IIT ROORKEE

NPTEL ONLINE CERTIFICATION COURSE

Charging Infrastructure

Lecture-23

Three-phase AC-DC Converter-I

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Recap

- Single-phase AC-DC Converter
- Concept of PWM

7 kW → OBC → 1-ϕ ⇒ 1-ϕ AC-DC

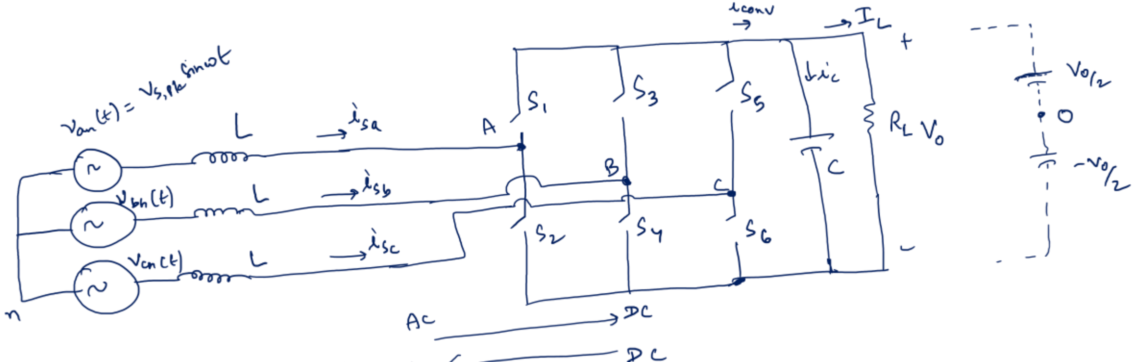
$$\Rightarrow V_{Ao}(t) \text{ (or) } = \frac{m V_{dc}}{2} \sin\omega t$$

$$\left(m = \frac{V_m}{V_c}\right) \Rightarrow V_m < V_c$$

Three-phase AC-DC Converter

↳ front-end AC-DC Converter (FEC)

↳ Active Rectifier



$v_{an}(t) = V_{s,pk}\sin\omega t$

$v_{bn}(t) = V_{s,pk}\sin(\omega t - 120)$

$v_{cn}(t) = V_{s,pk}\sin(\omega t - 240)$

For fundamental frequency

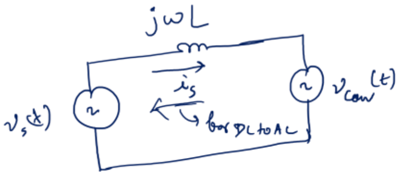
$f_m = f_s = 50Hz$ $\omega = 2\pi f_s$

$v_s(t) = V_{s,pk} \sin\omega t$

$i_s(t) = I_{s,pk} \sin\omega t$

$v_{conv}(t) = \frac{m V_0}{2} \sin\omega t$

$\left(m = \frac{V_m}{V_c}\right)$



$v_s(t) = v_{conv}(t) + j\omega L i_s$, using KVL

$\Rightarrow v_{conv}(t) = v_s(t) - j\omega L i_s$

In phasor form, $\vec{V}_{conv} = \vec{V}_s - j\omega L \vec{I}_s$

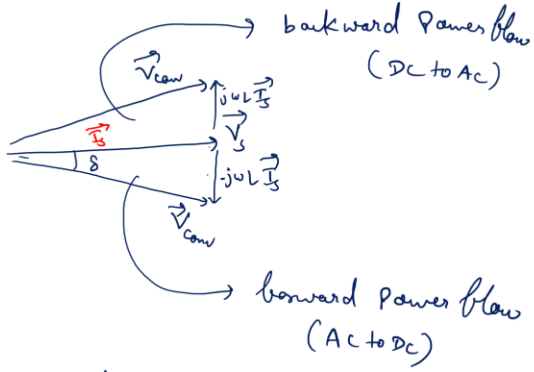
$$\left(\begin{array}{l} |\vec{V}_s| = V_{s,pk} \\ |\vec{I}_s| = I_{s,pk} \\ |\vec{V}_{conv}| = \frac{m V_0}{2} \end{array}\right)$$

For reverse power flow (from DC to AC)

$\Rightarrow$ Converter to source

In phasor form, $\vec{V}_{conv} = \vec{V}_s + j\omega L \vec{I}_s$

To have the unity power factor operation

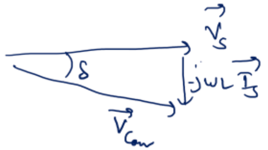


$\Rightarrow$ front-end converter because the power flow can be made bidirectional

⇒ By changing, the sign of 'δ' → we can change the direction of power flow

⇒ By changing the value of 'δ' → we can change the amplitude of phasor corresponds to voltage drop across inductor ⇒ the magnitude of current.

Calculation of inductor 'L'



$$\Rightarrow \quad |\vec{V}_{con}| = \sqrt{(-j\omega L \vec{I}_s)^2 + |\vec{V}_s|^2}$$

$$= \sqrt{\omega^2 L^2 |\vec{I}_s|^2 + |\vec{V}_s|^2}$$

$$\frac{mV_0}{2} = \sqrt{\omega^2 L^2 (I_{s,pk}^2) + V_{s,pk}^2}$$

$$\Rightarrow \quad L^2 = \frac{\left(\frac{mV_0}{2}\right)^2 - V_{s,pk}^2}{\omega^2 I_{s,pk}^2}$$

$$\Rightarrow \quad L = \sqrt{\frac{\left(\frac{m V_0}{2}\right)^2 - V_{s,pk}^2}{\left(2\pi f_s \cdot I_{s,pk}\right)^2}}$$

$\Rightarrow$ m = modulation index $\rightarrow$ 0.8 to 0.9

$f_s = f_m = 50\,Hz$

$I_{s,pk}$ = peak of the phase current $\rightarrow$ from specification

V_0 = DC-link voltage

$V_{s,pk}$ = peak of the phase voltage } from specification

$\Rightarrow$ the voltage drop across inductor (for fundamental frequency) must be within 10% of the supply voltage.

this has to be ensured

Rms current of this inductor = $\frac{I_{s,pk}}{\sqrt{2}}$ $\left[= \sqrt{\frac{1}{T}\int_0^T (I_{s,pk} \sin \omega t)^2 \cdot dt} \right]$

Thank You