MUFFAKHAM JAH

COLLEGE OF ENGINEERING AND TECHNOLOGY

EC-242 BASIC ELECTRONICS LAB

(For Mechanical, Production and CSE)

(With effect from the academic year 2015-2016)

STUDENT'S MANUAL

DEPARTMENT OF

ELECTRONICS AND COMMUNICATION ENGINEERING

Vision and Mission of the Institution

Vision

To be part of universal human quest for development and progress by contributing high calibre, ethical and socially responsible engineers who meet the global challenge of building modern society in harmony with nature.

Mission

- To attain excellence in imparting technical education from the undergraduate through doctorate levels by adopting coherent and judiciously coordinated curricular and co-curricular programs
- To foster partnership with industry and government agencies through collaborative research and consultancy
- To nurture and strengthen auxiliary soft skills for overall development and improved employability in a multi-cultural work space
- To develop scientific temper and spirit of enquiry in order to harness the latent innovative talents
- To develop constructive attitude in students towards the task of nation building and empower them to become future leaders
- To nourish the entrepreneurial instincts of the students and hone their business acumen.
- To involve the students and the faculty in solving local community problems through economical and sustainable solutions.

Vision and Mission of ECE Department

Vision

To be recognized as a premier education center providing state of art education and facilitating research and innovation in the field of Electronics and Communication.

Mission

We are dedicated to providing high quality, holistic education in Electronics and Communication Engineering that prepares the students for successful pursuit of higher education and challenging careers in research, R& D and Academics.

Program Educational Objectives of B. E (ECE) Program:

1. Graduates will demonstrate technical competence in their chosen fields of employment by identifying, formulating, analyzing and providing engineering solutions using current techniques and tools
2. Graduates will communicate effectively as individuals or team members and demonstrate leadership skills to be successful in the local and global cross-cultural working environment
3. Graduates will demonstrate lifelong learning through continuing education and professional development
4. Graduates will be successful in providing viable and sustainable solutions within societal, professional, environmental and ethical contexts

MUFFAKHAM JAH COLLEGE OF ENGINEERING AND TECHNOLOGY

BANJARA HILLS, ROAD NO-3, TELANGANA

LABORATORY MANUAL

FOR

EC 242 - BASIC ELECTRONICS LAB

(For Mechanical, Production and CSE)

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DEPARTMENT OF ELECTRONICS AND COMMUNICATIONS ENGINEERING

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BASIC ELECTRONICS LAB

(Code: EC 242)

B.E. (E.C.E.) II Year, II Semester

(For Mechanical, production and CSE)

List of Experiments: ***Page No:***

EXPERIMENT NO: 1

STUDY OF R, L, C AND MEASUREMENT OF R, L, C USING LCR METER AND COLOR CODE METHOD

Aim: Study R L C and Measurement of R L C using LCR meter and color code method.

Components required: - Resistors, capacitors and inductors

Theory:

Resistors:

A **resistor** is a passive two-terminal electrical component that implements electrical resistance as a circuit element. Resistors act to reduce current flow, and, at the same time, act to lower voltage levels within circuits The behavior of an ideal resistor is dictated by the relationship specified by Ohm's law:

$$V = I \cdot R.$$

Ohm's law states that the voltage (V) across a resistor is proportional to the current (I), where the constant of proportionality is the resistance (R). The ohm (symbol: Ω) is the SI unit of electrical resistance.

Symbols:

Fixed resistor

Variable resistor

Fig 1: Resistors

Applications:

1. By placing a resistor in series with another component such as LED (Light emitting diodes) the current through that component is reduced.

2. A series resistor can be used for speed regulation of DC motors such as used in locomotives.

3. An attenuator is a network of two or more resistors used to reduce the voltage of a signal.

4. A line terminator is a resistor at the end of a transmission line designed to match the impedance for maximum power transfer and hence minimize the reflection of the signal. All resistors dissipate voltage into heat. This is the principle behind electric heaters and irons.

<u>Color coding for fixed resistors</u>

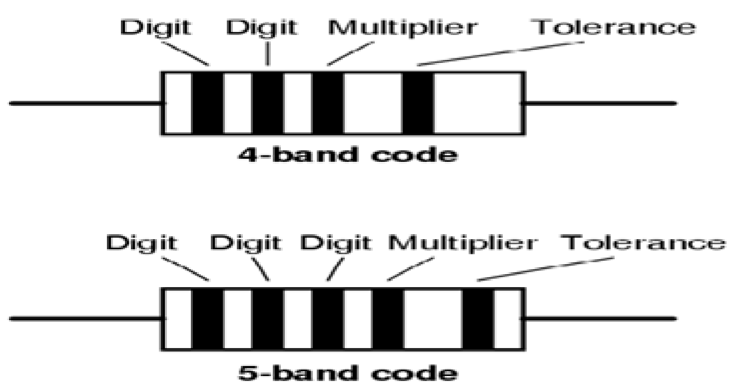


Fig 2: Resistor Bands

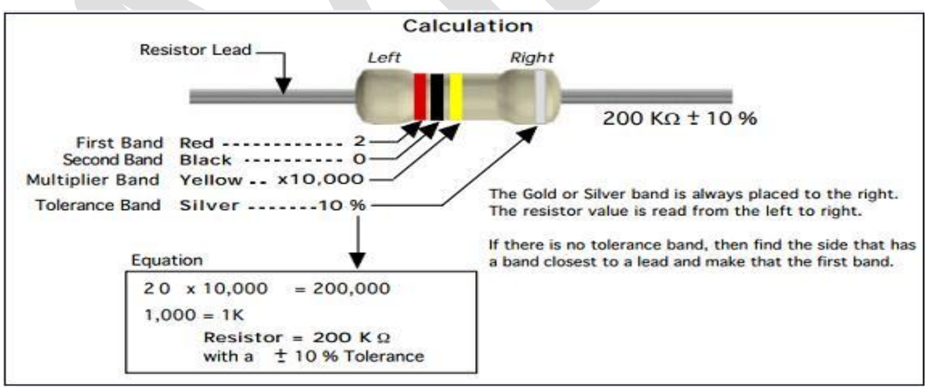


Fig 3: Description of Resistor bands

Table 1: Resistor color code table

The standard resistor color code table:

Color	Digit 1	Digit 2	Digit 3*	Multiplier	Tolerance	Temp. Coef.	Fail Rate
Black	0	0	0	$\times 10^0$			
Brown	1	1	1	$\times 10^1$	±1% (F)	100 ppm/K	1%
Red	2	2	2	$\times 10^2$	±2% (G)	50 ppm/K	0.1%
Orange	3	3	3	$\times 10^3$		15 ppm/K	0.01%
Yellow	4	4	4	$\times 10^4$		25 ppm/K	0.001%
Green	5	5	5	$\times 10^5$	±0.5% (D)		
Blue	6	6	6	$\times 10^6$	±0.25% (C)		
Violet	7	7	7	$\times 10^7$	±0.1% (B)		
Gray	8	8	8	$\times 10^8$	±0.05% (A)		
White	9	9	9	$\times 10^9$			
Gold				×0.1	±5% (J)		
Silver				×0.01	±10% (K)		
None					±20% (M)		

** 3rd digit - only for 5-band resistors*

Specifications:-

1. Resistance 1 Ω to several mega Ω.

2. Power Rating: - 1/10 watt to 100 watt.

3. Temperature Coefficient – it is a parameter indicating the rate of change of nominal resistance value as a function of temperature. It is expressed as ppm/°C or % per °C

4. Voltage Rating or the rated continuous working voltage of a resistor is given by $\sqrt{(W*R)}$ where W is the wattage rating in watts and R is the resistance value in ohms.

5. Noise, Frequency Response, Temperature Rating, Physical Size, Reliability etc**.**

All practical resistors also introduce small amount of inductance and capacitance which change the dynamic behavior of the resistor from the ideal.

Real Standard resistor values - E6 and E12 series:

Resistors are not available with every possible value, for example 22k and 47k are readily available, but 25k and 50k are not!. Electronic engineers and manufacturers have adopted a standard for resistors values. These are intended to keep the cost down and make it easier for to buy them from any supplier.

E6 series : Resistors with 20% tolerance 10, 15, 22, 33, 47, 68, ... then it continues 100, 150, 220, 330, 470, 680, 1000 etc.

E12 series : Resistors with 10% tolerance 10, 12, 15, 18, 22, 27, 33, 39, 47, 56, 68, 82, ... then it continues 100, 120, 150 etc.

Capacitor:

A **capacitor** (originally known as a **condenser**) is a passive two-terminal electrical component used to store energy electrostatically in an electric field. The forms of practical capacitors vary widely, but all contain at least two electrical conductors (plates) separated by a dielectric (i.e. insulator). Unlike a resistor, an ideal capacitor does not dissipate energy. Instead, a capacitor stores energy in the form of an electrostatic field between its plates.

An ideal capacitor is wholly characterized by a constant capacitance *C*, defined as the ratio of charge $\pm Q$ on each conductor to the voltage *V* between them, The unit of capacitance is farad , mathematically defines a Q = C/V

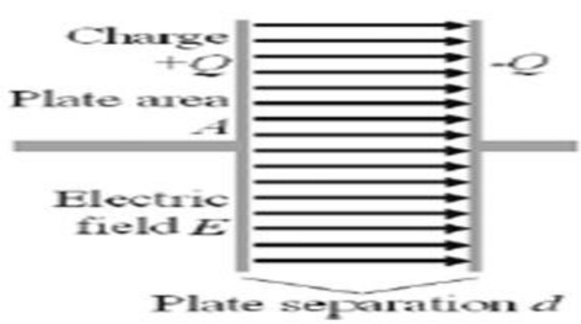


Fig 4: Parallel plate capacitor

Applications of capacitors:

Capacitors have very many uses in electronic and electrical systems:

- Energy storage devices.
- Used in power supplies to smooth the output of a full wave or half wave rectifier.
- Capacitors are connected in parallel with the power circuits of most electronic devices to shunt away the current fluctuations.
- Capacitors are used in power factor correction.
- Capacitors pass AC but block DC signals (when charged up to the applied dc voltage), they are often used to separate the AC and DC components of a signal. This method is known as *AC coupling*.
- Capacitors are also used in parallel to interrupt units of a high-voltage circuit breaker in order to equally distribute the voltage between these units. In this case they are called grading capacitors.
- The energy stored in a capacitor can be used to represent information, either in binary form, as in computers.
- Capacitors and inductors are applied together in tuned circuits to select information in particular frequency bands. For example, radio receivers rely on variable capacitors to tune the station frequency.

Symbols:

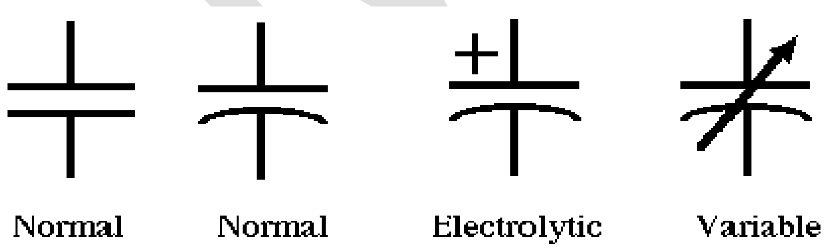


Fig 5: Capacitor symbols

Energy stored in a capacitor is given by

$$W = \int_0^Q V(q)\mathrm{d}q = \int_0^Q \frac{q}{C}\mathrm{d}q = \frac{1}{2}\frac{Q^2}{C} = \frac{1}{2}CV^2 = \frac{1}{2}VQ$$

Identification of capacitors:

Capacitors are labeled in different ways.

- Capacitor Labeled with number scheme

Ex:- “223” = 22 000 pF ,

"104" = 10 0000 pF ,

“393” = 39 000 pF

- Some capacitors are labeled implicitly

Ex: 4700pF, *250 V*

Color coded and labeled capacitors:

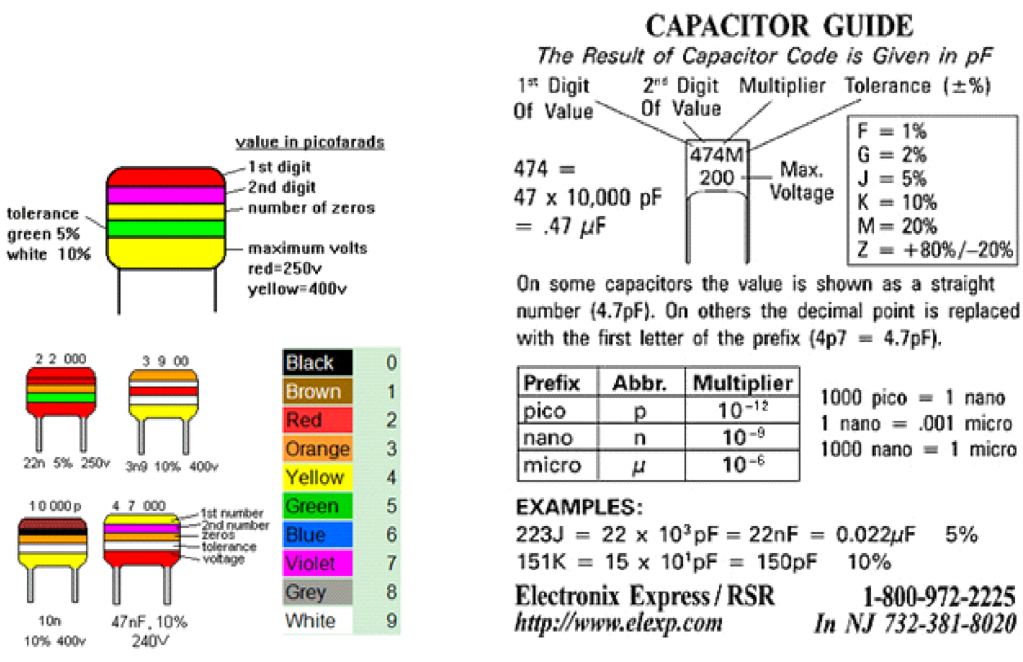


Fig 6: Color coded capacitors and labeled capacitors

Inductors:

An **inductor**, also called a **coil** or **reactor**, is a passive two-terminal electrical component which resists changes in electric current passing through it. It consists of a conductor such as a wire, usually wound into a coil. When a current flows through it, energy is stored temporarily in a magnetic field in the coil. When the current flowing through an inductor changes, the time-varying magnetic field induces a voltage in the conductor, according to Faraday's law of electromagnetic induction, which opposes the change in current that created it. As a result, inductors always oppose a change in current.

Inductance (*L*) results from the magnetic field around a current-carrying conductor; the electric current through the conductor creates a magnetic flux. Mathematically speaking, inductance is determined by how much magnetic flux φ through the circuit is created by a given current i .The voltage –current relation in an inductor is given as

$$v = \frac{d}{dt}(Li) = L\frac{di}{dt}$$

The unit of Inductance is 'Henry'. Basic inductance formula for a cylindrical coil:

$$L = \frac{\mu_0 \mu_r N^2 A}{l}$$

where

L = Inductance in henries (H)

μ_0 = permeability of free space = $4\pi \times 10^{-7}$ H/m

μ_r = relative permeability of core material

N = number of turns

A = area of cross-section of the coil in square metres (m^2)

l = length of coil in metres (m).

The energy stored by an inductor is

$$E_{\text{stored}} = \frac{1}{2}LI^2$$

Applications:

Inductors are used in electronic and electrical systems. Some of the applications are:

- Inductors along with capacitors are used in tuned circuits.
- Two (or more) inductors which have coupled magnetic flux form a transformer.
- Used as chokes in power supplies to remove residual hum or other fluctuations from the direct current output.
- An inductor is used as the energy storage device in a switched-mode power supply.

Table 2: Inductor color coding

Band	1	2	3	4
Meaning	1st Digit	2nd Digit	Multiplier (No. of zeros)	Tolerance %
Gold			x 0.1 (divide by 10)	+/-5%
Silver			x 0.01 (divide by 100)	+/-10%
Black	0	0	x1 (No Zeros)	+/-20%
Brown	1	1	x10 (0)	
Red	2	2	x100 (00)	
Orange	3	3	x1000 (000)	
Yellow	4	4	x10000 (0,000)	
Green	5	5		
Blue	6	6		
Violet	7	7		
Grey	8	8		
White	9	9		

Example: An inductor with color red violet brown and black , Therefore value is 27 x10 = µH with tolerance 20%

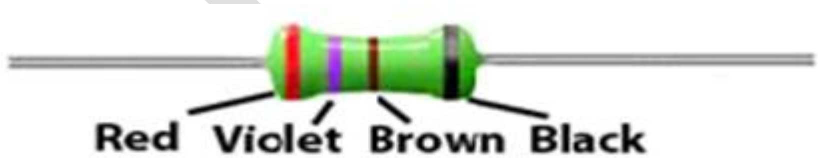
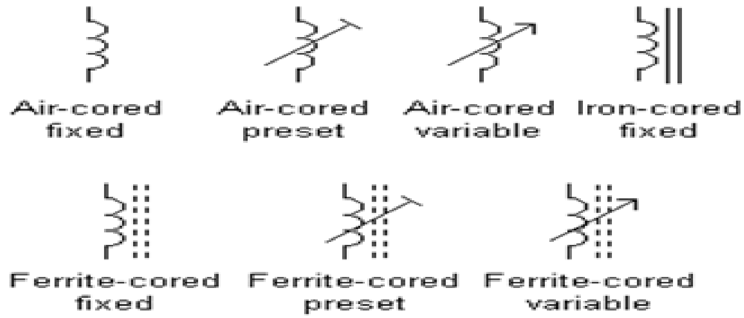


Fig 7: Color coded inductor

Symbols:



Theory:

An **LCR meter** is a type of electronic test equipment used to measure the inductance (L), capacitance (C), and resistance(R) of an electronic component. In the simpler versions of this instrument the impedance was measured internally and converted for display to the corresponding capacitance or inductance value. Usually the device under test (DUT) is subjected to an AC voltage source. The meter measures the voltage across and the current through the DUT. From the ratio of these the meter can determine the magnitude of the impedance, in combination with the impedance, the equivalent capacitance or inductance, and resistance, of the DUT can be calculated and displayed.

A **multimeter** is an electronic measuring instrument that combines several measurement functions in one unit also known as a VOM (Volt-Ohm meter or Volt-Ohm-milliammeter). A typical multimeter would include basic features such as the ability to measure voltage, current, and resistance. Digital multimeters (DMM, DVOM) display the measured value in numerals.

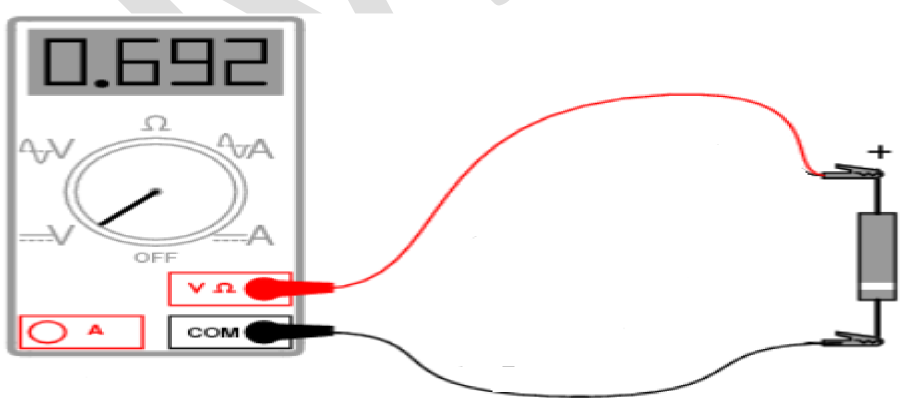


Fig 1: Multimeter

Procedure:

1. Perform zero adjustment.
2. Connect the two terminals of the component across the Multimeter/ LCR meter and record the reading by adjusting the Sliding switch.

A) Capacitance Measurements

- Set the function/range switch to the desired Cx socket
- Insert the capacitor lead directly into the Cx sockets.
- Read the capacitance directly from the display

Observations Tables:

Take set of components and use above procedure to measure value using LCR

.

Table 1: diode and transistor measurement

S.No	Compnents	Marked value	Components value using Multimeter
1.	Diodes (Si)		
2.	Diodes (Ge)		
3.	Transistor (Gain measurement)		

Table 2: Resistor

S.No	Resistance color Code	Resistane value using colour code(Ω)	Resistane value using LCR meter /Multimeter(Ω)
1			
2			
3			

Table 3: Capacitor

S.No	Code marked on Capacitor	Capacitance using LCR meter	Capacitance using Multimeter
1.			
2.			
3.			

Table 4: Electrolytic Capacitor

S.No	Capacitance Marked Value	Capacitance using LCR meter
1		
2		

Table 5: Inductor Measurement

S.No	Marked Value of Inductor	Inductance using LCR meter
1		
2		

Results: Given components have been measured using LCR meter and color code method successfully

EXPERIMENT NO: 2

CHARACTERISTICS OF SEMICONDUCTORS DIODE Ge , AND Si

Aim:

1. To plot Volt-Ampere Characteristics of Germanium, Silicon P-N Diode and Zener
2. To find cut-in voltage for Silicon and Germanium P-N Junction diode.
3. To find static and dynamic resistances in both forward and reverse biased conditions.

Components:

Name	Quantity
Diodes 1N4007(Si)	1
Diodes DR-25(Ge)	1
Resistor 1KΩ	1
Resistor 3.3KΩ	1

Equipment:

Name	Range	Quantity
Bread board		1
Regulated power supply	0-30V	1
Digital Ammeter	0-200μA/200mA	1
Digital Voltmeter	0-20V	1
Connecting Wires		

Specifications:

Silicon Diode 1N4007:	**Germanium Diode DR-25:**
Max Forward Current = 1A	Max Forward Current = 250mA
Max Reverse Current = 5.0μA	Max Reverse Current = 200μA
Max Forward Voltage = 0.8V	Max Forward Voltage = 1V
Max Reverse Voltage = 1000V	Max Reverse Voltage = 25V
Max Power Dissipation = 30mW	Max Power Dissipation = 250mW
Temperature = -65 to 200° C	Temperature = -55 to 75° C

Theory:

Donor impurities (pentavalent) are introduced into one-side and acceptor impurities into the other side of a single crystal of an intrinsic semiconductor to form a p-n diode with a junction called depletion region (this region is depleted off the charge carriers). This region gives rise to a potential barrier called Cut-in Voltage. This is the voltage across the diode at which it starts conducting. The P-N junction can conduct beyond this potential.

The P-N junction supports uni-directional current flow. If +ve terminal of the input supply is connected to anode (P-side) and –ve terminal of the input supply is connected the cathode. Then diode is said to be forward biased. In this condition the height of the potential barrier at the junction is lowered by an amount equal to given forward biasing voltage. Both the holes from p-side and electrons from n-side cross the junction simultaneously and constitute a forward current from n-side (injected minority current – due to holes crossing the junction and entering P- side of the diode). Assuming current flowing through the diode to be very large, the diode can be approximated as short- circuited switch.

If –ve terminal of the input supply is connected to anode (p-side) and +ve terminal of the input supply is connected to cathode (n-side) then the diode is said to be reverse biased. In this condition an amount equal to reverse biasing voltage increases the height of the potential barrier at the junction. Both the holes on P-side and electrons on N-side tend to move away from the junction there by increasing the depleted region. However the process cannot continue indefinitely, thus a small current called reverse saturation current continues to flow in the diode. This current is due to be negligible; the diode can be approximated as an open circuited switch.

The volt-ampere characteristics of a diode explained by the following equations:

$$I = I_0 \left(e^{\frac{V_D}{\eta\ V_T}} - 1 \right)$$

Where ,I = current flowing in the diode, I_0 = reverse saturation current

V_D = Voltage applied to the diode

V_T = volt- equivalent of temperature = k T/q = T/ 11,600 = 26mV (@ room temp)

η = 1(for Ge) and 2 (for Si)

It is observed that **Ge** diodes has smaller cut-in-voltage when compared to **Si** diode. The reverse saturation current in **Ge** diode is larger in magnitude when compared to silicon diode.

Theoretically the dynamic resistance of a diode is determined using the following equation:
Dynamic Resistance:

$$R_D = \frac{\eta \ V_T}{\mathrm{I}}$$

Circuit Diagrams:

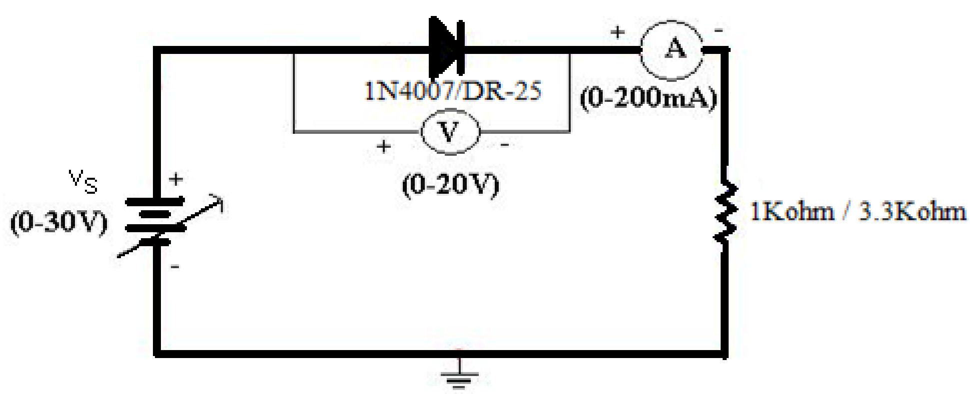


Fig. (1) - Forward Bias Condition

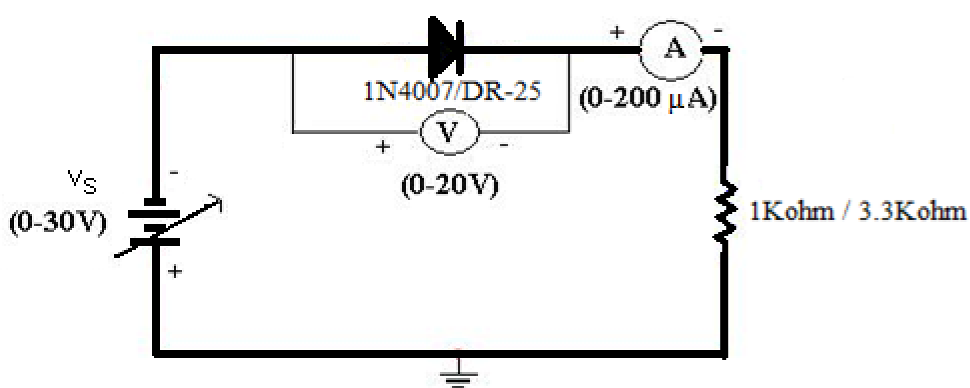


Fig. (2) - Reverse Bias Condition

Procedure:

Forward Bias Condition:

1. Connect the components as shown in the circuit diagram (1).
2. Vary the supply voltage such that the voltage across the Silicon diode varies from 0 to 0.6 V in steps of 0.1 V and in steps of 0.02 V from 0.6 to 0.76 V. In each step record the current flowing through the diode as I.
3. Repeat the above steps for Germanium diode and zener diode too but with the exception that the voltage across the diode should be varied in steps of 0.01 V from 0.1 to 0.3 V in step-2.

Reverse Bias Condition:

1. Connect the diode in the reverse bias as shown in the circuit diagram (2)
2. Vary the supply voltage such that the voltage across the diode varies from 0 to 10V in steps of 1 V. Record the current flowing through the diode in each step.
3. Repeat the above steps for Germanium diode and zener diode too and record the current in each step.
4. Now plot a graph between the voltage across the diode and the current flowing through the diode in forward and reverse bias, for Silicon Germanium and zener diodes on separate graph sheets. This graph is called the V-I characteristics of the diode.
5. Calculate the static and dynamic resistance of each diode in forward and reverse bias using the following formulae.

Static resistance, $R = V/I$

Dynamic resistance, $r = \Delta V/\Delta I$

Observations:

(a) Forward and Reverse bias characteristics of Silicon diode

Forward Bias Condition:

S. No.	Forward Voltage across the diode V_d (Volt)	Forward Current through the diode I_d (mA)

Reverse Bias Condition:

S. No.	Reverse Voltage across the diode V_R (Volt)	Reverse Current through the diode I_R (μA)

(b) Forward and Reverse bias characteristics of Germanium diode

Forward Bias Condition:

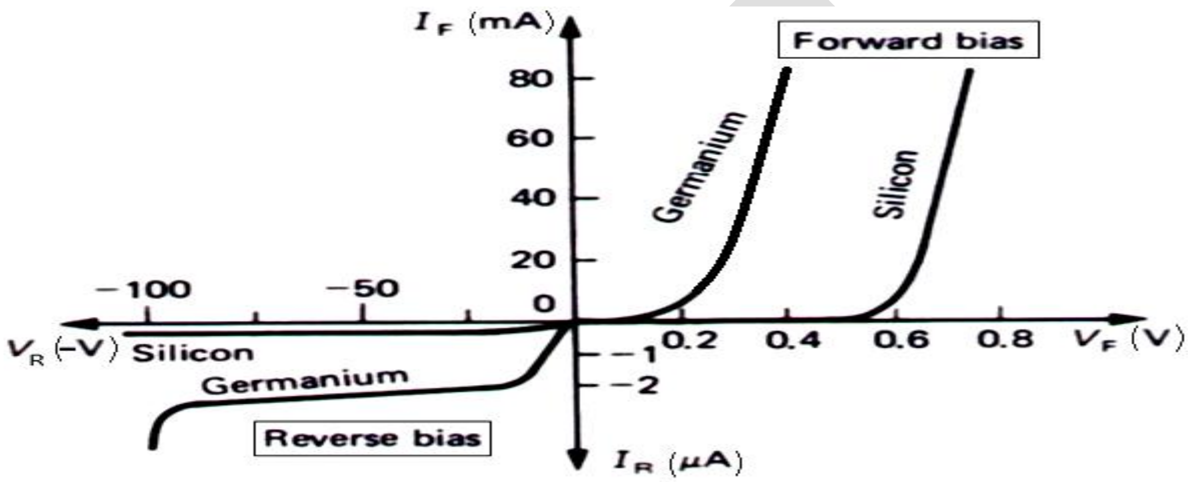
S. No.	Forward Voltage across the diode (volts)V_d (Volt)	Forward Current through the diode I_d (mA)

Reverse Bias Condition:

S. No.	Reverse Voltage across the diode (volts)V_r (Volt)	Reverse Current through the diode I_R (μA)

Graph:

1. Take a graph sheet and divide it into 4 equal parts. Mark origin at the center of the graph sheet.
2. Now mark +ve X-axis as , -ve X-axis as , +ve Y-axis as and –ve Y-axis as .
3. Mark the readings tabulated for Si forward biased condition in first Quadrant and Si reverse biased condition in third Quadrant.
4. Repeat the same procedure for plotting the Germanium characteristics.



Calculations from Graph:

Static forward Resistance

$R_{dc} = V_f / I_f \Omega$

Dynamic Forward Resistance

$r_{ac} = \Delta V_f / \Delta I_f \Omega$

Static Reverse Resistance

$R_{dc} = V_r / I_r \Omega$

Dynamic Reverse Resistance

$r_{ac} = \Delta V_r / \Delta I_r \Omega$

Precautions:

1. While doing the experiment do not exceed the readings of the diode. This may lead to damaging of the diode.
2. Connect voltmeter and ammeter in correct polarities as shown in the circuit diagram.
3. Do not switch ON the power supply unless you have checked the circuit connections as per the circuit diagram.

Results:

Cut in voltage = _______________ V

Static Forward Resistance = _______________ Ω

Dynamic Forward Resistance = _______________ Ω

Static Reverse Resistance = _______________ Ω

Dynamic Reverse Resistance = _______________ Ω

Volt-Ampere Characteristics of Silicon P-N Diode are studied.

Viva Questions:

1. What are trivalent and pentavalent impurities?

Ans: Doping is the process of adding impurity atoms to intrinsic silicon or germanium to improve the conductivity of the semiconductor.

Commonly Used Doping Elements

Trivalent Impurities to make p-Type: Aluminum (Al), Gallium (Ga), Boron(B) and Indium (In).

Pentavalent Impurities to make n-type: Phosphorus (P), Arsenic (As), Antimony (Sb) and Bismuth (Bi).

2. How PN junction diode does acts as a switch?

Ans: Apply voltage in one direction; it acts like an open circuit. Reverse the polarity of the voltage and it acts like a short circuit.

3. Diode current equation?

Ans: $I = I_S(e^{V_D/(\eta V_T)} - 1)$

4. What is the value of V_t at room temperature?

Ans: 25mV

5. Dynamic resistance expression?

Ans: $r_d = \Delta V / \Delta I$

EXPERIMENT NO:3

CHARACTERISTICS OF SEMICONDUCTORS ZENER DIODE

Aim:

1. To plot Volt-Ampere Characteristics of Zener Diode.
2. To find Zener break down voltage in reverse biased conditions.
3. To study the operation of Zener Diode as a voltage shunt regulator.

Components:

Name	Quantity
Zener Diodes 1N4735A/ FZ 6.2	1
Resistor 1KΩ	1

Equipments:

Name	Range	Quantity
Bread board		1
Regulated power supply	0-30V	1
Digital Ammeter	200mA	1
Digital Voltmeter	0-20V	1
Decade Resistance Box		1
Connecting Wires		

Specifications:

Breakdown Voltage = 5.1V

Power dissipation = 0.75W

Max Forward Current = 1A

Theory:

Zener diode is a heavily doped Silicon diode. An ideal P-N junction diode does not conduct in reverse biased condition. A Zener diode conducts excellently even in reverse biased condition. These diodes operate at a precise value of voltage called break down voltage.

A Zener diode when forward biased behaves like an ordinary P-N junction diode.

A Zener diode when reverse biased can undergo avalanche break down or zener break down.

Avalanche Break down:

If both p-side and n-side of the diode are lightly doped, depletion region at the junction widens. Application of a very large electric field at the junction may rupture covalent bonding between electrons. Such rupture leads to the generation of a large number of charge carriers resulting in Avalanche Breakdown.

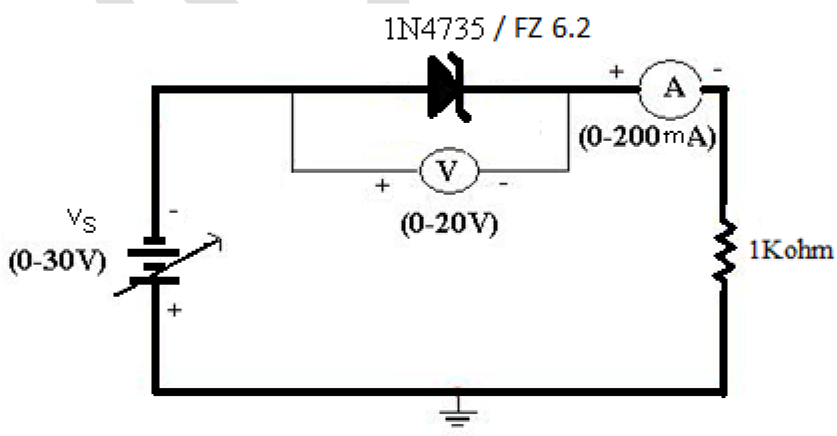
Zener Break down:

If both p-side and n-side of the diode are heavily doped, depletion region at the junction reduces. Application of even a small voltage at the junction may rupture covalent bonding and generate large number of charge carriers. Such sudden increase in the number of charge carriers results in zener mechanism.

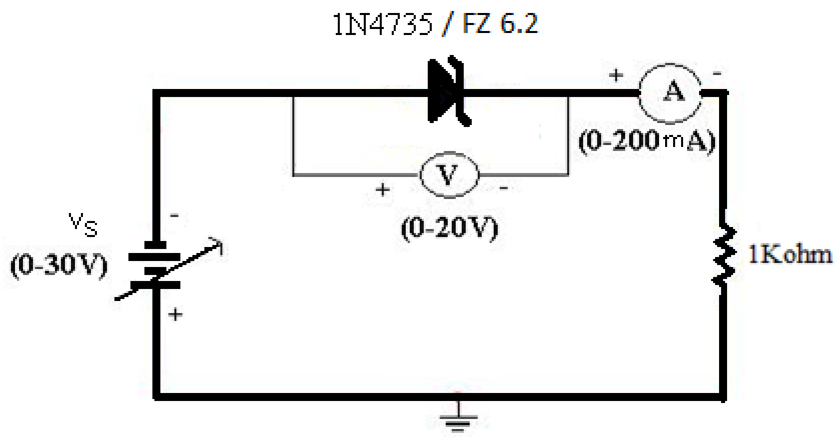
Regulator:

It is an electronic circuit that can provide a stable DC voltage irrespective of variations in the supply voltage, load current and temperature. A Zener diode can be used as a regulator.

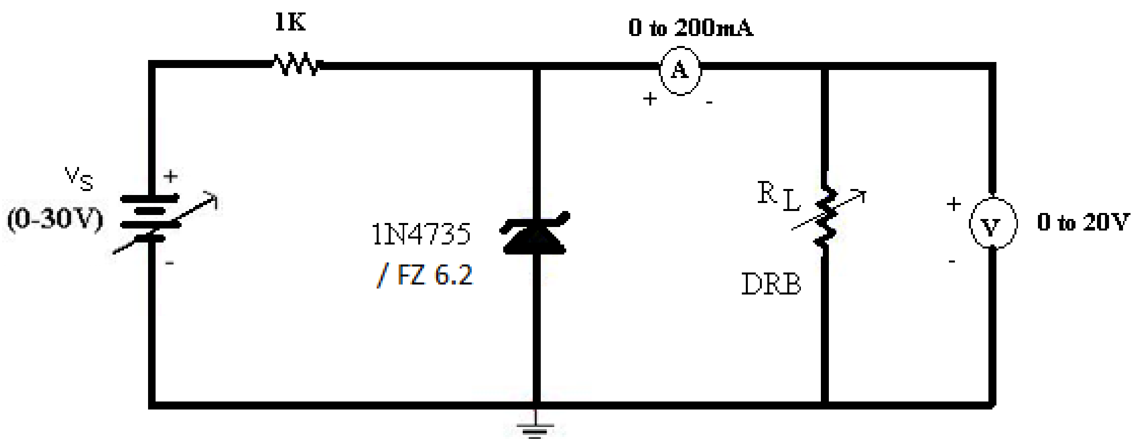
Circuit Diagram:



Fig(1)- Forward Bias Condition:



Fig(2)- Reverse Bias Condition:



Fig(3)- Zener Diode Regulator : Line Regulation and Load Regulation

Procedure:

Forward Bias Condition:

1. Connect the circuit as shown in figure (1).
2. Vary V_F gradually from 0 to 0.6 V in steps of 0.1 V and in steps of 0.02 V from 0.6 to 0.76 V. In each step record the current flowing through the diode as I_F.
3. Tabulate different forward currents obtained for different forward voltages.

Reverse Bias Condition:

1. Connect the Zener diode in reverse bias as shown in the figure (2). Vary the voltage across the diode in steps of 1V from 0 V to 6 V and in steps 0.1 V till its breakdown voltage is reached. In each step note the current flowing through the diode

2. Plot a graph between V and I . This graph will be called the V-I characteristics of Zener diode. From the graph find out the breakdown voltage for the diode.

Line regulation Characteristics:

1) Connect the circuit as shown in figure-3. Use a Decade Resistance Box (DRB) in place of the load.
2) Select load resistance as 1 KΩ . Vary the supply voltage in steps of 1 volt from 0 to 15 volt and in each step note down the corresponding value of load voltage (V_L).
3) Plot a graph between the supply voltage V_S and the output voltage V_L. This graph is called the line regulation characteristics.

Load regulation characteristics:

1) Connect the circuit as shown in figure-3. Use a Decade Resistance Box(DRB) in place of the load.
2) Set the supply voltage to 12 V and adjust the load current to 0 mA by keeping the resistance in the DRB at its maximum value.
3) Vary load resistance such that the load current(I_L) is increased in steps of 1 mA from 0 mA to 10 mA and note the voltage at the output(V_L). The supply voltage must be maintained constant at 12 V.
4) Plot a graph between the load current I_L and the output voltage V_L. This graph is called the load regulation characteristics.

Observations:

Forward Bias Condition:

S.No.	Forward Voltage across the diode V_F (volts)	Forward Current through the diode I_F (mA)

Reverse Bias Condition:

S.No.	Reverse Voltage across the diode V_R (volts)	Reverse Current through the diode I_R (mA)

b) Line regulation characteristics:

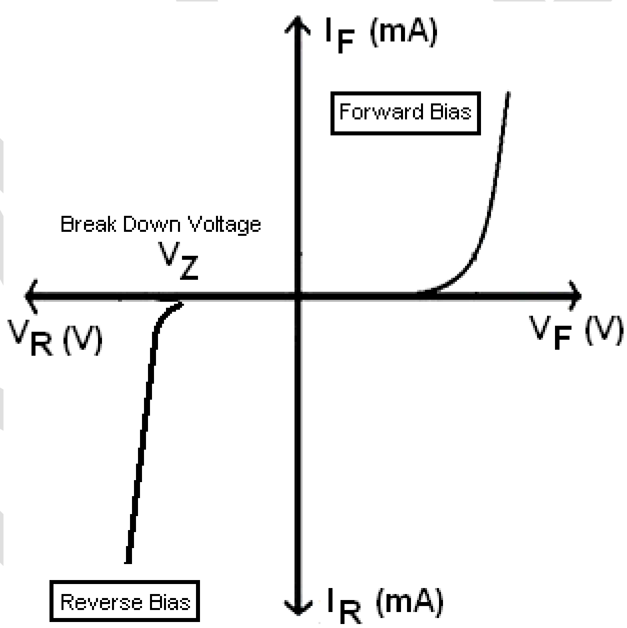
S. No.	V_S(Volt)	V_L(volt)

c) Load regulation characteristics:

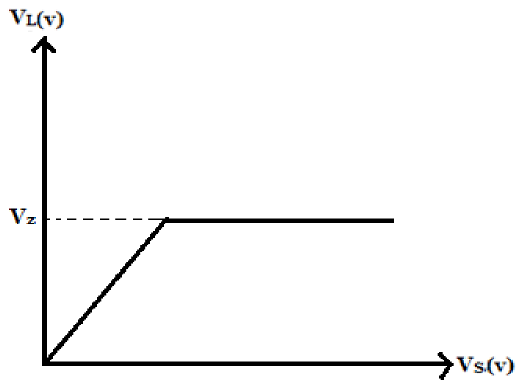
S. No.	I_L (mA)	V_L(volt)

Graph:

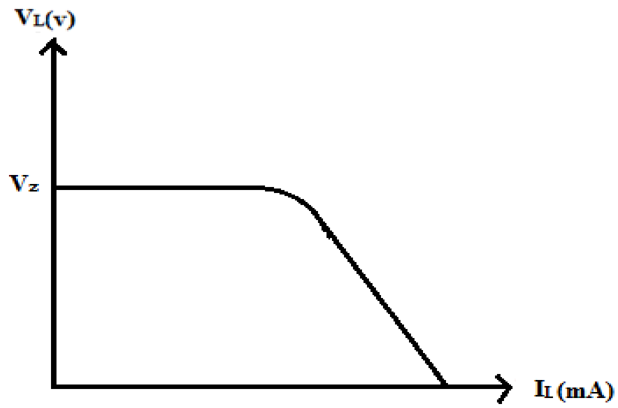
1. Take a graph sheet and divide it into 4 equal parts. Mark origin at the center of the graph sheet.
2. Now mark +ve X-axis as V_F, -ve X-axis as V_R, +ve Y-axis as I_F and –ve Y-axis as I_R.
3. Mark the readings tabulated for forward biased condition in first Quadrant and reverse biased condition in third Quadrant.



Fig(4).VI Characteristics of Zener Diode



Fig(5). Line Regulation



Fig(6). Load Regulation

Calculations from Graph:

Precautions:

1. While doing the experiment do not exceed the readings of the diode. This may lead to damaging of the diode.
2. Connect voltmeter and ammeter in correct polarities as shown in the circuit diagram.
3. Do not switch ON the power supply unless you have checked the circuit connections as per the circuit diagram.

Result:

1. The Zener Diode Characteristics have been studied.
2. The breakdown voltage of Zener diode in reverse bias was found to be = _____
3. Zener Diode as a shunt voltage regulator is studied.

Viva Questions:

1. What is the difference between p-n Junction diode and zener diode?

Ans: A zener is designed to operate stably in reverse breakdown, which is designed to be at a low voltage, between 3 volts and 200 volts. The breakdown voltage is specified as a voltage with a tolerance, such as 10 volts ±5%, which means the breakdown voltage (or operating voltage) will be between 9.5 volts and 10.5 volts.

A signal diode or rectifier will have a high reverse breakdown, from 50 to 2000 volts, and is NOT designed to operate in the breakdown region. So exceeding the reverse voltage may result in the device being damaged. In addition, the breakdown voltage is specified as a minimum only.

Forward characteristics are similar to both, although the zener's forward characteristics is usually not specified, as the zener will never be used in that region. A signal diode or rectifier has the forward voltage specified as a max voltage at one or more current levels.

2. What is break down voltage?

Ans: The breakdown voltage of a diode is the minimum reverse voltage to make the diode conduct in reverse.

3. What are the applications of Zener diode?

Ans: Zener diodes are widely used as voltage references and as shunt regulators to regulate the voltage across small circuits.

4. What is cut-in-voltage ?

Ans: The forward voltage at which the current through the junction starts increasing rapidly, is called the knee voltage or cut-in voltage. It is generally 0.6v for a Silicon diode.

5. What is voltage regulator?

Ans: A voltage regulator is an electronic circuit that provides a stable dc voltage independent of the load current, temperature and ac line voltage variations

EXPERIMENT NO: 4

STATIC CHARACTERISTICS OF BJT- COMMON EMITTER

Aim:

1. To plot the Characteristics of a BJT in Common Emitter Configuration.
2. To measure the h-parameters of a BJT in Common Emitter Configuration.

Components:

Name	Quantity
Transistor BC 107	1
Resistor 1KΩ	1

Equipment:

Name	Range	Quantity
Bread Board		1
Regulated power supply	0-30V	2
Digital Ammeter	0-200mA/0-200µA	1
Digital Voltmeter	0-20V	2
Connecting Wires		

Specifications:

For Transistor BC 107:

- Max Collector Current= 0.1A
- V_{ceo} max= 50V
- V_{EB0} = 6V
- V_{CB0} = 50V
- Collector power dissipation = 500mW
- Temperature Range = -65 to +150 ^{0}C
- h_{fe} = 110 - 220

Theory:

A BJT is called as Bipolar Junction Transistor and it is a three terminal active device which has emitter, base and collector as its terminals. It is called as a bipolar device because the flow of current through it is due to two types of carriers i.e., majority and minority carriers.

A transistor can be in any of the three configurations viz, Common base, Common emitter and Common Collector.

The relation between **, β , γ of CB, CE, CC are**

$$\boldsymbol{\alpha = \frac{\beta}{1+\beta} \qquad \beta = \frac{\alpha}{1-\alpha} \qquad \gamma = 1 + \beta = \frac{1}{1-\alpha}}$$

In CE configuration base will be input node and collector will be the output node .Here emitter of the transistor is common to both input and output and hence the name common emitter configuration.

The collector current is given as

$$I_C = \beta I_B + (1 + \beta) I_{CO}$$

Where I_{CO} is called as reverse saturation current

A transistor in CE configuration is used widely as an amplifier. While plotting the characteristics of a transistor the input voltage and output current are expressed as a function of input current and output voltage.

i.e, $V_{BE} = f(I_B, V_{CE})$ and

$I_C = f(I_B, V_{CE})$

Transistor characteristics are of two types.

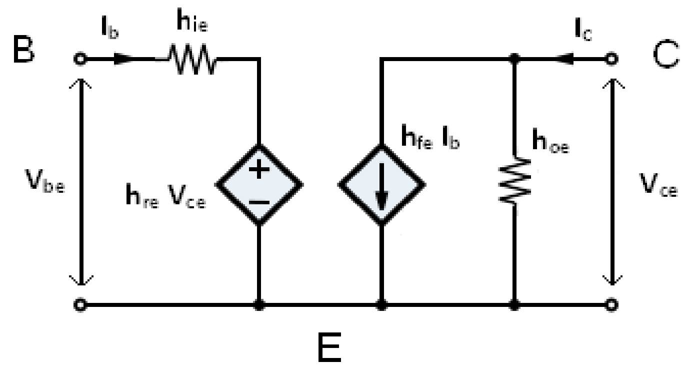
Input characteristics:- Input characteristics are obtained between the input current and input voltage at constant output voltage. It is plotted between V_{BE} and I_B at constant V_{CE} in CE configuration

Output characteristics:- Output characteristics are obtained between the output voltage and output current at constant input current. It is plotted between V_{CE} and I_C at constant I_B in CE configuration

The different regions of operation of the BJT are

J_E	J_C	REGION	APPLICATION
RB	RB	CUTT OFF	OFF SWITCH
FB	FB	SATURATION	ON SWITCH
FB	RB	ACTIVE	AMPLIFIER
RB	FB	REVERSE ACTIVE	ATTENUATOR

The Hybrid model of BJT and its typical values are as shown



Parameter	Typical value
h_{ie}	1.1 K Ω
h_{re}	250 ▯
h_{fe}	50
h_{oe}	25 ▯℧

The basic circuit diagram for studying input and output characteristics is shown in the circuit diagrams.

Circuit Diagram:

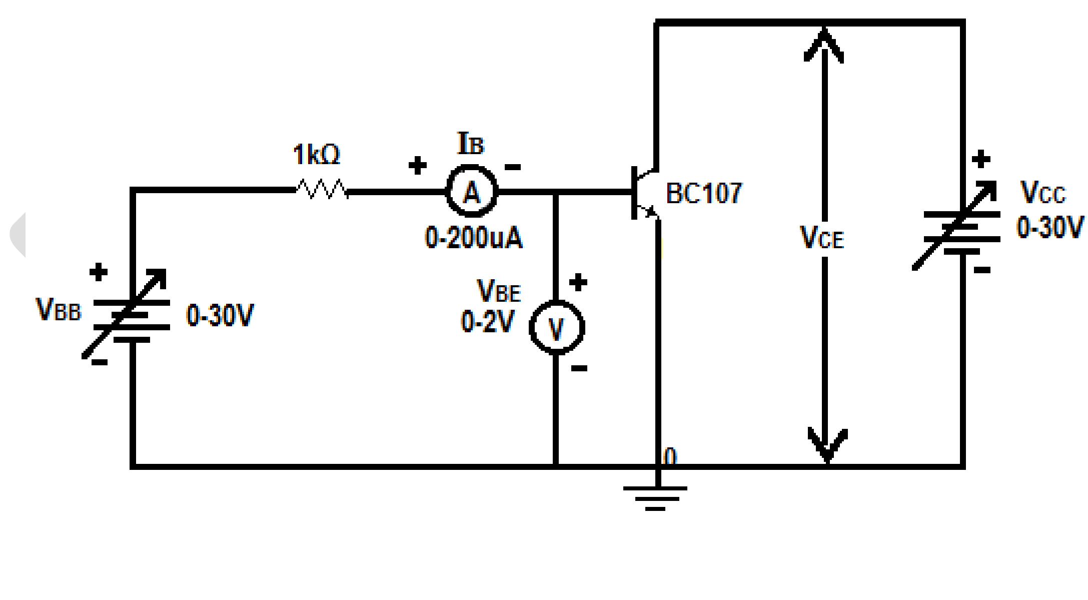


Fig.(1) - Input Characteristics:

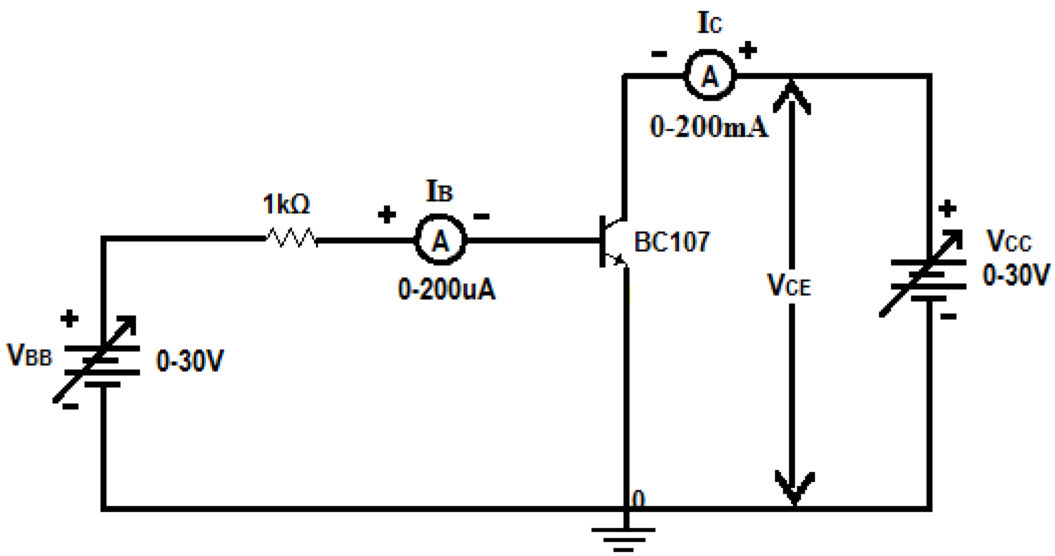
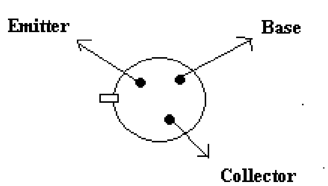


Fig. (2) - Output Characteristics

Pin assignment of Transistor:



Procedure:

Input Characteristics:

1) Connect the circuit as shown in fig.(1). Adjust all the knobs of the power supply to their minimum positions before switching the supply on.
2) Adjust the V_{CE} to 0 V by adjusting the supply V_{CC}.
3) Vary the supply voltage V_{BB} so that V_{BE} varies in steps of 0.1 V from 0 to 0.5 V and then in steps of 0.02 V from 0.5 to 0.7 V. In each step note the value of base current I_B.
4) Adjust V_{CE} to 1, 2V and repeat step-3 for each value of V_{CE}.
5) Plot a graph between V_{BE} and I_B for different values of V_{CE}. These curves are called input characteristics

Output Characteristics:

1) Connect the circuit as shown in fig. (2). All the knobs of the power supply must be at the minimum position before the supply is switched on.
2) Adjust the base current I_B to 20 µA by adjusting the supply V_{BB}.
3) Vary the supply voltage V_{CC} so that the voltage V_{CE} varies in steps of 0.2 V from 0 to 2 V and then in steps of 1 V from 2 to 10 V. In each step the base current should be adjusted to the present value and the collector current I_C should be recorded.
4) Adjust the base current at 40, 60 µA and repeat step-3 for each value of I_B.
5) Plot a graph between the output voltage V_{CE} and output current I_C for different values of the input current I_B. These curves are called the output characteristics.

Observations:

Table .(1) Input Characteristics

V_{CE} = 0V		V_{CE} = 5V	
V_{BE}(V)	**I_B(µA)**	**V_{BE}(V)**	I_B(µA)

Table.(2) Output Characteristics

I_B = 20µA		I_B = 40µA		I_B = 60µA	
V_{CE}(V)	**I_C(mA)**	**V_{CE}(V)**	**I_C(mA)**	**V_{CE}(V)**	**I_C(mA)**

Graph:

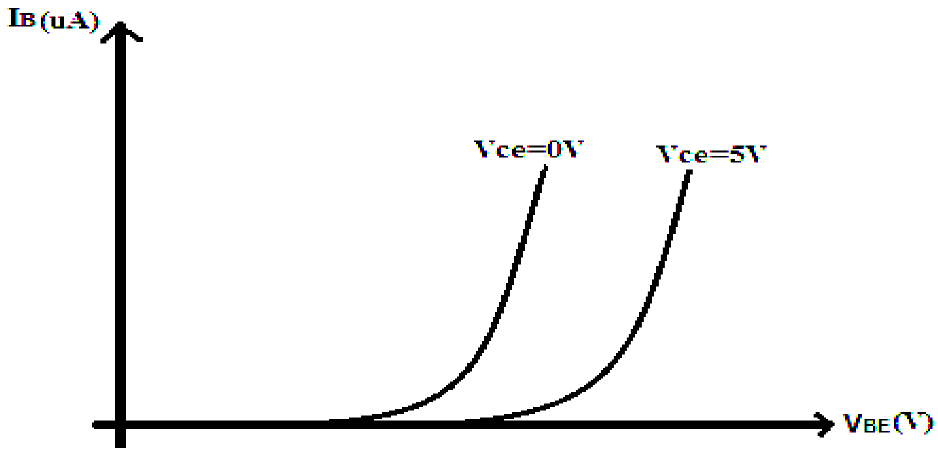


Fig.(3). Input Characteristics

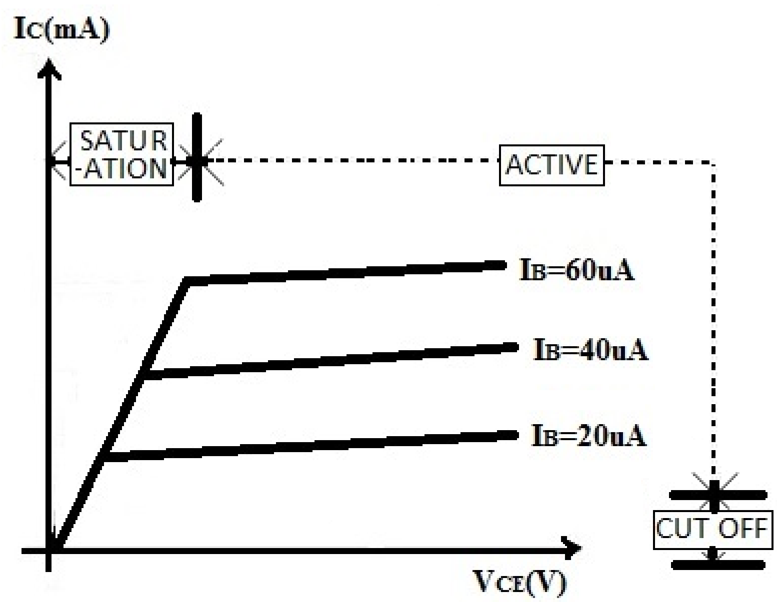


Fig.(4). Output Characteristics

<u>Calculations from Graph:</u>

1. **Input Impedance (h_{ie}):** It is ratio of input base voltage (V_{BE}) to the change in input base current(I_B) with the output collector voltage (V_{CE}) kept constant. It is the slope of the input characteristics I_B vs V_{BE} .

Therefore, $$hie = \frac{\Delta V_{BE}}{\Delta I_B}, \; V_{CE}\ \text{Constant} \quad (\Omega)$$

2. **Reverse voltage gain (h_{re}) :**It is the ratio of the change in the input base voltage (V_{BE}) and the corresponding change in output collector(I_C) voltage with constant input base current(I_B).It is the slope of V_{BE} vs V_{CE} curve.

Therefore, $$hre = \frac{\Delta V_{BE}}{\Delta V_{CE}}, \; I_B\ \text{constant}$$

3.Forward Current Gain (h_{fe}): It is the ratio of the change in the output collector current(I_C) to the corresponding change in the input base current (I_B) keeping output collector voltage (V_{CE}) constant. It is the slope of Ic vs I_B curve .

Therefore, $$hfe = \frac{\Delta Ic}{\Delta I_B}, \; V_{CE}\ \text{Constant}$$

4.Output Admittance (h_{oe}): It is the ratio of change in the output collector current (I_c) to the corresponding change in the output collector voltage(V_{CE}) with the input base current (I_B) kept constant. It is the slope of the output characteristics V_{CE} vs I_c

Therefore, $$hoe = \frac{\Delta Ic}{\Delta V_{CE}}, \; I_B\ \text{constant} \quad (\mho)$$

Inference:

1. Medium input and output resistances.
2. Smaller values if $\mathbf{V_{CE}}$ comes earlier cut-in-voltage.
3. Increase in the value of $\mathbf{I_B}$ causes saturation of the transistor of an earlier voltage.

Precautions:

1. While performing the experiment do not exceed the ratings of the transistor. This may lead to damage the transistor.
2. Connect voltmeter and ammeter in correct polarities as shown in the circuit diagram.

3. Do not switch ON the power supply unless you have checked the circuit connections as per the circuit diagram.
4. Make sure while selecting the emitter, base and collector terminals of the transistor.

Results:

1. Input and output Characteristics of a BJT in Common Emitter Configuration are studied.
2. Measured the h-parameters of a BJT in Common Emitter Configuration.

Viva Questions:

1. Can we replace transistor by two back to back connected diodes?

Ans: No, because the doping levels of emitter(heavily doped), base(lightly doped) and collector(doping level greater than base and less than emitter) terminals are different from p and n terminals in diode.

2. For amplification CE is preferred, why?

Ans: Because amplification factor beta is usually ranges from 20-500 hence this configuration gives appreciable current gain as well as voltage gain at its output on the other hand in the Common Collector configuration has very high input resistance(~750KΩ) & very low output resistance(~25Ω) so the voltage gain is always less than one & its most important application is for impedance matching for driving from low impedance load to high impedance source

3. To operate a transistor as amplifier, emitter junction is forward biased and collector junction is reverse biased, why?

Ans: Voltage is directly proportional to Resistance. Forward bias resistance is very less compared to reverse bias. In amplifier input forward biased and output reverse biased so voltage at output increases with reverse bias resistance.

4. Which transistor configuration provides a phase reversal between the input and output signals?

Ans: Common emitter configuration (180 DEG)

5. What is the range if β?

Ans: Beta is usually ranges from 20-500

EXPERIMENT NO: 5

STATIC CHARACTERISTICS OF BJT- COMMON BASE

Aim:

1. To study the input and output characteristics of a transistor in common base configuration.

Components:

Name	Quantity
Transistor BC 107	1
Resistor 1KΩ	1

Equipment:

Name	Range	Quantity
Bread board		1
Regulated power supply	0-30V	1
Digital Ammeter	200mA	1
Digital Voltmeter	0-20V	1
Connecting Wires		1

Specifications:

Transistor BC 107:

- Max Collector Current= 0.1A
- V_{ceo} max= 50V
- V_{EB0} = 6V
- V_{CB0} = 50V
- Collector power dissipation = 500mW
- Temperature Range = -65 to +150 ^{0}C
- h_{fe} = 110 - 220

Theory:

Bipolar Junction Transistor (BJT) is a three terminal (emitter, base, collector) semiconductor device. There are two types of semiconductors namely NPN and PNP. It consists of two PN junctions namely emitter junction and collector junction. Based on biasing of these junctions the different regions of operation of the BJT are

J_E	J_C	REGION	APPLICATION
RB	RB	CUTT OFF	OFF SWITCH
FB	FB	SATURATION	ON SWITCH
FB	RB	ACTIVE	AMPLIFIER
RB	FB	REVERSE ACTIVE	ATTENUATOR

The collector current equation is given as

$$I_C = \alpha I_E + I_{CO}$$

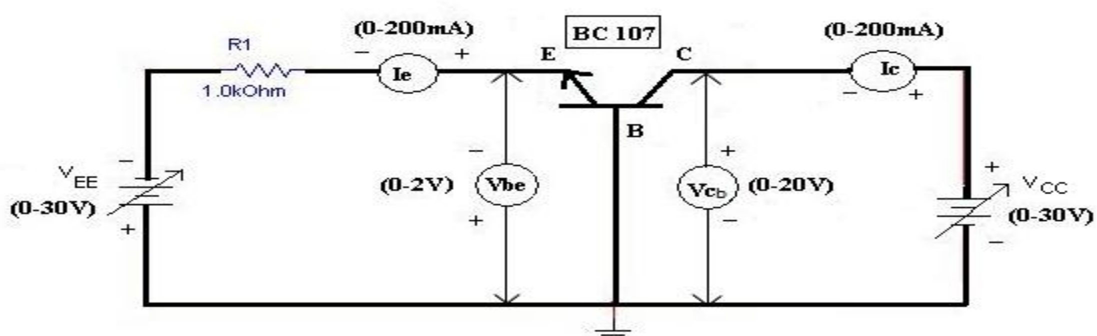
Where I_{CO} is called as reverse saturation current

The relation between **α, β , γ of CB, CE, CC are**

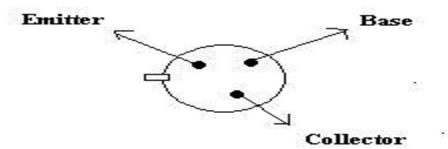
$$\boldsymbol{\alpha = \frac{\beta}{1+\beta} \qquad \beta = \frac{\alpha}{1-\alpha} \qquad \gamma = 1 + \beta = \frac{1}{1-\alpha}}$$

The basic circuit diagram for studying input characteristics is shown in the figure. The input is applied between emitter and base, the output is taken from collector and base. Here base of the transistor is common to both input and output and hence the name common base configuration. Input characteristics are obtained between the input current and input voltage at constant output voltage. It is plotted between $\mathbf{V}_{EE}$ and $\mathbf{I}_E$ at constant $\mathbf{V}_{CB}$ in CB configuration. Output characteristics are obtained between the output voltage and output current at constant input current. It is plotted between $\mathbf{V}_{CB}$ and $\mathbf{I}_C$ at constant $\mathbf{I}_E$ in CB configuration.

<u>Circuit Diagram:</u>



Pin assignment of Transistor:



Procedure:

Input Characteristics:

1. Connect the circuit as shown in the circuit diagram.
2. Keep output voltage V_{CB} = 0V by varying the RPS .
3. Varying V_{EE} gradually, note down emitter current I_E and emitter-base voltage(V_{BE}).
4. Repeat above procedure (step 3) for V_{CB} = 10V.

Output Characteristics:

1. Connect the circuit as shown in the circuit diagram.
2. Keep emitter current I_E = 2mA by varying V_{EE}.
3. Varying V_{CC} gradually, note down collector current I_C and collector-base voltage(V_{CB}).
4. Repeat above procedure (step 3) for I_E = 4mA, 8 mA .
5.

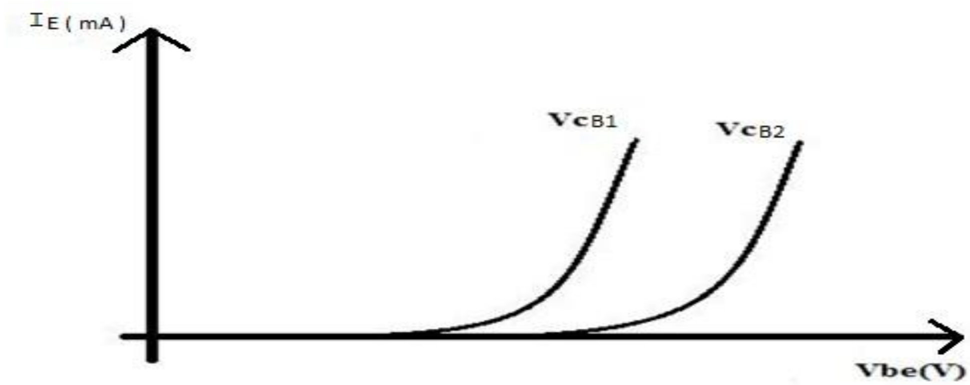
Observations:

Input Characteristics			
V_{CB} = 0V		V_{CB} = 10V	
V_{EE}(V)	I_E(mA)	V_{EE}(V)	I_E(mA)

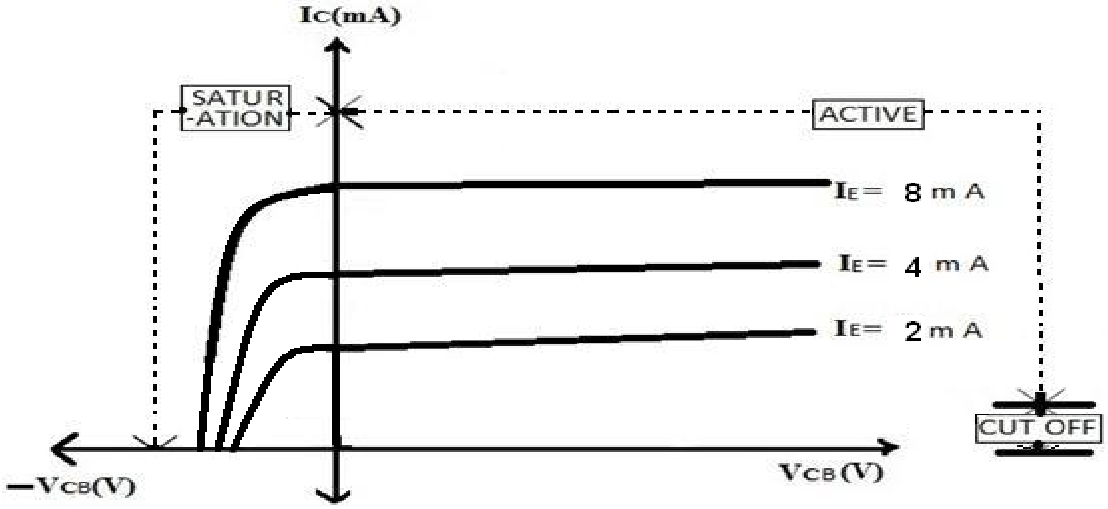
Output Characteristics					
I_E = 2mA		I_E = 4mA		I_E = 8mA	
V_{CB}(V)	I_C(mA)	V_{CB}(V)	I_C(mA)	V_{CB}(V)	I_C(mA)

Expected Waveform

Input Characteristics:



Output Characteristics:



1. Plot the input characteristics for different values of V_{CB} by taking V_{EE} on X-axis and I_E on Y-axis.
2. Plot the output characteristics by taking V_{CB} on X-axis and taking I_C on Y-axis taking I_E as a parameter.

Calculations from Graph:

1. **Input Characteristics:** To obtain input resistance find ΔV_{EE} and ΔI_E for a constant V_{CB} on one of the input characteristics.

$$R_i = \frac{\Delta V_{EE}}{\Delta I_E}(V_{CB} = constant)$$

2. **Output Characteristics:** To obtain output resistance find ΔI_C and ΔV_{CB} at a constant I_E.

$$R_o = \frac{\Delta V_{CB}}{\Delta I_c}(I_E = constant)$$

Results:

Input and Output characteristics of a Transistor in Common Base Configuration are studied.

R_i has been found out to be ___________.

Ro has been found out to be __________.

Viva Questions:

1. What is transistor?

Ans: A transistor is a semiconductor device used to amplify and switch electronic signals and electrical power. It is composed of semiconductor material with at least three terminals for connection to an external circuit. The term transistor was coined by John R. Pierce as a portmanteau of the term "transfer resistor".

2. Write the relation between α**,** β and γ**?**

Ans: $\alpha = \frac{\beta}{1+\beta}$ $\beta = \frac{\alpha}{1-\alpha}$ $\gamma = 1 + \beta = \frac{1}{1-\alpha}$

3. What is the range of α **?**

Ans: The important parameter is the common-base current gain, α. The common-base current gain is approximately the gain of current from emitter to collector in the forward-active region. This ratio usually has a value close to unity; between 0.98 and 0.998.

4. Why is α **is less than unity?**

Ans: It is less than unity due to recombination of charge carriers as they cross the base region.

5. Input and output impedance equations for CB configuration?

Ans: $h_{ib}=V_{EB}/I_E$, $1/h_{ob}=V_{CB}/I_C$

EXPERIMENT NO: 6

STATIC CHARACTERISTICS OF FET

Aim:

1.To study Drain Characteristics and Transfer Characteristics of a Junction Field Effect Transistor (JFET).

2.To measure drain resistance, transconductance and amplification factor.

Components:

Name	Quantity
JFET BFW 11	1
Resistor 1MΩ	1

Equipment:

Name	Range	Quantity
Bread Board		1
Regulated power supply	0-30V	1
Digital Ammeter	0-200mA	1
Digital Voltmeter	0-20V	2
Connecting Wires		

Specifications:

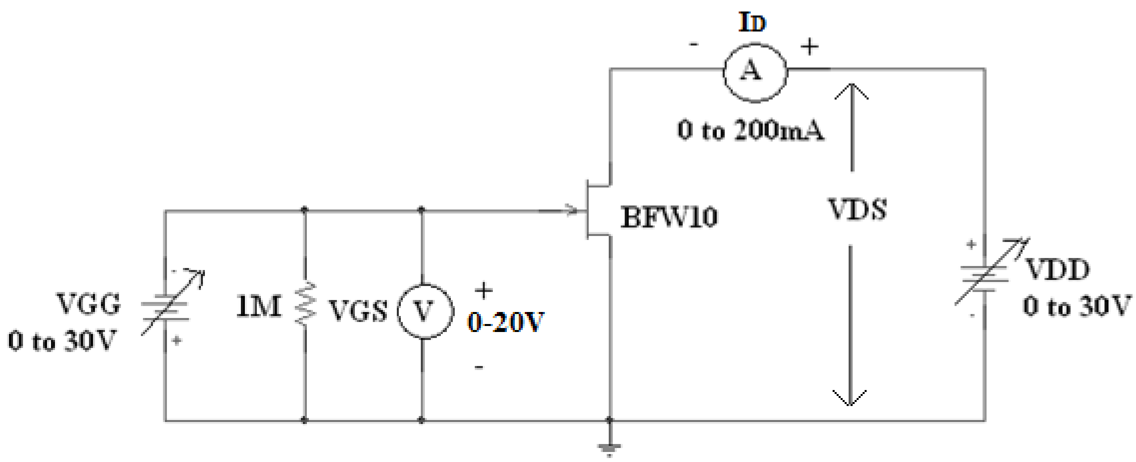
For FET BFW11:

Gate Source Voltage V_{GS} = -30V

Forward Gain Current I_{GF} = 10mA

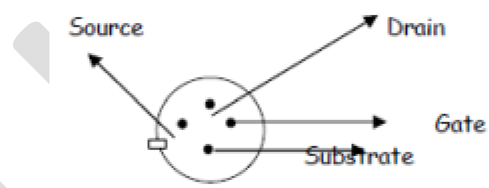
Maximum Power Dissipation P_D = 300mW

Circuit Diagram:



Fig(1).Characteristics of FET

Pin assignment of FET:



Theory:

A JFET is called as Junction Field effect transistor.

It is called a unipolar device because the flow of current through it is due to one type of carriers i.e., majority carriers where as a BJT is a Bi - Polar device, It has 3 terminals Gate, Source and Drain. A JFET can be used in any of the three configurations viz, Common Source, Common Gate and Common Drain.

The input gate to source junction should always be operated in reverse bias, hence input resistance $R_i = \infty$, $I_G \approx 0$.

Pinch off voltage V_P is defined as the gate to source reverse bias voltage at which the output drain current becomes zero.

In CS configuration Gate is used as input node and Drain as the output node. A JFET in CS configuration is used widely as an amplifier. A JFET amplifier is preferred over a BJT amplifier when the demand is for smaller gain, high input resistance and low output resistance. Any FET operation is governed by the following equation.

The drain current equation and trans conductance is given as

$$I_D = I_{DSS} \left(1 - \frac{V_{GS}}{V_P}\right)^2$$

$$g_m = \frac{\partial I_D}{\partial V_{GS}} = \frac{2}{|v_p|} \sqrt{I_D \, I_{DSS}}$$

Where I_{DSS} is called as Drain to Source Saturation current

V_p is called as the Pinch off voltage

The basic circuit diagram for studying drain and transfer characteristics is shown in the circuit diagram.

1. Transfer characteristics are obtained between the gate to source voltage (V_{GS}) and drain current (I_D) taking drain to source voltage (V_{DS}) as the parameter.
2. Drain characteristics are obtained between the drain to source voltage (V_{DS}) and drain current (I_D) taking gate to source voltage (V_{GS}) as the parameter.

Procedure:

Transfer Characteristics:

1) Connect the circuit as shown. All the knobs of the power supply must be at the minimum position before the supply is switched on.
2) Adjust the output voltage V_{DS} to 4V by adjusting the supply V_{DD}.
3) Vary the supply voltage V_{GG} so that the voltage V_{GS} varies in steps of -0.25 V from 0 V onwards. In each step note the drain current I_D. This should be continued till I_D becomes zero.
4) Repeat above step for V_{DS} = 8 V.
5) Plot a graph between the input voltage V_{GS} and output current I_D for output voltage V_{DS} in the second quadrant. This curve is called the transfer characteristics.

Drain Characteristics:

1) Connect the circuit as shown in figure. Adjust all the knobs of the power supply to their minimum positions before switching the supply on.
2) Adjust the input voltage V_{GS} to 0 V by adjusting the supply $V_{GG.}$
3) Vary the supply voltage V_{DD} so that V_{DS} varies in steps of 0.5 V from 0 to 4 V and then in steps of 1 V from 4 to 10 V. In each step note the value of drain current I_D.
4) Adjust V_{GS} to -1 and -2 V and repeat step-3 for each value of $V_{GS.}$

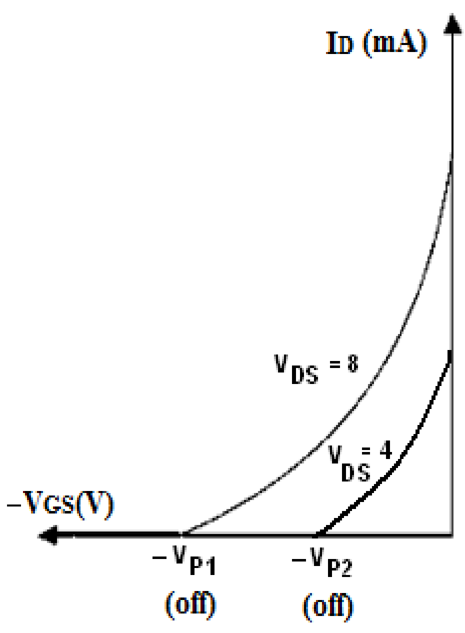
5) Plot a graph between V_{DS} and I_D for different values of V_{GS}. These curves are called drain characteristics.
6) Mark the various regions in the drain characteristics graph and calculate the drain resistance.

Observations:

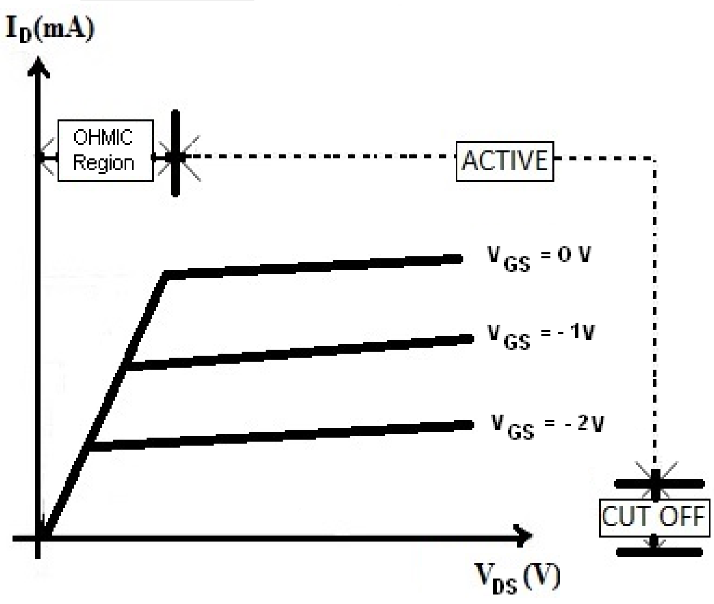
Transfer Characteristics			
V_{DS} = 4V		V_{DS} = 8V	
V_{GS}(V)	I_D(mA)	V_{GS}(V)	I_D(mA)

Drain Characteristics					
V_{GS} = 0V		V_{GS} = -1V		V_{GS} = -2V	
V_{DS}(V)	I_D(mA)	V_{DS}(V)	I_D(mA)	V_{DS}(V)	I_D(mA)

Graph



Transfer Characteristics



Drain Characteristics

1. Plot the drain characteristics by taking V_{DS} on X-axis and I_D on Y-axis at a constant V_{GS}.
2. Plot the transfer characteristics by taking V_{GS} on X-axis and taking I_D on Y-axis at constant V_{DS}.

Calculations from Graph:

1. **Drain Resistance (r_d):** It is given by the relation of small change in drain to source voltage(ΔV_{DS}) to the corresponding change in Drain Current(ΔI_D) for a constant gate to source voltage (ΔV_{GS}), when the JFET is operating in pinch-off region.
2. **Trans Conductance (gm):** Ratio of small change in drain current(ΔI_D) to the corresponding change in gate to source voltage (ΔV_{GS}) for a constant V_{DS}.

gm $= \frac{\Delta I_D}{\Delta V_{GS}}$ at constant V_{DS} (from transfer characteristics).

The value of **gm** is expressed in mho's ($\mho$) or Siemens (**s**).

3. **Amplification factor (μ):** It is given by the ratio of small change in drain to source voltage (ΔV_{DS}) to the corresponding change in gate to source voltage (ΔV_{GS}) for a constant drain current (I_D).

$$\mu = \left(\frac{\Delta V_{DS}}{\Delta I_D}\right) * \left(\frac{\Delta I_D}{\Delta V_{GS}}\right) = \frac{\Delta V_{DS}}{\Delta V_{GS}} = r_d * gm$$

Inference:

1. As the gate to source voltage (V_{GS}) is increased above zero, pinch off voltage is increased at a smaller value of drain current as compared to that when $V_{GS} = 0V$.
2. The value of drain to source voltage (V_{DS}) is decreased as compared to that when $V_{GS} = 0V$.

Precautions:

1. While performing the experiment do not exceed the ratings of the FET. This may lead to damage the FET.
2. Connect voltmeter and ammeter in correct polarities as shown in the circuit diagram.
3. Do not switch ON the power supply unless you have checked the circuit connections as per the circuit diagram.
4. Make sure while selecting the Source, Drain and Gate terminals of the transistor.

Results:

1. Drain Characteristics and Transfer Characteristics of a Field Effect Transistor are studied (FET).

2. Measured drain resistance, transconductance and amplification factor.

Viva Questions:

1. Why FET is called a Unipolar device?

Ans: FETs are unipolar transistors as they involve single-carrier-type operation.

2. What are the advantages of FET?

Ans: The main advantage of the FET is its high input resistance, on the order of 100 MΩ or more. Thus, it is a voltage-controlled device, and shows a high degree of isolation between input and output. It is a unipolar device, depending only upon majority current flow. It is less noisy. and is thus found in FM tuners and in low-noise amplifiers for VHF and satellite receivers. It is relatively immune to radiation. It exhibits no offset voltage at zero drain current and hence makes an excellent signal chopper. It typically has better thermal stability than a bipolar junction transistor (BJT)

3. What is transconductance?

Ans: Trasconductance is an expression of the performance of a bipolar transistor or field-effect transistor (FET). In general, the larger the transconductance figure for a device, the greater the gain(amplification) it is capable of delivering, when all other factors are held constant. The symbol for transconductance is gm. The unit is siemens, the same unit that is used for direct-current (DC) conductance.

4. What are the disadvantages of FET?

Ans: It has a relatively low gain-bandwidth product compared to a BJT. The MOSFET has a drawback of being very susceptible to overload voltages, thus requiring special handling during installation.The fragile insulating layer of the MOSFET between the gate and channel makes it vulnerable to electrostatic damage during handling. This is not usually a problem after the device has been installed in a properly designed circuit.

5. Relation between μ, g_m and r_d?

Ans: $\mu = g_m * r_d$

EXPERIMENT NO: 7

STUDY OF CRO AND MEASUREMENT OF VOLTAGE AMPLITUDE & FREQUENCY

Aim: Study of CRO and to find the Amplitude and Frequency using CRO.

Components and Equipments Required: Cathode-ray oscilloscope, Function Generator, CRO Probes and Bread Board

Theory:

An outline explanation of how an oscilloscope works can be given using the block diagram shown below:

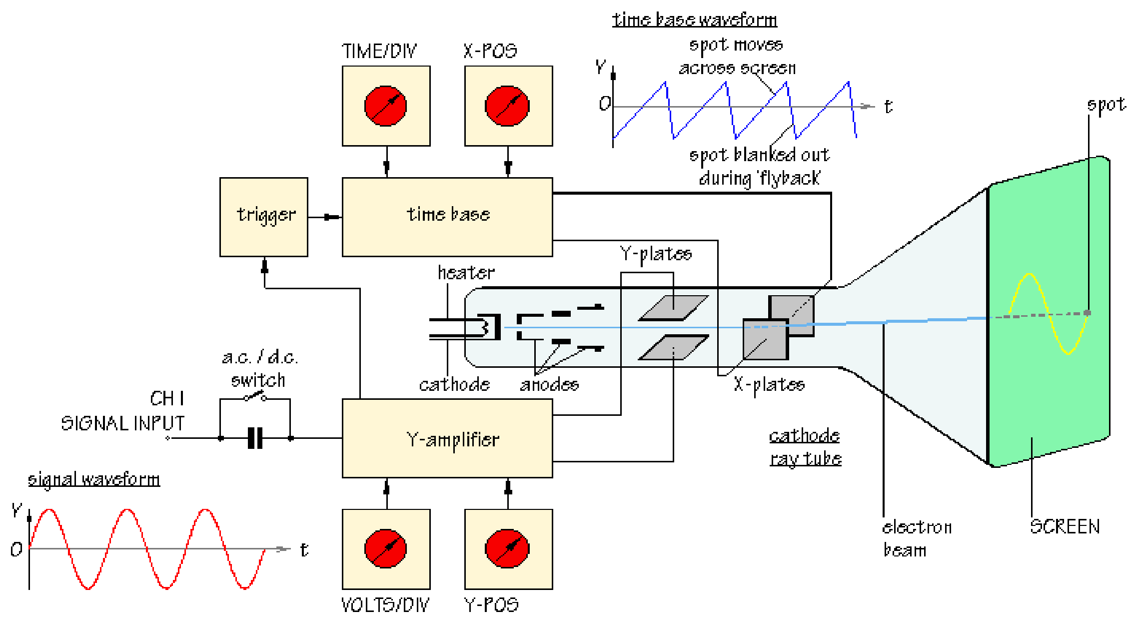


Fig 1: Cathode Ray Oscilloscope

Like a television screen, the screen of an oscilloscope consists of a **cathode ray tube**. Although the size and shape are different, the operating principle is the same. Inside the tube is a vacuum. The electron beam emitted by the heated cathode at the rear end of the tube is accelerated and focused by one or more anodes, and strikes the front of the tube, producing a bright spot on the phosphorescent screen.

The electron beam is bent, or deflected, by voltages applied to two sets of plates fixed in the tube. The horizontal deflection plates or **X-plates** produce side to side movement. As you can see, they are linked to a system block called the **time base**. This produces a saw tooth waveform. During the rising phase of the saw tooth, the spot is driven at a uniform rate from left to right across the front of the screen. During the falling phase, the electron beam returns rapidly from right ot left, but the spot is 'blanked out' so that nothing appears on the screen.In this way, the time base generates the X-axis of the *V*/*t* graph.

The slope of the rising phase varies with the frequency of the saw tooth and can be adjusted, using the TIME/DIV control, to change the scale of the X-axis. Dividing the oscilloscope screen into squares allows the horizontal scale to be expressed in seconds, milliseconds or microseconds per division (s/DIV, ms/DIV, µs/DIV). Alternatively, if the squares are 1 cm apart, the scale may be given as s/cm, ms/cm or µs/cm.

The signal to be displayed is connected to the **input**. The AC/DC switch is usually kept in the DC position (switch closed) so that there is a direct connection to the **Y-amplifier**. In the AC position (switch open) a capacitor is placed in the signal path. The capacitor blocks DC signals but allows AC signals to pass.

The Y-amplifier is linked in turn to a pair of **Y-plates** so that it provides the Y-axis of the the *V*/*t* graph. The overall gain of the Y-amplifier can be adjusted, using the VOLTS/DIV control, so that the resulting display is neither too small or too large, but fits the screen and can be seen clearly. The vertical scale is usually given in V/DIV or mV/DIV.

The **trigger** circuit is used to delay the time base waveform so that the same section of the input signal is displayed on the screen each time the spot moves across. The effect of this is to give a stable picture on the oscilloscope screen, making it easier to measure and interpret the signal.

Changing the scales of the X-axis and Y-axis allows many different signals to be displayed. Sometimes, it is also useful to be able to change the *positions* of the axes. This is possible using the **X-POS** and **Y-POS** controls. For example, with no signal applied, the normal trace is a straight line across the centre of the screen. Adjusting Y-POS allows the zero level on the Y-axis to be changed, moving the whole trace up or down on the screen to give an effective display of signlas like pulse waveforms whihc do not alternate between positive and negative values.

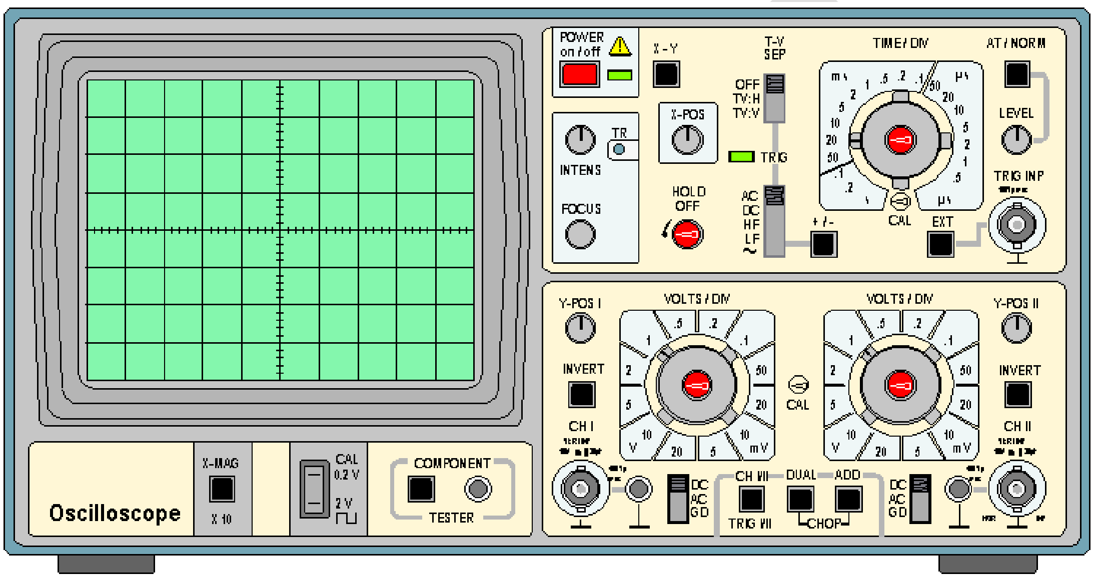
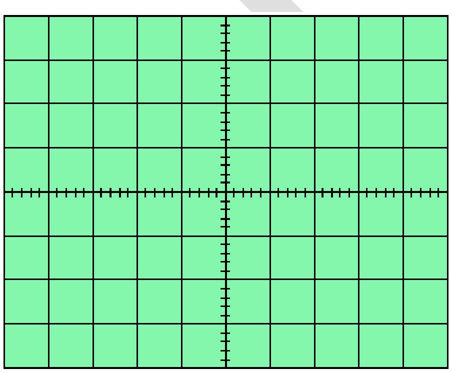
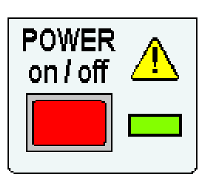
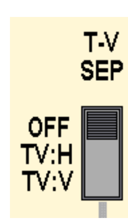


Fig 2: Front View of Oscilloscope

Screen: Usually displays a *V/t* graph, with voltage *V* on the vertical axis and time *t* on the horizontal axis. The scales of both axes can be changed to display a huge variety of signals.







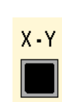


Fig 3: Screen display of Oscilloscope

On/Off Switch: Pushed in to switch the oscilloscope on. The green LED illuminates.

X-Y Control: Normally in the OUT position.

When the X-Y button is pressed IN, the oscilloscope does not display a *V*/*t* graph. Instead, the vertical axis is controlled by the input signal to CH II. This allows the oscilloscope to be used to display a *V*/*V* voltage/voltage graph.

The X-Y control is used when you want to display component characteristic curves, or Lissajous figures. (Links to these topics will be added later.)

TV-Separation: Oscilloscopes are often used to investigate waveforms inside television systems. This control allows the display to be synchronised with the televsion system so that the signals from different points can be compared.

Time / Div: Allows the horizontal scale of the *V*/*t* graph to be changed.

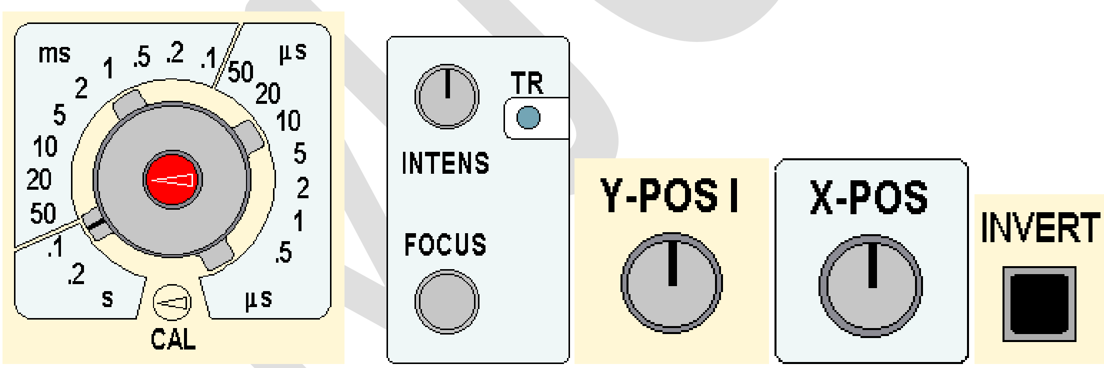


Fig 4: Time division, Intensity, focus, X-Y mode knobs

With more experience of using the oscilloscope, you will develop a clear understanding of the functions of the important trigger controls and be able to use them effectively.

Intensity And Focus: Adjusting the INTENSITY control changes the brightness of the oscilloscope display. The FOCUS should be set to produce a bright clear trace.

If required, TR can be adjusted using a small screwdriver so that the oscilloscope trace is exactly horizontal when no signal is connected.

X-POS: Allows the whole *V*/*t* graph to be moved from side to side on the oscilloscope screen.

This is useful when you want to use the grid in front of the screen to make measurements, for example, to measure the period of a waveform.

Y-POS I And Y-POS II: These controls allow the corresponding trace to be moved up or down, changing the position representing 0 V on the oscilloscope screen.

To investigate an alternating signal, you adjust Y-POS so that the 0 V level is close to the centre of the screen. For a pulse waveform, it is more useful to have 0 V close to the bottom of the screen. Y-POS I and Y-POS II allow the 0 V levels of the two traces to be adjusted independently.

Invert: When the INVERT button is pressed IN, the corresponding signal is turned upside down, or inverted, on the oscilloscope screen.This feature is sometimes useful when comparing signals.

CH I And CH II Inputs: Signals are connected to the BNC input sockets using BNC plugs.

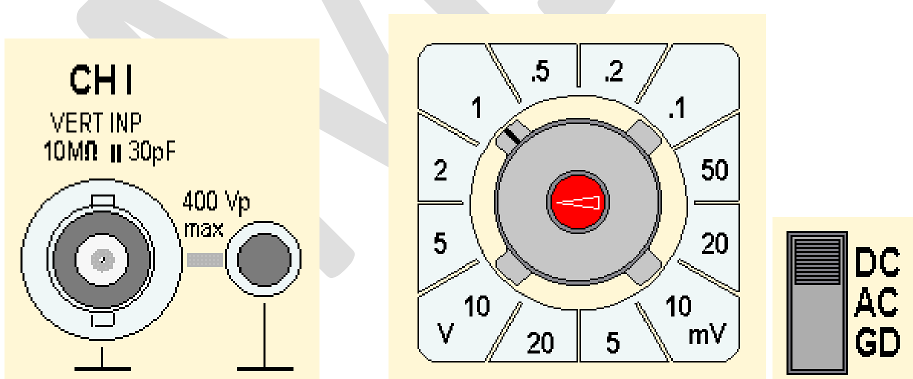


Fig 5: Voltage division, Channels, AC, DC and GD knobs

The smaller socket next to the BNC input socket provides an additional 0 V, GROUND or EARTH connection.

Volts / Div: Adjust the vertical scale of the *V*/*t* graph. The vertical scales for CH I and CH II can be adjusted independently.

DC/AC/GND Slide Switches: In the DC position, the signal input is connected directly to the Y-amplifier of the corresponding channel, CH I or CH II. In the AC position, a capacitor is connected into the signal pathway so that DC voltages are blocked and only changing AC signals are displayed.

In the GND position, the input of the Y-amplifier is connected to 0 V. This allows you to check the position of 0 V on the oscilloscope screen.The DC position of these switches is correct for most signals.

Trace Selection Switches: The settings of these switches control which traces appear on the oscilloscope screen.

Measurement of Amplitude & Frequency:

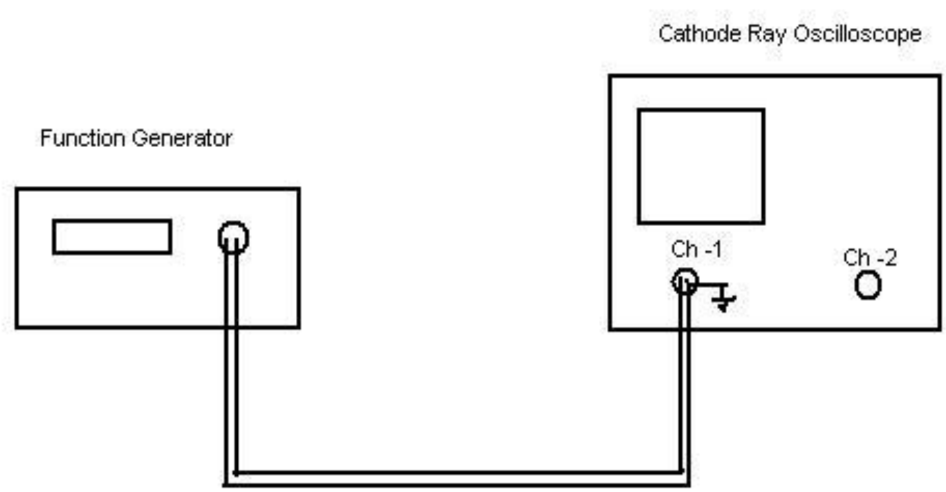


Fig 6: Block Diagram

Model waveforms:

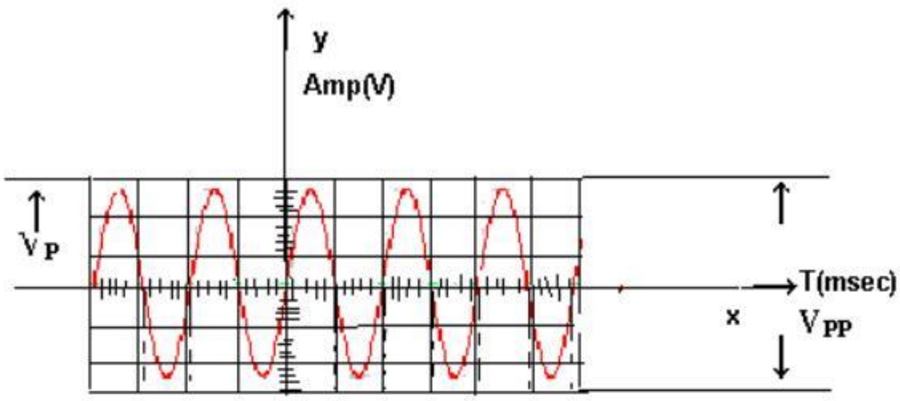


Fig 7: Sinusoidal waveform

A) Measurement of Amplitude:

Procedure:

1. Make the connections as per the diagram shown above.
2. Put the CRO on a single channel mode and bring the CRO into operation by adjusting the trace of the beam to a normal brightness and into a thin line.
3. Now apply the sinusoidal wave of different amplitudes by using the LEVEL and COARSE buttons of the function generator.
4. Note on the vertical scale the peak to peak amplitude (Vpp) .

Observations:

S.NO	No.of Vertical Divisions(X)	Voltage/ Division (Y)	Vp-p=X*Y	Vm=Vp-p/2

B) Measurement of Frequency:

Procedure:

- Make the connections as per the diagram shown above.
- Put the CRO on a single channel mode and bring the CRO into operation by adjusting the trace of the beam to a normal brightness and into a thin line.
- Now apply the sinusoidal wave of different frequencies by using the LEVEL and COARSE buttons of the function generator.
- Note on the an horizontal scale period (T) in second by observing difference between the two successive peaks of the waveform.

Observations:

S.NO	No.Of Horizantal Divisions(X)	Time/Division (Y)	T=X*Y	f=1/T

Results:

Measured voltage amplitude and frequency of given signal successfully

EXPERIMENT NO: 8

HALF WAVE AND FULL WAVE RECTIFIER WITHOUT FILTER

Aim: (i) To study the operation of Half wave and Full wave rectifier without filter

(ii) To find its:

1. Ripple Factor
2. Efficiency
3. Percentage Regulation

Components:

Name	Quantity
Diodes 1N4007(Si)	2
Resistor 1KΩ	1

Equipment:

Name	Range	Quantity
CRO	(0-20)MHz	1
CRO probes		2
Digital Ammeter, Voltmeter	[0-200µA/200mA], [0-20V]	1
Transformer	220V/9V, 50Hz	1
Connecting Wires		

Specifications:

Silicon Diode 1N4007:

Max Forward Current = 1A

Max Reverse Current = 5.0µA

Max Forward Voltage = 0.8V

Max Reverse Voltage = 1000V

Max Power Dissipation = 30mW

Temperature = -65 to 200° C

Theory:

A rectifier is a circuit that converts a pure AC signal into a pulsating DC signal or a signal that is a combination of AC and DC components.

A half wave rectifier makes use of single diode to carry out this conversion. It is named so as the conversion occurs for half input signal cycle.

During the positive half cycle, the diode is forward biased and it conducts and hence a current flows through the load resistor.

During the negative half cycle, the diode is reverse biased and it is equivalent to an open circuit, hence the current through the load resistance is zero. Thus the diode conducts only for one half cycle and results in a half wave rectified output.

A full wave rectifier makes use of a two diodes to carry out this conversion. It is named so as the conversion occurs for complete input signal cycle.

The full-wave rectifier consists of a center-tap transformer, which results in equal voltages above and below the center-tap. During the positive half cycle, a positive voltage appears at the anode of D1 while a negative voltage appears at the anode of D2. Due to this diode D1 is forward biased it results in a current Id1 through the load R.

During the negative half cycle, a positive voltage appears at the anode of D2 and hence it is forward biased. Resulting in a current Id2 through the load at the same instant a negative voltage appears at the anode of D1 thus reverse biasing it and hence it doesn't conduct.

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'.

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

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

Rectification Factor:

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

$$\eta = \frac{(V_{DC})^2}{(V_{AC})^2}$$

$$\eta_{HWR} = 40.6\%$$

$$\eta_{FWR} = 81\%$$

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

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

Circuit Diagram:

Half wave Rectifier (without filter):

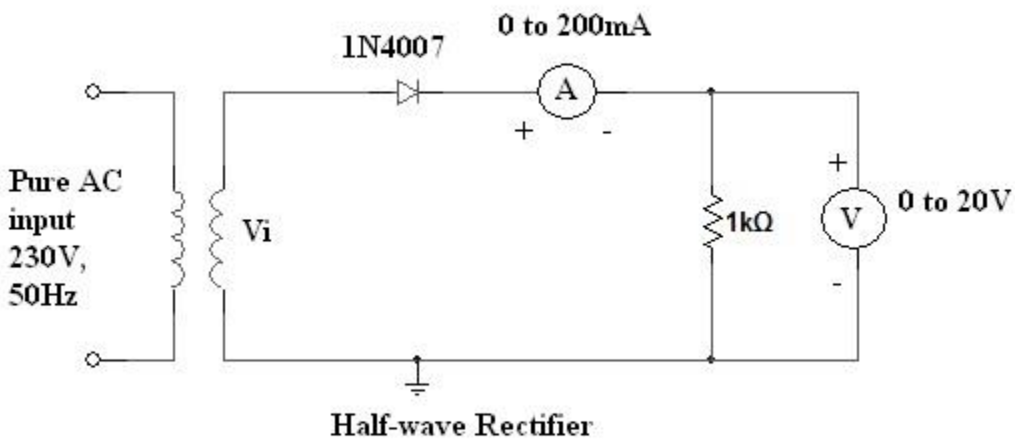


Figure1: Circuit diagram of Half-wave rectifier

Full Wave Rectifier (without filter):

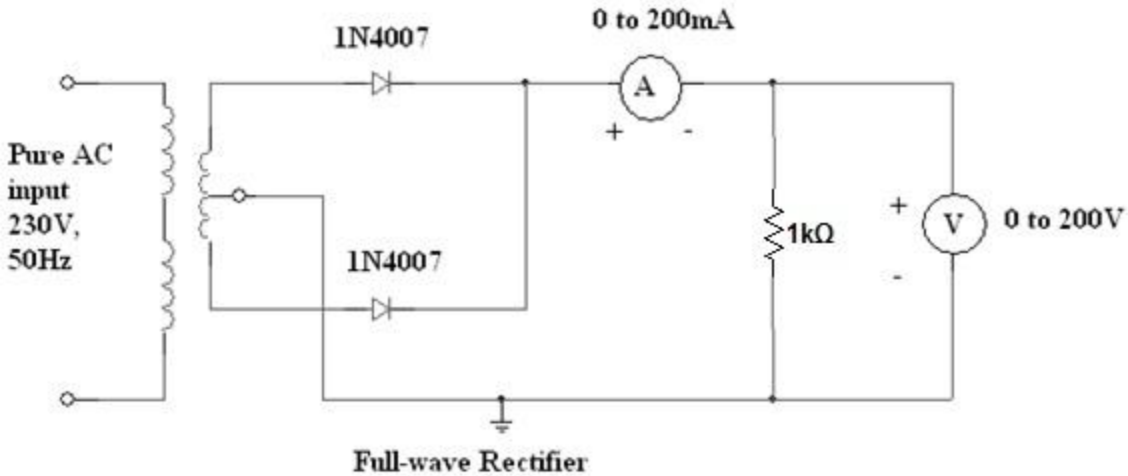


Figure 2: Circuit diagram of Full wave rectifier

Procedure:

PART-I: Half wave rectifier without filter:

1. Connect the circuit as shown in the figure-(1).
2. Connect the multimeter across the 1kΩ load.
3. Measure the AC and DC voltages by setting multimeter to ac and dc mode respectively.
4. Now calculate the ripple factor using the following formula.

$$\text{Ripple factor}(\gamma) = \frac{V_{AC}}{V_{DC}}$$

5. Connect the CRO channel-1 across input and channel-2 across output i.e load and Observe the input and output Waveforms.
6. Now calculate the peak voltage of input and output waveforms and also the frequency.

PART-II: Full wave rectifier without filter:

1. Connect the circuit as shown in the figure-(2).
2. Repeat the above steps 2-6
3. Plot different graphs for wave forms and ripple factor

Observations:

Table 1: Half wave rectifier without Filter

V_{AC}(V)	V_{DC}(V)	Ripple Factor $\gamma=\frac{Vac}{Vdc}$	Input Signal			Output Signal	
			Vm p-p(v)	Vm peak(v)	Frequency (Hz)	Vm p-p(v)	Frequency (Hz)

Table 2: Full wave rectifier without Filter

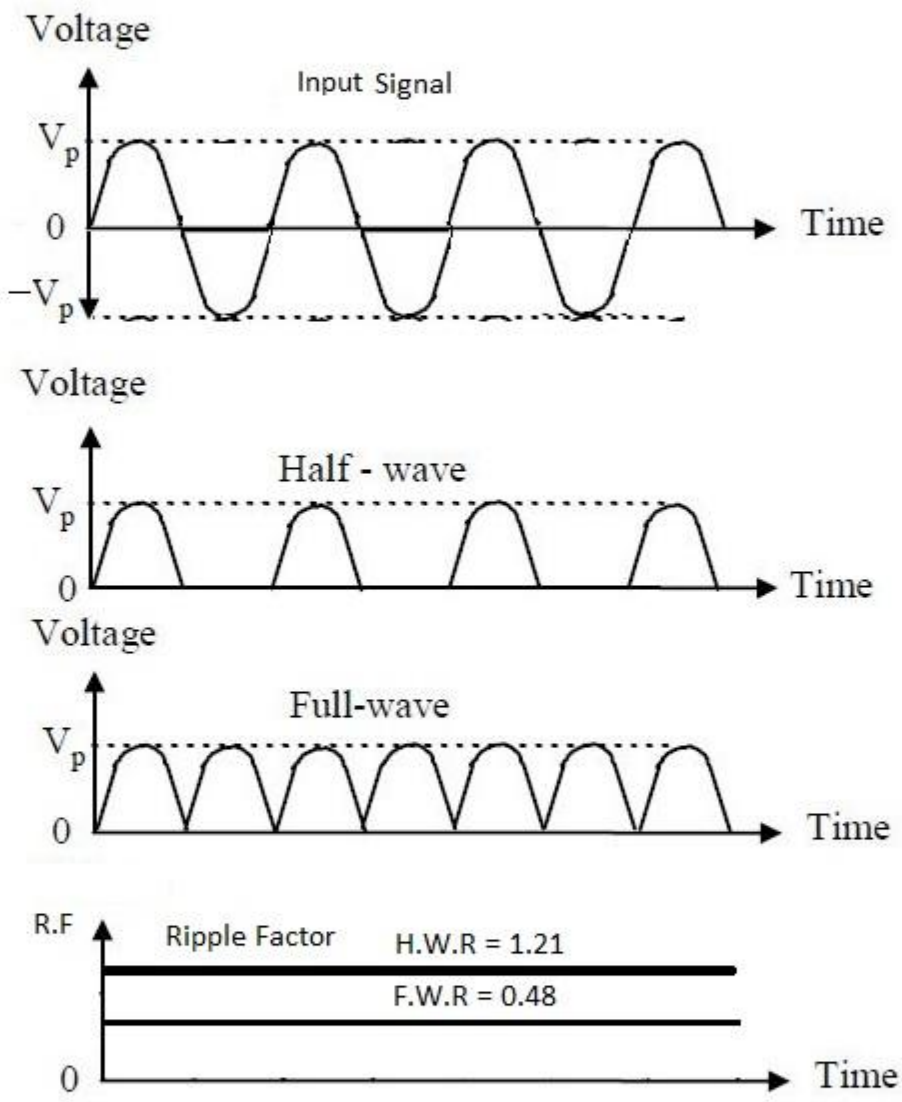
V_{AC}(V)	V_{DC}(V)	Ripple Factor $\gamma=\frac{Vac}{Vdc}$	Input Signal			Output Signal	
			Vm p-p(v)	Vm peak(v)	Frequency (Hz)	Vm p-p(v)	Frequency (Hz)

Calculations:

1. Ripple Factor = $\gamma_{HWR} = \frac{V_{AC}}{V_{DC}}$

2. Percentage Regulation = $\frac{V_{NL} - V_{FL}}{V_{FL}} \times \%$

Expected Waveforms:



Results:

1. Half Wave and Full Wave rectifier characteristics are studied.
2. Ripple factor of Half wave rectifier = -------------
3. Ripple factor of Full wave rectifier = -------------
4. Regulation of Half wave rectifier = -------------
5. Regulation of Full wave rectifier = -------------

Viva Questions:

1. What is a rectifier?

Ans: A rectifier is an electrical device that converts alternating current (AC), which periodically reverses direction, to direct current (DC), which flows in only one direction. The process is known as rectification.

2. What is a ripple factor?

Ans: Ripple factor can be defined as the variation of the amplitude of DC (Direct current) due to improper filtering of AC power supply. it can be measured by RF = v_{rms} / v_{dc}

3. What is efficiency?

Ans: Rectifier efficiency is the ratio of the DC output power to the AC input power.

4. What is PIV?

Ans: The peak inverse voltage is either the specified maximum voltage that a diode rectifier can block, or, alternatively, the maximum that a rectifier needs to block in a given application.

5. What are the applications of rectifier?

Ans: The primary application of rectifiers is to derive DC power from an AC supply. Virtually all electronic devices require DC, so rectifiers are used inside the power supplies of virtually all electronic equipment. Rectifiers are also used for detection of amplitude modulated radio signals. rectifiers are used to supply polarized voltage for welding.

6. Give some rectifications technologies?

Ans: Synchronous rectifier, Vibrator, Motor-generator set , Electrolytic ,Mercury arc, and Argon gas electron tube.

7. What is the efficiency of bridge rectifier?

Ans: 81 %

EXPERIMENT NO: 9

Half Wave and Full Wave Rectifier With Filter

Aim: (i) To study the operation of a Half wave and Full wave rectifier with filters

(ii) To find its Ripple Factor and Percentage Regulation

Components:

Name	Quantity
Diodes 1N4007(Si)	2
Resistor 1KΩ	1
Capacitor 100µF	2
Inductor (35 mH),	1

Equipment:

Name	Range	Quantity
CRO	(0-20)MHz	1
CRO probes		2
Digital Ammeter, Voltmeter	[0-200µA/200mA], [0-20V]	1
Transformer	220V/9V, 50Hz	1
Connecting Wires		

Specifications:

Silicon Diode 1N4007:

Max Forward Current = 1A

Max Reverse Current = 5.0µA

Max Forward Voltage = 0.8V

Max Reverse Voltage = 1000V

Max Power Dissipation = 30mW

Temperature = -65 to 200° C

Theory: A rectifier is a circuit that converts a pure AC signal into a pulsating DC signal or a signal that is a combination of AC and DC components.

In DC supplies, a rectifier is often followed by a filter circuit which converts the pulsating DC signal into pure DC signal by removing the AC component.

An L-section filter consists of an inductor and a capacitor connected in the form of an inverted L.

A π- section filter consists of two capacitors and one induction in the form symbol pi.

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'.

$$\gamma_{HWR\ L-section} = \frac{V_{AC}}{V_{DC}} = \frac{\pi}{2\sqrt{2}}\ \frac{X_C}{X_L}$$

where $X_L = \omega L,\ X_C = \frac{1}{\omega C}$

$$\gamma_{FWR\ \pi-section} = \frac{V_{AC}}{V_{DC}} = \sqrt{2}\ \frac{X_{C1}\ X_{C2}}{R\ X_L}$$

where $X_L = 2\omega L,\ X_C = \frac{1}{2\omega C}$

Circuit Diagram:

Half Wave Rectifier (with L-section filter):

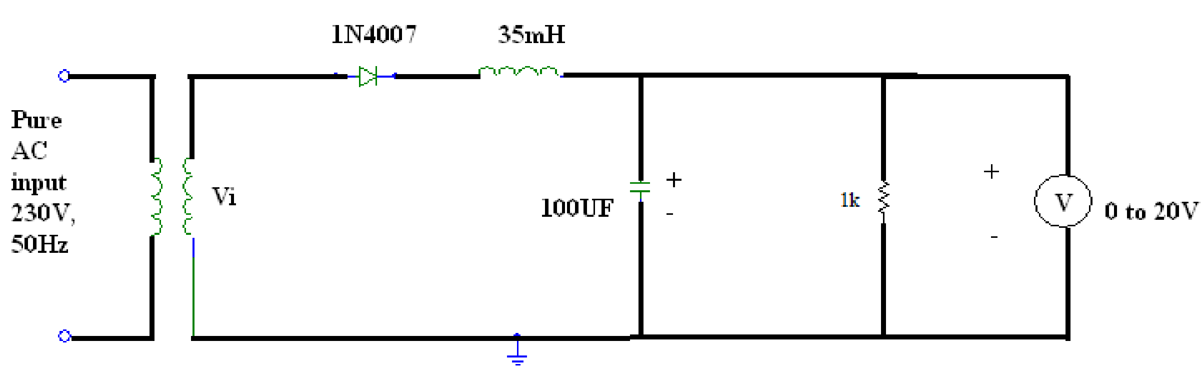


Figure 1: Half wave rectifier with L-section Filter

Full Wave Rectifier (with π-section filter):

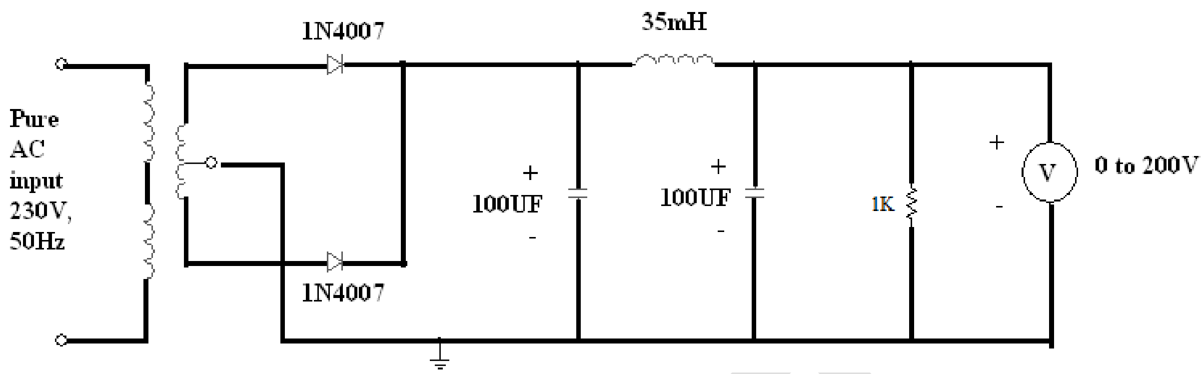


Figure 2: Full wave rectifier with π-section filter

Procedure:

PART-I:

Half wave rectifier with L-section filter:

1. Connect the circuit as shown in the figure-(1).
2. Connect the multimeter across the 1kΩ load.
3. Meassure the AC and DC voltages by setting multimeter to ac and dc mode respectively.
4. Now calculate the ripple factor using the following formula.

$$\text{Ripple factor}(\gamma) = \frac{V_{AC}}{V_{DC}}$$

5. Connect the CRO channel-1 across input and channel-2 across output i.e load and Observe the input and output Waveforms.
6. Now calculate the peak voltage of input and output waveforms and also the frequency.

PART-II: Full wave rectifier with π-section filter:

1. Connect the circuit with filter as shown in the figure-(2).
2. Repeat the above steps 2-6

Observations:

Table 1: Half wave rectifier with L-section filter

V_{AC}(V)	V_{DC}(V)	Ripple Factor $\gamma=\frac{Vac}{Vdc}$	Input Signal			Output Signal	
			Vm p-p(v)	Vm peak(v)	Frequency (Hz)	Vm p-p(v)	Frequency (Hz)

Table 2: Full wave rectifier with pi-Section filter

V_{AC}(V)	V_{DC}(V)	Ripple Factor $\gamma=\frac{Vac}{Vdc}$	Input Signal			Output Signal	
			Vm p-p(v)	Vm peak(v)	Frequency (Hz)	Vm p-p(v)	Frequency (Hz)

Calculations:

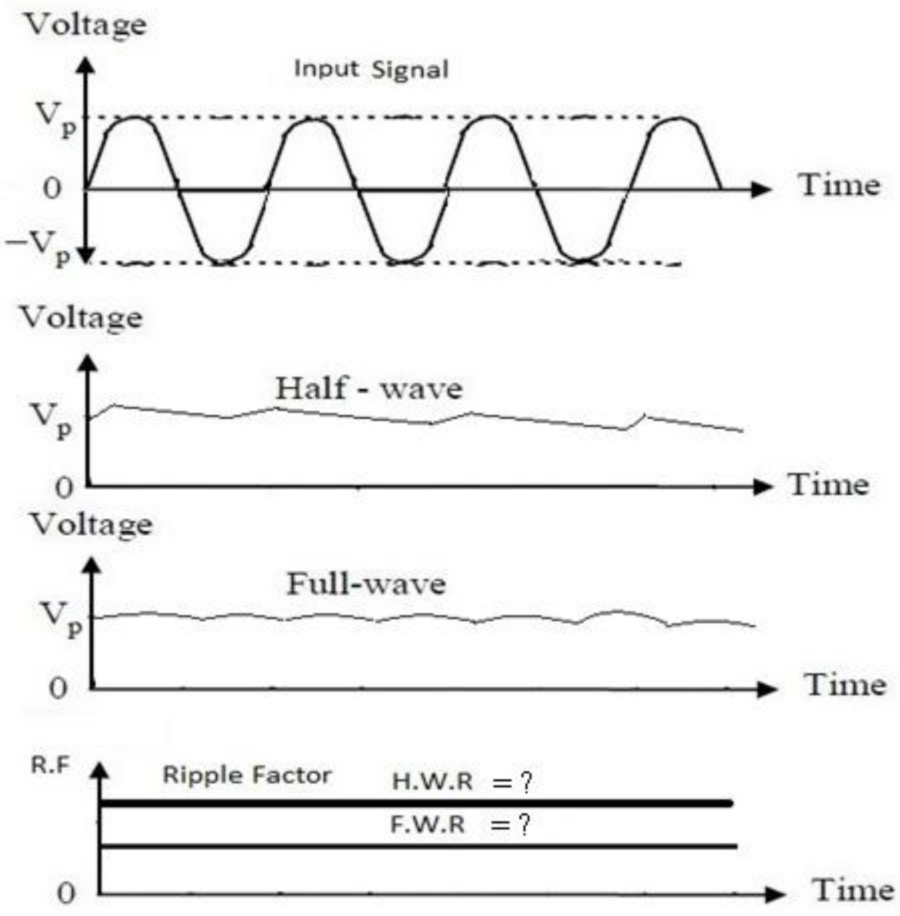
1. Ripple factor :

$$HWR_{L-SECTION} = \frac{Vac}{Vdc}$$

$$FWR_{\pi-Section} = \frac{Vac}{Vdc}$$

2. Percentage Regulation = $\frac{V_{DCNL} - VDC_{FL}}{V_{DCFL}} \times 100\ \%$

Expected Waveforms:



Result:

1. Full Wave rectifier characteristics are studied.
2. Ripple factor of Half wave with L-section filter = -------------
3. Ripple factor of Full wave with π-section filter = -------------
4. Regulation of Half wave with L-section filter = -------------
5. Regulation of Half wave with π -section filter = -------------

Viva Questions:

1. What is filter ?

Ans: Electronic filters are electronic circuits which perform signal processing functions, specifically to remove unwanted frequency components from the signal.

2. PIV center tapped FWR?

Ans: $2V_{m.}$

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

Ans: Capacitor allows AC and blocks DC signal.in rectifier for converting AC to DC, capacitor placed in parallel with output, where output is capacitor blocked voltage.If capacitance value increases its capacity also increases which increases efficiency of rectifier.

EXPERIMENT NO: 10

COMMON EMITTER AMPLIFIER

Aim:

1. To plot the frequency response of a Common Emitter BJT amplifier.
2. To find the cut off frequencies, Bandwidth and calculate its gain.

Components:

Name	Quantity
Transistor BC547	1
Resistor 74KΩ, 15KΩ, 4.7KΩ, 1KΩ, 2.2KΩ, 8.2KΩ	1,1,1,1,1,1
Capacitor 10µF,100µF, 1 KPF	2, 1,1

Equipment:

Name	Range	Quantity
Bread Board		1
Dual DC power supply	0-30V	1
Function Generator	(0-1)MHz	1
Digital Ammeter, Voltmeter	[0-200µA/200mA], [0-20V]	1
CRO	(0-20)MHz	1
CRO probes, Connecting Wires		

Specifications:

For Transistor BC 547:

- Max Collector Current= 0.1A
- V_{ceo} max= 50V
- V_{EB0} = 6V
- V_{CB0} = 50V
- Collector power dissipation = 500mW
- Temperature Range = -65 to +150 ^{0}C
- h_{fe} = 110 - 220

Theory:

An amplifier is an electronic circuit that can increase the strength of a weak input signal without distorting its shape. The common emitter configuration is widely used as a basic amplifier as it has both voltage and current amplification with 180^{0} phase shift.

The factor by which the input signal gets multiplied after passing through the amplifier circuit is called the gain of the amplifier. It is given by the ratio of the output and input signals.

Gain = output signal / input signal

A self bias circuit is used in the amplifier circuit because it provides highest Q-point stability among all the biasing circuits.

Resistors R1 and R2 forms a voltage divider across the base of the transistor. The function of this network is to provide necessary bias condition and ensure that emitter-base junction is operating in the proper region.

In order to operate transistor as an amplifier, the biasing is done in such a way that the operating point should be in the active region. For an amplifier the Q-point is placed so that the load line is bisected. Therefore, in practical design it is always set to Vcc/2. This will confirm that the Q-point always swings within the active region. Output is produced without any clipping or distortion for the maximum input signal. If not reduce the input signal magnitude.

The Bypass Capacitor: The emitter resistor is required to obtain the DC quiescent stability. However the inclusion of it in the circuit causes a decrease in amplification. In order to avoid such a condition, it is bypassed by capacitor so that it acts as a short circuit for AC and contributes stability for DC quiescent condition. Hence capacitor is connected in parallel with emitter resistance which increases the A.C gain.

The Coupling capacitor: An amplifier amplifies the given AC signal. In order to have noiseless transmission of a signal (without DC), it is necessary to block DC i.e. the direct current should not enter the amplifier or load. This is usually accomplished by inserting a coupling capacitor between two stages.

Frequency response :

The plot of gain versus frequency is called as frequency response,

The coupling and bypass capacitors causes the gain to fall at low frequency region and internal parasitic capacitance and shunt capacitor causes the gain to fall at high frequency region.

In the mid frequency range large capacitors are effectively short circuits and the stray capacitors are open circuits, so that no capacitance appear in the mid frequency range. Hence the mid band frequency gain is maximum.

Hence we get a Band Pass frequency response

Characteristics of CE Amplifier:

1. Large current gain.
2. Large voltage gain.

3. Large power gain.
4. Current and voltage phase shift of 180°.
5. Moderate output resistance.

Type	A_i	R_i	A_V	R_O
CE	$-h_{fe}$	h_{ie}	$-h_{fe}\dfrac{R_l'}{h_{ie}}$	∞ (40kΩ)

Design:

a) Design a single stage RC coupled amplifier using a BJT BC 547 in CE configuration to provide a gain of 100, V_{CC} = 12V, I_C = 1mA, V_{CE} = 6V and Stability factor is S = 10. Use R_C = 4.7KΩ. Use a transistor with β = 200, V_{BE} = 0.65V, h_{fe} = 50, h_{ie} = 1.5 KΩ.

Solution: Use, $I_C = \beta \times I_B$

$$\Rightarrow I_B = 5\mu A$$

Apply KVL to the output loop:

$$-V_{CC} + I_C \times R_C + V_{CE} + I_C \times R_E = 0$$

$$\Rightarrow R_E = 1.3K\Omega$$

Apply Thevenin's theorem to the base circuit, then

$$V_B = \frac{V_{CC} \times R_2}{R_1 + R_2} \text{ And } R_B = \frac{R_1 \times R_2}{R_1 + R_2}$$

We know that the stability factor for a self bias circuit is given by,

$$S = \frac{1+\beta}{1 + \dfrac{\beta \times R_E}{R_B + R_E}}$$

$$\Rightarrow R_B = 12.31K\Omega$$

Apply KVL to the input loop, then

$$-V_B + I_B \times R_B + V_{BE} - I_E \times R_E = 0$$

$$\Rightarrow V_B = 2.01\text{V}$$

Divide R_B with V_B:

$$\Rightarrow R_1 = \frac{V_{CC} \times R_B}{V_B} = 73.5K\Omega$$

Also, $R_B = \frac{R_1 \times R_2}{R_1 + R_2}$ $\Rightarrow R_2 = 14.8K\Omega$

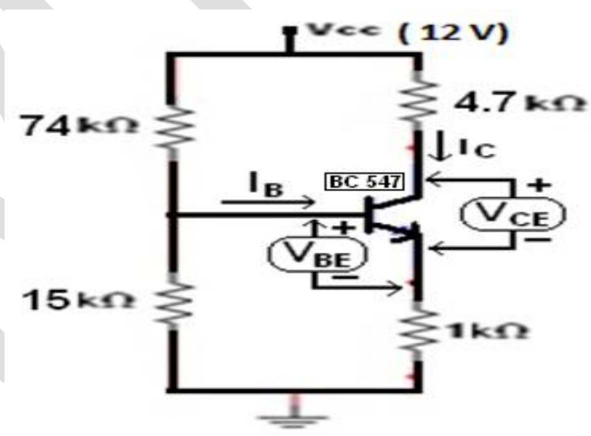
Design of R_L:-

We know that, gain $A_V = \frac{-h_{fe} \times R_L^{'}}{h_{ie}}$

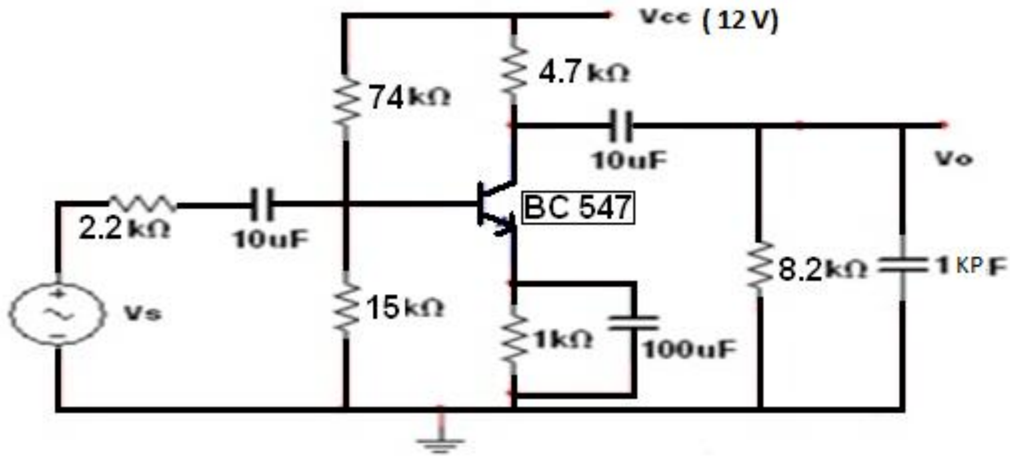
$$\Rightarrow R_L^{'} = 3K\Omega$$

But, $R_L^{'} = \frac{R_L \times R_C}{R_L + R_C}$ $\Rightarrow R_L = 8.3K\Omega$

Circuit Diagram:



Fig(1) DC bias for the BJT



Fig(2) RC Coupled CE BJT Amplifier

Procedure:

1. Connect the circuit as shown in fig 1 and obtain the DC bias conditions V_{BE}, I_B, V_{CE}, I_C.
2. Connect the circuit as shown in fig 2, Set source voltage as 30mV P-P at 1 KHz frequency using the function generator.
3. Keeping the input voltage as constant, vary the frequency from 30 Hz to 1 MHz in regular steps and note down the corresponding output P-P voltage.
4. Plot the graph for gain in (dB) verses Frequency on a semi log graph sheet.
5. Calculate the bandwidth from the graph.

Observations:

V_S = 30mV

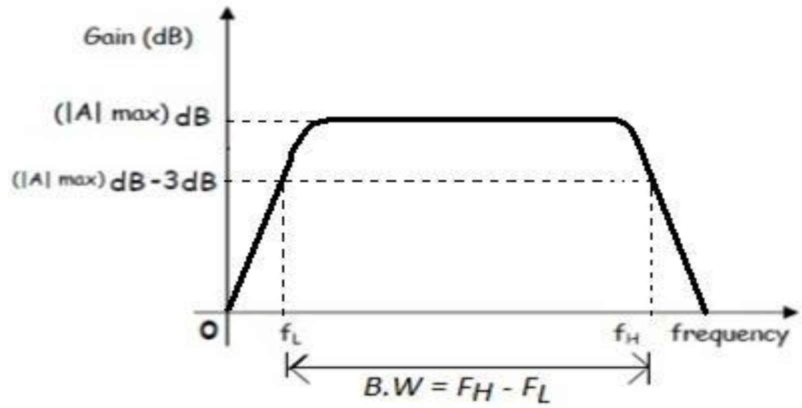
DC conditions:-

V_{BE} = ……………. V_{CE} = ………………

I_B = ……………… I_C = ………………..

Frequency	Vs (Volts)	Vo(Volts)	Gain = Vo/Vs	Gain(dB) = 20 log(Vo/Vs)

Graph: In the usual application, mid band frequency range are defined as those frequencies at which the response has fallen to 3dB below the maximum gain (|A| max). These are shown as f_L, f_H and are called as the 3dB frequencies or simply the lower and higher cut off frequencies respectively. The difference between the higher cut off and lower cut off frequency is referred to as the bandwidth (f_H - f_L).



Fig(3).Frequency Response Curve of RC coupled BJT CE Amplifier

Calculations from Graph:

Precautions:

1. While performing the experiment do not exceed the ratings of the transistor. This may lead to damage the transistor.
2. Connect signal generator in correct polarities as shown in the circuit diagram.
3. Do not switch ON the power supply unless you have checked the circuit connections as per the circuit diagram.
4. Make sure while selecting the emitter, base and collector terminals of the transistor.

Result:

1. The BJT CE amplifier is studied
2. The frequency response curve of the BJT CE amplifier is plotted.
3. Lower cutoff frequency, f_L = …………….
   Higher cutoff frequency, f_H = ……………

   Bandwidth = $f_H – f_L$ = ……………………

Viva Questions:

1. What is the equation for voltage gain?

Ans:

$$A_V = -h_{fe} \frac{R_l'}{h_{ie}}$$

2. What is cut off frequency?

Ans: In electronics, cutoff frequency or corner frequency is the frequency either above or below which the power output of a circuit, such as a line, amplifier, or electronic filter has fallen to a given proportion of the power in the pass band. Most frequently this proportion is one half the pass band power, also referred to as the 3 dB point since a fall of 3 dB corresponds approximately to half power. As a voltage ratio this is a fall to of the pass band voltage

3. What are the applications of CE amplifier?

Ans: Low frequency voltage amplifier, radio frequency circuits and low-noise amplifiers

4. What is active region?

Ans: The active region of a transistor is when the transistor has sufficient base current to turn the transistor on and for a larger current to flow from emitter to collector. This is the region where the transistor is on and fully operating. In this region JE in forward bias and JC in reverse bias and transistor works as an amplifier

5. What is Bandwidth?

Ans: Bandwidth is the difference between the upper and lower frequencies in a continuous set of frequencies. It is typically measured in hertz, and may sometimes refer to passband bandwidth, sometimes to baseband bandwidth, depending on context. Passband bandwidth is the difference between the upper and lower cutoff frequencies of, for example, a bandpass filter, a communication channel, or a signal spectrum. In case of a low-pass filter or baseband signal, the bandwidth is equal to its upper cutoff frequency.

EXPERIMENT NO: 11

RC PHASE SHIFT OSCILLATOR

Aim: To design an RC phase Shift Oscillator and Calculate the frequency of Oscillations.

Components:

Name	Quantity
Transistor BC 548	1
Resistor {1kΩ ,33 kΩ,4.7 kΩ(2),5.6 kΩ,6.8 kΩ)}	1
Electrolytic capacitor of 100 µF	1
Ceramic capacitor 1kpf	3

Equipment:

Name	Range	Quantity
Bread board		1
Regulated power supply	0-30V	1
Digital Ammeter	200mA	2
Digital Voltmeter	0-20V	2
Connecting Wires		1

Theory:

A phase-shift oscillator is a linear electronic oscillator circuit that produces a sine wave output. It consists of an inverting amplifier element such as a transistor or op amp with its output fed back to its input through a phase-shift network consisting of resistors and capacitors in a ladder network. The feedback network 'shifts' the phase of the amplifier output by 180 degrees at the oscillation frequency to give positive feedback. Phase-shift oscillators are often used at audio frequency as audio oscillators.

Circuit Diagram

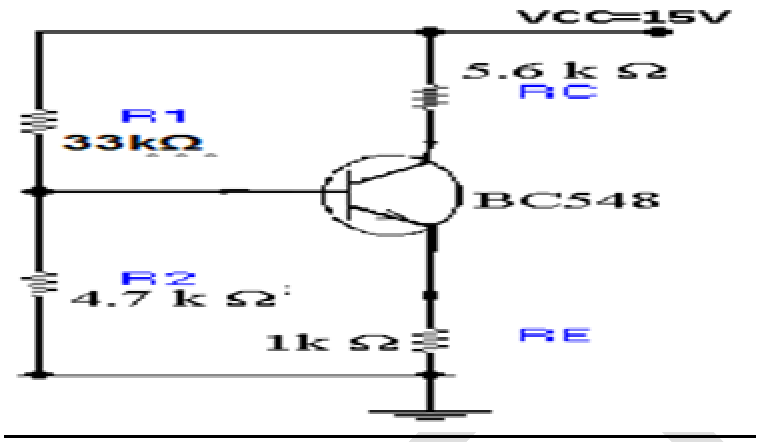


Fig 1: Self biased Circuit

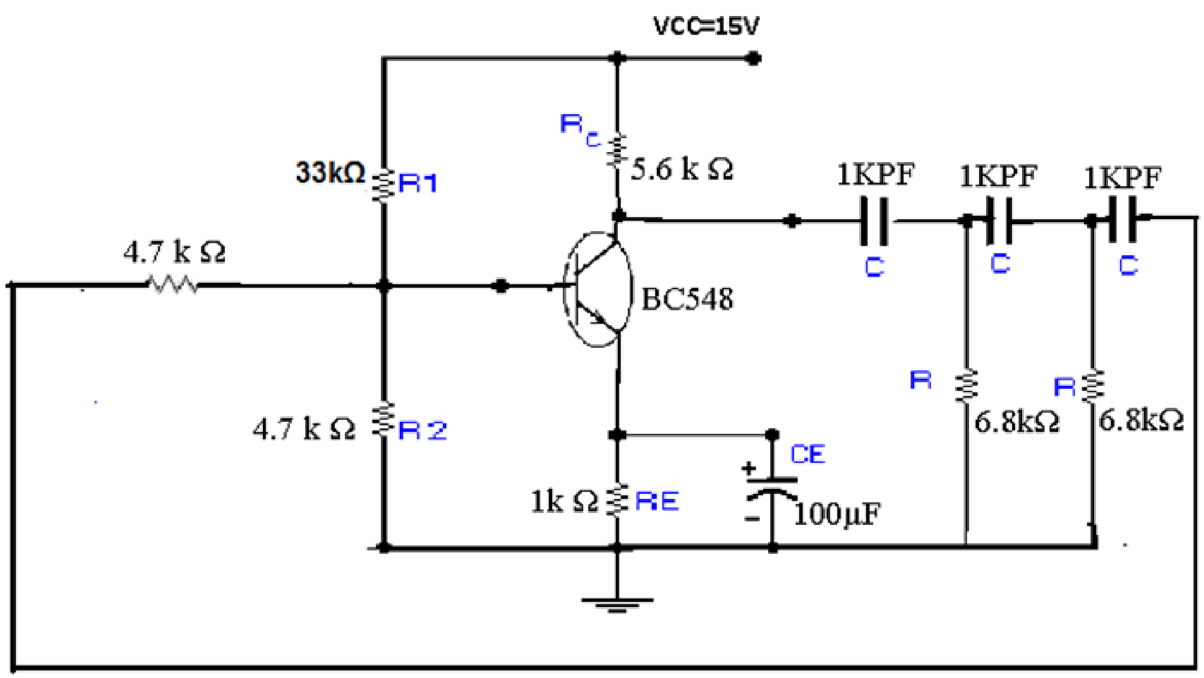


Fig 2: RC phase shift Oscillator circuit

Procedure:

1. Connect the circuit as shown in figure 1 and check the Dc Conditions. i.e.

   Calculate VBE,VCE,IB,IC.

2. Connect the circuit as shown in figure 2.
3. Connect the output terminal to any channel of the CRO.
4. Calculate the frequency and amplitude of the output sinusoidal signal.
5. Plot the Graph of the output waveform.
6. Calculate the theoretical value of the frequency.

$$f_T = 1/2\pi RC\sqrt{6+4K}$$

R_C =5.6kΩ

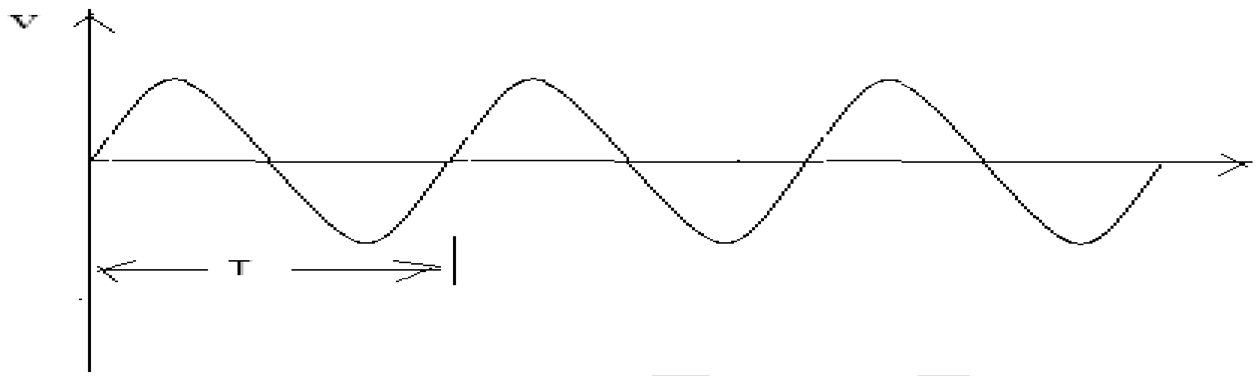
R=6.8 kΩ

C=1kpf

Observations:

Values	Theoretical Values	Practical Values

Expected Graph:



$f_p = 1 / T$ Hz

Results:

Designed an RC phase shift oscillator and calculated the frequency of oscillations successfully.

EXPERIMENT NO: 12

HARTLEY OSCILLATOR

Aim:

To design and study the operation of Hartley Oscillator using BJT and determine the frequency of oscillation.

Components:

Name	Quantity
Transistor BC547	1
Resistor 74KΩ, 15 KΩ, 4.7KΩ, 1KΩ,	1,1,1,1
Capacitor 4.7μF, 100 PF	2, 1
Inductor 70 μH	2

Equipment:

Name	Range	Quantity
Bread Board		1
Dual DC power supply	0-30V	1
Digital Ammeter, Voltmeter	[0-200μA/200mA], [0-20V]	1
CRO	(0-20)MHz	1
CRO probes, Connecting Wires		

Specifications:

For Transistor BC 547:

- Max Collector Current= 0.1A
- V_{ceo} max= 50V
- V_{EB0} = 6V
- V_{CB0} = 50V
- Collector power dissipation = 500mW
- Temperature Range = -65 to +150 ^{0}C
- h_{fe} = 110 - 220

Theory:-

An oscillator is an electronic circuit that provides an AC output without using any AC input. All Sinusoidal oscillator circuits use the concept of positive feedback to produce oscillations. An oscillator circuit must satisfy the Barkhausen's criterion of unity loop gain to produce oscillations.

Hartley's oscillator is a popular LC Oscillator circuit used at Radio Frequencies.

Design:

Q: Design Hartley's oscillator circuit to provide oscillations at a frequency of 850 KHz. Use BJT BC547 for which β = 200, h_{fe} = 50, h_{ie} = 1.5 KΩ and $V_{BE(active)}$ = 0.65V. The biasing conditions are as follows.V_{CC} = 12V, I_C = 1mA, V_{CE} = 6V and Stability factor is S = 10. Use R_C = 4.7KΩ.

Solution:

Use, $I_C = \beta \times I_B$

$$\Rightarrow I_B = 5\mu A$$

Apply KVL to the output loop:

$$-V_{CC} + I_C \times R_C + V_{CE} + I_C \times R_E = 0$$

$$\Rightarrow R_E = 1.3K\Omega$$

Apply Thevenin's theorem to the base circuit, then

$$V_B = \frac{V_{CC} \times R_2}{R_1 + R_2} \text{ And } R_B = \frac{R_1 \times R_2}{R_1 + R_2}$$

We know that the stability factor for a self bias circuit is given by,

$$S = \frac{1+\beta}{1+\dfrac{\beta \times R_E}{R_B + R_E}}$$

$$\Rightarrow R_B = 12.31K\Omega$$

Apply KVL to the input loop, then

$$-V_B + I_B \times R_B + V_{BE} - I_E \times R_E = 0$$

$$\Rightarrow V_B = 2.01\text{V}$$

Divide R_B with V_B:

$$\Rightarrow R_1 = \frac{V_{CC} \times R_B}{V_B} = 73.5K\Omega$$

Also, $R_B = \dfrac{R_1 \times R_2}{R_1 + R_2}$ $\Rightarrow R_2 = 14.8K\Omega$

We know that

$$f_o = \frac{1}{2\pi\sqrt{(L_1 + L_2 + 2M)C}}$$

Assume that $L_1 = L_2 = 70\mu H$ and $M = 45\mu H$. Then $C = 100$ PF.

Circuit diagram:-

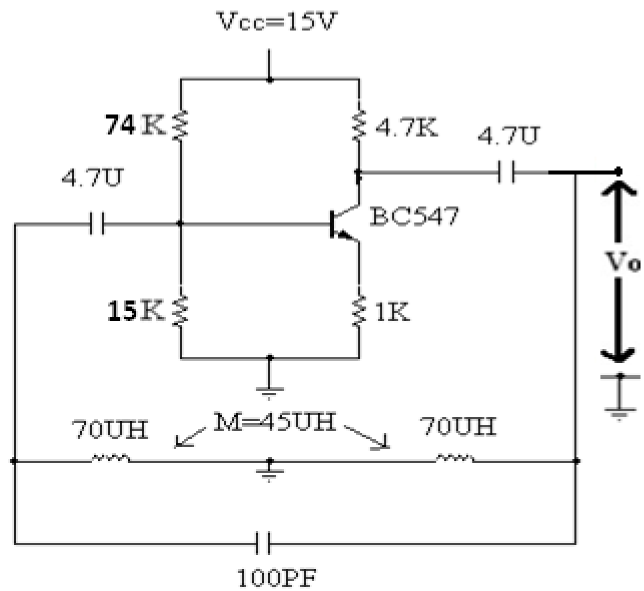


Fig (1): Hartley's Oscillator

Procedure:-

1) Connect the self bias circuit and check the DC conditions.
2) Connect other components of the oscillator circuit as shown in figure. Adjust the capacitance to 800 PF.
3) Observe the output voltage waveform on CRO screen. Note down its peak to peak amplitude and frequency.
4) Vary the capacitance in appropriate steps and record the frequency in each case.
5) Calculate the frequency theoretically also and record it in the table. Compare the theoretical and practical values.

Observations:-

DC conditions:-

V_{BE} = ……………. V_{CE} = ………………

I_B = ……………… I_C = ………………..

Sl. No.	**Capacitance (PF)**	**Frequency (Practically) (MHz)**	**Frequency** $f_o = \frac{1}{2\pi\sqrt{(L_1 + L_2 + 2M)C}}$

Result:-

Hartley oscillator circuit is designed for the given specifications and its operation is studied.

EXPERIMENT NO: 13

COLPITTS OSCILLATOR

Aim:

To design and study the operation of colpitts Oscillator using BJT and determine the frequency of oscillation.

Components:

Name	Quantity
Transistor BC547	1
Resistor 74KΩ, 15 KΩ, 4.7KΩ, 1KΩ,	1,1,1,1
Capacitor 4.7μF, 1 KPF	2, 1
Inductor 70 μH	1

Equipment:

Name	Range	Quantity
Bread Board		1
Dual DC power supply	0-30V	1
Digital Ammeter, Voltmeter	[0-200μA/200mA], [0-20V]	1
CRO	(0-20)MHz	1
CRO probes, Connecting Wires		

Specifications:

For Transistor BC 547:

- Max Collector Current= 0.1A
- V_{ceo} max= 50V
- V_{EB0} = 6V
- V_{CB0} = 50V
- Collector power dissipation = 500mW
- Temperature Range = -65 to +150 ^{0}C
- h_{fe} = 110 - 220

Theory:-

An oscillator is an electronic circuit that provides an AC output without using any AC input. All Sinusoidal oscillator circuits use the concept of positive feedback to produce oscillations. An oscillator circuit must satisfy the Barkhausen's criterion of unity loop gain to produce oscillations.

Colpitt's oscillator is a popular LC Oscillator circuit used at Radio Frequencies.

Design:

Q: Design Colpitt's oscillator circuit to provide oscillations at a frequency of 850 KHz. Use BJT BC547 for which β = 200, h_{fe} = 50, h_{ie} = 1.5 KΩ and $V_{BE(active)}$ = 0.65V. The biasing conditions are as follows.V_{CC} = 12V, I_C = 1mA, V_{CE} = 6V and Stability factor is S = 10. Use R_C = 4.7KΩ.

Solution:

Use, $I_C = \beta \times I_B$

$$\Rightarrow I_B = 5\mu A$$

Apply KVL to the output loop:

$$-V_{CC} + I_C \times R_C + V_{CE} + I_C \times R_E = 0$$

$$\Rightarrow R_E = 1.3K\Omega$$

Apply Thevenin's theorem to the base circuit, then

$$V_B = \frac{V_{CC} \times R_2}{R_1 + R_2} \text{ And } R_B = \frac{R_1 \times R_2}{R_1 + R_2}$$

We know that the stability factor for a self bias circuit is given by,

$$S = \frac{1+\beta}{1 + \frac{\beta \times R_E}{R_B + R_E}}$$

$$\Rightarrow R_B = 12.31K\Omega$$

Apply KVL to the input loop, then

$$-V_B + I_B \times R_B + V_{BE} - I_E \times R_E = 0$$

$$\Rightarrow V_B = 2.01\text{V}$$

Divide R_B with V_B:

$$\Rightarrow R_1 = \frac{V_{CC} \times R_B}{V_B} = 73.5K\Omega$$

Also, $R_B = \frac{R_1 \times R_2}{R_1 + R_2}$ $\Rightarrow R_2 = 14.8K\Omega$

We know that $f_o = \frac{1}{2\pi} \times \sqrt{\frac{1}{L}(\frac{1}{C_1} + \frac{1}{C_2})}$

Assume that $C_1 = C_2 = 1KPF$. Then

$L = 70\mu H$

Circuit diagram:-

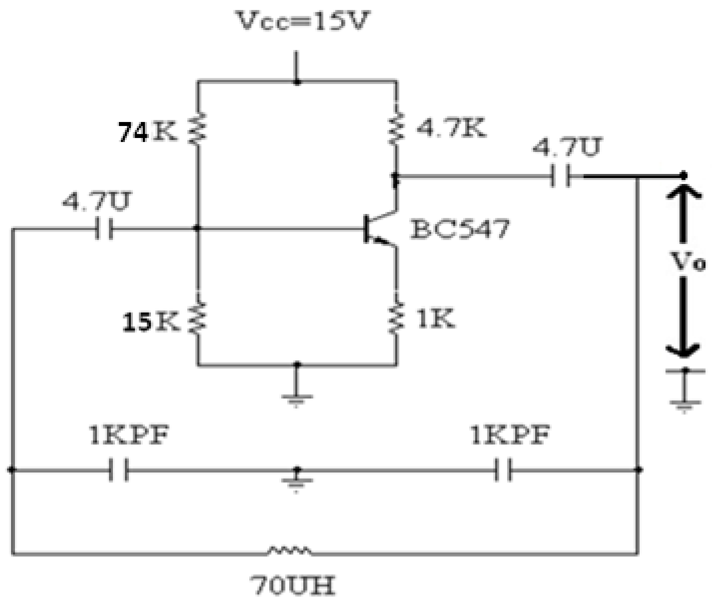


Fig (1): Colpitts Oscillator

Procedure:-

1) Connect the self bias circuit and check the DC conditions.
2) Connect other components of the oscillator circuit as shown in figure 1. Adjust the capacitance to 800 PF.
3) Observe the output voltage waveform on CRO screen. Note down its peak to peak amplitude and frequency.
4) Vary the inductance in appropriate steps and record the frequency in each case.
5) Calculate the frequency theoretically and record it in the table. Compare the theoretical and practical values.

Observations:-

DC conditions:-

V_{BE} = ……………. V_{CE} = ………………

I_B = ……………… I_C = ………………..

Sl. No.	**Inductance (µH)**	**Frequency (Practically) (KHz)**	**Frequency** $f_o = \frac{1}{2\pi} \times \sqrt{\frac{1}{L}(\frac{1}{C_1} + \frac{1}{C_2})}$

Result:-

Colpitts oscillator circuit is designed for the given specifications and its operation is studied.

EXPERIMENT NO: 14

SOLDERING AND DESOLDERING PRACTICE

Aim: To perform soldering and Desoldering of electronic components on PCB

Components Required:
- Soldering iron – 1
- Soldering iron stand – 1
- Soldering reel
- Sponge -1
- Flux-1
- Resisters-6
- Dotted board /PCB-1

Theory:

Soldering is a process for the joining of metal parts with the aid of a molten metal (SOLDER) where the melting temperature is situated below that of the material joined. Solder is an alloy of tin and lead used for fusing metals at relatively low temperatures of about 500 to 600 F. The joint where two metal conductors are to be fused is heated and then solder is applied so that it can melt and cover the connection. The reason for soldering connections is that it makes a good bond between the joint metal, covering the joint completely to prevent oxidation. The coating of solder provides protection for practically an indefinite period of time .

Mechanisms of Soldering:

The trick in soldering is to heat the joint, not the solder. When the joint is hot enough to melt the solder, the solder flows smoothly to fill the cracks forming a shiny cover without any air spaces. Do not move the joint until the solder has set, which takes only a few seconds. The small pencil soldering iron of 25W to 40W is helpful for soldering small connections where excessive heat can cause damage. This precaution is particularly important when working on PCB's where too much heat can soften the plastic form and loosen the printed wiring. A soldering iron for FET devices should have the tip grounded to eliminate the static charge.

Grades of Solder:

The three grades of solder generally used for electronic work are 40-60, 50-50, and 60-40 solder. The first figure is the percentage of tin while the other is the percentage of led.

The 60-40 solder costs more but it melts at the lowest temperature, flows more freely, takes less time to harden and generally makes it easier to do a good soldering job.

In addition to the solder, there must be flux to remove any oxide film on the metals being joined. Otherwise they cannot fuse. The flux enables the molten solder to wet the metals so that the solder can stick. The two types are ACIDFLUX and ROSINFLUX. The acid flux is more active in cleaning metals but it is corrosive. The rosin flux is always used for light soldering works in making wire connections. Generally the rosin is in the hollow core of solder intended for electronic work so that a separate flux in unnecessary. Such rosin core solder is the type which is generally used. It should be noted, though, that the flux is not a substitute for cleaning the metals to be fused. They must be shiny cleaned for the solder to stick.

Desoldering Technique:

On PCB's, de soldering is done to remove a defective components. De soldering is more important than the soldering. There are different methods of de soldering.

1. Using solder sucker: The solder sucker (de soldering pump) is first cocked and then the joint is heated in the same way as during soldering, and when the solder melts, the release button is pushed to disengage the pump. The method is repeated two to three times until the soldered components can be comfortably removed using long nose pliers.
2. Using wet de soldering wick: The wet de soldering wick is nothing but a fine copper braid used as a shield in co-axial cables. The de soldering wick is wet is using soldering flux and then it is pressed using the tip of the hot iron against the joint to be de soldered. The iron melts the solder, and it is drawn into the braid.

Precautions:

1. Mount the components at the appropriate places before soldering. Follow the circuit description and the component details, leads identification etc. Do not start soldering before making it confirmed that all the components are mounted at the right place.
2. Do not use a spread solder on the board, it may cause short circuit.
3. Do not under the fan while soldering.
4. Position the board so that gravity tends to keep the solder where you want it.
5. Do not over heat the components at the board. Excess heat may damage the components or the board.

6. The board should not vibrate while soldering, otherwise you will have a dry or a cold joint.

Figures:

Fig 1: Soldering iron

Fig 2: Sponge

Fig 3: Solder

Fig 4: Solder reel iron stand

Fig 5: Flux.

Fig 5: De-solder

Fig 6: Desoldering Sucker

Results: Soldering and Desoldering of electronics component have done successfully on the Copper clad board

APPENDIX

LABORATORY COURSE ASSESSMENT GUIDELINES

i. The number of experiments in each laboratory course shall be as per the curriculum in the scheme of instructions provided by OU. Mostly the number of experiments is 10 in each laboratory course under semester scheme and 18 under year wise scheme.

ii. The students will maintain a separate note book for observations in each laboratory course.

iii. In each session the students will conduct the allotted experiment and enter the data in the observation table.

iv. The students will then complete the calculations and obtain the results. The course coordinator will certify the result in the same session.

v. The students will submit the record in the next class. The evaluation will be continuous and not cycle-wise or at semester end.

vi. The internal marks of 25 are awarded in the following manner:
   a. Laboratory record - Maximum Marks 15
   b. Test and Viva Voce - Maximum Marks 10

vii. Laboratory Record: Each experimental record is evaluated for a score of 50. **The rubric parameters are as follows:**
   a. Write up format - Maximum Score 15
   b. Experimentation Observations & Calculations - Maximum Score 20
   c. Results and Graphs - Maximum Score 10
   d. Discussion of results - Maximum Score 5

While (a), (c) and (d) are assessed at the time of record submission, (b) is assessed during the session based on the observations and calculations. Hence if a student is absent for an experiment but completes it in another session and subsequently submits the record, it shall be evaluated for a score of 30 and not 50.

viii. The experiment evaluation rubric is therefore as follows:

Parameter	**Max Score**	**Outstanding**	**Accomplished**	**Developing**	**Beginner**	**Points**
Observations and Calculations	20					
Write up format	15					
Results and graphs	10					
Discussion of Results	5					

LABORATORY EXPERIMENT EVALUATION RUBRIC

CATEGORY	OUTSTANDING (Up to 100%)	ACCOMPLISHED (Up to 75%)	DEVELOPING (Up to 50%)	BEGINNER (Up to 25%)
Write up format	Aim, Apparatus, material requirement, theoretical basis, procedure of experiment, sketch of the experimental setup etc. is demarcated and presented in clearly labeled and neatly organized sections.	The write up follows the specified format but a couple of the specified parameters are missing.	The report follows the specified format but a few of the formats are missing and the experimental sketch is not included in the report	The write up does not follow the specified format and the presentation is shabby.
Observations and Calculations	The experimental observations and calculations are recorded in neatly prepared table with correct units and significant figures. One sample calculation is explained by substitution of values	The experimental observations and calculations are recorded in neatly prepared table with correct units and significant figures but sample calculation is not shown	The experimental observations and calculations are recorded neatly but correct units and significant figures are not used. Sample calculation is also not shown	The experimental observations and results are recorded carelessly. Correct units significant figures are not followed and sample calculations not shown
Results and Graphs	Results obtained are correct within reasonable limits. Graphs are drawn neatly with labeling of the axes. Relevant calculations are performed from the graphs. Equations are obtained by regression analysis or curve fitting if relevant	Results obtained are correct within reasonable limits. Graphs are drawn neatly with labeling of the axes. Relevant calculations from the graphs are incomplete and equations are not obtained by regression analysis or curve fitting	Results obtained are correct within reasonable limits. Graphs are not drawn neatly and or labeling is not proper. No calculations are done from the graphs and equations are not obtained by regression analysis or curve fitting	Results obtained are not correct within reasonable limits. Graphs are not drawn neatly and or labeling is not proper. No calculations are done from the graphs and equations are not obtained by regression analysis or curve fitting
Discussion of results	All relevant points of the result are discussed and justified in light of theoretical expectations. Reasons for divergent results are identified and corrective measures discussed.	Results are discussed but no theoretical reference is mentioned. Divergent results are identified but no satisfactory reasoning is given for the same.	Discussion of results is incomplete and divergent results are not identified.	Neither relevant points of the results are discussed nor divergent results identified

ix. The first page of the record will contain the following title sheet:

SAMPLE ASSESSMENT SHEET

NAME: **ROLL NO.**

Exp. No.	Date conducted	Date Submitted	Observations &Calculations (Max 20)	Write up (Max 15)	Results and Graphs (Max 10)	Discussion of Results (Max 5)	Total Score (Max 50)
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							
11							
12							

x. The 15 marks of laboratory record will be scaled down from the TOTAL of the assessment sheet.

xi. The test and viva voce will be scored for 10 marks as follows:
Internal Test - 6 marks
Viva Voce / Quiz - 4 marks

xii. Each laboratory course shall have 5 course outcomes.

The proposed course outcomes are as follows:

On successful completion of the course, the student will acquire the ability to:

1. Conduct experiments, take measurements and analyze the data through hands-on experience in order to demonstrate understanding of the theoretical concepts of ________________________, while working in small groups.

2. Demonstrate writing skills through clear laboratory reports.

3. Employ graphics packages for drawing of graphs and use computational software for statistical analysis of data.

4. Compare the experimental results with those introduced in lecture, draw relevant conclusions and substantiate them satisfactorily.

5. Transfer group experience to individual performance of experiments and demonstrate effective oral communication skills.

xiii. The Course coordinators would prepare the assessment matrix in accordance with the guidelines provided above for the five course outcomes. The scores to be entered against each of the course outcome would be the sum of the following as obtained from the assessment sheet in the record:

a. Course Outcome 1: Sum of the scores under 'Observations and Calculations'.
b. Course Outcome 2: Sum of the scores under 'Write up'.
c. Course Outcome 3: Sum of the scores under 'Results and Graphs'.
d. Course Outcome 4: Sum of the scores under 'Discussion of Results'.
e. Course Outcome 5: Marks for 'Internal Test and Viva voce'.

xiv. Soft copy of the assessment matrix would be provided to the course coordinators.

MUFFAKHAM JAH COLLEGE OF ENGINEERING AND TECHNOLOGY

Program Outcomes of B.E (ECE) Program:

PO1: Engineering knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

PO2: Problem analysis: Identify, formulate, research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences

PO3: Design/development of solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

PO4: Conduct investigations of complex problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

PO5: Modern tool usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.

PO6: The engineer and society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal, and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

PO7: Environment and sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

PO8: Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

PO9: Individual and team work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

PO10: Communication: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

PO11: Project management and finance: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

PO 12: Life-long learning: Recognise the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Program Specific Outcomes (PSOs) of ECE Department, MJCET

PSO1: The ECE Graduates will acquire state of art analysis and design skills in the areas of digital and analog VLSI Design using modern CAD tools.

PSO2: The ECE Graduates will develop preliminary skills and capabilities necessary for embedded system design and demonstrate understanding of its societal impact.

PSO3: The ECE Graduates will obtain the knowledge of the working principles of modern communication systems and be able to develop simulation models of components of a communication system.

PSO4: The ECE Graduates will develop soft skills, aptitude and programming skills to be employable in IT sector.