ExG as a Three Unipolar Input

Revision 0.04

Legal Notices and Disclaimer

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1. Introduction

This document supplements the Shimmer3 ECG and EMG user manuals (available on www.shimmersensing.com) and describes how to configure the *Shimmer3 ECG* or *Shimmer3 EMG* unit in a 3-unipolar lead input configuration (as opposed to a 2-bipolar input configuration by default for the *Shimmer3 EMG* unit and 2-bipolar plus 1-unipolar for the *Shimmer3 ECG* unit).

2. General Information

2.1. Safety Information

As a precaution, it is important to note that the ECG/EMG leads are not to be applied to the subject's body while unit is in a USB dock or multi-charger.

2.2. Pre-Requisites

- A *Shimmer3 ECG* unit or *Shimmer3 EMG* unit programmed with appropriate firmware. For example, *LogAndStream* (v0.8.0 or greater).
- Shimmer software such as Consensys (v1.1.0 or greater) or ShimmerCapture for Android. Alternatively, one of the Shimmer APIs or Instrumentation Drivers.
- Four DIN snap leads.
    - 9-inch and 18-inch leads are shipped with the *ECG/EMG Development Kit* and *ECG/EMG Bundles*.
    - Replacements can be purchased from www.shimmersensing.com.
- Surface ECG/EMG electrodes.
    - Disposable electrodes are shipped with the *ECG Development Kit* and *ECG Bundles*.
    - For replacements, see www.shimmersensing.com. Alternatively, the Covidien Kendall Disposable Surface EMG/ECG/EKG electrodes 1" (24mm) or Covidien Kendall Disposable Surface EMG/ECG/EKG electrodes 1 3/8" (35mm), available on www.bio-medical.com with product codes 'BRD H124SG' and 'BRD H135SG', respectively, and the Ambu Blue Sensor T electrodes, available from various suppliers, are all suitable options and have been validated for use with Shimmer equipment.

3. Using the ECG Unit

3.1. Basic System Overview

Figure 1 (below) gives a simplified block diagram of the internal operation of the Shimmer ECG/EMG unit when it is configured in Three-Unipolar Input mode. The three measurement electrodes are ExG1 Channel 2 (black), ExG2 Channel 1 (red) and ExG2 Channel 2 (brown). The reference electrode is configured to output a voltage reference of 1.21V. This reference voltage is half-way between the full input-range of the Shimmer's ADCs (approximately 0V to 3V) - thus allowing the voltage under measurement to swing positive or negative (approximately ±1.21V for a gain of 1). The white connector is configured to be disconnected internally and so serves no purpose in this configuration.
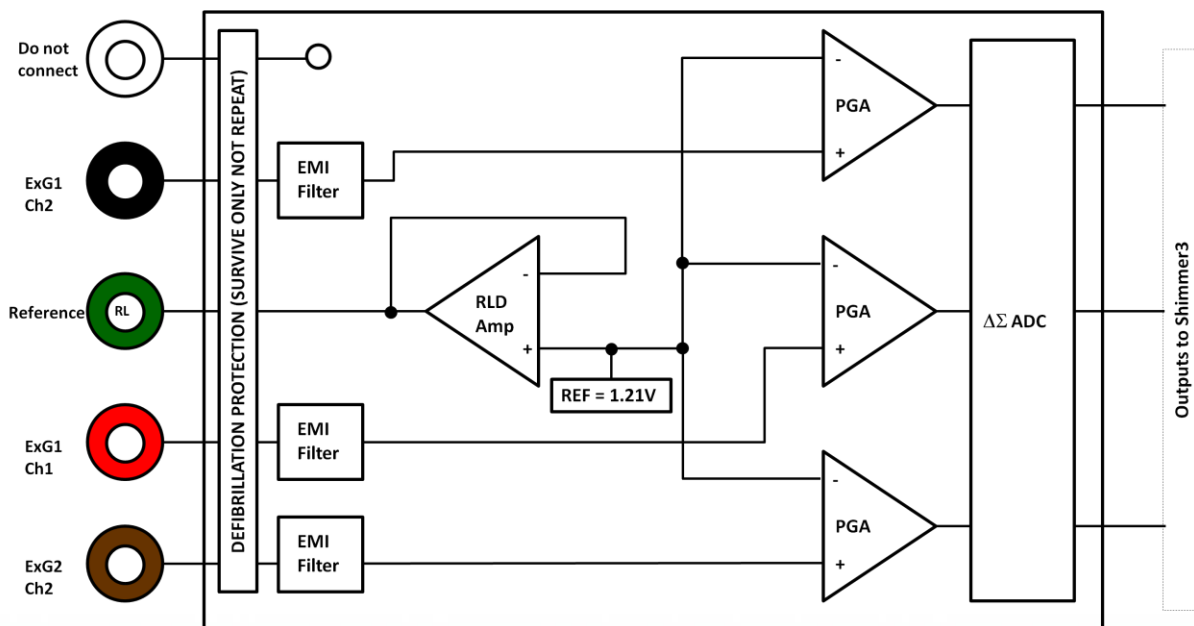

Figure 3-1: Simplified Block Diagram

- **Electrodes:**
  - White =   Not internally connected.
  - Black =   ExG Chip 1, Channel 2.
  - Green =   Right-leg-driver (RLD) ≈ 1.21 V when reference potential is set to fixed
  - Red =   ExG Chip 1, Channel 1.
  - Brown =   ExG Chip 2, Channel 2.

3.2. Configuration Options and Recommended Settings

The easiest way to use the Three-Unipolar Input mode is to use our Consensys software (v1.1.0 or greater) as this software has built-in support for this mode (available www.shimmersensing.com). Alternatively, if using our Android software or our APIs or Instrumentation Drivers, Shimmer provides the ability to manually enter the required ExG configuration bytes in order to configure the Shimmer ECG/EMG unit for this mode.

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Configuration using Consensys

1) The Three-Unipolar input mode can be enabled by accessing the "Advanced ECG/EMG" configuration view on the ECG/EMG tile in Consensys v1.1.0 or greater, as shown below:
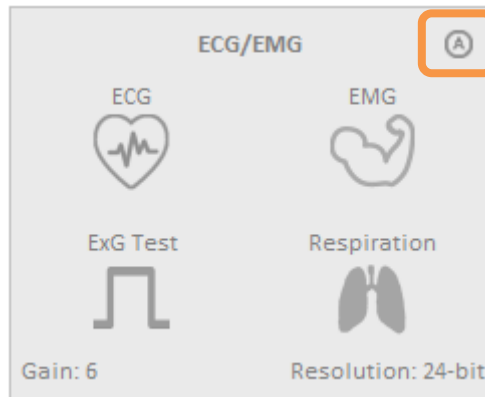
Figure 3-2: The Consensys configuration tile for ExG (e.g., ECG/EMG) highlighting how to access the "Advanced ECG/EMG" menu.

2) In the "Advanced ECG/EMG" menu, select the "Three Unipolar Inputs" option. You can now select your desired Gain and Resolution settings.

Figure 3-3: The "Advanced ECG/EMG" menu as accessed through the Consensys software. Note that the highlighted bytes are the specific bytes that need to be set manually if configuring Shimmer units using ShimmerCapture for Android or a Shimmer API or Instrumentation Driver.

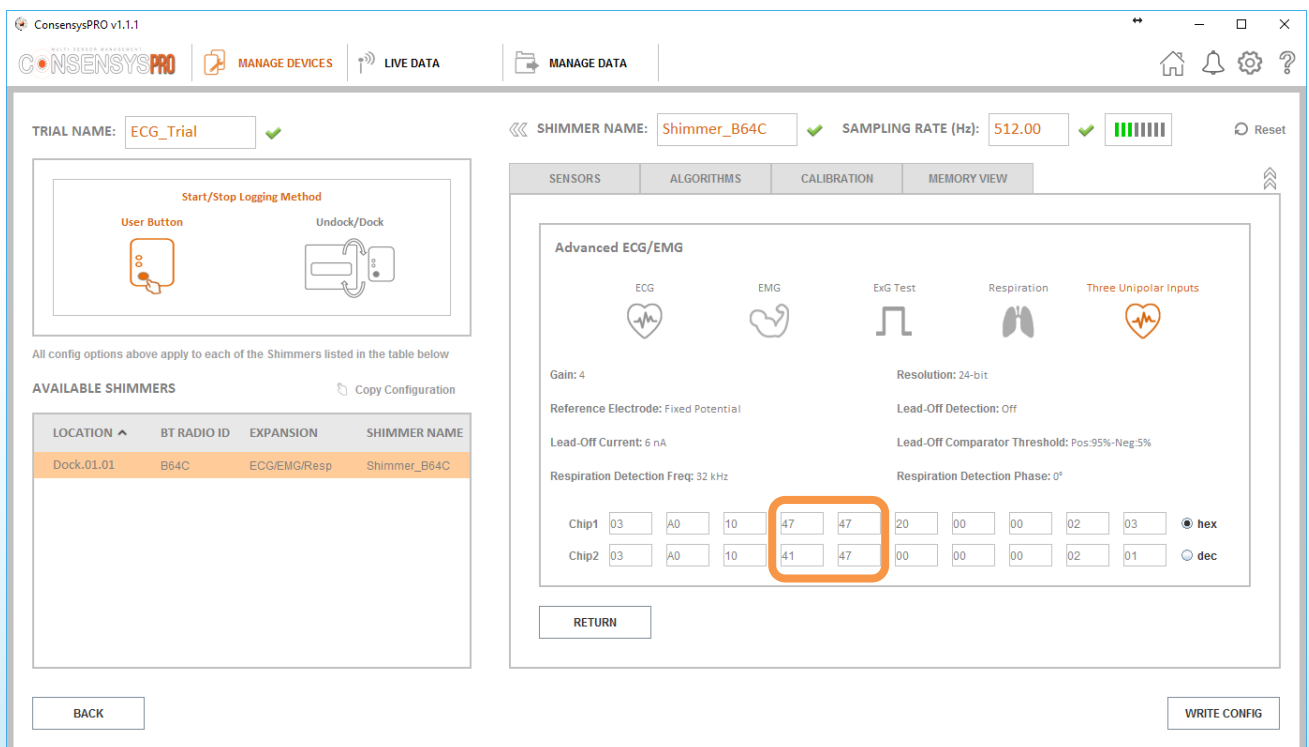3) The three output channels (ExG1_CH1, ExG1_CH2 and ExG2_CH2) corresponding to the three unipolar inputs will be then provided by the Shimmer while logging or streaming. For example, if streaming to Consensys, the channels will as below:
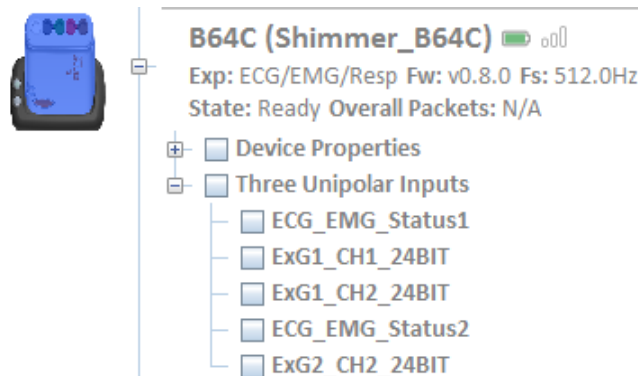

Figure 3-4:

Configuration using ShimmerCapture or an API/Instrumentation Driver

Please refer to the Shimmer3 ECG and EMG user manuals for a full description of the ExG configuration bytes. As described in the ECG and EMG user manuals, the ExG configuration bytes consist of 20 bytes - 10 for each ADS1292R chip used in the Shimmer3 ECG/EMG unit. To enter the Shimmer3 ECG/EMG unit into the Three-Unipolar Input mode, certain configuration bytes (namely MUX1 and M2 shaded in yellow below) need to be set to specific values for both chips.

Byte	Name	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0	CONFIG1: Configuration Register 1	0	0	0	0	0	Data Rate (DR2, DR1, DR0)		
1	CONFIG2: Configuration Register 2	1	0	1	0	X [1]	0	INT_TEST	TEST_FREQ
2	LOFF: Lead-Off Control Register	0	0	0	1	0	0	0	0
3	CH1SET: Channel 1 Settings	0	Gain1 (G1_2, G1_1, G1_0)			MUX1 (M1_3, M1_2, M1_1, M1_0)			
4	CH2SET: Channel 2 Settings	0	Gain2 (G2_2, G2_1, G2_0)			MUX2 (M2_3, M2_2, M2_1, M2_0)			
5	RLD_SENS: Right Leg Drive Sense Selection	0	0	PDB_RLD	RLD_LOFF_SENS	RLD Settings (RLD2N, RLD2P, RLD1N, RLD1P)			
6	LOFF_SENS: Lead-Off Sense Selection	0	0	0	0	0	0	0	0
7	LOFF_STAT: Lead-Off Status Selection	0	0	0	0	0	0	0	0
8	RESP1: Respiration Control Register 1	0	0	0	0	0	0	1	0
9	RESP2: Respiration Control Register 2	0	0	0	0	0	0	RLDREF_INT	1

Table 3-1 A high-level overview of the 10 configuration bytes required per ADS1292R chip in the Shimmer3 ECG/EMG unit.

[1] The Bit 3 in CONFIG2 denotes "X=0" for SR47-1 revision, and "X=1" for SR47-4 and greater revisions. This feature has been configured automatically in both LogAndStream 0.11.0 and SDLog_v0.19.0 (and newer).

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The required settings for the lower 4 bits of the MUX bytes are given in the table below. Chip2 Channel 1 is reserved for respiration circuitry and is therefore not used in the Three-Unipolar Input configuration - the setting of 0x1 below shorts the input to this channel. Each of the other channels (Chip 1 Channels 1 and 2 and Chip 2 Channel 2) require the same setting of 0x7. This configures them as unipolar input channels in-which they are measured with reference to the right-leg-driver (*i.e.*, internal reference in each chip - 1.21V).

| Chip | | MUX1_3 / MUX2_3 | MUX1_2 / MUX2_2 | MUX1_1 / MUX2_1 | MUX1_0 / MUX2_0 | Hex. |
		Bit 3	Bit 2	Bit 1	Bit 0	
Chip1	Channel 1 (byte 3)	0	1	1	1	0x7
	Channel 2 (byte 4)	0	1	1	1	0x7
Chip2	Channel 1 (byte 13)	0	0	0	1	0x1
	Channel 2 (byte 14)	0	1	1	1	0x7

Table 3-2 Recommended MUX settings for Three-Unipolar input lead configuration

Figure 3-5: A zoomed in view of the MUX bytes as they appear in Consensys. Note that within each of these bytes, Bits [3-0] control the MUX settings, Bits [6-4] control each channel's gain (i.e., Gain = 4 in this case) and Bit [7] is fixed at 0.

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