Module 3

14/3/22

Power factor $= \dfrac{\text{Active Power}}{\text{Apparent Power}} = \dfrac{VI\cos\phi}{VI}$

Assumption: V & I are purely sinusoidal.

In power electronics, due to presence of filters - even in R ckt, pf $\neq 1$.

We redefine power factor as.

$$p(t) = v(t).i(t)$$

$$v(t) = V_m \sin\omega t \qquad i(t) = \sum_n I_n \sin(n\omega t + \theta_n)$$

$$p(t) = V_m \sin\omega t \times \sum_n I_n \sin(n\omega t + \theta_n)$$

$$= V_m \left[\sum I_n \sin\omega t \sin n\omega t \cos\theta_n + \sum_n I_n \sin\omega t \cos n\omega t \sin\theta_n\right]$$

~~Cons~~

* Consider $n=1$ & take average value

$$p(t) = V_m \left[\frac{1}{2\pi}\int_0^{2\pi} I_1 \sin^2\omega t \cos\theta_1)\, d\omega t + \frac{1}{2\pi}\int_0^{2\pi} I_1 \sin\omega t \cos\omega t \sin\theta_1\, d(\omega t)\right]$$

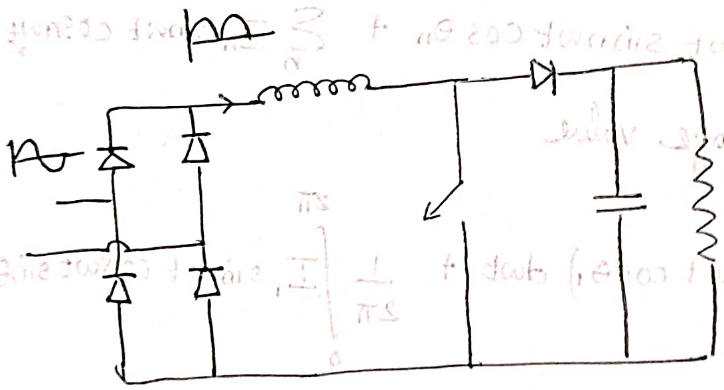
$$= V_m\left[\frac{I_1}{2\pi}\left[\int \frac{\cos 2\omega t - 1}{2}\right]_0^{2\pi} \cos\theta_1 + \frac{I_1}{2\pi}\left[\int \frac{\sin 2\omega t}{2}\right]_0^{2\pi} \sin\theta_1\right]$$

$$= \frac{V_m I_1}{2\pi}$$

$$= \frac{V_m I_1}{2}\left[\cos\theta_1\right] = \frac{V_m}{\sqrt{2}}\frac{I_1}{\sqrt{2}}\cos\theta_1$$

$$PF = \frac{V_{m(rms)}\, I_{1(rms)} \cos\theta_1}{V_{m(rms)}\, I_{(rms)}} = \underbrace{\frac{I_{1(rms)}}{I_{(rms)}}}_{\text{Distortion factor}} \underbrace{\cos\theta_1}_{\text{displacement factor}}$$

$\therefore$ PF = Distortion factor × Displacement factor.



Boost power factor correction of ckt.

functions: 1) Shaping of current - reduce distortion.

2) V_{dc} controll

$$P(t) \Rightarrow V_m I_1 \cos\theta_1 \sin^2 \omega t$$

$$\Rightarrow V_m I_1 \cos\theta_1 \left[\frac{1 - \cos 2\omega t}{2} \right]$$

$$= \underbrace{\frac{V_m I_1 \cos\theta_1}{2}}_{\text{Avg power}} - \underbrace{\frac{V_m I_1 \cos\theta_1}{2} \cos 2\omega t}_{\text{Ripple in power}}$$

For single phase 100Hz so large value capacitance required.

Capacitor has to handle $V_{dc} \times I_{ripple} = \frac{V_m I_1 \cos\theta_1}{2} \cos 2\omega t$

$$\therefore I_{ripple} = \frac{V_m I_1}{2 V_{dc}} \cos\theta_1 \cos 2\omega t$$

ripple in voltage $= \Delta V_{dc} = \frac{1}{C\omega} \int_0^{2\pi} I_{ripple} \, d(\omega t)$

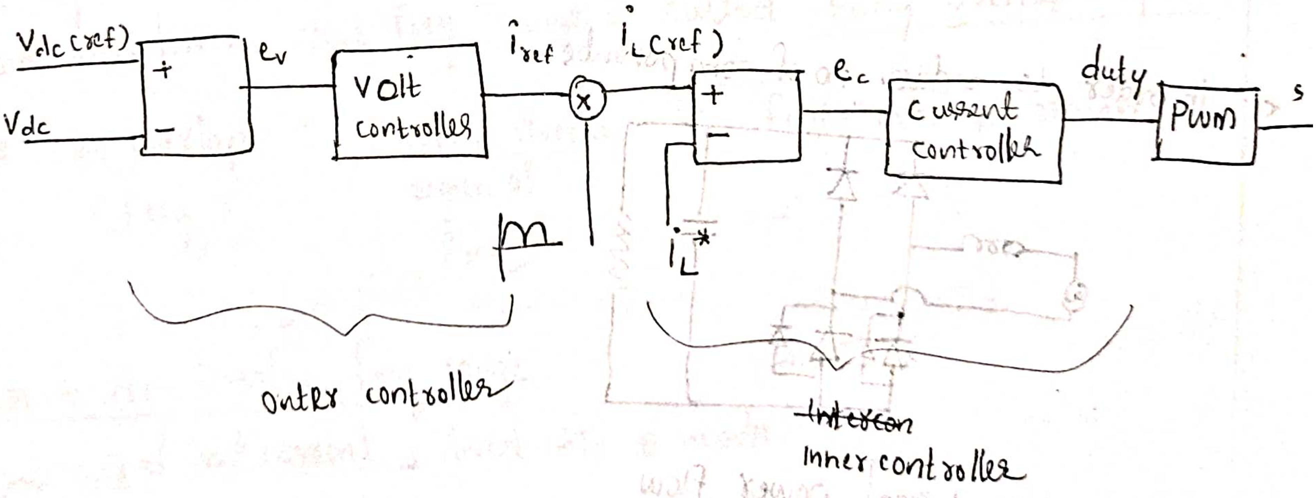
$$= \frac{1}{C\omega} \left[\frac{V_m I_1 \cos\theta_1}{2 V_{dc}} \right] \left[\frac{\sin 2\omega t}{2} \right]$$

Ripple in voltage, maximum

$$\boxed{\Delta V_{d\,max} = \frac{1}{4C\omega} \times \frac{V_m I_1 \cos\theta_1}{V_{dc}}}$$

$$\boxed{C \geq \frac{V_m I_1 \cos\theta_1}{4 \omega \, \Delta V_{dc(max)} \cdot V_{dc}}}$$

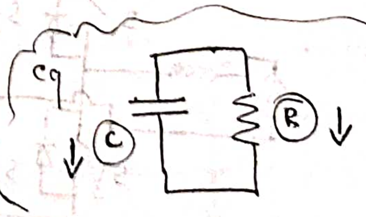
15/3/22 Controller Design for Boost pf correction ckt



* We need inner controller faster than outer controller

For that we need ~~lower~~ larger Bandwidth.

* We keep $BW = \frac{1}{10}$ " switching freq

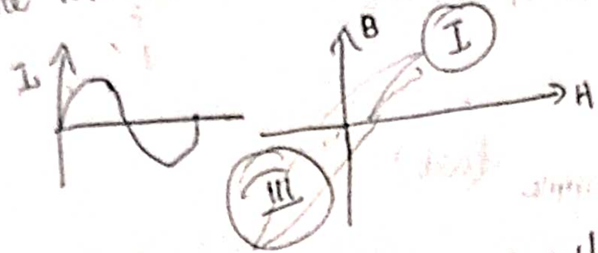


Low time const $= \frac{1}{RC}$

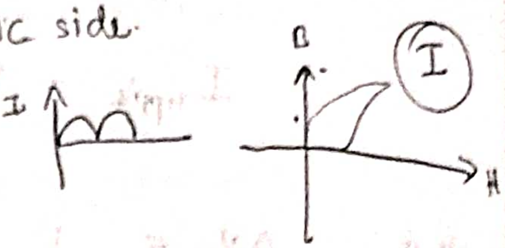
for faster response

$BW = \frac{1}{\text{time const}}$

* Inductor in AC side is preferred than, inductor in DC side
  - since low size ~~AC side~~ is required for AC side.

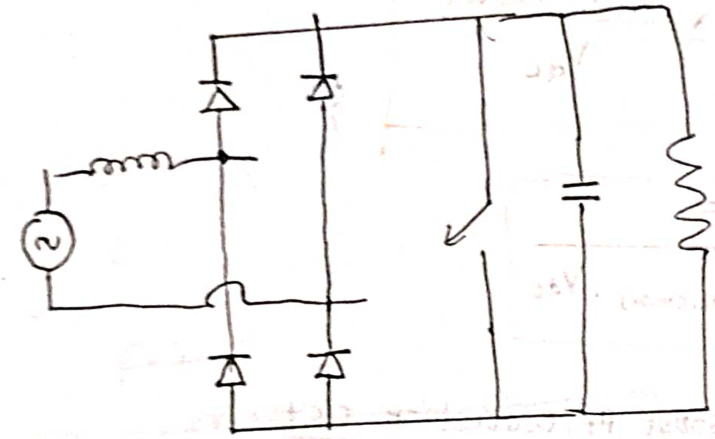


Does not go to saturation so easily

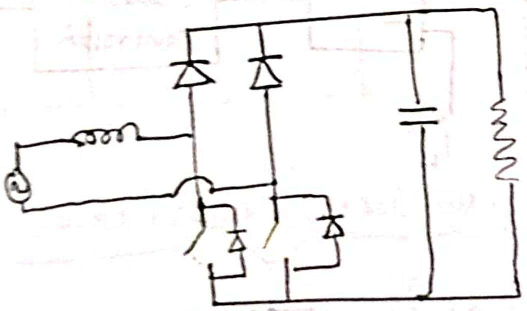


Close to saturation easily.

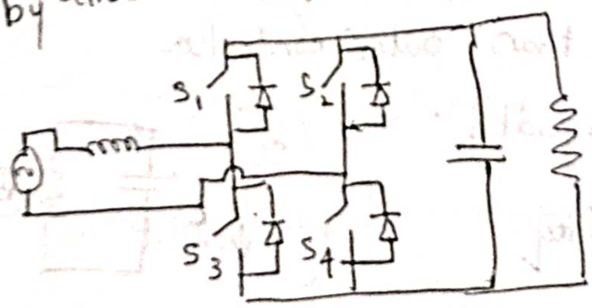
* So we are shifting inductor to AC side.



* In order to reduce no of components



* For by-directional power flow



Active front end PFC circuit

ac → dc	dc → ac
$S_3 \rightarrow +ve$	$S_1 \rightarrow +ve$
$S_4 \rightarrow -ve$	$S_2 \rightarrow -ve$