shimmer
DISCOVERY IN MOTION

ShimmerCapture
User Manual
Rev 0.5a

Legal Notices and Disclaimer

Table of Contents

1. Introduction

ShimmerCapture is a host side (PC) application that allows users to display and save data received from a single Shimmer device streaming over Bluetooth. The application allows the configuration of a range of parameters on the *Shimmer3*, and is primarily designed to demonstrate Shimmer's functionality. *ShimmerCapture* works in conjunction with the *Shimmer3 LogAndStream* firmware to allow simultaneous streaming of data over Bluetooth as well as the logging of data to the on-board microSD card. The current release of *ShimmerCapture* is available for use in Microsoft Windows environments or in Linux.

1.1. Scope

ShimmerCapture is not intended to be the answer to all host side application requirements but instead as a quick start application which for many users can act as a stepping stone for more advance Shimmer applications. A number of design decisions focused on simplicity over more advanced features and/or robustness, to allow the application to be as portable as possible.

1.2. Pre-Requisites

1. A *Shimmer3* device programmed with the latest version of *LogAndStream* or *BtStream* firmware or a *Shimmer2/2r* device programmed with the latest version of *BtStream* firmware.

   Note: The latest *LogAndStream* and *BtStream* firmware images are available for download from our website[1]. These images can be loaded onto the Shimmer devices using the *Shimmer3 Bootstrap Loader* Application (or the equivalent for Shimmer2/2r). See the *Shimmer User Manual* for details.

   Note: The Shimmer needs to be paired with the PC (over Bluetooth). For Windows, this procedure is explained in the quickstart section of the *Shimmer User Manual* and the corresponding tutorial video on YouTube[2].

2. The latest *ShimmerCapture* executable, available on our website[3].

3. **Windows**: Microsoft .NET Framework 4 is required. Most Windows Vista and Windows 7 computers will already have this installed. If this is not installed it can be downloaded from http://www.microsoft.com/net/

   The distributed application executable is targeted for .NET 4, but for developers who wish to create their own executables there is no problem using .NET 3 or .NET 2.

[1] http://www.shimmersensing.com/support/wireless-sensor-networks-download/category/19
[2] https://www.youtube.com/watch?v=C2UdTdfiQ1g
[3] http://www.shimmersensing.com/support/wireless-sensor-networks-download/category/21

Linux: Mono Framework runtime is required. There are precompiled binaries for most popular Linux versions, or, if necessary, it can be installed from source. For more information see http://www.mono-project.com

2. ShimmerCapture on Windows

2.1. Starting *ShimmerCapture*

Launch the *ShimmerCapture* application in Windows. Simply double click the application executable, there are no installation steps.

2.2. Connecting to a Shimmer

The Bluetooth serial port for the desired *Shimmer3*, as assigned during the pairing procedure, must be selected (for details on pairing a Shimmer device please refer to the *Shimmer User Manual*). This can be selected using the drop down menu, or by typing the value in manually. In Windows this will be in the form of “COM<nn>”. See *Shimmer User Manual* for more details.

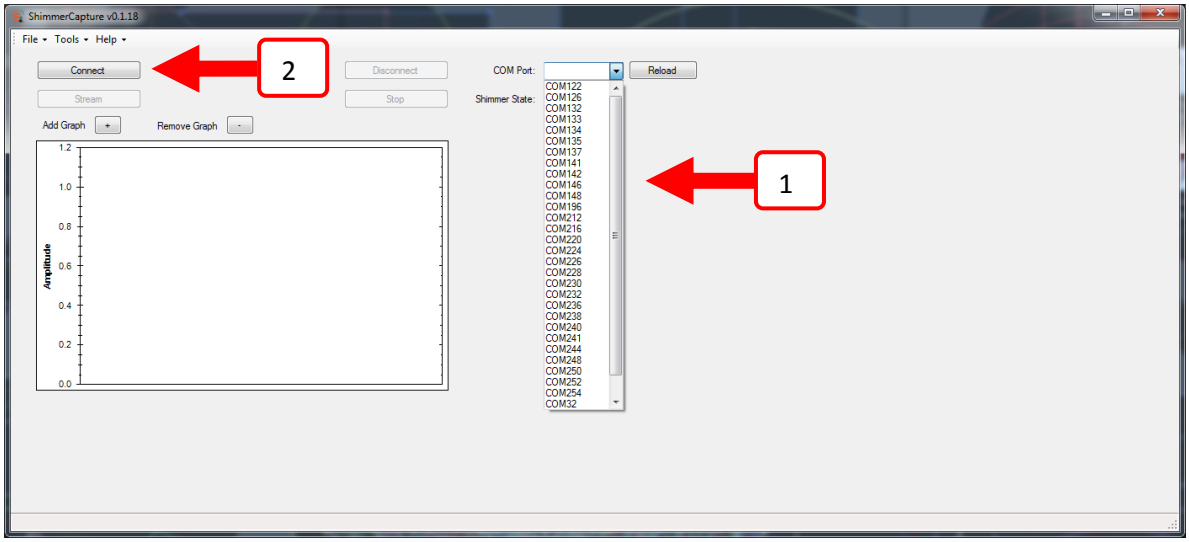


Figure 2-1 Selecting the COM port. Step 1 - Select the correct COM port, Step 2 - press the "Connect" button.

Once the correct serial port is selected, press the “Connect” button. While the *ShimmerCapture* application is connecting to the *Shimmer3*, the status bar of the application will indicate the stage of the connection sequence, as shown in Figure 2-2.

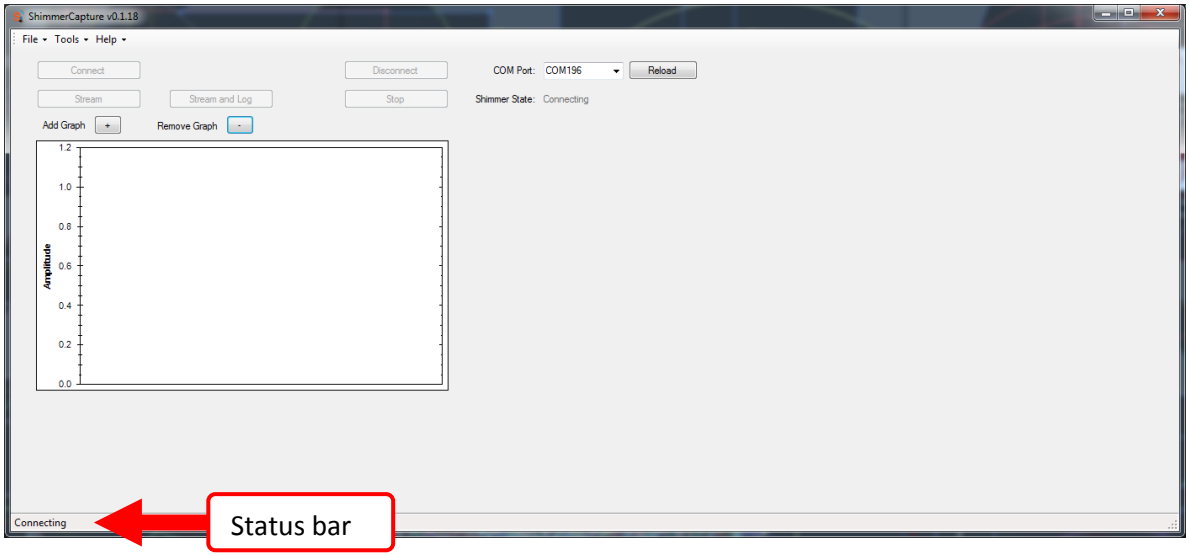


Figure 2-2 ShimmerCapture in the process of connecting.

Once connected the other buttons on the Control window will be enabled and the status bar at the bottom will be updated. The blue LED on the Shimmer will also illuminate to indicate connection status.

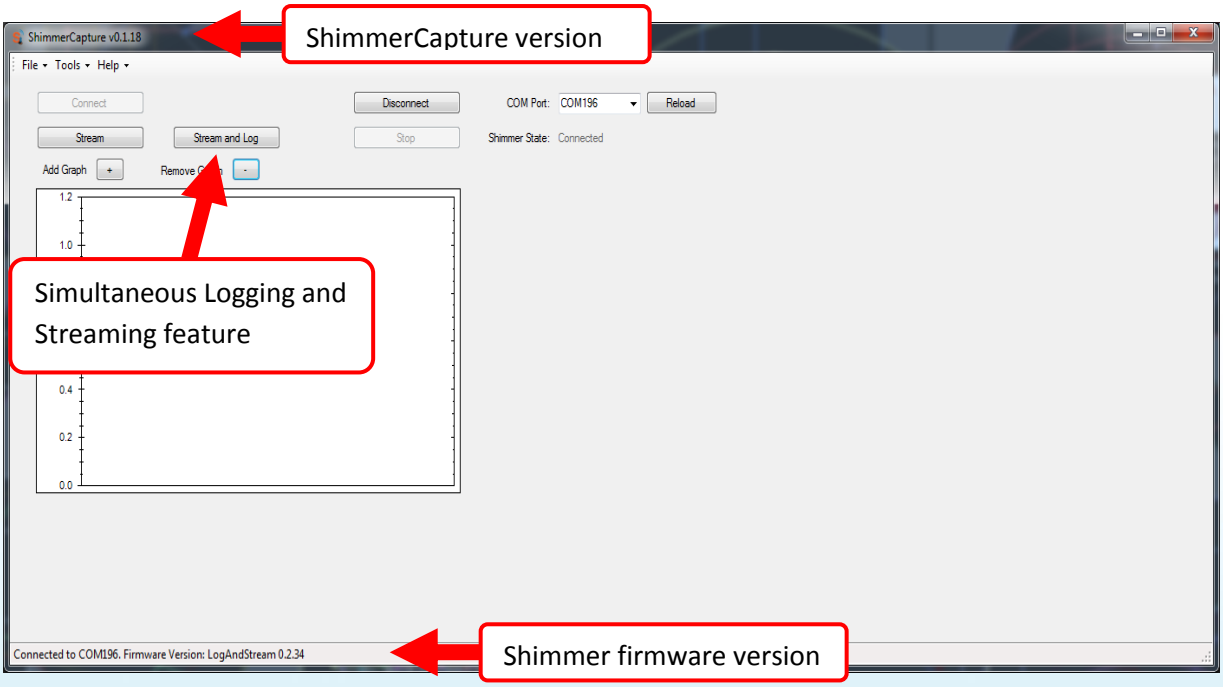


Figure 2-3 ShimmerCapture display once connected.

An important feature to note in *ShimmerCapture* can be seen in Figure 2-3. Similar to previous Shimmer Bluetooth streaming solutions, the "Stream" button enables streaming of data over the Bluetooth connection. However, a new feature of *ShimmerCapture* is the ability to simultaneously stream data over Bluetooth at the same time as logging to the on-board microSD card - which can be enabled by pressing the "Log+Stream" button. In both cases, the data can also be logged locally to the PC by selecting the appropriate option (Save to CSV) from the "Tools" menu.

While the *Shimmer3* device (programmed with *LogAndStream* firmware) is logging to the on-board microSD card, a Bluetooth connection can be established or disconnected at any time without interrupting the SD logging operation.

2.3. Configuring the Shimmer

2.3.1. Configuration Window

Once *ShimmerCapture* is connected to the *Shimmer3*, it reads the current configuration saved on the *Shimmer3*. To view or change this configuration select Tools -> Configuration. This will bring up the general configuration window, as shown in Figure 2-4.

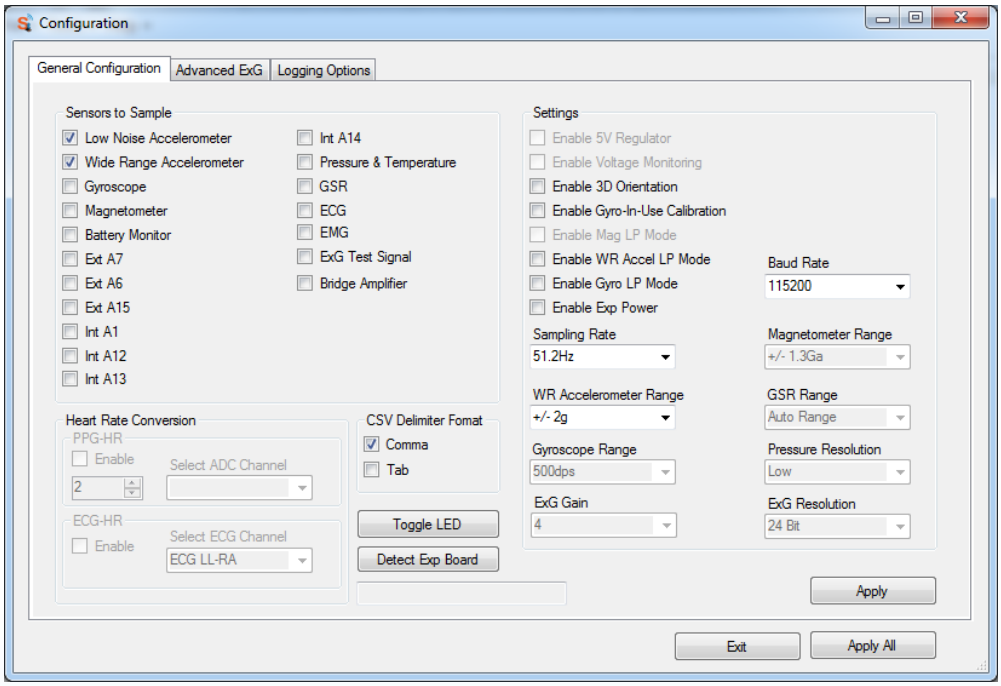


Figure 2-4 Configuring a Shimmer3 with programmed LogAndStream firmware.

Other than the "Toggle LED" command, no changes made in this window will be reflected on the *Shimmer3* until the "Apply" or "Apply All" button is pressed. The "Cancel" button will cancel any changes made since opening this window, other than the effect of the "Toggle LED" command.

> **Note:** The configuration panel settings cannot be changed while the *Shimmer3* is in the process of streaming data.

Sampling Rate:

> This can be modified by selecting a different rate from the drop down menu.
>
> **Note:** In the *ShimmerCapture* application, the sampling rate must be chosen from the dropdown box. If the user types in a value other than those listed in the dropdown box this value will be ignored during configuration.

Toggle LED:

Pressing this button immediately toggles the red LED on the Shimmer.

Sensors to sample:

The sensors of interest can be selected here. In the configuration window, the *Shimmer3*'s accelerometers are labelled as LNAccelerometer (Low Noise Accelerometer) and WRAccelerometer (Wide Range Accelerometer). The LNAccelerometer is an Analog accelerometer (KXRB5-2042) which has a single range (± 2 g). The WRAccelerometer is a digital accelerometer (LSM303DLHC) which has four different ranges (± 2 g, ± 4 g, ± 8 g and ± 16 g). The LNAccelerometer has lower noise levels when compared to the WRAccelerometer.

The *Shimmer3* also includes a Pressure sensor (BMP180). The pressure sensor's resolution is configurable (ultra low power, standard, high resolution and ultra high resolution). Users should take note of the maximum sampling rate of the BMP180 when selecting the *Shimmer3* sampling rate and the resolution mode - further details can be found in the BMP180 data sheet. Enabling the pressure sensor also enables the BMP180's temperature sensor channel.

In order to obtain meaningful data from the GSR and ExG (ECG or EMG) channels, the appropriate sensor module must be attached to the *Shimmer3*. The GSR and ExG sensors channels cannot be selected simultaneously as the *Shimmer3's* internal connector can only be connected to one of the corresponding expansion boards at the time.

Enable 3D Orientation:

This will enable the Accelerometer, Gyroscope and Magnetometer, the orientation of the *Shimmer3* device in terms of Quaternions will now be calculated and displayed when the user starts streaming again. Users should note that for best results, the *Shimmer3* device should be pre-calibrated using the *Shimmer 9DoF Calibration* application which is available for download from the Members area at www.shimmersensing.com.

Enable Gyro-On-The-Fly Calibration:

This will enable the calibration of the gyroscope while the Shimmer device is streaming. When enabled, the offset vector of the Gyroscope is recalculated when the Shimmer device is found to be stationary. Implementation details can be found in the *ShimmerCapture* source code.

Enable Low Power Magnetometer:

There are seven sampling rates for the *Shimmer3* (0.75 Hz, 1.5 Hz, 3 Hz, 7.5 Hz, 15 Hz, 30 Hz, 75 Hz, 220 Hz). The Magnetometer sampling rate is set to 15 Hz (*Shimmer3*) when low power magnetometer is enabled, otherwise the sampling rate of the Magnetometer is set as close as possible to the current sampling rate of the *Shimmer3* device.

Enable Low Power Accelerometer:

When low power mode is enabled, the sampling rate of the WRAccelerometer (LSM303DLHC) is set to 10 Hz. This low power mode will only be usable when the "WRAccel Range" is selected to be between ± 4 g and ± 16 g.

Enable Internal Exp Power:

This option is used to power-on a module or expansion board connected to the *Shimmer3*.

WRAccel Range:

This field selects the accelerometer range using a drop down menu. The *Shimmer3* features a digital accelerometer (WRAccelerometer) which has a user selectable range of ± 2 g, ± 4 g, ± 8 g or ± 16 g. This field is greyed out and not configurable if the WRAccelerometer sensor is not selected.

Enable Low Power Gyroscope:

When low power mode is enabled, the sampling rate of the *Shimmer3's* gyroscope is set to 31.25 Hz.

Gyro Range:

This field selects the gyroscope range using a drop down menu. The gyroscope on the *Shimmer3* four selectable ranges: 250 dps, 500 dps, 1000 dps and 2000 dps.

Pressure Resolution:

This field is used to set the resolution level of the Pressure sensor on the *Shimmer3*.

GSR Range:

This field selects the range of the GSR sensor using a drop down menu. When set to Auto-Range, the most suitable range for the current reading is selected by the shimmer itself. This field is greyed out and not configurable if the GSR sensor is not selected.

ExG Resolution:

Setting determines whether ECG/EMG data will be sent in 16-bit or 24-bit format. Users should note that 24-bit is the default format provided by the chips on the *ExG Expansion Board* and, if 16-bit data is selected, the 7 least significant bits and the 1 most significant bit of the ECG/EMG samples will be discarded by the firmware before transmitting the data over Bluetooth. In the instrument driver, the calibration procedure handles the different data types.

ExG Gain:

Setting determines the software configurable gain of the ExG channels. The recommended value for ECG or EMG data collection will be automatically chosen when the ECG or EMG

sensor, respectively, is enabled. Please refer to the *Shimmer ExG User Guide for ECG* or the *Shimmer ExG User Guide for EMG* for more details.

Baud Rate:

This field selects the baud rate of the Bluetooth module on the Shimmer3. Setting the baud rate to a higher value should allow streaming of more channels at a higher data rates while reducing packet loss. **Note:** In order to change the baud rate of the Shimmer3, the Shimmer3 must disconnect, and then reconnect with the ShimmerCapture application. The ShimmerCapture application automatically handles this disconnect/connect cycle but sometimes fails when trying to reconnect with the Shimmer device. If this occurs, please reconnect with the Shimmer as described in section 2.2.

Detect Expansion:

Pressing this button lets the user know which expansion board (if any) is attached to the Shimmer3.

Logging Delimiter Format:

This field specifies the file delimiter (comma or tab) when logging data to the csv file on the computer.

SD Logging Parameters:

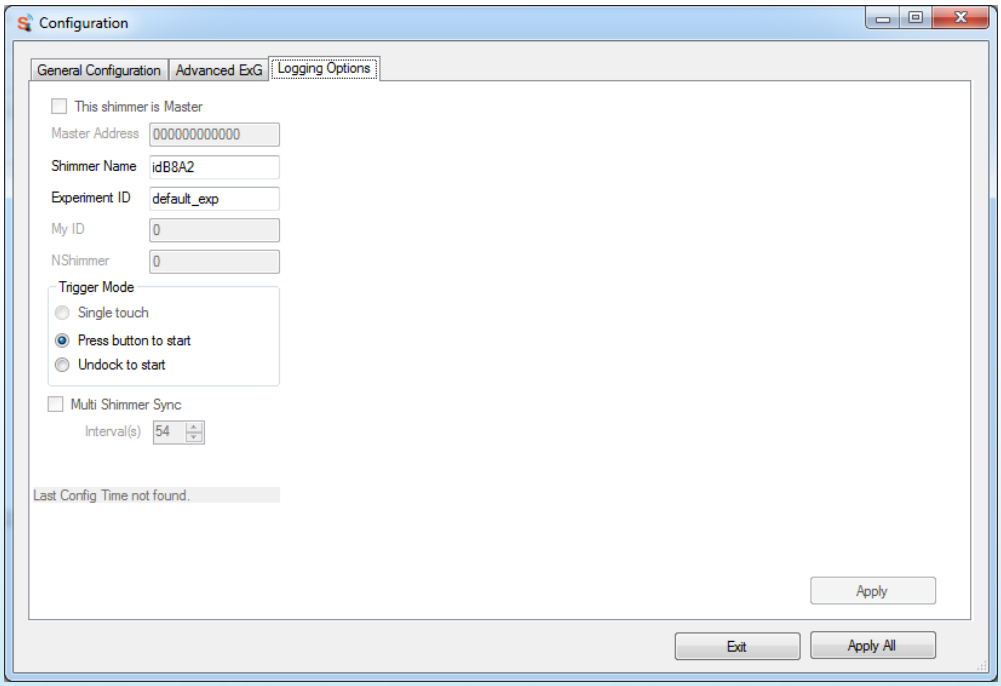


Figure 2-5 Configuring logging options for Shimmer3 with programmed LogAndStream firmware.

Shimmer Name: Used to give an appropriate name to the Shimmer unit. The entry is limited to 11 characters. If the field is left empty, the name will default to "idXXXX" where XXXX is the Bluetooth ID number specific to the Shimmer.

Experiment ID: Used to give an appropriate name to the current trial in the Shimmer unit. The entry is limited to 11 characters and has a default value of “default_exp”.

Trigger Mode:

The trigger mode allows the user to select how they wish to start and end data logging. The two available options are *Undock Start* and *Push Button Start*. The *Push Button Start* option is reliant on the *Shimmer3's* dedicated user button which is orange in colour and located beside the two LEDs. In *ShimmerCapture*, the default option is *Push Button Start*.

***Undock start*:**

If enabled, the following process begins when the Shimmer is removed from the dock.

1. The Shimmer unit will go into standby mode for up to 3 seconds.
2. The Shimmer unit will read the configuration file and create the required directories on the SD card.
3. The Shimmer unit will start SD logging.

SD logging will continue until the Shimmer unit is reset, powered off, replaced in the dock or the battery runs out, whichever happens soonest. Alternatively, once connected over Bluetooth through *ShimmerCapture*, pressing the "Stop" button on the *ShimmerCapture* control panel will also halt SD logging.

Repeatedly resetting the Shimmer unit will result in multiple logging sessions on the SD card.

Note: If using the *Undock Start* option, you must log for data for at least one minute to ensure data is successfully written to the SD card.

Push Button Start:

If enabled, undocking the Shimmer unit or powering it on and off, the dock will trigger the same steps 1 and 2 as above (*i.e.*, standby for 3 seconds followed by configuration). However, SD logging will not start until either the push button on the *Shimmer3* unit or the "Log+Stream" button in the *ShimmerCapture* Control panel is pressed. SD Data logging ends when the *Shimmer3's* push button is pressed again or when the Shimmer unit is reinserted into the dock. Enabling this option makes *Push Button Select* option enabled and available for selection.

Note: For more detailed information on the operation of the Trigger Mode options, consult the *LogAndStream for Shimmer3 Firmware User Manual*.

2.3.2. Configuring with/without the Shimmer Dock

A *Shimmer3* (programmed with *LogAndStream* firmware) can be configured through *ShimmerCapture* either with the *Shimmer3* placed on the *Shimmer Dock* or with it in an undocked

state. In both cases, *ShimmerCapture* will attempt to send the configuration information to the Shimmer3 Infomem (*i.e.*, a region of EEPROM memory in the Shimmer's microcontroller).

It is important to note that, on power-cycle or device reset, the *LogAndStream* firmware will attempt to load the last configuration parameters saved to the Infomem. Failing this scenario, default configuration values will be loaded. For more detailed information on the operation the configuration file and Infomem , consult the *LogAndStream Firmware User Manual*.

Undocked

When the *Shimmer3* is undocked, the configuration parameters are sent from the *ShimmerCapture* application to the *Shimmer3* where the firmware will automatically store the settings in Infomem. It will also attempt to create (or overwrite) the configuration file on the microSD card.

Docked

In the docked state, as before, the *Shimmer3* will save the configuration parameters to the Infomem. Once undocked the firmware will attempt to create (or overwrite) the configuration file on the microSD card

> **Note:** A *Shimmer3* programmed with *LogAndStream* firmware should not be configured while it is placed on a *Shimmer Multi Charger*. In this state, the *Shimmer3* thinks that it is connected to a *Shimmer Dock* and will surrender control of the microSD card. The settings will not be written to the configuration file and on next power-cycle or device reset, the settings in Infomem will be overwritten with old configuration parameters.
>
> **Note:** I*t is not recommended to dock the Shimmer unit while it is being configured or logging data. The Shimmer unit should either be powered off or in standby mode whenever it is docked.*

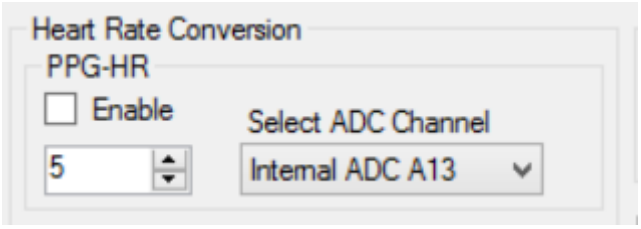
2.4. Configuring a Shimmer GSR+ Expansion Board

An external sensor option for the *Shimmer3* is the *Shimmer GSR+ Expansion Board*. Among other capabilities, this can be used to interface a PPG (Photoplethysmography) sensor to a *Shimmer3* device. To use PPG, the following must be enabled

- Int ADC A13 - The output of the sensor connected to the *GSR+ Expansion Board* is measured by the internal ADC A13
- Internal Exp Power (to power the external sensor e.g. PPG)

PPG data output will be under the category 'Internal ADC A13'. For further functionality information of the *GSR+ Expansion Board*, users are encouraged to read the *GSR+ Expansion Board User Guide*.

When using PPG users can use the PPG to HR algorithm to convert the PPG signal into Heart Rate (BPM). Snapshot of the dialog box within the configuration panel is as shown:-



The numerical combo box allows users to select the window size of the buffer to average over when calculating Heart Rate.

2.5. Configuring a Shimmer ExG Module

The "Advanced ExG" tab in the "Tools -> Configuration" menu allows users to configure a *ExG Expansion Board*.

Selecting "Advanced ExG" tab will open and ExG configuration form as shown below.

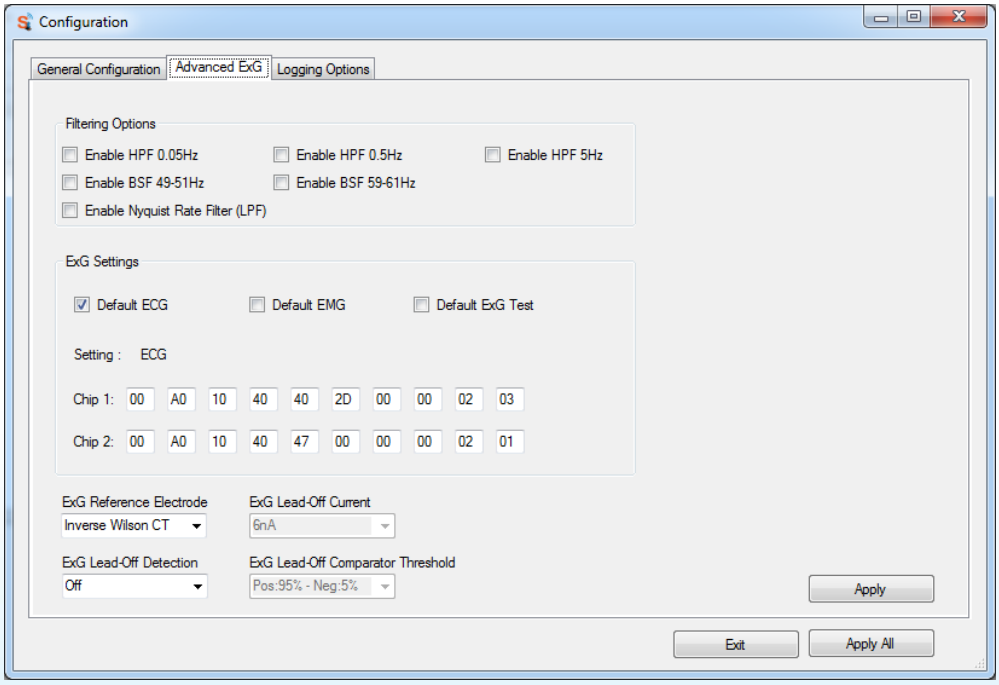


Figure 2-6 ExG Configuration window.

A selection of ExG filtering options are also provided in the “Advanced ExG” tab. If filtering is enabled, the raw and calibrated data will be filtered. Users should note that not all sampling frequencies are supported by the filters. For unsupported frequencies, with filtering enabled, the data remains unfiltered. For the high-pass filters, frequency rates of 51.2 Hz, 102.4 Hz, 204.8 Hz, 250.1 Hz, 512 Hz and 1024 Hz are supported. For the band-stop filters, frequency rates of 250.1 Hz, 512 Hz and 1024 Hz are supported. These filters are 2nd order Butterworth filters whose coefficients

can be found online[4]. Users should note that these filters are used as examples and that, depending on use case and application, other filtering options might perform better.

There are three default settings that are available for selection: *Default ECG, Default EMG and Default ExG Test*. For example, checking the "Default ECG" checkbox will update the 20 registers (*i.e.*, 10 register bytes for each ExG chip) on the user interface with the recommended default settings for ECG. Note that the register values in the user interface is only sent to the *Shimmer3* when the "Apply" or "Apply All" button is pressed. Updating the ExG gain settings will also update the registers in the GUI.

ExG Reference Electrode:

Setting determines whether the reference voltage used in the ExG amplifiers is a fixed reference voltage generated by the chip or taken from a feedback channel on the body. Please refer to the *Shimmer ExG User Guide for ECG* or the *Shimmer ExG User Guide for EMG* for more details.

ExG Lead-Off Detection, ExG Lead-Off Current, ExG Lead-Off Comparator Threshold:

The ***ExG Lead-Off*** settings are used to enable lead-off detection mode for the Shimmer3 and to choose the parameters for lead-off detection, such as the current applied to the body and the threshold levels.

The user can also choose to configure their ExG unit using a custom configuration by entering their desired configuration into the numeric text boxes list to the right of the "Chip 1" and "Chip 2" labels. The following are the 10 register bytes name and description. More detailed information on the ExG configuration bytes can be found within the *ExG User Guide for ECG* / *ExG User Guide for EMG*.

Byte Position	Name	Description
Byte 0	CONFIG1: Configuration Register 1	This register configures each ADC channel sample rate.
Byte 1	CONFIG2: Configuration Register 2	This register configures the test signal, clock, reference, and LOFF buffer.
Byte 2	LOFF: Lead-Off Control Register	This register configures the lead-off detection operation.
Byte 3	CH1SET: Channel 1 Settings	This register configures the power mode, PGA gain and multiplexer settings channels.
Byte 4	CH2SET: Channel 2 Settings	This register configures the power mode, PGA gain and multiplexer settings channels.
Byte 5	RLD_SENS: Right Leg Drive Sense Selection	This register configures the selection of the positive and negative signals from each channel for the right leg drive derivation.
Byte 6	LOFF_SENS: Lead-Off Sense Selection	This register selects the positive and negative side from each channel for lead-off detection.

[4] http://www-users.cs.york.ac.uk/~fisher/mkfilter/trad.html

Byte 7	LOFF_STAT: Lead-Off Status	The register stores the status of whether the positive or negative electrode on each channel is on or off.
Byte 8	RESP1: Respiration Control Register 1	This register controls the respiration functionality.
Byte 9	RESP2: Respiration Control Register 2	This register controls the respiration and calibration functionality.

Table 2-1 ExG Configuration Bytes Contents

ShimmerCapture provides a brief illustration of how the ExG lead off functionality can be used to detect whether all ECG leads are connected to the ExG board. See the following steps for illustration.

1. Enable the *Default ECG* checkbox, set the *ExG Lead-Off Detection* to *DC Current* as in Figure 2-7 and press the "Apply All" button.

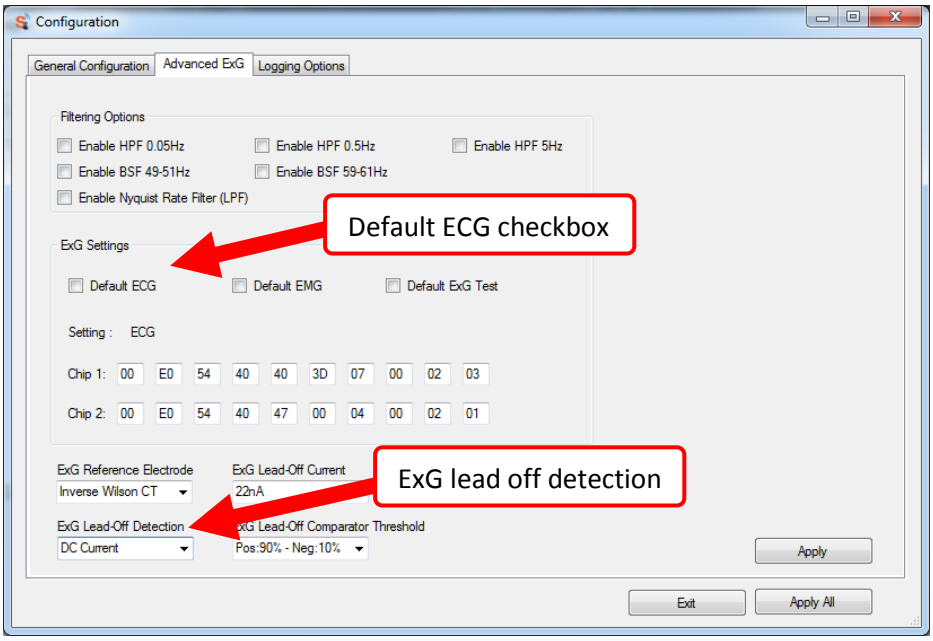


Figure 2-7 Advanced ExG tab for ECG lead off detection

2. Press the "Start" button to begin streaming the ECG signal and observer the "ExG Lead-Off Detection" checkboxes.

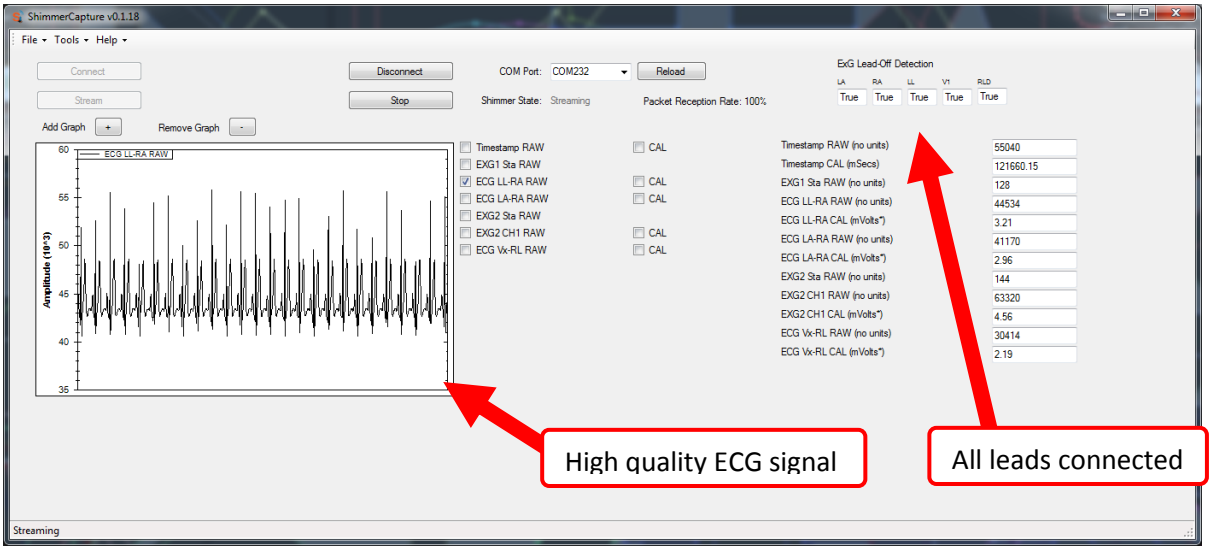


Figure 2-8 Streaming ECG signal with all leads connected

3. Remove one of the ECG leads and observe the “ExG Lead-Off Detection” checkboxes.

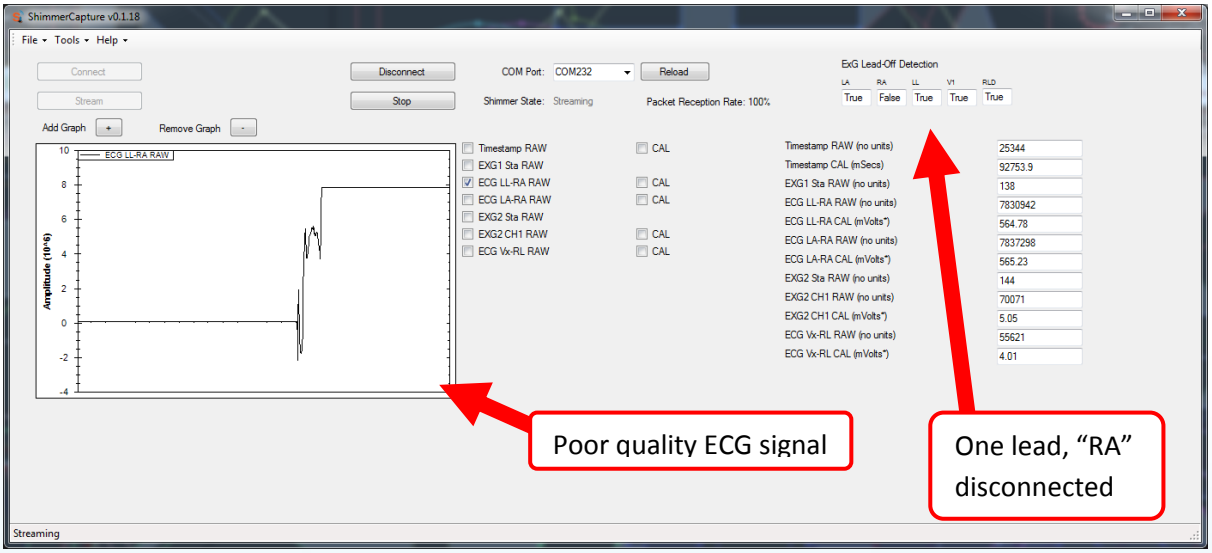
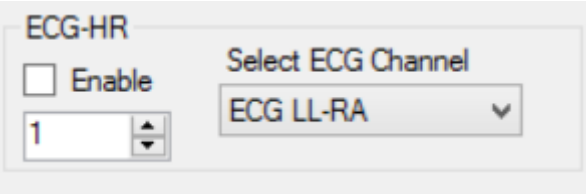


Figure 2-9 Streaming ECG signal with RA lead disconnected

When using ECG users can use the ECG to HR algorithm to convert the ECG signal into Heart Rate (BPM). Snapshot of the dialog box within the configuration panel is as shown:-



The numerical combo box allows users to select the window size of the buffer to average over when calculating Heart Rate.

2.6. Streaming Data

To stream data from the *Shimmer3*, press either of the “Stream only” or “Log+Stream” buttons on the *ShimmerCapture* control panel. Alternatively, if "Push Button Start" is enabled from the “Logging Options” configuration window, pressing the push button on the *Shimmer3* device will automatically start "Log+Stream" operations. To stop steaming and logging data, either press the "Stop" streaming button on the control panel or press the push button on the *Shimmer3* device. To stop streaming but continue logging, press the "Disconnect" button on the control panel.

The following screen shot shows a Shimmer streaming seven channels of data. The labels above the text boxes and on the graph windows show indicate the source of each channel..

Note: It is a known issue, that on rare occasions the parsing of the streamed data for LogAndStream firmware can be incorrect when a large number of channels are enabled with one of the ExG channels (ECG, EMG, ExG Test Signal). While Shimmer will make every effort to resolve this bug in a future release, users are reminded that *ShimmerCapture* is not intended to be the answer to all host side application requirements but instead as a quick start application which for many users can act as a stepping stone for more advance Shimmer applications. If a user does experience this bug, usually reducing the number of the channels the Shimmer is streaming eliminates the problem.

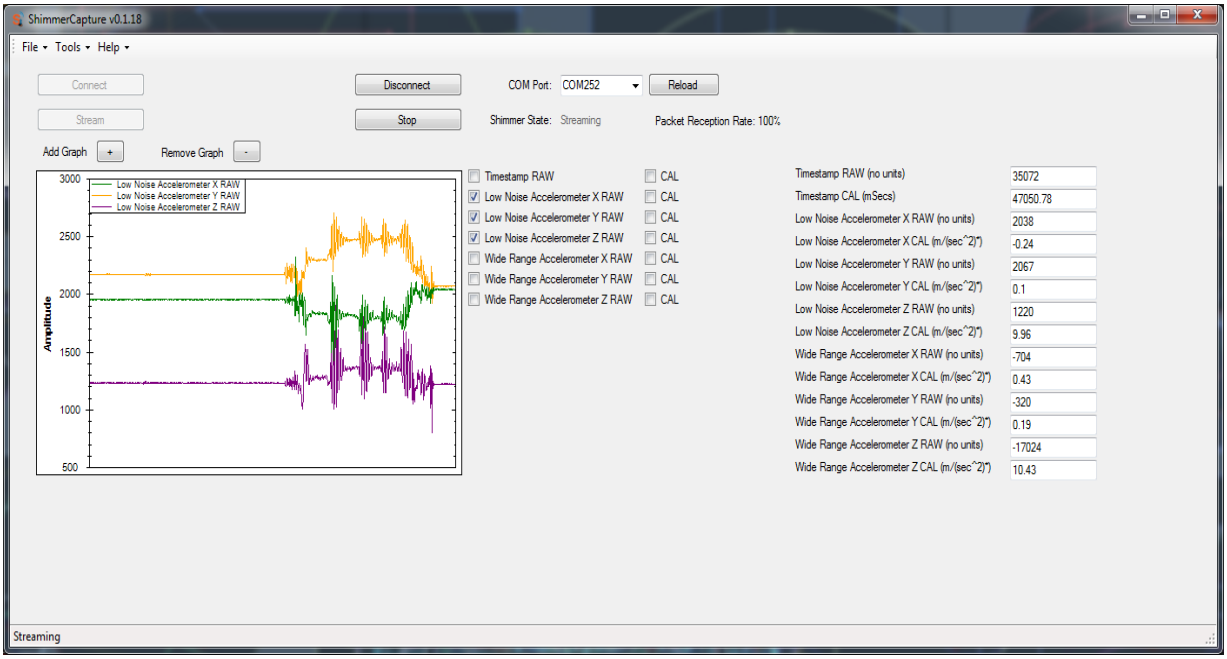


Figure 2-10 Streaming Data.

2.7. Status bar

The *ShimmerCapture* status bar provides a useful source of feedback for the state of the *Shimmer3* device and the *LogAndStream* firmware.

Connecting:

While *ShimmerCapture* is connecting the *Shimmer3*, the status bar is continually updated with the current step in the Bluetooth connection sequence.

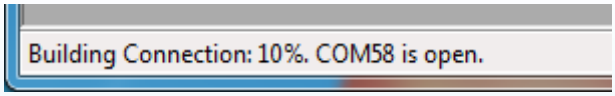


Figure 2-11 Status bar during Bluetooth connecting.

Bluetooth Streaming

After the "Stream only" button has been pressed, the status bar will change to "BT Streaming", as below:

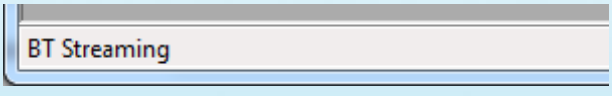


Figure 2-12 Status bar during Bluetooth Streaming only operation.

Once the "Stop" button is pressed from the "Stream only" mode, the following status bar text will appear:

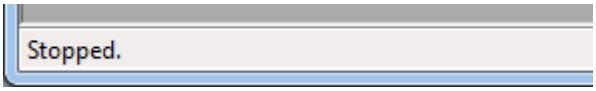


Figure 2-13 Status bar after Bluetooth streaming only operation.

Logging and Bluetooth Streaming

When the "Log+Stream" button is pressed, the status bar will show the "BTStream + SDLog" label. In addition to this, the current logging directory on the microSD card will also be listed. The name of the current directory is based on the configuration parameters set in the configuration window - in this case as those listed in Figure 2-4. In this example, the status bar lists the: trial name (*i.e.*, "Trial4R"), configuration time (*i.e.*, "1401898850"), device name (*i.e.*, "Shimmer1") and folder increment number (*i.e.*, "001"). More information on the representation of the configuration time can be found in the *ShimmerLog User Manual*.

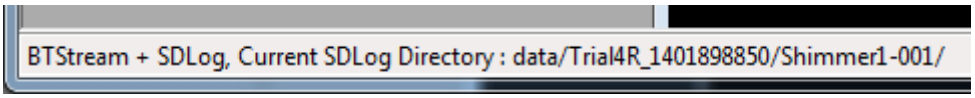


Figure 2-14 An example status bar message during Bluetooth streaming and SD logging.

Once the "Stop" button is pressed from the "Log+Stream" mode, the status bar will show the "Stopped" label as well as the last SD logging directory, as below:

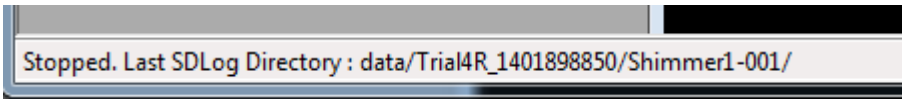


Figure 2-15 An example status bar message after the "Stop" button has been pressed on the control panel.

2.8. Disconnecting from a Shimmer

The “Disconnect” button in the Control window disconnects *ShimmerCapture* from the Shimmer. From "Stream only" mode this will halt all activity on the *Shimmer3* and it will return to idle mode waiting for user input. From "Log+Stream" mode, the Bluetooth link will disconnect but the logging of data to the SD will continue uninterrupted. Whilst the *Shimmer3* is logging, the user can choose to reconnect over Bluetooth at any stage and this will not interfere with the SD logging operation.

2.9. Saving data to a local file

The data being received by *ShimmerCapture* can be saved to a local file on the PC in a comma separated value format (CSV). This facility can be enabled by selecting *Tools* → *Save To CSV*. A tick mark will appear next to this item in the *Tools* menu when the data is being saved to file. Both raw and calibrated data will be logged to the file. An option to save the data in a tab delimited format can be found on the configuration window.

Selecting the "Save To CSV" option opens a new window asking for the name and location of the file to be used. The name defaults to “ShimmerData.csv” and the location defaults to the user’s home

folder. The ability to read or write to this file will be locked by the *ShimmerCapture* application until the “Save to CSV” option is deselected or the *ShimmerCapture* application is closed. This feature can be enabled in both "Stream only" mode and "Log+Stream" modes.

> **Note:** Any stop or restart streaming operation will not create a new CSV file for each streaming instance, instead data will be appended to the CSV file which is currently open.

2.10. Show/Hide Graphs

The graph windows can be hidden collectively by deselecting “Show Graphs” in the Tools menu. The graph windows can then be redisplayed by selecting the same option, i.e. *Tools → Show Graphs*.

2.11. 3D Orientation

ShimmerCapture can calculate the 3D orientation (in Quaternion) of the *Shimmer3* device using the Accelerometer, Gyroscope and Magnetometer. To enable this feature, ensure that the *Enable 3D Orientation* option is selected in the *Configuration* window. It is also recommended that the *Enable Gyro-In-Use Calibration* option is selected to give good quality estimations over time.

The orientation algorithm used was proposed in the following paper:

> Madgwick, Sebastian OH, Andrew JL Harrison, and Ravi Vaidyanathan. "*Estimation of imu and marg orientation using a gradient descent algorithm*." Rehabilitation Robotics (ICORR), 2011 IEEE International Conference on. IEEE, 2011.

It is strongly recommended that users calibrate their Shimmer devices, using the *Shimmer 9DoF Calibration Application*, prior to using the 3D orientation estimation function. The *Shimmer3* axis direction used should be the same as that shown in Figure 2-16. For further information it is recommended that the user refers to the *Shimmer 9DoF Calibration User Manual* and corresponding tutorial video on YouTube[5]. When calibrating the Shimmer device, users should always be mindful of the selected Magnetometer, Accelerometer and Gyroscope ranges from the configuration window of *ShimmerCapture*.

[5] https://www.youtube.com/watch?v=aI2WDecTtfs

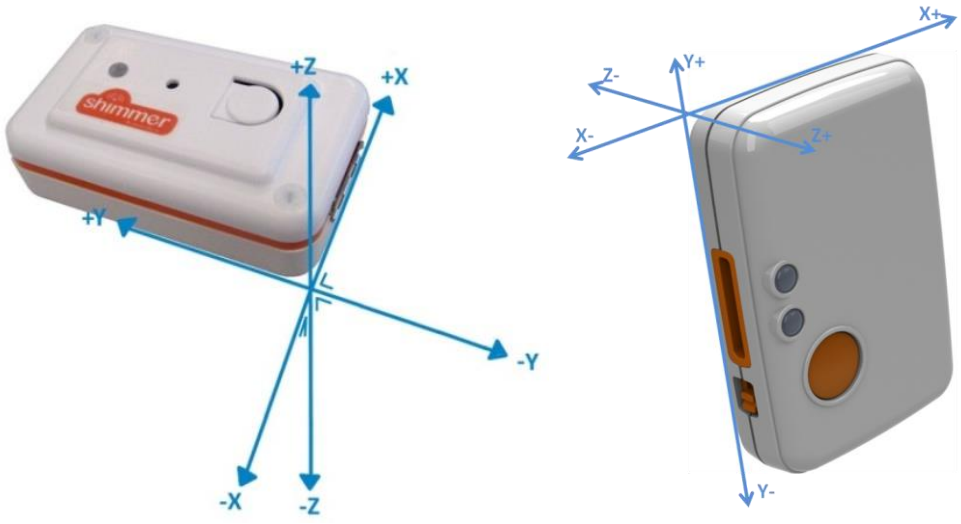


Figure 2-16 Shimmer Axis Direction for Shimmer2r (left) and Shimmer3 (right).

2.11.1. 3D Orientation Visualisation

ShimmerCapture includes a feature to visualise the 3D orientation of the Shimmer device, using a cube whose faces each have a different colour to represent each face of the Shimmer. To open the visualisation, follow *Tools > Show 3D Orientation*. This will open a new window, like that shown in Figure 2-17.

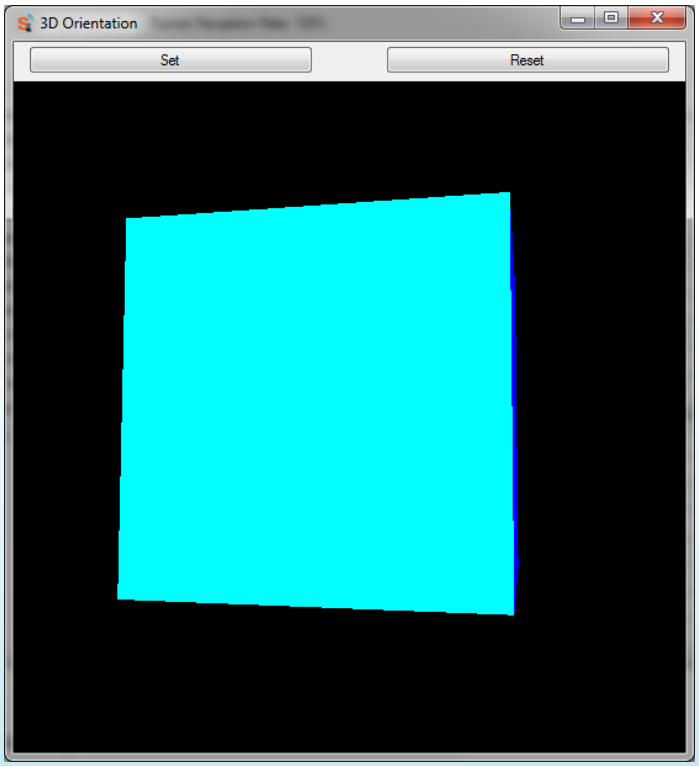


Figure 2-17 ShimmerCapture 3D Orientation visualisation window

To align the cube in the graphic with the physical orientation of the Shimmer, follow the steps below:

1. Start streaming data from the Shimmer (via the *Start* button on the main *ShimmerCapture* window).
2. Ensure that the Shimmer is not moving (e.g. leave it resting on a table) for the initial settling period while the orientation estimate converges to the streamed data - the graphic will become static when the estimate has converged (this should take no more than a few seconds).
3. Position the Shimmer device such that the *y*-axis of the device is pointing vertically upwards and the Shimmer sticker on the device is facing away from the screen, as demonstrated in Figure 2-19.

*Figure 2-18 Orientation of Shimmer before pressing "*Set*" button*

4. Press the "Set" button on the *3D Orientation* window to align the graphic with the Shimmer device. Once pressed, you should now see the red face of the cube, as shown in Figure 2-19. The red face represents the 'front' of the Shimmer.
5. Each face of the cube has a different colour. The face of the cube which corresponds to the back of the Shimmer device is purple, as shown in Figure 2-20.

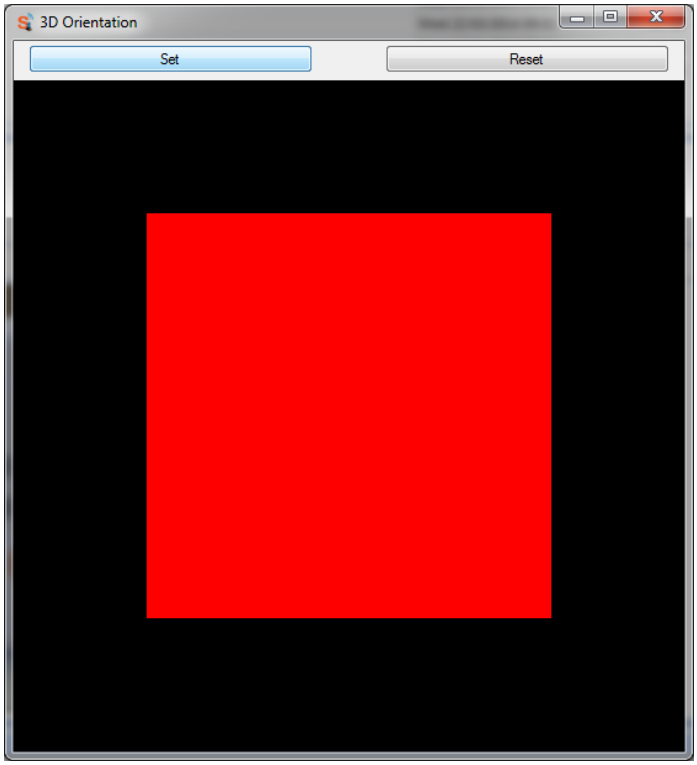


Figure 2-19 Representation of the 'front' face of the Shimmer Device.

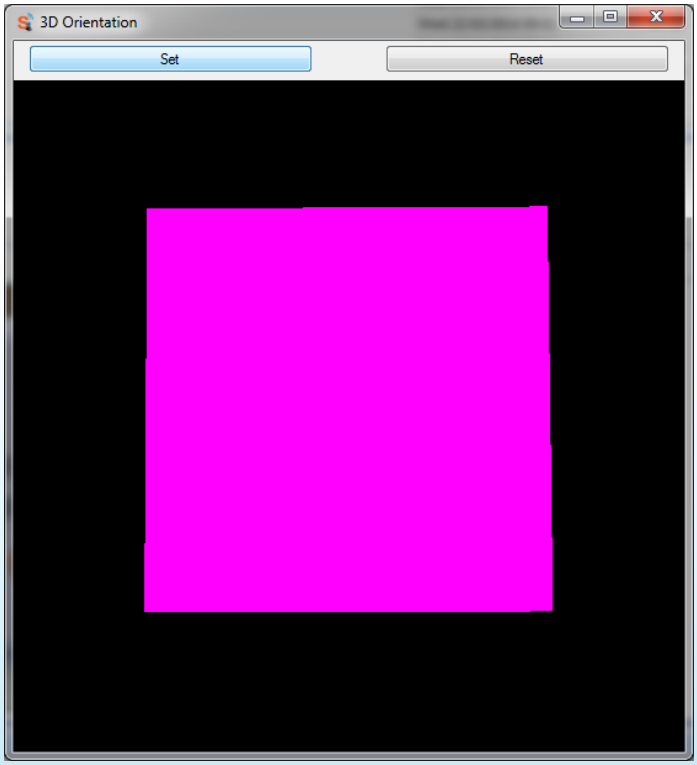


Figure 2-20 Representation of the 'back' face of the Shimmer Device.

To stop the 3D orientation visualisation, simply close the *3D Orientation* window.

3. ShimmerCapture on Linux

3.1. Pairing Bluetooth devices

3.1.1. Requirements

A working Bluetooth radio and the BlueZ Bluetooth libraries and tools need to be installed. See http://www.bluez.org for details.

The operation of pairing a Shimmer device in Linux to be used with *ShimmerCapture* might vary from distribution to distribution. The following procedure was tested in Ubuntu 10.04 (including ShimmerLive 10.04) , Slackware 13, and OpenSuse 11.3.

All the commands given here should be entered from the command line (in a terminal window).

1. Ensure the Bluetooth radio is available by running the "hciconfig" command.

   E.g.:

   ```
   tiny2@ShimmerLive:~/Desktop$ hciconfig
   hci0:   Type: USB
   BD Address: 00:19:0E:0A:D6:62 ACL MTU: 1021:8 SCO MTU: 64:1
   UP RUNNING PSCAN
   RX bytes:1013 acl:0 sco:0 events:34 errors:0
   TX bytes:1347 acl:0 sco:0 commands:34 errors:0
   ```

2. Scan for the Shimmer by running "hcitool scan".

   E.g. :

   ```
   tiny2@ShimmerLive:~/Desktop$ hcitool scan
   Scanning ...
           00:06:66:42:22:BD       RN42-22BD
           00:A0:96:28:DF:E8       FireFly-DFE8
           00:06:66:42:24:18       RN42-2418
   ```

3. To use the shimmer named RN42-2418, it must be bound to an rfcomm device. The "rfcomm bind <n> <MAC_ADDRESS>" command achieves this. The <n> gives the rfcomm device number, which must be different for each Shimmer paired, and the <MAC_ADDRESS> is the Shimmers MAC address, as can be seen from the "hcitool scan" output above. This command normally needs root privileges, so "sudo" is used.

   E.g.:

   ```
   tiny2@ShimmerLive:~/Desktop$ sudo rfcomm bind 0 00:06:66:42:24:18
   [sudo] password for tiny2:
   ```

4. Running the "rfcomm" command with no arguments shows which Shimmer is bound to which rfcomm device, along with the current connection status.

E.g.:

```
tiny2@ShimmerLive:~/Desktop$ rfcomm
rfcomm0: 00:06:66:42:24:18 channel 1 clean
rfcomm1: 00:A0:96:28:DF:E8 channel 1 clean
```

3.2. Using the *ShimmerCapture* executable

To connect to the Shimmer in *ShimmerCapture* enter "/dev/rfcomm<n>" in the "Select COM port" field.

For example, Figure 3-1 shows how to connect to Shimmer RN42-2418 which is bound to rfcomm0, as described above.

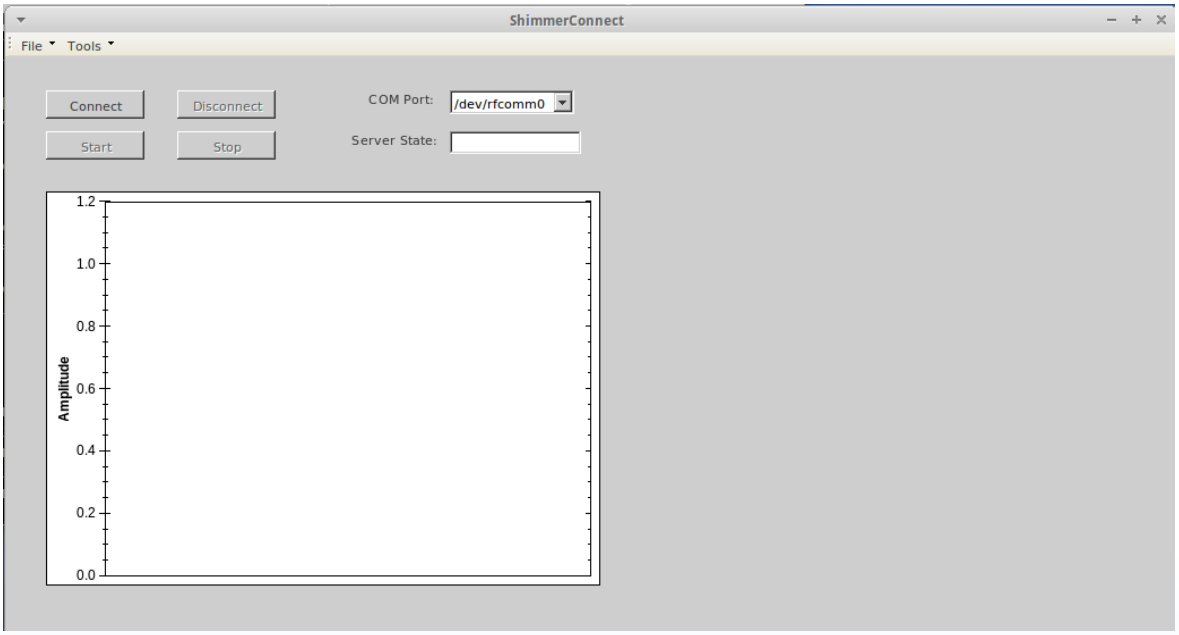


Figure 3-1 Connecting to a Shimmer in Linux

For all other functionality, follow the instructions for Windows, as detailed in Section 2 of this manual.

4. Appendix

4.1. ShimDv2 File Format

The *ShimmerCapture* application can log data locally to the PC in a format we have defined as SHIMDv2 (Shimmer Data version 2). SHIMDv2 format is a tab delimited text file which uses the extension *.dat*. The file contains both sensor data and header information.

Figure 4-1 shows a Shimmer data file in SHIMDv2 format. Each column represents either a Shimmer timestamp or a single sensor signal. The header consists of four rows. Considering only one column at a time, row 1 identifies the Object Name associated with that column; this is the device name given to the Shimmer when capturing the data in *Multi Shimmer Capture* (feature not currently available in *LogAndStream* firmware). The second row identifies the Property Name; this is the name of the signal (e.g. Timestamp, Accelerometer X, EMG etc). The third row identifies the format of the data, (e.g. CAL or RAW). The forth row identifies the units of the signal.

	A	B	C	D	E	F	G	H
1	Object	Object	Object	Object	Object	Object		
2	Timestam	ECG RA-LL	ECG LA-LL	Timestam	ECG RA-LL	ECG LA-LL		
3	RAW	RAW	RAW	CAL	CAL	CAL		
4	No unit	No unit	No unit	mSecs	mVolts*	mVolts*		
5	39649	2006	2029	1209.991	-0.22606	-0.12977		
6	40289	1971	1999	1229.523	-0.37258	-0.25536		
7	40929	2031	2056	1249.054	-0.1214	-0.01675		
8	41569	2029	2048	1268.585	-0.12977	-0.05024		
9	42209	1992	2013	1288.116	-0.28467	-0.19676		
10	42849	2059	2064	1307.648	-0.00419	0.016745		
11	43489	2131	2113	1327.179	0.297227	0.221873		
12	44129	2122	2084	1346.71	0.25955	0.100471		
13	44769	2044	2035	1366.241	-0.06698	-0.10466		
14	45409	1955	1983	1385.773	-0.43956	-0.32234		
15	46049	1983	2027	1405.304	-0.32234	-0.13815		
16	46689	1984	2037	1424.835	-0.31816	-0.09628		
17	47329	1929	1981	1444.366	-0.5484	-0.33072		
18	47969	1850	1964	1463.898	-0.87912	-0.40188		
19	48609	2697	2400	1483.429	2.666667	1.423339		
20	49249	2277	2114	1502.96	0.908425	0.22606		

Figure 4-1 Shimmer data file in SHIMDv2 format.

Note: An asterisk after the *Units* indicates that default offset and sensitivity values from the sensor data sheet have been used to calibrate the sensor data **(e.g. *mVolts**).**

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