CONTENTS

ELECTRONCIS

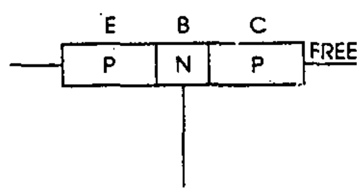
JUNCTION DIODE

EXPERIMENT No. 1

Object : To draw the characteristics of PN Junction Diode.

Apparatus used : Transistor, milliammeter and microammeter, battery, rheostat, voltmeter and connection wires.

Theory : If a transistor triode is given, instead of diode, then to operate the triode as diode one terminal is left free as shown in fig. (1).



E → Emitter
B → Base
C → Collector

Fig. (1)

The connections for forward and reverse bias are shown in the following figures :

(i) Forward bias : Connections are shown in the fig. (2).

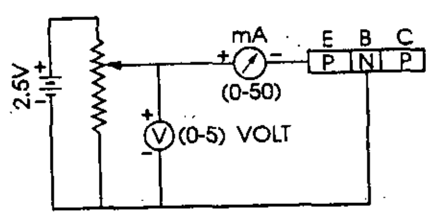


Fig. (2)

(ii) Reverse bias : Connections are shown in the fig. (3).

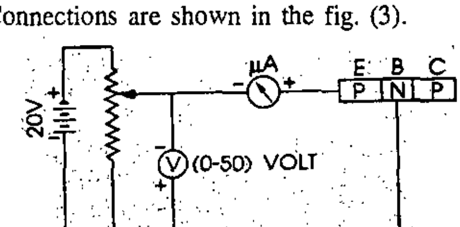


Fig. (3)

Procedure :

(A) Forward Biasing :

(i) Connections are made as shown in fig. (2).

(ii) With the help of rheostat, apply different voltages to the PN junction and note the corresponding reading of current in milliammeter.

(iii) Plot a graph in applied voltages and corresponding currents.

(B) Reverse Biasing :

Make the connections as shown in fig. (3) and proceed exactly in the same way as opted for forward biasing.

Observations :

S. No.	Forward Biasing		S. No.	Reverse Biasing	
	Voltage in Volt	Current in mA		Voltage in Volt	Current in μA
1	...	...	1	...	...
2	...	...	2	...	...
3	...	...	3	...	...
4	...	...	4	...	...
5	...	...	5	...	...
6	...	...	6	...	...

Calculations. (Graph Plotting) :

Plot two graphs—one for forward and another for reverse biasing between voltage applied and the corresponding current.

Result : The characteristics of junction diode ( ) are shown in the graphs fig. (4).

Precautions and sources of error :

(i) To avoid over heating of the transistor, current should not be passed for long duration.

(ii) Voltage applied should be well below the safety limit of the transistor.

(iii) Connections should be made carefully.

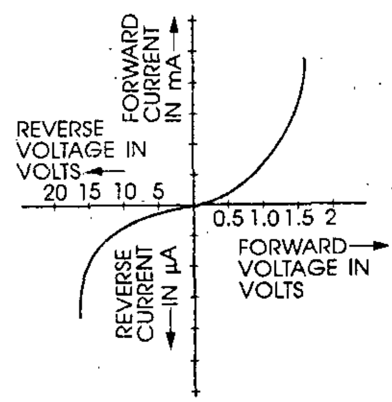


Fig. (4)

Viva-voce

Q. 1. What is a PN junction diode ?

Ans. When P-type germanium and N-type germanium crystals are joined together then a PN-junction diode is formed.

Q. 2. What do you mean by P-type germanium and N-type germanium ?

Ans. If an impurity is added to germanium from III group elements e.g., boron, then charge carriers are holes i.e. positive particles. The resulting crystal is called P-type germanium.

If an impurity is added to germanium from V group elements e.g. arsenic and antimony, then charge carriers are electrons i.e. negative particles. The resulting crystal is called N-type germanium.

Q. 3. What property does PN junction exhibit ?

Ans. It exhibits the property of rectification. That is, current flow on applying a voltage in one direction (forward bias, P as positive) is different from the current flow which results on applying the same voltage in opposite direction (reverse bias, P as negative).

Q. 4. What is the order of currents in the above two cases ?

Ans. In forward bias, current is in milliampere, while in reverse bias current is in microampere.

Q. 5. Mention the order of voltages with it.

Ans. In forward bias, voltages are less than 1 volt while in reverse bias upto 6 volt.

Q. 6. What if high voltage is applied in forward bias ?

Ans. High current will damage the junction.

Q. 7. Have you heard about turn over voltage ?

Ans. It is the critical value of reverse bias voltage beyond which the reverse current increases rapidly. The voltage greater than this critical value is called break down voltage because then junction is said to be in the breakdown region.

Q. 8. What is static and dynamic resistance offered by the diode ?

Ans. Static resistance is the resistance offered by the diode when only a steady direct current flows through it. But when a varying forward current flows through a diode then the resistance offered by the diode in the forward direction to the varying component of the current is called dynamic resistance.

TRANSISTOR CHARACTERISTICS

EXPERIMENT No. 2

Object : To draw characteristics of a PNP junction transistor ( ) in common emitter configuration and determination of current gain β.

Apparatus required : PNP transistor, batteries, voltmeter, millivoltmeter, milli and micro ammeters.

Theory : In common emitter arrangement we draw :

(i) I_c/I_b characteristics. We plot collector current versus base current for a constant collector voltage.

(ii) I_c/V_c characteristics. We plot collector current versus collector voltage for a constant base current.

(iii) Current gain β is given by

$$\beta = \left(\frac{\text{change in collector current}}{\text{change in base current}}\right)_{V_c \text{ constant}}$$

or

$$\beta = \left(\frac{\delta I_c}{\delta I_b}\right)_{V_c \text{ constant}}$$

The value of α can be calculated by using the relation

$$\alpha = \frac{\beta}{1+\beta}$$

Procedure :

(1) I_c/I_b characteristics :

(i) Make the connections as shown in fig. (1).

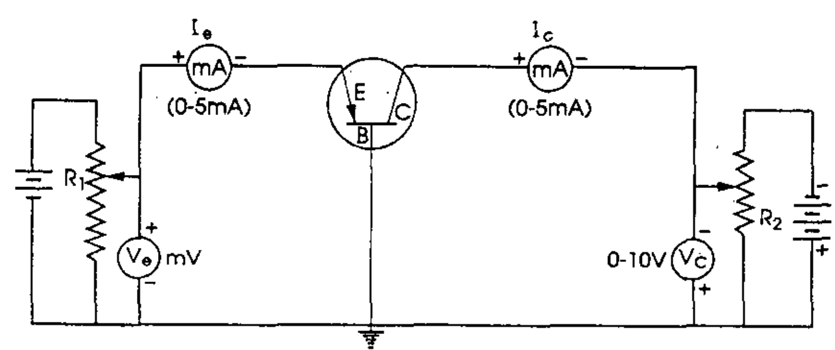


Fig. (1) Common base circuit.

(ii) Adjust the collector voltage to –2V by means of R_2 and keep it fixed for the whole experiment.

(iii) Adjust the base current to 20 μA by means of R_1 and note the collector current.

(iv) Increase base current in steps and note the corresponding collector current till the latter reaches, say about 4mA. If collector voltage changes then readjust it to –2V.

(v) Plot collector current against base current as shown in fig. (2).

(2) I_c/V_c characteristics :

(i) Adjust base current to 20 μA by means of R_1.

(ii) Increase collector voltage in steps of 1 volt by means of R_2 and note the corresponding collector current.

(iii) The base current is now adjusted to 40 μA, 60 μ A etc. and with every value of base current, procedure of point (ii) is repeated.

(iv) Plot curves between collector current and collector voltage as shown in fig. (3).

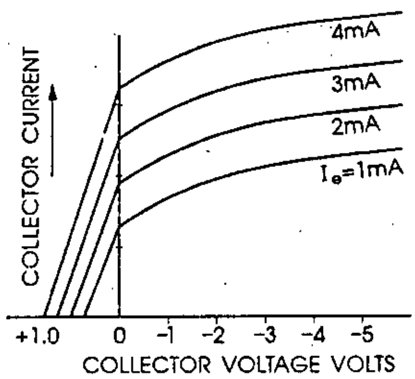


Fig. (2)

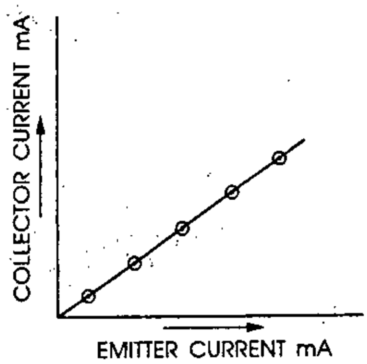


Fig. (3)

Observations :

(1) I_c/I_b Characteristies

Collector voltage = – 2V

S. No.	Base current I_b, in mA	Collector current, I_c, in mA
1	...	...
2	...	...
3	...	...
4	...	...
5	...	...
6	...	...

(2) I_c/V_c Characteristics :

S. No.	Collector Voltage, V_c, in volts	Collector current I_c in mA for base current			
		$I_b = 20\ \mu A$	$I_b = 40\ \mu A$	$I_b = 60\ \mu A$	$I_b = 80\ \mu A$
1	1	...	...	...	...
2	2	...	...	...	...
3	3	...	...	...	...
4	4	...	...	...	...
5	5	...	...	...	...
6	6	...	...	...	...

Result : Characteristics of PNP transistor ( ) in common base and common emitter arrangement have been plotted [Figs. (2) & (3)].

$$\text{Current gain } \beta = \frac{(I_c)_R - (I_c)_Q}{(I_0)_R - (I_b)_Q} = \ldots\ldots$$

Precautions and sources of error :

(1) Student should not, in hurry by mistake, connect the transistor directly to the a.c. switch. Battery, with correct polarity, is to be used.

(2) Voltages applied between different leads should not exceed the recommended value.

(3) Overheating of the transistor should be avoided.

Viva-voce

Q. 1. What is a triode transistor ?

Ans. It can be regarded as a commbination of two-junction PN diodes, one biased in the low impedance direction and the other in high impedance direction e.g. in a PNP transistor, emitter is biased in the forward direction while the collector is biased in the reverse direction.

Q. 2. What is PNP transistor ?

Ans. A junction transistor can be formed by growing a germanium or silicon crystal with two N-regions separated by very thin P region (called NPN arrangement) or with two P-regions fused on to a very thin N-region (called PNP arrangement).

Q. 3. What is emitter, collector and base ?

Ans. In PNP or NPN arrangement, the central region is called base-one of the outer layers as emitter and the other as collector.

Q. 4. Why is it called a transistor ?

Ans. A transistor is basically a resistor that amplifies electrical impulses as they are transferred through it from its input to its output terminals. The name transistor is derived from the words transfer and resistor.

Q. 5. What are the basic material for making transistor ?

Ans. Semiconductor germanium or silicon is used.

Q. 6. What is peculiar about a semiconductor ?

Ans. Its resistivity depends upon temperature and decreases with the rise in temperature.

Q. 7. What is the difference between a transistor and vacuum tube ?

Ans. (i) Transistor is current operated device while tube is a voltage operated device.

(ii) In transistor, output and input circuits are not isolated.

(iii) In transistor, input and output impedances widely differ.

Q. 8. What are the advantages of a transistor over a vacuum tube ?

Ans. (i) small size, light weight,

(ii) long operating life and more mechanical strength,

(iii) low current requirement.

Q. 9. How is the current conducted in a PNP transistor ?

Ans. Holes in emitter P region (emitter is biased positively) are repelled to base region. But base region is thin and lightly doped so the holes drift across the base, N, without meeting electrons to combine with. Thus holes reach the collector P region (biased negatively). For each hole, an electron is emitted from negative terminal of the battery and neutralises the hole. For each hole lost by combination, a covalent bond near emitter electrode breaks and a liberated electron from there enters the positive terminal of the battery while the new holes move towards the collector. This process continues. Thus holes move inside the material from emitter to collector while electrons move in the outer circuit from emitter to base. The current in outer emitter-base circuit is called emitter current I_e and the current in outer collector base circuit is called collector current, I_c.

Q. 10. Which regions in a transistor are heavily doped ?

Ans. Emitter region is heavily doped while the base region is lightly doped.

Q. 11. How is a PNP or NPN transistor biased ?

Ans. The emitter-base junction is forward biased while the collector base junction is reverse biased.

Q. 12. What is the fundamental relation between the currents in a bipolar transistor?

Ans. In the external circuit, the magnitudes of the emitter current, I_e, the base current I_b and the collector current, I_c, are given by

$$I_e = I_b + I_c$$

Base current is of the order of μA whereas I_e I_c of mA order.

Q. 13. Why is common emitter amplifier most widely used ?

Ans. (i) It has good current and voltage gains.

(ii) It has the highest power gain.

(iii) The difference between its input and output impedances is not very large. Therefore common-emitter circuits can be connected in cascade directly without using transformers for matching purposes.

Q. 14. Define static current amplification factors.

Ans. (i) α_{dc}, the static current amplification factor for a transistor in common base connection is the ratio of static (dc) collector current, I_c, to the static emitter current, I_e, at a constant collector voltage with respect to the emitter. That is

$$\alpha_{dc} = \frac{I_c}{I_e}, \text{ at constant } V_{cb}.$$

(ii) β_{dc}, the static current amplification factor for a transistor in the common-emitter connection, is the ratio of static (d.c.) collector current, I_c, to the static base current, I_b, at a constant collector voltage with respect to the emitter. That is

$$\beta_{dc} = \frac{I_c}{I_b}, \text{ at constant } V_{ce}.$$

Normally, the value of α_{dc} is greater than 0.9 and less than 1. Value of β_{dc} depending on the design, may be about 600. Its value (β_{dc}) highly depends upon the position of operating point, and it determines the quality of a transistor.

Q. 15. What are small signal current-amplification factors (a.c. current gains).

Ans. For a transistor in CB configuration

$$\alpha = \left(\frac{\partial I_c}{\partial I_e}\right)_{V_{cb}}$$

For a transistor in CE configuration

$$\beta = \left(\frac{\partial I_c}{\partial I_b}\right)_{V_{ce}}$$

In h-parameters, α is written as h_{fb} and β as h_{fe} as they are also called small signal forward current transfer ratio. They are related as $\beta = \frac{\alpha}{1-\alpha}$.

ZENER DIODE

EXPERIMENT No. 3

Object : To plot the characteristics of a Zener diode.

Apparatus required : Zener diodes of different ratings (4.5V, 6V, 9V). Milliammeter, Voltmeter, dc supply of 12 V, Rheostat.

Circuit Connections :

Under forward bias condition, zener diode acts like an ordinary PN junction diode. Therefore we study its characteristics only in reverse bias conditions as shown in fig. (1)

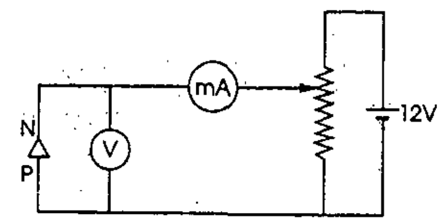


Fig. (1)

Procedure :

(i) Adjust the supply at 0 volt and note the current, if any.

(ii) Increase the supply voltage in steps of 0.5 volt and note the corresponding current each time.

(iii) At a particular voltage, V_z (depending upon the rating of zener diode e.g. for 4.5 volt zener, this particular voltage will be 4.5 volt) the current is maximum and there is no effect on this current if the voltage is further increased.

(iv) Repeat the whole procedure with a zener diode of some other ratings.

Observations :

Voltmeter readingvolt	Milliammeter readingmA
...	...
...	...
...	...
...	...
...	...

Result : Plot a graph in current and applied voltage fig. (2).

Precautions :

(i) Zener diode should be connected in reverse bias condition.

(ii) Rating of diode is an important consideration. Therefore when using this diode in voltage regulation, a current limiting resistor of appropriate value should be used in series with it so that the power dissipated across the junction is within its power handling capability.

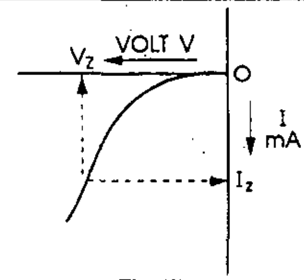


Fig. (1)

Viva-voce

Q. 1. What is a Zener diode ?

Ans. It is a PN junction diode which is operated under reverse bias condition in breakdown region at a given voltage of its inverse characteristic.

Q. 2. Is there any difference between this and the ordinary PN junction diode ?

Ans. Yes, concentration of acceptor and donor impurity atoms near the junction is carefully adjusted so that its characteristic beyond the turn over voltage becomes almost a vertical line.

Q. 3. What is the reason of using it as a voltage reference device ?

Ans. Beyond the turn over voltage, its characteristic becomes linear. In this region of its characteristic, the reverse voltage across the diode remains constant for a large change of the reverse current. Thus voltage is stabilised at a predetermined value (zener voltage, rating of zener diode) and this diode can be used as a voltage reference device for stabilising voltage at a predetermined value.

Q. 4. What is turn over voltage ?

Ans. The critical value of reverse voltage at which the reverse current increases rapidly is called turn over voltage.

Q. 5. How does zener act in forward bias conditions ?

Ans. Like an ordinary PN junction diode.

TUNNEL DIODE

EXPERIMENT No. 4

Object : To draw the characteristics of a Tunnel Diode.

Apparatus required : A tunnel diode, Milliammeter (0–500 mA). Millivoltmeter (0–500 mV), d.c. supply, Rheostat.

Circuit : The voltage is increased in the forward direction across the diode.

Procedure :

(i) Adjust the supply at zero volt and note the current, if any.

(ii) Increase supply voltage in steps of 20 mV and note the corresponding currents.

(iii) At a particular voltage, current will become maximum. Thereafter it decreases and reaches a minimum. But as the supply voltage is further incresed, current again increases.

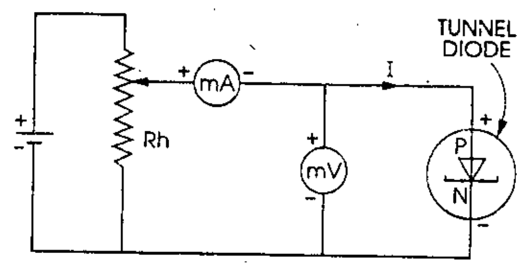


Fig. (1)

Observations :

S. No.	Millivoltmeter reading, V, mV	Milliammeter reading, I, mA
1	...	...
2	...	...
3	...	...
4	...	...
5	...	...
6	...	...

Result : Plot a graph in current, I and applied voltage, V, (fig. 2).

A germanium tunnel diode characteristics are shown in fig. (2).

Current is maximum (called peak current $I_p = 100\text{mA}$) at peak voltage denoted by V_p (= 60mV). The voltage and current corresponding to minimum are called valley voltage, V_v and valley current I_v. For a typical tunnel diode, these are listed below:

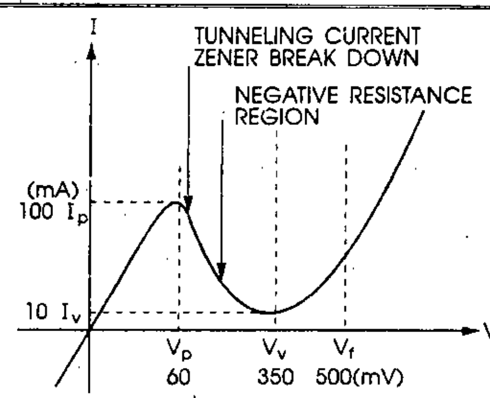


Fig. (2)

	Ge	Ga As	Si
I_p/I_v	8	15	3.5
V_p in volts	0.055	0.15	0.065
V_v in volts	0.35	0.50	0.42
V_f in volts	0.50	1.10	0.70

When voltage is increased beyond the valley voltage, the current in the diode increases in an exponential manner like current in ordinary p–n junction. The voltage at which current becomes equal to I_p in this region is called forward voltage (V_f). It is about 500 mV for a typical Ge tunnel diode.

Precautions :

(i) Tunnel diode is to be used in forward bias condition.

(ii) Ratings of the diode are to be taken into consideration.

Viva-voce

Q. 1. What is the construction of a tunnel diode ?

Ans. It is high conductivity PN junction diode having doping density about 1000 times higher than ordinary PN junction diode.

Q. 2. What is the effect of this higher doping ?

Ans. (i) It reduces the width of depletion layer to an extremely small value (about 1×10^{-5} mm).

(ii) It reduces the reverse break down voltage so that diode breaks down for any reverse voltage.

(iii) It produces a negative resistance region.

Q. 3. Why is it called a tunnel diode ?

Ans. Because of its extremely thin depletion layer, electrons are able to tunnel through the potential barrier at relatively low forward bias voltage (less than 0.05V).

Q. 4. What is the advantage of this tunneling process ?

Ans. Tunneling is much faster than normal crossing by the electrons across the depletion layer. This enables a tunnel diode to switch ON and OFF at a speed (*symbol* speed of light) much faster than ordinary diode. Thus they find use in high speed computer memories where very fast switching speeds are involved.

Q. 5. Of which materials are such diodes fabricated ?

Ans. They are fabricated from Germanium, Gallium-Arsenide and Silicon.

EXPERIMENT No. 5

Object : To plot output characteristics of FET and measure pinch off voltage.

Apparatus required : FET (BFW 10 or BFW 11), D.C. voltmeters (0-30V and 0-10V), D.C. milliammeters (0-50 mA and 0-50 μA), D.C. power supplies (for V_{GG} and V_{DD}).

Circuit : Circuit is shown in fig. (1). G is gate, D is drain and S is source. Current meter, I_D, may have a switch to put milliammeter or microammeter into the circuit (whichever is needed).

Procedure : (i) First disconnect V_{GG} and short circuit G and S terminals. Keep V_{DD} = 10 volt.

Now apply V_{GG} and find a value for which I_D becomes zero. This value of V_{GG} is called, V_p, the pinch off voltage.

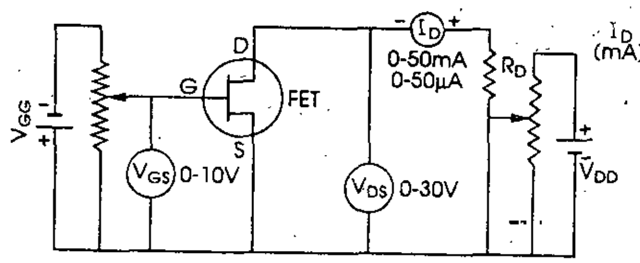


Fig. (1)

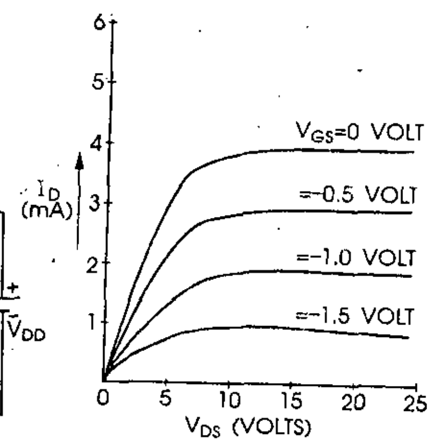


Fig. (2)

(ii) Now vary V_{DD} and note I_D for a fixed value of V_{GG}. Repeat this observation for various values of V_{GG} as shown in the table.

Observations :

(i) Pinch off voltage, V_p = ... volt.

(ii) Table for output characteristics :

S. No.	$V_{GS} = -1.5V$		$V_{GS} = -1.0V$		$V_{GS} = -0.5V$		$V_{GS} = -0$ volt	
	V_{DS}(Volt)	I_D(mA)	V_{DS}(Volt)	I_D(mA)	V_{DS}(Volt)	I_D(mA)	V_{DS}(Volt)	I_D(mA)
1	...	...	...	...	...		...	..
2	...	...	...	...	...	...	...	..
3	...	...	...	...	...	...	...	...
4	...	...	...	...	...	...	...	...
5	...	...	...	...	...	...	...	...

Result : Plot a graph in V_{DS} and I_D for various values of V_{GS} fig. (2). These are called output characteristics of FET.

Precautions and sources of error :

(i) Handle FET gently.

(ii) Gate should never be given a positive voltage.

(iii) Voltages, being applied, should not exceed the rated values.

Viva-voce

Q. 1. What is the structure of FET ?

Ans. An N-Channel FET is shown in fig. (3). A narrow bar of N-type semiconductor material is taken. Two *P* type junctions are diffused on opposite sides of it as shown in the figure. P & N type materials form two pn diodes or gates. The two *P*-regions are internally connected and together form gate terminal, *G*. The *N*-region between P regions is called channel. Ohmic contacts are made at the two ends of N-type bar-one contact is called source and the other as drain. Source and drain are interchangeable.

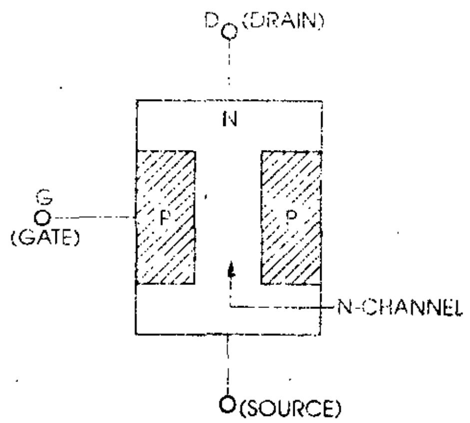


Fig. (3)

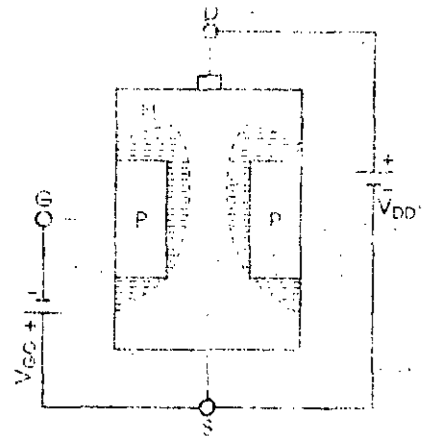


Fig. (4)

Q. 2. Explain the operation of FET.

Ans. When Drain is positive and gate is negative then *pn* junction towards drain side is reverse biased. Therefore depletion region (dotted or shaded portion) will be more extended on this side than towards source side (because on source side *p–n* junction is forward biased). When depletion region increases, drain current, I_D, decreases. Such a value of gate voltage (V_{GG}) which makes $I_D = 0$ is called pinch off voltage. At this stage depletion regions touch each other and block the channel fig. (4).

It is to be noted that conduction is only by one type of carrier, the majority carriers. The holes in P-type (when bar is of P-type material called P-channel FET) and electrons in N-type. As the FET is always reverse biased (gate is kept always negative) its input impedance is high.

Q. 3. Why is it called Field Effect Transistor ?

Ans. Because the current from source to drain can be controlled by the application of potential (i.e. electric field) on the gate. That is why FET is a voltage driven device like a vacuum tube. The input voltage (at the gate) controls the output current

Q. 4. What is the difference between a transistor and a FET ?

Ans. (i) In FET, only one type of carriers conduct the current whereas in a transistor both electrons and holes take part.

(ii) FET has high input impedance because of reverse bias (V_{GS} is negative) on the input circuit.

(iii) FET is voltage driven where as a transistor is current operated.

R-C COUPLED AMPLIFIER

EXPERIMENT No. 6

Object : To design and study amplifying characteristics of a single stage RC coupled amplifier.
Apparatus required : A valve 6J5; Two load resistors ($R_L = 30K\Omega$ and $47K\Omega$), Coupling condensers ($C_c = .01\mu F, .02\mu F, .04\mu F$), Cathode biasing arrangement ($R_k = 3K\Omega, C_k = 25\mu F$). Grid leak resistors ($0.47M\Omega, 0.1M\Omega$), input capacitor ($0.1\mu F$), V.T.V.M. High tension (0-250 volts), A.F. generator (0–50 kc/s).
Formula used : At a particular frequency,

$$\text{Voltage amplification} = \frac{\text{Output voltage}}{\text{Input voltage}}$$

Circuit design :

The plate is connected to positive of high tension through a load resistor, R_L. The cathode is connected to negative of high tension through a cathode resistor R_k (= $3K\Omega$) having a capacitor C_k (= $25\mu F$) across it. At input is connected an audio frequency oscillator. Input and output voltages are measured by a V.T.V.M. C_c is the coupling condenser and R_g is grid leak resistor of next stage. Circuit is shown in fig. (1).

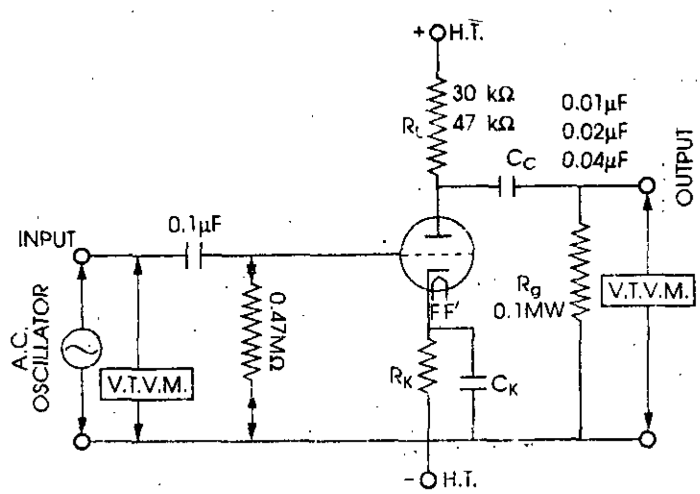


Fig. (1) Single stage RC coupled amplifier.

Procedure :

(i) Draw the circuit as shown in fig. (1).

(ii) Set $R_L = 30K\Omega$, $C_c = 0.01\ \mu F$

Keep the input voltage (output of oscillator) constant, equal to 1 volt. Vary the oscillator frequency from 10c/s to 50kc/s and note the output voltage at various frequencies.

(iii) With $R_L = 30K\Omega$, $C_c = 0.02\mu F$

repeat the procedure (ii)

(iv) With $R_L = 30K\Omega$, $C_c = 0.04\mu F$

repeat the procedure (ii)

(v) Now set $R_L = 47K\Omega$ and then repeat procedure (ii) for $C = .01, .02$ and $.04\mu F$ separately.

Observations :

Input voltage = 1.0 volt.

Frequency c/s	Output Voltage, Volt	Voltage amplification
10	17	17
50	...	...
100	...	...
500	...	...
1000	...	...
3000	...	...
5000	...	...
10,000	...	...
20,000	...	...
30,000	...	...
40,000	...	...
50,000	...	...

Result : Graph is plotted between voltage amplification and frequency for various values of load resistor (R_L = 30KΩ and 47KΩ) and coupling capacitor (C_c = .01, .02 and .04μF.). It is observed fig. (2) that voltage amplification is not constant at low and high frequencies but remains fairly constant at mid frequencies. At higher load values, length of flat portion of the response curve decreases.

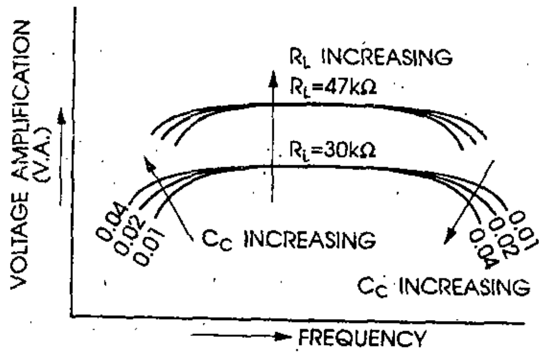


Fig. (2) Frequency response curve of RC.

Precautions and sources of error :

(i) Values of circuit elements should be chosen carefully.

(ii) Various voltages developed and applied in the circuit should correspond to circuit voltage requirements and tube limitations.

(iii) Prior to using V.T.V.M. its suitable range should be chosen first and then zero adjustment should be done.

Viva-Voce

Q. 1. What is R–C coupling ?

Ans. It is resistance capacitance coupling. It consists of two resistors and one capacitance, which is a connecting link between the two stages.

Q. 2. What is the other name for R–C coupling ?

Ans. Capacitive coupling.

Q. 3. Why capacitance in R–C coupling is known as blocking capacitor ?

Ans. The capacitance in R–C coupling allows only a.c. signal at one end of one stage to appear at the input of next stage while blocking the d.c. voltages and currents. So the d.c. biasing of the next stage is not infrared. Due to this reason capacitance is also keeps blocking capacitor.

SINGLE STAGE COMMON EMITTER AMPLIFIER

EXPERIMENT No. 7

Object : To study response characteristics of a transistorised RC coupled amplifier with and without negative current feed back.

Apparatus required : PNP transistor 2SB 77, or AC 125, Resistances of values shown in the circuit (2k, 3k, 5k, 22k, 5.1k, 470 Ω), Capacitances shown in the circuit (100 μf, 100μf, 50μf, 50μf). Audio frequency generator (0–50 kc/s), V.T.V.M. as output meter. High frequency (a.c.) millivoltmeter (0–500 mV), 6 volt d.c. supply.

Circuit Design :

Procedure : Refer to fig. (1).

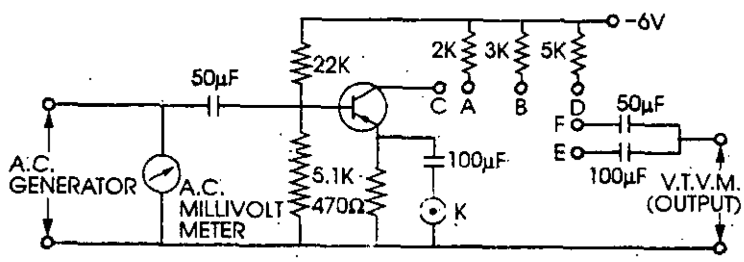


Fig. (1) Single RC Stage coupled amplifier. For current feedback switch K should be open.

(A) Without Current Feedback : Switch K is closed :

(i) Connect CA and CE.

Keep input voltage (10 mV) constant. Vary oscillator frequency from 10 c/s to 50 kc/s and note the output voltage at various frequencies.

(ii) Connect CB and CE.

Repeat the procedure written in (i).

(iii) Take similar set of observations by connecting.

CD & CE, CA and CF, CB and CF, CD and CF.

(B) With Current Feed back : Switch K is open.

Repeat the whole procedure detailed in above method (A).

Observations :

(A) *Without Current Feedback :*

Frequency c/s	Output in volts					
	C = 50 μ*f* withCA	CB	CD	*C* = 100 μ*f* withCA	CB	CD
	2k	3k	5k	2k	3k	5k
10	...	...	...	...	...	..
50	...	...	...	...	...	...
100	...	...	...	...	...	...
...	...	...	...	...	...	...
...	...	...	...	...	...	...
50,000	...	...	...	...	...	...

(B) *With Current Feed back.*

Prepare same table as in (A).

Result : Find voltage amplification at various frequencies by

$$V.A. = \frac{\text{output voltage}}{\text{input voltage}}$$

and then plot graphs in voltage amplification and corresponding frequencies. Do it for both the cases-with and without current feed back. Without feedback, curves will show rapid fall in gain at low and high frequencies but not so with feed back. (See Expt. 29 Graphs)

Sources of Error and Precautions :

(i) Input voltage should be kept low.

(ii) Take precaution about the polarities while connecting the supply.

(iii) Zero adjustment for every range of V.T.V.M. selected should be done.

Viva-Voce

Q. 1. What is the source of power in this experiment ?

Ans. An. A.C. Generator.

Q. 2. What is the main drawback of R.C. coupled amplifier ?

Ans. Blocking capacitor.

LC COUPLED AMPLIFIER

EXPERIMENT No. 8

Object : To determine the frequency response of a single stage LC coupled amplifier.

Apparatus required : A valve 6J5; Primary of a transformer for the use as inductance, L; Condensers (.01μF, .02μF, 0.1μF, 25μF); Resistors (0.47 MΩ, 0.1 MΩ, 3KΩ). V.T.V.M. High tension (0–250 volts). A.F. oscillator (0–50 kc/s)

Circuit : Refer to fig. 1 (a). L is primary of a transformer.

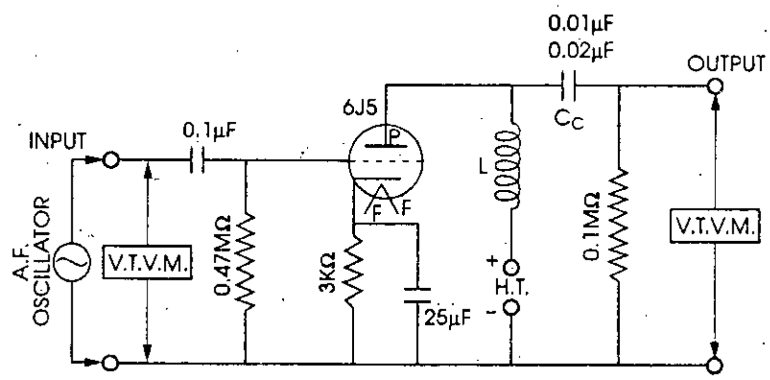


Fig. (1) Single-stage LC coupled ampifier.

Procedure :

(i) Wire the circuit as shown in fig. 1 (a).

(ii) Set $C_c = 0.01$ μF. Keep the input voltage (Output of A.F. Oscillator) constant at 1 volt, say. Vary the oscillator frequency from 10 c/s to 50 kc/s and record the output voltage at various frequencies.

(iii) Now set $C_c = 0.02$ μF, and repeat the procedure explained in above point (ii).

Observations :

$$\text{Voltage amplification} = \frac{\text{Output voltage}}{\text{input voltage}}$$

Input voltage = 1.0 volt

Frequency c/s	Output Voltage, Volt	Voltage amplification
10	...	...
50	...	...
100	...	...
...	...	...
...	...	...
50,000	...	...

Result : Graph fig. 1(b) is plotted between voltage amplification and frequency for various values of coupling condenser, C_c. It is observed that voltage amplification is constant for a very small range of frequencies, compared to RC coupled amplifier. Thus flat portion of the curve is shorter. The decrease in gain is greater at both low and high frequencies compared to RC coupled amplifier.

Precautions and sources of error :

Same as in case of RC coupled amplifier.

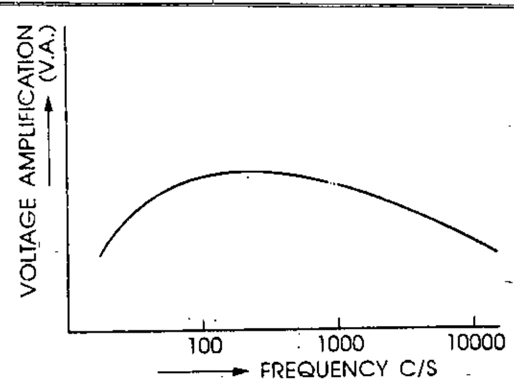


Fig. (1) Single RC Stage coupled amplifier. For current

TRANSFORMER COUPLED AMPLIFIER

EXPERIMENT No. 9

Object : To design and study amplifying characteristics of a single stage transformer coupled amplifier.

Apparatus required : Circuit elements and their values are indicated in fig. (1). V.T.V.M., Audio frequency oscillator (0–50 kc/s), Two output transformers (one of high grade and the other of low grade).

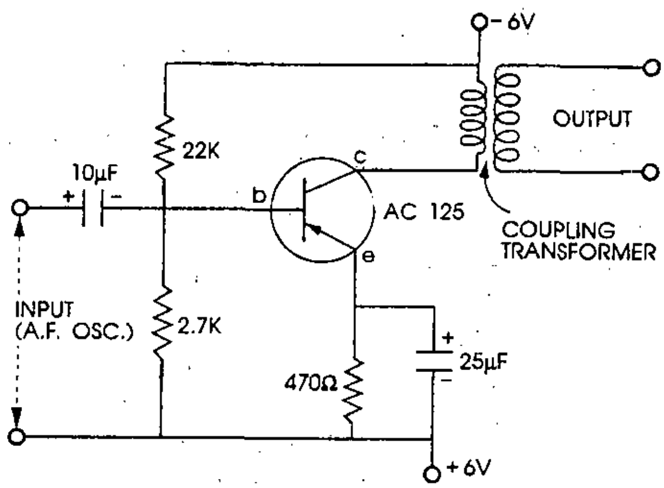


Fig. (1)

Circuit :

Procedure :

(i) First use high grade transformer for coupling. Keep input at 10 mV (this is output of audio oscillator connected at the input terminals). It is kept constant throughout the experiment.

Now vary oscillator frequency from 10 kc/s to 50 kc/s. Note output voltage at each frequency applied.

(ii) Repeat the procedure with a low grade transformer.

Observations :

Input voltage = 10mV

Freq. in c/s	High grade Transformer		Low grade Transformer	
	Output volt	Voltage amplification	Output volt	Voltage amplification
10	...	...	...	...
50	...	...	...	...
100	...	...	...	...
:	:	:	:	:
:	:	:	:	:
:	:	:	:	:
50 kc/s	...	...	...	...

Calculations : For each observation find :

$$\text{Voltage amplification} = \frac{\text{Output voltage}}{\text{Input voltage}}$$

$$= \frac{\text{output voltage in volts}}{10 \times 10^{-3} \text{ volt}}$$

$$= \ldots$$

Result : Plot graphs, fig. (2), for the two types of transformers in voltage amplification and frequency.

We note that frequency response curve for high grade transformer (a transformer having high inductance with negligible distributed capacitance) is fairly uniform.

Precautions and sources of error :

(i) Input voltage should be checked at every frequency. It should remain constant at all frequencies applied.

(ii) Use proper range of V.T.V.M. for input and output voltage measurements. For each range, zero of V.T.V.M. should be set.

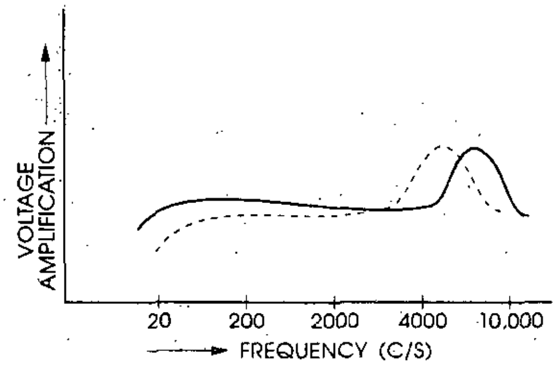


Fig. (2)

Viva-voce

Q. 1. What is voltage amplification ?

Ans. It is the ratio of the output voltage to the input voltage.

Q. 2. Does it change with input voltage frequency ?

Ans. Yes, we observe from frequency response curve that at low and high frequencies, it is reduced.

Q. 3. Why is voltage amplification reduced at low and high frequencies?

Ans. In the low frequency range, the reactance offered by the coupling condenser, C_c, $(= 1/\omega C_c)$ increases as the frequency decreases. The coupling condenser C_c and grid leak resistor, R_g act as voltage divider. When reactance of C_c increases, voltage across grid leak is reduced. This causes a decrease in voltage amplification at low frequencies.

At high frequencies, the reactance of the coupling capacitor, C_c, will be negligible, but various capacitances which shunt the C_c and R_g arise. They effectively decrease the load impedance and hence the voltage amplification.

Q. 4. What are these shunt capacitors ?

Ans. They include plate-cathode (C_{pk}) inter-electrode capacitance of the tube and also stray wiring capacity to the left and right sides of the coupling capacitor.

Q. 5. Explain fully the effect of C_c and R_g coupling ?

Ans. Coupling capacitor, C_c prevents the high voltage, applied to the plate of the valve, from reaching the grid of next stage valve. Function of resistor, R_g, is to provide a path for the leakage of electrons that would otherwise be collected at the grid side of C_c and then will bias the tube to cut off.

POWER AMPLIFIER

EXPERIMENT No. 10

Object : To study a push pull amplifier using transistors.

Apparatus required : Two PNP AC 128 transistors, input and output transformers, Resistances (6.8 KΩ, 560 Ω, 10 Ω), Power supply (0–12V d.c.), C.R.O., Audio frequency generator (A.F. oscillator), Output power meter.

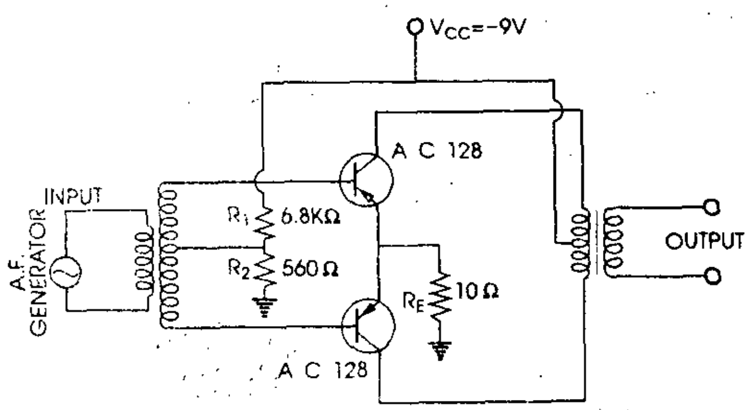


Fig. (1)

Circuit :

Procedure :

(i) Make the circuit as shown in fig. (1).

(ii) Apply input signal from A. F. oscillator. Keep the frequency at 1 kc/s.

(iii) Connect output power meter at the output terminals. Also connect a C.R.O. at these output terminals.

(iv) Keep load impedance, say 8 ohm, in the power meter.

(v) Now increase input voltage amplitude till the output wave shape gets distorted on C.R.O. screen. Note this input voltage. Reduce input voltage to 80% of this value. Also note reading of output power meter. It gives output power.

(vi) Now change load impedance in power meter and note output power from the meter.

(vii) Take various observations with different values of load impedance (in power meter).

Observations :

S.No.	Load impedance in ohm	Output powerin mW
1	...	...
2	...	...
3	...	...
4	...	...
5	...	...

Calculation : Plot a graph in output power and load impedance. From this graph, find the impedance for which the output power is maximum. This is the value of optimum load.

Result : Optimum load = ... ohm.

Precautions and sources of error :

(i) Negative polarity of voltage supply should be connected to the collector terminals of AC 128 which is a PNP transistor.

(ii) Various resistors used should be of appropriate value.

(iii) Output transformer should be of better quality as it should have minimum losses and should not cause any distortion in the output.

Viva-Voce

Q. 1. What is the importance of power amplifier ?

Ans. A power amplifier is designed to obtain maximum output power.

Q. 2. What are the main features of this amplifier ?

Ans. 1. Transistor with smaller β is used.

2. The base of the transistor is made thicker to handle large currents.
3. The size of the transistor is made large to dissipate the heat produced during operation.
4. Collector resistance is made low.
5. Collector current is high.
6. Input voltage is high.
7. Power output is high.

EMITTER FOLLOWER

EXPERIMENT No. 11

Object : To study voltage gain, input impedance, output impedance, and power gain of an emitter follower.

Apparatus required : A.F. generator (Keep its frequency at 1 kc/s), Resistors (470 K, 3.3 K, 12 K and 500 ohm potentiometer), capacitors (25 μF, 100μF), Transistor AC 126, Power Supply, C.R.O., Oscilloscope (C.R.O.) will also be used to measure V_{in}, V_{out} and other voltages in the circuit.

Circuit diagram :

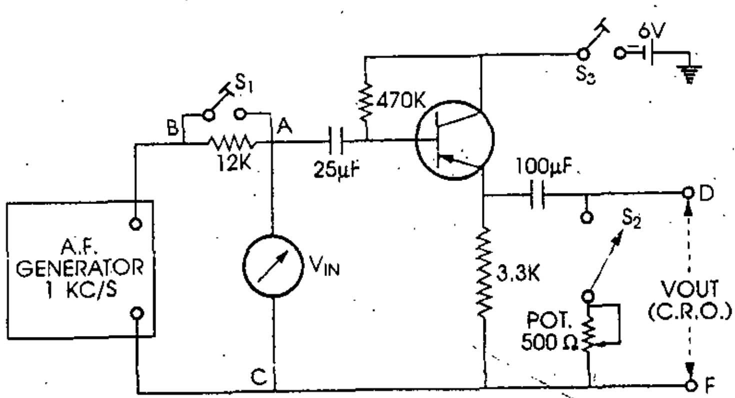


Fig. (1)

Procedure :

(A) For Voltage Gain :

(i) *With Power off : Close S_1 and open S_2.*

Set A.F. generator at zero output with its frequency at 1 kc/s. Connect C.R.O. at *D*, *F* points and adjust it for clear viewing.

(ii) *With Power ON :*

Now increase gain of A.F. generator so that an undistorted output, V_{out}, of about 150 mV appears on the C.R.O screen (connected at *D*, *F* points). Measure peak to peak value of V_{out} and also of V_{in} (input of generator at points *A* and *C*). Record them in the table and find voltage gain (= V_{out}/V_{in}).

(B) For Input Impedance : Power ON.

(i) Open switch S_1 and increase output of A.F. generator so that we get same, V_{in} between *A* and *C* points. Note V_{AB} across points *A* and *B*. Find input base signal current

$$i_{in} = \frac{V_{AB}}{R_{AB}} = \frac{V_{AB}}{12{,}000}$$

Record it in the table.

(ii) Find input resistance :

$$R_{in} = \frac{V_{in}}{i_{in}} = \ldots$$

Record it in the table.

(iii) Find input power

$$P_{in} = i_{in}^2 R_{in} = \ldots$$

Record it in the table.

(C) For output resistance : Power ON :

(i) *Close switch S_1 ; S_2 still open.*

Now reduce output of A.F. generator so that V_{out} measures 100 mV. Record it.

(ii) *Now close S_2 also :* It includes in the circuit the load resistance R_L (by potentiometer shown in fig. as POT). Adjust R_L (i.e. POT.) until output voltage is reduced to half the value (50 mV) recorded in above point (i).

(iii) Again open S_2 and measure the resistance, R_L (POT. value) This is output resistance, R_{out}.

(iv) Find output power,

$$P_{out} = V_{out}^2/R_{out} = \ldots \text{ Record it in the table.}$$

(D) For Power Gain :

Compute it using the relation,

$$A_p = \frac{P_{out}}{P_{in}} = \ldots$$

Observations :

Table-1 : Voltage gain : Input impedance and Input power.

V_{out} volt	V_{in} volt	Gain = V_{out}/V_{in}	V_{AB} volts	i_{in} amp.	R_{in} ohm.	$P_{in} = i_{in}^2.R_{in}$,watt
...	...	...	...	...	...	...

Table-2 : Output impedance : Output power and Power gain.

V_{out} volt	$V_{out}/2$ volts	$R_L = R_{out}$ohm	$P_{out} = V_{out}^2/R_{out}$watt	Power gain = P_{out}/P_{in}
...	...	...	...	...

Calculations :

(i) Voltage gain $= \dfrac{V_{out}}{V_{in}} = \ldots$

(ii) Input base signal current, $i_{in} = \dfrac{V_{AB}}{R_{AB}} = \ldots$ amp.

(iii) Input resistance, $R_{in} = \dfrac{V_{in}}{i_{in}} = \ldots$ ohm.

(iv) Input power $P_{in} = i_{in}^2 R_{in} = \ldots$ watt.

(v) Output resistance, $R_L = R_{out} = \ldots$ ohm.

(vi) Output power $P_{out} = V_{out}^2/R_{out} = \ldots$ watt.

(vii) Power gain $A_p = \dfrac{P_{out}}{P_{in}} = \ldots$

Result : Characteristics of an emitter follower as determined are :

Voltage gain = ...
Input resistance = ... ohm.
Output resistance = ... ohm.
Power gain = ...

Viva-Voce

Q. 1. The voltage gain of this amplifier is less than unity than why it is called an amplifier?

Ans. Actually it is used as an impedance matching device because its input impedance is very high while the output impedance is very low. This is used as the last stage of a signal generator. Now when the signal generator is connected to a circuits the oscillator is not loaded and its frequency remains constant. This is due to emitter follower because it is capable of giving power to a load without requiring much power at the input. So, it works as buffer amplifier.

Q. 2. What is the other name of emitter follower ?

Ans. Voltage series feedback.

BIAS STABILISATION : THERMAL EFFECTS

EXPERIMENT No. 12

Object : (i) To study thermal effects on the output of a transistor amplifier.

(ii) To study effect of emitter bypass resister for bias stabilisation.

Apparatus required : Transistor AC-127, C.R.O., A.F. generator, Resistors (350K, 340K, 130K, 3.3K, 470 Ω), Capacitors (25 μF, 10μF), Microammeter (0–100 μA), 6V battery.

Circuit diagram :

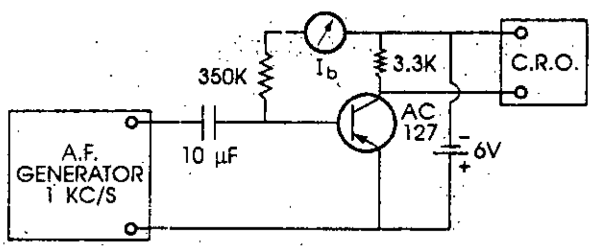


Fig. (1) (a) Unstablised amplifier.

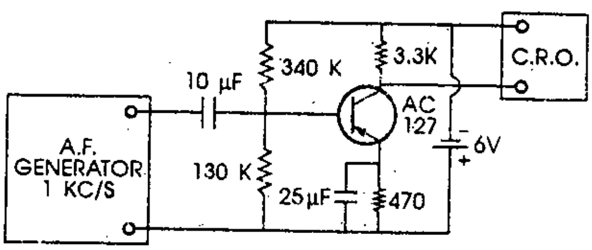


Fig. (b) Stabilised amplifier.

Procedure : (A) With Circuit of fig. 1. (a) :

(i) Keep A.F. generator frequency at 1 kc/s and adjust with the help of attenuator, a voltage level of its output to about 1 volt peak to peak. Set C.R.O. for clear viewing.

(ii) Put the transistor in a constant oil temperature bath and raise the temperature in steps of 1°C. Note the base current, I_b , for every degree rise in temperature. Observe the output waveform on the C.R.O. screen.

(iii) It is observed that as the temperature increases, output waveform start exhibiting distortion. Leakage current also increases. It means this type of biassing is not proper. Trace these waveforms on a trace paper.

(B) With Circuit of fig. 1 (b) :

(i) We change biassing. An emitter bypass capacitor of 25 μF is connected along with a resistor of 470 Ω to the emitter of AC-127. Also base biassing is changed. Circuit is shown in fig. 1. (b).

(ii) Put the transistor in a constant oil temperature bath and raise the temperature in steps of 1°C. Observe the output waveform on the C.R.O. screen. We note that, upto about 45°C rise in temperature, output waveform is distortion free. Trace these waveforms on a trace paper.

Observations :

Temp. °C	I_b μA	Output waveforms; Paste these on paper	
		with Fig. 1 (a)	with Fig. 1 (b)
...	...		
...	...		
...	...		
...	...		

Result : Thermal effects cause distortion in the output if type of biassing is not proper.

Viva-Voce

Q. 1. What is the source of power in this experiment ?

Ans. An AF generator of 1 KC/s frequency.

Q. 2. How would you change an unstablised amplifier into stabilised amplifier ?

Ans. By joining a capacitor along with a resistor to the emitter.

h-PARAMETERS

EXPERIMENT No. 13

Object : Measurement of h-parameters of a transistor (AC-126) at 1 kc/s.

Apparatus required : Transistor AC 126, Two inductances (each of 2H), Milliammeter (0-10 mA), Two resistances ($R_1 = 560\Omega, R_2 = 1000\Omega$), One switch (S), One capacitor (1000 μF), Two d.c. supplies ($V_{CC} = 9V, V_{BB} = 2.5V$), V.T.V.M., A.F. oscillator (output in mV range).

Circuit :

Inductance L_1 will offer appreciable impedance at 1 kc/s compared with transistor input resistance. In this circuit, for proper biassing conditions adjust V_{BB} and V_{CC} such that I_c is about 2 mA and V_{CE} is about 5 volt.

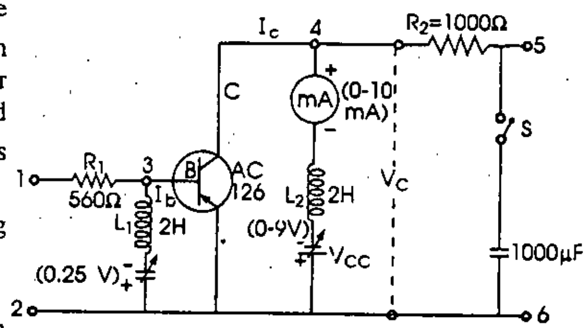


Fig. (1)

Procedure : First obtain proper biassing conditions.

(i) Switch (S) **ON**; that is $V_c = 0$:

Connect A.F. Oscillator between terminals 1 and 2 and set it at 1 kc/s with output voltage of about 10 mV.

Now measure, with the help of V.T.V.M., voltages V_{23} (voltage between terminals 2 and 3), V_{31}, V_{46} and V_{56}.

(ii) Switch (S) **OFF** ; That is $I_b = 0$;

Connect A.F. oscillator across terminals 5 and 6 (instead of 1 and 2).

Set its frequency at about 1 kc/s with output voltage of about 200 to 300 mV. Now measure voltages V'_{32}, V'_{46} and V'_{56} (prime has been used to differentiate them from switch ON values)

Observations :

Switch ON ($V_c = 0$)	Switch OFF ($I_b = 0$)
$V_{23} = \ldots$ volt	$V'_{32} = \ldots$ volt.
$V_{31} = \ldots$ volt	$V'_{46} = \ldots$ volt.
$V_{46} = \ldots$ volt	$V'_{56} = \ldots$ volt.
$V_{56} = \ldots$ volt	

Calculations : Note that $R_1 = 560\Omega$ and $R_2 = 1000\Omega$. h-parameters are:

$$h_{ie} = \frac{V_b}{I_b} (V_c = 0) \text{ and } h_{fe} = \frac{I_c}{I_b} (V_c = 0)$$

$$h_{re} = \frac{V_b}{V_c} (I_b = 0) \text{ and } h_{oe} = \frac{I_c}{V_c} (I_b = 0)$$

But $V_b = V_{23}$ $\qquad$ $V_b = V'_{32}$

$$I_b = \frac{V_{31}}{R_1} \quad \text{For } V_c = 0 \text{ Switch ON} \qquad I_c = \frac{V'_{56} - V'_{46}}{R_2} \quad \text{For } I_b = 0 \text{ Switch OFF}$$

$$I_c = \frac{V_{46} - V_{56}}{R_2} \qquad V_c = V'_{46}$$

Therefore in terms of measured voltage, we write the desired hybrid parameters as.

$$h_{ie} = \frac{R_1 V_{23}}{V_{31}} \text{ ohm.}$$

$$h_{fe} = \frac{(V_{46} - V_{56}) R_1}{R_2 V_{31}}$$

$$h_{re} = \frac{V'_{32}}{V'_{46}}$$

and $$h_{oe} = \frac{V'_{56} - V'_{46}}{R_2 V'_{46}} \text{ mho.}$$

Result : The measured h-parameters for the given transistor AC 126 at 1 kc/s are :

$h_{ie} = \ldots$ ohm.	Std. values,	$(1.7 \text{ to } 3.8\ k\Omega)$
$h_{re} = \ldots$		(13×10^{-4})
$h_{fe} = \ldots$		(100 to 300)
$h_{oe} = \ldots$ mho.		(100 to 170 μ-mho)

Viva-Voce

Q. 1. What is the importance of h-parameters for the transistor ?

Ans. As the transistor has low input impedance and high output impedance the hybrid h parameters (h for small signal device and H for large signal units) appears most useful for circuit analysis becauses they form a combination of impedance and admittance parameters and are selected to suit the low input and high output impedence of the transistor.

Q. 2. What is the value of voltage in present circuit when switch is on.

Ans. $V_c = 0$.

BAND GAP IN A SEMICONDUCTOR

EXPERIMENT No. 14

Object : To determine the band gap in a semiconductor using a PN junction diode.

Apparatus required : Power supply (d.c.-3 volts fixed), Microammeter, Electrically heated oven, Thermometer, Semiconductor diode (OA 79).

Formula used : A graph is plotted between log I_s and $(10^3/T)$ that comes out to be a straight line. Its slope is found.

Band gap, ΔE, in electron volts, is given by

$$\boxed{\Delta E = \frac{\text{slope of the line}}{5{\cdot}036} \text{ electron volt.}}$$

Theory : In a semiconductor there is an energy gap between its conduction and valence band. For conduction of electricity a certain amount of energy is to be given to the electron so that it goes from the valence band to the conduction band. The energy so needed is the measure of the energy gap, ΔE, between two bands.

When a *p-n* junction is reverse biased then current is due to minority carriers whose concentration is dependent on the energy gap, ΔE. The reverse current, I_s (saturated value) is a function of the temperature of the junction diode. For small range of temperature, the relation is expressed as

$$\text{Log } I_s = \text{Constant} - 5.036\, \Delta E\, (10^3/T)$$

where temperature T is in Kelvin, ΔE is in electron volts. A graph in log I_s and $(10^3/T)$ is plotted which comes out to be a straight line. The slope of this line will be 5.036 ΔE, giving the value of band gap for the semiconductor.

Procedure : Refer to fig. (1).

(i) Connect *p* and *n* sides of junction diode to microammeter and battery with polarity shown in fig. 1. Put the diode in place on the board for heating and fix a thermometer to measure the temperature.

(ii) Start heating by connecting oven's lead to mains and allow the oven temperature to increase upto 65°C.

(iii) As temperature reaches about 65°C, switch off the oven. The temperature will rise further, say to about 70°C and will become stable.

(iv) Now temperature will begin to fall. Take current (in μA) and temperature reading in steps of 5 μA fall in current.

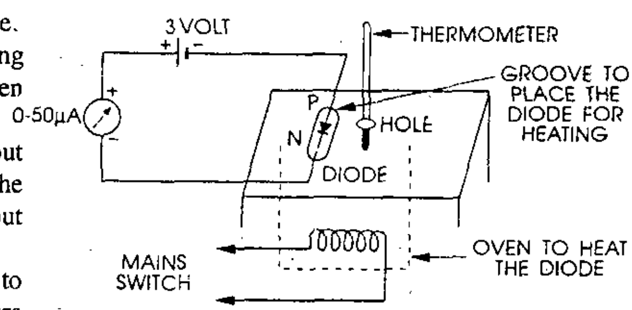


Fig. (1)

Observations :

Current I_s in μA	Temp., °C	Temp., T Kelvin	$10^3/T$	log I_s
...	...	...	...	...
...	...	...	...	...
...	...	...	...	...

Calculations :

Plot a graph in $\log I_s$ and $10^3/T$ fig. (2) and find slope *AB/BC*.

Find

$$\Delta E = \frac{AB/BC}{5.036} = \ldots \text{ electron volt.}$$

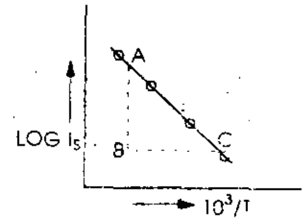


Fig. (2)

Result : Band gap for semiconductor (Ge) = ... eV

Standard result : for the semiconductor (Ge) = 0.7 eV

Percentage error = ... %.

Precautions and sources of error :

(i) Maximum temperature should not exceed 80°C.

(ii) Silicon diode, if used, will require a maximum temperature of the order of 125°C. Therefore oven and thermometer should be of this requirement.

(iii) Diode should be placed well within the goove so that it is in good contact of the heat of the oven.

Viva-voce

Q. 1. What is a band gap ?

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

Q. 2. What is band gap in a good conductor ?

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

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

Ans. When a *p-n* junction is reverse biased, then current is due to minority carriers whose concentration is dependent on energy gap or band gap.

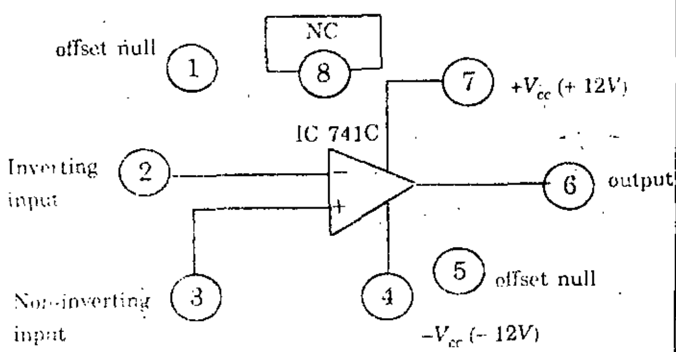
Note : Please refer to Four probe method for finding energy band gap, and for more questions.

OPERATIONAL AMPLIFIER

EXPERIMENT No. 15

Object : To study OP-AMP in (a) inverting mode (summing amplifier) (b) non-inverting mode (c) integrator (d) differentiator (e) difference amplifier.

Apparatus required : OP-AMP, IC (741C); Two voltage regulated supplies of +12 volt and –12 volt for supplying voltage to the 7 and 4 terminals of OP-AMP, respectively; C.R.O. with a facility to measure the amplitude of various waveforms displayed on screen in μV and mV. A V.T.V.M. and a millivoltmeter, various resistances and capacitances of values shown in the respective diagrams. Fixed positive dc voltage supplies V_1, V_2 and V_3 to be used as input voltage of the OP-AMP.



Base Connections of IC 741 C :

Characteristics :

Ideal voltage gain $= 2 \times 10^5$ (open loop gain)
Output impedance = 75 ohm
Input impedance = 2 Meg. ohm

(A) Inverting Mode Summing Amplifier :

(i) *Circuit and theory* : Circuit is shown in fig. (1). V_{id} is the input differential voltage. The output of the amplifier is given by

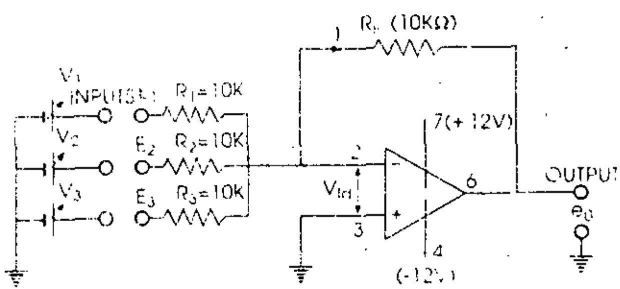


Fig. (1)

$$e_0 = \text{open loop gain} \times \text{input differential voltage}$$
$$= A_{OL} \times V_{id}$$

Since A_{OL} is almost infinite, V_{id} must be very small to have a finite output, e_0. Thus the point 2 in the circuit is virtually at ground potential.

Currents $I_1 + I_2 + I_3 = \dfrac{e_1}{R_1} + \dfrac{e_2}{R_2} + \dfrac{e_3}{R_3}$

As the current drawn by OP-AMP is negligible, the sum of these currents flows through R_F, so that output is

$$e_0 = -R_F \,.\, I = -R_F\left(\frac{e_1}{R_1} + \frac{e_2}{R_2} + \frac{e_3}{R_3}\right)$$
$$= -(e_1 + e_2 + e_3) = -(V_1 + V_2 + V_3) \qquad \ldots (1)$$

if $R_1 = R_2 = R_3 = R_F$. Thus output is the negative sum of the inputs. That is, phase of output is reversed.

(ii) Procedure :

(a) Make connections as shown in fig. (2). Connect terminal 7 to +12 volt supply and terminal 4 to −12 volt supply. Terminal 2 is connected to input voltages. Keep $R_1 = R_2 = R_3 = R_F = 10K\Omega$. For input voltages use supply V_1, V_2 and V_3.

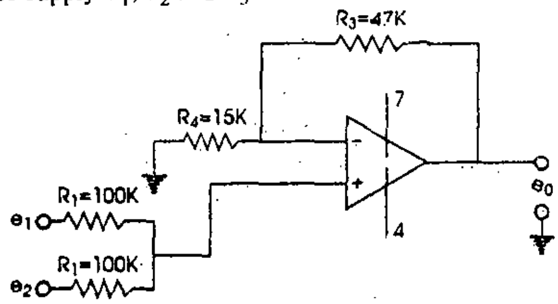


Fig. (2)

(b) Apply some values of V_1, V_2 and V_3. Measure them with the help of V.T.V.M. Measure output voltage, e_0 which will be reverse in polarity.

(c) Repeat the experiment by varying V_1, V_2 and V_3.

(iii) *Observation :* Calculated output $e_0 = V_1 + V_2 + V_3$

$$R_1 = R_2 = R_3 = R_F = 10K\Omega$$

S. No.	Input volt	Output e_0, volt	Calculated output volt	Difference volt
1	$V_1 = \ldots$ $V_2 = \ldots$ $V_3 = \ldots$	...	...	...
2	$V_1 = \ldots$ $V_2 = \ldots$ $V_3 = \ldots$	...	...	...
3	$V_1 = \ldots$ $V_2 = \ldots$ $V_3 = \ldots$	...	...	...

Result : We observe that output is the negative sum of the inputs.

(B) Non-inverting Mode :

(i) *Formula and circuit :* In this circuit, the input is given at noninverting terminal. Output is in phase with the input. Circuit is shown in fig. (3).

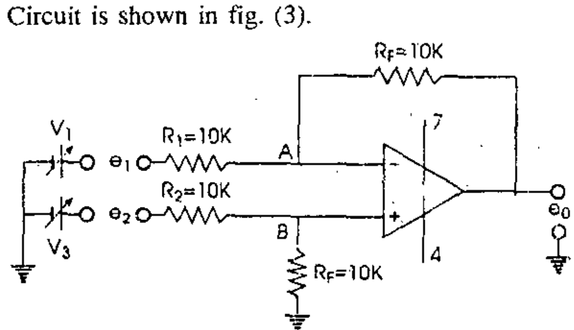


Fig. (3)

Output voltage, e_0 is given by

$$e_0 = \left(1 + \frac{R_3}{R_4}\right)\left[e_1 \cdot \frac{R_2}{R_1 + R_2} + e_2 \cdot \frac{R_1}{R_1 + R_2}\right] \qquad \ldots(2)$$

For calculating output, above relation will be used and the result will be tabulated.

(ii) *Procedure :*

(a) Refer to fig. 2. Keep $R_1 = R_2 = 100K\,\Omega$, $R_3 = 47\,K\Omega$ and $R_4 = 15K\Omega$. Use V_1 and V_2 for e_1 and e_2 inputs and measure them with V.T.V.M.

(b) Measure output, e_0.

(c) Repeat the experiment by changing values of V_1 and V_2.

(iii) *Observations :*

S.No.	Input volt	Output volt, e_0	Calculated output e_0. Eq. (2), volt	Difference volt
1	$V_1 = \ldots$ $V_2 = \ldots$	...	...	...
2	$V_1 = \ldots$ $V_2 = \ldots$	...	...	...
3	$V_1 = \ldots$ $V_2 = \ldots$	...	...	...

(iv) *Result :* Output e_0, is verified and is in phase with input.

(C) Difference Amplifier :

(i) *Circuit and Formula :* It is used to find the difference between two signals. The output is given by

$$e_0 = \frac{R_F}{R_1}(e_2 - e_1)$$

If $\quad R_F = R_1$ then

$$e_0 = (e_2 - e_1) \qquad \ldots (3)$$

and in that case, circuit acts as subtractor. Circuit is shown in fig. (4).

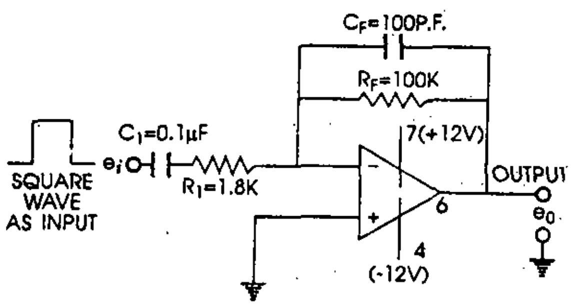


Fig. (4s)

(ii) *Procedure :*

(a) Refer to fig. (4). Keep $R_1 = R_F = 10\ \text{K}\Omega$. Use V_1 and V_2 for e_1 and e_2 inputs. Measure their values with V.T.V.M.

(b) Measure output, e_0, with V.T.V.M. Note if $V_1 > V_2$, output, e_0, will be negative and if $V_1 < V_2$, output e_0 will be positive.

(c) Repeat above steps for various values of V_1 and V_2.

(iii) *Observations :*

S.No.	Input volt	Output e_0 volt,	Calculated output Eq. (2), volt	difference volt
1	$V_1 = \ldots$ $V_2 = \ldots$	...	...	...
2	$V_1 = \ldots$ $V_2 = \ldots$	...	...	...
3	$V_1 = \ldots$ $V_2 = \ldots$	...	...	...

(iv) *Result :* We note that circuit acts as subtractor.

(D) Differentiator :

(i) *Formula and circuit :* The output of this circuit is proportional to the differential of the input. Output is given by

$$e_0 = -R_F C_1 \frac{de_i}{dt} \qquad \ldots (4)$$

Time constant $R_F C_1$ should be low compared to the period of input wave. Circuit is shown in fig. (5).

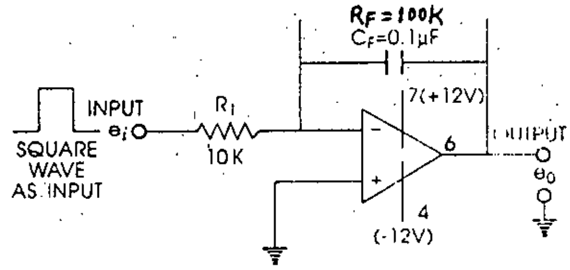


Fig. (5)

(ii) *Procedure :*

(a) Keep $R_1 = 1.8\ K\Omega$, $C_1 = 0.1\ \mu F$, $C_F = 100pF$, $R_F = 100\ K\Omega$.

(b) Use square wave as input from an oscillator. See the waveform on a C.R.O. Trace it.

(c) Connect C.R.O. at output points and increase input from zero till you get a differentiated output on C.R.O. Do not increase input amplitude too much as it will saturate the OP-AMP. Trace the differentiated output.

(d) Vary frequency of input square wave, trace it and again trace output also.

(iii) *Observation & Result :* Paste the input and output trace papers for various inputs.

(E) Integrator :

(i) *Formula and circuit :* This circuit performs an integration over the input. Values of R_1 and C_F are chosen such that time constant $R_1 C_F$ is high compared to the period of input square wave. Formula for the output, e_0, is

$$e_0 = -\frac{1}{R_1 C_F} \int e_i\, dt, \qquad \ldots (5)$$

where e_i is input voltage.

(ii) *Procedure :*

(a) Keep $R_1 = 10\ K\Omega$, $R_F = 100\ K\Omega$, $C_F = 0.1\ \mu F$. Use square wave from an oscillator as input. Trace its waveform on a trace paper by placing it on a C.R.O. screen.

(b) Connect C.R.O. to output points. Now increase input from zero to a value such that an integrated output is obtained on C.R.O. screen. Trace it on a paper.

(c) Use input wave of other frequencies. Trace input and corresponding output waveforms on a paper by placing it on C.R.O. screen

(iii) *Observation and Result :*

Paste all input and output waveforms traced on a trace paper from C.R.O. screen. Output waveforms show that input wave is integrated.

Precautions and sources of error :

(i) External connections to OP-AMP 741C should be made to the correct pins : Inputs to pin 2 or 3. Supply + 12V to pin 7, – 12V to pin 4. Pin 6 is for output.

(ii) Input voltage level should not reach such a high value that OP-AMP becomes saturated.

(iii) Various voltages applied to the pins of OP-AMP should not exceed the rating values provided.

(iv) Power supplies used for OP-AMP should be electronically regulated.

Viva-Voce

Q. 1. How is operational amplifier denoted ?

Ans. OP–AMP.

Q. 2. What does negative sign show in inverting amplifier ?

Ans. It shows that input and output are 180° out of phase.

EXPERIMENT No. 16

Object : To find the value of e/m for an electron by Thomson's method using bar magnets.
Apparatus required : Fitted CRT, D.C. Power Supply unit, two bar magnets, a compass box, a compass needle etc.
Procedure :

(1) Draw the North-South and East-west line using a compass needle. Place the cathode ray tube fitted in the wooden frame fig. (1) with its axis along the North South line so that the arms of the frame lie in the East West line.

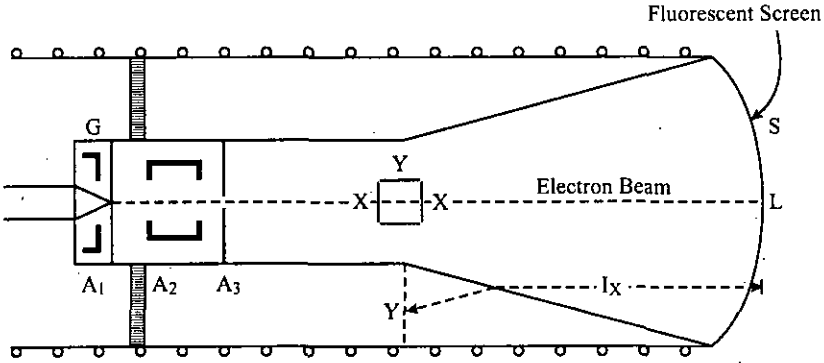


Fig. (1)

(2) Connect the cathode ray tube to the power supply unit. Switch on the current and wait till a luminous bright spot appears on the screen adjust the brightness and focus control so as to get a sharp bright point spot in the middle of the screen. Note the initial position of the spot on the scale fitted on the screen.

(3) Now apply a suitable defecting voltage so that the luminous spot is deflected by about 0.5 to 1.0 cm. Note the deflecting voltage *V.* and the position of the spot. Measure the distance through which the spot has moved and let it be *Y.*

(4) Place the bar magnets symmetrically on either side of the cathode ray tube along the arms of the wooden stand on which the tube is fitted such that there opposite poles face each other and their common axis is exactly at right angles to the axis of the cathode ray tube. Adjust the polarity as well as the distance of the magnets so that the luminous spot comes outback to its initial position. When the adjustment is prefect note the distance of the poles of the magnets on the side nearer to the cathods ray tube. Let the distances be r_1 and r_2.

(5) Remove the bar magnet, switch of the electric field applied to the deflecting plater and again note the intial position of the luminous spot. Reverse the polarity of the potential difference applied to the electric deflecting plates with the help of the reversing switch fitted in the power supply unit there by reversing the electric field. Again note the final position of the luminous spot and calculate *Y.*

(6) To find the value of the magnetic field *B* carefully remove the magnets and the cathode ray tube from the wooden stand. Place the compass box such that its centre lies exactly the point where the common axis of the bar magnets and the axis of the cathode ray tube intersect. Rotate the compass box about its vertical axis so that the pointer lies along the O-O line.

Place the magnets exactly in the same positions as in step 5 at distance r_1' and r_2' and again note the deflections Q_1' and Q_2' from the ends of the pointer of the compass box. The mean of these four deflection Q_1, Q_2, Q_7' and Q_2' gives the mean deflection Q if B_H is the horizontal component of earth's mangetic field then.

$$B = B_H \tan \theta.$$

(7) Take two more sets of observations by changing the value of V and hence that of the electric field.

Observations:

Data provided on the cathode ray tube by the manufactures
Length of the deflecting plates P or $Q = l =$ m
Distance of screen from the centre of the plates $L =$ m
Distance between the deflecting plates P and Q $d =$ m

S. No.	Applied voltage V	Direct Field							Reversed Field						
		Position of spot			Magnetic pole and distance				Position of spot			Magnetic pole and distance			
		Initial	Final	Deflection	Pole	r_1	Pole	r_2	Initial	Final	Differention	Pole	r_1'	Pole	r_2'
1	V_1										$Y_1 =$				
2	V_2										$Y_2 =$				
3	V_3										$Y_3 =$				

Result : The value of e/m is = ... coulmb/kg.

Precautions :

1. A power supply unit and the cathode ray tube which work at a high voltage should be handled with care.
2. There should be no extra magnetic field near the apparatus.
3. The magnetic needle should oscillate in simple harmonic motion and along the axis of the tube. Its translatory motions should be avoided as far as possible.
4. The cathode ray tube should be exactly in the magnetic meridian.
5. Since the square of the term $\int [\int H.dx]\, dx$ is occurring in the formula, it should be measured accurately.

Viva-Voce

Q. 1. What do you mean by specific charge on an electron ?

Ans. The ratio of charge to mass of an electron is known as specific charge of an electron.

Q. 2. What is the standard value of the specific charge (e/m) of an electron ?

Ans. The standard value of e/m = $(1.7592 \pm 0.0005) \times 10^7$ e.m.u./gm.

Q. 3. How is the electron deflected by a magnetic field ? In what direction is the field applied ?

Ans. The magnetic field (H) is applied at right angles to the direction of motion of electrons and the particles will be acted upon by a force (H_{ev}) in a direction perpendicular to both. This force is always perpendicular to the direction of motion and provides the necessary centripetal force and hence the path tranversed by the particle will be circular.

Q. 4. What is the screen made of ?

Ans. The fluorescent screen is made of glass which is painted on the inner surface by Willemite (Zn_2SiO_4).

EXPERIMENT No. 17

Object : To determine the electronic charge by Millikan's method.

Apparatus required : Millikan's apparatus, oil, spirit level, stop watch, vernier callipers, screw guage, a dip-stic wire etc.

Theory:- If a is the radious of the drop of oil of density, P, then weight of the drop

$$= 4/3\ \pi a^3\ \rho g.$$

As the drop is lying in a gas of density d, it experiences an upthurst $= 4/3 \pi a^3\ dg.$

$\therefore$ Resultant down word force $= 4/3\ \pi a^3\ (\rho - d)\ g.$

If the drop acquires a thermal velocity V, while moving downwards then

$$4/3\ \pi a^3\ (\rho - d)\ g = 6\pi\ \eta\ a\ v \qquad [\eta \text{ is the viscosity of air}]$$

$$a = \left[\frac{9\eta v}{2\,(\rho - d)\,g}\right]^{1/2}$$

Resultant upward force,

$$q = \frac{6\pi\eta}{E}\left[\frac{\rho v\eta}{2\,(\rho - d)\,g}\right]^{1/2} (v + v_{1})$$

where q is charge on the drop,

E is the electric field applied between the plates.

v_1= uniform velocity.

Procedure :

(1) Insert the dip-stick wire in the hole H and focus the microscope on the wire. Find the number of divisions of the microscope scale equivalent to the thickness of the wire.

(2) Remove the dip-stick and spray oil in the chamber by means of the atomiser. After a few seconds the oil drops will appear as tiny spots moving upwards in the field of view of the microscope. Switch on the H.T. and it will be noticed that a majority of the oil drops are unaffected some of the drops will appear to accelerate in the upwards direction. A few drops will appear to reverse direction and move in the downward direction.

(3) Select a small drop which moves downwards and note its motion when the field is switched off. Find the time t, it takes to cover say 3 divisions of the microscope scale.

(4) Switch on the field and find the time t_2 for its passage in the reverse direction.

(5) Repeat the observation a number of timer for different drops.

Observation :

Diameter of dip-stick with screw guage R = 1, 2, 3, 4.

Mean = ... cm.

No. of divisions of microscope scale equivalent to were thickness =

Magnitude of each microscope scale div. $B = \frac{R}{n}$ cm = ... m.

No. of div. (v_1) meters.	Time t_1				No. of div. Y_2 numbers	Time t_2				Pot. diff. V (volt)
	1	2	Mean	$v = \frac{\beta y_1}{t_1}$ ms^{-1}		1	2	Mean	$v_1 = \frac{\beta Y_2}{t_2}$ ms^{-1}	

Distance between plates x = ... cm

Density of oil P = ... gm/cc

Density of air d = ... gm/cl

Viscocity of air at t °C η = ... poise

Electric field $E = \frac{V}{x}$ = volt/meter.

Precautions:

(1) The apparatus should be levelled carefully.

(2) The plates should be cleaned before spraying.

(3) Low vapour pressure oil should be used.

(4) The positive of H.T. should be connected to the top plated.

(5) The microscope scale should be caliberated.

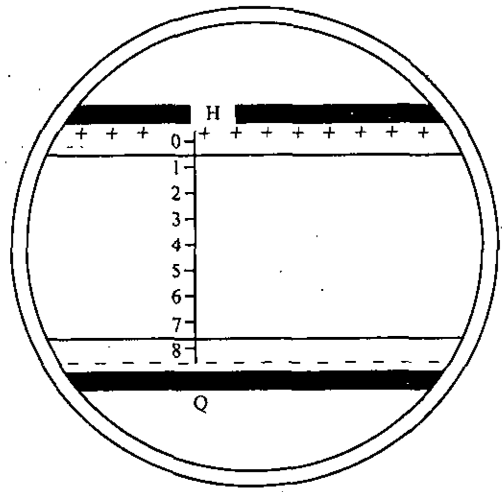


Fig. (1)

Result : The value of charge on electron is = ... coulomb.

Viva-Voce

Q. 1. How do you apply the potential difference across the plates ?

Ans. The potential difference between the plates is applied by the means of a power supply potential divider and commutator.

Q. 2. What part does the co-efficient of viscosity of the air play here ?

Ans. When no electric field is applied between the plates A and B, co-efficient of viscosity of air opposes the motion of oil drop under gravitational field, owing to which the oil drop soon acquires a steady terminal velocity.

Q. 3. What type of oil do you use ?

Ans. A non-volatile oil such as olive oil.

Q. 4. What type of microscope are you using ?

Ans. A telemicroscope.

EXPERIMENT No. 18

Object : To find the value of plank's constant and photo electric work function of the material of the cathode using a photo electric celle.

Apparatus required : A vacuum tube, photo cell, a rheostate moving coil galvanometer, scale arrangement one way key, a mercury camp light filters (red, yellow, green, blue voilet)

Procedure:

(1) Draw a diagram showing the scheme of connection and connect accordingly arrange the mercury lamp and the photo cell as shown and setup the lamp and scale arrangement of the galvanometer so that the spot of lights moving freely on the scale with the box closed adjust the sliding contract to the extreme point *P*. So that when the key *K* is introduced the voltmeter reads zero. Adjust the positions of the galvanometer scale so taht the spot of light with its central crosswire is at zero graduation.

(2) Slowly move the sliding contact to words *Q* (negative end of the battery) So that a negative potential of 0·05 V is applied to the anode *A* of the photo electric cell. The deflection will slightly decrease.

(3) Repeat the experiment with blue ($\lambda = 4360$ Å) green (5460 Å) yellow ($\lambda = 5780$ Å) and red ($\lambda = 6910$ Å) filters.

Record zero Reading

S. No.	Voltmeter (Negative)	Scale deflection with				
		Voilet filter	Blue filter	Green filter	Yellow filter	Red filter
	0 Volt – 0.05 – 0.10 – 0.15 : :					

(4) For each filter draw a graph between voltmeter reading (negative anode voltage) and deflection in cm from the graph, find the value of stopping potential Vs of which scale deflection is zero corresponding.

Filter	Voilet	Blue	Green	Yellow	Red
Wavelength	4050×10^{-10} m	4360×10^{-10} m	5460×10^{-10} m	5780×10^{-10} m	6910×10^{-10} m
Frequency $v = \frac{C}{x}$					
Stopping v_1					

(5) Plot a graph between stopping potential V_s taken along the *Y*-axis and corresponding frequency ν taken along the X-axis. The graph is straight line as shown. Take two points P_1 and P_2 sufficiently apart on the straight line. Find the values of stopping potentials V_1 and V_2 and frequencies V_1 and V_2 corresponding to P_1 and P_2.

Slope of the graph = $\tan\theta = \dfrac{r_2 - r_1}{v_2 - v_1}$

Now $e = 1{\cdot}59 \times 10^{-19}$ C. $= \dfrac{\Delta V_s}{\Delta \nu} =$ volt/sec.

∴ Plank's constant $h = e \tan\theta$.

$$= \frac{e\Delta \nu_s}{\Delta \nu} = 1.59 \times 10^{-19} \times \frac{\Delta \nu_s}{\Delta \nu}$$

= Joule sec.

Threshold frequency (ν_0) =

Photo-electric work function = $h\nu_{\sigma}$ = Jule.

Photo-electric work function

$$= OB \text{ electric volt}$$
$$= OB = 1.59\times10^{-19}\ OB \text{ Joule.}$$

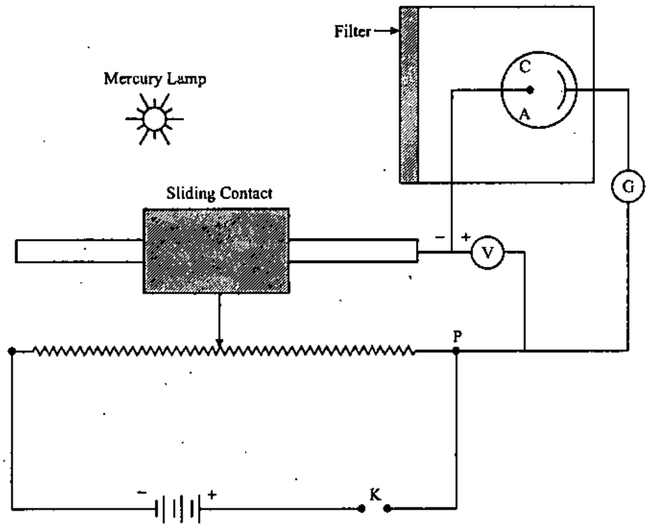


Fig. (1)

Precautions :

(1) While adjusting the galvanometer reading at zero mark and voltameter reading at O volt no light should fall on the photo cell.

(2) The distance between the mercury lamp and the photo cell should be kept constant during the experiment.

(3) When the value of negative potential for which the deflection is zero has been reached at least 3 more reading must be taken by further increasing negative potential in very small steps.

Results :

The value of Planck's constant (h) = ... Joule/sec.

The value of photo-electric work function = ... Joule.

Viva-Voce

Q. 1. Why should distance between the mercury lamp and photo cell kept constant ?

Ans. Because it directly influence the frequency of photo-cell.

Q. 2. Why mercury lamp is used in this experiment ?

Ans. Mercury lamp is used as a constant source of energy for photo cell.

EXPERIMENT No. 19

Object : To verify inverse square law of radiation using a photo electric cell.

Apparatus required : Vacuum tube, photo cell, a rehostate moving coil Galvanometer, scale arrangement one way key, a measuring lamp, light filters and an optical bench.

Theory:- If L is the luminous intensity of an electric lamp and E is the illuminasence at a point distant r_1 from it then according to inverse square law.

$$E = \frac{L}{r^2}.$$

$$E = \frac{L}{r^2} = \text{k}$$

Hence a graph between pho $1/r^2$ and θ is straight line which verifies inverse square low of radiations. Also $r^2\theta = a$ constant.

Procedure :

(1) Set the mercury vapour lamp and the photo electric cell enclosed in a of Box as described in Exp-17. On an optial bench. One connections of the photo-cell are made as shown with the difference that the positive terminal of the battery is connected to the anode A and the negative terminal to the cathode C.

(2) Place the violet filter $\lambda = 4050$ Å in front of the mercury lamp and obtain a deflection in the galvanometer with anode at zero potential. Adjust the distance of the mercury lamp and obtain a deflection in the galvanometer with anode zero potential. Note the positive potential applied as the photo electric cell.

(3) Note the position of the mercury lamp and the photo electric cell on the optical bench. Also note the deflection of the galvanometer.

(4) Keeping the voltage constant and position of the photo-cell fixed, increase the distances of the mercury lamp from the photo-cell in small steps. In each case note the position of the lamp on the optical bench and the deflection in the galvanometer.

(5) Repeat using blue (4360 Å) and green (5780 Å) filters. In each case starting with the minimum distance adjust the +ve voltage of the anode for saturation current for deflection of the galvanometer within scale keeping the voltage constant take difference observation by varying the distance.

Observations :

Filter violet $\lambda = 4050$ Å

Positive potential applied to the photo electric cell = v

Reading of photo electric cell on optical bench.

S. No.	Scale reading of lamp	Distance between lamp and photo cell	r^2	$1/r^2$	Deflection θ	$r^2\theta$
1.						
2.						
:						
:						

Similarly record observation for blue and green filters.

Result : As $r^2\theta$ is constant the inverse square law is verified.

Precautions: Same As in Exp. 17.

Viva-Voce : Same as Exp. 18.

EXPERIMENT No. 20

Object : To study the characteristics of a photo-voltaic cell solar cell?

Apparatus required : A solar cell, a D.C. Voltmeter a D.C. milliameter, a dial type resistance box, 2 one way keys a 100 w lamps, connecting wires. etc.

Procedure :

(1) Keep the solar module (Solar Cell) in the sun light for 15-20 minutes with the light rays following normally over it so that it gets properly activated.

(2) Draw a diagram showing the scheme of connections of the photo voltaic cell as shown and connected accordingly. The experiment is preferably performed in a dark room to avoid the effect of any stray light falling on the photo voltic cell.

(3) Place the 100W lamp close to the cells so that light from the lamp falls normally on the cell feet in the key R_1 keeping K_2 open) and note the reading of the voltmeter for open circuit V_{OC}. Take out the key K_1.

(4) Now put the key R_2 (keeping R_1 open) and make resistance R from which resistance box zero and not down the reading of milliameter under short circuit I_{SC}.

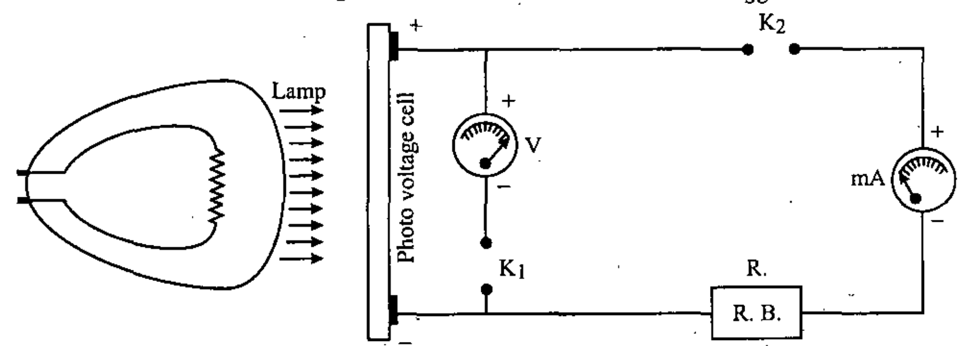


Fig. (1)

Observations :

Voltmeter reading for open circuit

$$V_{OC} = \text{volts.}$$

Milliameter reading with zero resistance box $I_{SC} = \text{mA}$

S. No.	R_{ohm}	Reading of		Power = $V \times I$ mW
		Voltmeter (V)	Milliammeter I_{MA}	

Precautions:

(1) The solar cell should be exposed to sun light before using it in experiment.

(2) Light from the lamp should fall normally on the cell.

Result : The power of the photo-voltaic cell = ... mW.

EXPERIMENT No. 21

Object : To study the voltage current ($V-I$) Power load ($VI-R$) areal and azimuthal characteristics of a photo voltalic cell.

Apparatus required : Same in Experiment 19 an adjustable slit to change the area (with mountaning arrangement) a circular frame dial system to change the angle of the photo-voltaic cell with proper mounting arrangement an optical bench with three uprights, connecting wires etc.

Procedure :

(1) Voltage current ($V-I$) characteristics see exp. 19.

(2) Power load ($VI-R$) characteristics sec exp. 19.

(3) Areal characteristics 1. Set the apparatus as shown in fig. (1) making proper connection of photo-voltaic cell with voltmeter dial type resistance box (R.B) milliammeter (or micro-ammeter) and keys R_1 and R_2.

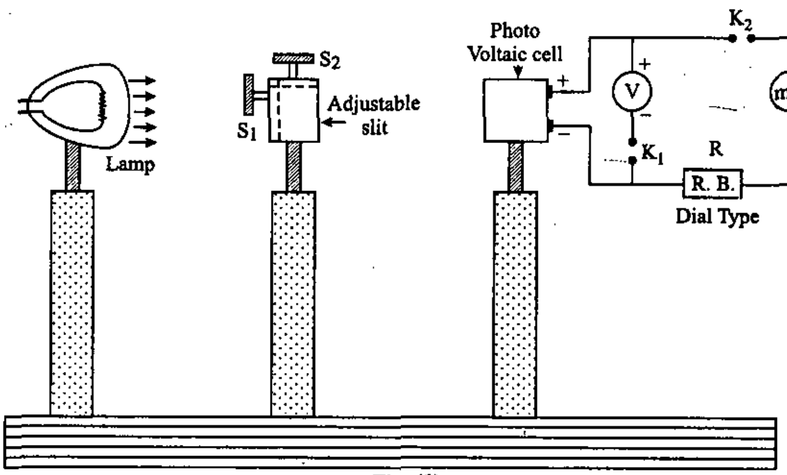


Fig. (1)

(4) Keep the key K_2 closed and K_1 open. Mount the adjustable slit on a upright. Adjust the slit with the screw S_1 and S_2 on it. So that the length and the width of the slit are minimum. Switch on the lamp and adjust its distance from the photo-voltaic cell so that the microammeter gives some reading.

(5) Gradually start increasing the area of the slit by increasing the length and breadth by 1mm at a time. Note the length breadth and the deflection is current in each case. Take about 6-7 readings.

Observations:

S.No.	Length the slit (C) in mm	Breadth of slit (b) in mm.	Area of slit $A = l \times b \cdot mm^2$	current in mA/ μ A (I)

(1) Graph : Ploat a graph between area A taken along the X-axis and the corresponding values of current I along Y-axis.

Azimuthal angle characteristics :

(2) Set the apparatus as in step 1. Mount the photo-voltic cell on the circular frame with dial system to change the angle of the cell on an up right. Set the area of the slit to a suitable convenient value. Adjust the distance between the lamp and the photo voltic cell so that the micro ammeter gives a proper large deflection.

(3) Repeat the observations by changing the distance.

(4) Plot a graph between angle turned taken along X-axis and current along Y-axis.

S.No.	Distance between lamp and photo volti Cell	Angle turned θ to right	Micro am meter reading	Angle turned θ to left	Microammeter reading I

Precautions :

(1) The solar cell should be exposed to sun light before using it in experiment.

(2) Light from the lamp should fall normally on the cell.

EXPERIMENT No. 22

Object : To draw the plateaucurve for a Geiger Muller counter.
Apparatus required : A Geiger, Scalar unit, A stopwatch, and radioactive source.
Procedure :

(1) Draw a diagram showing the scheme of connection and connect accordingly. Here R is a resistance of 2-5 megashm. Note that the scalar unit is not connected to the power supply. Connect the Geiger tube securely to the scalar unit. Turn the voltage contract know of the scalar unit to it lowest position and switch on the voltage and the count switch.

(2) Using a forceps place the radioactive source on the source holder just below the scaler unit begins to indicate pulses. Note the reading of the voltmeter. Pulses generally start from 800 volt or less. Determination the counting rate (CR) by noting the number of counts for one minute.

(3) From this threshold value increases in steps of 20-25 volt upto 1000 volt or to 9 voltage for which the counting rate increase to 10% above the plateaue value.

Caution:

(1) The counter switch should always be kept on to avoid excessive counting rates.

(2) Do not exceed the high voltage beyond a value that raises the counting rate 10% above the plateu value.

(3) Ploat a graph by taking voltage along that X-axis and the corrected counting rate $N = N' - b$ taken along the Y-axis.

$$V = V_1 + \frac{1}{3}(V_2 - V_1).$$

It is approximately 50 volts above the lower end of the plateau region *i.e.* V_1.

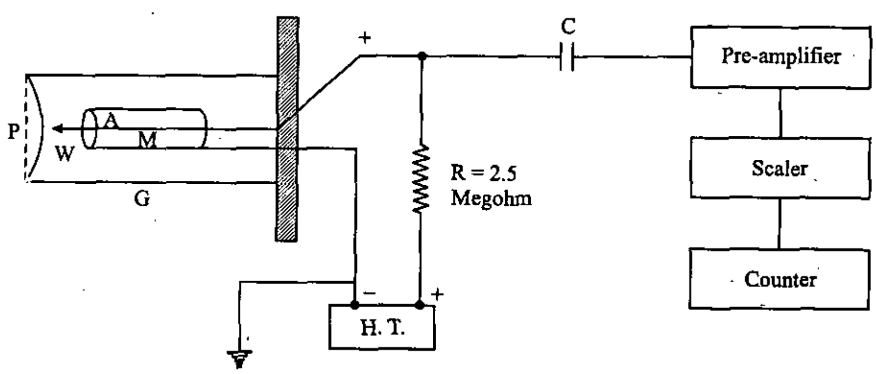


Fig. (1)

Observation :

S.No.	Voltage	Observed counting rate					Corrected counting rate $N = N' - b$
		With radio active source				Only back ground (b)	
		1	2	3	Mean N'		

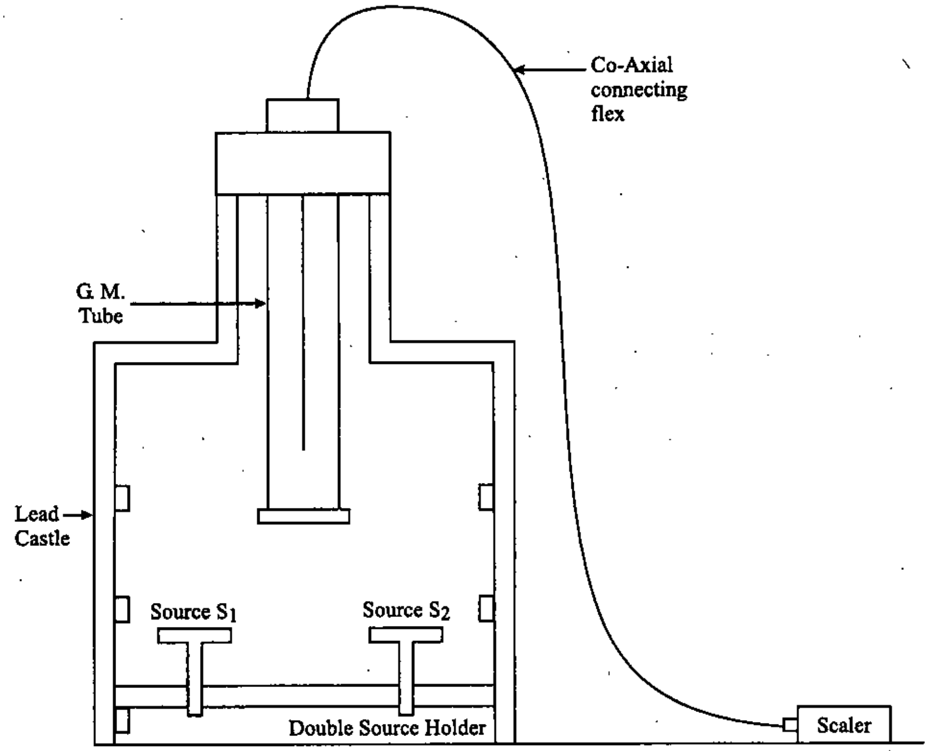


Fig. (2)

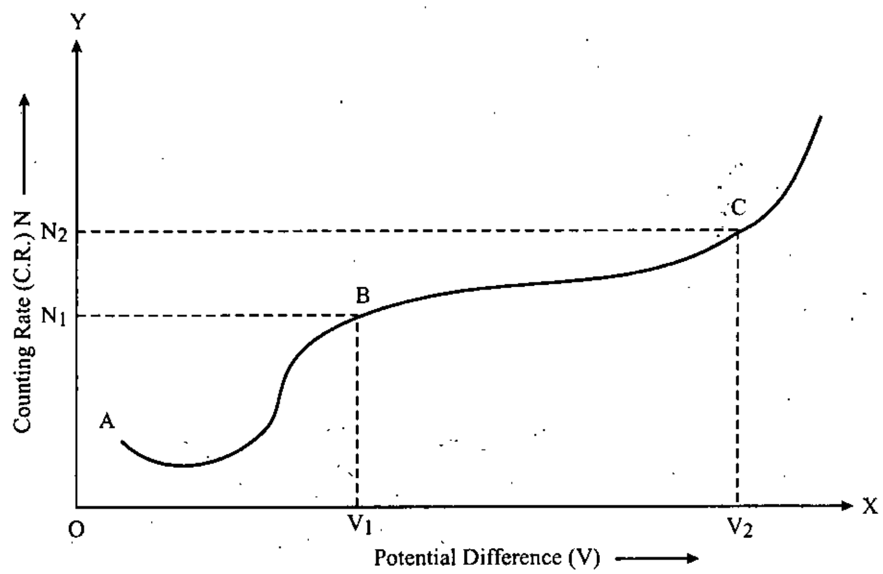


Fig. (3)

Precaution :

(1) Radio active material should be handled very carefully.

(2) The counting switch should always be kept on so that the counting rate does not exceed 10% above the plateau voltage.

(3) The radio active substance should be placed in the source holder just below the Geiger tube before increasing the high voltage slowly.

EXPERIMENT No. 23

Object : To find the dead time of a G.M. conter.

Apparatus required : Same as in Exp-21 double source holder two radio active sources Sr^{90} and Tl^{204}.

Procedure:

(1) Find the value of operating voltage as in Exp-21. Adjust the power supply at the oberating voltage. Find the back ground counting rate *i.e.*, number of phase perminute corresponding to the operating voltage. Using a forceps place the radio active source S_1 say Sr^{90} on the double source holder just below the Geiger tube.

(2) Fix the second radio active source S_2 say Tl^{204} in the double sources holder by the side of the first source and determine the counting rate of the two sources together keeping the operating voltage the same let it be n_3.

(3) Now remove the first radio active source S_1 without diserbing S_2 and determine the counting rate for the second source S_2 (Tl^{204}) with out diserbing its position and keeping the operating voltage same.

(4) Remove the second source S_2 and again find the background counting rate corresponding to the operating voltage.

(5) Repeat all the observation three times keeping the operaing voltage same.

Observations :

Operating voltage applied to G.M. = Volts

Background counting rate in beginning = pulse/min

Background counting rate in end 6_2 = pulse/min

Average background counting rate $= \dfrac{b_1 + b_2}{2}$ = pulse/mix

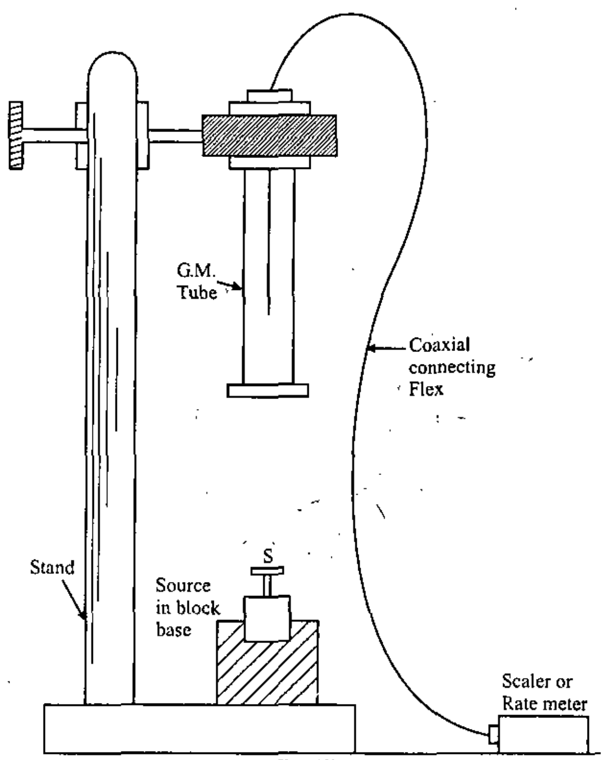


Fig. (1)

S. No.	Source	Counting rate				Observed count	Connected unit/sec
		1	2	3	Mean		
1.	$(S_1)\ Sr^{90}$					$n_1 =$	
2.	$Sr^{90} + Tl^{204}\ (S_1 + S_2)$					$n_2 =$	
3.	$S_2\ (Tl^{204})$					$n_3 =$	

Precaution :

(1) Same in Exp-21.

(2) The operating voltage must be kept constant.

(3) The second source must be placed in the side of first source. When the first source is removed the position of the second source should not be disturbed.

Viva-Voce

Q. 1. Write the principal of Geiger Muller counter.

Ans. When a large voltage *i.e.*, 1000 volts is applied between anode and the cathode of a counter, a large electric field is produced between these electrodes.

Q. 2. What is G.M. region ?

Ans. The region where avalanches are produced so rapidly that the ionisation current becomes completely independent of the primary ionisation is called G.M. region because it was first of all used be Gieger and Mullër.

Q. 3. What is the characteristic of this reigon ?

Ans. The ionisation pulse current in this region is capable of delivering 50–150 volts pulses across a resistance of Meg ohm at the time of the passage of a charged particle through the counter.

EXPERIMENT No. 24

***Object* :** To find the half life period of a given radioactive substance using a G.M. counter.
***Apparatus required* :** Same as in Exp. 22 and given suitable radioactive source.
***Procedure* :**

(1) Proceed as in Exp-22 and find the value of the operating voltage for the G.M. counter. Adjust the power supply at the operating voltage and find the background counting rate.

(2) Place the radioactive substance on the source holder just below the Geiger tube and riset the scaler unit to zero. Start the scalar unit and simultaneously start the stopwatch. Exactly after 1 minute stop the scalar unit but allow the stopwatch or the time recording divice continue working.

(3) When the stopwatch records exact 5 minutes restart the scalar unit and record the number of count in exact one minute *i.e.* from the end of 5th minute or beginning of 6th minute to the end of six minute.

(4) Again record the number of counts in one minute from the beginning to the end of 11th minute.

(5) Remove the radioactive source and again record the background counting rate.

Observations:

Record observation for plateau curve to find the voltage as in Exp. 22.

Operating voltage of the G.M. counter = Volts

Background counting rate :

in beginning b_1 = pulse/min.

in the end b_2 = pulse/rate.

Average background counting rate

$$b = \frac{b_1 + b_2}{2} = \text{pulse/min}$$

Time of start of scalar unit from the beginning in minutes	Counting rate per minute due to radio active sample.	
	Observed n'	Corrected $n = n' - b$

***Result* :** The half life period of given radioactive substance = ... min.

***Precautions* :**

(1) Radio active material should be handled very carefully.

(2) The counting switch should always be kept on so that the counting rate does not exceed 10% above the plateau voltage.

(3) The radio active substance should be placed in the source holder just below the Geiger tube before increasing the high voltage slowly.

(4) The radio-active source selected should have a half life reasonably longer than the time taken for noting the radioactive decay.

(5) Start the scalar unit and the time recording device simultaneously.

(6) Record the number of counts in one minute after every 5 minutes.

(7) The radio active source should be not disturbed during the experiment.

Viva-Voce

Q. 1. What is half life ?

Ans. The time in which any given substance reduces half of its initial amount is called half life period or half life time.

EXPERIMENT No. 25

Object : To study double slit interference by Helium Neon laser.

Apparatus required : He-Ne Laser source, a double slit compound of two slits each of width 0.0075 mm seperated by a distance 0.0541 mm. fitted in a frame with screen for vertical and horizontal motion, a higher power microscope.

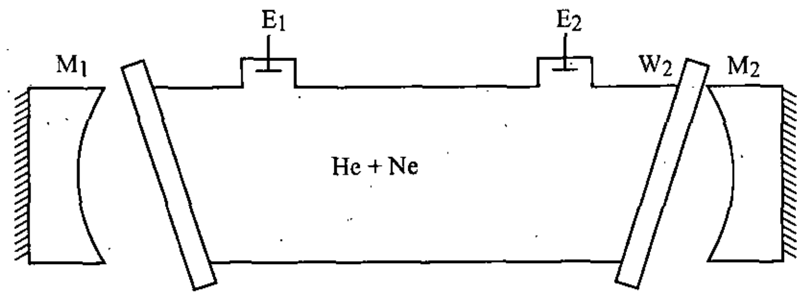


Fig. (1)

Procedure :

(1) Place the double slit in front of the He + Ne laser source such that the pair of slites lies across a diameter of the laser source close to the output window. Adjust the position of the He-Ne laser source so that the axis of the He-Ne is horizontal.

(2) Rotate the doube sit frame about a horizontal axis and in the vertical plane by means of a tangential screw so that the slites are vertical place a screen fifted with a mm scale at a small distance from the double sit so that it is parallel to the double slit frame.

(3) Switch on the power supply to the He-Ne laser source and let the laser beam fall on the double slit rotate the double slit frame about a vertical axis so that the laser beam falls normally on it. At this stage bright and dark interference fringes of equal with will be seen on the screen.

(4) Note the position of the centres of successive bright fringes on the mm scale fetted can the screen or with the help of a micrometer eye piece.

(5) Note the distance between the centres of the double slit frame and the screen.

Observations: For fringe width B.

S. No.	Order fringe	Reading on mm scale	Width of 3 fringes mm	Fringe width B (mm)

Mean fringe width $B = \ldots$ mm $= \ldots$ m

Measurement of distance between the centres of two slits (d)

Least count of microscope = … mm.

S. No.	Cross wire on double slit edge	Microscope reading			Distance (AD) = Reading at A – Reading at D)	Distance BC (Read B – Read C)	$d = \frac{AO+BC}{2}$
		Main scale	Vern scale	Total			

$$\therefore \qquad d = \frac{AD+BC}{2} = \ldots \text{ mm} = \ldots \text{ m}$$

Precautions :

(1) The double slit should be adjusted to vertical position and close to the outlet of the laser beam from the laser source.

(2) The slites should be narrow and closed to each other because the laser beam is always very narrow.

(3) The laser tube axis should be horizontal.

(4) The distance of the screen or the eye piece from the slit should be large so that the interference fringes have a measurable width.

(5) The laser source should be switched on only while taking the observation and immediately switched off there after.

Viva-Voce

Q. 1. Who was the inventor of He–Ne Laser ?

Ans. He–Ne Laser was first used by Ali Javan and his co-workers in 1961 in Bell Telephone Laboratories.

Q. 2. How many energy levels are used in its operation system ?

Ans. Its operation involves four energy levels — three in Neon and one in He.

Q. 3. What is the principal of He–Ne lasers ?

Ans. The working of He–Ne laser is based on the fact that Ne has energy levels very close to metastable energy levels of He.

Q. 4. In how many regions He–Ne laser can work ?

Ans. He–Ne laser can work in three distinct regions — in Red (632.8 nm), in the near infrared around 1.15 μm and in the infrared near 3.39 μm.

EXPERIMENT No. 26

Object : To determine the wavelength of laser light by using transmission diffraction grating.
Apparatus required : He – Ne Laser source, a transmission diffraction grating, a grating stand screen measuring tape and a mm scale.
Theory : When a parallel beam of monochromatic light is incident normally on a grating the transmitted light gives rise to primary maxima in certain directions given by the relation.

$$(a+b)\sin\theta_n = n\lambda.$$

where a is the width of transparency, b that of capacity, on the angle of diffrection for n^{th} order maximum and λ the wavelength of light.

For the first order spectrum $(a+b)\sin\theta_1 = \lambda$

For the second order spectrum $(a+b)\sin\theta_2 = 2\lambda$

Procedure :

(1) Place the He Ne laser source at one end of the table. Take out the grating carefully from the box holding it from the edge and without touching its surface, mount the grating on its stands.

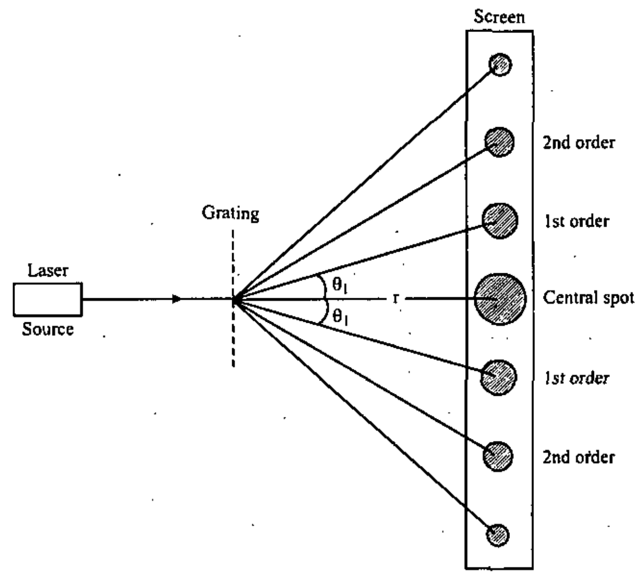


Fig. (1)

(2) Place a screen behind the grating at a suitable distance so that the light beam after passing through the grating produces several bright spots on the screen. Adjust the position of the screen so that the diffraction spots are sharp and bright. If necessary adjust the grating also.

(3) The brightest spot is the central maxima and symmetricallly situated on both sides of the central maxima there are several bright spots of diminishing intensity. The first bright spot on the either side is first order spectrum.

(4) The second brightness spot on the central maxima is the second order spectrum measure the distance between the central of the maxima and center of second bright spot (second order spectrum) on either side of the central maxima.

(5) Measure the distance of the centre of the central bright spot on the screen from the centre of gravity.

Observation and Record :

(a) Number of lines on the grating $= N$ per″

$$= \frac{N}{2.54} = \text{per cm}$$

$$= \frac{2.54}{N} = \ldots \text{ per cm.}$$

distance between centre of central bright maxima and centre of diffraction grating

$$r = \ldots \text{ cm}$$

First order spectrum :

Distance between the centre of central bright spot and centre of first bright spot (Ist order spectrum).

(1) On one side $x_1 = \ldots$ cm.

(2) On other $x_2 = \ldots$ cm.

Mean $\bar{x} = \ldots$ cm.

Angle of diffraction for Ist order maxima.

$$\theta_1 = \frac{x}{r} \ldots \text{ radian.}$$

$$= \frac{x}{r} \times \frac{180}{\pi} \text{ .... degree.}$$

$$\sin \theta_1 = \ldots$$

wavelength of laser light

$$\lambda = (a+b) \sin \theta_1 \qquad [\therefore n = 1]$$

$$= \text{cm} = \text{Å}.$$

Second order spectrum:

Distance between the centre of central bright spot and centre of second bright spot (second order spectrum)

(1) On one side Y_1 = cm.

(2) On other side Y_2 = cm.

Mean Y_1 = cm.

Angle of diffraction for 2nd order maxima

$$\theta_2 = \frac{Y}{r} \ldots \text{ radian}$$

$$= \frac{Y}{t} \times \frac{180}{\pi} \ldots \text{ degree.}$$

$$\sin \theta_2 = \ldots$$

Wavelength of cases light

$$2\lambda = (a+b) \sin \theta_2 \qquad [\therefore n = 2]$$

or

$$\lambda = \frac{1}{2}(a+b) \sin \theta_2$$

$$= \ldots \text{ cm} = \ldots \text{ Å}.$$

(b) Number of lines on the diffraction grating. Given for He-Ne laser $\lambda = 6328$ Å.
from first order spectrum.

Grating element $(a+b) = \dfrac{\lambda}{\sin \theta_1} = \ldots$ cm

$\therefore$ Number of lines per cm $= \dfrac{1}{a+b} = \ldots \text{ cm}^{-1}$

From second order spectrum.

Grating element $(a+b) = \dfrac{2\lambda}{\sin \theta_2} = \ldots$ cm

$\therefore$ Number of lines per cm of grating

$$= \ldots \text{ m} = \ldots \text{ cm}^{-1}.$$

Result : The wavelength of laser light is .... Å.

Precautions :

(1) The laser tube axis should be horizontal.

(2) The laser source should be switched on only while taking the observation and switched off immediately there after.

(3) The grating should be held from the edges and the ruled surface should not be touched.

(4) The light should fall on whole of the grating surface.

Viva-Voce

Q. 1. What is the principal of Laser action ?

Ans. The principal of laser is based on stimulated emission. The stimulated emission is the process in which a photon of right energy may include an atom in excited state to emit a photon and there by make a transition to the ground state. The excited atom would itself emit a photon and make a transition to the ground state, but the incident photon of right energy induces the excited atom to emit photon earlier.

Q. 2. What are the conditions of operating He–Ne laser ?

Ans. A working substance in the form of a mixture of helium and Neon gases in the ratio 7 : 1 at a total pressure about 1.1 torr (1 mm of Hg).