WOLLO UNIVERSITY

KOMBOLCHA INSTITUTE OF TECHNOLOGY

KOMBOLCHA
ETHIOPIA

ELECTRICAL ENGINEERING LABORATORY III MANUAL

DEPARTMENT
OF
ELECTRICAL & COMPUTER ENGINEERING

ELECTRICAL ENGINEERING LABORATORY III MANUAL

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Preface

This document has been prepared to serve as a laboratory manual for Electrical Engineering Laboratory-III for Electrical and Computer Engineering students with a purpose to provide the students with “hands-on” experience in the application of electronic principles through the design, construction, and implementation of several electronic circuits. The experiments cover relevant topics prescribed in the syllabus and are designed to reinforce the theoretical concepts taught in the classroom with practical experience in the lab. This lab manual can be used as instructional book for students, staff and instructors to assist in performing and understanding the experiments.

Acknowledgement

In the first place we would like to express our hearty thanks to God Almighty for giving us the inner strength, courage and ability to bring out this manual.

We would like to express our profound gratitude and deep regards to the support offered by our Deputy Scientific Director, Mr. Yichalewal Goshime.

We also express our deep sense of gratitude to our Engineering College Dean, Mr. Andualem Ali Yimam for his professional advice & guidance.

We would like to express our sincere thanks to the staff members of our Department for their encouragement and kind support.

We would like to express our gratitude to all the people who saw us through this book, to all those who provided support, talked things over, read, wrote and offered comments.

Last but not the least, we would like to thank all those who were directly or indirectly involved in helping us to bring out this manual successfully.

Abiy Tadesse Abebe & Shaik Irfan

CONTENTS

INTRODUCTION:

The objective of this laboratory manual is to make the students experimentally familiar with the operation of various electronic components and circuits .Students will understand the importance of negative feedback in amplifiers ,positive feedback and its applications in oscillators, switching circuits and triggering circuits by studying the properties of the fundamental amplifier building blocks using commercially available Operational Amplifiers and advanced Opamp configurations commonly found in practical applications. After completing this course the student will be able to analyze circuits experimentally and also learns the application of circuits in practical fields.

LABORATORY INSTRUCTIONS:

(i) Preparation : - Students should read, prepare, and understand the experiment before coming to lab.

(ii) Discipline : - Attendance on time in lab as scheduled is important.
- Each group in the lab is responsible for their bench condition (arrangement, cleaning, etc.) after finishing the experiment.

(iii) Reports: -The student is requested to submit a written formal report of the experiment in the next session .

LABORATORY SAFETY:

-Safety in the electrical engineering laboratory, as everywhere else, is a matter of the knowledge of potential hazards, following safety regulations and precautions, and common sense.

- Observing safety precautions is important due to pronounced hazards in any electrical engineering laboratory.

- Practice electrical safety at all times while constructing, analyzing and troubleshooting circuitry.

- Do not accompany any drinks or water with you inside the Lab.

- If you observed an electrical hazard in the lab area – NOTIFY THE INSTRUCTOR/LAB ASSISTANT IMMEDIATELY!

- Acquaint yourself with the location of the following safety items within the lab:
a. Fire extinguisher
b. First aid kit
c. Fire-exit

SAFETY PRECAUTIONS :

Precautions to be taken before powering the circuit

- Check for all the connections of the circuit and scope connections before powering the circuit, to avoid shorting or any ground looping, that may lead to electrical shocks or damage of equipment.
- Check any connections for shorting two different voltage levels.
- Double check your wiring and circuit connections. It is a good idea to use a point- to point wiring diagram to review when making these checks.

Precautions while switching ON the circuit

- Apply low voltages or low power to check proper functionality of circuits.
- Once functionality is proven, increase voltages or power, stopping at frequent levels to check for proper functioning of circuit or for any components is hot or for any electrical noise that can affect the circuit's operation.

Precautions while switching off or shutting down the circuit

- Reduce the voltage or power slowly till it comes to zero.
- Switch of all the power supplies and remove the power supply connections.
- Let the load be connected at the output for some time, so that it helps to discharge capacitor or inductor if any, completely.

Other Precautions

- No loose wires or metal pieces should be lying on table or near the circuit, to cause shorts and sparking.
- Avoid using long wires, that may get in your way while making adjustments or changing leads.
- Keep high voltage parts and connections out of the way from accidental touching and from any contacts to test equipment or any parts, connected to other voltage levels.
- When working with inductive circuits, reduce voltages or currents to near zero before switching open the circuits.
- BE AWARE of bracelets, rings, metal watch bands, and loose necklace (if you are wearing any of them), they conduct electricity and can cause burns. Do not wear them near an energized circuit.

- When working with energized circuits (while operating switches, adjusting controls, adjusting test equipment), use only one hand while keeping the rest of your body away from conducting surfaces.

HOW TO WRITE A LAB REPORT

A lab report for each experiment is to be submitted by each member (student) of a team one week after the lab session is completed. The lab report must contain the following:

1. Cover page containing:

   • Electronics Lab:
   • Experiment #______
   • Experiment Title: _________________________________
   • Group #: ___________
   • Your Name: ________________ & I.D. #: _________________

2. Objectives: Not copied from the lab manual

3. Specifications of Equipment Used:

4. Block Diagram or Circuit Diagram should be included

5. Formulae / Design if any, is to be given.

6. Procedure: Steps you did in the lab. It is not copied from the lab manual

7. Result or Analysis: Compare the Pre-lab results with those obtained in the experiment. Summary of what you discovered

8. Answers to Questions: Answer to observation questions in the lab experiment, lab review questions and lab safety review questions at the end of the experiment .

9. Conclusion: The conclusions based on the experiment and other observations must be clearly discussed in the laboratory report.

10. Remarks or Comments: You may write your comments regarding your experience of each lab experiment.

(The laboratory report will be graded for content and written English)

IDENTIFICATION OF CIRCUIT COMPONENTS

The experiments in this lab manual are designed to introduce various aspects of electronics starting from the simplest concepts such as Ohm's law and leading to practical electronic circuits including amplifiers, integrated circuits, waveform generators and oscillators. Each lab script is intended for a three-hour lab period. Some students may need more time to complete the labs, especially at the beginning when the equipment is still unfamiliar. The time can be used more efficiently if the student prepares in advance by reading the script.

Each workstation in the lab has the necessary equipment: an oscilloscope, a function (signal) generator, a multimeter and an experimental box. The multimeter can measure voltage, current, resistance and capacitance. The experimental box includes +/-15 V power supplies for operational amplifiers and a +5 V constant supply.

BREAD BOARD:

The bread board area on the experimental box has holes for component leads, #22 solid wire and ic pins. Don't try to force larger wire into these hole because it will spring them too far and ruin the board.

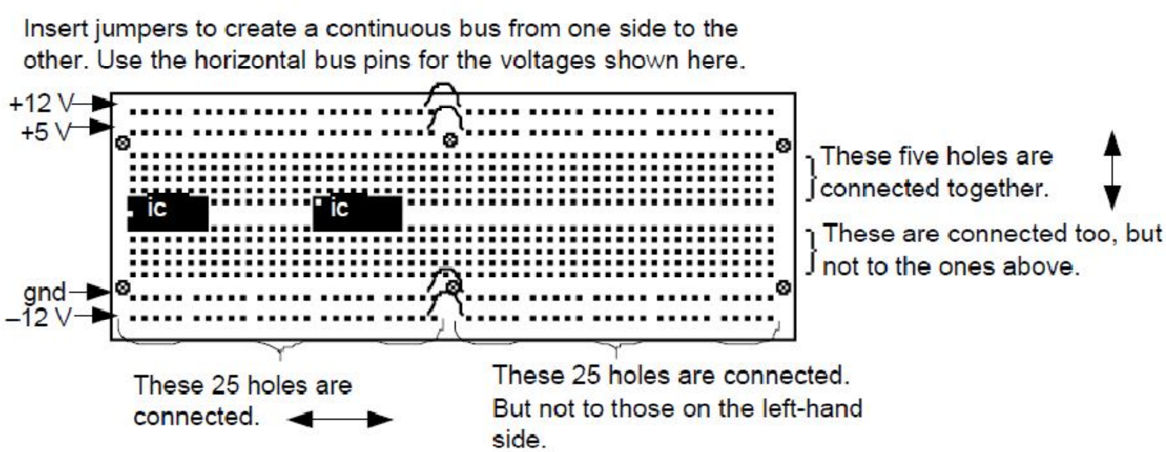


Fig: The Bread Board Area

The horizontal rows of holes on the top and bottom of the breadboard are connected together horizontally. The left and right halves are independent. We suggest that you use these horizontal rows for power supply voltages and ground. You may wish to put a jumper wire between the left and right halves so that the voltages are the same across the board. The vertical columns of holes are connected electrically in groups of five along a vertical line. The top and bottom halves are independent. Typically one inserts an ic chip straddling the centre trough. There are then four empty holes for making connections to each ic pin. When you plug ic's into the breadboard, a common convention is to put pin 1 on the left. For other components, make sure the leads are not in the same column of five unless you want them connected together.

OSCILLOSCOPE:

The oscilloscope has many knobs and buttons which may be confusing at first. It helps if you read this. If nothing seems to be happening press AUTOSTART.

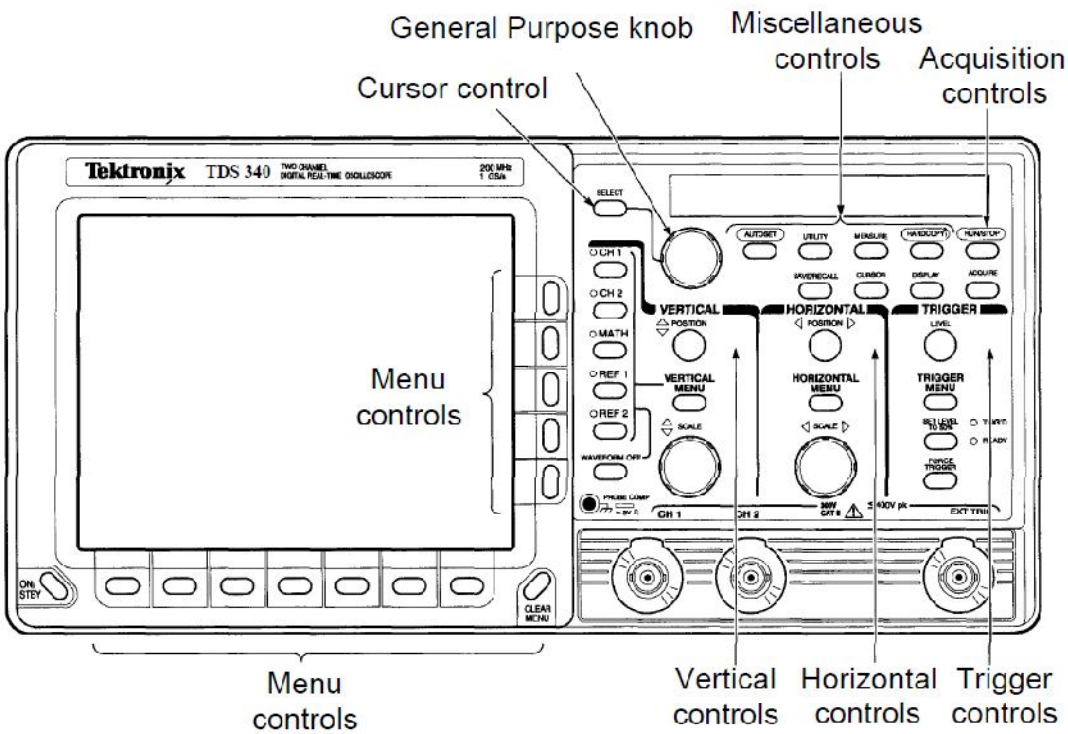


Fig: Oscilloscope front view

Learn how to show two signals on the oscilloscope display:

Adjust the function generator to produce a sine wave set the amplitude to 2 Vpp. Apply the sine wave signal from the function generator to Channel 1 of the oscilloscope. Simultaineously apply the SYNCH output signal of the function generator to Channel 2. Press, in sequence, the oscilloscope's AUTOSET, CLEAR

MENU and CH 1 buttons. AUTOSET should configure the scope to measure the signals coming into the inputs. The CLEAR MENU and CH 1 buttons ensure that the display is clean and your next operations will affect the CH 1 display. The green light next to CH 1 should be lit. You should see a 2 Vpp signal displayed on the CH 1 trace and a square wave displayed on the CH 2 trace.

Learn how to change the scale and position of the waveforms:

Turn the SCALE knob under VERTICAL. Notice how the display changes. The V/DIV legend beneath the display reflects the scale changes. Adjust the CH 1 scale to 1 V/div. Press CH 2 and investigate the VERTICAL SCALE adjustment as before and leave CH 2 on 1 V/div. Press CH 1. Play with the VERTICAL POSITION knob. Turn the HORIZONTAL SCALE knob and note how the displayed waveform changes. The legend beneath the display reflects the change in sweep rate. Move the trance left and right with the HORIZONTAL POSITION control.

After you have changed a few settings you should be able to return to the original configuration by pressing AUTOSET. The result of AUTOSET depends on the signals which input to the oscilloscope, so if you have changed the function generator output in any way AUTOSET will result in a different configuration.

Learn how to measure frequency:

Assuming that the horizontal time base is accurately calibrated. Centre the displayed waveform about a horizontal line. Measure the period from zero zero crossing to zero crossing and calculate the frequency. Compare with the value obtained using the MEASURE menu and from the function generator readout.

Learn how to Print:

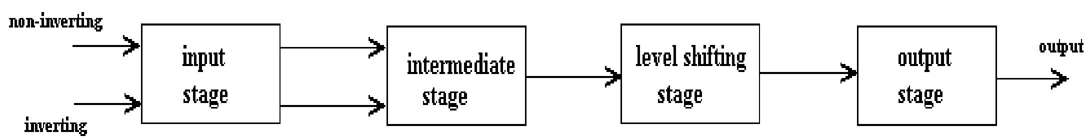
You can print the scope display on a printer using the HARDCOPY function. This is useful for recording results to put in your lab book. Before using HARDCOPY you must ensure that the output port and printing options are correctly configured. Use the UTILITY — I/O menu to select the hardcopy port (e.g., Centronics), Layout (e.g., portrait) and Hard Copy format (e.g., Epson printer)

IC 741 OP-AMP :

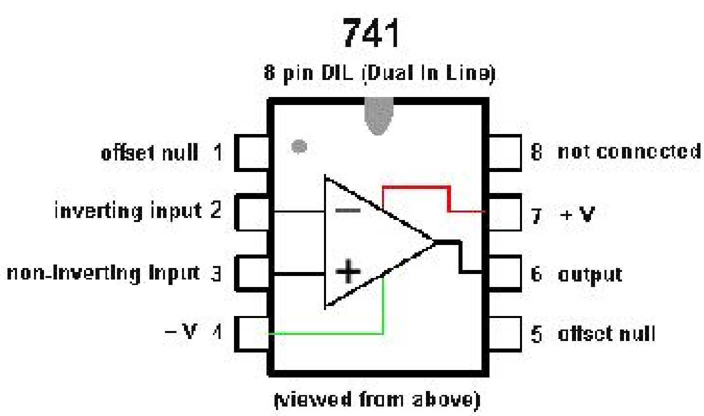
General Description:

The operational amplifier is a versatile device that can be used to amplify DC as well as AC input signals and was originally designed for performing mathematical operations such as addition, subtraction, multiplication, and integration. Thus the name operational amplifier seems from its original use for these mathematical operations and is abbreviated to op-amp. With the addition of suitable external feedback components, the modern day op-amp can be used for a variety of applications, such as AC and DC signal amplification, active filters, oscillators, comparators, Schmitt trigger, regulator, integrator, differentiator.
Generally, operational amplifiers are extremely high voltage gain circuits and they are standard building blocks of analogue circuits. The most commonly used op-amp is IC741.

Block Diagram Of Op-Amp:



Let's see the pin configuration and testing of 741 op-amps. Usually, this is a numbered counter clockwise around the chip. It is an 8 pin IC. They provide superior performance in integrator, summing amplifier and general feedback applications.



It is a 8-pin dual-in-line package with a pinout shown above.

Pin 1: Offset null.
Pin 2: Inverting input terminal.
Pin 3: Non-inverting input terminal.
Pin 4: –VCC (negative voltage supply).
Pin 5: Offset null.
Pin 6: Output voltage.
Pin 7: +VCC (positive voltage supply).
Pin 8: No Connection.

Features:

1. No frequency compensation required.
2. Short circuit protection
3. Offset voltage null capability
4. Large common mode and differential voltage ranges
5. Low power consumption
6. No latch-up

Specifications:

1. Voltage gain A = α typically 2,00,000
2. I/P resistance R_L = α Ω, practically 2MΩ
3. O/P resistance R =0, practically 75Ω
4. Bandwidth = α Hz. It can be operated at any frequency
5. Common mode rejection ratio = α (Ability of op amp to reject noise voltage)
6. Slew rate + α V/μsec (Rate of change of O/P voltage)

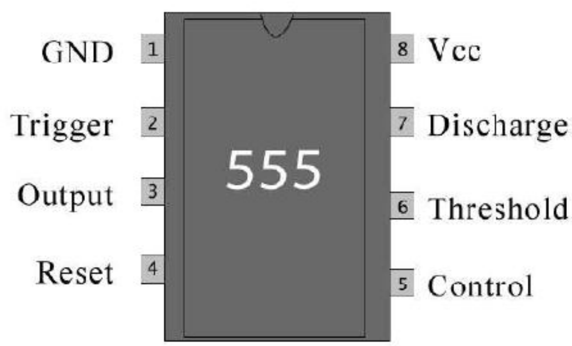
Applications:

1. AC and DC amplifiers
2. Active filters
3. Oscillators
4. Comparators and Regulators

IC 555-TIMER :

555-Timer is a very commonly used IC for generating accurate timing pulses. Let's see the pin configuration of 555 Timer. Usually, this is a numbered counter clockwise around the chip. It is an 8 pin IC packed in dual-in-line package.

Pin Configuration:



Function of Various Pins of 555 IC:

Pin (1) of 555 is the ground terminal; all the voltages are measured with respect to this pin.

Pin (2) of 555 is the trigger terminal, If the voltage at this terminal is held greater than one-third of V_{CC}, the output remains low. A negative going pulse from V_{cc} to less than $V_{ec}/3$ triggers the output to go High. The amplitude of the pulse should be able to make the comparator (inside the IC) change its state. However the width of the negative going pulse must not be greater than the width of the expected output pulse.

Pin (3) is the output terminal of IC 555. There are 2 possible output states. In the low output state, the output resistance appearing at pin (3) is very low (approximately 10 Ω). As a result the output current will goes to zero , if the load is connected from Pin (3) to ground , sink a current I_{Sink} (depending upon load) if the load is connected from Pin (3) to ground, and sinks zero current if the load is connected between $+V_{CC}$ and Pin (3).

Pin (4) is the Reset terminal. When unused it is connected to $+V_{cc}$. Whenever the potential of Pin (4) is drives below 0.4V, the output is immediately forced to low state. The reset terminal enables the timer over-ride command signals at Pin (2) of the IC.

Pin (5) is the Control Voltage terminal.This can be used to alter the reference levels at which the time comparators change state. A resistor connected from Pin (5) to ground can do the job. Normally 0.01µF capacitor is connected from Pin (5) to ground. This capacitor bypasses supply noise and does not allow it affect the threshold voltages.

Pin (6) is the threshold terminal. In both astable as well as monostable modes, a capacitor is connected from Pin (6) to ground. Pin (6) monitors the voltage across the capacitor when it charges from the supply and forces the already high O/p to Low when the capacitor reaches +2/3 V_{CC}.

Pin (7) is the discharge terminal. It presents an almost open circuit when the output is high and allows the capacitor charge from the supply through an external resistor and presents an almost short circuit when the output is low.

Pin (8) is the $+V_{cc}$ terminal. 555 can operate at any supply voltage from +3 to +18V.

Features of 555 IC

1. The load can be connected to o/p in two ways i.e. between pin 3 & ground 1 or between pin 3 & V_{CC} (supply)

2. 555 can be reset by applying negative pulse, otherwise reset can be connected to $+V_{cc}$ to avoid false triggering.
3. An external voltage effects threshold and trigger voltages.
4. Timing from micro seconds through hours.
5. Monostable and bistable operation
6. Adjustable duty cycle
7. Output compatible with CMOS, DTL, TTL
8. High current output sink or source 200mA
9. High temperature stability
10. Trigger and reset inputs are logic compatible.

Specifications:

1. Operating temperature : SE 555-- -55^oC to 125^oC
   NE 555-- 0^o to 70^oC
2. Supply voltage : +5V to +18V
3. Timing : µSec to Hours
4. Sink current : 200mA
5. Temperature stability : 50 PPM/^oC change in temp or 0-005% /^oC.

Applications:

1. Multivibrators
2. dc-ac converters
3. Digital logic probes
4. Waveform generators
5. Analog frequency meters
6. Infrared transmitters and Tachometers
7. Temperature measurement and control

Exp.No.1

INVERTING AMPLIFIER

AIM:

To design and construct a Inverting amplifier using IC741 Op-amp.

APPARATUS:

1. Operational Amplifier mA 741 IC –1No.
2. Resistors 1KOhm and 10KOhm
3. Dual Power supply(0-20V)
4. Regulated Power Supply.(0-20V)
5. Multimeter
6. CRO and Probes
7. Funtion Signal Generator.
8. Bread board
9.Connecting wires

THEORY:

INVERTING AMPLIFIER:

An op-amp connected as an inverting amplifier with a controlled amount of voltage gain is shown in fig.

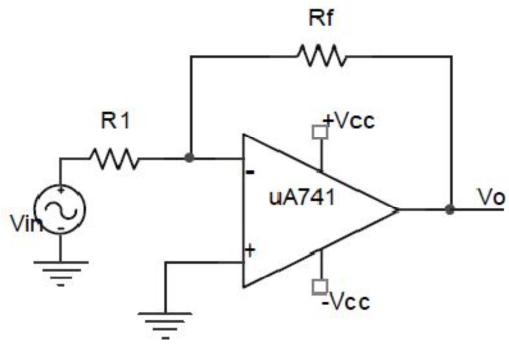


Fig: Inverting amplifier configuration of op-amp

The input signal is applied through a series input resistor R1 to the inverting input. The Non inverting input terminal is grounded. Also, the output is fed back through Rf to the same input. The non-inverting input is grounded. Rf and R1 together sets the gain of the amplifier. An expression for the output voltage of the inverting amplifier is written as

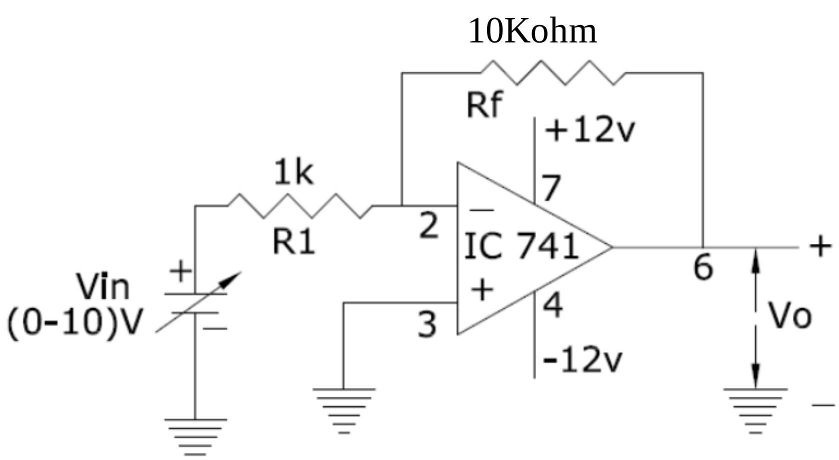
$$V_O = -\frac{R_f}{R_1}V_{in}$$

The –ve sign indicates inversion and the output voltage is 180^0 out of phase with respect to the input and amplified by gain A. The closed-loop gain of the inverting amplifier is, thus

$$A_{CL(I)} = -\frac{R_f}{R_1}$$

Assuming Rf is a 5k ohm resistor and R1 is a 1k ohm resistor, and Vin is +/- 1 volt triangle input, then Av would be -5 and Vout would be +/- 5volts triangle wave that is 180° out of phase compared to the input as shown in Expected Graph. Note how the output signal is 5 times larger than the input signal. For the special case, when Rf = R1 , Vout = - Vin a 180° phase shifted version of the input.
The interesting item about the inverting amplifier is that the gain is only a function of the ratio of the two resistors of R1 and R2.

CIRCUIT DIAGRAM:



PROCEDURE:

1.Initially set +Vcc = 12 volts and -Vcc to -12 volts.

2.Measure all resistors that are used in the amplifier circuits using the multimeter and record these values

3. As shown in the circuit diagram connect the circuit for Inverting amplifier on a breadboard

4.Before turning any power on, double check the wiring to make sure that it is correct. Make sure that the power supply to the op-amp is correctly wired as not to apply the incorrect polarity to the op-amp.
5. Input may be AC or DC voltages from function generator or DC power supply.

6. For DC input apply a 1-volt DC input to inverting input terminal of IC741 for Vin from the dc supply and check the output voltage Vo at the output terminal using the multimeter.

7.Compare practical Vo with the theoretical output voltage Vo = (-Rf /R1) Vin

8.For AC input connect the inverting input terminal of IC741 op-amp to function generator and output terminal to CRO.

9. Feed input from function generator and observe the output on CRO.

10. Draw the input and output waveforms on graph paper.

11. Compare the phase between the input and output waveforms.

TABULAR COLUMN:

S.NO	Vin	Vo = (-Rf /R1) Vin		Gain = Vo/Vin
		Theoretical	Practical	

EXPECTED GRAPH:

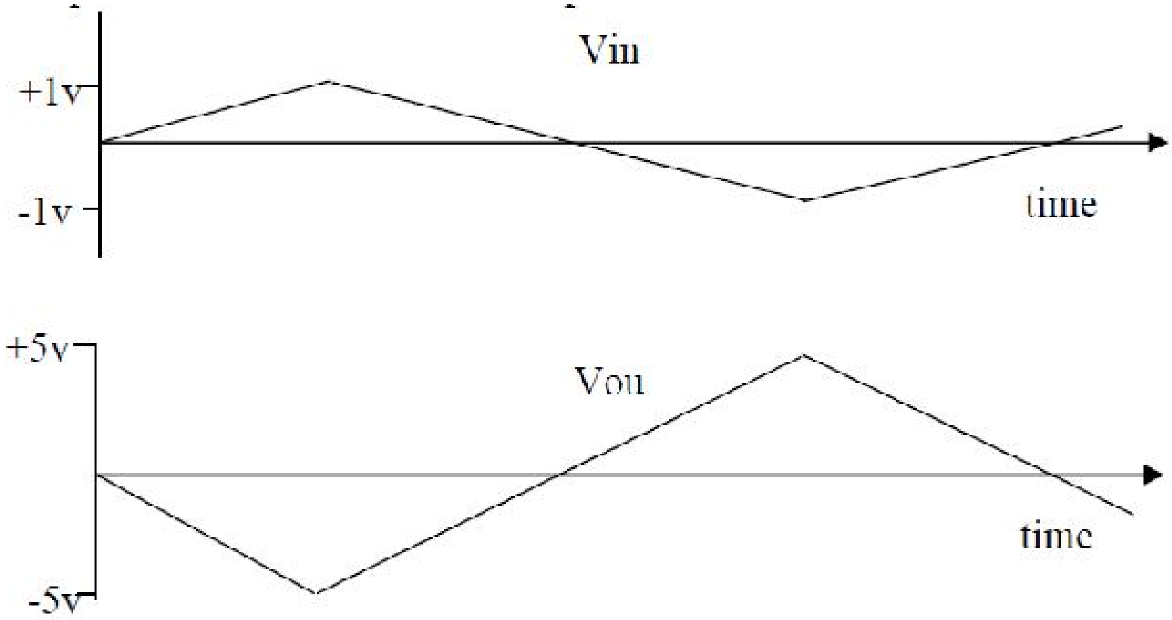


Fig: Output for -5 Gain Inverting Amplifier with a +/- 1 volt triangle wave input. R1=1k & R2=5k

WORKSHEET:

Input Waveform:

Output Waveform:

RESULT:

The Practical Values of V_o observed are equal to the Theoritical values. From this we can conclude that the Inverting Amplifier using 741 OP-AMP is satisfying its function properly. And it is also noticed that gain is depending on R_2 or R_f feedback Resistor.

Exp.No.2

NON - INVERTING AMPLIFIER

AIM:

To design and construct a Non- Inverting amplifier using IC741 Op-amp.

APPARATUS:

1. Operational Amplifier mA 741 IC –1No.
2. Resistors 1KOhm and 10KOhm
3. Dual Power supply(0-20V)
4. Regulated Power Supply.(0-20V)
5. Multimeter
6. CRO and Probes
7. Funtion Signal Generator.
8. Bread board
9.Connecting wires

THEORY:

NON - INVERTING AMPLIFIER:

An op-amp connected in a closed-loop configuration as a non-inverting amplifier with a controlled amount of voltage gain is shown in Fig

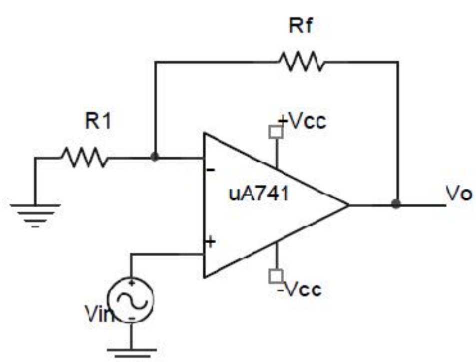


Fig: Non-inverting amplifier configuration of op-amp

The input signal is applied to the non-inverting (+) input. The output is applied back to the inverting(-) input through the feedback circuit (closed loop) formed by the input resistor R1 and the feedback resistor Rf. This creates –ve feedback as follows. Resistors R1 & Rf form a voltage-divider circuit, which reduces V_O and connects the reduced voltage V_f to the inverting input. The feedback is expressed as

$$V_f = (\frac{R_1}{R_1 + R_f})Vo$$

The difference of the input voltage, V_{in} and the feedback voltage, V_f is the differential input of the op-amp. This differential voltage is amplified by the gain of the op-amp and produces an output voltage expressed as

$$Vo = \left(1 + \frac{R_f}{R_1}\right)V_{in}$$

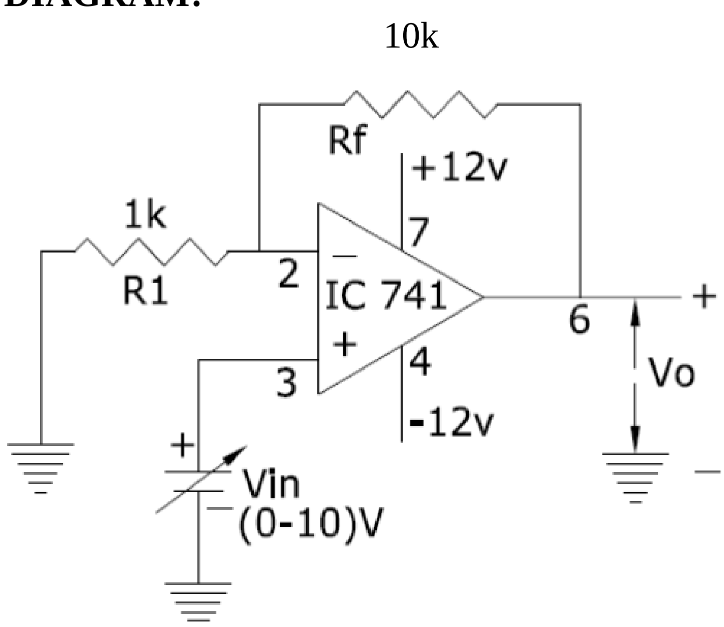
The closed-loop gain of the non-inverting amplifier is, thus

$$A_{CL(NI)} = 1 + \frac{R_f}{R_1}$$

Notice that the closed loop gain is

- Independent of open-loop gain of op-amp
- Set by selecting values of R1 and Rf

CIRCUIT DIAGRAM:



PROCEDURE:

1.Initially set +Vcc = 12 volts and -Vcc to -12 volts.

2.Measure all resistors that are used in the amplifier circuits using the multimeter and record these values

3. As shown in the circuit diagram connect the circuit for Non-Inverting amplifier on a breadboard

4.Before turning any power on, double check the wiring to make sure that it is correct. Make sure that the power supply to the op-amp is correctly wired as not to apply the incorrect polarity to the op-amp.

5.For DC input apply a 1-volt DC input to non-inverting input terminal of IC741 for Vin from the dc supply and check the output voltage Vo at the output terminal using the multimeter.

6.Compare practical Vo with the theoretical output voltage $V_o = V_{in}(1 + R_f / R1)$

7.For AC input connect the non-inverting input terminal of IC741 op-amp to function generator and output terminal to CRO.

8. Feed input from function generator and observe the output on CRO.

9. Draw the input and output waveforms on graph paper.

10. Compare the phase between the input and output waveforms.

TABULAR COLUMN:

S.NO	Vin	Vo = Vin (1+ Rf /R1)		Gain = Vo/Vin
		Theoretical	Practical	

EXPECTED GRAPH:

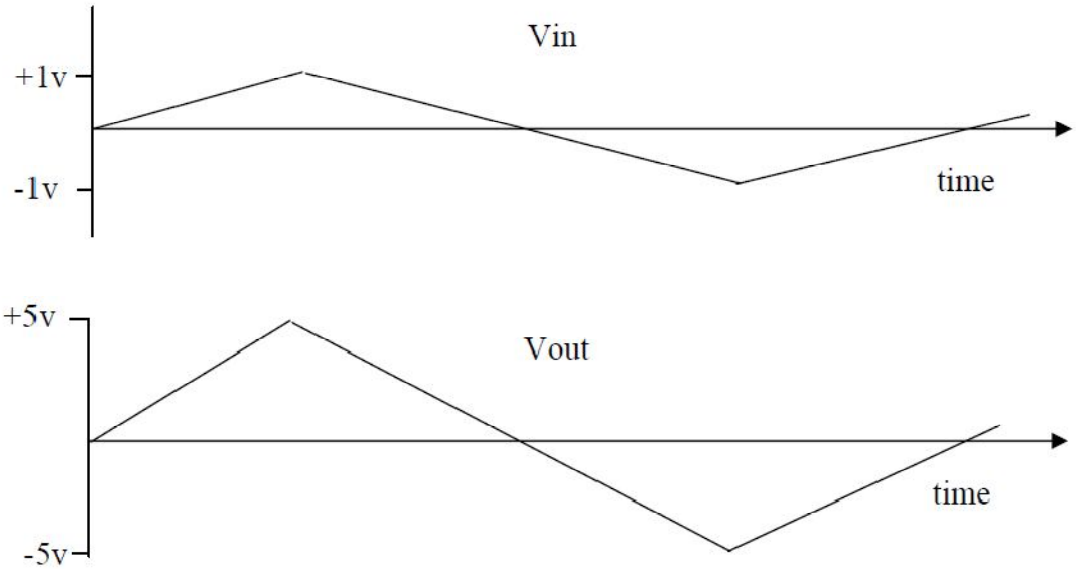
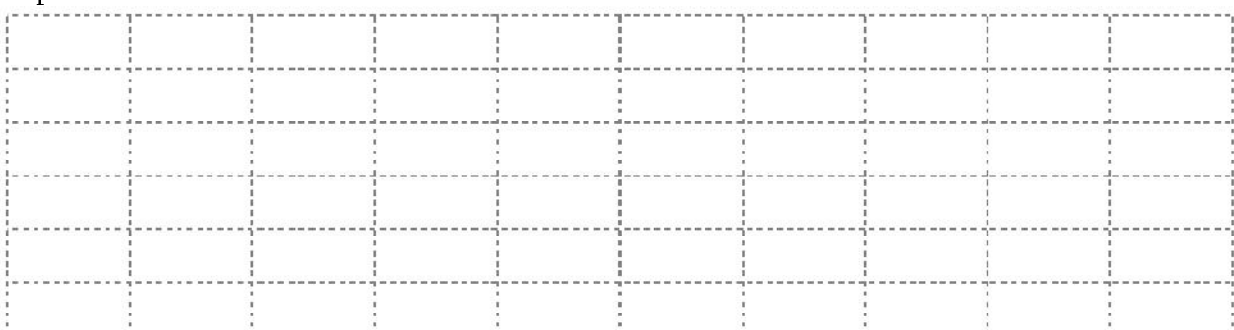


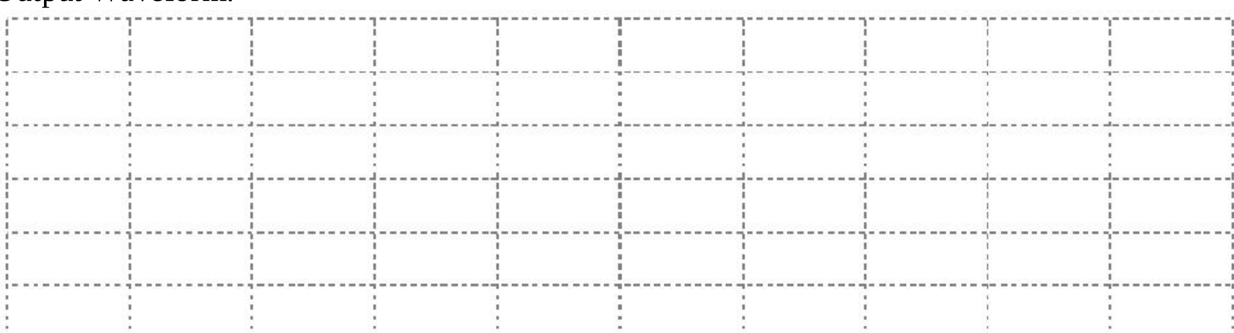
Fig: Output for +5 Gain Non-Inverting Amplifier with a +/- 1 volt triangle wave input. R1=1k & R2=4k

WORKSHEET:

Input Waveform:



Output Waveform:



RESULT:

The Practical Values of V_o observed are equal to the Theoritical values. From this we can conclude that the Non Inverting Amplifier using 741 OP-AMP is satisfying its function properly. And it is also noticed that gain is depending on R_2 or R_f feedback Resistor.

Exp.No.3

SUMMING AMPLIFIER-ADDER

AIM:

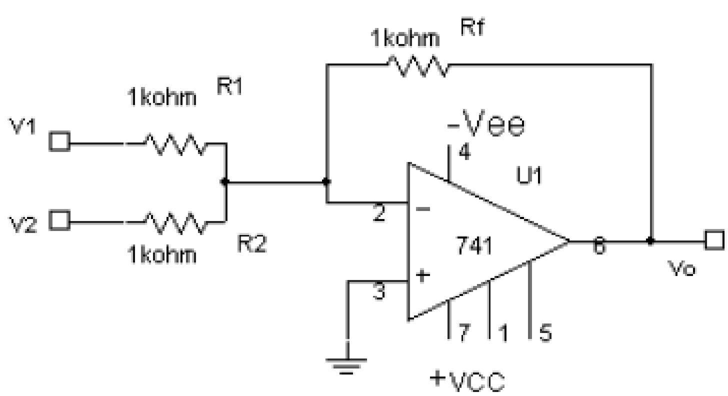
To design and construct a Summing amplifier or Adder using IC741.

APPARATUS:

1. Operational Amplifier mA 741 IC
2. Resistors 1KOhm
3. Dual Power supply(0-20V)
4. Regulated Power Supply.(0-20V)
5. Multimeter
6. Bread board
7. Connecting wires

THEORY:

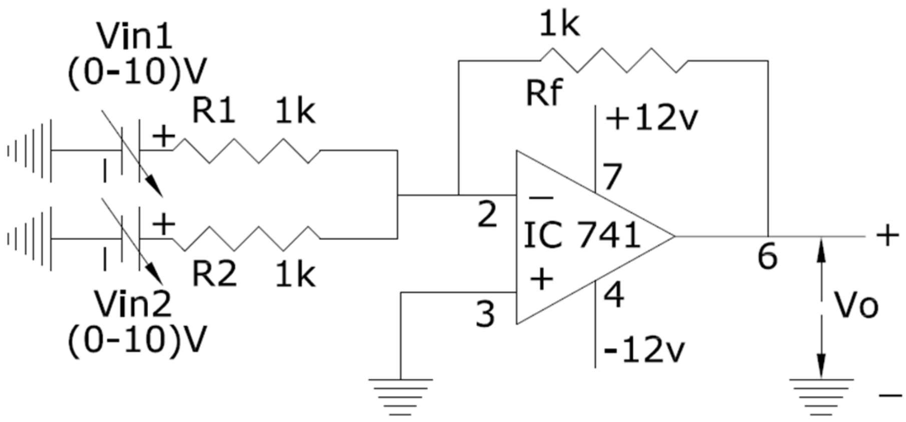
Op-amp can be used to design a circuit whose output is the sum of several input signals. Such a circuit is called a summing amplifier or an adder. Summing amplifier can be classified as inverting & non-inverting summer depending on the input applied to inverting & non-inverting terminals respectively.
The summing amplifier has two or more inputs, and its output voltage is proportional to the algebraic sum of its input voltages. Below figure shows a two-input inverting summing amplifier.



If all the three resistors are equal (R1=R2=Rf=R) then V_O = - (Vinl + Vin2)

The above equation shows that the output voltage has the same magnitude as the sum of two input voltages but with a –ve sign indicating inversion. If we connect the inputs to non inverting terminal then the adder is non inverting adder.

CIRCUIT DIAGRAM:



PROCEDURE:

1.Initially set +Vcc = 12 volts and -Vcc to -12 volts.

2.Measure all resistors that are used in the amplifier circuits using the multimeter and record these values

3. As shown in the circuit diagram connect the circuit for Summing amplifier on a breadboard

4.Before turning any power on, double check the wiring to make sure that it is correct. Make sure that the power supply to the op-amp is correctly wired as not to apply the incorrect polarity to the op-amp.

5.Apply dc voltages at each input terminal for V1 and V2 from the dc supply and check the output voltage Vo at the output terminal using the multimeter.

6. Tabulate 3 different sets of readings by repeating the above step.

7.Compare practical Vo with the theoretical output voltage VO = - (Vinl + Vin2)

TABULAR COLUMN:

V_1 (Volts)	V_2 (Volts)	Theoretical $V_o=-(V_1+V_2)$	Practical $V_o=-(V_1+V_2)$

RESULT:

The Practical Values of V_o observed are equal to the theoritical values and output is a true replica of addition of two input values. From this we can conclude that the Summing Amplifier or Adder using 741 OP-AMP is satisfying its function properly.

Exp.No.4

DIFFERENCE AMPLIFIER - SUBTRACTOR

AIM:

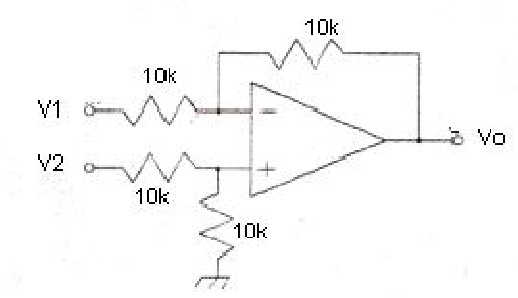
To design and construct a Subtractor using Op-amp IC741.

APPARATUS:

1. Operational Amplifier mA 741 IC
2. Resistors 10KOhm
3. Dual Power supply(0-20V)
4. Regulated Power Supply.(0-20V)
5. Multimeter
6. Bread board
7.Connecting wires

THEORY:

Op-amp can be used to design a circuit whose output is proportional to or equal to the difference of two input signals. Such a circuit is called a difference amplifier or a subtractor. Below figure shows circuit of a subtractor.

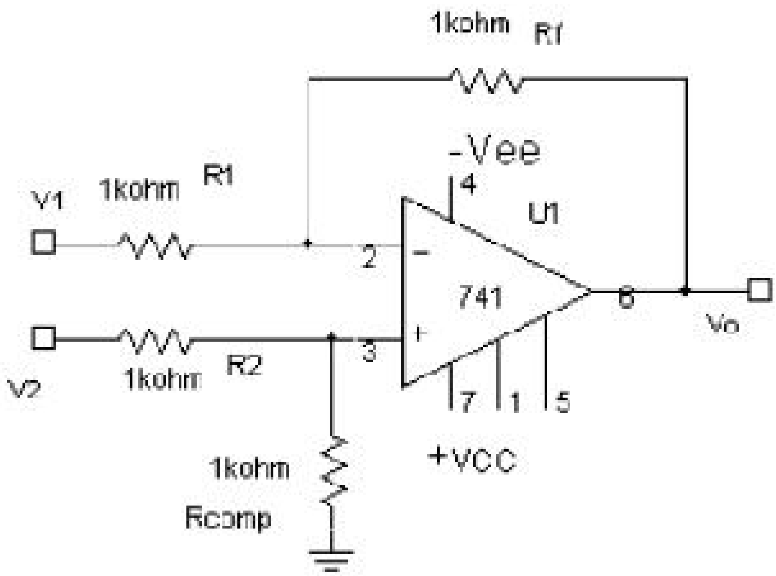


By connecting one input voltage V1 to inverting terminal and another input voltage V2 to the non – inverting terminal, we get the resulting circuit as the Subtractor. If all external resistance are equal in value, so the gain of the amplifier is equal to 1. The output voltages of the differential amplifier with a gain of unity is,

$$V_O = (V_2 - V_1)$$

Thus the output voltage Vo is equal to the voltage V_2 applied to the non – inverting terminal minus the voltage V_1 applied to the inverting terminal. Hence the circuit is called a Subtractor.

CIRCUIT DIAGRAM:



PROCEDURE:

1.Initially set +Vcc = 12 volts and -Vcc to -12 volts.

2.Measure all resistors that are used in the amplifier circuits using the multimeter and record these values

3. As shown in the circuit diagram connect the circuit for Subtractor on a breadboard

4.Before turning any power on, double check the wiring to make sure that it is correct. Make sure that the power supply to the op-amp is correctly wired as not to apply the incorrect polarity to the op-amp.

5.Apply dc voltages at each input terminal for V_1 and V_2 from the dc supply and check the output voltage Vo at the output terminal using the multimeter.

6. Tabulate 3 different sets of readings by repeating the above step.

7.Compare practical Vo with the theoretical output voltage $V_O = (V_2 - V_1)$

TABULAR COLUMN:

S.No.	V_1 Volts	V_2 Volts	Theoretical $V_o=V_2-V_1$	Practical V_o Volts

RESULT:

The Practical Values of V_o observed are equal to the theoritical values and output is a true replica of the subtraction values of the two inputs .
From this we can conclude that the Difference Amplifier or Subtractor using 741 OP-AMP is satisfying its function properly.

Exp.No.5

INTEGRATOR

AIM:

To design and verify the operation of a integrator circuit using op amp 741 IC.

APPARATUS:

1. Operational Amplifier mA 741 IC –1No.
2. Resistors 1KOhm and 10KOhm
3. Capacitor 0.1µf
4. Dual Power supply(0-20V)
5. Regulated Power Supply.(0-20V)
6. Multimeter
7. CRO and Probes
8. Funtion Signal Generator.
9. Bread board
10. Connecting wires

THEORY:

Integrator or the integration amplifier is a circuit in which “the output voltage waveform is the integral of the input voltage waveform” .Such a circuit is obtained by using a basic inverting amplifier configuration, if the feedback resistor R_f is replaced by a capacitor C_f.

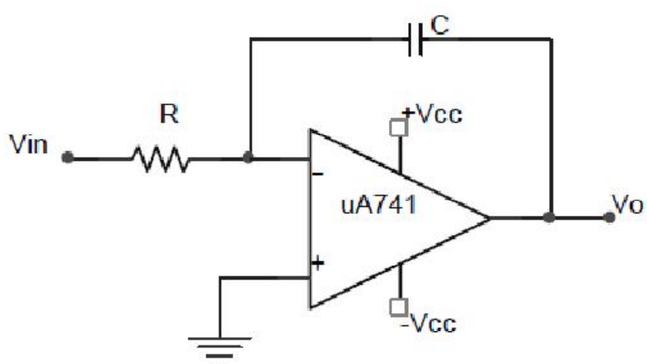


Figure: Basic Op-Amp Integrator

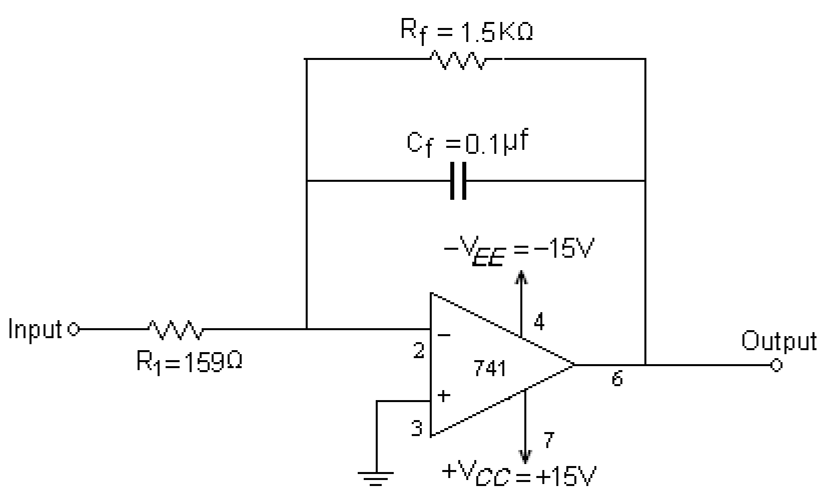
The output voltage is given by

$$V_0 = -\frac{1}{R_1 C_f} \int V_{in}\, dt$$

Thus, the output voltage is directly proportional to the negative integral of the input voltage and inversely proportional to the time constant R C_f.
If the input to the integrator is a square wave, the output will be a triangular wave, or if the input is a sine wave, the output will be a cosine wave.
For proper integration, RC has to be much greater than the time period of the input signal i.e,. $RC_f \geq T$.

Integrator has wide applications in
1.Analog computers used for solving differential equations in simulation arrangements.
2. A/D Converters
3. Signal wave shaping
4. Function Generators

CIRCUIT DIAGRAM:



PROCEDURE:

1. Initially set +Vcc = 12 volts and -Vcc to -12 volts.

2. Measure all resistors that are used in the amplifier circuits using the multimeter and record these values

3.As shown in the circuit diagram connect the circuit for Integrator on a breadboard

4.Before turning any power on, double check the wiring to make sure that it is correct. Make sure that the power supply to the op-amp is correctly wired as not to apply the incorrect polarity to the op-amp.

5. Apply square wave at the input terminals of the circuit using function Generator.

6. Connect channel-1 of CRO at the input terminals and channel-2 at the output terminals.

7. Observe the output of the circuit on the CRO which is a triangular wave and note down the position, the amplitude and the time period of Vin & Vo.

8. Now apply the sine wave as input signal.

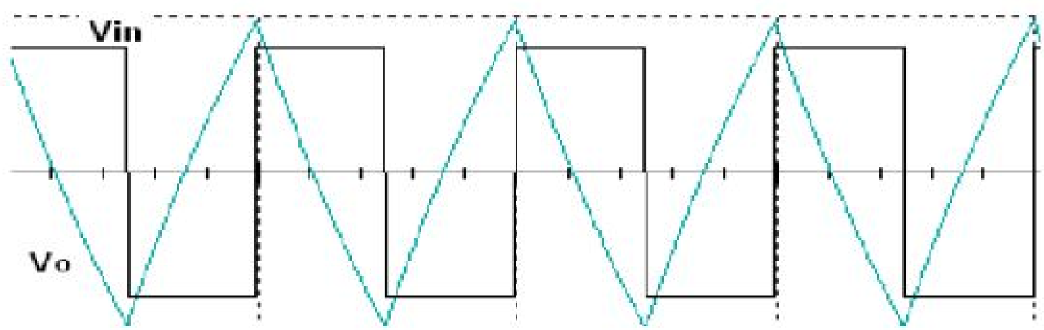
9. Observe the output of the circuit on the CRO which is a cosine wave (90^o phase shifted from the sine wave input) and note down the position, the amplitude and the time period of Vin & Vo.

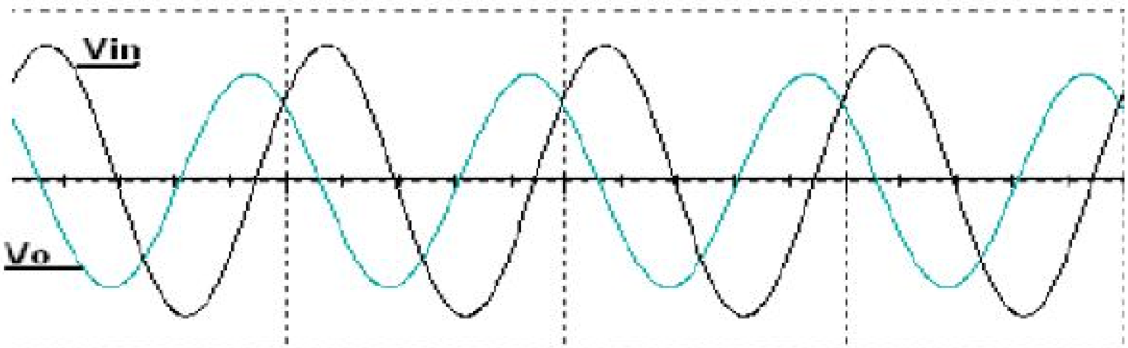
10. Plot the output voltages corresponding to square and sine wave inputs.

TABULAR COLUMN:

Sr.No.	I/P Voltage Vin	O/P Voltage Vo	Frequency in KHz.

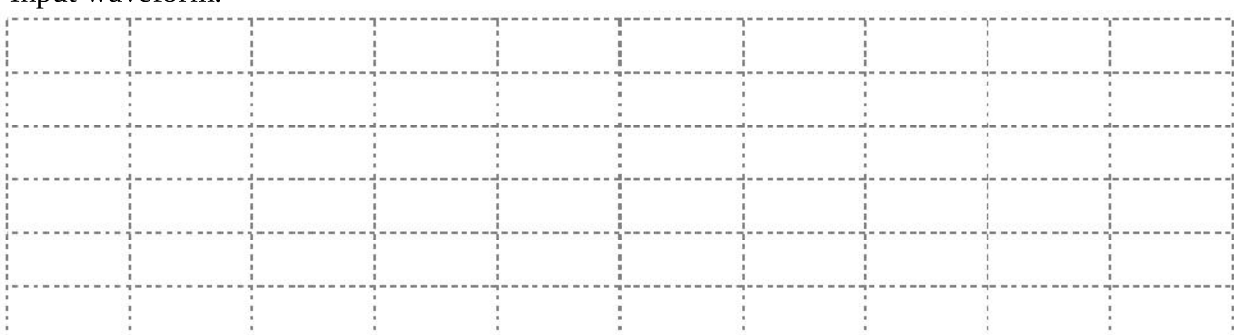
EXPECTED WAVEFORMS:



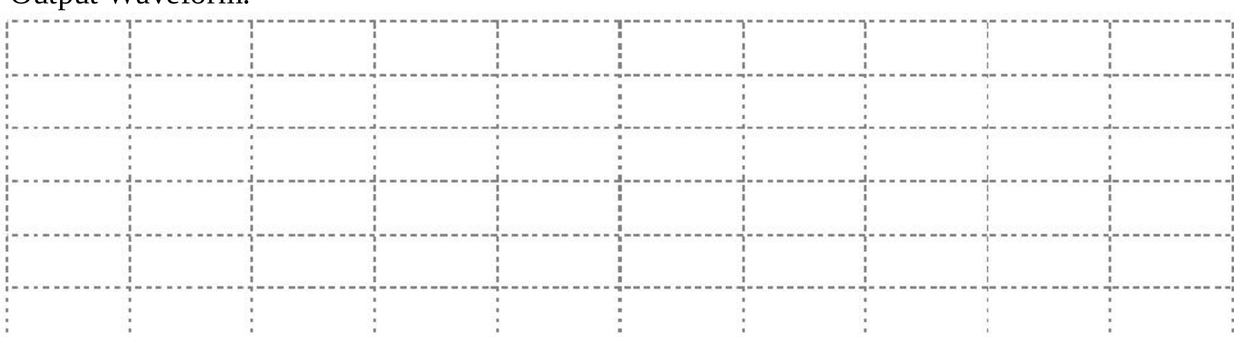


WORKSHEET:

Input waveform:



Output Waveform:



RESULT:

Hence an op-amp integrator simulates mathematical integration which is basically a summing process that determines the total area under the curve of a function ie., the integrator does integration of the input voltage waveform.Output of an integrator using op-amp 741 for a given input signal is observed and plotted From this we can conclude that the Integrator using IC 741 OP-AMP is satisfying its function properly.

Exp.No.6

DIFFERENTIATOR

AIM:

To design and verify the operation of a differentiator circuit using op amp 741 IC.

APPARATUS:

1. Operational Amplifier mA 741 IC –1No.
2. Resistors 1KOhm and 10KOhm
3. Capacitor 0.1µf
4. Dual Power supply(0-20V)
5. Regulated Power Supply.(0-20V)
6. Multimeter
7. CRO and Probes
8. Funtion Signal Generator.
9. Bread board
10. Connecting wires

THEORY:

Differentiator performs the reverse of integration function. Differentiator circuits as its name implies, performs the mathematical operation of differentiator, that is, the output waveform is the derivative of the input. The differentiator may be constructed from a basic inverting amplifier when an input resistor R1 is replaced by a capacitor C, An ideal differentiation is shown in below figure.

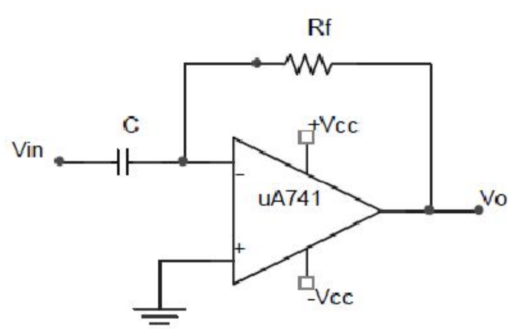


Figure: Basic Op-Amp Differentiator

The output voltage is given by

$$V_{out} = -RC \frac{dv_{in}}{dt}$$

Thus, the output Vo is equal to the $R_f C$ times the negative instantaneous rate of change of the input voltage Vin with time.. A linear, positive rate of input voltage change will result in a steady negative voltage at the output of the op-amp. Conversely, a linear, negative rate of input voltage change will result in a steady positive voltage at the output of the op-amp. This polarity inversion from input to output is due to the fact that the input signal is being sent (essentially) to the inverting input of the op-amp, so it acts like the inverting amplifier

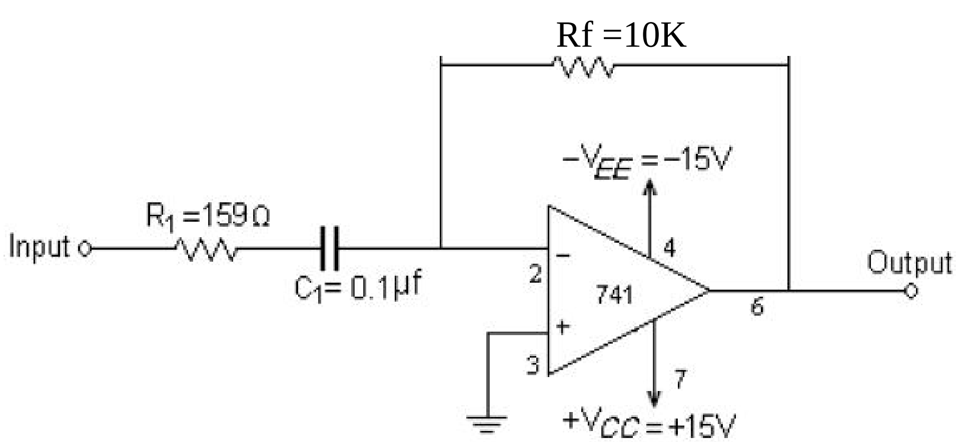
Since the differentiator performs the reverse of the integrators function, triangular wave input will produce a Square wave output ,or a cosine wave input will produce a sine wave output. If we apply square wave as input signal output is a spike wave .

The input signal will be differentiated properly if the time period T of the input signal is larger than or equal to $R_f C1$. That is, $T \geq R_f C1$

Differentiator has wide applications in

1. Monostable Multivibrator
2. Signal wave shaping
3. Function Generators.

CIRCUIT DIAGRAM:



PROCEDURE:

1.Initially set +Vcc = 12 volts and -Vcc to -12 volts.

2.Measure all resistors that are used in the amplifier circuits using the multimeter and record these values

3. As shown in the circuit diagram connect the circuit for differentiator on a breadboard

4.Before turning any power on, double check the wiring to make sure that it is correct. Make sure that the power supply to the op-amp is correctly wired as not to apply the incorrect polarity to the op-amp.

5. Apply sine wave at the input terminals of the circuit using function Generator.

6. Connect channel-1 of CRO at the input terminals and channel-2 at the output terminals.

7. Observe the output of the circuit on the CRO which is a cosine wave (90^o phase shifted from the sine wave input) and note down the position, the amplitude and the time period of Vin & Vo.

8. Now apply the square wave as input signal.

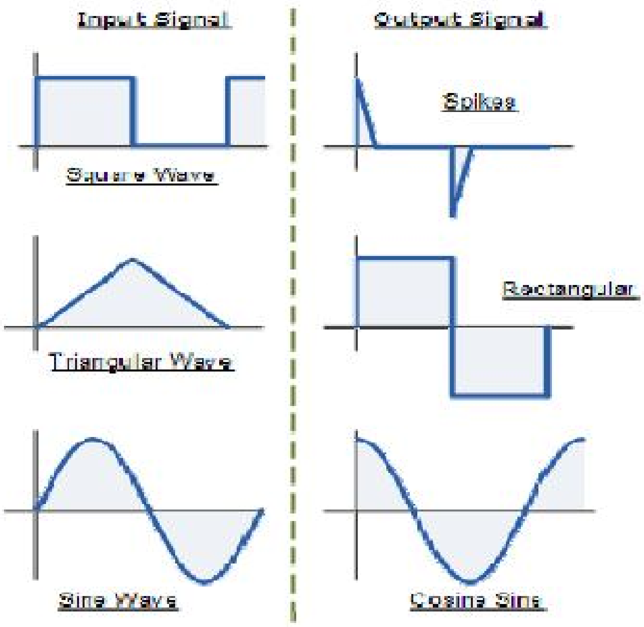
9. Observe the output of the circuit on the CRO which is a spike wave and note down the position, the amplitude and the time period of Vin & Vo.

10. Plot the output voltages corresponding to square and sine wave inputs.

TABULAR COLUMN:

Sr.No.	I/P Voltage Vin	O/P Voltage Vo	Frequency in KHz.

EXPECTED WAVEFORMS:



WORKSHEET:

Input Waveform:

Output Waveform:

RESULT:

Hence an op-amp differentiator simulates mathematical differentiation of the input voltage waveform.Output of an differentiator using op-amp 741 for a given input signal is observed and plotted .From this we can conclude that the differentiator using IC 741 OP-AMP is satisfying its function properly.

Exp.No.7

VOLTAGE FOLLOWER

AIM:

To design and construct a Voltage follower or unity gain amplifier using IC741.

APPARATUS:

1. Operational Amplifier mA 741 IC –1No.
2. Resistors 1KOhm
3. Dual Power supply(0-20V)
4. Regulated Power Supply.(0-20V)
5. Multimeter
6. CRO and Probes
7. Funtion Signal Generator.
8. Bread board
9. Connecting wires

THEORY:

Voltage follower is basically a non-inverting amplifier with RF=0 & R1= infinity. Here the output voltage is as same as that of the input voltage. Hence, the amplifier output is related to the input as,

$$V_{out} = V_{in}$$

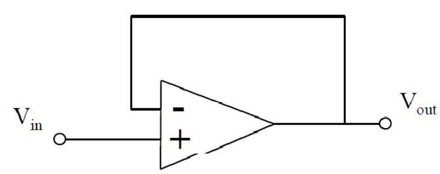


Fig: Voltage follower configuration of op-amp

Gain = 1 + (Rf / Rin) Here Rf is zero,

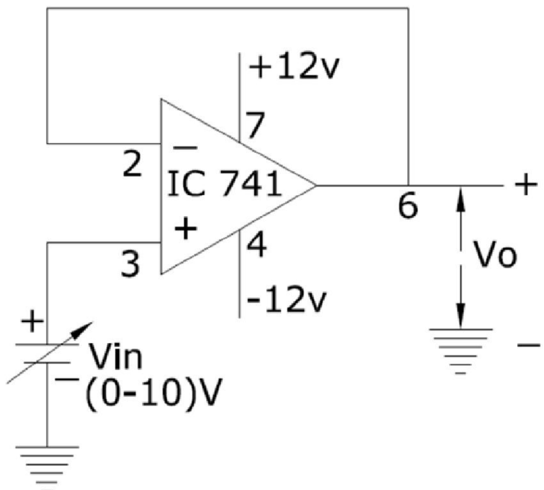
Gain = 1 + (0 / Rin)

Gain = 1 + 0

Gain = 1

The name ‘’follower’’ is due to the fact that the output voltage follows the input. Voltage followers are widely used to provide buffering between high internal resistance soures and a load.

CIRCUIT DIAGRAM:



PROCEDURE:

1.Initially set +Vcc = 12 volts and -Vcc to -12 volts.

2.Measure all resistors that are used in the amplifier circuits using the multimeter and record these values

3. As shown in the circuit diagram connect the circuit for Voltage Follower on a breadboard

4.Before turning any power on, double check the wiring to make sure that it is correct. Make sure that the power supply to the op-amp is correctly wired as not to apply the incorrect polarity to the op-amp.

5.For DC input apply a 1-volt DC input to non-inverting input terminal of IC741 for Vin from the dc supply and check the output voltage Vo at the output terminal using the multimeter.

6.Compare practical Vo with the theoretical output voltage Vo = Vin

7. For AC input connect the non-inverting input terminal of IC741 op-amp to function generator and output terminal to CRO.

8. Feed input from function generator and observe the output on CRO.

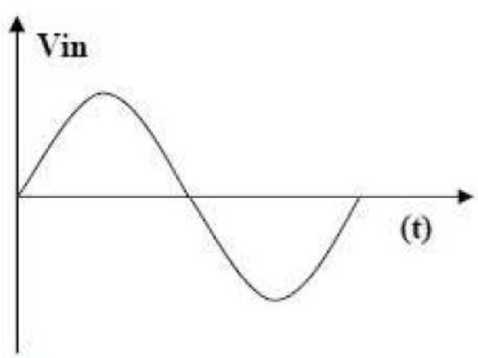
9. Draw the input and output waveforms on graph paper.

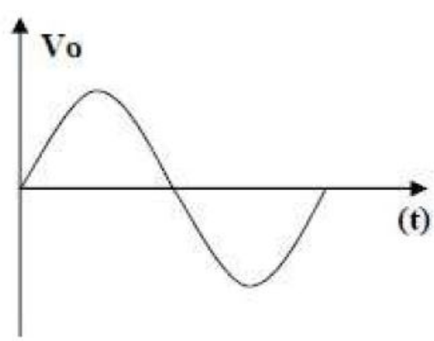
10. Compare the input and output waveforms.

TABULAR COLUMN:

S.No	V_{in}		V_{out}		Gain = V_{out}/V_{in}
	Theory	Practical	Theory	Practical	
1 2					
3					

EXPECTED GRAPH:





WORKSHEET:

Input Waveform:

Output Waveform:

RESULT:

The Practical Values of V_o observed are equal to the Theoritical values. From this we can conclude that the Non Inverting Amplifier using 741 OP-AMP is satisfying its function properly. And it is also noticed that gain is depending on R_2 or R_f feedback Resistor.

Exp.No.8

FUNCTION SIGNAL GENERATOR

AIM:

To generate square wave and triangular wave using IC741 Op-amp.

APPARATUS:

1. Operational Amplifier mA 741 IC –2No.
2. Resistors
3. Capacitors
4. Dual Power supply(0-20V)
5. Multimeter
6. CRO and Probes.
7. Bread board
8.Connecting wires

THEORY:

Function generator generates waveforms such as sine, triangular, square waves and so on of different frequencies and amplitudes. The circuit shown in fig is a simple circuit which generates square waves and triangular waves simultaneously.

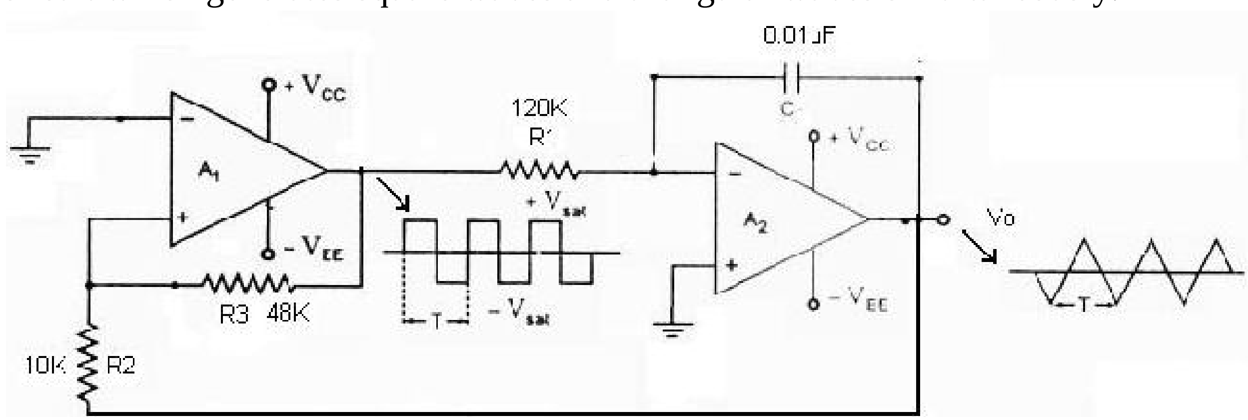


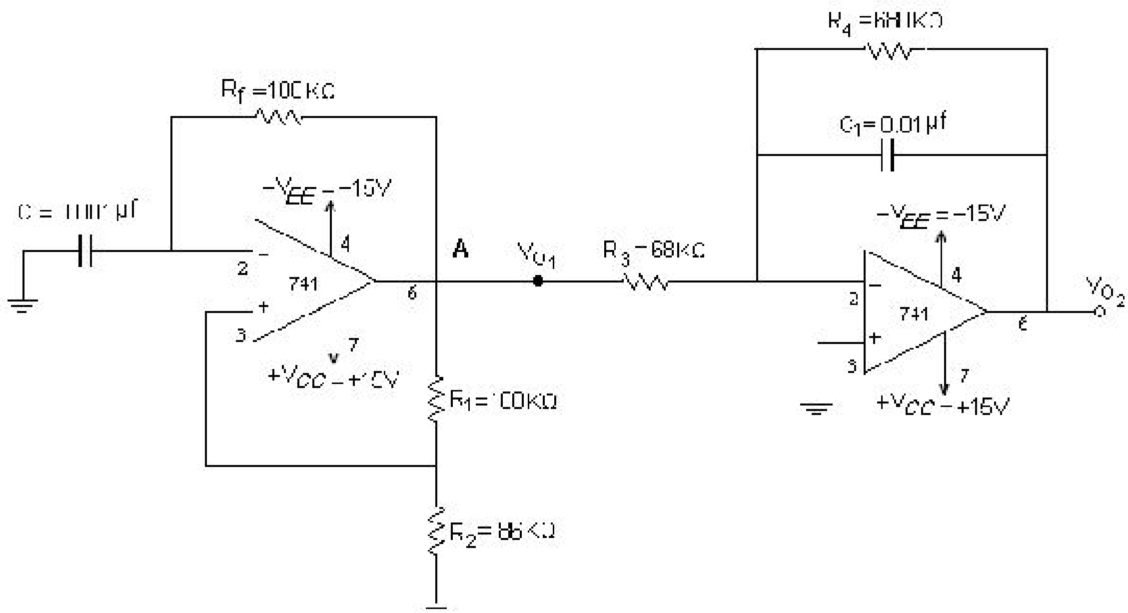
Fig: Signal Generator configuration of op-amp

Here the first section is a square wave generator and second section is an integrator. We know that the integrator output waveform will be triangular if the input to it is square-wave. When square wave is given as input to integrator it produces triangular wave. The rectangular-wave output of the square-wave generator drives the integrator which produces a triangular output waveform.

The input of integrator A2 is a square wave and its output is a triangular waveform, the output of integrator will be triangular wave only when R1 C> T/ 2 where T is the (period of square wave.)

It means that a wave generator can be formed by simply cascading an square-wave generator and a integrator, as illustrated in figure. This circuit needs a dual op-amp, capacitors, and resistors.

CIRCUIT DIAGRAM:



PROCEDURE:

1.Initially set +Vcc = 12 volts and -Vcc to -12 volts.

2.Measure all resistors that are used in the amplifier circuits using the multimeter and record these values

3.As shown in the circuit diagram connect the circuit on a breadboard.

4.Before turning any power on, double check the wiring to make sure that it is correct. Make sure that the power supply to the op-amp is correctly wired as not to apply the incorrect polarity to the op-amp.

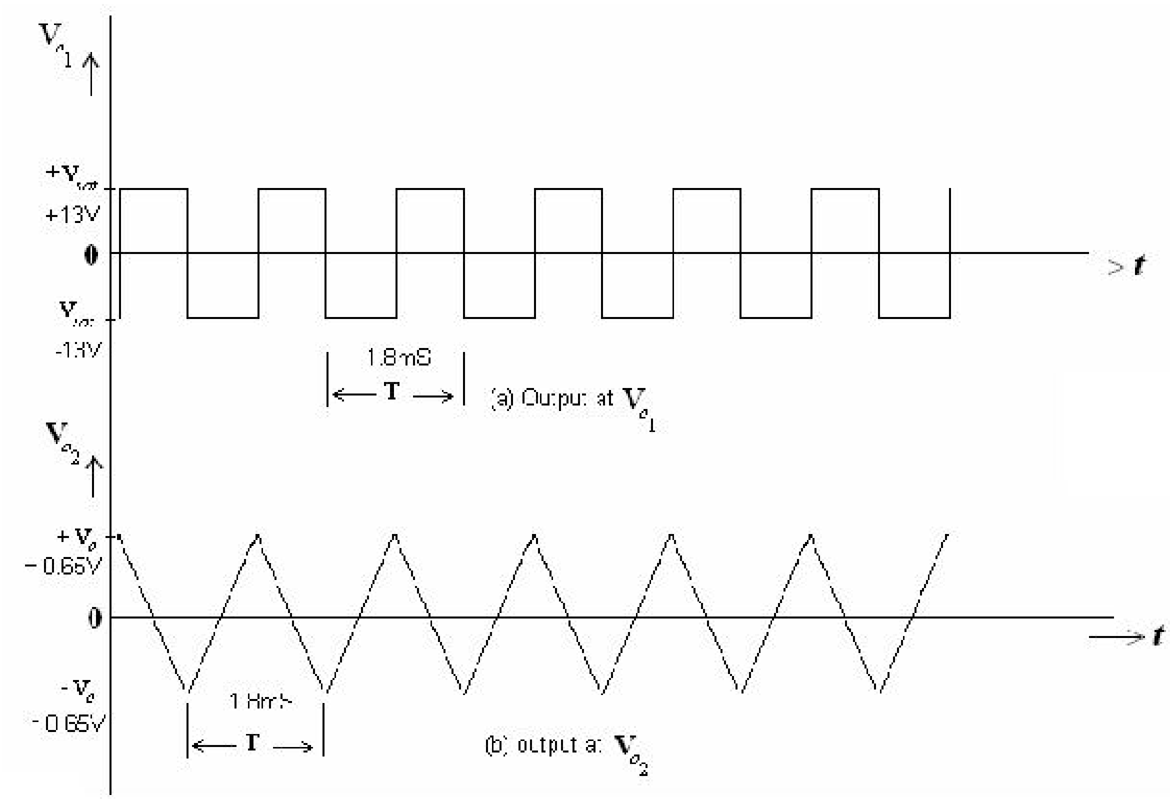
5.No Input signal is feed from function generator. It is self generating.

6.Observe the square wave output at 1st op-amp sixth pin and triangular wave output at 2nd op-amp sixth pin on CRO.

7.Calculate the frequency and amplitude of the square and triangular wave observed from the CRO. Frequency can be varied by changing RC combination.

8.Draw the output waveforms on graph paper.

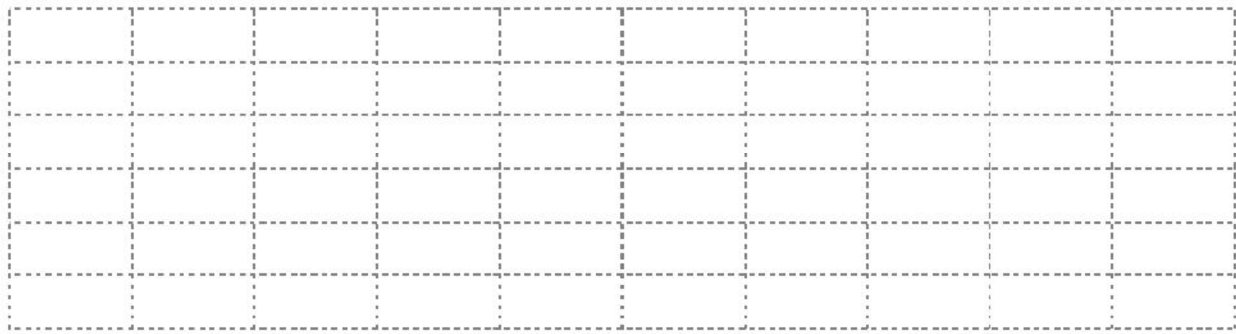
EXPECTED GRAPH:



WORKSHEET:

Output Waveform at V_{o1}:

Output Waveform at V_{o2}:



RESULT:

Hence Square and triangular waveforms are generated using 741 Op-Amp function generator and the output waveforms are observed.

Exp.No.9

SCHMITT TRIGGER using IC 741

AIM:

To design and construct a Schmitt trigger using IC741 Op-amp.

APPARATUS:

1. Operational Amplifier mA 741 IC –1No
2. Resistors
3. Dual Power supply(0-20V)
4. Multimeter
5. CRO and Probes
6. Funtion Signal Generator
7. Bread board
8.Connecting wires

THEORY:

Schmitt trigger converts an irregular –shaped waveform to a square wave or pulse. This circuit is also known as squaring circuit.
The input voltage Vin triggers (changes the state of) the output Vo every time it exceeds certain voltage levels called Upper threshold voltage, VUT and Lower threshold voltage, VLT. These threshold voltages are calculated as follows.

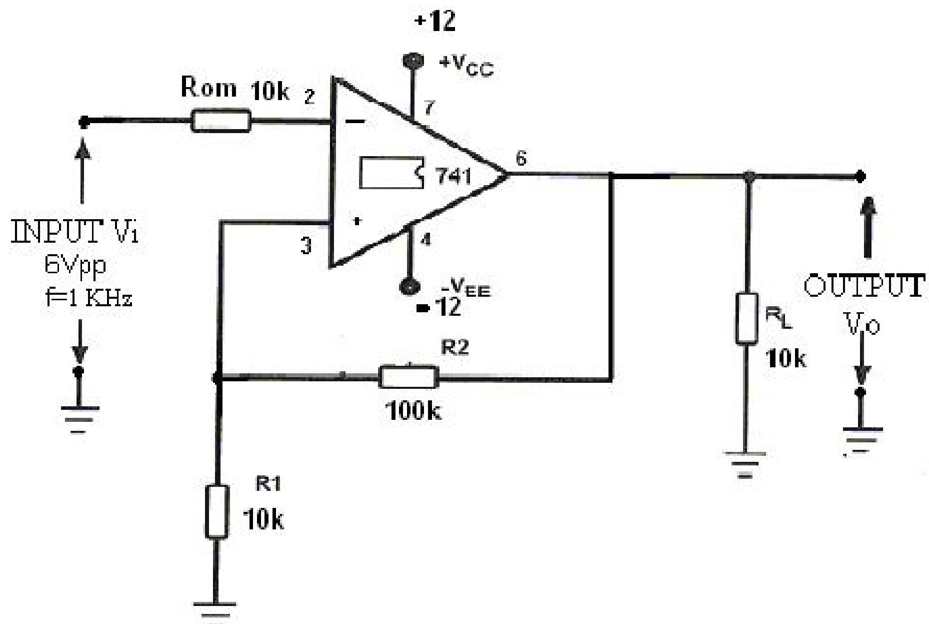
VUT = (R1/R1+R2) Vsat when Vo= Vsat

VLT = (R1/R1+R2) (-Vsat) when Vo= -Vsat

The hysteresis width is the difference between these two threshold voltages i.e. VUT – VLT.

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:



PROCEDURE:

1.Initially set +Vcc = 12 volts and -Vcc to -12 volts.

2.Measure all resistors that are used in the amplifier circuits using the multimeter and record these values

3. As shown in the circuit diagram connect the circuit for Schmitt Trigger on a breadboard.

4.Before turning any power on, double check the wiring to make sure that it is correct. Make sure that the power supply to the op-amp is correctly wired as not to apply the incorrect polarity to the op-amp.

5. Apply the input sine wave using function generator.

6. Connect the channel–1 of CRO at the input terminals and Channel-2 at the output terminals.

7. Observe the output square waveform corresponding to input sinusoidal signal.

8. Overlap both the input and output waves and note down voltages at positions on sine wave where output changes its state. These voltages denote the Upper

threshold voltage and the Lower threshold voltage (see EXPECTED WAVEFORMS below).

9. Verify that these practical threshold voltages are almost same as the theoretical threshold voltages calculated using formula.

10. Sketch the waveforms on graph paper by noting down the amplitude and the time period of the input Vin and the output Vo.

TABULAR COLUMN:

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						

EXPECTED GRAPH:

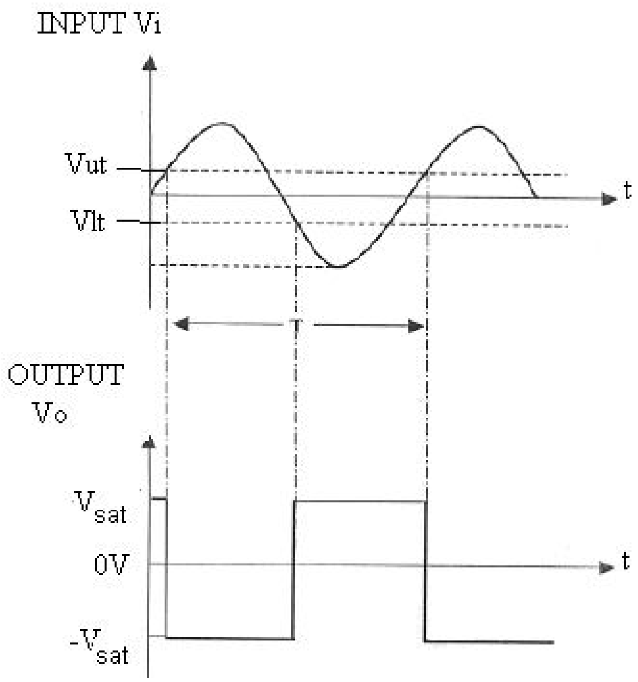


Figure shows that the output of the Schmitt trigger is a square wave when the input is a sinewave.

WORKSHEET:

Input Waveform:

Output Waveform:

RESULT:

Hence the output of Schmitt trigger using IC 741 Op-amp is observed.

Exp.No.10

SCHMITT TRIGGER using IC 555

AIM:

To design and construct a Schmitt trigger using IC555 Timer.

APPARATUS:

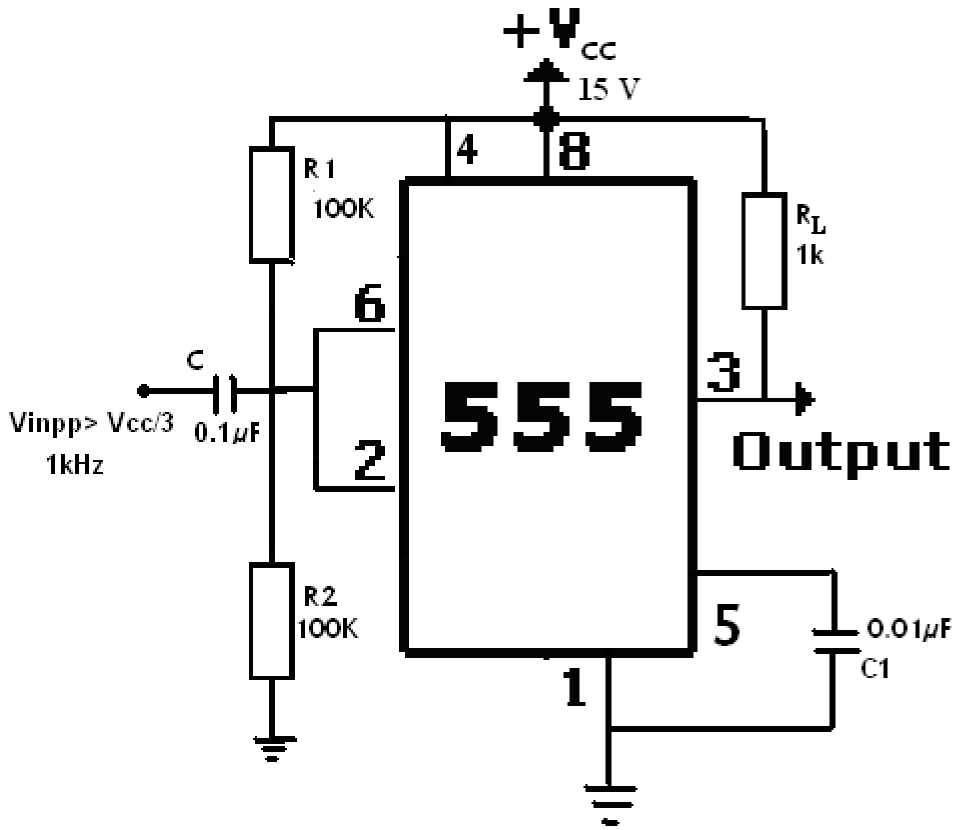
1. IC555 –1No
2. Resistors
3.Capacitors
4. Dual Power supply(0-20V)
5. Multimeter
6. CRO and Probes
7. Funtion Signal Generator
8. Bread board
9.Connecting wires

THEORY:

Schmitt trigger converts an irregular –shaped waveform to a square wave or pulse. 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. So this circuit is also known as squaring circuit.

555 timer can be used as Schmitt trigger. Here two internal comparators are tied together and externally biased at VCC/2 through R1 & R2. Since the upper comparator will trip at (2/3) VCC and the lower comparator at (1/3) VCC the bias provided by R1 & R2 is centered within these two thresholds. Thus a sine wave of sufficient amplitude (> VCC /6 = 2/3 VCC – VCC/2) to exceed the reference levels causes the internal flip–flop to alternately set and reset providing a square wave output The input voltage Vin triggers (changes the state of) the output Vo every time it exceeds certain voltage levels called Upper threshold voltage, VUT and Lower threshold voltage, VLT. The hysteresis width is the difference between these two threshold voltages i.e. VUT – VLT.

CIRCUIT DIAGRAM:



PROCEDURE:

1.Initially set +Vcc = 15 volts.

2.Measure all resistors that are used in the amplifier circuits using the multimeter and record these values

3. As shown in the circuit diagram connect the circuit for Schmitt Trigger on a breadboard.

4.Before turning any power on, double check the wiring to make sure that it is correct. Make sure that the power supply to the 555 is correctly wired as not to apply the incorrect polarity to the 555.

5. Apply the input sine wave with peak voltage greater than the designed voltage (Ut).using function generator.

6. Connect the channel–1 of CRO at the input terminals and Channel-2 at the output terminals.

7. Observe the output square waveform corresponding to input sinusoidal signal.

8. Overlap both the input and output waves and note down voltages at positions on sine wave where output changes its state. These voltages denote the Upper threshold voltage and the Lower threshold voltage (see EXPECTED WAVEFORMS below).

9. Verify that these practical threshold voltages are almost same as the theoretical threshold voltages calculated using formula.

10. Sketch the waveforms on graph paper by noting down the amplitude and the time period of the input Vin and the output Vo.

EXPECTED GRAPH:

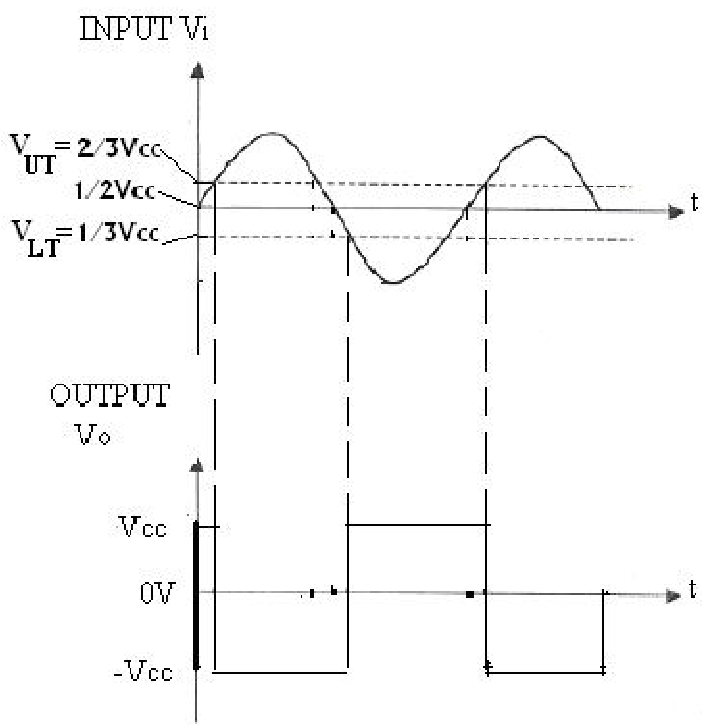


Figure shows that the output of the Schmitt trigger is a square wave when the input is a sinewave.

WORKSHEET:

Input Waveform:

Output Waveform:

RESULT:

Hence the output of Schmitt trigger using IC 555 Timer is observed.

Exp.No.11

ZERO CROSSING DETECTOR

AIM:

To verify the operation of a zero crossing detector circuit using IC741 Op-amp.

APPARATUS:

1. Operational Amplifier mA 741 IC –1No.
2. Resistors 1KOhm
3. Dual Power supply(0-20V)
4. Regulated Power Supply.(0-20V)
5. Multimeter
6. CRO and Probes
7. Funtion Signal Generator.
8. Bread board
9.Connecting wires

THEORY:

Comparator:

The simplest way to use an op-amp is open loop (no feedback resistors), as shown in figure (a). Because of the high gain of the op-amp, the slightest error voltage (typically in μV) produced maximum output swing. For instance, when V1 is greater than V2, the error voltage is positive and the output voltage goes to its maximum positive value (+Vsat), typically 1 to 2V less than the supply voltage. On the other hand, if V1 is less than V2, the output voltage swings to its maximum negative value (-Vsat).

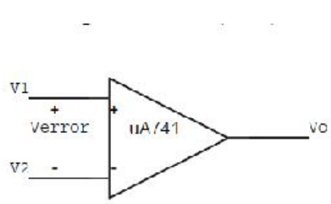
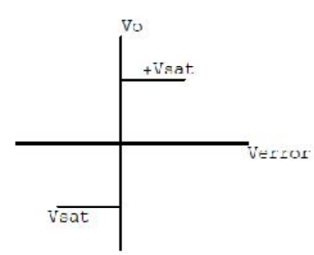


Fig (a) Comparator



(b) Input / Output Characteristics

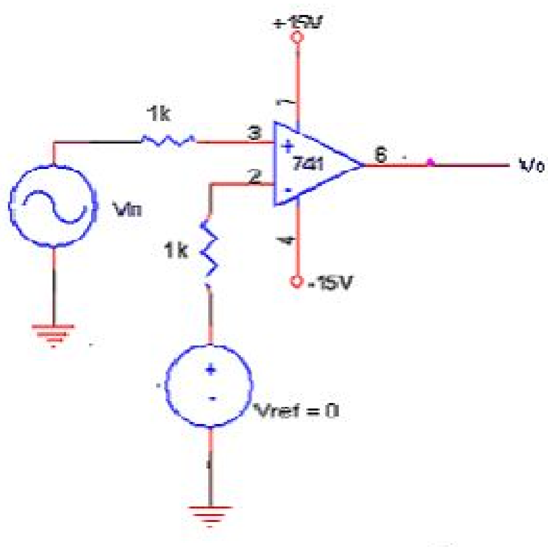
Fig (b) summarizes the action. A positive error voltage drives the output to +Vsat. A negative error voltage produces –Vsat when an op-amp is used like this, it is called a comparator because all it can do is compare V1 to V2, producing a saturated positive or negative output, depending on whether V1 is greater or less than V2.

Zero Cross Detector:

Zero crossing detector (ZCD) is an application of voltage comparator. It converts any time varying signal to square of same time period with amplitude ±Vsat. The reference voltage is set as zero volts. When the polarity of the input signal changes, output square wave changes polarity.

Zero-crossing detector is an applied form of comparator. comparator circuit can be employed as the zero-crossing detector provided the reference voltage Vref is made zero. Zero-crossing detector using op-amp comparator is depicted in figure. The output voltage waveform shown in figure indicates when and in what direction an input signal vin crosses zero volt.

CIRCUIT DIAGRAM:



PROCEDURE:

1.Initially set +Vcc = 12 volts and -Vcc to -12 volts.

2.Measure all resistors that are used in the amplifier circuits using the multimeter and record these values

3. As shown in the circuit diagram connect the circuit for Zero-crossing detector on a breadboard

4.Before turning any power on, double check the wiring to make sure that it is correct. Make sure that the power supply to the op-amp is correctly wired as not to apply the incorrect polarity to the op-amp.

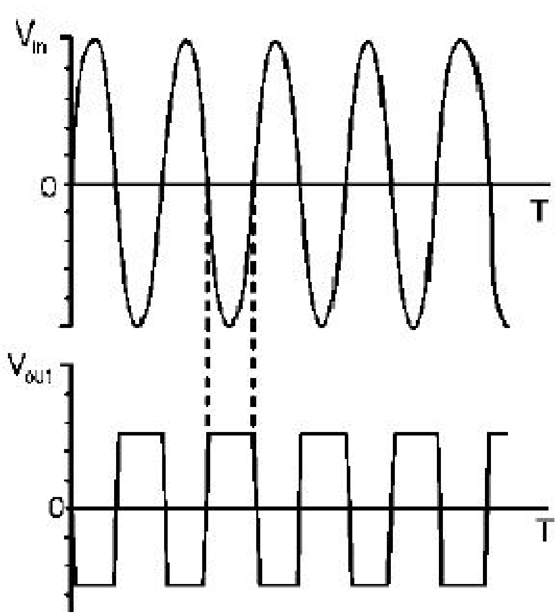
5.Feed input a sin wave with one volt peak to peak at 1 kHz from function generator and observe the output on CRO.

6. Draw the input and output waveforms on graph paper.

TABULAR COLUMN:

Sr.No.	I/P Voltage Vin	O/P Voltage Vo	Frequency in KHz.

EXPECTED GRAPH:



WORKSHEET:

Input Waveform:

Output Waveform:

RESULT:

Thus a Zero Cross Detector is also a comparator where op-amp compares the input voltage with the ground level. The output is a square wave and inverted form of the input. From this we can conclude that the zero crossing detector using 741 OP-AMP is satisfying its function properly.

Exp.No.12

RC PHASE SHIFT OSCILLATOR

AIM:

To design an RC Phase Shift Oscillator and compare it's theoretical and practical frequency of oscillation using IC741 Op-amp.

APPARATUS:

1. Operational Amplifier mA 741 IC –1No.
2. Resistors
3. Capacitors
4. Dual Power supply(0-20V)
5. Regulated Power Supply.(0-20V)
6. Multimeter
7. CRO and Probes
8. Funtion Signal Generator.
9. Bread board
10. Connecting wires

THEORY:

Oscillator is a circuit which generates output without any input. Oscillator can be defined as a device that converts dc to ac. Oscillators can be classified as:

Based on the components used:

RC Oscillators - RC Phase shift, Wien Bridge Oscillator
LC Oscillators - Colpitts, Hartley, Clapp Oscillator
Crystal Oscillators

Based on the type of waveform:

Sinusoidal Oscillators – RC Phase shift, Wien Bridge, Colpitts, Hartley….
Non-Sinusoidal Oscillators- UJT relaxation Oscillators

Based on frequency range:

Audio frequency oscillator – RC oscillators
Radio frequency oscillator – LC oscillators

Barkhausen's criterion for oscillations:

1) For sustained oscillations the phase shift around the circuit(amplifier and feedback circuit) should be 360^o or 0^o.
2) The magnitude of the loop gain of the oscillator should be greater than or equal to 1.

A Phase shift oscillator consists of an Op-Amp as the amplifying stage and three RC cascaded networks as the feedback circuit. The feedback circuit provides feedback voltage from the output back to the input of the amplifier. The Op-Amp is used in the inverting mode, therefore any signal that appears at the inverting terminal is shifted by 180^o at the output. An additional 180^o phase shift required for oscillation is provided by the 3 RC sections – each section providing a Phase shift of 60^o. Thus the total phase shift around the loop is 360^o (or 0^o). At some specific frequency when the phase shift of the cascaded RC sections is exactly 180^o and the gain of the amplifier is sufficiently large, the circuit will oscillate. This frequency is called the frequency of oscillation fo and is given by

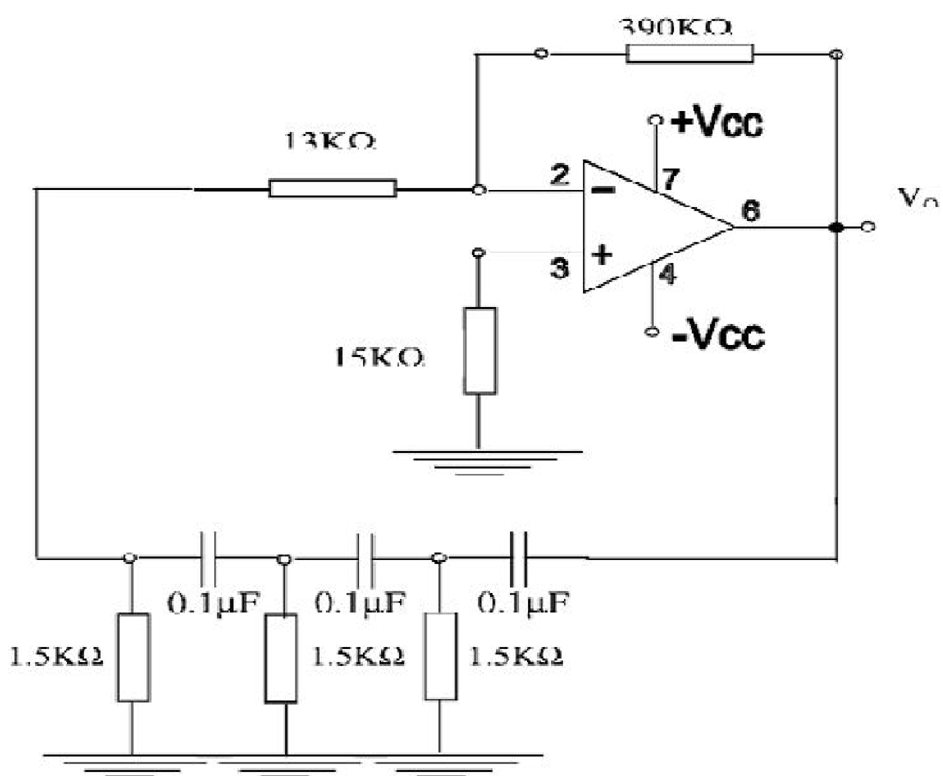
$$fo = 1/2\pi RC\sqrt{6} = 0.065/ RC$$

At this frequency, the magnitude of gain Av must be at least 29

$$\text{i.e., } Rf/R1 = 29.$$

Thus the circuit will produce a sinusoidal waveform of frequency fo if the gain is 29 and the total Phase shift around the circuit is exactly 360^o or 0^o.

CIRCUIT DIAGRAM:



PROCEDURE:

1. Initially set +Vcc = 12 volts and -Vcc to -12 volts.

2. Measure all resistors that are used in the amplifier circuits using the multimeter and record these values

3. As shown in the circuit diagram connect the circuit for Phase shift oscillator on a breadboard

4. Before turning any power on, double check the wiring to make sure that it is correct. Make sure that the power supply to the op-amp is correctly wired as not to apply the incorrect polarity to the op-amp.

5. No Input signal is feed from function generator. It is self generating.

6. Observe the output sinusoidal waveform at sixth pin of op-amp on CRO.

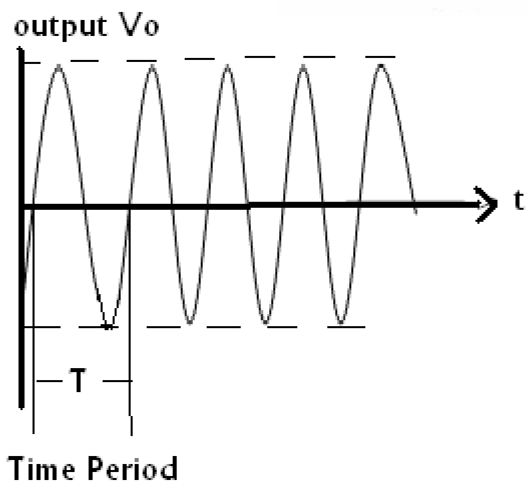
7. Calculate the practical frequency of oscillation $f_o = 1/T$ by observing the time period of the output sinusoidal waveform on the CRO and compare it with theoretical frequency of oscillation $f_o = 1/2\pi RC\sqrt{6}$.

8. Sketch the output waveform by noting the time period and peak to peak voltage of the output waveform.

TABULAR COLUMN:

S.NO	Output Voltage		Theoretical Frequency(Hz)	Practical Frequency(Hz)
	Vin (volt)	Time (m sec)		

EXPECTED GRAPH:



WORKSHEET:

Output Waveform:

RESULT:

Thus we have measured the amplitude and frequency of sinusoidal wave generated by RC Phase Shift Oscillator. The Practical Values of f_o observed are equal to the Theoritical values. From this we can conclude that the RC Phase Shift Oscillator using 741 OP-AMP is satisfying its function properly.

Exp.No.13

WIEN BRIDGE OSCILLATOR

AIM:

To design an Wien Bridge Oscillator and compare it's theoretical and practical frequency of oscillation using IC741 Op-amp.

APPARATUS:

1. Operational Amplifier mA 741 IC –1No.
2. Resistors
3. Capacitors
4. Dual Power supply(0-20V)
5. Regulated Power Supply.(0-20V)
6. Multimeter
7. CRO and Probes
8. Funtion Signal Generator.
9. Bread board
10. Connecting wires

THEORY:

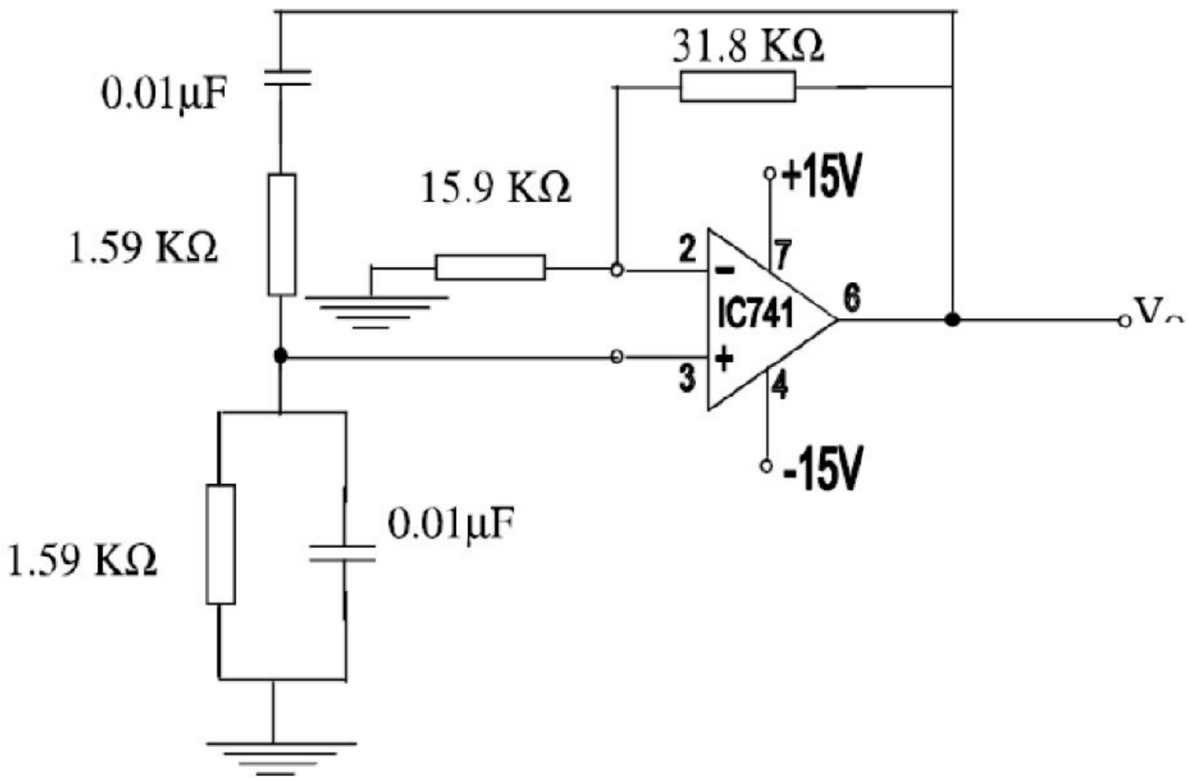
Wien Bridge Oscillator is one of the most commonly used audio-frequency oscillators because of its simplicity and stability,. The circuit diagram shows the Wien Bridge oscillator in which the Wien Bridge circuit is connected between the amplifier input terminals and output terminal. The bridge has a series RC network in one arm and a parallel RC network in the adjoining arm. In the remaining two arms of the bridge, resistors R1 & Rf are connected. The feedback signal in this circuit is connected to the non-inverting terminal, therefore the Op-Amp is working in non-inverting mode. Hence this amplifier doesn't provide any phase shift. Therefore the feedback network need not provide any phase shift. The condition of zero Phase shift around the circuit is achieved by balancing the bridge. When the bridge is balanced, the frequency of oscillation f_o is exactly the resonant frequency which is given by the equation

$$f_o = 1/2\pi RC = 0.159/RC$$

At this frequency the gain Av required for sustained oscillation is 3(practically it is more).

i.e. $Av = 1+Rf/R1 = 3.$

CIRCUIT DIAGRAM:



PROCEDURE:

1. Initially set +Vcc = 12 volts and -Vcc to -12 volts.

2. Measure all resistors that are used in the amplifier circuits using the multimeter and record these values

3. As shown in the circuit diagram connect the circuit for Wien Bridge oscillator on a breadboard

4. Before turning any power on, double check the wiring to make sure that it is correct. Make sure that the power supply to the op-amp is correctly wired as not to apply the incorrect polarity to the op-amp.

5. No Input signal is feed from function generator. It is self generating.

6. Observe the output sinusoidal waveform at sixth pin of op-amp on CRO.

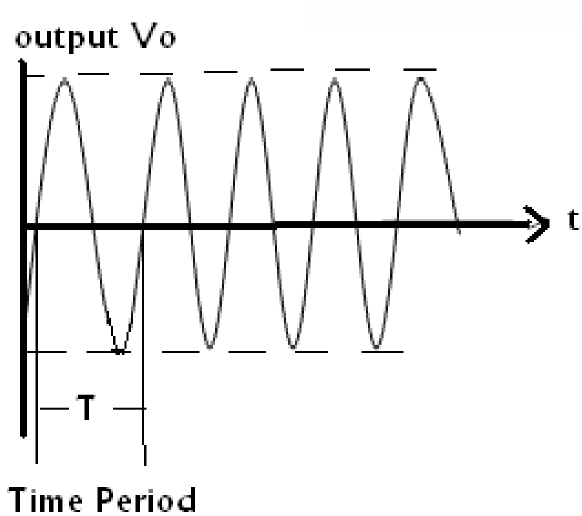
7. Calculate the practical frequency of oscillation $f_o = 1/T$ by observing the time period of the output sinusoidal waveform on the CRO and compare it with theoretical frequency of oscillation $f_o = 1/2\pi RC$.

8. Sketch the output waveform by noting the time period and peak to peak voltage of the output waveform.

TABULAR COLUMN:

S.NO	Output Voltage		Theoretical Frequency(Hz)	Practical Frequency(Hz)
	Vin (volt)	Time (m sec)		

EXPECTED GRAPH:



WORKSHEET:

Output Waveform:

RESULT:

Thus we have measured the amplitude and frequency of sinusoidal wave generated by Wien Bridge Oscillator. The Practical Values of f_o observed are equal to the Theoritical values. From this we can conclude that the Wien Bridge Oscillator using 741 OP-AMP is satisfying its function properly.

Exp.No.14

CURRENT TO VOLTAGE CONVERTER

AIM:

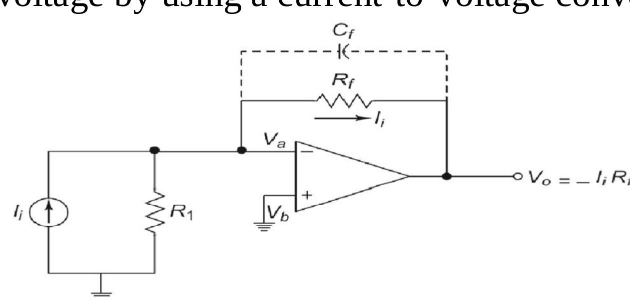
To design and construct a Current to Voltage Converter using Op-amp IC741.

APPARATUS:

1. Operational Amplifier mA 741 IC
2. Resistors 10 KOhm
3. Dual Power supply(0-20V)
4. Current Source
5. Multimeter
6. Bread board
7. Connecting wires

THEORY:

Op-amp can be used to design a circuit which can convert current to voltage. Such a circuit is called a current to voltage converter. The current through these devices can be converted to voltage by using a current-to-voltage converter.

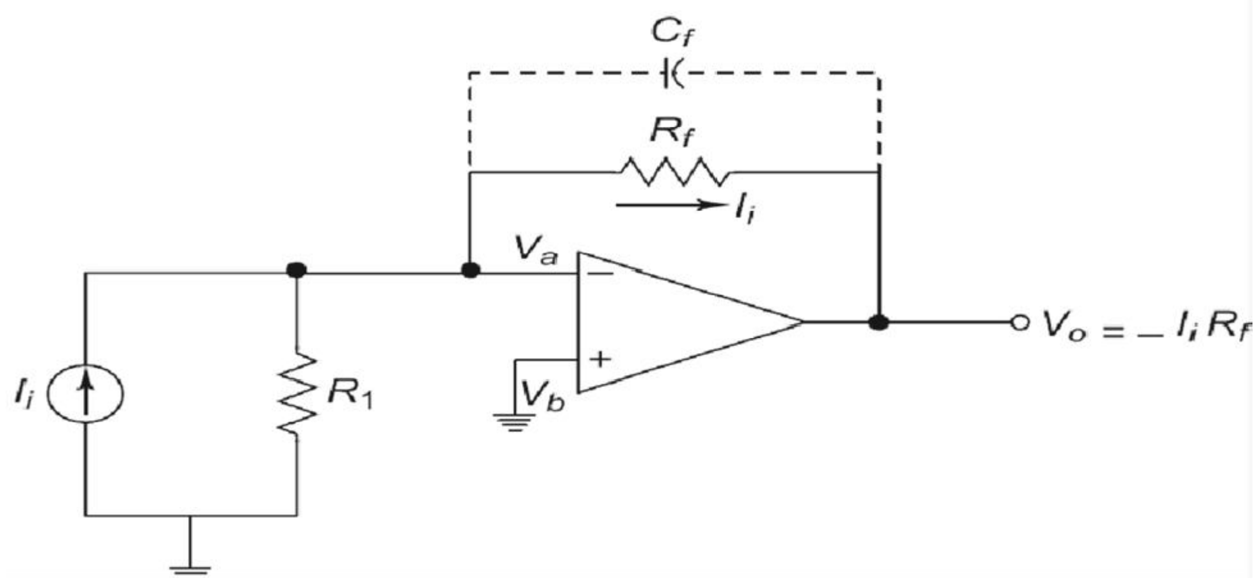


Above figure shows an op-amp used as I to V Converter Since the (-) input terminal is at virtual ground, no current flows through Rs and current ii flows through the feedback resistor Rf.

Thus the output voltage v_0 = - i Rf.

It may be pointed out that the lowest current that this circuit can measure will depend upon the bias current IB of the op-amp. This means that 741(IB = 3 nA) can be used to detect lower currents. The resistor Rf is sometimes shunted with a capacitor Cf to reduce high frequency noise and the possibility of oscillations.

CIRCUIT DIAGRAM:



PROCEDURE:

1.Initially set +Vcc = 12 volts and -Vcc to -12 volts.

2.Measure all resistors that are used in the amplifier circuits using the multimeter and record these values

3. As shown in the circuit diagram connect the circuit for `current to voltage converter` on a breadboard

4.Before turning any power on, double check the wiring to make sure that it is correct. Make sure that the power supply to the op-amp is correctly wired as not to apply the incorrect polarity to the op-amp.

5.Apply certain amount of current at input terminal pin-2 of an op-amp from the Current source and check the output voltage Vo at the output terminal pin -6 using the multimeter.

6. Tabulate 3 different sets of readings by repeating the above step.

7.Compare practical Vo with the theoretical output voltage $V_0 = -i\,Rf$.

TABULAR COLUMN:

S.NO	Input Current (I_{in})	$Vo = -(I_{in}) R_f$	
		Theoretical	Practical

RESULT:

The Practical Values of V_o observed are equal to the theoritical values . From this we can conclude that the current to voltage converter using 741 OP-AMP is satisfying its function properly.

Exp.No.15

DIFFERENTIAL AMPLIFIER

AIM:

To design and realize differential amplifier using IC741 Op-amp.

APPARATUS:

1. Operational Amplifier mA 741 IC –1No.
2. Resistors 1KOhm and 10KOhm
3. Dual Power supply(0-20V)
4. Regulated Power Supply.(0-20V)
5. Multimeter
6. CRO and Probes
7. Funtion Signal Generator.
8. Bread board
9. Connecting wires

THEORY:

INVERTING AMPLIFIER:

Differential amplifier: The differential amplifier is designed to amplify the difference of the two inputs. The simplest configuration is shown in Fig.

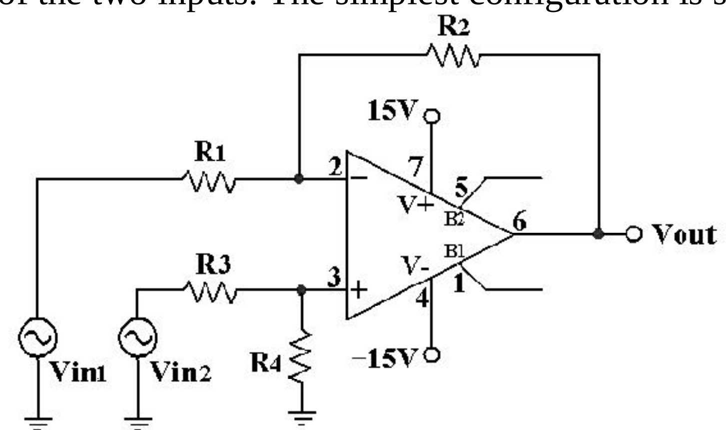


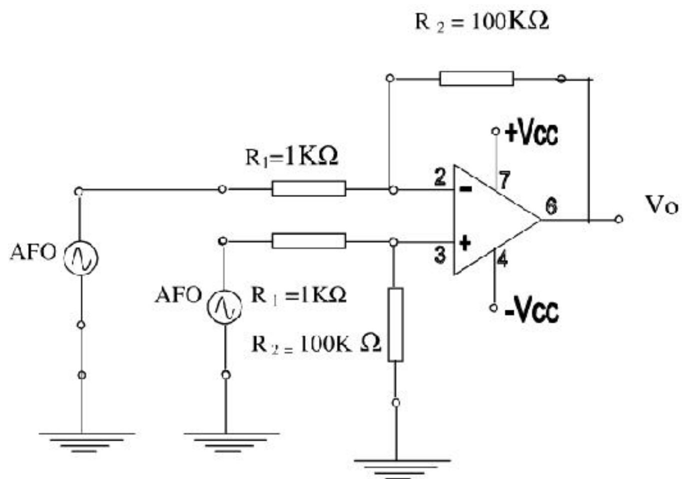
Fig: Differential Amplifier with R1=R3 and R2=R4

If the resistor values are chosen such that R2/R1=R4/R3, then the output of the amplifier is given by:

$$V_{out} = \frac{R_2}{R_1}(V_{in2} - V_{in1})$$

This expression shows that the amplifier amplifies the difference between the two input signals vin1-vin2 and rejects the common mode input signals; Vout = 0 if vin1=vin2. Therefore, the differential amplifier is used in very noisy environment to reject common noise that appears at both inputs. Such a circuit is very useful in detecting very small differences in signals. Since the gain can be chosen to be very large. For example, if R2=100R1, then a small difference V1-V2 is amplified 100 times.

CIRCUIT DIAGRAM:



PROCEDURE:

1.Initially set +Vcc = 12 volts and -Vcc to -12 volts.

2.Measure all resistors that are used in the amplifier circuits using the multimeter and record these values

3. As shown in the circuit diagram connect the circuit for differential amplifier on a breadboard

4.Before turning any power on, double check the wiring to make sure that it is correct. Make sure that the power supply to the op-amp is correctly wired as not to apply the incorrect polarity to the op-amp.

5. Inputs may be AC or DC voltages from function generator or DC power supply.

6.Apply DC inputs to both the input terminals of IC741 from the dc supply and check the output voltage Vo at the output terminal using the multimeter.

7. Readings are tabulated and gain is calculated .Compare practical Vo with the theoretical output voltage Vo = Rf /R1 (Vin2-Vin1)

TABULAR COLUMN:

S.NO	Vin		Vo = Rf /R1 (Vin2-Vin1)		Gain = Rf /R1
	Vin1	Vin2	Theoretical	Practical	

RESULT:

The Practical Values of V_o observed are equal to the Theoritical values. From this we can conclude that the Differential Amplifier using 741 OP-AMP is satisfying its function properly.

Exp.No.16

DAC using OP-AMP

To design and construct a Digital to Analog conversion for digital (BCD) inputs using IC741 Op-amp.

APPARATUS:

1. Operational Amplifier mA 741 IC
2. Resistors
3. Dual Power supply(0-20V)
4. Regulated Power Supply.(0-20V)
5. Multimeter
6. Bread board
7. Connecting wires

THEORY:

Nowadays digital systems are used in many applications because of their increasingly efficient, reliable and economical operation. Since digital systems such as microcomputers use a binary system of ones and zeros, the data to be put into the microcomputer have to be converted from analog form to digital form. The circuit that performs this conversion and reverse conversion are called A/D and D/A converters respectively. D/A converter in its simplest form uses an op-amp and resistors either in the R-2R form or binary weighted form.

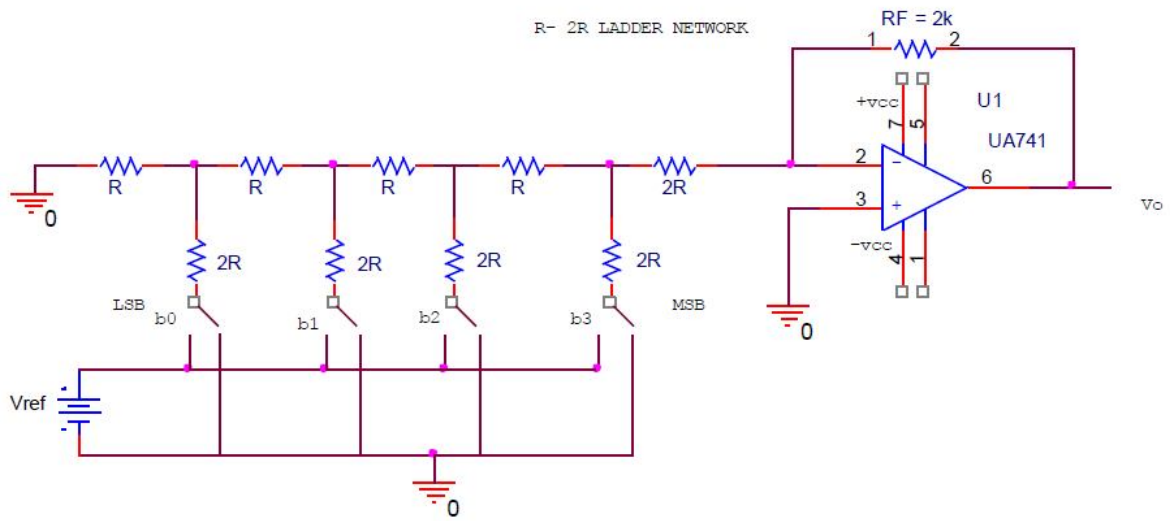
The fig. below shows D/A converter with resistors connected in R-2R form. It is so called as the resistors used here are R and 2R. The binary inputs are simulated by switches b0 to b3 and the output is proportional to the binary inputs. Binary inputs are either in high (+5V) or low (0V) state.

The analysis can be carried out with the help of Thevenin's theorem. The output voltage corresponding to all possible combinations of binary inputs can be calculated as below.

$$V0 = - RF \, [\, (b3/2R) + (b2/4R) + (b1/8R) + (b0/16R) \,]$$

Where each inputs b3, b2, b1 and b0 may be high (+5V) or low (0V).

CIRCUIT DIAGRAM:



PROCEDURE:

1. Initially set +Vcc = 12 volts and -Vcc to -12 volts.

2. Measure all resistors that are used in the amplifier circuits using the multimeter and record these values.

3. As shown in the circuit diagram connect the circuit for DAC on a breadboard

4. Before turning any power on, double check the wiring to make sure that it is correct. Make sure that the power supply to the op-amp is correctly wired as not to apply the incorrect polarity to the op-amp.

5. Apply different combination of binary inputs using switches from the dc supply and check the output voltage Vo at the output terminal using the multimeter. Where each inputs b3, b2, b1 and b0 may be high (+5V) or low (0V).

6. Tabulate different sets of readings by repeating the above step.

7. Compare practical Vo with the theoretical output voltage V_O.

TABULAR COLUMN:

Inputs	Output voltage	
b_3 b_2 b_1 b_0	Theoretical	Practical
0 0 0 0 . . . . . 1 1 1 1		

RESULT:

The Practical Values of V_o observed are equal to the theoretical values. From this we can conclude that the Digital to Analog converter using 741 OP-AMP is satisfying its function properly.

Exp.No.17

LOGARITHMIC AMPLIFIER

To design and construct a logarithmic amplifier using IC741 Op-amp.

APPARATUS:

1. Operational Amplifier mA 741 IC
2. Resistor 1K Ohm
3. Dual Power supply (0-20V)
4. Regulated Power Supply (0-20V)
5. Multimeter
6. Bread board
7. Connecting wires

THEORY:

Op-amp can be used to design a circuit whose output is the logarithm of input signals. Such a circuit is called a logarithmic amplifier.

Logarithmic amplifier can be designed by incorporating a diode in feedback part. Recall that the I-V curve of a diode has an exponential form. We can use that to make a logarithmic amplifier, where the output voltage is proportional to the log of the input voltage. Build the circuit using a 1N914 diode and see how it works, driving it with the variable dc supply. Note that there are an unknown muliplicative constant and offset on the output, so you won't simply observe Vout = log(Vin). Instead, measure Vout for a range of Vin and see if you observe a linear relationship on a semi-log graph. So Output Voltage of a logarithmic amplifier is given by the relation

$$Vout = - \log_{10} (Vin)$$

The reverse of logarithmic amplifier called Anti- logarithmic amplifier can be designed simply by interchanging diode and resistor. So if we place diode in place of resistor and a resistor in place of diode it acts like a Anti- logarithmic amplifier.

CIRCUIT DIAGRAM:

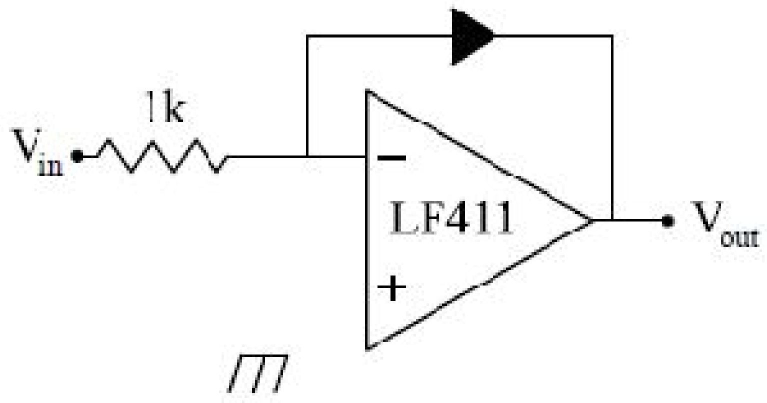


Fig: Logarithmic amplifier configuration of op-amp

PROCEDURE:

1. Initially set +Vcc = 12 volts and -Vcc to -12 volts.

2. Measure all resistors that are used in the amplifier circuits using the multimeter and record these values.

3. As shown in the circuit diagram connect the circuit for logarithmic amplifier on a breadboard

4. Before turning any power on, double check the wiring to make sure that it is correct. Make sure that the power supply to the op-amp is correctly wired as not to apply the incorrect polarity to the op-amp.

5. Apply different inputs from the dc supply and check the output voltage Vo at the output terminal using the multimeter.

6. Tabulate different sets of readings by repeating the above step.

7. Compare practical Vo with the theoretical output voltage $Vout = -\log_{10}(Vin)$.

TABULAR COLUMN:

S.NO	Vin	Vout = - $\log_{10}$ (Vin).	
		Theoretical	Practical

RESULT:

The Practical Values of V_o observed are equal to the theoretical values. From this we can conclude that the logarithmic amplifier using 741 OP-AMP is satisfying its function properly.

Exp.No.18

MONOSTABLE MULTIVIBRATOR using IC 555 TIMER

AIM:

To design and generate a pulse using Monostable Multivibrator by using IC555 Timer.

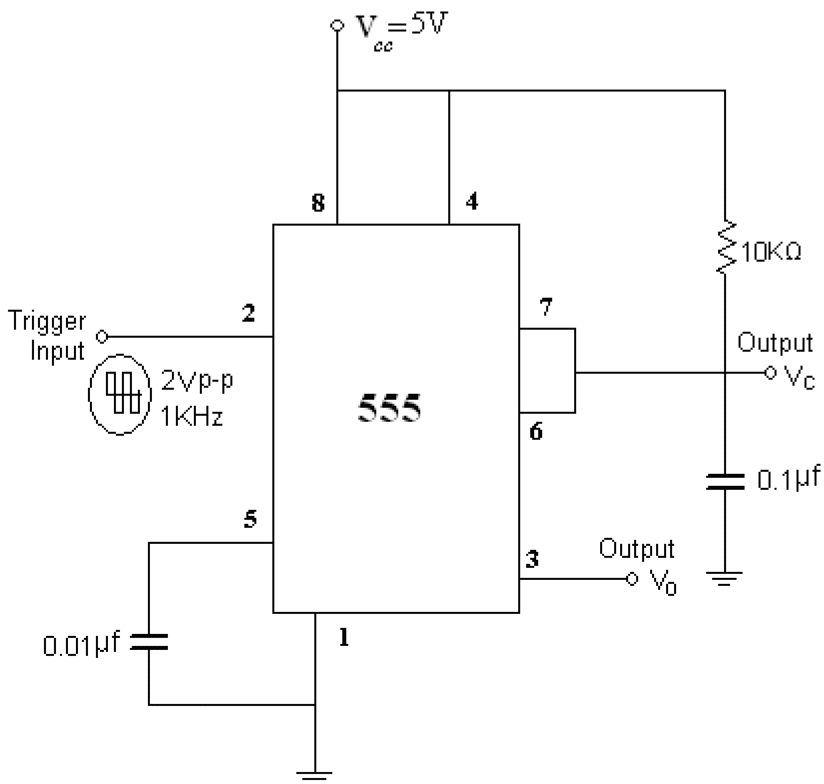
APPARATUS:

1. IC555-Timer –1No.
2. Resistors
3. Capacitor
4. Dual Power supply(0-20V)
5. Regulated Power Supply.(0-20V)
6. Multimeter
7. CRO and Probes
8. Funtion Signal Generator.
9. Bread board
10. Connecting wires

THEORY:

A Monostable Multivibrator, often called a one-shot Multivibrator, is a pulse-generating circuit in which the duration of the pulse is determined by the RC network connected externally to the 555 timer. In a stable or stand by mode the output of the circuit is approximately Zero or at logic-low level. When an external trigger pulse is obtained, the output is forced to go high ($\cong V_{CC}$). The time for which the output remains high is determined by the external RC network connected to the timer. At the end of the timing interval, the output automatically reverts back to its logic-low stable state. The output stays low until the trigger pulse is again applied. Then the cycle repeats. The Monostable circuit has only one stable state (output low), hence the name monostable. Normally the output of the Monostable Multivibrator is low.

CIRCUIT DIAGRAM:



DESIGN:

Consider V_{CC} = 5V, for given t_p

Output pulse width $t_p = 1.1\ R_A\ C$

Assume C in the order of microfarads & Find R_A

Typical values:

If C=0.1 µF , R_A = 10k then t_p = 1.1 mSec

Trigger Voltage = 4 V

PROCEDURE:

1. Initially set +Vcc = 5 volts.

2. Measure all resistors that are used in the amplifier circuits using the multimeter and record these values

3.As shown in the circuit diagram connect the circuit for Monostable Multivibrator on a breadboard.

4. Before turning any power on, double check the wiring to make sure that it is correct. Make sure that the power supply to the IC 555 is correctly wired as not to apply the incorrect polarity to the IC 555.

5. Apply Negative triggering pulses at pin 2 of frequency 1 KHz.

6. Observe the output waveform and measure the pulse duration.

7. Theoretically calculate the pulse duration as T_{high}=1.1. R_AC

8. Compare it with experimental values .

TABULAR COLUMN:

Trigger	Output wave	Capacitor output

EXPECTED GRAPH:

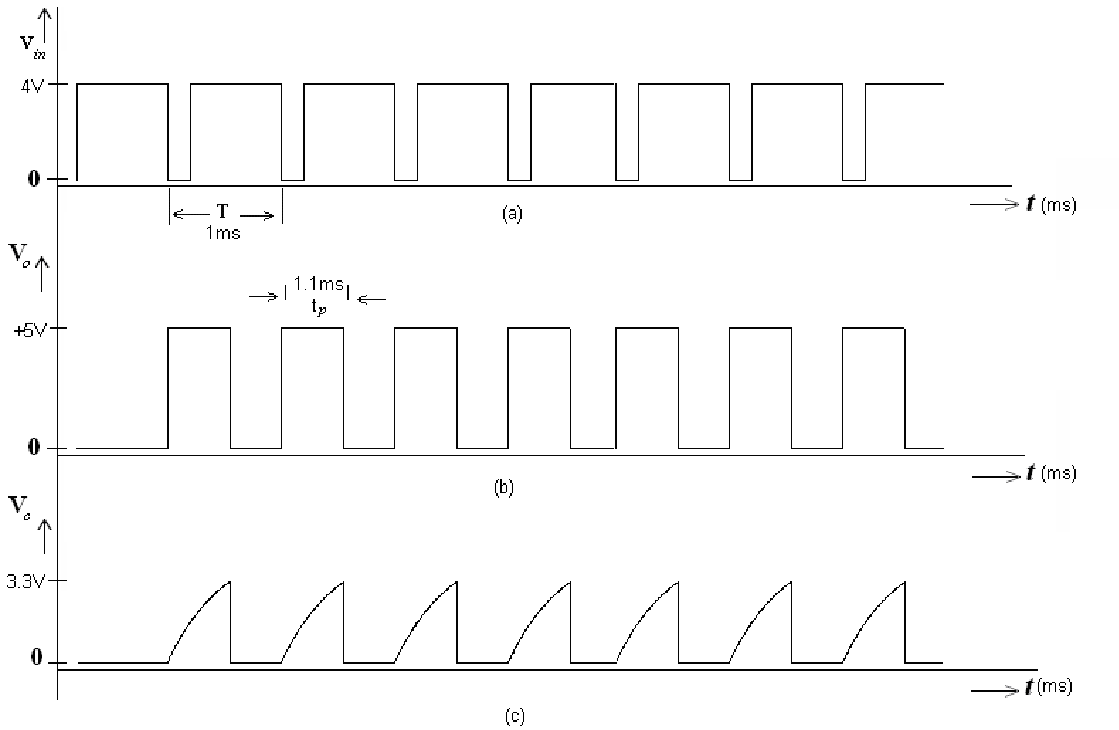
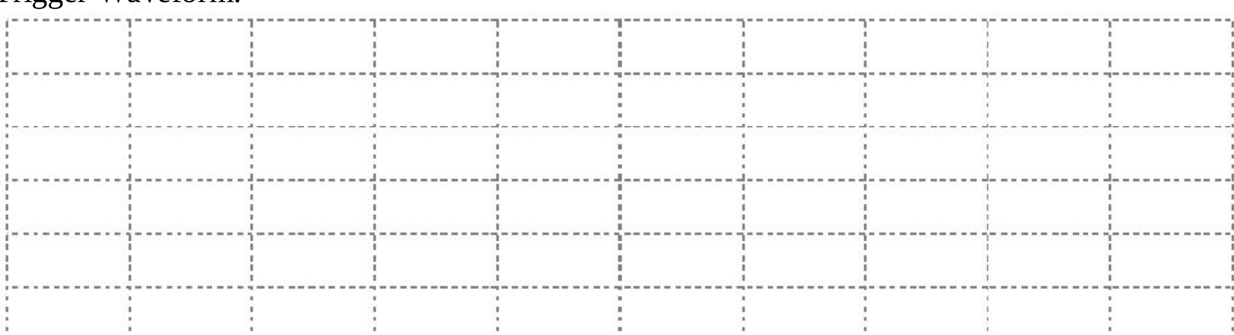


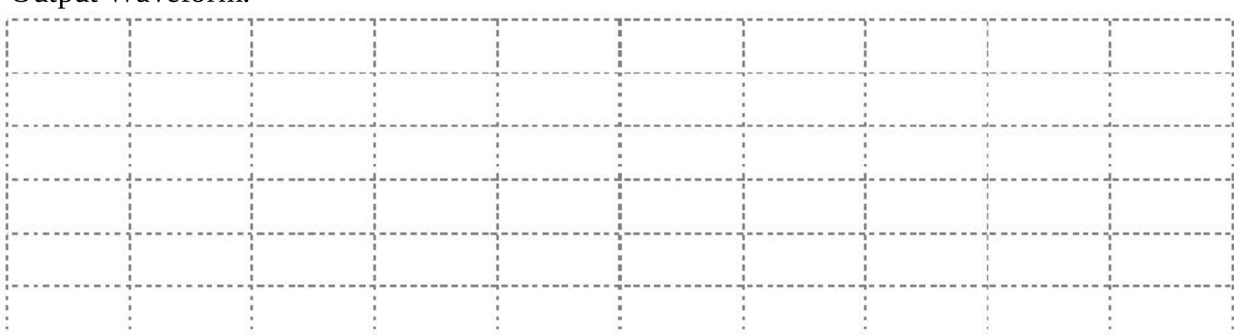
Fig: (a): Trigger signal (b): Output Voltage (c): Capacitor Voltage

WORKSHEET:

Trigger Waveform:



Output Waveform:



RESULT:

The Practical Values of V_o observed are equal to the Theoritical values. From this we can conclude that the Monostable Multivibrator using IC 555-Timer is satisfying its function properly.

Exp.No.19

ASTABLE MULTIVIBRATOR using IC 555 TIMER

AIM:

To design and generate unsymmetrical square and symmetrical square waveforms using Astable Multivibrator by using IC555 Timer.

APPARATUS:

1. IC555-Timer –1No.
2. Resistors
3. Capacitor
4. Dual Power supply(0-20V)
5. Regulated Power Supply.(0-20V)
6. Multimeter
7. CRO and Probes
8. Funtion Signal Generator.
9. Bread board
10. Connecting wires

THEORY:

When the power supply V_{CC} is connected, the external timing capacitor 'C" charges towards V_{CC} with a time constant (R_A+R_B) C. During this time, pin 3 is high ($\approx V_{CC}$) as Reset R=0, Set S=1 and this combination makes $\overline{Q}$=0 which has unclamped the timing capacitor 'C'.

When the capacitor voltage equals 2/3 V_{CC}, the upper comparator triggers the control flip flop on that $\overline{Q}$=1. It makes Q1 ON and capacitor 'C' starts discharging towards ground through R_B and transistor Q1 with a time constant R_BC. Current also flows into Q1 through R_A. Resistors R_A and R_B must be large enough to limit this current and prevent damage to the discharge transistor Q1.

The minimum value of R_A is approximately equal to $V_{CC}/0.2$ where 0.2A is the maximum current through the ON transistor Q1.

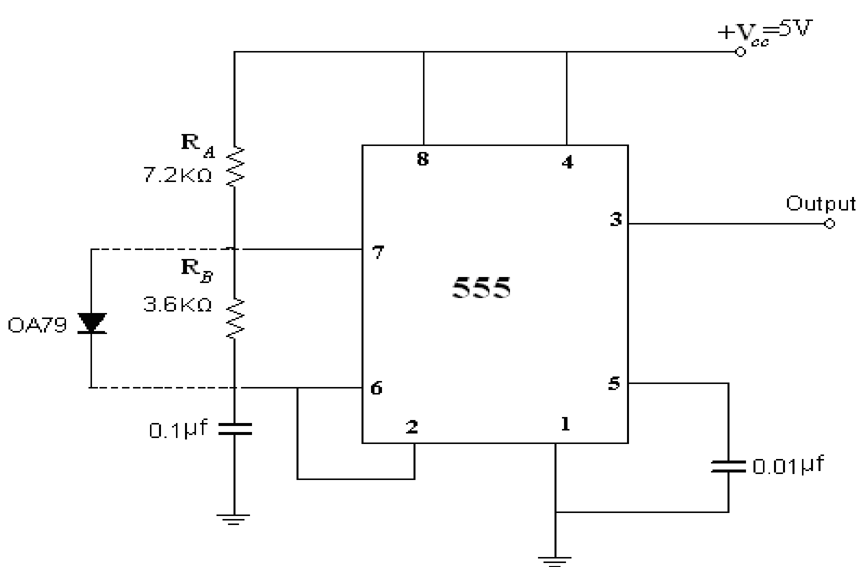
During the discharge of the timing capacitor C, as it reaches $V_{CC}/3$, the lower comparator is triggered and at this stage S=1, R=0 which turns $\overline{Q}=0$. Now $\overline{Q}=0$ unclamps the external timing capacitor C. The capacitor C is thus periodically charged and discharged between 2/3 V_{CC} and 1/3 V_{CC} respectively. The length of time that the output remains HIGH is the time for the capacitor to charge from 1/3 V_{CC} to 2/3 V_{CC}.

The capacitor voltage for a low pass RC circuit subjected to a step input of V_{CC} volts is given by $V_C = V_{CC}\,[1-\exp(-t/RC)]$

Total time period $T = 0.69\,(R_A + 2\,R_B)\,C$

$$f = 1/T = 1.44/(R_A + 2R_B)\,C$$

CIRCUIT DIAGRAM:



DESIGN:

Formulae: $f = 1/T = 1.44/(R_A+2R_B)\, C$

Duty cycle (D) = $t_c/T = R_A + R_B/(R_A+2R_B)$

MODEL CALCULATIONS:

Given f=1 KHz. Assuming c=0.1µF and D=0.25

$\therefore 1\text{ KHz} = 1.44/(RA+2R_B) \times 0.1\times10^{-6}$ and $0.25 = (R_A+R_B)/(R_A+2R_B)$

Solving both the above equations, we obtain $R_A = 7.2K\ \Omega$ and $R_B = 3.6K\ \Omega$

PROCEDURE:

1. Initially set +Vcc = 5 volts.

2. Measure all resistors that are used in the amplifier circuits using the multimeter and record these values

3.As shown in the circuit diagram connect the circuit for Astable Multivibrator on a breadboard.

4. Before turning any power on, double check the wiring to make sure that it is correct. Make sure that the power supply to the IC 555 is correctly wired as not to apply the incorrect polarity to the IC 555.

5.For Unsymmetrical Square wave Connect the circuit as per the circuit diagram shown without connecting the diode.

6.Observe and note down the waveform at pin 6 and across timing capacitor.

7. Measure the frequency of oscillations and duty cycle and then compare with the given values.

8. Sketch both the waveforms to the same time scale.

9.For Symmetrical Square wave Connect the circuit as per the circuit diagram shown by connecting the diode.

10. Choose $R_a=R_b$ = 10KΩ and C=0.1Mf.

11. Observe the output waveform, measure frequency of oscillations and the duty cycle and then sketch the o/p waveform.

TABULAR COLUMN:

Parameter	Unsymmetrical	Symmetrical
Voltage V_{PP}		
Time period T		
Duty cycle		

EXPECTED GRAPH:

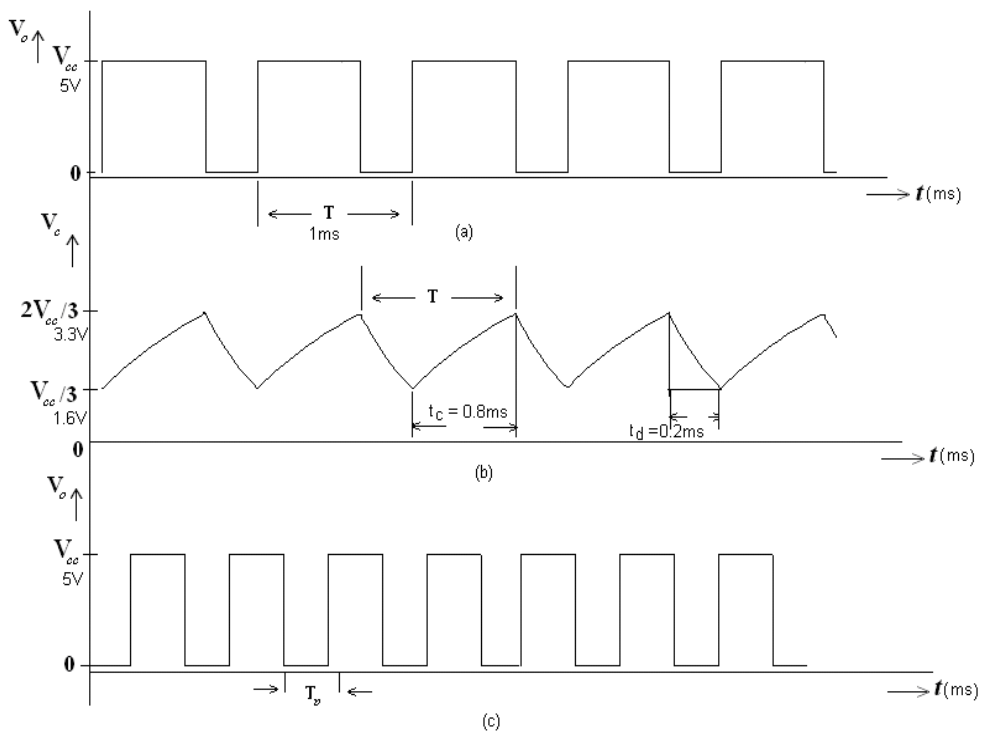


Fig (a): Unsymmetrical square wave output

(b): Capacitor voltage of Unsymmetrical square wave output

(c): Symmetrical square wave output

WORKSHEET:

Unsymmetrical square wave Output Waveform :

Capacitor voltage of Unsymmetrical square wave Output Waveform :

Symmetrical square wave Output Waveform :

RESULT:

From this we can conclude that the Astable Multivibrator using IC 555-Timer is satisfying its function properly.

Exp.No.20

NON – LINEAR OP-AMP CIRCUITS

AIM:

To study the operation of active diode circuits (precisions circuits) such as halfwave rectifier, clipper, and clamper circuits using Op-amp IC741.

APPARATUS:

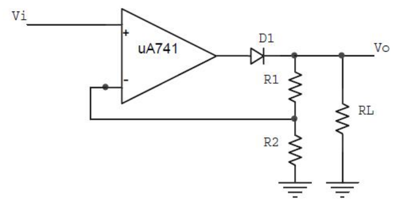
1. Operational Amplifier mA 741 IC
2. Resistors
3. Capacitors
4. Diode
5. Dual Power supply(0-20V)
6. Regulated Power Supply.(0-20V)
7. Multimeter
8. CRO and Probes
9. Funtion Signal Generator.
10. Bread board
11. Connecting wires

THEORY:

The use of op-amps can improve the performance of a wide variety of signal processing circuits. In rectifier circuits, the cut-in voltage drop that occurs with an ordinary semiconductor diode can be eliminated to give precision rectification waveforms can be limited and clamped at precise levels when op-amps are employed in clipping and clamping circuits. The error with peak detectors can also be minimized by the use of the op-amps.

Active half wave rectifier:

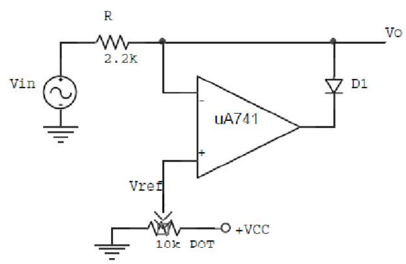
Op-amps can enhance the performance of diode circuits. For one thing, the op-amp can eliminate the effect of diode offset voltage, allowing us to rectify, peak-detect, clip, and clamp lowlevel signals (those with amplitudes smaller than the offset voltage). And because of their buffering action op-amps can eliminate the effects of source and load on diode circuits. Circuits that combine op-amps and diodes are called active diode circuits. Below figure shows active HWR.



When the input signal goes positive, the op-amp goes positive and turns on the diode. The circuit then acts as a conventional non-inverting amplifier, and the positive half-cycle appears across the load resistor. On the other hand, when the input goes negative, the op-amp output goes negative and turns off the diode. Since the diode is open, no voltage appears across the load resistor. This is why the final output is almost a perfect half-wave signal.

Active clipper:

Clipper is a circuit that is used to clip off (remove) a certain portion of the input signal to obtain a desired output wave shape. In op-amp clipper circuits, a rectified diode may be used to clip off certain parts of the input signal. Below figure shows an active positive clipper, a circuit that removes positive parts of the input signal. The clipping level is determined by the reference voltage Vref.



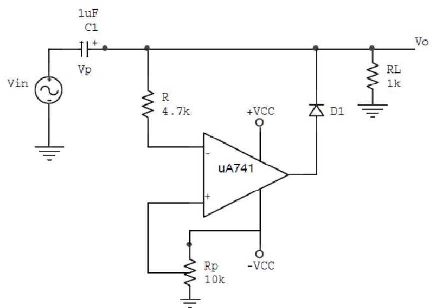
With the wiper all the way to the left, Vref is o and the non-inverting input is grounded. When Vin goes positive, the error voltage drives the op-amp output negative and turns on the diode. This means the final output VO is 0 (same as Vref) for any positive value of Vin.

When Vin goes negative, the op-amp output is positive, which turns off the diode and opens the loop. When this happens, the final output VO is free to follow the negative half cycle of the input voltage. This is why the negative half cycle appears at the output. To change the clipping level, all we do is adjust Vref as needed.

Active clamper:

In clamper circuits, a predetermined dc level is added to the input voltage. In other words, the output is clamped to a desired dc level. If the clamped dc level is positive, the clamper is called a *positive clamper*. On the other hand, if the clamped dc level is negative, it is called a *negative clamper*. The other equivalent terms for clamper are *dc inserter or dc restorer.*

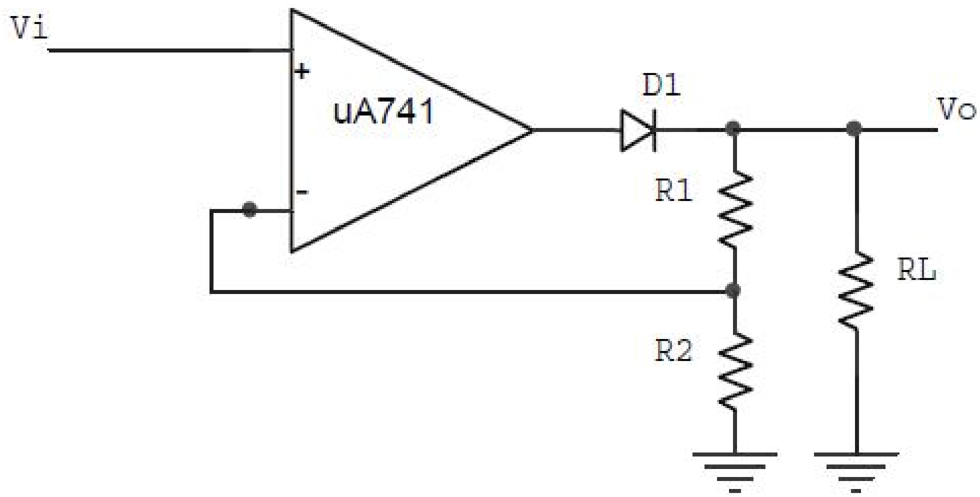
A clamper circuit with a variable dc level is shown in below figure. Here the input wave form is clamped at +Vref and hence the circuit is called a positive clamper.



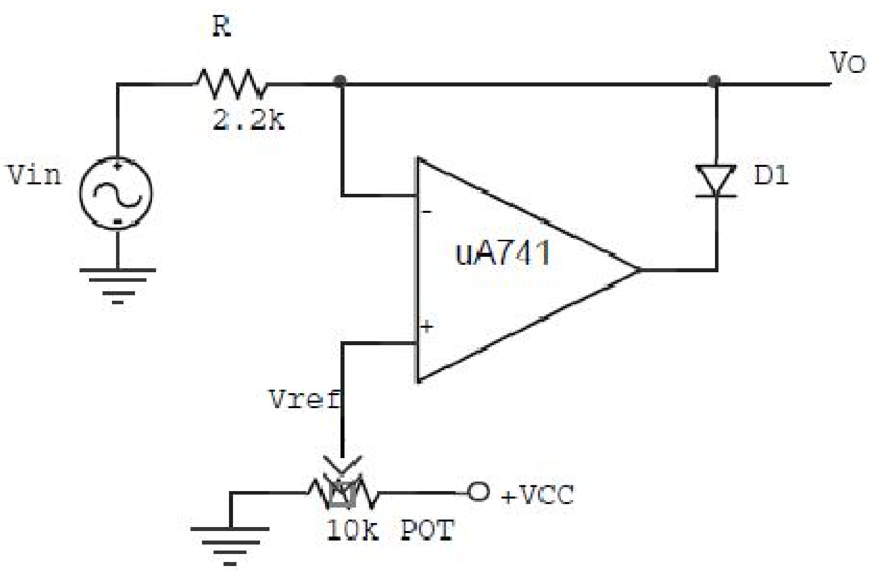
The output voltage of the clamper is a net result of ac and dc input voltages applied to the inverting and non-inverting input terminals respectively. Therefore, to understand the circuit operation, each input must be considered separately. First, consider Vref at the non-inverting input. Since this voltage is positive, is +VO is positive, which forward biases diode D1. This closes the feedback loop and the op-amp operates as a voltage follower. This is possible because C1 is an open circuit for dc voltage. Therefore VO = Vref. As for as voltage Vin at the inverting input is concerned during its negative half-cycle D1 conducts, charging C1 to the negative peak value of the VP. However, during the positive half-cycle of Vin diode D1 is reverse biased and hence the voltage VP across the capacitor acquired during the negative half-cycle is retained. Since this voltage VP is in series with the positive peak voltage VP, the output peak voltage VO=2VP. Thus the net output is Vref+VP, so the negative peak of 2VP is at Vref. For precision clamping C1Rd<<T/2, where Rd is the forward resistance of the diode D1 (100∧ typically) and T is the time period of Vin.

Resistor R is used to protect the op-amp against excessive discharge currents from capacitor C1 especially when the dc supply voltages are switched off. Negative clamping at a negative voltage is accomplished by reversing diode D1 and using the negative reference voltage –Vref.

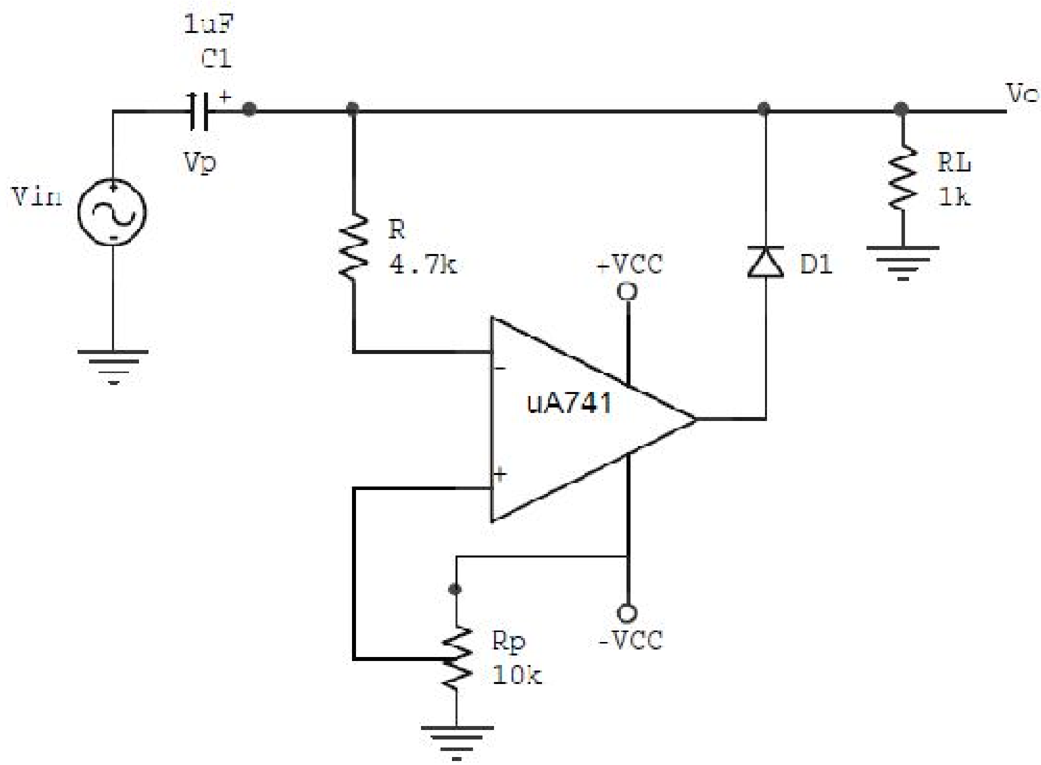
CIRCUIT DIAGRAM:



Circuit Diagram1: Circuit for Active Half Wave Rectifier.



Circuit Diagram 2: Circuit for Active Clipper



Circuit Diagram 3: Circuit for Active Clamper

PROCEDURE:

1.Initially set +Vcc = 12 volts and -Vcc to -12 volts.

2.Measure all resistors and capacitors that are used in the circuits using the multimeter and record these values.

3.Before turning any power on, double check the wiring to make sure that it is correct. Make sure that the power supply to the op-amp is correctly wired as not to apply the incorrect polarity to the op-amp.

4. For Active Half Wave Rectifier:

4.1. Choose the appropriate resistor values of R1 and R2. Consider RL = 10kΩ.
4.2 Feed sinusoidal input of amplitude 200mVPP and frequency 100Hz.
4.3 Using a CRO observe the input and output voltages simultaneously.
4.4 Determine the amplitude and frequency of the output voltage.
4.5 Record this values in table shown below.
4.6 Plot the input and output voltages on the same scale.

5. For Active clipper:

5.1 Feed 3VP, 1 KHz sinusoidal input from function signal generator.
5.2 Observe the input and output voltages on a CRO.
5.3 Look at output signal while turning the potentiometer through its entire range.
5.4 Record your readings in table shown below for a desired clipping level.
5.6 Plot the input and output voltages on the same scale.

6. For Active clamper:

6.1 Assemble a positive clamping circuit with clamping level at zero as shown in fig. Note that Vref = 0V. Use 1N4002 diode.
6.2 Feed 5VPP, 10 KHz sinusoidal input.
6.3 Using a CRO observe the input and output voltages simultaneously.
6.4 Determine the clamping levels of the output voltage.
6.5 Tabulate your readings in table shown below.
6.4 Plot the input and output voltages on the same scale.

TABULAR COLUMN:

Particulars	Amplitude	Time Period	Frequency
Input Voltage			
Output Voltage			

Tabular Column 1: Table for Active Half Wave Rectifier

Clipping Level =

Particulars	Amplitude	Time Period	Frequency
Input Voltage			
Output Voltage			

Tabular Column 2: Table for Active Clipper

Clamping level =

Particulars	Amplitude	Time Period	Frequency
Input Voltage			
Output Voltage			

Tabular column 3: Table for Active Clamper

EXPECTED GRAPH:

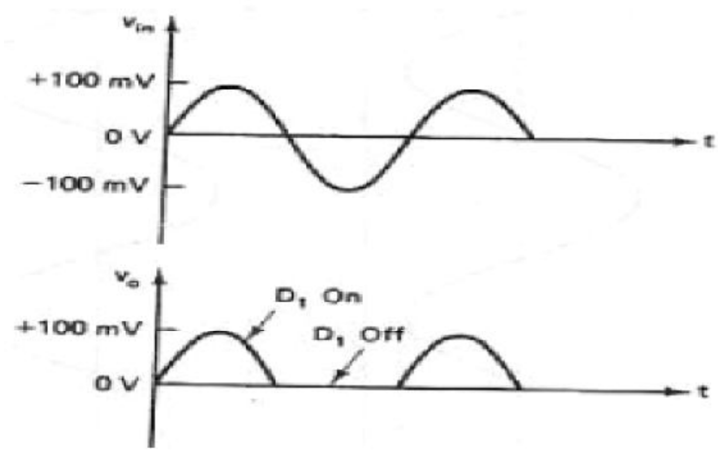


Fig: Input and Output waveforms of Active Half wave Rectifier.

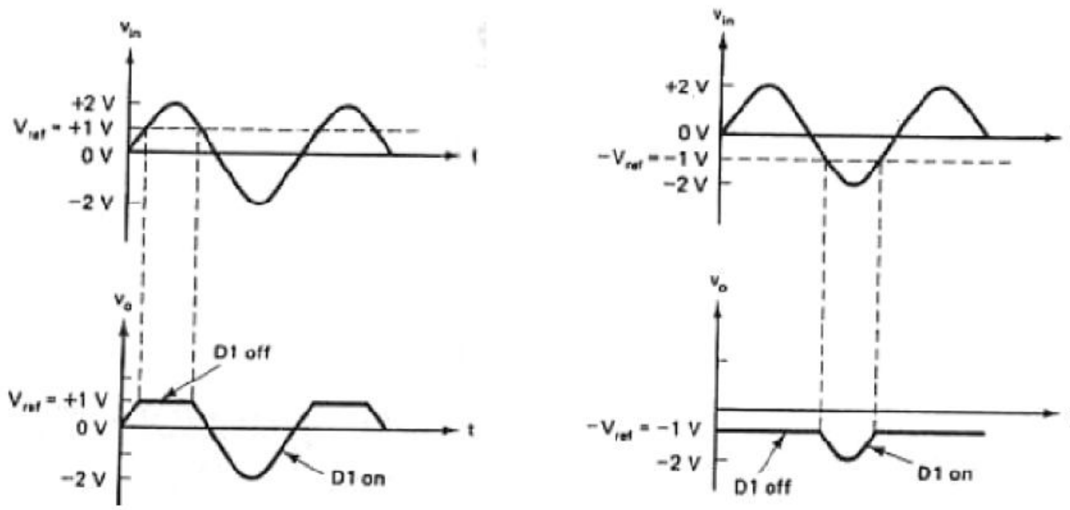
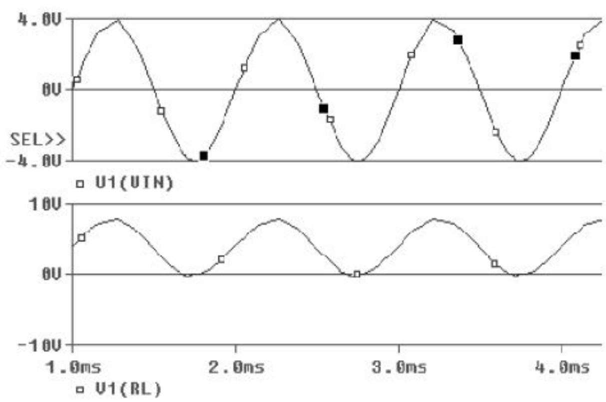
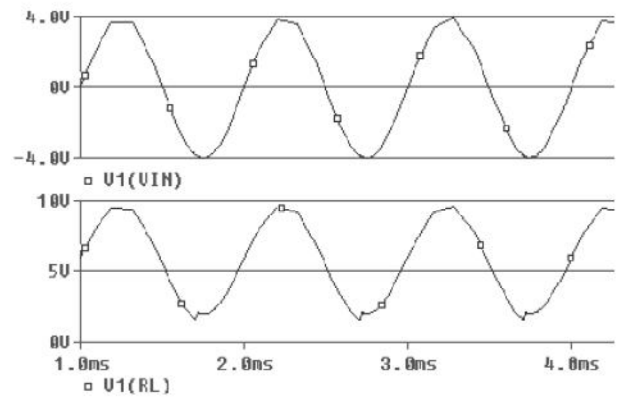


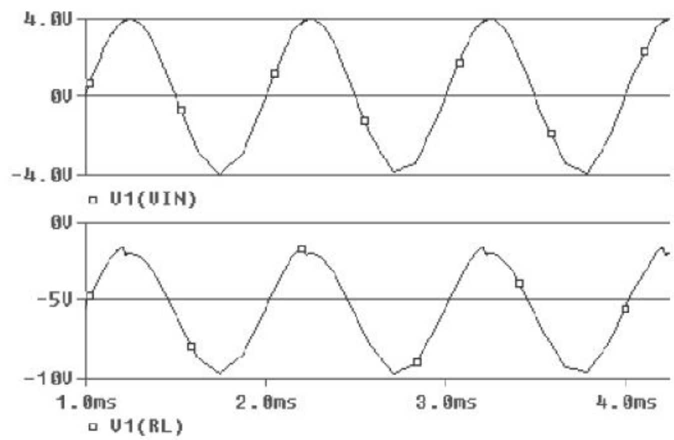
Fig: Input and Output waveforms of Active Clipper with +Vref and with –Vref



(i)



(ii)



(iii)

Fig: Input and Output waveforms of Active Clamper (i) with Vref=0V (ii) with +Vref (iii) with –Vref

WORKSHEET:

Input and Output Waveform of Active HWR:

Input and Output Waveform of Active Clipper :

Input and Output Waveform of Active Clamper :

RESULT:

From this we can conclude that the Active HWR, Active Clipper and Active Clamper using IC 741 OP-AMP is satisfying its function properly.

VIVA – QUESTIONS AND ANSWERS

1. What is an IC?

Ans: The term IC refers to complex electronic circuit consisting of a large number of components on a single substrate.

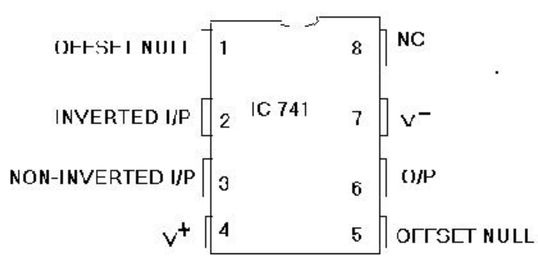
2. What are the advantages of IC?

Ans: For Cost reduction, Increased operating speed, Reduced power consumption and Improved functional performance.

3. Define an operational amplifier?

*Ans:*An operational amplifier is a direct-coupled, high gain amplifier consisting of one or more differential amplifier. By properly selecting the external components, it can be used to perform a variety of mathematical operations

4. Draw the pin diagram of IC 741?



5.State the ideal characteristics of Op-amp?

Ans: i) Open loop gain, Aol = ∞
ii) Input impedance, Ri = ∞
iii) Output Impedance, Ro = 0
iv) Zero Offset, Vo = 0
v) Bandwidth, BW = ∞

6.What happens when 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.

7. What is the gain of inverting amplifier in terms of resistances?

Ans: Gain $G = - R_f / R_{in}$

8. What is the effect of negative feedback on the voltage gain of an amplifier?

Ans: Increases stability of its voltage gain.

9. What is the gain of non-inverting amplifier in terms of resistances?

Ans: Gain $G = 1+(R_f / R_{in})$

10. Mention some of the linear applications of op – amps ?

Ans: Adder,subtractor,voltage–to-current converter, current–to-voltage converters, instrumentation amplifier, analog computation ,power amplifier, etc

11. 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,.

12. What are the areas of application of non-linear op- amp circuits?

Ans : Industrial instrumentation, Signal processing etc,.

13. What is Linear IC?

Ans: IC which accepts, process and produce analog signal is called linear IC.

Eg: IC741,IC555.

14.What is an Adder and Subtractor?

Ans: An Adder is a circuit which adds the magnitude of input signal. Subtractor is a circuit which subtracts the magnitude of input signals.

15.What are the applications of Adder and Subtractor?

Ans: These circuits are used in Calculators, Computers, microprocessors etc,.

16.State some applications of integrator?

Ans: a) Analog computers
b) ADC
c) Signal wave shaping circuits.

17.What is the effect of resistor Rf ,which is connected across the feedback capacitor Cf in practical integrator circuit?
Ans: The feedback resistor removes the high frequency noise signals.

18.If input of the integrator is a dc voltage then which type of waveform will be obtained at the output the integrator ?
Ans: Ramp waveform.

19. Write down the condition for good differentiation?
Ans: For good differentiation, the time period of the input signal must be greater than or equal to Rf C1 ,T > R f C1 Where, Rf is the feedback resistance.

20. What are the limitations of the basic differentiator circuit?
*Ans:*At high frequency, a differentiator may become unstable and break into oscillations. The input impedance decreases with increase in frequency , thereby making the circuit sensitive to high frequency noise.

21. Define analog signal?
Ans: When the amplitude of a signal varies continuously with respect to time,the signal is called analog.

22. What is unity gain circuit?
Ans: Voltage follower is called unity gain circuit. The circuit does not amplify and provides constant gain of unity.

23.If input of the square wave generator is a dc voltage then which type of waveform will be obtained at the output of square wave generator ?
Ans: Ramp waveform.

24.Which component is required to convert square wave into triangular wave ?
Ans: Integrator.

25. What is the other name for Schmitt trigger circuit?
Ans: Regenerative Comparator.

26. In Schmitt trigger which type of feedback is used?
Ans: Positive Feedback.

27. What is meant by hysteresis?

The comparator with positive feedback is said to be exhibit hysteresis , a deadband condition. When the input of the comparator is exceeds V_{utp}, its output switches from + V_{sat} to - V_{sat} and reverts back to its original state,+ V_{sat} ,when the input goes below V_{ltp} .

28.What are effects of input signal amplitude and frequency on output in Schmitt trigger circuit?

*Ans:*The input voltage triggers the output every time it exceeds certain voltage levels (UTP and LTP) .Output signal frequency is same as input signal frequency.

29.Why Schmitt trigger is called regenerative comparator?

Ans: The reference voltages LTP andUTP are regenerated depending on the output voltages +Vsat and –Vsat.

30. What is hysteresis voltage in Schmitt trigger?

*Ans:*The difference in voltage between lower and upper threshold voltage is called hysteresis voltage**.**

31. What is the effect of Vcc on output in Schmitt trigger?

Ans: The amplitude of the output signal is directly proportional to Vcc.

32.What is a comparator?

*Ans:*A comparator is a circuit which compares a signal voltage applied at one input of an op-amp with known reference voltage at other input. It is basically an Op-amp with output Vsat (»Vcc).

33. What is the difference between a basic comparator and ZCD?

*Ans:*Comparator has only one reference voltage whereas ZCD has zero reference voltage.

34. What are the characteristics of Comparator?

Ans: a) Speed of operation
b) Accuracy
c) Compatibility of the output.

35. What are the modes in which op-amp is operated with finite gain and infinite gain?

Ans: Open loop mode with infinite gain: Comparator
Closed loop mode with finite gain: Amplifier

36. What is the basic difference between a comparator and Schmitt trigger?
Ans: The comparator compares the input signal with reference voltage and gives the output whereas Schmitt trigger operates between two reference points LTP and UTP.

37.What is an oscillator?
*Ans:*An oscillator is basically a positive feedback circuit where a fraction of output voltage Vo is fed back to the input end of the basic amplifier, which is in phase with the signal to the basic amplifier.

38.Design a Wein bridge oscillator for a frequency of 1 KHz?
Ans:

f = 1/2 ΠRC
C = 0.1 μF
R = 1/2 ΠfC
R = 1/(2*3.14*1*10^3*0.1*10^-6)
R= 628 Ω

39. Wein bridge oscillator uses positive and negative feedback. Why?
Ans: Negative feedback is used for stability gain positive feedback is used for oscillation

40. What is the function of lead-lag network in Wein bridge oscillator?
Ans: The function of lag lead network is to obtain the zero degree phase shift.

41. State barkhausen criterion?
Ans: Magnitude $A\beta=1$ and Phase angle $\Phi = 0^o$ or 360^o

42.What are the requirements for producing sustained oscillations in feedback circuits?
Ans: For sustained oscillations,. The total phase shift around the loop must be zero at the desired frequency of oscillation, . At fo, the magnitude of the loop gain should be equal to unity.

43. Mention any two audio frequency oscillators?
Ans: RC phase shift oscillator
Wein bridge oscillator

44. Define slew rate?

Ans: It is defined as the maximum rate of change of output voltage caused by a step input voltage and is specified in volt per micro second. For IC 741 it is 0.5V/micro sec.

45. Define input offset voltage?

Ans: A small voltage applied to the input terminals to make the output voltage as zero when the two input terminals are grounded is called input offset voltage.

46. Define input offset current?

Ans: The difference between the bias currents at the input terminals of the op-amp is called as input offset current.

47.Why differential amplifier is used as an input stage of IC op-amp?

*Ans:*The differential amplifier eliminates the need for an emitter bye-pass capacitor. So, differential amplifier is used as an input stage in op-amp ICs .

48.Define CMRR of an op-amp?

Ans: The relative sensitivity of an op-amp to a difference signal as compared to a Common –mode signal is called the common –mode rejection ratio. It is expressed in decibels.CMRR= A_d/A_c

49. List all the types of DAC?

Ans: a) Weighted resistor
b) R-2R ladder
c) Inverted R-2R ladder.

50. What is the advantage of R-2R ladder over weighted resistor?

Ans: In weighted resistor, for higher order conversion the values of resistors become very high which is overcome in R-2R ladder which has only R and 2R values of resistors.

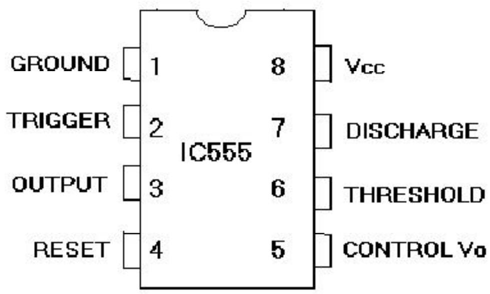
51. Define Resolution?

Ans: Smallest change in voltage which may be produced at the output of converter.

52.List the applications of Log amplifiers ?

Ans: Analog computation may require functions such as lnx, log x, sin hx etc. These functions can be performed by log amplifiers Log amplifier can perform direct dB display on digital voltmeter and spectrum analyzer Log amplifier can be used to compress the dynamic range of a signal.

53.*Draw the pin diagram of 555 Timer IC?*
Ans:



54. What is the advantage of 555 IC over op amp?
Ans: 555 IC generates accurate time delay compared to op amp .

55.List the basic blocks of IC 555 timer?
Ans: A relaxation oscillator.
R-S flip-flop
Two comparators
Discharge transistors

56.What is a multivibrator?
Ans: Multivibrators are a group of regenerative circuits that are used extensively in timing applications. It is a wave shaping circuit which gives symmetric or asymmetric square output. It has two states stable or quasi- stable depending on the type of multivibrator.

57.What are the various modes of operation of multivibrator? Explain
Ans: Astable mode – 2 quasi stable state
Monostable – 1 quasi and on stable state.
Bistable – 2 stable states.

58. What is quasi stable state?
Ans: Change from one state to another without any external trigger is termed as quasi stable state.

59.What do you mean by monostable multivibrator?
Ans: Monostable multivibrator is one which generates a single pulse of specified duration in response to each external trigger signal. It has only one stable state. Application of a trigger causes a change to the quasi-stable state. An external

trigger signal generated due to charging and discharging of the capacitor produces the transition to the original stable state.

60.What are the applications of monostable multivibrator ?
Ans: Missing Pulse Detector, Frequency Divider ,PWM ,Linear Ramp Generator.

61.What is the effect of C on the output in astable multivibrator ?
Ans: Time period of output depends on C

62.How do you vary duty cycle in astable multivibrator ?
Ans: By varying R_A or R_B.

63.What is the function of diode in astable multivibrator ?
Ans: To get symmetrical square wave.

64. On what parameters Tc and Td designed in astable multivibrator ?
Ans: R_A ,R_B and C.

65. Give the applications of Astable multivibrator mode of 555-timer?
Ans: a) Square wave generator
b) Voltage Controlled Oscillator (VCO)
c) FSK Generator
d) Schmitt trigger.

66. List the applications of monostable mode of 555 timer?
Ans: a) Missing Pulse detector
b) Linear ramp generator
c) Frequency divider

67.What are the other names of monostable multivibrator ?
Ans: Gating circuit, One-shot multivibrator.

68. Why monostable multivibrator is called as Gating circuit?
Ans: As it generates rectangular waveform at a definite time and thus could be used in gate parts of the system.

69. What do you mean by a precision diode?
Ans: The major limitation of ordinary diode is that it cannot rectify voltages below the cut – in voltage of the diode. A circuit designed by placing a diode in the

feedback loop of an op – amp is called the precision diode and it is capable of rectifying input signals of the order of mill volt.

70. Write down the applications of precision diode?

Ans: Half - wave rectifier
Full - Wave rectifier
Peak – value detector
Clipper
Clamper