ISOLATION AMPLIFIER

Isolation amplifiers are used mainly in ECG recording to prevent accidental internal cardiac shock. Isolation amplifiers provide insulation between the patient connector and the ac power mains line cord. Isolation amplifiers are mainly used to protect hospital patients, susceptible to electrical shock hazards.

The insulation amplifier is composed of an input amplifier, modulator, an isolation amplifier, a demodulator and an output amplifier. The isolation amplifier is really an energy converter. There is an input common and an output common that are electrically isolated from one another. Isolation barrier may be optical, magnetic transformer, capacitive or even heat transfer.

In the isolation amplifier electrical energy on the modulation side is converted to some non-electrically conductive energy in the barrier and then converted back to electrical energy on the demodulator side. Isolation amplifier actually operate on the principle of attenuation. A high barrier impedance acts in series between input and output. Isolation amplifier break ground loops to permit incompatible circuits to be interfaced together while reducing noise.

Block diagram of 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 1012Ω insulation between the patient and the power line in the hospital.

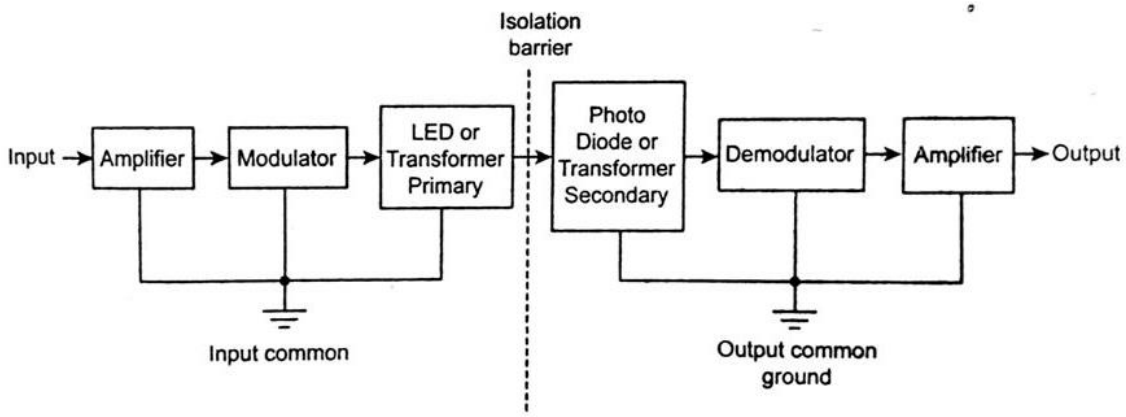

Fig: Block diagram of Isolation Amplifier

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.

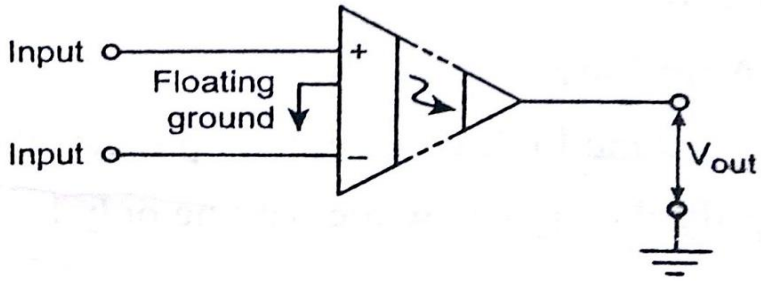

Fig: Symbol of Isolation Amplifier

The LED converts electrical signals into light energy. If the transformer acts as isolation barrier, modulator output connects the primary winding of the transformer. Energy from primary transformers 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.

Types of Isolation Amplifier:

There are two types of isolation amplifier.

- ❖ Darlington pair
- ❖ Boost rapping circuit

1. Darlington Pair:

- Darlington pair is an isolation amplifier which provides high input impedance with high currents gain. This is available in single case.
- Two transistors Q_1 and Q_2 are connected in common emitter compound connecting circuits.
- The input impedance as seen by the electrode transducers is found by multiplying the common emitted current amplification factor by the output impedance,
- Because the transistor are identical, the expression for the input impedance can be written as

$$z_i = \beta^2 z_0$$

- The emitter terminal of transistor Q_1 is directly connected to the base of transistor Q_2.

- The collectors of both transistors share a common load RL.
- Since the transistor Q_2 is the common leg of the circuit and the resulting input impedence z_i is very much greater than that of a single common emitter stage.
- For normal class A operation resistance R_B is chosen so that both edges are operating in the active region of their collector characteristics.
- X, Y and Z are 3 external terminals to the two transistors.

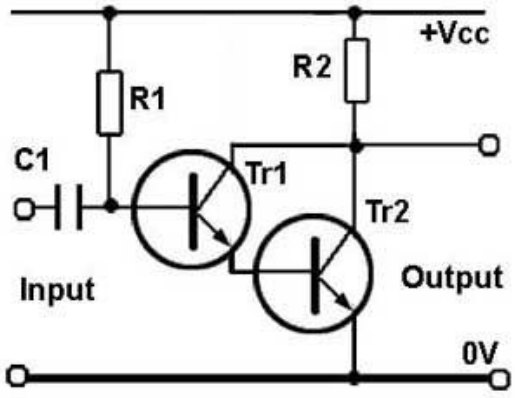

Fig: Darlington pair

2. Boosts Traping circuit

- To get very high input impedance, boosts rapping circuit is also used as isolation amplifier.
- In the cascade emitter follower circuit, a feedback network may be connected between the emitter of the second transistor Q_2 and the collector of the first transistor Q_1.
- The feedback voltage created by the bootstrap voltage dividing network R_1 and R_2 is injected into the collector circuit of the first transistor.
- An increase in signal level at the input of the circuit causes an increase in signal through the divider at the collector, changing the transistors bias point.
- This is in turn, increases. The input impedance collection changing the transistors which is more than 50 meha ohms.
- The feedback developed is proportional to the values of R_1 and R_2 in series and R_3 in series.
- The resistor R_4 is used to limit the current flowing through Q_2.
- Even though the voltage gain 0.9 the current and power gains are very high.

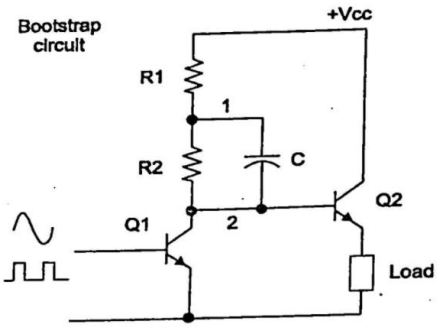

Fig: Bootstrap circuit

ECG Isolation Amplifier Circuit:

The signals from the different leads are given to the low pass filter having a cut off frequency about 10kHz. This filtering reduces the interference caused by electro surgery and radio frequency emission. The filter circuit is followed by high voltage and over voltage protection circuits so that the amplifier can withstand large voltages during defibrillation.

Now the signals are fed into the lead selector switch which is used to device the required lead configuration and the output of lead selector is given to a dc amplifier. The dc amplifier can also receive a standard dc voltage of 1mV through a push button for calibration purposes. The primary of an isolated low capacitance power transformer is connected with the 100KHz oscillator.

The secondary of that transformer along with the rectifier and filter circuits is used to obtain isolated power supply of ±6V for operating the devices in the isolated portion of the circuit. The synchronous modulator modulates the ECG signal from the dc amplifier, at 100khz in a linear manner. Another transformer is used to deliver the output from the driver of the modulator to the synchronous demodulator.

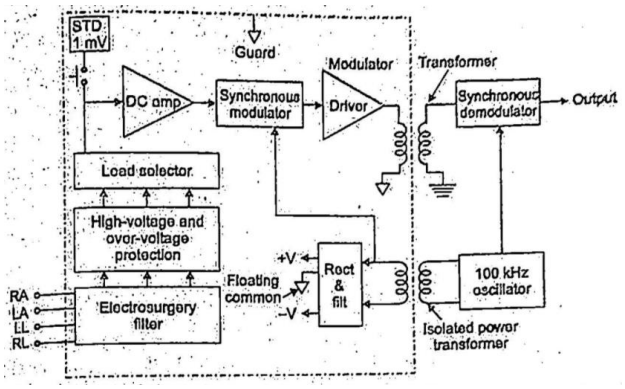

Fig: Block diagram of an isolation preamplifier commonly used in modern ECG machines

The figure shows a block diagram of an isolation preamplifier used in modern electrocardiographs. Difference signals obtained from the right arm (RA), left arm (LA) and right leg (RL) is given to a low pass filter.

Filtering is required on the input leads to reduce interference caused by electrosurgery and radio frequency emissions and sometimes from the 50kHz current used for respiration detection. The filter usually has a cut off frequency higher than 10kHz. A multistage filter is needed to achieve a suitable reduction in high frequency signal.

The filter circuit is followed by high voltage and over voltage protection circuits so that the amplifier can withstand large voltages during defibrillation. However, the price of this protection is a relatively high amplifier noise level arising from the high resistance in each level.

The oscillator frequency of 100kHz is chosen as a compromise so that reasonable size transformers could be used and that the switching time is not too fast, so that inexpensive transistors and logic circuitry can be utilized. A square wave is utilized to minimize the power requirements of the driven transistors. Isolation of the patient preamplifier can also be obtained using an optical isolated.