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22EC201-ELECTRON DEVICES & CIRCUIT THEORY

UNIT-III

SPECIAL SEMICONDUCTOR DEVICES AND APPLICATIONS

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SYLLABUS

Tunnel diode, Vractor diode, UJT, SCR, DIAC, TRIAC,– Power BJT– Power MOSFET – DMOS – VMOS Optoelectronic Devices: Photoconductive sensors – Photoconductive cell – Photovoltaic sensors– Photo emissive sensors –Light emitters - Optocoupler.

INTRODUCTION

WHAT ARE POWER DEVICES???

- A power device is semiconductor device used as a switch or rectifier in power electronics (for example - switch-mode power supply). Such a device is also called a power device

INTRODUCTION

WHAT ARE DISPLAY DEVICES???

- A display device is an output device for presentation of information in **visual or tactile form**. When the input information that is supplied has an electrical signal the display is called an electronic display

- Example: CRT ,LCD,PLASMA

INTRODUCTION

WHAT IS THYRISTORS

- It is a 4 layer PN-PN device, which has 3 PN junctions.

2 SWITCHING STATES(acts as switch)

- ON STATE(Conducting state)
- OFF STATE(Non conducting state)

INTRODUCTION

- THYRISTOR TAXONOMY

UNI-DIRECTIONAL- Thyristors which conduct in forward direction alone are known as Uni-directional thyristors.

Scr

Lascr

Gto

INTRODUCTION

- THYRISTOR TAXONOMY
- BI-DIRECTIONAL-Thyristors which conduct both in forward and reverse direction are known as bi-directional thyristors.

Triac

Diac

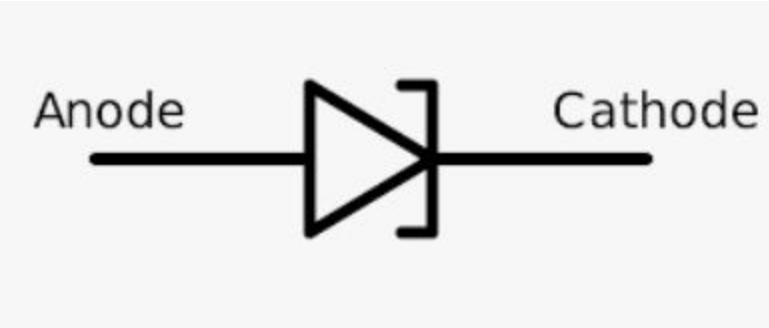
TUNNEL DIODE

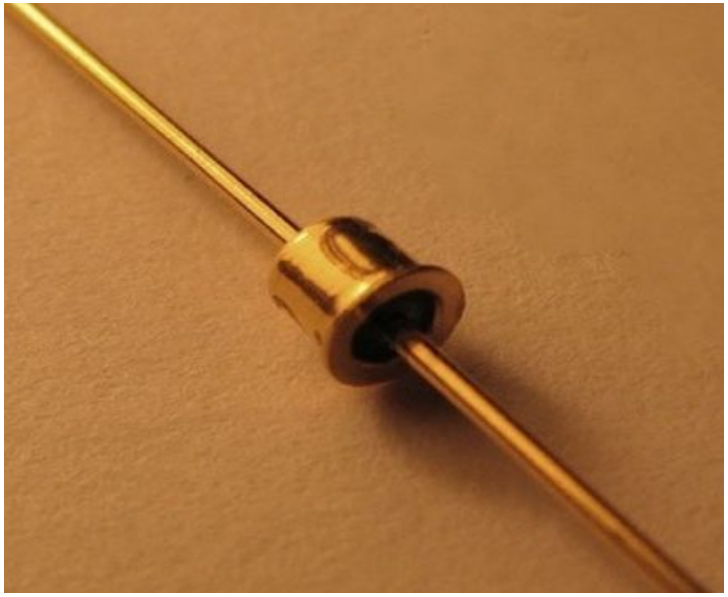
- Introduction
- Symbol
- Construction
- V-I Characteristics
- Energy level diagrams
- Equivalent circuit
- Ad’s & Dad’s
- Applications

Introduction

- Introduced by ESAKI in the year-1958.
- It exhibits negative resistance under low forward bias condition.
- It is heavily doped PN junction diode in which the electric current causes decreases as voltage increases.

Symbol





Construction

- Ordinary PN junction diode has impurity concentration of about 1 part in 10^8.
- With this, amount of doping width of depletion layer is of the order 5 Microns.
- Potential barriers restrains the flow of carriers from majority carrier side to minority carrier side.

Con..

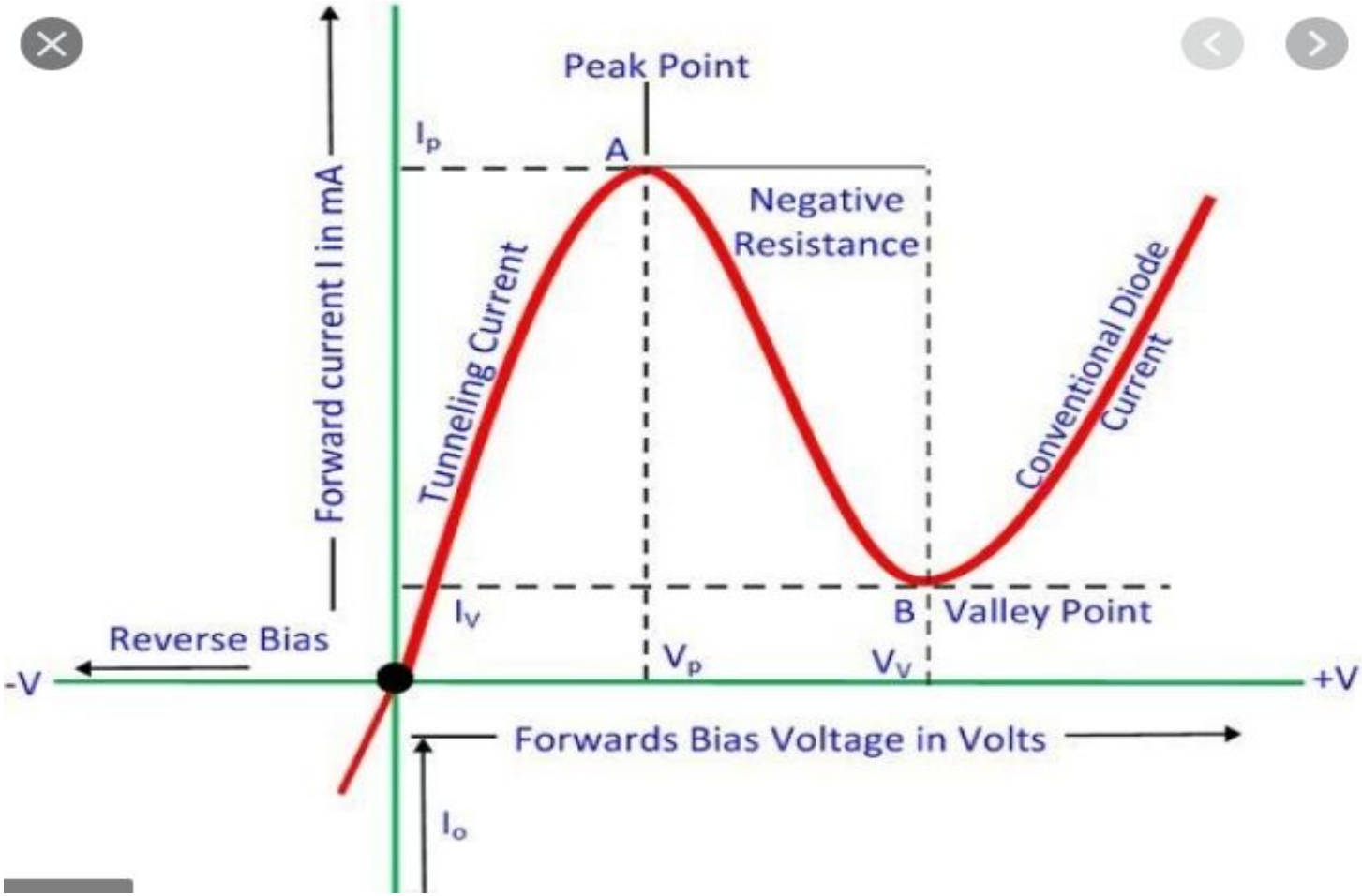
- If the device characteristics are completely changes. width of junction barrier varies inversely as the square root of the impurity concentration.
- Therefore reduced from 5 microns to less than 100 degrees A.(10^-8)
- Thickness is only about $1/50^{th}$ of the wavelength of visible light.

Con..

- For such thin potential energy barriers, the electrons will penetrate through junction rather than surrounding them.

- **The quantum mechanical behavior is referred to as tunneling & hence these high impurity density PN junction devices are called as TUNNEL DIODES.**

V-I Characteristics



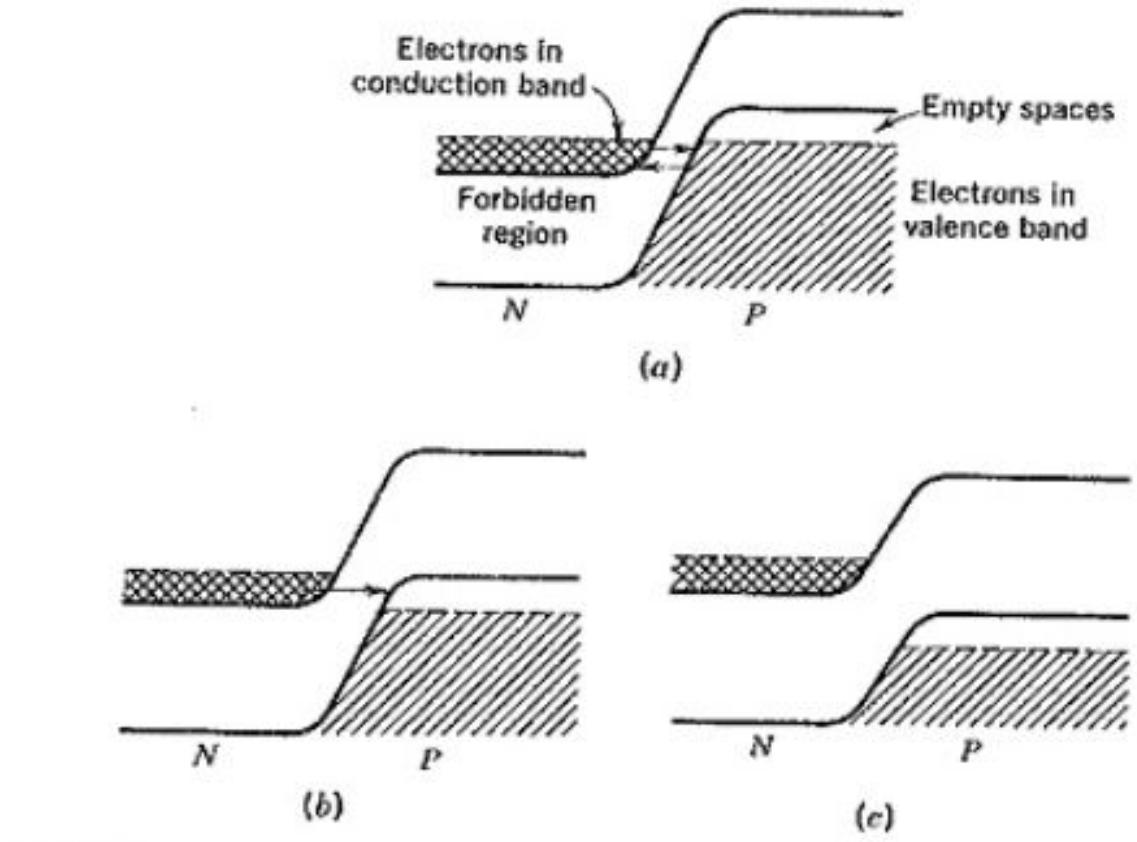
Con..

- I_F rises sharply as the applied voltage is increased.(where as in PN junction it rises slowly)
- I_R increase larger & compatable than other diodes(due to thickness of the diode)
- As forward bias is increased beyond POINT A,
- I_F drops & continuous until POINT B is reached-> called VALLEY VOLTAGE.

Con..

- At POINT B current(I) again starts increasing as bias is increased.
- Beyond this point characteristics resembles as ORDINARY DIODE.

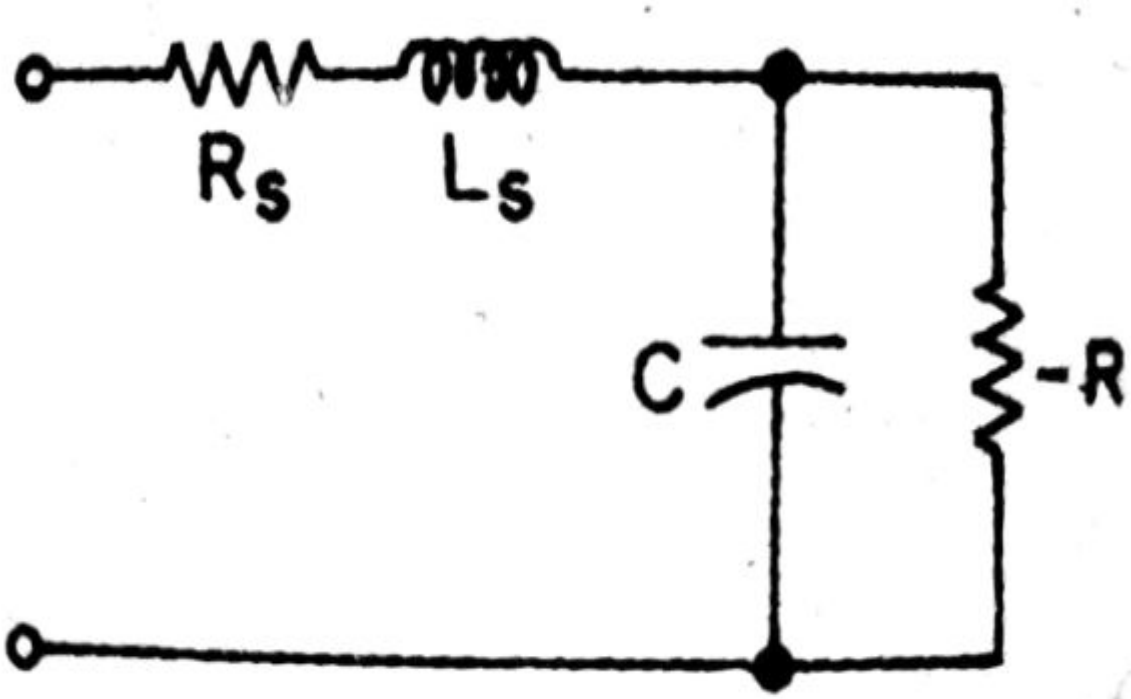
Energy level diagrams



Con..

- (i) When bias is zero dotted lines are at same height.
- (ii) When bias is applied-’P’ side is lowered compare to N-SIDE.
- Electrons in CB of N-SIDE see empty energy level on P-SIDE.
- WHEN FORWARD BIAS is raised beyond point ‘C’ then TUNNELING WILL DECREASE.

Equivalent circuit



Advantages

- LOW Noise
- High Speed
- Low power consumption
- Easy operation

Disadvantages

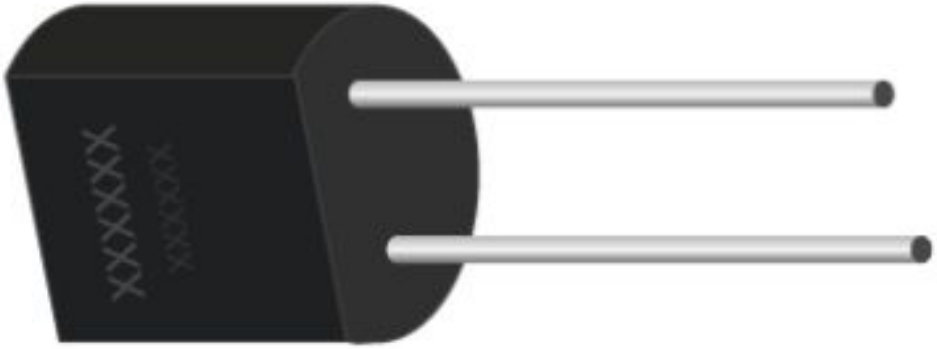
- NO ISOLATION BETWEEN INPUT AND OUTPUT CIRCUIT.

APPLICATIONS

- Used in Ultra high speed switch
- As amplifier
- Microwave oscillator
- Relaxation oscillator.

VARACTOR DIODE

- Invented by-ERIK KOLLBERG-1989, SWEDEN



Varactor Diode

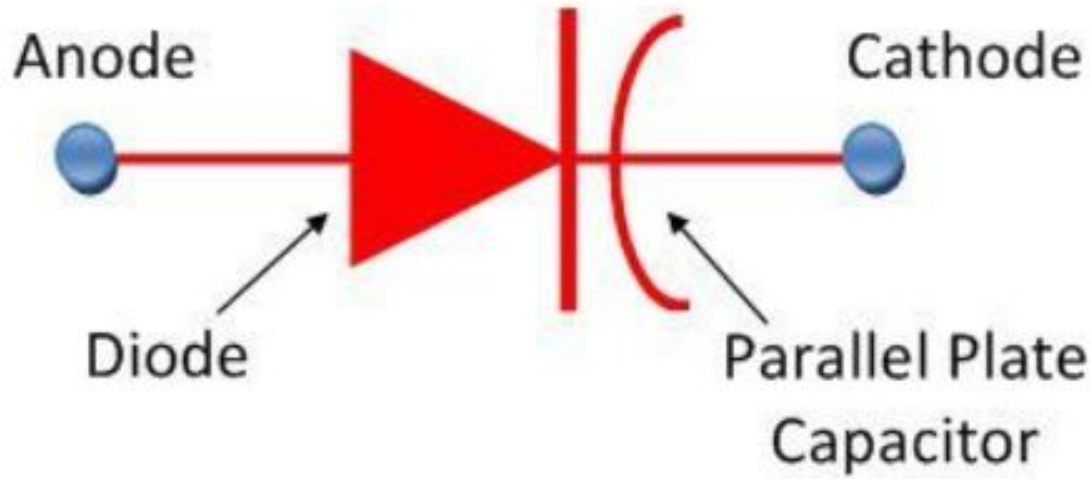
Highlights

- What is Varactor Diode
- Symbol
- Construction & Operation
- Characteristics
- Applications

What is Varactor Diode

- It is also called as VARICAP, TUNING (or) VOLTAGE VARIABLE CAPACITOR DIODE, VARIABLE CAPACITOR DIODE.
- It is a junction diode with small impurity dose at junction.
- Varactor diode are manufactured with Gallium Arsanide.

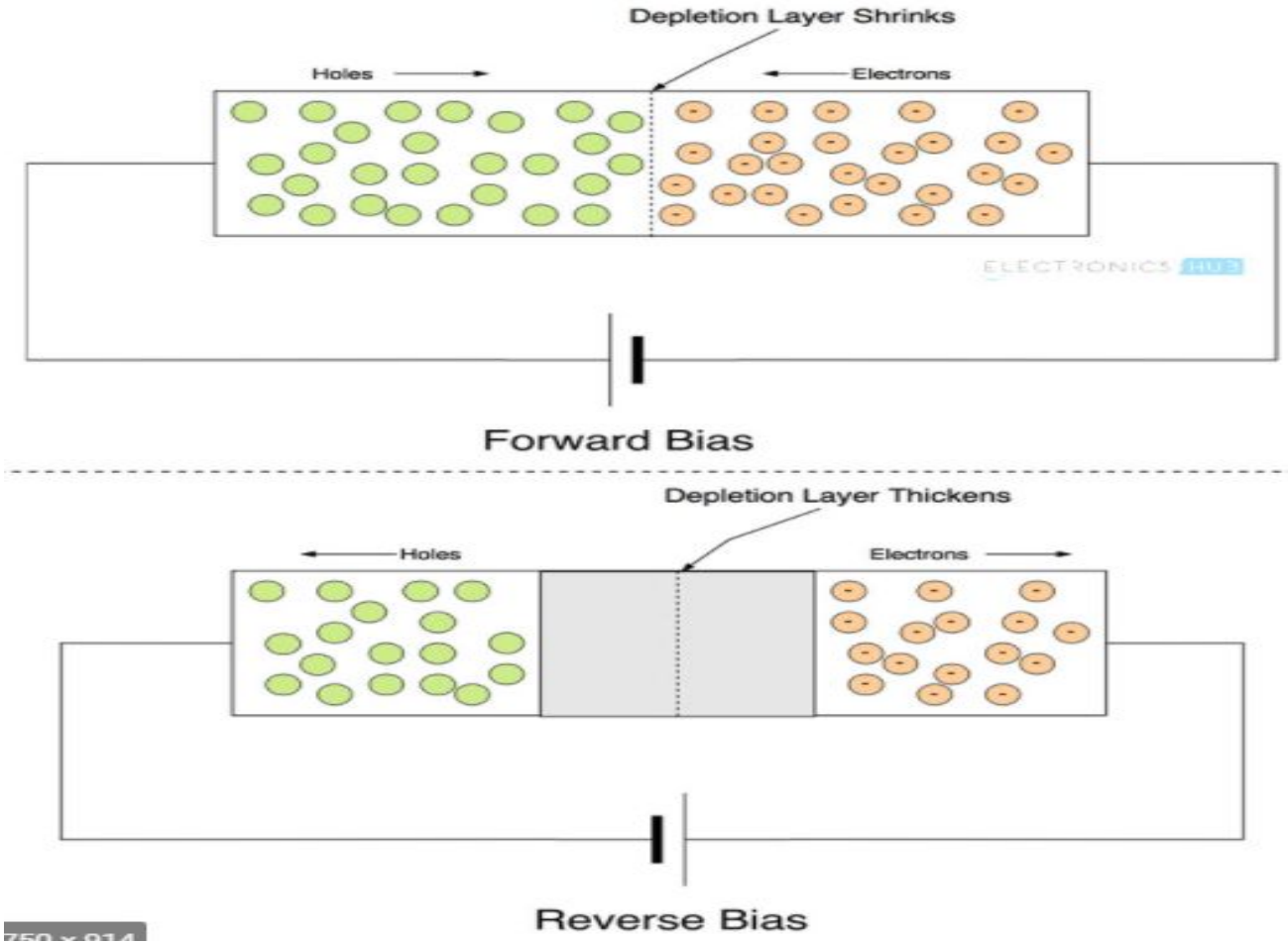
SYMBOL



Con..

- Its junction capacitance can be varied electronically.
- Mode of operation depends on the capacitor that exists at PN junction when element is REVERSE BIAS.

Con..


Depletion Layer Shrinks
Holes
Electrons
Forward Bias
Depletion Layer Thickens
Holes
Electrons
Reverse Bias

Con..

- Larger the REVERSE BIAS applied across the diode width of depletion layer becomes wider.

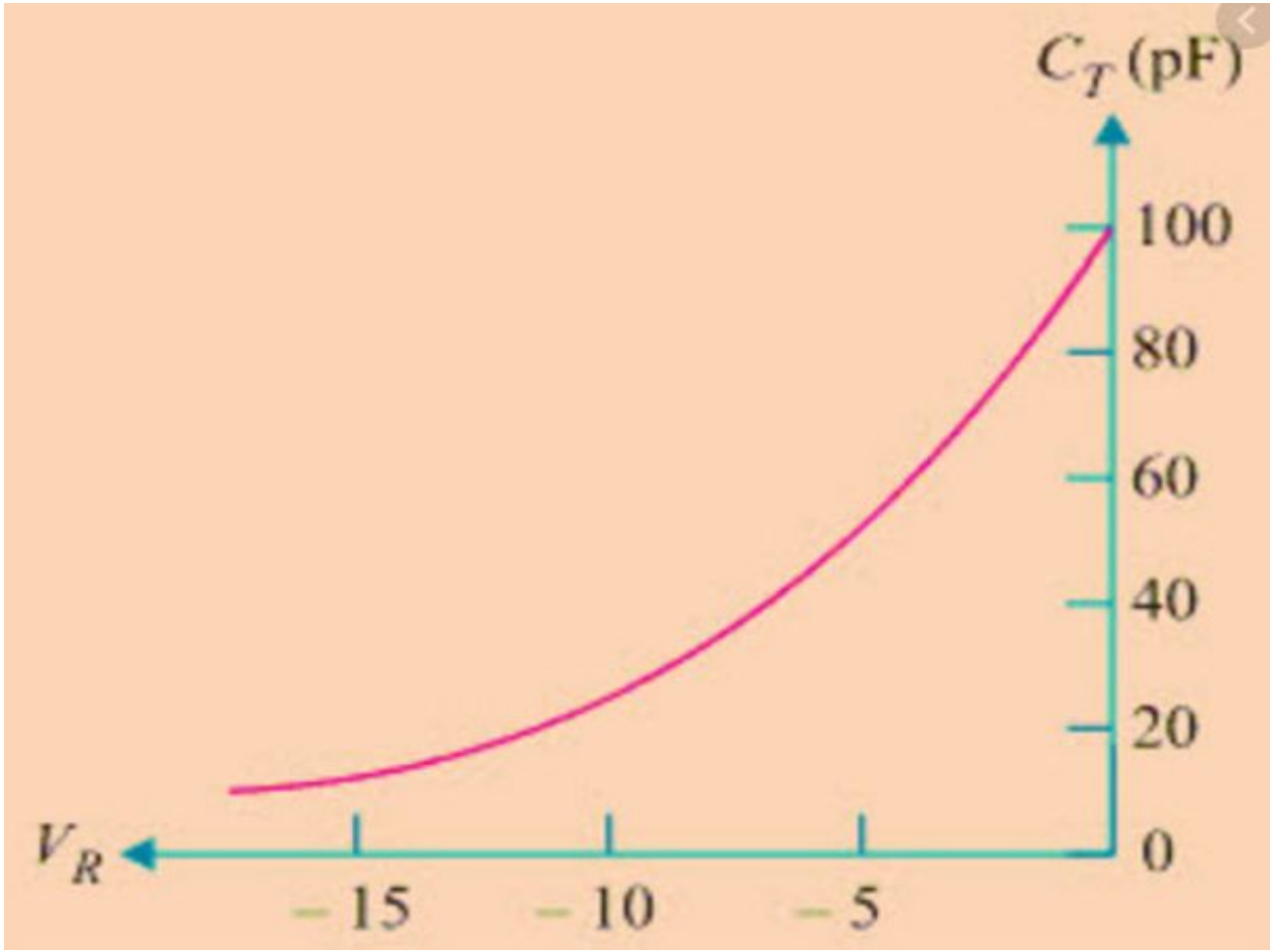
- Conversely, by decreasing REVERSE BIAS voltage depletion width becomes NARROW.

Transition Capacitance

- As the capacitance is inversely proportional to distance between plates, C_T=1/W. the C_T varies inversely with reverse voltage.

$$C_T = \frac{\epsilon A}{W}$$

CHARACTERISTICS



Con..

- Increase in REVERSE BIAS voltage will result in increase in depletion region width & Subsequent decrease in $C_{T.}$
- In terms of Applied voltage

$$C_T = \frac{K}{(V_T + V_R)\text{^}n}$$

N=1/2 for alloy junction

N=1/3 for diffused junction

Con..

- In terms of capacitance at zero bias condition C(0) as a function capacitance of V_R is

$$C_{T(VR)}=\frac{C(0)}{(1+\left|V_R/V_T\right|_{\wedge}n}$$

APPLICATIONS

- FM radio
- TV Rx
- BPF
- AFC
- RF phase shifter
- Photo detector

UJT(Double Based Diode)

- General information
- What is UJT
- Symbol, construction &equivalent circuit of UJT
- UJT operation
- V-I characteristics
- UJT relaxation oscillator
- Applications

UJT

General information

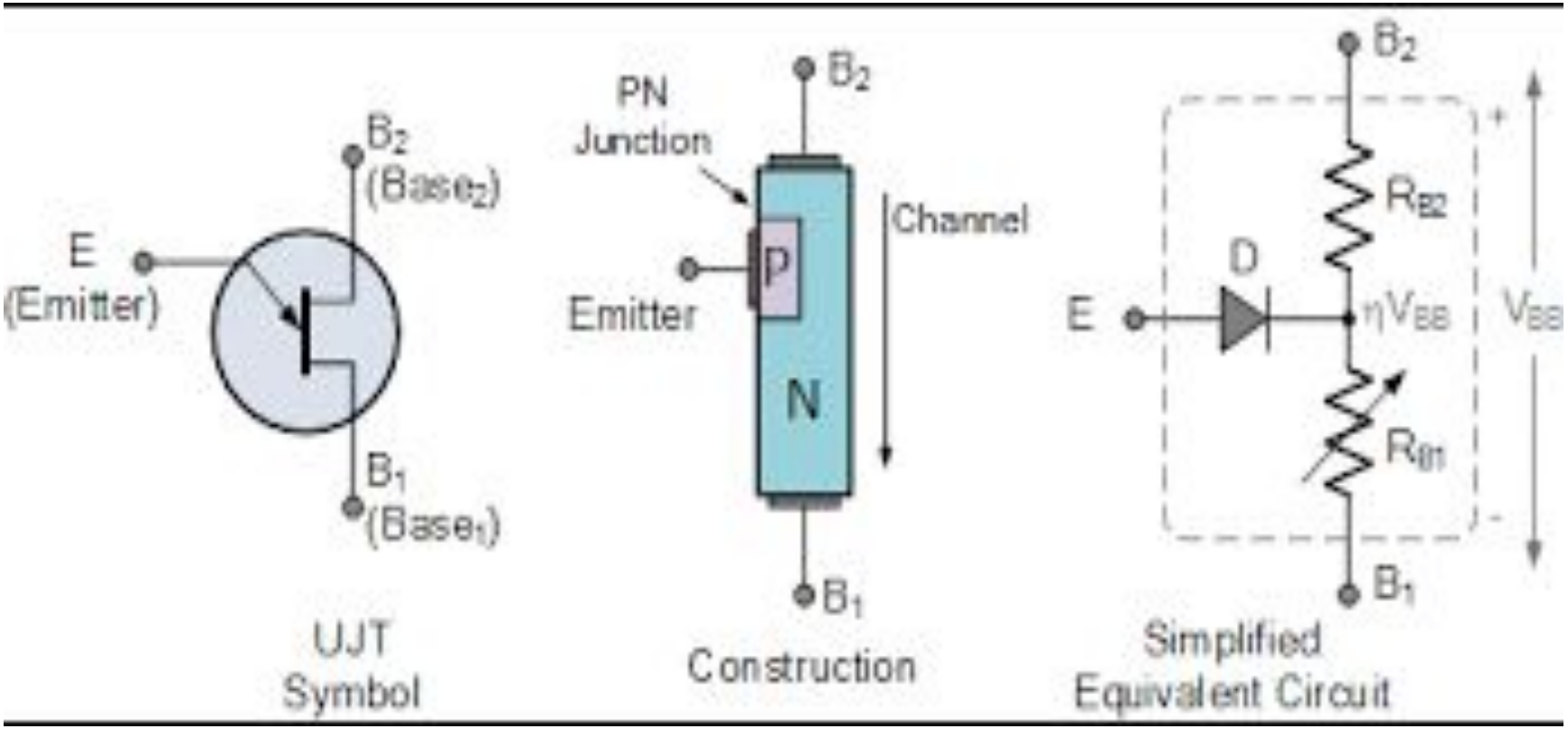
- Invented by-Generic electric-1957

WHAT IS UJT

- It is a 3 terminal semiconductor switching device.
- 1 PN junction
- 3 leads
- It is referred to as Uni junction transistor

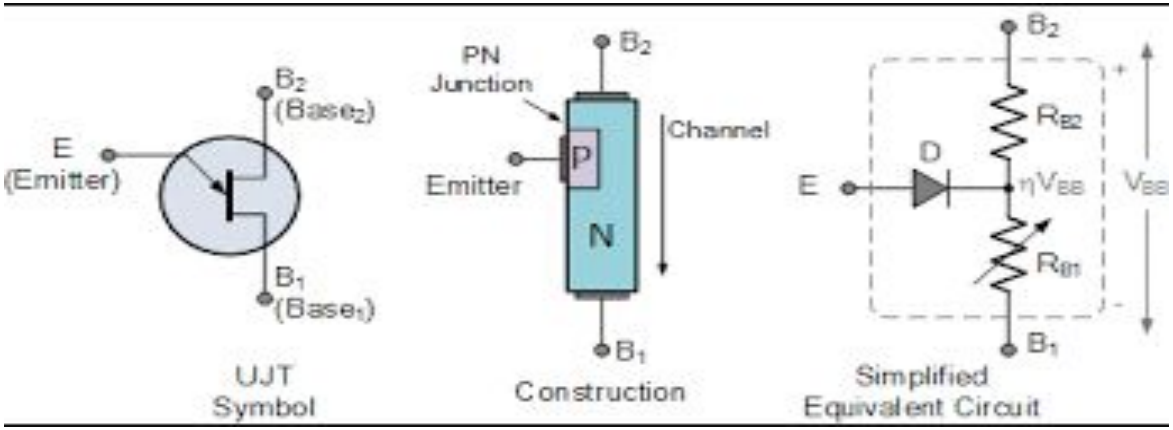
UJT

- SYMBOL, CONSTRUCTION& EQUIVALENT CIRCUIT.

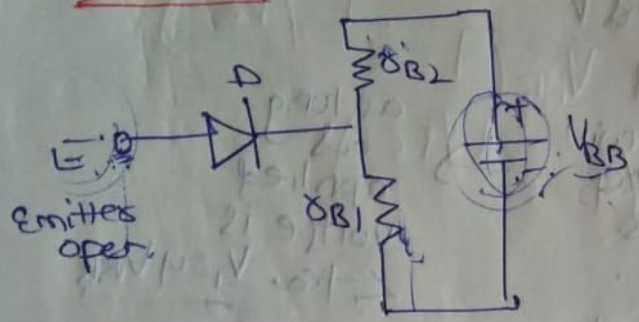


CONSTRUCTION

- It consists of **lightly doped N-Type silicon bar** with **heavily doped P-Type material** alloyed to its one side closer to base B2 for producing single PN junction.
- In UJT the 3 terminals are labelled as EMITTER, BASE(B2) & BASE (B1).



INTRINSIC STANDOFF RATIO



→ with Emitter open, V_{BB} is applied b/w 2 bases (B2 & B1)

→ Voltage divides across resistance r_{B1} & r_{B2}.

Voltage drop across r_{B1} is $V_1 = \eta V_{BB}$ (intrinsic standoff ratio)

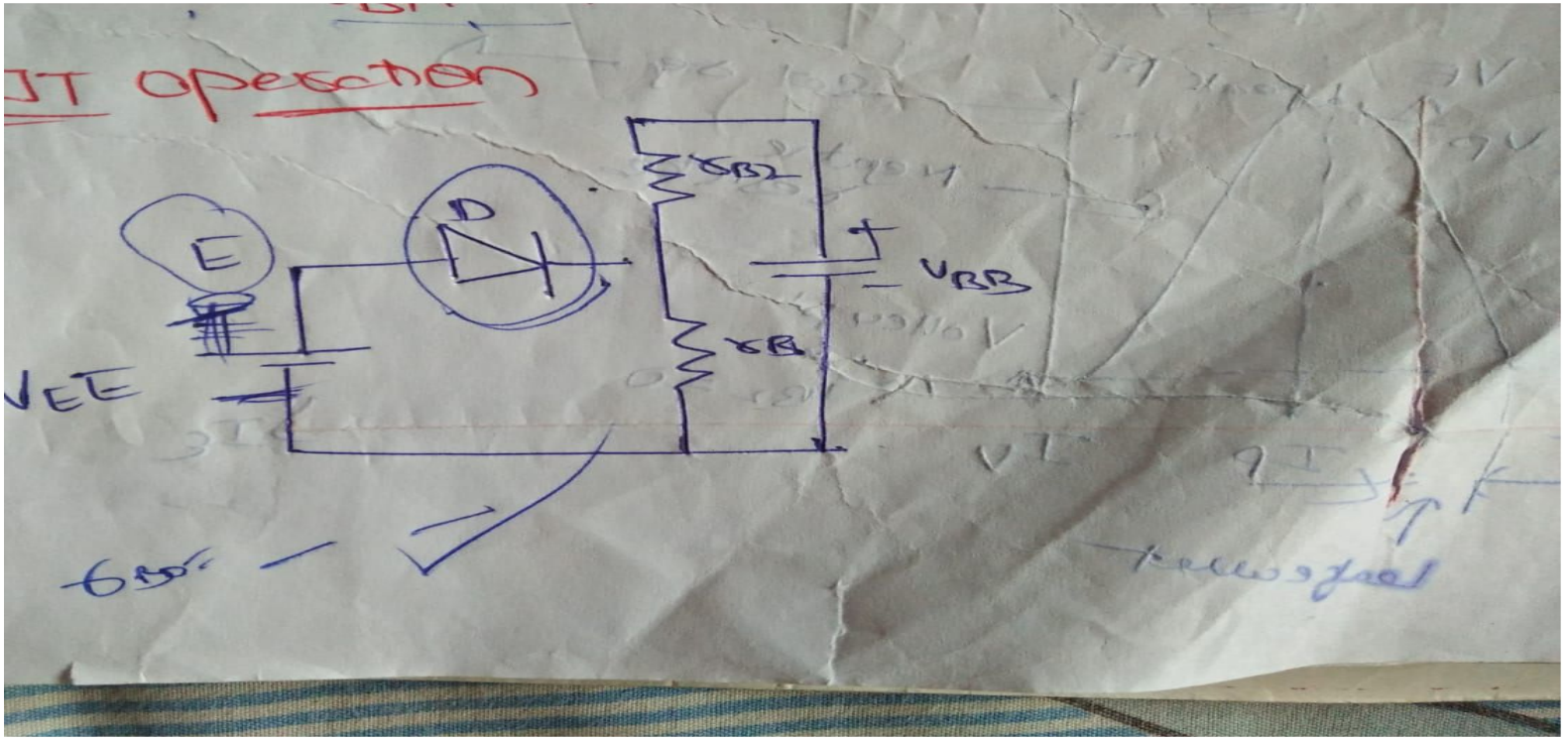
$$\eta = \frac{r_{B1}}{r_{B1} + r_{B2}}$$

(or)

$$\eta = \frac{r_{B1}}{r_{BB}}$$ ✓

$$\therefore V_1 = \frac{r_{B1}}{r_{B1} + r_{B2}} \cdot V_{BB} \qquad \because V_{BB} = \frac{r_{B1}}{r_{BB}} \cdot V_{BB}$$

UJT OPERATION



CON..

$$VRB1 = \frac{RB1}{RB1 + RB2} * VBB$$

* Emitter diode (D) by reverse biased across RB, I_E is cut off.
* but small leakage current flows from B_2 to emitter due to minority carriers
* if +ve voltage (VEE) applied to emitter → PN will be RB → as long as applied voltage is < ηV_{BB}
* if V_{EE} exceeds V_1 → diode FB because
* As Emitter voltage exceeds $(V_1 + V_D)$ i.e $(\eta V_{BB} + V_D)$ → diode conducts → I_E flows

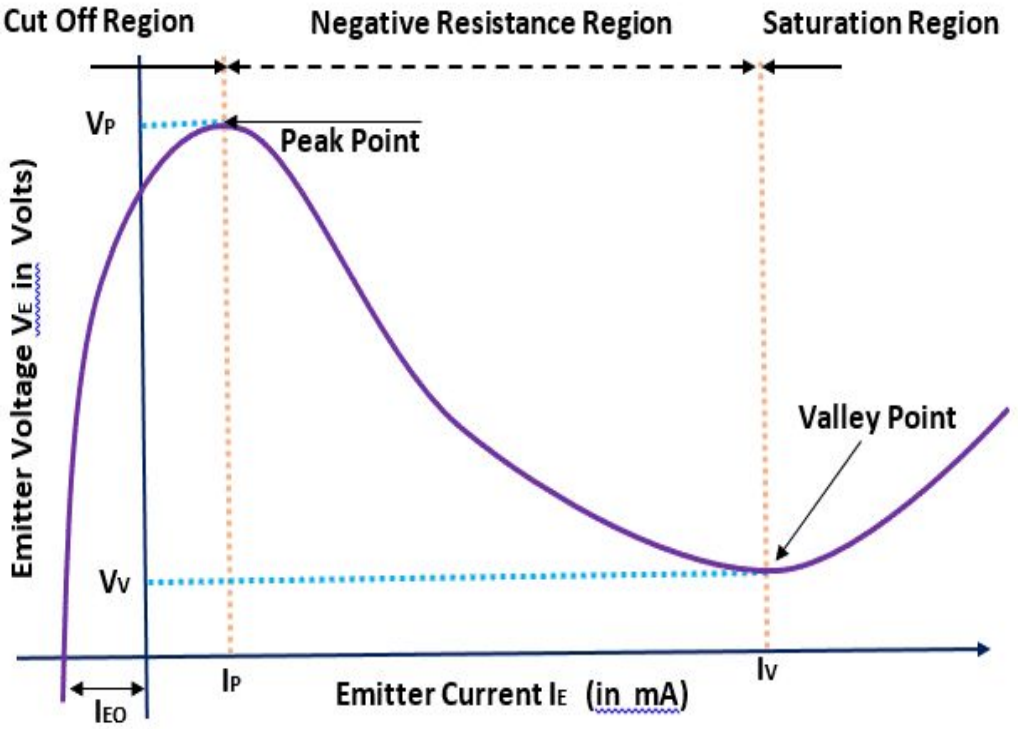
pt to pt voltage

Value of emitter voltage which causes the diode to conduct is called pt to pt voltage (V_P)

$$V_P = \eta V_{BB} + V_D$$

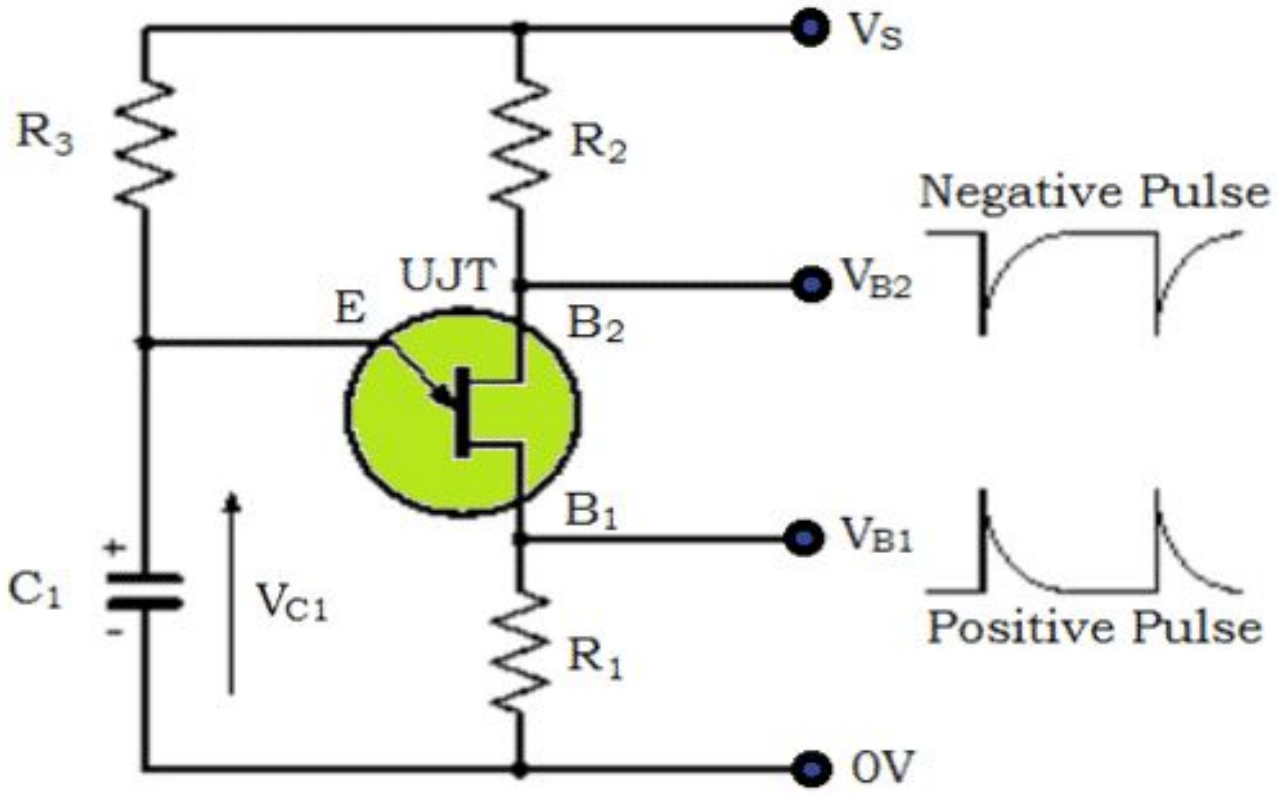
Characteristics Curve of Unijunction Transistor (UJT)

- The characteristics of Unijunction Transistor (UJT) can be explained by three parameters:
- Cutoff
- *Negative Resistance*
- *Saturation*



UJT

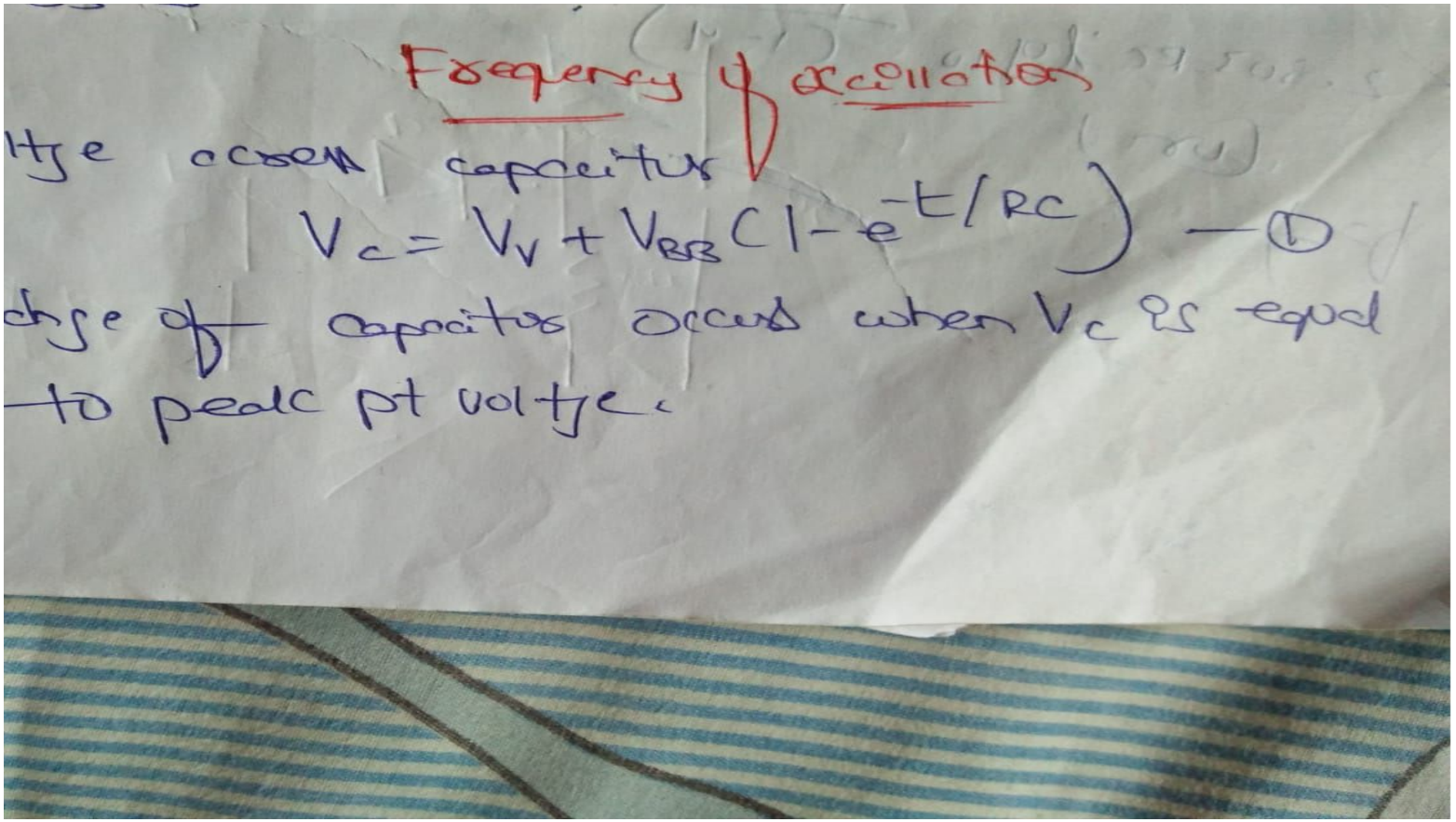
- UJT RELAXATION OSCILLATOR



UJT

- UJT as relaxation oscillator consists of UJT & capacitor ‘C’.
- Which is charged through ‘R’ as supply voltage is **switched ON.**

derivation



$V_p = V_D + \eta V_{BB}$ — (2)

i.e $V_p = V_c$

Sub (2) in (1)

$$V_D + \eta V_{BB} = V_v + V_{BB}(1 - e^{-t/RC})$$

$$\eta V_{BB} = V_{BB}(1 - e^{-t/RC})$$

$$e^{-t/RC} = 1 - \eta$$

taking log on both sides

$$\ln(e^{-t/RC}) = \ln(1-\eta)$$

$$\frac{-t}{RC} = \ln(1-\eta)$$

$$t = -RC \ln(1-\eta)$$

$$t = RC \ln(1-\eta)^{-1}$$

(or)

$$t = RC \ln \frac{1}{1-\eta}$$ (13)

$$t = 2.303\, RC \log_{10} \frac{1}{(1-\eta)}$$

(or)

$$\eta = \frac{1}{7}$$

Applications of Uni junction Transistor (UJT)

The Uni junction Transistor can be employed in variety of applications such as:

- Switching Device
- Triggering Device for Triacs and SCR's
- Timing Circuits
- For phase control
- In saw tooth generators
- In simple relaxation oscillators

TRIAC

OUTLINE

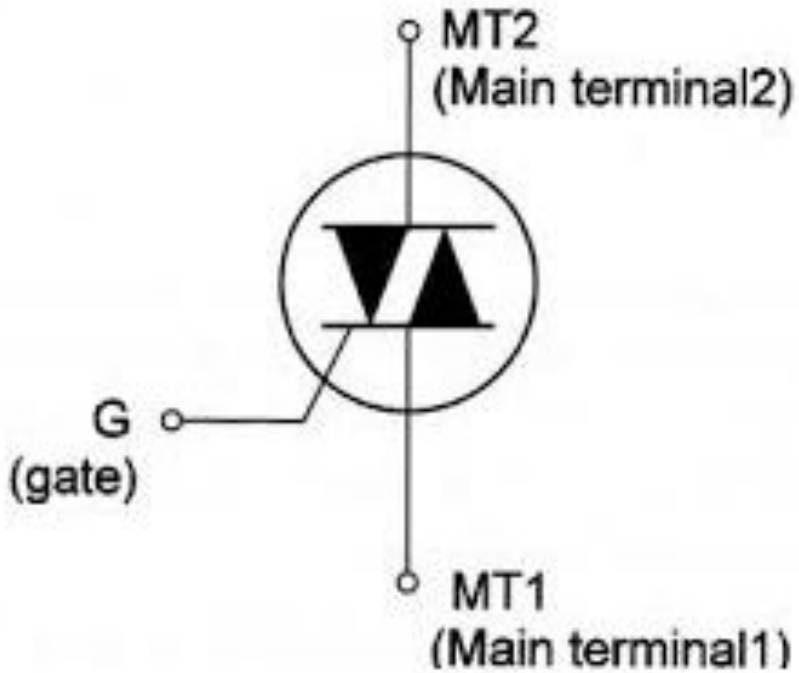
- GENERAL INFORMATION
- SYMBOL
- CONSTRUCTION
- EQUIVALENT CIRCUIT
- OPERATION
- V-I CHARACTERISTICS
- APPLICATIONS

GENERAL INFORMATION

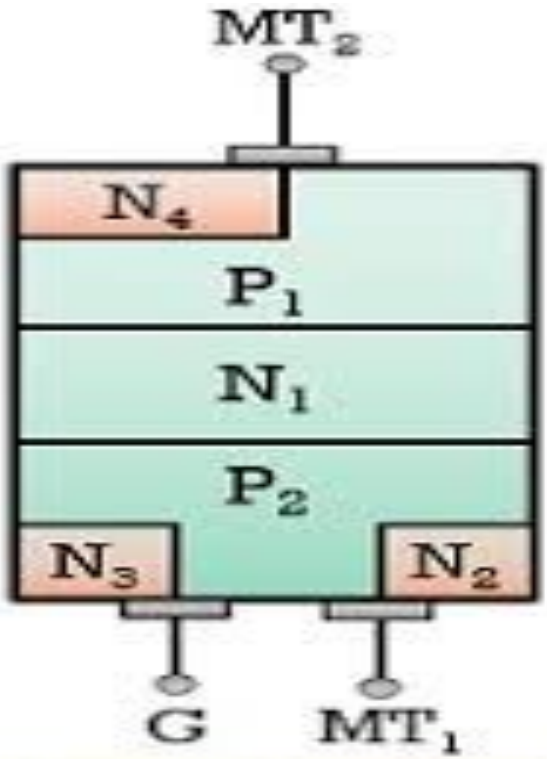
- Bill Gutzwiller- invented TRIAC
- (1957-1963)-General Electric.

SYMBOL

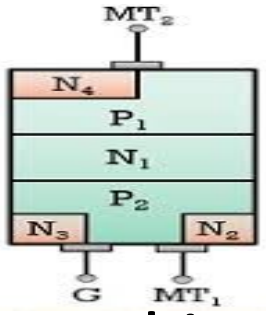
TRIODE A.C SWITCH



COSTRUCTION



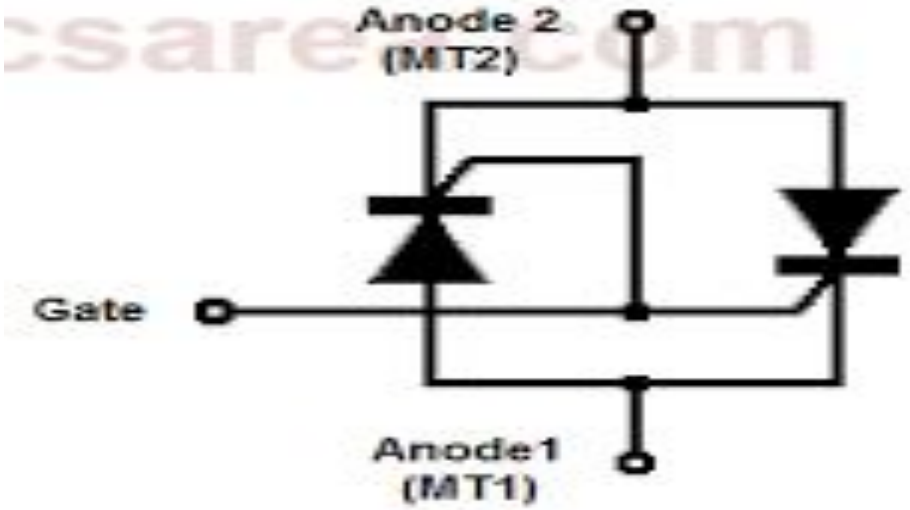
TRIAC



- TRIAC behaves like 2 SCR's connected in parallel. but opposite in directions with a common gate terminal.
- TRIAC consists of two 4 layers switches in parallel. These switches are **P1 N1 P2 N2** &**P2 N1 P1 N4.**
- TRIAC has 2 main terminals MT1 & MT2(main terminal) and one GATE terminal 'G'.

TRIAC

- EQUIVALENT CIRCUIT



Triac equivalent circuit

TRIAC

OPERATION

WHEN GATE (+VE)

(i)MT2(+ve) & G(+ve)

- Operation of TRIAC is identical to SCR.
- Current flow s through **P1 N1 P2 N2** (from MT2 to MT1)

(ii) MT2(-ve) & G (+ve)

- Current flows through **P2 N1 P1 N4** from MT1 to MT2.

TRIAC

WHEN GATE IS (-ve)

(i) MT2(+ve) & G(-ve)

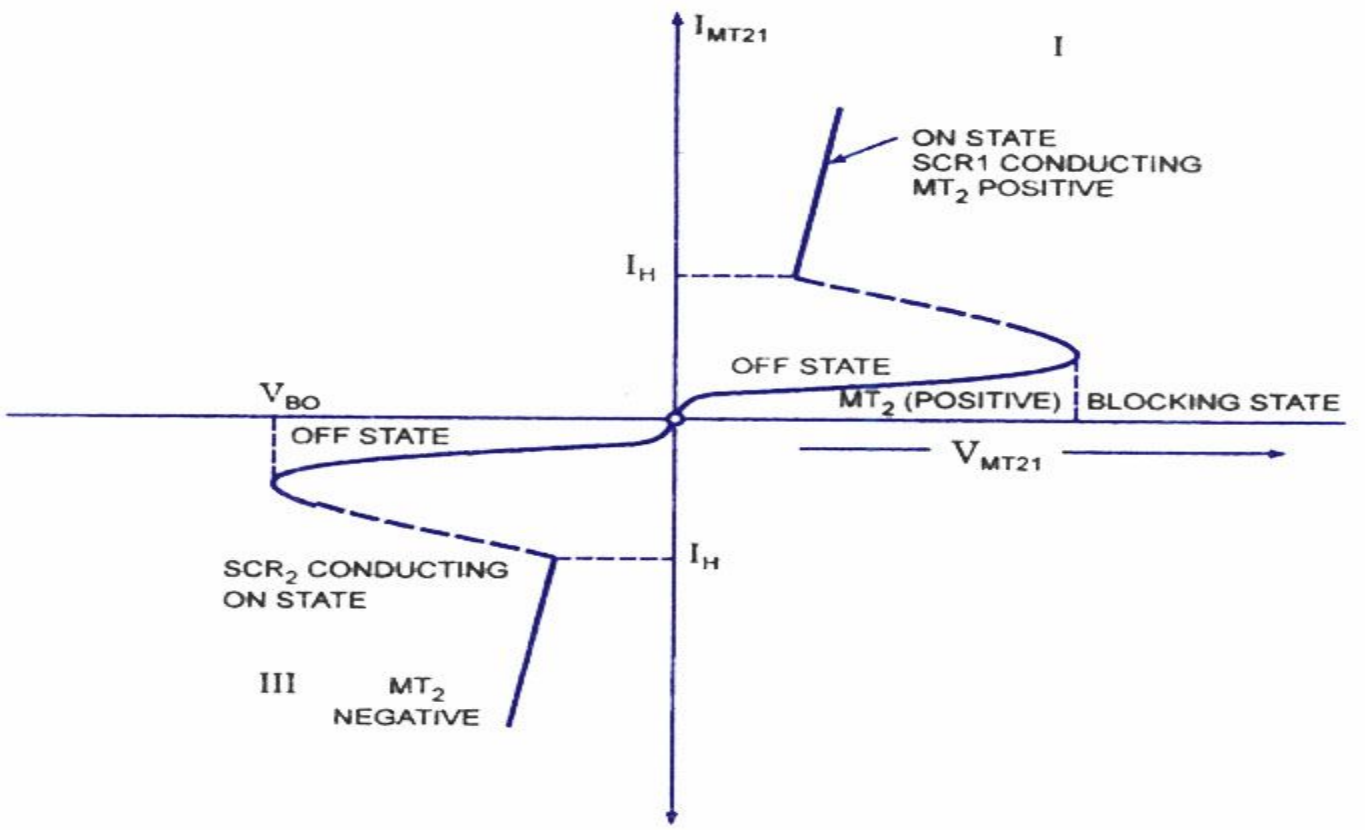
- Current flows through **P1 N1 P2 N2** from MT2 to MT1.
- This mode less efficient than mode l but better than MODE 2.

(ii)MT2 (-ve) & G (+ve)

- Current flows through **P2 N1 P1 N4** from MT1 to MT2.
- Slightly less efficient model.

TRIAC

- V-I CHARACTERISTICS



V-I Characteristic of a Triac

TRIAC

APPLICAIONS

- Phase control
- Motor speed control
- Heater control

DIAC

OUTLINE

- GENERAL INFORMATION
- SYMBOL
- CONSTRUCTION
- EQUIVALENT CIRCUIT
- OPERATION
- V-I CHARACTERISTICS
- APPLICATIONS

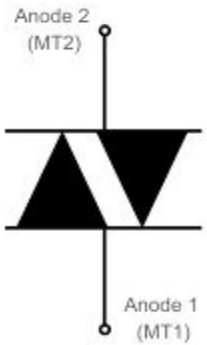
DIAC

GENERAL INFORMATION

- Concept developed by Bill Gutzwiller and built by Gordon Hall (GE)(1957).

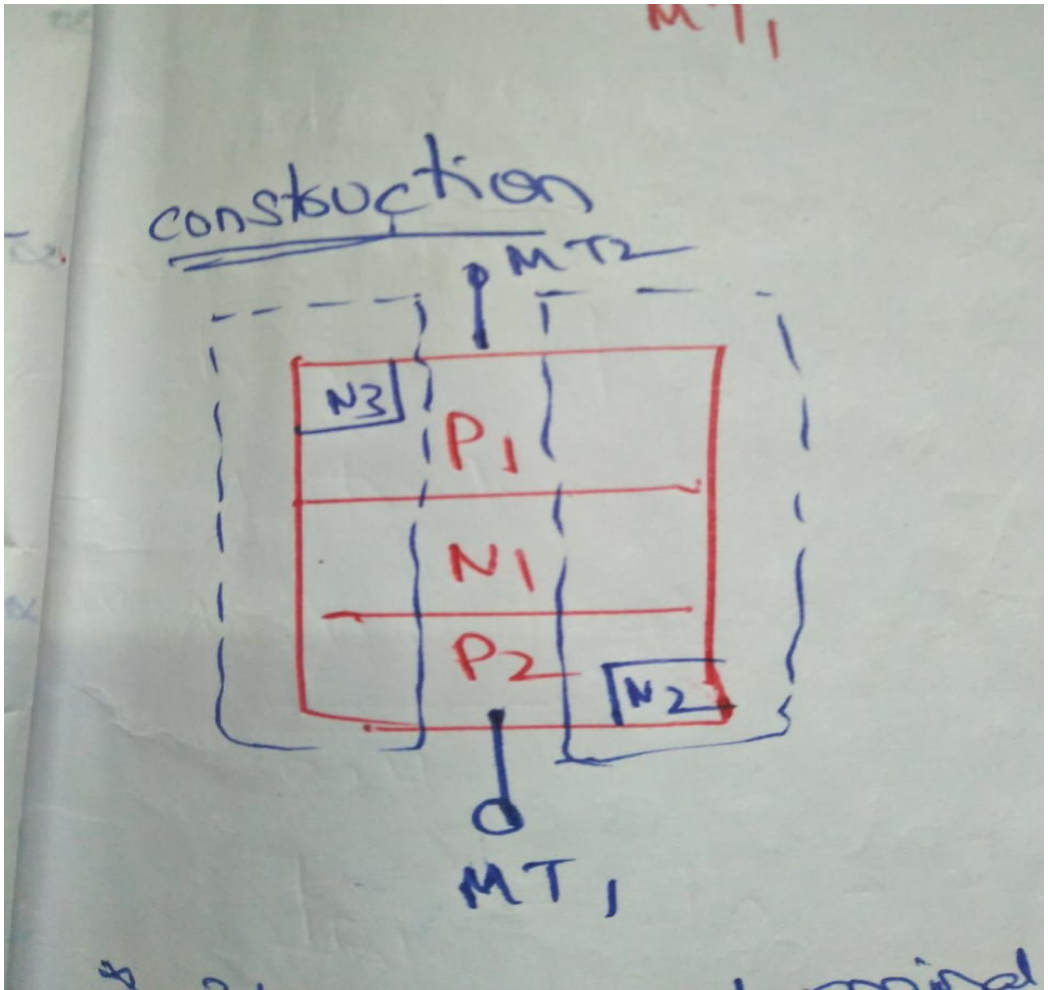
DIAC

SYMBOL



DIAC

CONSTRUCTION



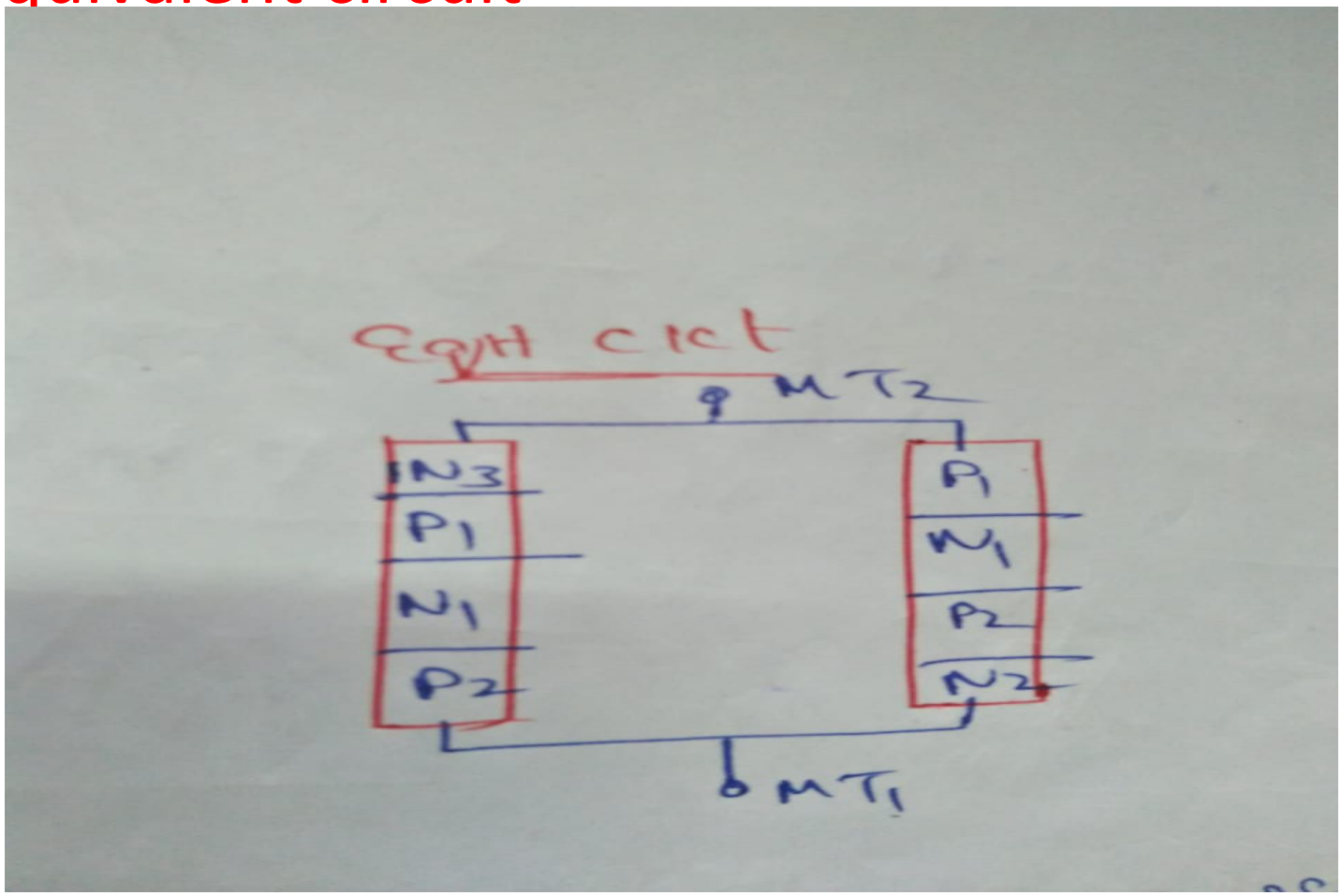
DIAC

CONSTRUCTION

- 3 Layer, 2 terminals, in which current passes in either direction.
- Acts as bi-directional avalanche diode.
- It does not have any control terminal.
- Has 2 junctions J1 & J2.
- Though DIAC resembles bipolar transistor the center layer is free from any connection with terminals.

DIAC

Equivalent circuit



DIAC

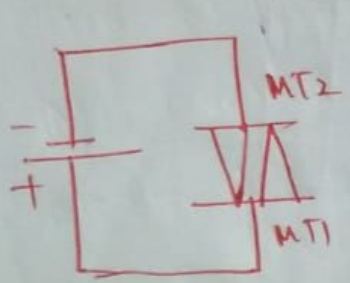
OPERATION

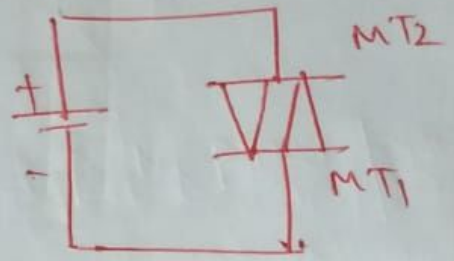
- Consists of two 4 layer diodes connected in parallel. But opposite in directions.
- 4 layer diodes are **P1 N1 P1 N2** & **P2 N1 P1 N3**
- DIAC has 2 main terminals-MT2 & MT1.

Operation

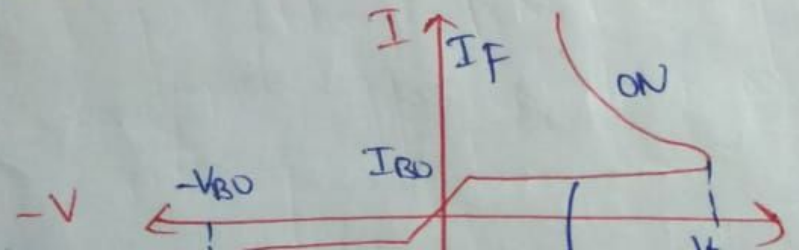
(i) for +ve half cycle → MT_1 (+ve) w.r.t MT_2 → DIAC passes current through diode $P_2 N_1 P_1 N_3$ → from MT_1 to MT_2.

(ii) for -ve half cycle → MT_2 (+ve) w.r.t MT_1 → DIAC passes through the diode $P_1 N_1 P_2 N_2$ → from MT_2 to MT_1



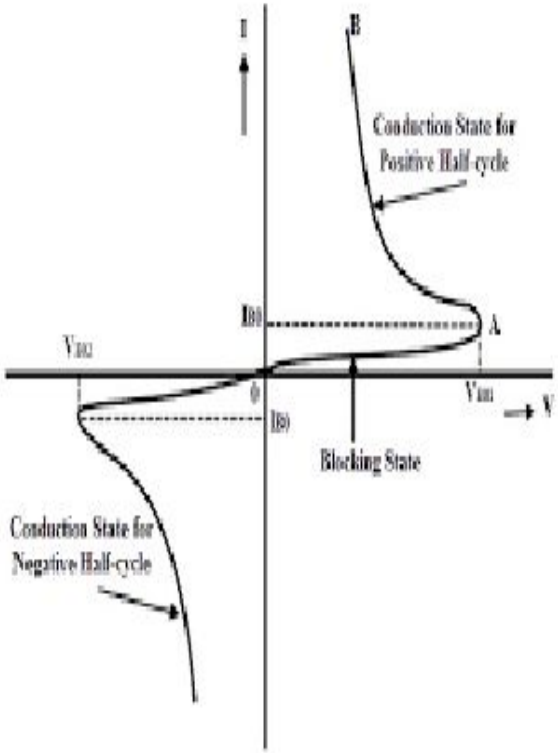


→ As long as the doping level at 2 ends is same the device will have identical characteristics.



DIAC

- V-I characteristics



DIAC

APPLICATIONS

- Used as triggering device in triac phase control circuits for light dimming , motor speed control ,heater control.

4.SCR

- General information
- What is SCR
- Symbol & Structure of SCR
- Operation of SCR
- V-I Characteristics of SCR
- SCR Equivalent circuit
- Applications of SCR
- YOUTUBE LINK

SCR

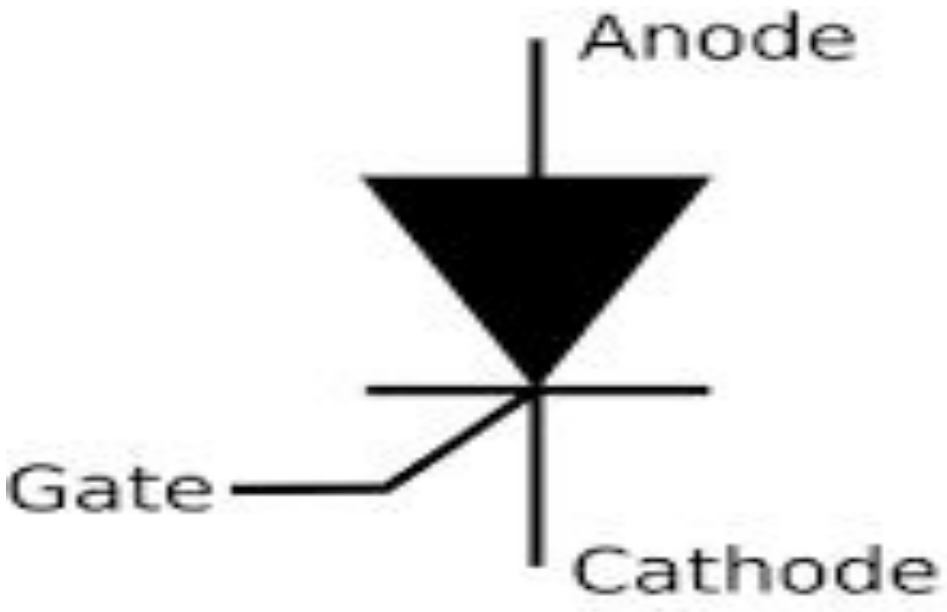
GENERAL INFORMATION

- Gordon Hall and Frank W. "Bill" Gutzwiller invented SCR-1957

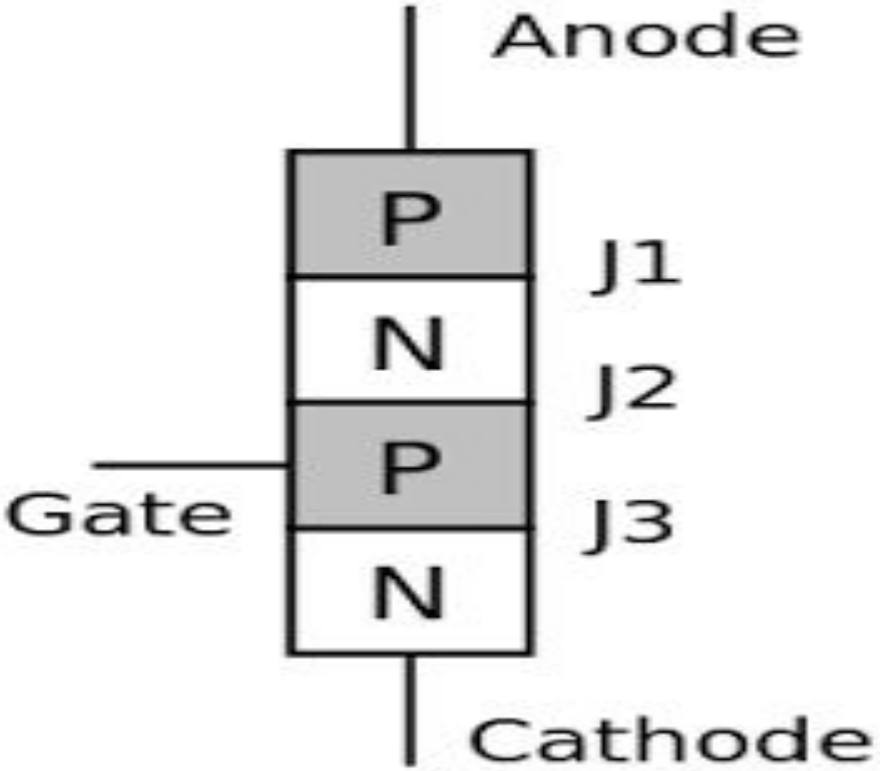
WHAT IS SCR?

- **Silicon control rectifier.**
- **It is an Uni-directional device, 4 layers ,3 terminal device.**
- It is constructed of silicon material with a third terminal for control purpose.
- As leakage current in silicon is small compared to Germanium, SCR's are made of Silicon and not germanium.

SYMBOL

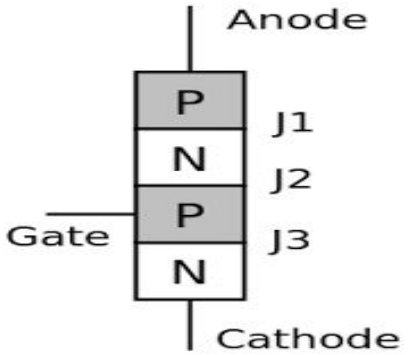


CONSTRUCTION



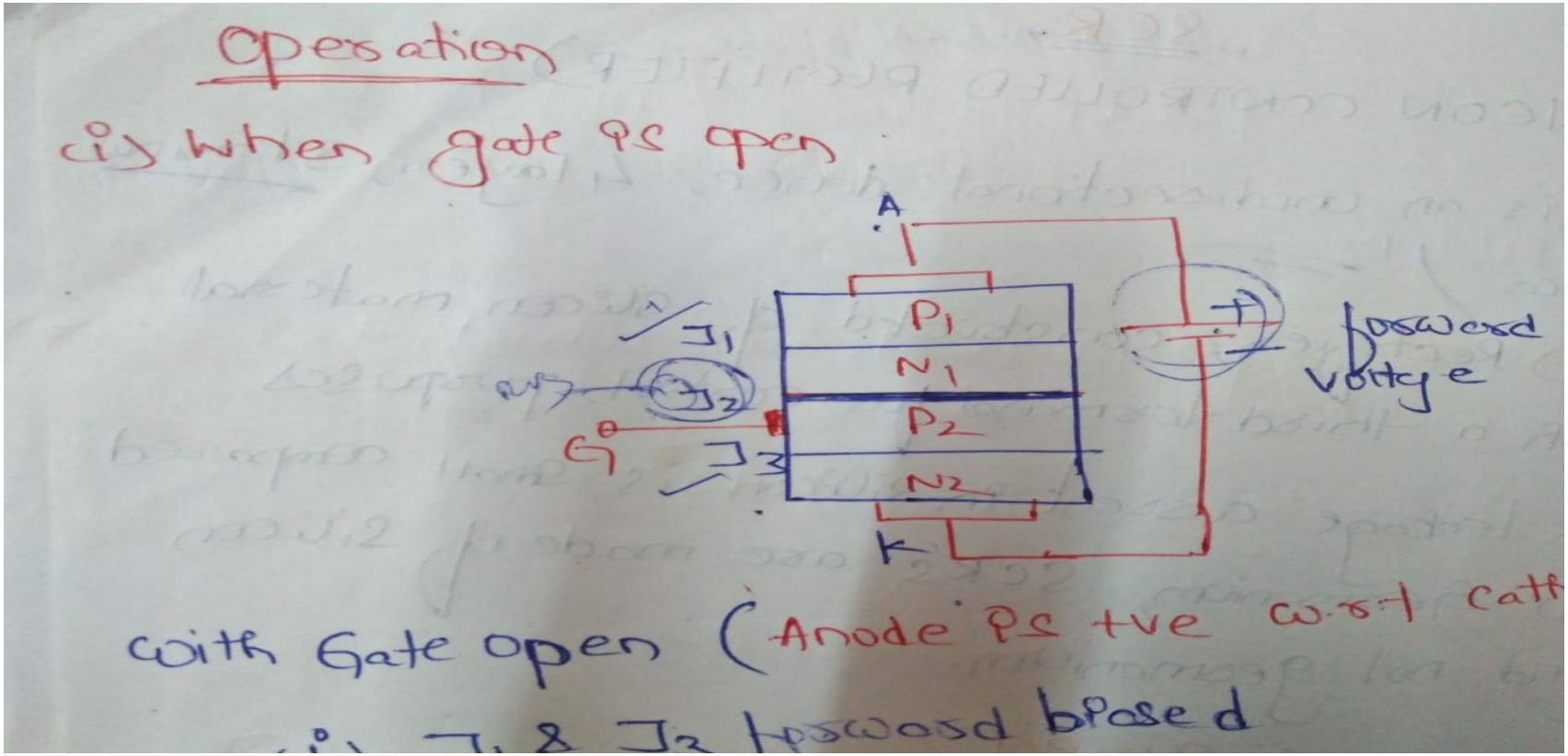
CONSTRUCTION

- It consists of 3 JUNCTIONS-J1,J2,J3 and 3 Terminals.
- **ANODE(A)**: Terminal taken out from P-LAYER
- **CATHODE(K)**: Terminal taken out from N-LAYER
- **GATE(G)**: From P-LAYER near to cathode



OPERATION

- WHEN GATE IS OPEN

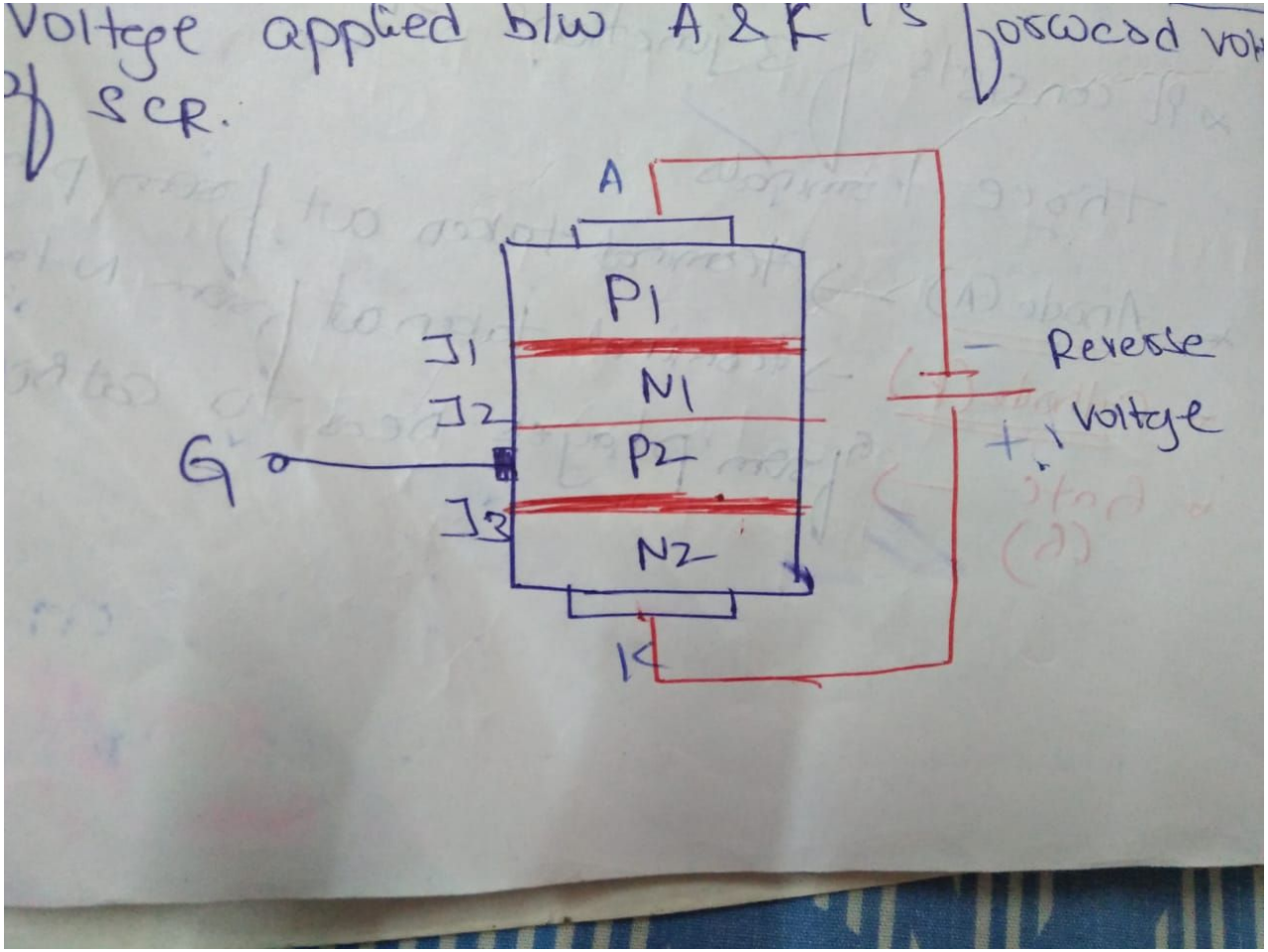


SCR

OPERATION

- With GATE OPEN(anode is +ve w.r.t cathode)
- **J1 & J3 FB**
- **J2 is RB**
- There is depletion region around J2 and only leakage current flows which is negligible.
- When SCR is said to be **OFF STATE-** We call it as **forward blocking state** of SCR.
- Voltage applied between A&K is forward voltage of SCR.

SCR


Voltge applied b/w A & K is
of SCR.
A
P1
J1
N1
J2
G
P2
J3
N2
K
Reverse
Voltge
+

OPERATION

- With GATE open, cathode is made +ve w.r.t anode.
- **J1 & J3-RB**
- **J2- FB**
- Voltage applied between A & K in reverse voltage and SCR is said to be in **reverse blocking state**.
- In forward blocking state, if the applied voltage is increased the current increases slowly un till the break over voltage is reached.

SCR

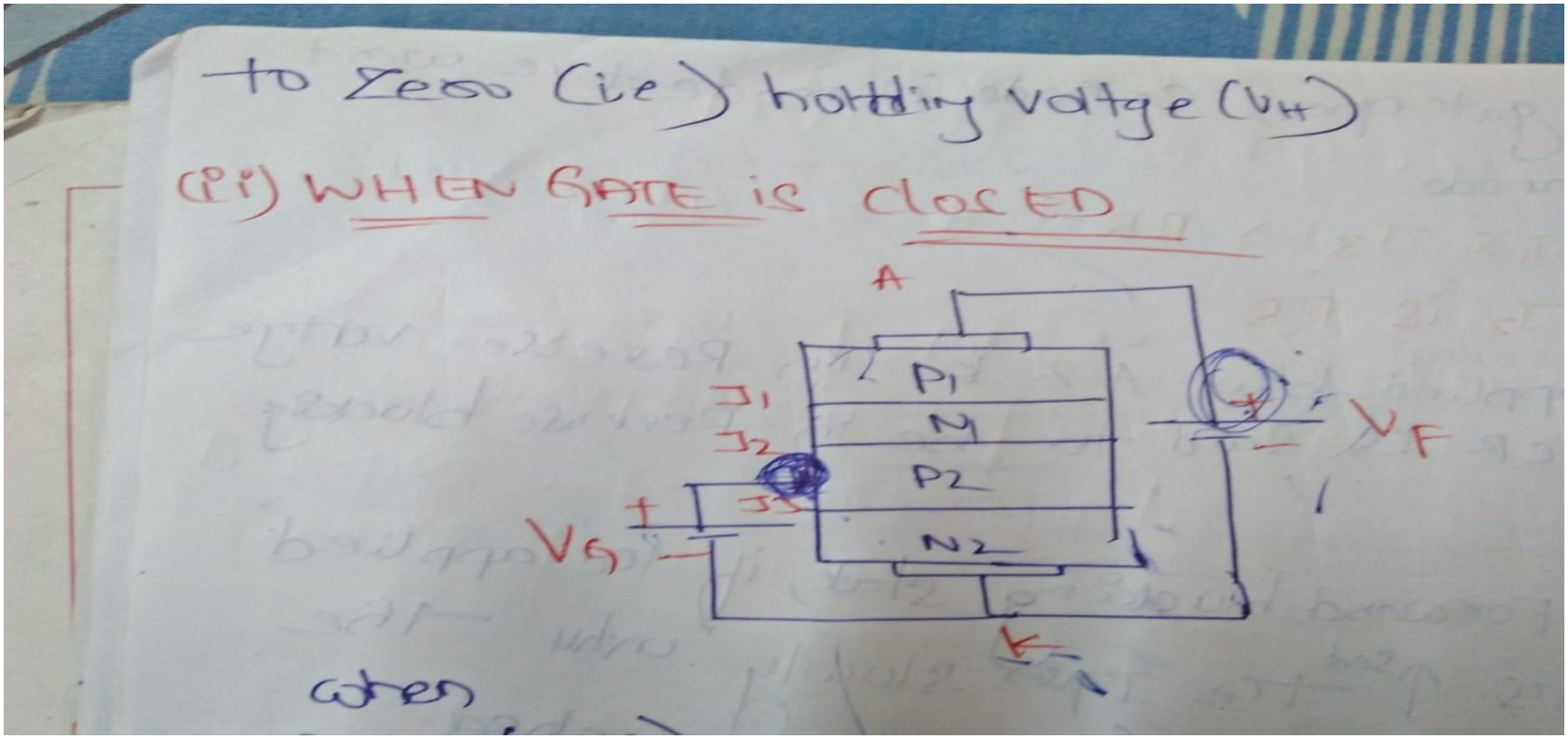
- Once break over voltage is reached, the current abruptly increases & voltage drop across the device decreases sharply.
- At this point the diode switches over from **OFF to ON state.**

HOLDING CURRENT

- Once device is fired into conduction, a minimum amount of current is known as **HOLDING CURRENT.**
- It is required to flow to keep the device in **ON STATE.**

CONSTRUCTION

- WHEN GATE IS CLOSED



SCR

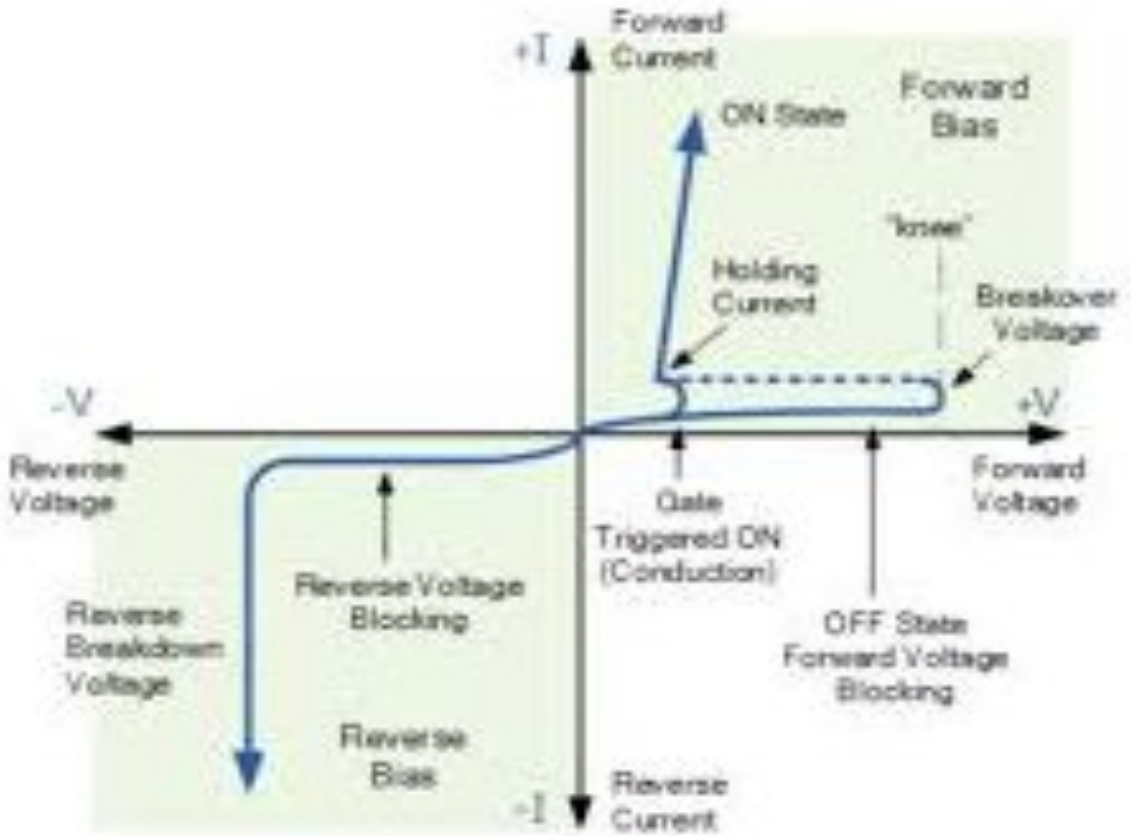
CONSTRUCTION

- When GATE is +ve w.r.t cathode
- Electrons from N-type cathode cross J3 to reach positive terminal of battery.
- Holes moves towards –ve terminal of battery.
- This constitutes **GATE CURRENT**.
- This current increases anode current as some of the electrons cross J2.

SCR

- As more electrons cross J2 anode current increases further.
- Due to regenerative action,J2 breaks out & SCR conducts sharply.
- **IF A TO K VOLTAGE REVERSED**-then device enters into reverse blocking region.

V-I characteristics

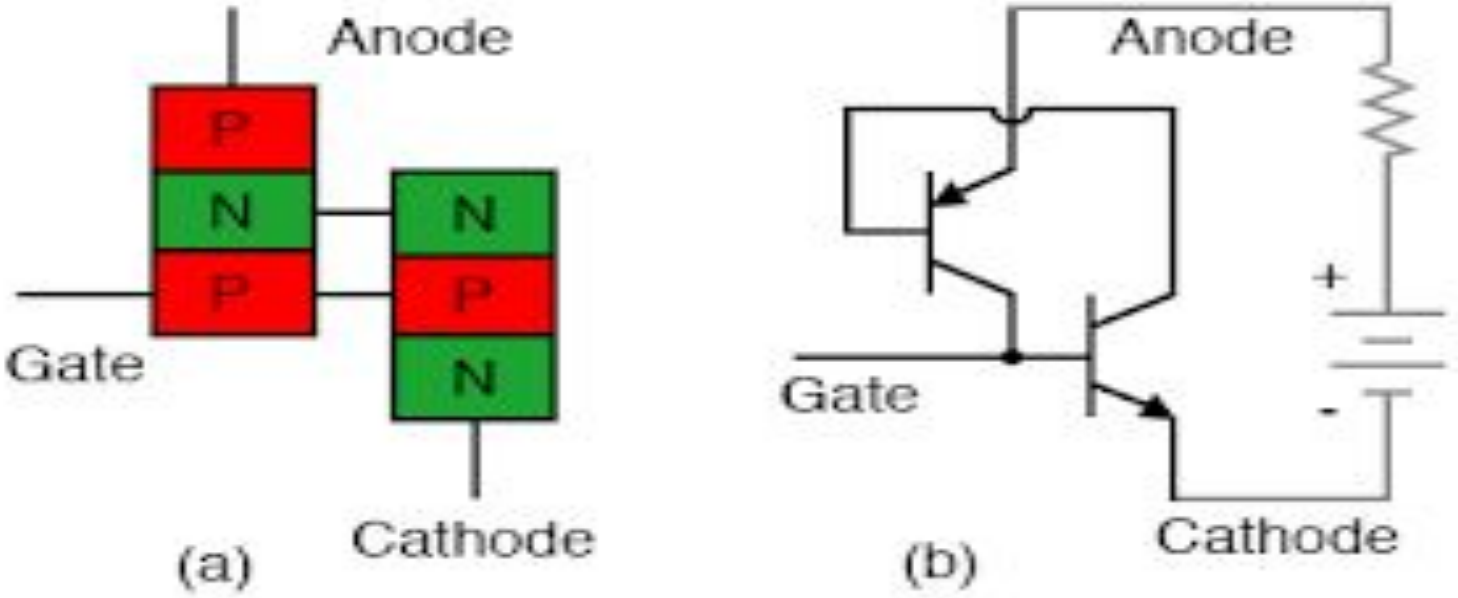


SCR

V-I Characteristics

- SCR conducts in first quadrant only.
- When gate signal is applied.
- SCR is made sufficient FB(to cross holding current limit).once it starts to conduct once in conducting state, it continues to conduct even if gate signal is removed.

SCR EQUIVALENT CIRCUIT



SCR

- Device is connected back to back.
- Collector of each transistor is connected to the base of other transistor.
- If +ve value of gate current is given at GATE this constitutes base current of transistor Q2.
- Here SCR acts as ON switch & it will pass current from anode to cathode.

A to K.

* Assume leakage current of Q_1 to be negligibly small,

$$I_{B1} = I_A - I_{E1}$$

$$= I_A - \alpha_1 I_A$$

$$I_{B1} = (1 - \alpha_1) I_A \quad -(1)$$

w.k.t

$$I_{B1} = I_{C2} \quad -(2)$$

&

$$I_{C2} = \alpha_2 I_K \quad -(3)$$

Sub (2) & (3) in (1)

$$(1 - \alpha_1) I_A = \alpha_2 I_K \quad -(4)$$

w.k.t

$$I_K = I_A + I_G$$

$$I_A = \frac{\alpha_2 I_G}{1-(\alpha_1+\alpha_2)}$$

If $\alpha_1+\alpha_2 = 1$, then $I_A = \infty$.

The anode current I_A reaches very high value approaching infinity.

∴ the device suddenly triggered into ON state from OFF state. This characteristic of the device is

SCR

APPLICATIONS

- Motor speed control
- Battery charger
- Inverter
- Power supplies
- Relay control

YOUTUBE LINK

- https://www.youtube.com/watch?v=AhFDWfFjdOE

OPTO COUPLER

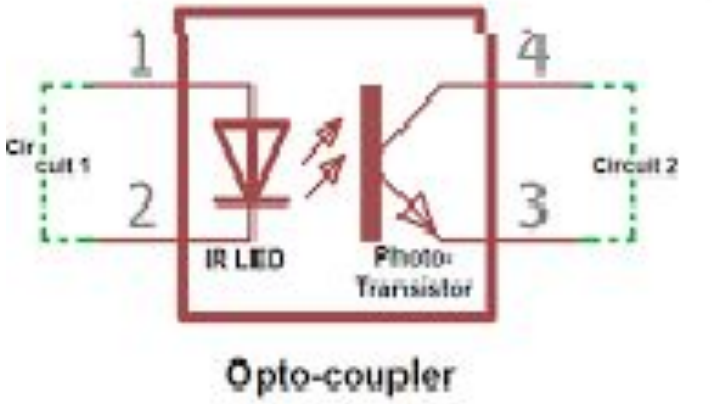
OUTLINE

- General information
- What is OPTO COUPLER
- Various types of OPTO COUPLER
- Photo diode OPTO COUPLER
- Photo transistor OPTO COUPLER
- Characteristics of OPTO COUPLER
- Advantages
- Applications

OPTO COUPLER

General Information

- Akmenkalns- invented OPTO COUPLER-1963



Opto-coupler

OPTO COUPLER

What is OPTO COUPLER???

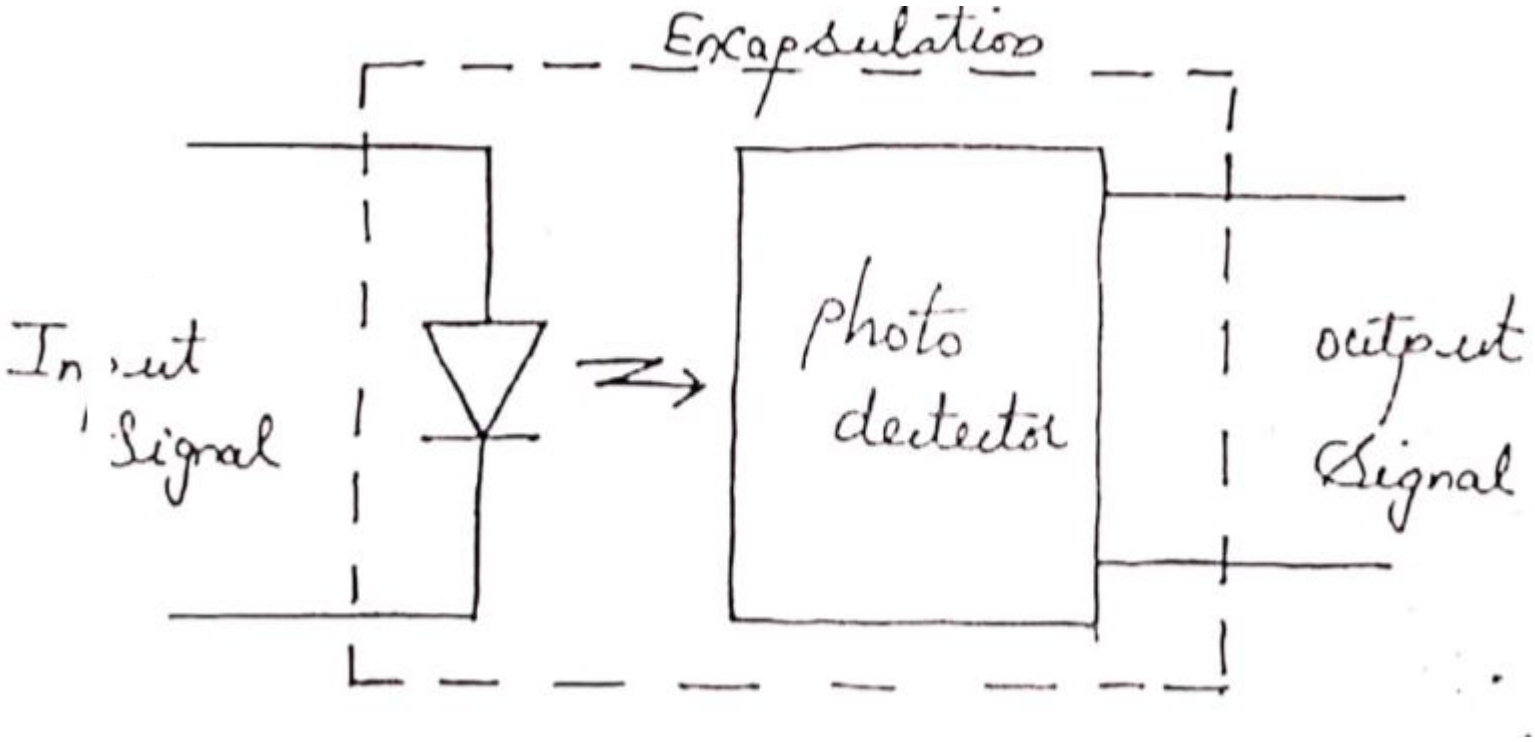
- OPTO COUPLER is a solid state component in which **LED, LIGHT PATHS & LIGHT DETECTORS** are enclosed within the component and cannot be changed externally.

OPTO COUPLER

OPTO ISOLATOR.

- OPTO COUPLER provides electrical isolation between the circuits, it is called as **OPTO ISOLATOR.**
- OPTO ISOLATOR allows signal transfer without coupling wires , capacitors or transformers.
- It can couple digital(ON/OFF) or Analog (continuous) signal.

OPTO COUPLER



The opto isolator, also referred to as an optoelectronic coupler, generally consists of an Infrared LED, photodetector such as PIN photodiode (for fast switching), phototransistor, Darlington pair or photo-SCR, Combined in a single package.

Opto isolators transduce input voltage to proportional light intensity by using LEDs. The light is transduced back to output voltage using light sensitive devices.

GaAs LEDs are used to provide spectral matching with the silicon sensors.

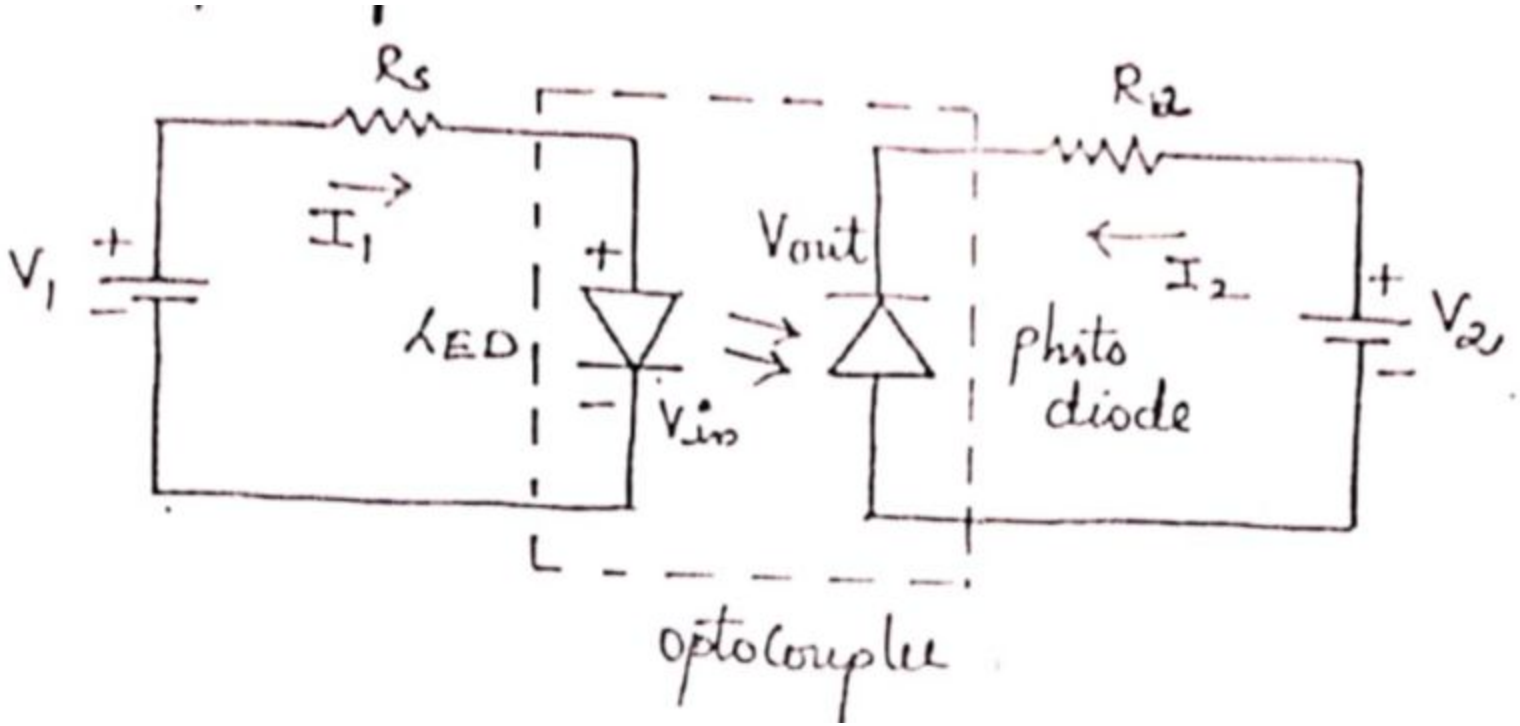
OPTO COUPLER

TYPES OF OPTO COUPLER

- Photo diode
- Photo transistor
- Photo darling ton
- Photo SCR

OPTO COUPLER

PHOTO DIODE OPTOCOUPLER



OPTO COUPLER

- It has LED- i/p side
- Photodiode-o/p side
- Source voltage(V1) &series resistor-FB
- sets up current through LED
- Hence LED emits the light.
- Emitted light falls on photodiode & it sets up reverse current in o/p circuit
- Output voltage=V_2-I_2R_2

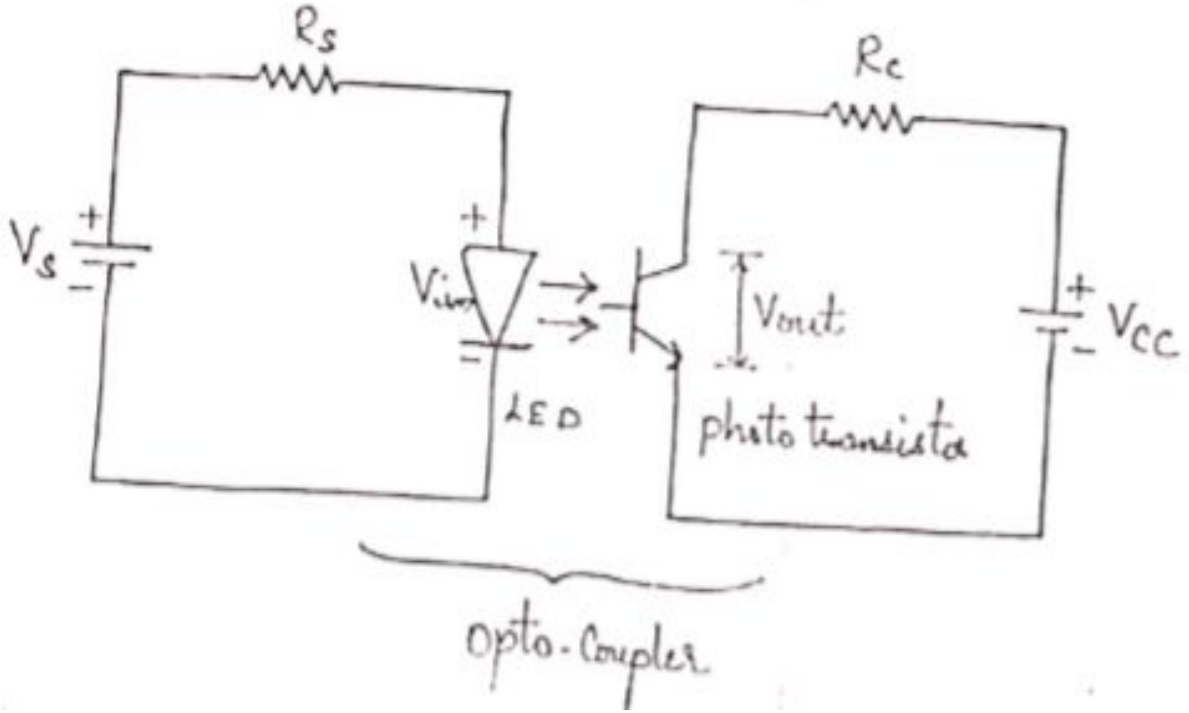
OPTO COUPLER

PHOTO TRANSISTOR OPTO COUPLER

- It has **LED-i/p side** & **photo transistor-o/p side**.
- Source voltage & series resistor are FB.
- It sets up current through LED.
- Due to forward current, LED emits the light.
- $V_{out}=V_{cc}-I_cR_c$.

OPTO COUPLER

The output current is proportional to the amount of incident light incidence on the emitter



OPTO COUPLER

CHARACTERISTICS

- Current transfer ratio
- i/p to o/p isolation voltage
- Maximum collector emitter voltage
- Bandwidth
- Response time

OPTO COUPLER

ADVANTAGES

Small response time

Compact & light weight

Unidirectional signal transfer

OPTO COUPLER

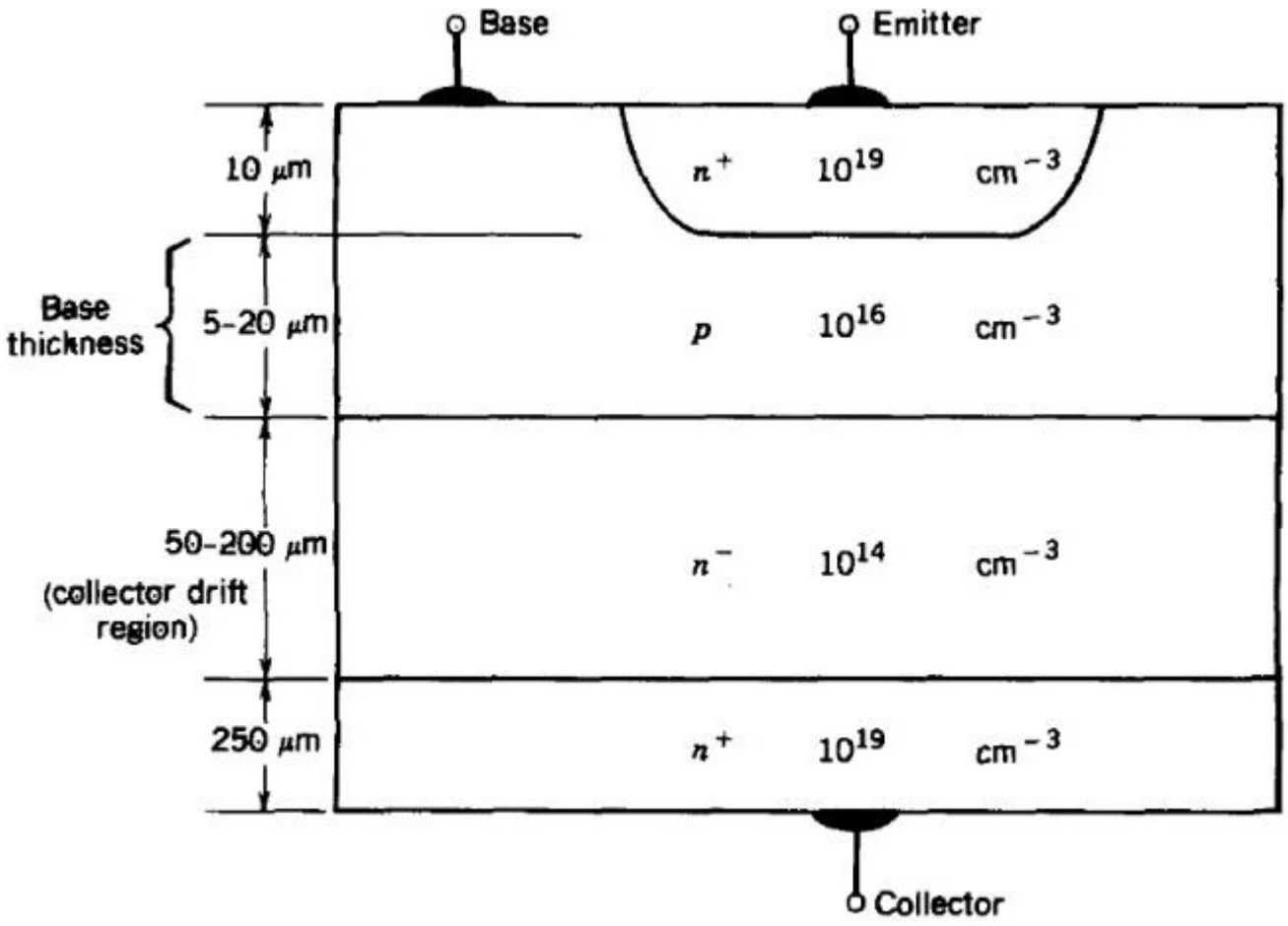
APPLICATIONS

- Used in interface in logic circuits
- In driving motors, alarms & relays
- High power choppers and inverters.

POWER BJT

- Similar to the small signal BJT, power BJT are bipolar devices with three terminals, collector, base and emitter.
- The structure of power BJT is made different from small signal BJTs in order to decrease the ON-state resistance and increase the OFF state depletion width.
- The P-N layer of BJT are made in vertical structure unlike the small signal BJT.
- This vertical structure maximize the cross-sectional area of the BJT regions of emitter , base and collector. Since because of the ON-state resistance.

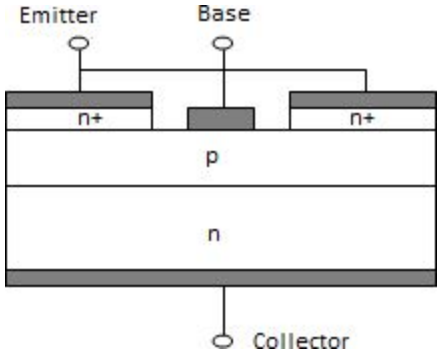
STRUCTURE OF POWER BJT:



- the power BJT reduces due to the increase in area of current flow resistance reduces ,the power dissipation in the devices reduces.
- The lightly doped collector drift region determines the breakdown voltage of the transistor

TYPES OF POWER BJT:

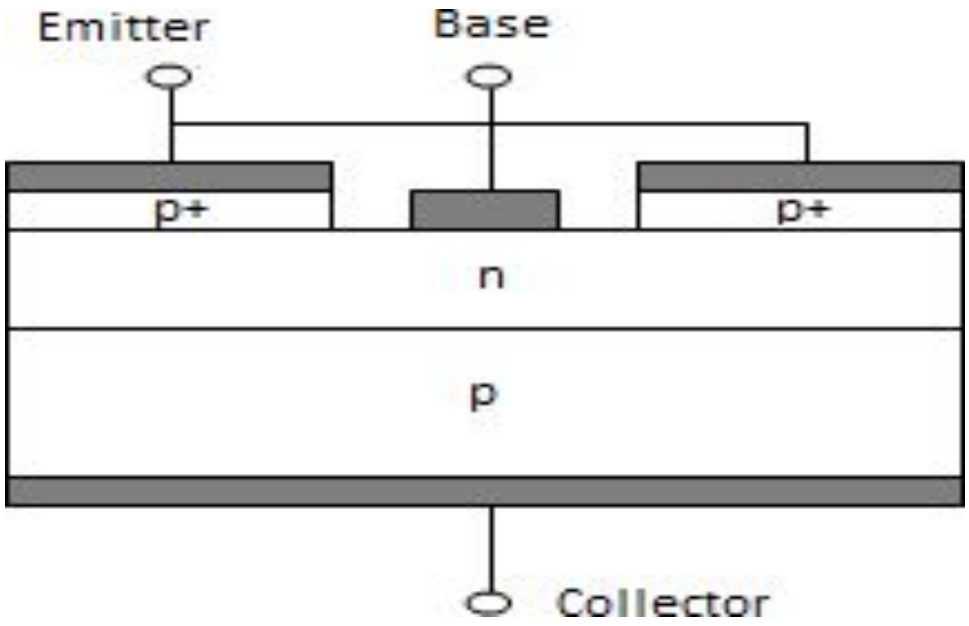
- Similar to low signal BJTs the power BJT have two types
- **NPN BJT:**
- In NPN type ,there are two n^+ regions for emitter and a narrow P-type base. The collector is a narrow N-type region with heavy doping.



PNP BJT

- In PNP type, there are two p+ regions for the emitter with narrow n-base and the collector side P- layer is narrow and heavily doped .
- The two emitter with interleaved base structure allows the base and collector currents to flow through two parallel paths ,resulting in a low ON state collector–emitter resistance
- since parallel resistance reduces effective resistance.

PNP BJT



STEADY STATE CHARACTERISTICS OF BJT

- characteristics of power BJT is obtained from output characteristics plotted between collector Ic & collector voltage VCE for different values of base current IB
- Generally BJT, have three regions of operation namely

•Cut-off region

•Active region

•Saturation region

ADVANTAGES:

- Have small turn ON & turn OFF times
- Have small ON-state losses.

DISADVANTAGES:

- Drive circuits is complex
- Storage change in base increase switching time

APPLICATIONS:

- Used in switched mode power supplies (SMPS)

POWER MOSFET

- Power MOSFET is a voltage controlled device as the output current ID is controlled by the input voltage (VGS).
- The powerMOSFET has three terminals called drain(D),source(S)and gate(G).
- It is a unipolar device as its operation depends upon the flow of majority carriers only.
- It has a very high input impedance in the order of 109Ω. As the gate draws a very small leakage current ,in the order of nanoampere ,power MOEFET do not exhibit the problem of second breakdown. Due to electrostatic discharge, power MOSFET must be handled carefully.

TYPES OF POWER MOSFET:

The main types of power MOSFET are enhancement and depletion type. They can be further classified as n-channel and p-channel MOSFETs . Since the depletion type is normally ON at VGS =0v, enhancement type is more commonly used for switching operations.

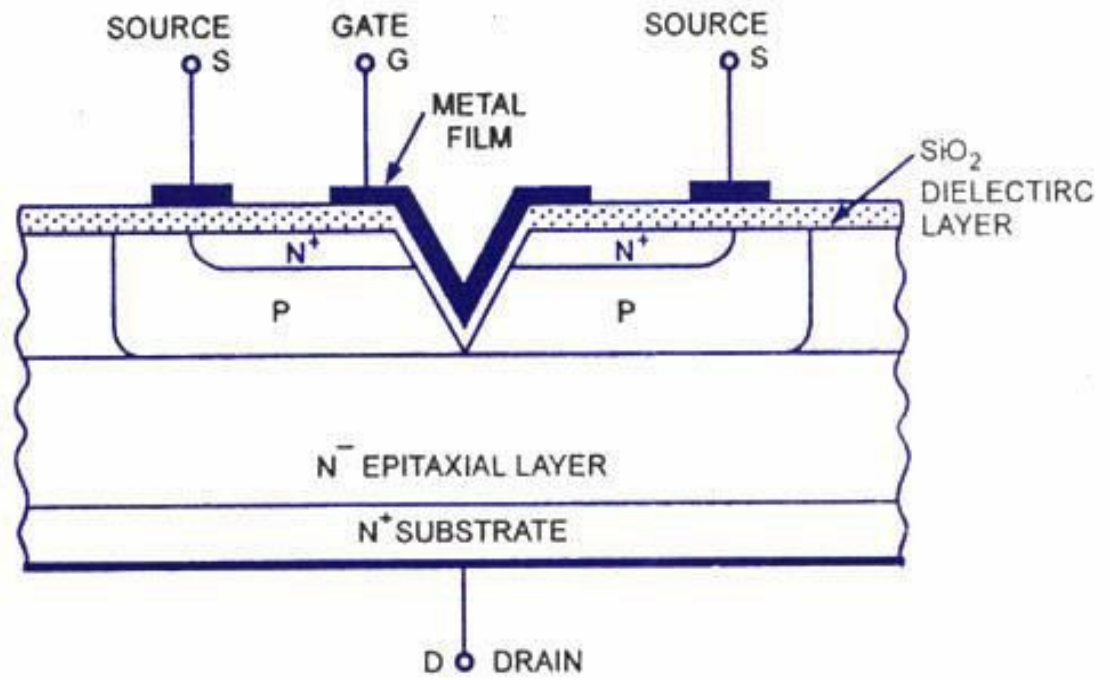
- Based on the constructional features, power MOSFETs are of two types:
- double diffused MOS(DMOS)
- V-Groove (or) vertical MOS(VMOS)

- Both the MOSFET structures have vertical alignment of source and drain regions instead of planar structure.
- Such vertical structure increases the area of cross-section of source, drain and gate regions, thereby decreasing ON-state resistance .
- But due to high input impedance offered by MOSFET, the ON-resistance of power MOSFET is larger than power BJT.
- Hence ON-state power dissipation is more in power MOSFET

DOUBLE –DIFFUSED MOS (DMOS):

- A double diffused MOS is very useful in high power & high frequency applications. On the other side of n+ substrate ,a metal layer is deposited to form the drain terminal. p- regions are formed on the n- drain drift region .
- The doping density of p- layer is 1016 cm-3 for the n+ region diffused on p- layer with 1019 cm-3 doping density .
- Above this,sio2 layer is formed. Metal contacts are made etching the sio2 layer for source and gate terminals.

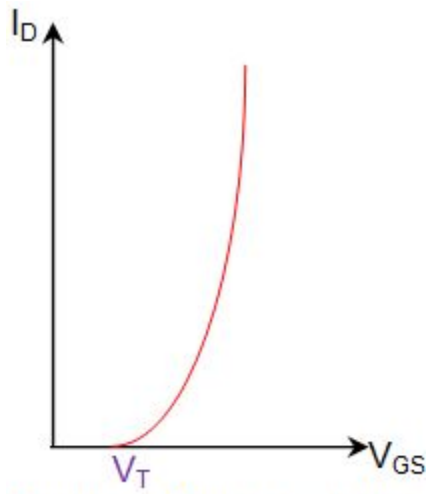
GROOVE MOS (VMOS):



N-Channel V-MOSFET

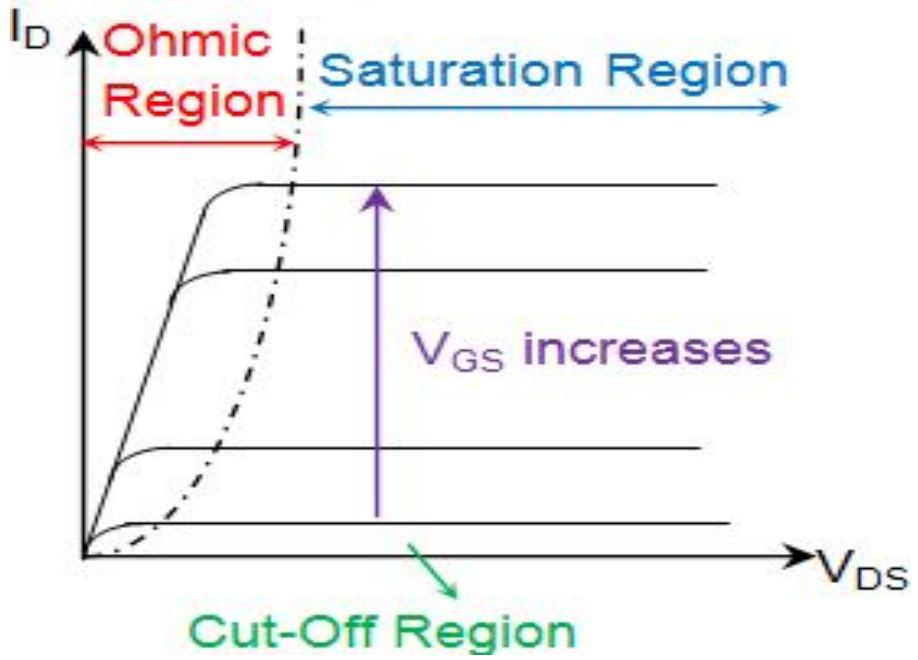
- The VMOS design is changed to suit for medium power application.
- In VMOS, the V shaped gate increase the cross sectional area of the source drain path. This reduces the ON state resistance of the device allowing it to handle high powers.
- The main drawback of the VMOS FET is that the structure is more complicated and is expensive.
- The advantage of the VMOS is that the formation of the depletion layer deep into the n-type drift region increases the breakdown voltage VBO of the device up to 50v.

TRANSFER CHARACTERISTICS:



Transfer Characteristics

OUTPUT (OR) DRAIN CHARACTERISTICS



APPLICATIONS OF POWER MOSFET:

–High frequency switching applications

- Used in switched mode power suppliers (SMPS) & Inverters

ADVANTAGE:

- No second breakdown
- High switching speed

DISADVANTAGE:

- High ON-state resistance & there by more power loss
- More electrostatic discharge

Outline

- General information
- What is phototransistor
- Symbol
- Construction
- Operation
- Applications

PHOTOTRANSISTOR

GENERAL INFORMATION

- Invented by-William Shockley-1951

PHOTOTRANSISTOR

What is phototransistor

- Also called as **PHOTODUODIODE.**
- It is much more sensitive semiconductor photo device than the PN-JN.
- Current produced by photo diode is very low which cannot be directly used in control applications. therefore this current should be amplified before applying to control circuits.

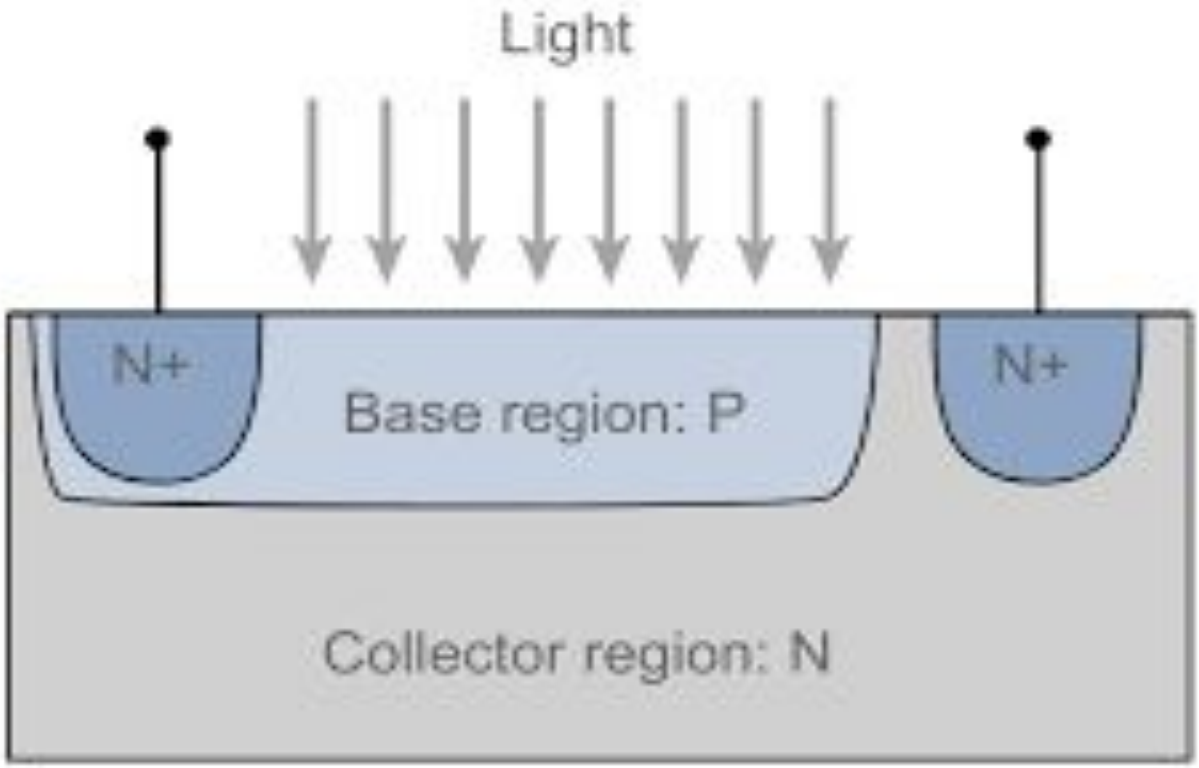
PHOTOTRANSISTOR

- Phototransistor is a light detector which combines **PHOTO DIODE & TRANSISTOR** is **BIPOLAR TRANSISTOR** can also be used as a PHOTODETECTOR.
- WHEN PHOTO TRANSISTOR IS ILLUMINATED-

  It permits a larger flow of current has high gain.

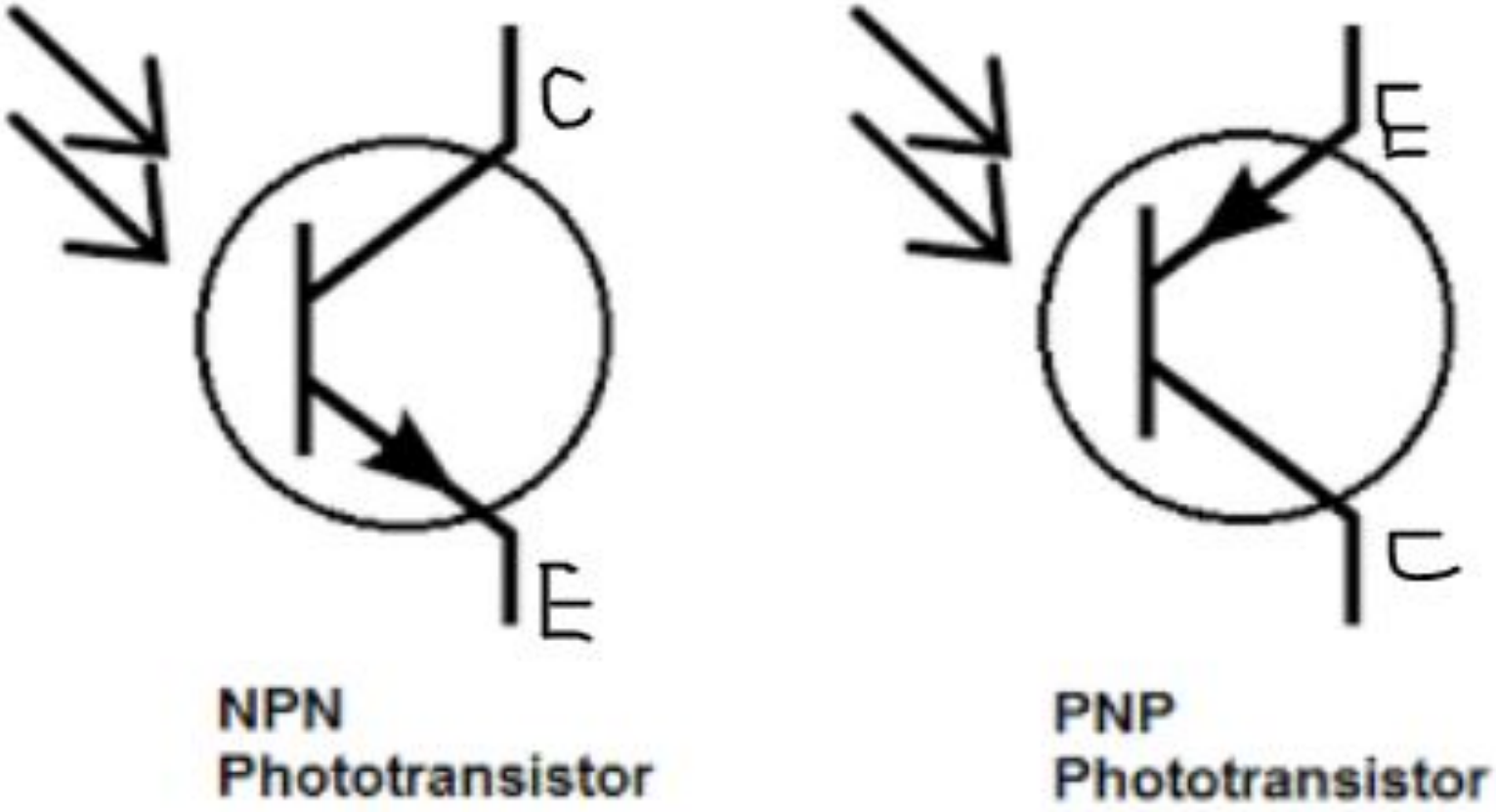
PHOTOTRANSISTOR

- Fig-



PHOTOTRANSISTOR

symbol



PHOTOTRANSISTOR

CONSTRUCTION

- Device has large B-C junction area and is usually operated with the BASE o/c.
- Connected in CE-configuration.
- In this, base current is supplied by the current created by the light falling on the base BC photo diode junction.
- i.e radiation is concentrated on the region near collector junction.

PHOTOTRANSISTOR

OPERATION

- EMITTER JUNCTION is slightly FB(o/c- base) & COLLECTOR JUNCTION is RB(i.e transistor biased in active region).
- Case 1- WHEN THERE IS NO RADIANT EXCITATION

Case 1- WHEN THERE IS NO RADIANT EXCITATION

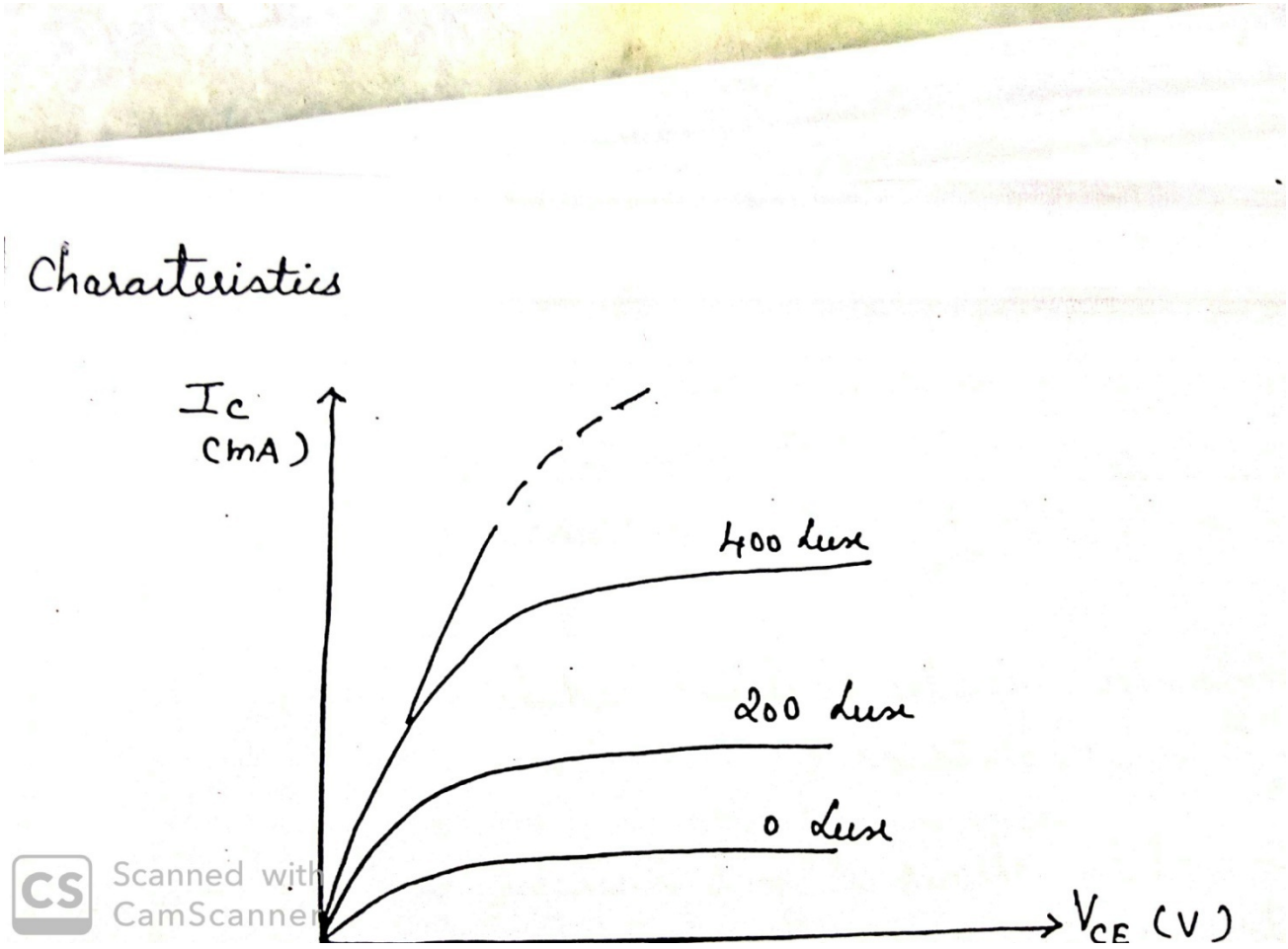
- Minority carriers are generated thermally, the electrons crossing from B toC and holes crossing from C to B constitute the reverse saturation collector current.

2. WHEN LIGHT IS TURNED ON

- Additional minority carriers are photo generated and the total collector current is
- $I_c=(1+\beta)(I_{co}+I_L)$
- Where IL-Reverse saturation current due to light.

PHOTOTRANSISTOR

GRAPH



PHOTOTRANSISTOR

APPLICATIONS

- Light detection systems
- Light operated switches
- Level indicators
- relays

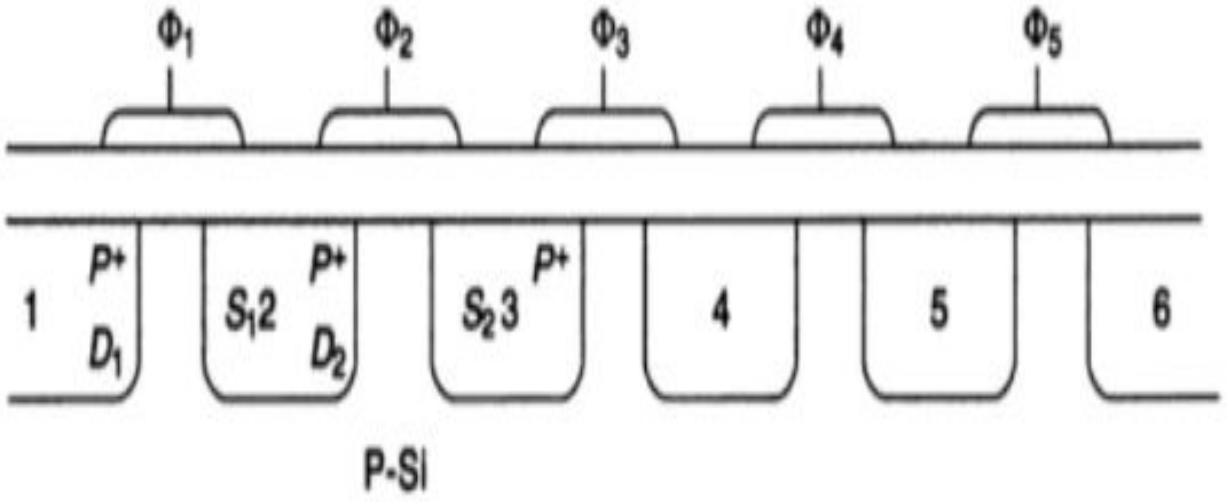
Bucket Brigade Device(BBD)

- Bucket Brigade Device(BBDs) are formed by connecting a series of capacitors with switches, generally FET.
- A single storage element consists of two capacitor switch units.
- The BBD operates on the basis of charge transfer to the adjacent wells.
- The BBD structure consists of series of MOS transistors(MOSFET)

Con..

- Here the drain of the first transistor acts as the source of the adjacent transistor and so on.
- In a P-channel BBD, the source and drain region are P+ regions and left floating , Except at the input and output and thus acts as a reservoirs of charge.
- The device is structured such that the capacitance C associated with the left hand cell L is much larger due to the larger gate overlap than that of right hand cell

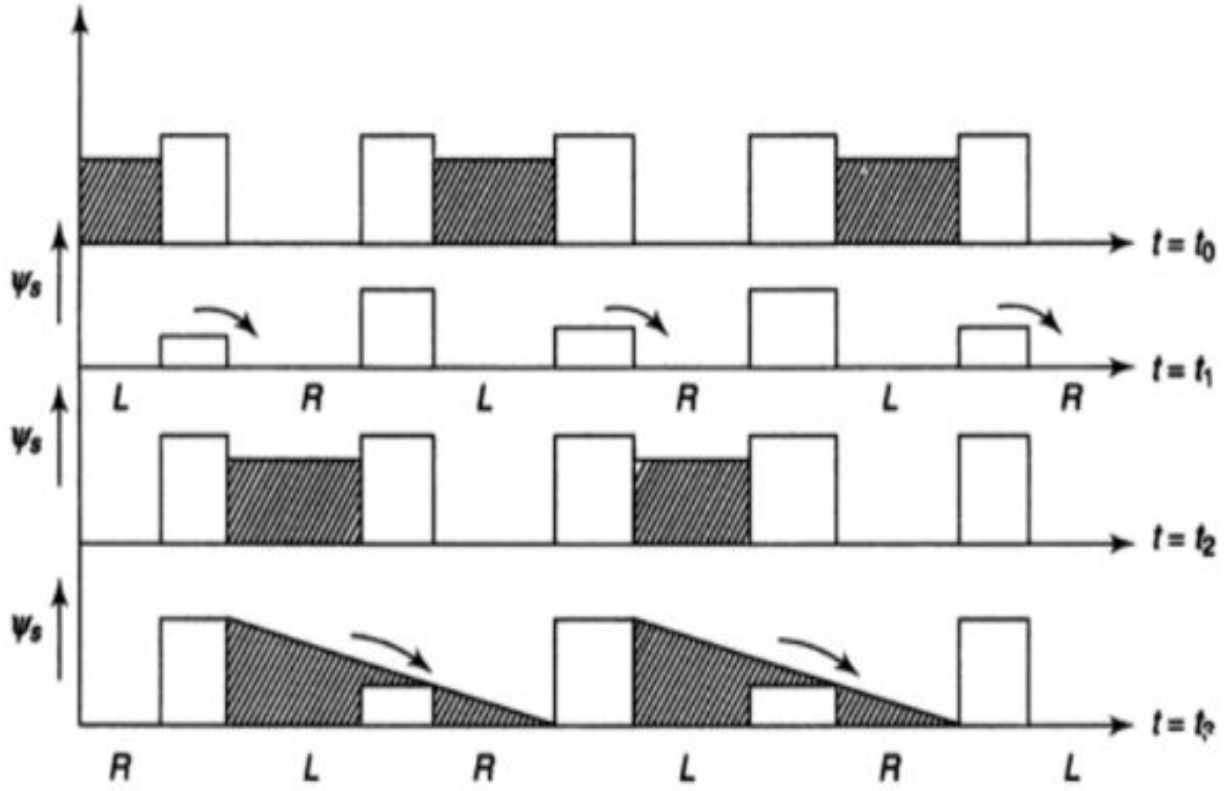
Structure of BBD



Con..

- Since (C_L>>C_R , QL->0, the charge flow will continue till the left hand cell ‘L’ contains practically no charge.
- At t2 all the channels are OFF and large potential barrier exists preventing any carrier flow.
- At t3, the phase 2 is high and phase 1 is low. Hence all the even numbered region behaves like L-Type region and transfer charge to R-Type regions.

Charge transfer in BBD with 2 phase clock



Con..

- BBD normally operate at lower maximum frequencies than CCD’s. because the transfer speed is limited by the charge flowthrough the channel.
- BBD have larger cell area.

APPLICATIONS

- BBDs are used in areas such as audio delay lines to implement reverberation.
- Modern commercial BBDs can transfer at 1MHz.
- Integration density and performance are better in CCD structure.

.

THANK YOU