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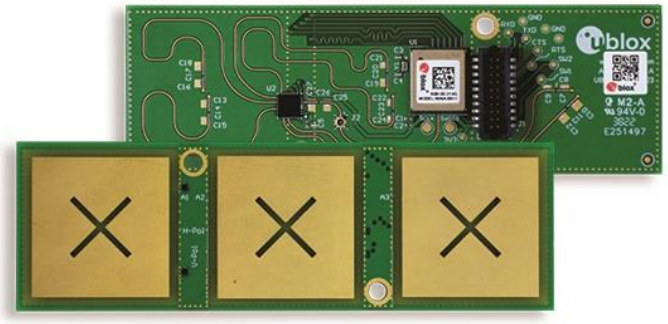
ANT-B11

Direction Finding antenna board

System integration manual



Abstract

This manual provides a functional overview combined with best-practice design guidelines for integrating the ANT-B11 Angle of Arrival antenna board in direction finding and indoor positioning applications.

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Document information

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Document status description	
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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**
ANT-B11	Early Production Information

☞ For information about the related hardware, software, and status of listed product types, see also the ANT-B11 data sheet [1]

☞ u-connectLocate is renamed to u-locateEmbed.

Contents

1 Functional description

1.1 Overview

The ANT-B11 is a versatile Angle of Arrival antenna board equipped with three, dual-polarized, patch antennas for direction finding and 2D positioning, as shown in Figure 1.

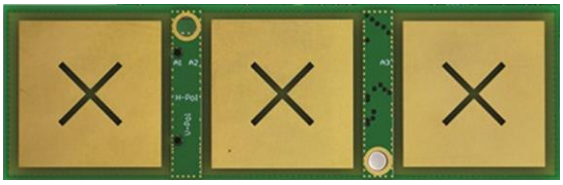

Figure 1: ANT-B11 with antennas and mounting holes

ANT-B11 measures the angle of arrival for an incoming Bluetooth Low Energy (LE) radio signal on a single plane depending on the way it is oriented.

The ANT-B11 board hosts a single NINA-B411 stand-alone Bluetooth Low Energy (LE) module. The module controls the antennas and applies an angle calculation algorithm to the received signals to determine the angle of arrival of the advertising tag. The angle of arrival is calculated by the u-locateEmbed software running on the embedded MCU in the module. The angle data is then delivered over the UART port of the ANT-B11.

1.2 Software information

☞ ANT-B11 must be flashed with the latest version of u-locateEmbed software. See also 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 Pin assignment

Figure 2 shows the pin positions on the ANT-B11 connector.

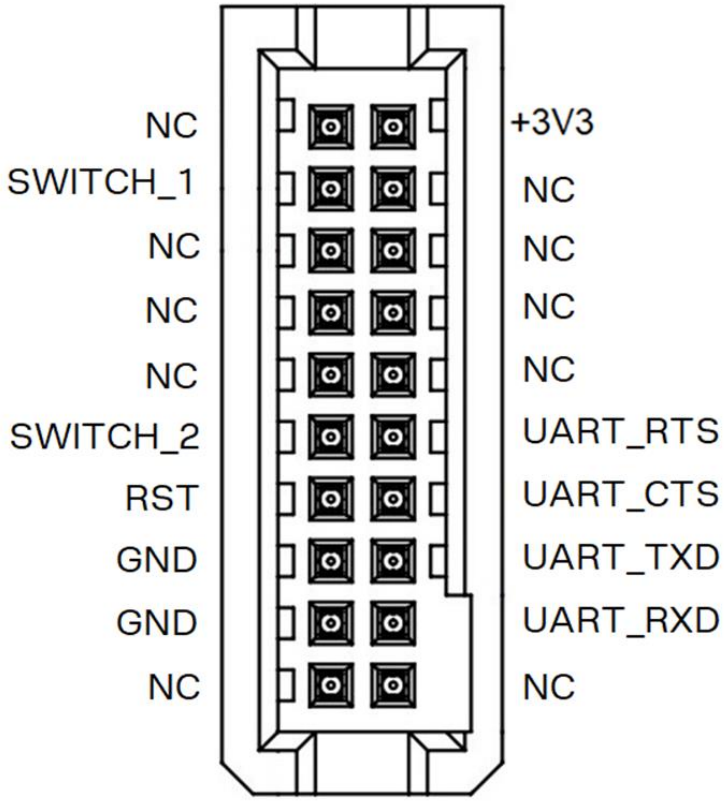

Figure 2: ANT-B11 connector pin assignment

2.2 Pin description

Table 1 describes the ANT-B11 pins located on the bottom side of the board.

Pin#	Description	Pin	Description
2	+3V3	3	SWITCH_1
11	SWITCH_2	12	UART_RTS
13	RST	14	UART_CTS
15	GND	16	UART_TXD
17	GND	18	UART_RXD

Table 1: ANT-B11 pinout

2.3 UART pin connection

2.3.1 Overview

For UART connection, connect the following pins from the ANT-B11 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** (pin 15 or 17). Ground connection.
- **+3V3** (pin 2). Power supply.
- **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 can communicate with ANT-B11 over the UART interface through the pin header located at 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-B11 board. The adapter is used to connect the cable harness between the ANT-B11 pin header and the USB-to-Serial adapter. As ANT-B11 is powered by the USB-to-Serial Adapter, there is no need for external power supply.

Figure 3 shows how the USB adapter connects to the ANT-B11 pin header. The adapter features a signal expansion board, which for test purposes has been mounted on the standard 1.27 mm header.

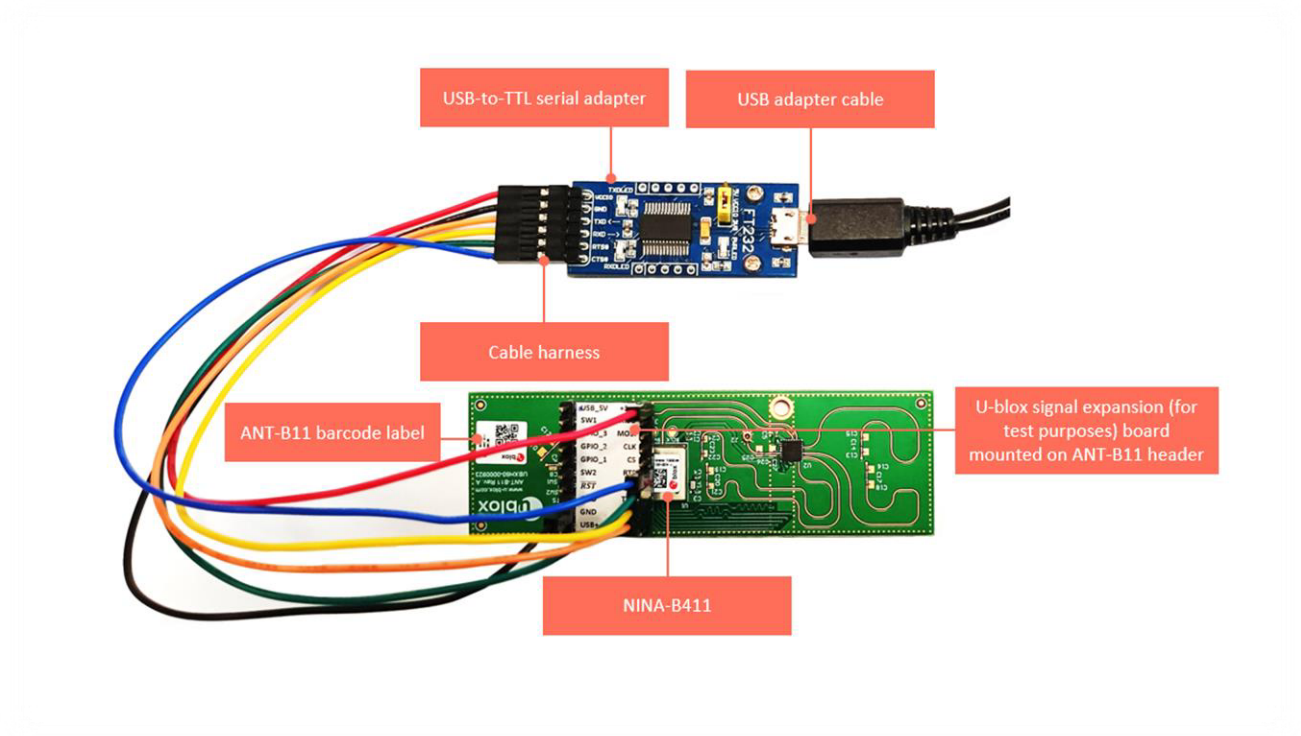

Figure 3: ANT-B11 with UART to USB serial converter

Figure 4 shows (from left to right) suggested components to connect ANT-B11 to the host PC.

- USB adapter cable with male USB Type-A connector to male mini-B connector
- FTDI FT232RL USB-to-TTL Serial Converter Adapter Module 5 V and 3.3 V for Arduino
- Female-to-female jumper set
- Dual-row, 1.27 mm pitch, 20-pin, female adapter (to avoid pin damage on the ANT-B11 board)

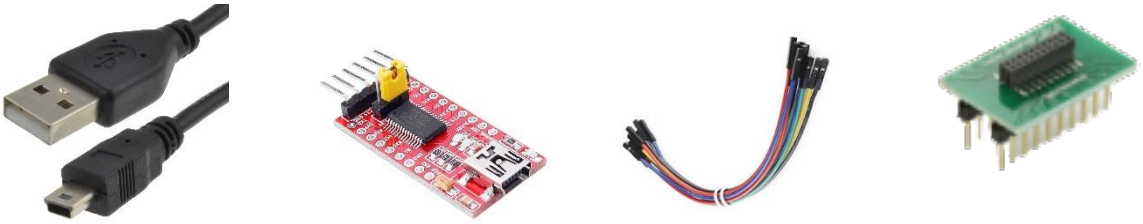

Figure 4: Components required for PC connection

To connect ANT-B11 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 [3] to establish the serial connection to the COM port, but any terminal emulator can be used.

2.4 Control signals

ANT-B11 supports 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.

☞ **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-B11.

ANT-B11 header pin	Description
3	SWITCH_1
11	SWITCH_2
13	RST (RESET)

Table 2: ANT-B11 system control signals

3 Design-in

As a full antenna board that includes a single pin header as its sole physical interface, the design of the ANT-B11 board from an electrical point of view is quite simple. However, the application board must be designed with a matching pin header to which ANT-B11 is connected.

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

3.1 Connecting to the host

The ANT-B11 antenna 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.

3.2 Mounting and mechanical considerations

The ANT-B11 antenna board must be mounted with the *antenna* side facing the room where the tracked tags are moving. The antennas must also 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.

For optimal results with 2D indoor positioning, it is advisable place the ANT-B11 antenna board and tracked tags at the same height. See also 2D positioning.

Any enclosure or holder for ANT-B11 boards can be designed to utilize the two mounting holes located close to the top and bottom edges of the board, as shown in Figure 5.

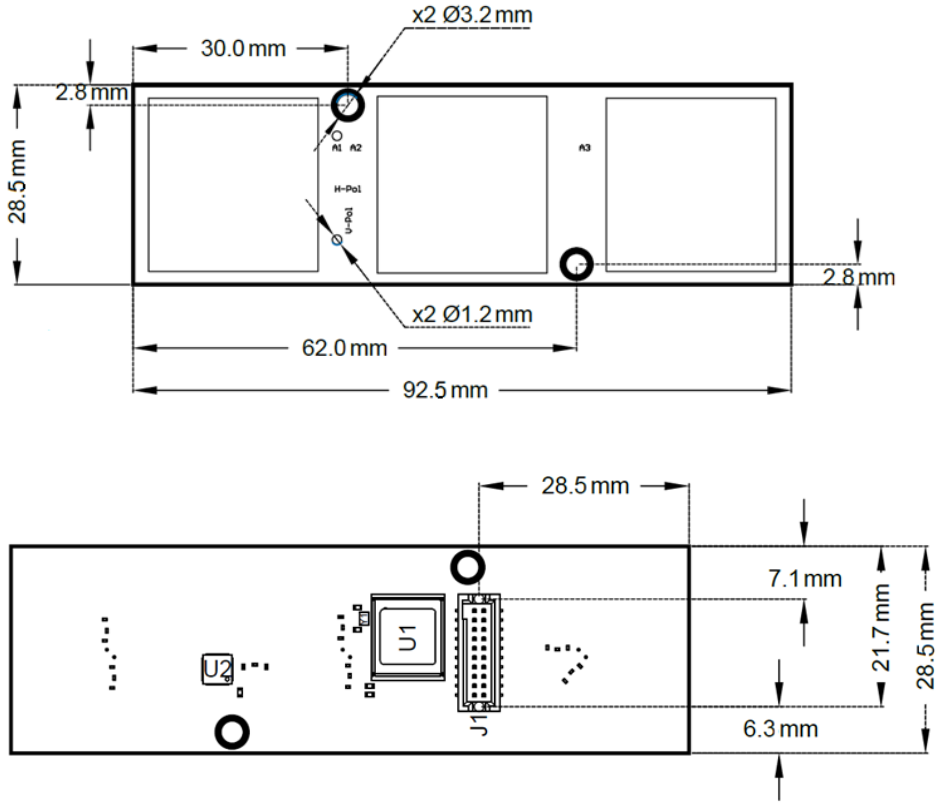

Figure 5: Physical dimensions of the ANT-B11 board

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 can 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.

3.3 Direction finding

In ANT-B11, the u-locateEmbed algorithm calculates angles in one dimension only. Two angles, *"direct_angle"* and *"elevation_angle"* are reported but *"elevation_angle"* is always shown as zero (0).

To simplify the graphical representation of the tag angle in a 3D diagram, the complementary angle *(direct')* on which the reported angles *(direct_angle)* is calculated is shown in Figure 6. The angle shown is between the y-axis and the tag gradient from the origin point. The white dots represent the antenna board. The x- and y-axis represent the normal orientation of the board.

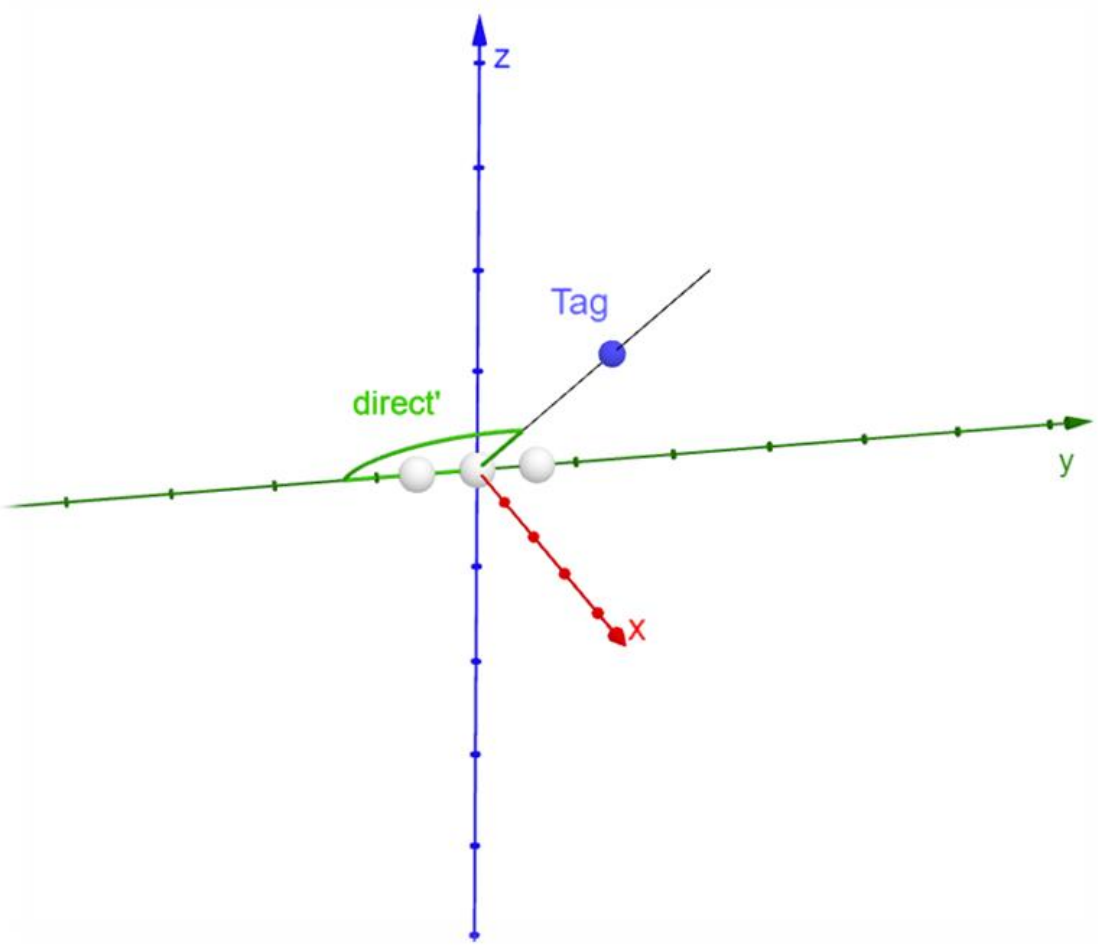

Figure 6: The measured direct_angle based on direct'

The algorithm reports the *direct_angle*, where: **direct_angle**=90°-direct'.

Note that the calculated angle, *direct_angle*, is positive from the positive x-axis to negative y-axis but negative from the positive x-axis towards the positive y-axis.

When the tag is moving along the x-axis, the reported angle should be zero.

3.4 2D positioning

ANT-B11 can be used for 2D positioning calculation by utilizing the output *direct_angle* into either u-blox u-locateEngine or third-party positioning engine application.

☞ It is advisable to place ANT-B11 and the tracked tags at the same height. ANT-B11 should also be placed perpendicular to the floor.

Figure 7 shows the relationship between the ANT-B11 antenna board and tracked tag when they are placed on the same plane for 2D positioning.

Three white dots represent ANT-B11 antenna board, and the x- and y-axis represent the normal orientation of the board, the complementary angle (*direct'*) of the reported angle (*direct_angle*) is shown in Figure 7. ANT-B11, the tracked tag, and the measured *direct'* angle are on the same rose-colored plane. For further information about the angles, see also Direction finding.

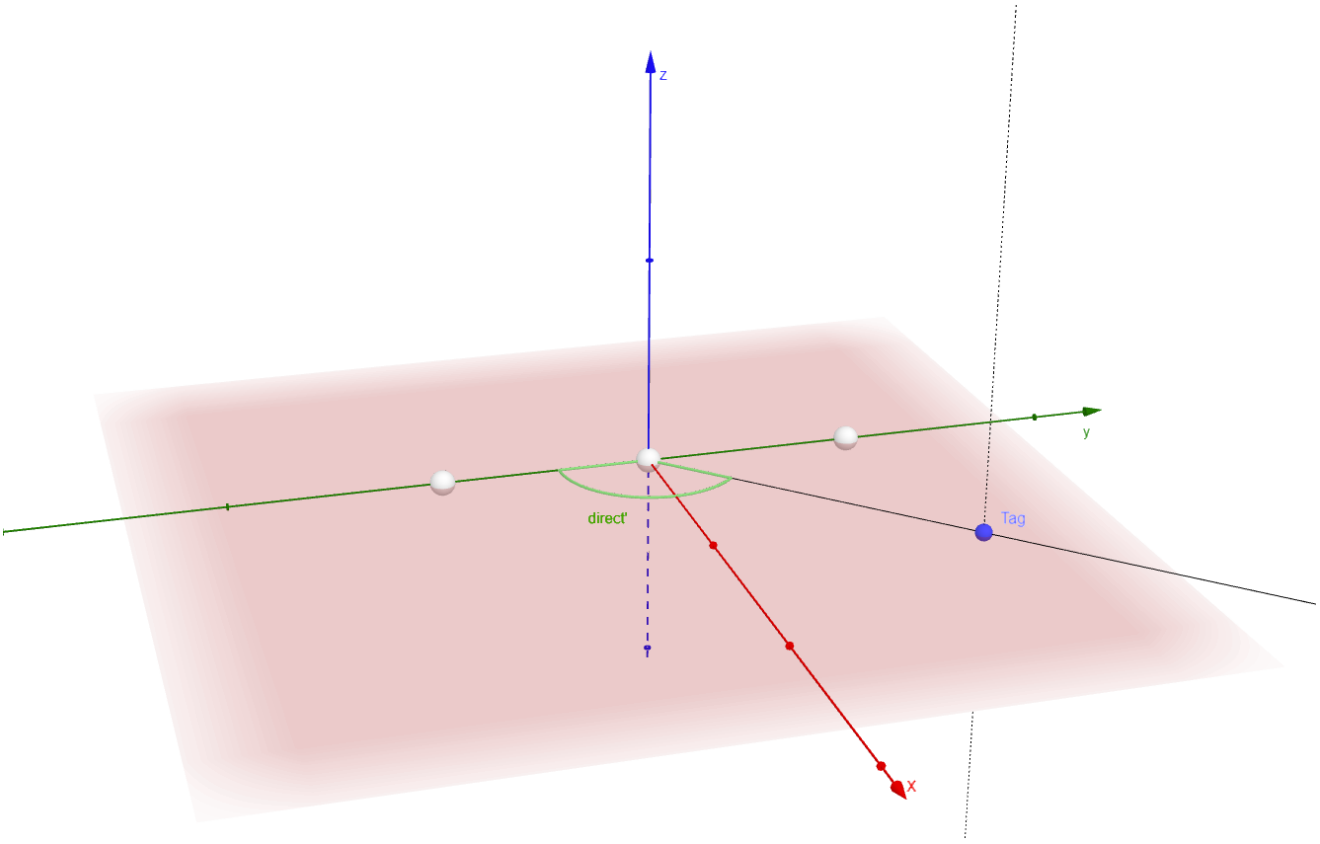

Figure 7: ANT-B11 and tracked tag are placed on the same plane for 2D positioning use case

3.4.1 Avoiding angle discrepancies

When the tag is **NOT** on the same plane as the ANT-B11 antenna board, the reported angle must be considered from a 3D perspective. In this scenario, the tracked tag is moving in a vertical direction away from the rose-colored plane where ANT-B11 is situated. The movement increases the *elevation'* angle and introduces an element of discrepancy in the reported angle.

⚠ As the reliability of the reported angle depredates proportionally to an increase in the elevation angle, the tracking of tags in this scenario is not recommended by u-blox.

Figure 8 describes the use case scenario where the tracked tag moves away from the rose-colored plane where ANT-B11 is situated. Note that the *elevation'* angle is complementary to the *elevation_angle*.

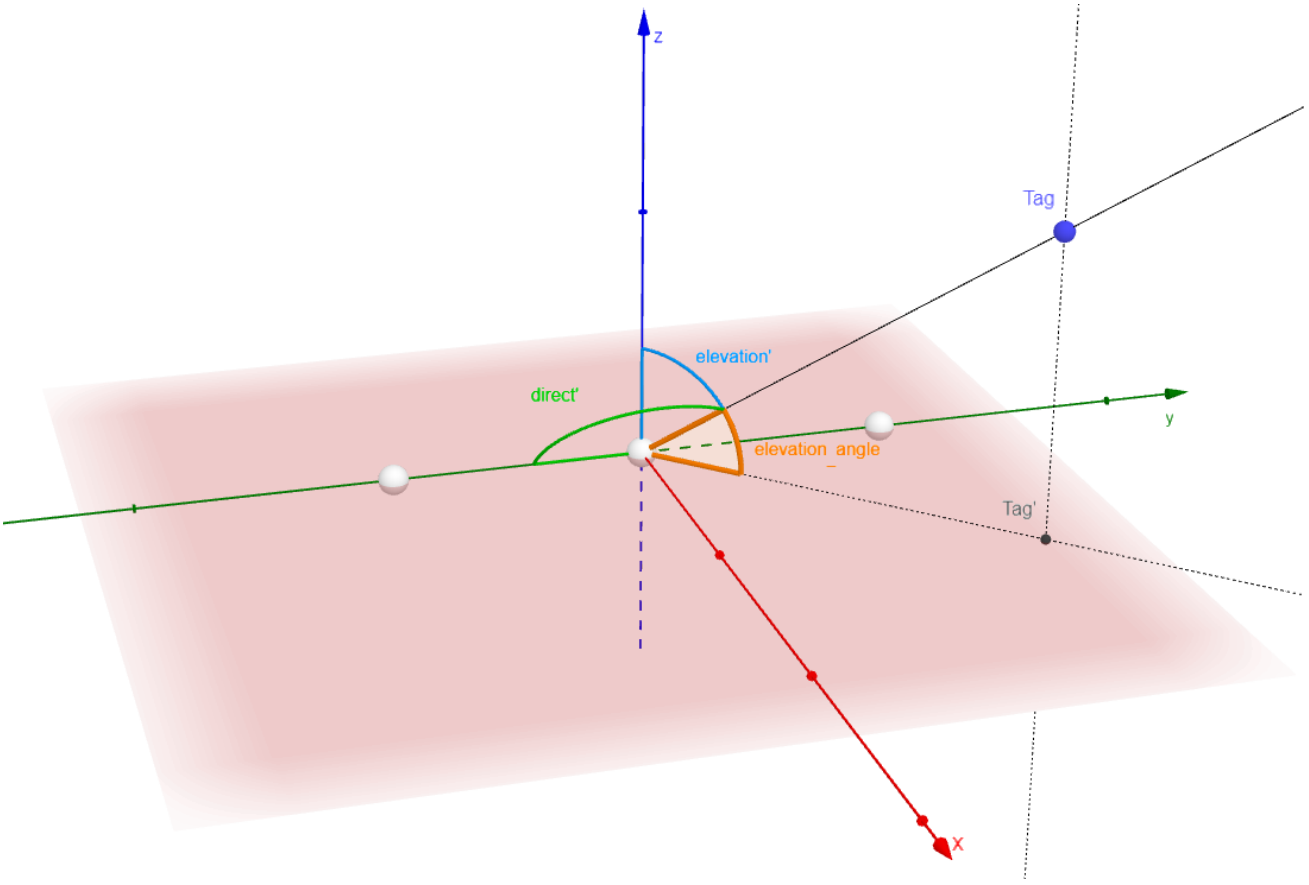

Figure 8: move tag away from ANT-B11 located plane

☞ The *direct_angle* and *elevation_angle* are further described in the u-locateEmbed AT command manual [2].

An element of discrepancy in the positioning calculation occurs when ANT-B11 and the tracked tag are not on the same plane. The discrepancy becomes greater as the theta angle increases, as shown as in Figure 9.

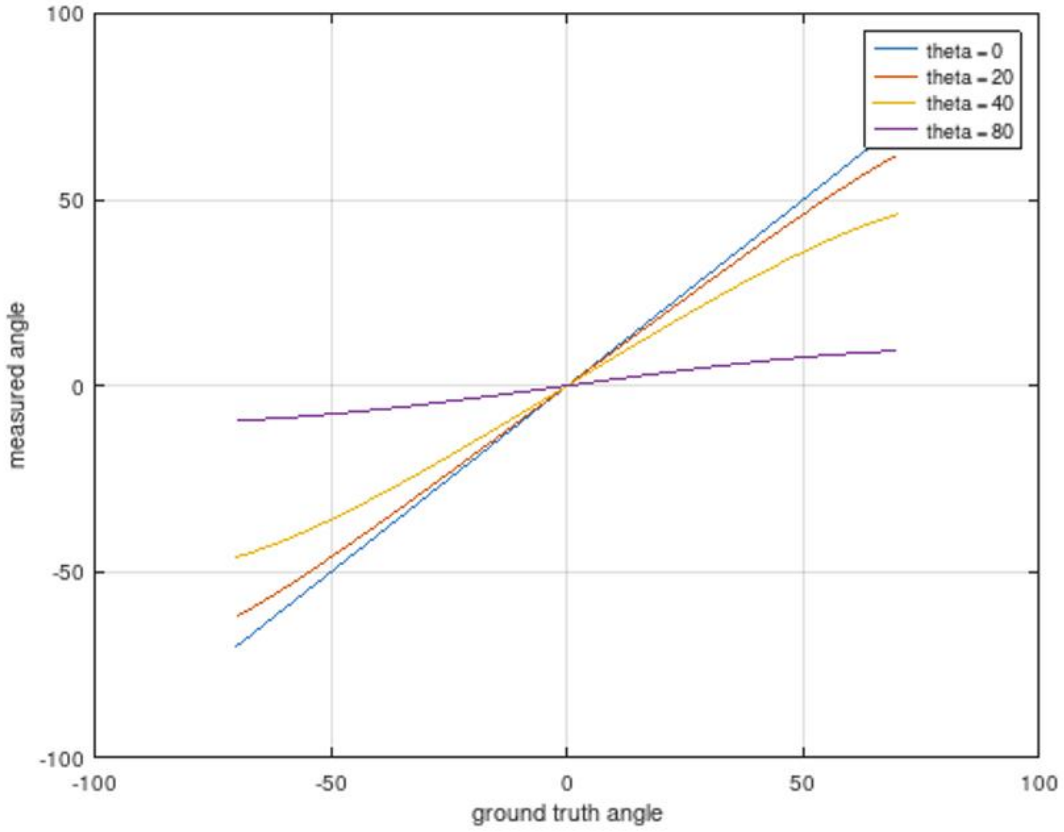

Figure 9: The element of discrepancy for 2D positioning when ANT-B11 and tracked tag are not on the same plane

This potential for discrepancy in the positioning calculation makes it advisable to have the tag and ANT-B11 (as much as possible) at the same height, as described in 2D positioning.

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 angle of a moving tag. The software runs on the NINA-B411 module, which is connected to the antenna array on the ANT-B11 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 one dimension from the anchor to the tag. The range of the calculated angles is -90 to 90 degrees. For more information regarding the output angles, see also Design-in.

⚠ 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.

☞ Users must ensure their ANT-B11 boards are flashed with the latest version of u-locateEmbed. Flashing u-locateEmbed software over the UART interface requires s-center 6.1 or later. Check regularly the u-locateEmbed web page for updates [3].

To flash the software over the UART interface using s-center [3]:

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 10. Make sure the flashing speed is set to 115200.
5. Select **Update**.

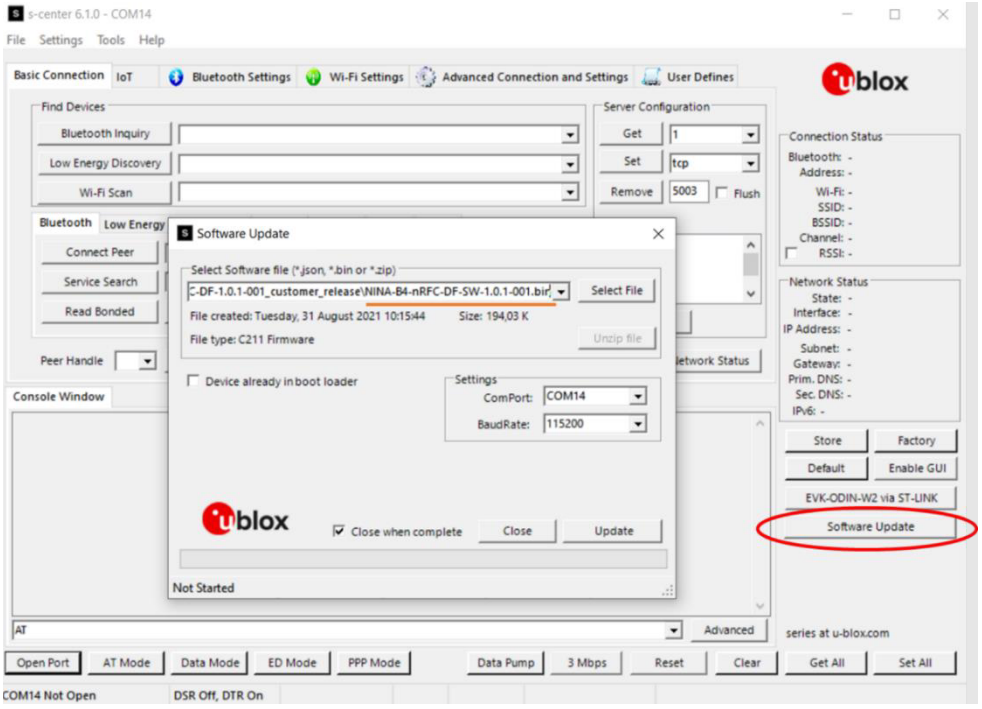

Figure 10: Updating the software on the board using s-center

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 example 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 [5] 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 defined 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:

```
ATUDFFILT=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 [1].

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 [9], the tag must fulfill the following requirements:

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

☞ The default namespace filter in the u-locateEmbed software is filtering on the namespace 0x4E494E412D4234544147. It is necessary to change this to the namespace used by the tag.

5 Handling

⚠ ANT-B11 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 11.

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

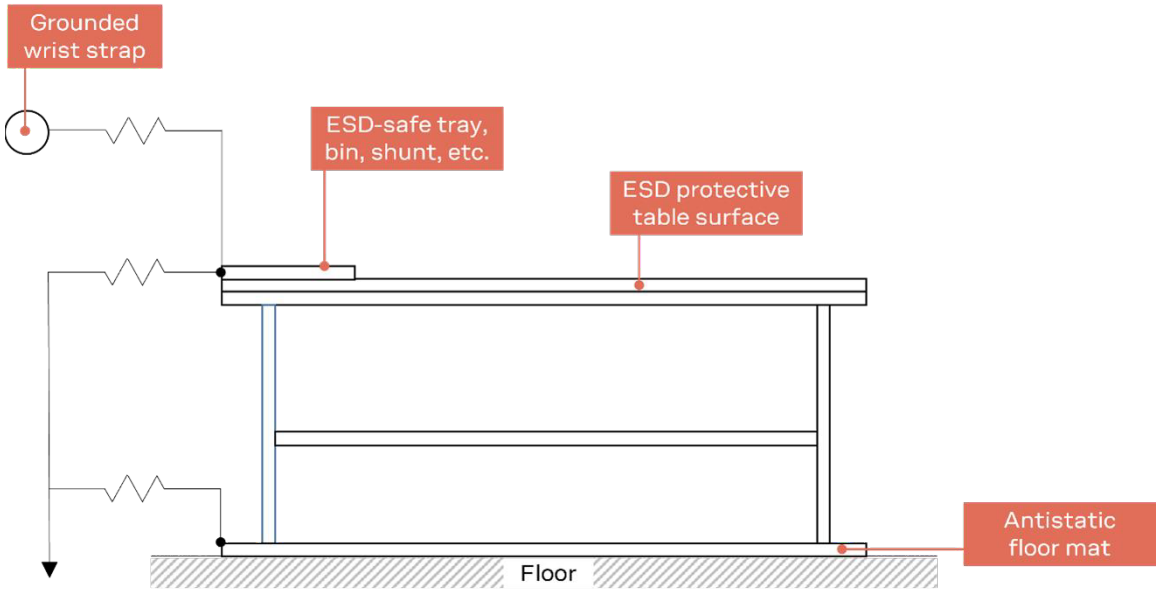

Figure 11: Standard workstation setup for safe handling of ESD-sensitive devices

5.2 Packaging, shipping, storage, and moisture preconditioning

For information pertaining to reels, tapes or trays, moisture sensitivity levels (MSL), shipment and storage, as well as drying for preconditioning, refer to the ANT-B11 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.

In applications that use 25 tags or more, the tags that don't 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 time limit of five seconds here can be re-configured with the "`AT+UDFSCANCFG=1,<new_timer>`".

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

C Low power mode

For a flexible approach to power consumption, 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.

C.1 Radio

Use any of the following methods to decrease power consumption in the radio:

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

C.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. Defines the time interval at which the radio scans for new tags.
9	16 (10ms)	0.625 ms	4-16384 (less/equal of tag 8)	Scan window. Defines how long the radio scans 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.

C.1.2 Adjust the frequency of CTEs transmissions

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

It's 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 [1].

C.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.

C.2 RGB LEDs

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

☞ Only valid for boards with RGB LEDs.

C.3 MCU power save modes

C.3.1 Overview

There are two power save modes available on the antenna board. Turn off UART RX or turn off the MCU.

In UART 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.

In MCU shutdown mode the MCU of the antenna board is shut off and the AoA algorithm is not running. Settings that are not saved are not preserved, and the u-locateEmbed software starts in the same way as it does during the initial power-up.

C.3.2 Enter and exit power save mode

To put the antenna board in sleep mode, use the AT+UPWRSAVE=<mode> command, where the <mode> parameter defines the sleep mode and how the antenna board can wake up from sleep mode. There are four different combinations of sleep modes and wake up procedures available.

Turning off the UART RX:

- **AT+UPWRSAVE=1** By sending any character to the UART, the host wakes up the UART.
- **AT+UPWRSAVE=2** The host pulls GPIO1 low to wake up the UART.

☞ After waking up the UART the host must wait ~50 ms before sending an AT command. To return to sleep mode and save additional power, send the AT+UPWRSAVE=<mode> command again.

☞ The power save method where the UART RX is turned off is available in u-locateEmbed version 3.0 or later

Use the following commands to turn off the MCU and disable AoA:

- **AT+UPWRSAVE=3** By sending any character to the UART, the host wakes up the MCU.
- **AT+UPWRSAVE=4** The host pulls GPIO1 low to wake up the MCU.

☞ The power save method, where the MCU is turned off, is available in u-locateEmbed version 3.2 or later

☞ For modes 3 and 4, the host should wait for the Startup event +STARTUP over the UART before sending AT command.

☞ 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-B11 data sheet, UBX-22037630
[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

☞ 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	26-Jun-2023	mape	Initial release
R02	17-Nov-2023	lliu	Updated flashing instructions and added information describing the angle measurements in u-connectLocate software.
R03	07-Feb-2024	lliu	Updated u-connectLocate to u-locateEmbed. Added appendix, low power mode. Added section, angle definition. Renamed angle1 to direct_angle in angle definition. Added figure of ANT-B11 with UART to USB serial converter in Connection to a host using USB-to-UART adapter.
R04	14-Oct-2024	lliu	Added new figures to show physical dimensions of the board in Mounting and mechanical considerations. Added Direction finding and 2D positioning sections. Modified the document Abstract and updated Functional description.
R05	31-Jan-2025	mape	Added new power save modes in appendix C 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.