Date : 22-04-17

EEE-~~1241~~ 2141

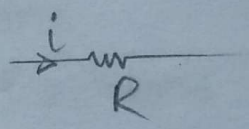
Electronic Device & Circuits

Electrical

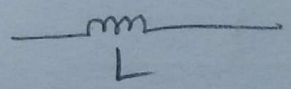
= I – through conductors
(current)

= V & I → Linear

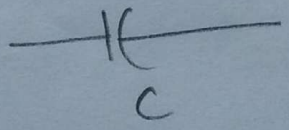
$v = iR$



$v_L = L\frac{di}{dt}$

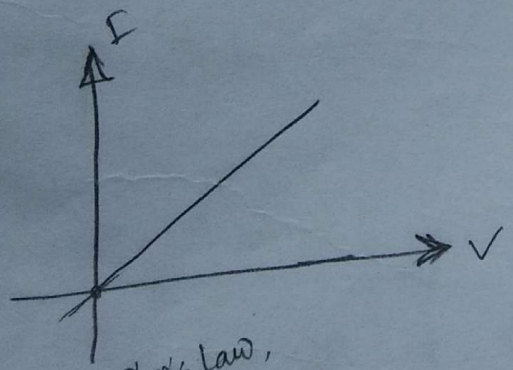


$\int i_c dt = \int C\frac{dV_c}{dt}\cdot dt$



$\int i_c dt = C v_c$

$v_c = \frac{1}{C}\int i_c dt$



Ohm's Law,

$V = IR$

$I = \frac{1}{R} \times V$

$y = m x$

Linear

Electronic

= I – through semiconductor
(current)

= V & I → non-linear

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Devices

- Diode — Clipper, Rectifier
- BJT
- FET → JFET, MOSFET
- Op-amp.

Power Electronic Device

SCR
UJT

Book Reference:

Electronic Devices & Circuits Theory
by Robert Boylestad

Lubaba - Room No. - 413

Phone: 01777012143

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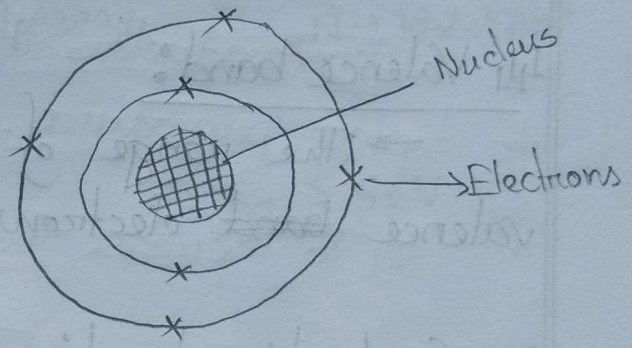
Atomic Structure:

Atoms are basic building blocks of a material.

→ 3 sub-atomic particles:

- Protons
- Neutrons
- ~~Electo~~ Electrons



Valence Electrons:

→ Electrons in the outermost orbit of an atom

→ Determine the physical, Chemical & electrical properties.

Energy Bond:

The range of energies possessed by an electron in a solid.

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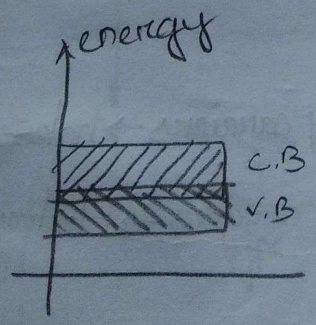
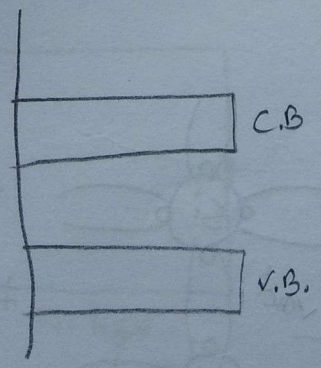
Conductor

Semiconductor

Conductor	Semiconductor	Insulator
→ No. of valence electrons are less than 4	→ No. of valence electrons are exactly 4	→ No. of valence electrons are more than 4.
$_{11}Na \rightarrow 1s^2 2s^2 2p^6 3s^1$	$_{14}Si \rightarrow 1s^2 2s^2 2p^6 3s^2 3p^2$	$_{7}N \rightarrow 1s^2 2s^2 2p^3$
→ V.B. & C.B. are overlapped	→ $E_g = 1.1\,eV$ [Si]	→ $E_g > 5\,eV$
→ Temperature ↑ R ↑ conductivity ↓ (+ve temperature co-efficient)	→ Temperature ↑ R ↓ (−ve temperature co-efficient)	→ T ↑ R ↓





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Date :

→ Valence band
→ Conduction band
→ Forbidden energy band/gap

Valence band:

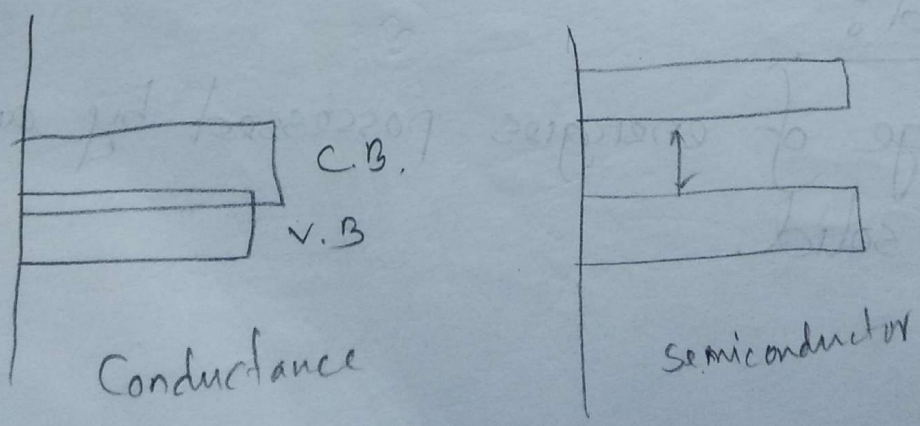
→ The range of energies possessed by valence ~~band~~ electrons.

Conduction band:

→ Energy band formed due to merging of energy levels associated with the free electrons.

Forbidden Energy Gap:

→ The band gap between V.B. & C.B. where no electrons are found.



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Intrinsic Semiconductor:

Semiconductor in pure form.

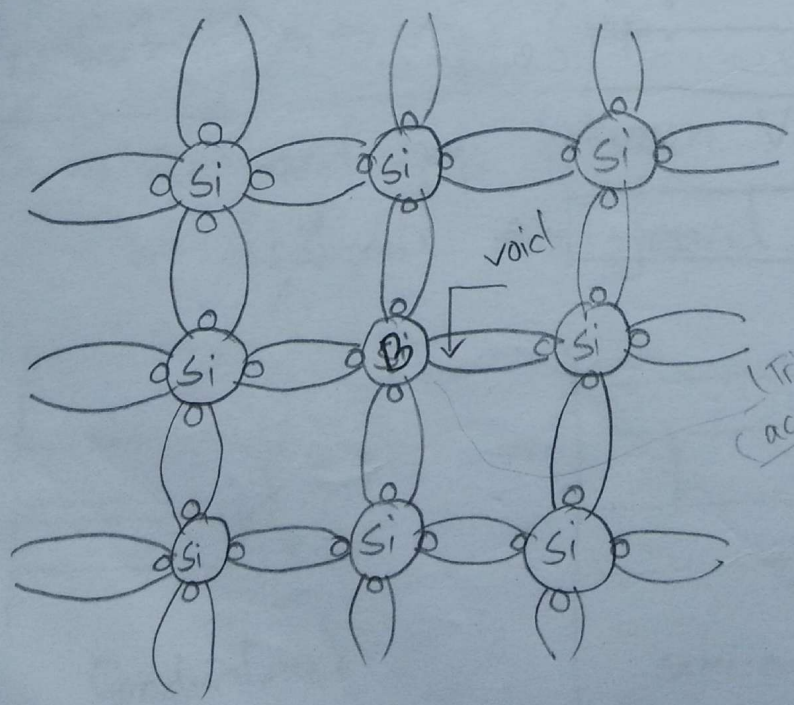
Extrinsic Semiconductor:

Semiconductors that have been subjected to doping procedure.

To increase the conductivity

- p-type
- n-type

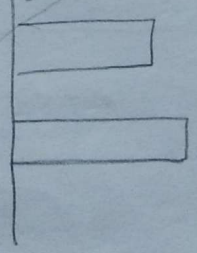
p-type:



majority carriers → holes

Minority carriers → Electrons

(Trivalent atom)
(acceptor atom)



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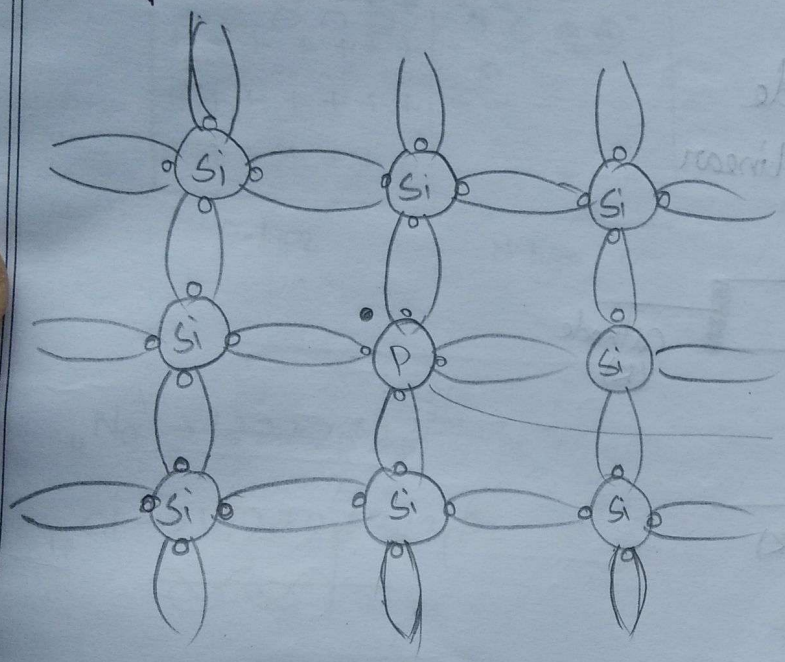
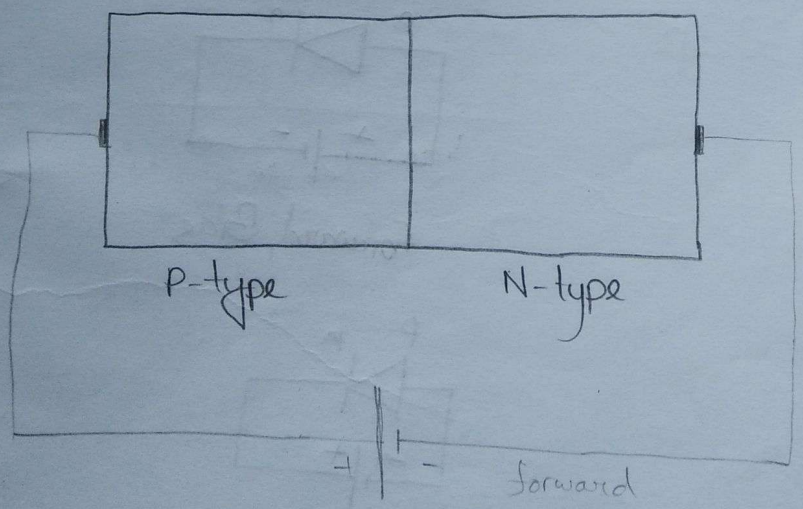
n-type :



Majority carriers → electrons

Minority carriers → holes

[pentavalent atom]



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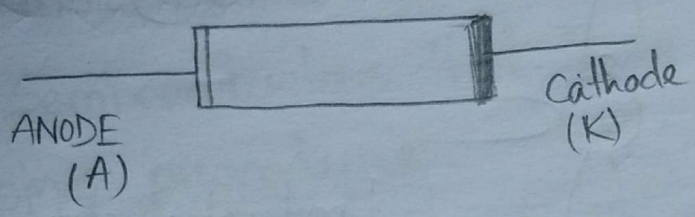
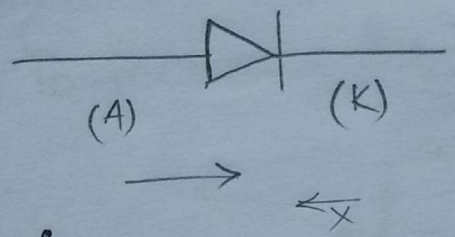
Diode

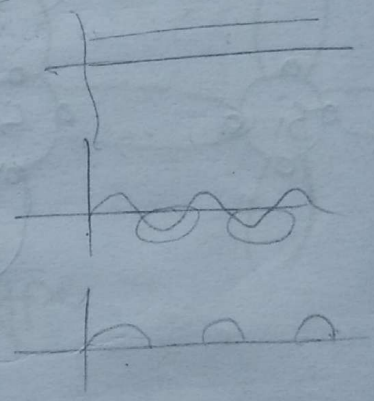
→ pn junction diode

→ Bipolar & Non-Linear





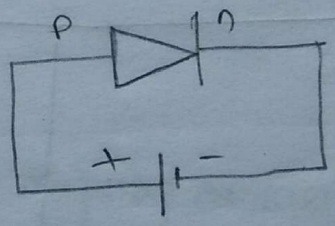
Bias:



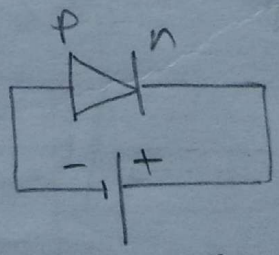
Application:

i) Rectifier
ii) Signal Limiter
iii) Voltage Regulator
iv) Switches

Bias



Forward Bias



Reverse Bias

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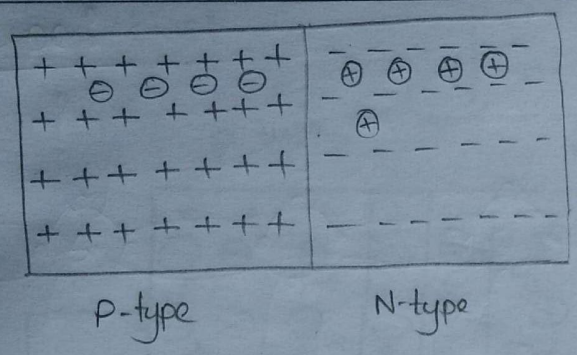

$_{11}Na^{+} \rightarrow 1s^2 2s^2 2p^6 3s^1$

$_{17}Cl^{-} \rightarrow 1s^2 2s^2 2p^6 3s^1 3p^5$

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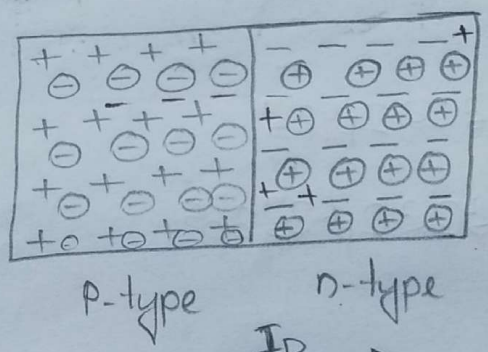
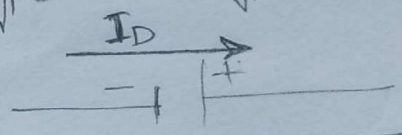
PN junction Diode:

→ No bias
→ Forward bias
→ Reverse bias

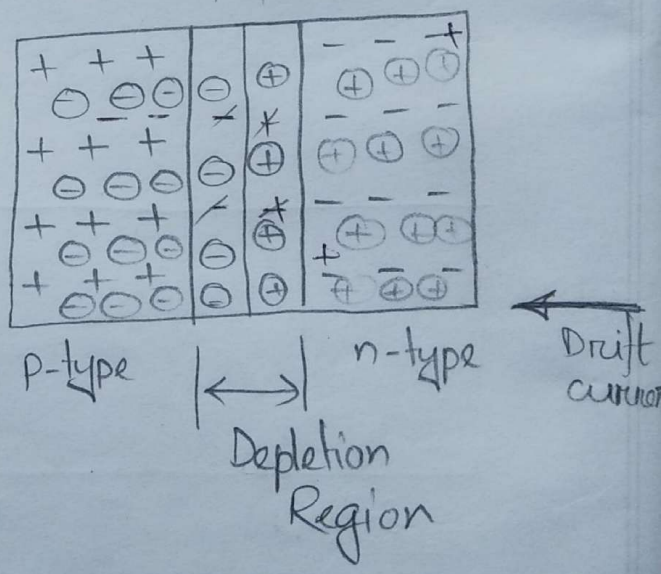
No bias

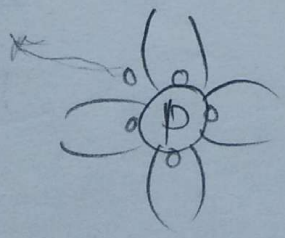




$_{11}Na^{\oplus} \rightarrow 1s^2 2s^2 2p^6 \cancel{3s^1}$

$_{17}Cl^{\ominus} \rightarrow 1s^2 2s^2 2p^6 3s^2 3p^5$





I_D → Diffusion current → Majority carrier

Drift current → minority carrier

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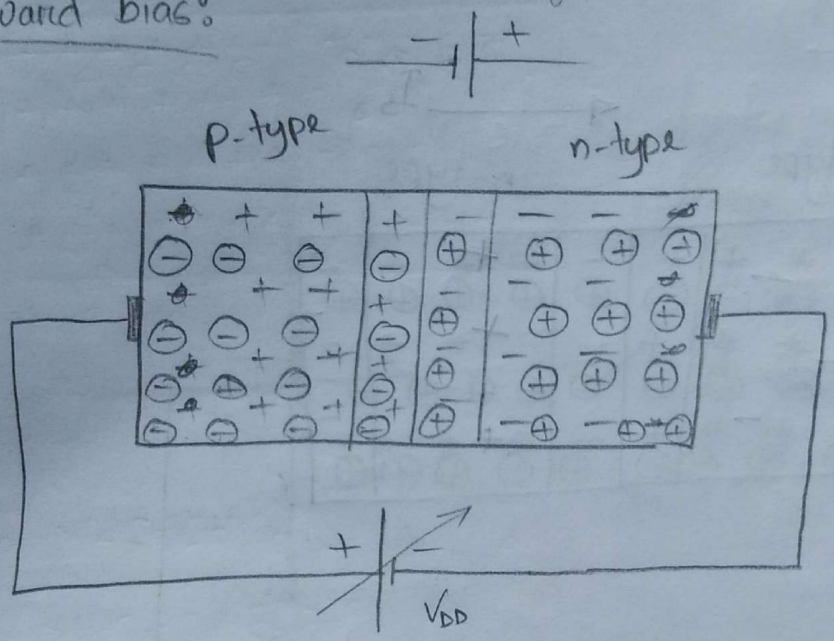
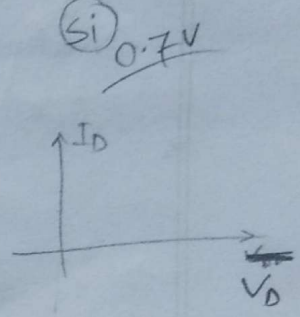
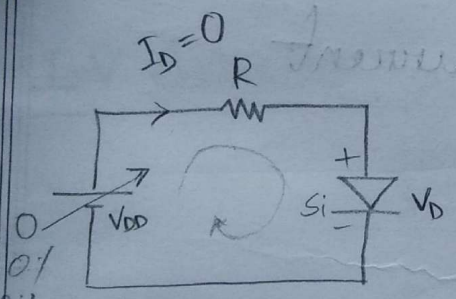
$\longrightarrow I_D$ (Forward Diode Current)

Date : .....

forward bias:



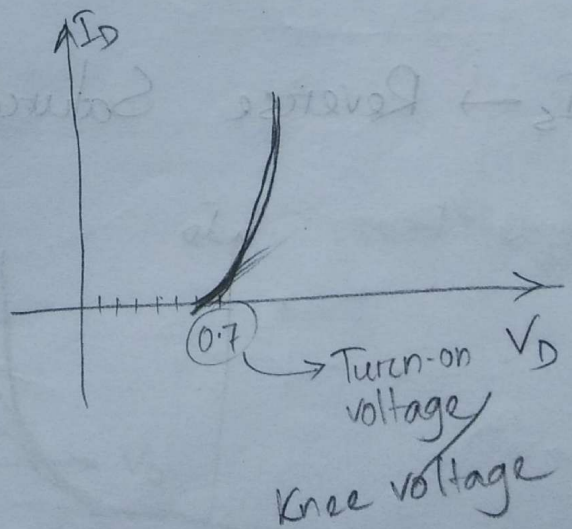




KVL,

$$-V_{DD} + I_D R + V_D = 0$$

0.7 $\boxed{V_D = V_{DD}}$



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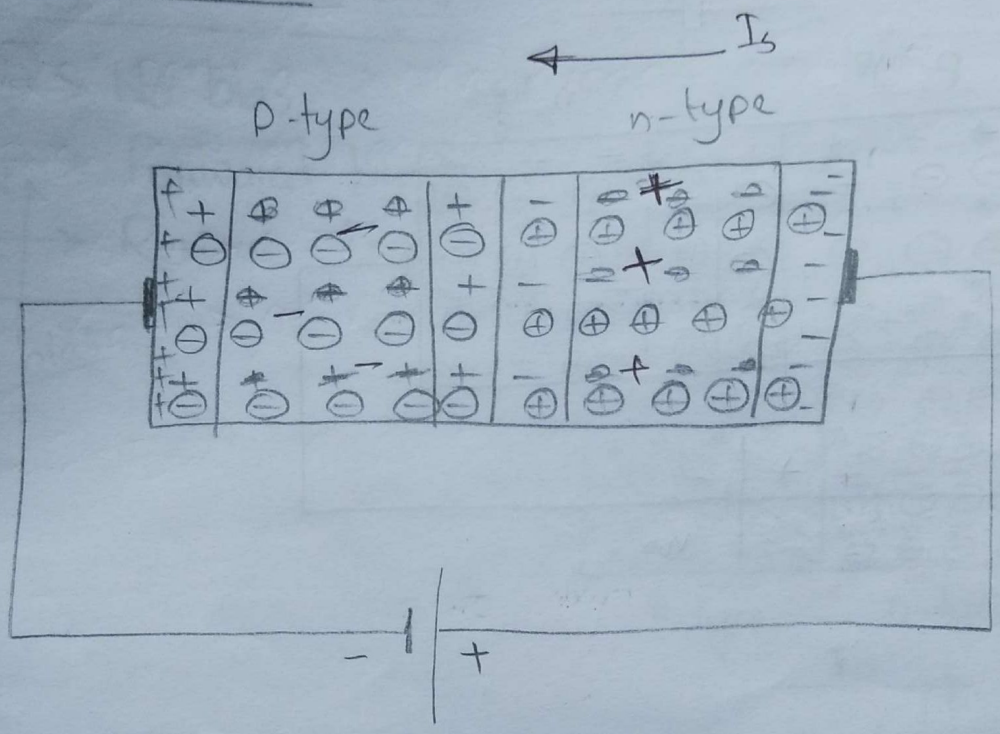
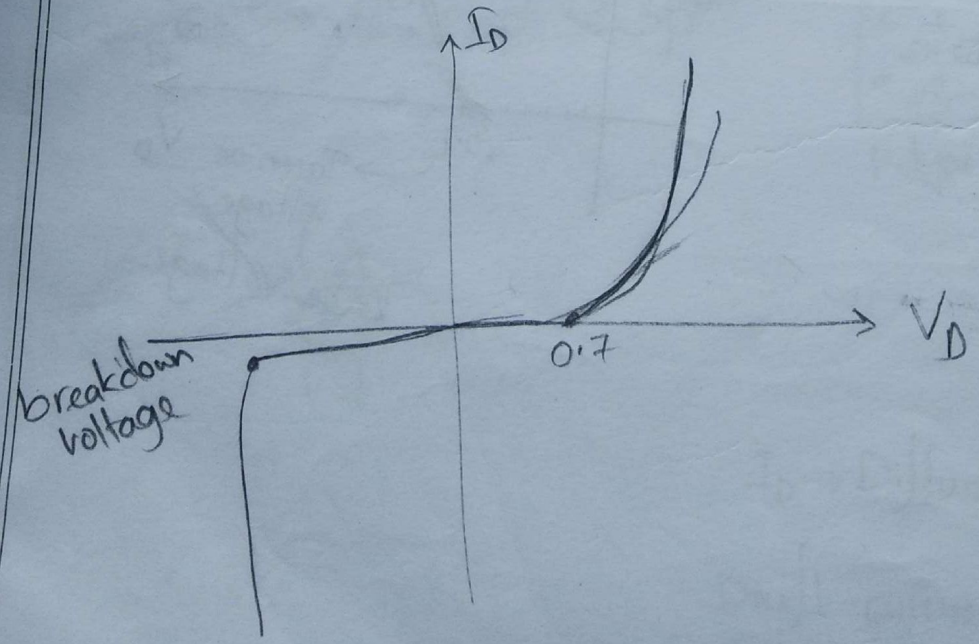
Reverse bias:



$I_s \rightarrow$ Reverse Saturation Current



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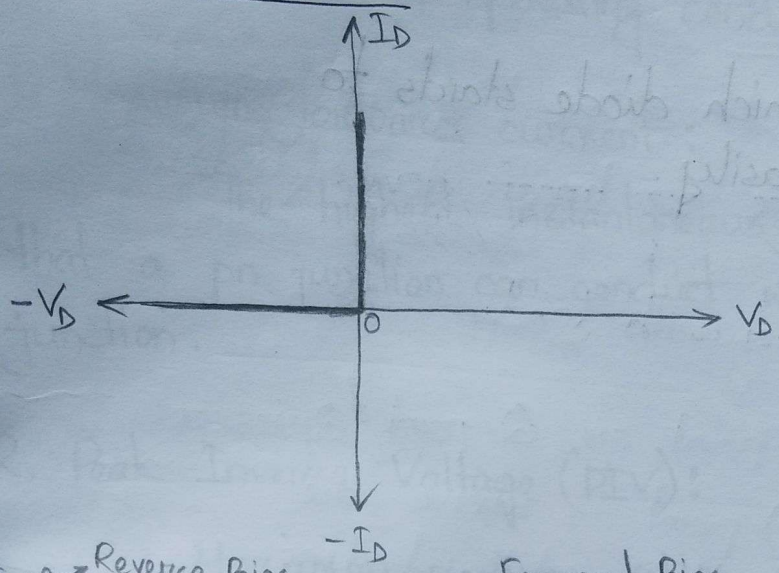
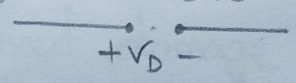
Ideal Diode:

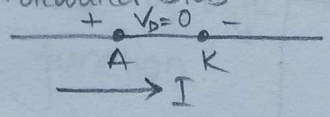


$I_D = 0 \rightarrow$ Reverse Bias



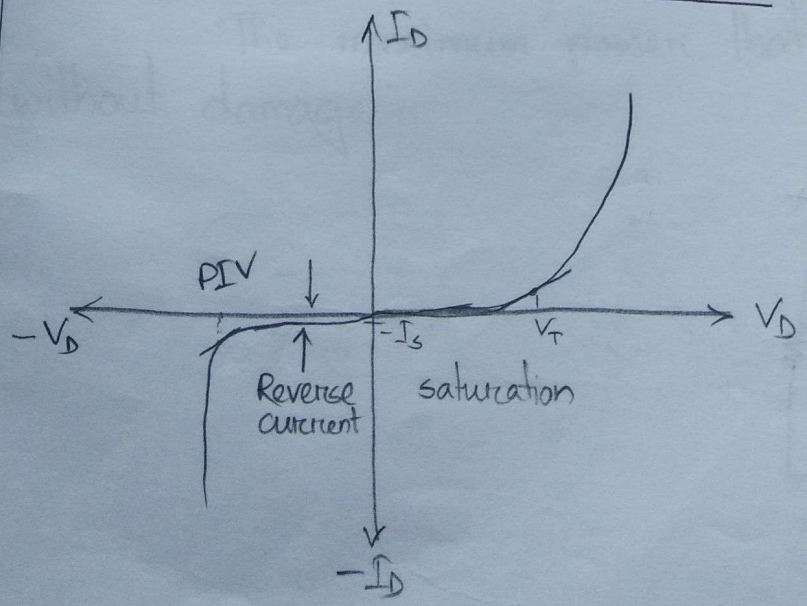
open circuit - এর মত behave করে।

Forwaard Bias



short circuit এর মত behave করে।

I-V characteristics of a Diode



PIV — Peak Inverse Voltage

Date : .....

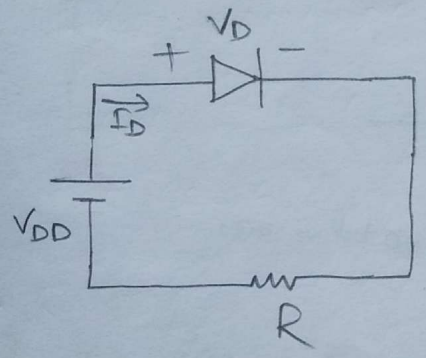
Threshold voltage:

The point at which diode starts to conduct current easily.

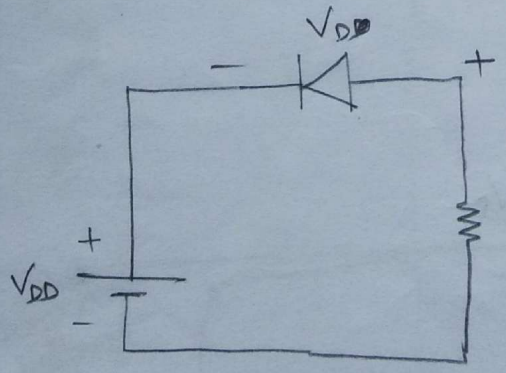
Si → 0.7V

Ge → 0.3V

Forward Bias



Reverse Bias



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Date : .....

Limitations in the operating condition of pn junction:

1. Maximum forward current:

The highest instantaneous forward current that a pn junction can conduct without damage to the junction.

2. Peak Inverse Voltage (PIV):

Maximum reverse voltage that can be applied without damage to the junction.

3. Maximum power rating:

The maximum power that can be dissipated without damage.

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Date : .....

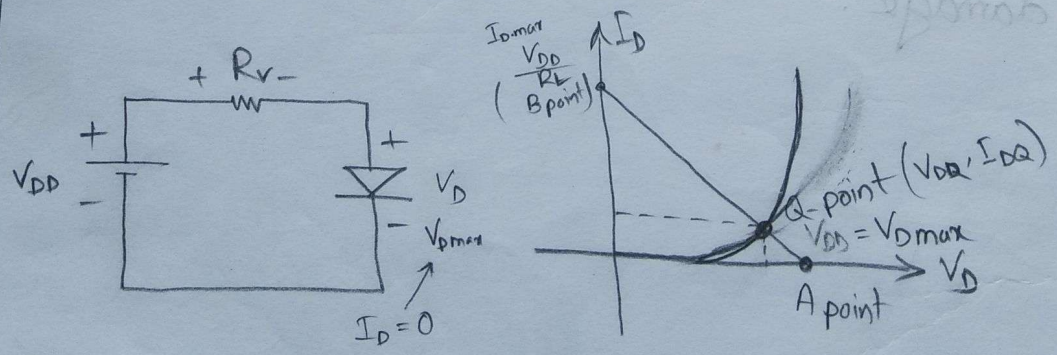
Load-line Analysis:

→ Represents the linear part of the circuit connected to the non-linear device (diode).

→ Load line varies with load.

→ The operating point or Q-point/Quiescent (Rest, unmoving) point is where the characteristic curve and load line intersects.

→ Q-point is picked to operate the diode at a ~~single~~ safe average value.



KVL,

$$-V_{DD} + I_D \times R_L + V_D = 0$$

$$\Rightarrow V_{DD} = I_D R_L + V_D \quad \text{——— (1)}$$

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Date : .....

$I_D = 0 \longrightarrow$ open circuit

$\Rightarrow V_{DD} = \cancel{I_D R_L}^{\,0} + V_D$

$\therefore V_D = V_{DD}$

$V_D = 0 \longrightarrow$ short circuit

$V_{DD} = I_D R_L$

$\Rightarrow I_D = \dfrac{V_{DD}}{R_L}$

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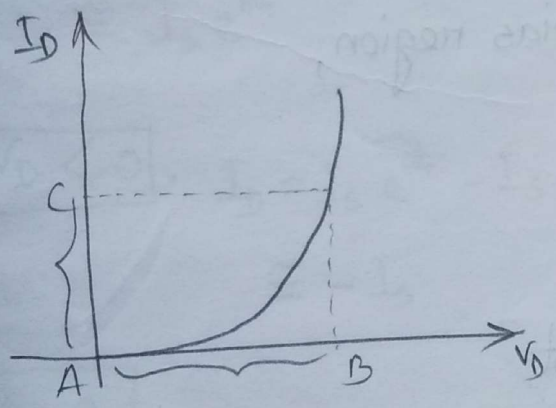
DC or Static Resistance:

The application of a DC voltage to a ckt containing a diode will result in an operating point on the characteristic curve that does not change with time.

The resistance of the diode is known as static resistance and can be found simply finding the corresponding level of V_D & I_D.

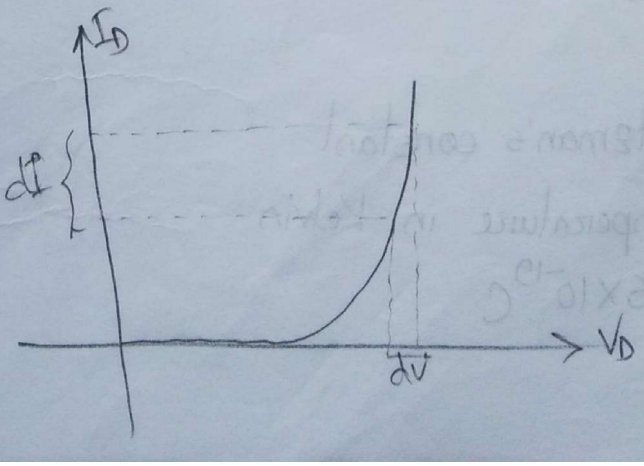


$$R_D = \frac{V_D}{I_D} = \frac{AB}{AC}$$

Dynamic Resistance:

For non-ohmic devices we define dynamic resistance, as,

$$r_d = \frac{dv}{di}$$



$$\boxed{r_d = \frac{dv}{di}}$$

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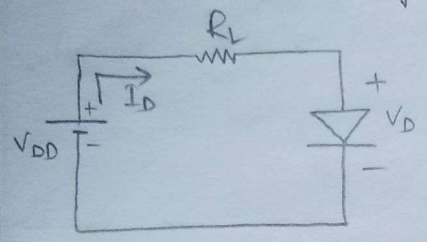
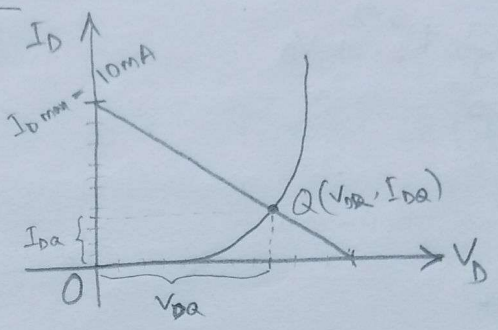
Date : 04-05-17

Load Line Analysis:





$V_{DD} = 10V$

$R_L = 1K$

Find, a) V_{DQ} & I_{DQ}

b) V_{R_L}.

(a) ⇒

By KVL,

$$-V_{DD} + I_D R_L + V_D = 0$$

$$\Rightarrow -10 + I_D R_L + V_D = 0$$

$$\Rightarrow I_D R_L + V_D = 10$$

$$V_D = 0, \quad I_{D\,max} = \frac{10}{R_L}$$

$$= \frac{10}{1K}$$

$$= 10mA$$

$$I_D = 0, \quad V_{D\,max} = 10V$$

(b) $V_{R_L} = I_{DQ} \times R_L$

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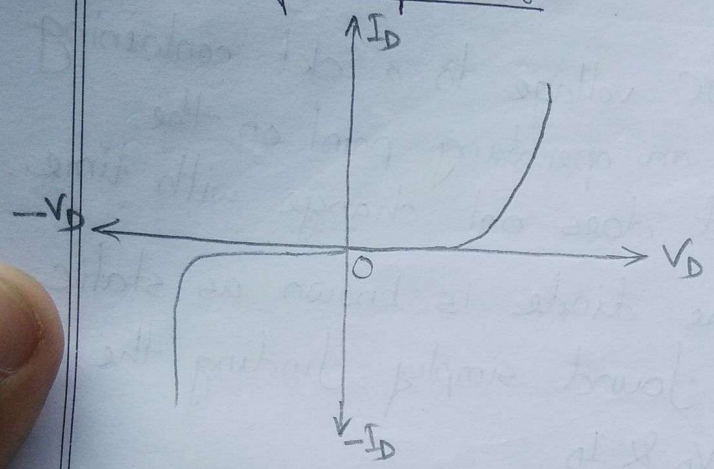
Date : .....

Shockley's equation:



For forward and reverse-bias region,

$$I_D = I_S\left(e^{\frac{V_D}{nV_T}} - 1\right)$$

I_D = Diode current

I_S = Reverse saturation current

V_D = Applied forward voltage ~~acro~~ across Diode.

n = Ideality factor (1~2)

V_T = Thermal voltage

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

K = Boltzman's constant

T = Temperature in Kelvin

$q = 1.6 \times 10^{-19} C$

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~~n = Ideality factor~~

$V_T =$

$$I_D = I_S\left(e^{\frac{V_D}{nV_T}} - 1\right)$$

when

$\boxed{V_D > 0V}$

$$I_D = I_S\, e^{\frac{V_D}{nV_T}} - I_S$$

$$\cong I_S\, e^{\frac{V_D}{nV_T}}$$

$\boxed{V_D < 0}$, $I_D = I_S\, e^{\frac{V_D}{nV_T}} - I_S$

$$\cong -I_S$$

$\boxed{V_D = 0}$,

$$I_D = I_S - I_S$$

$$= 0$$

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Date : .....

III Simplified Diode Model:

1. Ideal Diode model
2. Simplified/constant voltage drop model.
3. Piecewise linear model
4. Small-signal model

Piecewise Linear Model:

The exponential curve is approximated by two straight lines, line A with zero slope and line B with a slope of $\frac{V_D}{I_D} = \frac{1}{R_D}$ $\boxed{\frac{I_D}{V_D} = \frac{1}{R_D}}$

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1. Line A represents that I_D is zero for voltages between zero & V_{DD}. To model this behaviour a battery of V_{DO} is used. It does not mean that diode is a source of voltage. The battery simply indicates it opposes the flow of current in a forward direction ~~will~~ until V_{DO} is reached.

2. Ideal diode is used to indicate that no current flows in the circuit in reverse direction.

3. Line B indicates constant slope (resistance). So, addition of R_D.

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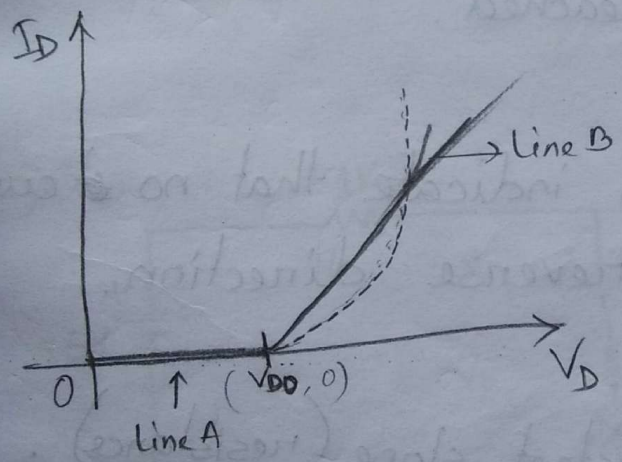
Piece-wise Linear Model:

The exponential curve is approximated by two straight lines. Line A with zero slope and line B with a slope of

$$\frac{I_D}{V_D} = \frac{1}{R_D}$$



For line A,

$I_D = 0, \quad 0 \leq V_D \leq V_{DO}$

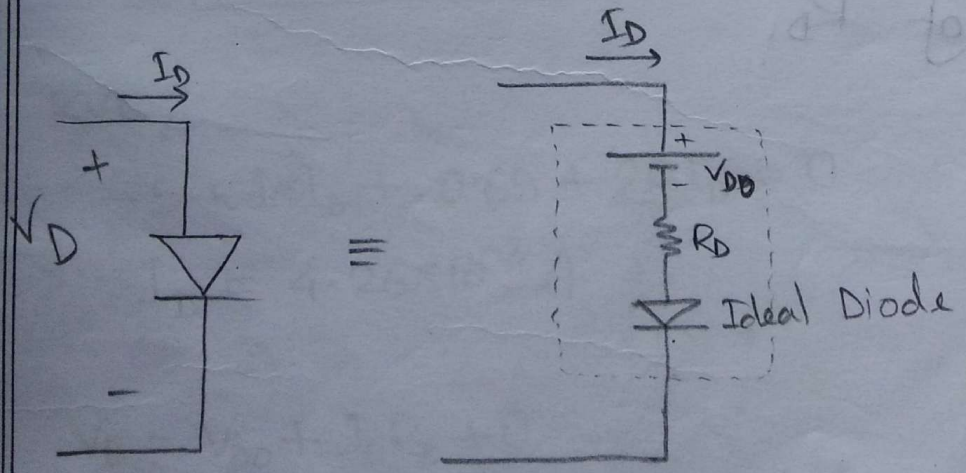
For line B,

$[(y-y_1) = m(x-x_1)]$

$I_D - 0 = \frac{1}{R_D}(V_D - V_{DO})$

$I_D R_D = V_D - V_{DO}$

$\boxed{V_D = V_{DO} + I_D R_D}$ $\quad V_D > V_{DO}$



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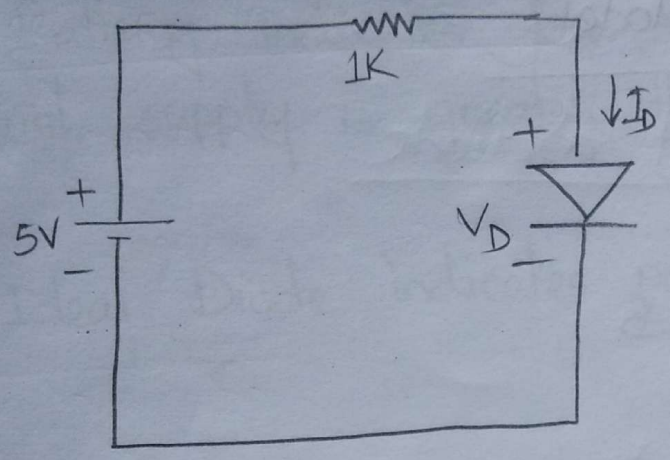
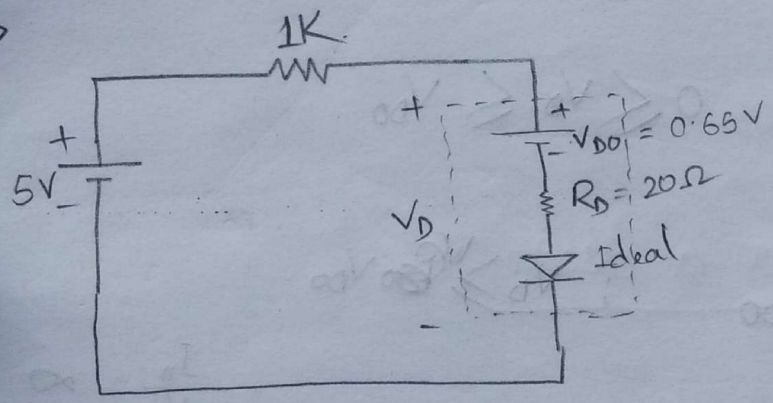


Using piece-wise linear Model, find, I_D & V_D.

Given, $R_D = 20\Omega$.

$V_{D0} = 0.65V$

⇒



KVL,

$$-5 + 1\times10^3 I_D + 0.65 + 20 I_D = 0$$

$$\Rightarrow \quad I_D = 4.26\times10^{-3} A.$$

$$V_D = V_{D0} + I_D R_D + 0$$

$$= 0.65 + (4.26\times10^{-3} \times 20)$$

$$= 0.73V$$

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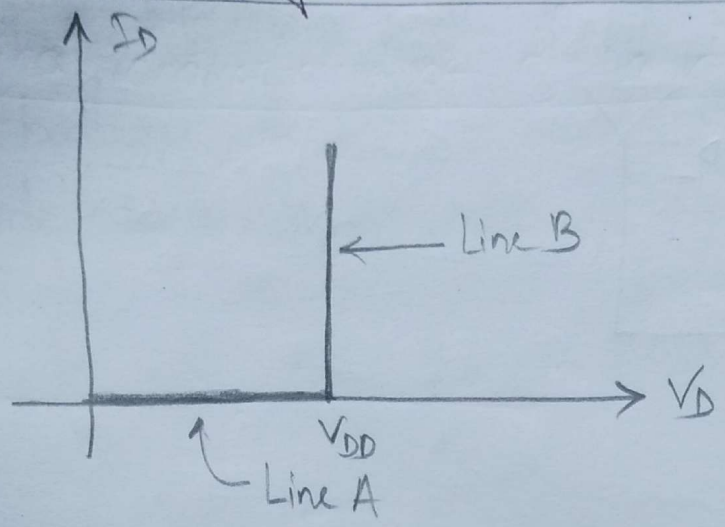
Constant voltage Drop Model:



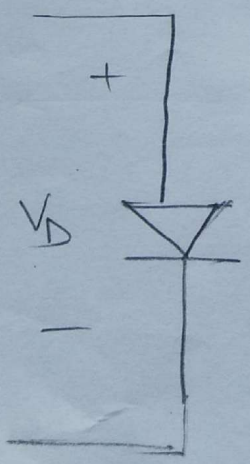
Line A, $I_D = 0$, $0 \leq V_D \leq V_{DO}$

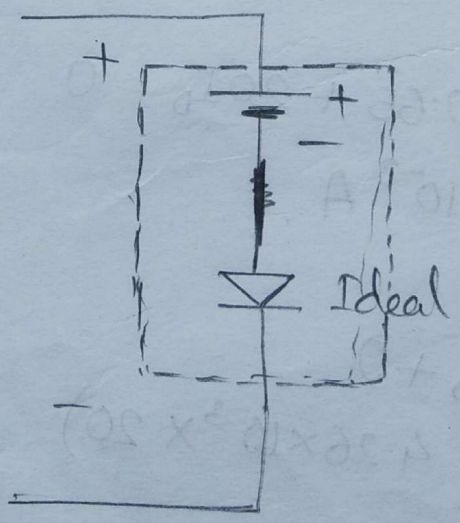
Line B, $V_D = V_{DO}$; $V_D \geq V_{DO}$

$$\frac{I_D}{V_D} = \infty$$

$$\Rightarrow \frac{1}{R_D} = \frac{1}{0}$$

$$\Rightarrow R_D = 0$$





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1. Battery indicates ~~fow~~ forward I_D will not flow until supply is greater than V_{D0}.

2. Ideal Diode indicates no I_D in reverse direction.

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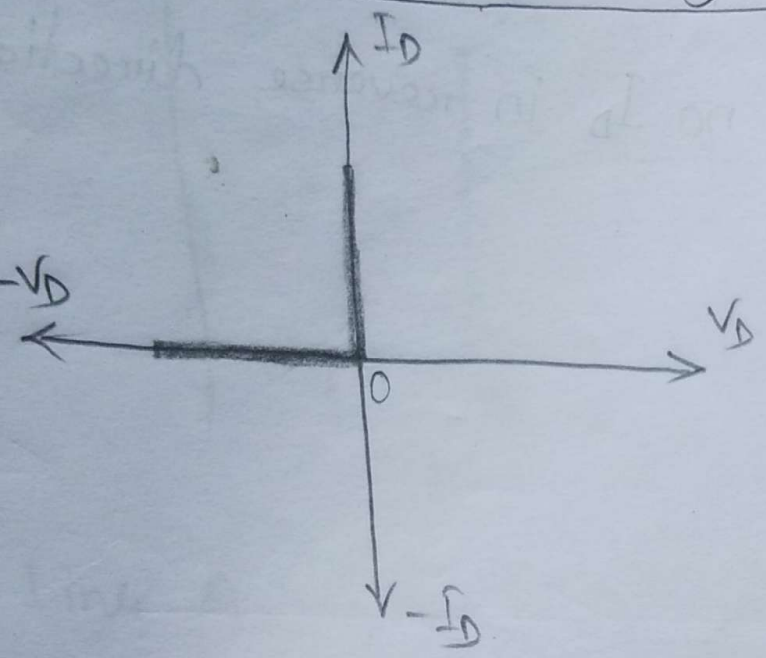
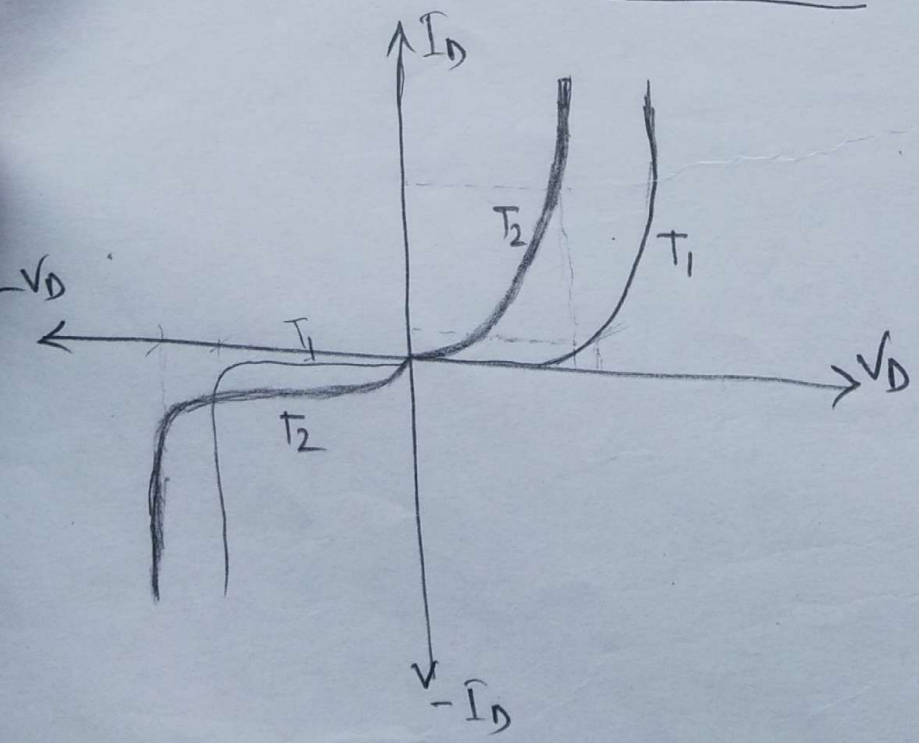
Ideal diode Model:

Ideal characteristics of a diode



Temperature effect on a diode:



$T_1 \longrightarrow e^-$

$T_2 \longrightarrow e^- e^-$

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- In forward bias region, the characteristics of a Si diode shifts to left at a rate of ~~2.5mA~~. 2.5mV per degree centigrade increase in temperature.

- In reverse bias region, the reverse saturation current of a Si diode doubles for every 10°C raise in temperature.

- With increase in temperature, loosely bonded electrons are already free and to free other electrons, it would take more voltage more voltage than earlier. So, at larger temperature more voltage is needed to cause the breakdown incident.

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By KVL,

$\cancel{-10 + 4.7 I_D + 0.7 + 2.2}$

$-10 + 4.7\times10^3 \times I_D + 0.7 + 2.2\times10^3 \times I_D - 5 = 0$

$\therefore I_D = 2.07\times10^{-3} A$

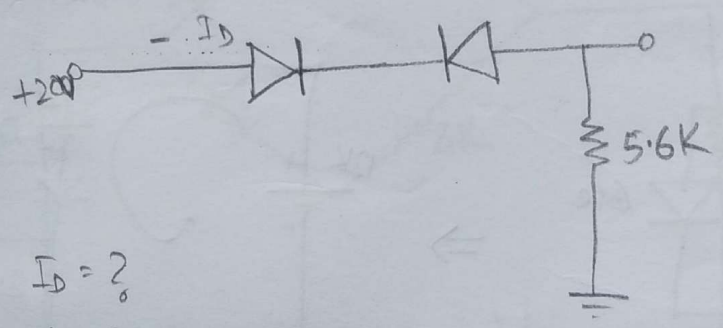
parallelly voltage drop same,

$V_0 = 2.2K \times I_D - 5$

$= 2.2\times10^3 \times 2.07\times10^{-3} - 5$

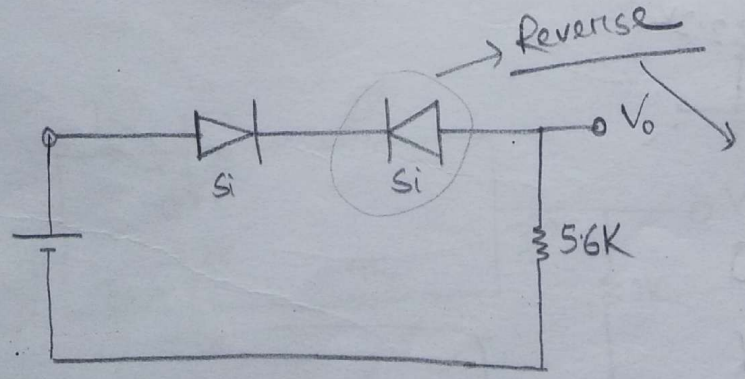
$= -0.446V.$

#



$I_D = ?$

$V_0 = ?$



$I_D = 0 A$

$V_0 = 0V$

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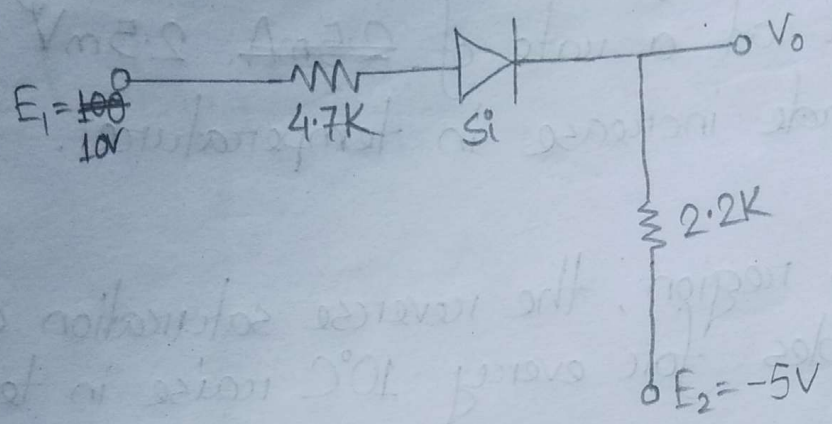
* কিছু বলা না হলে,
constant voltage Drop Model

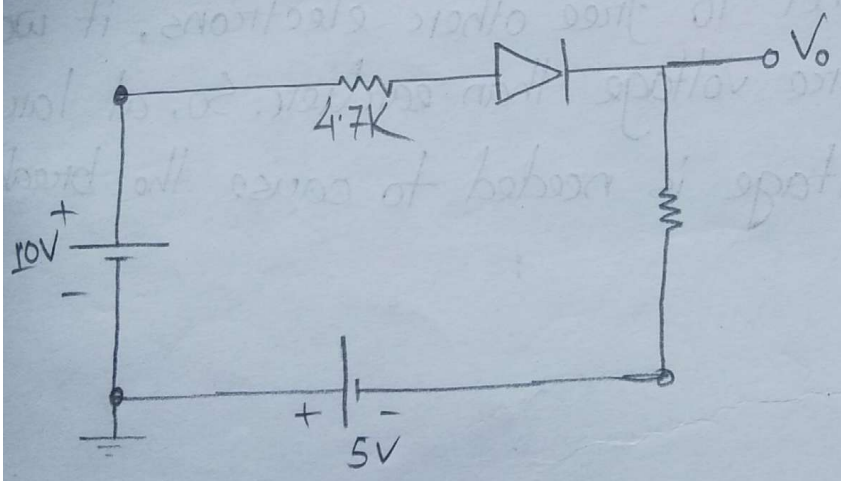
Date :

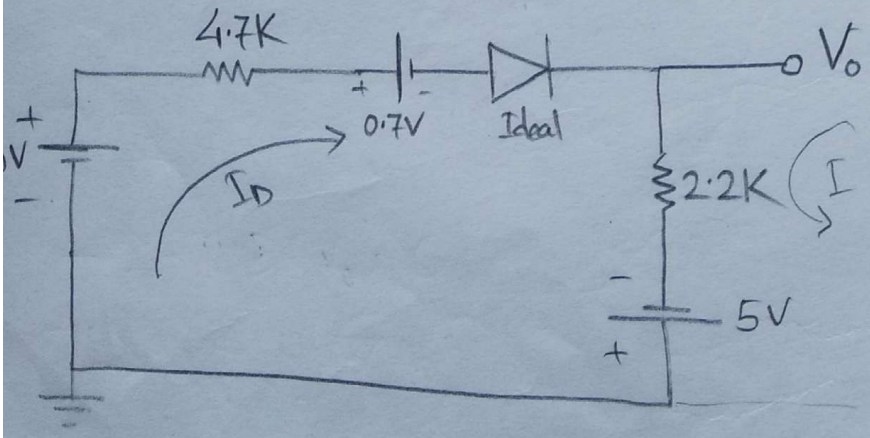
#



$V_o = ?$

⇒





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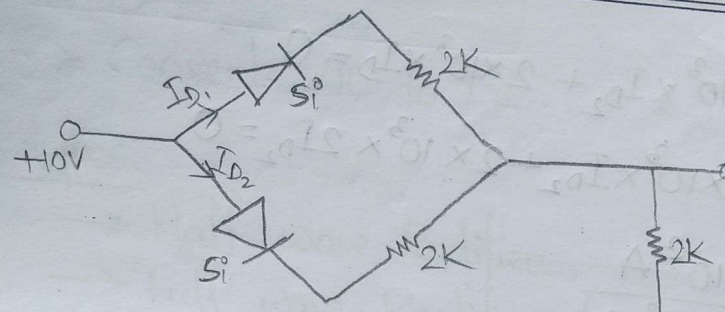
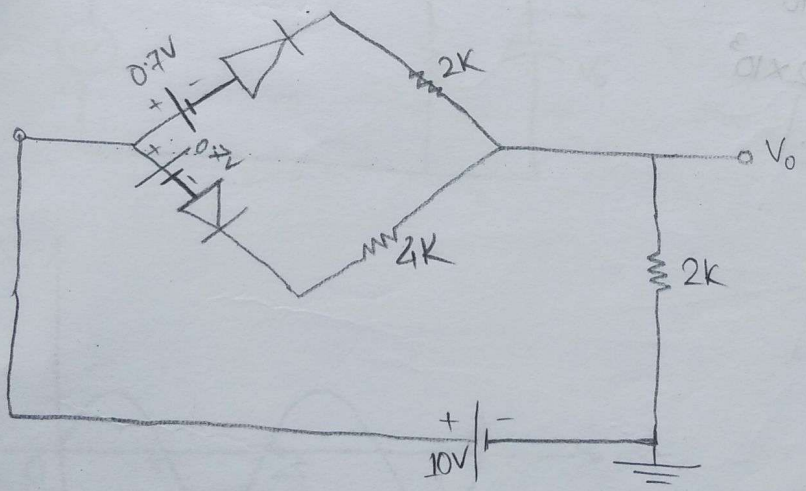
Date : 13-05-17

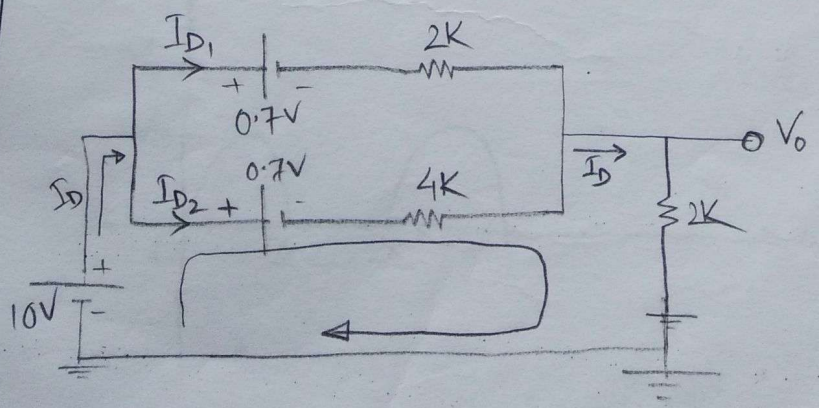
#



Find, I_{D_1} & V_o

⇒





$I_D = I_{D_1} + I_{D_2}$

$I_{D_1} = I_{D_2}$

$I_D = I_{D_1} + I_{D_1}$

$I_D = 2I_{D_1} = 2I_{D_2}$

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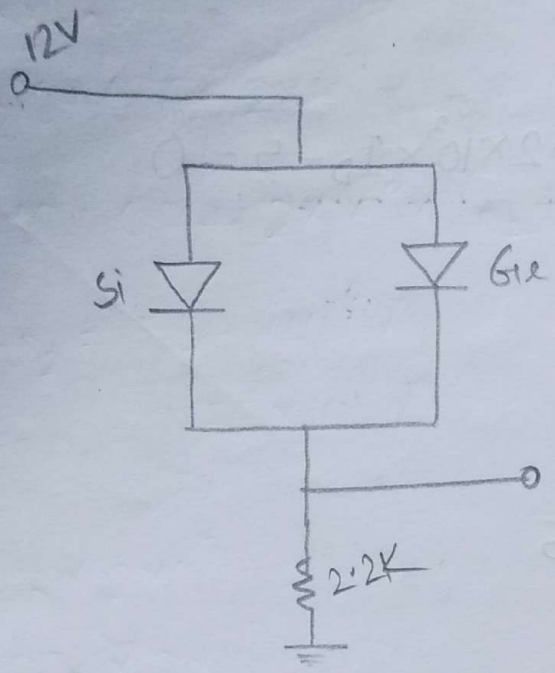
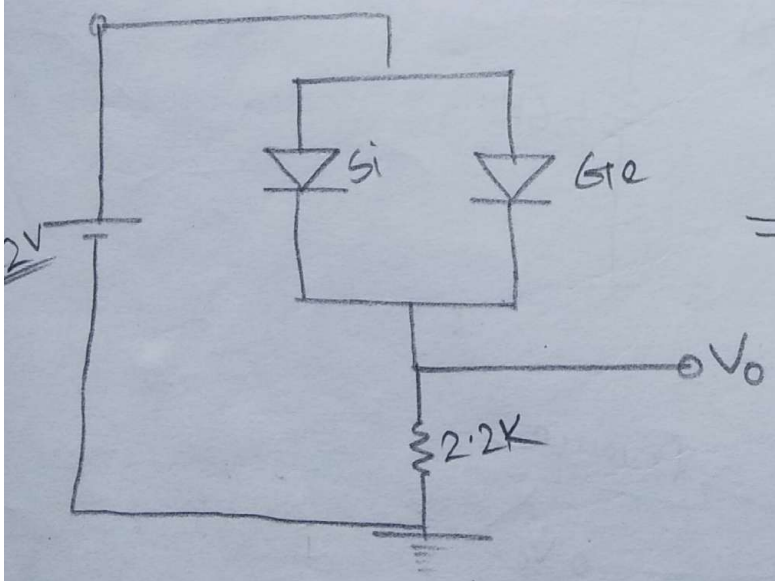
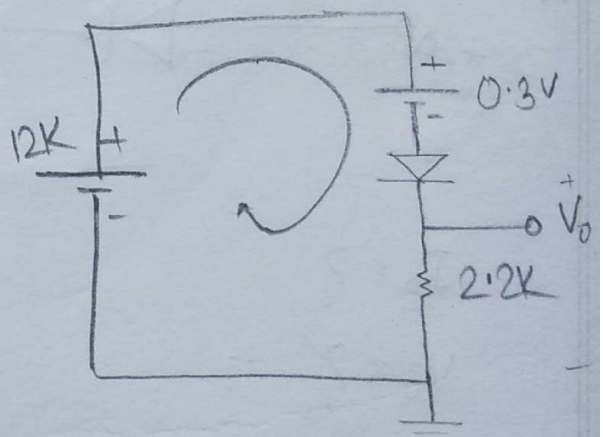




$\Rightarrow$



$-12 + 0.3 + V_0 = 0$

$\Rightarrow V_0 = 11.07\,V$

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By KVL,

$$-10+0.7+2\times10^3\times I_{D_2}+2\times10^3\times I_D=0$$

$$\Rightarrow -10+0.7+2\times10^3\times I_{D_2}+2\times10^3\times 2I_{D_2}=0$$

$$\Rightarrow I_{D_2}=1.55\times10^{-3}\,A$$

$$\therefore I_{D_1}=\boxed{1.55\times10^{-3}\,A}$$

$$V_0=I_D\times2\times10^3$$

$$=2I_{D_1}\times2\times10^3$$

$$=\boxed{6.2V.}$$

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Date : .....

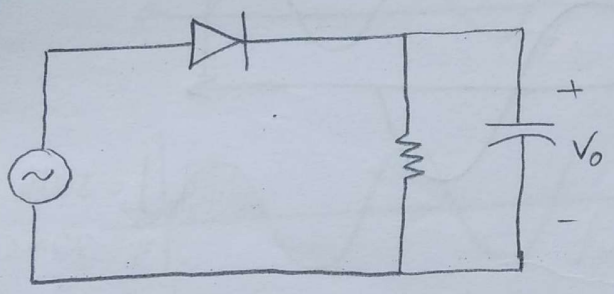
Rectifier

→ Converts AC to DC

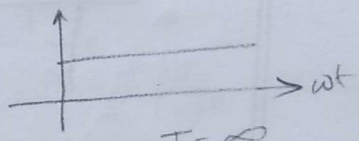
2 types

→ Half wave Rectifier

→ full wave Rectifier

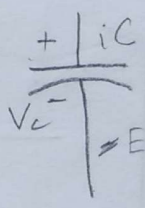


$i = \frac{dq}{dt}$



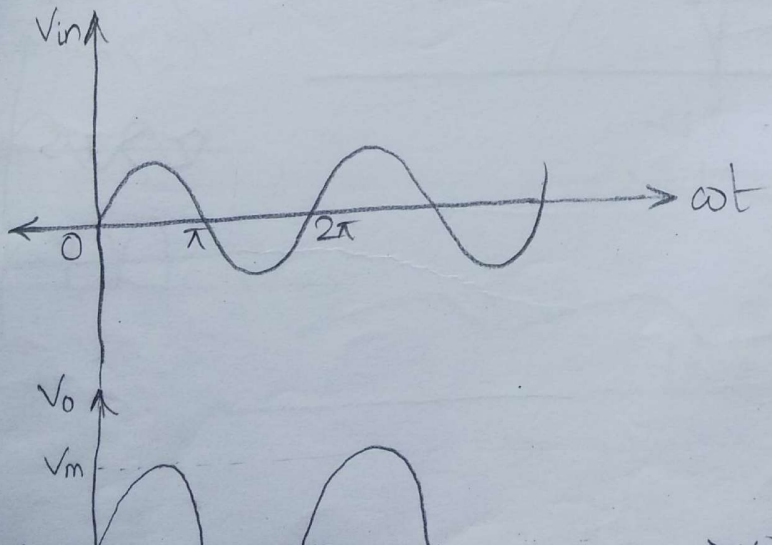
$T = \infty$

$f = 0$



capacitor

→ Energy storing device



Pulsating DC.

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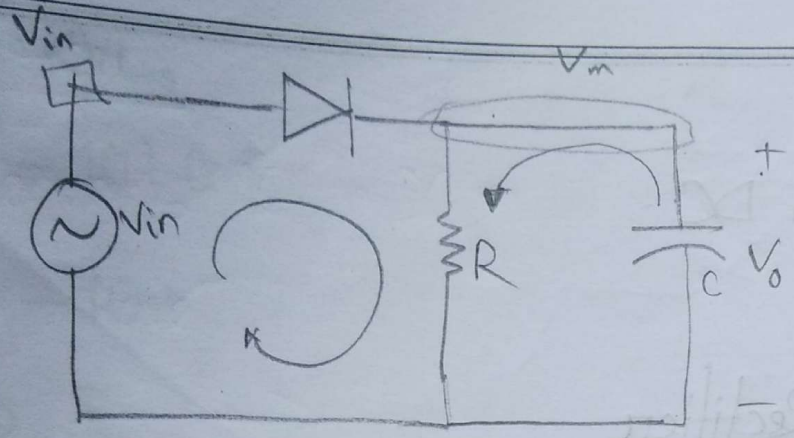
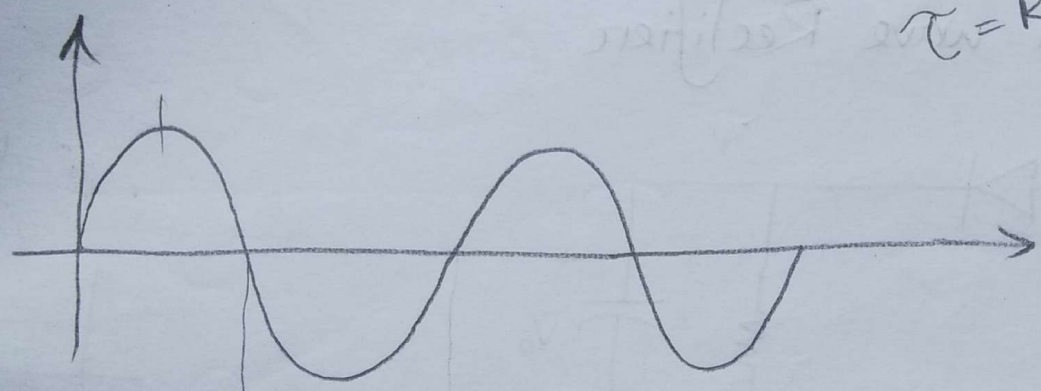
Date : .....



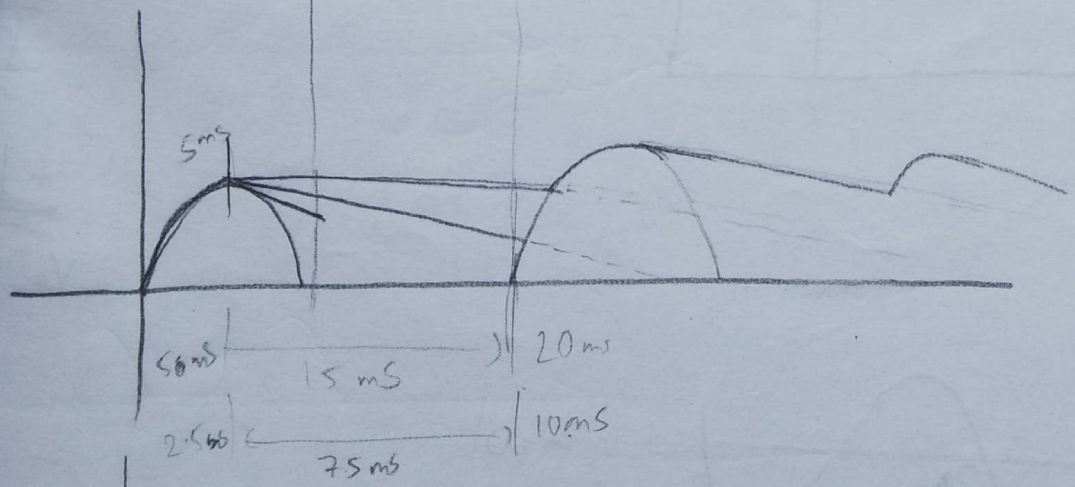
discharge time ↑

$\tau = RC \uparrow$ sec



$f = 50\,Hz$

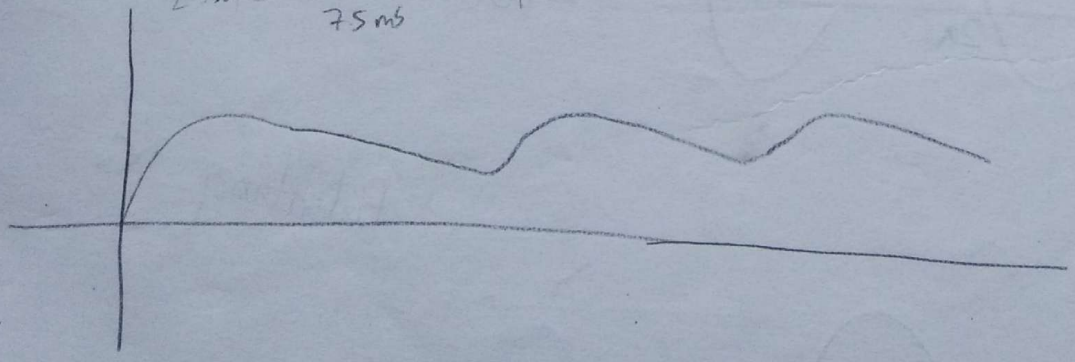
$T = 20\,ms$



$f = 100\,Hz$ $T = 10\,mS$

$\tau > 15\,mS$

$\tau > 7.5\,mS$



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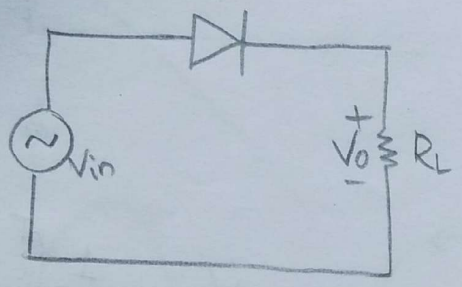
Date : 16-05-17

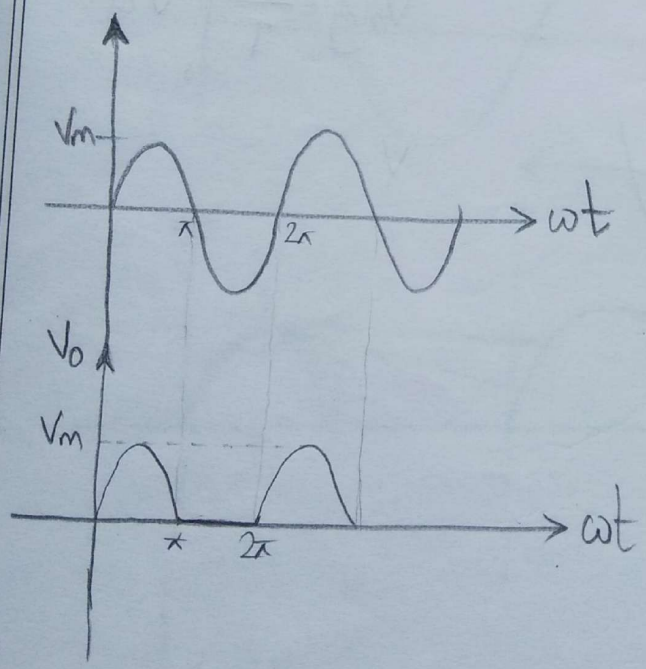
Rectifier

* half wave rectifier's efficiency

Converts AC to DC

- Half wave





$$V_{avg} = \frac{1}{T}\int_0^1 v_o(\omega t)\, d(\omega t)$$

$=$

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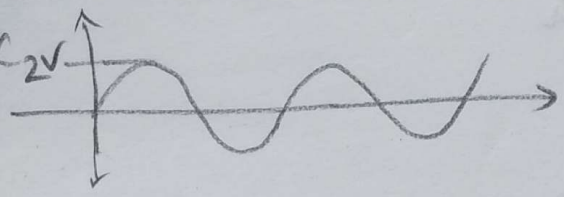
Date : .....

Average Value

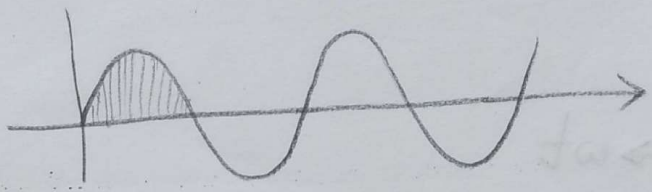
RMS Value

2V DC

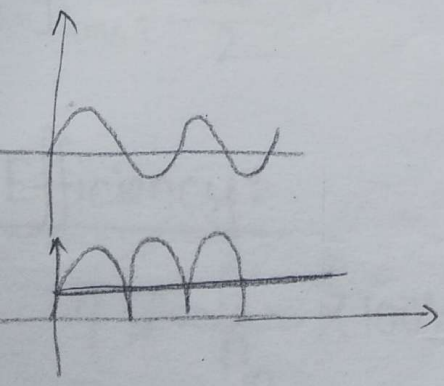
2V peak AC



$$V_{avg} = \frac{1}{T}\int_0^T v\,dt$$



V



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

So, $I_{avg} = \frac{I_m}{\pi}$

$$V_{rms} = \sqrt{\frac{1}{T}\int_0^T v_o^2(\omega t)\, d(\omega t)}$$

$$V_{rms} = \frac{V_m}{2}$$

$$I_{rms} = \frac{I_m}{2}$$

Efficiency:

$$\eta = \frac{P_o}{P_{in}} \times 100\%$$

$$\underset{dc}{P_o} = I_{avg}^2 \times R_L$$

$$\underset{ac}{P_{in}} = I_{rms}^2 \times (r_f + R_L)$$

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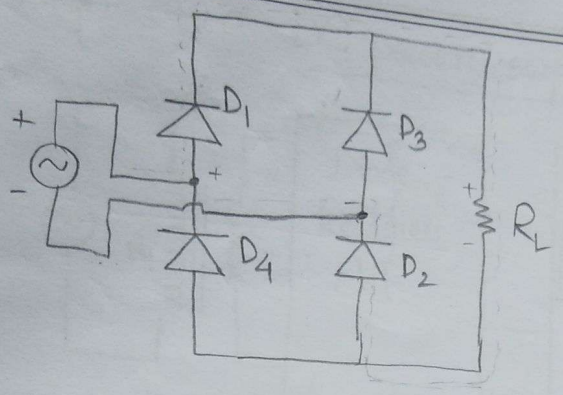
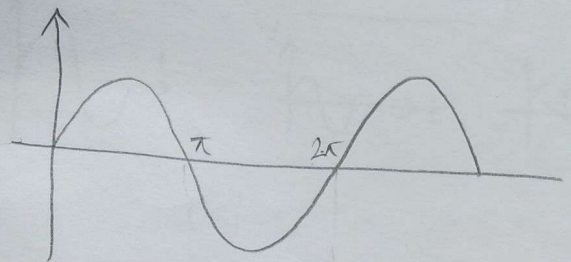
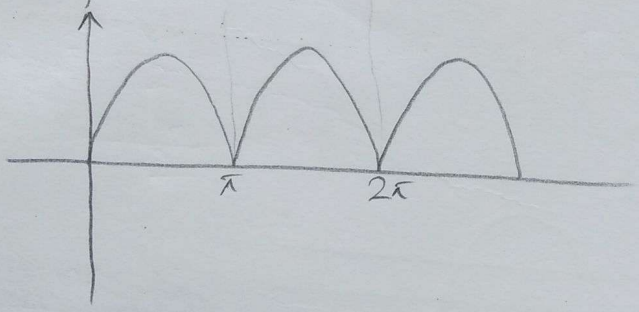
Date : .....







$$V_{avg} = \frac{1}{T}\int_0^T v_0(\omega t)\, d(\omega t)$$

$$V_{rms} = \sqrt{\frac{1}{T}\int_0^T v_0^2(\omega t)\, d(\omega t)}$$

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

$$V_{rms} = \frac{V_m}{\sqrt{2}}$$

$$I_{rms} = \frac{I_m}{\sqrt{2}}$$

So, $I_{avg} = \frac{2I_m}{\pi}$

$$P_o = I_{avg}^2 \times R_L \quad , \quad P_{in} = I_{rms}^2 \times (R_s + R_L)$$

$$\eta = \frac{P_o}{P_{in}} \times 100\% = \frac{\frac{4I_m^2}{\pi^2}}{\frac{I_m^2}{2}} \times 100\%$$

$$= 81\%$$

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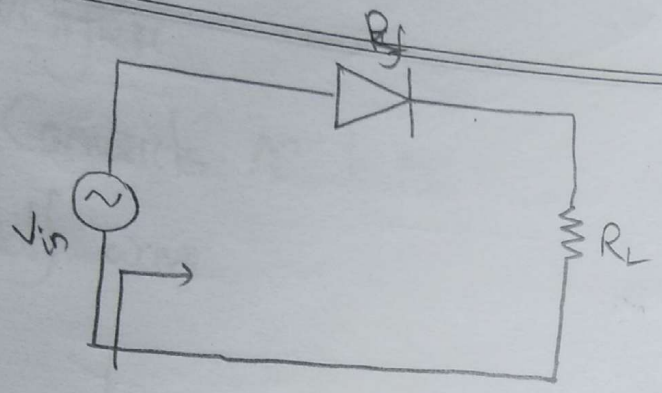
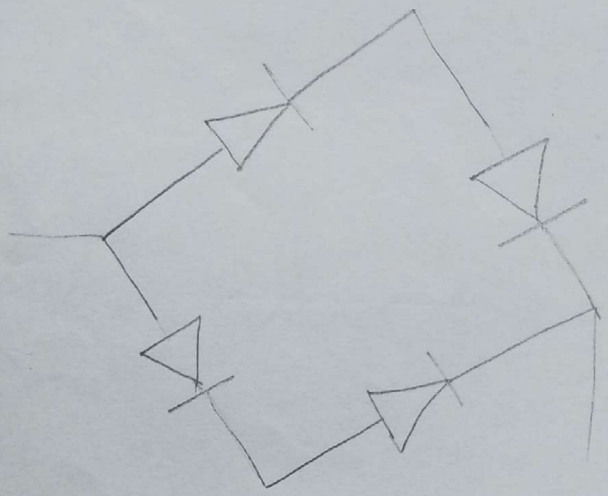


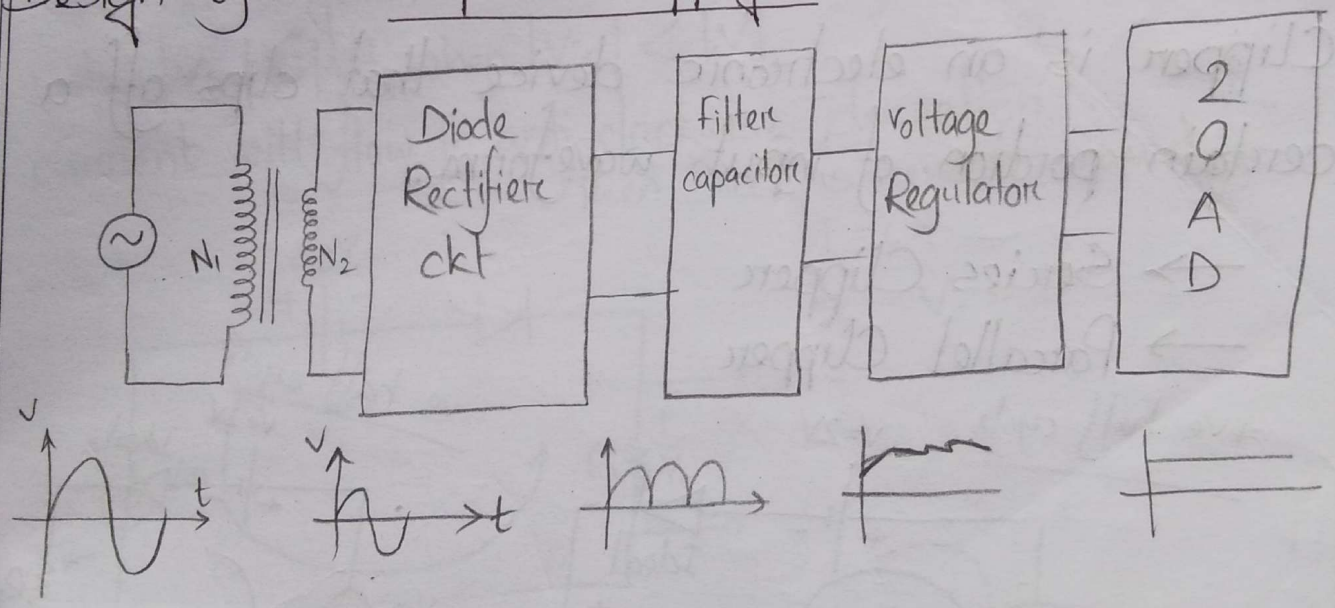
$$\eta = \frac{\frac{I_m^2}{\pi^2}}{\frac{I_m^2}{4}} \times 100\%$$

$$= 40.5\%$$



Date : .....

Design of a DC power supply:



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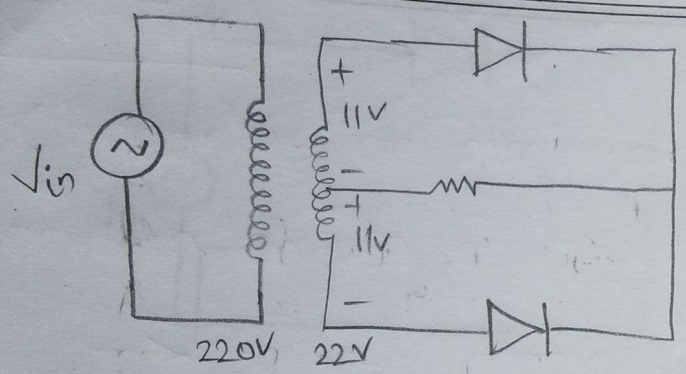
central-tapped rectifier

Date : .....



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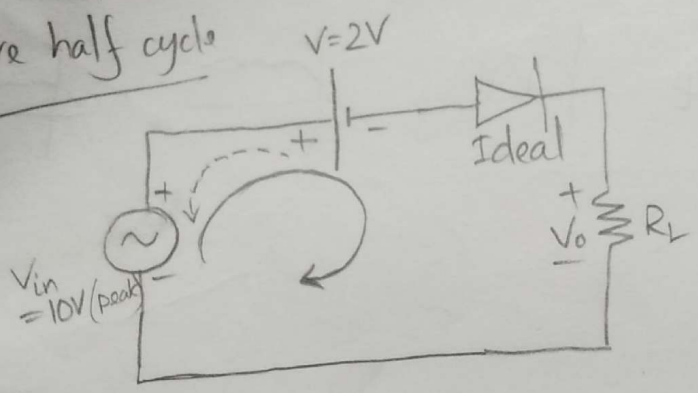
Date : 18-05-17

Clipper

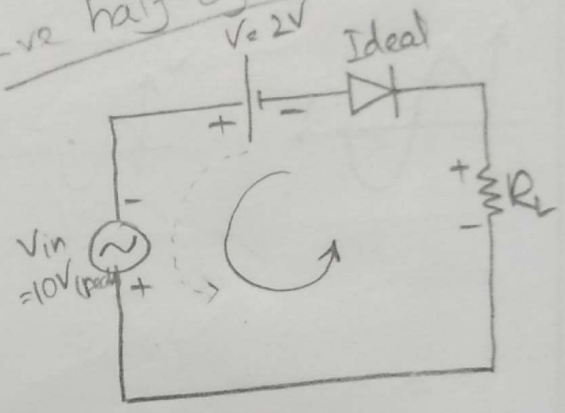
Clipper is an electronic device that clips off a certain portion of input wave-form.

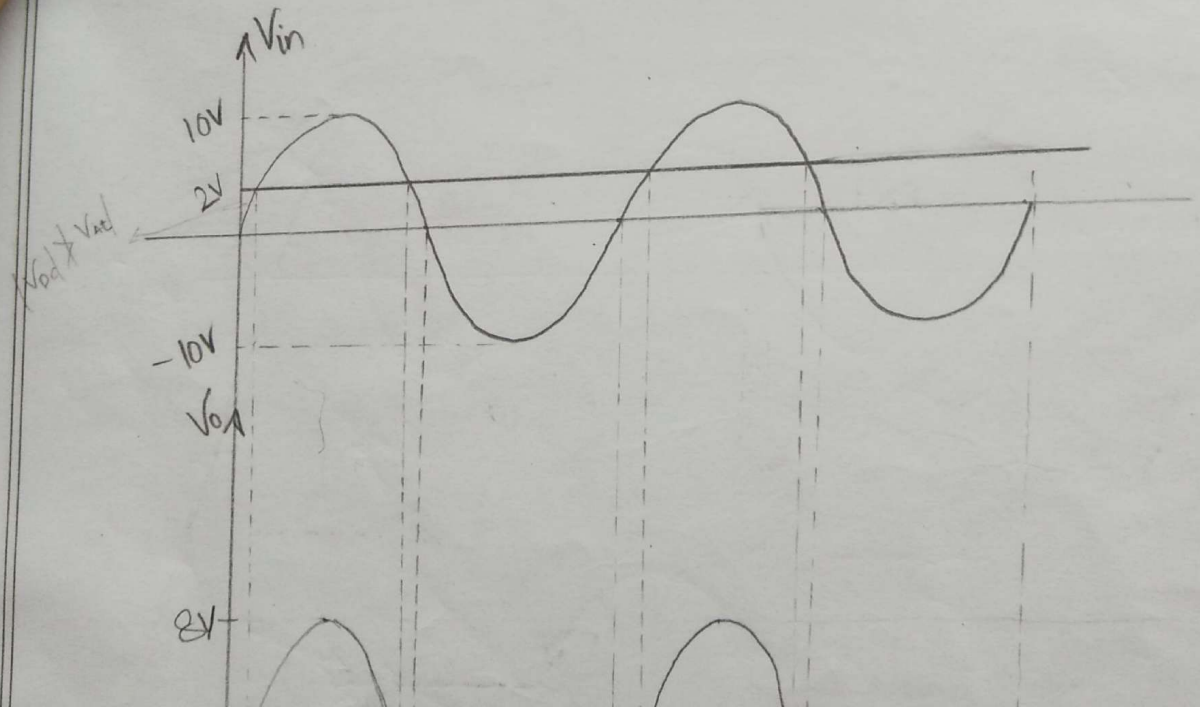
→ Series Clipper
→ Parallel Clipper

+ve half cycle



-ve half cycle





Scanned by CamScanner

Date : .....

+ve half cycle,

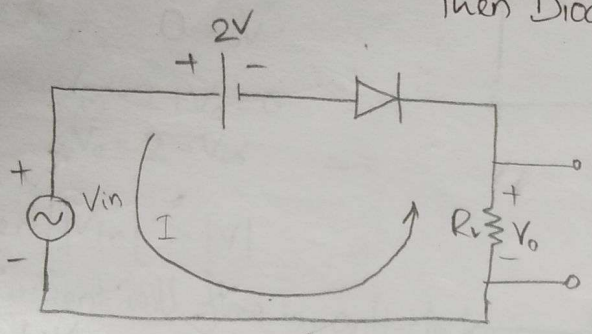
~~when $|V_{in}| \leq |V|$~~, when, $|V_{in}| < |V|$

current will flow in anti-clockwise direction.

Then Diode is reverse-biased

$I = 0$.

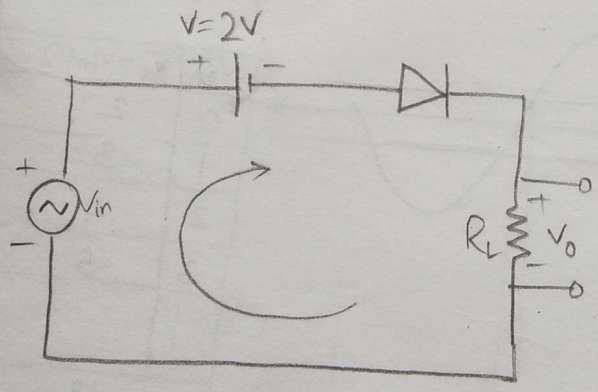
$V_o = 0$



when $|V_{in}| > |V|$

current will flow in clock-wise direction,

Then Diode is forward-biased.



KVL,

~~10~~

~~10~~ $-V_{in} + V + V_o = 0$

~~$-V_{in} + 2$~~

~~and,~~

$\Rightarrow V_o = V_{in} - V$

$$\boxed{V_o = V_{in} - 2}$$

V_{in}	$V_o = V_{in} - 2$
2	0
3	1
4	2
5	3
⋮	
10	8

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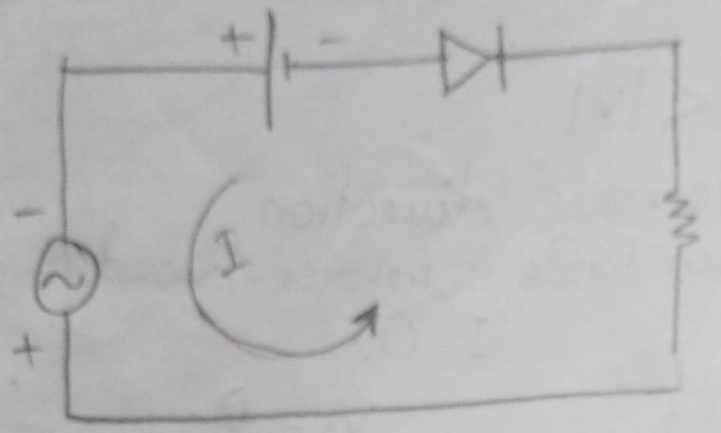
Date :

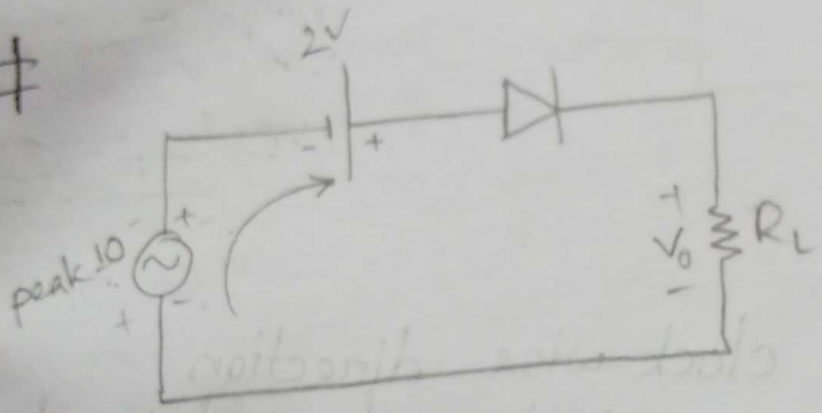


-ve half cycle:
current will flow anticlockwise

$I = 0$

$V_o = 0$

#

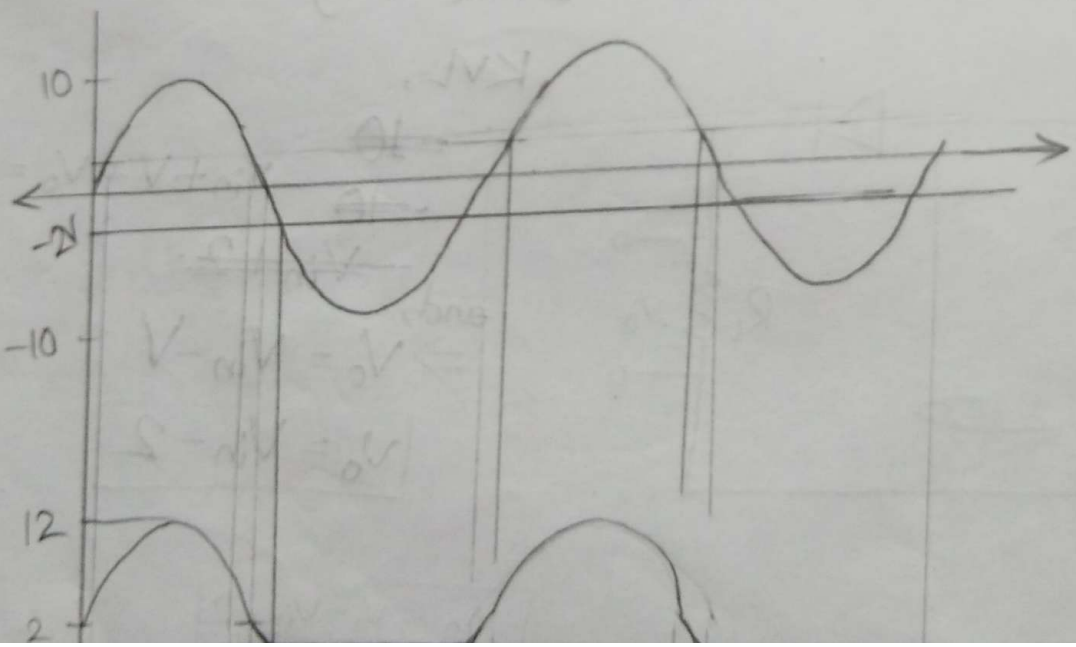


+ve half cycle:

KVL,

$-V_{in} - 2 + V_o = 0$

$\Rightarrow V_o = V_{in} + 2$



V_{in}	$V_o = V_{in}+2$
0	2
1	3
2	4
3	5
⋮	
10	12

Scanned by CamScanner

KVL,

$+V_{in} - 2 + V_o = 0$

$V_o = 2 - V$

Date : .....

-ve half cycle,

when $|V_{in}| < |V|$

current will flow in clock-wise direction.

KVL,

$+V_{in} - 2 + V_o = 0$

$V_o = 2 - V_{in}$

V_{in}	$V_o = 2 - V_{in}$
0	2
1	1
2	0

when $|V_{in}| > |V|$

current will flow in anti-clockwise direction

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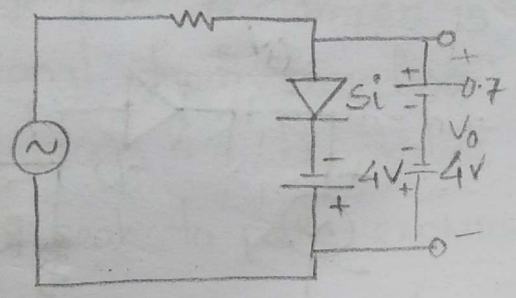
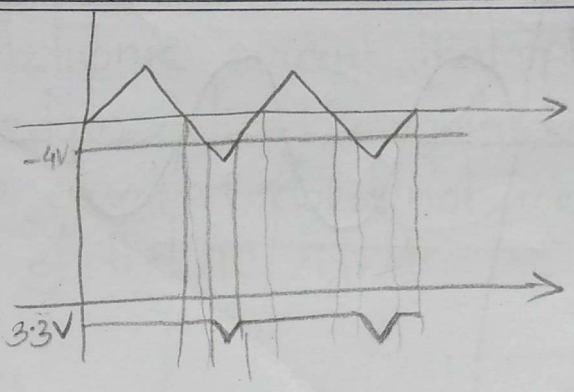
Date : .....





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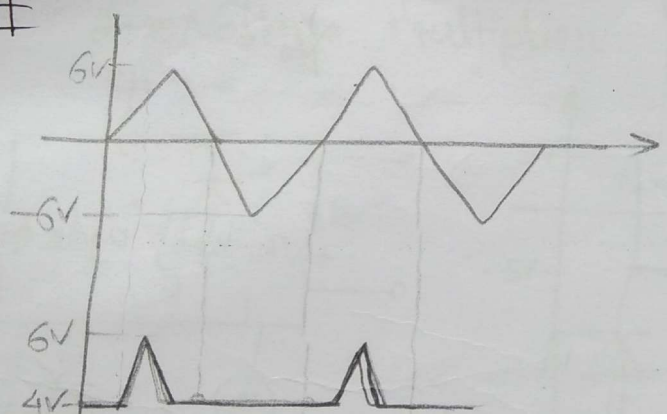

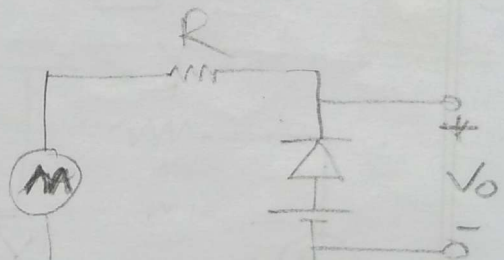

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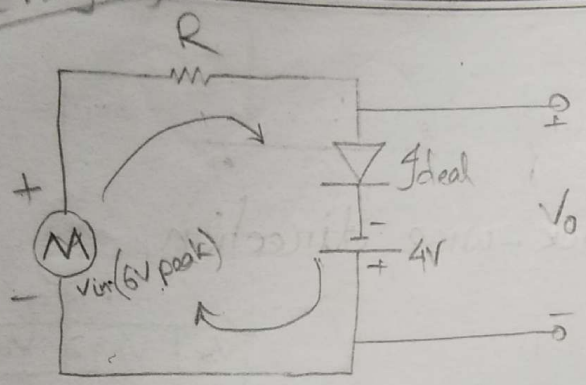
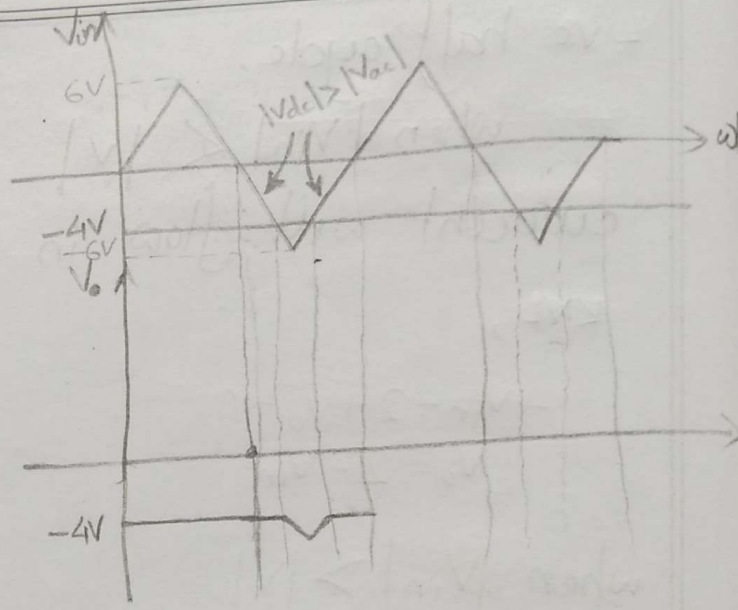
Parallel Clipper

Date : 23-05-17

+ve half cycle



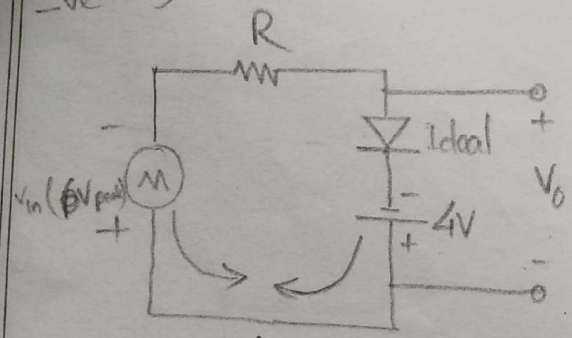


+ve half cycle,

I → clockwise

Diode → ON

−ve half cycle,



−ve half cycle,

when $|V_{dc}| > |V_{ac}|$

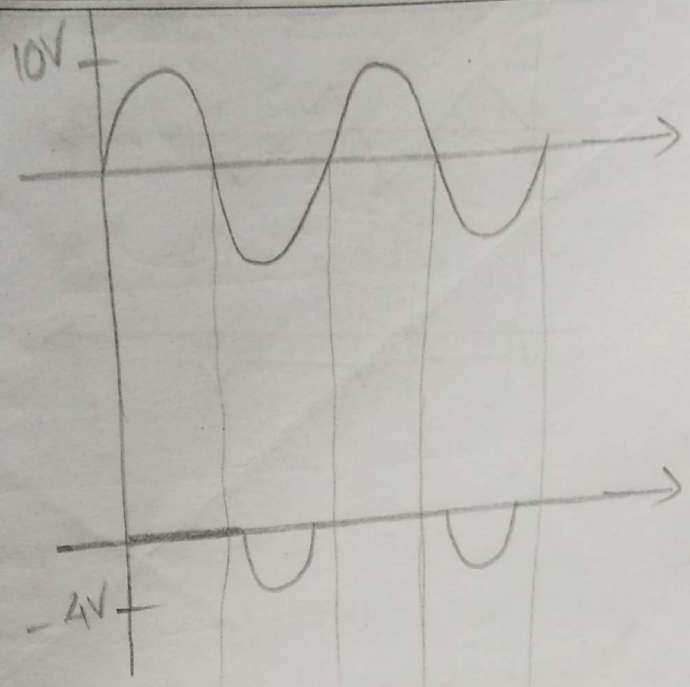
Diode → ON

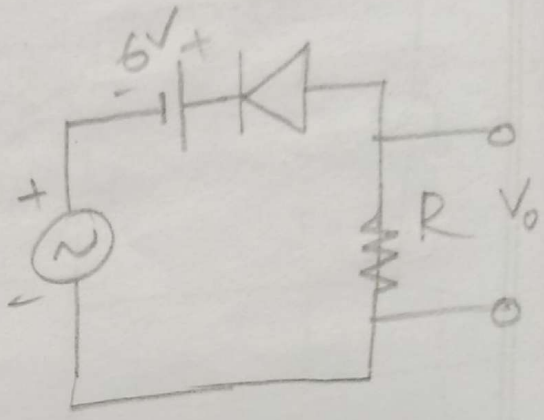
$V_o = -4$

when $|V_{ac}| > |V_{dc}|$

Scanned by CamScanner

Date : .....

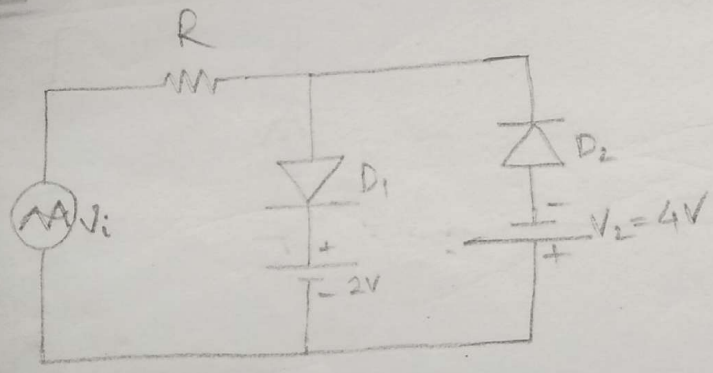




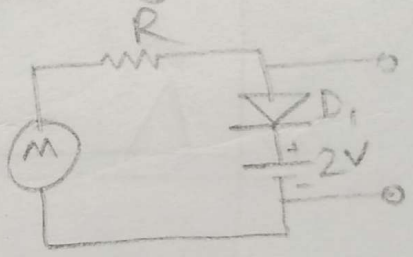
$-V_{in} - V_o + 6 = 0$

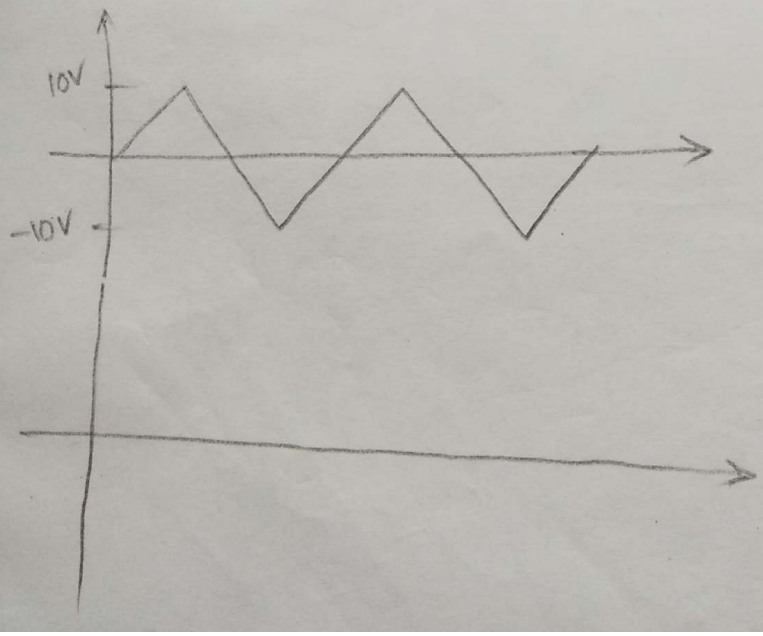
$V_o = -10 + 6$

$= -4$

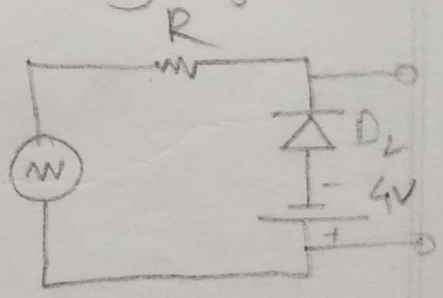


+ve half cycle,





-ve half cycle,



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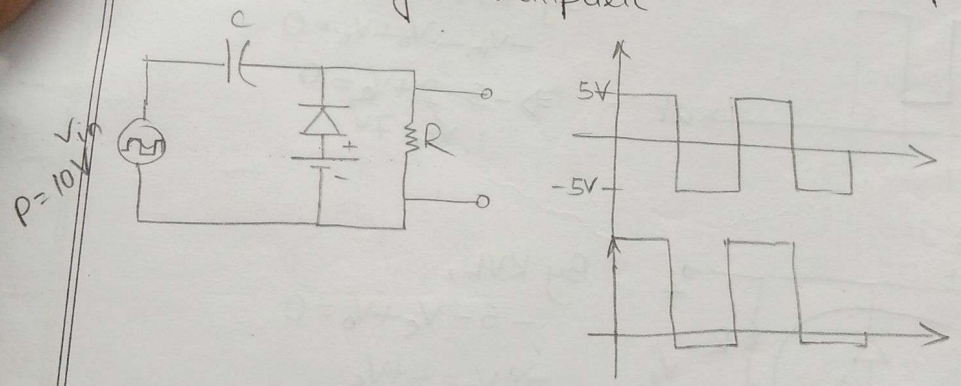
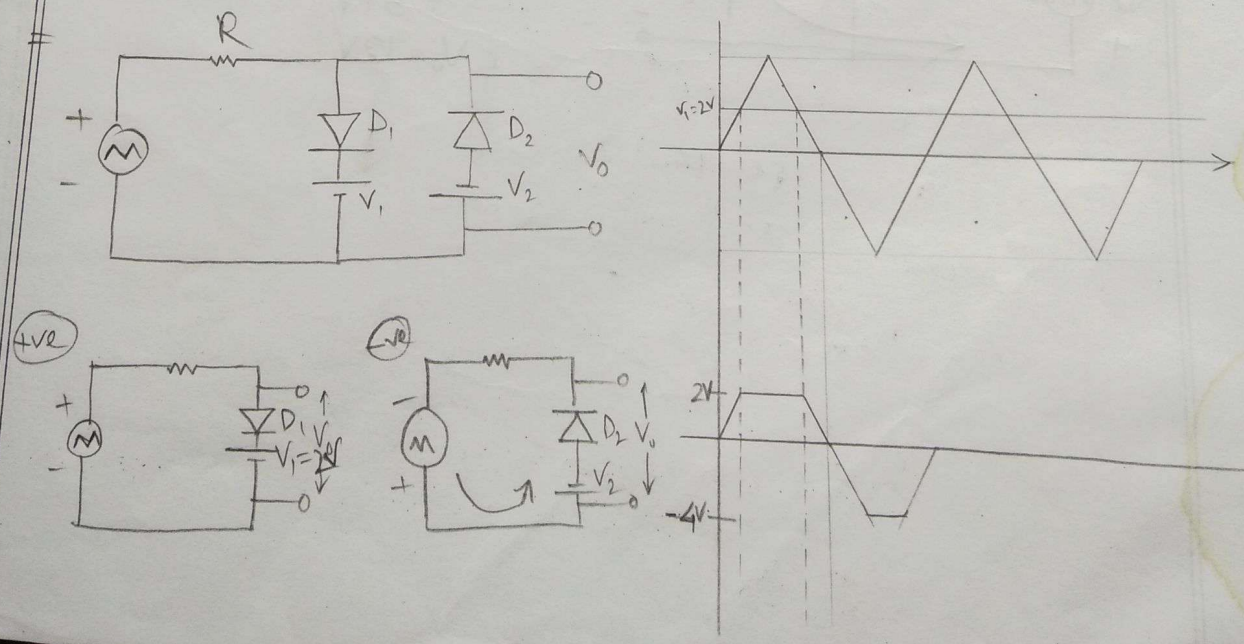
Date : 25-05-17

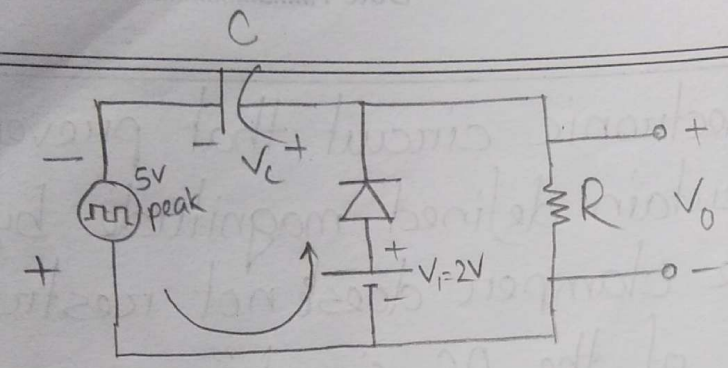
Clampers: A clampers is an electronic circuit that prevents a signal from exceeding a certain defined magnitude by shifting it's DC value. The clampers does not restrict the peak to peak excursion of the AC signal

→ Base Line Stabilizers
→ Television receivers
→ Oscilloscope and computer display
→ Voltage Multiplier





Date : .....

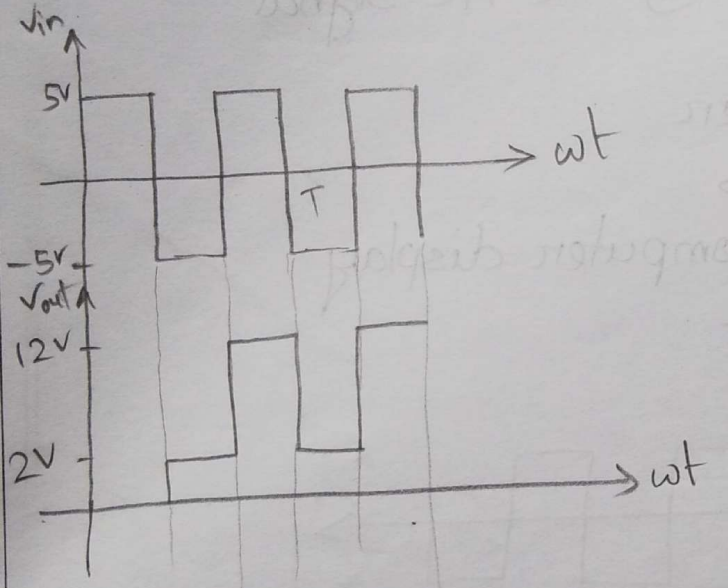


Start from that half cycle at which diode is turned ON

+ve half cycle, Diode off

-ve half cycle, Diode → ON

I = anticlockwise



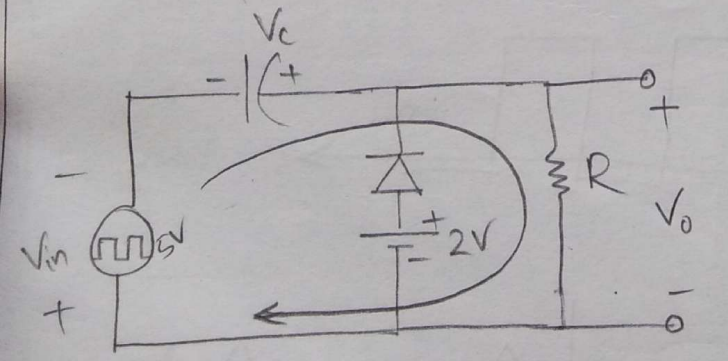
$t < \tau$

By KVL,

$$-V_{in} - V_0 + V_c = 0$$

$$\Rightarrow -5 - 2 + V_0 = 0$$

$$\therefore V_c = 7V$$



By KVL,

$$-5 - V_c + V_0 = 0$$

$$\Rightarrow V_0 = 5 + V_c$$

$$= 5 + 7$$

$$\therefore V_0 = 12V$$

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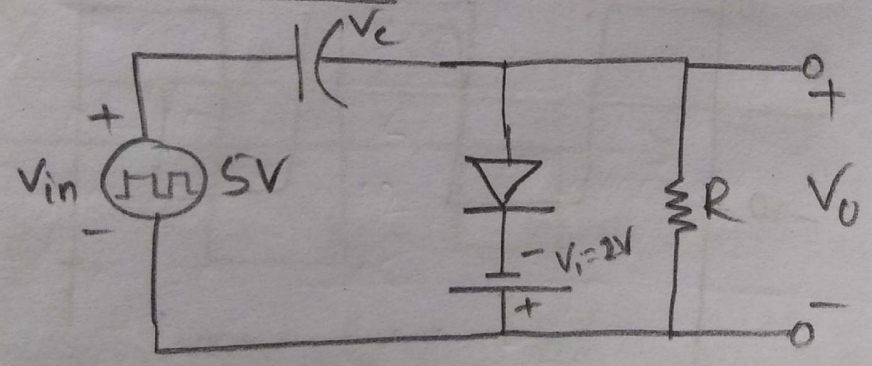
Date : .....

Home Work:



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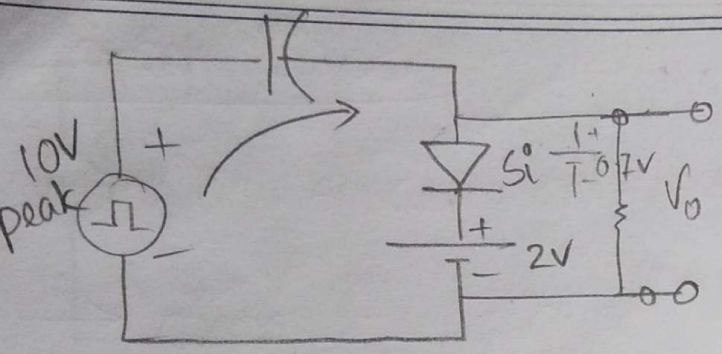
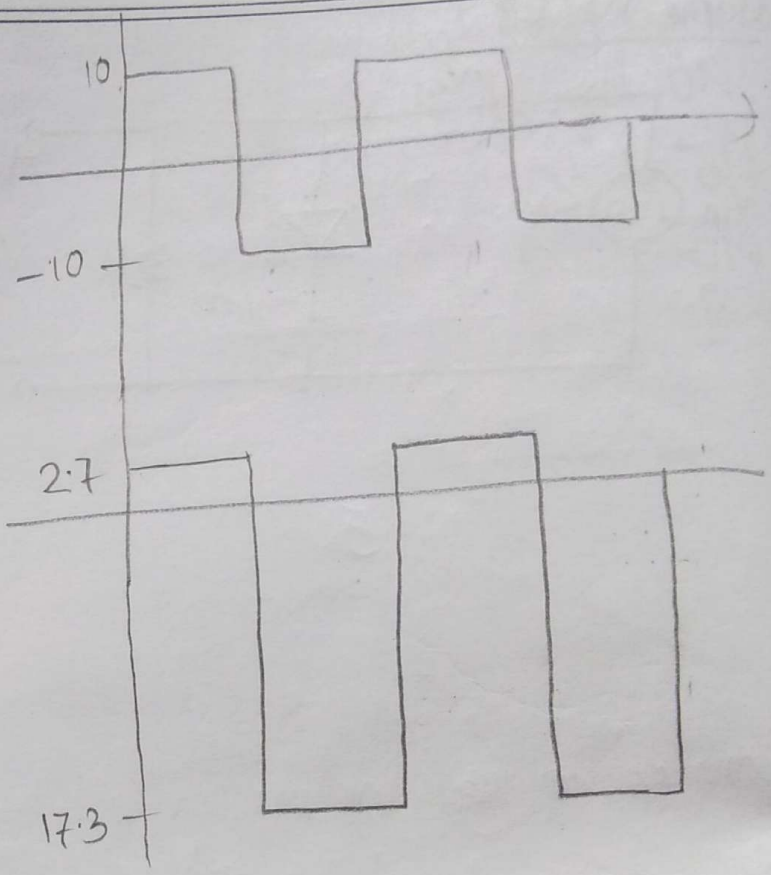
Date : 27-05-17

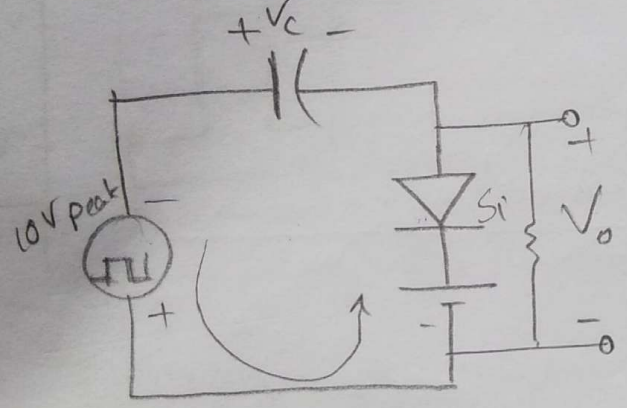




$-V_{in}+V_c+V_0=0$

$-10+V_c+2.7=0$

$V_c=7.3V$



$-V_{in}-V_0-V_c=0$

$\Rightarrow V_0=-V_{in}-V_c$

$=-10-7.3$

$=-17.3$

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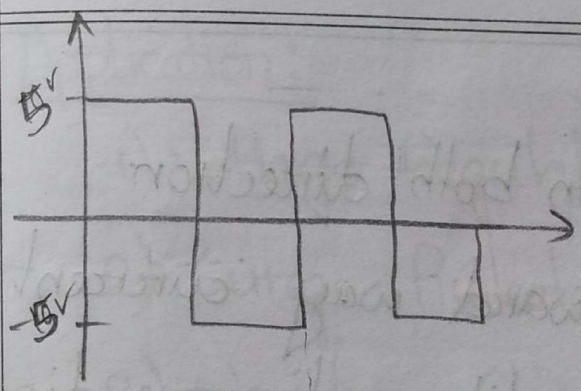
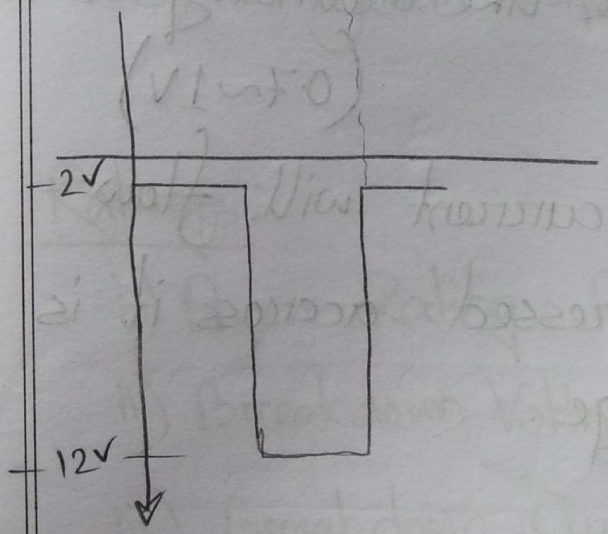
Date : .....





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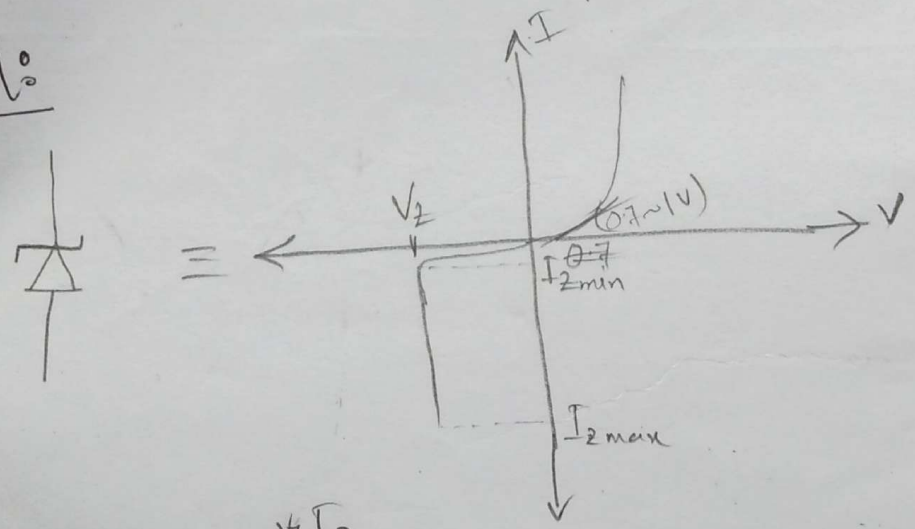
Zener Diode:

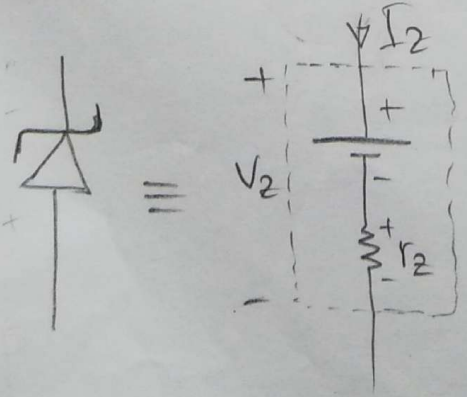
→ Allows current to flow in both direction

→ When it is placed in forward way current flows at a lower voltage like ordinary diode (0.7~1V)

→ In reverse direction no current will flow until ~~we~~ the voltage inpressed accross it is equal to the zener voltage.

Symbol:





$$V_Z = I_Z r_Z + V_{Z0}$$

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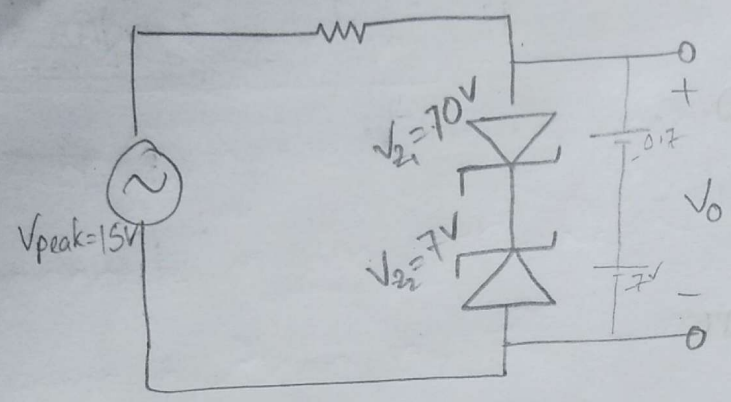
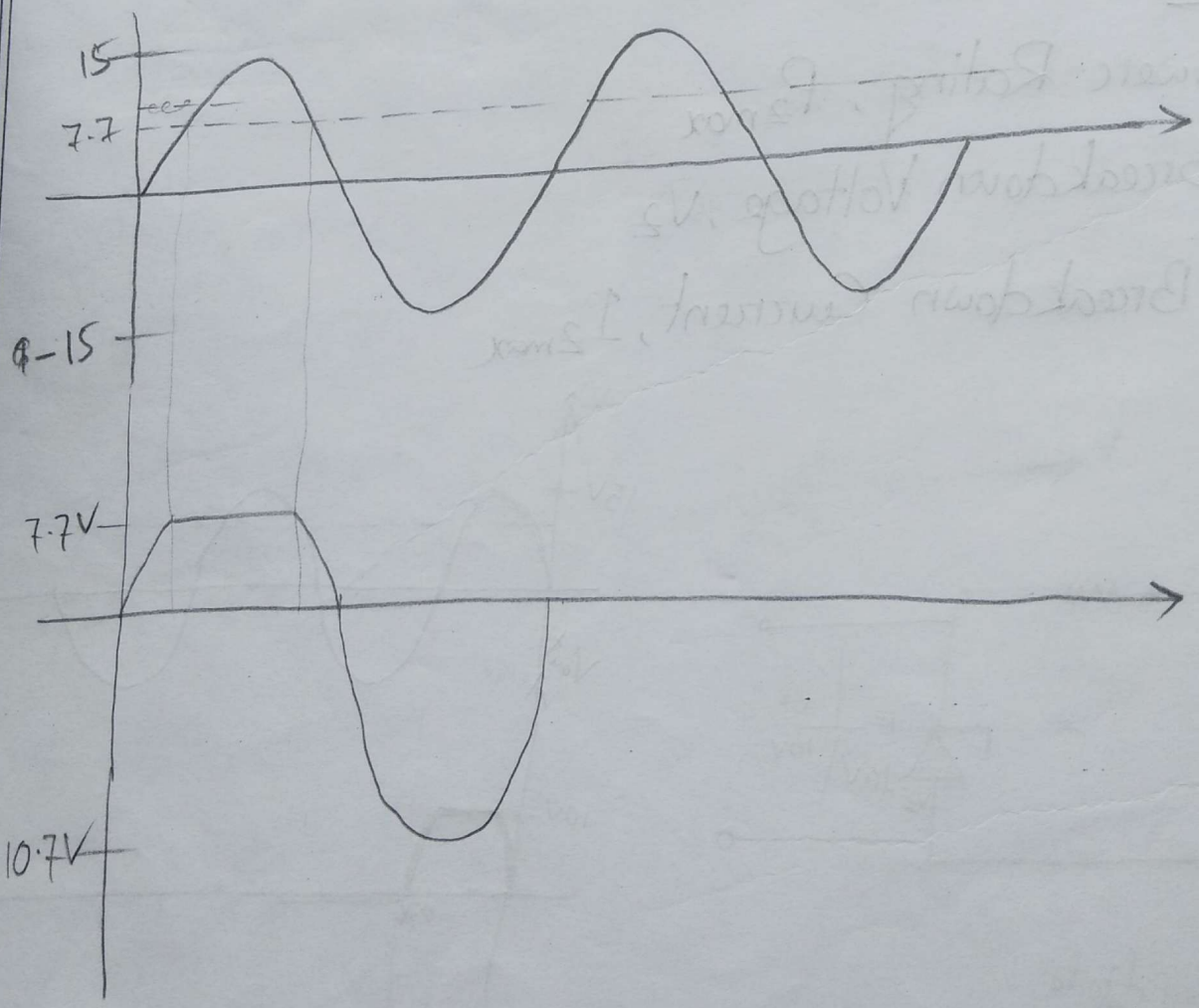
Date : .....





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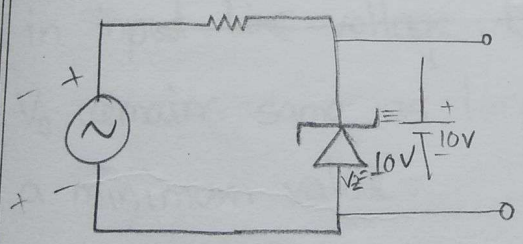
Date : .....

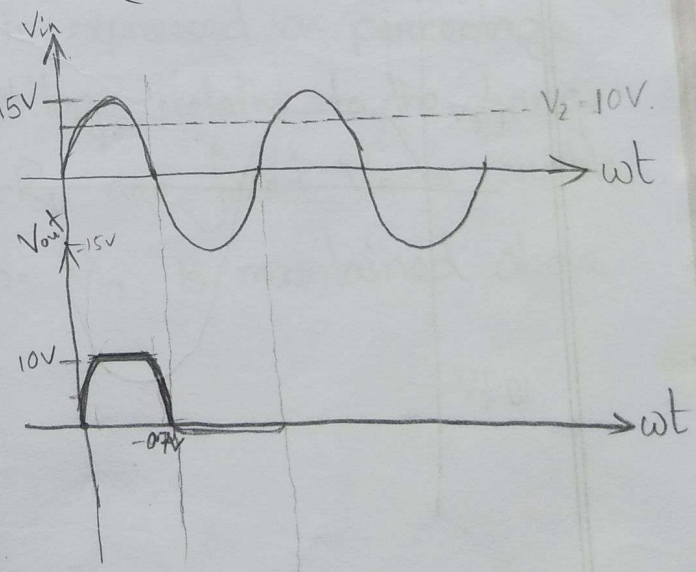
Application:

1) Voltage Regulation
2) Surge Protector
3) Waveform Clipper

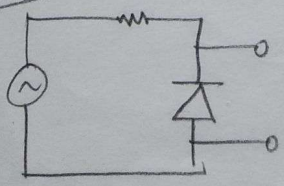
Ratings:

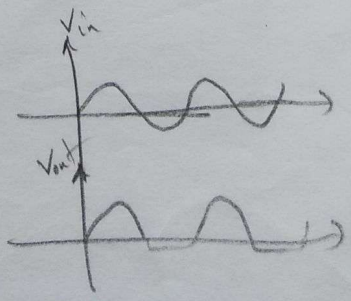
i) Power Rating, P_{Zmax}
ii) Breakdown Voltage, V_Z
iii) Breakdown Current, I_{Zmax}





if regular diode,





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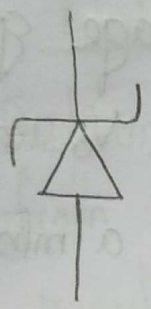
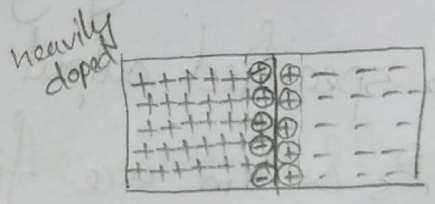
Date : 01-06-17

Multiplication

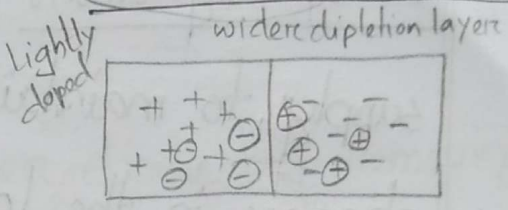
Zener Diode



Zener Break down



Avalanche Breakdown



Line Regulation

Line Regulation is the ability of the power supply to maintain it's specified output voltage over changes in the input line voltage. It is expressed as percentage of change in the output voltage relative to the change in input line voltage. R_s & R_L are fixed V_{in} is variable. V_o remains same as long as V_{in} is maintained above a minimum value.

$$\frac{\Delta V_o}{\Delta V_{in}} \times 100\%$$

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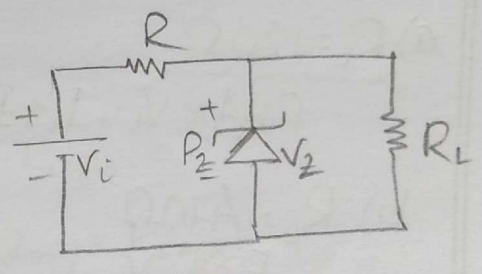
Date : 06·06·17

Zener Diode

Maths

1. Determine the state of the zener diode by removing it from the network and calculating the voltage accross the resulting open ckt.

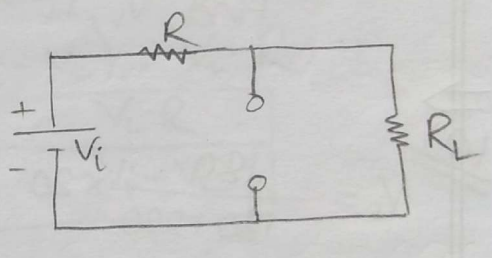


$$V_L = \frac{R_L}{R_L + R} \times V_i$$

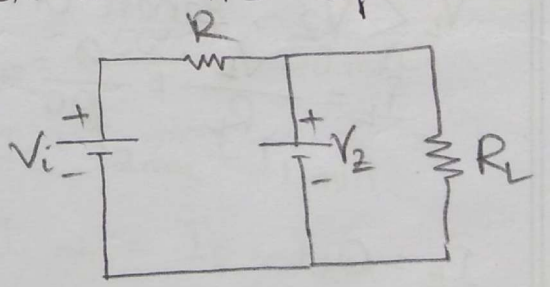
if $V_L < V_Z$, zener is off.

$I_Z = 0$

if $V_L > V_Z$, zener is ON



2. If zener is ON replace zener with it's equivalent model/ckt



$V_Z = V_L$

$I_R = I_L + I_Z$

$I_L = \frac{V_Z}{R_L}$ & $I_Z = I_R - I_L$

& $P_Z = V_Z I_Z$

$I_R = \frac{V_R}{R} = \frac{V_i - V_Z}{R}$

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Load Regulation: It is the ability of the power supply to maintain its specified output voltage given changes in the load. R_s & V_{in} are fixed. V_o remains same as long as R_L is maintained above a minimum value.

$$\frac{\Delta V_o}{\cancel{\Delta V}\,\Delta I_L} \times 100\%$$

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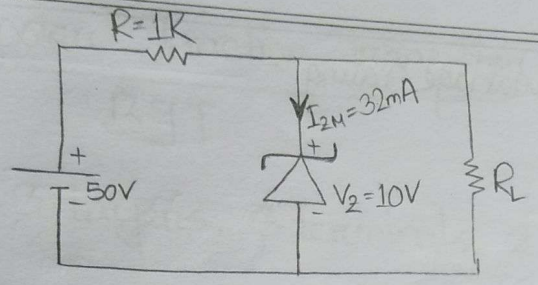

(a) Find the range of R_L & I_L to output voltage = 10V.

Find the waltage rating of zener diode.

R_L Min

$$I_{L_{max}} = \frac{V_L}{R_{L_{min}}}$$

$$I_{L_{min}} = \frac{V_L}{R_{L_{max}}}$$

$R_{L_{max}}$

$$V_L = \frac{R_{L_{min}}}{R + R_{L_{min}}} \times V_i$$

$$\Rightarrow V_L R + V_L R_{L_{min}} = R_{L_{min}} \times V_i$$

$$\Rightarrow R_{min}(V_i - V_L) = V_L \cdot R$$

$$\Rightarrow \boxed{R_{min} = \frac{V_L \cdot R}{V_i - V_L}}$$

(a) $$R_{L_{min}} = \frac{10}{50-10} \times 1K$$

$$= 250\Omega$$

$$I_{L_{max}} = \frac{10}{250} A = 0.04A$$

$$I_R = I_Z + I_L$$

$$I_R = \frac{50-10}{1} = 40\ mA$$

$$I_R = I_{Z_{max}} + I_{L_{min}}$$

$$I_{L\,min} = I_R - I_{ZM}$$

$$= (40-32)mA$$

$$= 8mA$$

$$R_{L_{max}} = \frac{10}{8}$$

$$= 1.25K$$

$$= 1250\Omega$$

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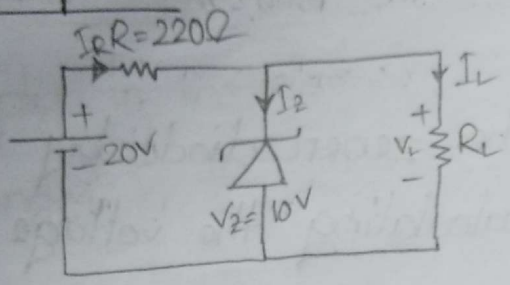
Example



a) $R_L = 180\Omega$

Find, V_L, I_L, I_Z

b) $R_L = 470\Omega$

Find, V_L, I_L & I_Z

⇒ (a)

$$V_L = \frac{180}{180+220} \times 20$$

$$= 9V$$

$V_L < V_Z$, Zener OFF

$$I_L = \frac{V_L}{R_L} = \frac{9}{180} = 0.05A$$

$I_Z = 0$.

(b)

$$V_L = \frac{470}{470+220} \times 20$$

$$\boxed{V_L = 13.62V}$$

$V_L > V_Z$, Zener ON

$V_L = 10V$

$$\boxed{I_L = \frac{10}{470} = 0.021A}$$

$$I_R = \frac{20-10}{220}$$

$$= 0.045A$$

$\therefore I_R = I_Z + I_L$

$$I_Z = I_R - I_L$$

$$= (0.045 - 0.021)A$$

$$= 0.024A$$

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Date : 08-06-17

Bipolar Junction Transistor

BJT

→ 3 Layers, 3 terminals, 2 junctions. [Bipolar]

→ 2 types

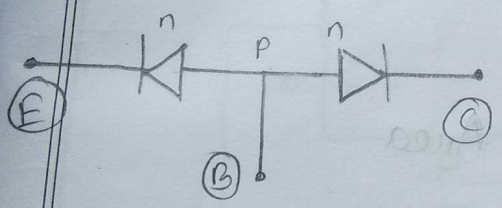
NPN PNP

→ 1947, Bardeen & Walter

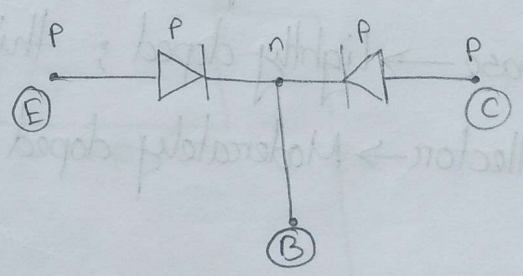
→ 1951, Morderm Version, Shockley

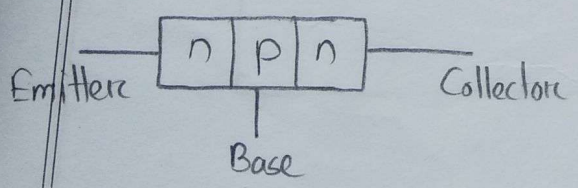
→ Transfer of Resistor

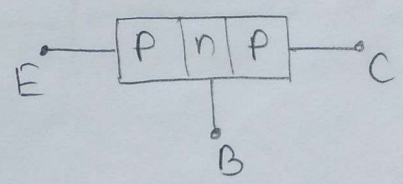
n p n

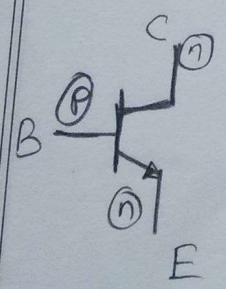


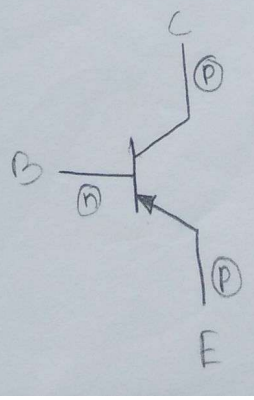
p n p











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(b) $P_{Z_{max}} = V_Z I_{Z_{max}}$ } waltage rating

$= 10 \times 32mA$

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3 doped Regions

Modes of Operation

EBT	CBT	Mode	Use
Forward	Forward	Saturation	ON-state (switch)
Forward	Reverse	Active	Amplifier
Reverse	Reverse	Cut-off	OFF-state (switch)

Emitter → heavily doped; Moderate Area

Base → Lightly doped ; thin Area

Collector → Moderately doped ; large Area

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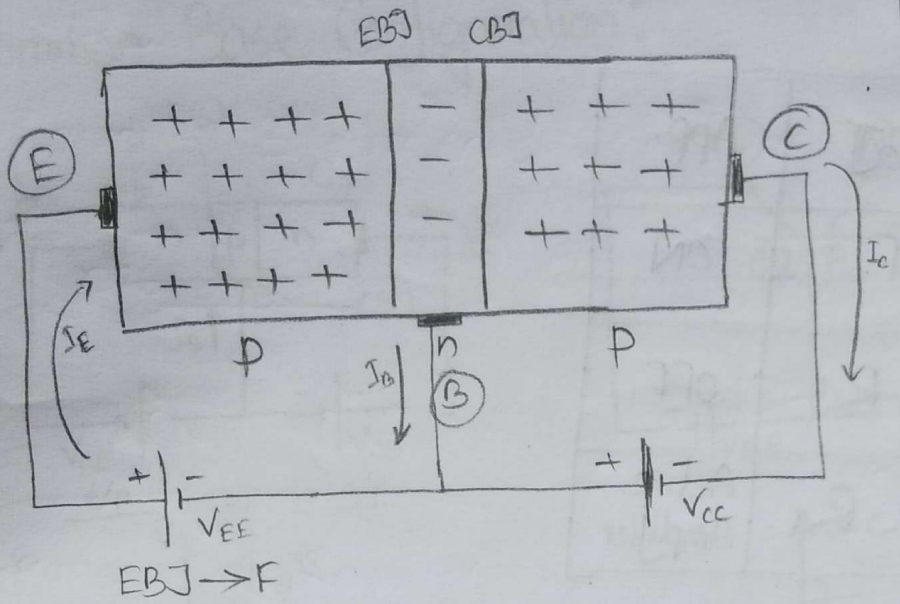
Date : 10-06-17

Working Principle



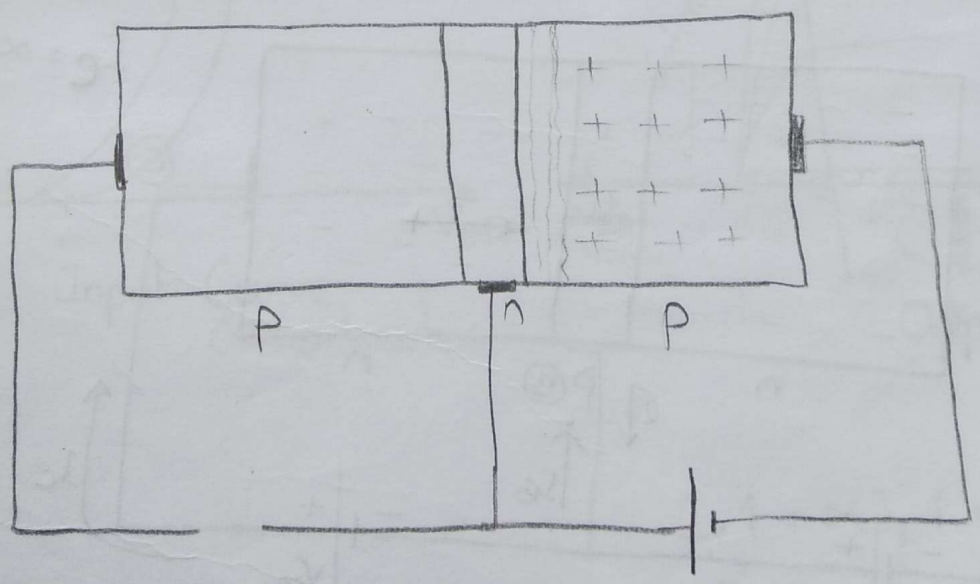
$$I_E = I_B + I_C$$

$$\therefore I_C = \alpha I_E$$

$$\alpha < 1$$

$$I_C = \alpha I_E + I_{CBO}$$

$$V_{CC} >> V_{EE}$$



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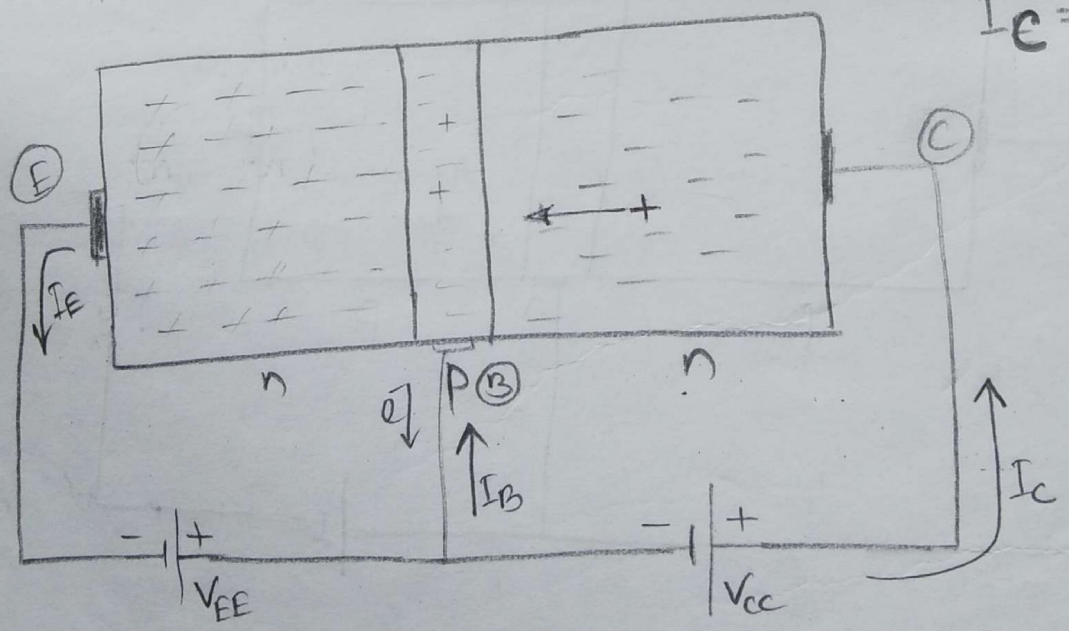
Date : .....

Mode of operation

EBJ	CBJ	APP.
F	F	ON
R	R	OFF
F	R	Active Amplifier

$I_E = I_B + I_C$

$I_C = \alpha I_E + I_{CBO}$



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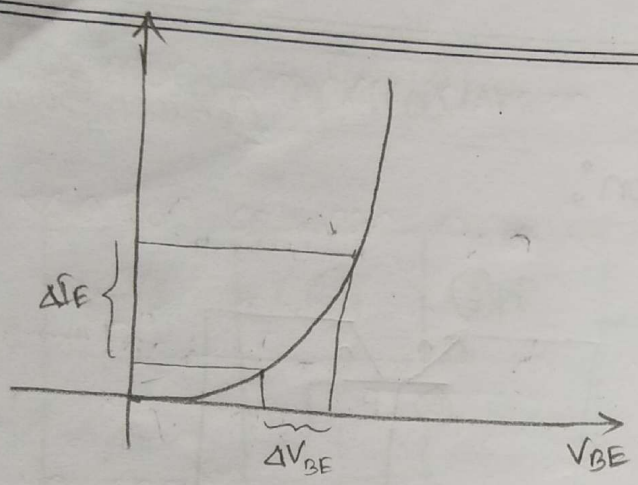
Date : .....



Input Characteristics

$r_o \uparrow = \Delta V_{CB} \uparrow$
$= \Delta I_C \downarrow$

$r_i = \dfrac{\Delta V_{BE} \downarrow}{\Delta I_E \uparrow}$

$I_C = \alpha I_E$

$\alpha = \dfrac{I_C}{I_E}$

→ common base current gain.

$\beta = \dfrac{I_C}{I_B}$

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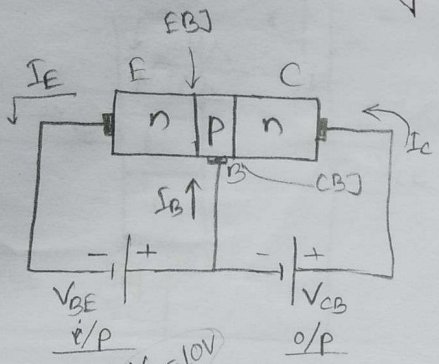
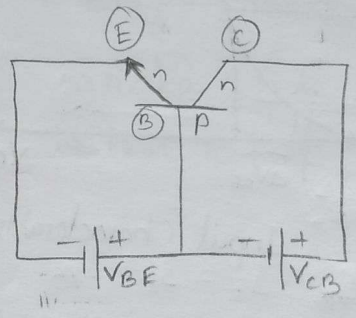
Date : 13-06-17

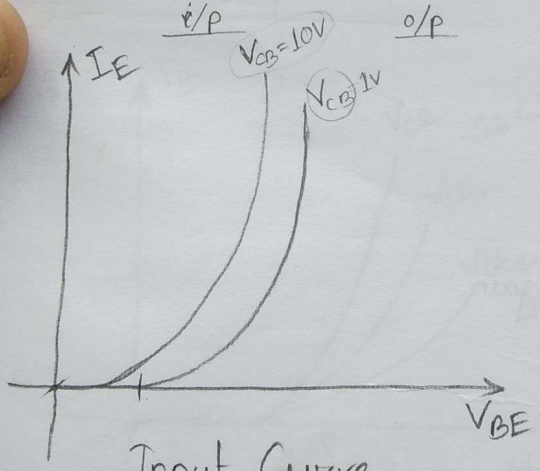
Characteristics Curve

Common Base Configuration:

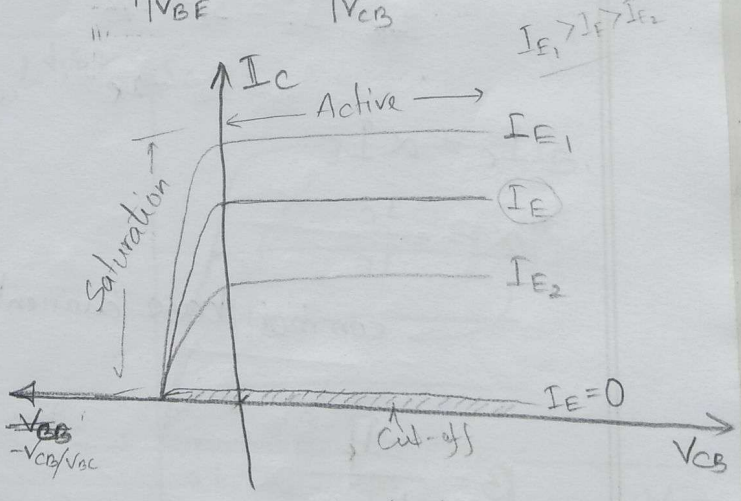
Common Base: E (BE) C (CB) — I/P O/P







Input ~~Curve~~ Characteristics



Output Characteristics

$$I_C \uparrow = \alpha I_E \uparrow + I_{CBO}$$

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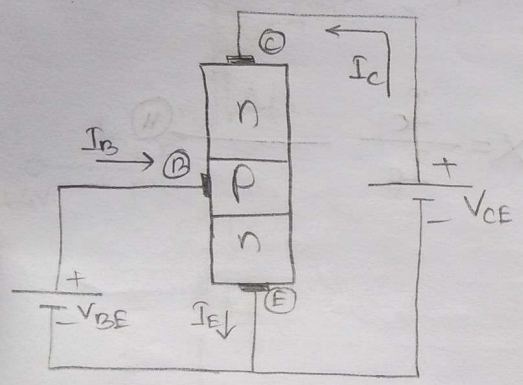
Date : 15-06-17

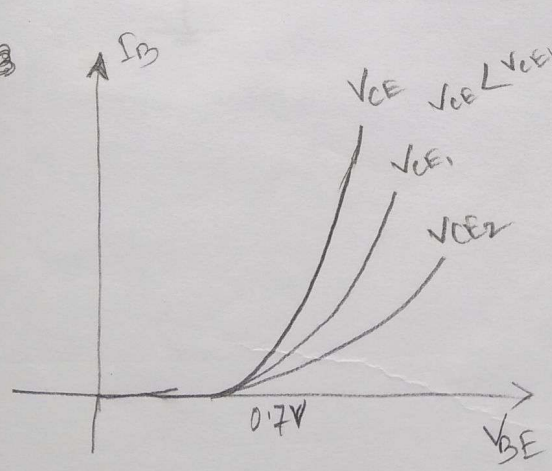
Common Emitter Configuration:

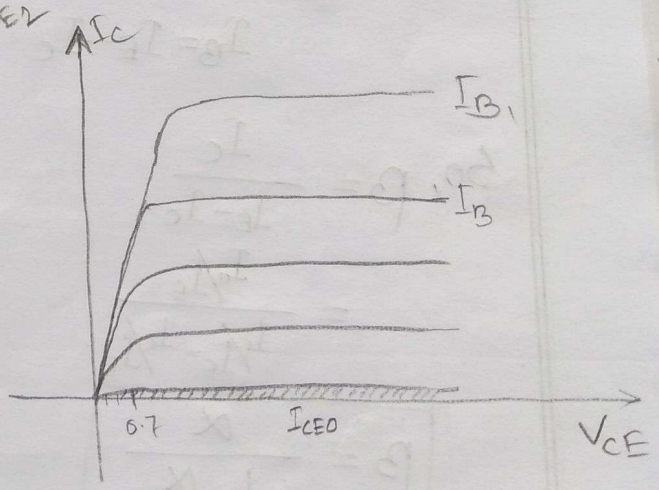


EBJ → forward

To make CBJ → Reverse

we have to keep $V_{BE} \ll V_{CE}$





Input characteristics

$$\Delta r_i \downarrow = \frac{\Delta V_{BE} \downarrow}{\Delta I_B \uparrow}$$

Output Characteristics

$$\Delta r_o \uparrow = \frac{\Delta V_{CE} \uparrow}{\Delta I_C \downarrow}$$

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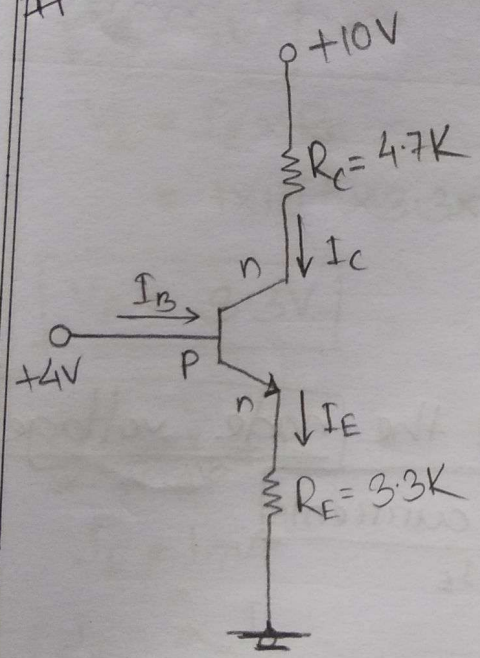
Date :

#



$V_{B} = ?$

$V_{CB} = ?$

$V_E = ?$

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Date :

Common emitter current gain, $\beta = \frac{I_C}{I_B}$

Relation between β & α:

$$\beta = \frac{I_C}{I_B} \quad \text{——— (i)} \quad \& \quad \alpha = \frac{I_C}{I_E} \quad \text{——— (ii)}$$

We know;

$$I_E = I_C + I_B$$

$$I_B = I_E - I_C$$

So, $\beta = \frac{I_C}{I_E - I_C}$

$$= \frac{I_C/I_E}{I_E/I_E - I_C/I_E}$$

$$\boxed{\beta = \frac{\alpha}{1-\alpha}}$$

Similiarly,

$$\alpha = \frac{I_C}{I_C + I_B}$$

$$= \frac{I_C/I_B}{I_C/I_B + I_B/I_B}$$

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

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$I_E = I_C + I_B$

or, $I_C = \beta I_B$ Date : .....

$\boxed{V_B = 4V}$

$V_E = I_E \times R_E$

$= 1\times10^{-3} \times 3.3\times10^{3}$

$\boxed{V_E = 3.3V}$

~~$I_E = I_B + I_C$~~

$I_E = 1mA$

$I_C = \alpha I_E$

$I_B = \beta I_B$

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

$$= \frac{100}{100+1}$$

$$= \frac{100}{101}$$

$= 0.99$

$= (0.99 \times 1)\,mA$

$= 0.99mA$

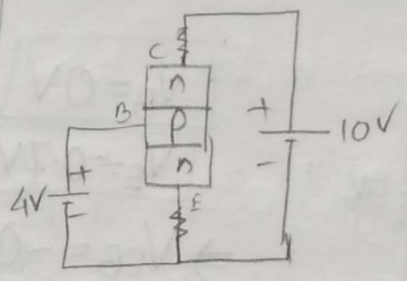
$I_B = 0.01\,mA$

By KVL,

$-10 + 4.7\times10^{3} \times 0.99\times10^{-3} + V_C = 0$

$\boxed{V_C = \quad}$

** Mode of operation



V_B (p-type)

V_E (n-type)

$V_P > V_n \rightarrow$ forward

$V_B > V_E$

$4 > 3.3$

$V_{BE} = +0.7V$

BEJ $\rightarrow$ Forward

CBJ $\rightarrow$ Reverse

$V_C > V_B$

$V_n > V_P$

Reverse

CBJ $\rightarrow$ Reverse

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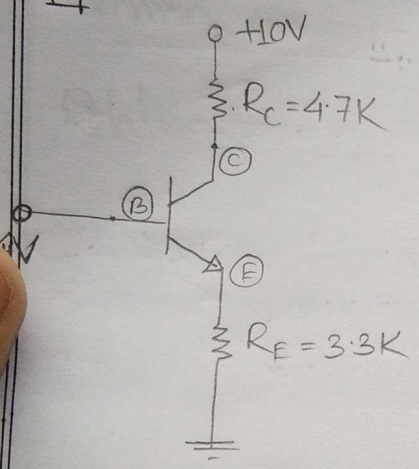
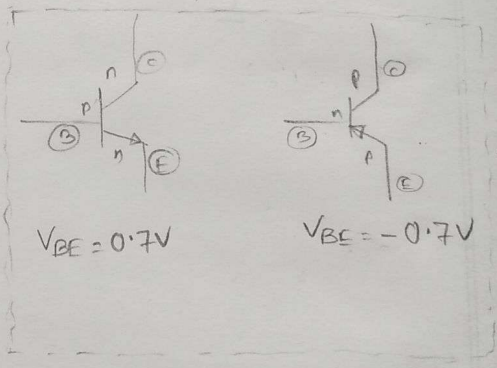
Date : 04-07-17

Ex 1

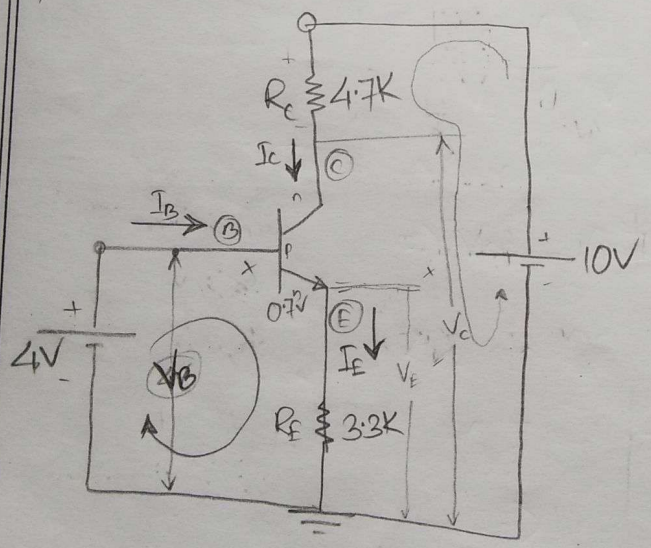


$\boxed{\beta = 100}$

Determine all the $\boxed{\text{node voltages}}$ V_B, V_C, V_E
and $\boxed{\text{branch currents}}$ I_B, I_C, I_E



⇒



KVL in BE loop,

$$-4 + 0.7 + 3.3K\, I_E = 0$$

$$I_E = \frac{3.3}{3.3K}$$

$$I_E = 1mA$$

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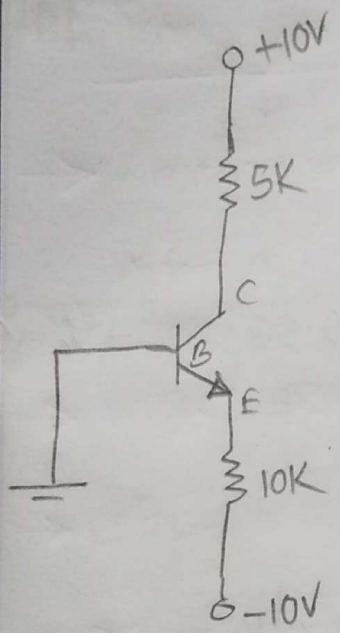
Date : 06-07-17



i) find Node Voltages & branch currents

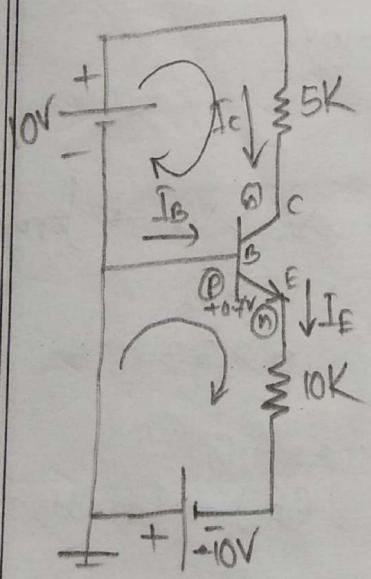
ii) Find Mode of operation

Given,

$V_E = -0.7V$

$\beta = 50$

$\Rightarrow$



$\boxed{V_B = 0V}$

$\boxed{V_E = -0.7V}$

$\Rightarrow V_{EB} = -0.7V$

$\Rightarrow V_{BE} = +0.7V$

KVL in BE Loop,

$+0.7 + I_E \times 10K - 10 = 0$

$\Rightarrow I_E = \frac{9.3}{10}$

$\boxed{I_E = 0.93mA}$

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$$\alpha = \frac{\beta}{1+\beta} = \frac{50}{51} = 0.98$$

Date : .....

$$I_C = \alpha I_E$$

$$= \frac{50}{1+50} \times 0.93$$

$$= (0.98 \times 0.93)\,mA$$

$$\boxed{I_C = 0.91\,mA}$$

$$I_B = I_E - I_C$$

$$= (0.93 - 0.91)\,mA$$

$$\boxed{I_B = 0.02\,mA.}$$

KVL in CB loop,

$$-10 + 5K \times I_C + V_C = 0$$

$$\Rightarrow V_C = 10 - 5\times10^3 \times 0.91\times10^{-3}$$

$$\boxed{V_C = 5.45V}$$

n-p-n

C B E

$V_P > V_n$

$V_B > V_E$

BEJ → forward

$V_n > V_P$

$V_C > V_B$

CBJ → Reverse

∴ Active Region.

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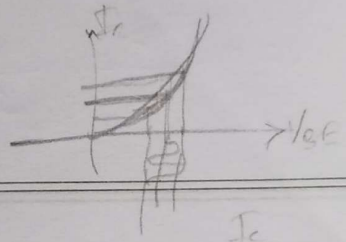

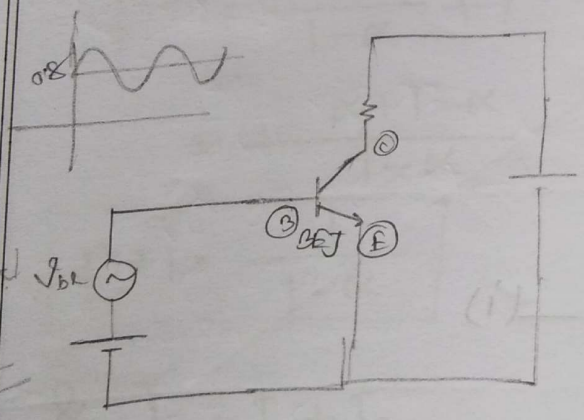

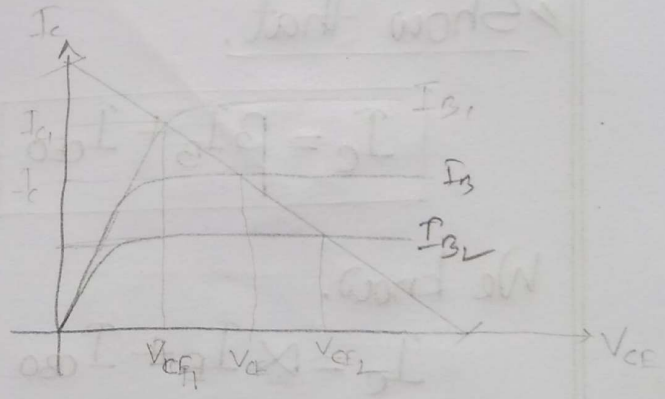

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Date :

[H] Transistore Amplifying Action:

→ Amplifying action is done by tranfering a current from a low to high resistance circuit.

→ weak signal is applied to EBJ

→ EBJ is forward biased

→ DC is applied to make EBJ always forward

→ AC varies but DC voltage should be such that it always makes EBJ forward.

→ Input Resistance is low. Small change is AC voltage causes change in I_B

→ I_B changes so does I_C

→ I_C flowing through R_C produces large voltage accross it.

So, weak signal is amplified to a large signal.

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

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

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

& $I_E = I_C + I_B$

$$= \beta I_B + I_B$$

$$\boxed{I_E = (\beta+1) I_B}$$

I_{CBO} = collector to base current with emitter open circuited

I_{CEO} = collector to emitter current with base open circuited

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Date : 08-07-17

Show that,

$$\boxed{I_C = \beta I_B + I_{CEO}}$$

We know,

$$I_C = \alpha I_E + I_{CBO} \quad \text{———} (i)$$

$$\& \quad I_E = I_C + I_B$$

From eqn (i),

$$I_C = \alpha(I_C + I_B) + I_{CBO}$$

$$\Rightarrow I_C = \alpha I_C + \alpha I_B + I_{CBO}$$

$$\Rightarrow I_C(1-\alpha) = \alpha I_B + I_{CBO}$$

$$\Rightarrow I_C = \frac{\alpha}{1-\alpha} I_B + \frac{1}{1-\alpha} I_{CBO}$$

$$\Rightarrow I_C = \beta I_B + (1+\beta) I_{CBO}$$

$$\Rightarrow \boxed{I_C = \beta I_B + I_{CEO}} \quad \left[\text{As } (1+\beta) I_{CBO} = I_{CEO}\right]$$

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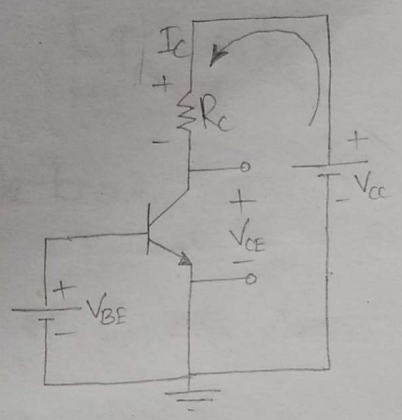
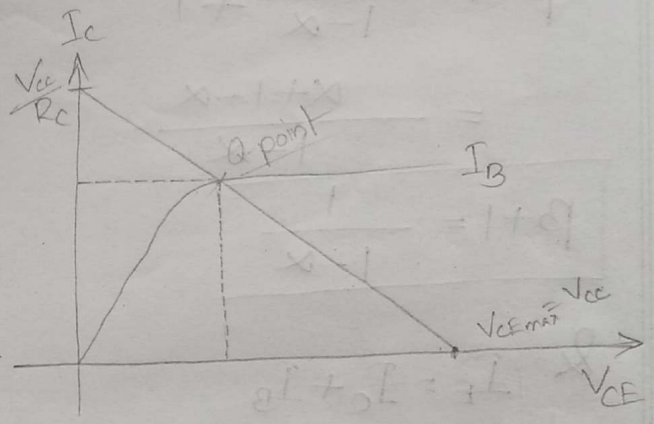
Date : .....





CE ⇒ $\beta > \alpha$

$I_C = \beta I_B$

KVL,

$-V_{CC} + I_C R_C + V_{CE} = 0$

$\Rightarrow V_{CC} = I_C R_C + V_{CE}$ ——— (i)

$I_C = 0,$

$V_{CE} = V_{CC} - \cancel{I_C R_C}^{\,0}$

$V_{CE\,max} = V_{CC}$

$V_{CE} = 0,$

$$\boxed{I_{C\,max} = \frac{V_{CC}}{R_C}}$$

$$\boxed{V_{CE\,max} = V_{CC}}$$

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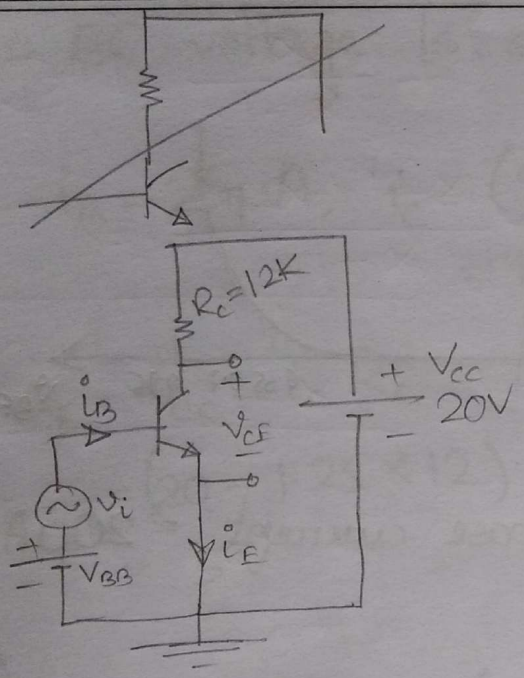

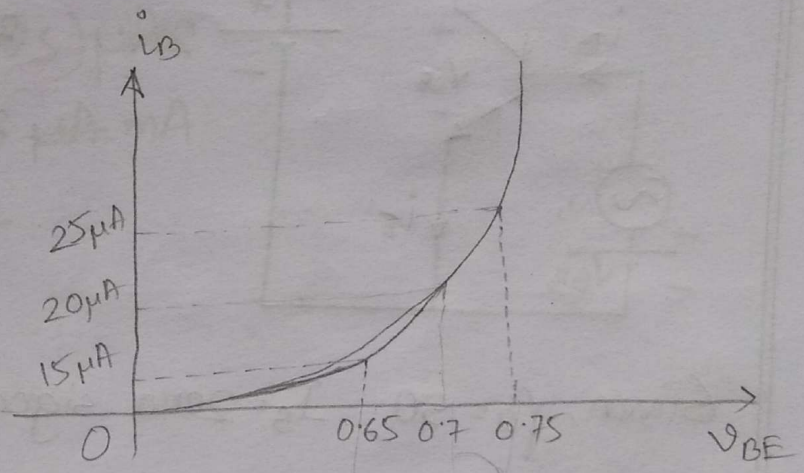

Given, $\beta = 50$

I_B = zero signal base current = 20μA

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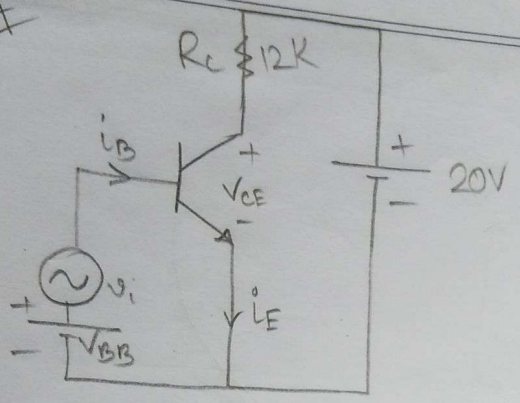
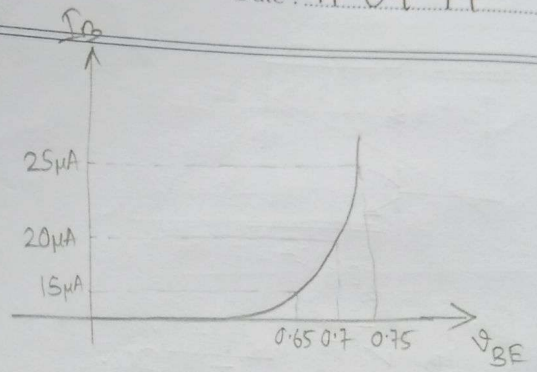
Date : 11-07-17

#



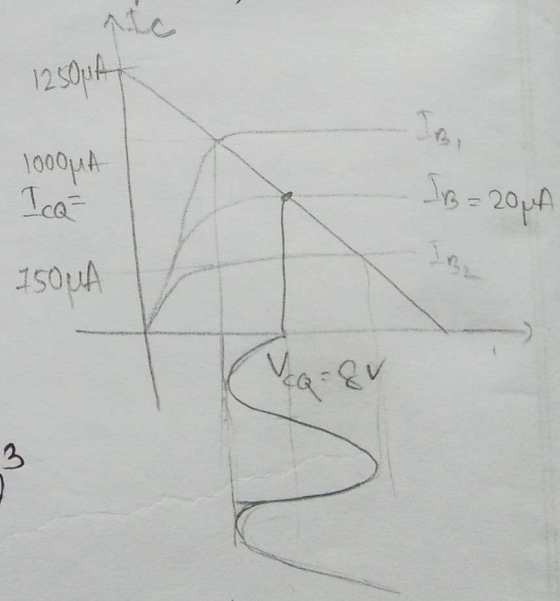


Given, $\beta = 50$; I_B = zero signal base current = 20μA

find the voltage gain.

Solⁿ: The zero signal collector current is,

$$I_C = \beta I_B$$
$$= (50 \times 20)\,\mu A$$
$$= 1000\,\mu A$$



$$V_{CE} = V_{CC} - I_C R_C$$
$$= 20 - 1000 \times 10^{-6} \times 12 \times 10^{3}$$

$$\therefore V_{CE} = 8\,V$$

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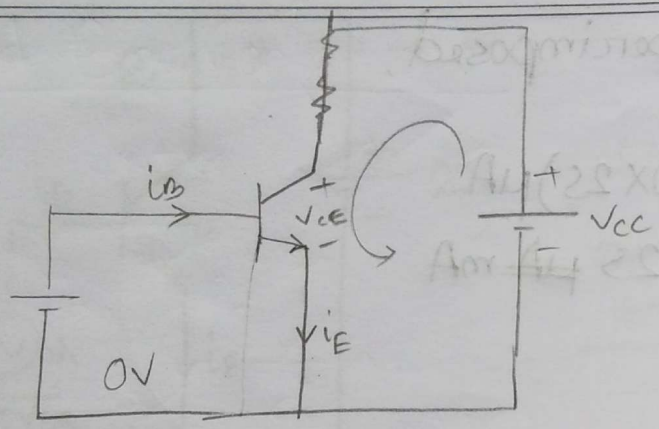
Transistor acts like an inverter

Date : .....



LL

$I_B = 0$

$I_C = \beta I_B = 0$

$V_{CE} = V_{CC} - \cancel{I_C R_C} \rightarrow 0$

$V_{CE} = V_{CC}$

LH

LH

I_B

$I_C = \beta I_B$

$V_{CE} = V_{CC} - I_C R_C$ → I_C বড় হিসাবে Maximum voltage এসাবে

So, $\boxed{V_{CE} = V_{CC} - I_C R_C}$

VL

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Date : .....

when AC voltage is superimposed,

at, $i_B = 25\mu A$, $i_c = (50 \times 25)\mu A$

$= 1.25$ ~~μA~~ mA

& $V_{CE} = V_{cc} - i_c R_c$

$= (20 - 1.25 \times 12)$

$= 5V$

and

at, $i_B = 15\mu A$, $i_c = (50 \times 15)\mu A$

$= 0.75 mA$

$\therefore V_{CE} = V_{cc} - i_c R_c$

$= (20 - 0.75 \times 12) V$

$= 11V$

So, $\Delta V_i = (0.75 - 0.65) V$

$= 0.1V$

& ~~ΔV~~ $\Delta V_{CE} = (11 - 5) V$

$= 6V$

$\therefore$ voltage gain $= \dfrac{\Delta V_i}{\Delta V_o}$

$= \dfrac{6}{0.1}$

$= 60$ (Ans.)

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Date : 13-07-17

Fixed Bias Configuration: (base-resistance method)

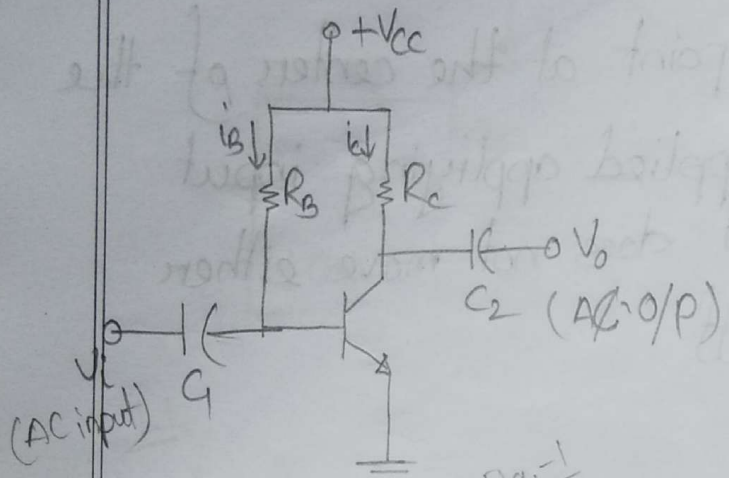
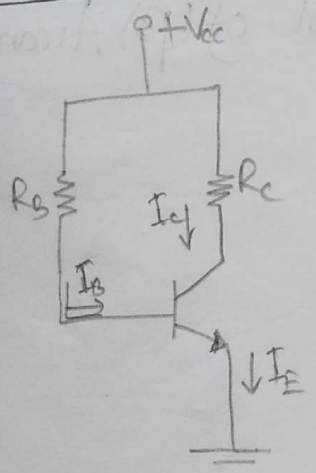
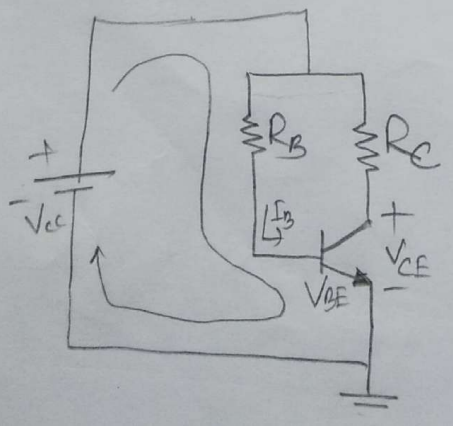


Fig.-1

DC equivalent circuit:



KVL in Base Emitter loop:



$$-V_{CC} + I_B R_B + V_{BE} = 0$$

$$\Rightarrow I_B = \frac{V_{CC} - V_{BE}}{R_B}$$

I_B can be set by varying R_B

& $I_C = \beta I_B$

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Date : .....

Requirement of a biasing circuit:

1. Establish the operating point at the center of the active region such that ~~applied~~ appliying input signal, the operating point does not move either into saturation or cut off.

2. Stabilized the collector current, I_c against temperature.

3. Make operating point independent of (β), transistor parameter.

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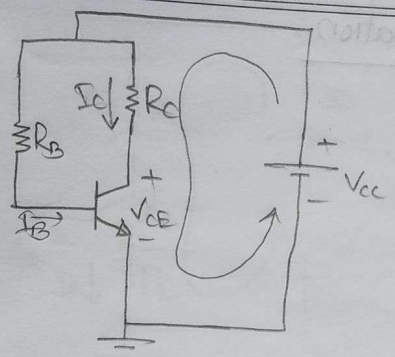
Date : .....



KVL in collector-emitter loop,

$$-V_{CC} + I_C R_C + V_{CE} = 0$$

$$\Rightarrow V_{CE} = V_{CC} - I_C R_C$$

So, Q point is set at (V_{CEQ}, I_{CQ})

Advantages & Disadvantages

Q

Fig.-1

a) find I_{BQ} & I_{CQ}

b) V_{CEQ} ..... Given

c) V_B & V_C $\boxed{\beta = 50}$

d) $V_{BC} = V_B - V_C$

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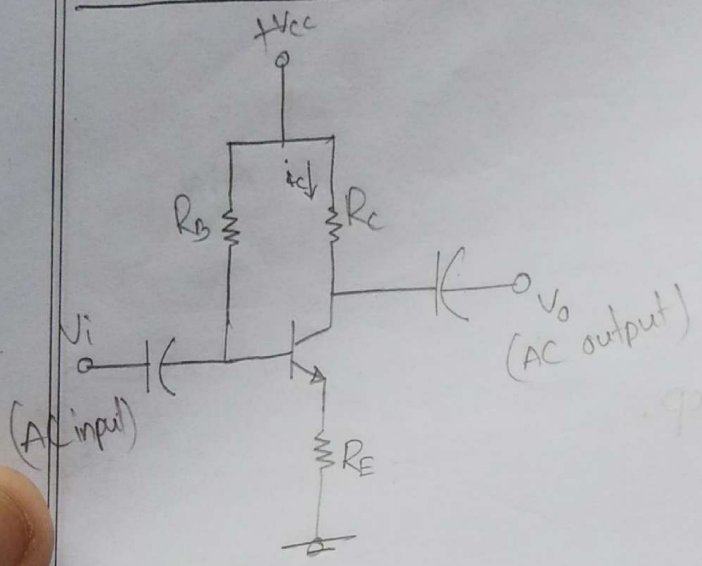
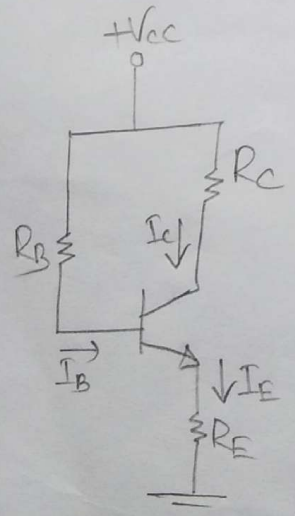
Date : .....

Emitter Stabilized Bias Configuration:

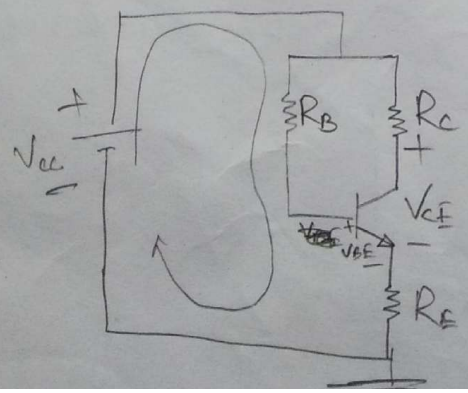


DC equivalent circuit:



$$I_E = I_B + I_C$$
$$I_E = I_B + \beta I_B$$
$$I_E = I_B(1+\beta)$$

KVL in Base-Emitter loop:



$$-V_{CC} + I_B R_B + V_{BE} + I_E R_E = 0$$

$$\Rightarrow I_B R_B + V_{BE} + (1+\beta) I_B R_E = V_{CC}$$

$$\Rightarrow I_B = \frac{V_{CC} - V_{BE}}{R_B + (1+\beta) R_E}$$

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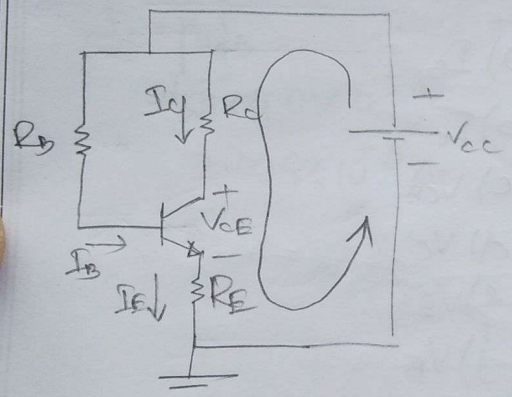
Date : .....



KVL in collector-emitter loop,

$$-V_{CC} + I_C R_C + V_{CE} + I_E R_E = 0$$

$$\Rightarrow V_{CE} = V_{CC} - I_C R_C - I_E R_E$$

$$\boxed{V_{CE} = V_{CC} - I_C(R_C + R_E)}$$

$I_E = I_C + I_B$

I_B is very small

$$\boxed{I_E \cong I_C}$$

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Date : .....

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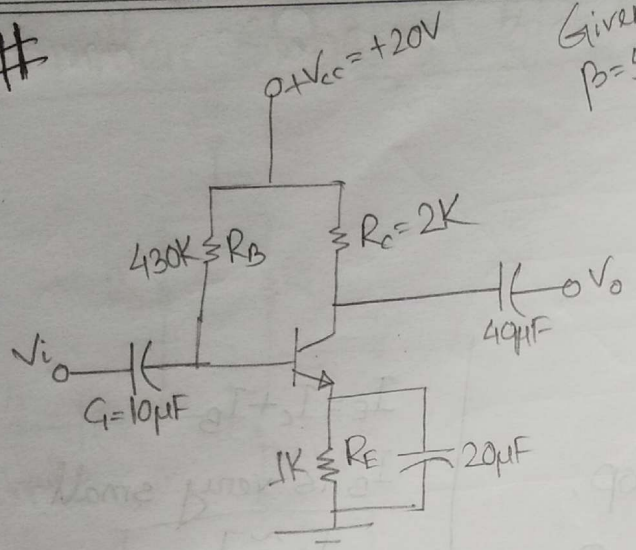
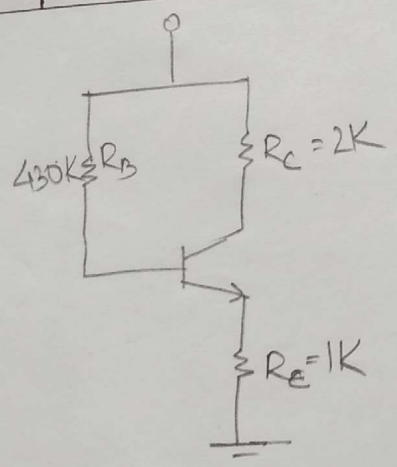


Given,
$\beta = 50$

a) I_B
b) I_C
c) V_{CE}
d) V_C
e) V_E
f) V_B
g) V_{BC}

DC equivalent Circuit:



KVL in Base-Emitter loop

$$-V_{CC} + I_B R_B + (1+\beta) I_B R_E + V_{BE} = 0$$

$$\Rightarrow I_B = \frac{V_{CC} - V_{BE}}{R_B + (1+\beta) R_E} = \frac{20 - 0.7}{430\times10^3 + 51\times1\times10^3}$$

$$= 4.01\times10^{-5}\ A$$

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Date : .....

$I_C = \beta I_B$

$= (50 \times 4.01 \times 10^{-5})$

$= 2.006 \times 10^{-3} A$

KVL in collector - emitter loop,

$-V_{CC} + I_C R_C + V_{CE} + I_E R_E = 0$

$\Rightarrow V_{CE} = V_{CC} - I_C R_C - I_E R_E$

$V_{CE} = V_{CC} - I_C (R_C + R_E)$

$= 13.980 \, (A \ldots)$

$V_C = V_{CE} + I_E R_E$

$V_{BC} = V_B - V_C$

$V_E = I_E R_E$

$V_B = V_{BE} + I_E R_E$

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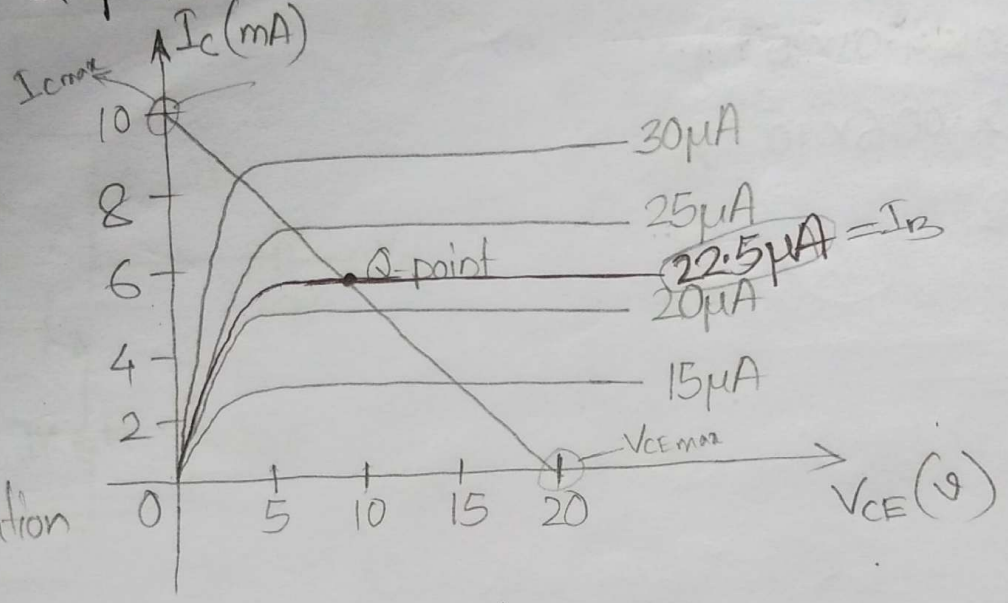
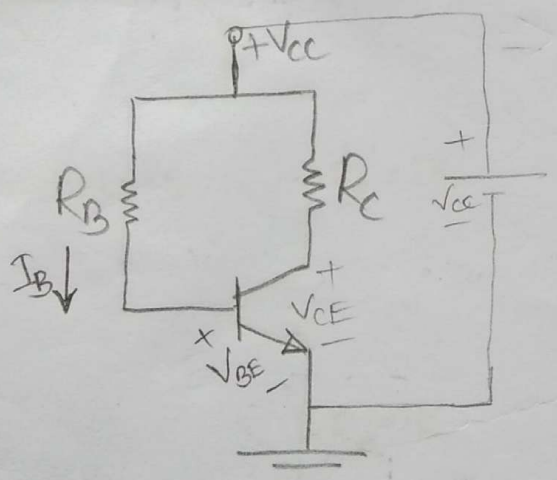
Date : 15-08-17

Given the Q-point and the load line

Find,
a) V_{CC}
b) R_C
c) R_B
for a fixed bias configuration



Sol^n:



$$V_{CC} = \cancel{I_C R_C}^{\,0} + V_{CE} \qquad I_C = 0$$

$$\Rightarrow \boxed{V_{CE_{max}} = V_{CC}}$$

$$= 20V$$

$$I_{Cmax} = \frac{V_{CC}}{R_C} \quad \Big| V_{CE} = 0$$

$$10 = \frac{20}{R_C}$$

$$R_C = \frac{20}{10mA} = 2K$$

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Date : .....

KVL in BE loop,

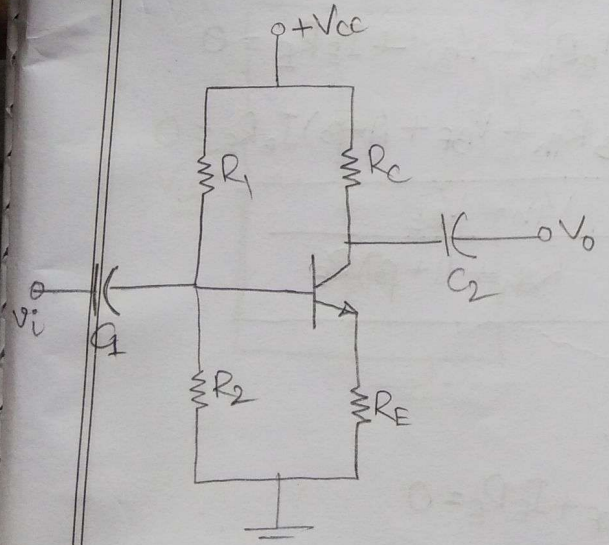
$$-V_{CC} + I_B R_B + V_{BE} = 0$$

$$\Rightarrow R_B = \frac{V_{CC} - V_{BE}}{I_B}$$

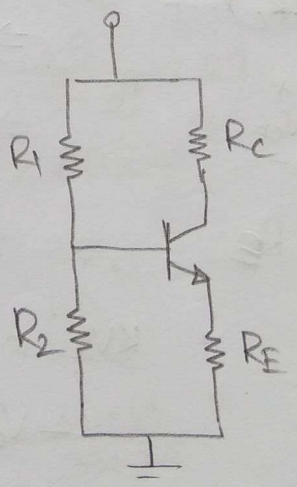
$$= \frac{20 - 0.7}{22.5 \times 10^{-6}}$$

$$= 857.77K$$

Voltage Divider Bias



DC Equivalent circuit:



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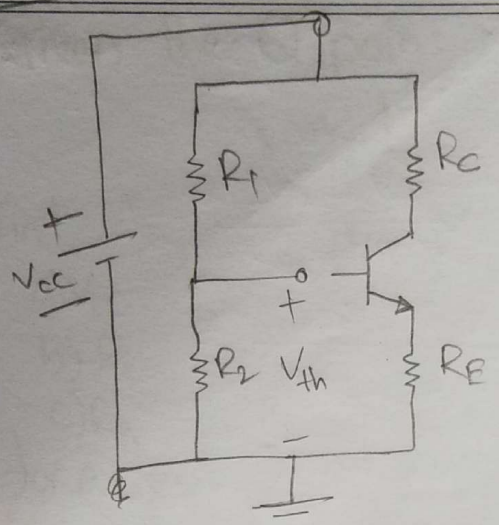
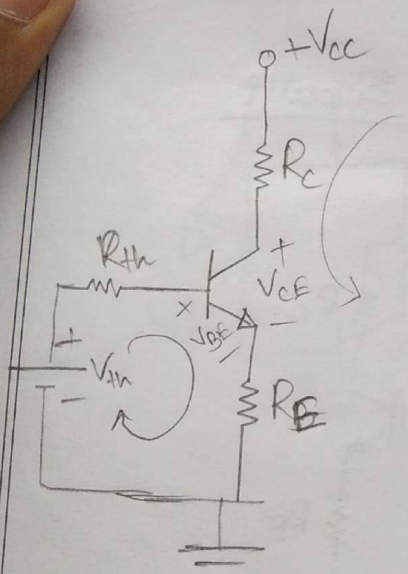
Thevenin's circuit

Date : .....



$$V_{th} = \frac{R_2}{R_1 + R_2} \times V_{cc}$$

$$R_{th} = R_1 \| R_2$$



KVL in BE loop,

$$\Rightarrow -V_{th} + I_B R_{th} + V_{BE} + I_E R_E = 0$$

$$\Rightarrow -V_{th} + I_B R_{th} + V_{BE} + (1+\beta) I_B R_E = 0$$

$$\Rightarrow \boxed{I_B = \frac{V_{th} - V_{BE}}{R_{th} + (1+\beta) R_E}}$$

KVL in CE loop,

$$-V_{cc} + I_C R_C + V_{CE} + I_E R_E = 0$$

$$\Rightarrow V_{CE} = V_{cc} - I_C R_C - I_E R_E$$

$$I_C = \beta I_B$$

$$I_E = I_B + I_C$$

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Date : .....

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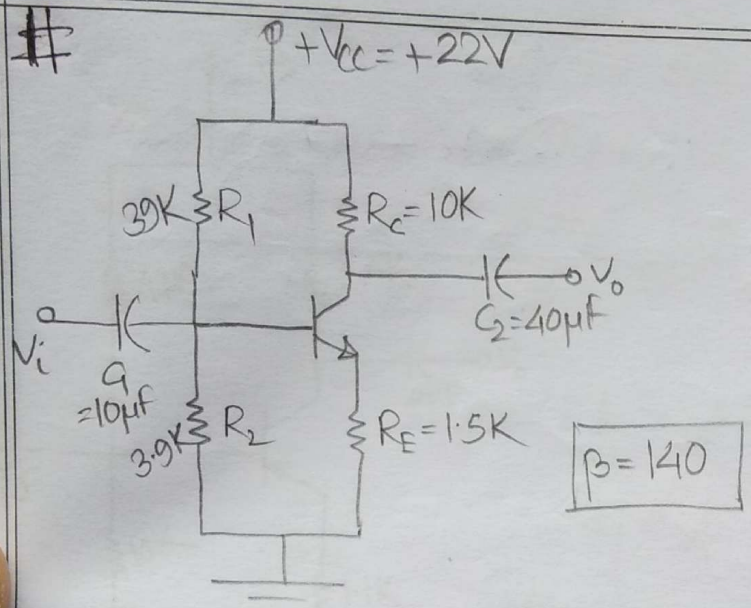
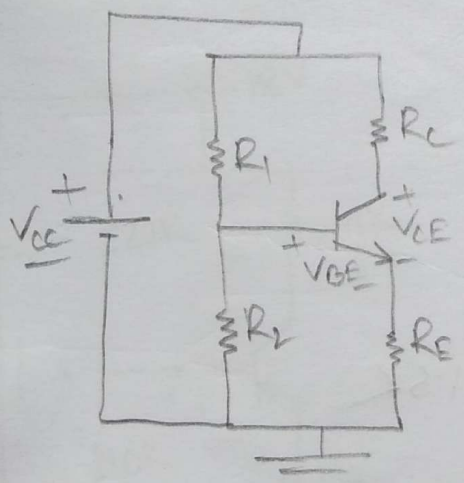


DC equivalent circuit :



$$V_{th} = \frac{R_2}{R_1+R_2} \times V_{cc}$$

$$= \frac{3.9}{3.9+39} \times 22$$

$$= 2.002V$$

$$R_{th} = R_1 \parallel R_2$$

$$= \frac{R_1 R_2}{R_1+R_2}$$

$$= \frac{3.9 \times 39}{39+3.9}$$

$$= 3.55K$$

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Date : .....

KVL in loop,

$$I_B = \frac{V_{th} - V_{BE}}{R_{th} + (1+\beta)R_E}$$

$$= \frac{2.002 - 0.7}{3.55 + (1+140)1.5}$$

$$= 6.045\,\mu A$$

$$I_C = \beta I_B = 140 \times 6.045 = 0.85\,\cancel{\mu A}\ mA$$

$$I_E = I_C + I_B$$

KVL in CE loop,

$$V_{CE} = V_{CC} - I_C R_C - I_E R_E$$

$$= 22 - 0.85mA \times 10K - I_E \times 1.5K$$

$$=$$

Self Bias

$I_C = \beta\uparrow I_B\downarrow$

$\beta\uparrow$

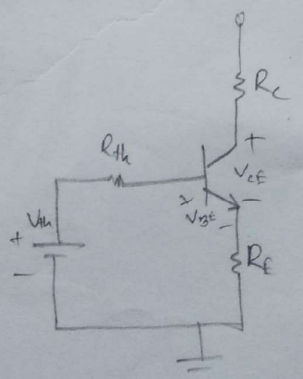
$I_C\uparrow$

$I_E\uparrow$

$I_E R_E\uparrow$

$I_B\downarrow$

$I_C\downarrow$



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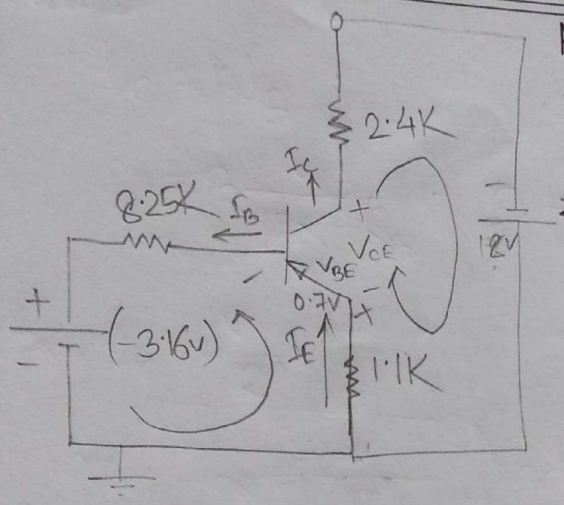
current এর দিক
KVL করতে হবে। p থেকে n → 0.7V

Date : .....



KVL in BE loop,

$$-3.16 + 1.1K \times I_E + 0.7 + 8.25K \times I_B = 0$$

$$\Rightarrow I_B = \frac{3.16 - 0.7}{1.1K(1+120) + 8.25K}$$

$$I_B = 17.40\mu A$$

$$\therefore I_C = \beta I_B$$

$$= (1+\beta) I_B$$

$$[\because I_E \cong I_C]$$

KVL in CE loop,

$$-18 + 1.1K \times I_E - V_{CE} + I_C \times 2.4K = 0$$

$$\Rightarrow V_{CE} = I_C [1.1K + 2.4K] - V_{CC}$$

$$V_{CE} = -10.65V$$

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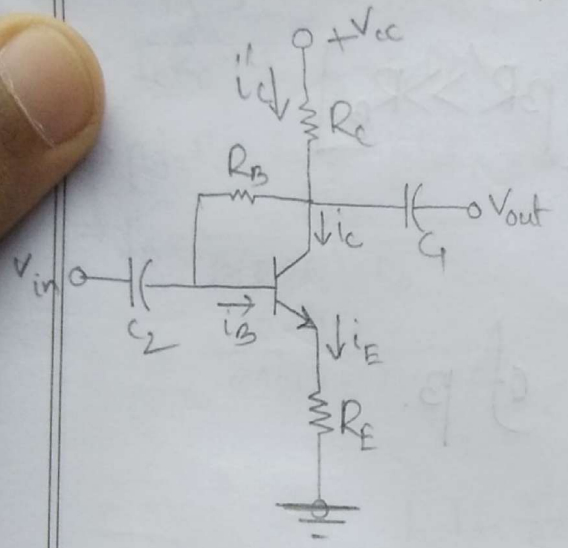
Date : 20-07-17

DC Bias with voltage feedback:



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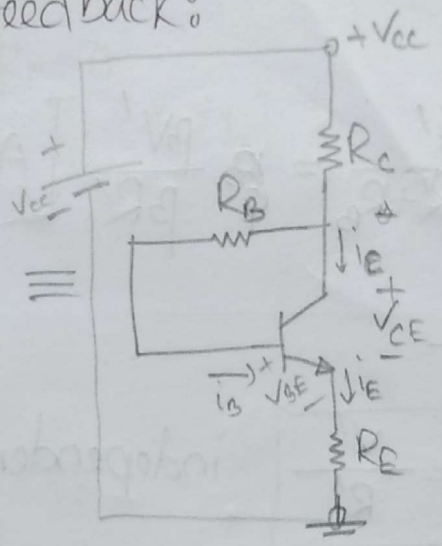

current through R_C is not I_C

but, $I_C' = I_C + I_B$

$\cong I_C$

$I_C' \cong \beta I_B$

KVL in BE loop,

$\Rightarrow -V_{CC} + I_C' R_C + I_B R_B + V_{BE} + I_E R_E = 0$

$\Rightarrow I_C' R_C + I_B R_B + I_C R_E = V_{CC} - V_{BE}$ [Let, $I_E \cong I_C$]

$\Rightarrow \beta I_B R_C + I_B R_B + \beta I_B R_E = V_{CC} - V_{BE}$

$\Rightarrow I_B [\beta R_C + R_B + \beta R_E] = V_{CC} - V_{BE}$

$\therefore I_B = \dfrac{V_{CC} - V_{BE}}{\beta(R_C + R_E) + R_B}$

$\Rightarrow I_B = \dfrac{V'}{\beta R' + R_B}$

Let, $V_{CC} - V_{BE} = V'$

$R_C + R_E = R'$

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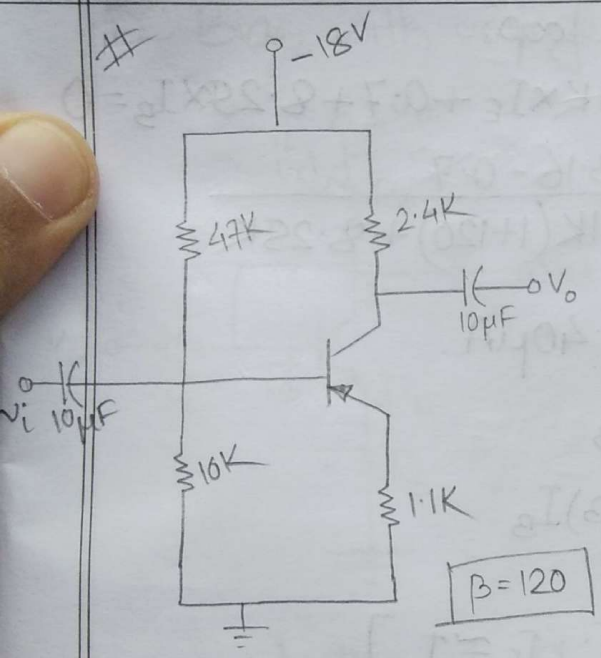
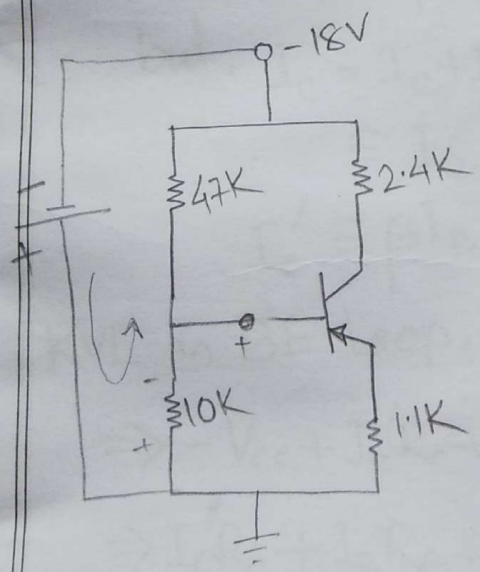
Date : 18-07-17

#



$\beta = 120$



$$V_{th} = \frac{10K}{10K+47K} \times (-18V)$$

$$= -3.16V$$

$$R_{th} = 10K \parallel 47K$$

$$= 8.25K$$

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Quiz-4
Date :

Now,

$$I_C = \beta I_B$$

$$= \beta \frac{V'}{\beta R' + R_B} = \frac{\beta V'}{\beta R'} \quad [\text{As, } \beta R' >> R_B]$$

So, $I_C = \frac{V'}{R'}$

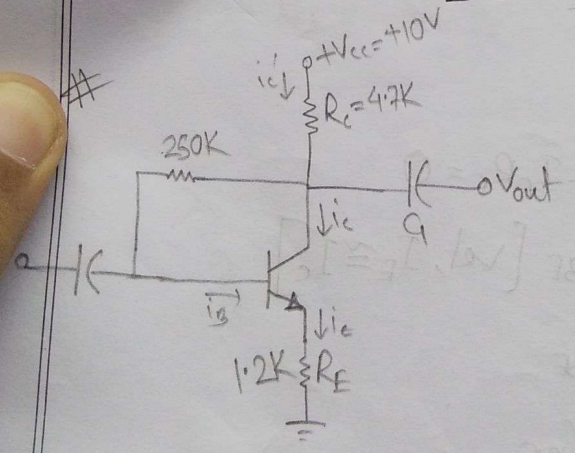
or, $\boxed{I_{CQ} = \frac{V'}{R'}}$ independent of β.

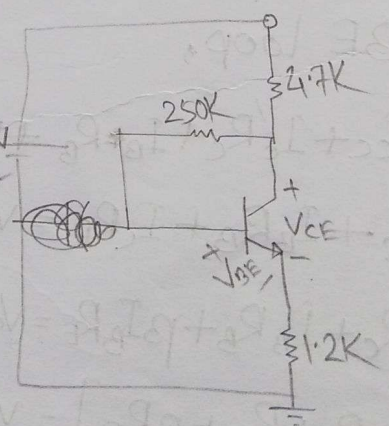
Now, KVL in CE loop,

$$-V_{CC} + I_C' R_C + V_{CE} + I_E R_E = 0$$

$$\Rightarrow V_{CE} = V_{CC} - I_C' R_C - I_E R_E \quad \left[\begin{array}{l} I_C' \cong I_C \\ \& \ I_C \cong I_E \end{array}\right]$$

$$V_{CE} = V_{CC} - I_C [R_C + R_E]$$





$\beta = \infty$

Date : .....

KVL in loop BE,

$$-V_{CC} + I_C' R_C + I_B R_B + V_{BE} + I_E R_E = 0$$

$$\Rightarrow I_C R_C + I_B R_B + I_C R_E = V_{CC} - V_{BE} \quad [\text{Let, } I_E \cong I_C]$$

$$\Rightarrow \beta I_B R_C + I_B R_B + \beta I_B R_E = V_{CC} - V_{BE}$$

$$\Rightarrow I_B = \frac{V_{CC} - V_{BE}}{\beta(R_C + R_E) + R_B}$$

$$= \frac{10 - 0.7}{90(4.7 + 1.2) + 250K}$$

$$=$$

$$I_C = \beta I_B \quad \Big| \quad I_C = \frac{V'}{R'} = 1.5\,mA$$

$$= 90 \times$$

$$V_{CE} = V_{CC} - I_C [R_C + R_E]$$

$$= 3.68\,V.$$

Example:

4.13, 4.14, 4.19, 4.20, 4.21, 4.27.

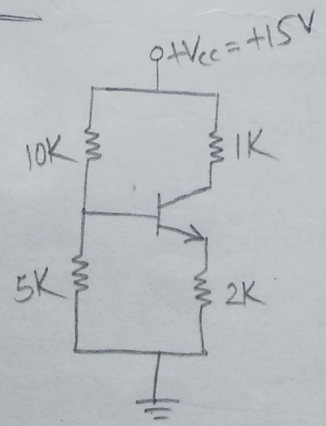


Fig. shows a voltage divider bias method. Draw the D.C. load line determine operating point.

Assume, $V_{BE} = 0.7V$

$\beta = 50$

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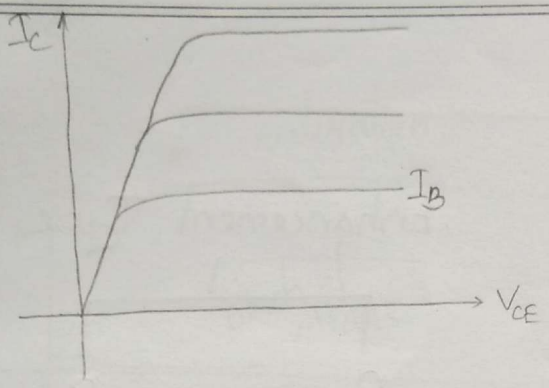
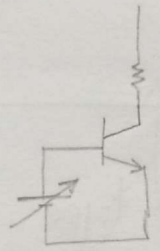


$I_C = \beta I_B$



FET

- MOSFET
- ~~JFET~~

# BJT	FET
1. Bipolar	1. Unipolar
2. Current Control	2. Voltage control
3. Voltage gain ↑	3. Voltage gain ↓
4. Noise ↑	4 Noise ↓ (Impedance)
5. Sw speed	5. Sw speed

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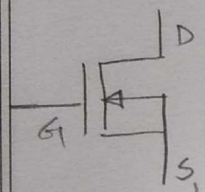
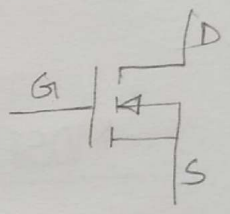
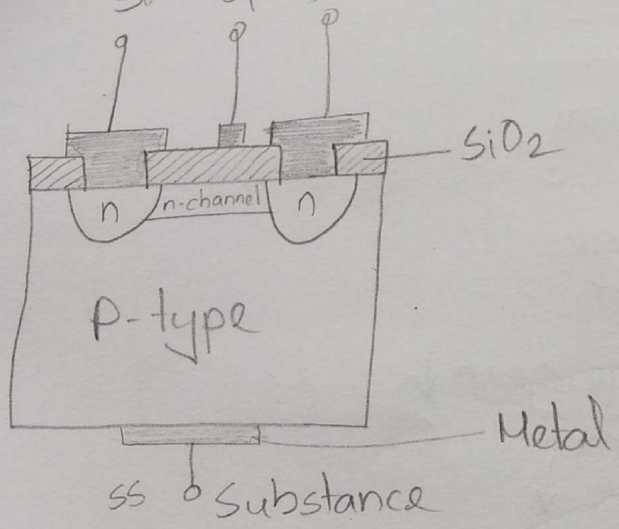
MOSFET

- Depletion type (channel present)
  - n-channel
  - p-channel
- Enhancement Type
  - n
  - p





construction:



operation

$V_{GS} = 0V$
$V_{DS} = +ve$

$V_{GS} < 0V$
$V_{DS} = +ve$

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Date : 29-07-17

OPAMP

Operational Amplifier: It is a high gain amplifier which can do many mathematical operation & to which a feedback can be used to control its gain & output characteristics.

Operational
↓
mathematical operation [addition
Subtraction, multiplication,
Solution, differentiation,
Integration]

Amplifier
↓
can amplify input signal

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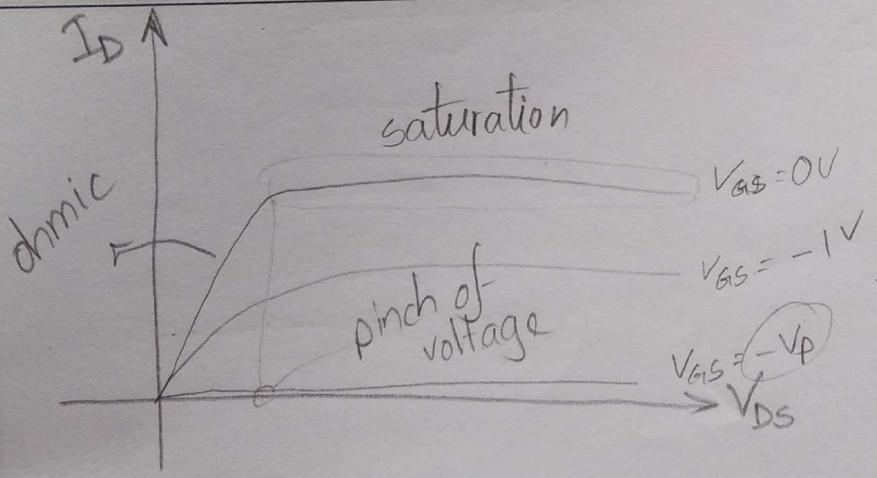

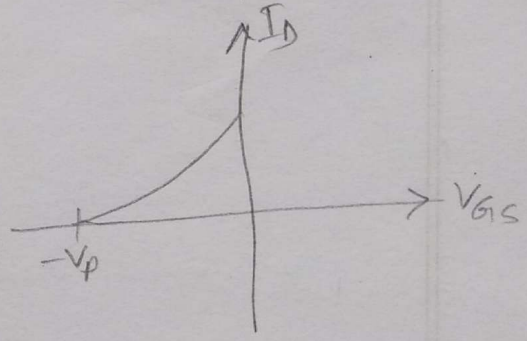

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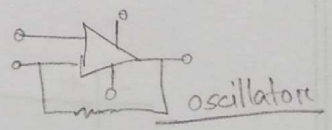
Characteristics of Ideal op-amp:

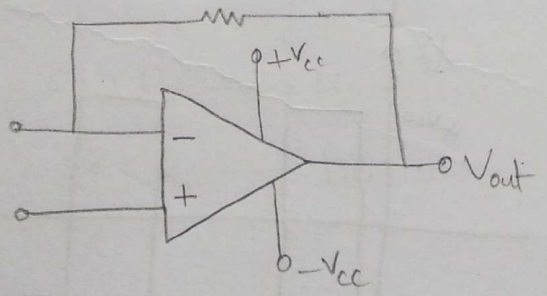
i) Input impedance is infinite.
ii) Output impedance is zero.
iii) Open loop gain in infinite.
iv) Bandwidth is ~~infit~~ infinite
v) Direct coupling [can amplify DC too]

Operating mode:

1. Comparator : Without feedback
2. Amplifier : with feedback



+ve → feedback থাকলে
→ oscillator.



feedback → (−ve) input

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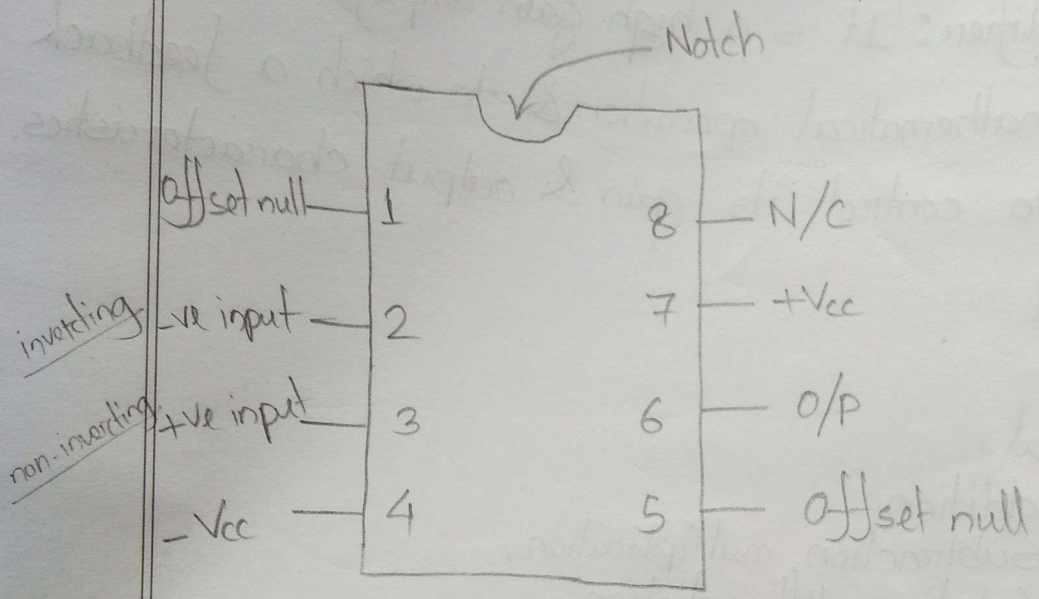
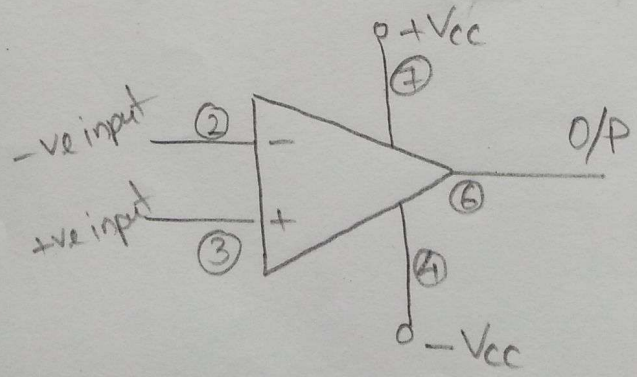
PIN Configuration



- Offset null is used to provide a way to balance out internal voltage

Symbol



- Internal Construction
  → 14 BJT/4 MOS

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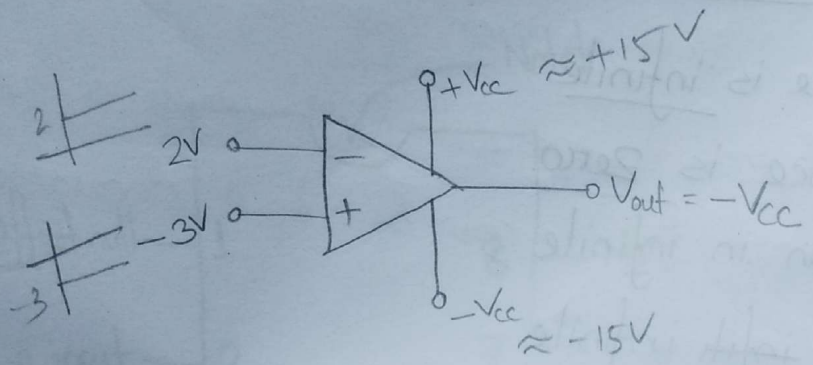
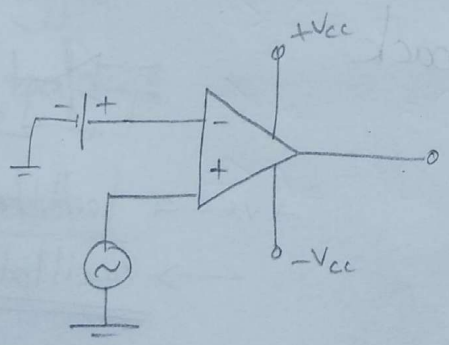
Comparator : without feedback (open loop)

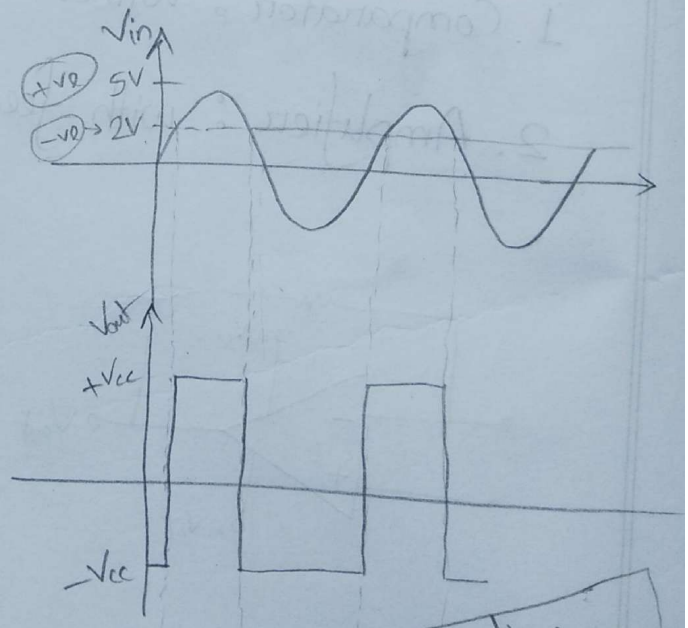


$$\boxed{V_0 = (V_+ - V_-) \times A_{OL}}$$ → open loop gain

$= (-3-2) \times A_{OL}$

$= -5 \times A_{OL}$





Non-inverting +2V level crossing detector

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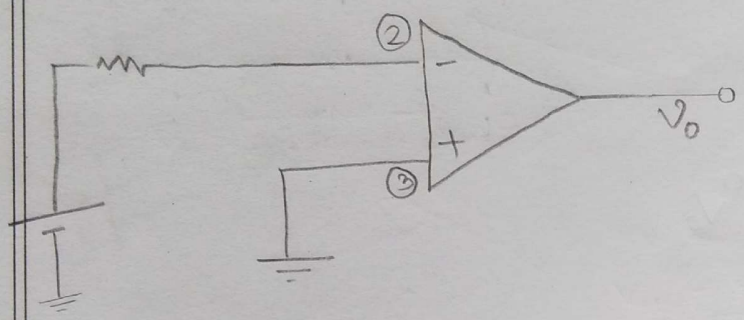
Virtual Short



$$V_o = E_d \times Gain$$

$$\Rightarrow \frac{V_o}{Gain} = E_d$$

$$\Rightarrow \frac{V_o}{\infty} = V_+ - V_-$$

$$\Rightarrow 0 = V_+ - V_-$$

$$\Rightarrow V_+ - V_- = 0$$

$$\Rightarrow V_+ = V_-$$

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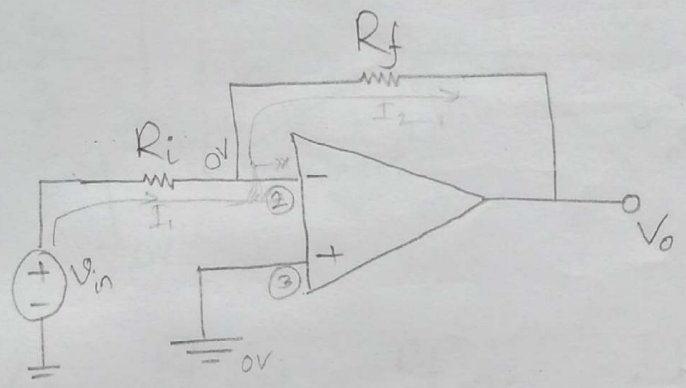
Date : 01-08-17

Inverting Amplifier



$$I_1 = I_2$$

$$\Rightarrow \frac{V_{in} - 0}{R_i} = \frac{0 - V_o}{R_f}$$

$$\Rightarrow \boxed{V_o = -\frac{R_f}{R_i} \times V_{in}}$$

$$\text{gain} = \frac{V_o}{V_i} = -\frac{R_f}{R_i}$$

$R_f > R_i \longrightarrow$ Multiplier

$R_f < R_i \longrightarrow$ Divider

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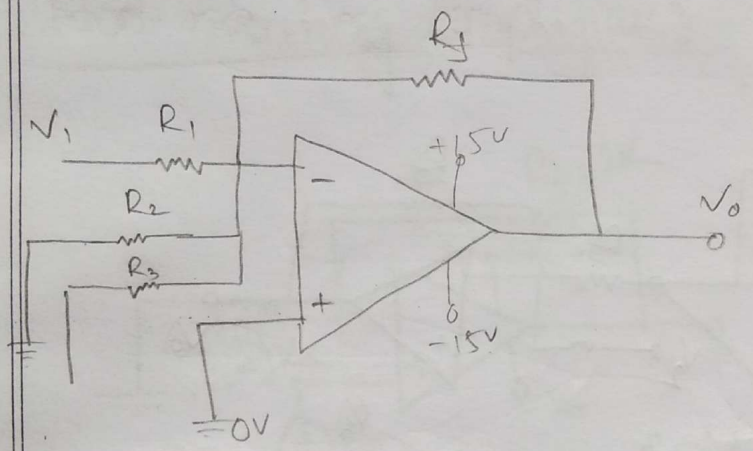
Date : .....



$$V_{01} = -\frac{R_f}{R_1} \times V_1$$

$$V_{02} = -\frac{R_f}{R_2} \times V_2$$

$$V_{03} = -\frac{R_f}{R_3} \times V_3$$

$$V_0 = -\frac{R_f}{R_i} \times V_1 - \frac{R_f}{R_2} \times V_2 - \frac{R_f}{R_3} \times V_3$$

$$= -(V_1 + V_2 + V_3) \qquad \boxed{R_f = R_1 + R_2 + R_3}$$

Inverting Adder

If $V_0 = -3V_1 - 4V_2 - 5/3\, V_3$

$$\frac{R_f}{R_1} = 3$$

$$R_1 = \frac{R_f}{3}$$

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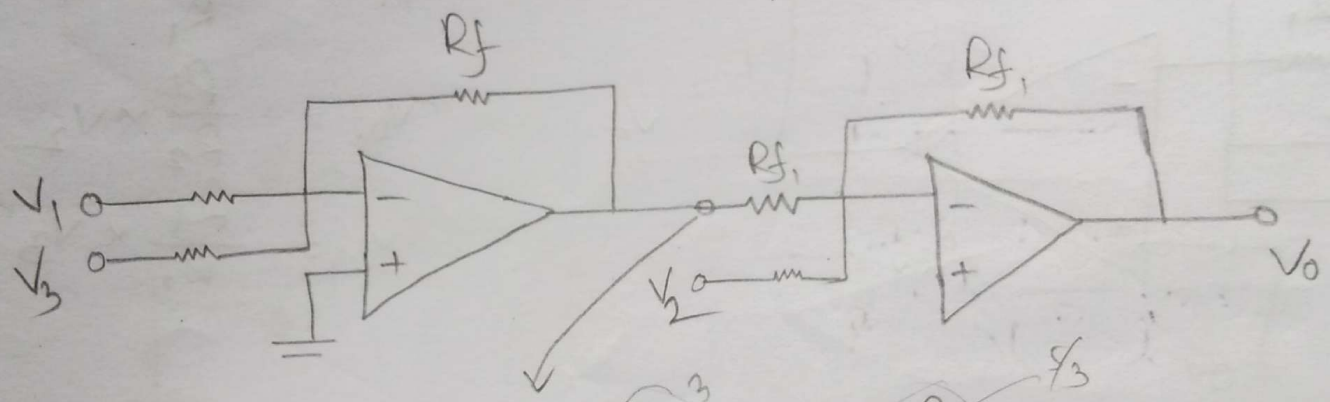
$V_0 = +3V_1 - 4V_2 + 5/3\, V_3$

subtractor

Date : .....



$$V_{01} = -\frac{R_f}{R_1} \times V_1 - \frac{R_f}{R_3} \times V_3$$

3

5/3

$$V_0 = -\frac{R_{f_1}}{R_{f_1}} \times V_{01} - \frac{R_{f_1}}{R_2} \times V_2$$

$$= \frac{R_f}{R_1} \times V_1 + \frac{R_f}{R_3} \times V_3 - \frac{R_{f_1}}{R_2} \times V_2$$

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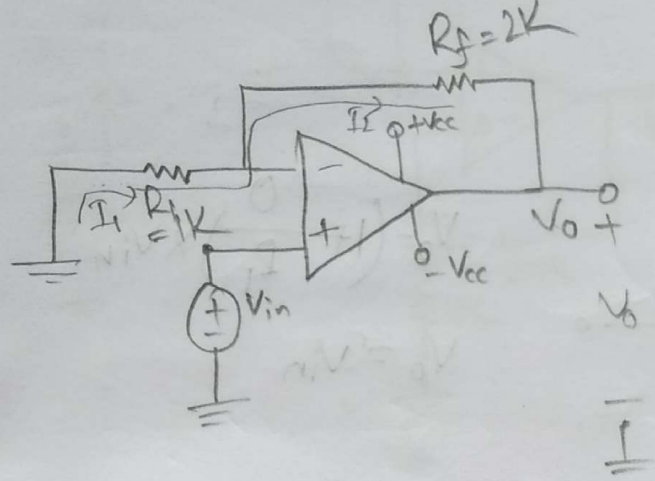
Date : 03-08-17

Non-inverting Amplifier:



$$I_1 = I_2$$

$$\frac{0 - V_{in}}{R_1} = \frac{V_{in} - V_o}{R_f}$$

$$\frac{-V_{in}}{R_1} = \frac{V_{in}}{R_f} - \frac{V_o}{R_f}$$

$$\frac{V_o}{R_f} = \frac{V_{in}}{R_f} + \frac{V_{in}}{R_1}$$

$$V_o = V_{in}\left(1 + \frac{R_f}{R_1}\right)$$

$$V_o = \left(1 + \frac{R_f}{R_1}\right) \times V_{in}$$

$$= \left(1 + \frac{R_f}{\infty}\right) V_{in}$$

$$V_o = V_{in}$$

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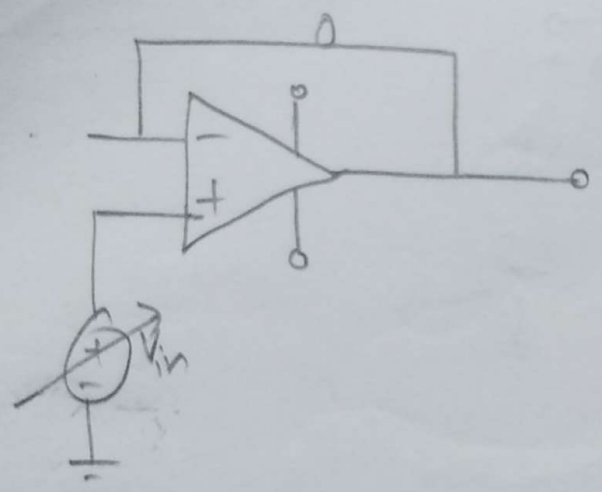
Very Voltage Follower / Source follower:

Isolation Amplifier:



$$V_o = \left(1 + \frac{0}{R_1}\right) \times V_{in}$$

$$V_o = V_{in}$$

Unity gain amplifier

It works as a voltage buffer that ~~po~~ provides a means of isolating an input signal stage from a output or load stage.

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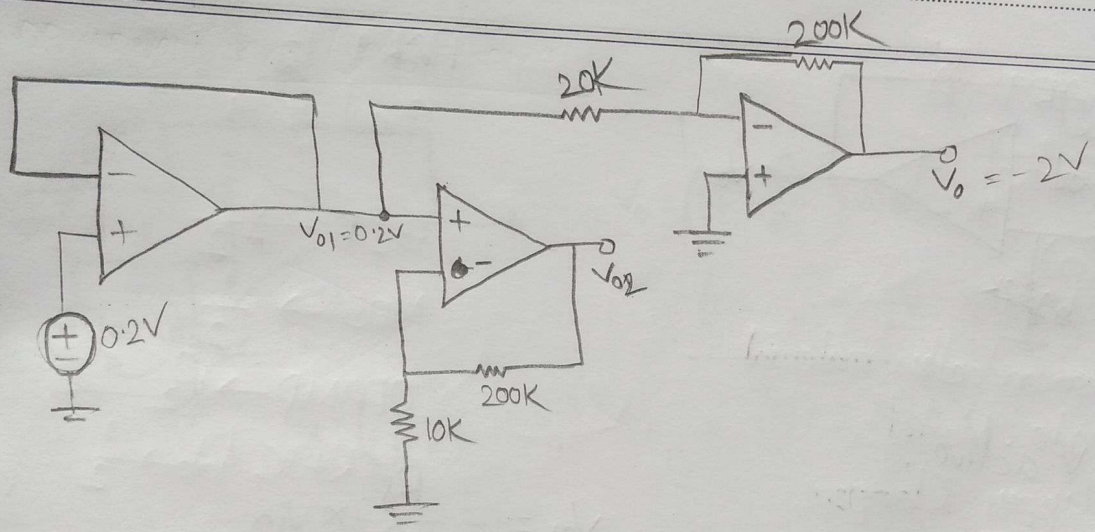
Date : .....

#



$$V_{01} = \left(1 + \frac{R_1}{R_f}\right) V_{in}$$

$$V_{01} = V_{in} = 0.2V$$

$$V_0 = -\frac{R_f}{R} \times V_{in}$$

$$= -\left(\frac{200K}{20K} \times 0.2\right) V$$

$$= -2V$$

$$V_{02} = \left(1 + \frac{200K}{10K}\right) \times 0.2V$$

$$= 21 \times 0.2 V$$

$$= 4.2 V$$

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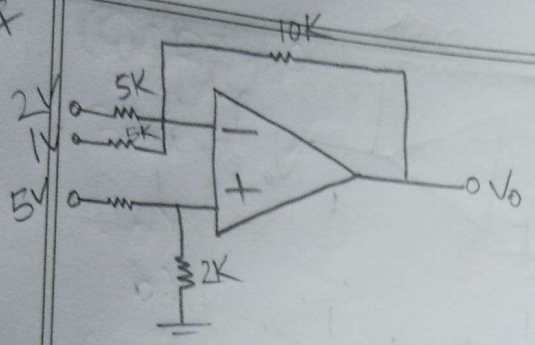
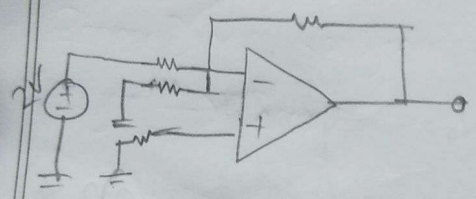
Date :

#



2V active,

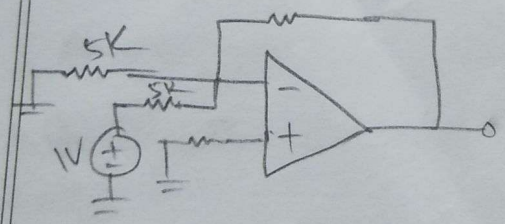


$$V_{o1} = -\frac{R_f}{R_1} \times V_{in}$$

$$= -\left(\frac{10K}{5K} \times 2\right) \cancel{V_{in}}$$

$$= -4V$$

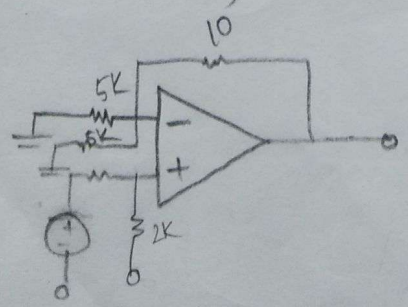
1V active.



$$V_{o2} = -\left(\frac{10K}{5K} \times 1\right) V$$

$$= -2V$$

5V active,



$$\cancel{V_{o3} = \left(1 + \frac{R_f}{R_1}\right) V_{in}}$$

$$\cancel{= \left(1 + \frac{10}{2}\right) \times 5}$$

$$\cancel{= 6 \times 5}$$

$$\cancel{= 30\,V}$$

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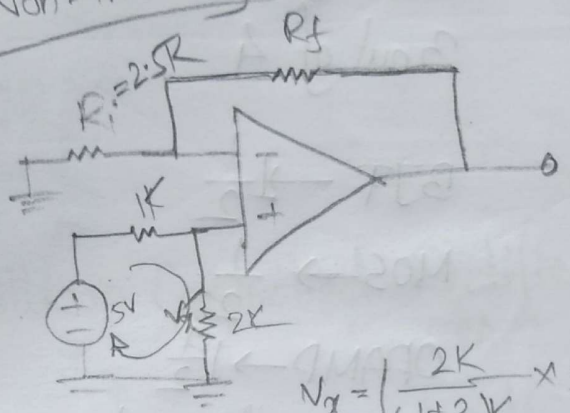
Non-inverting



$$V_o = \left(1 + \frac{R_f}{R_i}\right) \times V_x$$

$$= \left(1 + \frac{10K}{2.5K}\right) \times 3.33V$$

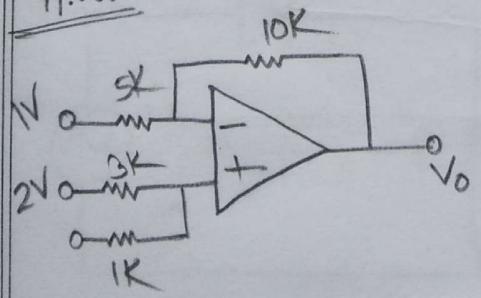
$$= (5 \times 3.33)V$$

$$V_x = \left(\frac{2K}{(1+2)K} \times 5\right) V$$

$$= 3.33V$$

$$V = V_{01} + V_{02} + V_{03}$$

H.W.



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PART - A

3 out of 4

1. a)

b.)

Semiconductor material

Diode, Model,

Clipper, Clamper,

Zener Diode, Rectifier

(BJT) → Theory

PART - B

3 out of 4

BJT → $1\frac{1}{2}$

MOS → $\frac{1}{2}$

OPAMP → $1\frac{1}{2}$

SCR+IC fab → $\frac{1}{2}$

Q

BJT → 2 set

OPAMP → 1 set

MOS → $\frac{1}{2}$ "

SCR+IC → $\frac{1}{2}$ "

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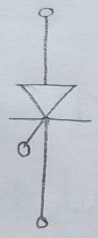
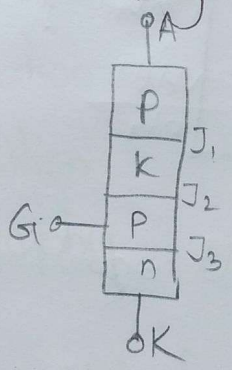
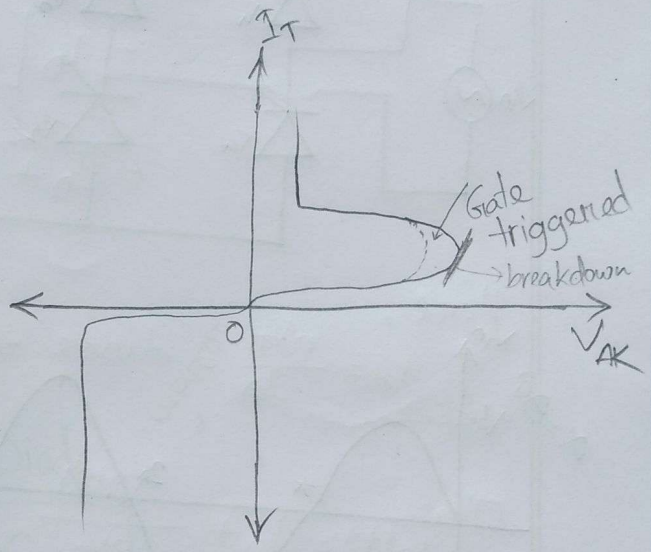
Thyristor

OR
SCR

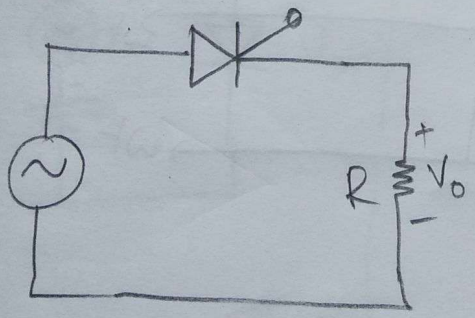
Sillicon Controlled Rectifier

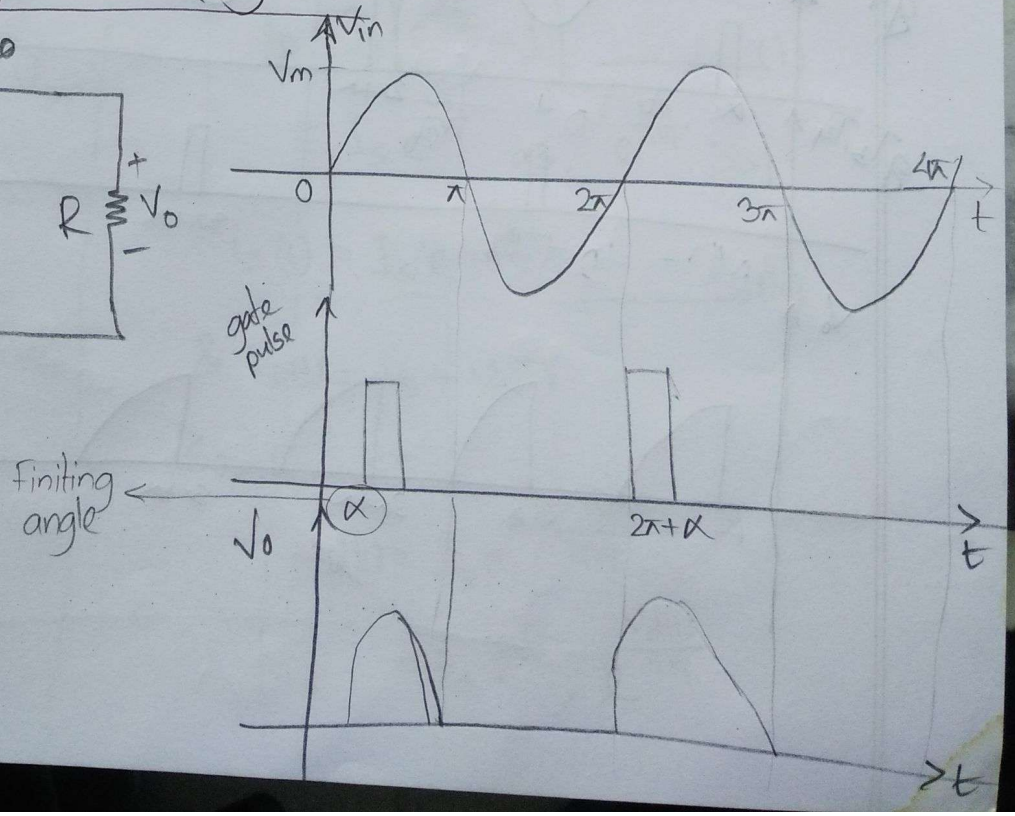






Controlled half wave Rectifier





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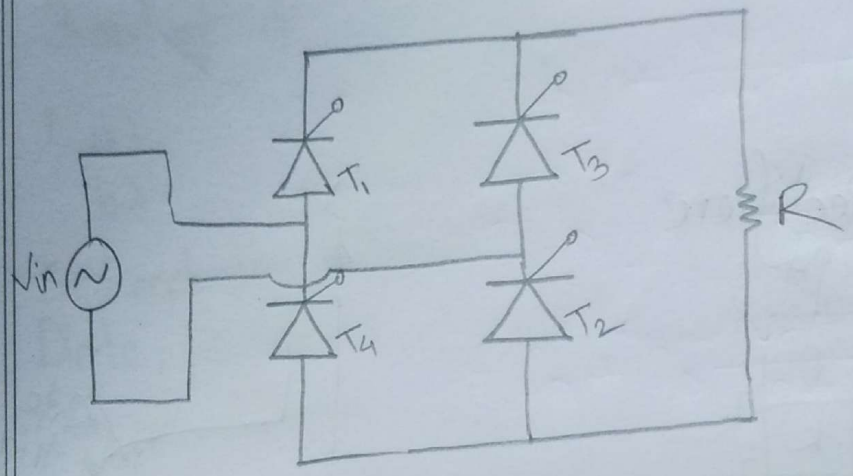
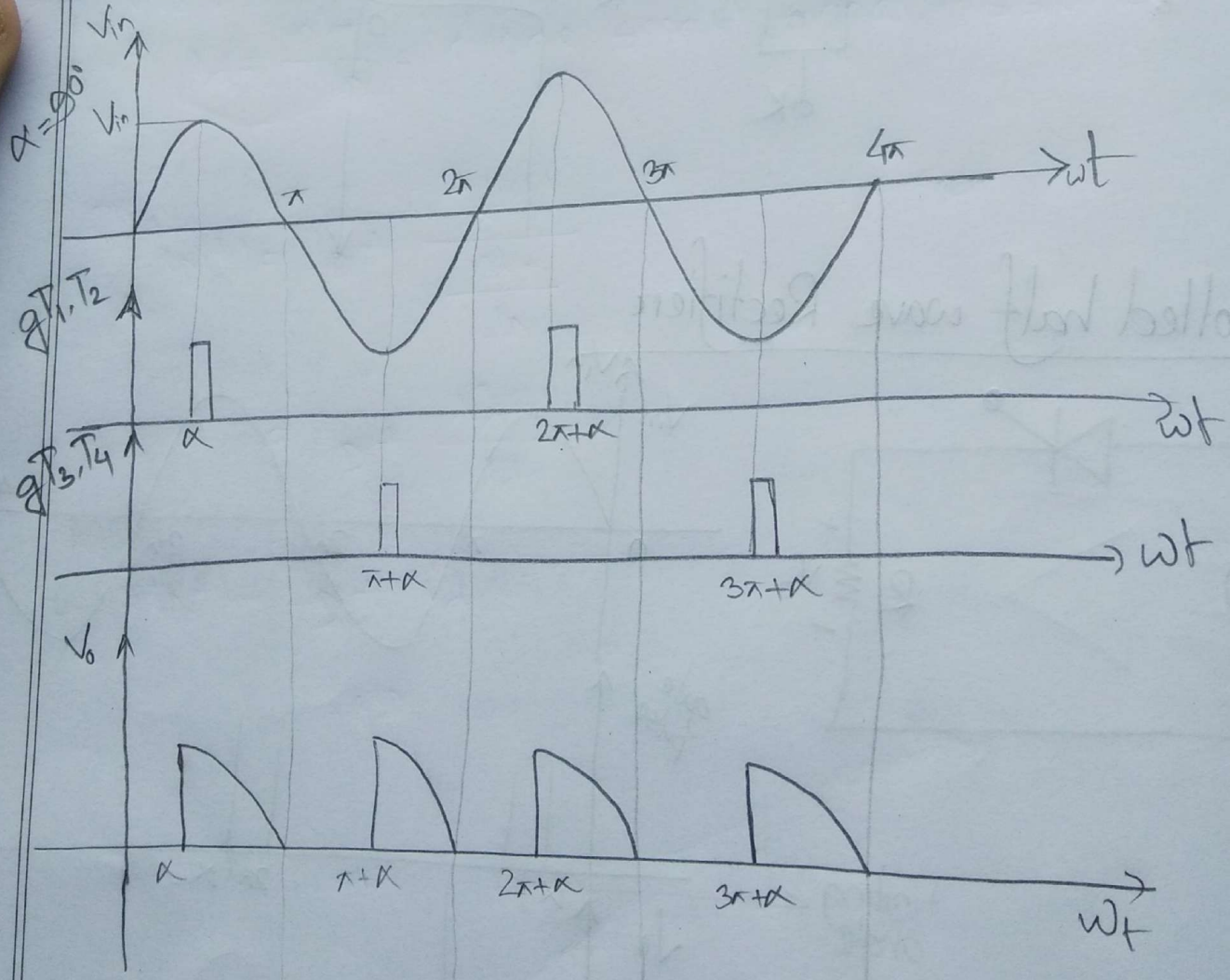
Controlled full wave rectifier:





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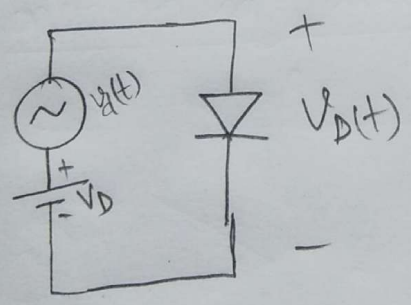
VLSI Fabrication

→ Water Preparation
→ Diffusion System
→ Ion implementation
→ Oxidation
→ Deposition
→ Lithography

Small Signal Model of a Diode



For DC,

$$I_D = I_s\left[e^{\frac{V_D}{nV_T}} - 1\right] \quad \text{——— (i)}$$

$$\cong I_s e^{\frac{V_D}{nV_T}} \quad \text{as, } e^{\frac{V_D}{nV_T}} \gg 1$$

$$i_D(t) = I_s e^{\frac{v_D(t)}{nV_T}} \quad \text{——— (ii)}$$

$$\& \; v_D(t) = V_D + v_d(t)$$

So, From (ii),

$$i_D(t) = I_s e^{\frac{[V_D + v_d(t)]}{nV_T}}$$

$$= I_s e^{\frac{V_D}{nV_T}} \cdot e^{\frac{v_d(t)}{nV_T}}$$

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$$i_D(t) = I_D\, e^{\frac{v_d(t)}{nV_T}}$$

$$= I_D\left[1 + \frac{v_d(t)}{nV_T} + \frac{\left[\frac{v_d(t)}{nV_T}\right]^2}{\lfloor 2} + \cdots\right]$$

$$= I_D\left[1 + \frac{v_d(t)}{nV_T}\right]$$

$$= I_D + I_D\frac{v_d(t)}{nV_T}$$

Here,

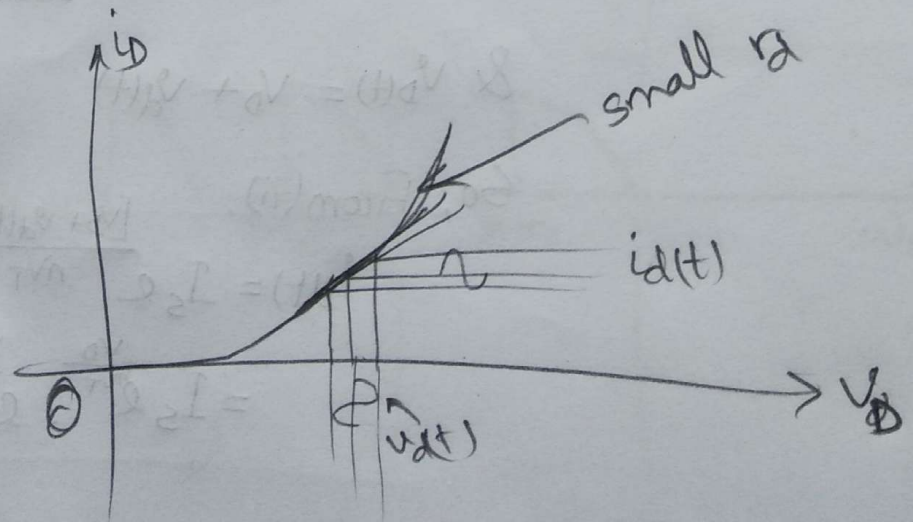
$r_d = \frac{nV_T}{I_D}$ = diode small signal resistance

or,

$$i_D(t) = I_D + \frac{v_d(t)}{\frac{nV_T}{I_D}}$$

$$= I_D + \frac{v_d(t)}{r_d}$$

$$i_D(t) = I_D + i_d(t)$$



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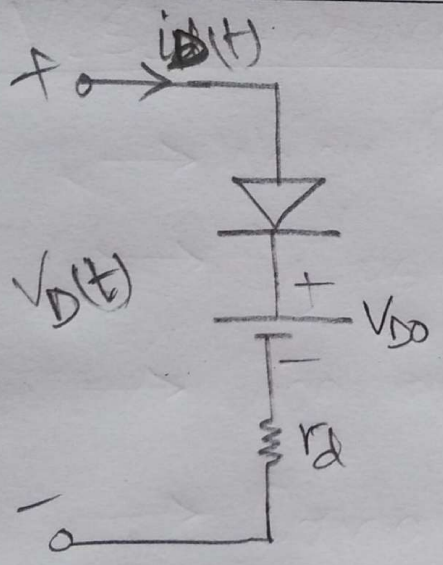

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