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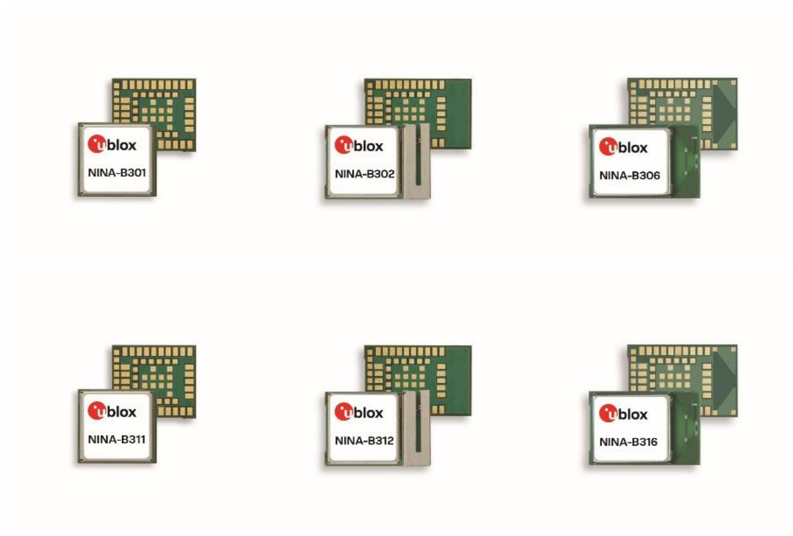
NINA-B3 series

Stand-alone Bluetooth 5 low energy modules

System integration manual



Abstract

This document describes the system integration of the NINA-B3 series stand-alone Bluetooth 5 low energy modules.

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Document information

Title	NINA-B3 series	
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Product status	Corresponding content status	
Functional Sample	Draft	For functional testing. Revised and supplementary data will be published later.
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Engineering Sample	Advance Information	Data based on early testing. Revised and supplementary data will be published later.
Initial Production	Early Production Information	Data from product verification. Revised and supplementary data may be published later.
Mass Production / End of Life	Production Information	Document contains the final product specification.

This document applies to the following products:

Product name	Type number	Open CPU	PCN reference	Product status
NINA-B301	NINA-B301-00B-00		N/A	Initial production
NINA-B302	NINA-B302-00B-00		N/A	Initial production
NINA-B306	NINA-B306-00B-00		N/A	Initial production

Product name	Type number	u- connectXpress software version	PCN reference	Product status
NINA-B311	NINA-B311-00B-00	1.0.0	N/A	Initial production
NINA-B311	NINA-B311-01B-00	2.0.0	N/A	Initial production
NINA-B312	NINA-B312-00B-00	1.0.0	N/A	Initial production
NINA-B312	NINA-B312-01B-00	2.0.0	N/A	Initial production
NINA-B316	NINA-B316-01B-00	2.0.0	N/A	Initial production

Contents

1 System description

1.1 Overview and applications

The NINA-B3 series modules are small stand-alone Bluetooth 5 low energy microcontroller unit (MCU) modules. The NINA-B3 features full Bluetooth 5, a powerful Arm® Cortex®-M4 with FPU, and state-of-the-art power performance. The embedded low power crystal in the NINA-B3 series improves power consumption by enabling optimal power save modes.

The NINA-B3x2 comes with an internal antenna, while the NINA-B3x1 has a pin for use with an external antenna. The internal PIFA antenna is specifically designed for the small NINA form factor and provides an extensive range, independent of ground plane and component placement. The NINA-B3 series is globally certified for use with the internal antenna or a range of external antennas. This greatly reduces time, cost, and effort for customers integrating the NINA-B3 in their designs.

The NINA-B3 series includes the following two sub-series as listed in the table below:

Model	Description
NINA-B30 series	Bluetooth 5 module with a powerful Arm Cortex-M4 with FPU, and state-of-the-art power performance. Both the variants of NINA-B30 are open CPU modules that enable customer applications to run on the built-in Arm Cortex-M4 with FPU. With 1 MB flash and 256 kB RAM, they offer the best-in-class capacity for customer applications on top of the Bluetooth low energy stack. NINA-B301 has a pin for use with an external antenna, NINA-B302 comes with an internal PIFA antenna, and NINA-B06 has an internal PCB antenna integrated in the module PCB. The internal antennas are specifically designed for the small NINA form factor and provides an extensive range, independent of ground plane and component placement.
NINA-B31 series	Bluetooth 5 module with a powerful Arm Cortex-M4 with FPU and u-connectXpress software pre-flashed. The software in NINA-B31 modules provides support for u-blox Bluetooth low energy Serial Port Service, GATT client and server, beacons, NFC™, and simultaneous peripheral and central roles – all configurable from a host using AT commands. The NINA-B31x modules provide top grade security, thanks to secure boot, which ensures the module only boots up with original u-blox software. NINA-B311 has a pin for use with an external antenna, NINA-B312 comes with an internal PIFA antenna, and NINA-B16 has an internal PCB antenna integrated in the module PCB. The internal antennas are specifically designed for the small NINA form factor and provides an extensive range, independent of ground plane and component placement.

	NINA-B301	NINA-B302	NINA-B306
Grade			
Automotive			
Professional	•	•	•
Standard			
Radio			
Bluetooth qualification	v5.0	v5.0	v5.0
Bluetooth profiles	G	G	G
Bluetooth output power EIRP [dBm]	10	10	10
Max range [meters]	1400	1400	1400
NFC for "Touch to Pair"	•	•	•
Antenna type	p	i	b
Application software			
Open CPU for embedded customer applications	•	•	•
Interfaces			
UART	♦	♦	♦
SPI	♦	♦	♦
I^2C	♦	♦	♦
I^2S	♦	♦	♦
USB	♦	♦	♦
GPIO pins	38	38	38
AD converters (ADC)	♦	♦	♦
Features			
GATT server and client	♦	♦	♦
Throughput [Mbit/s]	1.4	1.4	14
Maximum Bluetooth connections	20	20	20
Secure boot	♦	♦	♦
Mesh networking	♦	♦	♦
FOTA	♦	♦	♦

G = GATT

p = Antenna pin
i = Internal PIFA antenna
b = Internal PCB antenna

♦ = Feature enabled by HW. The actual support depends on the open CPU application SW.

Table 1: NINA-B30 series main features summary

	NINA-B311	NINA-B312	NINA-B316
Grade			
Automotive			
Professional	•	•	•
Standard			
Radio			
Bluetooth qualification	v5.0	v5.0	v5.0
Bluetooth profiles	G	G	G
Bluetooth output power EIRP [dBm] *	10	10	10
Max range [meters] *	1400	1400	1400
NFC for "Touch to Pair"	•	•	•
Antenna type *	p	i	b
Application software			
u-connectXpress	•	•	•
u-connectScript	•	•	•
Interfaces			
UART	1	1	1
GPIO pins	28	28	28
Features			
AT command interface	•	•	•
Script engine – JavaScript	•	•	•
GATT server and client	•	•	•
Extended Data Mode	•	•	•
Low Energy Serial Port Service	•	•	•
Throughput [Mbit/s]	0.8	0.8	0.8
Maximum Bluetooth connections	8	8	8
Secure boot	•	•	•

G = GATT p = Antenna pin i = Internal PIFA antenna b = PCB antenna

Table 2: NINA-B31 series main features summary

⚠ Regulations in the European market require the maximum output power of the radio to be limited. See Section 5.1 for more information.

1.2 Architecture

1.2.1 Block diagrams

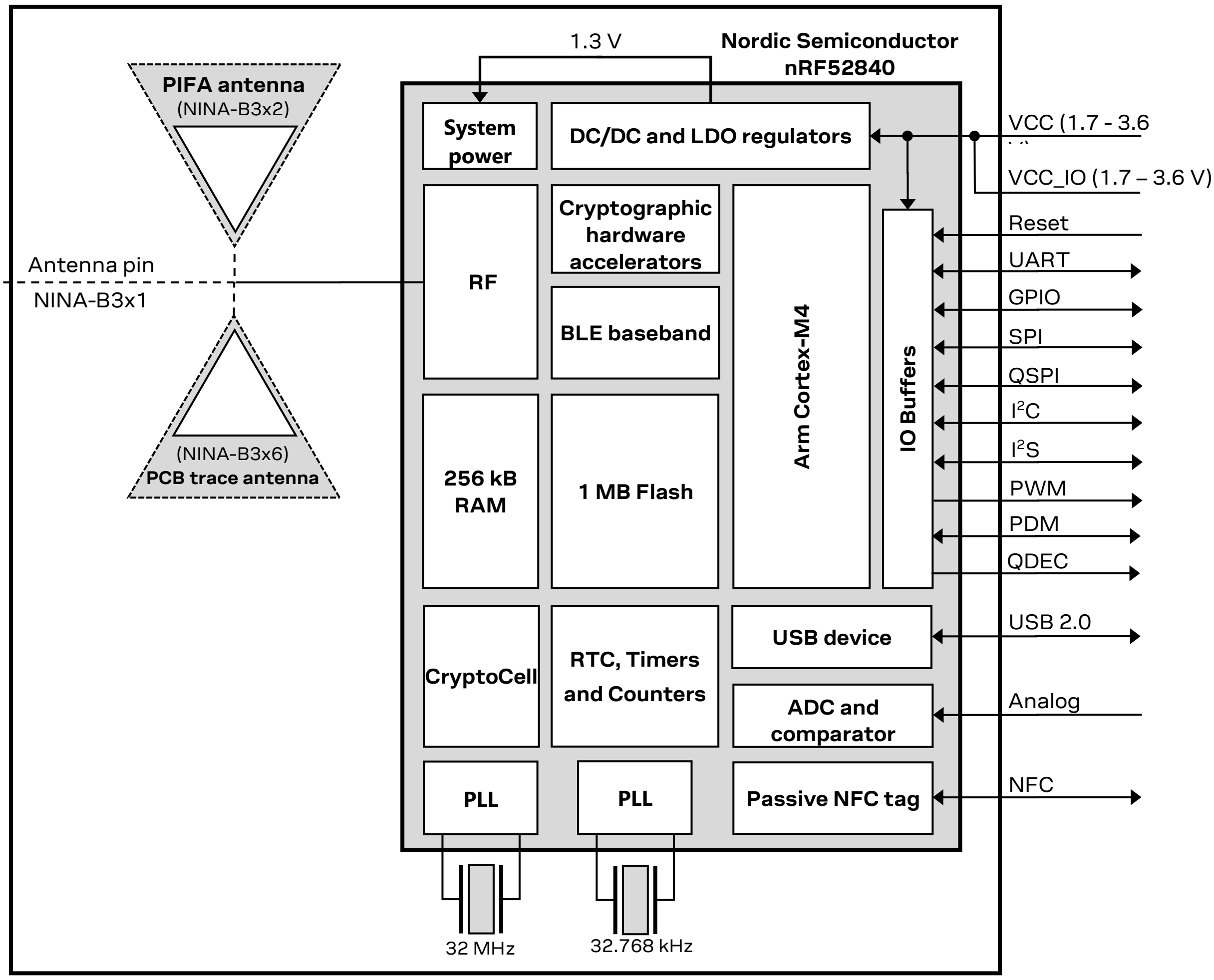


Figure 1: Block diagram of the NINA-B3 series

1.2.2 Hardware options

The NINA-B3 series modules use an identical hardware configuration except for the different PCB sizes and antenna solutions. An on-board 32.768 kHz low power crystal is always included and an integrated DC/DC converter for higher efficiency under heavy load situations.

1.2.3 Software options

The NINA-B3 series module can be used either together with the pre-flashed u-connectXpress software or as an open CPU module where you can run your own application developed with the Nordic SDK development environment inside the NINA-B3 module. The various software options are described in detail in section 2.

1.3 Pin configuration and function

See the NINA-B3 series Data Sheet [2] for information about pin configuration and function.

1.4 Supply interfaces

1.4.1 Main supply input

The NINA-B3 series uses an integrated DC/DC converter to transform the supply voltage presented at the **VCC** pin into a stable system core voltage. Because of this, the NINA-B3 modules are compatible for use in battery powered designs.

While using the NINA-B3 with a battery, it is important that the battery type can handle the peak power of the module. For the battery supply, consider adding extra capacitance on the supply line to avoid capacity degradation. See the *NINA-B3 series Data Sheet [2]* for information about voltage supply requirements and current consumption.

Rail	Voltage requirement	Current requirement (peak)
VCC	1.7 V – 3.6 V	20 mA
VCC_IO	Tied to VCC	

Table 3: Summary of voltage supply requirements

☞ The current requirement in Table 3 considers using the u-connectXpress software with UART communications. But it does not include any additional I/O current. Any use of external push-buttons, LEDs, or other interfaces will add to the total current consumption of the NINA-B3 module. The peak current consumption of the entire design will need to be taken into account when considering a battery powered solution.

1.4.2 Digital I/O interfaces reference voltage (VCC_IO)

On the NINA-B3 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-B3 with a battery, the I/O voltage level will vary with the battery output voltage, depending on the charge of the battery. Level shifters might be needed depending on the I/O voltage of the host system.

1.4.3 VCC application circuits

The power for NINA-B3 series modules is provided through the VCC pins, which can be one of the following:

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

The SMPS is the ideal choice when the available primary supply source has a higher value than the operating supply voltage of the NINA-B3 series modules. The use of SMPS provides the best power efficiency for the overall application and minimizes the current drawn from the main supply source.

⚠ While selecting SMPS, ensure that the AC voltage ripple at the switching frequency is kept as low as possible. Layout shall be implemented to minimize impact of high frequency ringing.

The use of an LDO linear regulator is convenient for a primary supply with a relatively low voltage where the typical 85-90% efficiency of the switching regulator leads to minimal current saving. Linear regulators are not recommended for high voltage step-down, as they will dissipate a considerable amount of energy.

DC/DC efficiency should be evaluated as a tradeoff between active and idle duty cycles of the specific application. Although some DC/DC can achieve high efficiency at extremely light loads, a typical

DC/DC efficiency quickly degrades as idle current drops below a few mA, greatly reducing the battery life.

Due to the low current consumption and wide voltage range of the NINA-B3 series module, a battery can be used as a main supply. The capacity of the battery should be selected to match the application. Care should be taken so that the battery can deliver the peak current required by the module. See the *NINA-B3 series Data Sheet [2]* for the electrical specifications.

It is considered as best practice to have decoupling capacitors on the supply rails close to the NINA-B3 series module, although depending on the design of the power routing on the host system, capacitance might not be needed.

1.5 System function interfaces

1.5.1 Module reset

You can reset the NINA-B3 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.

1.5.2 Internal temperature sensor

The radio chip in the NINA-B3 module contains a temperature sensor used for over temperature 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.

1.6 Debug – Serial Wire Debug (SWD)

The primary interface for debugging is the SWD interface. The NINA-B30 series modules provide an SWD interface for flashing and debugging. The two pins **SWDIO** and **SWDCLK** should be made accessible on header or test points.

The SWD interface is disabled on the NINA-B31 series modules.

1.7 Serial interfaces

⚠ As the NINA B3 module can be used with both the u-connectXpress and open CPU based applications, based on the Nordic SDK, the available interfaces and the pin mapping may vary. For detailed pin information, see the Pin configuration and function section.

1.7.1 Universal Asynchronous Serial Interface (UART)

The NINA-B3 series module 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-B3 module.

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

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-B3 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

See the NINA-B3 series Data Sheet [2] for characteristics information about the UART interface.

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

Table 4: Default settings for the COM port while using the u-connectXpress software

It is recommended to make the UART available either as test points or connected to a header for a software upgrade.

The I/O level of the UART will follow the VCC voltage and it can thus be in the range of 1.8 V and 3.6 V. If you are connecting the NINA-B3 module to a host with a different voltage on the UART interface, a level shifter should be used.

1.7.2 Serial Peripheral Interface (SPI)

NINA-B3 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.

1.7.3 Quad serial peripheral interface (QSPI)

The Quad Serial Peripheral Interface enables connection of external memory to the NINA-B3 module in order to increase the application program size. The QSPI uses the following signals:

- CLK, serial clock output, up to 32 MHz
- CS, Chip/Slave select output, active low, selects which slave on the bus to talk to
- D0, MOSI serial output data in single mode, data I/O signal in dual/quad mode
- D1, MISO serial input data in single mode, data I/O signal in dual/quad mode
- D2, data I/O signal in quad mode (optional)
- D3, data I/O signal in quad mode (optional)

1.7.4 I²C interface

The Inter-Integrated Circuit (I²C) interfaces can be used to transfer or receive data on a 2-wire bus network. The NINA-B3 modules 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 Electrical specifications in the NINA-B3 series Data sheet [2] for recommended resistor values.

1.7.5 USB 2.0 interface

The NINA-B3 series modules 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, required in order 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.

1.8 GPIO pins

In an un-configured state, NINA-B3 modules have 38 GPIO pins and no analog or digital interfaces. All interfaces or functions must be allocated to a GPIO pin before use. Eight of the 38 GPIO pins are analog enabled, meaning that they can have an analog function allocated to them. In addition to the serial interfaces, Table 6 shows the digital and analog functions that can be assigned to a GPIO pin.

Function	Description	Default NINA-B3 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 Bluetooth LE connection is maintained	BLUE**	Any

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

Table 5: GPIO custom functions configuration

1.8.1 Analog interfaces

Eight out of the 38 digital GPIOs 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.

1.8.1.1 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 6 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 6: Acquisition vs. source impedance

1.8.1.2 Comparator

The comparator compares voltages from any analog pin with different references as shown in Table 7. 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 - 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 7
- Differential Mode: Two analog pin voltage levels are compared, optionally with a 50 mV hysteresis

1.8.1.3 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.

1.8.1.4 Analog pin options

The following table 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, 1.8V or 2.4V
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 7: Possible uses of the analog pin

1.9 Antenna interfaces

☞ The antenna interface is different for each module variant in the NINA-B3 series.

1.9.1 Antenna pin – NINA-B3x1

The NINA-B3x1 is equipped with an RF pin. The RF pin has a nominal characteristic impedance of 50 Ω and must be connected to the antenna through a 50 Ω transmission line to allow reception of radio frequency (RF) signals in the 2.4 GHz frequency band.

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

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

1.9.1.1 Antenna matching

The antenna return loss should be as good as possible across the entire band when the system is operational, in order to provide optimal performance. The enclosure, shields, other components and surrounding environment will impact the return loss seen at the antenna port. Matching components are often required to re-tune the antenna to bring the return loss within an acceptable range.

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

1.9.1.2 Approved antenna designs

NINA-B3 modules come with a pre-certified design that can be used to save costs and time during the certification process. To take advantage of this service, the customer is required to implement an antenna layout according to the u-blox reference designs. The reference design is described in Appendix B.

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

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

1.9.2 Integrated antenna – NINA-B3x2/B3x6

The NINA-B3x2 and NINA-B3x6 modules are equipped with an integrated antenna on the module. This will simplify the integration, as there will be no need to do an RF trace design on the host PCB. By using NINA-B3x2 or NINA-B3x6, the certification of the NINA-B3 series modules can be reused, thus minimizing the effort needed in the test lab. The NINA-B3x2 modules use an internal metal sheet PIFA antenna, while the NINA-B3x6 modules have a PCB trace antenna that uses antenna technology licensed from Proant AB.

1.9.3 NFC antenna

The NINA-B3 series modules include a Near Field Communication interface, capable of operating as a 13.56 MHz NFC tag at a bit rate of 106 kbps. As an NFC tag, data can be read from or written to the NINA-B3 modules using an NFC reader; however the NINA-B3 modules are not capable of reading other tags or initiating NFC communications. Two pins are available for connecting to an external NFC antenna: **NFC1** and **NFC2**.

1.10 Reserved pins (RSVD)

Do not connect the reserved (**RSVD**) pin. The reserved pins are allocated for future interfaces and functionality.

1.11 GND pins

Good connection of the module's GND pins with a solid ground layer of the host application board is required for correct RF performance. It significantly reduces EMC issues and provides a thermal heat sink for the module.

See the Module footprint and paste mask and Thermal guidelines sections for information about ground design.

2 Software

The NINA-B3 series modules can be used either with the pre-flashed u-connectXpress software, or as an open CPU module in which you can run your own application developed with the Nordic SDK development environment inside the NINA-B3 module.

The software on the NINA-B3 module contains the following parts:

- SoftDevice S140 is a Bluetooth® low energy (LE) central and peripheral protocol stack solution
- Optional bootloader
- Application

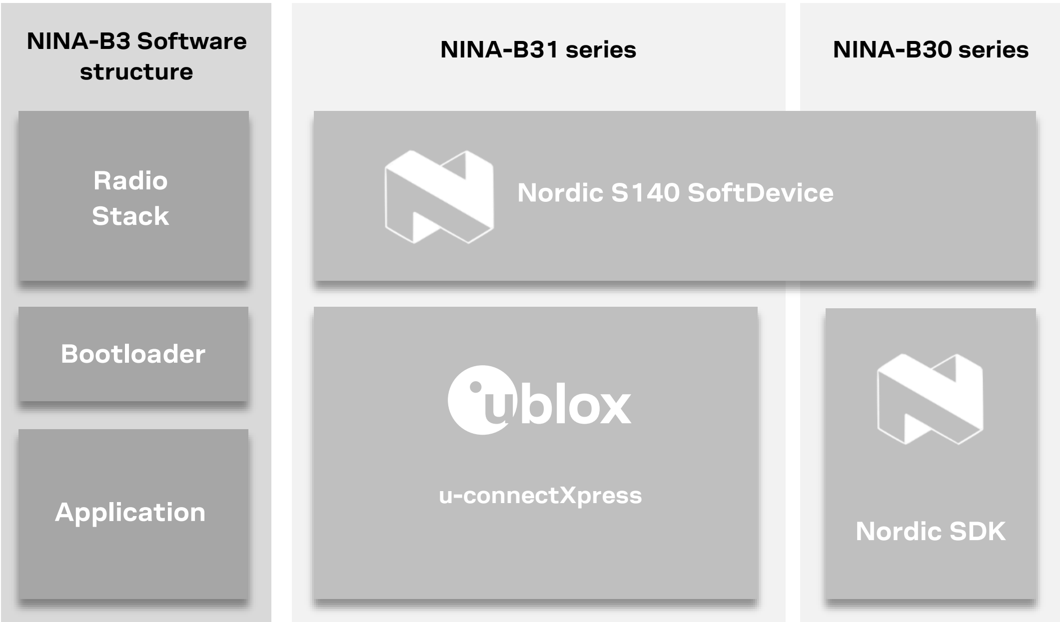


Figure 2: NINA-B3 software structure and available software options

2.1 u-connectXpress software

The NINA-B31 series modules are delivered with the u-blox secure boot loader and u-connectXpress software pre-flashed.

The u-connectXpress software enables use of the Bluetooth Low Energy functions, controlled by AT commands over the UART interface. Examples of supported features are u-blox Low Energy Serial Port Service, GATT server and client, central and peripheral roles, and multidrop connections. More information on the features and capabilities of the u-connectXpress software and how to use it can be found in NINA-B31 Getting Started [13] and the u-connect AT Commands Manual [3].

2.2 Open CPU

2.2.1 Nordic SDK

The Nordic nRF5 SDK provides a rich development environment for various devices and applications by including a broad selection of drivers and libraries. The SDK is delivered as a plain zip archive, which makes it easy to install. The SDK comes with support for the SEGGER Embedded Studio, Keil and IAR IDEs, as well as the GCC compiler, which offers the freedom to choose the IDE and compiler.

2.2.1.1 Getting started on the Nordic SDK

When working with the Nordic SDK on the NINA-B3 series module, follow the steps below to get started with the Nordic Semiconductor toolchain and examples:

1. Download and install the nRF Connect application and install the Programmer app, which allows programming over SWD, from www.nordicsemi.com.
2. Download and install the latest SEGGER Embedded Studio from www.segger.com.
3. Download and extract the latest nRF5 SDK found on http://www.nordicsemi.com/eng/Products/Bluetooth-low-energy/nRF5-SDK to the directory that you want to use to work with the nRF5 SDK.
4. Read the information in the SDK Release Notes and check the nRF5 software development kit documentation available at the Nordic Semiconductor Infocenter [11].

2.2.1.1.1 Nordic tools

More information and links to all available tools as well as supported compilers can be found in the Nordic Semiconductor Software and Tools page - https://www.nordicsemi.com/Software-and-Tools

2.2.1.1.2 Support – Nordic development forum

For support on questions related to the development of software using the Nordic SDK, refer to the *Nordic development zone* - https://devzone.nordicsemi.com/

2.2.1.2 Create a custom board for Nordic SDK

The predefined hardware boards included in the Nordic SDK are Nordic development boards only. To add support for a custom board, a custom board support file with the name custom_board.h can be created. This file should be located in the folder "...\components\boards\". The custom board can then be selected by adding the define statement - #define BOARD_CUSTOM.

☞ The above-mentioned file location is according to the Nordic nRF5 SDK version 15.3.0.

Figure 3 shows an example of how the custom board support file can look like for the EVK-NINA-B3.

```
#ifndef CUSTOM_BOARD_H
#define CUSTOM_BOARD_H

#ifdef __cplusplus
extern "C" {
#endif

#include "nrf_gpio.h"

// In this file PIN 25 is used as button SWITCH_1, if the GREEN led
// should be used it is possible to defined that one instead.
#define LEDS_NUMBER    2

#define LED_1          NRF_GPIO_PIN_MAP(0,13)       // RED
#define LED_2          NRF_GPIO_PIN_MAP(1,00)       // BLUE
// #define LED_3       NRF_GPIO_PIN_MAP(0,25)       // GREEN

#define LEDS_ACTIVE_STATE 0

#define LEDS_LIST { LED_1, LED_2 }

#define LEDS_INV_MASK  LEDS_MASK

#define BSP_LED_0      LED_1
#define BSP_LED_1      LED_2
// #define BSP_LED_2   LED_3

#define BUTTONS_NUMBER 2

#define BUTTON_1       25  // SWITCH_1
#define BUTTON_2       2   // SWITCH_2
#define BUTTON_PULL    NRF_GPIO_PIN_PULLUP

#define BUTTONS_ACTIVE_STATE 0

#define BUTTONS_LIST { BUTTON_1, BUTTON_2 }

#define BSP_BUTTON_0   BUTTON_1
#define BSP_BUTTON_1   BUTTON_2

#define RX_PIN_NUMBER  NRF_GPIO_PIN_MAP(0,29)
#define TX_PIN_NUMBER  NRF_GPIO_PIN_MAP(1,13)
#define CTS_PIN_NUMBER NRF_GPIO_PIN_MAP(1,12)
#define RTS_PIN_NUMBER NRF_GPIO_PIN_MAP(0,31)
#define HWFC           true

#define BSP_QSPI_SCK_PIN   19
#define BSP_QSPI_CSN_PIN   17
#define BSP_QSPI_IO0_PIN   20
#define BSP_QSPI_IO1_PIN   21
#define BSP_QSPI_IO2_PIN   22
#define BSP_QSPI_IO3_PIN   23

// Arduino board mappings
#define ARDUINO_SCL_PIN             24  // SCL signal pin
#define ARDUINO_SDA_PIN             16  // SDA signal pin

#define ARDUINO_13_PIN              NRF_GPIO_PIN_MAP(0, 7)
#define ARDUINO_12_PIN              NRF_GPIO_PIN_MAP(0, 2)
#define ARDUINO_11_PIN              NRF_GPIO_PIN_MAP(0, 15)
#define ARDUINO_10_PIN              NRF_GPIO_PIN_MAP(0, 14)
#define ARDUINO_9_PIN               NRF_GPIO_PIN_MAP(0, 12)
#define ARDUINO_8_PIN               NRF_GPIO_PIN_MAP(1, 9)

#define ARDUINO_7_PIN               NRF_GPIO_PIN_MAP(0, 10)
#define ARDUINO_6_PIN               NRF_GPIO_PIN_MAP(0, 9)
#define ARDUINO_5_PIN               NRF_GPIO_PIN_MAP(0, 11)
#define ARDUINO_4_PIN               NRF_GPIO_PIN_MAP(0, 13)
#define ARDUINO_3_PIN               NRF_GPIO_PIN_MAP(0, 31)
#define ARDUINO_2_PIN               NRF_GPIO_PIN_MAP(1, 12)
#define ARDUINO_1_PIN               NRF_GPIO_PIN_MAP(1, 13)
```

Figure 3: Example of EVK-NINA-B3 custom board support file

```
#define ARDUINO_A0_PIN            NRF_GPIO_PIN_MAP(0, 4)
#define ARDUINO_A1_PIN            NRF_GPIO_PIN_MAP(0, 30)
#define ARDUINO_A2_PIN            NRF_GPIO_PIN_MAP(0, 5)
#define ARDUINO_A3_PIN            NRF_GPIO_PIN_MAP(0, 2)
#define ARDUINO_A4_PIN            NRF_GPIO_PIN_MAP(0, 28)
#define ARDUINO_A5_PIN            NRF_GPIO_PIN_MAP(0, 3)

#define RASPBERRY_PI_3_PIN        NRF_GPIO_PIN_MAP(0, 24)
#define RASPBERRY_PI_5_PIN        NRF_GPIO_PIN_MAP(0, 16)
#define RASPBERRY_PI_7_PIN        NRF_GPIO_PIN_MAP(0, 15)
#define RASPBERRY_PI_11_PIN       NRF_GPIO_PIN_MAP(0, 14)
#define RASPBERRY_PI_13_PIN       NRF_GPIO_PIN_MAP(0, 19)
#define RASPBERRY_PI_15_PIN       NRF_GPIO_PIN_MAP(0, 17)
#define RASPBERRY_PI_19_PIN       NRF_GPIO_PIN_MAP(0, 21)
#define RASPBERRY_PI_21_PIN       NRF_GPIO_PIN_MAP(0, 23)
#define RASPBERRY_PI_23_PIN       NRF_GPIO_PIN_MAP(0, 7)
#define RASPBERRY_PI_27_PIN       NRF_GPIO_PIN_MAP(0, 26)
#define RASPBERRY_PI_29_PIN       NRF_GPIO_PIN_MAP(1, 15)
#define RASPBERRY_PI_31_PIN       NRF_GPIO_PIN_MAP(1, 11)
#define RASPBERRY_PI_33_PIN       NRF_GPIO_PIN_MAP(1, 3)
#define RASPBERRY_PI_35_PIN       NRF_GPIO_PIN_MAP(1, 2)
#define RASPBERRY_PI_37_PIN       NRF_GPIO_PIN_MAP(1, 8)

#define RASPBERRY_PI_8_PIN        RX_PIN_NUMBER
#define RASPBERRY_PI_10_PIN       TX_PIN_NUMBER
#define RASPBERRY_PI_12_PIN       NRF_GPIO_PIN_MAP(0, 13)
#define RASPBERRY_PI_16_PIN       NRF_GPIO_PIN_MAP(0, 20)
#define RASPBERRY_PI_18_PIN       NRF_GPIO_PIN_MAP(0, 22)
#define RASPBERRY_PI_22_PIN       NRF_GPIO_PIN_MAP(0, 12)
#define RASPBERRY_PI_24_PIN       NRF_GPIO_PIN_MAP(0, 27)
#define RASPBERRY_PI_26_PIN       NRF_GPIO_PIN_MAP(0, 6)
#define RASPBERRY_PI_28_PIN       NRF_GPIO_PIN_MAP(1, 14)
#define RASPBERRY_PI_32_PIN       NRF_GPIO_PIN_MAP(1, 10)
#define RASPBERRY_PI_36_PIN       NRF_GPIO_PIN_MAP(1, 1)
#define RASPBERRY_PI_38_PIN       NRF_GPIO_PIN_MAP(1, 9)
#define RASPBERRY_PI_40_PIN       NRF_GPIO_PIN_MAP(0, 11)


#ifdef __cplusplus
}
#endif

#endif // CUSTOM_BOARD_H
```

Figure 4: Example of EVK-NINA-B3 custom board support file (continued)

The custom board can then be selected by adding the define statement: #define BOARD_CUSTOM.

You can add the BOARD_CUSTOM define statement in SEGGER Embedded Studio 3.40 by following the instructions provided below:

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

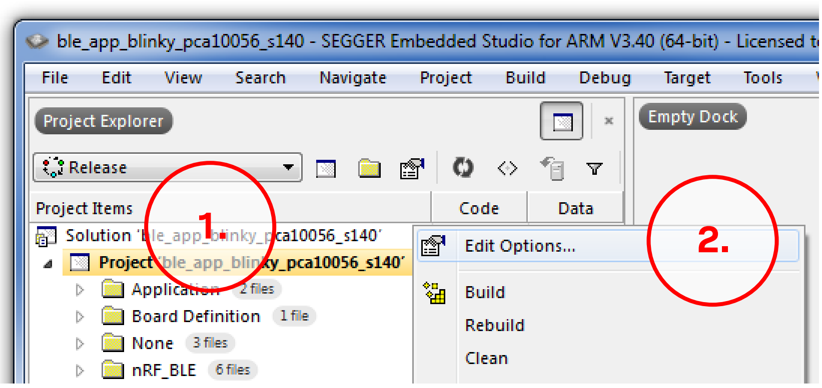


Figure 5: Screenshot with steps to modify the Define statement in SEGGER Embedded Studio

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

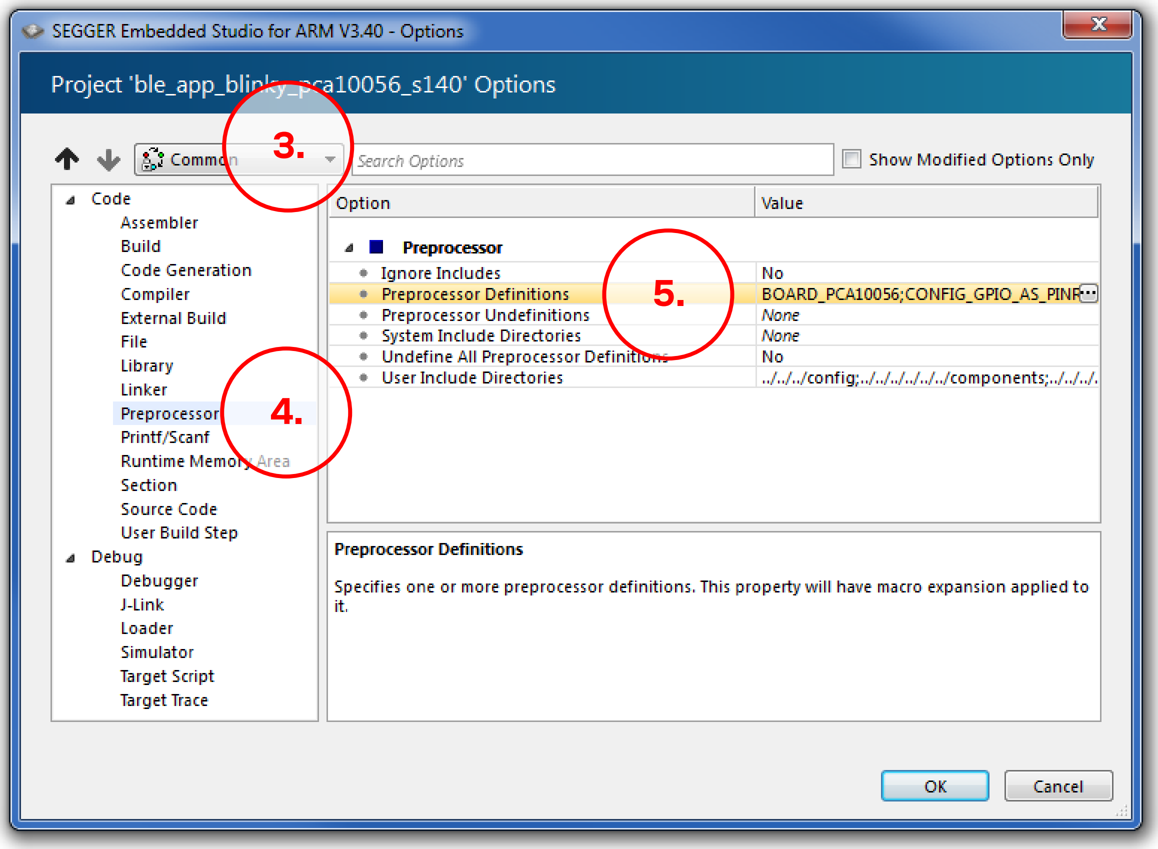


Figure 6: Screenshot with steps to modify the Define statement in SEGGER Embedded Studio

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

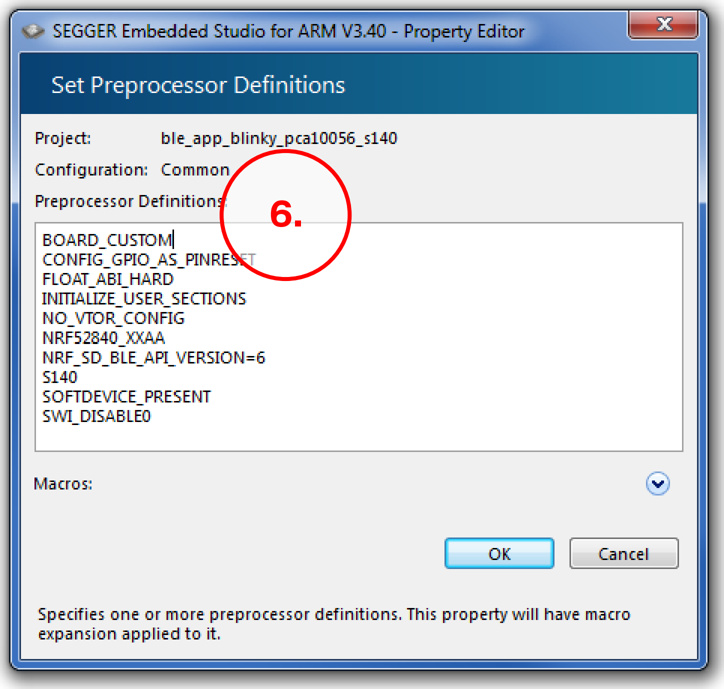


Figure 7: Screenshot with steps to modify the Define statement in SEGGER Embedded Studio

2.2.2 Bluetooth MAC address and other production data

The open CPU (B30x) variants of the NINA-B3 modules is provided with a Bluetooth MAC address programmed similar to that in the u-connectXpress variant. 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 nRF52840 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 the serial number and other information that can be valuable to save. If you want to save the whole memory area use the following commands:

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

For additional information and instructions on saving and using the public Bluetooth device address, see reference [14].

2.3 Flashing the NINA-B31 u-blox software

It is possible to reflash the NINA-B31 module using the UART interface whenever a new version of the u-connectXpress software is available.

2.3.1 UART flashing

The u-connectXpress software for UART flashing contains two separate .bin files. One bin file contains the application and the other contains the SoftDevice as listed below:

- Application – NINA-B31X-FWx.x.x.bin
- SoftDevice – NINA-B31X-SDx.x.x.bin

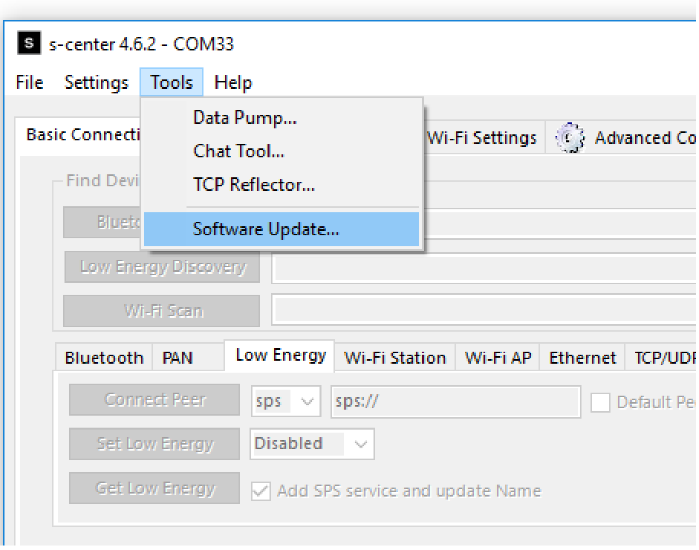
A signature file for each of the above-mentioned files is also included, as well as a .json header file.

2.3.1.1 Software flashing using s-center

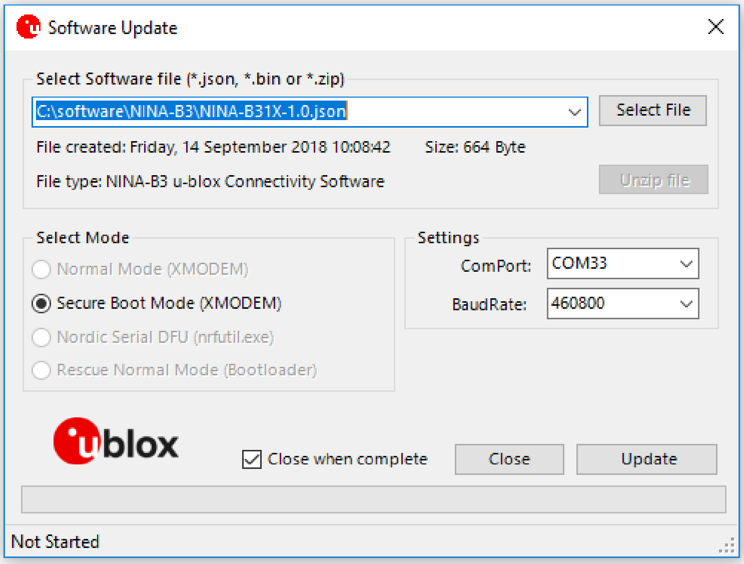
⚠ Flashing of u-blox software requires s-center software version 4.6.2 or later.

To flash the module using s-center,

1. Select **Tools** > **Software Update** as shown in the following screenshot:



2. Select the .json file.



3. Secure Boot Mode will be set automatically, ensure that the correct COM port is selected then click the **Update** button to start the process.
4. The module will then reboot into the bootloader and the flashing of the SoftDevice and the application will start.

2.3.1.2 Software flashing using AT command

The flashing functionality in the NINA-B31x module can manage two signed binary images. Image0 is the application. Image1 is the SoftDevice. The SoftDevice is updated using dual banked approach. Hence a SoftDevice update will invalidate the application currently flashed in the module, so it is required to flash the application after a SoftDevice update.

Use the AT+UFWUPD AT command to update the software.

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

The file download uses an XMODEM protocol. The UART hardware flow is not used during the software update. See the u-connect AT Commands Manual [3] for information about the firmware update command.

☞ The XMODEM protocol uses standard XMODEM-CRC16 protocol and 128 bytes packets.

2.3.1.2.1 Sample commands executed while flashing the application only

1. Run the AT+UFWUPD command to trigger the u-connectXpress software to accept an application bin file for download. The application size can be found in the `NINA-B31X-CF-x.x.json` file; the size should be entered in decimal notation. The signature for the application is available in the `NINA-B31X-SI-x.x.x-xxx.txt` file.


```
{
  "Label": "ConnectivitySoftware",
  "Description": "NINA-B31X u-blox connectivity software",
  "File": "NINA-B31X-SW-0.10.0-007.bin",
  "Version": "INA-B31X-SW-0.10.0-007",
  "Address": "0x26000",
  "Size": "0x4C1CC",
  "Id": "0x0",
  "Permissions": "rwx",
  "SignatureFile": "NINA-B31X-SI-0.10.0-007.txt"
},
```



```
AT+UFWUPD=0,115200,0,311468,kTPvexp7NrJmTOv1bG/Cue91m5nyBNncOs3DS8+Wc/+9VMNDWIJC2
GSUBlmm+XV5RK34Rqym9EfGsAWmWqm/MWBjelcxNFDWRJViIcs3OAhVShoI2Z1LmGLlm2wEgHYwd9KWL/
y5OvzXzcE6AInajv30ASDXn7wj3kJ5/eQ2PE583wukYcaFZJ3YCHfNekgZZEYdA2GWvaYcIdkHNfXqN6J
7G/VBolau1EIGvN3yBEaCk7h6BKOQ1G+5z4CskTL+tRk+6Ks6SPayiH2XMh3LXVOAF7KDYtlwttJKtqmL
9iIpmAY9Pr9j69OBlug//4lm+LMOGOoBOIz7yJzsQfrGwA==,NINA-B3-APPLICATION,rwx
```


2. When a 'C' character is received from the module, XMODEM download is ready to begin from the host.

```
CCCCCCC
```

3. Send the application bin file using XMODEM protocol.
4. After a successful file transfer, the module will automatically start the application.

```
+STARTUP
```

2.3.1.2.2 Sample commands executed when flashing the SoftDevice and application

1. Start the bootloader mode using either:
   - The AT command - `AT+UFWUPD=1,115200`
   - Press the SW1 and SW2 buttons during a module reset
2. The "`s <imageid> <signature>`" command stores the SoftDevice signature. The image id of the SoftDevice is 1. The signature is available in the `NINA-S140-SI-x.x.x.txt` file.


```
> s 1 SFRBdoI82ZR8cvTKrYudqq3eOOm6D6OewEUGhMzaPONxcTGr4WuYrBVgKB4z3kQ/k+bOsGaGbpl
XkZdcXfdr2TaKNmVZd78w9zXYWrK9gbM4kjlD8NxqZ9wCOklBZNjNrNHBPDIe1OnSPUdJ4WkrIlzrSr3n
w7V4aIL1dKCOcK9ggaj9o2CRuEDI35OVSPHfWaGc5IfT2CvNfAmq4QCDIwjVPDVQT/y/o42tymnImATRi
P+ioHyTaNEaW39L98WAWlTxms2EgvW6DJTO989MP3qdefKmos5mBfX4DkWiI26OdY8sedQKONY7ZbNqWo
WXYMWQpJCztAyZ1c6GqJFIWw==

OK
>
```

3. The "`x <imageaddress> <imagesize> <imagename> <permissions> <imageid>`" command triggers the bootloader to accept a file transfer using XMODEM protocol. The image address and image size can be found in the NINA-B31X-CF-X.Y.json file. Set permission to read/write, rw.


```
{
  "Label": "SoftDevice",
  "Description": "S140 softdevice from Nordic for NINA-NRF",
  "File": "NINA-S140-SD-6.0.0.bin",
  "Version": "NINA-S140-SD-6.0.0",
  "Address": "0x0",
  "Size": "0x253C8",
  "Id": "0x1",
  "Permissions": "rw",
  "SignatureFile": "NINA-S140-SI-6.0.0.txt"
}
```


```
> x 0 0x253C8 NINA-B3-SOFTDEVICE rw 1
```

4. When a "`C`" character is received from the module, the XMODEM download is ready to begin from the host.

```
> x 0 0x253C8 NINA-B3-SOFTDEVICE rw 1
CCCC
```

5. After a successful download of the SoftDevice image, the application image must be flashed.

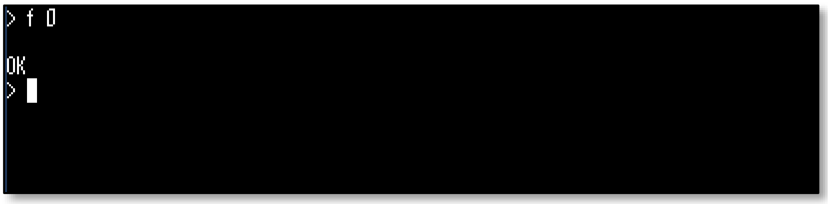
```
> x 0 0x253C8 NINA-B3-SOFTDEVICE rw 1
CCCCCCCCCCCCCC
OK
>
```

6. The application is flashed like the SoftDevice. Use image address and image size for the application image, which can be found in the `NINA-B31X-CF-x.x.json` under the label – u-connect. The image id of the application is 0. The application's signature is available in the `NINA-B31X-SI-x.x.x-xxx.txt` file. Set permission to read/write/execute, rwx.

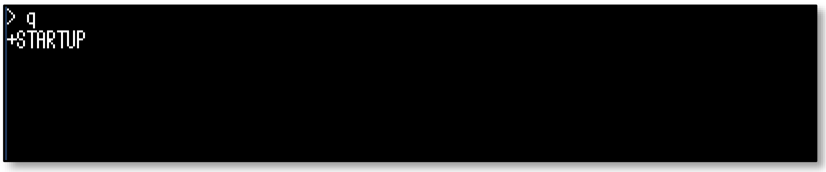
```
> s 0 MKx+IEcsjVZafZiC1D7JU1AP1jOIztpYFJCY6rxSFJNdD9sF3vPNFP7TXVpMmb20G6YhanB+W5u
T2SdDVn+xFME8PBbb2+j+HGHO+vFx2nC+HoQFMLBHTu81do2VqNwa/GC31tECDmwCCELX+OxCe1O1b2DJ
I7ZJo3QeS1TeM8BJ33vFSag1QegJEXR3OZ7ROkgiasLKuw8Bb5pfPzGVdiN/F1/fwFUJgFcOWeZE1A/+f
zWDd4tlbNdNo/5cCfiAK3KFap59zm1u+pwPyuEO/OOksidTgycT/k2yD8H3tttWeaA6Gpog+kInITIsCF
eQmsu1vZrfB9TtYEKsqDW/Rg==

OK
>
```

```
> x 0x26000 0x4C1CC NINA-B3-APPLICATION rwx 0
CCCCCCCCCCCCCC
OK
>
```

7. Store the application image (image id 0) as the startup image with the "`f <imageid>`" command.



8. Reset the module to start up the module with the newly flashed software.



2.4 Flashing the NINA-B30 open CPU software

The NINA-B30 open CPU module can be flashed with the SWD interface.

2.4.1 SWD flashing

For SWD flashing, an external debugger has to be connected to the SWD interface of the NINA-B30 module. Then an external tool such as the J-flash or the nRF Connect Programmer from Nordic Semiconductor.

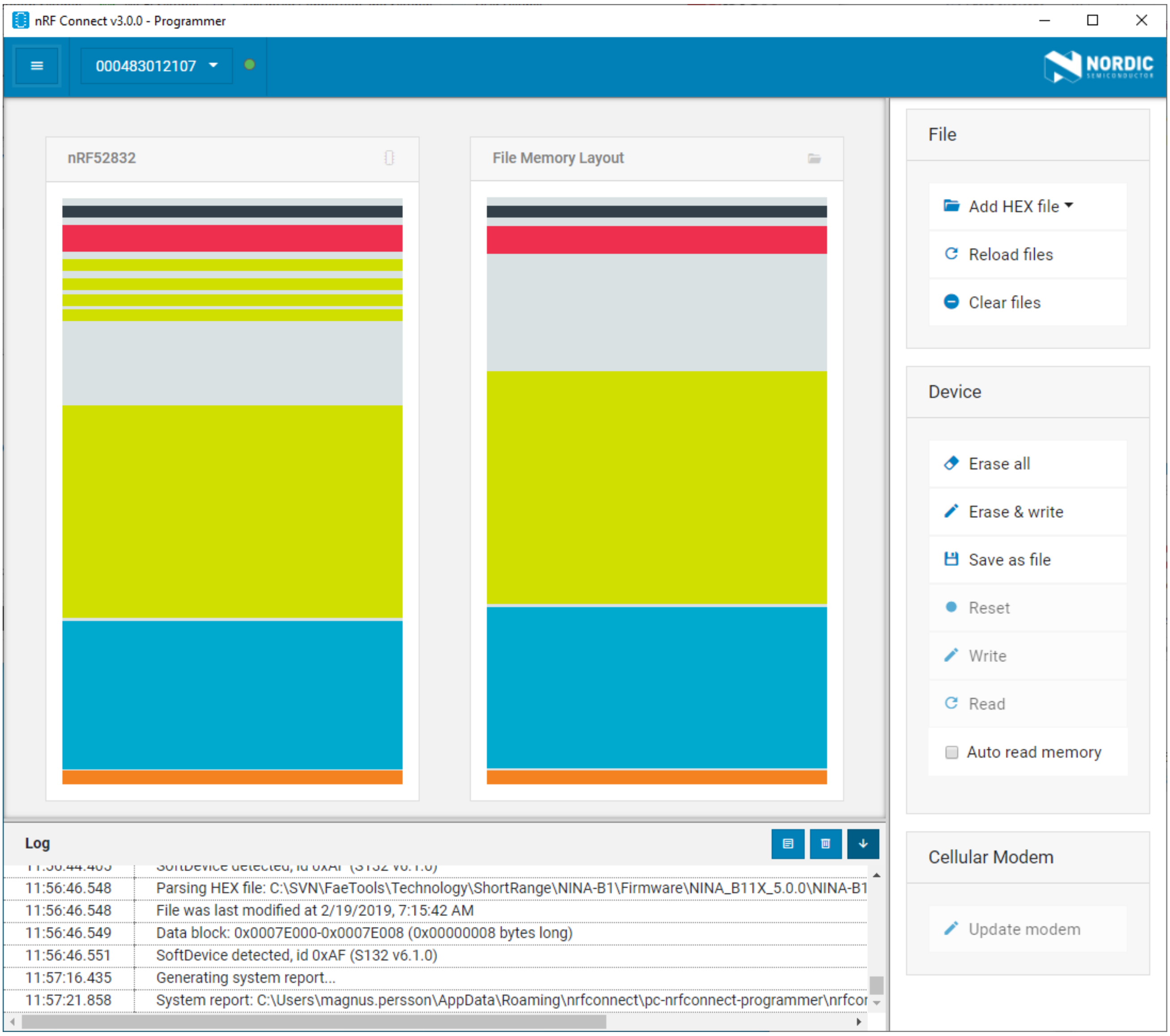
☞ The external debugger SEGGER J-Link BASE works with the NINA-B30 modules.

☞ The EVK-NINA-B30 evaluation kit incorporates an onboard debugger and can therefore be flashed without any external debugger.

2.4.1.1 Flashing the software

⚠ Flashing the software will erase the Bluetooth device address, which must be manually rewritten to the module after flashing. Ensure that you make a note of your Bluetooth device address before continuing with the flashing procedure. See section 2.2.2 for additional information.

In the nRF Connect Programmer, drag and drop the hex files you want to program into the GUI as shown in the following screenshot:


nRF Connect v3.0.0 - Programmer
000483012107
NORDIC
nRF52832
File Memory Layout
File
Add HEX file
Reload files
Clear files
Device
Erase all
Erase & write
Save as file
Reset
Write
Read
Auto read memory
Cellular Modem
Update modem
Log
11:56:46.548 Parsing HEX file: C:\SVN\FaeTools\Technology\ShortRange\NINA-B1\Firmware\NINA_B11X_5.0.0\NINA-B1
11:56:46.548 File was last modified at 2/19/2019, 7:15:42 AM
11:56:46.549 Data block: 0x0007E000-0x0007E008 (0x00000008 bytes long)
11:56:46.551 SoftDevice detected, id 0xAF (S132 v6.1.0)
11:57:16.435 Generating system report...
11:57:21.858 System report: C:\Users\magnus.persson\AppData\Roaming\nrfconnect\pc-nrfconnect-programmer\nrfcor

3 Design-in

3.1 Overview

For an optimal integration of NINA-B3 series modules in the final application board, it is recommended to follow the design guidelines stated in this chapter. Every application circuit must be properly designed to guarantee the correct functionality of the related interface, although a number of points require special attention during the design of the application device.

The following list provides some important points sorted by rank of criticality in the application design, starting from the highest relevance:

1. Module antenna connection: **Ant** pad.

The antenna circuit affects the RF compliance of the device integrating the NINA-B3 modules with the applicable certification schemes. Follow the recommendations provided in section 3.2 for schematic and layout design.

2. Module supply: **VCC**, **VCC_IO**, and **GND** pins.

The supply circuit affects the performance of the device integrating the NINA-B3 series module. Follow the recommendations provided in section 3.3.3.2 for schematic and layout design.

3. Analog signals: GPIO

Analog signals are sensitive to noise and should be routed away from high frequency signals.

4. High speed interfaces: **UART, SPI** and **SWD** pins.

High speed interfaces can be a source of radiated noise and can affect compliance with regulatory standards for radiated emissions. Follow the recommendations provided in sections 3.5.1 and 3.3.3.2 for schematic and layout design.

5. System functions: RESET_N, I2C, GPIO and other System input and output pins.

Accurate design is required to guarantee that the voltage level is well defined during module boot.

6. Other pins:

Accurate design is required to guarantee proper functionality.

3.2 Design for NINA family

The NINA-B3 is based on the Nordic nRF52840 chip that has larger dimensions when compared to the nRF52832 that is used in NINA-B1. Because of this and to enable more GPIO pins underneath the module, the size of the NINA-B3 series needs to be increased. For instance, the module size of the NINA B3x2 is 10 x 15.0 mm as compared to the NINA-B112, which is 10 x 14.0 mm.

Pinouts for both the NINA-B1 and W1 are supported so that all modules in the NINA series can be placed interchangeably on each other's footprints. However, to accommodate the larger dimension of the NINA-B3, a keep-out area of 1 mm should be reserved during design. Otherwise the mechanical design of the NINA-B3 is identical to the NINA-B1 and W1 modules.

3.3 Antenna interface

As the unit cannot be mounted arbitrarily, the placement should be chosen with consideration so that it does not interfere with radio communications. The NINA-B3x2 with an internal surface mounted antenna cannot be mounted inside a metal enclosure. No metal casing or plastics using metal flakes should be used. Avoid metallic based paint or lacquer as well. The NINA-B3x1 offers more freedom, as an external antenna can be mounted further away from the module.

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

3.3.1 RF transmission line design (NINA-B3x1 only)

RF transmission lines, such as the ones from the **ANT** pad up to the related antenna connector or up to the related internal antenna pad, must be designed so that the characteristic impedance is as close as possible to 50 Ω. Figure 8 illustrates the design options and the main parameters to be taken into account when implementing a transmission line on a PCB:

- The micro strip (a track coupled to a single ground plane, separated by dielectric material).
- The coplanar micro strip (a track coupled to ground plane and side conductors, separated by dielectric materials).
- The strip line (a track sandwiched between two parallel ground planes, separated by dielectric materials).

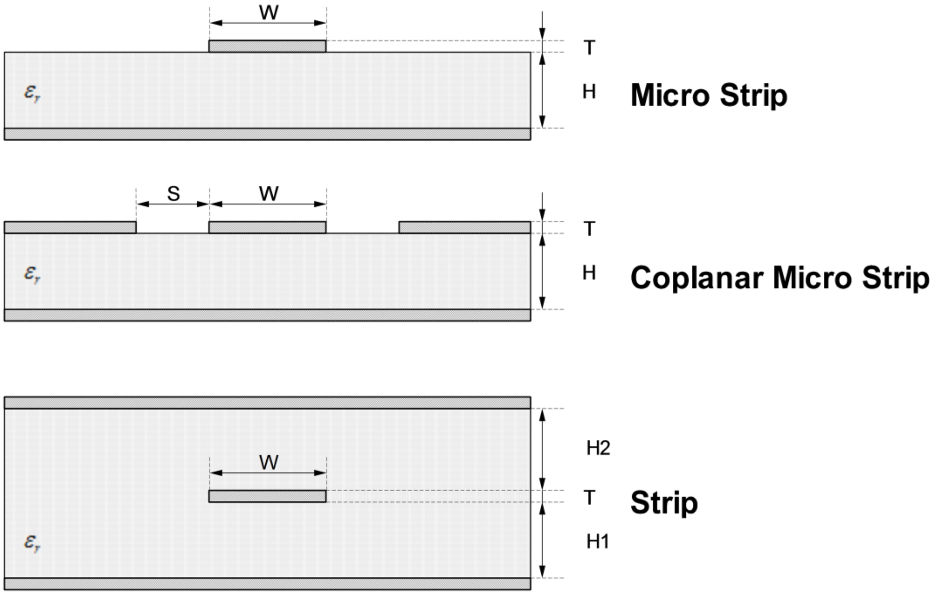


Figure 8: Transmission line trace design

To properly design a 50 Ω transmission line, the following remarks should be taken into account:

- The designer should provide enough clearance from surrounding traces and ground in the same layer; in general, a trace to ground clearance of at least two times the trace width should be considered and the transmission line should be 'guarded' by ground plane area 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 to provide the final values that are usually calculated using dedicated software and available stack-ups from production. It could also be possible to request an impedance coupon on the panel's side in order to measure the real impedance of the traces.
- FR-4 dielectric material, although its high losses at high frequencies can be considered in RF designs providing that:

    - RF trace length must be minimized to reduce dielectric losses.
    - If traces longer than a few centimeters are needed, it is recommended to use a coaxial connector and cable to reduce losses.
    - Stack-up should allow for thick 50 Ω traces and at least 200 µm of trace width is recommended to ensure good impedance control over the PCB manufacturing process.
    - FR-4 material exhibits poor thickness stability and thus less control of impedance over the trace length. Contact the PCB manufacturer for specific tolerance of controlled impedance traces.
- The transmission lines width and spacing to GND must be uniform and routed as smoothly as possible: route RF lines in 45° angle or in arcs.
- Add GND stitching vias around transmission lines.
- Ensure solid metal connection of the adjacent metal layer on the PCB stack-up to the main ground layer, providing enough vias on the adjacent metal layer.
- Route RF transmission lines far from any noise source (as switching supplies and digital lines) and from any sensitive circuit to avoid crosstalk between RF traces and Hi-impedance or analog signals.
- Avoid stubs on the transmission lines; any component on the transmission line should be placed with the connected pad over the trace. Also avoid any unnecessary component on RF traces.

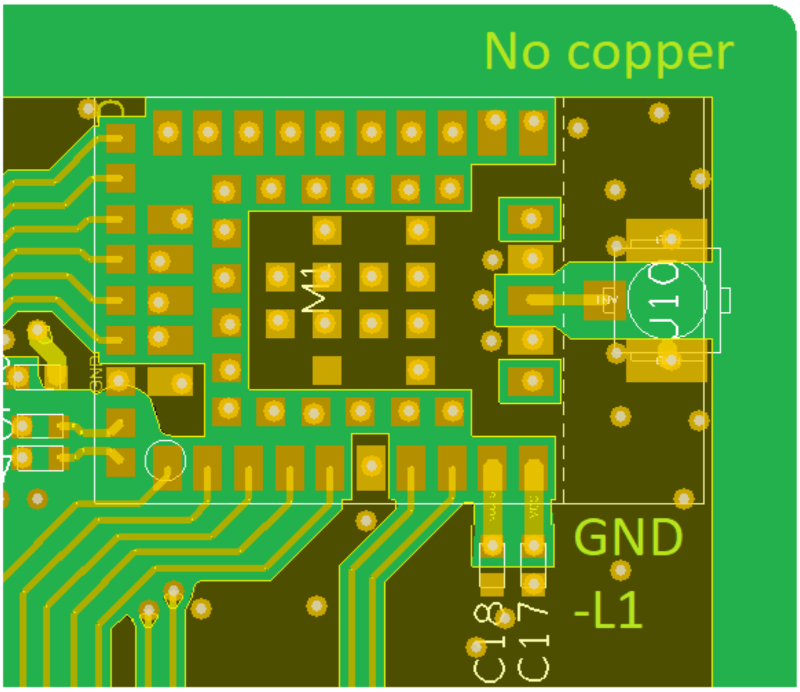


Figure 9: Example of RF trace and ground plane design from NINA-B3 Evaluation Kit (EVK)

3.3.2 Antenna design (NINA-B3x1 only)

NINA-B301 and NINA-B311 is suitable for designs where an external antenna is needed due to mechanical integration or placement of the module.

Designers must take care of the antennas from all perspectives at the beginning of the design phase when the physical dimensions of the application board are under analysis/decision, because the RF compliance of the device integrating the NINA-B3 module with all the applicable required certification schemes heavily depends on the radiating performance of the antennas. The designer is encouraged to consider one of the u-blox suggested antenna part numbers and follow the layout requirements.

- External antennas, such as a linear monopole:

  - o External antennas basically do not impose any physical restrictions on the design of the PCB where the module is mounted.
  - o The radiation performance mainly depends on the antennas. It is required to select antennas with optimal radiating performance in the operating bands.
  - o RF cables should be carefully selected with minimum insertion losses. Additional insertion loss will be introduced by low quality or long cables. Large insertion loss reduces radiation performance.
  - o A high quality 50 Ω coaxial connector provides proper PCB-to-RF-cable transition.
- Integrated antennas such as patch-like antennas:
  - o Internal integrated antennas impose physical restrictions on the PCB design:

    An integrated antenna excites RF currents on its counterpoise, typically the PCB ground plane of the device that becomes part of the antenna; its dimension defines the minimum frequency that can be radiated. Therefore, the ground plane can be reduced down to a minimum size that should be similar to the quarter of the wavelength of the minimum frequency that needs to be radiated, given that the orientation of the ground plane related to the antenna element must be considered.

    The RF isolation between antennas in the system must be as high as possible and the correlation between the 3D radiation patterns of the two antennas must be as low as possible. In general, an RF separation of at least a quarter wavelength between the two antennas is required to achieve a maximum isolation and low pattern correlation; increased separation should be considered if possible to maximize the performance and fulfill the requirements in Table 8.

    As a numerical example, the physical restriction to the PCB design can be considered as shown below:

    Frequency = 2.4 GHz → Wavelength = 12.5 cm → Quarter wavelength = 3.125 cm[1]
  - o Radiation performance depends on the entire product and antenna system design, including product mechanical design and usage. Antennas should be selected with optimal radiating performance in the operating bands according to the mechanical specifications of the PCB and the entire product.

Table 8 summarizes the requirements for the antenna RF interface.

Item	Requirements	Remarks
Impedance	50 Ω nominal characteristic impedance	The impedance of the antenna RF connection must match the 50 Ω impedance of the **ANT** pin.
Frequency Range	2400 - 2500 MHz	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 the S_{11}, as the VSWR, refers to the amount of reflected power, measuring how well the primary antenna RF connection matches the 50 Ω characteristic impedance of the **ANT** pin. The impedance of the antenna termination must match as much as possible the 50 Ω nominal impedance of the **ANT** pin over the operating frequency range, thus maximizing the amount of the power transferred to the antenna.
Efficiency	> -1.5 dB (> 70%) recommended > -3.0 dB (> 50%) acceptable	The radiation efficiency is the ratio of the radiated power to the power delivered to the antenna input; the efficiency is a measure of how well an antenna receives or transmits.
Maximum Gain	+3 dBi	Higher gain antennas could be used, but must be evaluated and/or certified. See Section 0 for more information on regulatory requirements.

Table 8: Summary of antenna interface (ANT) requirements for NINA-B3

[1] Wavelength referred to a signal propagating over the air

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

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

3.3.2.1 RF Connector Design

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

Table 9 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.

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 9: U.FL compatible plug connector

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

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

Consider that SMT connectors are typically rated for a limited number of insertion cycles. 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 increase the difficulty for the end user to replace the antenna with higher gain versions and 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 (that is, clearance, a void area) in the area below the connector between the GND land pads.
- If the connector's RF pad size is wider than the micro strip, remove the GND layer beneath the RF connector to minimize the stray capacitance thus keeping the RF line 50 Ω. For example, the active pad of the UF.L connector must have a GND keep-out (that is, clearance, a void area), at least on the first inner layer to reduce parasitic capacitance to ground.

3.3.2.2 Integrated antenna design

If integrated antennas are used, the transmission line is terminated by the integrated antennas themselves. The following guidelines should be followed:

- The antenna design process should begin at the start of the whole product design process. Self-made PCBs and antenna assembly are useful in estimating overall efficiency and the radiation path of the intended design.
- Use antennas designed by an antenna manufacturer providing the best possible return loss (or VSWR).
- Provide a ground plane large enough according to the related integrated antenna requirements. The ground plane of the application PCB may be reduced down to a minimum size that must be similar to one quarter of wavelength of the minimum frequency that needs to be radiated, although overall antenna efficiency may benefit from larger ground planes.
- Proper placement of the antenna and its surroundings is also critical for antenna performance. Avoid placing the antenna close to conductive or RF-absorbing parts such as metal objects, ferrite sheets and so on as they may absorb part of the radiated power or shift the resonant frequency of the antenna or affect the antenna radiation pattern.
- It is highly recommended to strictly follow the detailed and specific guidelines provided by the antenna manufacturer regarding correct installation and deployment of the antenna system, including the PCB layout and matching circuitry.
- Further to the custom PCB and product restrictions, antennas may require tuning/matching to comply with all the applicable required certification schemes. It is recommended to consult the antenna manufacturer for the design-in guidelines and plan the validation activities on the final prototypes like tuning/matching and performance measures (see Table 8).
- 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-B3 modules.

3.3.3 On-board antenna

If a plastic enclosure is used, it is possible to use NINA-B3 with the embedded antenna. In order to reach an optimum operating performance, follow the instructions provided in the sections below.

3.3.3.1 NINA-B3x2

- The module shall be placed in the corner of the host PCB with the antennas feed point in the corner (pin 15 and 16), as shown in Figure 10. Other edge placements positions, with the antenna closest to the edge, are also possible. These will however give moderate reduced antenna performance compared to the corner placement.
- A large ground plane on the host PCB is a prerequisite for good antenna performance.
- The host PCB shall include a full GND plane underneath the entire module, including the antenna section. This to facilitate efficient grounding of the module.
- High / large parts including metal shall not be placed closer than 10 mm to the module's antenna.

- At least 5 mm clearance between the antenna and the casing is needed. If the clearance is less than 5 mm, the antenna performance will be affected. PC and ABS gives less impact and POS type plastic gives more.
- The module shall be placed such that the antenna faces outwards from the product and is not obstructed by any external items in close vicinity of the products intended use case.

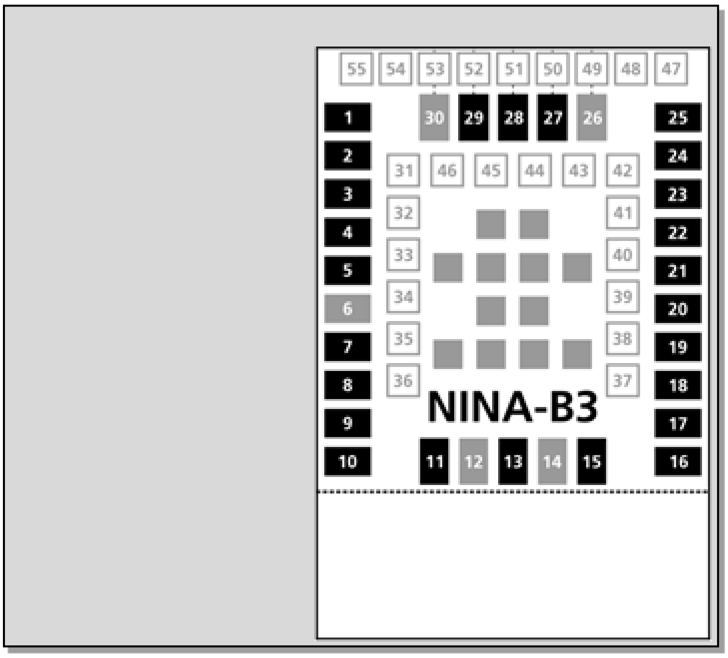


Figure 10: NINA-B3x2 with internal antenna

⚠ Take care when handling the NINA-B3x2. Applying force to the NINA-B3x2 module might damage the internal antenna.

⚠ Make sure that the end product design is done in such a way that the antenna is not subject to physical force.

3.3.3.2 NINA-B3x6 – PCB trace antenna

- The module shall be placed in the center of an edge of the host PCB.
- A large ground plane on the host PCB is a prerequisite for good antenna performance. It is recommended to have the ground plane extending at least 10 mm on both sides of the module. See Figure 11.
- The host PCB shall include a full GND plane underneath the entire module, with a ground cut out under the antenna according to the description in Figure 12.
- The NINA-B3x6 has 4 extra GND pads under the antenna that need to be connected for a good antenna performance. Detailed measurements of the footprint including this extra GND pads can be found in the NINA-B3 series Data Sheet [2].
- High / large parts including metal shall not be placed closer than 10 mm to the module's antenna.
- At least 10 mm clearance between the antenna and the casing is needed. If the clearance is less than 10 mm, the antenna performance will be affected. PC and ABS gives less impact and POS type plastic gives more.
- The module shall be placed such that the antenna faces outwards from the product and is not obstructed by any external items in close vicinity of the products intended use case.

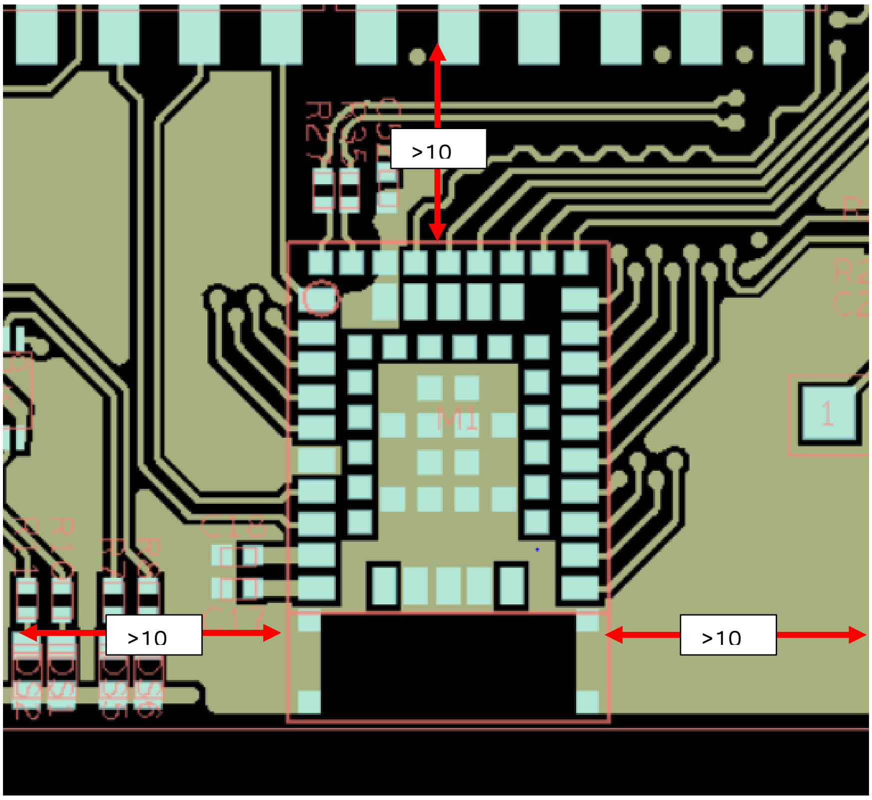


Figure 11: Extend GND plane outside the NINA-B3x6 module

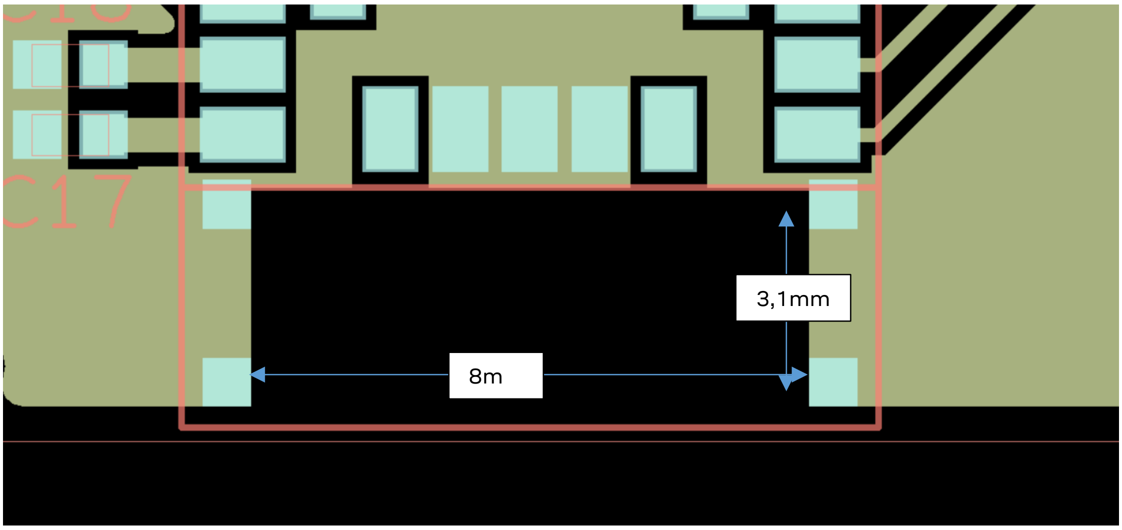


Figure 12: Size of the GND cut out for the NINA-B3x6 module

3.4 Supply interfaces

3.4.1 Module supply design

A good connection of the module's VCC pin with DC supply source is required for correct RF performance. The guidelines are summarized below:

- The VCC connection must be as wide and short as possible.
- The VCC connection must be routed through a PCB area separated from sensitive analog signals and sensitive functional units. It is a good practice to interpose at least one layer of PCB ground between the VCC track and other signal routing.

There is no strict requirement for adding bypass capacitance to the supply net close to the module. But depending on the layout of the supply net and other consumers on the same net, bypass capacitors might still be beneficial. Though the GND pins are internally connected, connect all the available pins to solid ground on the application board, as a good (low impedance) connection to an external ground can minimize power loss and improve RF and thermal performance.

3.5 Serial interfaces

3.5.1 Asynchronous serial interface (UART) design

The layout of the UART bus should be made so that noise injection and cross talk are avoided.

It is recommended to use the hardware flow control with RTS/CTS to prevent temporary UART buffer overrun.

The flow control signals RTS/CTS are active low thus a 0 (ON state =low level) will allow the UART to transmit.

- CTS is an input to the NINA-B3 module and if the host applies a 0 (ON state = low level), then the module is allowed to transmit.

- RTS is an output off the NINA-B3 module and the module will apply a 0 (ON state = low level) when it is ready to receive transmission.

3.5.2 Serial peripheral interface (SPI)

The layout of the SPI bus should be made so that noise injection and cross talk are avoided.

3.5.3 I^{2}C interface

The layout of the I^{2}C bus should be made so that noise injection and cross talk are avoided.

3.5.4 QSPI interface

The layout of the QSPI bus should be made so that noise injection and cross talk are avoided.

3.5.5 USB interface

The layout of the USB bus should be made so that noise injection and cross talk are avoided.

3.6 NFC interface

⚠ The pins for the NFC interface can also be used as normal GPIOs. In NINA-B30 series modules, ensure that the NFC pins are configured correctly in software. Connecting an NFC antenna to the pins configured as GPIO will damage the module. In NINA-B31 series modules, the NFC pins will always be 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-B3 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. In order to comply with European regulatory demands, the NFC antenna must be placed in such a way that the space between the NINA-B3 module and the remote NFC transmitter is always within 3 meters during transmission.

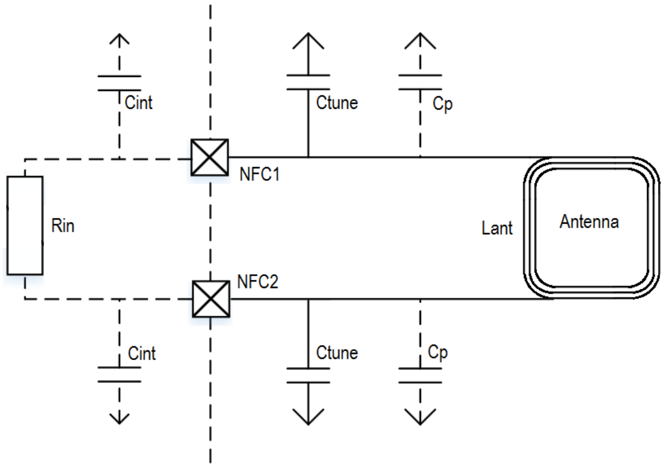


Figure 13: NFC antenna design

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

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

3.6.1 Battery protection

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

If the battery used does not tolerate a return current, a series diode must be placed between the battery and the device in order to protect the battery.

3.7 General High Speed layout guidelines

These general design guidelines are considered as best practices and are valid for any bus present in the NINA-B3 series modules; the designer should prioritize the layout of higher speed buses. Low frequency signals are generally not critical for layout.

⚠ One exception is represented by High Impedance traces (such as signals driven by weak pull resistors) that may be affected by crosstalk. For those traces, a supplementary isolation of 4w from other buses is recommended.

3.7.1 General considerations for schematic design and PCB floor-planning

- Verify which signal bus requires termination and add series resistor terminations to the schematics.
- Carefully consider the placement of the module with respect to antenna position and host processor.
- Verify with PCB manufacturer allowable stack-ups and controlled impedance dimensioning.
- Verify that the power supply design and power sequence are compliant with NINA-B3 series module specification (refer to section 1.4).

3.7.2 Module placement

- Accessory parts like bypass capacitors should be placed as close as possible to the module to improve filtering capability, prioritizing the placement of the smallest size capacitor close to module pads.

⚠ Particular care should be taken not to place components close to the antenna area. The designer should carefully follow the recommendations from the antenna manufacturer about the distance of the antenna vs. other parts of the system. The designer should also maximize the distance of the antenna to Hi-frequency buses like DDRs and related components or consider an optional metal shield to reduce interferences that could be picked up by the antenna thus reducing the module's sensitivity.

- An optimized module placement allows better RF performance. See Antenna interfaces section for more information on antenna consideration during module placement.

3.7.3 Layout and manufacturing

- Avoid stubs on high speed signals. Even through-hole vias may have an impact on signal quality.
- Verify the recommended maximum signal skew for differential pairs and length matching of buses.
- Minimize the routing length; longer traces will degrade signal performance. Ensure that the maximum allowable length for high speed buses is not exceeded.
- Ensure that you track your impedance matched traces. Consult with your PCB manufacturer early in the project for proper stack-up definition.
- RF and digital sections should be clearly separated on the board.
- Ground splitting is not allowed below 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 to the ground plane. In this case, if the designer needs to change the ground reference, an adequate number of GND vias must be added in the area of transition 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 a reference plane change is unavoidable, some capacitors should be added in the area to provide a low impedance return path through the different reference planes.
- Trace routing should keep a distance greater than 3w from the ground plane routing edge.
- Power planes should keep a distance from the PCB edge sufficient to route a ground ring around the PCB, and the ground ring must then be connected to other layers through vias.

3.8 Module footprint and paste mask

The mechanical outline of the NINA-B3 series module can be found in the NINA-B3 series Data Sheet [2]. The proposed land pattern layout reflects the pad's layout of the module.

The Non Solder Mask Defined (NSMD) pad type is recommended over the Solder Mask Defined (SMD) pad type, which implements the solder mask opening 50 µm larger per side than the corresponding copper pad.

The suggested paste mask layout for the NINA-B3 series modules is to follow the copper mask layout as described in the NINA-B3 series Data Sheet [2].

⚠ These are recommendations only and not specifications. The exact mask geometries, distances, and stencil thicknesses must be adapted to the specific production processes of the customer.

3.9 Thermal guidelines

The NINA-B3 series modules have been successfully tested from -40 °C to +85 °C. The NINA-B3 series module is a low power device and will generate only a small amount of heat during operation. A good grounding should still be observed for temperature relief during high ambient temperatures.

3.10 ESD guidelines

The immunity of devices integrating NINA-B3 modules to Electrostatic Discharge (ESD) is part of the Electromagnetic Compatibility (EMC) conformity, which is required for products bearing the CE marking, compliant with the R&TTE Directive (99/5/EC), the EMC Directive (89/336/EEC) and the Low Voltage Directive (73/23/EEC) issued by the Commission of the European Community.

Compliance with these directives implies conformity to the following European Norms for device ESD immunity: ESD testing standard *CENELEC EN 61000-4-2* and the radio equipment standards *ETSI EN 301 489-1*, *ETSI EN 301 489-7*, *ETSI EN 301 489-24*, the requirements of which are summarized in Table 10.

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

The applicability of ESD immunity test to the whole device depends on the device classification as defined by *ETSI EN 301 489-1*. Applicability of 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 10: 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-B3 is manufactured taking into account specific standards to minimize the occurrence of ESD events; the highly automated process complies with IEC61340-5-1 (STM5.2-1999 Class M1 devices) standard, and therefore the designer should implement proper measures to protect any pin that may be exposed to the end user from ESD events.

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

4 Handling and soldering

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

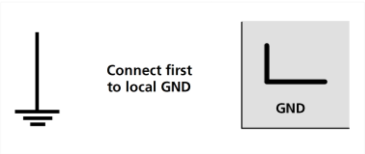
4.1 Packaging, shipping, storage and moisture preconditioning

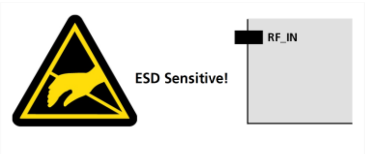
For information pertaining to reels, tapes or trays, moisture sensitivity levels (MSL), shipment and storage, as well as drying for preconditioning, refer to the NINA-B3 series Data Sheet [2] and u-blox Package Information Guide [1].

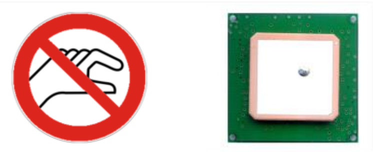
4.2 Handling

The NINA-B3 series modules are Electrostatic Discharge (ESD) sensitive devices and require special precautions during handling. Particular 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 taken into account whenever handling the receiver:

- Unless there is a galvanic coupling between the local GND (i.e. the work table) and the PCB GND, then the first point of contact when handling the PCB must always 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 (e.g. patch antenna ~10 pF, coax cable ~50-80 pF/m, soldering iron, …)
- 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).







4.3 Soldering

4.3.1 Reflow soldering process

The NINA-B3 series modules are surface mount modules supplied on a FR4-type PCB with gold-plated connection pads and produced in a lead-free process with a 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-B3 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 used is dependent on the thermal mass of the entire populated PCB, heat transfer efficiency of the oven and particular type of solder paste used. The optimal soldering profile used 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 11: Recommended reflow profile

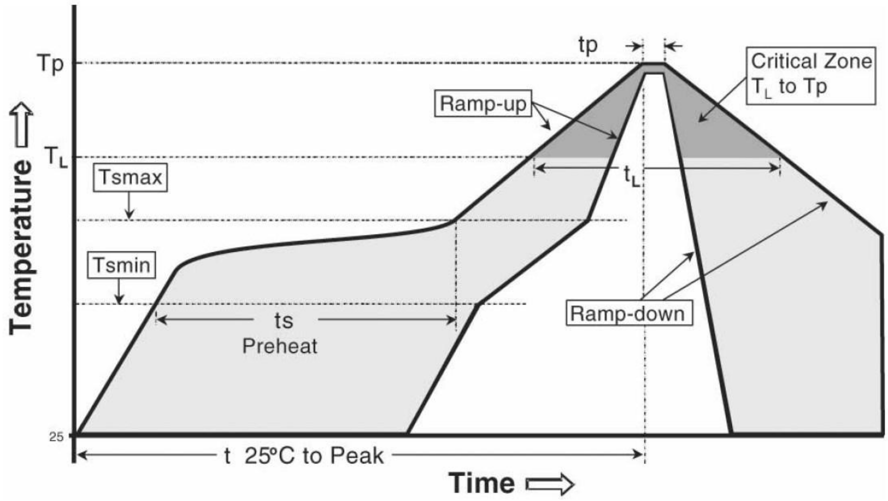


Figure 14: Reflow profile

☞ 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 11 should be taken as general guidelines for a Pb-free process. Refer to the JEDEC J-STD-020C [4] standard for further information.

4.3.2 Cleaning

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

- Cleaning with water will lead to capillary effects where water is absorbed in the gap between the baseboard and the module. The combination of residues of soldering flux and encapsulated water leads to short circuits or resistor-like interconnections between neighboring pads. Water will also damage the sticker and the ink-jet printed text.

- Cleaning with alcohol or other organic solvents can result in soldering flux residues flooding into the two housings, areas that are not accessible for post-wash inspections. The solvent will also damage the sticker and the ink-jet printed text.
- Ultrasonic cleaning will permanently damage the module, in particular the crystal oscillators.

For best results, use a "no clean" soldering paste and eliminate the cleaning step after the soldering process.

4.3.3 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 etc., may damage the module. Use of ultrasonic processes on an end product integrating this module will void the warranty.

5 Regulatory information and requirements

The NINA-B3 series modules are certified for use in different regions and countries such as Europe, USA and Canada. See the NINA-B3 series Data Sheet [2] for a list of approved countries/regions where NINA-B3 modules are approved for use. Each market has its own regulatory requirements that must be fulfilled, and the NINA-B3 series modules comply with the requirements for a radio transmitter in each of the listed markets.

In some cases, limitations must be placed on the end product that integrates a NINA-B3 module to comply with the regulatory requirements. This section lists the limitations and requirements that a module integrator must take into consideration. This section is divided into different subsections for each market. A checklist is included at the end of this section to summarize some of the requirements for each market.

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

5.1 ETSI – European market

5.1.1 Compliance statement

Detailed information about European Union regulatory compliance for the NINA-B3 series modules is available in the NINA-B3 Declaration of Conformity [12].

⚠ Module integrators are required to make their own "Declaration of Conformity", in which test standards and directives that are tested and fulfilled by the end product are listed.

5.1.2 NINA-B3 Software security considerations

⚠ An end user cannot be allowed to change the software on the NINA-B3 module to any unauthorized software, or modify the existing software in an unauthorized way. A module integrator must consider this in the end product design. Typically, the SWD interface (the **SWDCLK** and **SWDIO** pins) must not be accessible by the end user.

5.1.3 Output power limitation

The Radio Equipment Directive requires radio transmitters that have an Equivalent Isotropically Radiated Power (EIRP) of 10 dBm or more, to either implement an adaptivity feature or reduce its medium utilization.

The NINA-B3 series modules are based on the Nordic Semiconductor nRF52840 chip, which supports multiple radio protocols such as Bluetooth low energy, IEEE 802.15.4 with thread etc.

Since Bluetooth low energy does not support either adaptivity or reduced medium utilization, a NINA-B3 Bluetooth LE implementation on the European market must have an EIRP of less than 10 dBm.

⚠ In the European market, it is the end product manufacturer that holds the responsibility that these limitations are followed. If the u-blox module integrator is not the end product manufacturer, the module integrator should make sure that this information is shared with the end product manufacturer.

☞ Radio protocols based on 802.15.4, which supports adaptivity is allowed an EIRP of 10 dBm or higher.

EIRP is calculated as:

$$EIRP(dBm) = P_{TX}(dBm) - L(dB) + G_{TX}(dBi)$$

where P_{TX} is the output power of the transmitter, L is the path loss of the transmission line between the transmitter and antenna, and G_{TX} is the maximum gain of the transmit antenna. Consider the following for each of these components:

- Output power:
    - The output power setting of the NINA-B3 module. An end product user must not be able to increase the setting above the 10 dBm EIRP limit, by sending configuration commands etc.
    - The operating temperature of the end product. The output power of a transmitter is typically increased as the ambient temperature is lowered. The operating temperature range of NINA-B3 is -40 to +85 °C, and across this range the output power can typically vary by 1 dB. The output power at the lowest operating temperature (yielding the highest output power) must be considered for the EIRP calculation.
- Path loss – Long antenna cables or PCB traces, RF switches, etc. will attenuate the power reaching the antenna. This path loss should be measured and taken into consideration for the EIRP calculation.
- Antenna gain - The maximum gain of the transmit antenna must be considered for the EIRP calculation.

5.1.3.1 Implementation in the NINA-B31 series

In the u-connectXpress software, output power can be configured by using the Bluetooth configuration AT command.

```
AT+UBTCFG=4,<output power>
```

The default output power setting is '6', which typically corresponds to +6 dBm output power at room temperature. This setting is based on the following assumptions:

- -40 °C is the lowest operating temperature of the end product
- The path loss is negligible
- The maximum antenna gain of the end product antenna is +3 dBi.

With these assumptions, the EIRP will be just below the 10 dBm limit. If, for instance the antenna gain is instead +2 dBi and an antenna cable with 1 dB path loss is used, a higher output power setting could be used.

☞ The maximum output power setting, '8', typically corresponds to +8 dBm output power, though the output power setting does not match the actual output power 1:1. Use a power meter or spectrum analyzer to measure the actual output power before committing to a power setting.

5.1.3.2 Implementation in the NINA-B30 series

An integrator of the open CPU variant of the NINA-B3 series on the European market must make sure that an end user cannot in any way configure the output power of the radio to 10 dBm EIRP or above.

5.1.4 Safety Compliance

⚠ In order to fulfill the EN 60950-1 safety standard, the NINA-B3 series modules must be supplied with a Class-2 Limited Power Source.

5.2 FCC/ISED – US/Canadian markets

5.2.1 Compliance statements

The NINA-B3 series modules comply with Part 15 of the FCC Rules and with Industry Canada license-exempt RSS standard(s). Operation is subject to the following two conditions:

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

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

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

⚠ Since u-blox cannot control how integrators of NINA-B30 will operate the module, an extra precaution is required by the FCC/ISED. Customers of NINA-B30 will be required to undergo a 'Change in ID' process, see Section 5.2.5 for more information.

⚠ The NINA-B3 modules are for OEM integrations only. The end product has to be professionally installed in such a manner that only the authorized antennas can be used. See Section 5.2.3 for more information.

⚠ Any changes to hardware, hosts or co-location configuration may require new radiated emission and SAR evaluation and/or testing. Any changes or modifications NOT explicitly APPROVED by u-blox may cause the NINA-B3 module to cease to comply with the FCC rules part 15 thus void the user's authority to operate the equipment on the US market.

Model	FCC ID	ISED Certification Number
NINA-B301	XPYNINAB30	8595A-NINAB30
NINA-B302	XPYNINAB30	8595A-NINAB30
NINA-B306	XPYNINAB30	8595A-NINAB30
NINA-B311	XPYNINAB31	8595A-NINAB31
NINA-B312	XPYNINAB31	8595A-NINAB31
NINA-B316	XPYNINAB31	8595A-NINAB31

Table 12: FCC IDs and ISED Certification Numbers for the NINA-B3 series modules

5.2.2 RF Exposure

The NINA-B3 series modules comply with the FCC radiation exposure limits and the requirements of IC RSS-102 issue 5 radiation exposure limits set forth for an uncontrolled environment.

☞ Having a separation distance of minimum 10 mm between the user and/or bystander and the antenna and /or radiating element ensures that the maximum output power of NINA-B3 is below the SAR test exclusion limits presented in KDB 447498 D01v06 (US market limits).

☞ Having a separation distance of minimum 15 mm between the user and/or bystander and the antenna and /or radiating element ensures that the output power (e.i.r.p.) of NINA-B3 is below the SAR evaluation Exemption limits defined in RSS-102 issue 5 (Canadian market limits).

5.2.3 Antenna selection

⚠ For NINA-B301 and NINA-B311, an external antenna connector (U.FL. connector) reference design is available (Appendix B.1) and must be followed to comply with the NINA-B30/NINA-B31 FCC/IC modular approval. Use only those antennas that have been authorized for use with NINA-B3; see Section 5.10 for a list of pre-approved antennas.

☞ u-blox has provided these pre-approved antennas and reference design to enable quick time to market, but it is possible and encouraged for customers to add their own antennas and connector designs. These must be approved by u-blox and in some cases tested. Contact your nearest u-blox support for more information about this process.

5.2.4 IEEE 802.15.4 channel map limitation

The 2.4 GHz band used by 802.15.4 communications is segmented into 16 channels, ranging from channel 11 at 2405 MHz to channel 26 at 2480 MHz, with 5 MHz channel spacing. Due to the wide spectral properties of the 802.15.4 signal, the use of channel 26 results in too much power being transmitted in the FCC restricted band starting at 2483.5 MHz. As a result, channel 26 must not be used on the US/Canadian market.

5.2.4.1 Implementation in NINA-B31 series

IEEE 802.15.4 is currently not supported in the u-connect software. No additional effort is needed.

5.2.4.2 Implementation in NINA-B30 series

Integrators of the open CPU variant of the NINA-B3 series will have to make a “change in FCC ID” filing to inherit the test results of the u-blox FCC compliance tests. In this filing process it must be made clear that the software application has been limited to not use channel 26, and that it cannot be ‘unlocked’ by an end user. It should not be possible for an end user to change the software on the module to any unauthorized or modified software that allows the use of 802.15.4 channel 26. Typically, the SWD interface on the NINA-B30 module, which allows full access to all registers and code space, must be made unavailable to end users.

5.2.5 Change in ID/Multiple Listing process

☞ A Change in ID can be done only for the NINA-B30 series.

The open CPU feature of the NINA-B30 series allows customers to create their own software applications using the NINA-B3 hardware. This software will have full control of radio parameters, and it is possible to configure the radio in a way that it will be non-compliant with the FCC regulatory requirements.

For any product including an FCC/ISED approved radio device, it will be the sole responsibility of the FCC/ISED ID holder, in this case u-blox, to ensure that the product complies with the FCC radio regulations. Since the software applications created by integrators of the NINA-B30 series cannot be controlled by u-blox, the module integrator will have to take over this responsibility. This process is known as a ‘change in ID’ in the US and ‘multiple listing’ in Canada.

Most FCC accredited test houses can provide the service to make a change in ID. Module integrators can also make an application themselves to a Telecommunication Certification Body (TCB). Typically, the following documentation has to be submitted:

- A permission letter, signed by u-blox, that allows the module integrator (or test house) to make the change in ID.
- An application letter stating that there is no change in the design, circuitry, or construction of the NINA-B30 module, and that the original NINA-B30 test results are still representative of the new product. Minor cosmetic differences are allowed but must be described.
- Photos of the product showing the nameplate or label containing the new FCC ID.
- The user manual for the product.
- (Optional) Short- and long-term confidentiality requests. The FCC typically makes all submitted photos and documentation publically available on their website. Applicants can request that certain sensitive information is published later or not at all.

5.2.6 End product verification requirements

⚠ The modular transmitter approval of NINA-B3, or any other radio module, does not exempt the end product from being evaluated against applicable regulatory demands.

The evaluation of the end product shall be performed with the NINA-B3 module installed and operating in a way that reflects the intended end product use case. The upper frequency measurement range of the end product evaluation is the 5th harmonic of 2.4 GHz as declared in 47 CFR Part 15.33 (b)(1).

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

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

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

5.2.7 End product labelling requirements

5.2.7.1 US market

An end product using the NINA-B3 series modules must have a label containing, at least, the information shown in Figure 15 or Figure 16. The label must be affixed on an exterior surface of the end product such that it will be visible upon inspection in compliance with the modular approval guidelines developed by the FCC. In accordance with 47 CFR § 15.19, the end product shall bear the following statement in a conspicuous location on the device:

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

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

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

In case, where the final product will be installed in locations where the end user is unable to see the FCC ID and/or this statement, the FCC ID and the statement shall also be included in the end product manual.

5.2.7.2 Canadian market

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

The Innovation, Science and Economic Development Canada certification label of a module shall be clearly visible at all times when installed in the host product; otherwise, the host product must be labelled to display the Innovation, Science and Economic Development Canada certification number for the module, preceded by the word “Contains” or similar wording expressing the same meaning, as shown in Figure 15 or Figure 16.

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

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

This device contains FCC ID: XPYNINAB30 IC: 8595A-NINAB30

Figure 15: Example of an end product label that includes a NINA-B30 series module

This device contains FCC ID: XPYNINAB31 IC: 8595A-NINAB31

Figure 16: Example of an end product label that includes a NINA-B31 series module

5.2.8 End product user manual requirements

5.2.8.1 US market

As stated in Section 5.2.7.1, labelling requirements for the US market, the following statement shall be placed in a prominent section of the instruction manual, when it cannot feasibly be placed on the physical device:

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

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

The statement “this device contains” along with the FCC ID of NINA-B30 or NINA-B31, as shown in Figure 15 or Figure 16 shall also be placed in the instruction manual when it cannot be placed on the physical device.

5.2.8.2 Canadian market

User manuals for license-exempt radio apparatus shall contain the following text, or an equivalent notice that shall be displayed in a conspicuous location, either in the user manual or on the device, or both:

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

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

Under Industry Canada regulations, this radio transmitter can only operate using an antenna of a type and maximum (or lesser) gain approved for the transmitter by Industry Canada. To reduce potential radio interference to other users, the antenna type and its gain should be chosen in such a way that the equivalent isotropically radiated power (e.i.r.p.) is not more than that is necessary for successful communication.

Le manuel d'utilisation des appareils radio exempts de licence doit contenir l'énoncé qui suit, ou l'équivalent, à un endroit bien en vue dans le manuel d'utilisation ou sur l'appareil, ou encore aux deux endroits.

"Le présent appareil est conforme aux CNR d'Industrie Canada applicables aux appareils radio exempts de licence. L'exploitation est autorisée aux deux conditions suivantes:

1. l'appareil ne doit pas produire de brouillage;
2. l'utilisateur de l'appareil doit accepter tout brouillage radioélectrique subi, même si le brouillage est susceptible d'en compromettre le fonctionnement."

Conformément aux réglementations d'Industry Canada, cet émetteur radio ne peut fonctionner qu'à l'aide d'une antenne dont le type et le gain maximal (ou minimal) ont été approuvés pour cet émetteur par Industry Canada. Pour réduire le 25ecess d'interférences avec d'autres utilisateurs, il faut choisir le type d'antenne et son gain de telle sorte que la puissance isotrope rayonnée équivalente (p.i.r.e) ne soit pas supérieure à celle requise pour obtenir une communication satisfaisante.

5.3 MIC - Japanese market

5.3.1 Compliance statement

The NINA-B3 series modules comply with the Japanese Technical Regulation Conformity Certification of Specified Radio Equipment (ordinance of MPT N°. 37, 1981), Article 2, Paragraph 1:

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

5.3.2 48-bit address requirement

Radio devices on the Japanese market, which can be connected directly or indirectly to a public network, must have an at least 48-bit (12 hex) long ID code. In practice this means that the device addresses used in the radio communication protocol (Bluetooth, Thread, ZigBee, Gazell etc.) must be at least 48 bits.

☞ Note that this requirement is not applicable to devices only intended for use in private or personal networks.

5.3.2.1 Implementation in the NINA-B30 series

The requirements on a NINA-B30 design depend on the used radio protocol(s):

- The Bluetooth protocol uses 48-bit addressing, no additional effort is needed.
- IEEE 802.15.4 based protocols, such as Thread and ZigBee, use (at the MAC layer) a combination of 16- and 64-bit addresses. The 16-bit ('short') address can be used to reduce overhead in communications. However, each device must have a 64-bit ('extended') address, and can always be accessed using this address. Because of this no additional effort is needed when using an 802.15.4 based protocol.
- Protocols based on the 2.4 GHz proprietary mode do not necessarily follow any standards, so there is no guarantee that the 48-bit addressing requirement will be fulfilled. If the end product can be connected to, or accessed through, a public network using a proprietary protocol, it is the end product manufacturer's responsibility to make sure that the protocol uses at least 48-bit addressing.

⚠ Failure to comply with these requirements will void the NINA-B3 Japan certification, and it will be illegal to place the end product on the Japanese market.

5.3.2.2 Implementation in the NINA-B31 series

All the radio communication protocols supported in the NINA-B31 series use at least 48 bit long addressing. No further actions are required by the module integrator.

5.3.3 End product labelling requirement

When a product integrating a NINA-B3 series module is placed on the Japanese market the product must be affixed with a label with the "Giteki" marking as shown in Figure 17. The marking must be visible for inspection.

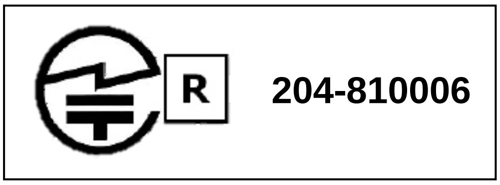


Figure 17: Giteki mark, R and the NINA-B3 MIC certification number

☞ The required minimum size of the Giteki mark is Ø3.0 mm.

5.3.4 End product user manual requirement

As the MIC ID is not included on the NINA-B3 series label, the end product manufacturer must include a copy of the NINA-B3 Japan Radio Certificate to the end product technical documentation.

☞ Contact the u-blox support team in your area to obtain a copy of the NINA-B3 Japan Radio Certificate (see the Contact

5.4 NCC – Taiwanese market

5.4.1 Compliance statements

- 經型式認證合格之低功率射頻電機，非經許可，公司、商號或使用者均不得擅自變更頻率、加大功率或變更原設計之特性及功能。
- 低功率射頻電機之使用不得影響飛航安全及干擾合法通信；經發現有干擾現象時，應立即停用，並改善至無干擾時方得繼續使用。前項合法通信，指依電信法規定作業之無線電通信。低功率射頻電機須忍受合法通信或工業、科學及醫療用電波輻射性電機設備之干擾。

Statement translation:

- Without permission granted by the NCC, any company, enterprise, or user is not allowed to change frequency, enhance transmitting power or alter original characteristic as well as performance to an approved low power radio-frequency devices.
- The low power radio-frequency devices shall not influence aircraft security and interfere legal communications; If found, the user shall cease operating immediately until no interference is achieved. The said legal communications means radio communications is operated in compliance with the Telecommunications Act. The low power radio-frequency devices must be susceptible with the interference from legal communications or ISM radio wave radiated devices.

5.4.2 End product labelling requirement

When a product integrating a NINA-B3 series module is placed on the Taiwanese market, the product must be affixed with a label or marking containing at least the following information:

5.4.2.1 NINA-B301 Label

Contains Transmitter Module

內含發射器模組: CCAI18LP1970T4

Figure 18: Example of an end product label that includes a NINA-B301 module

5.4.2.2 NINA-B302 Label

Contains Transmitter Module

內含發射器模組: CCAI18LP197AT6

Figure 19: Example of an end product label that includes a NINA-B302 module

5.4.2.3 NINA-B306 Label

Contains Transmitter Module

內含發射器模組: CCAI19LP1670T0

Figure 20: Example of an end product label that includes a NINA-B306 module

5.4.2.4 NINA-B311 Label

Contains Transmitter Module

內含發射器模組: CCAI18LP197BT8

Figure 21: Example of an end product label that includes a NINA-B311 module

5.4.2.5 NINA-B312 Label

Contains Transmitter Module

內含發射器模組: CCAI18LP197CT0

Figure 22: Example of an end product label that includes a NINA-B312 module

5.4.2.6 NINA-B316 Label

Contains Transmitter Module

內含發射器模組: CCAI19LP1680T3

Figure 23: Example of an end product label that includes a NINA-B316 module

Any similar wording that expresses the same meaning may be used. The marking must be visible for inspection.

☞ Note that each NINA-B3 module variant has its own certification number.

Module variant	NCC ID
NINA-B301	CCAI18LP1970T4
NINA-B302	CCAI18LP197AT6
NINA-B306	CCAI19LP1670T0
NINA-B311	CCAI18LP197BT8
NINA-B312	CCAI18LP197CT0
NINA-B316	CCAI19LP1680T3

Table 13: NINA-B3 series NCC ID certification numbers

5.5 KCC – South Korean market

5.5.1 Compliance statement

The NINA-B3 series modules are certified by the Korea Communications Commission (KCC).

5.5.2 End product labeling requirements

When a product containing a NINA-B3 series module is placed on the South Korean market, the product must be affixed with a label or marking containing the KCC logo and certification number as shown in the following figures:

R-C-ULX-NINA-B30

Figure 24: Sample label of an end product that includes a NINA-B30 series module

R-C-ULX-NINA-B31

Figure 25: Sample label of an end product that includes a NINA-B31 series module

5.5.3 End product user manual requirements

The KCC logo and NINA-B3 certification numbers shown in section 5.5.2 must also be included in the end products user manual.

5.6 Anatel Brazil compliance

When a product containing a NINA-B3 module is placed on the Brazilian market, the product must be affixed with a label or marking containing the Anatel logo, NINA-B3 Homologation number: 03851-19-05903 and a statement claiming that the device may not cause harmful interference but must accept it (Resolution No 506).

ANATEL
03851-19-05903

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

Statement translation:

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

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

In case, where the final product will be installed in locations where the end-user is not able to see the Anatel logo, NINA-B3 Homologation number and/or this statement, the Anatel logo, NINA-B3 Homologation number and the statement shall also be included in the end-product manual.

5.7 Australia and New Zealand regulatory compliance

The NINA-B3 modules are compliant with AS/NZS 4268:2012/AMDT 1:2013 standard – Radio equipment and systems – Short range devices – Limits and methods of standard measurement made by the Australian Communications and Media Authority (ACMA).

The NINA-B3 module test reports can be used as part of evidence in obtaining permission the Regulatory Compliance Mark (RCM). To meet overall Australian and/or New Zealand compliance on the end product, the integrator must create a compliance folder containing all the relevant compliance test reports.

More information on registration as a Responsible Integrator and labeling requirements will be found at the following websites:

Australian Communications and Media Authority web site http://www.acma.gov.au/.

New Zealand Radio Spectrum Management Group web site www.rsm.govt.nz.

5.8 South Africa regulatory compliance

The NINA-B3 modules are compliant and certified by the Independent Communications Authority of South Africa (ICASA). End products that are made available for sale or lease or is supplied in any other manner in South Africa shall have a legible label permanently affixed to its exterior surface. The label shall have the ICASA logo and the ICASA issued license number as shown in the figure below. The minimum width and height of the ICASA logo shall be 3 mm. The approval labels must be purchased by the customer's local representative directly from the approval authority ICASA. A sample of a NINA-B3 ICASA label is included below:

More information on registration as a Responsible Integrator and labeling requirements will be found at the following website:

Independent Communications Authority of South Africa (ICASA) web site - https://www.icasa.org.za

5.9 Integration checklist

The following checklist can be used to get an overview of the requirements of each market. It is in no way a complete list of all actions required, but should cover the essentials of integrating a NINA-B3 radio module.

General requirements

☐ The SWD interface cannot be accessed by an end product user.

Specific to the European market

☐ The E.I.R.P of the end product is measured to be within the applicable limit.

☐ A Class-2 limited power source is used to supply the module.

☐ A Declaration of Conformity has been created.

Specific to the US and Canadian markets

☐ (NINA-B30) A Change in ID/Multiple Listing has been performed.

☐ (NINA-B3x1) The antenna connector reference design has been followed and a pre-approved antenna is used with the end product. If not, then u-blox has been contacted to get approval to make changes and/or add a new antenna.

☐ (NINA-B30) If 802.15.4 is used, the radio channel 26 has been disabled and end product users' cannot enable it.

☐ The fundamental and out of band emissions of the end product has been measured and complies with the applicable limits.

☐ An SDoC has been created, or an accredited test lab has been used to certify the end product.

☐ The end product labelling requirements are fulfilled.

- ☐ The end product documentation requirements are fulfilled. The necessary legal statements are included at a prominent location in the user guide.

Specific to the Japanese market

- ☐ (NINA-B30) If applicable, the product fulfills the 48-bit addressing requirements.
- ☐ The end product labelling requirements are fulfilled.
- ☐ A copy of the NINA-B3 Japan Radio Certificate has been included in the end product technical documentation

Specific to the Taiwanese market

- ☐ The end product labelling requirements are fulfilled.

Specific to the South Korean market

- ☐ The end product labelling requirements are fulfilled.
- ☐ The end product user manual requirements are fulfilled.

Specific to the Brazilian market

- ☐ The end product labelling requirements are fulfilled.
- ☐ The end product user manual requirements are fulfilled.

Specific to the Australian and/or New Zealand markets

- ☐ The end product labelling requirements are fulfilled.
- ☐ A compliance folder containing all the relevant compliance test reports is created and available.

Specific to the South African market

- ☐ The end product labelling requirements are fulfilled.

5.10 Pre-approved antennas list

This section lists the different external antennas that are pre-approved for use together with the NINA-B3 series modules.

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

5.10.1 Antenna accessories

Name	U.FL to SMA adapter cable
Connector	U.FL and SMA jack (outer thread and pin receptacle)
Impedance	50 Ω
Minimum cable loss	0.5 dB, The cable loss must be above the minimum cable loss to meet the regulatory requirements. Minimum cable length 100 mm.
Comment	The SMA connector can be mounted in a panel. See Appendix B.1 for information how to integrate the U.FL connector.
Approval	RED, MIC, NCC, KCC, ANATEL, ACMA and ICASA

Name	U.FL to Reverse Polarity SMA adapter cable
Connector	U.FL and Reverse Polarity SMA jack (outer thread and pin)
Impedance	50 Ω
Minimum cable loss	0.5 dB, The cable loss must be above the minimum cable loss to meet the regulatory requirements. Minimum cable length 100 mm.
Comment	The Reverse Polarity SMA connector can be mounted in a panel. See Appendix B.1 for information how to integrate the U.FL connector. It is required to followed this reference design to comply with the NINA-W1 FCC/IC modular approvals.
Approval	FCC, IC, RED, MIC, NCC, KCC, ANATEL, ACMA and ICASA

5.10.2 Single band antennas

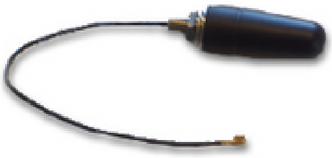
NINA-B302 and NINA-B312 (u-blox LILY antenna)	
Manufacturer	ProAnt
Gain	+3 dBi
Impedance	N/A
Size (HxWxL)	3.0 x 3.8 x 9.9 mm
Type	PIFA
Comment	SMD PIFA antenna on NINA-B302 and NINA-B312. Should not be mounted inside a metal enclosure.
Approval	FCC, IC, RED, MIC, NCC, KCC, ANATEL, ACMA and ICASA

NINA-B306 and NINA-B316	
Manufacturer	ProAnt
Gain	+3 dBi
Impedance	N/A
Size (HxWxL)	1.1 x 3.4 x 10 mm
Type	PCB trace
Comment	PCB antenna on NINA-B306 and NINA-B316. Should not be mounted inside a metal enclosure.
Approval	FCC, IC, RED, MIC, NCC, KCC, ANATEL, ACMA and ICASA

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

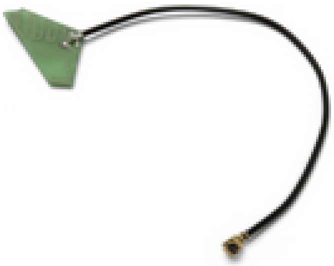
Ex-IT 2400 RP-SMA 28-001	
Manufacturer	ProAnt
Polarization	Vertical
Gain	+3.0 dBi
Impedance	50 Ω
Size	Ø 12.0 x 28.0 mm
Type	Monopole
Connector	Reverse Polarity SMA plug (inner thread and pin receptacle).
Comment	This antenna requires to be mounted on a metal ground plane for best performance. To be mounted on the U.FL to Reverse Polarity SMA adapter cable. An SMA version antenna is also available but not recommended for use (Ex-IT 2400 SMA 28-001).
Approval	FCC, IC, RED, MIC, NCC, KCC, ANATEL, ACMA and ICASA

Ex-IT 2400 MHF 28-001	
Manufacturer	ProAnt
Polarization	Vertical
Gain	+2.0 dBi
Impedance	50 Ω
Size	Ø 12.0 x 28.0 mm
Type	Monopole
Cable length	100 mm
Connector	U.FL. connector
Comment	This antenna requires to be mounted on a metal ground plane for best performance. To be mounted on a U.FL connector. See Appendix B.1 for information how to integrate the U.FL connector. It is required to followed this reference design to comply with the NINA –B3 FCC/IC modular approvals.
Approval	FCC, IC, RED, MIC, NCC, KCC, ANATEL, ACMA and ICASA



Ex-IT 2400 RP-SMA 70-002	
Manufacturer	ProAnt
Polarization	Vertical
Gain	+3.0 dBi
Impedance	50 Ω
Size	Ø 10 x 83 mm
Type	Monopole
Connector	Reverse Polarity SMA plug (inner thread and pin receptacle)
Comment	To be mounted on the U.FL to Reverse Polarity SMA adapter cable. An SMA version antenna is also available but not recommended for use (Ex-IT 2400 SMA 70-002).
Approval	FCC, IC, RED, MIC, NCC, KCC, ANATEL, ACMA and ICASA

InSide-2400	
Manufacturer	ProAnt
Gain	+3.0 dBi
Impedance	50 Ω
Size	27 x 12 mm (triangular)
Type	Patch
Cable length	100 mm
Connector	U.FL. connector
Comment	Should be attached to a plastic enclosure or part for best performance. To be mounted on a U.FL connector. See Appendix B.1 for information how to integrate the U.FL connector. It is required to followed this reference design to comply with the NINA-W1 FCC/IC modular approvals.
Approval	FCC, IC, RED, MIC, NCC, KCC, ANATEL, ACMA and ICASA



FlatWhip-2400 SMA	
Manufacturer	ProAnt
Gain	+3.0 dBi
Impedance	50 Ω
Size	Ø 50.0 x 30.0 mm
Type	Monopole
Connector	SMA plug (inner thread and pin)
Comment	To be mounted on the U.FL to SMA adapter cable.
Approval	RED, MIC, NCC, KCC, ANATEL, ACMA and ICASA

FlatWhip-2400 RP-SMA	
Manufacturer	ProAnt
Gain	+3.0 dBi
Impedance	50 Ω
Size	Ø 50.0 x 30.0 mm
Type	Monopole
Connector	Reverse Polarity SMA plug (inner thread and pin receptacle).
Comment	To be mounted on the U.FL to SMA adapter cable.
Approval	FCC, IC, RED, MIC, NCC, KCC, ANATEL, ACMA and ICASA

6 Product testing

6.1 u-blox In-Series production test

u-blox focuses on high quality for its products. All units produced are fully tested automatically in the production line. A stringent quality control process has been implemented in the production line. Defective units are analyzed in detail to improve the production quality.

This is achieved with automatic test equipment (ATE) in the production line, which logs all production and measurement data. A detailed test report for each unit can be generated from the system. Figure 26 illustrates the typical automatic test equipment (ATE) in a production line.

The following tests are performed as part of the production tests:

- 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 26: Automatic test equipment for module testing

6.2 OEM manufacturer production test

As the testing is already performed by u-blox, an OEM manufacturer does not need to repeat software tests or measurement of the module's RF performance or tests over analog and digital interfaces in their production test.

However, an OEM manufacturer should focus on:

- Module assembly on the device; it should be verified that:
  - Soldering and handling processes have not damaged the module components
  - All module pins are well soldered on the device board
  - There are no short circuits between pins
- Component assembly on the device; it should be verified that:

- Communication with host controller can be established
- The interfaces between 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 measurement of module current consumption 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 (communication with the host controller, check interfaces) and to perform basic RF performance tests.

6.2.1 "Go/No go" tests for integrated devices

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

A very simple test can be performed by just scanning for a known Bluetooth low energy device and checking the signal level.

☞ These kinds of test may be useful as a "go/no go" test but not for RF performance measurements.

This test is suitable to check the functionality of the communication with the host controller and the power supply. It is also a means to verify if components are well-soldered.

A basic RF functional test of the device including the antenna can be performed with standard Bluetooth low energy devices as remote stations. The device containing the NINA-B3 series module and the antennas should be arranged in a fixed position inside an RF shield box to prevent interferences from other possible radio devices to obtain stable test results.

Appendix

A Glossary

Abbreviation	Definition
ADC	Analog to digital converter
ATE	Automatic test equipment
LE	Bluetooth Low Energy
CTS	Clear To send
DCX	Data/Command signal
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
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
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

Abbreviation	Definition
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

Table 14: Explanation of the abbreviations and terms used

B Antenna reference designs

Designers can take full advantage of NINA-B3's Single-Modular Transmitter certification approval by integrating the u-blox reference design into their products. This approach requires compliance with the following rules:

- Only listed antennas can be used. Refer to NINA-B3 series Data sheet [2] for the listed antennas.
- Schematics and parts used in the design must be identical to the reference design, please use u-blox' validated parts for antenna matching.
- PCB layout must be identical to the one provided by u-blox, please implement one of the reference designs included in this section or contact u-blox.
- The designer must use the PCB stack-up provided by u-blox. RF traces on the carrier PCB are part of the certified design.

The available designs are presented in this section.

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

When using the NINA-B301/B311 together with this antenna reference design, the circuit trace layout must be made in strict compliance with the instructions below.
Components connected to the RF trace must be kept as indicated in the reference design. The reference design uses a U.FL micro coaxial connector to connect the external antenna via a 50 Ω coaxial cable.

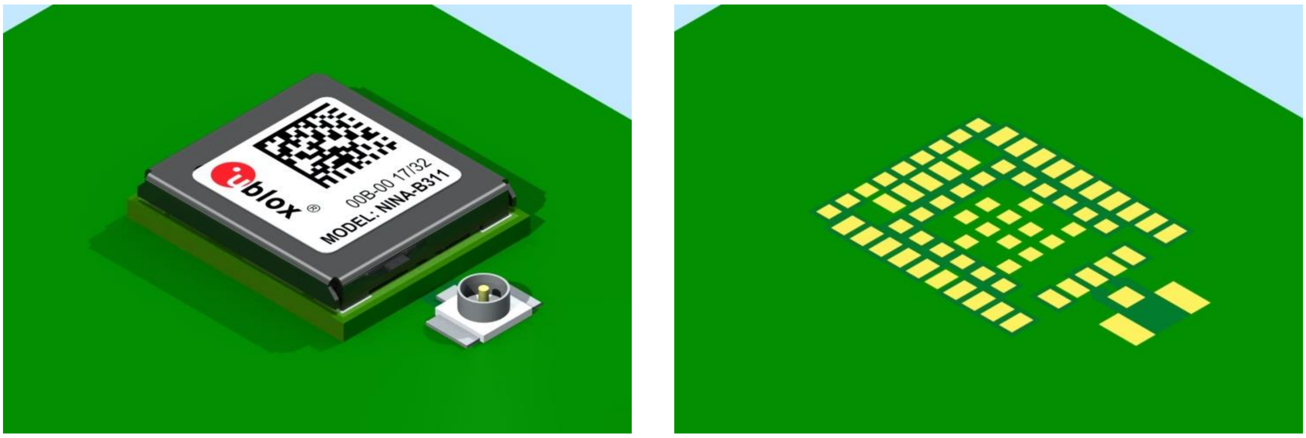


Figure 27: Antenna reference design

B.1.1 Floor plan

This section describes where the critical components and copper traces are positioned on the reference design.

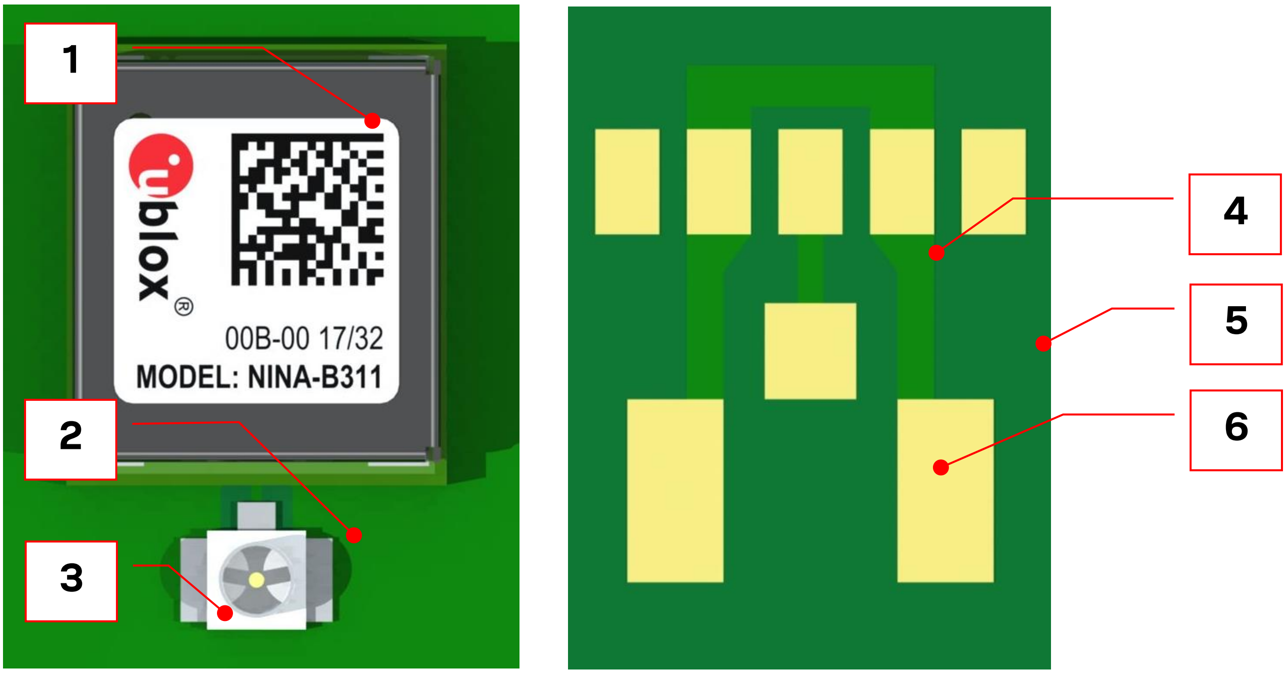


Figure 28: NINA-B301/B311 antenna reference design

Reference	Part	Manufacturer	Description
1	NINA-B301/B311	u-blox	NINA-B3 module with antenna pin
2	U.FL-R-SMT-1(10)	Hirose	Coaxial connector, 0 – 6 GHz, for 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 top layer GND-trace, see Figure 30
6	Copper keep out		Keep this area free from any copper on the top layer

Table 15: 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 29 and Table 16. GND stitching vias should be used around the RF trace to ensure a proper GND connection. No other components are allowed within this area.

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

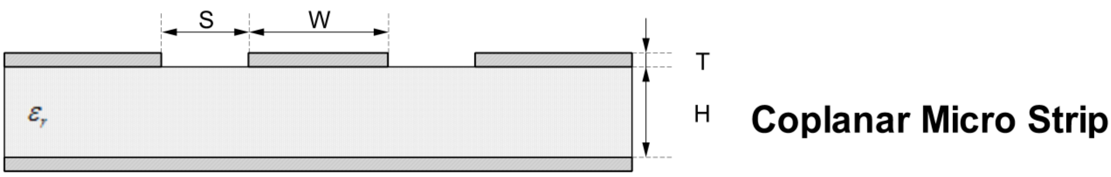


Figure 29: Coplanar micro-strip dimension specification

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 16: Coplanar micro-strip 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 micro-strip. However, at the conductor width and height specified in Table 16, the increased spacing to GND does not affect the trace impedance significantly for short trace lengths, and it will still be close to 50 Ω.

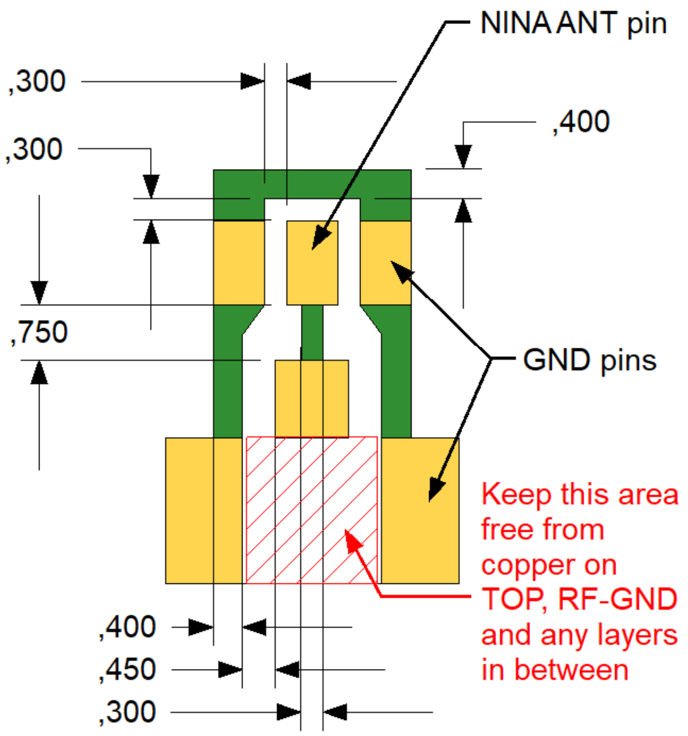


Figure 30: RF trace and minimum required GND trace of the U.FL antenna connector reference design. Dimensions are shown in mm.

Related documents

[1] u-blox package information guide, UBX-14001652
[2] NINA-B3 series data sheet, UBX-17052099
[3] u-connect AT commands manual, UBX-14044127
[4] JEDEC J-STD-020C - Moisture/Reflow Sensitivity Classification for Non Hermetic Solid State Surface Mount Devices.
[5] IEC EN 61000-4-2 - Electromagnetic compatibility (EMC) - Part 4-2: Testing and measurement techniques – Electrostatic discharge immunity test
[6] 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
[7] IEC61340-5-1 - Protection of electronic devices from electrostatic phenomena – General requirements
[8] ETSI EN 60950-1:2006 - Information technology equipment – Safety – Part 1: General requirements
[9] FCC Regulatory Information, Title 47 – Telecommunication
[10] JESD51 – Overview of methodology for thermal testing of single semiconductor devices
[11] Nordic Semiconductor InfoCenter - https://infocenter.nordicsemi.com/index.jsp
[12] NINA-B3 declaration of conformity, UBX-18053818
[13] NINA-B31 getting started, UBX-18022394
[14] Using the public IEEE address from UICR, UBX-19055303

☞ For regular updates to u-blox documentation and to receive product change notifications, register on our homepage (www.u-blox.com).

Revision history

Revision	Date	Name	Comments
R01	16-Nov-2017	apet, ajoh, ajah, kgom	Initial release.
R02	22-Mar-2018	apet	Removed references to application development using Arm Mbed for NINA-B30x open CPU modules.
R03	8-Jun-2018	apet, kgom	Updated Nordic SDK section to SDKv15 (section 2.2.1). Updated flashing instructions in Flashing the NINA-B31 u-blox connectivity software (section 2.3).
R04	13-Sep-2018	ajoh, kgom	Changed the product status to Initial Production. Updated Table 1 and Table 2. Updated regulatory information section with instructions on how to comply with regulatory restrictions for different global markets (section 5). Added information about an FCC approved antenna connector reference design in Appendix B.
R05	14-Feb-2019	ajoh, fbro, mper	Added instructions for using s-center to flash NINA-B31 (section 2.3.1.1). Added instructions on how to put an end product on the Japanese and Taiwanese markets (section 5). Added the software version for java script. Added the new antenna type NINA-B3x6.
R06	16-Apr-2019	ajoh, fbro	Changed the product status to Initial Production. Updated Section 5 to reflect the change with respect to SWD interface access, which applies for all NINA-B3 variants. Also added regulatory guidelines for the South Korean market. Updated some values in recommended reflow profile (Table 11).
R07	10-May-2019	fbro	Updated u-connectScript version to 1.0.1 and modified the product status for NINA-B31x-20B to Initial Production. Included information about Bluetooth MAC address (section 2.2.2). Corrected information about UART flow control (section 3.5.1). Updated Single band antennas (section 5.10.2).
R08	23-Sep-2019	mape	Updated some links to Nordic InfoCenter (section 2.2.1.1). Removed nRF Go Studio and replaced with nRF Connect Programmer (section 2.4.1).
R09	20-Dec-2019	mwej	Added instructions on how to put an end product on the Brazilian, Australian, New Zealand and South Africa markets (section 5).
R10	20-Apr-2020	mape	Removed all u-connectScript references. Included small correction in the chapter *Flashing the NINA-B31 u-blox software*, section 2.3.1.2.1.

Contact

For complete contact information, visit us at www.u-blox.com.

u-blox Offices

North, Central and South America

u-blox America, Inc.

Phone: +1 703 483 3180
E-mail: info_us@u-blox.com

Regional Office West Coast:

Phone: +1 408 573 3640
E-mail: info_us@u-blox.com

Technical Support:

Phone: +1 703 483 3185
E-mail: support@u-blox.com

Headquarters
Europe, Middle East, Africa

u-blox AG

Phone: +41 44 722 74 44
E-mail: info@u-blox.com
Support: support@u-blox.com

Asia, Australia, Pacific

u-blox Singapore Pte. Ltd.

Phone: +65 6734 3811
E-mail: info_ap@u-blox.com
Support: support_ap@u-blox.com

Regional Office Australia:

Phone: +61 2 8448 2016
E-mail: info_anz@u-blox.com
Support: support_ap@u-blox.com

Regional Office China (Beijing):

Phone: +86 10 68 133 545
E-mail: info_cn@u-blox.com
Support: support_cn@u-blox.com

Regional Office China (Chongqing):

Phone: +86 23 6815 1588
E-mail: info_cn@u-blox.com
Support: support_cn@u-blox.com

Regional Office China (Shanghai):

Phone: +86 21 6090 4832
E-mail: info_cn@u-blox.com
Support: support_cn@u-blox.com

Regional Office China (Shenzhen):

Phone: +86 755 8627 1083
E-mail: info_cn@u-blox.com
Support: support_cn@u-blox.com

Regional Office India:

Phone: +91 80 405 092 00
E-mail: info_in@u-blox.com
Support: support_in@u-blox.com

Regional Office Japan (Osaka):

Phone: +81 6 6941 3660
E-mail: info_jp@u-blox.com
Support: support_jp@u-blox.com

Regional Office Japan (Tokyo):

Phone: +81 3 5775 3850
E-mail: info_jp@u-blox.com
Support: support_jp@u-blox.com

Regional Office Korea:

Phone: +82 2 542 0861
E-mail: info_kr@u-blox.com
Support: support_kr@u-blox.com

Regional Office Taiwan:

Phone: +886 2 2657 1090
E-mail: info_tw@u-blox.com
Support: support_tw@u-blox.com