SIDDHARTHA INSTITUTE OF TECHNOLOGY & SCIENCES

IC APPLICATIONS LAB

DEPARTMENT OF

ELECTRONICS AND COMMUNICATION ENGINEERING

LINEAR IC EXPERIMENTS
INTRODUCTION

Basic Components:

1] Resistor: The *resistor* is a passive electrical component which creates resistance in the flow of electric current.

2] Capacitor: *Capacitor* is an electronic component that stores electric charge. It allows AC signal and Blocks DC signal.

3] Inductor: An *inductor* is a passive electronic component that stores energy in the form of a magnetic field
.

4] Diode: A semiconductor device with two terminals as Anode and Cathode, typically allowing the flow of current in one direction only.

5] Transistor: A semiconductor device with three terminals(Base,Emitter,Collector) generally used for amplifying the signals.

Instruments:

1]Bread Board: A **breadboard** is a solder less device for temporary prototype connections using **electronic components** based on **circuit** designs. Most **electronic** components in **electronic circuits** can be interconnected by inserting their leads or terminals into the holes and then making connections through wires where appropriate.

2]Multimeter: A **multimeter** or a multitester, also known as a VOM (volt-ohm-milliammeter), is an **electronic** measuring instrument that combines several measurement functions in one unit. A typical **multimeter** can measure voltage, current, and resistance.

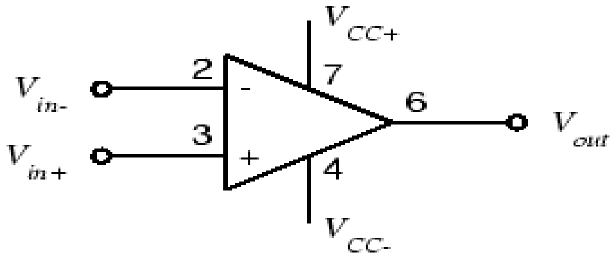
3] Regulated Power Supply: A **regulated power supply** is an electronic circuit which converts unregulated AC into a constant DC. With the help of a rectifier it converts AC **supply** into DC. Its function is to **supply** a stable voltage, to a circuit or device that must be operated within certain **power supply** limits.

4] Function generator:A **function generator** is a electronic equipment used to generate different types of electrical waveforms over a wide range of frequencies. Some of the most common waveforms produced by the **function generator** are the sine, square, triangular and sawtooth shapes.

5] CRO (Cathode ray oscilloscope): An oscilloscope, previously called an oscillograph, and informally known as a scope, **CRO** (for **cathode-ray oscilloscope**), is a type of electronic test instrument that allows observation of constantly varying signal voltages, usually as a two-dimensional plot of one or more signals as a function of time.

<u>OP-AMP:</u>

An operational **amplifier** (often **op-amp** or **opamp**) is a DC-coupled high-gain electronic voltage **amplifier** with a differential input and, usually, a single-ended output.
The basic circuit diagram of OP-AMP as shown below.



Where Vin- = Inverting input
Vin+ = Non inverting input
Vcc+= Positive power supply
Vcc-= Negative power supply. It is also denoted as Vee
Vout= Out put

Ideal Characteristics of op-amp:

Parameter	Symbol	Ideal op-amp
Open loop voltage gain	AOL	∞
Output impedance	Zout	0
Input impedance	Zin	∞
Input offset current	Iios	0
Input offset voltage	Vios	0
Bandwidth	B.W	∞
CMMR	P	
Slew Rate	S	∞
Input bias current	Ib	0
PSRR	PSRR	0

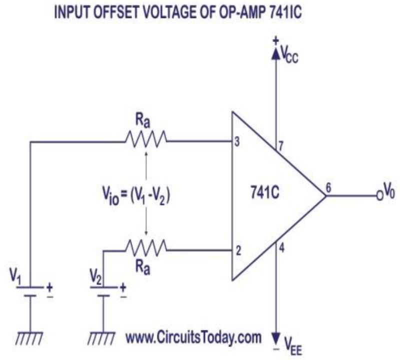
IC741 OP-AMP

The most common op-amp is the 741 and it is used in many circuits. The op-amp is a linear amplifier with an amazing variety of uses. Its main purpose is to amplify a week signal. The 741 IC op-amp looks like a chip and it is a general purpose op amp. The 741IC op amp consists of 8 pins. The most important pins are pin-2, pin-3 and pin-6 because pin 2 and 3 represent inverting and non-inverting terminals where pin6 represents voltage out.

BASIC SPECIFICATION OF IC 741 OP-AMP

1. Input Offset Voltage

Input offset voltage is the voltage that is applied between the two input terminals of the op-amp to null the output. The figure is show below.



Input Offset Voltage Of Op-amp 741 IC

In the figure V1 and V2 are the input dc voltages are Ra represents the resistance applied. The input offset voltage Vio could have a positive value or a negative value. Therefore, its absolute value is listed in the datasheet. It is always better to have smaller values of input offset voltage and this indicates that the input terminal are matched better. Lowest values are 15uV for an ideal precison op-amp and the maximum value if 6mV dc.

2. Input Offset Current

Input Offset Current is the algebraic difference between the currents into the inverting and non-inverting terminals.

Input Offset Current, Iio = |Ib1 – Ib2|

Ib1 – Non-inverting input current

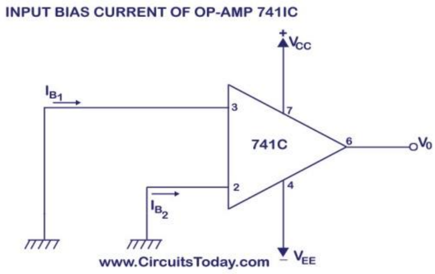
Ib2 – Inverting input current

The maximum input offset current value for 741 IC is 200nA. This value decreases as the matching between the two input terminals is improved and may reduce down to almost 6nA.

3. Input Bis Current

Input bias current is the average value of the inverting and non-inverting current.

Input Bias Current, Ib = (Ib1 + Ib2)/2



Input Bias Current of op-amp 741IC

Maximum input bias current is 500nA and minimum value is ±7nA.

4. Differential Input Resistance

Differential Input Resistance is the equivalent resistance that is measured from any one of the input terminals by keeping the other terminal connected to ground. The value for 741 IC may go as high as 2megaohms.

5. Input Capacitance

Input Capacitance is the equivalent capacitance that us measured from any one of the input terminals by keeping the other terminal connected to ground. The typical value for 741 IC is 1.4pF.

6. Offset Voltage Adjustment Range

The op-amp has pins 1 and 5 marked as offset null to determine the offset voltage adjustment range. This can be found out by connecting a 10K POT between the pin 1 (negative offset null) and pin 5 (positive offset null) and the wiper of the port should be connected to the ground. By changing the POT value, the output offset voltage can be reduced to 0V. The range through which the POT is varied to get the input offset voltage is the offset voltage adjustment range. For a 741 IC, typical value is ±15mV.

7. Input Voltage Range

The same voltage when applied to both the input terminals of the 741 IC, is called the common mode voltage and the op-amp is said to have a common mode configuration. The input voltage rage for a 741 IC is ±13V. This indicate that the common mode voltage for a 741 IC can be as high as +13V and as low as -13V without disturbing the proper working of the IC. It can also be said that the input voltage range is the range of common mode voltages over which the offset voltages apply. This method is usually carried out to know the degree of matching between the inverting and non-inverting terminals.

8. Common Mode Rejection Ratio (CMRR)

CMRR is the ratio of the differential voltage gain to the common mode voltage gain.

CMRR = Differential Voltage Gain (Ad)/ Common Mode Voltage Gain (Acm)

If the value of CMRR is high, there is better matching between the 2 input terminals. For 741IC, CMRR is 90dB.

9. Supply Voltage Rejection Ratio (SVRR)

The change in the op-amp's offset voltage caused by variations in supply voltage is called SVRR. The change in supply voltage can be denoted by dV and the corresponsing change in input offset voltage can be denoted by dVio.

SVRR = Change in input offset voltage (dVio) / Change in supply voltage (dV)

For 741 IC, SVRR = 150uV/V.

The lower the value of SVRR, the better will be the op-amp performance.

10. Large Signal Voltage Gain

Large signal voltage gain is the ratio between the output voltage and the voltage difference between the two input terminals.

Voltage Gain, A = Output Voltage (Vo)/ Differential output voltage (Vid)

Typical values of large signal voltage gain for 741 IC is 200,000.

11. Output Voltage Swing

The output voltage swing of the 741 IC is a 26 volt peak-to-peak undisturbed as sine wave for ac input signals (that is a value between +13V and -13V), for a load resistance value greater than or equal to 2kiloohms. This range shows the values of positive and negative saturation voltages of op-amp. The op-amp voltage swing value will not be greater than the supply voltage +VCC and -VEE

12. Output Resistance

Output Resistance is the equivalent resistance that is measured between the output terminal (Pin 6) and Ground. Typial values of output resistance of 741 IC is 75ohms.

13. Output Short Circuit Current

The op-amp has a short circuit protection built in for a certain ancient value. For 741 IC, this value is 25mA. But, for a higher current the IC will fail. Nobody would knowingly connect the output of the op-amp to the ground. But if something like that is done accidentally, the current flowing through will have a high value. This is why short circuit protection is provided. For currents higher than 25mA, external short circuit protection must be provided for 741 IC.

14. Supply Current

The supply current is the current drawn by the 741 IC from the power supply. Typical value of supply for 741 IC is 2.8mA.

15. Power Consumption

For the 741 IC to operate properly, a certain amount of quiescent power must be consumed by the op-amp. This power is called power consumption and typical value is 85mW.

16. Transient Response

Transient response is a very important factor that is used for selecting an op-amp in ac applications. Transient response along with steady state response constitutes that total response of a practical network to a given input. The response portion where a fixed value is attained right before the output is called transient response. Once reached, this fixed value remains at that level and is thus called the steady state. The steady state response does not depend on time and transient response is time invariant. Characteristics of transient response include rise time and percent of overshoot. Transient response is inversely proportional to the unity gain bandwidth of op-amp. The bandwidth will be high when the value of rise time is low.

17. Slew Rate (SR)

Slew Rate is one of the most important parameters for selecting op-amps for high frequencies. SR is the maximum rate of change of output voltage per unit of time and is expressed in volts per microseconds.

Slew Rate, SR = dVo/dt

By calculating slew rate we can easily find out the rate in which the output of the op-amp changes in response to changes in the input frequency. The slew rate changes with change in voltage gain and is usually specified at unity gain. The slew rate of an op-amp is always fixed. Hence, if the slope requirements of the output signals are greater than the slew rate, then distortion occurs.In the case of the 741 IC the slew rate is 0.5V/uS, which is very small. This is one reason why the 741 IC is considered not suitable for high frequency applications, such as oscillators, comparators, and filters

<u>IC741 PIN DIAGRAM AND PIN DISCRIPTION:</u>

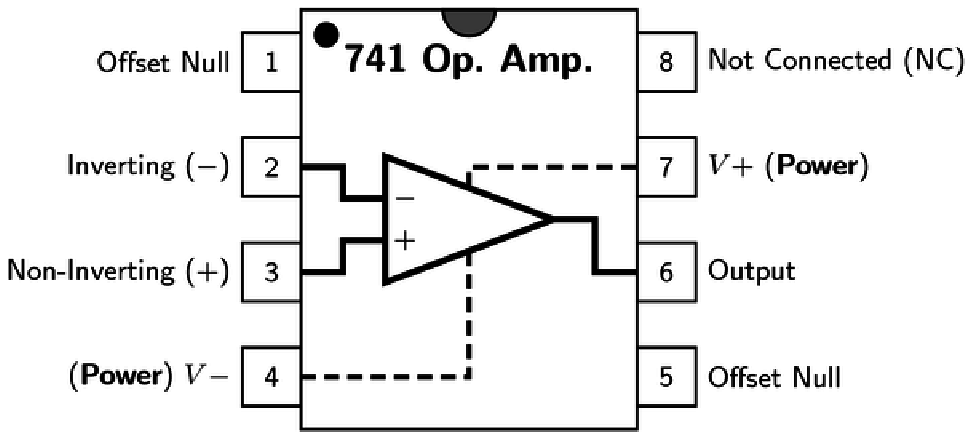


FIG:IC741 PIN DIAGRAM

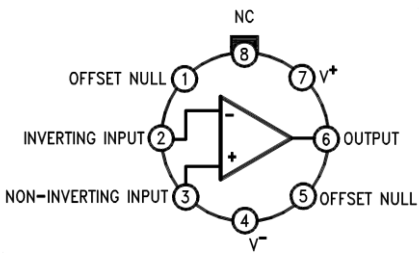


FIG:8 PIN METAL CAN PACKAGE

PIN DESCRIPTION:

PINS		INPT/OUT PUT	DESCRIPTION
NAME	**NO**		
Inverting Input	2	I	Inverting Input Signal
Nc	8	NA	No Connect, Should Be Left Floating
Non Inverting Input	3	I	Non Inverting Input Signal
Offset Null	1,5	I	Offset null pin used to eliminate the offset voltage and balance the input voltages
Output	6	O	Amplified signal output
V+	7	I	Positive supply voltage
V-	4	I	Negative supply voltage

PARAMETERS OF 741 OP-AMP:

Parameter	Symbol	Ic741
Open loop voltage gain	AOL	2×10^5
Output impedance	Zout	75MΩ
Input impedance	Zin	2 MΩ
Input offset current	Iios	200A
Input offset voltage	Vios	1mv
Bandwidth	B.W	1MHz
CMMR	P	90db
Slew Rate	S	0.5v/µsec
Input bias current	Ib	80nA
PSRR	PSRR	30µv/v

EXPERIMENT: 1
INVERTING AMPLIFIER USING OP-AMP

AIM:

To design an Inverting Amplifier for the given specifications using Op-Amp IC 741.

APPARATUS REQUIRED:

S.No	Name of the Apparatus	Range	Quantity
1.	Function Generator	3 MHz	1
2.	CRO	30 MHz	1
3.	Dual RPS	0–30V	1
4.	Op-Amp	IC 741	1
5.	Bread Board		1
6.	Resistors	As required	
7.	Connecting wires and probes	As required	

THEORY:

The input signal V_i is applied to the inverting input terminal through R_1 and the non-inverting input terminal of the op-amp is grounded. The output voltage V_o is fed back to the inverting input terminal through the R_f - R_1 network, where R_f is the feedback resistor. The output voltage is given as,

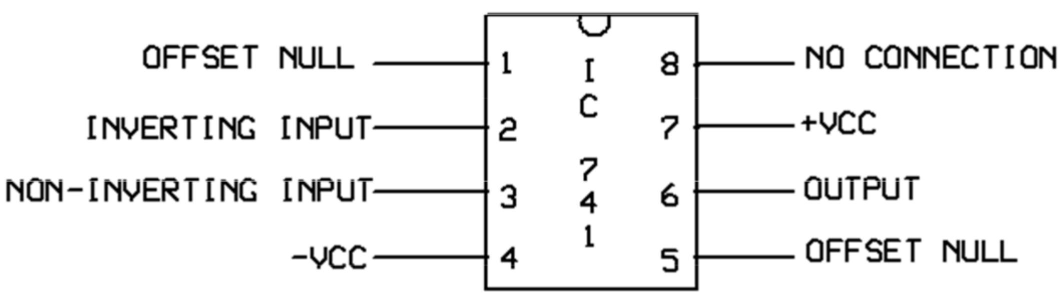
$$V_o = -A_{CL} V_i$$

Here the negative sign indicates that the output voltage is 180^0 out of phase with the input signal.

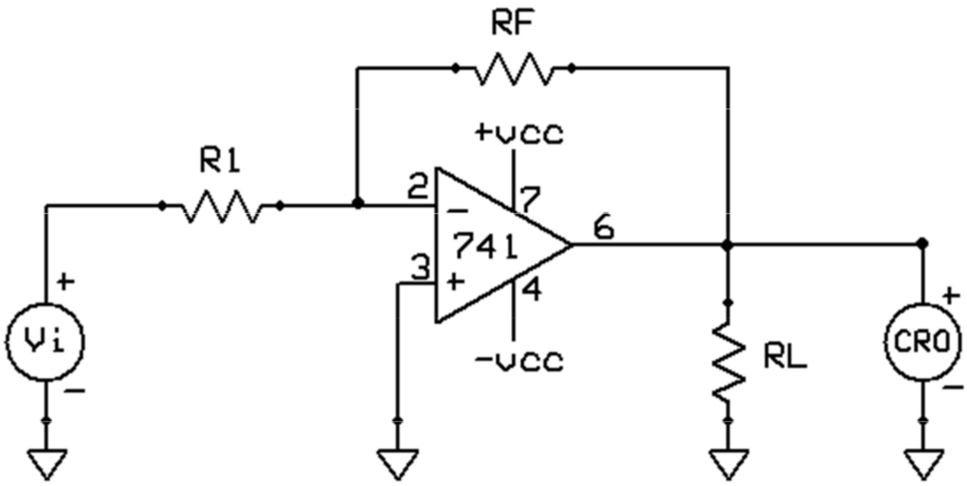
PROCEDURE:

1. Connections are given as per the circuit diagram.
2. $+V_{cc}$ and $-V_{cc}$ supply is given to the power supply terminal of the Op-Amp IC.
3. By adjusting the amplitude and frequency knobs of the function generator, appropriate input voltage is applied to the inverting input terminal of the Op-Amp.
4. The output voltage is obtained in the CRO and the input and output voltage waveforms are plotted in a graph sheet

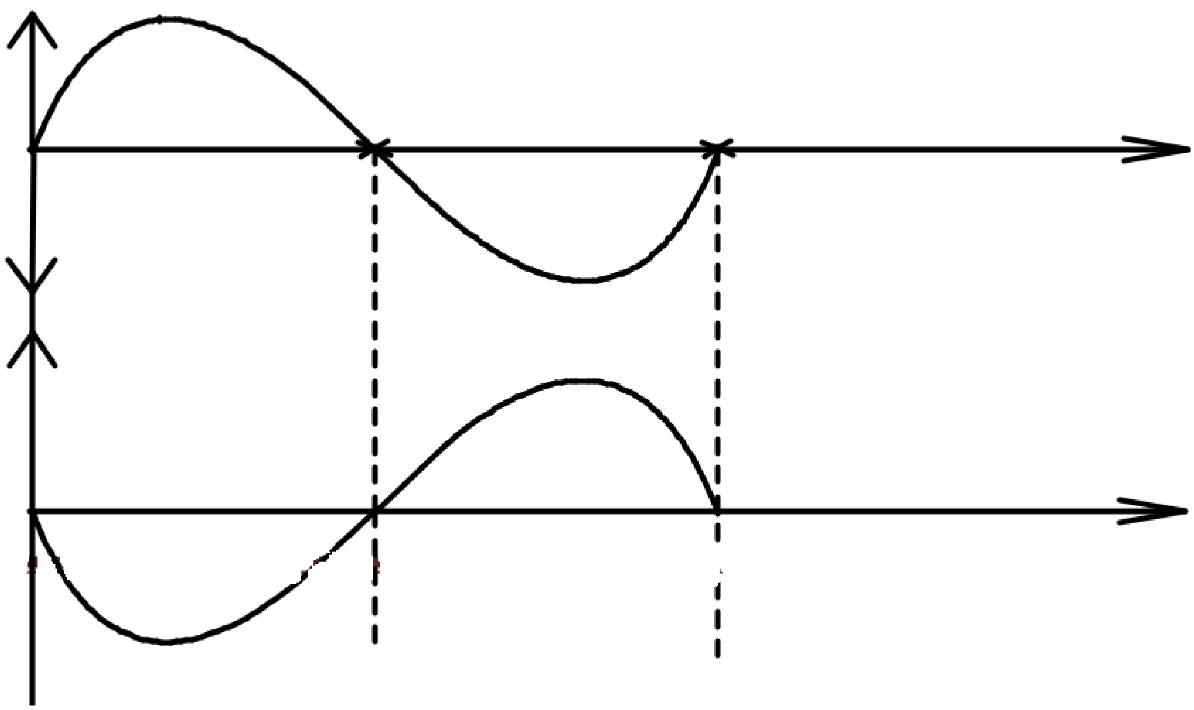
PIN DIAGRAM:



CIRCUIT DIAGRAM OF INVERTING AMPLIFIER:



MODEL GRAPH:



RESULT:
The design and testing of the inverting amplifier is done and the input and output waveforms were drawn.

(B) NON - INVERTING AMPLIFIER USING OP-AMP

AIM:

To design a Non-Inverting Amplifier for the given specifications using Op-Amp IC 741.

APPARATUS REQUIRED:

S.No	Name of the Apparatus	Range	Quantity
1.	Function Generator	3 MHz	1
2.	CRO	30 MHz	1
3.	Dual RPS	0–30V	1
4.	Op-Amp	IC 741	1
5.	Bread Board		1
6.	Resistors	As required	
7.	Connecting wires and probes	As required	

THEORY:

The input signal V_i is applied to the non - inverting input terminal of the op-amp. This circuit amplifies the signal without inverting the input signal. It is also called negative feedback system since the output is feedback to the inverting input terminals. The differential voltage V_d at the inverting input terminal of the op-amp is zero ideally and the output voltage is given as,

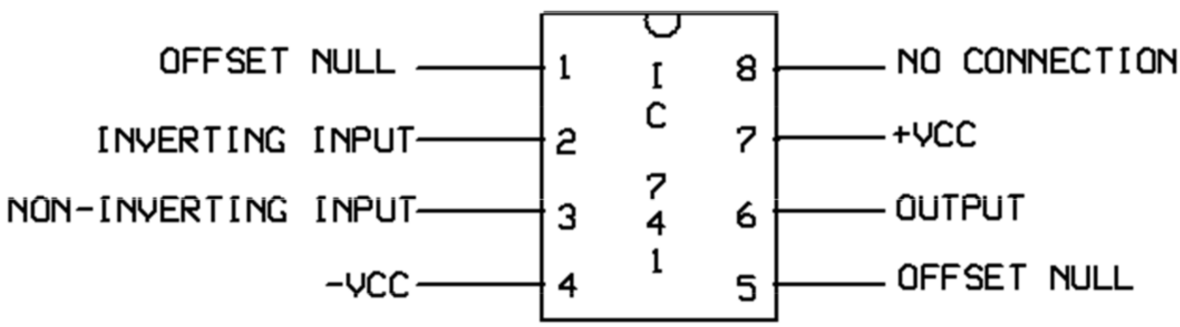
$V_o = A_{CL} V_i$

Here the output voltage is in phase with the input signal.

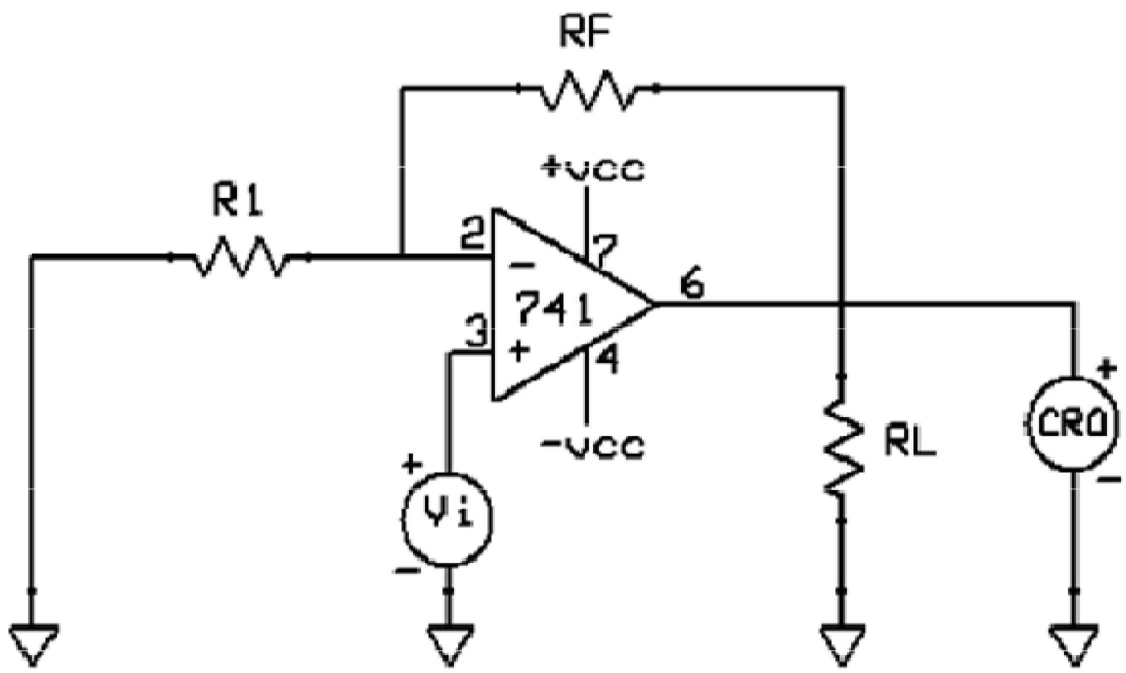
PROCEDURE:

1. Connections are given as per the circuit diagram.
2. + V_{cc} and - V_{cc} supply is given to the power supply terminal of the Op-Amp IC
3. By adjusting the amplitude and frequency knobs of the function generator, appropriate input voltage is applied to the non - inverting input terminal of the Op-Amp.
4. The output voltage is obtained in the CRO and the input and output voltage waveforms are plotted in a graph sheet.

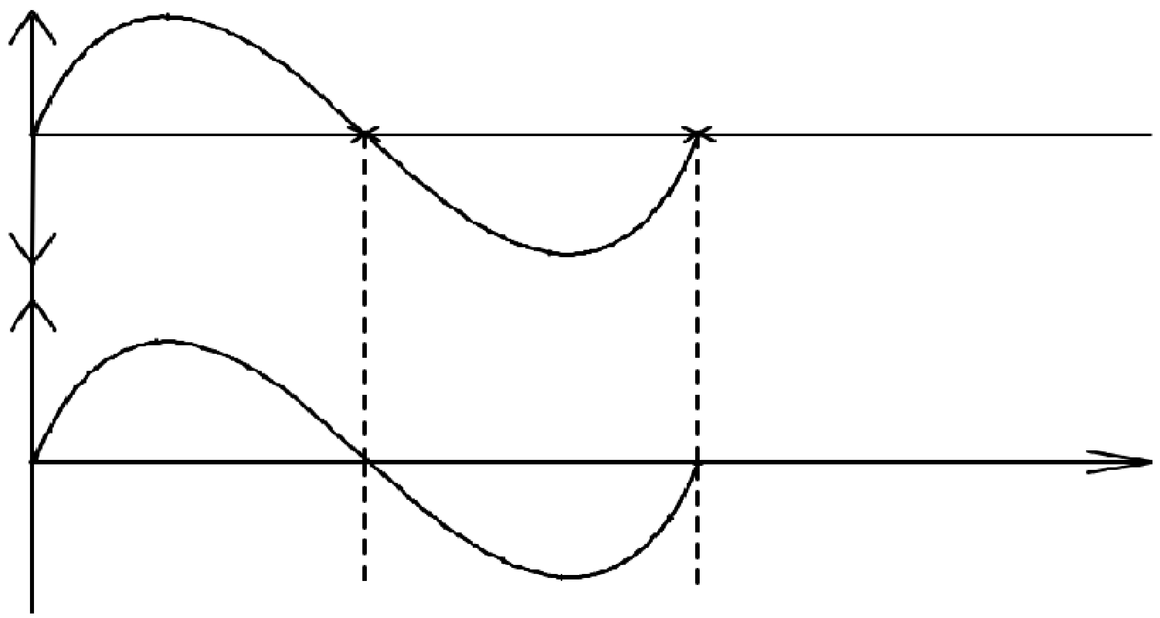
PIN DIAGRAM:



CIRCUIT DIAGRAM OF NON INVERITNG AMPLIFIER:



MODEL GRAPH:



RESULT:

The design and testing of the Non-inverting amplifier is done and the input and output waveforms were drawn.

EXPERIMENT: 2

(A). ADDER USING OP-AMP

Aim:

I) To design adder circuit using op-amp
II) To design subtractor circuit using op-amp
III) To design comparator circuit using op-amp

EQUIPMENTS AND COMPONENTS:

APPARATUS:

S.No.	Name of the component/equipment	Quantity
1	Op amp 741 IC	1
2	Resistance R =10KΩ	2
3	Resistance RF=10KΩ	1
4	Rcomp=3.3 KΩ	1
5	Dual Regulated Power supply	2
6	Bread Board	1
7	Multimeter or CRO	1
8	Connecting wires	

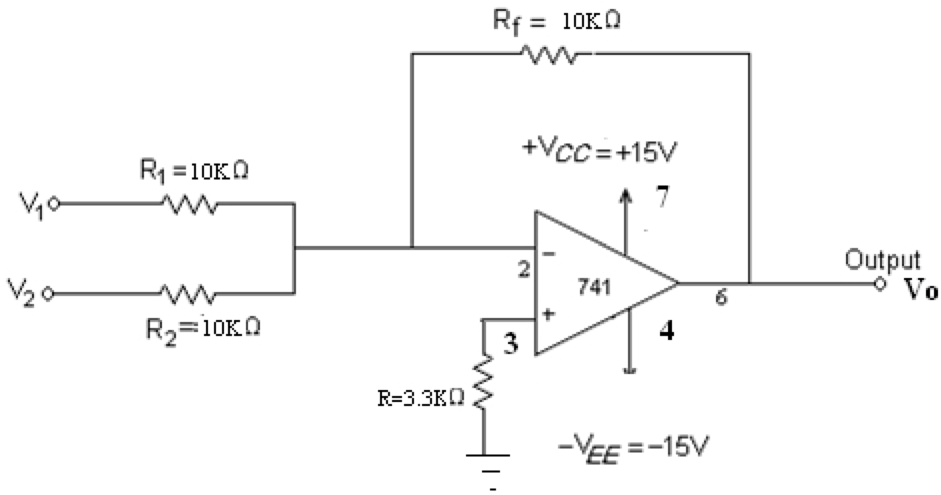
THEORY:

Op-Amp may be used to design a circuit whose output is the sum of several input signals such a circuit is called a summing amplifier or summer. We can obtain either inverting or non inverting summer.The circuit diagrams shows a two input inverting summing amplifier. It has two input voltages $V_1$and V_2, two input resistors R_1 ,R_2 and a feedback resistor R_f.Assuming that op-amp is in ideal conditions and input bias current is assumed to be zero, there is no voltage drop across the resistor R_{comp} and hence the non inverting input terminal is at ground potential. By taking nodal equations.

Rcom= R1//R2//Rf
= 10k//10k//10k
=3.3k

$V_1/R_1 + V_2/R_2 + V_0/R_f = 0$
$V_0 = -[(R_f/R_1) V_1 + (R_f/R_2) V_2]$ And here
$R_1 = R_2 = R_f = 10K$
$V_0 = -(V_1 + V_2)$
Thus output is inverted and sum of input.

CIRCUIT DIAGRAM:



PROCEDURE:

- Connect the circuit as shown in figure.
- Apply +Vcc =+15V and –Vcc = – 15V to Pin 7 and 4 of 741IC
- Apply the i/p voltage V1 and V2.
- Measure the o/p voltage using Multi meter or CRO
- Verify with theoretical value.
- Repeat the above for different values of V1 and V2

TABULAR COLOUM:

S.NO	V1(VOLTAGE)	V2(VOLTAGE)	THEORITICAL(V0)	PRATICAL(V0)
1	3V	5V	-8V	-8V
2				
3				

PRECAUTIONS:

- Check the circuit connections before switching on the power supply.
- Check the continuity of the connecting wires.

RESULT:
An adder circuit using IC741 op-amp is designed and verified.

(B). SUBTRACTOR USING OP-AMP

Aim: To design subtractor circuit using op-amp

EQUIPMENTS AND COMPONENTS:

APPARATUS:

S.No.	**Name of the component/equipment**	**Quantity**
1	Op amp 741 IC	1
2	Resistance R =10KΩ	2
3	Resistance RF=10KΩ	1
4	Rcomp=10KΩ	1
5	Dual Regulated Power supply	2
6	Bread Board	1
7	Multimeter or CRO	1
8	Connecting wires	

THEORY:

The basic difference amplifier can be used as a subtractor. The signals to be subtracted are connected to opposite polarity inputs i.e. in inverting or non-inverting terminals of the op-amp.A circuit that finds the difference between two signals is called a subtractor. The two inputs are applied at the inverting & non inverting terminal of op-amp. If all external resistances are equal in value, so the gain of the amplifier is equal to 1. The output voltage of the differential amplifier with a gain of unity is

$V0=-(Rf/R1)V1+V2(R2/(R1+R2))(1+Rf/R1)$

$Rf=R2$

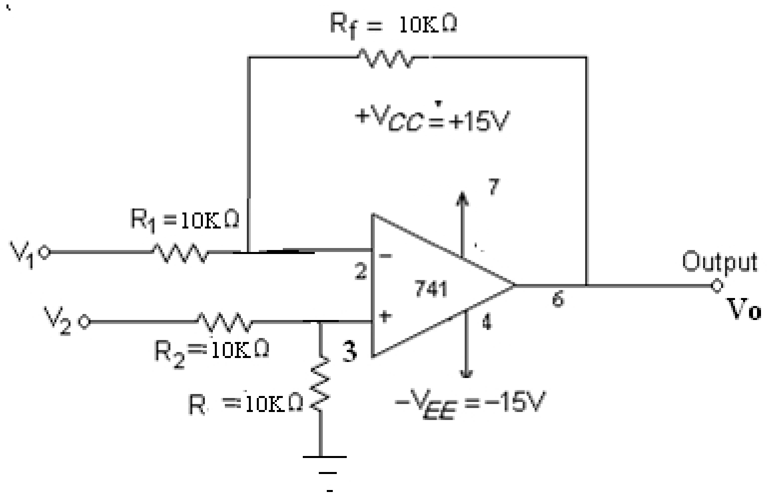
$V0=-(R2/R1)V1+V2(R2/(R1+R2))((R1+R2)/R1)$

$R1=R2$

$V0= -V1+V2$

$V0=V2-V1$

CIRCUIT DIAGRAM:



PROCEDURE:

- Connect the circuit as shown in the subtractor circuit diagram
- Apply the supply voltages of +15V to pin 7 and -15V to pin 4 of IC 741
- Apply DC voltage from regulated power supply to inputs V_1 and V_2.
- Apply V_1 = 1V and Increase V_2 from 0V to 5V in steps of 1V. Repeat the same for V_1 = 3V and V_1 = 5V.
- Note down the Vo using Voltmeter.
- Compare theoretical and practical values.

TABULAR COLOUM:

S.NO	V1(VOLTAGE)	V2(VOLTAGE)	THEORITICAL(V0)	PRATICAL(V0)
1	**2V**	**3V**	**1V**	**1V**
2				
3				

PRECAUTIONS:

- Check the circuit connections before switching on the power supply.
- Check the continuity of the connecting wires.

RESULT:
An subtractor circuit using IC741 op-amp is designed

EXPERIMENT NO: 3
COMPARATORS USING OP-AMP

Aim: To design comparator circuit using op-amp

EQUIPMENTS AND COMPONENTS:

APPARATUS:

S.No.	Name of the component/equipment	Quantity
1	Op amp 741 IC	1
2	Resistance R =1KΩ	2
3	Resistance R0=2.2KΩ	1
4	CRO	1
5	Function generator	1
6	Dual Regulated Power supply	2
7	Bread Board	1
8	Connecting wires	

THEORY:

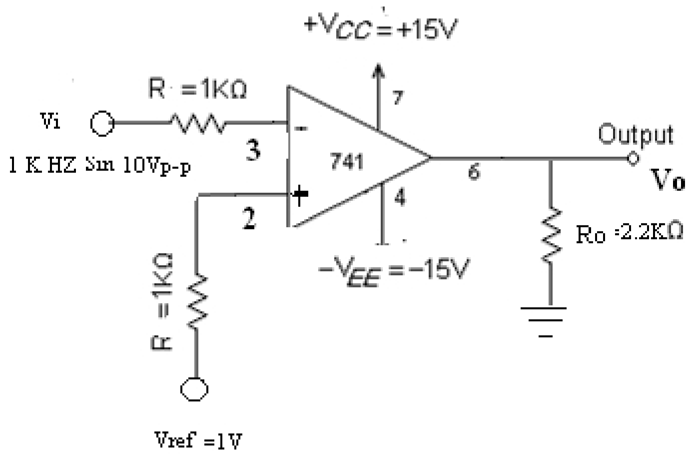
A comparator is a circuit which compares a signal voltage applied at one input of an op-amp with a known reference voltage at the other input . It is basically an open loop op-amp with output ±Vsat as in the ideal transfer characteristics.

It is clear that the change in the output state takes place with an increment in input Vi of only 2mv. This is the uncertainty region where output cannot be directly defined There are basically 2 types of comparators.

1. Non inverting comparator and.
2. Inverting comparator.

The applications of comparator are zero crossing detector , window detector, time marker generator and phase meter.
In non-inverting comparator Vin is given to the positive terminal and V ref is given to the negative terminal. When Vin > Vref the out put is +Vsat and Vin <Vref the output is –Vsat.
In an inverting comparator input is given to the inverting terminal and Vref is given to non inverting terminal.

CIRCUIT DIAGRAM:



PROCEDURE:

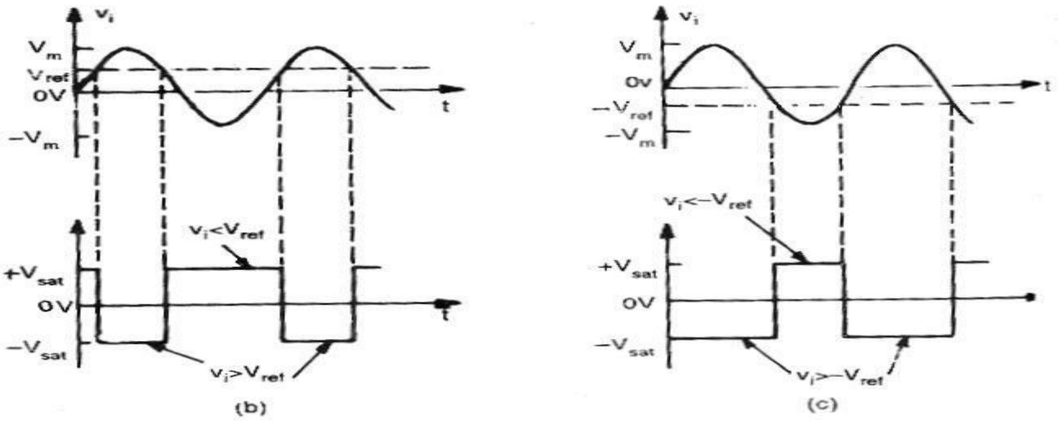
- Connect the circuit as shown in circuit diagram.
- Give the Vref as 1v
- Using the function generator give sine wave signal of Vi = 2V pp at 1 kHz.
- Using a CRO observe the input and output waveform simultaneously. Plot the output waveform.
- Note down time period and frequency of the output wave form and Plot the graph.

OBSERVATIONS:

Vin = +2v, -2v

Vout = -Vsat, +V sat
V sat = +Vcc – Approx 2V
-Vsat = -VEE + Approx 2v

GRAPH:



RESULT: Comparator using IC741 op-amp is designed**.**

Viva Questions:

1**. Mention some of the linear applications of op–amps?**
Ans: Adder, subtractor, voltage –to- current converter, current –to- voltage converters, instrumentation amplifier, filter etc.
2. Mention some of the non – linear applications of op-amps?
Ans: Rectifier, peak detector, clipper, clamper, sample and hold circuit, log amplifier, anti – log amplifier, multiplier etc.
3. What happens when the common terminal of V+ and V- sources is not grounded?
Ans: If the common point of the two supplies is not grounded, twice the supply voltage will get applied and it may damage the op-amp.
4. What are the ideal characteristics of an op-amp?
Ans: Ideal characteristics of an op-amp are
Open loop gain infinite
Input impedance : infinite
Output impedance : zero
Bandwidth : infinite
5. What is a comparator?
Ans: A comparator is a circuit which compares a signal voltage applied at one input of an op-amp with a known reference voltage at the other input. It is an open loop op-amp with output + /- Vsat.
6. Why IC 741 is not used for high frequency applications?

Ans: IC741 has limited bandwidth because of the predominance of capacitance present in the circuit. As frequency increases, the output gets reduced.

7. In the comparator circuit, if the reference voltage is zero, what is the duty cycle of the Vo. How the duty cycle is effected by varying the reference voltage (in the positive direction and –ve direction).

Ans: 50%, Duty cycle decreases if the reference voltage is increased and it is increased when reference voltage is reduced.

8. A comparator converts sinusoidal wave to __ wave.

Ans: Square wave.

9. What is duty cycle?

Ans: It is the ratio of the time period of the positive cycle to that of the time period of the entire cycle in percentage.

10. What is slew rate? What are its units?

Ans: It is the rate of change of the output voltage when a step input voltage is given. It is measured as V/μSec.

EXPERIMENT: 4
INTEGRATOR CIRCUIT USING IC741

AIM: Design and verify the functionality of Integrator using IC 741 Op-Amp.

EQUIPMENTS AND COMPONENTS:

APPARATUS:

S.No.	Name of the component/equipment	Quantity
1	Op amp 741 IC	1
2	Resistance R1 =1KΩ	1
3	Resistance Rf =10KΩ	1
4	Capacitor Cf=0.1µF	1
5	CRO	1
6	Function generator	1
7	Dual Regulated Power supply	2
8	Bread Board	1
9	Connecting wires	

THEORY:
The circuit provides an output voltage which is proportional to the time integral of the input and R1CF is the time constant of the integrator. It may be noted that there is a negative sign in the output voltage, and therefore, this integrator is also known as an inverting integrator. The gain Av is infinite for an ideal op-amp, so the effective time constant of the op-amp integrator becomes very large which results in perfect integration.

$V0=-1/R1Cf\int VI(t)dt$

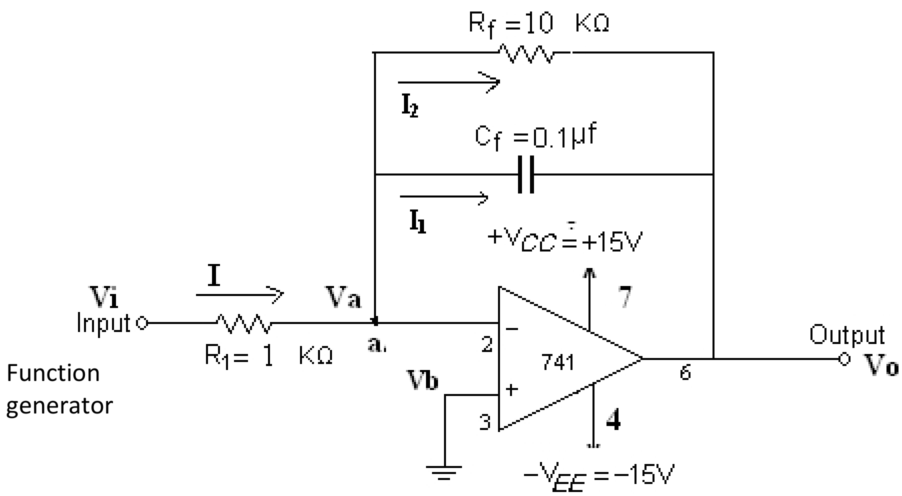
It is implemented using an op-amp in inverting configuration with –ve feedback. Capacitor is used in feedback path and register used in input path.

The gain of the integrator at low freq can be limited to avoid the saturation problem by adding a shunt resister Rf across feedback capacitor.

For an i/p sine wave the o/p will be cosine wave.

For an i/p square wave the o/p will be triangular wave.

Circuit Diagram:



$$f = \frac{1}{2\pi R_f C_f} = 159\text{Hz}$$

$$= \frac{1}{2\pi X 10^{3} X 10 X 0.1 X 10^{-6}}$$

$$= \frac{1}{6.28 X 10^{-3}}$$

=159Hz

This is a very important freq and tells us where the useful integration range start, if i/p freq is lower than f the ckt acts as a simple inverting amplifier and no integration results. At the freq f 50% accuracy results. if freq is 10 times 99% accuracy can result.

The gain of the above the circuit is

$|A| = |Vo/Vi| = (Rf/R1)/(\sqrt{1 + (2\pi f R f C f)^2})$

Here Rf=10k R1=1k and Cf=0.1µ

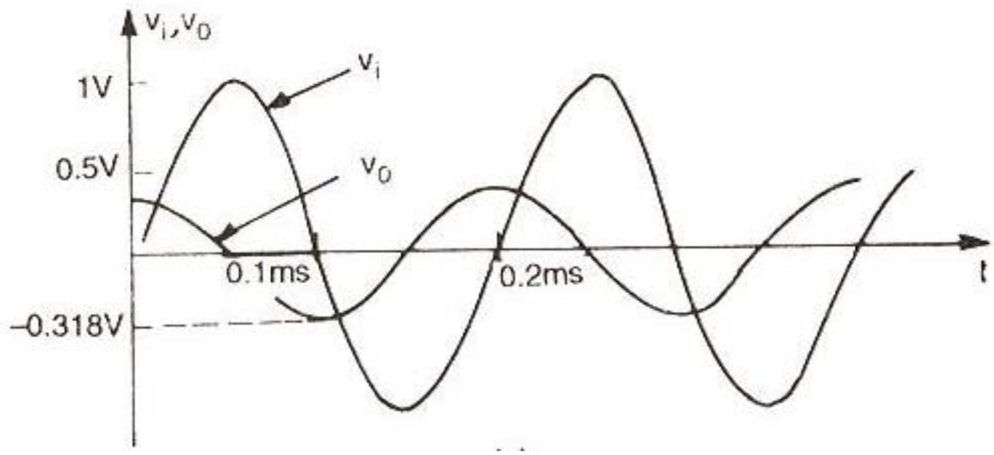
Hence gain is approx=1

Procedure:

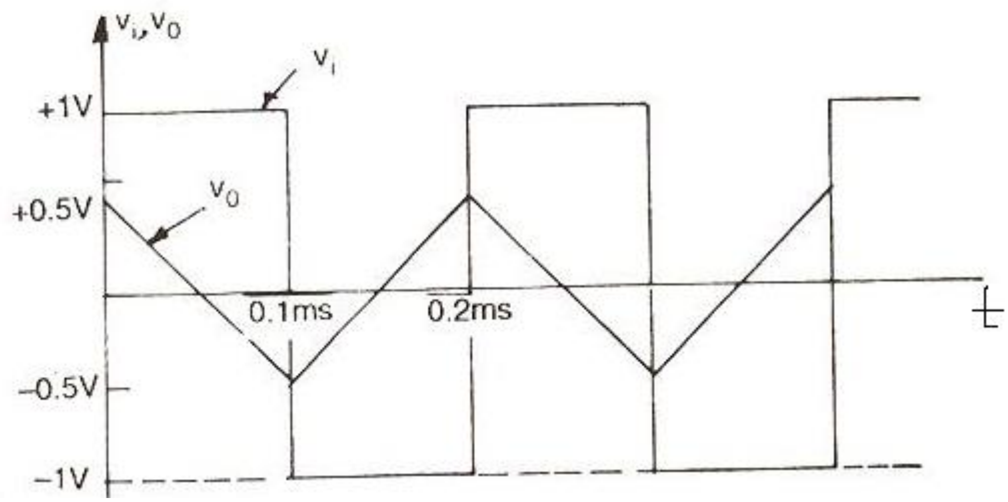
1. Connect the circuit according to the circuit diagram.
2. Apply sine wave to the input terminal of integrator circuit.
3. Set the input voltage peak to peak of 1 to 4 volts and frequency from 159Hz to 1.59KHz.
4. Note down the input and output wave form. Draw the waveform on graph paper
5. Apply a square wave to the i/p terminal of integrator ckt .

6. Set the i/p voltage peak to peak of 1 to 4 volts and frequency from 159Hz to 1.59KHz.
7. Note down the input and output wave form. Draw the waveform on graph paper

Typical Input and Output Waveforms:



Output waveform for sine wave



Output waveform for square wave

RESULT: Hence op-amp as integrator is verified.

EXPERIMENT: 5
DIFFERENTIATOR CIRCUIT USING IC741

AIM:

Design and verify the functionality of Differentiator using IC 741 Op-Amp

EQUIPMENTS AND COMPONENTS:

APPARATUS:

S.No.	Name of the component/equipment	Quantity
1	Op amp 741 IC	1
2	Resistance Rc =4.7KΩ	1
3	Resistance Rf =10KΩ	1
4	Capacitor C1=0.1μF	1
5	CRO	1
6	Function generator	1
7	Dual Regulated Power supply	2
8	Bread Board	1
9	Connecting wires	

THEORY:
As the name suggests, the circuit performs the mathematical operation of differentiation, i.e. the output voltage is the derivative of the input voltage.

$$V_o = - R_f C_1 \frac{dVin}{dt}$$

It is implemented using an op-amp in inverting configuration with –ve feedback.it contains a capacitor in input path. Rcom need not be used as it is used only compensate for bias current.

Gain=f/fa where fa=1/2πRfC1
For f=fa gain will be 1.

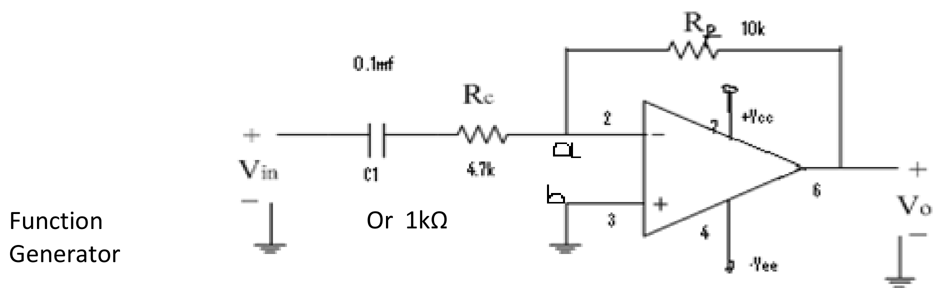
It will increase at the rate of +20db/decade at high freq and becomes unstable.
For a sine wave input the out put will be cosine.
Assume C1 =0.1μf and Rf=10kΩ
F=1/2π X 10^4 X 10^-7
=159Hz
For a square wave the output wave form consists of +ve and _ve spike of Vsat which is approx 13 volts for a+15v power supply. During the time periods input is constant, differential output will be zero. However when input transits both +ve and _ve levels the slope is infinite for ideal square wave.

If we put a series register along with C1 then amplitude of spike reduces. More the register less the amplitude. It is because gain reduces. It will convert narrow square wave o/p to real spike the register value of 1KΩ or 4.7KΩ can be used.

Series register will not make any difference for sine wave o/p which is approx same as i/p.

Differentiator has wide applications in
1. Monostable Multivibrator
2. Signal wave shaping
3. Function Generators.

CIRCUIT DIAGRAM:

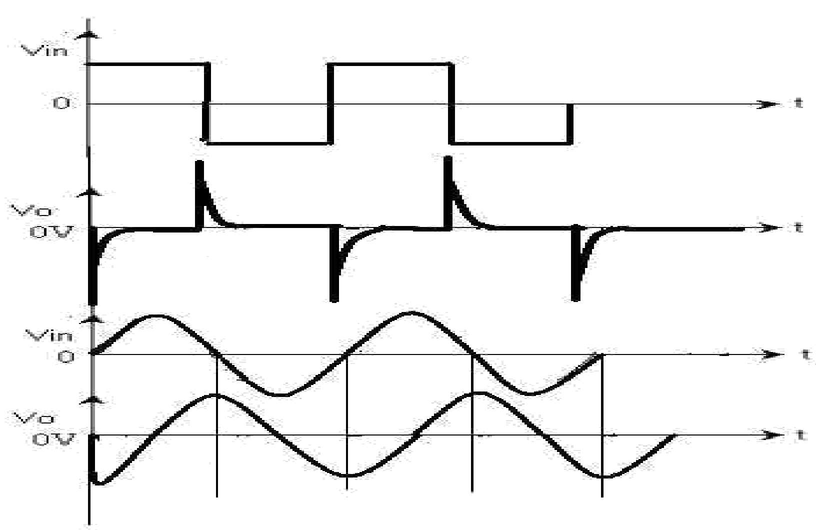


f= $\frac{1}{2\pi R_f C_f}$ **=159Hz**

PROCEDURE:

- Connect the circuit according to the circuit diagram.
- Apply sine wave to the input terminal of differentiator circuit.
- Set the input voltage 4V peak to peak and frequency at 1.5KHz.
- Note down the input and output wave form. Draw the waveform on graph paper

INPUT AND OUTPUT WAVEFORMS:



RESULT: Hence op-amp as differentiator id verified.

Viva Questions:

1. Define integrator.

Ans: An integrator is a device to perform the mathematical operation known as integration, a fundamental operation in calculus. The integration function is often part of engineering and scientific calculations. Electronic analog integrators were the basis of analog computers.

2. Define differentiator.

Ans: A Differentiator is a circuit that is designed such that the output of the circuit is proportional to the time derivative of the input.

3. Write down output voltage formula for the integrator.

Ans: $$V_o(t) = -\frac{1}{R_1 C_f} \int V_i(t)\, dt$$

4. Write down output voltage formula for the differentiator.

Ans: $$V_o(t) = -R_1 C_f \frac{d}{dt} V_i(t)$$

5. What is the output of the differentiator for square wave input?

Ans: Spikes

6. What are the problems in an ordinary op-amp differentiator? What are the changes in the circuit of the practical differentiator to eliminate these problems?

Ans: Problems in an Ordinary op-amp differentiator are instability and high frequency noise. A Resistor is added in series with the capacitor at the input and a capacitor is added in parallel to the resistor in the feedback circuit in the practical differentiator to eliminate the above problems.

7. What are the problems in an ordinary op-amp Integrator? What are the changes in the circuit of a practical integrator?

Ans: The gain of an integrator at low frequency is very high and the circuit goes to saturation. The feedback capacitor is shunted with a resistor in the practical integrator to overcome the above problem.

8. What is a lossy integrator?

Ans: The practical integrator is known as lossy integrator.

9. How a sine wave and cosine wave can be discriminated?

Ans: When t = 0, Sine wave amplitude is zero and the cosine wave amplitude is maximum.

10. Why integrators are preferred over differentiators in electronic circuits?

Ans: In differentiators, the gain increases at high frequency and are not stable

EXPERIMENT: 6
FIRST ORDER ACTIVE LOW PASS FILTER

AIM: To Design And Plot The Frequency Response Curve Of First Order Low Pass Filter.

EQUIPMENTS AND COMPONENTS:

APPARATUS:

S.No.	Name of the component/equipment	Quantity
1	Op amp 741 IC	1
2	Resistance R1=10KΩ	1
3	Resistance R=3.3KΩ	1
4	Resistance Rf =10KΩ	1
5	Capacitor C=47nF	1
6	CRO	1
7	Function generator	1
8	Dual Regulated Power supply	2
9	Bread Board	1
10	Connecting wires	

THEORY:

Filters are classified as follows:
Based on components used in the circuit

- Active filters – Use active elements like transistor or op-amp(provides gain)in addition to passive elements
- Passive filters – Use only passive elements like resistors, capacitors and inductors, hence no gain here.

Based on frequency range

- Low pass filter(LPF) – Allows low frequencies
- High pass filter(HPF) – Allows high frequencies
- Band pass filter(BPF) – Allows band of frequencies
- Band reject filter(BRF) – Rejects band of frequencies

All pass filter – Allows all frequencies but with a phase shift

Active Filter is often a frequency – selective circuit that passes a specified band of frequencies and blocks or attenuates signals of frequencies outside this band.

These Active Filters are most extensively used in the field of communications and signal processing. They are employed in one form or another in almost all sophisticated electronic systems such as Radio, Television, Telephone, Radar, Space Satellites, and Bio-Medical Equipment.

Active Filters employ transistors or Op – Amps in addition to that of resistors and capacitors. Active filters have the following advantages over passive filters. (1) Flexible gain and frequency adjustment. (2) No loading problem (because of high input impedance and low output impedance) and (3) Active filters are more economical than passive filters.

A first – Order Low – Pass Butterworth filter uses RC network for filtering. Note that the op-amp is used in the non-inverting configuration; hence it does not load down the RC network. Resistors R_1 and R_F determine the gain of the filter.

The gain Af=1+Rf/R1
In ckt Rf=R1=10k
Hence Af=2

The gain magnitude equation of the Low – Pass filter can be obtained by converting equation into its equivalent polar form, as follows

$$|V_o / V_{in}| = A_F / \sqrt{1 + \left(\frac{f}{fc}\right)2}$$

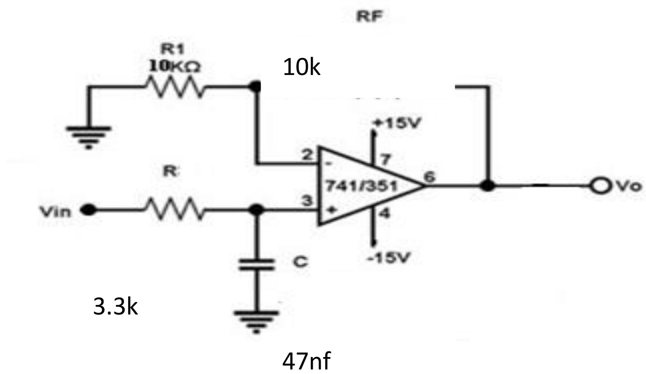
Where fc =1/(2πRC)=High-cut off frequency
The gain at cut of frequency Fc=0.707 x Af =0.707 x 2=1.414

The operation of the low – pass filter can be verified from the gain magnitude equation. 1. At very low frequencies, that is $f < f_H$

1. $|V_o / V_{in}| = A_F$
2. At $f = f_c$ $|V_o / V_{in}| = A_F/\sqrt{2} = 0.707\ A_F$
3. At $f > f_c$ $|V_o / V_{in}| < A_F$

Thus the Low – Pass filter has a constant gain A_F from 0 Hz to the almost high cut-off frequency, f_H, it has the gain $0.707A_F$ at exactly f_H, and after f_H it decreases at a constant rate with an increase in frequency. The gain decreases 20 dB (= 20 log 10) each time the frequency is increased by 10. Hence the rate at which the gain rolls off after f_H is 20 dB/decade. The frequency $f = f_H$ is called the cut-off frequency because the gain of the filter at this frequency is down by 3 dB (=20log 0.707) from 0 Hz. Other equivalent terms for cut-off frequency are -3dB frequency, break frequency, or corner frequency

CIRCUIT DIAGRAM:



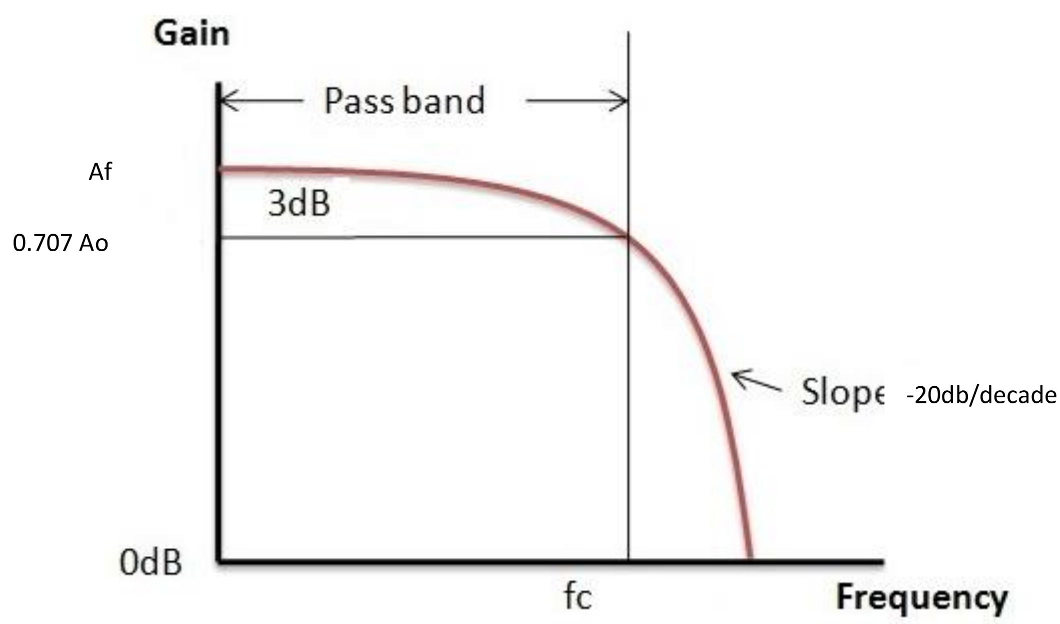
PROCEDURE:

1. Connect the circuit diagram as shown in the figure.
2. Switch ON the power supply.
3. Give the input voltage V_{in} = 4V & frequency f_{in}=1KHz using function generator.
4. By varying the input frequency range from 0Hz to 10KHz in regular intervals, note down the output voltage.
5. Calculate the gain (V_o/V_{in}) and Gain in dB = 20 log (V_o/V_{in}) at every frequency and Plot the graph
6. Find out the high cut-off frequency, f_H (at Gain= Constant Gain, A_f – 3 dB) from the frequency response plotted.
7. Verify the practical (f_H from graph) and the calculated theoretical cut-off frequency ($f_H = 1/2\pi RC$).

TABLE:

S.No.	Input Frequency f(Hz)	Output Voltage V_o (V)	Gain Magnitude $\lvert V_o/V_{in} \rvert$	Gain in dB = $20\log\lvert V_o/V_{in} \rvert$

EXPECTED GRAPH:



RESULT: Hence First Order Low Pass Filter is designed and Cut off Frequency is Verified

(B)FIRST ORDER ACTIVE HIGH PASS FILTER

AIM: To Design And Plot The Frequency Response Curve Of First Order High Pass Filter.

EQUIPMENTS AND COMPONENTS:

APPARATUS:

S.No.	Name of the component/equipment	Quantity
1	Op amp 741 IC	1
2	Resistance R1=10KΩ	1
3	Resistance R=3.3KΩ	1
4	Resistance Rf =10KΩ	1
5	Capacitor C=47nF	1
6	CRO	1
7	Function generator	1
8	Dual Regulated Power supply	2
9	Bread Board	1
10	Connecting wires	

THEORY:

First Order High Pass Filter consists of RC network for filtering. First Order High Pass filter can be constructed from a First Order Low Pass filter simply by interchanging frequency determining components R & C . Op-Amp is used in the non – inverting configuration. Resistor R_1 and R_F determine the gain of the Filter.
The voltage gain magnitude equation of the High-pass filter is

$$|V_o / V_{in}| = (A_F(f/f_L))/\sqrt{1+\left(\frac{f}{f_L}\right)2}$$

where $A_F = 1 + R_F / R_1$
f = Operating (input) frequency
$f_L = 1/(2\pi RC)$=Low-cut off frequency

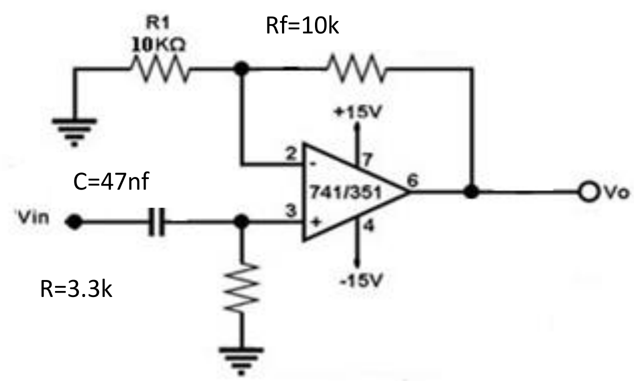
This is the frequency at which the magnitude of the gain is 0.707 times its pass band value. Obviously, all frequencies higher than f_L are Pass Band frequencies, with the highest frequency determined by the closed-loop bandwidth of the OP-Amp.
The operation of the high–pass filter can be verified from the gain magnitude equation. . At very low frequencies, that is $f < f_L$

1.| V_o / V_{in} |< A_F
2.At f = f_H | V_o / V_{in} |= $A_F/\sqrt{2}$= 0.707 A_F
3.At f >f_H | V_o / V_{in}| = A_F

For example, in the first order High – Pass filter the gain rolls – off or increases at the rate of 20dB/decade in stop band, that is for input signal frequency lesser than Low cut-off frequency (f_L) ;

High Pass filter has constant gain A_F, after the Low cut-off frequency onwards (f_L).

CIRCUIT DIAGRAM:



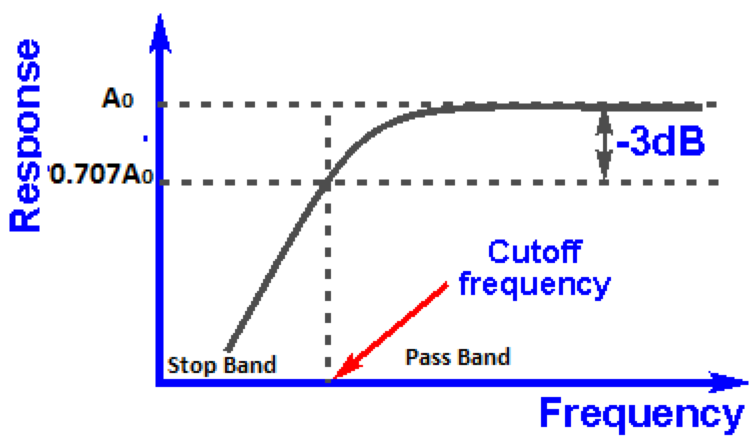
PROCEDURE:

1. Connect the circuit diagram as shown in the figure.
2. Switch ON the power supply.
3. Give the input voltage V_{in} = 4V & frequency f_{in}=1KHz using function generator.
4. By varying the input frequency range from 0Hz to 10KHz in regular intervals, note down the output voltage.
5. Calculate the gain (V_o/V_{in}) and Gain in dB = 20 log (V_o/V_{in}) at every frequency and Plot the graph
6. Find out the Low cut-off frequency, f_L (at Gain= Constant Gain, A_f – 3 dB) from the frequency response plotted.
7. Verify the practical (f_L from graph) and the calculated theoretical cut-off frequency ($f_L = 1/2\pi RC$).

TABLE:

S.No.	Input Frequency f(Hz)	Output Voltage V_o (V)	Gain Magnitude $\| V_o/V_{in} \|$	Gain in dB = $20\log\| V_o/V_{in} \|$

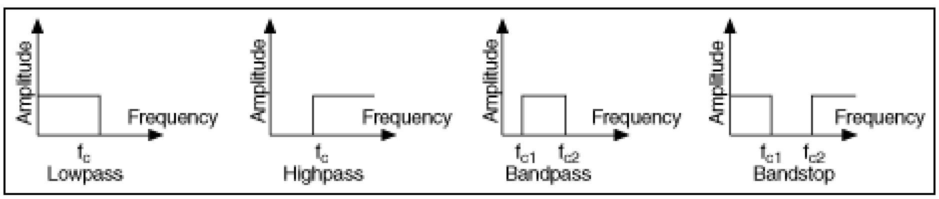
EXPECTED GRAPH:



RESULT: Hence First Order High Pass Filter is Designed And Cut Off Frequency is Verifiy

Viva Questions:

1. Give the formula for cutoff frequency for the low pass filter?
Ans: $F_h = 1/ 2\pi RC$.
2. What is the difference between analog filter and digital filter?
Ans: Analog filter has less performance whereas digital filters have better performance. Digital filters are used in DIP applications.
3. To obtain a band reject filter, LPF and HPF are to be connected in ___________ method.
Ans: In Series with low value of cut off frequency for LPF and high value of cut off frequency for HPF.
4. To obtain a band pass filter, LPF and HPF are to be connected in ___________ method.
Ans: In Series with high value of cut off frequency for LPF and low value of cut off frequency for HPF.
5. What is bandwidth?
Ans: The frequency band between the low cut off and high cut off.
6. Define cut off frequency?
Ans: point which is 3dB less than the max gain (0.707 of max gain)
7. Draw the frequency response plot for an ideal filters.
Ans:



8. What are an active filter and a passive filter?
Ans: Active filter uses active components like Op-Amps. Passive filter uses passive components like R, L and C.
9. What is a filter?
Ans: An electronic circuit which passes the signal of frequencies which are required and rejects the signal of frequencies which are not required.
10. What is the rate of fall of the gain in stop band for first order and second order filter.
Ans: 20dB/decade or 6dB/octave for 1st order filter, 40dB/decade or 12dB/octave for 2^{nd} order filter.

Experiment No: 7
Wave Form Generator (Sine Wave Generator)

AIM: To design a Waveform Generator which generates Sine waveforms using IC741 and to verify it's various output waveforms.

APPARATUS:

S.No.	Name of the component/equipment	Quantity
1	Op amp 741 IC	1
2	Resistance Ri=10KΩ	1
3	Resistance R1=3.3KΩ	1
4	Resistance R2=3.3KΩ	1
5	Resistance R3=4.7KΩ	1
6	Capacitor C1=47nF	1
7	Capacitor C2=47nF	1
8	CRO	1
9	Function generator	1
10	Dual Regulated Power supply	2
11	Bread Board	1
12	Connecting wires	

THEORY:
Waveform generator using IC741 is a circuit which generates Sine wave, Square wave and Triangular wave. This circuit is a combination of Wien Bridge oscillator, Zero crossing detector (Comparator with zero reference voltage) and Integrator. The Wien Bridge oscillator generates Sine wave which is fed to the input of Zero crossing detector. This detector gives the square wave output which is connected to the input of the Integrator which in turn produces the Triangular wave output.

The frequency of oscillations of the Sine wave output of Wien Bridge oscillator is given by f_o = **$1/2\pi RC$**

$= 1/(2\pi x3.3x10^3x47x10^{-9})$
= 1.02khz

T=1ms **f=1/t=1.02khz**

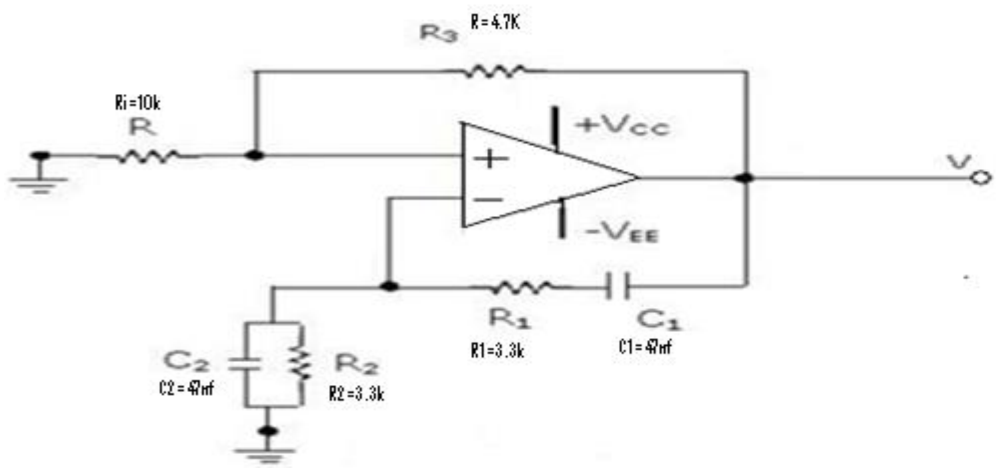
The frequency of oscillations of Square and Triangular wave outputs will also be the same frequency as that of the Sine wave output.

For theory of individual circuits i.e. Wien Bridge oscillator, Zero Crossing Detector and Integrator, please refer to the THEORY section of respective experiments mentioned earlier in this manual.

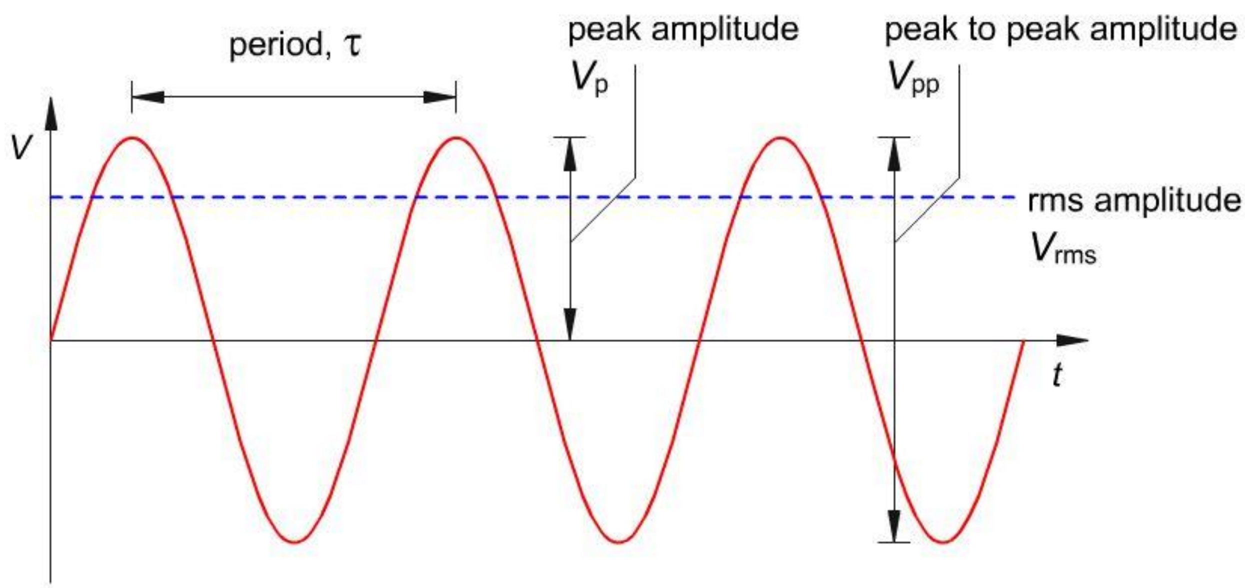
DESIGN for Wien Bridge Oscillator:

1. Choose a desired frequency of oscillation, say f_o =500 Hz.
2. Choose a value for capacitor C (0.1 µF) and then calcul ate the value of R by using the equation for f_o ($f_o = \mathbf{1/2\pi RC}$).
3. Choose a value for R_1 **(10 KΩ) and calculate the value of** R_f from the gain equation ($A_v = 1+R_f/R_1 = 3$). (Note: In practical, the value of R_f may need to be varied to be more than the calculated value.)

Circuit Diagram



EXPECTED WAVEFORM:



PROCEDURE:

Sine wave Generator:

1. Connect the circuit as per the circuit diagram.
2. Switch ON the power supply.
3. Connect output to the CRO.
4. Adjust the potentiometer to get an undistorted waveform.
5. Note down the amplitude and the time period, T of the sine wave and calculate the frequency of oscillation, $f_o = 1 / T$.
6. Verify the practical frequency of oscillation calculated in the preceding step with the theoretical value, $f_o = 1/2\pi RC$.plot the wave form

CALCULATIONS:

THEORETICAL Frequency of Oscillation
$f_o = 1/2\pi RC$

PRACTICAL Frequency of Oscillation
$f_o = 1/T$

Result: To design a Waveform Generator which generates Sine waveforms using IC741 and to verify it's various output waveforms.

(B)SQUARE WAVE GENERATOR

AIM: To design a Waveform Generator which generates Sine waveforms using IC741 and to verify it's various output waveforms.

APPARATUS:

S.No.	Name of the component/equipment	Quantity
1	Op amp 741 IC	1
2	Resistance R1=10KΩ	1
3	Resistance R2=10KΩ	1
4	Resistance Rf=10KΩ	1
5	Capacitor C=47nF	1
6	CRO	1
7	Function generator	1
8	Dual Regulated Power supply	2
9	Bread Board	1
10	Connecting wires	

Theory

Square wave can be defined as a non sinusoidal periodic waveform that can be represented as an infinite summation of sinusoidal waves. It has an amplitude alternate at a regular frequency between fixed minimum and maximum value with the same duration. Square wave generator are generally used in electronics and in signal processing. The square wave is the special case of rectangular wave. The square wave generator is just like a Schmit trigger circuit in which the reference voltage for the comparator depends on the output voltage. It is also said to be astable multivibrator.

F=1/t=0.96khz

Where t=.1ms

+Vsat=+Vcc=10.1≈2v

-Vsat=-Vcc=-10.1≈2v

T=2RCloge((1+β)/(1-β))

β=R2/(R1+R2)=1/2 (whare R!=R2)

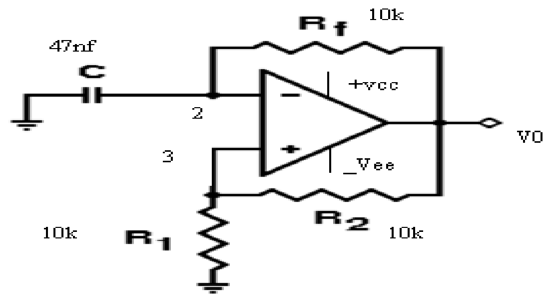
t=2RClog3≈2.2RC

f=1/t=1/2.2RC

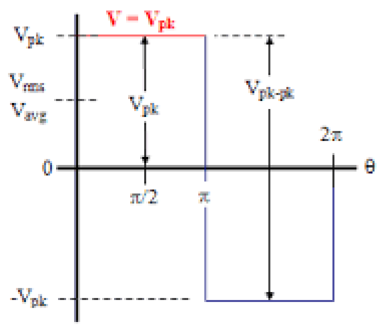
$=1/(2.2x10x10^3x47x10^{-9}$

F=0.96khz

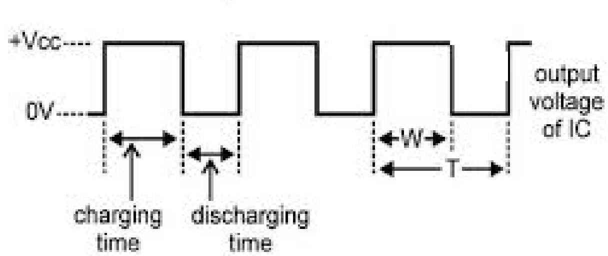
CircuitDiagram



EXPECTED WAVEFORMS:



<u>OR</u>



Procedure

1. Switch OFF the power supply.
2. Connect the components/equipment as shown in the circuit diagram.
3. Switch ON the power supply.
4. Connect the input to the channel-1 of CRO and output to the channel-2 of CRO.
5. Observe the square wave output at channel-2 and note down the amplitude and time period, T of the wave form.
6. Verify that the frequency of oscillation of both the input and the output waves is same. Also verify that both the input and the output waves are in same phase.

7. Plot the output waveform in accordance with the input waveform

Result: To designed a Waveform Generator which generates Sine waveforms using IC741 and to verify it's various output waveforms.

VIVA QUESTIONS:

1. What are the different ways of generating Sinusoidal waves?
Ans: Sinusoidal voltage wave forms are generated using Oscillators. The different types of oscillators for generating sine wave are: Phase shift oscillator, Wein-Bridge oscillator, Hartley oscillator, Colpitts Oscillator etc.
2. What are different ways of generating square wave voltage waveforms?
Ans: Astable multivibrator using 741 or 555 ICs, zero crossing comparators by giving sinusoidal wave, Schmitt trigger, PLL circuit etc.
3. What is phase-shift oscillator?
Ans: A phase-shift oscillator contains an inverting amplifier (creating 180 deg phase shift) and a feedback circuit which shifts the phase of the amplifier output by 180 degrees. The total phase shift will be 0^0 or 360^0 degrees to meet the Barkhausen criterion.
4. What is formula for frequency of oscillations for RC phase shift oscillator?
Ans: $f = 1 / 2\pi RC\sqrt{6}$
5. How a triangular wave can be generated?
Ans: Integrating square wave.
6. What is formula for frequency of oscillations for Astable square wave generator?
Ans:

$$T = 2 \times 2.303\ R_1C_1 \log_{10}\left(\frac{2R_3 + R_2}{R_2}\right) \text{ Second}$$

f = 1/T
7. What is the frequency of oscillations of triangular wave when it is generated by integrating the square wave?
Ans: Same as the frequency of the input square wave.
8. For a circuit to act as an integrator, how the time constant has to be?
Ans: It has to be of high value.
9. What is barkhausen criterion for oscillations?
Ans: The total phase shift around loop must be 0^0 or 360^0 degrees.
The loop gain should be equal to unity. i.e. $|A\beta| = 1$
10. Why three RC sections are used in the feedback for RC phase shift oscillator?
Ans: It is difficult to generate 180^0 deg phase shift with two RC sections. More than 3 sections can also be used, but it complicates the circuit diagram (more components are required).

EXPERIMENT: 8
MONOSTABLE MULTIVIBRATOR USING IC 555

AIM: To study monostable multivibrator using IC555 and to calculate output frequency.

APPARATUS:

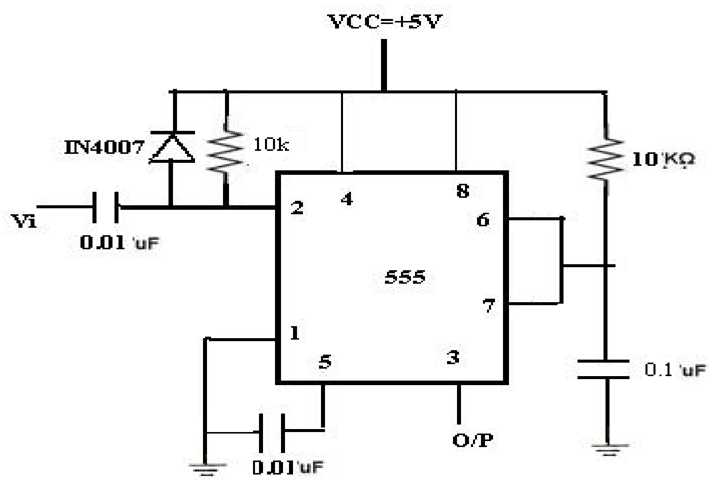
S.No.	Name of the component/equipment	Quantity
1	Op amp IC555	1
2	Resistances R=10KΩ	2
3	Diode	1
4	Capacitor C=0.1µF	1
5	Capacitors C=0.01µF	2
6	CRO	1
7	Function generator	1
8	Dual Regulated Power supply	2
9	Bread Board	1
10	Connecting wires	

THEORY:

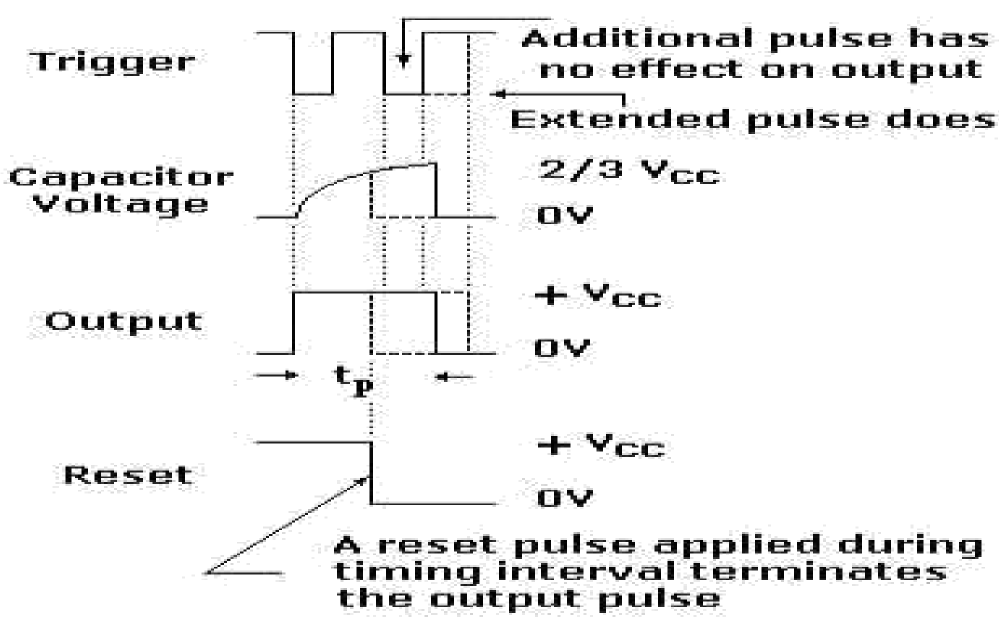
Monostable multivibrator is also called as one–shot Multivibrator. When the output is low, the circuit is in stable state, transistor T1 is ON and Capacitor C is shorted to the ground. However, upon application of a negative trigger pulse to Pin–2, transistor T1 is turned OFF, which releases short circuit across the external capacitor and drives the output High. The capacitor C now starts charging up toward V_{CC} through R. However when the voltage across the external capacitor equals 2/3 $V_{CC,}$ upper **comparator's output switches from l**ow to high which in turn derives the output to its low state. And the output of the flip flop turns transistor T1 ON, and hence the capacitor C rapidly discharges through the transistor. The output of the Monostable remains low until a trigger pulse is again applied. Then the cycle repeats. The time during which the output remains high is given by

$$t_p = 1.1\ R$$

Circuit Diagram:



EXPECTED WAVEFORMS:



CALCULATIONS:

THEORETICAL Pulse width

R = C =

t_p = 1.1 RC =

PRACTICAL Pulse width

t_p =

PROCEDURE:

1. Connect the components/equipment as shown in the circuit diagram.
2. Switch ON the power supply.
3. Connect function generator at the trigger input.
4. Connect channel-1 of CRO to the trigger input and channel-2 of CRO to the output (Pin 3).
5. Using Function Generator, apply 1 KHz square wave with amplitude of approx. equal to 9 V_{pp} at the trigger input.
6. Observe the output voltage with respect to input and note down the pulse width and amplitude.
7. Now connect channel-2 of CRO across capacitor and observe the voltage across the capacitor and note it down.
8. Compare the practical pulse width noted in the step above with its theoretical value (t_p=1.1 RC)

Result: To studied monostable multivibrator using IC555 and to calculateed output frequency

EXPERIMENT: 9
ASTASBLE MULTIVIBRATOR USING IC555

AIM: To design an Astable Multivibrator using IC555 and compare **it's** theoretical and practical time period and duty cycle.

APPARATUS:

S.No.	Name of the component/equipment	Quantity
1	Op amp IC555	1
2	Resistances R1=10KΩ	1
3	Resistances R2=10KΩ	1
4	Capacitor C1=0.1µF	1
5	Capacitor C2=0.1µF	1
6	CRO	1
7	Function generator	1
8	Dual Regulated Power supply	2
9	Bread Board	1
10	Connecting wires	

THEORY:
An Astable multivibrator, often called a free-running Multivibrator, is a rectangular-wave-generating circuit. Unlike the Monostable multivibrator, this circuit does not require an external trigger to change the state of the output, hence the name free running. However, the time during which the output is either high or low is determinate by the Two resistors and a capacitor, which are externally connected to the 555 timer.

Figure 1 shows the 555 timer connected as an Astable multivibrator. Initially, when the output is high, capacitor C starts charging towards V_{cc} through R_A and R_B. However as soon as voltage across the capacitor equals 2/3 V_{cc}, comparator 1 triggers the flip-flop, and the output switches low. Now the capacitor C starts discharging through R_B and the transistor Q_1. When the voltage across C equals 1/3 V_{cc}**, comparator 2's output triggers the flip**-flop, and the output goes high. Then the cycle repeats. The output voltage and the capacitor voltage waveforms are shown in the following figures.

As shown in this figure, the capacitor is periodically charged and discharged between 2/3 V_{cc} and 1/3 V_{cc}, respectively. The time during which the capacitor charges from 1/3 V_{cc} to 2/3 V_{cc} is equal to the time the output is high and is given by

$$t_c = 0.69\,(R_1 + R_2)\,C \qquad (1)$$

Similarly, the time during which the capacitor discharges from 2/3 V_{cc} to 1/3 V_{cc} is equal to the time the output is low and is given by

$$t_d = 0.69\,(R_2)C \qquad (2)$$

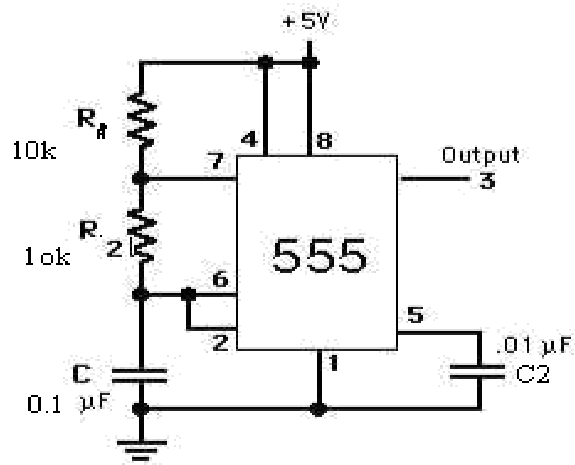
Thus the total time period of the waveform is

$$T = t_c + t_d = 0.69(R_1 + 2R_2) \qquad (3)$$

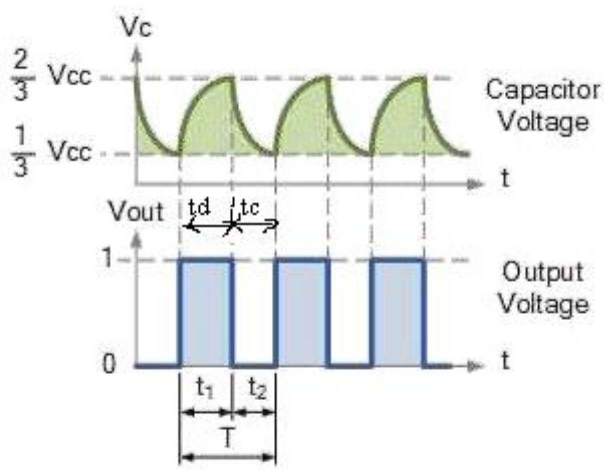
Therefore the frequency of oscillation is $f_o = 1/T = 1.45/(R_1 + 2R_2)C$

And $$\% \text{ Duty cycle} = (t_c/T) *100 \qquad (4)$$

Circuit Diagram:



Expected Wave forms:



CALCULATIONS:
THEORETICAL time periods
$t_c = 0.69 (R_1 + R_2) C$
$t_d = 0.69 (R_2)C$

Total time period of the waveform, $T = t_c + t_d$

$\%$ Duty Cycle = $(t_c / T) *1$
PRACTICAL (from output waveforms)

time period, T =
% Duty cycle

PROCEDURE:

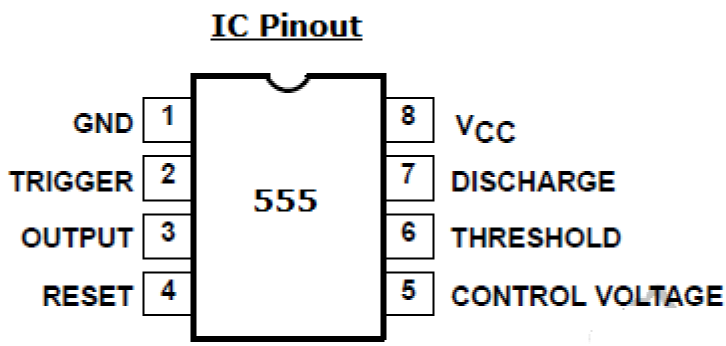
1. Connect the components/equipment as shown in the circuit diagram.
2. Switch ON the power supply.
3. Connect channel-1 of CRO to the output (Pin 3).
4. Observe the output voltage and note down the time period and duty cycle.
5. Now connect channel-2 of CRO across capacitor and observe the voltage across the capacitor and note it down.
6. Compare the practical time period and duty cycle.

Result: An Astable Multivibrator using IC555 Timer is Constructed and Studied.

VIVA QUESTIONS:

1. Define duty cycle?
Ans: The ratio of the time of the high output to the time of the total output is the duty cycle
$Duty\ Cycle = {}^{Ton}/_{Ton + Toff}$

2. Draw the pin diagram of 555 timers?
Ans:



3. What are the applications of 555 timers in monostable mode?
Ans: Missing pulse detector, Frequency divider, Pulse width modulation etc.
4. Explain capacitor output waveform in monostable mode?
Ans: Tin stable state, FF output is zero and the discharge transistor Qd is ON and the capacitor voltage is zero through Qd. Whenever a trigger is given, FF goes to high level, Qd is OFF and the Capacitor charges through R till it reaches 2/3 V_{cc} which makes the FF output to zero and the process repeats. The charging time of the capacitor from zero to 2/3 V_{cc} is the time of the pulse width.
5. Write down the expression for output pulse width in monostable mode?
Ans: $T = 1.1R_1C_1$
6. Why the number has come for 555 IC as 555?
Ans: It has three 5K Resistors at the input of the comparators to get 2/3 V_{cc} and 1/3 V_{cc}, hence the name came as 555.
7. Write down the expression for output pulse width in Astable mode?
Ans: $T = 0.69(R_A + 2R_B)C$, $T_{ON} = 0.69(R_A + R_B)C$, $T_{OFF} = 0.69R_BC$
8. What are the applications of 555 timers in Astable mode?
Ans: Square wave generator, FSK generator, pulse position modulator etc.
9. What is a quasi stable state and what is a steady state?

Ans: A quasi stable state is also known as temporary state, where the output stays in this state only for a fixed time and goes back to the stable state after that time period. A stable state is a state where the output will be in that state until unless an external trigger is given.

10. What are the other names for the Monostable Multivibrator and Astable Multivibrator?

Ans:

Monostable Multivibrator: pulse width generator, one shot, delay generator.

Astable Multivibrator: free running oscillator, clock signal, square wave generator.

EXPERIMENT: 10
SCHMITT TRIGGER CIRCUITS USING 741IC

AIM: To study the Schmitt trigger characteristics by using IC741 and compare theoretical and practical values of the Upper Threshold voltage, V_{UT} and the Lower Threshold voltage, V_{LT}.

APPARATUS:

S.No.	Name of the component/equipment	Quantity
1	Op amp IC 741	1
2	Resistances R1=1KΩ	1
3	Resistances R2=1KΩ	1
4	Resistances R3=0.5KΩ	1
5	CRO	1
6	Function generator	1
7	Dual Regulated Power supply	2
8	Bread Board	1
9	Connecting wires	

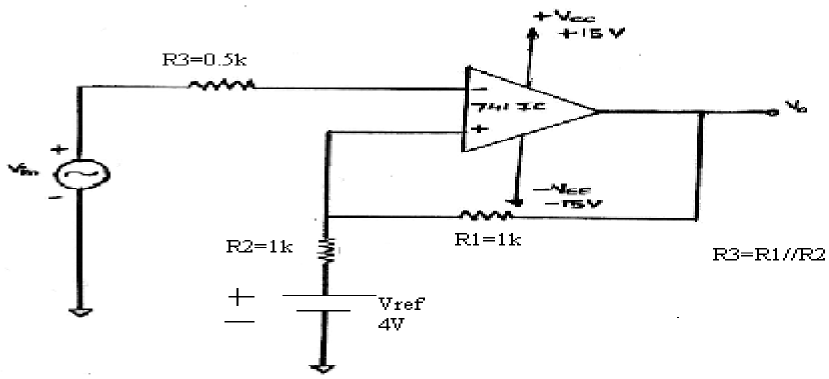
THEORY:

Circuit shows an inverting comparator with positive feedback. This circuit converts an irregular shaped waveform to square wave or pulse. This circuit is known as Schmitt trigger or Regenerative.
comparator or Squaring circuit. The input voltage V_{in} triggers (changes the state of) the output V_o every time it exceeds certain voltage levels called Upper threshold voltage, V_{UT} and Lower threshold voltage, V_{LT}. The hysteresis width is the difference between these two threshold voltages i.e. $V_{UT} – V_{LT}$. These threshold voltages are calculated as follows.

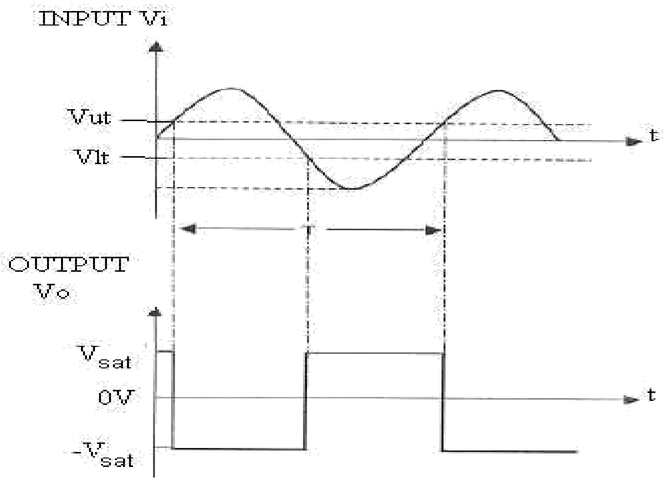
$$V_{UT} = (R_1/R_1+R_2)\ V_{sat} \qquad \text{when } V_o= V_{sat}$$
$$V_{LT} = (R_1/R_1+R_2)\ (-V_{sat}) \qquad \text{when } V_o= -V_{sat}$$

The output of Schmitt trigger is a square wave when the input is sine wave or triangular wave, where as if the input is a saw tooth wave then the output is a pulse wave.

.Circuit Diagram:



Expected Waveforms:



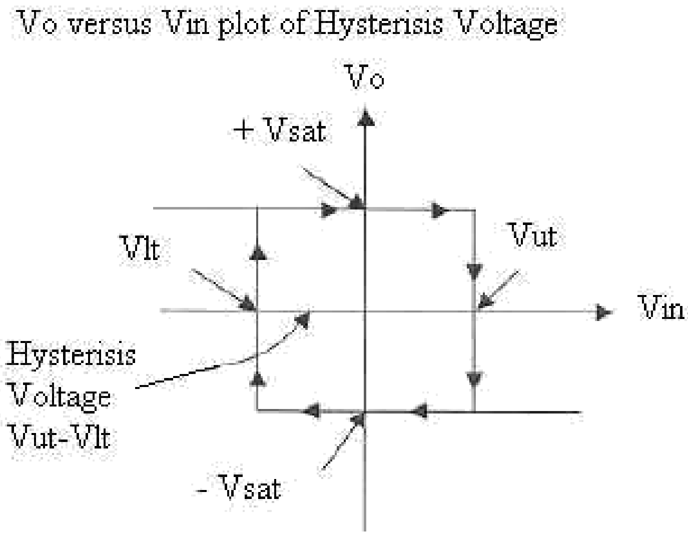


TABLE:

S.No	Theoretical Values				Practical value	
	R_1	R_2	$V_{ut}=\frac{R_1}{R_1+R_2}(+V_{sat})$	$V_{lt}=\frac{R_1}{R_1+R_2}(-V_{sat})$	V_{ut}	V_{lt}
1						
2						
3						

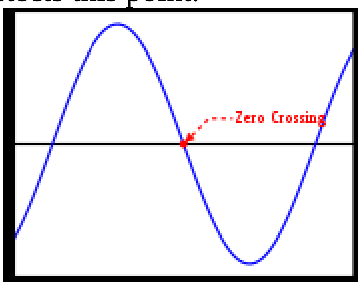
PROCEDURE:

Connect the circuit as shown in figure.
Apply +Vcc =+15V and –Vcc = – 15V to Pin 7 and 4 of 741IC
Connect the o/p of the oscillator to CRO and observe the waveform
Calculate upper trigger potential and Lower trigger potential.
Verify with theoretical value Vut =+Vsat (R2/R1+R2) and Vlt = –Vsat (R2/R1+R2).

Result: Schmitt trigger Circuit Using IC741 is Studied and Threshold Voltage and Hysteresis are recorded.

VIVA QUESIONS:

1. What are the circuits used to generate square wave?
Ans: Schmitt Trigger, Astable Multivibrator, Zero Cross Detector, PLL.
2. Short notes on zero crossing detector?
Ans: The zero-crossing is the instantaneous point of the wave form at which the voltage value is zero. In a sine wave or other simple waveform, this normally occurs twice during each cycle. Zero cross detector detects this point.



3. Define hysteresis width?
Ans: When the input is higher than a certain chosen threshold, the output is high; when the input is below a different (lower) chosen threshold, the output is low; when the input is between the two, the output retains its value. This dual threshold action is called hysteresis.
4. What are the other names for Schmitt Trigger?
Ans: Regenerative Comparator, Squarer Unit.
5. What is the duty cycle of the output square wave of the Schmitt Trigger?
Ans: 50%
6. What is a Schmitt Trigger?

Ans: Schmitt trigger is a regenerative comparator. It converts sinusoidal input into a square wave output. The output of Schmitt trigger swings at upper and lower threshold voltages, which are the reference voltages of the input waveform.

7. For what requirements, Schmitt Trigger is used?

Ans: When two levels are to be compared there may be oscillation at the border. Having hysteresis this problem is solved.

8. Define UTP and LTP. What are the values of UTP and LTP for the above circuit?

Ans: Upper threshold(Trigger) point, Lower Threshold (Trigger) points – these are the points where the input signal is compared. The values are UTP = $+V_{sat} \cdot R_2 / (R_1 + R_2)$ and LTP = $-V_{sat} \cdot R_2 / (R_1 + R_2)$

9. What is the basic difference between the comparator and Schmitt trigger?

Ans: comparator compares with a fixed reference where as Schmitt trigger compares at two different references UTP and LTP.

10. Which type of feedback is used in Schmitt trigger?

Ans: +ve feedback

EXPERIMENT: 11

IC565-PLL APPLICATIONS

AIM: To study the operation of NE565 PLL
To use NE565 as a multiplier

EQUIPMENTS AND COMPONENTS:

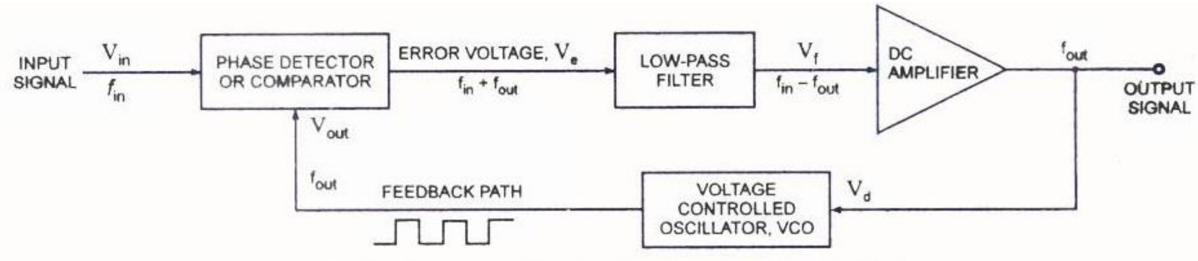
S.No.	Name of the component/equipment	Quantity
1	Op amp IC 741	1
2	Resistances R=10KΩ	1
3	Resistances R=680Ω	1
4	Resistances R1=10KΩ	1
5	Capacitor C=1μF	1
6	Capacitor C1=0.01μF	1
7	CRO	1
8	Function generator	1
9	Dual Regulated Power supply	2
10	Bread Board	1
11	Connecting wires	

THEORY

The 565 is available as a14-pin DIP package. It is produced by Signatic Corporation. The output frequency of the VCO can be rewritten as

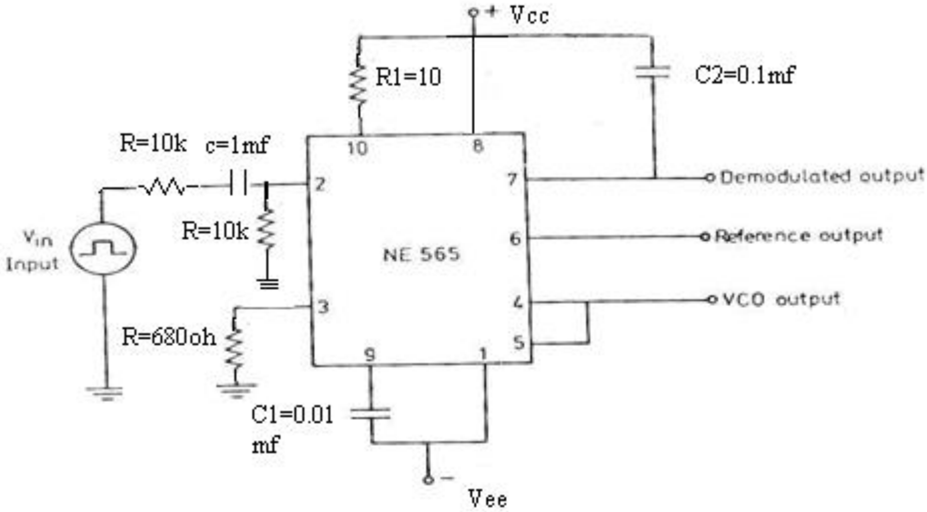
$$f_o = 0.25 / R_T C_T \text{ Hz.}$$

Where R_T and $C_T$are the external resistor and capacitor connected to pin8 and pin9. A value between 2k and 20k is recommended for R_T .The VCO free running frequency is adjusted with R_T and C_T to be at the centre for the input frequency range.



Block Diagram of Basic Phase-Locked Loop (PLL)

Circuit diagram



PROCEDURE:

i. Connect the circuit using the component values as shown in the figure

ii. Measure the free running frequency of VCO at pin 4 with the input signal Vin set = zero. Compare it with the calculated value = 0.25/ RTCT

iii. Now apply the input signal of 1Vpp square wave at a 1kHz to pin 2

iv. Connect 1 channel of the scope to pin 2 and display this signal on the scope

v. Gradually increase the input frequency till the PLL is locked to the input frequency. This frequency f1gives the lower ends of the capture range. Go on increase the input frequency, till PLL tracks the input signal, say to a frequency f2. This frequency f2 gives the upper end of the lock range. If the input frequency is increased further the loop will get unlocked.

vi. Now gradually decrease the input frequency till the PLL is again locked. This is the frequency f3, the upper end of the capture range. Keep on decreasing the input frequency until the loop is unlocked. This frequency f4 gives the lower end of the lock range

The lock range □fL = (f2 – f4) compare it with the calculated value of □ 7.8 fo 12

Also the capture range is □fc = (f3 – f1). Compare it with the calculated value of capture range.

viii. To use PLL as a multiplie5r, make connections as showin in fig. The circuit uses a 4-bit binary counter 7490 used as a divide-by-5 circuit.

ix. Set the input signal at 1Vpp square wave at 500Hz

Vary the VCO frequency by adjusting the 20K□ potentiometer till the PLL is locked. Measure the output frequency

Repeat step 9 and 10 for input frequency of 1kHz and 1.5kHz.

OBSERVATIONS:

fo = __________ fL = __________ fC = __________

RESULT: Hence Verified theoretical and Practical Values. Successfully Verified PLL and Capture Range, Lock Range and Free Running (VCO) Frequency.

fo = __________
fL = __________
fC = __________

VIVA QUESTIONS:

1. What are the basic blocks of a PLL?
Ans: A phase detector, low pass filter, amplifier and a V_{CO} in feedback loop.
2. Define V_{CO}?
Ans: A voltage controlled oscillator is an oscillator circuit in which the frequency of oscillations is controlled by an externally applied voltage.
3. What is the formula for the free running frequency F_o of 565 PLL?
Ans:

$$f_O \simeq \frac{1.2}{4R_1C_1}$$

4. What is PLL?
Ans: A PLL is a closed loop system designed to lock output frequency and phase to the frequency and phase of an input signal.
5. Define lock range?
Ans: When PLL is in lock, it can track frequency changes in the incoming signal. The range of frequencies over which the PLL can maintain lock with the incoming signal is called as lock range.
6. Define pull-in time?
Ans: The total time taken by the PLL to establish lock is called pull-in time.
7. Define capture range?
Ans: The range of frequencies over which the PLL can acquire lock with the input signal is called as capture range.
8. What is the function of the LPF in PLL?
Ans: Controls the capture range and lock range of PLL.
9. What are the applications of PLL?
Ans: Frequency multiplication / Division, Frequency translation, AM detection, FM Demodulation, FSK Demodulator etc.
10. Which is greater – lock in range or capture range?
Ans: Lock in Range.

EXPERIMENT No: 12
VOLTAGE REGULATOR USING IC 723, THREE TERMINAL VOLTAGE REGULATORS – 7805, 7809, 7912

AIM: To study the Fixed Voltage Regulators (1) 7805
(2) 7809
(3) 7812
(4) 7912
(5) 723 Variable Voltage Regulator

Theory:

DC power for electronic circuits is most conveniently obtained from commercial ac lines by using rectifier - filter system, called a dc power supply. The rectifier-filter combination constitutes an ordinary dc power supply . The dc voltage from an ordinary power supply remains constant so long as ac mains voltage or load is unaltered . However, in many electronic applications, it is desired that dc voltage should remain constant irrespective of changes in ac mains or load. Under such situations, voltage regulating devices are used with ordinary power supply. This constitutes regulated dc power supply and keeps the dc voltage at fairly constant value.

ORDINARY DC POWER SUPPLY

An ordinary or regulated dc power supply contains a rectifier and a filter circuit as shown in Fig-1. The output from the rectifier is pulsating dc. These pulsations are due to the presence of ac component in the rectifier output. The filter circuit removes the ac component so that steady dc voltage is obtained across the load.

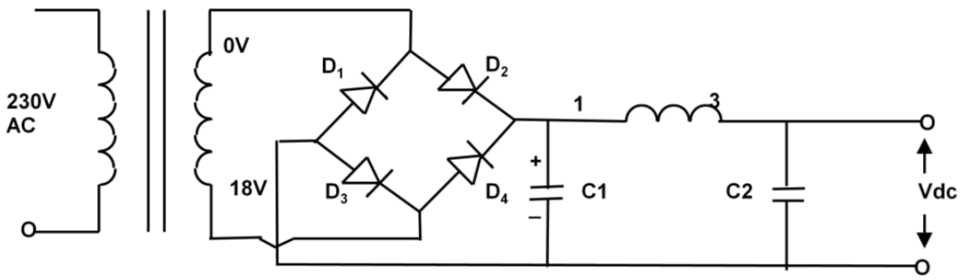
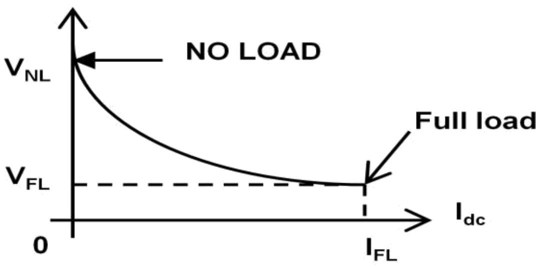


Fig -1.

Limitations : An ordinary dc power supply has two following drawbacks:
1. The dc output voltage changes directly with input ac voltage.
2. The dc output voltage decreases as the load current increases. This is due to voltage drop in (a) Transformer windings (b) Rectifier (c) Filter circuit

These variations in dc output voltage may cause inaccurate or erratic operation or even malfunctioning of many electronic circuits. Eg. In an oscillator, the frequency will shift and in transmitters, distorted output will result, Therefore, ordinary power supply is unsuited for many applications and is being replaced by regulated power supply.



% voltage regulation = $(V_{NL} - V_{FL}) / V_{FL} * 100$ V_{NL} = dc output voltage at no load.
V_{FL} = dc output voltage at full load

HARDWARE SPECIFICATIONS

1. Built - in 16V - 0 - 16V / 350mA 12V
   - 0 - 12V / 350mA
   8V - 0 - 8V / 350mA AC sources
2. Bridge rectifier using IN4007 diodes - 1No.

3. Filter capacitors (470□F / 35V) - 2Nos.
4. Fixed Voltage Regulator 7805 - 1No.
   7809 - 1No.
   7812 - 1No.

   7912 - 1No.
5. Variable Voltage Regulator using 723 IC

PROCEDURE:

1. Connect the circuit as shown in fig
2. Connect different load resistors available in the front panel, note down the output current and voltage.
3. Also test the circuit with 12V - 0 - 12V, 16V - 0 - 16V AC sources also.
4. Remove 7805 and connect 7809, 7812 also repeat 2 and 3 steps.

CIRCUIT DIAGRAMS:

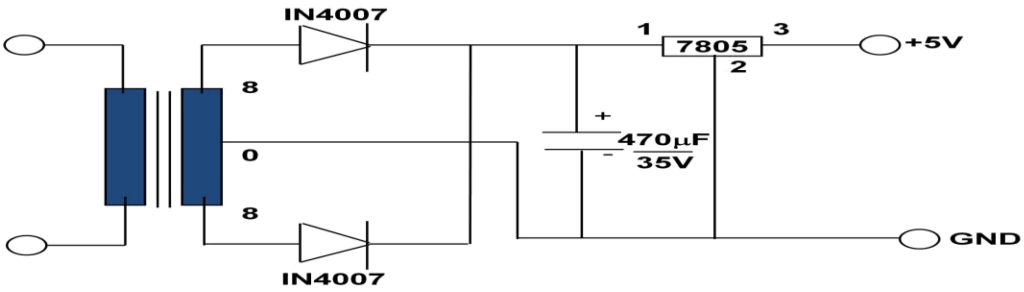


Fig - 4

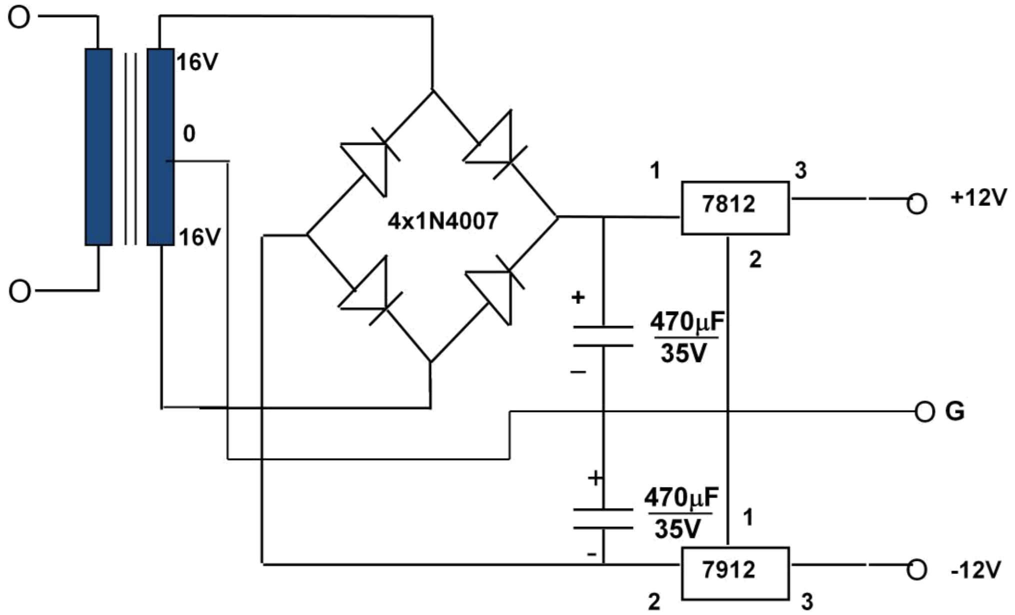


Fig - 5

RESULT: Hence verified theoretical and Practical Values of Voltage Regulator.

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(i) RC PHASE SHIFT OSCILLATOR

I. AIM:

To Design a RC Phase Shift Oscillator for the output frequency is 200 Hz.

II. *EQUIPMENTS AND COMPONENTS: (i).*

APPARATUS

1. CRO (Dual channel) - 1 No
2. Bread Board – 1 No
3. Dual Channel Power Supply – 1 No

1. CRO: The 20 MHz dual channel oscilloscope 201 is a compact, low line and light weight instrument. It is a general purpose Dual Trace Oscilloscope having both vertical amplifiers offering a bandwidth of DC-20 MHz and maximum sensitivity of 2mv/cm. The 201 offers five separate add-on modules.

- Frequency counter
- Curve Tracer
- Power Supply
- Function Generator
- Digital Voltmeter

The add-on modular enhance measuring capabilities of instrument at low cost.

2. Bread Board : Wire Connections are usually carried out using a system called Bread Board. It is a rectangular array of holes with internal connections divided into a number of nodes. This component divided into a number of modes. This component has a provision on which any circuit can be constructed by interconnecting components such as registers, capacitors, diodes, transistors etc., for testing the circuit.

4. Dual channel power supply: this power supply unit is specially developed for laboratory use, where low ripple and noise and high voltage regulation is to be maintained both the voltage or current is indicated by the panel meter. The outputs are floating, current limited, self recovery on removal of fault this is a cv/cc type power supply employing a well known series regulator technique. The unit operates on a supply voltage of 230v, 1 amp, 50Hz, single phase AC.

iii. COMPONENTS:

1. 3.3kΩ Resistor – 1 No.
2. 33kΩ Resistor – 1 No.
3. 1MΩ Resistor – 1 No.
4. 0.1 μF Capacitor – 1 No.
5. Operational Amplifier – 1 No.

iv. DESCRIPTION OF COMPONENTS:

1. 3.3kΩ Resistor – 1No.

Most circuits need contrast resistances. There are different types of resistors available for different applications. Typical specifications of 3.3kΩ resistor are
Rating: 3.3kΩ to 10kΩ
Wattage: ¼ W to 2 W
Tolerance: Normally ±5% and above.

2. 33kΩ Resistor – 1No.

Most circuits need contrast resistances. There are different types of resistors available for different applications. Typical specifications of 33kΩ resistor are
Rating: 33kΩ to 10MΩ
Wattage: ¼ W to 2 W
Tolerance: Normally ±5% and above.

3. 1M Ω Resistor – 1No.

Most circuits need contrast resistances. There are different types of resistors available for different applications. Typical specifications of 1MΩ resistor are
Rating: 1MΩ to 10MΩ
Wattage: ¼ W to 2 W
Tolerance: Normally ±5% and above.

4. 0.1 μF Capacitor –1 No.

Capacitors are made by sandwiching an insulating material between two conductors which from the electrodes. These are rated by their maximum working voltage. The breakdown voltage depends upon temperature and hence upon the losses in the dielectric.
The factors to be considered in the choice of capacitors are
1) Required Capacity
2) Working Voltage
3) Tolerances
The Specifications of 0.1 μF capacitor are
1) Capacity – 0.1 μF
2) Voltage range 16v to 3kv
3) Tolerance ±10%

5. Operational Amplifier

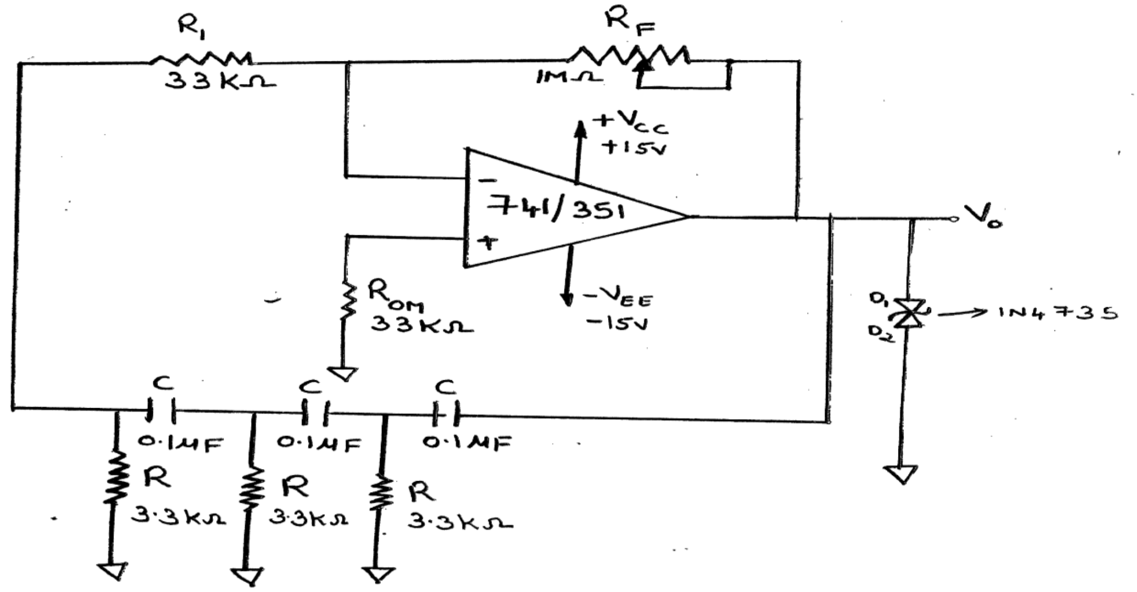
The operational amplifier has five basic terminals that is two input terminals one output terminal and two power supply terminals. The terminal with a (-) sign is called inverting input terminal and the terminal with (+) sign is called non-inverting input terminal.

741C (Commercial grade op-amp)
Operating temperature range 0 to 75 degrees centigrade

III. *THEORY:*

The Phase Shift Oscillator consist of an operational amplifier as the amplifying stage and three RC cascaded networks as the feed back circuits the amplifier will provide 180 degrees phase shift. The feed back network will provide another phase shift of 180 degrees.

IV. *CIRCUIT DIAGRAM:*



V. PROCEDURE:

i. Construct the circuit as shown in the circuit diagram.
ii. Adjust the potentiometer R_f such that an output wave form is obtained.
iii. Calculate the output wave form frequency and peak to peak voltage.
iv. Compare the theoretical and practical values of the output waveform frequency.

VI. *OBSERVATIONS:*

The frequency of oscillation = _______

VII. *CALCULATIONS:*

i. The frequency of oscillation f_o is given by

ii. The frequency of oscillation f_o is given by

$$f_o = \frac{1}{2\pi\sqrt{6}RC} = \frac{0.065}{RC}$$

iii. The gain A_v at the above frequency must be at least 29

i.e.

$$\frac{R_F}{R_1} = 29$$

i.

$f_o = 200Hz$

Let C = 0.1μF Then

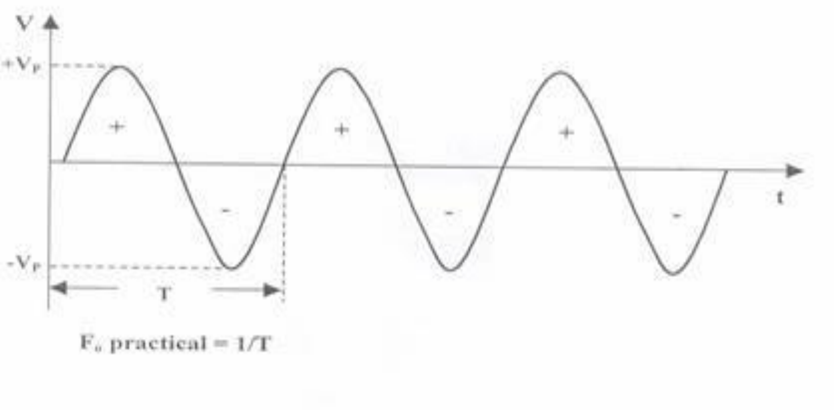
$$R = \frac{0.065}{200X10^{-7}} = 3.25k\Omega \text{ (choose } 3.3k\Omega)$$

To prevent loading of the amplifier because of RC networks it is necessary that

$R_1 \geq 10R$ Therefore $R_1 = 10R = 33\ k\Omega$

Then $R_F = 29\ (33\ k\Omega) = 957\ k\Omega$ (choose $R_F = 1M\Omega$)

GRAPH:



The frequency of oscillation of the **RESULT:**

VII RESULT:

The frequency of oscillation of the RC phase shift oscillator = -- Hz

IX INFERENCE:

i. The working of RC phase shift oscillator is observed and the output is plotted.
ii. The frequency response of the RC phase shift oscillator is plotted
iii. It is observed that the gain doesn’t sustain beyond 5 KHz

X PRECAUTIONS:

i. Check the circuit connections before switching on the power supply.
ii. Pin No.1 and Pin No.8 should be left free.
iii. Check the continuity of the connecting wires.

(ii) WEIN BRIDGE OSCILLATOR

I. **AIM:** To Design Wein Bridge Oscillator so that the output frequency is 965 Hz.

II. *EQUIPMENTS AND COMPONENTS:*

(i) APPARATUS

1. CRO (Dual channel) - 1 No
2. Bread Board – 1 No
3. Dual Channel Power Supply – 1 No

1. CRO: The 20 MHz dual channel oscilloscope 201 is a compact, low line and light weight instrument. It is a general purpose Dual Trace Oscilloscope having both vertical amplifiers offering a bandwidth of DC-20 MHz and maximum sensitivity of 2mv/cm. The 201 offers five separate add-on modules.

- Frequency counter
- Curve Tracer
- Power Supply
- Function Generator
- Digital Voltmeter

The add-on modular enhance measuring capabilities of instrument at low cost.

2. Bread Board: Wire Connections are usually carried out using a system called Bread Board. It is a rectangular array of holes with internal connections divided into a number of nodes. This component divided into a number of modes. This component has a provision on which any circuit can be constructed by interconnecting components such as registers, capacitors, diodes, and transistors etc., for testing the circuit.

3. Dual channel power supply: this power supply unit is specially developed for laboratory use, where low ripple and noise and high voltage regulation is to be maintained both the voltage or current is indicated by the panel meter. The outputs are floating, current limited, self recovery on removal of fault this is a cv/cc type power supply employing a well known series regulator technique. The unit operates on a supply voltage of 230v, 1 amp, 50Hz, single phase AC.

iii. COMPONENTS:

1. 12kΩ Resistor – 1 No.
2. 50kΩ Resistor – 1 No.
3. 3.3kΩ Resistor – 1 No.
4. 0.05μF Capacitor – 1 No.

5. Operational Amplifier – 1 No.

iv. DESCRIPTION OF COMPONENTS:

1. 12kΩ Resistor – 1 No.

Most circuits need contrast resistances. There are different types of resistors available for different applications. Typical specifications of 12kΩ resistor are
Rating: 12kΩ to 20kΩ
Wattage: ¼ W to 2 W
Tolerance: Normally ±5% and above.

2. 50kΩ Resistor – 1 No.

Most circuits need contrast resistances. There are different types of resistors available for different applications. Typical specifications of 50kΩ resistor are
Rating: 50kΩ to 10MΩ
Wattage: ¼ W to 2 W
Tolerance: Normally ±5% and above.

3. 3.3 kΩ Resistor – 1 No.

Most circuits need contrast resistances. There are different types of resistors available for different applications. Typical specifications of 3.3.kΩ resistor are
Rating: 3.3kΩ to 6kΩ
Wattage: ¼ W to 2 W
Tolerance: Normally ±5% and above.

4. 0.05 µF Capacitor –1 No.

Capacitors are made by sandwiching an insulating material between two conductors which from the electrodes. These are rated by their maximum working voltage. The breakdown voltage depends upon temperature and hence upon the losses in the dielectric.

The factors to be considered in the choice of capacitors are
1) Required Capacity
2) Working Voltage
3) Tolerances

The Specifications of 0.5 µF capacitor are
1) Capacity – 0.5 µF
2) Voltage range 16v to 3kv
3) Tolerance ±10%

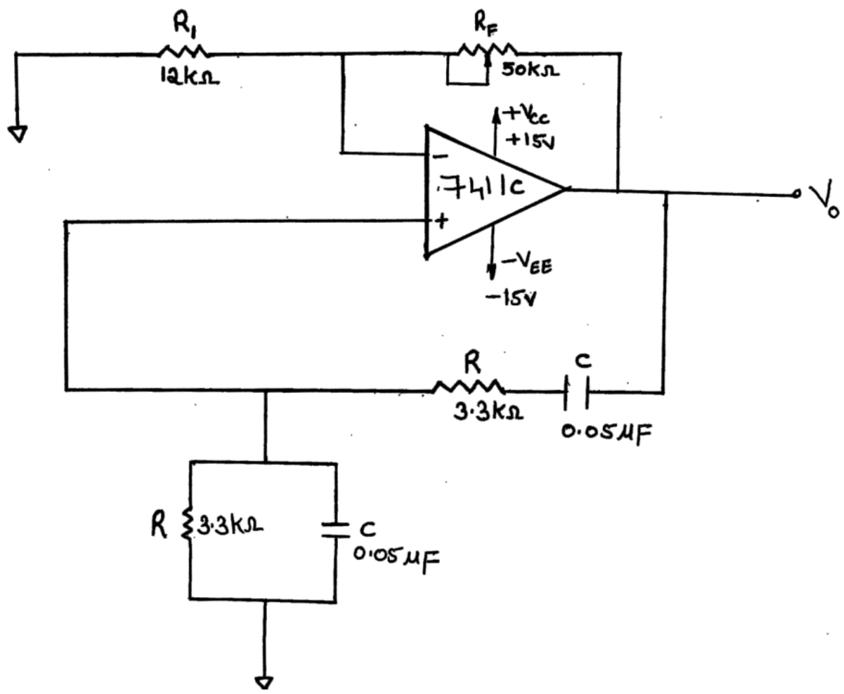
5. Operational Amplifier

The operational amplifier has five basic terminals that is two input terminals one output terminal and two power supply terminals. The terminal with a (-) sign is called inverting input terminal and the terminal with (+) sign is called non-inverting input terminal.
741C (Commercial grade op-amp)
Operating temperature range 0 to 75 degrees centigrade

III. *THEORY:*

In this oscillator the Wein Bridge Circuit is connected between the amplifier input terminals and the output terminal. The bridge has a series RC network in one arm and parallel RC network in the adjoining arm. In the remaining two arms of the bridge resistors R1 and RF are connected. The total phase-shift around the circuit is 0^o when the bridge is balanced.

IV. *CIRCUIT DIAGRAM:*



V. **PROCEDURE:**

i. Construct the circuit as shown in the circuit diagram.
ii. Adjust the potentiometer R_f such that an output wave form is obtained.
iii. Calculate the output wave form frequency and peak to peak voltage.
iv. Compare the theoretical and practical values of the output waveform frequency.

VI. *OBSERVATIONS:*

The frequency of oscillation = _______

VII. *CALCULATIONS:*

The frequency of oscillation f_o is exactly the resonant frequency of the balanced Wein Bridge and is given by $f_o = 1/(2\pi RC)$

= 0.159 / RC

The gain required for sustained oscillations is given by A_v= 3. i.e., $R_f = 2R_1$

Let C = 0.05 μF

Then f_o = 1/ (2πRC)

→ R = 1/ ($2\pi f_o C$)

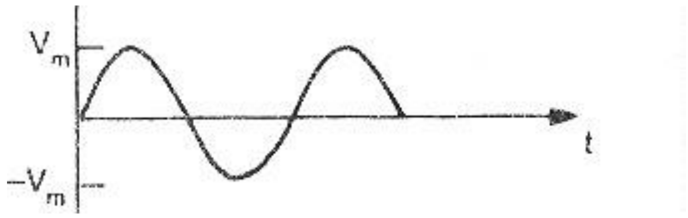
→ = 3.3 k Ω

Now let R_1 = 12 kΩ

Then $R_f = 2R_1$ = 24 kΩ

Use R_f = 50 kΩ potential meter.

VIII. *GRAPH:*



IX. RESULT:

The frequency of oscillation of the Wein Bridge oscillator =----------

X. *INFERENCE:*

i. The working of Wein Bridge oscillator is observed and the output is plotted.
ii. The frequency response of the Wein Bridge oscillator is plotted
iii. It is observed that the gain doesn't sustain beyond 5 KHz

XI. *PRECAUTIONS:*

i. Check the circuit connections before switching on the power supply.
ii. Pin No.1 and Pin No.8 should be left free.
iii. Check the continuity of the connecting wires.

XII. *APPLICATIONS:*

These are used in sine wave oscillators for audio frequencies

Generally they are used in the application of function generators.

XIII. EXTENSION:

i. Design the circuit for different frequencies of oscillations.
ii. For higher frequencies the gain does not sustain and should be observed.

XIV. REVIEW QUESTIONS

i. State the two conditions of oscillations
ii. Classify the oscillators
iii. What is the phase shift in case of the phase shift oscillator?
iv. Explain how to measure the phase difference of two signals
v. In WEIN BRIDGE oscillator what phase shift does the opamp provide?
vi. In what mode the opamp is used in the wein bridge oscillator?
vii. What phase shift is provided by the feedback network?
viii. What is the minimum gain that the inverting opamp should have?
ix. For high frequencies which kind of opamp should be used?
x. What is the condition for so that the oscillations will not die out?