DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

BM3491 Biomedical Instrumentation

UNIT-III BIOAMPLIFIERS

3.1 Need for Bio amplifier, Differential Bio amplifier

3.1.1 Need for Bio amplifier:

i. biological/bioelectric signals have ***low amplitude*** and low frequency. Therefore, to increase the amplitude level of bio-signals amplifiers are designed. The outputs from these amplifiers are used for further analysis and they appear as ECG, EMG, or any bioelectric waveforms

ii. A Bio amplifier is an electrophysiological device, a variation of the instrumentation amplifier, used to gather and increase the signal integrity of physiologic electrical activity for output to various sources. It may be an ***independent unit***, or ***integrated*** into the electrodes.

iii. A bio-amplifier, or biological amplifier, is a device designed to ***amplify bioelectric*** signals originating from living organisms. These signals are typically weak and need to be strengthened for various applications in medical diagnostics, research, and monitoring. Bio amplifiers play a crucial role in capturing and processing signals from physiological processes within the human body or other living organisms.

Here are some common reasons for the need of bio amplifiers:

1. **Signal Enhancement**: Bioelectric signals generated by the human body, such as those from the heart (ECG), brain (EEG), muscles (EMG), or other physiological processes, are often very weak. Amplification is necessary to make these signals measurable and interpretable.
2. **Medical Diagnostics**: Bio-amplifiers are extensively used in medical diagnostics to monitor and analyze various physiological parameters. For example, an ECG amplifier is used to monitor the electrical activity of the heart, providing essential information for diagnosing cardiac conditions.

3. **Research and Studies**: In scientific research, bio amplifiers are employed to study and understand various biological processes. Researchers use them to investigate the electrical activity of the nervous system, study muscle contractions, and explore brain function.
4. **Neuroscience:** In neuroscience, bio amplifiers are crucial for studying brain activity. EEG (electroencephalogram) amplifiers, for instance, help researchers and clinicians understand brainwave patterns and diagnose neurological disorders.
5. **Prosthetics and Human-Machine Interfaces**: Bioamplifiers are essential components in the development of prosthetics and human-machine interfaces. They help in capturing and interpreting signals from muscles or nerves to control prosthetic limbs or interface with computers.
6. **Sleep Monitoring:** Bioamplifiers can be used in sleep studies to monitor brain activity during different sleep stages. EEG amplifiers are particularly important in sleep research and diagnostics.
7. **Rehabilitation and Physical Therapy**: Bioamplifiers are employed in rehabilitation settings to monitor and assess muscle activity. EMG (electromyography) amplifiers, for example, can help therapists evaluate muscle function and design appropriate rehabilitation programs.

In summary, bio-amplifiers are crucial tools in various fields, particularly in medicine and research, where the amplification of weak bioelectric signals allows for better understanding, diagnosis, and treatment of physiological conditions.

3.1.2 Differential Bio-amplifier:

A differential amplifier is a type of electronic amplifier that amplifies the difference between two input voltages but suppresses any voltage common to the two inputs.

Differential amplifiers offer many advantages for manipulating differential signals. They provide immunity to external noise; a 6-dB increase in dynamic range, which is a clear advantage for low-voltage systems; and reduced second-order harmonics.

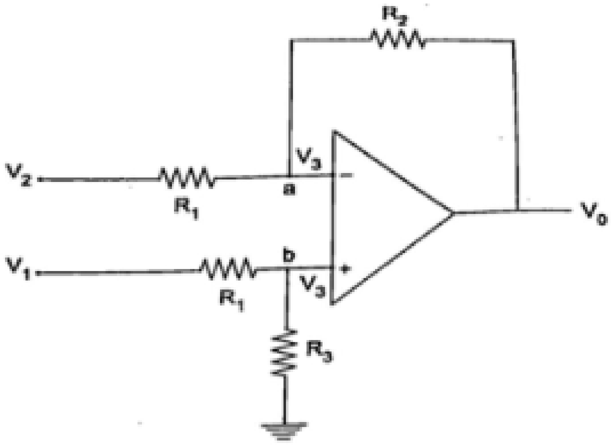

Fig: Differential Amplifier

1. Single Ended Mode:
   - When either V1 or V2 is equal to zero, the operation of the differential amplifier is known as single ended mode of operation.
   - If V1=0 the differential amplifier is operating in the non-inverting mode and if V2=0 it is operating in the inverting mode.

2. Differential Mode:
   - In this mode, the two input signals are equal but have opposite polarity at every instant of time.

     ∴ $V_1 = -V_2 = V_0$ We have seen that

     $$V_o = \frac{R_2}{R_1}(v_2 - v_1)$$

     $$V_0 = \left(\frac{2R_2}{R_1}\right) v_1$$

   - In this case the input signals are called differential mode signals.
   - Since an operational amplifier, has a pair of differential input terminals, it is easily connected for use in a differential configuration.
   - The differential voltage at the input terminals of the OP-amp is zero, that is nodes a and b are at the same potential designated as V_3.
   - The nodal equations at a is

$$\frac{v_3 - v_2}{R_1} + \frac{v_3 - v_0}{R_2} = 0$$

The nodal equation at b is

$$\frac{v_3 - v_1}{R_1} + \frac{v_3}{R_2} = 0$$

Rearranging, we get

$$\left(\frac{1}{R_1} + \frac{1}{R_2}\right) v_3 - \frac{v_2}{R_1} = \frac{v_0}{R_2} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots..(3)$$

$$\left(\frac{1}{R_1} + \frac{1}{R_2}\right) v_3 - \frac{v_1}{R_1} = 0 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots..(4)$$

Subtracting (4) from (3) we get

$$\left(\frac{1}{R_1}\right) v_1 - v_2 = \frac{v_o}{R_2}$$

$$\left(\frac{R_2}{R_1}\right) v_1 - v_2 = v_0$$

3. Common Mode:

The input voltages appearing at the input terminals 1 and 2 are identical both in amplitude and phase at every instant of time and the circuit is said to be operating in the common mode.

$$V_1 = V_2 = V_{CM}$$

$$V_0 = o$$

- These input signals are called common mode signal.
- Thus, the common mode input signals produce no voltage at the output of the ideal amplifier.

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