

**DEPARTMENT OF  
ELECTRONICS AND COMMUNICATION  
ENGINEERING  
IV – SEMESTER  
EC1256 – LINEAR INTEGRATED CIRCUITS LAB  
LAB MANUAL**



**KCT COLLEGE OF ENGG & TECH.,  
FATEHGARH**

**PUNJAB TECHNICAL UNIVERSITY**

**Subject Name** : **Linear Integrated Circuits Lab**  
**Subject Code** : **EC 1256**  
**Semester** : **IV**  
**Branch** : **ECE**

### LIST OF EXPERIMENTS

Design and Testing of

1. Inverting, Non – inverting and Differential amplifiers.
2. Integrator and Differentiator.
3. Instrumentation amplifier.
4. Active low pass and band pass filter.
5. Astable, monostable multivibrator and Schmitt trigger using Op – amp.
6. Wein bridge and RC Phase shift oscillator using Op – amp.
7. Astable and monostable multivibrator using NE 555 timer.
8. Frequency multiplier using PLL.
9. DC power supply using LM 317.
10. Study of SMPS control IC SG 3524 / SG3525.
11. Simulation of Experiments 3, 4, 5, 6 and 7 using PSpice netlists

Note: Op-Amps uA741, LM 301, LM311, LM 324 & AD 633 may be used

Expt. No.1

APPLICATIONS OF OP-AMP - I  
( INVERTING AND NON – INVERTING AMPLIFIER)

1. a. INVERTING AMPLIFIER

AIM:

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

APPARATUS REQUIRED:

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

THEORY:

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

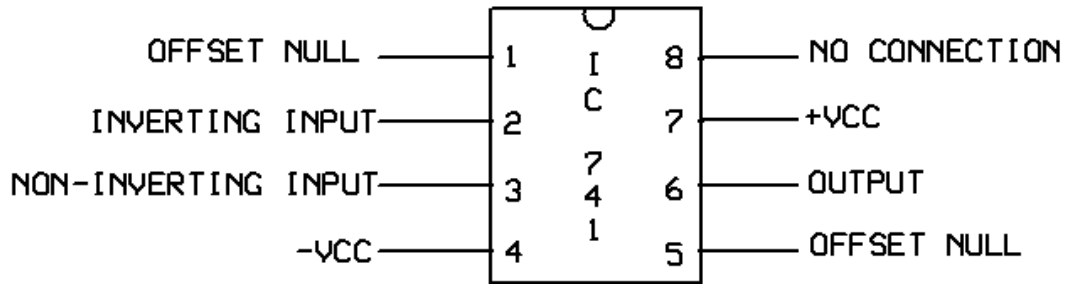
$$V_o = -A_{CL} V_i$$

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

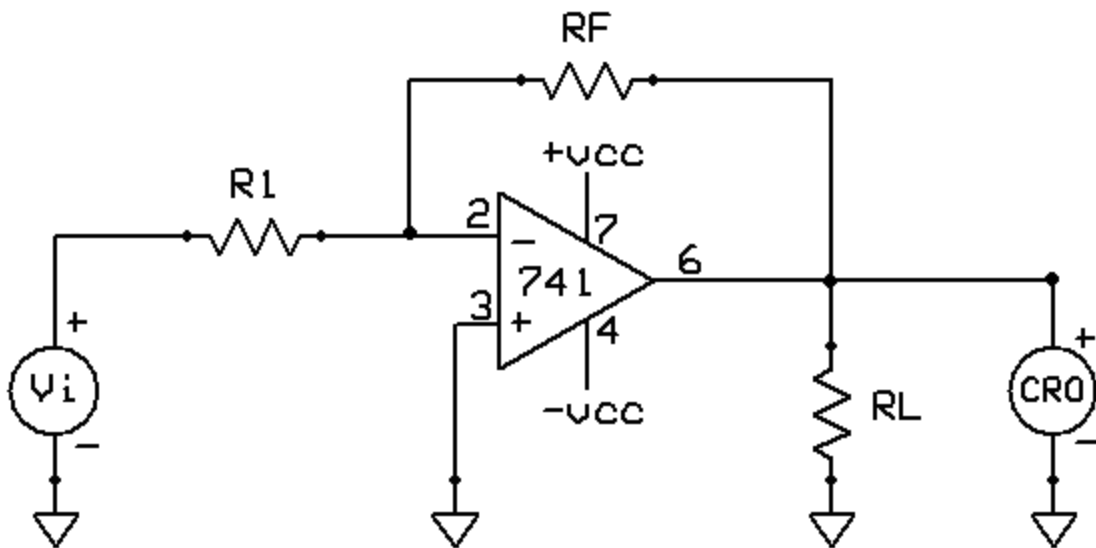
PROCEDURE:

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

PIN DIAGRAM:



CIRCUIT DIAGRAM OF INVERTING AMPLIFIER:



DESIGN:

We know for an inverting Amplifier  $A_{CL} = R_F / R_1$   
 Assume  $R_1$  ( approx.  $10\text{ K}\Omega$  ) and find  $R_F$   
 Hence  $V_o = -A_{CL} V_i$

OBSERVATIONS:

S.No	Input	Output	
		Practical	Theoretical
1.	Amplitude ( No. of div x Volts per div )		

2.	Time period ( No. of div x Time per div )			
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MODEL GRAPH:

RESULT:

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

#### 1. b. NON - INVERTING AMPLIFIER

AIM:

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

APPARATUS REQUIRED:

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

THEORY:

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

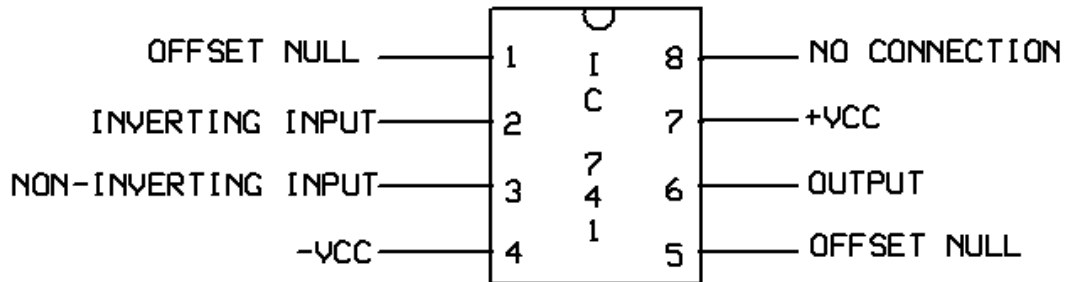
$$V_o = A_{CL} V_i$$

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

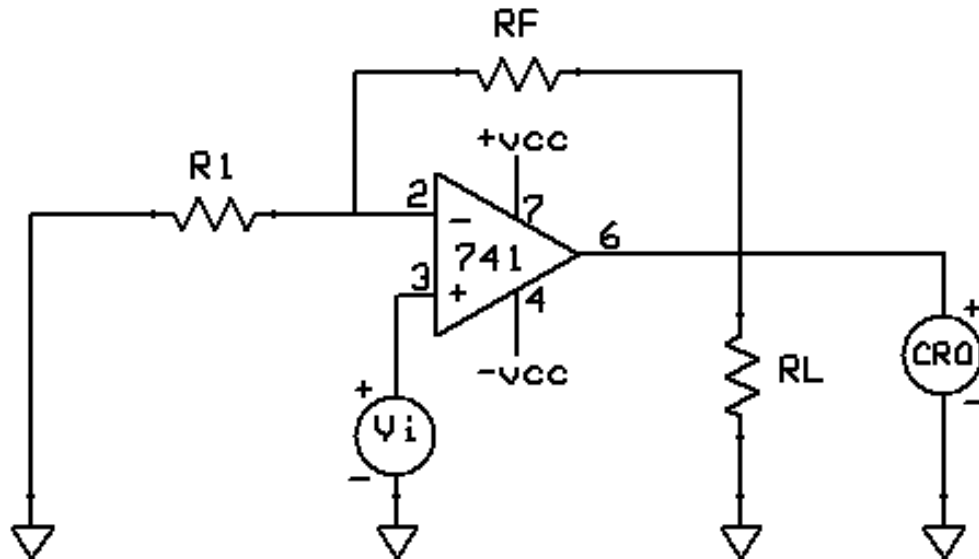
#### PROCEDURE:

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

#### PIN DIAGRAM:



#### CIRCUIT DIAGRAM OF NON INVERTING AMPLIFIER:



DESIGN:

We know for a Non-inverting Amplifier  $A_{CL} = 1 + (R_F / R_1)$

Assume  $R_1$  ( approx.  $10\text{ K}\Omega$  ) and find  $R_f$

Hence  $V_o = A_{CL} V_i$

OBSERVATIONS:

S.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.

Expt. No.2

APPLICATIONS OF OP-AMP - II  
(DIFFERENTIATOR AND INTEGRATOR)

2. a. DIFFERENTIATOR

AIM:

To design a Differentiator circuit for the given specifications using Op-Amp IC 741.

APPARATUS REQUIRED:

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

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  $R_1$  is replaced by a capacitor  $C_1$ . The expression for the output voltage is given as,

$$V_o = -R_f C_1 (dV_i/dt)$$

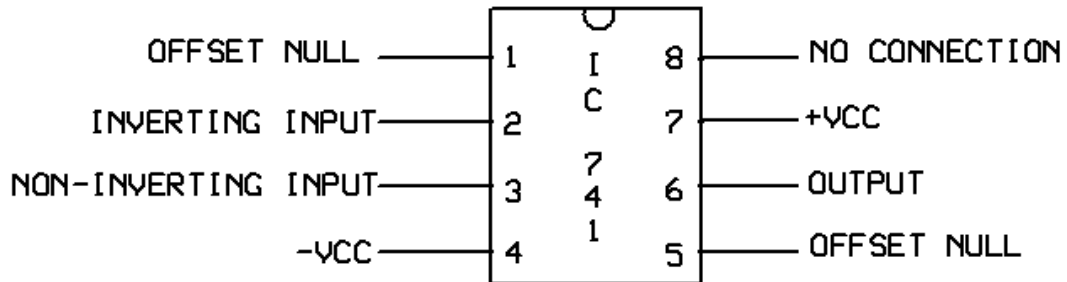
Here the negative sign indicates that the output voltage is  $180^\circ$  out of phase with the input signal. A resistor  $R_{comp} = R_f$  is normally connected to the non-inverting input terminal of the op-amp to compensate for the input bias current. A workable differentiator can be designed by implementing the following steps:

1. Select  $f_a$  equal to the highest frequency of the input signal to be differentiated. Then, assuming a value of  $C_1 < 1 \mu\text{F}$ , calculate the value of  $R_f$ .
2. Choose  $f_b = 20 f_a$  and calculate the values of  $R_1$  and  $C_f$  so that  $R_1 C_1 = R_f C_f$ .

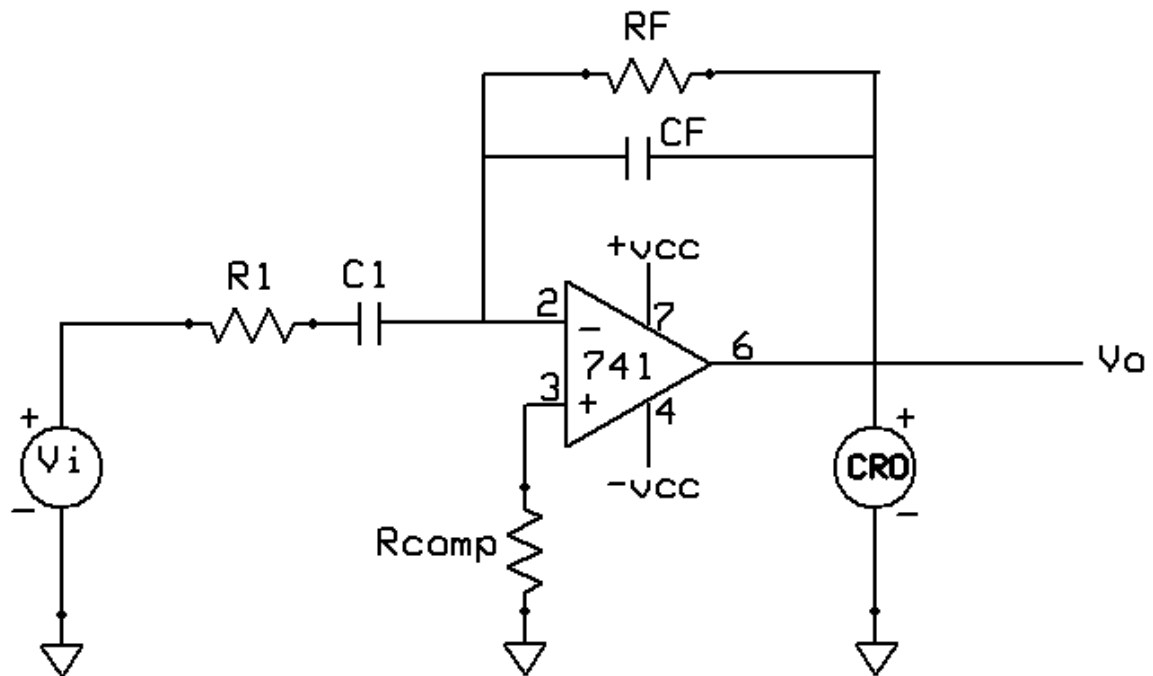
The differentiator is most commonly used in waveshaping circuits to detect high frequency components in an input signal and also as a rate-of-change detector in FM modulators.



PIN DIAGRAM:



CIRCUIT DIAGRAM OF DIFFERENTIATOR:



DESIGN :

[ To design 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.]

Given  $f_a = 1 \text{ KHz}$

We know the frequency at which the gain is 0 dB,  $f_a = 1 / (2\pi R_f C_1)$

Let us assume  $C_1 = 0.1 \mu\text{F}$  ; then

$$R_f = \frac{1}{2\pi f_a C_1}$$

Since  $f_b = 20 f_a$ ,  $f_b = 20 \text{ KHz}$

We know that the gain limiting frequency  $f_b = 1 / (2\pi R_1 C_1)$

$$\text{Hence } R_1 = \frac{1}{2\pi f_b C_1}$$

Also since  $R_1 C_1 = R_f C_f$  ;  $C_f = \frac{R_1 C_1}{R_f}$

Given  $V_p = 1 \text{ V}$  and  $f = 1000 \text{ Hz}$ , the input voltage is  $V_i = V_p \sin \omega t$

We know  $\omega = 2\pi f$

$$\begin{aligned} \text{Hence } V_o &= -R_f C_1 (dV_i/dt) \\ &= -0.94 \cos \omega t \end{aligned}$$

#### PROCEDURE:

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

#### OBSERVATIONS:

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

### 2. b. INTEGRATOR

#### AIM:

To design an Integrator circuit for the given specifications using Op-Amp IC 741.

#### APPARATUS REQUIRED:

S.No	Name of the Apparatus	Range	Quantity
1.	Function Generator	3 MHz	1

2.	CRO	30 MHz	1
3.	Dual RPS	0 – 30 V	1
4.	Op-Amp	IC 741	1
5.	Bread Board		1
6.	Resistors		
7.	Capacitors		
8.	Connecting wires and probes	As required	

## 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  $C_f$ . The expression for the output voltage is given as,

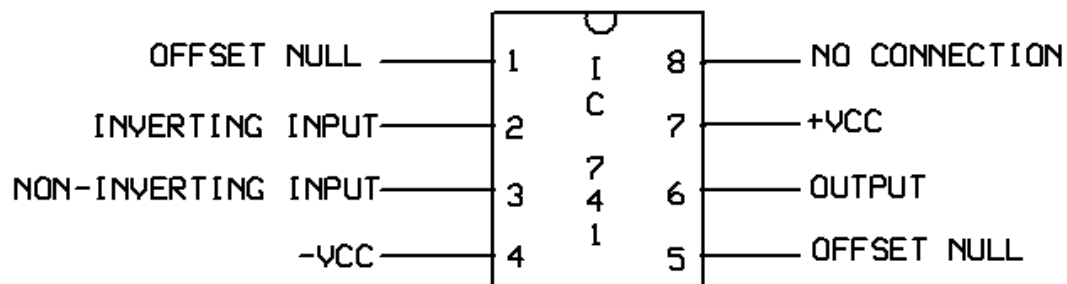
$$V_o = - (1/R_f C_f) \int V_i dt$$

Here the negative sign indicates that the output voltage is  $180^\circ$  out of phase with the input signal. Normally between  $f_a$  and  $f_b$  the circuit acts as an integrator. Generally, the value of  $f_a < f_b$ . The input signal will be integrated properly if the Time period  $T$  of the signal is larger than or equal to  $R_f C_f$ . That is,

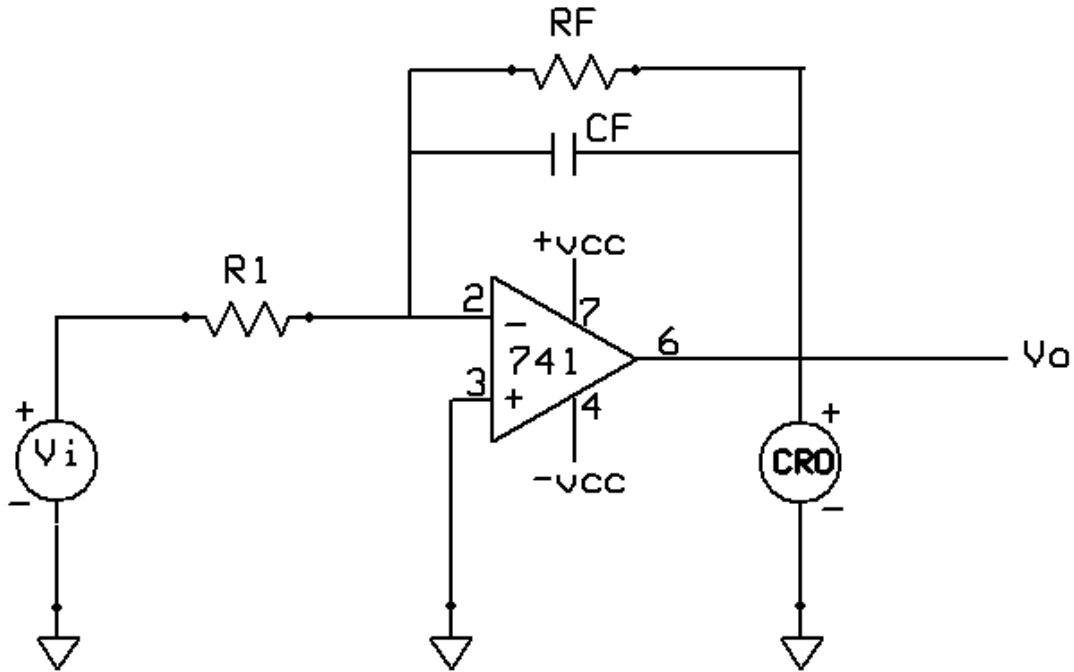
$$T \geq R_f C_f$$

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

## PIN DIAGRAM:



## CIRCUIT DIAGRAM OF INTEGRATOR:



DESIGN:

[ To obtain the output of an Integrator circuit with component values  $R_1 C_f = 0.1 \text{ms}$  ,  $R_f = 10 R_1$  and  $C_f = 0.01 \mu\text{F}$  and also if 1 V peak square wave at 1000Hz is applied as input.]

We know the frequency at which the gain is 0 dB,  $f_b = 1 / (2\pi R_1 C_f)$

Therefore  $f_b = \underline{\hspace{2cm}}$

Since  $f_b = 10 f_a$  , and also the gain limiting frequency  $f_a = 1 / (2\pi R_f C_f)$

We get ,  $R_1 = \underline{\hspace{2cm}}$  and hence  $R_f = \underline{\hspace{2cm}}$

PROCEDURE:

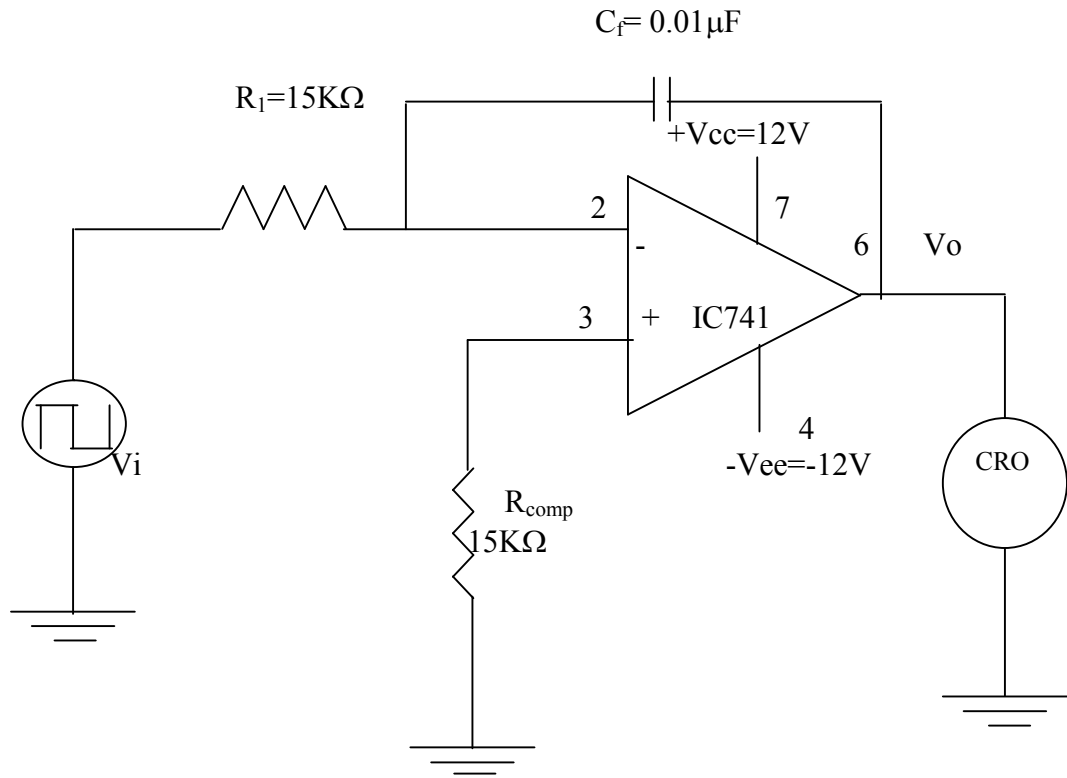
1. Connections are given as per the circuit diagram.
2. + V<sub>cc</sub> and - V<sub>cc</sub> supply is given to the power supply terminal of the Op-Amp IC.
3. By adjusting the amplitude and frequency knobs of the function generator, appropriate input voltage is applied to the inverting input terminal 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:

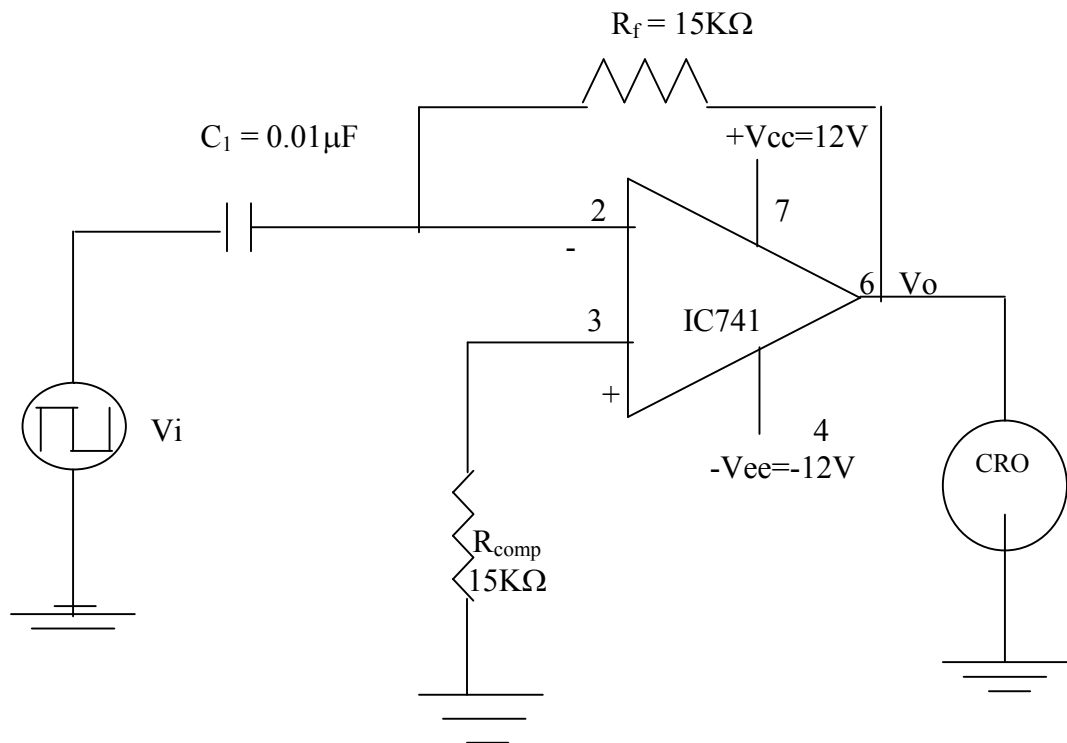
S.No		Input	Output
1.	Amplitude ( No. of div x Volts per div )		
2.	Time period		

( No. of div x Time per div )

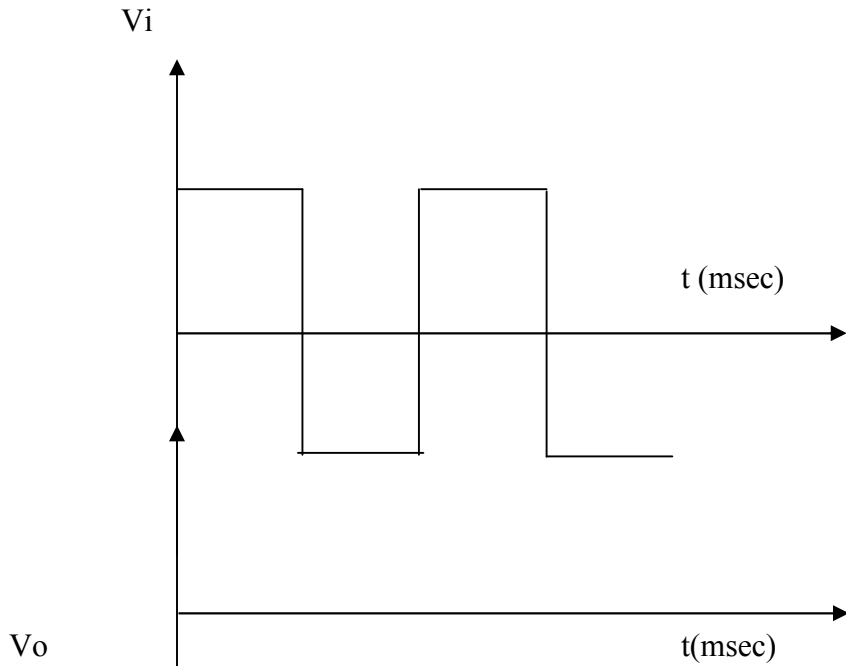
CIRCUIT DIAGRAM:  
INTEGRATOR



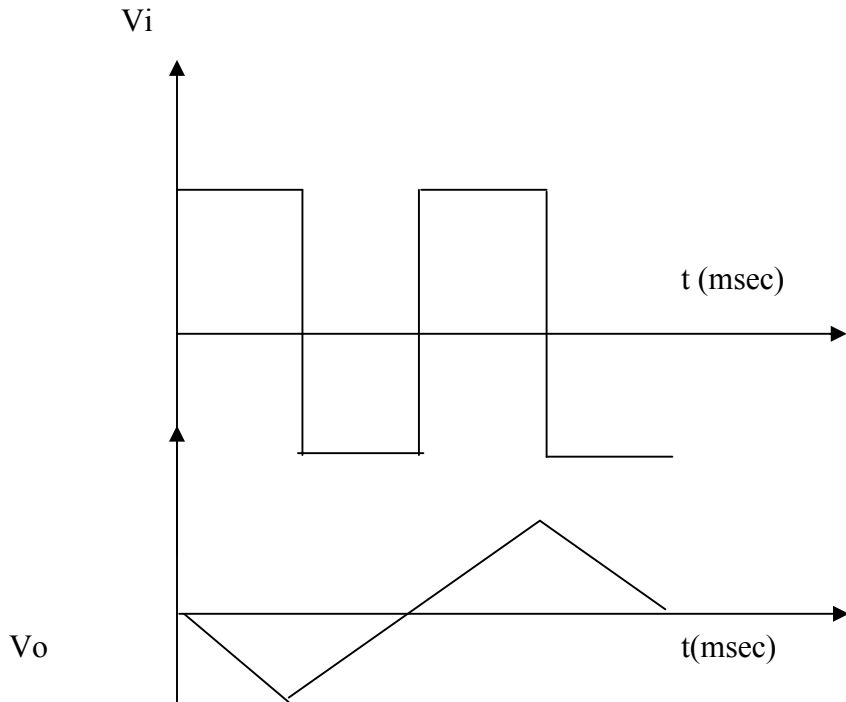
DIFFERENTIATOR



MODEL GRAPH: DIFFERENTIATOR



MODEL GRAPH: INTEGRATOR



RESULT:-

Thus the integrator and differentiator using op-amp is studied.

## 3. SECOND ORDER ACTIVE LOW PASS FILTER

AIM:

Design a second order active Butterworth low pass filter having upper cut off frequency 1 KHz, also determine its frequency response using IC 741.

APPARATUS REQUIRED :

S.NO	ITEM	RANGE	Q.TY
1	OP-AMP	IC741	1
2	RESISTOR	10K $\Omega$ , 1.5K $\Omega$ 5.6 K $\Omega$	1 1 1
3	Capacitor	0.1 $\mu$ F	1
4	CRO	-	1
5	RPS	DUAL(0-30) V	1

DESIGN:

Given:  $f_H = 1 \text{ KHz} = 1 / (2\pi RC)$

Let  $C = 0.1 \mu\text{F}$ ,  $R = 1.6 \text{ K}\Omega$

For  $n = 2$ ,  $\alpha$  (damping factor) = 1.414,

Passband gain =  $A_o = 3 - \alpha = 3 - 1.414 = 1.586$ .

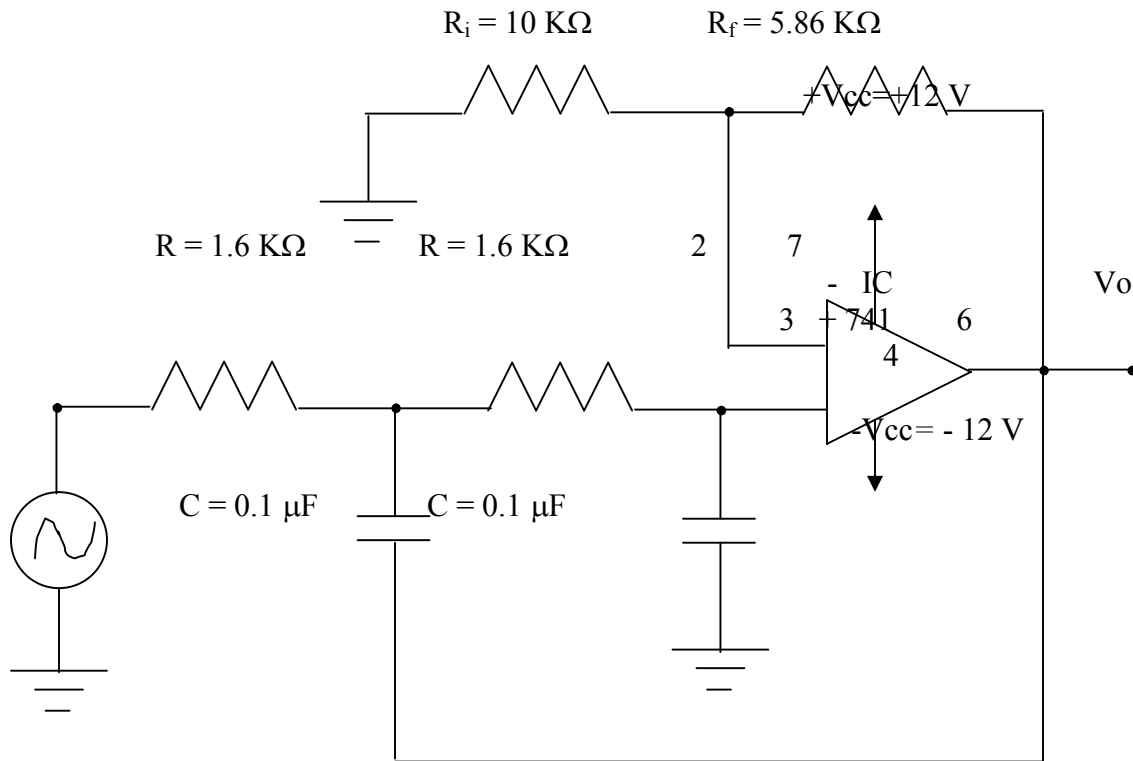
Transfer function of second order butterworth LPF as:

$$H(s) = \frac{1.586}{s^2 + 1.414s + 1}$$

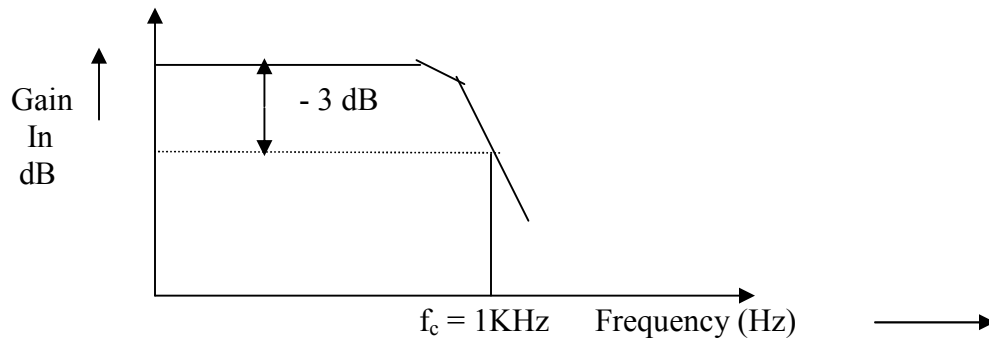
Now  $A_o = 1 + (R_f / R_1) = 1.586 = 1 + 0.586$

Let  $R_1 = 10 \text{ K}\Omega$ , then  $R_f = 5.86 \text{ K}\Omega$

CIRCUIT DIAGRAM:



Frequency Response Characteristics: (Use Semi – log Graph):





THEORY:

An improved filter response can be obtained by using a second order active filter. A second order filter consists of two RC pairs and has a roll-off rate of -40 dB/decade. A general second order filter (Sallen Kay filter) is used to analyze different LP, HP, BP and BSF.

PROCEDURE :

The connections are made as shown in the circuit diagram. The signal which has to be made sine is applied to the RC filter pair circuit with the non-inverting terminal. The supply voltage is switched ON and the o/p voltages are recorded through CRO by varying different frequencies from 10 Hz to 100 KHz and tabulate the readings. Calculating Gain through the formula and plotting the frequency response characteristics using Semi-log graph sheet and finding out the 3 dB line for  $f_c$ .

OBSERVATION:

$$V_{IN} = 1 \text{ Volt}$$

S.No.	FREQUNCY Hz	O/P voltage $V_O$ Volts	$A_v=20 \log V_o/V_i$ dB

RESULT:

Thus the second order Active Low Pass filter is designed and its frequency response characteristic curves are drawn.

## 4. SQUARE WAVE GENERATOR

AIM:

To design a square wave generator circuit for the frequency of Oscillations of 1KHZ

APPARATUS REQUIRED :

S.NO	ITEM	RANGE	Q.TY
1	OP-AMP	IC741	1
2	RESISTOR	4.7K $\Omega$ , 1K $\Omega$ 1.16K $\Omega$	1 1 1
3	CAPACITOR	0.1 $\mu$ F	1
4	CRO	-	1
5	RPS	DUAL(0-30) V	1

DESIGN:

$$F=1\text{KHZ} \quad T=1\text{ms}$$

$$R_2=1\text{K}\Omega, C=0.1\mu\text{F}$$

$$R_1=1.16R_2=1.16\text{K}\Omega \cong 1\text{K}\Omega+100\Omega$$

$$T=2RC$$

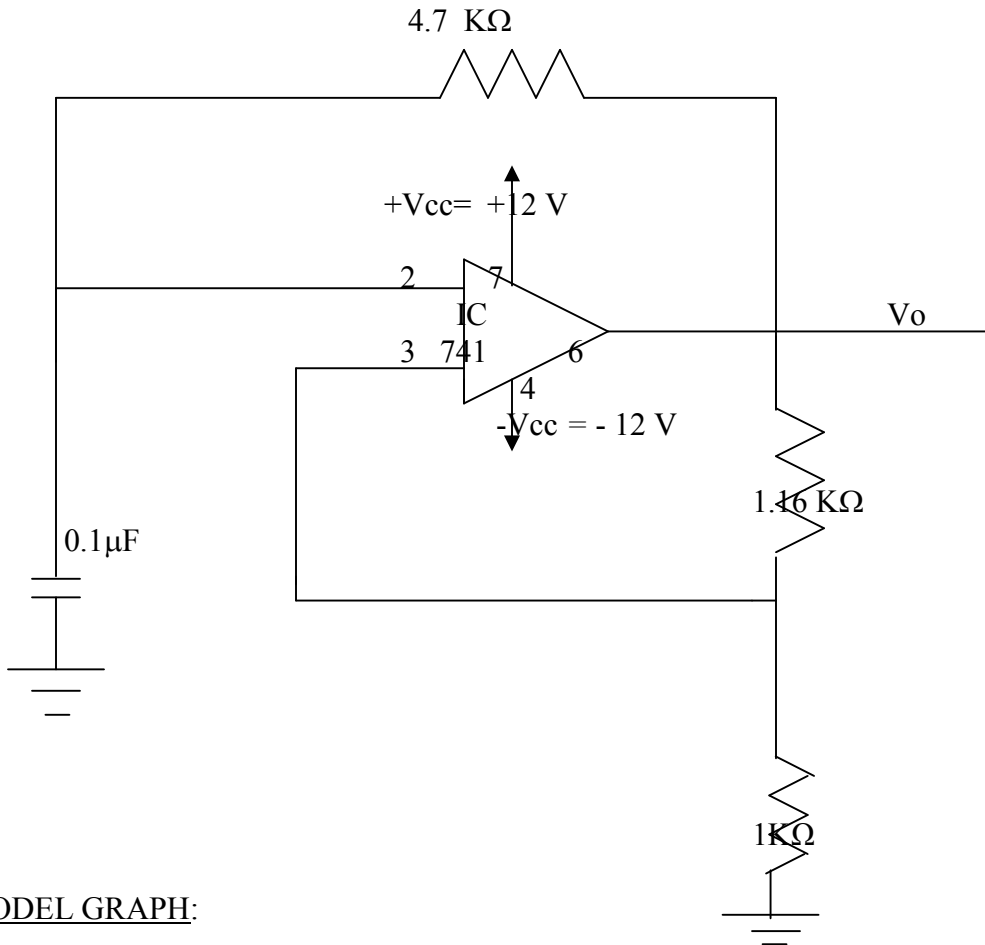
$$R=T/2C =5\text{K}\Omega$$

$$\cong 4.7\text{K}\Omega$$

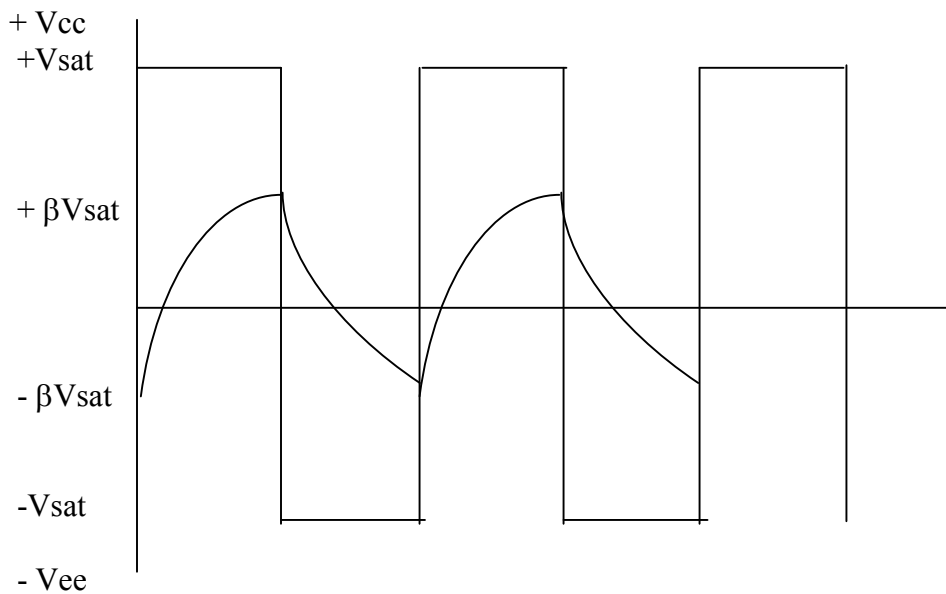
THEORY:

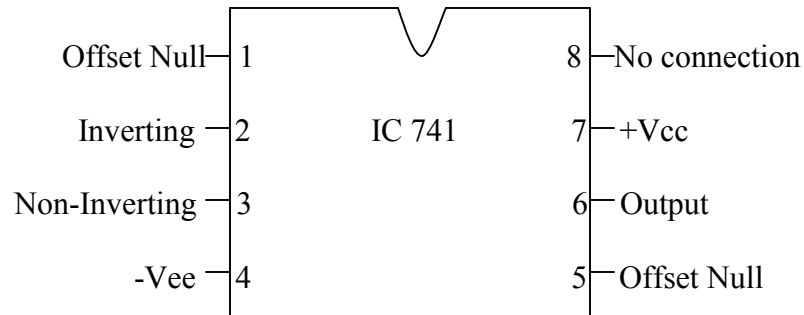
A simple op-Amp square wave generator is also called as free running oscillator, the principle of generation of square wave output is to force an op-amp to operate in the saturation region . A fraction  $\beta=R_2/(R_1+R_2)$  of the output is fed back to the (+) input terminal. The output is also fed to the (-) terminal after integrating by means of a low pass Rc combination in astable multivibrator both the states are quasistables. the frequency is determined by the time taken by the capacitor to charge from  $-\beta V_{\text{sat}}$  to  $+\beta V_{\text{sat}}$ .

CIRCUIT DIAGRAM:



MODEL GRAPH:



Pin Diagram:PROCEDURE:

1. The connection is given as per the circuit diagram.
2. connect the CRO in the output and trace the square waveform.
3. calculate the practical frequency and compare with the theoretical Frequency.
4. plot the waveform obtained and mark the frequency and time period.

RESULT:

Thus the square waveforms are generated using square wave generator

Theoretical frequency=

Practical frequency=

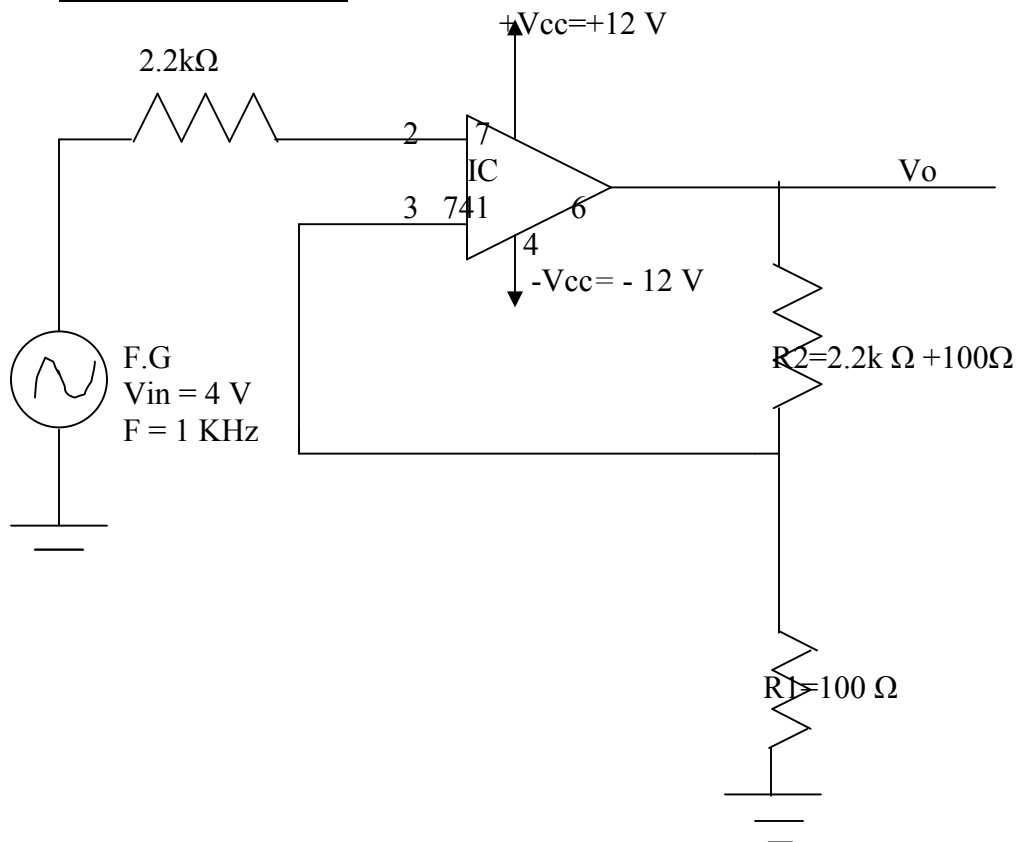
## 5. SCHMITT TRIGGER

AIM:

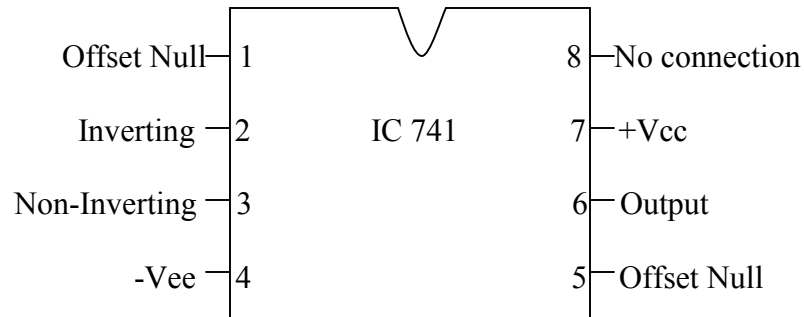
To study the Schmitt trigger using IC 741.

APPARATUS REQUIRED :

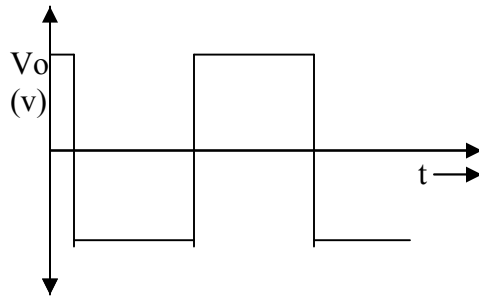
S.NO	ITEM	RANGE	Q.TY
1	OP-AMP	IC741	1
2	RESISTOR	100K $\Omega$ , 2.2K $\Omega$	2 1
3	CRO	-	1
4	RPS	DUAL(0-30) V	1

CIRCUIT DIAGRAM:

Pin Diagram:



O/P wave form:



### THEORY:

Schmitt trigger is useful in squaring of slowly varying i/p waveforms.  $V_{in}$  is applied to inverting terminal of op-amp. Feedback voltage is applied to the non-inverting terminal. LTP is the point at which output changes from high level to low level. This is highly useful in triangular waveform generation, wave shape pulse generator, A/D convertor etc.

### PROCEDURE :

The connections are made as shown in the circuit diagram. The signal which has to be made square is applied to the inverting terminal. Here the i/p is a sine waveform. The supply voltage is switched ON and the o/p waveform is recorded through CRO. The UTP and LTP are also found and the theoretical and practical values are verified.

$$LTP = R1 / (R1 + R2) \times (-V_{sat})$$

$$UTP = R2 / (R1 + R2) \times (+V_{sat})$$

Design :

$$+V_{sat} = +V_{cc} = 15v$$

$$-V_{sat} = -V_{ee} = -15v$$

RESULT:The Schmitt trigger circuit is connected and the waveforms are drawn and theoretical and practical values for the trip points are verified. Theoretical values =

Practical values =

### 6.Design of Instrumentation Amplifier

Aim:

Design of Instrumentation Amplifier with Digital Indication and to study its working.

Apparatus required:

Instrumentation Amplifier Kit

Digital multimeter

Connecting wires

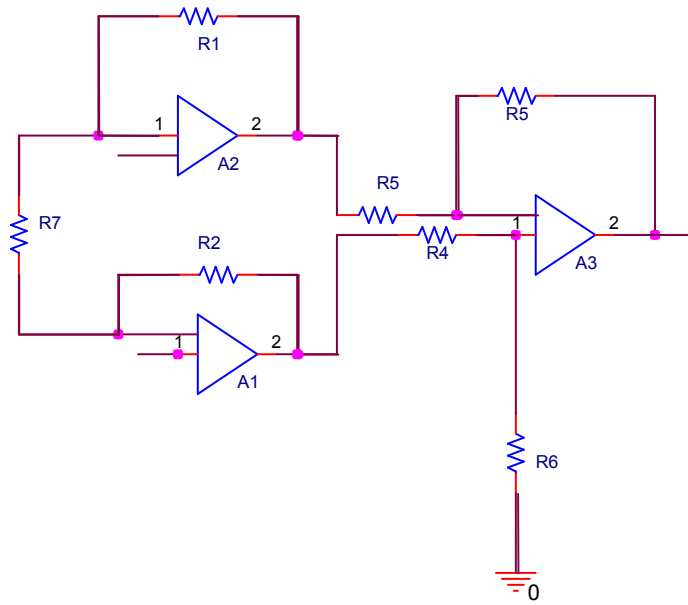
Procedure:

- 1.Patch the connections and connect the design resistance  $R_g$  extending to have the desired gain.
- 2.Measure the input voltage at  $V_{in1}$  and  $V_{in2}$  using digital multimeter.
- 3.The difference in  $V_{in2}$ -  $V_{in1}$  is amplified and indicated in LCD display.
- 4.Check the theoretical value with the experimental value.

TABULATION:

S.No	THEORETICAL VALUE					PRACTICAL VALUE
	GAIN SETTING	$V_{IN1}$ (mv)	$V_{IN2}$ (mv)	$V_{IN2} - V_{IN1}$	$V_{out}$ (mv)	$GAIN = V_{out} / V_{IN2} - V_{IN1}$

CIRCUIT DIAGRAM:



Result:

Thus the instrumentation amplifier with digital indication was designed and the working of this was studied.



## 7.RC PHASE SHIFT OSCILLATOR

AIM:

To construct a RC phase shift oscillator to generate sine wave using op-amp.

APPARATUS REQUIRED:

S.NO	ITEM	RANGE	Q.TY
1	OP-AMP	IC-741	1
2	RESISTOR	16KΩ, 32KΩ, 1.59KΩ,	1 2
3	CAPACITOR	0.1μf	2
4	CRO	-	1
5	RPS	DUAL(0-30) V	1

THEORY:

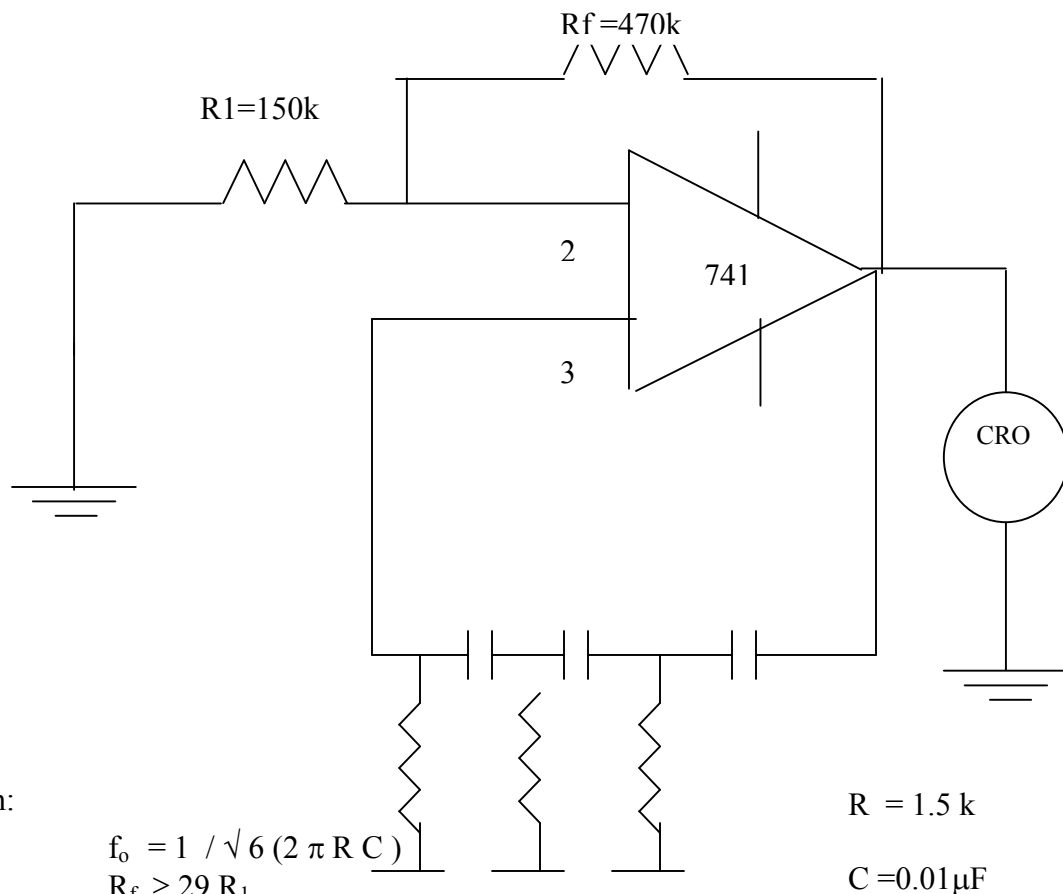
Basically, positive feedback of a fraction of output voltage of a amplifier fed to the input in the same phase, generate sine wave.

The op-amp provides a phase shift of 180 degree as it is used in the inverting mode. An additional phase shift of 180 degree is provided by the feedback Rc network. The frequency of the oscillator  $f_o$  is given by

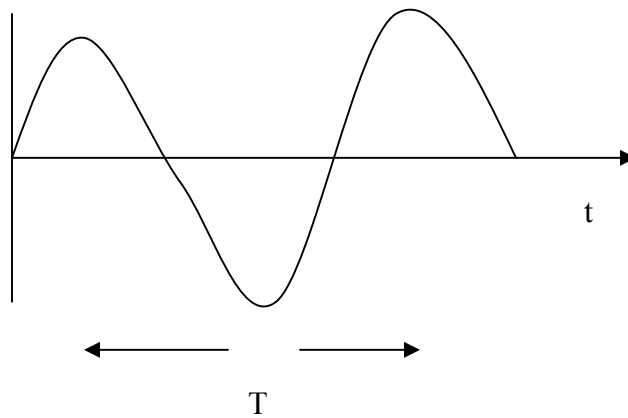
$$f_o = 1 / \sqrt{6} (2 \pi R C)$$

Also the gain of the inverting op-amp should be atleast 29, or  $R_f \geq 29 R_1$

## RC PHASE SHIFT OSCILLATOR



## MODEL GRAPH:



Observations:

Time period =

Frequency =

Amplitude =

Procedure:

1. Connect the circuit as shown in fig. With the design values.
2. Observe the output waveforms using a CRO. For obtaining sine wave adjust  $R_f$ .
3. Measure the output wave frequency and amplitude.

Result:

The sine wave output signal is obtained in RC phase shift oscillator.

Frequency  $f =$

## 8. WEIN BRIDGE OSCILLATOR

AIM:

To construct a wein bridge oscillator for  $f_0 = 1 \text{ kHz}$  and study its operation

APPARATUS REQUIRED:

S.NO	ITEM	RANGE	Q.TY
1	OP-AMP	IC-741	1
2	RESISTOR	16K $\Omega$ , 32K $\Omega$ , 1.59K $\Omega$ ,	1 2
3	CAPACITOR	0.1 $\mu\text{f}$	2
4	CRO	-	1
5	RPS	DUAL(0-30) V	1

THEORY:

In wein bridge oscillator ,wein bridge circuit is connected between the amplifier input terminals and output terminals . The bridge has a series rc network in one arm and parallel network in the adjoining arm. In the remaining 2 arms of the bridge resistors R1 and Rf are connected . To maintain oscillations total phase shift around the circuit must be zero and loop gain unity. First condition occurs only when the bridge is p balanced . Assuming that the resistors and capacitors are equal in value ,the resonant frequency of balanced bridge is given by

$$f_0 = 0.159 / RC$$

Design :

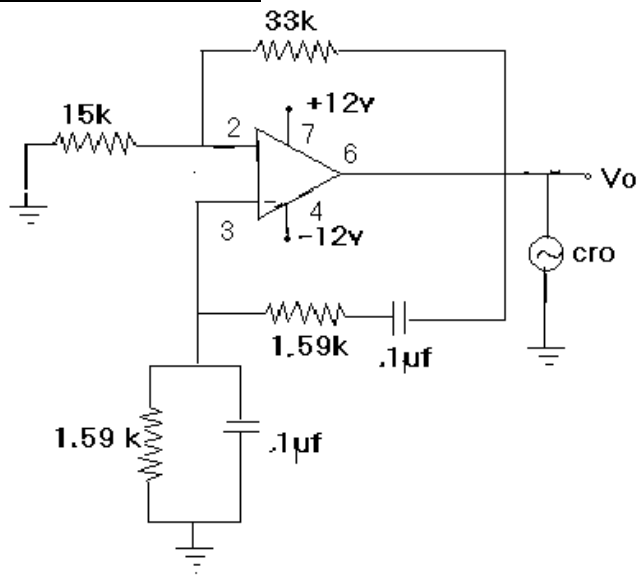
At the frequency the gain required for sustained oscillations is given by

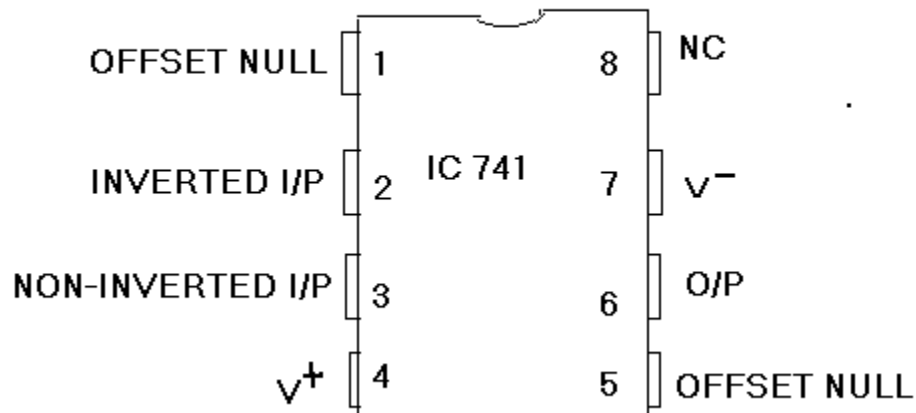
$$1 + R_f / R_1 = 3 \text{ or } R_f = 2R_1$$

$$f_0 = 0.65 / RC \text{ and } R_f = 2R_1$$

Calculation:Theoretical

$$F_r = 1/(2*3.14*R*C)$$

CIRCUITDIAGRAM

PIN DIAGRAM:Calculation:

Theoretical:  $F = 1/(2 \cdot 3.14 \cdot R \cdot C)$

Practical:  $F = 1/T$

PROCEDURE:

Connections are made as per the diagram. R, C, R<sub>1</sub>, R<sub>f</sub> are calculated for the given value of F<sub>o</sub> using the design. Output waveform is traced in the CRO.

RESULT :

Hence the wein bridge oscillator is studied and its output waveform traced.

## 9.MONOSTABLE MULTI VIBRATOR

AIM:

Design the monostable multivibrator using the IC555.

APPARATUS REQUIRED:

S.NO	ITEM	RANGE	Q.TY
1	IC	NE555	1
2	RESISTOR	9K $\Omega$	1
3	CAPACITOR	0.01 $\mu$ F 0.1 $\mu$ F	1 1
4	RPS	(0-30) V	1
5	CRO	-	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.

DESIGN :

$$T = 0.1\text{ms}$$

$$C = 0.01\mu\text{F}$$

$$T = 1.096RC$$

$$R = T / 1.096C = (0.1 * 10^{-3}) / (1.096 * 0.01 * 10^{-6}) \\ = 9.12 \text{ K}\Omega$$

$$R \cong 9 \text{ K}\Omega$$

CIRCUIT DIAGRAM :PINDIAGRAM:PROCEDURE:



The connections are made as per the diagram. The value of R is chosen as  $9k\Omega$ . 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 (uf)	Theoretical( $T=1.095 RC(ms)$ )	Practical T(ms)

### RESULT:

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

## 10.ASTABLE MULTIVIBRATOR

Aim:

To study the application of IC555 as an astable multivibrator.

APPARATUS REQUIRED :

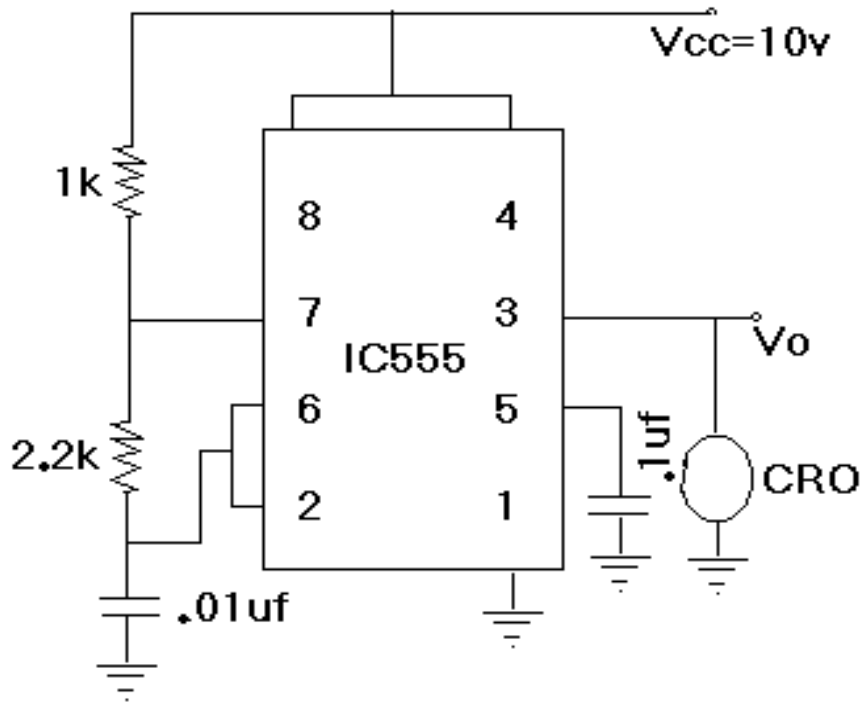
S.NO	ITEM	RANGE	Q.TY
1	IC	NE555	1
2	RESISTOR	1K $\Omega$ , 2.2K $\Omega$	1 1
3	CAPACITOR	0.1 $\mu$ F 0.01 $\mu$ F	1 1
4	CRO	-	1
5	RPS	DUAL(0-30) V	1

Theory:

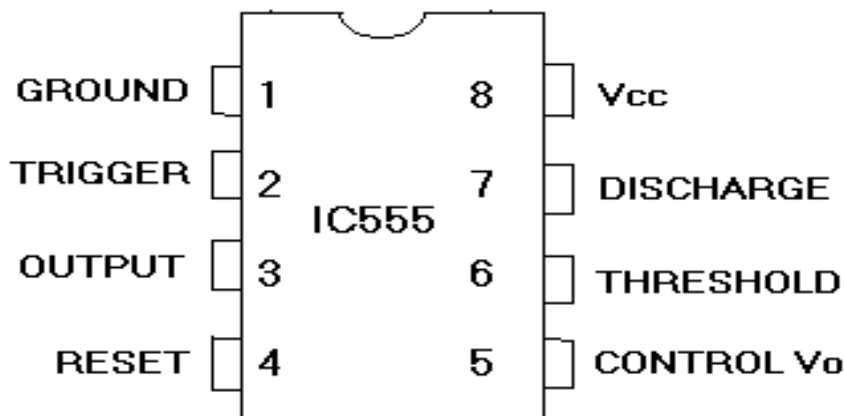
The IC555 timer is a 8 pin IC that can be connected to external components for astable operation. The simplified block diagram is drawn. The OP-AMP has threshold and control inputs. Whenever the threshold voltage exceeds the control voltage, the high output from the OP –AMP will set the flip-flop. The 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  $+V_{cc}/3$ , the OP-Amp output goes high and resets the flip flop.

Circuit diagram:



PIN 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 (uf)	Theoretical time period(us)	Practical time period(us)	Theoretical freq (kHz)	Practical freq(kHz)

Calculation:

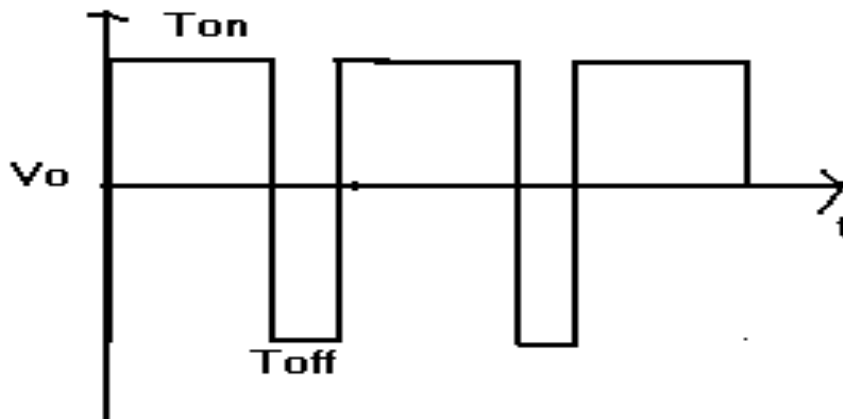
Theoretical:

$$T = 0.69(R_a + R_b)C = 0.69(1 * 10^3 + 2.2 * 10^3) * 0.01 * 10^{-6} = 0.22 \mu s$$

PRACTICAL:

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

MODEL GRAPH:



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

## 11. PLL CHARACTERISTICS

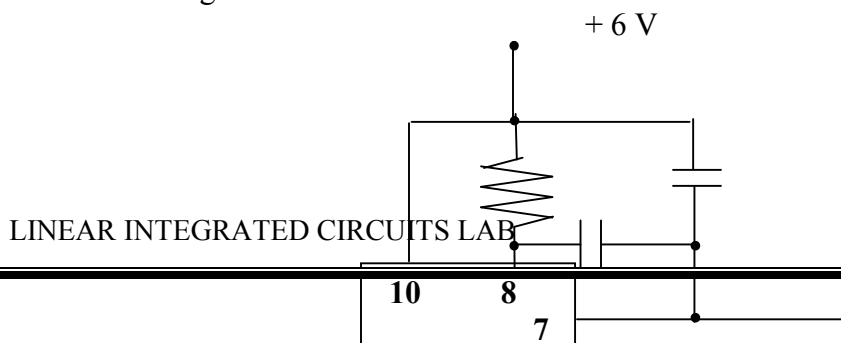
### Aim:

To construct and study the operation of PLL IC 565 and determine its Characteristics.

### Apparatus Required:

S.No	Components	Range	Quantity
1	IC 565	-	1
2	Resistors	6.8 K $\Omega$	1
3	Capacitors	0.001 $\mu$ F 0.1 $\mu$ F, 1 $\mu$ F	1 each
4	FunctionGenerator (Digital)	1 Hz – 2 MHz	1
5	C.R.O	-	1
6	Dual Power Supply	0- 30 V	1

### Circuit Diagram:



$R_1 = 6.8 \text{ K}\Omega$      $C = 1 \mu\text{F}$

$C_1 = 0.01 \mu\text{F}$

Demodulated O/p  
Reference O/p  
VCO O/p ( $f_o$ )

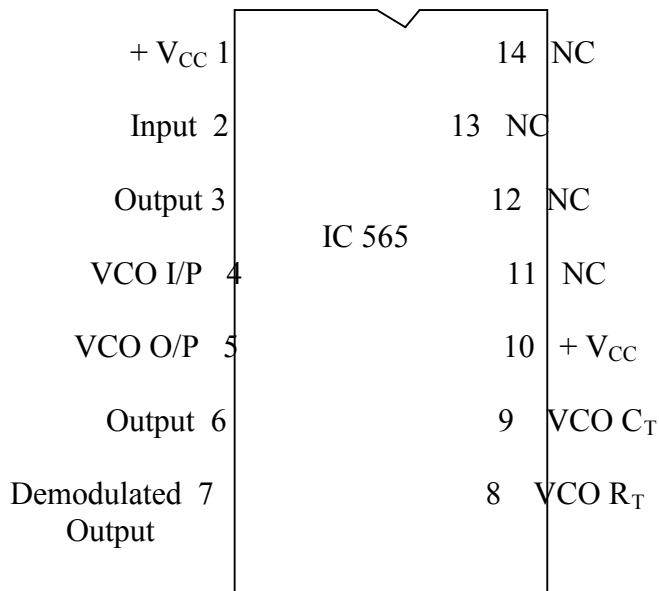
Function  
Generator  
(Square  
Wave)

$V_i$  Input

$C_T = 0.001 \mu\text{F}$

- 6 V

Pin Diagram (IC 565 - PLL)



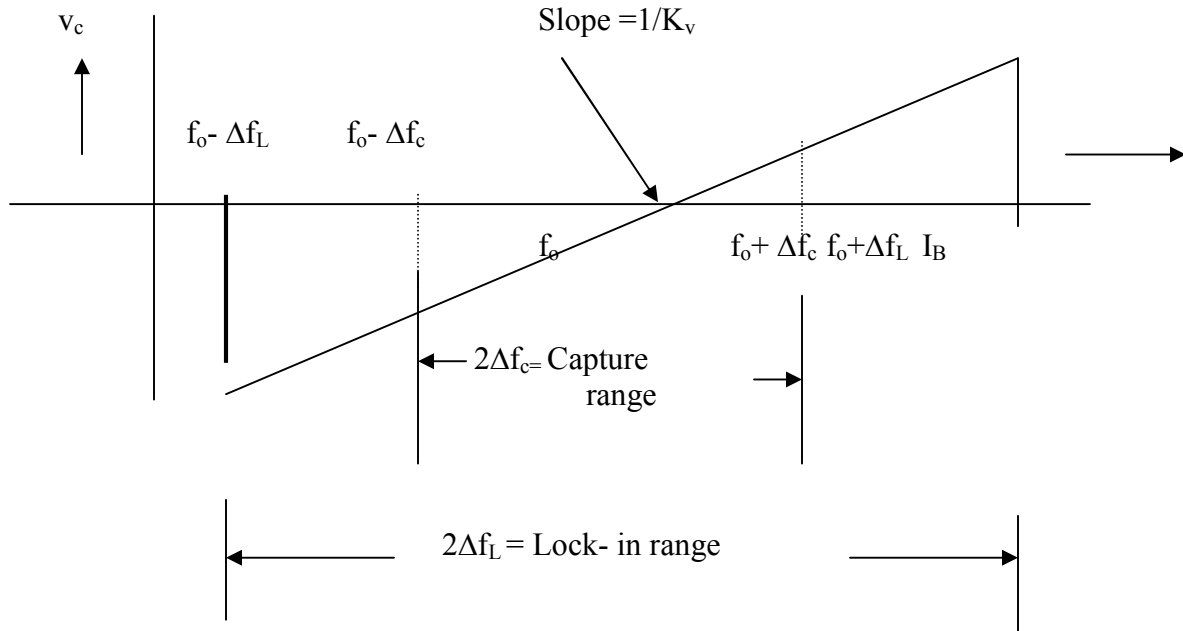
Procedure:

1. The connections are given as per the circuit diagram.
2. Measure the free running frequency of VCO at pin 4, with the input signal  $V_i$  set equal to zero. Compare it with the calculated value  $= 0.25 / (R_T C_T)$ .
3. Now apply the input signal of  $1 V_{PP}$  square wave at a 1 KHz to pin 2. Connect one channel of the scope to pin 2 and display this signal on the scope.
4. Gradually increase the input frequency till the PLL is locked to the input frequency. This frequency  $f_1$  gives the lower end of the capture range. Go on increasing the input frequency, till PLL tracks the input signal, say, to a frequency  $f_2$ . This frequency  $f_2$  gives the upper end of the lock range. If input frequency is increased further, the loop will get unlocked.
5. Now gradually decrease the input frequency till the PLL is again locked. This is the frequency  $f_3$ , the upper end of the capture range. Keep on decreasing the input frequency until the loop is unlocked. This frequency  $f_4$  gives the lower end of the lock range.
6. The lock range  $\Delta f_L = (f_2 - f_4)$ . Compare it with the calculated value

of  $\pm 7.8 f_0 / 12$ . Also the capture range is  $\Delta f_c = (f_3 - f_1)$ . Compare it with the calculated value of capture range.

$$\Delta f_c = \pm (\Delta f_L / (2\pi)(3.6)(10^3) C)^{1/2}$$

Model Graph



Result :

Thus the PLL circuit is constructed and its Characteristics is determined.

## 12. FREQUENCY MULTIPLIER USING PLL

Aim:

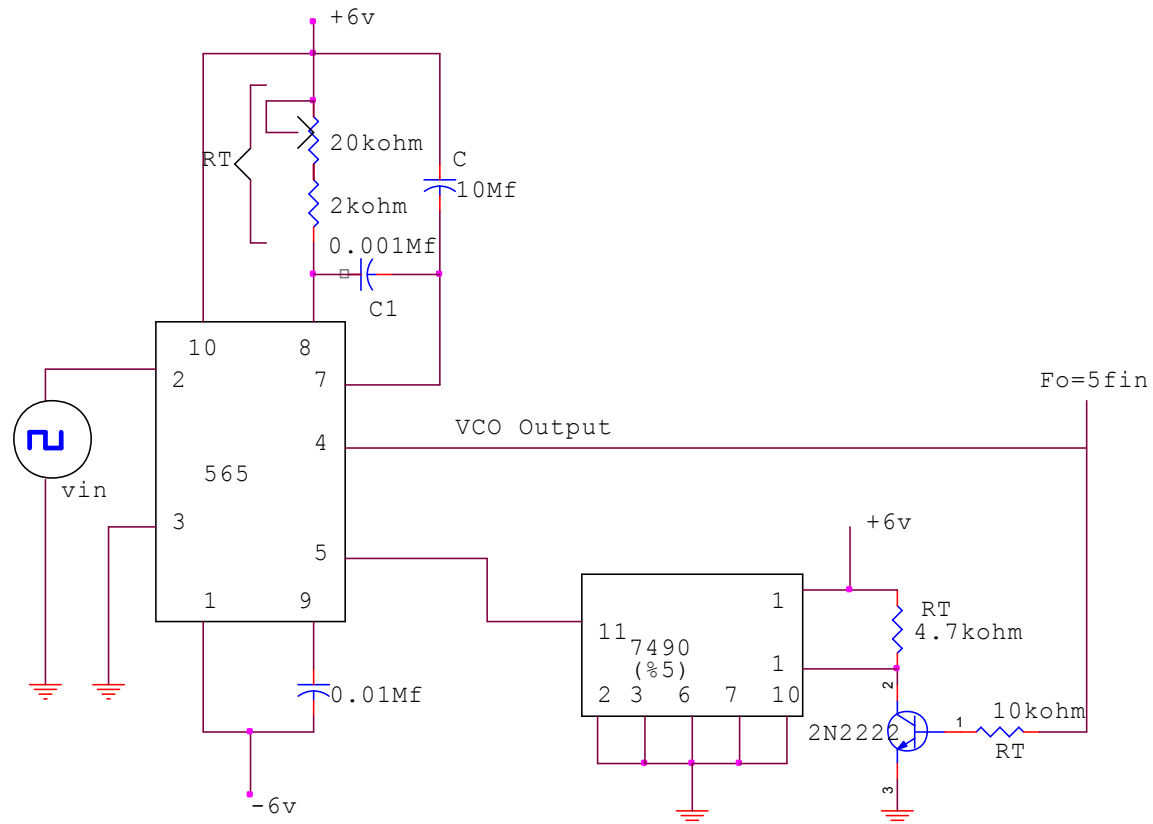
To construct and study the operation of frequency multiplier using IC 565.

Apparatus Required:

S.No	Components	Range	Quantity
1	IC 565,IC 7490,2N2222	-	1
2	Resistors	20 K $\Omega$ , 2k $\Omega$ , 4.7k $\Omega$ ,10k $\Omega$	1
3	Capacitors	0.001 $\mu$ F 10 $\mu$ F	1 each
4	FunctionGenerator (Digital)	1 Hz – 2 MHz	1
5	C.R.O	-	1
6	Dual Power Supply	0- 30 V	1
7.			

Circuit Diagram:





#### Procedure:

1. The connections are given as per the circuit diagram.
2. The circuit uses a 4-bit binary counter 7490 used as a divide-by-5 circuit.
3. Measure the free running frequency of VCO at pin 4, with the input signal  $V_i$  set equal to zero. Compare it with the calculated value  $= 0.25 / (R_T C_T)$ .
4. Now apply the input signal of  $1 V_{PP}$  square wave at 500 Hz to pin 2.
5. Vary the VCO frequency by adjusting the  $20k\Omega$  potentiometer till the PLL is locked. Measure the output frequency. It should be 5 times the input frequency.
6. Repeat steps 4,5 for input frequency of 1 kHz and 1.5 kHz.

#### Result :

Thus the frequency multiplier circuit using PLL is constructed and studied.

#### 11. IC VOLTAGE REGULATOR: (Using IC 723)

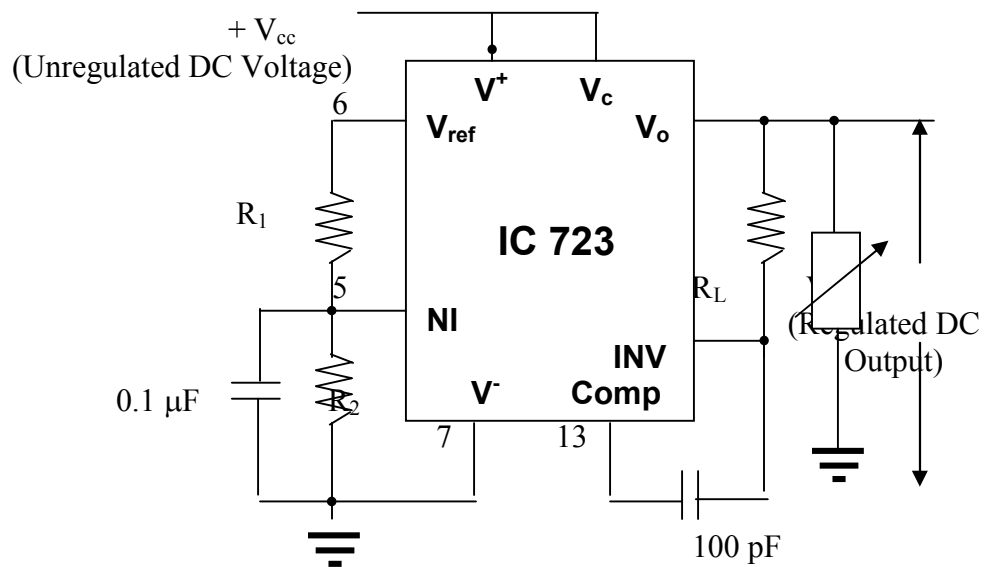
#### Aim:

## Design &amp; Construct a low voltage IC regulator (Using IC 723)

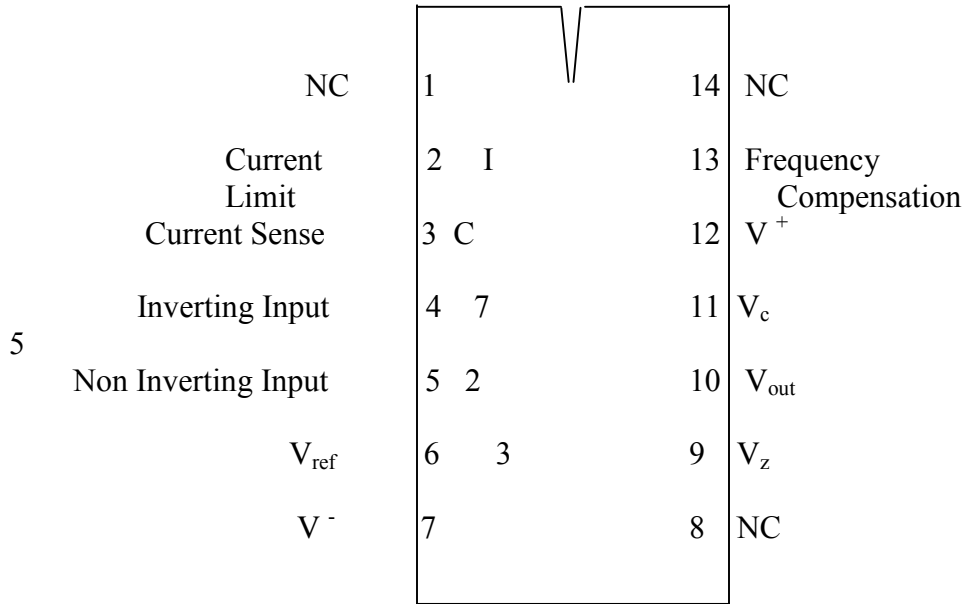
Apparatus Required:

S.No.	ITEM	SPECIFICATION	QTY
1	IC 723		2
2	Resistors		1
3	Capacitors	100 $\mu$ F / 25 V	2
3	R. P. S	(0- 30) V, 1 mA	1
4	Rheostat	(0-350 $\Omega$ ), 1.5 A	1
5	Bread Board and Connecting Wires		

Circuit Diagram:



PIN DIAGRAM: (IC 723):



TABULAR COLUMN:

LOAD REGULATION:

INPUT VOLTAGE =     Volts

S.No.	LOAD RESISTANCE (Ω)	OUTPUT VOLTAGE (V)

LINE REGULATION:

LOAD RESISTOR =     KOhms

S.No.	INPUT VOLTAGE (V)	OUTPUT VOLTAGE (V)

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RESULT:

The low voltage IC regulator is constructed and the regulation characteristics are tabulated and drawn its characteristics.