HVDC

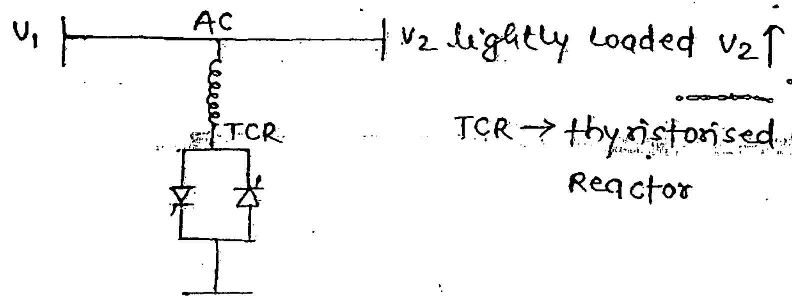
* We can Xmit the power by using EHVAC (or) HVDC.

Features of AC lines:-

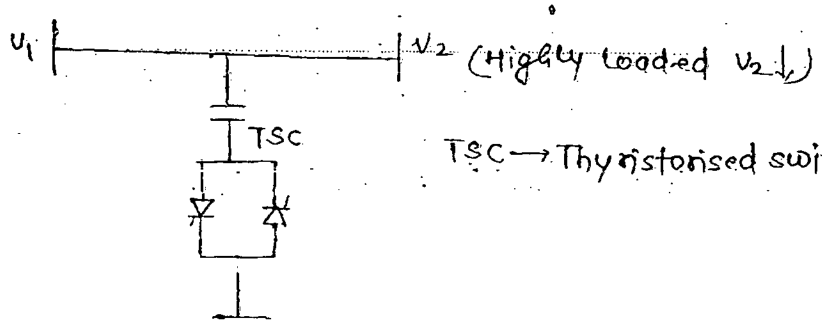
(1) The power flow magnitude & dirⁿ can't be quickly & easily control.

(2) The transient stability limit is lesser in the AC line when compared with dc line.

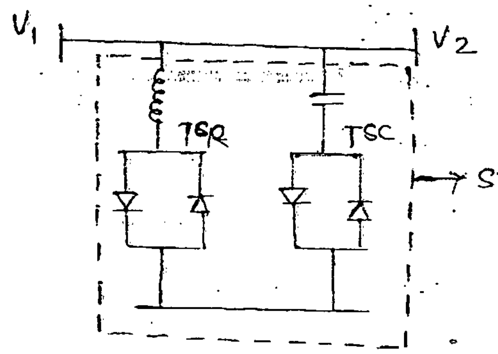
(3) The other prob. associated with AC lines are skin effect, corona losses, radio & T.V interference b/n the comm. lines & power lines.



TCR → thyristorised Control Reactor

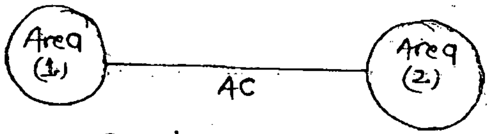


TSC → Thyristorised switch capacitance

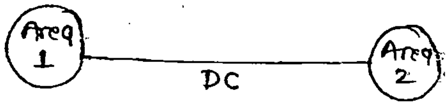


→ SVC (Static vars Compensating)

(4) Intermediate substation are installed in the ac line to compensate the reactive power automatically as per the requirement of the line.



Synchronous tie [Frequencies must be same]



Asynchronous tie [freq. need not be same].

(5) The sys. disturbance in one of area results in power swings. If the power swings are unstable then it may lead to cascading of tripping the alternators & this results in large scale blackouts.

(6.) With ac interconnection the freq. disturbance in one area is transfered to other area.

(7.) If multiple no. of areas is interconnected by ac line then the fault level of the system increases.

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★ HVDC → It is economical to Xmit bulk power over long distance.

Advantages →

(1.) The power flow magnitude & dirn can be quickly & easily controlled.

(2.) The transient stability limit is improved in the dc line.

(3.) There is no skineffect prob. in the dc line.

(4.) The other prob. likes corona losses, radio & tv interfererance is very much reduced in the dc lines.

(5.) HVDC is used for underground or submarine cables even for short distance (because dc cables will not charge contineously)

(6.) HVDC can utilised earth for its return path.

(7.) The power x^n capacity of a bipolar HVDC line is almost same as that of 3ϕ single ckt ac line.

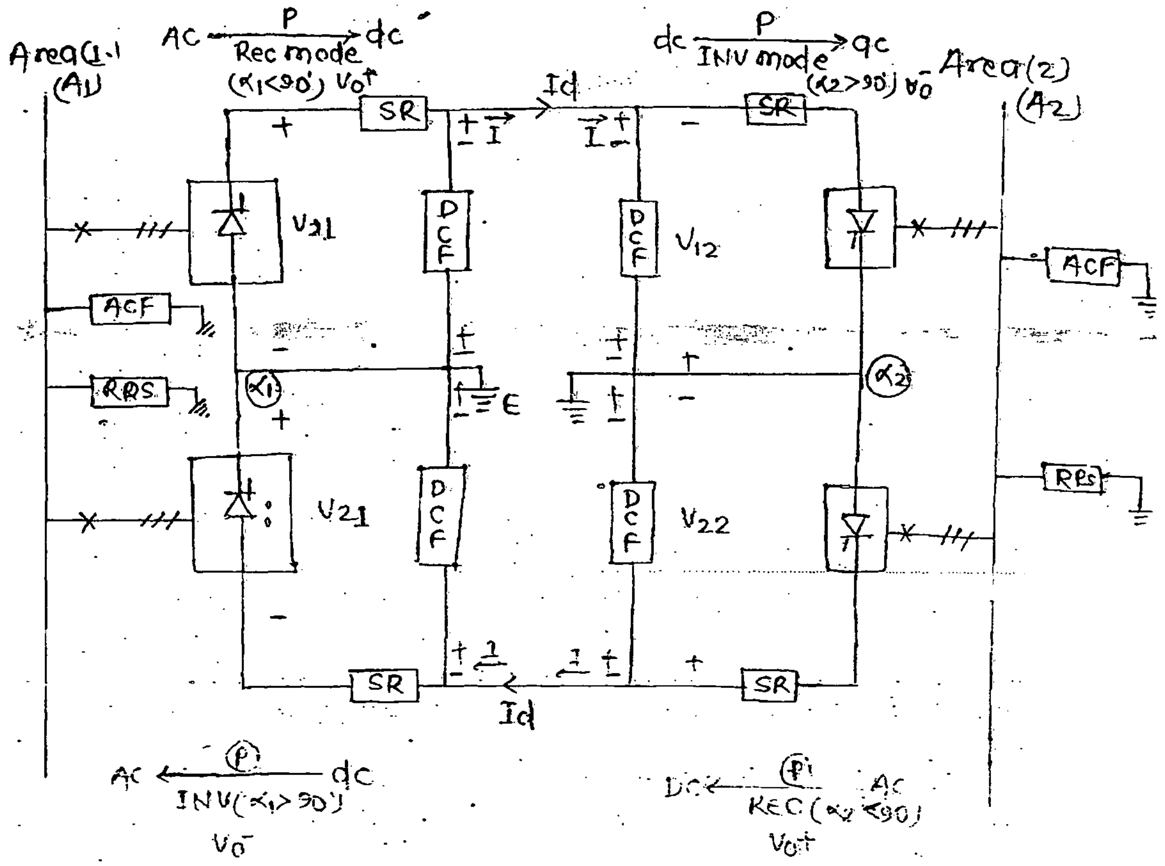
(8.) We can interconnect 2 independant areas at different freq. because it is an asynchronous type.

(9.) With dc interconnection the freq. disturbance in one area can't be Xfered to other area.

(10) If multiple no. of areas are interconnected with dc line then the fault level of the sys. will not be subtansily increased.

Type of HVDC →

(1) Bipolar HVDC →



SR → Smoothning Reactor

DCF → DC Filter

ACF → AC Filter

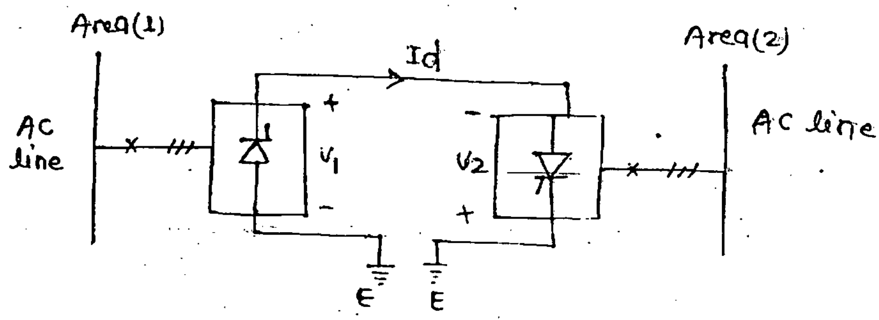
RPS → Reactive power source (To compensate the required Power for converter operation)

{± Ref

{± Actual ($A_1 \xrightarrow{P} A_2$)

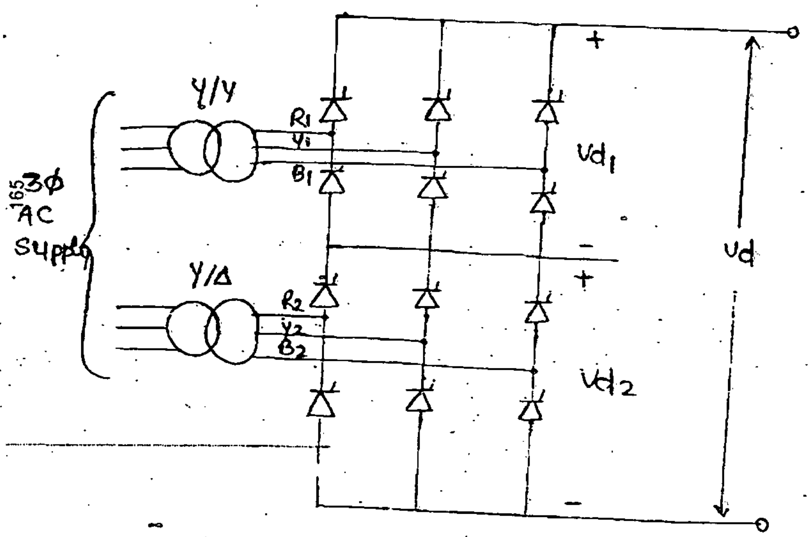
{± Actual ($A_1 \xleftarrow{P} A_2$)

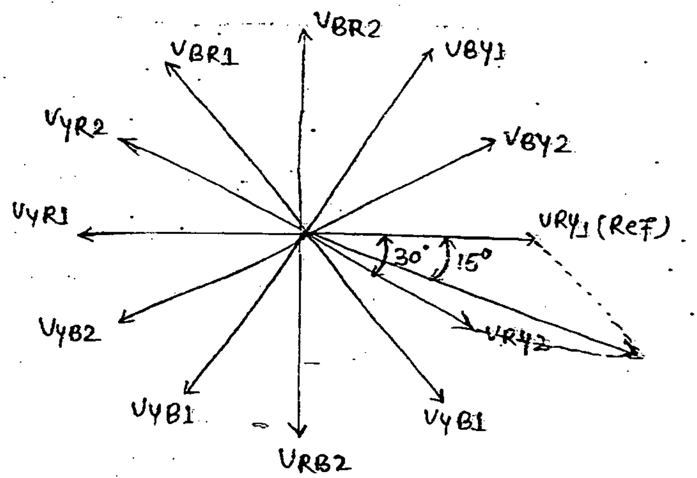
(2) Monopolar HVDC →

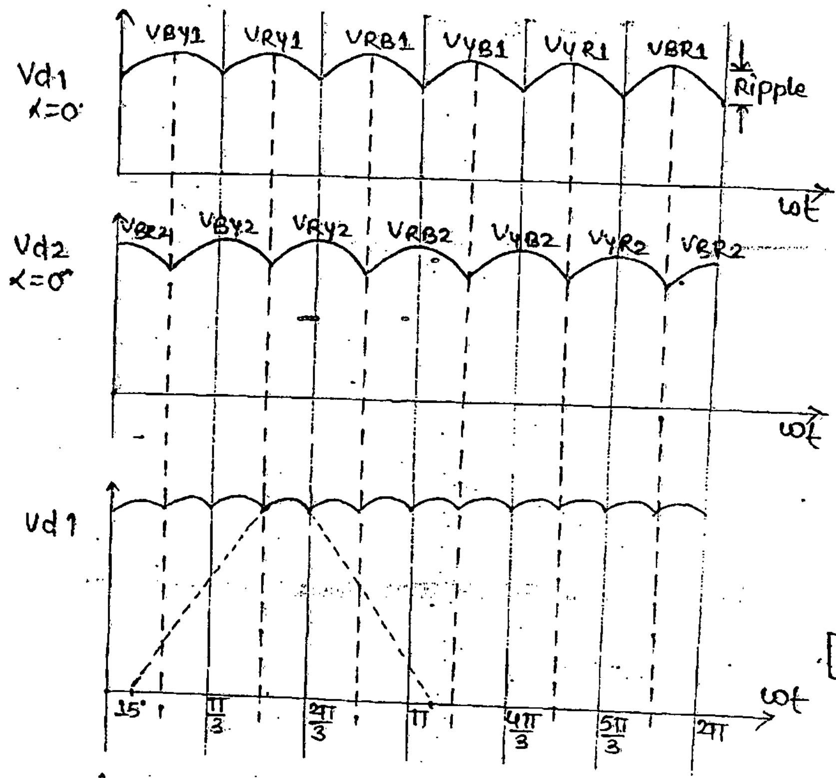


* In order to reduce the harmonics the 6 pulse conr is replaced by the 12 pulse conr.

12 pulse Converter →







$V_{RY1} = V_{m1}\sin\omega t$

$V_{RY2} = V_{m1}\sin(\omega t - 30°)$

$V_d = V_{RY1} + V_{RY2}$

$V_d = V_m[\sin\omega t + \sin(\omega t - 30)]$

$= V_{m1} \cdot 2\sin(\omega t - 15) \cos 15$

$\boxed{V_d = 1.93 V_{m1} \sin(\omega t - 15)}$

Harmonics on Ac side →

Harmonics on Ac side of m pulse conv^r (I_s) → $mk \pm 1$

Harmonics on Ac side of 2 pulse conv^r (I_s) → $2k \pm 1 = 3, 5, 7, 9 \ldots$

6 pulse conv^r (I_s) → $6k \pm 1 = 5, 7, 11, 13 \ldots$

12 pulse con^r (I_s) → $12k \pm 1 = 11, 13, 23, 25.$

Harmonics on dc side →

Harmonics on dc side of m puls con^r (V_o) = mk

2 pulse con^r (V_o) = $2k$

6 pulse con^r (V_o) = $6k$

12 pulse con^r (V_o) = $12k$

(11/57) $\frac{V}{F}$ control of IM

$N_s = \frac{120 f}{P} = \frac{120 \times 50}{2} = 3000 \text{rpm}$

$s_r = \frac{N_s - N_r}{N_s} = \frac{3000 - 2850}{3000} = 0.05$

[redacted] For 40Hz

$$N_s = \frac{120f}{P} = \frac{120 \times 40}{2} = 2400$$

$$\frac{1}{2} s_r = \frac{N_s - N_r}{N_s}$$

$$\frac{0.05}{2} = \frac{2400 - N_r}{2400}$$

$$\boxed{N_r = 2340\,rpm}$$

(14/58)

$V_o = E_b + (I_o R_a) \rightarrow$ Neglected

$\because E_b \propto N$

It half the rated speed

$$\frac{N}{2} \propto \frac{E}{2} \propto \frac{440}{2} = 220$$

$$\frac{3V_{ml}}{\pi} \cos\alpha = 220$$

$$\frac{3 \times 440\sqrt{2} \cos\alpha}{\pi} = 220$$

$$PF = \frac{3}{\pi} \cos\alpha = \frac{1}{2\sqrt{2}}$$

~~$\alpha = 0.354$~~ ; $\boxed{\frac{3}{\pi} \cos\alpha = 0.354}$

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(15/58) $\alpha \downarrow, V_o \uparrow, \omega \uparrow$

(16/58)

Regenerated Power $= V_o \cdot I_o$

$= V_s (1 - \alpha) I_o$

$= 600 (1 - 0.7) 100$

$= 18\,kW$

{ Because Regenerative braking is done only in Boost conr. Hence $V_0 = V$.

Inverter Question

(1/49)

$2d = 120^\circ$

$d = 60^\circ$

$V_{on} = \frac{2\sqrt{2}}{n\pi} \sin nd \; V_s$

$V_{o1} = \frac{2\sqrt{2}}{\pi} \sin d . V_s$

$= \frac{2\sqrt{2}}{\pi} . 1 . \sin d$

$= 0.78V$

(4/49)

$\frac{V_{o3}}{(V_{o1})_{max}} = \frac{\frac{2\sqrt{2}}{3\pi} V_s \sin 3d}{\frac{2\sqrt{2}}{\pi} V_s}$

$= \frac{\sin 3d}{3} = 19.6\%$

(5/49)

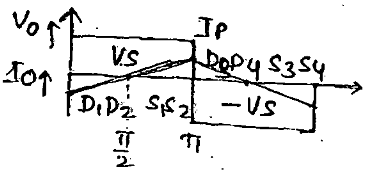
$g = \frac{2\sqrt{2} \sin d}{\sqrt{(2d)\pi}}$; $2d = 150 = \frac{5\pi}{6}$ rad

$d = 75$

$g = \frac{2\sqrt{2} . \sin 75}{\sqrt{\frac{5\pi}{6} . \pi}}$ $g = 0.95$

THD = 31.8%

(7/50)



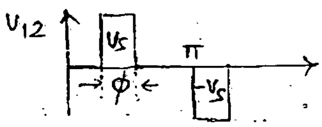
$\pi/2$ to π ; $S_1S_2 \to ON$, $V_o = V_s$

$L\frac{di}{dt} = V_s$; $\int_0^{I_p} di = \frac{V_s}{\omega L} \int_{\pi/2}^{\pi} d(\omega t)$

$I_p = \frac{V_s}{\omega L} . \frac{\pi}{2} = \frac{V_s}{4fL} = 10A$

(11/50)

$V_{12} = V_1 - V_2$



$V_{12} = V_s \left(\frac{\phi}{\pi}\right)^{1/2}$

(12/50)

$|Z_n| = X_{Ln} = n\omega L$

$V_{on} = K_n . V_{o1}$ $(K_n < 1)$

$I_{on} = \frac{V_{on}}{|Z_n|} = \frac{K_n V_{o1}}{n . \omega L} = \frac{K_n}{n} . I_{o1}$

(13/51)

$D \to \phi = \tan^{-1} \frac{X_L - X_C}{R}$

$= \tan^{-1}\left(\frac{X_L - 0}{0}\right) = 90'$

$\omega t = \pi/2$ rad

$t = \pi/2\omega$ rad $= \frac{1}{4f}$ sec

$t = 5ms$

conv. (1.) →

(1.) RLC ; $\omega t_c = \phi = \tan^{-1} \frac{X_C - X_L}{R}$; $\omega = \frac{2\pi}{T} = \frac{2\pi}{0.2 \times 10^{-3}}$

$\tan(\omega t_c) = \frac{X_C - X_L}{R}$ $t_c = (SF) t_q$

$= 2.(12) \times 10^{-6}$

$\tan\left[\frac{2\pi}{0.2 \times 10^{-3}} \times 24 \times 10^{-6} \times \left(\frac{180}{\pi}\right)\right] = \frac{X_C - 12}{3}$ $= 24 \times 10^{-6}$

$X_C = 14.7\Omega$, $\frac{1}{\omega C} = 14.7$

$C = 2.15 \mu F$