Basics of Engineering

PN junction Diode VI characteristics

SPARKS ACADEMY

Types of materials

Conductivity → flow of charges

Unit of conductivity ⇒ Siemens/meter (S/m)

Conductor

Good

eg. Silver

Copper

Gold

Al

(Semiconductor)

moderate

eg. Silicon (Si)

Germanium (Ge)

GaAs

Gallium Arsenide

insulator

poor

Wood

Glass

Teflon

SC

SC

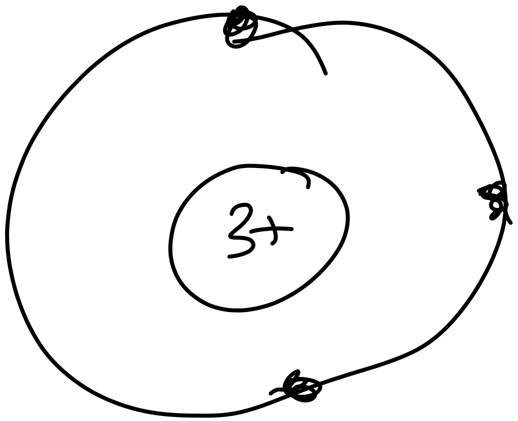
- **Intrinsic S.C** (pure)
- **Exterinsic SC**
  - P type S.C
  - N type SC

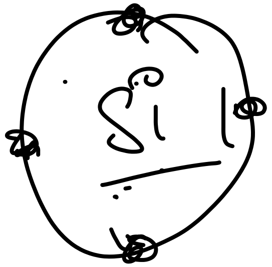
Doping :- The process of adding (impurities) to change conductivity.

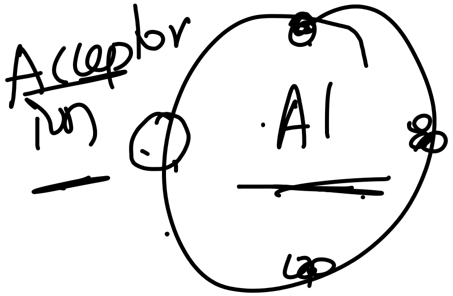
Dopend :-
- p type
- n type

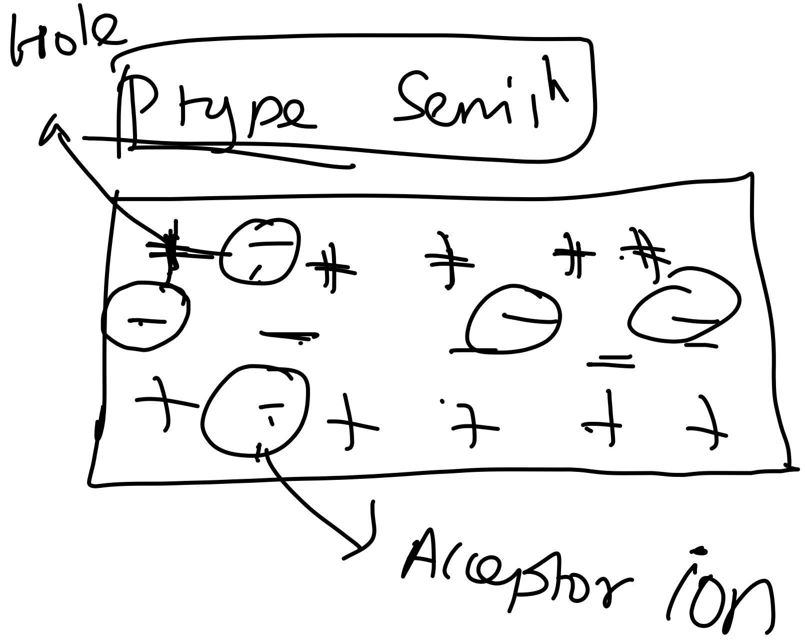
P type Semi Conductor

Trivalent Atoms → Al, Boron, Gallium







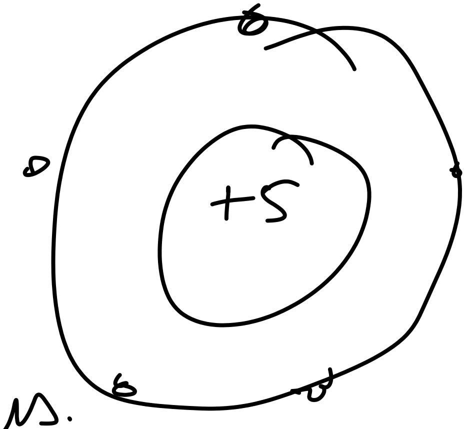


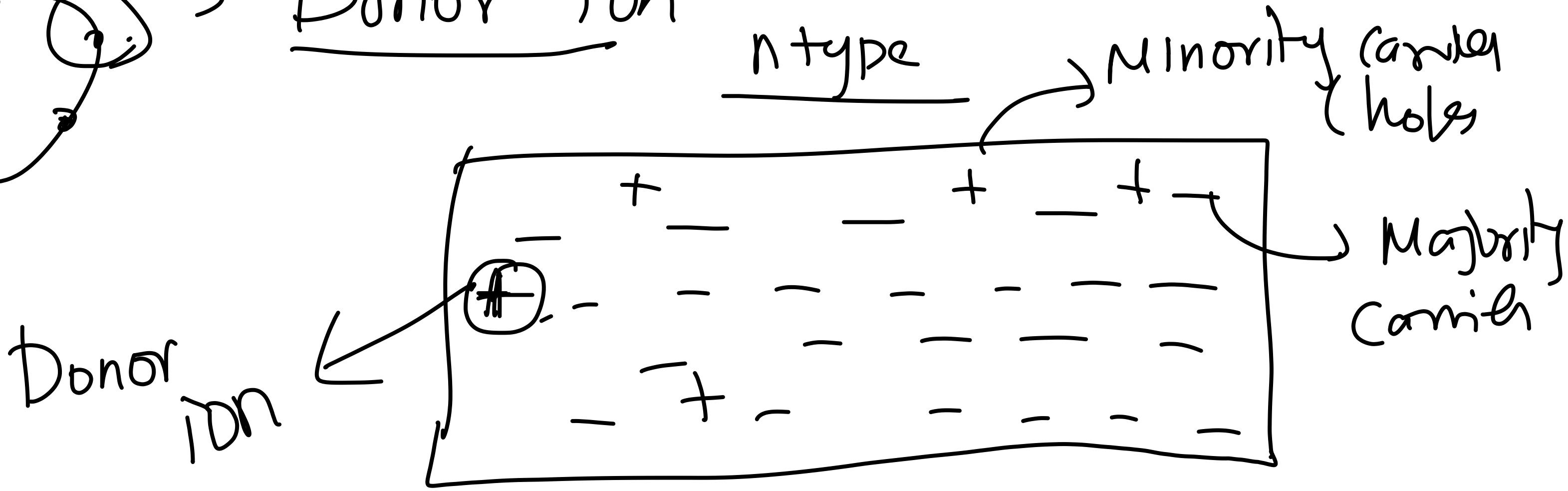
O + → holes

– → electron

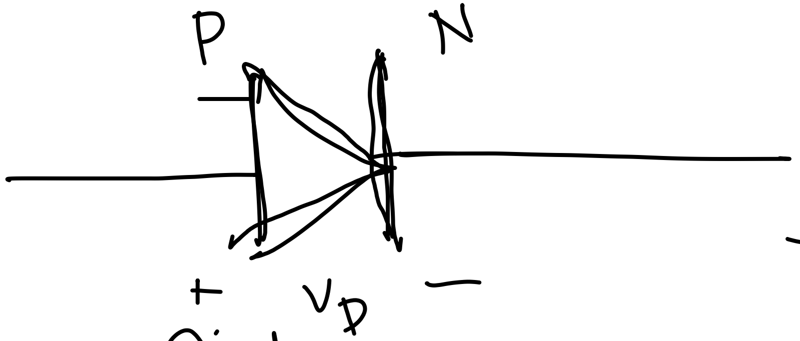
n type Semiconductor.

Pentavalent Atom →
- Arsenic
- Antimony
- phosphorus.



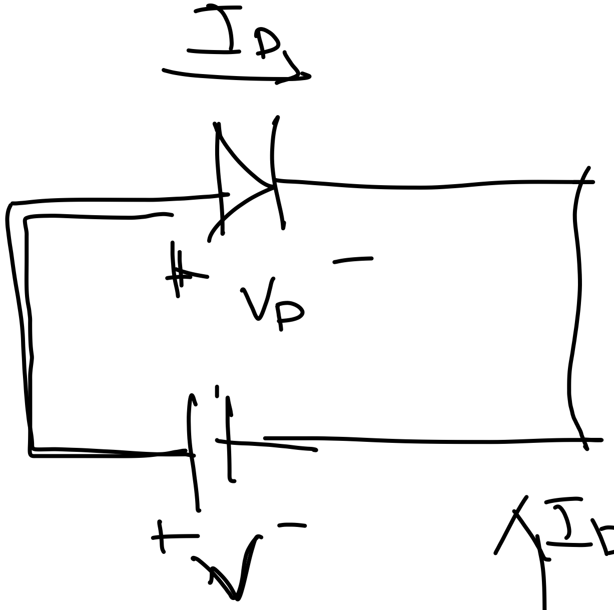


PN Junction Diode

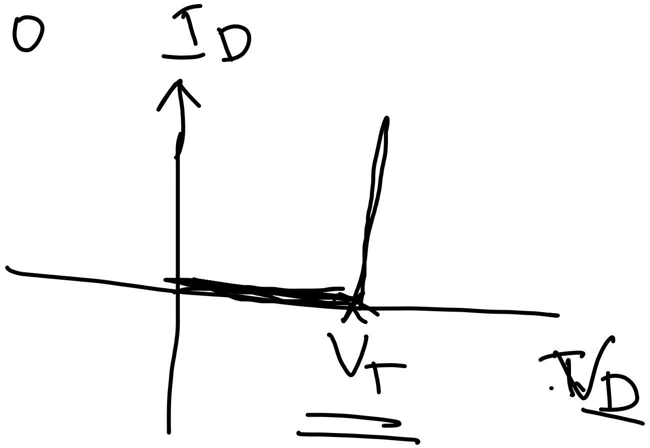


Ideal VI characteristics :-

Frwd Bias



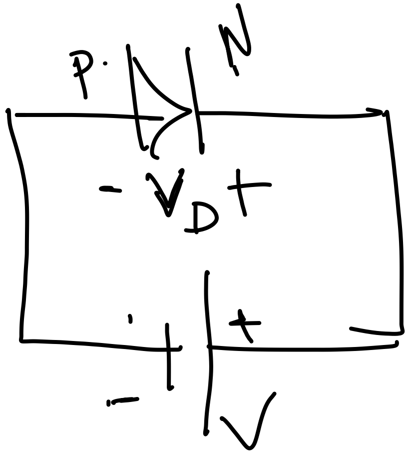
Current = 0

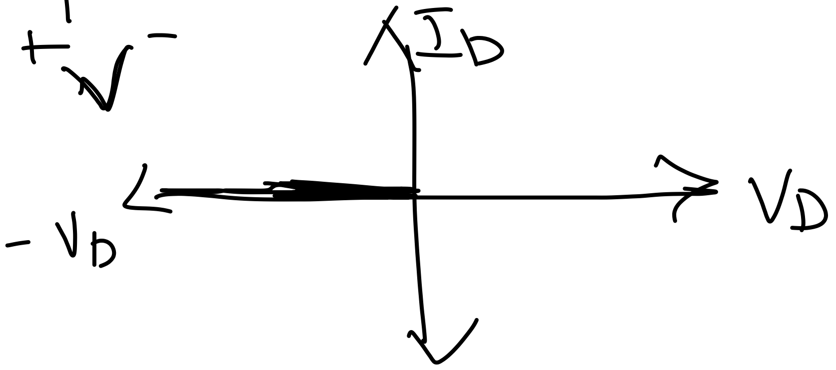


V_T → Threshold Vtg

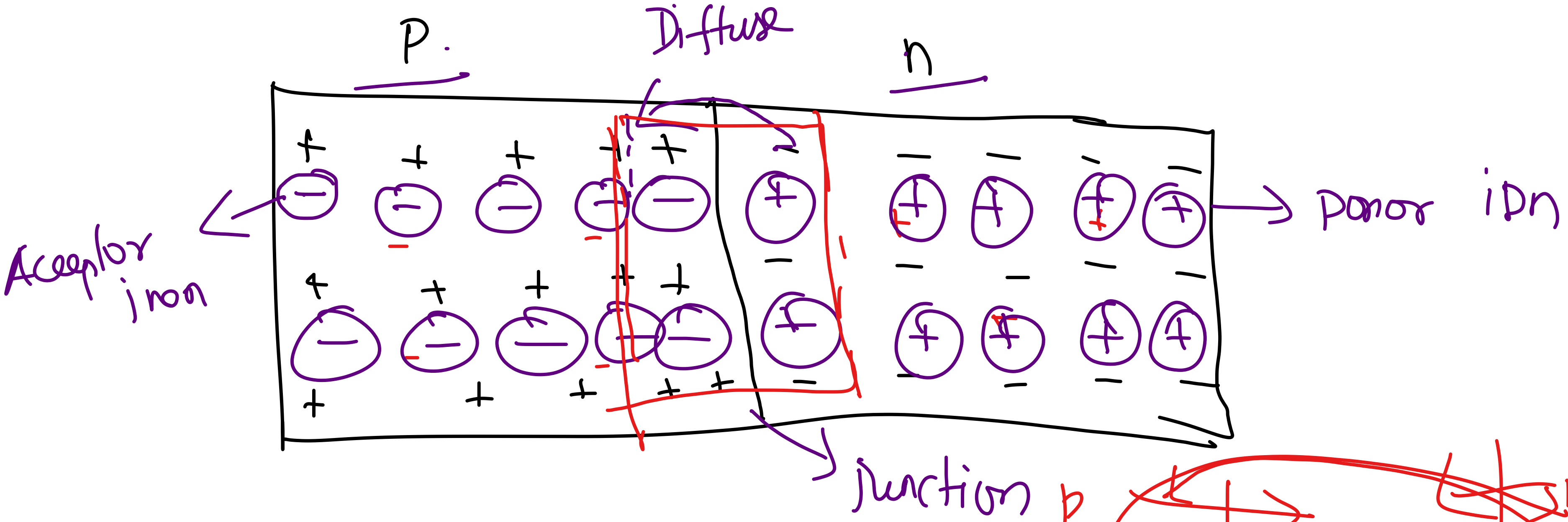
Cut in Vtg

Reverse Bias :





Ptype Si ntype



→ electron hole pair

→ immobile ions

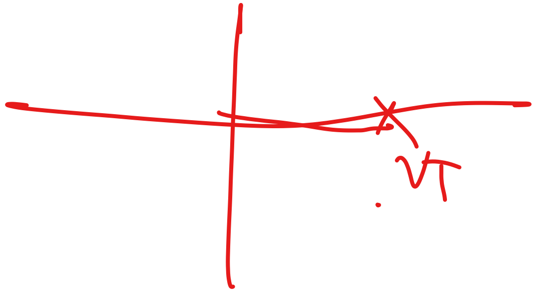
→ potential create

Depletion Region

→ Depletion region

→ Built in Vtg / Built in potential.

→ cutt off Vtg

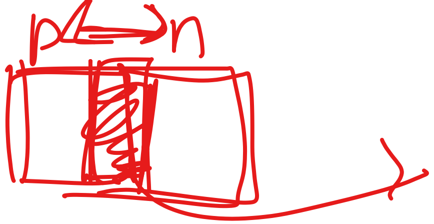


→ Barrier

Barrier potential

→ over all current = 0

no external Bias

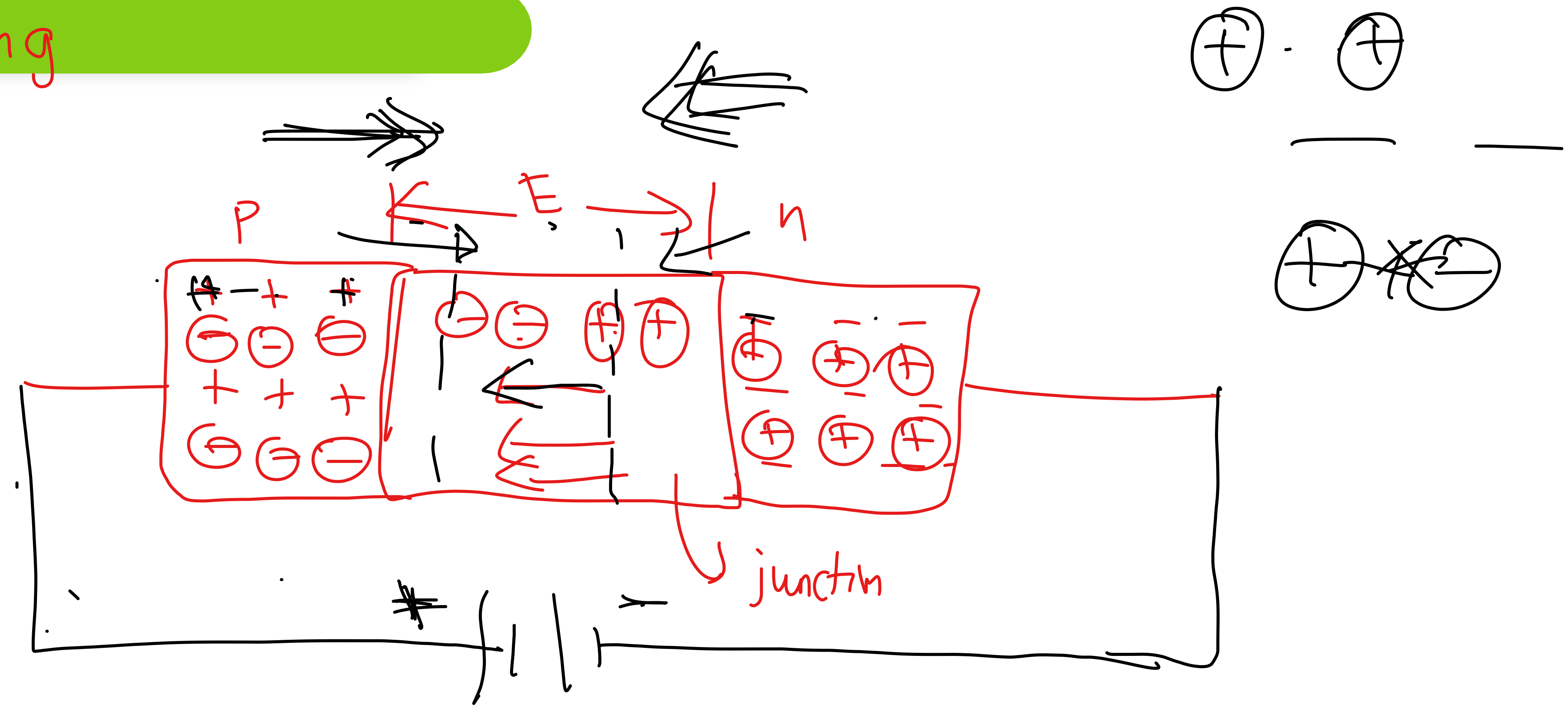


ω

Si = 0.7 V

Ge = 0.3 V

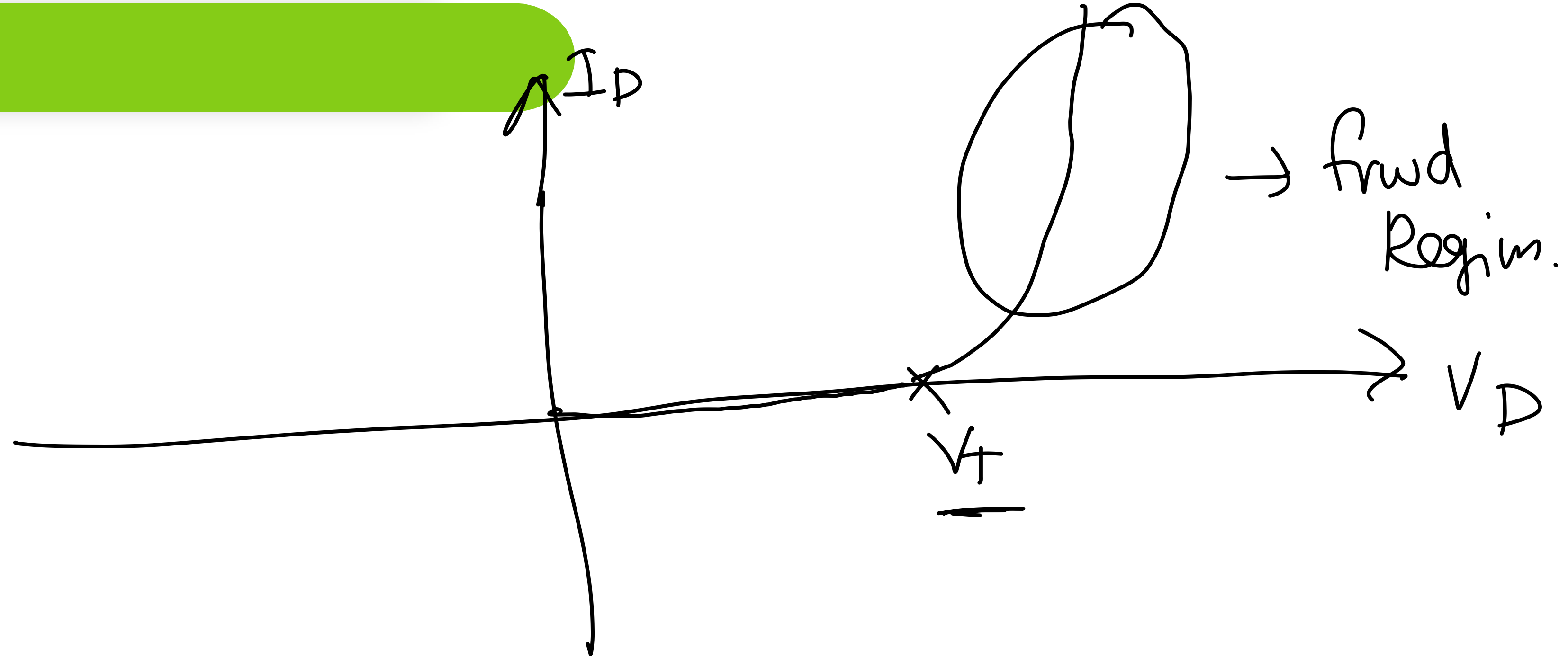
Biasing



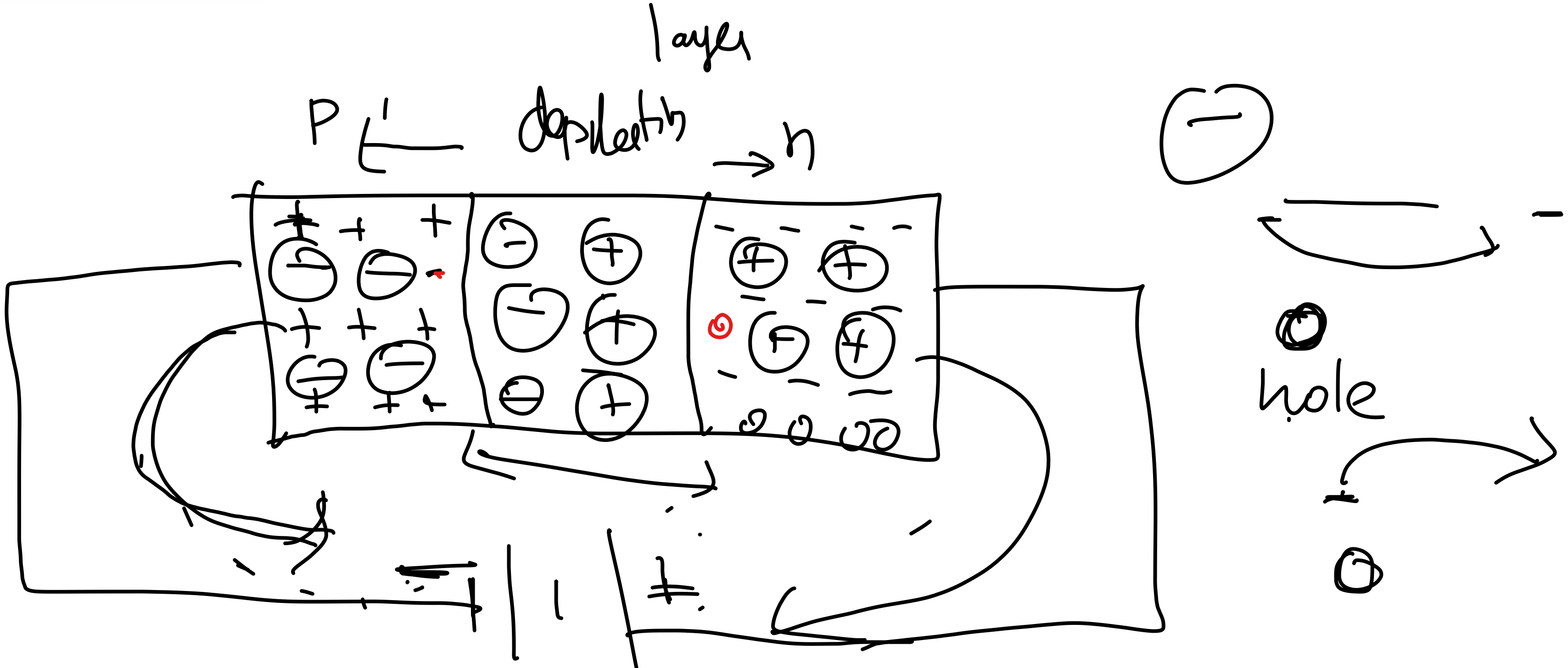
0.7V

Forwd Majority carr

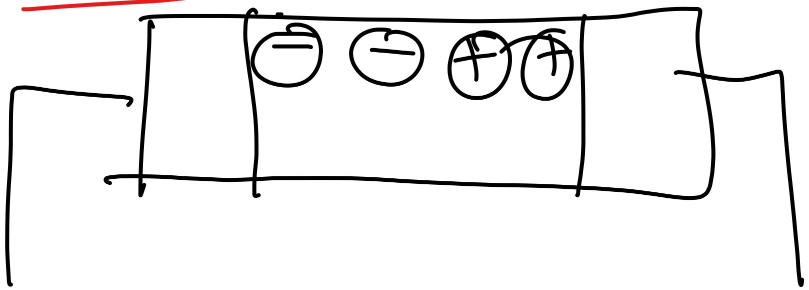
VI



Reverse Bias

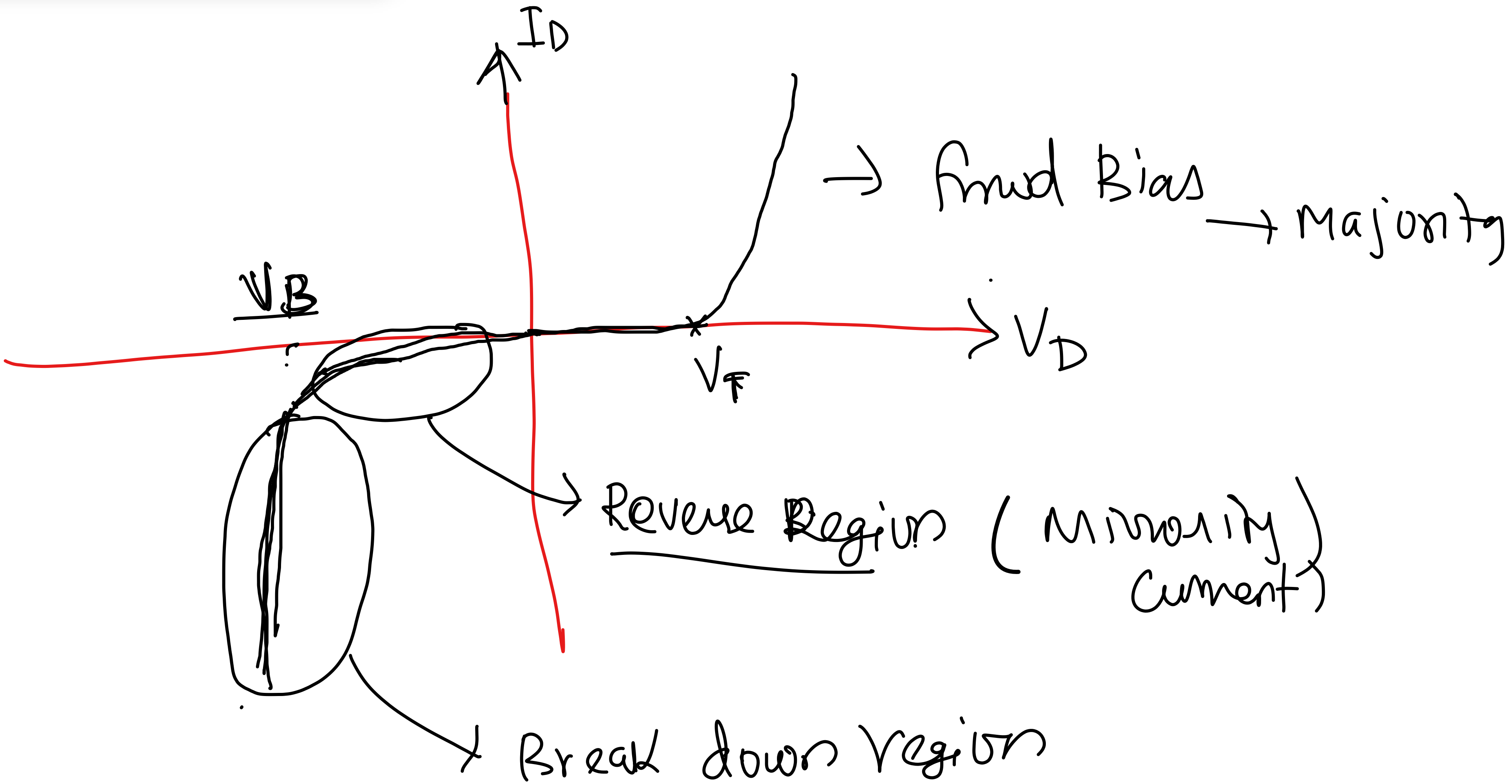


Reverse Saturation current I_s



V_B

VI



I_D
V_B
V_F
V_D
→ Frwd Bias → Majority
Reverse Region (Minority current)
Break down region

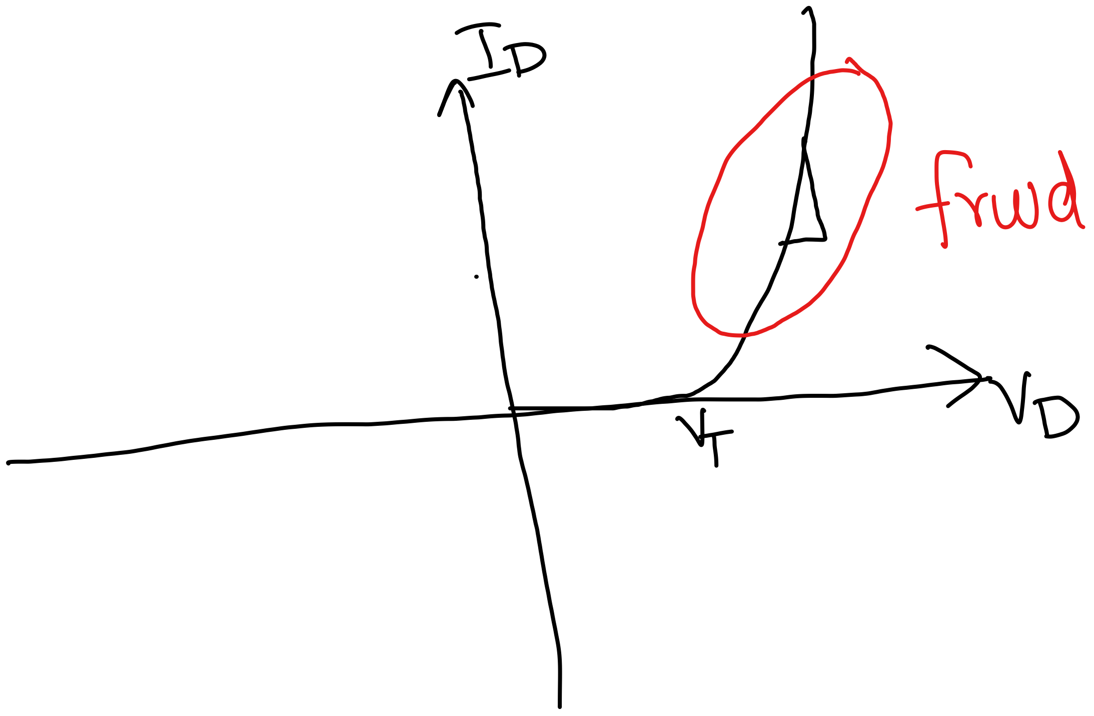
Basics of Engineering

Zener Diode

SPARKS ACADEMY

VI

$$\underline{\underline{R_D}} = \frac{V_D}{I_D}$$



$$\underline{\underline{I_D}} = \underline{\underline{I_s}}\left[\left(e^{\frac{V_d}{\eta V_T}}\right) - 1\right]$$

I_s Saturation Current

$\underline{\eta}$ – ideality factor

V_d – V_{tg} diode

$V_T \rightarrow$ Thermal Voltage

$V_T \propto T$

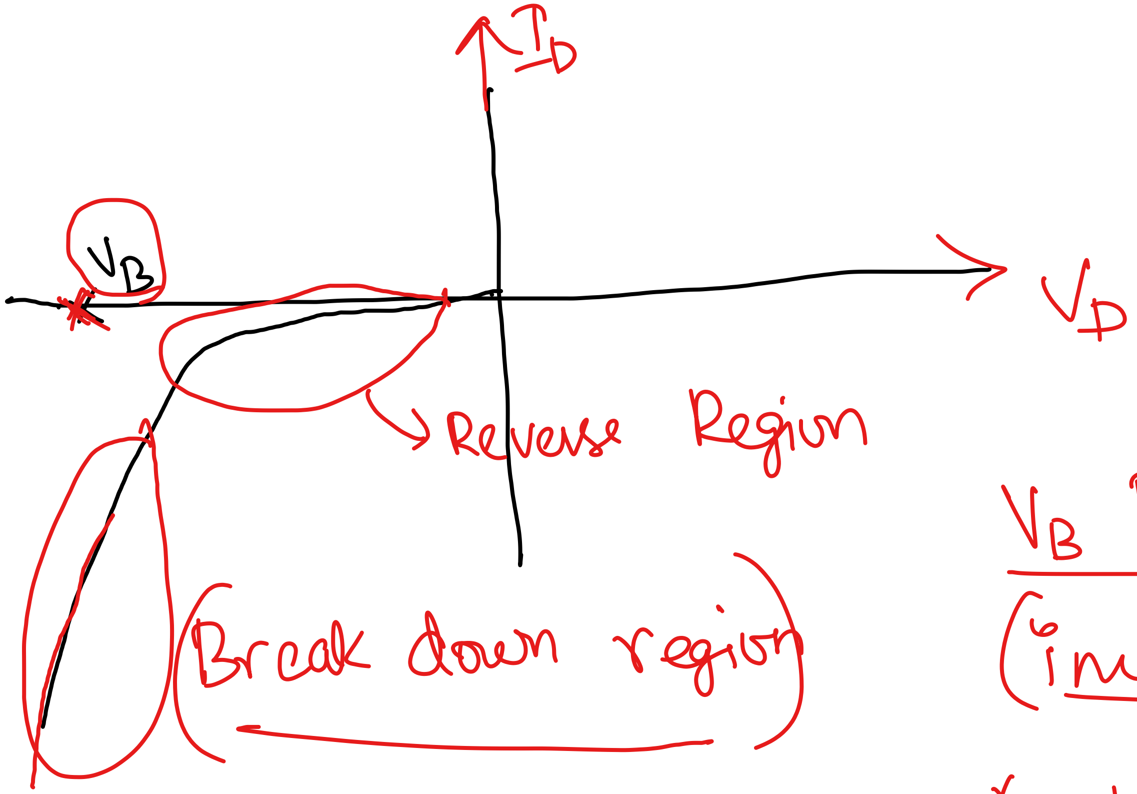
$$V_T = \frac{kT}{q}$$

K - boltzmann's constant $(1.38 \times 10^{-23}\ J/K)$

T - Temperature

q - charge of electron. $(1.6 \times 10^{-19}\ C)$

Reverse Bias



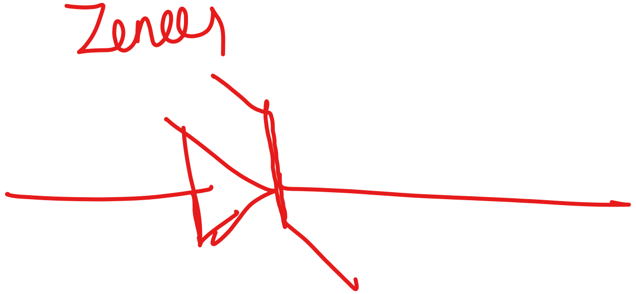
V_B Break down Vtg

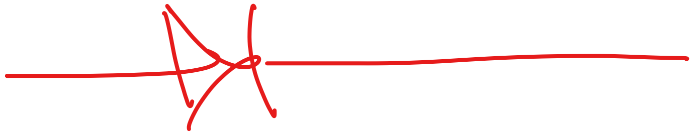
(impact ionization)

Avalanche effect

Avalanche Breakdown

Zener diode



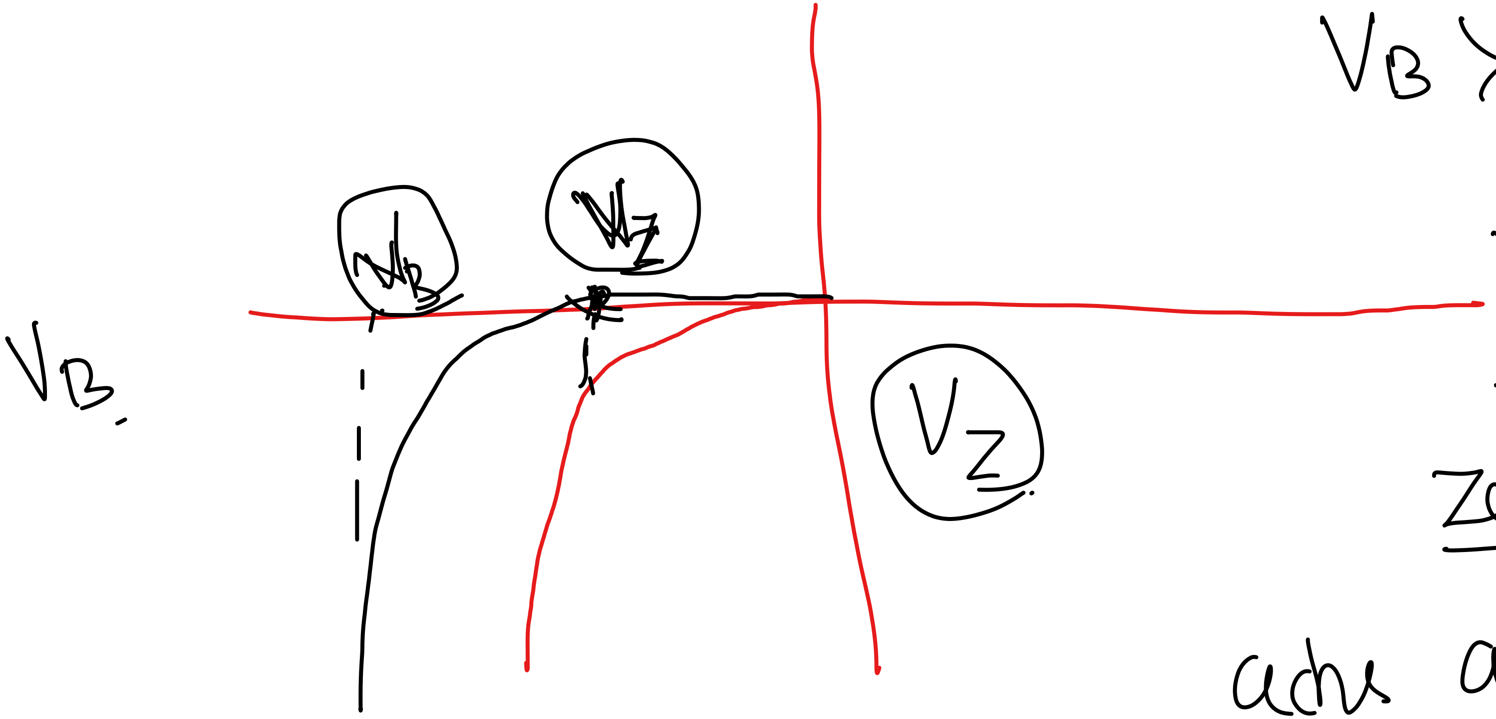


10V

Vz

6V

$V_B > V_z$

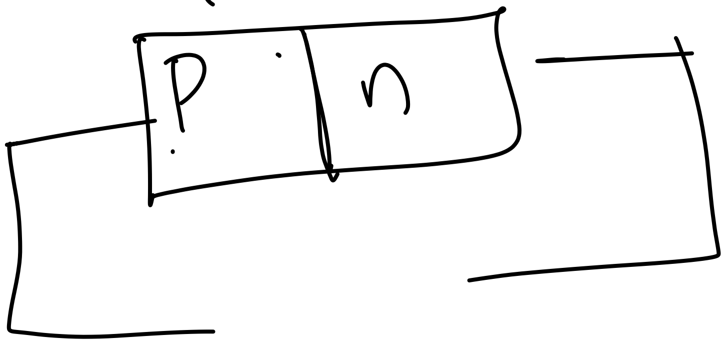


V_z X

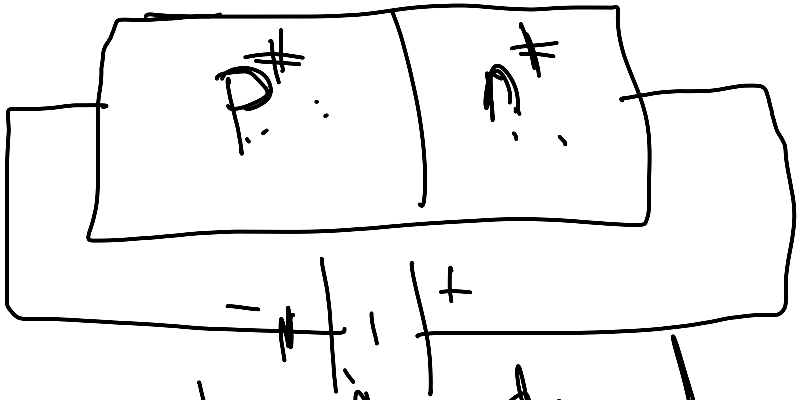
Zener diode acts as a Vtg regulator

Pn diode.

PN

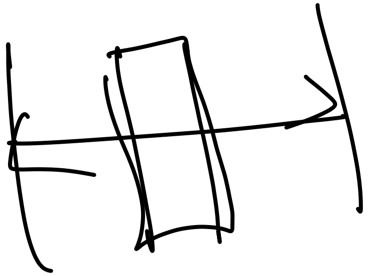


Zener diode



p^{+} → heavily doped

n^{+} →



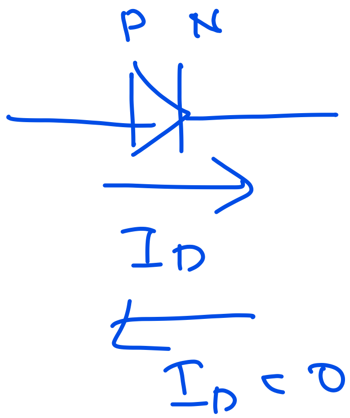
Basics of Engineering

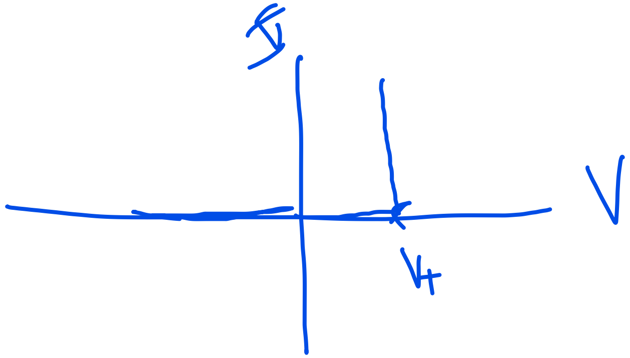
Half Wave and Full Wave Rectifier

SPARKS ACADEMY

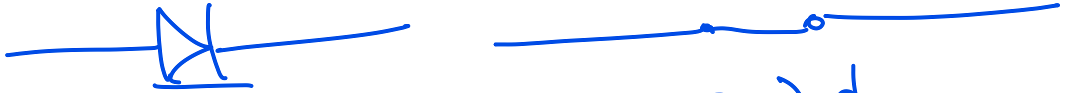
Diode – VI

ideal



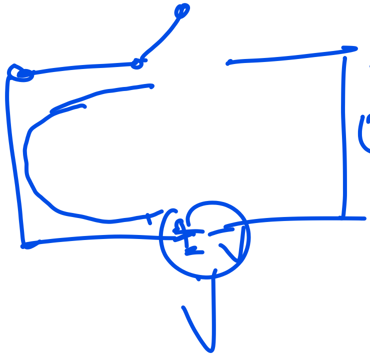


Frwd Bias I_D



closed switch

Reverse Bias $I_D = 0$



open switch

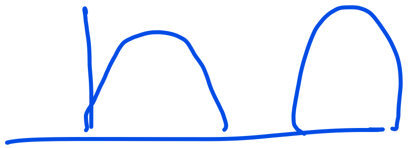
PN

Rectification:-

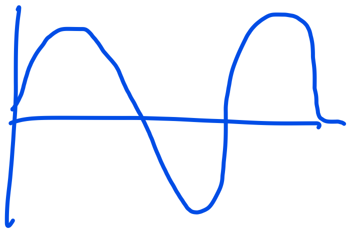
Ac signal to DC signal

pulsating dc

DC



Rectification ⇒ Ac to DC

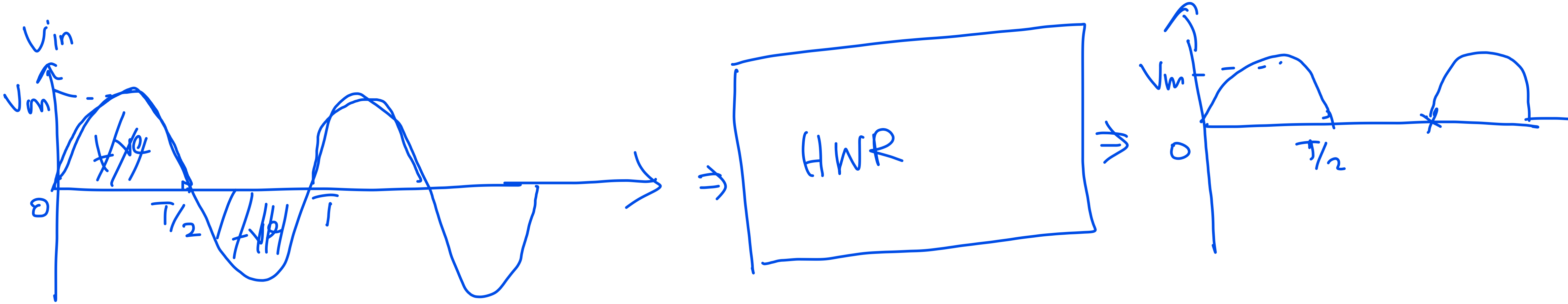


Rectifier:-

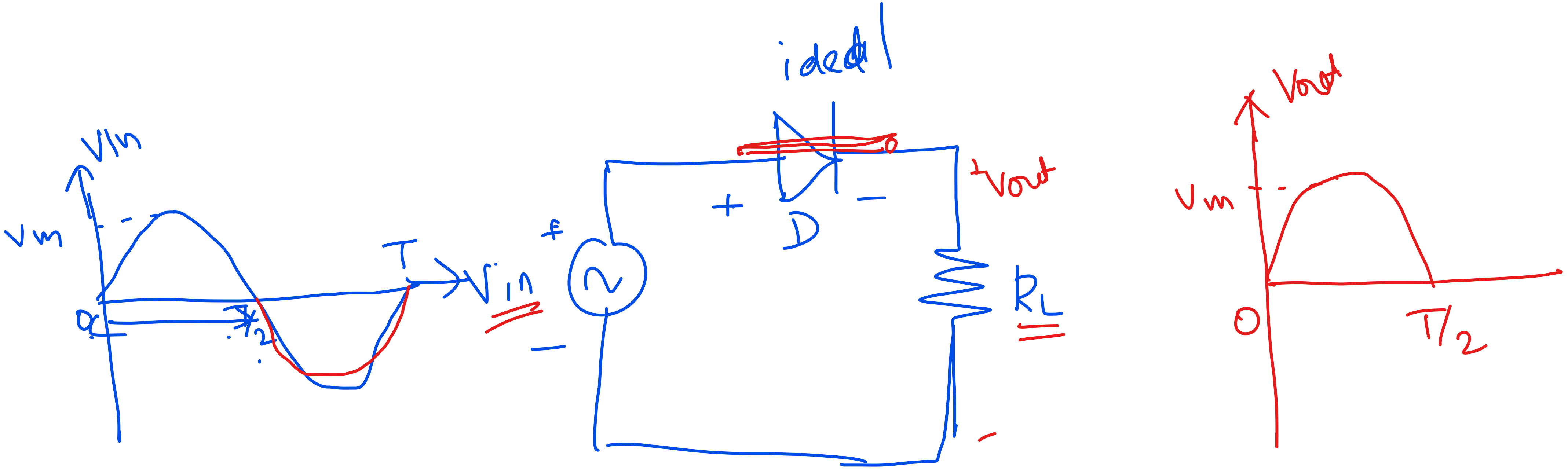
Types of Rectifier.

- Halfwave
- Fullwave Rectifier.

Halfwave Rectifier :-



ckt Diagram

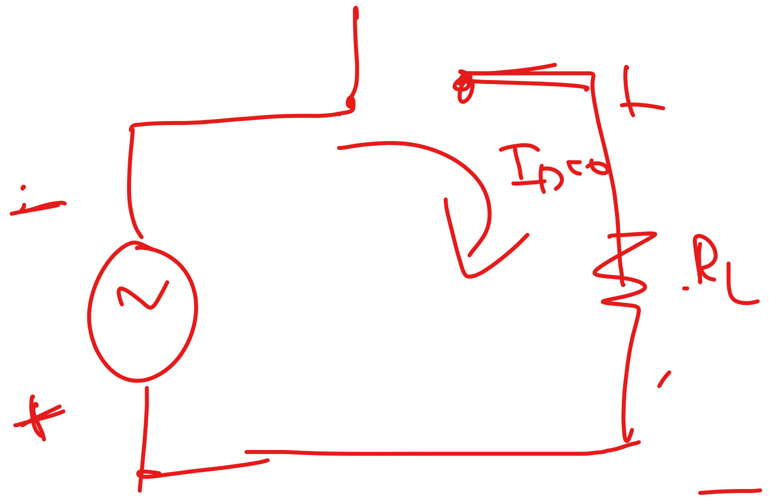


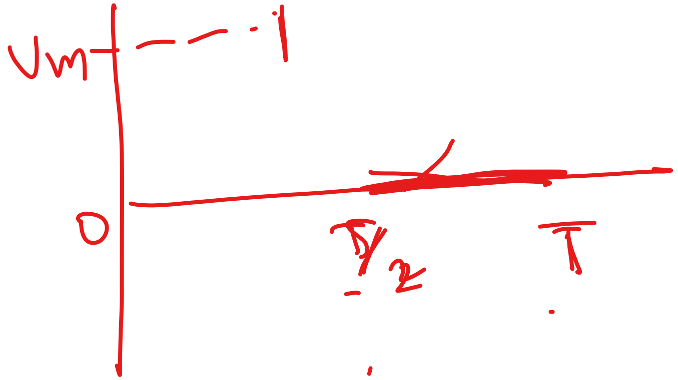
1^{st} half cycle D is frwd Bias

↳ closed switch

2nd half cycle.

Reverse Bias. ⇒ Open switch → $I_D = 0$



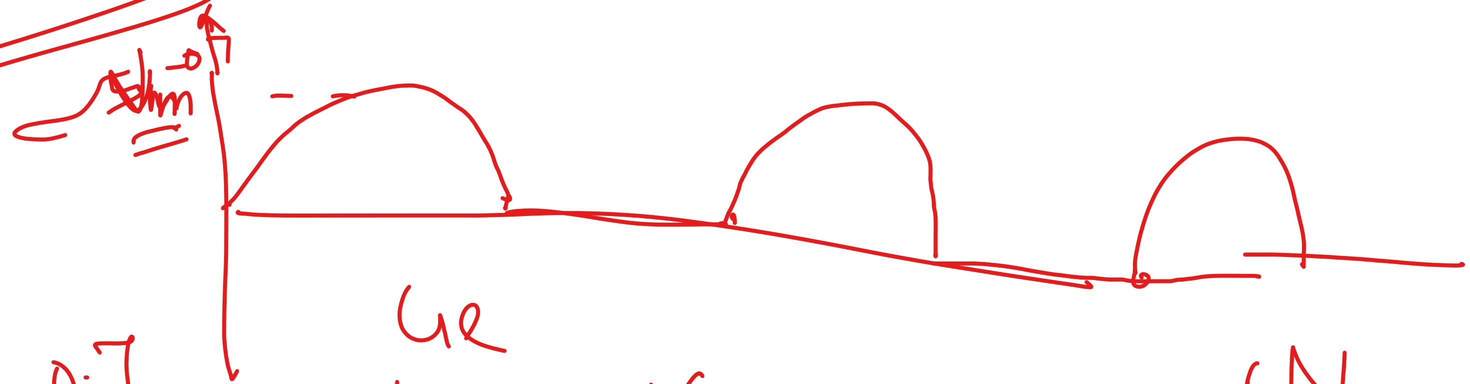


Ideal

Non Ideal

Vtg drop

O/P wave form



Si

Vm-0.7

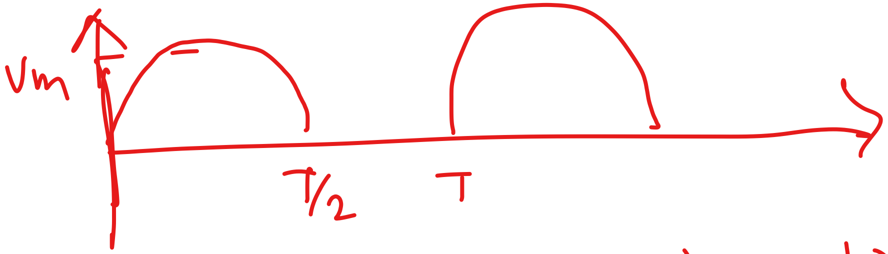
Ge

Vm - 0.3V

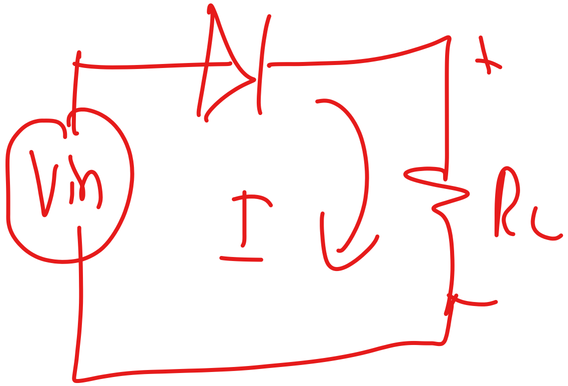
0.7V

Performance:-

1) Avarage value (dc value) :-



$$V_{avg} = \frac{1}{T}\int_0^T v(t)\,dt \qquad v(t) = \begin{cases} V_m \sin(\omega t) & 0 < t < T/2 \\ 0 & T/2 < t < T \end{cases}$$



$$\boxed{V_{avg} = \frac{V_m}{\pi}}$$

$$\boxed{I_{avg} = \frac{I_m}{\pi}} \qquad I(t) = \begin{cases} I_m \sin\omega t & 0 < t < T/2 \\ 0 & T/2 < t < T \end{cases}$$

2) RMS Value

$$V_{rms} = \left[\frac{1}{T}\int_0^T v^2(t)\,dt\right]^{1/2}$$

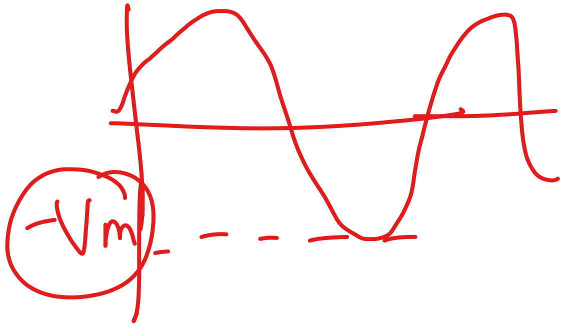
$$V_{rms} = V_m/2$$

$$I_{rms} = I_m/2$$

$$I_m = \frac{V_m}{R_L}$$

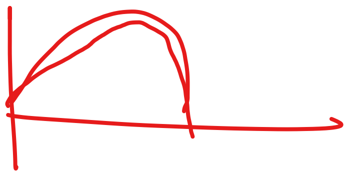
$$I_{avg} = \frac{I_m}{\pi} = \frac{V_m}{\pi R_L}$$

3) Peak Inverse Voltage PIV:-

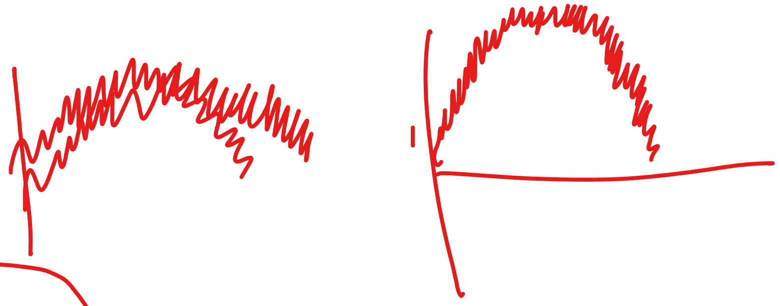


⇒ RB maximum Vtg ⇒ PIV

Half wave



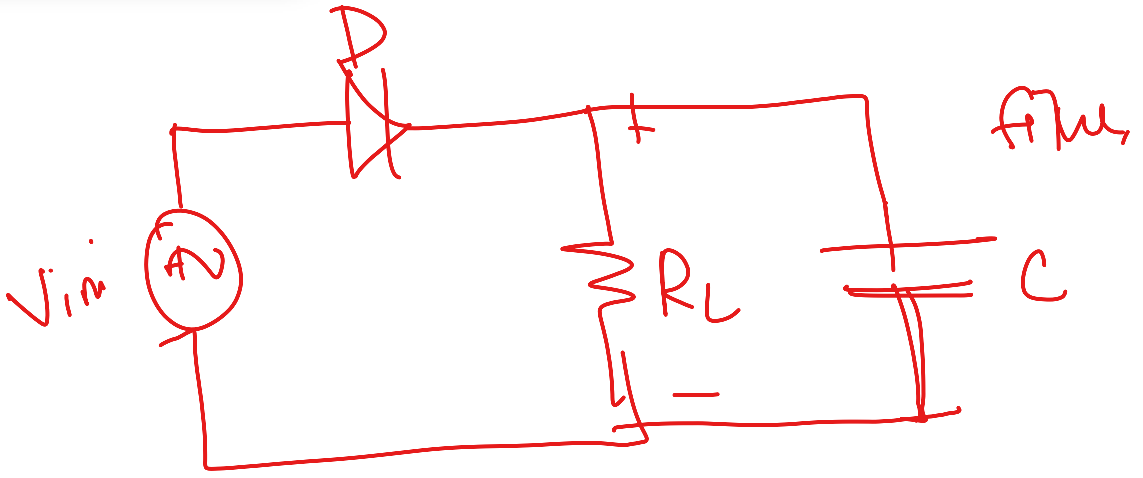
$$PIV = V_m$$



4) Ripple factor:-

$$\gamma = \frac{I_{rms}}{I_{DC}} = 1.21$$

filter cirut



5) **efficiency** :-

$$\eta = \frac{\text{DC Output power}}{\text{AC Input power}}$$

$$\boxed{\eta = 40.6\%}$$

Application .

⇒ Ac to Dc Conversion

⇒ Demodulation

$PIV = V_m$

output frequency = f

ripple factor = 1.21

$\eta = 40.6\%$

$RMS = V_m/2$

Average Value (dc Value) $= \frac{V_m}{\pi}$

Full Wave Rectifier:

'f' ⇒ '2f'

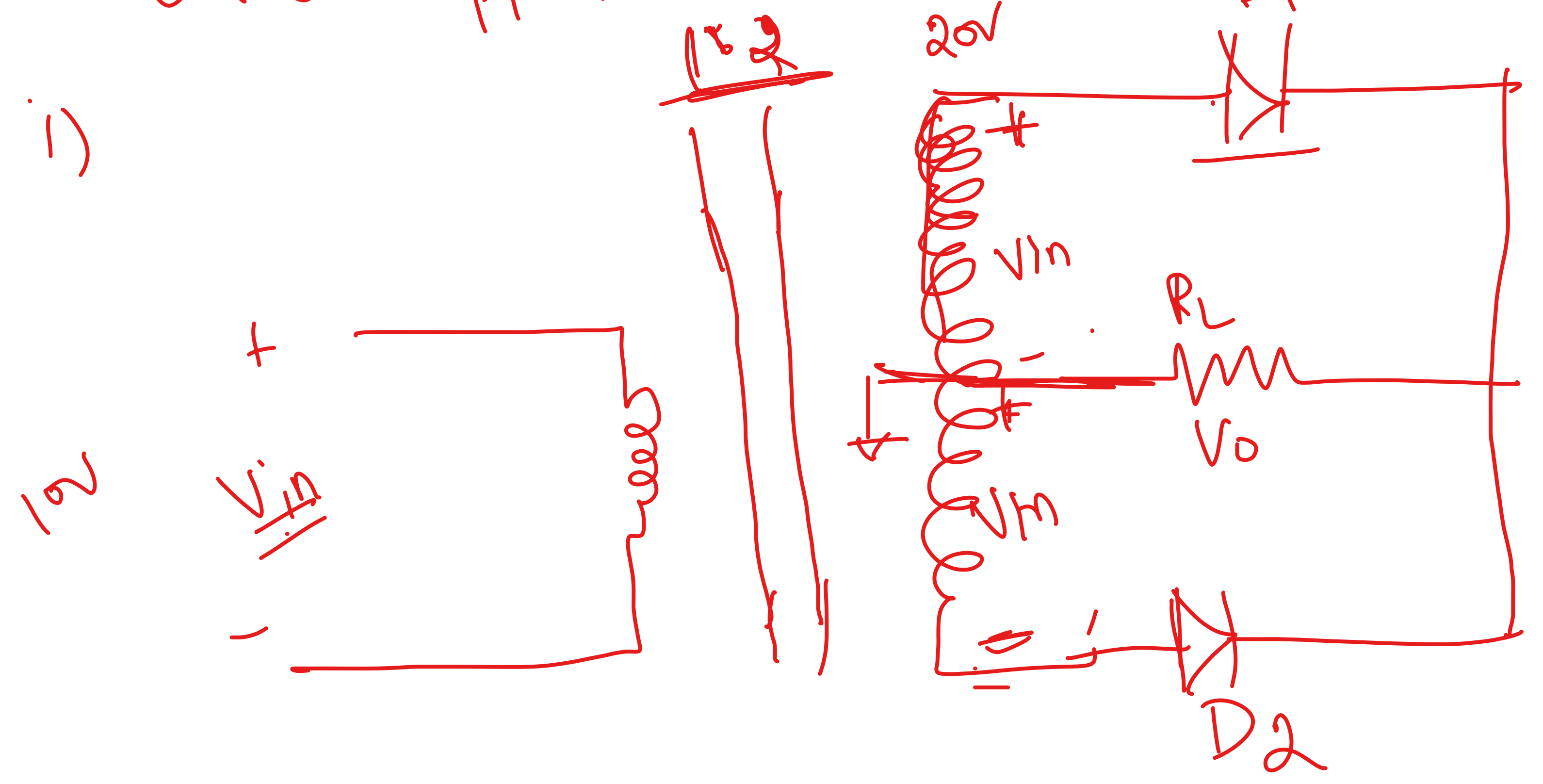
$T' = T/2$

$F' = 2f$

2 Methods

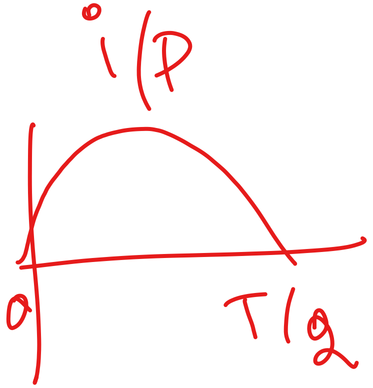
i) Center tapped Transformer

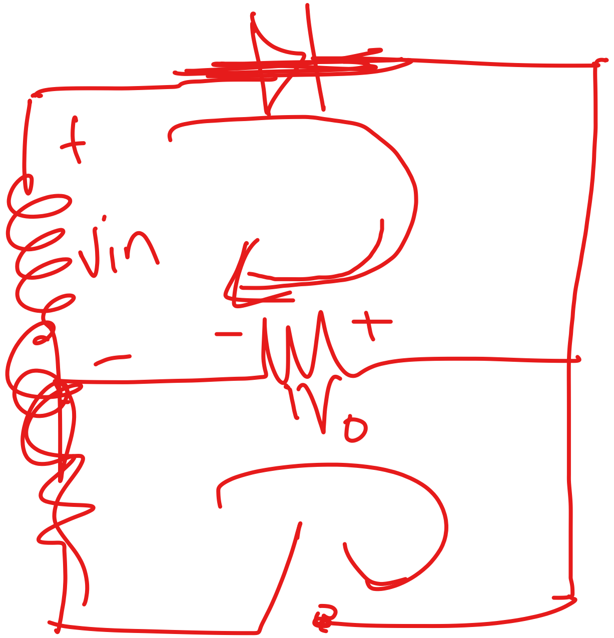
Diode Bridge Rectifier

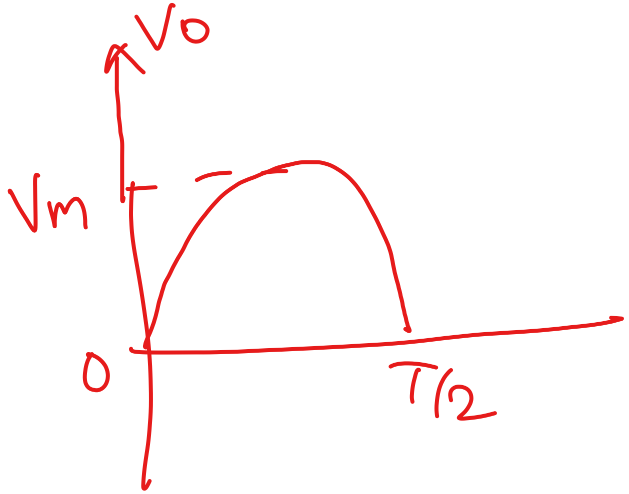


Center tapped Transformer:

ideal







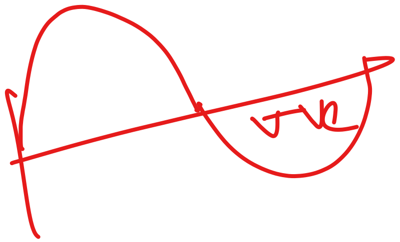
1st half cycle D_1 - FB ⇒ closed ⇒ on

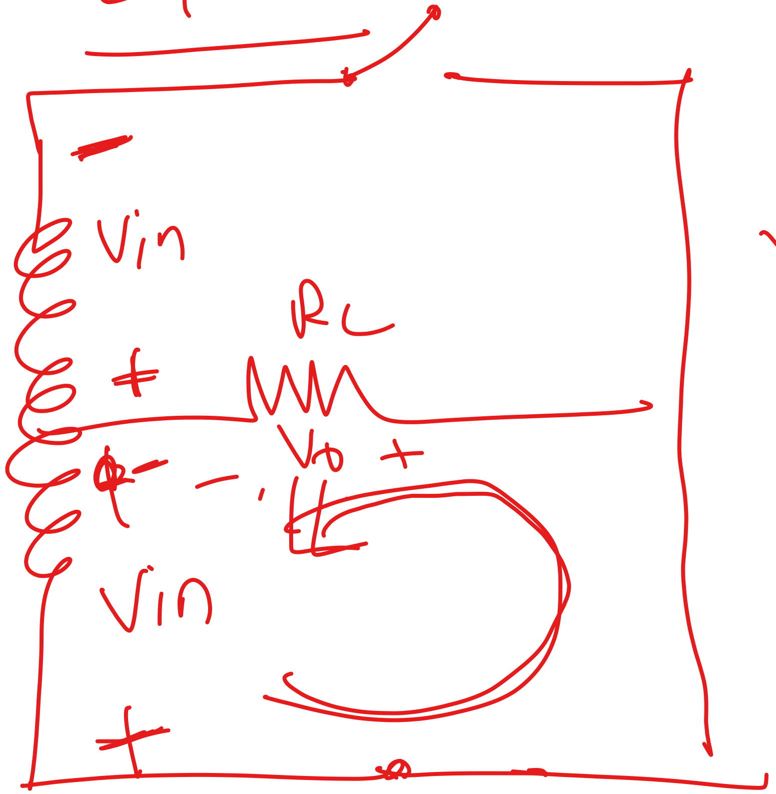
D_2 → RB → open — X

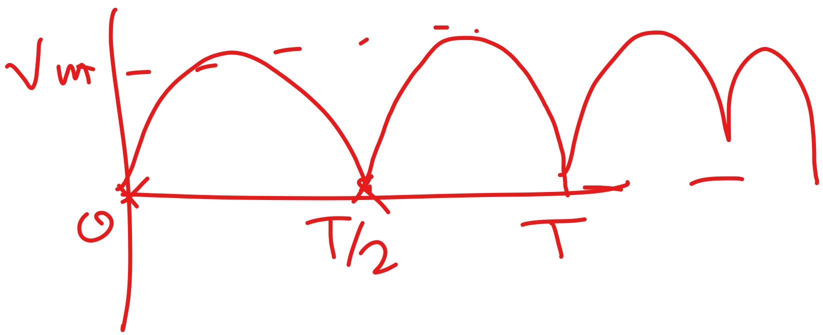
2nd half cycle

↳ D_2 → FB → closed

D_1 → RB → open







Average Vtg :-

HWR $V_{avg} = \frac{V_m}{\pi}$

FWR $V_{avg} = \frac{2V_m}{\pi}$

V_{avg} HWR = 5V

FWR $V_{avg} = 2 \times 5 = 10V$

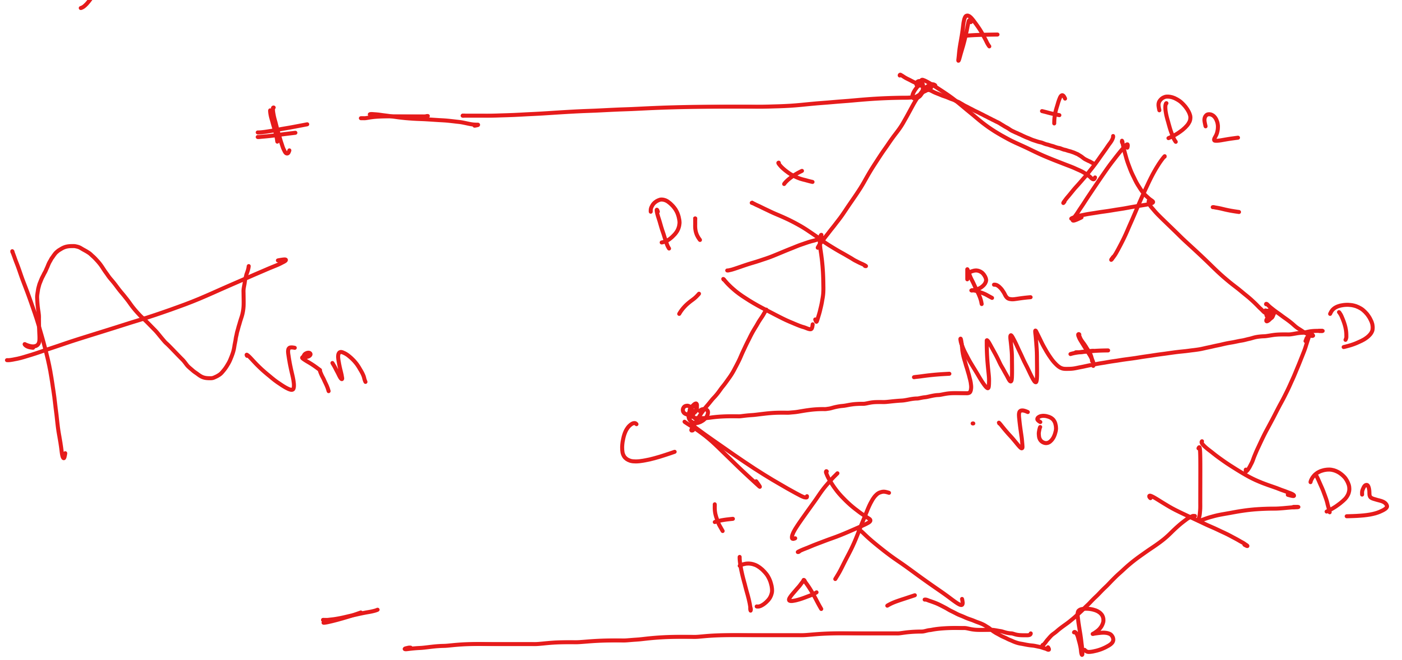
$$V_{avg} = \frac{2(V_m - 0.7)}{\pi} \text{ (si)}$$

$$V_{avg} = \frac{2(V_m - V_T)}{\pi}$$

2) Peak Inverse Vtg

$$PIV = 2V_m$$

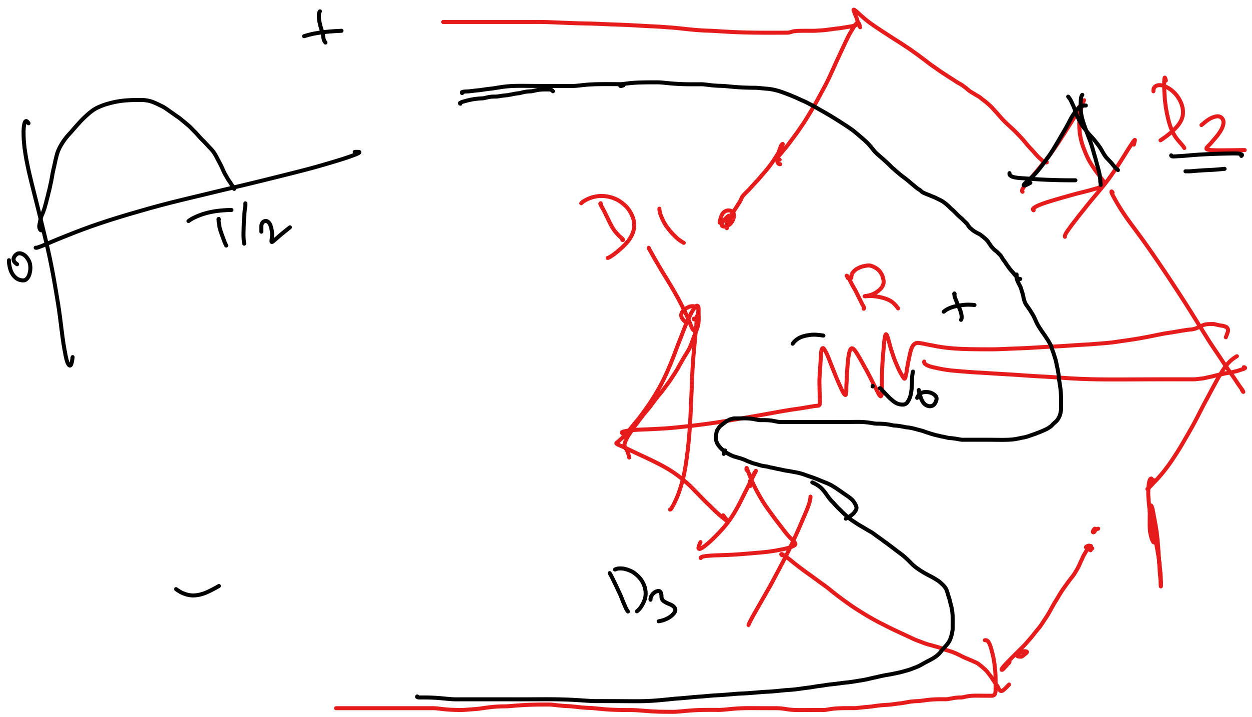
2) Full wave Bridge Rectifier ckt:-

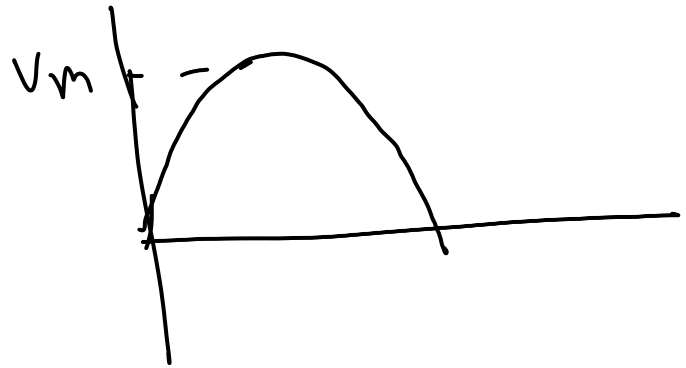


1st half cycle

D_2 D_4 ⇒ FB ON

D_1 D_3 ⇒ RB OFF

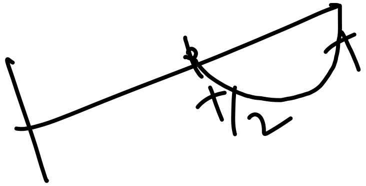


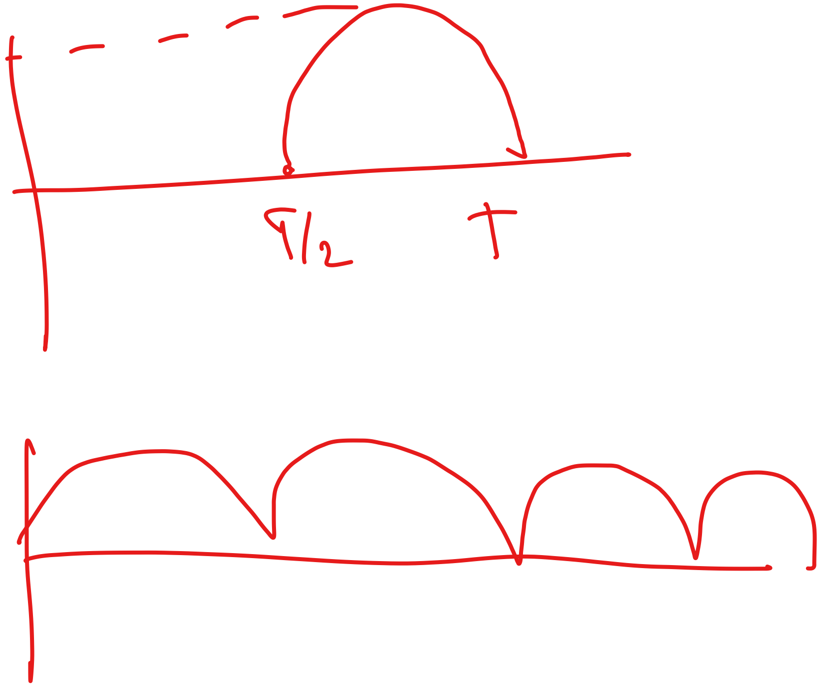


2^{nd} half cycle

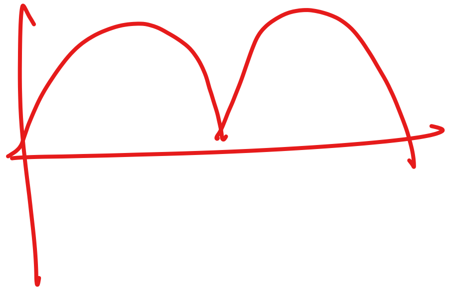
RB D2 & D4 OFF

D1 & D3 FB ON





$$V_{avg} = \frac{2V_m}{\pi} \quad \text{(ideal)}$$



$$V_{avg} = \frac{2(V_m - 2V_T)}{\pi}$$

Si $= 0.7V$

Ge $= 0.3V$

3) Peak Inverse Voltage

$$PIV = V_m$$

4) Ripple factor.

$$r = \frac{V_{rms}}{V_{dc}} = \underline{\underline{0.43}}$$

(without filter)

$\boxed{1.21}$

Half wave

<u>With filter</u>

$$r = \frac{V_{rms}}{V_{dc}} = \frac{1}{4\sqrt{3}\, f R_L C}$$

Efficiency

$$\eta = \frac{\text{DC Output power}}{\text{AC Input power}}$$

$= 81.2\%$

HWR 40.6%

Summary

Performance	Center taped Transformer	Bridge Rectifier	HWR
PIV	2Vm	Vm	Vm
Output frequency	2f	2f	f
Ripple factor	0.43	0.43	1.21
Efficiency	81.2%	81.2%	40.6%

RMS Value	$V_m/\sqrt{2}$	$V_m/\sqrt{2}$	$V_m/$
Average Value (dc Value)	$\frac{2(V_m - V_T)}{\pi}$	$\frac{2(V_m - 2V_T)}{\pi}$	$\frac{V_m}{\pi}$