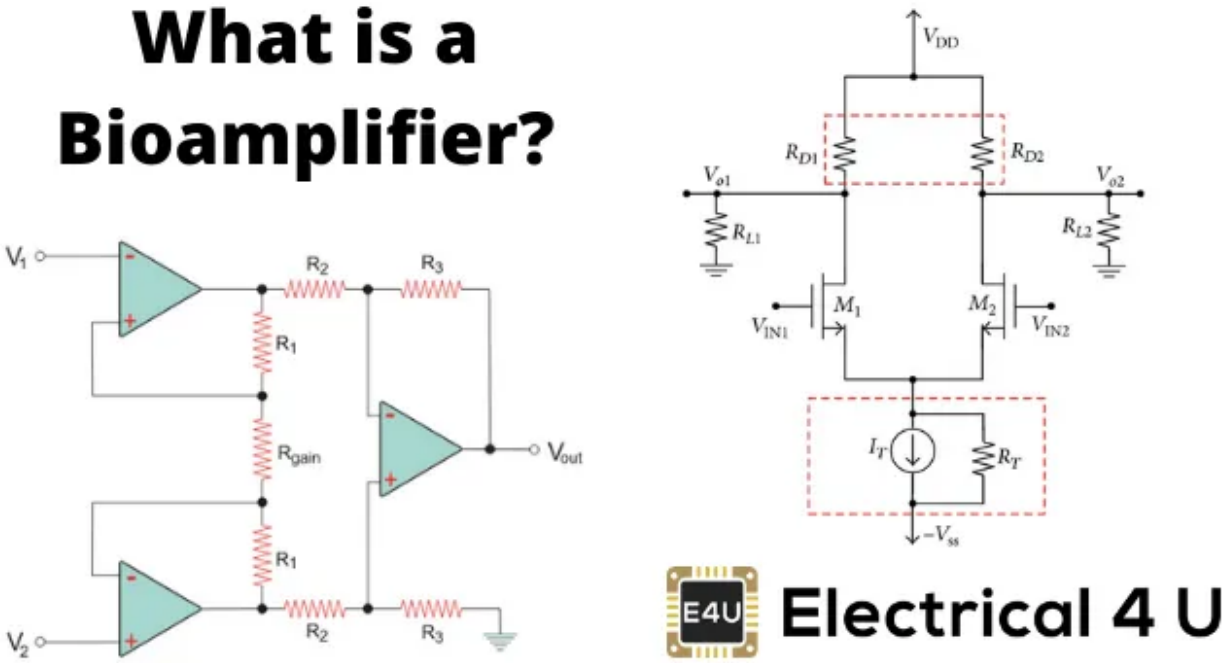
Biological Amplifiers and Types of Biological Amplifiers

Last updated March 7, 2021 by Vidya Muthukrishnan



Why is Bio Amplifier Required?

Generally, biological/bioelectric signals have low amplitude and low frequency. Therefore, to increase the amplitude level of biosignals amplifiers are designed. The outputs from these amplifiers are used for further analysis and they appear as ECG, EMG, or any bioelectric waveforms. Such amplifiers are defined as Bio Amplifiers or Biomedical Amplifiers.

Basic Requirements for Biological Amplifiers

1. The **biological amplifier** should have a high input impedance value. The range of value lies between 2 MΩ and 10 MΩ depending on the applications. Higher impedance value reduces distortion of the signal.

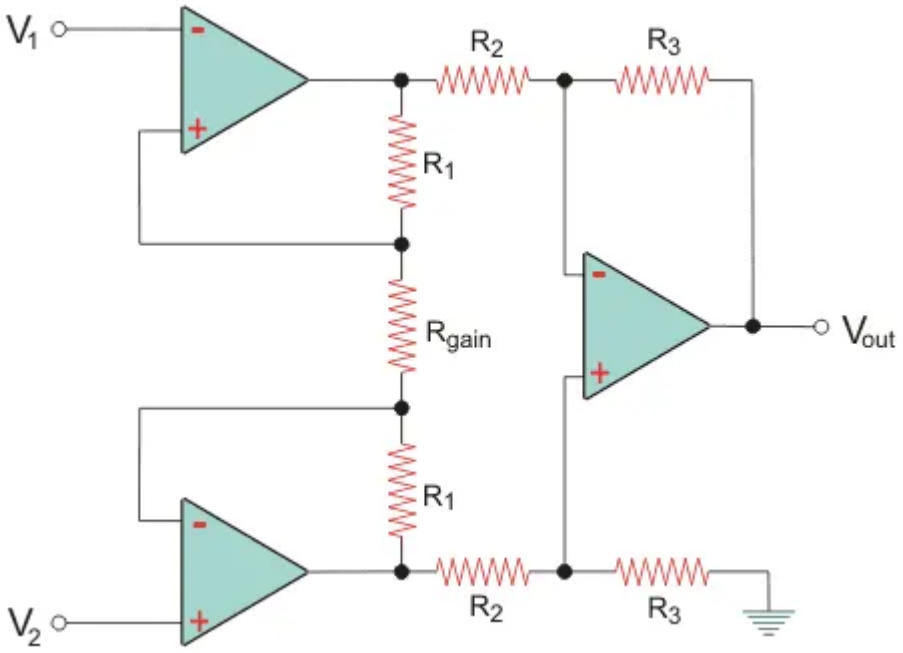
2. When electrodes pick up biopotentials from the human body, the input circuit should be protected. Every bio-amplifier should consist of isolation and protection circuits, to prevent the patients from electrical shocks.
3. Since the output of a bioelectric signal is in millivolts or microvolt range, the voltage gain value of the amplifier should be higher than 100dB.
4. Throughout the entire bandwidth range, a constant gain should be maintained.
5. A bio-amplifier should have a small output impedance.
6. A good bio-amplifier should be free from drift and noise.
7. Common Mode Rejection Ratio (CMRR) value of amplifier should be greater than 80dB to reduce the interference from common mode signal.
8. The gain of the bio-amplifier should be calibrated for each measurement.

Types of Bio Amplifiers

1. Differential Amplifier
2. Operational Amplifier
3. Instrumentation Amplifier
4. Chopper Amplifier
5. Isolation Amplifier

Instrumentation Amplifier

In biomedical applications, high gain and the high input impedance are attained with an instrumentation amplifier. Usually, a 3-amplifier setup forms the instrumentation amplifier circuit. The output from the transducer is given as input to the instrumentation amplifier. Before the signal goes to the next stage, a special amplifier is required with high CMRR, high input impedance and to avoid loading effects. Such a special amplifier is an instrumentation amplifier, which does all the required process.



To each input of the differential amplifier, the non-inverting amplifier is connected. From the figure, the amplifier on the left side acts as non-inverting amplifiers.

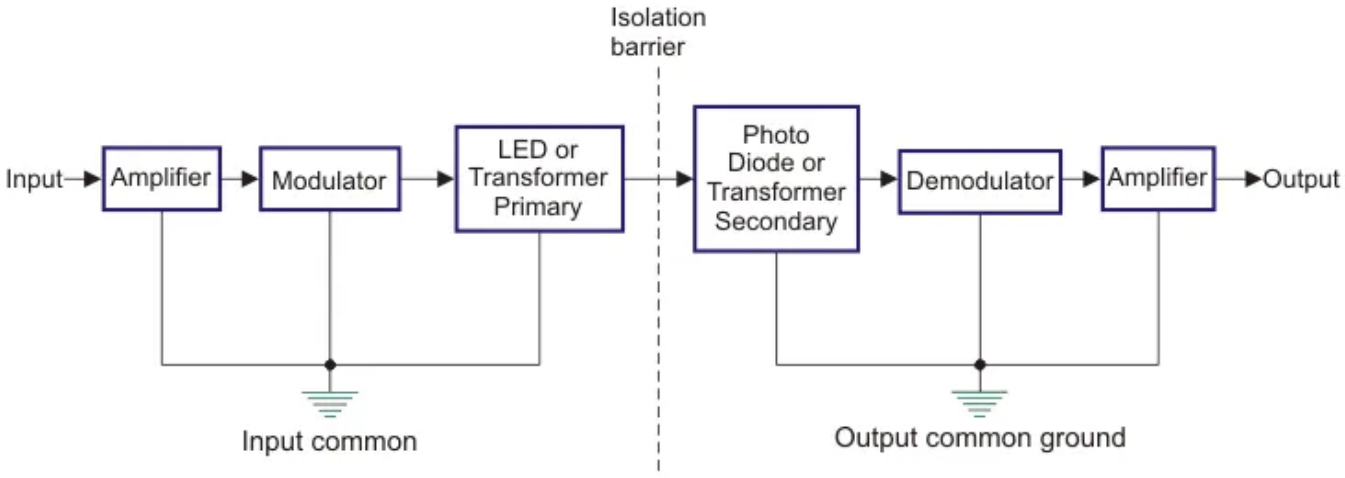
They are combined together to form the input stage of the instrumentation amplifier. The third op-amp is the difference amplifier, and it is the output of the instrumentation amplifier.

The output from the difference amplifier V_{out} is the difference between two input signals given at the input points. V_{O1} is the output from op-amp 1 and V_{O2} is the output from op-amp 2.

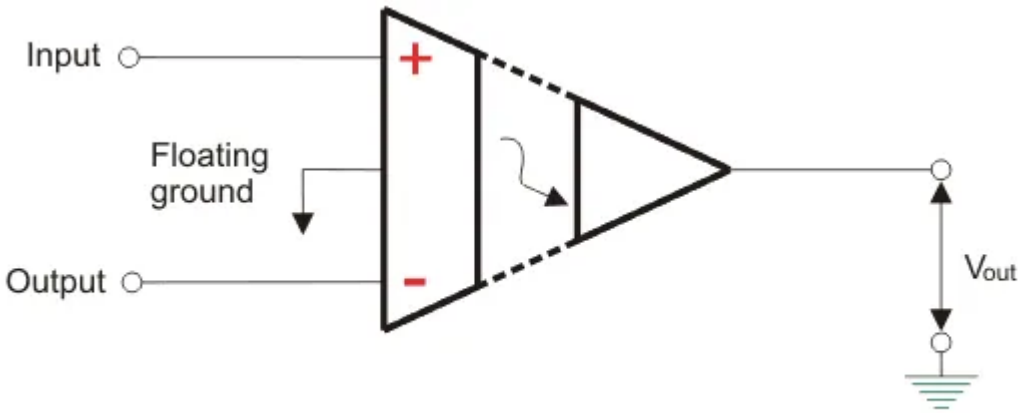
$$V_{out} = \frac{R_3}{R_2}(V_{O1} - V_{O2})$$

Isolation Amplifier

Isolation amplifiers are known as Pre-amplifier isolation circuits. An isolation amplifier increases the input impedance of a patient monitoring system. It also helps to isolate the patient from the device. Using the isolation amplifier prevents accidental internal cardiac shock. It provides up to 1012 Ω insulation between the patient and the power line in the hospital.



Block Diagram of Isolation Amplifier



Symbol of Isolation Amplifier

The electrical signals are obtained with electrodes. The signals received goes to the amplifier block, where signals amplification occurs. After amplification, the signal enters the modulation block. When either it goes to the isolation barrier, optical cable or transformer can be used. If in case of optical cable, modulator output travels to LED. The LED converts electrical signals into light energy. If the transformer acts an isolation barrier, modulator output connects the primary winding of the transformer. Energy from primary transfers to the secondary winding based on the mutual induction principle. At the next stage, secondary output enters the demodulation block. Finally, the amplified demodulated signal is obtained.

ECG Isolation Amplifier

During ECG measurement, signals generated from all leads are sent to the low pass filter. This filter is named as Electro surgery filters because it decreases the interference between

electrosurgery and radio frequency. Next block is the high voltage and overvoltage protection that can withstand large voltage during defibrillation.

Proceeding further, it goes to Lead Selector Switch block, which selects the required configuration. Lead selection output goes to the DC amplifier. We have a transformer, whose primary winding is connected to the oscillator and secondary to rectifier and filter. ECG signal is modulated with the Synchronous modulator. The second transformer delivers the output from the synchronous modulator to the synchronous demodulator. The output from the demodulator is fed as input to the power amplifier.

About Vidya Muthukrishnan

Vidya Muthukrishnan is currently employed as a Senior Engineer in a product based IT company. She has 5 years of professional teaching experience, previously Assistant Professor in the Department of Instrumentation and Control Engineering at the Sri Krishna College of Technology. She also has 1 year of industry experience with TCS, India. Vidya completed her B.Tech Electronics and Instrumentation from SASTRA University and M.Tech in Biomedical Engineering from VIT University Vellore.

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