R18 B.TECH ECE.

# I.C APPLICATIONS LABORATORY

## 2ND Year, ECE, Semester - II

# OBSERVATION BOOK

Department of Electronics and Communication Engineering
MAHATMA GANDHI INSTITUTE OF TECHNOLOGY
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# MAHATMA GANDHI INSTITUTE OF TECHNOLOGY
## (Affiliated to Jawaharlal Nehru Technological University, Hyderabad)

## Department of
## ELECTRONICS & COMMUNICATION ENGINEERING

**This Observation Book belongs to**

**Name :----------------------------------------------------------------**

**Roll No :---------------------------------------------------------------**

**Class :- --------------------------------Sem-----------------------**

**Academic Year :-------------------------------------------------**

**Faculty**

**1.-----------------------------------------**

**2. ------------------------------------**

**Lab technician**

**1.-----------------------------------------**

**2.-----------------------------------------**

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# JAWARLAL NEHRU TECHNOLOGICAL UNIVERSITY
# MAHATMA GANDHI INSTITUTE OF TECHNOLOGY

**B.TECH II/IV II SEMESTER**

## ELECTRONICS & COMMUNICATION ENGINEERING

**R18 B.TECH ECE.**

# I.C APPLICATIONS LAB

**Lab Code: EC407PC**

**Note:**

❖ Verify the functionality of the IC in the given application.

**Design and Implementation of:**

1. Inverting and Non-inverting Amplifiers using Op Amps.
2. Adder and Subtractor using Op Amp.
3. Comparators using Op Amp.
4. Integrator Circuit using IC 741.
5. Differentiator circuit using Op Amp.
6. Active Filter Applications – LPF, HPF (first order)
7. IC 741 wave form Generators – Sine, Square wave and Triangular waves.
8. Mono-stable Multivibrator using IC 555.
9. Astable Multivibrator using IC 555.
10. Schmitt Trigger Circuits – using IC 741.
11. IC 565 – PLL Applications.
12. Voltage Regulator using IC 723.
13. Three Terminal Voltage Regulators –7805, 7809, 7912.

**BEYOND SYLLABUS**

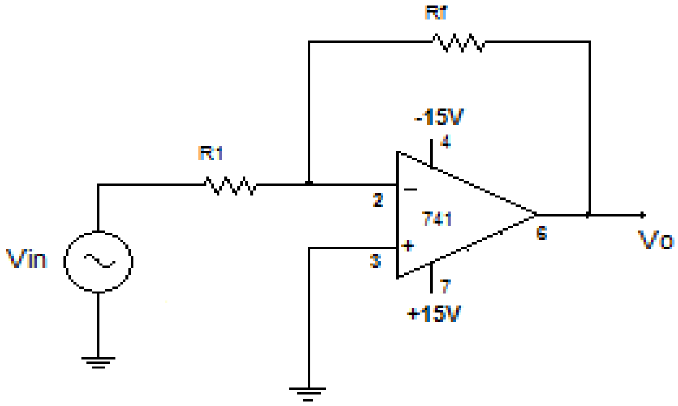
14. D/A Converter using Op-Amp 741.
15. Wien bridge oscillator using Op-amp 741.
16. A/D Converter.

# 1. INVERTING AMPLIFIER AND NON INVERTING AMPLIFIERS
## (A) INVERTING AMPLIFIER

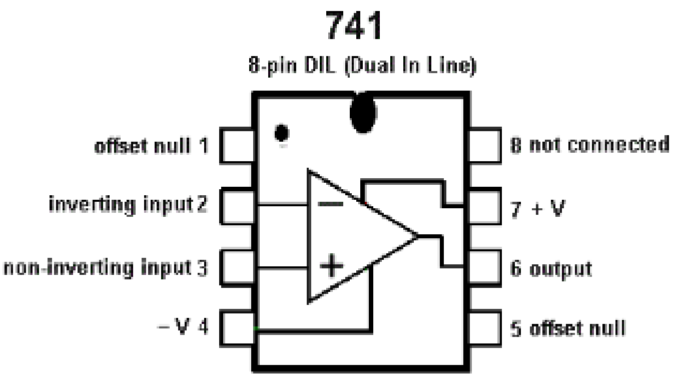
**AIM:-** To design and study the closed loop voltage gain of Inverting Amplifier circuit.

**COMPONENTS & EQUIPMENT REQUIRED :-**
Function generator, CRO, Regulated Power supply, Resistors, 741 IC, Bread board, connecting wires, CRO probes …….etc

**CIRCUIT DIAGRAM:-**




**PIN CONFIGURATION:-**




**FORMULAS:-**

Theoretical

$$V_o = -\frac{R_f}{R_1} V_{in}$$

| Theoretical Gain = | Practical Gain = |
|---|---|
| $A_v = \frac{R_f}{R_1}$ | $A_v = \frac{V_0}{V_{in}}$ |

**PROCEDURE:-**

1. Connect the circuit as shown in the circuit diagram.
2. Give the input signal as specified in table.
3. Switch on the power supply.
4. Observe the output wave form an inverted and note down the amplitude using CRO
5. Draw the necessary wave forms on the graph sheet.
6. Calculate theoretical and practical gain values
7. Connect Rf = 7.5KΩ and R1=2.2 KΩ.
8. Apply a sinusoidal signal of frequency 100Hz and amplitude $V_{in}$ = 1V and note down the output voltage $V_o$. Calculate the voltage gain $A_v = V_0/V_i$ and $A_v$ in dB = 20 $\log_{10} V_o/V_i$.
9. Repeat the above step by keeping $V_i$ constant and vary the frequency in steps up to 1MHz.
10. Plot the frequency response graph and calculate band width from the graph.

**EXPECTED WAVE FORMS:-**

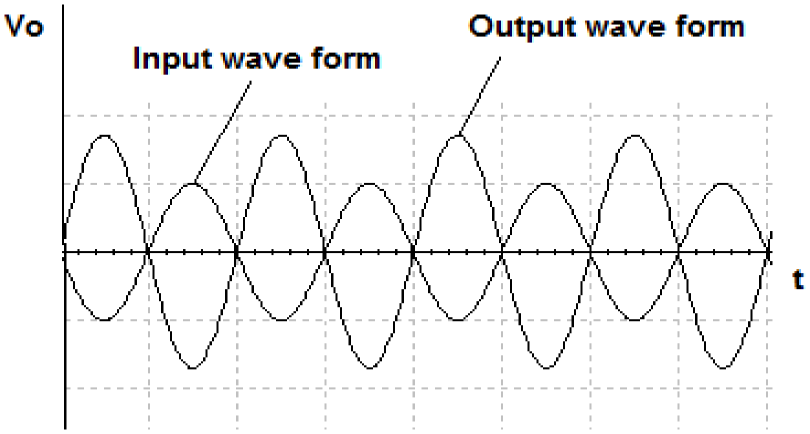



**TABLE:-**

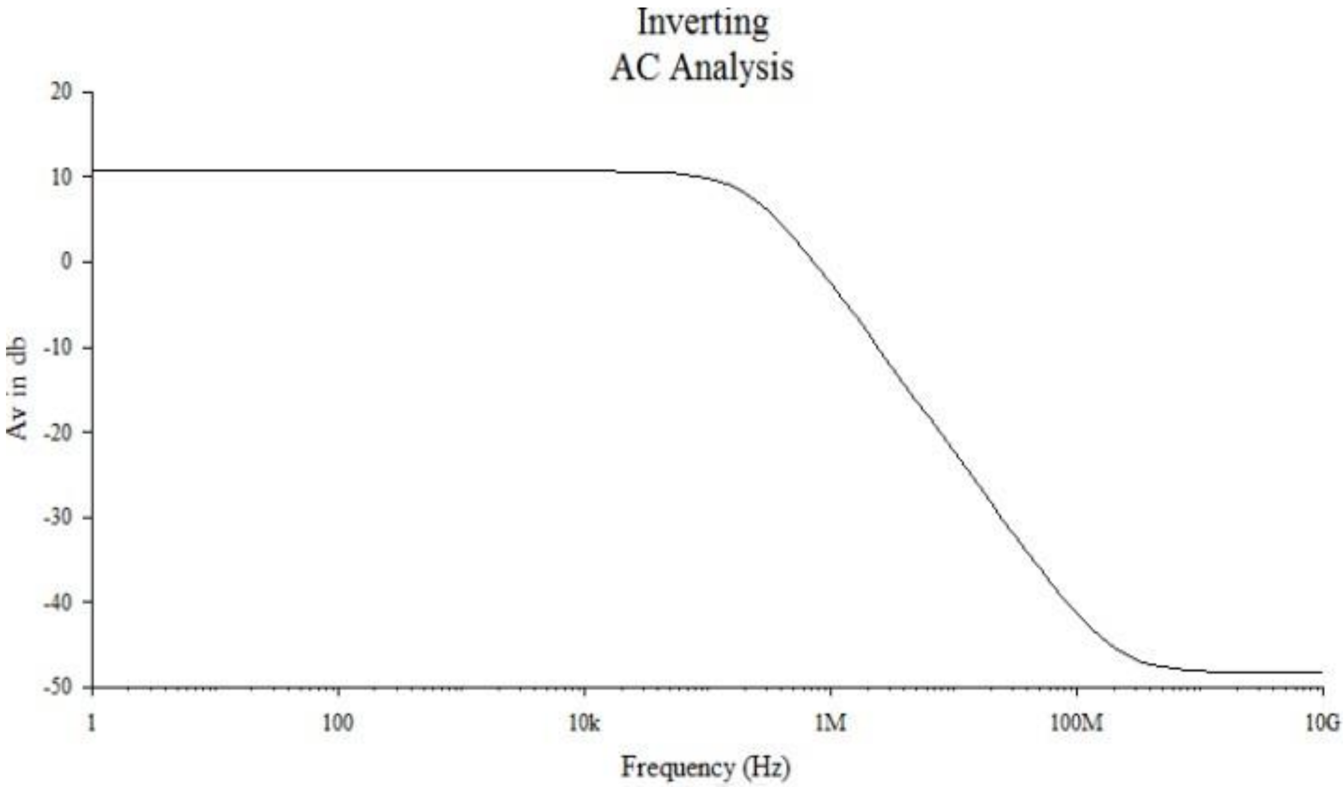
| Resistor values | frequency | Input amplitude | Gain (Thr) | Gain (Pra) | Vo (Thr) V | Vo (Pra) V |
|---|---|---|---|---|---|---|
| Rf=7.5 KΩ R1=2.2 KΩ | 1khz | 500mv | | | | |
| | 1khz | 1v | | | | |

## OBSERVATIONS:-

$V_i = 1V$

| S.No | Frequency(Hz) | Output voltage($V_o$) | $A_v = \frac{V_o}{Vi}$ | $A_v$ in dB = 20 $\log_{10}$.Av |
|---|---|---|---|---|
| | | | | |

**EXPECTED GRAPH:-**




**Result:**

Inverting amplifier is designed and closed loop gain from the output wave form is observed

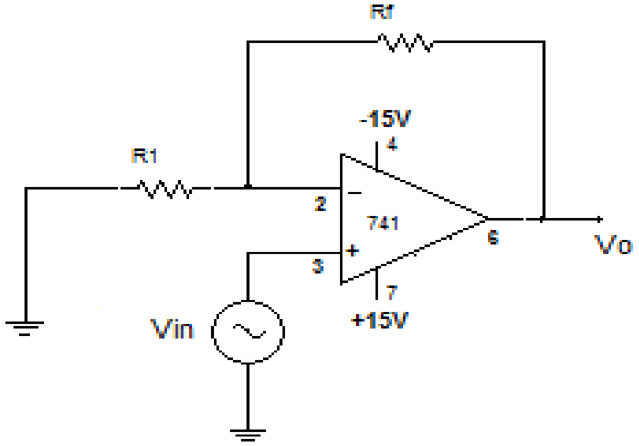
## (B). NON-INVERTING AMPLIFIER

**AIM:** To design and study the closed loop voltage gain of Non Inverting Amplifier circuit.

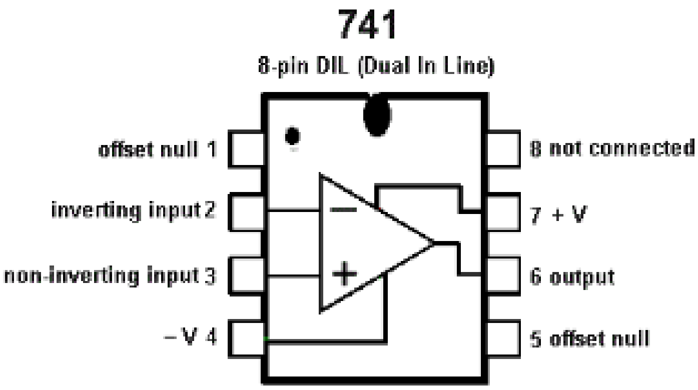
**COMPONENTS & EQUIPMENT REQUIRED :-**

Function generator, CRO, Regulated Power supply, Resistors, 741 IC, Bread board, connecting wires, CRO probes …….etc

**CIRCUIT DIAGRAM:-**




**PIN CONFIGURATION:-**




**FORMULAS:-**

Theoretical

$$V_o = (1 + \frac{R_f}{R_1})V_{in}$$

| Theoretical Gain = | Practical Gain = |
|---|---|
| $A_v = 1 + \frac{R_f}{R_1}$ | $A_v = \frac{V_0}{V_{in}}$ |

**PROCEDURE:**

1. Connect the circuit as shown in the circuit diagram.
2. Give the input signal as specified in table.
3. Switch on the power supply.
4. Observe the output wave form a non-inverted and note down the amplitude using CRO
5. Draw the necessary wave forms on the graph sheet.
6. Calculate theoretical and practical gain values
7. Connect Rf = 7.5KΩ and R1=2.2 KΩ.
8. Apply a sinusoidal signal of frequency 100Hz and amplitude $V_{in}$ = 1V and note down the output voltage $V_o$. Calculate the voltage gain $A_v = V_0/V_i$ and $A_v$ in dB = 20 $\log_{10} V_o/V_i$.
9. Repeat the above step by keeping $V_i$ constant and vary the frequency in steps up to 1MHz.
10. Plot the frequency response graph and calculate band width from the graph.

**EXPECTED WAVE FROM:-**

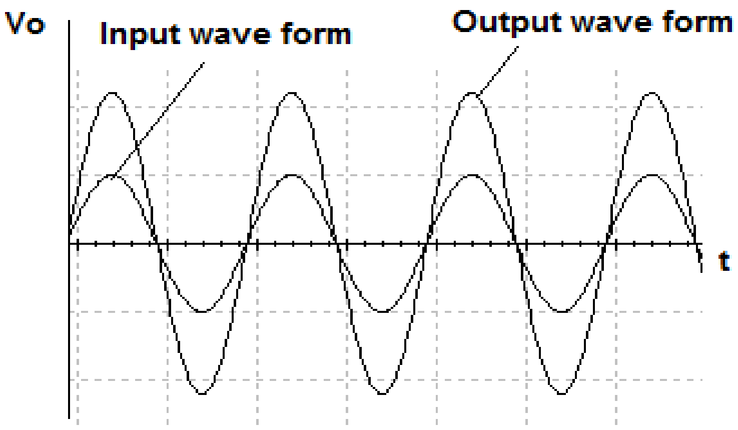


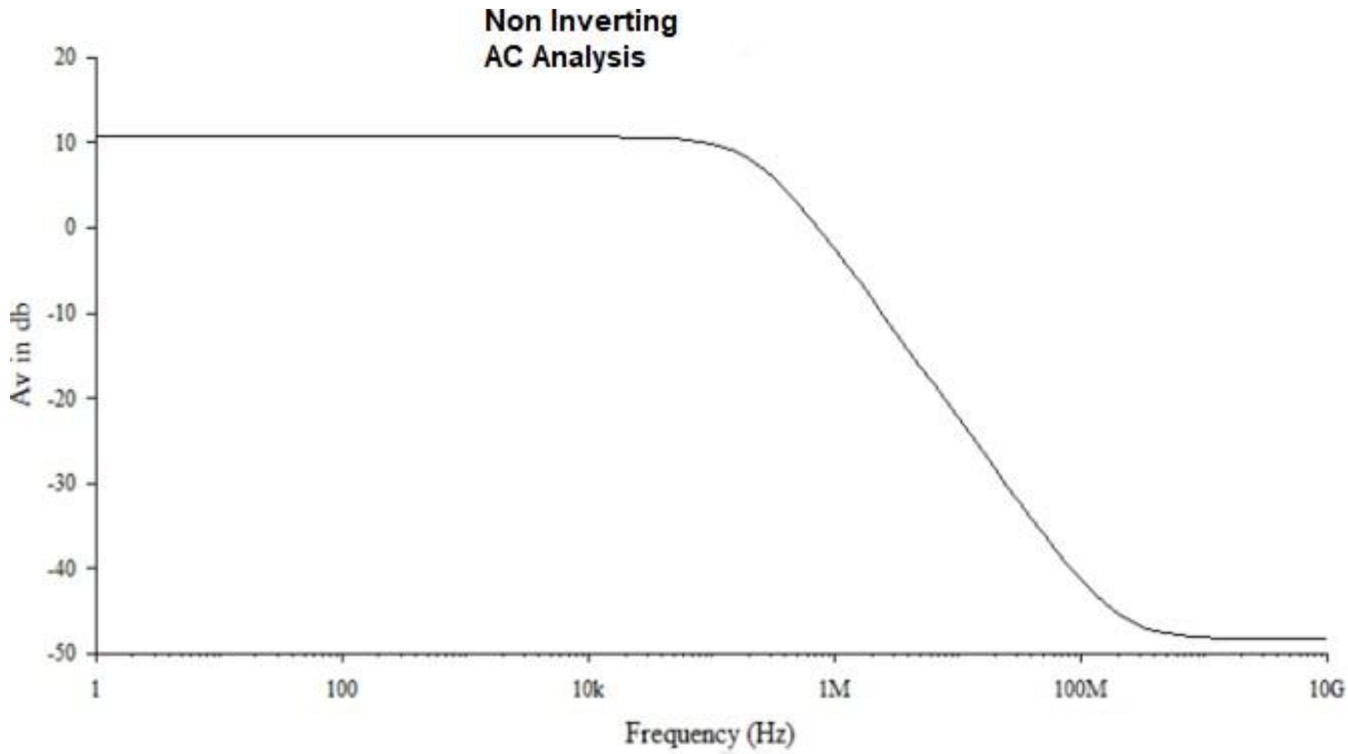

**TABLE:-**

| Resistor values | frequency | Input amplitude | Gain (Thr) | Gain (Pra) | Vo (Thr) V | Vo (Pra) V |
|---|---|---|---|---|---|---|
| Rf=7.5 KΩ R1=2.2 KΩ | 1khz | 500mv | | | | |
| | 1khz | 1v | | | | |

**OBSERVATIONS:-** $V_i = 1V$

| S.No | Frequency(Hz) | Output voltage($V_o$) | $A_v = \frac{V_o}{Vi}$ | $A_v$ in dB = 20 $\log_{10}.Av$ |
|---|---|---|---|---|
| | | | | |

**EXPECTED GRAPH:-**




**RESULT:-**

Non Inverting amplifier is designed and closed loop gain from the output wave form is observed

## VIVA QUESTIONS

1. Why would you want an inverting amplifier?
2. What is the current is of the inverting amplifier circuit?
3. What is the gain of a non inverting amplifier?
4. What is the use of negative feedback in op amp?
5. What is non inverting?
6. What is non inverting comparator?
7. What is an inverting amplifier?
8. What is meant by virtual ground or virtual earth?

# 2).ADDER AND SUBTRACTOR USING OP AMP

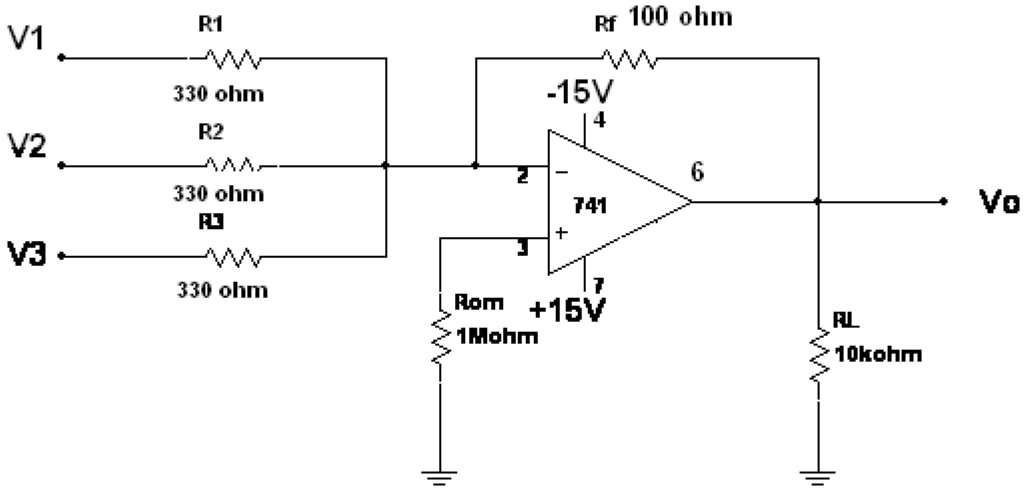
## (A). ADDER

**AIM:-** To design and study adder and subtractor circuits using IC741.

**COMPONENTS & EQUIPMENT REQUIRED :-**

IC741, Rf = 100Ω, R1 = R2 = R3 = 330Ω, RL = 10KΩ, Rom = 1MΩ, Bread board, connecting wires, Multimeter, Regulated power supplies ……. etc

**CIRCUIT DIAGRAM:-**




**PROCEDURE:-**

1. Connect the components as per the circuit diagram.
2. Apply V1 = V2 =V3 = 2V and observe output voltage in CRO or multimeter.
3. Repeat the above procedure for V1 =2V,V2 = -3V, V3 = 5Vand also V1 =5V,V2 = -6V, V3 =-2V.

**OBSERVATIONS:-**

| S.No | $V_1$(V) | $V_2$(V) | $V_3$(V) | Vo(Theoretical) V $V_o = \frac{-R_f}{R_1}(V_1 + V_2 + V_3)$ | Vo (Practical) V |
|---|---|---|---|---|---|
| 1. | 2 | 2 | 2 | | |
| 2. | 2 | -3 | 5 | | |
| 3. | 5 | -6 | -2 | | |

**ASSIGNMENT:-**

1. Draw the non-inverting adder circuit diagram.
2. Design a circuit whose output voltage $V_o$= - $(V_1 + V_2 + V_3)$.
3. Design a summing amplifier to add three DC input voltages. The output of this circuit must be equal to two times the negative sum of the inputs.
4. Design a scaling amplifier circuit that will amplify the first input by a factor of 2 and the second by a factor of 3.Use inverting configuration for the scaling amplifier.

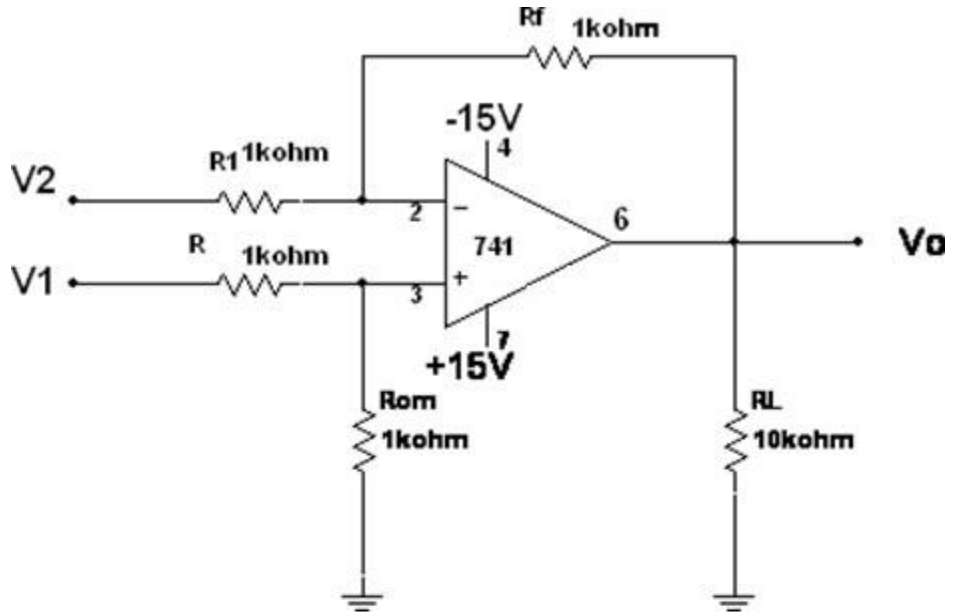
## (B). SUBTRACTOR

**AIM:-** To design and study subtractor circuits using IC741.

**COMPONENTS & EQUIPMENT REQUIRED :-**

IC741, Rf = R1 = Rom = 1KΩ, RL = 10KΩ, Bread board, connecting wires, Multimeter ……. etc

**CIRCUIT DIAGRAM:-**




**PROCEDURE:-**

1. Connect the components as per the circuit diagram.
2. Apply V1 =10V, V2 = 5V and observe output voltage in CRO or multimeter.
3. Repeat the above procedure for V1 =5V,V2 = 10V and also V1 =V2 =10V.

**OBSERVATIONS:-**

| S.No | $V_1$(V) | $V_2$(V) | Vo(Theoretical) V $V_o = (V_1 - V_2)$ | Vo (Practical) V |
|---|---|---|---|---|
| 1. | 10 | 5 | | |
| 2. | 5 | 10 | | |
| 3. | 10 | 10 | | |

## VIVA QUESTIONS

1. Explain the difference between inverting and non-inverting summing amplifiers.
2. Design an averaging circuit with for DC inputs.
3. Draw the non-inverting adder circuit diagram.
4. Design a circuit whose output voltage Vo= - ($V_1 + V_2 + V_3$).
5. Design a summing amplifier to add three DC input voltages. The output of this circuit must be equal to two times the negative sum of the inputs.
6. Design a scaling amplifier circuit that will amply the first input by a factor of 2 and the second by a factor of 3.Use inverting configuration for the scaling amplifier.
7. Draw an op-amp whose output is $V_1+2V_2-3V_3-V_4$.

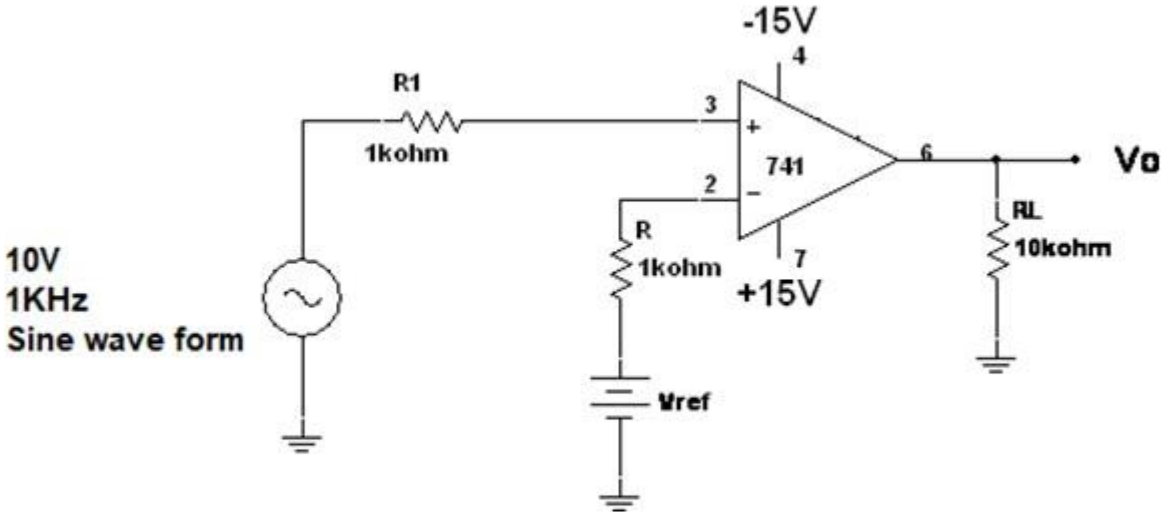
# 3.COMPARATORS USING OP AMP

**AIM:-**To design and study comparator circuits using IC741.

**COMPONENTS & EQUIPMENT REQUIRED :-**

IC 741, $R_1$ = R = 1 K Ω, $R_L$ = 10 k Ω, Function generator, CRO, Bread board, connecting wires, Regulated Power supply, CRO probes ……. etc

**CIRCUIT DIAGRAM :-**




**PROCEDURE :-**

1. Connect the components as per the circuit diagram.
2. Apply a sine wave with input voltage $V_i$ = 10 $V_{pp}$ , f = 1 kHz , $V_{ref}$ = 3V
3. Observe the input and output wave forms in CRO.
4. Repeat the above procedure with $V_{ref}$ = -3v and $V_{ref}$ = 0v.
5. Draw the wave forms on a graph sheet.

**EXPECTED WAVE FORMS:-**

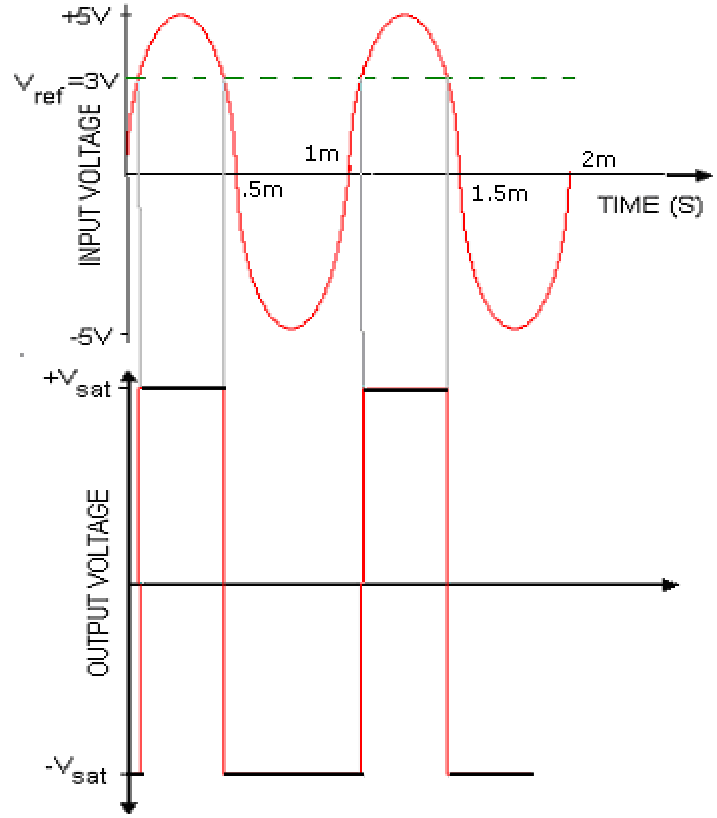



Fig. (a) When $V_{ref}$ = 3V

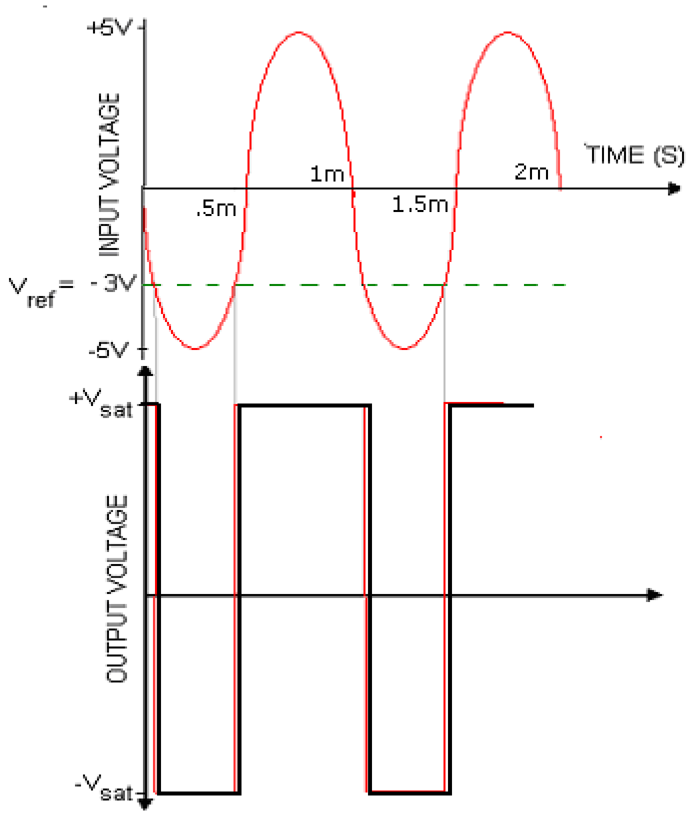



Fig. (b) When $V_{ref}$ = - 3V

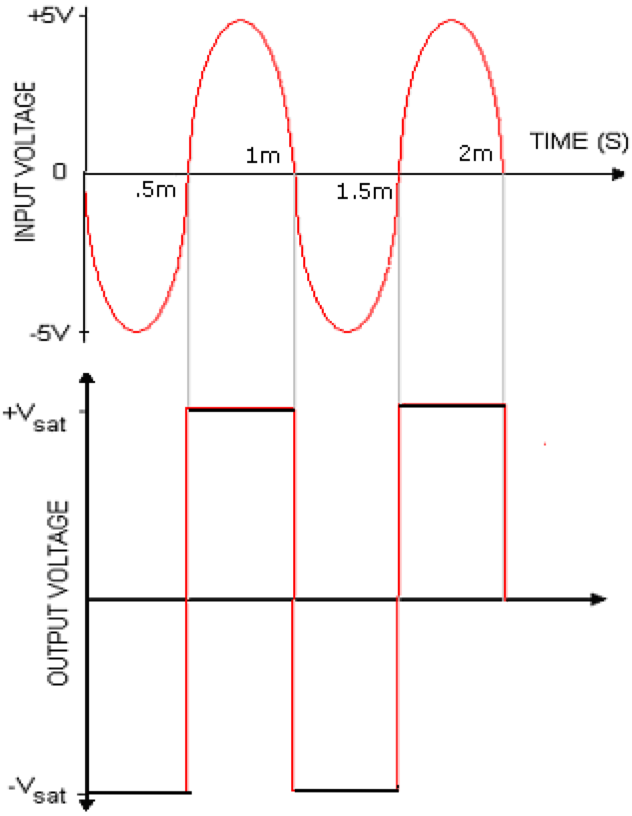



Fig. (c) When $V_{ref} = 0V$

## TABLE:-

| CASE | +VSAT | -VSAT |
|---|---|---|
| **At Vref = +3V**<br>**Vref = -3V**<br>**Vref = 0V** | | |

## VIVA QUESTIONS

1. List different types of comparators.
1. Draw the characteristics of an ideal comparator and that of a practical compactor.
2. What are the applications of comparator.
3. What is the other name for regenerative comparator.
4. Name the comparator that helps to find unknown input.
5. Zero crossing detectors is also called as.
6. How the op-amp comparator should be chosen to get higher speed of operation.

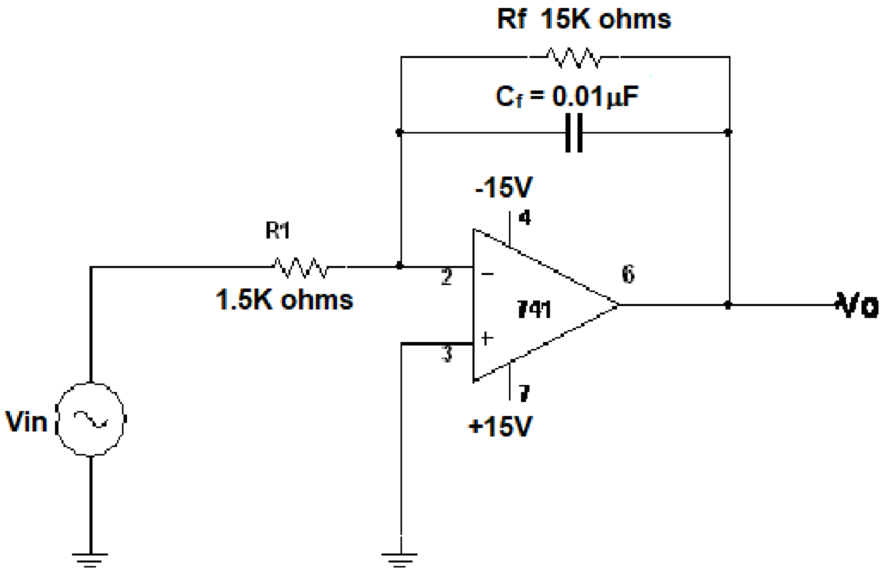
# 4. INTEGRATOR CIRCUIT USING IC 741

**AIM:-** To design and study the operation of an integrator using IC741.

**COMPONENTS & EQUIPMENT REQUIRED :-**

IC741, $R_f = 15k\Omega$ , $R_1 = 1.5k\Omega$ and $1k\Omega$, $C_f = 0.01\mu F$ Each 1No, Bread board, Function generator, CRO, connecting wires, Regulated power supply, CRO probes ……. etc

**CIRCUIT DIAGRAM:-**




**THEORY:-** Gain limiting frequency $f_a = \dfrac{1}{2\pi R_F C_F}$

Frequency at which gain is zero $f_b = \dfrac{1}{2\pi R_1 C_F}$

Use $C_f = 0.1\mu F$ , $R_f = 15k\Omega$ and $R_1 = 1.5K\Omega$.

**To Plot the frequency response:-**

1. Connect the circuit as per the circuit diagram.
2. The circuit functions as an integrator when $R_1C_f >> T$ i.e., say $R_1C_f = 10T$.

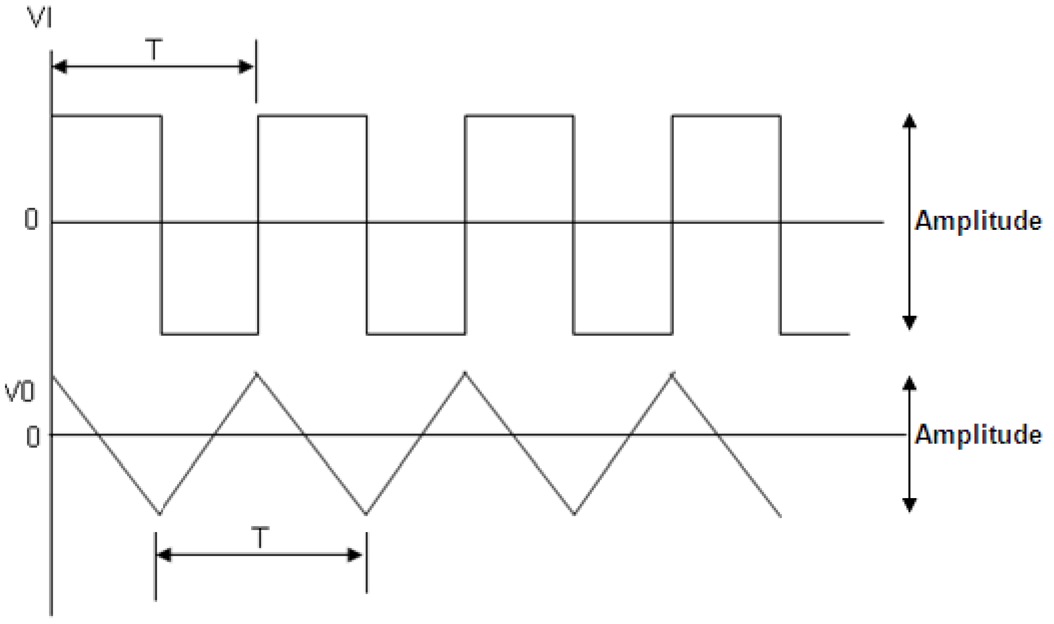
   Let $R_f = 15k\Omega$, $R1 = 1.5K\Omega$, $Cf = 0.01\mu F$.

   Therefore, $.T = \dfrac{1.5K\Omega \times 0.01\mu F}{10} = 0.0015ms$

   where T = time period of input signal.

   Apply a square wave signal frequency f= 1/T i.e., 666.6 KHz and observe output wave form of a triangular note of input and output wave forms and compare theoretical and practical.
3. Apply a sinusoidal signal of frequency 100Hz and amplitude $V_{in} = 0.1V$ and note down the output voltage $V_o$. Calculate the voltage gain $A_v = V_0/V_i$ and $A_v$ in dB = 20 log10 $V_o/V_i$.
4. Repeat the above step by keeping $V_i$ constant and vary the frequency in steps up to 1MHz.
5. Plot the frequency response graph and calculate $f_a$ and $f_b$ from the graph.

**INTEGRATOR FUNCTION WAVE FORMS :**




**FORMULAS:-**

1) $Vo = -\frac{1}{R1Cf}\int_0^t Vin(t)dt$

2) Maximum Gain = $A_V = \frac{Rf}{R1}$

**TABLE 1:-** **Integrator function output waveform values**

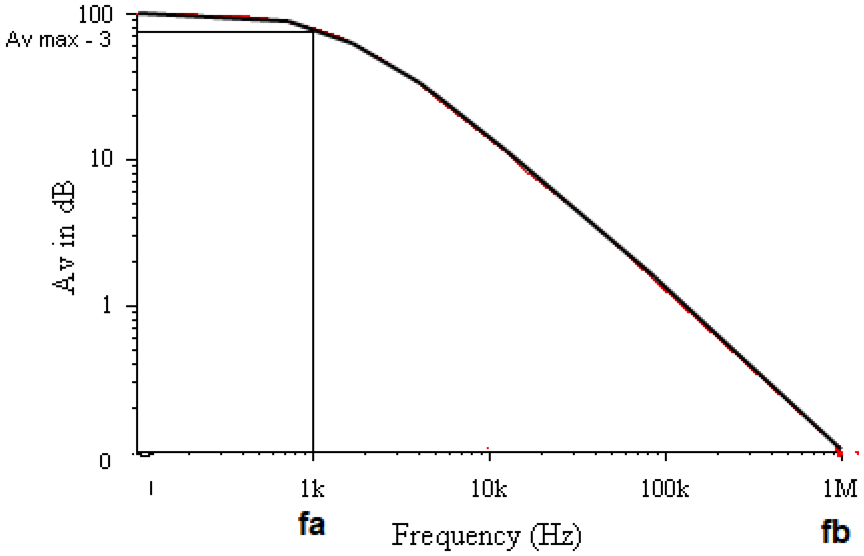
| PARAMETERS | THEORETICAL VALUE | PRACTICAL VALUE |
|---|---|---|
| Vo (Amplitude) | | |

**OBSERVATIONS:-**

**$V_i$ = 0.1V**

| S.No | Frequency(Hz) | Output voltage($V_o$) | $A_v = \frac{V_o}{Vi}$ | $A_v$ in dB = 20 $\log_{10}$.Av |
|---|---|---|---|---|
| | | | | |

**EXPECTED GRAPH:-**




**<u>TABLE 2:-</u>** **Frequency response fa and fb values**

| PARAMETERS | THEORETICAL VALUE | PRACTICAL VALUE |
|---|---|---|
| **1. fa =** | | |
| **2. fb =** | | |
| **3. Maximum Gain =** | | |

## <u>VIVA QUESTIONS</u>

1. Explain the difference between the integrator and differentiator.
2. What are the applications of integrator.
3. What are the limitations of the basic integrator.
4. Why the feedback capacitor In a practical integrator is shunted by a resistor $R_f$.
5. If square wave is applied to an integrator what is the output.
6. Define CMRR
7. Explain what is an integrator.
8. What is the output of an integrator.

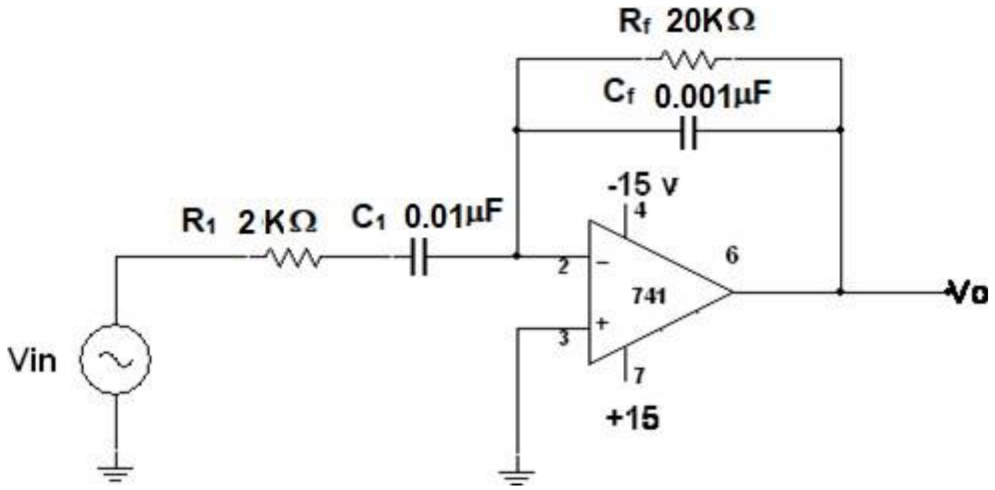
# 5. DIFFERENTIATOR CIRCUIT USING OP AMP

**AIM:-** To design and study the operation of a differentiator using IC741.

**COMPONENTS & EQUIPMENT REQUIRED :-**

IC741, $R_f = 20k\Omega$, $R_1 = 2K\ \Omega$, $C_f = 0.001\mu F$, $C_1=0.01\mu F$, Bread board, Function generator, CRO, connecting wires, Regulated power supply, CRO probes ……. etc

**CIRCUIT DIAGRAM:-**




**THEORY:-**

Frequency at which gain is zero (0 dB) $f_a = \dfrac{1}{2\pi R_F C_1}$

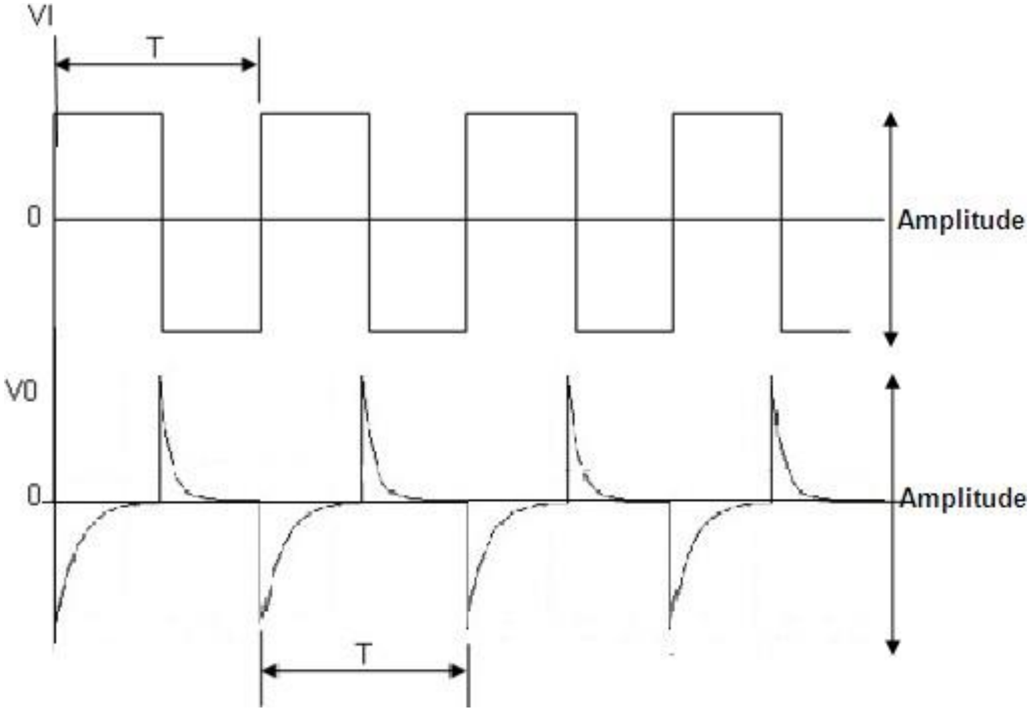
Gain limiting frequency $f_b = \dfrac{1}{2\pi R_1 C_1}$

Use $C_f = 0.001\mu F$ , $C_1 = 0.01\mu F$, $R_F = 20\ k\Omega$ and $R_1= 2K\Omega$.

**To plot the frequency response:-**

1. Connect the circuit as per the circuit diagram.
2. The circuit functions as differentiator when $R_FC_1 << T$ i.e., say $R_FC_1 = \dfrac{T}{10}$
    a. $T = 10R_FC_1 = 10 * 20K * 10^{-3} * 0.01 * 10^{-6} = 2ms.$
    b. where T = time period of input signal.
    c. Apply a square wave signal frequency f= 1/T i.e., 500Hz and observe output wave form Containing positive and negative spikes. Make note of input and output wave forms and compare with theoretical and practical.
3. Apply a sinusoidal signal of frequency 100Hz and amplitude $V_{in} = 0.1V$ and note down the output voltage $V_o$. Calculate the voltage gain $A_v = V_0/V_i$ and $A_v$ in dB = 20 log10 $V_o/V_i$.
4. Repeat the above step by keeping $V_i$ constant and vary the frequency in appropriate steps up to 1MHz.
5. Plot the frequency response graph and calculate $f_a$ and $f_b$ from the graph.

**DIFFERENTIATOR FUNCTION WAVE FORMS :**




**FORMULA:-**

$$\text{Maximum Gain} = A_v = \frac{f_b / f_a}{2}$$

**OBSERVATIONS:-**

**$V_i$ = 0.1V**

| S.No | Frequency(Hz) | Output voltage($V_o$) | $A_v = \frac{V_o}{Vi}$ | $A_v$ in dB = 20 $\log_{10}$.Av |
|---|---|---|---|---|
| | | | | |

**EXPECTED GRAPH:-**

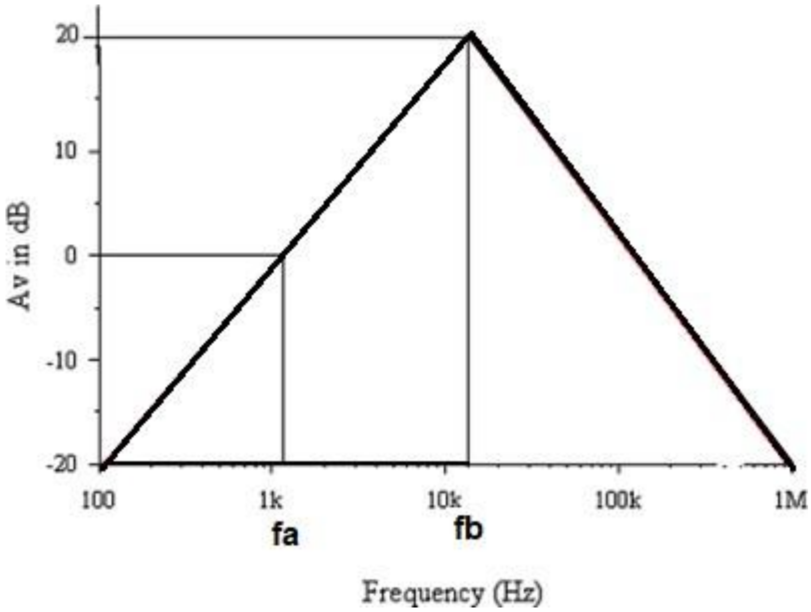



**TABLE 2:- Frequency response fa and fb values**

| PARAMETERS | THEORETICAL VALUE | PRACTICAL VALUE |
|---|---|---|
| 1. fa =<br>2. fb =<br>3. Maximum Gain = | | |

## VIVA QUESTIONS

1. What are the applications of differentiator.
2. What are the limitations of an ordinary op-amp differentiator.
3. Explain why integrators are preferred over differentiator in analog computer.
4. What is the purpose of adding feedback capacitor $C_f$ in op-amp differentiator.
5. Why resistor $R_1$ is connect in series with capacitor $C_1$ in op-amp differentiator.
6. Define slew rate.
7. Explain what is an differentiator.
8. What is the output of differentiator.

# 6.ACTIVE FILTER APPLICATIONS – LPF, HPF (FIRST ORDER)

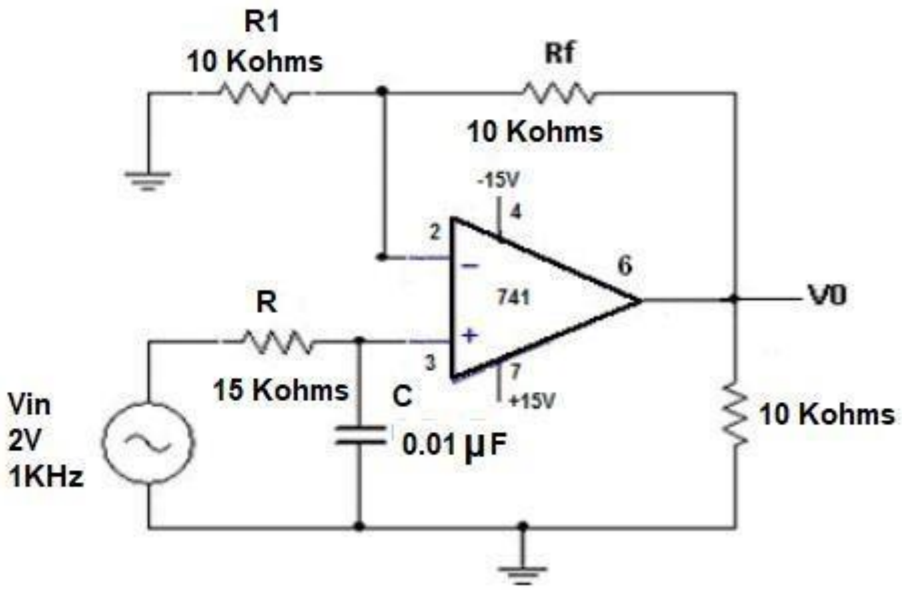
## (A)ACTIVE LOW PASS

**AIM:-** (a). To study the operation of active low pass first order filter.
(b). To plot the frequency response of a filter and compare theoretical and practical values

**COMPONENTS & EQUIPMENTS REQUIRED :-**

1. Resistors - 10kΩ - 3 no`s, 15kΩ- 1 no
2. capacitors – 0.01μF – 1 no
3. Function generator, Bread board, Regulated power supply, CRO probes
4. Op-amp IC 741
5. CRO .etc

**CIRCUIT DIAGRAM :-**




**PROCEDURE:-**

1. For 1KHz upper 3 – db frequency and pass band gain of the circuit using the formulas.

$$f_H = \frac{1}{2\pi RC}, \quad A_v = 1 + \frac{R_F}{R_1} \quad \text{Since non - inverting}$$

2. Apply $V_i = 2$ Vpp and very the frequency from 100Hz to 100 KHz.
3. Plot the frequency response on the semi – log graph sheet and indicate pass band and stop band.
4. Calculate upper 3 – db frequency from the graph.
5. Compare theoretical and practical upper 3 – db frequencies.
6. Compare practical and theoretical values.

**EXPECTED GRAPH:-**

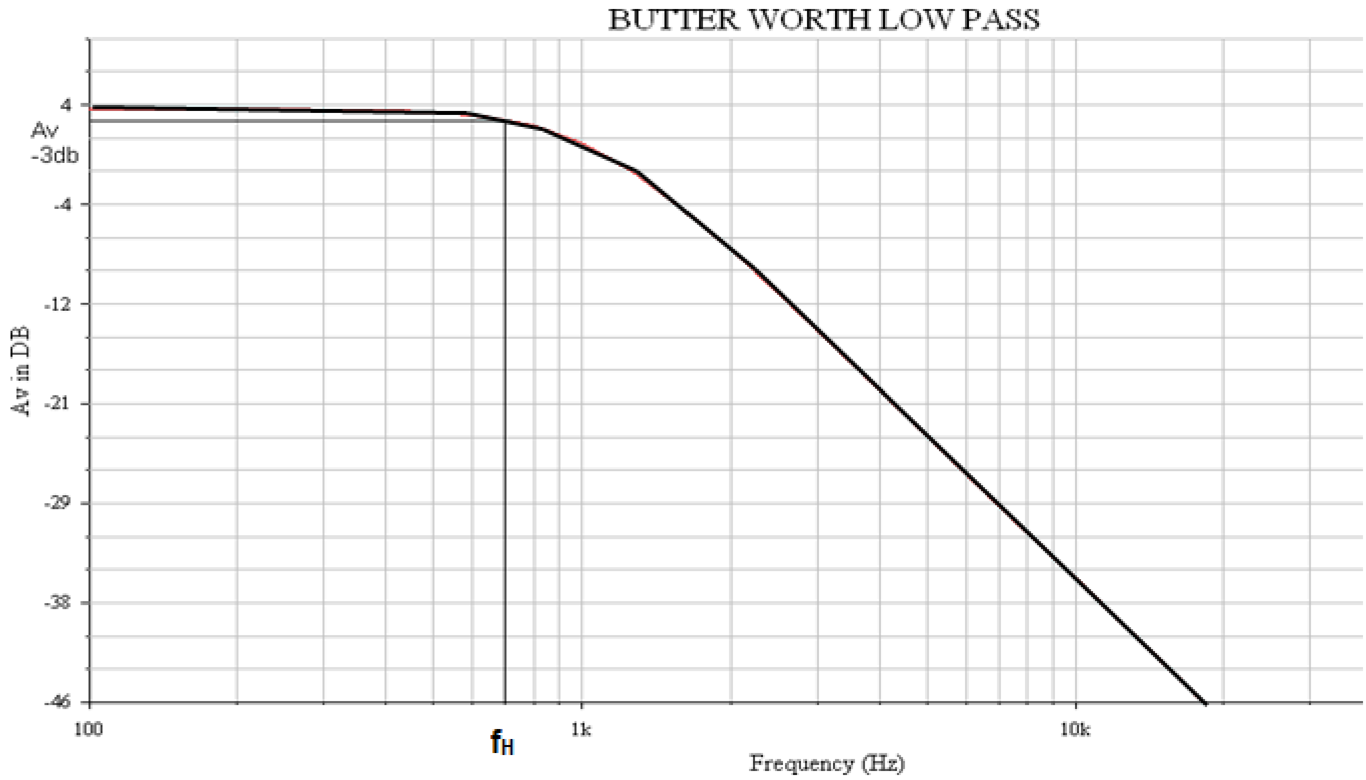



**TABLE 1:-**

| PARAMETERS | THEORETICAL VALUE | PRACTICAL VALUE |
|---|---|---|
| 1. $f_H$ =<br>2. Av =<br>3. Roll of rate = | | |

**OBSERVATIONS :-**

**Vi = 2V**

| S.NO | FREQUENCY | OUTPUT VOLTAGE ($V_O$) | $A_v = \frac{V_o}{Vi}$ | $A_v$ in dB = 20 $\log_{10}$.Av |
|---|---|---|---|---|
| | | | | |

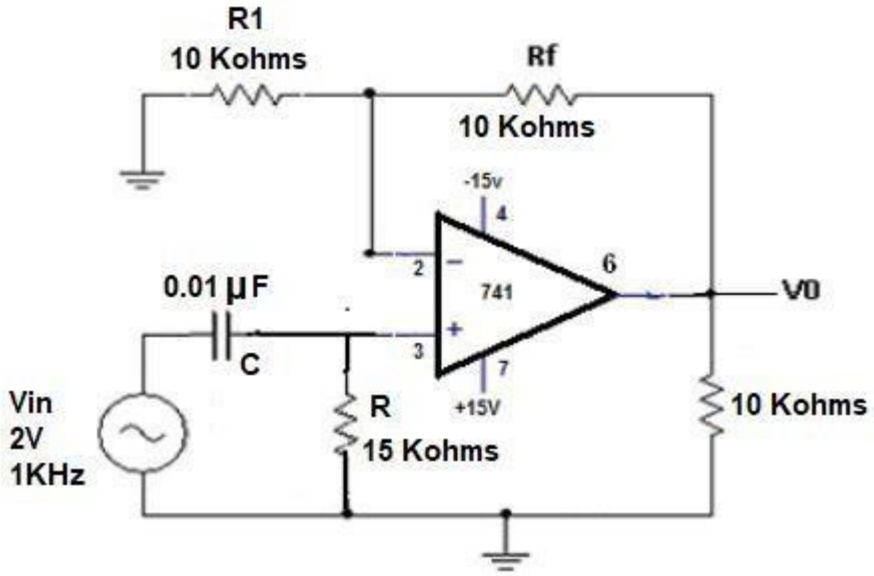
## (A). ACTIVE HIGH PASS

**AIM:-** (a). To study the operation of active high pass first order filter.
(b). To plot the frequency response of a filter and compare theoretical and practical values

**COMPONENTS & EQUIPMENTS REQUIRED :-**

1. Resistors - 10kΩ - 3 no`s, 15kΩ- 1 no
2. capacitors – 0.01µF – 1 no
3. function generator, Bread board, Regulated power supply, CRO probes
4. Op-amp IC 741
5. CRO .etc

**CIRCUIT DIAGRAM :-**




**PROCEDURE:-**

1. For 1KHz upper 3 – db frequency and pass band gain of 1.586 (second order butter worth) design the circuit using the formulas.

$$f_L = \frac{1}{2\pi RC}, \quad Av = 1 + \frac{R_F}{R_1} \quad \text{Since non - inverting}$$

2. Apply $V_i = 2$ Vpp and very the frequency from 100Hz to 100 KHz.
3. Plot the frequency response on the semi – log graph sheet and indicate pass band and stop band.
4. Calculate upper 3 – db frequency from the graph.
5. Compare theoretical and practical upper 3 – db frequencies.
6. Compare practical and theoretical values.

**EXPECTED GRAPH:-**

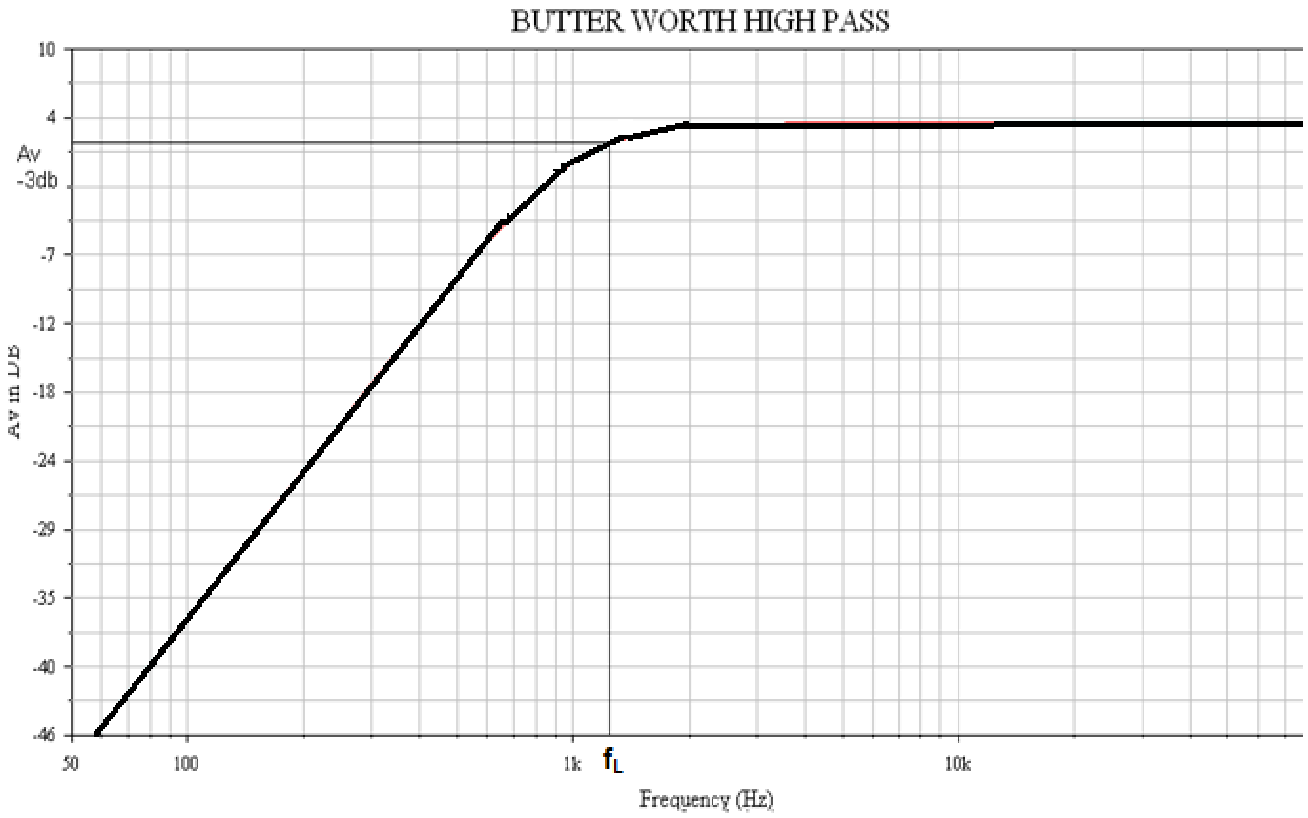



**TABLE 1:-**

| PARAMETERS | THEORETICAL VALUE | PRACTICAL VALUE |
|---|---|---|
| 1. $f_L$ =<br>2. Av =<br>3. Roll of rate = | | |

**OBSERVATIONS :-**

**Vi = 2V**

| S.NO | FREQUENCY | OUTPUT VOLTAGE ($V_O$) | Av = Vo/Vi | Av in db = 20 LOG $_{10}$ . Av |
|---|---|---|---|---|
| | | | | |

## VIVA QUESTIONS

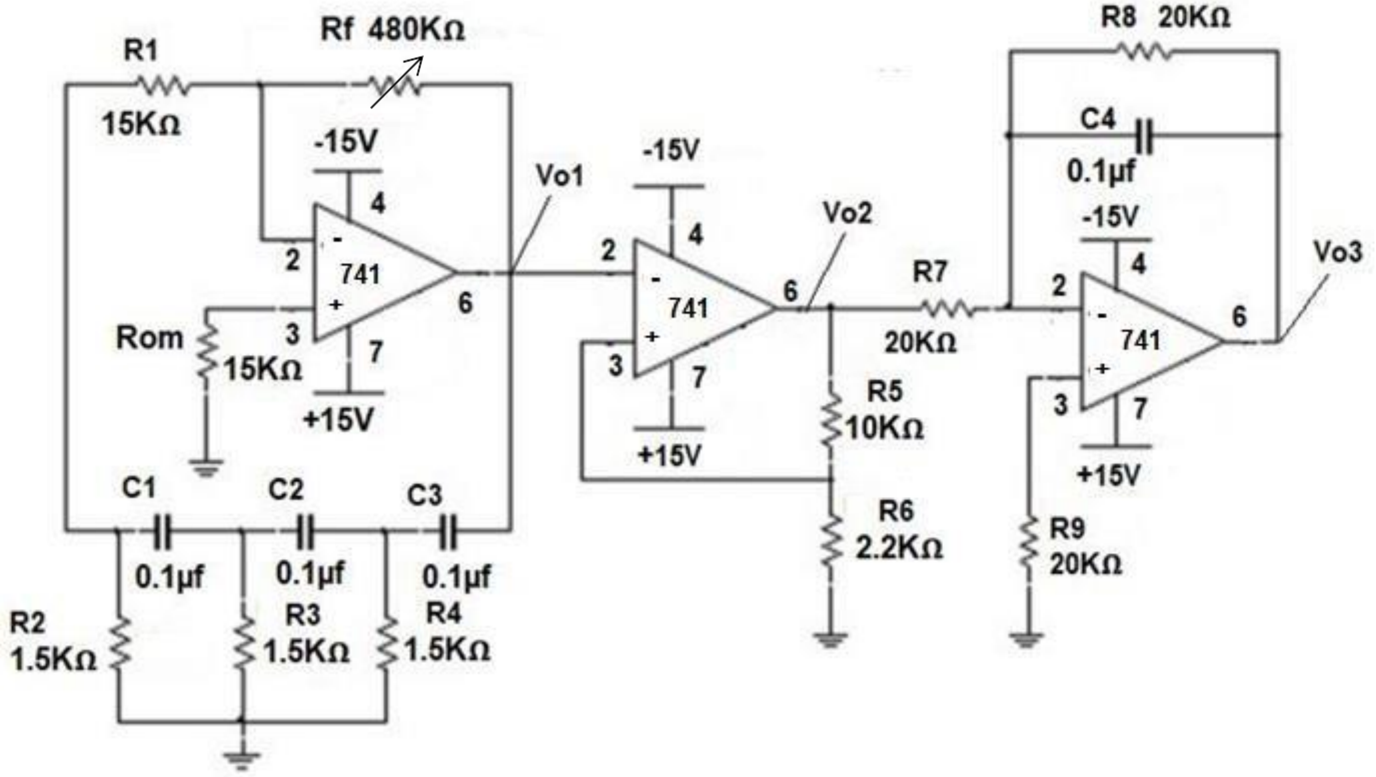
1. Why active filters are preferred.
2. Discuss the disadvantages of passive filters.
3. What is the roll-off rate of a first order filter.
4. What are the advantages of higher order filter.
5. What is a Sallen-key filter.
6. Define Bessel , Butter worth and chebyshev filters, and compare their response.
7. What is an all-pass filter.
8. What are the applications of all –pass filter.
9. List the most commonly used filters.
10. How are filters classified.

# 7.IC 741 WAVE FORM GENERATORS

**AIM:-** To study the operation of wave forms (sine,square ans triangle) generator using ic 741.

**COMPONENTS & EQUIPMENT REQUIRED :-**
IC 741 – 3 No`s , 15KΩ - 2 no`s, 480KΩ - 1no`s,1.5KΩ - 3no`s
0.1µf - 4 No`s, IC 741 - 3 no`s, 10KΩ - 1no, 2.2KΩ - 1no
20KΩ - 3 no`s, connecting wires , CRO, DRB,Regulated power supply, CRO probes ……etc

## CIRCUIT DIAGRAM:-




$$f = \frac{1}{2\pi\sqrt{6}RC}$$

**R= 1.5 kΩ, C= 0.1µF**

**PROCEDURE:-**

1. Connect the components as per the circuit diagram.
2. Observe the output wave forms at vo1 Sine wave form,vo2 Square wave form and vo3 Triangular wave form.
3. Note down amplitude and time periods of all wave forms.
4. Compare theoretical and practical frequency values.
5. Draw the output wave forms on a graph sheet.

**EXPECTED WAVE FORMS:-**

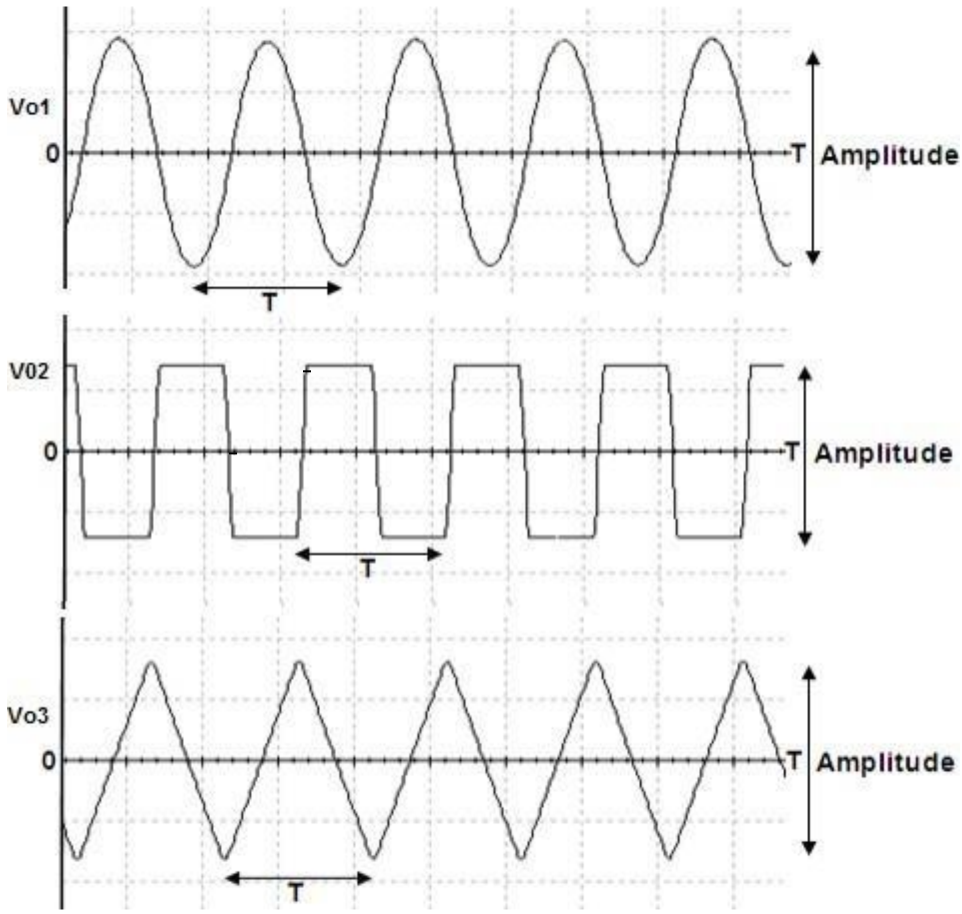



**TABLE 1:-**

| PARAMETERS | THEORETICAL VALUE | PRACTICAL VALUE |
|---|---|---|
| f = | | |

**TABLE 2:-**

| PARAMETERS | AMPLITUDE VALUE | TIME PERIOD VALUE |
|---|---|---|
| SINEWAVE AT V01 =<br>SQUAREWAVE AT V02 =<br>TRIANGULAR AT V03 = | | |

## VIVA QUESTIONS

1. Function generator uses two important circuits to generator square wave and triangular wave what are they.
2. which multivibrator is used as square wave generator.
3. Derive an expression for frequency of oscillation of astable multivibrator.
4. Which circuit is used to convert square wave in to triangular wave.
5. design a triangular wave so that fo = 2kHz and vo = 7V (pp). assume Vsat = 14V and Vcc = -+15V . using schmittrigger circuit design the above function generator circuit.
6. how the function generator is called as free- running multivibrator and why
7. write applications of function generator
8. Name the circuit that converts any input signal to square wave.
9. what is the condition for low-pass circuit to act as integrator.
10. write the expression for the frequency of function generator.

# 8. MONO-STABLE MULTIVIBRATOR USING IC 555

**AIM:-** To study the operation of monostable multivibrator using 555 timer and compare theoretical and practical results .

**COMPONENTS & EQUIPMENT REQUIRED :-**
555 Timer , $R_a$ = 1k Ω , $R_b$ = 1.2k Ω , $R_c$ = 1.8k Ω , R = 4.7k Ω , $C_1$= 0.1μF ,C = 0.1μF , $C_2$ = 0.01 μF , BC 107 transistor, Bread board, Function generator, CRO, connecting wires, Regulated power supply, CRO probes ……. etc

**FORMULA :-**

$$T_P = 1.1\,RC \qquad R = 4.7K\Omega \;\;, C = 0.1\mu F$$

**CIRCUIT DIAGRAMS:-**

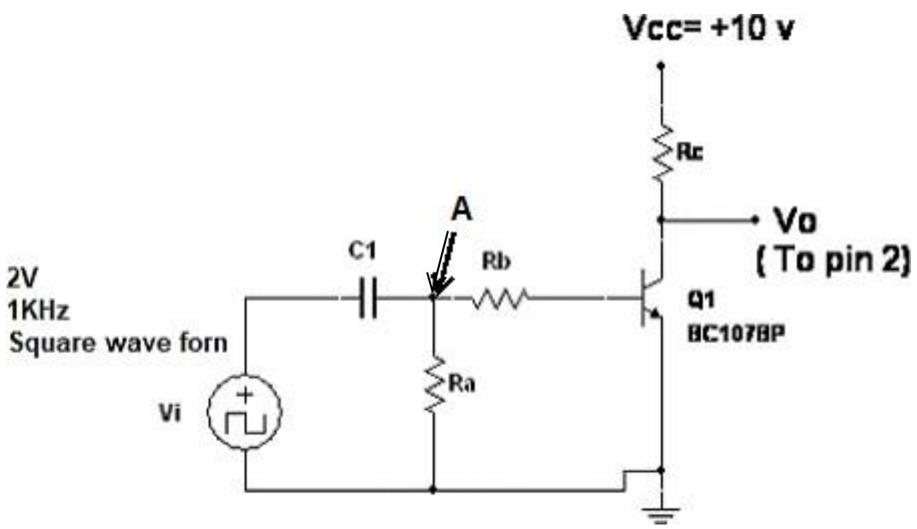



**Figure 1: Trigger circuit.**

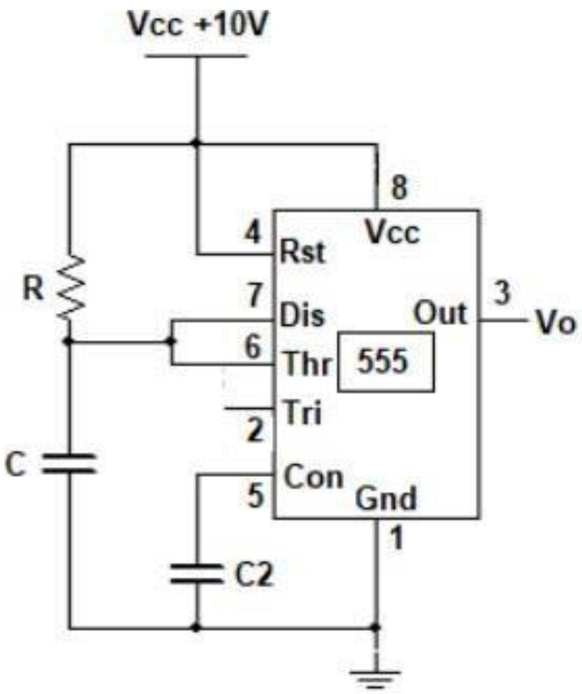
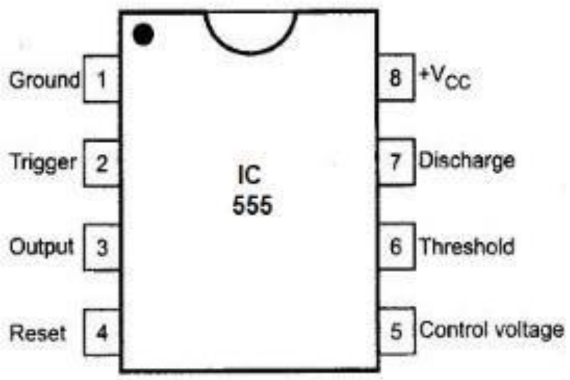



**Figure-2: Monostable multivibrator circuit**




**555 Timer pin diagram**

**PROCEDURE:-**

1. Connect the components as per the circuit diagram.
2. Observe negative going triggering pulses at the output of the trigger circuit and connect them to trigger input of IC 555.
3. Draw the output Vo at pin no. 3 and capacitor voltage at pin no. 6 on a graph sheet.
4. Measure the pulse width $T_P$ of the monostable multivibrator using CRO and compare with the theoretical value.

**EXPECTED WAVE FORMS:-**

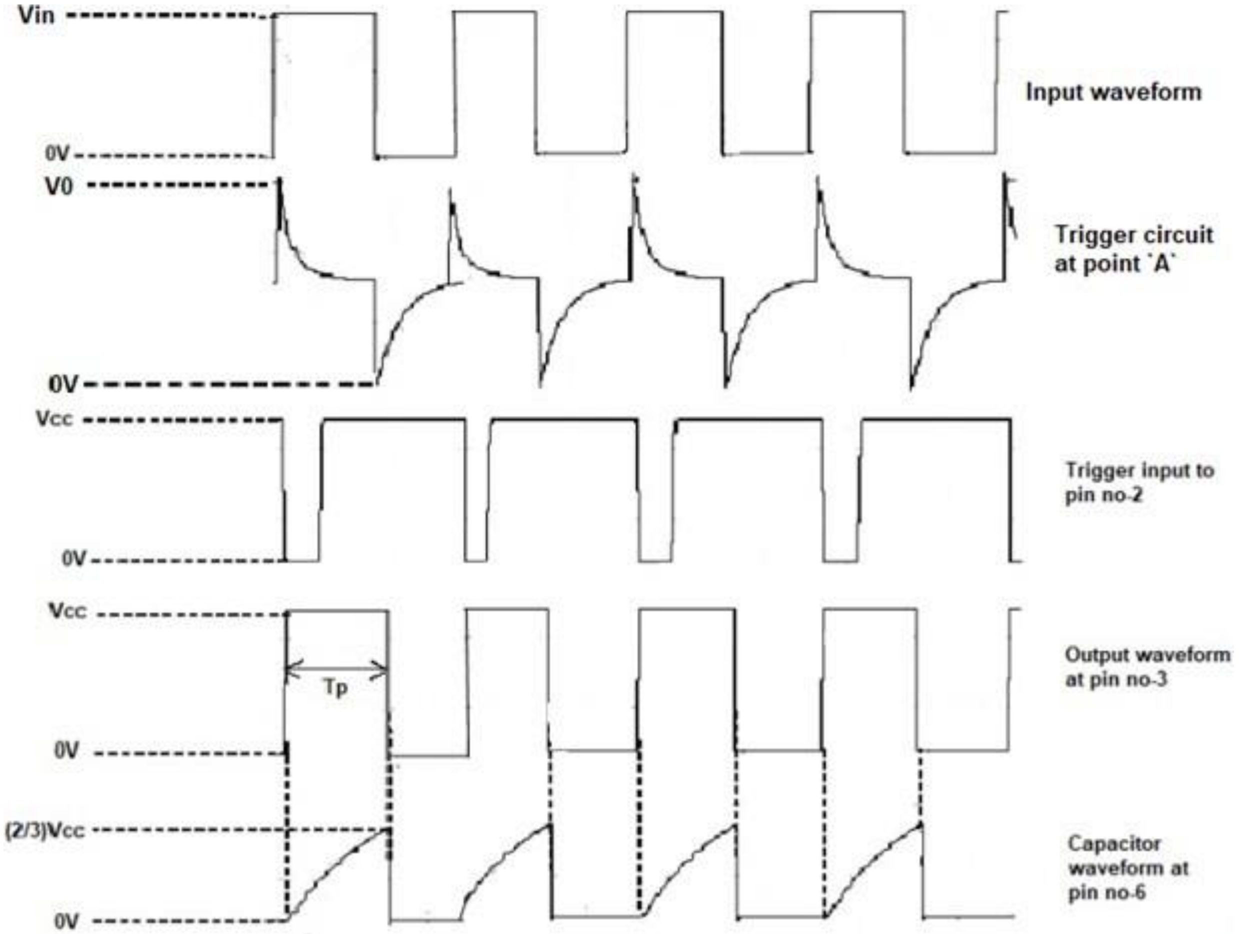



**TABLE 1:-**

| PARAMETERS | THEORETICAL VALUE | PRACTICAL VALUE |
|---|---|---|
| $T_P$ = <br> 2/3 Vcc = | | |

**TABLE 2:-**

| PARAMETERS | AMPLITUDE VALUE | TIME PERIOD VALUE |
|---|---|---|
| 1. Waveform at point A(Trigger ckt) =<br>2. Trigger circuit o/p waveform =<br>3. Output waveform at pin 3 = | | |

| PARAMETER | TIME PERIOD VALUE |
|---|---|
| 1. Spike duration = | |

## VIVA QUESTIONS

1. Discuss some application of timer in monostable mode.
2. What is the expression for pulse width of monostable multivibrator.
3. What must be the relation between pulse width tp and the period T of the input trigger signal if the 555 is to be used as a divide by for network.
4. Briefly explain the difference between the two operating modes of the 555 timer.
5. Explain the function of reset pin in 555 timer.

# 9. ASTABLE MULTIVIBRATOR USING IC 555

**AIM:-** To construct a Astable Multivibrator and observe the wave forms of a 1KHz square wave form generator using a 555 timer for duty cycle

(a) D = 62% Asymmetrical

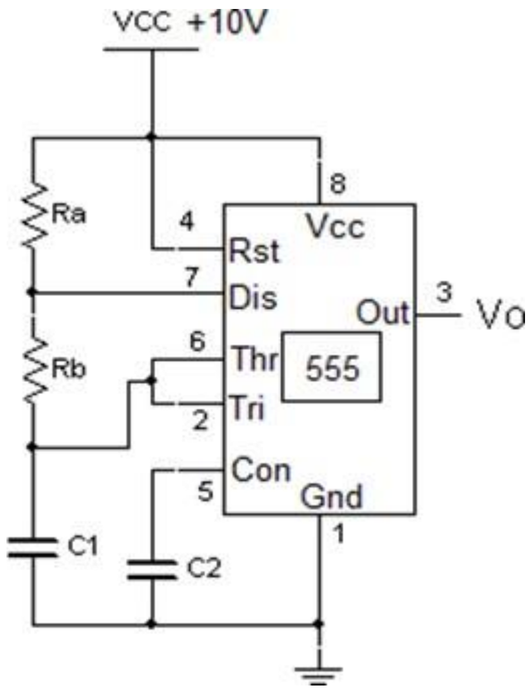
(b) D = 50%. Symmetrical

**COMPONENTS & EQUIPMENT REQUIRED :-**

(a) For 62% $R_A$ =3.9KΩ, $R_B$ =5.6KΩ, $C_1$ = 0.1μf, $C_2$ = 0.01μf.

(b) For 50% $R_A = R_B$ = 7.5 KΩ, $C_1$ = 0.1μf, and $C_2$ = 0.01μf, IC 555, Bread board, CRO, Regulated power supply, connecting wires, DRB, CRO probes ……. etc

## (A) ASYMMETRICAL CIRCUIT DIAGRAM:-




**FORMULA:-**

| ASYMMETRICAL |
|---|
| $T_{ON}$ = 0.69 (Ra+Rb)C1 |
| $T_{OFF}$ = 0.69(Rb)C1 |
| T = TON + TOFF |
| F = 1/T = 1/0.69 (Ra+2Rb)C1 |
| % Duty Cycle = $T_{ON}$/T*100 (OR) $= \frac{Ra + Rb}{Ra + 2Rb} x100$ |

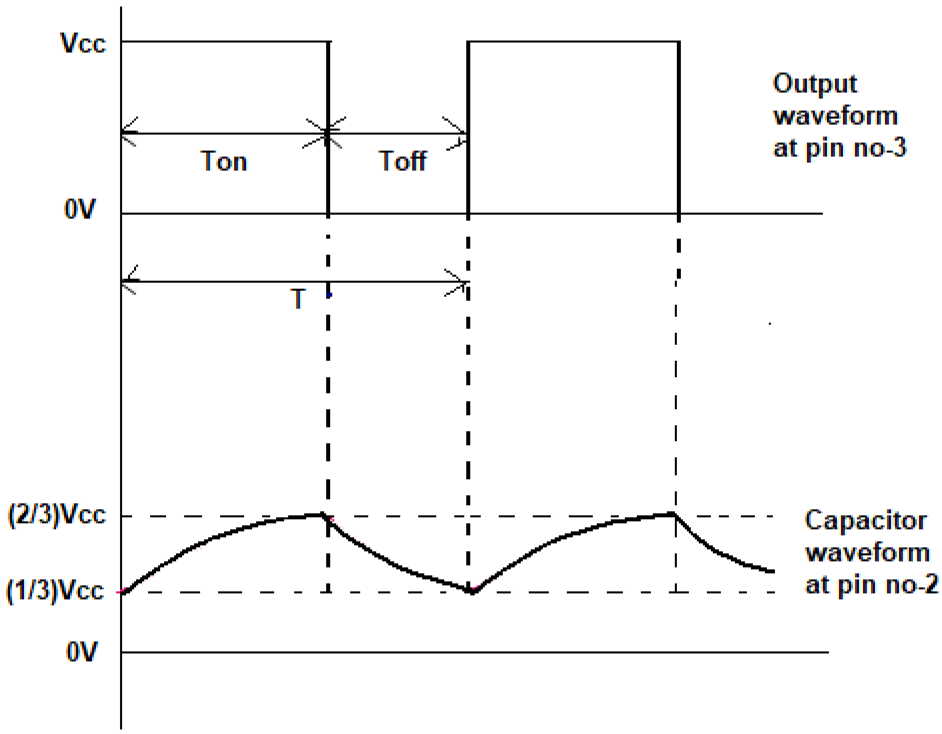
**PROCEDURE:-**

1. Connect the components as per circuit diagram using $R_A$ =3.9KΩ, $R_B$ =5.6KΩ, $C_1$ = 0.1μf And $C_2$ = 0.01μf
2. Observe and sketch the capacitor voltage wave form (pin-6) and output wave form (pin-3) measure the frequency & duty cycle of the O/P wave form.

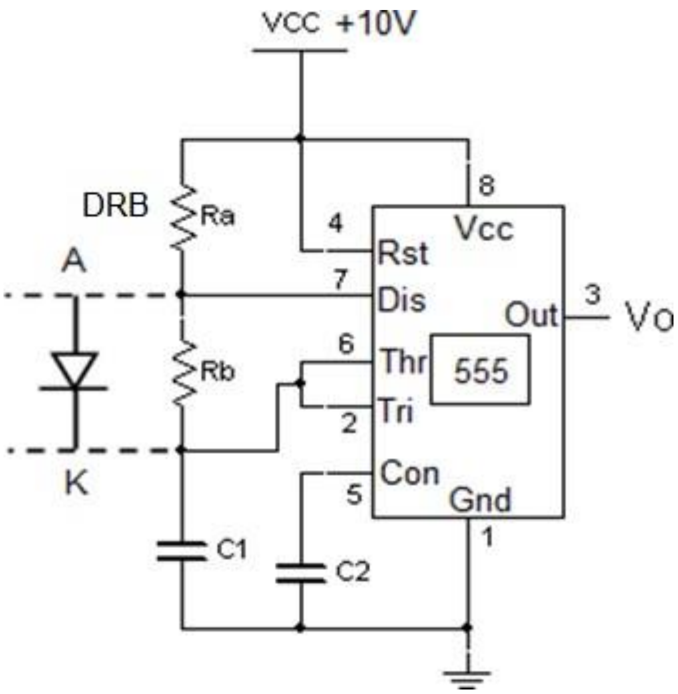
**TABLE 1:- ASYMMETRICAL**

| PARAMETERS | THEORETICAL VALUE | PRACTICAL VALUE |
|---|---|---|
| $T_{ON}$ | | |
| $T_{OFF}$ | | |
| T | | |
| F | | |
| % Duty Cycle | | |
| 2/3 Vcc | | |
| 1/3 Vcc | | |

**ASYMMETRICAL WAVE FORMS:-**



## (B) SYMMETRICAL CIRCUIT DIAGRAM:-




**FORMULA:-**

| SYMMETRICAL (Ra = Rb) |
|---|
| $T_{ON}$ = 0.69 (Ra)C1 |
| $T_{OFF}$ = 0.69(Rb)C1 |
| T = TON + TOFF |
| F = 1/T = 1/0.69 (Ra+Rb)C1 |
| % Duty Cycle = $T_{ON}$/T*100 (OR) $= \frac{Ra}{2Ra} x100$ |

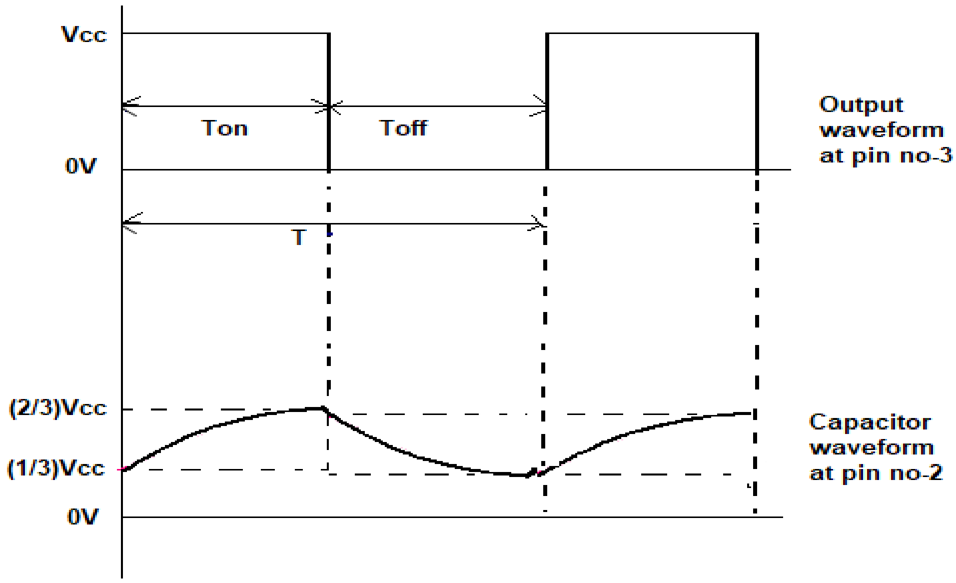
**PROCEDURE:-**

1. Connect the components as per circuit diagram, $R_A$ =DRB ,$R_B$ =7.5KΩ and connect diode across Rb
2. Observe and sketch the capacitor voltage wave form (pin-6) and output wave form (pin-3) measure the frequency & duty cycle of the O/P wave form.
3. Initially adjust the resistance box to 7.5 KΩ observe the output wave form on CRO and slowly adjust the resistance box until 50% duty cycle.

**TABLE 2:- SYMMETRICAL**

| PARAMETERS | THEORETICAL VALUE | PRACTICAL VALUE |
|---|---|---|
| $T_{ON}$ | | |
| $T_{OFF}$ | | |
| T | | |
| F | | |
| % Duty Cycle | | |
| 2/3 Vcc | | |
| 1/3 Vcc | | |

**SYMMETRICAL WAVE FORMS:-**




## VIVA QUESTIONS

1. List important features of 555 timer.
2. What are the two basic modes in which the 555 timer operates.
3. Discuss some applications of timer in astable mode.
4. Define duty cycle.
5. Write the expression for % duty cycle of astable multivibrator.
6. An astable multivibrator is also known as a.

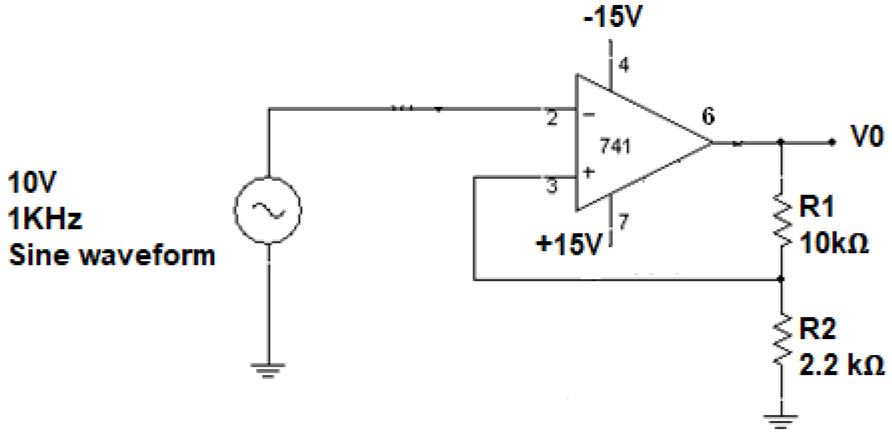
# 10. SCHMITT TRIGGER CIRCUITS – USING IC 741

**AIM:-** To design a Schmitt trigger circuit using IC 741. Draw input and output wave forms and transfer characteristic .

**COMPONENTS & EQUIPMENT REQUIRED :-**

IC 741 , $R_1$= 10kΩ , $R_2$= 2.2 kΩ, Bread board, CRO, Function generator, Regulated power supply, connecting wires, CRO probes ……. etc

**CIRCUIT DIAGRAM :-**




**FORMULAS:-**

$$UTP = \frac{R2}{R1+R2} \times (+Vsat)$$

$$LTP = \frac{R2}{R1+R2} \times (-Vsat)$$

**PROCEDURE :-**

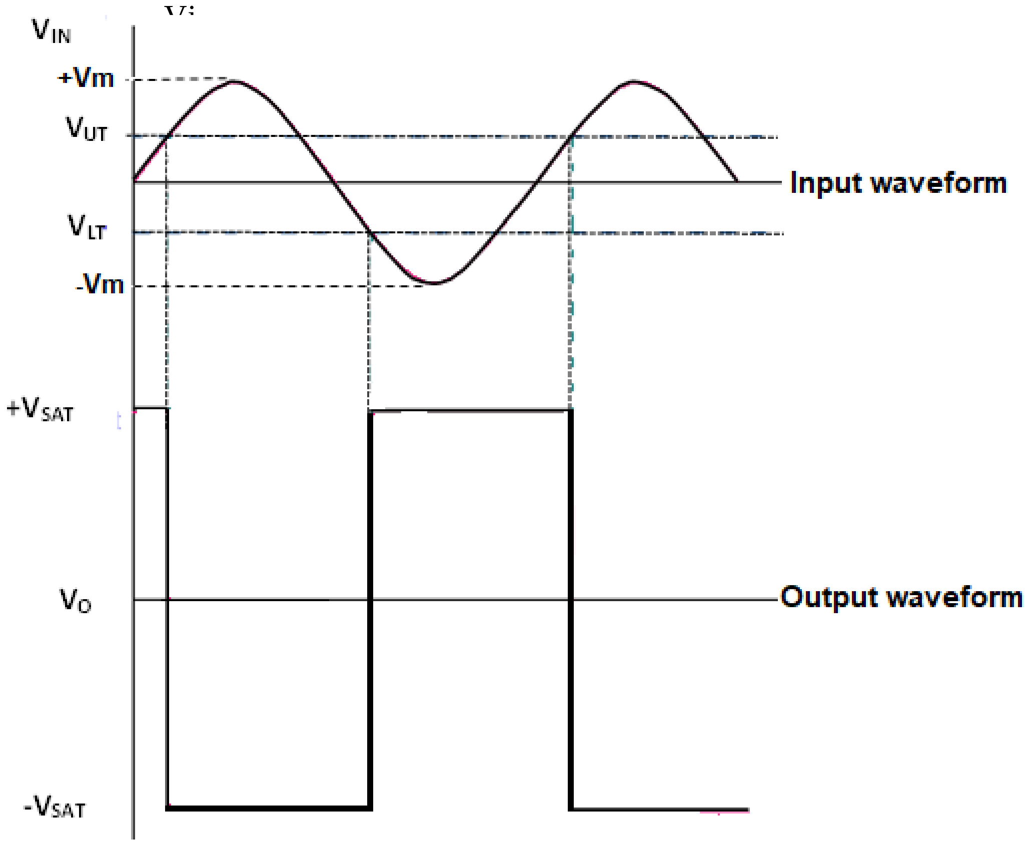
1. Connect the components as per the circuit diagram.
2. Observe the output voltage, which is at positive saturation $V_+$ initially.
3. Apply a DC input voltage and increase it from 0 v slowly, observing the output.
4. Note down the input voltage at which output transition occurs from $V_+$ to $V_-$. This isupper triggering point ( UTP ).
5. Then slowly decrease the input while observing the output . Note down the input voltage at which reverse transition occurs in the output i.e. from $V_-$. to $V_+$ . This is lower triggeringpoint (LTP ).
6. Find the hysteresis voltage which is the difference between UTP and LTP.

$$V_H = V_{UTP} -- V_{LTP}$$

7. Apply a sine wave input of 10 v at 1kHz. adjust sinewave to center point and move square wave towards sinewave of positive and negative edges and measure UTP and LTP points shown in expected waveform and compare with hysteresis values
8. Measure and sketch output and transfer characteristics.
9. From transfer characteristic measure LTP , UTP and hysteresis voltage $V_H$.

## EXPECTED WAVE FORMS:

**Input and output wave forms:**




## TRANSFER CHARACTERISTICS:-

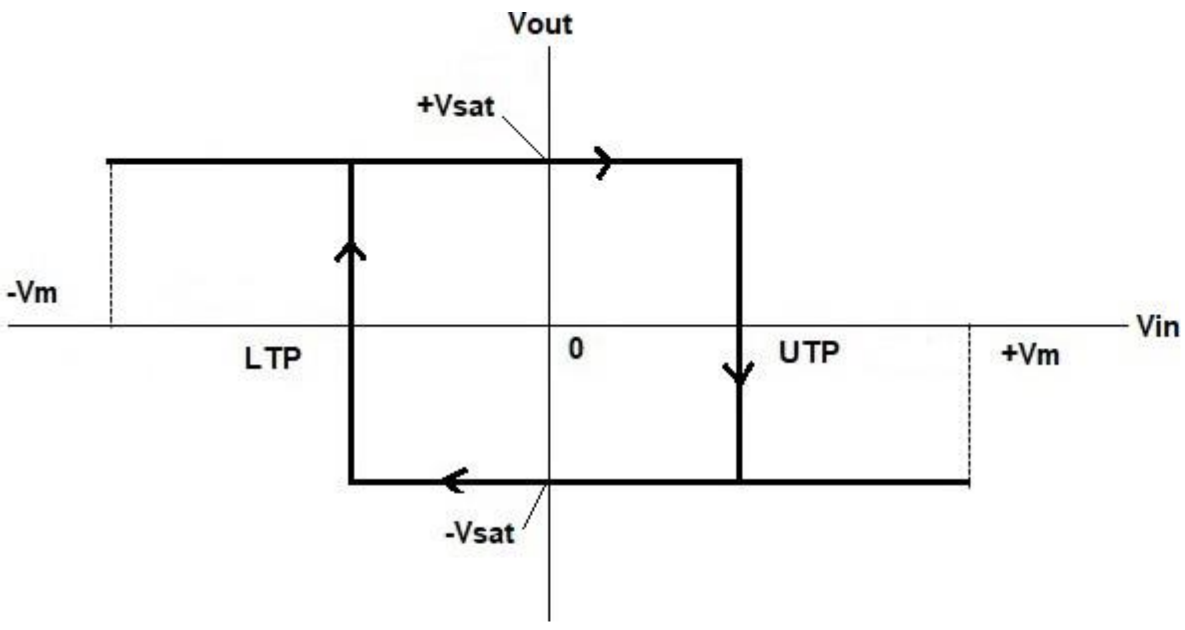


**TABLE 1:-** **using dual channels (moving vertical position nob)**

| PARAMETERS | THEORETICAL VALUE | PRACTICAL VALUE |
|---|---|---|
| $V_{UT}$ = | | |
| $V_{LT}$ = | | |
| $+V_{SAT}$ = | | |
| $-V_{SAT}$ = | | |

**TABLE 2:-** **TRANSFER CHARACTERISITICS (using XY mode)**

| PARAMETERS | THEORETICAL VALUE | PRACTICAL VALUE |
|---|---|---|
| $+V_{SAT}$ = | | |
| $-V_{SAT}$ = | | |
| UTP = | | |
| LTP = | | |

## VIVA QUESTIONS

1. Which circuit is called squaring circuit.
2. What is hysteresis.
3. How schmittrigger circuit using IC 741 is different from that using IC 555.
4. What are the applications of schmittrigger circuit.
5. What is the other name for regenerative comparator.
6. What parameters determine the hysteresis.
7. Draw the voltage characteristics of schmittrigger.
8. If triangular wave is applied to schmittrigger as input what is the output.
9. What are the different types of comparators.
10. How schmittrigger is different from comparator.

# 11. IC 565 – PLL APPLICATIONS

**AIM :-** To determine the free running frequency, lock range and capture range of a given Phase Locked Loop (PLL) circuit using IC 565.

**COMPONENTS & EQUIPMENT REQUIRED :-**

1. Phase locked loop trainer kit
2. Digital Multimeters................2 Nos.
3. Dual Trace Oscilloscope
4. Signal Generator

**THEORY :-**

Phase locked loop is a versatile electronic servo system that compares the phase and frequency of a given signal with those of an internally generated reference signal. It is used for the frequency multiplication. FM stereo detector, FM demodulator, frequency shift keying decoders, local oscillator in TV and FM tuner.

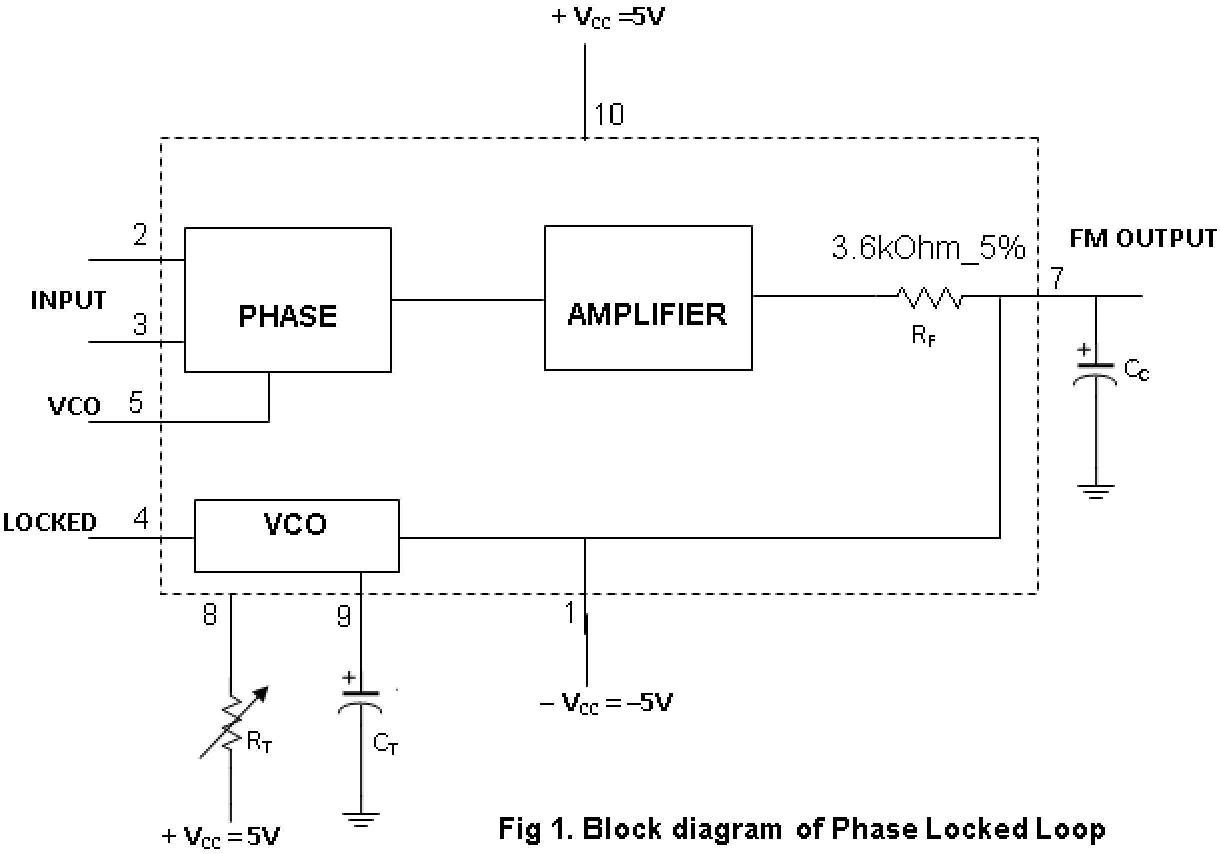



**Fig 1. Block diagram of Phase Locked Loop**

**Free running frequency:** When there is no input signal to the pin 2, PLL said to be in free running mode with its frequency determined by its circuit elements $R_t$ and $C_t$. Free running frequency is given by:

$$f_o = \frac{0.3}{R_t C_t} \qquad (1)$$

where $R_t$ is the timing resistor, $C_t$ is the timing capacitor.

**Lock Range ($f_L$):** Lock range of the PLL is the range of frequencies in which the already locked PLL will remain in lock, and this is given by: $f_L = \pm \frac{8 f_o}{V_{cc}}$ (2)

where $V_{CC}$ is the supply voltage ($+V_{CC} - (-V_{CC})$)

**Capture Range ($f_C$):** The capture range of the PLL is the range of frequencies onto which it will lock prior to being in lock. The capacitor Cc and internal resistance 3.6 KΩ from low pass RC filter to remove the original frequencies, their harmonics and the sum frequency are approximately given by:

$$f_C = \left[\pm \frac{1}{2\pi}\right] \sqrt{\frac{2\pi f_L}{3.6x10^3 xCc}} \qquad (3)$$

**CIRCUIT DIAGRAM :-**

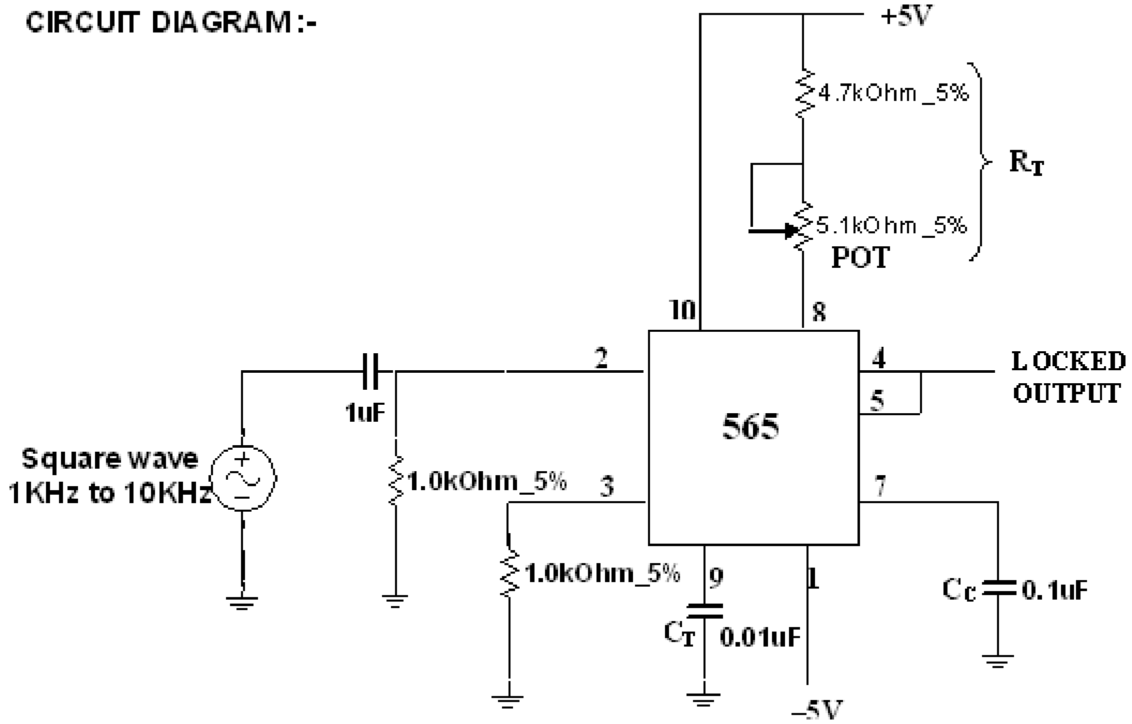



Fig 2. PLL Circuit using IC 565

**PROCEDURE :-**

1. Switch ON the trainer. Observe the output of the square wave generator using CRO and measure the frequency range using DMM. Frequency range should be around 1KHz to 10 KHz.

**Free running frequency:**

2. Calculate the free-running frequency range of the circuit for different values of timing resistor $R_t$ (To measure $R_t$ ; switch off the trainer and measure the resistance between pins 8 and 10 using DMM). Tabulate the readings and compare theoretical and practical values of $f_o$.
3. Connect 0.1μF capacitor ($C_c$) to the circuit and short the pins 4 & 5. Measure the minimum and maximum free running frequencies obtainable at the output of the PLL (Pin4) by varying the potentiometer. Compare your results with your calculations from step 3 (theoretical value). Simultaneously you can observe the output signal using CRO.

**Lock Range:**

4. Calculate the theoretical lock range of the circuit for a 5 KHz free running frequency and record in a table.
5. Connect pins 4 & 5 with the help of springs and adjust potentiometer to get free running frequency of 5 KHz. Connect square wave generator output to the input of the PLL circuit. Provide a 5KHz square signal of 1V (p-p) approximately (make this input frequency as close to the VCO frequency as possible).

6. Connect the DMMs to the i/p and o/p of the PLL (you can also connect oscilloscope simultaneously).
7. Observe the i/p and o/p frequencies while slowly increasing the frequency of the square wave at the i/p. For some range o/p and i/p are equal (this is known as locking and PLL is said to be locked with i/p signal). Record the frequency at which the PLL breaks lock (o/p frequency of the PLL will be around VCO frequency and in oscilloscope you will se a jittery wave form when it breaks lock instead of clean square wave). This frequency is called as upper end of the lock range and record this as $F_2$.

8. Beginning at 5KHz, slowly decrease the frequency at the i/p and determine the frequency at which the PLL breaks lock on the low end and record it as $F_1$.

9. Find lock range from $F_2$-$F_1$ and compare with the theoretical values obtained in step 4.

**Capture Range:**

10. Calculate the theoretical capture range of the circuit for a 5KHz free running frequency considering filter capacitor (Cc) is 0.1μF.

11. With the CRO and DMM still on pin 4, slowly increase the i/p frequency from minimum (say 1KHz). Record frequency (as $F_3$) at which the i/p and o/p frequencies of the PLL equal, this is known as lower end of the capture range.
12. Now keep i/p frequency at maximum possible (say 10KHz) and slowly reduce and record the frequency (as $F_4$) at which the i/p and o/p frequency of PLL are equal. This is known as upper end of capture range.
13. Find capture range from $F_4$-$F_3$, and compare it with the theoretical value obtained in step 10.
14. Repeat steps from 10 to 13 for Cc = 0.2μF.

**RESULTS :-**

Compare theoretical and practical results.

## VIVA QUESTIONS

1. Define capture range.
2. Define lock range.
3. Which is greater capture range or lock range.
4. List the basic building blocks of a PLL.
5. What are the applications of PLL.
6. Define pull-in-time.
7. What is the role of a LPF in PLL.
8. What is the function of VCO in PLL.
9. What is a phase –locked loop.
10. What is the major difference between digital and analog PLL`s.

# 12. VOLTAGE REGULATOR USING IC 723

**AIM :-** To study the operation of precision voltage regulator IC 723.

**COMPONENTS & EQUIPMENT REQUIRED :-**

1. Voltage regulators trainer kit ………1 No
2. Digital multimeters(DMM)................ 2 Nos.
3. DC ammeter, (0-200) mA , ...………..1 No, connecting wires ….etc

**PROCEDURE :-**

1. Connect the trainer to the mains and switch on the supply.
2. Measure the output of the regulated power supply, i.e 0 to + 40 V and 0 to – 40V using digital multimeter(DMM).

**A) Low voltage regulator using IC 723:**

1. Connect the circuit as shown in Figure 1.

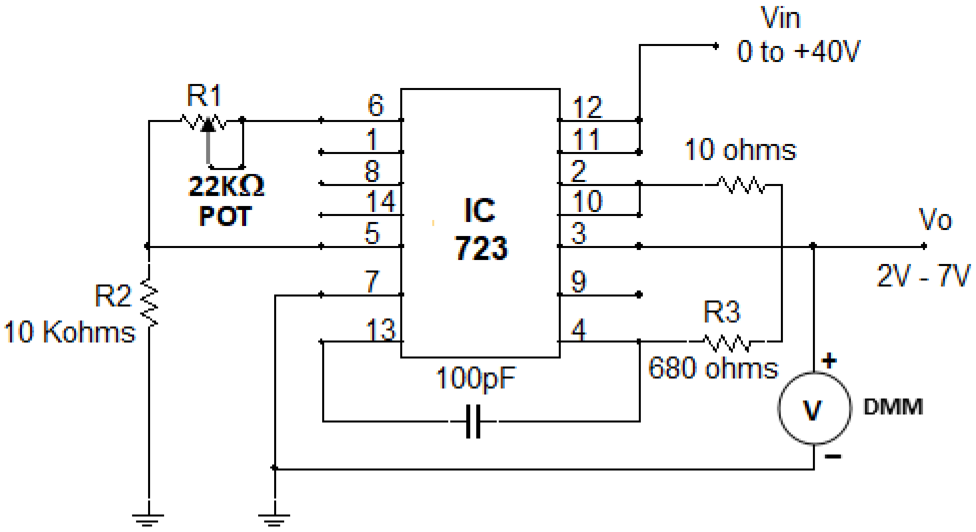



**Figure 1 : Low voltage regulator using IC723**

2. By varying $R_1$ measure the output voltage.
3. Calculate the theoretical voltage and compare it with practical value.
4. The output voltage is given by : $$\frac{V_{ref}\, R_2}{R_1 + R_2}$$

   where $V_{ref}$ is the voltage at pin 6. $R_1$ is selected value, $R_2$ is 10 KΩ.

**TABLE:-**

| $R_1$ | Vref | THEORETICAL V0 | PRACTICAL V0 |
|---|---|---|---|
| | | | |

## B) High voltage regulator using IC 723:

1. Connect the circuit as shown in Figure 2.
2. By varying $R_1$ measure the output voltage.
3. Calculate the theoretical voltage and compare it with practical value.
4. The output voltage is given by : $\dfrac{V_{ref}(R_1 + R_2)}{R_2}$

   where $V_{ref}$ is the voltage at pin 6. $R_1$ is selected value, $R_2$ is 5.1 KΩ.

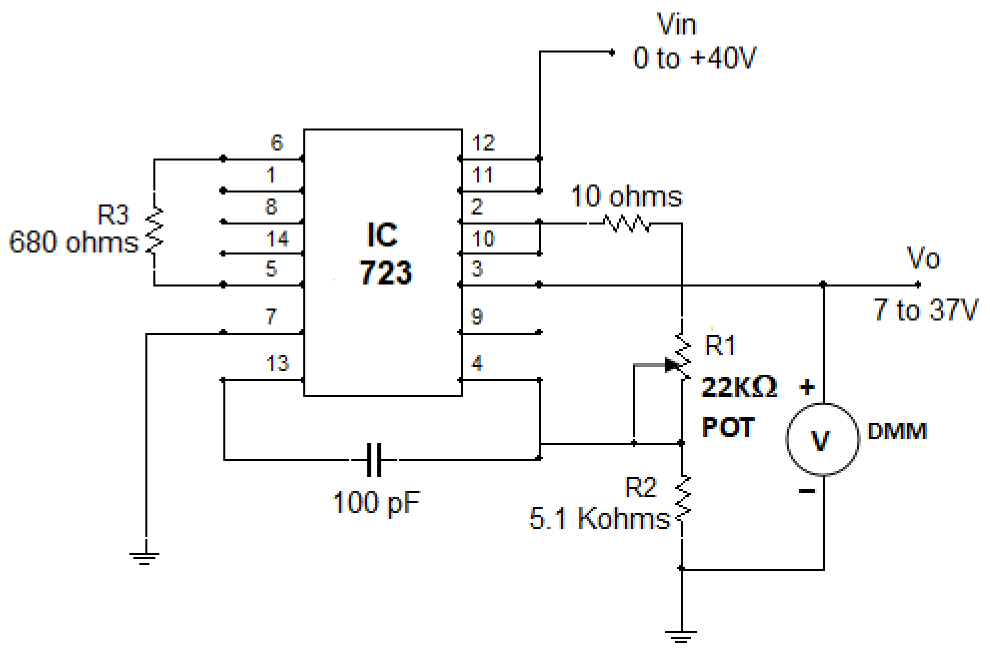



**Figure 2 : High voltage regulator using IC723**

**Table:-**

| $R_1$ | $V_{ref}$ | THEORETICAL V0 | PRACTICAL V0 |
|---|---|---|---|
| | | | |

**RESULTS :-**

1. Compare theoretical and practical results.

## VIVA QUESTIONS

1. List different types of voltage regulators.
2. What is a voltage reference? Why is it needed.
3. What are the advantages of adjustable voltage regulators over the fixed voltage regulators.
4. What are the applications of 3 terminal IC regulators.
5. What are the features of IC 723.
6. What is meant by line regulation.
7. What is meant by load regulation.
8. What is a voltage regulator.

# <u>13.THREE TERMINAL VOLTAGE REGULATORS –7805, 7809, 7912</u>

**AIM :-** To study the operation of following three terminal IC voltage regulators: 7805, 7809 and 7912.

**COMPONENTS AND EQUIPMENT REQUIRED :-**

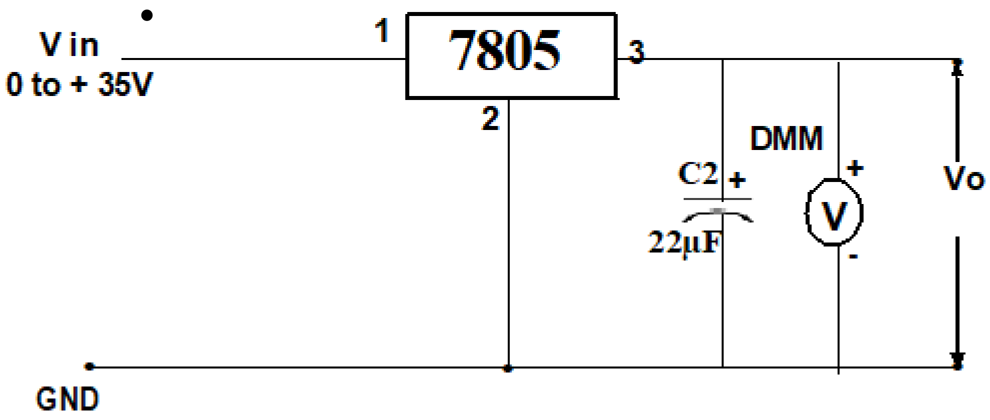
1. Voltage regulators 7805, 7809 and 7912
2. Digital multimeters(DMM) ……… 2 Nos.
3. DC ammeter, (0-200) mA, connecting wires …..etc

**PROCEDURE :-**

1. Connect the trainer to the mains and switch on the supply.
2. Measure the output of the regulated power supply, i.e 0 to + 40 V and 0 to – 40V using digital multimeter(DMM).

**1. Fixed voltage regulators: - (a) 7805(+5V)**

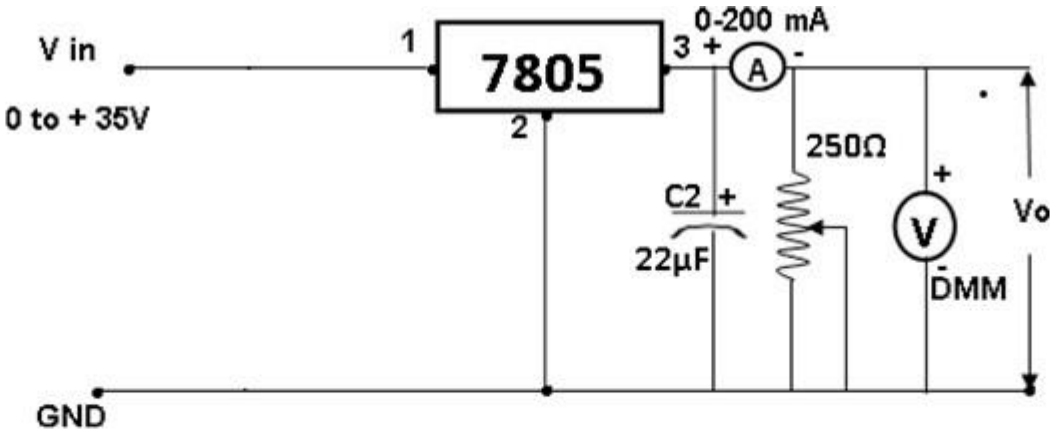
3. Connect the circuit as shown in the figure to observe the line regulation.




4. By varying $V_{in}$ supply in steps measure the corresponding output $V_o$ and record in a tabulated form as shown below.

| $V_{in}$ | $V_o$ |
|---|---|
| | |

5. Plot the graph between $V_{in}$, $V_o$ and observe the line regulation.
6. Connect the circuit as shown below to observe the load regulation.




7. Measure and record the output voltage $V_o$ (No load) i.e. at zero (0) load current.
8. By varying the load 500 Ω, 1KΩ and 2KΩ , measure the load current $I_L$, corresponding output voltage $V_o$ and record them as shown below.

| $R_L$ | $I_L$ | $V_o$ (V) | Load regulation |
|---|---|---|---|
| | | | |

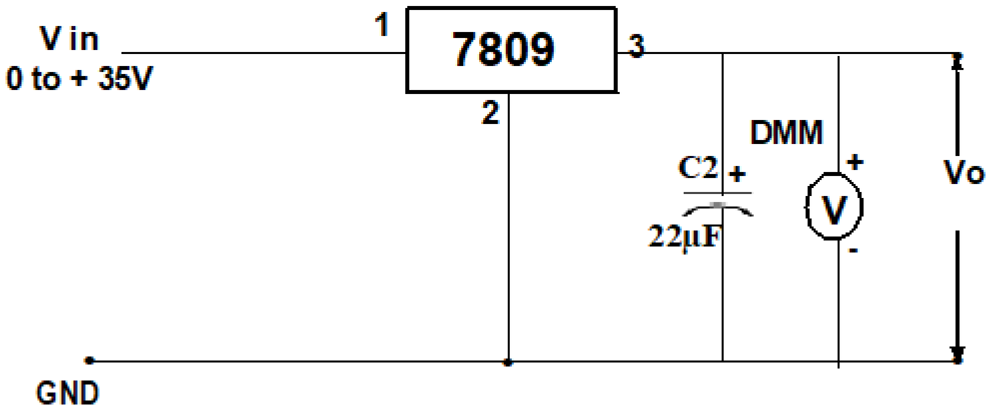
9. Calculate load regulation using

$$\frac{V_0\,(noload)-V_0}{V_0}$$

10. Plot the graph between $I_L$ on x-axis, $V_0$ on y-axis and observe the load regulation.

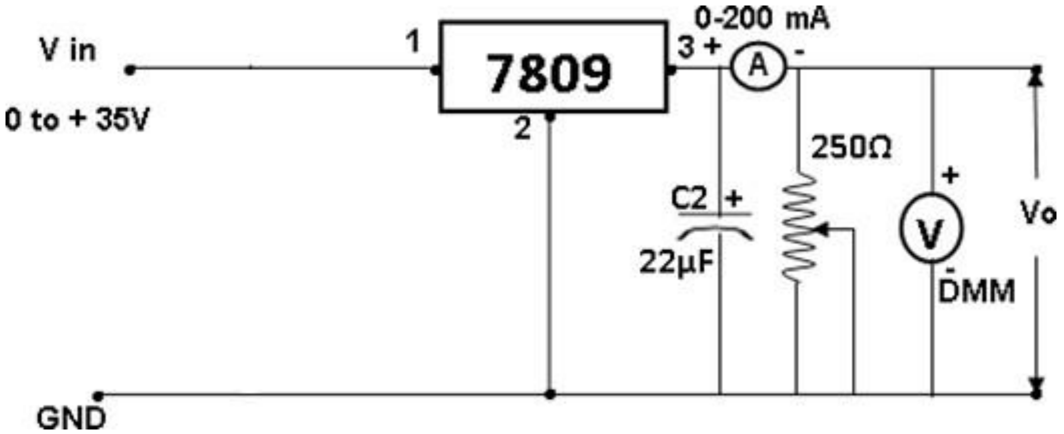
**2. Fixed voltage regulators: - (b) 7809(+9V)**

11. Connect the circuit as shown in below for the line regulation.



| $V_{in}$ | $V_o$ |
|---|---|
| | |

12. Repeat the steps 4 and 5 above for line regulation.
13. Connect circuit as shown in below for load regulation.

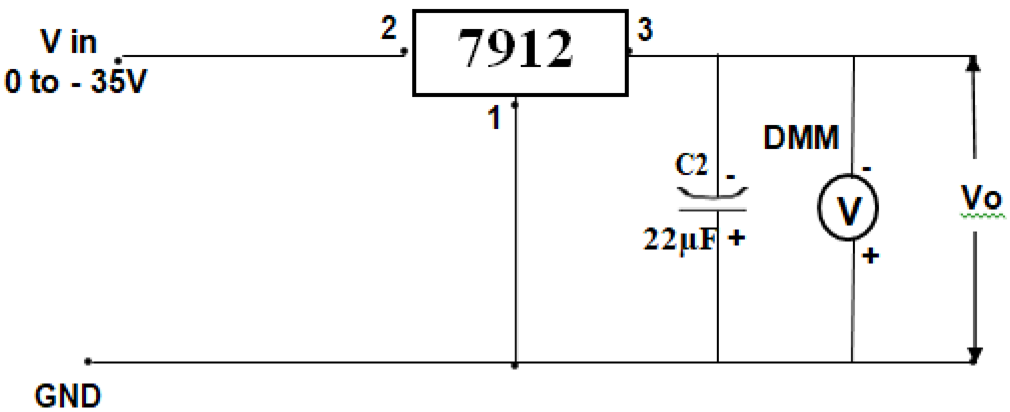



| $R_L$ | $I_L$ | $V_o$ (V) | Load regulation |
|---|---|---|---|
| | | | |

14. Repeat the above steps 7 to 10 for load regulation.

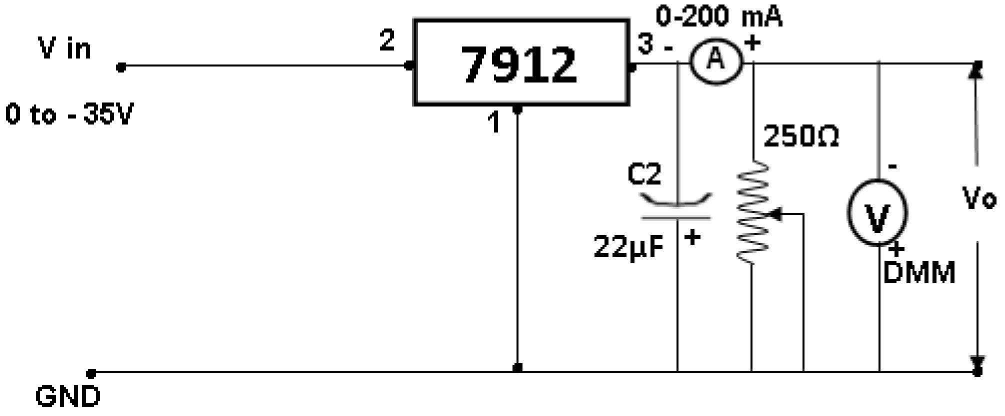
**3. Fixed voltage regulators: - (c) 7912(-12V)**

15. Connect the circuit as shown in below for the line regulation.




16. Repeat the steps 4 and 5 above for line regulation.

| $V_{in}$ | $V_o$ |
|---|---|
| | |




| $R_L$ | $I_L$ | $V_o$ (V) | Load regulation |
|---|---|---|---|
| | | | |

17. Connect circuit as shown in below for load regulation.
18. Repeat the above steps 7 to 10 for load regulation.

## VIVA QUESTIONS

1. What is the function of a voltage regulator.
2. What voltage options are available in 78XX voltage regulators.
3. What voltage options are available in 79XX voltage regulators.
4. List the characteristics of 3 terminal IC regulators.
5. What are the limitations of 3 terminal IC regulators.

# BEYOND SYLLABUS

## 14.4-BIT D/A CONVERTOR

**AIM :-** To convert 4-bit digital signal to analog signal.

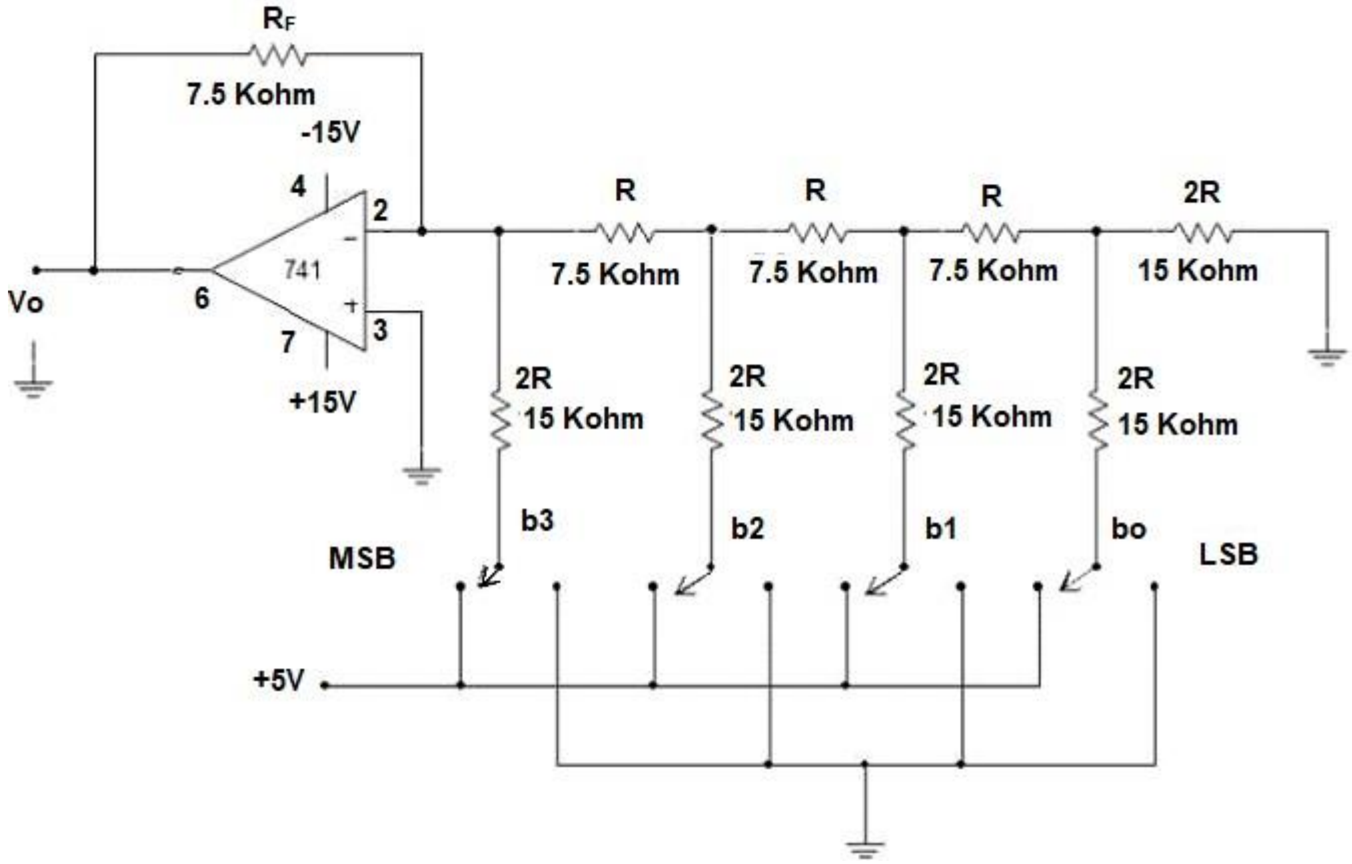
**COMPONENTS AND EQUIPMENT :-**

1. Op amp 741--1No, 7.5Kohms …4 No`s, 15Kohms ….5 No`s
2. Digital Multimeter (DMM) ……1 No
3. Connecting wires…................etc

**THEORY :-**

Digital to analog conversion is necessary in all computer application to enable the computer to communicate with or control real world analog devices. The purpose of this experiment is to introduce you to a common 4-bit digital to analog converter.

**CIRCUIT DIAGRAM :-**



**CIRCUIT DISCRIPTION :-**

For this operation Op-Amp is connected in inverting configuration. The binary inputs are simulated by switches $b_0$ through $b_3$ and the output is proportional to the binary inputs. Binary inputs can either be the high (+5V) or low (0V) state. The output voltage equation is give by.

$$V_0 = -R_f\left(\frac{b_3}{2R} + \frac{b_2}{4R} + \frac{b1}{8R} + \frac{b_0}{16R}\right)$$

In this expression $R_f$ = 7.5KΩ and R = 7.5KΩ, for example.

1. When b3 is high and all other inputs are low then the O/p voltage is

$$V_0 = -R_f\left(\frac{5}{2R} + \frac{0}{4R} + \frac{0}{8R} + \frac{0}{16R}\right)$$

$$= -7.5K\Omega\left(\frac{5}{2x7.5K\Omega}\right)$$

$$= -2.5 \text{ V}$$

2. When all inputs are in high state then O/P voltage is

$$\mathbf{V_0} = -7.5K\Omega\left(\frac{5}{2x7.5K\Omega} + \frac{5}{4x7.5K\Omega} + \frac{5}{8x7.5K\Omega} + \frac{5}{16x7.5K\Omega}\right)$$

$$= -4.657\text{V}$$

**PROCEDURE : -**

1. Study the operation of the circuit
2. Connect the circuit diagram give above and connect op amp voltages -15V to pin 4 and +15V to pin 7
3. Connect DMM at pin 6 and ground.
4. Note down the O/P voltages for different combination of digital inputs and compare it with the theoretical values.

**TABLE:-**

| SR. NO | DIGITAL INPUT | | | | THEORITICAL VALUE | ANALOG OUTPUT |
|---|---|---|---|---|---|---|
| | b3 | b2 | b1 | bo | | |
| 0 | 0 | 0 | 0 | 0 | | |
| 1 | 0 | 0 | 0 | 1 | | |
| 2 | 0 | 0 | 1 | 0 | | |
| 3 | 0 | 0 | 1 | 1 | | |
| 4 | 0 | 1 | 0 | 0 | | |
| 5 | 0 | 1 | 0 | 1 | | |
| 6 | 0 | 1 | 1 | 0 | | |
| 7 | 0 | 1 | 1 | 1 | | |
| 8 | 1 | 0 | 0 | 0 | | |
| 9 | 1 | 0 | 0 | 1 | | |
| 10 | 1 | 0 | 1 | 0 | | |
| 11 | 1 | 0 | 1 | 1 | | |
| 12 | 1 | 1 | 0 | 0 | | |
| 13 | 1 | 1 | 0 | 1 | | |
| 14 | 1 | 1 | 1 | 0 | | |
| 15 | 1 | 1 | 1 | 1 | | |

**RESULTS : -**

We observed that the theoretical and practical values at analog output voltage by the given digital inputs.

## VIVA QUESTIONS

1. Name the essential parts of a DAC.
2. How many resistors are required in an 8-bit weighted resistor DAC.
3. Classify DAC on the basis of their output.
4. Why is an inverter R-2R ladder network DAC better than R-2R ladder DAC.
5. Define resolution of DAC.
6. Define linearity of DAC.
7. How many levels are possible in a 2-bit DAC.
8. What is the resolution if the output range is 0 to 3V in a 2-bit DAC.
9. What is the difference between A/D and D/A converter.
10. What are the applications of DAC.

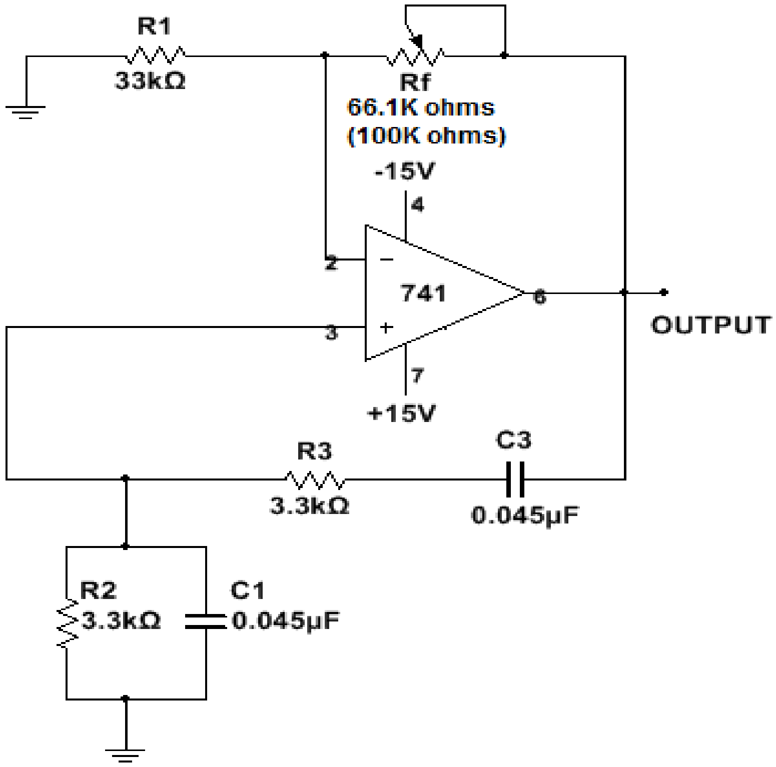
## 15.WIEN BRIDGE OSCILLATOR

**AIM:-** To design a wien bridge oscillator for f=1KHz and study its operation.

**COMPONENTS & EQUIPMENTS REQUIRED :-**

1. Resistors - 33kΩ -1 No, 3.3kΩ 2 No`s, 100kΩ -pot 1No
2. capacitors – 0.045µF – 2 No`s
3. Op-amp IC 741
5. CRO , Regulated power supply, CRO probes.
6. connecting wires................etc

**CIRCUIT DIAGRAM :-**




**THEORETICAL FORMULA:-**

$$f = \frac{1}{2\pi RC}$$

**PROCEDURE : -**

1. Connect the circuit as per diagram.
2. Observe the output wave form at pin 6.
3. Calculate frequency of the output wave form.
4. Compare theoretical and practical frequencies.

**RESULT:-** Designed and studied of wien bridge oscillator and compared theoretical and practical values

## VIVA QUESTIONS

1. What is the phase shift produced by wien bridge oscillator?
2. Classify oscillator?
3. What is the practical gain criterion for wien bridge oscillators?
4. In wien bridge oscillators which op-amp configuration is used?
5. What are the factors that effect the frequency stability in oscillators?
6. State barkhausen criteria for oscillator?

## 16.3-BIT A/D CONVERTER

**AIM : -** To study the operation of the 3-bit simultaneous A/D converter.

**COMPONENTS AND EQUIPMENT REQUIRED :-**

1. A/D converter trainer kit
2. Digital multimeter (DMM)

**THEORY :-**

The simultaneous method of A/D conversion is based on the use of a number of comparator circuits. One such system using seven comparators is shown in Figure 1. The analog signal to be digitized serves as one of the inputs to each comparator. The second input is a standard reference voltage. The reference voltages used are +V/8, +V/4, +3V/8, +V/2, +5V/8, +3V/4 and +7V/8.The system is the capable of accepting an analog input voltages between 0 and +5V. When the analog input signal exceeds the reference voltage to any comparator, that comparator turns on (output of the comparator goes high). The number of comparators required is equal $2^n - 1$, for an n-bit digital output.

$$1 \text{ LSB value} = \frac{V_{cc}}{2^n} = \frac{5}{2^3} = \frac{5}{8} = 0.625\text{V, where n= 3 (for a 3-bit converter)}$$

$$\text{Output} = \frac{Input Voltage}{1 LSB\ Value}$$

**Case 1:** If input voltage $\mathbf{V_a = 1V}$

$$\text{Output} = \frac{1}{0.625}$$

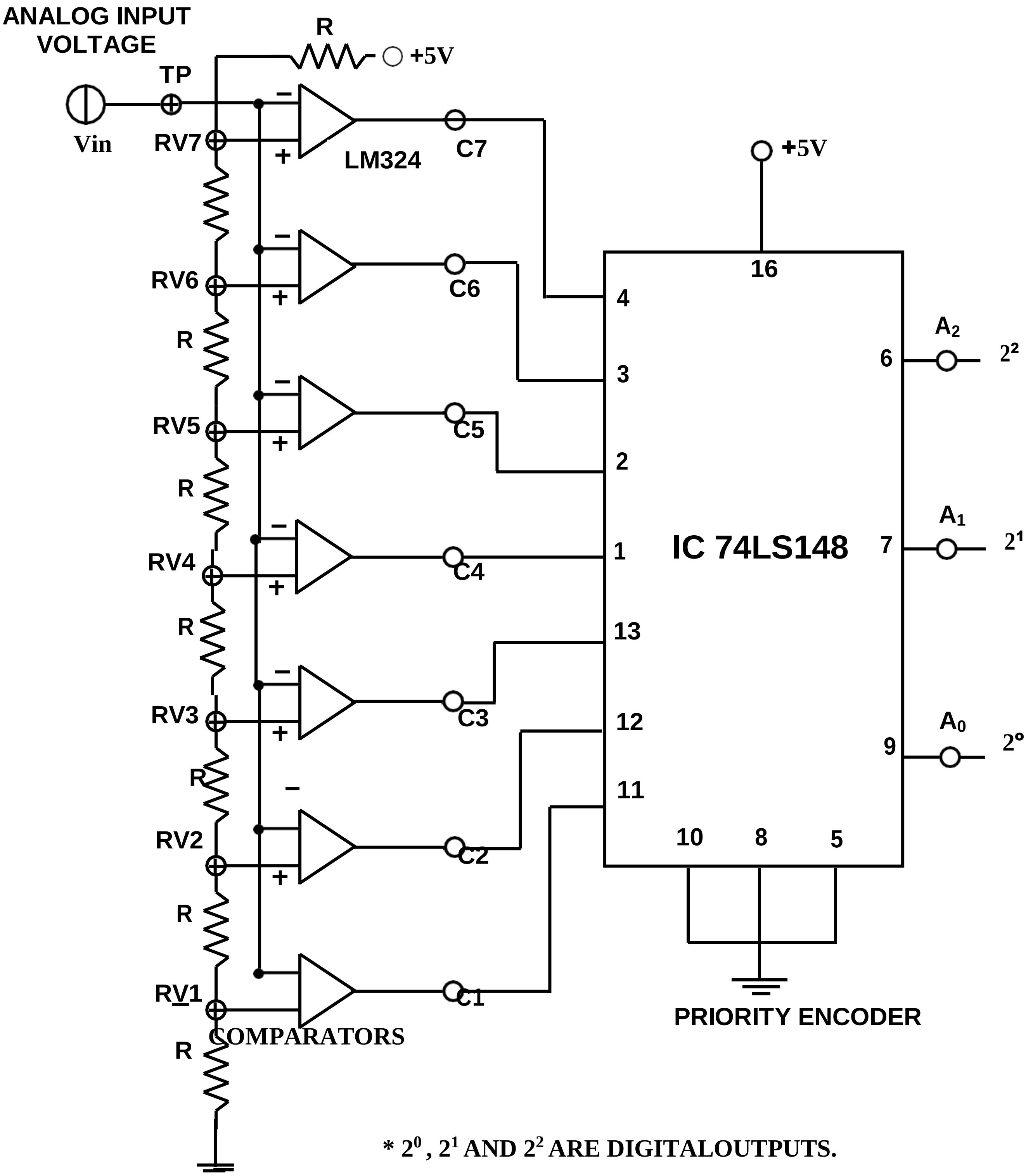
$= (1.6)_{10}$
$= (1)_{16}$
$\mathbf{= (001)_2}$

**Case 2:** If input voltage $\mathbf{V_a = 5V}$

$$\text{Output} = \frac{5}{0.652}$$

$= (8)_{10}$
$= (8)_{16}$
$\mathbf{= (111)_2}$

## CIRCUIT DIAGRAM :-




* $2^0$ , $2^1$ AND $2^2$ ARE DIGITALOUTPUTS.

Figure 1. 3-bit simultaneous A/D converter

**TRUTH TABLE :-**

| Analog Input Voltage | Comparator Outputs | | | | | | | Digital Output | | |
|---|---|---|---|---|---|---|---|---|---|---|
| V= 5V | $C_1$ | $C_2$ | $C_3$ | $C_4$ | $C_5$ | $C_6$ | $C_7$ | $2^2$ | $2^1$ | $2^0$ |
| 0 to V/8 | Low | Low | Low | Low | Low | Low | Low | 0 | 0 | 0 |
| V/8 to V/4 | High | Low | Low | Low | Low | Low | Low | 0 | 0 | 1 |
| V/4 to 3V/8 | High | High | Low | Low | Low | Low | Low | 0 | 1 | 0 |
| 3V/8 to V/2 | High | High | High | Low | Low | Low | Low | 0 | 1 | 1 |
| V/2 to 5V/8 | High | High | High | High | Low | Low | Low | 1 | 0 | 0 |
| 5V/8 to 3V/4 | High | High | High | High | High | Low | Low | 1 | 0 | 1 |
| 3V/4 to 7V/8 | High | High | High | High | High | High | Low | 1 | 1 | 0 |
| 7V/8 to V | High | High | High | High | High | High | High | 1 | 1 | 1 |

**PROCEDURE :-**

1. Connect the circuit as shown in circuit diagram.
2. Vary the analog input voltage between 0-5V and verify the above truth table.

**RESULTS :-**

Compare the theoretical and practical values of the analog voltage at the transitions from one digital output to the another.

$$\frac{fb/fa}{2}$$