Experiment No. 1.

Aim: To study about electronic components and instruments

Apparatus: Breadboard, Resistor, capacitor, Diode, Transistor, Integrated circuit, multimeter, power supply, CRO.

Theory:

① Breadboard:

A breadboard is a solderless device for temporary prototype with electronics and test circuits / design. most electronic components in electronic circuits can be interconnected by inserting their leads or terminals into holes and then making connections through wires wherever appropriate.

② Resistor:

A resistor is a positive two terminal electrical component that implements electrical resistance as a circuit element. In electronic circuits, resistors are used to reduce current flow, adjust signal levels to divide voltage, bias active element and terminate transmission lines among other uses.

Black	0	0	10^0
Brown	1	1	10^1
Red	2	2	10^2
Orange	3	3	10^3
Yellow	4	4	10^4
Green	5	5	10^5
Blue	6	6	10^6
Violet	7	7	10^7
Grey	8	8	10^8
White	9	9	10^9

Eg : (i) Red Orange Red
$= 23 \times 10^2 \ \Omega$
$= 2.3 \ K\Omega$

(ii) Brown Red Black
$= 12 \times 10^0$
$= 12 \ K\Omega$

3) Capacitor :

A capacitor is a positive two terminal electronic component that stores electrical energy in an electric field. The effect of capacitor is known as capacitor.

It is a device used to store an electric charge, consisting of one or more pairs of conductors separated by an insulator. The effect of capacitor is known as capacitance.

4) Diode :

The most common function of a diode is to allow an electric current to pass in one direction.

It is a semiconductor device with two terminals typically allowing the flow of current in one direction.

They can be used as rectifiers, signals, modulators, etc.

⑤ Transistor :

As transistor is a semi conductor device used to amplify or switch the electric signals and electric power. It is composed of a semiconductor material. Usually, with at least three terminals for connection to an external circuit.

⑥ Integrated Circuits :

An integrated circuits or IC is a small chip that can function as an amplifier oscillator, timer microprocessor or even computer memory. An IC is made up of silicon, that can hold her anywhere to hundred of million transistors, Resistors and Capacitors.

⑦ Multimeter :

A multimeter is known as (V-O-M) is an electronic carrying experiment that combines several management functions in one unit. A typical multimeter can measure unique voltage analog multimeter uses a micrometer with a moving pointer the display reading

⑧ Power Supply :

A power Supply is an external device that supplies electric power to an external load. The primary function of primary simple is to convert electric current from source to the current voltage current, frequency to power. It is a frequency type subject/Power the load

9 CRO [Cathod Ray Oscilloscope]

Cathod Ray Oscilloscope is an electronic test instrument, It is used to obtain waveforms, when different input signals are given frequency

Control Panel / Knobs & Functions :

1. Brightness :
   - (a) To control the intensity of bright spot.
   - (b) Connected to the control grid
   - (c) It should be low to get a clear and sharp trace

2. Focus :
   - (a) To control the sharpness of the bright spot
   - (b) Sharpness of bright spot is also affected by the brightness.

3. X - shift :

   To adjust horizontal position of bright spot or trace displayed on screen

4. Y - shift :

   To adjust vertical position of bright spot or trace display on screen.

5. Y - gain : (Volt / Div)

   To control magnitude of the vertical deflection of bright spot or trace display on the screen by adjusting the screen

Experiment No. 2.

Aim: 1. To plot the frequency response of a common emitter BJT amplifier.
2. To find the cut off frequencies, bandwidth and calculate its gain.

Components: Transistor BC 547, Resistor [10 kΩ, 2.2 kΩ, 100 kΩ) Capacitor [10 μF, 100...

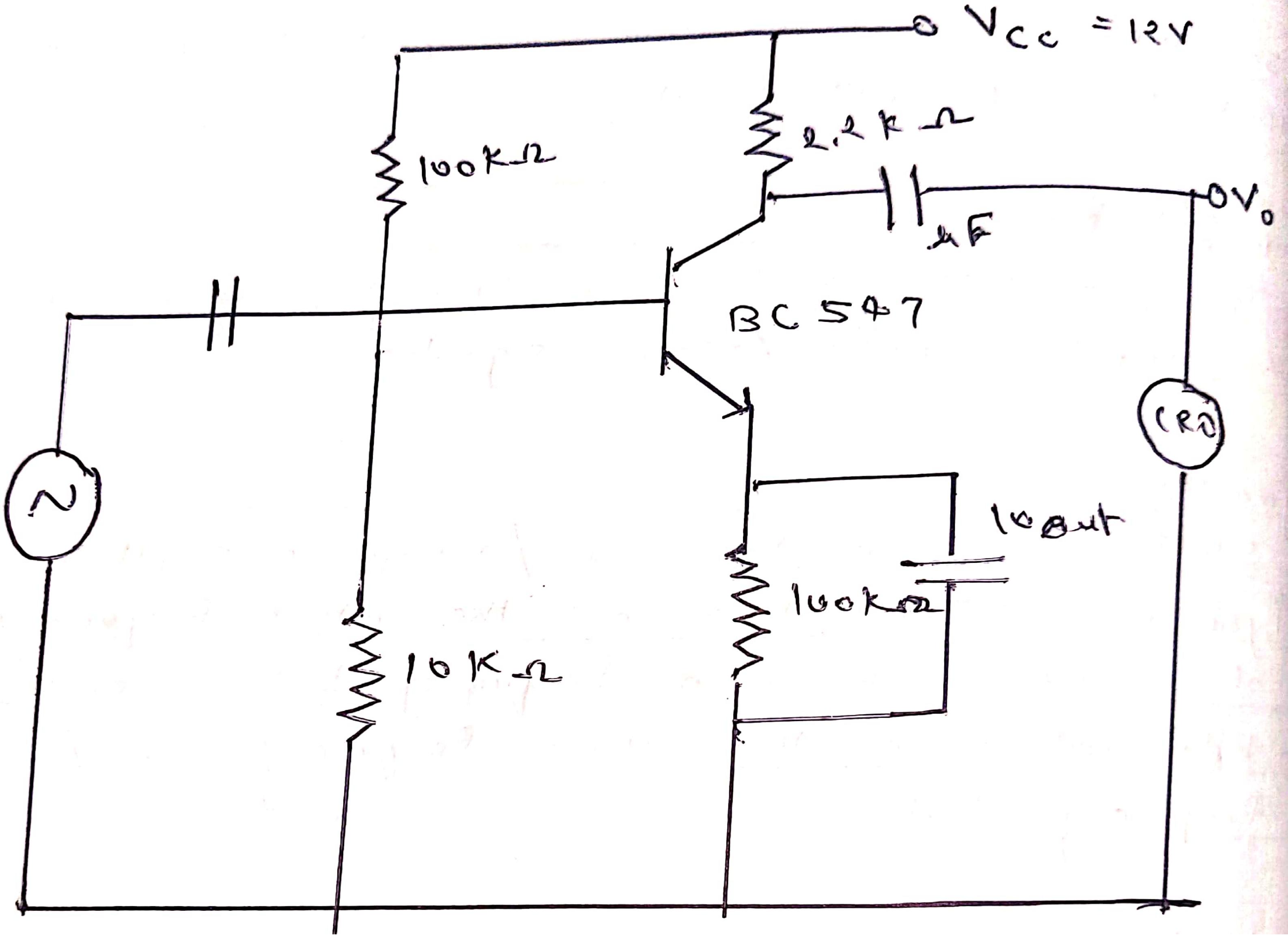
Equipment: Breadboard, Dual pc power supply [0-30 V], Function generator [0-1 MHz], Digital Ammeter [0 - 200 μA / 200 mA] Digital Voltage [0-20 V], CRO [0-20 MHz], CRO probes and connecting wires

Specifications:

for transistor BC 547

① max collector current · BC547
② V_{CEO} max = 50 V
③ V_{EBO} = 6 V
④ V_{CBO} = 50 V
⑤ Collector power dissipation = 500 mW
⑥ Temperature range = -65 to +150 °C
h_{fe} = 110 - 220

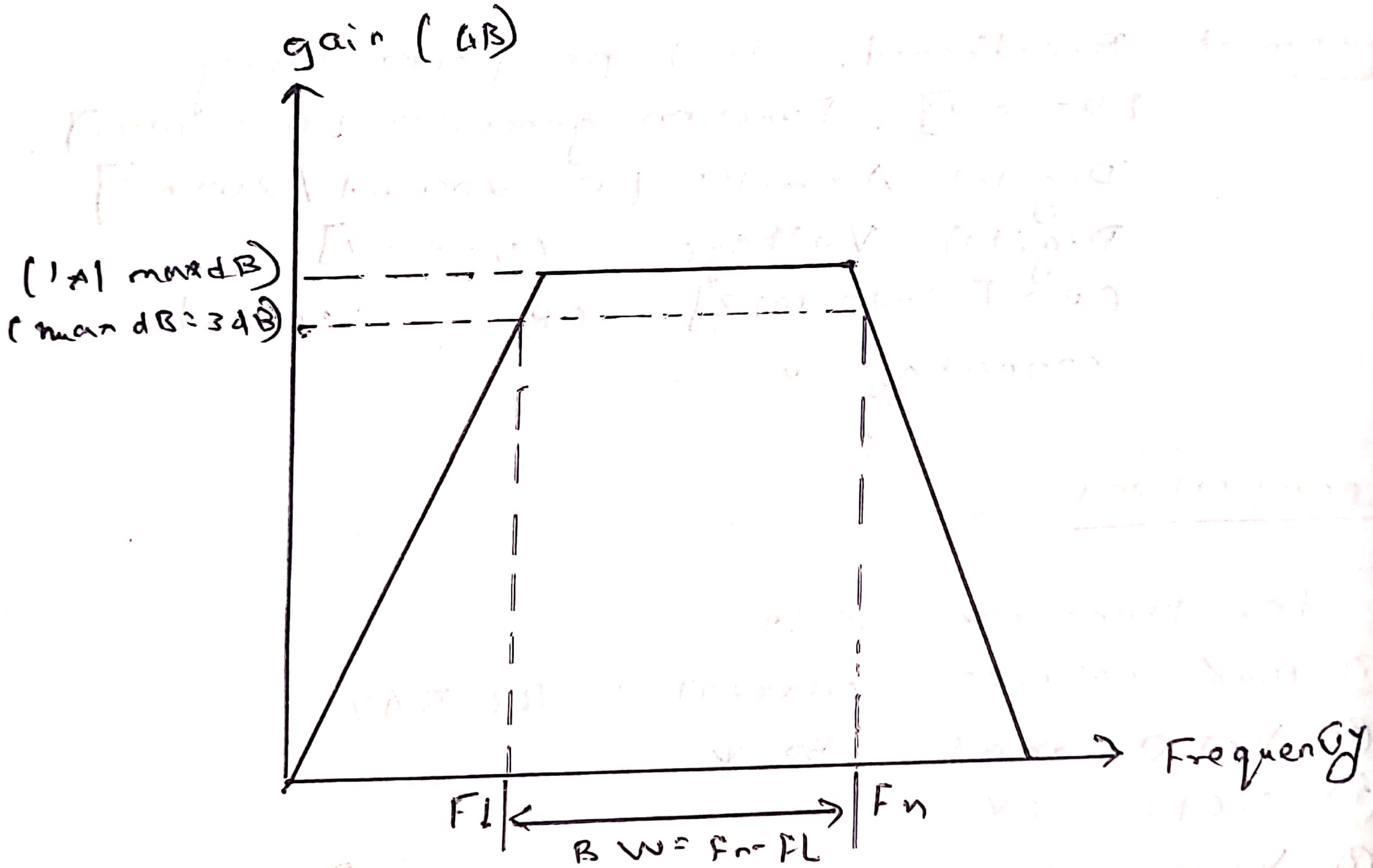
CE BJT AMPLIFIER



Graph :

In usual application, mid-band frequency range is defined as those frequencies at which the response has fallen to 3dB below the max gain (|A| max). These are shown as f1 and fn are called 3dB frequencies.

Frequency response curve of RC coupled BJT CE Amplifier



Theory :

An amp is an electronic circuit that can increase the strength of a weak input signal without distorting the shape. The CE configuration is widely used as a basic amplifier as it has both voltage and current amplification with 180° phase shift.

The factor by which the input signal gets multiplied after passing through the amplifier circuit is called gain of amplifier.

$$\text{Gain} = \frac{\text{Output signal}}{\text{Input Signal}}$$

A self bias circuit is used in amplifier circuit because it provides highest Q point stability among all the biasing circuit.

Resistors R_1 & R_2 form voltage divider across the base of transistor. The function of network is to provide necessary bias condition and ensure that emitter bias function is operating in the proper region.

The Bypass capacitor -

The emitter resistor is required to obtain the rc Q stability. However, the inclusion of it in ckt causes decrease in amplification. To avoid such bypass condition

The coupling capacitor.

An amplifier amplifies the given ac signal. In order to have noiseless transmission of a signal (without DC), it is necessary to block DC. i.e the direct current should not enter the amplifier. This is accomplished by coupling capacitor

Characteristics of CE amplifier.

1. large current gain
2. large voltage gain
3. large power gain
4. Current and voltage phase shift of 180°
5. Moderate Output resistance.

Procedure:

1. Connect the circuit. Set source voltage as 50 mV, p.p. at 1KHz frequency.
2. Keeping input voltage constant, vary frequency from 50 Hz to 1 MHz in regular steps
3. Plot graph for gain in dB v/s frequency
4. Calculate bandwidth of graph.

Precautions:

1. While performing the experiment do not exceed ratings of transistors
2. Make sure while selecting emitter, base collector and terminal.
3. Connect signal generator in correct polarities.

Conclusion:

1. BJT CE amplifier is studied
The frequency response curve of BJT CE is plotted

Experiment No. 3

Aim: To implement working of Colpitt's Oscillator using multisim

Theory:

The resistor will provide biasing for transistor. Transistors are connected in CE configuration. Therefore it is introduce a phase shift of 180° between its input and output. The feedback networks will provide additional 180° phase shift.

Frequency Oscillator

$$f = \frac{1}{2\pi\sqrt{LC}}$$

$$C, \frac{C1C2}{C1+C2}$$

As in case of transistor phase shift oscillator, Transistor gain is important. It is expected that the oscillator frequency should remain constant.

Advantages:

1. Simple construction
2. Can obtain High frequency

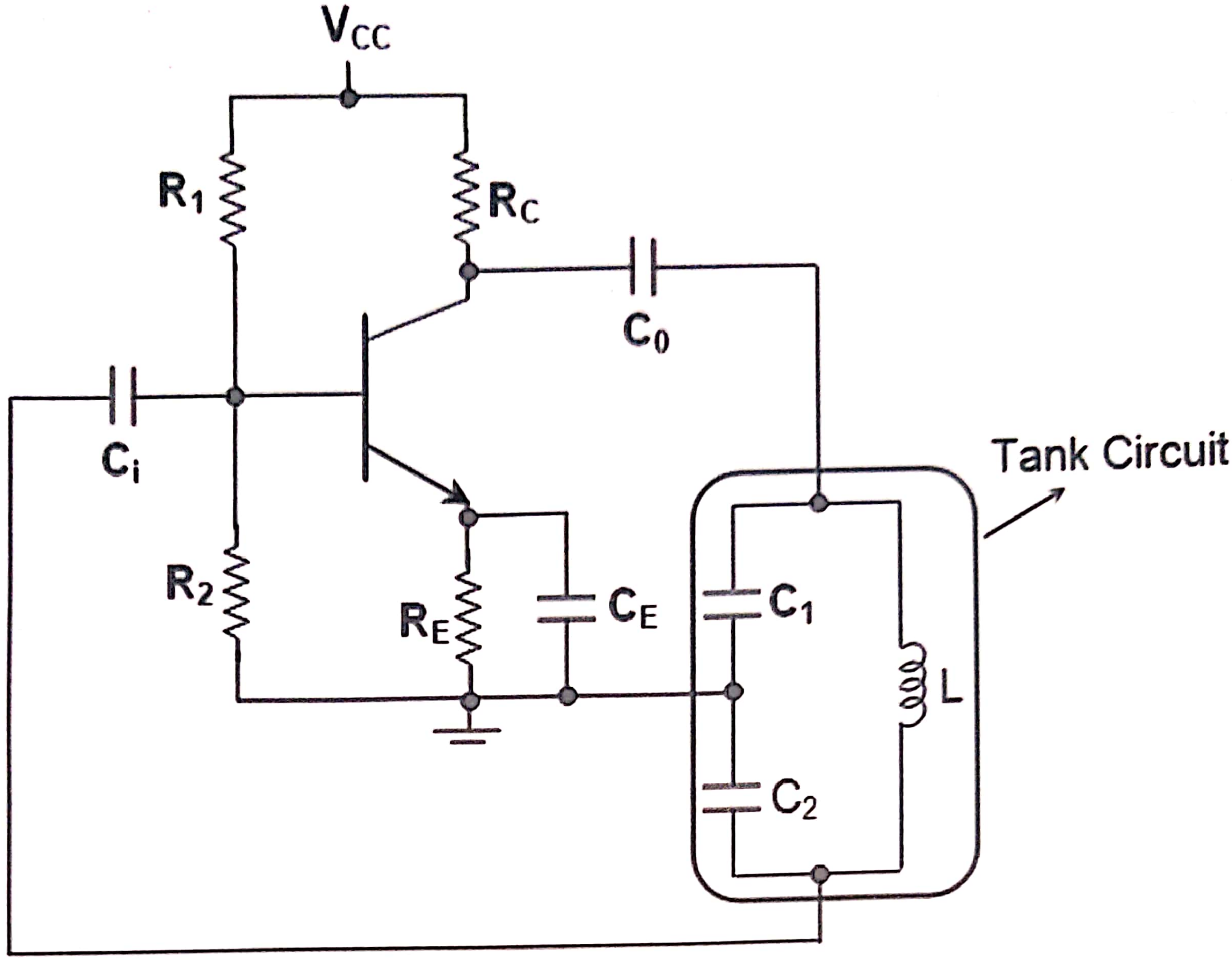


Figure 1 Colpitts Oscillator

Theoretically $f = \dfrac{1}{2\pi\sqrt{LC}}$

$$C = \frac{C_1 C_2}{C_1 + C_2}$$

$$\frac{1\,\mu F \times 1\,\mu F}{(1+1)\,\mu F}$$

$$C = 0.5 \times 10^{-6}$$

$$f = \frac{1}{2\pi\sqrt{1\,mH \times 0.5 \times 10^{-6}}}$$

$$f = 7.117\ KHz$$

Practically, $f = 1/T$

$$= 4.7123\ KHz$$

DisAdvantages of Colpitt's Oscillator :

① Difficult to adjust feedback as it demands change in capacitor value.

② Poor frequency stability.

Applications :

① As a high frequency generator.

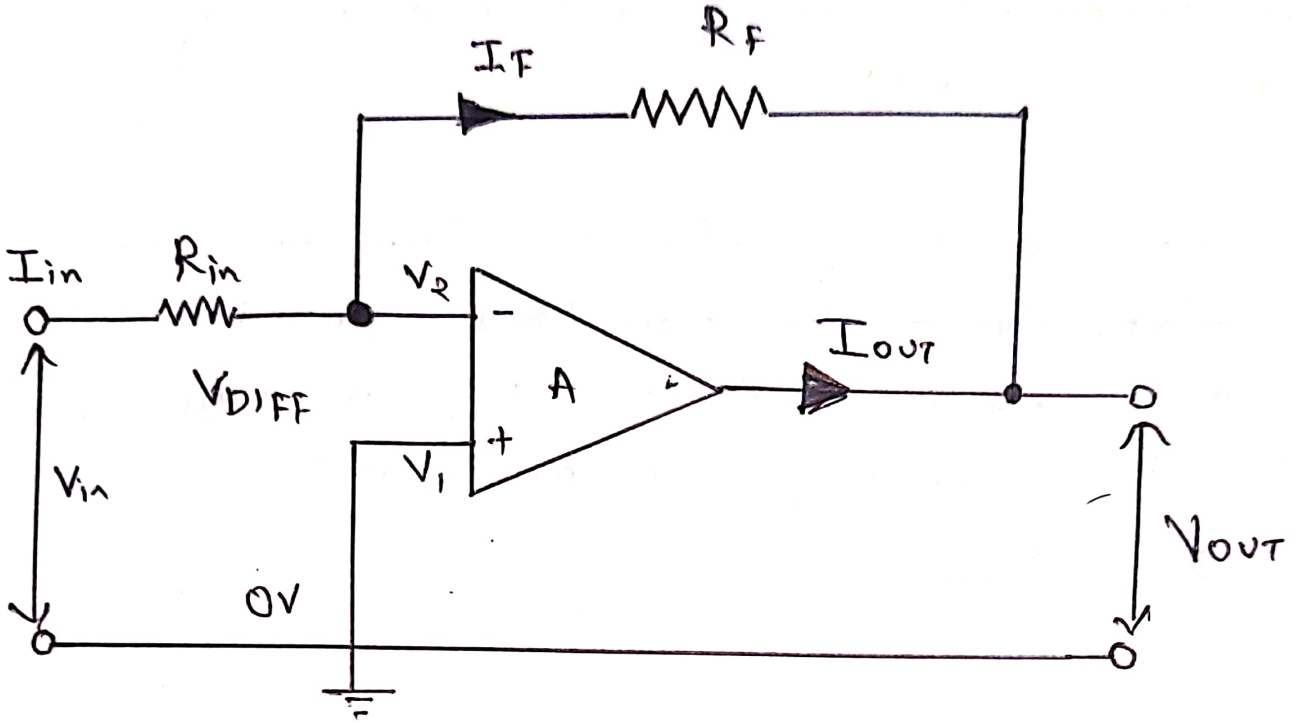
Experiment No. 4.

Aim: Implementation of inverting and non-inverting amplifier using IC 741.

Objectives: The experiment is off to familiarise ourselves with the operational amplifier characteristics and circuit connections for the inverting and non-inverting amplifiers.

Equipment:

1. Resistors : 1 KΩ (2 nos.), 10 KΩ (2 nos), 20 KΩ, 33 KΩ, 47 KΩ, 68 KΩ
2. Operational Amplifier μA 741
3. Digital Multimeter (DMM)
4. Oscilloscope
5. Function Generator (AC Power Supply)
6. DC Power Supply
7. DMM Probes × 2 nos.
8. Oscilloscope Probes × 2 nos.
9. BNC - crocodile clips Probe × 1 No.
10. Crocodile clips Connectors × 4 nos.
11. Protoboard
12. Wire 22 AWG × 6 nos.



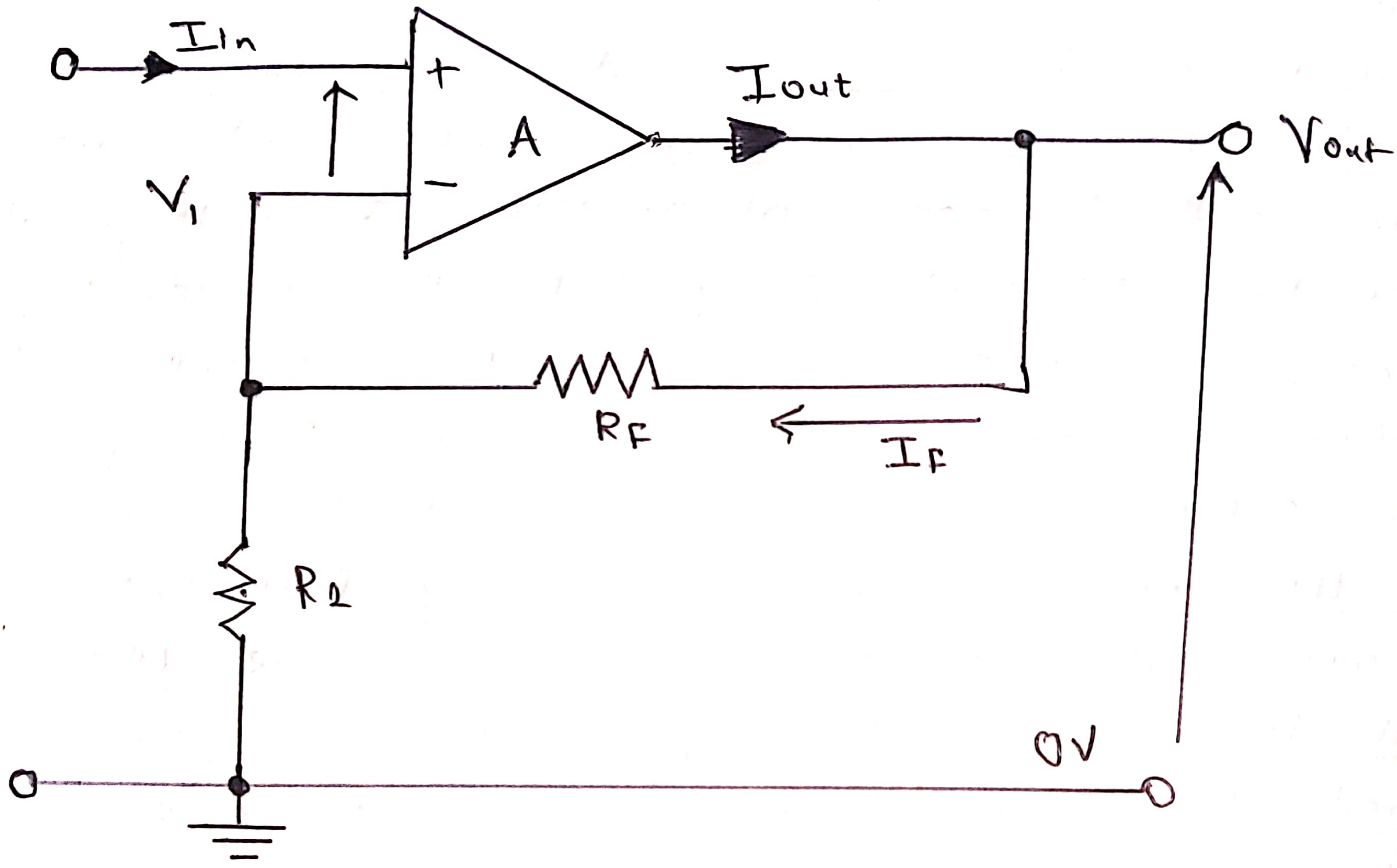
Applying KCL at inverting node we can calculate voltage gain,

Voltage gain (A) = $V_{OUT} / V_{in} = -R_F / R_{in}$

Theory :

① Inverting Amplifier.

In an inverting amplifier circuit, the operational amplifier inverting input receives feedback from the output of the amplifier. Assuming the OPAMP is ideal and applying the concept of virtual short at the input terminals of OP-AMP. The voltage at the inverting terminal is equal to the non-inverting terminal. The non-inverting input of the operational amplifier is connected to the ground. As the gain of the OPAMP itself is very high and the output from the amplifier is matter of only few volts, this means that the difference between the two input terminals is exceedingly small and can be ignored. As the non-inverting input of the operational amplifier is held at ground potential this means that the inverting input must be virtually at earth potential.



The voltage gain can be calculated by applying KCL at the inverting node.

$$\text{Voltage gain } (A) = V_{out} / V_{in}$$

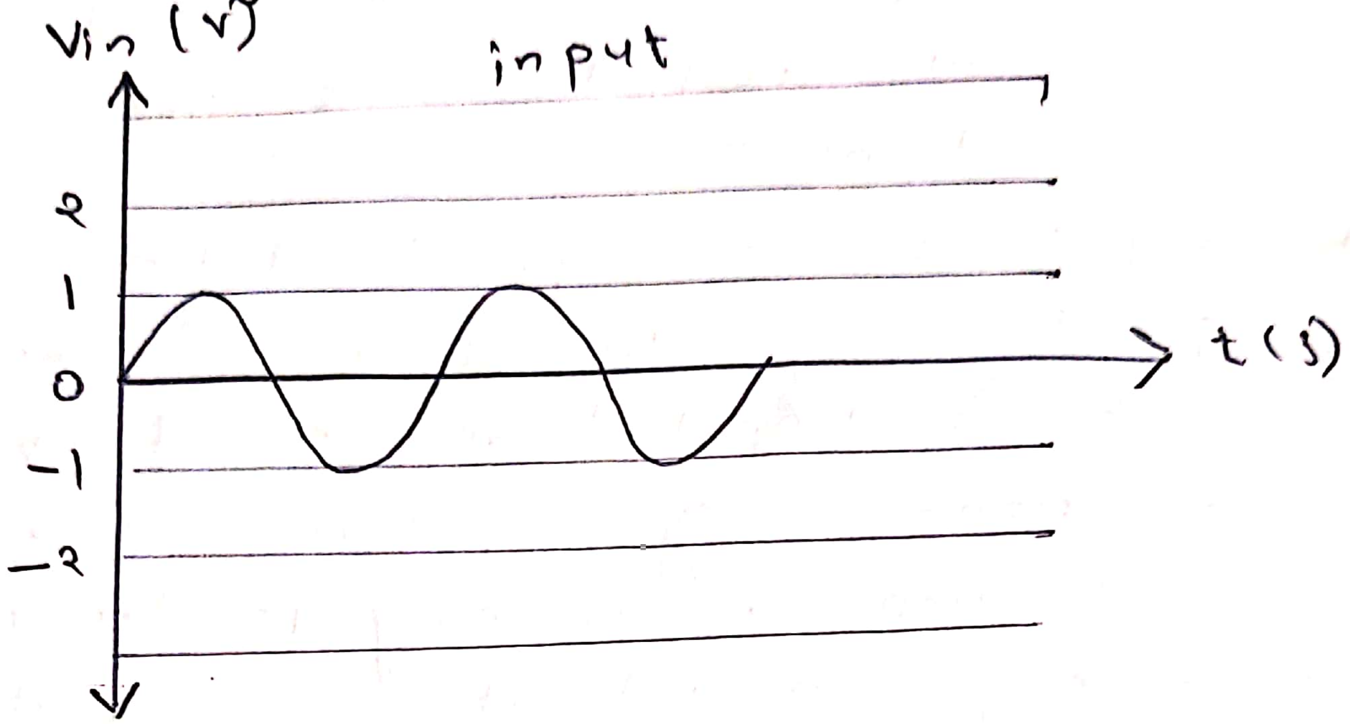
$$= \left(1 + \frac{R_F}{R_{in}}\right)$$

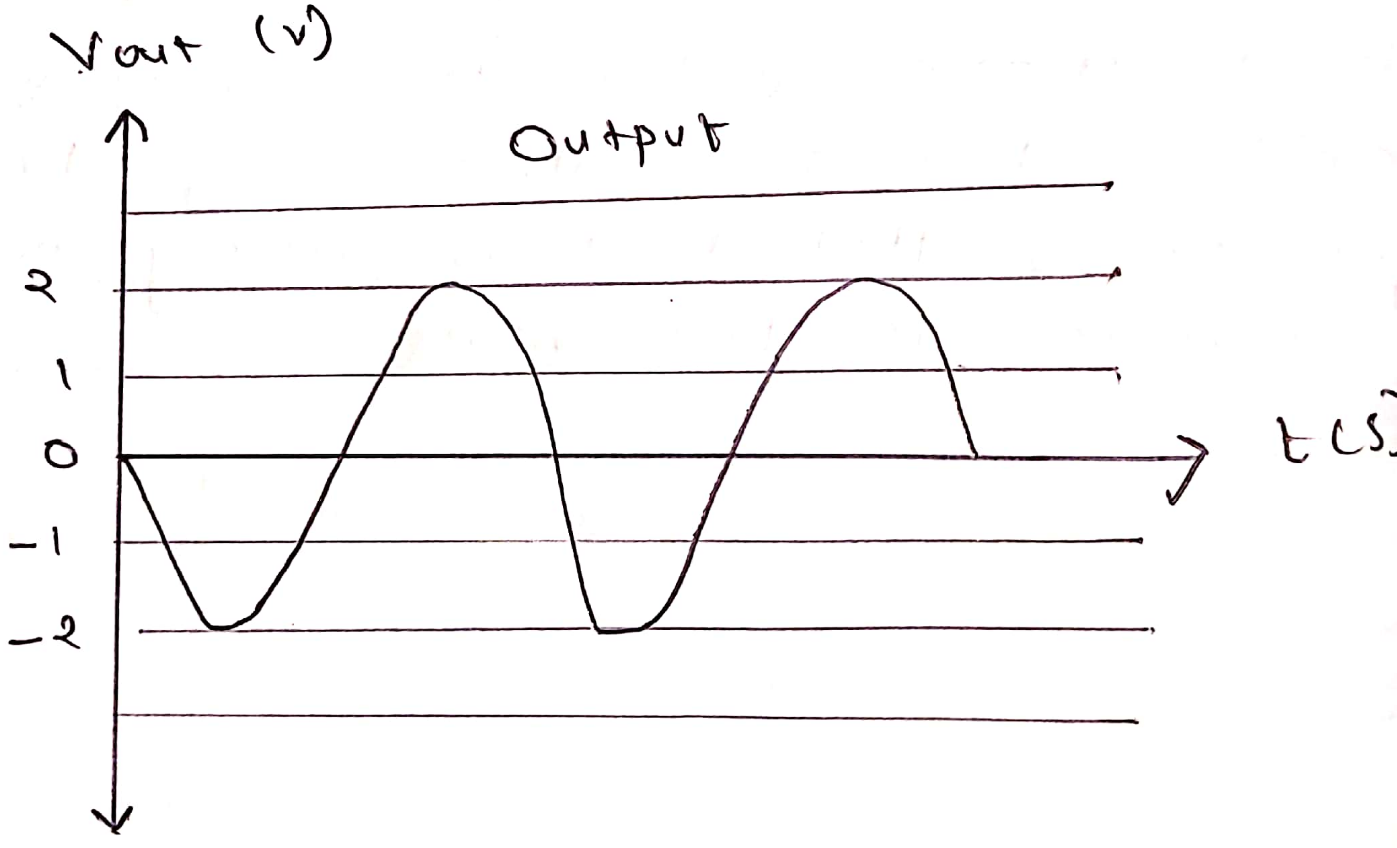
(2) Non-inverting Amplifier

The non-inverting amplifier is one in which the output is in phase with respect to the input. The feedback is applied at the inverting input. However, the input is now applied at the non-inverting input. The output is a non-inverted (in terms of phase) amplified version of input. The gain of the non-inverting amplifier circuit for the operational amplifier is easy to determine. The calculation hinges around the fact that the voltage at both inputs is the same. This arises from the fact that the gain of the amplifier is exceedingly high. If the output of the circuit remains within the supply rails of the amplifier, then the output voltage divided by the gain means that there is virtually no difference between the two inputs.

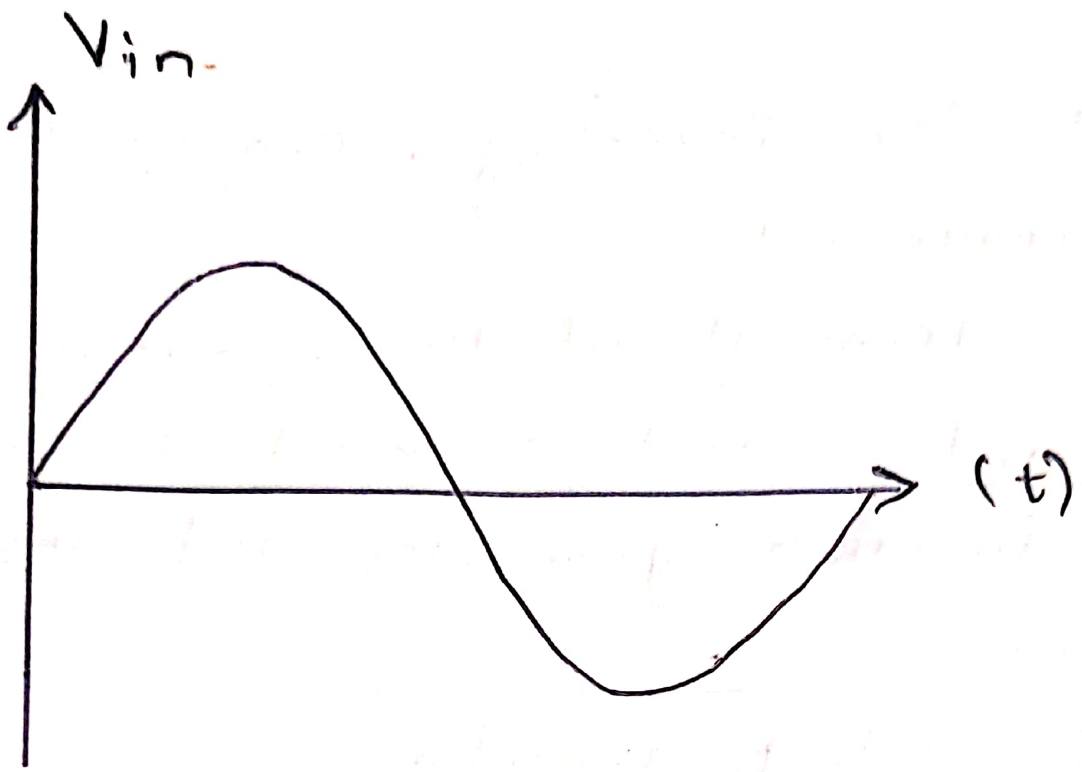
Output Waveforms :

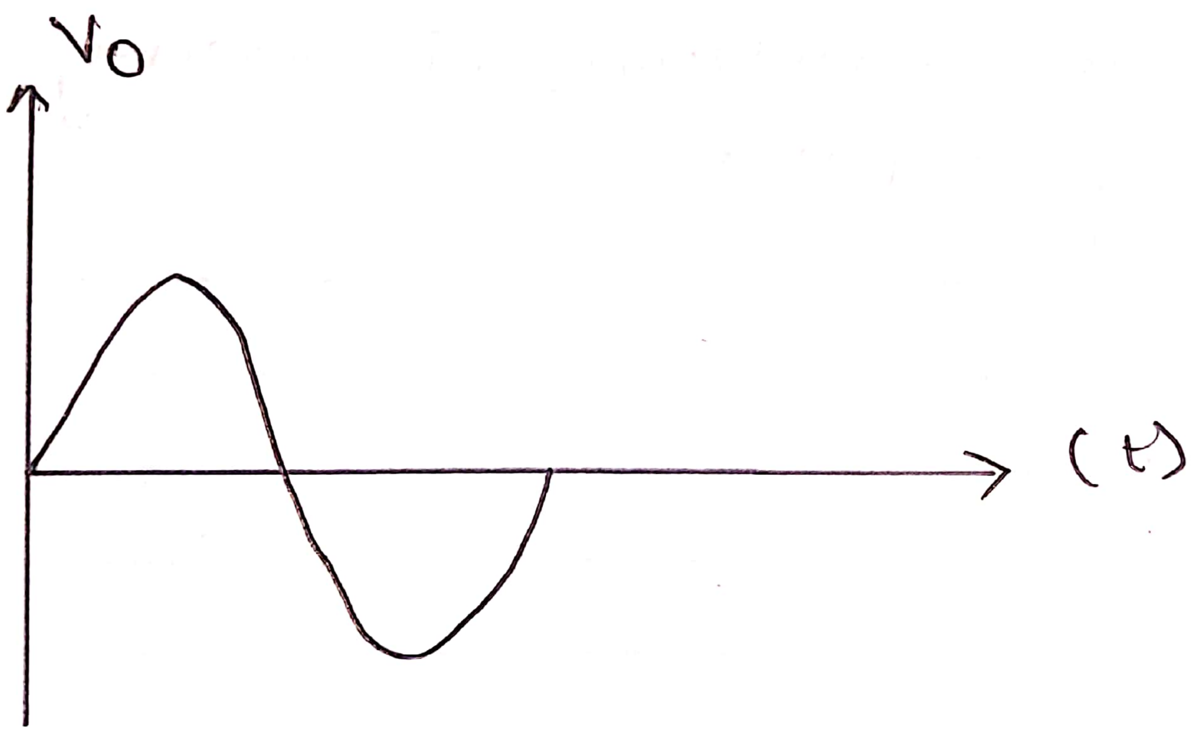
① Inverting Amplifier





② Non- Inverting Amplifier.





Procedure:

1. Connect the circuit for inverting, non inverting amplifier on a breadboard.
2. Connect the input terminal of the op-amp to function generator and output terminal to CRO.
3. Feed input from function generator and observe the output on CRO.
4. Observe input and output waveform.

Result: Hence verified and drawn the operation and respective waveforms of inverting and non-inverting amplifier.

Experiment No. 5.

Aim: Implementation of integrator using IC 741

Apparatus:

1. DC Power Supply × 1 No.
2. CRO × 1 No.
3. Breadboard × 1 No.
4. Function Generator × 1 No.

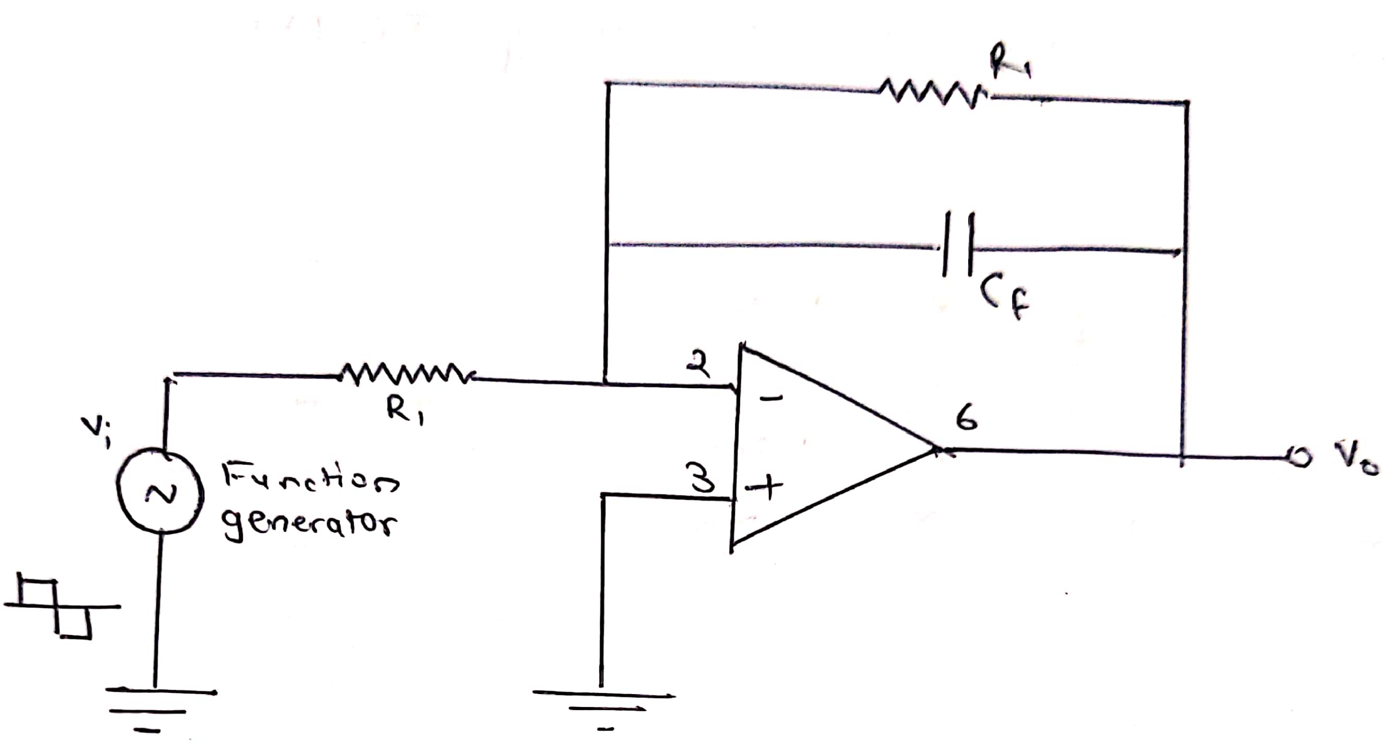
Components:

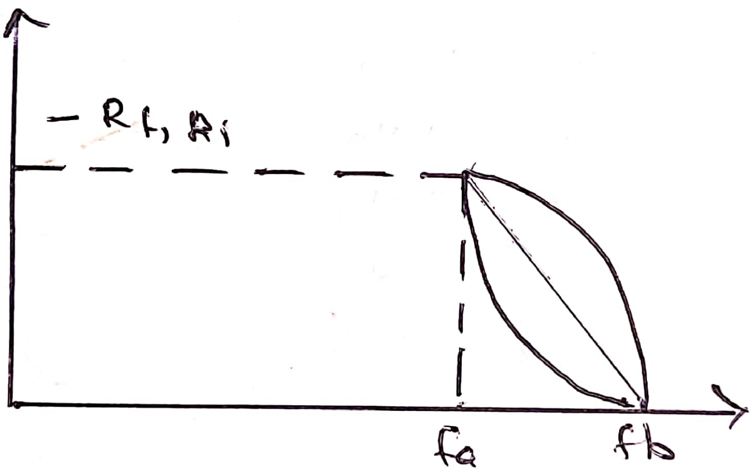
1. 15 KΩ Resistor × 2 No.
2. 820 Resistor × 1 No.
3. 1.5 KΩ Resistor × 1 No.
4. 0.01 F Capacitor × 2 No.
5. 0.5 nF Capacitor × 1 No.
6. IC 741 × 1 No.

Theory:

The operation amplifier can be used in many applications. It can be used as integrator and differentiator. In integrator the circuit performs the mathematical operation of integration that is the output waveform is the integrative of the input wave form. or good integration, one must

Circuit Diagram:





$$fa = \frac{1}{2\pi R_F C_F} = \frac{1}{2\pi \times 100 \times 10^3 \times 0.01 \times 10^{-6}}$$

$$= \frac{1}{2\pi \times 10^5 \times 10^{-8}}$$

Integrator
160 Hz - 150 kHz

$$= \frac{10^3}{2\pi}$$

$$= 159.22$$

$$\approx 160 Hz$$

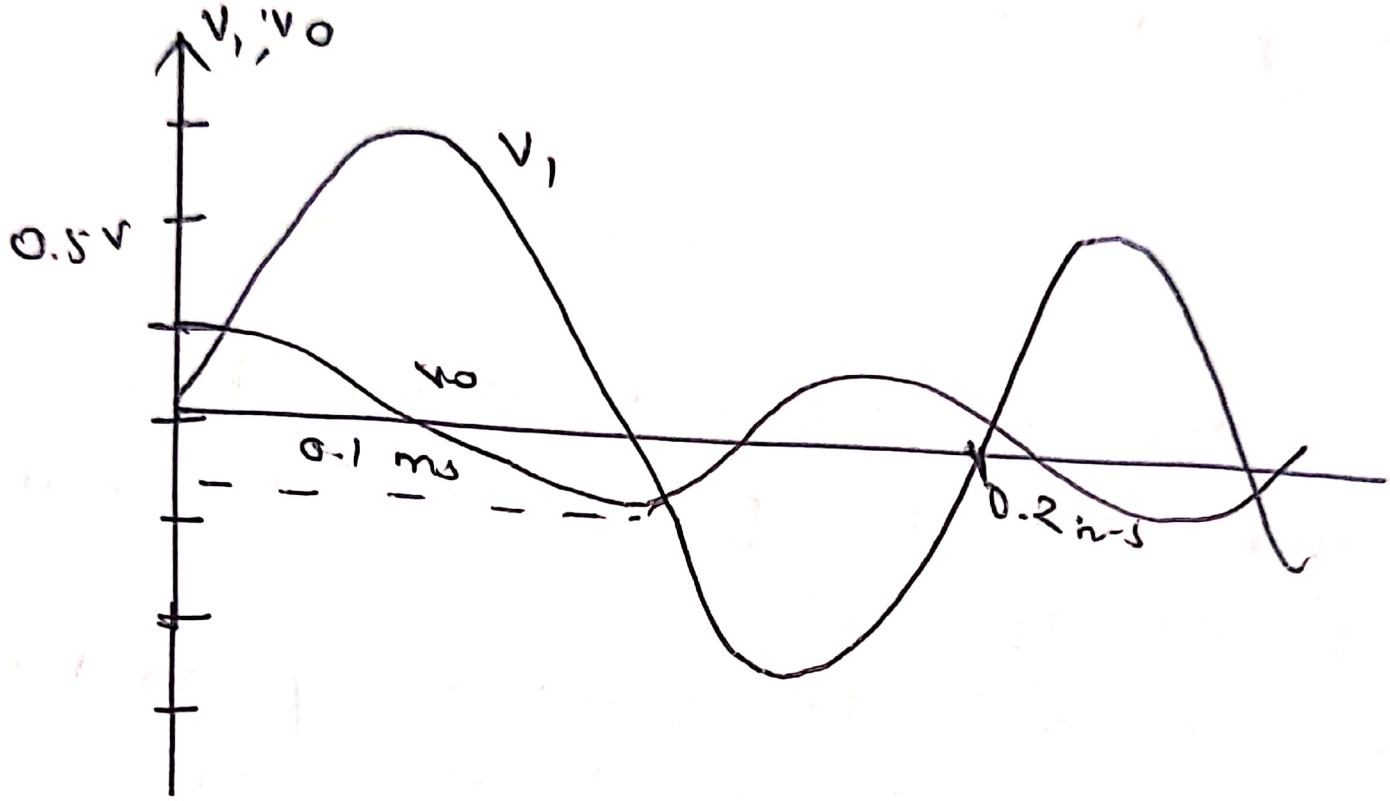
ensure that the time period of the input signal is smaller than or equal to $R_f C_1$. the practical integrator eliminates the problem of instability and high frequency noise.

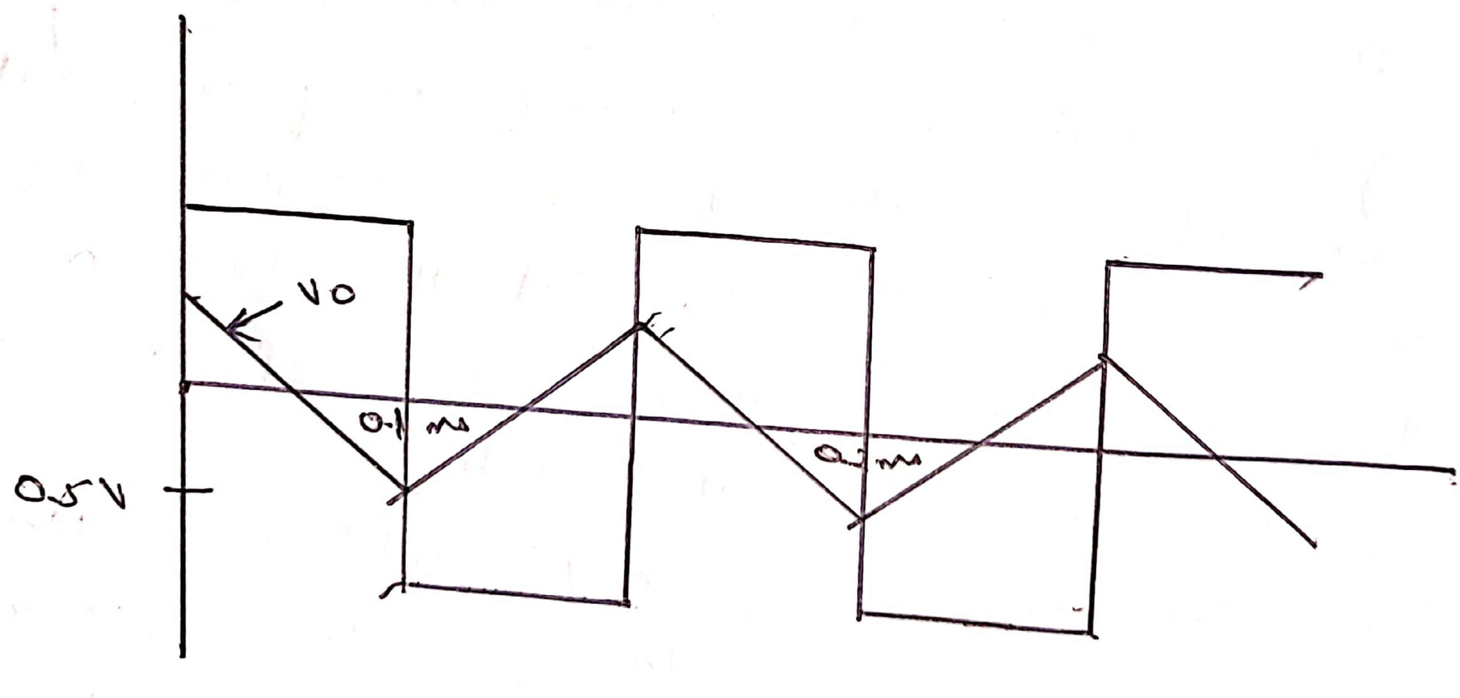
Procedure :

1. Connect the integrator circuit as shown. Adjust the signal generator to produce a 5 Volt peak sine wave at 100 Hz.
2. Observe input V_i and V_o simultaneously on the oscilloscope measure and record the peak value of V_o and the phase angle of V_o with respect to V_i.
3. Repeat step 2 while increasing the frequency of input signal. Find the maximum frequency at which circuit offers differentiation. Compare it.
4. Connect the integrated circuit. Set the function generator to produce a square wave of 1V peak to peak amplitude at 500 Hz.
5. Slowly adjust the input frequency until the output is good triangular waveform. Measure the amplitude and frequency of the input and output waveforms
6. Verify the relationship between $R_1 C_f$ and input frequency for good integration $f > f_a$ & $T < R_1 C_1$ where $R_1 C_f$ is the time constant.

Graph:

Integrator -





Observations:

(1) The time period and amplitude of the output waveform of differentiator circuit.

(2) The time period and amplitude of the integrated waveform

Calculations:

Integrator - Design an integrator that integrates a signal whose frequency are between 1 KHz and 10 KHz

$$f_b = \frac{1}{2 R_1 C_f}$$

The frequency at which the gain is 0 dB.

$$f_a = \frac{1}{2 R_f C_f}$$

f_a: Gain limiting frequency.

The circuit acts as integrator for frequencies between f_a and f_b.

Generally, $f_a < f_b$.

Therefore choose, $f_a = 1$ KHz.

$f_b = 10$ KHz

Let $C_f = 0.01$ F

Therefore $R_1 = 1.59$ K

Choose $R_1 = 1.5$ K, $R_f = 15$ K

Integrator - $f_a = \frac{1}{2 R_f C_f}$

$$f_b = \frac{1}{2\pi f_1 C_F}$$

$$= \frac{1}{2\pi \times 10 \times 10^3 \times 0.01 \times 10^{-6}}$$

$$= \frac{1}{2\pi \times 10^4 \times 10^{-8}}$$

$$= \frac{10^4}{2\pi}$$

$$= \frac{10000}{2\pi}$$

$$= 1.59 \text{ kHz}$$

Experiment No. 6

Aim: Implementation of Zero crossing detector using IC 741

Objective: To understand the working and implementation of zero crossing detector using OPAMP in open loop mode

Components: IC 741, Resistors, Wires

Instruments: CRO, Function generator, power supply

Theory:

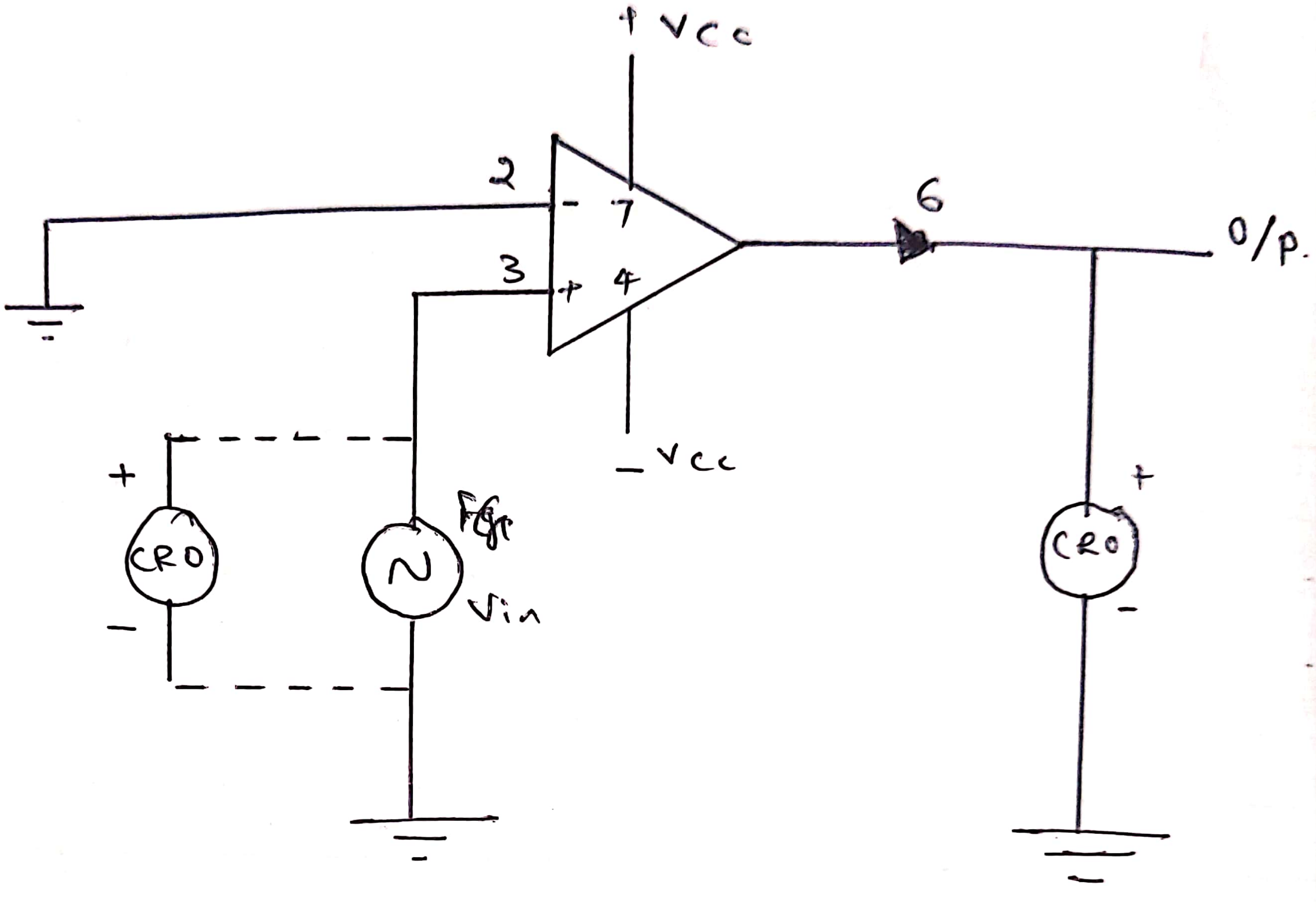
① Zero crossing detector is nothing but basic comparator circuit with a zero reference voltage applied to non-inverting terminal.

Operation:

① When input sine wave crosses zero and become positive at instant $t=0$, the differential input voltage Vd becomes negative and output voltage will switch to $V(sat)$.

② When sine wave again crosses zero and becomes negative at instant $t=T/2$, the differential input voltage becomes positive and

Circuit diagram for Non-inverting ZCD :



Observation:

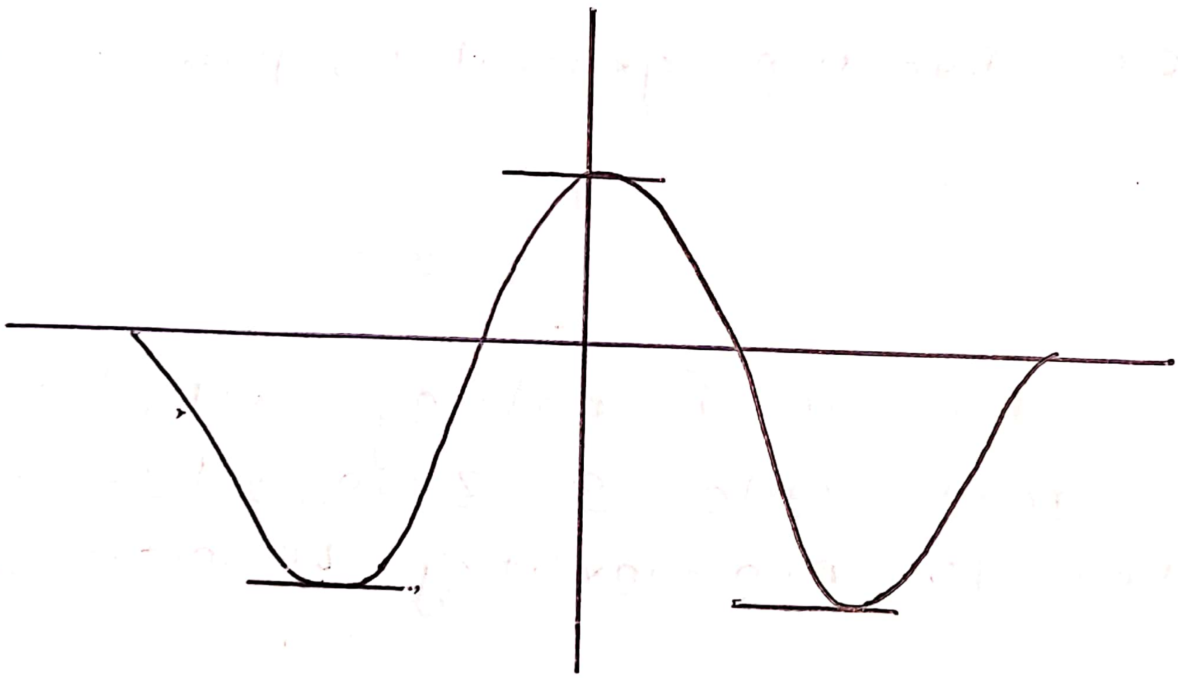
$V_{in} = 3.6$ div $\times 0.5$ V/div $= 1.8$ V

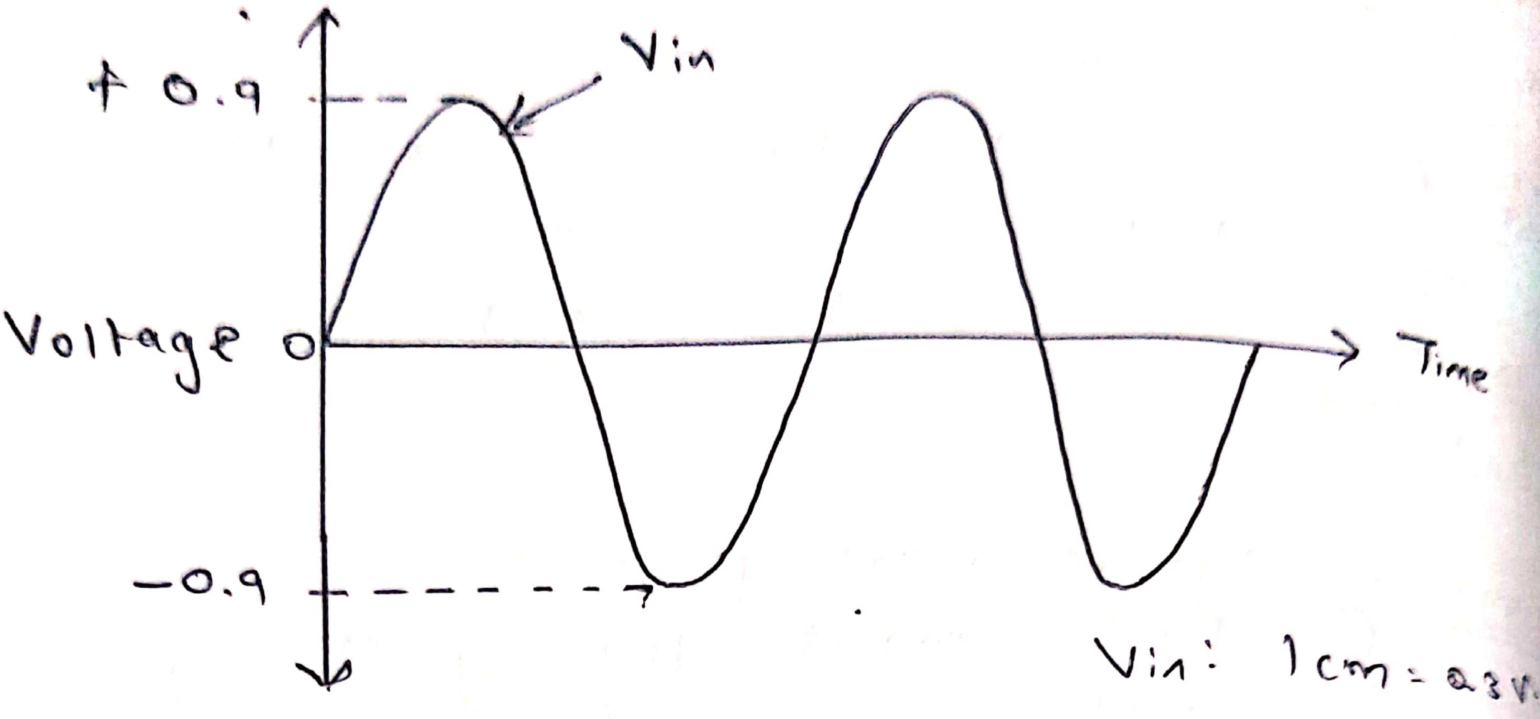
$V_{out} = 5$ div $\times 5$ V/div $= 25$ V

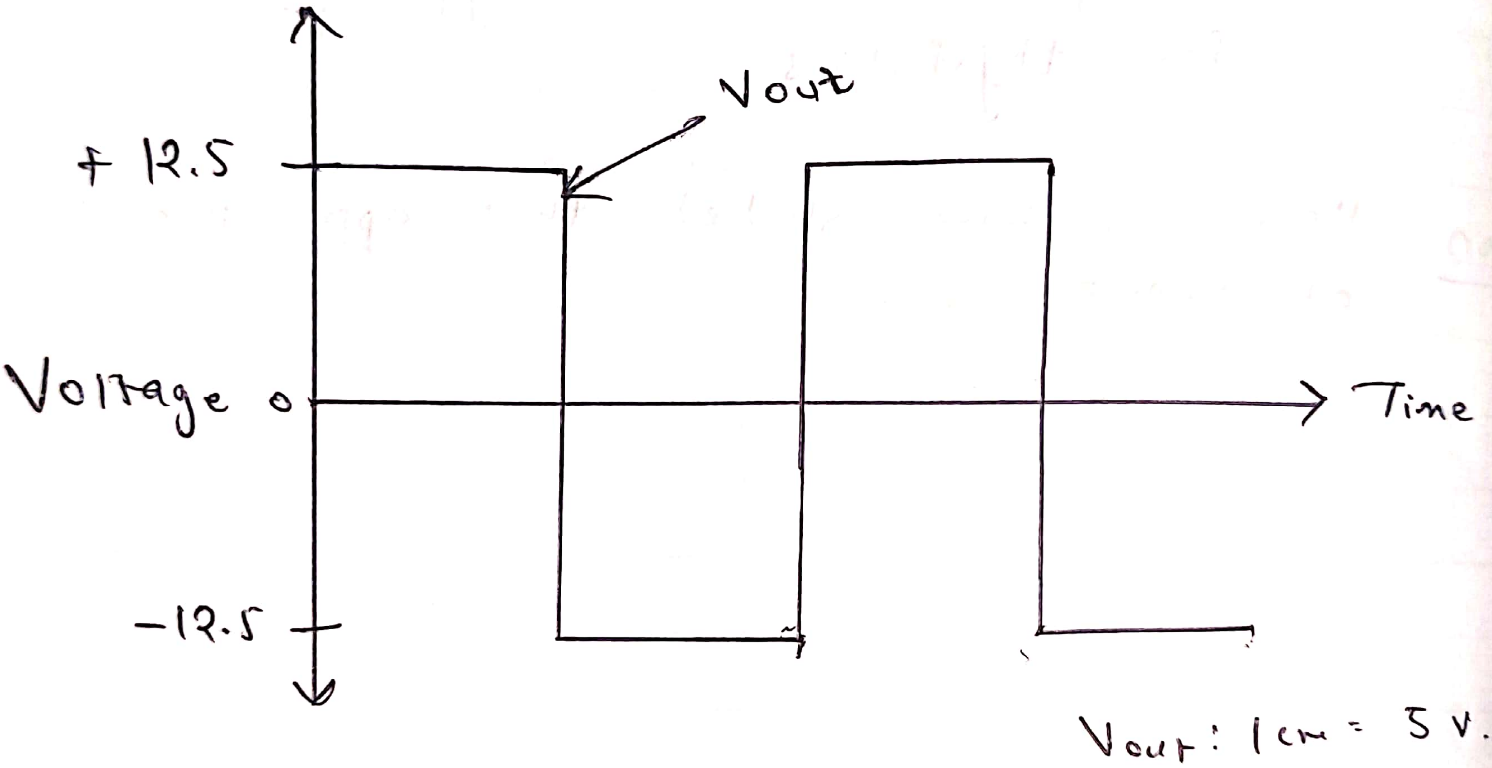
frequency $= 1.347$ KHz

V_{in} : 1.3 V.

V_{out} :







Non-inverting zero crossing detector.

output voltage will swing to $+V_o(sat)$ as now the +ve terminal is more +ve than (-) terminal.

3. The zero crossing detector thus switches its output from one state to another everytime when input voltage crosses the zero.
4. It is also known as sine wave to square wave detector.

Applications:
1. Square wave generator
2. In the mains supply synchronizing circuit.
3. microprocessor based triggering circuit for thyristors.

Conclusion: Here we have studied that application of OPAMP as zero.

Experiment No 7.

Aim: Modulation and Demodulation of AM.

Equipments:

1. Modules ACL-AM & ACL-AD.
2. Power supply
3. 20 MHz Oscilloscope
4. Connecting Links
5. Frequency Counter

Theory:

In amplitude modulation the amplitude of high frequency sine wave (carrier) is varied in accordance with the instantaneous value of the modulating signal.

Consider a sine wave signal $V_c(t)$ with frequency f.

$V_m(t) = B \cdot \sin(2\pi f \cdot t)$

And another sine signal $V_c(t)$ is called modulating signal $V_c(t)$ is called carrier signal

$V_c(t) = A \cdot \sin(2\pi F \cdot t)$

The signal $V_m(t)$ is called modulating signal the signal $V_c(t)$ is called carrier signal.

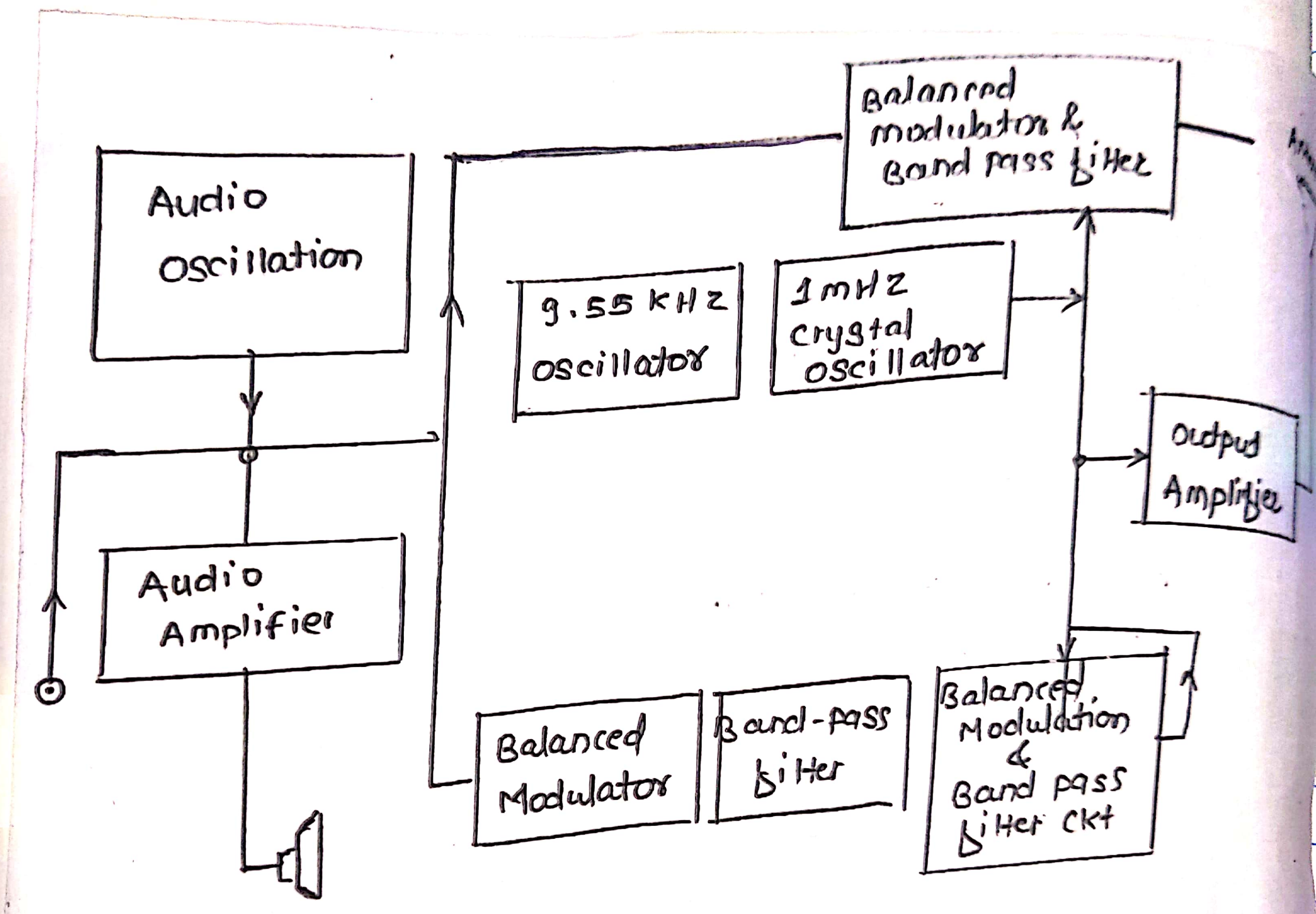
Vary the amplitude of the carrier $V_c(t)$ adding the modulating signal $V_m(t)$ to A.

$V_m(t) = [A + K \cdot B \cdot \sin(2\pi f \cdot t)] \cdot \sin(2\pi F \cdot t)$

$= A \cdot [1 + m \cdot \sin(2\pi f \cdot t)] \cdot \sin(2\pi F \cdot t)$

with K = Constant of proportionality

Block Diagram of Amplitude Modulation



The modulation index m can be calculated as

$$m = \frac{H-h}{H+h} \cdot 100\%$$

Procedure:

(a) Modulation:

1. Connect SINE OUT post of FUNCTION GENERATOR Section (ACL-Am) to the i/p of Balance Modulator) (ACL-Am) SIGNAL IN post.
2. Connect Output of VCO (ACL-Am) RF OUT post to the input of Balance Modulator l, CARRIER IN post.
3. Connect the power supply with proper polarity to the kit ACL-Am & ACL-AD, while connecting this, ensure that the power supply is OFF.
4. Switch on the power supply and carry following presetting

   Function Generator - Level about 0.5 Vpp; FREQ about 1 KHz

   VCO - Level about 1 Vpp; FREQ about 450 KHz Switch on 500 KH.

   Balanced Modulator - Carrier Null completely rotated, clockwise or counter clockwise.
5. Connect the oscilloscope to the inputs of modulator post. and detect modulating signal and carrier signal

(6) Vary the amplitude of the modulating signal and note that the modulated signal can result saturation or over modulation.

B. Demodulation

(1) Refer figure for connections
(2). Connect O/P of function generator section (ACL-AM) OUT post to the i/P of balance modulator signal in post.
(3) Connect O/P of VCO (ACL-AM) OUT post to the input of balance modulator (ACL-AM) Carrier In post.
(4) Connect the power supply with proper polarity to the kit ACL-AM & ACL-AD, while connecting this, ensure that the power supply is OFF.
(5) Switch on the power supply and carry following presettings.

Function generator - Sine level about 0.5 Vpp ; FREQ about 1 KHz.

VCO - Level about 2 Vpp ; FREQ about 800 KHz switch on 1500 KHz.

Balanced modulator - Carrier null completely rotates clockwise or counter clockwise

(6) Local Oscillator (ACL-AD) - 1300 KHz. 2V.

Experiment No. 8

Aim: Modulation and Demodulation PAM, PWM, PPM.

① Pulse Width Modulation and Demodulation.

Equipments:

1. Experimenter kit DCL - 08
2. Connecting chords
3. Power Supply
4. 20 MHz Dual trace oscilloscope.

Theory:

Pulse Width Modulation.

This technique of modulation controls the variation of duty cycle of the square wave (with some fundamental frequency) according to the input modulating signal. Here the amplitude variation of the modulated signal is reflected in the ON period variation of square wave. Hence, it is a technique of V to T conversation.

Pulse Width Demodulation

The input signal is pulse width modulation, so the ON time of signal is changing according to the modulating signal. In the demodulation technique during the ON time of PWM signal one counter is enabled. At the end of ON time, counter gives a particular count which directly corresponds to the amplitude of input signal. Then this count is fed to a DAC. The output of DAC corresponds to the amplitude of input signal. Thus the output we get the original modulating signal extracted from PWM wave.

Procedure :

1. Connect the power supply with proper priority and switch it on.
2. Put Jumper JP3 to 2nd position.
3. select 1 KHz 1V-pp sine wave signal generated onboard.
4. Connect this signal to PWM / PPM IN. Observe the output wave.
5. Hort the following post:
   PWM Out and BUF in
   BUF Out and PWM DMOD in.
   DMOD Out and FIL in.
6. Observe the Pulse Width Demodulated Outpur at FIL OUT.
7. Repeat it for different input signal and different sampling clocks.

② Pulse Amplitude Modulation and Demodulation

Equipments:

1. Experimenter kit DCL-08.
2. Connecting chords
3. Power Supply
4. 20 MHz Dual trace oscilloscope

Theory:

In pulse amplitude modulation, the signal is sampled at regular intervals and the amplitude of each sample is made proportional to the amplitude of the signal at the instant of sampling. This amplitude of each sample is hold for the sample duration to make pulses flat top. The pulse amplitude demodulator consists of active low pass Butterworth filter. It filters out the sampling frequency and their harmonics from the modulated signal and recovers the base band by integrated action.

Procedure :

1. Connect the power supply with proper polarity to the kit DCL-08 and switch it on.
2. Select 16 KHz sampling frequency by jumper JP1.
3. Connect the 1 KHz, 2 Vp-p sine wave signal generated onboard to PAM. IN post.
4. Observe the pulse Amplitude modulation output at PAM OUT post.
5. Short the following posts.
   PAM OUT and AMP IN
   AMP OUT and FIL IN
6. Keep the amplifier gain control potentiometer P5 to maximum completely clockwise.
7. Observe the pulse Amplitude Demodulated signal at FIL OUT, which is same as the input signal.

(3) Pulse Position Modulation and Demodulation

Equipments:

1. Experimenter Kit DCL - 08.
2. Connecting chords
3. Power Supply
4. 20 MHz Dual Trace Oscilloscope

Theory:

The position of the TTL pulse is changed on time scale according to the variation of input modulating signal amplitude, Width of the pulses and amplitude of the pulses remain same.

Demodulation.

This pulse position modulated signal is converted into PWM pulse from using monostable multivibrator. This signal is then demodulated using the same technique of PWM demodulation. In this technique, during ON time of PWM signal one counter is enabled. At the end of ON time, counter gives a particular count which directly corresponds to the amplitude of input signal. Then this count is fed to DAC. The output of DAC corresponds to the amplitude of input signal.

Procedure :

1. Connect the power supply with proper polar[ity]
2. Put jumper JP3 to 2^{nd} position.
3. Select 1 K·Hz , 1·V - pp sine wave signal generated onboard.
4. Connect the selected signal to the PWM/PPM in
5. Observe the PPM output at PPM Out post with shifted position on Time scale.
6. observe the variation in pulse position. Apply 1-30 Hz sine wave signal to PWM /PPM IN. post vary the frequency from 1-30 Hz.
7. Short the posts
   PPM OUT and BUF IN
   BUF OUT and PPM DMOD IN

Experiment No. 9

Aim: Time Division multiplexing and Demultiplexing.

Objectives: ① To examine signal sampling, aliasing and signal reconstruction
② To implement a time division multiplexing system using simulator.

Theory:

While two or more messages need to be transmitted in a RF channel simultaneously, some transmission schemes, such as TDM, FDM and CDMA, etc. have been proposed for satisfying this requirement. Among these, TDM is the most fundamental one. The Time Division multiplexer (TDM MUX) module is used to recombine two analog signals into one data stream. It should be noted that, each signal should be sampled at the Nyquist rate ($f_s > 2B$) in order to avoid aliasing. Also, Time Division Multiplexer (TDM DEMUX) is used to reconstruct the original signals from the multiplexed data stream.

Procedure:

1. Carry out the following connections and switch settings.
2. Connect power supply in proper polarity to the kit DCL - 02 and switch it on.
3. Connect 250 Hz, 500 Hz, 1 KHZ, 2 KHZ sine wave signal from function generator to the multiplexer input channel Ch0, Ch1, CH2, Ch3 to IN0, IN1, IN3 of filter section.
4. Connect the sampling clock Rx sync of the receiver section respectively.
5. Set the amplitude of the sine wave as desired. Take observations as mentioned.

Conclusion:

Thus, we studied TDM pulse modulation/Demodulation with transmitter clock and channel identification information linked directly to the resistor.

Experiment No. 10

Aim: Study on FM receiver.

List of components:

1. IC - LM 386
2. T1 BF 494
3. T2 BF 495
4. 4 turn 22 SWG 4 mm dia air core
5. C1 220 nF
6. C2 2.2 nF
7. C 100 nF * 2
8. C4 10 μF
9. C5 10 μF (25 V)
10. C7 47 nF
11. C8 220 μF (25 V)
12. C9 100 μF (25 V) * 2
13. R 10 KΩ * 2
14. R3 1 KΩ
15. R4 10 KΩ
16. Variable resistance
17. Variable capacitance
18. Speaker
19. Switch
20. Antenna
21. Battery

Advantages:

1. Improved noise immunity
2. Low power is required to be transmitted to obtain the same quality of received signal at the receiver.
3. FM transmission covers a larger area with the same amount of transmitted power.
4. Transmitted power remains constant
5. All the transmitted power is useful.

Disadvantages:

1. Very large bandwidth is required
2. Since the space wave propagation is used the radius of transmission is limited by the line of sight.
3. FM transmission and reception equipments are complex.

Applications:

1. Radio broadcasting.
2. Some TV broadcasting
3. Satellite communication
4. Police wireless.

(8)

Block Diagram of FM receiver.