Bio-Amp

Technical Reference

e-Gizmo Bio-Amp is an instrumentation amplifier designed to pick-up minute electrical voltage generated by living biological organ like the human body. Its main feature is the use of signal Opto-isolation and high CMRR instrumentation amplifier input.

- Galvanically isolated input means danger of electrocution is almost nil, and high common mode range.

- Common Mode Rejection Ratio CMRR is a figure of merit describing the ability of the amplifier to reject common mode noise on its inputs. When used correctly, a high CMRR will effectively block 60Hz hum and other external noises from and will prevent them from overwhelming your desired signal.

Aside from the instrumentation amplifier front-end, the Bio-Amp is also equipped with a two stage opamp gain and filter circuit with socketed components. The socketed RC components allows you to experiment, and adjust the gain and response to your preference quite easily. As shipped, the Bio-Amp can function as an Electro Cardiograph ECG input module.

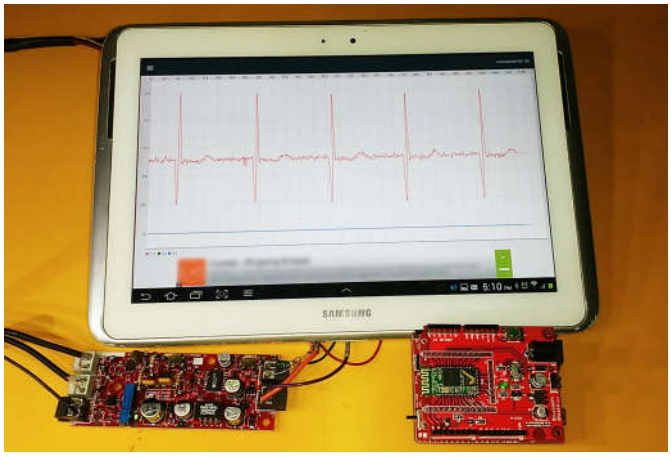


Figure 1. The Bio-Amp module (top) and a working ECG demo using a gizDuino with Bluetooth shield and an Android tablet.

CIRCUIT DESCRIPTION

Input Stage

The input stage is a standard configuration instrumentation circuit based on AD8223 U2. DC output offset of U2 can be adjusted by way of RV1. The REF input of U2 requires a very low impedance source that necessitates the use of a voltage follower circuit formed by U1B. U1A provides the “guard” bias. The guard bias minimizes the attenuating effect of the probe shield parasitic capacitance to the high frequency components of the signal.

Gain Stage

U3 forms a two stage ac gain block with frequency response users can also trim. C4/C7 determines the low frequency roll off, while C5/C8 similarly sets the high frequency cutoff. R10-R11 and R12-R13 are the gain determining components. This circuit is more or less a garden variety ac gain block, hence we will just leave the details up for your self discovery.

Isolated Output Stage

Dangerous current from AC mains just have a way of finding a path towards people, even when working with low voltage circuits and equipment that draws power from a household AC source. For this reason, you should never attach anything to a person that connects to an AC powered equipment.

Unless, of course, if the circuit is built with protection from that risk, like the Bio-Amp. The isolated output stage transfer allows the signal acquired by the input circuitry to be coupled to the output without any electrical link connecting the output with the input circuitry. This is what essentially defines the Bio-Amp, the isolation feature.

Central to this circuitry is the linear optocoupler U6. Inside the optocoupler is an infrared emitter radiating equally on two identical infrared receivers. One receiver is used to couple the signal to the output circuitry, and the other is used to couple back a representative signal as a negative feedback used to make the conversion linear and accurate.

U5 is the active element of the emitter side, buffered by Q1, and form a linearizing servo loop using the signal sampled from the emitter side infrared receiver. U7, on the other hand, amplifies the signal coming from the output infrared receiver and presents it in its output as an accurate replica of the input stage signal.

Isolated Power Supply

To achieve complete isolation, the power supply used with the circuitry must also be isolated. U4 is an isolated DC/DC converter that does that purpose. It provides an isolated and regulated 5VDC source taken from the output circuit’s 12VDC rail with the use of internal transformer and DC to AC to DC conversion circuitry.

Figure 2. Input noise rejection relies heavily on the quality of electrical contact with your body. This can be achieved only with the use of good electrodes. Cheap disposable electrodes, such as those shown in the photo, will do an ample job when used correctly.

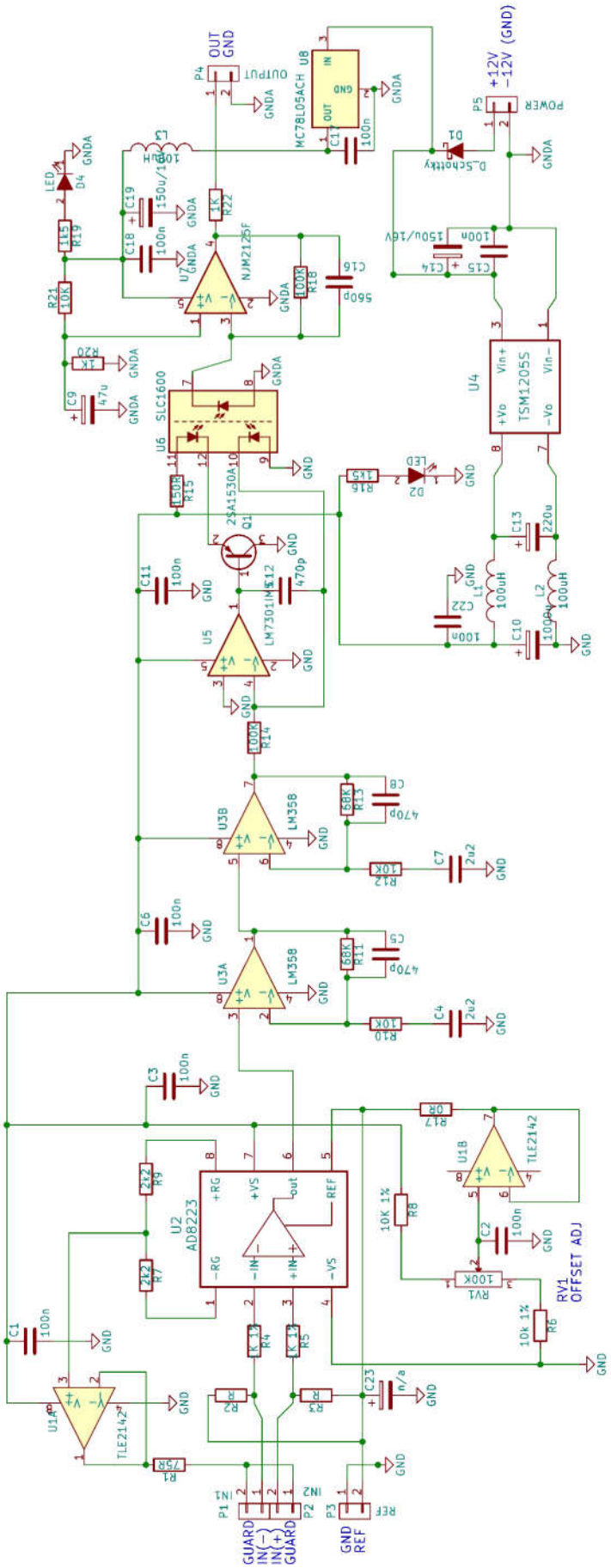


Figure 3. Complete schematic diagram of the Bio-Amp. To achieve full galvanic isolation, the signal is coupled to the output by means of a linear opto isolation circuit. DC power isolation is provided by an isolated DC/DC converter.

APPLICATION WIRING EXAMPLE

The Bio-Amp, as shipped, has a gain of about 900, and out-of-the-box can be used as an ECG amplifier. Figure 4 shows how to wire it as an ECG monitor.

The important points to remember are:

1. Use shielded wires for +IN and -IN input. All wires kept signal wire protrusion to bare minimum length. This will prevent 60Hz hum and other extraneous noise from entering the system and messing up measurements.
2. The shield braid wires must be connected to the “GUARD” terminal.
3. Do not connect anything else with the isolated input section of the circuit.

NOTE ON R3 AND R4.

R3 and R4 are unpopulated (vacant) as shipped. You will need to install at least one only if your application does not have a physical circuit connection to REF or GND terminal. Start with 1Mohm and experiment until you find the best value. Generally, picking a value for R3 or R4 much greater than the source impedance of the bio object you are probing will give you good results.

ECG, ELECTRODE PADS AND CONDUCTIVE GEL

The electrode’s quality of connection to your body plays a huge role in the performance of the Bio-Amp. If you set up with a poor connection, you will get poor results. Your acquired signal may be swammped with 60Hz noise and other unwanted artifacts. To get good results, you should always use fresh disposable electrode pads to ensure good electrical contact.

Or you can DIY cheap reusable pads and equally cheap conductive gel as discussed in this instructable. This instructable also includes a short discussion on how to properly use these pads.

http://www.instructables.com/id/How-to-make-ECG-pads-conductive-gel/

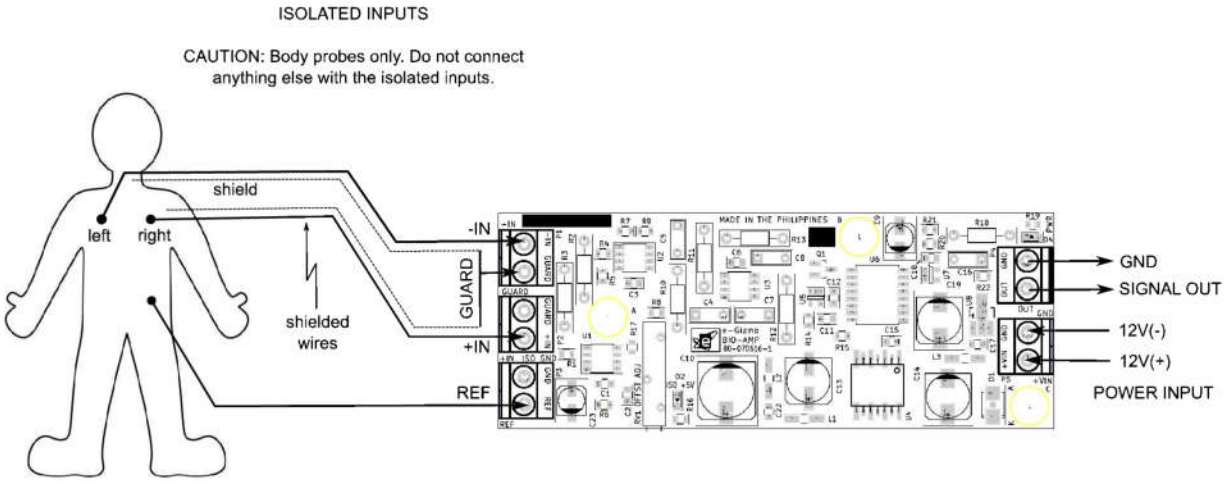
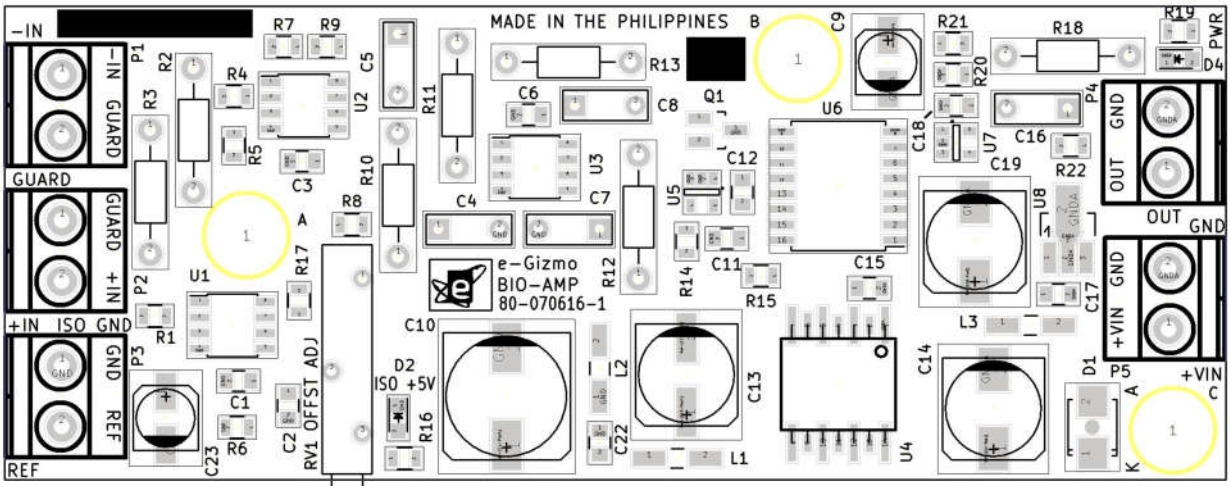
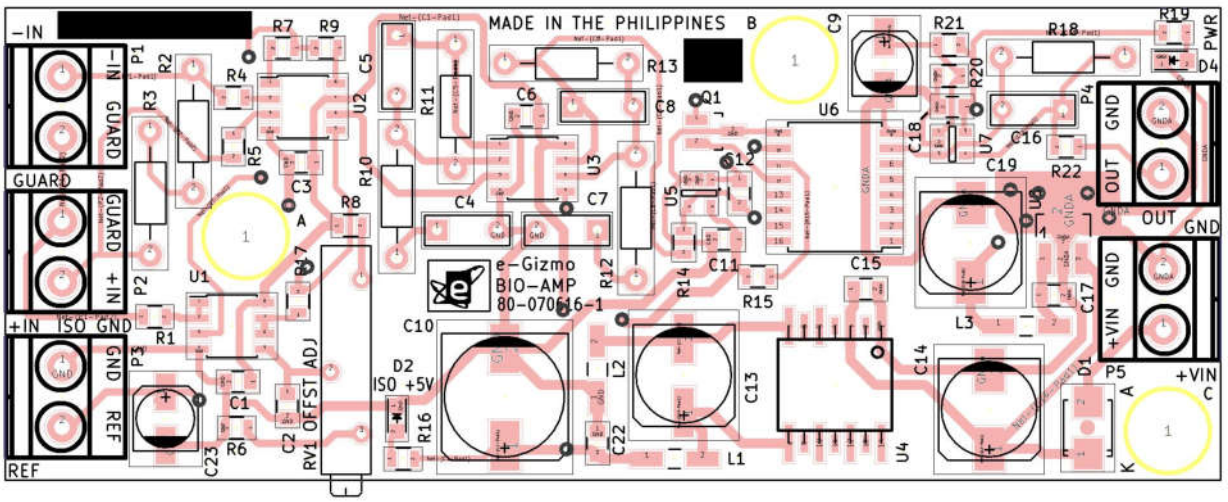


Figure 4. General wiring example. In this example, the Bio-Amp is used as an ECG amplifier. Use of shielded wire for the +/- input electrodes are required. Note that the outer shields must be wired to the "GUARD" inputs. REF does not require a shielded connection.

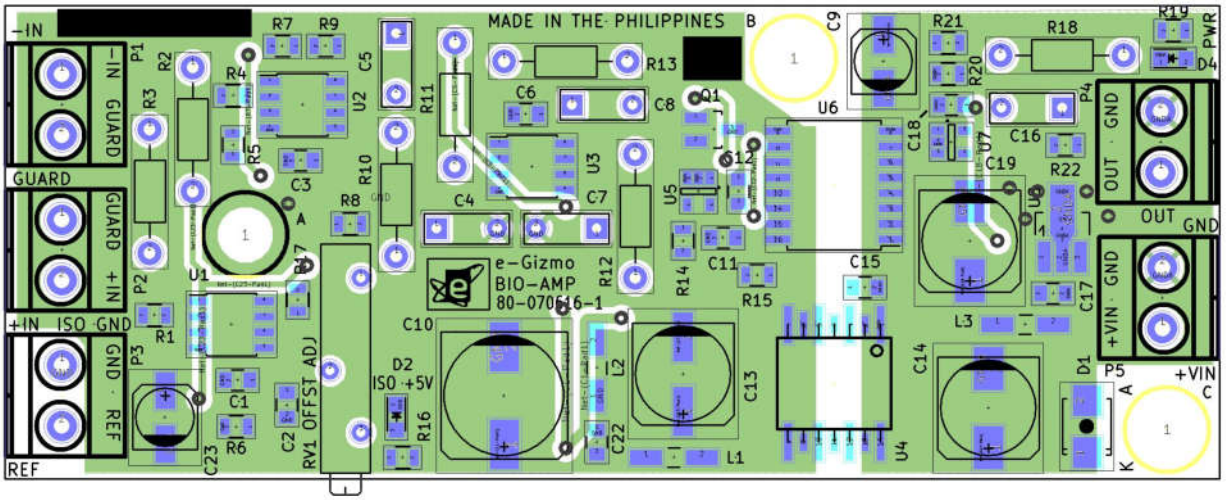
PCB COMPOSITES GUIDE



COMPONENT LAYOUT



COMPONENT LAYOUT WITH TOP COPPER PATTERN



COMPONENT LAYOUT WITH BOTTOM COPPER PATTERN