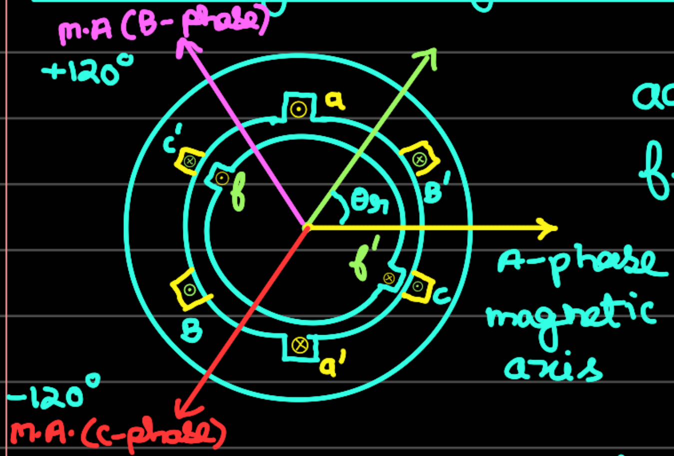
Day-22

→ **Synchronous machine -**

Stator/armature winding → 3-phase sinusoidally distributed windings

Rotor/Field winding → Sinusoidally distributed with DC excitation, supplied through slip ring and brushes

→ **modelling of cylindrical rotor SM:**

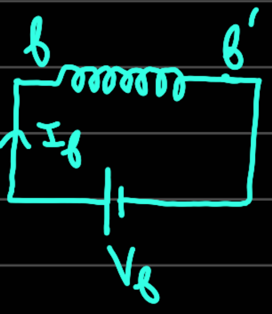


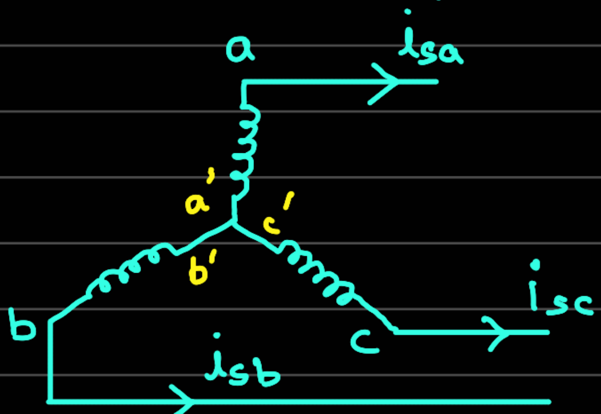
aa' → Stator A-phase winding

ff' → Field winding

Magnetic axis (of A-phase) : axis along which the fundamental component of spatial air-gap MMF due to A-phase excitation is at its +ve peak

$$\frac{d\theta_r}{dt} = \omega_r \quad \text{(rotor-speed)}$$





$$v_{sa} = i_{sa} R_s + \frac{d\psi_{sa}}{dt} \quad \text{(motor)}$$

$$v_{sa} = -i_{sa} R_s - \frac{d\psi_{sa}}{dt} \quad \text{(Generator)}$$

($sa \rightarrow$ stator a-phase)

$$\left.\begin{aligned} v_{sb} &= -i_{sb} R_s - \frac{d\psi_{sb}}{dt} \\ v_{sc} &= -i_{sc} R_s - \frac{d\psi_{sc}}{dt} \\ v_f &= i_f R_f + \frac{d\psi_f}{dt} \end{aligned}\right\} \text{Assumed lump model}$$

$$\psi_{sa} = L_{aa} i_a + L_{ab} i_b + L_{ac} i_c + L_{af} i_f$$

L_{aa} → self-inductance of A-phase winding

self-inductance of A-phase winding → $L_{sa} + L_{ma}$

L_{sa} → leakage inductance of A-phase winding

L_{ma} → magnetising inductance of A-phase winding

L_{ab} → mutual-inductance between A and B phase winding

$$\psi_{sb} = L_{ba} i_a + L_{bb} i_b + L_{bc} i_c + L_{bf} i_f$$

$$\psi_{sc} = L_{ca} i_a + L_{cb} i_b + L_{cc} i_c + L_{cf} i_f$$

$$\psi_f = L_{fa} i_a + L_{fb} i_b + L_{fc} i_c + L_{ff} i_f$$

$$v_{sa} = -i_{sa} R_s - \frac{d\psi_{sa}}{dt}$$

- Self-inductance of A-phase winding :

$$L_{aa} = \frac{\psi_{sa}}{i_a}\Bigg|_{i_b = i_c = i_f = 0}$$

L_{aa} is independent of θ_r

- mutual inductance between the stator windings.

$$L_{ab} = \frac{\psi_{sa}}{i_b}\Bigg|_{i_a = i_c = i_f = 0}$$

independent of θ_r

But L_{af} depends on θ_r

$$L_{af}(\theta_r) = L_{af\,max} \cos\theta_r$$

out of 16 inductances, 10 are time-independent

$$L_{bf}(\theta_r) = L_{bf\,max} \cos(\theta_r + 120°)$$

$$L_{cf}(\theta_r) = L_{cf\,max} \cos(\theta_r - 120°)$$

$$v_{sa} = -i_{sa}R_s - \frac{d\psi_{sa}}{dt}$$

$$\psi_{sa} = \underbrace{L_{aa}}_{L_{la}+L_{ma}} i_{sa} + L_{ab}\, i_{sb} + L_{ac}\, i_{sc} + L_{af}\, i_f$$

$$L_{ma} = N_s^2 \Big/ \left(\frac{l_g}{\mu_0 \pi r l}\right)$$

$$L_{ab} = \frac{-N_s^2 \mu_0 \pi r l}{2 l_g} = -\frac{L_{ms}}{2}$$

$$L_{af} = \frac{\mu_0 \pi r l N_s N_r}{l_g} \cos\theta_r$$