EGM-L210

AREA GAMMA MONITOR

LORA ENABLED

elementz
Engineers Guild Pvt Ltd

Contents

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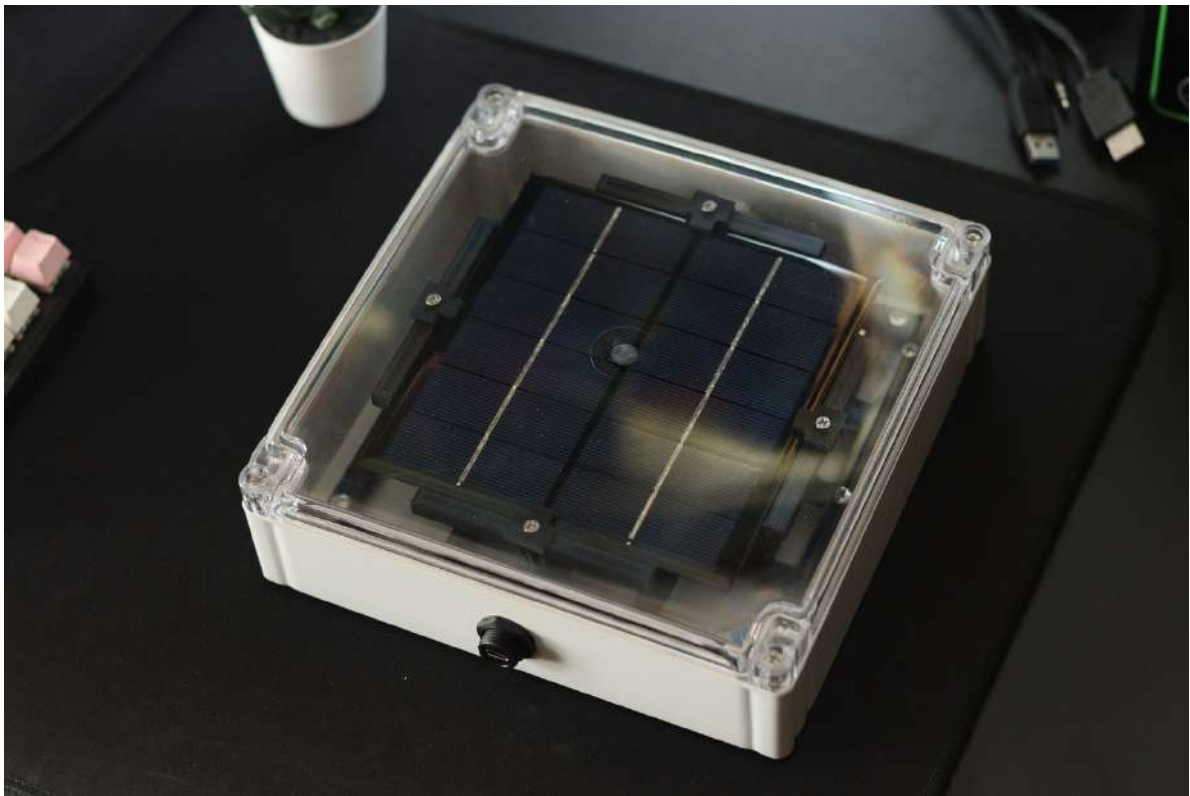
Chapter 1

Overview

Figure 1.1: EGM-L210Y - Outdoor AGM

Figure 1.2: EGM-L210X1 - Indoor AGM

Figure 1.3: EGM-L210X2 - Indoor AGM

EGM-L210 is a series of Outdoor and Indoor Area Gamma Monitors capable of telemetry with LoRa-based Chirp Spread Spectrum Modulation. EGM-L210 makes use of BG51, a sensor comprising an array of PIN Diodes designed to be sensitive towards Gamma Radiations. The device also supports a re-configurable telemetry cycle. All the EGM-L210 devices can be paired with any LoRaWAN gateway.

EGM-L210Y series is specifically made for Outdoor applications, while EGM-L210X is for Indoor applications. EGM-L210Y does support a solar panel to completely avoid human intervention to charge the internal battery. EGM-L210X is primarily a permanent wall powered device where the internal battery acts as a backup source fulfilling the function of a UPS.

- Compact Size & Lightweight

- IP65 Enclosure (ABS Base with Polycarbonate Lid)

- Detector Sensitivity of 5 cpm/μSv/h

- 1 μSv/h to 100 mSv/h Dose Rate

- Energy Response of 70 keV to 2 MeV

- High Immunity to RF and Electrostatic Fields

- Uses LoRa Modulation for Telemetry with over 1.5km Range (Line of Sight)

- Full Charge in 5 Hour with Type C Charging Port

- 1.3" 128 * 64px OLED Display for **L210X1** Indoor Devices

- 192mm * 96mm, 128 * 32px RGBW LED Matrix Display for **L210X2** Indoor Devices

- 6V 500mA (3W) Solar Panel for **L210Y** Outdoor Devices

- Unlimited Battery Life for Outdoor Units (Under Ideal Conditions)

- Re-configurable Telemetry Cycle from 60 to 21600 Seconds

- 6 Layer High Precision PCB with Gold Plated Pads

- Built in Automotive Grade Temperature and Humidity Sensor (SHTC3)

1.1 Technical Specifications

Parameter	Min	Max	Unit	Remarks
Operating Voltage		3.3	V	
Current Consumption (Indoor)	40	45	mA	3600s Telemetry
Current Consumption (Outdoor)	1.5	2	mA	3600s Telemetry
Battery Capacity (L210X1)		2500	mAh	3C 18650 Li-Ion
Battery Capacity (L210X2)		3500	mAh	LG 18650 Li-Ion
Battery Life (L210X1)	38	40	hours	3600s Telemetry
Battery Life (L210X2)	50	53	hours	3600s Telemetry
Battery Life (Outdoor)	30	35	days	3600s Telemetry, Without Solar Energy
Charging Current		545	mA	
Solar Panel (Outdoor)		500	mA	6V (3W)
Operating Range	-40	85	°C	
Dose Rate Range	1	100000	uSv/h	
Energy Response	70	2000	KeV	
Detector Sensitivity		5cpm	cpm/μSv/h	±15%
LoRa Frequency	865	867	MHz	8 Channel
LoRa Spread Factor	7	12		Default - SF12
LoRa Bandwidth	125	250	KHz	Default - 125KHz
Enclosure Type		ABS		
Dimensions	210*210*60	211*211*61	mm	
Total Weight (Outdoor)	799	810	g	
Total Weight (Outdoor)	722	984	g	Varies with Display

Chapter 2

Hardware

The chapter describes the general hardware overview of the EGM-L210.

2.1 Sensor

EGM-L210 uses the BG51 sensor made by Teviso. Custom Aluminum Shielding and Power Filtering was done in order to improve immunity from RF and Power Fluctuations. The sensor specifications are listed below,

- Detector sensitivity: 5 cpm/μSv/h

- Energy response: 50 KeV to above 2 MeV

- 5 cpm ± 15% Detector Sensitivity

- High immunity to RF and electrostatic fields
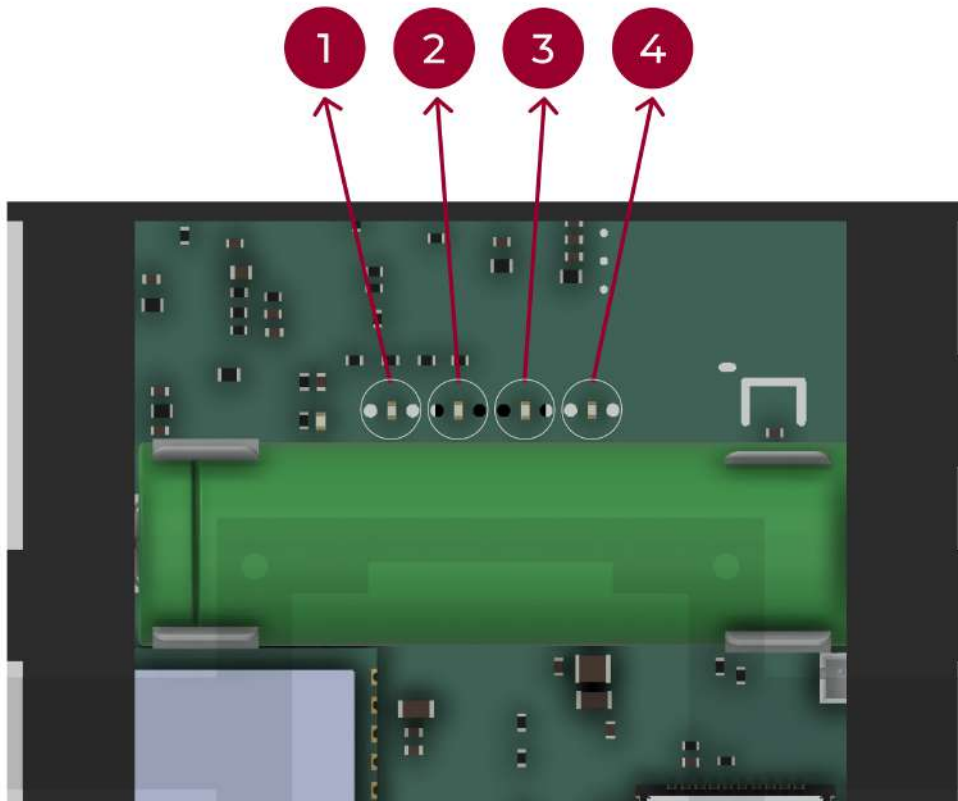
2.2 LED Indicators

Figure 2.1: EGM-L210X LEDs

EGM-L210 dosimeter makes use of 4 LED indicators.

- The LED marked **1** in the image 2.1 is the **USB Status Indication**. This Green LED will only work when the device is powered by a USB Type-C Cable.

    - If ON: USB is Connected
    - If OFF: USB is Not Connected

- The LED marked **2** in the image 2.1 is the **Power Status Indication**. This Blue LED will only work if the device is turned on.

- The LED marked **3** in the image 2.1 is the **Full Charge Indication**. This Orange LED will only work when the device is powered by a USB Type-C Cable.

    - If ON: Device Completely Charged
    - If OFF: Device Not Completely Charged

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- The LED marked **4** in the image 2.1 is the **Charging Indication**. This Orange LED will only work when the device is powered by a USB Type-C Cable.

  - **–** If ON: Device is Charging
  - **–** If OFF: Device is Not Charging

Note: The LEDs are not visible in Outdoor AGM, the Power LED will not be permanently On if the device is turned on. The device will only turn on the LED during the Telemetry Cycle to reduce current consumption.

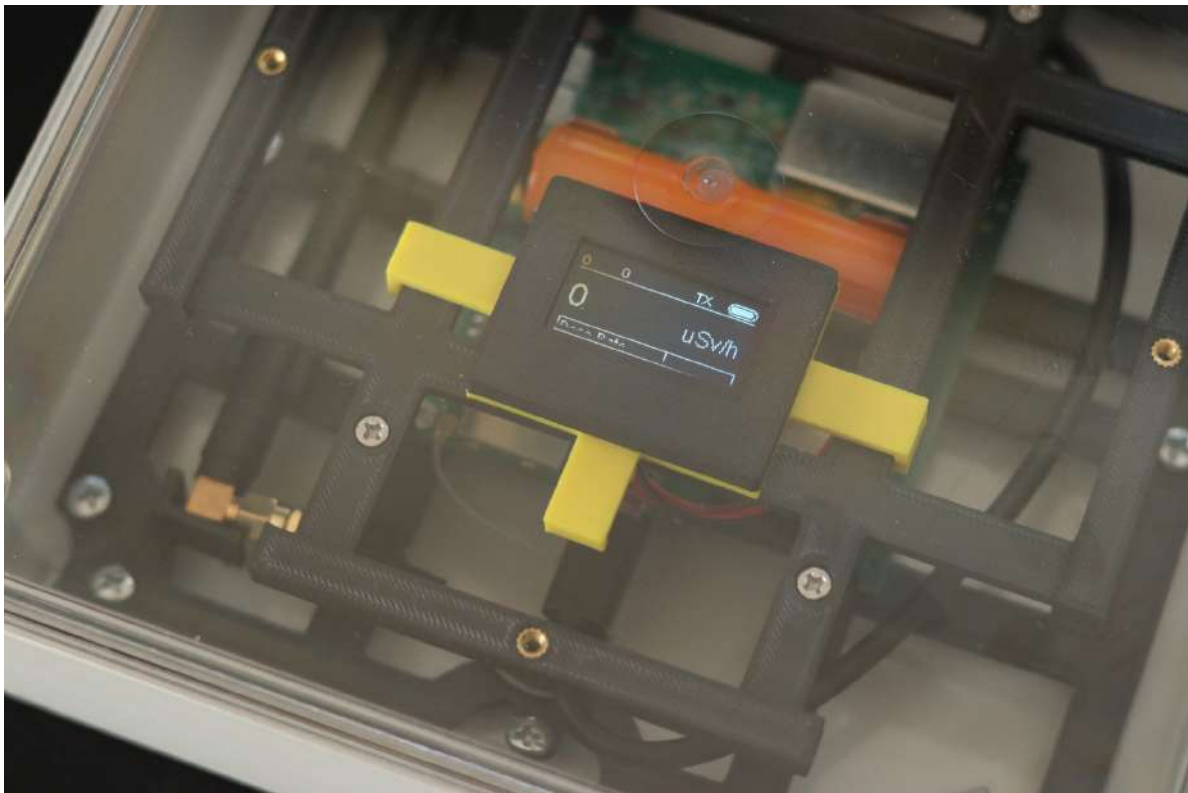## 2.3   Display Layout (L210X1)

Figure 2.2: EGM-L210X1 Display

EGM-L210X1 comes with a 1.3" OLED Display with 128*64 Pixel resolution. By default, the device consists of a single page showcasing Dose Rate.

Note: The Dose Rate shown in the display is a 40s moving window averaged value, while the transmitted Dose Rate is computed with the configured Telemetry length.
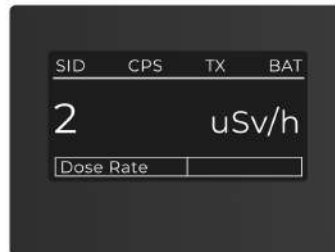
PAGE 1

Total Dose

Figure 2.3: EGM-L210 Display Layout

2.3.1 Header and Footer

The Header from right to left consists of **Session ID**, **Counts Per Second**, **Transmission Active**, and **Battery Bar**. The Footer represent the page number and the corresponding page name.

- Session ID: This is currently unused in AGMs.

- Counts Per Second (CPS)

- Transmission Active: **TX** tag represents whether the Transmission is Active or Not & **CF** tag represent whether Wi-Fi Access Point is available for configuration.
  On Low Battery, the Indoor AGM Device will automatically turn off, while the Outdoor AGM will check periodically if the device has sufficient capacity to enter normal operation.

- Battery Bar: This is a slider which shows the current state of charge (SOC).

The type of pages which the device can show are listed below.

2.3.2 Dose Rate Page

This page shows the Dose Rate on the left side of the screen. This value will automatically scale to mSv unit to show within the screen. The corresponding unit will be shown on the right side of the screen.

2.4 Display Layout (L210X2)

Figure 2.4: EGM-L210X2 Display

EGM-L210X2 comes with a large 192 * 192mm RGBW Display with 128*32 Pixel resolution. By default, the device consists of a single page showcasing Dose Rate. The display is connected to a daughter board, then to the main board.

The device only has a single page where the Dose Rate, Unit, and the Battery Level is shown. The Dose Rate will be shown in red color in alarm condition. This page is also capable of showing errors if the Display Board loses connection with the main board.

Note: The Dose Rate shown in the display is a 13-minute moving window averaged value, while the transmitted Dose Rate is computed with the configured Telemetry length.

2.5   Connectors

Figure 2.5: L210X1, L210Y Connector

EGM-L210X1 and EGM-L210Y make use of a USB Type C Connector on the bottom to both charge the device and turn on the device.

Figure 2.6: L210X2 Connectors

EGM-L210X2 has a USB Type C Connector on the bottom to both charge the device and turn on the device. For the display, a separate 5V power has to be connected to the DC Jack.

Please make sure to use 5V DC Supply. Higher voltage than 5V can damage the display. The display will not use the backup power supply if 5V DC Supply is not provided.
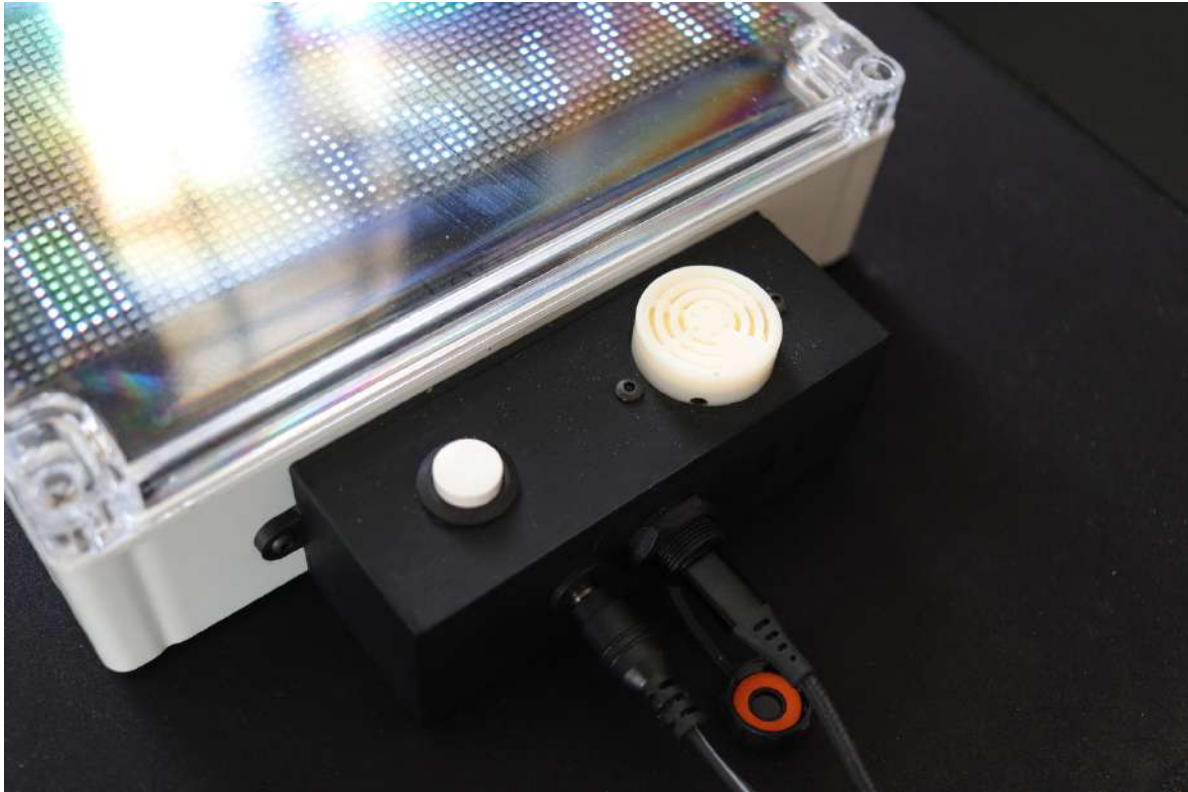
2.6   Alarm Support (L210X2)

Figure 2.7: L210X2 Alarm Hardware

The device has a buzzer along with a button to control the alarm status of the device. The button strictly acts as the snooze button if the Alarm is triggered.

The device keep track of up to 24-hour average dose rate, if the current 13-minute moving window average dose rate is greater than the 24-hour average dose rate, the device will trigger an alarm by beeping the buzzer and shows the dose rate on screen in red color. The device will also inform the Server, thereby notifying the control room. The alarm will automatically turn off after 2 minutes. This can be reconfigured up to 10m by accessing the Webpage Configuration.

The Alarm can be snoozed with the push button, also with the server. The snooze interval can be controlled by the server. The previously configured snooze interval will be executed if the push button is pressed. The device supports 15 to 3810 minute snooze interval in 15m increments. This can be reconfigured by accessing the Webpage Configuration.

2.7 Antenna

EGM-L210 uses a Rubber Duck Antenna connected to the onboard UFL Connector. Listed below are the antenna specifications.

- Frequency: 865-867 MHz

- VSWR: 1.5

- Gain: 5dBi

- Connector: UFL

- Weight: 3g +- 0.5g

2.8 Frequency Plans

The device supports up to 8 Channels for Telemetry. Three channels are allocated to Area Gamma Monitor, as shown in the table below. The devices dynamically switch between frequencies to bring randomness in channel usage.

Channel	Frequency (Hz)	Devices
0	865062500	Area Gamma Monitor
1	865402500	Area Gamma Monitor
2	865985000	Area Gamma Monitor
3	865742500	Teledosimeter
4	866185000	Teledosimeter
5	866385000	Teledosimeter
6	866585000	Teledosimeter
7	866785000	Teledosimeter

Chapter 3

Usage

The configuration of **L210X1** and **L210Y** devices can only be accessed with a webpage, whereas **L210X2** devices can be accessed with a webpage or with the ERAD Configurator.

In order to connect to the device using Wi-Fi, refer to the section 3.2. For devices with support for ERAD Configurator, refer to the section 3.4.

3.1   Turning On AGM

Connecting a Powered USB Type C Cable will turn on the AGM Device. The display within EGM-L210X will turn on, indicating the device has turned on. EGM-L210Y's LED indicators are unable to be seen when the Solar Panel is installed. So, if the device has enough charge, then it will turn on.

It is recommended to charge EGM-L210Y at least 5 hours before deployment. Since EGM-L210X is wall powered, charging before deployment is not mandatory.

L210X1, L210Y can only be powered off using the Configuration Page. L210X2 can be powered off using the Configuration Page or ERAD Configurator.

3.2   Accessing the Configuration (Wi-Fi)

Following is the procedure to connect to AGM Outdoor and Indoor devices.

- Make sure to turn on the device (Refer 3.1).

- Plug a powered USB Type C Cable more than 4 Times within 8 Seconds, this means more than 4 insertions and 4 removals needs to be done.

- The device will now create a Wi-Fi Access Point (Hotspot). Connect to that Wi-Fi network.

  Note: The Wi-Fi Access Point will have a name in the format **AGMXXXXXXXXXXXXX**. Validate it with the label on the device. The default password will be **123456789**.
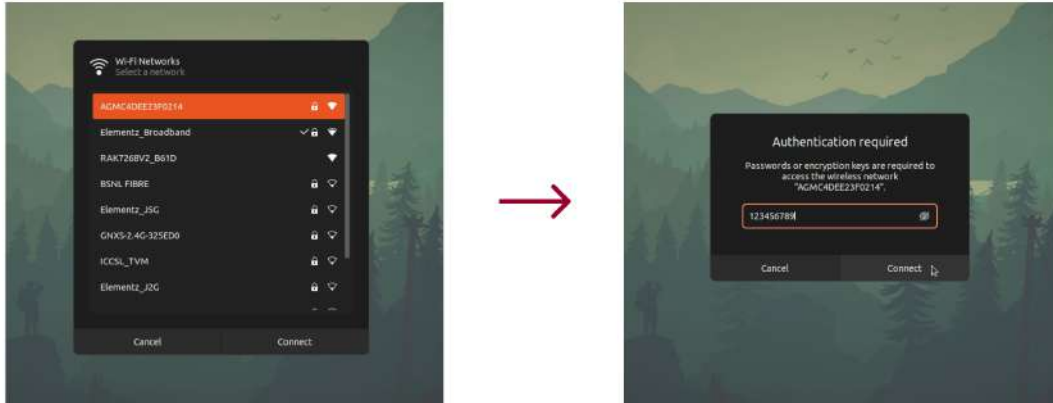

Figure 3.1: Connecting to Wi-Fi Access Point

- Once the computer is connected to the Wi-Fi access point, access 192.168.4.1 on a web browser.

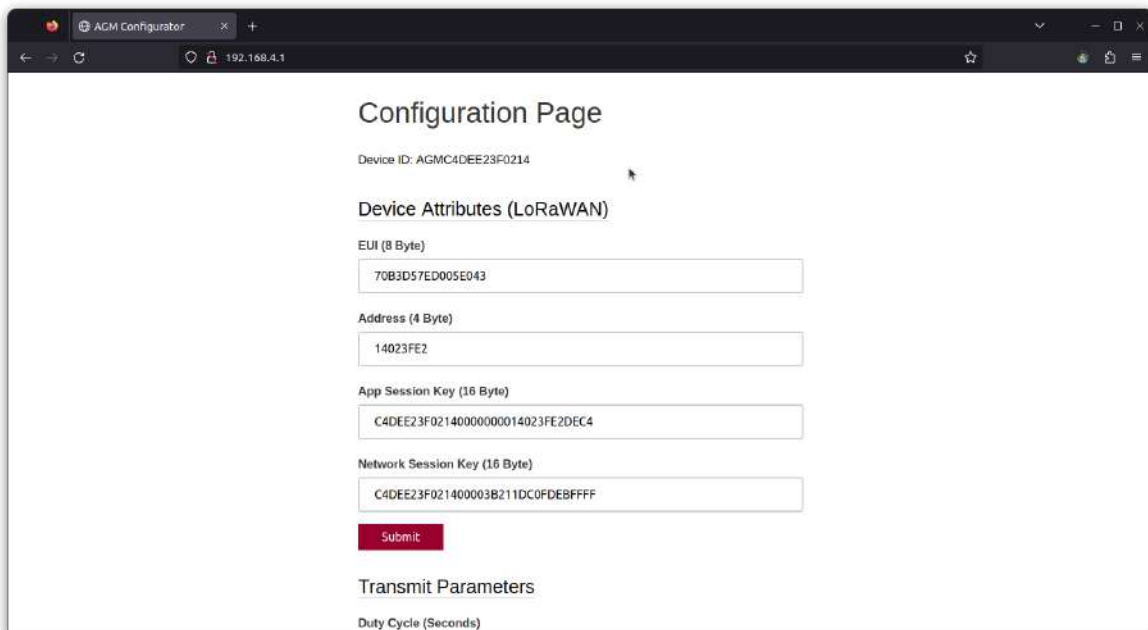- A configuration page will load with all the modifiable parameters.

Figure 3.2: Configuration Page

Note: The Wi-Fi Access Point will only be available for 5 minutes. After that, the device will go to Normal Mode working. The Computer will automatically disconnect from the Wi-Fi access point on Power Off or Reboot or 5 minute Timeout.

3.2.1 Modifying a Configuration Parameter

There are 5 main sections within the configuration page, Device Attributes, Transmit Parameters, Calibration, Alarm, and Actions. Changes in Configuration needs to be saved by using the Save Button in the **Actions** section.

Do note that some of the device would not support certain sections
Connect the device with the configurator as mentioned in 3.2. Following is the procedure to get or modify configuration of the AGM.

- Make the Required Changes in Configuration.
  For example, Set the Duty Cycle to 3600 so that the device transmits data every 3600 seconds.

- On Clicking the **Configure** Button of the Modified Section, a **Status Tag** will show on the right of the button. A **Success** tag will be shown if the configuration has been successfully modified as shown in 3.3.
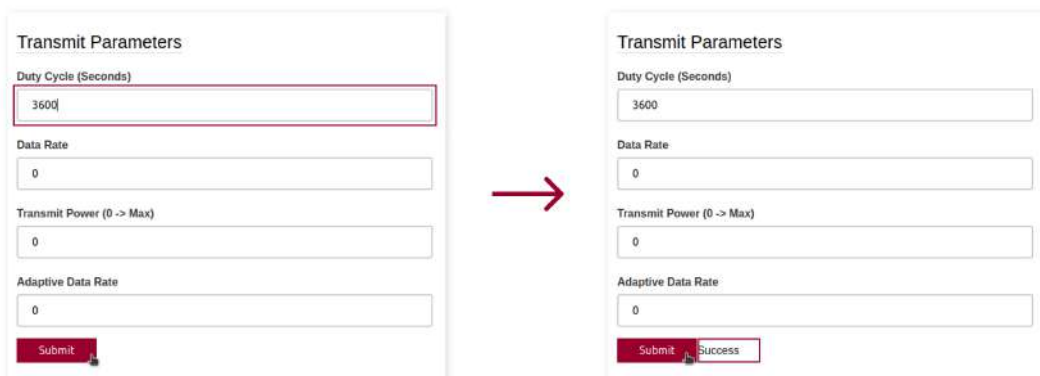

Figure 3.3: Modifying Telemetry Duty Cycle

- Once the Configuration Parameters have been changed, Go to the **Actions** Section & Save the configuration by clicking the **Save** Button. A corresponding **Status Tag** will show right below the button as shown in 3.3.
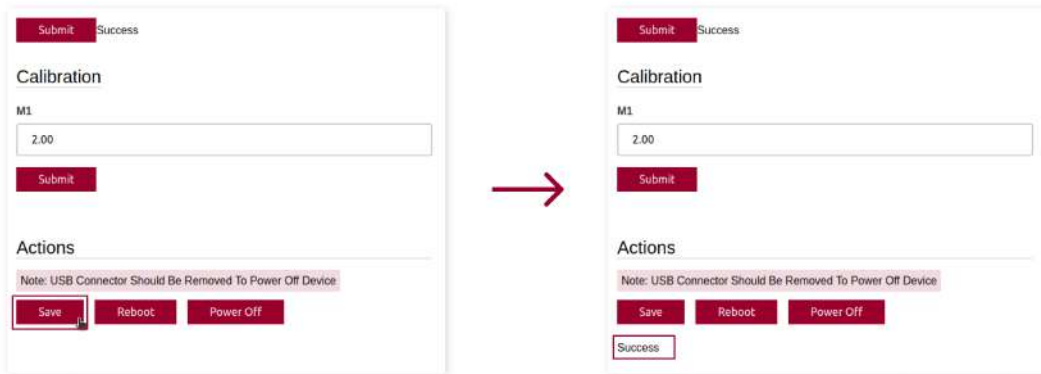
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Figure 3.4: Save Configuration

- Now click on **Reboot** if the device should enter the Normal Working Mode with the new Configuration, or Click on Power Off if the device needs to be Turned Off (**Note: Remove Type C Cable Before Powering Off**).
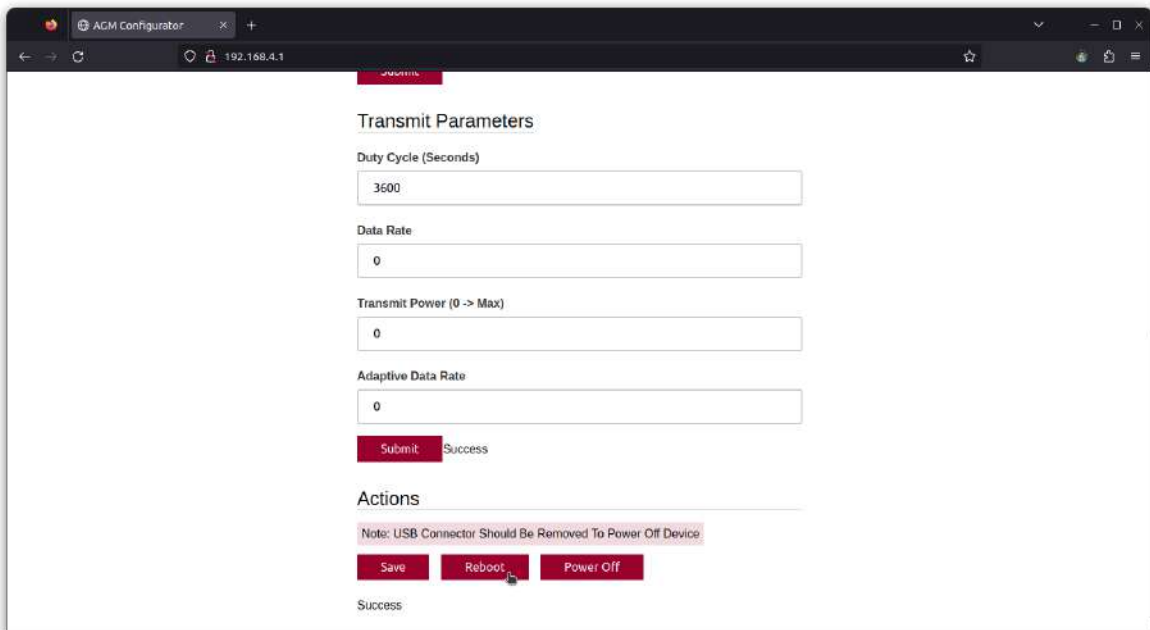

Figure 3.5: Reboot Device or Power Off Device

Follow the same procedure from 3.2 to do the same for multiple devices.

3.2.2   Turning Off AGM

Connect the device as mentioned in 3.2. Following is the procedure to Turn Off AGM.

- Go to the **Actions** Section.

- Remove the Type C Cable from AGM if connected.

- Click on **Power Off** Button. Wi-Fi access point will automatically be disconnected.

Follow the same procedure from 3.2 to do the same for multiple devices.

ERAD Configurator V2.X is used to control the configuration parameters, which includes both Telemetry Cycle and Calibration Constants. The same utility is used to turn OFF and reset the reading. To ensure the proper functioning of the configurator, the following prerequisites should be done before running the configurator.

3.3   Prerequisites for ERAD Configurator

The following steps need to be done before using the Teledosimeter Configurator. These steps have to be repeated for every PC that will run the Configurator.

3.3.1   Ubuntu 20.04 or Above

- Open terminal and run the following command. This command is to give the user additional permission.

```
sudo usermod -aG dialout $USER
```
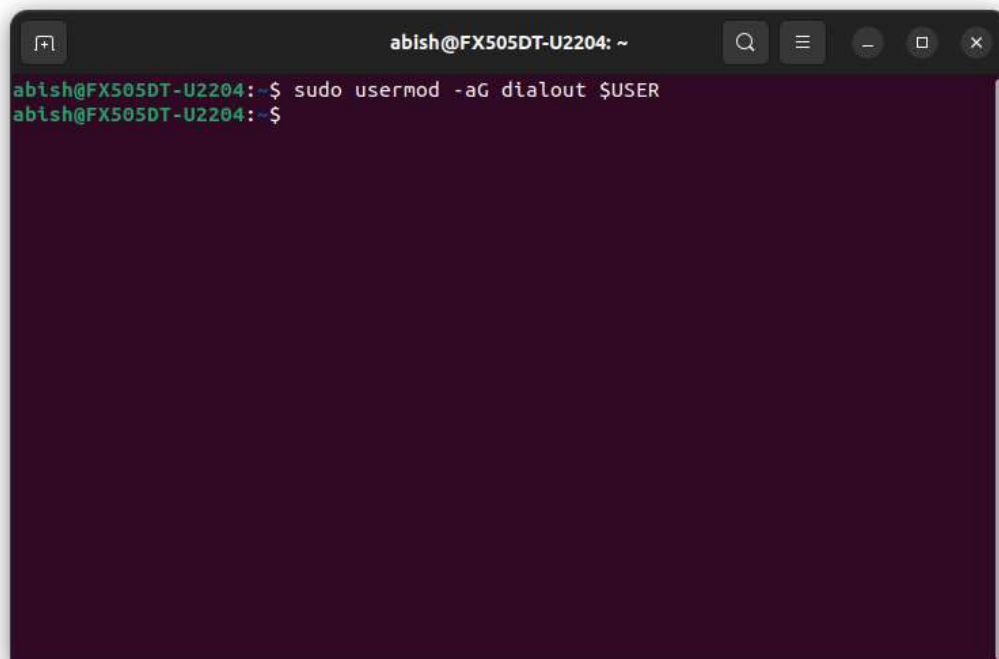

Figure 3.6: Prerequisite: Adding Path to Group

- Restart the computer

- Right Click on Configurator, Select **Properties** and Check **Allow executing file as program** in the **Permission** Tab.
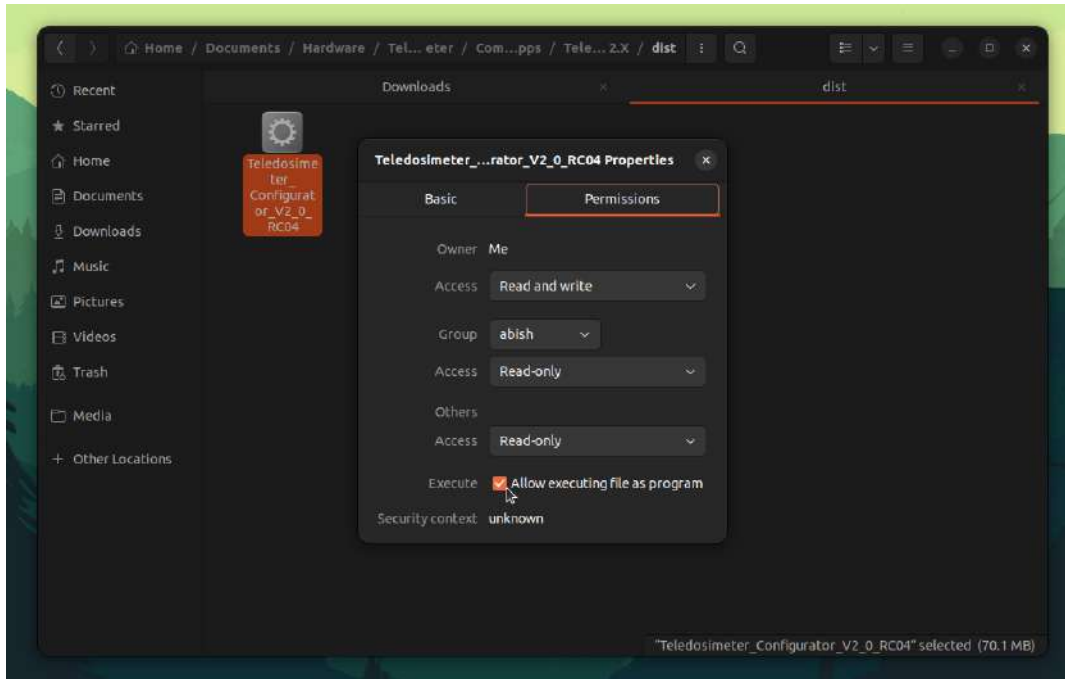

Figure 3.7: Adding File Run as Executable

3.3.2 Windows 10 or Above

- Check Whether PC is 64bit or 32bit.

- Install CP210X Driver from Silicon Labs (**Source**). Make sure to choose either 32bit or 64bit, depending upon the PC.

- Restart the computer

3.4 Accessing the Configuration (ERAD Configurator)

Following is the procedure to connect L210X2 with the Configurator.

- Open the ERAD Configurator V2.2 Software.

- Connect L210X2 device to computer with the supplied USB Type C Cable.

- Click on **Refresh** Button and Check for Open Ports.
  Note: Ports will be in format, **/dev/ttyUSBX** in Linux and **COMX** on Windows. If

showing **"No Connected Ports"**, it would probably be a malfunctioning cable or Prerequisites has not been as mentioned in 3.3.
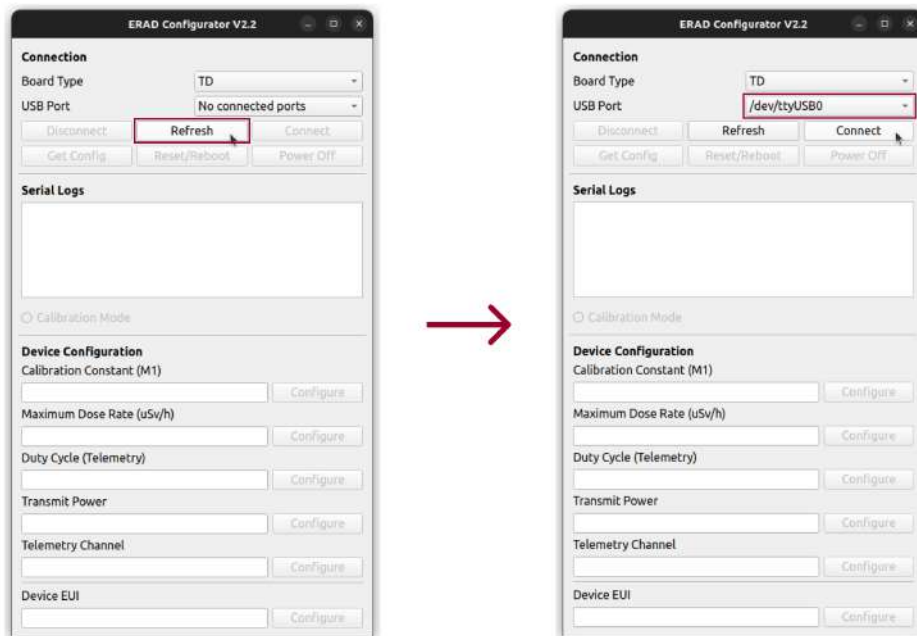

Figure 3.8: Connecting Dosimeter with Configurator

- Select the Port from the **USB Port** Drop down, and Click on **Connect** Button.

- Once the device is connected, the **Connect** button will be disabled.

- ERAD Configurator V2.2 or above automatically tries to retrieve configuration upon connecting to a device. If Configuration is not received, Click on **Get Config** Button to retrieve all the Parameters currently saved within the device.
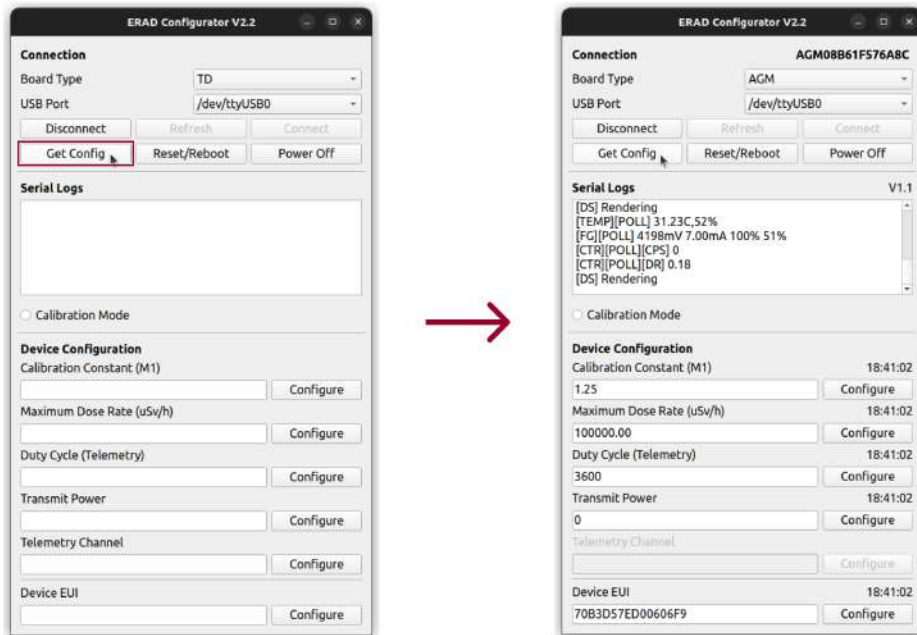
Figure 3.9: Settings Saved Parameters from Device
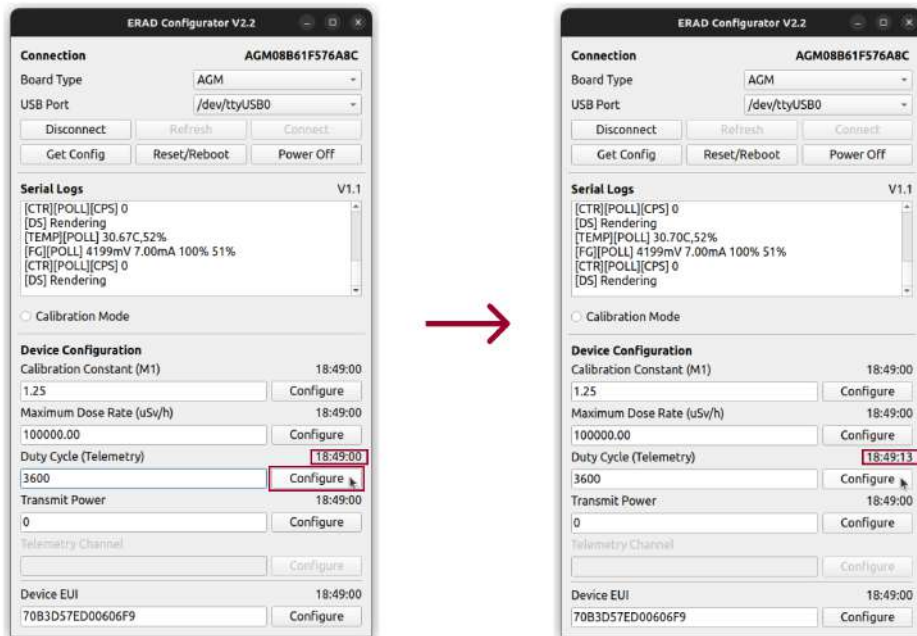
3.4.1 Modifying a Configuration Parameter

Figure 3.10: Modifying Telemetry Duty Cycle

A turned on device showcases a functioning **Power Status Indicator** LED (Refer 2.2).

Connect the device with the configurator as mentioned in 3.4. Following is the procedure to get or modify configuration of the Teledosimeter within the Configurator.

- Click on **Get Config** Button.

- Make the Required Changes in Configuration.
  For example, Set the Duty Cycle to 3600 so that the device transmits data every 3600 seconds.

- On Clicking the **Configure** Button of the Changed Parameter, the time just above the **Configure** Button will be updated. This confirms the successful operation.

- Click on **Disconnect** Button.

Follow the same procedure from 3.4 to do the same for multiple devices.

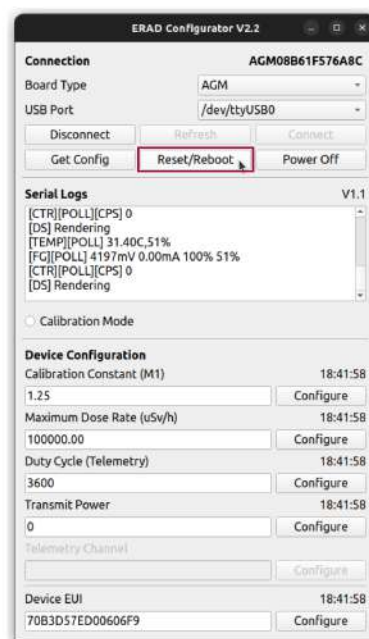## 3.4.2 Reset Dose Rate

Figure 3.11: Reset Dose Rate

A turned on AGM showcases a functioning **Power Status Indicator** LED (Refer 2.2).

Connect the device with the configurator as mentioned in 3.4. Following is the procedure to reset the AGM within the Configurator.

- Click on **Reset** Button.

- Remove the Type C Cable from AGM.

- Click on **Disconnect** Button.

Follow the same procedure from 3.4 to do the same for multiple devices.
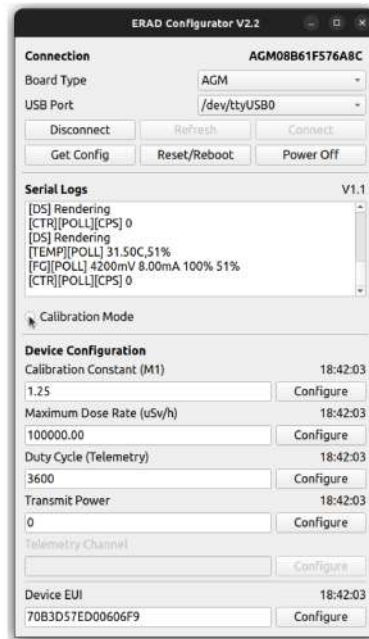
3.4.3 Calibration Mode

Figure 3.12: Calibration Mode

ERAD Configurator V2.2 or higher supports **Calibration Mode**, which can be turned on by clicking the radio button as shown in image 3.12. This will disable Telemetry if the calibration facility suggests avoiding any RF transmission during the calibration procedure.
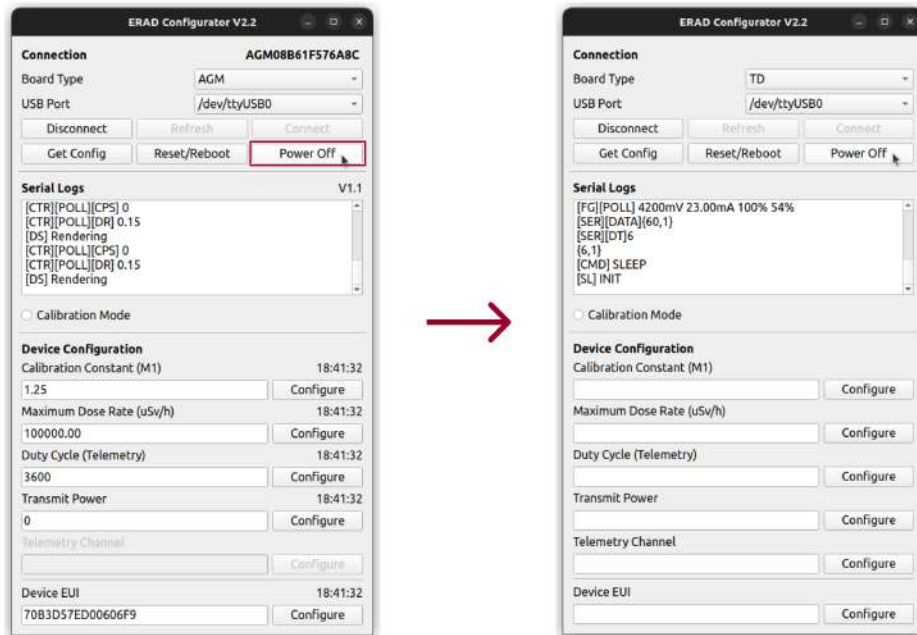
3.4.4 Turning Off AGM

Figure 3.13: Powering Off AGM

A turned on Dosimeter showcases a functioning **Power Status Indicator** LED (Refer 2.2).

Connect the device with the configurator as mentioned in 3.4. Following is the procedure to Turn Off Teledosimeter with the Configurator.

- Click on **Power Off** Button.

- Remove the Type C Cable from AGM.

- Click on **Disconnect** Button.

Follow the same procedure from 3.4 to do the same for multiple devices.

Chapter 4

Calibration and LoRa Specification

4.1   LoRa Parameters

The subsequent list comprises the LoRa parameters that have been preconfigured on the EGM-L210. The device joins a LoRaWAN network with Authentication By Personalization (ABP). The devices were tested with a Wisgate Edge Lite 2 LoRaWAN Gateway manufactured by RAKWireless, which is an 8 Channel Gateway Supporting 49 Demodulators. Upon request, a preconfigured LoRaWAN Gateway with a High Gain Outdoor Antenna will be bundled along with the devices.

- Frequency: 865 - 867 MHz

- Bandwidth: 125 kHz

- Spreading Factor: 12

- Duty Cycle: 3600 Second (0 - 15 Random Time Addition)

4.2   Calibration Information

Each and every device shipped will have a calibration certificate. The devices are calibrated at **Avantec**, an AERB recognized calibration facility.

The Following Reference Instrument was used for Calibration,

- Instrument: 10cc Ion Chamber

- Model: IC10016

- Traceability No: BARC/RSSD/RSS/CAL/C-144/2022

Source with the Following Parameters were used for Calibration,

- Radionuclide: Cobalt 60 (60Co)

- Energy / Unit: 1.25 MeV

- Exposure Rate: 5.00 mSv/h

List of Abbreviations

LoRa	Long Range
RSSI	Received Signal Strength Indicator
VSWR	Voltage Standing Wave Ratio
CPS	Counts Per Second
CPM	Counts Per Minute
mSv	milli Sievert
uSv	micro Sievert
VCC	Voltage Common Collector
Tx	Transmitter
Rx	Receiver
MHz	Mega Hertz
UART	Universal Asynchronous Receiver-Transmitter
SOH	State of Health
SOC	State of Charge
AGM	Area Gamma Monitor
UPS	Uninterruptible Power Supply