DSI-STREAMER

DATA ACQUISITION SOFTWARE

User Manual

Version 0.8.05

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1 Disclaimer

The DSI-Streamer software was designed for use in scientific and engineering research environments.

The DSI-Streamer software is not a medical diagnostic acquisition or review product.

The DSI-Streamer software is intended to allow users to acquire and review signals from Wearable *Sensing* systems.

Wearable *Sensing* and its subsidiaries does not warrant that these signals are useful for any particular purpose, either implied or otherwise, and specifically disclaims responsibility for use of the signals.

The specifications, information and performance of the DSI-Streamer software, may be changed without notice. Since the use of this information and the conditions in which the software is used are beyond the control of Wearable *Sensing* and its subsidiaries, it is the obligation of the customer and/or the equipment operator to determine the correct and safe selection and settings and conditions of use of the software.

The DSI-Streamer software is provided on "AS IS" basis. WEARABLE *SENSING*, INCLUDING ITS SUBSIDIARIES, DISCLAIMS ANY AND ALL WARRANTIES EXPRESSED, STATUTORY OR IMPLIED WITH RESPECT TO THE SOFTWARE, INCLUDING BUT NOT LIMITED TO ANY IMPLIED WARRANTIES OF MERCHANTABILITY, NON-INFRINGEMENT OR THIRD PARTY RIGHTS AND FITNESS FOR A PARTICULAR PURPOSE.

2 System Overview

Wearable *Sensing*'s DSI-Streamer software is designed to allow the acquisition, storage, and review of data acquired using Wearable *Sensing*'s EEG systems. This includes Wearable *Sensing*'s DSI-24, DSI-6, DSI-7, and the DSI-Mini EEG systems.

The key functionality of the DSI-Streamer software includes:

1. Command and control of EEG system
2. Confirmation that adequate contact has been made between sensors and scalp
3. Real-time display of acquired EEG data, including High Pass and Low Pass filtering of acquired data
4. Record EEG data streams (with external trigger inputs) to PC hard disk
5. Record EEG data streams (with external trigger inputs) to internal memory on EEG system
6. Replay pre-recorded EEG data
7. Saving data into CSV and EDF file format

This User Manual describes installation, use and operation of the DSI-Streamer software.

3 Software Installation

3.1 System Requirements

- Operating System: Windows XP/Vista/Windows7/Windows 8
- Minimum Available Hard Disk Space: > 10 MB
- Minimum RAM: > 120 MB

3.2 Installation of DSI-Streamer Software

DSI-Streamer is an executable file that does not require installation.

The software is included in the **Software** folder on the USB drive provided with the EEG hardware. Simply drag the folder into the destination folder on your computer's hard drive. This will copy the folder and its contents.

The DSI-Streamer application is the ".exe" file. It is named:

DSI-Streamer-v.0.**x**.**x**.**x**.exe

where the "**x**"s have replaced numbers that indicate the version number of the software.

Simply launch the ".exe" file to run the DSI-Streamer application.

3.3 Installation of Hardware Drivers for Wired Operation

The following describes the installation of software drivers required in order to receive data from Wearable *Sensing*'s EEG hardware via a wired connection.

- Run the Silicon Laboratories driver wizard ("CP210x_VCP_Win_XP_S2K3_Vista_7 v6.5.3.exe") included on the USB drive. The window in Figure 1 should appear.
  Verify that the version of the driver is **6.5.3** or higher (Figure 2). Some of the earlier versions of their driver will not work for newer computers.
- Click **Next** and agree with the use statement if it is acceptable.

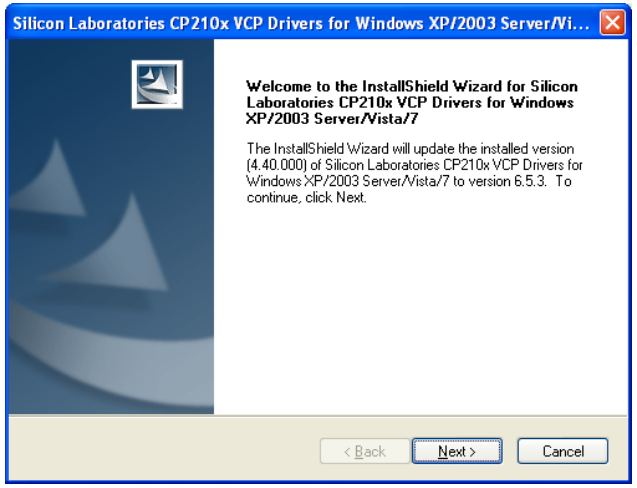


Figure 1 – Good version of Silicon Laboratories driver. Must be 6.5.3 or higher.

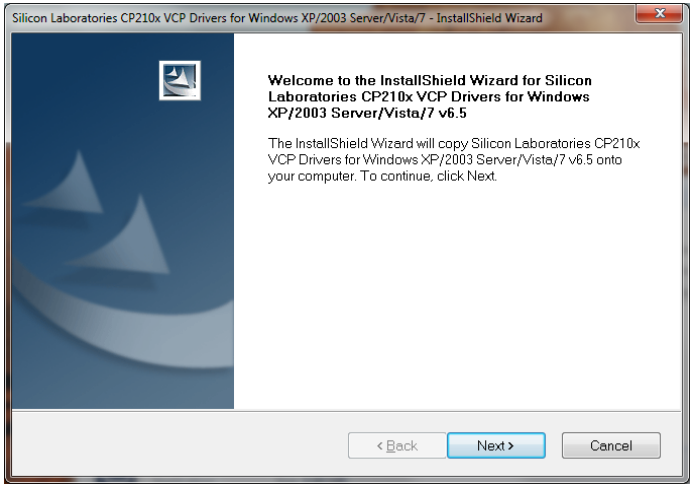


Figure 2 –WRONG version of driver. Must be 6.5.3 or higher.

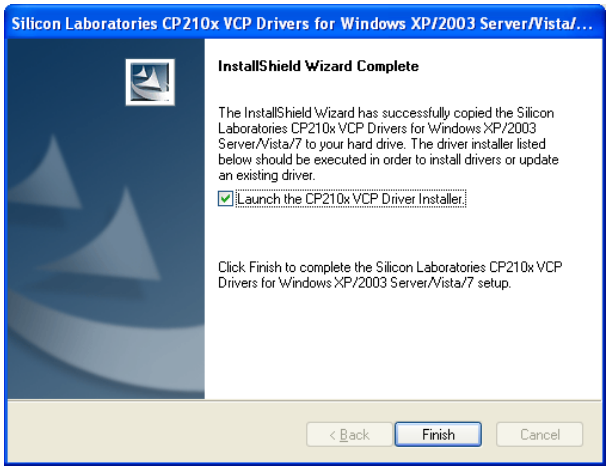


Figure 3 – Window that appears at conclusion of driver installation.

Figure 4 – Final VCP driver install window.

- Allow the software wizard to install the Virtual Communications Port (VCP) driver automatically.
  At the end of installation, the window in Figure 3 should appear.
- Click on **Finish** to bring up the final VCP driver install window (Figure 4).
- In the event you get an error screen after selecting **Install**, then you may need to install the driver manually.
  Please let your IT assist you at this point as it will require updating/installing the driver through the device manager.
- The window in Figure 5 will appear on Windows 7 after a successful driver installation. In some cases this message will not appear until the system is plugged in to the USB socket.

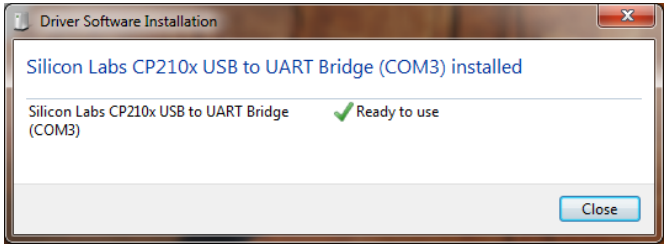


Figure 5 – Example in which Windows reports COM3 has been assigned to the System.

- Make note of the comport number the VCP has been assigned to as it may be needed later.

- A reboot of the system at this point may be advisable and may required depending upon the operating system.

3.4 Installation of Drivers for Bluetooth® Operation

The following describes the installation of software drivers required in order to receive data from Wearable *Sensing*'s EEG hardware via a Bluetooth® connection.

- Plug in the Bluetooth® USB module supplied with the EEG hardware. The first time the Bluetooth® module is plugged in to the computer, the computer will begin a procedure to automatically install the drivers for the Bluetooth® device.
  If the computer you are using has built-in Bluetooth®, or are using a different module for Bluetooth® communications, then the drivers will already have been installed on your computer.

4 Preparing and Donning System

The following briefly describes how to prepare and don the Wearable *Sensing*'s EEG system in order to acquire EEG data. The user is referred to the relevant User Manuals for the specific system being used for additional details.

- Clean sensors with isopropyl alcohol or 70% ethanol using power brush and then air dry sensors.
- Place recharged batteries in system and position headset on head.
- Ensure proper alignment of Fz sensor to arrow on forehead and of C3 and C4 sensors to ear holes.
  For DSI-Mini users, position the sensors where desired.
- Adjust tension to secure headset against the scalp.
- Work sensors through hair by pushing down and rotating sensors using the provided tool.
- Turn power on by pressing the power button twice with a 1 second interval.
- When system is on and searching for a wireless connection, the Status light will flash green for DSI-24 or blue for .DSI-7
  - To verify if the system is ON or OFF, press the **Status** button.
- Identify the COM port which was assigned to the system by looking in the Bluetooth® settings.
  This procedure is described in the next section
- Launch the DSI-Streamer software.

5 Connection to EEG Hardware

5.1 Identify Communication Ports for Wired Connection to EEG System

The following describes the procedure for identifying the communications port used by the EEG system when connected to your computer.

- Open the Windows Control Panel.
- Open the **System** file.
- Click on **Device Manager** under the **Hardware** tab (Figure 6).
- Expand the **Ports (COM & LPT)** subsystem.
- There should be an entry "Silicon Labs CP210x USB to UART Bridge (COM**#**)" where **#** has been replaced by a number (Figure 7).
- Note this number and close the **Device Manager**.

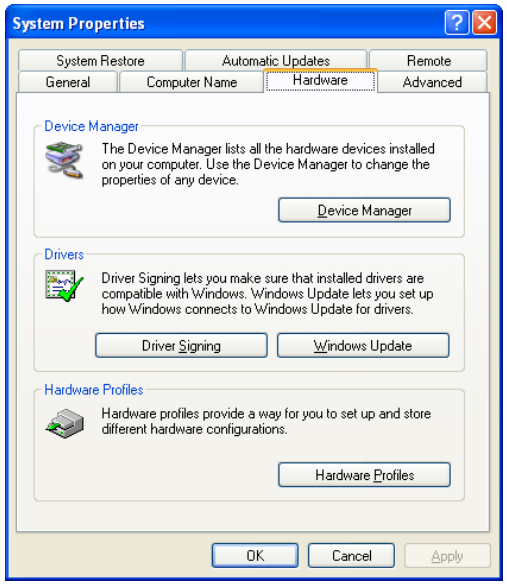


Figure 6 – Hardware tab under the System Properties control panel.

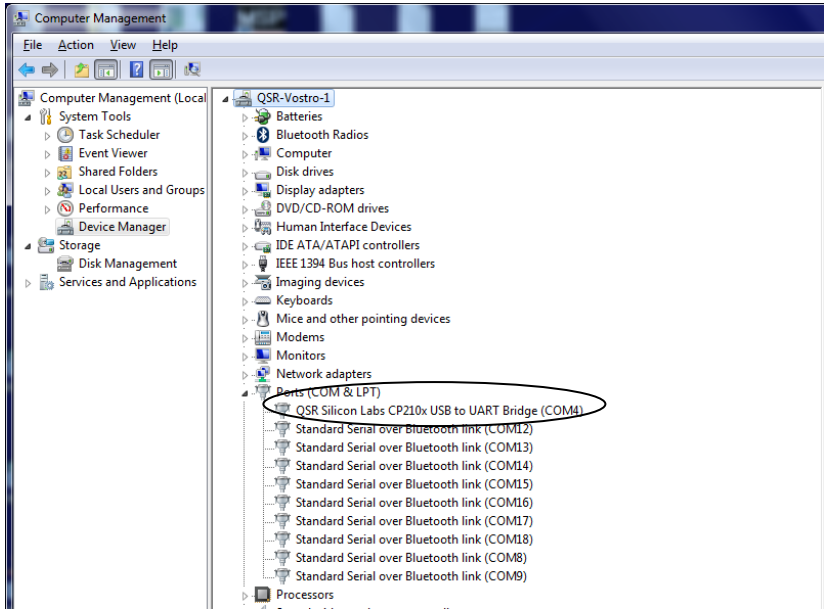


Figure 7 – Device Manager, showing the Silicon Laboratories driver.

5.2 Identify Communication Ports for Bluetooth® Connection

The following describes the procedure for adding the EEG system as a valid Bluetooth® device that can connect to your computer. The communications ports are assigned as part of the installation procedure. The following images and steps illustrate the procedures for Win 7 OS with generic Bluetooth® drivers, different OS and drivers may have a different interface, but the general procedure is generally as follows.

- Turn on the EEG system. This will make the system seek a Bluetooth® connection.
- Right click on the Bluetooth® icon in the System Tray. Select "Add Device".

- The Add Bluetooth Device Wizard window will open (Figure 8).
- Select the checkbox for "My device is set up and ready to be found."
- Click **Next** to advance to the Select Bluetooth® Device window (Figure 9).

Figure 8 – Bluetooth Device Wizard window.

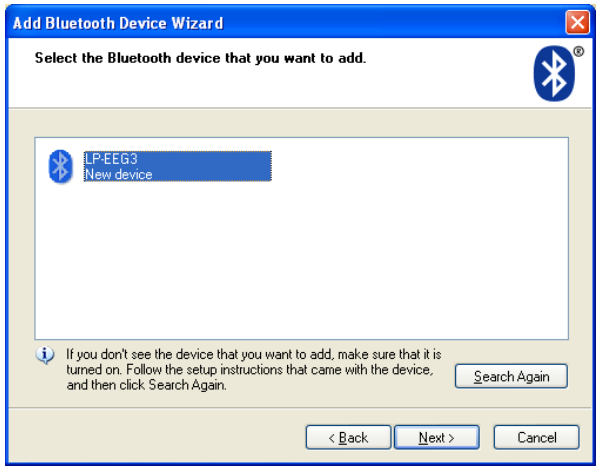


Figure 9 – Select Bluetooth Device window.

- Select the EEG device.
    - The name for the Wearable *Sensing*'s EEG system will appear in the window.
    - It can be identified by having a "DSI" prefix.
- Click **Next** to advance to the Bluetooth® Passkey window (Figure 10).
- Select the radio button for "Use the passkey found in the documentation:"
  Enter the passkey "**1111**".
- Click **Next** to advance to the Installing Bluetooth® Device window (Figure 11).

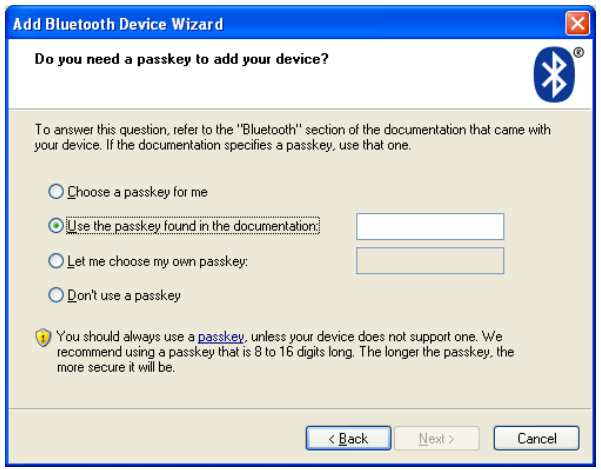


Figure 10 – Bluetooth Passkey window.

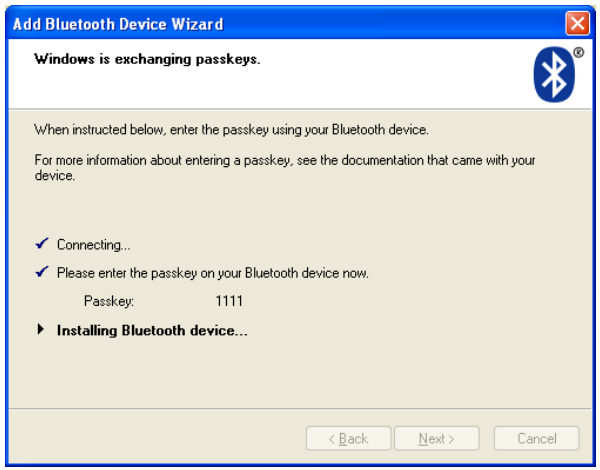


Figure 11 – Installing Bluetooth Device window.

- Once installation has been completed, the assigned communication ports are reported in the Completing the Add Bluetooth Device Wizard (Figure 12).
- Take note of the communication ports assigned to the Bluetooth® Device.
  These will be required to make connection to the EEG hardware in the DSI-Streamer software.
  In practice, the **Outgoing** port will be required.
- Click **Finish** to close the Add Bluetooth Device Wizard.

Figure 12 – Completing the Add Bluetooth Device Wizard.
Take note of the serial communications ports assigned to the Bluetooth device.

5.3 Connect to EEG System

Connecting the DSI-Streamer software to the EEG system is done by selecting the **Data Source** tab in the main window (Figure 13).

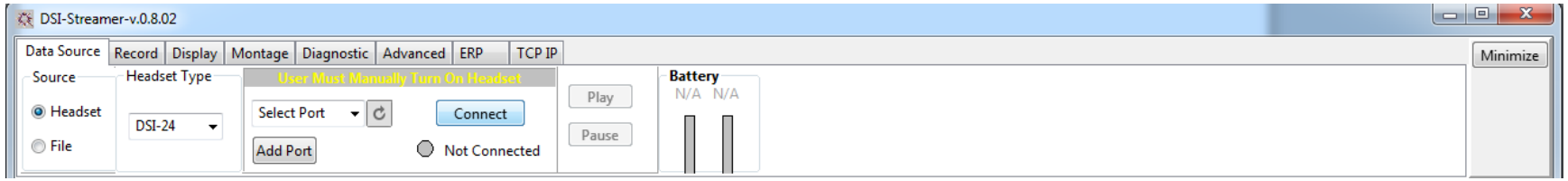


Figure 13 – Data Source tab configured for connection to EEG system.

- Select the **Headset** option under **Source**.
  The **File** option is used for playback of EEG data.
- From the drop-down menu under **Headset Type**, choose the option corresponding to your Wearable *Sensing* EEG hardware.
- Choose the COM port corresponding to your wired/Bluetooth® connection from the COM port drop-down menu.
  Refer to Sections 5.1 & 5.2 to identify the COM ports in use, if not already known.
  - The Add Port button allows you to add a COM port to the list in the drop-down menu if the desired COM port is not present in the list.
    This only occurs if the COM port is added after the software is opened.
    The button will refresh the COM port list, if it is not populated
    Closing the application and re-running the software will also update the list in the drop-down menu.
- Press the **Connect** button.
  Note: The headset has to be turned on manually, and it is recommended to do so prior to pressing the **Connect** button.
  - The **Play** button changes to an **Interrupt** button while DSI-Streamer attempts to connect to the headset.
    If you wish to terminate an attempt to connect, press this **Interrupt** button that appears.
  - The status indicator in the Data Source tab should eventually change from Grey ("Not connected/connecting") to Yellow ("Connected").
  - At this point the **Play** button will no longer be grayed out.
  - The Connect button will change to **Power Off**.
  - The battery indicators should indicate the approximate remaining duration of each battery. (this feature is not yet enabled for DSI-6 or DSI-Mini)

6 EEG Data Acquisition Using DSI-Streamer

6.1 Starting Data Acquisition

Data streaming is commenced by clicking the **Play** button in the **Data Source** tab in the main window.

- Press the **Play** button to start data streaming.
  - The status light should from Yellow ("Connected") to Green ("Data Streaming") and data should start streaming
- Each EEG channel is plotted to the right of its name (Figure 14).
  - The name is specified by the montage selected for display (see Section 8.2).
- The number at the far right of each trace is either:
  - The peak-to-peak amplitude of the filtered signal for the displayed signal (see Section 8.1 for filtering), or
  - DC offset of the acquired (unfiltered) data.

  The reported values are calculated using the most recent second of data acquired.
  Selection can be changed in the **Display** tab.
- The status of the **Trigger** inputs are indicated by diamonds shown in the bottom left of Figure 14, one for each trigger input.
  - DSI-Mini, DSI-6 or DSI-7: 4 trigger inputs.
  - DSI-24 or ANI: 8 trigger inputs.

  The diamond corresponding to the activated trigger bit will flash for one second for 1 second for each trigger pulse received.
  The trigger channel timeseries plot will display the trigger value and duration of the trigger as the bottom trace in blue.
- The occurrence of dropped packets due to poor Bluetooth® connectivity or processor overload is indicated by the **Data Lost** indicator.
  - **Green** "No Data Lost": Good connectivity, no dropped data packets
  - **Yellow** "n% of dropped packets": Problematic connectivity; percentage value indicates the percentage of data packets not received.
  - **Red** "Severe Data Loss": No data received from EEG hardware.
- Time elapsed since starting measurement indicated by **T** value.
  The **T** value shown corresponds to the location of the vertical line running through the data window.

- Click the **Stop** button to stop data streaming from the EEG system.
- Click the **Power Off** button to turn off the EEG system.

Figure 14 – DSI-Streamer streaming EEG data.

6.2 Recording EEG Data Files (i) Recording to PC Hard Disk

Once data is streaming from the EEG system, data can be recorded by selecting the **Record** tab in the main window (Figure 15).

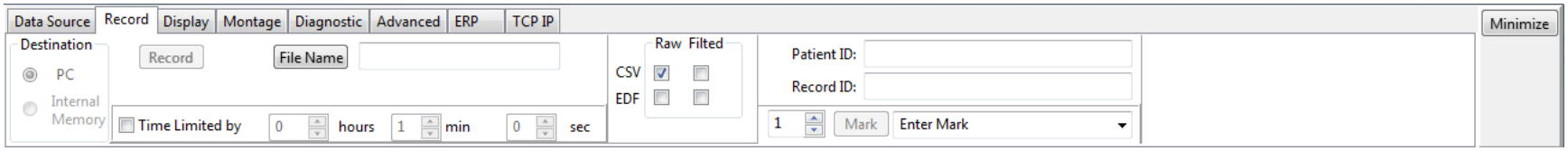


Figure 15 – Record tab with option for writing data to PC selected.

- Select the **PC** radio button.
  - The recording options shown to the right of the radio buttons in Figure 15 will automatically appear.
  - The radio buttons in the *Destination* group are active only if the headset is connected and internal memory in the headset is detected. Otherwise control of the destination is disabled and set to *PC*.
    PC refers to data being stored on the computer's harddrive
    Internal Memory refers to data being stored on the headset's internal memory for later download
    Recording can be done both on the PC and internal memory at the same time, but each recording is controlled independently
  - The **Record** button will not become active until data is streaming.
  - By default, the **PC** option is selected each time the DSI-Streamer application is opened.
- Click the **File Name** button to open a **Save File As** dialog window.
  Enter the filename and to specify the destination directory.
- The filename entered by the user will appear in the edit field to the right of the **File Name** button.
  - The filename can also be entered directly into the edit field.
    The path of the file name in this case would be either: a) home directory (the one where DSI-Streamer application file is located) if The *Filename* button has not been used or b) the last directory selected with the *FileName* button.
  - An empty edit field will generate files with the DSI-Streamer default filename (data).
- If a filename already exists an index number will be appended to the filename.
  - Index has format "_xxxx", beginning with "_0001".
  - Index will automatically be incremented unless a file with a appended index number is selected, in which case "_0001" will be appended to the appended filename.

- Once a filename is entered, the **Record** button will no longer be grayed out.
- To specify the duration for data recording, click the check box next to **Time Limited By**.
    - Enter the duration of recording (hours:minutes:seconds), with each number entered separately in the corresponding edit fields.
    - If the check box is not checked, then recording will continue until stopped by the user.
- The **Record** button will change to **Stop** when the **Record** button is pressed.
    - If the **Time Limited By** option is not selected, data acquisition will continue until the **Stop** button is pressed
- Data can be saved in 2 different file types: **comma-separated-value** (**.csv**) or **European Data format (.edf)**
- Data saved in the files can be **Raw** (no software filtering), or **Filtered** (according to the settings in the Display Tab).
    - These are indicated by the filtering suffix appended to the base name: "_raw" and "_filtered".
      The "_0001" suffix is appended after the filtering suffix.
- Up to 4 files can therefore be generated from a single recording.
- **Patient ID** and **Record ID** information can be entered and will be saved in the data output files.
- Press the **Record** button to start recording the file.
- A red marker will at the bottom right of the screen indicates "Recording" status and display recording (or remaining) time during recording. (Figure 17)
- Files are saved in the directory you specified.
- See Section 6.6 for more details about the contents of the EEG data files written by DSI-Streamer.

6.3 Inserting Custom Marks into Data

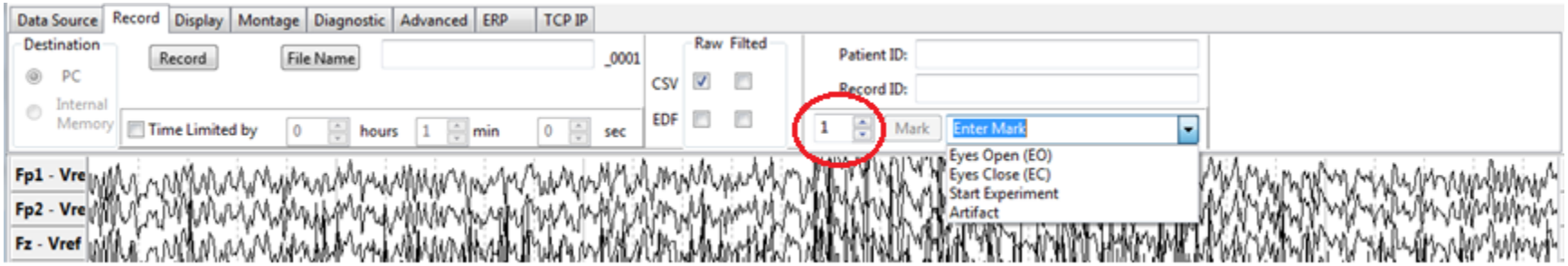


Figure 16 – Custom Event Menu

Under the **Record** tab, there is a software event marker that allows users to insert custom event markers into a data stream, during recording. This can be done both when streaming data from a headset, or when replaying datafrom a file. There are three elements of this function:

- **Bit Value:** On the left side of this bar, circled in red in Figure 16, the number displayed is the bit value of the event to be marked in the data.
    - **For a DSI-**7, this can be any value from 1-15. For a **DSI-24,** this value can be from 1-255.
- "**Mark" button:** When this button is pressed, an event with the Bit Value and Event Label displayed is created at that instant.
    - Note that this button is only active while the data is being recorded.
- **Label Menu:** As seen in Figure 16, by default this menu contains 4 labels. When an event is labeled, the .csv file generated will contain the text that is shown in this menu.
    - To add your own custom labels, simply click the text in this menu, and type out a label of your choosing., as shown in Figure 17:

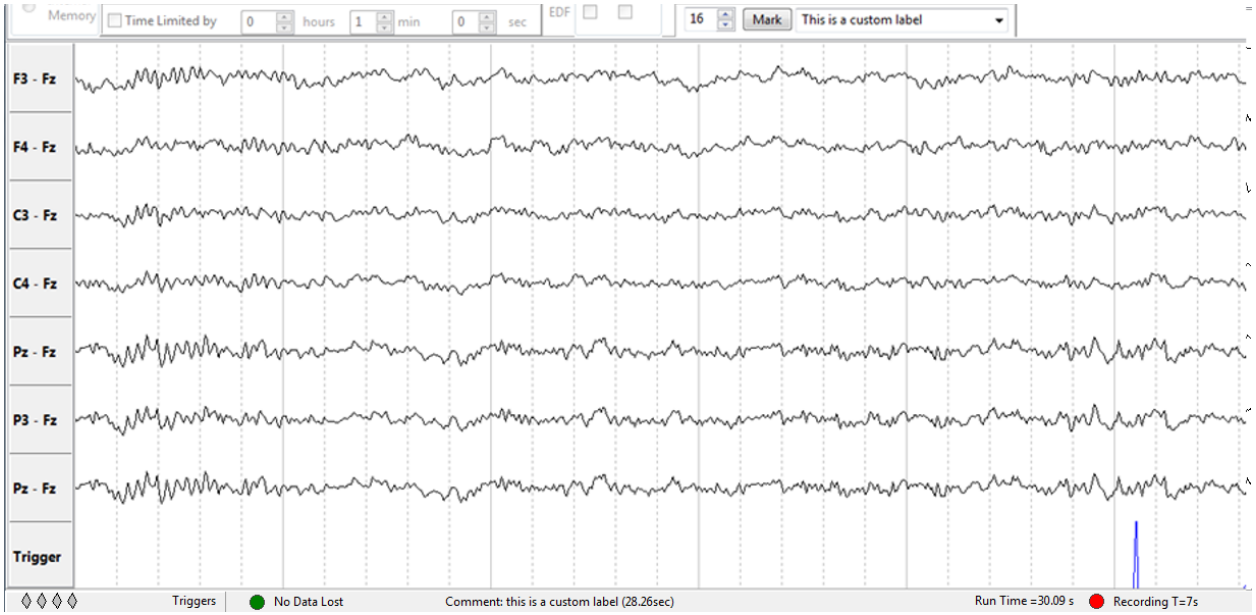


Figure 17 – A custom event has been inserted

13.9833	-10.8	88.8	28.5	9.9	7.8	28.8	105.6	1	25170	0	97	
13.9867	-8.7	91.5	31.5	10.2	8.4	31.5	109.5	1	25176	0	98	
13.99	-8.4	93.3	33	10.2	7.5	32.4	112.2	0	25182	0	99	
13.9933	-10.5	92.7	32.4	9.3	5.4	31.8	113.1	0	25188	0	100	
13.9967	-13.8	90.9	30	8.7	3.6	30.6	112.2	0	25194	0	101	
14	-15.9	88.8	27.9	9	2.4	28.8	110.1	0	25200	0	102	
14.0033	-16.2	88.2	27	9.6	2.1	27.3	108.3	16	25206	0	103	This is a custom label
14.0067	-15.6	89.4	27.3	10.2	2.4	25.8	107.4	16	25212	0	104	
14.01	-15.9	90.9	28.2	10.8	2.7	24.3	107.4	16	25218	0	105	
14.0133	-17.7	91.8	28.2	10.5	2.7	22.8	106.8	0	25224	0	106	
14.0167	-21	90.9	27.3	9.9	2.7	21.3	104.7	0	25230	0	107	
14.02	-23.7	88.5	26.1	9.3	3	20.7	102	0	25236	0	108	

Figure 18 – An Event Marked in the .csv With Custom Label

In Figure 17, an event is market with a value of 16 a label of "This is a custom label" during recording, producing the spike in the Trigger channel seen the lower right corner. The labels are visible in the bottom bar of DSI-Streamer (seen in are recorded in the far right column of the .csv data file generated during this recording, shown in

13.9833	-10.8	88.8	28.5	9.9	7.8	28.8	105.6	1	25170	0	97	
13.9867	-8.7	91.5	31.5	10.2	8.4	31.5	109.5	1	25176	0	98	
13.99	-8.4	93.3	33	10.2	7.5	32.4	112.2	0	25182	0	99	
13.9933	-10.5	92.7	32.4	9.3	5.4	31.8	113.1	0	25188	0	100	
13.9967	-13.8	90.9	30	8.7	3.6	30.6	112.2	0	25194	0	101	
14	-15.9	88.8	27.9	9	2.4	28.8	110.1	0	25200	0	102	
14.0033	-16.2	88.2	27	9.6	2.1	27.3	108.3	16	25206	0	103	This is a custom label
14.0067	-15.6	89.4	27.3	10.2	2.4	25.8	107.4	16	25212	0	104	
14.01	-15.9	90.9	28.2	10.8	2.7	24.3	107.4	16	25218	0	105	
14.0133	-17.7	91.8	28.2	10.5	2.7	22.8	106.8	0	25224	0	106	
14.0167	-21	90.9	27.3	9.9	2.7	21.3	104.7	0	25230	0	107	
14.02	-23.7	88.5	26.1	9.3	3	20.7	102	0	25236	0	108	

Figure 18.

6.4 Recording EEG Data Files (ii) Recording to EEG Headset Internal Memory

As above, once data is streaming from the EEG system, data can be recorded by selecting the **Record** tab in the main window (Figure 19).

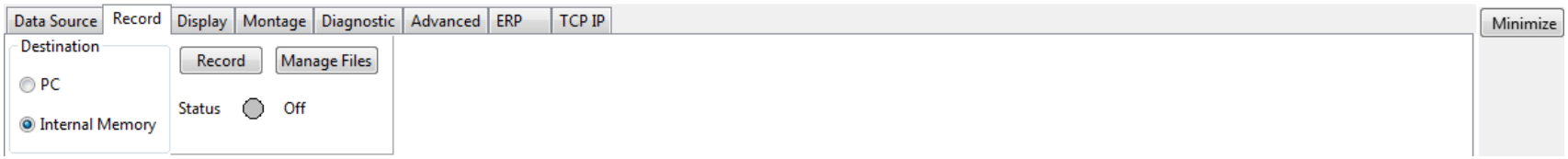


Figure 19 – Record tab with option for writing data to EEG headset internal memory selected.

- Select the **Internal Memory** radio button.
  - The recording options shown to the right of the radio buttons in Figure 19 will automatically appear.
  - The radio buttons will not become active until a headset is connected.
  - The **Record** button will not become active until data is streaming.
  - The **Internal Memory** option is only active if a headset configured with internal memory is connected to the PC.
- Click on the **Record** button to begin writing data to the headset's internal memory.
  - The **Status** indicator will change from **Off** (Grey), to **Connecting** (Yellow), and finally to **Recording** (Green).
  - The **Record** button will change to **Stop**. Use the **Stop** button to end recording.
  - Failure for **Status** to reach **Recording** state may indicate that the wireless connection from the PC to the headset is poor and the command to begin recording is not being received.
- Note that data written to internal memory is allocated in ½-hour segments
  - The internal memory has enough space for up to 60 hours continuous recording.
  - However, 4 five minute recordings will use 2 hours (equivalent) of internal memory, or a 35 minute recording will use 2 hours (equivalent).
- Recording will continue until either of the following:
  - The **Stop** button is pressed.
  - The headset is turned off.

6.4.1 Retrieving EEG Data Files from Headset Internal Memory

Data can be retrieved from internal memory using the fast-USB cable supplied with the headset.

Do not attempt to connect the headset to the PC via the Fast-USB while data is being written to the headset's internal memory. This may cause an error that can corrupt previously recorded data and damage the internal memory (requiring replacement of memory components). You should stop recording data onto the internal memory or reset power to the headset before connecting the Fast USB cable.

Plug the 2.5mm jack into the headset prior to plugging the USB connector into the PC

- Connect the fast USB to the headset and the PC running DSI-Streamer.
  - **Note: Plug the 2.5mm jack into the headset prior to plugging the USB connector into the PC.**
  - When the cable is plugged in, the **Record** button will become inactive.
- Click the **Manage Files** button to open the **Internal Memory Interface** dialog window (Figure 20).
  - At this step, if the headset is not connected to the PC, the message in Figure 21 will appear. Check the fast USB cable.

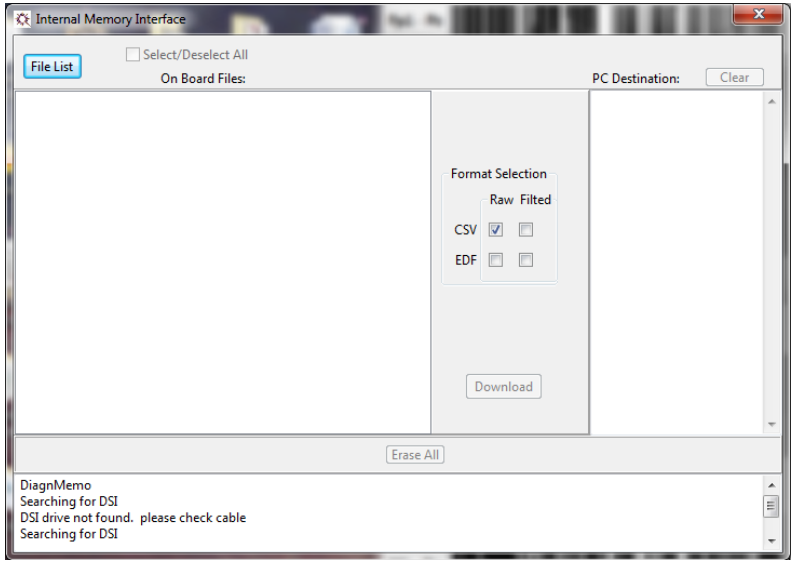


Figure 20 – Record Internal Memory Dialog Window.

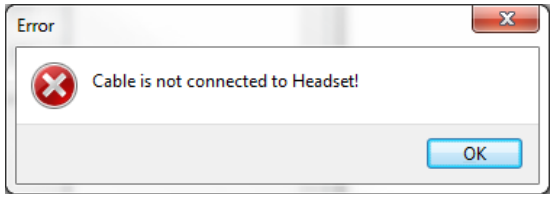


Figure 21 – Error message displayed when headset is not connected to PC.

- Click on **File List** button to see the files recorded to internal memory. An example is shown in Figure 22.
  - Each recording will appear as a separate file.
  - The start time (determined using the headset's internal Real-Time Clock), and duration for each file are displayed.

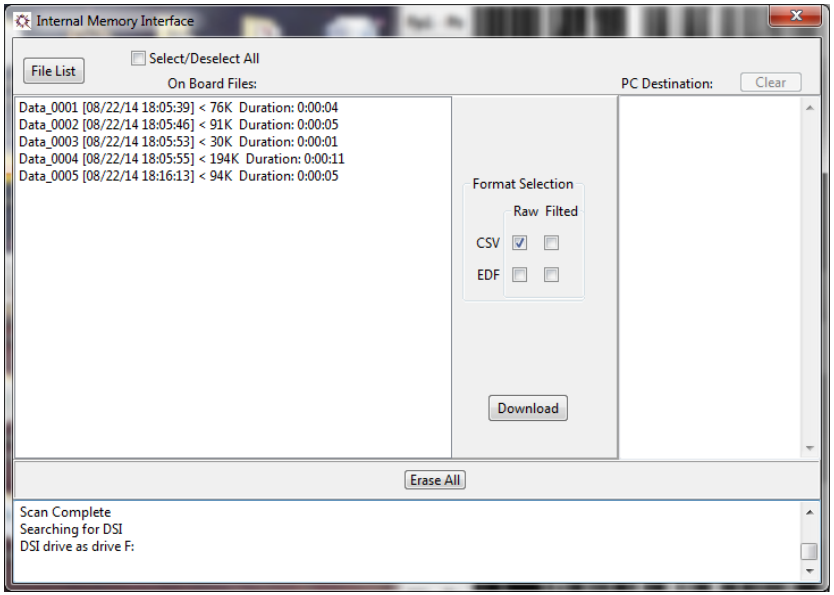


Figure 22 – Files stored in headset internal memory.

- Select the files you wish to download from those displayed in the **File List** window.
- The filtering applied to downloaded data and the file format(s) for saving downloaded files are indicated by the check boxes:
  - Data can be saved in 2 different file types: **.csv** or **.edf** (as per Section 6.2 Recording EEG Data Files (i) Recording to PC Hard)

- Filtering can be selected (as per Section 6.2 Recording EEG Data Files (i) Recording to PC Hard).
  Filtering is set by the filter selections under the **Display** tab.

- Click the **Download** button to download data from the headset and write to the PC hard disk.
- A **Save File** dialog will appear. Choose the location and filename for the downloaded files.
  - The entered filename will be used as a base name.
  - The filter suffixes "_raw" and "_filtered" will be added automatically.
  - If more than one file is selected for download, or if the filename already exists an index number will be appended to the filename (as per Section 6.2 Recording EEG Data Files (i) Recording to PC Hard)
  - Date and time in headers of files converted into edf or csv format (see section 6.6) indicate at the beginning of data recording and not at time of the conversion
- The names of downloaded files written to disk appear in the **PC Destination** window, as illustrated in Figure 23.
  - The list of file names appearing in the **PC Destination** window can be cleared using the **Clear** button.
  - The **Clear** button does not delete files from the hard disk; it only reinitializes the files displayed in the **PC Destination** window.

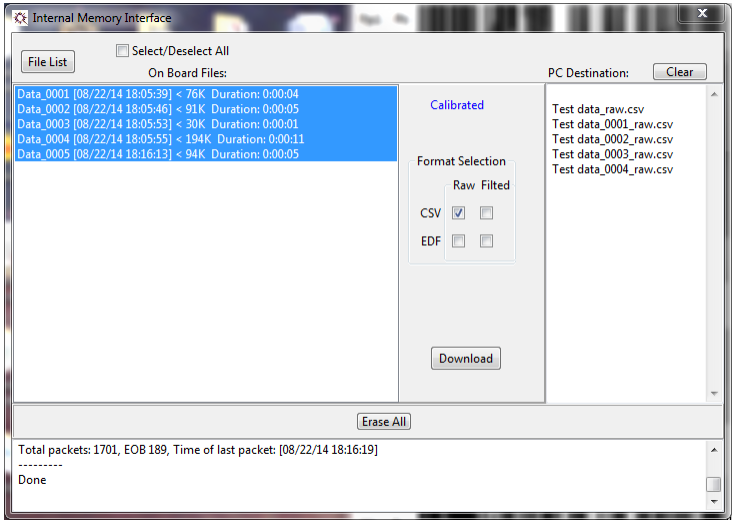


Figure 23 – Internal memory files downloaded to PC hard disk.

- Data stored in the headset's internal memory can be erased using the **Erase All** button.
  - Note that this will erase **ALL** contents of internal memory, not only the selected file.
- Date and time information recorded in headers (see section 6.5) of files exported into edf or csv format indicate time at the beginning of data recording and not that of export

6.5 Replaying DSI-Streamer Files

Data previously recorded using DSI-Streamer can be replayed by selecting the **File** option in the **Data Source** tab in the main window (Figure 24).

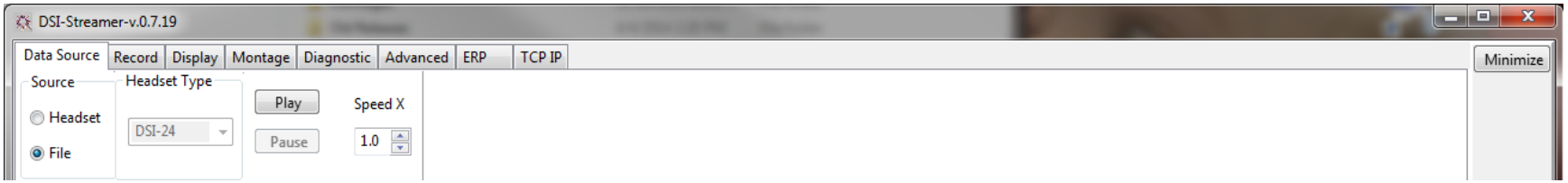


Figure 24 – Options for playback of previously recorded data.

- Press the **Play** button to open an "Open existing file" dialog window (Figure 25).
  - Select the file to replay.

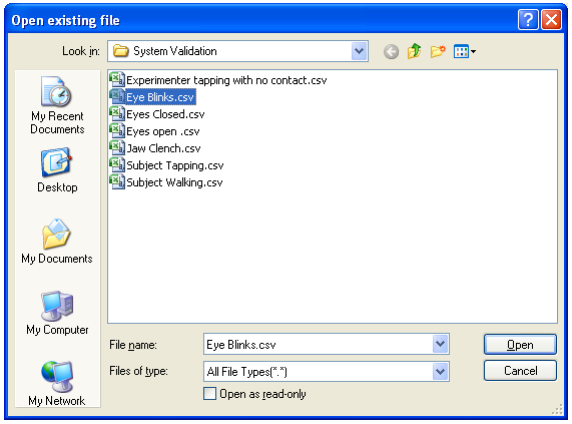


Figure 25 – Open existing file dialog window.

- The selected data file will be opened and played back from the start of the file (Figure 26).
  - The **Play** button changes to a **Stop** button.
  - The **Pause** button is no longer grayed out.

- The Headset Type is automatically detected from the data files (for newer datafiles), or can be manually selected before the start of replay.
- The "Replay at speed X" option controls the playback speed.
    - Enter a number > 1 to play back data faster (i.e. use a value of 2 to display 2 seconds of acquired data for every second of playback.)
- Data playback can be paused/resumed by clicking the **Pause** button.
- Data playback can be stopped by clicking the **Stop** button.
- Refer to Sections 8.1 & 8.2 for how to change montages & display parameters.

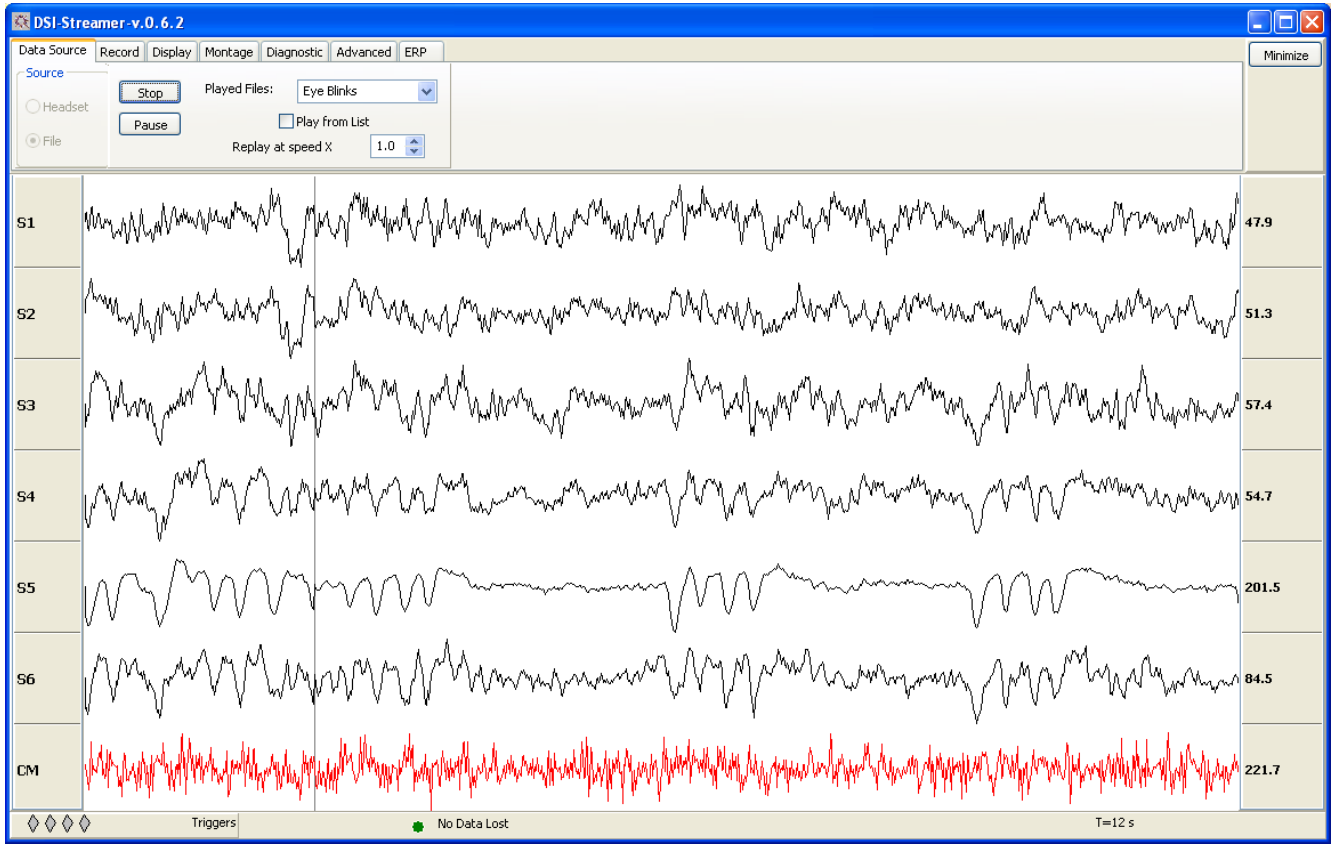
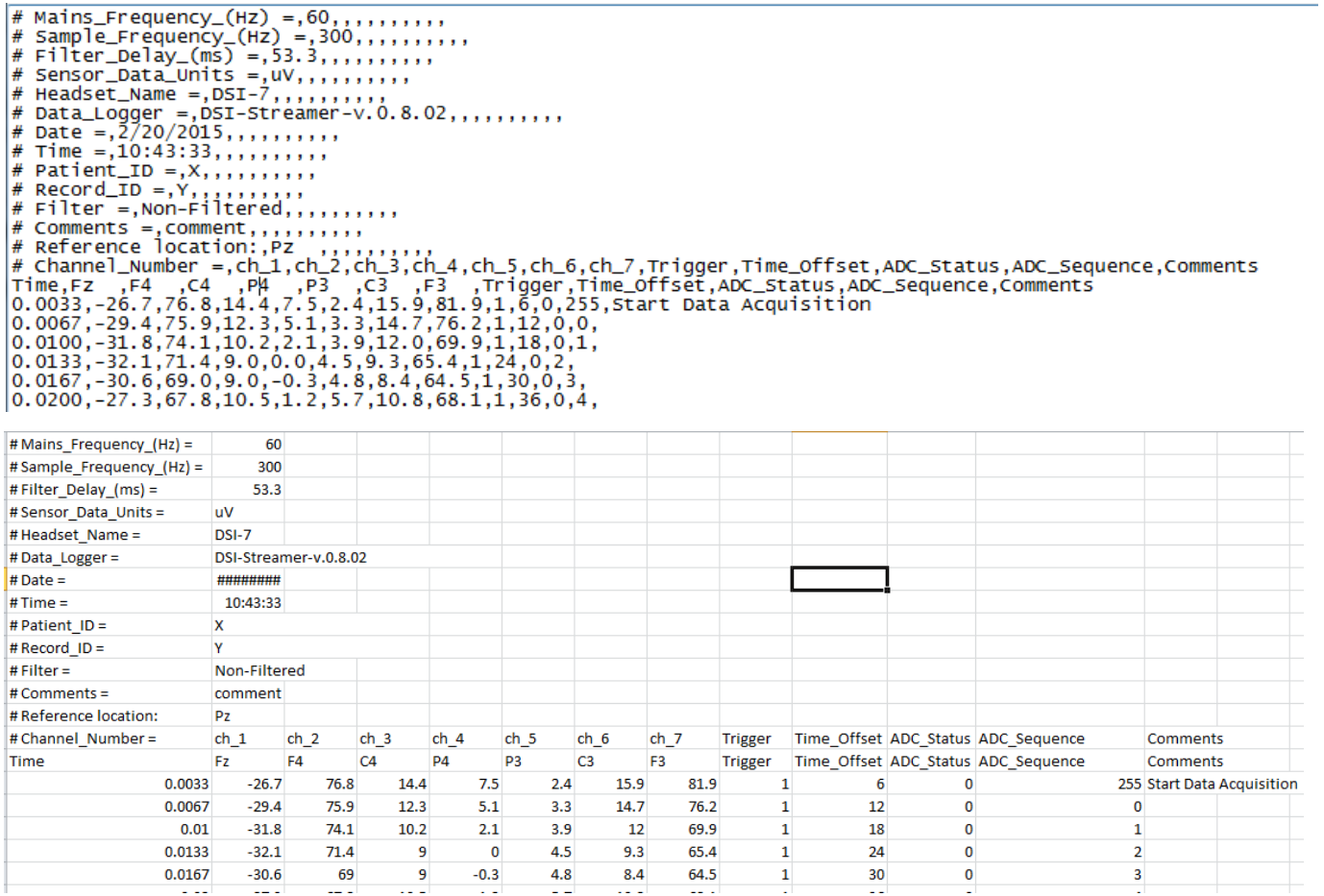


Figure 26 – Playback of a DSI-Mini EEG file showing eye-flutters.

6.6 Data Format for DSI-Streamer .CSV Files

Figure 27 shows a DSI-Streamer .CSV file opened using a text editor and a spreadsheet editor.



```
# Mains_Frequency_(Hz) =,60,,,,,,,,,
# Sample_Frequency_(Hz) =,300,,,,,,,,,
# Filter_Delay_(ms) =,53.3,,,,,,,,,
# Sensor_Data_Units =,uV,,,,,,,,,
# Headset_Name =,DSI-7,,,,,,,,,
# Data_Logger =,DSI-Streamer-v.0.8.02,,,,,,,,,
# Date =,2/20/2015,,,,,,,,,
# Time =,10:43:33,,,,,,,,,
# Patient_ID =,X,,,,,,,,,
# Record_ID =,Y,,,,,,,,,
# Filter =,Non-Filtered,,,,,,,,,
# Comments =,comment,,,,,,,,,
# Reference location:,Pz  ,,,,,,,,,
# Channel_Number =,ch_1,ch_2,ch_3,ch_4,ch_5,ch_6,ch_7,Trigger,Time_Offset,ADC_Status,ADC_Sequence,Comments
Time,Fz  ,F4  ,C4  ,P4  ,P3  ,C3  ,F3  ,Trigger,Time_Offset,ADC_Status,ADC_Sequence,Comments
0.0033,-26.7,76.8,14.4,7.5,2.4,15.9,81.9,1,6,0,255,Start Data Acquisition
0.0067,-29.4,75.9,12.3,5.1,3.3,14.7,76.2,1,12,0,0,
0.0100,-31.8,74.1,10.2,2.1,3.9,12.0,69.9,1,18,0,1,
0.0133,-32.1,71.4,9.0,0.0,4.5,9.3,65.4,1,24,0,2,
0.0167,-30.6,69.0,9.0,-0.3,4.8,8.4,64.5,1,30,0,3,
0.0200,-27.3,67.8,10.5,1.2,5.7,10.8,68.1,1,36,0,4,
```

# Mains_Frequency_(Hz) =	60											
# Sample_Frequency_(Hz) =	300											
# Filter_Delay_(ms) =	53.3											
# Sensor_Data_Units =	uV											
# Headset_Name =	DSI-7											
# Data_Logger =	DSI-Streamer-v.0.8.02											
# Date =	########											
# Time =	10:43:33											
# Patient_ID =	X											
# Record_ID =	Y											
# Filter =	Non-Filtered											
# Comments =	comment											
# Reference location:	Pz											
# Channel_Number =	ch_1	ch_2	ch_3	ch_4	ch_5	ch_6	ch_7	Trigger	Time_Offset	ADC_Status	ADC_Sequence	Comments
Time	Fz	F4	C4	P4	P3	C3	F3	Trigger	Time_Offset	ADC_Status	ADC_Sequence	Comments
0.0033	-26.7	76.8	14.4	7.5	2.4	15.9	81.9	1	6	0	255	Start Data Acquisition
0.0067	-29.4	75.9	12.3	5.1	3.3	14.7	76.2	1	12	0	0	
0.01	-31.8	74.1	10.2	2.1	3.9	12	69.9	1	18	0	1	
0.0133	-32.1	71.4	9	0	4.5	9.3	65.4	1	24	0	2	
0.0167	-30.6	69	9	-0.3	4.8	8.4	64.5	1	30	0	3	

Figure 27 – DSI-Streamer data file opened using a text editor (top) and a spreadsheet editor (bottom).

The file possesses the following features:

- Comma separated value (.csv) format.
- Header information:
  - Each line in the header contains the same number of entries as the number of data columns (as indicated by the trailing commas)
  - Line 1: **Mains_Frequency** – used to specify notch filtering in post-processing.
  - Line 2: **Sampling_Frequency** (in Hz)
  - Line 3: **Filter_Delay** – delay (in ms) introduced by digital filters in the firmware of Wearable *Sensing*'s EEG systems.
  - Line 4: **Sensor_Data_Units** – uV or ADC counts.
  - Line 5: **Headset_name** – Wearable *Sensing*'s EEG hardware used to acquire data.
  - Line 6: **Data_Logger** – Wearable *Sensing*'s EEG software and version used to acquire data.
  - Line 7: **Date** – Date of start of data acquisition (mm/dd/yyyy).
  - Line 8: **Time** – Time of start of data acquisition (hh/mm/ss).
  - Line 9: **Patient_ID** – Subject ID information that can be entered in the record tab.
  - Line 10: **Record_ID**—Record ID information that can be entered in the record tab.
  - Line 11: **Filter** – Indicator or whether the saved data is **Non-Filtered** or **Filtered**.
  - Line 12: **Comments**—field for entering comments about the file
  - Line 13: **Channel_Number** – Followed by text descriptors for each channel of data acquisition.
  - Line 14: **Column headers** – Header of data columns: Time, and text descriptors for each channel of data acquisition, Triggers, and error checking fields (Time_offset, ADC_Status, and ADC_sequence)

- Data information:
  - Column 1: **Time** – Time in seconds since start of acquisition.
  - Column 2 to N+1: **Channel number –** Channel number of N channels of acquisition, including reference sensor.
  - Column N+2: **Trigger** – Value of multi-input trigger, expressed as a decimal number.
    Value is derived from a binary representation of the M triggers, where 0=no trigger, 1=trigger.
  - Column N+3: **TimeOffset** – Number of system clock ticks elapsed since system was turned on.
    The example in Figure 27 has 6 clock ticks per data reading.
  - Column N+4: **ADC_Status** –Status of Analog/Digital Converter used by Wearable *Sensing*'s engineers troubleshooting purposes.
  - Column N+5: **ADC_Sequence** – Sequence number of Analog/Digital Converter that is used for identifying dropped data packets.
  - Column N+6: **Comments:** When inserting custom events, any event labels go into this column. See Chapter 6.3 for more details.

7 ERP Analysis

The analysis and presentation of ERP data can be controlled using the **ERP** tab in the main window (Figure 28).

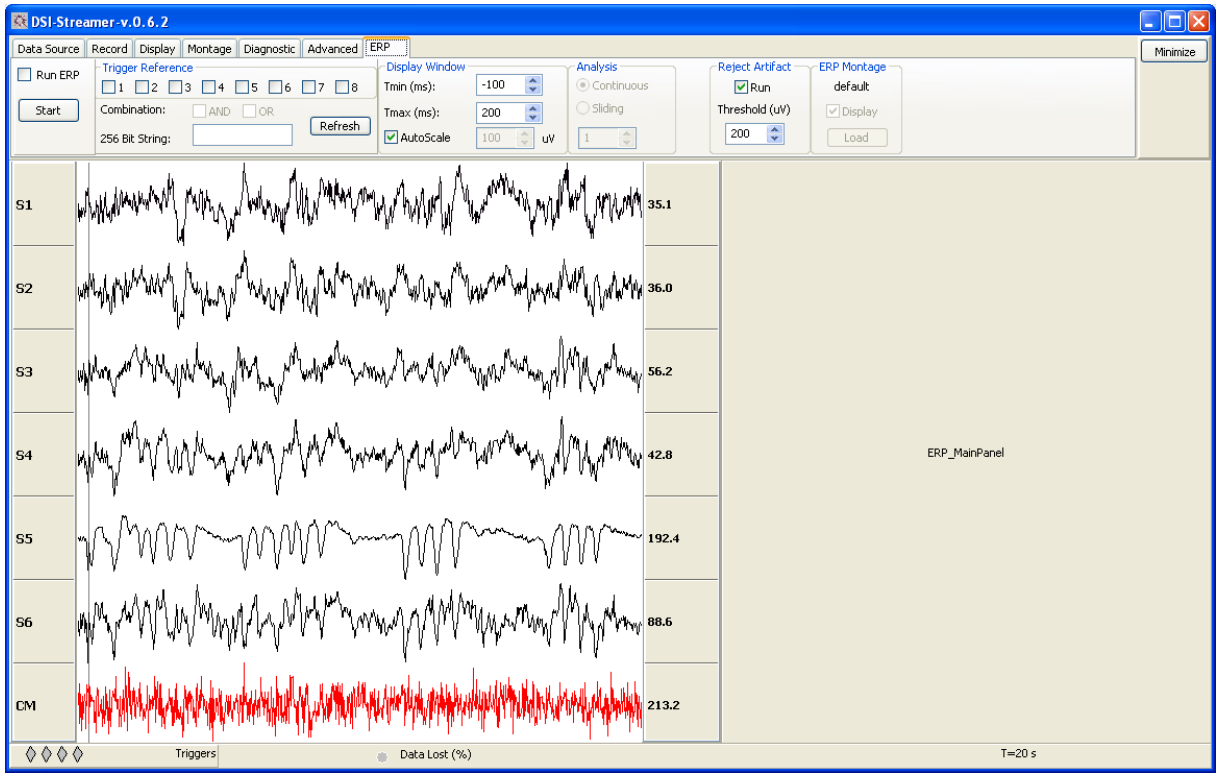


Figure 28 – ERP tab.

The ERP tab is not yet fully supported. Updated documentation will be provided when ERP functionality is complete.

8 Modifying the Display in DSI-Streamer

8.1 Setting Display Parameters

The presentation of EEG data can be modified by selecting the **Display** tab in the main window (Figure 29).

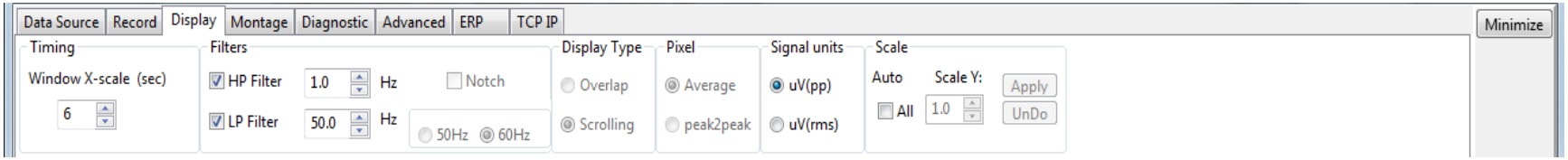


Figure 29 – Display options for EEG data.

- **Timing** section: Time (X-axis) control
  - **Window X-scale** changes the horizontal time span of the display. This option is inactive during streaming or replay.
  - Data updates at a rate set by the **Screen Refresh Rate** (under the **Advanced** tab). Default is update rate of 5 times per second.
- **Filters** section: High Pass & Low Pass filtering applied to displayed data. (*Data can be saved unfiltered or with the Filters specified here (See section 6.2)).*
  - Check the **HP Filter** checkbox to turn on a high pass filter with a corner frequency set by the **HP Filter** edit field.
  - Check the **LP Filter** checkbox to turn on a FIR low pass filter with an upper frequency limit set by the **LP Filter** edit field.
  - At present, no notch filters are included.
- **Display Type** section
  - Specifies the type of screen refresh, whether the data scroll across the screen or overlap following a tracer. *(This option is currently disabled.)*
- **Pixel** section: determines how data is interpolated on the vertical axis. *(This option is currently disabled.)*
  - **Average**" Display graph plots the average y-value spanning the time duration of a horizontal pixel.
  - **Peak2Peak**" Display graph plots vertical bars spanning the peak-to-peak amplitude of the signal at each horizontal pixel.
- **Signal Units** section: sets the value that appears at the right of each trace (see Figure 14).
  - **uV(pp)** radio button: peak-to-peak voltage (max.-min.) for data filtered using settings from the Filter section, for the data displayed on the screen.
  - **Offset** radio button: DC offset of the acquired (unfiltered) data.
    Note that in Wearable *Sensing*'s EEG hardware this does not correspond to the DC offset at the input of the sensor; the signals from Wearable *Sensing*'s EEG sensors are AC-coupled prior to digitization. The option for displaying the DC offset is provided as a diagnostic tool.
- **Scale** section: Voltage (Y-axis) controls
  - Check the **Auto** checkbox to autoscale each channel, which causes a separate scaling is applied to each channel, based on the peak-to-peak signal voltage observed on the channel.
  - Uncheck the **Auto** checkbox to enable manual **scaling**. The number entered into the edit field multiplies or divides the y-scale of ALL channels.

8.2 Setting Montages

The montage is the selection of EEG channels, or combinations of EEG channels, that are displayed on the screen during data streaming or playback. Montages can be created or selected using the **Montage** tab in the main window (Figure 30).

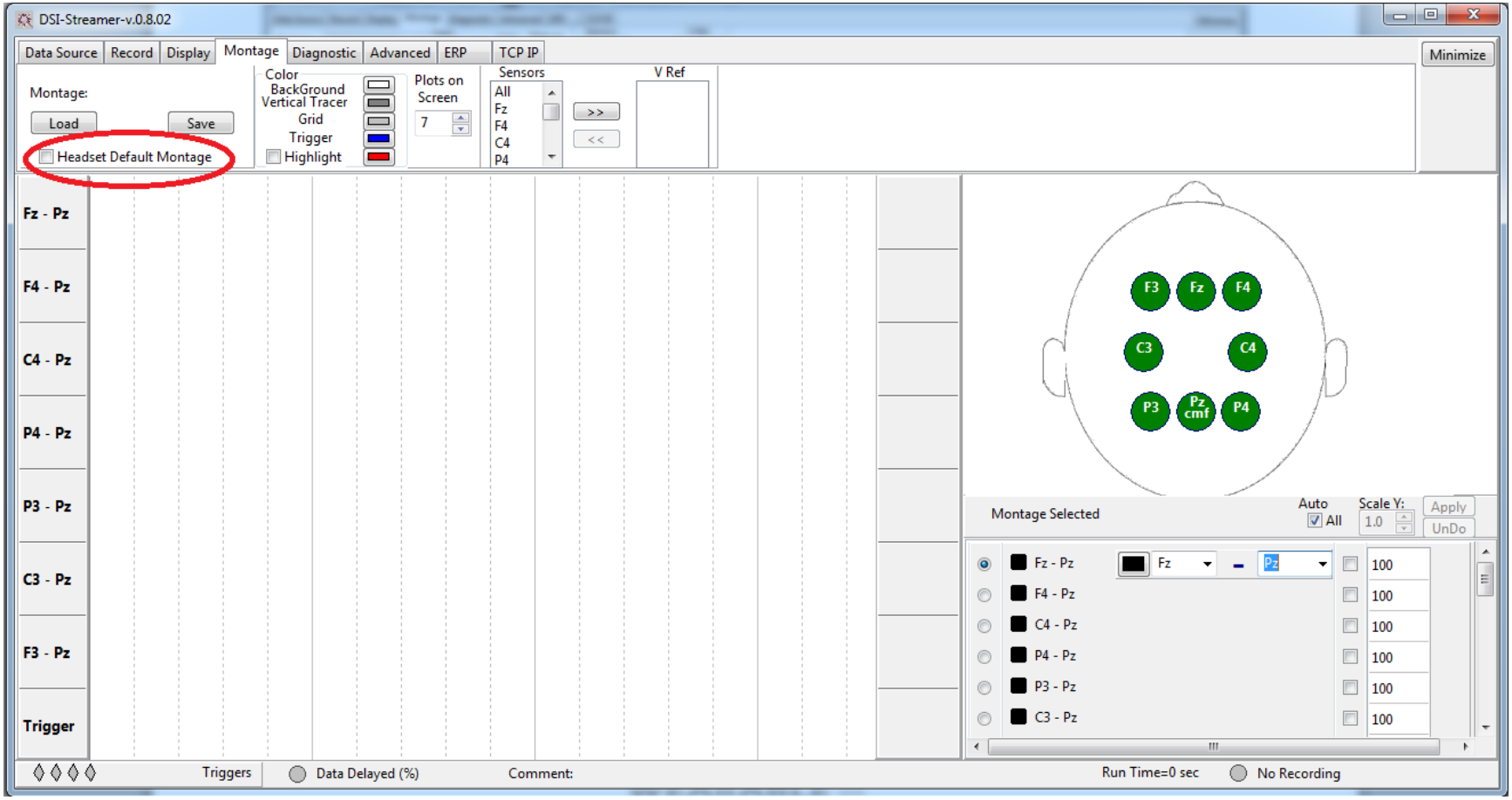


Figure 30 – Montage tab showing default montage for DSI-7.

Montage Controls:

- **Headset Default Montage Checkbox (circled in** Figure 30 **in red)**
  - When this checkbox is checked, the default montage for a given headset will be used for displaying data
  - To change any features of the montage, this box must first be unchecked.

- **Montage selected** (lower right corner of **Montage** tab)
  - Click the radio button for the channel that you wish to change.
  - Use the two drop-down menus to select channels to create a difference signal (i.e. re-reference the signal in one sensor to another sensor).
    In Figure 30, channel 1 has been assigned Fp1-Pz and is being re-assigned to Fp1-C3.
    The label at the left of the trace will show this difference when the montage is loaded.
  - Select "None" from the rightmost drop-down menu to display the signal from the left drop-down menu with respect the system's default reference sensor.
  - Select "None" from both drop-down menus remove channel from montage.
  - Select "CM" from the leftmost drop-down menu to display the signal system's Common-Mode signal (which can be used for assessment of Electromagnetic Interference (EMI). (See headset user manuals for more information)
  - Check the AutoScale check-boxes to specify which channels to Autoscale
  - Checking the Global **Auto** checkbox, autoscales each channel, by applying separate scaling to each channel, based on the peak-to-peak voltage.
    - Or you can manually scale All Channels: The number entered into the edit field multiplies or divides the y-scale of ALL channels.
  - Up to 24 channels may be assigned.
  - Click the color panel to the left of the drop-down menus to open the color palette (**Figure 31**). Choose a color for the channel.
  - Changes take place immediately.
- *Note that changes to the montage only affect the display montages.* ***The saved data are unaffected****.*

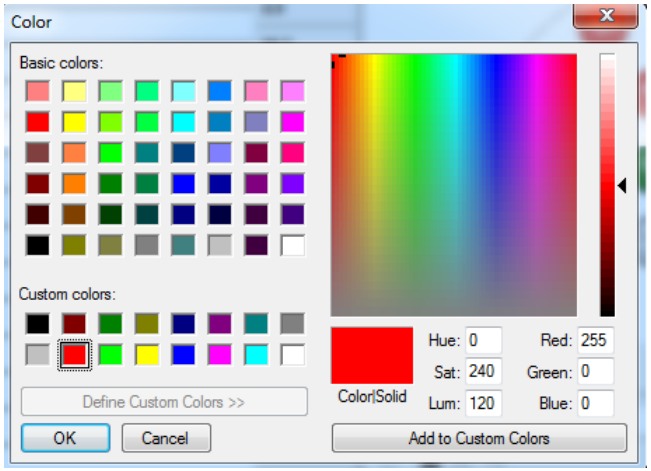


Figure 31 – Color palette

- **Plots on Screen** edit field
  - Displays the first N channels in the channel list (where N is the number in the **Plots on Screen** edit field).
- **Color** pane
  - Click the **Background** color panel to change the background of the display.
  - Click the **Vertical Tracer** color panel to change the color of the vertical tracer.
- Click the **Save** button to save current settings to a new montage file.
  - This will open a “Save file as” dialog window (Figure 32).
- Click the **Browse** button to load previously saved montages.
  - This will open a “Open existing file” dialog window (Figure 33).
  - Valid DSI-Streamer montage files are saved with a “.mtg” extension.

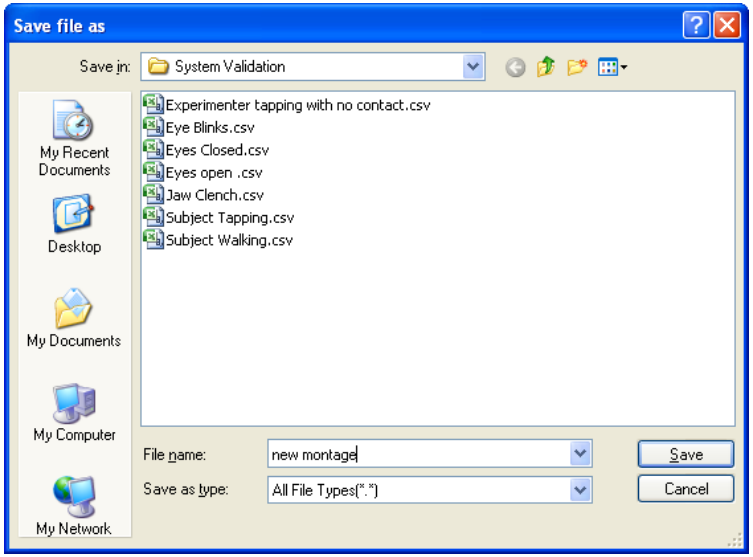


Figure 32 – Save File As dialog window for montage.

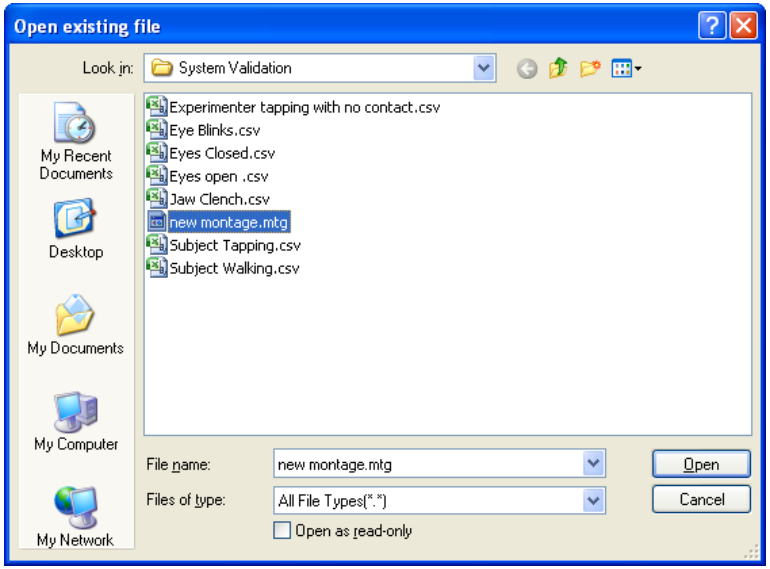


Figure 33 – Open Existing File dialog window for montage.

- **Virtual Reference**
  - These two selection windows allow users to add custom virtual reference channel (V-Ref)
  - Selected sensors are moved between windows with the arrow buttons
  - Signals from sensors in the V-Ref window are averaged to calculate V-Ref
    - V-Ref is available as a channel to use in montage creation

- **Highlight Channel**
  - A single channel can be highlighted using the Highlight checkbox.
  - Check the checkbox, as circled in red in Figure 34.
  - Click on a Channel's name, on the left-hand side of the display.
  - This should highlight the channel in the color selected next to the "Highlight" checkbox.
    - In Figure 34, Channel "F3 – Vref" was highlighted in red.

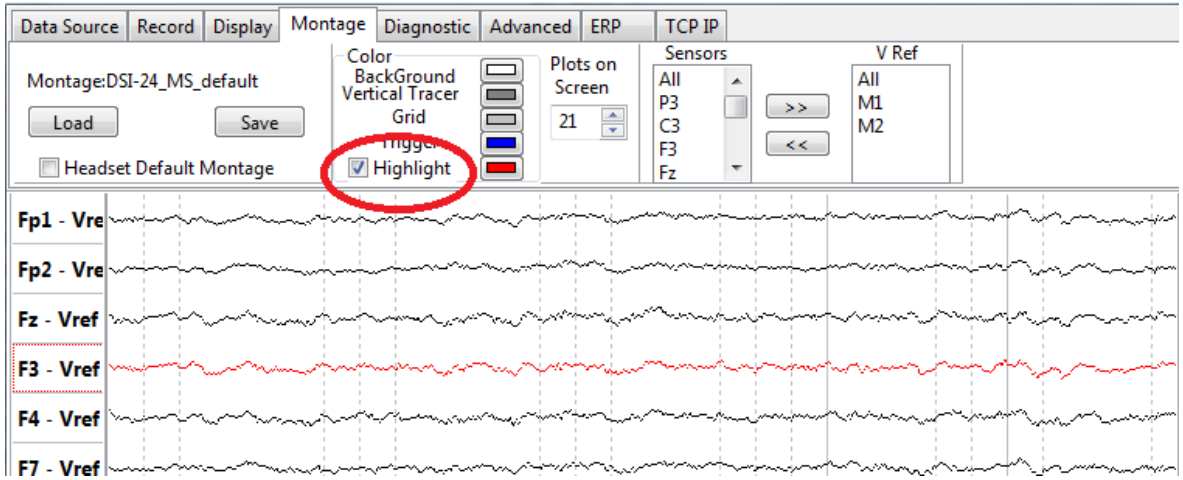


Figure 34 – Highlighting a Channel

8.3 Transverse Montage

DSI-Streamer's default montages include Transverse and Longitudinal which are commonly used in EEG visualizations. To access these montages, observe the following steps:

- When EEG data is streaming, uncheck the "Default Montage" checkbox, as described in Section 8.2.
- Press the "Load" button, and go to the "DSI-Streamer_v.x.x.x/Montages" folder, as seen in Figure 35.
    - Note that the "v.x.x.x" above will be the version of the DSI-Streamer in question, such as 0.8.04, as seen in the Figure.
- If using the DSI-24 headset, select "DSI-24_Transverse.mtg". Otherwise, Select "DSI-7_Transverse.mtg" if using DSI-7.

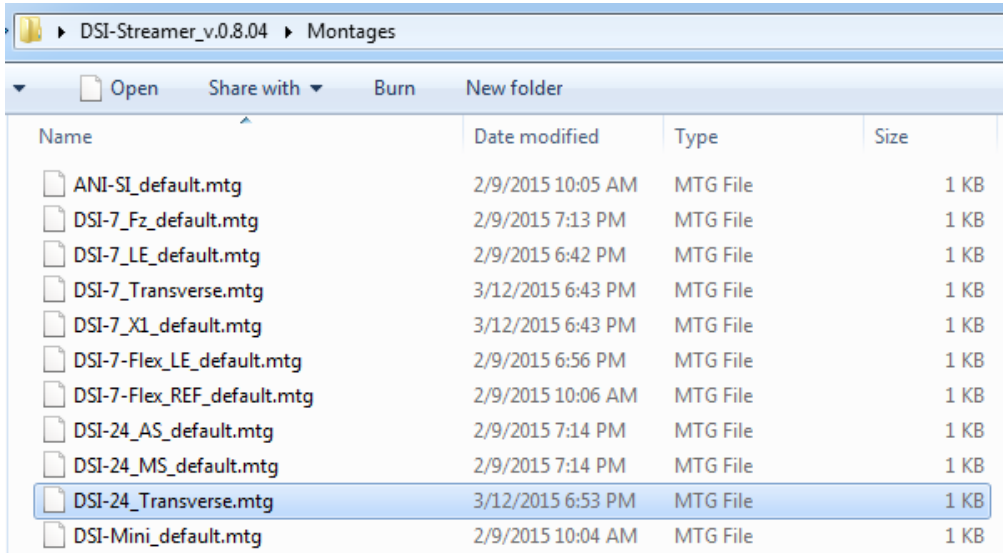


Figure 35 – Montages Folder

8.4 Customizing the Montage (DSI-Flex only)

When running DSI-Streamer with a DSI-Flex EEG system, it is possible to customize the montage labels.

Sensor Locations S1-S7 can be assigned customized names by entering values into the cells in the table seen in the right-hand side of the Montage tab:

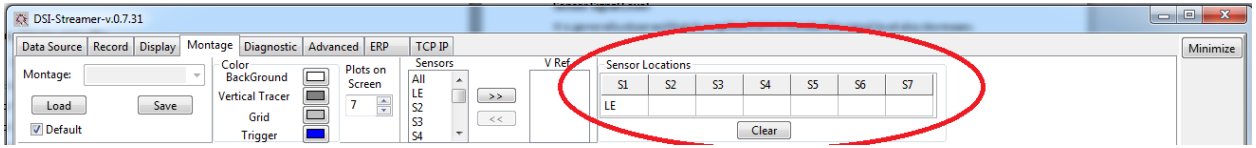


Figure 36 – The Sensor Locations Table

The customized montage names should be stored in any Montage files or EEG data recordings saved in DSI-Streamer.

If you are not seeing the Sensor Locations table seen in the image above, make sure that in the Data Source tab, you have selected “DSI-7 Flex” as the Headset Type in the Data Source tab, as seen in

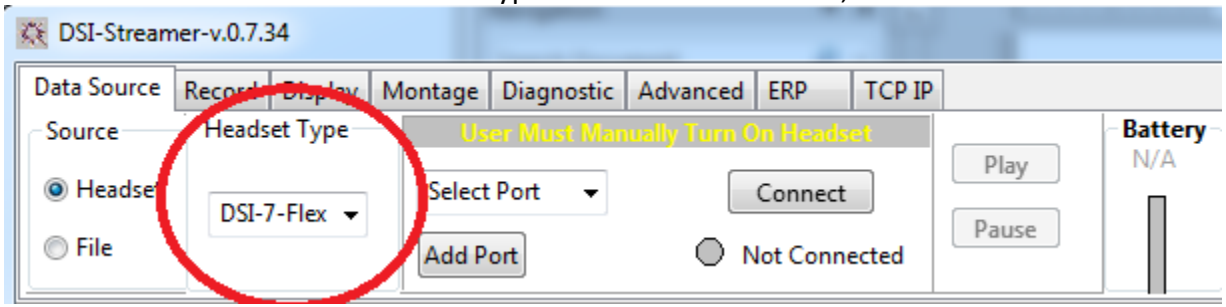


Figure 37 :

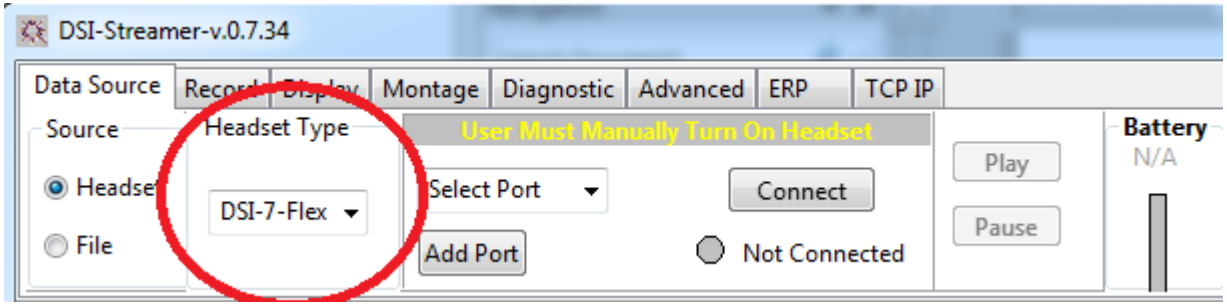


Figure 37 – Specifying Headset Type

9 TCP/IP Socket Tab

9.1 Opening a TCP/IP socket

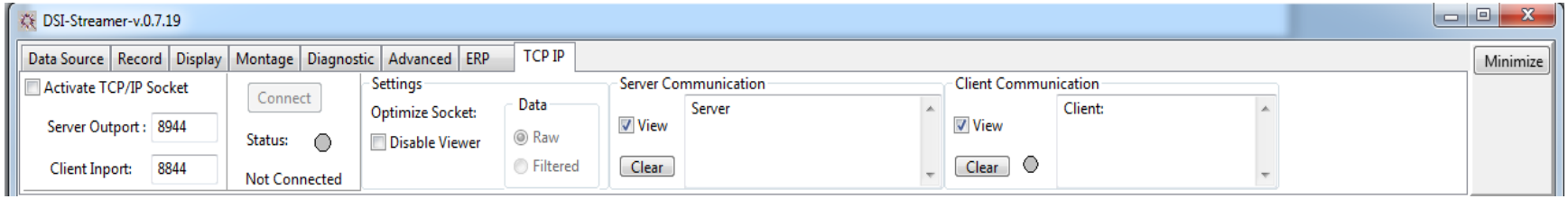


Figure 38 – TCP IP Tab

When the **Activate TCP/IP Socket** checkbox is checked, DSI-Streamer opens an output socket that streams data in real-time. DSI-Streamer opens a port (default: **8844)** as a server and listens for connections. This value can be modified in the **Client Inport** dialogue box in the **TCP IP** tab, as seen in Figure 38 above.

When a client connects to the socket, DSI-Streamer:

- Sends a greeting packet
- Displays feedback in the Client Communication box that the client has connected.

When the TCP/IP **Start** streaming button is pressed:

- sends montage packet(s),

- sends a data rate packet,
- sends a start data packet.
- Begins streaming data if the sensors are running.

As events occur, the appropriate event packet is sent. The greeting, montage, data rate, start data, and stop data packets are all event type packets. The communication protocol and byte structure of the packets is described in *Appendix 1: TCP IP Packet structure*.

9.2 Features of the TCP IP tab

The examples discussed in this section focus on TCP/IP communications in general.
For more information about interfacing DSI-Streamer and QStates for online EEG classification, consult the QStates User Manual.

a. When software such as QStates is prepared to begin receiving information from DSI-Streamer, Check the **Activate TCP/IP Socket** box, as seen in Figure 39:

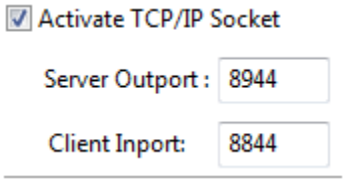


Figure 39 – Activate TCP/IP Socket

b. DSI-Streamer will open a server which can be accessed via the port specified in **Client Inport.**

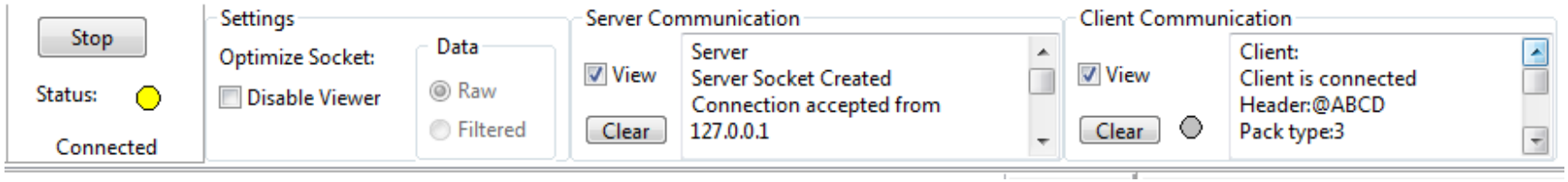


Figure 40 – TCP IP Socket is Connected

c. The **Disable Viewer** box prevents computer resources from being spent on the active display of data. For slower computers, this may be necessary to reduce data transmission lag.

d. Information from both clients and servers can be seen in the **Client Communication** and **Server Communication** windows above. You may disable these windows with the **View** checkboxes.

e. You may halt client and server communications with the **Stop** button at any time. To resume communications, press the **Start** button.

9.3 Interfacing DSI-Streamer with QStates

One of the purposes of TCP/IP socketing in DSI-Streamer is to allow Quasar's QStates software to classify streaming EEG data in real time. This function can be used either with data streaming from a DSI headset or from a previously recorded DSI-Streamer data file. To connect DSI-Streamer to QStates, do the following:

- Open Q-States, and press the "Classify Data" button.
- Select 1, 2, or 3 models from the model database, then press the "Real-Time" button, circled in red in Figure 41.
- A window should appear with text that reads, "Real Time Classification has started". .

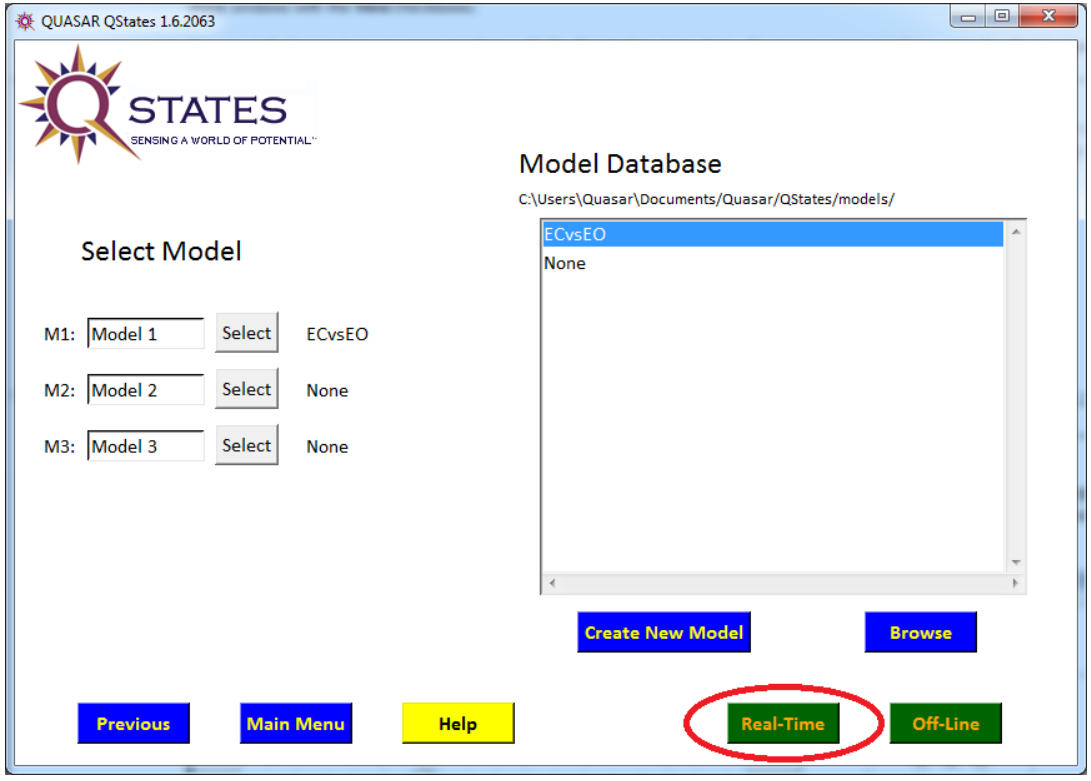


Figure 41 – Q-States Model Selection

- Open DSI-Streamer, and begin streaming data either from a file, or from a headset in the “Data Source” tab.
    - If needed, see Section 6.1 for more information on streaming from a headset or Section 6.5 for directions on how stream from a file.
- Go to the TCP IP tab, and check the “Activate TCP/IP Socket” checkbox, as described in 9.2
- Your Firewall may present a warning, as seen in Figure 42. Allow DSI-Streamer access.

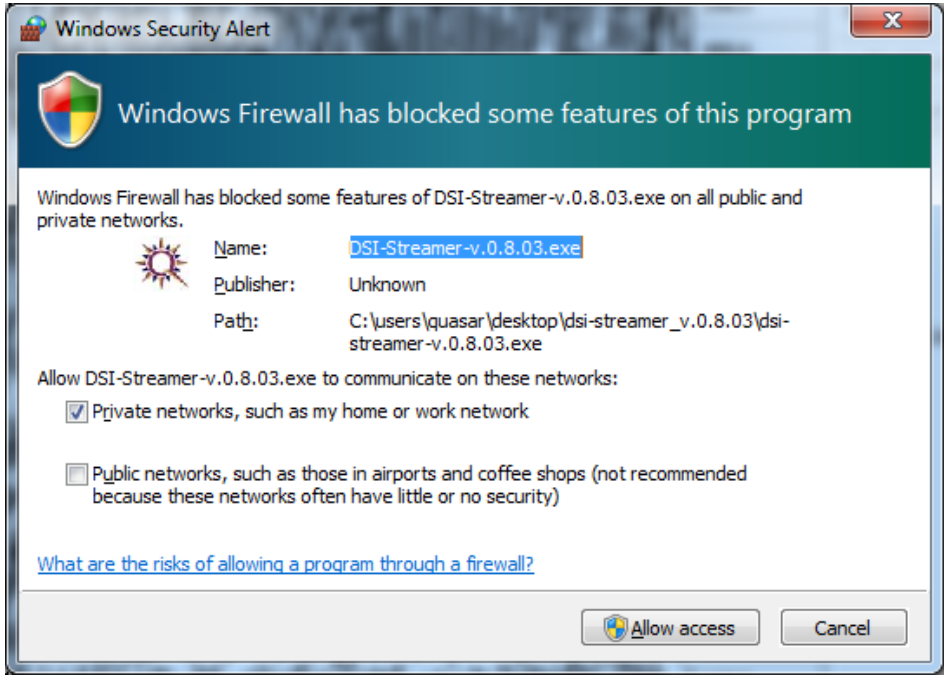


Figure 42 – Firewall Warning

- DSI-Streamer should now be connected with Q-States.
- Both the TCP-IP tab of DSI Streamer (Figure 43) and Q-States (Figure 44) should confirm the connection.
- For information on how to perform real-time classification, refer to the QStates user manual.

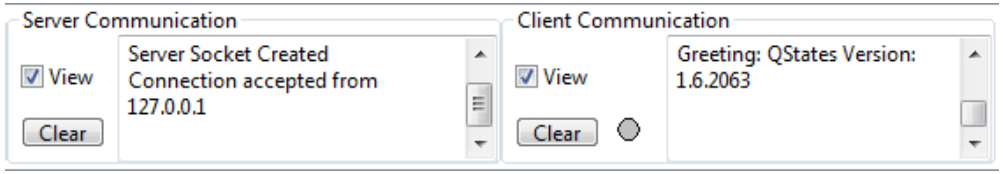


Figure 43 – DSI-Streamer Confirms Connection

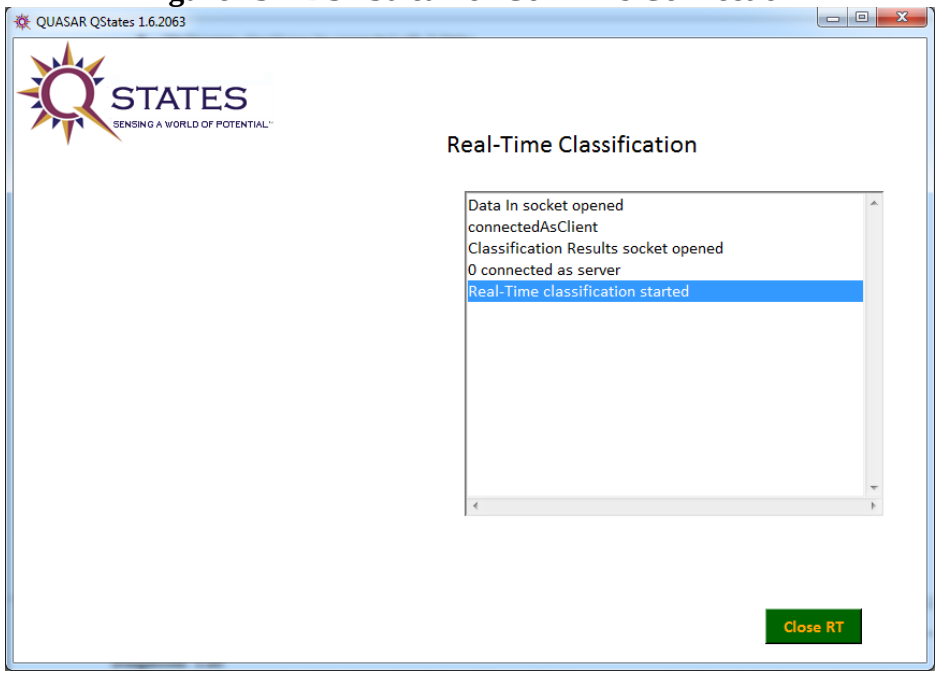


Figure 44 – QStates Confirms Connection

- In the right side of the DSI-Streamer TCP IP tab, you should see the QStates Interface and a Classification Results graph, as seen in Figure 45.
- For each model you selected in QStates, you have the option to display it as "MVNPDF" or "Linear" by using the dropdown menus in the top portion of the display seen in Figure 45.
    - These methods are explained in the QStates manual.
    - The percentage values on the right represent how close the data is to the "high" data selected when training the QStates model, as compared to the "low" state. In Figure 45, we see an "Eyes Closed vs Eyes Open" model, where the participant has alternating periods with his eyes open, and closed.
- The "Reset" button will refresh all values seen in the interface. All classification data displayed will only be shown from that point, forward.
- The "Save to File" button will produce a .csv file with the classification results for the series of time points through which the classification has been running.
- The **Classification Results** displayed in the graph on the bottom are color-coded to the models selected in the drop-down menus above.
    - The range of this display can be altered by unchecking the "All" checkbox below the display. The range can then be narrowed by altering the "Start Time" and "End Time" values.

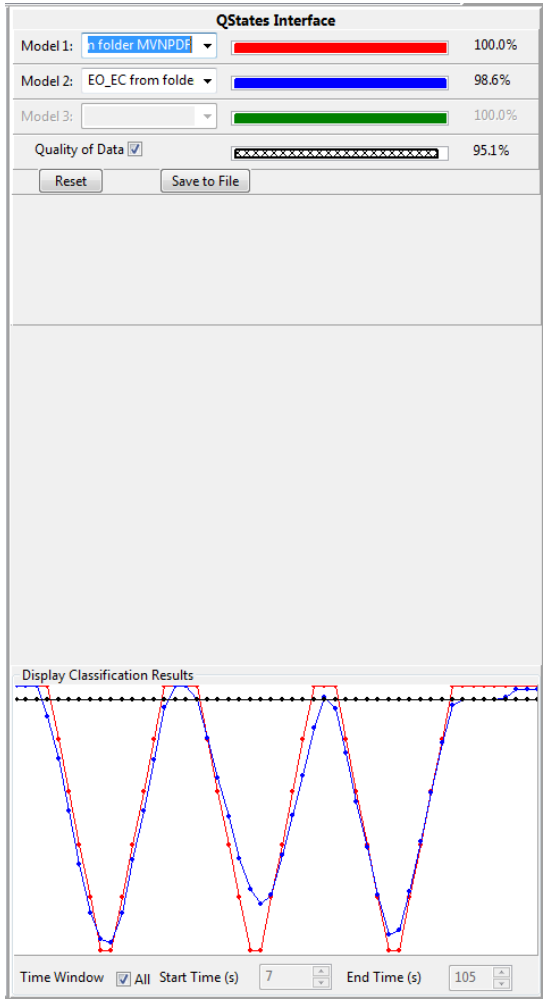


Figure 45 – QStates Interface and Classification Results: Eyes Closed vs Eyes Open

10 Determining Proper Operation of EEG Hardware

Diagnostic Tab

Under the **Diagnostic** tab in the main window (Figure 46), there are several tools to help the user determine proper operation of the system. It has been designed to provide feedback to the user about the operation of the hardware, including contact impedance & noise levels, and to provide suggested troubleshooting procedures.

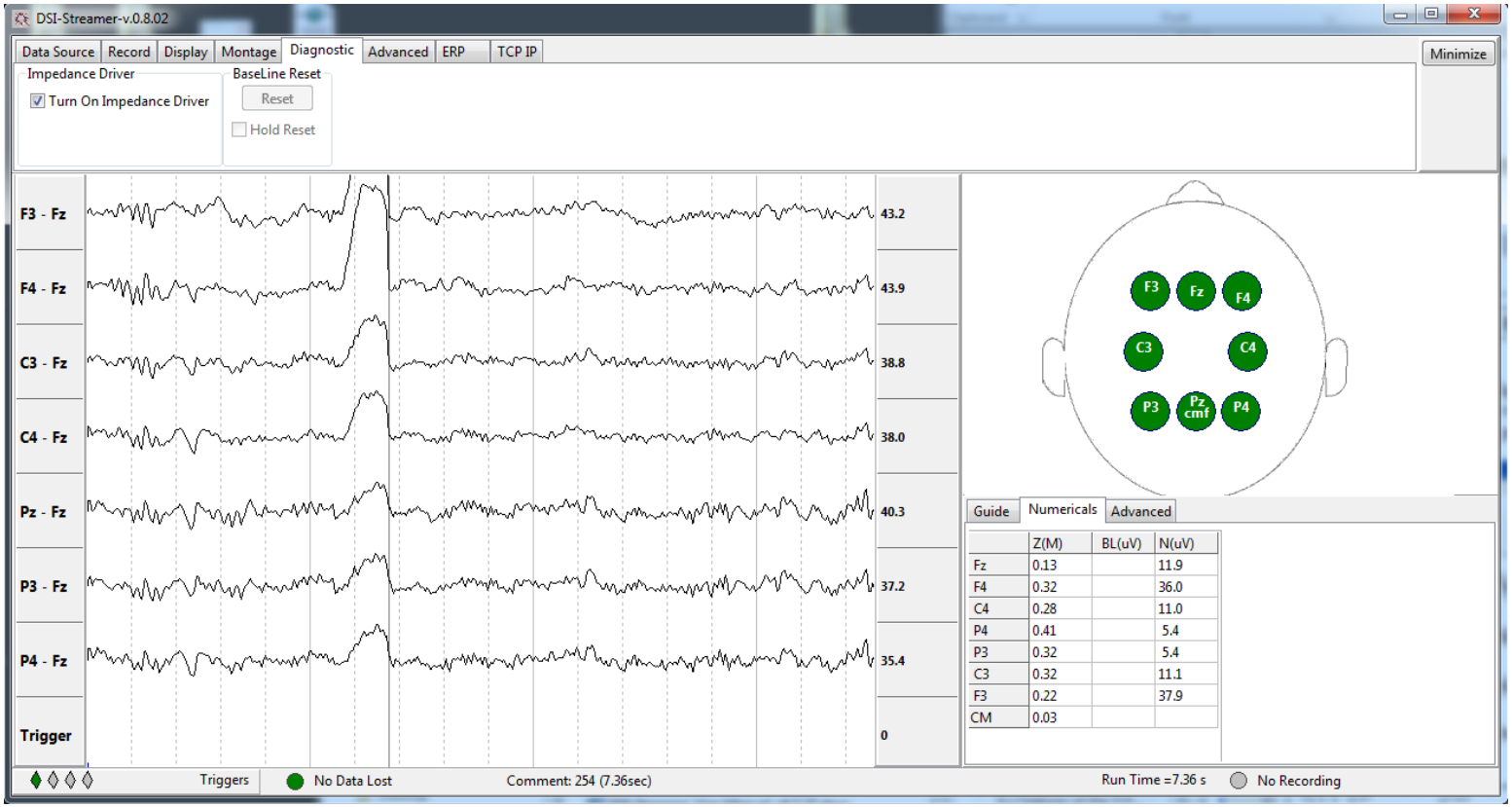


Figure 46 – Diagnostic tab.

Features of the display:

- Contact impedances for the CMF reference sensor and the GND connection are shown in the upper panel.
- **Impedance Driver:** When checked, this activates the Impedance Driver, which applies a miniscule and safe electrical current at 110 and 130Hz to the scalp of the person wearing the DSI-Streamer EEG headset. This allows measurement of the impedance between the electrodes and the scalp.
- **Baseline Reset** control is included in the upper panel.
  Manipulation of the sensors frequently results in transients that can take several minutes to die away. For this reason, the DSI-Mini system is equipped with a Baseline Reset function that momentarily increases the corner frequency of each sensor's high-pass filter to ≈15 Hz. This facilitates a rapid return to equilibrium after the transient.
  - Becomes active when connected to an EEG system.
  - Click the **Reset** button to turn on the Baseline Reset function.
    Reset function is active for 1 second.
  - Check the **Hold** checkbox to hold the Reset function active indefinitely the next time the **Reset** button is clicked.
  - While the Reset function is being held active, unclick the **Hold** checkbox and click the **Reset** button to turn off the Reset function.
- Streaming data shown in left panel.
  - The display parameters set by the **Display** tab are still used, with the exception that the horizontal scale has been compressed for the diagnostic panels to the right.
- The top panel on the right contains a **Sensor Map**.
- Sensor status is indicated by the color of the sensor icons
  - **Green**: Proper operation
  - **Yellow**: Marginal operation; check the **Diagnostic Sub-Tab** for recommended action.
  - **Red**: Poor/faulty operation. Consult the **Diagnostic Sub-Tab** for recommended action.

- The **Guide Sub-Tab** (Figure 47) is a trouble shooting guide.
- Users can click on sensors in the **Sensor Map** to obtain troubleshooting information for any particular sensor whose icon is **Yellow** or **Red**.
- Follow the instructions of this guide until all sensors icons are **Green** ("Sensor is Good") message will appear.

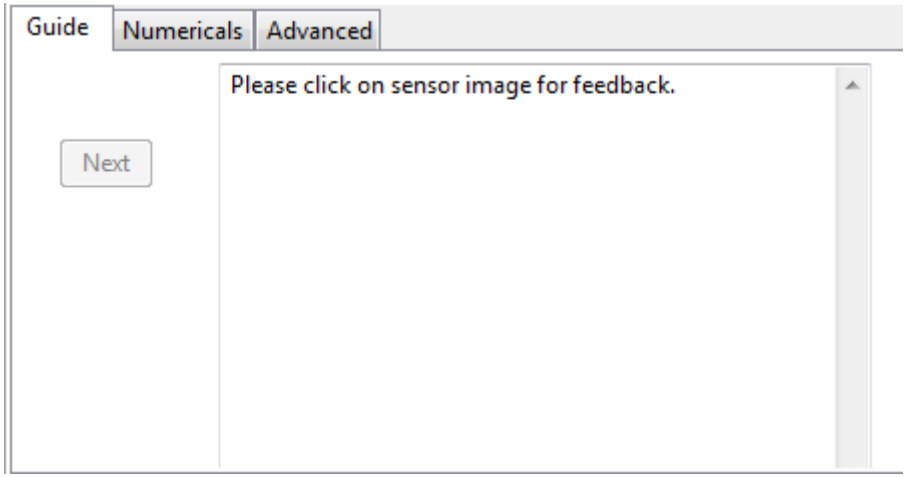
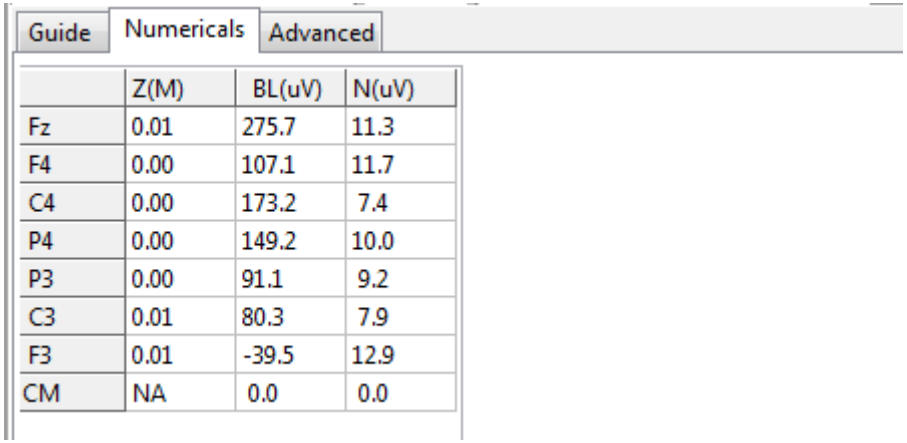


Figure 47 – Guide Sub-tab.

- The **Numericals** subtab displays the following values: Z(M), BL(uV), and N(uV). Figure 48 Z(M) lists contact Impedance, in megaohms. These values will only be populated if the Impedance Driver is activated.
  - Target **impedance** values are **< 1 Mohm**.
- BL(uV) is the baseline voltage in microvolts.
  - BL values should be below 5000 uV
  - BL can be reset by using the "Baseline Reset" button. This is useful if the amplifiers become saturated during donning.
- N(uv) is the measure of RMS noise on a sensor, also in microvolts.
  - Target noise(**N (µVrms)**) values are < **15µVrms**.
    Noise values are the standard deviation of data after filtering in a 100Hz bandwidth, which is independent of the filter settings under the **Display** tab.



	Z(M)	BL(uV)	N(uV)
Fz	0.01	275.7	11.3
F4	0.00	107.1	11.7
C4	0.00	173.2	7.4
P4	0.00	149.2	10.0
P3	0.00	91.1	9.2
C3	0.01	80.3	7.9
F3	0.01	-39.5	12.9
CM	NA	0.0	0.0

Figure 48– Numericals sub-tab.

- The **Advanced Sub-Tab** (Figure 49) allows the user to specify which **Diagnostic Parameters** are used to affect the sensor icon colors.
  - Click the checkboxes to select which parameters are used.
  - **Clipping** turns sensor icons **Red** when amplifier saturation (clipping) occurs. *Clipping cannot be turned off.*
  - **Impedance**, **Noise** and Baseline voltage turn icons **Yellow** or **Red** depending on set thresholds.
  - These thresholds are set in the **Settings Sub-Tab**.
- **Exclude** panel
  - EEG sensors can be ***excluded*** from diagnostic considerations via selection from the **Add to List** drop-down menu.
  - Select a sensor from the **Exclude** window and click on the **Delete** button to reinstate a sensor.
- Uncheck the **'Lock Settings' checkbox** to see the 'Settings' subtab.
  This Sub-tab is for Advanced Users.

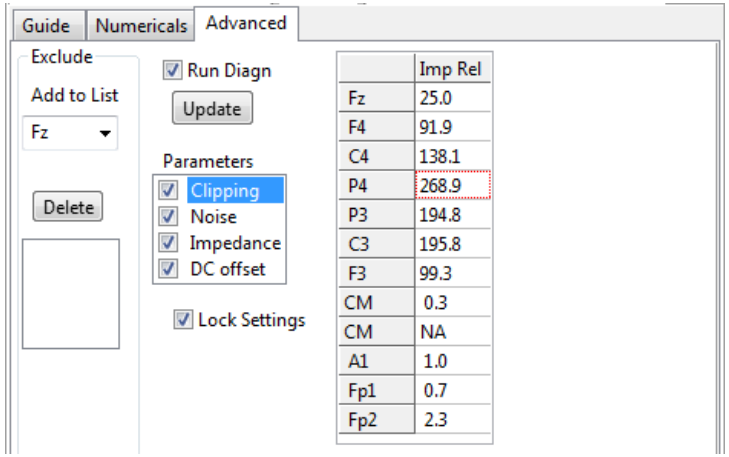


Figure 49 – Advanced sub-tab.

- The **Settings Sub-Tab** (Figure 50) provides a list of parameters to control the **Guide** parameters
  - **Impedance, dB, Noise, DC offset** thresholds are set here.
  - **Impedance** radio buttons specify the impedance values (Sensors or CMF) to be displayed.
  - **Sampling Frequency** can be modified to for systems that support multiple sampling rates.

This Sub-tab is for Advanced Users, and to be seen, it must be unlocked in the 'Advanced' tab.

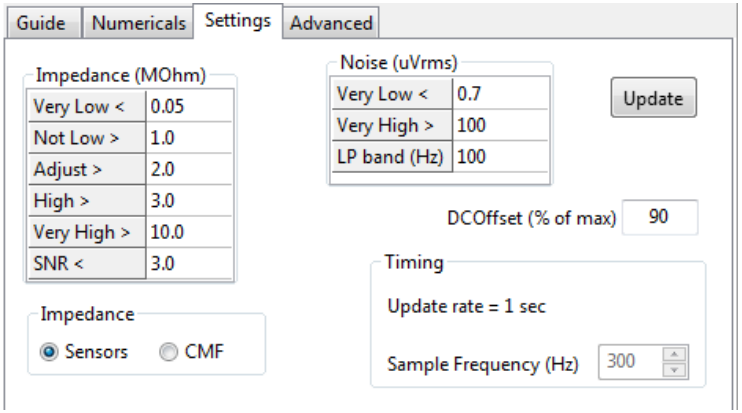


Figure 50 – Settings sub-tab.

11 Advanced Features

The **Advanced** tab in the main window (Figure 51) provides a list of controls that open Control windows and define the file header information that appear in EEG data files saved by DSI-Streamer. The primary purpose of this Tab is intended to assist Customer Service in troubleshooting in the event that technical issues are experienced by the user. However, "Trigger" and "Trigger Fix", the two features highlighted in Figure 51 may be useful to those who use external devices to send event information to DSI-Streamer.

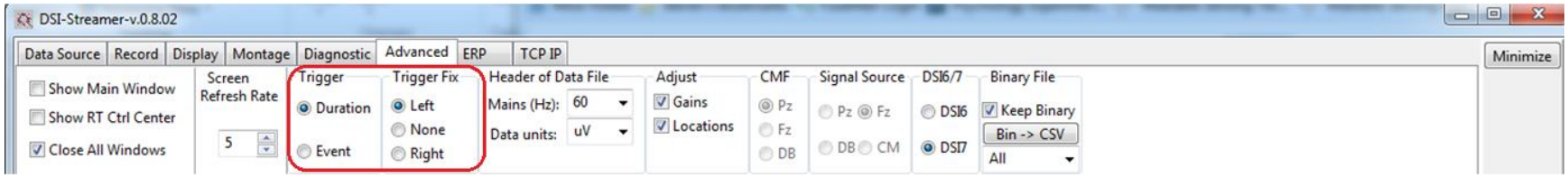
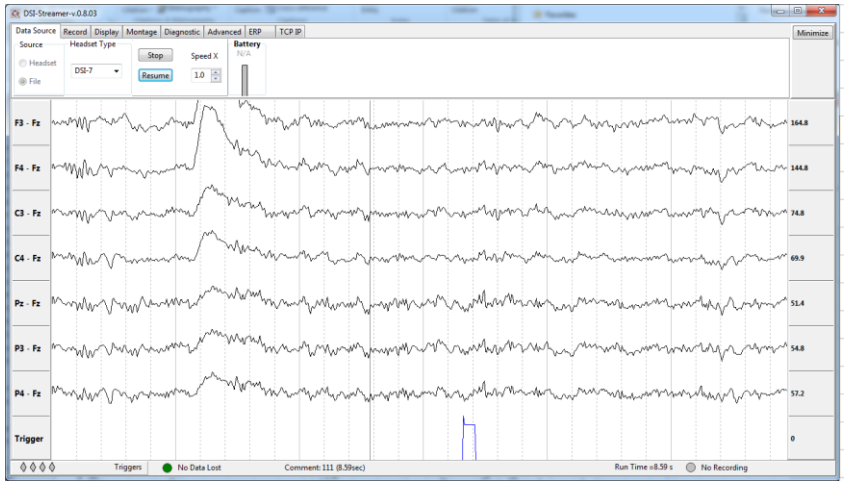


Figure 51 -- Advanced Tab with "Trigger" and "Trigger Fix" Highlighted

Do not change any of the parameters under the Advanced tab unless instructed to do so by* Wearable *Sensing's Customer Service, or unless they are described in this Section.

11.1 Trigger Fix

When DSI-Streamer is recording streaming data, several devices are able to communicate to DSI-Streamer through the Trigger Cable. This data is shown in the Trigger channel. Sometimes, as seen in Figure 52, the Trigger signal may have a slight irregularity to it. What should have been purely a series of 4's in the Trigger values starts off with an anomalous 5.



3.1667	103.5	119.7	-15.9	90.9	152.7	24.6	25.8	0	5700	0	18
3.17	91.5	140.7	-8.1	122.7	168.6	42	32.4	0	5706	0	19
3.1733	118.8	138.6	-8.7	107.4	163.5	40.5	45	0	5712	0	20
3.1767	86.4	105.3	-34.2	72.6	138.3	8.4	14.7	0	5718	0	21
3.18	116.4	168	19.2	153.3	192.6	65.1	56.4	5	5724	0	22
3.1833	80.4	99.9	-41.1	69.9	127.8	1.2	2.7	4	5730	0	23
3.1867	90.6	130.2	-9.9	108.9	162.3	32.4	30.3	4	5736	0	24
3.19	127.8	173.7	21	151.2	193.2	65.7	53.1	4	5742	0	25
3.1933	76.2	86.7	-57	43.5	110.4	-18.9	-8.4	4	5748	0	26
3.1967	140.1	186.9	37.2	164.1	214.5	87.6	75	4	5754	0	27
3.2	79.5	111	-42	80.7	131.7	10.5	-2.7	4	5760	0	28
3.2033	114.6	134.1	-17.1	88.5	156.9	28.8	29.1	4	5766	0	29
3.2067	126.6	178.5	19.5	145.2	188.4	67.2	52.2	4	5772	0	30
3.21	100.2	121.5	-30	76.8	129.9	6.9	6.3	4	5778	0	31
3.2133	133.8	159.9	12.3	117	174.3	54.6	58.8	4	5784	0	32
3.2167	96.9	152.7	-2.1	130.5	163.8	45	31.5	4	5790	0	33
3.22	120.9	138.6	-10.5	96.3	151.2	33.6	39.3	4	5796	0	34

Figure 52 – An Irregular Trigger, in DSI-Streamer (Left) and in the Recorded .CSV (Right)

There are 3 different ways that DSI-Streamer can deal with this irregularity when recording the data. In the "Trigger Fix" field of the Advanced Tab, circled in red in Figure 51, there are three options: "Left", "None", and "Right". While none of these will alter how the data is displayed in the DSI-Streamer window while the data is streaming, they will affect how data is logged in the "Trigger" column, as seen in Figure 53:

a)

91.8	62.1	0	7608
87.6	67.2	0	7614
73.2	63.6	1	7620
56.1	51	1	7626
43.8	37.2	1	7632
37.5	31.2	1	7638
37.8	40.2	1	7644
47.1	63.9	1	7650
66.9	93.6	0	7656

b)

91.8	62.1	0	7608
87.6	67.2	3	7614
73.2	63.6	1	7620
56.1	51	1	7626
43.8	37.2	1	7632
37.5	31.2	1	7638
37.8	40.2	1	7644
47.1	63.9	1	7650
66.9	93.6	0	7656

c)

91.8	62.1	0	7608
87.6	67.2	1	7614
73.2	63.6	1	7620
56.1	51	1	7626
43.8	37.2	1	7632
37.5	31.2	1	7638
37.8	40.2	1	7644
47.1	63.9	1	7650
66.9	93.6	0	7656

Figure 53 – Trigger Fix Option: a) Left Trigger Fix, b) No Trigger Fix, and c) Right Trigger Fix

Above, we see the three different Trigger Fix settings dealing with the same event:

- "Left" setting replaces the anomalous value with whatever came before it, in this case, a "0".

- "None" option does not modify the anomalous value, leaving an incongruous 3 before a series of 1's.
- "Right" replaces the anomalous value with what came afterwards, in this case, 1.

11.2 Trigger Event and Trigger Duration

Also seen in the red circle in Figure 51 is the option to set Trigger to either "Duration", or "Event".

- "Duration", the default value, records all points in time where the Trigger value is nonzero.
- "Event", if selected, reduces these triggers to a single value, as seen in Figure 54. These are the first nonzero values from their counterparts in Figure 53.

91.8	62.1	0	7608
87.6	67.2	0	7614
73.2	63.6	1	7620
56.1	51	0	7626
43.8	37.2	0	7632
37.5	31.2	0	7638
37.8	40.2	0	7644
47.1	63.9	0	7650
66.9	93.6	0	7656

91.8	62.1	0	7608
87.6	67.2	3	7614
73.2	63.6	0	7620
56.1	51	0	7626
43.8	37.2	0	7632
37.5	31.2	0	7638
37.8	40.2	0	7644
47.1	63.9	0	7650
66.9	93.6	0	7656

91.8	62.1	0	7608
87.6	67.2	1	7614
73.2	63.6	0	7620
56.1	51	0	7626
43.8	37.2	0	7632
37.5	31.2	0	7638
37.8	40.2	0	7644
47.1	63.9	0	7650
66.9	93.6	0	7656

Figure 54 – 'Left' Event, 'None' Event, 'Right' Event

11.3 Data Recovery in case of system crash

In the case of a DSI-Streamer crash, the binary files generated by DSI-Streamer (.dsi files) may be used to generate .csv data files. Simply press the "Bin->CSV" button in the right side of this tab, and select the .dsi file generated during the crashed recording session.

In addition, if you do not want DSI-Streamer to retain this .dsi file with each recording, uncheck the "Keep Binary" checkbox when loading from the .dsi binary file. This will delete the binary file when it has been restored into a .csv data file during the normal course of operation. See Section 13.2 for further information.

12 Appendix 1: TCP IP Packet structure

All packets sent through Wearable *Sensing*'s TCP/IP socketing have the same header structure. The purpose of the header is to have a delimiter to define the beginning of the packet and to define the packet type, length of the packet and the packet number. The header consists of 12 bytes. The packet data follows the header.

All numeric data is in **big-endian format**, both for unsigned integers and floating point numbers.

The "Byte Offset" indicates the byte number in the packet where the given packet element starts. Notice that the Packet Start element begins at byte offset = 0 and is 5 bytes long. That means that the Packet Start element is the first 5 bytes of the packet. Also notice that the byte offset plus the element length is the byte offset of the next element.

	Field	**Byte Offset**	**Element Length**	**Data Type**	**Description**
Header	Packet Start	0	5 bytes	ASCII	All packets start with "@ABCD "
	Packet Type	5	1 byte	Unsigned Integer	1 EEG Sensor Data 2-4 Reserved 5 Event
	Packet Length	6	2 bytes	Unsigned Integer	Number of bytes in the packet after the header.
	Packet Number	8	4 bytes	Unsigned Integer	The packet number starts at 0. The server increments for every packet it sends.
Data		12	Packet Length number of bytes	Depends on Packet Type	Packet payload

12.1 Event Packets

Event packets, like all other packets start with the 12 byte header that is described in the proceeding section. An event packet will be identified by having a value of 5 in the packet type byte (fifth byte) of the packet header. The first 8 bytes of an event packet data section describe the event type and the sending node. If there is a message included with the event, it will be included as an ASCII string following the 8 byte event description.

Field	Byte Offset	Element Length	Data Type	Description
Header	0	12 bytes	Mixed	Described in previous section
Event Code	12	4 bytes	Unsigned Integer	See table below
Sending Node	16	4 bytes	Unsigned Integer	0 Not applicable 1 System node
Length of Message	20	4 bytes	Unsigned Integer	The number of bytes in the string. This element will only be present if there is a message attached.
Message	24	Variable	ASCII	The message is optional, not all events have messages.

12.2 Event Codes

The following table describes the meaning of the event codes. The “Status” column indicates the implementation status, NI indicates that the event code is not implemented.

Code	Event	Description	Message
1	Greeting/Version	Server's version and id info.	DSI-Streamer Version: x.y
2	Data start	Data acquisition started on a node	No message
3	Data stop	Data acquisition stopped on a node	No message
4-8	Reserved		
9	Sensor Map	Send a node's sensor list.	Comma delimited list of sensors connected to the node. Disconnected sensors are named '-'.
10	Data Rate	Send user's mains frequency (50 or 60 Hz) and sensor sampling frequency (300, 600, or 900 Hz)	Message contains mains frequency and sampling frequency

12.3 EEG Sensor Data Packet

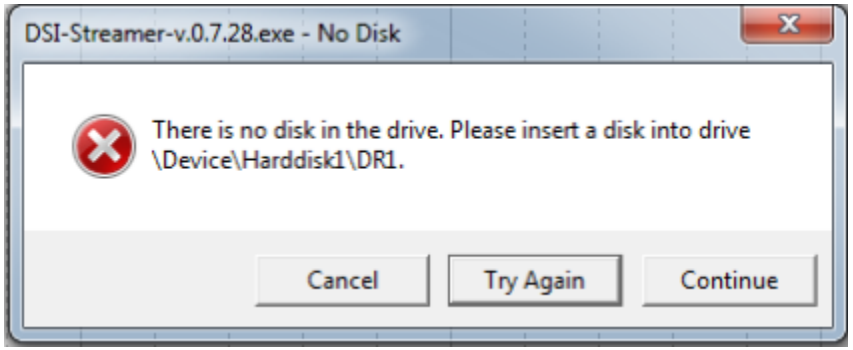
The data section of the EEG sensor packets starts with a timestamp and an ADC status indicator followed by EEG data, typically 25 channels, with Trigger data (TRG) being sent as Ch25.

Field	**Byte Offset**	**Element Length**	**Data Type**	**Description**
Header	0	12 bytes	Mixed	Described in previous section
Timestamp	12	4 bytes	Float	Timestamp of the data point
Data Counter	16	1 byte	Unsigned Integer	Data packet counter from the node *(currently produces 0's only)*
ADC Status	17	6 bytes	Unsigned Integer	2-bits per channel: 00 = off, 01 = OK, 10 = rail low, 11 = rail high (*currently produces sample data*)
Ch1 Data	23	4 bytes	Float	EEG sensor data in uV
Ch2 Data	27	4 bytes	Float	EEG sensor data in uV
…	…	4 bytes	Float	EEG sensor data in uV
ChN Data	4*(Nch-1) + 23	4 bytes	Float	EEG sensor data in uV
ChN+1	4*Nch + 23	4 bytes	Float	Trigger Value (0 or 1)

13 Troubleshooting

13.1 Conflict with Missing SD-Card

As of DSI-Streamer 0.7.28, some users may see the following error window when trying to connect a DSI headset to DSI-Streamer:



If this happens, check if your computer has an SD card slot. If so, place an empty SD card in the slot after closing DSI-Streamer, and try opening it again. It should now be possible to connect DSI-Streamer with your DSI headset. If further issues arise, please contact Wearable Sensing for technical support.

13.2 Restoring Data from a Crashed Recording

In the unfortunate event that DSI-Streamer should crash while recording, it is still possible to recover the data from that recording. DSI-Streamer saves a binary (.dsi) file whenever you record EEG data. This .dsi file can be opened and translated into a .csv data file.

- Note: If you do not want the .bin file to be stored during data recording, to save hard drive space at the risk of losing data during a crash, you may uncheck the "Keep Binary" box.

To recover data from a .bin file, perform the following steps:

- Click on the "Bin -> CSV" button, circled in red in Figure 55.

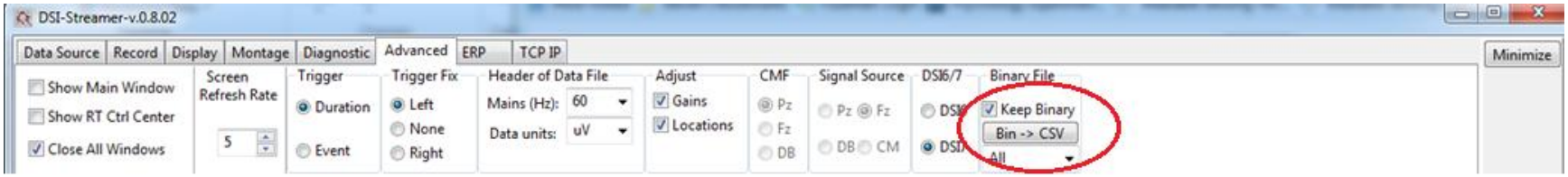


Figure 55 – "Binary File" Tools in the Advanced Tab

- Go to the folder where the EEG data was originally going to be saved. There should be a .bin file with the name you assigned to the recording. Select it.
- There should now be a .csv file generated from the .bin.
- If desired, a single channel from the montage can be selected using the pull-down menu below the "Bin -> CSV" button. All channels are loaded by default.

13.3 Troubleshooting Wired Mode

In case you have trouble connecting the headset in wired mode, it is helpful to follow the following series of operations in order. If you are having trouble getting data to stream, make sure you have done the following:

- Make sure that DSI-Streamer and the DSI-Headset are both deactivated.
- Insert the USB cable into the headset, and connect it to your PC
- Now turn ON the headset by double pressing the Power button.
- Open DSI-Streamer software. It should automatically go to the Diagnostic tab.
    - When you go to the "Data Source" tab, the active COM port should already be the COM port associated with the wired connection.
- Data should now stream properly from your DSI Headset to DSI Streamer through the wired connection.
- If you still have difficulty streaming data through wired mode, please do not hesitate to contact Wearable Sensing for further troubleshooting assistance.

13.4 Troubleshooting Bluetooth Connections

Sometimes, when attempting to set up a Bluetooth connection with Wearable Sensing's DSI Headsets, there may be difficulties in getting the headset to communicate to DSI-Streamer after pairing it through Bluetooth. If you are having this issue, the following steps may address the issue:

- Make sure that your Bluetooth Dongle is connected, and that your headset is active.
- Right-click the Bluetooth symbol in the System Tray, as described in Section 5.2. Select "Show Bluetooth Devices".
    - For the Toshiba Bluetooth Stack, select "Bluetooth Settings".

- If there are any DSI Headsets that are shown in the devices, remove all of them, including any associated with the headset you are trying to connect.
- Deactivate your headset by holding the On/Off button until the lights on the headset begin blinking rapidly.
- Disconnect, and then reconnect the Bluetooth dongle.
- Reactivate the DSI Headset.
- Follow the steps described in Section 5.2 to pair the headset to your computer, once again.
- If DSI-Streamer is still unable to receive data, repeat the previous steps, but try a different USB port when reconnecting the Bluetooth Dongle
- If these steps do not produce satisfactory results, please contact Wearable Sensing for further assistance.

If you have any other troubles with DSI-Streamer or other Wearable Sensing products, please contact us:

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