TO STUDY EFFECTS OF 1 MeV ELECTRON IRRADIATION ON SOME ELECTRONIC COMPONENTS

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" TO STUDY EFFECTS OF 1 MeV ELECTRON IRRADIATION ON SOME ELECTRONIC COMPONENTS"

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BY

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CERTIFICATE

Certified that the dissertation entitled "To study effects of 1 MeV electron irradiation on some electronic components" which is submitted by Shri. SHRIRAM WAGH to the University of Poona for the award of the degree of Master of Philosophy embodies original work of the candidate himself carried out under my supervision and guidance.

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DECLARATION

I hereby state that the work described in this dissertation entitled "To study effects of 1 MeV electron irradiation on some electronic components" has not been submitted previously to this or any other University for the M.Phil degree or any other degree, diploma or academic award.

21.1.88

(SHRIRAM WAGH)

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(S.R. WAGH)

CONTENT

CHAPTER - I

INTRODUCTION AND BRIEF SUMMARY OF THE WORK CARRIED OUT

I.1 Introduction :

This project deals with to study the effect of radiation of 1 MeV electron on different electronic components. We are interested to study effect of radiation on semiconducting material such as germanium and silicon which is widely used today. They are used for fabricating a large galaxy of electronic devices which manipulate, amplify, switch and control currents and voltages, pr ocess and store information and generage electric power by the photovoltaic effect.

Radiation effect in semiconductors has remained a field of interest for the last few years. However, increasing use of germanium or silicon devices in space applications has created a new interest in the subject as these devices have to function in a radiation environment. The structural defects produced by space radiation play an important role in the efficiency of these devices. The defects created in silicon by different particles like electrons, protons, and neutrons at not very high energies are similar in nature and can be stimulated by 1 MeV electrons in the laboratory.

Also annealing play vital role in radiation defect in semiconductors. In this project we deal with the annealing effect on beta of transistor. Annealing is used in crystal in which radiation effect present are unstable. In general with respect to time they return to its stable state at any temperature.

It may be mentioned here that the Microtron which has been operating from the last many years in this department was used for different purposes such as for the lifetime measurement, phase measurement, $e^- - e^-$ scattering, and radiation damage study in silicon, germanium, solar cells and different electronic components.

The transport properties in semiconductors play a vital role because of the many applications in devices. The fundamental transport properties like the mobility, carrier concentration and life time are the basic which govern the electrical conductivity in semiconductor material.

I.2 Summary of the work presented :

In this section a brief account of the work presented in the thesis is reviewed.

In Chapter II, basic theory of semiconductor devices and irradiation effect on semiconductor devices have been discussed in brief.

In Chapter III, the effect of 1 MeV electron irradiation on LED, FET and UJT are explained with their circuit diagram and theory related to radiation damage to the corresponding components under the different bias condition. Also details of experimental set up, observation, result and discussion are given in brief for each component separately.

The Chapter IV is divided into three parts. The Part I contains effect of neutron irradiation on SCR with experimental setup, theory and results in brief.

In the Part II, the effect of irradiati n of 1 MeV electron and annealing on the gain of transistor are discussed in brief.

In the Part III, effect of 1 MeV electron irradiation on the parameter of OPAMP and the TTL IC are discussed in brief.

In the Chapter V, the designing and use of pulser circuit for the Microtron is explained in brief.

CHAPTER - II

IRRADIATION EFFECT ON SEMICONDUCTOR DEVICES

2.1 Introduction :

Radiation effects in electronic systems using semiconductor devices have become of increasing interest. Electronic systems that need to operate in space, near nuclear reactors, isotopic nuclear sources, or accelerators must be designed to tolerate the effects of nuclear irradiation (Ref.1).

Radiation causes changes in the physical properties of semiconductors e.g. life time, carrier concentration and resistivity. If relations between the physical and electrical characteristics of semiconductors are understood, then changes in the physical properties caused by radiation can be transformed into changes in the electrical properties (Ref.2).

At beginning around 1950, studies of the processes of radiation defect formation and the influence of these defects on the properties of semiconductors have attracted the attention of many investigators in connection with the further development of semiconductor physics. At present, many important projects in this field are being undertaken in various laboratories in the USSR, USA, France, Canada and elsewhere, and the number of papers published on this subject runs in hundreds.

2.2 Physical characteristic of semiconductors :

The physical characteristic of semiconductor devices are area, width, impurity concentration, resistivity and lifetime of each region of semiconductor components.

2.2.1 Impurities and carriers :

Si is IVth group element having four electron in outer most shell forming covalent bonds with four silicon atoms. In perfect lattice structure, electrons are either in valance band or conduction band. The electron cannot have energy in forbidden gap i.e. energy lies in between V.B. and C.B. For silicon energy gap is 1.11 eV. The most of majority electrons forming covalent bonds have energy in V.B. It is possible for electrons to receive energy from thermal agitation, light photon or other radiation to break the bond and become free electron. The free electron has energy corresponding to state in C.B. and is available for conduction of current in Si crystal.

The ejection of electron from covalent bond, creates positive charge at bond called hole. This hole is filled by electron from neighbouring atom which leaves another hole in adjacent bond. So successively filling vacancies of electron positions result in a net oppositely directed motion of positive charge. Thus net motion of positive charge is caused by motion of electrons. The original ejection of electron creates two charge carriers hole and electron. This process is called hole electron generation.

Recombination : It is process in which electron from conduction band return back and form bond with missing electron. At thermal equilibrium, in perfect crystal lattice, number of electron in C.B. equal to number of holes in V.B. This concentration of holes or electrons is called intrinsic carrier concentration.

The concentration of holes and electrons can be changed by adding small quantities of impurities to Si crystal. The impurities from Vth group have five valance electron. The Vth valance electron is very lightly bound which can easily ionized by adding small amount of energy, such impurity which easily give electron called donor impurity. At room temperature essentially all the donor atoms are ionized.

If we assume that large number of electron in C.B. would cause reduction in number of holes in V.B. because the large number of available electron would increase the probability of recombination of holes. If rate of recombination is proportional to number of available electron, number of holes should be decreases from intrinsic carrier concentration by factor to increase in electrons i.e. n / n_i

$$\text{hole concentration} = p = \frac{n_i}{n / n_i} \quad \frac{n_i^2}{n}$$

$$p.n. = n_i^2 \qquad \ldots(2.1)$$

If a group III element is added to crystal electron will missing from covalent bonds and corresponds hole will occur in V.B. when element takes electron from neighbouring atom to complete bond is called acceptor impurity. Again by same logic equation (2.1) follows :

If both donar and acceptor atoms are added to crystal the carrier concentration depend on net difference in impurities concentration between acceptor and donar.

2.2.2 Carrier recombination and generation :

The perfect crystal was assumed in such ways that electron could not have energy corresponding to energy between valance band and conduction band. If we assumed that energy required to the electron to C.B. was a step increase equal to or greater than energy gap. For imperfect crystal neither assumption is correct. But some crystal have imperfection for which energy states are allowable in energy gap. These imperfection are defect. Minority carrier life time is defined as mean time during which electrons spend in C.B. or holes spend in V.B. before recombination. Also the recombination rate per carrier is defined as the reciprocal of minority carrier life time.

2.3 Defects :

In radiation damage, lattice defect take place in crystal. This lattice defect is divided mainly in two parts (a) point defect (b) dislocation.

2.3.1 Point defect :

The simplest departures from perfection which may anticipated in perfect lattice them missing atom from normal positions (vacancies) and atoms residing in non-normal lattice position (interstitials) both are present in FCC lattice. If atoms of forcing substance are present in host lattice these may be able to displace lattice atoms from their normal sites and become substitutional. Point defect occurs in following circumstances.

(a) An atom is removed from its regular lattice site, the defect is vacancy.

(b) An atom is in site different from regular lattice site, defect is an interstitial. An interstitial defect can be of same spacies as the atoms of lattice or of different nature.

(c) An impurity occupies substitutional site.

2.3.2 Dislocation :

The simple point defect according to the Crawfold are formed du due to (i) One and two dimensional arrangement of misplaced atom such as line dislocation, screw and plane dislocation, grain boundary and external surface (ii) Arrangement of dislocation which may be described in terms of volume defects and which are important in plastically deformed solids (iii) Specified defects such as stacking fault, boundaries between regions of different magnetization. There are two type of dislocations.

1. Edge dislocation :

If we introduces part of extra plane of atoms into simple cubic structure, then lattice is strongly disturbed near the edge of this plane. The edge is known as dislocation line and defect is called edge dislocation. Clearly this type of dis-location may be theoretically formed by making imaginary partial cut into lattice and shering one side of cut lattice relative to other end perpendicular to surface.

2. Screw dislocation :

In screw dislocation, the dislocation line is at inner edge of cut. If one side of cut lattice is sheared parallel to surface then different type of dislocation is formed called screw dislocation. In this case misplaced atom will on axis helices with dislocation line as axis. The important features of simple dislocation which will take place during measurement of radiation damage effects are (i) A dislocation line can never end with a crystal either it follows closed path or it extends to surface. (ii) Any motion of part or all dislocation line results in deformation of lattice. (iii) The case of motion of dislocation depends on direction of attempted motion. (iv) Because of stress concentration surrounding dislocation, two or more can interact with another.

2.3.3 Defect modification :

The displacement damage in semiconductor devices which were passive during irradiation i.e. zero voltage and current during irradiation and where damage effect are measured typically a few hours after creation of damage. Under these condition damage effect are fairly consistent.

Variation of injection level or after irradiation can substantially alter the damage effects. Damage effect is function of time exposure and it is dependent on injection level and temperature.

The changes in displacement damage effect with time, injection level and temperature are due to changes in both number of defects and types of defects that tends to dominate the displacement damage effects. The changes in types and number of defects are due to time, injection level and temperature is nothing but defect modification.

The steady-state effect caused by carrier injection during or after irradiation are called electrical defect modification.

The steady state effect caused by increase in temperature are called thermal defect modification. The variation in electrical and thermal conditions with respect to time is known as transient defect modification.

2.4 Annealing :

The term annealing is used for thermal defect modification and changes in the displacement damage effect with time. This term implies a reduction in the damage effect due to the recombination of crystal vacancies and interstitials, returning crystal to its original condition. In practice it is difficult to know whether a reduction in specific effect is due to annihillation of vacancies interstitial pair or formation of a different defect complex which is independent on life time or impurity concentration. Both Hill and Werthein found that the large number of defect in electron irradiated silicon with allowable energies near valance and conduction band. These defects are in effective in causing radiation damage effect because of location of their allowable energy state in energy gap. Thus increasing in damage effect observed with time, injection level and temperature. From the above support we conclude that defect modification is reordering of defect complexes that includes vacancy interstitial annihillations.

2.5 Type of radiation effect :

Radiation effect to semiconductor devices are produced by four types of radiation which affect the performance of electronic circuits are protons, neutrons, gamma rays and electrons. Radiation is defined as amount of radiation that deposits 100 erg/gm of silicon differ only by scale factor. The electrical behaviour of semiconductor devices are changes due to two fundamental types of radiation.

(i) Ionisation effect :

Ionisation is knocking of orbital electron from an atom to form ionized atom and free electron.

(ii) Displacement effect :

Physical damage to crystal lattice produced by knocking an atom from its normal lattice position to another location in lattice.

Displacement effect take place mainly due to bombardment by gamma rays, electrons and protons. Displacement effect are due to creation of defect in crystals lattice that introduced additional state in energy gap. These defects can acts as additional recombination centre which cause reduction in minority carrier life time or they acts as additional impurities that change net impurity concentration. For silicon change in impurity concentration due to radiation is reduction in concentration which tends to make Si more intrinsic.

Two type of defects are created generally by radiation. The first group called simple defects, includes at most a few atoms associated together to form a relatively stable defect. The second group, called a defect cluster involves a large disordered region of as many as a few hundred atoms.

Formation of vacancy - interstitial pairs :

The large defect cluster results from neutron irradiation in which a large amount of K.E. is transferred to single Si atom. Simple defects are characteristic of low energy electron, gamma rays, and proton damage in which energy imparted to any single Si atom is small. Displacement damage in semiconductor electronic components is usually large defect clusters because damage is caused mainly by neutron bombardment (Ref.2).

Displacement of Si atom from its normal position require about 15 eV K.E. Therefore there is a threshold of radiation energy required to cause displacement damage. An electron with an energy of about 250 KeV is required to impart 15 eV to a silicon atom. Let us imagine that a low energy electron has transferred slightly more than the threshold energy to a silicon atom and that atom has loaded in crystal at some distance from its original position as shown by 1 in fig. (2.1). The original atom in lattice is called an interstitial atom. The displacement of Si atom in lattice is called vacancy. The vacancy like hole is very mobile at room temperature and can move easily through Si crystal. Displacement damage appear due to simple defect is caused either by recombination of vacancy and another atom or by two vacancy called divacancy. That form stable complex at room temperature. The vacancy can be move to a position adjacent to impurity atom as shown by arrows 2 and 3 forming vacancy impurity complex. If the vacancy migrates to the interstitial the damage is eliminated since this combination returns the crystal to its original condition. Thus displacement affect does not affect the electrical characteristic of Si but combination of vacancy can cause significant changes in the life time. Other possible combination are divacancy, the impurity vacancy and a dislocation vacancy.

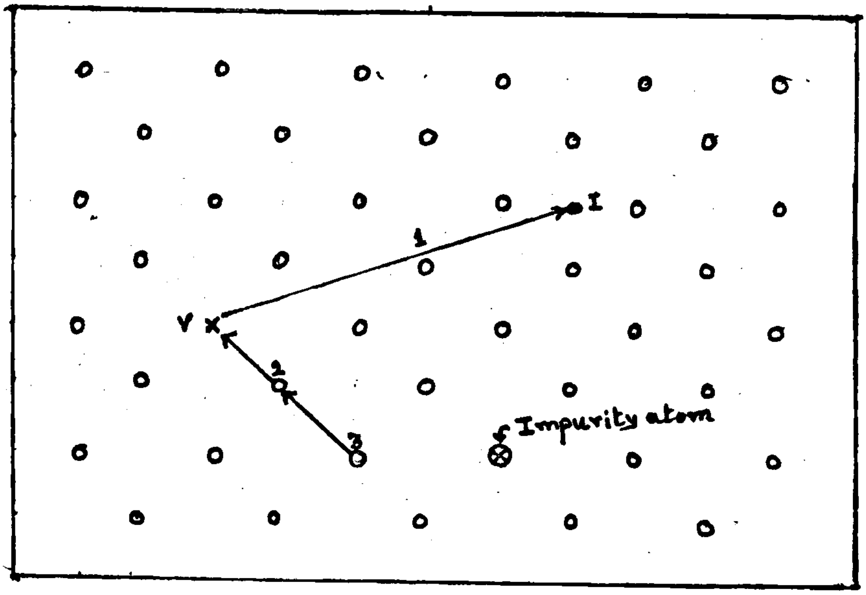


Fig (2.1) Formation of a Vacancy - interstitial pair.

Defect form in crystal lattice due to radiation damage effect depends on charge state during defect formation, numbers and types of impurity present and number of dislocation in crystal etc.

Two major effect of electron or neutron displacement damage can be given by two equations;

$$R = R_0 + \Delta R = R_0 + K \phi \qquad \ldots (2.2)$$

$$N = N_0 - \left(\frac{\Delta N}{\Delta \phi} \right) \phi \qquad \ldots (2.3)$$

where K - damage constant

$\left(\frac{\Delta N}{\Delta \phi}\right)$ - carrier removal rate

which gives change in combination rate per carrier and impurity concentration as function of radiation exposure.

CHAPTER - III

EFFECT OF 1 MeV ELECTRON IRRADIATION ON LED, FET AND UJT

3.1 Light Emitting Diode (LED) :

3.1.1 Introduction :

The communication technology satellite uses LED's in various systems. The purpose of experiment done was to measure the effect of electron irradiation on commercially available LEDs. GaAsP and GaP LEDs were chosen, as these LEDs have many application on displays, as opto-coupler or opto-isolators and as transmitters for fiber optic systems. Three different colour (green, yellow and red) in three different modes (round, flat and knotch) were irradiated with 1 MeV electrons. The specific LED parameters studied were I-V characteristic and output resistance. This data was used to calculate damage coefficient for LEDs.

3.1.2 Experimental procedure :

The electrical circuit for the measurement of resistance of LED after electron irradiation is as shown in Fig. (3.1). The experimental arrangement during irradiation of the devices is shown in Photograph (3.1). Also the mounting of samples on Faraday cup before irradiation is shown in Photograph (3.2). After each dose, samples are removed for the measurement. Measurement condition after each dose was kept constant. But during irradiation of LEDs a practical difficulty arised that the

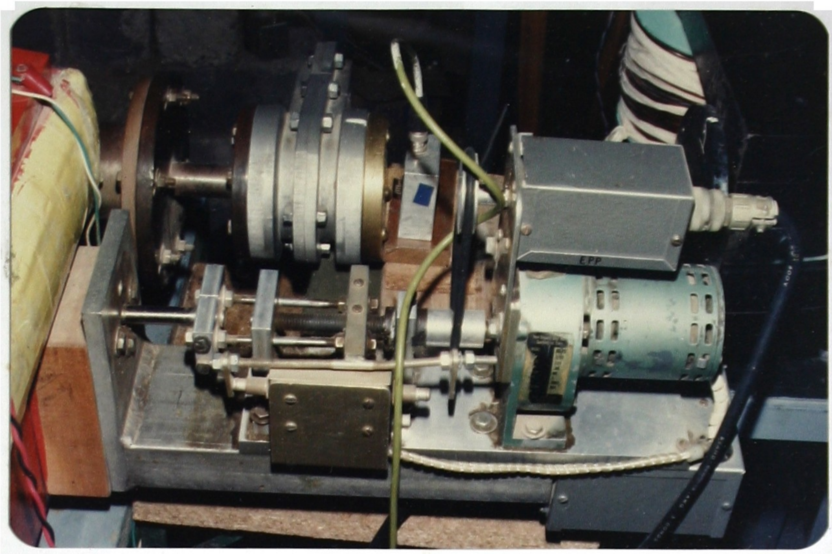


PHOTO-3.1 EXPERIMENTAL SET-UP DURING IRRADIATION.

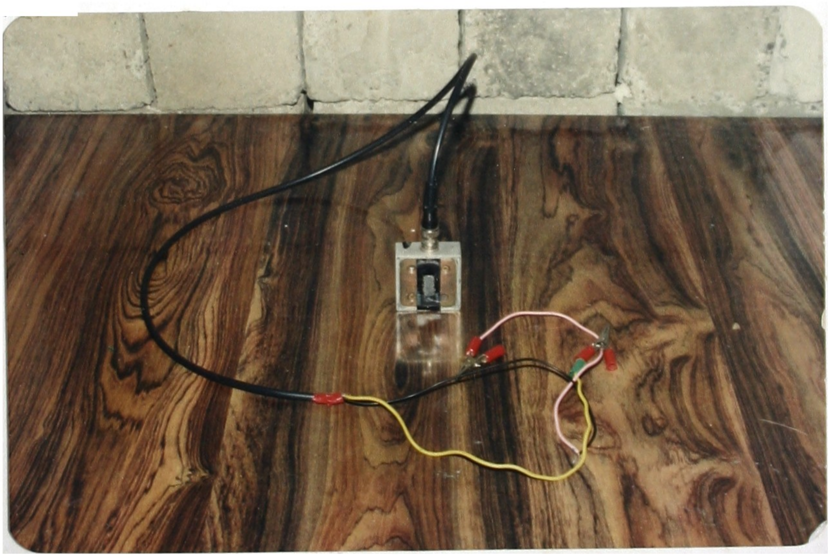
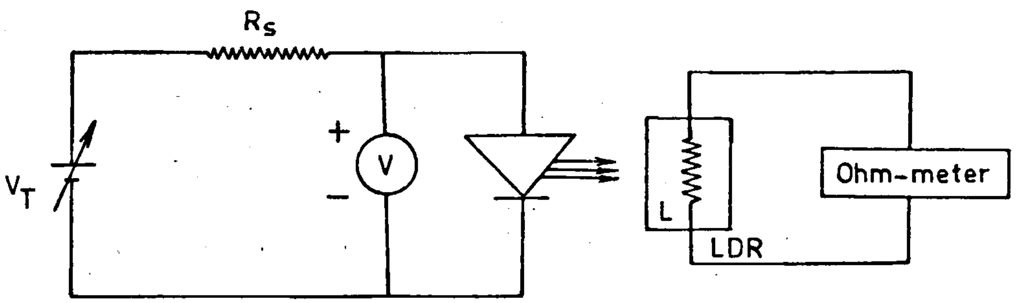


PHOTO-3.2 SAMPLE HOLDER.



Fig·3·1 - Ciruit for measurement of resistance of LED

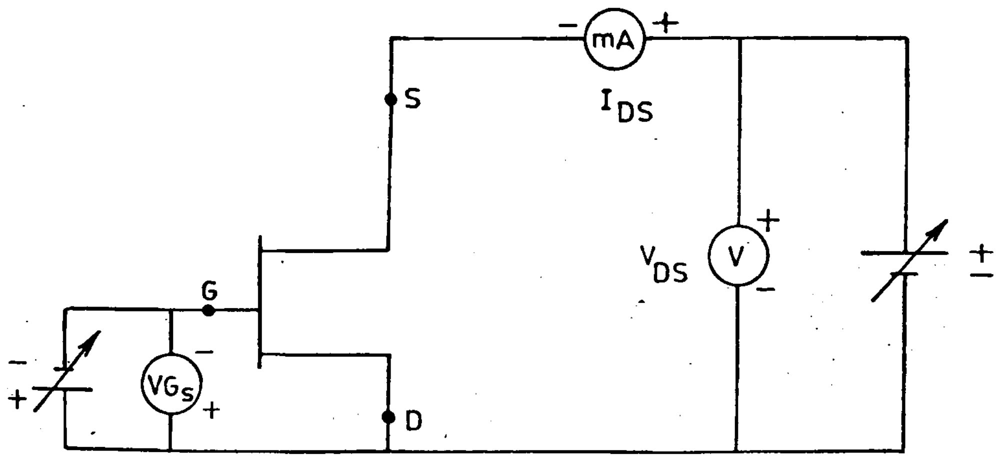


Fig:3·5 -Characteristic of JFET BFW 10/11 electron beam does not pass through epoxy layer or glass cover before striking the semiconductor chip. For this purpose we have grinded the LEDs in such way that the electron beam can strike over the semiconductor chip. The total flux used were 10^{12} to 10^{14} e^-/cm^2.

3.1.3 Results and Discussion :

In the diode the current vary with λ as follows :

$$L \propto \lambda^{\beta} \quad e^{(qv_j / nkT)} \qquad \ldots (3.1)$$

$$I \propto \lambda^{-\alpha} \quad e^{(qv_j / mkT)} \qquad \ldots (3.2)$$

where $v_j = v_T - IRs$

L = Infra-red light intensity

λ = Minority carrier life time

v_j = Voltage appearing at junction of diode

v_T = Voltage applied to diode current

IRs = Voltage drop across series resistance R_s.

n = Constant equal to one

β = Should be 1 or ½ depending on L is proportional to or independent of p region acceptor or n region donor density respectively.

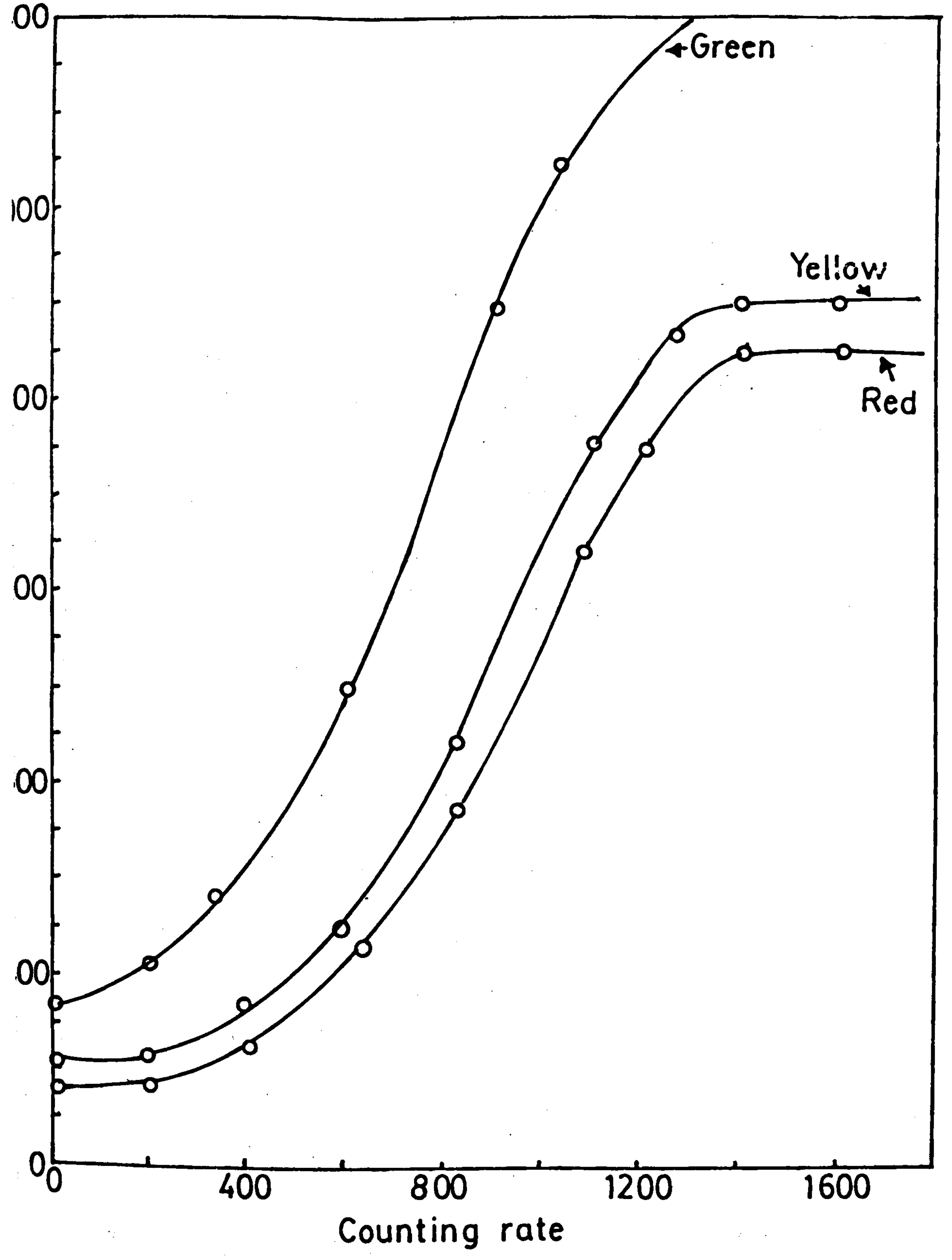
In equation (3.2) alpha should be ½ for diffusion current and m is the effective average value of diffusion current. A value m equal to two is found to be accurate for the diode at current density below about 10 mA/cm^2 where diffusion component is negligible. The L-V relationship of equation (3.1) follows n = 1 and it is found that light intensity depends completely on diffusion current.

The carrier life time after irradiation (λ) can be written in terms of the initial carrier life time (λ_o), the electron fluence $\emptyset$ and damage coefficient K as

$$\lambda = \frac{\lambda_o}{1 + \lambda_o K \phi} \qquad \ldots (3.3)$$

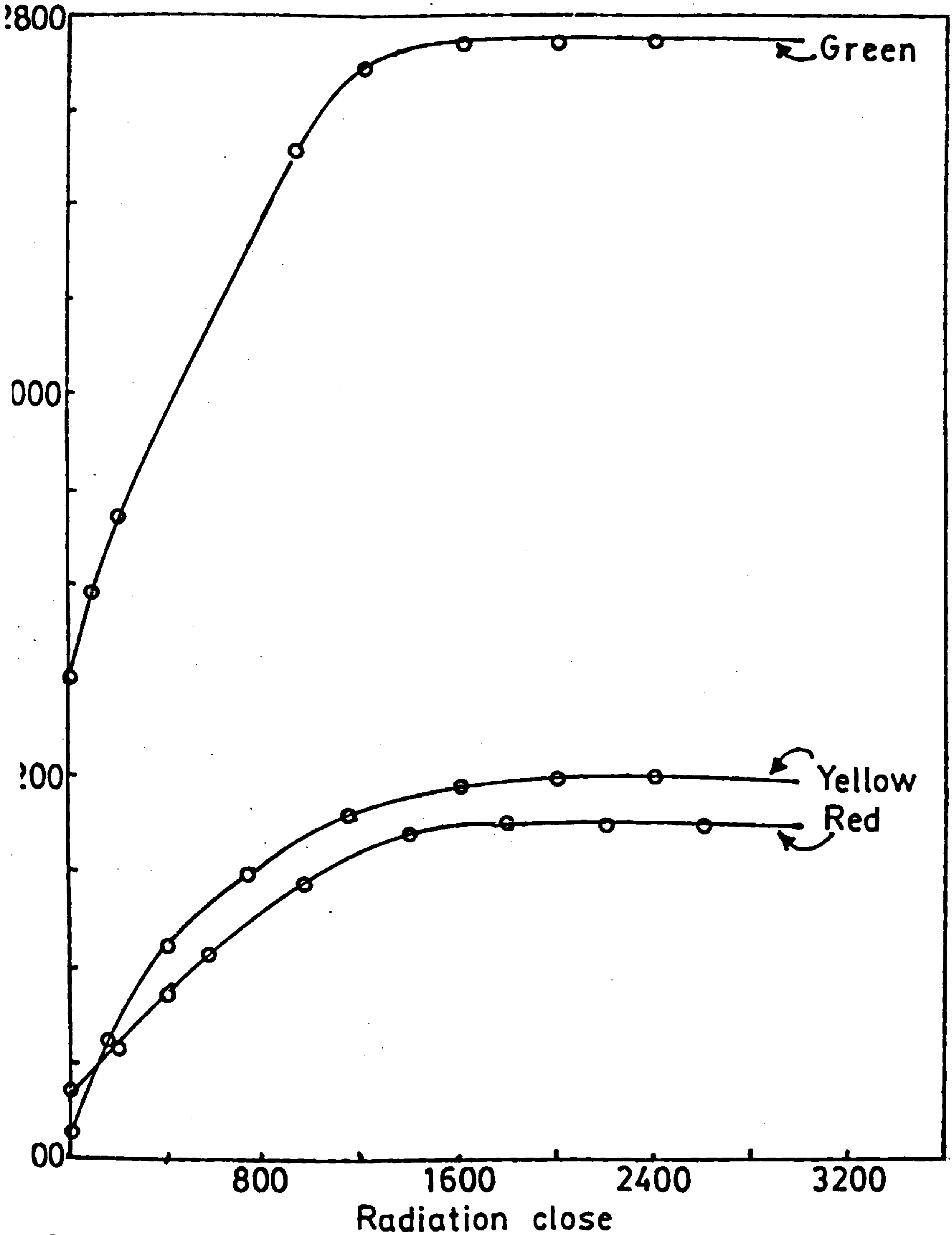
One can see that as the electron fluence increases corresponding initial percentage of light output goes on decreasing and resistance of LED goes on increasing. This study has been made by photo sensitive device LDR with experimental arrangement as shown in Fig. (3.1). The graph of electron fluence (in terms of counting rate) versus output resistance of LED (in terms of light intensity) is shown in Fig. (3.2, 3.3 and 3.4) for round, knotch and flat LEDs respectively. From the graph we conclude that as electron fluence goes on increasing, light intensity of LED decreases and corresponding O/P resistance of LED increases.

A photoconductor is a device in which excess carriers generated by incident light changes resistance. In some photoconductor light is absorbed in only part of thickness of

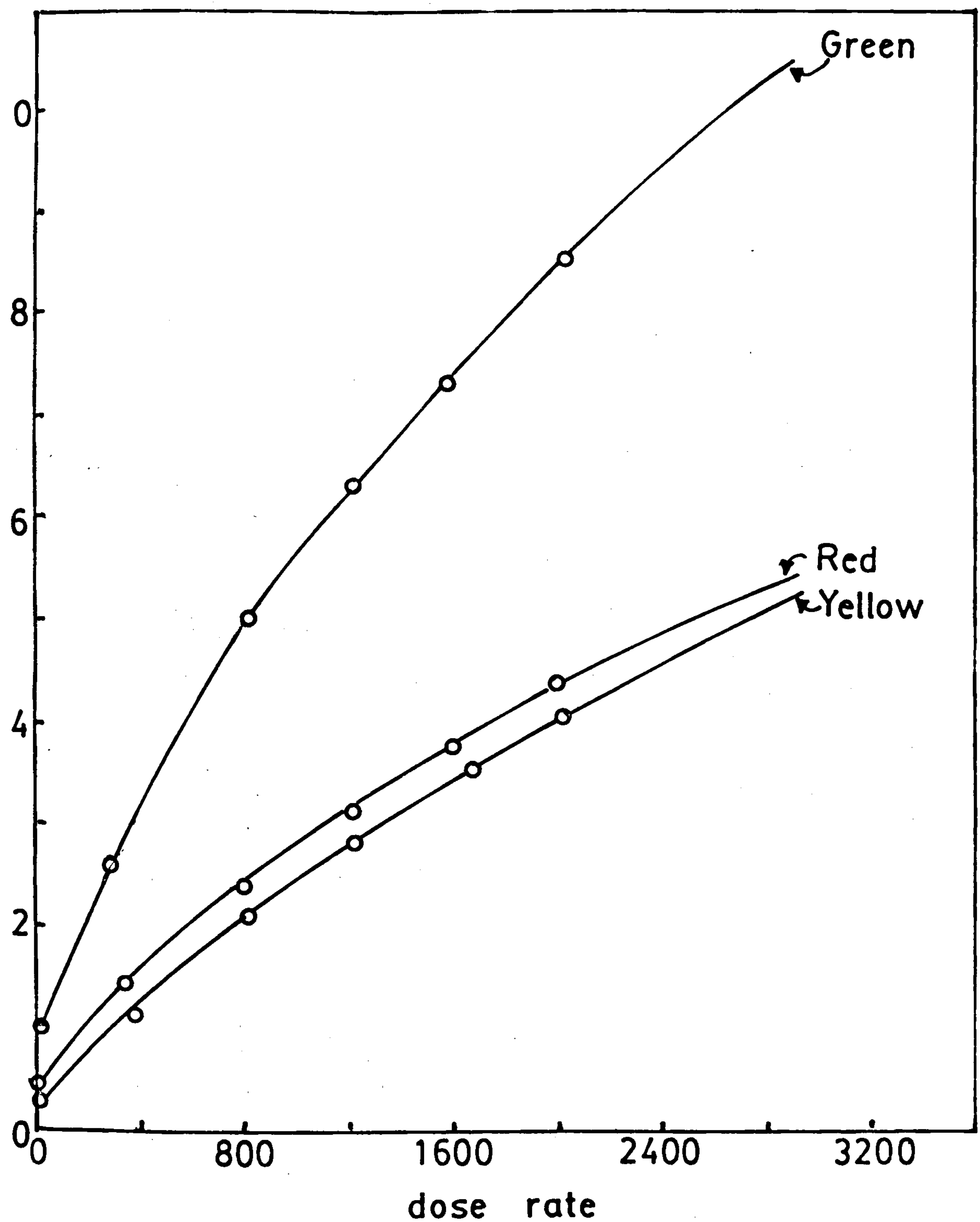


MeV ELECTRON RADIATION EFFECT ON LED (Round)

FIG - 3.2



-33
1 MeV ELECTRON RADIATION DAMAGE EFFECT ON LED
(KNOTCH)



1 MeV ELECTRON RADIATION EFFECT ON LED (Flat)

FIG-3.4

conductive material. Thus sensitivity of photoconductor is proportional to lifetime of excess carriers. Displacement effect tends to introduce extra recombination centre that shorten the carrier lifetime and decreases sensitivity. LEDs have been irradiated with 1 MeV electron and resulting device degradation has been measured. At constant voltage operation at 10^{13} e^{-}/cm^{2} LED reduces the light O/P about 70% - 90% of its initial value and resistance was found to increase to about 10 to 30% of its initial value. Thus for diodes studied, light intensity varied linearly with minority carrier lifetime. Also reciprocal lifetime increases linearly with radiation dose.

3.2 Field Effect Transistor (FET) :

3.2.1 Introduction :

The effect of neutron radiation was studied in GaAs FET already (Ref. 13 and 14). The present work is done on the study of electron radiation in JFET. The changes in current voltage characteristic at some gate current in JFET has been studied for 1 MeV electron irradiation. The peak voltage of JFET and source to drain current, when gate is shorted decrease after electron irradiation. The radiation effects on JFET's is very interesting because they are more radiation sensitive as compared to the other types of transistor. The radiation damage introduces traps or additional electron state in the forbidden gap and this cause great increase of g-r noise in a JFET.

3.2.2 Experimental procedure :

The JFET's used in this work are commercially available n-channel devices. Two pieces of JFET's such as BFW10 and BFW11 are irradiated at bias voltage VGs = OV and we observed O/P characteristic of I_D versus VDs. The pinch-off voltage (V_P), and drain source current (I_{DSS}) when gate shorted to source are measured before and after irradiation. Net change in these quantities were discussed for irradiated electron fluences. These measurements and electron irradiation were carried out at room temperature. The circuit diagram for measurement of above parameter is shown in Fig. (3.5). The discrete FETs described above were irradiated with 1 MeV electrons under different normal bias conditions for different fluences lies in between range $3x10^{13}$ to $2x10^{14}$ e^- / cm^2. Typical result for saturated drain current (I_D) at VGS = 0, saturated drain current when gate shorted (I_{DSS}) and pinch off voltage (V_P) for JFET BFW10 are shown in Fig. (3.6) and for JFET BFW11 are shown in Fig. (3.7).

3.2.3 Results and Discussion :

We observe here that there is degradation in I_D, I_{DSS} and gain. The decrease in the pinch-off voltage with increasing total dose, indicates that the degradation mechanism is carrier removal resulting from displacement damage. According to displacement effect,

$$N(\phi) = N(o) \frac{V_P(\phi)}{V_P(0)} \qquad \ldots (3.4)$$

EFFECT OF RADIATION OF 1MeV ELECTRON ON $I_D - V_{DS}$ CHA[s] OF FET BFW 10 AT VGS=0

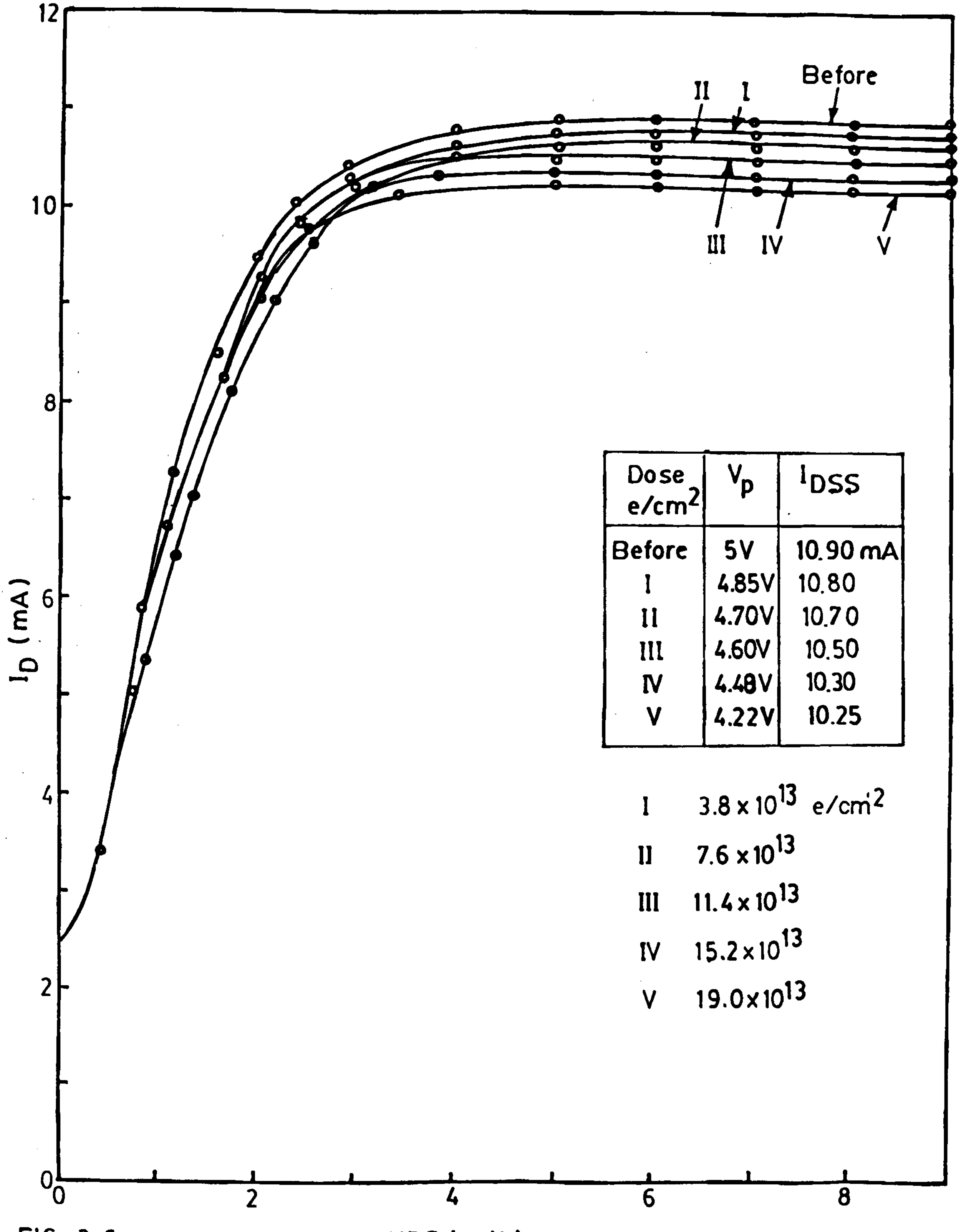
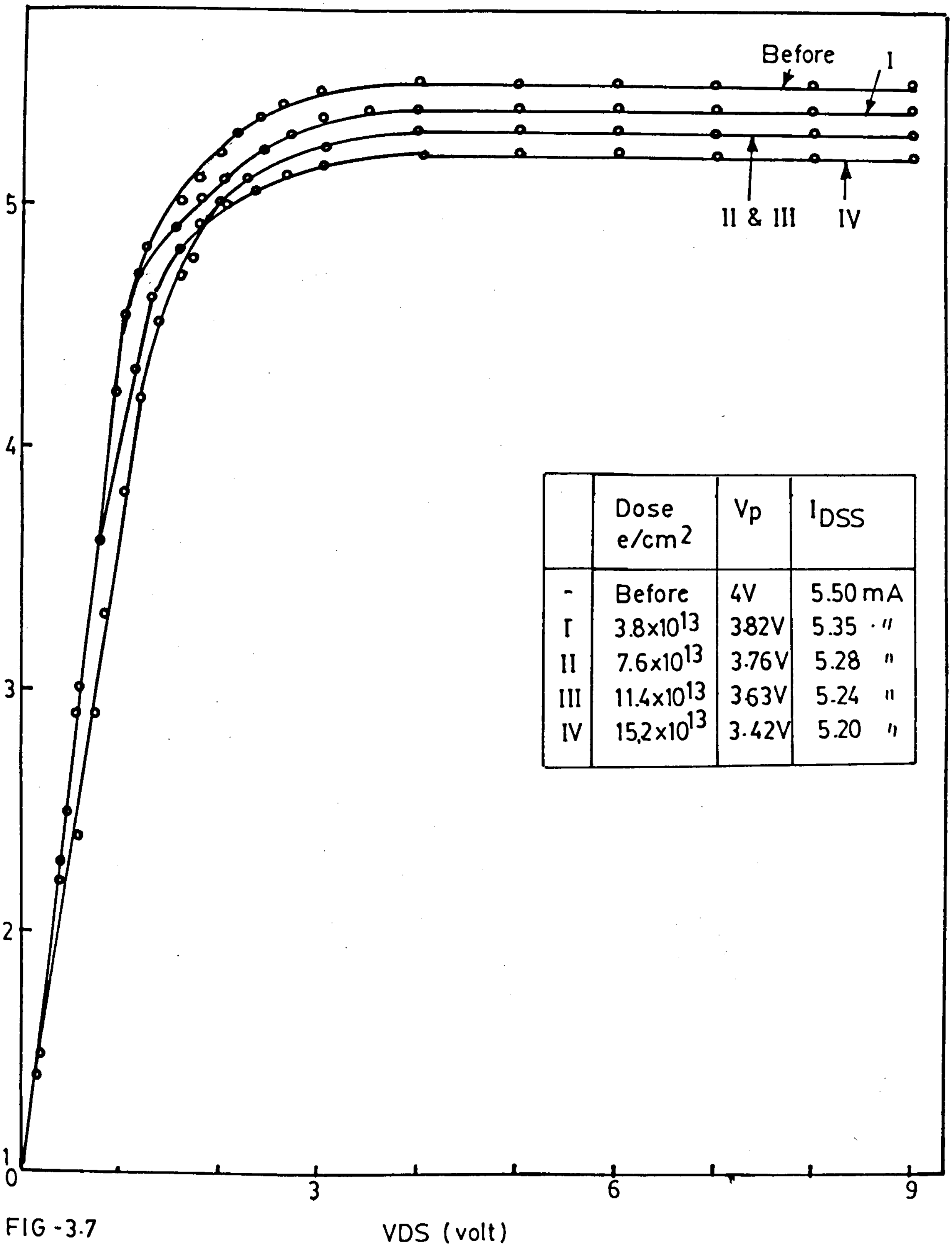


FIG-3.6

EFFECT OF RADIATION OF 1MeV ELECTRON ON $I_D - V_{DS}$ CHA^s OF FET BFW 11 WHEN VGS=0



	Dose e/cm^2	Vp	I_{DSS}
-	Before	4V	5.50 mA
I	3.8×10^{13}	3.82V	5.35 "
II	7.6×10^{13}	3.76V	5.28 "
III	11.4×10^{13}	3.63V	5.24 "
IV	15.2×10^{13}	3.42V	5.20 "

FIG -3.7

where $N(\phi)$ - carrier concentration after irradiation.

$N(o)$ - carrier concentration before irradiation

$V_p(\phi)$ - pinch off voltage after irradiation

$V_p(0)$ - pinch off voltage before irradiation.

Using initial and final value of pinch off voltage from Figs. (3.6) and (3.7) and equation (3.4) we have

$$N(\phi) = 0.84\ N(0) \quad \text{for BFW10}$$
$$N(\phi) = 0.82\ N(0) \quad \text{for BFW11} \qquad \ldots (3.5)$$

Thus from equation (3.5) we conclude that a decrease in carrier concentration is about 16% and 18% for BFW10 and BFW11 respectively. Also from the graphs we observe that there is degradation of I_{DSS} near about 8 to 10% is due to trapping of injected electrons and holes in gate oxide. The pinch off voltage of JFET can be given by

$$V_p = \frac{qNW^2}{8\epsilon} \qquad \ldots (3.6)$$

where W - channel width of JFET

N - initial impurity concentration

From the above discussion, it is observed that initial carrier concentration reduces due to the total dose exposure, that will reduces the pinch off voltage.

The pinch off current (I_{DSS}) is given by

$$I_{DSS} = I_P = \frac{Gm_o\ V_P}{3} \qquad \ldots (3.7)$$

But transconductance (Gm_o) is proportional to carrier concentration. Thus the reduction in carrier concentration by the surface effect reduces the transconductance ultimately pinch off current have been reduced. The change in channel resistance takes place due to increase in the resistivity in silicon by displacement effect.

3.3 Unijunction Transistor (UJT) :

3.3.1 Introduction :

The present work is done under electron irradiation for the different electron fluences. The UJT has two doped regions with three external leads. This device has one emitter and two bases. The emitter is heavily doped and small in size compared to gate of FET. The n region is heavily doped. There are many application of UJT such as autoswitchable diode, relaxation oscillator and in so many current controlled circuits, sweep generator and trigger circuit. The purpose of this task is to study the effect of 1 MeV electron irradiation on the I-V characteristic of UJT at different base voltages. Also we observe the frequency response of relaxation oscillator by using UJT before and after the irradiation.

3.3.2 Experimental procedure :

The UJT used in this experiment is the n channel device.

They are generally used in so many electronic circuit for different purposes. The single piece of UJT such as 2N2646 were irradiated at varies base voltages (1) V_{B2B1} = 2V (2) VB_2B_1 = 4V and observed the I_E-V_E characteristic by the irradiation of 1 MeV electron. Also the another parameter such as peak voltage and current, valley voltage and current and frequency of relaxation oscillator were measured after and before irradiation. The range of electron fluence is 10^{13} e^- /cm^2 to 10^{14} e /cm^2. These above measurements and electron irradiation were carried out at room temperature. The circuit arrangement for measurement of electrical parameter and I-V characteristic of UJT is shown in Fig. (3.8). The circuit arrangement for measurement of frequency of relaxation oscillator using 2N2646 is shown in Fig. (3.9).

3.3.3 Results and Discussion :

The typical result for peak voltage and current, valley voltage and current for UJT 2N2646 are shown in Fig. (3.10) and (3.11) at different base voltages V_{B1B2} = 2V and V_{B1B2} = 4V respectively. We observe from the Figs. (3.10) and (3.11) that after irradiation the peak voltage and current remain constant, but valley voltage and valley current changes. The valley voltages increase and valley current decrease after irradiation. The forward I_E-V_E characteristic for UJT at typical base voltage is related to diffusion length as,

$$L = \sqrt{D\lambda \cdot \lambda} = \sqrt{\mu_n \cdot \frac{KT}{q} \lambda} \quad \ldots (3.8)$$

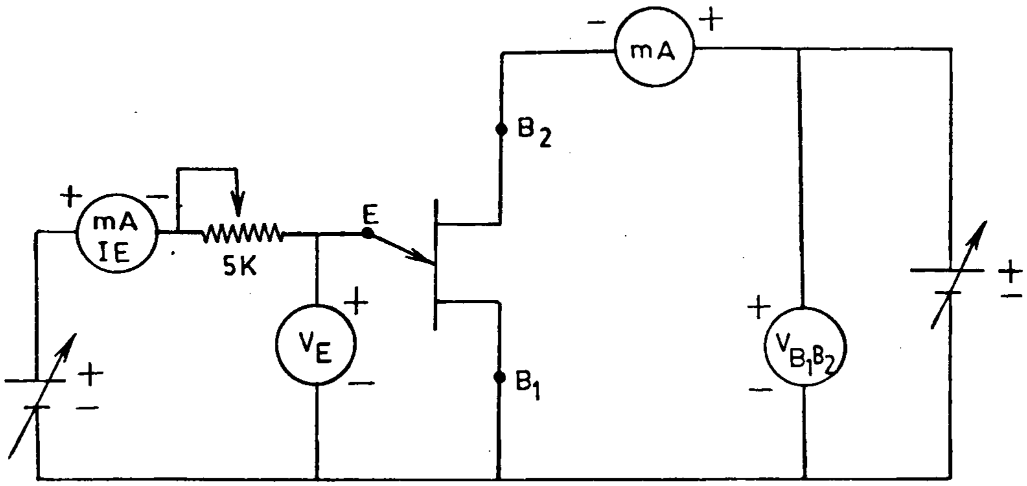


Fig-3.8 - $I_E - V_E$ Characteristic of UJT 2N 2646

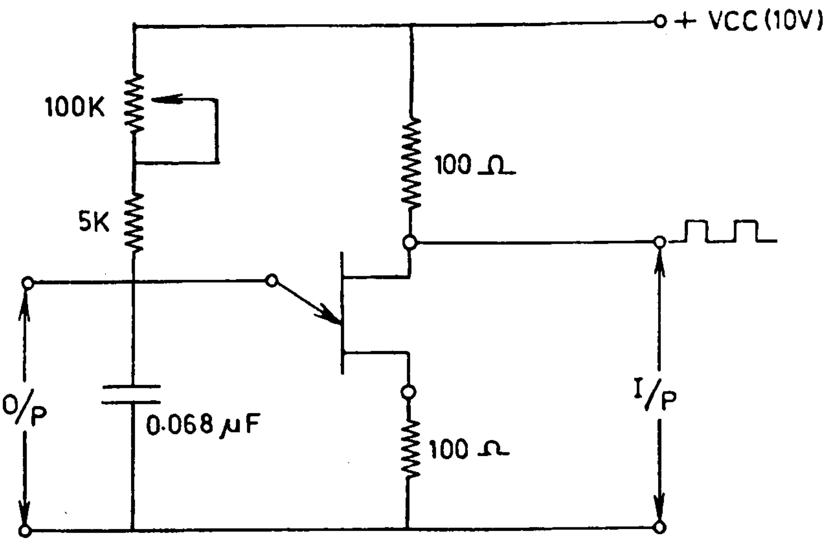
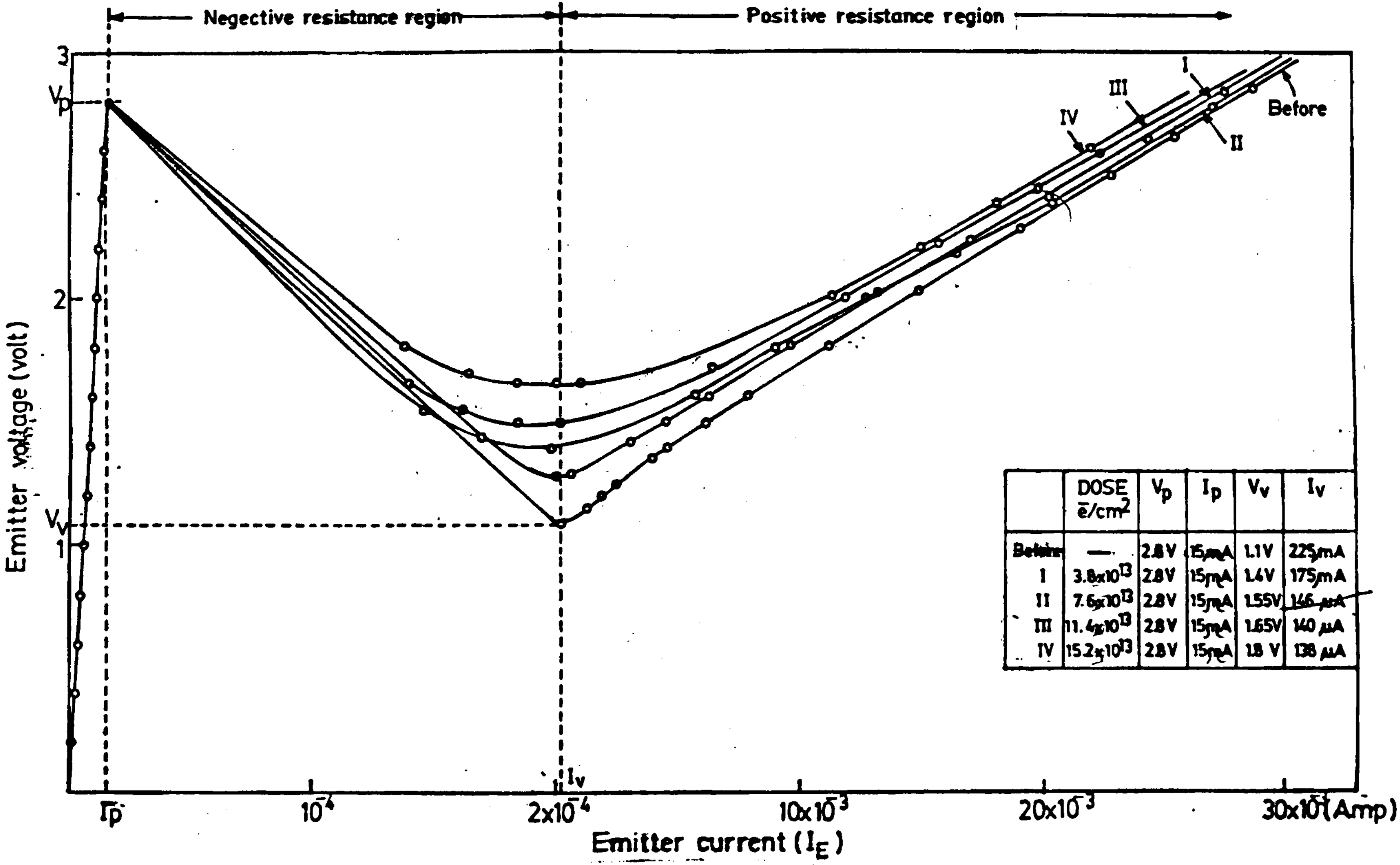


Fig-3.9 - Relaxation Oscillat‹ - using 2N 2646

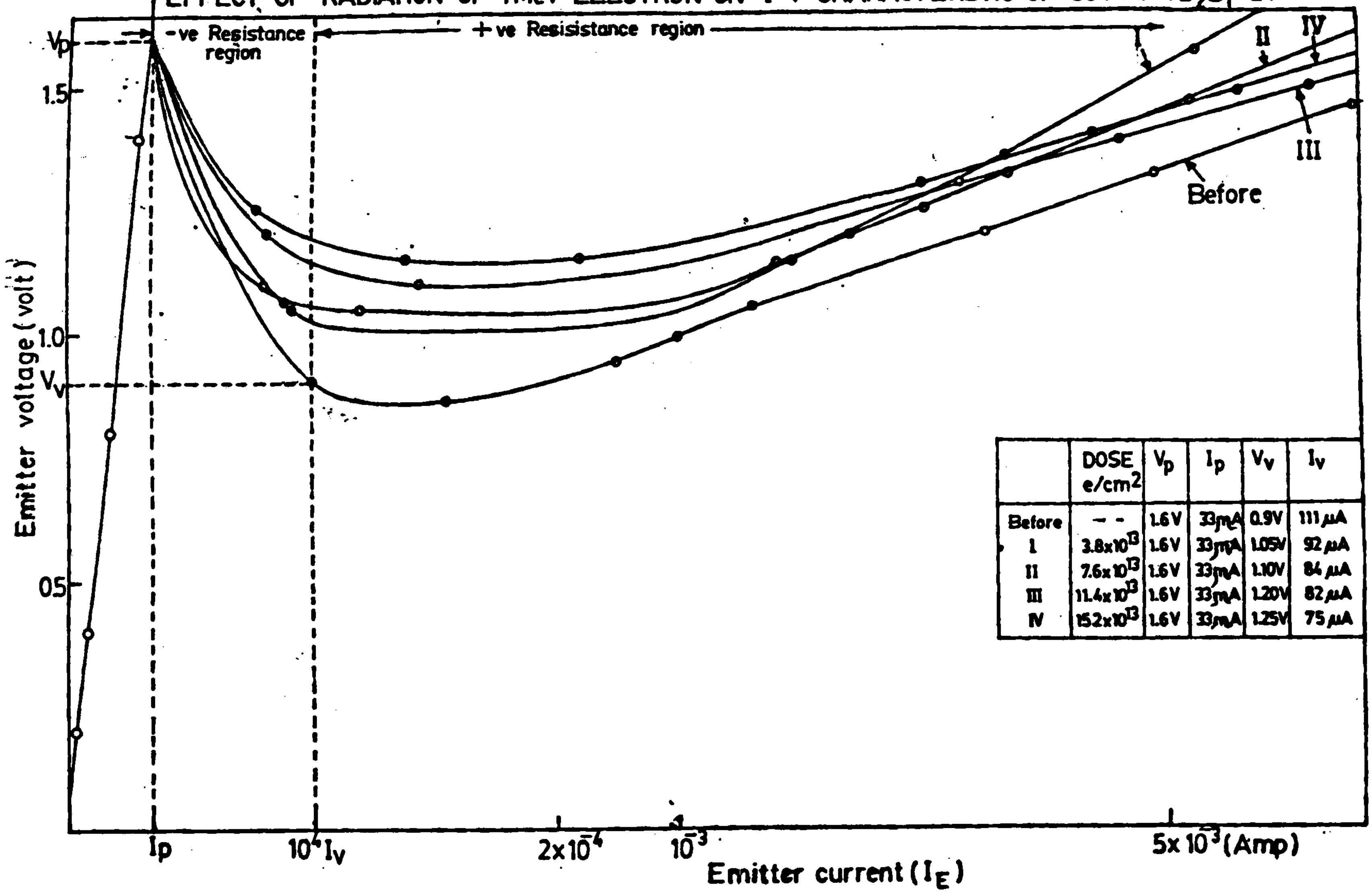
EFFECT OF RADIATION OF 1MeV ELECTRON ON I-V CHARACTERISTIC OF UJT AT $V_{B_2B_1} = 4$ VOLT



	DOSE $\bar{e}/cm^2$	V_p	I_p	V_v	I_v
Before	—	2.8 V	15 μA	1.1 V	225 μA
I	3.8×10^{13}	2.8 V	15 μA	1.4 V	175 μA
II	7.6×10^{13}	2.8 V	15 μA	1.55 V	146 μA
III	11.4×10^{13}	2.8 V	15 μA	1.65 V	140 μA
IV	15.2×10^{13}	2.8 V	15 μA	1.8 V	138 μA

FIG-3.11

EFFECT OF RADIATION OF 1MeV ELECTRON ON I-V CHARACTERSTIC OF UJT AT $V_{B_2B_1}$ =2V



	DOSE e/cm²	V_p	I_p	V_v	I_v
Before	- -	1.6V	33mA	0.9V	111 μA
I	3.8×10^{13}	1.6V	33mA	1.05V	92 μA
II	7.6×10^{13}	1.6V	33mA	1.10V	84 μA
III	11.4×10^{13}	1.6V	33mA	1.20V	82 μA
IV	15.2×10^{13}	1.6V	33mA	1.25V	75 μA

FIG-3.10

Also the total peak voltage at particular base voltages is given by

$$V_P = \frac{2kT}{q} \ \ln \ \frac{I_p W}{2qA\ Dn_1} \qquad \ldots (3.9)$$

As diffusion length is short as compare to base width, the majority current flowing through emitter region remains constant. Hence the peak voltage remains constant. But valley voltage is that voltage at which current as well as forward voltage increases due to increase in resistivity by displacement effect. As resistivity increases that causes decrease in resistance in negative region of the UJT that results the increase in valley voltage and decrease in valley current. Thus as valley increases, the area of negative resistance region decreases, that reduces the diffusion length of base region.

The change in frequency of relaxation oscillator causes only due to the change in minority carrier in base region B_1B_2.

The frequency of relaxation oscillator is given by

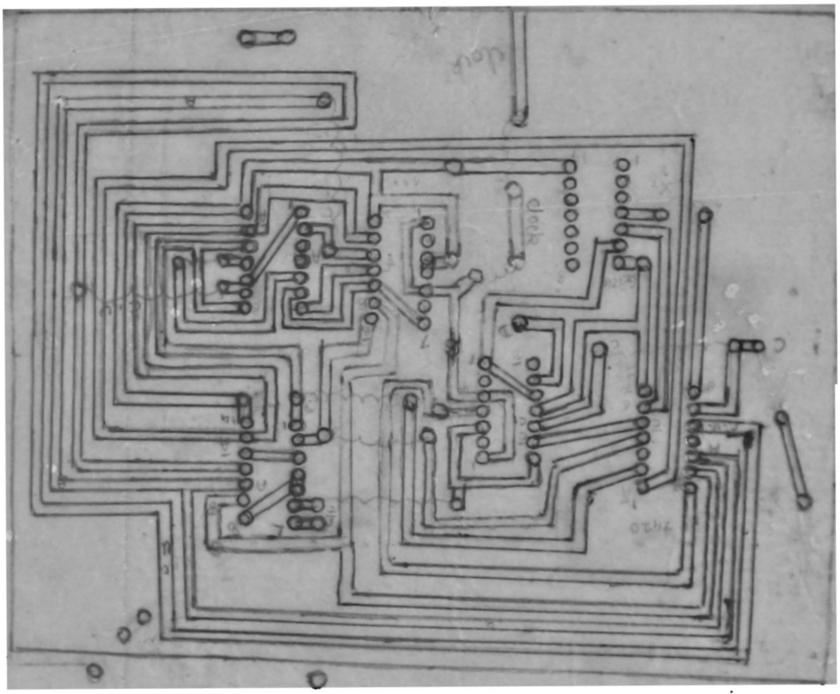
$$f_r = \frac{1}{2\ \pi\ (reCB_1B_2 + t_b)} \qquad \ldots (3.10)$$

where re - emitter forward resistance

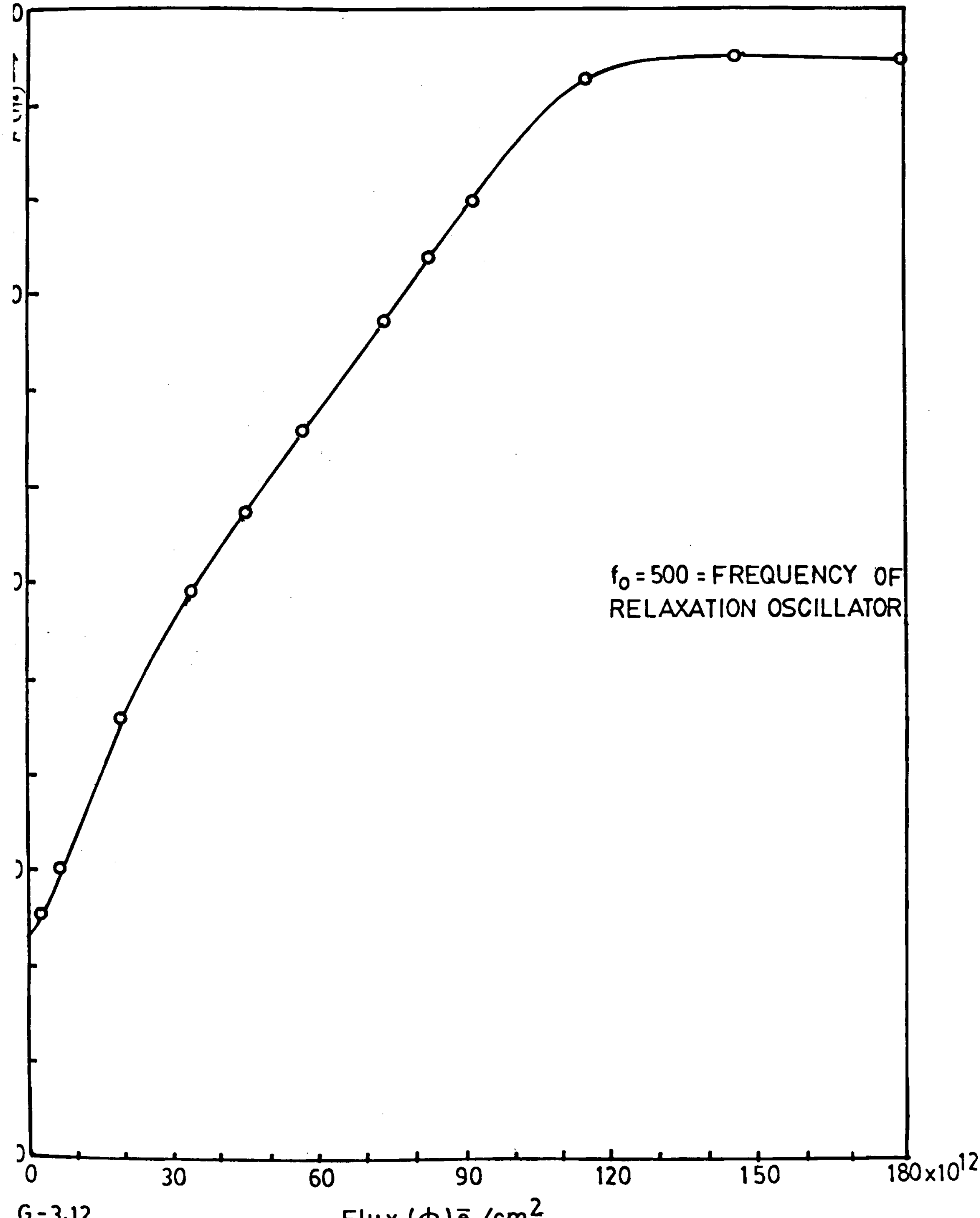
CB_1B_2 - diffusion capacitance between base B_1 and B_2

t_b - transist time between base B_1 and B_2

The diffusion capacitance in semiconductor devices is affected by the minority carrier in base region. From the Fig. (3.12) the frequency of relaxation oscillator before irradiation is 500 Hz. But upto the electron irradiation dose of 1.5×10^{14} e^-/cm^2, frequency of relaxation oscillator increases and after that it remains constant. By the calculation the frequency of relaxation oscillator is found to be increased by 43% of its initial value.


clock

'FECT OF RADIATION OF 1MeV ELECTRON ON FREQUENCY OF RELAXATION OSCILLATOR USING UJT 2N 2646



G-3.12

CHAPTER - IV

PART (I) : EFFECT OF NEUTRON IRRADIATION ON SCR :

4.1 Introduction :

The SCR used in this work is commonly used for industrial purpose known as four layer diode rectifier or thyristor. It consist of combination of two transistor n-p-n and p-n-p having three terminal anode, cathode and gate.

SCR is a bistable device that can be triggered from its high resistance to low resistance state by a current signal on the third lead. The SCR is fabricated by diffusing a p-layer into both sides of a lightly doped in type Si wafer and then diffusing an n region into one of the two p region. The diffused n region is the cathode of the SCR, the upper p region is the gate and lower p region is the anode. In normal operation the rectifier is biased with anode positive and cathode negative. The physical and schematic configuration of SCR is shown in Fig. 4.2(a) and 4.2(b).

The upper three layer form n-p-n transistor in which cathode is emitter, gate is base and lightly doped n region is collector. The lower three layer form a p-n-p transistor in which gate region is collector, the resistive n region is base and anode is emitter.

4.2 Experimental Procedure :

In the present work, the effect of neutron irradiation on SCR is studied. The neutron flux $\sim 10^9 N/cm^2/sec$ was used, using

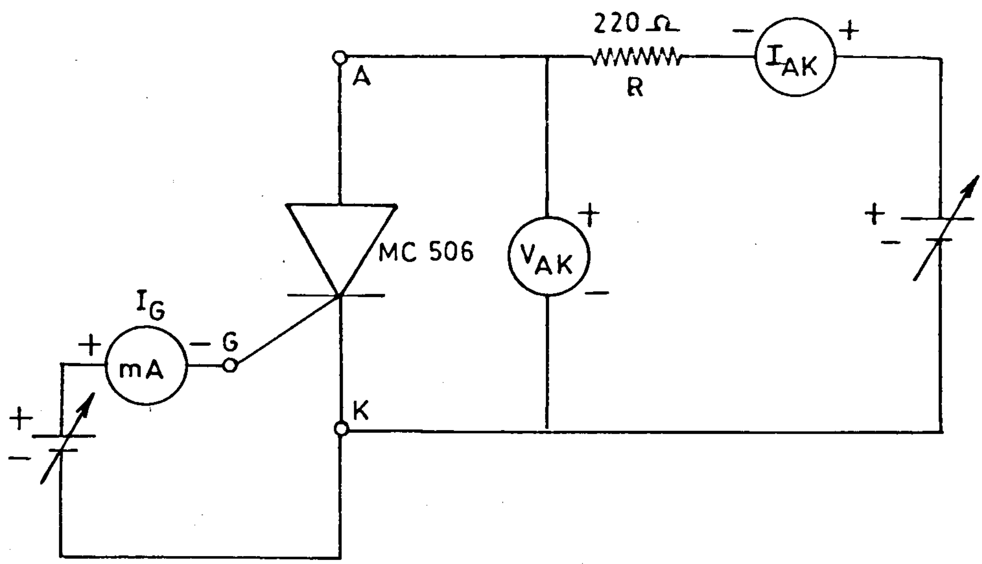
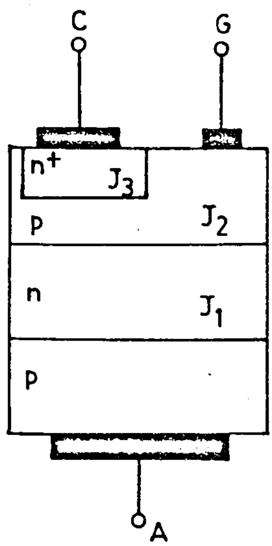
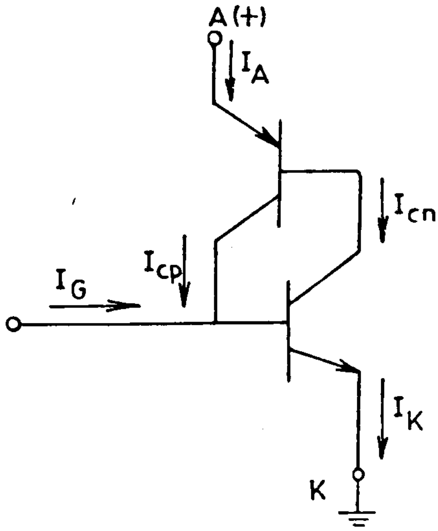


Fig 4.1 -Firing Characteristic of SCR



(a) Physical Configuration of SCR



(b) Schematic Configuration of SCR

Fig 4.2

facilities of the Department of Chemistry, University of Poona. The SCR 506 M.C. was irradiated with neutron at various gate current and observe the I-V characteristic. From the I-V characteristic of SCR the firing voltage and current are measured before and after irradiation. The net change in these parameter is discussed for the SCR irradiated with neutron flux in the range 10^{13} to 5×10^{14} N/cm^2. The above measurement are carried out at room temperature. The circuit diagram for measurement of above parameter is shown in Fig. (4.1).

4.3 Results and Discussion :

The relations between gain and current for pair of transistor are given below.

$$I_{CP} = (1 + h_{FEP}) I_{CBO} + h_{FEP} (I_{CN}) \quad \ldots (4.1)$$

$$I_{CN} = (1 + h_{FEN}) I_{CBO} + h_{FEN} (I_{CP} + I_G) \quad \ldots (4.2)$$

where h_{FEN} and h_{FEP} be current gain of two transistor

I_{CN} - is n-p-n transistor collector current

I_{CP} - is p-n-p transistor collector current

I_{CBO} - leakage current same for both transistor since both have same collector base junction J_2.

The individual collector current can be given by

$$I_A = I_{CP} + I_{CN}$$

$$= \frac{2I_{CBO}\,(1 + h_{FEN})\,(1 + h_{FEP}) + h_{FEN}\,I_G}{1 - h_{FEN} \cdot h_{FEP}} \quad \ldots (4.3)$$

At low current, the product of gain is less than one and anode current is small. The gain can be increased by current level or by raising the voltage at junction.

The value of the firing voltage and current after irradiation at different gate current are shown in Table (4.1). Both, the firing voltage and the anode current of the SCR have been found to increase after irradiation at gate current values $I_G = 0$ and $I_G = 50$ mA. The $I_{AK} - V_{AK}$ characteristic of SCR at $I_G = 0$ and $I_G = 50$ mA are shown in Fig. (4.3) and Fig. (4.4). The change in current and firing voltage is mainly due to change in carriers life time caused by neutron displacement damage effect. This effect is similar to one observed in transistors after 1 MeV electron irradiation. It has been found that the gain of transistor decrease with the electron fluence. The product h_{FEN} and h_{FEP} in SCR decreases and the anode current increases. As the anode current increases, the corresponding firing voltage also increases.

We have also irradiated SCR with 1 MeV electron but due to its thick metallic case, the electron could not penetrate into the silicon material. From above discussion we conclude that the typical SCR characteristic is very sensitive to neutron displacement damage, this is mainly due to the fact that the gain and the saturation voltage depend on the minority carrier life time.

Table (4.1) : Effect of neutron irradiation on firing voltage and current of SCR.

Source	$I_G = 0$		$I_G = 50$ mA	
Thermal Neutron	Firing voltage V_{fr} (v_{out})	Firing current I_{fr} (mA)	V_{fr}(v_{out})	I_{fr}(mA)
Before radiation	3.9	8.00	3.4	7.20
After 6 hours (2×10^{13} N/cm^2)	4.5	9.49	4.0	8.40
After 30 hours (1×10^{14} N/cm^2)	6.8	16.80	6.6	14.30
After 54 hours (2×10^{14} N/cm^2)	9.2	17.80	8.2	15.20
After 119 hours (4×10^{14} N/cm^2)	13.0	19.50	12.5	17.00

Effect of radiation of ... neutron on SCR charactorstics at IG = 0 mA

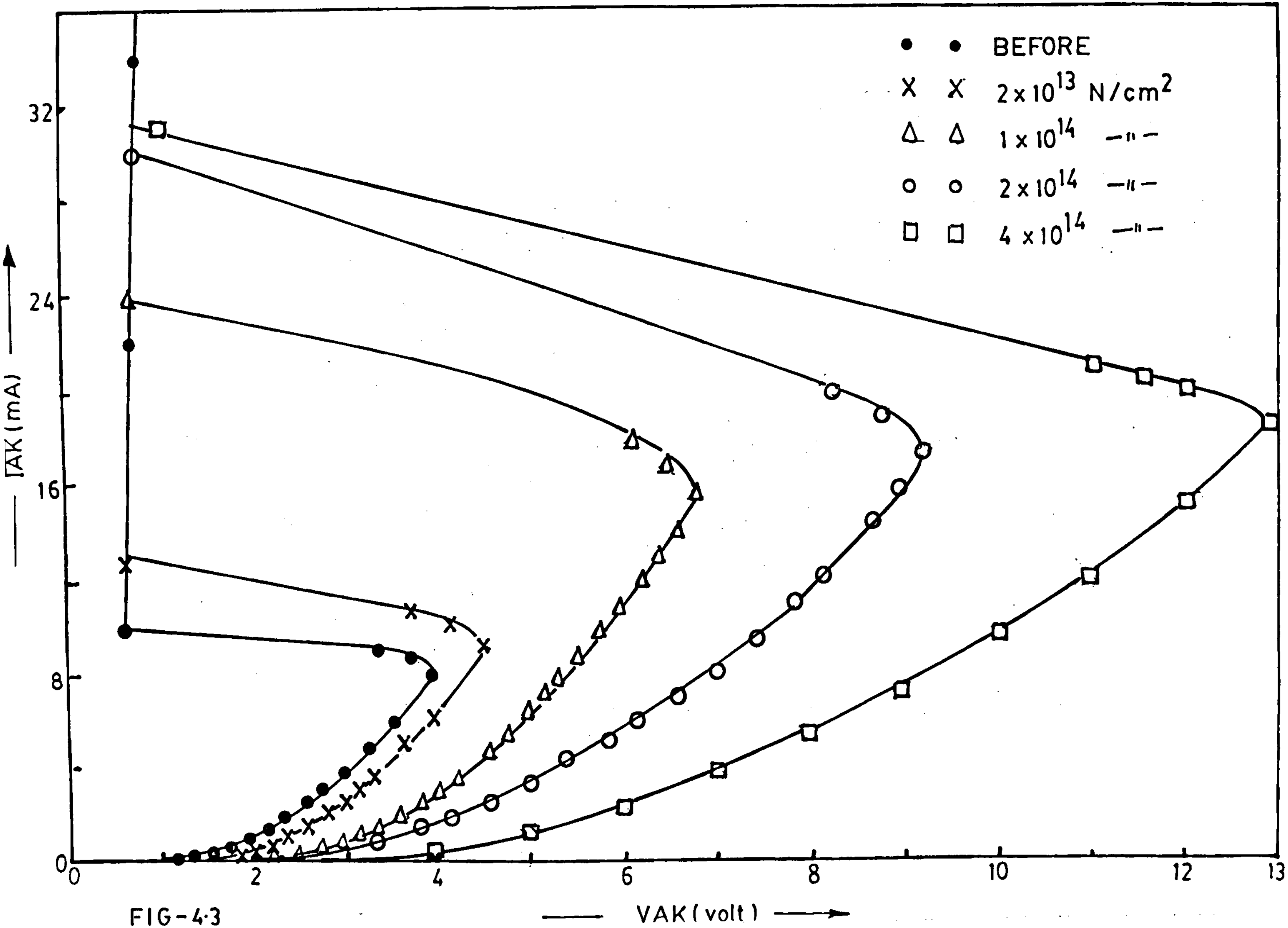
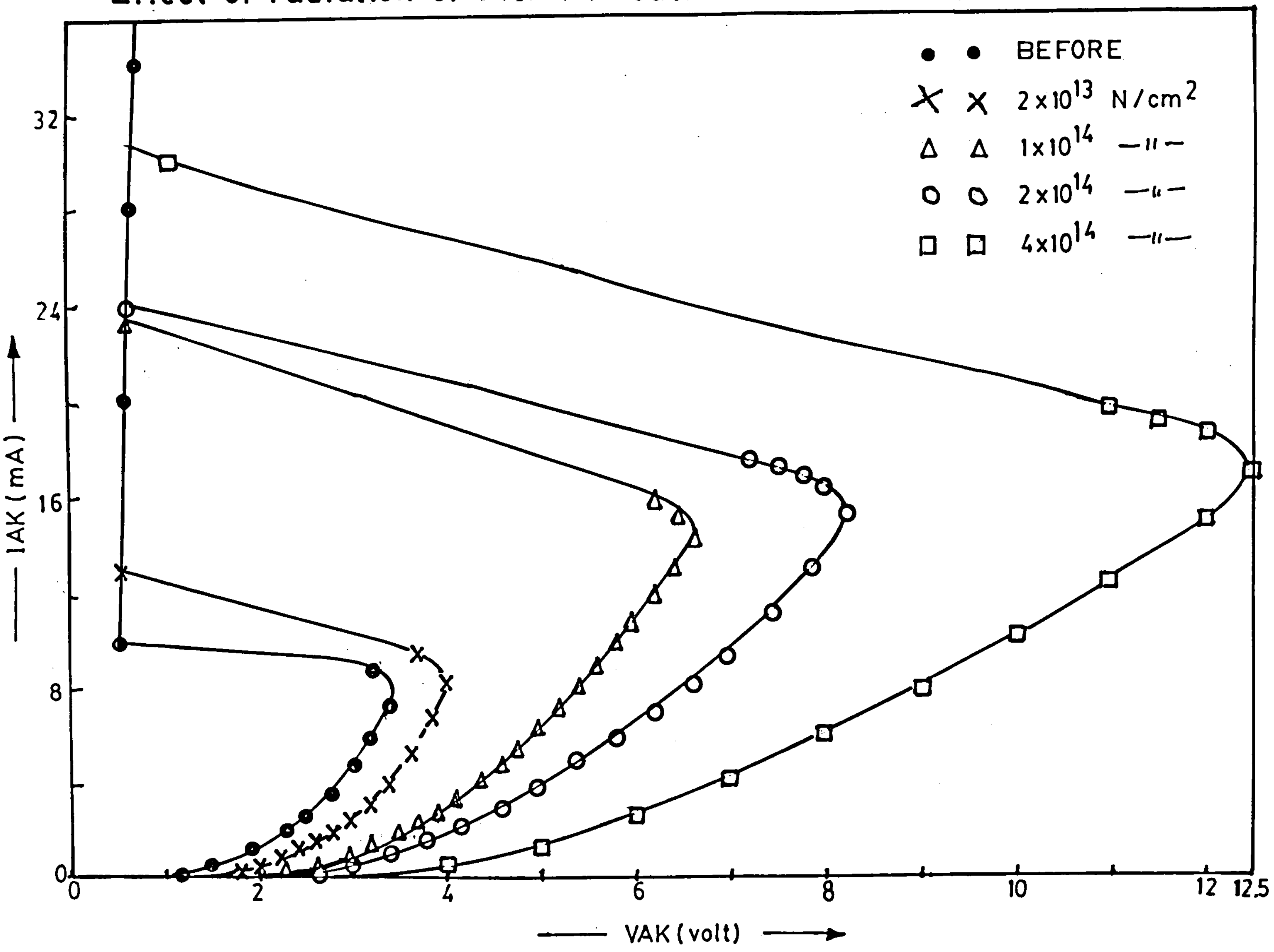


FIG-4·3

Effect of radiation of neutron on SCR charactorstics



PART (II) : EFFECT OF IRRADIATION OF 1 MeV ELECTRON AND ANNEALING ON GAIN OF TRANSISTOR :

4.4.1 Introduction :

The transistors are mostly used for amplifications purpose i.e. to amplify the weak signal and gives the output signal having large amplitude large power etc. In this chapter the results of study of the effect of 1 MeV electron irradiation and annealing on the gain of the transistor are reported. In silicon crystal, when the defects due to radiation are created, one can bring the crystal to original condition by process of annealing. The result of annealing in removing the defects of the electron irradiated transistor are also discussed.

4.4.2 Experimental Procedure :

We know that transistors are available in n-p-n and p-n-p mode. The two pieces of n-p-n transistors (BC.-148C, BC.-149C) and single piece of p-n-p transistor (BC158B) are irradiated at different dose level by 1 MeV electron. The current of transistor (hfe) i.e. amplification factor is measure before and after irradiation by using the standard instrument of Aplab known as Beta tester. Also the gain of the electron irradiated transistor after annealing at different time interval is measured. The measurement of gain after electron irradiation is done at room temperature.

4.4.3 Results and Discussion :

(A) Effect of 1 MeV electron irradiation on the gain of transistor

Transistor gain is the transistor parameter which is most sensitive to displacement radiation. The reciprocal gain is a convenient parameter for analysis because the base current components that vary with radiation appear in the numerator so the reciprocal gain is given by,

$$\frac{1}{h_{FE}} = \frac{I_B}{I_C} = \frac{(I'_D + I_{RG} + I_S + I_{RB} - I_{CBO})}{IC} \qquad \ldots (4.4)$$

where I'_D - reverse diffusion current is due to injection of holes from base into the emitter.

I_{RG} - recombination regeneration current

I_S - surface current are produced by the majority carriers flowing into emitter base space charge region.

I_{RB} - base recombination current is that portion of normal diffusion current (I_D) which recombines in base before reaching collector base junction.

I_{CBO} - collector leakage current is produced primarily by carriers flowing out of the collector base space charge region.

The effect of neutron irradation on the gain can be written as,

$$\frac{1}{h_{FE}} = \frac{I_B}{I_C} = \frac{I_{B(O)}}{I_C} + \frac{\Delta I_B}{I_C} = \frac{1}{h_{FEO}} + \frac{\Delta I_B}{I_C} \qquad \ldots (4.5)$$

where

$$\frac{\Delta I_B}{I_C} = \frac{\Delta I'_D + \Delta I_{RG} + \Delta I_S + \Delta I_{RB} - \Delta I_{CBO}}{I_C} \qquad \ldots (4.6)$$

The effect of radiation on the emitter efficiency term I'_D / I_C for n-p-n transistor is

$$\frac{I'_D}{I_C} = \frac{D_p W_b n_p}{2 D_n L_p N_D} \qquad \ldots (4.7)$$

This term is small compared to other component in reciprocal gain due to (i) the decrease of minority carrier lifetime in the emitter which causes reduction in diffusion length L_p in emitter. (ii) the reduction in lifetime which is proportional ϕ^{-1} and and the reduction in the diffusion length is proportional to $\phi^{-\frac{1}{2}}$.

The surface term $\Delta I_S / I_C$ is caused by radiation induced ionization. So this term can dominate the damage effect for small total exposures but it overcome by displacement damage effect.

The percentage increase in junction leakage can be large due to displacement damage. Hence the leakage current is generally small compared to other base current component and which can be neglected. So eliminating three base current components from the equation (4.5). We get,

$$\frac{1}{h_{FE}} = \frac{1}{h_{FEO}} + \frac{\Delta I_{RG}}{I_C} + \frac{\Delta I_{RB}}{I_C} \qquad \ldots (4.8)$$

where the recombination generation term can be written as,

$$\frac{I_{RG}}{I_C} = \frac{I_{RG}\,(W_b)}{qA\text{-}D_n \cdot \Delta_n} \qquad \ldots (4.9)$$

The gain degradation before irradiation can be put in the form

$$\Delta \frac{1}{h_{FE}} = \frac{\Delta I_B}{I_C} = t_b\,(\Delta R') = t_b K'\phi \qquad \ldots (4.10)$$

where K' - composite damage constant.

$\Delta R'$ - change in recombination rate per carrier.

Thus the degradation in the gain after irradiation is given by

$$\frac{1}{h_{FE}} = \frac{1}{h_{FEO}} + t_b\,K'\phi \qquad \ldots (4.11)$$

According to data reported by Van Lint (Ref.1) the displacement effect produced by electrons is function of majority carrier, resistivity and carrier injection level. He also observed that the life time damage constant is related to the radiation dose by the equation,

$$\frac{1}{\lambda} = \frac{1}{\lambda_o} + K\lambda\phi \qquad \ldots (4.12)$$

where λ - minority carrier lifetime

λ_o - pre-irradiated life time

ϕ - electron fluence

$K\lambda$ - lifetime damage constant

It is expected that wide base transistor will undergo greater degradation of h_{FE} than other device. The degradation in the gain of the transistors BC 148C, BC 149C and BC 158B by electron irradiation is shown in Fig. (4.5) at different dose. In this case the electron fluence is taken in terms of counts. Thus from the above discussion we observe that ($\frac{1}{h_{FE}}$) is approximately proportional to the total dose i.e. h_{FE} is very sensitive to the electron irradiation.

(B) <u>Effect of annealing on the gain of transistor</u> :

When a crystal that contains defects is reaches a temperature at which the defect are mobile and structural rearrangements of the defects occurs. These rearrangement can result in self destroying process such as the recombination of vacancies and interstitials, diffusion of vacancies and other defect entities such as crystal imperfection and impurities. The net result is that either the crystal restrore its pre-irradiation condition or new defects are formed. All of these processes are called annealing. These changes in the defect are reflected as changes in the electrical properties of the crystal. The annealing of defects can either restore the electrical properties toward their pre-irradiation value or increase the changes that are originally produced by the particle irradiation. Thus "annealing" means changes, towards the pre irradiation value, while "reverse annealing" means changes in same direction as peoduced by irradiation. The radiation annealing is an injection annealing

FFECT OF ELETRON IRRADIATION ON CURRENT GAIN OF TRANSISTER

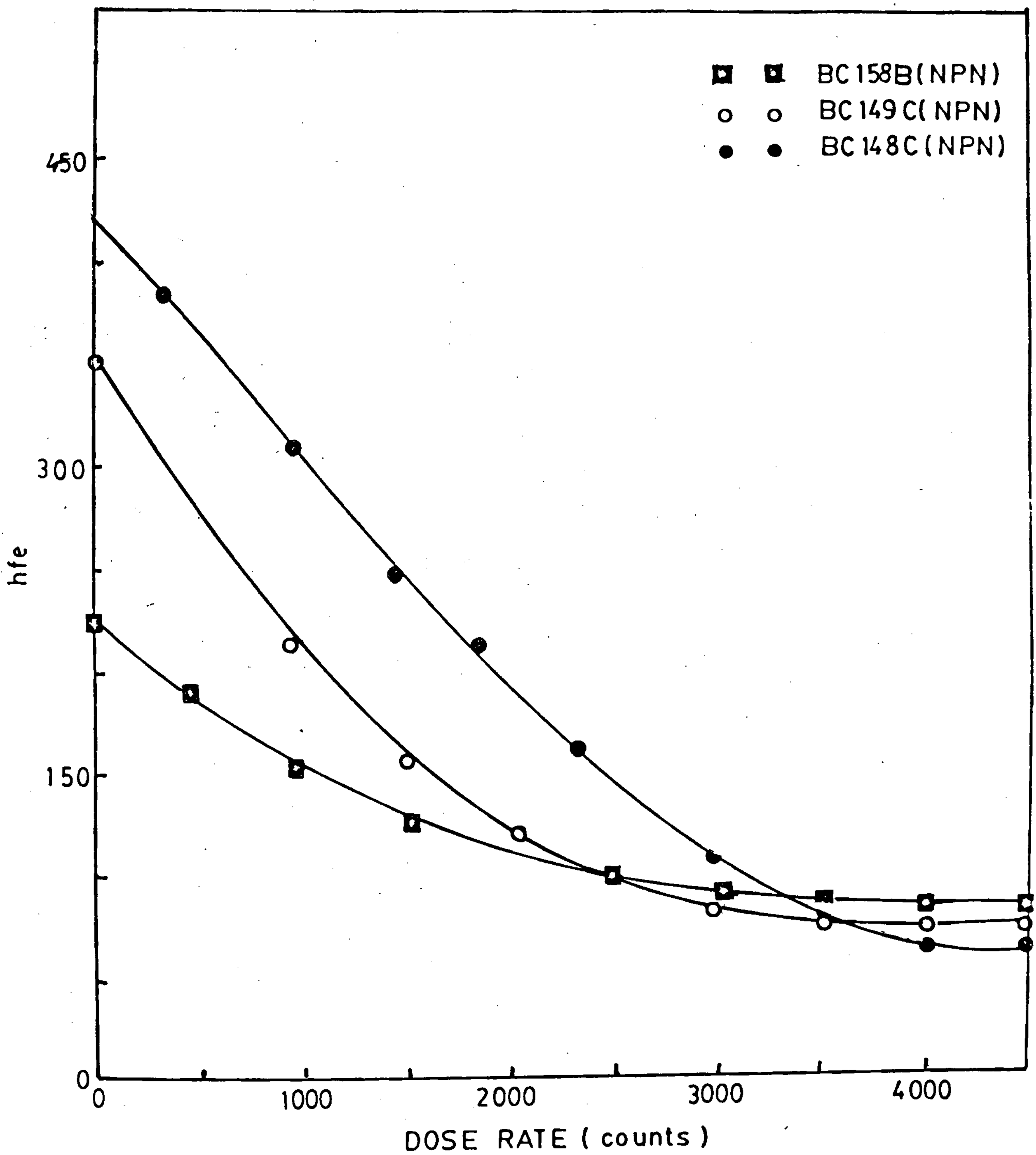


FIG-4.5

process in which the ionization produce the stable defects.

Variation of the injection level or temperature during or after the irradiation can be substantially alter the damage effects. The change in the displacement damage effect with time, injection level, and temperature are due to changes in both the number of defects and the types of defects that tend to dominate the displacement damage effect. These changes in both kind and number of defects as function of time, injection level and temperature are all included in the general term 'defect modification'. The steady state effects caused by carrier injection during or after irradiation are called '<u>electrical defect</u>' modification. The steady state effects caused by increased in temperature are called thermal defect modifications. The effect of thermal defect modification after the irradiation of 1 MeV electron radiation on the gain of transistor such as BC 148C, BC 149C and BC 158C are observed in the present work. The Fig. (4.6) shows the graph of annealing temperature versus gain of transistors BC 148C, BC 149C and BC 158B. So after annealing above room temperature the gain of transistor goes on increasing steadily and try to reach towards its original value before the irradiation. From the Fig. (4.6) it is observed that the gain of transistor does not reach to its original value but tried to reach towards its original value. At higher temperature the gain of transistor remain constant below 20 to 25% of its original value. Above discussion is only for n-p-n transistor. But in case of p-n-p transistor there is some variation i.e. as annealing

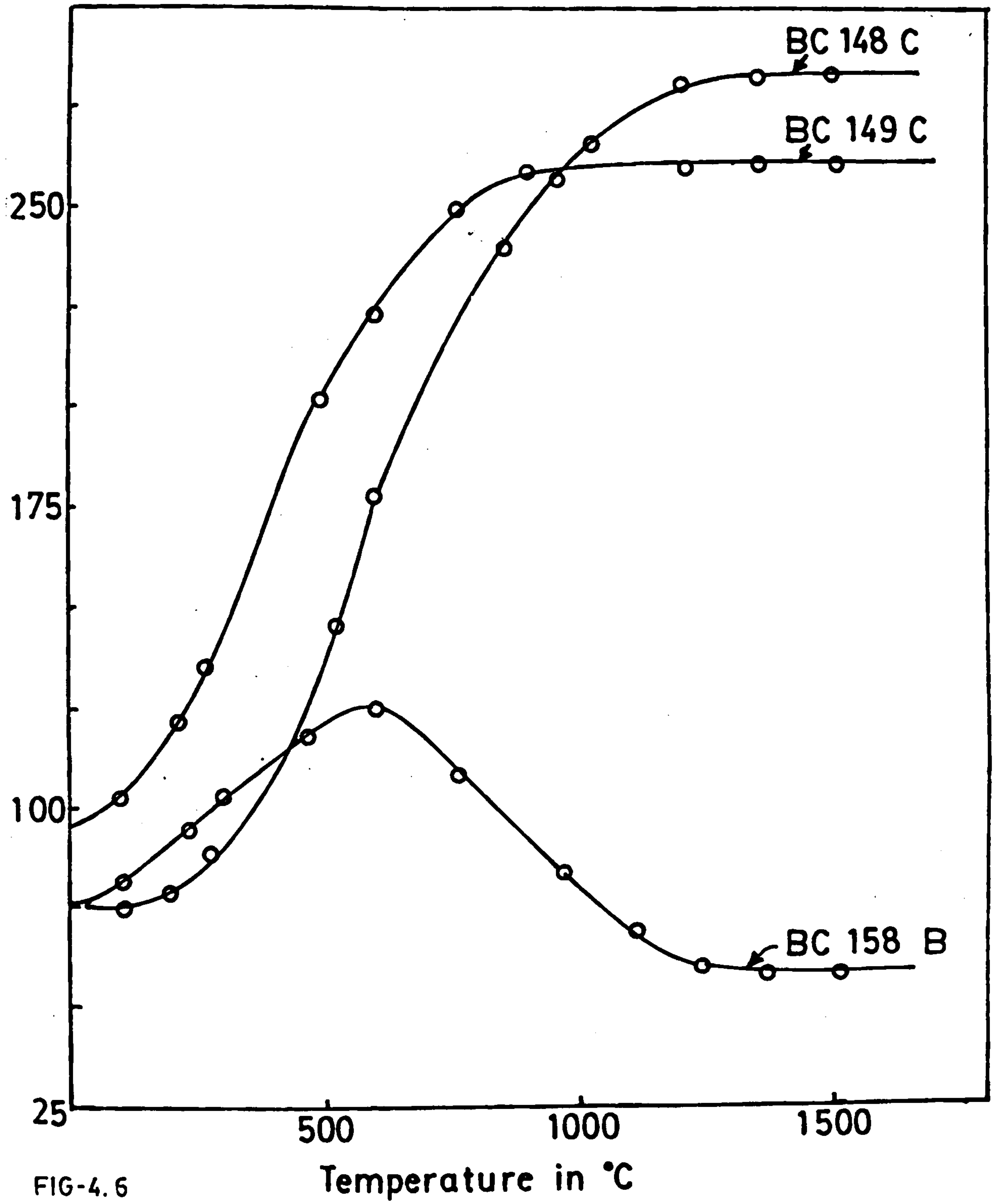


FIG-4.6

EFFECT OF ANNELING TEMPERATURE ON CURRECT GAIN
OF TRANSISTER

temperature increases corresponding current gain increases initially and then the current gain goes on decreases below that of pre-irradiated value, that means the annealing effect observed in this case of p-n-p transistor is of both types i.e. forward annealing and reverse annealing.

The transient defect modification with time as function of electrical and thermal conditions. The effect of transient defect modification on the current gain of transistor BC 148C, BC 149C and BC 158B is shown in Fig. (4.7). From Fig. (4.7) we observed that current gain increases as annealing time of device increases. This result is true only in case of n-p-n transistor. But in case of p-n-p transistor both types of transient damage effect i.e. forward and reverse transient damage effect are observed. Thus the term annealing is used for change indisplacement damage effect w.r.t. time. Also due to annealing one can reduce irradiation defects which are caused due recombination of vacancies interstitials.

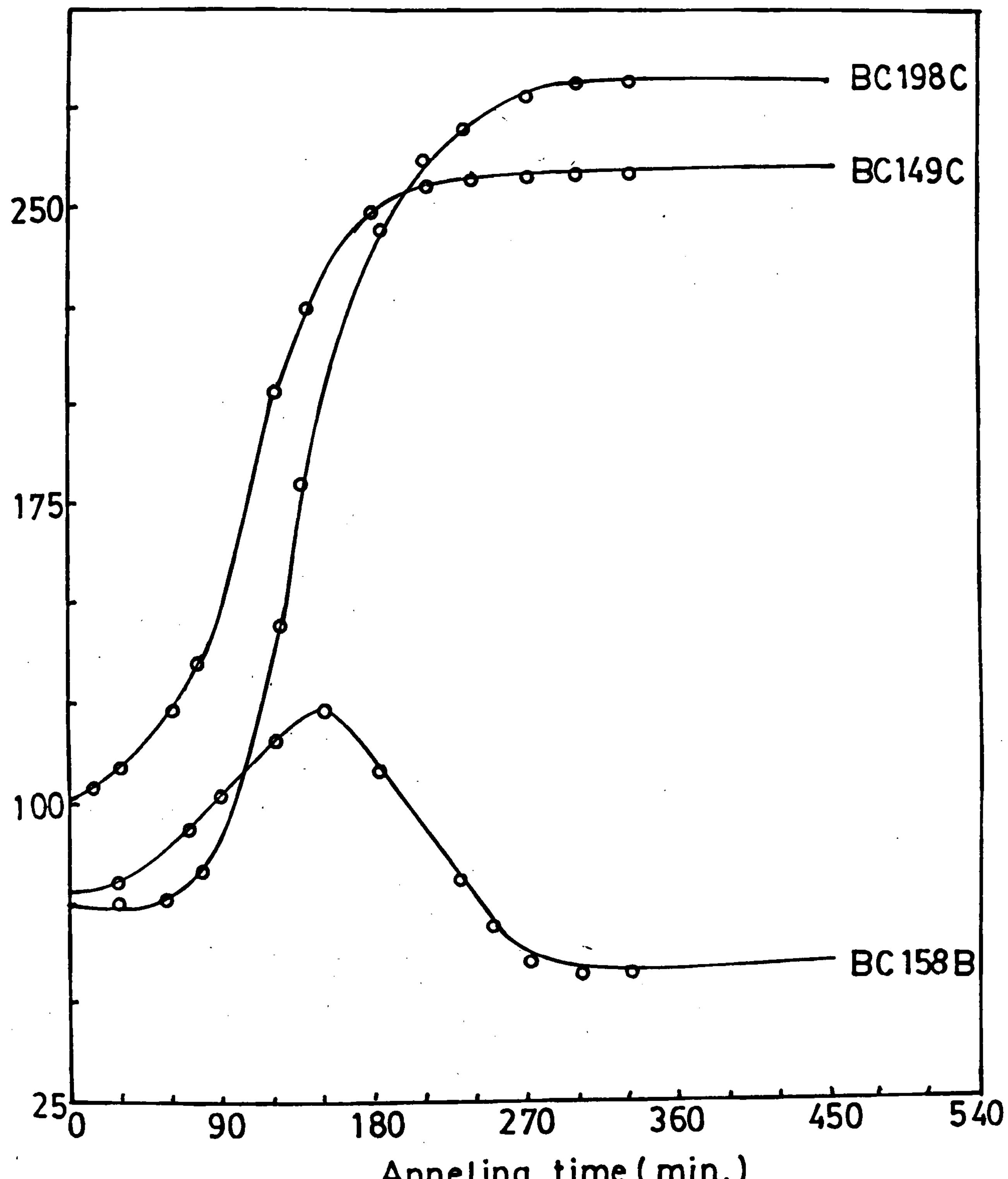


FIG-4.7

EFFECT OF ANNELING TIME ON CURRENT GAIN OF TRANSISTER

PART (III) : EFFECT OF 1 MeV ELECTRON ON OPERATIONAL AMPLIFIER AND TTL IC :

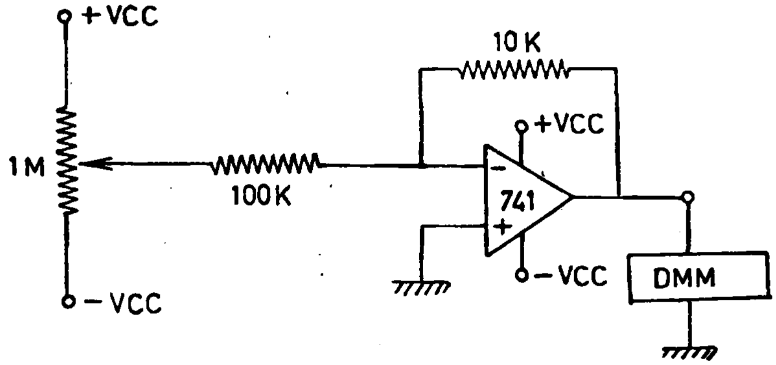
4.5 Operational Amplifier (OPAMP).

4.5.1 Introduction :

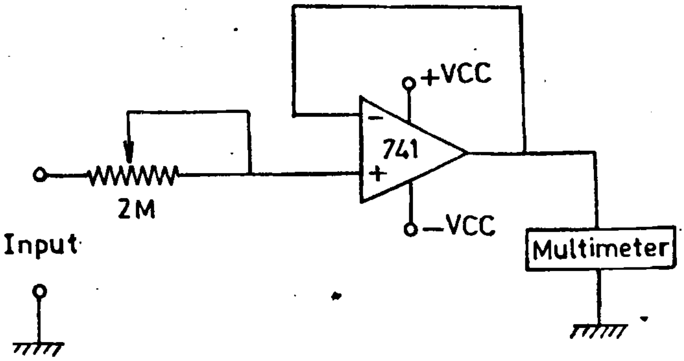
OPAMP is device which perform mathematical operation such as addition, substraction, integration and multiplication. The OPAMP is pasically differential amplifier that means it amplify the difference of input signal at the output. OPAMP is widely used in the oscillator, amplifier, transistor, transmitter, T.V. and other industrial applications. In the present work OPAMP 741 is irradiated by 1 MeV electron at room temperature. In this present work we studied the frequency response and the OPAMP parameter after 1 MeV electron irradiation.

4.5.2 Experimental procedure :

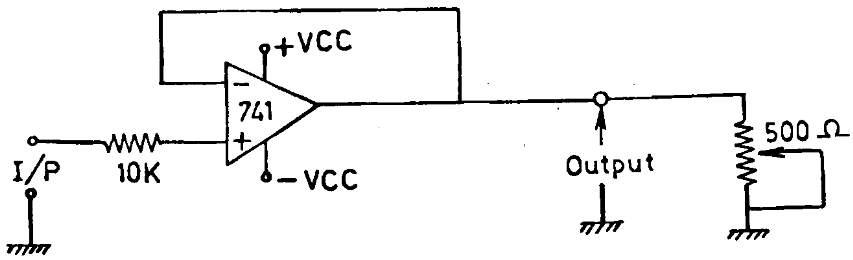
The OPAMP parameters such as input impedence, output impedence and input offset voltage are measured before and after irradiation. Also the gain frequency response of OPAMP is studied after electron irradiation. The circuit arrangement for measurement of above OPAMP parameters are shown in Figs. (4.8a,b,c) and frequency response in Fig. (4.9). The OPAMP 741 is irradiated at electron fluence in the range of $4x10^{12}$ to $4x10^{14}$ e^{-}/cm^{2}. An OPAMP (uA 741) is test using simple circuit having the theoretical close loop gain ten as shown in Fig. (4.9). However observed gain was less than ten. During the measurement of frequency response the voltage of input signal is kept constant equal to 1.5V.



(a) I/P offset Voltage



(b) I/P Impedence



(c) O/P Impedence

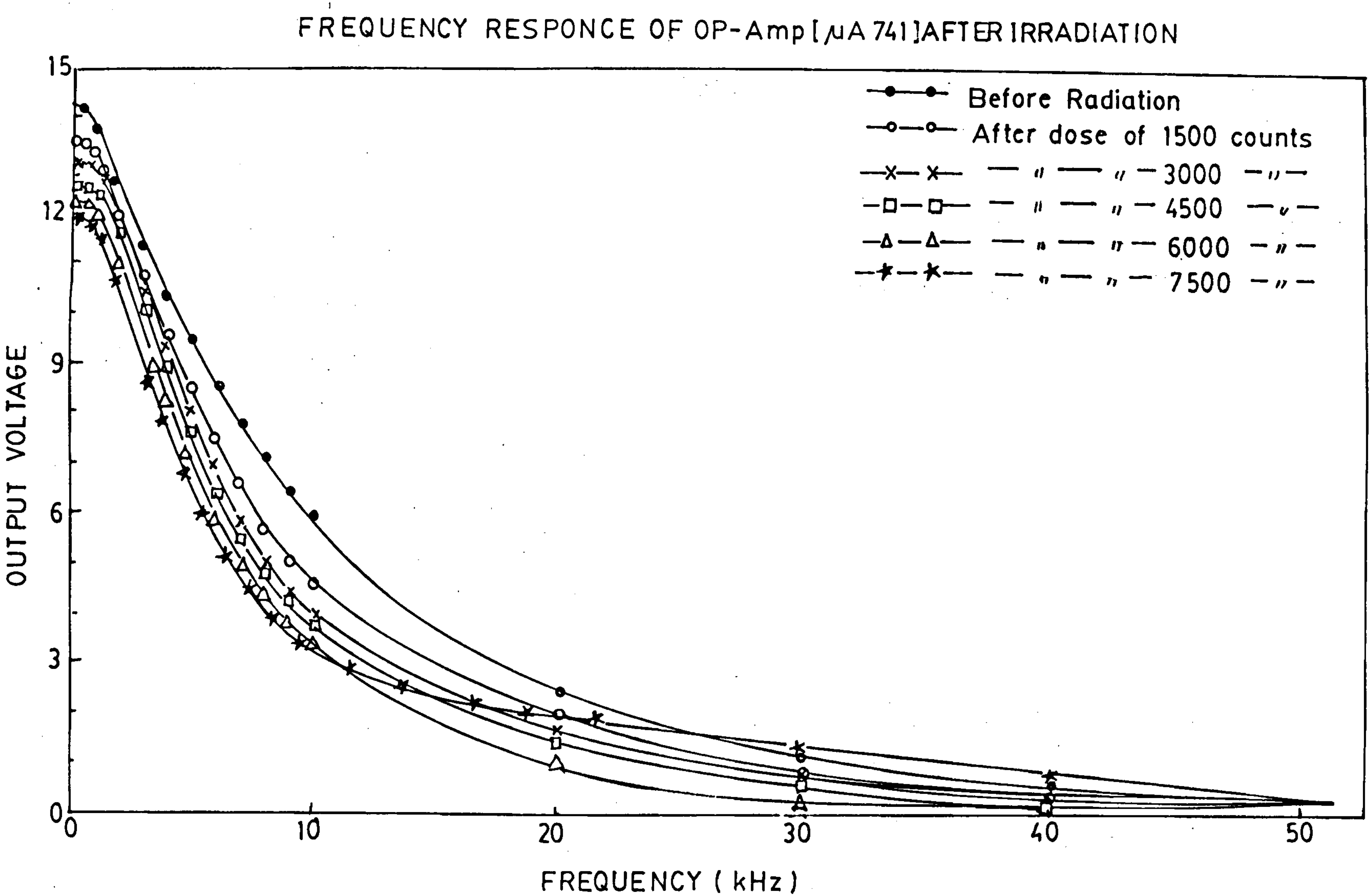
Fig:4·8 :– Measurement of O/P-AMP Parameter

4.5.3 Results and Discussion :

The change in the frequency response of OPAMP after and before irradiation is shown in Fig. (4.10). From the Fig. (4.10) the output of the amplifier for the fixed input of 1.5 V with varying frequency right from 100 Hz to 50 KHz has been studied. The gain of the amplifier shows continuous decrease with electron fluences. The change in OPAMP parameter before and after the irradiation is tabulated in Table (4.2). From (*) impedence of OPAMP have decreased while input offset voltage of OPAMP increased. These change in OPAMP can be take place due to displacement damage effect. The above observed effect can be attributed to OPAMP which shows complex recovery and degradation effect due to specific change in the gain of transistors.

According to CERN Laboratory II radiation group report (Ref.5) due to irradiation by high energy protron, the input offset voltage of OPAMP increased by factor of 125 and input bias current increased by factor of 27. Also the damage suffered by the Co^{60} -source input offset voltage increased by factor of 3 and input bias current increased by factor of 23. Similarly damage suffered by 1 MeV electron irradiation, the input impedence decreased by about 25% and output impedence decreased by about 42% of its pre-irradiated value. But input offset voltage increased four time of its pre-irradiated value. Whereas the gain of the amplifier increased four times of its pre-irradiated value where as gain of amplifier decreased by about 15% of its

(*) this table we observed that output and input



FREQUENCY RESPONCE OF OP-Amp [μA 741] AFTER IRRADIATION
Before Radiation
After dose of 1500 counts
— " — " — 3000 — " —
— " — " — 4500 — " —
— " — " — 6000 — " —
— " — " — 7500 — " —
OUTPUT VOLTAGE
FREQUENCY (kHz)
15
12
9
6
3
0
0
10
20
30
40
50

FIG - 4.10

Table 4.2 : OPAMP PARAMETERS AFTER IRRADIATION OF 1 MeV ELECTRON

Parameter	Before radiation	After Radiation				
		Dose I(1500) $3.8\times10^{13} e/cm^2$	Dose II(3000) $7.6\times10^{13} e/cm^2$	Dose III(4500) $11.4\times10^{13} e/cm^2$	Dose IV(6000) $15.2\times10^{13} e/cm^2$	Dose V(7500) $19.0\times10^{13} e/cm^2$
Input (R_i) Impedence (K-Ω)	210.00	198.20	175.90	171.25	167.85	162.50
Output (R_o) impedence (Ω)	111.00	85.10	75.00	70.25	68.87	64.40
Input offset voltage (mV) (e.s)	2.8	6.0	8.4	10.0	10.8	11.2

original value. Thus from above discussion we can say that after the irradiation the OPAMP shows permanent degradation effect in the parameters and frequency response.

4.6 TTL integrated circuit (TTL IC) :

4.6.1 Introduction :

Integrated circuits are usually classified as either monolithic or hybrid. The monolithic IC is a circuit in which all active and passive components are made in or on the same piece of silicon and interconnections between components are formed by deposition of metal films. The hybrid IC consists of discrete parts assembled in single can or package which are manually interconnected. Also new technology have been developed to manufacture the ICs known as Integrated Injection Logic (I^2L). The I^2L is a new high density, lower power bipolar LSI technology that gives major performance advantages over other bipolar and MOS/LSI technology. The purpose of this experiment is to see the radiation.

4.6.2 Experimental Procedure :

The TTL devices selected for this study include the SN 7400N NAND gate, SN 7473N Bistable multivibrator, SN 7493N four bit counter and 5N 74121N monostable multivibrator. In present work the parameters studied are (i) Output sink current (I_{out}) of NAND gate (IC 7400) (ii) Output pulse width (Δ t) of monostable (IC 74121) and (iii) Output frequency (f_o) of bistable multivibrator (IC 7473) and four bit counter (IC 7493). The

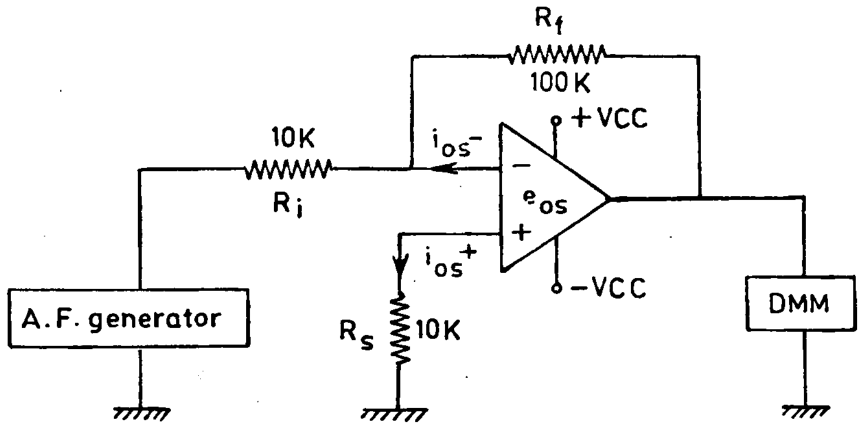


Fig: 4.9 – Frequency Response.

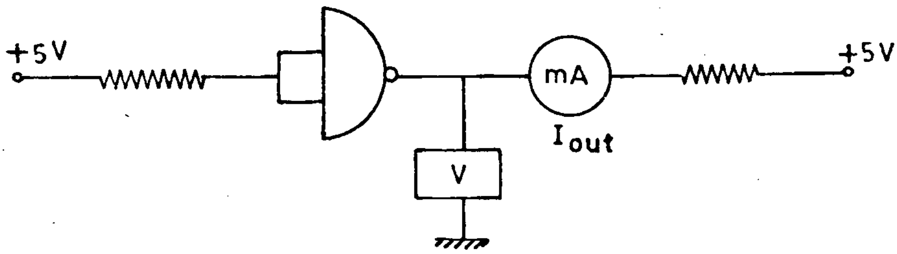


Fig: 4.11 – Output sink current of NAND gate SN 7400N.

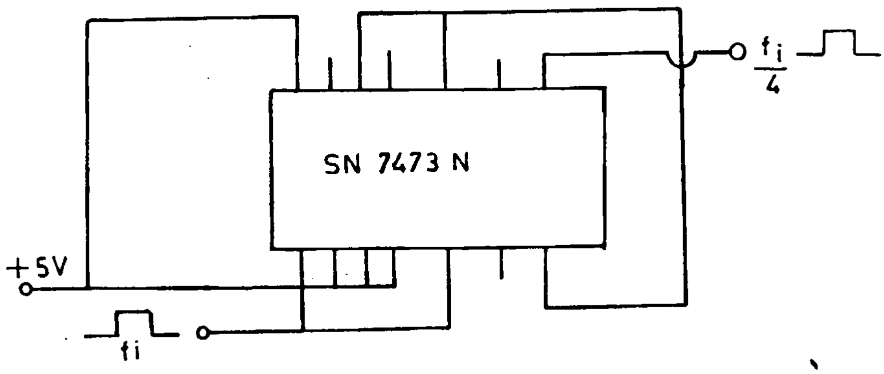
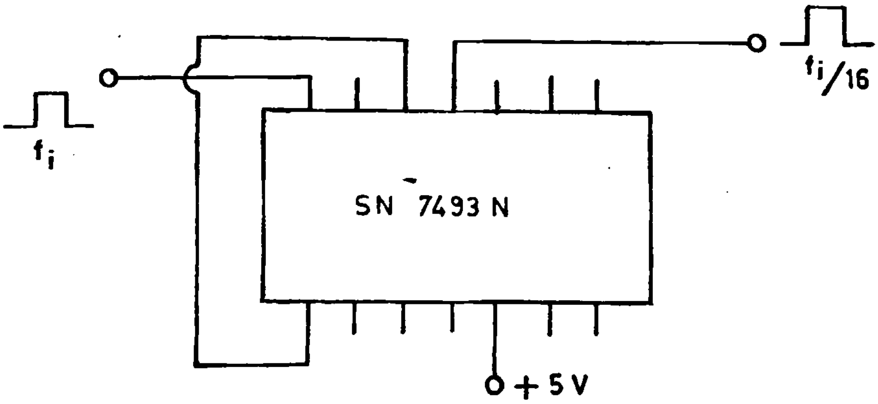


Fig: 4.12 – Frequency of Bistuble Multivibrutor



Fig·4·13 - Frequency of Four bit Counter

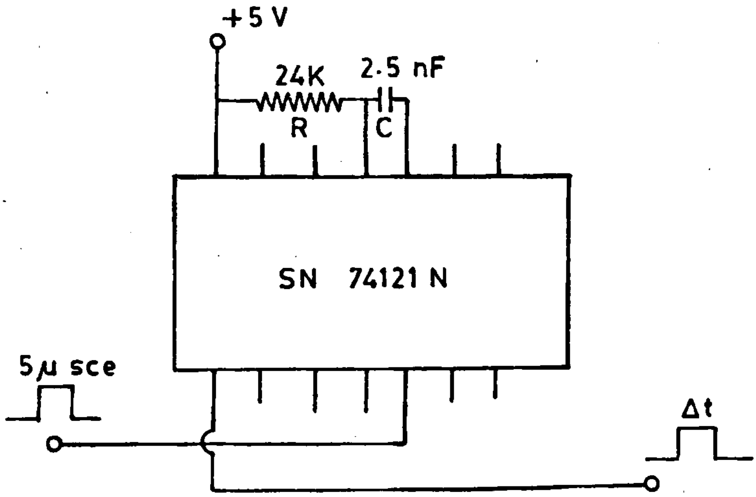


Fig:4·14 - Pulse Width of Monostable - Multivibrator.

diagrams of the circuits used for the measurement of above parameters are shown in Figs. (4.11 - 4.14).

4.6.3 Results and Discussion :

The change in output sink current of NAND gate verses electron fluence is shown in Fig. (4.15). From this Fig. I_{out} of NAND gate reduced by 40% of its pre-irradiated value at $5x10^{14}$ e^-/cm^2. The change in output pulse width of monostable multivibrator verses electron fluence is shown in Fig. (4.16). From this figure one can see that pulse width of monostable multivibrator increases upto $5x10^{14}$ e^-/cm^2 after that change in pulse width could not be recorded. Thus pulse width increased by 12% of its pre-irradiated at $5x10^{14}$ e^-/cm^2. But the frequency of bistable multivibrator and four bit counter remains unchanged upto 10^{15} e^-/cm^2. This is because the frequency of both is independent on the propogation delay, interface state charge and interface traps.

Thus the degradation in TTL IC performance can be understood when fundamental transistor characteristic, mobility and threshold voltage are known, which are related to the bias condition, oxide traps and interface state charge. Thus the subsequent change in IC performance is correlated directly to observe transistor performance. When we consider that timing is changes in IC during irradiation, at that time it is necessary to consider the bias state of transistor, because the charge build up is function of bias condition. The change in timing of IC depends on mobility degradation, interface state charge, oxide traps and threshold voltage.

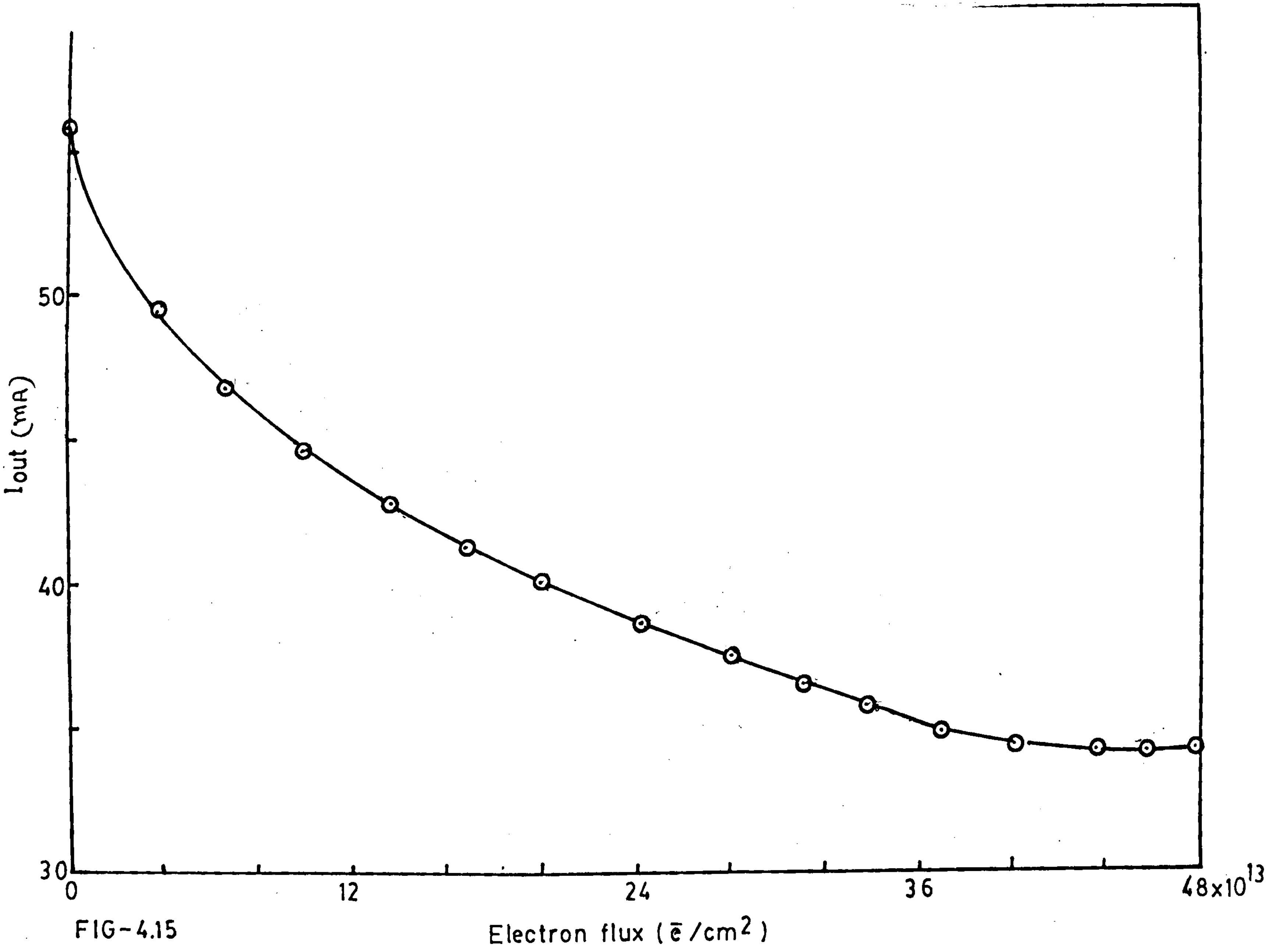


FIG-4.15

EFFECT OF IRRADIATION ON PULSE WIDTH OF MONOSTABLE MULTIVIBRATOR SN 74121 H USING 1 MeV ELECTRON

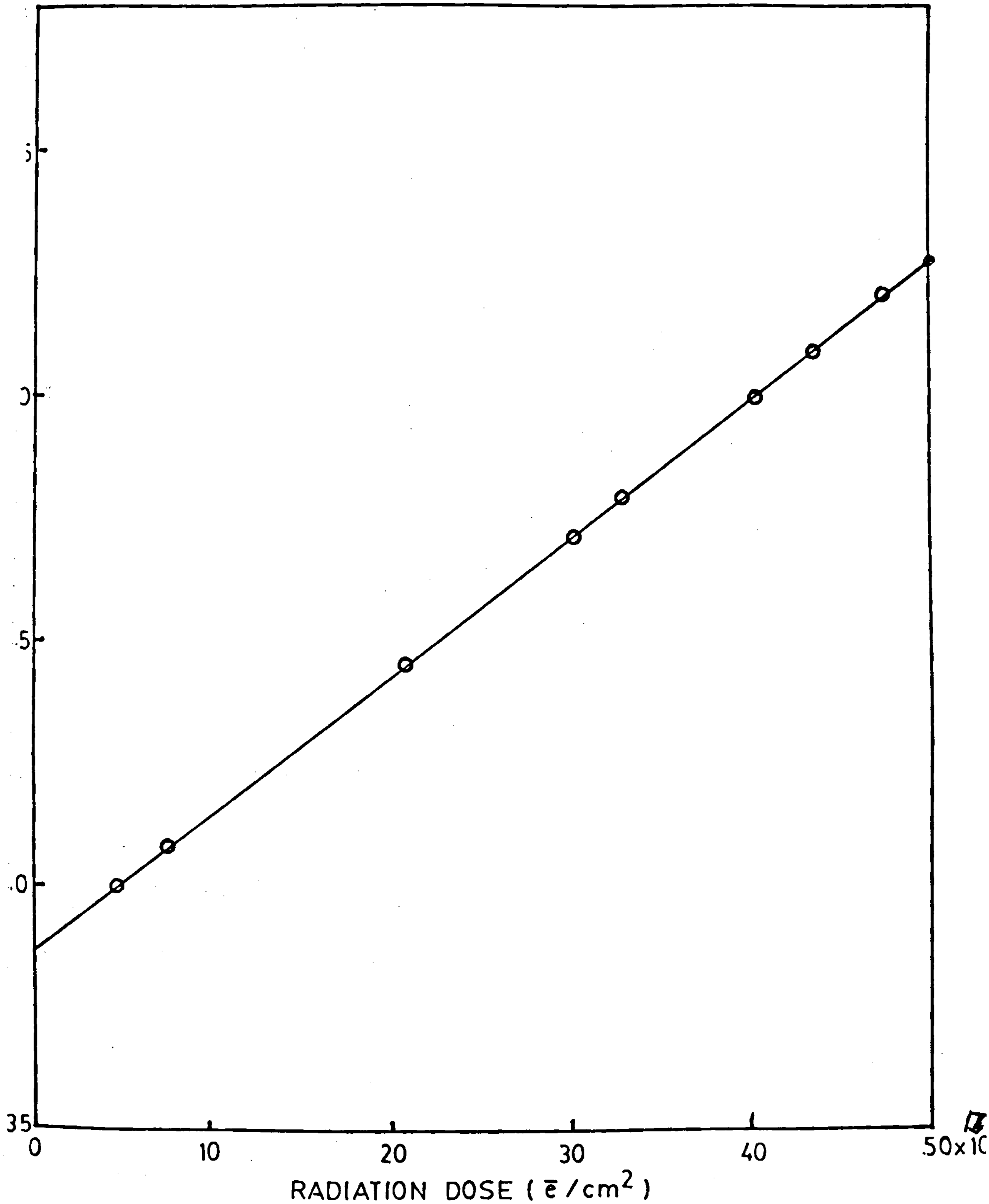


FIG-4.16

CHAPTER - V

TO DESIGN AND BUILT A PULSER CIRCUIT FOR THE MICROTRON

5.1 Introduction :

In Microtron electrons from a electron gun are injected in a microwave cavity. The microwave is excited by S band (2700 MHz to 3000 MHz) magnetron. The microwave power is fed in the cavity in pulse mode for duration of approximate two micro-seconds. When the voltage in cavity is develop to appropriate value, the electron cathode of the gun is also given negative voltage of 30 KV for duration two microseconds. In this way the electrons are injected in the cavity only when the cavity is excited. The gun modulator excite the magnetron with in term feeds power to microwave cavity where as the gun modulator provides negative pulse to cathode of electron gun. However using the common pulse circuit both gun modulator and magnetron modulator are trigger simultaneously. But the actual pulse going to gun modulator is delayed using delay line circuit. In the present system the pulse repetition rate used is 50 pps. As one tries to increase the pulse repitition rate the average output current increases. The author has therefore design and built one pulse circuit in which the pulse repetition rate can be varied from 40 pps to 120 pps. The circuit has been successfully tested on the present microtron circuit.

5.2 Details of pulser circuit :

The block diagram of the pulser circuit is shown in Fig.(5.1).

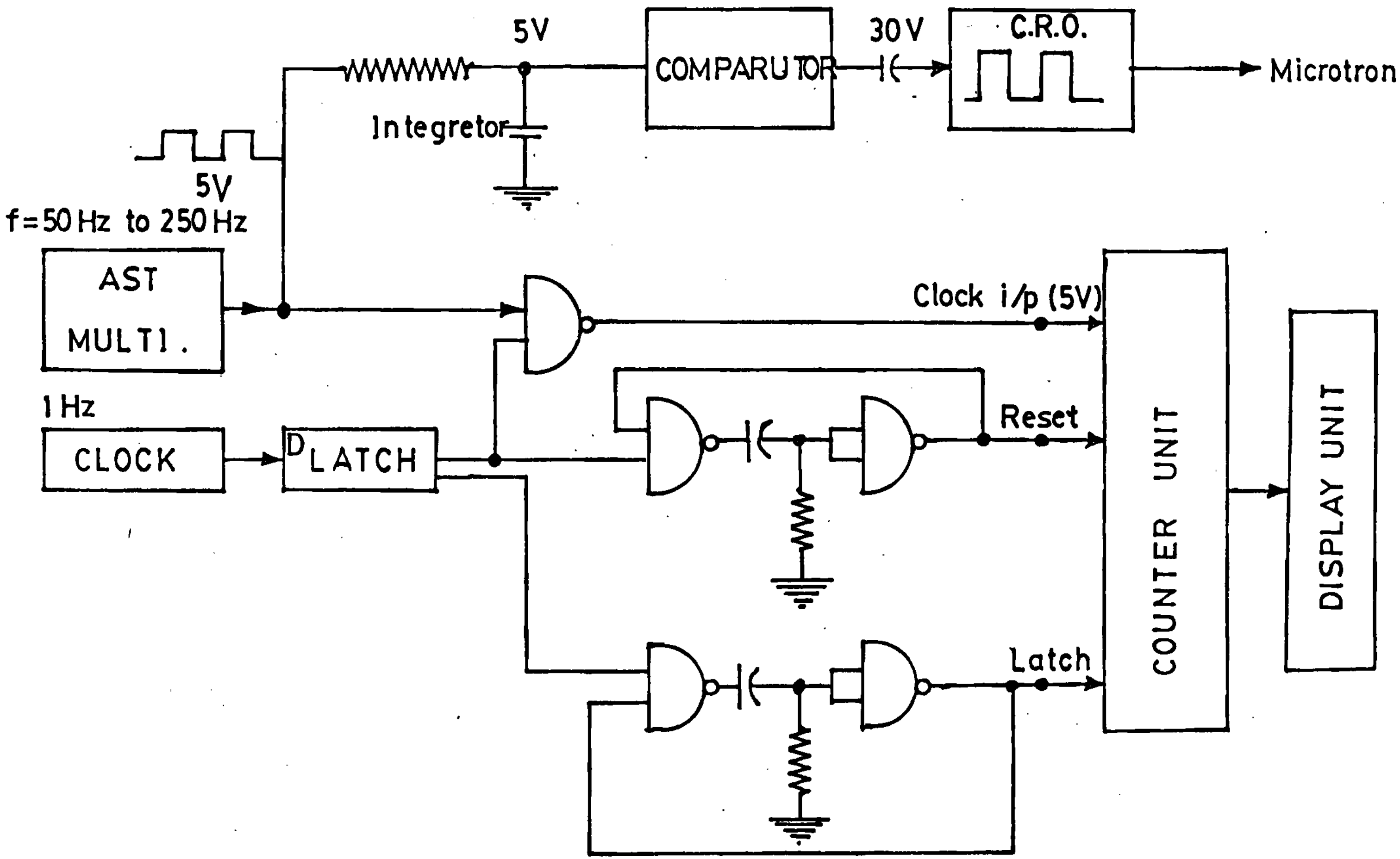


FIG - 5-1 CIRCUIT TO CONTROL THE REPETATION RATE OF MICROTRON

The pulse repitition rate control circuit consist astable multi-vibrator, 1 Hz clock, comparator and counter. On the front panel there is knob to adjust the frequency of clock to 1 Hz. The oscillator circuit is build by using IC 741 as in astable mode, whose frequency can be varies from 15 to 280 Hz. On the front there is frequency variable knob. With the help of comparator LM 324 we have increased the amplitude of oscillator upto 30 volts which is required to trigger gun and magnetron modulator. There are knobs separetly fixed to adjust the gain and input offset voltage of comparator.

Thus the use of pulser circuit is to trigger simultaneously the electron gun and the magnetron modulator. In present system the pulse repetition rate is 50 pps. As one tries to increase pulse repetition rate, the average output current increases. The average output current increases when we increases the frequency of the pulser circuit. In the Table (5.1) the change in frequency and counts per minute is tabulated. Thus from this table as frequency of pulser circuit increases corresponding count rate per minute increases, that will increases average output current. The pulser circuit with and without gain and offset adjustment is shown in Photograph (5.2). Also the pulser circuit which is fitted on the control panel of microtron is shown in Photograph (5.3) and the main parts of microtron are shown in Photograph (5.4).

PHOTO 5.2 PULSER CIRCUIT.

5.2.A * WITHOUT GAIN AND OFFSET ADJUSTMENT.

5.2.B * WITH GAIN AND OFFSET ADJUSTMENT.

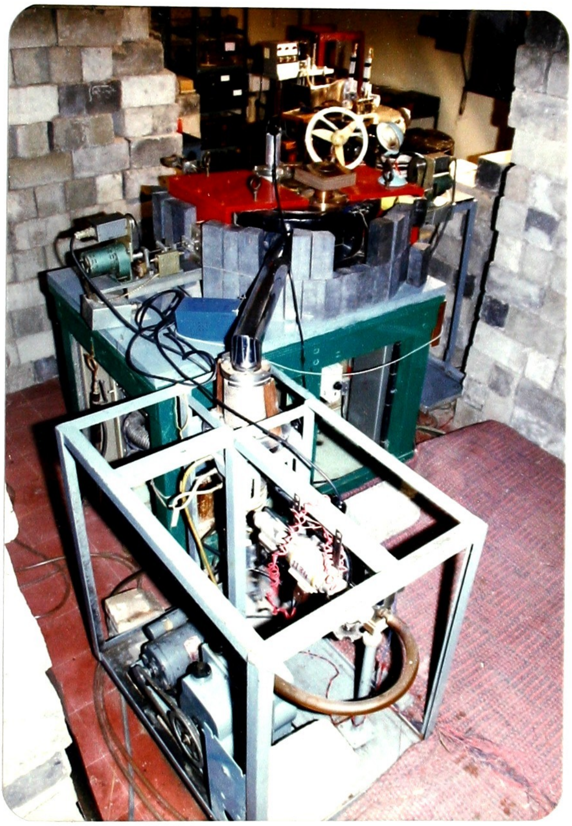


PHOTO - 5.4 MAIN PARTS OF PU MICROTRON.

PHOTO-5·3 CONTROL PANEL OF PU MICROTRON

WITH PULSER CIRCUIT.

Table 5.1

Frequency (Hz)	*Counts perminute
40	44
50	54
60	64
70	73
80	88
90	93
100	100
110	105
120	110

* 1 count = 6.3×10^{11} electrons.

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