Nadar Saraswathi College of Engineering & Technology

NSCET E-LEARNING PRESENTATION

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Electrical and Electronics engineering

III YEAR/ Vth Semester

OMD551 Basics of Biomedical Instrumentation

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TOPIC NAME

UNIT 03 –SIGNAL CONDITIONING CIRCUITS

"**Learning** is not attained by chance, it must be sought for with ardor and attended to with diligence."

—Abigail Adams

SIGNAL CONDITIONING CIRCUITS

- Need for bio amplifier
- Differential bio amplifier
- Impedance matching circuit, isolation amplifier and
- Power line interference
- Right leg driven ECG amplifier
- Band pass filtering

NEED FOR BIO AMPLIFIER

Generally bio signals are having low amplitude and low frequency so amplifier are needed to boost the amplitude level of the bio signals the output of this amplifier is displayed as EEG or ECG waveform these amplifiers are known as bio amplifiers.

Bio medical amplifiers

Amplifiers that have been designed specifically for processing of bio potentials are known as bio potential amplifiers.

TYPES OF AMPLIFIERS

- Differential amplifier
- Operational amplifier
- Instrumentation amplifier
- Chopper amplifier
- Isolation amplifier

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DIFFERENTIAL BIO AMPLIFIER

- The differential amplifier is an excellent device for using in bio medical recording systems.
- Its excellence lies in its ability to reject common mode interference signals which are invariably picked up by electrodes from the body along with the useful bio electric signals.

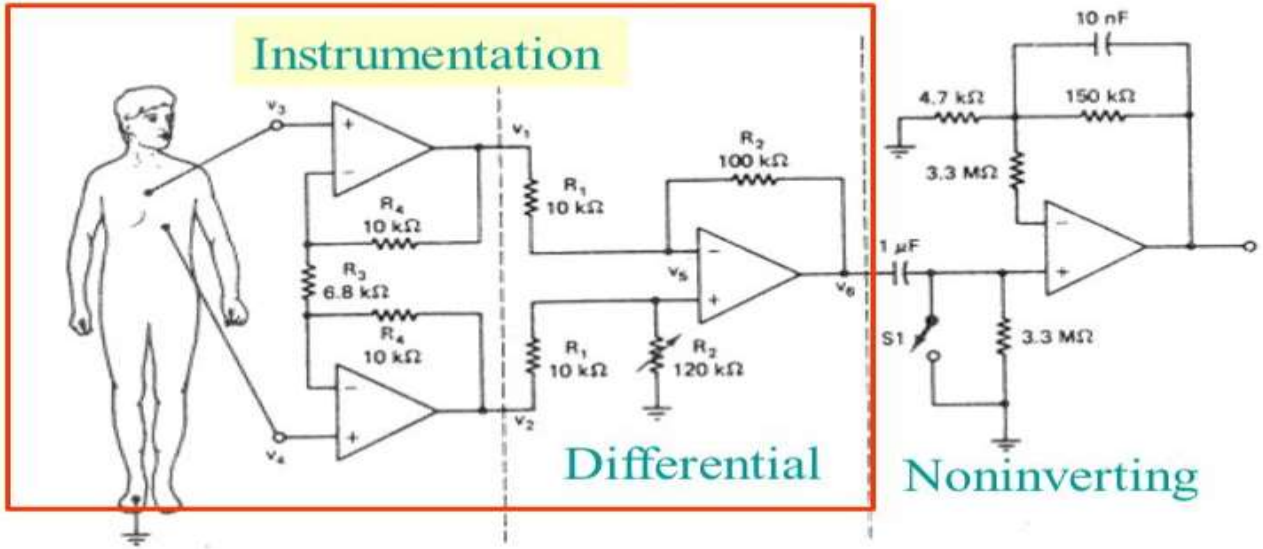
TYPES OF MODES IN DIFFERENTIAL AMPLIFIER

- Difference mode
- Common mode

DIFFERENTIAL AMPLIFIER IN ECG RECORDING SYSTEM

Differential Amplifiers

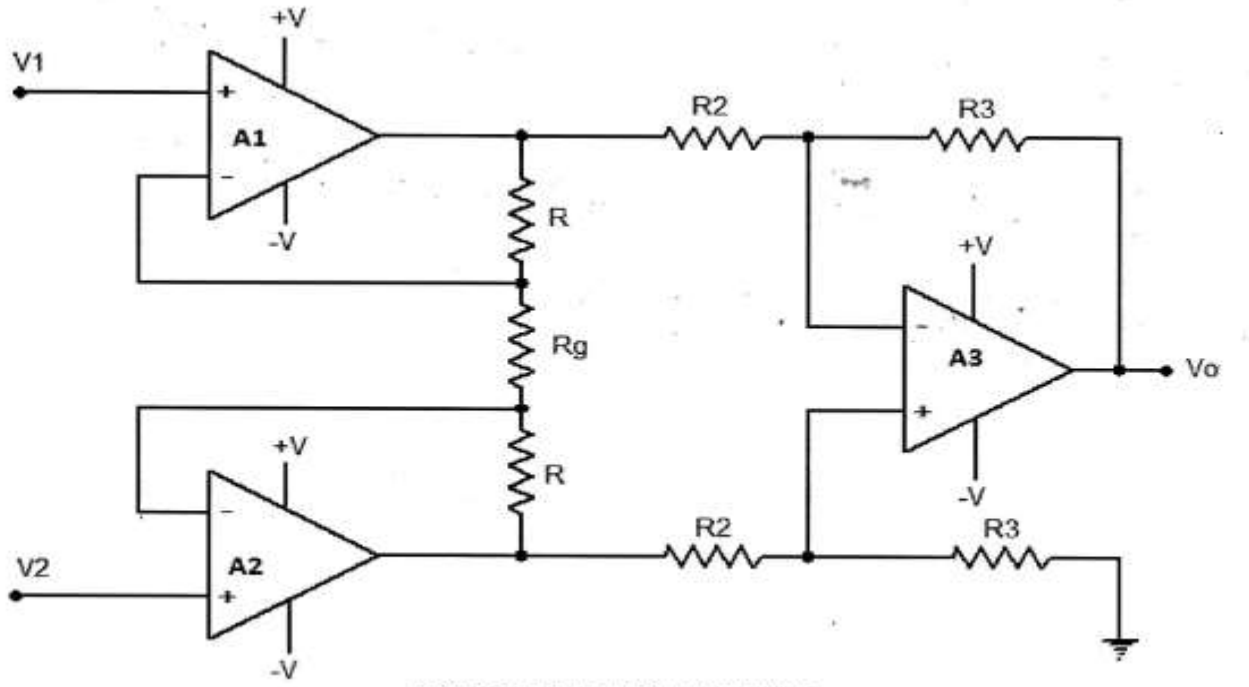
- Combination of Inverting and Noninverting Amp
- Can reject 60Hz interference
- Electrocardiogram amplifier



IMPEDANCE MATCHING CIRCUIT

Instrumentation amplifier is a kind of differential amplifier with additional input buffer stages. The addition of input buffer stages makes it easy to match (impedance matching) the amplifier with the preceding stage. Instrumentation are commonly used in industrial test and measurement application.

IMPEDANCE MATCHING CIRCUIT



INSTRUMENTATION AMPLIFIER

ISOLATION AMPLIFIER:

- It is important to protect the user from the hazards of electrical shock. Electrical shock can always present a safety risk with electrical circuits and it is important to consider the problem seriously.
- Isolation amplifiers can be used to break ground loops, eliminate source ground connections, and provide isolation protection to patient and electronic equipment.

ISOLATION AMPLIFIER

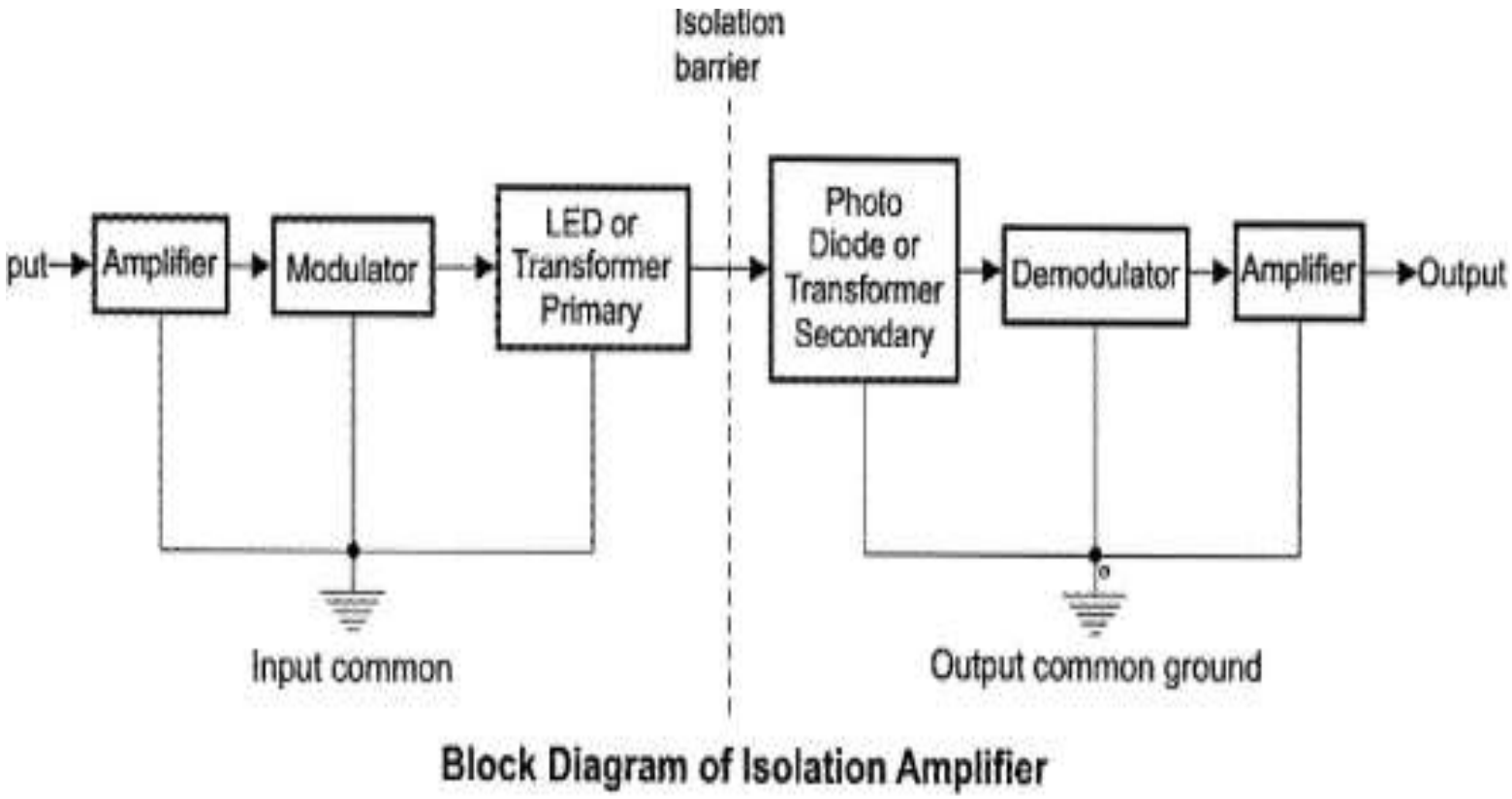
Three methods are used in the design of isolation amplifiers:

(i) Transformer isolation

(Ii) optical isolation

(iii) capacitive isolation.

ISOLATION AMPLIFIER



Block Diagram of Isolation Amplifier

(I) TRANSFORMER ISOLATION TYPE

- It uses either a frequency-modulated or a pulse width modulated carrier signal with small signal bandwidths up to 30 kHz to carry the signal.
- It uses an internal de-to-de converter comprising of a 20 kHz oscillator, transformer, rectifier and filter to supply isolated power.

TRANSFORMER ISOLATION TYPE

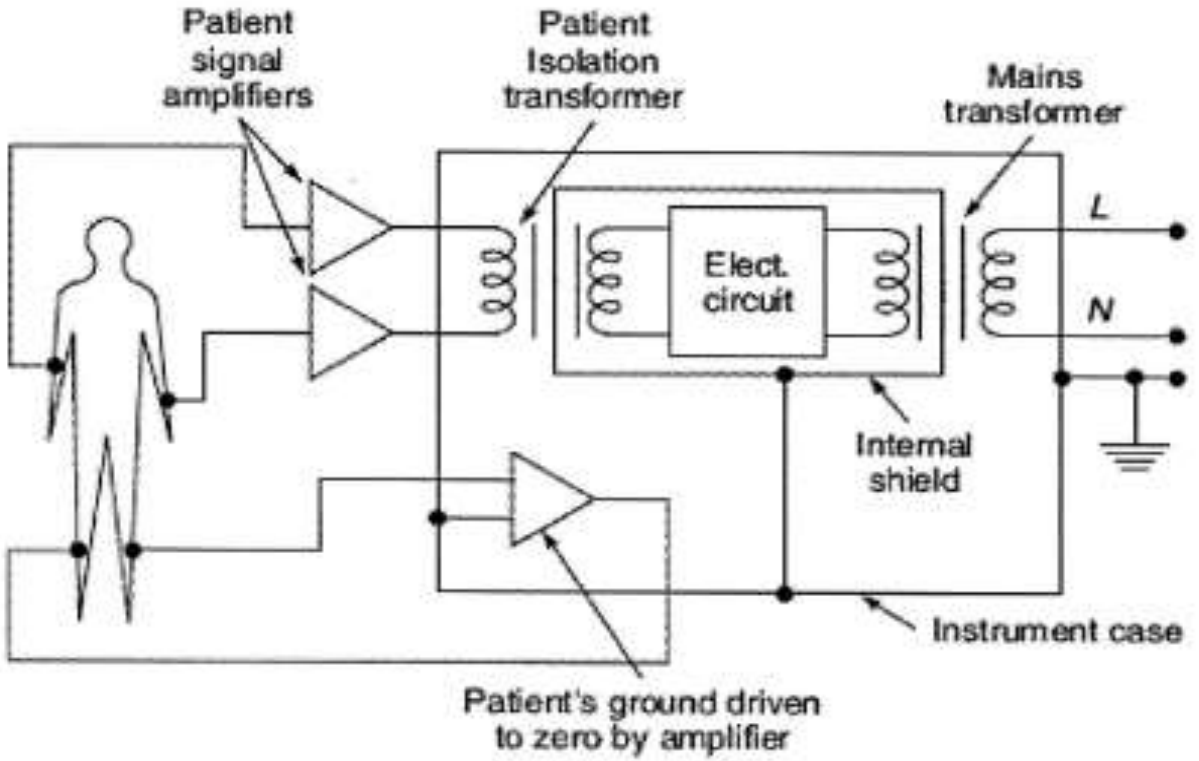


Figure 3.5.1 Transformer isolation type

(II) OPTICAL ISOLATION TYPE

- Isolation could also be achieved by optical means in which the patient is electrically connected with neither the hospital line nor the ground line. A separate battery operated circuit supplies power to the patient circuit and the signal of interest is converted into light by a light source (LED).
- This light falls on a phototransistor on the output side, which converts the light signal again into an electrical signal having its original frequency, amplitude and linearity. No modulator/ demodulator is needed because the signal is transmitted optically all the way.

OPTICAL ISOLATION TYPE

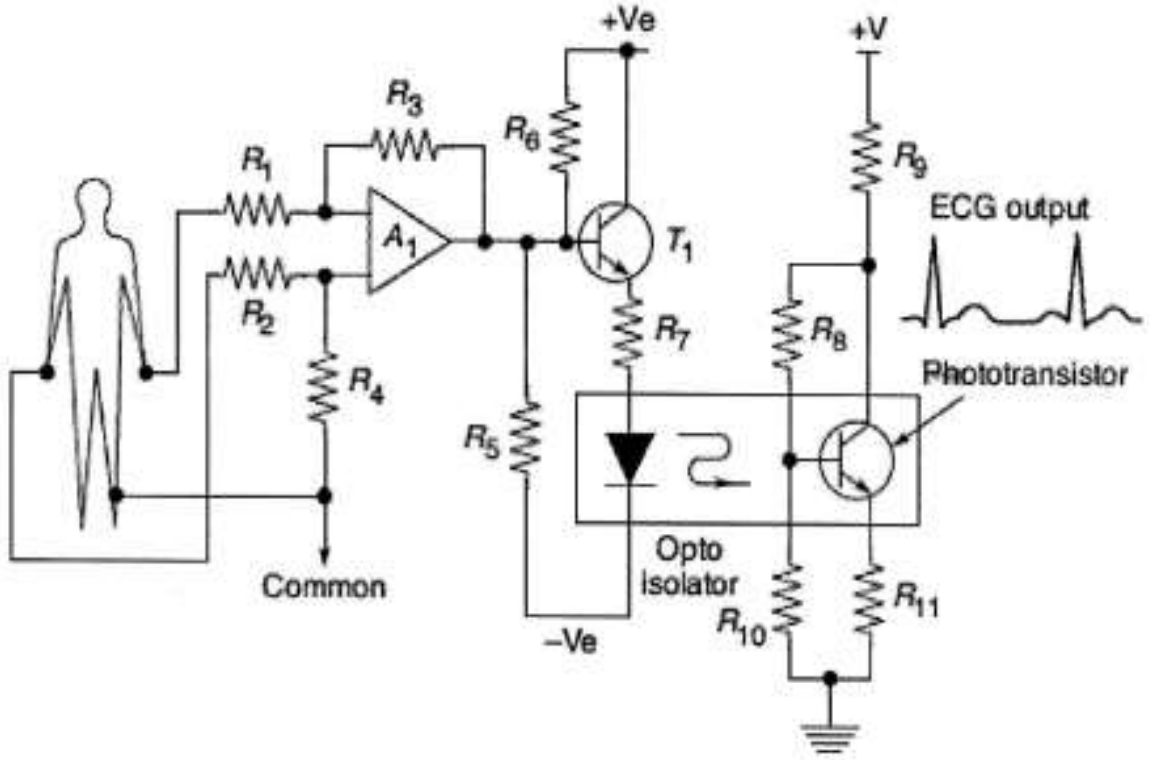
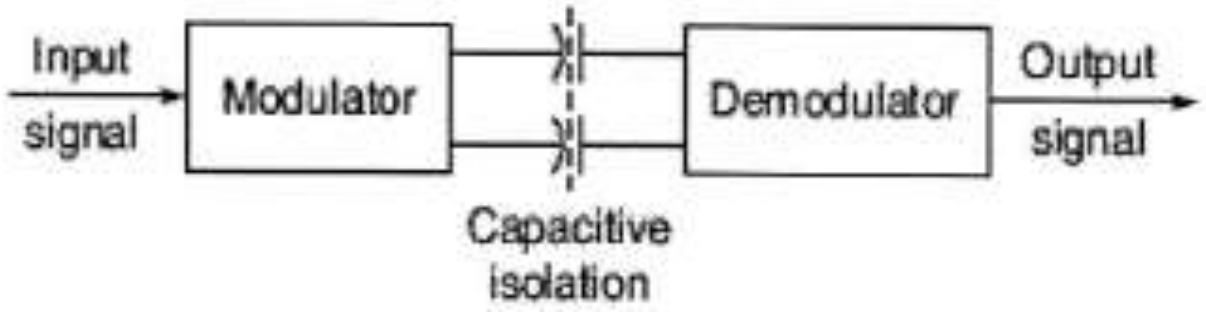


Figure 3.5.2 Optical isolation type

(III) CAPACITIVE ISOLATION TYPE

The capacitive method uses digital encoding of the input voltage and frequency modulation to send the signal across a differential capacitive barrier. Separate power supply is needed on both sides of the barrier. Signals with bandwidths up to 70 kHz can be conveniently handled in this arrangement.

CAPACITIVE ISOLATION TYPE

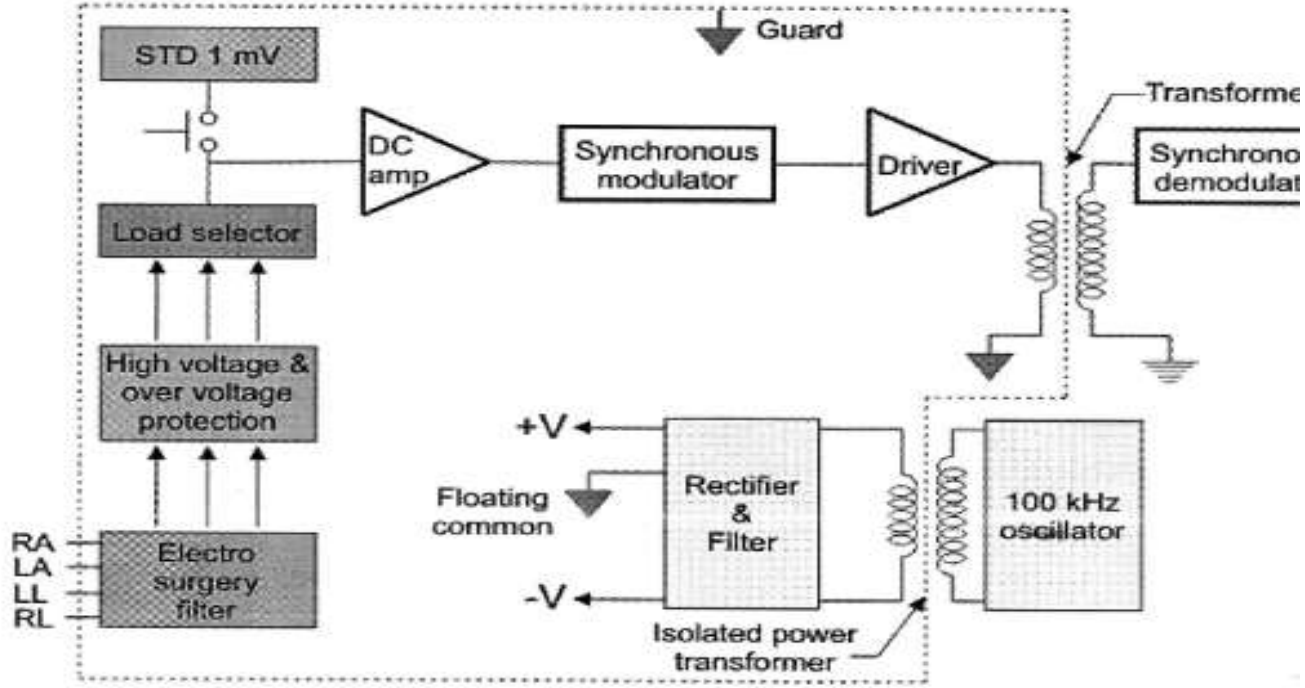


- It uses digital encoding of the input voltage and frequency modulation.
- The input voltage is converted to proportional charge on the switched capacitor.
- It has modulator and demodulator circuits.
- The signals are sent across a differential capacitive barrier.

ADVANTAGES

- Ripple noises are removed.
- It avoids device noise, radiated noise and conducted noise.
- High immunity to magnetic noise.
- High gain stability and linearity.

ECG Isolation Amplifier:



THE RELATIVE MERITS OF THE THREE TYPES OF ISOLATION TECHNIQUES ARE:

- All three types are in common use, though the transformer isolation amplifier is more popular.
- Opto-coupled amplifier uses a minimum number of components and is cost effective, followed by the transformer coupled amplifier. The capacitor coupled amplifier is the most expensive.
- Opto-isolated amplifiers offer the lowest isolation voltage (800 V continuous) between
- input and output; transformer coupled 1200 V and capacitance coupled 2200 V.
- Isolation resistance levels are of the order of 1010, 1012 and 1012 ohms for transformer coupled, opto-coupled and capacitance coupled amplifiers respectively.
- Gain stability and linearity are best for capacitance coupled versions-0.005%, and transformer and opto-coupled amplifier-0.02%.

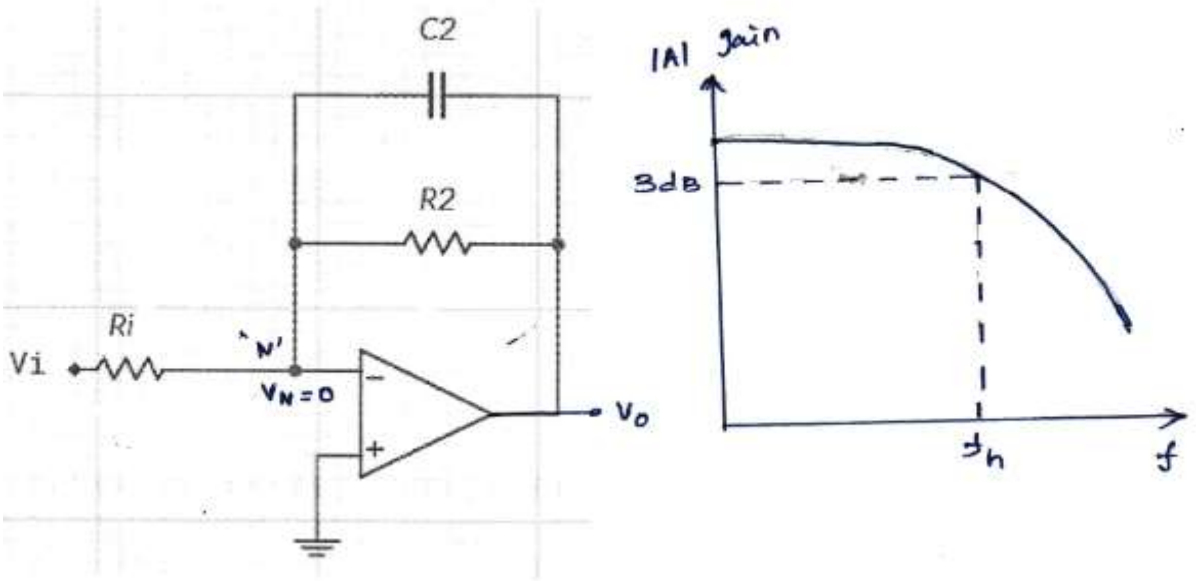
BAND PASS FILTER

In general ,the ECG signal is nature weak and only around 1mV amplitude.

Therefore filter and amplifier circuits were designed into 3 stages with a total gain of 1000 to bring the sign around 1V.Circuit designed included of instrumentation amplifier,bandpass filter and filter. The frequency bandwidth of ECG is between 0.05Hz until 100 Hz.

LOW PASS FILTER USING OP-AMP

The Low pass filter is useful for attenuating high frequency noises and allows the frequency signals. The Low Pass filter circuit using one op-amp shown in the fig :



Apply KCL at node 'N'

$$\frac{V_i'}{R_1'} = -\frac{V_0}{R_2 \,||\, \frac{1}{j\omega C_2}}$$

$$\frac{V_i'}{R_1} = -\frac{V_0}{\frac{R_2 \times 1/j\omega C_2}{R_2 + 1/j\omega C_2}}$$

$$\frac{V_i'}{R_1} = -\frac{V_0}{\frac{R_2}{1+j\omega R_2 C_2}}$$

$$\frac{V_i'}{R_1} = -\frac{V_0\ (1+j\omega R_2 C_2)}{R_2}$$

$$\frac{V_0}{V_i'} = -\frac{R_2}{R_1}\ \frac{1}{1+j\omega R_2 C_2}$$

$$\frac{V_0}{V_i'} = -\frac{R_2}{R_1}\ \frac{1}{1+j\omega\tau}$$

where $\tau = R_2 C_2$, time constant

let $f_h = \frac{1}{2\pi R_2 C_2}$, $\omega = 2\pi f$

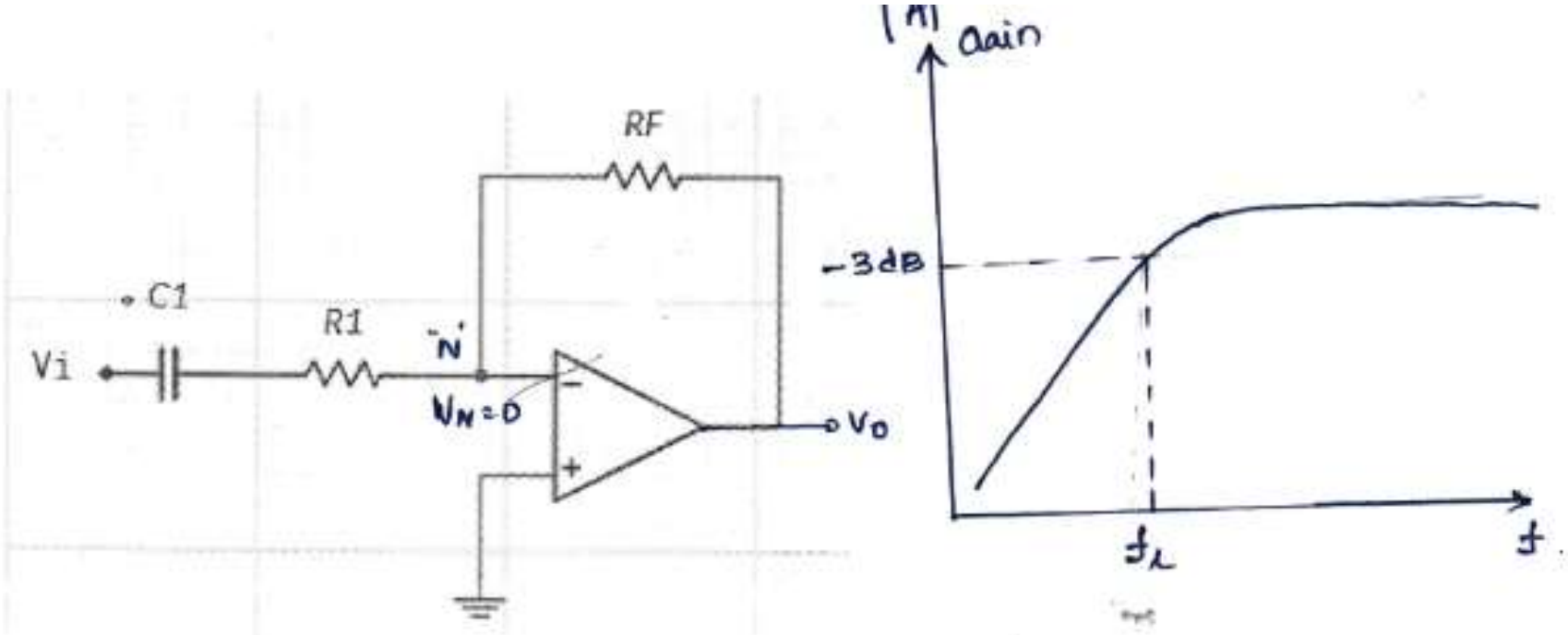
$$\frac{V_0}{V_i'} = -\frac{R_2}{R_1}\left(\frac{1}{1+j2\pi f R_2 C_2}\right)$$

$$\frac{V_0}{V_i'} = -\frac{R_2}{R_1}\left(\frac{1}{1+j(f/f_h)}\right)$$

where $f_h \Rightarrow$ Higher cut off frequency of LPF.

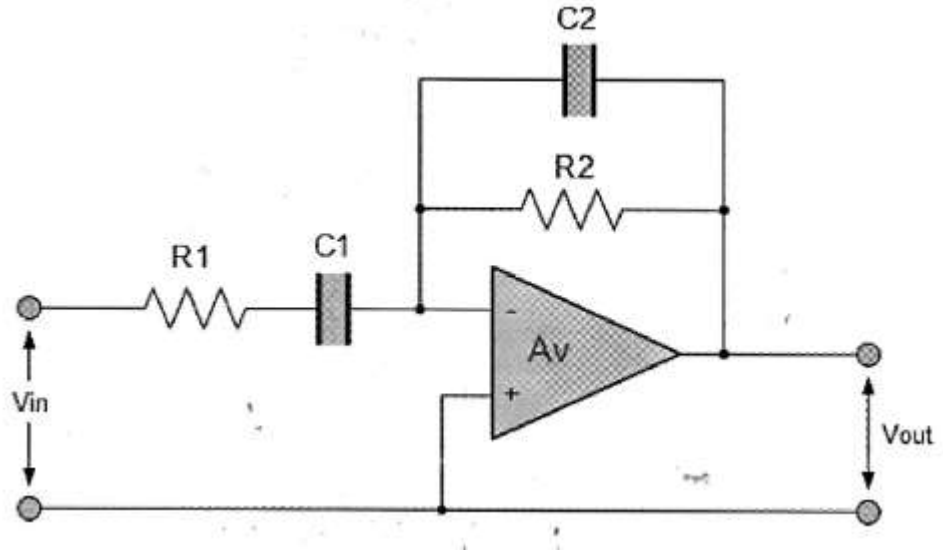
HIGH PASS FILTER

High pass filter allows the higher frequencies which are above lower cut off frequency .Such a circuit is useful for amplifying a small ac voltage that rides on top of a large DC voltage, because ci block dc.


RF
C1
R1
Vi
N
VN=0
Vo
|A| Gain
-3dB
fL
f

BAND PASS FILTER

Cascading of High pass filter followed by Low pass filter results in a band pass filter. Band pass filter which amplifies frequencies over a desired range and attenuates higher and lower frequencies. But this configuration having two op-amp. The band pass filter is designed by one op amp is given in the fig.



$$\frac{V_i}{R_1 + 1/j\omega C_1} = -\frac{V_o}{R_F}$$

$$\frac{V_i}{\frac{1+j\omega R_1 C_1}{j\omega C_1}} = -\frac{V_o}{R_F}$$

$$\frac{j\omega C_1}{1+j\omega R_1 C_1} V_i = -\frac{V_o}{R_F}$$

$$\frac{V_o}{V_i} = -R_F \frac{j\omega C_1}{1+j\omega R_1 C_1}$$

Multiply & divided by R_1

$$\frac{V_o}{V_i} = -\frac{R_F}{R_1} \frac{j\omega R_1 C_1}{1+j\omega R_1 C_1}$$

where Time constant $\tau = R_1 C_1$

$$\frac{V_o(j\omega)}{V_i(j\omega)} = A = -\frac{R_F}{R_1} \frac{j\omega\tau}{1+j\omega\tau}$$

Let $f_L = \frac{1}{R_1 C_1 2\pi}$

$$A = -\frac{R_F}{R_1} \frac{j\omega\tau}{1 + j\,2\pi f R_1 C_1}$$

$$A = -\frac{R_F}{R_1} \frac{j\omega\tau}{1 + j\,(f/f_L)}$$

where f_L is lower cut off frequency of HPF.