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Catena4430 Operational Manual

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PROPRIETARY NOTICE AND DISCLAIMER

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Rev A	2024-05-21	Initial Release
Rev B	2024-06-20	Second Release
Rev C	2024-07-03	Third Release

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1 Introduction

This document serves as the Quick Start Guide MCCI Catena® 4430 Activity Sensor.

2 Catena 4430 Fully Assembled Unit

The MCCI Catena® 4430 Activity Sensor is a flexible open-source IoT sensor for monitoring animals in laboratories, animal hospitals, etc. It is a ready-to-use platform for wireless IoT applications using LoRaWAN® technology or the Sigfox network.

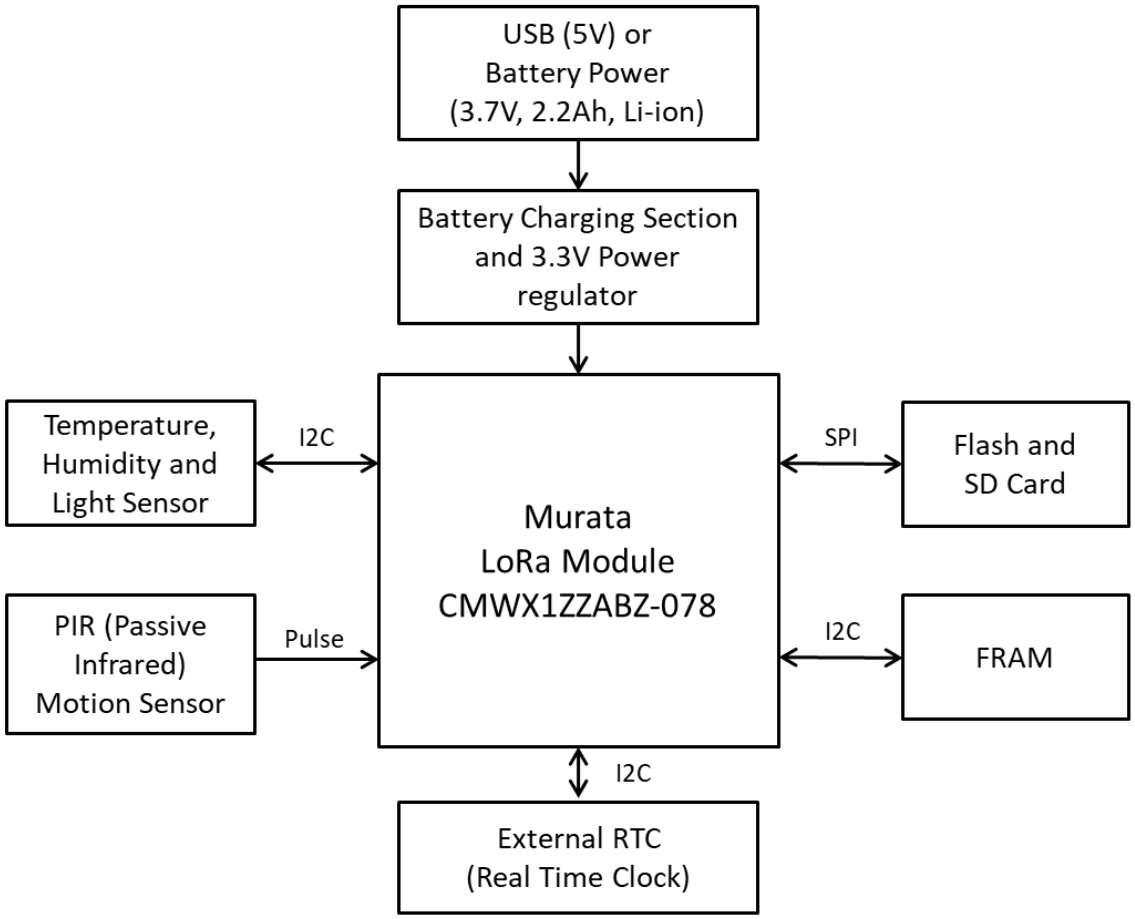
It is used for measuring environmental, activity and on-board parameters like,

1. Temperature: measures the ambient temperature of the environment.
2. Humidity: measures the air's moisture content or relative humidity.
3. Pressure: refers to atmospheric pressure, typically measured in psi. (The pressure data will not be available for the version 2 base board – Catena 4610)
4. Gas Concentration: measures the environment's Carbon dioxide (CO2) gas concentrations.
5. Activity: monitors the animal activity.
6. Pellet: measures the number of pellets consumed by the animal.
7. Battery Voltage: monitors the Battery voltage of the Catena 4430, ensuring proper functioning.
8. Boot Count: refers to the number of times the Catena 4430 has been Powered ON/Booted UP.
9. Version: fetches the firmware version.
10. Time: fetches the epoch time from the network.

Figure 1 Catena 4430 Assembled Unit

3 Block Diagram

Figure 2 Block diagram of Catena 4430



4 Circuit Description

This section explains the circuit implemented in the Catena4430 Complete.

4.1 Power Supply

The device can be powered via a USB connection providing 5V or a rechargeable Li-ion battery rated at 3.7V, 2.2Ah. The power management system includes a battery charging section and a 3.3V power regulator to supply a stable voltage to the entire circuit.

4.2 Main Controller

At the core of the device is the Murata LoRa Module CMWX1ZZABZ-078, which handles the communication and processing tasks. This module integrates the ARM Cortex-M0+ MCU with a LoRa transceiver, making it suitable for low-power wide-area network (LPWAN) applications.

4.3 Sensors and Interfaces

Temperature, Humidity, and Light Sensor: Connected via the I2C bus to the LoRa module, this sensor measures environmental parameters and transmits the data to the main controller for processing.

PIR (Passive Infrared) Motion Sensor: This sensor detects motion and sends pulse signals to the LoRa module, which can be used for activity monitoring or security applications.

External RTC (Real Time Clock): Also interfaced through I2C, the RTC ensures accurate timekeeping, essential for time-stamped data logging and scheduled operations.

4.4 Memory and Storage

FRAM (Ferroelectric RAM): Interfaced via I2C, FRAM provides non-volatile memory with fast write capabilities and high endurance, suitable for frequently updated data.

Flash and SD Card: Connected through the SPI interface, this provides additional storage options for data logging, firmware updates, or other large storage needs.

4.5 Connectivity

The Murata LoRa module's built-in transceiver allows the device to communicate over long distances using the LoRaWAN protocol, making it ideal for IoT applications requiring remote monitoring and control.

4.6 Functional Summary

The MCCI Catena 4430 Activity Sensor is designed for low-power IoT applications. It collects environmental and activity data through its various sensors, processes this data using the Murata LoRa module, and transmits it over the LoRaWAN network. The device also includes advanced power management to ensure long-term operation in remote locations without frequent battery changes.

5 Turning ON the device

The Catena 4430 is a fully assembled self-contained device with a rechargeable battery installed within its enclosure. The device has a Slide switch on one of its sides, to power it ON and OFF.

Please follow the steps below to learn more about turning ON the device:

- Position the device facing the backside upwards as shown in Figure 3.
- Carefully slide the back enclosure using the finger.
- The Catena4430 board will be visible. Notice the OFF ON label on the board as shown in Figure 4 (Marked Yellow). It is the slide switch.
- Gently slide the switch position to the ON side. It will turn ON the Catena4430 board.
- Now carefully close the enclosure by placing the enclosure's backside slide into the position.

Note: In this design, the Catena 4430 board is mounted inside the enclosure. After the Catena 4430 board is enclosed, the slide switch terminal is not visible from the outside. However, by opening the enclosure, the slide switch can be accessed.

Figure 3 Catena4430 Enclosure Back Side

Figure 4 Catena4430 Board Slide Switch

The device can be powered by two methods:

- **Via Battery:** The rechargeable battery is available in the assembled unit. When the switch is ON position, the device will be powered.

- **Via Micro USB cable:** This method is useful when the device is deployed stationary. When the device is powered via a Micro USB Connector, it charges the rechargeable battery in use. Also, this method requires the switch position to be ON.

LED Indication:

The device has 2 LED lights.

Table 1 Indication LED Details

LED color	Description
RED color	It is power LED. It blinks when the device is powered ON
Orange Color	It is charging LED. It glows when the battery is recharging.

6 Usage of Micro USB Port

The Micro B USB port on the board serves the following functions:

6.1 Supply to the Board

- By connecting the Micro USB connector to the respective port, provides power to the board as shown in Figure 5 (Marked Yellow).
- This implies that the Micro USB port is used to supply power to the device when the device is deployed.

Figure 5 Catena4430 Micro USB Port Cutout

6.2 Charging Rechargeable Battery

- The system utilizes a 4V LiPo batteries rechargeable battery.
- When the USB connector is connected to the board through the Micro USB port, it initiates the charging process for the rechargeable battery.
- This suggests that the Mirco B port serves the dual purpose of supplying power to the board and charging the connected rechargeable battery.

6.3 Serial Data via Serial Terminal

The device data can be monitored using a Serial Terminal (for example: Tera Term). Connect the USB Micro B connector to the device and the standard type A connector to the laptop as shown in Figure 10. Get the enumerated COM port for the device from `Device Manager` and connect it to the Serial Terminal.

Figure 6 Catena4430 Micro USB Connection

7 Serial Command

The serial commands are used to configure the various modules in the device such as RTC and LoRaWAN modules. To use the serial commands, follow the Section 4.3 Serial Data via Serial Terminal and establish a serial connection.

7.1 Configure RTC via Serial Commands

The configuration of RTC plays a major role as the device stores the data in an SD card based on the date and time of the measurement. The RTC clock runs in the UTC/GMT/Z time zone.

7.1.1 Date

`date` is the serial command to set and get the time in the RTC module.

- To get the date, enter the command.
  - `date`
- To set the date and time, enter the command.
  - `date yyyy-mm-dd hh:mm:ssz`
  - example: `date 2024-05-05 10:45:20z`
- To set only the date, enter the command.
  - `date yyyy-mm-dd`
  - example: `date 2024-05-05`
- To set only the time, enter the command.
  - `date hh:mm:ssz`
  - example: `date 10:45:20z`

7.2 Provision the LoRaWAN module via Serial Commands

The provisioning of the device stores the LoRaWAN network keys to the device to transmit the data over the air. The keys include;

- Device Unique ID
- Application Key
- Application Join ID

7.2.1 LoRaWAN Configure

`lorawan configure` is the serial command to provision the device.

- To get the existing configured keys, enter the command.
  - `lorawan configure`
- To set the Device Unique ID, enter the command (8 bytes value).
  - `lorawan configure deveui xx-xx-xx-xx-xx-xx-xx-xx`
- To set the Application Key, enter the command (16 bytes value).
  - `lorawan configure appkey xx-xx-xx-xx-xx-xx-xx-xx-xx-xx-xx-xx-xx-xx-xx-xx`
- To set the Application Join ID enter the command (8 bytes value).
  - `lorawan configure appeui xx-xx-xx-xx-xx-xx-xx-xx`
- To load the keys to LMIC (for data transmission over the air), enter the command.
  - `lorawan configure join 1`

8 FCC Test

Catena 4430 firmware supports the test feature for moving ahead with FCC certification. Here, commands are given via Serial Terminal to transmit the data bytes in desired Channel, Spreading Factor, Transmission Power.

To carry out the FCC testing, follow the section 6.3 Serial Data via Serial Terminal and establish a serial communication between the device and the laptop.

The FCC Test software supports two modes:

- Normal Mode.
- FCC Test mode.

During the device boot-up, the application waits 30 seconds to choose between Normal Mode and FCC Test Mode.

- To run the device in Normal Mode, enter the command:
  - `mode normal`

- To run the device in FCC Test Mode, enter the command:
  - `mode test`.

If no mode is selected within 60 seconds during device boot-up, the device will automatically run in normal mode.

8.1 FCC Commands

The following are the commands used in the FCC testing.

- To transmit the data once:
  - Syntax: `fcc send {channel} {Spreading Factor} {TxPower} {Payload}`
  - Example to send data on channel 15, spreading factor 3 (SF7), Tx power 21, and Payload 67:
    `fcc send 15 3 21 67`
- To repeat the transmission for some counts:
  - Syntax: `fcc repeat {count} {TxInterval} {channel} {Spreading Factor} {TxPower} {payload bytes}`
  - Example to repeat a data 5 times with Tx Interval 100 ms on channel 15, spreading factor 3 (SF7), Tx power 21, and Payload 67:
    `fcc repeat 5 100 15 3 21 67`
- To frequency hop between channels for some counts:
  - Syntax: `fcc fhss {count} {TxInterval} {start channel} {end channel} {SF} {TxPower} {payload bytes}`
  - Example to frequency hopping a data 5 times with Tx Interval 100 ms between starting channel 15 to ending channel 20, spreading factor 3 (SF7), Tx power 21, and Payload 67:
    `fcc fhss 5 100 15 20 3 21 67`

8.1.1 FCC Command Parameters

This section explains the various parameters to be provided in the FCC command.

8.1.1.1 Count

This parameter is used only in `fcc repeat` command. It refers to the number of transmissions that need to be done.

8.1.1.2 Tx Interval

This is also used only in `fcc repeat` command, the interval between two data transmissions, that is time between end of a data transmission to start of the next transmission. It should be provided in milliseconds (Range: 5 to 500 milliseconds). The Tx Interval is given to increase the transmission interval between two transmissions. When there is no need to increase the transmission interval, provide Tx Interval as 5 milliseconds which is the lowest Tx Interval.

8.1.1.3 Channel

Table 2 Channel vs Command

Channel	Frequency	Command	Bandwidth
0 to 63 (64 Channels)	902.3 to 914.9 MHz (200 kHz increments)	0, 1, 2, 3, …, 63	125 kHz
64 to 71 (8 Channels)	902.3 to 914.9 MHz (1.6 MHz increments)	64, 65, 66, 67, …, 71	500 kHz

8.1.1.4 Start Channel and End Channel

This is the starting channel and ending channel for frequency hopping. The device will transmit the data in various range of frequencies starting with the start channel selection frequency and ending with the ending channel frequency. For example, when the start channel is 15 and the end channel is 20, the frequency hopping starts from 905.3Mhz and ends at 906.3MHz (for more channel vs frequency, refer to section 8.1.2 LoRaWAN US915 Channel number with respective Frequency.

8.1.1.5 Spreading Factor

The following table explains the available spreading factors.

Table 3 Spreading Factor vs Command

Spreading Factor	Command
FSK	0
SF7	1
SF8	2
SF9	3
SF10	4
SF11	5
SF12	6
SFrfu	7

8.1.1.6 Tx Power

This is transmission power in dBm. For the US, the default Tx Power is 21 dBm.

8.1.1.7 Payload

This is the user bytes.

8.1.2 LoRaWAN US915 Channel number with respective Frequency

Channel Number	Frequency
0	902.3
1	902.5
2	902.7
3	902.9
4	903.1
5	903.3
6	903.5
7	903.7
8	903.9
9	904.1
10	904.3
11	904.5
12	904.7
13	904.9
14	905.1
15	905.3
16	905.5
17	905.7
18	905.9
19	906.1
20	906.3
21	906.5
22	906.7
23	906.9
24	907.1
25	907.3
26	907.5
27	907.7
28	907.9
29	908.1
30	908.3
31	908.5
32	908.7
33	908.9
34	909.1
35	909.3
36	909.5
37	909.7
38	909.9
39	910.1
40	910.3
41	910.5
42	910.7
43	910.9
44	911.1
45	911.3
46	911.5
47	911.7
48	911.9
49	912.1
50	912.3
51	912.5
52	912.7
53	912.9
54	913.1
55	913.3
56	913.5
57	913.7
58	913.9
59	914.1
60	914.3
61	914.5
62	914.7
63	914.9
64	903.0
65	904.6
66	906.2
67	907.8
68	909.4
69	911.0
70	912.6
71	914.2

8.2 FCC Test Example Log

The following are some examples of FCC command output logs using the serial terminal (Tera Term).

Figure 7 FCC Send Command Output Log Screenshot

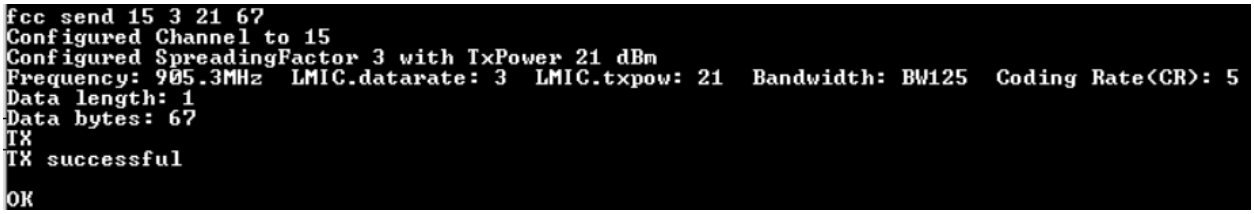
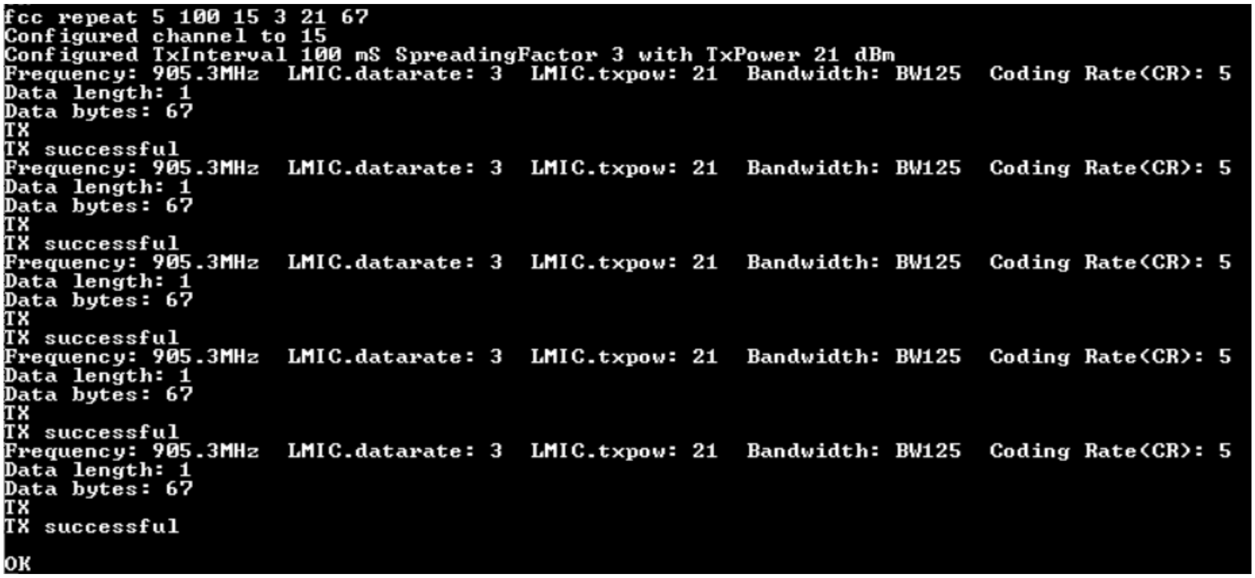


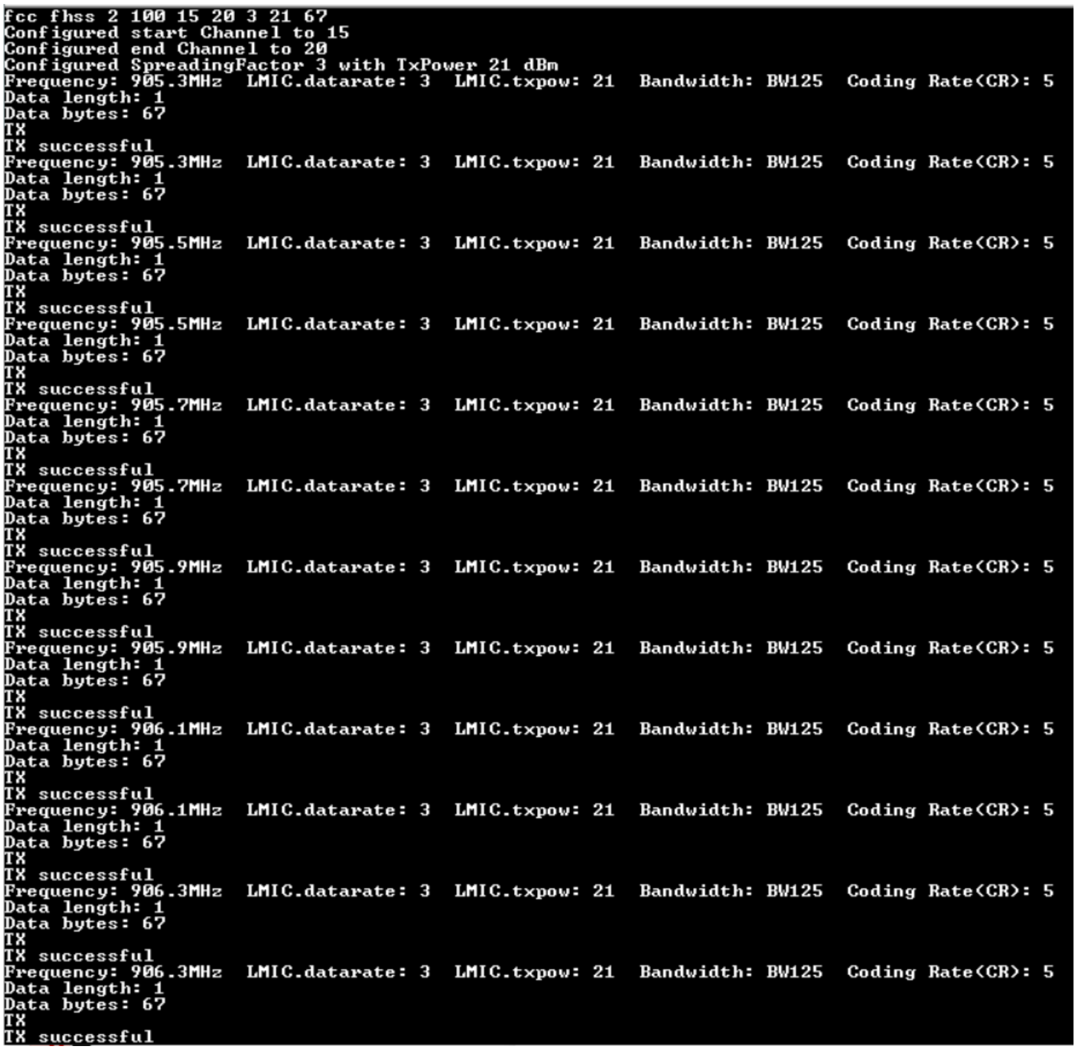
Figure 8 FCC Repeat Command Output Log Screenshot



```
fcc repeat 5 100 15 3 21 67
Configured channel to 15
Configured TxInterval 100 mS SpreadingFactor 3 with TxPower 21 dBm
Frequency: 905.3MHz  LMIC.datarate: 3  LMIC.txpow: 21  Bandwidth: BW125  Coding Rate(CR): 5
Data length: 1
Data bytes: 67
TX
TX successful
Frequency: 905.3MHz  LMIC.datarate: 3  LMIC.txpow: 21  Bandwidth: BW125  Coding Rate(CR): 5
Data length: 1
Data bytes: 67
TX
TX successful
Frequency: 905.3MHz  LMIC.datarate: 3  LMIC.txpow: 21  Bandwidth: BW125  Coding Rate(CR): 5
Data length: 1
Data bytes: 67
TX
TX successful
Frequency: 905.3MHz  LMIC.datarate: 3  LMIC.txpow: 21  Bandwidth: BW125  Coding Rate(CR): 5
Data length: 1
Data bytes: 67
TX
TX successful
Frequency: 905.3MHz  LMIC.datarate: 3  LMIC.txpow: 21  Bandwidth: BW125  Coding Rate(CR): 5
Data length: 1
Data bytes: 67
TX
TX successful

OK
```

Figure 9 FCC FHSS Command Output Log Screenshot



```
fcc fhss 2 100 15 20 3 21 67
Configured start Channel to 15
Configured end Channel to 20
Configured SpreadingFactor 3 with TxPower 21 dBm
Frequency: 905.3MHz  LMIC.datarate: 3  LMIC.txpow: 21  Bandwidth: BW125  Coding Rate(CR): 5
Data length: 1
Data bytes: 67
TX
TX successful
Frequency: 905.3MHz  LMIC.datarate: 3  LMIC.txpow: 21  Bandwidth: BW125  Coding Rate(CR): 5
Data length: 1
Data bytes: 67
TX
TX successful
Frequency: 905.5MHz  LMIC.datarate: 3  LMIC.txpow: 21  Bandwidth: BW125  Coding Rate(CR): 5
Data length: 1
Data bytes: 67
TX
TX successful
Frequency: 905.5MHz  LMIC.datarate: 3  LMIC.txpow: 21  Bandwidth: BW125  Coding Rate(CR): 5
Data length: 1
Data bytes: 67
TX
TX successful
Frequency: 905.7MHz  LMIC.datarate: 3  LMIC.txpow: 21  Bandwidth: BW125  Coding Rate(CR): 5
Data length: 1
Data bytes: 67
TX
TX successful
Frequency: 905.7MHz  LMIC.datarate: 3  LMIC.txpow: 21  Bandwidth: BW125  Coding Rate(CR): 5
Data length: 1
Data bytes: 67
TX
TX successful
Frequency: 905.9MHz  LMIC.datarate: 3  LMIC.txpow: 21  Bandwidth: BW125  Coding Rate(CR): 5
Data length: 1
Data bytes: 67
TX
TX successful
Frequency: 905.9MHz  LMIC.datarate: 3  LMIC.txpow: 21  Bandwidth: BW125  Coding Rate(CR): 5
Data length: 1
Data bytes: 67
TX
TX successful
Frequency: 906.1MHz  LMIC.datarate: 3  LMIC.txpow: 21  Bandwidth: BW125  Coding Rate(CR): 5
Data length: 1
Data bytes: 67
TX
TX successful
Frequency: 906.1MHz  LMIC.datarate: 3  LMIC.txpow: 21  Bandwidth: BW125  Coding Rate(CR): 5
Data length: 1
Data bytes: 67
TX
TX successful
Frequency: 906.3MHz  LMIC.datarate: 3  LMIC.txpow: 21  Bandwidth: BW125  Coding Rate(CR): 5
Data length: 1
Data bytes: 67
TX
TX successful
Frequency: 906.3MHz  LMIC.datarate: 3  LMIC.txpow: 21  Bandwidth: BW125  Coding Rate(CR): 5
Data length: 1
Data bytes: 67
TX
TX successful
```

9 FCC Warning

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.
Any changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

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.

To maintain compliance with FCC's RF Exposure guidelines, This equipment should be installed and operated with minimum 20cm distance between the radiator and your body: Use only the supplied antenna.

10 Usage of SD Card

The SD Card on the board serves the following functions:

10.1 Storing the Data on the SD Card

- SD Card on the board can be utilized for storing the device data. The device measures the data in a 6-minute interval.
- The SD Card data file will be stored in a .DAT file format. The name format of the file `<Date>.DAT`. Date (`YYYYMMDD`) for each day passes the Date increases. Based on the Date, we can fetch the respective Date data.

10.2 Firmware Update via SD Card

This is a feature to load the firmware via SD Card without getting the board into DFU mode. Version 0.4.1 and the later version of the sketch support this feature.

10.2.1 Steps to update a Firmware via SD Card

- As the board is loaded with version 0.4.1 firmware, this feature is supported.
- Get the bin file of the sketch needed to be loaded.
- Rename the bin file as "`update.bin`".
- Get the SD card from the board and connect the SD card to a laptop and place the renamed bin file inside the root directory of the SD card.
- Now insert SD back into the board.
- This will load the bin file and once the firmware update is successful, the bin file in the SD will be erased.
- While loading the new firmware, the RED LED will blink rapidly.
- After that, the board will REBOOT itself so there is no need to RESET the board.
- When the board is connected with the Serial Terminal while firmware update via the SD Card process, the following upload log can be seen in the Serial Terminal.

```
cMeasurementLoop::fsmDispatch: enter stTryToUpdate
Attempting to load firmware from update.bin
................................................................................
................................................................................
................................................................................
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................................................................................
................................................................................
................................................................................
................................................................................
........
download succeded.
cMeasurementLoop::fsmDispatch: enter stRebootForUpdate
Rebooting to apply firmware
```

10.3 How to access an SD Card

If we need to remove the SD card from the Catena4430 board, we must follow the steps below:

- Before attempting to remove the SD card, ensure that the Catena4430 board is powered down completely.
- At the bottom of the enclosure, two cutouts are given as shown in Figure 10 (one for Micro B connector and one for SD Card – Marked Yellow).
- Using a paperclip on the SD Card cutout, carefully push the SD card into the slot to engage the release mechanism (A click sound indicates the successful release mechanism).

- Once the SD card is released, carefully remove it from the slot.
- After checking the SD card, carefully insert it back into the slot and push it again. (A click sound indicates the successful SD Card insertion)

Figure 10 Catena4430 SD Card Slot Cutout

10.4 SD Card Data Format

The data will be stored in the SD Card for each measurement cycle. The following is the data which are stored in the SD Card:

Table 4 SD Card data header details

S.no	Data Header	Description
1	**Time**	Current date and time
2	**DevEUI**	Unique device serial number
3	**Raw**	Raw bytes of data to network in HEX
4	**Port**	Uplink port in use to transmit the data to network
5	**Vbat**	Battery voltage
6	**Version**	Firmware version in use
7	**BootCount**	Board reboot count
8	**T**	Environmental data: Temperature
9	**RH**	Environmental data: Relative Humidity
10	**P**	Environmental data: Pressure
11	**Light**	Ambient Light data
12	**CO2**	Carbon dioxide gas concentration
13	**P[0].delta**	Pellet: Recent pellet feeder count
14	**P[0].total**	Pellet: Total pellet feeder count
15	**P[1].delta**	Pellet: Recent pellet feeder count
16	**P[1].total**	Pellet: Total pellet feeder count
17	**Act[7]**	Activity: Average activity data 7
18	**Act[6]**	Activity: Average activity data 6
19	**Act[5]**	Activity: Average activity data 5
20	**Act[4]**	Activity: Average activity data 4
21	**Act[3]**	Activity: Average activity data 3
22	**Act[2]**	Activity: Average activity data 2
23	**Act[1]**	Activity: Average activity data 1
24	**Act[0]**	Activity: Average activity data 0

11 Firmware Update via DFU Method

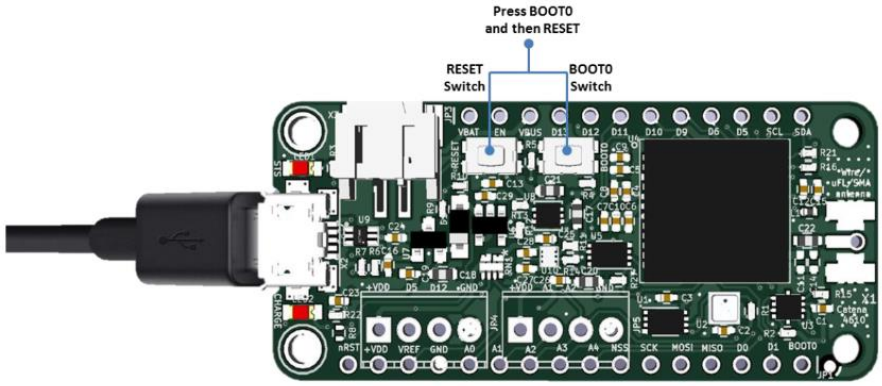
This method of firmware update is applicable for all the Catena4430 boards as it is not dependent on software versions. It consists of two major processes:

- Installing the STM32 BOOTLOADER driver for Catena4610 base board. (This is a one-time process)
- Loading the DFU firmware using the DFU update package.

11.1 Putting the Board in BOOT Mode/DFU Mode

- Open the Catena4430 enclosure back side and remove the Catena4430 board from the enclosure slot.
- Connect the Micro USB cable to the Catena4430 board and put the board in BOOT mode/DFU mode by pressing and holding the BOOT0 button and then pressing the RESET button on the board as shown in Figure 11. This will put the board in Boot mode/DFU Mode.

Figure 11 Boot and Reset Button on Catena4610 Base Board

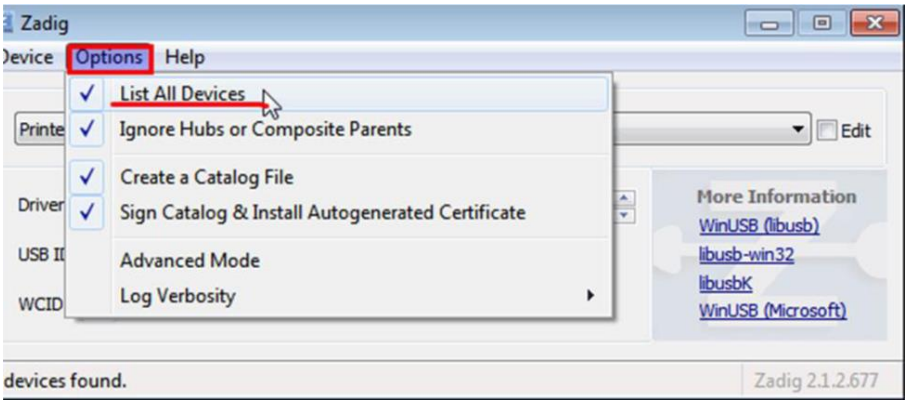


- Verify the STM32 BOOTLOADER driver in Device Manager as shown in the Figure 14.

11.2 Steps to Install STM32 Bootloader Driver (One-Time Process)

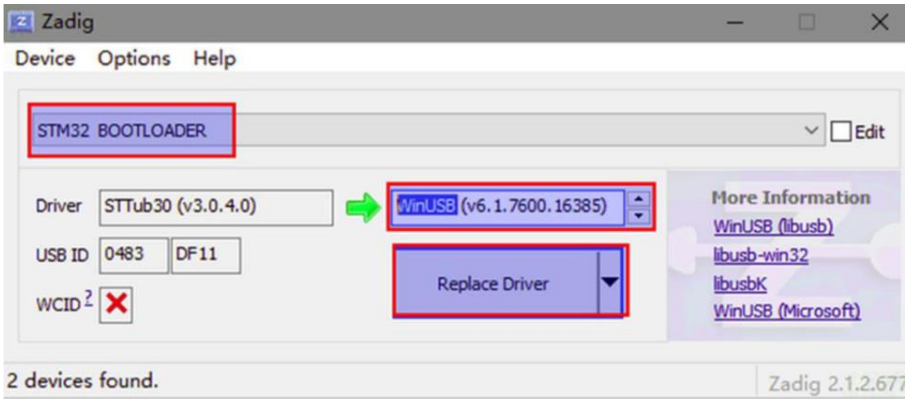
- For PC with an Operating System less than Windows 10, this step is necessary for the first time of using the device in BOOT mode/DFU mode.
- Follow the section 11.1 Putting the Board in BOOT Mode/DFU Mode and put the board in BOOT mode/DFU mode.
- As the Catena4430 base board (Catena4610 board) required an STM Bootloader driver during DFU mode; download and install a driver update tool (Zadiq tool).
- Open the Zadiq tool and select `Options -> List All Devices` as shown in the Figure 12.

Figure 12 Zadiq Tool options



- Select `STM32 BOOTLOADER` from the device dropdown, select `WinUSB (v6.1.7600.16385)` as the new driver, and click `Replace Driver` as shown in the Figure 13.

Figure 13 Replacing STM32 BOOTLOADER using Zadiq Tool



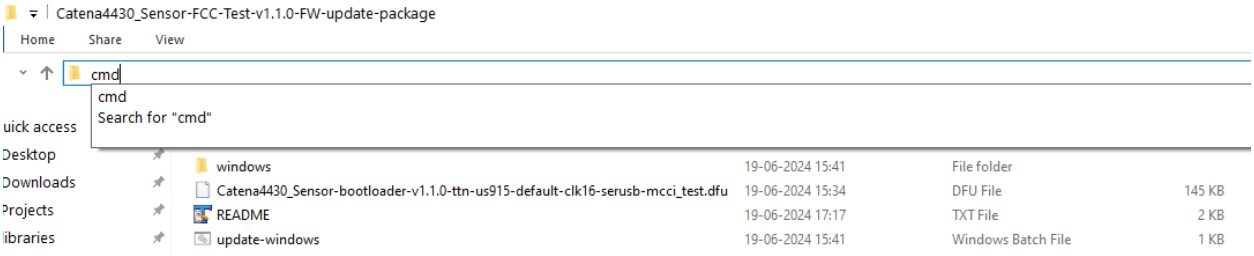
- Once the new driver is replaced successfully, verify the STM32 BOOTLOADER driver in Device Manager as shown in the Figure 14.

Figure 14 STM32 BOOTLOADER Enumeration

11.3 Steps to Update a Firmware via DFU Method

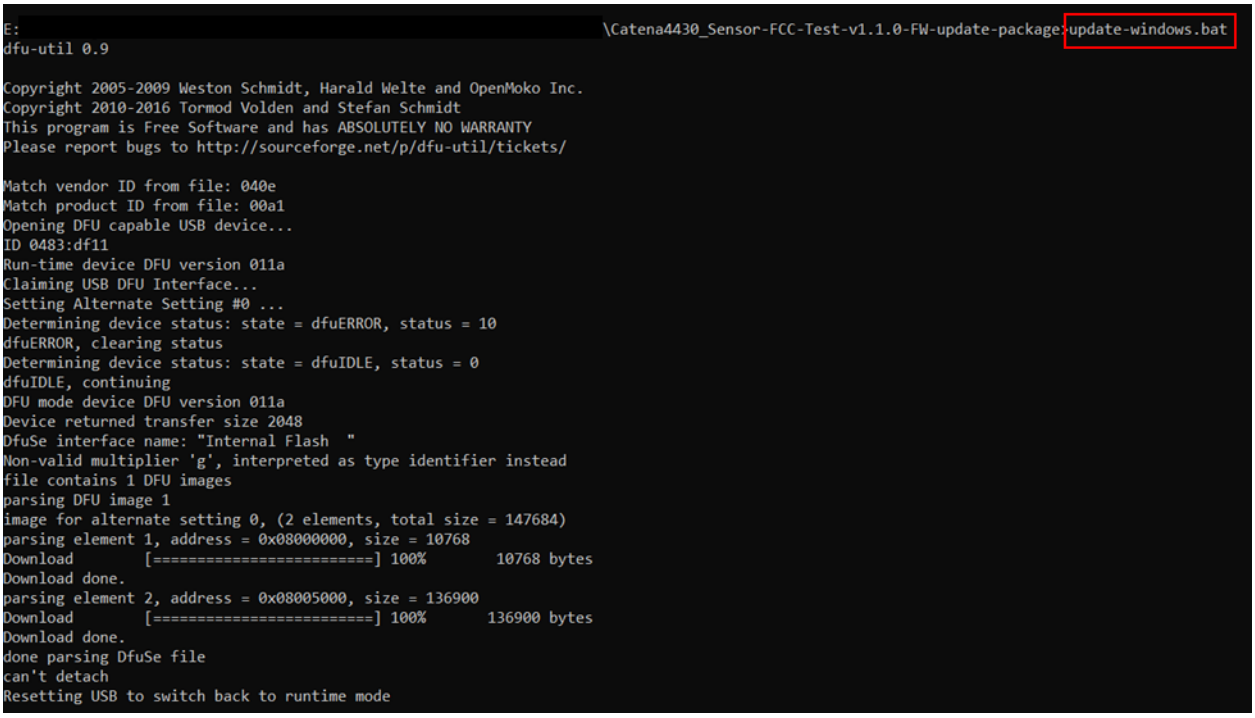
- Follow the section 11.1 Putting the Board in BOOT Mode/DFU Mode and put the board in BOOT mode/DFU mode.
- Get the DFU file to be loaded and the DFU update package by referring to the 12 Getting Help.
- Download and extract the DFU update package in the desired folder.
- Navigate into the DFU update package and open the Command Prompt in that location by typing `cmd` and pressing the Enter key as shown in the Figure 15.

Figure 15 Open Command Prompt



- Once the Command Prompt is open, use the command `update-windows.bat` as shown in the Figure 16. it will load the DFU firmware.

Figure 16 Firmware Update Command Prompt Log



- Now press the RESET button on the board to get back from BOOT mode/DFU mode.
- Open Serial Terminal such as Tera Term and verify the details in Software Enumeration for change in Software.

12 Getting Help

For any support or assistance, please contact techsupport@mcci.com