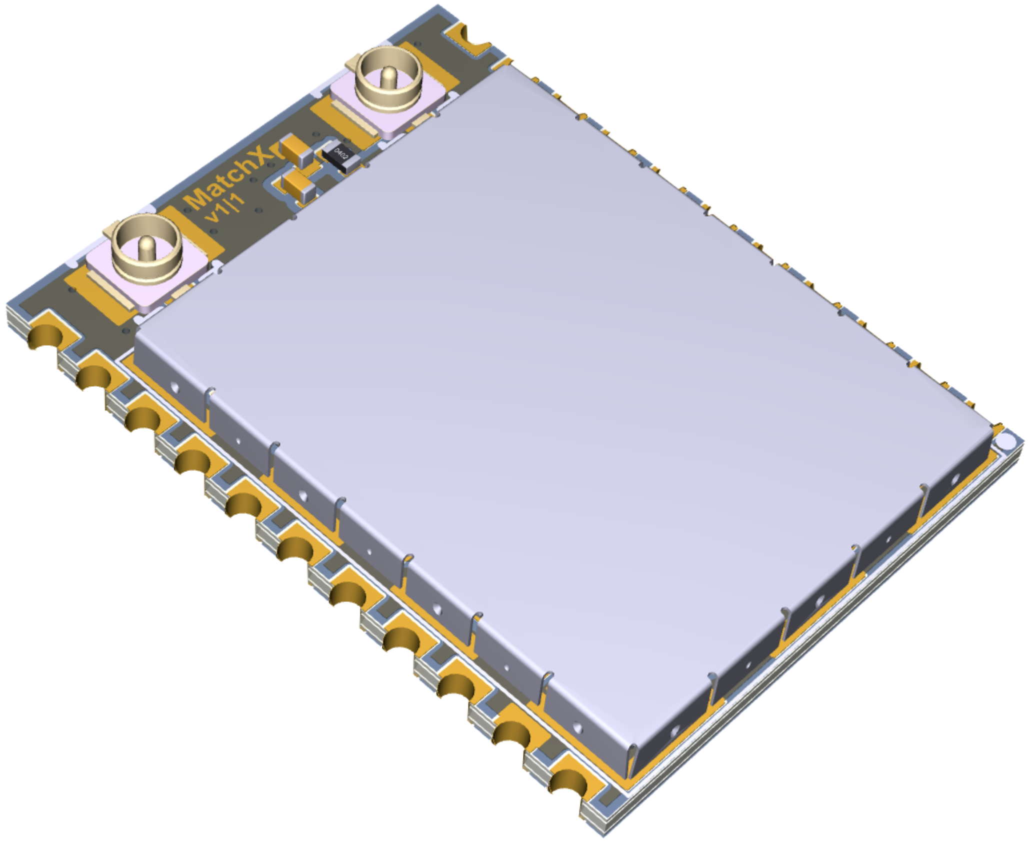


# MatchX MX1731 Core

BLE and LoRa enabled System on Module

(Preliminary)

## User Guide

V1.0

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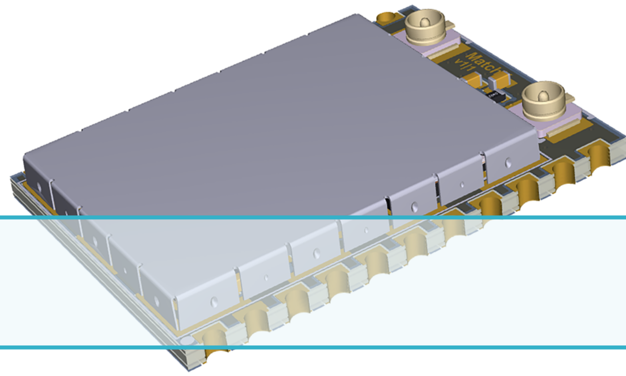
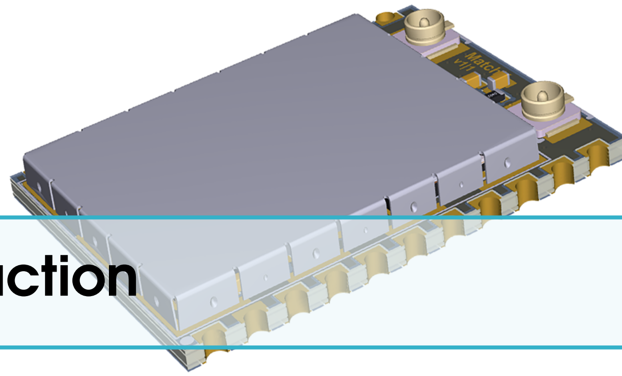
*First release, Nov 2017*



# Contents



# 1. Introduction

## 1.1 Product overview

The LPWAN Core module by MatchX is a high performance, ready to use system on module allowing you to kick-start your IoT project. It is an incredibly flexible solution that can be deployed in a various number of applications which require long distance communication and long battery life. The unique combination of both LoRa and Bluetooth Low Energy makes non-contact firmware updates easy, especially when the device is mounted in a difficult or unaccessible place.

This guide covers both the US and EU version of the Core module. The main differences between these two versions are listed in Table 1.1.

| Parameter | US | EU |
|---|---|---|
| Operating Frequency Band | 902-928MHz | 863-870MHz |
| Maximum Output Power | +17dBm | +14dBm |
| Lora BW | 500k/125kHz | 125kHz |
| SF | 7-10 | 7-12 |
| Certification | IEC 60950-1 | EN 300200 |
| | FCC PART 15.247 | EN 301489 |

Table 1.1: Comparison of different regions

### 1.1.1 Lora

The MatchX Module uses LoRa communication to send messages over long distances (up to 20km in open spaces). This unique modulation scheme guarantees robust wireless communication even in difficult from RF point of view environments such as high-rise city landscapes or within the inside of buildings. The module can output up to 18dBm of power and is fully LoraWAN compatible. It's uniquely designed to work with the MatchX Box gateway and can also be used with a LoraWAN compatible Gateway of your choice.

### 1.1.2 BLE

The module offers a novel firmware solution upgrade by augmenting LoRa, together with Bluetooth Low Energy (BLE). As LoRa protocol is not suitable for transmitting large amounts of data, MatchX has combated this with BLE, offering a quick, robust and remote way of updating your software. It is a perfect method in cases where a sensor may be mounted in an unaccessible place like in a basement, sealed container box or behind a wall. Moreover BLE together with provided mobile app enables you to configure your module and read its status and additional data.

## 1.2 Main Features

Long range, long battery life, flexible sensor configuration and wireless firmware update are the key features that are offered by the Core module.

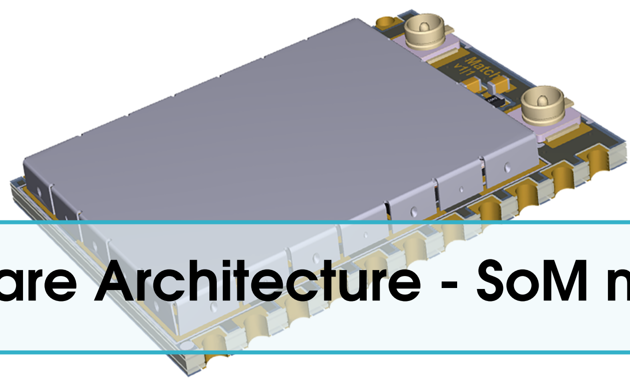
### 1.2.1 Hardware

- +18dBm output power in 868MHz
- -146dBm sensitivity of LoraWAN packets
- integrated LoRa and BLE antennas connectors
- 0 Hz up to 96 MHz 32-bit ARM Cortex-M0 microcontroller
- Dialog DA14680
- Semtech SX1276
- Li-ION battery charger
- ultra low power design

### 1.2.2 Software

- Runs LoRa and Bluetooth stack simultaneously
- Bluetooth low energy (Bluetooth 4.2 specification)
- Low power consumption modes
- Easy to use software package
- Eclipse-based IDE
- Firmware upgrade over the air
- Mobile application

R Currently there is no Class B support in server yet, but the hardware and firmware are fully prepared for Class B specification, it is expected to support Class B in future firmware upgrade.



# 2. Hardware Architecture - SoM module

## 2.1 Pin-out and pin description of the SoM module

The pin-out of the MatchX Core SoM module can be seen on Figure 2.1 and the description of the pins in Table 2.1. On top of the module there are two UF.L RF connectors, the one on the left is the LoRa antenna connector, a suitable 868MHz in EU and 915MHz in US, 50 Ohm antenna is expected to be connected on these port. The other connector is for connecting the 2.4GHz, 50 Ohm BLE antenna. Please contact MatchX for antenna recommendation.

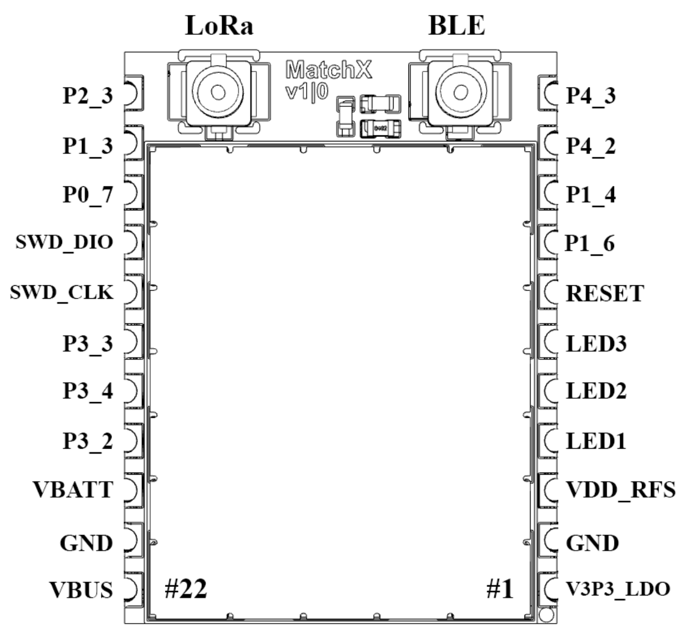



Figure 2.1: Pin-out of the SoM module.

| Pin number | Name | Description |
|---|---|---|
| 1 | V3P3_LDO | 3.3V output of the internal LDO |
| 2 | GND | Ground |
| 3 | VDD_RFS | Supply voltage of the radio front-end |
| 4 | LED1 | Open drain output type, LED driver |
| 5 | LED2 | Open drain output type, LED driver |
| 6 | LED3 | Open drain output type, LED driver |
| 7 | RESET | Reset signal, active high |
| 8 | P1_6 | General Purpose I/O P1_6 / NTC resistor for battery temperature sensing |
| 9 | P1_4 | General Purpose I/O P1_4 / ADC1 / battery temperature sensing |
| 10 | P4_2 | General Purpose I/O P4_2 |
| 11 | P4_3 | General Purpose I/O P4_3 |
| 12 | P2_3 | General Purpose I/O P2_3 |
| 13 | P1_3 | General Purpose I/O P1_3 / ADC2 |
| 14 | P0_7 | General Purpose I/O P0_7 / ADC3 |
| 15 | SWD_DIO | Serial Wire Debug interface I/O signal / GPIO P0_6 / ADC4 |
| 16 | SWD_CLK | Serial Wire Debug interface clock signal / GPIO P2_4 / ADC7 |
| 17 | P3_3 | General Purpose I/O P3_3 |
| 18 | P3_4 | General Purpose I/O P3_4 |
| 19 | P3_2 | General Purpose I/O P3_2 |
| 20 | VBATT | Battery voltage input |
| 21 | GND | Ground |
| 22 | VBUS | 5V supply, charging voltage |

Table 2.1: USB-C connector pins description.

The module can be powered in two ways:

1. By connecting the VBATT to a battery voltage (2.7V to 4.2V).
2. By supplying +5V on the VBUS pin.

If both power sources are present, the battery will be charged form +5V power supply. The charging current and charging characteristics for different battery types is software configurable. The module provides **V3P3_LDO** voltage, it is a output of internal LDO of the DA14680 MCU, and it can be used to supply external devices, but the maximum current drawn can't be grater than 100mA. By default **VDD_RFS** is connected to **V3P3_LDO** with an external 0R resistor. The current draw of **VDD_RFS** is around 35mA during transmission with +14dBm power output and around 90mA with +17dBm power. This has to be taken in consideration when planning the power budget of **V3P3_LDO**. When even higher RF transmission power is required it is advisable to use different power source for **VDD_RFS**. On the Evaluation Board it can be done by using 3.3V output of the low power converter.

The source of **V3P3_LDO** is **VBUS** when present or **VBATT** otherwise. As it is a output of a LDO, when **VBUS** is not present, and **VBATT** drops below 3.3V the **V3P3_LDO** will follow the battery voltage. By default all GPIO are referenced to **V3P3_LDO** (it is also possible to configure 1.8V as the GPIO level, each GPIO can be configured individually) so care must be taken to ensure that no voltage higher than **V3P3_LDO** is presented to any GPIO. This may happen when powering external devices, that connect to SoM module, from a boost converter.

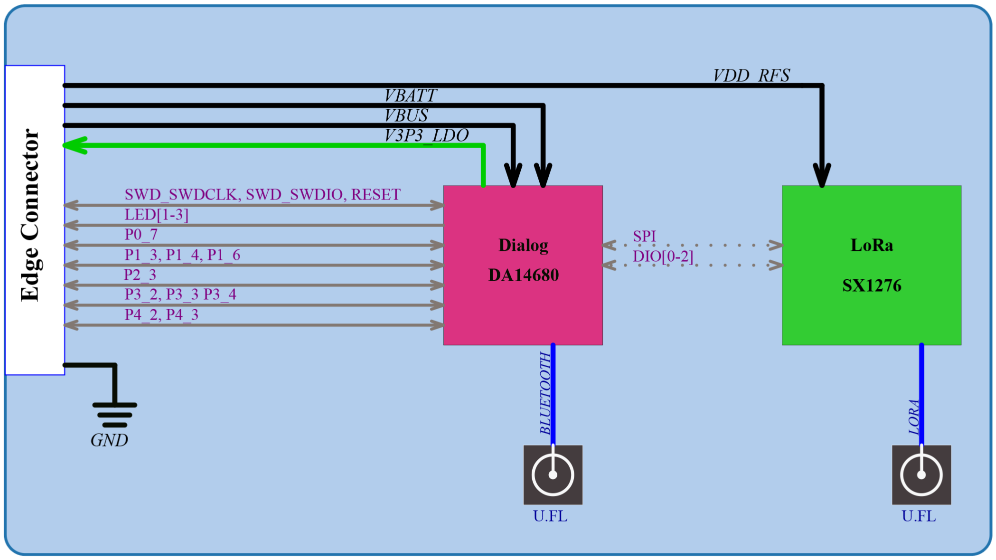



Figure 2.2: Block diagram of the Core module.

## 2.2 Operating frequency bands

### 2.2.1 EU 863-870MHz ISM Band

In the European region the EN300220-2 V3.1.1 (2017-02) regulation defines the allowed frequency allocation and spectrum access. Every device working in this band must comply with these rules as shown in the Table 2.3. EU regulations restrict the maximum radiated power as well as the duty cycle of the transmission in different frequency bands.To comply with the duty cycle requirement the transmitting device must wait after every transmitted packet. The time device has to wait depends on the time on air of transmitted packet and this in turn depends on the length of the packet and spreading factor SF. This relation and required wait time can be seed in Table 2.2 According to LoRaWAN specification every device has to implement at least 3 channels as follows:

- 868.10 MHz
- 868.30 MHz
- 868.50 MHz

The SoM is preconfigured to work with the MatchX Box gateway and additionally to the 3 mandatory channels 5 additional channels are defined. The list of all preconfigured channels can be found in Table 2.4.

### 2.2.2 US 902-928MHz ISM Band

These frequencies band can be used in USA, Canada and all other countries that adopt the entire FCC-Part15 regulations in 902-928 ISM band. For these region MatchX uses predefined frequencies

| Spreading Factor (125kHz Lora) | Bit rate (bps) | Range (depends on conditions) | Time on air (ms) (10 bytes payload) | 0.1% duty cycle waiting time | 1% duty cycle waiting time |
|---|---|---|---|---|---|
| SF7 | 5470 | 2 km | 56 ms | 1 min | 6s |
| SF8 | 3125 | 4 km | 100 ms | 1 min 40s | 10s |
| SF9 | 1760 | 6 km | 200 ms | 3 min 20s | 20s |
| SF10 | 980 | 8 km | 370 ms | 6 min 10s | 37s |
| SF11 | 440 | 14 km | 740 ms | 12 min 20s | 1 min 14s |
| SF12 | 290 | 20 km | 1400 ms | 23 min 20s | 2min 20s |

Table 2.2: Modules operating frequencies.

| Operational Frequency band | | Maximum e.r.p | Channel access and occupation rules (e.g. Duty cycle or LBT + AFA) | Band number from EC Decision 2013/752/EU [i.3] | Class 1 subclass number according Commission Decision 2000/299/EU [i.7] |
|---|---|---|---|---|---|
| K | 863,000 MHz to 865,000 MHz | 25 mW e.r.p. | $\leq$ 0,1% duty cycle or polite spectrum access | 46a | 66 |
| L | 865,000 MHz to 868,000 MHz | 25 mW e.r.p. Power density: -4,5 dBm/100 kHz | $\leq$1 % duty cycle or polite spectrum access | 47 | 67 |
| M | 868,000 MHz to 868,600 MHz | 25 mW e.r.p. | $\leq$1% duty cycle or polite spectrum access | 48 | 28 |
| N | 868,700 MHz to 869,200 MHz | 25 mW e.r.p. | $\leq$0,1% duty cycle or polite spectrum access | 50 | 29 |
| O | 869,400 MHz to 869,650 MHz | 25 mW e.r.p. | $\leq$0,1% duty cycle or polite spectrum access | 54a | 130 |
| P | 869,400 MHz to 869,650 MHz | 500 mW e.r.p. | $\leq$10 % duty cycle or polite spectrum access | 54b | 30 |
| Q | 869,700 MHz to 870,000 MHz | 5 mW e.r.p. | No requirement | 56a | 31 |
| R | 869,700 MHz to 870,000 MHz | 25 mW e.r.p. | $\leq$1% duty cycle or polite spectrum access | 56c | 69 |

Table 2.3: EU wide harmonized national radio interfaces.

| Frequency | Bandwidth | Maximum e.r.p | Channel access |
|---|---|---|---|
| 864.7 MHz | 125 kHz | 14 dBm | ≤0,1% duty cycle |
| 864.9 MHz | 125 kHz | 14 dBm | ≤0,1% duty cycle |
| 865.1 MHz | 125 kHz | -4.5 dBm | ≤1% duty cycle |
| 865.3 MHz | 125 kHz | -4.5 dBm | ≤1% duty cycle |
| 868.1 MHz | 125 kHz | 14 dBm | ≤1% duty cycle |
| 868.3 MHz | 125 kHz | 14 dBm | ≤1% duty cycle |
| 868.5 MHz | 125 kHz | 14 dBm | ≤1% duty cycle |
| 868.8 MHz | 125 kHz | 14 dBm | ≤0,1% duty cycle |

Table 2.4: Core Module operating frequencies in EU 863-870MHz ISM Band.

listed in Table 2.5. The FCC regulation puts restriction on the maximum dwell time of 400ms in uplink, thats why the maximum allowed spreading factor is SF10.

| Channel number | Frequency | Channel number | Frequency |
|---|---|---|---|
| 1 | 903.90 MHz | 5 | 904.70 MHz |
| 2 | 904.10 MHz | 6 | 904.90 MHz |
| 3 | 904.30 MHz | 7 | 905.10 MHz |
| 4 | 904.50 MHz | 8 | 905.30 MHz |

Table 2.5: Modules operating frequencies (uplink) in US 902-928MHz ISM Band.

### 2.2.3 Australia 915-928MHz ISM Band

These frequencies band can be used in Australia region. For these region MatchX uses predefined frequencies listed in Table 2.6. All channels use 125kHz bandwidth and maximum of +20dBm output power can be reached.

| Channel number | Frequency | Channel number | Frequency |
|---|---|---|---|
| 1 | 915.20 MHz | 5 | 916.00 MHz |
| 2 | 915.40 MHz | 6 | 916.20 MHz |
| 3 | 915.60 MHz | 7 | 916.40 MHz |
| 4 | 915.80 MHz | 8 | 916.60 MHz |

Table 2.6: Modules operating frequencies (uplink) in Australia 915-928MHz ISM Band.

## 2.3 Connection

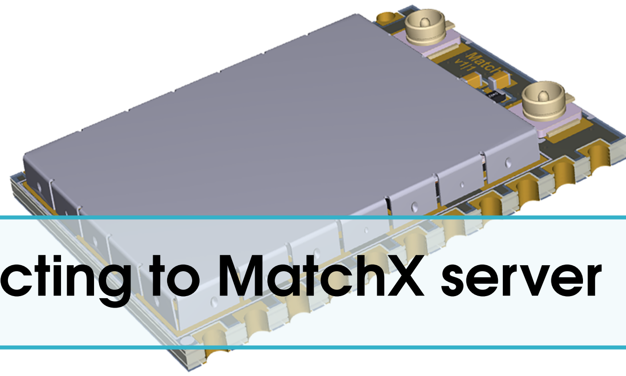
### 2.3.1 Power

The Core module can be supplied directly from rechargeable lithium battery. As long as the battery is charged there is no other power connection required for the module to work.Alternatively the module can be powered by +5V supply connected to VBus pin. Core SoM integrates internal Lithium battery charger which will charge the battery connected to its VBatt pin from VBus voltage.Charger can be disabled in software if the application doesn't require it.

Important!
MatchX strongly recommends to charge the battery within specified temperature range of 0 to +45°C. Charging outside of these recommended conditions may lead to either reduced battery life or permanent damage.

### 2.3.2 Bluetooth connection

The Core module implements Bluetooth Low Energy (Bluetooth 4.2 specification) with SUOTA (Software Update Over The Air) feature. The only hardware requirement is a connection of 2,4GHz, 50 Ohm antenna to BLE antenna port.



# 3. Connecting to MatchX server

Every Core module comes with preprogrammed unique MAC address, AppEUI and LoraWAN DevKey (also referred as AppKey by different sources). The DevKey is used to ensure a secure communication and data encryption between the module and application server. AppEUI is used to communicate with the application that registered on the Lora server. Care must be taken with storing the DevKey in a safe place and ensuring it is not compromised.

The products will come with a QR code sticker, which gives the Serial Number of the device. By typing in the S/N at the registration of the MatchX LPWAN Cloud, the preprogrammed APP EUI, MAC address and DevKey will be associated automatically.

## 3.1 Registering a node on MarchX server

Registering a node on MatchX server is a straight forward process. The user needs to know nodes DevKey, DevEUI and AppEUI. For more information about these keys refer to section 4.5.

Go to matchx.io and under 'Cloud' find an appropriate server according to region the node should be deployed. In this example we are using *https://eux.matchx.io* for Europa region. Register an account using valid email address. Go to your dashboard and click on 'Application' tab and than press 'Create application' button (see Figure 3.1).

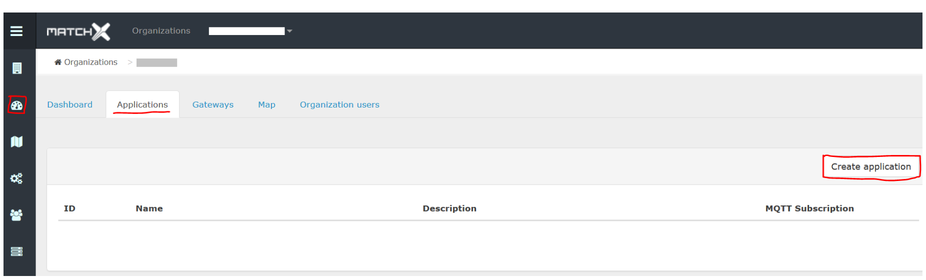



Figure 3.1: Creating new Application.

Fill out the 'Application name' and 'Application description' fields and click 'Submit'. Click on your newly created application and under 'Nodes' tab click on the 'Create node' button.

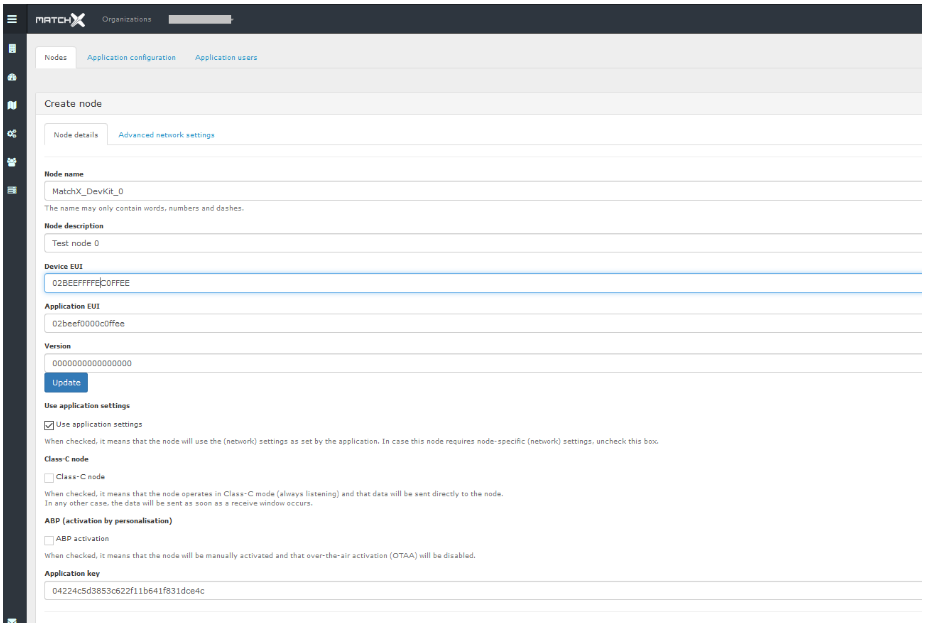



Figure 3.2: Creating new node.

Fill out information about DevKey, DevEUI and AppEUI. Device EUI should be in 64bit format (with fffe in the middle) like on Figure 3.2. Click on 'Submit' button. The node is now created, you can click on 'View' under 'Frame Logs' to see all messages belonging to the node like it is shown on Figure 3.3.

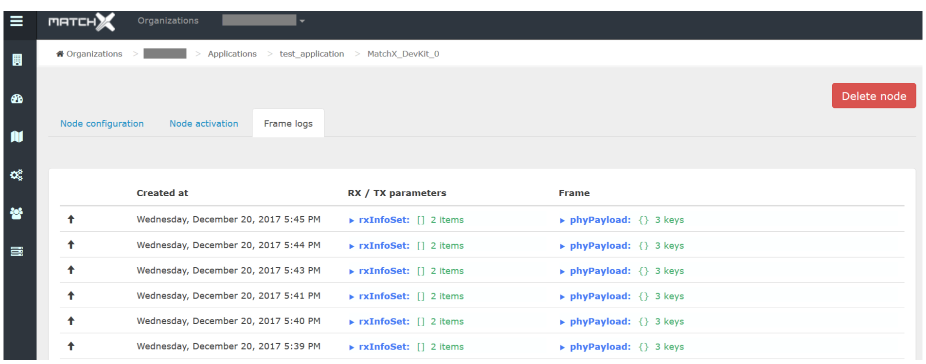
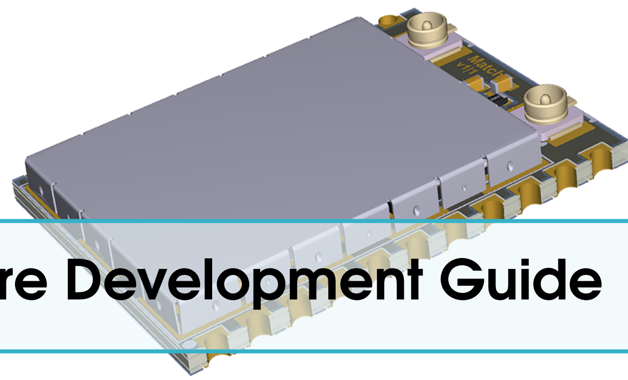



Figure 3.3: Nodes messages.



# 4. Software Development Guide

The purpose of this chapter is to help user to quickly install all necessary software components and establish hardware connections needed to start software development using MarchX Core SoM and Development Kit. MatchX is providing the Dev Kit Firmware (DKF) to be a starting point for further software development according to individual needs.

## 4.1 References

SoM module is based on Dialog DA14680 microcontroller so it is advisable to get familiar with the following documents available on Dialog Semiconductors website:

- DA14680-01 DS, Datasheet, Dialog Semiconductor
- UM-B-057-SmartSnippets Studio user guide, User manual, Dialog Semiconductor
- UM-B-047 DA1468x Getting Started, User manual, Dialog Semiconductor
- UM-B-044 DA1468x Software Platform Reference, User manual, Dialog Semiconductor
- UM-B-056 DA1468x Software Developer's Guide, Dialog Semiconductor

## 4.2 Prerequisites

- MatchX Development Kit
- USB-C cable and 5V charger
- UART-USB converter
- JLink programmer
- Dialog's Semiconductor SmartSnippets DA1468x SDK
- SmartSnippets Studio package
- MatchX Dev Kit Firmware
- Operating System (Windows or Linux)

## 4.3 Software development under Windows OS

The easiest way to install and configure all required tools is to install Dialogs SmartSnippets Studio package (it can be downloaded from the company website after registration). Experienced users can try to install all cross-compilation tools and configure they favorite SDE manually, but using Dialogs software the whole process is straight forward. Please follow UM-B-057 User Manual from Dialog for details about the installation.

After successful installation of SmartSnippets Studio and J-Link programmer, you should have gcc cross-compilation tools installed and proper PATH entry should exist, to check it you can open command line window and type `arm-none-eabi-gcc -v` The result should be similar to what is shown on Figure 4.1. In these example we are using gcc version 4.9.3 20150529.

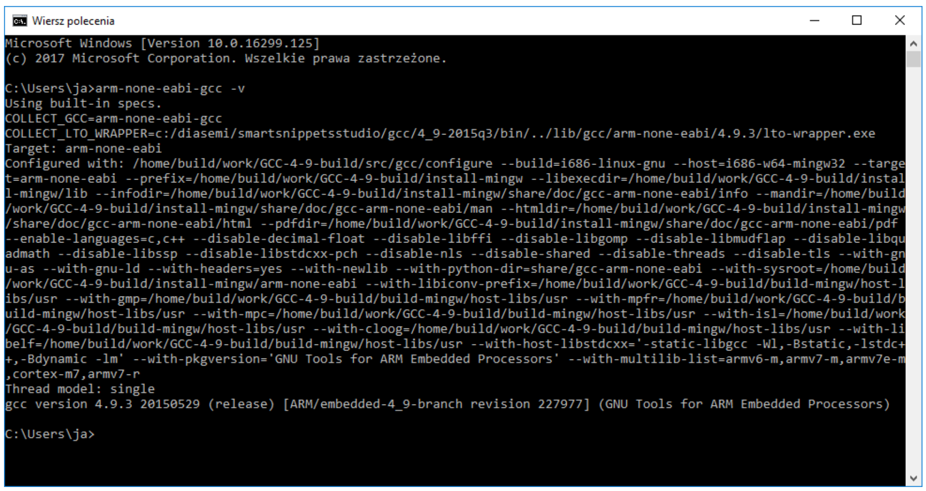



Figure 4.1: Checking ARM tools installation.

Download the Dialog's Semiconductor SmartSnippets DA1468x SDK (in the example the SDK version 1.0.8.1050.1 has been used) and MatchX Dev Kit Frmware. Both SDK and Dev Kit Firmware should be put in one folder (for example SmartSnippet workspace folder). DKF folder contains a make file which can be executed by navigating to the firmware folder and typing `make` in the command line window. This command will compile the firmware. If everything has been setup correctly the compilation process should return no errors and a binary file should be generated as a result, see Fugure 4.2.

After the software has been successfully compiled it can be programmed through J-Link programmer using a script provided by Dialog Semi. In command line window navigate to the DKF folder. The programming script `initial_flash.bat` should be located in SDK folder:
`DA1468x_SDK_BTLE_v_1.0.8.1050.1\utilities\scripts\suota\v11\`
It takes two parameter - path to the .bin file with firmware and path to the J-Link tools. The syntax is as follows:
`{Path}\initial_flash.bat "{Path to firmware}" "{Path to J-Link}"`
The example of the command can be seen on Figure 4.3. Before executing it the Dev Kit board has to be powered on and J-Link programmer has to be connected to SWD port on J101. Only GND, SWDCK and SWDIO are necessary to program the board. After successful programming process the screen should look similar as on Figure 4.4. On default DKF configures pins 5 and 6 on the

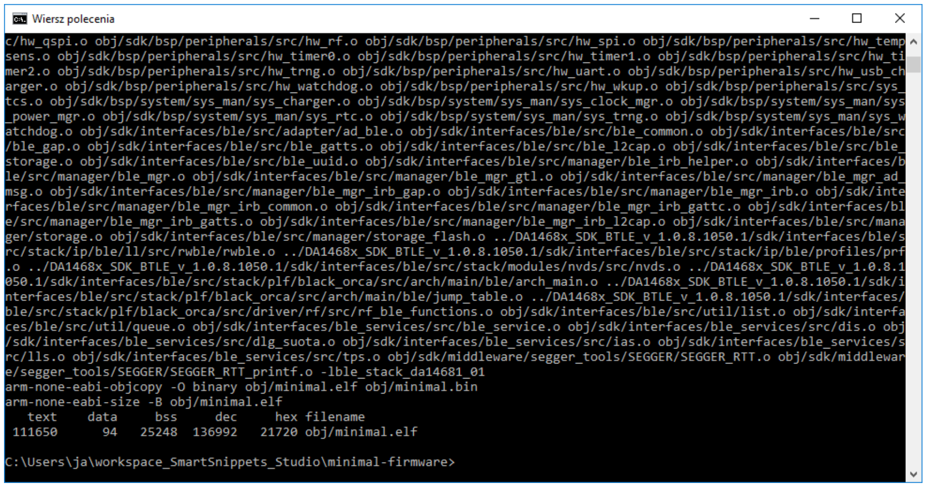



Figure 4.2: Compilation process of DKF.

J102 connector to be UART TX and RX respectively. By connecting a UART-to-USB converter to these pins the firmware will output the console messages. The output information sent after reset and UART configuration can be seen on Figure 4.5.

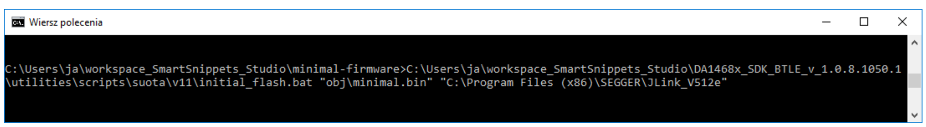



Figure 4.3: Example of programming command.

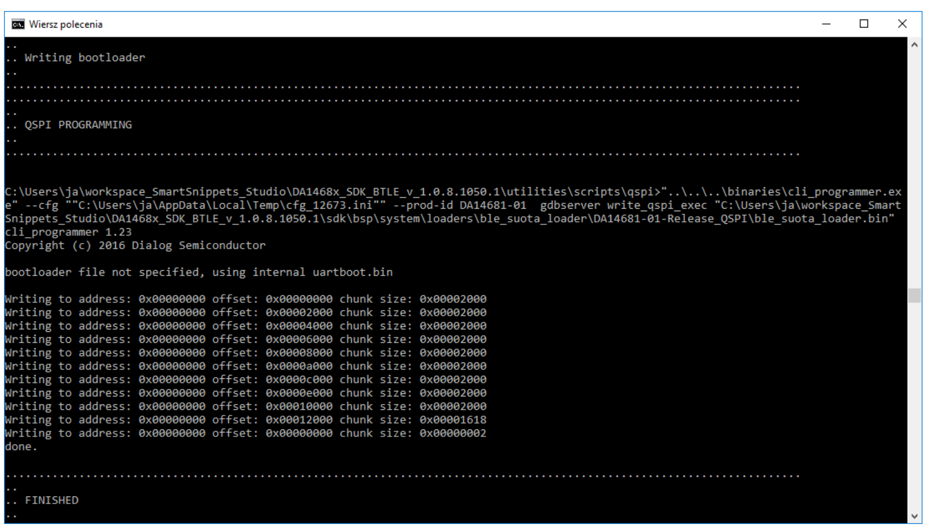



Figure 4.4: Programming completed successfully.

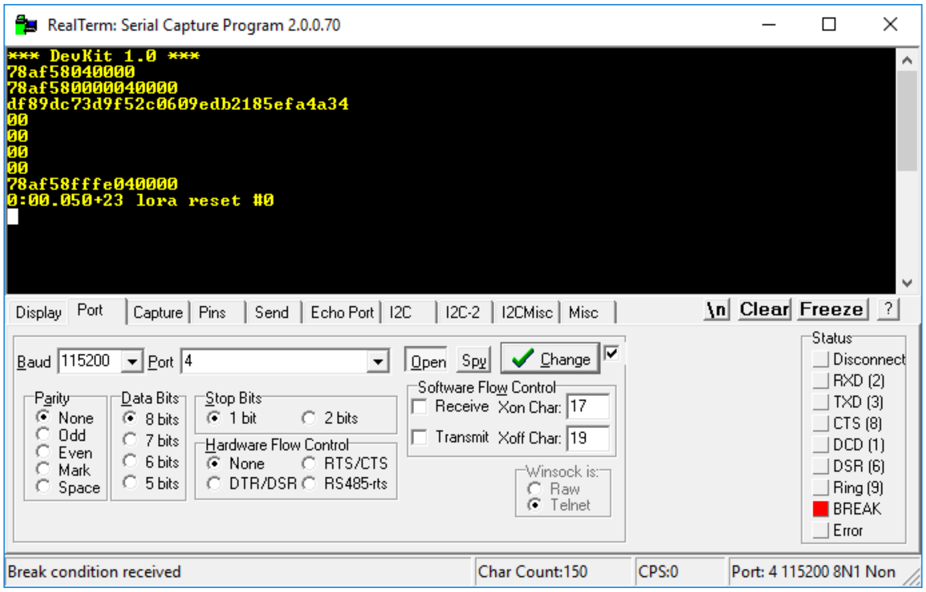



Figure 4.5: Console output of the Dev Kit after reset.

### 4.3.1 Using SmartSnippet Studio

As MatchX DKF is a makefile based project it is possible to port it quite easily to different IDE and use different operating systems. SmartSnippet Studio is a Dialog Semiconductors IDE based on Eclipse. It offers makefile project import capabilities.

In order to import the project, open the SmartSnippet IDE.The folder structure should be the same as in previous section, both SDK and DKF should be in SmartSnippet workspace folder. Go to **File->Import** and choose **'Existing Code as Makefile Project'** like on Figure 4.6.

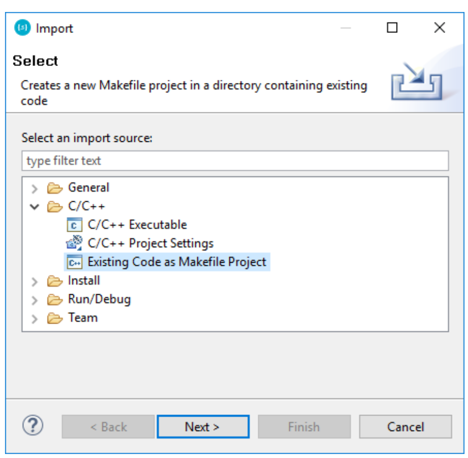



Figure 4.6: Import makefile project window.

Click **Next**. On the next window navigate to the DKF folder. Choose **'Cross ARM GCC'** and press **Finish**. The software should be correctly imported and you should be able to compile it by going to **Project->Build All** or pressing the build icon.

To program the just compiled firmware into DK you need to import "scripts" project to your workspace. To do that go to **File->Import** and choose **'Existing Projects into Workspace'** like on Figure 4.7.

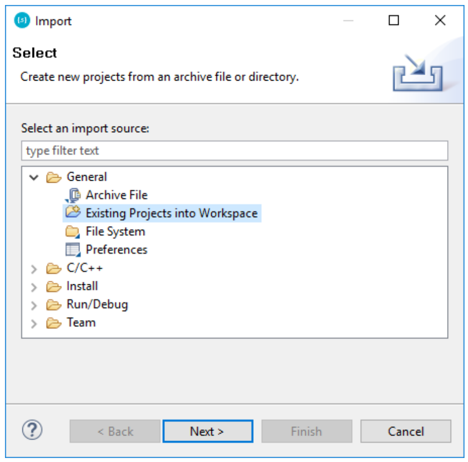



Figure 4.7: Import existing project window.

Click **Next**. On the next window navigate to the script folder that should be located in `<sdk_root>\utilities\scripts`. See Figure 4.8 and Figure 4.9

Now all the scripts should be available, but in order to use them they must be slightly modified to point to a correct .bin file. Click on **'External Tools Configuration'** as shown on Figure 4.10.

It is best to copy the **'suota_initial_flash_jtag_win'** script by right clicking on it and pressing **'Duplicate'** then renaming it. The **'Argument'** section has to be modified to contain correct path to compiled firmware. The variables values can be modified by clicking **'Variables'** button. The compiled .bin file is stored in **obj** folder in the project directory.

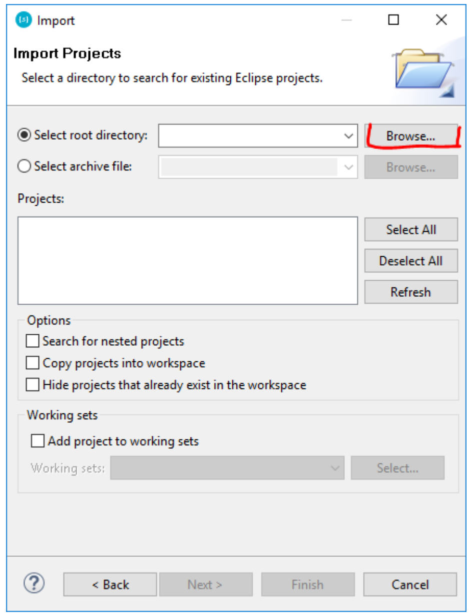



Figure 4.8: Importing eXisting project browse window.

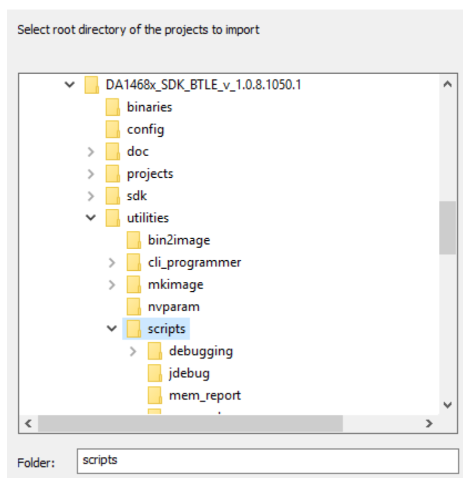



Figure 4.9: Browse window.

## 4.4 Software development under Linux

Software developing under Linux operating system is straight forward. The easiest way to setup the environment is to install the the SmartSnippet Studio from Dialog and following the installation guide in **UM-B-057** User guide from Dialog. Download the Dialog's Semiconductor SmartSnippets DA1468x SDK (in the example the SDK version 1.0.8.1050.1 has been used) and MatchX Dev Kit Frmware. Both SDK and Dev Kit Firmware should be put in one folder (for example SmartSnippet workspace folder). Open the terminal and navigate to DKF folder. The project contains make file

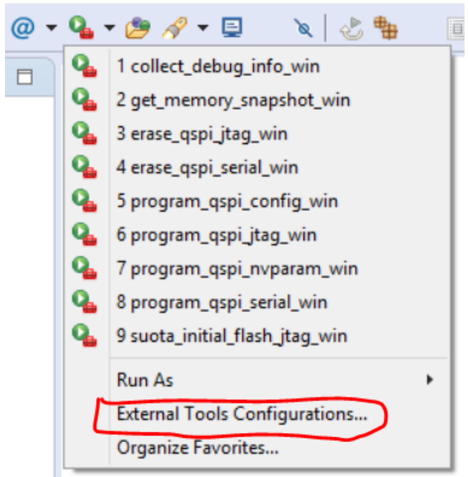



Figure 4.10: Scripts.

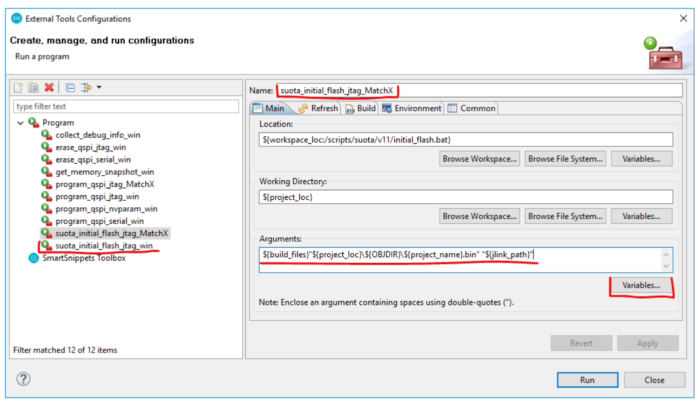



Figure 4.11: Scripts editing.

that takes over the compilation process. The firmware will be compiled by invoking `make` command. Programming the DK board is done by invoking `make` command with `firstflash` parameter.

## 4.5 Setting DevEUI, AppEUI and DevKey

To ensure the highest level of security in LoRaWAN network and Over the Air Activation (OTTA) 3 different keys have to be programmed into every end node.

- **DevEUI** - 6 bytes global end-device ID in IEEE EUI48 address space that uniquely identifies the end-device, also used by Bluetooth. It is converted to IEEE EUI64 by inserting 0xFFFE in the bytes 4 and 5. e.g. 78af58fffe040000
- **AppEUI** - 8 bytes global application ID in IEEE EUI64 address space that uniquely identifies the application provider (i.e., owner) of the end-device
- **DevKey** - 16 bytes unique AES-128 key

These keys are programmed by MatchX and stored in a special region of the nonvolatile memory

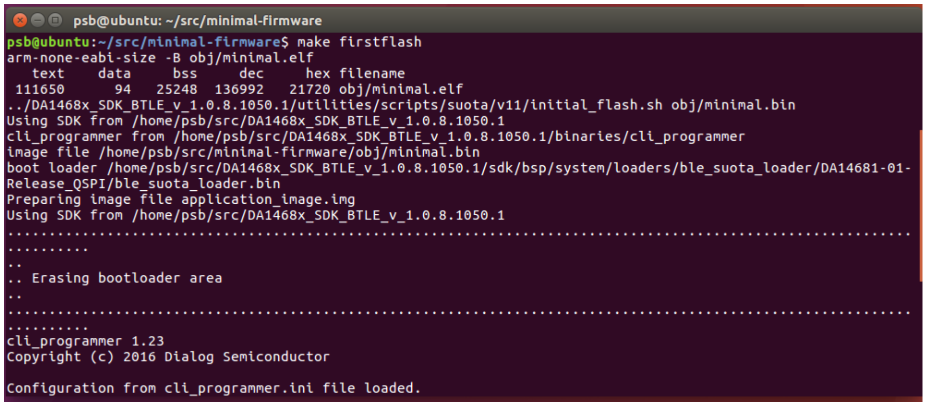



Figure 4.12: Programming DK board.

of the Dialog microcontroller. They will be preserved during flashing of the new firmware, however they will be lost by performing full flash erase. The default values are defined in `lora\param.c`. In Dev Kit Firmware the values of these keys are printed on UART console on power up, see Figure 4.13

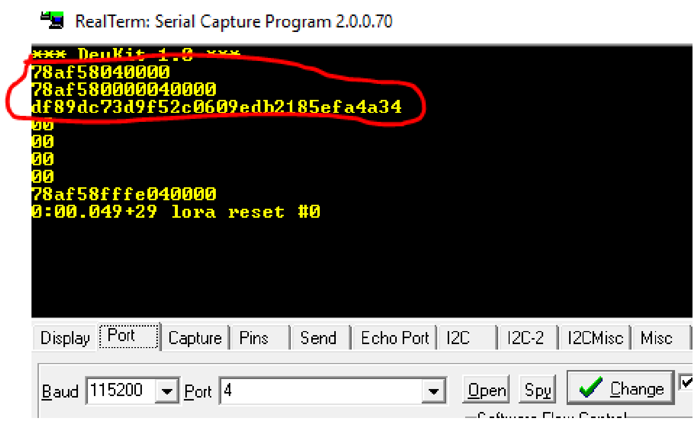



Figure 4.13: Displaying the keys on UART console.

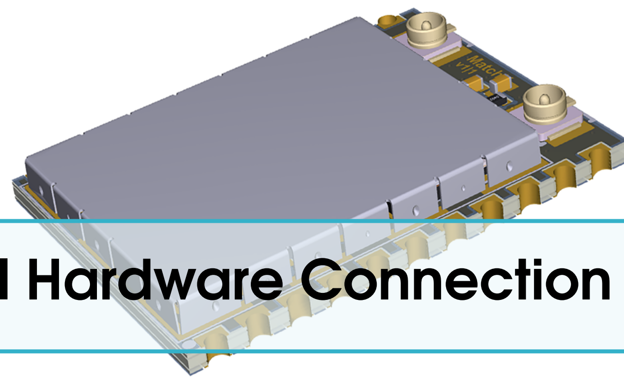
The values of DevEUI, AppEUI and DevKey can also be changed from UART console by using **param** command. The syntax is as follow:

```
param x value
```

where x = 0 for DevEUI, 1 for AppEUI and 2 for DevKey, value is a hexadecimal value to be set.

When value field is not specified the command will output current value of the parameter (except DevKey, which will not be shown).

DevKey is a AES-128 encryption key used for secure communication. It should be kept secret and only known to the sensor owner, this is why it is recommended to not display it on the UART in a final version of the firmware by removing `#define DEBUG` line in **param.c** file. It is also recommended to change its value before registering the node on the server.



# 5. Typical Hardware Connection

Figure 5.1 shows the typical hardware connection.

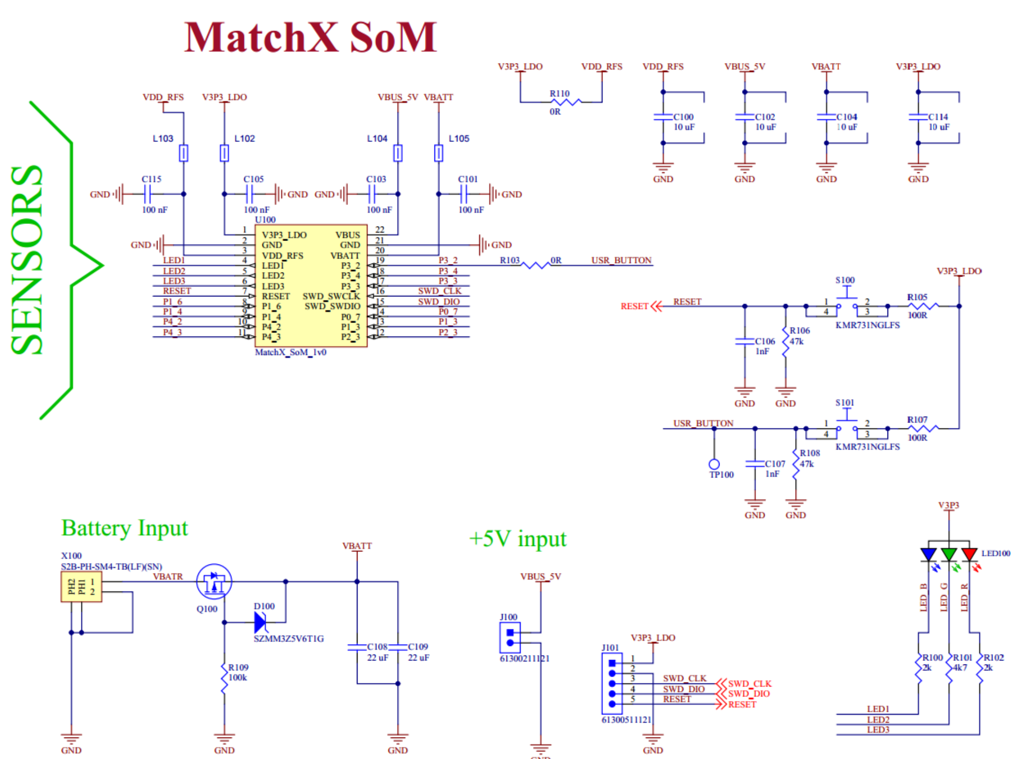



Figure 5.1: MatchX Core reference circuit.

## 5.1 Digital Interfaces

Interfaces such as SPI, UART, I2C etc. can be multiplexed to any GPIO pin which gives flexibility with sensor connection. By default P1_4 and P1_6 are used as UART console interface by MarchX firmware.

## 5.2 Analog Interfaces

Pins P1_3, P1_4, P0_7, SWD_IO and SWD_CLK can be used as analog inputs to internal ADC converter. In order to use SWD pins as analog inputs the programming and debug function of these pins has to be disabled first in the software. It is advisable to implement some delay between reset and disabling SWD function so the debug function can be entered after hardware reset.

Pins P1_6 and P1_4 can be also used as temperature sensing pins for battery charging and protection. Please refer to Dialog Semiconductor DA14680 datasheet for more details.

## 5.3 Programming Interface

The main programming interface is Serial Wire Debug (SWD) interface comprising of SWD_IO, SWD_CLK and optionally Reset. Additionally it is possible to use pins P1_3 and P2_3 to communicate with internal bootloader as described in UM-B-041 Production Line Tool User Manual by Dialog Semiconductors. This interface can be used with Dialog software and Production Line Tool to perform firmware flashing and production testing.

## 5.4 Antenna connection

The MX1721 Core module has been tested and certified with MatchX MX1733 Development board (Dev Kit). The Dev Kit is using two SMA connectors to connect external dipole antennas and two U.FL connectors to connect RF signal from Core module. The connection is shown on Figure 5.2. To connect the Core module to the antenna port two coaxial U.FL to U.FL pigtail cables of the length of 43mm are used (shown on Figure 5.3).

Between U.LF and SMA connectors on the Dev kit there are few passive components for matching and ESD protection. The detailed schematic can be seen on Figure 5.4 and layout on Figure 5.5 (the details about the Dev Kit boards, together with schematics and gerber files can be found on the company websites `www.matchx.io`). All inductors, capacitors, resistors and ESD components have 0402 size. The matching circuit has been designed in the way to match the antenna to 50Ohm impedance.

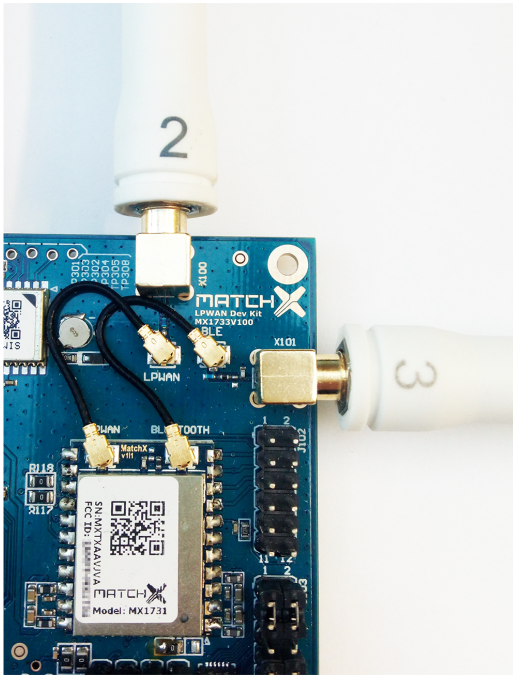



Figure 5.2: MatchX Core reference connection.

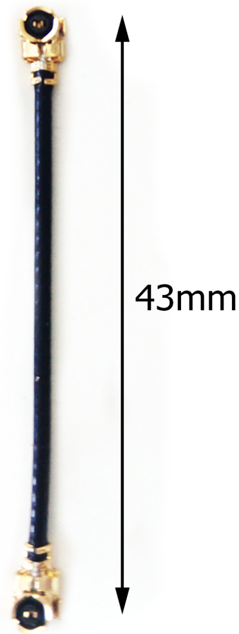



Figure 5.3: RF cable size.

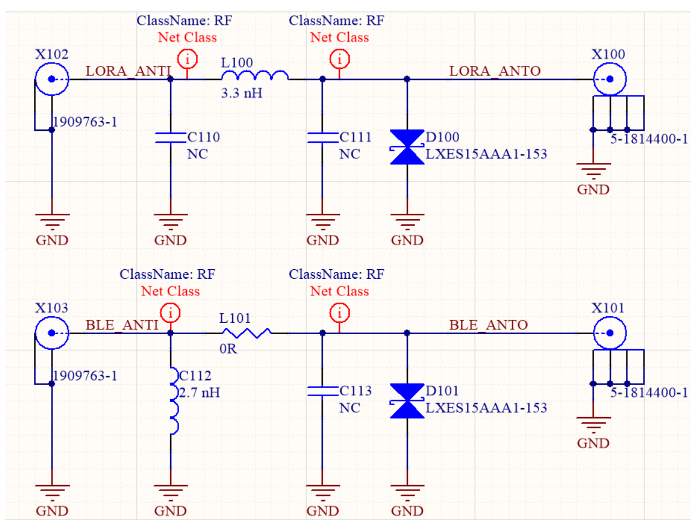



Figure 5.4: MatchX Core antenna connection circuit.

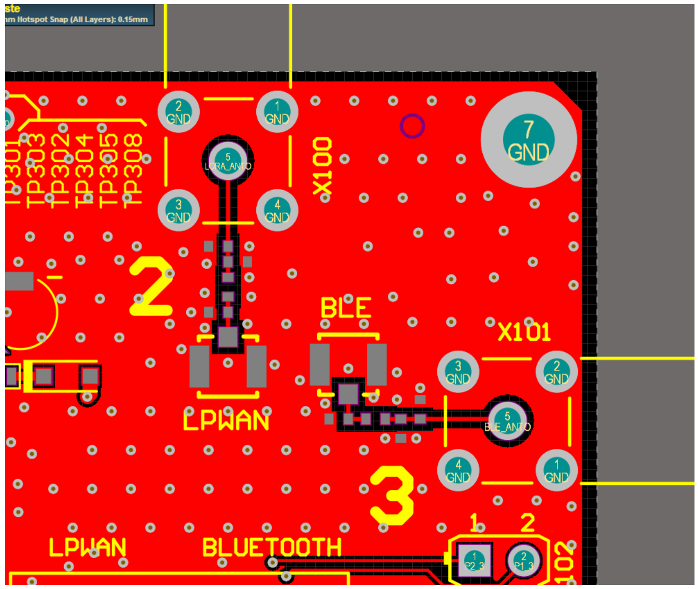
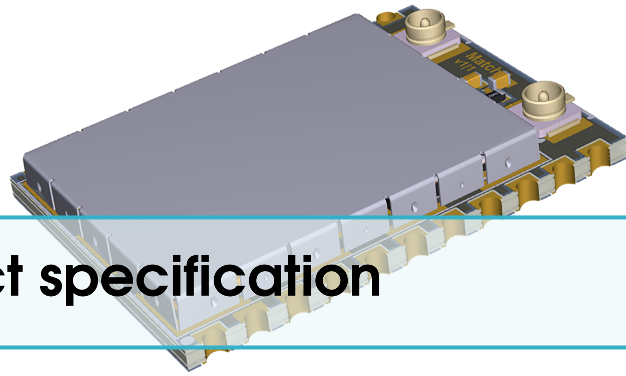



Figure 5.5: MatchX Core reference circuit.



# 6. Product specification

The MatchX Core SoM is designed for enhanced LPWAN performance and manageability. In this chapter we briefly introduce the specifications for both hardware and software.

## 6.1 Hardware environment

The Core Module is designed to make design process of smart connected LPWAN devices as easy as possible. It can be easily incorporated into existing solution or be a core controlling unit for new design. Together with MatchX Dev Kit hey help to kickstart your project by providing test and evaluation hardware for proof of concept and enable programmers to develop software before custom hardware is ready.

| Item | Description |
|---|---|
| MCU | DA14680, 0 Hz up to 96 MHz 32-bit ARM Cortex-M0 |
| Memory | 8Mb Flash, 64kB OTP, 128kB ROM, 144kB SRAM |
| Interfaces | $I^2C$, $I^2S$, PCM, SPI, UART, GPIOs |
| Wireless | Bluetooth 4.1 and LoRa |
| Battery | Li-poly battery charging and managing system |
| Size | 23 x 17.4 x 3mm |

Table 6.1: Key hardware specifications

.

## 6.2 Software environment

To facilitate an easy network deployment, we have included many software features, which include but are not limited to:

- Open source SDK and software support

- Over The Air software update
- Mobile App for Android and iPhone smartphones
- Free cloud service for managing and visualizing sensors data

## 6.3 RF performance

There are two RF systems in the module, which include Lora, and Bluetooth. In this section we briefly introduce the performance of these systems. For Lora, both the "transmission" and "receive" performance are listed in Table 6.2 and "Bluetooth" can be found in Table 6.3.

| Item | Value |
|---|---|
| TX Max | +18dBm |
| RX | down to -148dBm |

Table 6.2: Lora RF performance

For Bluetooth is listed in Table 6.3.

| Item | Value |
|---|---|
| Output Power | 0dBm |
| Sensitivity | -94dBm |

Table 6.3: Bluetooth performance.

## 6.4 Electrical characteristics

| Symbol | Description | Min | Max | Unit |
|---|---|---|---|---|
| $V_{BATT}$ | Battery voltage | 2.7 | 4.2 | V |
| $V3P3_{LDO}$ | Voltage output on the internal LDO | $V_{BATT}$ | 3.3 | V |
| $I_{V3P3_{LDO}}$ | Current output of 3V3_SNR | 0 | 100mA | mA |
| $V_{GPIO}$ | Voltage on any GPIO pin | 0 | $V3P3_{LDO}$ | V |
| $V_{BUS}$ | USB charging voltage | 4.2 | 5.75 | V |
| $I_{BUS}$ | USB charging current supply | | 300 | mA |
| $T_{op}$ | Operating Temperature | -40 | +85 | °C |

Table 6.4: Operating Range.

## 6.5 Antenna characteristics

The SoM module is equipped with two U.FL connectors: 2.4GHz for Bluetooth and one for 868MHz (915MHz in US version) LoRa antenna. The parameters of the recommended antennas can be found in Table 6.6. It is recommended to use dipole antennas as they are less susceptible to ground plane size and are less prone to detuning by surrounding objects.

| Symbol | Description | Min | Max | Unit |
|---|---|---|---|---|
| $I_{IDLE}$ | Current consumption, MCU awake, no RF activity | | 10 | mA |
| $I_{SEND}$ | Current consumption,sending LoRa packet | | 75 | mA |
| $I_{SLEEP}$ | Current consumption in sleep mode | | <10 | $\mu$A |

Table 6.5: Current consumption.

| Parameter | 2.4GHz antenna | 868MHz (EU version) | 915MHz (US version) |
|---|---|---|---|
| Center Frequency | 2.44GHz | 868MHz | 915MHz |
| Bandwidth | 101MHz | 40MHz | 40MHz |
| Gain | 3dBi | 2.5dBi | 2.5dBi |
| Type | Dipole | Dipole | Dipole |

Table 6.6: Parameters of recommended antennas.

## 6.6 Dimensions

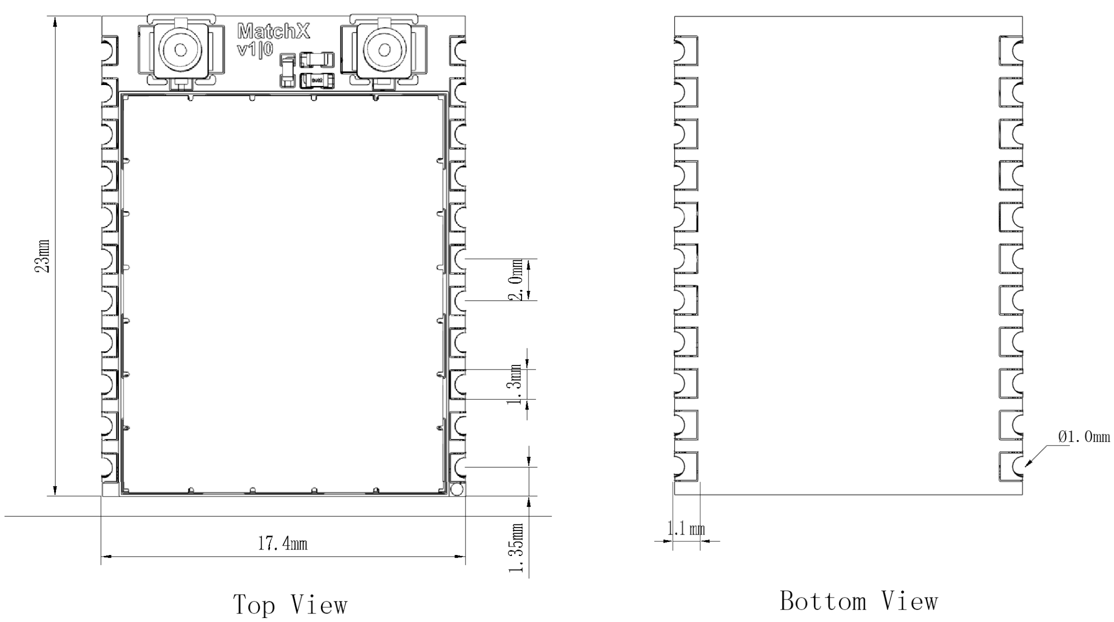



Figure 6.1: Dimension of the SoM module, all dimensions in mm.

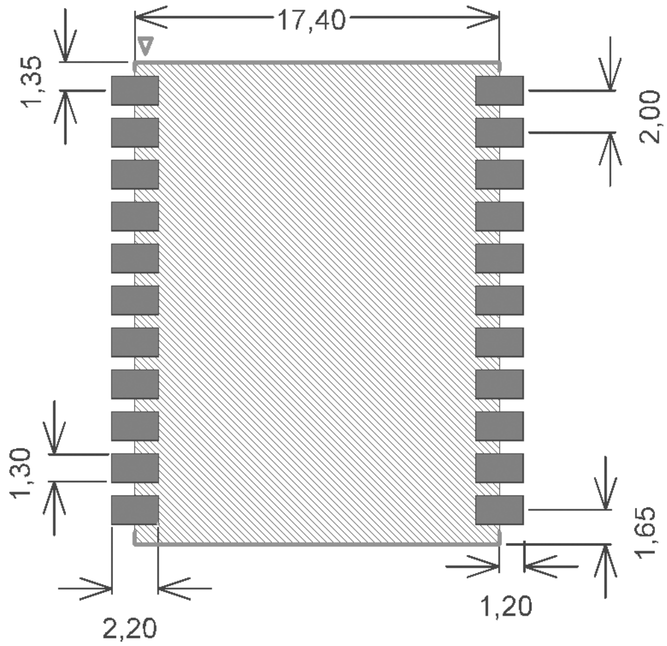
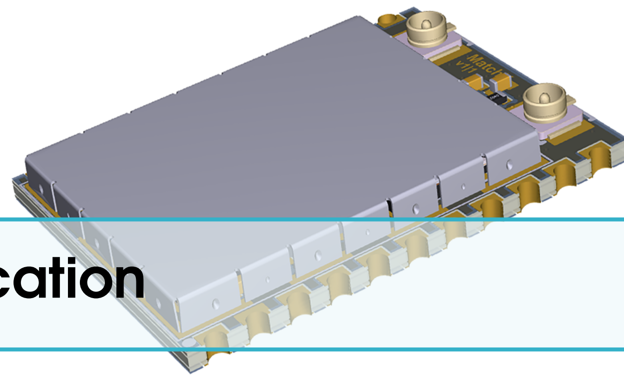



Figure 6.2: Recommended footprint (top view), all dimensions in mm.



# 7. Certification

This section outlines the regulatory information for the MX1731 module for the following countries/regions:

- United States
- EU

## 7.1 FCC

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

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

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

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

**NOTE:** The manufacturer is not responsible for any radio or TV interference caused by unauthorized modifications to this equipment. Such modifications could void the users authority to operate the equipment.

This equipment complies with FCC radiation exposure limits set forth for an uncontrolled environment. This equipment should be installed and operated with minimum distance of 20 cm between the radiator and your body. This transmitter must not be co-located or operating in conjunction with any other antenna or transmitter.

**ORIGINAL EQUIPMENT MANUFACTURER (OEM) NOTES**
The OEM must certify the final end product to comply with unintentional radiators before declaring compliance of the final product to Part 15 of the FCC rules and regulations. Integration into devices that are directly or indirectly connected to AC lines must add with Class II Permissive Change.

The OEM must comply with the FCC labeling requirements. If the modules label is not visible when installed, then an additional permanent label must be applied on the outside of the finished product which states:
"Contains transmitter module FCC ID: **2AMPF-MX1731**".
Additionally, the following statement should be included on the label and in the final products user manual:
"This device complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions:

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

The module is limited to installation in mobile or fixed applications. Separate approval is required for all other operating configurations, including portable configuration with respect to Part 2.1093 and different antenna configurations.
**Professional installation:**
When they have not been tested and granted in this manner, additional testing and/or FCC application filing may be required. The most straightforward approach to address additional testing conditions is to have the grantee responsible for the certification of at least one of the modules submit a permissive change application.

When having a module grantee file a permissive change is not practical or feasible, the following guidance provides some additional options for host manufacturers. Integrations using modules where additional testing and/or FCC application filing(s) may be required are: (A) a module used in devices requiring additional RF exposure compliance information (e.g., MPE evaluation or SAR testing); (B) limited and/or split modules not meeting all of the module requirements; and (C) simultaneous transmissions for independent collocated transmitters not previously granted together.

This Module is limited modular approval, it is limited to OEM installation ONLY. Integration into devices that are directly or indirectly connected to AC lines must add with Class II Permissive Change. (OEM) Integrator has to assure compliance of the entire end product include the integrated Module.

Additional measurements (15B) and/or equipment authorizations (e.g Verification) may need to be addressed depending on co-location or simultaneous transmission issues if applicable. (OEM) Integrator is reminded to assure that these installation instructions will not be made available to the end user of the final host device.

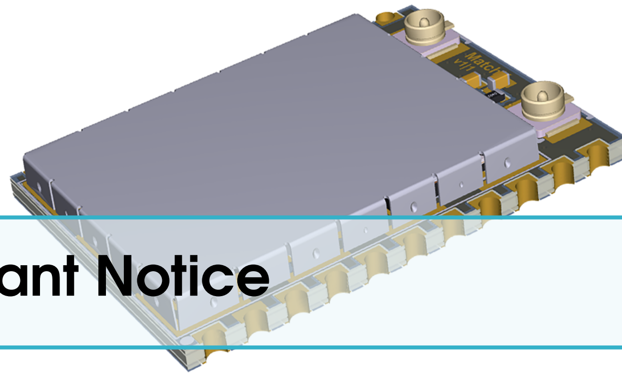
### 7.1.1 Antenna information

To maintain modular approval in the United States, only the antenna types that have been tested shall be used.It is permissible to use different antenna manufacturer provided the same antenna type and antenna gain (equal to or less than) is used. Testing of the MX1731 module was performed with the antenna types listed in Table 6.6.

## 7.2 CE

RF exposure information: The Maximum Permissible Exposure (MPE) level has been calculated based on a distance of 20 cm between the device and the human body. To maintain compliance with RF exposure requirement, use product that maintain a 20cm distance between the device and human body.

Hereby, **MatchX GmbH** declares that the radio equipment type **MX1731** is in compliance with Directive 2014/53/EU. The full text of the EU declaration of conformity is available at the following internet address: `www.matchx.io`.



# 8. Important Notice

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