1. Characteristics of Zener Diode

Aim:-To plot the characteristic curves for the zener diode and hence to determine knee and breakdown voltage.

Apparatus: Zener diode, Power Supply, dc milliammeter and dc voltmeter.

Theory/Principle: A PN junction is known as a semiconductor or crystal diode, so called because PN junction is grown out of a crystal.

Biasing a diode means applying appropriate DC voltage to a diode. A forward biased diode conducts easily whereas reverse biased diode practically conducts no current. It means that forward resistance of a diode is quite small as compared with its reverse resistance.

Forward current is the current flowing through a forward biased diode. Every diode has a maximum value of forward current, which it can safely carry. If this value is exceeded, the diode may be destroyed due to excessive heat. Reverse current or leakage current is the current that flows through the reverse biased diode. This current is due to the minority carriers. Under normal operating voltages the reverse current is quite small. Its value is extremely small for silicon diodes but it is appreciable for germanium diodes. Peak inverse voltage is the maximum reverse voltage that a diode can withstand without destroying the junction. If the reverse voltage across a diode exceeds this value, the reverse current increases sharply and breaks down the junction due to excess heat. Peak inverse voltage is important when diode is used as a rectifier.

Zener diode is a heavily doped PN junction diode, meant to operate in reverse bias condition. The breakdown or zener voltage depends upon the amount of doping. If the diode is heavily doped, depletion layer will be thin and consequently the breakdown of the junction will occur at a lower reverse voltage. On the other hand, a lightly doped diode has a higher breakdown voltage. When zener diode is forward biased, its characteristics are just same as ordinary diode.

Circuit Diagram:

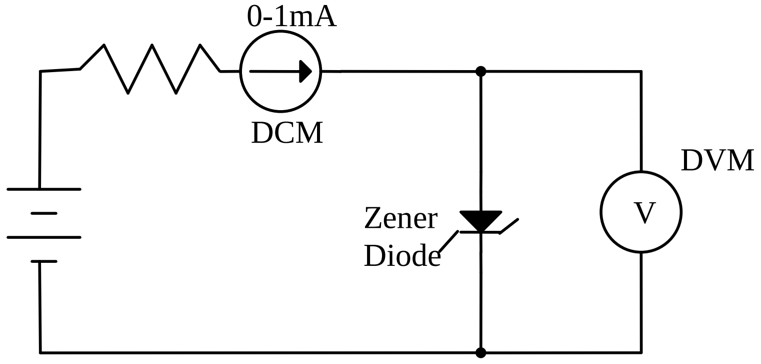


Fig.1:-Forward Bias setup

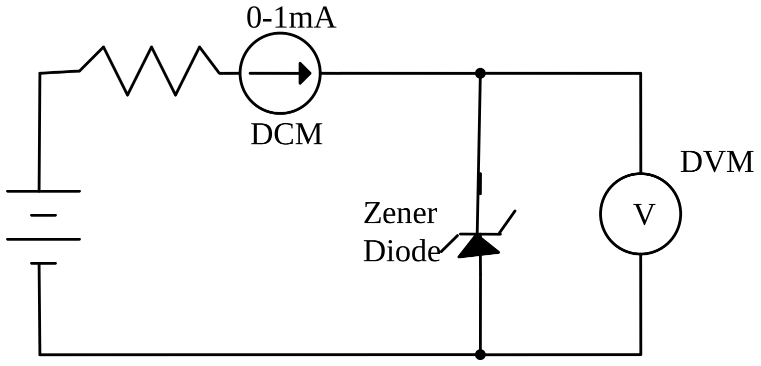


Fig.2:-Reverse Bias setup.

Expected Graph:

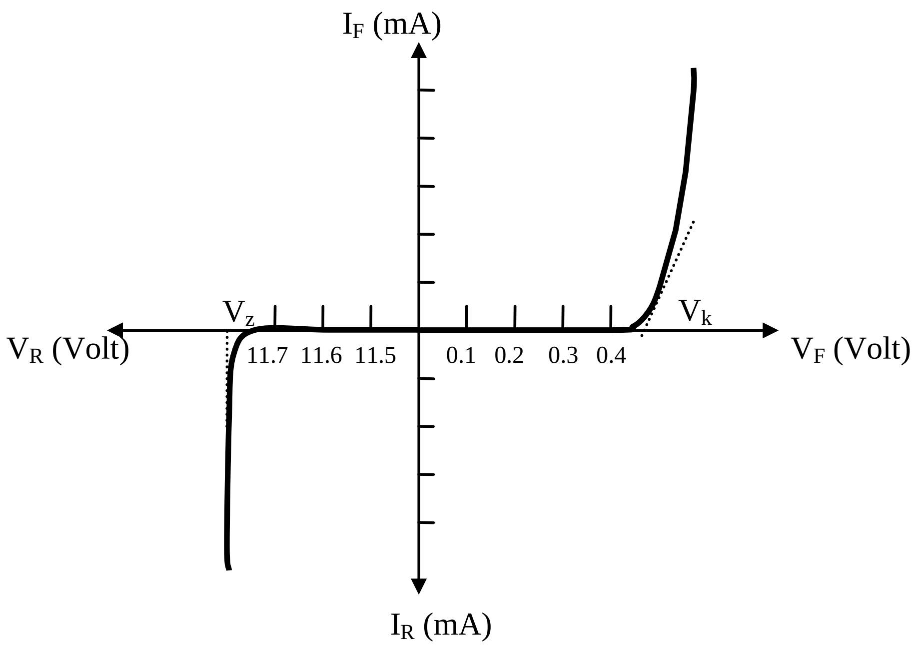


Fig.3:- Zener Diode Characteristics

Experimental Procedure:

The circuit connections are made as shown in the Fig.1. Initially the voltage is set at 0V. The voltage is then varied in the steps of 0.1V and the corresponding reading of the ammeter is noted. This set of reading corresponds to the forward bias.

The circuit is then made for reverse bias as shown in Fig.2. The current is measured by varying voltages in steps of 1V (in steps of 0.1 after the current starts increasing).

A graph is plotted by taking voltage along X-axis and current along Y-axis. The knee voltage is found by drawing a tangent in the forward bias at a point where the current starts increasing at a faster rate. The breakdown voltage is found by extending the curve to the X-axis in the reverse bias.

Table.1: Characteristics of a Zener diode.

Forward Bias		**Reverse Bias**	
Voltage 'V_f' in V	**Current 'I_f' in mA**	**Voltage 'V_r' in V**	**Current 'I_r' in mA**

Result: The Knee voltage = ……………………..V

The Breakdown voltage = ……………….V

Inference: **(To be written by the student through keen observations and the result obtained in his/her experiment)**

Viva Questions:

1. What is a semiconductor?
2. What is the difference between intrinsic and extrinsic semiconductors?
3. Define P-N junction diode?
4. How Zener diode differs from P-N junction diode?
5. Define valence electrons? How much is the valency of intrinsic semiconductor (silicon or germanium)?
6. Draw the crystal structure of silicon?
7. What is doping? What are the impurity materials used in doping?
8. What kind of additions takes place in the band structure when doping is done for a semiconductor?
9. Define biasing of a diode? Explain the biasing curves of both zener diode and junction diode?
10. Explain the operation of zener diode in both forward bias and in reverse bias?
11. Define avalanche breakdown and zener breakdown?
12. What is a knee voltage?
13. Mention different applications of a diode and zener diode?
14. Is there any other types of diodes exist?
15. Why the common name "crystal diode" is used for all diodes?
16. What are minority and majority carriers?

Sample Viva Questions with answers:

1) What do you mean by Characteristics of a Zener Diode?

A Graph showing the variation of voltage applied across the terminals of a diode to the corresponding current is called characteristics of a diode. In case of junction diodes, there are two types of characteristics, forward and reverse characteristics.

2) Explain the flow of current in zener diode under reverse biasing condition.

In case of reverse biasing condition, the external field is established in a direction such as to help internal field. Under this biasing the holes in P- region and electrons in N- region are pushed away from the junction with the result that the depletion or barrier layer is thickened and hence increases the potential barrier, therefore, the flow of current stops. Only a few thermally generated minority carriers produce a very small current.

3) Explain the flow of current in zener diode under forward biasing condition.

In the case of forward biasing condition, the zener diode behaves like an ordinary p-n junction diode. In this case the external field is established in a direction such as to oppose the internal field. The external field is much stronger than internal field. In this arrangement holes move along the external field from p-region to n-region and electrons move opposite to the field from n-region to p-region, that is, the majority carriers from each side move across the junction. The potential barrier or depletion layer at the junction wiped out and a substantial current flows depending upon the density of n- and p- carriers.

4) What is Zener diode?

It is a specially designed heavily doped silicon (or germanium) p-n junction diode (reduced width of the depletion layer) which can operate in the reverse breakdown voltage region continuously without being damaged.

5) What do you mean by doping?

The process of introducing the impurity in a semiconductor is called doping.

6) What is Zener breakdown?

If the reverse potential across the zener diode is increased beyond a certain value, the current increases very rapidly due to zener breakdown. Zener breakdown occurs when the applied electric field or potential is so high that the valence band electrons are pulled out to the conduction band in large numbers resulting in breakdown. Thus, a zener breakdown, direct rupture of covalent bonds take place by thermally generated carriers having acquired high energy due to strong electric field.

7) What do you mean by avalanche breakdown?

When the reverse voltage is made sufficiently high the thermally generated electrons and holes acquire high energy from the applied potential and make ionizing collisions with the atoms of the crystal. These collisions produce further electrons, which in turn collide with further atoms. The commutative effect of such collisions results in the breakdown of the junction. Due to this avalanche multiplication the reverse current increases abruptly to high value. This is called avalanche breakdown and may damage the junction.

8. What are the differences between avalanche breakdown and zener breakdown?

In general zener breakdown occurs below 8V and avalanche breakdown occurs at higher voltages (~20 V). The Zener breakdown is characterized by the soft knee, whereas avalanche breakdown is hard knee type. Zener breakdown voltage has a negative temperature coefficient, while the avalanche breakdown voltage exhibits positive temperature coefficient.

9. How the width of the depletion region in the reverse biased diode varies with the impurity concentration.

The width of the depletion region of a reverse biased diode varies as the square root of the impurity concentration.

10. How the value of the potential barrier depends on the amount of doping of the semiconductor?

The value of potential barrier decreases with heavy amount of doping of the semiconductor.

11. Why the silicon diode is preferred compare to germanium diode?

Silicon diodes are preferred compare to germanium diodes because of its higher temperature to current capability.

12. Under what condition a zener diode behaves like an ordinary p-n junction diode?

A zener diode behaves as an ordinary p-n junction diode when it is used in forward bias conditions.

13. What is the main application of a zener diode?

An important application of zener diode is its use as voltage regulator. The regulating action takes place due to the fact that in reverse breakdown region; a very small change in voltage produces a very large change in current.

2. Transistor Characteristics

Aim:To study the input and output characteristics curves of the given NPN transistor and hence to determine the amplification factor.

Apparatus: An NPN Transistor, regulated power supply, voltmeters and ammeters

Theory/Principle: A transistor is a three terminal semiconductor device The three terminals are the emitter, the base and the collector. A transistor transfers a signal from low resistance to high resistance; hence it is named as transistor.

In a transistor, the N and P type semiconductor sections are alternated. Though it is a continuous body of a single crystal, the doping is done in such a way that either a P section appears in between two N sections (the NPN transistor), or an N section appears in between two P sections (the PNP transistor). The middle appears to be sandwiched between the other two, namely the emitter and the collector. In comparison to the doping level of the collector, the emitter is always heavily doped in order to provide a large supply of charge carriers, and the base is lightly doped to minimize the recombination that occurs in it between the electrons and the holes. The collector will be having a large area in order to efficiently gather the charge carriers. In order to identify the terminals you should carefully observe the transistor. You can locate a small projecting flap at its bottom edge. The nearest lead to this tab is always the emitter lead, and the farthest one is the collector lead. The lead between the emitter and the collector is the base lead.

The emitter base junction of a transistor is forward biased whereas collector base junction is reverse biased. If for a moment we ignore the presence of emitter base junction, then practically no current would flow in the collector circuit because of the reverse bias. However, if the emitter base junction is also present then forward bias on it causes the emitter current to flow. It is seen that this emitter current almost entirely flows in the collector circuit; therefore the current in the collector circuit depends on the emitter current. If the emitter current is zero, then collector current is nearly zero. However, if the emitter current is 1mA then collector current is also about 1mA.

Working of NPN transistor: The forward bias causes the electrons in the N type emitter to flow towards the P type base. This constitutes the emitter current I_e. As these electrons flow through the P type base, then tend to combine with holes. As the base is lightly doped and very thin, therefore, only a few electrons combine with holes to constitute base current I_b. The remainder cross over into the collector region to constitute collector current I_c. In this way, almost the entire emitter current flows in the collector circuit. It is clear that emitter current is the sum of collector and base currents.

i.e., $I_e = I_b + I_c$ ......(1)

Current amplification factor is the ratio of output current to the input current.
Current amplification factor in common emitter configuration is the ratio of change in collector current to the change in base current, denoted by β.

$$\beta = \left(\frac{\Delta I_c}{\Delta I_b}\right)_{constant\ V_{ce}} \quad .....(2)$$

Further, the current amplification factor in common base mode is denoted by α. The relation between the current amplification factors in common emitter and common base modes is as below:

$$\alpha = \frac{\beta}{1+\beta} \quad ....(3)$$

where ΔI_c is change in collector current corresponding to change in base current.
ΔI_b is change in base current.
V_{ce} collector emitter voltage, which is kept constant in volts
V_{be} change in base-emitter voltage in volts.

Circuit Diagram:.

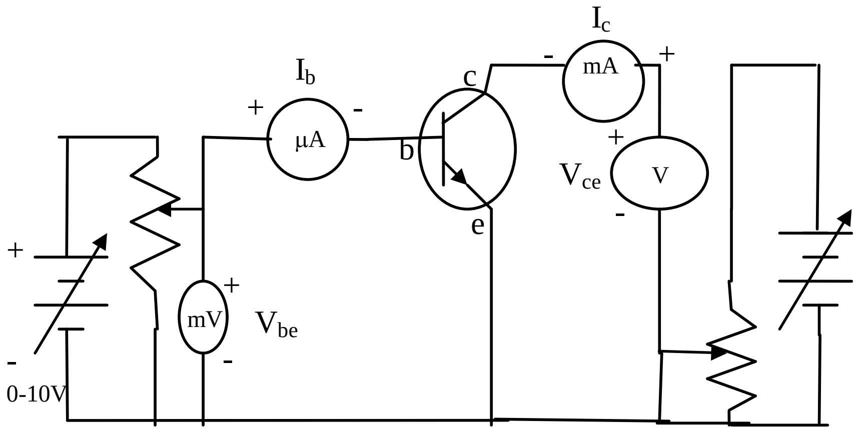


Fig.1:-NPN Transistor in CE configurations.

Expected Graphs:

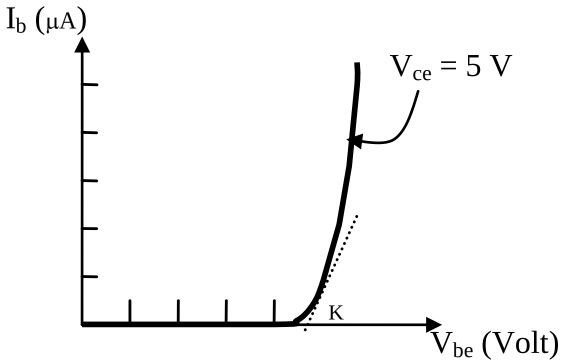


Fig.2:- Input Characteristics of a transistor

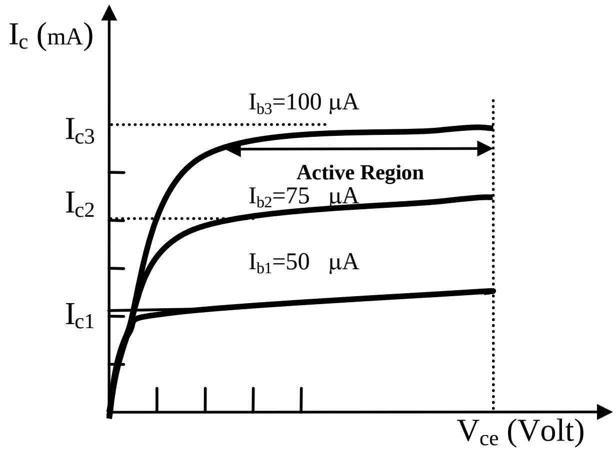


Fig.3: Output Characteristics of a transistor

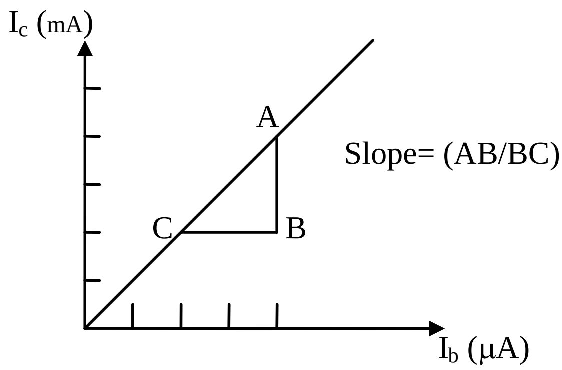


Fig.4:- Transfer characteristics of a transistor

Experimental Procedure: The circuit connections are made and the transistor is connected in CE configurations.

Input Characteristics: The collector emitter voltage (V_{ce}) is kept constant. Now the base emitter voltage (V_{be}) is varied and the corresponding base current I_b readings are noted. Similarly, one more set of readings are taken by keeping V_{ce} constant. A graph of V_{be} against I_b is plotted.

Output Characteristics: The base current I_b is kept constant and collector emitter voltage V_{ce} is varied and corresponding current I_c are noted. Similarly, one more set of readings are taken for constant base current. A graph is plotted and β is found from the graph.

Table.1:- Input Characteristics

V_{CE} = 5 in volts	
V_{BE} in Volts	I_B in µA
0.1	
0.2	
0.3	
0.4	
0.5	
0.6	
0.7	
0.8	

Table.2:- Output Characteristics

I_B= in μA		I_B= in μA	
V_{CE} in Volts	I_c in mA	V_{CE} in Volts	I_c in mA
0.1		0.1	
0.2		0.2	
0.3		0.3	
0.4		0.4	
0.5		0.5	
0.6		0.6	
0.7		0.7	
0.8		0.8	
0.9		0.9	
1.0		1.0	

Table.3:- Transfer Characteristics

V_{CE}= in V	
I_B in μA	I_c in mA
10	
20	
30	
40	
50	
60	
70	
80	
90	
100	

<u>Result:</u> The input and output characteristics of transistor is studied and the values of β and α are found.

β=……….(from output characteristics graph)
β=……….(from transfer characteristics graph)
α=………..

<u>Inference:</u> (To be written by the student through keen observations and the result obtained in his/her experiment)

<u>Viva Questions:</u>

1. What is a transistor? How many types of transistors are there?
2. What are the comparative differences in the doping concentration between the emitter, base and the collector
3. Which are the 3 basic transistor connection modes?
4. Which among the emitter, base and collector, appear in the input part, and which two in the output part in the common emitter configuration? What do the names input and output represent?
5. What do you mean when you say the value of amplification is 100?
6. What is the meaning of saying α = 0.99?
7. What do you mean by saying transistor characteristics?
8. How do you identify the emitter base and collector of a transistor by physical inspection?
9. Describe the flow of electrons starting from the emitter in the circuit under CE configuration for an NPN transistor?
10. What does an arrow in a transistor symbol represent, and what does the direction of the arrow indicate in a transistor symbol?

11. Though the collector is reverse biased, the collector current is highest in the circuit. Why is it so?
12. What happens if the emitter is reverse biased?
13. What are the applications of transistor?
14. Which type of material is replacing the silicon transistors?

Sample Viva Questions with answers:

1. What is meant by characteristics of a transistor? What is its use?

The transistor is a semiconductor triode and regarded as a combination of two junction PN diodes. One biased in low impedance direction and the other in high impendence direction. Characteristics of a transistor are the curves showing the variation of current with voltage when the transistor is connected in different configurations. It is used to study its performance as well as in calculating the current gain, voltage gain and power gain of a circuit.

2. In how many ways can a transistor be used? Which of these circuits is better?

A transistor can be used in the following three ways:

1) Common base or grounded base configuration (CB)
2) Common emitter or grounded emitter configuration (CE)
3) Common collector or grounded collector configuration (CC)

Among these three, common emitter circuit is the most efficient one because it has the highest voltage. This circuit produces phase reversal between input and output signal, which the other two circuits do not.

3. Why the central region (base) of a transistor is made very thin compared with emitter and collector region?

The central region of a transistor is made very thin to reduce the recombination of holes and electrons in this middle region so that there is an appreciable amount of collector current.

4. Is there any difference in the size of emitter and collector regions? Give the proper reasons?

Yes, in some transistors the thickness of the collector is larger than emitter. While using a transistor most of the heat is produced at the collector junction. Therefore, to dissipate heat collector is made wider than base and emitter.

5. Why NPN transistors are preferred over to PNP transistors?

It is because in the NPN transistors the current carriers are electrons, which have high mobility of energy. In NPN transistors we have high conduction than PNP.

6. Why the input resistance of a transistor is low and output resistance is high?

In transistors, the emitter is always forward biased and collector is always reverse-biased. In the emitter circuit, a small emitter to base voltage produce a large emitter current I_e, therefore input resistance to a small input voltage impressed on the emitter is very low. The reverse biased collector collects all the charge carries reaching to it through the base. Hence, a large change in the collector to base voltage produces only a small change in collector current. This implies that output resistance of the transistor is very high.

7. Why does the collector current in a transistor less than emitter current?

In either type of transistor the collector current is always less than the emitter current because of the recombination of electrons occurring in the base region.

8. What is the basic difference between PNP and NPN transistors?

The basic difference between the two transistors is that in PNP transistor the charge carriers are holes, whereas in NPN transistor the charge carriers are electrons.

9. Why does a transistor called a reversible device?

Transistor is called a reversible device because in transistors we can interchange emitter and collector so they have bi-directional facilities, which does not exist in case of vacuum tube thermionic valves.

10. What are the applications of a transistor?

Transistors are used as

i) Small signal amplifiers
ii) Audio frequency power amplifiers
iii) Oscillators
iv) Pulse circuits
v) Switches etc.,

3. LCR Circuits.

Aim: To draw the frequency response curve for series and parallel LCR circuits and to determine resonance frequency, bandwidth, inductance and quality factor of the circuit.

Apparatus: Audio frequency oscillator (AFO), Inductors, Capacitors, Resistors, ac milliammeter etc.,

Theory/Principle: Band Width = $(f_1 - f_2)$ in Hz

Inductance of the coil = $L = \dfrac{1}{4\pi^2 f_r^2 C}$ Henry

Quality Factor= Q= $\dfrac{2\pi f_r L}{R}$

Where,
- f_r Resonate Frequency in Hz
- C Capacitance in Micro Farad
- R Resistance in Ohms
- L Inductance in Henry
- f_1 Lower cut-off frequency in Hz
- f_2 Upper cut-off frequency in Hz

Circuit Diagram:

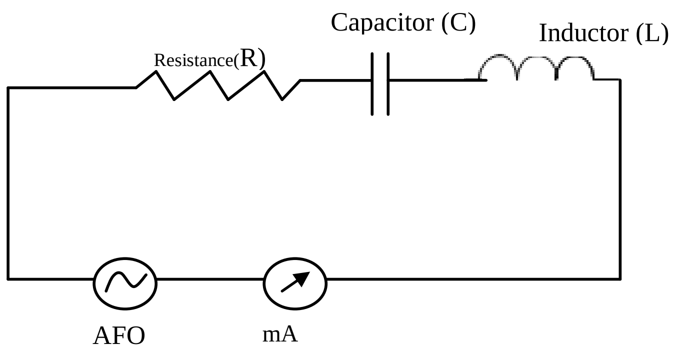


Fig.1:- Circuit connection for the Series LCR resonance.

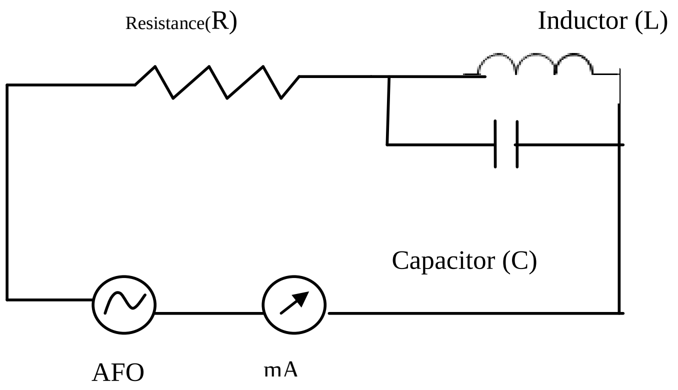


Fig.2:- Circuit connection for the Parallel LCR resonance.

Expected Graph:

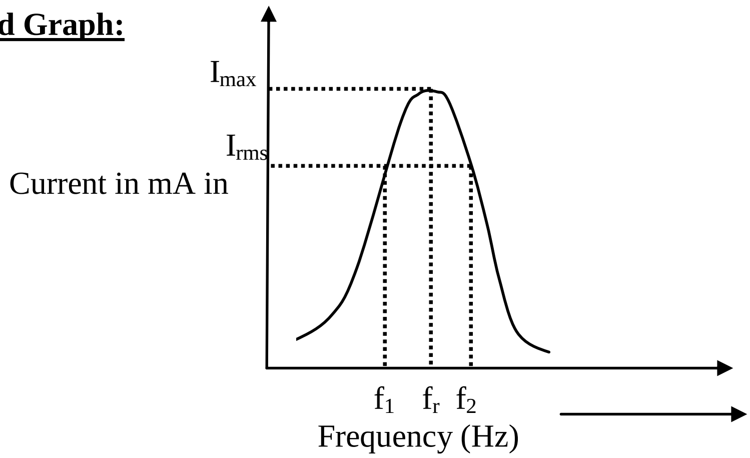


Fig.3:- Graph for Series LCR Circuit.

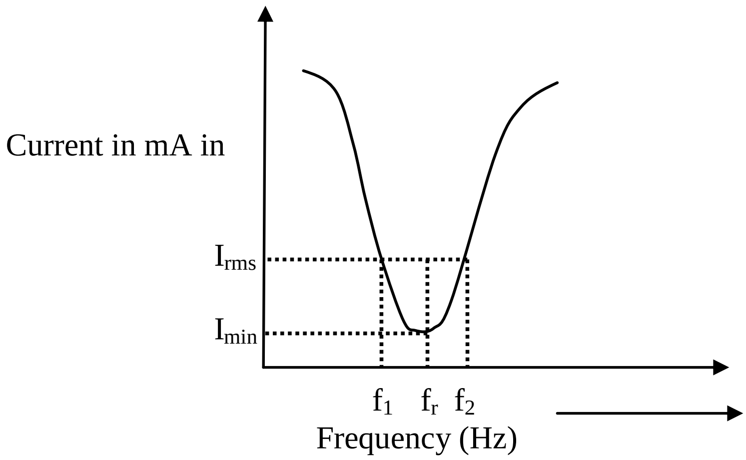


Fig.3:- Graph for Parallel LCR Circuit.

Experimental Procedure:

Series resonance Circuit:

The series LCR circuit is connected as shown in Fig.1. The frequency is varied in steps of milli ammeter readings are noted. A graph of frequency against current is plotted. Frequency corresponding to maximum current, I_m gives resonant frequency f_r. A line parallel to x-axis corresponding to I= $0.707I_m$ is drawn to cut the curve at two points which correspond to frequencies f_1 and f_2 respectively. $(f_2 - f_1)$ gives bandwidth, whose value indicates sharpness of resonance. The value of inductance, L and quality factor Q is determined using given formulae.

Parallel resonance circuit: The above experiment is repeated by connecting the parallel resonance circuit as in Fig.2. The milli ammeter readings are noted by varying audio frequency as before. A graph of frequency against current is plotted. A line parallel to x-Axis corresponding to I_{min} X 0.707 is drawn to cut curve at points which correspond to frequencies f_1 and f_2 respectively. The bandwidth, value of inductance, L and quality factor Q are calculated using given formulae.

Calculations:

1. Series LCR Resonant cirtuit
   a. Resonant frequency f_r (from graph)=……… Hz

   b. The unknown value of self inductance $L = \frac{1}{4\pi^2 f_r^2 C}$ =………..Henry

c. Bandwidth = $(f_2\text{-}f_1)$ Hz (from graph)
d. Quality factor (Q)= $f_r/(f_2\text{-}f_1)$
e. Quality factor from theory (Q) = $Q = \frac{1}{R}\left(\frac{\sqrt{L}}{\sqrt{C}}\right)$ (from theory)

2. Parallel LCR Resonant circuit
   a. Resonant frequency f_r (from graph)=……… Hz
   b. The unknown value of self inductance $L = \frac{1}{4\pi^2 f_r^2 C}$ =………..Henry

Table.1:- Series Resonance

Frequency in Hz	Current in mA

Table.2:- Parallel Resonance

Result:

Parameter	**Series LCR**	**Parallel LCR**
Resonant frequency		
Bandwidth		
Inductance of coil		
Quality factor		
Quality factor(from theory)		

Inference: **(To be written by the student through keen observations and the result obtained in his/her experiment)**

Viva Questions:

1. What is the aim of this experiment?
2. Define inductance of a coil. Mention its unit?
3. Define capacitance of a capacitor. Mention its unit?
4. Define resistance of a material. State ohm's law?
5. On which principle this experiment is based?

6. What is resonance? Give example.
7. Define Bandwidth, resonance frequency and quality factor of an ac circuit?
8. What is series and parallel resonant circuit?
9. Mention few applications of a LCR circuit?
10. What is a capacitor? Define dielectric constant of a material?
11. How to calculate the r.m.s value of a current?
12. Why the rms value of ac current and voltage will be considered.

<u>Sample Viva Questions with answers:</u>

1. Define Wave form, Amplitude, Cycle, Time Period, Frequency and Phase?

The shape of the curve obtained by plotting the instantaneous values of voltage or current against time gives the waveform of an alternating quantity. The waveforms of AC currents and voltage are not limited to sine waves, they may be square wave or triangular waves etc., The maximum value of the current or voltage whether positive or negative is called its amplitude. One complete set of positive and negative values of an alternating quantity is known as cycle. The time period of an alternating quantity is the time required to complete one cycle. The number of cycles per second of an alternating quantity is called frequency. Hence frequency of an alternating quantity is the reciprocal of the time period and is expressed in Hertz or cycles/second. Phase of an alternating quantity at any instant represents the fraction of the time period of that alternating quantity that has elapsed since the current last passed through the zero position of reference. Phase is also expressed in terms of angle in radians.

2. What happens to the current and voltage signals; when passed through inductance, resistance and capacitance separately?

When an alternating current is passed through the circuit in which only inductance alone a magnetic flux is setup, which induces alternating emf in the inductance. In this current wave lags the voltage wave by $\pi/2$ radians. The average power in a pure inductive circuit is zero. In a circuit containing pure resistance only the current and voltage waves will be in same phase. When an alternating voltage is applied to the plates of a condenser, they are first charged in one direction and then in the opposite direction. This makes the current leads the applied voltage wave by $\pi/2$ radians.

3. How you define inductive reactance and capacitive reactance.

The quantity ωL is called inductive reactance, it is denoted by X_L its units are ohms $X_L = \omega L = 2\pi f L$ where f is the frequency. The quantity $1/\omega C$ is called reactance or capacitive reactance and denoted by Xc. When C is in Farad the Xc is in ohm.

4. What are Series Resonance and parallel Resonance Circuits?

In a R, L and C connected in series the impedance is given by $Z=\sqrt{R^2+(X_L-X_c)^2}$ When $X_L=X_C$ at resonant frequency the impedance is minimum and equal to the resistance. This shows current and voltage are in phase. That is the frequency of the applied voltage coincides with the natural frequency of the circuit. Such a circuit is also called acceptor circuit. In a R, L and C connected in parallel when the current is zero, $X_L=X_C$. Hence at resonant frequency this circuit does not allow the current to flow i.e., it offers infinite impedance to the flow of current. Parallel resonance circuit works as a perfect choke for AC. Such circuits are called rejector circuit.

5. What is Q of a circuit?

Qualitatively the sharpness of resonance curve is determined by a quality factor called Q of the circuit. It is defined as the ratio of reactance of either the inductance or capacitance at the resonant frequency to the total resistance of the circuit. In series circuit, if sharper the response i.e., higher the Q value, the more highly selective the acceptor circuit is. Greater the ‘Q’ value smaller is the bandwidth; in turn the sharper is the resonance.

6. How Q of a circuit varies in the Parallel Resonance circuit?

A parallel Resonance circuit gives a current magnification equal to the quality factor at resonance similar to the voltage magnification by a series. The resonant frequency in parallel resonance is no longer independent of the resistance in the circuit as in the case with series resonance. Hence the resistance R should be kept as low as possible in rejector circuit.

7. What is bandwidth?

It is the range of frequencies over which the power falls within a specified fraction of the maximum value.

4. Measurement of Dielectric Constant by charging and discharging of capacitor

Aim: Using capacitors of known physical dimensions, dielectric constant is determined by charging-discharging it through resistor

Apparatus: RC Charging and discharging experimental setup consisting of digital stop clock, digital dc voltmenter, set of resistors and set of capacitors of known dimensions, dc power supply of 5V.

Theory and Principle:

A parallel plate condenser is formed by keeping two metallic plates parallel to each other. By applying a potential across the two plates an electric field is produced inside the space between the two plates. By placing an electrically insulated material within the plates the capacitance can be increased. The resulting capacitance of the parallel plate condenser is given by

$$C = K\frac{\varepsilon_0}{d}A \quad \ldots(1)$$

Where, C is the capacitance in Farad.
K is dielectric constant
ε_0 is the permittivity 8.85×10^{-12} Fm^{-1}.
A is the area of the plate
d is the distance between the plates or thickness of the dielectric material.

Charging and Discharging of a Capacitor

A capacitor can be charged using a resistor and a DC source. The capacitor will charge exponentially. The instantaneous voltage across the capacitor during charging is given by

$$V_{charge} = V_0\,(1-e^{-t/RC}) \quad \ldots(2)$$

Figure -1 shows charging-discharge circuit arrangements using DC voltage source. When the switch is thrown to the discharge position the capacitor looses its charge hence it discharges through R. Therefore, the voltage across capacitor starts decreasing until it becomes zero. The instantaneous voltage across the capacitor during discharge is given by

$$V_{discharge} = V_o\,(e^{-t/RC}) \quad \ldots(3)$$

Where R is resistance in ohms
C is capacitance in Farad
t is the instantaneous time
V_o is the maximum voltage to which capacitor is charged

Figure-2 shows the charge-discharge curve. The charge-discharge curve intersects at a point P. At this instant of time T_p the voltage across the condenser is the same during charge and discharge process. Therefore, we have

$V_{Charge} = V_{discagrge}$

$(1-e^{-Tp/RC}) = (e^{-Tp/RC})$

i.e. $\frac{1}{2} = e^{-tp/RC}$

$\ln(\frac{1}{2}) = {}^{-T}{}_{P}/RC$

$RC = -T_P \ln 0.5$

$$C = \frac{0.693T_P}{R} \quad \ldots(4)$$

By physically measuring the dimensions of the capacitor dielectric constant can be determined.

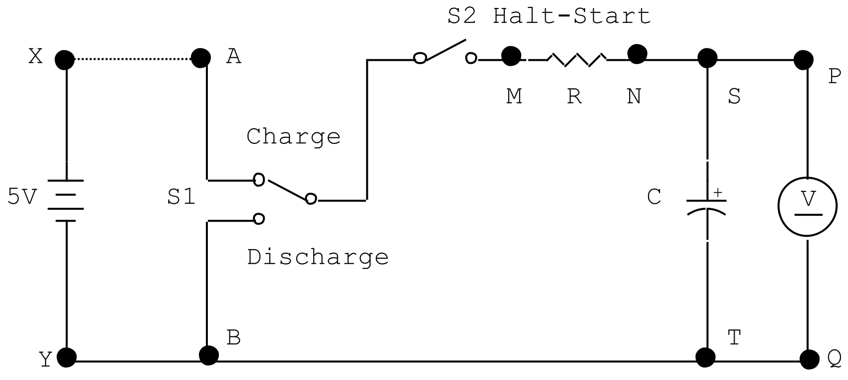
$$K = \frac{T_p d}{0.693\varepsilon_0 AR} = \frac{1.44T_p d}{\varepsilon_0 AR} \quad \ldots(5)$$

The capacitor dimensions are mentioned in mm in general. Hence equation 5 is rewritten as

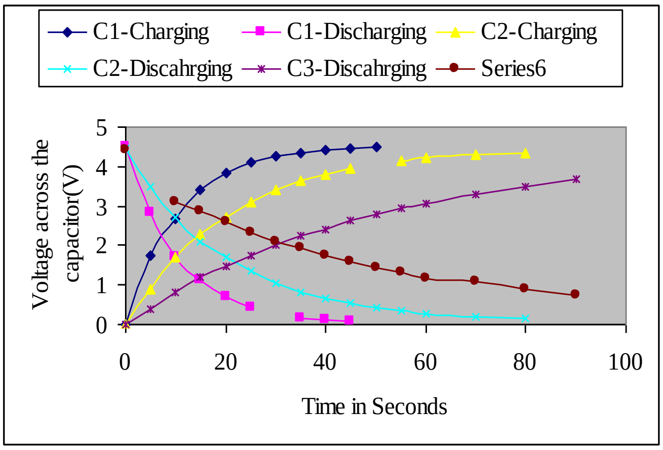
$$K = \frac{1.44\, T_P\, d}{\varepsilon_0\, AR}.10^{-6} \quad \ldots(6)$$

Where A is anode foil area in mm^2
d is the separation between the foils or the thickness of the paper in mm
R is the resistance Ohms
T_P is in seconds
$\varepsilon o = 8.85x10^{-12}F/m$

Circuit Diagram:



Expected Graph:



Experimental Procedure:

1. The circuit connections are made as shown in Circuit Diagram. R selected as 100KΩ and Capacitor $C_1$is selected and connected to the circuit using patch cords.

2. The digital stop clock is reset by pressing reset button. The display indicates 00.0.

3. The digital DC voltmeter and 5V-power supplies are connected to the circuit

4. Switch S1 (Charge-discharge) is thrown to the charge position.

5. Switch S2 (Halt-Start) is thrown to the start position watching the digital stop clock and the voltmeter.

6. The clock is stopped by controlling Halt-Start switch after 5 seconds and the voltmeter reading is noted. The capacitor is charged for 5 seconds and voltage across the capacitor after 5 second is noted from the voltmeter in Table.

Time(sec)	C1, R=100KΩ		C2, R=100KΩ		C3, R=100KΩ	
	Voltage across the capacitor in Volts					
	During Charging	During Discharging	During Charging	During Discharging	During Charging	During Discharging
0						
5						
10						
15						
20						
25						
30						
35						
40						
45						
50						
55						
60						
70						
80						
90						

7. The capacitor is further charged by starting the clock. After 10, 15, 20 seconds the clock is stopped to note down voltage across the capacitor. The readings obtained are noted..

8. Trial is repeated until the capacitor is charged completely. In each case the capacitor voltage is noted at an interval of 5 seconds and noted in Table.

9. When the capacitor is charged to maximum voltage (4.5V and above), the charging is stopped and the charge discharge switch is thrown to discharge position and clock is reset.

10. The voltage across the discharging capacitor is noted after 5 seconds interval by stopping clock after five seconds. This is done until the capacitor is discharged fully.

11. Experiment is repeated for different capacitance values. And the corresponding readings are noted in Table.

12. A graph is drawn taking time on X-axis and voltage along the Y-axis as shown in Figure. The charging and discharging curve intersects at a point P, where the voltage across the capacitor during charging and discharging remains the same. The time at which voltage across the capacitor during charging and discharging is noted.

    Dielectric constant is determined using equation-1.

$$K=\frac{1.44\,T_P\,x\,10^{-3}\,d}{\varepsilon_0 AR}$$

13. Experiment is repeated for C_2 and C_3 capacitors. The Reading obtained is tabulated in Table.

Result:

The Results obtained are tabulated in Table-3

Table-3

Parameters	**C_1**	**C_2**	**C_3**
T_P(sec)			
K			

Inference: **(To be written by the student by the observations and the result obtained in his/her experiment)**

Viva Questions:

1. What is a capacitor?
   Capacitor is a device used to store charge.
2. What is meant by capacitance?
   Ability to store charge in a capacitor is called capacitance and it is measured in farad, F.
3. What is the relation between Q, C & V?
   Q=CV, Q, charge stored(coulomb), C capacitance(farad), V(voltage).
4. Define one farad.
   It is the amount of charge required to raise the potential by 1 volt.

5. What is dielectric?
   Dielectric is an insulator which is used to increase the capacitance of the capacitor.
6. Classify dielectrics?
   It is classified into polar and non-polar dielectrics.
7. The dielectric constant depends on what factors?
   It depends on frequency, material and temperature.
8. State coulombs law of charges.
   It states that force of attraction or repulsion between two charges is directly proportional to the product of the charges and inversely proportional to the square of the distance between them.
9. What is an electric field?
   It is the region of space in which a charged body experience force. It is measured in volt per meter.
10. Describe the phasor diagram for pure resistor, I & V will be in phase, phasor I leads V by 90 degree bur in case of a inductor V lead I by 90 degree.
11. When does the body get charged?
    When a body rubbed with another body it gets charged due to loss or gain of electron.
12. What are electric lines of forces?
    It is the path travelled by a unit positive charge from positive charge to negative charge.

5. Determination of Planck's constant

Aim: To Determine planck's constant using known wavelength LED light.

Apparatus: Planck's constant experimental setup consisting of 0-10V peak to peak sine wave generator, digital peak reading voltmeter, six different known wavelength LED lights and dual trace oscilloscope.

Theory/Principle: The packet of energy is given by

$$E=h\upsilon \qquad \ldots 1$$

Where "h" is a universal constant now called as Planck's constant in honor of the inventor. LED is a two terminal solid-state lamp, which emits light with very low voltage and current. The light energy radiated by forward biasing is given by equation-1.

$$E=\frac{hc}{\lambda} \qquad \ldots 2$$

Where c is the velocity of the light
λ is the wavelength of the light emitted and 1/λ is the wave number
h is Planck's constant

If V is the forward voltage applied across the LED terminals that makes it emit light (it is also called forward knee voltage) then the energy given to the LED is given by

$$E = eV \qquad \ldots 3$$

Where e is electronic charge

LEDs are very high efficiency diodes and hence this entire electrical energy is converted into light energy, then equating equations 2 and 3,

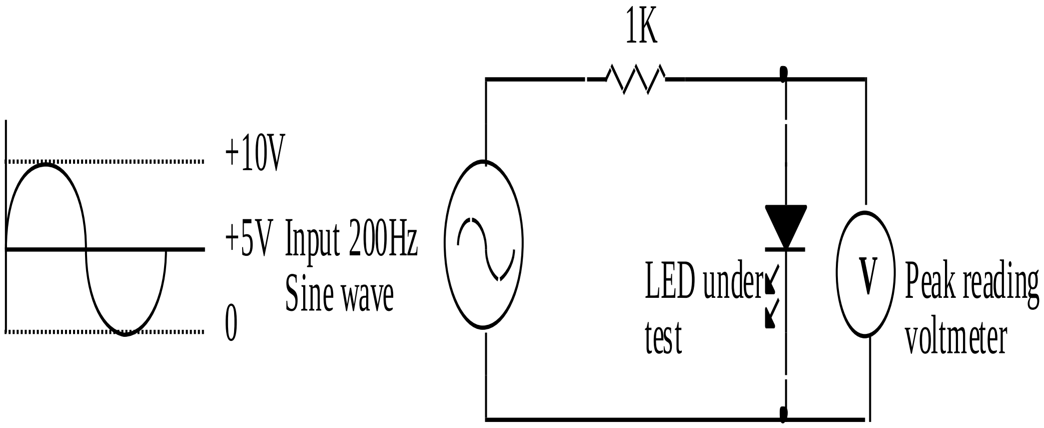
$$eV=\frac{hc}{\lambda} \qquad \ldots 4$$

From which Planck's constant is given by

$$h=\frac{eV\lambda}{c} \qquad \ldots 5$$

In equation-5 for different wavelength light, the forward knee voltage is determined and the value of h is calculated. Moreover, e/c =5.33 x 10^{-28} coulomb/meter is a universal constant and hence the product λV must be a constant. This enables the determination of Planck's constant.

Circuit Diagram:



Expected Graph:

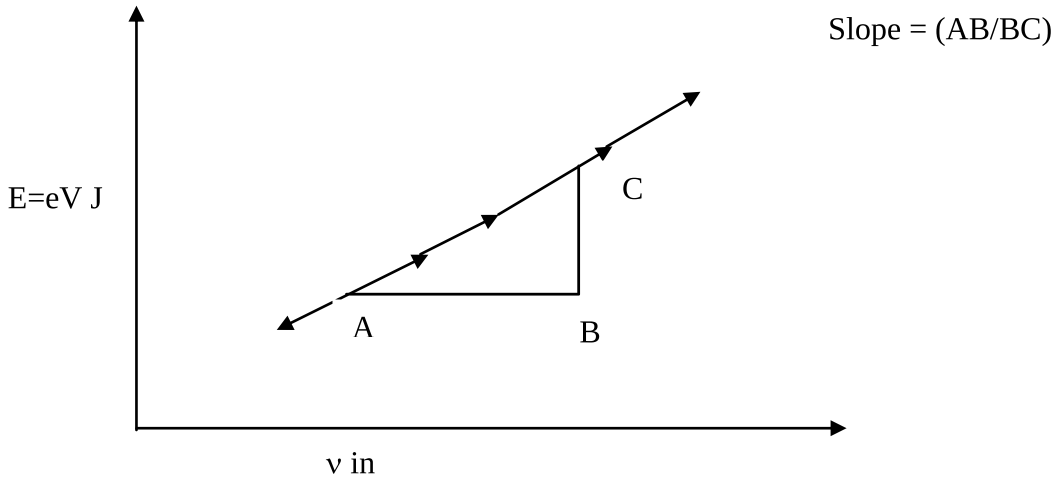


Figure-2, Variation of Energy with fequency

Experimental Procedure:

1. The circuit is rigged as shown in Figure-2. The input to the LED is an ac signal. The rectified output appears across the LED is a unidirectional pulsating. Hence, a peak reading meter is used to read voltage across the LED.
2. Using a digital peak reading voltmeter the voltage across the LED is measured and recorded in Table-1 for given color LED light.

3. Trial is repeated by changing the LED and the corresponding knee voltage is noted in Table-1.

4. The product of wavelength and knee voltage is determined and its average value is calculated.

   Average λV
5. The slope of the graph of Energy versus frequency gives the Planck's constant. This value can be cross checked by substituting the value of average λV in equation 5. The results will be tabulated in table 2.

Table-1:- *Knee voltage for different color LED using peak reading meter*

Color	Wavelength (nm)	Knee Voltage (V)	$\lambda V x10^{-9}$	E=eV $x10^{-19}$ J	$\nu = c/\lambda$ $x10^{14}$ Hz
Yellow	576				
Green	548				
Blue	350				
Red	620				
Average λV =					

Result: The results obtained are tabulated in Table-2.

Table-2

Parameters	Experimental	Theoretical
$\lambda V_{Average}$		
h(Js) Graphical Calculated		$6.526x10^{-34}$

Inference: **(To be written by the student through keen observations and the result obtained in his/her experiment)**

Viva Questions:

1. What is the value of Planck's constant?
   The value of Planck's constant $h=6.625x10^{-34}$ j-s.
2. What h represents
   It represents angular momentum.
3. Who proposed discrete behavior for an object of subatomic dimensions?
   In 1900 Max Plank proposed.
4. What is the relation between E, h and f?
   In 1905, Einstein stated that electromagnetic radiation is localized in photons with frequency f and energy E=hf.
5. What are LED's
   LED's have p-n junction where voltage yields a flow of current in turn gives light output.
6. What produces light from the junction?
   The carriers (electrons & holes) are injected across the junction producing light.
7. What is the advantage of this method of finding value of h?
   This method is effective, efficient and very simplistic. Simple and straight forwardmethod for finding the value of h.

1. What is the value of Planck's constant?
   The value of Plank's constant h = 6.625 x 10^{-34} j / s]

2. What 'h' represent?
   It represents angular momentum.

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   In 1990, Max Planck proposed.

4. What is the relation between E, h & f?

   In 1905, Einstein stated that electromagnetic radiation is localized in photons with frequency f & energy E – hf.

5. What Neil Bohr proposed ?

   In 1913, Neil Bohr extended idea to electron existing between states of discrete energy. Transistors are accompanied by absorption or emission of photons with $f = E / h$.

6. who found the fundamental theory ?

   in 1905, Einstein found fundamental theory which proposes that light is composed of photons having energy quanta.

7. What are LED's?

   LED's have p n junction where voltage yields a flow of current.

8. What produce light from the junction ?

   The carriers (electrons & holes) are injected across the junction producing light.

9. What is ς and its value ?

   ς is the correction for random error. Its value is 1.05. it is evident that the errors in the experiment were random than the experiment were random than the systematic.

10. What is the advantage of this method of finding h ?

    This method is effective, efficient, & very simplistic. Simple & straight forward method for finding the value of h.

Electrical Resistivity (Four Probe Method)

1.What is 4 probe method ?

In this method a wire or a small structure is contacted at 4 locations.

2.What for 4 probe method is used ?

It is used to determine the specific resistivity (Ωm) of metal line during electrical characterization of metallic deposition of thin metal line.

3.What is the principle used in 4 probe method ?

Current is forced through outer pins 1 & 4 & a drop voltage across pins 2 & 3 is measured using a very high through pin 2 & 3 is nearly 0. In these case the individual n additional contact resistance does not play a role as it cancels out of the equations.

4.What is an ohmic resistor ?

If the behavior of the structure of I/V curve is a straight line. Then the structure behaves as ohmic resistor.

5.What is the advantage of 4 probe method over other methods of measuring resistivity?

In most of other methods, the current carrying contacts injects minority carriers which ultimately modify the resistance of the material.

6.What is meant by electrical resistivity (ρ)?

It is the property of the material by the virtue of which it opposes the flow of current. It is also defined as the reciprocal of electrical conductivity $(\Omega m)^{-1}$. Its unit is Ωm i.e., $\rho = l/\sigma = RA/L$.

6. Determination of Fermi Energy

Aim: Determination of Fermi Energy and Fermi Temperature of Copper by studying resistance variations at different temperatures.

Apparatus: The complete experimental setup is shown in Figure-1, DC regulated power supply, digital milli ammeter, Digital milli-voltmeter (DMV), Heating arrangements, Thermometer 0-160 degree, and solenoid of copper wire.

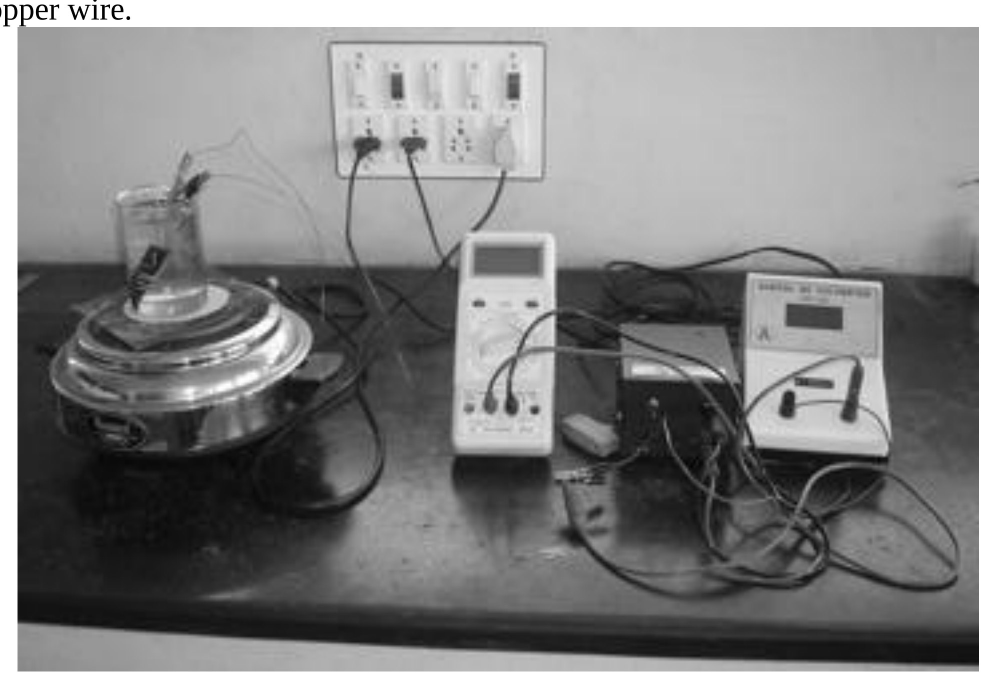

Figure-1, Fermi Energy Experimental Setup

Theory/Principle:

$$E_F = \left[\frac{ne^2\pi Ar^2}{L\sqrt{2m}}\right]^2 \times \left(\frac{\Delta R}{\Delta T}\right)^2 \quad ....1$$

Where 'V_F' is Fermi velocity, τ is the relaxation time and T is the absolute temperature, then the mean free path of electrons is given by

$\lambda_F = V_F\tau$

and the constant $A = \lambda_F \times T = 7.4 \times 10^{-6}$

T is the reference temperature of the wire in Kelvin (318 K)

r is the radius of the wire.

L is the length of the metal wire

$e = 1.602 \times 10^{-19}$ C is electron charge.

m is mass of the electron = 9.1×10^{-31} kg.

n is the electron density (8.464×10^{28} /Kg mol)

$\frac{\Delta R}{\Delta T}$ is the slope of the straight line obtained by plotting resistance of the metal against absolute temperature of the metal.

(The value of the big bracket quantities is 7.047×10^{-7})

It is possible to define a Fermi temperature below which the gas can be considered degenerate. This temperature depends on the mass of the fermions and the energy. For metals, the electron gas's Fermi temperature is generally many thousands of Kelvin, so they can be considered degenerate. Fermi temperature T_F can be obtained by the relation

$$E_F = kT_F \qquad \ldots 2$$

Where $k = 1.38 \times 10^{-23}$ J K^{-1} is Boltzmann constant.

The number of free electrons in metal per unit volume is given by,

$$n = \frac{N\rho}{M} \qquad \ldots 3$$

Where $N = 6.023 \times 10^{26}$ per m^3 is Avogadro number
ρ = density of the metal
M = Mass number of the metal

Circuit Diagram:

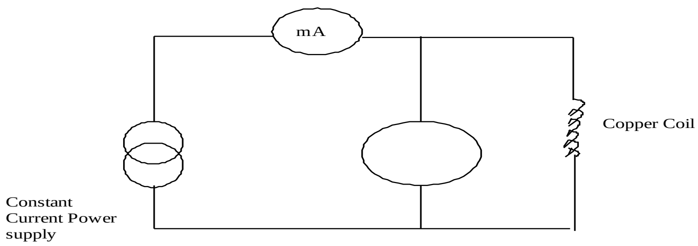

Figure 2:- Circuit Diagram for Fermi energy experiment.

Expected Graph:

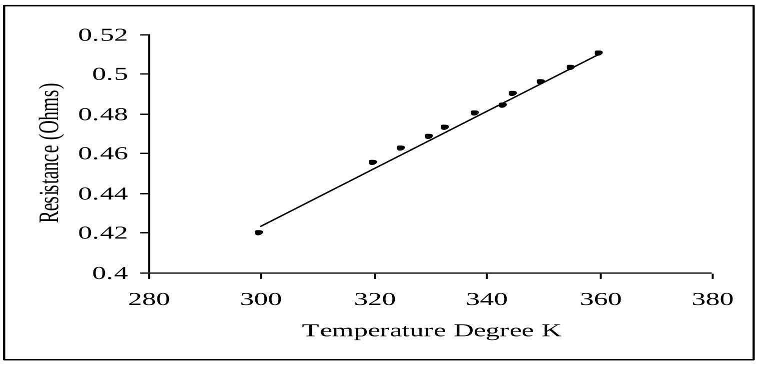

Figure-3, Variation of resistance with temperature for copper wire

Experimental Procedure:

1. About 3.6 meters length copper wire is taken and its radius is determined and cross sectional area is calculated. Its mass number and density are noted from Clark's table.

   L_{Copper} = 3.58m, Radius r = $0.26x10^{-3}$m
   Cross sectional area = πr^2 = $0.212x10^{-6}m^2$
   Density ρ = 8930 Kg m^{-3}
   Mass number M = 63.54 gm

2. The wire is wound over an insulating tube (20-30mm dia) to form a coil. The coil is immersed in pre heated liquid paraffin or water as shown in the experimental setup. The two ends of the coiled wire is connected to a power supply through a milli ammeter. And milli voltmeter is connected across the coil.

3. A thermometer is immersed in the beaker containing liquid paraffin or water and coil. When the thermometer attains steady temperature the temperature is noted.

4. The power supply is switched on and voltage and currents are noted in Table-1. The liquid is allowed to cool by continuous stirring and power supply is switched off until another steady temperature is reached.

5. Trial is repeated taking reading in the interval of 5 degree and until the temperature reach 45 degree. At each temperature the voltages and currents measured are noted in Table-1.

6. A graph is drawn taking temperature in degree K along X-axis and resistance on Y axis as shown in Figure-3. The slope of straight line is calculated.

Table-1:-*Resistance variation with temperature*

Temperature		Voltage	Current	Resistance
ºC	**ºK**	**(mV)**	**(mA)**	**(Ω)**

By knowing the Fermi Energy, Fermi Temperature can be calculated by using Equation no. 2 i.e.,
$T_F = \frac{E_F}{K}$, where E_F is to be taken in Joules.

Result:-

Metal	Mass No Z	Fermi Energy (eV)		Fermi Temperature (T) $x10^3$K	
		Experimental	**Theoretical**	**Experimental**	**Theoretical**
Copper	29		7.0		8.13

Inference: **(To be written by the student through keen observations and the result obtained in his/her experiment)**

Viva Questions:

1. What is a Fermi Energy?
2. Does this Fermi Energy exist for semiconductors?
3. Define 1eV?
4. For which metal the Fermi Energy we are determining?
5. State Ohm's law?
6. Why water is to be stirred continuously throughout the experiment?
7. Why copper is taken in the form of a coil? Why can't we take it as a simple stretched wire?
8. Read the graph obtained in this experiment?
9. Define atomic number and atomic mass of an element?
10. What is Fermi Temperature?
11. The mathematical expression for Fermi energy?

Sample Viva Questions with answers:

1. What is meant by Fermi energy?
   It is the energy of the highest occupied level at zero absolute.

2. What is the unit for Fermi energy?
   Its unit is eV. leV = 1.6 x 10-9C

3. What is meant by Fermi factor?
   It is the probability of occupation of given energy state for a metal in thermal equilibrium.
4. What is the formula for Fermi factor?
   It is calculated by f (E) = $\dfrac{1}{e^{E-Ef/kBT}+1}$
5. What is the relation between E_F & n at 0^0 K?
   Ef = Bn2/3 where B = h2
6. What is the relation between E_F & n at T.0^0 K?
   $$E_F = E_{F0} xl - \pi^2 \frac{(k_B T)^2}{12(E_{Fo})^2}$$
7. What is meant by Fermi temperature T_F?
   It is the temperature at which the average thermal energy of the free electrons in a solid becomes equal to the Fermi energy at 0^0K. it this temperature at which gas can be considered degenerate. It depends on mass of fermions and energy.

8. What is the relation between E_F & T_F?
   $E_F = k_B T_F$

9. What is meant by Fermi velocity?
   It is the velocity of those electrons which occupy the Fermi level. It is measured by $V_F = \sqrt{2E_F/m}$

10. What is meant by Fermi Dirac distribution?

    It is the representation which depicts the details of distribution of electrons among the various available energy levels of a material under thermal equilibrium conditions. Fermi factor is called a Fermi Dirac distribution function.

11. What is the effect of temperature on E_F?

    At T = 0 K Fermi level will be at the center of the energy gap, but as the temperature increases E_F moves towards the conduction band.

12. What are the factors on which E_F depends?

    E_F depends on the material and the temperature.

13. Are the energy levels lying above E_F are empty at 0 K?

    Yes, they are empty, but below E_F are filled.

14. How many electrons are their n each energy level?

    According to Paul's exclusion principle, there are 2 electrons are their in each energy level.

15. State Paul's exclusion principle?

    It states that no 2 electrons having same quantum number can occupy the same time.

16. What are the values of Fermi factor at different temperatures?

    1. When $E>E_F$ T = 0K f (E) = 0
    2. When $E>E_F$ T = 0K f (E) = 1
    3. When T>0K $E=E_F$ f (E) = ½

17. What is meant by mean free path (λ)?

    It is the average distance traveled by the conduction electrons between successive collisions with lattice ions. It is measured in m.

18. What is meant by collision time (τ)?

    The average time that elapse between 2 successive collisions of an electron with the lattice points is called mean collision time.

19. What is meant by relaxation time (τ_r)?

    Due to sudden disappearance of an electric field across a metal the average velocity of its conduction electrons decays exponentially to zero. And the time required in this process for the average velocity to reduce to l/e times its value just when the field is turned off, is known as relaxation time.

20. What is the relation between τ & τ_r?

    $\tau_r = \tau /1 - < \cos\theta >$ $<\cos\theta> = 0$ when collision between electron and lattice point is elastic & isotropic then $\tau_r = \tau$

21. What is the relation between $\tau_r = \tau$

    $N_A = 6023 \times 10^{26}$ / Kmole

22. What is the meant by drift velocity?

The velocity of the electron in the steady state in an applied electric field is called the drift velocity(m/s).

23. If the dimension of the wire is changed will it affect the value of E_F?

    No. E_F depends on the temperature & material but not on the dimension.

24. What is Fermi level?

    It is used to describe the top of the collection of energy levels at the absolute zero temperature.

25. From where does the Fermi level concept come from?

    It comes from Fermi Dirac statistics.

26. What are fermions?

    Electrons in metals & semiconductors are called fermions.

27. What is meant by Fermi gas?

    It is a collection of non – reacting Fermi ions.

28. What is the importance of Fermi energy?

    It helps to understand electrical & thermal properties of solids. It explains why electrons do not contribute significantly to the specific heat of solids at room temperature T. it gives information about the velocity of electrons which participate in ordinary electrical conduction.

29. What is the effect of atomic number Z on E_F & T_F?

    As Z value decreases E_F & T_F increase.

7. Verification of Stefan's Law

Aim: To verify Stefan's law by Electrical method.

Apparatus: 6 V Power supply, Digital Voltmeter, Digital Ammeter, 6V/6W Tungsten filament bulb.

Theory/Principle: In 1879 Austrian physicist Stephen Josef Stephan using such a black body radiator first arrived at an empirical formula to account for heat radiation. According him the energy radiated per unit area form a black body is directly proportional to fourth power of surface temperature. Writing in the form of an equation

$$\frac{E}{A} \alpha\, T^4 \qquad \ldots..1$$

Where E is thermal energy, A is the total surface area of the black body and T is the surface temperature

$$\frac{E}{A} = \sigma\, T^4 \qquad \ldots 2$$

$$\sigma = \frac{E}{A\, T^4} \qquad \ldots 3$$

The constant appearing in the equation is the combined contribution of Stephan and Boltzman hence known as Stephan-Boltzman constant $\sigma = 5.670 \times 10^{-8} W/m^2K^4$. Stephen's law is very useful for astronomical studies. Using which temperature, surface area etc can be calculated.

For bodies other than black body, we have

$$P = C\,[T^m - T_0^m]$$

Where 'P' is the power emitted by a body at a temperature 'T' surrounded by another body at temperature T_0. C is constant depending upon the material and area of the body; m is very near to the value 4. The above equation can be written as

$$P = C\, T^m \left[1 - \frac{T_0^m}{T^m}\right] \qquad \ldots\ldots..4$$

If $T > T_0$ then $P = C\,T^m$ or

$$Log_{10} P = m\, Log_{10} T + Log_{10} C$$

It is of the form y=m x + C, equation to a straight line. Since resistance is proportional to the temperature, we can verify Stefan's law by the equation $Log_{10} P = m\, Log_{10} R + Log_{10} C$

-

Circuit Diagram:

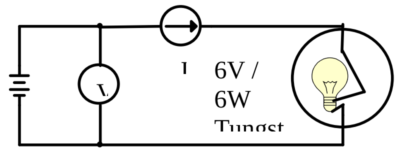

Fig1:- Circuit diagram of the experiment

Expected Graph:

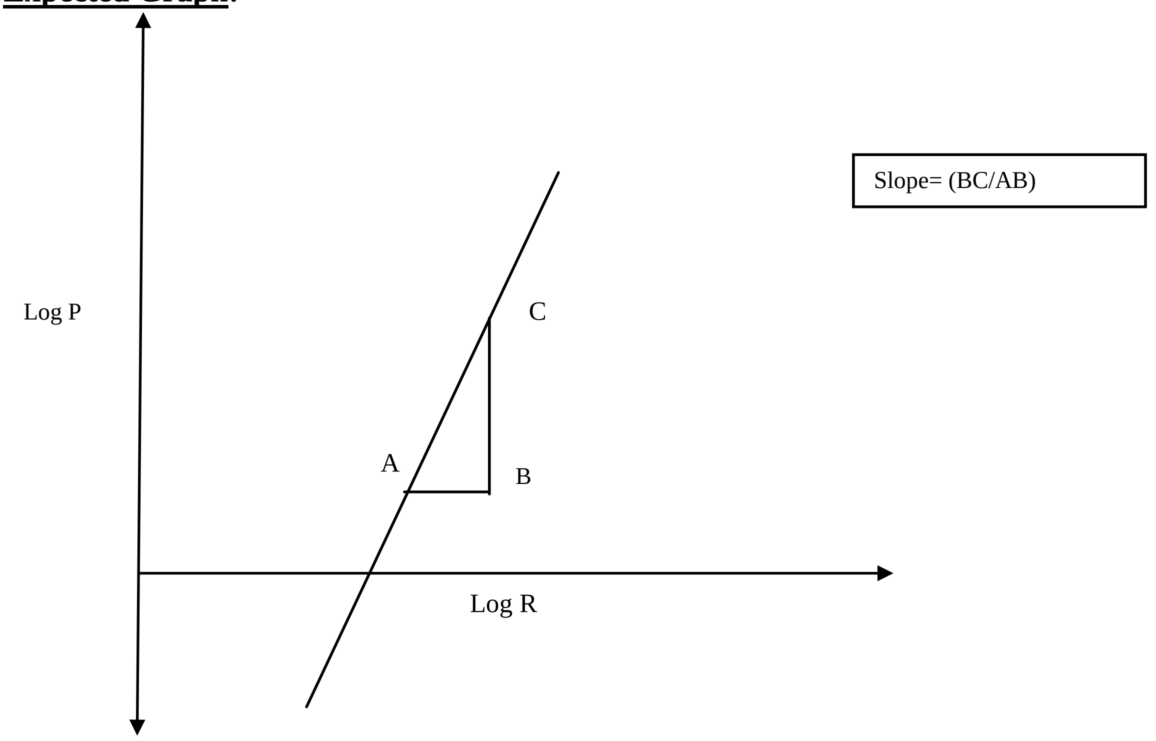

Fig.2 :- Expected graph for this experiment

Experimental Procedure:

1. The circuit is constructed and the bulb with tungsten filament is used as a radiating body having a temperature T.
2. For a very small value of voltage, the corresponding currents are recorded in table-1. The ratio of (V/I) gives the filament resistance including lead resistance.
3. The product of V and I gives the value of power(P). A graph is then plotted between Log P and Log R, which gives a straight line.
4. This verifies Stefan's law in the form $P=CT^m$ (or $P=CR^m$). The slope of straight line gives 'm' to be nearly equal to 4. This is called the fourth power law also.

Result:

The graph of Log P Versus Log T comes out to be a straight line. Further the slope of the line m=…….. which is close to 4. Hence $P=CT^m$ law is verified.

Inference: **(To be written by the student through keen observations and the result obtained in his/her experiment)**

Viva Questions:

1. State the statement of Stefan's law of radiation?
2. By which method the Stefan's law is verifying in this experiment?
3. Why tungsten filament bulb is preferred here?

Sample Viva Questions with answers:

1. What are meant by black body ?

   Black body is the one which absorbs all radiation which incident on it. On heating black body stats emitting radiations called black body radiation which are independent of nature of body and depends on the temperature of black body.

2. Why black body is called as black body ?

   Due to the fact that whatever may be the color of incident radiation the body appears black.

3. How does this law differ from Newton's law of cooling ?]

   Newton's law of cooling is applicable only when the difference of temperature between the body and the surroundings is very small. This law , in fact, can be deduced from Stefan's law assuming the temperature difference as small.

4. Can the value of Stefan's constant be determined from this method ?

   Yes, taking the value of 'n' as 4, the value of C can be obtained from $E = \sigma (T^4 - T^4_0)$ or from the value of the intercept of the graph also, the value of C can be obtained from P = log C + nlog T, if the radiating body is not assumed as a black body. Assuming this to be a black body, this value of C so obtained will correspond to the Stefan's Law.

5. Is this method superior to the conventional thermal method ?

   This method id though not very precise and accurate. However it has some points of advantages. The bulb is never truly a black body and at steady state, the power radiated is never equal to V . I exactly. The working theory in this method is to some extent approximate, nevertheless, the method is very simple and the accessories are easy to procure. It gives an approximate idea about Stefan's Law, Stefan's constant and the verification of the law.

6. Define Stefan's law.

   It states that total radiant energy emitted per second from the unit surface area of a perfectly black body is proportional to the fourth power of its absolute temperature.

7. What is Stefan's constant ?

   If E denotes the total energy emitted per second from unit surface area of a black body then by Stefan's law, we have $E = \sigma T^4$.

8. What is a black body ?

   A body which absorbs all the incident radiations, irrespective, is called a black body.

9. Do you know about Kirchoff's law of black body radiation ?

It states that at any temperature, the ratio of emissive power of the absorptive power of a given wavelength is same for all bodies.

10. What is emissive power and absorptive power ?

Emissive power: At a particular temperature and for a given wavelength, it is defined as the radiant energy emitted per unit time per unit surface area of the vody within a unit wavelength range.

Absorptive power : At a particular temperature and for a given wavelength, it is defined as the ratio of the radiant energy absorbed per second per unit surface area of the body to the total energy falling per unit time on the same area.

11. State wein's law ?

The wavelength corresponding to the maximum energy is inversely proportional to the absolute temperature.

12. Explain the distribution of black body radiation spectrum ?

The amount of energy radiated by a black body id not uniformly distributed over all the wavelength emitted by the body but it is maximum for a particular wavelength. The value of wavelength is different for different temperature and varies with temperature.

13. Define solar constant?

Solar constant defined as the amount of energy received / sec/unit area of a perfect black surface at a mean distance of the earth from the sun in the absence of earth's atmosphere, the surface being perpendicular to the direction of sun rays. (1.34 KW/m).

14. Mention the properties of black body radiation ?

Black body radiations travel with velocity of light, straight line, obeys inverse square law, travel in vacuum, reflected refracted diffracted polarized and without affecting the intervening medium the waves travel.

15. What are the modes of transmission of heat.

Conduction, convection and radiation. Conduction is the mode of transmission of heat in which heat travels from the hot part of the body to its cold part without actual motion of heated particles. Convection is the mode of transmission of heat from one part of the medium to the other by the bodily motion of heated particles. Radiation is mode of transmission of heat which heat is transferred from one body to another without heating the intervening medium.

16. Distinguish between hotness and temperature ?

Sensation of hotness is called heat. Degree of hotness is called temperature.

8. Diffraction Grating

<u>Aim:-</u>To determine the wavelength of spectral lines using 625nm laser light and different plane transmission gratings.

<u>Apparatus:</u> 625nm diode laser, Indian assembled 500LPI (lines per inch) or Indian assembled 15000LPI or imported 15000 LPI gratings, image screen, sodium vapor lamp. The complete experimental setup is shown in Figure-3.

Figure-1, 500LPI Diffraction Grating used in this experiment

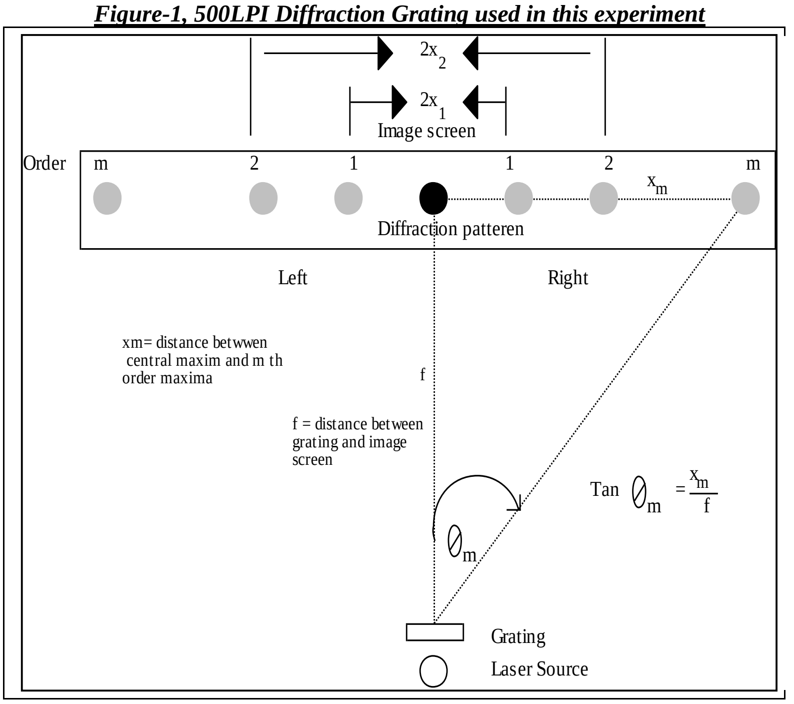

Figure-2, Process of diffraction using grating

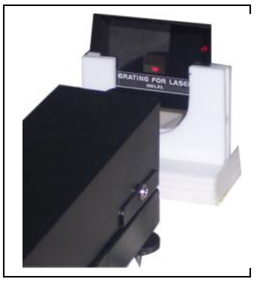

Figure-3, Complete experimental setup

Theory/Principle:

$$d\sin\theta = m\lambda \quad \ldots 1$$

Where d is grating constant or the distance between two consecutive rulings
θ is the angle of diffraction
m = 1, 2, 3… m is called order of diffraction
λ is the wavelength of the light used

In the above equation all the terms are constant except θ. The angle θ can be measured by experiment either using spectrometer or by measuring accurately the distance between source and image and distance between the consecutive maximums. Different order of diffraction is the result of different incident angle θ. Hence to specify order θ has been rewritten as θ_m, which indicate the diffraction angle for m^{th} order. Figure-6 indicates process of diffraction, using laser light and grating. The m^{th} order diffraction angle is given by

$$\theta_m = \tan^{-1}\left(\frac{x_m}{f}\right) \quad \ldots 2$$

Where x_m is the distance of m^{th} order diffraction pattern from the centre 0^{th} order diffraction
f is the distance between the screen and the grating

Distance f between the grating and the image screen is our choice which can be fixed as required and the distance x_m can be measured accurately from the diffraction pattern. Hence angle of diffraction θ_m can be determined.

Substituting θ_m in Eaquation-1, wavelength of the given

$$\lambda = \frac{d\,\mathrm{Sin}\,\theta_m}{m} \quad \ldots 3$$

Experimental Procedure:

Diffraction with 500LPI grating

1. The laser is placed on a study table and switched on. At about one to one and half meters away on the path of the laser a white laminated wooden screen is placed. The leveling screws of the laser are adjusted such that the laser beam exactly falls on the centre of the screen. The exact distance between the grating stand and image screen are noted

   f = ………..m = ……….cm

2. The 500LPI grating is now placed on the grating stand close to the laser source and the diffraction pattern is observed as shown in the Figure-4. Equally spaced diffracted laser light spots are observed. The total numbers of spots are counted. The central direct ray is very bright in the picture as the order increased the brightness deceased.

   Maximum order of diffraction observed = 8.

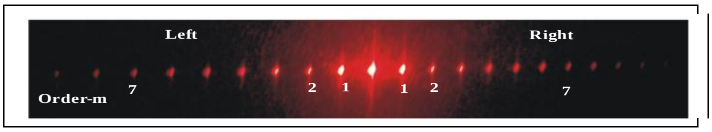

Figure-4, Diffraction pattern observed f=2m

3. The centre of the spots of the diffraction pattern are marked on the screen (where the graph sheet is affixed earlier) using a pencil and after marking the entire diffraction pattern, the image screen is removed and the distances between consecutive order of diffraction is measured using a scale and tabulated in Table-1. The distance between the two first orders diffraction spots are measured.

   $2x_1 = \ldots\ldots\ldots\ldots$ cm

   Similarly the distance between two second order diffraction spots are measured and recorded in Table-1.

   $2x_2 = \ldots\ldots\ldots$cm

   This is continued up to 6th order

   $2x_6 = \ldots\ldots\ldots\ldots$cms

4. Using equation-2 diffraction angles are calculated for first order diffraction and noted in Table-1

$$\theta_m = \tan^{-1}\left(\frac{x_m}{f}\right) =$$

$$\theta_1 = \tan^{-1}\left(\frac{x_1}{f}\right) =$$

   Similar calculations are made for different orders of the diffraction and the diffraction angle is calculated and presented in Table-1.

5. Wavelength of the given laser light source is calculated equation-3.

   i.e.,
$$\lambda = \frac{d\,\mathrm{Sin}\,\theta_m}{m}$$

   Similar calculations are done for different orders of the diffraction and the wavelength can be obtained is tabulated in Table-1. And the average value of wavelength of the laser is calculated.

Table-1:-*Diffraction angle for different order*

500 LPI grating, f=……….cm, d=42130			
Diffraction Order (m)	**Distance $2x_m$(cm)**	**Diffraction angle (θ_m)°**	$\lambda = \frac{d\ Sin\ \theta}{m}$ **(nm)**
1			
2			
3			
4			
5			
6			
Average λ =			**nm**

Using the grating constant and the diffraction angle for given source of light; we can determine the wavelength of the given light source.

Result:

Wavelength of the given light source is =……………………………nm

Inference*:* **(To be written by the student through keen observations and the result obtained in his/her experiment)**

Sample Viva Questions with answers:

1. What is meant by diffraction & classify?
   Bending of light around the edge of an obstacle is called diffraction. It is classified into Fresnel and Fraunoffer diffraction.

2. What is the condition for diffraction?
   Size of the object should be comparable with that of the wave length of the light source. Since greeting constant and wave length are of the same order (10^{-6} meter. Diffraction takes place.

3. What is grating?
   Grating is a plain glass plate on which ruling two rulings is called a grating constant. Width of opaque and transmitted line is called grating element.

4. What are the function of collimator and telescope?
   Collimator renders parallel race where as telescope converges different race at the focal point of high piece.

5. What kind of diffraction we are studying?
   We are studying Fraunoffer diffraction.

6. What do you understand by angle minimum deviation?
   It is that angle of incident at which deviation is minimum and intensity is maximum.

7. What is the effect of no. of ruling on the diffraction spectrum?
   Higher the no. of ruling we get less orders with more gaps.

8. Distinguish between diffraction and interference.

   Diffraction : Bending of light around the edges of an obstacle is called diffraction. Intensity of bright & dark fringes are different. And they are not equally spaced.

   Interference : it is the modification distribution of light energy due to the super position of two or more waves. Intensity of bright and dark fingers are uniform and equally spaced. The interference take place between 2 separate wave fronts originating from the 2 coherent sources while in the case of diffraction the interference take place between the secondary wavelets originating from different points of the exposed parts of the same wave front. In interference pattern or maxima or minimum have same intensity. But it is different in diffraction pattern.

9. Distinguish between diffraction and dispersion ?

   Diffraction : Bending of light around the edges of an obstacle is called diffraction. In this case lover the wave length lower will be the deviation.

   Dispersion : when white light pass through a prism it splits into its constituent colors. This phenomenon is called dispersion. In this case lower the wave length will be the deviation.

10. Distinguish between Fresnel and fraunoffer diffraction ?

    Fresnel : Incident wave fronts are spherical source to screen distance in finite and no lenses are used for studying diffraction. Ex. Diffraction at a aperture .

    Fraunoffer : Incident wave fronts are plane or cylindrical source to screen distance is infinite and lenses are use for studying diffraction. Ex. Diffraction an arrow slit.

11. Define wave length ?

    It is a distance traveled by a wave at the end of 1 second.

12. Distinguish between polychromatic & monochromatic source .

    Polychromatic source is one which produces radiations having different wave lengths. Ex. Mercury vapour lamp.

    Monochromatic source is one which produces radiations having single wave length. Ex Sodium vapour lamp.

13. Define principle maxima and secondary maxima ?

    A principle maximum is formed by those secondary wavelets which travel normal to the slit in addition to principle maxima at alpha = 0 there are weak secondary maxima between equally space minima.

14. Distinguish between transmitting & reflecting grating.

    If rulings are drawn on a transparent glass plate by a diamond point it is called transmitting grating. If the rulings are drawn on a silvered glass plate then it is called reflecting grating.

15. What is the effect of grating element on the diffraction pattern ?

    Larger the ruled surface (grating element) smaller will be the angular half width and shaper are the maximum.

9. Band Gap determination of Semiconductor

Aim: Determination of semiconductor energy band gap by passing small forward current through junction diodes.

Apparatus: Semiconductor diode, Constant current source 50-250 μA, digital micro ammeter, 0-200μA, digital dc voltmeter 2V/20V. 250ml beaker, 10ml test tube, thermometer and stand.

Theory/Principle: Energy gap is a very important parameter of semiconductor that decides its applicability. Pure semiconductors or intrinsic semiconductors are not available easily for measurements. Extrinsic semiconductors are easily available for E_G measurements. However, the presence of impurity atom will slightly modify the energy gap of the parent element. Hence, to reduce the contribution of impurity atoms the impurity atoms as subdued by passing very low forward current. When the forward current is low, most of the impurity atoms are quiet and do not participate in conduction. Hence, conduction is purely due to parent element; hence, one can make use extrinsic semiconductor in energy gap determination. Varieties of extrinsic semiconductors are available in pn junction form that can be used for the measurement of energy gap. Table-1 lists various semiconductor samples easily available in the market for energy gap determination.

Table-1: Various semiconductor materials available for this experiment

Materials	Device	E_G (eV)
Si	Diode 4007	1.15
Ge	Diode DR25	0.67
GaP	LED Green	2.22
GaPN	LED yellowish green	2.17
GaAsP	Led Yellow	2.10
Ga AsP N	LED Orange red	1.99
GaAsAl	LED standard red	1.92
GaAsSi	LED infrared	1.30
SiC	LED Blue	3.50
GaAsP	LED white	4.20

Junction diode

A pn crystal is called junction diode. Diode can be forward or reverse biased using a voltage source. During forward bias forward current flows through the diode. The forward current is given by [1,2]

$$I_F = I_R\left(e^{qV/\eta kT} - 1\right) \quad \ldots(1)$$

Where I_F is called forward current

I_R is called reverse current or reverse saturation current q is electronic charge e =1.6x10^{-19} Coulomb

η is called ideality factor varies between 1 and 1.5 [2]

k is Boltzman constant = 1.38x10^{-23}J/K

T is temperature in degree Kelvin

When the diode is reverse biased negligible reverse current flows through the diode. The reverse current is given by

$$I_R = BT^3\left(e^{-E_G/\eta kT}\right) \qquad \ldots(2)$$

The reverse current in case of silicon diode is zero that makes it a perfect diode. Germanium diodes (obsolete at present) show reverse current and gets the name leaky diode. LEDs also have very small reverse current. The reverse current is temperature dependent. The constant B appearing in equation 2 is a constant connected with the structure or the area of the depletion region.

Substituting equation 2 in equation 1

$$I_F = BT^3\left(e^{-E_G/\eta kT}\right)\left(e^{qV/\eta kT} - 1\right) \qquad \ldots(3)$$

$$e^{E_G/\eta kT} = \frac{BT^3}{I_F}\left(e^{qV/\eta kT} - 1\right) \qquad \ldots(4)$$

Taking natural logarithm of both the sides

$$\frac{E_G}{\eta kT} = \ln\left(\frac{BT^3}{I_F}\right) + \frac{qV}{\eta kT} \qquad \ldots(5)$$

$$V = \frac{E_G}{q} - \left[\ln\left(\frac{BT^3}{I_F}\right)\right]\frac{\eta kT}{q} \qquad \ldots(6)$$

Equation 6 represents a straight-line graph with slope

$$Slope = -\ln\left(\frac{BT^3}{I_F}\right)\frac{\eta k}{q} \qquad \ldots(7)$$

And Y-intercept

$$Y_{int\,ercept} = \frac{E_G}{q} \qquad \ldots(8)$$

Knowing the Y intercept the energy gap can be calculated. From the slope, B can be determined.

$$E_G = qY_{int\,ercept} \qquad \ldots(9)$$

$$\frac{q\,Slope}{\eta k} = \ln\left(\frac{BT^3}{I_F}\right) \qquad \ldots(10)$$

Rising to the power of e

$$e^{qSlope/\eta k} = \frac{BT^3}{I_F} \qquad \ldots(11)$$

From equation 11, the constant appearing in the reverse current equation B can be evaluated.

$$B = \frac{I_F}{T^3} e^{qSlope/\eta k} \qquad \ldots(12)$$

To determine the energy gap E_G a small constant current of the order of 100 –200 μA is passed through the diode at various temperatures. The voltages developed at the junction are noted. The junction voltage versus temperature graph is drawn. From the straight-line graph, Y intercept gives the E_G directly in electron volt. From the slope, constant B is calculated using equation-12. For small forward current of the order of hundreds of microampere e^{slope} is unity. Which indicate that the graphs for different diodes are all parallel and the constant B is independent of diode material, it depends only on the forward current, hence it is connected with majority carriers.

Knowing the Y intercept the energy gap can be calculated.

$$E_G = qY_{intercept} \qquad \ldots (13)$$

Circuit Diagram:

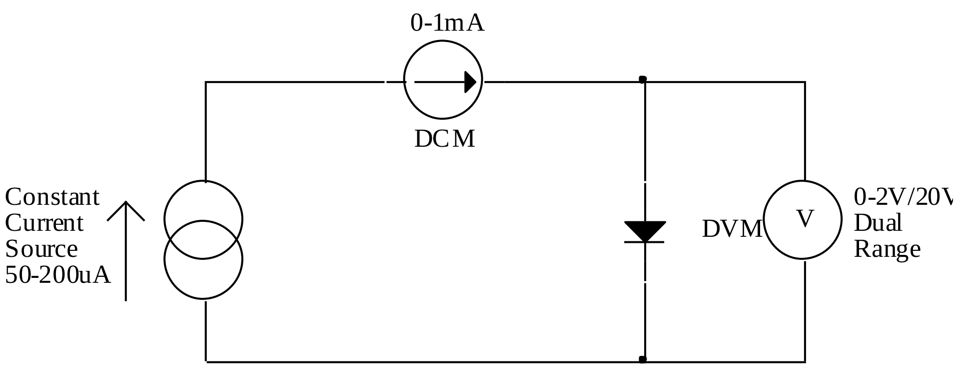

Fig.1:-Circuit diagram for determination of energy gap of a given semiconductor

Expected Graph:

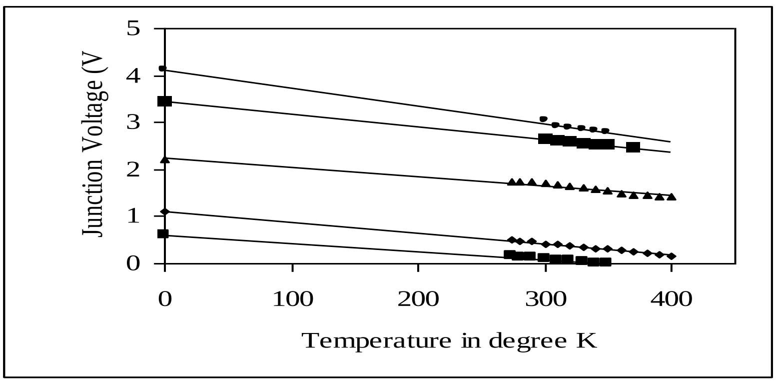

Fig.2:- The graph of Junction voltage (V)in volt versus Temperature (T) in Kelvin.

Procedure: The diodes are provided with long (15 inch) wires that can be directly connected to the constant current source, in series with a digital dc micro ammeter and circuit is completed as shown in Fig1.

1. Silicon diode is selected and circuit is rigged as shown in Circuit diagram (Fig.1). The diode along with the thermometer is placed inside the test tube such that diode and thermometer bulb are side by side.
2. The test tube is placed in the beaker and liquid paraffin or water is heated on a hot plate in a boiling pan, when boiling paraffin/water is transferred to the beaker.
3. After few minutes when the temperature is steady, the current through the diode is set to 100µA by adjusting the constant current source knob. The current should remain constant through out the experiment. The steady temperature is noted
4. At this temperature the junction voltage is also noted
5. As liquid paraffin/water cools, the temperature decreases. Junction voltage is noted for different temperature at 5˚C interval. The readings obtained are tabulated in Table2.

Table2: Observation of temperature and junction voltage.

Temperature		**Junction Voltage (in Volts)**
˚C	**˚K**	**Current (I)=………mA**

6. A graph is drawn taking temperature in degree K along X-axis and junction voltage along Y-axis as shown in expected graph. The straight-line curve is extended to cut the Y-axis and the Y intercept at 0 K is noted.
   $Y_{\text{intercept-Si}}$ = ………

   Energy gap of Silicon semiconductor is calculated using equation-5

   $E_G = qY_{intercept} =$

   The Y_{ntercept} directly reads the energy gap in electron volt.

Results:

Table.3: The energy gap of a given semiconductor diode both experimental and theoretical value.

Device	Material	E_G(eV)	
		Expt	Thet
IN 5408	Si		1.2

<u>Inference:</u> (To be written by the student by the observations and the result obtained in his/her experiment)

<u>Viva Questions:</u>

1. What is a semiconductor?
2. What is the difference between intrinsic and extrinsic semiconductors?
3. Whose energy it is, that are represented in the energy band diagrams?
4. What are valence band and conduction bands?
5. For conduction to take place is it always necessary that the electrons are available in conduction band.
6. For solid sodium, there is a considerable gap between the conduction band and valence band; yet it is a good conductor. How it is so?
7. What is energy gap?
8. What kind of additions takes place in the band structure when doping is done for a semiconductor?
9. In a doped semiconductor. How the conduction occurs at room temperature/ Explain why there is no conductivity at temperature close to 0^0K.
10. The electrical conductivity increases with rise of temperature in semiconductors, where as it decreases in case of conductors. Explain why it is so?
11. Are there any materials for which energy gap is zero?
12. Are there any materials for which energy gap is infinity?
13. Is there energy gap for gases also

<u>Sample Viva Questions with answers:</u>

1. What is a band gap ?

   This is the energy gap between the conduction and valence bands of a semiconductor (or insulator.)

2. What is band gap in a good conductor ?

   There is no band gap as the two bands overlap in their case.

3. How reverse current is produced across a p-n junction and on what factors does it Dopant?

   When a p – n junction is reverse biased, then current is due to minority carriers whose concentration is depend on energy gap or band gap.

4. What is energy band gap ?

   It is the energy gap between the valence and conduction bands of the crystal.

5. How do you differentiate between a conductor, an insular and a semiconductor in relation to energy gap ?

In conductors, the valence and conduction bands overlap each other. In insulators, there is large energy gap between valence and conduction bands, while in semiconductors this energy gap is not too large so that at room temperature the thermal energy gained by some of the electrons in the valence band is sufficient to make them jump conductions band, crossing this energy gap.

6. Do you know about intrinsic and extrinsic semiconductor?

A pure or natural semiconductor is called an intrinsic semiconductors e.g. silicon and germanium. But it has small electrical conductivity when some pentavalent (like arsenic) or trivalent (like boron) impurity is added to it then it is called an extrinsic semiconductor.

7. Why a semiconductor behaves as an insulator at zero degree Kelvin ?

At 0K, electrons in valence band do not have sufficient energy to cross the energy band gap so as to reach to conduction band and to make them available for conduction of electricity. Thus semiconductor behaves as an insulator.

8. What is the advantage of four probe method over other methods of measuring resistivity ?

In most of the other methods, the current carrying contacts inject minority carriers which ultimately modify the resistance of the material.

9. What are semi – conductors, insulators and conductors ?

Semi –conductors are those materials whose electrical conductivity is between conductors and insulators. Insulators are those non – metallic materials which do not have free electrons to condom current, capable of carrying an electric current.

10. Name some semi- conductors ?

Germanium, Selenium, silicon and Indium.

11. What are free electrons ?

Free electrons are those electrons that have become dislodged from the outer shell of an atom.

12. Describe the structure of germanium?

Germanium is a trivalent atom i.e it has four valence electrons in its outer shell which can react with four elements of other atoms. Its atomic number is 32. The crystal study shows that germanium has crystalline structure and its atoms assume the special diamond structure.

13. What are the covalent bonds in germanium ?

When germanium is in crystalline from its atoms assume the typical diamond structure atom shares its valence electrons with adjacent atoms in a strong end so that four orbital electron pairs are associated with each nucleus these electron pairs are known as covalent bonds nucleus that no free electrons are available to conduct through the germanium i.e, these covalent bonds are responsible for chemical and electrical inactiveness of germanium.

14. What type of conductor is pure germanium ?

A pure germanium crystal, because of covalent bonds, is a non conductor of electricity.

15. What do you mean by duping ?

Doping is a process of introducing a small amount of an impurity into the germanium crystal.

16. Explain the effect of doping a germanium crystal.

The conductivity of germanium crystal is enhanced by adding the impurities from V or III group of periodic table e.g., arsenic or antimony from V group or indium from III group. When antimony or arsenic having five electrons in their outermost shell are introduced into the germanium crystal, the fifth electron of the impurity atom does not find a place in the symmetrical covalent bond structure and is free to move about through the crystal. These free electrons are then available as current carriers.

17. On what factors does the conductivity of germanium crystal depend ?

The conductivity of the crystal depends upon the type and amount of impurity added.

18. What is N – Type germanium?

Germanium crystal when doped with pentavalent impurities such as arsenic and antimony is know as N – type germanium because negative particles i.e. electrons are the chief carriers of electricity.

19. What is donor impurity?

When pentavalent impurity like arsenic or antimony is added to the pure germanium crystal, then the impurity atom donates electrons to the crystal conductivity, therefore it is called donor impurity.

20. Explain the electron conduction through N – type germanium.

When pentavalent impurity is introduced into the pure germanium crystal, four out of the five valence electrons of impurity atom i.e arsenic will from covalent bonds with four valence electrons of germanium atom as shown in fig. The remaining fifth electron is free to move about the crystal under the action of an electric field these free electrons donated by impurity atoms will move towards the positive terminal of the voltage source, Relatively few donor atoms within germanium permit fairly small electric current through the germanium crystal.

21. What is a P –type germanium ?

If impurity added to germanium is from the II group e.g Indium this type of germanium is called P – type germanium because positive particles i.e, holes are the chief carriers of electricity.

22. What is acceptor impurity ?

When trivalent impurity atom is added to germanium crystal, impurity atom that contribute holes are called acceptor because they accepts electrons from surrounding germanium atoms.

23. What do you mean by a hole ?

Hole indicates the deficiency or absence of an electron. It behaves like a positively charged particle when an electric field is applied across the crystal.

24. Explain the hole conduction through a P – type germanium ?

When trivalent impurity atom is introduced into the germanium crystal three valence electrons of impurity atom will from covalent bonds with 3 valence electrons of germanium atoms. The impurity atoms borrow electrons from surrounding germanium atom, having a deficiency of electrons or holes in their place, under the influenced of an electric field, electrons within the crystal will move towards the positive terminal of the voltage source and jump into the available holes of indium near the positive terminal. Since there are no free electrons available, the deficit indium atoms near positive terminal steal electrons from their neighbors to the left by disrupting their covalent bonds. This creates new holes in adjacent atoms to the left of those that have been filled. As electrons move towards the positive terminal, the holes will move u the negative terminal. As the holes reach the negative terminal, electrons enter the crystal and combine with the holes, this cancelling them. At the same time, loosely held electron that filled the holes near the positive terminal are attracted away from their atoms into the positive terminal which again drift towards the negative terminal. Thus current conduction occurs by means of hole inside the crystal.

25. What are values of energy gap of silicon & germanium?

Silicon & Germanium energy gap values are 1.1 & 0.7 eV respectively at 20^0C.

26. What is the effect of doping on depletion region?

As the doping level increases width of the depletion region decreases.

27. What is the effect of temperature on the energy gap?

As temperature increases energy gap decreases.

28. What are the factors on which energy gap depends?

It depends on the material & temperature.

10. Initial Magnetizing curve of a Ferro magnetic material (B-H Curve Experiment).

Aim:- To Draw initial magnetization curve and to determine the relative permeability of a given Ferrite pot-core transformer.

Apparatus: H Curve Experimental set-up consisting of ac power supply, ferrite core transformer, RC integrator and a Cathode Ray Oscilloscope(CRO).

Theory/Principle:

$$H = \frac{N_p I}{l} \qquad \ldots(1)$$

Where H is called magnetizing force (A/m)
N_P is the number turns of the primary winding
I is the current passing through the wire. (A)
l is magnetic length or the length one round winding. (M)

The magnetic flux linked by a current carrying coil is given by

$$\varphi_B = BA_C N_S \qquad \ldots(2)$$

Where B is the magnetic flux intensity measured in tesla.
A_C is the core area
N_S is number of secondary turns
B can be evaluated as

$$B = \frac{RC}{N_s A} V_C \qquad \ldots(3)$$

While choosing value of RC the basic equality of timing has to be maintained for proper integration of the input signal.

$$T \geq RC,$$

Where T is the period of the input signal (50HZ or T=20msec).
We have selected R=100K and C = 0.1µF that accounts to RC = 0.01sec =10msec
N_s is the number of turns in secondary coil, A is the Area of the coil

$$\text{Slope} = \frac{B}{H} = \mu \qquad \ldots4$$

The relative permeability is calculated by dividing equation -4 by the permeability of free space ($\mu_o = 1.25x10^{-6}$)

Circuit Diagram:

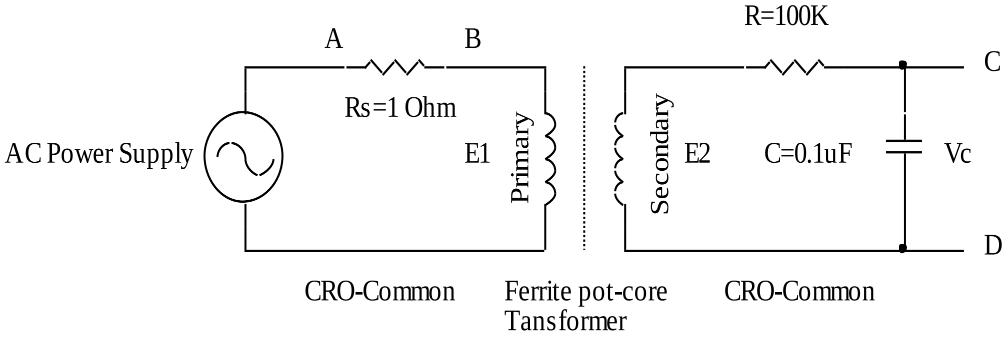

Fig:- Circuit connection

Expected Graph

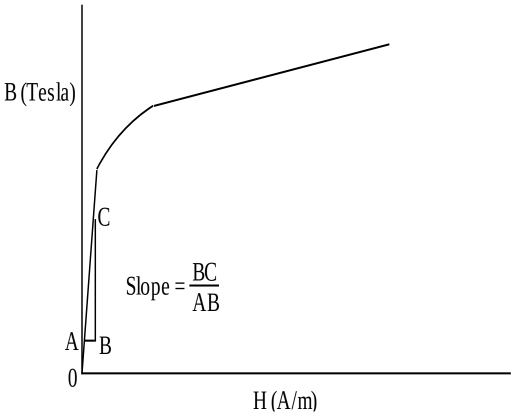

Fig.2:- The graph of magnetic flux density (B) versus applied magnetic field(H)

Procedure:

1. The circuit connections are made as shown in circuit diagram.
2. Channel-2 of the CRO (Or Y-input incase of a single trace CRO) is connected across resistance R_S (with positive to A and negative to B). The time base switch of the CRO is turned to External position.
3. The AC power supply voltage knob is set to 2V position and the voltage across the resistance R_S is measured.

   Voltage across R_S = ... mV peak to peak or = ……..mV rms. Hence the current flowing through R_S

   $$I = \frac{V_S}{R_S} \text{ mA} \qquad \text{…..(1)}$$

   The current flowing through R_S is same as primary current. Since R_S =1 Ohm, V_S = I.
4. For different values of input AC the current flowing in the primary are recorded and tabulated in Table-1.

5. Trial is repeated for all the 6 different switch positions of ac input supply. The corresponding primary current is noted. Magnetizing force is calculated using equation-1.

Table-1:-*Magnetizing force and induced magnetic intensity*

Voltage across V_S mV(PP)	Primary Current I (mA)		Magnetizing Force H(A/m)	Voltage across the capacitor V_C(V)		Magnetic Intensity B (Tesla) $x10^{-3}$
	(PP)	(rms)		(PP)	(rms)	

6. The CRO connection is now removed from AB. And connected across the integrating capacitor to measure V_C.

7. For ac input voltage at position 2V, the voltage across the capacitor is noted

V_C = Volt peak-to-peak = V

Magnetic intensity B is calculated using equation-3

$$B = \frac{RC}{N_s A} V_C \text{ Tesla} \qquad \text{....(2)}$$

8. Trial is repeated by changing input voltage. In each case voltage across the capacitor is noted and B is calculated and presented in Table-1.

9. Initial magnetizing curve is drawn taking H along X-axis and B along Y axis as shown in expected graph. Slope is calculated at the initial linear portion of the curve. The relative permeability is calculated by dividing slope by the permeability of free space ($\mu_o = 1.25x10^{-6}$).

<u>Result:</u> The relative permeability of the given ferrite pot-core transformer is ....

<u>Inference*:*</u> (To be written by the student by the observations and the result obtained in his/her experiment)

<u>Sample Viva Questions with answers:</u>

1. What do you mean by hysteresis loss?

   It has been observed that when we magnetise a magnetic material, certain amount of work is to be done i.e energy is spent in magnetization. The same work is nor recovered when the magnetization field is switched off. Thus this is balance of energy left with the specimen, which is lost as heat, is called hysteresis loss.

2. Why is the work not totally recovered?

   Because some molecular magnets do not come back in their premagnetisation orientation. This is due to retentivity.

3. What is retentivety ?

   The value of intensity of magnetization (I) for which the magnetizing field is zero is called retentivity.

4. What is intensity of magnetization(I) ?

   It is the magnetic moment per unit volume of the specimen of the material.

5. What is hysteresis ?

   We observe that through the magnetizing field becomes zero yet the intensity of magnetization does not become zero. This lagging of intensity of magnetization behind the magnetizing field is called hysteresis.

6. Why an integrating circuit is used with the secondary?

   The e.m.f across the secondary coil is a measure of rate of change of magnetic flux density (dB / dt) and not of magnetic flux density (B). Hence an integrating circuit is used so that a potential difference proportional to flux density (B) may be applied to Y – plates.

7. What should be the value of resistors in the integration circuit ?

   It should be high.

8. Where from you magnetizing field (H)?

   Magnetizing field (H) is simply n, I, where n is the number of turns unit length in the primary and I is the current in the primary of solenoid. Therefore potential difference across a resistor introduced in the primary of the solenoid will be a measure of magnetizing field.

9. How do you get a B – H curve then ?

   Potential difference proportional to H is applied to X – plates of C.R.O whereas potential difference proportional to B is applied to Y – plates of C.R.O.

10. How do you relate the hysteresis loss with area of B – H curve ?

    Hysteresis loss per unit volume per cycle of magnetization.

    $$= \frac{\text{area of B – H curve}}{\mu_0}$$

11. What is μ_0 ?

    It is free space permeability.

12. What is relative permeability?

    It is the degree of which the magnetic field can penetrate a material.

13. What is the relation between B, H and I ?

    $B = \mu_0 (H + I)$

14. Define magnetic field ?

    It is the region in which a unit north pole experience a force.

15. Define m, M, I, x, & μ_r ?

m, pole strength of a pole is the force experience by a similar pole placed at a distance of l m from the similar one. A.M magnetic moment is the product of pole strength and the two times distance between north and the South pole. Am. I, intensity of magnetization is the ratio of magnetic moment to its volume A/m^2.

H, intensity of magnetization at a point is the force experienced by a unit north pole placed at the point A/m^2 susceptibility is the ease with which magnetic material gets magnetized. μ_r permeability is the freeness with which magnetic lines of force enters the material.

$$\mu_r = x+1$$

16. What is μ_r ?

It is permeability of free space its value is $4\pi \times 10^{-7}$

17. Distinguish between hard and soft magnetic ?

Hard (steel) will have large hysteresis loss where as soft (soft iron) has low loss.