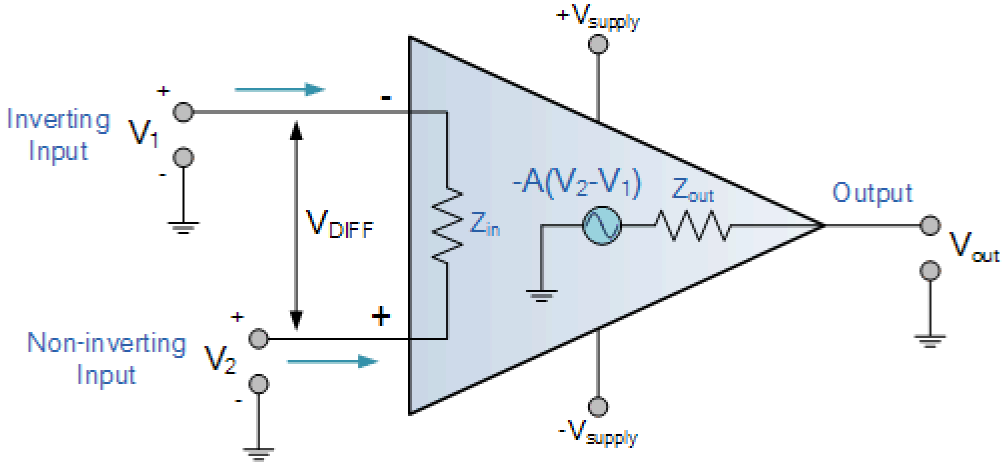
Laboratory Manual

Analog Integrated Circuits Laboratory



Department of Instrumentation Engineering
JORHAT ENGINEERING COLLEGE
Jorhat, Assam-785007

Do’s

- Be punctual, maintain discipline & silence.
- Keep the Laboratory clean and tidy.
- Leave your shoes in the rack outside.
- Handle the equipments carefully.
- Save all your files properly.
- Come prepared with programs/algorithms/related manuals.
- Follow the procedure that has been instructed.
- Get the signature on experiment result sheet daily.
- For any clarification contact faculty/staff in charge only.
- Log off the system properly before switching off.

Don’ts

- Avoid unnecessary chat or walk.
- Disfiguring of furniture is prohibited.
- Avoid using cell phones unless absolutely necessary.
- Do not use personal pen drives without permission.
- Do not displace monitor, keyboard, mouse etc.
- Avoid late submission of laboratory reports

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IN 407	AIC Laboratory	IV semester	L-T-P 0-0-2	1 Credit

Experiment No.	Title of the Experiment	Objective of the Experiment
1	Implement a non-Inverting (NI) amplifier circuit using opamp	To study the input and output waveform of NI amplifier
2	Implement an inverting amplifier circuit using opamp.	To study the input and output waveform of inverting amplifier
3	Performance evolution of a summing amplifier circuit.	To study a summing amplifier circuit
4	Implement a differential amplifier circuit using opamp.	To study a differential amplifier circuit using opamp
5	Implement an integrator circuit using op-amp.	To study an integrator circuit using op-amp.
6	Study an op-amp based differentiator circuit.	To study an op-amp based differentiator circuit.
7	Develop an IC 555 Timer as Astable Multivibrator.	To study the operation of Astable Multivibrator using an IC 555.
8	Implementation and study an IC 555 Timer as Monostable Multivibrator.	To study an IC 555 Timer as Monostable Multivibrator.

Text Books:

1. Op-Amps and Linear Integrated Circuit, R. A. Gayakwad, Prentice Hall of India,
2. Op-Amps and Linear Integrated Circuits 4th Ed 2017 – Dr Sanjay Sharma, S. K. Kataria & Sons Publication
3. Linear Integrated Circuit 3rd Ed 2010 – D. Roy Chowdhury and S. Jain, New Academic Science Ltd.

Student Profile	
Name	
Roll Number	
Department	
Year	

Student Performance		
Sl. No.	**Title of the Experiment**	**Remarks**
1	Implement a non-Inverting (NI) amplifier circuit using opamp.	
2	Implement an inverting amplifier circuit using opamp.	
3	Performance evolution of a summing amplifier circuit.	
4	Implement a differential amplifier circuit using opamp.	
5	Implement an integrator circuit using op-amp.	

6	Study an op-amp based differentiator circuit.	
7	Develop an IC 555 Timer as Astable Multivibrator.	
8	Implementation and study an IC 555 Timer as Monostable Multivibrator.	

Office Use	
Checked and found **...** **Grade/ Marks** **...** **Signature** **..**	

Experiment No. 1:

Implement a non-Inverting amplifier circuit for R_1= 100 Ω and R_F= 1.5 K Ω and display the input and output waveform for sinusoidal input of frequency 1 KHz.

AIM: To implement a non-Inverting Amplifier for the given specifications using Op-Amp IC 741.

List of Equipment /Software

Following equipment/software is required:

- MULTISIM

Category Soft-Experiment

THEORY:

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

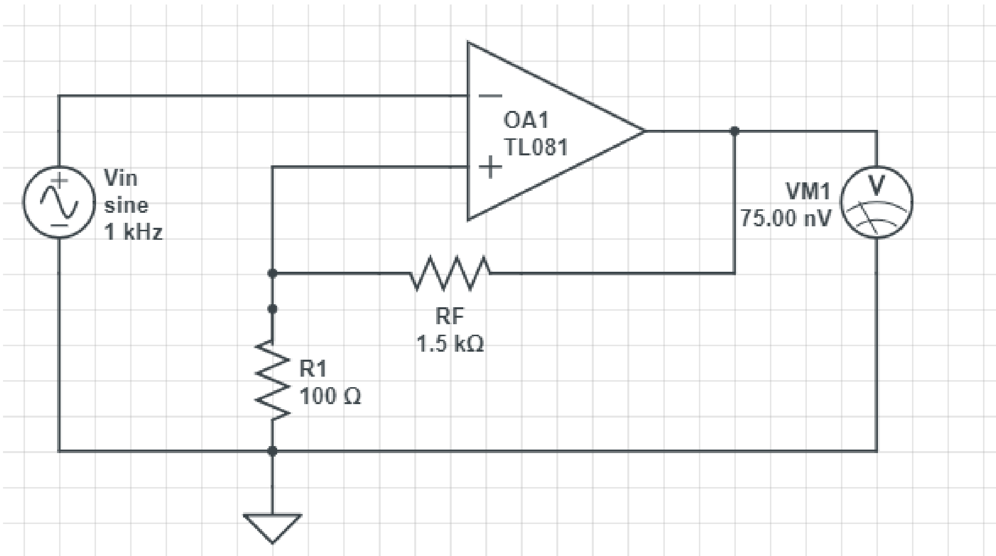
$V_o = A_{CL} V_{in}$

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

PROCEDURE:

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

CIRCUIT DIAGRAM:



APPARATUS REQUIRED:

Sl. No.	Name of the Apparatus	Range	Quantity
1.	Function Generator	1 KHz	1
2.	CRO	20 MHz	1
3.	Dual RPS	0 – 30 V	1
4.	Op-Amp	IC 741	1
5.	Resistors	R_1= 100 Ω and R_F= 1.5 K Ω	

DESIGN:

We know for a Non-inverting Amplifier $A_{CL} = 1 + (R_F / R_1)$
Assume R1 (approx. 100 Ω) and find RF
Hence $Vo = A_{CL}$ Vin

OBSERVATIONS:

Sl. No	Input	Output	
		Practical	Theoretical
1.	Amplitude (No. of div x Volts per div)		
2.	Time period (No. of div x Time per div)		

MODEL GRAPH:

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

Experiment No. 2:

Implement an inverting amplifier circuit for R_1= 100 Ω and R_F= 1.5 K Ω and display the input and output waveform for sinusoidal input of frequency 1 KHz.

AIM: To implement an inverting Amplifier for the given specifications using Op-Amp IC 741.

List of Equipment /Software

Following equipment/software is required:

- MULTISIM

Category Soft-Experiment

THEORY:

The input signal Vin is applied to the inverting input terminal through R1 and the non-inverting input terminal of the op-amp is grounded. The output voltage Vo is fed back to the inverting input terminal through the Rf - R1 network, where Rf is the feedback resistor. The output voltage is given as,

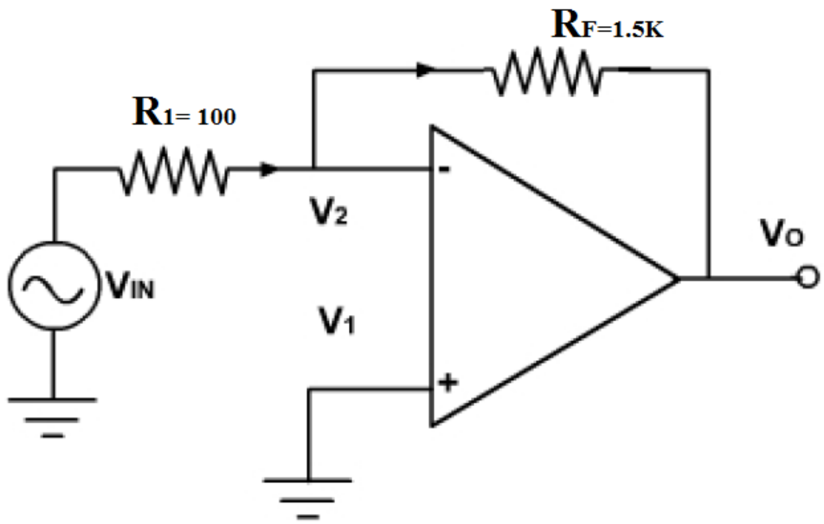
Vo = - ACL Vin

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

PROCEDURE:

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

CIRCUIT DIAGRAM:



APPARATUS REQUIRED:

Sl. No.	Name of the Apparatus	Range	Quantity
1.	Function Generator	1 KHz	1
2.	CRO	20 MHz	1
3.	Dual RPS	0 – 30 V	1
4.	Op-Amp	IC 741	1
5.	Resistors	R_1= 100 Ω and R_F= 1.5 K Ω	

DESIGN:

We know for an inverting Amplifier ACL = RF / R1
Assume R1 (approx. 100 Ω) and find RF
Hence Vo = - ACL Vin

OBSERVATIONS:

Sl. No	Input	Output	
		Practical	Theoretical
1.	Amplitude (No. of div x Volts per div)		
2.	Time period (No. of div x Time per div)		

MODEL GRAPH:

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

Experiment No. 3:

Performance evolution of a summing amplifier circuit for R_1= 10KΩ, R_2=47 KΩ and R_F= 10 K Ω and calculate the output for different input voltages.

Aim: To implement and setup a summing amplifier circuit with OP AMP 741C and verify the output.

List of Equipment /Software

Following equipment/software is required:

- MULTISIM

Category Soft-Experiment

THEORY:

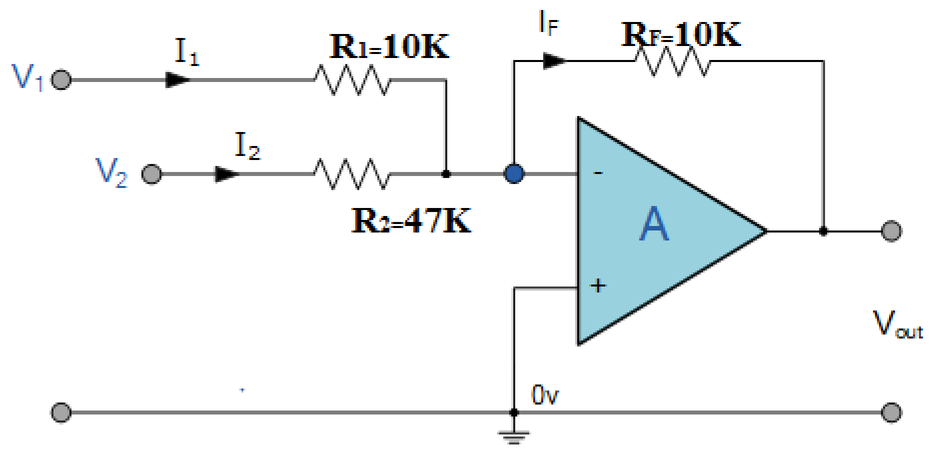
Op-amp can be used to design a circuit whose output is the sum of several input signals. Such a circuit is called a summing amplifier or an adder. Summing amplifier can be classified as inverting & non-inverting summer depending on the input applied to inverting & non-inverting terminals respectively. Circuit Diagram shows an inverting summing amplifier with 2 inputs. Here the output will be amplified version of the sum of the two input voltages with 180^0 phase reversal.

$$V_{out} = -\left[\frac{R_F}{R_1}V_1 + \frac{R_F}{R_2}V_2\right]$$

PROCEDURE:

1. Check the components.
2. Setup the circuit on the breadboard and check the connections.
3. Switch on the power supply.
4. Give V1 = +12 V DC and V2 =+5V DC.
5. Observe the output voltage.
6. Repeat the procedure with V1 =1Vpp / 1 KHz sine wave and V2 = +1.5Vdc.
7. Make sure that the CRO selector is in the D.C. coupling position**.**
8. Observe input and output on two channels of the oscilloscope simultaneously.
9. Note down and draw the input and output waveforms on the graph.

CIRCUIT DIAGRAM:



APPARATUS REQUIRED:

Sl. No.	Name of the Apparatus	Range	Quantity
1.	Function Generator	3 MHz	1
2.	CRO	30 MHz	1
3.	Dual RPS	0 – 30 V	1
4.	Op-Amp	IC 741	1
5.	DC voltage source	12 V and 5 V	
6.	Resistors	R_1= 10K Ω, R_2= 47K Ω and R_F= 10 K Ω	

DESIGN:

The output voltage of an inverting summing amplifier is given by Vo = -(Rf / Ri)(V1+V2)

Let R1 = 10 KΩ, R2 = 47 KΩ

Then RF = 10 KΩ

Then $V_{out} = -[1V_1 + 0.213V_2]$

OBSERVATIONS:

V1= 12 DC, V2= 5 DC, Then Vo=?

V1 =1Vpp / 1 KHz sine wave and V2 = +1.5Vdc. Then Vo=?

RESULT: Observe the input and output voltages on a Multimeter as well as CRO. Compare the experimental results with the theoretical value.

Experiment No. 4:

Implement a differential amplifier circuit with R_f=R_1=R_2=10k

AIM: To implement a difference amplifier circuit with OPAMP IC 741C and verify the output.

List of Equipment /Software

Following equipment/software is required:

- MULTISIM

Category Soft-Experiment

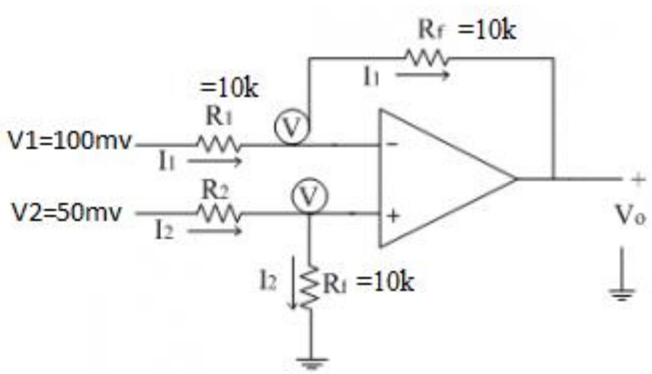
THEORY:

A difference amplifier is a circuit that gives the amplified version of the difference of the two inputs, Vo =A (V1-V2), Where V1 and V2 are the inputs and A is the voltage gain. Here input voltage V1 is connected to inverting terminal and V2 to the non-inverting terminal. This is also called as differential amplifier. Output of a differential amplifier can be determined using super position theorem. When V2=0, the circuit becomes an inverting amplifier with input V1 and the resulting output is V02= -Rf /R1 (V1). When V1=0, the circuit become a non-inverting amplifier with input V2 and the resulting output is V02= Rf/R2 (V2).

Therefore the resulting output according to super position theorem is

$$V_0 = V01 + V02 = \left[\frac{R_f}{R_2}V_2 - \frac{R_f}{R_1}V_1\right]$$

CIRCUIT DIAGRAM:



PROCEDURE

1. Check the components.
2. Setup the circuit on the breadboard and check the connections.
3. Switch on the power supply.
4. Give V1 = +100 mV DC with polarity as shown.
5. Give V2= +250 mV DC.
6. Observe the output voltage in multimeter.

APPARATUS REQUIRED:

Sl. No.	Name of the Apparatus	Range	Quantity
1.	Op-Amp	IC 741	1
2.	DC voltage source	100 V and 50 V	
3.	Resistors	R_1= 10K Ω, R_1= 10K Ω, R_2= 10 K Ω and R_f= 10 K Ω	
4.	Multimeter	As required	
5.	Connecting wires and probes	As required	

Design:

Given the gain = 1
Vo = V01+ V02 = Rf/R1(V1-V2)
That is R_f / R_1 = 1
Let R_1=R_2 = 10KΩ
Then R_f = 10KΩ

OBSERVATIONS:

V_1= 100 mV DC
V_2= 50 mV DC
Then Vo=?

RESULT: Observe the input and output voltages on a Multimeter. Compare the experimental results with the theoretical value.

Experiment No. 5:

Implement an integrator circuit for R_1= 1 KΩ, R_F= 1MΩ and C=0.1µF and display the input and output waveform for sinusoidal input of frequency 1 KHz.

AIM: To implement an Integrator circuit for the given specifications using Op-Amp IC 741.

List of Equipment /Software

Following equipment/software is required:

- MULTISIM

Category Soft-Experiment

APPARATUS REQUIRED:

Sl. No	Name of the Apparatus	Range	Quantity
1.	Function Generator	1 KHz	1
2.	CRO	20 MHz	1
3.	Dual RPS	0 – 30 V	1
4.	Op-Amp	IC 741	1
5.	Resistors	R_1= 1 KΩ, R_F= 1MΩ	
6.	Capacitors	C=0.1µF	

THEORY:

A circuit in which the output voltage waveform is the integral of the input voltage waveform is the integrator. Such a circuit is obtained by using a basic inverting amplifier configuration if the feedback resistor R_F is replaced by a capacitor C. The expression for the output voltage is given as,

$Vout = -(1/ R_F C) \int Vs\, dt$

Here the negative sign indicates that the output voltage is 180^0 out of phase with the input signal. Normally between fa and fb the circuit acts as an integrator. Generally, the value of fa < fb . The input signal will be integrated properly if the Time period T of the signal is larger than or equal to R_F C. That is,

$T \geq R_F C$

The integrator is most commonly used in analog computers and ADC and signal-wave shaping circuits.

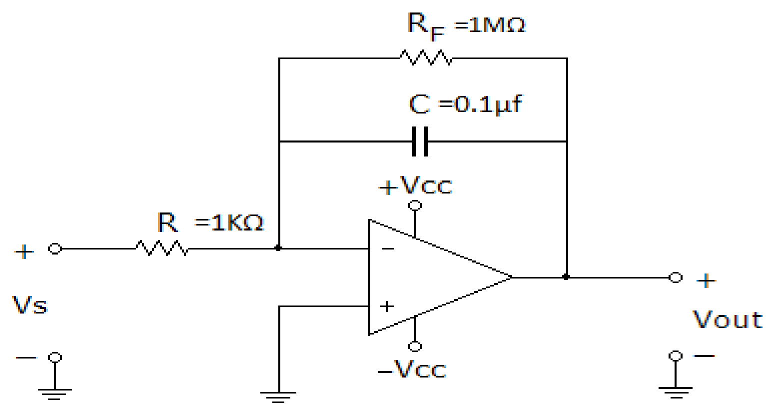
DESIGN:

To obtain the output of an Integrator circuit with component values R_1= 1 KΩ, R_F= 1MΩ and C = 0.1 μF and also if 1 V peak square wave at 1000Hz is applied as input.

PROCEDURE:

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

CIRCUIT DIAGRAM:



OBSERVATIONS:

Sl. No		Input	Output
1.	Amplitude (No. of div x Volts per div)		
2.	Time period (No. of div x Time per div)		

RESULT: Observe the input and output voltages on a CRO. Compare the experimental results with the theoretical value.

Experiment No. 6:

Study an op-amp based differentiator circuit for R_F= 10KΩ and C=0.05µF and display the input and output waveform for sinusoidal input of frequency 1 KHz.

AIM: To develop a Differentiator circuit for the given specifications using Op-Amp IC 741.

List of Equipment /Software

Following equipment/software is required:

- MULTISIM

Category Soft-Experiment

APPARATUS REQUIRED:

Sl. No	Name of the Apparatus	Range	Quantity
1.	Function Generator	1 KHz	1
2.	CRO	20 MHz	1
3.	Dual RPS	0 – 30 V	1
4.	Op-Amp	IC 741	1
5.	Resistors	R_F= 10KΩ	
6.	Capacitors	C=0.05µF	

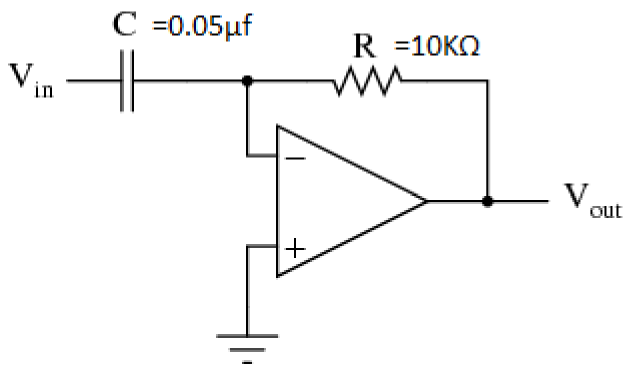
THEORY:

The differentiator circuit performs the mathematical operation of differentiation; that is, the output waveform is the derivative of the input waveform. The differentiator may be constructed from a basic inverting amplifier if an input resistor R1 is replaced by a capacitor C. The expression for the output voltage is given as,

$V_o = - R C (dV_{in} /dt)$

The differentiator is most commonly used in wave shaping circuits to detect high frequency components in an input signal and also as a rate–of–change detector in FM modulators.

CIRCUIT DIAGRAM:



DESIGN:

To develop a differentiator circuit to differentiate an input signal that varies in frequency from 10 Hz to about 1 KHz. If a sine wave of 1 V peak at 1000Hz is applied to the differentiator, draw its output waveform.

PROCEDURE:

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

OBSERVATIONS:

Sl. No		Input	Output
1.	Amplitude (No. of div x Volts per div)		
2.	Time period (No. of div x Time per div)		

RESULT: Observe the input and output voltages on a CRO. Compare the experimental results with the theoretical value.

Experiment No. 7:

Implement an IC 555 Timer as Astable Multivibrator.

AIM: To study the application of IC555 as an astable multivibrator.
List of Equipment /Software

Following equipment/software is required:

- MULTISIM

Category Soft-Experiment

APPARATUS REQUIRED:

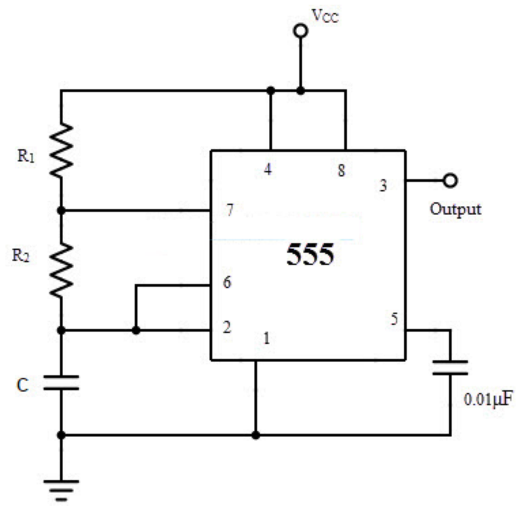
S.NO	ITEM	RANGE	Q.TY
1	IC	NE555	1
2	Resistor	1KΩ,	1
		2.2KΩ	1
3	Capacitor	0.1μF	1
		0.01μF	1
4	CRO	-	1
5	RPS	DUAL(0-30) V	1

THEORY:

The IC555 timer is a 8 pin IC that can be connected to external components for astable operation. The simplified block diagram is drawn. The OP-AMP has threshold and control inputs. Whenever the threshold voltage exceeds the control voltage, the high output from the OP –AMP will set the flip-flop. The collector of discharge transistor goes to pin 7. When this pin is connected to an external trimming capacitor, a high Q output from the flip flop will saturate the transistor and discharge the capacitor. When Q is low the transistor opens and the capacitor charges.

The complementary signal out of the flip-flop goes to pin 3 and output. When external reset pin is grounded it inhibits the device. The on – off feature is useful in many application. The lower OP- AMP inverting terminal input is called the trigger because of the voltage divider. The non-inverting input has a voltage of +Vcc/3, the OP-Amp output goes high and resets the flip flop.

CIRCUIT DIAGRAM:



PROCEDURE :

The connections are made as per the circuit diagram and the values of R and C are calculated assuming anyone term and they are settled. The output waveform is noted down and graph is drawn and also the theoretical and practical time period is verified.

OBSERVATION:

C (μf)	Theoretical time period(us)	Practical time period(us)	Theoretical freq (kHz)	Practical freq(kHz)

CALCULATION:

Theoretical:

$$T = 0.69(R_1+R_2)C$$

Practical:

$$T = T_{on} + T_{off}$$

RESULT: Thus the astable multivibrator circuit using IC555 is constructed and verified its theoretical and practical time period.

Experiment No 8:

Implementation and study an IC 555 Timer as Monostable Multivibrator.

AIM: Implement the monostable multivibrator using the IC555.

List of Equipment /Software

Following equipment/software is required:

- MULTISIM

Category Soft-Experiment

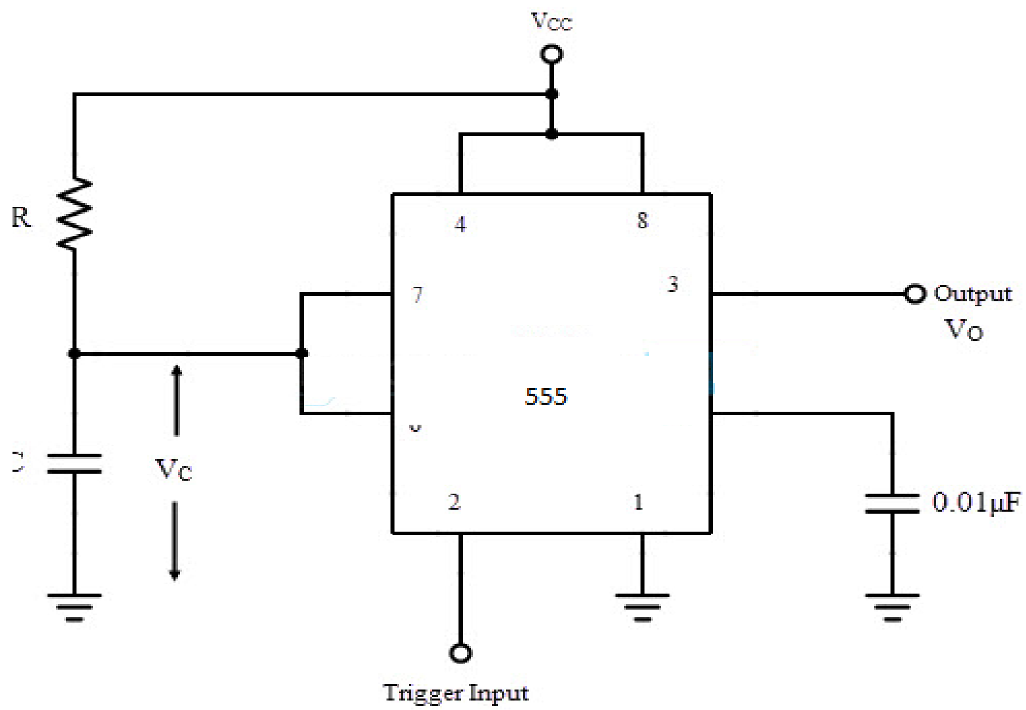
APPARATUS REQUIRED:

Sl. NO	ITEM	RANGE	Q.TY
1	IC	NE555	1
2	Resistor	91KΩ,	1
		2.2KΩ	1
3	Capacitor	0.1μF	1
		0.01μF	1
4	CRO	-	1
5	RPS	DUAL(0-30) V	1

THEORY:

A monostable multivibrator has one stable state and a quasistable state. When it is triggered by an external agency it switches from the stable state to quasistable state and returns back to stable state. The time during which it states in quasistable state is determined from the time constant RC. When it is triggered by a continuous pulse it generates a square wave. Monostable multi vibrator can be realized by a pair of regeneratively coupled active devices, resistance devices and op-amps.

CIRCUIT DIAGRAM:



DESIGN :

T = 0.1ms
C = 0.01μF
T = 1.096RC
R = T / 1.096C = $(0.1*10^{-3}) / (1.096*0.01*10^{-6})$ = 9.12 KΩ
R ≅ 9 KΩ

PROCEDURE:

The connections are made as per the diagram. The value of R is chosen as 9kΩ. The DCB is set to the designed value. The power supply is switched on and set to +5V. The output of the pulse generator is set to the desired frequency. Here the frequency of triggering should be greater than width of ON period (i.e.) T >W. The output is observed using CRO and the result is compared with the theoretical value. The experiment can be repeated for different values of C and the results are tabulated.

OBSERVATION:

C (μf)	Theoretical (T=1.095 RC (ms)))	Practical T(ms)

RESULT: Thus the monostable multivibrator using IC555 is designed and its output waveform is traced.