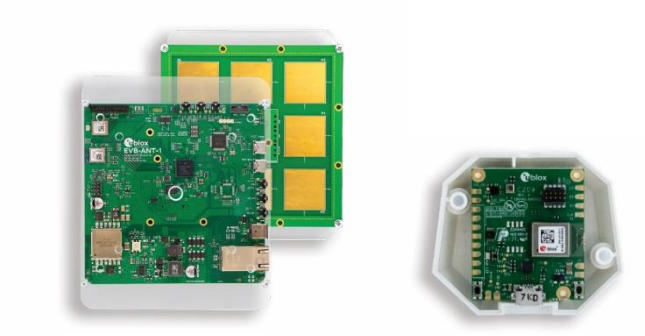
S

XPLR-AOA-3

Evaluation kit for ANT-B10 antenna boards

User guide



Abstract

Comprising an ANT-B10 antenna board, EVB-ANT-1 development platform, and C209 tag, the XPLR-AOA-3 explorer kit provides a complete Angle of Arrival anchor point – and all you need for developing direction-finding and indoor positioning applications.

This document describes the operation and assembly of the kit components and explains the procedures for loading the necessary software. It also includes a Quick start guide to get the XPLR-AOA-3 up and running as quickly as possible.

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C1-Public

Document information

Title	**XPLR-AOA-3**	
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This document applies to the following products:

Product name	Ordering code
XPLR-AOA-3	XPLR-AOA-3-01

☞ ANT-B10 antenna board hosts the NINA-B411-40B, which is a special NINA-B411 variant, standalone Bluetooth module running the u-connectLocate software that supports the u-blox angle-of-arrival (AoA) algorithm.

Contents

1 Quick start guide

Install s-center evaluation software

s-center is a powerful and easy-to-use tool for evaluating, configuring, and testing u-blox short range modules. Running on Windows 10 operating systems, the software allows end users to configure and assess the performance of u-blox short range modules.

Use the following procedure to download and install the s-center software and documentation. The software can be downloaded from the u-blox s-center product page and is available free of charge.

1. Download the latest s-center software to your computer.
2. Open the s-center setup installer to install the software.
3. Select Launch button in the installer or open the application from the Windows Start button.

Install the serial port drivers

EVB-ANT-1 includes a mounted FTDI chip that provides the serial port connectivity. The driver for the UART is normally installed automatically when the board is connected to the PC. If the driver does not start automatically, the driver files can be retrieved from the manufacturer's web site at https://ftdichip.com/.

Connect the ANT-B10 board

Connect the ANT-B10 board to the EVB-ANT-1 board. Physically align the boards and gently plug the 20-pin, male and female header connectors together. See also Assembling the kit.

Install u-connectLocate software on the ANT-B10

u-connectLocate is continuously improved with performance and quality enhancements and it is strongly recommended to always use the latest available version of the u-connectLocate software. See also Flashing using s-center.

Install host software on the EVB-ANT-1

See EVB-ANT-1 .

Install tag software

See C209 Software and flashing.

Test the system

See ANT-B10 configuration and testing for a description of setup and running of the system with the ANT-B10 connected directly to the PC, or EVB-ANT-1 software for a description on how to send the anchor events to a positioning engine over an ethernet or Wi-Fi network.

2 Product description

Comprising an ANT-B10 antenna board, EVB-ANT-1 development platform and C209 tag, the XPLR-AOA-3 explorer kit provides a complete Angle of Arrival anchor point – and all you need for developing direction-finding and indoor positioning applications.

The antenna board runs the u-blox developed u-connectLocate software, while the development board runs an open-source demonstration software that relays angle events from the antenna board. The C209 tag runs example, open-source, tag software. All the cables and adapters that are necessary for mechanically connecting the boards are also included in the kit.

An off-the-shelf pin header on EVB-ANT-1 allows easy connection to ANT-B10. For an overview of the EVB-ANT-1 board and external connections, see also EVB-ANT-1 overview.

☞ The ANT-B11 antenna board [22] features an identical pin header to that used on ANT-B10. Consequently, all information referencing ANT-B10 in this document is also applicable for ANT-B11.

Figure 1 shows the main components of the XPLR-AOA-3 kit with mounted ANT-B10 (left), ANT-B10 antenna board (center), and C209 tag (right).

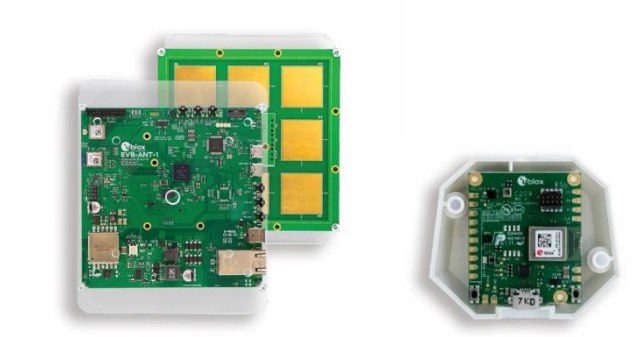


Figure 1: Complete XLPR-AOA-3 kit - showing the EVB-ANT-1 application board (front left), ANT-B10 antenna board (back left) and C209 tag (right)

☞ For information about using the XPLR-AOA-3 kit for indoor positioning and the positioning engine client software for Windows, see also the Bluetooth indoor positioning guide [21].

For general information about Bluetooth direction finding, watch the u-blox webinars [2] and study the Bluetooth SIG technical overview [3].

2.1 Kit includes

- EVB-ANT-1 board
- ANT-B10 antenna board (hosting the NINA-B411 Bluetooth Low Energy module)
- C209 tag (hosting the NINA-B406 Bluetooth Low Energy module)
- Mounting materials. For mounting instructions, see Assembling the kit.
  - Single plexiglass mounting panel
  - Four 30 mm M3 standoffs
  - Four 8 mm M3 standoffs
  - Four M3x6 screws

2.2 Assembling the kit

1. Connect to the ANT-B10 board to the EVB-ANT-1 board. Physically align the boards and gently plug the 20-pin, male and female, header connectors together. Figure 2 shows the location of the header connectors on each board.

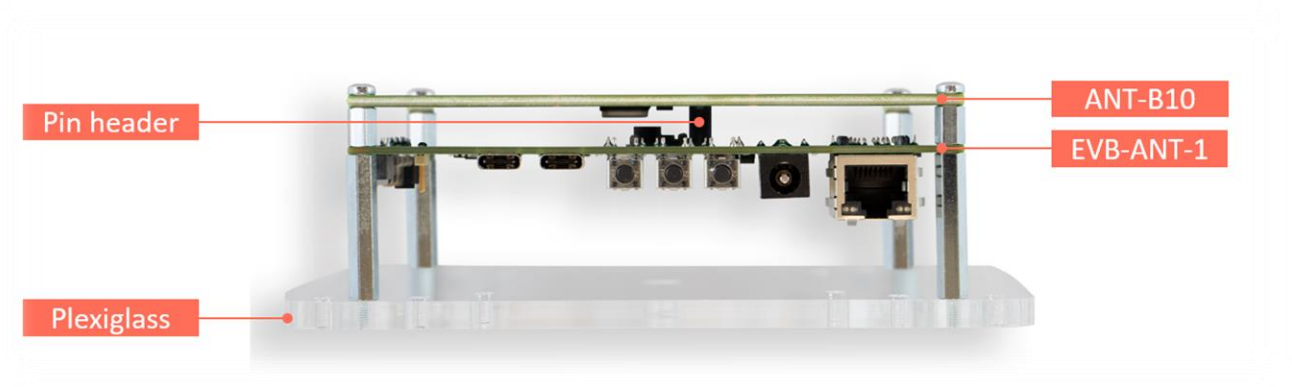


Figure 2: Assembled XPLR-AOA-3 kit showing EVB-ANT-1 and ANT-1 headers

2. Using the supplied standoffs and screws, assemble the two PCBs to the plexiglass, as shown in Figure 3. The assembly order of the components (see Kit includes) are as follows:
   a. Plexiglass
   b. M3 30 mm standoff
   c. EVB-ANT-1 PCB (connector side up)
   d. M3 8mm standoff
   e. ANT-B10 PCB with connector side down, fix the connectors together
   f. M3x6 screw

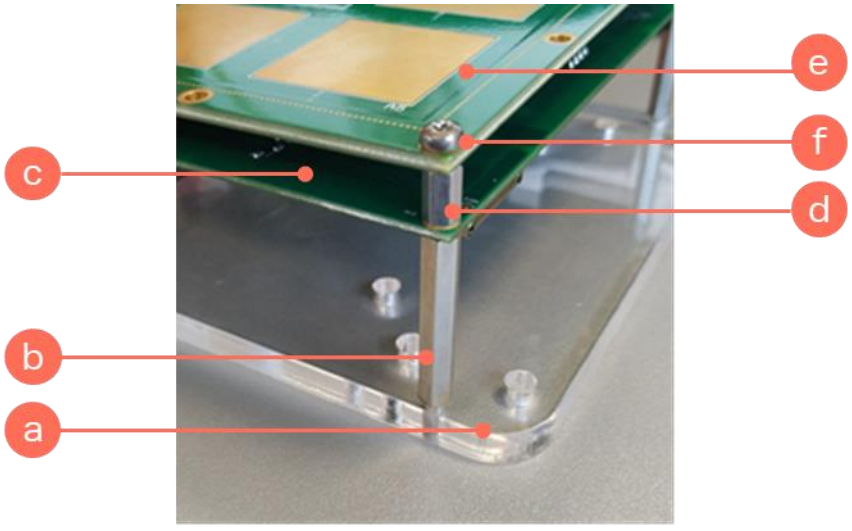


Figure 3: ANT-B10 and EVB-ANT-1 with plexiglass enclosure

☞ The plexiglass has a 3/8" UNC thread available in the middle of the panel. This can be used to connect tripods or via an adapter set use ¼" camera clamps or tripods. It can also be used to mount the anchor node to a wall or ceiling.

⚠ The EVB-ANT-1 PCB is electrostatically sensitive and should not be handled without proper precautions.

3 ANT-B10

The ANT-B10 antenna board provides a versatile Bluetooth® direction finding board equipped with eight, dual-polarized, patch antennas for direction finding, as shown in Figure 4 and Figure 5.

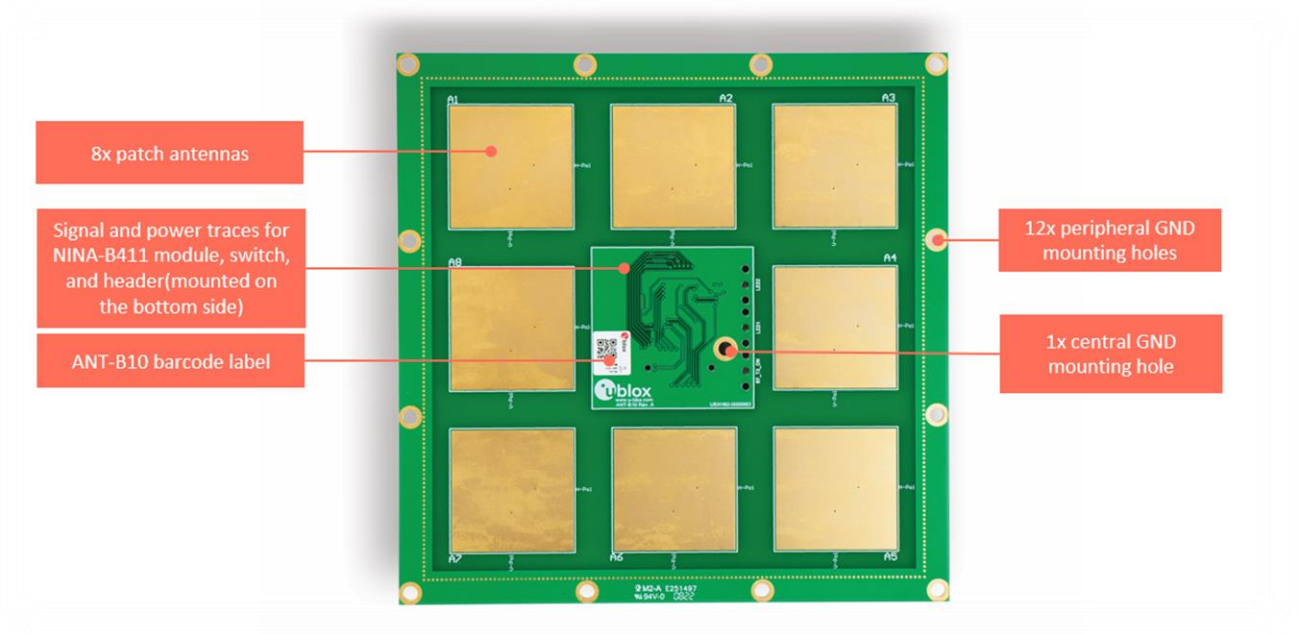


Figure 4: ANT-B10 board – top view showing antennas, traces, and mounting holes

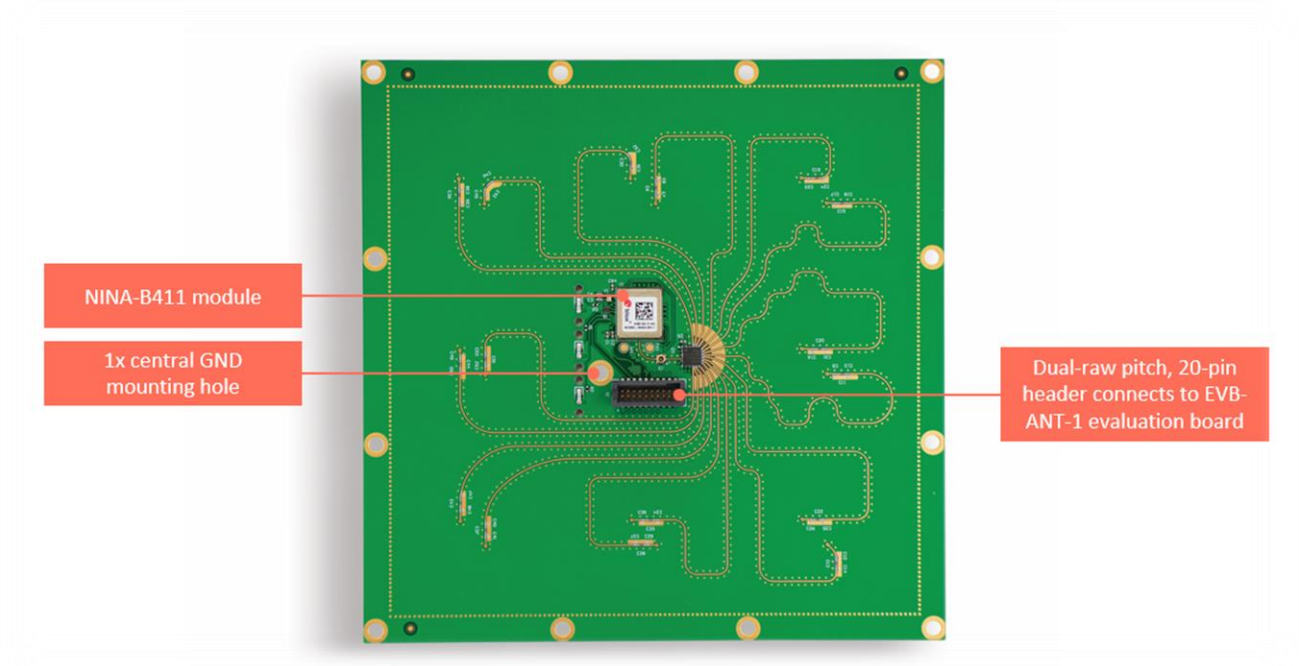


Figure 5: ANT-B10 - bottom view showing NINA-B411 module, switch, and header

The ANT-B10 antenna 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 compute the tag angles. The angles are calculated by the u-connectLocate software running on the embedded Microcontroller Unit (MCU) in the module. The angles are delivered over the UART port of the ANT-B10. Future u-connectLocate software releases are planned to support USB and SPI interfaces.

For more information about ANT-B10, see the ANT-B10 data sheet [1] and ANT-B10 system integration manual [17].

3.1 Flashing using s-center

u-connectLocate 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-connectLocate software over the UART interface requires s-center 6.1 or later.

☞ To flash the software, you can access the UART on ANT-B10 via the EVB-ANT-1 board when the kit is fully assembled. Alternatively, you can connect the pin header directly to a PC. See also UART connections to board and Connecting to a PC.

To flash the software over the UART interface using s-center [7]:

1. Download the u-connectLocate software container from the u-connectLocate product page [4].
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.

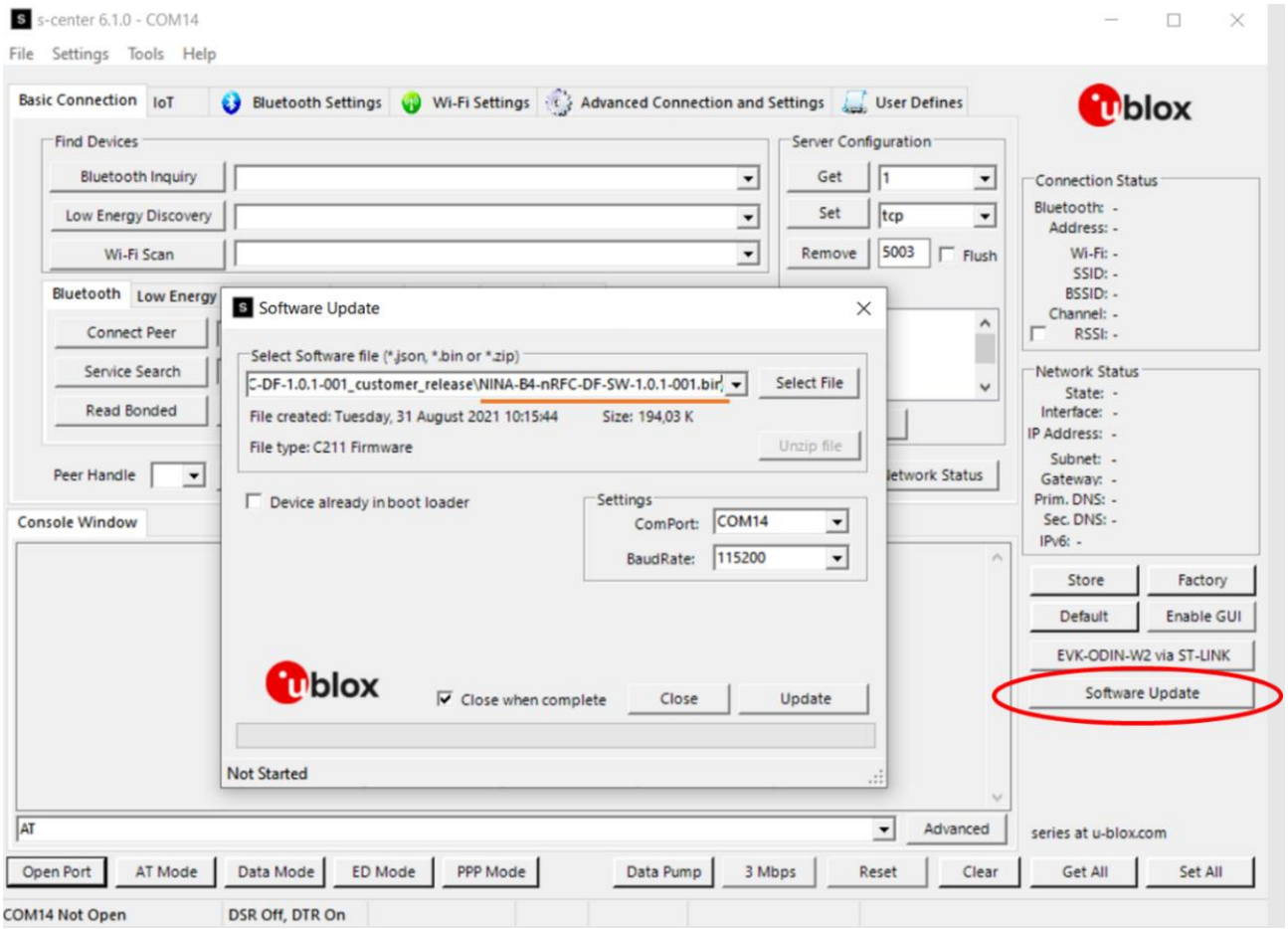


Figure 6: Updating the software on the board using s-center

3.2 Flashing from the Command line

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

1. Download the u-connectLocate software container from the u-connectLocate product page [4].
2. Put the device into firmware update mode; either:
   a. Enter the AT+UFWUPD command [11] 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-connectLocate 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-connectLocate 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 the default baud rate of 115200 or your chosen baud rate.

3.3 ANT-B10 configuration and testing

A green LED light indicates that the board is powered on.

Having connected the COM port, the board is ready to receive AT commands. For information about the AT commands to use for configuring direction finding, see the u-connectLocate AT commands manual [18].

s-center supports specific direction-finding AT commands in the Angle of Arrival tab, as shown in Figure 8. The COM port can also be used with a terminal emulator to type in AT commands.

Once the system is setup, each anchor reports angle calculation events (+UUDF) over the serial port connection. When ANT-B10 detects a beacon it reports events like this:

```
+UUDF:CCF9578E0D8A,-42,20,0,0,37,"CCF9578E0D89","",15869,23
+UUDF:CCF9578E0D8B,-41,10,4,0,38,"CCF9578E0D89","",15892,24
+UUDF:CCF9578E0D8A,-42,-10,2,0,39,"CCF9578E0D89","",15921,25
…
```

The data reported in these events can be used to estimate a position of the tracked beacon. The parameters of the +UUDF event are (from left to right):

- Eddystone instance ID
- RSSI of 1st polarization
- Angle 1
- Angle 2
- Reserved
- Detected channel
- Anchor ID as set by AT+UDFCFG tag 4.
- User defined strings as set by AT+UDFCFG tag 2.
- Timestamp
- Periodic advertising sequence number

In the events reported above, the beacon is moving from one side of the anchor to the other as angle1, which is given as the third parameter in the event (shown in bold).

The beacon moves from a positive value (20) to a negative value (-10). The movement of the tag for these events is shown in Figure 7.

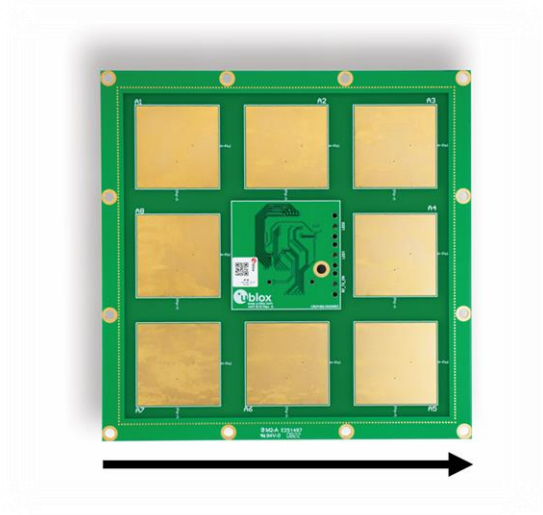


Figure 7: Tag movement

The optimal distance between anchor nodes and tags is approximately 2–15 m.

A slight degradation in the accuracy of the reported angle can be expected close to the outer limits of the angle range. To maximize accuracy, the anchor should normally point to the center of the area of interest.

For information describing how the u-connectLocate algorithm calculates the direction or angles of moving tags, see u-connectLocate software.

Angle events can also be visualized in the s-center [7] using the “IoT > Angle of Arrival” tab, as shown in Figure 8.

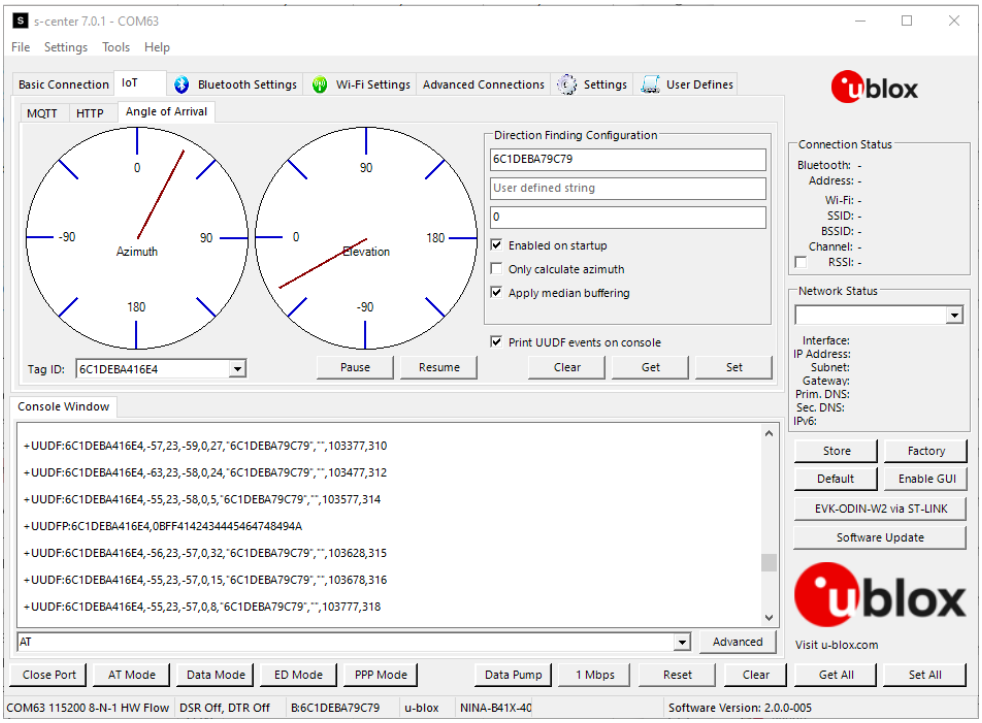


Figure 8: s-center with Angle of Arrival tab

☞ By default, the “Print UUDF events on console” check box is deselected. This means that `+UUDF` angle events are not printed on the console.

3.4 Connecting to a PC

3.4.1 Overview

A host PC can communicate directly with ANT-B10 over UART interface (TX, RX, CTS, RTS) through EVB-ANT-1. The pin-headers connecting the two boards together is physically located in the center of each board. See also Assembling the kit.

To test ANT-B10 as a standalone unit independently of EVB-ANT-1, the host PC can also attach to the UART interface through an expansion board fitted to the underside of the antenna board.

Attaching a USB-to-TTL serial adapter to the expansion board with an adjoining cable harness allows convenient access and control of the UART interface from the PC through the ANT-B10 header. Figure 9 shows the USB adapter attached to ANT-B10 through the standard 1.27 mm pin header.

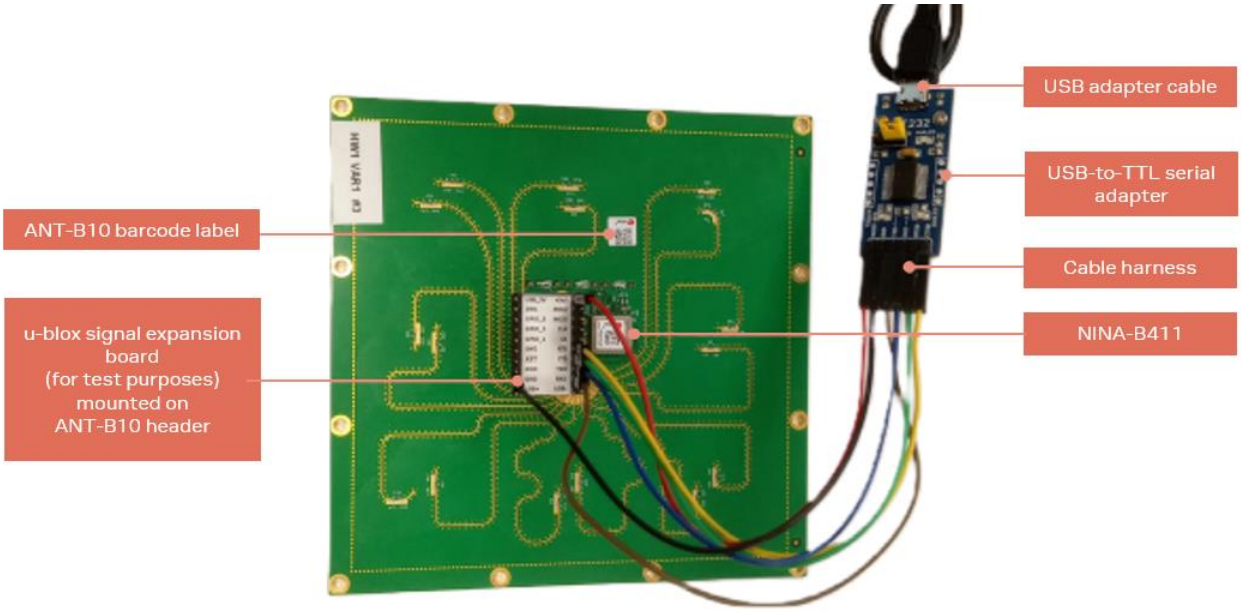


Figure 9: ANT-B10 with UART to USB serial converter

☞ As ANT-B10 is powered by the USB-to-Serial Adapter there is no need for external power supply.

To connect ANT-B10 to the host PC:

1. Plug in the USB-to-Serial adapter
2. Open the Windows Device Manager to identify the COM port number of the board.
3. Use s-center [7] or your preferred terminal emulator to establish the serial connection to the COM port.
4. Connect the COM port to the s-center tool [7] or the terminal emulator with the following port settings:
   - 115200 kbps
   - 8 data bits, no parity, 1 stop bit (8N1)
   - Flow control enabled using RTS/CTS

3.4.2 Pin description for UART connection

Using the cable harness, connect the following pins from the ANT-B10 header to USB-to-Serial adapter:

- **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
- **GND** (pin 15 or 17)
- **+3V3** (pin 2)

☞ If flow control is not used the **UART_CTS** pin is internally pulled down, but it is good practice to connect **UART_CTS** to **GND**.

Figure 10 shows the pin positions on the ANT-B10 connector.

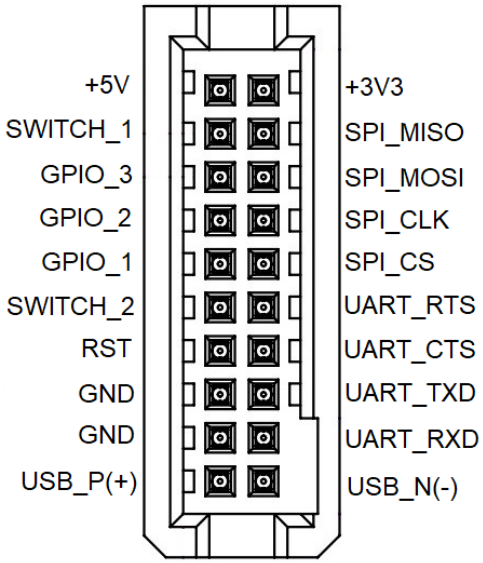


Figure 10: ANT-B10 connector pin assignment (top view)

3.4.3 Suggested accessories

Figure 11 shows (from left to right) the components needed to connect ANT-B10 directly to the host PC.

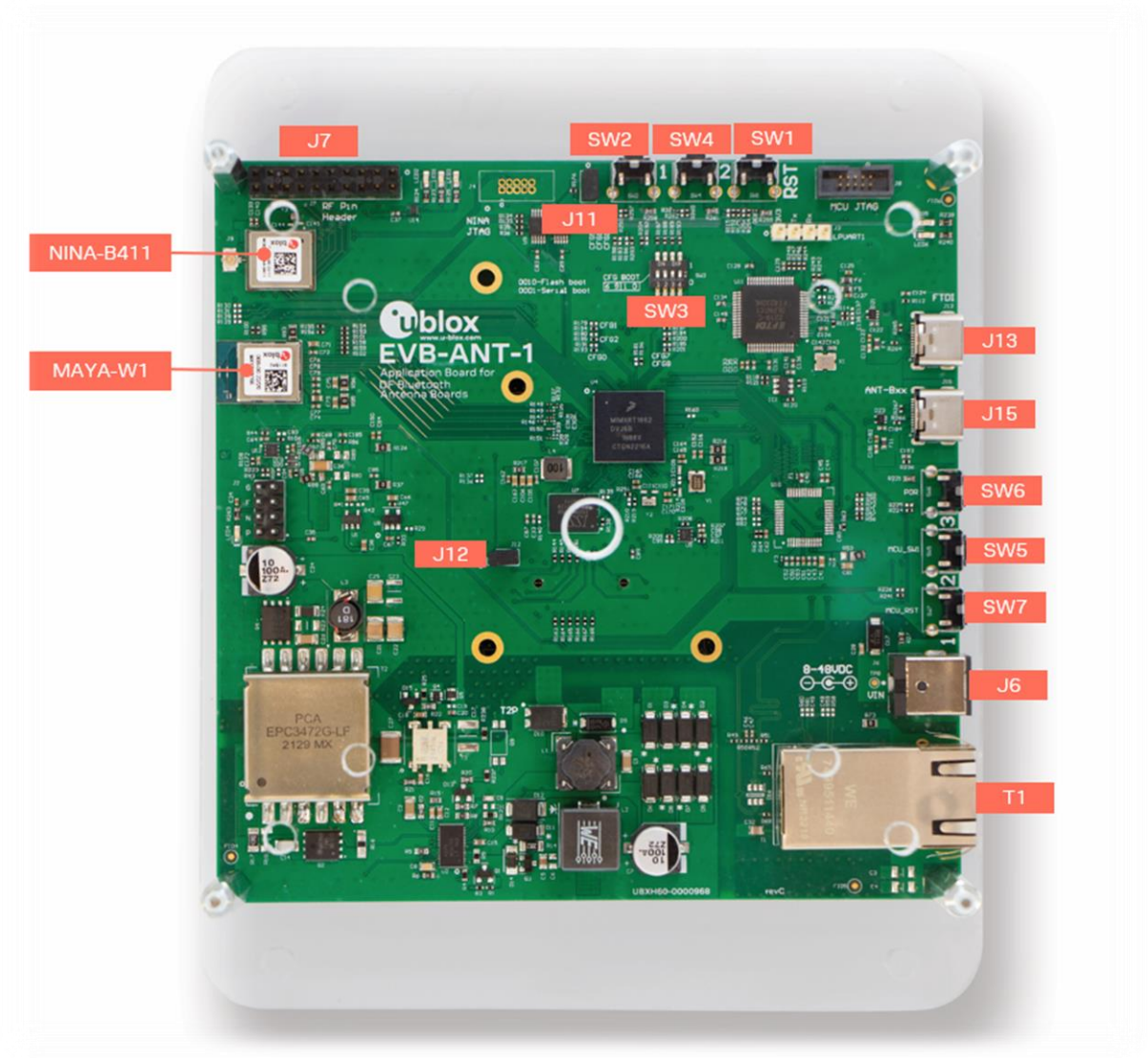
- USB adapter cable with male USB Type-A connector to male mini-B connector
- FTDI FT232RL USB-to-TTL Serial Converter Adapter Module 5 V and 3.3 V for Arduino
- Female-to-female jumper set
- Dual-row, 1.27 mm pitch, 20-pin, female adapter (to avoid pin damage on the ANT-B10 board)

Figure 11: Components required for PC connection

4 EVB-ANT-1

The EVB-ANT-1 application board offers developers a quick and easy way to evaluate the ANT-B10 and ANT-B11 antenna boards. It features the NXP i.MX RT1062 Microcontroller Unit (MCU) for configuring and developing direction finding applications, as well as an Ethernet PHY chip and u-blox MAYA-W1 Wi-Fi module.

Figure 12 shows the modules, jumpers, and connectors on the board that are referenced throughout this document.



J7:	Custom antenna header	SW3:	Boot options (Internal boot/serial downloader)
SW2:	Antenna board connector button (SWITCH1)	SW5:	MCU (NXP i.MX RT1062) user button/reset
SW4:	Antenna board connector button (SWITCH2)	SW6:	System reset
SW1:	Antenna board connector button (RESET)	SW7:	MCU (NXP i.MX RT1062) MCU reset
J11:	Select NINA UART on-board EVB (remove)	J13:	USB type C
J12:	Select NINA UART on ANT-B1 host (remove)	J15:	USB type C
J6:	Barrel jack power connector (auxiliary jack, DC 9-57V)	T1:	RJ45 Ethernet connector (PoE)

Figure 12: EVB-ANT-1 board showing mounted plexiglass base enclosure, modules, jumpers, and connectors

4.1 Introduction

EVB-ANT-1 is a versatile application board for evaluating a system setup, using the ANT-B10 antenna board [1] or other antenna boards.

The EVB-ANT-1 application board can be used as:

- an anchor point passing raw or processed angle events from the antenna board to a server. See also Anchor point.
- a host board for evaluating other antenna boards,. See also Custom antenna support.
- a positioning engine server
- a preprocessor applying filtering or other reformatting of the angle events from the antenna board before passing them on to the network

EVB-ANT-1 has a connector and mechanical dimensions that make it suitable for mounting an ANT-B1x-board. The board is protected with an enclosed plexiglass, as shown in Figure 2.

4.2 EVB-ANT-1 overview

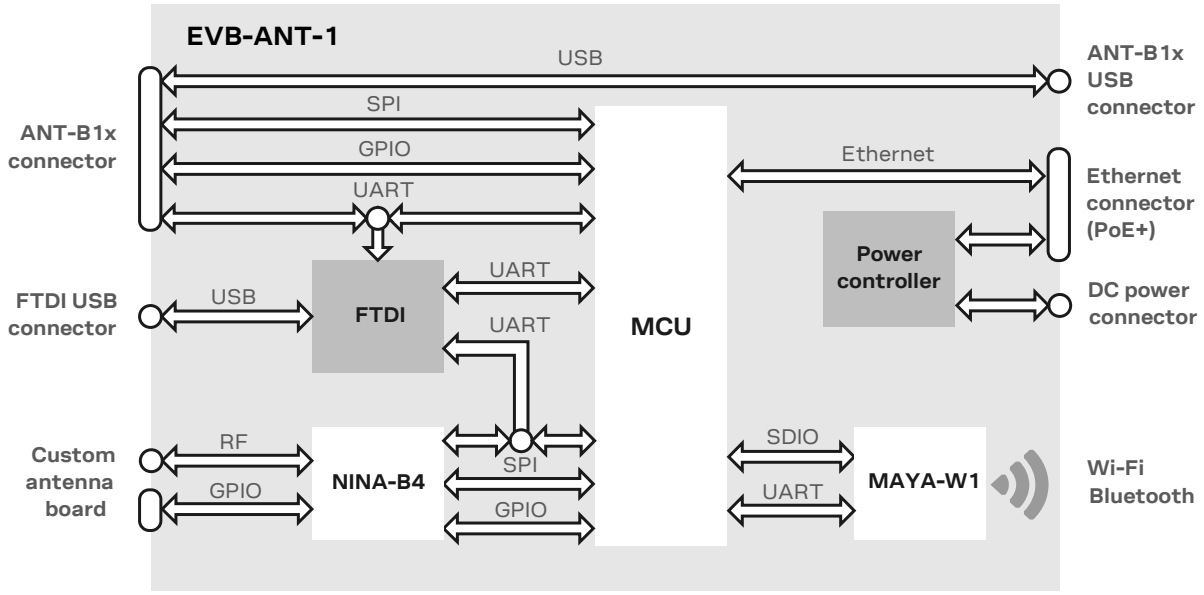


Figure 13 EVB-ANT-1 block diagram

The main components of the EVB-ANT-1 include:

- MAYA-W1 Wi-Fi module for Wi-Fi and Bluetooth connectivity
- Arm® Cortex®-M7 Core MCU (NXP i.MX RT1060 family)
- Ethernet controller for ethernet connectivity
- Power over Ethernet (PoE) controller for powering the board using an Ethernet cable
- NINA-B411 Bluetooth module running u-connectLocate software for evaluating external antenna boards
- Quad UART-to-USB converter providing access to the serial interfaces of the MCU, ANT-B10, and the onboard NINA-B4 module

4.3 Main EVB-ANT-1 use cases

4.3.1 Anchor point

In this use case, the EVB-ANT-1 primarily supports ANT-B family antenna boards and routes direction finding data to a position engine. For this purpose, the microcontroller must communicate with the ANT-B family antenna board Bluetooth module using UART (or SPI) through the ANT-B family connector. Direction finding data is then forwarded through the chosen communication interface – either Ethernet or Wi-Fi using the MAYA-W1 module.

The highlighted areas in Figure 14 show the EVB-ANT-1 components involved in this use case.

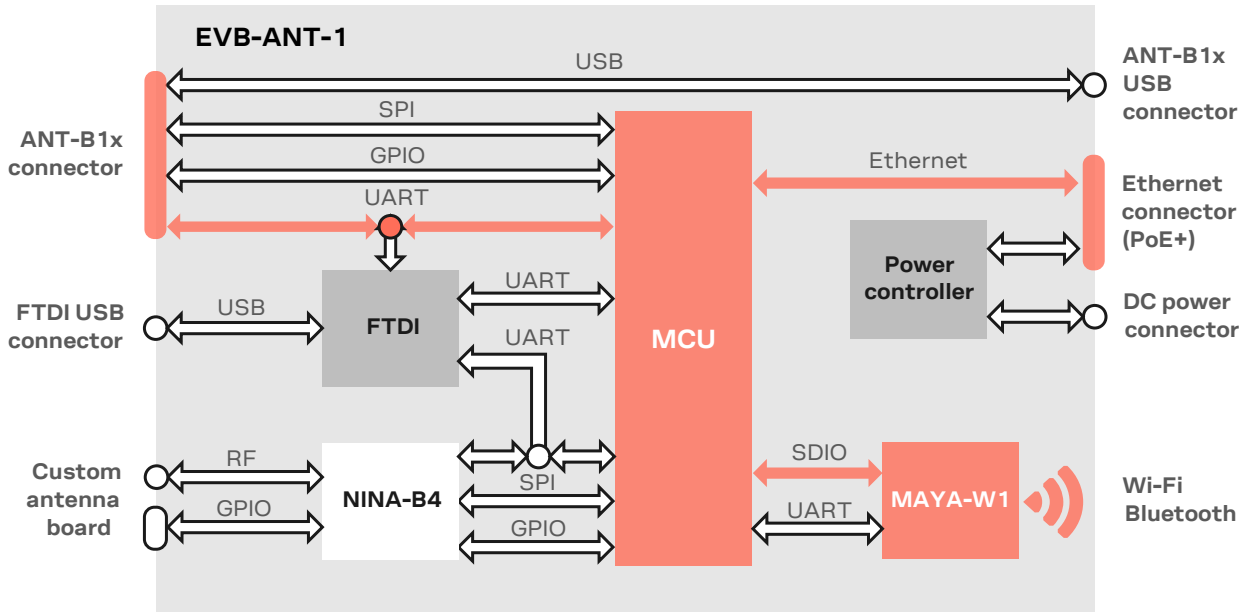


Figure 14: EVB-ANT-1 components involved in the anchor point use case

4.3.2 Custom antenna support

EVB-ANT-1 also supports custom antenna boards that contain an antenna array and an RF switch. To support the use case, an onboard NINA-B411 Bluetooth module can connect to a custom antenna board through a 2.54 mm pitch connector. The module includes the power, the RF switch control signals, and the U.FL connector for the RF signals. The MCU connects to the onboard NINA-B411 through the UART or SPI (pending software support), and GPIOs. Direction finding data can be communicated to a host through the chosen communication interface – either Ethernet or Wi-Fi using the MAYA-W1 module.

The highlighted areas in Figure 15 show the EVB-ANT-1 components involved in this use case.

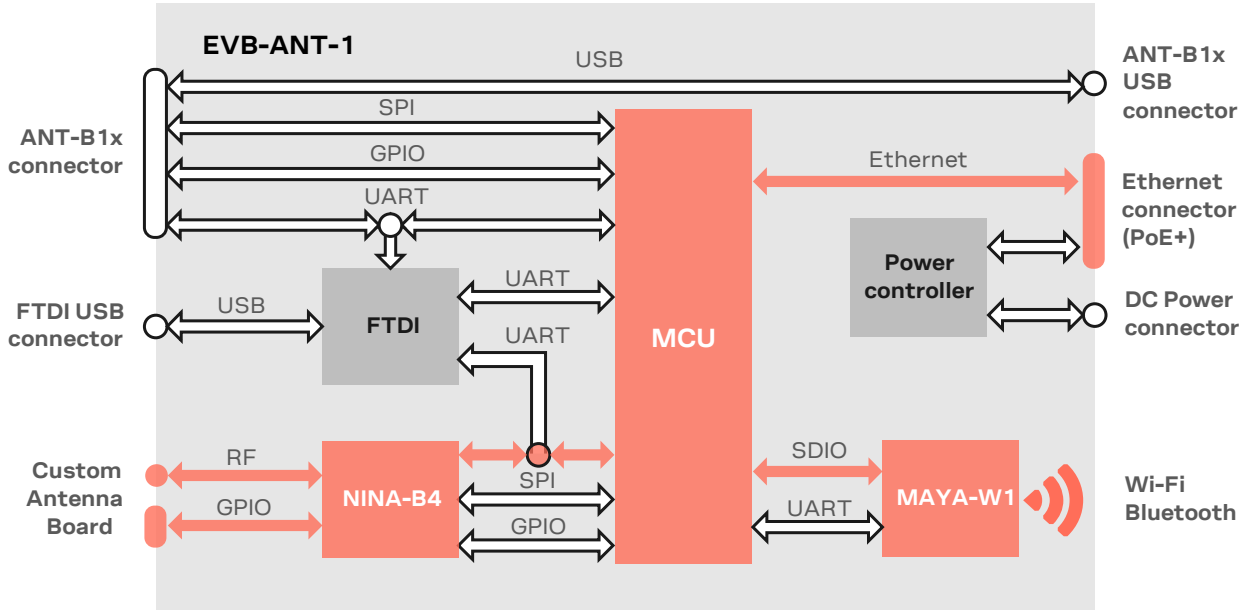


Figure 15: EVB-ANT-1 components involved in antenna evaluation

High speed GPIOs from the onboard NINA-B411 module are broken out to a 20 pin (2x10), 2.54 mm pitch header along with 5 V and 3.3 V power supplies. These GPIOs can be used to drive RF switches that facilitate custom switching of the antenna array. The connector pinout is shown in Figure 16.

Table 1 shows the available signals on the antenna header. These signals are the same as those used on the NINA-B411 hosted on ANT-B family antenna board. Access to these pins from the header pin make it easier to test custom antenna boards.

NINA-B4 pin	Pin name	Header pin	Note
IO 47	SWITCH_D0	4	High speed GPIO
IO 48	SWITCH_D1	8	
IO 49	SWITCH_D2	12	
IO 50	SWITCH_D3	16	
IO 51	SWITCH_D4	18	
IO 52	SWITCH_EN	12	
IO 44	GPIO1	3	General purpose I/O
IO 46	GPIO2	7	General purpose I/O
IO 45	GPIO3	11	General purpose I/O

Table 1: Pins on the NINA-B411 connected to the custom antenna header

The RF signal can be connected to the antenna board through the onboard NINA-B4 U.FL connector, with control signals, as shown in Figure 16.

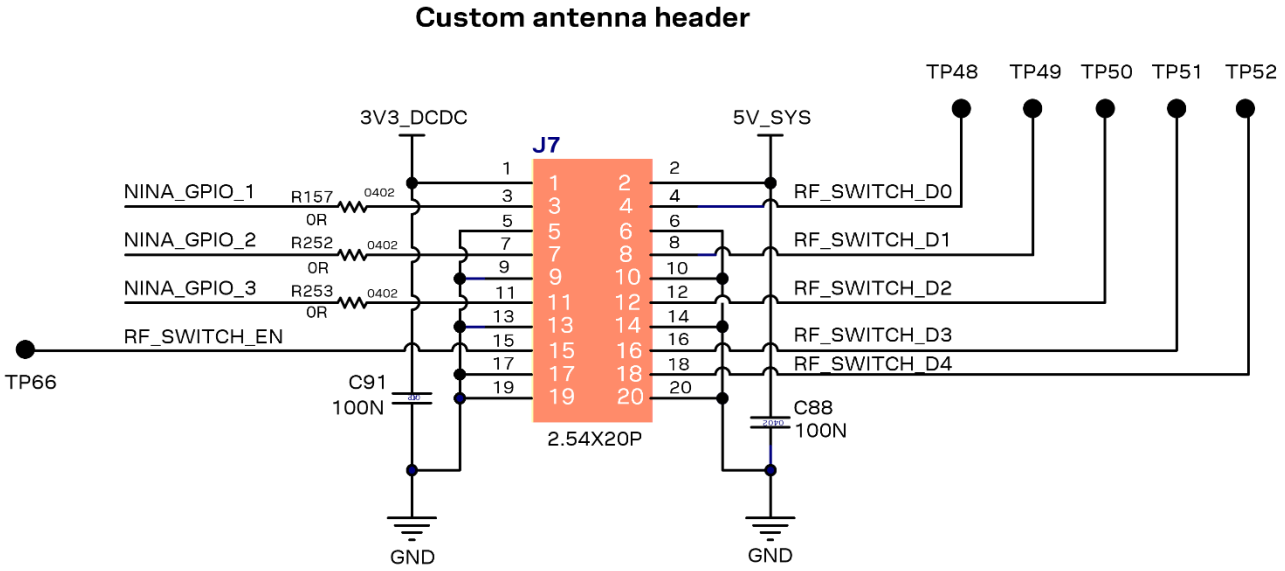


Figure 16: NINA-B4 connector to custom antenna board

4.4 UART connections to board

EVB-ANT-1 supports a quad-channel UART interface that connects to:

- MCU
- NINA-B411 module hosted on the ANT-B family
- onboard NINA-B411 module hosted on EVK-ANT-B1

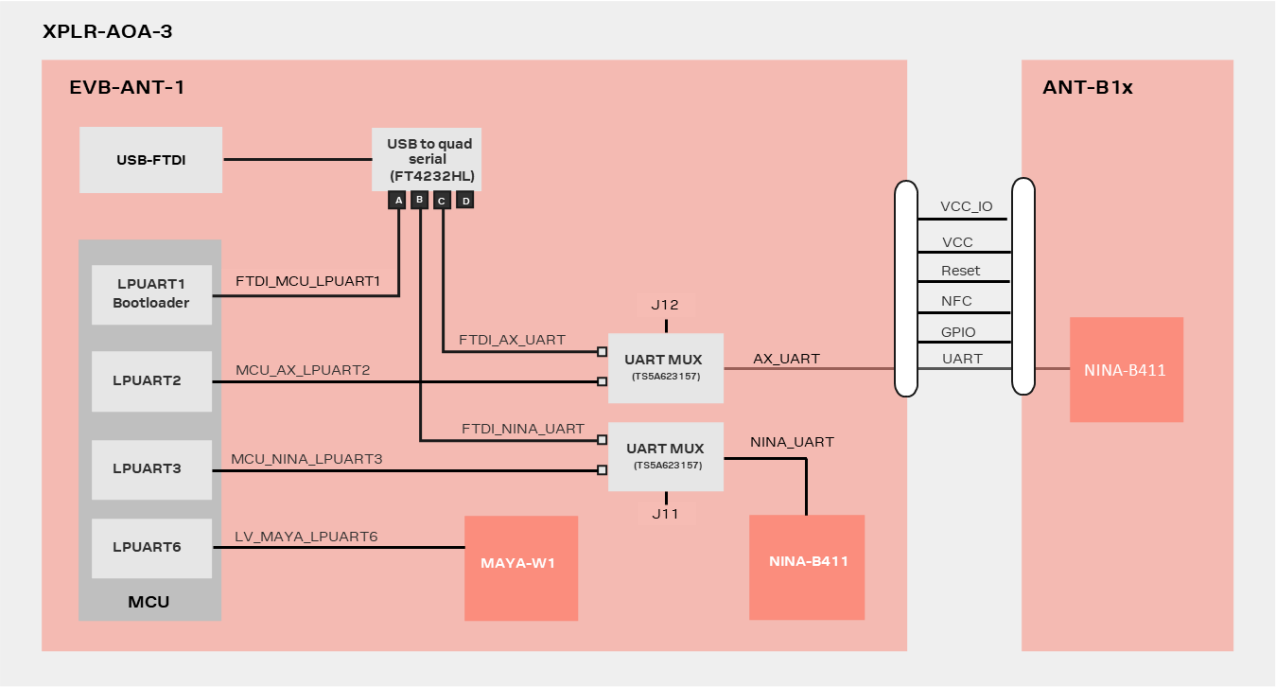


Figure 17: UART connections over USB

The UART connections on the ANT-B family and onboard NINA-B411 are connected to the MCU by default. It is possible to connect directly from the USB connector to either:

- NINA-B411 hosted on the ANT-B family board (with jumper J12 removed)
- onboard NINA-B411 (with jumper J11 removed)

The connection options make it possible to perform software updates or configuration through the UART interface. For jumper locations, see Figure 12.

4.5 EVB-ANT-1 software

4.5.1 Default software

The board comes flashed with example software that implements the Anchor point use case.

The software is developed using NXP's MCUXpresso Software and Tools and is available as an open-source resource from the dedicated GitHub repository [19].

Follow the `README` file in the GitHub repository for further instructions.

4.5.2 Flashing

EVB-ANT-1 is normally flashed over the JTAG interface on the board. A debugger and a cable for the 19-pin JTAG interface is needed.

The code is stored on a NOR flash connected to the MCU.

It is also possible to use the Serial downloader over USB. This is done by changing the boot configuration to start up in Serial downloader mode, see Boot options.

4.5.3 Web configuration interface

EVB-ANT-1 supports an Ethernet web interface that is preconfigured with IP address 192.168.1.102 and subnet mask 255.255.255.0. To connect EVB-ANT-1 to a router or directly to a PC, enter "http://192.168.1.102/" in your browser and configure the platform with the same subnet as the connected device. The network parameters are configured from the web interface on port 80 of each device, as shown in Figure 18. For further information about configuring the platform, see also the `README.md` notes in EVB-ANT-1 software GitHub repository [19].

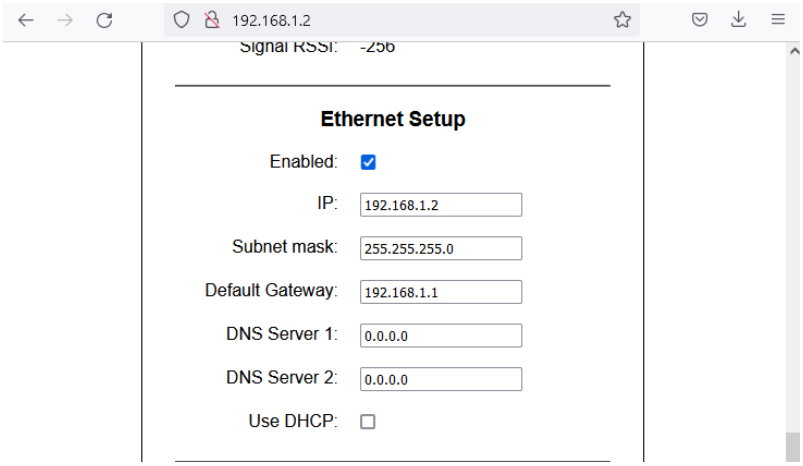


Figure 18: EVB-ANT-1 default software configuration interface with Ethernet network configuration

☞ The Anchor point is enabled in the default software on EVB-ANT-1.

From the web configuration interface, you can:

- Configure network settings for Wi-Fi and ethernet. The default IP address of EVB-ANT-1 is a fixed IP address of 192.168.1.102.
- Send UDP packets containing angle events generated by the anchor. It is often convenient to broadcast the address of the network, as shown in Figure 19.
- Configure the active NINA-B411 module as either the NINA-B411 mounted on the ANT-B10 board or the onboard NINA-B411 (connected to the custom antenna header).

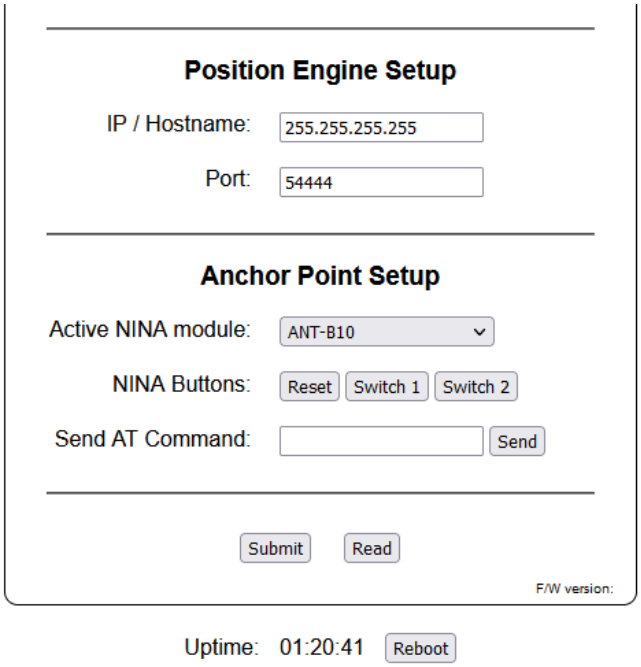


Figure 19: Configuring the active NINA-B411 and destination for angle events

After updating the configuration, select **Submit** to send it to the MCU and save it to flash. Select **Read** to retrieve current configuration.

4.5.4 SW Reset

To reset EVB-ANT-1 software settings, press and hold the SW5 button for 2 seconds during board bootup. The location of SW5 and other buttons is shown in Figure 12.

4.6 Boot options

Use the SW3 DIP switches to set the board in regular boot mode or serial downloader mode, as shown in Table 2.

Switch/Boot option	Switch 1	Switch 2	Switch 3	Switch 4
Boot from flash	Off	Off	On	Off
Serial Downloader	Off	Off	Off	On

Table 2: Boot options using switch SW3

4.7 Powering options

EVB-ANT-1 is powered by either:

- Power over Ethernet
- An auxiliary jack (DC 9-57V)
- USB type C (2 connectors available on the board)

The powering options for the platform are controlled with jumper J2, as shown in Figure 20.

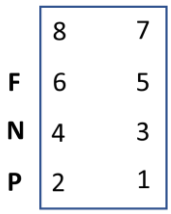


Figure 20: Jumper J2 powering options

J2 jumper settings are described in Table 3.

Jumper position	Pins	Power setting
P	1–2	Power over Ethernet or barrel jack. When the barrel jack is present and connected to a voltage source, the device automatically gives priority to that, even if a PoE switch is also connected to the ethernet plug.
N	3–4	USB connector J15 (USB interface of the ANT-B10).
F	5–6	USB connector J13 (USB connector of the FTDI chip for UART connection to the processors on EVB-ANT-1 or the antenna board).

Table 3 Jumper J2 settings

4.8 Mechanical specifications

EVB-ANT-1 Dimensions: 126.09 mm x 126.09 mm.

EVB-ANT-1 has four mounting holes that match the four corner holes on the ANT-B family antenna board for screw mounting, as shown in Figure 21.

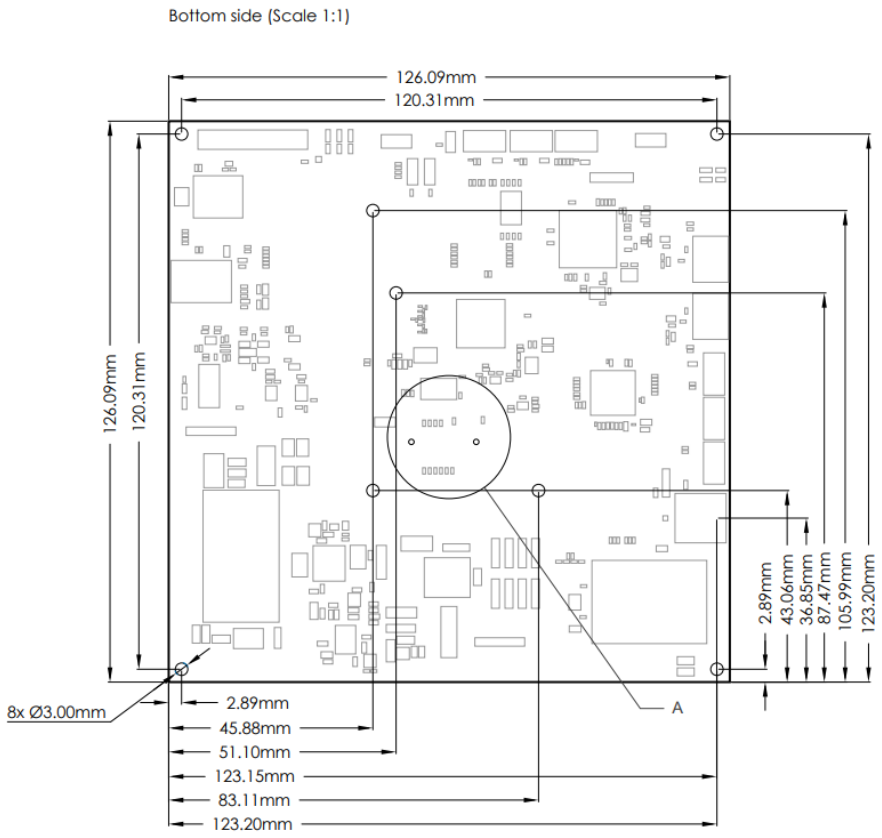


Figure 21: EVB-ANT-1 mechanical dimensions

4.9 Notes

4.9.1 Hardware and software revisions

The hardware revisions available for EVB-ANT-1 are shown in Table 4.

Hardware revision	Notes
B	Initial revision
C	Offers improved ethernet stability compared to revision B

Table 4 EVB-ANT-1 hardware revisions

The revisions of EVB-ANT-1 example software now available on GitHub [19] are shown in Table 5.

Software revision	Notes	Compatibility
0.1	Initial version published	Hardware revision B only
1.0	General updates	Compatible with hardware revisions B and C

Table 5 EVB-ANT-1 example software revisions

4.9.2 Limitations and known issues

The issues described in this section relate to both the EVB-ANT-1 hardware and the example software from GitHub [19].

- The ethernet functionality works best if the ethernet cable is plugged to the board before startup.
- To implement changes in the configuration, EVB-ANT-1 must be rebooted.
- The configuration web page doesn't use secure communication
- The Wi-Fi pass phrase is stored internally in the module in plain text and not encrypted

5 C209 tag

The C209 is a tag based on the NINA-B406 Bluetooth LE module. C209 tags are delivered with bootloader software only and do not include the tag software. Please see 5.2 on how to flash tag software. The tag runs tag software that sends Bluetooth 5.1 advertisement messages to the ANT-B10 antenna board, which determine the direction of the tag using the u-connectLocate software.

☞ C209 is an example implementation of a tag, which is not optimized nor available as a separate product.

5.1 Overview

The C209 provides a versatile beacon example that is suitable for use as an AoA tag. It is advisable to test ANT-B10 boards together with C209 tags and u-blox C209 tag software [12].

Figure 22: C209 tag in open plastic enclosure

C209 tags are based on the open CPU NINA-B406 module variant. C209 tags run on custom tag software that advertises an Eddystone beacon using extended advertising and periodic advertising with a Constant Tone Extension added to the periodic advertising packets. This CTE is used by the u-connectLocate direction finding software that runs on the antenna application board and calculates the Angle of Arrival.

The namespace included in the transmitted Eddystone-UID beacon is `0x4E494E412D4234544147` and the instance ID is based on the MAC address of the NINA-B406 found on the module QR code label.

C209 tags are powered by a single CR2032 battery (*not included*) or through the USB connector.

C209 tags include several sensors for use in a multitude of different applications. The on-board sensors include:

- LIS2DW12 accelerometer
- APDS-9306 ambient light sensor
- BME280 humidity, pressure, and temperature sensor

The main components of any C209 tag are shown in Figure 23.

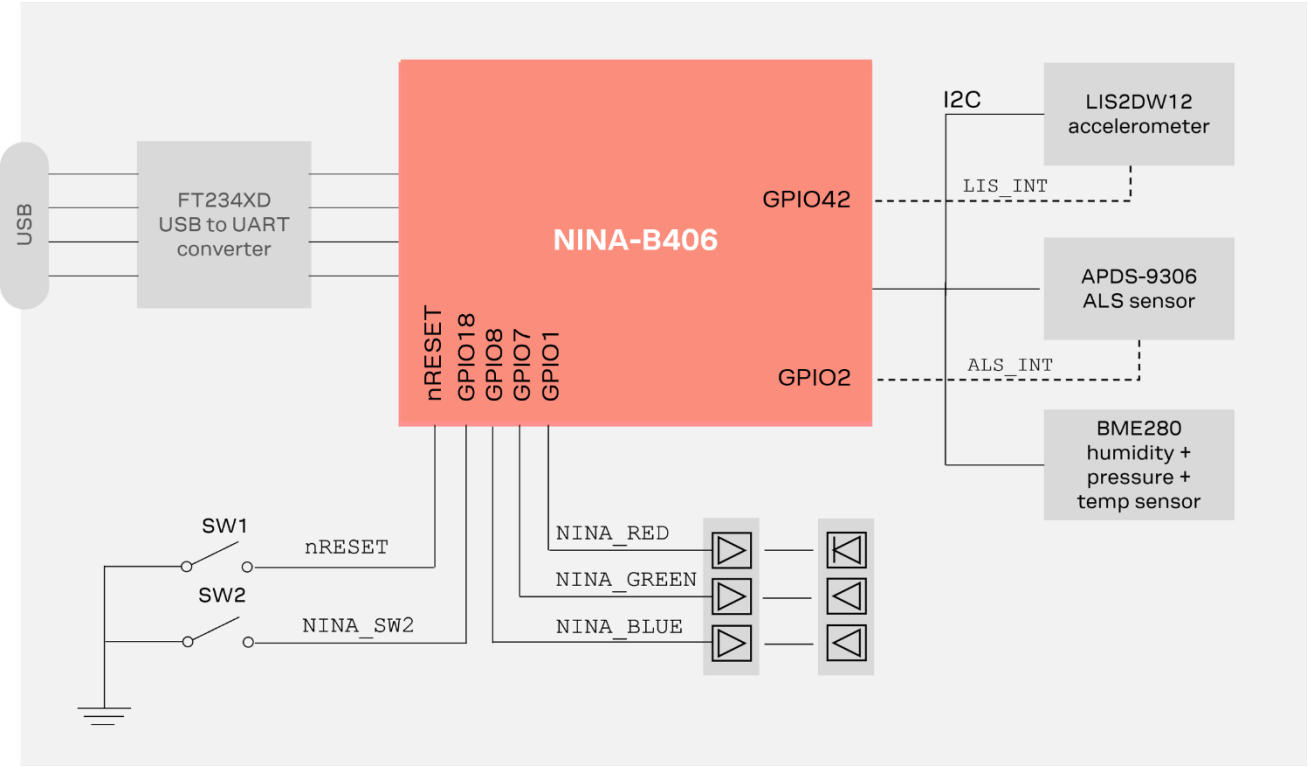


Figure 23: C209 main functional components

The important pin definitions on the C209 application board are described in Table 6.

No.	Name	I/O	Description	Remarks
GPIO_1	RED	O	RED system status signal	Active low
GPIO_2	LIS_INT	I	Interrupt signal from Ambient Light Sensor	May cause current leak in default configuration. See C209 GitHub repository [12] for more information.
GPIO_7	GREEN	O	GREEN system status signal	Active low
GPIO_8	BLUE	O	BLUE system status signal	Active low
GPIO_18	SWITCH_2	I	Switch_2 button	Active low
GPIO_20	UART_RTS	O	UART request to send control signal	Used only when hardware flow control is enabled
GPIO_21	UART_CTS	I	UART clear to send control signal	Used only when hardware flow control is enabled
GPIO_22	UART_TXD	O	UART data output	
GPIO_23	UART_RXD	I	UART data input	
GPIO_42	LIS_INT	I	Interrupt signal from accelerometer	

Table 6: Important pin definitions on the C209

For more information about programming the module, see also the NINA-B4 system integration manual [13] and NINA-B40 data sheet [14]. See also C209 schematics.

☞ Although the sensors on the C209 application board are not used in the latest direction-finding tag software from u-blox, the sensors can be utilized in any customer application.

5.2 C209 Software and flashing

C209 tags are delivered with bootloader software only and do not include the tag software (available from Github [12]) needed for the device to advertise Bluetooth beacons to anchor nodes.

The bootloader on C209 tags is different than that supplied on anchor nodes, and the nrfutil [15] flashing tool is needed to install software over the UART interface with the boot loader.

u-blox C209 tag software can be installed using the DFU bootloader or an external debugger. Precompiled packages for each installation option are available from the u-blox C209 software repository [12].

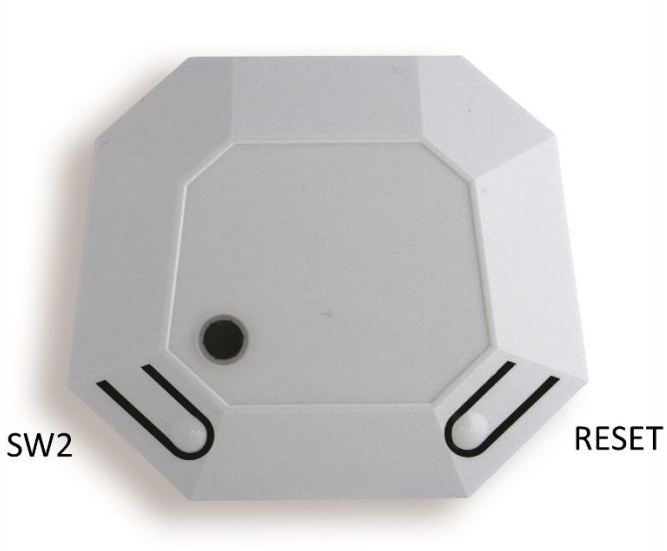


Figure 24: C209 with enclosure

5.2.1 Installing tag software with the DFU bootloader using s-center

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

To flash C209 tags over the UART using s-center [7].

1. Download and unpack the `c209_aoa_tag_<version>.zip` file from the u-blox C209 software repository using this direct link, or go to the "Releases" section in the main GitHub repository page [12]. The unpacked file includes the `NINA-B4-DF-TAG-SW-<version>.zip` file used for the installation.
2. Press and hold the SW2 button on the C209 while resetting the board (by inserting the USB cable or clicking the RESET button) to set the bootloader in "download" mode. See also Figure 24.
3. Open s-center on the correct COM port once the module is in the software download mode.
4. Select **Software Update**.
5. In the "Software Update" dialog, select the `NINA-B4-DF-TAG-SW-<version>.zip` file from the software container, as shown in Figure 25. Make sure the flashing speed is set to 115200, and that you select the zip from a folder with "`for_dfu_boot`" in the name.
6. Press **Update**.

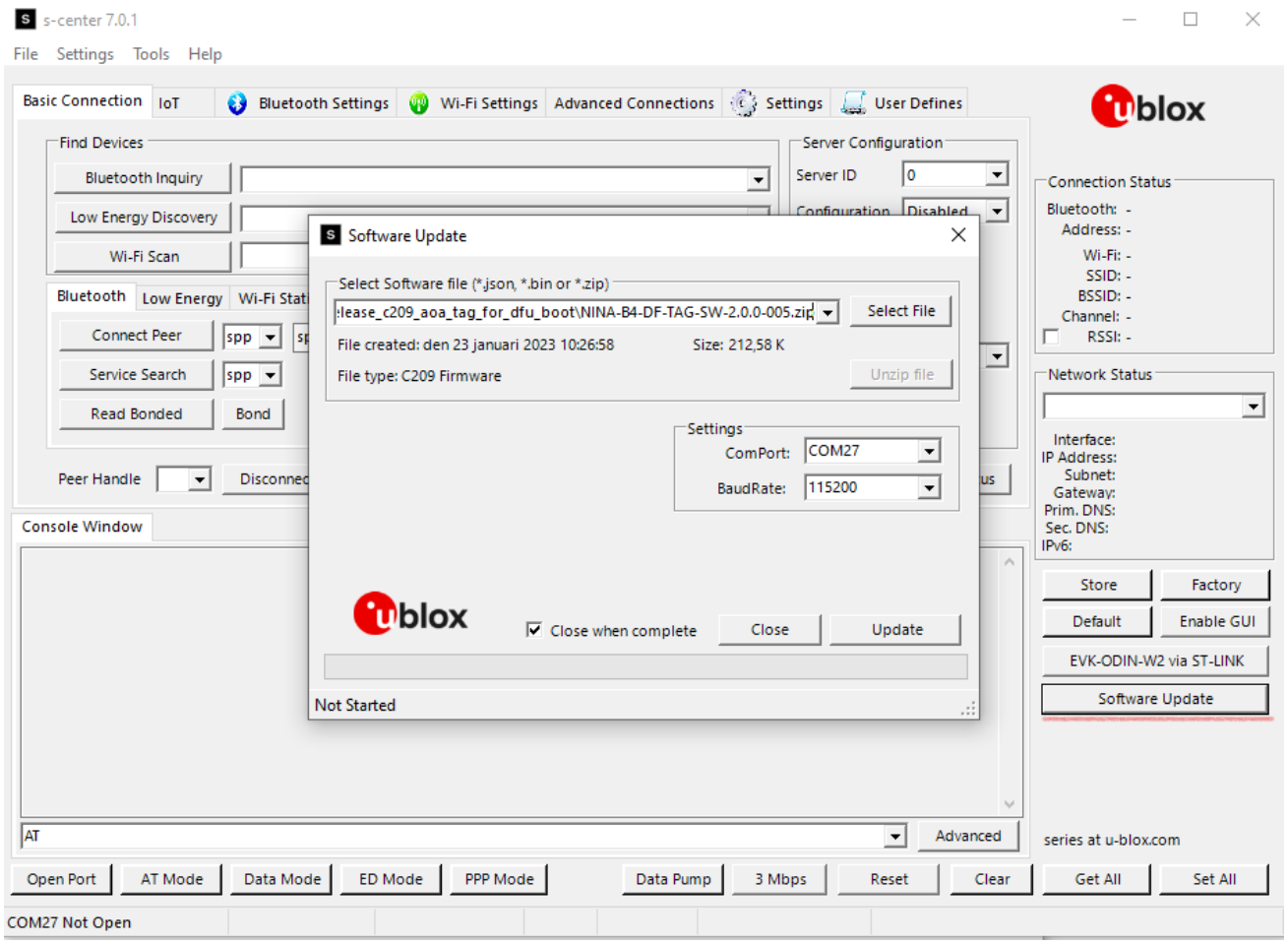


Figure 25: Updating the software on the C209 board using s-center

5.2.2 Installing tag software on the command line with the DFU bootloader

To install C209 tag software with the pre-flashed DFU bootloader on NINA-B406:

1. Download and install the nrfutil flashing tool from the Nordic Github repository [15].
2. Download and unpack the `c209_aoa_tag_<version>.zip` file from the u-blox C209 software repository using this direct link, or go to the "Releases" section from the main GitHub repository page [12]. The unpacked file includes the `NINA-B4-DF-TAG-SW-<version>.zip` file used for the installation, in one of the folders with "`for_dfu_boot`" in the name.
3. Press and hold the SW2 button on the C209 while resetting the board (by inserting the USB cable or clicking the RESET button) to set the bootloader in "download" mode. See also Figure 24.
4. Use the following command to install the C209 tag software using nrfutil:

```
nrfutil dfu serial -pkg NINA-B4-DF-TAG-SW-<version>.zip -p COMXX -b 115200 -fc 1
```

☞ Replace `COMXX` with the appropriate COM port for your system and `<version>` with the current version.

5.2.3 Installing tag software using a debugger

C209 tag software can also be installed using a debugger connected through the J10 10-pin contact on the PCB. To install C209 tag software with the pre-flashed DFU bootloader on NINA-B406:

1. Download the `c209_aoa_tag_<version>.zip` from the u-blox C209 software repository [12] and read the releases section.
2. Unzip the downloaded file.
3. Connect the debugger to the 10-pin contact on the C209.
4. Flash the hex file from the folder named `release_c209_aoa_tag_no_boot_required` in the unpacked the zip using your debugger.

☞ This operation will overwrite the boot loader on the module. The C209 GitHub repository [12] includes instructions for restoring the boot loader.

5.3 Configuration and handling

5.3.1 Configuring advertising interval

Press the SW2 button on the C209 to change the advertising interval.

When SW2 is pressed, the advertising interval cycles through the available advertising intervals. For best performance, it is advisable to use the fastest advertising interval. The LED will blink shortly to indicate the advertising interval, with 1 blink indicating the fastest advertising.

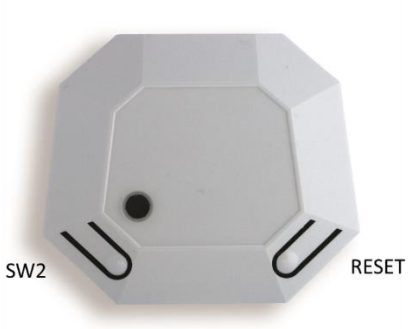


Figure 26: C209 with cover and buttons

C209 tags are simply configured over the UART interface using AT commands.

The AT commands that can be used to configure the interface are described in Table 7.

Command	Description
`AT+UMLA=1`	Read Local MAC address
`AT+GMM`	Read the model identifier, NINA-B4-TAG
`AT+TXPWR=<valid_tx_power>`	<valid_tx_power> can be one of: -40, -30, -20, -16, -12, -8, -4, 0, 2, 3, 4, 5, 6, 7, 8 (dBm)
`AT+TXPWR?`	Query the set TX power

Table 7: C209 AT commands

☞ For `+TXPWR` to take effect the software must be reset – either by pressing the reset button or power cycling the module. The configuration is persistently stored in flash.

All commands are echoed and responded with either `\r\nOK\r\n` or `\r\nERROR\r\n`, and should be terminated with `\r`.

☞ The UART interface is available for 10 seconds after reset with the settings 115200 bps, with no flow control.

5.3.2 Enabling/disabling advertising

Press and hold the SW2 button for ~3 seconds to enable/disable advertising. If the tag is advertising, press and hold the button to stop it advertising. The onboard RGB LED blinks blue when advertising is enabled. The blinking interval correlates to the advertising interval.

5.3.3 Restore Eddystone Instance ID

All u-blox modules are delivered with a u-blox MAC address, which is written into the UICR register.

If the MAC address is accidentally erased, for example during a reflash of the software, this information is lost. If this happens, the Eddystone Instance ID transmitted in the C209 advertising beacon will not match the MAC address of the module. To correct this:

1. Scan the QR code on the module label. The information in the code includes a code that includes the MAC address (shown here in bold): H85(**CCF9578E0D89**)0400.
2. While having a debugger connected to the SWD interface of the board enter these commands to reinstate the MAC address **CCF9578E0D89** into the UICR of the module:

   ```
   nrfjprog --memwr 0x10001080 --val 0x8E57F9CC
   nrfjprog --memwr 0x10001084 --val 0xFFFF890D
   ```

   Another example for which the MAC address given in the scan code is **0123456789AB**:

   ```
   nrfjprog --memwr 0x10001080 --val 0x67452301
   nrfjprog --memwr 0x10001084 --val 0xFFFFAB89
   ```

3. After writing the MAC address, reset the module. The module now transmits the correct Eddystone Instance ID for the C209 tag.

6 u-connectLocate software

u-connectLocate 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 the purpose of simplifying the graphical representation of tag angles in a 3D diagram, the complementary angles (angle1' and angle2') on which the reported angles (angle1 and angle2) are calculated are shown in Figure 27. The angles shown are between the y-axis, z-axis and the tag gradient from the origin point. The white dots represent the antenna board, and the x-axis represents the normal orientation of the board.

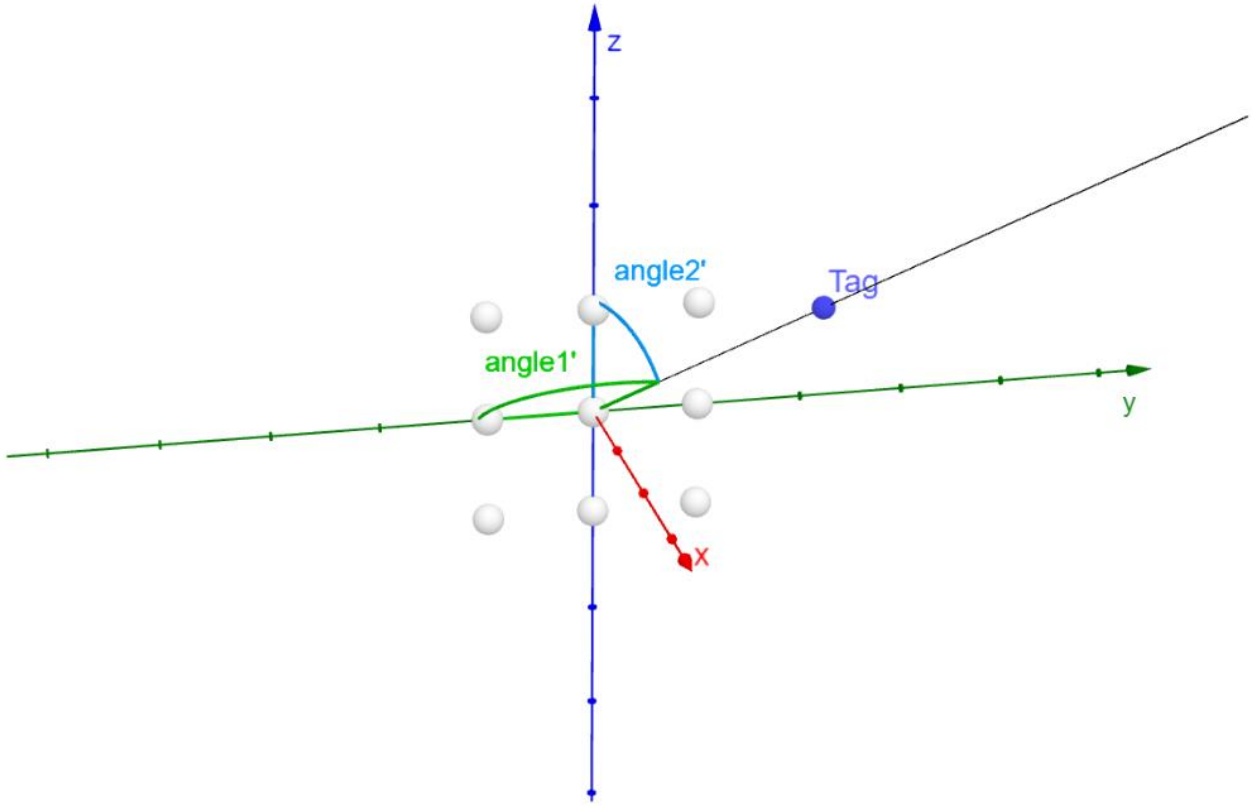


Figure 27: 3D space diagram – showing complementary angles on which the reported angles are based

u-connectLocate reports two angles, “angle1” and “angle2”, where:

- **angle1**=90°-angle1'
- **angle2**=90°-angle2'

Note that “angle1” is positive from the positive x-axis to negative y-axis but is negative from the positive x-axis towards the positive y-axis. Conversely, “angle2” is positive from the positive x-axis towards the positive z-axis but is negative in going 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.

⚠ Upgrading the software resets all settings to factory default.

6.1 Configuration example

By default, u-connectLocate comes pre-configured to track all u-blox tags. The tags advertise with the Eddystone namespace `0x4E494E412D4234544147`, which by default is tracked in u-connectLocate. 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=1,2,”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. For further information, see the u-connectLocate AT command manual [18].

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

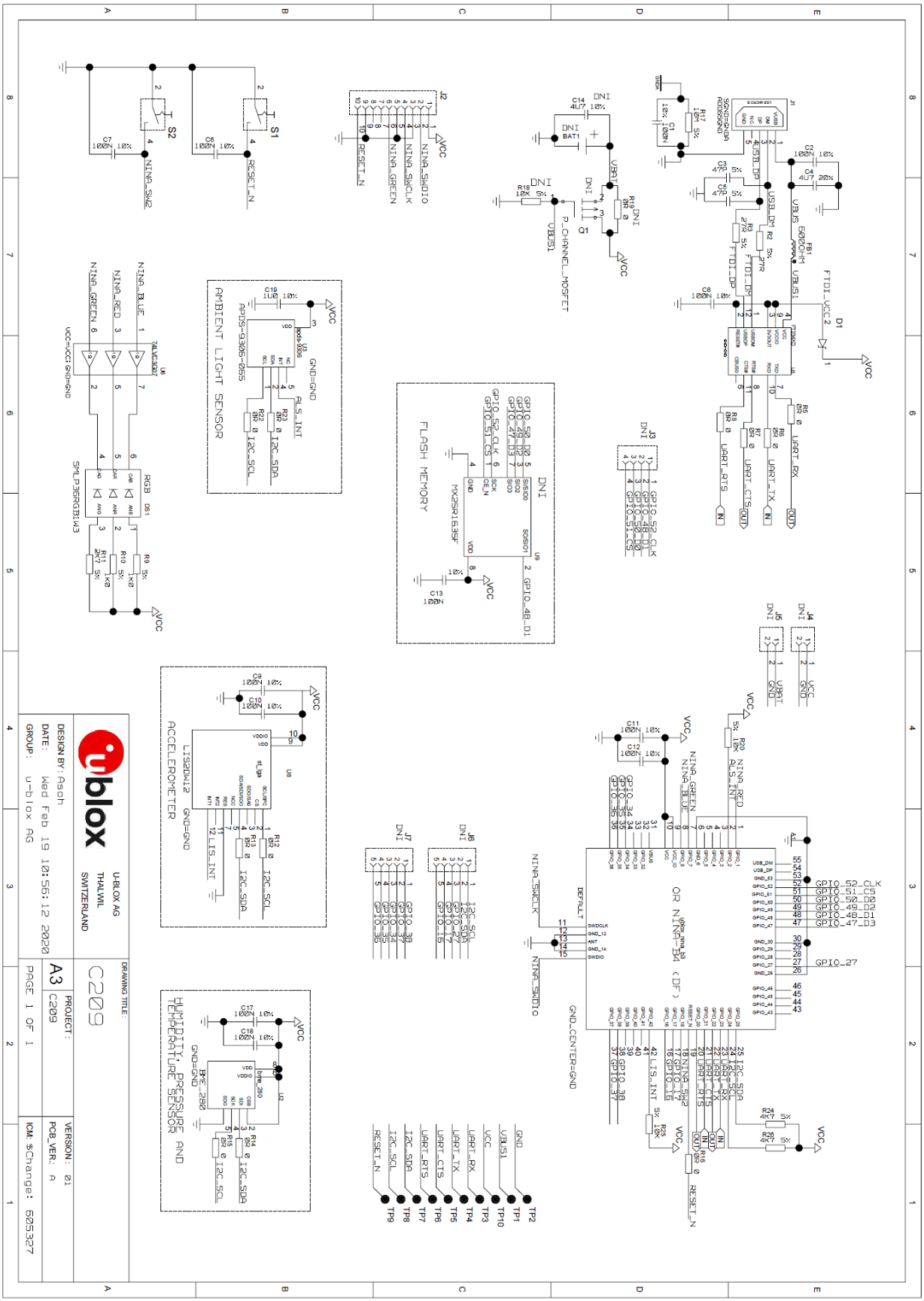
Appendix

A Glossary

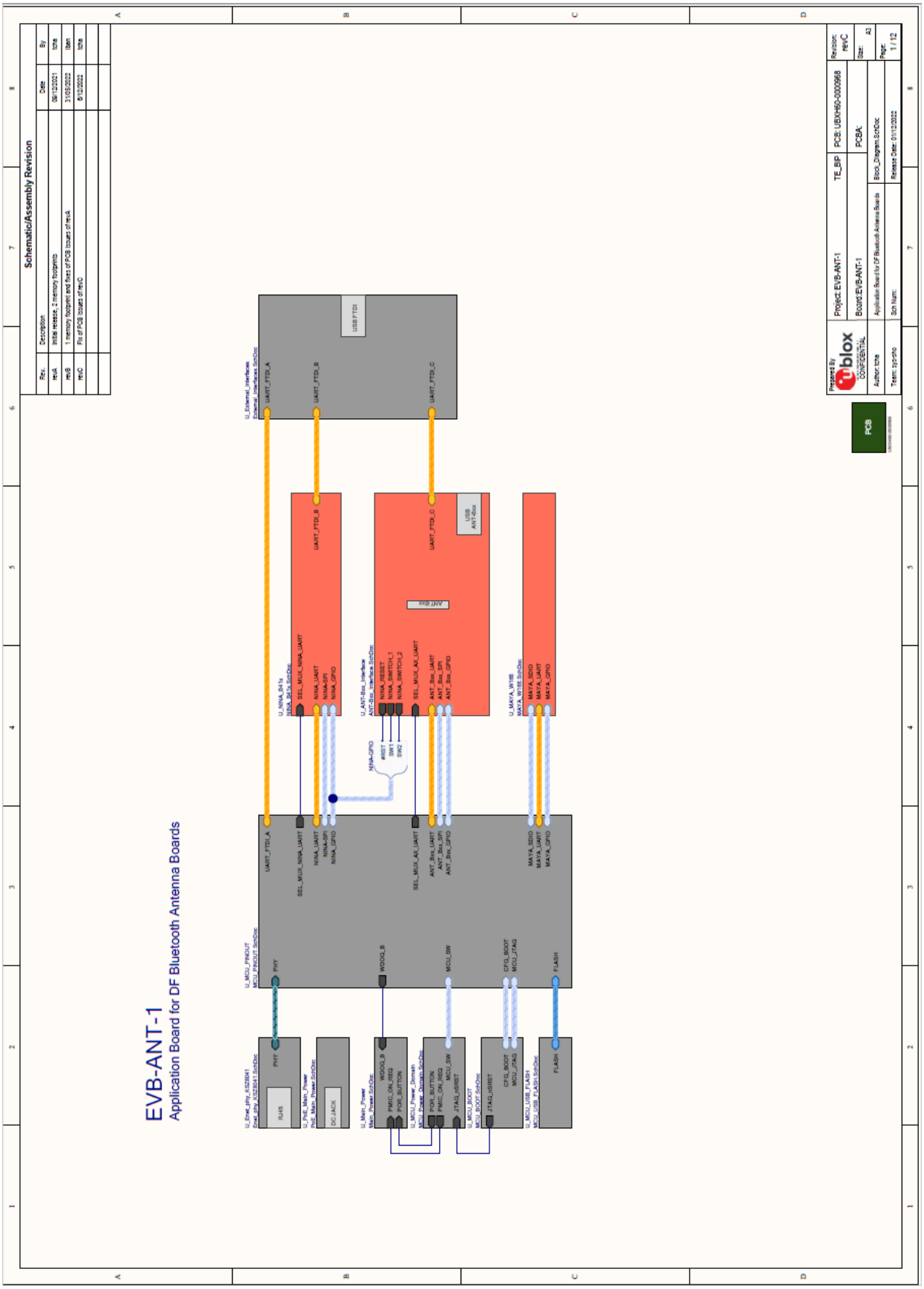
Abbreviation	Definition
AoA	Angle of Arrival
AoD	Angle of Departure
ASCII	American Standard Code for Information Interchange
ARM	Arm (Advanced RISC Machines) Holdings
CPU	Central Processing Unit
CTE	Constant Tone Extension
MCU	Microcontroller Unit
PoE	Power over Ethernet
RSSI	Received Signal Strength Indication

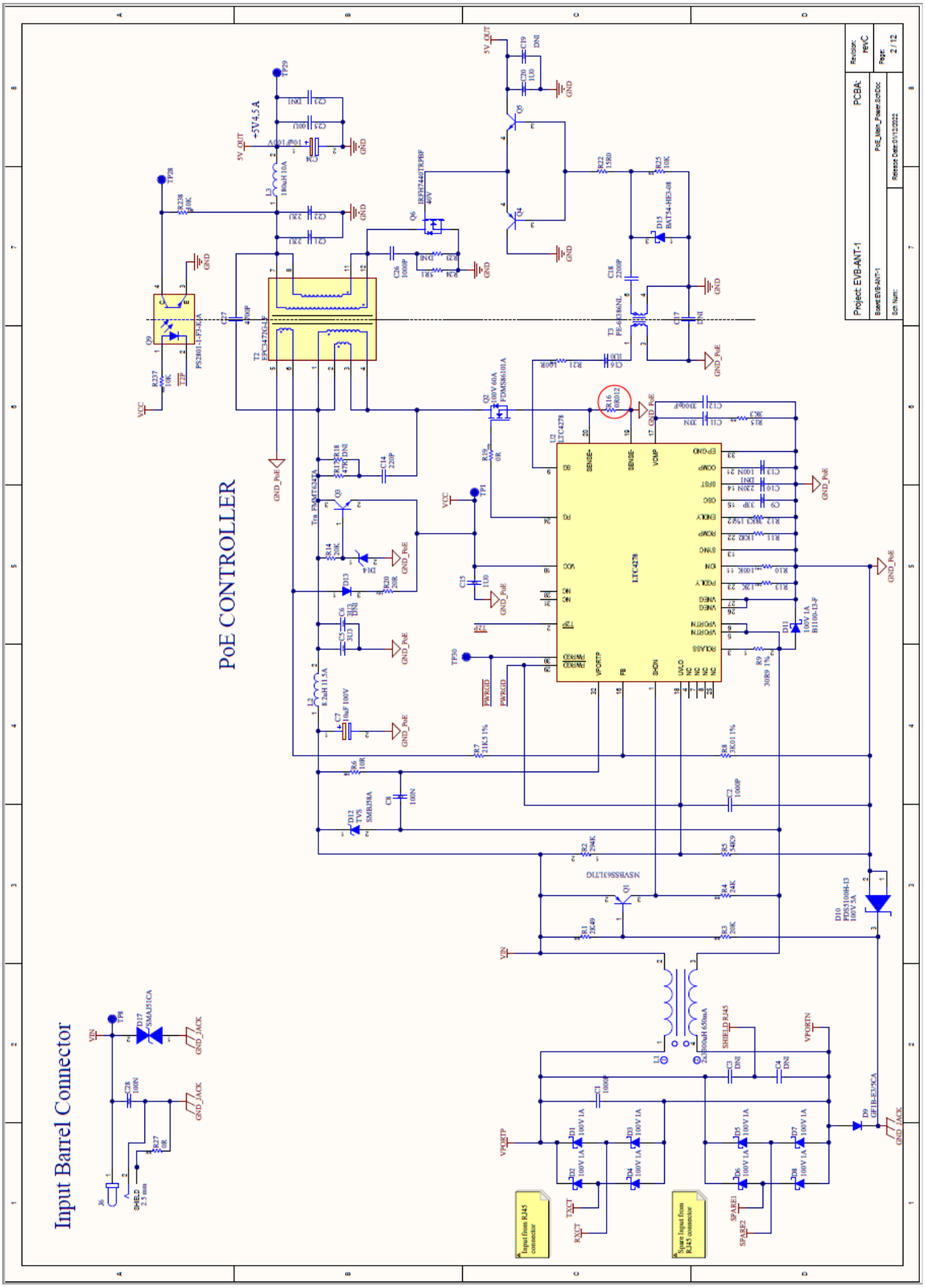
Table 8: Explanation of the abbreviations and terms used

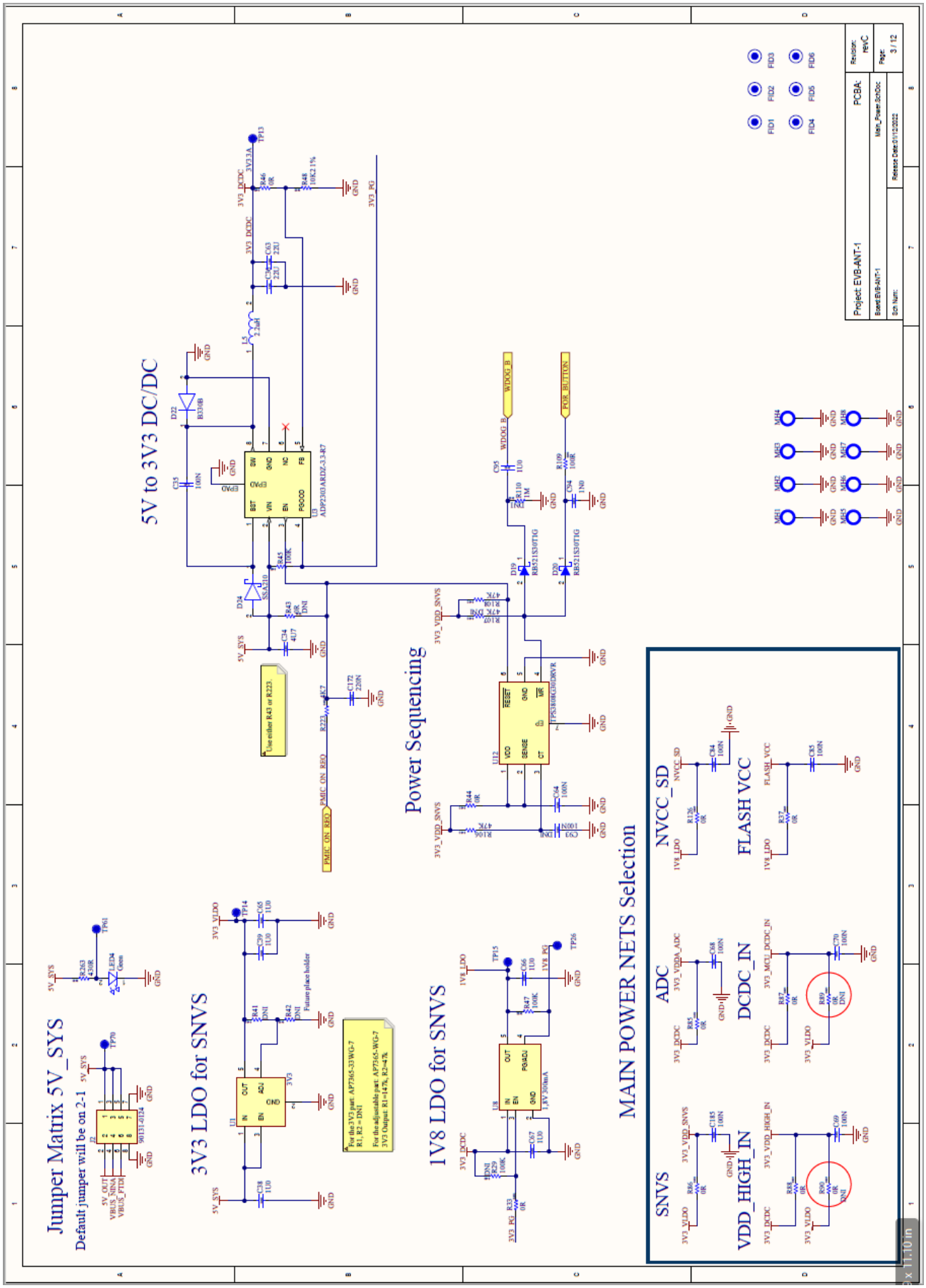
B C209 schematics

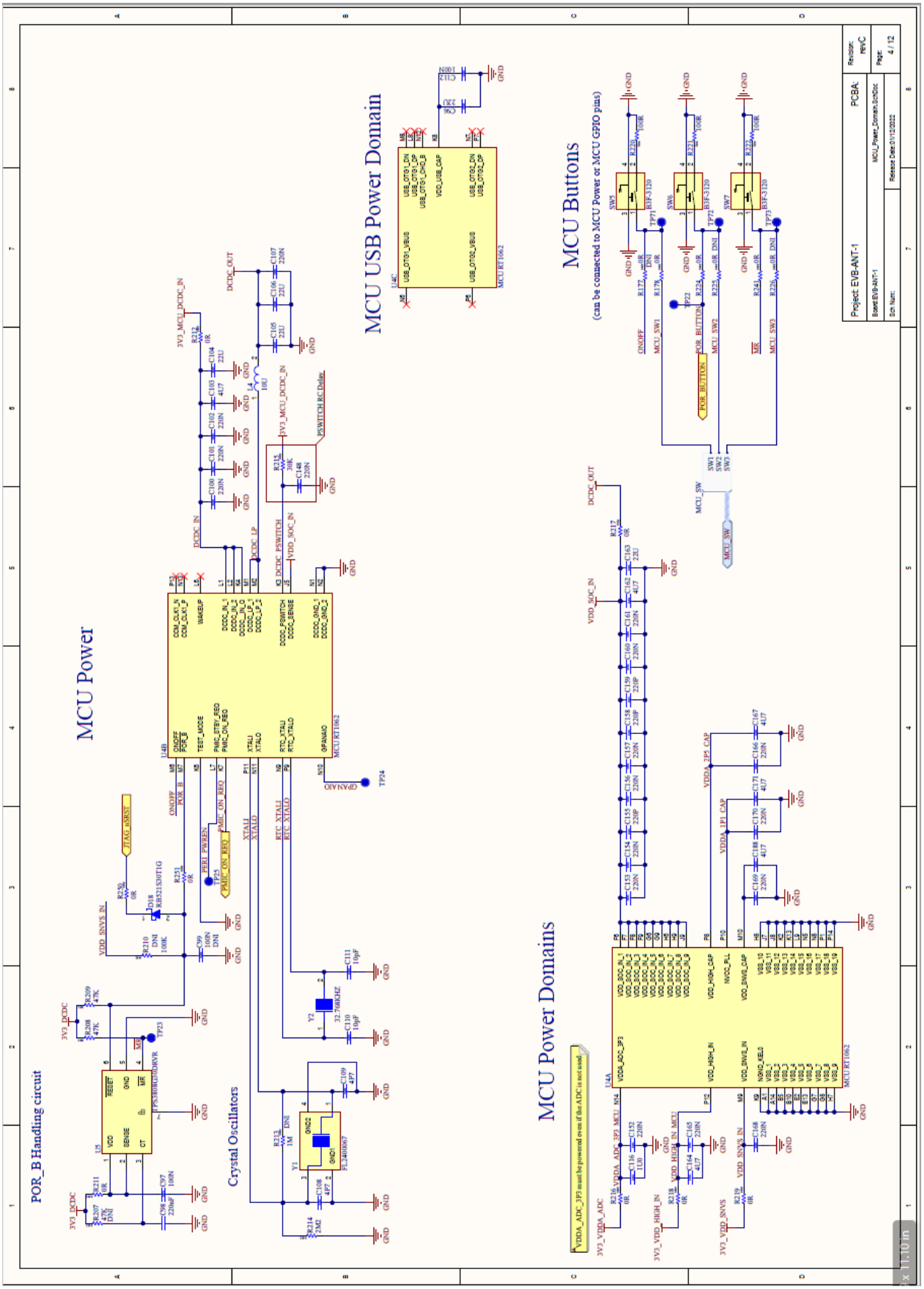


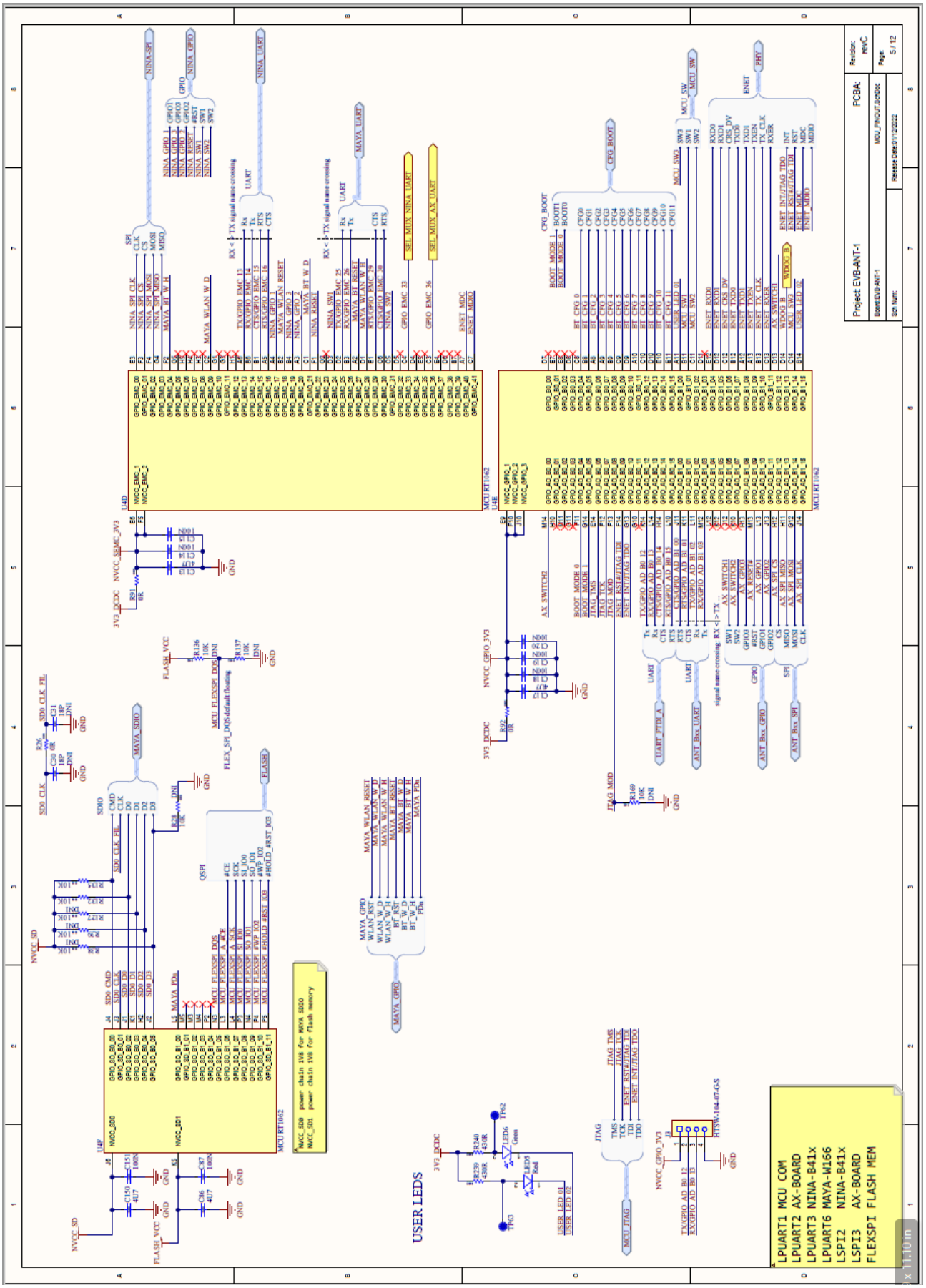
C EVB-ANT-1 schematics




PoE CONTROLLER
Input Barrel Connector
Project: EVB-ANT-1
PCBA:
Board:EVB-ANT-1
PoE_Main_Power.SchDoc
Release Date:01/12/2022
Release: revC
Page: 2 / 12
Bill Num:
LTC4278
Input from RJ45 connector
Spare Input from RJ45 connector


5V to 3V3 DC/DC
Power Sequencing
3V3 LDO for SNVS
1V8 LDO for SNVS
Jumper Matrix 5V_SYS
Default jumper will be on 2-1
MAIN POWER NETS Selection
SNVS
ADC
NVCC_SD
FLASH VCC
DCDC_IN
VDD_HIGH_IN
Project: EVB-ANT-1
PCBA:
Revision: revC
Page: 3 / 12


MCU Power
MCU USB Power Domain
MCU Buttons
(can be connected to MCU Power or MCU GPIO pins)
MCU Power Domains
POR_B Handling circuit
Crystal Oscillators
Project: EVB-ANT-1
PCBA:
Revision: rev.C
Page: 4/12
MCU_Power_Domains.SchDoc
Release Date: 01/13/2022
Sch Num:
Board EVB-ANT-1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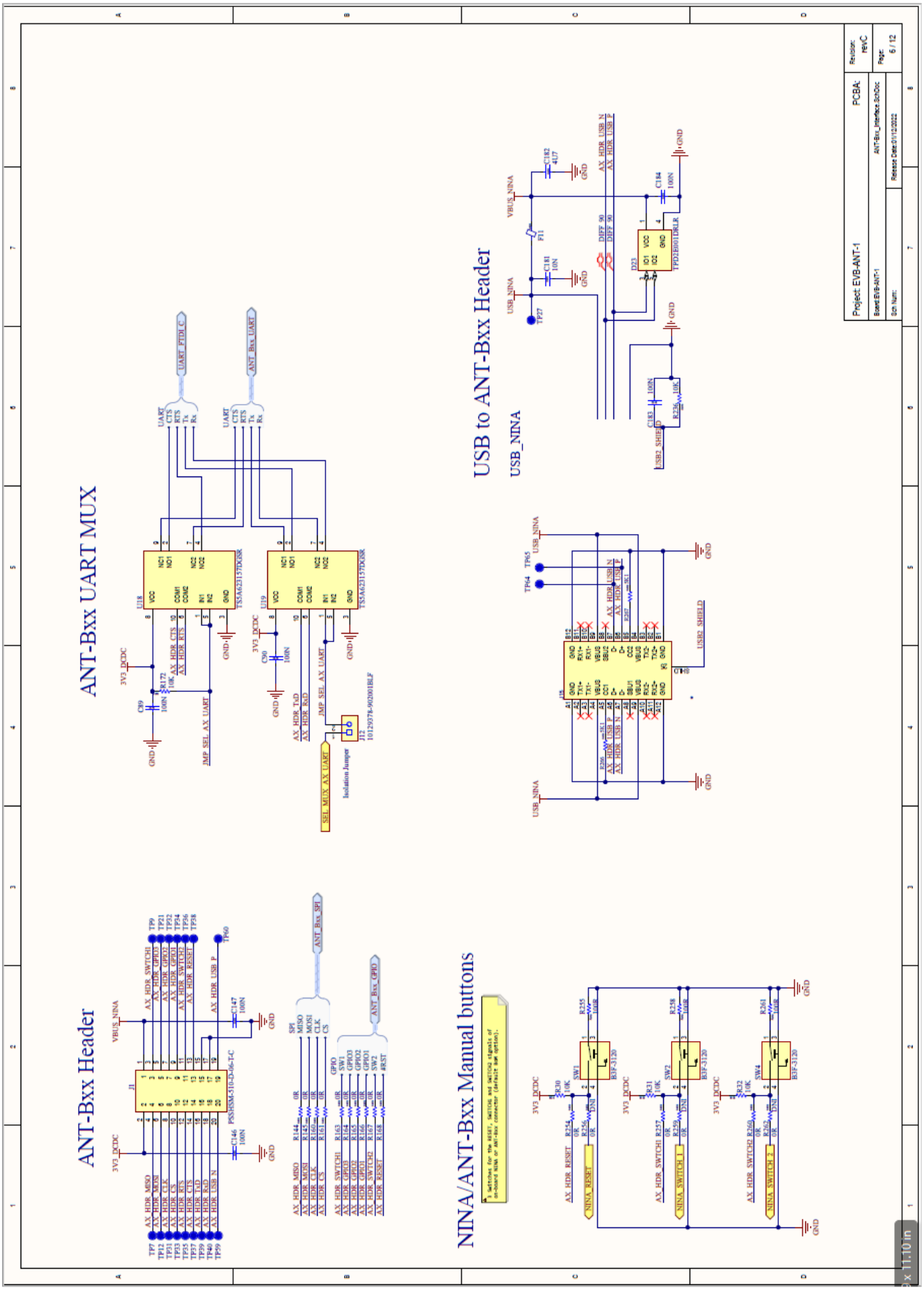
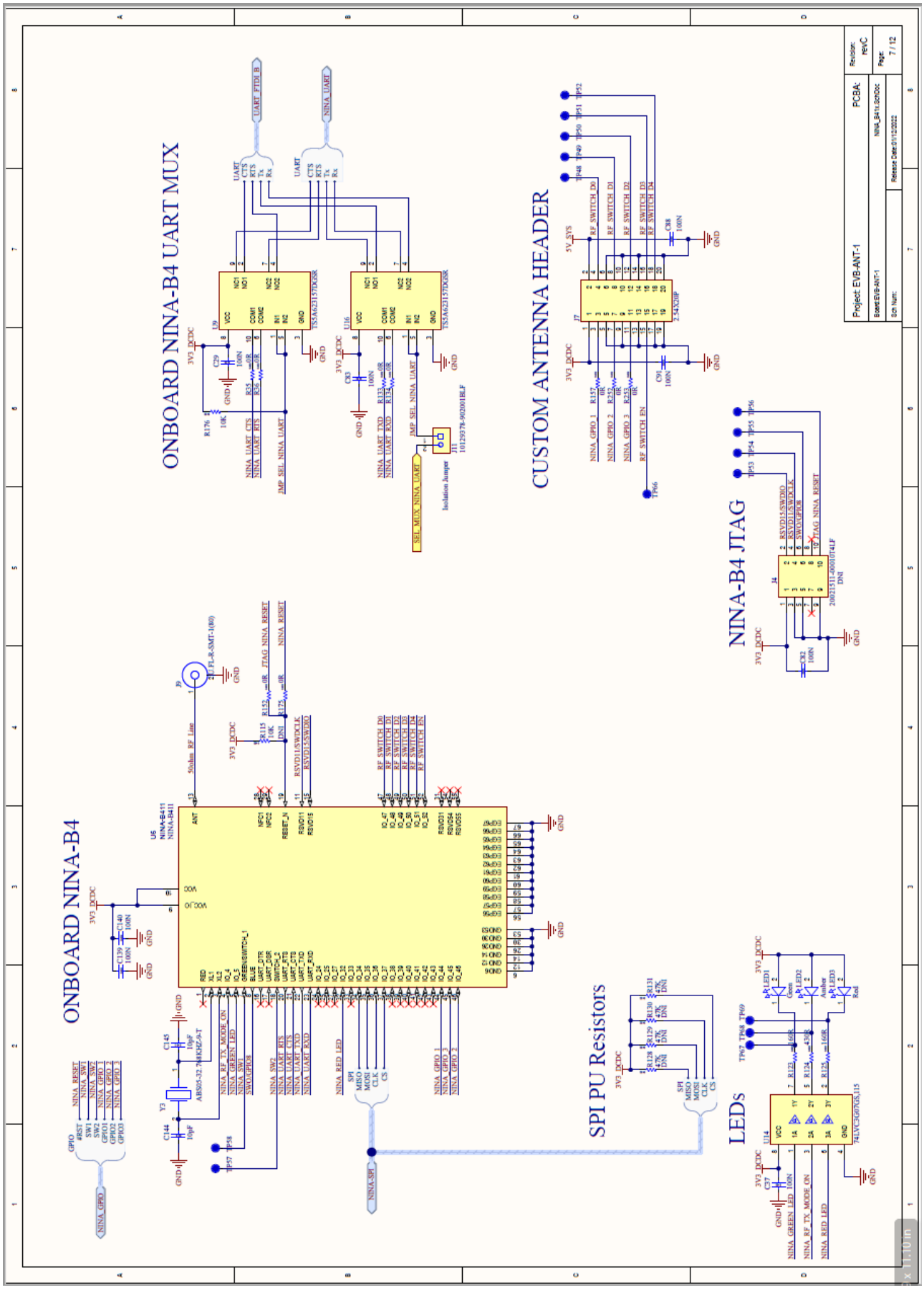
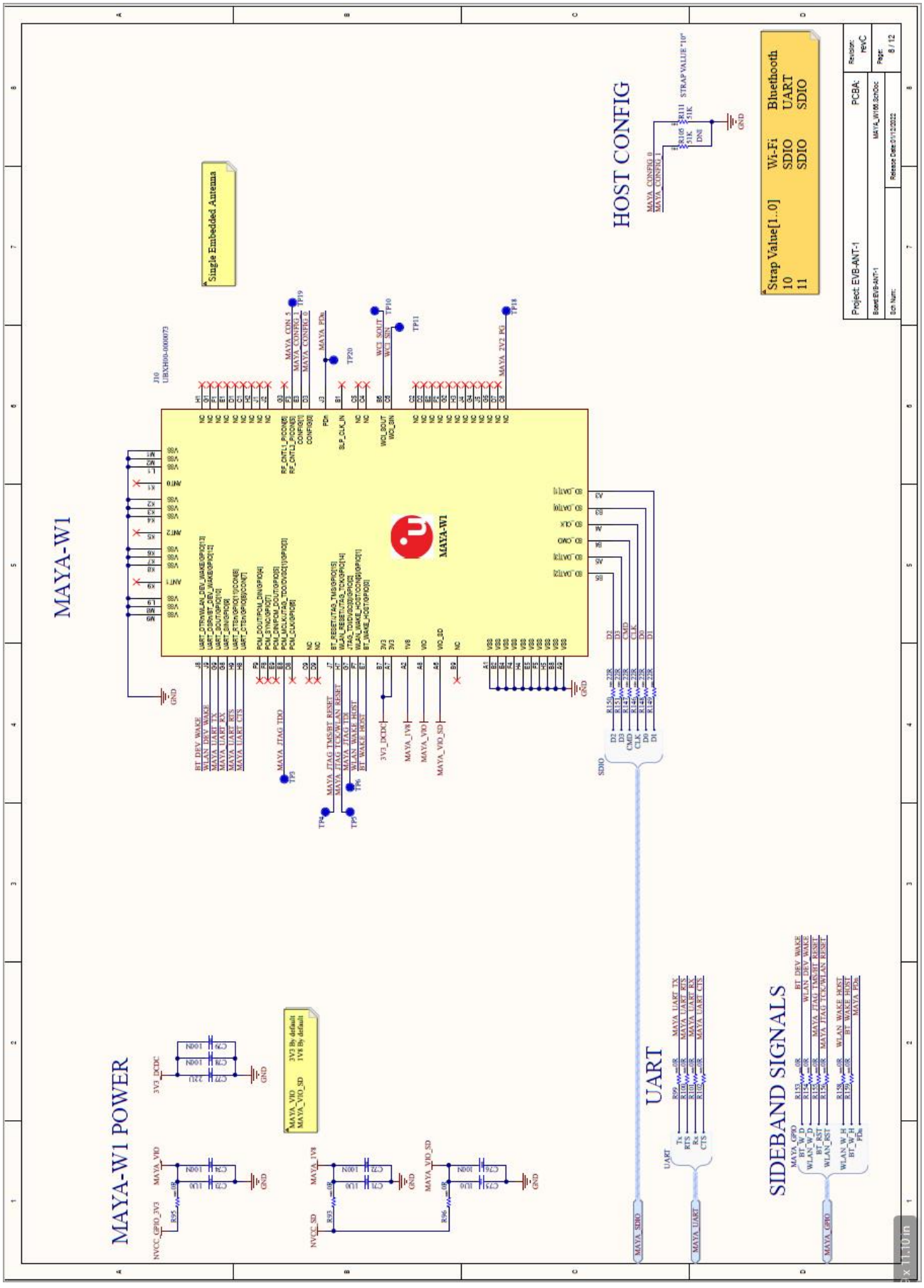
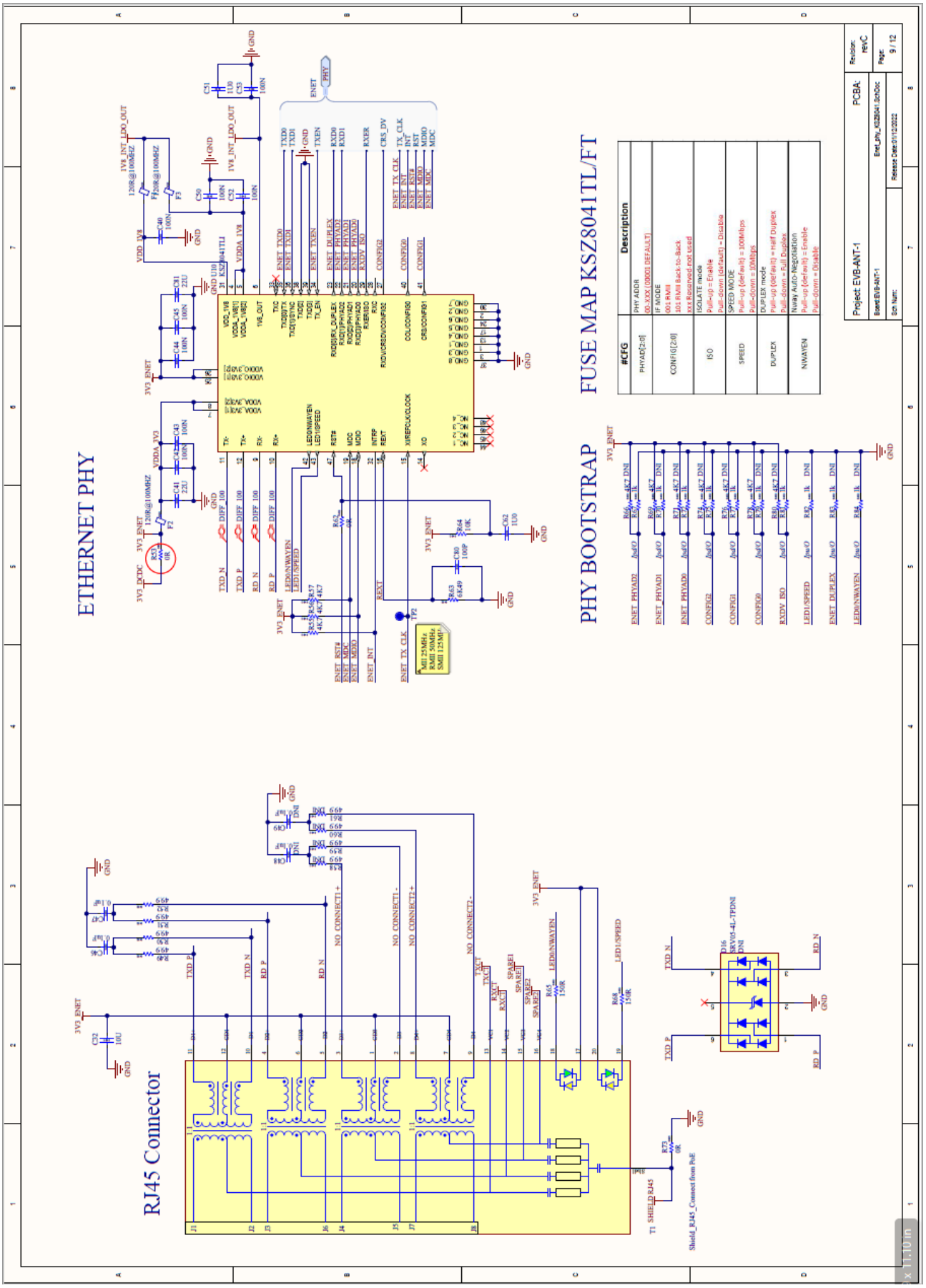
PCBA:
Board: EVB-ANT-1
Sch Num:
MCU_PINOUT.SchDoc
Release Date: 01/10/2022
Revision: revC
Page: 5 / 12
USER LEDS
LPUART1 MCU COM
LPUART2 AX-BOARD
LPUART3 NINA-B41x
LPUART6 MAYA-W166
LSPI2 NINA-B41x
LSPI3 AX-BOARD
FLEXSPI FLASH MEM


ANT-Bxx UART MUX
USB to ANT-Bxx Header
USB_NINA
ANT-Bxx Header
NINA/ANT-Bxx Manual buttons
Project: EVB-ANT-1
PCBA:
Revision: rev'C
Page: 6 / 12
Board: EVB-ANT-1
Release Date: 01/12/2022
ANT-Bxx_Interface.SchDoc
Isolation Jumper
TSSA6231S7DGSR
TPD2EB001DRLR
PSSHSM-510-D-06-T-C


ONBOARD NINA-B4 UART MUX
CUSTOM ANTENNA HEADER
NINA-B4 JTAG
ONBOARD NINA-B4
SPI PU Resistors
LEDs
Project: EVB-ANT-1
PCBA:
Board: EVB-ANT-1
Sch Num:
Revision: revC
Page: 7 / 12
Release Date: 01/01/2022


MAYA-W1
MAYA-W1 POWER
UART
SIDEBAND SIGNALS
HOST CONFIG
Single Embedded Antenna
Strap Value[1..0]
10
11
Wi-Fi
SDIO
SDIO
Bluetooth
UART
SDIO
Project: EVB-ANT-1
PCBA:
Revision:
rev.C
Page:
8 / 12
MAYA_W1 SCH.SchDoc
Release Date: 01/12/2022
Sch Num:
Board: EVB-ANT-1
3V3 Rb default
1V8 Rb default
MAYA_VIO
MAYA_VIO_SD
MAYA_SDIO
MAYA_UART
MAYA_GPIO


ETHERNET PHY
PHY BOOTSTRAP
FUSE MAP KSZ8041TL/FT
RJ45 Connector
Project: EVB-ANT-1
PCBA:
Board: EVB-ANT-1
Sch Num:
Eval_phy_KSZ8041 SchDoc
Release Date: 01/12/2022
Revision:
rev1C
Page:
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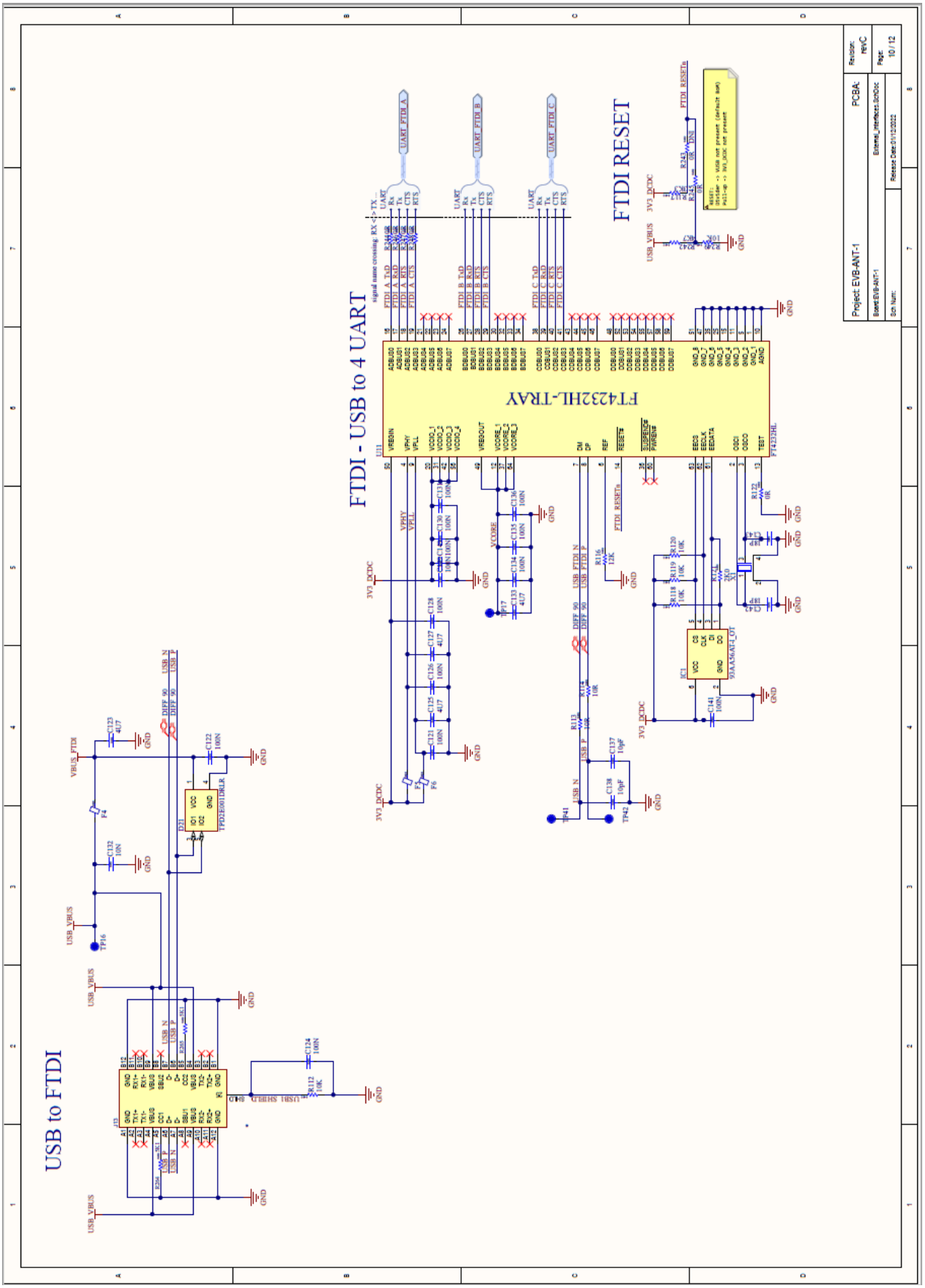
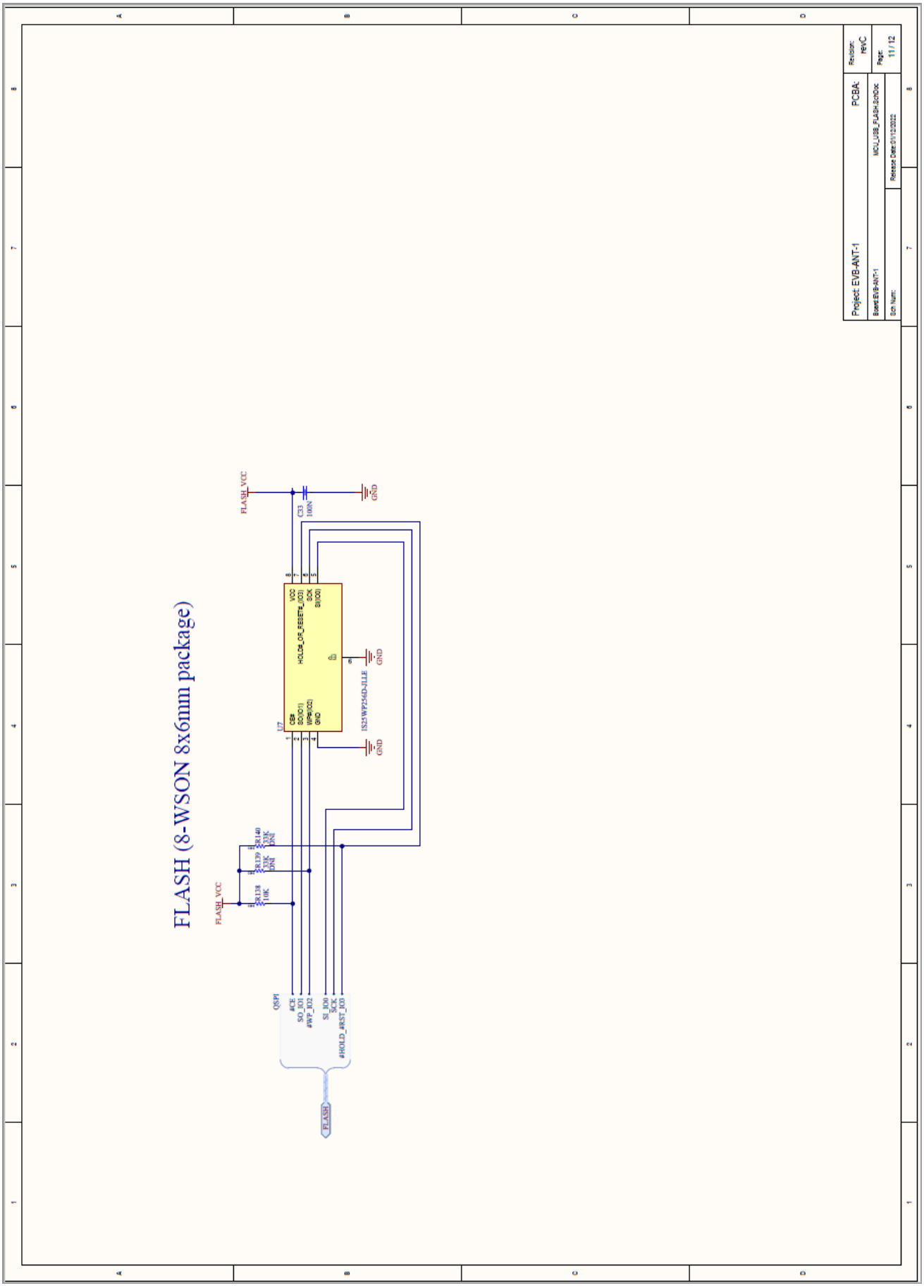

FTDI - USB to 4 UART
FTDI RESET
USB to FTDI
FT4232HL-TRAY
Project: EVB-ANT-1
PCBA:
Revision:
rev.C
Page:
10 / 12
Board:EVB-ANT-1
External_Interfaces.SchDoc
Release Date:01/01/2022
Sch Num:


FLASH (8-WSON 8x6mm package)
FLASH_VCC
C33
100N
GND
U7
HOLD#_OR_RESET#_IO3
VCC
SCK
SI/IO0
CS#
SO/IO1
WP#/IO2
GND
IS25WP256D-JLLE
R139
10K
R140
10K
R138
10K
QSPI
#CE
SO_IO1
#WP_IO2
SI_IO0
SCK
#HOLD_#RST_IO3
FLASH
Project: EVB-ANT-1
PCBA:
Board:EVB-ANT-1
MCU_USB_FLASH_2xOsc
Sch Num:
Release Date:01/13/2022
Revision:
rev0
Page:
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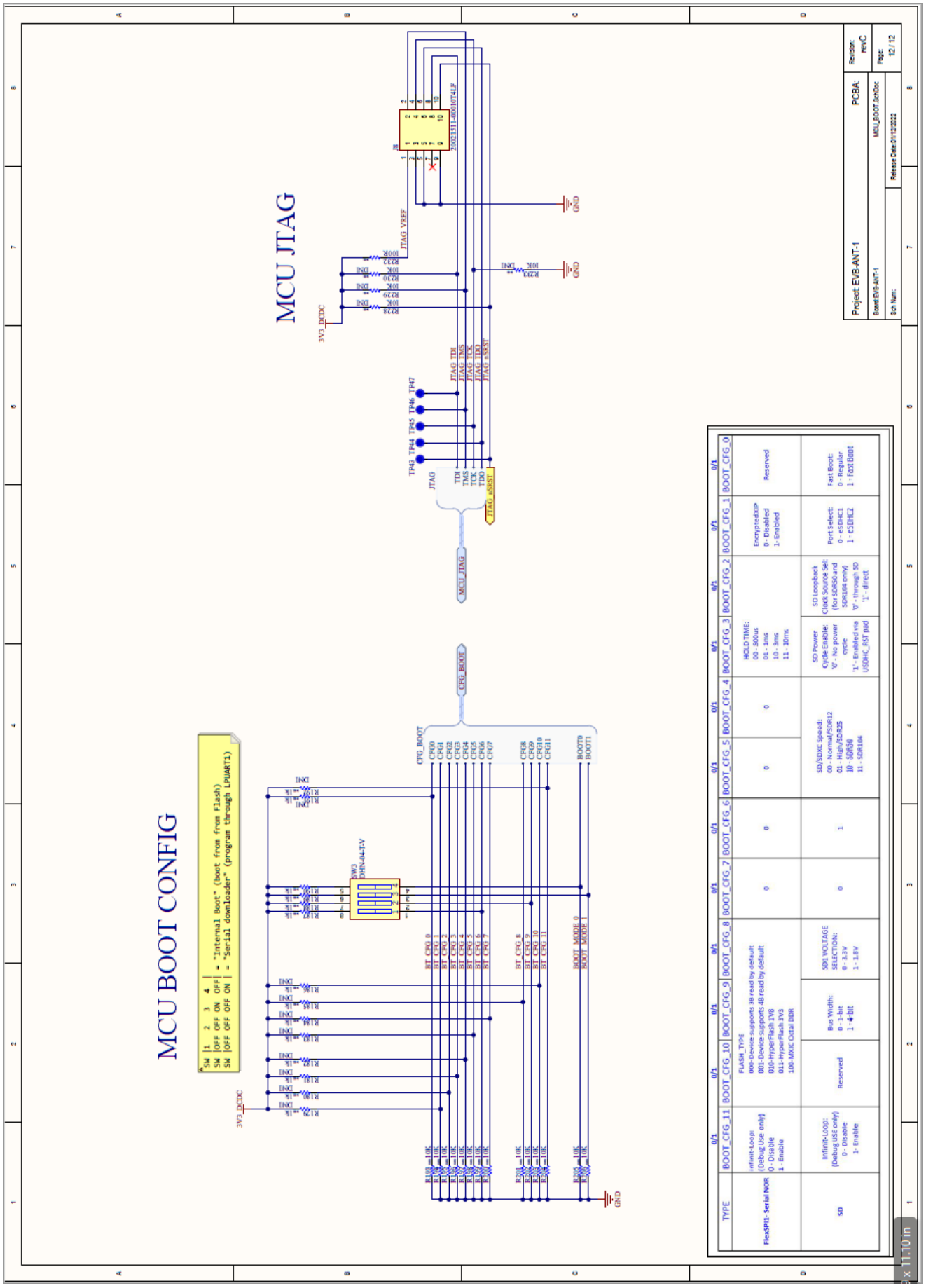
MCU JTAG
MCU BOOT CONFIG
Project: EVB-ANT-1
PCBA:
Board:EVB-ANT-1
MCU_BOOT.SchDoc
Sch Num:
Release Date:01/12/2022
Revision:
rev.C
Page:
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SW "Internal Boot" (boot from Flash)
SW "Serial downloader" (program through LPUART1)
TYPE
FlexSPI1: Serial NOR
SD
BOOT_CFG_11
BOOT_CFG_10
BOOT_CFG_9
BOOT_CFG_8
BOOT_CFG_7
BOOT_CFG_6
BOOT_CFG_5
BOOT_CFG_4
BOOT_CFG_3
BOOT_CFG_2
BOOT_CFG_1
BOOT_CFG_0

Related documentation

[1] ANT-B10 data sheet, UBX-22008373
[2] u-blox webinars, https://www.u-blox.com/en/webinar
[3] Bluetooth Direction Finding: A Technical Overview
https://www.bluetooth.com/bluetooth-resources/bluetooth-direction-finding/
[4] u-connectLocate product page, https://www.u-blox.com/en/product/u-connectlocate
[5] newtmgr download: https://mynewt.apache.org/latest/newtmgr/install/install_windows.html
[6] Newt Manager Guide: https://mynewt.apache.org/latest/newtmgr/index.html
[7] s-center, https://www.u-blox.com/en/product/s-center
[8] s-center user guide, UBX-16012261
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[10] u-connectLocate product page, https://www.u-blox.com/en/product/u-connectlocate
[11] u-connectXpress AT commands manual, UBX-14044127
[12] C209 tag software GitHub repository: https://github.com/u-blox/c209-aoa-tag
[13] NINA-B4 system integration manual, UBX-19052230
[14] NINA-B40 series data sheet, UBX-19049405
[15] nrfutil, https://github.com/NordicSemiconductor/pc-nrfutil/releases
[16] XPLR-AOA-3 product page, https://www.u-blox.com/en/product/xplr-aoa-3-kit
[17] ANT-B10 SIM, UBX-22025788
[18] u-connectLocate AT commands manual, UBX-22025586
[19] EVB-ANT-1 software GitHub repository: https://github.com/u-blox/evb-ant-1
[20] Serial Downloader user guide, https://spsdk.readthedocs.io/en/latest/apps/sdphost.html
[21] Bluetooth indoor positioning application note, UBX-21006395
[22] ANT-B11 product page, https://www.u-blox.com/en/product/ant-b11-antenna-board

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Revision history

Revision	Date	Name	Comments
R01	29-Mar-2022	mape	Initial release
R02	3-May-2022	mape	Noted the need to flash ANT-B10 with u-connectLocate in Software section. Minor change in Document information and other small corrections.
R03	20-Jan-2023	mape	Restructured document, moved content to u-connectLocate AT commands manual and ANT-B10 system integration manual. Renamed to XPLR-AOA-3 user guide. Added EVB-ANT-1 chapter and related schematics.
R04	3-Mar-2023	mape	Improvements in C209 Software and flashing. Minor corrections throughout document.
R05	23-May-2023	mape	Updated for software version 1.0 and hardware revision C. Added notes describing anchor accuracy and UUDF events in ANT-B10 configuration and testing. Corrected Cortex MCU references. Added information describing access to the Web configuration interface. Included notes describing Limitations and known issues. Updated flashing procedure in Installing tag software with the DFU bootloader using s-center. Updated images and added other minor editorial changes.
R06	30-Jun-2023	mape	Added description of buttons connected to MCU in EVB-ANT-1.
R07	17-Nov-2023	Iliu, mape	Updated Flashing from the Command line for ANT-B10. Added description of how the u-connectLocate algorithm calculates the direction or angles of moving tag in u-connectLocate software. Updated angle definitions in ANT-B10 configuration and testing. Add information about the C209 tag being delivered with bootloader software. Updated all XPLR-AOA-3 images to reflect the latest hardware.

Contact

u-blox AG

Address: Zürcherstrasse 68
8800 Thalwil
Switzerland

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