuTTy. Alternatively, you can send all AT commands described in this section using the s-center software in AT mode. The examples given in this procedure have been created and tested on EVK-NINA-B41 using TeraTerm. See also the u-connectXpress AT command manual [6] and Bootloader protocol specification [25].

The bootloader must be running when the software is "sent" to the module. You start the bootloader using either:

- AT commands
- Pressing the SW1 and SW2 buttons simultaneously during a module reset (initiated by setting **RESET_N** low). See also Module reset.

☞ In contrast to the s-center configuration, UART hardware flow is not used for updating software using AT commands. The file download uses standard XMODEM-CRC16 protocol and 128 bytes packets.

Prerequisites

As a prerequisite to updating software using AT commands, you must open the JSON file included in the download container and make note of the defined values to be parsed with the update command. You also need to copy the signatures given in the related txt files, as shown in Figure 18. This information is needed during the install. The defined values to include in the command, together with the signature file (`NINA-B41X-SI-x.x.x-xxx.txt`), are shown in Table 18.


```
[
  {
    "Label": "ConnectivitySoftware",
    "Description": "NINA-B41X u-blox connectivity software",
    "File": "NINA-B41X-SW-1.0.0-001.bin",
    "Version": "NINA-B41X-SW-1.0.0-001",
    "Address": "0x26000",
    "Size": "0x4C95C",
    "Id": "0x0",
    "Permissions": "rwx",
    "SignatureFile": "NINA-B41X-SI-1.0.0-001.txt"
  },
  {
    "Label": "SoftDevice",
    "Description": "S140 softdevice from Nordic for NINA-NRF",
    "File": "NINA-S140-SD-6.1.1.bin",
    "Version": "NINA-S140-SD-6.1.1",
    "Address": "0x0",
    "Size": "0x25DE8",
    "Id": "0x1",
    "Permissions": "rw",
    "SignatureFile": "NINA-S140-SI-6.1.1.txt"
  }
]
```


Figure 17: Defined values for ConnectivitySoftware and SoftDevice as shown in the JSON file


```
N04lae2U7ztBojLvyBmHJKvuQmyioscrE3kdQviDcqSwST59Dg8WZbcN5C6xwZtA3vE/A0M2h3JulhVv49UIIjzhTZwY
LLrnWGNWgu4cAPkmMHkZa5MZl/QSb/GeT8naXe7oVTS2S2NzXX83N+ovmTVBMpkfQiEoNJw5u5+agXq3J4kz9g1LylUN
tHbucAJR5cs1hsrOC+UZSULY2+4jNqxdN3m6BlvQyycxJCJ2J49cnB85RdY4bfJlPGTwcqtGp2Z014Y/Z7PjeNOMoTFU
KZDWN6e+U8a8e6pULCBLqBH5gC/UU/aSLJLsLL64VEKt2NJB5lZ2fqgzZr82Dqmrpw==
```


Figure 18: Typical ConnectivitySoftware and SoftDevice signature file

Command syntax

You use the software update command `AT+UFWUPD` with following syntax to update both the u-connectXpress and SoftDevice software.

```
AT+UFWUPD=<mode>,<baud_rate>[,<id>,<size>,<signature>,<name>,<flags>]
```

The defined values for each parameter are shown in Table 18.

Parameter	Type	Description
`<mode>`	Enumerator	Download mode: 0: Update mode for the ConnectivitySoftware through the serial port 1: Bootloader mode for update of the SoftDevice through the serial port.
`<baud rate>`	Enumerator	Baud rate in bits per second: 115200 (default), 230400, 460800, or 921600
`<id>`	Integer	ID number of the software image.
`<size>`	Integer	Size of the firmware image. Enter the size integer for the respective software as defined in the `NINA-B41X-SI-x.x.x-xxx.txt` file. Shown in hex format in the JSON file but must entered as bytes in decimal notation in the command.
`<signature>`	String	RSA signature of the firmware image as base64-encoded string. Enter the 344-character text string defined in the `NINA-B41X-SI-x.x.x-xxx.txt` file.
`<name>`	String	The name of the firmware. Maximum string length is 22.

Parameter	Type	Description
`<flags>`	String	Permissions for using the firmware image. Permission flags are marked in UNIX style: "`rwx`" is the default flag for the u-connectXpress software. "`rw`" is the default flag for other binary images.

Table 18: Defined values for update parameters

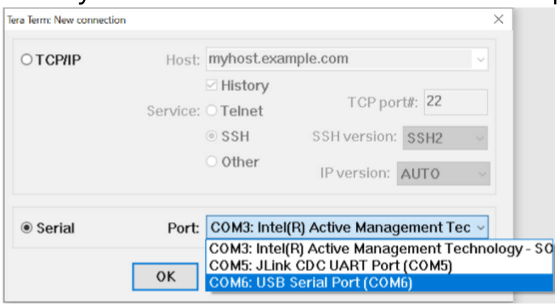
4.1.1.2.1 Setting up the serial port

☞ You can send AT text commands to NINA-B4 to execute tasks using open-source terminal emulator software that supports XMODEM like TeraTerm or ExtraPuTTy. Alternatively, you can send all AT commands described in this section using the s-center software in AT mode. See also the s-center user guide [22].

Procedure

The examples in this procedure have been created and tested on EVK-NINA-B41 using TeraTerm.

1. Connect the supplied serial cable from the J8 connector on EVK-NINA-B4 to the USB port your computer. For further information about setting up EVK-NINA-B4, see also EVK-NINA-B4 user guide [24].
2. Download and unzip the latest u-connectXpress software from u-blox Product Resources.
3. Discover the COM port number for the USB Serial Port on your computer (MS Windows: **Start>Device Manager>Ports**). See also "Setting up the evaluation board" in the EVK-NINA-B4 user guide [24].
4. Start your chosen terminal emulator and open the connection to the USB serial port (COMx).



5. Setup the serial port and connection. Set "Speed" to 115200 with all other parameters set to default. Select **New setting**.

4.1.1.2.2 Updating u-connectXpress connectivity software only

☞ You can send AT text commands to NINA-B4 to execute tasks using open-source terminal emulator software that supports XMODEM, like TeraTerm or ExtraPuTTy. Alternatively, you can send all AT commands described in this section using the s-center software in AT mode. See also the s-center user guide [22].

Procedure

The examples in this procedure have been created and tested on EVK-NINA-B41 using TeraTerm.

1. Setup the serial port connection. See also Setting up the serial port.
2. Enter Software version identification AT+GMR command to find out the current version of your u-connectXpress software.

```
AT+GMR
"2.0.0-025"
OK
```

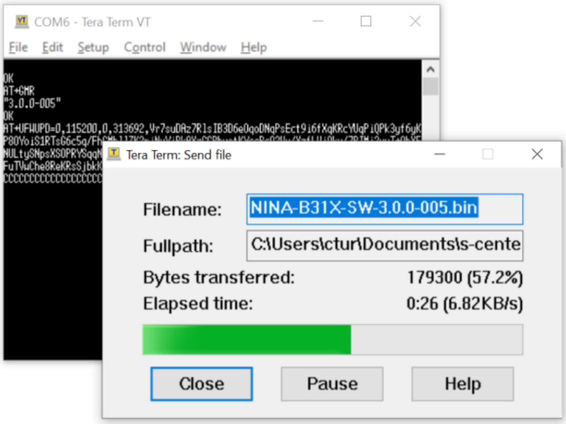
3. Prepare the module to accept a binary file for download and start the bootloader at the appropriate baud rate. Enter the Update software **AT+UFWUPD** command together with the ConnectivitySoftware values defined in the NINA-B41X-CF-<version>.json file and the signature in the NINA-B41X-SI-x.x.x-xxx.txt file. The bootloader must be running when the software is "sent" to the module in the next step. Note particularly that <mode>=0, <name>=ConnectivitySoftware, and <flags>=rwx. See also Prerequisites and Command syntax.

```
AT+UFWUPD=0,115200,0,313692,Vr7suDAz7RlsIB3D6eOqoDNqPsEct9i6fXqKRcYUqPiQPk3yf6yKP8
OYoiS1RTsG6c5q/FhGMhllZK2niNuYiPkAXrCGBhwstKYccRcO2Vx/XzfLWiOkv/7PIMi2uyT+9hXFNULt
ySNpsXSOPRYSqqNhYC9Numhwe0y5Fgi6SB90jiElDZRTaMZog34jfJCPdy2+U6M2w12Zss1sS16FFuTVwC
he8ReKRsSjbkKmT3Ft34TJrrLvcwJKxlcWx1DV1pm2NY6fGNfKo1b9FG9z+3Iq/GstvkEXa9uS0fdWDM5V
d6BNT7fVubi2JLvc5k+QCJotbYyGChmjfHhx16o2BA==,ConnectivitySoftware,rwx
```

NINA-B4 returns a series of "C" characters for as long as the bootloader is running.

```
CCCCCCCCCCCCCCCCCCCCCCCCCCC
```

4. While the bootloader is running, send the u-connectXpress NINA-B41X-SW-3.0.0-0.005.bin file to NINA-B4. The file is sent using XMODEM protocol.



5. Once the binary file has been sent, NINA-B4 displays the greeting text +STARTUP. Enter the Software version identification AT+GMR command again to make sure that the latest software version is now installed.

```
+STARTUP
AT+GMR
"3.0.0-005"
OK
```

4.1.1.2.3 Updating both the SoftDevice and u-connectXpress connectivity software

The SoftDevice is updated with AT commands using dual-banked approach, and as a SoftDevice update overwrites the application currently flashed in the module it is also necessary to flash the ConnectivitySoftware application after the SoftDevice update.

☞ You can send AT text commands to NINA-B4 to execute tasks using open-source terminal emulator software that supports XMODEM, like TeraTerm or ExtraPuTTy. Alternatively, you can send all AT commands described in this section using the s-center software in AT mode. See also the s-center user guide [22].

Procedure

The examples in this procedure have been created and tested on EVK-NINA-B41 using TeraTerm.

1. Setup the serial port connection. See also Setting up the serial port.
2. Prepare NINA-B4 to accept the SoftDevice binary file for download at the defined baud rate. Enter the Update software **AT+UFWUPD** command together with the SoftDevice values `<mode>` and `<baudrate>` defined in the `NINA-B41X-CF-<version>.json` file. Note particularly that `<mode>=1`. See also Prerequisites and Command syntax.

```
AT+UFWUPD=1,115200
>
```

3. Enter the configuration action command "`l`" to list all firmware images and check the current version of your SoftDevice.

```
> l
image_id                00
image_name              ConnectivitySoftware
image_addr              00026000
size                    0004C95C
permissions             rwx-----
signature
Vr7suDAz7RlsI...
...a9uS0fdWDM5Vd6BNT7fVubi2JLvc5k+QCJotbYyGChmjfHhx16o2BA==

image_id                01
image_name              NINA-S140-SD-6.1.1
image_addr              00000000
size                    00025DE8
permissions             rw------
signature
KHIsyhdHDIwzWf9...
...WGhe4vy6jj3kUnSosh6rrcIxqfcUDVQ4T1NwIy3wsR7SDWzE8ZmOHiU0/IEFHKY

OK
>
```

4. Store the SoftDevice signature. Enter the configuration action command `s` together with the SoftDevice values for `<imageid> <signature>` defined in the `NINA-B41X-CF-<version>.json` file and `NINA B31X-SI-x.x.x-xxx.txt` signature file. Note particularly that the `<image id>` of the SoftDevice is 1. See also Prerequisites and Command syntax.

```
> s 1
MT9MR1FCE6IY1qaPse1FatzN1Cjuea0/sVpgv670y8FwH8LYFANspk5Yl+DfOXwFcgqWKcHmN0lcKAt4b2
ugu+BItwsoQpbzwDnWLUwDJBIa6ZgsdLx/kTUNW3hWdGvQuFIfwXk4NhvX/3RlIOmPqM/shkN7tF4kaSeS
/aUpUb81edKC57kQa8L0uWXVhRyI3OwoGkvXBMKoKVIphFgP6WwKdwanrI6TWID5Ii6P16XU2s2XdG8LVo
oVqnIDO5iD4RbHMv9b5FwcyDVNrJiT8Ky7ybV/AwCh+LM8TDoHsmhvuuHICSzeQ6vdTMXXYELNXuhjsTht
EbMLiA9/NtMwlw==

OK
>
```

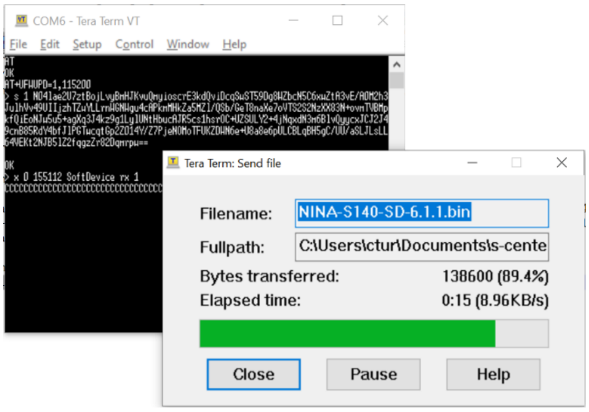
5. Prepare the bootloader to accept a file transfer using XMODEM protocol. Enter the configuration action command “x” together with the SoftDevice values `<imageaddress>, <imagesize> <imagename>, <permissions> and <imageid>` defined in the `NINA-B41X-CF-<version>.json` file.

```
> x 0 155260 SoftDevice rw 1
```

NINA-B4 returns a series of ‘C’ characters for as long as the bootloader is running.

```
CCCCCCCCCCCCCCCCCCCCCCCCCCC
```

6. While the bootloader is running, send the SoftDevice `NINA-S140-SD-x.x.bin` file to NINA-B4. The file is sent using XMODEM protocol.



NINA-B4 displays the greeting text `+STARTUP` once the binary file has been sent.

7. Having flashed the SoftDevice, you now flash the connectivity software in the same way. To initially store the signature of the connectivity software, enter the configuration action command “s” together with the ConnectivitySoftware values `<imageid> <signature>` defined in the `NINA-B41X-CF-<version>.json file` and signature in the `NINA B41X-SI-x.x.x-xxx.txt` file.

```
> s 0
ff52l1nTW2lNFI72umSFCZ3mPDloaKDDf686J50KkLmKk01xycoOHNQuuAijTEgZU9aT49g78kcz+Rs/ZC
0jTDBUCT+opw3QahEqnobuWGogKwZL2XAGHhKTYogUrvvzWGXS9hBDCov/e1F5S2T3DRixLRXBec6rc92L
Libw8dxEqNWXL+RBd9ckuJ9K4Z0yqisUGrbGe+0Pv8JR75UUV9un6DF9ECTN4HQoVco3F53DWbDc6FBYke
JHQzbgDL/AXi3GXgJ3tZ2xaXUWpodFT6Dsk/hTKjq8aosz7ImN+71SCHDACv+TVaEBMQfiXIfrFZm9V/mt
i7/kAGVbPOw1Hg==

OK
>
```

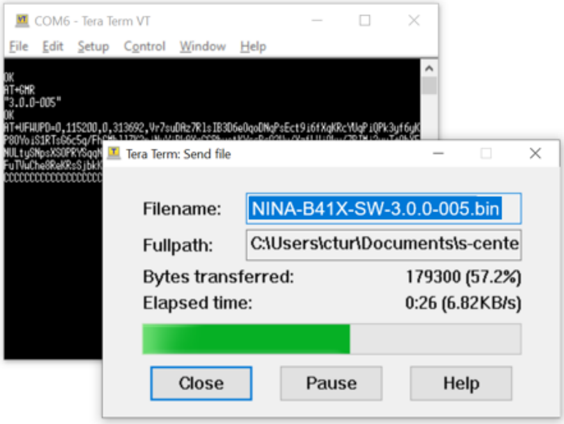
8. Prepare the bootloader to accept a file transfer using XMODEM protocol. Enter the configuration action command “x” with the ConnectivitySoftware values <imageaddress>, <imagesize>, <imagename> <permissions>, and <imageid> defined in the NINA-B41X-CF-<version>.json file.

```
> x 0 155260 ConnectivitySoftware rwx 0
```

NINA-B4 returns a series of ‘C’ characters for as long as the bootloader is running.

```
CCCCCCCCCCCCCCCCCCCCCCCCCCC
```

9. While the bootloader is running, send the u-connectXpress NINA-B41X-SW-x.y.z-<buildnr>.bin file to NINA-B4. The file is sent using XMODEM protocol.



10. Set the connectivity software as the startup image. Once the binary file has been sent, enter the configuration action command “f” with the ConnectivitySoftware value <imageid> defined in the NINA-B41X-CF-<version>.json file.

```
> f 0
OK
>
```

11. Enter the configuration action command “q” to reset and start the module with the newly flashed software.

```
> q
+STARTUP
```

For further information about bootloader commands and their parameter syntax, see the u-connectXpress bootloader protocol specification [25]and u-connectXpress AT commands manual [6].

4.2 Low frequency clock source

NINA-B4x modules are delivered without an external low frequency crystal oscillator (LFXO). The low frequency oscillator is used for power save and by the radio block. The u-connectXpress software has an auto sense functionality to detect whether a low frequency crystal oscillator is mounted on the board. For further information see the respective datasheet [2][3].

The EVK NINA-B41x is delivered with an external low frequency crystal oscillator mounted.

5 Handling and soldering

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

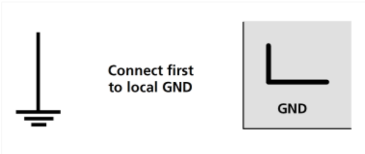
5.1 Packaging, shipping, storage, and moisture preconditioning

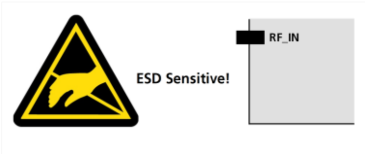
For information pertaining to reels, tapes or trays, moisture sensitivity levels (MSL), shipment and storage, as well as drying for preconditioning, refer to the respective NINA-B4 series data sheet [2] [3] and u-blox package information guide [1].

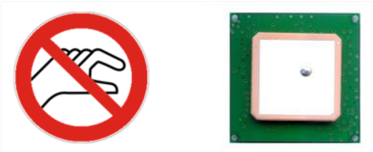
5.2 Handling

NINA-B4 series modules are Electrostatic Discharge (ESD) sensitive devices and require special precautions during handling. Care must be exercised when handling patch antennas, due to the risk of electrostatic charges. In addition to standard ESD safety practices, the following measures should be considered whenever handling the receiver:

- Unless there is a galvanic coupling between the local GND (workbench ground for example) and the PCB GND, the first point of contact when handling the PCB must be between the local GND and PCB GND.
- Before mounting an antenna patch, connect the ground of the device
- When handling the RF pin, do not come into contact with any charged capacitors and be careful when contacting materials that can develop charges, for example, the patch antenna (~10 pF), coaxial cable (~50-80 pF/m), soldering iron, and so on.
- To prevent electrostatic discharge through the RF input, do not touch any exposed antenna area. If there is any risk that such an exposed antenna area is touched in a non-ESD protected work area, implement proper ESD protection measures in the design.
- When soldering RF connectors and patch antennas to the receiver's RF pin, make sure to use an ESD safe soldering iron (tip).







5.3 Soldering

5.3.1 Reflow soldering process

NINA-B4 series modules are surface mounted and supplied on a FR4-type PCB with gold-plated connection pads. The modules are manufactured in a lead-free process with lead-free soldering paste. The bow and twist of the PCB is maximum 0.75% according to IPC-A-610E. The thickness of solder resist between the host PCB top side and the bottom side of the NINA-B4 series module must be considered for the soldering process.

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

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

Process parameter		Unit	Target
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	-	1

Table 19: Recommended reflow profile

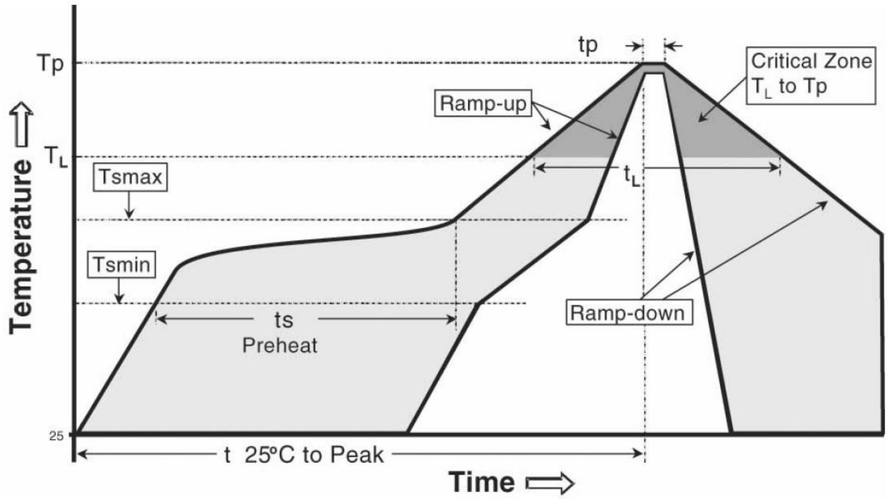


Figure 19: Reflow profile

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

☞ After reflow soldering, optical inspection of the modules is recommended to verify proper alignment.

⚠ Target values in Table 19 should be taken as general guidelines for a Pb-free process. Refer to the JEDEC J-STD-020C [9]standard for further information.

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 housings 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, in particular the crystal oscillators. For best results, use a "no clean" soldering paste and eliminate the cleaning step after the soldering process.

5.3.3 Other remarks

- Only a single reflow soldering process is allowed for boards with a module populated on them.
- 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. The Miniature Wave Selective Solder process is preferred over the traditional wave soldering process.
- Hand soldering is not recommended.
- Rework is not recommended.
- Conformal coating may affect the performance of the module, so 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, and so care is required in 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 made at the customer's own risk and will void the module’s warranty. The numerous ground pins are adequate to provide optimal immunity to interferences.
- The module contains components that are sensitive to ultrasonic waves. Use of any ultrasonic processes, such as cleaning, welding, and so on, may damage the module. Use of ultrasonic processes on an end product integrating this module will void the warranty.

Appendix

A Glossary

Abbreviation	Definition
ABS	Acrylonitrile butadiene styrene
ADC	Analog to Digital Converter
ATE	Automatic Test Equipment
LE	Bluetooth Low Energy
CTS	Clear To Send
DCX	Data/Command Signal
DFU	Device Firmware Update
DDR	Dual-Data Rate
EMC	Electro Magnetic Compatibility
EMI	Electro Magnetic Interference
ESD	Electro Static Discharge
FCC	Federal Communications Commission
GATT	Generic ATTribute profile
GND	Ground
GPIO	General Purpose Input/Output
I^2C	Inter-Integrated Circuit
IDE	Integrated Development Environment
IEEE	Institute of Electrical and Electronics Engineers
LDO	Low Drop Out
LED	Light-Emitting Diode
MAC	Media Access Control
MISO	Master Input, Slave Output
MOSI	Master Output, Slave Input
MSL	Moisture Sensitivity Level
NFC	Near Field Communication
NSMD	Non Solder Mask Defined
PCB	Printed Circuit Board
PIFA	Planar Inverted-F Antenna
PC	Polycarbonate
QDEC	Quadrature DECoder
QSPI	Quad Serial Peripheral Interface
RF	Radio Frequency
RoHS	Restriction of Hazardous Substances
RSSI	Received Signal Strength Indicator
RTS	Request to Send
RXD	Receive Data
SCL	Signal Clock
SDL	Specification and Description Language
SMA	SubMiniature version A
SMD	Solder Mask Defined
SMPS	Switching Mode Power Supply

SMT	Surface-Mount Technology
SPI	Serial Peripheral Interface
SWD	Serial Wire Debug
Thread	Networking protocol for Internet of Things (IoT) "smart" home automation devices to communicate on a local wireless mesh network
THT	Through-Hole Technology
TXD	Transmit Data
UART	Universal Asynchronous Receiver/Transmitter
UICR	User Information Configuration Registers
USB	Universal Serial Bus
VCC	IC power-supply pin
VSWR	Voltage Standing Wave Ratio
Zigbee	Open standard protocol, full-stack solution for most large smart home ecosystem providers

Table 20: Explanation of the abbreviations and terms used

B Antenna reference designs

Designers can take full advantage of the Single-Modular Transmitter certification approval of NINA-B4 by integrating the u-blox reference design for these modules into their products. This approach requires compliance with the following rules:

- Only listed antennas can be used. For the list of approved antennas, see also the NINA-B4 certification, application note [8].
- 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 that provided by u-blox. Implement one of the reference designs described in this appendix 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.

All available designs are described in this appendix.

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

When using NINA-B401/B411 modules together with this antenna reference design, the circuit trace layout must be made in strict compliance with the instructions given in this section.

Components connected to the RF trace must be kept as shown in the reference design. The reference design uses a surface-mounted U.FL micro coaxial connector to which the external antenna plugs through a 50 Ω coaxial cable, as shown in Figure 20.

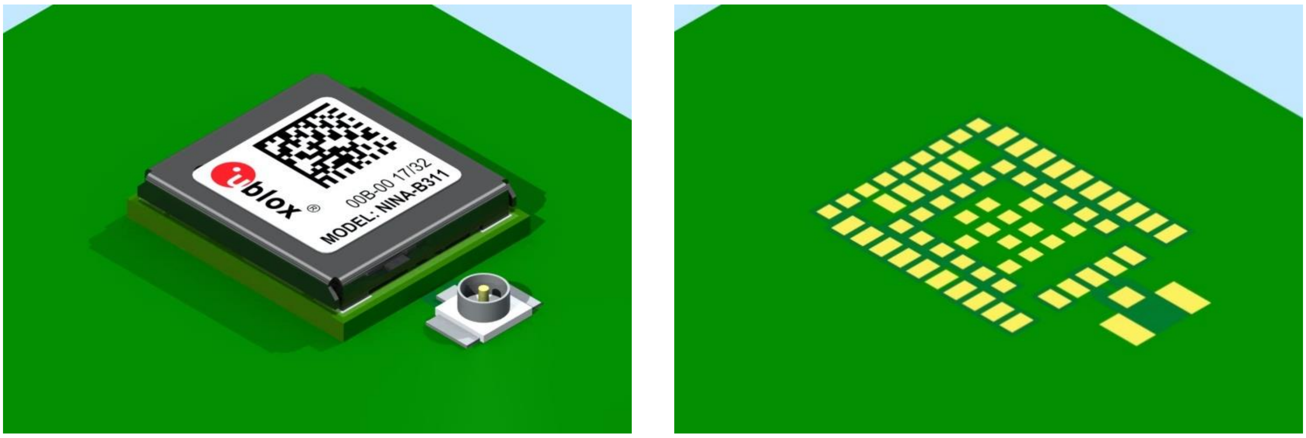


Figure 20: Antenna reference design

B.1.1 Floor plan

Figure 21 shows where the critical components and copper traces are positioned on the reference design.

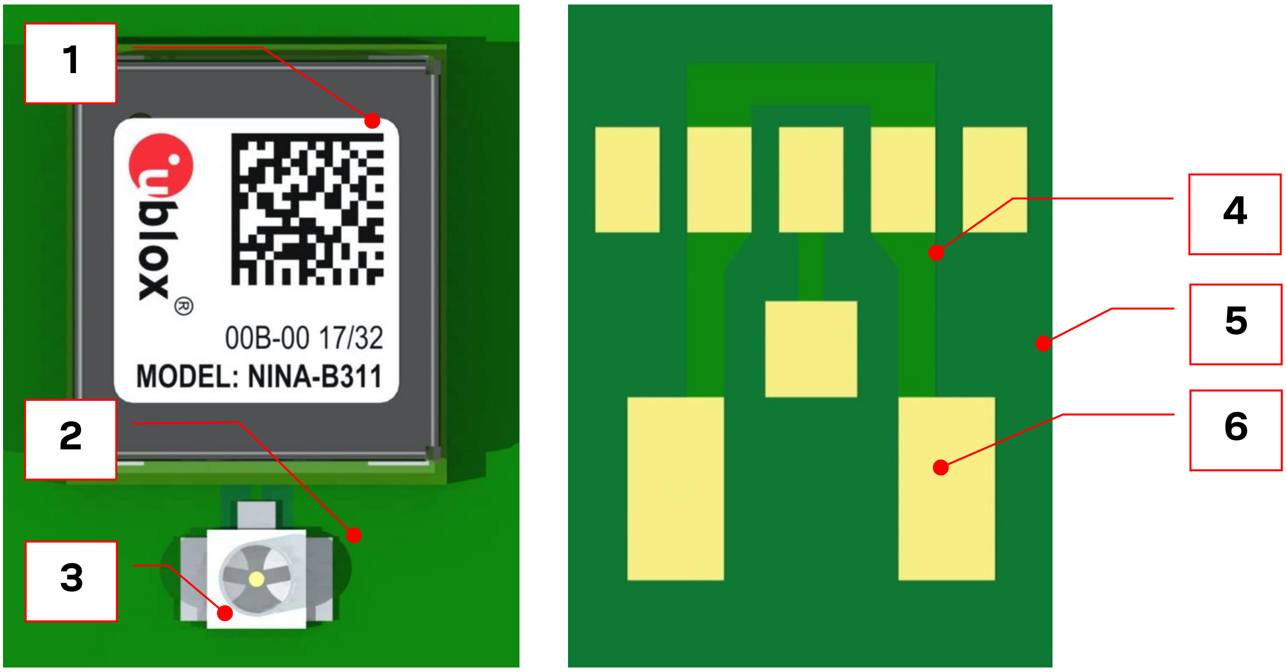


Figure 21: NINA-B401/B411 antenna reference design

Reference	Part	Manufacturer	Description
1	NINA-B401/B411	u-blox	NINA-B4 module with antenna pin
2	U.FL-R-SMT-1(10)	Hirose	Coaxial connector with shield cutoff frequency of 0–6 GHz for plugging the external antenna.
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 for top-layer GND trace, as shown in Figure 23
6	Copper keep-out area		Keep this area free from any copper on the top layer

Table 21: Included parts in the antenna connector design

B.1.2 RF trace specification

The 50 Ω coplanar micro-strip dimensions used in the reference design are shown in Figure 22 and Table 22. 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” must 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.

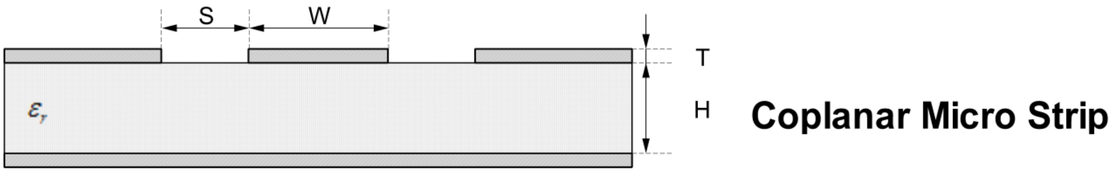


Figure 22: Coplanar micro-strip dimension specification

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 22: Coplanar microstrip specification

☞ The GND spacing requirements of the NINA ANT and U.FL connector RF pins are greater than the spacing requirement of a 50 Ω coplanar microstrip. However, the increased spacing to GND does not affect the trace impedance significantly for short trace lengths of width and height shown in Table 22. Consequently, the trace impedance for traces with these dimensions is still close to 50 Ω.

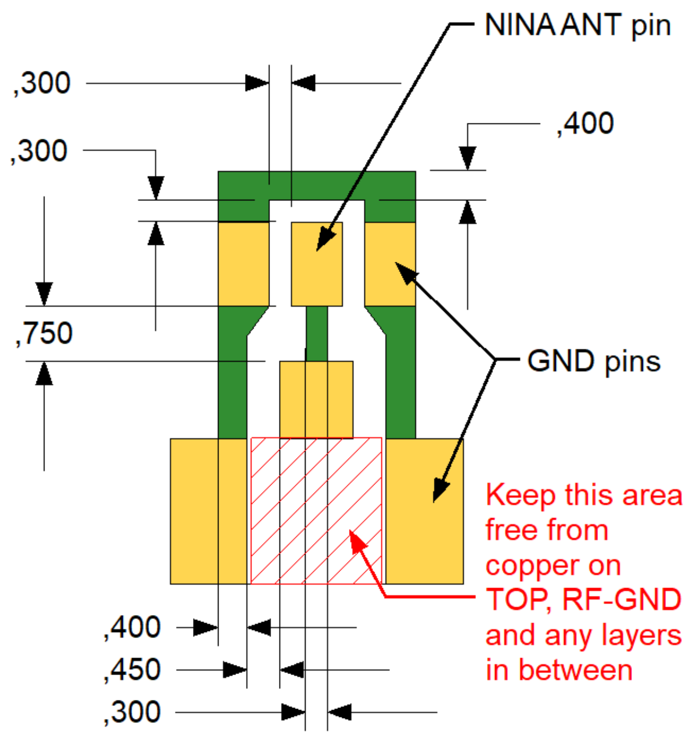


Figure 23: RF trace and minimum dimensions in millimeters for the GND trace of the U.FL antenna connector in the reference design

Related documents

[1] Packaging information reference, UBX-14001652
[2] NINA-B4 series data sheet, UBX-19049405
[3] NINA-B41 series data sheet, UBX-20035327
[4] NINA-B40 series, product summary, UBX-19047297
[5] NINA-B41 series, product summary, UBX-20045962
[6] u-connectXpress AT commands manual, UBX-14044127
[7] NINA nested design and migration, application note, UBX-17065600
[8] NINA-B4 certification, application note, UBX-20037320
[9] JEDEC J-STD-020C - Moisture/Reflow Sensitivity Classification for Non Hermetic Solid State Surface Mount Devices
[10] IEC EN 61000-4-2 - Electromagnetic compatibility (EMC) - Part 4-2: Testing and measurement techniques – Electrostatic discharge immunity test
[11] ETSI EN 301 489-1 - Electromagnetic compatibility and Radio spectrum Matters (ERM); ElectroMagnetic Compatibility (EMC) standard for radio equipment and services; Part 1: Common technical requirements
[12] IEC61340-5-1 - Protection of electronic devices from electrostatic phenomena – General requirements
[13] ETSI EN 60950-1:2006 - Information technology equipment – Safety – Part 1: General requirements
[14] JESD51 – Overview of methodology for thermal testing of single semiconductor devices
[15] Nordic Semiconductor Infocenter, https://infocenter.nordicsemi.com/index.jsp
[16] NINA-B4 Declaration of conformity, UBX-20043953
[17] u-connectXpress user guide, UBX-16024251
[18] Using the public IEEE address from UICR, UBX-19055303
[19] Tag-Connect pad connector - http://www.tag-connect.com/TC2030-CTX
[20] u-blox shortrange open CPU github repository, https://github.com/u-blox/u-blox-sho-OpenCPU
[21] RC oscillator configuration for nRF5 open CPU modules, UBX-20009242
[22] s-center user guide, UBX-16012261
[23] XPLR-AOA explorer kits, user guide, UBX-21004616
[24] EVK-NINA-B4 user guide, UBX-19054587
[25] u-connectXpress bootloader protocol specification, UBX-17065404

☞ 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	12-Dec-2019	fbro,mape	Initial release.
R02	14-Jan-2020	mape	Minor corrections.
R03	27-Mar-2020	hisa	Updated NINA-B400 product status to “Prototype”. Updated front page module images.
R04	20-Nov-2020	lber	Updated the product status of NINA-B400 and NINA-B406 variants from “Prototype” to “Engineering sample”. Revised SWD and UART flashing information in sections 2.8 and 3.2. Included editorial changes in all chapters.
R05	23-Dec-2020	mape	Divided chapter 1.5 into two subchapters. Added chapter 1.5.2. Minor corrections to 1.5.1 Added note in 3.12 about how to save MAC address when not using the u-blox supplied bootloader. Minor corrections.
R06	22-Jan-2021	lber	Added NINA-B401 and NINA-B411 product variants with subsequent revision to the design-in and antenna descriptions in chapter 2. Added handling and soldering information, section 5.
R07	1-Jul.2021	mape, lber	Updated the product status of all module variants to Initial Production in Document information. Revised Updating NINA-B41 software section. Added information describing u-connectLocate software. Added new appendix to describe Antenna reference design.

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