SmartEverything FOX

User Guide

Rev. 0.0

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Revision Sheet

Release No.	Date	Revision Description
Draft. 0.5	21/04/2015	First Release

Table 1: Document History

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Chapter 1 Introduction

This document describes Amel Technology SmartEverything FOX SoM (System On Module) based on Atmel D21 Ultra low-power microcontroller using the 32-bit ARM® Cortex®-M0+ processor.

The SmartEverything FOX Board provides the following peripherals or modules:

- Atmel Crypto Authentication chpset
- Dynaflex 868Mhz Antenna
- Sigfox Module
- GPS Module with Embedded Antenna
- Proximity sensor
- Humidity and Temperature sensor
- Axis sensors
- Pressure Sensor
- NFC NTAG I2C Interface
- Bluetooth Low Energy (BLE) Interface

The SmartEverything FOX Board is supported by the Arduino IDE for a fast and easy software development cycle. The software can also be developed using the Atmel Studio IDE commonly preferred by professional software engineers.

1.1 Board Specifications

Characteristics	Value
Clock speed	
Connector	
Board supply voltage	
Temperature	0°C to +70°C or -40°C to +85°C
Dimensions	
RoHS status	Compliant

Table 2: Board Specifications

Chapter 2 Hardware

2.1 External View

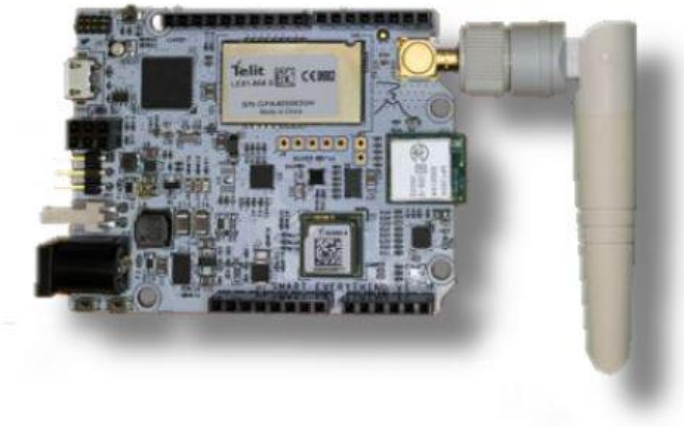

Figure 1: Front View

2.2 SmartEverything FOX Block Diagram

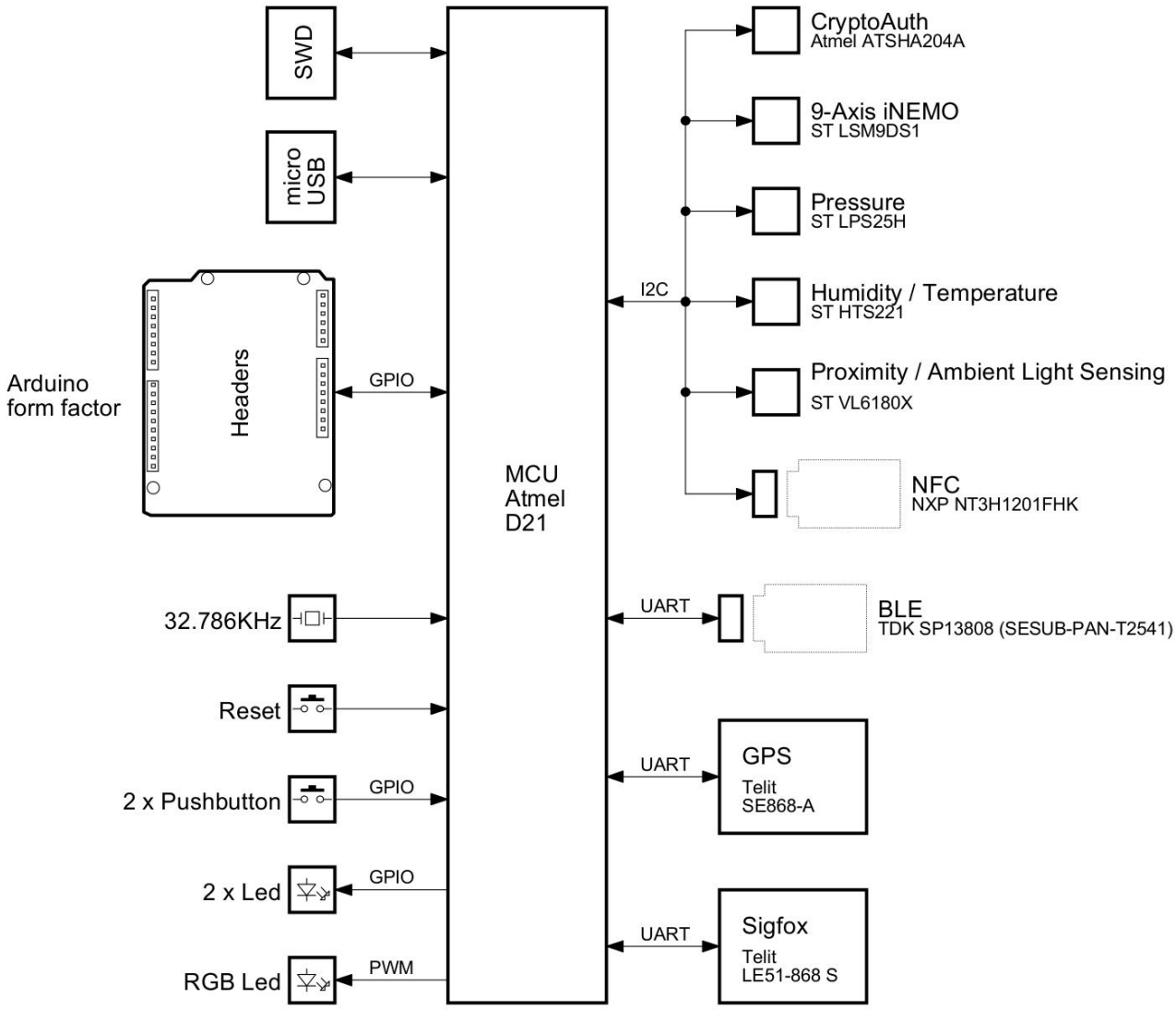

Figure 2: SmartEverything Block Diagram

2.3 ATMEL SAML21 Ultra low-power ARM® Cortex®-M0+ MCU

Atmel D21 Ultra low-power microcontroller using the 32-bit ARM® Cortex®-M0+ processor is the core of the entire board.

2.3.1 ATMEL SAMD21 Internal Memory

- 32/64/128/256KB in-system self-programmable Flash
- 4/8/16/32KB SRAM Main Memory
- 4/4/8/12KB SRAM Low power Memory

Leave only the memory size used by the SAMD21 used on the board.

2.3.2 Clock Circuitry

- 16-channel Direct Memory Access Controller (DMAC)
- 12-channel Event System
- Up to five 16-bit Timer/Counters (TC), configurable as either:
  - One 16-bit TC with compare/capture channels
  - One 8-bit TC with compare/capture channels
  - One 32-bit TC with compare/capture channels, by using two TCs
- Three 16-bit Timer/Counters for Control (TCC), with extended functions:
  - Up to four compare channels with optional complementary output
  - Generation of synchronized pulse width modulation (PWM) pattern across port pins
  - Deterministic fault protection, fast decay and configurable dead-time between complementary output
- 32-bit Real Time Counter (RTC) with clock/calendar function
- Watchdog Timer (WDT)
- CRC-32 generator
- One full-speed (12Mbps) Universal Serial Bus (USB) 2.0 interface
  - Embedded host and device functions
  - Eight endpoints
- One True Random Generator (TRNG)
- One Configurable Custom Logic (CCL)
- One 12-bit, 1Msps Analog-to-Digital Converter (ADC) with up to 20 channels
  - Differential and single-ended input
  - Automatic offset and gain error compensation
  - Oversampling and decimation in hardware to support 13-, 14-, 15- or 16-bit resolution
- 12-bit, 1Msps Dual Output Digital-to-Analog Converter (DAC)
- Two Analog Comparators (AC) with window compare function
- Three Operational Amplifiers (OPAMP)

Leave only the feature usable on the board and remove the feature unusable.

2.3.3 Clock Circuitry

Add here info about clock frequency.

2.3.4 Reset Circuitry

Add here info about reset circuity.

2.3.5 Power Supply Circuitry

The board can be powered by three different power supply sources:

- 2 x AA 1,5 V batteries (1.4V to 3.2V)
- A 5V to 45V input
- A 5V Mini USB connector

Both the way to power supply the board guarantee the full functionality of all the components and peripherals.

All the components can work with the voltage range provided by the batteries with the exception of the GPS module that require at least 2.8V. This voltage is provided by the Step-Up DC/DC converter directed controlled by the MCU
When the Step-Up is off the input voltage is provided by the batteries.

Step-Up Status	Power Supply	Notes
Step-Up ON	3V	
Step-Up OFF	Batteries voltage (1.4V – 3.2V)	

Table 3: Power Supply Step-Up management

The Step-Up is directed controlled by the MCU. The user, depending of the purpose of the application, can decide the better policy to use:
If the Step-Up is normally off, the GPS can stay off and turned on only when necessary. This policy reduce the power consumption but the GPS require more time to acquire the coordinates.
If the application requires a frequent usage of the GPS, it is better to keep the Step-Up and the GPS on.

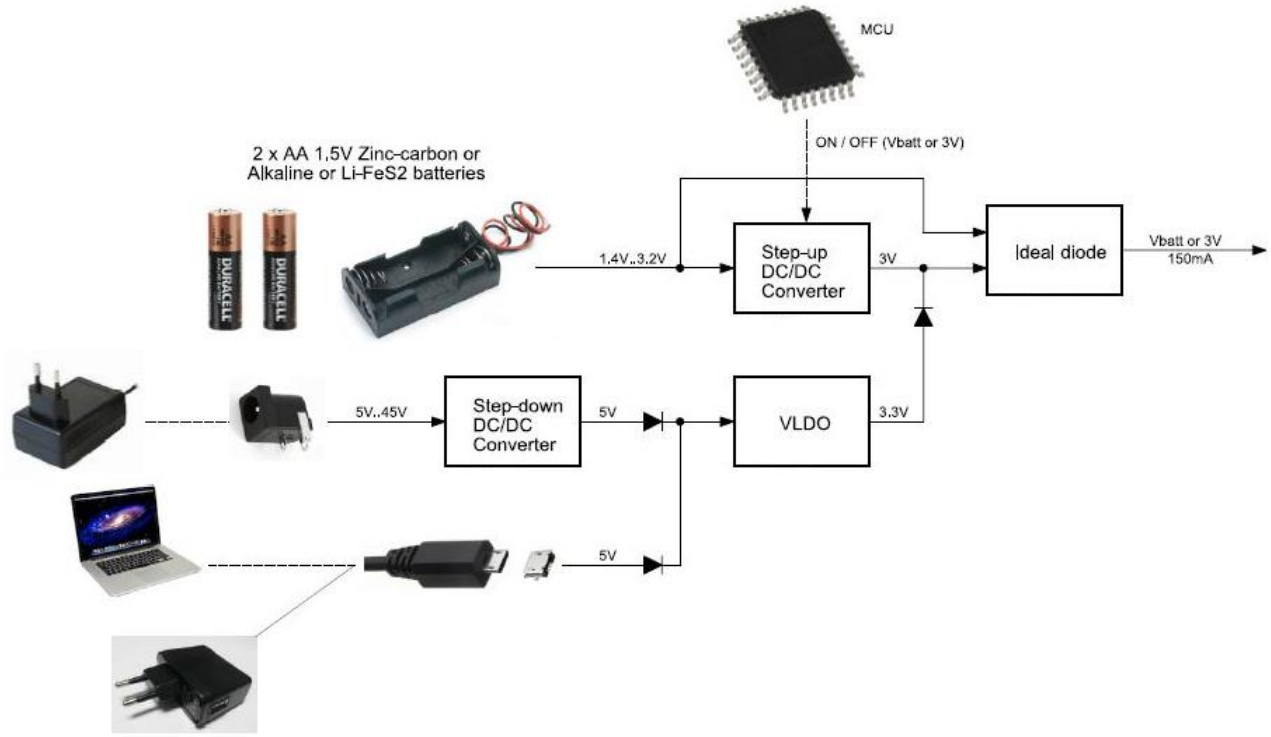

Figure 3: Power Supply block diagram

Name	Nominal	Description	Range
J12	3 V	Battery Power Supply	1.4V to 3.2V
J13	5V to 45V	External Power Supply	5V to 45V
USB	5V	USB Port	5V

Table 4: Power Supply Connectors and ranges

Add here info about power consumption.

More information can be found on the ATMEL SAMD21 Data Sheet (See the link in the References and Useful Links chapter)

2.4 Crypto Authentication Chip (ATMEL ATSHA204A)

The ATSHA204A is a member of the Atmel CryptoAuthentication™ family of high-security hardware authentication devices. It has a flexible command set that allows use in many applications, including the following, among others:

- Anti-counterfeiting
- Protecting Firmware or Media
- Exchanging Session Keys
- Storing Data Securely
- Checking User Passwords

2.4.1 Device Features

The ATSHA204A device includes an Electrically Erasable Programmable Read-Only Memory (EEPROM) array that can be used for key storage, miscellaneous read/write data, read-only, secret data, consumption logging, and security configuration.

Access to the various sections of memory can be restricted in a variety of ways, and the configuration can then be locked to prevent changes.

The ATSHA204A features a wide array of defense mechanisms specifically designed to prevent physical attacks on the device itself or logical attacks on the data transmitted between the device and the system

Hardware restrictions on the way keys are used or generated provide further defense against certain styles of attack.

Access to the device is made through a standard I2C interface.

Each ATSHA204A ships with a guaranteed unique 9-byte (72-bit) serial number. Using the cryptographic protocols supported by the device, a Host system or remote server can prove that the serial number is authentic and is not a copy. Serial numbers are often stored in a standard Serial EEPROM, which can be easily copied with no way for the Host to know if the serial number is authentic or if it is a clone. The entire serial number must be utilized to guarantee uniqueness.

2.4.2 Cryptographic Operation

The ATSHA204A supports a standard challenge-response protocol to simplify

programming. In its most basic installation, the Host system sends a challenge (i.e. a number) to the device in the Client, which combines that challenge with a secret key by using the Message Authentication Code (MAC) command from the system and sends that response back to the system.

This basic operation can be expanded in many ways because of the flexible command set of the ATSHA204A.

For a complete explanation about the possible Cryptographic Operations check the Data Sheet (See the link in the References and Useful Links chapter)

2.5 Dynaflex 868Mhz Antenna (915/2)

Add here info about antenna

2.6 Sigfox Module (Telit LE51-868 S)

Telit LE51-868 S module is a high performance module designed to cover the 863-870MHz unlicensed band. It provides the Telit proprietary Star Network protocol and it is able to act as a certified Sigfox™ gateway.

The following protocol stack are preloaded:

- LE51-868 S SIGFOX™ Network Software.
- “Star Network” Protocol stack

2.6.1 Main Features

The LE51-868 S module is a complete solution from serial interface to RF interface. The LE51-868 module has a digital part and a RF part. The radio link on Sigfox network is a Half-Duplex bidirectional link.

The digital part has the following functionalities:

- Communication interface
- I/O management
- Micro controller with embedded Telit Software Stack supporting Sigfox protocol

The RF part has the following functionalities:

- Frequency synthesis
- Front-end
- Power amplification
- Packet handling

More information can be found on relevant Data Sheet (See the link in the References and Useful Links chapter)

2.7 GPS Module with Embedded Antenna (Telit Jupiter SE868-A)

The Telit Jupiter SE868-A is a GPS Module designed to fully support GPS, QZSS, GLONASS and it is Galileo ready. It has an embedded SMT antenna and it is able to track GPS + GLONASS (and eventually Galileo) constellations simultaneously and to provide the position through the standard serial interface (UART)

The module software can increase the position accuracy supporting:

- Ephemeris file injection (A-GPS)
- Satellite Based Augmentation System (SBAS)

More information can be found on relevant Data Sheet (See the link in the References and Useful Links chapter)

2.8 Proximity sensor (ST VL6180X)

The ST VL6180X is a proximity and light sensing module. The sensor precisely measures the time the light takes to travel to the nearest object and reflect back to the sensor (Time-of-Flight) and calculate the distance.

It combines an IR emitter, a range sensor and an ambient light sensor in a single package.

Atmel D21 MCU controls and reads the results using an I2C interface.

More information can be found on relevant Data Sheet (See the link in the References and Useful Links chapter)

2.9 Humidity and Temperature sensor (ST HTS221)

The HTS221 is a compact sensor for relative humidity and temperature. It provides the measurement information through digital serial interfaces to the Atmel D21 processor

The sensing element consists of a polymer dielectric planar capacitor structure capable of detecting relative humidity variations and is manufactured using a dedicated ST process.

2.9.1 Characteristics

- 0 to 100% Relative Humidity range
- High rH sensitivity: 0.004% rH/LSB
- Humidity accuracy: ± 4.5% rH, 20 to +80% rH
- -40 to 120 °C Temperature range
- Temperature accuracy: ± 0.5 °C,15 to +40 °C
- Factory calibrated

More information can be found on relevant Data Sheet (See the link in the References and Useful Links chapter)

2.10 Axis sensors (ST LSM9DS1)

The LSM9DS1 is a 3D digital linear acceleration sensor, a 3D digital angular rate sensor, and a 3D digital magnetic sensor.

The LSM9DS1 has a linear acceleration full scale of ±2g/±4g/±8g, a magnetic field full scale of ±4/±8/±12/±16 gauss and an angular rate of ±245/±500/±2000 dps.

It communicates with the Atmel MCU through the I2C interface.

More information can be found on relevant Data Sheet (See the link in the References and Useful Links chapter)

2.11 Pressure Sensor (ST LPS25H)

The LPS25H is a compact absolute piezoresistive pressure sensor. It communicates with the Atmel MCU through the I2C interface. The sensing element consists of a suspended membrane realized inside a single mono-silicon substrate.

2.11.1 Characteristics

- 260 to 1260 hPa absolute pressure range
- High-resolution mode: 1 Pa RMS
- High overpressure capability: 20x full scale
- Embedded temperature compensation

More information can be found on relevant Data Sheet (See the link in the References and Useful Links chapter)

2.12 NFC NTAG I²C (NXP NTAG I²C NT3H1101FHK)

NFC is the abbreviation for Near Field Communication. NFC is a set of ideas and technology that enables devices to establish radio communication with other devices by touching them together or bringing them into proximity (typically less than 10 cm close).

The NTAG I²C is a chip offering a NFC Forum compliant contactless interface. The module is connected to the main Atmel SAMD21 MCU through a UART interface

An additional SRAM mapped into the memory allows a fast data transfer between the RF and I²C interfaces and vice versa, without the write cycle limitations of the EEPROM memory.

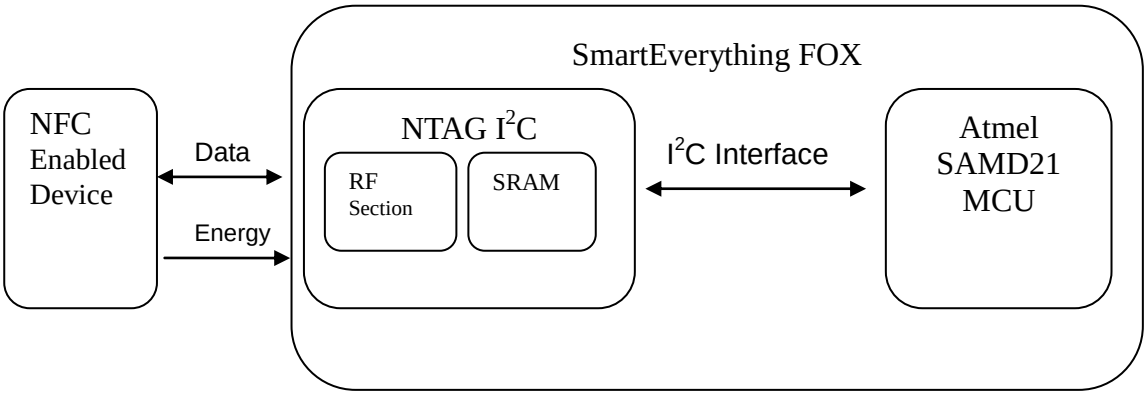

Figure 4: NFC TAG Block Diagram

More information can be found on relevant Data Sheet (See the link in the References and Useful Links chapter)

2.13 Bluetooth Low Energy (TDK SESUB-PAN-T2541)

TDK SESUB-PAN-T2541 is a integrated 2.4-GHz Bluetooth® low energy (BLE) smart compliant transceiver module based on a Texas CC2541 System-on-Chip Solution for 2.4-GHz Bluetooth® low energy Applications.

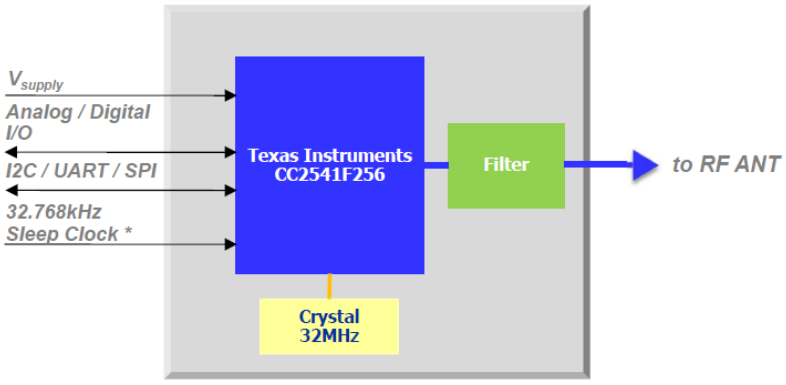

Figure 5: TDK SESUB-PAN-T2541 block diagram

The Texas CC2541 System-on-Chip is based on a 8051 CPU core, and provide memory, peripherals and the RF receiver and transmitter
The module is connected to the main Atmel SAMD21 MCU through a UART interface

2.13.1 Characteristics

Program Memory: In System Programmable 256K Flash
Bluetooth Stack: Embedded BT-Stack from TI available
TX Output Power: 0 dBm (typ) [Class 2]
High RX Sensivity: -94 dBm (typ)

More information can be found on relevant Data Sheet (See the link in the References and Useful Links chapter)
The module on the board is provided with the firmware able to communicate with the ATMEL SAMD21 MCU

2.14 Board Interfaces and Connector

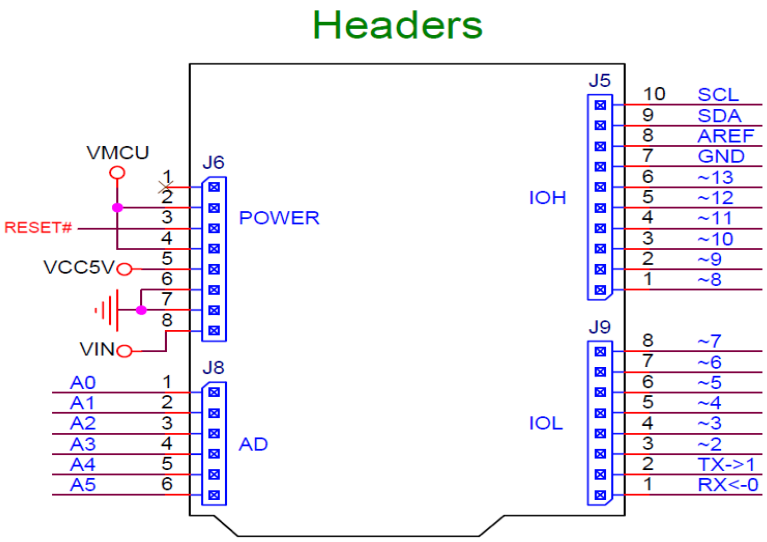

Figure 6: Headers pinout

The following table must be completed

Name	Conn.	Pin	Description
D8	J5	1	Digital I/O D8 / PWM
D9	J5	2	Digital I/O D9 / PWM
D10	J5	3	Digital I/O D10 / PWM
D11	J5	4	Digital I/O D11 / PWM
D12	J5	5	Digital I/O D12 / PWM
D13	J5	6	Digital I/O D13 / PWM
GND	J5	7	Ground pin
AREF	J5	8	Analogue Reference (used by ADC)
SDA	J5	9	
SCL	J5	10	
NC	J6	1	Not Connected
VMCU	J6	2	
RESET	J6	3	Reset
VMCU	J6	4	
Vcc 5V	J6	5	
GND	J6	6	Ground pin
GND	J6	7	Ground pin
Vin	J6	8	External Power Supply Input
A0	J8	1	Analog Input A0
A1	J8	2	Analog Input A1
A2	J8	3	Analog Input A2
A3	J8	4	Analog Input A3
A4	J8	5	Analog Input A4
A5	J8	6	Analog Input A5
D0 / RX	J9	1	Digital I/O D0 / Serial RX
D1 / TX	J9	2	Digital I/O D1 / Serial TX
D2	J9	3	Digital I/O D2 / PWM
D3	J9	4	Digital I/O D3 / PWM
D4	J9	5	Digital I/O D4 / PWM
D5	J9	6	Digital I/O D5 / PWM
D6	J9	7	Digital I/O D6 / PWM
D7	J9	8	Digital I/O D7 / PWM

Table 5: Arduino Compatible Headers

Chapter 3 Mechanical Information

3.1 Main components layout

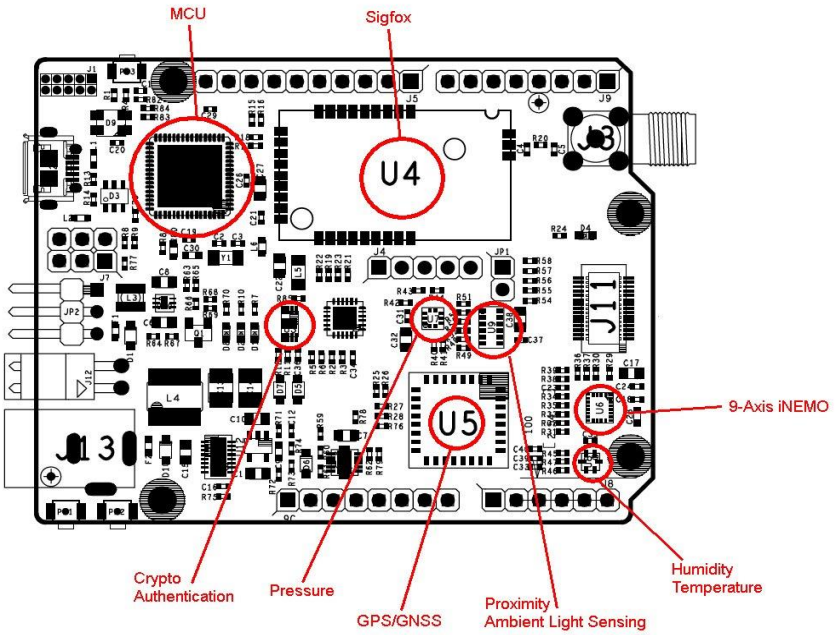

Figure 7: Main Component layout (top)

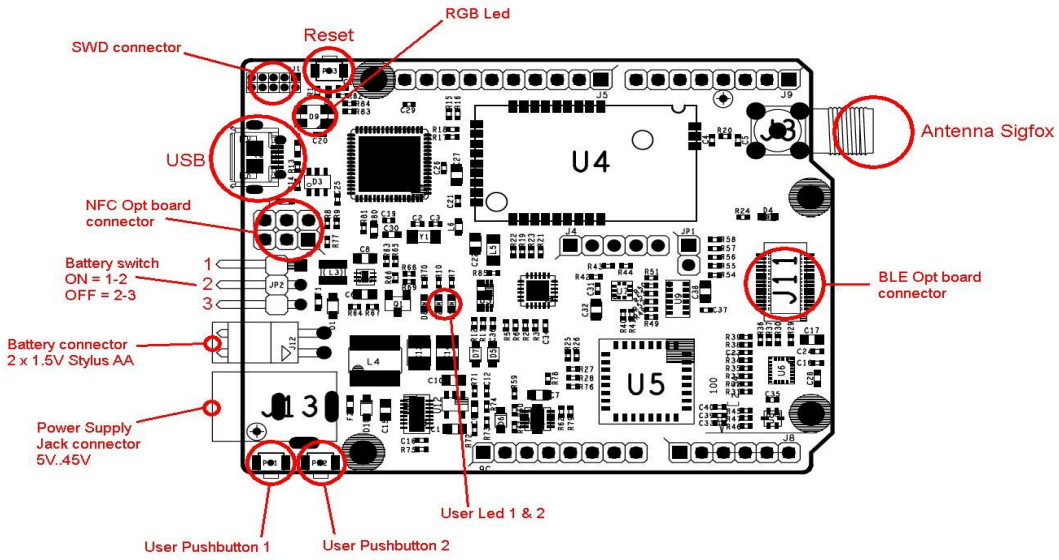

Figure 8: Main Component layout (top #2)

3.2 Mechanical Characteristics

Add here mechanical information

Figure 9: Dimensions

Chapter 4 Software Development

The following chapters provides an overview about how a user can develop its software and run it on the SmartEverything FOX board.

There are two main ways to develop a software load and debug it on the card:

- Using the Arduino IDE and Sketch Projects
- Using the Atmel Studio and Standard C/C++ language

When developing a software running on a microcontroller it is important to have some tools to easily debug the code and fix what does not work as expected

The Atmel SAMD21 provides the Atmel's Embedded Debugger (EDBG): a full debug interface without the need for additional debugger. This feature makes easier the software debugging. EDBG supports a virtual COM port that can be used for device programming and allows a traditional Arduino boot loader functionality.
The possibilities to use an external debugger like the JTAGICE3 is still available.

Chapter 5 Getting Started with Arduino IDE and Sketch Projects

The chapter will be completed after ArduinoIDE will support the board

5.1 Tools

The following tools are needed:

- Arduino IDE (Release X.X.X or newer)
- USB cable

5.2 Setup the Environment

Download and install the Arduino IDE from the Arduino web site (See the links in the References and Useful Links chapter)
Connect the SmartEverything FOX board to the PC with the USB cable
Installing the Driver

5.3 Compile the Example project

Run the ArduinoIDE
In the Tool → Board menu select the SmartEverything FOX board

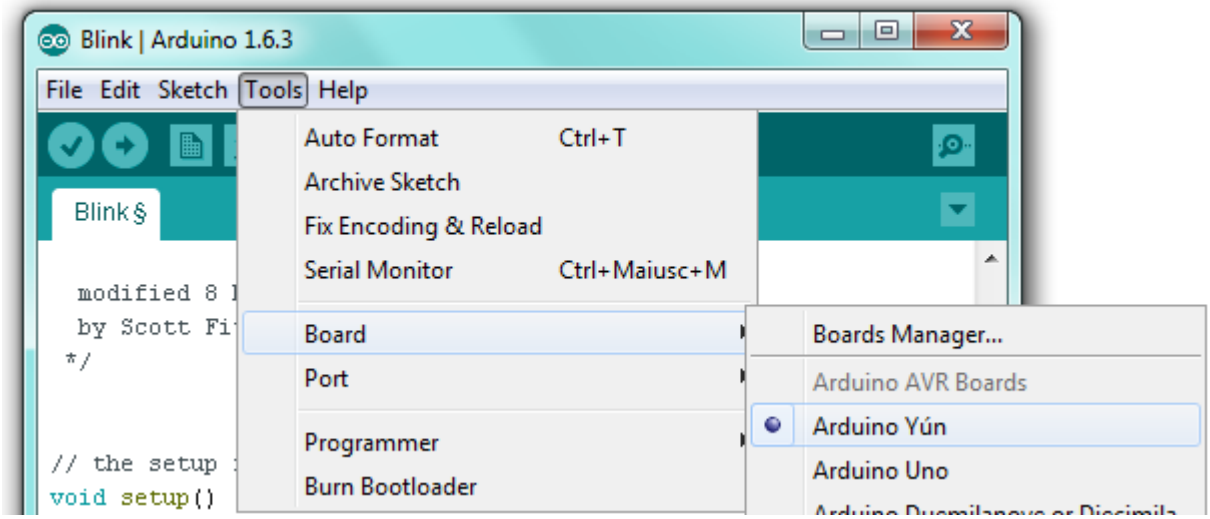

Figure 10: ArduinoIDE Select the board

In the Tool → Port menu select the relevant installed port

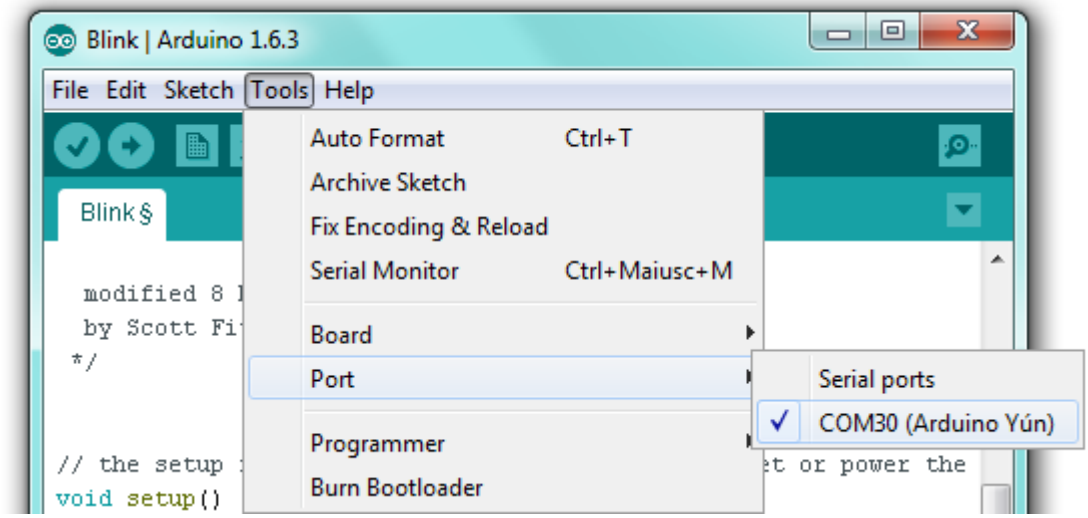

Figure 11: ArduinoIDE: Select the port

In the File → Example → 01.Basic menu select the Blink sketch example

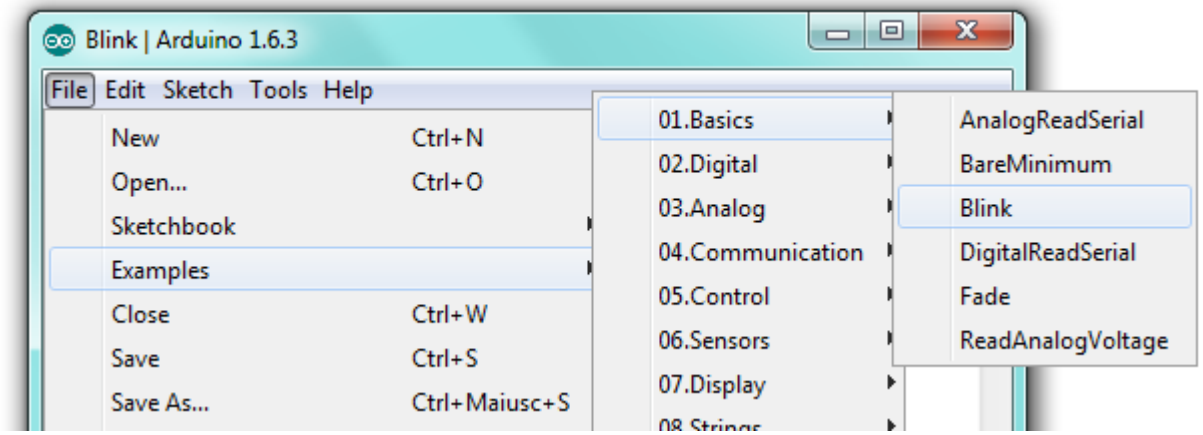

Figure 12: ArduinoIDE: Select the example

Explain here the necessary modification

5.4 Run the software

Verify the code

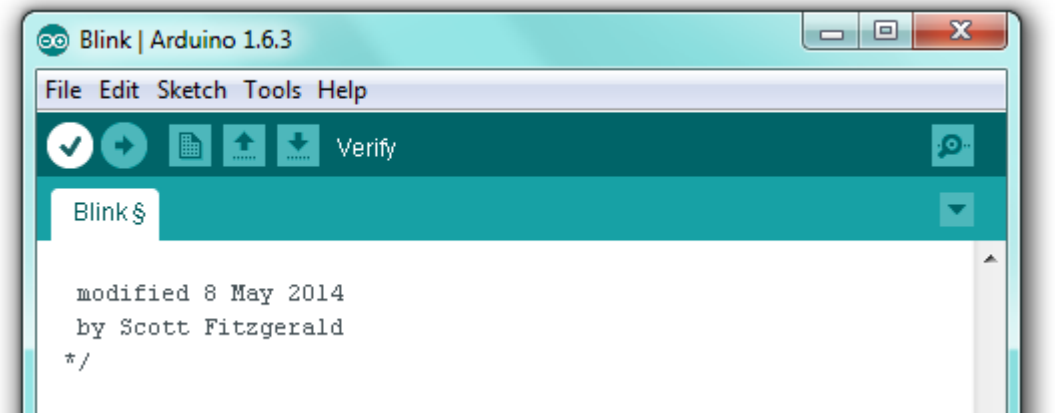

Figure 13: ArduinoIDE: Verify the code

Load the software on the Connect the SmartEverything FOX board

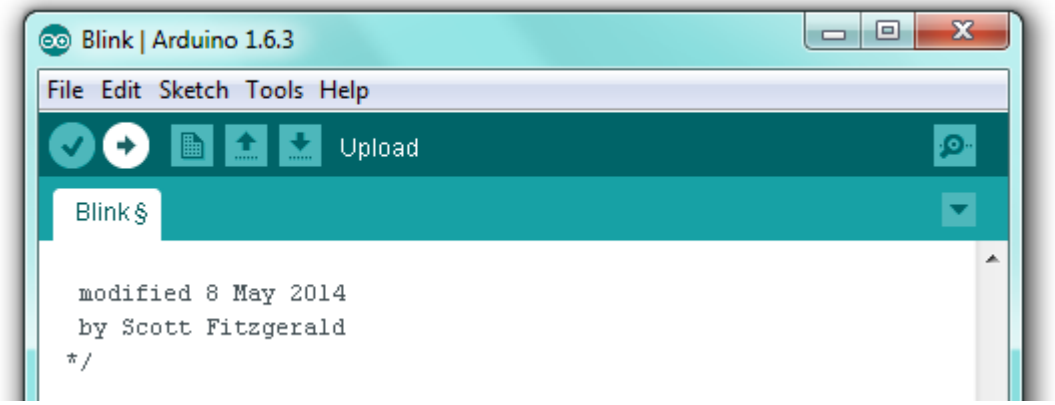

Figure 14: ArduinoIDE: Upload the code

Explain here what the board does while it is running the code

Chapter 6 Getting Started with Atmel Studio Project

The chapter will be completed after Atmel Studio IDE will support the board

6.1 Tools

The following tools are needed:

- Atmel Studio (Release X.X.X or newer)
- USB cable or JTAGICE3 Debugger

6.2 Setup the Environment

Download and install the Atmel Studio from the Atmel web site (See the links in the References and Useful Links section)
Connect the SmartEverything FOX board to the PC with the USB cable

6.3 Compile the Example project

Download the demo project from the following link

Compile the project

6.4 Run the software

Load and run the software on the Connect the SmartEverything FOX board

Chapter 7 References and Useful Links

Add here all the links to data sheets, web sites and tools

7.1 Data sheets

- ATMEL SAML21 Ultra low-power ARM® Cortex®-M0+ MCU
- Crypto Authentication Chip (ATMEL ATSHA204A)
- Dynaflex 868Mhz Antenna (915/2)
- Sigfox Module (Telit LE51-868 S)
- GPS Module with Embedded Antenna (Telit Jupiter SE868-A)
- Proximity sensor (ST VL6180X)

- Humidity and Temperature sensor (ST HTS221)
- Axis sensors (ST LSM9DS1)
- Pressure Sensor (ST LPS25H)
- NFC NTAG I2C (NXP NTAG I2C NT3H1101FHK)
- Bluetooth Low Energy (TDK SESUB-PAN-T2541)

7.2 Tools

- Arduino IDE
- Atmel Studio

7.3 Web Sites

- Amel Technology – www.amel-tech.com
- Arduino – www.arduino.cc
- Atmel – www.atmel.com