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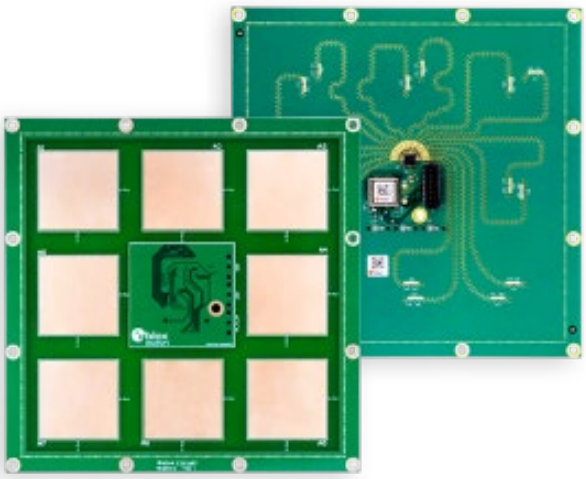
# ANT-B10

## Direction Finding antenna board

### System integration manual




## Abstract

This manual provides a functional overview combined with best-practice design guidelines for integrating the ANT-B10 Bluetooth® direction finding antenna board in customer applications.



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# Document information

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This document applies to the following products:

| **Product name** | **Document status** |
|---|---|
| ANT-B10 | Early Production Information |

☞ u-connectLocate is renamed to u-locateEmbed.

☞ The ANT-B10 antenna board hosts the NINA-B411-40B, which is a specialized variant of the NINA-B411. This module variant runs the u-locateEmbed software supporting the u-blox angle-of-arrival (AoA) algorithm.

☞ For information about the related hardware, software, and status of listed product types, see also the ANT-B10 data sheet [1].

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# 1 Functional description

## 1.1 Overview

The ANT-B10 is a versatile Bluetooth direction finding board equipped with eight, dual-polarized, patch antennas for direction finding, as shown in Figure 1.

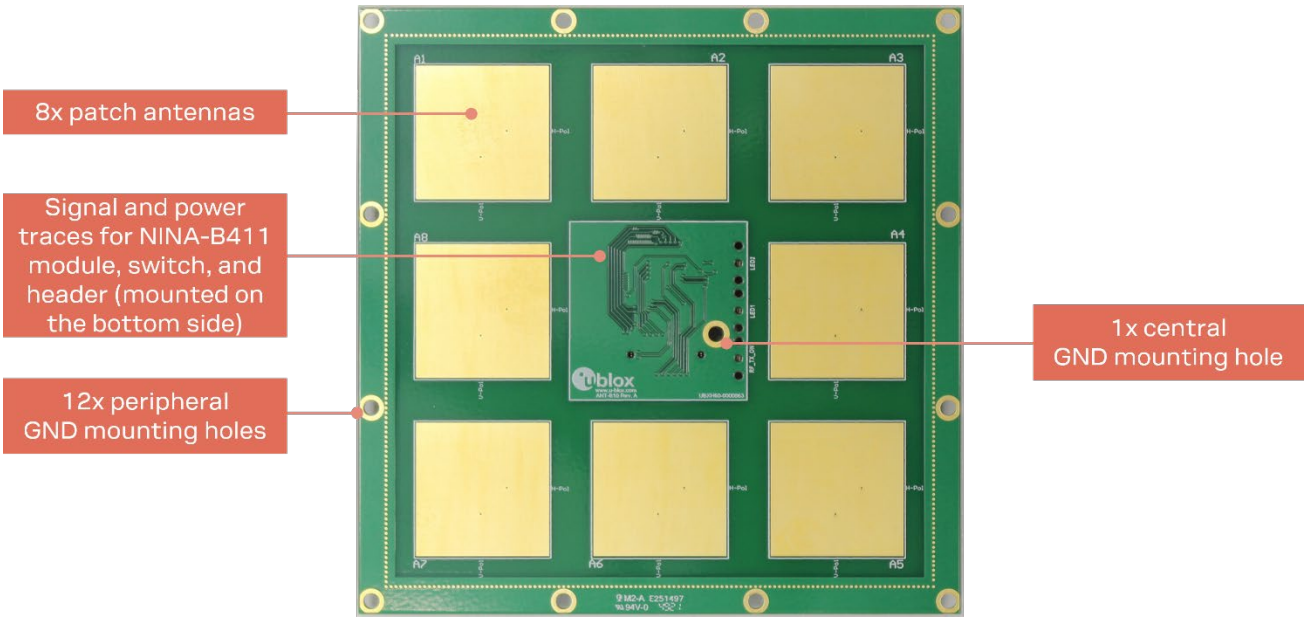


**Figure 1: ANT-B10 board showing antennas and mounting holes**

The board hosts a single NINA-B411 Bluetooth Low Energy (LE) module, which controls the antennas and applies an angle calculation algorithm to the received signals to determine the angle of arrival of the advertising tag. The angles are calculated by the u-locateEmbed software running on the embedded MCU in the module. The angles are delivered over the UART port of the ANT-B10. Support for USB and SPI interfaces is planned for future u-locateEmbed software versions.

An overview of the main building blocks of ANT-B10 is shown in Figure 2, where it can be seen how an RF antenna switch is used to select input from the different antennas on the board. The switch is controlled by five GPIO signals.

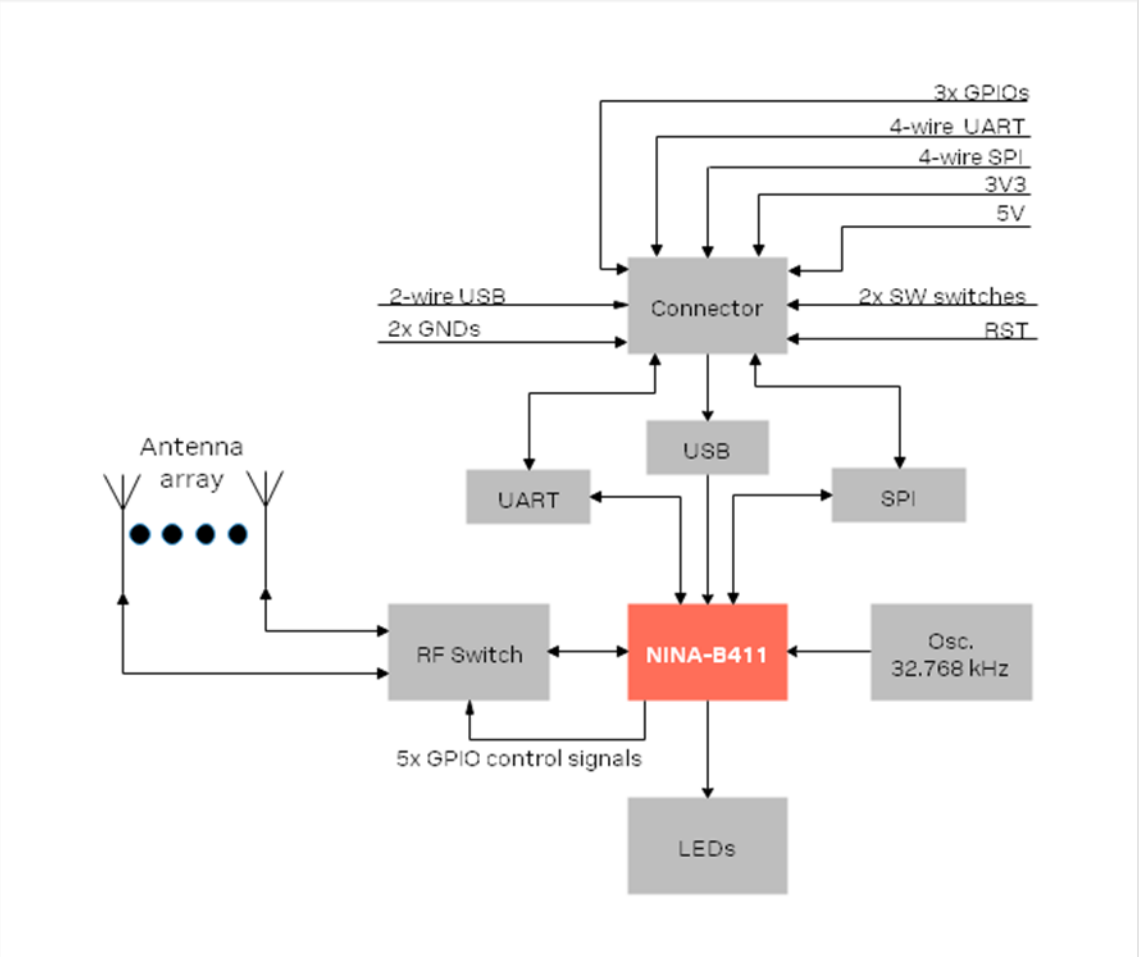


**Figure 2 ANT-B10 block diagram.**

## 1.2 Software information

☞ ANT-B10 must be flashed with the u-locateEmbed software. See u-locateEmbed software.

For software updates and further information about the software, see also the u-locateEmbed product page [3].

# 2 System function interfaces

## 2.1 Assignment

Figure 3 shows the pin positions on the ANT-B10 interface.

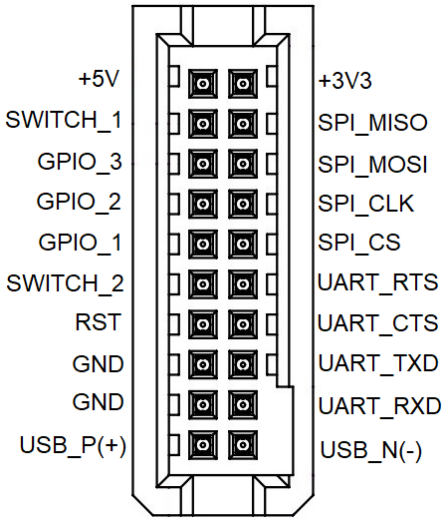


**Figure 3: ANT-B10 pin assignment (top view)**

☞ A 20-pin surface mount header connector (PTSHSM-510-D-06-T-C) with a 1.27 mm pitch from Major League Electronics [12] provides the physical interface for the ANT-B10 board.

## 2.2 Pin description

Table 1 describes the ANT-B10 pins located on the bottom side of board.

| Pin# | Description | Pin# | Description |
|---|---|---|---|
| 1 | +5V (USB) | 2 | +3V3 |
| 3 | SWITCH_1 | 4 | SPI_MISO |
| 5 | GPIO_3 | 6 | SPI_MOSI |
| 7 | GPIO_2 | 8 | SPI_CLK |
| 9 | GPIO_1 | 10 | SPI_CS |
| 11 | SWITCH_2 | 12 | UART_RTS |
| 13 | RST | 14 | UART_CTS |
| 15 | GND | 16 | UART_TXD |
| 17 | GND | 18 | UART_RXD |
| 19 | USB_P(+) | 20 | USB_N(-) |

**Table 1: ANT-B10 pinout**

## 2.3 UART pin connection

### 2.3.1 Overview

For UART connection, connect the following pins from the ANT-B10 header to the host:

- **UART_TXD** (pin 16)
- **UART_RXD** (pin 18)
- **UART_CTS** (pin 14) – optional for UART flow control
- **UART_RTS** (pin 12) – optional for UART flow control

☞ If flow control is not used, the **UART_CTS** pin is internally pulled down. However, it is good practice to connect **UART_CTS** to **GND**. Configure the UART connection not to use flow control using the command `AT+UMRS=<baud rate>,0`.

Other necessary pins:

- **GND** ground connection (pin 15 or 17)
- **+3V3** power supply (pin 2)
- **SWITCH_2** forces the board into the software update (boot loader) mode when driven low during board reset.
- **SWITCH_1** resets the board to its default settings when driven and then held low for at least 5 seconds – or until the `+STARTUP` event is received over the UART.

Unused pins are reserved for future use.

### 2.3.2 Connection to a host using USB-to-UART adapter

A host PC communicates with ANT-B10 over the UART interface through the pin header located in the center of the bottom side of the board. To protect the board from physical damage, a dual-row, 1.27 mm pitch, 20-pin, female adapter should be mounted on the pin-header of the ANT-B10 board. The adapter is used to connect the cable harness between the ANT-B10 pin header and the USB-to-Serial adapter. As ANT-B10 is powered by the USB-to-Serial Adapter, there is no need for external power supply.

Figure 4 shows how the USB adapter connects to the ANT-B10 pin header. The adapter features a signal expansion board, which for test purposes has been mounted on the standard 1.27 mm header.

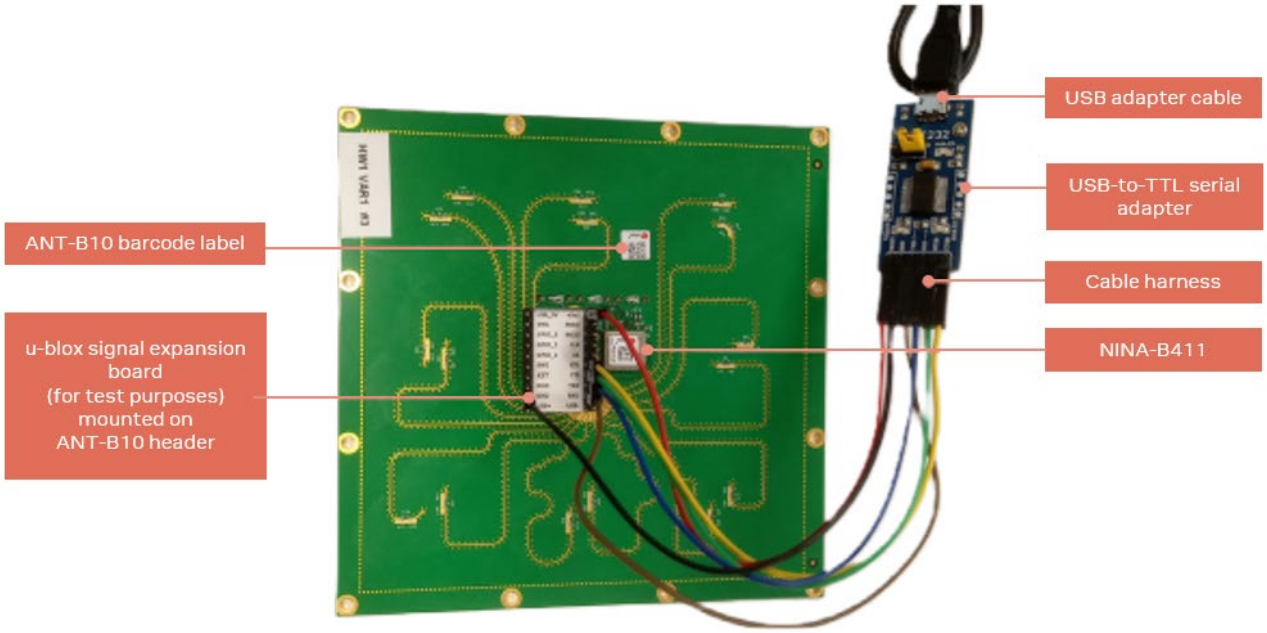


**Figure 4: ANT-B10 with UART to USB serial converter**

To connect ANT-B10 to the host PC, plug in the USB-to-Serial adapter and open the Windows Device Manager to identify the COM port number of the board. It is advisable to use s-center [4] to establish the serial connection to the COM port, but any terminal emulator can be used.

## 2.4 Native USB

Native USB is a full-speed Universal Serial Bus (USB) interface that is compliant to USB 2.0 and supports transfer speeds up to 12 Mbit/s. The interface is accessible through the 20-pin header connector.

☞ Native USB is planned for future release but is not currently supported.

## 2.5 SPI

ANT-B10 supports a Serial Peripheral Interface with serial clock frequencies up to 8 MHz. The interface is accessible through the 20-pin header connector.

The characteristics of the SPI interface include:

- Pin configuration in master mode:
  - **SCLK**, Serial clock output
  - **MOSI**, Master Output Slave Input data line
  - **MISO**, Master Input Slave Output data line
  - **CS**, Chip/Slave select output, active low, selects which slave on the bus to talk to. Only one select line is enabled by default but more can be added by customizing a GPIO pin.
  - **DCX**, Data/Command signal, this signal is optional but is sometimes used by the SPI slaves to distinguish between SPI commands and data
- Pin configuration in slave mode:
  - **SCLK**, Serial clock input
  - **MOSI**, Master Output Slave Input data line
  - **MISO**, Master Input Slave Output data line
  - **CS**, Chip/Slave select input, active low, connects/disconnects the slave interface from the bus.
- Both master and slave modes are supported.
- The serial clock supports both normal and inverted clock polarity (CPOL) and data should be captured on rising or falling clock edge (CPHA).

☞ SPI is planned for future release but is not currently supported.

## 2.6 LEDs and system control signals

ANT-B10 supports status LEDs and system control signals used specifically for programming.

### 2.6.1 LEDs

The antenna board is equipped with the following status LEDs:

- Green LED: Power good
- Blue LED: Not currently used
- Red LED: Not currently used

### 2.6.2 Control signals

ANT-B10 uses the following control signals for programming/updating through the UART interface.

- **SWITCH_1** and **SWITCH_2** input control signals
- Bootloader mode: To enter bootloader mode, **SWITCH_2** must be driven low during startup.
- Factory reset: To restore all settings to their factory default, **SWITCH_1** must be driven low during start up and then held low for 10 seconds.

☞ **RST**, **SWITCH_1,** and **SWITCH_2** are controlled by the software.

Table 2 describes the pin definitions and system control signals used by NINA-411 and ANT-B10.

| ANT-B10 header pin | Description |
|---|---|
| 3 | SWITCH_1 |
| 11 | SWITCH_2 |
| 13 | RST (RESET) |

**Table 2 ANT-B10 system control signals**

# 3 Design-in

## 3.1 General information

As a full antenna board that includes a single pin header as its sole physical interface, the design-in of the ANT-B10 board from an electrical point of view is quite simple. The user simply must feature a matching pin header on their application board where ANT-B10 will be connected.

This chapter describes several aspects of the mechanical and system design to consider when integrating the board into customer applications.

## 3.2 Connecting to the host

The ANT-B10 board has the following default port settings:

- 115200 kbps
- 8 data bits, no parity, 1 stop bit (8N1)
- Flow control enabled using RTS/CTS

It is possible to change the baud rate up to 1 Mbps and disable flow control.

## 3.3 Mounting and mechanical considerations

The ANT-B10 board should be mounted with the *antenna* side facing the room where the tracked tags are moving. The antennas should be positioned with the best possible direct line of sight to the tags. The antennas are ideally positioned to avoid pillars and similar objects in the room. The boards can be mounted on walls, in corners, and from ceilings.

Any enclosure or holder for ANT-B10 boards can be designed to utilize the mounting holes that are placed along the edges of the board, as shown in Figure 5.

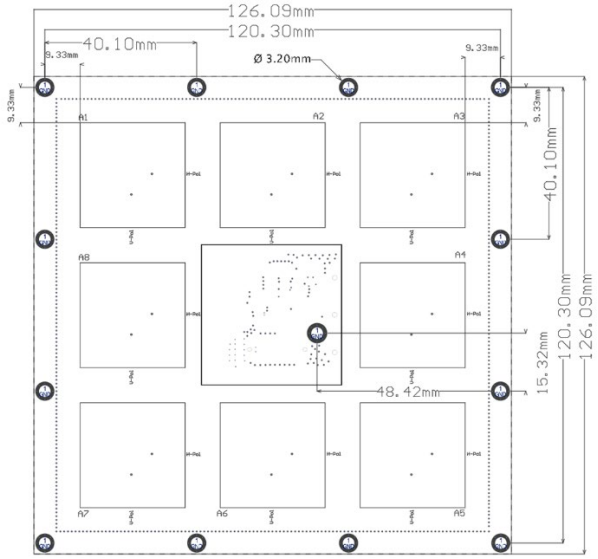


**Figure 5: ANT-B10 board dimensions**

Any enclosure designed for the boards should not include metal casing or plastic with metal flakes. Metallic-based paint or lacquer should also be avoided. A clearance of at least 10 mm between the antenna and the casing is recommended. Antenna performance may be adversely affected if the clearance is less.

The use of polycarbonate (PC) and acrylonitrile-butadiene-styrene (ABS) plastics for enclosure materials has less impact on radio signals than POS-type plastics.

# 4 u-locateEmbed software

u-locateEmbed software can track a certain number of tags and report their angles in `+UUDF` events over the UART connection. The software employs an algorithm to detect the direction or angles of a moving tag. The software runs on the NINA-B411 module, which is connected to the antenna array on the ANT-B10 board.

As the antenna array on the board detects the Constant Tone Extension (CTE) advertised in a tag beacon, the algorithm calculates the angles in two dimensions from the anchor to the tag. The calculated range of the angles is -90 to 90 degrees. For more information regarding to the output angles, see also Definition of output angles.

⚠ Upgrading the software resets all settings to factory default.

## 4.1 Flashing using s-center

u-locateEmbed software is continuously improved with performance and quality enhancements. The antenna board comes pre-flashed with the software, but updating to the latest available version is strongly recommended.

☞ Flashing u-locateEmbed software over the UART interface requires s-center 6.1 or later.

To flash the software over the UART interface using s-center [4]:

1. Download the u-locateEmbed software container from the u-locateEmbed product page [3].
2. Open s-center on the correct COM port once the module is in software download mode.
3. Select **Software Update**.
4. In the “Software Update” dialog select the binary file in the software container, as shown in Figure 6. Make sure the flashing speed is set to 115200.
5. Select **Update**.

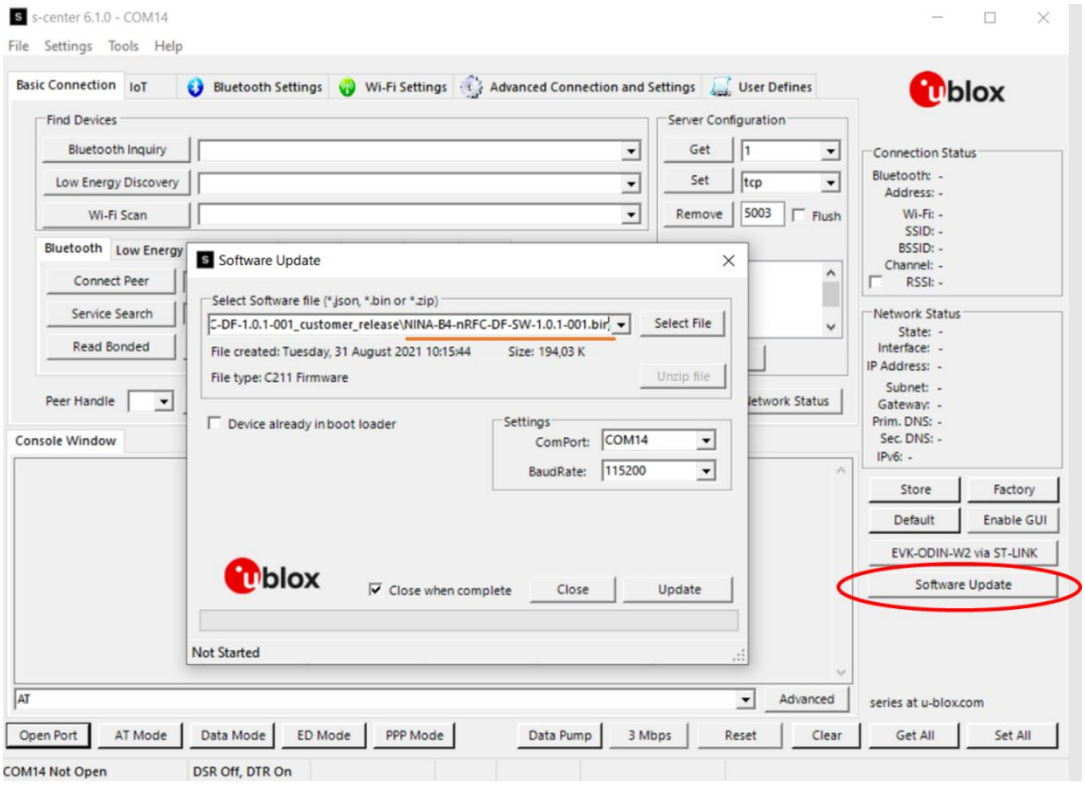


**Figure 6: Updating the software on the board using s-center**

## 4.2 Flashing from the Command line

To flash the software over the UART interface from the Command line:

1. Download the u-locateEmbed software container from the u-locateEmbed product page [3].
2. Put the device into firmware update mode; either:
   a. Enter the AT+UFWUPD command [2] to select the appropriate baud rate. The following command sets the baud rate to 1Mbit/s.
   ```
   AT+UFWUPD=0,1000000
   ```
   b. Boot the board into Software Update mode by connecting the **SWITCH_2** pin to ground while powering up the board. This sets the default baud rate to 115200.
3. Flash the u-locateEmbed software using the bundled (Windows only) newtmgr executable. Alternatively, follow the Newt Manager Guide [6] to install the newtmgr application tool for MAC OS, Linux, and Windows.
4. Use newtmgr to install u-locateEmbed software on the NINA-B411 module:
   ```
   newtmgr --conntype=serial --connstring="COMXX,baud=XXX,mtu=512" image upload <binary image>
   ```
5. Press the reset button to reset the application board or reset it with newtmgr:
   ```
   newtmgr --conntype=serial --connstring="COMXX,baud=XXX" reset
   ```

☞ Replace COMXX with your actual port number, baud=XXX to either default baud rate 115200 or your chosen baud rate.

## 4.3 Configuration example

By default, u-locateEmbed comes pre-configured to track all u-blox tags. The tags advertise with the Eddystone namespace 0x4E494E412D4234544147, which by default is tracked in u-locateEmbed. So, if you are only using the u-blox C209 tags, no configuration is needed.

Each anchor node can be configured with beacons to track. An example for how to set up the anchor to track two tags is shown below:

```
AT+UDFFILT=1,1 // Clear namespace
AT+UDFFILT=1,2,”6E616D65737061636578”
AT+UDFFILT=2,2,“CCF9578E0D8A”
AT+UDFFILT=2,2,”CCF9578E0D8B”

AT+UDFENABLE=1 (Tracking is enabled by default, so this is optional)
```

These commands set up the anchor to track the two tags with the given MAC addresses in the Eddystone name space (6E616D65737061636578) used by the tags.

The sequence described above reflects the most simplistic use case. Further configuration is possible using the AT+UDFCFG command. See the u-locateEmbed AT commands manual [2].

The settings are saved using the AT&W command, followed by a restart (AT+CPWROFF).

## 4.4 Requirements on tag advertisements

When using tag software other than the u-blox example based on the Zephyr OS [10], the tag must fulfill the following requirements:

- CTEInfo and CTE fields must be part of the periodic advertising packets as specified in the Bluetooth Core Specification [11].
- CTE must be 160 microseconds long.
- Payload in the extended advertisements must include an Eddystone UID frame.

☞ The default namespace filter in the u-locateEmbed software filters on the namespace 0x4E494E412D4234544147. The namespace must be change to that used by the tag.

# 5 Handling

⚠ ANT-B10 boards are Electrostatic Sensitive Devices that demand the observance of special handling precautions against static damage. Failure to observe these precautions can result in severe damage to the product.

## 5.1 ESD handling precautions

⚠ As the risk of electrostatic discharge in the RF transceivers and patch antennas of the module is of particular concern, standard ESD safety practices are prerequisite. See also Figure 7.

When connecting test equipment or any other electronics to the board, the first point of contact must always be to local GND.

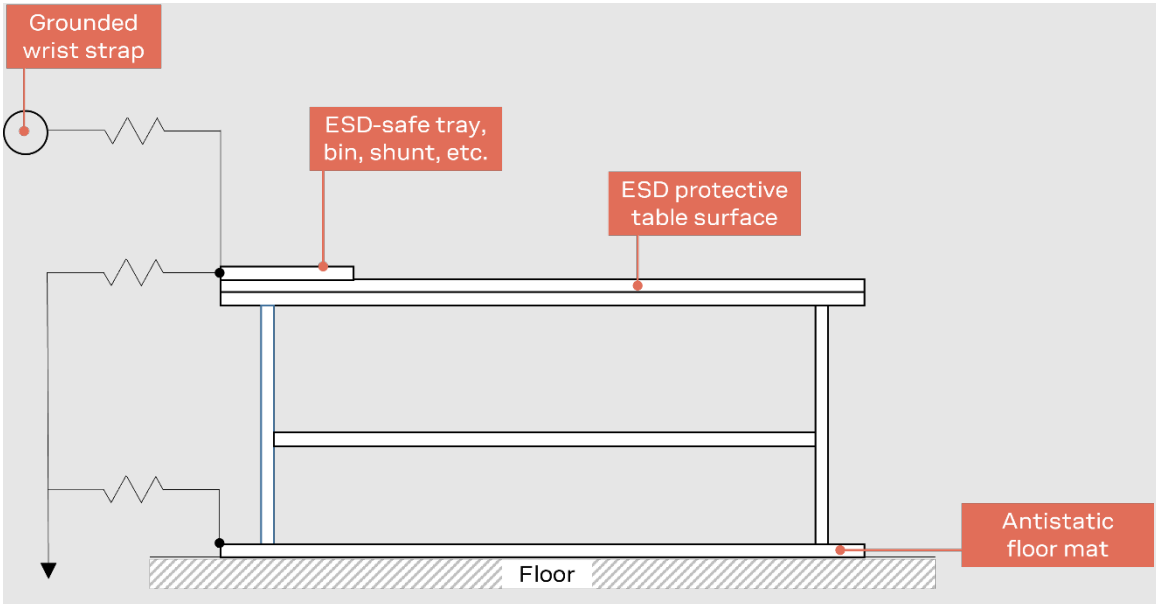


**Figure 7: Standard workstation setup for safe handling of ESD-sensitive devices**

## 5.2 Packaging, shipping and storage preconditioning

For information about shipment and storage, see the ANT-B10 data sheet [1] and Product packaging guide [7].

# Appendix

# A Glossary

| Abbreviation | Definition |
|---|---|
| AoA | Angle of Arrival |
| AoD | Angle of Departure |
| ASCII | American Standard Code for Information Interchange |
| ARM | Arm (Advanced RISC Machines) Holdings |
| CPU | Central Processing Unit |
| CTE | Constant Tone Extension |
| RSSI | Received Signal Strength Indication |
| TBD | To be defined |

**Table 3: Explanation of the abbreviations and terms used**

# B Limitations

The u-locateEmbed software (2.0 and higher) supports continuous tracking of up to 25 individual tags.

When tracking more than 25 tags, the tags that do not send any data for more than five seconds are considered idle and are removed from the list of tracked tags. Newly identified tags are automatically added to the list of tracked tags. The five-second default timeout can be re-configured by "`AT+UDFSCANCFG=1,<new_timer>`".

When there are more than 25 tags within reach a round-robin scheduling algorithm is applied enabling the module to track all tags. As not all visible tags are continuously tracked, this causes some lag in the reporting for individual tags.

# C Definition of output angles

Figure 8 shows three angles that can be output from ANT-B10:

- azimuth – azimuth_angle
- elevation – elevation_angle
- direct' - the complementary angle of direct angle: $direct\_angle = 90^o - direct'$

The white dots represent the antenna board. The x- and y-axis represent the outward normal orientation of the board.

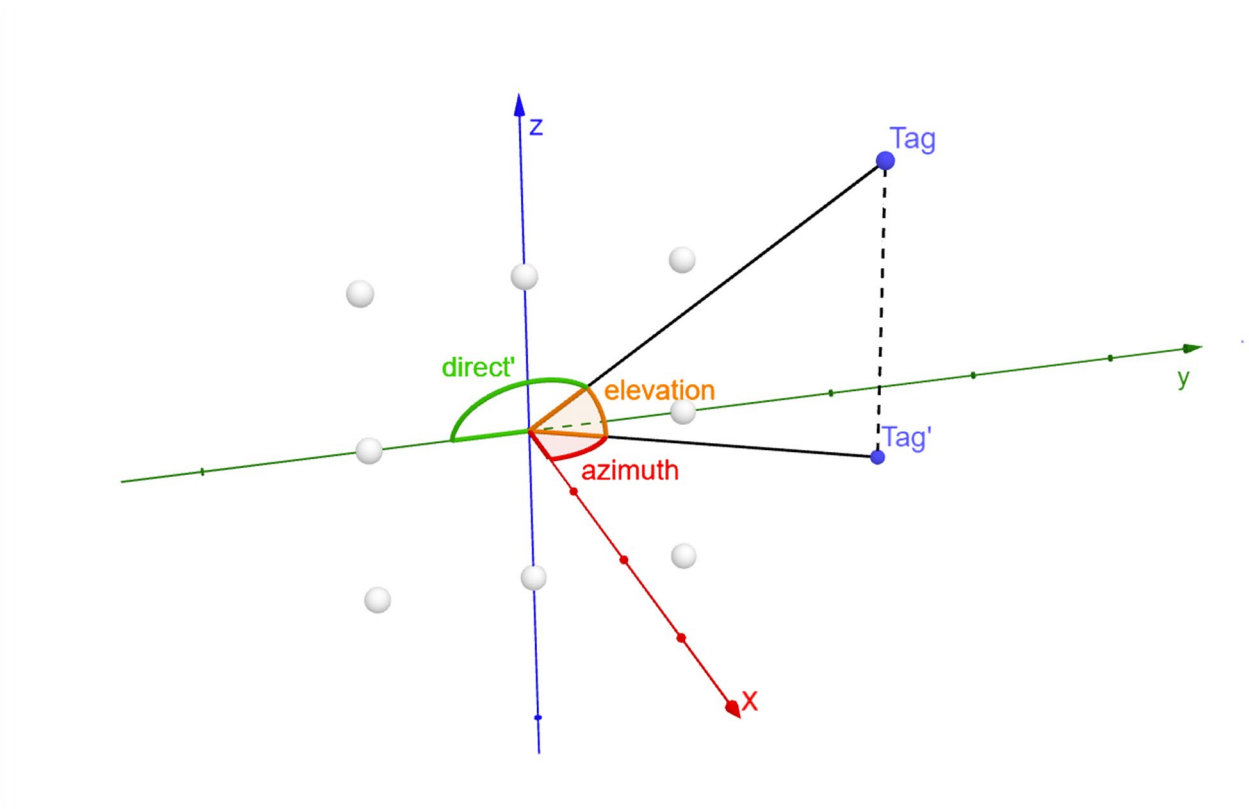


**Figure 8: 3D space diagram – illustrate three angles**

By default, u-locateEmbed reports “azimuth_angle” and “elevation_angle”.

```
+UUDF:<ed_instance_id>,<rssi>,<azimuth_angle>,<elevation_angle>,<not_used>,<channel>,
<anchor_id>,<user_defined_str>,<timestamp_ms>,<periodic_event_counter>
```

u-locateEmbed can be configured to output “direct_angle” and “elevation_angle” with “AT+UDFCFG=13,0”, where:

```
+UUDF:<ed_instance_id>,<rssi>,<direct_angle>,<elevation_angle>,<not_used>,<channel>,
<anchor_id>,<user_defined_str>,<timestamp_ms>,<periodic_event_counter>
```

Note that the calculated range of the angles is -90 to 90 degrees.

“azimuth_angle” and “direct_angle” are positive from the positive x-axis to negative y-axis but is negative from the positive x-axis towards the positive y-axis. Conversely, “elevation_angle” is positive from the positive x-axis towards the positive z-axis but is negative from the positive x-axis toward negative z-axis.

When the tag is moving along the x-axis, the two reported angles should both be zero.

☞ Software versions prior to u-locateEmbed 3.0 always report direct_angle.

# D Low power mode

For a flexible approach to saving power, explore the power-saving features supported in u-locateEmbed software v3.0.0 and later. To reduce power consumption on the antenna board hosting the module, you can configure low-power modes in the radio, RGB LEDs, and UART.

☞ Low power modes are only supported on ANT-B10 and ANT-B11.

## D.1 Radio

The methods for decreasing power consumption of the radio, include:

- Controlling the radio duty cycle
- Adjusting the frequency of CTEs transmissions
- Disabling radio scanning

### D.1.1 Control the radio duty cycle when scanning for new tags

By default, u-locateEmbed uses a100% radio duty cycle to scan for new tags to track. This minimizes the time it takes to find new tags entering the area. The drawback with this approach is that the current consumption is high.

Controlling the radio duty cycle when scanning tags is intended for anchors that are powered by battery. To run an anchor on battery the radio duty cycle needs to be decreased.

To configure the duty cycle, use the `AT+UDFSCANCFG=<parameter tag>[,<param>]` command to adjust the default value (16x0.625=10 ms) of parameter tags 8 and 9, as described in Table 4.

| Param. tag | Default | Unit | Range | Help |
|---|---|---|---|---|
| 8 | 16 (10ms) | 0.625 ms | 4-16384 (greater/equal of tag 9) | Scan interval. What interval the radio will scan for new tags. |
| 9 | 16 (10ms) | 0.625 ms | 4-16384 (less/equal of tag 8) | Scan window. How long the radio will scan for tags at each interval. |

**Table 4: Parameter tags for configuring the duty cycle**

Setting a scan window smaller than scan interval reduces radio utilization and power, while causing detection of new tags to take longer time.

Changing any of the above parameters described in Table 4 affect the time it takes to find a new tag. The values of these parameters are configured as a trade-off between the power consumption versus time taken to find new tags. The user must find an acceptable current consumption level with consideration to the time it takes to find new tags.

### D.1.2 Adjust the frequency of CTEs transmissions

Fewer angle events also reduce power consumption. Anchors do not, however, have control over the received AoA packets. Instead, the tags can adjust the frequency of CTEs transmissions.

It is also possible to filter out tags with low RSSI using `AT+UDFSCANCFG=10,<rssi>`. This can help with reducing power consumption. For more information about the `AT+UDFSCANCFG` command, see the u-locateEmbed AT command manual [2].

### D.1.3 Disable radio scanning when all tags in filter are synced

Use the command `AT+UDFCFG=12,1` to stop u-locateEmbed from background scanning after new tags when all tags in the filter are synced. This mode is useful when the application is only tracking one or a few specific tags. When u-locateEmbed is synced to those tags, it doesn't look for others. A tag filter (`+UDFFILT`), based on instanceID, must be defined for this option to work.

## D.2 RGB LEDs

To reduce power consumption, disable the RGB LEDs using the command AT+USYSCFG=1,<on/off>.

## D.3 UART

Once enabled, the UART increases power consumption on the antenna board. To reduce power consumption, put the UART in sleep mode.

In sleep mode, the UART receive on anchor side is disabled and power consumption in the UART is reduced by ~400uA. The host continues to receive events from the u-locateEmbed software, such as +UUDF events, but is unable to send AT commands.

### D.3.1 Enter sleep mode

To put the UART in sleep mode, use the AT+UPWRSAVE=<wakeup_mode> command, where the <wakeup_mode> parameter defines how the UART can wake up from sleep mode.

### D.3.2 Wake from sleep mode

Having put the UART in sleep mode there are then two different ways with which to wake up UART:

- **AT+UPWRSAVE=1** By sending any character to the UART, the host wakes up the UART. After sending a character the host must wait ~50ms before sending an AT command. To return to sleep mode and save additional power, send the AT+UPWRSAVE=1 command again.
- **AT+UPWRSAVE=2** The host pulls GPIO1 low to wake up the UART.

☞ Sending a character to wake up the UART can create garbage, which then causes the host to receive an ERROR after the first AT command is sent to enable the UART. To make sure that the u-locateEmbed software is in sync with host, always enter "AT" after wake up.

# Related documentation

[1] ANT-B10 data sheet, UBX-22008373
[2] u-locateEmbed AT commands manual, UBX-22025586
[3] u-locateEmbed product page, https://www.u-blox.com/en/product/u-locateEmbed
[4] s-center, https://www.u-blox.com/en/product/s-center
[5] newtmgr download: https://mynewt.apache.org/download/
[6] newtmgr guide: https://mynewt.apache.org/latest/newtmgr/index.html
[7] Product packaging guide, UBX-14001652
[8] NINA-B4 system integration manual, UBX-19052230
[9] NINA-B4 certification, application note, UBX-20037320
[10] u-blox tag software example, https://github.com/u-blox/c209-aoa-tag
[11] Bluetooth Core Specification, available from https://www.bluetooth.com/specifications/specs/
[12] Connector datasheet, https://mlelectronics.com/part/PTSHSM-5

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# Revision history

| Revision | Date | Name | Comments |
|---|---|---|---|
| R01 | 14-Sep-2022 | mape | Initial release. |
| R02 | 23-Dec-2022 | mape | Added Requirements on tag advertisements. |
| R03 | 27-Sep-2023 | mape, lliu | Added Limitations and other minor editorial changes. Updated Flashing with mtu parameter. Added image in General information. |
| R04 | 17-Nov-2023 | lliu | Updated flashing instructions and added information describing the angle measurements in u-locateEmbed software. |
| R05 | 26-Jan-2024 | lliu | Renamed u-connectLocate to u-locateEmbed. Updated angle definition. Added appendix, low power mode. |

# Contact

**u-blox AG**

Address: Zürcherstrasse 68
8800 Thalwil
Switzerland

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