**BIOPAC Systems, Inc.**
Registered to ISO 9001:2015

APPLICATION NOTE

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02.08.18

## Application Note 172    SS29L Multi-Lead ECG Cable

### Overview

The SS29L Multi-Lead ECG Cable permits high-resolution multi-lead ECG recordings. The lead configuration allows the user to simultaneously record Leads I, II, III, aVR, aVL, aVF, plus one precordial chest lead. A 12-lead ECG recording can be obtained by alternating the chest lead electrode from position V1 through V6.

The SS29L has three labeled smart sensors, which plug into the MP36/36R/35 hardware. All three smart sensors descend from the electrode lead connector, which incorporates five pinch leads. The electrode cable is labeled and color-coded to conform to international standards so that electrode placement is fail-safe. The SS29L is a student friendly device that replaces an expensive and confusing lead selector box. The compact and intuitive design of the cable assembly decreases setup time and provides an easy alternative to a once complex setup.
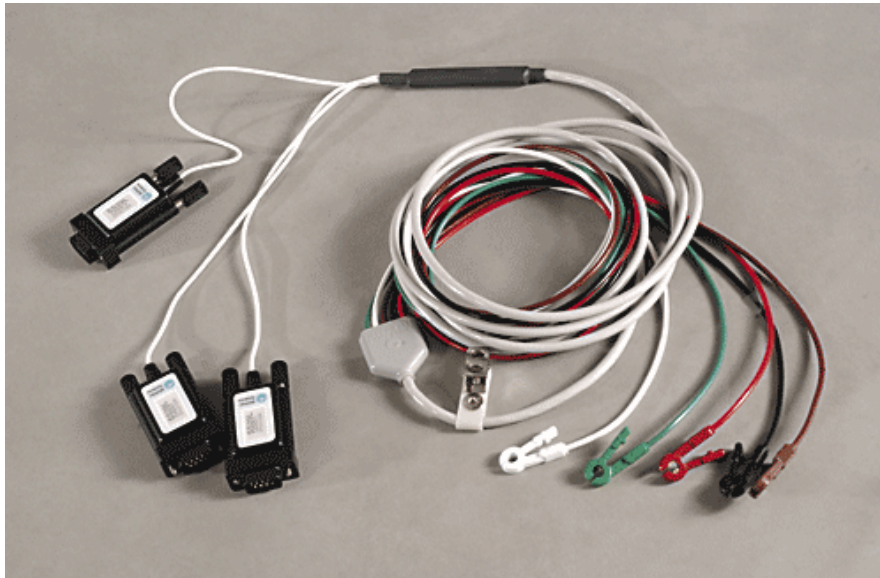


### Equipment Needed:

- Biopac Student Lab System (MP36/35) or Acq*Knowledge* with MP36R
- SS29L Multi-Lead ECG Cable
- EL503 Electrodes
- GEL100-Electrode Gel
- ELPAD-Abrasive Pads

### Hardware Setup:

Connect the three smart sensors to the MP3x/4x unit. Please make sure that all sensors are securely fastened in their sockets. A good connection is very important.

Lightly abrade the skin (using the ELPAD), before electrode placement to decrease the impedance between the electrode and the skin surface.

The figure on the following page indicates the correct placement of the electrodes and leads.

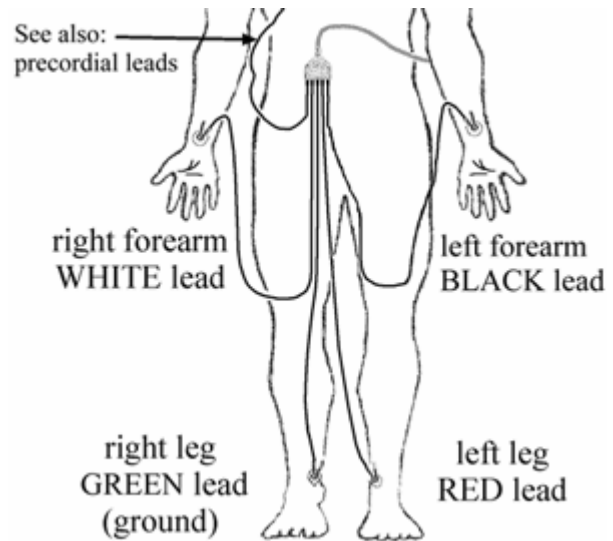**Electrode placement for Leads I and II**

Left Leg (LL) = RED lead

Left Arm (LA) = BLACK lead

Chest (C) = BROWN lead (see V1-V6 attachment)

Right Arm (RA) = WHITE lead

Right Leg (LL) = GREEN lead

## Software Setup

Traditionally, separate amplifiers would be placed at each vertex of the Einthoven's Triangle. However, Einthoven's Law states that if the values for any two points of the triangle are known, the third can be computed. Using the Biopac Student Lab Pro software we can calculate Lead III from Lead I and Lead II.

1. Select **Set Up Data Acquisition > Channels** from the **MP** menu.

2. Under the Analog tab, check **Acquire**, **Plot**, and **Values** for three of the four channels.

3. Make sure **CH1** is selected and click **Setup**.

4. Click the **Preset** button ▼ and select the first **ECG** preset.

5. Label CH1 **Lead I**, CH2 **Lead II**, and CH3 as **Chest**, as shown in the following example:
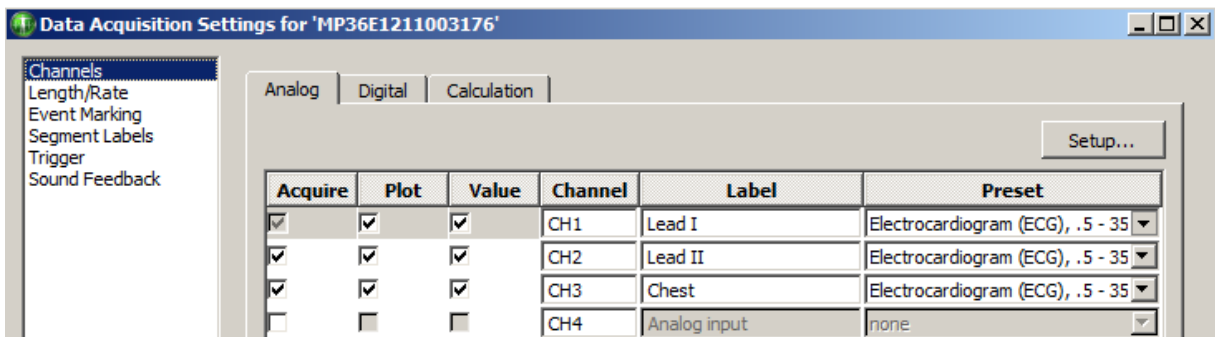


6. Repeat the procedure for **CH2** and **CH3**. All three channels use the **ECG** preset.

## Using the Math Calculation-Software Setup

1. Select the **Calculation** tab.

2. Choose **Math** as the Calculation channel preset.

3. Label channel **C1** as **Lead III**.
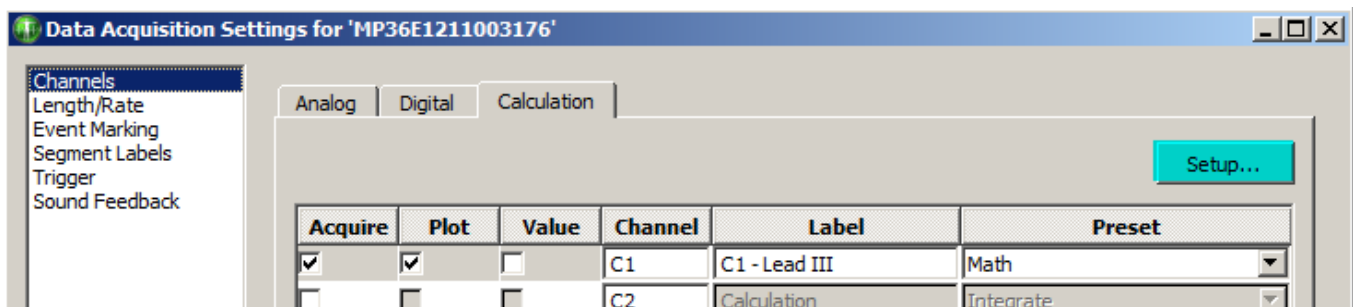
4. Click **Setup** and use the Math Calculation pull-down menus to input the following settings and click OK:



**Lead III** is now assigned to Calculation channel C1:

<p align="center">**Lead III = Lead II - Lead I**</p>

To record the next three leads, it's necessary to calculate the Augmented leads, also termed the Goldberger leads. These leads are derived, using advanced vector-cardiography from Leads I, II, and III. No additional electrodes or amplifiers are required. Use the following steps to calculate the Augmented leads and add them to the graph data.

Enable Calculation channel **C2** by checking the Acquire, Plot, and Value boxes. Calculation channel C2 will contain the **aVR** equation: **aVR = (Lead I +Lead II)/2**

1. Choose **Expression** as from the Calculation Preset menu and click OK.



2. Use **C2 – aVR** as the Label.

3. Enter the following into the Expression field: **CH1+CH2/2** and click OK.



<p align="center">**aVR Calculation**</p>

Enable Calculation channel **C3** by checking the Acquire, Plot, and Value boxes. Calculation channel C3 will contain the **aVL** equation: <u>**aVL = (Lead I-Lead III)/2**</u>

4. Choose **Expression** as from the Calculation Preset menu and click OK.

5. Use **C3 – aVL** as the Label.

6. Enter the following into the Expression field: **CH1-C1/2** and click OK.

**aVL Calculation**

Enable Calculation channel **C4** by checking the Acquire, Plot, and Value boxes. Calculation channel C4 will contain the **aVF** equation: <u>**aVL = (Lead II+Lead III)/2**</u>

7. Choose **Expression** as from the Calculation Preset menu and click OK.

8. Use **C4 – aVF** as the Label.

9. Enter the following into the Expression field: **CH2+C1/2** and click OK.
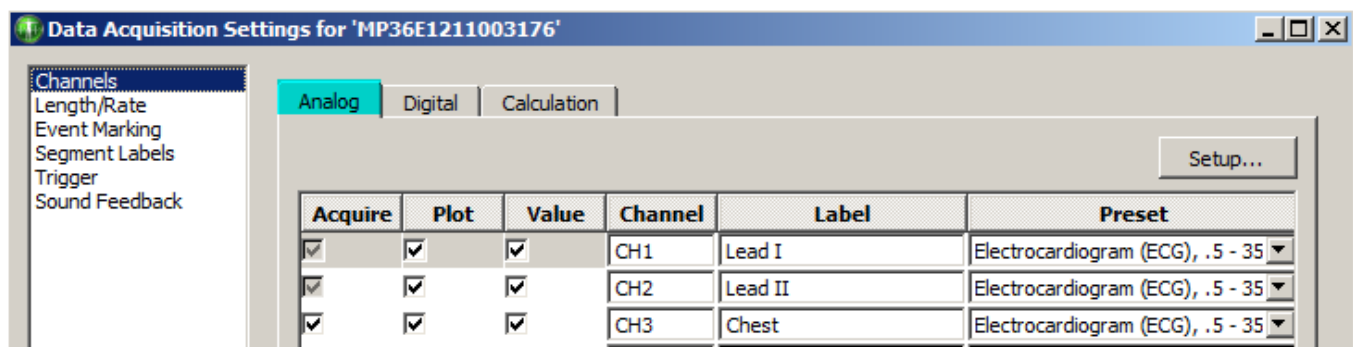
**aVF Calculation**

The Calculation channels and labeling should appear as follows:
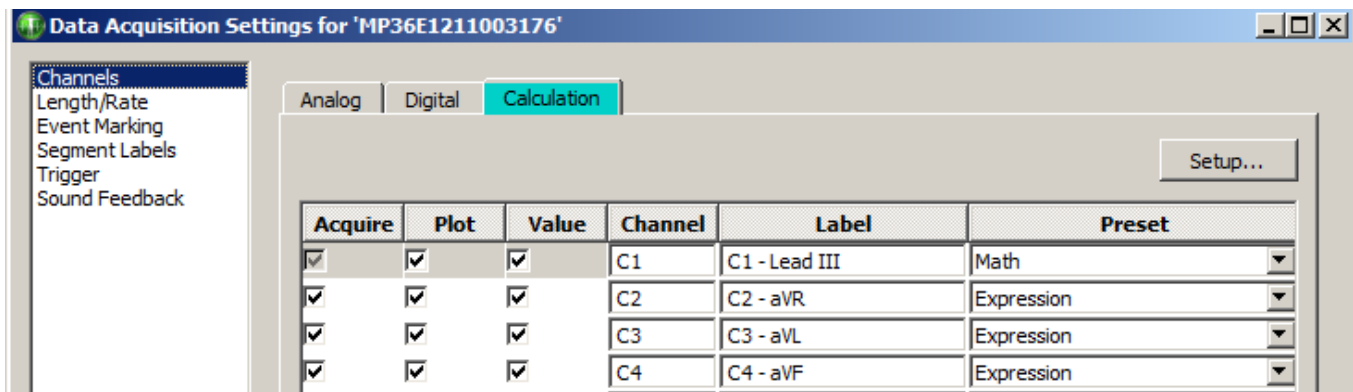


The Analog channels and labeling should appear as follows:



## Precordial Lead Recording

At this point, use the chest lead to record any of the six precordial leads. Each precordial channel is referenced to a Wilson terminal placed inside the SS29L assembly. The Wilson terminal is a circuit which finds the mean electrical axis of Leads I, II and III. The Wilson terminal creates an "indifferent" or suitable reference electrode for the precordial leads (V1 – V6). The following electrode positions respectively locate the precordial leads V1 through V6.

| Electrode placement for precordial leads (for 12-lead ECG option) | |
|---|---|
| **V1** 4$^{th}$ intercostal space, right of sternum<br><br>**V2** 4$^{th}$ intercostal space, left of sternum<br><br>**V3** midway between V2 and V4<br><br>**V4** 5$^{th}$ intercostal space, in the mid-clavicular line<br><br>**V5** same level as V4, at anterior axillary line (between V4 and V6)<br><br>**V6** in 5$^{th}$ intercostal space, in the mid-axillary line |  |
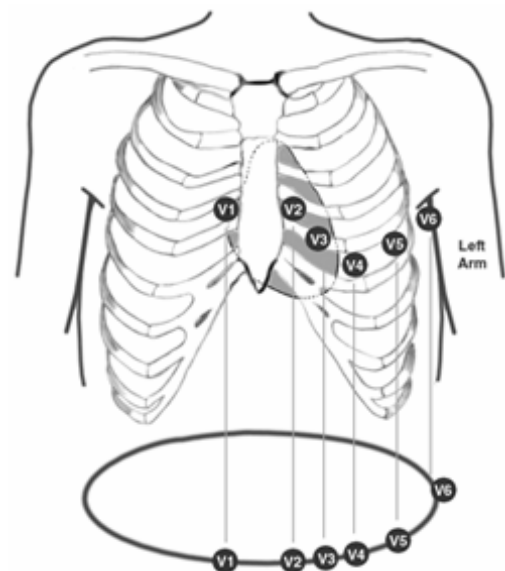
By moving the Chest lead from electrode V1 to V6 ,the respective signal from the precordial lead will be evident in channel A3 of the recording. Taking measurements from these chest sites, together with the six lead ECG obtained from Lead I and Lead II (using the Expression evaluators), will allow you to record a 12-Lead ECG with minimum of setup time.