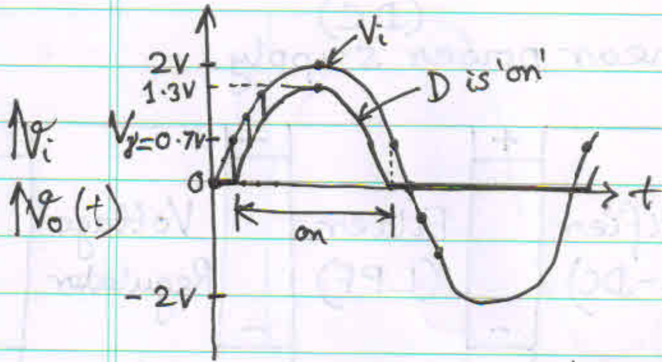
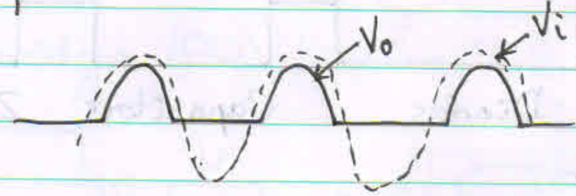
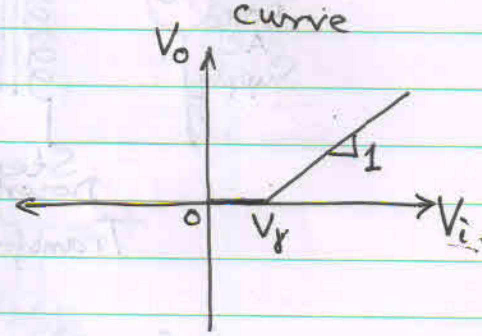


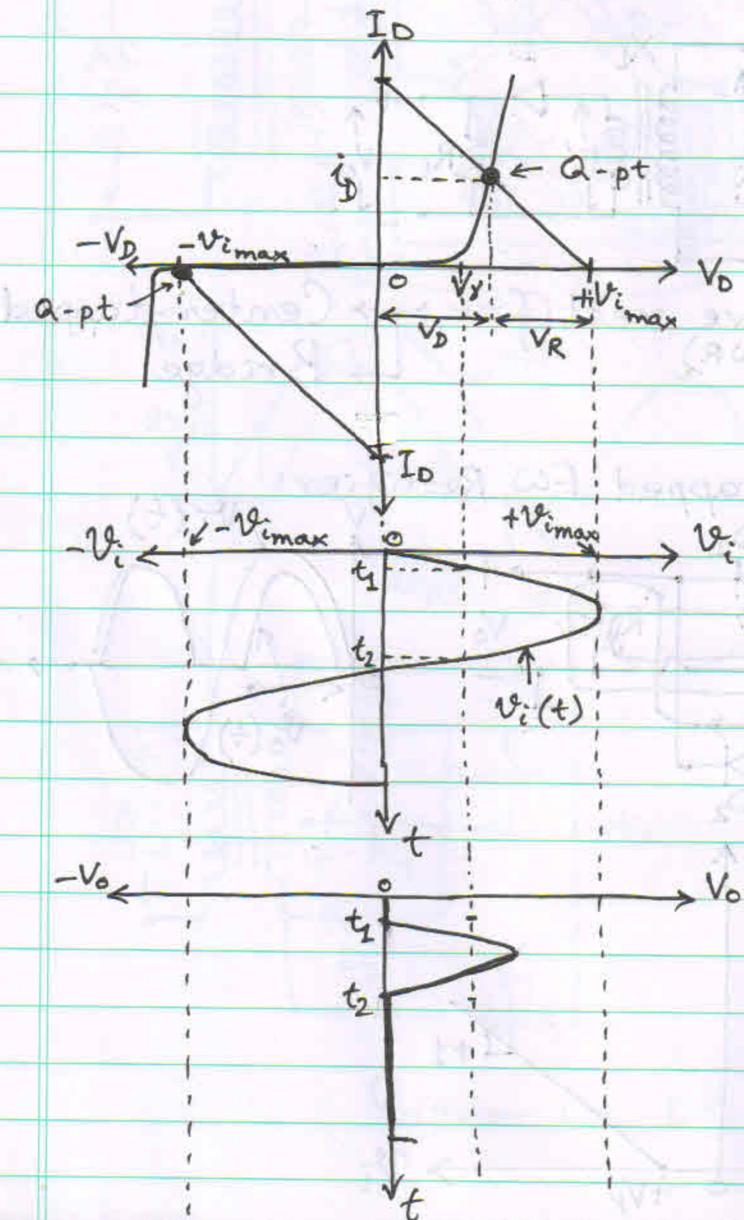
$$V_i = V_R + V_D \quad (V_R \rightarrow I_D \cdot R_D)$$

$$V_i = V_o + V_D$$



Transfer func^n curve

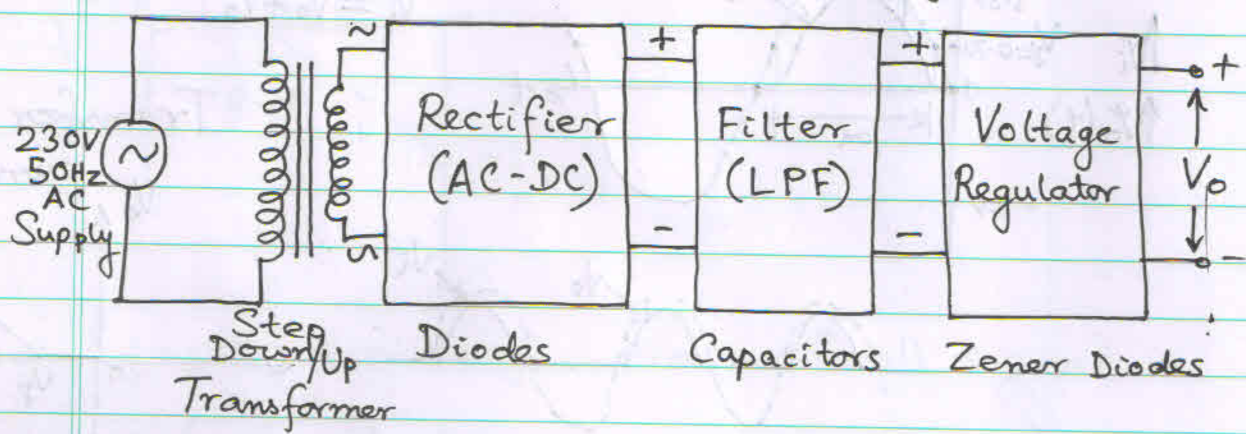




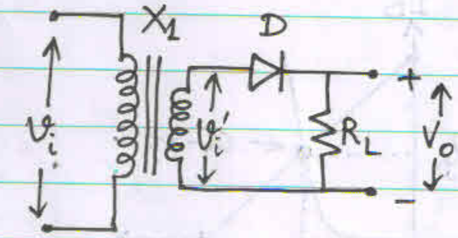
$$i_D(t) = \frac{v_i(t) - V_\gamma}{R_L}$$

$$v_o(t) = v_i(t) - V_\gamma$$

ii) A typical linear power supply: (DC)

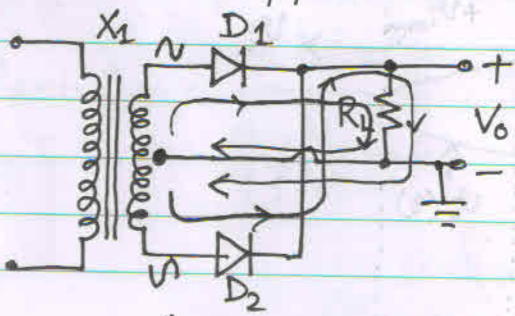


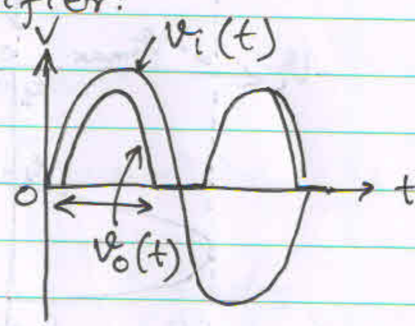
i) (cont.)

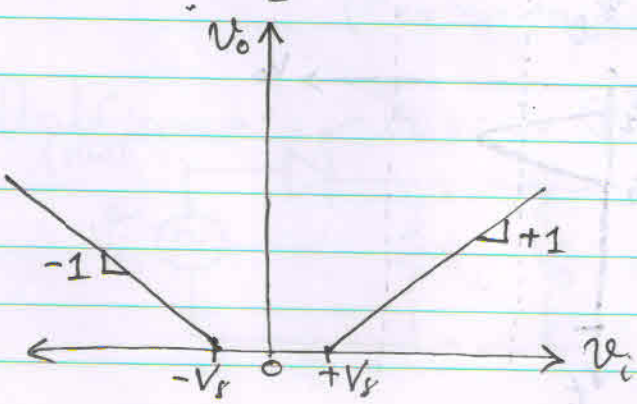


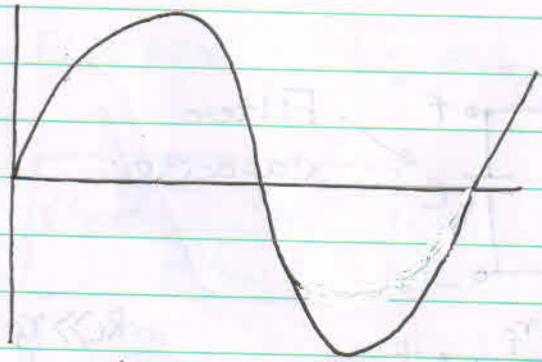
iii) Full-wave rectifier (FWR) → Center-tapped
→ Bridge

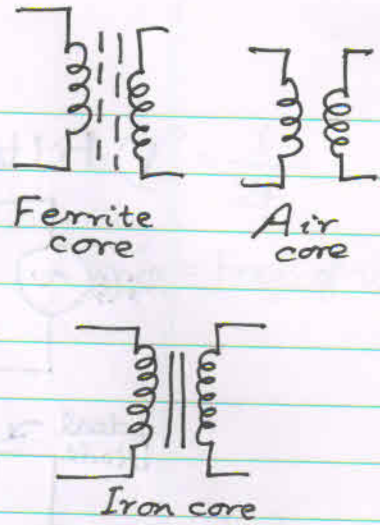
Center-tapped FW Rectifier:



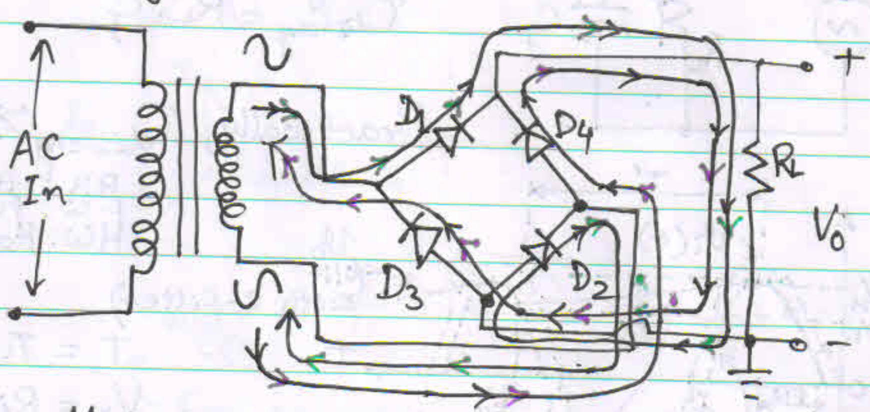


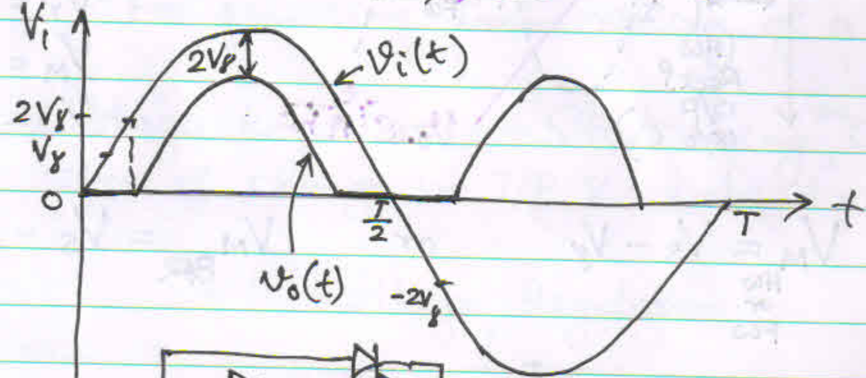


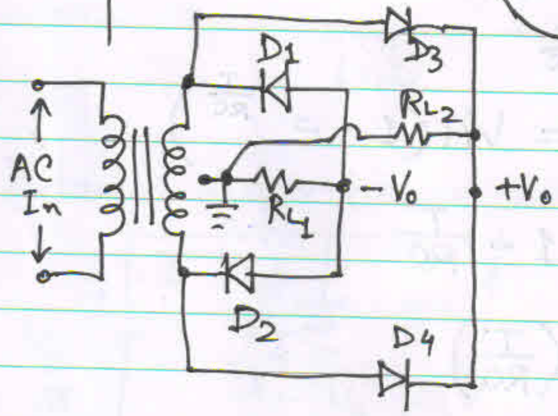


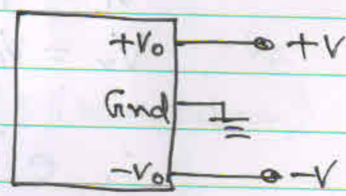


iv) Bridge (FW) Rectf.:



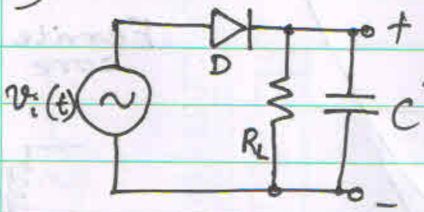




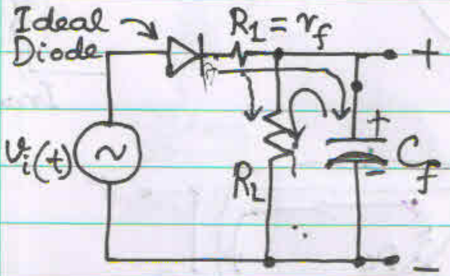


Bipolar Lin. DC. P.S.

V) Filters



Filter capacitor

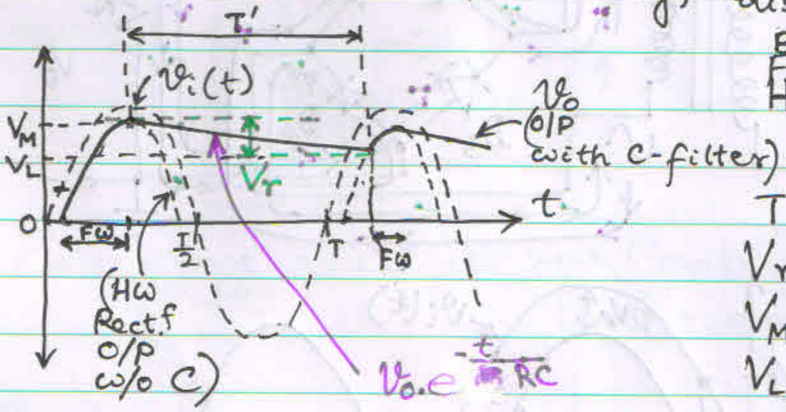


$R_L \gg r_f$

$\tau_{chg.} = R_1 \cdot C_f = r_f \cdot C_f$

$\tau_{dis\text{-}chg} = R_L \cdot C_f$

Practically, $\tau_{dis\text{-}chg} \gg \tau_{chg.}$



BR : Bridge
FW : Full-wave
HW : Half-wave

T = Time period of v_i

V_r = Ripple voltage

V_M = Max. load V

V_L = Min. load V

$V_{M_{HW \text{ or } FW}} = V_S - V_\gamma$ or $V_{M_{BR}} = V_S - 2V_\gamma$

$\boxed{\begin{matrix} R = R_L \\ C = C_f \end{matrix}}$

$V_L = V_M \cdot e^{-\frac{T}{RC}}$

$V_r = V_M - V_L = V_M\left(1 - e^{-\frac{T}{RC}}\right)$; $T' \ll R_L C_f$

$\therefore e^{-\frac{T'}{RC}} \approx 1 - \frac{T'}{RC}$

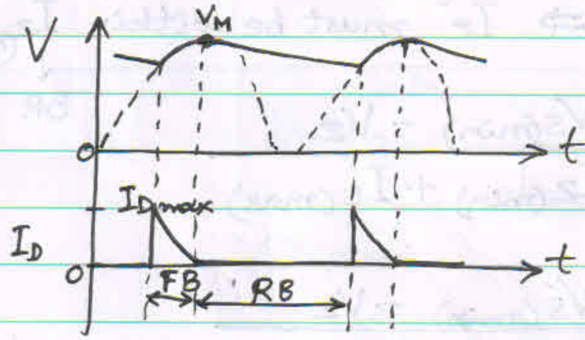
$\therefore V_r = V_M\left(\frac{T'}{RC}\right)$

Assuming, $T' \cong T$; $V_{r_{HW}} = V_M \cdot \left(\frac{T}{RC}\right)$

For, FW case, $V_{r_{FW}} = \dfrac{V_M}{2fRC}$; $\because T' = \dfrac{1}{2f}$

$f = \frac{1}{T}$ = Freq. of $v_i(t)$

$$\therefore \boxed{C_f \geq \frac{V_M}{2V_{r_{FW}} f \cdot R_L}}$$



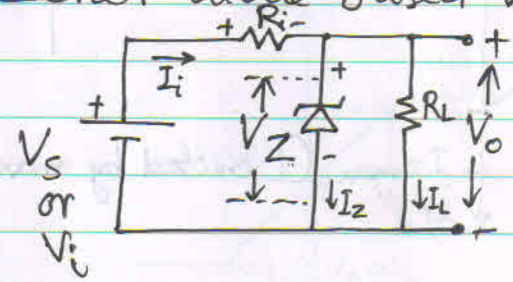
$$i_{D_{avg(FW)}} = \frac{1}{\pi}\sqrt{\left(\frac{2V_r}{V_M}\right)} \cdot \frac{V_M}{R}\left(1 + \frac{\pi}{2}\sqrt{\left(\frac{2V_M}{V_r}\right)}\right)$$

For selecting $I_{max.}$ rating of a diode.

vi) Voltage Regulator → Stabilizing an O/P V irrespective of change in I/P V or a load impedance.

Voltage Regulation → Line, Load

Zener diode based V-reg. → RB (break-down) ↙ V_Z



$$R_i = \frac{V_S - V_Z}{I_i} \; ; \; V_S > V_Z$$

$$= \frac{V_S - V_Z}{I_Z + I_L}$$

$$\therefore I_Z = \frac{V_S - V_Z}{R_i} - I_L \; ; \; I_Z \ll I_L$$

Also, $I_L = \frac{V_Z}{R_L} = \frac{V_0}{R_L}$

For a reliable V-reg operation, a zener diode must be operated in a break-down region, & power dissipation (average) must not exceed its rated value $\Rightarrow$ I_Z must be within $\underset{\downarrow \\ BR}{I_{Z(min)}}$ & $\underset{\downarrow \\ P}{I_{Z(max)}}$

$$\therefore \quad R_i = \frac{V_{S(min)} - V_Z}{I_{Z(min)} + I_{L(max)}}$$

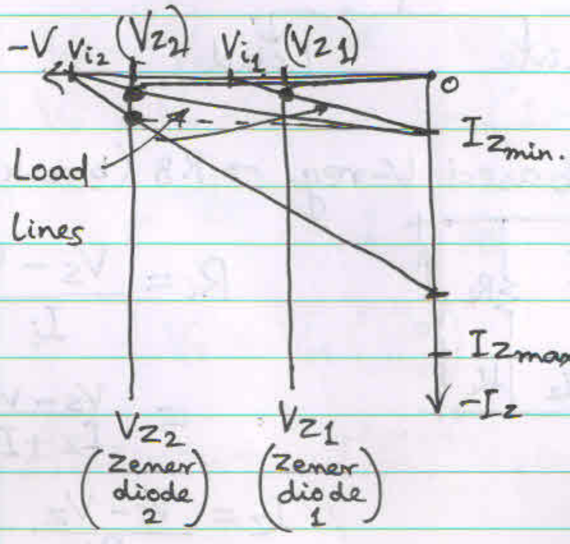
$$\& \quad R_i = \frac{V_{S(max)} - V_Z}{I_{Z(max)} + I_{L(min.)}}$$

By equating these eq^{n}s:-

$$I_{Z(max)} = \frac{I_{L(max)} \cdot [V_{S(max.)} - V_Z] - I_{L\,min.} \cdot [V_{S(min)} - V_Z]}{V_{S(min)} - 0.9\,V_Z - 0.1\,V_{S(max.)}}$$

&, Power dissipation across a zener diode:

$$P_{Z(max.)} = I_{Z(max.)} \cdot V_Z$$



$$\text{Line/source regulation} = \frac{\Delta v_L}{\Delta v_s} \times 100\%$$

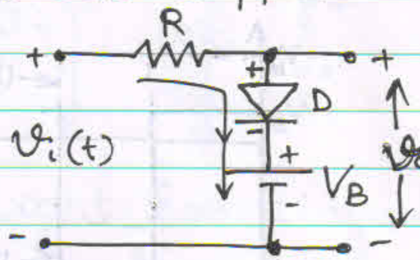
$$\text{Load regulation} = \frac{v_{L(\text{no-load})} - v_{L(\text{full-load})}}{v_{L(\text{full-load})}} \times 100$$

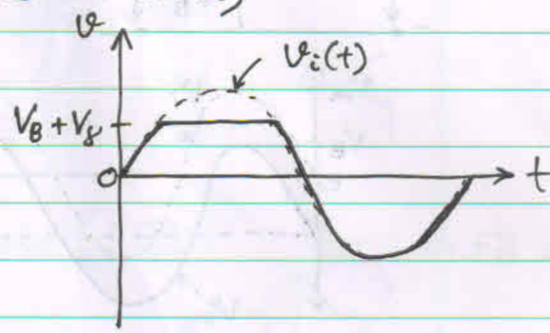
Voltage Limiter Circuits

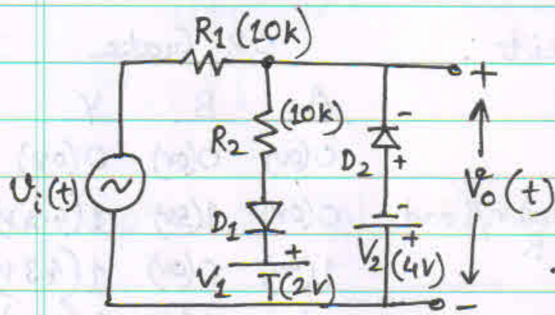
→ AC

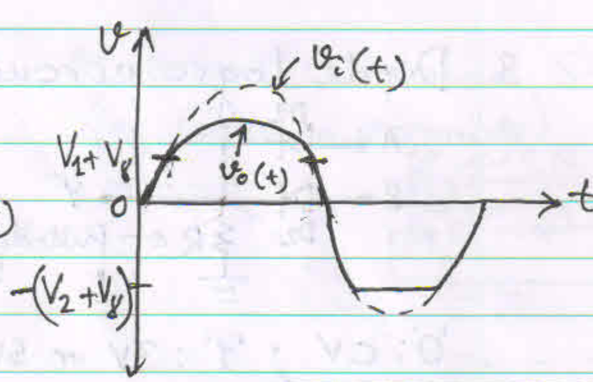
- Clipper (Series & Parallel)
- Clamper

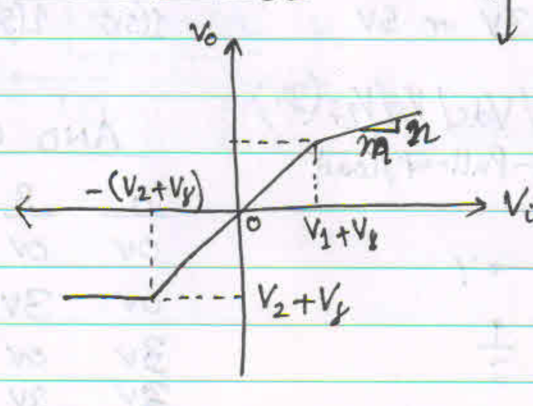
1) Diode Clipper:

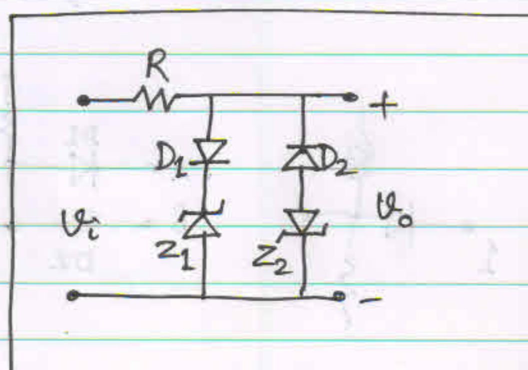




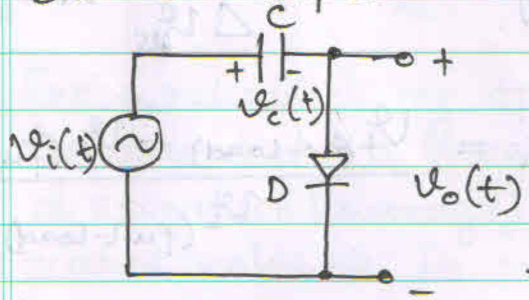




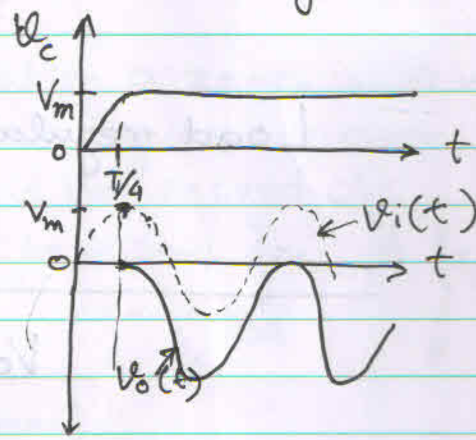


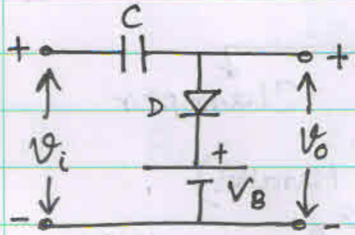


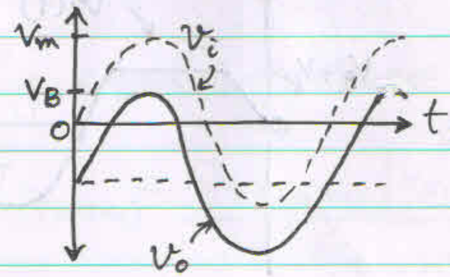
2. Diode clamper → Shifts entire signal.

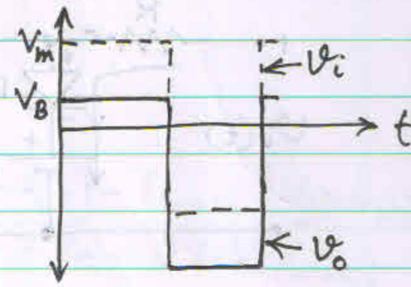


⇒

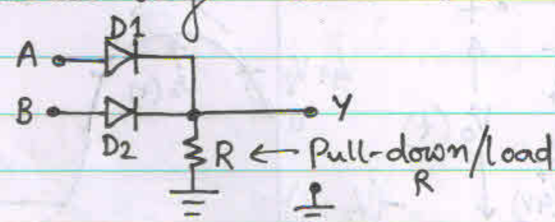








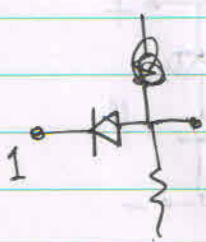
3. Diode logic circuit :

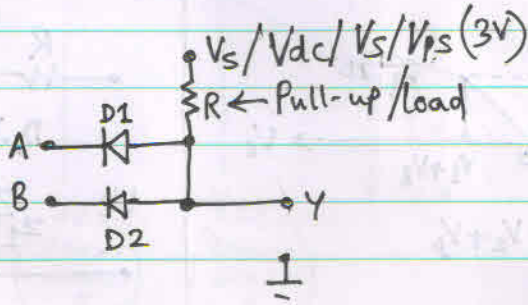


OR Gate

A	B	Y
0(0V)	0(0V)	0(0V)
0(0V)	1(5V)	1(4.3V)
1(5V)	0(0V)	1(4.3V)
1(5V)	1(5V)	1(4.3V)

'0': 0V ; '1' : 3V or 5V





AND Gate

A	B	Y
0V	0V	0.7V
0V	3V	0.7V
3V	0V	0.7V
3V	3V	3V

Photo-diode

4. Diode as a light sensor: 

Photons supplied at a p-n junction (RB) causes generation of excess e^- & h^+. An applied E-field utilizes such carriers & contributes to an increased RB leakage I (also known as photo-current)

$$I_p = \eta\, e\, \phi\, A$$

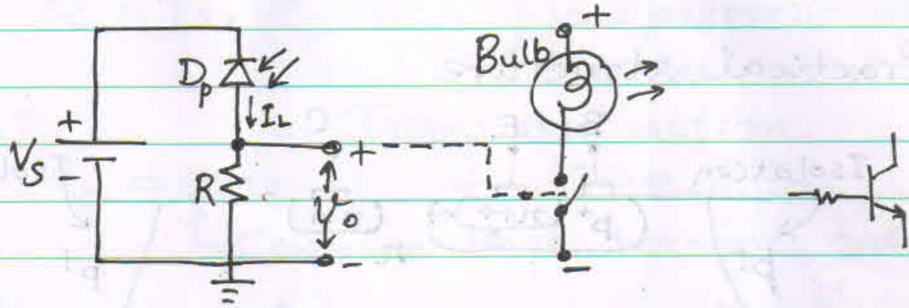
Photo-current

Quantum efficiency

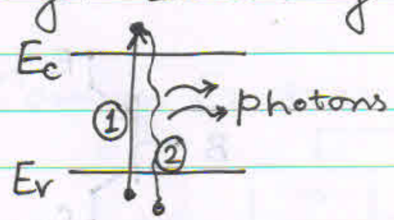
Charge of an electron

Photon flux density ($/cm^2$-s)

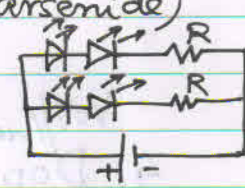
Junction area



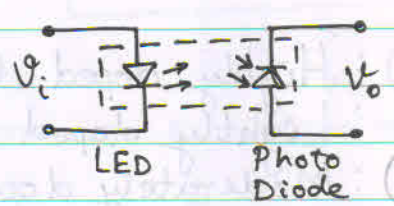
5. Light Emitting Diode (LED) : Used in FB only



Material: Compound S-C. (e.g. Gallium arsenide)

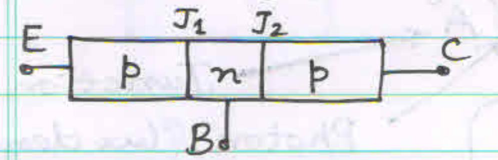


6. Opto-coupler/isolator:

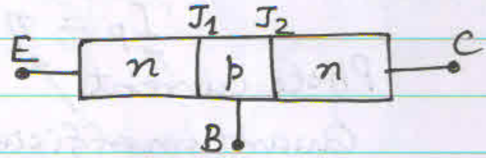


Bipolar Junction Transistor (BJT)

1. Transistor: Transfer of resistance (I/P to O/P).
   - → 3 terminals (Emitter, Base & Collector)
     (E) (B) (C)
   - → 2-junctions (J_1 & J_2)

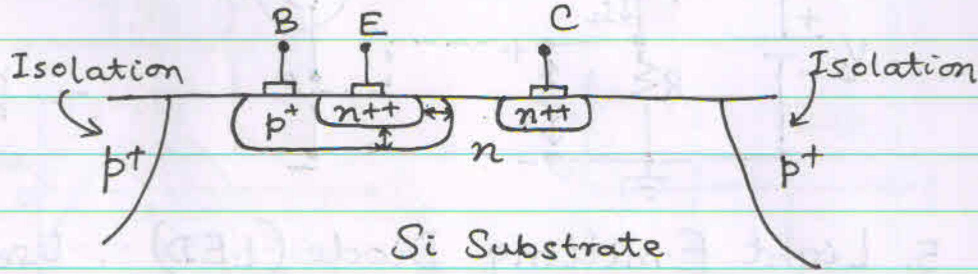


pnp transistor

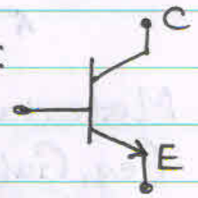


npn transistor

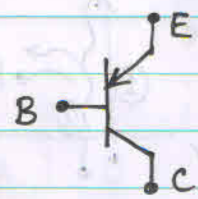
2. Practical structure



3. Symbols:



npn



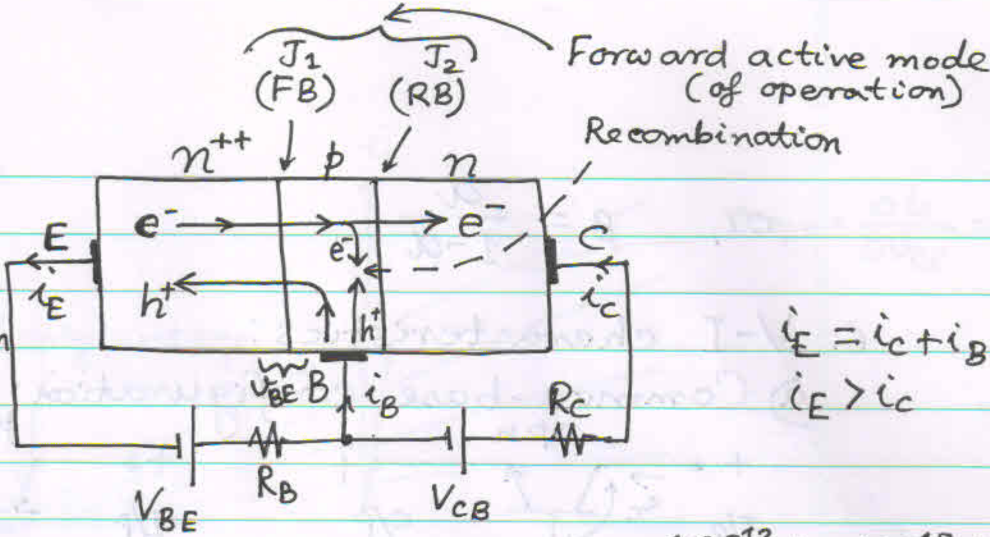
pnp

Vol./Area &

4. Doping profile:
   (Medium) Emitter (E): Highly doped (10^{19})
   (Largest) Collector (C): Lightly doped (10^{15})
   (Smallest) Base (B): Moderately doped (10^{17})
   } cm^{-3}

5. Transistor currents (BJT): Both e^- & h^+ are responsible (bipolar).

→ Common Base Configuration



$i_E = i_C + i_B$

$i_E > i_C$

$$i_E = I_{EO}\left[e^{\frac{v_{BE}}{V_T}} - 1\right] \cong I_{EO}.e^{\frac{v_{BE}}{V_T}}$$

10^{-12} to 10^{-15} A

$$i_C = I_S.\, e^{\frac{v_{BE}}{V_T}}$$

i_C is proportional to $e^{\frac{v_{BE}}{V_T}}$ & independent of RB B-C V.

Transistor action.

$i_C = \alpha . i_E$ & $I_S = \alpha . I_{EO}$

Common-base current gain ($\leqslant 1$)

$$i_B \propto e^{\frac{v_{BE}}{V_T}}$$