

12 lead ECG using Octal Bio Amp

Introduction

Typically in teaching and many research applications the electrocardiogram (ECG) is obtained from just three leads: two on opposite sides of the heart and one remote from the heart. This is based on the Einthoven triangle, formed by the left and right shoulders and the pubis. According to this model, the electrical events of the heart can be represented by the cardiac vector, assumed to lie in the center of this equilateral triangle. (Figure1) For Practical reasons, surface electrodes are attached to the arms and a leg (the left leg is used by convention) as they can be seen as extensions of the leads.

The standard limb leads are bipolar:

- lead I records the potential difference between the left and right arms
- lead II records the difference between the right arm and left leg
- lead III records the difference between the left arm and left leg

Leads I, II and III are oriented in the frontal plane at 0, 60 and 120° from the horizontal plane of the body and – for a normal cardiac axis – the electrical events of the heart are represented as positive-going potentials. In addition to these standard bipolar limb leads, potentials at +90, -30 and -150° from the horizontal plane can be measured via the unipolar limb leads. These are calculated from the bipolar limb leads by referencing one electrode to the two opposite electrodes:

- lead aVR measures at the right arm
- lead aVL measures at the left arm and lead aVF measures at the left leg

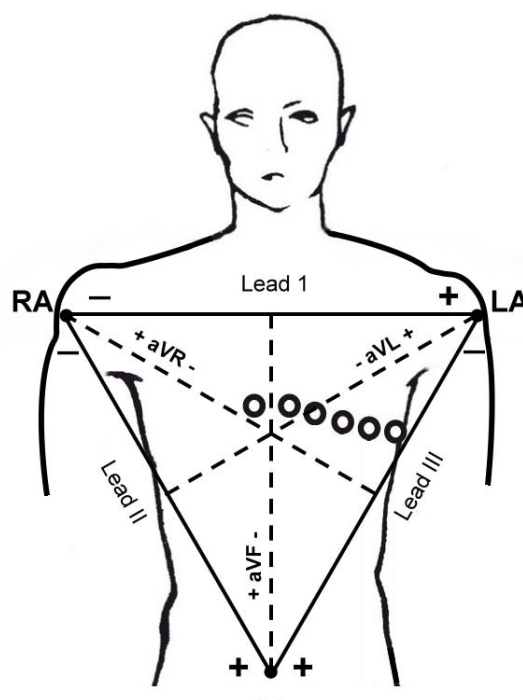


Figure 1a: Einthoven Triangle

Theoretically they should be recorded relative to the zero potential from Wilson's central terminal located at the midpoint of the three leads $1/3(aVR + aVL + aVF)$ or $(I - II + III)$. However, because the heart is a three dimensional organ a more complete picture of the cardiac electrical events can be obtained by using additional surface electrodes.

Unipolar chest leads are placed at specific sites along the chest wall (Figure 1b):

- V1 and V2 on either side of the sternum, in the right and left 4th intercostal spaces respectively
- V3 halfway between V2 and V4,
- V4 in the left 5th intercostal space, in the midclavicular line,
- V5 in the anterior axillary line horizontal to V4
- V6 in the midaxillary line, horizontal to V5.

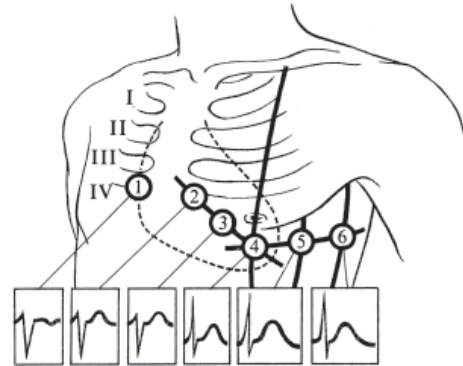


Figure 1b: Unipolar Chest Lead Placement

Using the ML138 Octal Bio Amp



Figure 2: ML138 Octal Bio Amp

The ML138 Octal Bio Amp (Figure 2) can be used to record 8 ECG leads and reconstruct the remainder using the Arithmetic function in LabChart. In the example below, V1-V6 and Leads I-II have been recorded directly using the Octal Bio Amp, using the left leg as a common reference. Lead III, aVR and aVF are calculated with the arithmetic functions. These arithmetic functions can be saved in a LabChart settings file, the derived channels being computed automatically as new data is acquired.

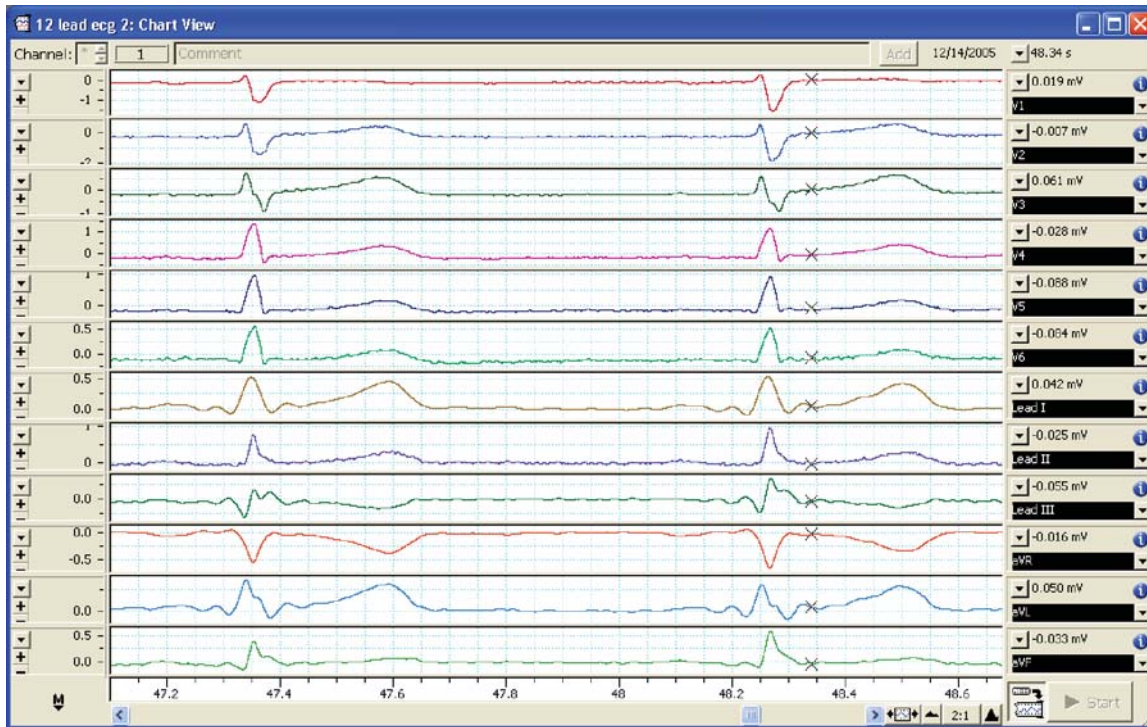


Figure 3: Sample recording

In the example file (Figure 3) V1-V6 are on channels 1-6, Lead I and II are on channels 7 and 8. The redundant leads are calculated on channels 9 (lead III), channel 10 (aVR), channel 11 (aVL) and channel 12 (aVF).

Equipment Setup

V1-V6 Electrode Placement and Connection

The recording was made with each positive lead wire in Channels 1 to 6 to the chest lead positions for V1-V6 using the following procedure:

The six positive chest leads are placed as follows:

- | | |
|---|----------------|
| V1 Fourth intercostal space to the right of the sternum | - to Channel 1 |
| V2 Fourth intercostal space to the left of the sternum | - to Channel 2 |
| V3 Directly between leads V2 and V4 | - to Channel 3 |
| V4 Fifth intercostal space at midclavicular line | - to Channel 4 |
| V5 Level with V4 at left anterior auxiliary line | - to Channel 5 |
| V6 Level with V5 at left midaxillary line | - to Channel 6 |

- 1) Locating the V1 position (fourth intercostal space) is important as it is used to place the remaining leads. To locate the V1 position, place a finger at the notch in the top of the sternum (Angle of Louis).
- 2) Move finger down about 4 cm until a slight horizontal ridge or elevation is found.
- 3) Locate the second intercostal space on the subject's right side, lateral to and just below the Angle of Louis.
- 4) Move down two more intercostal spaces to the fourth intercostal space. This is the V1 position.
- 5) Attach V1, V2, V4, and V6, and then attach V3 and V5.

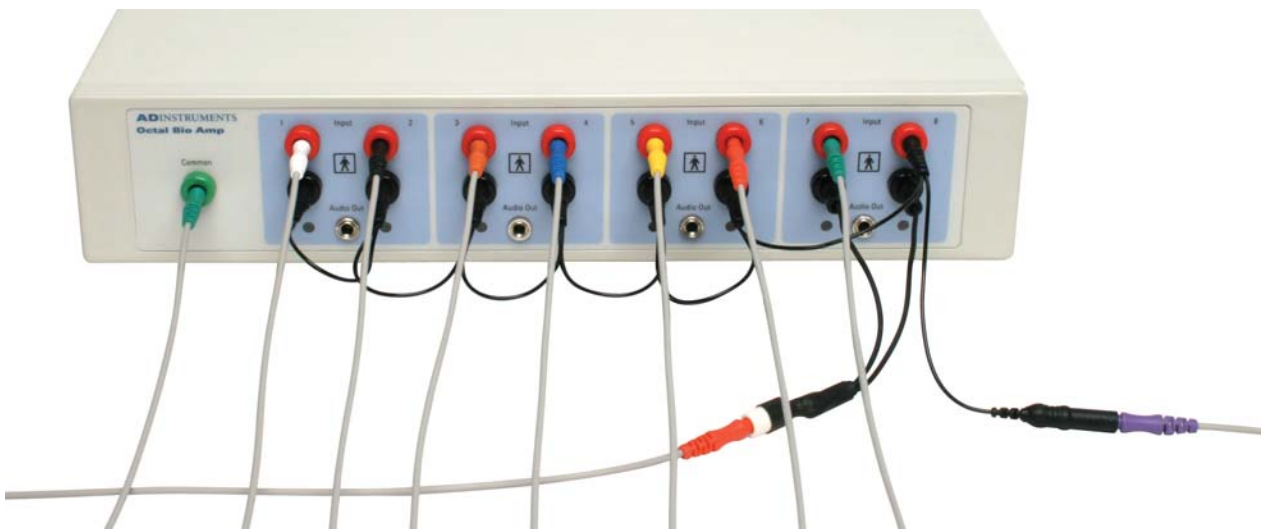


Figure 4: Input Connections

The negative inputs for channel 1-6 were linked together using a jumper lead and all attached to the Left leg. Theoretically this should be attached to the central terminal (CT) position which is the sum of the vectors $CT = (aVL + aVR + aVF)/3$, and should remain at approximately a zero potential over the whole cardiac cycle.

The CT potential can be calculated using the arithmetic function in LabChart.

Lead I & Lead II Placement and Connection

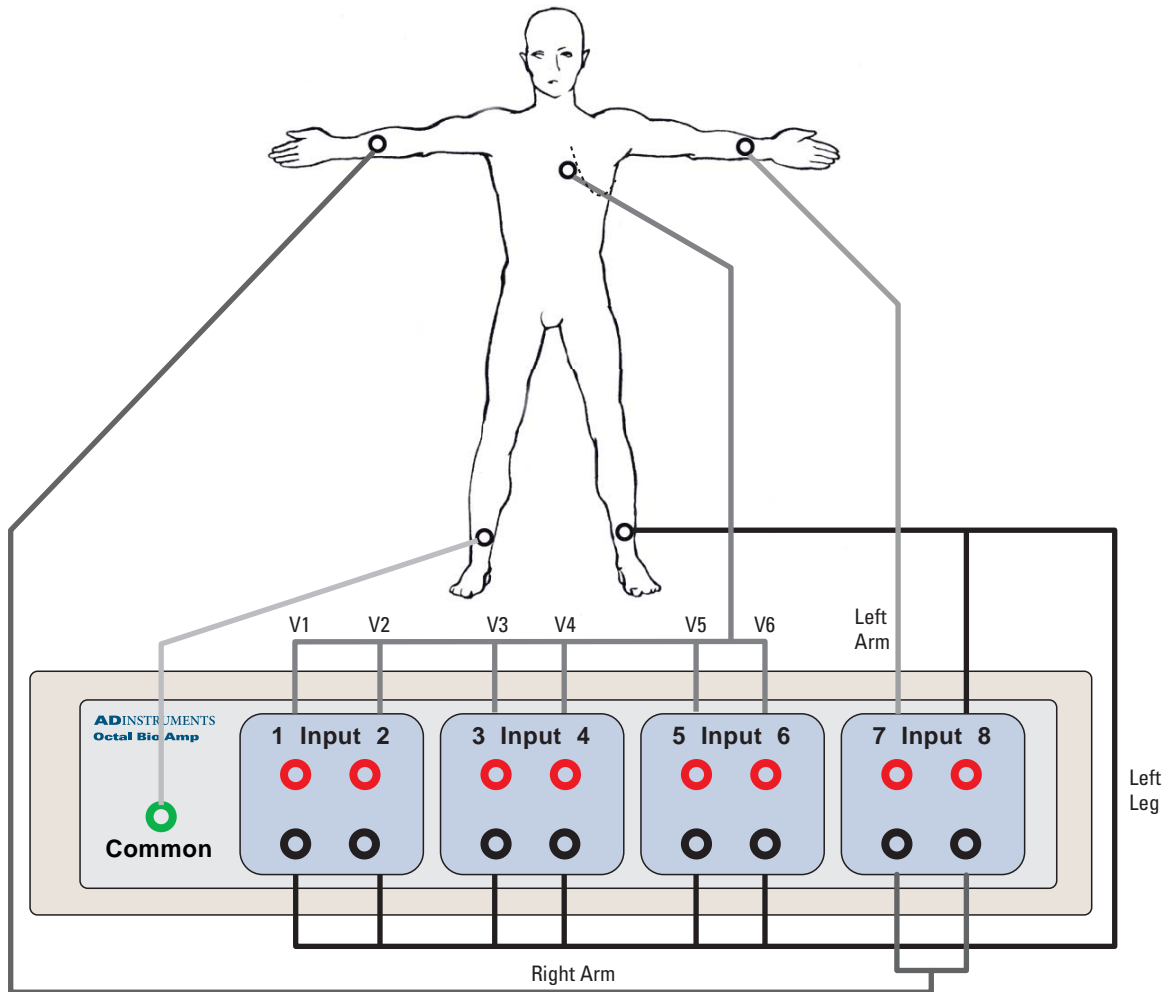


Figure 5: Lead Placement and Connections

The negative inputs for channel 7 and 8 for Lead I and II are attached to the Right Arm. (These negative inputs may be linked if more convenient. However if noise becomes a problem then it may be preferable to have two separate negative lead connections for Lead I and II.) Attach the Common input to the Right Leg.

After attaching the electrodes, open LabChart and under the Command menu use the DC restore all Inputs before recording.

