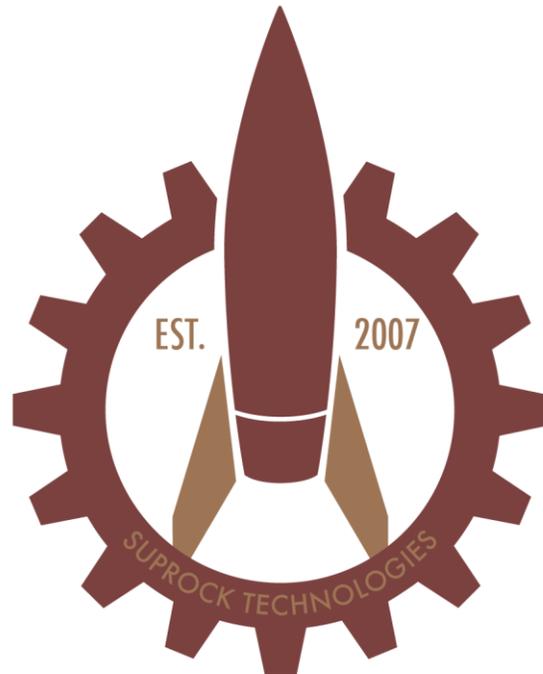


# SUPROCK TECHNOLOGIES MONDO USER MANUAL



Analytical Monitoring (MONDO) Software.



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## Introduction

A primary application of the analytical monitoring (MONDO) software is extracting and visualizing data that has been produced by the Acheron data acquisition (DAQ) software. The purpose of this program is to provide an end-user the ability to visualize, graph, and extract data for external analysis purposes. Several time and frequency analyses are supported in the MONDO software.

The core of the MONDO software is the ability to access the .apd format of packet data collected from Suprocktech Acheron devices. The MONDO software reads raw telemetry data and enables the user to prepare graphs for reporting purposes. Power Spectral Density (PSD) computations can be performed on the data with several options relating to the computation method, windowing, etc. that is applied. Spectrograms can also be generated by plotting PSD outputs on a time basis. Finally, time traces of the data can be generated. There is an export option, to publish comma separated variable (CSV) files. The CSV format can be useful for external data analysis, archiving, historian applications, etc.

Functional examples are provided with an emphasis on the TDMS application.

***This software is not for Commercial Sale and is provided without charge to support applicable hardware installations.*** No representations or warranties are made regarding the fitness of this software for a particular use. This software has been presented as-is. Specific application cases, including those under NRC jurisdiction, may include examination of the software code and libraries for cyber security compliance. On a case by case basis, Suprock Technologies will provide this information under NDA with the end-user to satisfy such requirements.

Parts of this software, related to Quad Telemetry module devices, was developed by Suprock Technologies under work with the Electric Power Research Institute (EPRI). Under agreement with EPRI, the distributable (compiled) software will be made available to commercial entities possessing an EPRI commercialization contract. These commercial entities may not resell, modify, or rebrand this software. The software may be used to support compatible telemetry hardware applications.

Suprock Technologies will remain responsible for versioning and releasing updates to this software and the Asphodel Protocol Library. Such updates may relate to new types of hardware or upgraded firmware releases for existing hardware.

## Software Installation

The analytical monitoring software must be installed on a suitable computer. Prior to installation, please ensure that the PC minimum specifications are as follows:

- 4 GB ram
- x86 processor
  - Dual core or better
  - Intel i5 or better
- 1024x768 screen resolution
- Minimum 64Gb storage

An example of an acceptable computer is the Microsoft Surface Pro. This is a compact computer capable of running the TDMS system.

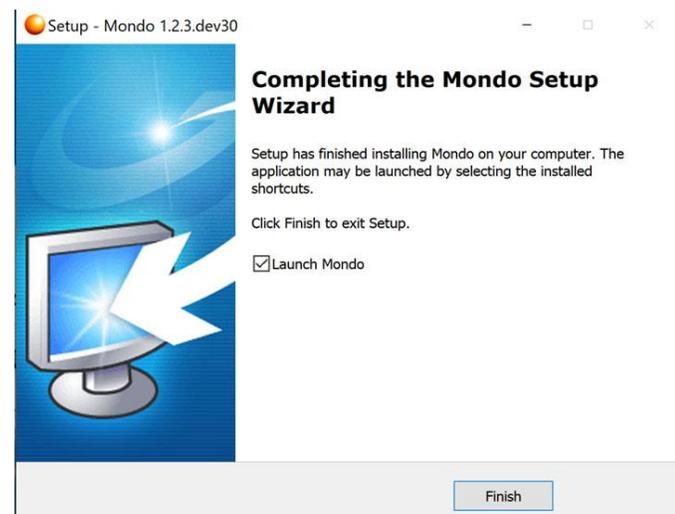
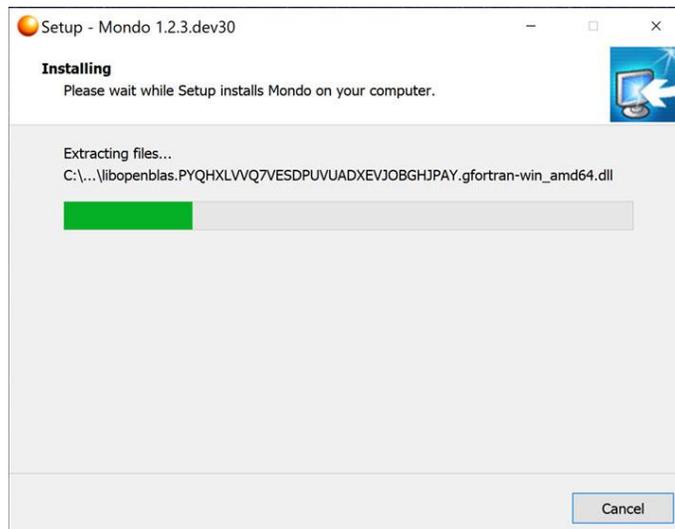
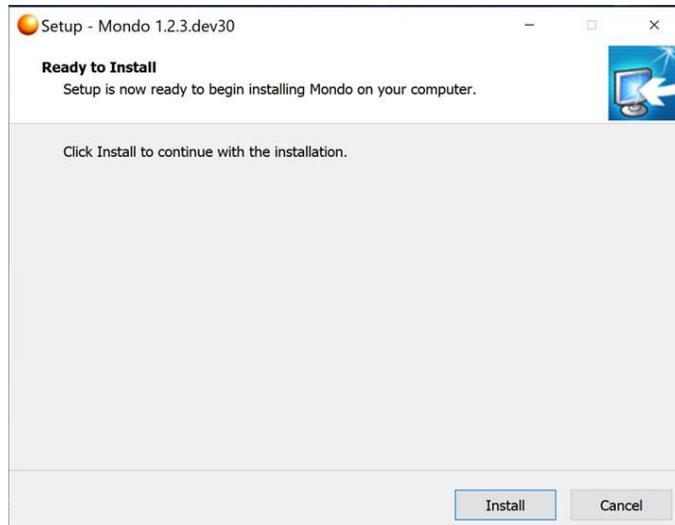
For installation in the field, touch screen monitors are preferred but not required for operation.

**To begin software installation, execute the provided installer package and follow the wizard. The software will automatically create and install to a “Mondo” folder located in \Program Files.**

**Click install to begin installation.**

**Next page will show bar with installation progress.**

**The installation is complete, if you would like Mondo to launch when you press finish, leave the box checked next to “Launch Mondo”**



## MONDO program functionality

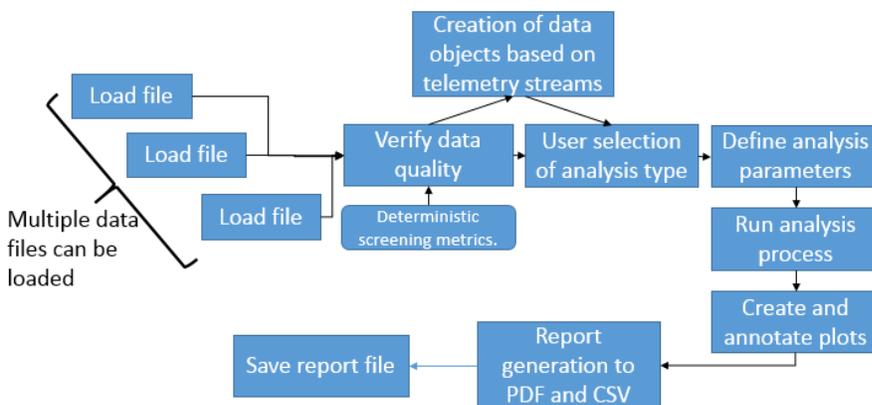
The MONDO program is structured to load data and unpack the data from APD files. This data can be exported (unpacked to CSV) or graphically visualized.

APD files are files are saved from the telemetry during data acquisition using packet protocol format from the Suprock Asphodel Protocol. This data is the raw data format from the telemetry modules and it is structured optimally for storage space on disk. The data is formatted and packed on the telemetry module before it is sent through the radio to the receiver hardware. The DAQ program has saved this data in the original format to disk. The default file size is up to 10m of data in time at which point a new file is started. Files can be concatenated and the transition between files is continuous.

The functional diagram of the MONDO software is a unidirectional flow where file(s) are chosen by the user for analysis. The MONDO program loads the data and screens the data for lost packets or other errors that could impact the data quality.

If a frequency analysis type is chosen, the user will be prompted to enter analysis parameters. Once these parameters are chosen the MONDO program will execute the analysis on the selected data and create outputs in the form of plots.

Plots generated by the MONDO program are navigable and can be saved to disk in a variety of output formats. These outputs are useful for reporting and sharing.



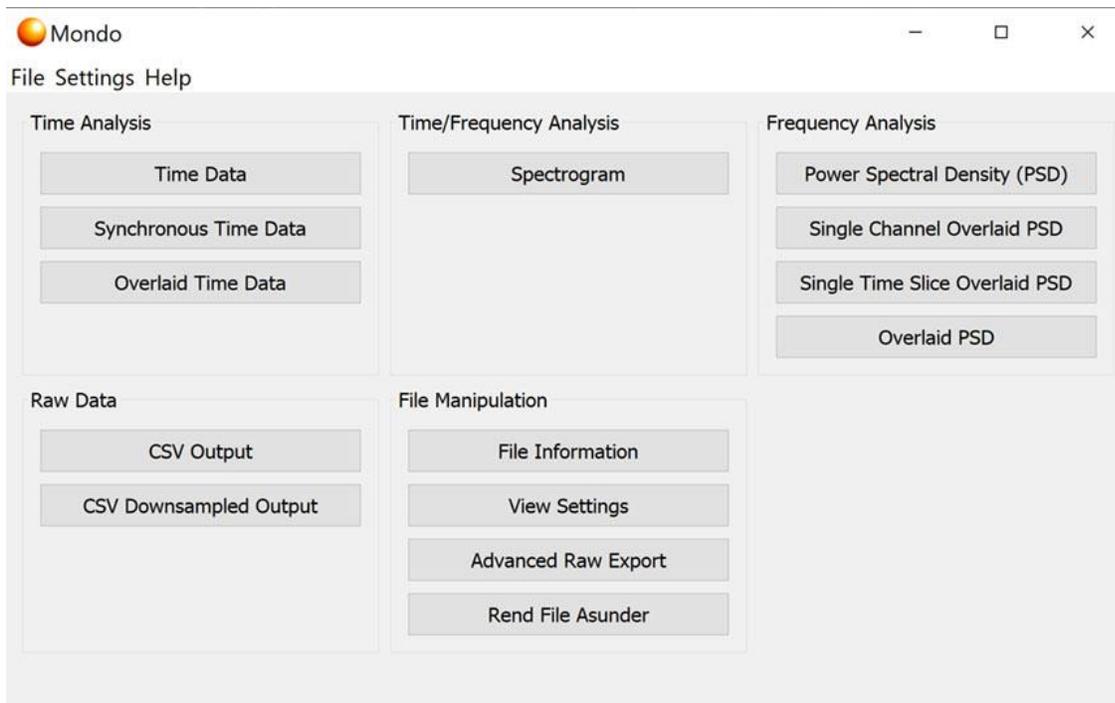
The MONDO program is modular and is designed for future expansion of the analysis types and options. The program has been architected in this way to accommodate future research and applications with various new types of dynamics data.

## MONDO Main Window

After starting the MONDO software you will be welcomed by the Main Window. This window is the base environment where the modules composing MONDO are accessed.

There are three categories of analysis available:

1. Time analysis – Plotting time data from a file for inspection. Synchronous time data is the ability to use a strobe on the TDMS hardware to time-align plots from different telemetry modules.
2. Time/Frequency analysis – The spectrogram function performs frequency analysis over windows that span a time base.
3. Frequency Analysis – Production of a Power Spectral Density plot that shows the frequencies present in the selected data. The Overlaid PSD function can plot various PSDs from different data files to compare the spectra between different sensors or time.
4. Raw Data – Outputs raw data to .csv, if there are too many datapoints for excel, or other non-scientific programs, data can be downsampled for export to csv. This format is portable into other analysis applications if a specific analysis or custom analysis is desired beyond the capability of the MONDO program.
5. File Manipulation – Has further options for file export such as JSON and packet, file information, and file/device settings.



## Basic GUI operations

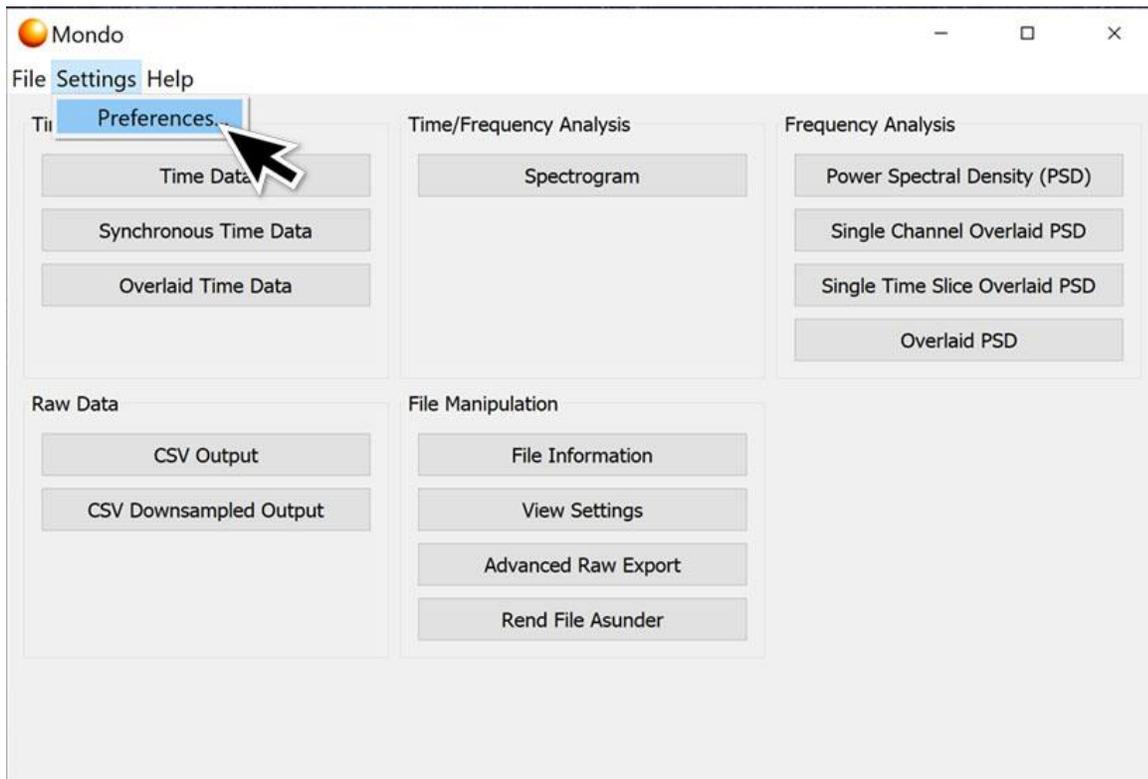
### File

Under the File menu there is an Exit option. This option executes a program exit and all windows (including any open plot windows) will be closed.

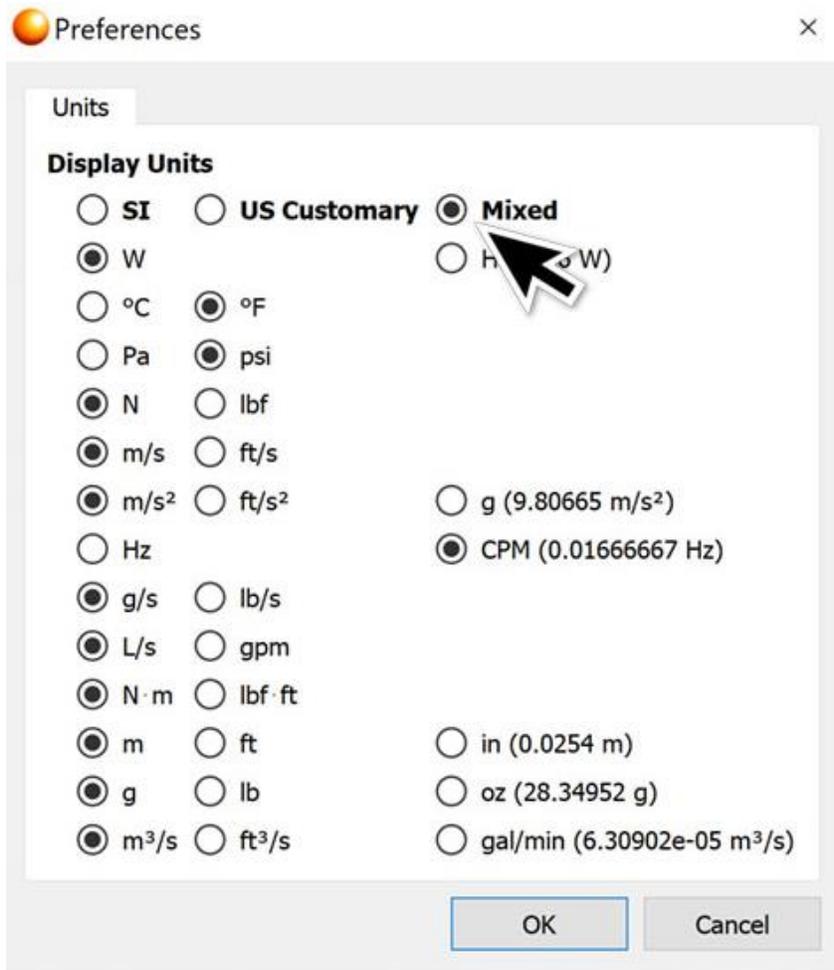
### Preferences (display units)

The default display units for Mondo are all in metric. Many of our customers in the US have requested an option for pressure to be displayed in PSI. Also, the signal from the tachometer is set to Hz by default where traditionally RPM is preferable. Procedure is as follows:

1. Click on Settings - Preferences



2. A dialog will pop up, at the top, one can choose metric units, US customary units for the English system, for mixed units click "mixed." "Mixed" allows the user to select their own customized mix of units, such as CPM in place of Hz in applications measuring RPM.

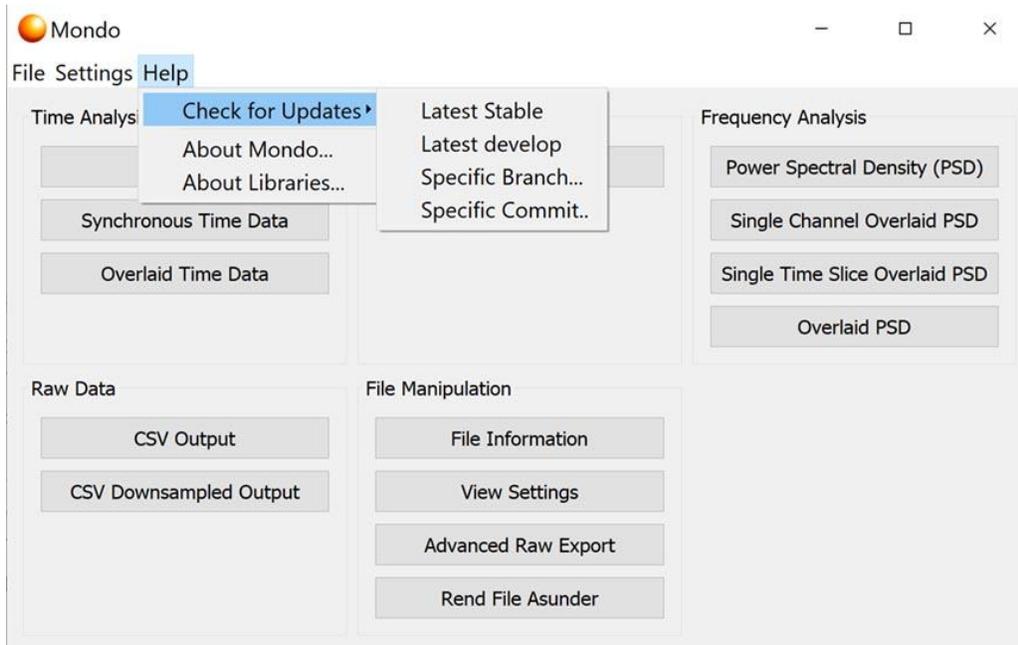


3. When desired units are chosen, press "OK" and files opened in MONDO will then be displayed in the requested units.

## Help

### [Check for updates](#)

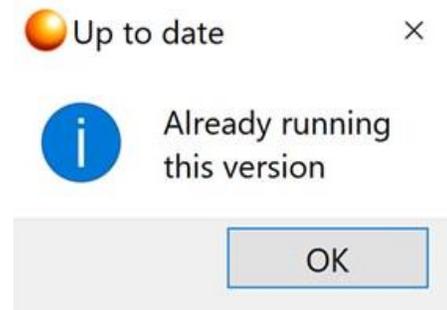
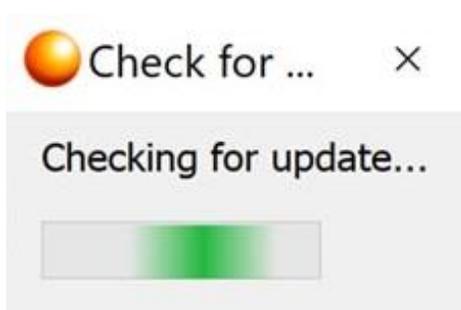
The check for updates option allows the user to download the latest version of the software from the program itself without going to the suprocktech.com website to download the latest version.



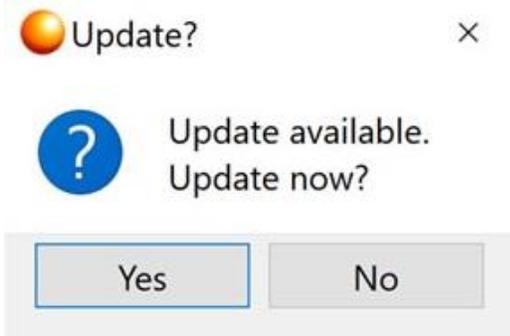
### [Latest stable](#)

This is the most commonly used function for updating the software, clicking this function will search our servers for the latest stable release of MONDO. Steps below:

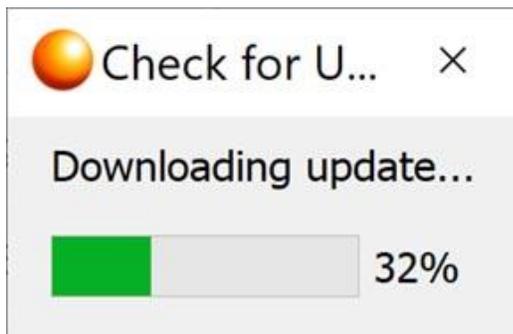
1. Click help -> Check for Updates -> Latest stable. MONDO will check for updates to itself. If the latest version is already installed, a dialog box will pop up and say "Up to date" Click ok to go back to MONDO activities. If the software is not up to date, proceed to step 2



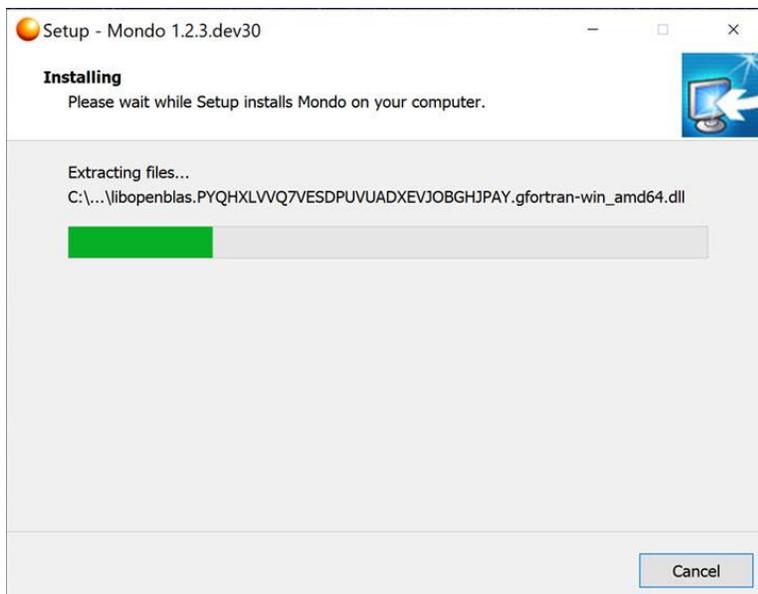
2. If there is an available update, the program will ask if you would like to update now. If so, click Yes. Clicking no will exit the update procedure and take one back to the main window.



3. A new progress bar will come up with download progress.



4. Once the download is complete, your new version of MONDO will install automatically.

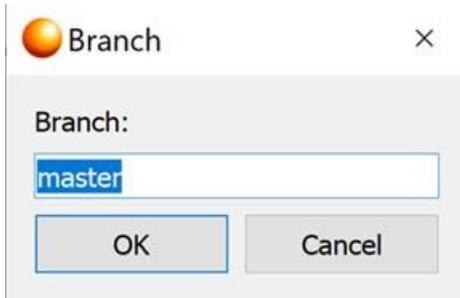


### Latest develop

The Latest develop option of updates searches for, downloads and installs the latest development version of MONDO to your computer. Once the process is started, the steps to execute this function are identical to “latest stable” above. **It is recommended that one does not run development software versions on critical equipment without first consulting Suprocktech.**

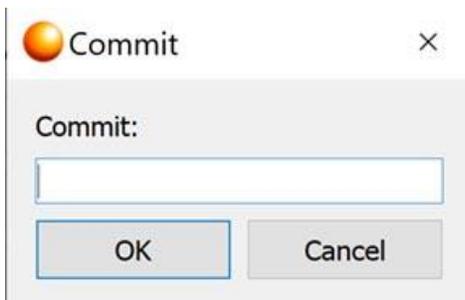
### Specific branch

This allows the user to select a version from a Specific branch of the repository. The default branch is “master” downloading from the master branch will result in the latest stable version. Writing in “develop” will result in the program searching for and downloading the latest development version. **It is recommended that one does not run development software versions on critical equipment without first consulting Suprocktech.**



### Commit

Commit allows the user to download a software version from a specific commit, this option is rarely used unless indicated by Suprocktech personnel.

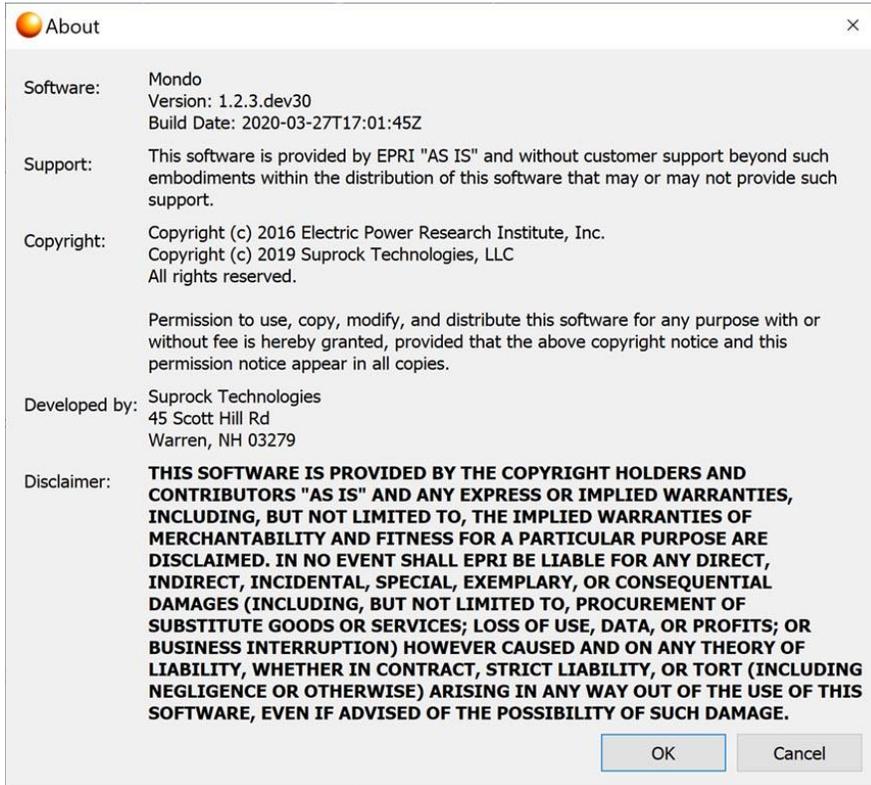


## About

The Help menu provides an About tab with information on the MONDO software and information related to EPRI license of the software.

## About MONDO

Shows build and disclaimer information about MONDO



## About Libraries

About libraries displays all of the library versions of the software.

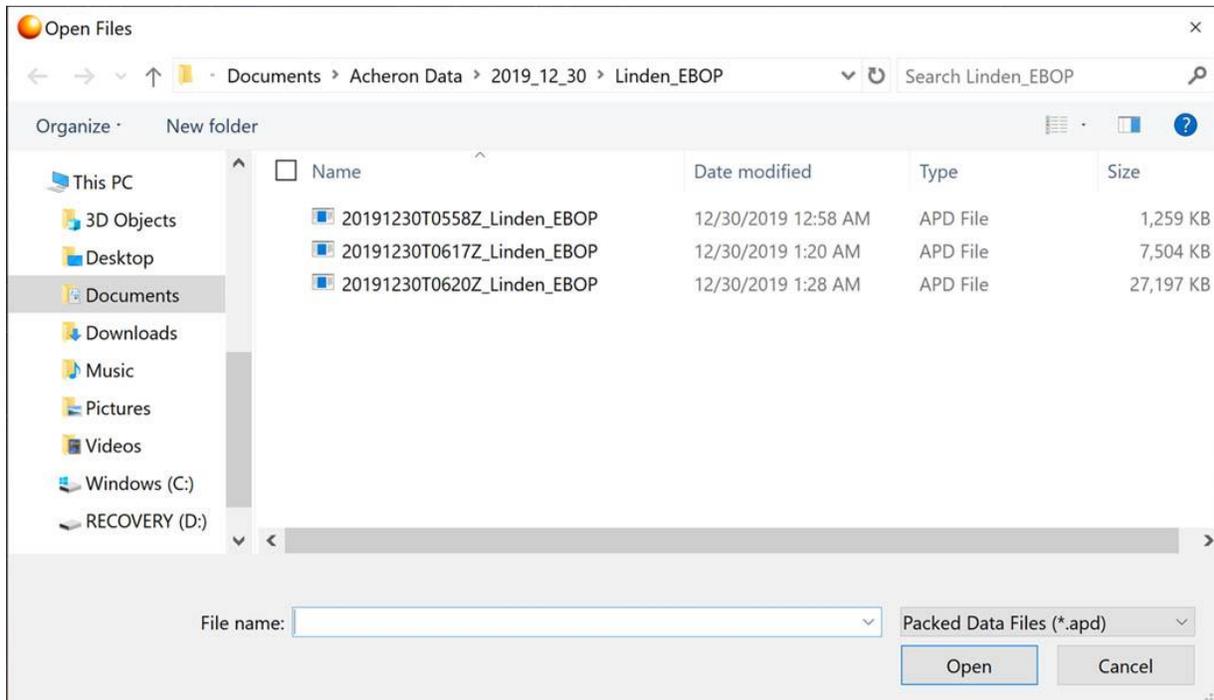


## Common operations

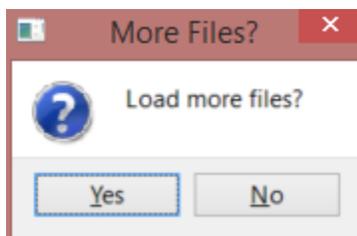
### Opening files

There are several basic operations common across analysis types. The first operation is a standard file navigation to load files of interest into the MONDO software. A user should choose a file from this menu to begin the analysis, plot, or export process. The default location for saved files from the ACHERON data collection program is X:/Users/**Username**/Documents/Acheron Data

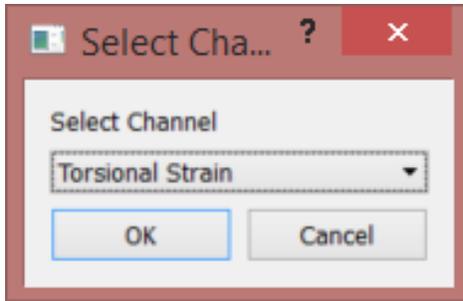
1. Clicking on any of the modules in the MONDO program will result in a dialog asking you to choose a data file. Files created by the ACHERON DAQ are in \*.apd format.



2. Once a file has been selected the MONDO program will prompt a user to select additional files if the user desires to concatenate multiple files for a longer analysis period.



3. Once the user confirms or rejects adding additional files, a drop-down menu appears and prompts the user to select what type of channel from the data is going to be analyzed.



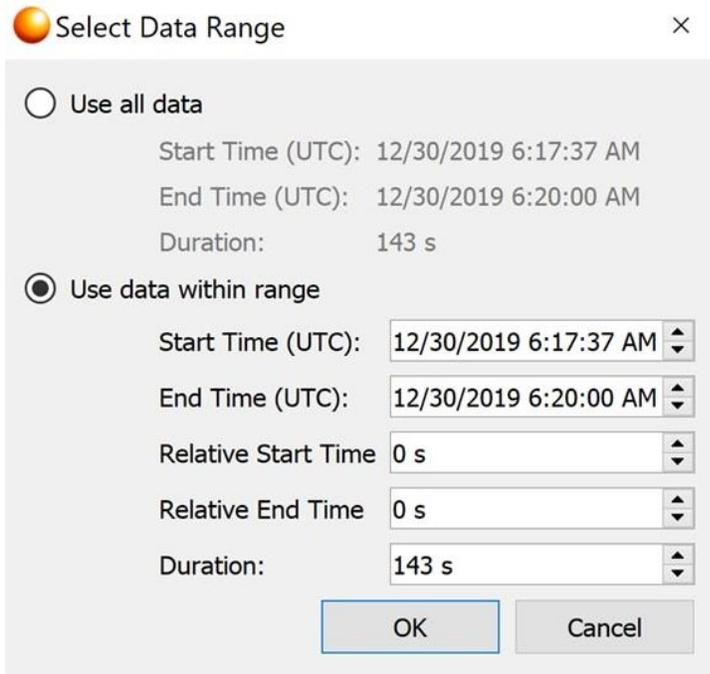
Examples:

- **Torsional Strain** – The strain channel representing torsional surface strain on the shaft. This channel represents one of the two primary variables for torsional vibration monitoring.
- **Lateral Strain** – This channel represents bending and axial shaft surface strain.
- **Radial Acceleration** – This channel is the radial acceleration in the reference frame of the telemetry. This should not be confused with XY radial acceleration in the stationary reference frame.
- **Tangential Acceleration** – The channel representing torsional dynamic motion on the shaft surface. This is the second primary variable representing torsional vibration on the shaft.
- **Light** – This channel is a sensor that is detecting ambient light in the environment. The sensor can also detect strobe. This is useful for specific applications involving strobe or phasors.
- **RF Power Voltage** – The measurement of internal voltage rail related to power rectification on the radio.
- **RF Power Current** – The measurement of internal current being consumed by the circuit.
- **Temperature** – The temperature at the telemetry location on the shaft.
- **Tachometer** – Detecting a phasor pulse and computing the time between pulses.
- **Phase Timer** – Counting the time elapsed between phasing pulses (useful for time aligning multiple modules)
- **Voltage** – Voltage

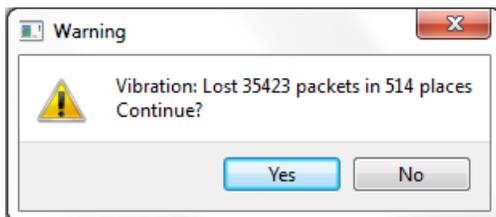
4. Once the user has chosen the channel, the data will be parsed by the MONDO program. This is an important step in extracting the asphodel packet formats and screening for gaps or missing packets that could affect the analysis routines.



5. Once the data is loaded, the user will be prompted to select a time range within the data. This can be useful when an event is known to exist a specific range in time. You will have the option loading all of the data during the collection period or select a specific time range. There are two ways of choosing a data range:
  - a. UTC: if the time the event happened is known, a start time and end time can be filled in.
  - b. Relative time: relative time lets the user select a time within the data relative to the beginning of the file.



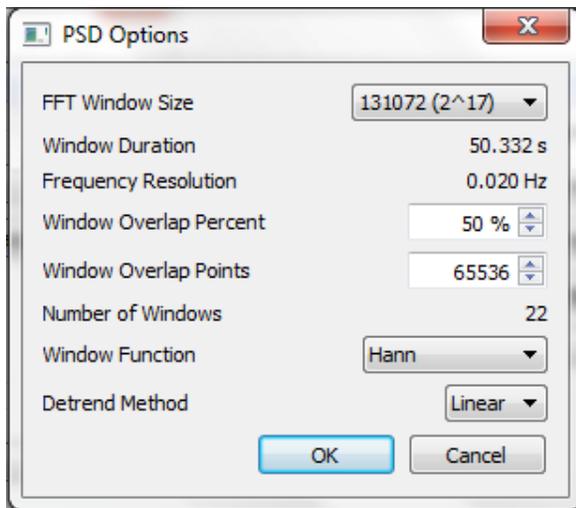
6. If any packets have been lost during data recording, the program will display a warning. If this is acceptable click yes. If not, select another file.



7. If "Yes" was clicked or the file is fully intact with no lost packets, the program will then take you to the "PSD Options" or, if you are on Time Domain, straight on to the data.

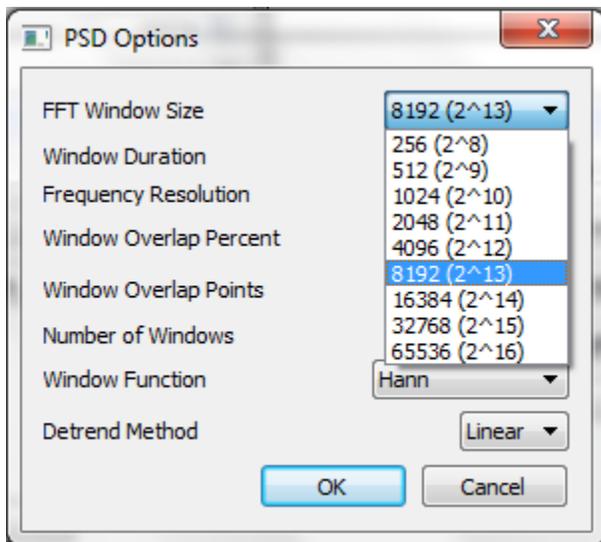
## PSD Options

When opening a file in Frequency domain (PSD) or time/frequency domain, the program will pull up a dialog with options that govern the display of the data.



Under the PSD options window one can select desired FFT parameters. The program will automatically calculate optimal FFT window size based on sample rate and length of file, however, if the user wishes to make a compromise for greater frequency or time resolution, it can be done through manipulation of these options:

FFT Window size:



FFT window size is measured in samples. Clicking on FFT window size will yield a dropdown that lets the user select various options for window size. If the window increases in length then you have fewer windows spread across the duration of your file and therefore a greater time interval between each - i.e. lower temporal resolution. Decreasing window size yields an increase in time resolution, with a corresponding decrease in frequency resolution.

### Window Duration

Calculated duration of each window based on chosen parameters.

### Frequency Resolution

Calculated frequency resolution based on chosen parameters.

### Window overlap percent and Window overlap points

Window overlap can be manipulated for greater time resolution in a given window size. Making changes to Overlap percent will have an effect on window overlap points and vice versa. Note: Increasing window overlap results in longer processing times.

### Number of windows:

Calculated number of windows to be displayed based on chosen parameters and file length.

### Window function:

Choose the desired window function based on type of input data. The different types of functions have their advantages and disadvantages.

#### *Hann*

Hann windowing tends to be good for bringing out relevant information in datasets that exhibit non-periodic stochastic behaviour. Use Hann when you have random narrowband signal, sine waves or combinations of sine waves, vibration data, or as a starting point when content is unknown.

#### *Hamming*

Side lobe reduction action of Hamming functions make it helpful for picking out peaks in closely spaced sine type frequencies.

#### *Flat Top*

Flat top functions are generally used when amplitude accuracy is important.

#### *Uniform*

Great for random broadband signals and picking up two nearby frequencies with similar amplitudes.

### Detrend Method

Choose between linear method, mean method or no detrending at all.

## Modules

The modules in the main window correspond to the different ways to open and display files for time, time/frequency, and frequency analysis.

### Time Data

Opening a file using the time data module will open and display your data in the time domain. You will see how your data changes over time. Getting started opening files in time domain is a straightforward procedure, following the steps in [Opening files](#).

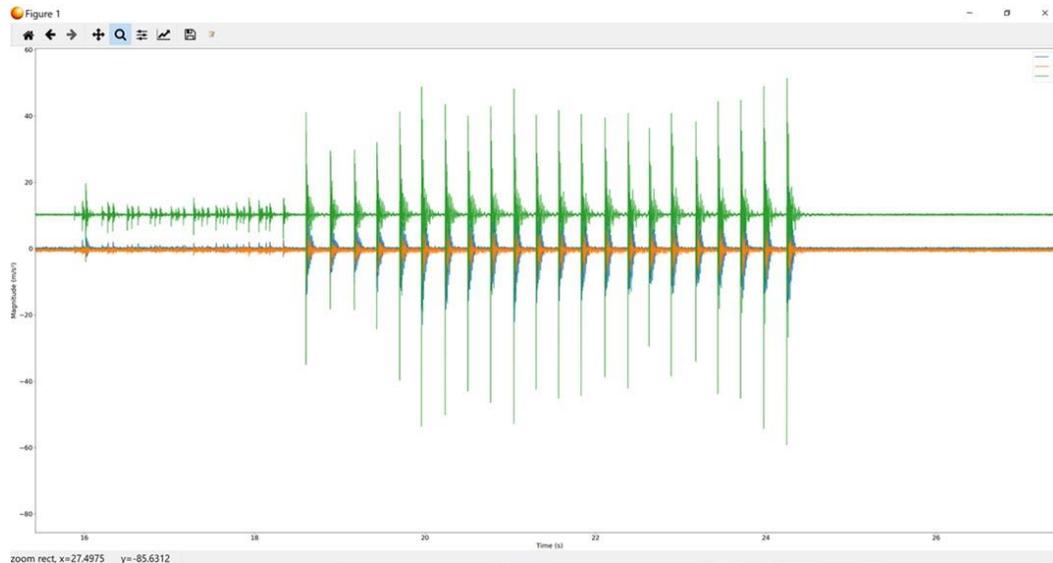
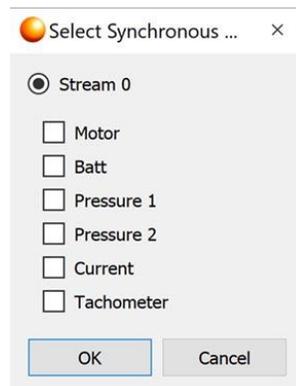


Figure 1 Sample data in the time domain

### Synchronous time data

Synchronous time data is for concurrent display of data from two or more different channels or devices. If the unit on different channels you wish to view is the same, the data will be overlaid with color coded lines. If the data is in two or more different units, the data will display separately in its own window.

When using this feature, follow steps described in [Opening files](#). When loading from a multi-channel device, the software will ask which channels you would like to display in MONDO. Select the channels you wish to see and continue opening as usual.



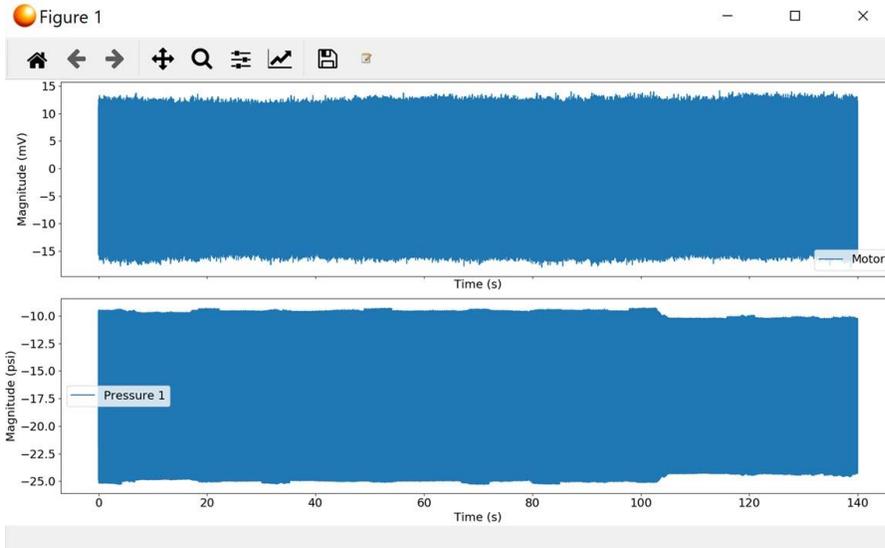


Figure 2 Example synchronous time data

### Overlaid Time Data

Overlaid time data is similar to synchronous time data but the difference is the files/channels displayed do not necessarily have to start/come from the same time or even the same file. This is useful for comparing behavior of different machines or even different runs on the same machine.

Opening Overlaid Time Data follows the usual steps to open files in MONDO described in [Opening files](#), however opening data channels from different files is done in batches:

1. After one or more channels are open for a given file in the usual manner, the program will ask the user to name the batch:



2. After naming the batch, the program will ask if one would like to load more batches:



3. After loading however many files/channels are desired for batch 2, the program will ask the user to name batch 2:



4. The user may continue in this manner until all desired batches are loaded. To stop adding files and display data, click “no” when the program asks to load more batches.

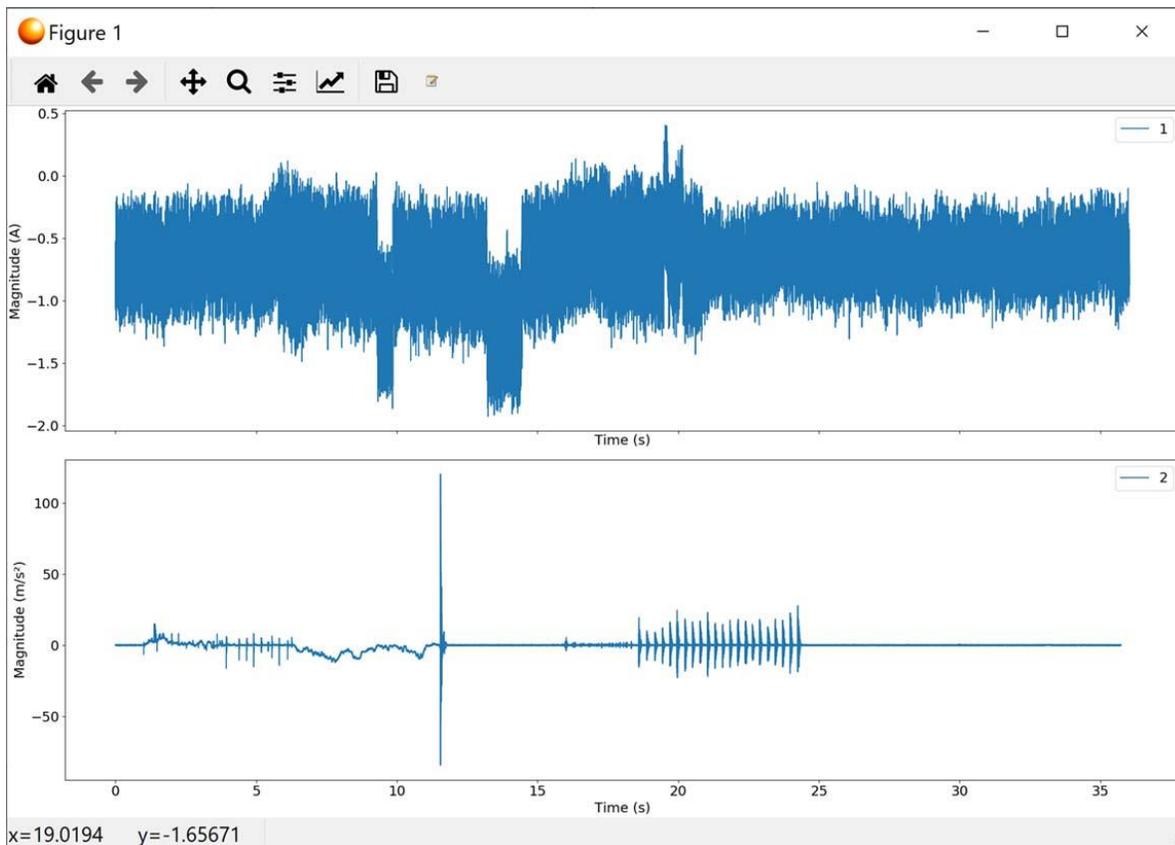


Figure 3 Example overlaid time data: two batches from completely different files.

## Spectrogram

The spectrogram function performs frequency analysis over windows that span a time base. It is useful for seeing frequencies shift over a given period of time.

The procedure for opening files in spectrogram mode is described in [Opening files](#).

### Identifying non-linear frequencies related to foundation cracks.

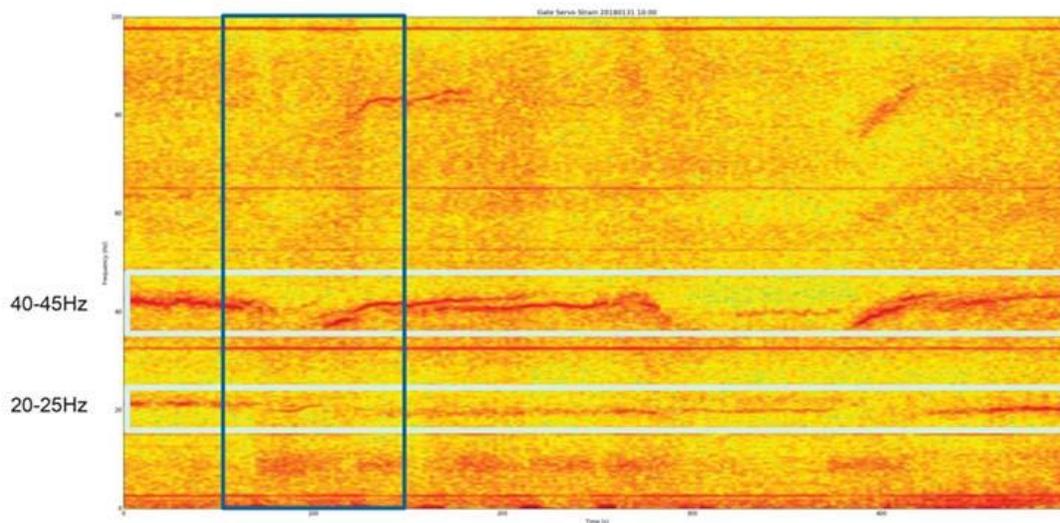


Figure 4 Example spectrogram: the darker red represents more energy density at a given frequency and how it changes over time

## Power Spectral Density (PSD)

A Power Spectral Density plot is a visualization device for frequency analysis that shows the amplitude (power) of a signal as a function of frequency.

Opening files in this mode follows the standard [Opening files](#) sequence. Opening files in the frequency domain also brings up the PSD options dialog, to review what these options do, refer to the [PSD Options](#) section of this manual.

### Single Channel Overlaid PSD

The single channel overlaid feature allows the user to overlay a channel over multiple time slices. Please be advised it is only possible to overlay data that was recorded at the same sampling rate.

Opening Single Channel Overlaid files follows the usual [Opening files](#) sequence. The software will prompt the user to open the datasets in batches.

1. After one or more channels are open for a given file in the usual manner, the program will ask the user to name the batch:



2. After naming the batch, the program will ask if one would like to load more batches:



3. After loading however many files/channels are desired for batch 2, the program will ask the user to name batch 2:

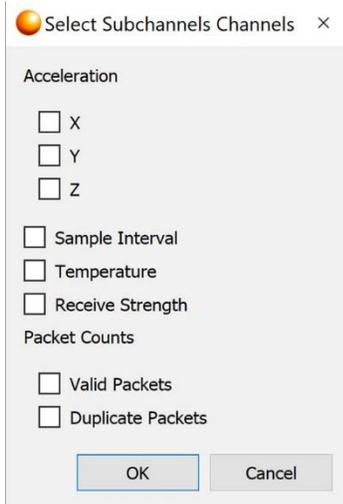


4. The user may continue in this manner until all desired batches are loaded. To stop adding files and display data, click "no" when the program asks to load more batches.

### Single Time Slice Overlaid PSD

Single Time Slice Overlaid PSD lets the user create an overlaid plot of different channels over the same time slice. Opening data using this module is the same as [Opening files](#) but with one extra step:

Once a dataset is loaded, the software will list all of the subchannels contained therein. Click on the check boxes corresponding to the channels you wish to plot and click ok.



Once the plot is loaded, it will look something like this:

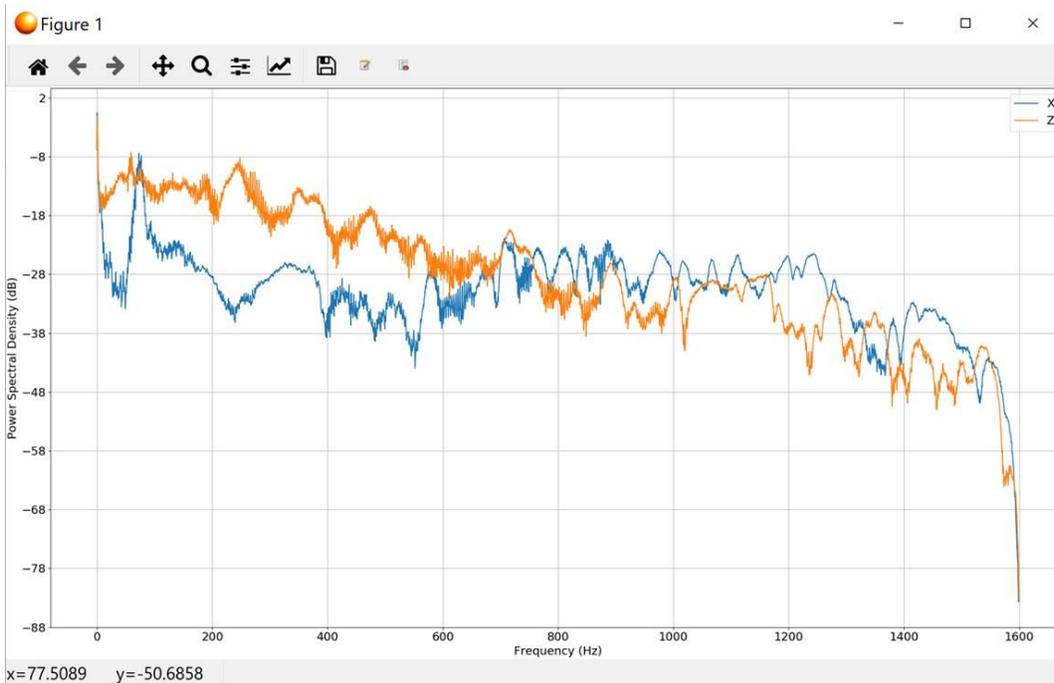


Figure 5 Example of single overlaid time slice PSD

In this example, accelerometer data of differing axes is plotted on a single graph. One can see which frequencies correspond to certain energy levels depending on the axis being measured.

### Overlaid PSD

Overlaid PSD is for the user to overlay data from any time slice or channel with wild abandon. It is useful for comparing diverse data from different instances or more easily overlaying data for reporting purposes.

Similar to time overlaid and PSD overlaid, the different files are loaded in batches.

1. After one or more channels are open for a given file in the usual manner, the program will ask the user to name the batch:



2. After naming the batch, the program will ask if one would like to load more batches:



3. After loading however many files/channels are desired for batch 2, the program will ask the user to name batch 2:



4. The user may continue in this manner until all desired batches are loaded. To stop adding files and display data, click "no" when the program asks to load more batches.

Below is an example of overlaid PSD, one dataset is accelerometer data, the other is amperage from an electric motor.

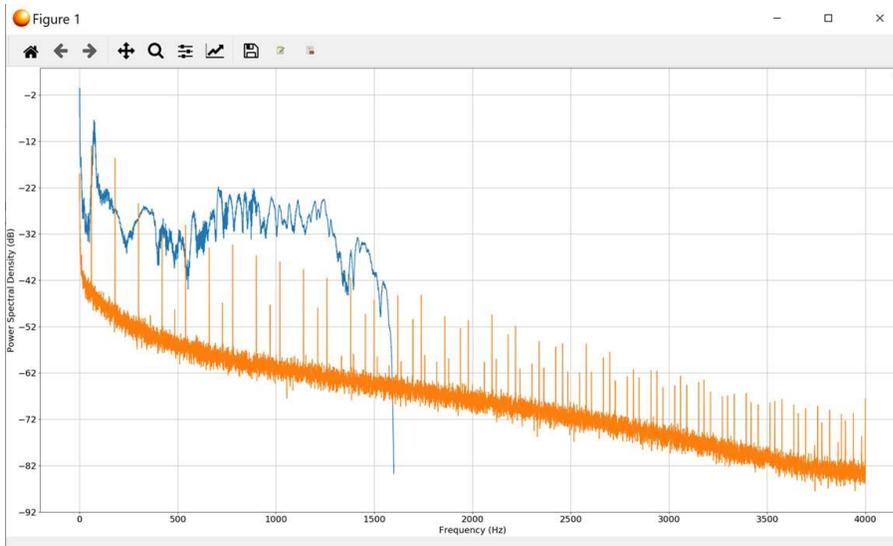


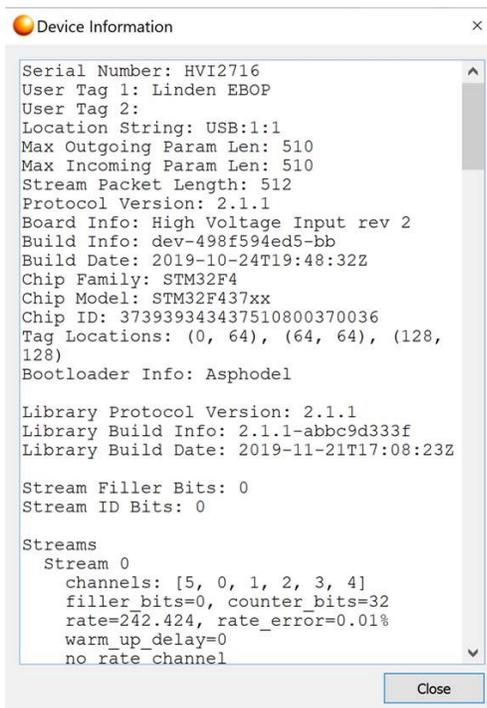
Figure 6 Example of overlaid PSD, with completely unrelated datasets

## File Manipulation

The file manipulation section of MONDO is for viewing file information, the settings of the device that created the data, breaking files apart, and exporting to different formats.

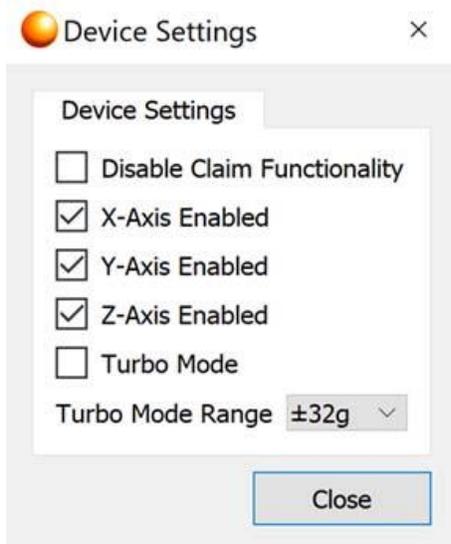
## File Information

The file information function is for extracting information from asphodel .apd data files. Opening a file in this mode pops up a dialog with information about the file, its protocol, and the device it was created by.



## View Settings

Choosing a file after clicking “view settings” will generate a dialog box that displays the settings of the device used to capture said file. The dialog box will be different depending on the device that used to write the file, i.e. accelerometer vs an analog input device, etc.



## Advanced Raw Export

Advanced raw export is a tool for exporting files in either JSON or .packet file types. This feature is rarely used except for support or debugging if necessary, under guidance from Suprock.

### JSON

Pulls the telemetry configuration from a data file which amounts to the NVM settings and channel information.

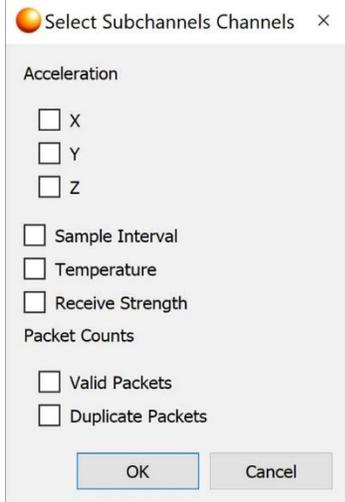
### Packet

Packet is packet binary configuration also reserved for support or debugging if necessary

## Rend File Asunder

This feature is used to break up files in to 2 or more files across user defined set points.

1. Clicking “Rend File Asunder” will bring up a dialog box to select a data file.
2. Choose the file you choose to chop, then click “open”
3. If the file has more than one channel, the user will be asked to select which channels will be included in the resultant files. Choose desired channels, and click ok.



4. The file will open, the top of the plot will show the keyboard/mouse shortcuts for selecting set points for the big chop.
  - a. Left click: Creates a split point
  - b. Middle Click/Backspace: Undo/deletes latest split point
  - c. Right click/enter: Done

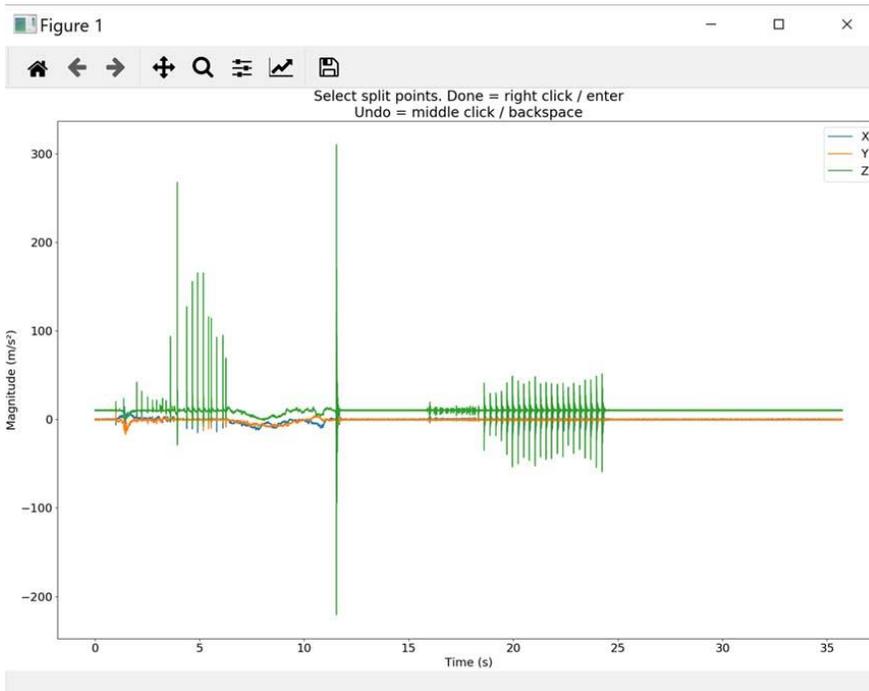


Figure 7 The data

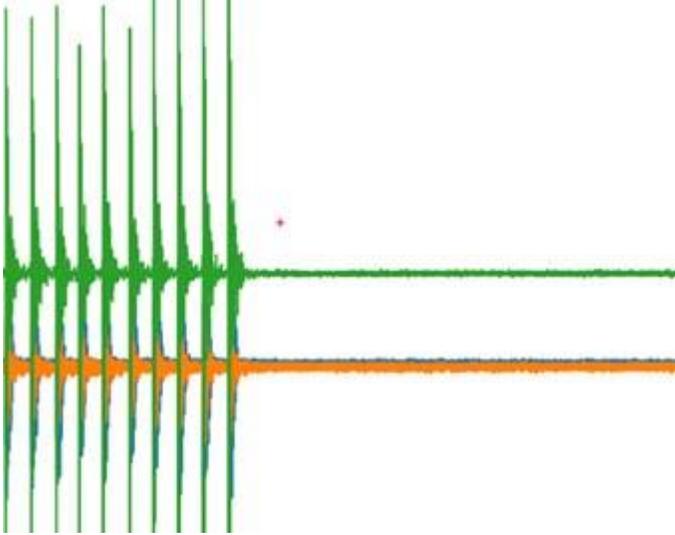
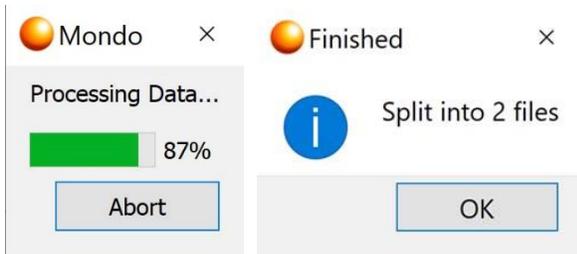
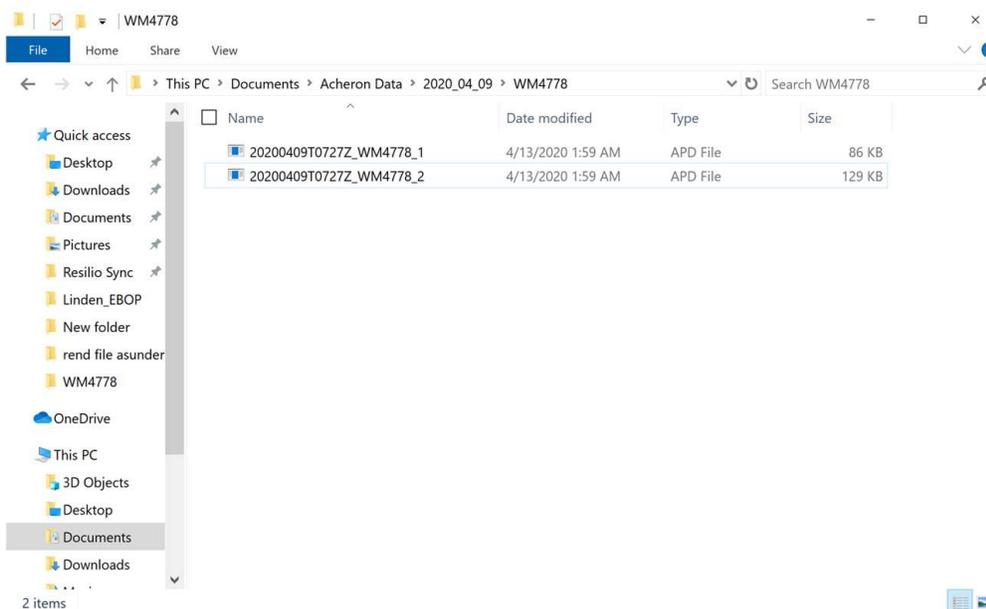


Figure 8 The split points appear as small red crosshairs

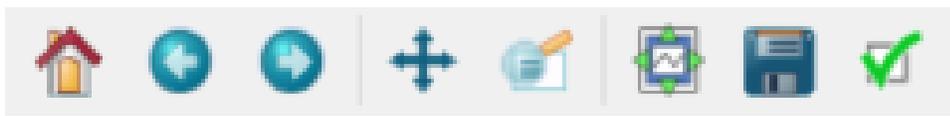
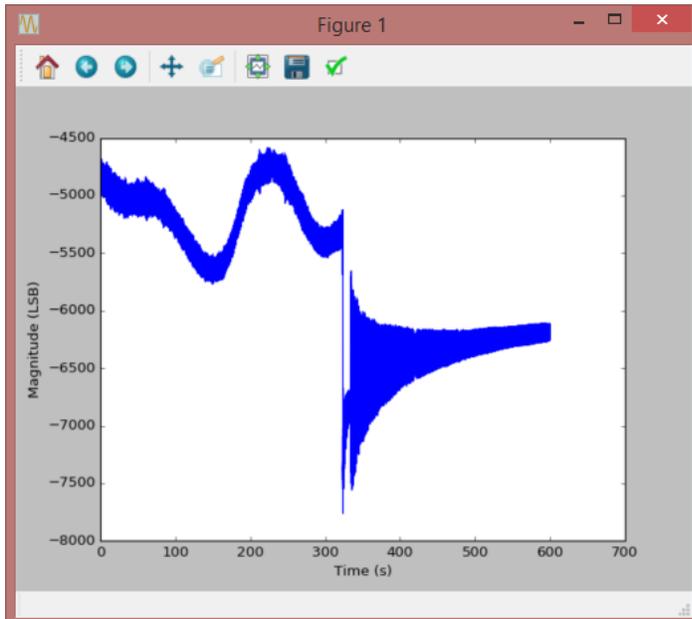
- Once the split point(s) are selected, pressing enter or right click will instruct the program to rend the file asunder. The file will process and the user is notified when the process is complete.



- The file fragments are now saved in their original locations, renamed with numbers in chronological order. Behold! Thine file hast been cleft in twain.



## Plot Navigation



The plot navigation window has a simple row of icons similar to what one would see in a document or image viewing program:

### Home Button



The home button takes the plot back the default scale and view when it was first loaded.

### Back and Forward Buttons



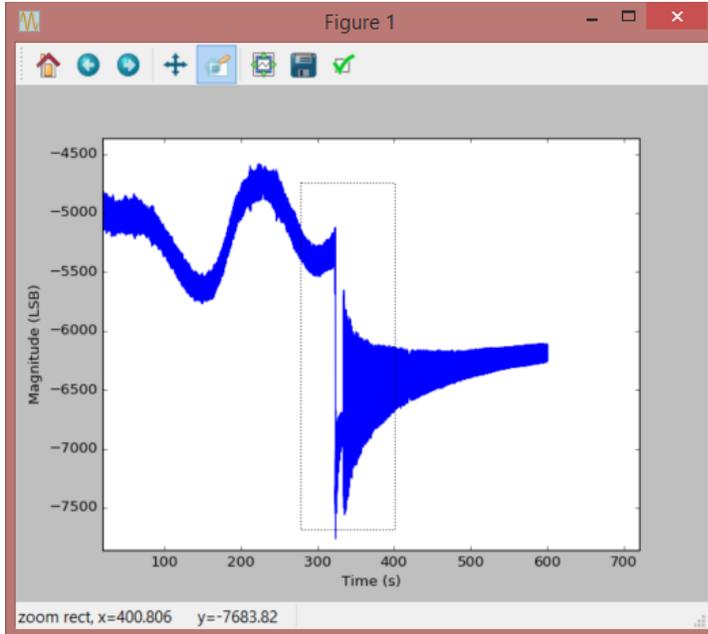
The back and forward buttons work just the way they do on a web browser. Back to the previous, or forward to the next view.

### Pan Button

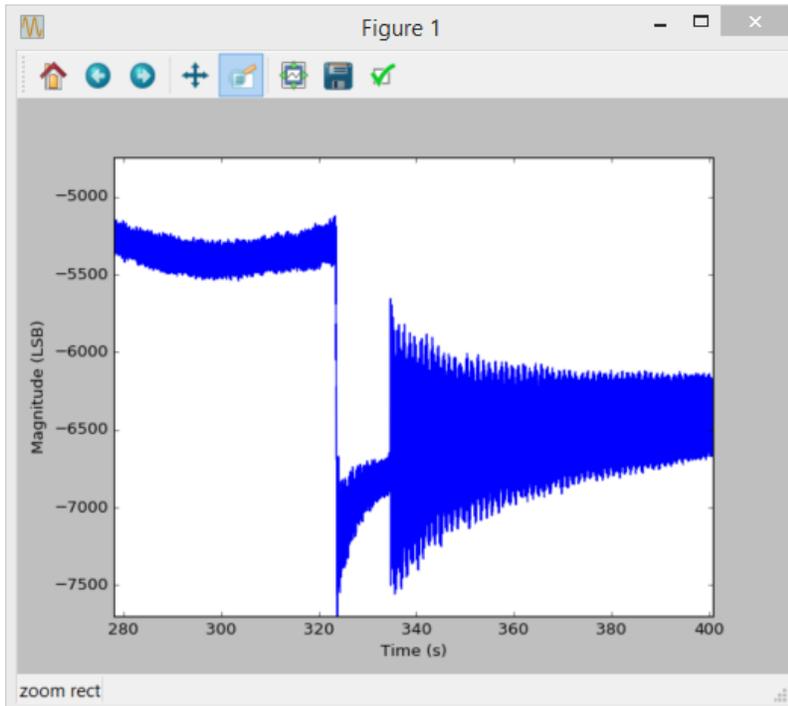


Clicking on the pan button enables panning of the plot through click and drag functionality. Clicking and dragging with the left mouse button pans the axes. This allows moving certain points through the visible area when zoomed in, for example. Clicking and dragging with the right mouse button affects axis zoom.

### Zoom Button



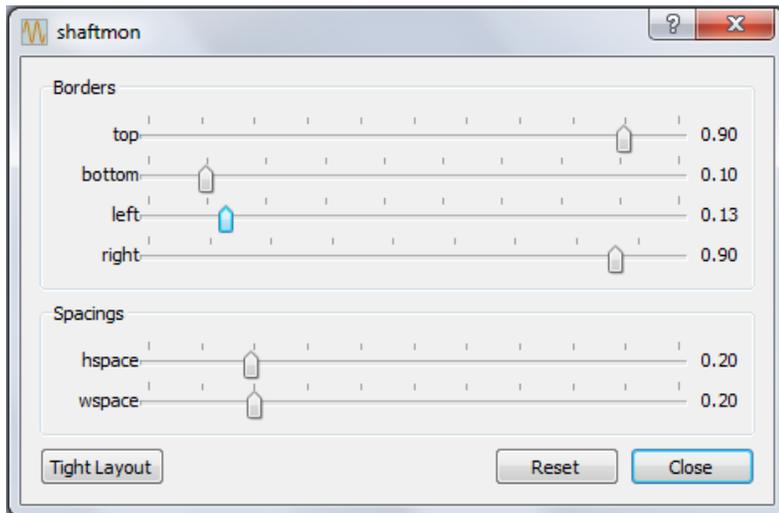
Clicking on the zoom tool allows the user to use click and drag functionality to draw a rectangle wherever the user wishes the visible area to be. Any mistakes here can be cleared using the back or home buttons.



## Configure subplots



Clicking the configure subplots button brings up a popup window that allows the manipulation of viewable area whenever there are two or more plots in the same window. I.e. when using the sync time data function.



The configure subplot window contains a series of sliders that adjust the user's view.

**Borders** sliders adjust the indent and borders of all plots in the viewable area.

**Spacings** sliders adjust the spacing between plots whenever there is more than one plot in a single window.

**Tight layout** makes the borders as small as possible while still maintaining full view of axes and scale.

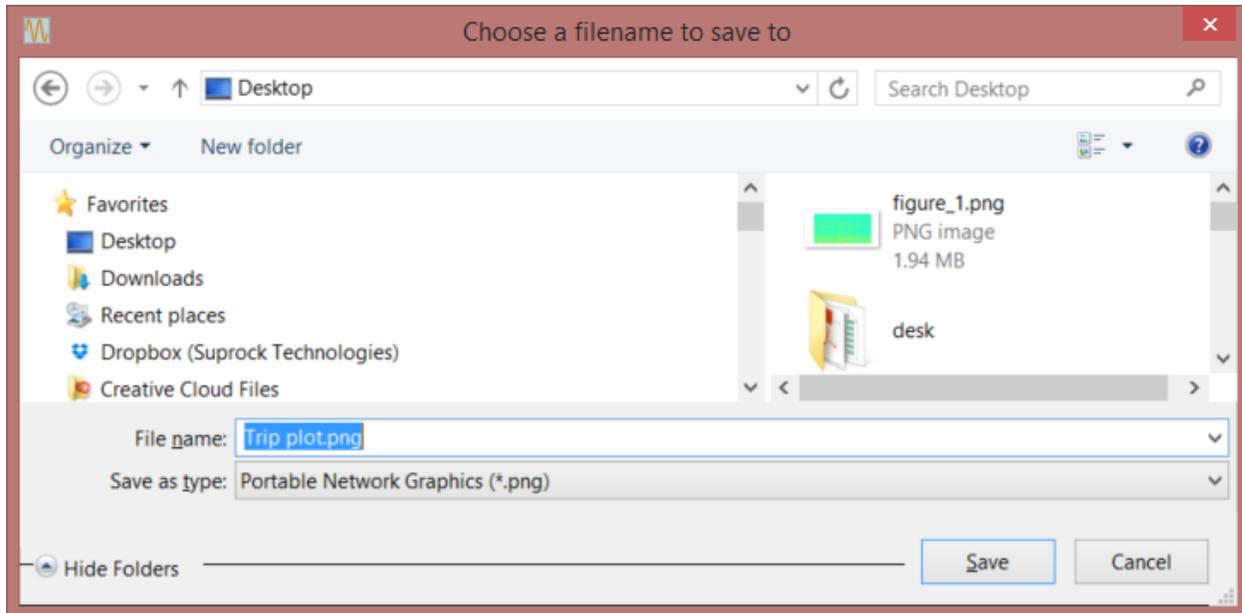
**Reset** Brings the view back to default for that particular window size.

**Close** Maintains subplot view settings, closes adjustment window, and returns to the fun.

## Saving plots



Clicking on the save icon brings up a dialog window with save settings.

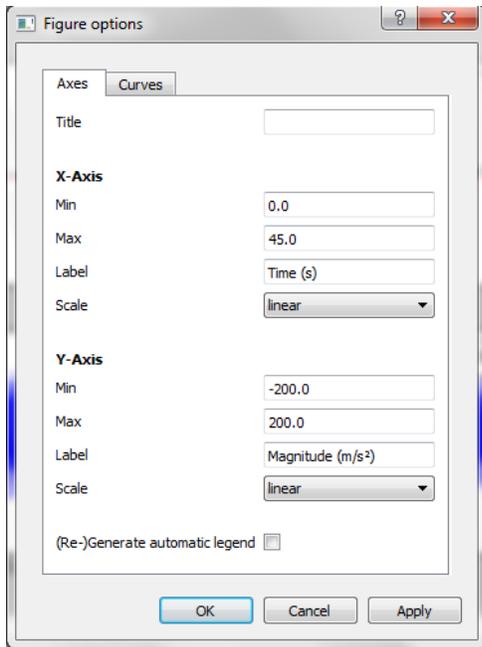


The user's selected view can be saved in a variety of image, vector and document formats. Just choose desired save location, name your file, and choose optimal format.

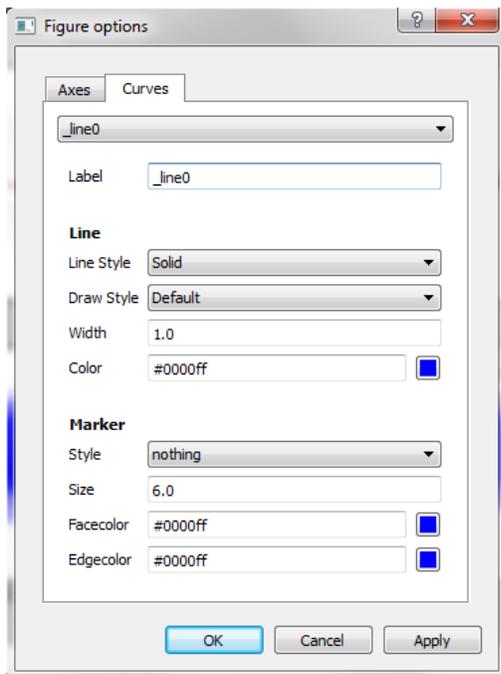
## Figure options



The figure options button brings up a dialog that allows the user to set parameters for the axes and the lines.



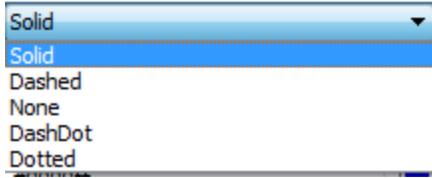
Axes options allows the user to set a title for the plot, set min and max values for plotted data, rename the axes, and set whether the scale will be shown in linear or logarithmic terms.



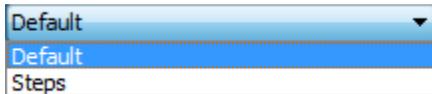
Curves tab opens the possibility of changing the way plot lines and curves are displayed. In plots with overlaid data the drop down menu at the top is used to choose which line is being configured.

Label is for changing line label for keeping track of specific lines.

Line Style drop menu for choosing what style of line is desired

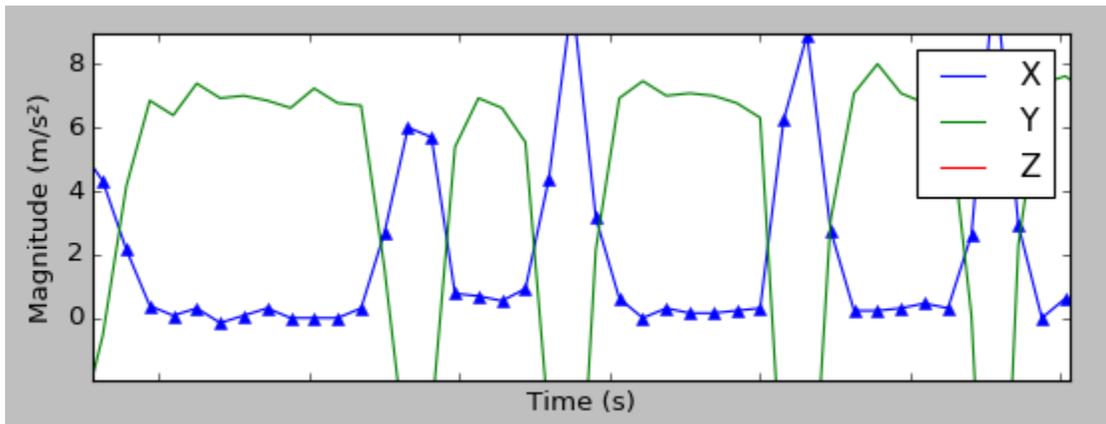


**Draw Style** drop down determines whether the lines are drawn in the default curve style or stepped from data point to data point.



**Color** Sets line color for selected line.

**Markers** The marker section allows the user to set different types of display markers for relevant data points.



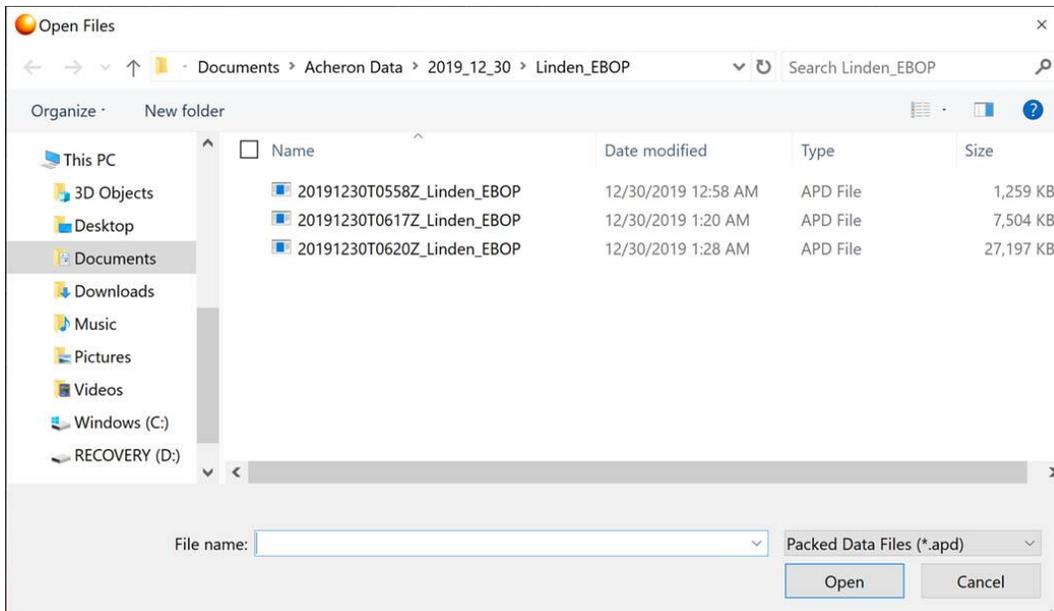
*Sample acceleration data with markers*

## Raw Data

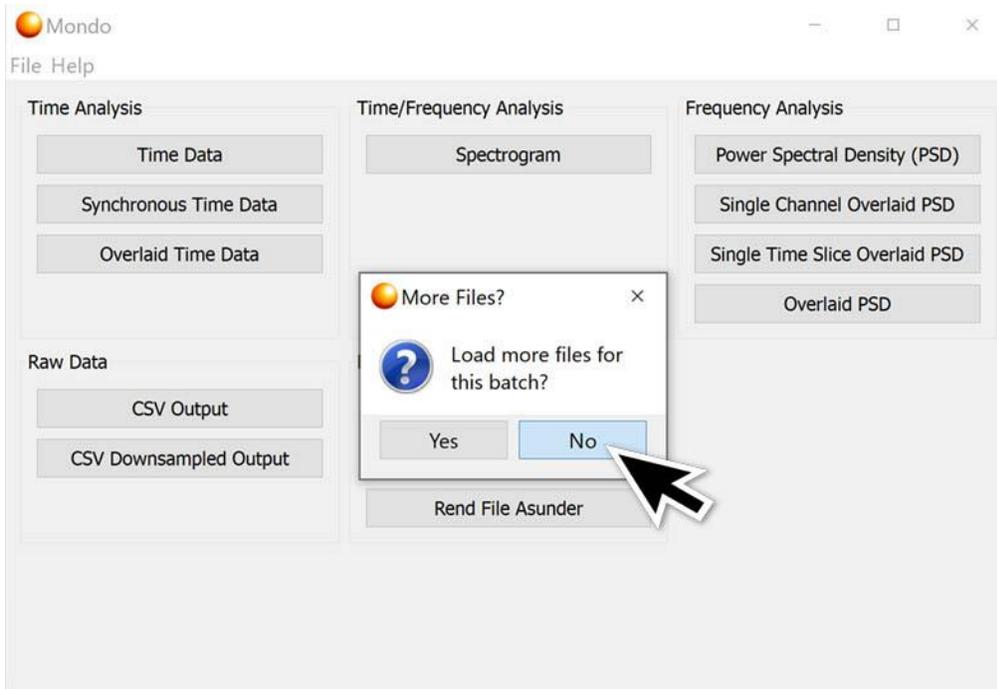
### Saving and Exporting data files as CSV

Exporting CSV Data output is similar in procedure to opening files for view/saving as image:

1. Clicking the CSV Output button brings up a file opening dialog. Choose which file you would like to export then click open.

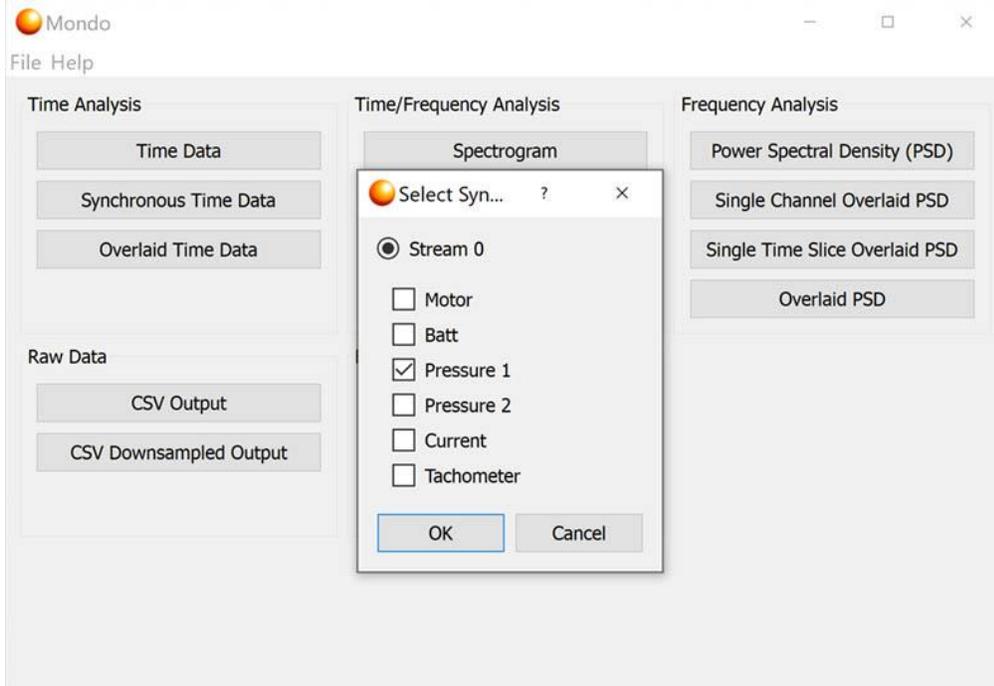


2. The software will ask if the user would like to add more files for concatenation:



For the purposes of EBOP test, it shouldn't be necessary to link more than one file together. Please click "no"

3. A dialog will pop up asking which synchronous channels the user wishes to include in the csv export file.

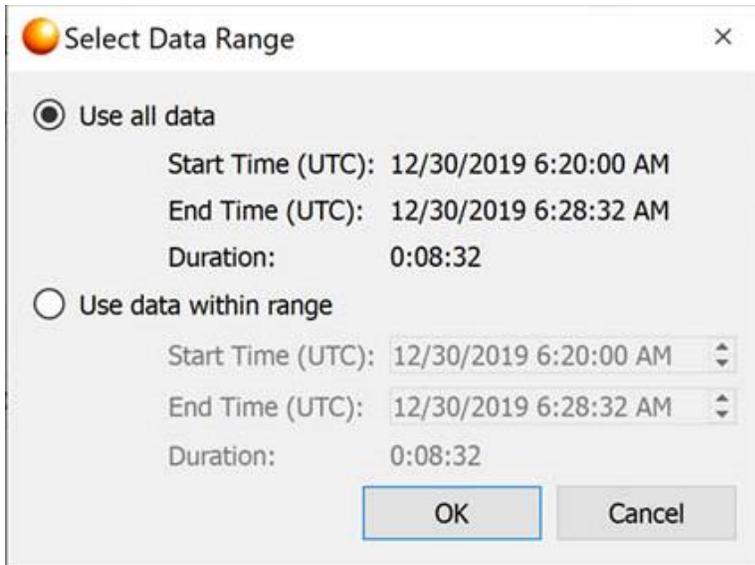


Check the boxes next to the channel(s) you would like to see in this CSV file in particular. Then click “ok”

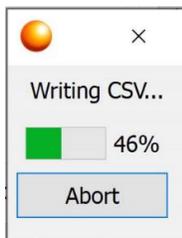
You will then see the loading progress bar:



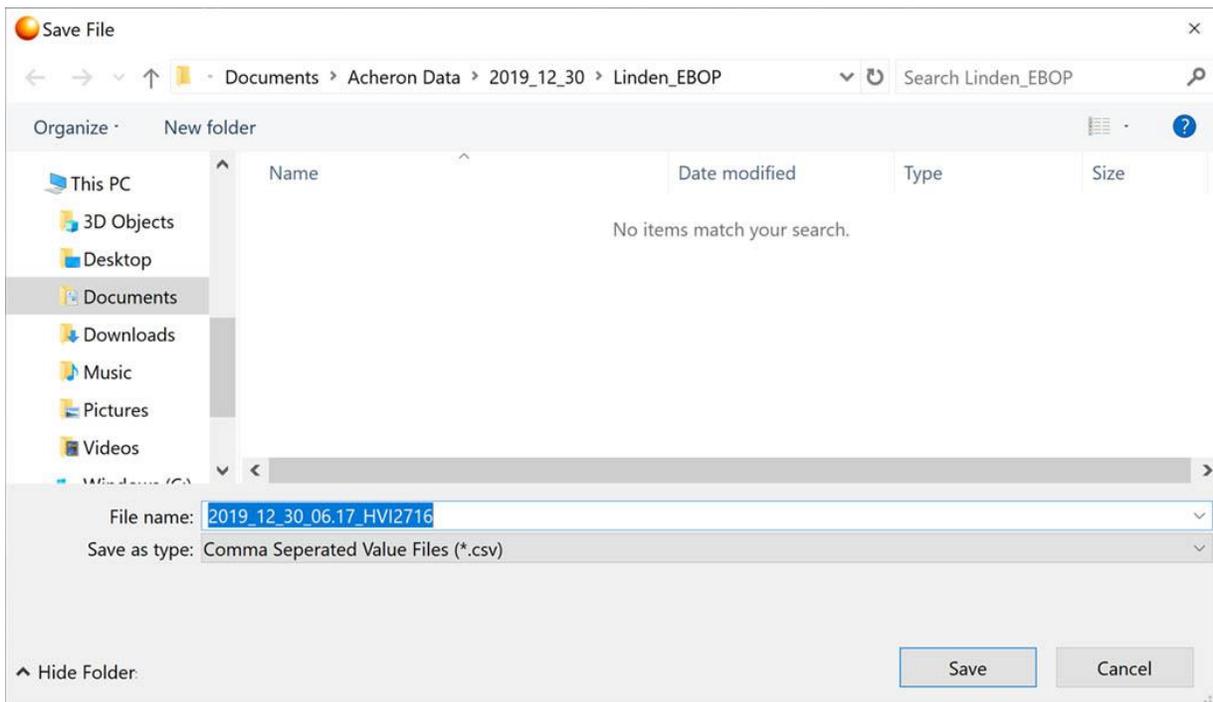
4. The next window will prompt you to choose whether you want to export the entire file or a certain time range. Times are in UTC.



Click ok, and a CSV file will be generated.



5. When the file is finished loading a dialog will prompt you to choose a filename and save location:



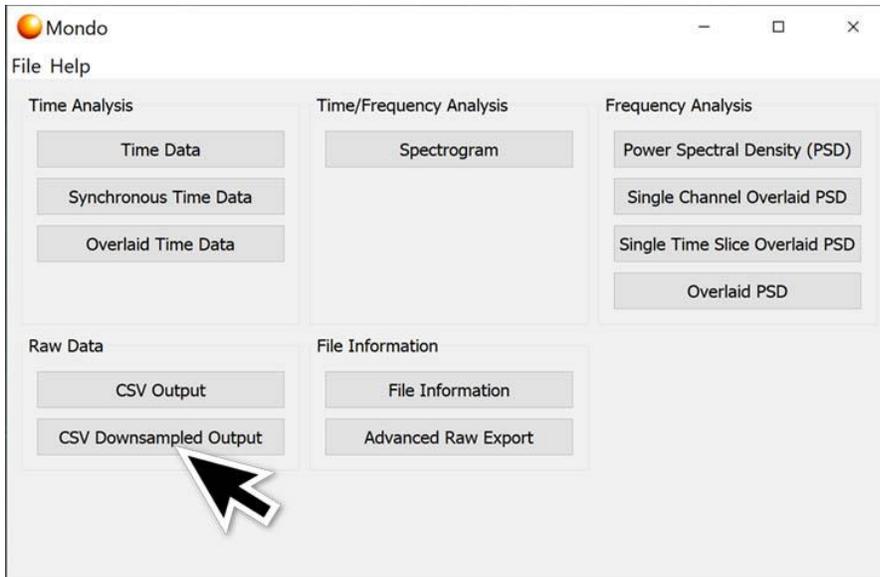
Type a name, choose a save location, then click “Save.”

Your file will save to your desired location.

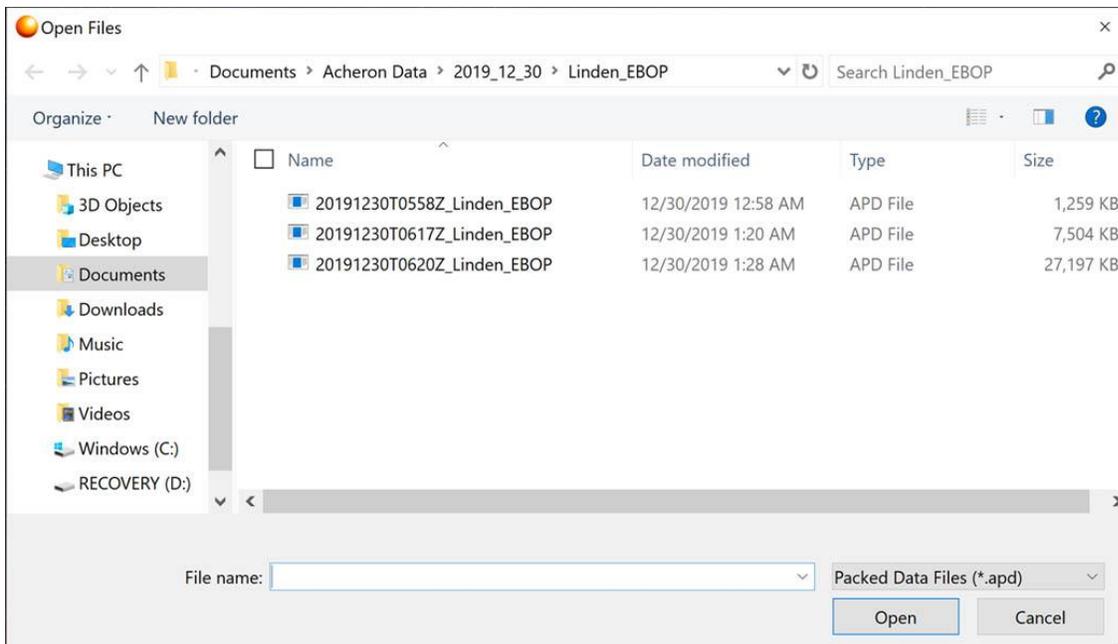
### Downsampled CSV for Excel graphing

Mondo is capable of graphing .apd files created by the telemetry, however @8ksps, if one wishes to graph data using a spreadsheet program such as Microsoft excel, the number of datapoints can quickly overwhelm such programs. Enter the downsampled CSV feature on Mondo:

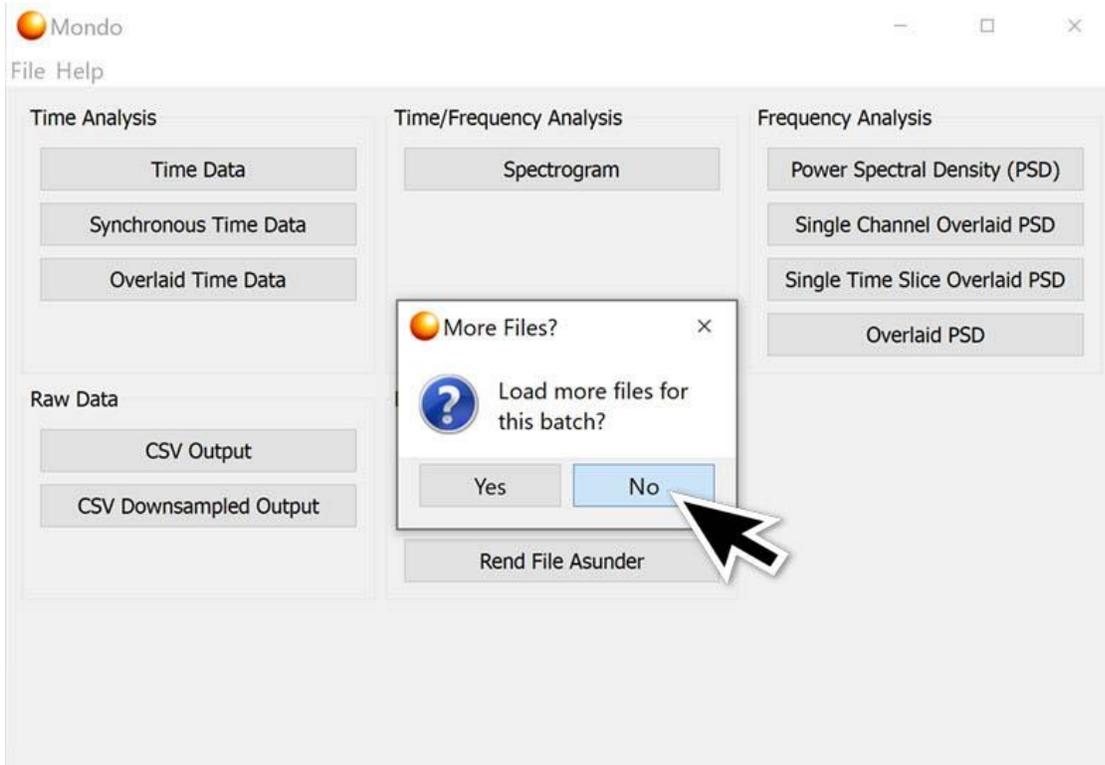
1. Open Mondo and click on “Downsampled CSV output”



2. Dialog box will pop up prompting the user to choose desired file. Choose your desired file and click “Open.”

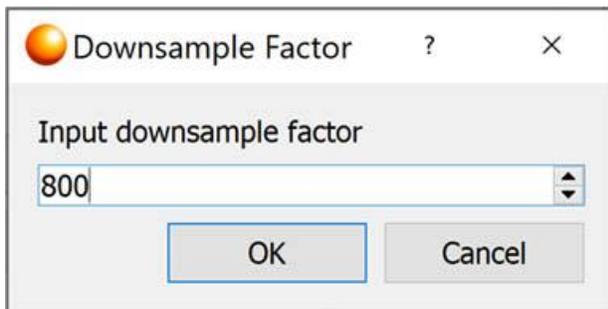


3. The software will ask if the user would like to add more files for concatenation:



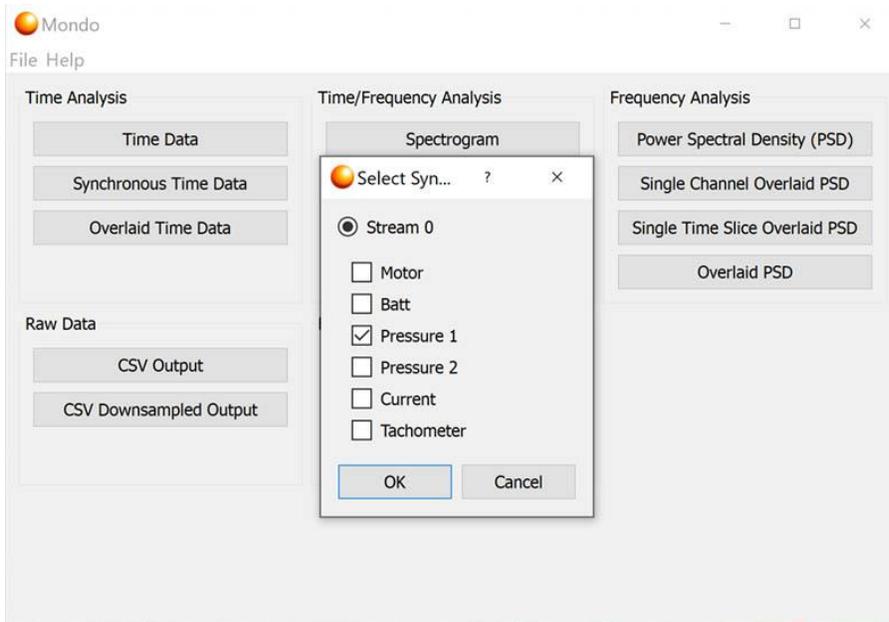
For the purposes of EBOP test, it shouldn't be necessary to link more than one file together. Please click "no"

4. A dialog box will pop up asking for the user to provide a "downsample factor" The downsample factor is a divisor that will be based on the default sample rate of 8ksps. For example, writing 2 results in an effective sample rate of 4ksps ( $8,000\text{sps} / 2 = 4,000\text{sps}$ ). A factor of 800 would result in a sample rate of 10sps etc.



Once the user has calculated the factor and is satisfied, click "ok."

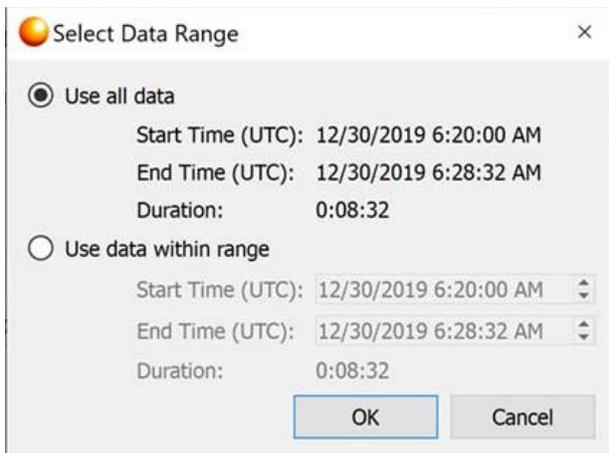
6. A dialog will pop up asking which synchronous channels the user wishes to include in the csv export file.



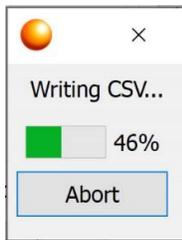
Check the boxes next to the channel(s) you would like to see in this CSV file in particular. Then click “ok”  
 You will then see the loading progress bar:



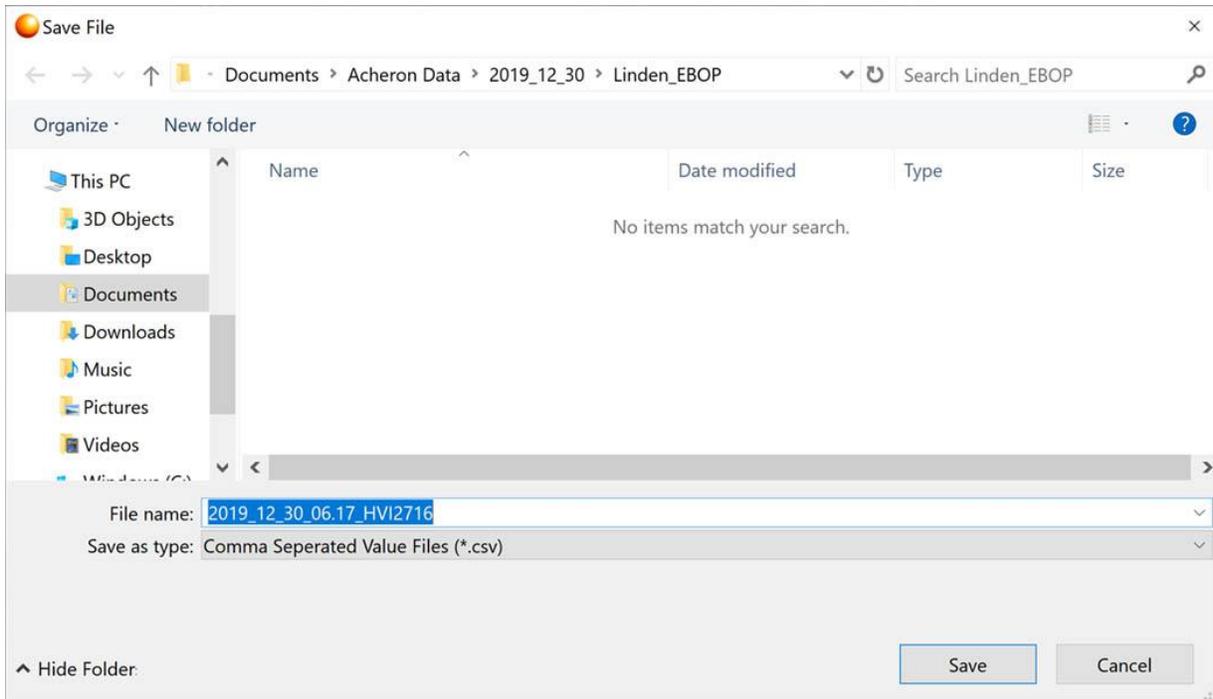
7. The next window will prompt you to choose whether you want to export the entire file or a certain time range. Times are in UTC.



Click ok, and a CSV file will be generated.



8. When the file is finished loading a dialog will prompt you to choose a filename and save location:



Type a name, choose a save location, then click “Save.”

Your file will save to your desired location.