LABORATORY MANUAL

ANALOG ELECTRONICS LAB

Department of Instrumentation Engineering

JORHAT ENGINEERING COLLEGE

Assam-785007

DO'S

- **Be punctual.**
- **Maintain discipline & silence.**
- **Keep the Laboratory clean and tidy.**
- **Enter Laboratory with shoes.**
- **Handle instruments with utmost care.**
- **Come prepared with circuit diagrams, writing materials and calculator.**
- **Follow the procedure that has been instructed.**
- **Return all the issued equipments properly.**
- **Get the signature on experiment result sheet daily.**
- **For any clarification contact faculty/staff in charge only.**
- **Shut down the power supply after the experiment.**

DON'Ts

- **Avoid unnecessary chat or walk.**

- **Playing mischief in the laboratory is forbidden.**
- **Disfiguring of furniture is prohibited.**
- **Do not start the experiment without instructions.**
- **Avoid using cell phones unless absolutely necessary.**
- **Avoid late submission of laboratory reports.**

3RD SEMESTER BE (IN)

Analog Electronics Lab (EI181313)

Experiment No	Title of the experiments	Objective of the experiments
1	Characteristics of P-N junction diode for forward bias and reverse bias.	To plot the VI characteristics of a P-n Junction diode as forward and reverse bias
2	To study of H.W rectifier circuits and F.W rectifier circuits	i)to plot the output characteristics of H.W rectifier i)to plot the output characteristics of H.W rectifier
3	Transistor characteristics in C-B configuration	i)To plot the I/P and O/P characteristics of transistor in C-B configuration ii)To obtain the CB configuration

4	Transistor characteristics in C-E configuration	i)To plot the I/P and O/P characteristics of transistor in CE Configuration ii)To obtain the CE configuration
5	Transistor characteristics in C-C configuration	i)To plot the I/P and O/P characteristics of transistor in CC Configuration ii)To obtain the CC configuration
6A	Study of inverting Op-amp	Study of inverting Op-amp by using multisim & plot the output characteristics
6B	Study of non-inverting Op-amp	Study of inverting Op-amp by using multisim & plot the output characteristics
7	Study of active filters	Study of High pass, bandpass, lowpass, notch filter by using multisim and plot the filtered output wave.

INTRODUCTION TO MULTISIM

National instruments Multisim is a simulation tool that can be used to expedite the analysis and design of various circuits, including ones containing digital devices, transistors, diodes, op amps, and even motors. This handout is not intended to be exhaustive, but rather it will get you started in simulating Direct Current (DC) circuits. Alternating Current (AC), transient, and frequency response capabilities will be discussed later in the course

Ni LABVIEW background

NI Multisim (formerly **MultiSIM**) is an electronic schematic capture and simulation program which is part of a suite of circuit design programs, along with NI Ultiboard. Multisim is one of the few circuit design programs to employ the original Berkeley SPICE based software simulation. Multisim was originally created by a company named Electronics Workbench Group, which is now a division of National Instruments. Multisim includes microcontroller simulation (formerly known as MultiMCU), as well as integrated import and export features to the printed circuit board layout software in the suite, NI Ultiboard.

Multisim was originally called **Electronics Workbench** and created by a company called Interactive Image Technologies. At the time it was mainly used as an educational tool to teach electronics technician and electronics engineering programs in colleges and universities. National Instruments has maintained this educational legacy, with a specific version of Multisim with features developed for teaching electronics.

In 1999, Multisim was integrated with Ultiboard after the original company merged with Ultimate Technology, a PCB layout software company.

In 2005, Interactive Image Technologies was acquired by National Instruments Electronics Workbench Group and Multisim was renamed to NI Multisim.

EXPERIMENT NO : 1

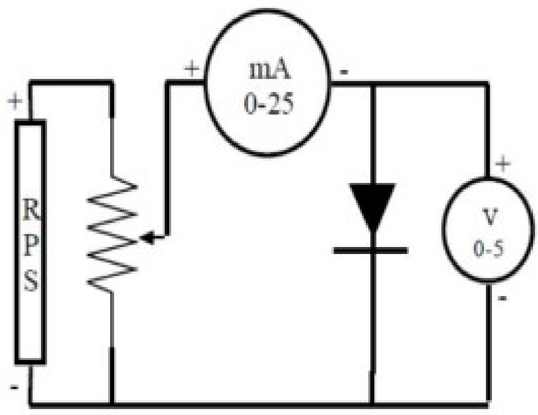
AIM:

To study the characteristics of PN junction diode for forward bias and reverse bias

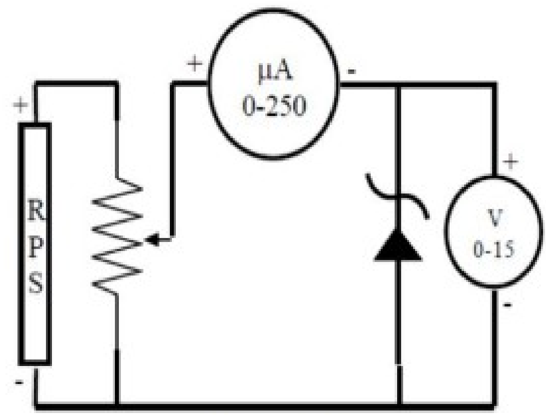
Apparatus:

Sl. No.	Item	Range/Type	Quantity
1	PN junction diode	Rectifier	1
2	PN junction diode	Zener	1
3	Regulated dc power supply	-	1
4	dc Milliammeter	0 - 25 mA	1
5	dc Microammeter	0 - 250 µA	1
6	dc Voltmeter	0 - 5 V	1
7	dc Voltmeter	0 - 15 V	1
8	Rheostat	Any	1

Diagram:



Forward Bias



Reverse Bias

Theory:

A p-n junction diode conducts only in one direction. The V-I characteristics of the diode are curve between voltage across the diode and current through the diode. When external voltage is zero, circuit is open and the potential barrier does not allow the current to flow. Therefore, the circuit current is zero. When P-type (Anode is connected to +ve terminal and n- type (cathode) is connected to –ve terminal of the supply voltage, is known as forward bias. The potential barrier is reduced when diode is in the forward biased condition. At some forward voltage, the potential barrier altogether eliminated and current starts flowing through the diode and also in the circuit. The diode is said to be in ON state. The current increases with increasing forward voltage.

When N-type (cathode) is connected to +ve terminal and P-type (Anode) is connected to the –ve terminal of the supply voltage is known as reverse bias and the potential barrier across the junction increases. Therefore, the junction resistance becomes very high and a very small current (reverse saturation current) flows in the circuit. The diode is said to be in OFF state. The reverse bias current is due to minority charge carriers.

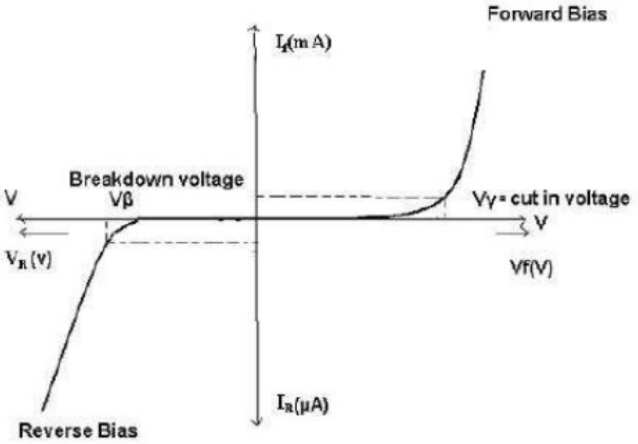
Procedure:

Step 1: Connect as in the circuit diagram

Step 2: Place the potentiometer at the minimum position

Step 3: Slowly increase the potential difference across the diode in steps and note down the readings. Continue up to full scale deflection of the ammeter. Step 4: Plot the V-I characteristics and calculate static and dynamic resistances. Step 5: Connect as in the circuit diagram (Reverse bias) taking a Zener diode. Repeat Step 2 to Step 3 and observe the avalanche breakdown voltage and compute Zener resistance.

Model waveform :



Experimental table :

Sl No	Forward bias		Reverse bias	
	Voltage(V)	Current(μA)	Voltage(V)	Current(μA)
1				
2				
3				
4				
5				
6				

Results and Discussion:

Viva Questions:-

1. Define depletion region of a diode?
2. What is meant by transition & space charge capacitance of a diode?
3. Is the V-I relationship of a diode Linear or Exponential?
4. Define cut-in voltage of a diode and specify the values for Si and Ge diodes?
5. What are the applications of a p-n diode?
6. Draw the ideal characteristics of P-N junction diode?
7. What is the diode equation?
8. What is PIV?
9. What is the break down voltage?
10. What is the effect of temperature on PN junction diodes?

Experiment No-2:

AIM:

To simulate Rectifier circuits like Half wave and Full wave Rectifier.

Facilities/material required:

1. MULTISIM Software Loaded PC 1 No.
2. Printer = 1 No.

Description:

1. Theory
2. Diode Symbol
3. Design Circuit
4. Simulation Procedure
5. Output Waveform

Theory:

A rectifier is an electronic device that converts an alternating current into a direct current by using one or more P-N junction diodes.

Half Wave Rectifier is a diode circuit which is used to transform Alternating Voltage (AC Supply) to Direct Voltage (DC Supply). A single diode is used in the HWR circuit for the transformation of AC to DC. Half Wave Rectifier circuit allows the one – half cycle of the AC Supply waveform to pass and blocks the other half cycle.

A semiconductor device that is used to change the complete AC cycle into pulsating DC is known as a full-wave rectifier. This circuit uses the full wave of the i/p AC signal whereas the half-wave rectifier uses the half-wave. This circuit is mainly used to overcome the drawback of half-wave rectifiers like low-efficiency drawback. These rectifiers have some fundamental advantages over their half-wave rectifier counterparts. The average (DC) output voltage is higher than for the half-wave rectifier, the output of this rectifier has much less ripple than that of the half-wave rectifier producing a smoother output waveform

Bridge Rectifiers are circuits that convert alternating current (AC) into direct current (DC) using diodes arranged in the bridge circuit configuration. Bridge rectifiers typically comprise of four or more diodes. The output wave generated is of the same polarity irrespective of the polarity at the input. Bridge rectifiers for a particular application are selected by considering the load current requirements. These bridge rectifiers are quite advantageous as they can be constructed with or without a transformer and are suitable for high voltage applications.

Ripple Factor:

Ripple factor is defined as the ratio of the effective value of AC components to the average DC value. It is denoted by the symbol 'γ'.

$$\gamma_{HWR} = \frac{V_{AC}}{V_{DC}} = 1.21 \qquad \gamma_{FWR} = \frac{V_{AC}}{V_{DC}} = 0.48$$

Rectification Factor:

The ratio of output DC power to input AC power is defined as efficiency.

$$\eta = \frac{(V_{DC})^2}{(V_{AC})^2} \qquad \eta_{HWR} = 40.6\% \qquad \eta_{FWR} = 81\%$$

Percentage of Regulation:

It is a measure of the variation of AC output voltage as a function of DC output voltage.

Percentage of regulation = $\left(\frac{V_{NL} - V_{FL}}{V_{FL}}\right) * 100$ %

V_{NL} = Voltage across load resistance, when minimum current flows through it.

V_{FL} = Voltage across load resistance, when maximum current flows through.

For an ideal rectifier, the percentage regulation is 0 percent. The percentage of regulation is very small for a practical half wave and full wave rectifier.

Peak- Inverse – Voltage (PIV):

It is the maximum voltage that has to be with stood by a diode when it is reverse biased

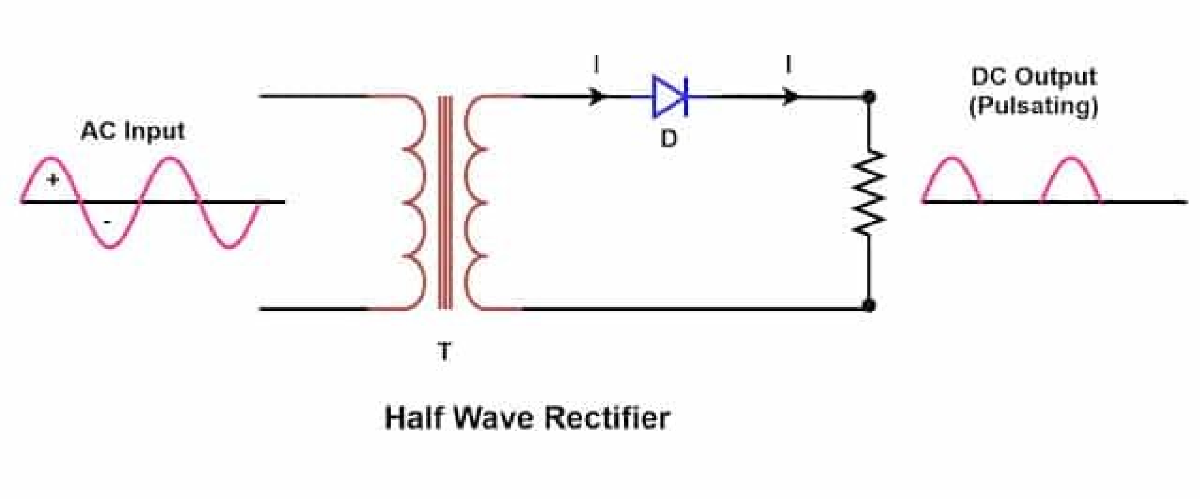
$PIV_{HWR} = Vm$ $\qquad$ $PIV_{FWR} = 2Vm$

Comparison of Half-wave and Full-wave rectifier

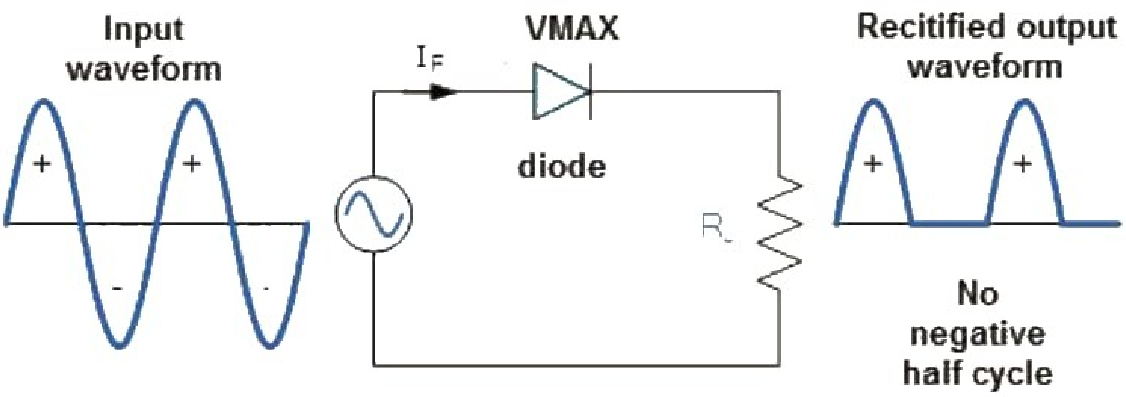
S. No.	Particulars	Type of Rectifier	
		Half-Wave	Full-Wave
1.	No. of diodes	1	2
2.	Maximum Rectification Efficiency	40.6%	81.2%
3.	$V_{d.c}$ (no load)	$\frac{V_m}{\pi}$	$\frac{2V_m}{\pi}$
4.	Ripple Factor	1.21	0.48
5.	Peak Inverse Voltage	V_m	$2V_m$
6.	Output Frequency	f	2f
7.	Transformer Utilization Factor	0.287	0.693

DESIGN CIRCUIT:

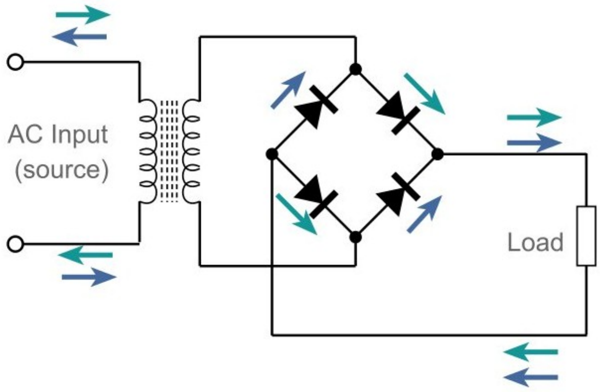
Half wave Rectifier circuit

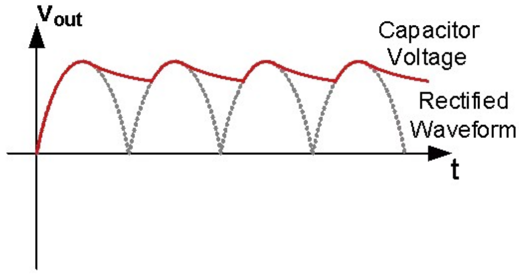


Full wave Rectifier circuit:



Bridge Rectifier Circuit:





Procedure:

Step 1: Connect as in the circuit diagram in Fig. (a) and measure the output voltage with both dc and ac voltmeter (PMMC and MI).
Step 2: Compute the ripple factor.
Step 3: Repeat Steps (1) and (2) for Fig. (b). Compare the performance of FW and HW rectifiers.
Step 4: Connect as in the circuit diagram in Fig.(c)without connecting RL and measure both dc and ac output voltages using a Multimeter.
Step 5: Observe filtering action i.e. note that dc voltage increases and the ac or the ripple voltage decreases.
Step 6: Connect RL and note the dc voltage at RLmax and RLmin and compute the voltage regulation.
Step 7: Repeat Steps (4) to (6)

Experimental table :

Sl No.	Type of Rectifier	Type of Filter	Vo dc	Vo ac	Ripple Factor	With RL		
						At RL max V_{oNL}	At RL min V_{oFL}	% Regulation
1	HW	-------						
2	FW	-------						

3	FW	C						
4	FW	L						

Results and Discussion:

Viva Questions:

1. What is a rectifier?

2. What is a ripple factor?

3. What is efficiency?

4. What is PIV?

5. What are the applications of rectifier?

6. Give some rectifications technologies?

7. What is the efficiency of bridge rectifier?

8. What is filter?

9. PIV center tapped FWR?

10. In filters capacitor is always connected in parallel, why?

EXPERIMENT NO-3

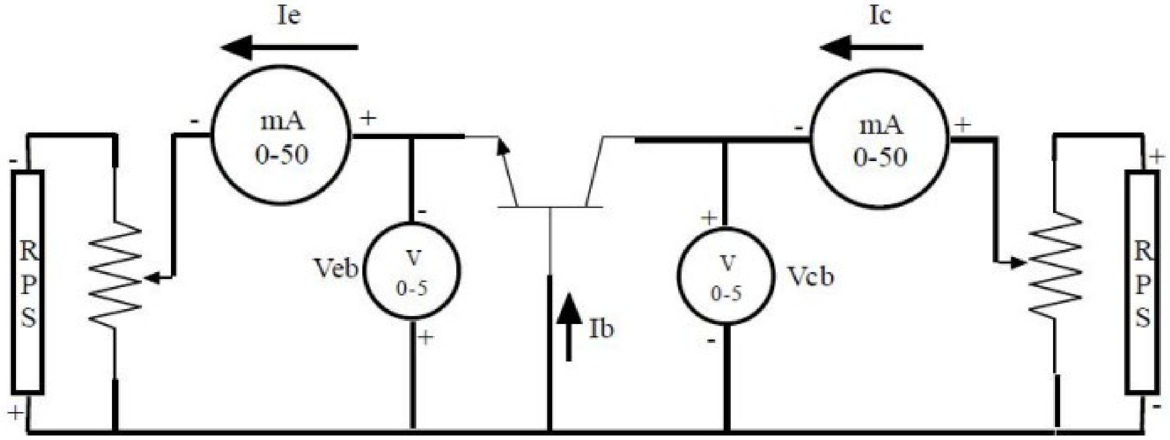
AIM:

To study the characteristics of a Common Base Configuration(CB)

Theory:

A transistor is a three terminal active device. The terminals are emitter, base, collector. In CB configuration, the base is common to both input (emitter) and output (collector). For normal operation, the E-B junction is forward biased and C-B junction is reverse biased. With an increasing the reverse collector voltage, the space-charge width at the output junction increases and the effective base width 'W' decreases. This phenomenon is known as "Early effect". Then, there will be less chance for recombination within the base region. With increase of charge gradient with in the base region, the current of minority carriers injected across the emitter junction increases. The current amplification factor of CB configuration is given by, α= IC/ IE

Circuit Diagram:



Procedure:

Step 1: Connect as in the circuit diagram and keep Potential divider at Minimum position.

Step 2: Plot input characteristics: Keep the output voltage constant (say 0 V). Increase the input voltage gradually to increase in steps of 5 mA from 0 mA and note down the meter readings. Take about 15 readings. Plot versus . Repeat Step 2 for another (say 3 V).

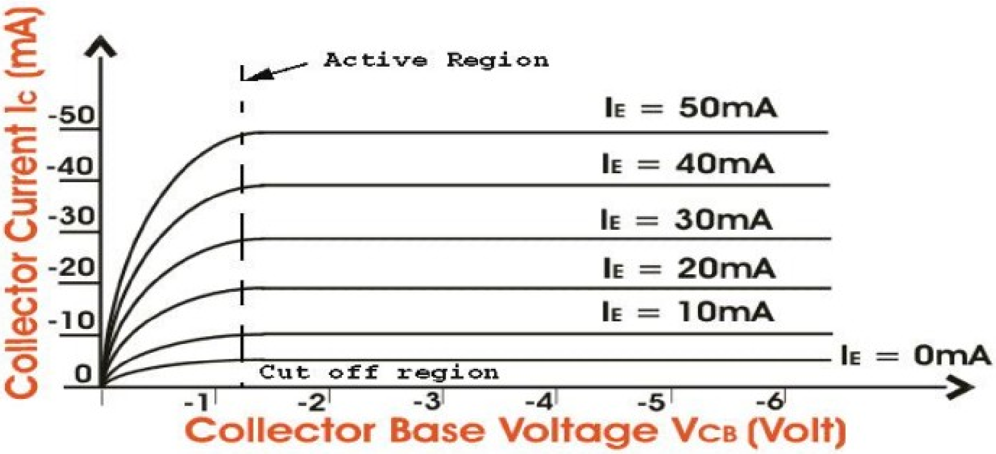
Step 3: Plot output characteristics: Keep the input current constant (say 10 mA). Increase the output voltage gradually in steps of 1 V from 1 V and note down the meter readings for . Take about 15 readings. Plot versus . Repeat Step 3 for two more values of (say 20 mA and 30 mA).

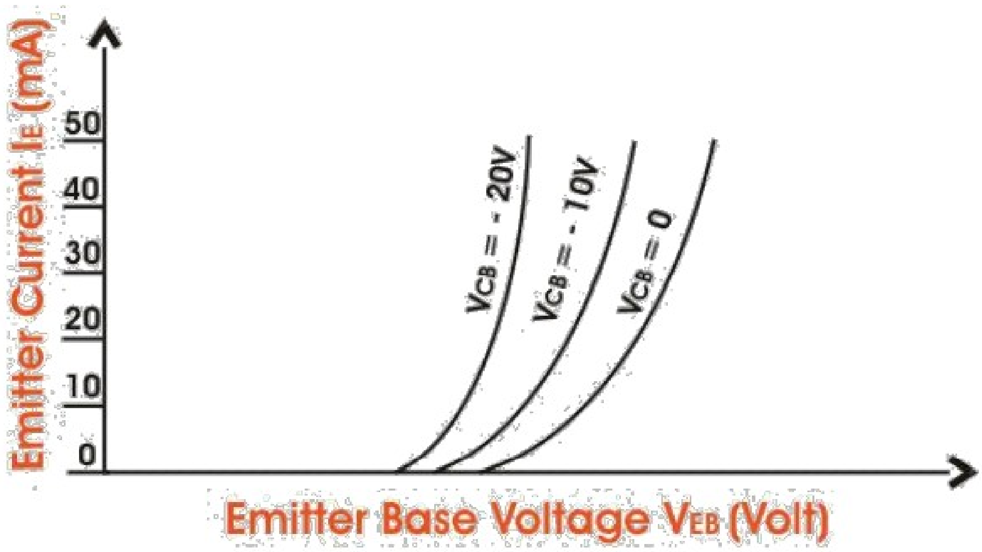
Experimental table :

Sl No.	Input Characteristics				Output Characteristics					
	V_{CE} = 0V		V_{CE} = 3V		I_B = 60µA		I_B= 120µA		I_B=180µA	
	V_{BE}(V)	I_B(µA)	V_{BE}(V µA)	I_B(µA)	V_{CE}(V)	I_C(mA)	V_{CE}(V)	I_C(mA)	V_{CE}(V)	I_C(mA)
1										
2										
3										
4										

Results:

Model Characteristics:





Results:

VIVA QUESTIONS:

1. What is the range of α for the transistor?
2. Draw the input and output characteristics of the transistor in CB configuration?
3. Identify various regions in output characteristics?
4. What is the relation between α and β?
5. What are the applications of CB configuration?
6. What are the input and output impedances of CB configuration?
7. Define α(alpha)?
8. What is EARLY effect?
9. Draw diagram of CB configuration for PNP transistor?
10. What is the power gain of CB configuration?

EXPERIMENT NO-4

AIM:

To study the characteristics of a Common Emitter Configuration(CE)

Theory:

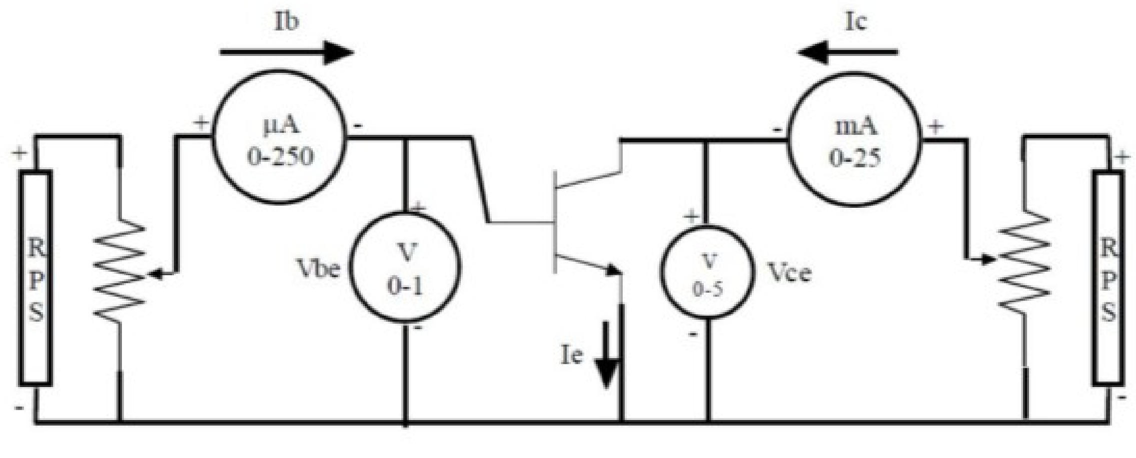
A transistor is a three terminal device. The terminals are emitter, base, collector. In common emitter configuration, input voltage is applied between base and emitter terminals and output is taken across the collector and emitter terminals. Therefore the emitter terminal is common to both input and output. The input characteristics resemble that of a forward biased diode curve. This is expected since the Base-Emitter junction of the transistor is forward biased. As compared to CB arrangement IB increases less rapidly with VBE. Therefore input resistance of CE circuit is higher than that of CB circuit. The output characteristics are drawn between Ic and VCE at constant IB. the collector current varies with VCE unto few volts only. After this the collector current becomes almost constant, and independent of VCE. The value of VCE up to which the collector current changes with VCE is known as Knee voltage. The transistor always operated in the region above Knee voltage, IC is always constant and is approximately equal to IB. The current amplification factor of CE configuration is given by β

= IC/IB

Apparatus:

Sl. No.	Item	Range/Type	Quantity
1	NPN transistor	----	1
2	Regulated dc power supply	0 – 30 V	2
4	dc Milliammeter	0 - 25 mA	1
5	Dc Microammeter	0 – 250 µA	1
6	Multimeter	Digital	1
7	Rheostat	1500 Ω, 1 A	2

Circuit Diagram:



Procedure:

Step 1: Connect as in the circuit diagram and keep Potential divider at Minimum position.

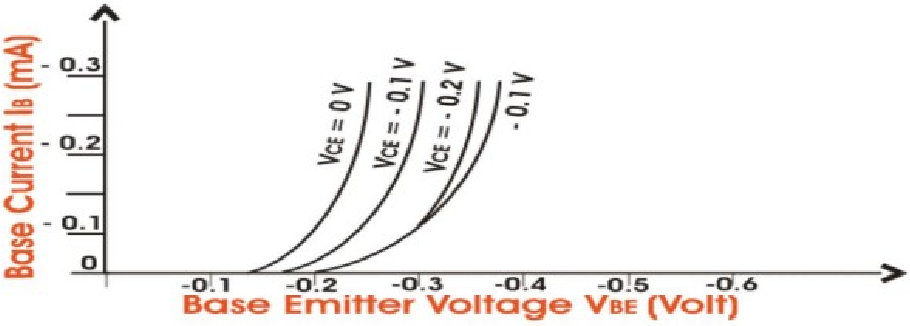
Step 2: Plot input characteristics: Keep the output voltage constant (say 0 V). Increase the input voltage gradually such that increases in steps of 20 A from 0 A and note down the meter readings. Take about 15 readings. Plot versus . Repeat Step 2 for another (say 3 V).

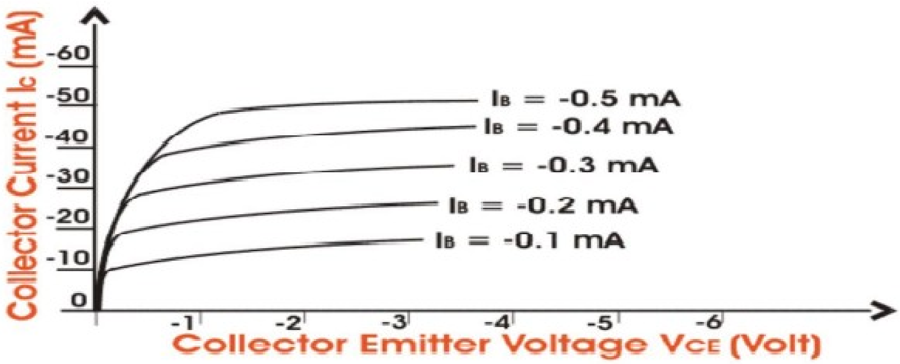
Step 3: Plot output characteristics: Keep the input current constant (say 20 A). Increase the output voltage gradually such that increases in steps of 1 mA (or 2 mA or 3 mA in other two cases respectively) from 0 mA and note down the meter readings. Take about 15 readings. Plot versus . Repeat Step 3 for two more values of (say 30 A and 60 A).

Experimental table :

Sl No.	Input Characteristics				Output Characteristics					
	V_{CE} = 0V		V_{CE} = 3V		I_B = 60µA		I_B= 120µA		I_B=180µA	
	V_{BE}(V)	I_B(µA)	V_{BE}(VµA)	I_B(µA)	V_{CE}(V)	I_C(mA)	V_{CE}(V)	I_C(mA)	V_{CE}(V)	I_C(mA)
1										
2										
3										
4										

Model Graphs:





Results:

VIVA QUESTIONS:

1. What is the range of b for the transistor?

2. What are the input and output impedances of CE configuration?

3. Identify various regions in the output characteristics?

4. What is the relation between a and b

5. Define current gain in CE configuration?

6. Why CE configuration is preferred for amplification?

7. What is the phase relation between input and output?

8. Draw diagram of CE configuration for PNP transistor?

9. What is the power gain of CE configuration?

10. What are the applications of CE configuration?

EXPERIMENT NO-5

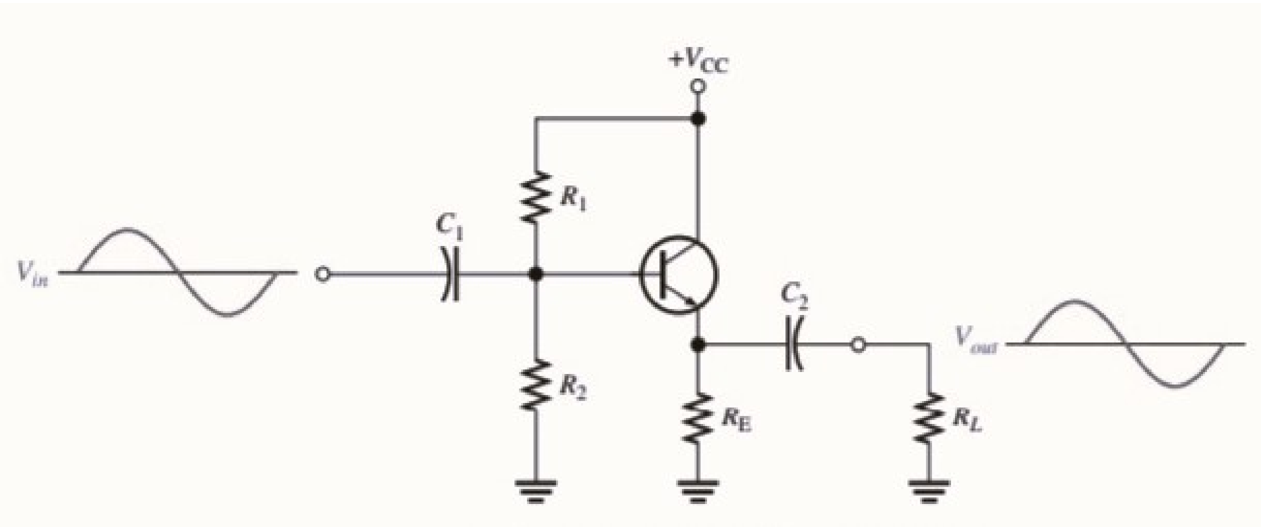
AIM:

To study the characteristics of a Common Collector Configuration(CC)

Theory:

In this configuration, the base terminal of the transistor serves as the input, the emitter terminal is the output and the collector terminal is common for both input and output. Hence, it is named as common collector configuration. The input is applied between the base and collector while the output is taken from the emitter and collector.In common collector configuration, the collector terminal is grounded so the common collector configuration is also known as grounded collector configuration.

Circuit Diagram:



Procedure:

Step 1: Connect as in the circuit diagram and keep Potential divider at Minimum position.

Step 2: Plot input characteristics: Keep the output voltage constant (say 0 V). Increase the input voltage gradually such that increases in steps of 20 A from 0 A and note down the meter readings. Take about 15 readings. Plot versus. Repeat Step 2 for another (say 3 V).

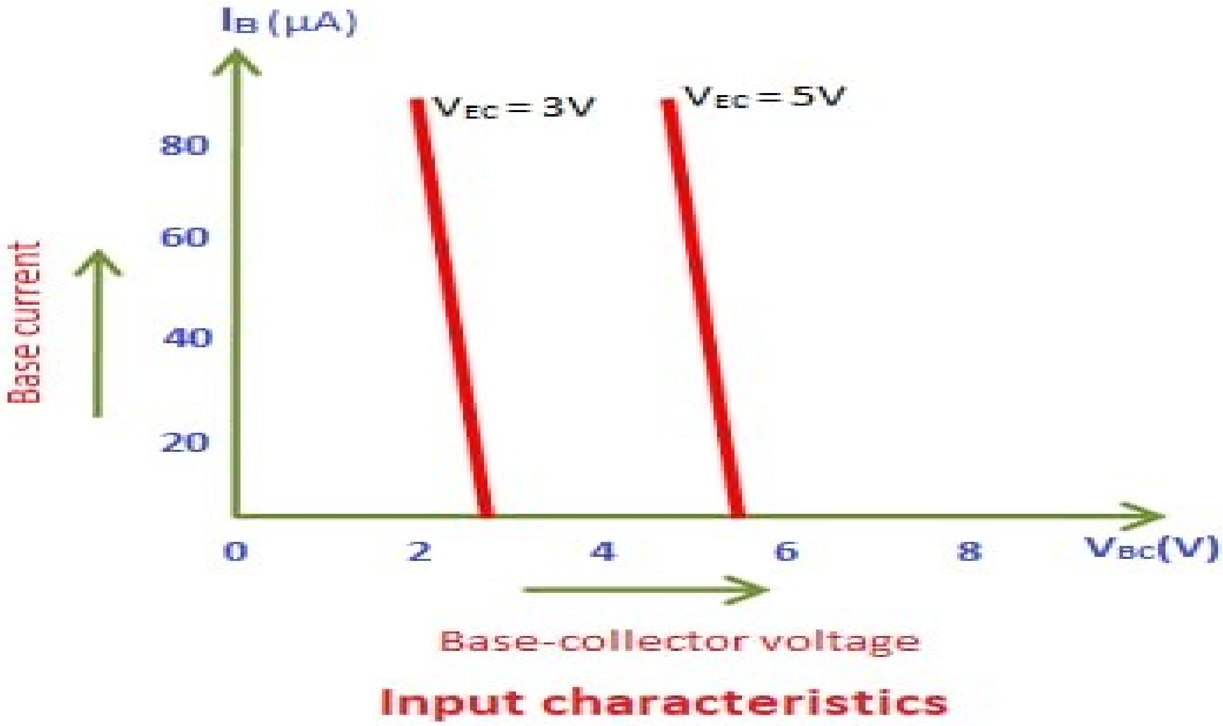
Step 3: Plot output characteristics: Keep the input current constant (say 20 A). Increase the output voltage gradually such that increases in steps of 1 mA (or 2 mA or 3 mA in other two cases respectively) from 0 mA and note down the meter readings. Take about 15 readings. Plot versus . Repeat Step 3 for two more values of (say 30 A and 60 A).

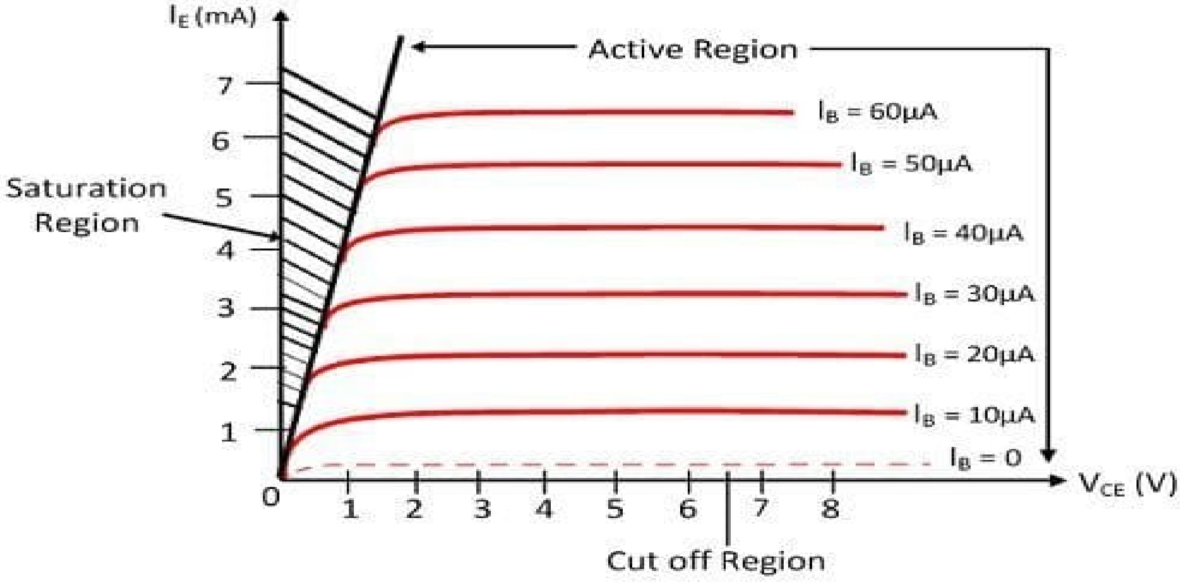
Experimental table:

Sl N	Input Characteristics		Output Characteristics		
	V_{CE} = 0V	V_{CE} = 3V	I_B = 60µA	I_B= 120µA	I_B=180µA

o.	V_{BE}(V)	I_B(μA)	V_{BE}(V μA)	I_B(μA)	V_{CE}(V)	I_C(mA)	V_{CE}(V)	I_C(mA)	V_{CE}(V)	I_C(mA)
1										
2										
3										
4										

Model Graphs:





Output Characteristic Curve

Results:

VIVA QUESTIONS:

1. What are the input and output impedances of CC configuration?
2. Identify various regions in the output characteristics?
3. Define current gain in CE configuration?
4. Why CC configuration is not preferred for amplification?
5. What is the phase relation between input and output?
6. Draw diagram of CC configuration for PNP transistor?
7. What is the power gain of CC configuration?
8. What are the applications of CC configuration?

EXPERIMENT NO-6A

AIM: To study Op-amp as Inverting Amplifier

Theory:

Inverting Operational Amplifier Negative Feedback is the process of "feeding back" a fraction of the output signal back to the input, but to make the feedback negative, we must feed it back to the negative or "inverting input" terminal of the op-amp using an external Feedback Resistor called Rf. The inverting operational amplifier is basically a constant or fixed-gain amplifier producing a negative output voltage as its gain is always negative.

Circuit Diagram:

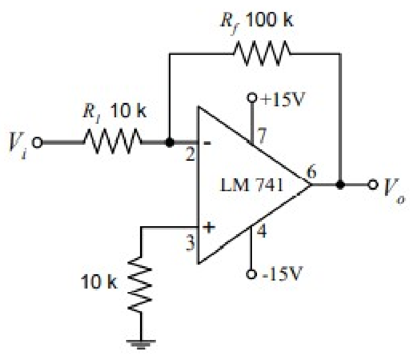


Fig 1. Circuit diagram of inverting amplifier

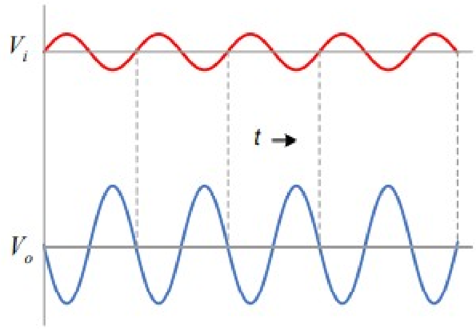


Fig 2. Input and output waveforms of inverting amplifier

Procedure:

Set up the circuit as shown in Fig 1. The circuit gives a closed loop gain $A_{CL} = -(R_f/R_1)$. This gain is very small compared to the open loop gain of the op-amp. Test the circuit by applying the input signal of suitable amplitude (say 1V peak to peak) from a function generator. Observe the output waveform on the CRO and determine actual gain.

The expression for gain is $A_{CL} = -(R_f/R_1)$

Let amplifier to be designed with a gain of (-10), select input resistance R1=10kΩ

Feedback resistance, $R_f = (A_{CL} \times R_1)$

$$= -(-10 \times 10 \times 10^3) = 100k\Omega$$

Experimental table :

Input Frequency F kHz	Input voltage (p-p) V_i V	Output voltage (p-p) V_o V	Gain $A_{CL} = V_o/V_i$

RESULT

The basic op-amp circuits of inverting amplifiers were designed set up and output waveforms were obtained in a CRO. The gain obtained are

Inverting amplifier:

Gain = ………….

VIVA QUESTIONS:

1. What is an op-amp?
2. What is called a differential amplifier?
3. What are the properties of an Ideal op-amp?
4. What is an inverting operational amplifier?
5. Write the Gain formula for an inverting op-amp.
6. List a few applications of the operational amplifier.
7. What is called input offset voltage of an Op-amp?
8. What is called output offset voltage of an Op-amp?

EXPERIMENT NO-6B

AIM: To study Op-amp as Non-Inverting Amplifier

Theory:

A non-inverting amplifier is an op-amp circuit configuration which produces an amplified output signal. This output signal of non-inverting op amp is in-phase with the input signal applied. In other words, a non-inverting amplifier behaves like a voltage follower circuit. A non-inverting amplifier also uses negative feedback connection, but instead of feeding the entire output signal to the input, only a part of the output signal voltage is fed back as input to the inverting input terminal of the op-amp.

Circuit Diagram:

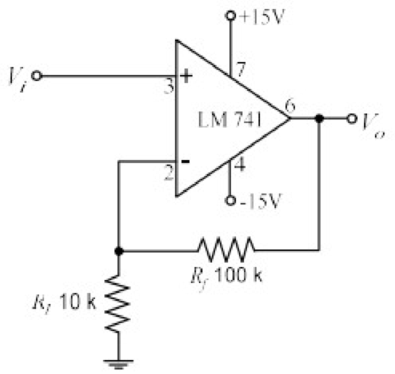


Fig 3. Circuit diagram of non-inverting amplifier

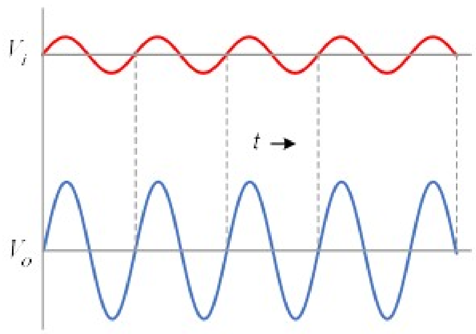


Fig 4. Input and output waveforms of non-inverting amplifier

Procedure:

The circuit of a non-inverting amplifier is shown in Fig 3. Its closed loop gain is $A_{CL} = (1+R_f/R_1)$. The circuit is tested by applying the input signal of suitable amplitude (say 1V peak to peak) from a function generator. Observe the output waveform on the CRO and determine actual gain.

The expression for gain is $A_{CL} = (1+R_f/R_1)$

Let amplifier to be designed with a gain 11 and select R1 = 10kΩ

Feedback resistance, Rf = $(A_{CL} - 1) R_1$

$= (10-1) \times 10 \times 10^3 = 100k\Omega$

Experimental table :

Input Frequency f kHz	Input voltage (p-p) V_i V	Output voltage (p-p) V_o V	Gain $A_{CL} = V_o/V_i$

RESULT

The basic op-amp circuits of non-inverting amplifiers were designed set up and output waveforms were obtained in a CRO. The gain obtained are

Non-Inverting amplifier:

Gain = ………….

VIVA QUESTIONS:

1. What is an op-amp?
2. What is called a differential amplifier?
3. What are the properties of an Ideal op-amp?
4. What is a non-inverting operational amplifier?
5. Write the Gain formula for a non-inverting op-amp.
6. List a few applications of the operational amplifier.
7. What is called input offset voltage of an Op-amp?
8. What is called output offset voltage of an Op-amp?

EXPERIMENT NO-7

AIM: To study active filters 1. High-pass

2. Low-pass

3. Band-pass

4. Notch filter

THEORY:

An Active Filter is a type of analog circuit implementing an electronic filter using active components, typically an amplifier. Amplifier included in a filter design can be used to improve the cost, performance and predictability of a filter.

Types –

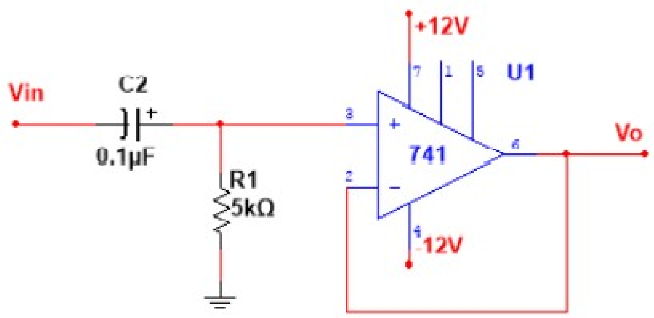
a) High-Pass Filter: Attenuation of frequencies below their cut off points.

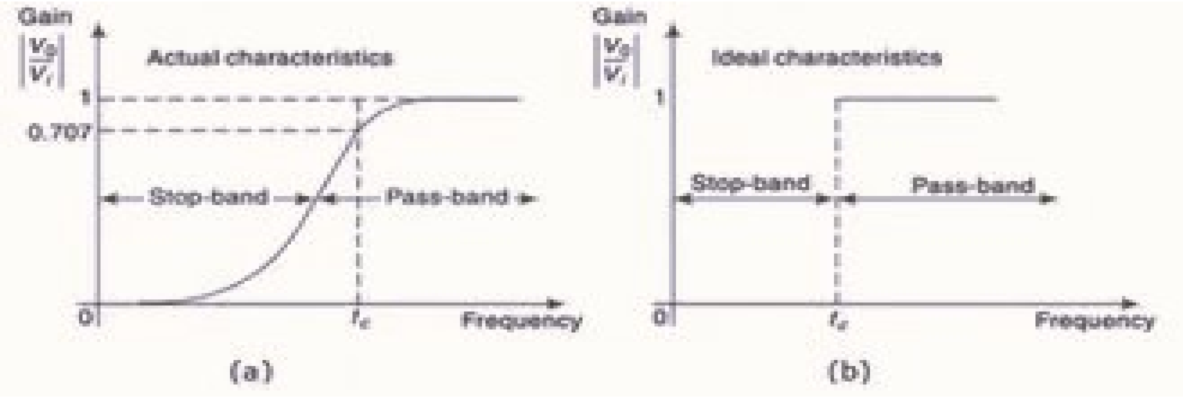
b) Low-Pass Filter: Attenuation of frequencies above their cut off points.

c) Band-Pass Filter: Attenuation of frequency is above and below those they allow to pass.

d) Notch Filter: Attenuation of certain frequencies will.

A) HIGH-PASS FILTER:





Procedure

1. Connect circuit diagram according to given circuit shown in Figure

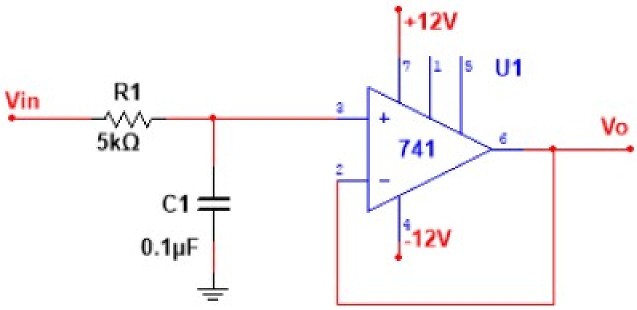
2. Adjust the frequencies of Vin using function generator and apply on circuit and analyse waveform from oscilloscope.

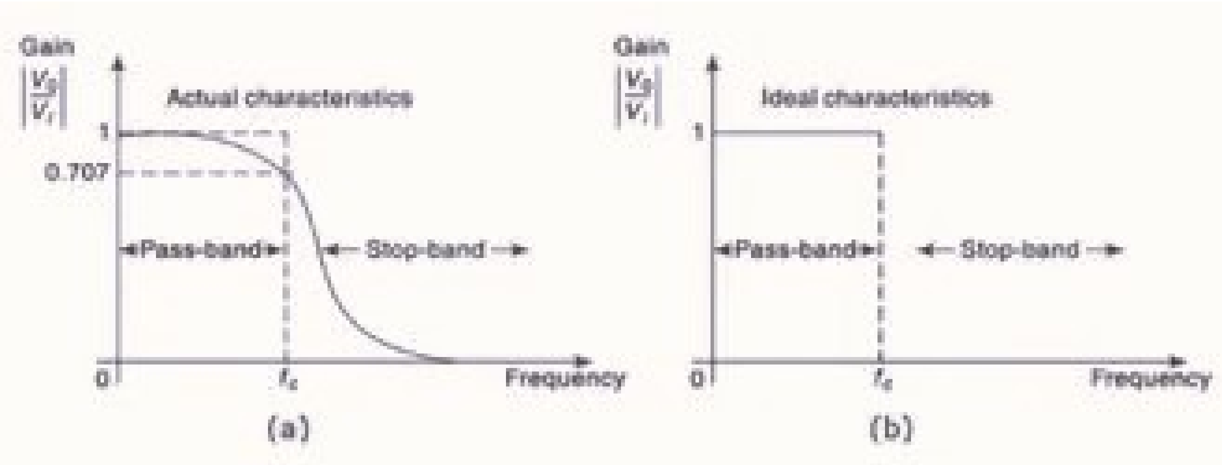
3. Measure Vo and record in table.

4. Determine cut off frequency fc.

5. Draw the graph between Vo and f.

B) LOW-PASS FILTER:





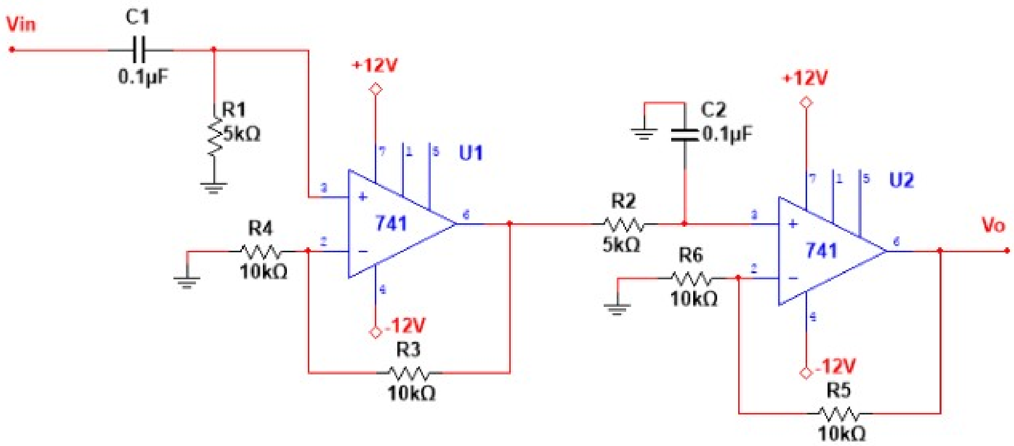
Procedure

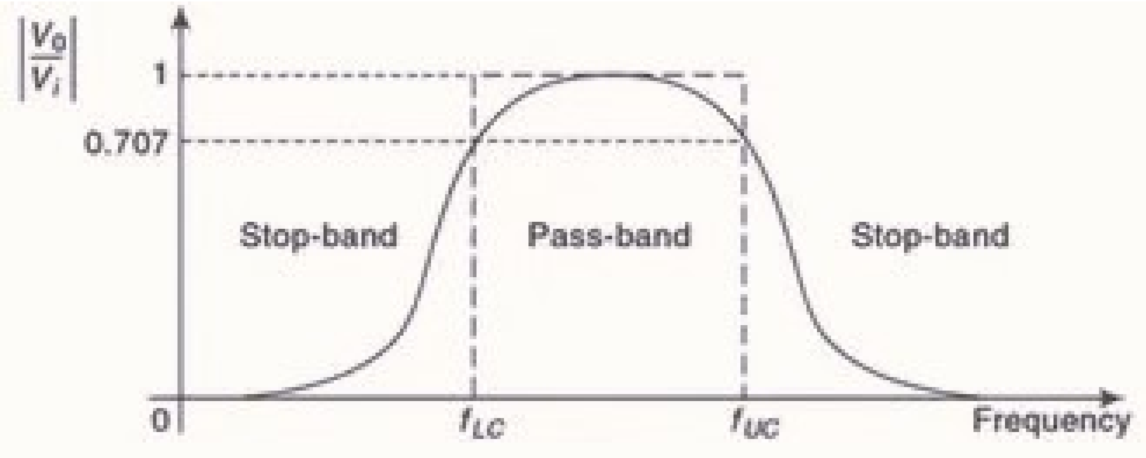
1. Connect circuit diagram according to given circuit shown in Figure

2. Adjust frequencies of input voltages Vin using function generator and apply on civet and analyse waveform from oscilloscope.

3. Determine critical frequency fc and draw a graph between Vo and f.

C) BAND-PASS FILTER:





Procedure

1. Connect circuit diagram according to given circuit shown in Figure.

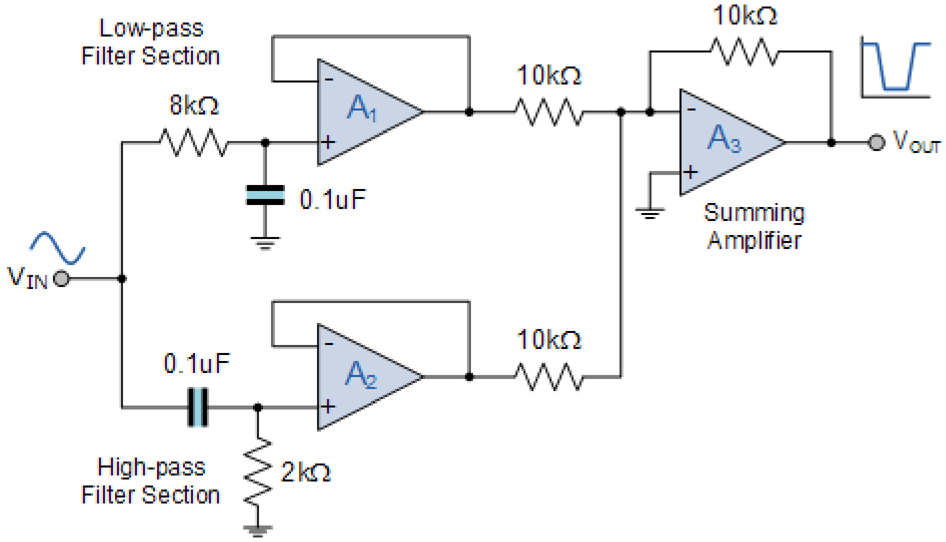
2. Adjust frequencies of Vin using function generator and apply on circuit and analyse waveform from oscilloscope.

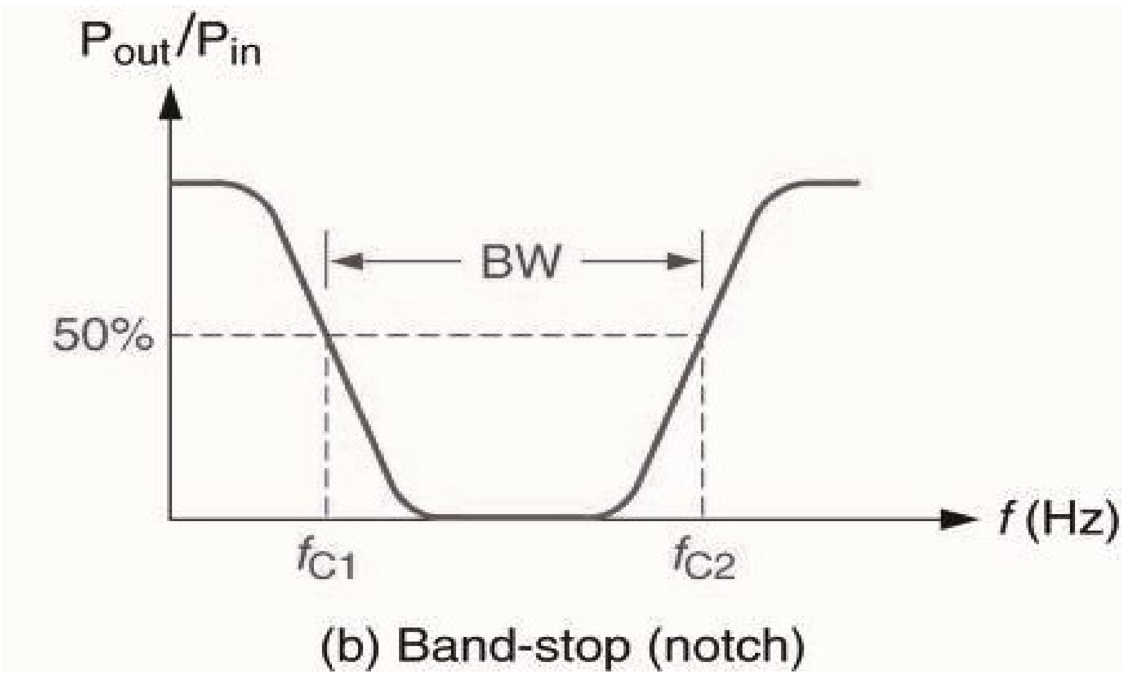
3. Measure Vo and record in table.

4. Calculate fc1 and fc2 and BW.

5. From the values of the table draw a graph between frequency and voltage Vo.

D) NOTCH FILTER:





Experimental table:

f(Hz)									
Vo (p-p)									

Viva Questions:

1. Which filter performs exactly the opposite to the band-pass filter?
2. In which filter the output and input voltages are equal in amplitude for all frequencies?
3. The gain of the first order low pass filter
4. Name the filter that has two stop bands?