S

ANNA-B112

Stand-alone Bluetooth® LE module

System integration manual

Abstract

Targeted towards hardware and software engineers, this document describes how to integrate ANNA-B112 modules in application products. It explains the hardware design-in, software, component handling, regulatory compliance, and testing of the modules. It also lists the external antennas approved for use with the module. With embedded Bluetooth® LE stack and u-connectXpress software, this module is tailored for OEMs who wish to have the shortest time-to-market. The OEMs can also embed their own application using for example the Nordic nRF5 SDK, Zephyr, Wirepas Mesh or Arm® Mbed™ integrated development environment (IDE).

UBX-18009821 - R11
C1-Public

www.u-blox.com

Document information

Title	**ANNA-B112**
Subtitle	Stand-alone Bluetooth® LE module
Document type	System integration manual
Document number	UBX-18009821
Revision and date	R11 28-Mar-2025
Disclosure restriction	C1-Public

Document status descriptions	
Draft	For functional testing. Revised and supplementary data will be published later.
Objective specification	Target values. Revised and supplementary data will be published later.
Advance information	Data based on early testing. Revised and supplementary data will be published later.
Early production information	Data from product verification. Revised and supplementary data may be published later.
Production information	Document contains the final product specification.

This document applies to the following products:

Product name	Document status
ANNA-B112	Production information

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

Contents

1 System description

1.1 Overview

ANNA-B112 is an ultra-small, high-performing, standalone Bluetooth® Low Energy (LE) module. The System in Package (SiP) module features Bluetooth LE, a powerful Arm® Cortex®-M4 microprocessor with FPU, and state-of-the-art power performance.

ANNA-B112-0XB is delivered with u-connectXpress software that provides support for u-blox Bluetooth LE Serial Port Service, GATT client and server, beacons, NFC™, and simultaneous peripheral and central roles – all configurable from a host by using AT commands.

To embed their own applications, OEMs can erase the pre-flashed u-connectXpress software or flash their application onto a blank ANNA-B112-70B module using the Nordic nRF5 SDK, nRF Connect SDK (including Zephyr RTOS), Wirepas Mesh, or Arm® Mbed™. ANNA-B112 also includes an integrated antenna that provides a range of up to 160 m and an antenna pin for the design-in of an external antenna.

ANNA-B112 has full modular approval for Europe (ETSI RED), Great Britain (UKCA), US (FCC), Canada (IC / ISED RSS), Taiwan (NCC), South Korea (KCC), Japan (MIC), Australia / New Zealand (ACMA / RCM mark), Brazil (ANATEL), South Africa (ICASA), and China (SRRC). ANNA-B112 is verified against Bluetooth Core 5.0.

1.2 Product features

Grade		
Automotive		
Professional	•	
Standard		
Radio		
Chip inside	nRF52832	
Bluetooth qualification	v5.0	
Bluetooth low energy	•	
Bluetooth output power EIRP [dBm] *	5 / 8	
Max range [meters] *	160 / 190	
NFC	•	
Antenna type (see footnotes)	chip / pin	
Application software		
u-connectXpress	•	
Open CPU for embedded applications		•
Interfaces		
UART	1	♦
SPI		♦
I²C		♦
I²S		♦
PDM and PWM		♦
GPIO pins	11	25
AD converters [number of bits]		12
Features		
AT command interface	•	
MCU (see footnotes)		M4F
RAM [kB]		64
Flash [kB]		512
Simultaneous GATT server and client	•	♦
Low Energy Serial Port Service	•	
Throughput [Mbit/s]	0.8	1.4
Maximum Bluetooth connections	7	20
Bluetooth mesh		♦
FOTA		♦

* = The different values are for use with internal/external antenna

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

pin = Antenna pin
chip = Internal chip antenna
M4F = 64 MHz Arm® Cortex-M4 with FPU

Table 1: ANNA-B112 main features summary

1.2.1 Module architecture

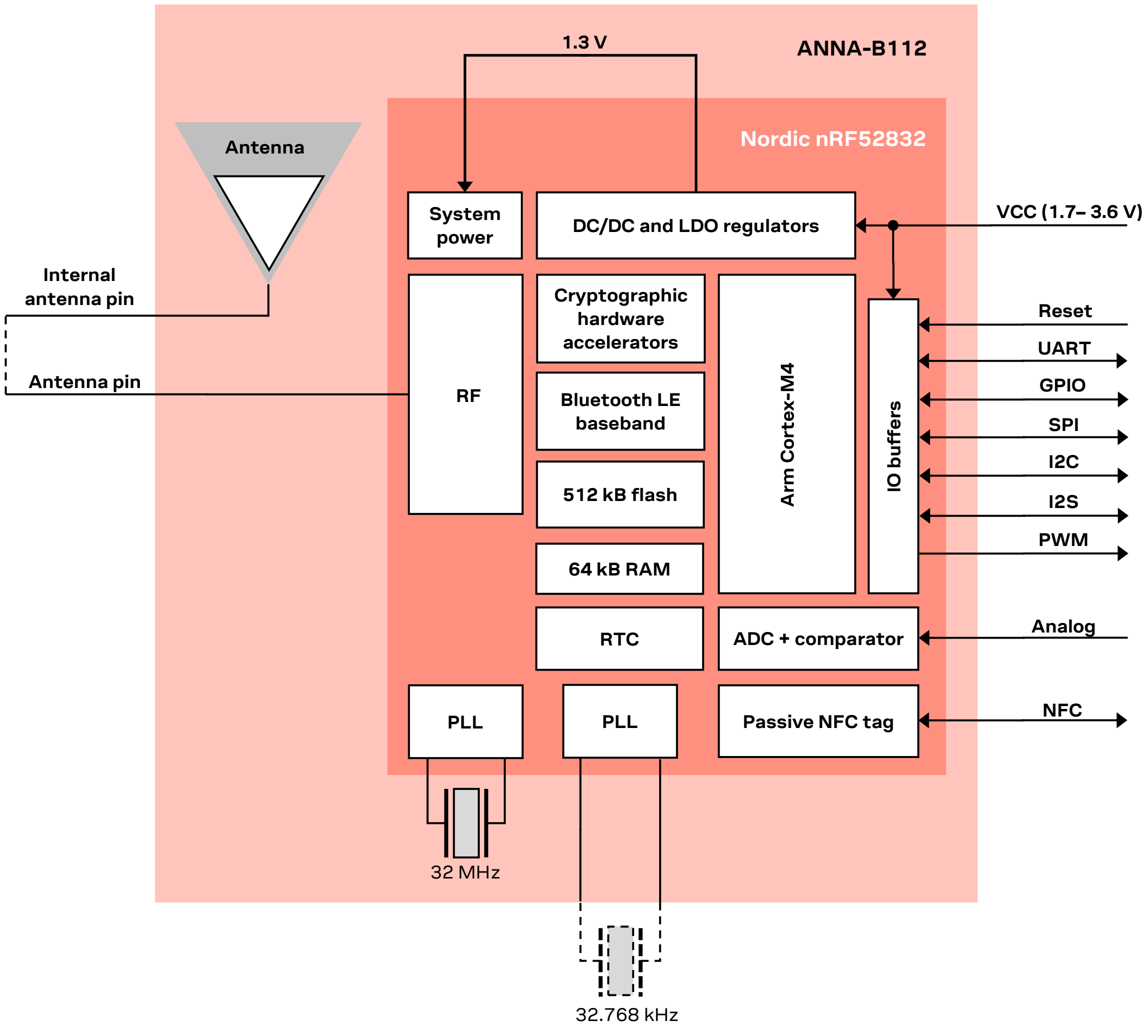


Figure 1: ANNA-B112 block diagram

1.2.2 Hardware options

The ANNA-B112 module is designed for use with either an internal antenna or by connecting to an external antenna. It contains an integrated DC/DC converter for higher efficiency under heavy load situations. External components are limited to only an optional 32.768 kHz low power crystal.

1.2.3 Software options

The ANNA-B112 module can be used together with pre-flashed u-connectXpress software or as an Open CPU module where you can run your own application developed with either Arm® Mbed™, Nordic SDK, Zephyr or Wirepas Mesh development environment inside the module. The different software options are described in more detail in Software.

u-connectXpress software comes with a separate mesh variant that is available for download only.

ANNA-B112-70B is delivered with empty flash memory. This module variant can be used to avoid the need to remove the u-connectXpress software when the final product includes a custom application, or when the pre-flashed software is incompatible with the hardware design of the final product.

1.3 Pin configuration and function

See the ANNA-B112 data sheet [2] for information about pin configuration and function.

1.4 Supply interfaces

1.4.1 Main supply input

ANNA-B112 features an integrated DC/DC converter or LDO to regulate the supply voltage from the VCC pin into a stable system core voltage. This makes it well-suited for battery-powered designs.

When using a battery, it is important that the battery type can handle the peak power of the module. When using a battery supply, consider adding extra capacitance on the supply line to avoid capacity degradation. For information about voltage supply requirement and current consumption, see the ANNA-B112 data sheet [2].

Rail	Voltage requirement	Current requirement (peak)
VCC	1.7 V – 3.6 V	15 mA

Table 2: Summary of voltage supply requirements

☞ Table 2 describes the module current requirements when using the u-connectXpress software with UART communication – without any additional I/O current. Any use of external push buttons, LEDs, or other interfaces increases the total current consumption of the module. The peak current consumption of the entire design must be considered in battery powered solutions.

1.4.2 Digital I/O interfaces reference voltage

On the ANNA-B112 module, the I/O voltage level is the same as the supply voltage and is internally connected to the supply input **VCC**.

When using ANNA-B112 module 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 ANNA-B112 is provided through the VCC pins, which can be one of the following:

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

An SMPS is the ideal choice when the available primary supply source has higher value than the operating supply voltage of the ANNA-B112 module. It provides the best power efficiency for the overall application and minimizes current drawn from the main supply source.

⚠ When using an SMPS, ensure that AC voltage ripple at switching frequency is kept as low as possible. The layout must 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 cycle 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, which greatly reduces the battery life.

Due to the low current consumption and wide voltage range of the ANNA-B112 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 ANNA-B112 data sheet [2] for the electrical specifications.

It is considered as best practice to have decoupling capacitors on the supply rails close to the ANNA-B112 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 ANNA-B112 module 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 ANNA-B112 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 Low power clock

The ANNA-B112 module uses a 32.768 kHz low power clock to enable different sleep modes. This clock can be generated from an internal or external clock source.

Different options for generating the clock include:

- Internal oscillator
- External crystal oscillator
- External clock source

The u-connectXpress software automatically senses the clock input and uses the external crystal if available; otherwise, it runs the internal oscillator. This automatic sense functionality adds additional time during startup (about 1s). If the startup time is critical or more detailed settings are needed, then set the low power clock settings using AT commands. See also Low power clock settings for u-connectXpress software.

To fully utilize the low current consumption of the ANNA-B112 module, an external crystal or external clock source is needed. The internal oscillator increases the current consumption in sleep mode.

☞ An external crystal is required by the mesh variant of u-connectXpress as well as some third-party software like Wirepas Mesh for example.

The following sections describe the different hardware options for the low power clock source and the implications of your choice of hardware on both the cost and performance of the ANNA-B112 module. For practical guidance about how to configure the oscillator on nRF5 open CPU modules, see the application note *RC oscillator configuration for nRF5 open CPU modules* [15].

1.6.1 External crystal

ANNA-B112 has two input pins for connecting an external crystal as source for the low power clock. This setup enable ANNA-B112 to run with the lowest overall power consumption. Figure 1 shows the components used on the ANNA-B112 EVK.

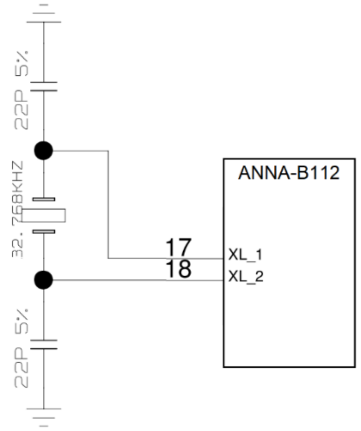


Figure 2: Connecting ANNA-B112 to an external crystal oscillator

Component	Value	Note
Crystal oscillator	32.768 kHz – 20 ppm	EPSON FC-12M used on ANNA-B112 EVK
Capacitors	22pF	

Table 3: Components used on the EVK-ANNA-B112 EVK evaluation kit

1.6.2 Internal oscillator

Using ANNA-B112 with the internal oscillator reduces the Bill of Materials (BOM), which improves cost savings for the end product. However, this also increases the power consumption during sleep.

When using the internal oscillator, clock pins (pin 17 and pin 18) should be connected to ground.

⚠ The application must ensure calibration of the internal oscillator at least once every 8 seconds to ensure +/-250ppm clock stability.

1.6.3 External clock source

An external clock source generated from a host CPU can also be used. The clock source can be either a low-swing signal or full-swing signal.

The electrical parameters are described in Table 4 and Table 5.

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

Table 4: Electrical parameters for a low swing clock

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

Table 5: Electrical parameters for a full swing clock

1.6.4 Low power clock settings for u-connectXpress software

The low power clock settings for the u-connectXpress software are stored in a special flash area and can be written only once. The only way to clear the settings is to erase the flash memory. See also Flashing over the SWD interface.

This section describes the AT command and the available settings for the low power clock.

This AT command requires the module to be set in production mode:

- `AT+UPROD=1`
    - Set the module in production mode
- `AT+UPRODLFCLK=`
    - Command to change the settings on the low power clock
    - For syntax and descriptions of this command, see Table 6
- Reset the module to restart in normal connectivity software

Description

AT Command	Description
AT+UPRODLFCLK=<source>[,<value1>[,<value2]]	

Syntax

Response	Description
OK	Successful response to AT+UPRODLFCLK=<source>[,<accuracy>]
+UPRODLFCLK: <source>[,<value1>[,<value2>]] OK	Successful response to AT+UPRODLFCLK
ERROR	When command fails

Defined values

Parameter	Type	Description
<source>	Number	Allowed values are: (default = automatic detection) 0: Internal oscillator 1: External crystal 3: External clock
<value1>	Number	**When <source> = 0; internal oscillator:** (default = 16) Calibration timer interval in 1/4 second, allowed 1-32 **When <source> = 1; external crystal:** External crystal accuracy: (default = 7) 0: 250 PPM 1: 500 PPM 2: 150 PPM 3: 100 PPM 4: 75 PPM 5: 50 PPM 6: 30 PPM 7: 20 PPM 8: 10 PPM 9: 5 PPM 10: 2 PPM 11: 1 PPM

Parameter	Type	Description
<value2>	Number	**When <source> = 0; internal oscillator:** (default = 2) Temperature change calibration interval: 0: Always calibrate even if the temperature has not changed. 1: Invalid, do not use 2-32: Check the temperature and only calibrate if it has changed, however calibration will take place every X intervals even if no change in temperature.

Table 6: Settings

The internal oscillator needs to be calibrated to maintain its accuracy. The interval of the calibration should be selected so that the temperature does not change more than 0.5 °C between calibrations.

There are two settings for the calibration - Calibration timer interval and Temperature change calibration interval.

- *Calibration timer interval* sets the interval when the need for calibration is checked.
- Temperature change calibration interval sets the number of calibrations timer intervals counted before a calibration is forced.
  - 0: Always calibrate even if the temperature has not changed.
  - 2-32: Check the temperature and calibrate only if it has changed. The calibration is taken every X count of the calibration timer interval – even if there is no change in the temperature.

Calibrating the unit more often will increase the current consumption.

When using internal oscillator as source the user must make sure that the settings calibrate the internal oscillator at least once every 8 seconds to ensure +/-250ppm clock stability. It is recommended that you keep the default values, as described in Table 6.

1.6.5 Selecting clock source

As described above, the selection of clock source is a tradeoff between BOM count and current consumption. The increase in current consumption when using the internal oscillator depends on both the software settings as well as the surrounding environment.

The internal oscillator adds approximately 400 nA, while the calibration contributes around 1 µA, depending on the settings. The standby current of ANNA-B112 then increases from 2.2 µA to 3.6 µA, an increase of about 60%.

For active use cases when the module is not in standby the increase of current is negligible. So, if the application is in standby for longer periods of time then an external crystal might be worth adding.

Table 7 shows the average current consumption for a beacon advertising at different intervals, both with external crystal oscillator as well as internal oscillator. The use case is an advertisement event (4.7 ms), +4 dBm output power and 31 bytes payload at 3.3 V.

Advertise interval	External crystal oscillator	Internal oscillator	Increase in current
1 s	18 µA	19.5 µA	8 %
10 s	3.8 µA	5.2 µA	37 %
60 s	2.4 µA	3.9 µA	63 %

Table 7: Average current consumption (theoretical calculations)

1.7 Debug – serial wire debug (SWD)

The primary interface for debug is the SWD interface. The SWD interface can also be used for software upgrade.

The two pins, **SWDIO** and **SWDCLK**, should be made accessible on header or test points.

1.8 Serial interfaces

The available interfaces and pin mapping may vary depending on whether the ANNA-B112 is utilized with u-connectXpress software or an open CPU-based application. For detailed pin information, see the ANNA-B112 data sheet [2].

1.8.1 Universal asynchronous serial interface (UART)

The ANNA-B112 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 4 wire UART with hardware flow control and 2-wire UART with only **TXD** and **RXD**. If using the UART in 2-wire mode, **CTS** should be connected to GND on the ANNA-B112 module.

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

The u-connectXpress software adds the **DSR** and **DTR** pins to the UART interface. These pins are not used as originally intended, but used instead to control the state of the ANNA-B112 module. Depending on the current configuration, **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 ANNA-B112 data sheet [2] for characteristic information about the UART interface.

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

Table 8: Default settings for the COM port while using the u-connectXpress software

It is recommended that you connect the UART interface to a header for software upgrade, or make the signals available as test points.

The IO level of the UART follows the VCC voltage and is therefore in the range of 1.8 V and 3.6 V. Use a level shifter if you are connecting ANNA-B112 to a host with a different voltage on the UART interface.

1.8.2 Serial peripheral interface (SPI)

ANNA-B112 supports up to three serial peripheral interfaces that can operate in both Main and Sub modes with a maximum serial clock frequency of 8 MHz in both these modes. The SPI interfaces use the following 4 signals:

- SCLK
- MOSI
- MISO
- CS

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

1.8.3 I2C interface

The Inter-Integrated Circuit (I2C) interfaces can be used to transfer or receive data on a 2-wire bus network. The ANNA-B112 module contains up to two I2C bus interfaces and can operate as both Controller and Target nodes using both standard (100 kbps) and fast (400 kbps) transmission speeds. The interface uses the **SCL** signal to clock instructions and data on the **SDL** 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.

1.9 GPIO pins

The ANNA-B112 module can provide up to 25 pins, which can be configured as general-purpose input or output. 8 GPIO pins are capable of handling analog functionality. All pins are capable of handling interrupts.

Function	Description	Default ANNA-B1 pin	Configurable GPIOs
General purpose input	Digital input with configurable edge detection and interrupt generation.		Any
General purpose output	Digital output with configurable drive strength, pull-up, pull-down, open-source, open-drain and/or slew rate.		Any
Pin disabled	Pin is disconnected from input buffers and output drivers.	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 the software application/ Wake up event.		Any
ADC input	8/10/12-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 complex pulse width modulation waveforms		Any
Connection status indication	Indicates if a BLE connection is maintained	BLUE**	Any

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

Table 9: GPIO custom functions configuration

1.9.1 Analog interfaces

8 out of the 25 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.

1.9.1.1 ADC

The Analog to Digital Converter (ADC) can sample up to 200 kHz using different inputs as sample triggers. Table 10 shows the sample speed in correlation to the maximum source impedance. It supports 8/10/12-bit resolution. Any of the eight analog inputs can be used both as single-ended inputs and as differential pairs for measuring the voltage across them. The ADC supports full 0 V to VCC input range.

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

Table 10: Acquisition versus source impedance

1.9.1.2 Comparator

The comparator compares voltages from any analog pin with different references, as shown in Table 11. It supports full 0 V to VCC input range and can generate different software events to the rest of the system.

1.9.1.3 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.

1.9.1.4 Analog pin options

Table 11 shows the supported connections of the analog functions.

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

Analog function	Connects to
ADC single-ended input	Any analog pin or VCC
ADC differential input	Any analog pin or VCC pair
Comparator IN+	Any analog pin
Comparator IN-	Pin 24 or 25, VCC, 1.2 V, 1.8 V, 2.4 V
Low-power comparator IN+	Any analog pin
Low-power comparator IN-	Pin 24 or 25, 1/16 to 15/16 VCC in steps of 1/16 VCC

Table 11: Possible uses of analog pin

1.10 Antenna interface

ANNA-B112 is equipped with an internal antenna integrated in the module. Depending on how the RF pins are connected, the internal antenna can be bypassed, and an external antenna can be used instead. Table 12 describes how the RF related pins shall be connected for each antenna solution.

	External antenna	Integrated antenna module placed in the corner of the PCB	Integrated antenna module placed on the side of the PCB
Pin 1 – ANT_PCB	GND*	GND pattern	NC
Pin 2 – ANT_GND	GND	NC	GND pattern
Pin 3 – ANT_GND	GND	NC	GND pattern
Pin 5 – ANT_INT	GND*	Connect to pin 6 – ANT	Connect to pin 6 – ANT
Pin 6 - ANT	Connect to external antenna	Connect to pin 5 – ANT_INT	Connect to pin 5 – ANT_INT

*Connect to GND for better layout, not critical for function

Table 12: ANNA-B112 Antenna options

1.10.1 Integrated antenna

ANNA-B112 is equipped with a certified integrated antenna in the module. To take advantage of the ANNA-B112 certification, the customer is required to implement the specific ground plane design according to u-blox reference design. The reference design is described in Appendix B.

1.10.2 Antenna pin (external antenna)

ANNA-B112 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 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.

1.10.2.1 Antenna matching

The antenna return loss should be as good as possible across the entire band when the system is operational 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.

1.10.2.2 Approved antenna designs

ANNA-B112 comes with a pre-certified design that can be used to save costs and time during the certification process. The antenna path is routed to a U.FL connector and the external antenna is connected to the U.FL connector.

To take advantage of the ANNA-B112 certification, the customer is required to implement an antenna layout that is in accordance with the u-blox reference design, as 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 respective regulatory agencies.

1.10.3 NFC antenna

The ANNA-B112 module includes a Near Field Communication interface, which is 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 ANNA-B112 modules using an NFC reader. However, ANNA-B112 is not capable of reading other tags or initiating NFC communications. Two pins are available for connecting to an external NFC antenna: **NFC1** and **NFC2**.

1.11 Reserved pins (RSVD)

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

1.12 GND pins

Good connection of the module's GND pins with 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.

For information about ground designs, see Module footprint and paste mask and Thermal guidelines.

2 Software

ANNA-B112 can be used either with the preflashed u-connectXpress software or as an Open CPU module that can run your own application developed using Arm Mbed, Nordic SDK or the Wirepas Mesh development environment inside the ANNA-B112 module.

The software on the ANNA-B112 module contains of the following parts:

- SoftDevice S132 is a Bluetooth LE central and peripheral protocol stack solution
- Optional bootloader
- Application

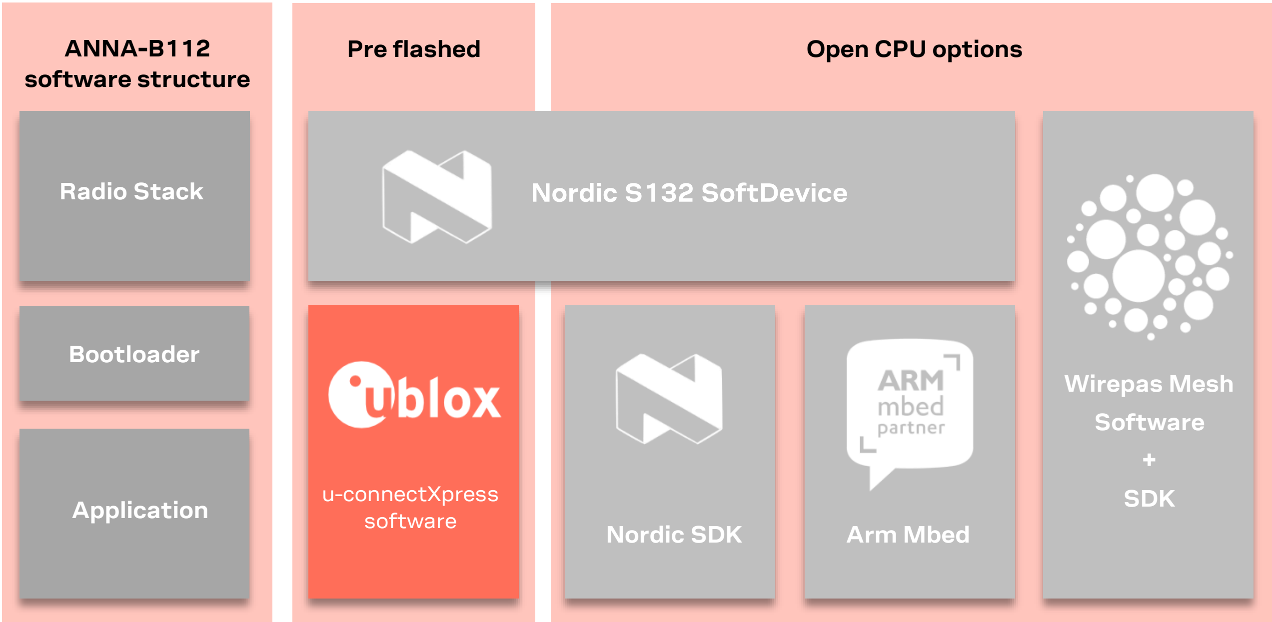


Figure 3: ANNA-B1 software structure and available software options

2.1 u-connectXpress software

2.1.1 Standard edition

The ANNA-B112-0XB module is delivered with the preflashed u-connectXpress software.

The u-connectXpress software enables the use of the Bluetooth LE functions, which are 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 information about using it can be found in the u-connectXpress software user guide [3] and u-connectXpress AT commands manual [4].

2.1.2 Mesh edition

u-ConnectXpress with Bluetooth Mesh support is also available in a separate edition available for download. For more information about the mesh software, see also the application note *Bluetooth Mesh with u-connect software* [21].

2.2 Open CPU

2.2.1 Nordic nRF Connect with Zephyr

Included in the Nordic nRF Connect SDK, Zephyr [16] is a widely adopted open-source Real Time Operating System (RTOS) that is supported on a multitude of chipsets, including the nRF52832 chip in the ANNA-B1 module. The Zephyr project is supported by the Linux Foundation.

Nordic Semiconductor provides the nRF Connect SDK for development using the Zephyr OS.

2.2.1.1 Getting started with Zephyr on the ANNA-B1 module

Follow the procedure below to get started with Zephyr:

1. Install the *Toolchain Manager* from the *nRF Connect for Desktop* application.
2. From the *nRF Connect for Desktop* application install the nRF Connect SDK.
3. Install the Visual Studio Code IDE. For more information, see the nRF Connect SDK page [20].

If a command line environment is preferred, see the Getting Started section on the Zephyr website [16] for more information.

2.2.1.2 Board configuration in Zephyr

The Zephyr OS is like Linux. It uses a similar structure of make files and config files as the Linux kernel. It also uses a device tree file to set up the pin mapping for your board.

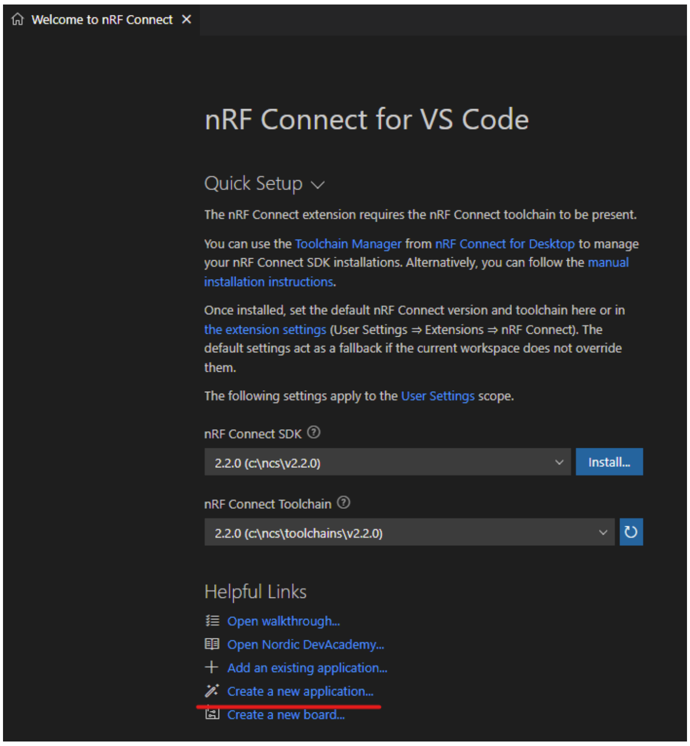
An example configuration for EVK-ANNA-B1 is included in the Zephyr distribution. It is advisable to check the u-blox shortrange open CPU GitHub repository [17] in case there is a more recent version not yet accepted into the Zephyr distribution.

You can copy the configuration from the u-blox shortrange open CPU repository to the `<install directory>/zephyr/boards/arm` folder and the build the project from your preferred environment.

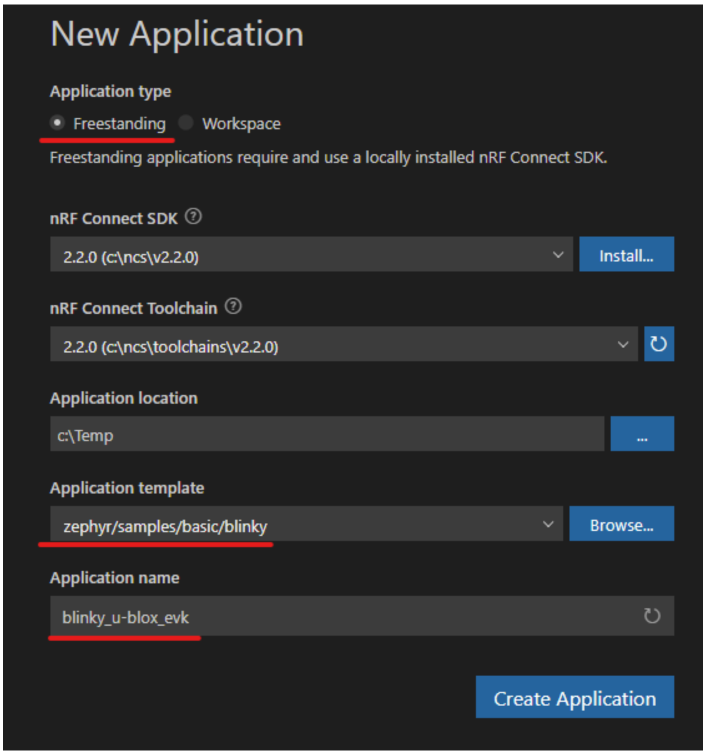
2.2.1.3 Building for the ANNA-B1 EVK using nRF Connect SDK

To build the blinky sample using the nRF Connect SDK:

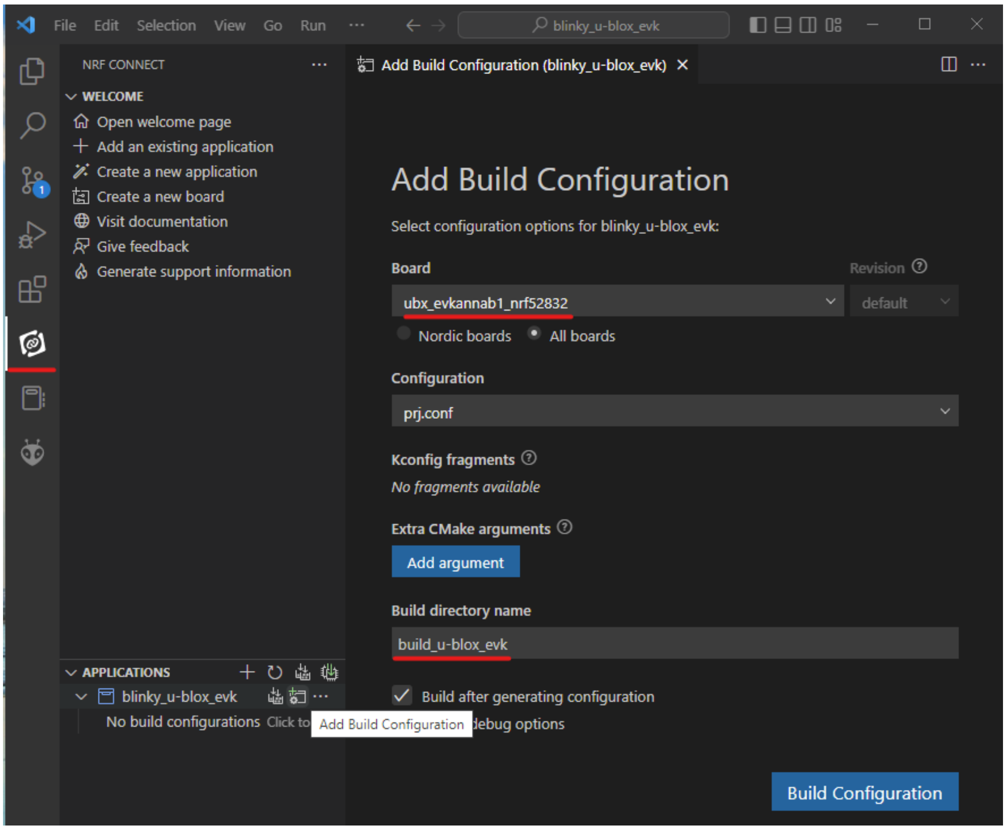
1. Open Visual Studio Code from the Toolchain manager. This sets up the environment variables correctly for nRF Connect SDK.
2. From Visual Studio Code open the sample and create a new application.



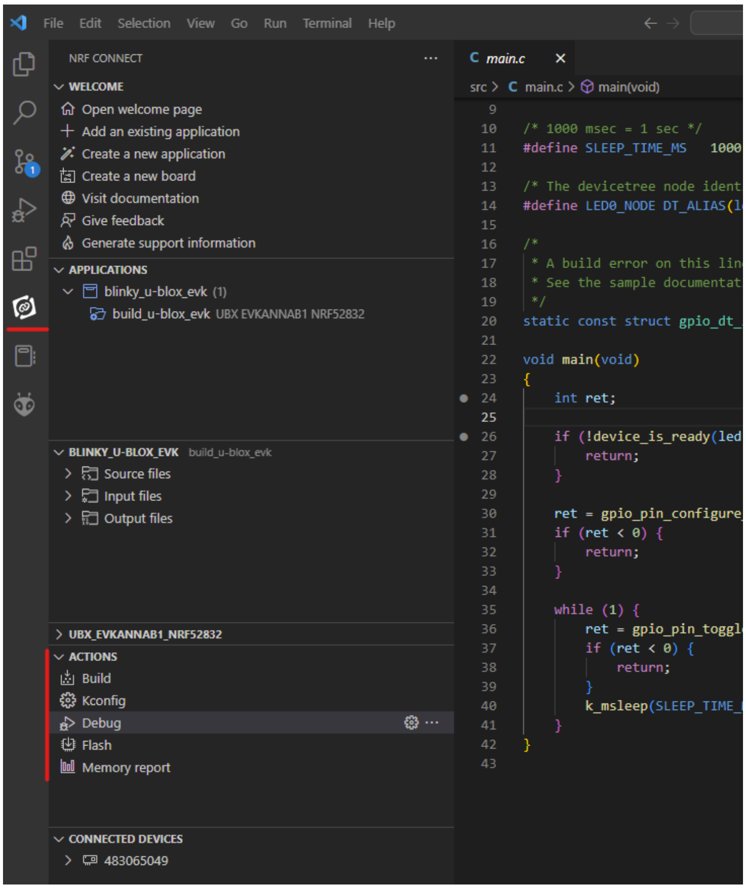
3. Create a copy of the Blinky sample located outside the Zephyr tree. You can then build and debug the example using the nRF Connect plugin to Visual Studio Code. This operation will create a copy of the Blinky sample located outside the Zephyr tree.



4. Build and debug the example using the nRF Connect plugin to Visual Studio Code.



5. Configure the ACTIONS



2.2.1.4 Building for ANNA-B1 EVK using the Zephyr command-line environment

To build and flash the "blinky" example from Zephyr for the ANNA-B1 EVK, move to the zephyr folder in your installation and on the shell prompt enter:

```
~/zephyrproject/zephyr$ west build -b ubx_evkannab1_nrf52832 samples/basic/blinky
~/zephyrproject/zephyr$ west flash
```

The example board configuration also contains documentation. The files are in reStructuredText format. For information on how to generate HTML or PDF output from these files, refer to the Zephyr Project documentation [18].

2.2.1.5 Low Frequency clock source configuration

An external 32 kHz crystal oscillator is the default low-frequency clock source chosen for nRF52832-based boards in Zephyr OS. The clock source can be changed by changing the kernel configuration options:

- CLOCK_CONTROL_NRF_SOURCE
- CLOCK_CONTROL_NRF_ACCURACY_PPM

For up-to-date information about these options, see the Zephyr project documentation [18] and the application note RC oscillator configuration for nRF5 open CPU modules [15].

2.2.2 Nordic nRF5 SDK

The Nordic nRF5 Software Development Kit (SDK) provides a rich development environment for different 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 Segger Embedded Studio, Keil µVision, GCC make files, and IAR support, which gives the freedom to choose the IDE and compiler.

☞ For new projects the Zephyr OS and nRF Connect SDK is in general recommended.

2.2.2.1 Getting started with the Nordic nRF5 SDK

When working with the Nordic SDK on the ANNA-B112 module, use the following procedure 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. Other SWD capable programmers can also be used.
2. Download and install the latest SEGGER Embedded Studio from www.segger.com, or use another supported IDE.
3. Download and extract the latest nRF5 SDK available at: http://www.nordicsemi.com/eng/Products/Bluetooth-low-energy/nRF5-SDK. Save the software container to the directory you want to use 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 [13].

The easiest way to get started with the Nordic SDK is to copy one of the examples in the SDK to get started. Choose the example that most resembles what you want to achieve and use the board definition that best matches your board. If you are building for ANNA-B1 the closest board definition is *pca10040.*

2.2.2.2 Create a custom board for Nordic nRF5 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 can be created. This is normally located in the folder `…\components\boards\` or together with the `sdk_config .h` file in the `config` folder of the example.

☞ The file locations given above are valid for Nordic nRF5 SDK version 17.0.

Example

The following example shows what the custom board support file can look like for EVK-ANNA-B112.

```
#ifndef BOARD_CUSTOM_H
#define BOARD_CUSTOM_H

#ifdef __cplusplus
extern "C" {
#endif

#include "nrf_gpio.h"

// In this case PIN 25 is used as button SW1, if the green led
// should be used it is possible to defined that one instead.
#define LEDS_NUMBER    2

#define LED_1          27    // Red
#define LED_2          26    // Blue
//#define LED_3        25    // Green

#define LEDS_ACTIVE_STATE 0

#define LEDS_LIST { LED_1, LED_2 }

#define BSP_LED_0      LED_1
#define BSP_LED_1      LED_2

#define LEDS_INV_MASK  LEDS_MASK

#define BUTTONS_NUMBER 2

#define BUTTON_1       25    // SW1
#define BUTTON_2       24    // SW2
#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  2
#define TX_PIN_NUMBER  3
#define CTS_PIN_NUMBER 19
#define RTS_PIN_NUMBER 11
#define HWFC           true

// Low frequency clock source to be used by the SoftDevice
#define NRF_CLOCK_LFCLKSRC      {.source        = NRF_CLOCK_LF_SRC_XTAL,            \
                                 .rc_ctiv       = 0,                                \
                                 .rc_temp_ctiv  = 0,                                \
                                 .xtal_accuracy = NRF_CLOCK_LF_XTAL_ACCURACY_20_PPM}

#ifdef __cplusplus
}
#endif

#endif // BOARD_CUSTOM_H
```

This board file can also be downloaded from the u-blox shortrange open CPU GitHub repository [17].

To make the build system use your custom board file define the build variable `BOARD_CUSTOM` in the build configuration. If you build on an existing example, undefine the default `BOARD_PCA10040`.

2.2.2.3 Adding the board configuration to your project

A flexible way of adding a board to your project is to add a new build configuration to your Segger Studio project and then use this configuration to select the correct board file for your build. By adding several configurations, you can build for several targets from the same Segger Studio project. For example, you can use the following procedure to build from both your custom board and u-blox EVK to test your code on different platforms:

1. Add a build configuration in the Segger Studio project.

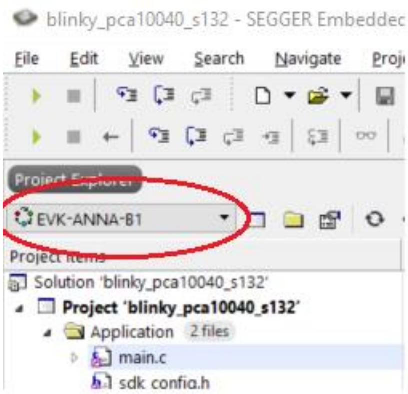


Figure 4 Add a build configuration to Segger Studio

2. Configure the build configuration to use your board definition. Remember to undefine the configuration for the original board, assuming you are basing your project on an example from the Nordic nRF5 SDK.

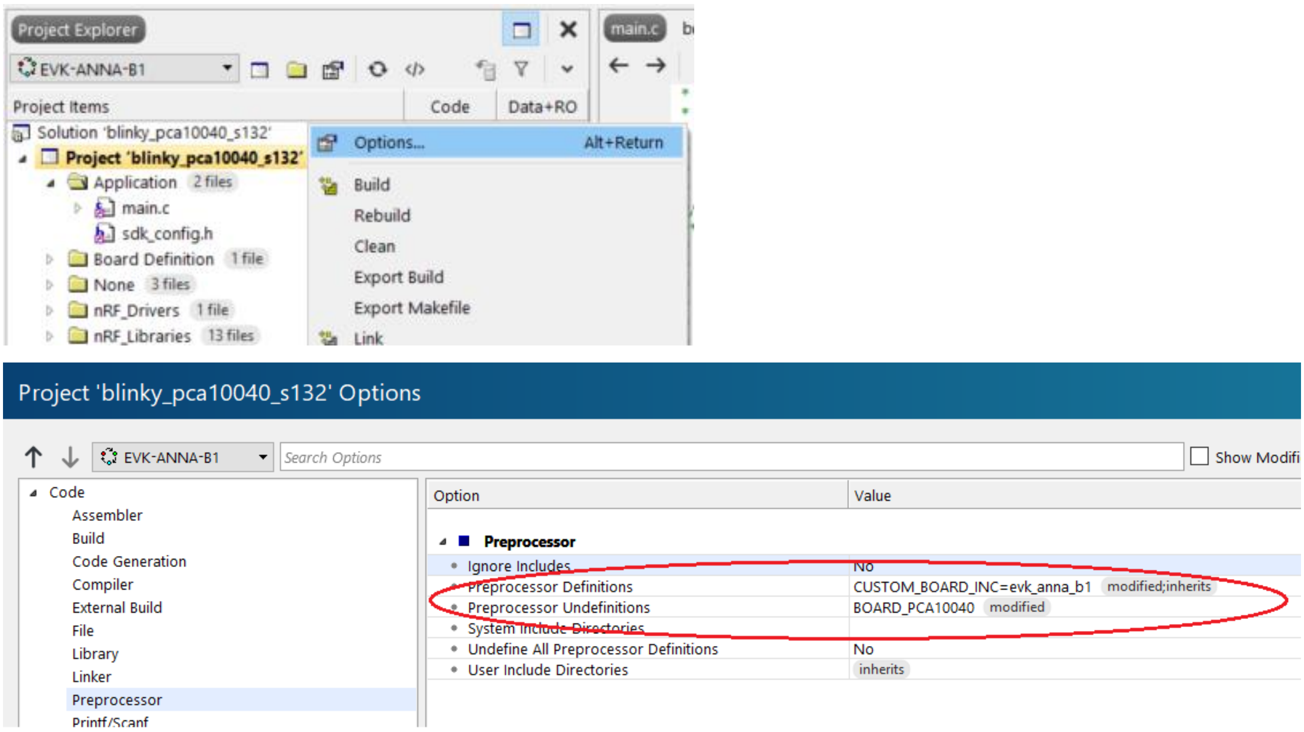


Figure 5: Setting up board configuration to use `evk_anna_b1.h` board file

The build for your configuration now uses your custom board file.

2.2.3 Support – Nordic development forum

For support related to the Nordic nRF5 SDK or nRF Connect SDK, see the Nordic development zone website at: https://devzone.nordicsemi.com/.

2.2.4 Arm Mbed OS

Arm Mbed OS is an open-source embedded operating system designed specifically for the "things" in IoT (Internet of Things). It includes all the features to develop a connected product, including security, connectivity, RTOS, and drivers for sensors and I/O devices. With an RTOS core based on the widely used open-source CMSIS-RTOS RTX, Arm Mbed OS supports deterministic, multithreaded, real time software execution. Arm Mbed OS has native support for building across the Arm Compiler 5, GCC, and IAR compiler toolchains.

☞ Arm Mbed OS is not supported on later Nordic Semiconductor based modules. For new projects, the Zephyr OS and nRF Connect SDK is in general recommended.

2.2.4.1 Getting started with the Arm Mbed OS

A list of prerequisites for getting started with Arm Mbed OS 5 development on EVK-ANNA-B112 is available at https://github.com/ARMmbed/mbed-os-example-ble#getting-started.

Mbed CLI is the name of the Arm Mbed command line tool that enables the full Mbed workflow. You can use the tool to control repository versions, maintain dependencies, update from remotely hosted repositories (GitHub, GitLab, and mbed.org), and invoke Arm Mbed's own build system. Documentation describing the installation and usage of the Mbed CLI is available at https://github.com/ARMmbed/mbed-cli#introduction.

For information about how to create a build target for EVK-ANNA-B112, see Create a custom target for Arm Mbed .

Bluetooth LE examples from Arm Mbed are available at: https://github.com/ARMmbed/mbed-os-example-ble.

2.2.4.2 Create a custom target for Arm Mbed

Add target

1. Add a new JSON object to the `targets.json` file located in the `\mbed-os\targets\` folder.

   The following example shows the JSON target object for EVK-ANNA-B112. For a list of the known properties in the Arm Mbed build system, see "Standard properties" in reference [5].

☞ The location of the `targets.json` is the same as that in Arm Mbed OS release 5.6

```
"UBLOX_EVK_ANNA_B112": {
    "supported_form_factors": ["ARDUINO"],
    "inherits": ["MCU_NRF52"],
    "macros_add": [
        "BOARD_PCA10040",
        "NRF52_PAN_12",
        "NRF52_PAN_15",
        "NRF52_PAN_58",
        "NRF52_PAN_55",
        "NRF52_PAN_54",
        "NRF52_PAN_31",
        "NRF52_PAN_30",
        "NRF52_PAN_51",
        "NRF52_PAN_36",
        "NRF52_PAN_53",
        "S132",
        "CONFIG_GPIO_AS_PINRESET",
        "BLE_STACK_SUPPORT_REQD",
        "SWI_DISABLE0",
        "NRF52_PAN_20",
        "NRF52_PAN_64",
        "NRF52_PAN_62",
        "NRF52_PAN_63"],
    "device_has_add": [
        "ANALOGIN",
        "I2C",
        "I2C_ASYNCH",
        "INTERRUPTIN",
        "LOWPOWERTIMER",
        "PORTIN",
        "PORTINOUT",
        "PORTOUT",
        "PWMOUT",
        "RTC",
        "SERIAL",
        "SERIAL_ASYNCH",
        "SLEEP",
        "SPI",
        "SPI_ASYNCH",
        "SPISLAVE",
        "FLASH"],
    "release_versions": ["2", "5"],
    "device_name": "nRF52832_xxAA"
```

Pin mapping

2. Create a folder with the same name as the JSON object added (above) previously. The folder should be located at `\mbed-os\targets\TARGET_NORDIC\TARGET_NRF5\TARGET_MCU_NRF52832\`.

   For EVK-ANNA-B1, the folder is called `TARGET_UBLOX_EVK_ANNA_B112`.

   In this new folder, there should be two files, `device.h` and `PinNames.h`.

   The file `device.h` contains the `#include object.h`.

```
#ifndef MBED_DEVICE_H
#define MBED_DEVICE_H

#include "objects.h"

#endif
```

   `PinNames.h` should declare and define a couple of enumerations to configure the custom pin mapping. The following example shows the contents of the `PinNames.h` file for EVK-ANNA-B112.

```
#ifndef MBED_PINNAMES_H
#define MBED_PINNAMES_H

#include "cmsis.h"

#ifdef __cplusplus
extern "C" {
#endif

    typedef enum {
        PIN_INPUT,
        PIN_OUTPUT
    } PinDirection;

#define PORT_SHIFT  3

    typedef enum {
        // nRF52 pin names
        p0 = 0,
        p1 = 1,
        p2 = 2,
        p3 = 3,
        p4 = 4,
        p5 = 5,
        p6 = 6,
        p7 = 7,
        p8 = 8,
        p9 = 9,
        p10 = 10,
        p11 = 11,
        p12 = 12,
        p13 = 13,
        p14 = 14,
        p15 = 15,
        p16 = 16,
        p17 = 17,
        p18 = 18,
        p19 = 19,
        p20 = 20,
        p21 = 21,
        p22 = 22,
        p23 = 23,
        p24 = 24,
        p25 = 25,
```

```
        p26 = 26,
        p27 = 27,
        p28 = 28,
        p29 = 29,
        p30 = 30,
        p31 = 31,
      NC = (int)0xFFFFFFFF,     // Not connected

//ANNA-B112 module pin names
ANNA_B112_IO_13 = p14,
ANNA_B112_IO_14 = p15,
ANNA_B112_IO_15 = p16,
ANNA_B112_IO_16 = p18,
ANNA_B112_IO_17 = p0,
ANNA_B112_IO_18 = p1,
ANNA_B112_IO_19 = p3,
ANNA_B112_IO_20 = p2,
ANNA_B112_IO_21 = p9,
ANNA_B112_IO_22 = p10,
ANNA_B112_IO_23 = p5,
ANNA_B112_IO_24 = p4,
ANNA_B112_IO_25 = p31,
ANNA_B112_IO_26 = p30,
ANNA_B112_IO_27 = p29,
ANNA_B112_IO_28 = p28,
ANNA_B112_IO_29 = p27,
ANNA_B112_IO_30 = p25,
ANNA_B112_IO_31 = p26,

ANNA_B112_IO_34 = p11,
ANNA_B112_IO_35 = p19,
ANNA_B112_IO_36 = p22,
ANNA_B112_IO_37 = p23,
ANNA_B112_IO_38 = p24,

ANNA_B112_IO_45 = p20,


// EVK-ANNA-B112 board
LED1 = ANNA_B112_IO_29,  // Red
LED2 = ANNA_B112_IO_30,  // Green/SW1
LED3 = ANNA_B112_IO_31,  // Blue
LED4 = NC,

SW1 = ANNA_B112_IO_30,
SW2 = ANNA_B112_IO_38,

D0 = ANNA_B112_IO_20,
D1 = ANNA_B112_IO_19,
D2 = ANNA_B112_IO_35,
D3 = ANNA_B112_IO_34,
D4 = ANNA_B112_IO_29,
D5 = ANNA_B112_IO_31,
D6 = ANNA_B112_IO_22,
D7 = ANNA_B112_IO_21,

D8 = ANNA_B112_IO_13,
D9 = ANNA_B112_IO_38,
D10 = ANNA_B112_IO_36,
D11 = ANNA_B112_IO_37,
D12 = ANNA_B112_IO_16,
D13 = ANNA_B112_IO_45,

D14 = ANNA_B112_IO_14,
D15 = ANNA_B112_IO_15,
```

```
A0 = ANNA_B112_IO_24,
A1 = ANNA_B112_IO_23,
A2 = ANNA_B112_IO_28,
A3 = ANNA_B112_IO_27,
A4 = ANNA_B112_IO_26,
A5 = ANNA_B112_IO_25,


// Nordic SDK pin names
RX_PIN_NUMBER = p2,
TX_PIN_NUMBER = p3,
CTS_PIN_NUMBER = p19,
RTS_PIN_NUMBER = p11,
I2C_SDA0 = p15,
I2C_SCL0 = p16,


// Arm Mbed interface pins
USBTX = TX_PIN_NUMBER,
USBRX = RX_PIN_NUMBER
} PinName;
typedef enum {
    PullNone = 0,
    PullDown = 1,
    PullUp = 3,
    PullDefault = PullUp
} PinMode;

#ifdef __cplusplus
}
#endif
#endif
```

Build software

3. In the Arm Mbed CLI, compile software by using the name of the object created in the `targets.json` file as a parameter to the board flag. For the EVK-ANNA-B112 example, use the build command:

```
mbed compile -t GCC_ARM -m UBLOX_EVK_ANNA_B112
```

2.2.5 Wirepas Mesh

ANNA-B112 can also be used together with the Wirepas Mesh software stack. This allows ANNA-B112 to be used in a true, large-scale, mesh environment.

Wirepas Mesh is third party software licensed from Wirepas.

For more information about Wirepas Mesh software, contact your local u-blox support team.

2.2.6 Saving Bluetooth MAC address and other production data

ANNA-B112-0XB comes with a Bluetooth MAC address programmed. See also Reading the Bluetooth device address. This address is used by the customer application – if needed.

ANNA-B112-70B module comes with an empty flash.

The MAC address is programmed in the CUSTOMER[0] and CUSTOMER[1] user information configuration registers of the of the nRF52832 chip. The address can be read and written using either Segger J-Link utilities or the Nordic `nrfjprog` utility.

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

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

UICR (user information configuration registers) memory also holds the serial number and other information that can be useful to save. If you want to save and restore the whole memory area, you use the commands:

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

☞ Note that the user information configuration registers hold the boot loader start address, which can confuse the boot process during open CPU development. In this instances, the MAC address must be written separately.

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

2.3 Flashing ANNA-B112

It is possible to reflash ANNA-B112 using either the UART or SWD interface whenever a new version of the u-connectXpress software is available. ANNA-B112-70B module variants do not have any software preloaded and must be flashed over SWD.

⚠ Flashing of u-connectXpress software is normally done over UART. If the flash is erased or any other software is flashed on ANNA-B112, the SoftDevice and the u-blox bootloader must be flashed over SWD before the u-connectXpress software can be flashed over UART again. See also Flashing over the SWD interface.

Open CPU software is flashed over the SWD interface.

2.3.1 Flashing over UART

To use the UART interface, the module must have a bootloader that supports flashing over UART. The u-connectXpress software includes a bootloader that can flash the u-connectXpress software over UART.

The u-connectXpress software for UART flashing contains two separate binary files and one json file:

- `s132_nrf52_x.x.x_softdevice.bin` contains the SoftDevice.
- `ANNA-B112-SWx.x.x.bin` contains the application.
- `ANNA-B112-Configuration-x.x.x.json` contains the bin file name, flash address, size, and crc for the SoftDevice. It also includes the bin file name and the flash address for the application.

The XMODEM protocol is used for flashing. Flow control is not used. The following pins should be made available as either headers or test points to flash the module:

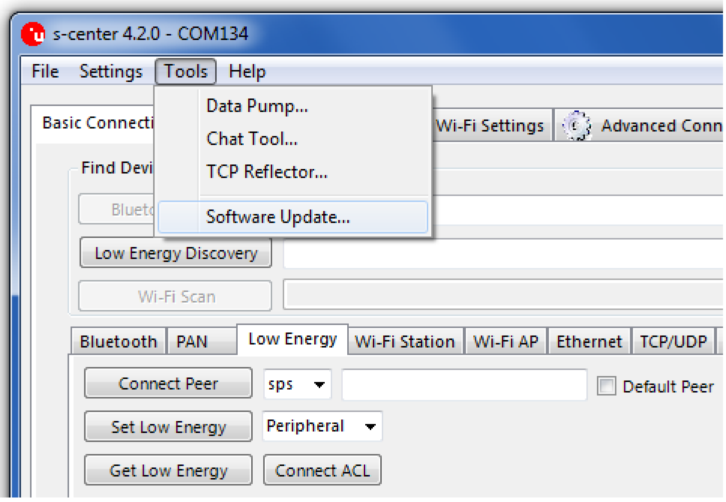
- **UART** (RX, TX)
- **RESET_N**
- **SWITCH_1** and **SWITCH_2**

2.3.1.1 s-center

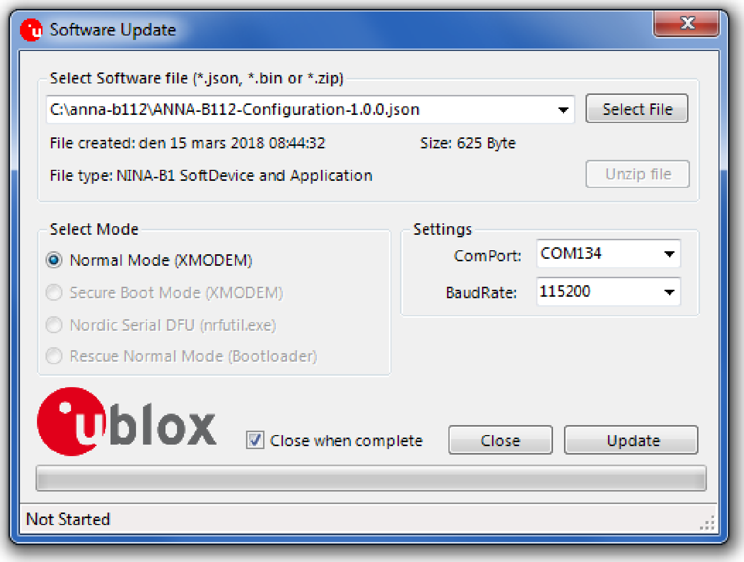
☞ Flashing of u-connectXpress software requires s-center software version 4.2.0 or later.

To flash the module using s-center:

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



2. Select the json file.



3. Set the correct COM port, ensure that the Normal Mode is selected, and select **Update**. The module reboots into the bootloader and the flashing of the SoftDevice and application starts.

2.3.1.2 Terminal application

The bootloader included in the u-connectXpress software supports the XMODEM protocol

Flashing the SoftDevice

Follow the procedure below to flash the SoftDevice using a terminal application.

1. Connect to the module using Tera Term, and set the serial settings as shown in Figure 6.

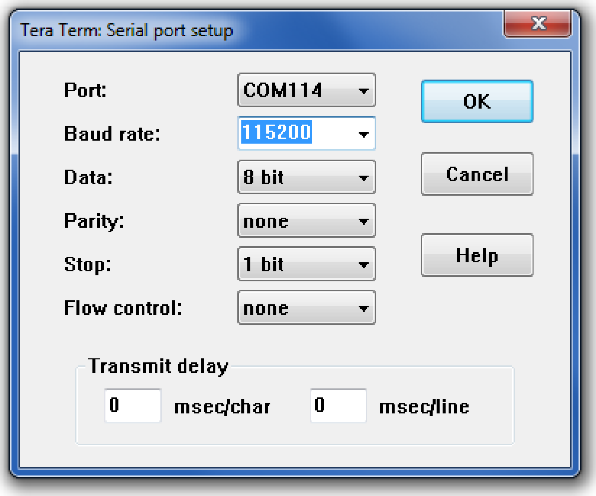


Figure 6: Screenshot that shows serial settings

2. Start the bootloader mode using either of the following methods:
   a. AT command `AT+UFWUPD=1,115200`. See also u-connect AT commands manual [4] .
   b. Press the SW1 and SW2 buttons during the module reset
      The bootloader prompt “>” is displayed when the bootloader mode has started.

☞ The bootloader times out and resumes the application after 10 seconds.

3. The command `x [SoftDevice address]` sets the bootloader in file transfer mode. The address can be found in the json configuration file included in the software package.


```
{
  "Label": "SoftDevice",
  "Description": "Softdevice from NordicSemi",
  "File": "s132_nrf52_5.0.0_softdevice.bin",
  "Version": "s132_nrf52_5.0.0_softdevice",
  "Address": "0x0",
  "Size": "0x224A8",
  "Crc32": "0xAB70DDB4"
}
```


Figure 7: Example of SoftDevice information from the json configuration file

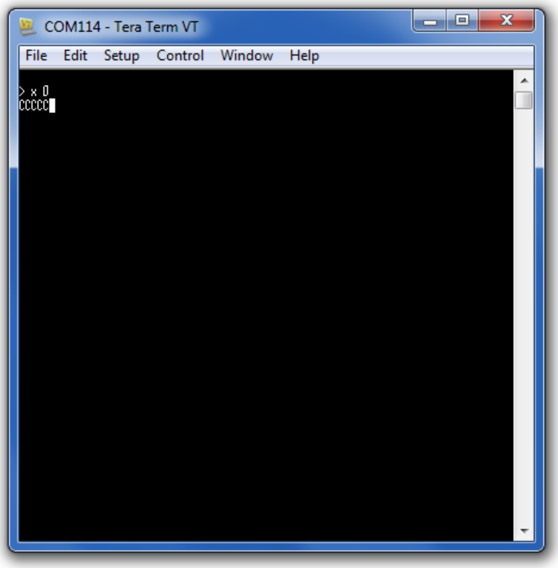


Figure 8: Screenshot that shows file transfer mode

4. When the bootloader displays "`ccc`" (see also Figure 8), it is ready to receive the SoftDevice bin file. Send the file using the XMODEM protocol.

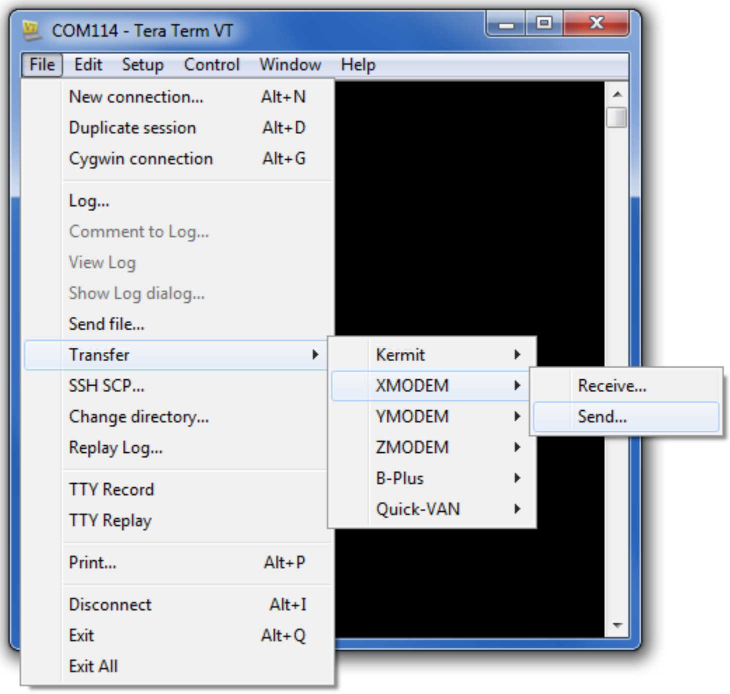


Figure 9: Screenshot that shows how to send the file using XMODEM protocol

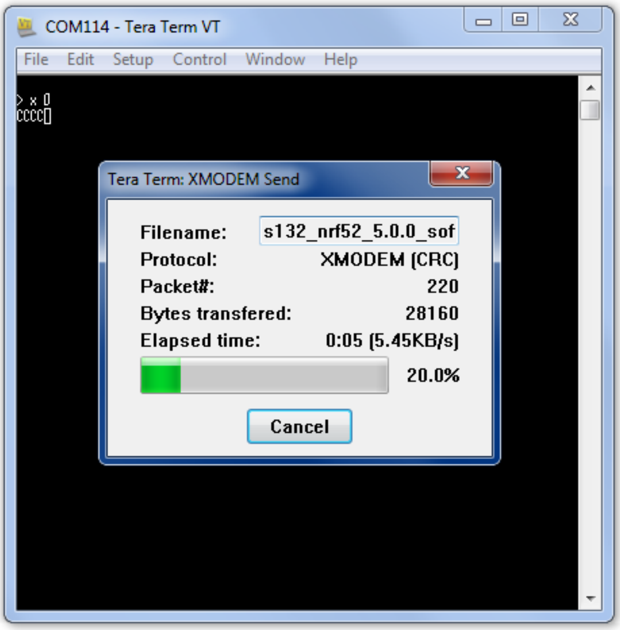


Figure 10: Screenshot shown during file transfer

5. An `OK` response indicates a successful file transfer.

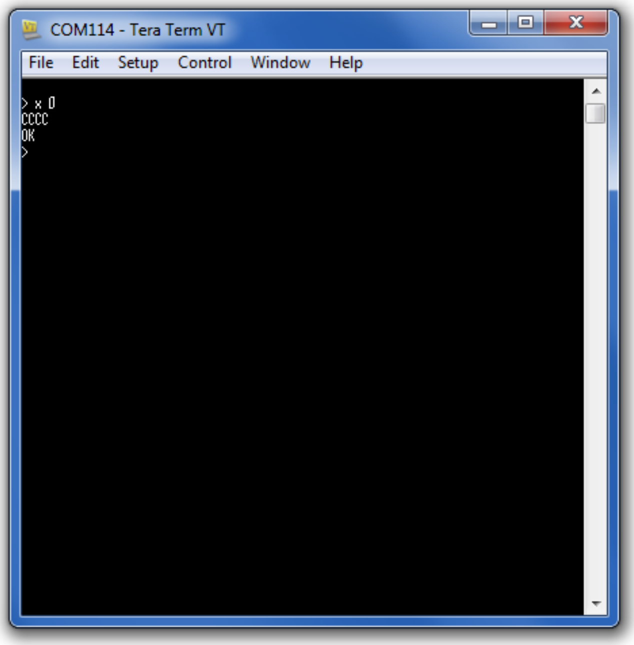


Figure 11: Screenshot shown on successful file transfer

6. Verify the transferred file using the command:
   `c SOFTDEVICE [SoftDevice size] [SoftDevice CRC32]`
   The size and crc can be found in the json configuration file, as shown in Figure 12.

```
{
  "Label": "SoftDevice",
  "Description": "Softdevice from NordicSemi",
  "File": "s132_nrf52_5.0.0_softdevice.bin",
  "Version": "s132_nrf52_5.0.0_softdevice",
  "Address": "0x0",
  "Size": "0x224A8",
  "Crc32": "0xAB70DDB4"
}
```

Figure 12: SoftDevice information example from the json configuration file

7. An OK response indicates a successfully flashed SoftDevice.

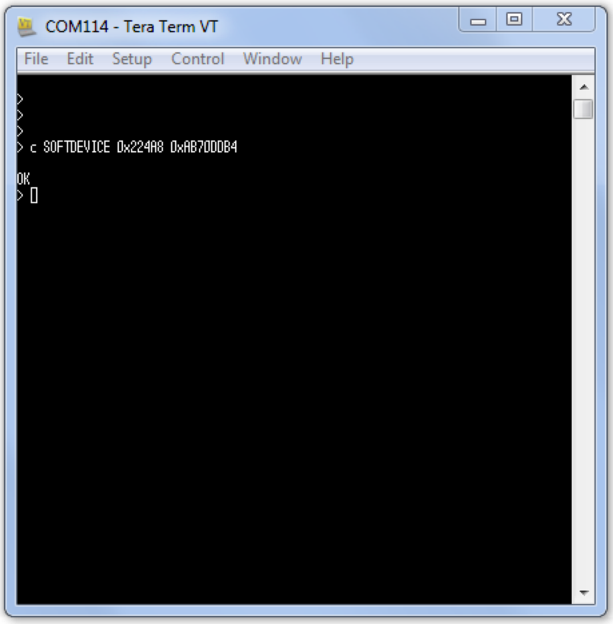


Figure 13: Screenshot shown on successful verification of the transferred file

Flashing the application software

1. Use command `x [Application address]` to set the bootloader in file transfer mode. The application address can be found in the json configuration file.

```
{
  "Label": "ConnectivitySoftware",
  "Description": "ANNA-B112 Firmware",
  "File": "ANNA-B112-FW1.0.0-001.bin",
  "Version": "ANNA-B112-FW1.0.0-001",
  "Address": "0x23000"
},
```

Figure 14: Example of application information from the json configuration file

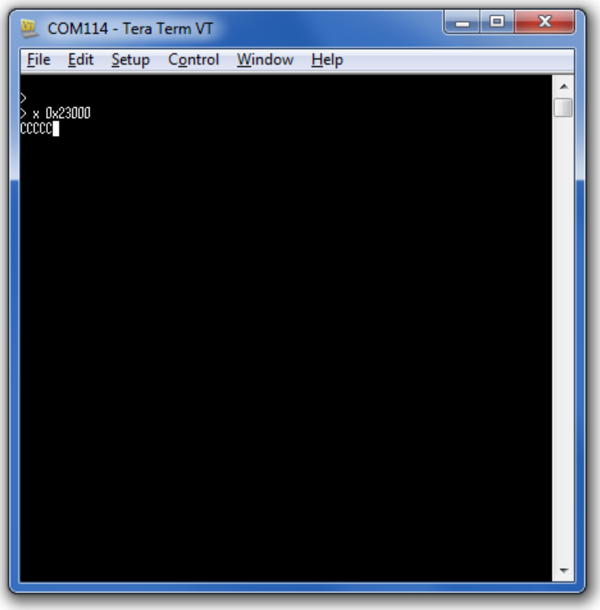


Figure 15: Screenshot shown on file transfer mode

When the bootloader displays `ccc`, as shown in Figure 15, it is ready to receive the application bin file.

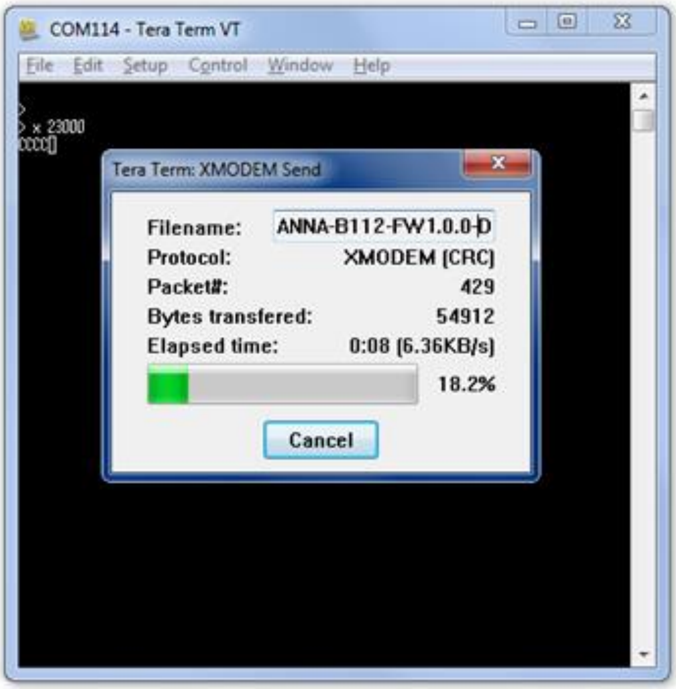


Figure 16: Screenshot shown during file transfer

2. Send the file using the XMODEM protocol, as shown in Figure 17 .

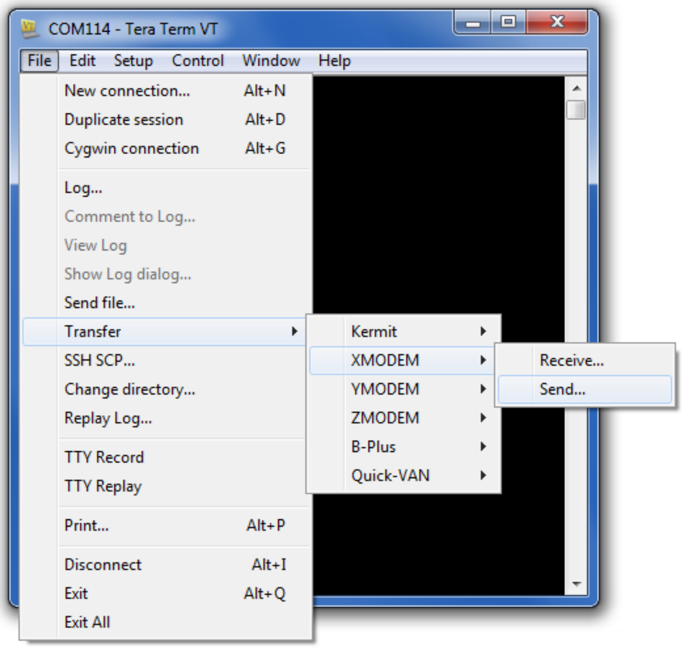


Figure 17: Screenshot showing how to send the file using XMODEM protocol

3. An `OK` response indicates a successful file transfer. The application software does not require verification of the size and CRC.

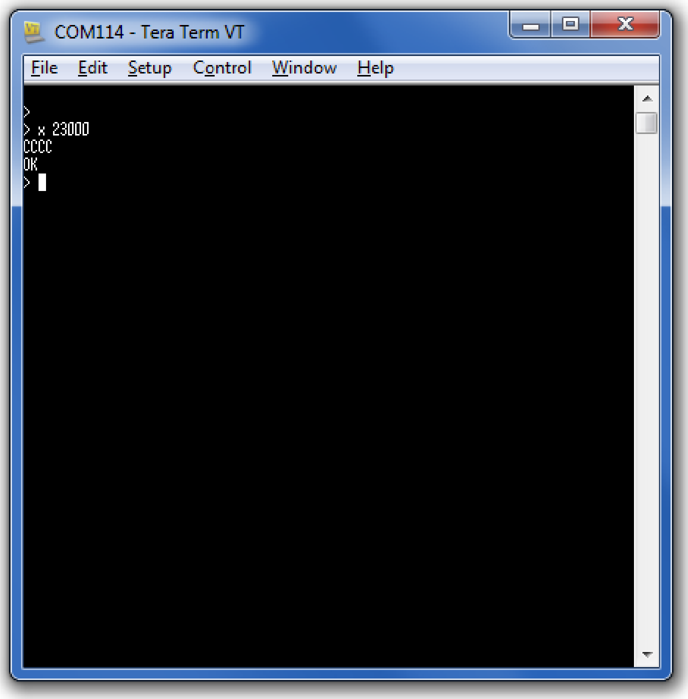


Figure 18: Screenshot shown on successful file transfer

4. Power cycle the module to start the u-connectXpress software.

2.3.2 Flashing over the SWD interface

For SWD (Serial Wire Debug) flashing, an external debugger must be connected to the SWD interface of the ANNA-B112 module. Then, use an external tool such as J-flash or the nRF Connect Programmer from Nordic Semiconductor to flash the module.

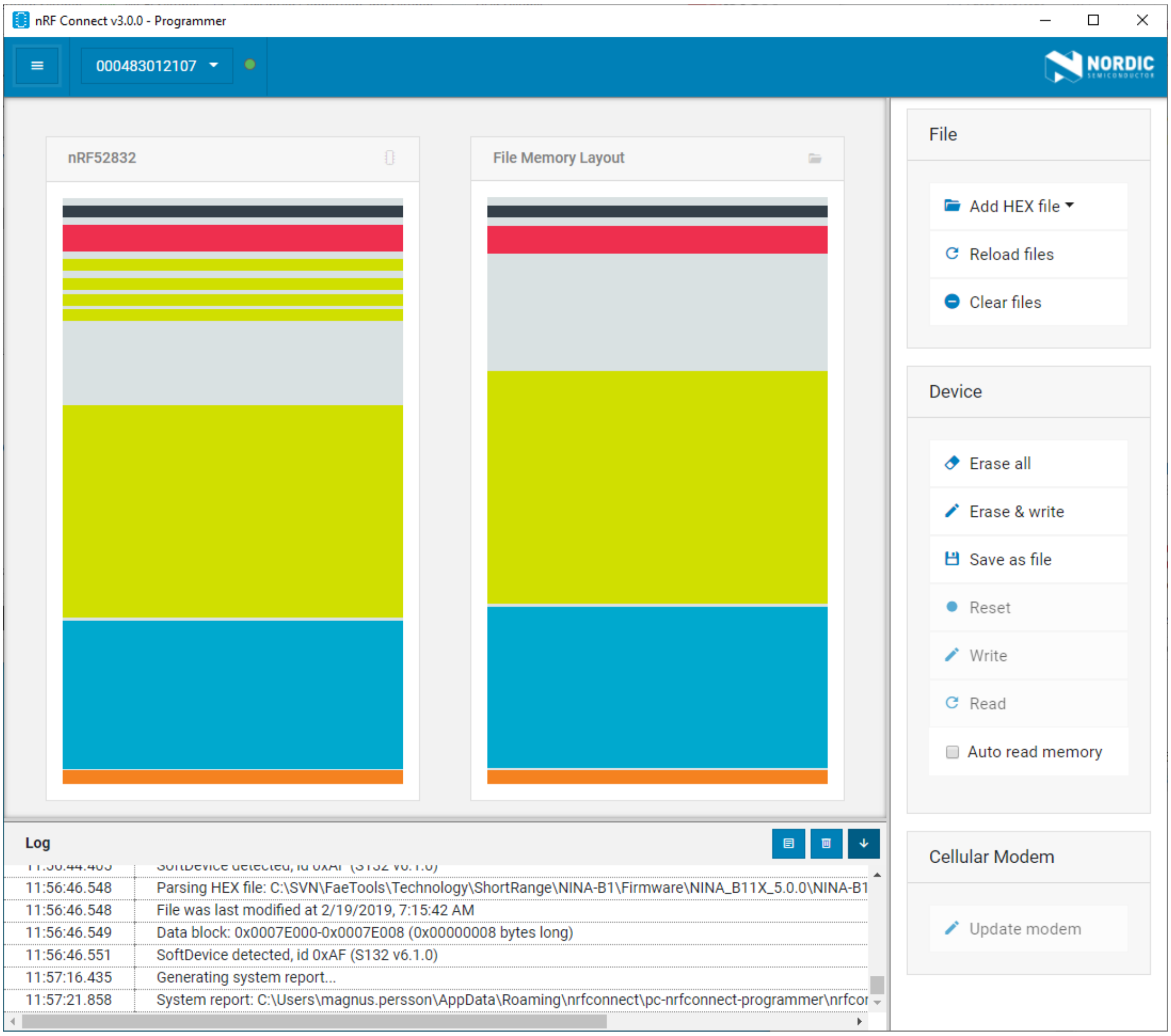
☞ The external debugger SEGGER J-Link BASE is verified to work with ANNA-B112.

☞ The EVK-ANNA-B112 evaluation kit incorporates an on-board debugger and can therefore be flashed without any external debugger.

2.3.2.1 Flashing the software

⚠ If the UICR region is erased when flashing the software using the SWD interface, the Bluetooth device address is also erased. In these instances, the Bluetooth device address 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 also Reading the Bluetooth device address.

1. In the nRF Connect Programmer, drag and drop the hex files you want to program into the GUI:



2. To reflash the u-connectXpress software, flash the following files:
   - SoftDevice
   - Bootloader – if applicable
   - Application
   - u-connectXpress software validation file – if applicable
3. Go to the ANNA-B112 product page [28], where the following `.hex` files are available for u-connectXpress firmware updates:
   - SoftDevice: `s132_nrf52_xxx.hex`
   - Bootloader: `ANNA-B112_BOOT_xxx.hex`
   - Application: `ANNA-B112_SW_xxx.hex`
   - u-connectXpress software validation file: `valid_s132_nrf52_xxx_softdevice.hex`

☞ When developing and flashing open CPU applications, choose **Erase all** to remove the u-connectXpress software and associated parameters before flashing the custom application. Alternatively use the ANNA-B112-70B module version.

⚠ When the new u-connectXpress software has been flashed, remember to restore the Bluetooth device address if necessary. See also Restoring the Bluetooth device address.

2.3.2.2 Reading the Bluetooth device address

Flashing the software can erase the Bluetooth device address, which must then be manually rewritten to the module after flashing. Make a note of your Bluetooth device address before continuing with the flashing procedure.

The Bluetooth device address of your module can be accessed in either of the two ways described in the following subsections:

2.3.2.2.1 AT command

If your product device is operational and running u-connectXpress software, execute the following command to read the Bluetooth device address. The command response, including the device address, is shown here in **bold**:

```
AT+UMLA=1
+UMLA: D4CA6EB00613
OK
```

2.3.2.2.2 nrfjprog command line utility

You can also read the MAC address stored in the flash memory. To read or restore this address use the `nrfjprog` utility, as described in Saving Bluetooth MAC address and other production data.

2.3.2.3 Restoring the Bluetooth device address

When the new u-connectXpress software has been flashed to the module, it is important to restore the Bluetooth device address.

1. To enable writing of the Bluetooth device address, execute the following command and wait for the startup event.

   ```
   AT+UPROD=1
   OK
   +STARTUP
   ```

2. To write your Bluetooth device address to the flash memory of the device and reset the device, execute the following commands. Replace the Bluetooth device address shown in **bold** with your own.

   ```
   AT+UPRODPW=1,D4CA6EB00613
   OK
   AT+CPWROFF
   OK
   +STARTUP
   ```

3. Verify that you have successfully written your Bluetooth Device address to the device using the following command:

   ```
   AT+UMLA=1
   +UMLA: D4CA6EB00613
   OK
   ```

⚠ The Bluetooth device address is stored permanently. If you make a mistake, the only way to rewrite the Bluetooth device address is to repeat the procedure described in Flashing the software. Failure to restore the Bluetooth device address can cause some malfunctions in the software.

3 Design-in

3.1 Overview

For an optimal integration of ANNA-B112 in the final application board, it is advisable to follow the design guidelines stated in this section. Every application circuit must be properly designed to guarantee the correct functionality of the related interface; however, a number of points require a high level of attention during the design of the application device.

The following list provides important points sorted by rank of importance in the application design – starting with the most relevant:

- Module antenna connection:
- Antenna circuit affects the RF compliance of the device integrating ANNA-B112 module with applicable certification schemes. For schematic and layout design recommendations, see Antenna interface.
- Module supply: **VCC**, and **GND** pins.
  - The supply circuit affects the performance of the device integrating ANNA-B112 module. For schematic and layout design recommendations, see Supply interfaces.
- Analog signals: GPIO
  - Analog signals are sensitive to noise and should be routed away from high frequency signals.
- 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. For schematic and layout design recommendations, see Asynchronous serial interface (UART) design.
- 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.
- Other pins: Accurate design is required to guarantee proper functionality.

3.2 Antenna interface

As the unit cannot be mounted arbitrary, the placement should be chosen with consideration so that it does not interfere with radio communication. The ANNA-B112 using the internal antenna cannot be mounted in a metal enclosure. No metal casing or plastics using metal flakes should be used. Avoid metallic based paint or lacquer as well. Using the ANNA-B112 with external antenna offers more freedom as the 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 design used in the module's FCC type approval or certify their own designs.

3.2.1 ANNA-B112 internal antenna design

⚠ If a metal enclosure is required, ANNA-B112 an antenna pin with external antenna has to be used.

It is advisable to place the ANNA-B112 module so that the internal antenna is in the corner of the host PCB. The next best option is to position the antenna along one side of the host PCB ground plane. It is beneficial to have a large ground plane on the host PCB and have a good grounding for the ANNA-B112 module. Detailed description of the antenna trace and requirements can be found in Appendix B.

3.2.1.1 Board size considerations

For a large PCB, (such as a board where the length and width are larger than one wavelength (61.5 mm), the shape and size of the ground plane is not critical.

For smaller PCBs where the length and the width are below one wavelength (61.5 mm), the size and shape of the ground plane is an important factor. See examples in appendix B.4.

3.2.1.2 Antenna trace design

The two versions of the trace design for using the internal antenna are described in appendix B.

3.2.2 ANNA-B112 external antenna design

3.2.2.1 Antenna trace design

The certified trace design to a U.FL connector is described in appendix B.

3.2.3 General antenna design guidelines

Designers must take care of the antennas from all perspective at the beginning of the design phase when the physical dimensions of the application board are under analysis/decision as the RF compliance of the device integrating ANNA-B112 module with all the applicable required certification schemes heavily depends on the radiating performance of the antennas. The designer is encouraged to consider one of the u-blox suggested antenna part numbers and follow the layout requirements.

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

  Integrated antenna excites RF currents on its counterpoise, typically the PCB ground plane of the device that becomes part of the antenna. The ground plane size can be reduced down to the size of the module itself and still generate good radiated power. However, the antenna radiated power tends to fluctuate the smaller ground plane, especially below about 1.2 PCB wavelength. Care must be taken to find an optimum by measuring radiated power or range. See the examples provided in Appendix B.4.

  The RF isolation between antennas in the system must be as high as possible and the correlation between the 3D radiation patterns of the two antennas has to be as low as possible. In general, an RF separation of at least a quarter wavelength between the two antennas is required to achieve a maximum isolation and low pattern correlation; increased separation should be considered, if possible, to maximize the performance and fulfil the requirements in Table 13.

  As numerical example, the physical restriction to the PCB design can be considered, where:
  Frequency = 2.4 GHz → Wavelength = 12.5 cm → Quarter wavelength = 3.125 cm
- Radiation performance depends on the whole product and antenna system design, including product mechanical design and usage. Antennas should be selected with optimal radiating performance in the operating bands according to the mechanical specifications of the PCB and the whole product.

Table 13 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 LE
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	See Qualifications and approvals	The maximum antenna gain must not exceed the value specified in type approval documentation to comply with the radiation exposure limits specified by regulatory agencies.

Table 13: Summary of antenna interface requirements for ANNA-B112

In both the cases, 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 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 FCC in the United States).

3.2.3.1 RF transmission line design

RF transmission lines, such as the ones from the antenna output 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 19 shows the design options for implementing a transmission line, namely:

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

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

- Width (W) – shows the width of the copper layer on the top layer
- Distance (S) – shows the distance between the top copper layer and the two adjacent GND planes.
- Dielectric substrate thickness (H) – shows the distance between the GND reference on the bottom plane and the copper layer on the top layer.
- Thickness of the copper layer (T) – can also be represented by “Base Copper Weight”, which is commonly used as the parameter for PCB stack-up.
- Dielectric constant (ε_r) defines the ratio between the electric permeability of the material against the electric permeability of free space.

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

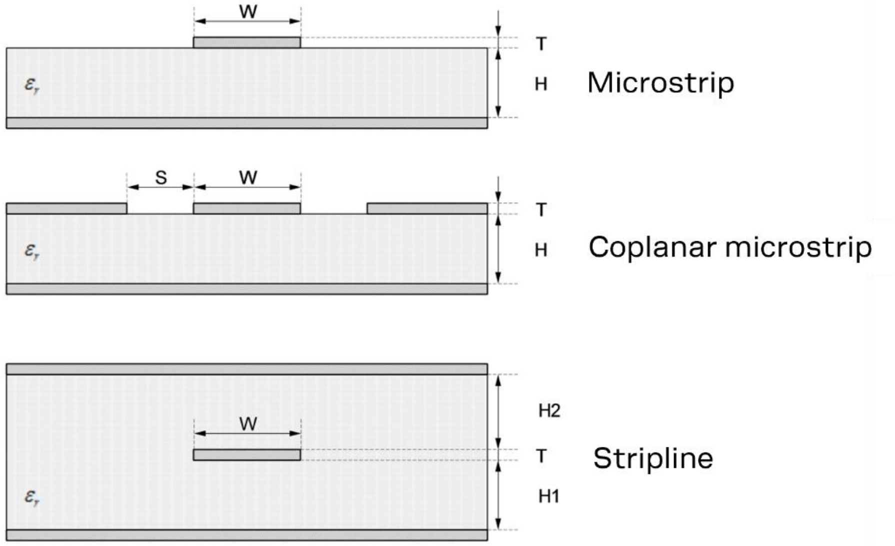


Figure 19: Transmission line trace design

To properly design a 50 Ω transmission line, the following points should be considered:

- The designer should provide enough clearance from surrounding traces and ground in the same layer; in general, a trace to ground clearance of at least two times the trace width should be considered. The transmission line should be 'guarded' by ground plane area on each side.
- The characteristic impedance can be calculated as first iteration using tools provided by the layout software. It is advisable to ask the PCB manufacturer to provide the final values that are usually calculated using dedicated software and available stack-ups from production. It could also be possible to request an impedance coupon on panel's side to measure the real impedance of the traces.
- FR-4 dielectric material has high losses at high frequencies but can be considered in RF designs provided that the RF trace length is minimized to reduce dielectric losses.
- If traces longer than few centimeters are needed, a coaxial cable and connector are recommended to reduce losses.
- Stack-up should allow for wide 50 Ω traces and at least 200 µm trace width is recommended to assure good impedance control over the PCB manufacturing process.
- FR-4 material exhibits poor thickness stability and thus less control of impedance over the trace length. Contact the PCB manufacturer for specific tolerance of controlled impedance traces.
- The transmission lines' width and spacing to 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 main ground layer, providing enough vias on the adjacent metal layer.
- Route RF transmission lines far from any noise source (such as switching supplies and digital lines) and any sensitive circuit to avoid crosstalk between RF traces and Hi-impedance or analog signals.
- Avoid stubs on the transmission lines; any component on the transmission line should be placed with the connected pad over the trace. Also avoid any unnecessary component on RF traces.

3.2.3.2 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 14 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 14: 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, 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 U.FL connector to a more robust connector such as SMA fixed on panel.

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

The following recommendations apply for proper layout of the connector:

- Strictly follow the connector manufacturer's recommended layout:
- SMA Pin-Through-Hole connectors require GND keep-out (that is, clearance, a void area) on all the layers around the central pin up to annular pads of the four GND posts.
- 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 microstrip, 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.

3.2.3.3 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 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 has to be radiated, however overall antenna efficiency may benefit from larger ground planes.
  Proper placement of the antenna and its surroundings is also critical for antenna performance. Avoid placing the antenna close to conductive or RF-absorbing parts such as metal objects, ferrite sheets and so on as they may absorb part of the radiated power or shift the resonant frequency of the antenna or affect the antenna radiation pattern.
- It is highly recommended to strictly follow the detailed and specific guidelines provided by the antenna manufacturer regarding correct installation and deployment of the antenna system, including PCB layout and matching circuitry.
- Further to the custom PCB and product restrictions, antennas may require tuning/matching to comply with all the applicable required certification schemes. It is recommended to consult the antenna manufacturer for the design-in guidelines and plan the validation activities on the final prototypes like tuning/matching and performance measures. See also Table 13.
- 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 ANNA-B112 module.

3.3 Supply interfaces

3.3.1 Module supply design

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 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.

3.4 Data communication interfaces

3.4.1 Asynchronous serial interface (UART) design

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

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

- If CTS is 1, then the Host/Host Controller is allowed to send.
- If CTS is 0, then the Host/Host Controller is not allowed to send.

3.4.2 Serial peripheral interface (SPI)

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

3.4.3 I2C interface

The layout of the I2C bus should be done so that noise injection and cross talk are avoided.

3.5 NFC interface

⚠ Ensure that the NFC pins are configured correctly. Connecting an NFC antenna to the pins configured as GPIO will damage the module.

The NFC antenna coil must be connected differentially between 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 equations:

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

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

An antenna inductance of Lant = 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.

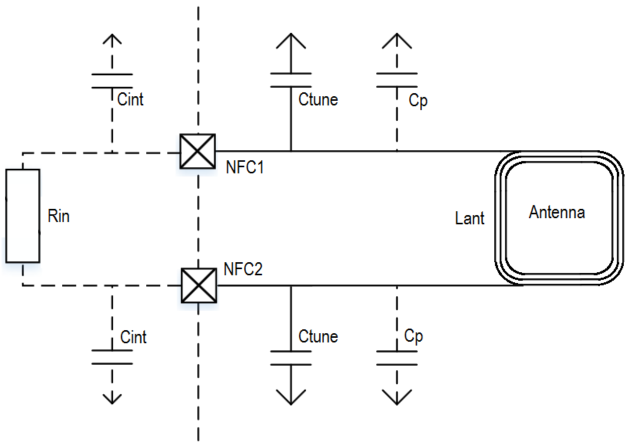


Figure 20: NFC antenna design

ANNA-B112 modules have been tested with a 3x3 cm PCB trace antenna, so it is recommended to keep an antenna design close to these measurements. You can still use a smaller or larger antenna as long as it is tuned to resonate at 13.56 MHz.

To comply with European regulatory demands, the NFC antenna must be placed in such a way that the space between the ANNA-B112 module and the remote NFC transmitter is always within 3 meters during transmission.

3.5.1 Battery protection

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

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

3.6 General High Speed layout guidelines

These general design guidelines are considered as best practices and are valid for any bus present in the ANNA-B112 module; the designer should prioritize the layout of higher speed busses. 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 busses is recommended.

3.6.1 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 ANNA-B112 module specification. See Supply interfaces.

3.6.2 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.

⚠ Take care not to place components close to the antenna area. Designers should carefully follow the recommendations from the manufacturer when deciding the distance between the antenna and other parts of the system. Designers should also maximize the distance of the antenna to high-frequency busses like DDRs and other related components or consider an optional metal shield to reduce interferences that could otherwise be picked up by the antenna and subsequently reduce module sensitivity.

- An optimized module placement allows for better RF performance. The design aspects to consider when deciding where the module is best placed are described in Antenna interface.

3.6.3 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 maximum allowable length for high-speed busses 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 bus length to reduce potential EMI issues from digital busses.
- All traces (including low speed or DC traces) must couple with a reference plane (GND or power); Hi-speed busses 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 busses 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, the ground ring must then be connected to other layers through vias.

3.7 Module footprint and paste mask

The mechanical outline of the ANNA-B112 series module can be found in the ANNA-B112 series data sheet [2]. The Proposed land pattern layout reflects the pads' layout of the module.

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

The suggested paste mask layout for the ANNA-B1 should follow the copper mask layout, as described in ANNA-B1 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.

3.8 Thermal guidelines

ANNA-B112 has been successfully tested in -40 °C to +85 °C. The ANNA-B112 module is a low power device and generates only a small amount of heat during operation. A good grounding should still be observed for temperature relief during high ambient temperature.

3.9 ESD guidelines

The immunity of devices integrating ANNA-B112 module to Electro-Static Discharge (ESD) is part of the Electro-Magnetic Compatibility (EMC) conformity, which is required for products bearing the CE marking, compliant with the R&TTE Directive (99/5/EC), the EMC Directive (89/336/EEC) and the Low Voltage Directive (73/23/EEC) issued by the Commission of the European Community.

Compliance with these directives implies conformity to the following European Norms for device ESD immunity: ESD testing standard CENELEC EN 61000-4-2 and the radio equipment standards ETSI EN 301 489-1, ETSI EN 301 489-7, ETSI EN 301 489-24, the requirements of which are summarized in Table 15.

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

The applicability of ESD immunity test to the whole device depends on the device classification as defined by ETSI EN 301 489-1. Applicability of ESD immunity test to the related device ports or the related interconnecting cables to auxiliary equipment, depends on 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, device classification, see *ETSI EN 301 489-1*. For the contact and air discharges definitions, see CENELEC EN 61000-4-2.

The Electro-Magnetic Compatibility ESD immunity requirements, as defined by CENELEC EN 61000-4-2, ETSI EN 301 489-1, ETSI EN 301 489-7, ETSI EN 301 489-24, are described in Table 15.

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

Table 15: Electro-Magnetic Compatibility ESD immunity requirements

ANNA-B112 is manufactured with consideration to specific standards that minimize the occurrence of ESD events. The highly automated process complies with IEC61340-5-1 (STM5.2-1999 Class M1 devices) standard. Designers should implement proper measures to protect from ESD events and safeguard any pin that may be exposed to the end user.

Compliance with standard protection levels 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.

⚠ ANNA-B112 modules are Electrostatic Sensitive Devices that demand the observance of special handling precautions against static damage. Failure to observe these precautions can result in severe damage to the product.

4.1 ESD handling precautions

As the risk of electrostatic discharge in the RF transceivers and patch antennas of the module is of particular concern, standard ESD safety practices are prerequisite. See also Figure 21.

Consider also:

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

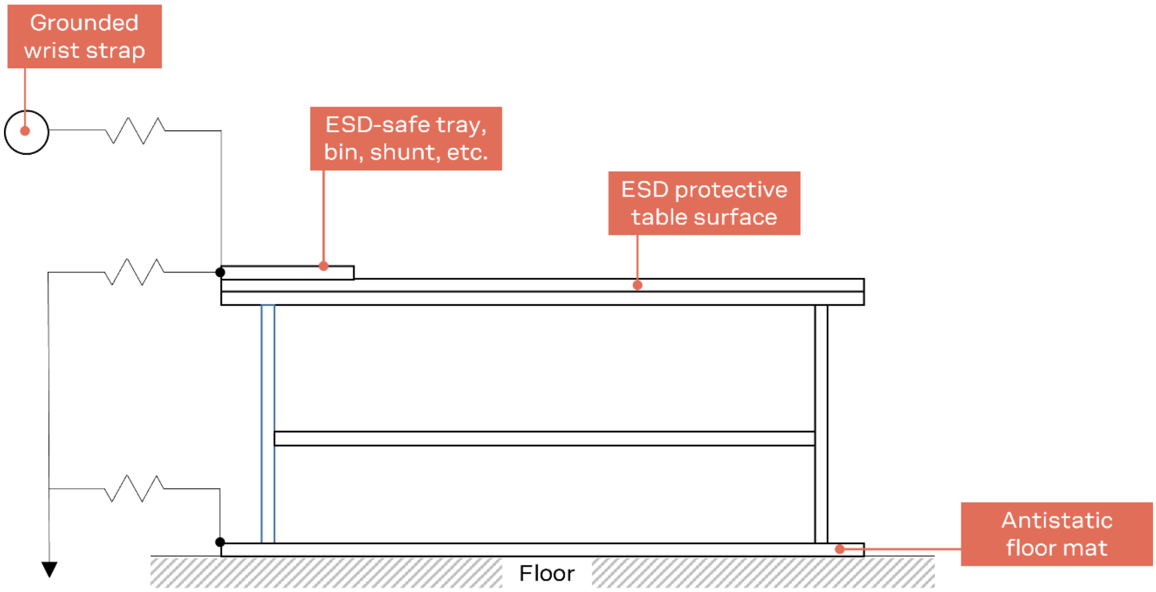


Figure 21: Standard workstation setup for safe handling of ESD-sensitive devices

4.2 Packaging, shipping, storage, and moisture preconditioning

For information pertaining to reels, tapes, or trays, moisture sensitivity levels (MSL), storage, shipment, and drying preconditioning, see the ANNA-B112 data sheet [2], and Product packaging guide [1].

4.3 Reflow soldering process

ANNA-B112 is a surface-mount module supplied on a FR4-type PCB with gold plated connection pads. It is manufactured 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 ANNA-B112 must be considered for the soldering process.

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

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

⚠ The target values given in Table 16 and Figure 22 are given as general guidelines for a Pb-free process only. For further information, see also the JEDEC J-STD-020E standard [6].

Process parameter		Unit	Value
Pre-heat	Ramp up rate to $\mathbf{T_{SMIN}}$	K/s	3
	$\mathbf{T_{SMIN}}$	°C	150
	$\mathbf{T_{SMAX}}$	°C	200
	$\mathbf{t_S}$ (from 25 °C)	s	110
	$\mathbf{t_S}$ (Pre-heat)	s	60
Peak	$\mathbf{T_L}$	°C	217
	$\mathbf{t_L}$ (time above $\mathbf{T_L}$)	s	60
	$\mathbf{T_P}$ (absolute max)	°C	245
	$\mathbf{t_P}$ (time above $\mathbf{T_P}$-5 °C)	s	10
Cooling	Ramp-down from $\mathbf{T_L}$	K/s	6
General	$\mathbf{T_{to\ peak}}$	s	300
	Allowed reflow soldering cycles	-	2

Table 16: Recommended reflow profiles

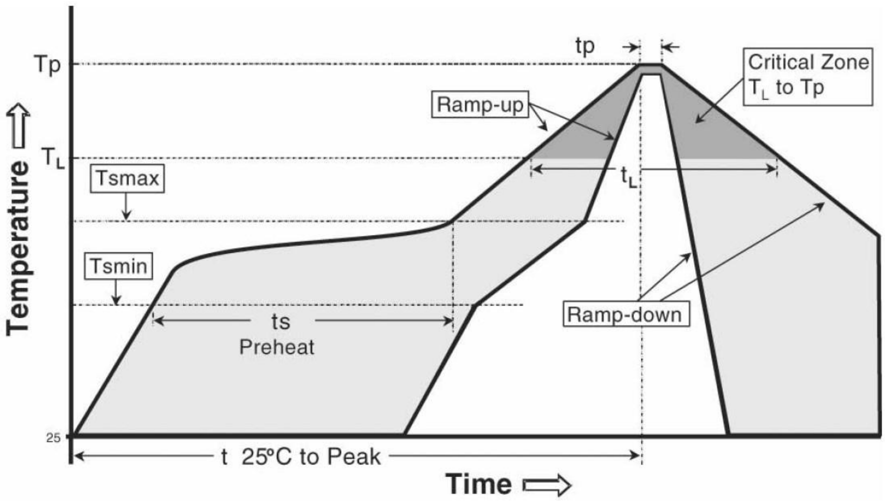


Figure 22: Reflow profile

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

4.3.1 Repeated reflow soldering

For application boards with components on both sides, a two-reflow process may be required. In such cases, ANNA-B112 can be mounted in both reflow cycles. To reduce the risk of detachment due to its relatively higher weight compared to other components on the board, it is advisable to place the module on the side of the board that undergoes the final cycle. This reduces the risk of detachment due to its relatively higher weight compared to other components.

Mounting the module in an upside-down position (with the module on the underside of the board during reflow) is not recommended, as this increases the likelihood of detachment.

⚠ u-blox does not provide warranty coverage for damages to NORA-W40 modules caused by performing more than two total reflow soldering processes (one for mounting the module and one for mounting other components).

4.3.2 Cleaning

Cleaning the module is not recommended. Residues underneath the module 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.
- Cleaning with alcohol or other organic solvents can result in soldering flux residues flooding into areas that are not accessible for post-wash inspections.
- 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 Potting

If potting is required for the ANNA-B112 module, it is recommended to use a material with similar parameters as used in the module. The important parameters are described in Table 17.

The thickness of the potting should also be considered to avoid warpage of the PCB.

Parmeter	Unit	Value
Shrinkage	%	0.17
Modulus (25 °C)	MPa	20000
Modulus (260 °C)	MPa	500

Table 17: Parameters potting

If the antenna and/or antenna trace is covered by the potting, it will affect the RF characteristics of the module. This might also affect the certification of the module and the antenna will most likely be classified as a new antenna requiring recertification.

⚠ No hardware troubleshooting will be done by u-blox support on the potted modules.

4.3.4 Other remarks

- Boards with combined through-hole technology (THT) components and surface-mount technology (SMT) devices may require wave soldering to solder the THT components. Only a single wave soldering process is allowed for boards populated with the module. *Miniature Wave Selective Solder* process is preferred over traditional wave soldering process.
- Hand soldering is not recommended.
- Rework is not recommended.
- Grounding metal covers: attempts to improve grounding by soldering ground cables, wick or other forms of metal strips directly onto the EMI covers is done at the customer's own risk and will void 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 Qualifications and approvals

5.1 Country approvals

ANNA-B112 modules are certified for use in different regions and countries, such as Europe, Great Britain, USA, and Canada. See also the ANNA-B112 series data sheet [2] for a list of approved countries/regions where ANNA-B112 modules are approved for use. Each market has its own regulatory requirements that must be fulfilled, and ANNA-B112 series modules must comply with the requirements for a radio transmitter in each of the listed markets.

In some cases, limitations must be placed on the end-product that integrates an ANNA-B112 module to comply with the regulatory requirements.

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

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

5.2 European Union regulatory compliance

Information about regulatory compliance of the European Union for ANNA-B112 modules is available in the ANNA-B112 declaration of conformity [22].

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

ANNA-B112 modules comply with the essential requirements and other relevant provisions of Radio Equipment Directive (RED) 2014/53/EU.

5.2.2 Compliance with the RoHS directive

ANNA-B112 modules comply with the "Directive 2015/863/EU" of the European Parliament and the Council on the Restriction of Use of certain Hazardous Substances in Electrical and Electronic Equipment" (RoHS).

5.3 CE End-product regulatory compliance

For guidance concerning end product marking in accordance with RED can be found at: http://ec.europa.eu/

For guidance concerning the restrictions while operating the ANNA-B112 in Wi-Fi mode in European countries, see European Union regulatory compliance.

⚠ The EIRP of the ANNA-B112 module must not exceed the limits of the regulatory domain that the module operates. Depending on the host platform implementation and antenna gain, integrators must limit the maximum output power of the module through the host software. See Pre-approved antennas for the list of approved antennas and information about the corresponding maximum transmit power levels.

5.4 Great Britain regulatory compliance

For information about the regulatory compliance of ANNA-B112 modules against requirements and provisions in Great Britain, see also the ANNA-B4 UKCA Declaration of Conformity [23].

5.4.1 UK Conformity Assessed (UKCA)

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

ANNA-B4 series modules have been evaluated against the essential requirements of the Radio Equipment Regulations 2017 (SI 2017 No. 1206, as amended by SI 2019 No. 696).

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

5.5 FCC/ISED – US/Canadian markets

Model	FCC ID	ISED Certification Number
ANNA-B112	XPYANNAB1	8595A-ANNAB1

Table 18: FCC IDs and ISED Certification Numbers for the ANNA-B112 modules

5.5.1 Compliance statements – US

ANNA-B112 modules have received Federal Communications Commission (FCC) CFR47 Telecommunications, Part 15 Subpart C "Intentional Radiators" modular approval in accordance with Part 15.247 Modular Transmitter approval. Limited module procedures are not applicable.

ANNA-B112 modules and its antenna(s) must not be co-located or operating in conjunction with any transmitter. If the module is to be co-located with another transmitter, additional measurements for simultaneous transmission are required.

ANNA-B112 modules comply 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.

⚠ ANNA-B112 modules are for OEM integrations only. The end-product must be professionally installed in such a manner that only the authorized antennas can be used. See also Pre-approved antennas.

⚠ 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 ANNA-B112 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.

5.5.2 Compliance statements – Canada

The ANNA-B112 radio transmitter [IC: 8595A-ANNAB1] has been approved by Innovation, Science and Economic Development Canada to operate with the antenna types listed in the Pre-approved antennas, with the maximum permissible gain indicated. Antenna types not included in this list that have a gain greater than the maximum gain indicated for any type listed are strictly prohibited for use with this device.

ANNA-B112 modules comply with Innovation, Science and Economic Development Canada's license-exempt RSS(s). Operation is subject to the following two conditions:

1. This device may not cause interference.
2. This device must accept any interference, including interference that may cause undesired operation of the device.

L'émetteur radio ANNA-B112 [IC: 8595A-ANNAB1] a été approuvé par Innovation Sciences et Développement économique Canada pour fonctionner avec les types d'antennes énumérés dans la liste des antennes préapprouvées, avec le gain maximal admissible indiqué. Les types d'antenne non inclus dans cette liste qui ont un gain supérieur au gain maximum indiqué pour tout type répertorié sont strictement interdits pour une utilisation avec cet appareil.

Les modules ANNA-B112 sont conformes au CNR d'Innovation, Sciences et Développement économique Canada qui s'applique aux appareils radio exempts de licence. L'exploitation est autorisée dans les 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 lefonctionnement.

5.5.3 RF Exposure

ANNA-B112 modules comply with the FCC radiation exposure limits and the requirements of ISED 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 ANNA-B112 is below the SAR test exclusion limits presented in KDB 447498 D01v06 [29] (US market limits).

☞ Having a separation distance of minimum 10 mm between the user and/or bystander and the antenna and /or radiating element ensures that the output power (EIRP.) of ANNA-B112 is below the SAR evaluation Exemption limits defined in RSS-102 issue 5 (Canadian market limits).

KDB 996369 D03 section 2.4 [30] (limited module procedures) is not applicable to the ANNA-B112 modules.

5.5.4 Antenna selection

KDB 996369 D03 section 2.5 [30] (trace antenna designs) is not applicable to the ANNA-B112 series modules.

When an external antenna connector (U.FL connector) is used with ANNA-B112, the antenna reference design layout specified in Appendix B.3 must be followed to comply with the ANNA-B112 FCC/ISED modular approval. Use only those antennas that have been authorized for use with ANNA-B112. See also the 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 local u-blox support for more information about this process.

5.5.5 End-product verification requirements

⚠ The modular transmitter approval of ANNA-B112, 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 ANNA-B112 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 th^{e} 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 must either market the end-product under a Suppliers Declaration of Conformity (SDoC) or to certify the product using an accredited test lab. Contact your local u-blox support for more information about test requirements.

5.5.6 End-product labelling requirements

5.5.6.1 US market

ANNA-B112 is assigned the FCC ID number: XPYANNAB1

The final host device, into which this RF Module is integrated must be labeled with an auxiliary label stating the FCC ID of the RF Module, such as:

> Contains FCC ID: XPYANNAB1
> 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 following statement must be included in the end-user manual or guide:

> Changes or modifications to this unit not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.
> This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:
> - Reorient or relocate the receiving antenna.
> - Increase the separation between the equipment and receiver.
> - Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
> - Consult the dealer or an experienced radio/TV technician for help.

☞ 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 cases 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.

5.5.6.2 Canadian market

The ANNA-B112 module is certified for use in Canada under Innovation, Science and Economic Development Canada (ISED) Radio Standards Specification (RSS) RSS-247 Issue 2 and RSSGen. The host product shall be properly labelled to identify the modules within the host product.

The 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, such as:

> Contains transmitter module IC: 8595A-ANNAB1
> This device contains license-exempt transmitter(s)/receiver(s) that comply with Innovation, Science and Economic Development Canada’s license-exempt RSS(s). Operation is subject to the following two conditions:
> 1. This device may not cause interference.
> 2. This device must accept any interference, including interference that may cause undesired operation of the device.

Le périphérique hôte final, dans lequel ce module RF est intégré "doit être étiqueté avec l’etiquettette auxiliaire indiquant le CI du module RF, tel que:

> Contient le module émetteur IC: 8595A-ANNAB1
> L’émetteur/récepteur exempt de licence contenu dans le présent appareil est conforme aux CNR d’Innovation, Sciences et Développement économique 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 lefonctionnement.

5.6 Japan radio equipment compliance

5.6.1 Compliance statement

The ANNA-B112 module complies 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".

5.6.2 End product labelling requirement

When a product integrating a ANNA-B112 series module is placed on the Japanese market the product must be affixed with a label with the “Giteki” marking as shown in Figure 23. The marking must be visible for inspection.

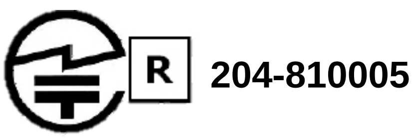


Figure 23: Giteki mark, R and the ANNA-B112 MIC certification number

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

5.6.3 End product user manual requirement

As the MIC ID is not included on the ANNA-B112 marking, the end product manufacturer must include a copy of the ANNA-B112 Japan Radio Certificate to the end product technical documentation.

5.7 NCC Taiwan compliance

5.7.1 Taiwan NCC Warning Statement

- 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.

5.7.2 ANNA-B112 labeling requirements for end product

When a product integrated with an ANNA-B112 module is placed on the Taiwan market, the product must be affixed with a label marking as shown below. The label can use wording such as the following:

Contains Transmitter Module

內含發射器模組: CCAI18LP2200T2

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

5.8 KCC South Korea compliance

The ANNA-B112 series modules are certified by the Korea Communications Commission (KCC).

When a product containing an ANNA-B112 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 figure below. This information must also be included in the product user manuals.

R-C-ULX-ANNA-B112

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

5.9 Brazil compliance

When a product containing ANNA-B1 module is placed on the Brazilian market, the product must be affixed with a label or marking containing the ANATEL logo, ANNA-B1 Homologation number: 03850-19-05903 and a statement claiming that the device may not cause harmful interference but must accept it (Resolution No 506).

ANATEL
03850-19-05903

"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 unable to see the ANATEL logo, ANNA-B1 Homologation number and/or this statement, the ANATEL logo, ANNA-B1 Homologation number, and the statement shall also be included in the end product manual.

5.10 Australia and New Zealand regulatory compliance

The ANNA-B1 module is compliant with the standards made by the Australian Communications and Media Authority (ACMA).

The modules are compliant with AS/NZS 4268:2012 standard – Radio equipment and systems – Short range devices – Limits and methods of standard measurement. The test reports of ANNA-B1 module can be used as part of the product certification and compliance folder. For more information on the test reports, contact your local support team

The ANNA-B1 module test reports can be used as part of evidence in obtaining permission for the Regulatory Compliance Mark (RCM). To meet overall Australian and/or New Zealand end product compliance, the integrator must create a compliance folder containing all the relevant compliance test reports such as RF, EMC, electrical safety, and DoC (Declaration of Conformity) and so on. It is the responsibility of the integrator to know what is required in the compliance folder for ACMA compliance.

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

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

5.11 South Africa regulatory compliance

The ANNA-B1 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-B1 ICASA label is included below:

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

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

5.12 SRRC China Radio Transmission Equipment Type Approval

⚠ The SRRC modular approval for ANNA-B112 is only valid when using the internal antenna.

⚠ In accordance with the provisions on the Radio Regulations of the People's Republic of China, the ANNA-B112 module with the product name ANNA-B112 conforms to the provisions with its CMIIT ID: 2021DJ6698.

5.12.1 ANNA-B112 labeling requirements for end product

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

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

本设备包含型号核准代码(分别)为: CMIIT ID: 2021DJ6698的无线电发射模块。

5.12.2 ANNA-B112 shielding

Figure 24 shows the shielding and cover areas of ANNA-B112, which includes an antenna area and shield cover area. The RF unit of ANNA-B112 is located under the shield cover.

如下图中绿色和橘黄色方框部分所，ANNA-B112由两部分组成: 天线区域和屏蔽罩区域。ANNA-B112的射频元器件位于该模块的屏蔽罩下方。

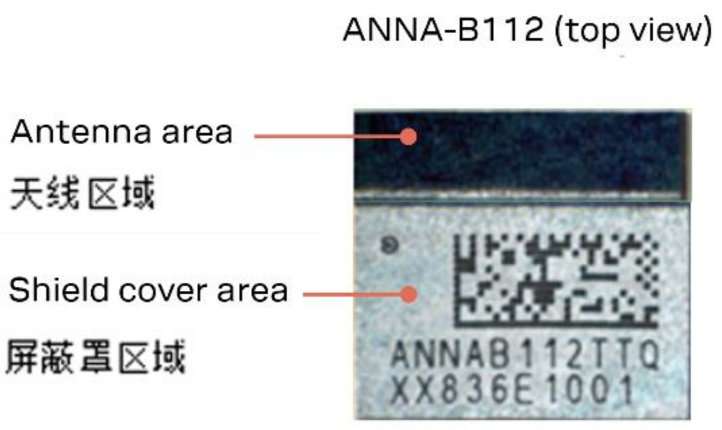


Figure 24: ANNA-B112 shielding and cover areas

Figure 25 shows the shield cover of ANNA-B112 SiP shield its RF unit through its three parts:

- Metal coating (green)
- Metal fence at the border between the shield area and antenna area (amber)
- PCB traces exposed to three edges except for the metal fence side of the shield cover area of the module (blue).

All three parts are connected to GND of the ANNA-B112 module.

如下图所示，ANNA-B112的屏蔽罩是通过三个部分把该模块的射频元器件完全屏蔽起来的: 金属图层（图中红色部分），金属栅栏（图中紫色部分）以及暴露在ANNA-B112模块的屏蔽罩区域除了金属栅栏侧的其他三个边缘的PCB走线（图中浅蓝色部分)。所有的这三个部分都是跟ANNA-B112模块的GND连接起来的。

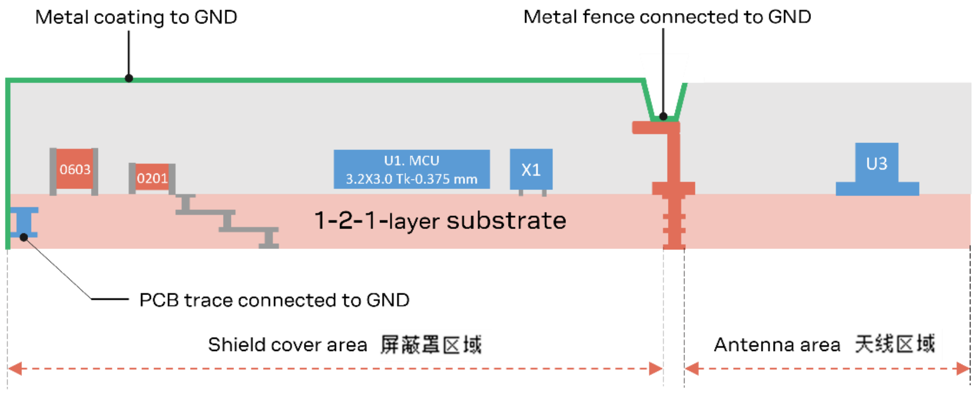


Figure 25: ANNA-B112 SiP shield its RF unit showing metal coating, metal fence and PCB traces

5.13 Safety compliance

For compliance with safety standard EN 62368-1 [10], ANNA-B112 modules must be supplied with a Class-2 Limited Power Source.

5.14 Bluetooth qualification

If an end-product uses the trademarked word "Bluetooth" and/or the Bluetooth logo in its documentation, packaging, and/or marketing materials, then the end-product manufacturer must be a member of the Bluetooth SIG and the end-product must be listed.

Membership login is required using the same credentials given for the Bluetooth SIG website [26]. For information about the Bluetooth qualification process, see the Bluetooth qualification process overview [25]. New declarations can be submitted through the Bluetooth SIG Launch Studio [27].

5.14.1 Bluetooth declarations for u-connectXpress

The ANNA-B112 module has been verified against Bluetooth Core 5.0. For end products integrating ANNA-B112 modules together with the pre-installed u-connectXpress software, no further testing is required. If the End Product is to be Bluetooth listed, the QDID listed in Table 19 shall be referenced in the End Product listing.

Bluetooth version	Bluetooth product type	QDID	Listing date	Nordic SoftDevice S132 version	u-connectXpress software version
5.0	End Product	119389	2018-10-05	5.0.0 or later	1.0.0 or later

Table 19: ANNA-B112 Bluetooth QDIDs

5.14.2 Bluetooth declarations for open CPU

For end-products developed with open CPU configurations that use u-blox Bluetooth LE modules based on Nordic Semiconductor nRF5 chipsets, additional testing is not required. If the End Product is to be Bluetooth listed:

- Applications using nRF Connect SDK (NCS) will refer to both the Host subsystem and SoftDevice Controller subsystem QDIDs that correspond with the version of NCS used for development.
- Applications using nRF5 SDK must refer to the End Product QDID for the SoftDevice version used for development.

See the compatibility matrix for the nRF52832 CPU [24] for the list of SDK versions and corresponding Bluetooth QDID listings.

5.15 Antennas

This section describes the various antennas that can be used together with the module.

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

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

- FCC - The antenna is included in the FCC test reports and thus approved for use in countries that accept the FCC radio approvals, primarily US.
- IC - The antenna is included in the IC (Industrie Canada) test reports and thus approved for use in countries that accept the IC radio approvals, primarily Canada.
- RED - The antenna is included in the ETSI test reports and thus approved for use in countries that accept the Radio Equipment Directive, primarily the European countries.
- MIC - The antenna is included in the Japanese government affiliated MIC test reports and thus approved for use in the Japanese market.
- NCC - The antenna is included in the Taiwan NCC test reports and thus approved for use in Taiwan.
- KCC - The antenna is included in the KCC test reports and thus approved for use in South Korea.
- ANATEL – The antenna is included in the Brazil ANATEL test reports and thus approved for use in Brazil.
- ACMA – The antenna is included in the Australia and New Zealand test reports and thus approved for use in Australia and New Zealand.
- ICASA – The antenna is included in the South Africa ICASA test reports and thus approved for use in South Africa.
- SRRC – The internal antenna (only) is included in the China SRRC test reports and thus approved for use in China.

5.15.1 Pre-approved antennas

ANNA-B112 internal antenna	
Gain	+0.7 dBi
Comment	Internal antenna on ANNA-B112. See also Antenna interface. Should not be mounted inside a metal enclosure.
Approval	FCC, IC, RED, UKCA, MIC, NCC, KCC, ANATEL, ACMA, ICASA, and SRRC.

FXP75.07.0045B	
Manufacturer	Taoglas
Gain	+2.5 dBi
Impedance	50 Ω
Size	5.9 x 4.1 x 0.24 mm
Type	Patch, Flexfilm
Connector	U.FL
Cable length	45 mm
Comment	Should be attached to a plastic enclosure or part for best performance. For more information, see antenna data sheet. Should not be mounted inside a metal enclosure. To be mounted on a U.FL connector.
Approval	FCC, IC, RED, UKCA, MIC, NCC, KCC, ANATEL, ACMA and ICASA

PC17.07.0070A	
Manufacturer	Taoglas
Gain	+1.0 dBi
Impedance	50 Ω
Size	24.0 x11.0x 0.8 mm
Type	Patch, PCB
Connector	U.FL
Cable length	70 mm
Comment	Should be attached to a plastic enclosure or part for best performance. For more information, see antenna data sheet. Should not be mounted inside a metal enclosure. To be mounted on a U.FL connector.
Approval	FCC, IC, RED, UKCA, MIC, NCC, KCC, ANATEL, ACMA and ICASA

FXP74.07.0100A	
Manufacturer	Taoglas
Gain	+4.0 dBi
Impedance	50 Ω
Size	47.0 x 7.0 x 0.1 mm
Type	Patch, Flexfilm
Connector	U.FL
Cable length	100 mm
Comment	Should be attached to a plastic enclosure or part for best performance. For more information, see antenna data sheet. Should not be mounted inside a metal enclosure. To be mounted on a U.FL connector.
Approval	RED, UKCA, MIC, KCC, ANATEL, ACMA and ICASA

FXP72.07.0053A		
Manufacturer	Taoglas	
Gain	+5.0 dBi	
Impedance	50 Ω	
Size	31.0 x 31.0 x 0.1 mm	
Type	Patch, Flexfilm	
Connector	U.FL	
Cable length	53 mm	
Comment	Should be attached to a plastic enclosure or part for best performance. For more information, see the antenna data sheet. Should not be mounted inside a metal enclosure. To be mounted on a U.FL connector.	
Approval	RED, UKCA, MIC, KCC, ANATEL, ACMA and ICASA	

6 Product testing

6.1 u-blox in-series production test

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

The Automatic test equipment (ATE) deployed in u-blox production lines logs all production and measurement data – from which a detailed test report for each unit can be generated.
Figure 26 shows the ATE typically used during u-blox production.

u-blox in-line production testing includes:

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

Figure 26: Automatic test equipment for module test

6.2 OEM manufacturer production test

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

OEM manufacturer testing should ideally focus on:

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

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

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

6.2.1 "Go/No go" tests for integrated devices

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

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

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

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

A basic RF functional test of the device that includes the antenna can be performed with standard Bluetooth LE devices configured as remote stations. In this scenario, the device containing ANNA-B112 and the antennas should be arranged in a fixed position inside an RF shield box. The shielding prevents interference from other possible radio devices to ensure stable test results.

Appendix

A Glossary

Abbreviation	Definition
ADC	Analog to Digital Converter
ATE	Automatic Test Equipment
CLI	Command Line Interface
CTS	Clear To Send
DDR	Dual-Data Rate
EMC	Electro-Magnetic Compatibility
EMI	Electro Magnetic Interference
ESD	Electro Static Discharge
EVK	Evaluation Kit
aFCC	Federal Communications Commission
GATT	Generic ATTribute profile
GND	Ground
GPIO	General Purpose Input/Output
IC	Industry Canada
I2C	Inter-Integrated Circuit
JSON	JavaScript Object Notation
LDO	Low Drop Out
LE	Bluetooth Low Energy
LED	Light-Emitting Diode
MAC	Media Access Control
MSL	Moisture Sensitivity Level
NSMD	Non Solder Mask Defined
PCB	Printed Circuit Board
RF	Radio Frequency
RoHS	Restriction of Hazardous Substances
RSSI	Received Signal Strength Indicator
RTOS	Real Time Operating System
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
THT	Through-Hole Technology
TXD	Transmit Data
UART	Universal Asynchronous Receiver/Transmitter
VCC	IC power-supply pin

B Antenna reference designs

Designers can take full advantage of ANNA-B112'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 ANNA-B112 data sheet [2] for the listed antennas.
- Schematics and parts used in the design must be identical to u-blox. RF components may show different behavior at the frequencies of interest due to different construction and parasitic; use u-blox's validated parts for antenna matching.
- PCB layout must be identical to the one provided by u-blox. Implement one of the reference designs included in this section or contact u-blox.
- The designer must use the stack-up provided by u-blox. RF traces on the carrier PCB are part of the certified design.

Three different reference designs are available as listed below:

- Using the internal antenna with the module in the corner of the PCB
- Using the internal antenna with the module along the edge of the PCB
- Using an external antenna by a short trace to a U.FL connector

B.1 Internal antenna reference design with module at PCB corner

When using the ANNA-B112 together with this antenna reference design, the circuit trace layout must be made in strict compliance with the instructions below.

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

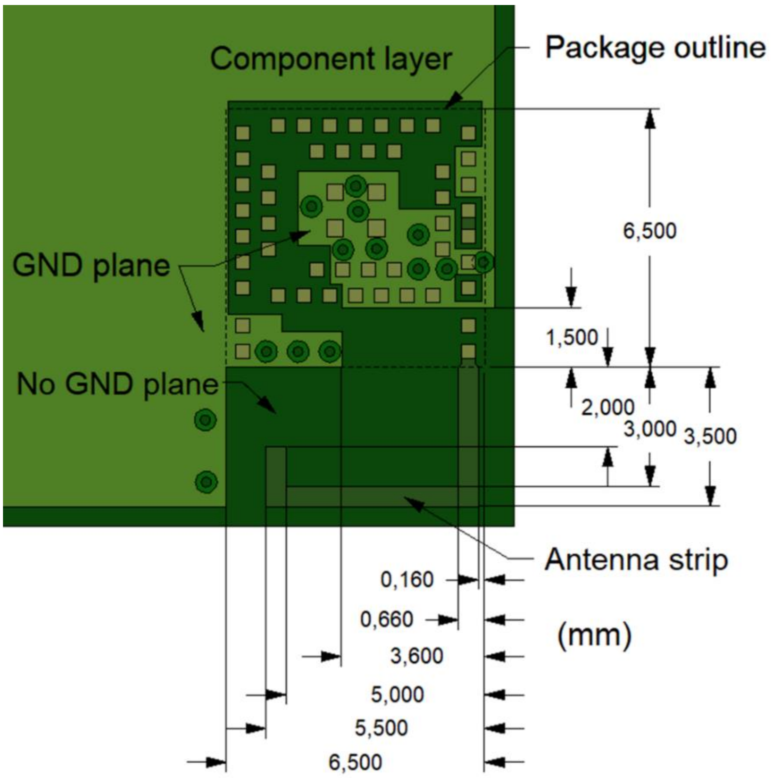


Figure 27: Reference design for internal antenna, corner version, top layer (traces and vias for other signals not included)

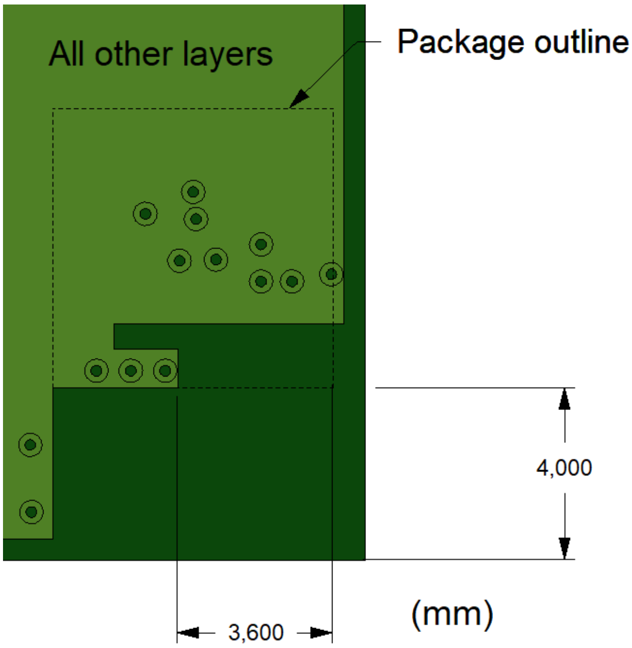


Figure 28: Reference design for internal antenna, corner version, other layer (traces and vias for other signals not included)

B.2 Internal antenna reference design with module along PCB edge

When using the ANNA-B112 together with this antenna reference design, the circuit trace layout must be made in strict compliance with the instructions below.

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

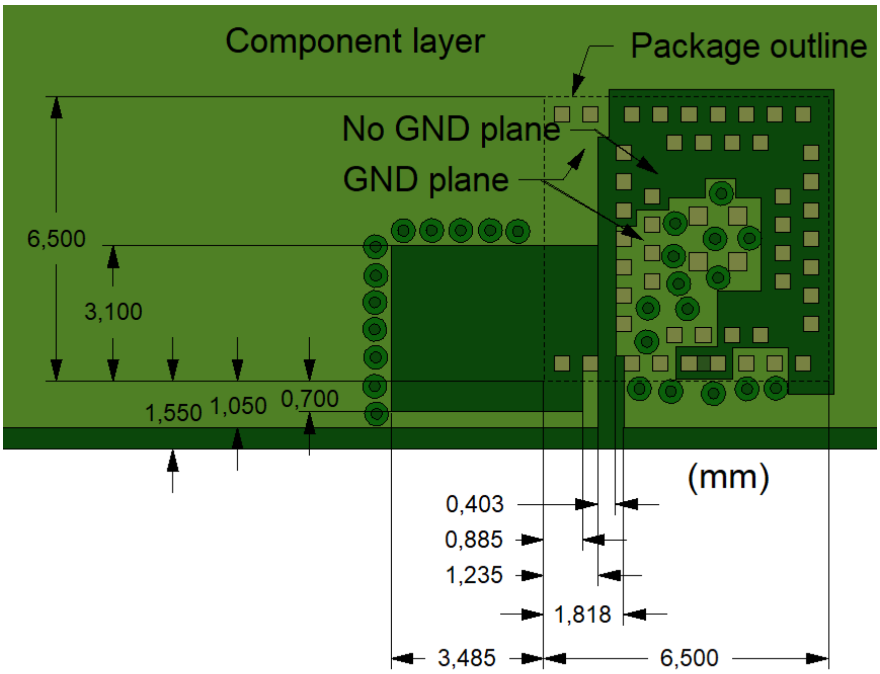


Figure 29: Reference design for internal antenna, edge version, top layer (traces and vias for other signals not included)

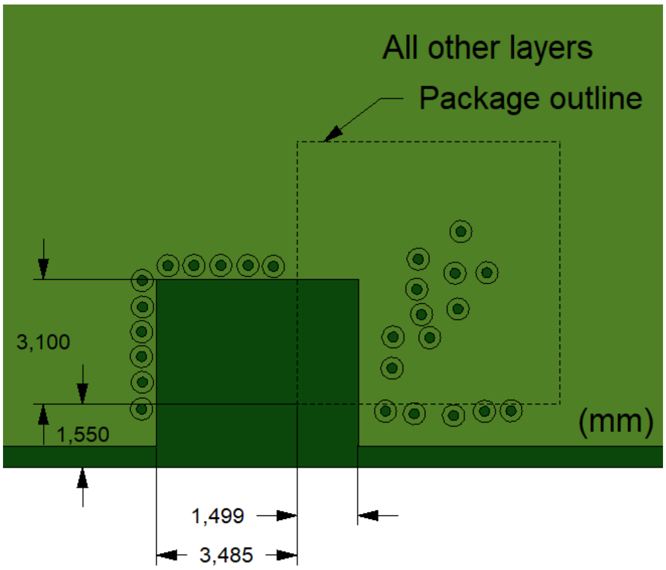


Figure 30: Reference design for internal antenna, edge version, other layers (traces and vias for other signals not included)

B.3 Reference design for external antennas (U.FL connector)

When using ANNA-B112 together with this antenna reference design, the circuit trace layout must be made in strict compliance with the instructions below.

All the components placed on each RF trace must be kept as indicated in the reference design. The reference design uses a micro coaxial connector that is connected to the external antenna via a 50 Ω pigtail.

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

Part	Manufacturer	Description
U.FL-R-SMT-1(10)	Hirose	Coaxial Connector, 0 – 6 GHz, for external antenna

Table 20: U.FL connector used in the ANNA-B112 reference design

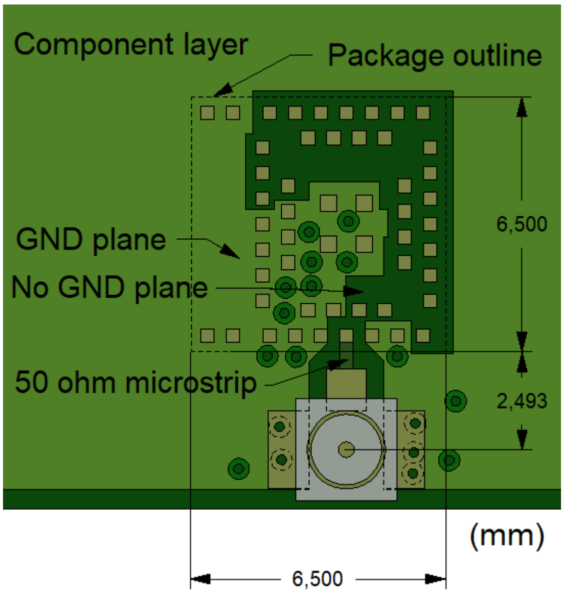


Figure 31: Reference design for external antenna, top layer (traces and vias for other signals not included)

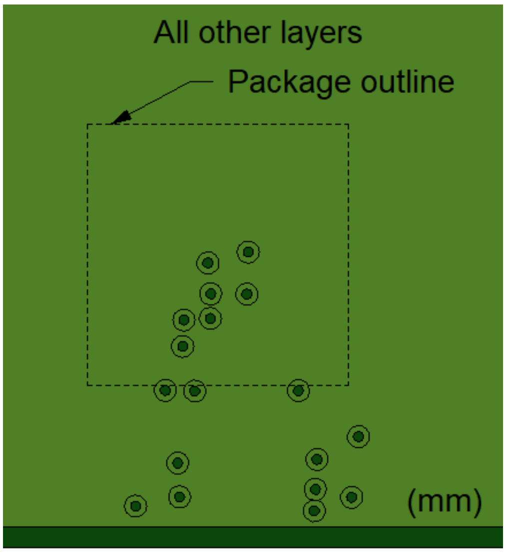


Figure 32: Reference design for external antenna, other layers. (traces and vias for other signals not included)

The 50 Ω coplanar microstrip dimensions used in the reference design are stated in Figure 33 and Table 21. The GND plane beneath the RF trace must be intact.

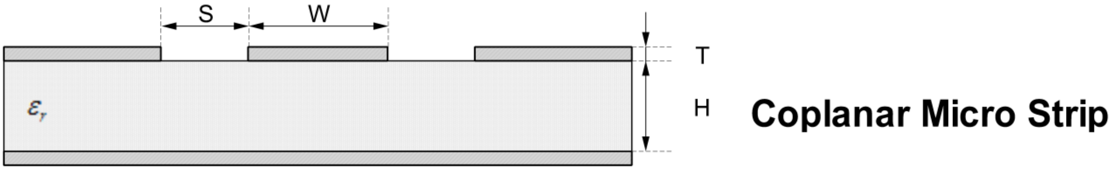


Figure 33: Coplanar microstrip dimension specification

Item	Value
T	Solder mask: 20 +/- 10 µm Copper film and plating/surface coating: 35 +/- 15 µm
ε_r	3.77 +/- 0.5

Table 21: Coplanar microstrip specification

B.4 Examples of application ground plane miniaturizations

The following boards are used as examples to show what's possible when reducing board size. Since the radiated power fluctuates when using a small ground plane, care must be taken to ensure a sufficient range and radiated power for every application ground plane size. Range measurement in a field, line of sight recommended, or measure the radiated power in an RF diagnostic chamber are two ways to confirm antenna efficiency.

B.4.1 Example application 1

The C8_1 board with ANNA-B1 module in the corner, mounted to the left as shown in Figure 34 is the first example that shows what can be achieved by shrinking the board size.

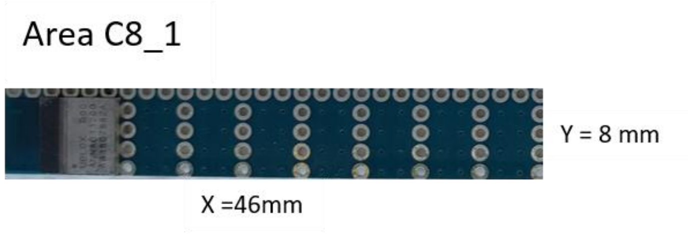


Figure 34: An example of ground plane miniaturization and still having a good range, about 250 m

The graph shown in Figure 35 visualizes the correlation between the total radiated power, TRP, and the ground plane size. The C8_1 board represents the peak power of -5.67 dBm. It has a wavelength part of 0.75 in x-axis and 0.14 in Y-axis corresponding to 46 mm and 8 mm respectively. Additionally, the TRP patterns of the C8_1 board illustrate a nice round even shape as shown in Figure 36.

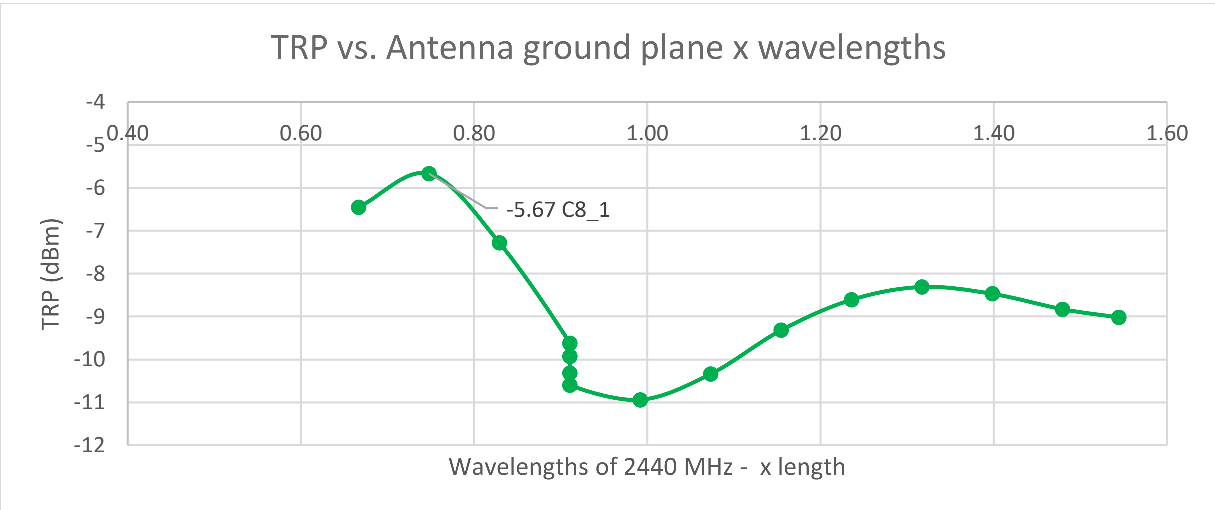


Figure 35: The C8_1 board, TRP peak, can be found in the TRP graph where different board sizes in wave lengths are plotted

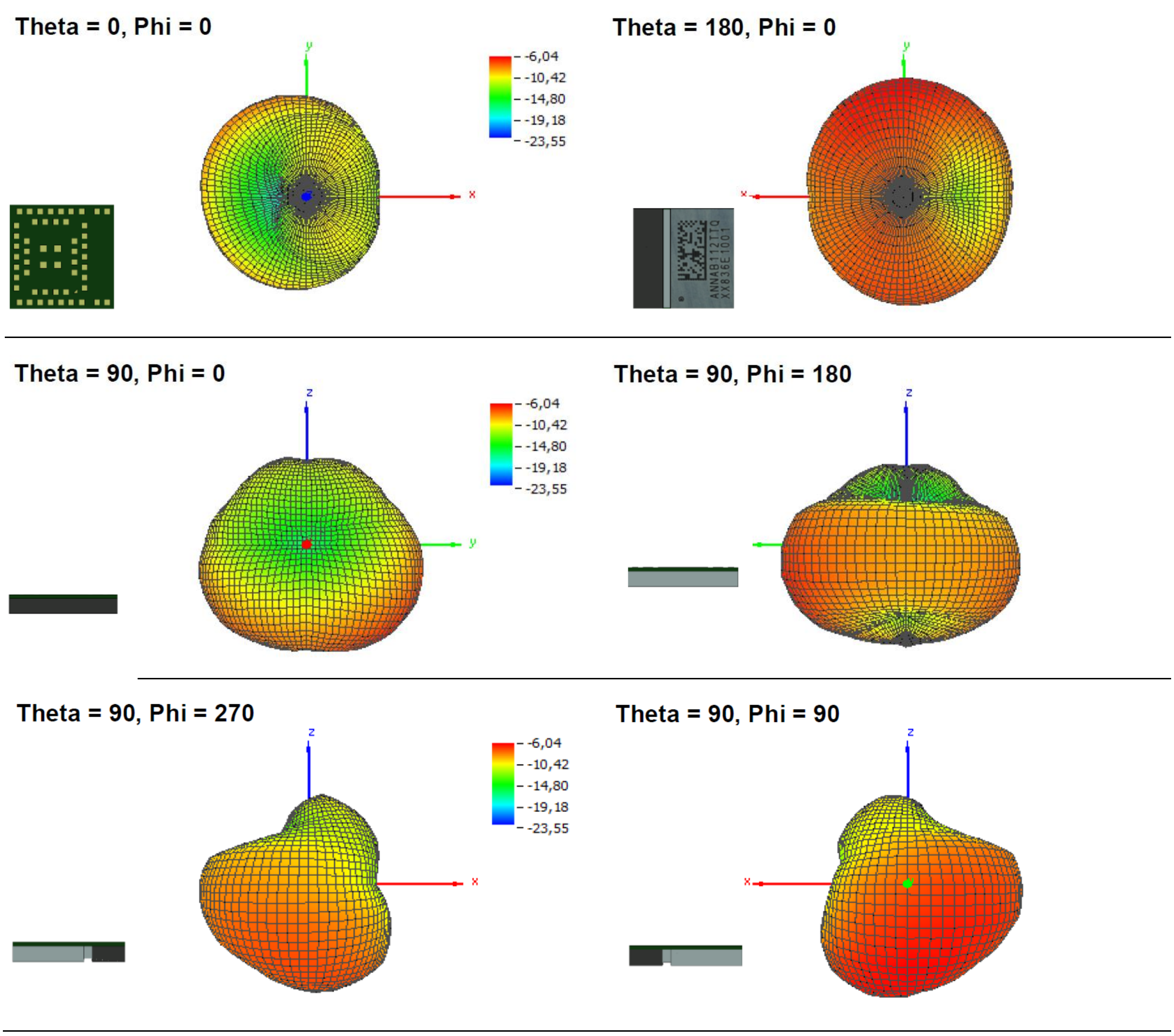


Figure 36: The C8_1 graphs show the total radiation power patterns. Integrating the graph the TRP is achieved, -5.67 dBm. A spherical shape is ideal.

B.4.2 Example application 2

The tiny device in Figure 37 is an example of building with both range and miniaturization in mind. In this case they go hand in hand. It gives a TRP of – 8.4 dBm corresponding to a range of about 100 m, the size of the module itself.

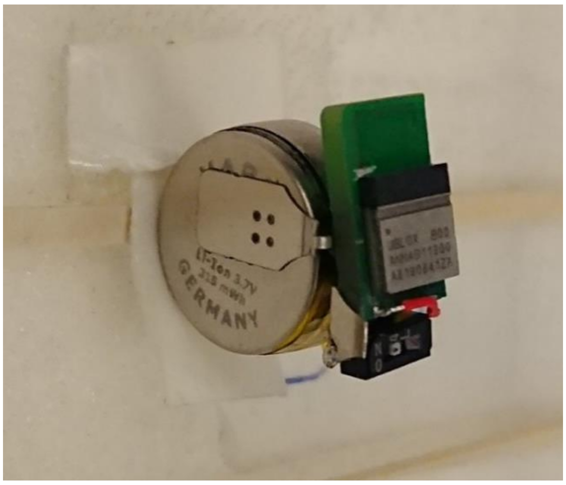


Figure 37: A tiny ANNA-B1 application including coin cell battery with the range of about 100 m, size 7.5 x 12 mm

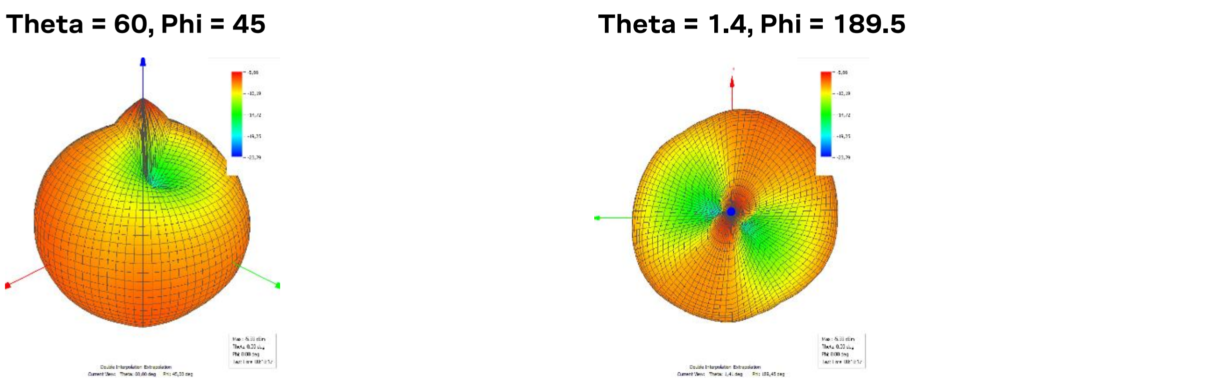


Figure 38: The tiny ANNA-B1 graphs show the total radiation power patterns. Integrating the graph the TRP is achieved, -8.4 dBm. A spherical shape is ideal.

Related documents

[1] Product packaging guide, UBX-14001652
[2] ANNA-B112 data sheet, UBX-18011707
[3] u-connectXpress software user guide, UBX-16024251
[4] u-connect AT commands manual, UBX-14044127
[5] Adding and configuring Mbed targets, https://docs.mbed.com/docs/mbedmicro-api/en/latest/api/md_docs_mbed_targets.html
[6] JEDEC J-STD-020C - Moisture/Reflow Sensitivity Classification for Non Hermetic Solid State Surface Mount Devices
[7] IEC EN 61000-4-2 - Electromagnetic compatibility (EMC), Part 4-2: Testing and measurement techniques – Electrostatic discharge immunity test
[8] 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
[9] IEC61340-5-1 - Protection of electronic devices from electrostatic phenomena – General requirements
[10] EN 62368-1 - Audio/video, information and communication technology equipment - Part 1: Safety requirements
[11] FCC Regulatory Information, Title 47 – Telecommunication
[12] JESD51 – Overview of methodology for thermal testing of single semiconductor devices
[13] Nordic Semiconductor Infocenter, https://infocenter.nordicsemi.com/index.jsp
[14] Using the public IEEE address from UICR, UBX-19055303
[15] RC oscillator configuration for nRF5 open CPU modules, UBX-20009242
[16] Zephyr Project, https://www.zephyrproject.org/
[17] u-blox shortrange open CPU github repository, https://github.com/u-blox/u-blox-sho-OpenCPU
[18] Zephyr Project Documentation, https://docs.zephyrproject.org
[19] https://devzone.nordicsemi.com/nordic/short-range-guides/b/getting-started/posts/adjustment-of-ram-and-flash-memory
[20] nRF Connect SDK page at Nordic Semiconductor, https://www.nordicsemi.com/Software-and-tools/Software/nRF-Connect-SDK
[21] Bluetooth Mesh with u-connect software, UBX-19025268
[22] ANNA-B1 EU declaration of conformity, UBX-18058993
[23] ANNA-B1 UKCA declaration of conformity, UBX-22026465
[24] Nordic Semiconductor, nRF52832 Bluetooth compatibility matrix
[25] Bluetooth qualification process overview, https://www.bluetooth.com/develop-with-bluetooth/qualification-listing/
[26] Bluetooth SIG website
[27] Bluetooth Launch Studio website (login required)
[28] ANNA-B112 product page
[29] FCC KDB 447498 RF Exposure
[30] FCC KDB 996369 Modular Approval

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

Revision history

Revision	Date	Name	Comments
R01	27-Mar-2018	fbro, apet	Initial release.
R02	16-May-2018	fbro, kgom	Changed the product status to Engineering Sample. Updated main features summary (Table 1). Include antenna trace design information (Appendix B). Updated target values in recommended reflow profiles (Table 16) and information about cleaning the module (section 4.3.1).
R03	6-Nov-2018	fbro	Changed the product status to Initial Production. Updated trace design information (Appendix B). Added information about low power clock (section 1.6) and potting (section 4.3.3).
R04	20-Dec-2018	lalb	Updated section 1.1 with information that the certification for Taiwan has been completed.
R05	2-Apr-2019	hekf, fbro	Added new software version 2.0.0, new ordering codes/type numbers in the table on page 2. Updated section 1.1 with information that the certification for South Korea has been completed. Updated Table 1. Added more information about the selection of low power clock source (section 1.6.5). Clarified the ground plane and signals (no design change), concerning all figures in Antenna reference designs, appendix B. Replaced "u-blox connectivity software" with "u-connectXpress software" in all instances. Replaced all references to the “ANNA-B112 GettingStarted” guide with the new document “Using u-connectXpress user guide”. Updated the document name of the “u-blox Short Range AT commands manual” to the new name “u-connect AT commands manual” (UBX-14044127).
R06	27-Sep-2019	fbro, mape, hekf	Added more information about potting requirements. Rearranged Antenna interface (section 3.2) for better clarity. Removed minimum GND length of 3.5 mm from antenna trace design in Appendix B. Removed the deprecated tool nRFGo Studio, and replaced with a description of the nRF Connect Programmer tool, which is now promoted by Nordic Semiconductor. Changed recommendation for running without external Xtal to connect XL_1+XL_2 to ground. Added information about ground plane and example applications in section 3.2.1.1 and B.4.
R07	30-Mar-2020	fbro, mape, ctur	Changed product status to Mass Production. Updated antenna pin recommendations in Table 12 when using an external antenna (connect unused pins to GND instead of NC).
R08	6-Nov-2020	mape	Added ANNA-B112-70B variant.
R09	09-Feb-2021	mape	Added information about how to use build configurations for nRF5 SDK for open CPU. Included information about Zephyr configurations. Added information about mesh SW.
R10	02-May-2023	mape	Updated Nordic nRF Connect with Zephyr to the latest nRF Connect SDK. Added declaration and nRF compatibility matrix for open CPU configurations in Bluetooth qualification. Together with additional references in Related documents. Added Qualifications and approvals (moved from data sheet) with added Great Britain regulatory compliance and CE End-product regulatory compliance statement and references. Included descriptions of dielectric and other parameters in RF transmission line design. Updated Product testing. Added ubxlib section.
R11	28-Mar-2025	mape	Removed ubxlib section. Added Repeated reflow soldering section. Included several minor editorial improvements throughout the document.

Contact

u-blox AG

Address: Zürcherstrasse 68
8800 Thalwil
Switzerland

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