SRM INSTITUTE OF SCIENCE AND TECHNOLOGY

DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

18ECC202J – LINEAR INTEGRATRD CIRCUITS

LABORATORY MANUAL

SEMESTER IV

SRM Institute of Science andTechnology ,Tiruchirappalli, Tamilnadu-621105.

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Lab 10: Design of LPF, HPF, BPF and Band Reject Filters

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Ex. No : 1	BASIC OP-AMP CIRCUITS
DATE :	

AIM:

1. To measure the following parameters of op-amp.
   i)Input bias current ii) Input offset voltage

2. To operate and obtain the output of i) Summing amplifier ii) Subtractor.

APPARATUS REQUIRED:

S.No.	APPARATUS	TYPE	RANGE	QUANTITY
1)	Op-Amp	µA741		1
2)	Resistors		100 / 10K / 1M	2 / 4/ 2
3)	Capacitors		0.01µF	1
4)	Signal Generator			1
5)	CRO			1
6)	Dual power supply			1
7)	Bread Board			1
8)	Connecting wires			

THEORY:

Input bias current: The inverting and noninverting terminals of an op-amp are actually two base terminals of transistors of a differential amplifier. In an ideal op-amp it is supported that no current flows through these terminals. However, practically a small amount of current flows through these terminals which is on the order of nA (typical and maximum values are 80 and 1500nA) in bipolar op-amps and pA for FET op-amps. Input bias current is defined as the average of the currents entering into the inverting and noninverting terminals of an op-amp. To compensate for bias currents a compensating resistor R_{comp} is used. Value of R_{comp} is parallel combination of the resistors connected to the inverting terminal. Input bias current $I_B = \left.\frac{(I_{B1} + I_{B2})}{2}\right|$, where I_{B1} and I_{B2} are the base bias currents of the op-amp

Input offset voltage: Even if the input voltage is zero, output voltage may not be zero. This is because of the circuit imbalances inside the op-amp. In order to compensate this, a small voltage should be applied between the input terminals. Input offset voltage is defined as the voltage that must be applied between the input terminals of an op-amp to nullify the output voltage. Typical and maximum values of input offset voltage are 2mV and 6mV.

Summing Amplifier: Op-amp may be used to perform summing operation of several input signals in inverting in inverting and non-inverting mode. The input signals to be summed up are given to inverting terminal or non-inverting terminal through the input resistance to perform inverting and non-inverting summing operations respectivel.

Subtractor: The basic difference amplifier can be used as a subtractor. The signals to be subtracted are connected to opposite polarity inputs i.e. in inverting or non-inverting terminals of the op-amp.

PROCEDURE:

i) Input Bias Current:

1. Connect the circuit as shown.
2. Measure the output voltage from which the inverting input bias current can be calculated as $I_B^- = Vo / R$
3. Connect the circuit as shown .
4. Measure the output voltage from which the non-inverting input bias current can be calculated as $I_B^+ = Vo / R_f$.
5. Average of magnitude of both I_B^- and I_B^+ gives the input bias current.

ii) Input Offset Voltage:

1. Connect the circuit as shown.
2. Measure the output voltage using multimeter.
3. Calculate offset voltage as $V_{ios} = V_o / (1+ R_f / R_1)$.

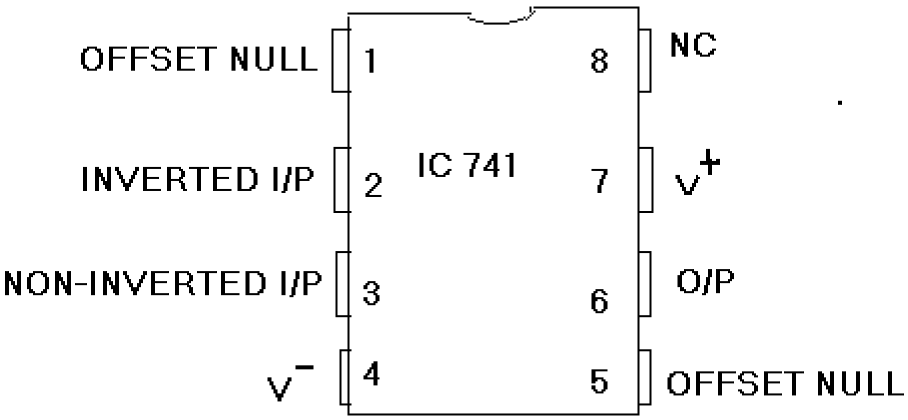
iii) Inverting Summing Amplifier:

1. Connect the circuit as shown in figure.
2. Connect batteries for voltage V_1, V_2.
3. Measure and note the output voltage and compare it with theoretical value , $Vo = -(R_f / R_i) (V_1+V_2)$.

iv) Subtractor:

1. Connect the circuit as shown in figure.
2. Measure and note the output voltage and compare it with theoretical value, $Vo = (V_1- V_2)$.

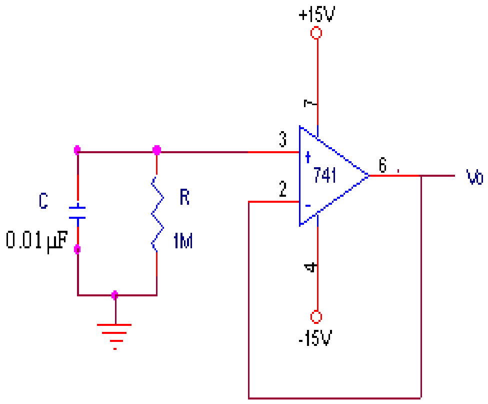
PIN DIAGRAM:

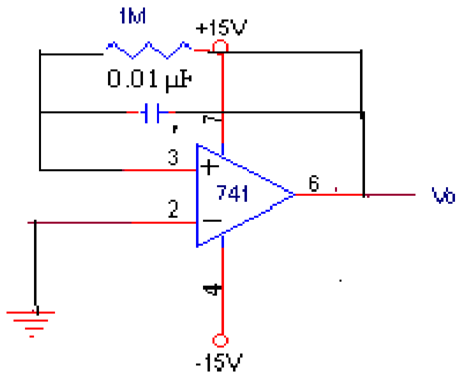


CIRCUIT DIAGRAMS:

1) To measure the following parameters:

i)To measure input bias current:

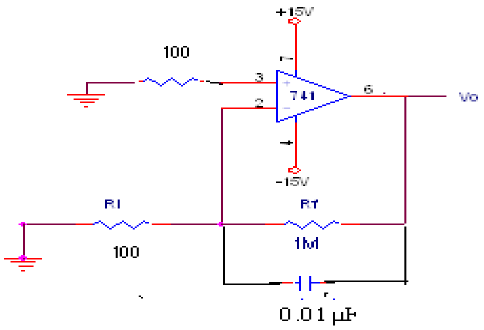




TABULAR COLUMN:

SI.NO	$I_B^- = Vo/R$	$I_B^+ = Vo/R_f.$
	Input bias current , $I_B = \frac{I_B^+ + I_B^-}{2} =$	

ii)To measure input offset voltage :



TABULAR COLUMN:

SI.NO	$V_{ios} = V_o / (1 + R_f / R_1)$..
	$V_o =$

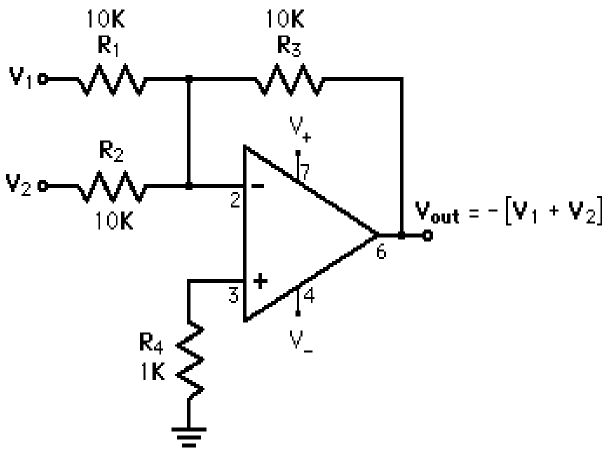
TYPICAL VALUES OF ELECTRICAL CHARACTERISTICS OF µA741:

Input bias current = 80-500nA

Input offset voltage = 1-5mV

2. To know the applications of op-amp:

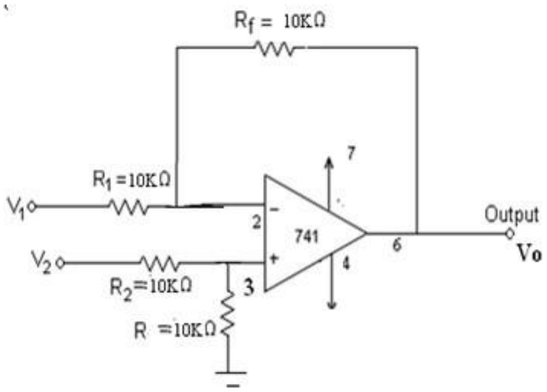
i) Summing Amplifier:



TABULAR COLUMN:

S.No.	V_1	V_2	**Theoretical** **$V0 = -(V_1 + V_2)$**	**Practical** **V0**

ii) Subtractor:



TABULAR COLUMN:

S.No.	V1	V2	Theoretical V0=V1-V2	Practical V0

RESULT:

1. The input bias current and input offset voltage of the op-amp were determined.

   Input bias current = ...A
   Input offset voltage = ... mV

2. The applications of op-amps like summing amplifier and subtractor were understood.

Ex. No : 2	INTEGRATORS AND DIFFERENTIATORS
DATE :	

AIM: To demonstrate the use of op-amp as Integrator and Differentiator .

APPARATUS REQUIRED:

S.No.	APPARATUS	TYPE	RANGE	QUANTITY
1)	Op-Amp	μA741-		1
2)	Resistors		1.5K / 10K/ 15K / 100K	2/2/ /1 / 1
3)	Capacitors		0.1 μ F / 0.01 μ F	1 / 1
4)	Signal Generator			1
5)	CRO			1
6)	Dual power supply			1
7)	Bread Board			1
8)	Connecting wires			

THEORY:

Integrator: Integrator is used to integrate the input waveform. i.e; $V_O = \int V_{in}\, dt$. Here in the inverting amplifier configuration, the feedback resistor R_f is replaced by capacitor C_f. Integrators are commonly used in wave shaping news, signal generators etc. For proper wave integration, T >> RC. Gain and linearity of the o/p are two advantages of op-amp integrators. Linearity is due to linear charging of capacitor. Its limitation is for Vin=0 and for low frequencies, $X_{Cf} = \infty$ or the capacitor C_f acts as an open circuit. Therefore the op-amp integrator works as an open loop amplifier and the gain becomes infinity or very high.

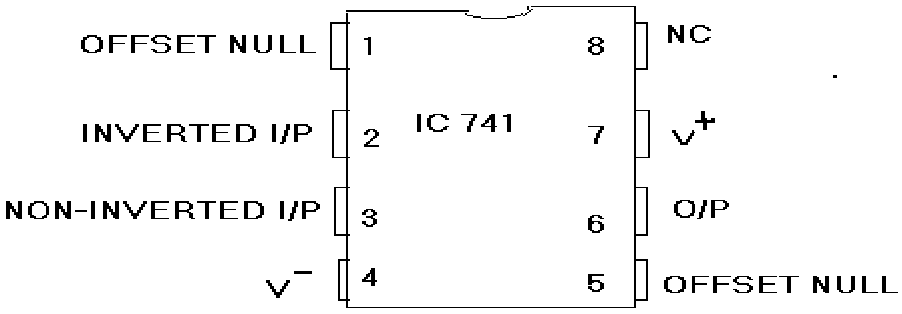
Differentiator: Here the output waveform is the derivative of the i/p waveform. In a basic inverting amplifier, if R_1 is replaced by C_1, we get the differentiator. But at high frequencies, the gain of the circuit (Rf/XC1) increases with increase in frequency at the rate of 20dB/decade. This makes the circuit unstable. Also X_{C1} decreases when frequency increases.

PROCEDURE:

Integrator & Differentiator:

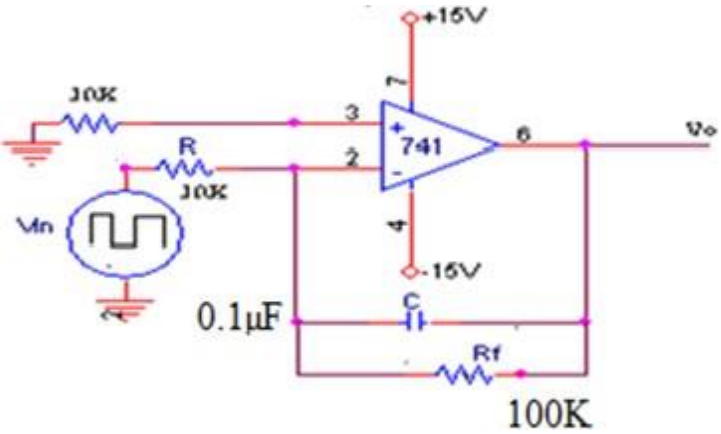
1. Connections are made as per the diagram.
2. Apply an i/p voltage of 1-2Vpp with 1kHz frequency and check the waveform on the CRO.
3. Measure the value of V_O by varying the frequency of the i/p signal.
4. Calculate gain using the formulae 20 log (V_O /V_{IN}).

PIN DIAGRAM:

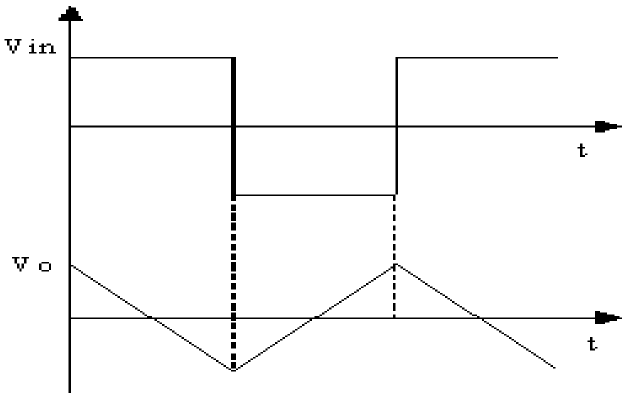


CIRCUIT DIAGRAM:

Integrator:



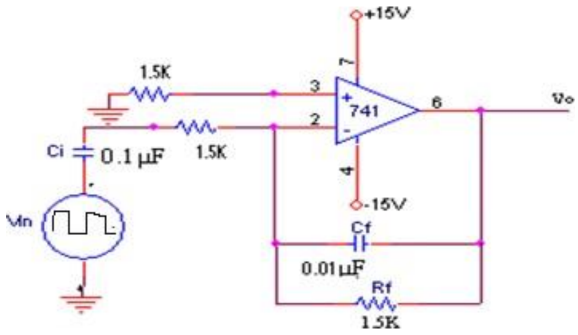
Model Graph:



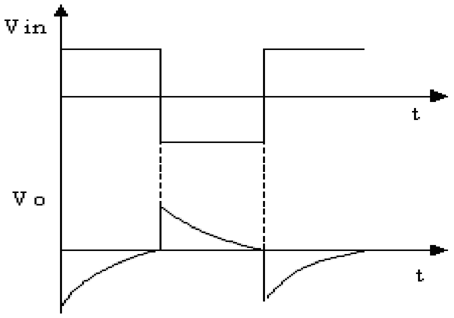
TABULAR COLUMN:

S.No:	INPUT		OUTPUT	
	Vin (V)	Time (msec)	Vout(V)	Time (msec)

Differentiator:



Model Graph:



TABULAR COLUMN:

S.No:	INPUT		OUTPUT	
	Vin (V)	Time (msec)	Vout(V)	Time (msec)

RESULT:

Thus the output waveforms of integrator and differentiator were obtained and the graphs were drawn.

Ex. No : 3	FULLWAVE RECTIFIER
DATE :	

Aim: To demonstrate the use of op-amp as rectifier.

APPARATUS REQUIRED:

S.No.	APPARATUS	TYPE	RANGE	QUANTITY
1)	Op-Amp	µA741		2
2)	Resistors		10K	6
4)	Signal Generator			1
5)	CRO			1
6)	Dual power supply			1
7)	Bread Board			1
8)	Diodes	IN4148		1

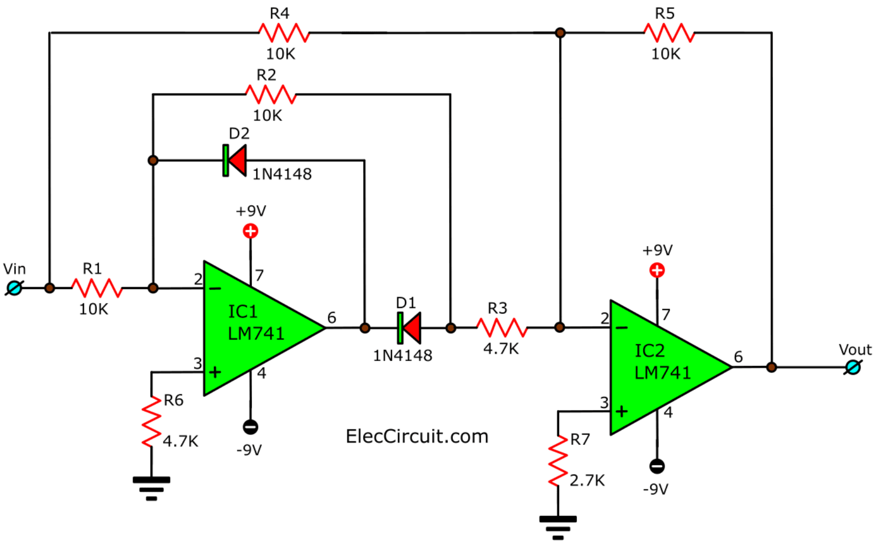
THEORY:

When the AC input voltage is half negative. It causes the output of IC_1 will be -Vin. Meanwhile, some AC input voltage via R4 by having R5 is feedback. So, the output of IC_2 will be + Vin. Then when the AC input is half positive, the output of IC_1 will be negative. Because D1 conducts current until getting the output 2 times of Vin is -2V. Once the signal is through the IC_2, which is an inverting amplifier circuit, the output will be + 2V. At the same time, the positive AC input voltage will appear at pin 2 of IC_2 as + Vin. This causes the output at pin 6 to appear as-Vin. Therefore, the sum of voltage at pin 6 of IC2 will be + 2Vin – Vin. Which is equal to + Vin. We will see that the output of IC2 will be + Vin, regardless of whether the AC input voltage is Positive or Negative. The output will be a Pulsating pattern which is still a component of AC. We can make complete DC by another filter circuit.

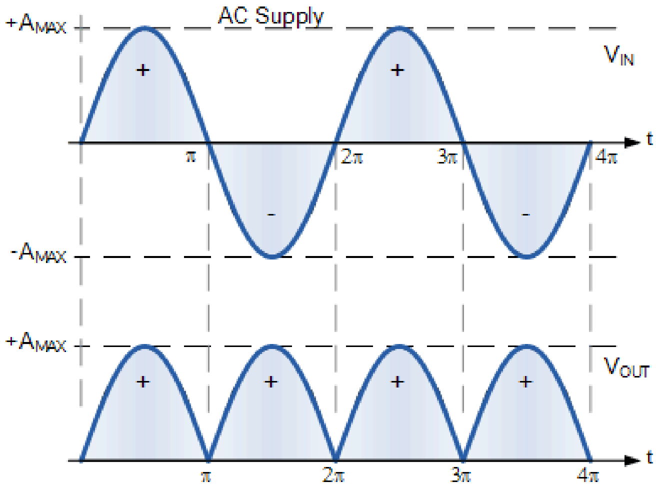
PROCEDURE:

1.Connect the circuit as shown in the figure.
2.Connect an alternating waveform to the non-inverting input of the op- amp.
3.Connect a reference voltage source to inverting input of the op-amp.
4. Plot the input and output waveforms.

Circuit Diagram:



Waveform:



Rectified Output Waveform

Tabulation:

Waveform	VOLTAGE (V)	TIME (ms)	Frequency (Hz)
Input			
Output			

RESULT:

Thus the output of rectifier is obtained and the graphs have been drawn.

Ex. No : 4	COMPARATOR
DATE :	

AIM:

To obtain the output of voltage comparator and zero crossing detector.

APPARATUS REQUIRED:

S.No.	APPARATUS	TYPE	RANGE	QUANTITY
1)	Op-Amp	μA741		1
2)	Resistors		1K	2
4)	Signal Generator			1
5)	CRO			1
6)	Dual power supply			1
7)	Bread Board			1
8)	Connecting wires			

THEORY:

Voltage Comparator: A comparator is a circuit which compares a signal voltage applied at one input of an op-amp with output ± V_{sat} = (V_{cc}). If the signal is applied to the inverting terminal of the op-amp it is called inverting comparator and if the signal is applied to non-inverting terminal of the op-amp it is called non-inverting comparator. In an inverting comparator if input signal is less than reference voltage, output will be $+V_{sat}$. When input signal voltage is greater than reference voltage output will be $–V_{sat}$. The vice-versa takes place in non-inverting comparator.

PROCEDURE:

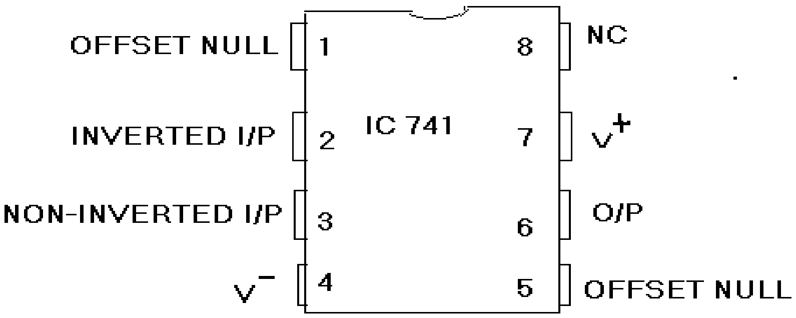
1) Voltage comparator:

1. Connect the circuit as shown in the figure.
2. Connect an alternating waveform to the non-inverting input of the op-amp.
3. Connect a reference voltage source to inverting input of the op-amp.
4. Plot the input and output waveforms.

2) Zero crossing detector:

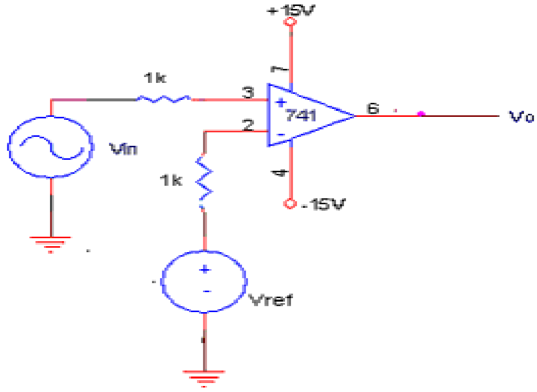
1. Connect the circuit as shown in figure.
2. Connect the input to a signal generator generating a sin wave with one volt peak to peak at 1kHz.
3. Connect the input and output to dual channel CRO and compare the input and output.
4. Plot the input and output waveforms on a graph.

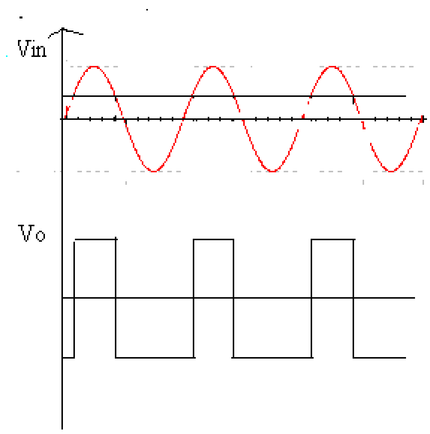
PIN DIAGRAM:



CIRCUIT DIAGRAM:

Voltage Comparator:

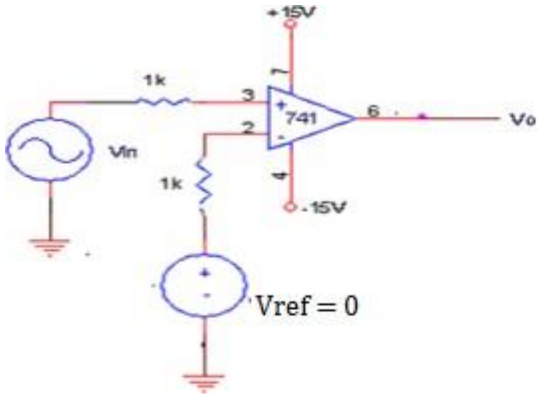




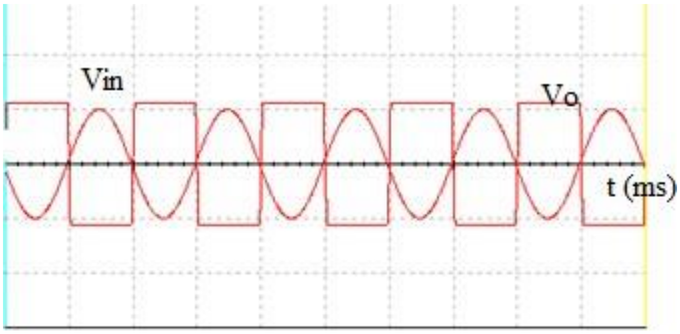
TABULAR COLUMN:

SI. NO	INPUT		OUTPUT	
	VOLTAGE (V)	TIME (ms)	VOLTAGE (V)	TIME (ms)

Zero Crossing Detector:



MODELGRAPH:



TABULAR COLUMN:

SI. NO	INPUT		OUTPUT	
	VOLTAGE (V)	TIME (ms)	VOLTAGE (V)	TIME (ms)

<u>RESULT:</u>

Thus the output of voltage comparator and zero crossing detector were obtained and the graphs have been drawn

Ex. No : 5	WAVESHAPING CIRCUITS
DATE :	

AIM:

To know the operation of clippers and clampers.

APPARATUS REQUIRED:

S.No.	APPARATUS	TYPE	RANGE	QUANTITY
1)	Op-Amp	µA741		1
2)	Resistors		4.7K Ω/ 1KΩ / 10 KΩ / 10KΩ POT	1 / 2 / 2 / 1
3)	Capacitors		0.1 µ F	1
4)	Signal Generator			1
5)	Diode	IN 4001		1
6)	CRO			1
7)	Dual power supply			1
8)	Bread Board			1
9)	Connecting wires			

THEORY:

1) Clipper :

Clipper is a circuit that removes positive or negative level of the input signal and can be designed using op amp with rectifier diodes. The op amp is basically used as a voltage follower with the feedback path ,the reference voltage determines the level of voltage to be clipped both either positive or negative . A negative clipper is obtained by just reversing the diode.

2) Clamper :

Clamper is a circuit used to add D.C voltage to the input signal .It is also called a D.C inverter or/ restorer.

PROCEDURE:

1.Clippers:

1. Connect the trainer to mains and switch on the power supply
2. Measure the output voltage of regulated power supply i.e. +12V and -12V using digital multimeter
3.Observe the output of the on board signal generator with the help of Oscilloscope Signal should be sine wave of 1KHZ frequency with 10Vpp amplitude or connect external signal generator

4. Connect the circuit as shown.
5. Observe the input and output waveforms with the help of dual trace Oscilloscope and compare them with the expected waveform
6. Repeat the same at different voltage source by varying 10 K pot
7. Now connect a negative V ref fig. and observe the wave forms

Negative clippers

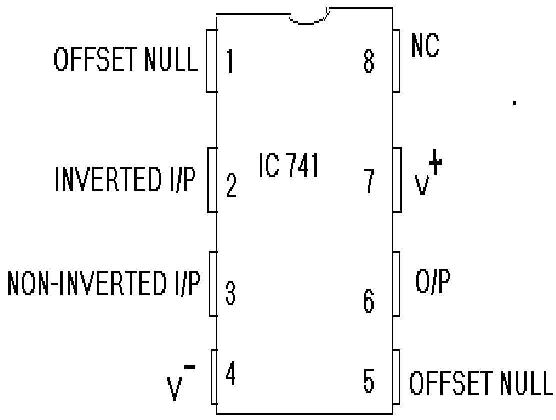
8. Connect the circuit as shown.
9. Observe the input and output waveforms with the help of dual trace Oscilloscope and compare them with the expected waveform.
10. Repeat the same at different voltage source and positive Vref ..

Clampers:

Positive clampers

1. Connect the circuit as shown in fig.
2. Observe the input and output waveforms with the help of dual trace Oscilloscope and compare them with the expected waveform.
3. Repeat the same at different voltage source and changing the Vref

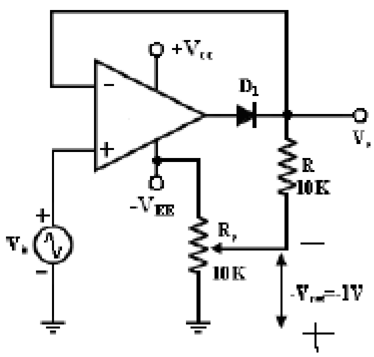
PIN DIAGRAM:

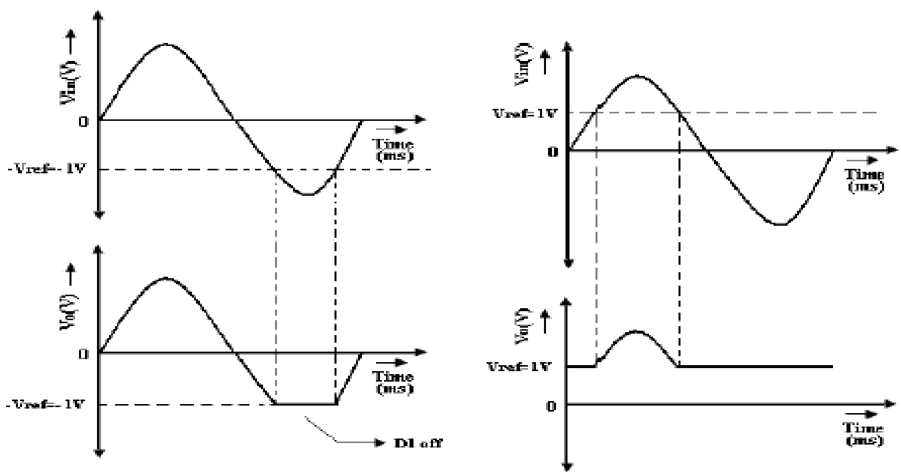


CIRCUIT DIAGRAM:

1) **Clippers:**

NEGATIVE CLIPPER:

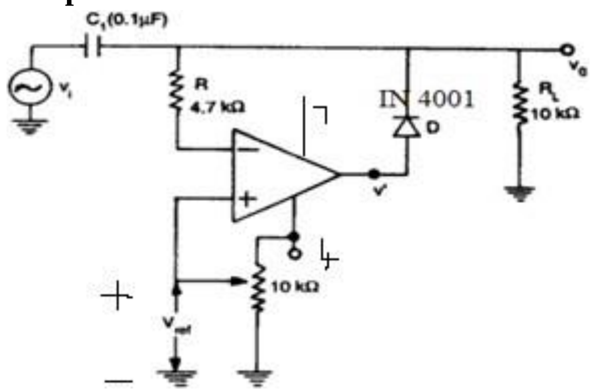


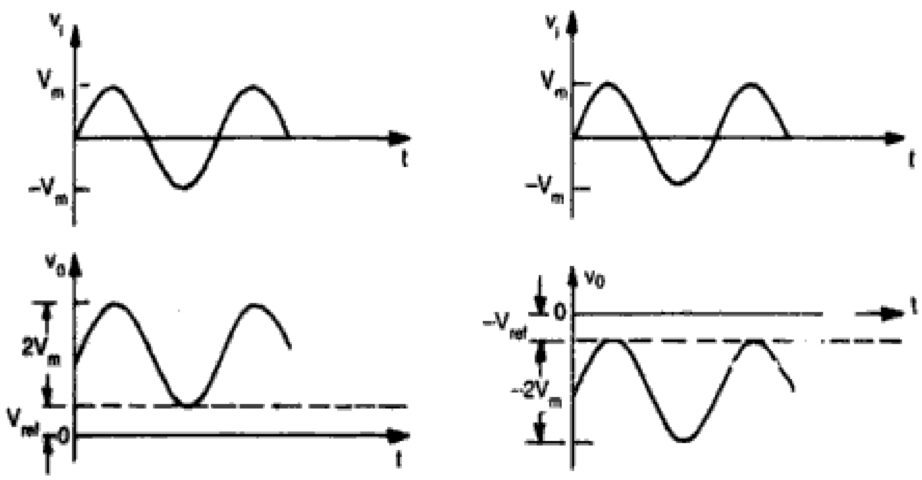


TABULAR COLUMN:

S.No:	INPUT		OUTPUT	
	Vin (V)	Time (msec)	Vout(V)	Time (msec)

2) Clamper:





Waveforms for $+V_{ref}$ / Waveforms for $-V_{ref}$

TABULAR COLUMN:

S.No:	INPUT		OUTPUT	
	Vin (V)	**Time (msec)**	**Vout(V)**	**Time (msec)**

RESULT:

The operation of clipper and clamper have been studied and its output waveforms have been drawn

Ex. No :06	RC PHASE SHIFT OSCILLATOR AND WEIN BRIDGE OSCILLATOR
DATE :	

AIM:

To design and test RC phase shift oscillators using IC µA 741.

APPARATUS REQUIRED:

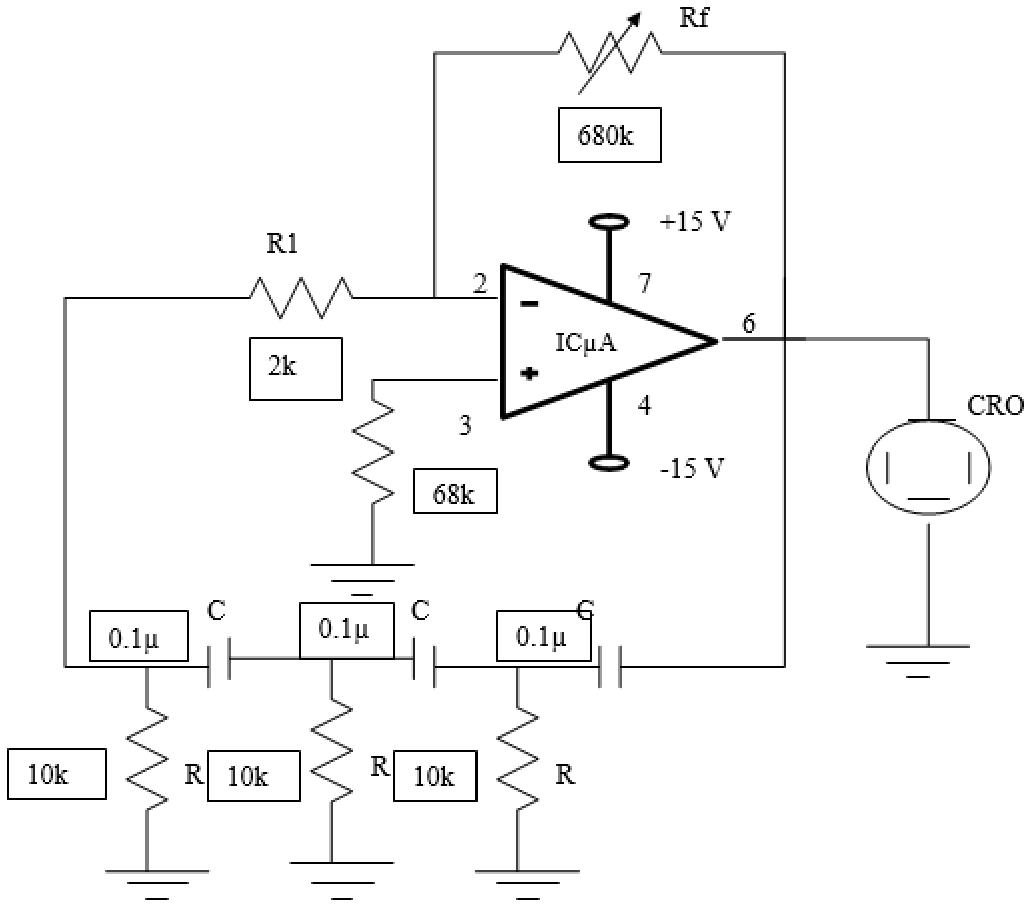
S.NO.	APPARATUS	RANGE	QUANTITY
1	Power supply	(0 - +15)V	1
2	Signal generator	(0-3)MHz	1
3	CRO	(0-30)MHz	1
4	IC	IC µA 741	1
5	Resistor	680kΩ,6.8kΩ,220kΩ,4.7kΩ	3,2,2,1
6	Capacitor	0.1µf	3

THEORY:

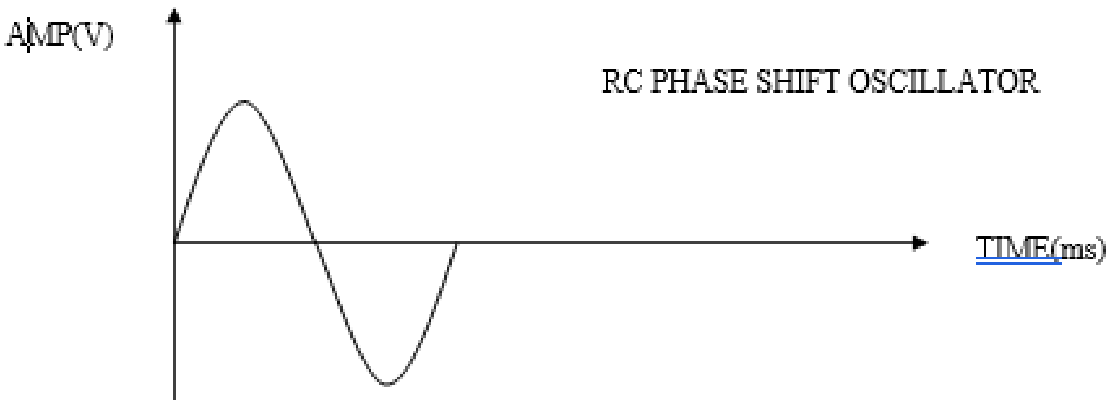
RC PHASE SHIFT OSCILLATOR:

RC phase shift oscillator using op-amp, in inverting amplifier mode. Thus it introduces a phase shift of 180^0 between the input and output. The feedback network consists of 3 RC sections producing each 60^0 phase shift. Such a circuit is known as RC phase shift network. The circuit is generating its own output signal and a stage of oscillator sustained. the phase shift produced by op-amp is 180^0.the op-amp with a gain of 29 and RC network is of equal resistor and capacitor connected feedback the op-amp output and input terminals..

Circuit Diagram:



Model Graph:



Tabulation:

S.NO.	AMPLITUD (V) *volts*	TIME(T) *ms*	F = 1/T *Hz*

EXPERIMENTAL PROCEDURE: RC PHASE SHIFT OSCILLATOR:

1 Circuit connections are given as per the EXPERIMENTAL SETUP.

2 Supply is switched ON.

3 360^0 phase shift output is obtained at the output.

4 The inverting op-amp produce 180^0 and RC network produce another 180^0

5 Frequency is calculated by the formula f =1/T

RESULT:

Thus the RC phase shift oscillator was designed and tested using IC µA 741.

Ex. No :07	**Astable Multivibrator using IC 555**
DATE :	

AIM:

To design and test astable multivibrator circuits using IC 555.

APPARATUS REQUIRED:

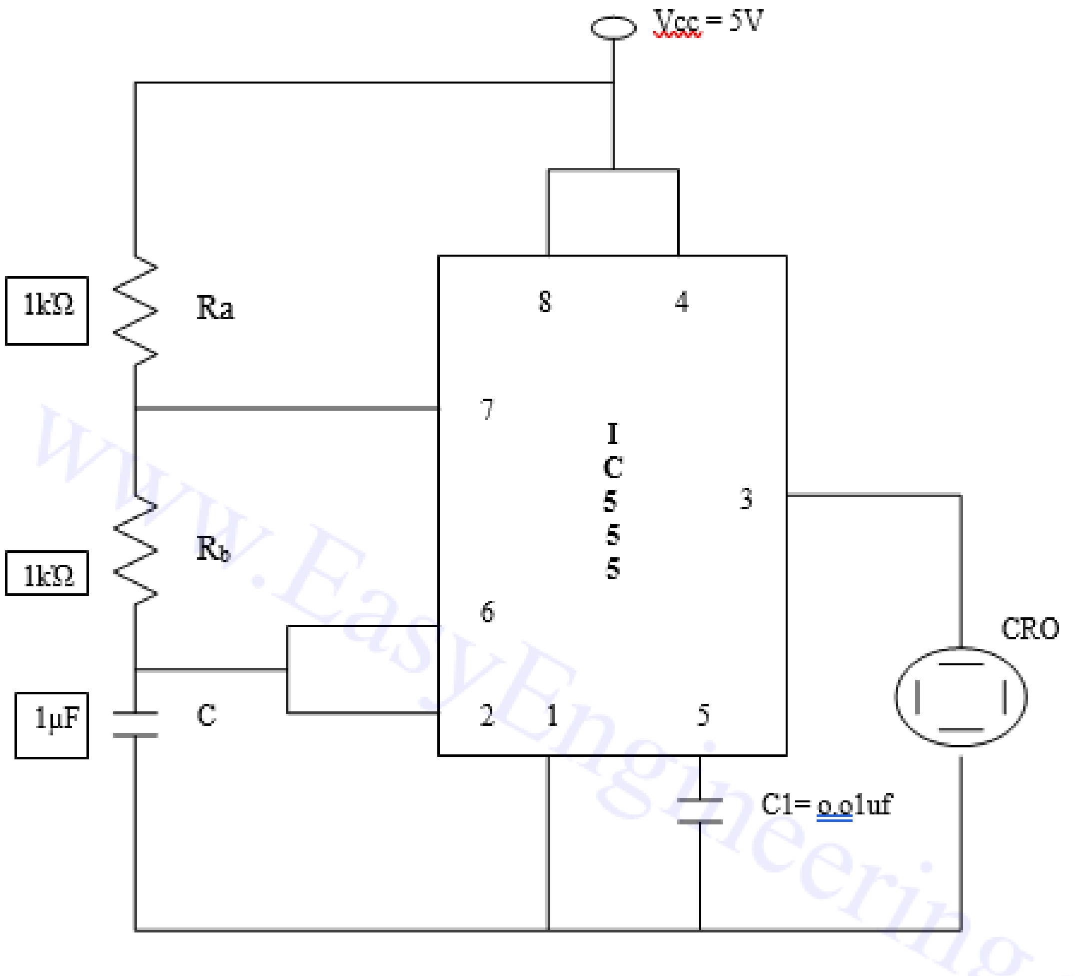
S.NO.	APPARATUS	RANGE	QUANTITY
1	Power Supply	(0 - +15)V	1
2	Signal generator	(0-1)MHz	1
3	CRO	(0-30)MHz	1
4	IC	IC 555	1
5	Resistor	1kΩ,2kΩ	1,1
6	Capacitor	0.1µf	1

THEORY:

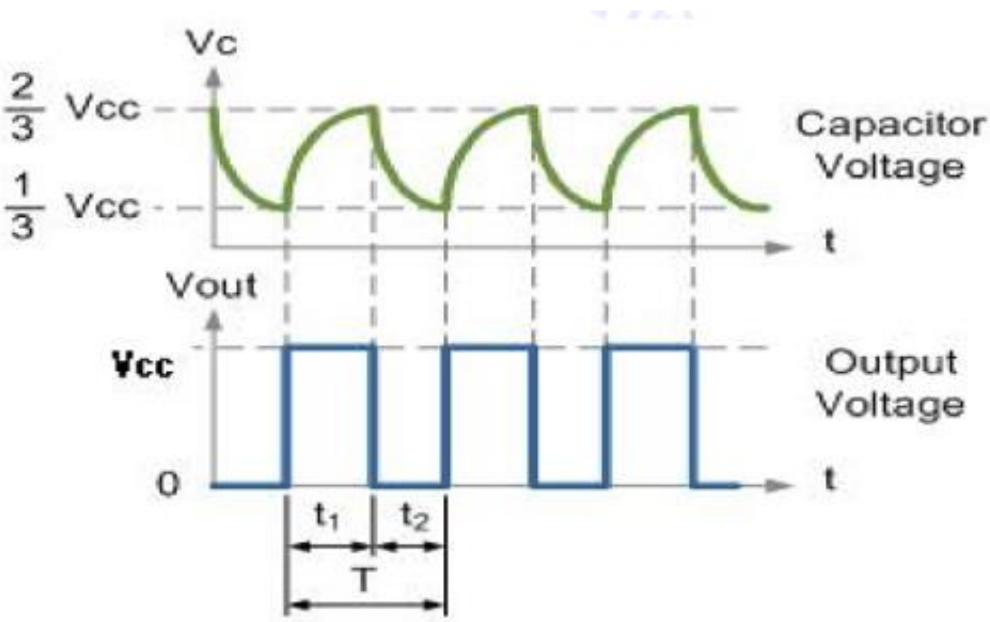
ASTABLE MULTIVIBRATOR:

The astable multivibrator is also called the free running multivibrator. It has two quasi states i.e. no stable states as such the circuit conditions oscillate between the components values used to decide the time for which circuit remains in each stable state. The principle of square wave output is to force the IC to operate in saturation region. Whenever input at the negative input terminal just exceeds Vref switching takes place resulting in a square wave output. In astable multivibrator both stable states and one quasi states are present.

CIRCUIT DIAGRAM:



MODEL GRAPH:(ASTABLE MULTIVIBRATOR)



TABULATION

S.NO	WAVEFORM	AMPLITUDE (V) *VOLTS*	TIME (T) *ms*	F =1/T *Hz*
1	CAPACITOR			
2	OUTPUT			

EXPERIMENTAL PROCEDURE:

1 Connections are as per the EXPERIMENTAL SETUP.

2 Supply is switched ON after checking the connections.

3 For monostable multivibrator trigger pulse is given and for stable it is not necessary.

4 Output square wave is noted from CRO.

5 The frequency is calculated by input.

RESULT:

Thus the Astable multivibrators is designed and tested using IC555

Ex. No :08	Monostable Multivibrator using IC 555
DATE :	

AIM:

To design and test mono stable multivibrator circuits using IC 555.

APPARATUS REQUIRED:

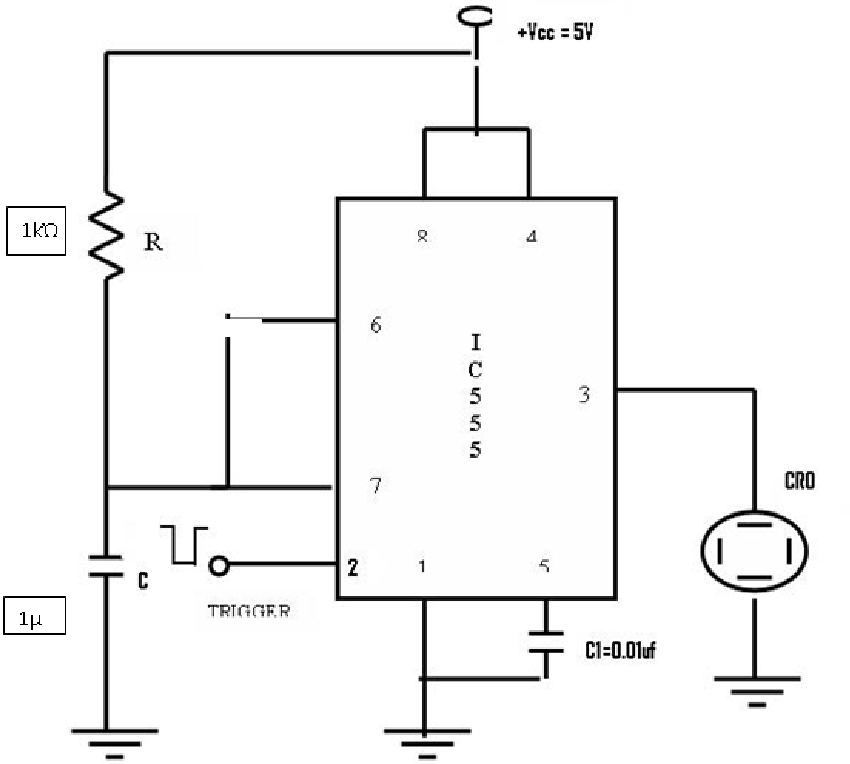
S.NO.	APPARATUS	RANGE	QUANTITY
1	Power Supply	(0 - +15)V	1
2	Signal generator	(0-1)MHz	1
3	CRO	(0-30)MHz	1
4	IC	IC 555	1
5	Resistor	1kΩ,2kΩ	1,1
6	Capacitor	0.1µf	1

THEORY:

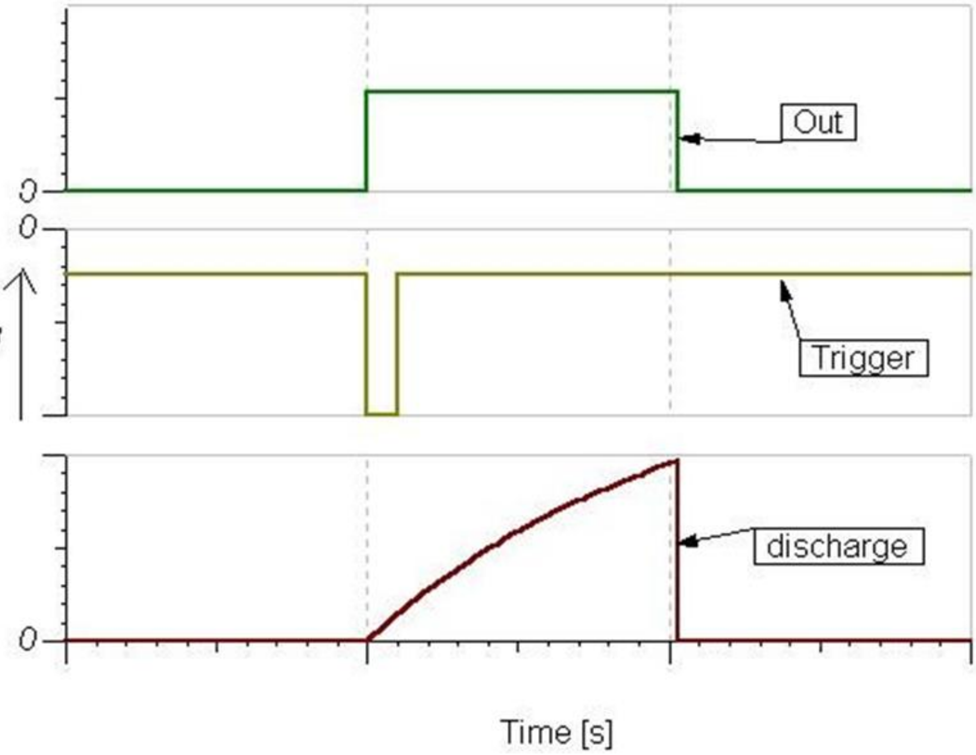
ASTABLE MULTIVIBRATOR:

The astable multivibrator is also called the free running multivibrator. It has two quasi states i.e. no stable states as such the circuit conditions oscillate between the components values used to decide the time for which circuit remains in each stable state. The principle of square wave output is to force the IC to operate in saturation region. Whenever input at the negative input terminal just exceeds V_{ref} switching takes place resulting in a square wave output. In astable multivibrator both stable states and one quasi states are present.

CIRCUIT DIAGRAM:



MODEL GRAPH:



TABULATION

S.NO.	WAVEFORM	AMPLITUDE (V) *VOLTS*	TIME (T) *ms*	FREQ. f=1/T *Hz*
1	**CAPACITOR**			
2	**TRIGGER**			
3	**OUTPUT**			

EXPERIMENTAL PROCEDURE:

1. Connections are as per the EXPERIMENTAL SETUP.
2. Supply is switched ON after checking the connections.
3. For monostable multivibrator trigger pulse is given and for stable it is not necessary.
4. Output square wave is noted from CRO.
5. The frequency is calculated by input.

RESULT:

Thus the mono stable multivibrators is designed and tested using IC555

Ex. No : 09	**Active Low Pass and High Pass Filter**
DATE :	

AIM:

To design and test low pass and high pass filter using IC 741.

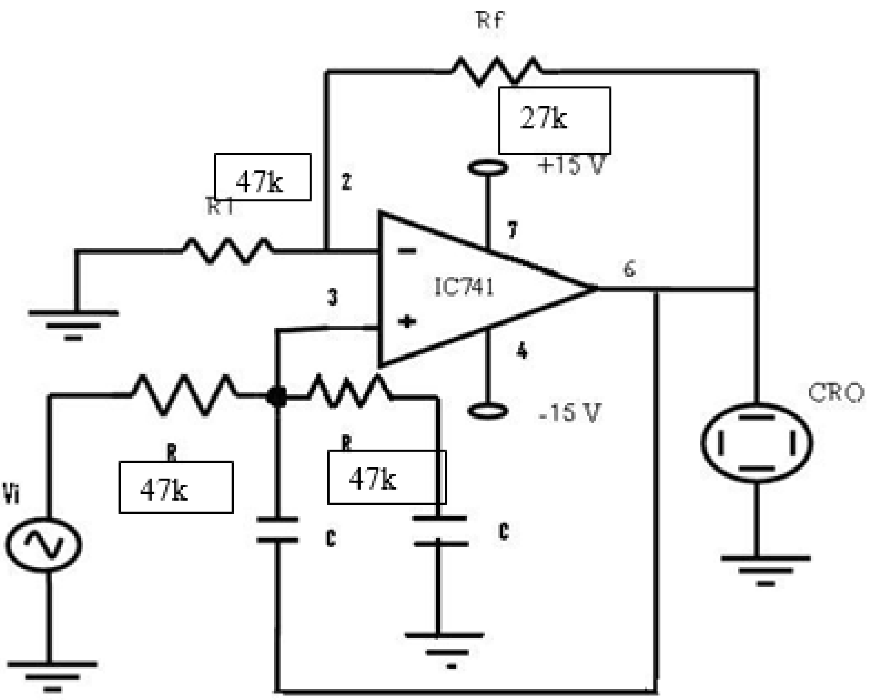
APPARATUS REQUIRED:

S.NO.	APPARATUS	RANGE	QUANTITY
1	Dual power supply	(0 - +15)V	1
2	CRO	(0-30)MHz	1
3	IC	µA 741	1
4	Resistor	10kΩ,5kΩ,	4,2
6	Capacitor	0.1µf,10µf	2,1

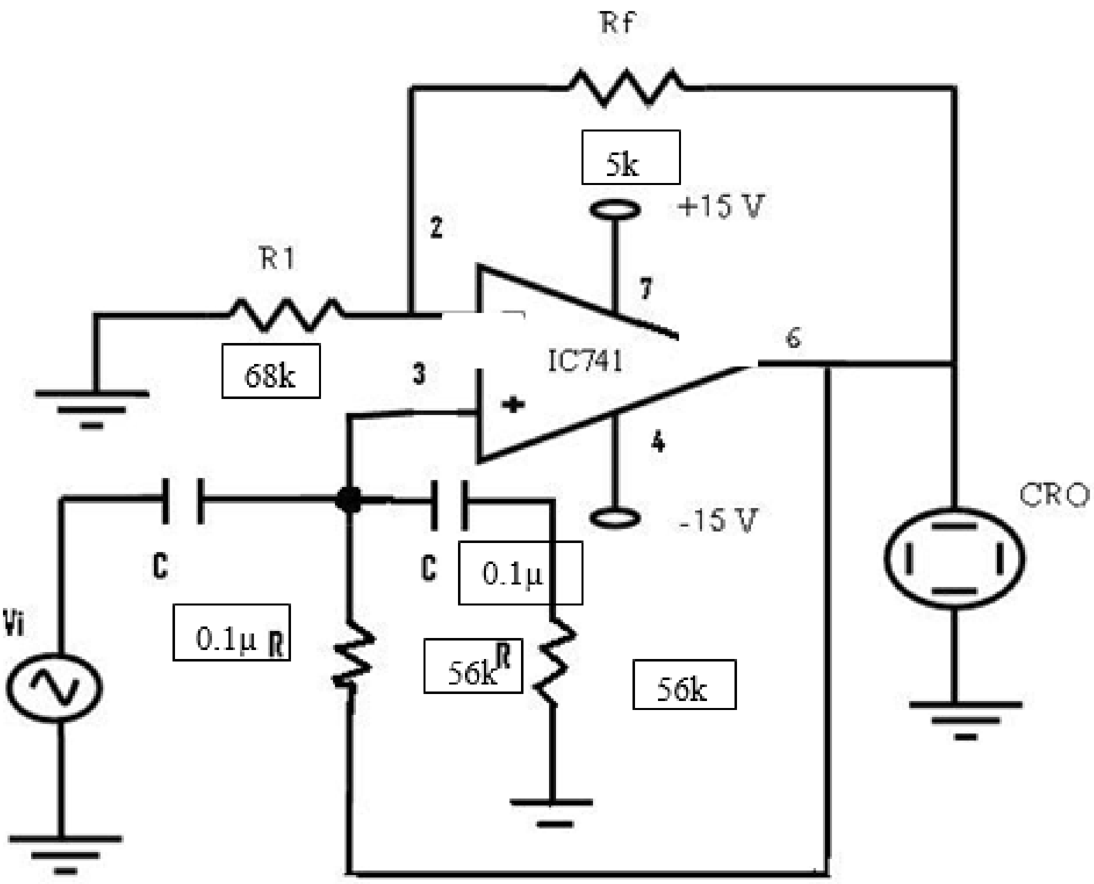
Theory:

The first order low pass and high pass filter is realized RC circuit used along with an op-amp in non-inverting configuration. A low pass and high pass filter has constant gain. Bandwidth of electric filters are used in circuits which require the separation of signals according to their frequencies. a first order low pass filter consists of a single RC network connected to the positive input terminal of non-inverting op-amp amplifier. Resistors R_i and R_f determine the gain of the filter in the pass band.

Circuit Diagram: Low Pass filter



Circuit Diagram: High Pass filter

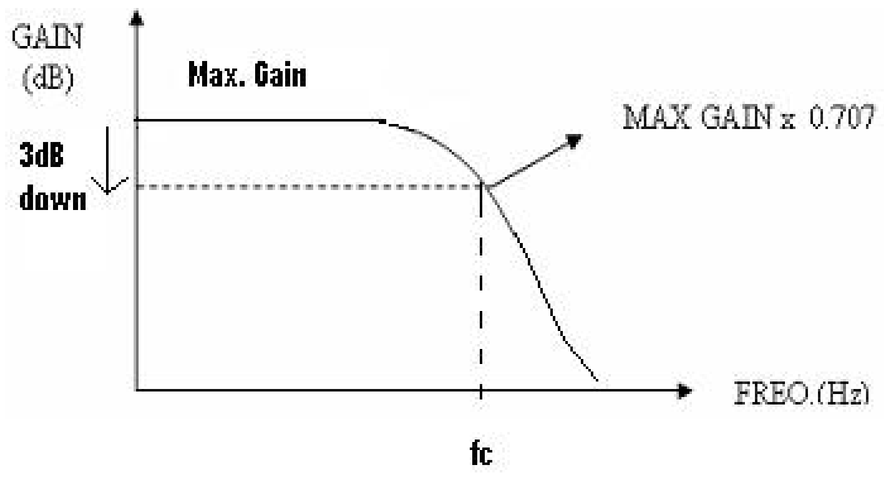


TABULATION-(ACTIVE LOW PASS FILTER) :

V_{in} =

S.NO	INPUT FREQUENCY (F_i) *Hz*	OUTPUT VOLTAGE (V_o) *mV*	GAIN = $20LOG(V_0/V_{in})$

MODEL GRAPH:

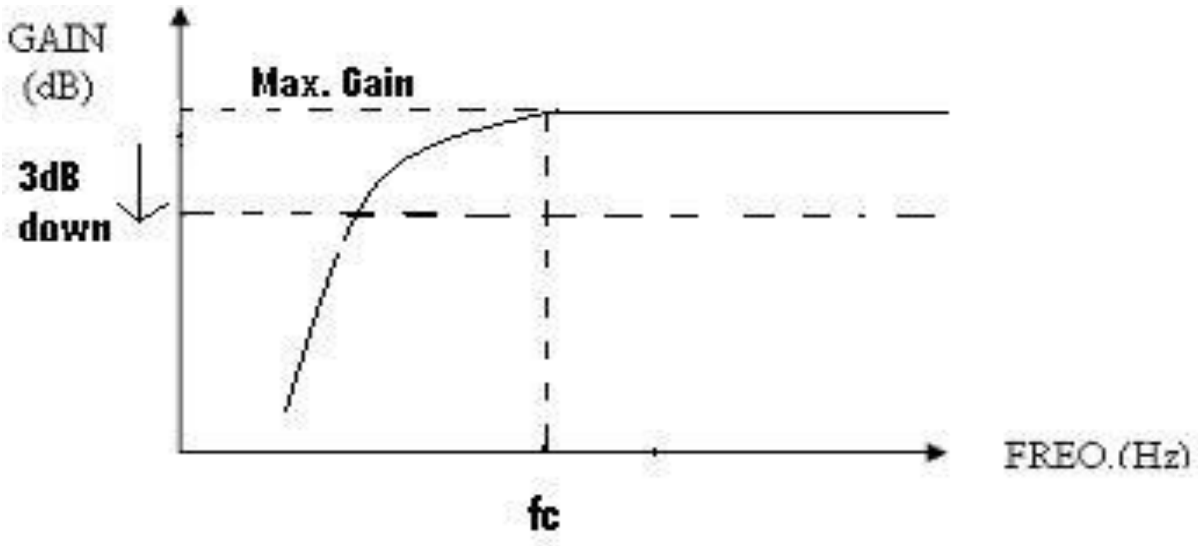


TABULATION –(ACTIVE HIGH PASS FILTER):

V_{in} =

S.NO.	INPUT FREQUENCY (F_i) *Hz*	OUTPUT VOLTAGE (V_o) *mV*	GAIN = 20LOG(V_o/V_{in})

MODEL GRAPH:



EXPERIMENTAL PROCEDURE:

1. connections are given as per the EXPERIMENTAL SETUP
2. Supply is switched ON after checking the connections.
3. Input voltage is set to 1V and by changing the input frequency, output voltage is measured.
4. The procedure is applied to active low pass, high pass and band pass filters.

RESULT:

Thus the low pass and high pass filters are designed and tested using IC741.

Ex. No : 10	Active Band Pass Filter
DATE :	

AIM:

To design and test band pass filter using IC 741.

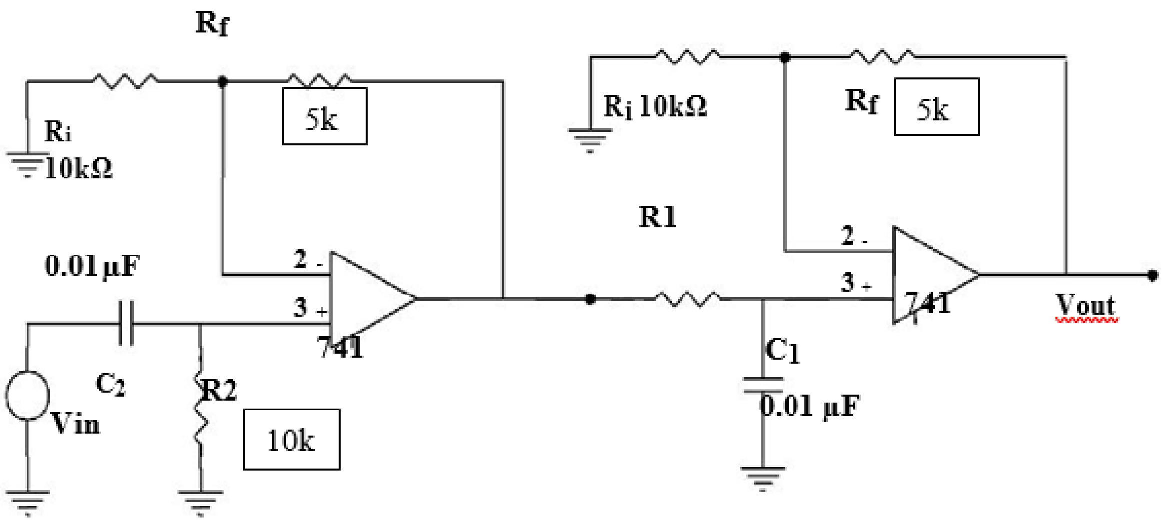
APPARATUS REQUIRED:

S.NO.	APPARATUS	RANGE	QUANTITY
1	Dual power supply	(0 - +15)V	1
2	CRO	(0-30)MHz	1
3	IC	μA 741	1
4	Resistor	10kΩ,5kΩ,	4,2
6	Capacitor	0.1μf,10μf	2,1

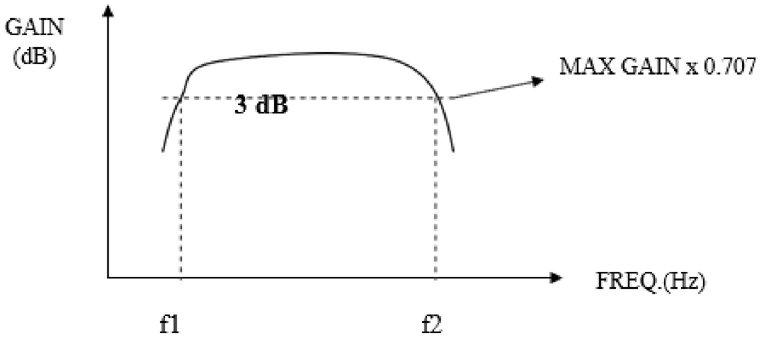
Theory:

The first order bandpass pass filter is realized RC circuit used along with an op-amp in non-inverting configuration. A low pass and high pass filter cascaded to realize the band pass filter. Bandwidth of electric filters are used in circuits which require the separation of signals according to their frequencies. a first order low pass filter consists of a single RC network connected to the positive input terminal of non-inverting op-amp amplifier. Resistors R_i and R_f determine the gain of the filter in the pass band

Circuit Diagram:



MODEL GRAPH:



TABULATION:

Vin =

S.NO.	INPUT FREQUENCY (F_i) *Hz*	OUTPUT VOLTAGE (Vo) *mV*	GAIN = 20LOG(Vo/Vin)

EXPERIMENTAL PROCEDURE:

1 Connections are given as per the EXPERIMENTAL SETUP

2 Supply is switched ON after checking the connections.

3 Input voltage=1V and by changing the input frequency, output voltage is measured.

4 The procedure is applied to active low pass, high pass and band pass filters.

RESULT:

Thus the bandpass filters is designed and tested using IC741.

Ex. No : 11	Voltage Regulator Using LM 317
DATE :11	

AIM:

To conduct an experiment in order to get regulated output using LM 317.

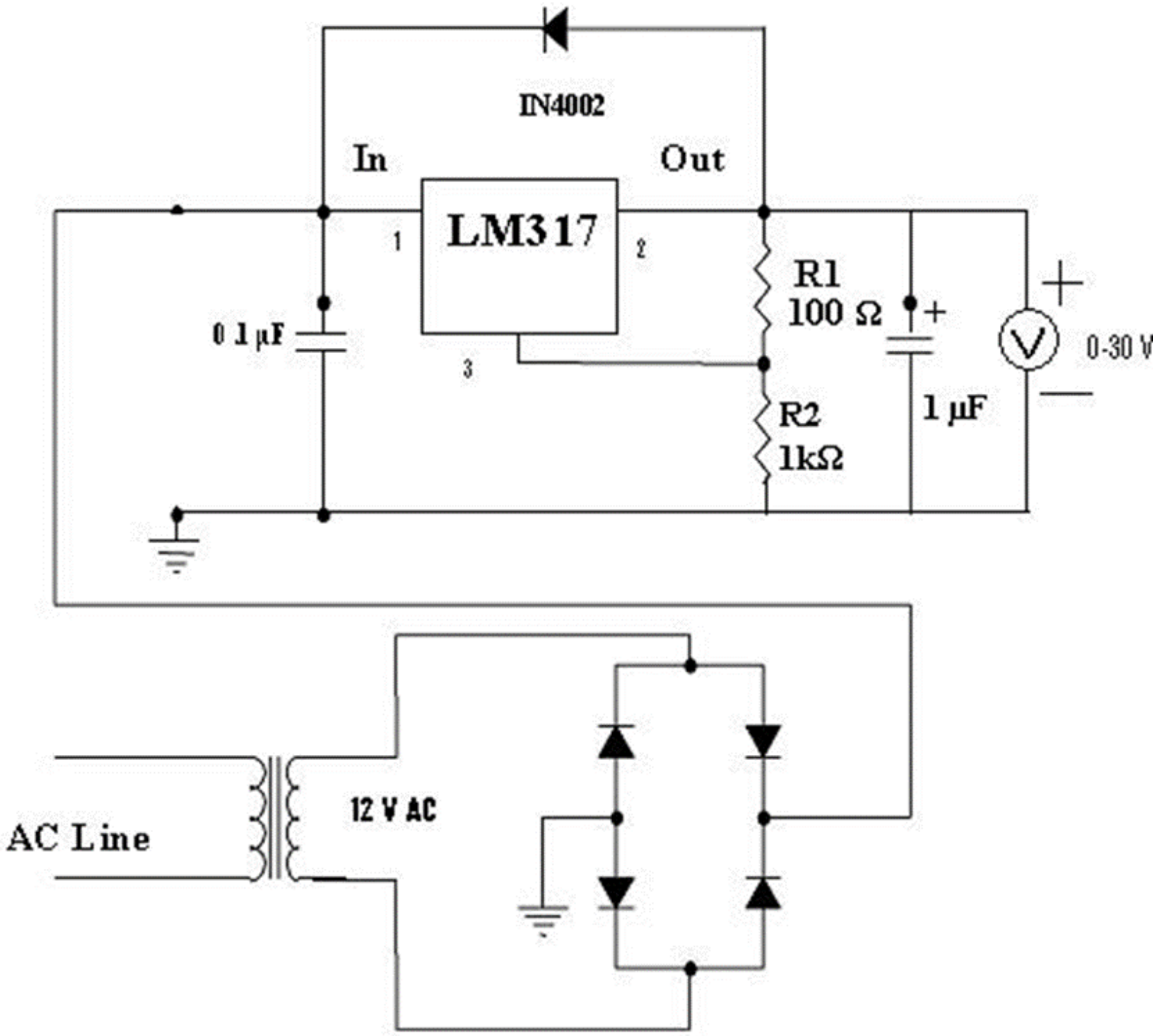
APPARATUS REQUIRED:

S.NO.	APPARATUS	RANGE	QUANTITY
1	Dual power supply	(0 - +15)V	1
2	Resistor	240Ω , 1.4KΩ	Each 1
3	Capacitor	1µF	1
4	Bread Board	-	1

THEORY:

The basic voltage regulator in its simplest form consists of a) voltage reference Vr b) error amplifier c) feedback network d) active series or shunt control unit. the voltage reference generates a voltage level which is applied to the comparator circuit, which is generally error amplifier. The second input to the error amplifier obtained through feedback network. Generally using the potential divider, the feedback signal is derived by sampling the output voltage. The error amplifier converts the difference between the output sample and the reference voltage into an error signal. This error signal in turn controls the active element of the regulator circuit, in order to compensate the changes in the output voltage. Such an active element is generally a transistor.

Circuit Diagram:



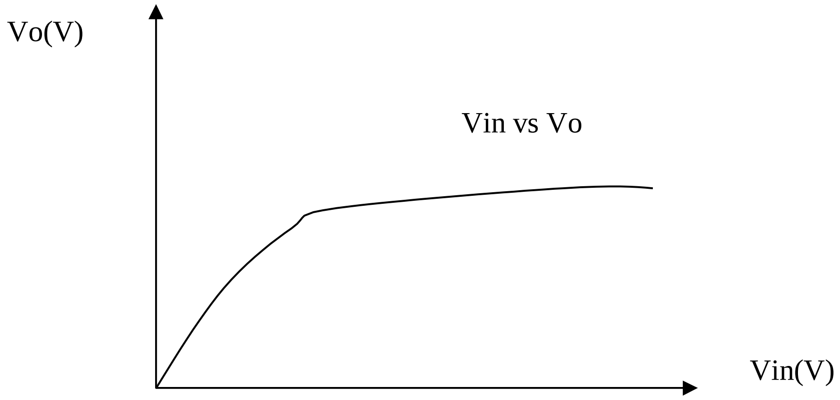
DESIGN PROCEDURE:

Besides fixed voltage regulator, Ic voltage regulators are available which allow the adjustment of the output voltage. The output voltage can be adjusted from 1.2V to as high as 5.7V with the help of such regulators. in such regulator IC's common terminal plays the role of control input and hence called as adjustment terminal. The LM 317 series is the most commonly used three terminal adjustable regulators. These devices are available in a variety of packages which can be easily mounted and handled. The power rating of such regulators is 1.5Am.the maximum input voltage of LM 317 is 40V.

TABULATION-(DC POWER SUPPLY):

S.NO.	Vin *volts*	Vo *volts*

MODEL GRAPH:



EXPERIMENTAL PROCEDURE:

1. Connections are given as per the experimental setup.
2. The input voltage is given to the circuit and output voltage varies from zero.
3. Then the output voltage attains the designed value and then it is irrespective of input voltage (the output becomes constant.

RESULT :

Thus the experiment is conducted using LM 317 and the regulated output is obtained using the op-amp circuit.

Ex. No : 12	Design and implementation of rectangular waveform generator
DATE :	

Aim

To design and implement a rectangular waveform generator (Op-Amp relaxation oscillator) using a simulation package and demonstrate the working of it.

Apparatus Required

S.No	Apparatus	Type	Range	Quantity
1	OP-AMP	IC741		1
2	Resistor		1 kΩ, 1 kΩ, 100 kΩ	Each 1
3	Capacitor		10 nF	1
4	Voltage source		12 V DC	2
5	Voltage probe			1

Software Required

https://www.multisim.com/

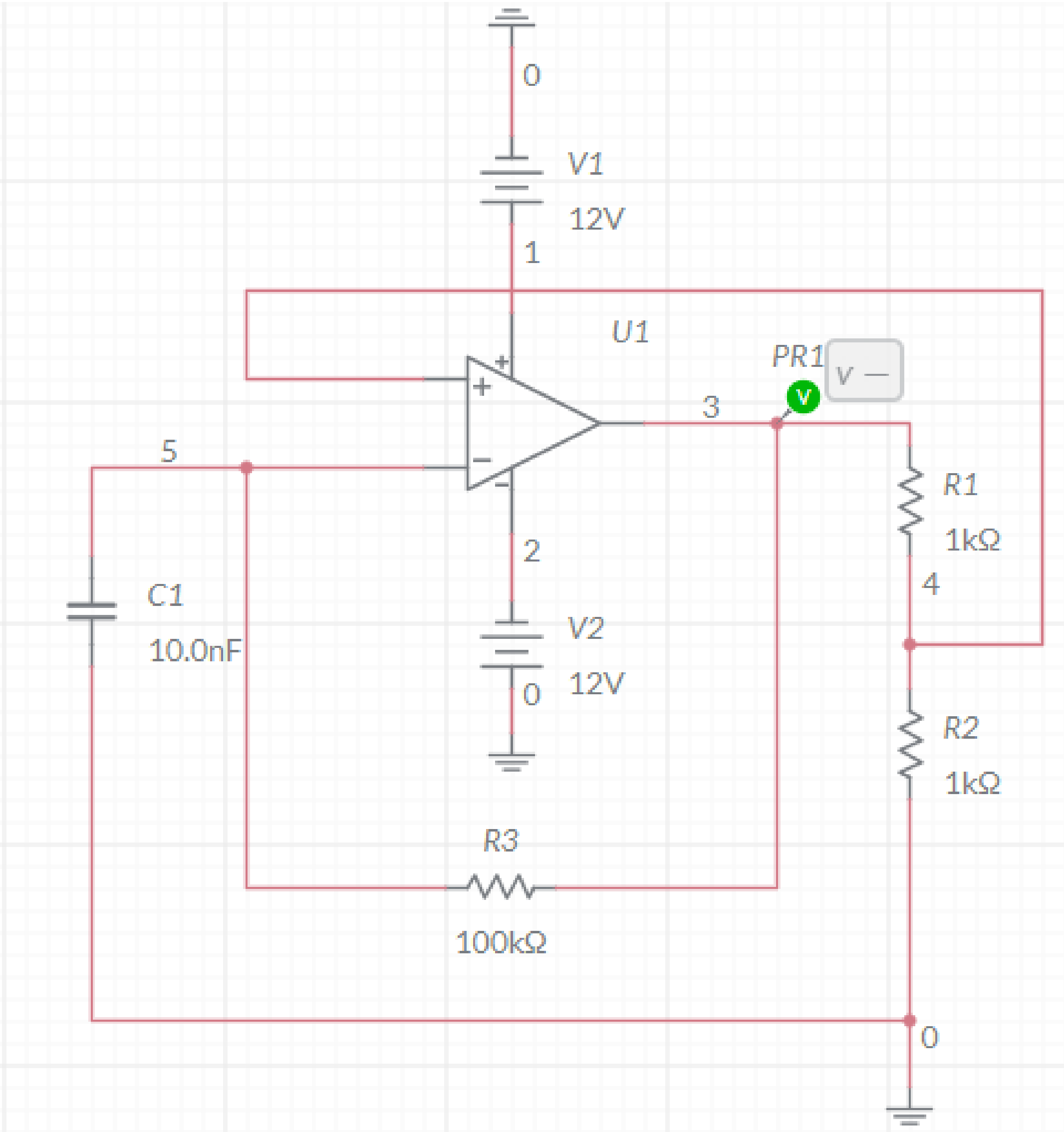
Theory

Rectangular Waves are generated when the Op-Amp is forced to operate in the saturation region. That is, the output of the op-amp is forced to swing respectively between +Vsat And -Vsat resulting in the generation of square wave. The square wave generator is also called a free-running or astable Multivibrator Assuming the voltage across capacitor C is zero at the instant the d.c Supply voltage at +Vcc and VEE are applied. Initially the capacitance C acts, as a short circuit. The gain of the Op-Amp is very large hence V_1 drives the output of the Op-Amp to its saturation.

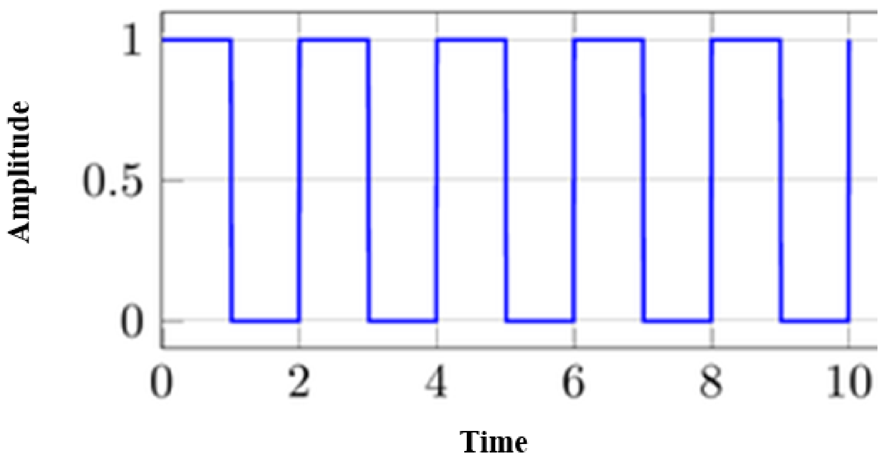
Procedure

I. Make the connections as per the circuit diagram.
II. Adjust the values of resister and capacitor to the desired value.
III. Measure the voltage using voltage probe and obtain the graph in grapher window.
IV. Tabulate the readings.

Circuit Diagram



Model graph



Tabulation

Amplitude(V)	Time period (ms)	Frequency (Hz)

Result

Thus, the rectangular wave generator was designed, and the corresponding values are tabulated.