LNCT GROUP OF COLLEGES
"WORKING TOWARDS BEING THE BEST"

Name of Student: ______________________________

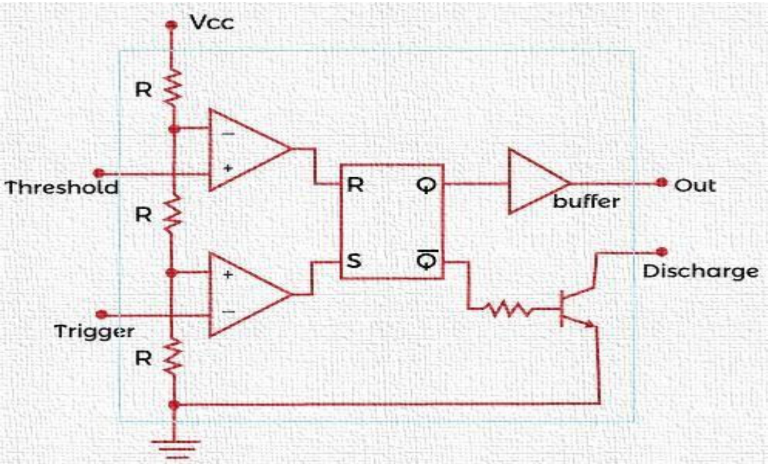
Enrollment No.: ______________________________

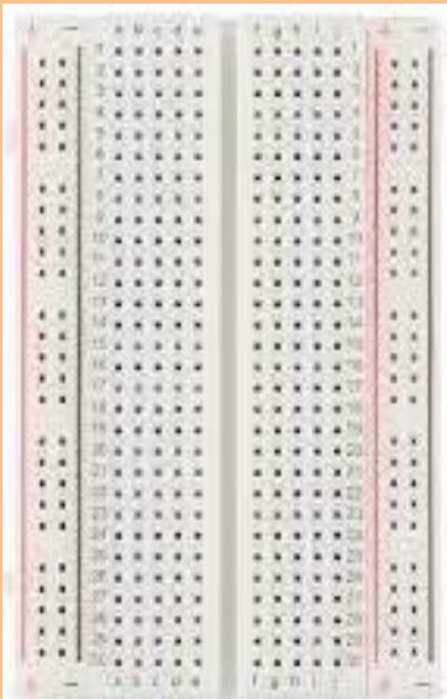
Class: ______________________________

Section: ______________________________

Session: ______________________________

Analog Circuits [EC-405]
Lab Manual





Department of Electronics & Communication Engineering
LAKSHMI NARAIN COLLEGE OF TECHNOLOGY AND SCIENCE
Kalchuri Nagar, Raisen Road Bhopal (MP) 462023

Vision and Mission of the Department

Vision

To be world-wide recognized for adopting and keeping innovation and entrepreneurship mindset as abreast of learning to produce professionals as valuable, ethical and moral resource for industry and society.

Mission

- To establish an ecosystem where students could grow with innovative practices followed in communication engineering.
- Adopt the global approaches to transform the young aspirant into engineering professional catering the society with ethical and patriotic zeal.
- Facilitate and felicitate the learners to have close interactions with the industry experts and researchers for keeping them updated of the current and future needs of the society.
- To develop the mindset of learners for being innovative and entrepreneurial in becoming successful professional.

Program Specific Outcomes

(PSO's)

- To analyze, design and develop solutions of real time problems and industry needs.
- Ability of effectively communicating with the professionals and preparation of reports, documents and presentation while working in teams.
- Knowledge and understanding of latest developments in the field of VLSI, Embedded system, Networking, Matlab and other major tools necessary for keeping pace with the industry.
- Ability of solving complex engineering problems with ethical and law full approach to prevent the society and environment from adverse impacts.

Program Educational Objectives (PEO's)

Student will

- The graduate will have the knowledge and skills of analog and digital communication in providing necessary solutions to the real world problems.
- The graduate will be able to design, develop, analyze and implement the modern tools and systems involving principles of electronics and telecommunication engineering.
- The graduate will be following the ethical practices of the core industry and supporting software industry in providing most acceptable solution to the society.
- The graduate will have the innovative mindset of learning and implementing the latest technological advancements and research outcomes in the electronic hardware and software to keep pace with the rapid developments in socio economic world.

Course: Analog Circuits (EC-405)

Course Outcomes (CO's)

CO1 Analyze positive and negative feedback circuits.

CO2 Determine AC and DC parameters for various differential amplifiers.

CO3 Analyze various circuits in inverting and non-inverting mode using Op-Amp.

CO4 Design astable and monostable multivibrator using 555 timer.

CO5 Implement various voltage regulator circuits using Op-Amp.

INDEX

Name of Student:______________________**Enrollment No.:** ___________________

S. No.	Title of the Experiment	Date of Experiment	Date of Submission	Remark
1	Implement Single stage R-C coupled CE Amplifier and Plot its Frequency Response			
2	Determine frequency of oscillation of RC phase shift Oscillator.			
3	Determine frequency of oscillation of Wien Bridge Oscillator.			
4	Implement Inverting and Non-Inverting amplifier using Op-Amp 741/LM324 IC and determine the gain.			
5	Implement Integrator and Differentiator using Op-Amp 741/LM324 IC and observe output waveform.			
6	Implement Comparator using Op-Amp 741/LM324 IC and observe output waveform.			

7	Implement Schmitt Trigger using Op-Amp 741/LM351 IC and observe output waveform.			
8	Implement Low Pass Filter (LPF) using Op-Amp 741/LM351 IC and plot frequency response curve.			
9	Implement High Pass Filter (HPF) using Op-Amp 741/LM351 IC and plot frequency response curve.			
10	Design Astable multivibrator using IC 555 timer and determine its frequency of operation.			

Code of Conducts for the Laboratory

- All bags must be left at the indicated place.
- The lab timetable must be strictly followed.
- Be **PUNCTUAL** for your laboratory session.
- Noise must be kept to a minimum.
- Workspace must be kept clean and tidy at all time.
- Handle the experiment kit and interfacing kits with care.
- All students are liable for any damage to the accessories due to their own negligence.
- Students are strictly **PROHIBITED** from taking out any items from the laboratory.
- Students are **NOT** allowed to work alone in the laboratory without the Lab Supervisor
- Report immediately to the Lab Supervisor if any malfunction of the accessories, is there.
- Before leaving the lab Place the stools properly.
- Please check the laboratory notice board regularly for updates.

Date of Experiment: ____________

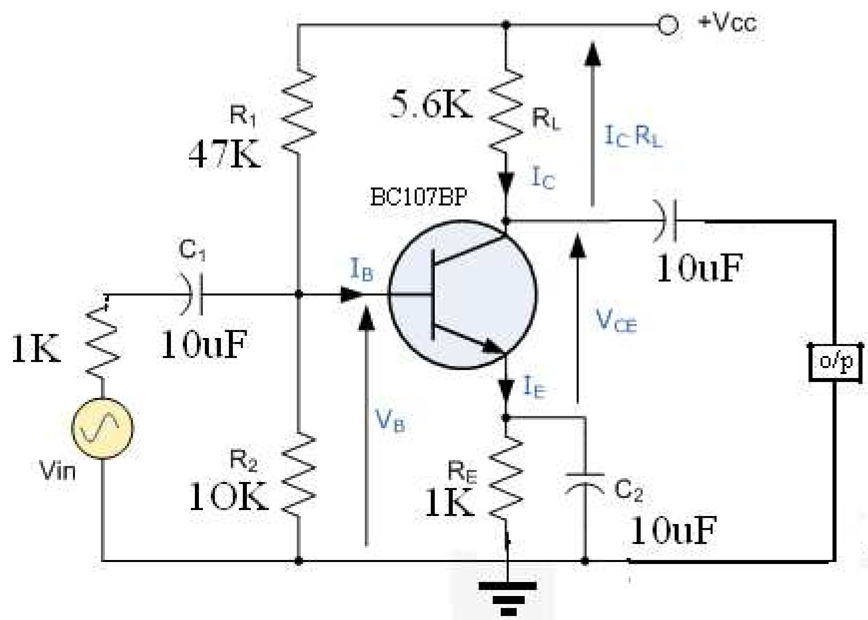
EXPERIMENT NO: 1

Aim: Implement Single stage R-C coupled CE Amplifier and Plot its Frequency Response.

Apparatus/Components Required:

1. Transistor BC107
2. Resistors
3. Capacitors
4. CRO
5. Signal generator

Circuit Diagram:



Theory:

The CE amplifier is a small signal amplifier. This small signal amplifier accepts low voltage ac inputs and produces amplified outputs. A single stage BJT circuit may be employed as a small signal amplifier; has two cascaded stages give much more amplification.

Designing for a particular voltage gain requires the use of a negative feedback to stabilize the gain. For good bias stability, the emitter resistor voltage drop should be much larger than the base-emitter voltage. And R_E resistor will provide the required negative feedback to the circuit. CE amplifier provides necessary gain to the circuit. All bypass capacitors should be selected to have the smallest possible capacitance value, both to minimize the physical size of the circuit for economy. The coupling capacitors should have a negligible effect on the frequency response of the circuit.

Procedure:

1. Connect the circuit as per the circuit diagram.
2. Give l00Hz signal and 20mV_{p-p} as V_{in} from the signal generator.
3. Observe the output on CRO and note down the output voltage.
4. Keeping input voltage constant and by varying the frequency in steps 100Hz-1MHz, note down the corresponding output voltages.
5. Calculate gain in dB and plot the frequency response on semi log sheet.

Observation Table:

Input voltage (V_{in}) = ... Volts

Sr. No	Frequency (Hz)	Output Voltage V_o (Volts)	Gain $A_v = \frac{V_o}{V_{in}}$	Gain dB=20log(Av)
1	100			
2	300			
3	500			
4	1K			
5	3K			
6	5K			
7	10K			
8	30K			
9	50K			
10	100K			
11	300K			

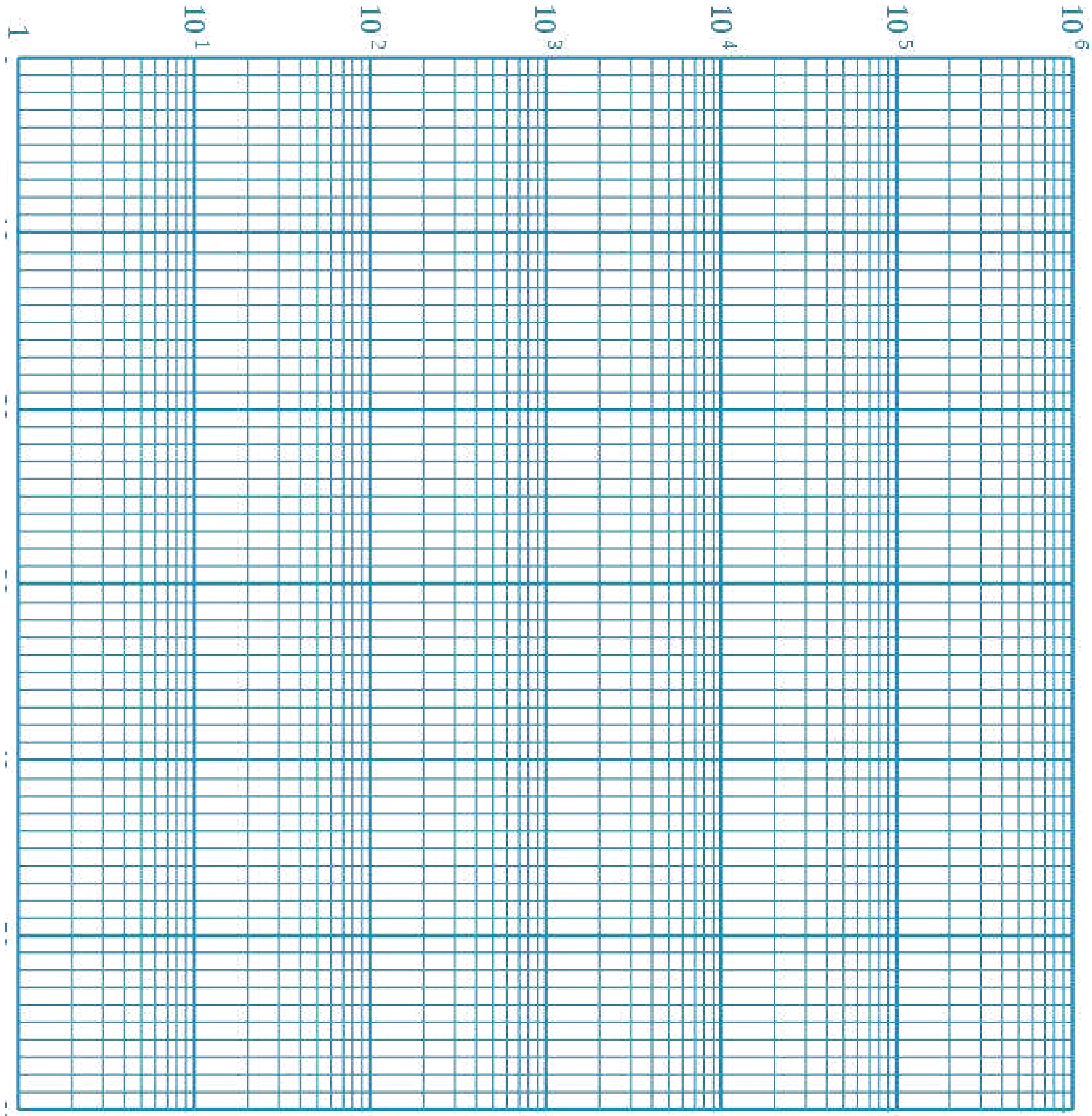
12	500K			
13	1M			

Precautions:

01. Wires should be checked for good continuity.
02. Transistor terminals must be identified and connected carefully.

Result:

- Lower cut-off frequency (f_L):______________Hz
- Higher cut-off frequency (f_H):______________Hz
- Bandwidth of amplifier (BW):______________Hz



Signature of Faculty

Date of Experiment: ____________

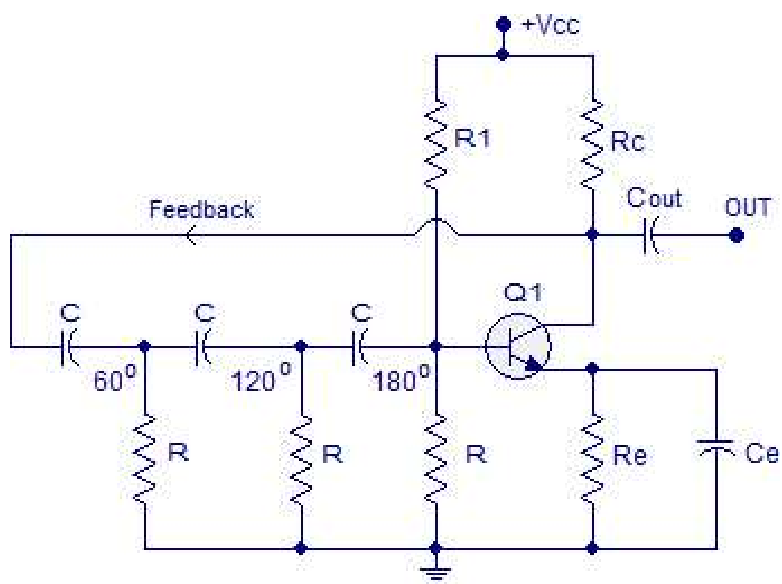
EXPERIMENT NO: 2

Aim: Determine frequency of oscillation of RC phase shift Oscillator.

Apparatus/Components Required:

1. Transistor BC107
2. Resistors
3. Capacitors
4. CRO
5. Signal generator

Circuit Diagram:



Theory:

The oscillator is an amplifier with positive feedback that generates a number of waveforms usually used in instrumentation and test equipments. An oscillator that generates a sinusoidal output is called a harmonic oscillator; the transistor is usually acts in the active region. The output of the relaxation oscillator is not sinusoidal depending on the transient rise and decay of voltage in RC or RL circuits. There are two types of RC oscillators:

1. RC Phase shift Oscillator
2. Wien Bridge Oscillator

1. Phase shift oscillators in which the output of an amplifier must be 180º out of phase with input. A general circuit diagram of a phase shift oscillator is shown in figure, where the amplifier is an ideal one. A phase shift network (usually a resistor-capacitor network) is used to produce an additional phase shift of 180º at one particular frequency to develop the required positive feedback. From the mesh network equations of the feedback network, we find the feedback factor β as, $\beta = -\frac{V_f}{V_o} = -\frac{1}{(1-5\alpha^2-j(6\alpha-\alpha^3))}$

Where α = 1/ωRC

The phase shift of the feedback network must be 180 then:

$$6\alpha - \alpha^3 = 0$$

$$\alpha = \sqrt{6}$$

So, $\boldsymbol{f = \frac{1}{2\pi RC\sqrt{6}}}$

At this frequency β= 1/29 and it is required that (A) must be at least 29 to satisfy oscillation condition. The phase shift oscillator is used to the range of frequencies for several hertz to several kilohertz and so includes the range of audio frequencies. The frequency depends on the impedance elements in the phase shift network. The phase shift oscillator circuit is not very suitable for generating variable frequency because the resistors and capacitors must be simultaneously changed to obtain the required frequency control over a wide range therefore it is used mostly in fixed frequency applications.

Procedure:

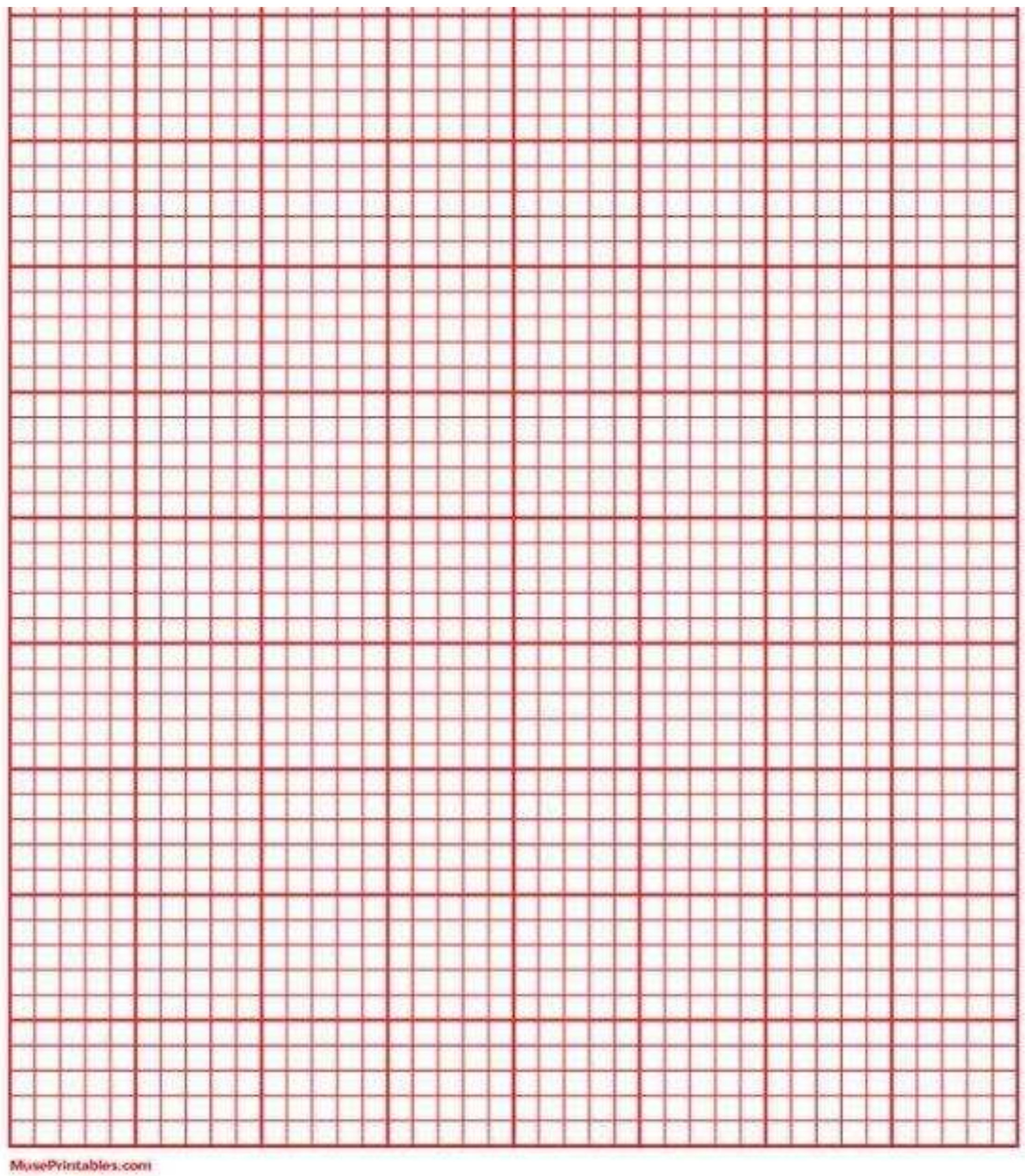
1. Connect the circuit as shown in figure.
2. Measure the frequency of oscillation (f) and the amplitude of the output voltage.
3. Measure and draw the waveform on graph paper.

Result:

R1 = R2 = R3 = R =..............Ω

C1 = C2 = C3 = C =................F

The frequency of oscillation of RC Phase shift Oscillator is ………………. Hz.



Signature of Faculty

Date of Experiment: ____________

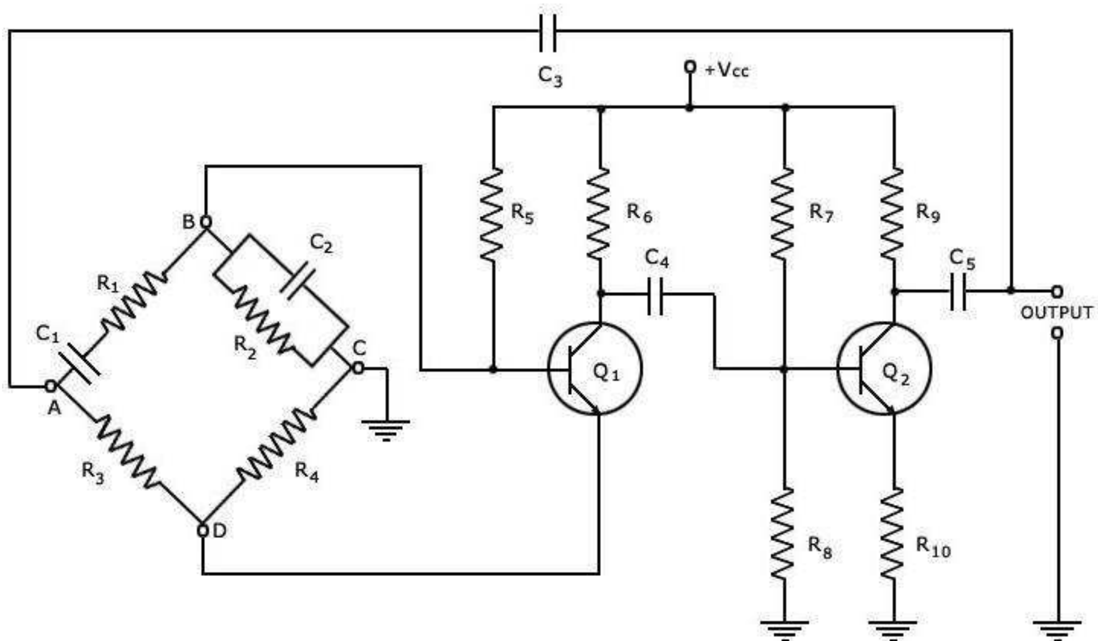
EXPERIMENT NO: 3

Aim: Determine frequency of oscillation of Wien Bridge Oscillator.

Apparatus/Components Required:

1. Transistor BC107
2. Resistors
3. Capacitors
4. CRO
5. Signal generator

Circuit Diagram:



Theory:

The oscillator is an amplifier with positive feedback that generates a number of waveforms usually used in instrumentation and test equipments. An oscillator that generates a sinusoidal output is called a harmonic oscillator; the transistor is usually acts in the active region. The output of the relaxation oscillator is not sinusoidal depending on the transient rise and decay of voltage in RC or RL circuits. There are two types of RC oscillators:

1. RC Phase shift Oscillator
2. Wien Bridge Oscillator

2. The Wien bridge oscillator is used to obtain variable frequency signal. The frequency of oscillation can be changed by using two gang variable capacitors or two gang variable resistors. The circuit diagram is shown in figure. In this circuit, there are two types of feedback:-

a. positive feedback through Z1 and Z2 whose components determine the frequency of oscillation.

b. negative feedback through Rl and R2 whose elements affect the amplitude of oscillation.

Feedback factor is $\beta = \frac{-V_f}{V_o} = \frac{-Z_2}{Z_1+Z_2}$

The gain of amplifier is $A = 1 + \frac{R_3}{R_4}$

The loop gain Aβ is given by

$$A\beta = \frac{-\alpha}{3\alpha - j(1-\alpha^2)}\left(1 + \frac{R_3}{R_4}\right)$$ Where $\alpha = \omega RC$

To satisfy the condition of oscillation $A\beta = 1$ and $\alpha = 1$.

Then $1 + \frac{R_3}{R_4} = 3$

And $\boldsymbol{f = \frac{1}{2\pi RC}}$

Continuous variation of frequency is accomplished by varying simultaneously two capacitors. Change in frequency range accomplished by switching in different values for the two identical resistors R.

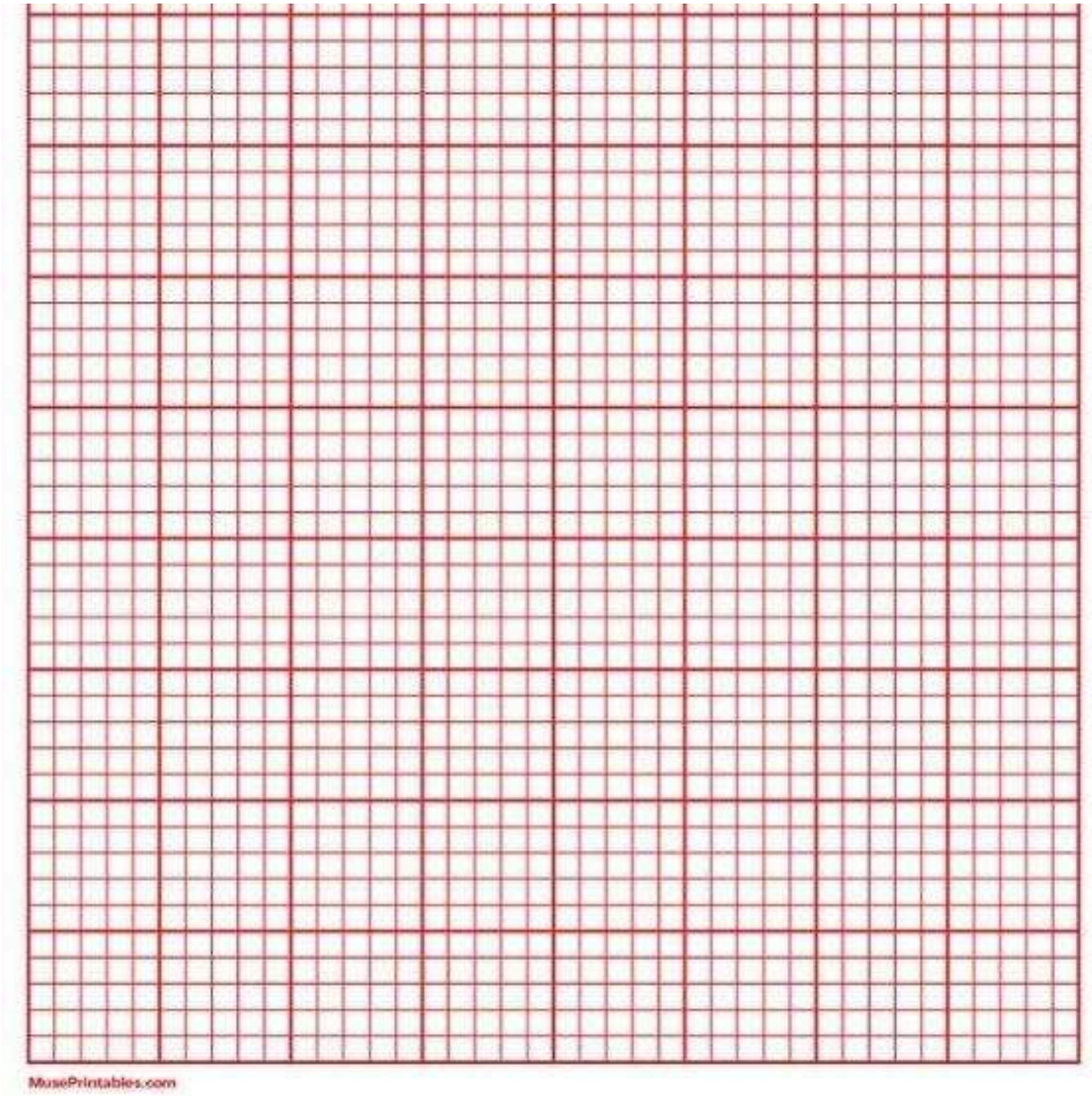
Procedure:

1. Connect the circuit as shown in figure.

2. Measure the frequency of oscillation (f) and the amplitude of the output voltage.
3. Measure and draw the waveform on graph paper.

Result:

- R1 = R2 = R = ... Ω
- C1 = C2 = C = ... F
- The frequency of oscillation of Wien bridge Oscillator is ………………. Hz.



Signature of Faculty

Date of Experiment: ____________

EXPERIMENT NO: 4

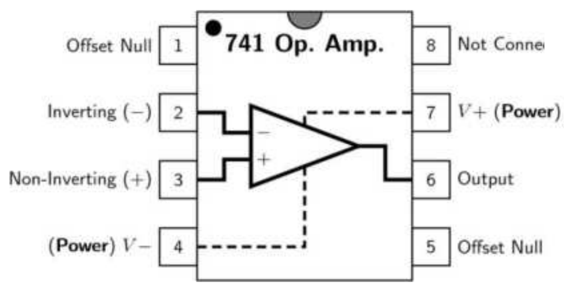
Aim: Implement Inverting and Non-Inverting amplifier using Op-Amp 741/LM324 IC and determine the gain.

Apparatus/Components Required:

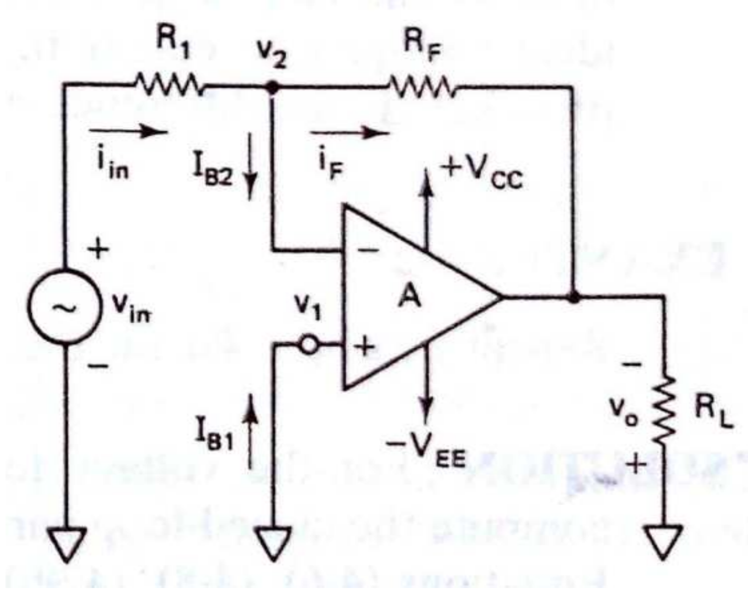
1. IC 741/324 - 1
2. Resistors 1K - 2
3. Bread-board - 1
4. Function generator, CRO, Connecting wires etc.

Circuit Diagram:

PIN Diagram of IC 741/324



Theory: (1) Inverting Amplifier:



Closed Loop Voltage Gain (A_F)

Applying KCL on input node v_2

$$i_{in} = i_F + I_B$$

Since R_i is very large, the input bias current I_B is negligibly small

Therefore $i_{in} \approx i_F$

$$\frac{v_{in} - v_2}{R_1} = \frac{v_2 - v_o}{R_F} \quad \text{\_\_\_\_(1)}$$

As we know that

$$v_o = Av_{id} = A(v_1 - v_2)$$

$$v_{in} - v_2 = \frac{v_o}{A}$$

since $v_1 = 0$

$$v_2 = -\frac{v_o}{A}$$

substituting the value of v_2 in equation (1)

$$\frac{v_{in} - \left(-\frac{v_o}{A}\right)}{R_1} = \frac{\left(-\frac{v_o}{A}\right) - v_o}{R_F}$$

$$\frac{Av_{in} + v_o}{AR_1} = \frac{-v_o - Av_o}{AR_F}$$

Or

$$Av_{in}R_F + v_oR_F = -v_oR_1 - Av_oR_1$$

$$Av_{in}R_F = -v_o(R_1 + AR_1 + R_F)$$

$$A_F = \frac{v_o}{v_{in}} = -\frac{AR_F}{R_1 + R_F + AR_1}$$ (exact) -------------- (2)

since gain of op-amp A is very large

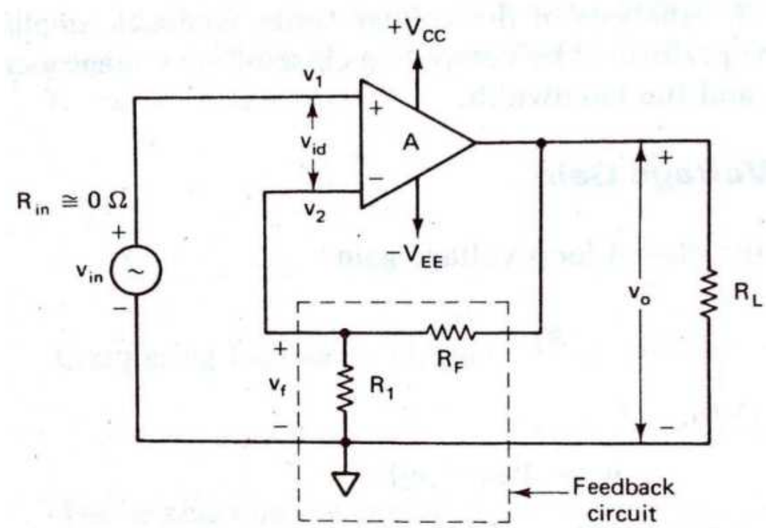
$AR_1 >> R_1 + R_F$

equation (2) can be written as

$$A_F = \frac{v_o}{v_{in}} = -\frac{R_F}{R_1}$$ (ideal) ---------------------------------- (3)

The negative sign indicates that input and output signals are out of phase by 180̊.

(2) Non-Inverting Amplifier:



Closed Loop Voltage Gain (A_F)

The output voltage of feedback amplifier is given by

$$vo = Av_{id} = A(v_1 - v_2)$$

from figure we can see that

$$v_1 = v_{in}$$

And

$$v_2 = v_f = \frac{v_o R_1}{R_1 + R_F}$$

Therefore

$$v_o = A\left(v_{in} - \frac{v_o R_1}{R_1 + R_F}\right)$$

$$v_o\left(1 + \frac{AR_1}{R_1 + R_F}\right) = Av_{in}$$

which gives

$$v_o = \frac{A(R_1 + R_F)v_{in}}{R_1 + R_F + AR_1}$$

Thus

$$A_F = \frac{v_o}{v_{in}} = \frac{A(R_1 + R_F)}{R_1 + R_F + AR_1}$$ (exact) ----------------- (4)

Generally ***A*** is very large ($2x10^5$)

Therefore

$$AR_1 \gg (R_1 + R_F)$$

And

$$(R_1 + R_F + AR_1) \cong AR_1$$

Thus

$$\boldsymbol{A_F = \frac{v_o}{v_{in}} = 1 + \frac{R_F}{R_1}}$$ (ideal) ----------------------- (5)

Observation Table:

(1) Inverting Amplifier

Sr. No	Input Voltage (V_{in})	Output Voltage (V_{out})	Gain (Practically) $A_F = \frac{V_{out}}{V_{in}}$	Gain (Theoretically) $A_F = -\frac{R_F}{R_1}$	% Error
1					

(2) Non-Inverting Amplifier

Sr. No	Input Voltage (V_{in})	Output Voltage (V_{out})	Gain (Practically) $A_F = \frac{V_{out}}{V_{in}}$	Gain (Theoretically) $A_F = 1 + \frac{R_F}{R_1}$	% Error
1					

Calculation:

R_1 =............ Ω

R_F = ... Ω

Theoretically gain in Inverting Mode

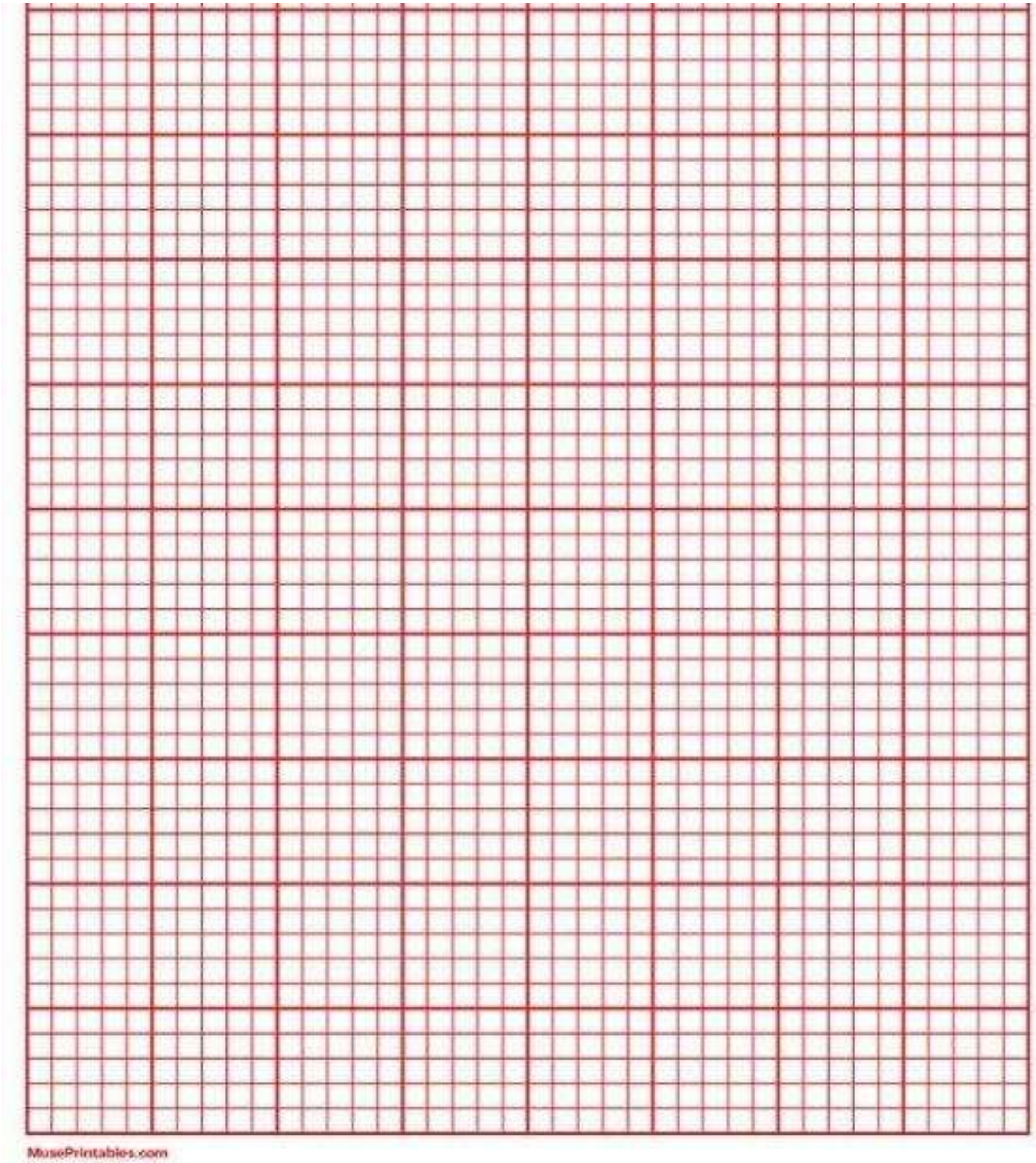
$$A_F = -\frac{R_F}{R_1} = \frac{\dots\dots\dots\dots}{\dots\dots\dots\dots} = \_\_\_\_\_\_$$

Theoretically gain in Non-Inverting Mode

$$A_F = 1 + \frac{R_F}{R_1} = \frac{\dots\dots\dots\dots}{\dots\dots\dots\dots} = \_\_\_\_\_\_\_$$

Result:

Gain of inverting and non-inverting amplifiers are verified and Input and output waveforms are plotted in graph paper.



Signature of Faculty

Date of Experiment: ____________

EXPERIMENT NO: 5

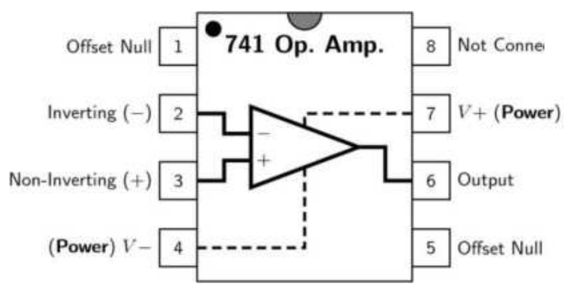
Aim: Implement Integrator and Differentiator using Op-Amp 741/LM324 IC and observe output waveform.

Apparatus/Components Required:

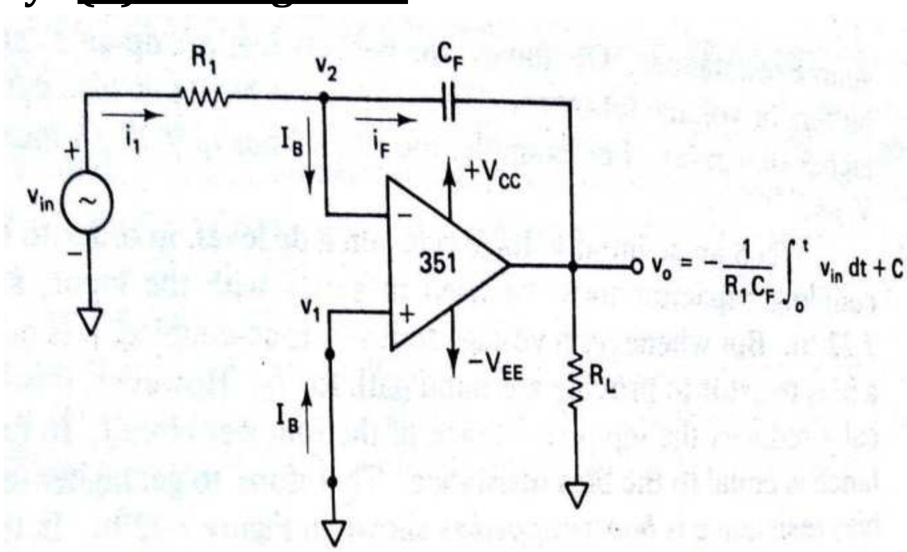
1. IC 741/324 - 1
2. Resistors 100Ω - 1
3. Capacitor 0.47µF - 1
4. Bread-board - 1
5. Function generator, CRO, Connecting wires etc.

Circuit Diagram:

PIN Diagram of IC 741/324



Theory: <u>(1) Integrator:</u>



Integrator is a circuit which performs the mathematical operation of integration. In integrator output waveform is the integration of input waveform. Integrator is obtained by replacing feedback resistor R_F of inverting amplifier by a capacitor C_F.

Applying KCL at input node we have $I_{in} = I_B + I_F$

Since I_B is negligible small $I_{in} \approx I_F$

$$\frac{v_{in} - v_2}{R_1} = C_F \frac{d}{dt}(v_2 - v_0)$$

according to virtual ground concept $\boldsymbol{v_1 = v_2 = 0V}$

$$\frac{v_{in}}{R_1} = C_F \frac{d}{dt}(-v_0)$$

integrating both side

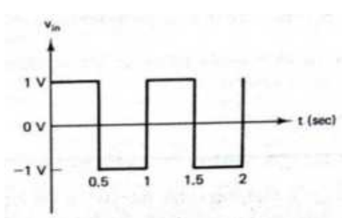
$$\int_0^t \frac{v_{in}}{R_1} dt = \int_0^t C_F \frac{d}{dt}(-v_0)\, dt$$

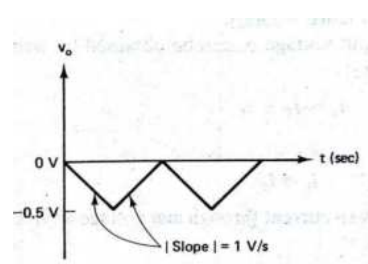
$$= C_F(-v_0) + const.$$

Therefore

$$\boxed{v_0 = -\frac{1}{R_1 C_F}\int_0^t v_{in} dt + const.}$$

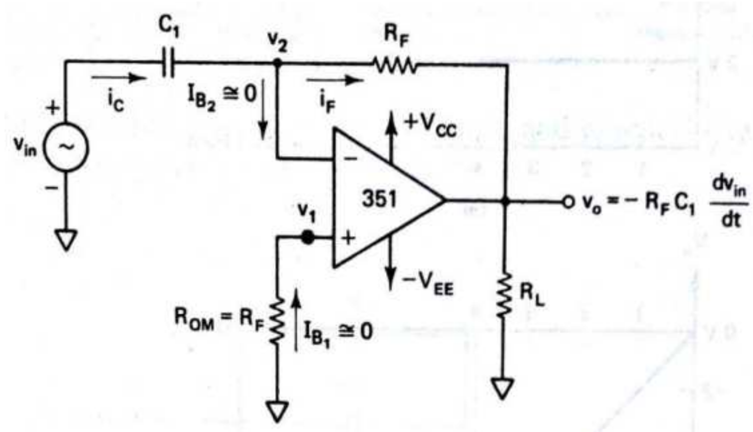
The input and output waveforms of integrator are shown in figure below.





Input Waveform Output Waveform

(2) Differentiator:



Differentiator is a circuit which performs the mathematical operation of differentiation. In differentiator output waveform is the derivative of input waveform.

Differentiator is obtained by replacing input resistor R_1 of inverting amplifier by a capacitor C_1.

Applying KCL at input node we have $I_{in} = I_B + I_F$

Since I_B is negligible small $I_{in} \approx I_F$

$$C_1 \frac{d}{dt}(v_{in} - v_2) = \frac{v_2 - v_o}{R_F}$$

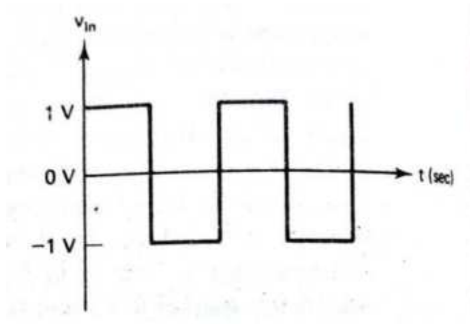
according to virtual ground concept $v_1 = v_2 = 0V$

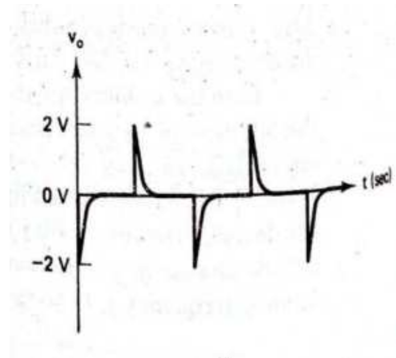
$$C_1 \frac{d}{dt} v_{in} = -\frac{v_o}{R_F}$$

$$v_o = -R_F C_1 \frac{d}{dt} v_{in}$$

Thus the output voltage is equal to the ($-R_F C_1$) times the rate of change of input voltage.

The input and output waveforms of differentiator are shown below:





Input Waveform   Output Waveform

Result:

Input and output waveforms of integrator and differentiator are observed and plotted on graph paper.

Signature of Faculty

Date of Experiment: ____________

EXPERIMENT NO: 6

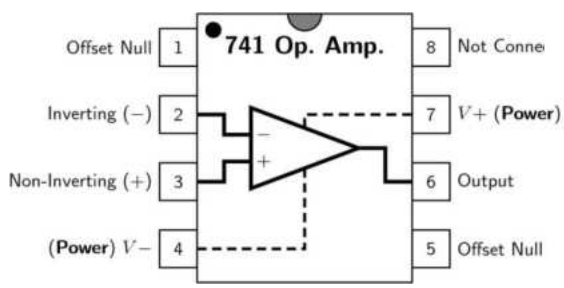
Aim: Implement Comparator using Op-Amp 741/LM324 IC and observe output waveform.

Apparatus/Components Required:

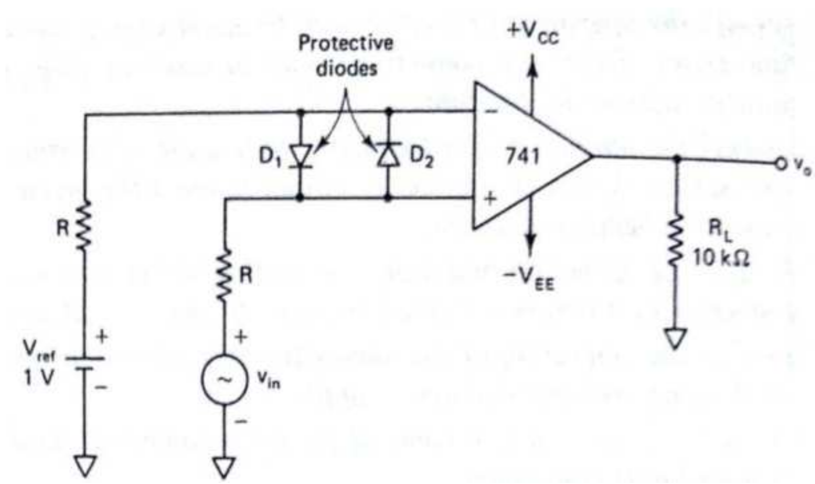
1. IC 741/324 - 1
2. Resistors 100Ω - 2
3. DC Source - 1
4. Bread-board - 1
5. Function generator, CRO, Connecting wires etc.

Circuit Diagram:

PIN Diagram of IC 741/324



Theory:



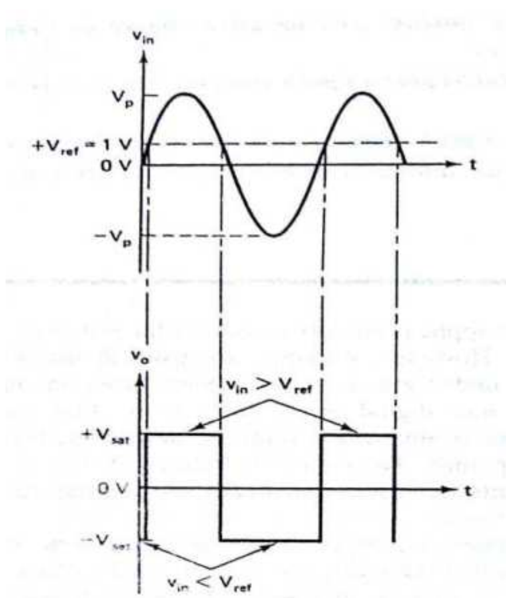
As shown in figure a fixed reference voltage V_{ref} of 1V is applied to the inverting input terminal, and time varying signal V_{in} is applied to the non-inverting input terminal. Because of this arrangement, the circuit is called the ***Non-Inverting Comparator***.

When V_{in} is less than V_{ref}, the output voltage v_o is at $(-V_{sat})$ because the voltage at the inverting input is higher than that of non-inverting input voltage. On the other hand, when V_{in} is greater than V_{ref}, Non-inverting input voltage becomes positive with respect to inverting input, and V_o goes to $(+V_{sat})$. Thus V_o changes from one saturation level to another.

In short, comparator is a type of analog-to-digital convertor. It is also called voltage-level-detector because for a desired value of V_{ref}, the voltage level of input can be detected.

As shown in figure diodes D_1 and D_2 protect the op-amp from damage due to excessive input voltage V_{in}. Because of these diodes, the difference input voltage V_{id} of the op-amp is clamped to either ***0.7V*** or ***-0.7V***. Hence these diodes are called ***clamp diodes***.

Result:



Input

Output

Input and output waveforms are shown in the graph paper.

Signature of Faculty

Date of Experiment: ____________

EXPERIMENT NO: 7

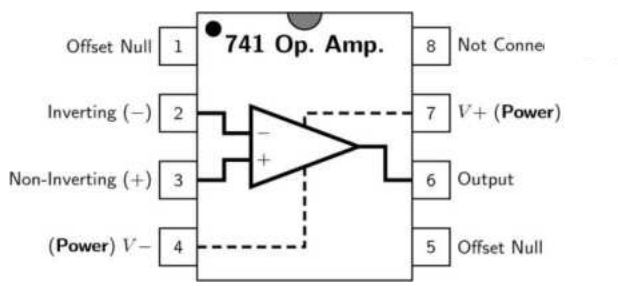
Aim: Implement Schmitt Trigger using Op-Amp 741/LM351 IC and observe output waveform.

Apparatus/Components Required:

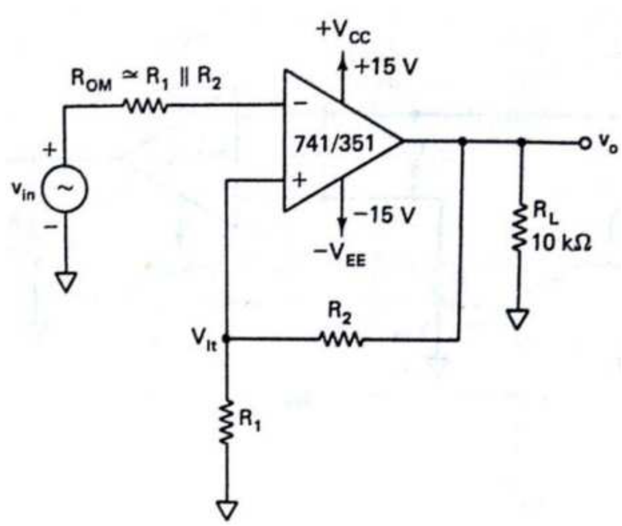
1. IC 741/351 - 1
2. Resistors 100Ω - 2
3. Resistors 56kΩ - 1
4. Bread-board - 1
5. Function generator, CRO, Connecting wires etc.

Circuit Diagram:

PIN Diagram of IC 741/351



Theory:



Schmitt trigger is inverting comparator with positive feedback. It converts an irregular shaped waveform to a square wave.

In Schmitt trigger input voltage V_{in} changes the states of output V_o every time it exceeds certain voltage levels called the upper threshold voltage V_{ut} and lower threshold level V_{lt}. These threshold voltage can be measured by voltage divider circuit. When $V_o = +V_{sat}$, the voltage across R_1 is called the upper threshold voltage V_{ut}.

It is given by $V_{ut} = \frac{R_1}{R_1+R_2}(+V_{sat})$

On the other hand, when $V_o = -V_{sat}$, the voltage across R_1 is referred to as lower threshold voltage V_{lt}.

It is given by $V_{lt} = \frac{R_1}{R_1+R_2}(-V_{sat})$

The Schmitt trigger exhibit hysteresis condition. That is when the input of comparator exceeds Vut, its output changes from $+V_{sat}$ to $-V_{sat}$ and revert back to its original state $+V_{sat}$, when the input goes below V_{lt}.

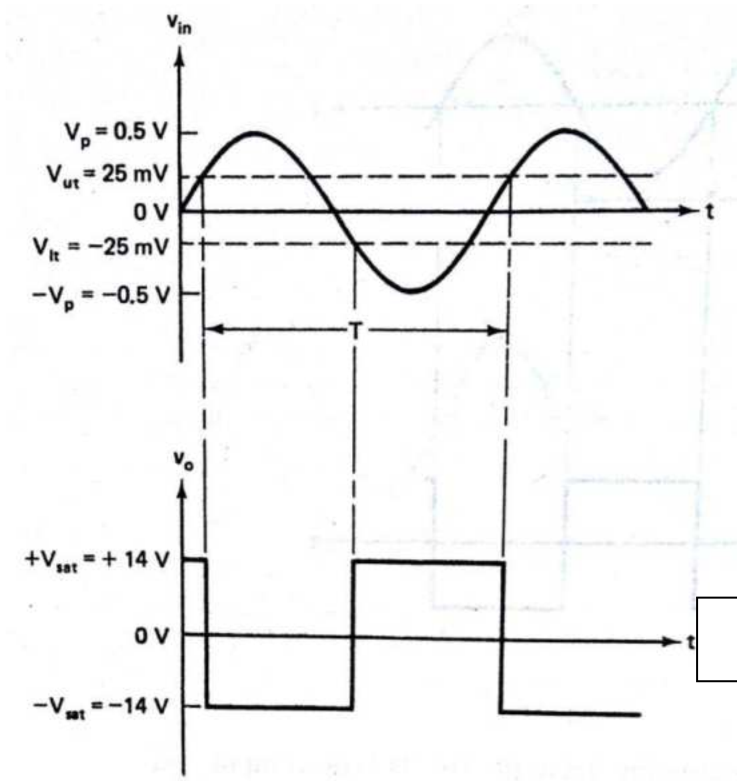
The hysteresis voltage is given by

$$V_{hy} = V_{ut} - V_{lt}$$

$$V_{hy} = \frac{R_1}{R_1+R_2}[+V_{sat} - (-V_{sat})]$$

Result:

Input and output waveforms are shown in the graph paper.



Input

Output

Signature of Faculty

Date of Experiment: ____________

EXPERIMENT NO: 8

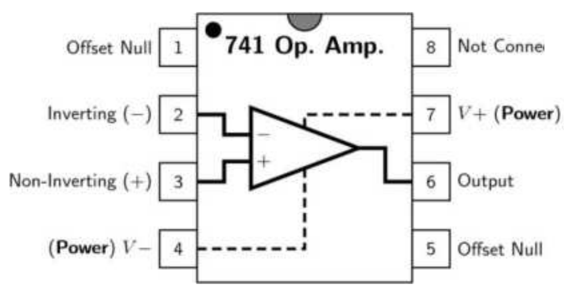
Aim: Implement Low Pass Filter (LPF) using Op-Amp 741/LM351 IC and plot frequency response curve.

Apparatus/Components Required:

1. IC 741/351 - 1
2. Resistors 10kΩ - 3
3. Capacitor 0.01µF - 1
4. Bread-board - 1
5. Function generator, CRO, Connecting wires etc.

Circuit Diagram:

PIN Diagram of IC 741/351



Theory

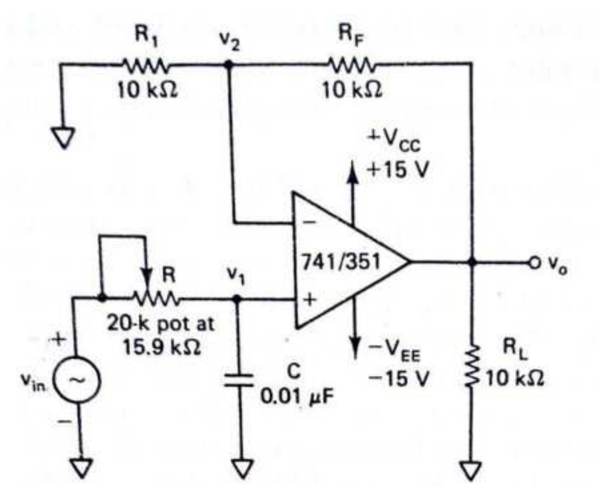


Figure shows a first order low pass Butter-worth filter that uses an RC network for filtering, op-amp is used in non-inverting configuration, R_1 and R_F decides the gain of the filter.

The Op-amp is used in non-inverting configuration. The output of filter is given by

$$V_o = \left(1 + \frac{R_F}{R_1}\right) V_1 \qquad Where \qquad V_1 = \frac{X_C}{R + X_C} V_{in}$$

$$Since \qquad X_C = \frac{1}{j2\pi fc}$$

$$V_1 = \frac{\frac{1}{j2\pi fc}}{R + \frac{1}{j2\pi fc}} V_{in}$$

The output voltage is given by

$$V_o = \left(\frac{V_{in}}{1 + j2\pi fRc}\right)\left(1 + \frac{R_F}{R_1}\right)$$

The gain of filter is

$$\frac{V_o}{V_{in}} = \left(\frac{A_F}{1 + j2\pi fRc}\right)$$

where $A_F = 1 + \frac{R_F}{R_1}$ (the gain of op-amp)

Let $f_H = \frac{1}{2\pi RC}$ (Higher cutoff frequency)

$$\frac{V_o}{V_{in}} = \frac{A_F}{1 + j\left(\frac{f}{f_H}\right)}$$

The gain and phase magnitude is given by

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

$$\phi = -\tan^{-1}\left(\frac{f}{f_H}\right)$$

The frequency response can be plot as

At frequency less than cutoff frequency f_H ($f < f_H$)

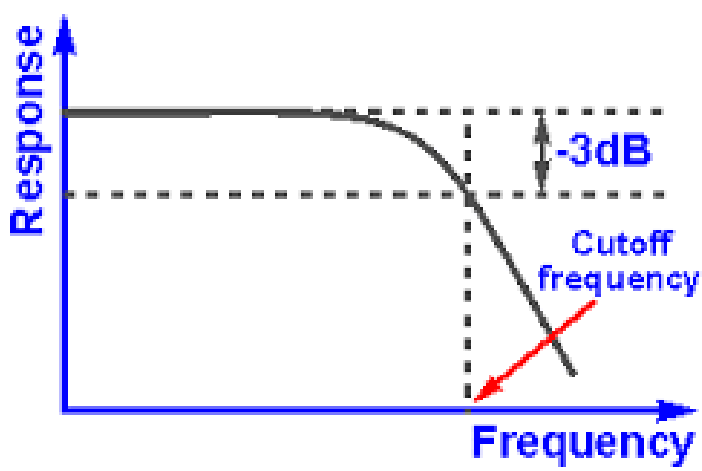
$$\left|\frac{V_o}{V_{in}}\right| \approx A_F$$

At ($f = f_H$) cutoff frequency

$$\left|\frac{V_o}{V_{in}}\right| = \frac{A_F}{\sqrt{2}} = 0.707A_F$$

At frequency higher than cutoff frequency ($f > f_H$)

$$\left|\frac{V_o}{V_{in}}\right| < A_F$$



Observation Table:

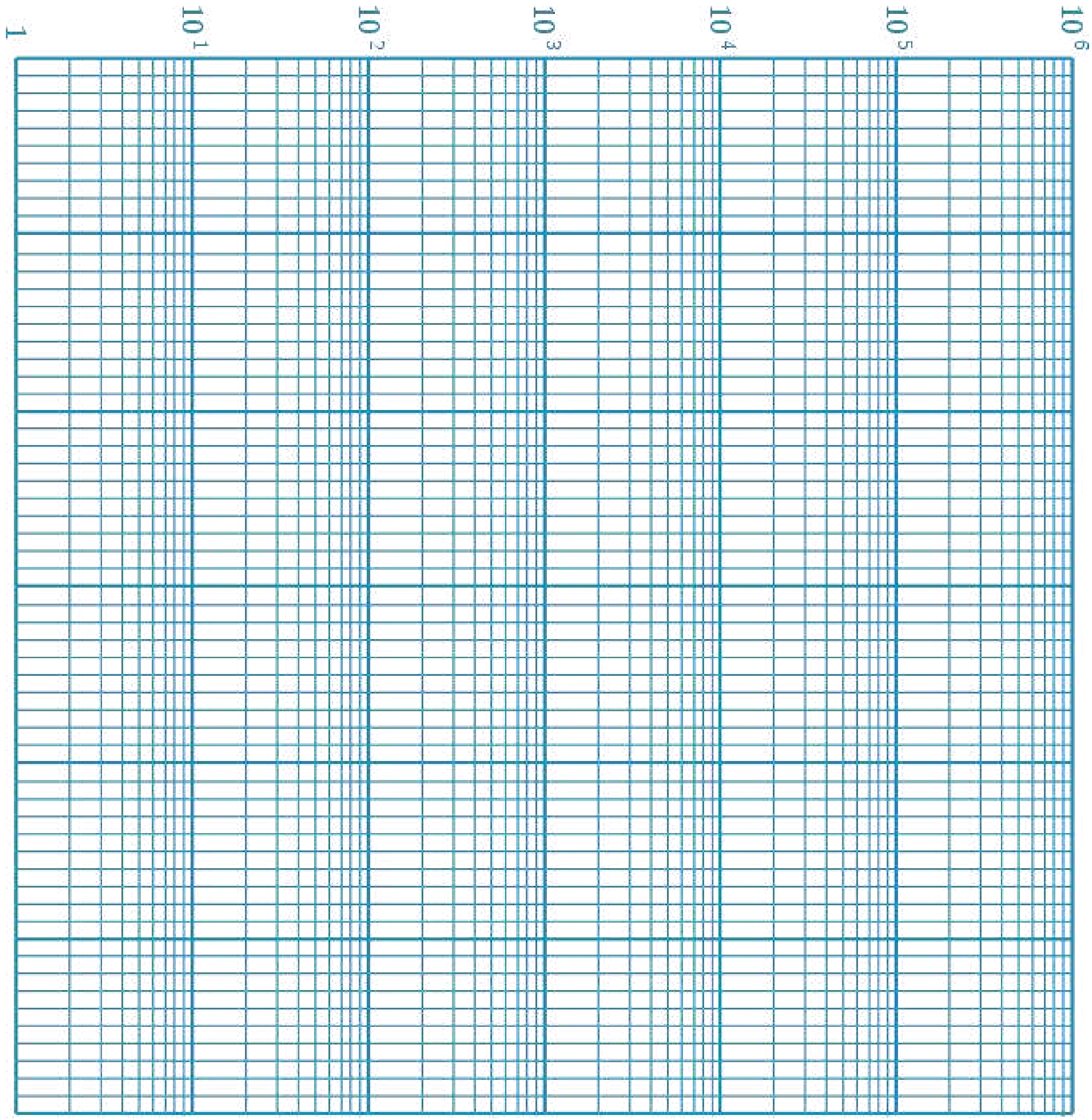
Input Voltage V_{in} =-------- volts

Sr. No.	Frequency (f) (in Hertz)	Output Voltage (V_o) (in Volts)	Gain Magnitude $A = \frac{V_o}{V_{in}}$	Gain in Decibel (dB) $A_{dB} = 20log\frac{V_o}{V_{in}}$
1	100Hz			
2	200Hz			
3	500Hz			
4	1k			
5	2k			
6	5k			
7	10k			
8	20k			
9	50k			
10	100k			
11	200k			
12	500k			
13	1M			

Result:

Graph is plotted between frequency and Decibel gain on semilog graph paper.

Higher cut-off frequency of Low Pass Filter (LPF) is f_H =..............Hz.



Signature of Faculty

Date of Experiment: ____________

EXPERIMENT NO: 9

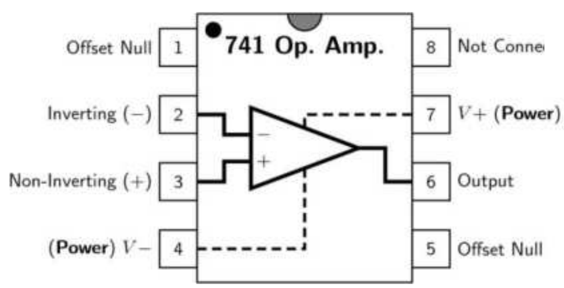
Aim: Implement High Pass Filter (HPF) using Op-Amp 741/LM351 IC and plot frequency response curve.

Apparatus/Components Required:

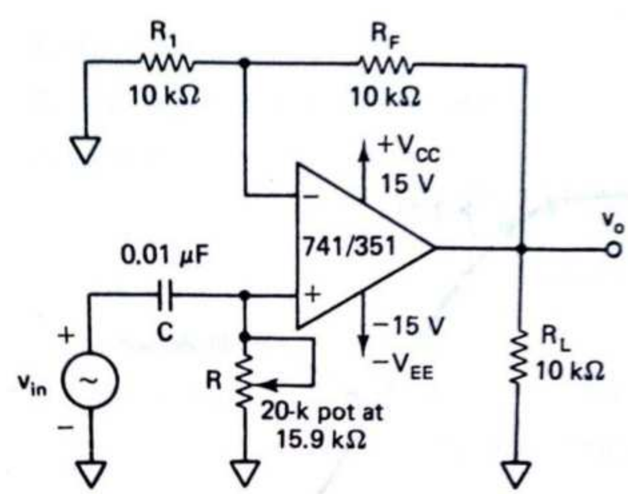
1. IC 741/351 - 1
2. Resistors 10kΩ - 3
3. Capacitor 0.01µF - 1
4. Bread-board - 1
5. Function generator, CRO, Connecting wires etc.

Circuit Diagram:

PIN Diagram of IC 741/351



Theory



Circuit diagram of High Pass Filter is shown in figure.

Cut off frequency of HPF is known as Lower cut-off frequency (f_L).

At this frequency magnitude of gain is 0.707of its pass band gain.

All frequency higher than cut-off frequency pass band frequencies.

The output of filter is given by:

$$V_o = \left(1 + \frac{R_F}{R_1}\right) V_1$$

Where V_1 is given by

$$V_1 = \frac{V_{in} R}{R + \frac{1}{j2\pi f C}} = \frac{j2\pi f RC}{1 + j2\pi f RC} V_{in}$$

The output voltage is given by

$$V_o = \frac{A_F (j2\pi f RC)}{1 + j2\pi f RC} V_{in}$$

The gain of filter is given by

$$\frac{V_o}{V_{in}} = \frac{A_F (j2\pi f RC)}{1 + j2\pi f RC}$$

where $A_F = 1 + \frac{R_F}{R_1}$ (the gain of op-amp)

Let $f_L = \frac{1}{2\pi RC}$ (Lower cutoff frequency)

$$\frac{V_o}{V_{in}} = \frac{A_F j\left(\frac{f}{f_L}\right)}{1 + j\left(\frac{f}{f_L}\right)}$$

Hence magnitude of voltage gain is

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

The frequency response can be plot as

At frequency less than cutoff frequency f_L ($f < f_L$)

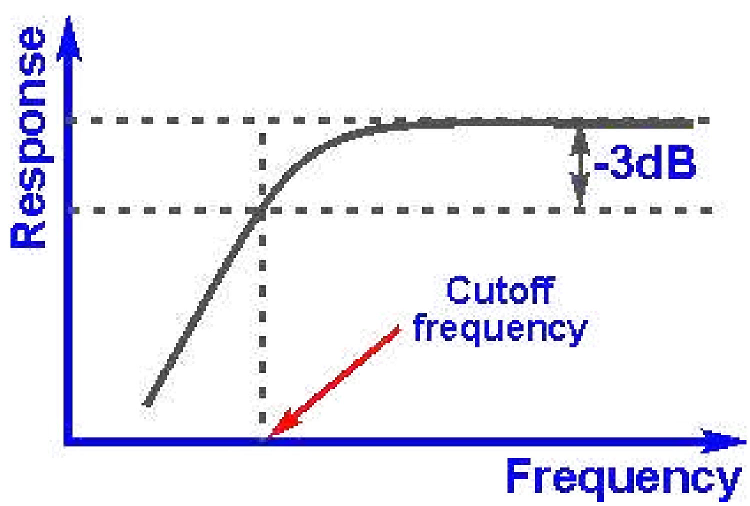
$$\left|\frac{V_o}{V_{in}}\right| < A_F$$

At ($f = f_L$) cutoff frequency

$$\left|\frac{V_o}{V_{in}}\right| = \frac{A_F}{\sqrt{2}} = 0.707A_F$$

At frequency higher than cutoff frequency ($f > f_L$)

$$\left|\frac{V_o}{V_{in}}\right| \approx A_F$$



Observation Table:

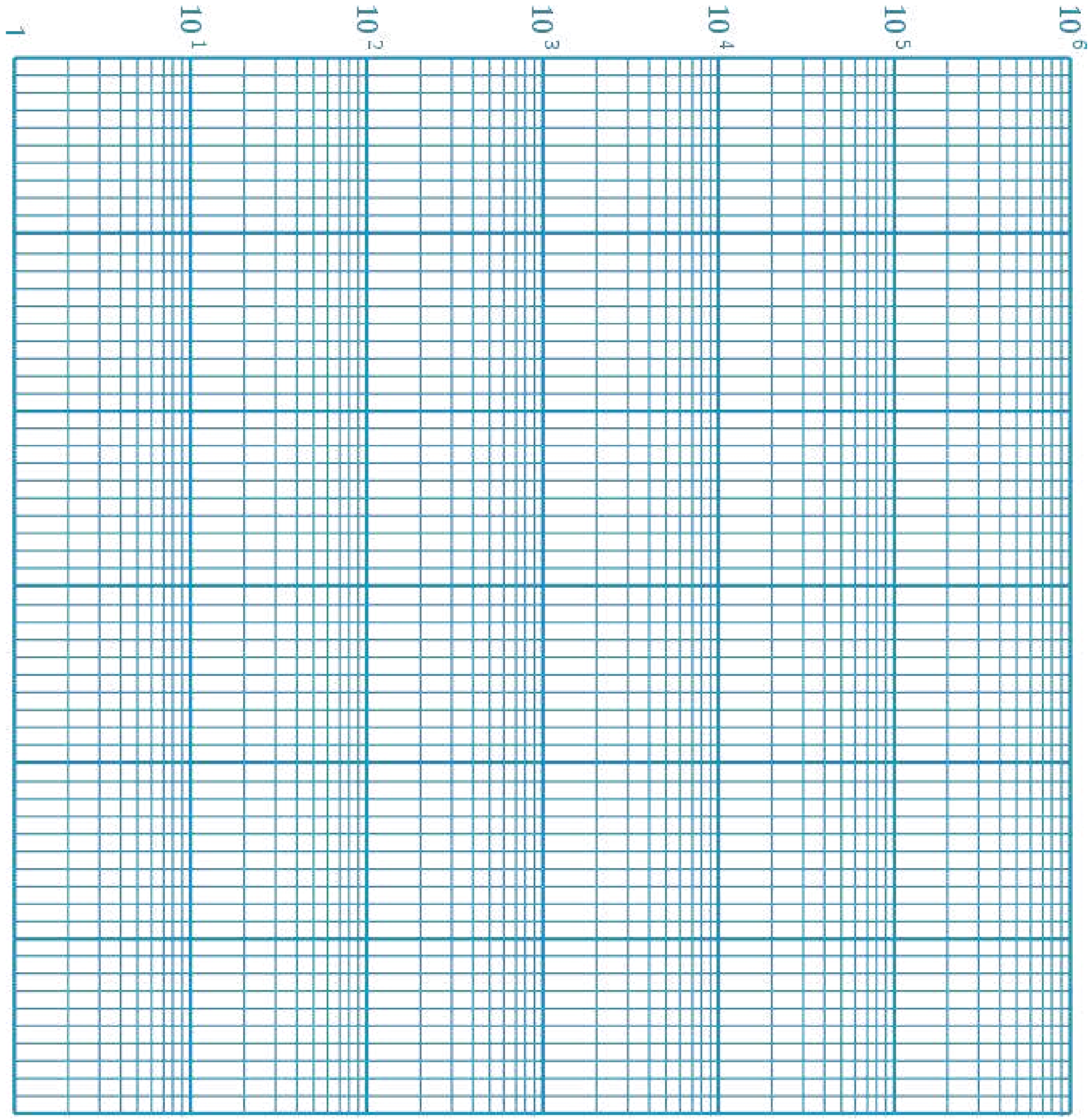
Input Voltage Vin = --------volts

Sr. No.	Frequency (f) (in Hertz)	Output Voltage (V_o) (in Volts)	Gain Magnitude $A = \frac{V_o}{V_{in}}$	Gain in Decibel (dB) $A_{dB} = 20log\frac{V_o}{V_{in}}$
1	100Hz			
2	200Hz			
3	500Hz			
4	1k			
5	2k			
6	5k			
7	10k			
8	20k			
9	50k			
10	100k			
11	1M			

Result:

Graph is plotted between frequency and Decibel gain on semilog graph paper.

Lower cut-off frequency of High Pass Filter (HPF) is f_L = ...Hz.



Signature of Faculty

Date of Experiment: ____________

EXPERIMENT NO: 10

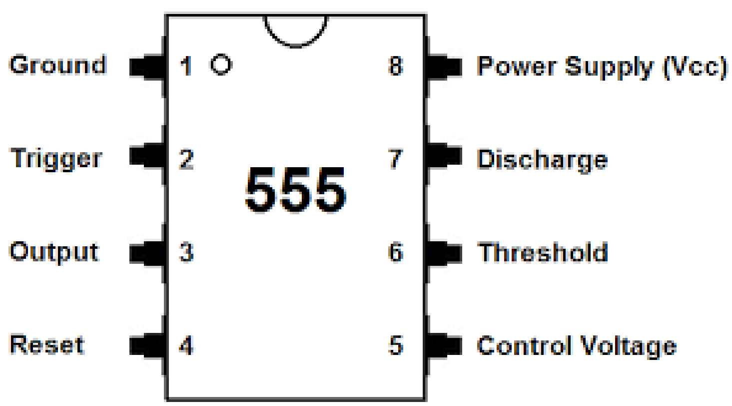
Aim: Design Astable multivibrator using IC 555 timer and determine its frequency of operation.

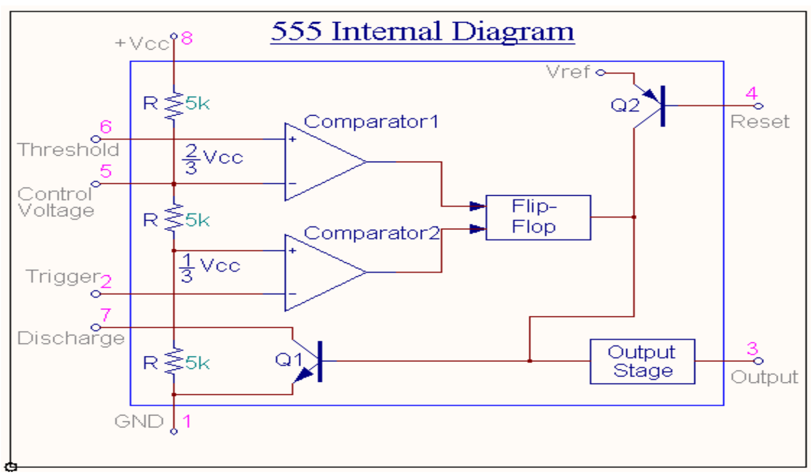
Apparatus/Components Required:

1. IC 555 Timer - 1
2. Resistors 10kΩ - 3
3. Capacitor 0.01μF - 1
4. Bread-board - 1
5. Function generator, CRO, Connecting wires etc.

Circuit Diagram:

PIN Diagram and Internal diagram of IC 555 Timer





Theory:

The 555 Timer is a monolithic timing circuit that can produce accurate and highly stable time delay or oscillation. The PIN diagram and internal diagrams are shown in figure.

Description of various PIN of 555 timer are as follows:

PIN 1 – Ground – All voltages are measured with respect to this terminal.

PIN 2 – Trigger – The output of timer depends on amplitude of the external trigger pulse applied to this PIN. If the voltage at this pin is higher than $+V_{cc}/3$, the output of comparator 2 goes low.

PIN 3 – Output – There are two ways to connect a load with output terminal.

(i) Between output (3) and ground terminal (1).

(ii) Between output (3) and $+V_{cc}$ (8)

When the output is low, load is connected between output and $+V_{cc}$ terminal. The current flows through the load is known as sink current. On the other hand when output is high, load is connected between output and ground terminal and current flows through is known as source current. The maximum value of source and sink current is 200mA.

PIN 4 – Reset – The 555 timer can be reset by applying a negative pulse to this pin. When the reset function is not used it should connected to $+V_{cc}$ to avoid any possibility of false triggering.

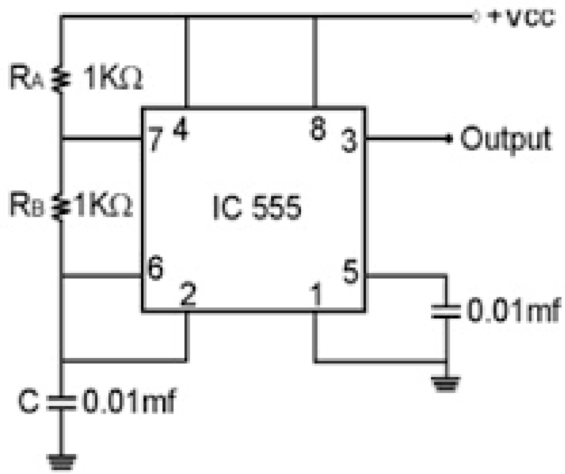
PIN 5 – Control Voltage – An external voltage applied to this terminal changes the threshold as well as trigger voltage. When the pin is not used it is bypassed to ground through a capacitor to prevent any noise problem.

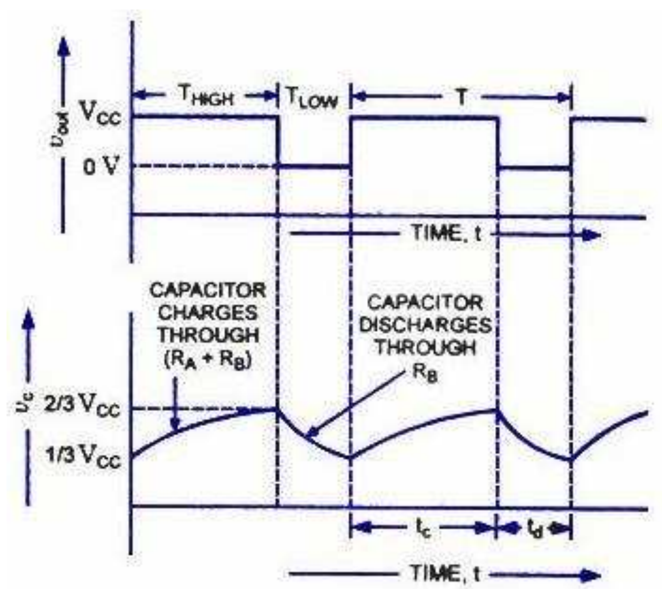
PIN 6 – Threshold – This is non-inverting input terminal of comparator 1 which monitor the voltage across the external capacitor. When the voltage at this pin is higher than control voltage $2V_{cc}/3$, the output of comparator 1 goes high.

PIN 7 – Discharge – This pin is connected internally to the collector of transistor Q_1. When flip-flop output is high transistor Q_1 saturate which short the external capacitor.

PIN 8 – (+V_{cc}) – The supply voltage +5V to +18V is applied to this pin with respect to ground pin.

555 Timer as Astable Multivibrator





As shown in circuit diagram the threshold input is connected to the trigger input. Two external resistors R_A and R_B and a capacitor C is used in the circuit.

This circuit has no stable state, the circuit changes its state automatically hence the operation is also called free running non-sinusoidal oscillator.

Operation:

When the supply is switched on, capacitor C start charging through the resistors R_A & R_B.

When the voltage across capacitor increases by $2V_{cc}/3$, comparator 1 gives high output which set the flip-flop. The flip-flop output Q becomes high and the output of multivibrator (3) goes low. The high Q drives transistor in saturation and capacitor start discharging through resistor R_B and discharge transistor.

When capacitor voltage becomes less than $V_{cc}/3$, comparator 2 output goes high which reset the flip-flop and output of multivibrator (3) goes high. This cycle repeats. Thus when capacitor is charging, output is high while when it is discharging the output is low. Finally we get rectangular wave at output.

The capacitor C charges through R_A & R_B, it's charging time (on time) can be determine by charging equation of capacitor

$$\frac{V_{cc}}{3} = \frac{2V_{cc}}{3}\left(1 - e^{-T_{ON}/RC}\right)$$

$$\frac{1}{2} = \left(1 - e^{-T_{ON}/RC}\right)$$

$$e^{\frac{-T_{ON}}{RC}} = \frac{1}{2}$$

$T_{ON} = -RC\ ln(0.5) = 0.693RC$

Since $R = R_A + R_B$

$T_{ON} = 0.693(R_A + R_B)C$

The capacitor discharge through resistor R_B, hence discharging or off time can be determining by:

$$\frac{V_{cc}}{3} = \frac{2V_{cc}}{3} e^{\frac{-T_{OFF}}{R_B C}}$$

$T_{OFF} = - R_B C \ln(0.5) = 0.693 R_B C$

The time period for one cycle is

$T = T_{ON} + T_{OFF}$

$T = 0.693(R_A + R_B)C + 0.693R_B C$

$T = 0.693(R_A + 2R_B)C$ sec

The frequency of output wave is given by

$$f = \frac{1}{T} = \frac{1}{0.693(R_A + 2R_B)C} \quad Hz$$

$$\boxed{f = \frac{1.44}{(R_A + 2R_B)C} \quad Hz}$$

Duty Cycle:

Duty cycle is defined as the ratio of ON time to the time period of the cycle.

$$\boxed{D = \frac{T_{ON}}{T} \times 100\% = \frac{T_{ON}}{T_{ON} + T_{OFF}} \times 100\%}$$

Result:

R_A = ………. Ohm, R_B = ………. Ohm, C = ... Farad.

Theoretical frequency is ....Hz

Practical frequency is .... Hz.

Signature of Faculty