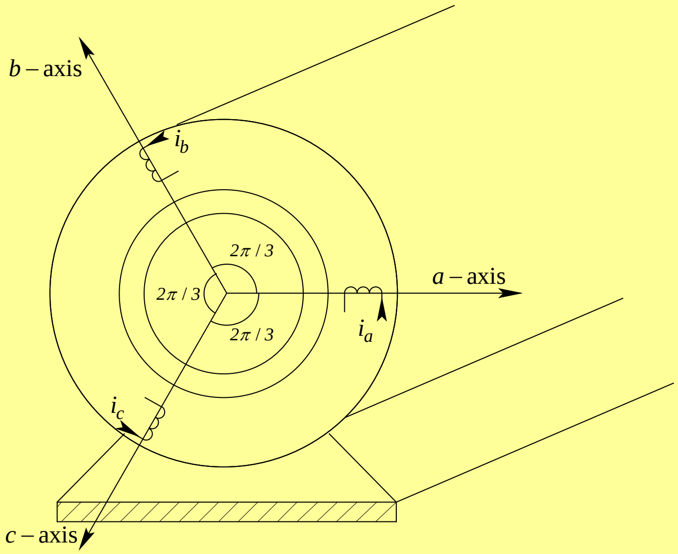
Induction Motors:
Balanced, Sinusoidal Steady State Operation

- Induction motors under balanced sinusoidal steady state (Rated voltage at rated frequency)
- Structure
- Principle of Operation – rotor electrically “open”

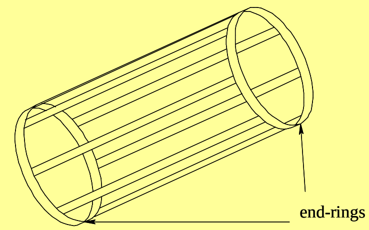
Induction Motors

- General Purpose
- Adjustable speed drives
- Servo drives

Structure

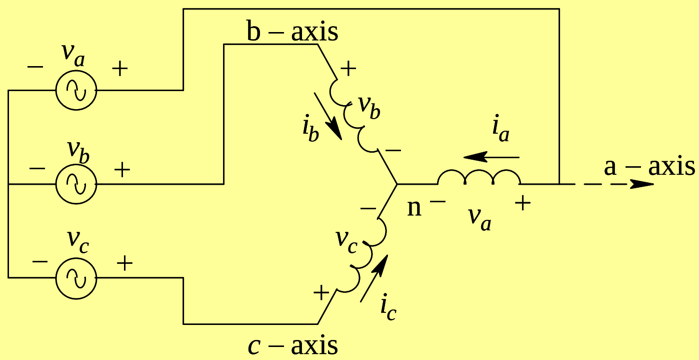


Simple representation of three phase stator windings

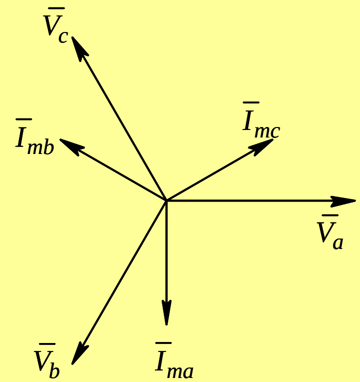


Squirrel-cage rotor

Stator Representation



(a)



(b)

- Assumptions : R_s, $L_{s,leakage} = 0$

$$v_a(t) = \sqrt{2}\,E\,\cos(2\pi ft)$$

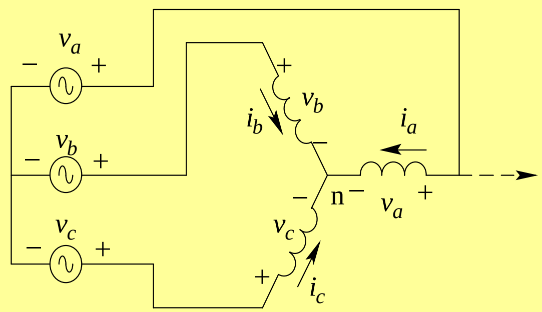
$$v_b(t) = \sqrt{2}\,E\,\cos(2\pi ft - \frac{2\pi}{3})$$

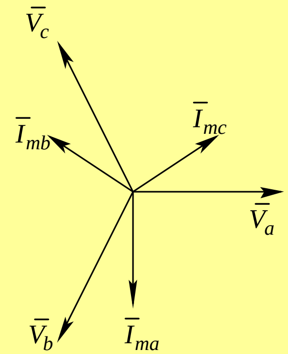
$$v_c(t) = \sqrt{2}\,E\,\cos(2\pi ft - \frac{4\pi}{3})$$

$$\omega_{syn} = \omega = 2\pi f$$ (for a 2-pole machine)

$$\omega_{syn} = \frac{2}{p}\omega = \frac{2}{p}(2\pi f)$$ (for a p-pole machine)

Electrically Open-circuited Rotor





- Only magnetizing currents are present because rotor is inert
- Magnetizing currents set up rotating flux

$$\hat{I}_m = \frac{\hat{V}}{\omega L_m}$$

$$\vec{i}_{ms}(t) = \frac{3}{2}\hat{I}_m \angle(\omega t - \frac{\pi}{2})$$

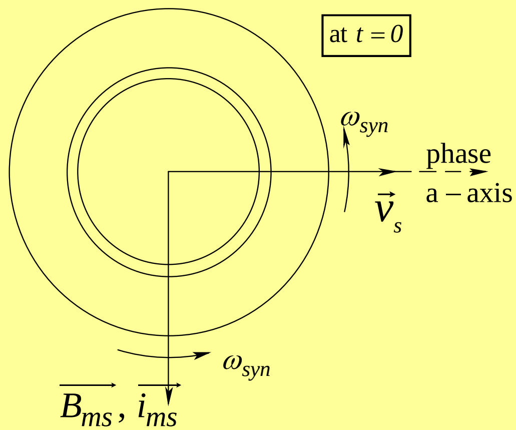
$$i_{ma}(t) = \hat{I}_m \cos(\omega t - \pi/2), \text{ etc.}$$

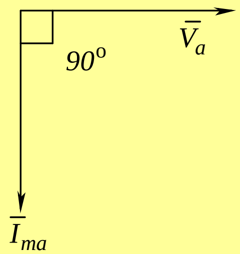
$$\hat{I}_{ms} = \frac{3}{2}\hat{I}_m$$

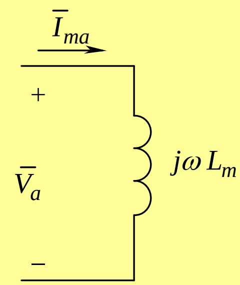
$$\vec{v}_s(t) = \frac{3}{2}\hat{V}\angle\omega t$$

$$\hat{V}_s = \frac{3}{2}\hat{V}$$

Electrically Open-circuited Rotor Fields







- $\overrightarrow{B_{ms}}$ is a constant magnitude, rotating flux

$$\vec{i}_{ms}(t) = \frac{3}{2}\hat{I}_m \angle(\omega t - \pi/2) = \hat{I}_{ms}\angle(\omega t - \pi/2)$$

$$\vec{H}_{ms}(t) = \frac{N_s \, \vec{i}_{ms}}{2\ell_g}$$

$$\vec{B}_{ms}(t) = \mu_0 \, \vec{H}_m(t) \therefore \; \vec{B}_{ms}(t) = \frac{\mu_0 \, N_s}{2\ell_g}\hat{I}_{ms}\angle(\omega t - \pi/2)$$

Summary

Induction motors under balanced sinusoidal steady state (Rated voltage at rated frequency)

- Structure
- Principle of Operation – rotor electrically "open"