Writing Sample 2 – Mayo Clinic Tragus

Overview

The Tragus User Manual was an internal training document. It is, by design, less formal than Writing Sample 1 because we were working under a set of entirely different constraints. This was a project developed for research purposes and the intended audience was basically an audience of one, the lone researcher who was slated to oversee setting up and operating the hardware and software. This was not a marketed product, but was instead produced at the request of the Mayo Clinic Medical Education and Research Lab. The manual was written with the idea that future teams would have a starting point should the project prove viable and be expanded upon. This was a very intensive writing assignment requiring in-depth hardware and software SME feedback.

The project presented several challenges that I'll detail below. I think that the challenges I encountered make this an interesting project to discuss as a writing sample. It does provide a good look into my instructional writing style, though I did have to make many stylistic and linguistic concessions on this project.

Writing Sample Considerations

1. How much of the content did you write? Choose one: More than 50% (explain).
    a. If you wrote only portions of the document, tell us which portions you wrote.

This was about a 60/40 split between me and the Software Engineer. I designed the document, wrote the hardware setup instructions from scratch, compiled appendices, obtained images where I could, and setup placeholders for the software technical information. The Software Engineer provided the technical information for the software.

Complicating matters, the software was still in the design phase, so in many instances there were not updated or clear screenshots. I had no access to the software and was reliant on the engineer to provide screenshots and updated technical information as there was only one copy of the software.

We were all working completely virtually, so I was never in physical proximity to the hardware or software. Software screenshots and hardware photos were provided by the stakeholders on the other end of our virtual office.

Based on the circumstances, we were all relatively happy that we were able to meet the needs of the project.

2. Does the document represent your original writing, or is it existing content that you revised?

This was a completely original document. No previous version of this product existed. I designed the document and gathered technical information from SME interviews and design documents found in the Content Management System. Some stakeholders were steadfast on certain language decisions. Effectively engaging with differing personality types was a major strength of mine on this project.

3. Where did you get the information to write the document?

Databases (EPDM, SharePoint), Software Engineer, Mechanical Engineer, Research Laboratory Technician

4. Was the document edited by other people for grammar and style? Choose one:

a. ▸ Moderate editing
b. If so, who edited the document?

The Software Engineer also served as de facto Project Manager for this project. This was his software and I respected that. In a way, he was my customer, so I was happy to let him make decisions with language or grammar. At the beginning of the project, I used a very traditional departmental template. The engineer couldn't quite explain why he didn't like the manual, but I could tell there was some sense of dissatisfaction. A few weeks into the project, I took a weekend to do a basic redesign, and something about the redesign lifted a weight off the project and we started to really make good progress.

5. Share how you obtained any code samples.

N/A

6. Was a company style guide used to write this document?

Yes and no. This manual was not required to follow the company style guide, but I did make some basic decisions to keep it on-brand. The header is a good example of this.

7. Provide any additional useful context for the sample, such as deadlines, achievements, etc. If you edited the content after it was published, what changes did you make and why?

As previously mentioned, we achieved our goal despite several challenges. It was published on-time and delivered with the product, and it proved effective in training the intended audience on how to install and operate the equipment.

8. Was this document part of a larger documentation set?

N/A

Tragus User Manual

System Assembly and Operation

Table of Contents

1 About this guide

1.1 Roles and Responsibilities

The user(s) is responsible for using the Tragus system in a safe manner, according to the instructions provided below. The user(s) must report any significant mechanical or safety issues revealed during general use. The user(s) is responsible for utilizing the device in a manner consistent with the General Safety Precautions and Assembly Instructions.

2 Introduction

2.1 Purpose

The purpose of this User Manual is to describe the setup and operational instructions for the Tragus hardware and software. It describes how to setup the hardware at delivery, how to install, run, and operate the software, and how to troubleshoot common issues.

2.2 Scope

The scope of this document includes the operational instructions and safety precautions for the Tragus application, host enclosure, remote enclosure, and animal harness.

3 The Tragus System

This document describes the setup and operational instructions for the Tragus system. Tragus is a mobile, battery-powered platform that samples voltages with precision of tens of microvolts on either 1 or 2 channels at up to 20,000 samples per second or up to 8 channels at up to 5,000 samples per second. It can tolerate and continue recording during substantial electroporation pulses (though the incoming signal will be blocked during the actual pulses). The device can capture ECG or other physiological signals including from the vagus nerve as it innervates near the tragus. Tragus can send sampled data to the Tragus Application via USB cable in wired mode or via custom RF protocol in wireless mode. The Tragus Application (TA) facilitates set up of data collection as well as storage and display of sampled data.

3.1 Components

- Windows PC workstation with installed Tragus application
- Host Enclosure with micro USB port
- Remote Enclosure with micro USB port
- (2) Batteries
- Micro USB cable
- Electrode leads (not provided)

3.2 System Operations

The Tragus System is comprised of 3 main elements; the remote enclosure, the host enclosure, and the Tragus software installed on a Windows PC with a minimum of 2 TB of available hard drive space for recording. Under a typical recording procedure, the user will plug in EITHER the Host Enclosure (for wireless operation) OR the Remote Enclosure (for wired operation) into the Windows PC.

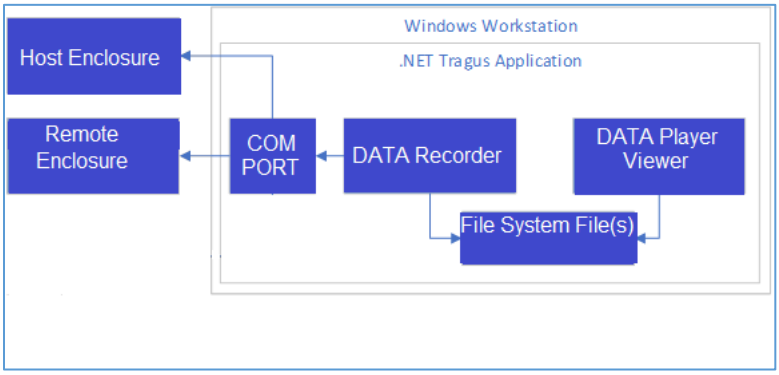

Figure 1: System Architecture

- Remote Enclosure
- Host Enclosure
- Tragus Application
- Windows PC with 2 TB available hard drive space for recording

4 Installing, Starting, and Stopping the System

4.1 Hardware Setup

The system is comprised of the remote enclosure, host enclosure, two batteries, (10) cables for front end board electrodes (not provided), a Micro USB cable to attach the host enclosure to the PC, and a remote enclosure bag that attaches to the animal (not provided).

4.1.1 Remote Enclosure Setup

Figure 2: Remote Enclosure

1. Connect the TENS 7000 to the remote unit using the supplied cable.
2. (Optional) Set the radio channel by jumping or unjumping pins 2 and 4 on EXT1.
3. Insert the remote unit into the animal harness bag. The ports on the unit should be facing toward the bag opening.
4. Attach the electrode leads to the desired channels. The "Ref" channel must be used to obtain a reliable signal.

Figure 3: Electrode Lead Connected to Remote Enclosure

5. Attach the animal harness. The remote enclosure rests in the animal harness with ports facing upwards.

Figure 4: Animal Harness

6. Attach sterilized electrodes to leads and animal in desired locations.
7. For wireless operation, connect one battery to the remote unit using a USB cable.
8. For wired operation, connect the remote unit to the PC using the supplied micro USB cable.

Note: The remote will automatically detect whether it is in wired or wireless mode.

4.1.2 Host Enclosure Setup (for wireless operation)

Figure 5: Host Enclosure

1. Connect the host enclosure to the PC using the supplied Micro USB cable.
2. (Optional) Set the radio channel by jumping or unjumping pins 2 and 4 on EXT1.

4.2 Changing the Batteries on the Remote Enclosure

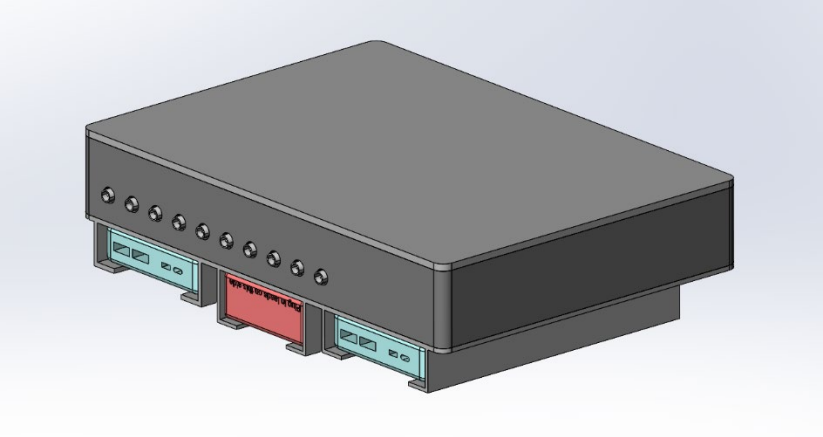

Figure 6: Battery Slots on Remote Enclosure

The remote enclosure needs to maintain continuous power for an uninterrupted recording. The remote enclosure holds two batteries allowing the user to swap out a spent battery and replace it with a charged battery.

1. During normal operation, the batteries should be placed in the battery slots.

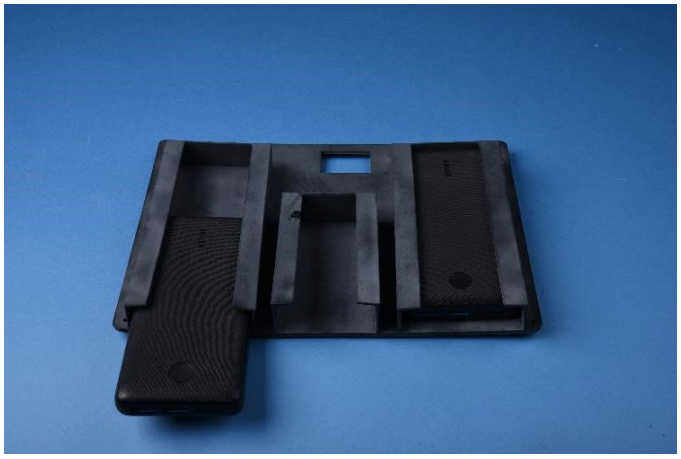

Figure 7: Battery Slots

2. Batteries are connected to the device using micro-USB cables. Each battery has 2 USB type A outputs, and either may be used.

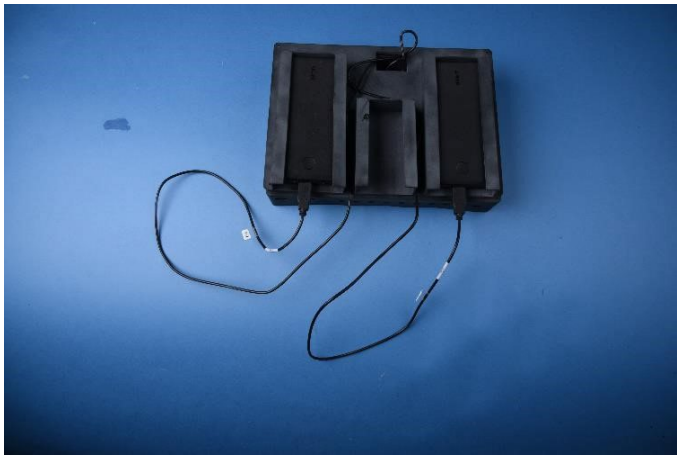

Figure 8: Micro-USB Cables attached to Batteries

3. Connect a fully charged battery to the remote enclosure.

Note: Ensure that a charged battery is connected before disconnecting a spent battery.

4. Unplug and remove the spent battery that you intend to replace. Connect the spent battery to a charger.
5. Repeat these steps as needed to ensure continuous power and uninterrupted recording.

Note: If the USB cables become disconnected from the device, they should be fed through the hole in the enclosure and connected to the micro-USB ports on the power board, shown below.

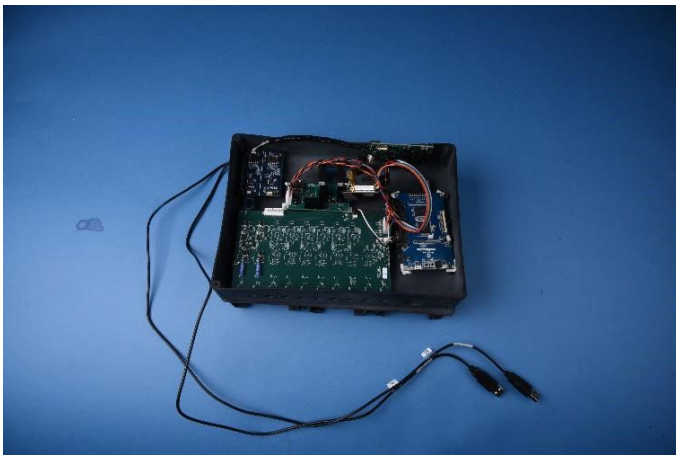

Figure 9: Micro-USB Cable Enclosure Hole

4.3 Set the Wireless Channel

The wireless channel is set using pins 2 and 4 on EXT1. A jumper must be used on both the host and remote units for them to communicate. A remote without a jumper will only communicate with a host without a jumper. A remote with a jumper will only communicate with a host with a jumper.

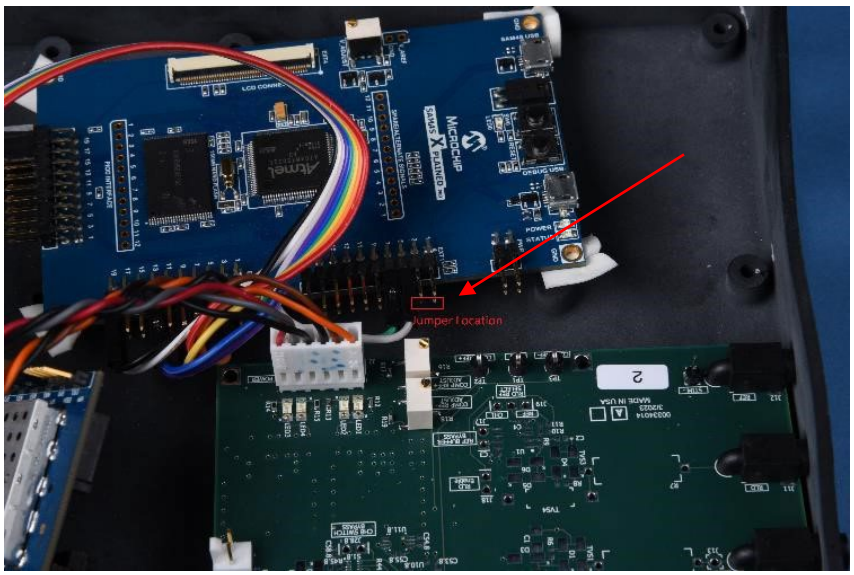

Figure 10: Remote Unit Jumper Location

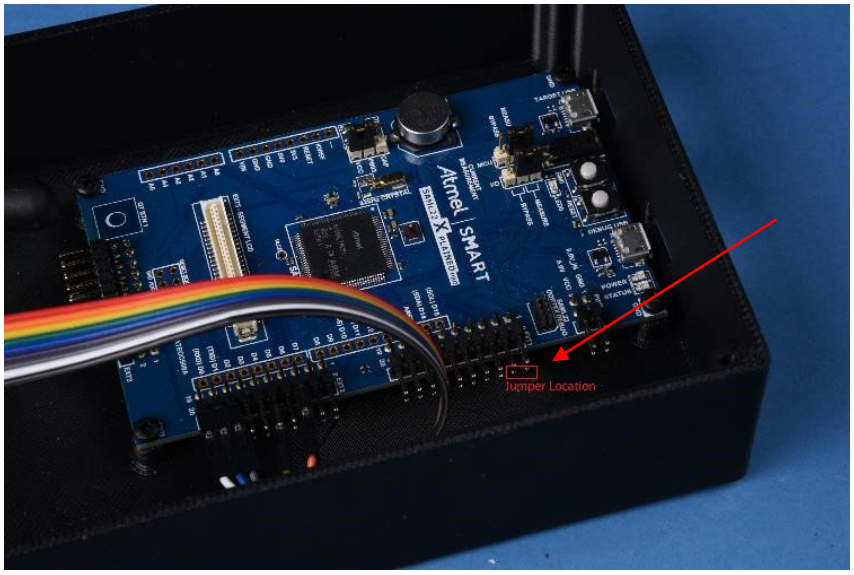

Figure 11: Host Unit Jumper Location

4.4 Tragus Hard Drive Storage Requirements

The Tragus Application records to a PC hard drive in the form of stored comma-separated values (CSV) Excel files. In cases where recordings will be run continuously for days-at-a-time, the user will need to ensure ample hard drive space is available. A minimum of at least 2 TB of hard drive space is recommended.

4.5 Installing the Tragus Software

An MSI will be made available on the network. Users will need at least temporary administrative permission to install it. Click on the MSI to begin the installation and follow the prompts from the Wizard.

1. Click on the MSI to begin the Tragus Application Setup Wizard.

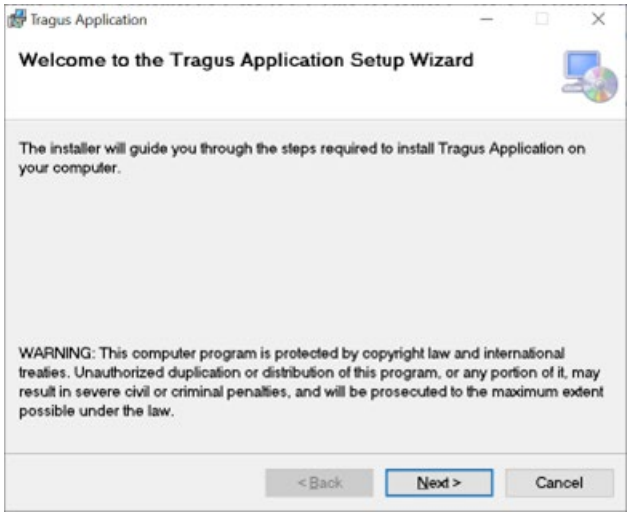

Figure 12: Tragus Application Setup Wizard

2. Select the installation folder desired.

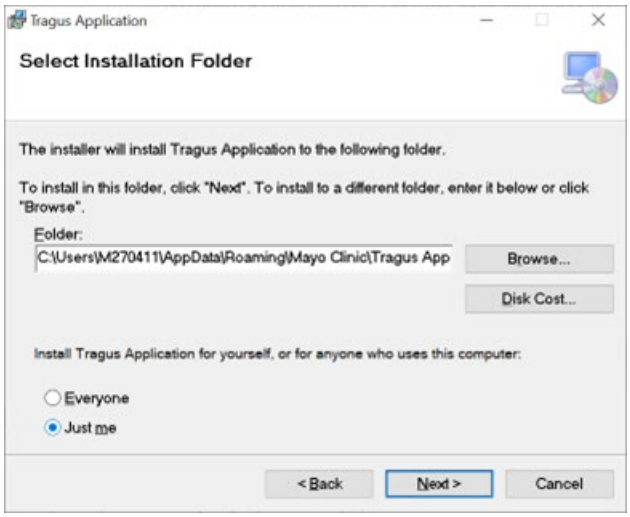

Figure 13: Select Installation Folder

3. On the Confirm Installation screen, press Next.

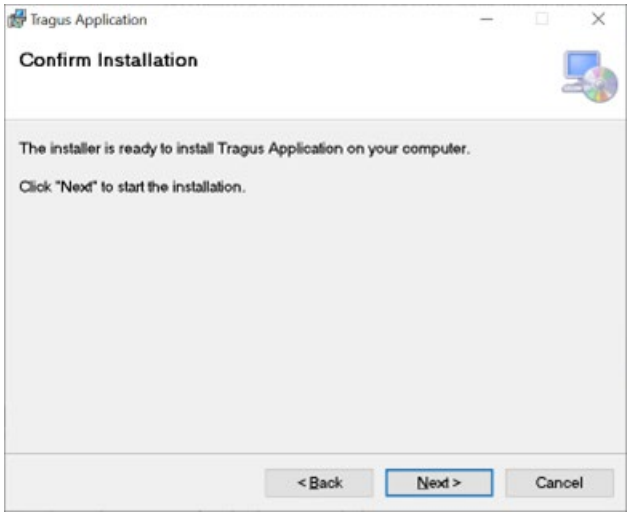

Figure 14: Confirm Installation

4. Close the Wizard once the install is complete.

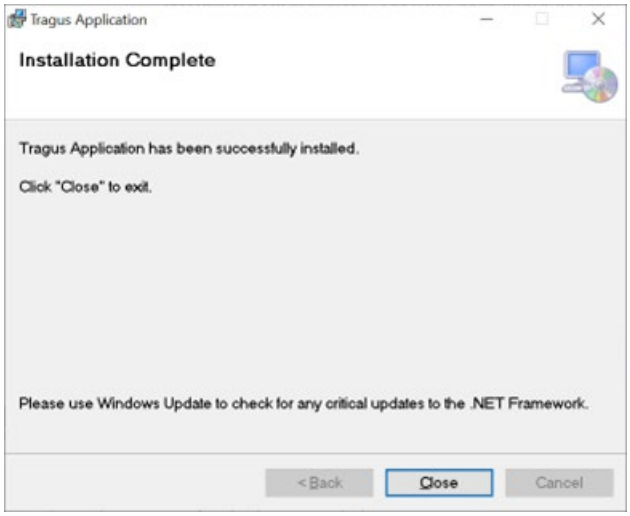

Figure 15: Installation Complete

4.6 Tragus Recording Procedure

To start a recording with Tragus:

1. For wireless operation, connect the Host Enclosure board to the Windows workstation via USB cable.
2. For wireless operation, ensure the Remote Enclosure board is connected to its power supply (battery).
3. Alternately, for wired operation, connect the Remote Enclosure to the Windows PC via USB cable.

Continue with the steps below for both Wired and Wireless recording:

4. Open the Tragus application.
5. Select the desired COM Port. COM Port selection can be determined by unplugging the Micro USB from the Host Enclosure. The associated COM Port will disappear from the drop-down menu in the user interface of the Tragus Application.

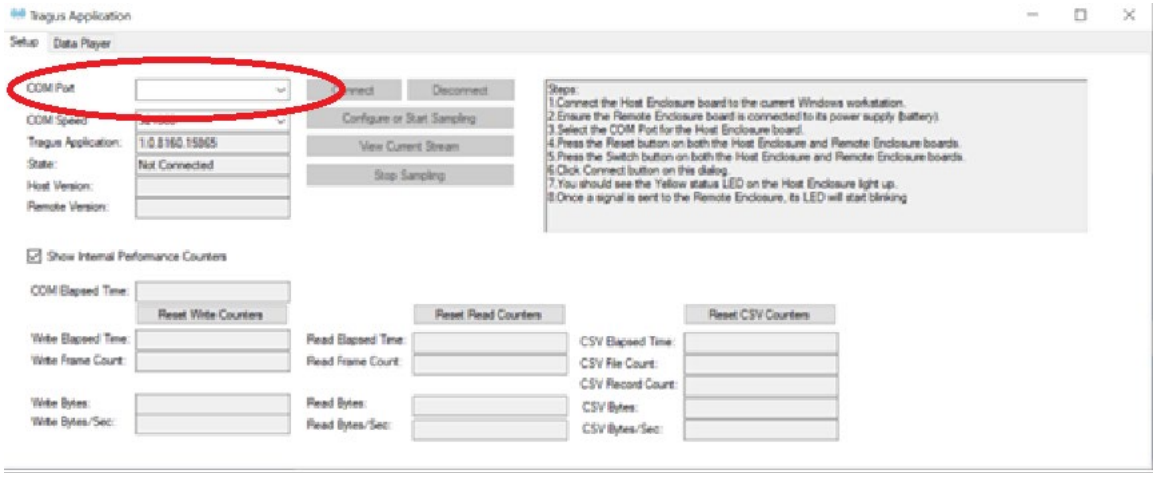

Figure 16: Select COM Port

6. The Yellow status LED on the Host Enclosure will blink approximately 1 time per second.
7. Plug the Micro USB back into the Host Enclosure. A green LED will illuminate on the enclosure and the COM Port will be available in the drop-down menu.
8. Once the desired COM Port is selected, click **Connect**. The UI screen will update and the Connect button will be disabled.
9. Choose the desired channel(s) for recording.
10. If desired, browse to select a folder where the recorded data files will be stored (Shown in 2nd green box of Figure 17 below).

11. Click **Configure** or **Start Sampling** (Shown in the 3rd green box of Figure 17 below).

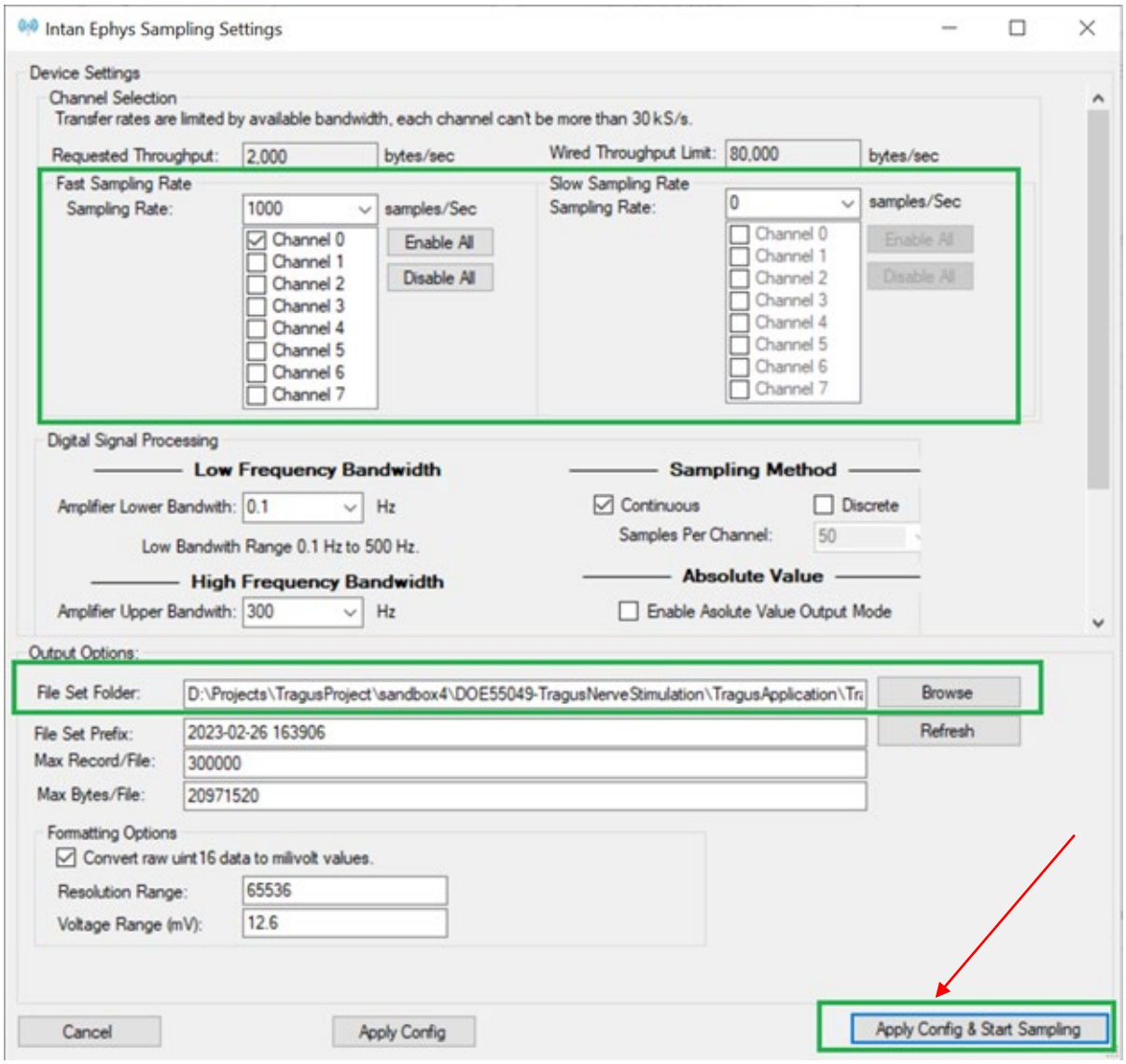

Figure 17: Configure & Start Sampling Button

12. After a few data packets have been collected, the **View Current Stream** button will become enabled (Shown in Figure below). Click this button, select the desired channels, and plots of those channels will be displayed.
13. Click **Stop Sampling** or **Disconnect** to end the recording session (Shown below). The saved CSV files will be in the folder designated by the user in Step 12 above.

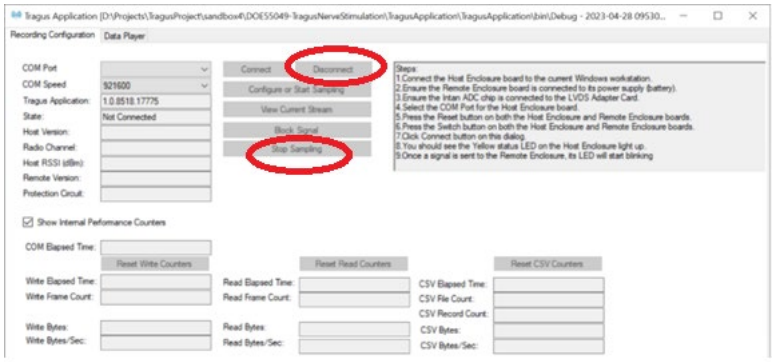

Figure 18: Stop Sampling and Disconnect Buttons

Common Diagnostic Steps:

- Inside the Remote Enclosure, the Intan ADC chip needs to be connected to the LVDS Adapter Card.
- Before clicking **Connect**, resync both boards by pressing their Reset and SW0 buttons. See Appendix C – Manual Reset.

4.7 Checking the Status of a Recording

1. To view the real-time data collection of the channel being recorded, click **View Current Stream**. From there, click on the **Data Player** tab.

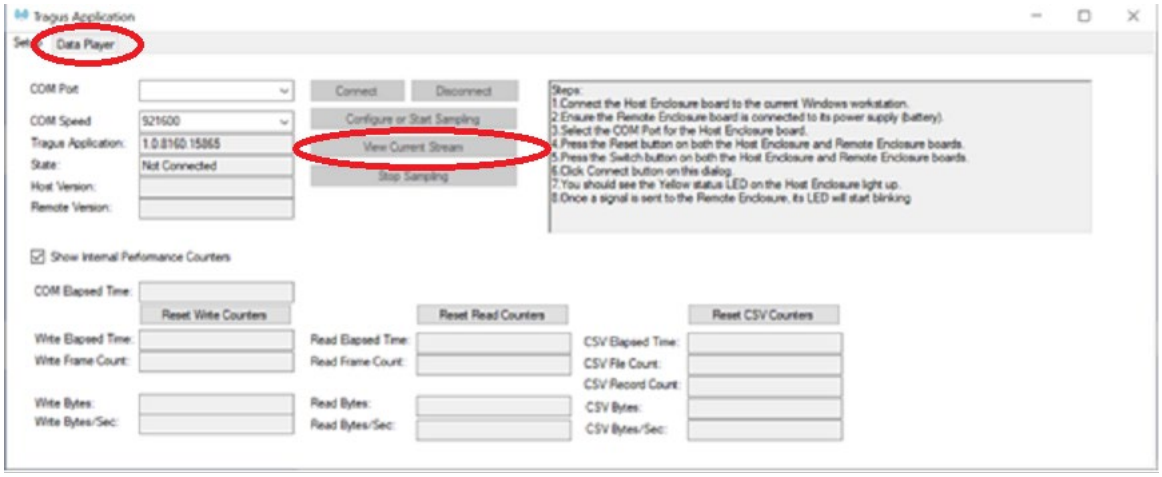

Figure 19: View Current Stream

2. The **Data Player** tab shows a continuously updated window of the data currently being recorded.

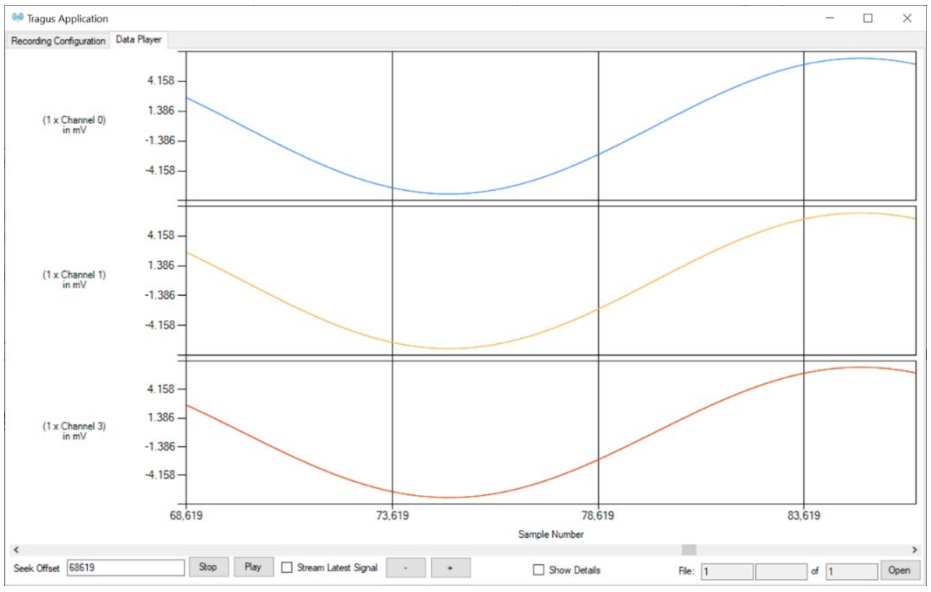

Figure 20: Data Player Tab

4.8 Choosing Sampling Settings

The **Intan Ephys Sampling Settings** tab allows the user to specify how to configure and record the device.

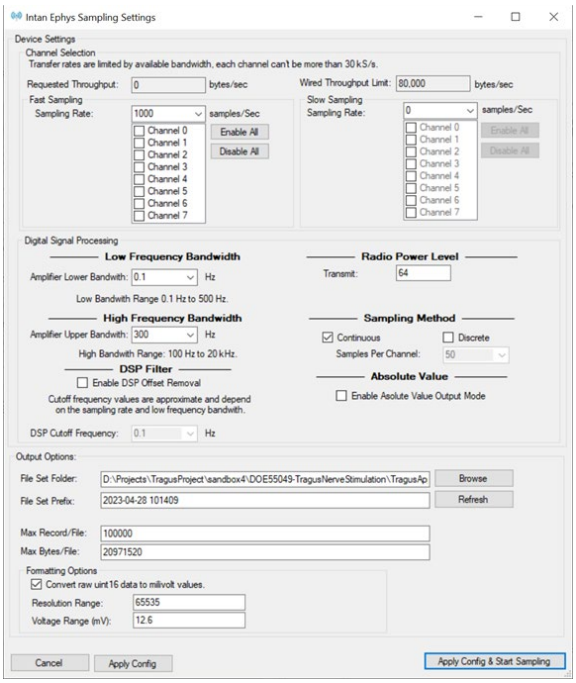

Figure 21: Intan Ephys Sampling Settings

The user can determine settings as follows:

- **Channel Selection** Up to 8 channels that can be recorded at the same time. As the Sampling rate goes up, there is a limit on the number of channels that can be recorded at the same time.
- **Required Bandwidth** Combines the selected number of channels with the sample rate to highlight how much data will be needed per sec to service that request.
- **Max Sample Rate Per Sec** Configures the Intan ADC's behavior.
- **Amplifier Lower Bandwidth** High Pass Filter
- **Amplifier Higher Bandwidth** Low Pass Filter
- **DSP Offset Removal** Cutoff frequency values are approximate and depend on the sampling rate and low frequency bandwidth.

- **DSP Cutoff Frequency** The frequency at which to apply the cutoff.
- **Sampling Method Continuous** Keep sampling until the user stops the recording session.
- **Sampling Method Discrete** Collect a specified number of samples.
- **Enable Absolute Value Output Mode** Prevent negative voltage values.

Output Settings:

- **File Set Folder** The directory for the current recording session. This required field starts out empty, but the Browser defaults to the directory with the TA executable. You are free to specify any valid folder location local or remote. If you are viewing the streaming data, fast IO will help.
- **File Set Prefix** The file names that are generated have the format [File Set Prefix]_[0000000000].csv. So, the prefix can be anything that does not contain the underscore '_' character. This field will default to a current timestamp. You can get an updated timestamp if you wish by pressing the Refresh button.
- **Max Record/File** This is rollover criteria for the CSV consumer. If the next record would cause the stream to exceed this criterion, the current file will be closed and a new file started. When this happens, the file number of the filename will be incremented by one.
- **Max Bytes/File** This is rollover criteria for the CSV consumer. If the next record would cause the stream to exceed this criterion, the current file will be closed and a new file started. When this happens, the file number of the filename will be incremented by one.
- **Formatting Options** Controls whether the csv files contain counts or voltage values. Using the following formula:
  millivolts = ([CountValue]-([ResolutionRange]/2)) ([VoltageRange]/[ResolutionRange])

- **Resolution Range** The ADC generates ushort/UInt16 values. That means 65,536 makes sense as a value.
- **Voltage Range** This value comes from the ADC's Least Significant Bit metric.
- **Enable Place Holder Data** If there are gaps in the sequence number, there is a software optimization choice of generating empty values or using a gap map to avoid generating extra IOPs. For the moment, this feature only supports generating null values for the missing sequence numbers.

Buttons

- **Cancel** Closes the form.
- **Apply Config** Sends a configuration command to the COM port.
- **Apply Config & Start Sampling** Applies the configuration parameters requested in this UI and then issues a start sampling command. This is the most common button to use on this UI.

5 Navigating the Data Player

The user should become comfortable navigating the Data Player and interpreting the data presented. The main area of the Data Player graphical user interface is presented via line chart, each showing rendered channel data. Each Line Chart is rendering one or more signals. The Y axis can be specified but is typically the sample count range 0-65,535 or the millivolt range -6.3 - +6.3. The X axis is always the number of samples from the beginning of the recording. The horizontal scroll bar shows your current progress through the current file set.

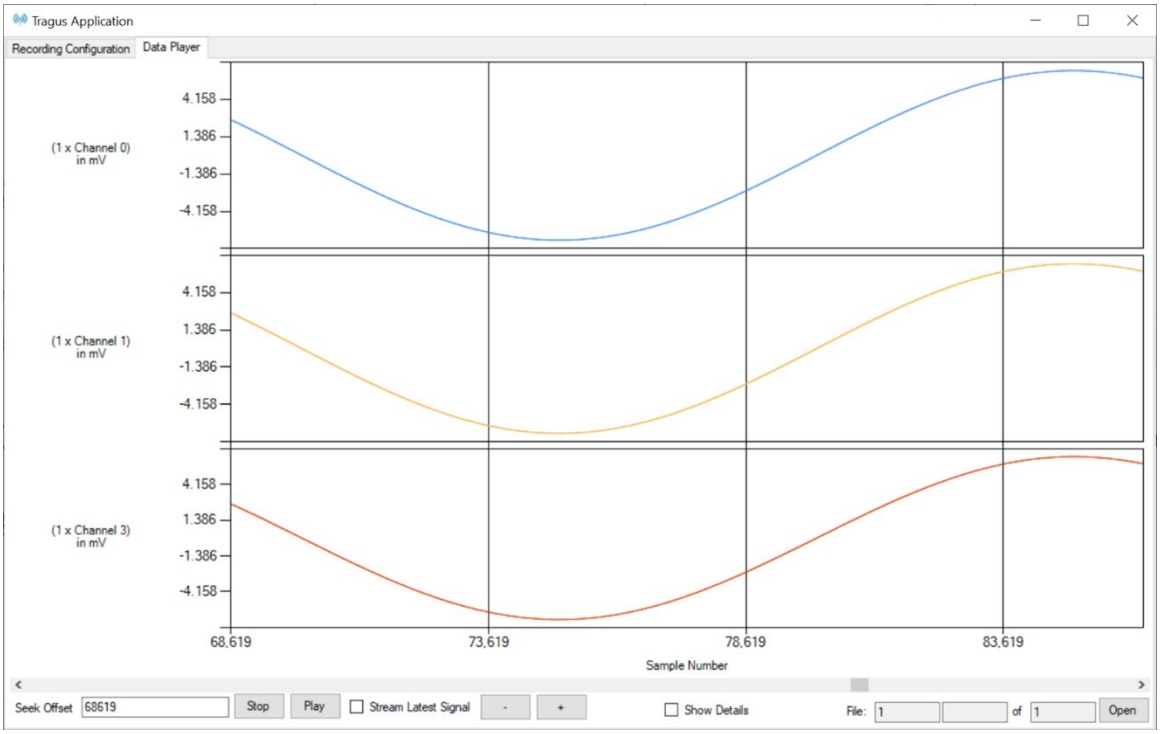

Figure 22: Data Player Interface

The GUI has four navigation options:

- **Stream Latest Signal** This mode will constantly read the end of the last file in the file set. It will then look for the sample offset that is the configured Window Width from the end and render this range of samples.

- **Play Velocity** The notion of velocity is a change per unit time. In this case, advance the window by a given number of samples every second. The velocity can be positive, move forward, or negative and move backwards in time. If you press the Play button, the scroll wheel will go into velocity mode, and you can quickly change the Window Width value.

- **Horizontal Scroll** Interacting with this slider allows you to navigate anywhere within the current file set. If you press the horizontal scroll bar, the scroll wheel will go into scrolling mode and you can quickly change the Window Begin value.

- **Seek Offset** Enables you to enter a specific number and navigate to that location.

5.1 View Contents of a Recording

The contents of a given recording file can be accessed by clicking the **View Current Stream** button or selecting the Data Player tab and clicking **Open** in the lower right-hand corner.

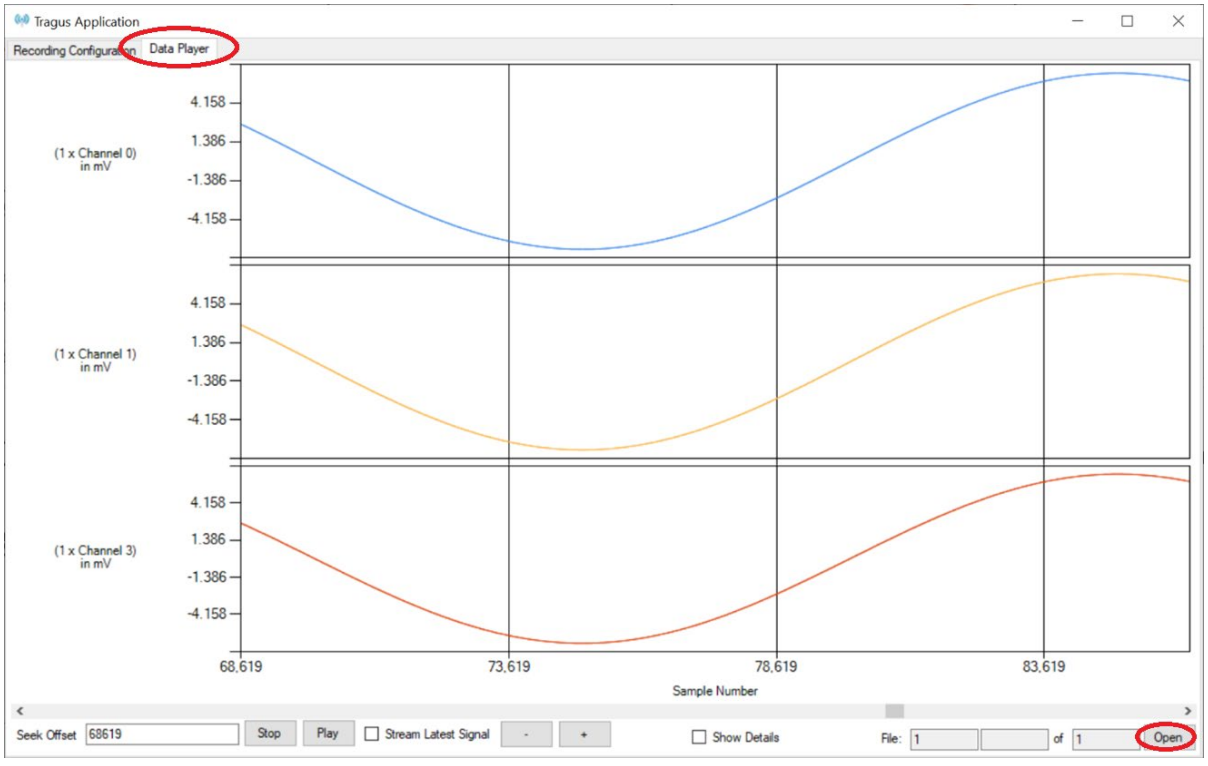

Figure 23: Click Open on Data Player Viewer

5.2 Show Details Chart

In some instances, the user may find it helpful to have the Show Details dialog box checked.

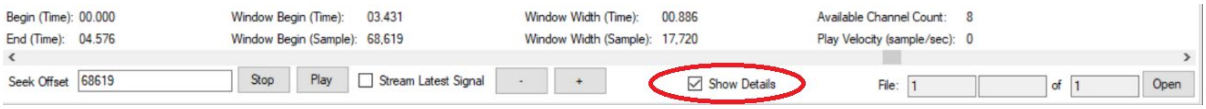

Figure 24: Show Details

While the user may not find it necessary to always display these details, when selected, the data provided may offer helpful context when trying to locate a specific portion of the file set. The time values all have the following format: 123:23:59:59.999. Unless the value really is multiple days, the leading time units will not be shown.
Navigation for the Show Details display:

- **Seek Offset** Available when Stream Latest Signal is not checked. Enables you to enter an offset type enter and navigate to that location.
- **Stop** Sets the Play Velocity (sample/sec) to zero. This activity also puts the scroll wheel on your mouse into velocity mode,
- **Play** Sets the Play Velocity (sample/sec) to one. This activity also puts the scroll wheel on your mouse into velocity mode.
- **Stream Latest Signal** Continuously checks for the length of the last file in the file set. Then shows a Window width worth of records. This updates every half a second. Larger windows and more channels can create challenges for this functionality.
- **Minus** Shrink the Window Width by 10 percent.
- **Plus** Grow the Window Width by 10 percent.
- **Show Details** Controls whether the Show Detail Fields are displayed.
- **File** Indicates which file contains the currently displayed samples. The current window can span two files which is why there are two fields.

- **Of** Indicates the total number of files in the current file set.
- **Open** Allows you to open a new file set or see more details about the currently selected file set.

Show Detail Fields:

- **Begin Time (Time)** This is typically 00.000, unless an early file in your file set has been removed from disk.
- **End Time (Time)** The last value in the current file set.
- **Window Begin (Time)** The beginning of the current window in time units.
- **Window Begin (Sample)** The exact offset of the beginning of the current window.
- **Window Width (Time)** The length of the current window. You can zoom in or out by pressing the + or – buttons and then using your scroll wheel.
- **Available Channel Count** This is the actual number of raw channel values in the current file set. This might be confusing if you include a composed column in the current view.
- **Play Velocity (sample/sec)** The number of samples that the window will advance by when the next second comes around.

5.3 Chart Configuration Dialog

The Chart Configuration Dialog allows the user to research a File Set more deeply. Once a File Set is chosen, there are a certain number of channels available. The actual channels that are plotted are in the Signals to Plot list. File Set Navigation is intuitive in that it echoes fields that are in the Show Details section of the chart. Compose Signals allows you to build up a polynomial of different signals into a new composite signal.

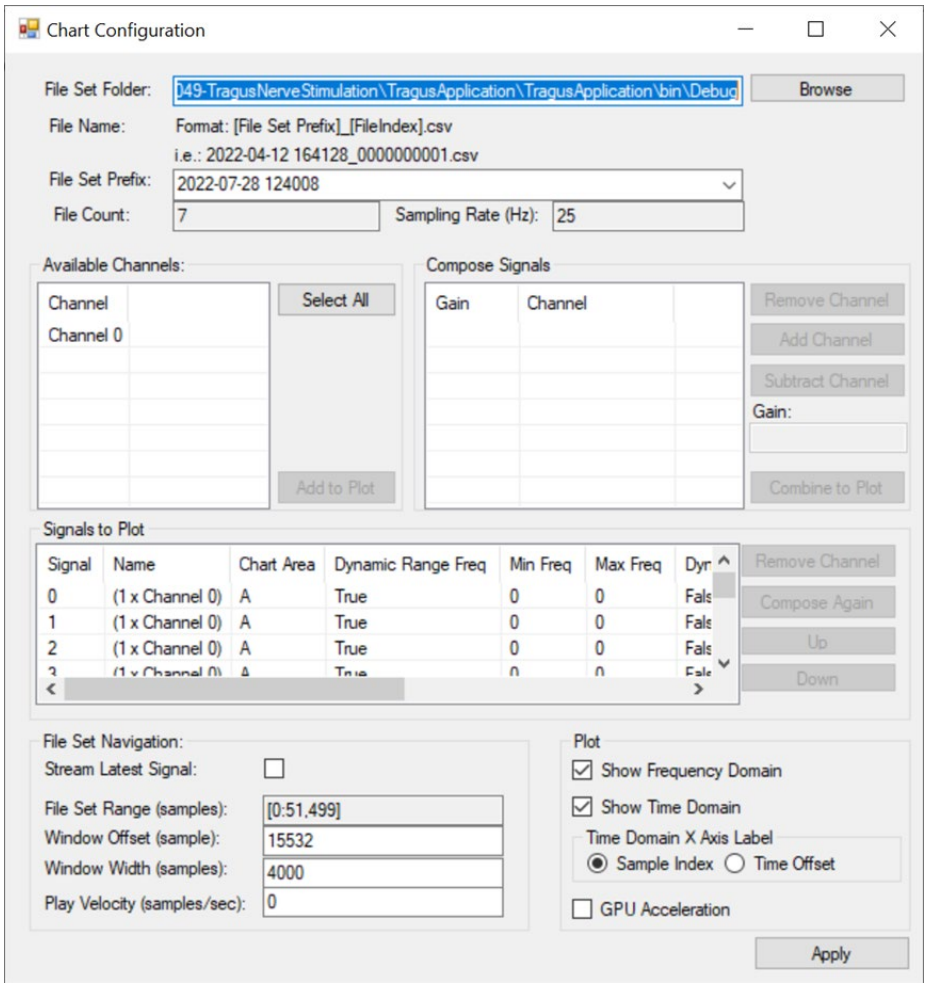

Figure 25: Chart Configuration

- **File Set Folder** The folder that contains the collection of files in the file set.

- **File Set Prefix** The prefix that links the collection of files together in each file set. Clicking the drop down will generate a distinct and sorted list of the file sets in the current folder.

- **File Count and Sampling Rate (Hz)** Provide insight into how this File Set was generated.

- **Available Channels** Lists the channels that are contained in the current file set. Select one or more available channels. Add to the Compose Signals List using Add Channel or Subtract Channel. Add to the Signals to Plot list by double clicking or clicking Add to Plot.

- **Compose Signals** A list of channels that you can combine like a polynomial into a new composite channel. The gain field represents the coefficient for a given signal. Example: (1 x Channel 0) + (-1 Channel 1) would subtract every value in Channel 1 from Channel 0.

- **Remove Channel** Will remove the selected channels from the Signals to Plot list.

- **Add Channel** Add the currently selected Available Channel to the Compose Signals list, default the Gain coefficient to the value 1.

- **Subtract Channel** Add the currently selected Available Channel to the Compose Signals list, default the Gain coefficient to the value -1.

- **Combine to Plot** Combine all of the channels in the Compose Signals list into a single polynomial. Remove all the entries from the Combine to Plot list and create one new synthetic/polynomial signal in the Signals to Plot list.

- **Signals To Plot** The collection of signals that are actual plotted on the screen. There's an additional details dialog that we'll cover next that provides additional customization to this collection to channels.

- **Remove Channel** Remove the currently selected row(s) from the Signals to Plot list.

- **Compose Again** Move a selected channel from the Signals to Plot list backup into the Compose Signals List.

- **Up / Down** Allows you to change the relative position of the currently selected channel.

- **Stream Latest Signal** Same behavior as the Stream Latest signal checkbox on the chart UI.
- **Window Offset (Sample)** Navigate to a given offset of the file set.
- **Window Width (Sample)** Modify the number of samples that are displayed in the current chart window.
- **Play Velocity (Sample/sec)** Modify the rate at which the file is playing.
- **Plot Show Frequency Domain** Show a periodogram of the current window's worth of time domain samples.
- **Plot Show Time Domain** The currently selected window of time domain samples that are retrieved from the file set.
- **Plot Time Domain X Axis Label Sample Index** Render the sample values which start at 0 for the file set and increment for each sample.
- **Plot Time Domain X Axis Label Time Offset** Given the sample index and the sampling rate, show the time delta relative to the beginning of the recording.
- **Plot GPU Acceleration** Offload some of the calculations to the current workstation's most powerful GPU. Currently, only the FFT conversion uses this capability.
- **Apply** Closes this window and renders the requested channels.

5.4 Chart Area Properties Dialog

To open the Chart Area Properties Dialog:

1. Double-click a single line in the Signals to Plot listing or select multiple lines and right-click the grouping.

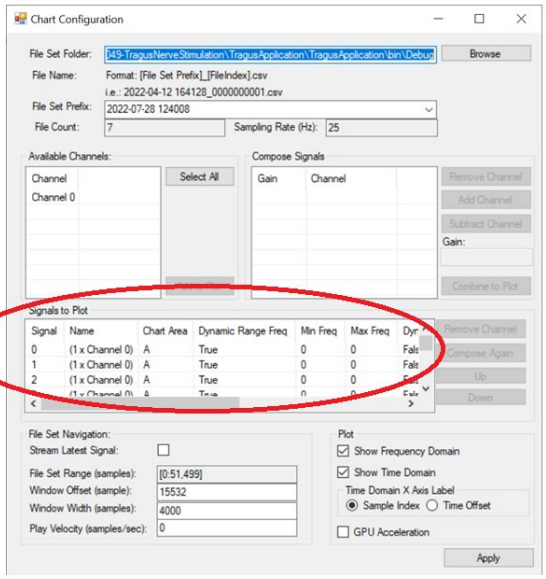

Figure 26: Select Signal to Open Chart Area Properties

2. The Chart Area Properties Dialog will open.

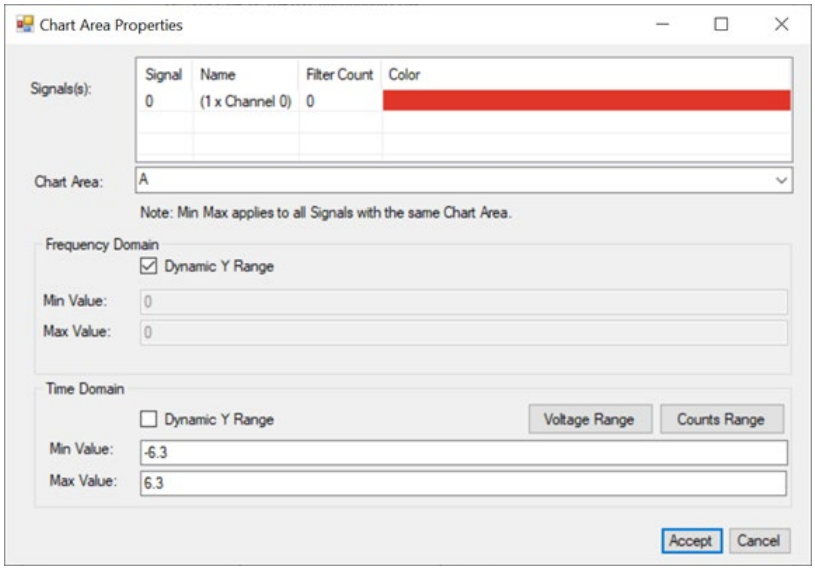

Figure 27: Chart Area Properties Dialog

The channels that have the same Chart Area are grouped together in one Y axis. All channels in one Chart Area do not need to be selected to update that Chart Area's Y axis scale.

- **Signals** – Whatever you double click on or have selected when you right click will be listed in this list view.
- **Chart Area** – The drop down contains an alphabetically sorted distinct list of Chart Areas in the current Signals to Plot list.
- **Frequency Domain Dynamic Y Range – Typically the range for a periodgram can vary substantially. Most often, you'll want the data to drive the dB range of the Periodgram's Y axis.**
- **Frequency Domain Min Value & Max Value** – Specify the min/min Y dB value for the periodogram.
- **Time Domain Dynamic Y Range** – Since the ADC/Intan hardware drives the voltage range, it is less common that you will want a dynamic Y range for the Time Domain.
- **Voltage Range and Counts Range** – Easy way to populate Min and Max with common values.
- **Min Value and Max Value** – Specify the range of the Y axis for the currently specified Chart Area.
- **Accept** – Update Signals to Plot with the updated properties defined in this dialog.
- **Cancel** – Exit out of this dialog without making any changes.

5.5 Signal Properties

Navigate to the Signal Properties dialog by double clicking on any Signal rows in the Chart Area Properties.

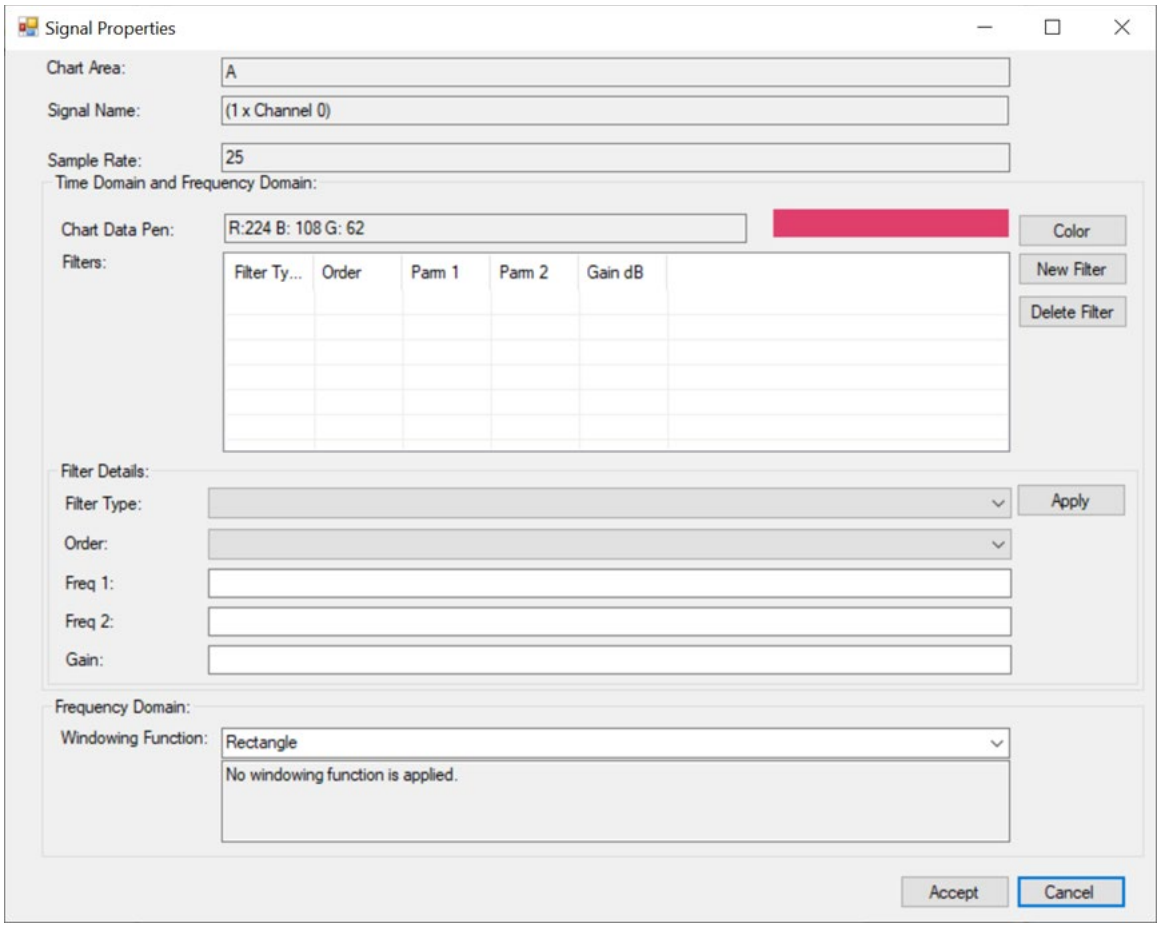

Figure 28: Signal Properties

- **Chart Area –** The current Chart Area that owns this Signal.
- **Signal Name –** The current name of the signal that this dialog is configuring.
- **Sample Rate –** The Sample Rate in Hz that this dialog is configuring.
- **Time Domain & Frequency Domain Chart Data Pen –** The color used when rendering this signal.

- **Time Domain & Frequency Domain Filters –** A list of filters that will be applied to the current signal.
- **Time Domain & Frequency Domain New Filter –** Blank out the Filter Detail fields so that a new filter can be added to the list.
- **Time Domain & Frequency Domain** Delete Filter – Remove the currently selected filter from the list.
- **Filter Details Filter Type –** A list of filters that can be applied to the signal.
- **Filter Details Apply –** Add or Update the current Filter Details to the list.
- **Frequency Domain Windowing Function –** These functions are applied to the time domain data just before applying the frequency domain. This reduces frequency leakage. The default is a Rectangle window.

5.6 Navigating a File Set

Each file in a File Set is a self-contained set of data. It contains a header and might contain a footer if the file has been capped off.

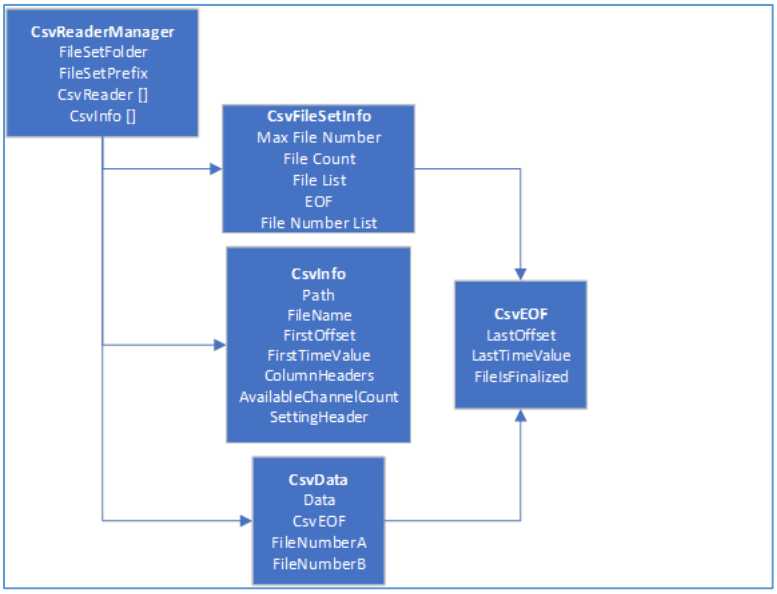

Figure 29: Csvreadermanager Object Model

6 Appendix A – Host Unit Assembly

The following parts lists are intended to be up to date but this User Manual is not the controlling document for Tragus hardware. The latest released schematic and BOM take precedence.

Enclosure Parts List

- Host Enclosure Bottom (DOE00333073 Pm.05)
- Host Enclosure Top (DOE00333074 Pm.07)
- Top Hole Cover (DOE00333307 Pm.08)

PCB Parts List

- Atmel SAML22 (Digi-Key: ATSAML22-XPRO-B-ND)
- EZRadioPro (Digi-Key: 4463CPCE20C460-ND)
- Antenna (Digi-Key: 343-ANT-450-RHR-SMA-ND)

Cable Parts List

- Cbl, Micro-Radio (DOE00346144)

Fasteners

- M2.5x12 screws, 4x
- 6/32x1/4 screws, 2x
- 6/32x1 screws, 4x

Before installation in the enclosure, the microcontroller and the radio must be connected by the micro-radio cable. The following table should be used to connect the Atmel SAML22 to the EZRadioPro.

RF Name	VDD	GND	SDN	GP1/2	NSEL	MOSI	MISO	SCLK	NIRQ	GP1
Cable color [WIP]	BLK	WHT	RED	-	GRY	PRPL	BLU	GRN	YLW	ORG

Eval Ext HDR #	20	19	6	-	15	16	17	18	10	5
Eval Name	VCC	GND	PB05		PA17	PA18	PA16	PA19	PC01	PB04

1. Assemble the host electronics as shown.

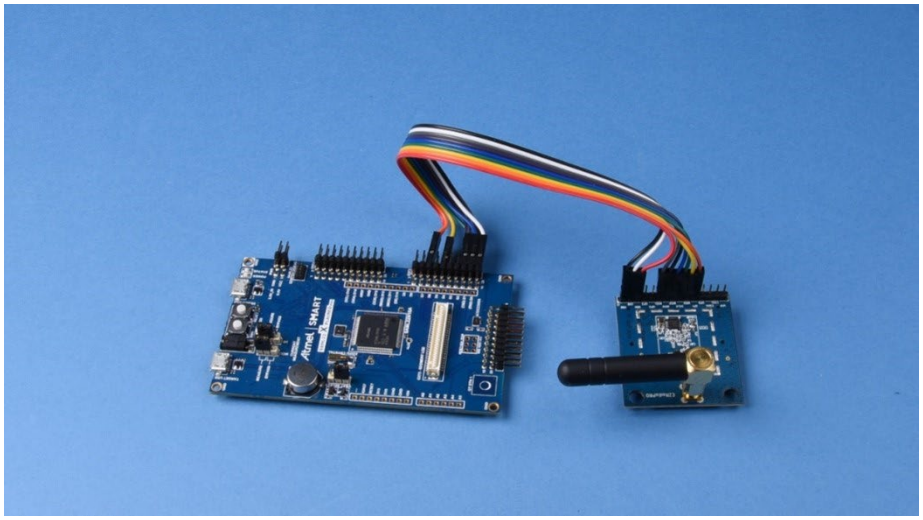

Figure 30: Host Electronics

2. The microcontroller dev board is attached to the enclosure via 4x M2.5x12 screws. The radio dev board is attached to the enclosure via 2x 6/32x1/4 screws. The assembled host unit is shown below.

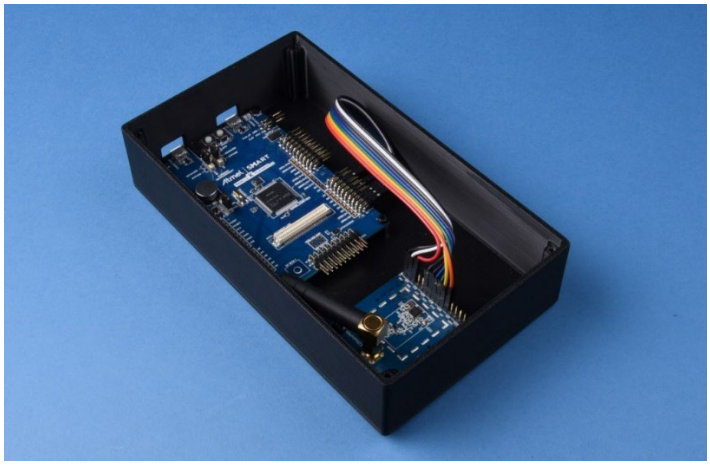

Figure 31: Microcontroller Dev Board

3. The enclosure lid may be attached using 4x 6/32x1 screws, but the tolerances allow the lid to fit snugly without the use of screws.

Figure 32: Enclosure Lid

4. The hole cover may be inserted into place or removed at the user's convenience.

Figure 33: Hole Cover

7 Appendix B – Remote Unit Assembly

The following parts lists are intended to be up to date but this User Manual is not the controlling document for Tragus hardware. The latest released schematic and BOM take precedence.

Enclosure Parts List

- Remote Enclosure Base (DOE00342877 Pm.02)
- Battery and TENS Holder (DOE00343388 Pm.02)
- Remote Enclosure Top (DOE00343649 Pm.01)
- Top Hole Cover (DOE00343400 Pm.02)

PCB Parts List

- Front-End Board (DOE00334014 Pm.04)
- Power Board (DOE00338331 Pm.03)
- Wireless RF Pico Board (Digi-Key: 4463CPCE20C460-ND)
- RF Antenna (Digi-Key 343-ANT-450-RHR-SMA-ND)
- Intan 16ch Headstage (Intan: #C3334)
- Intan LVDS Adapter (Intan: #C3490)
- Microchip ATSAM4S-XPRO (ATSAM4S-XPRO-ND)

Cable Parts List

- Cbl, Micro->Radio (DOE00346144)
- Cbl, Power->Micro (Digi-Key: 102-1092-BL-00050)
- Cbl, Power->Front-End (DOE00347894)
- Cbl, Micro->Intan (DOE00347895)
- Cbl, Battery->Power (Digi-Key: 102-1092-BL-00050)
- Cbl, Tens->Front-End (DOE00347896)
- Cbl, Electrode (Medical Conduit; AMA-5003-1701-FBM)
- Cbl, Block (DOE00347897)

Fasteners

- M2.5x12 screws, 16x
- 6/32x1/4 screws, 2x
- 6/32x1 screws, 8x

Other Parts List

- Anker 325 Power Bank (Amazon)
- TENS 7000 (Amazon)

1. Locate the mounting locations of each board in the remote enclosure shown in the image below.

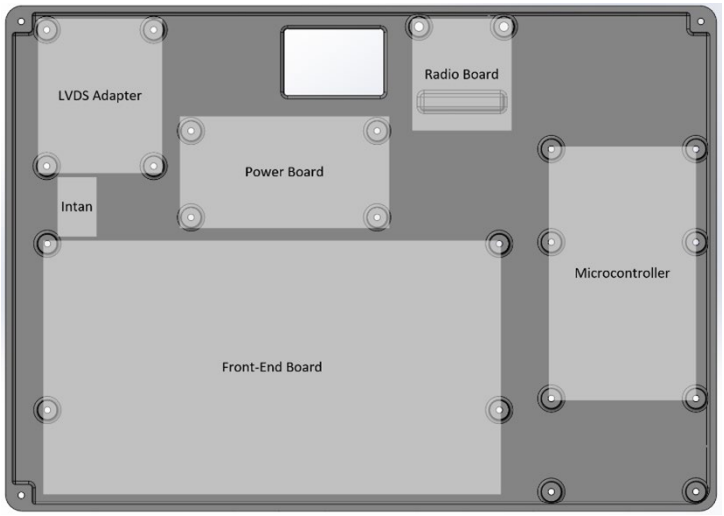

Figure 34: Mounting Locations

2. The following screws are used to attach the PCBs to the enclosure:
    a. Front-End Board: M2.5x12, 4x
    b. Power Board: M2.5x12, 4x
    c. Microcontroller: M2.5x12, 4x
    d. LVDS Adapter: M2.5x12, 4x
    e. Radio Board: 6/32x1/4 screws, 2x
3. The assembled main compartment of the host enclosure should resemble the image below.

Figure 35: Assembled Main Compartment

4. The following table should be used to connect the EZRadio board to the microcontroller.

RF Name	VDD	GND	SDN	GP1/2	NSEL	MOSI	MISO	SCLK	NIRQ	GPIO1 (CTS)	GPIO0	GPIO2
Cable color [WIP]	BLK	WHT	RED	-	GRY	PRPL	BLU	GRN	YLW	ORG	-	-
											-	
Eval Ext HDR (HDR# - Pin#)	2-20	2-19	2-7	-	*1-5*	2-14	2-13	*1-7*	2-10	2-4	-	-
Eval Name	VCC	GND	PC19	-	PA24	PA22	PA21	PA23	PC27	PB1	-	-

5. The TENS and battery holder mounts to the bottom of the main section of the enclosure using 4x 6/32x1 screws. The image below shows how batteries and TENS unit are mounted in the enclosure.

Figure 36: Battery and TENS Unit Holder

6. Power from the batteries is provided via a micro-USB cable that feeds through the hole in the main section of the enclosure as shown below.

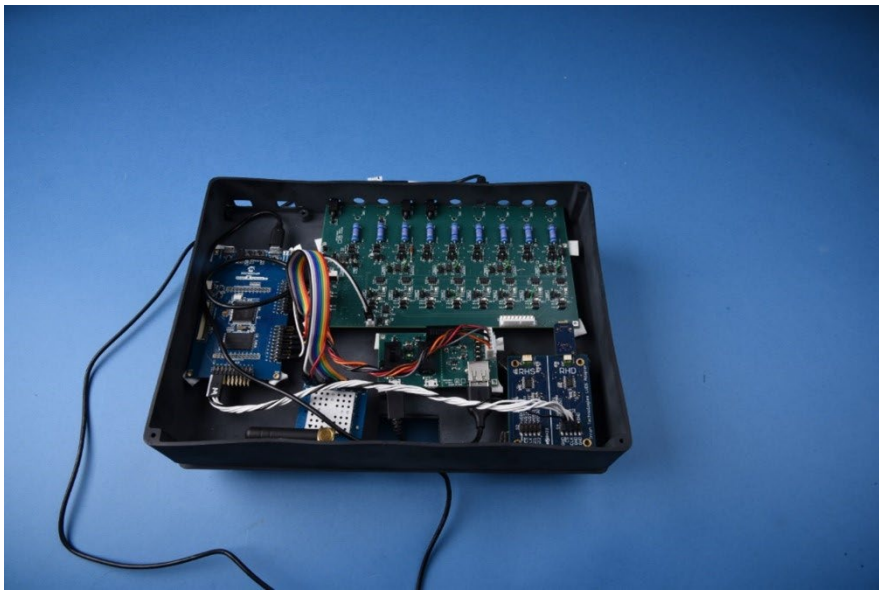

Figure 37: Micro-USB Cable through Hole in Enclosure

7. The top of the enclosure is attached using 4x 6/32x1 screws. The alignment of the opening should be above the microcontroller as shown below.

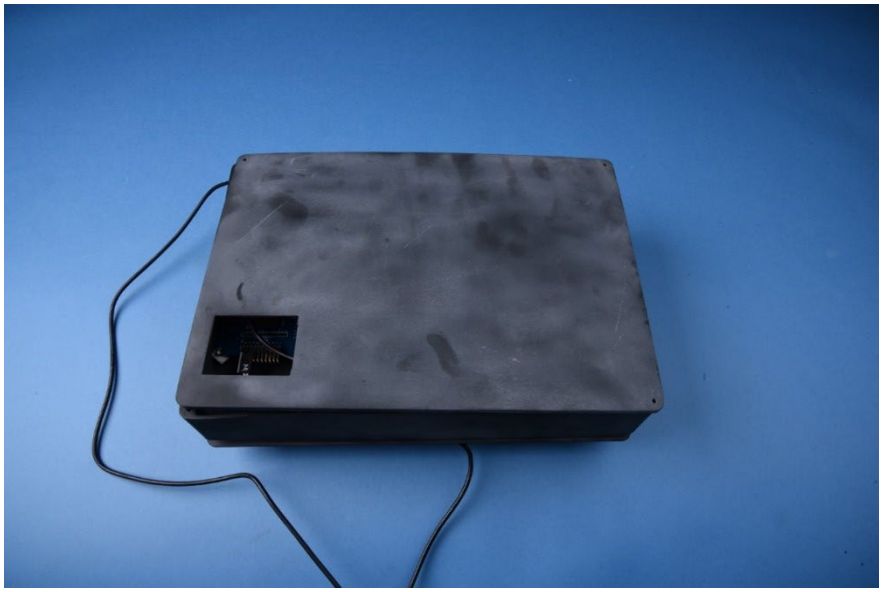

Figure 38: Top of Enclosure

8 Appendix C – Manual Reset

If the device becomes inoperable, the on-board, manual reset button may be used to restore device functionality. To access the reset button, remove the door on the enclosure lid. The reset button and lid on the remote unit are shown in the images below. The same lid and button may be found on the host.

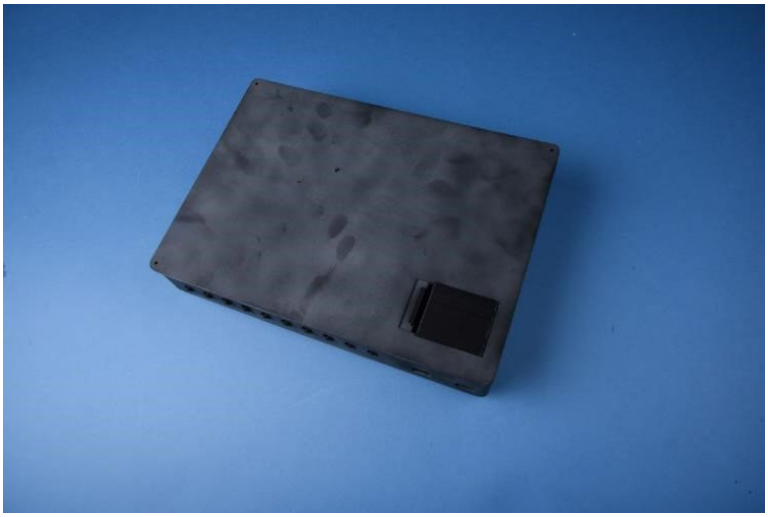

Figure 39: Enclosure Lid Door

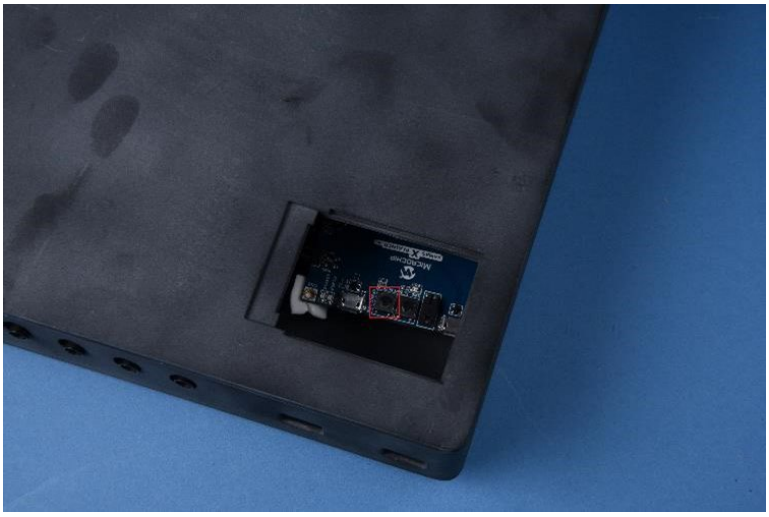

Figure 40: Reset Button