# Lecture 9

Monday, 7 September 2009
10:41 AM

## Three Phase Connections

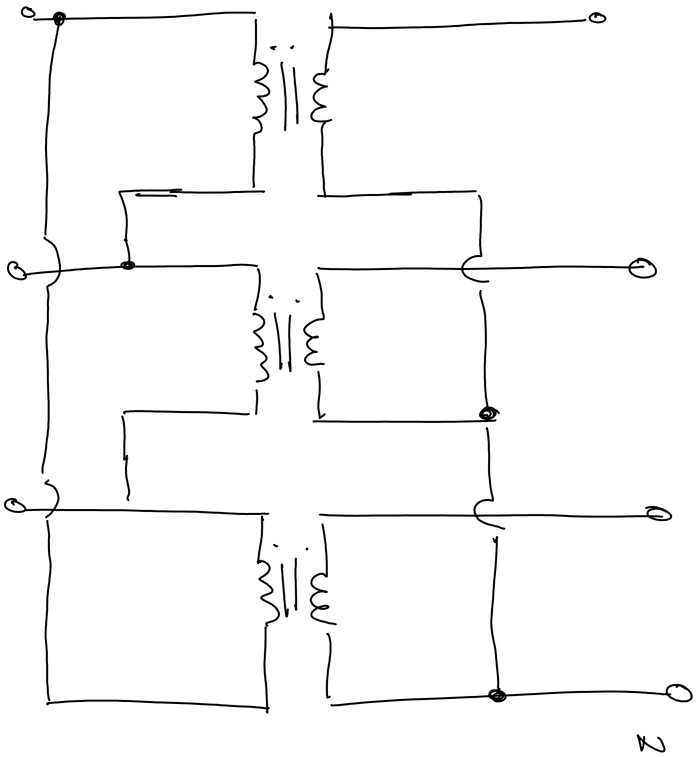
3 similar, 1∅ t/F may be connected to give 3-phase transformation.

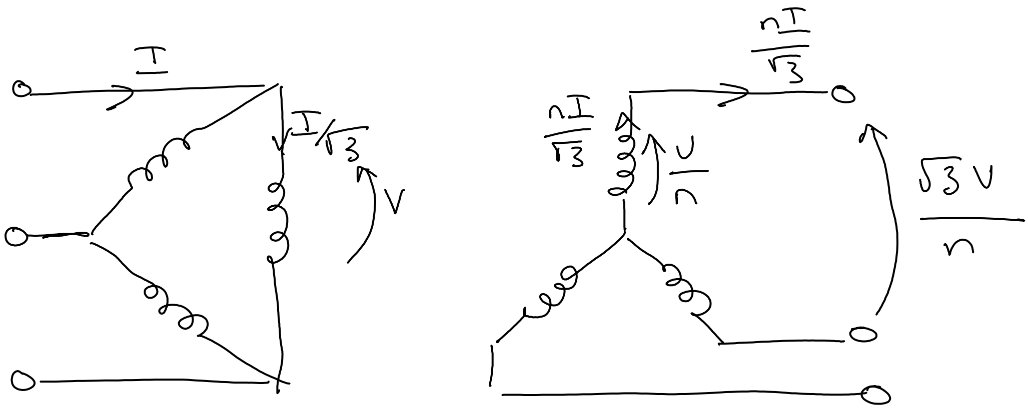
Both 1° and 2° may be connected in ⅄ or $\Delta$
→ 4 combinations

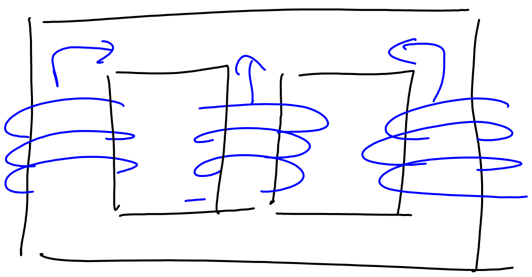
$\Delta - Y$ ; $\Delta - \Delta$ ; ⅄ $- \Delta$ ; ⅄ $-$ ⅄

Eg $\Delta - Y$

let $a = N_1/N_2$





← 3 phase transformer

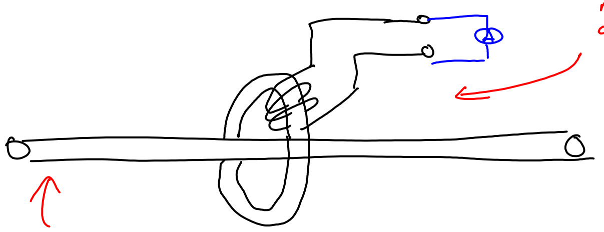
## Current Transformers

known as ct's

used in metering and protection applications.

usually has $N_1$ small and $N_2$ large.

often has a single turn primary.




could be considered voltage step-up t/f because

$$\frac{N_1}{N_2} < 1$$

should always be operated with a s/cct 2° (often an ammeter)

(often an ammeter)

## Voltage Transformers

- known as vt's
- same as other t/f's
- used in voltage metering
- step-down t/f ie $\frac{N_1}{N_2} > 1$

**END TRANSFORMERS**

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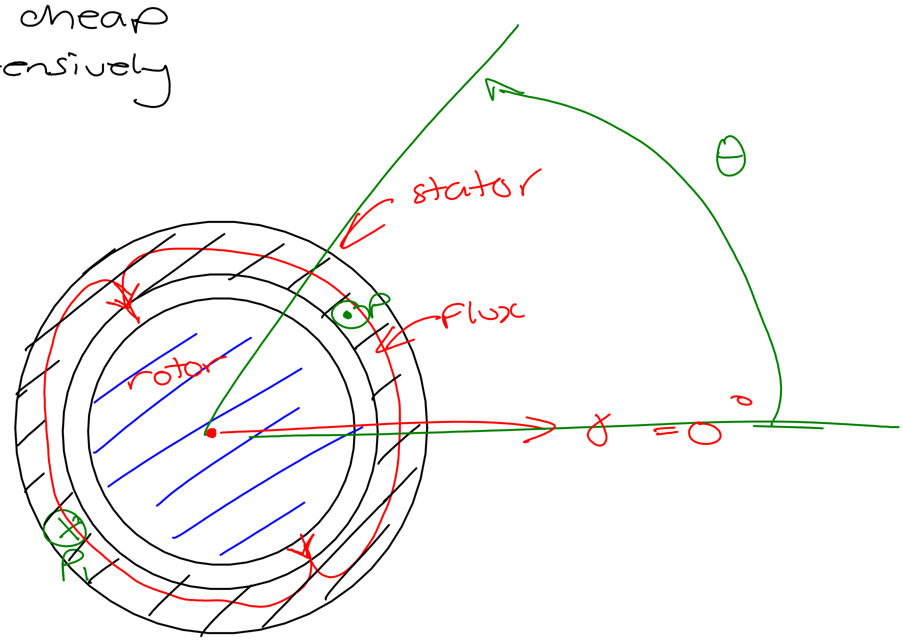
## INDUCTION MOTORS

- our discussion will concern 3$\phi$ IM's
- typically used as motors

  ∴ Elec Energy → [IM] → Mech Energy.

- relatively cheap
- used extensively



Consider a single winding (sinusoidally distributed) to be placed on the stator as shown.

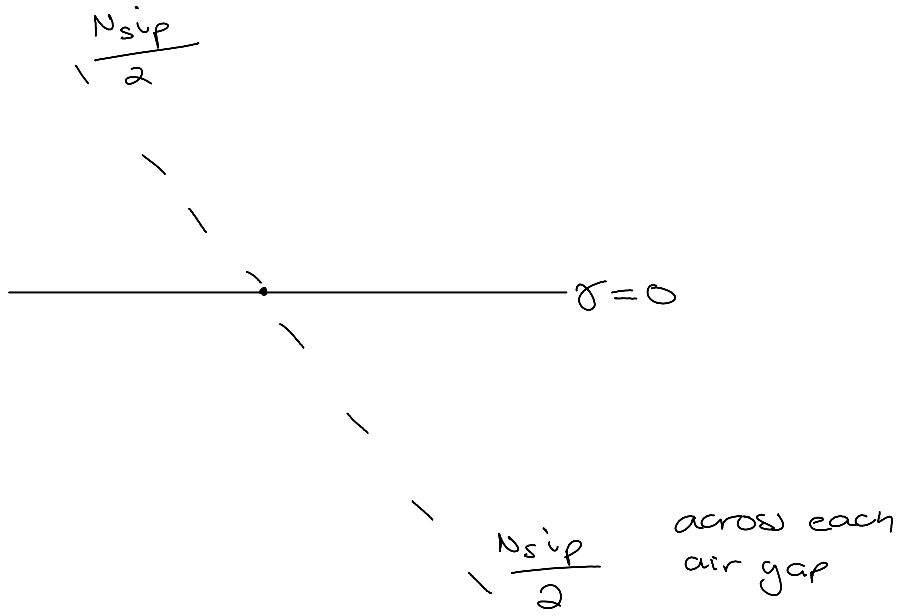
The center turn is shown at an angle $\gamma$ to the reference.

No of turns $= N_s$

Current $= i_p$

$\mathcal{F}_s = N_s i_p = \phi \mathcal{R}$

$\mathcal{R} = \dfrac{l}{\mu A}$




Now consider the mmf in a path at angle $\theta$

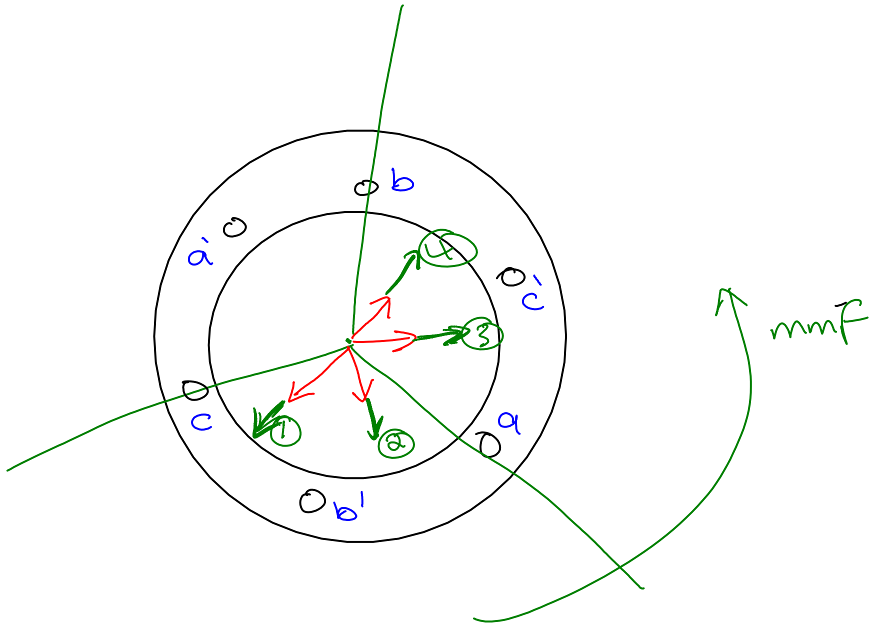
$$\mathcal{F}(\theta) = N_s i_p \cos\left(\frac{\pi}{2} + \gamma - \theta\right)$$

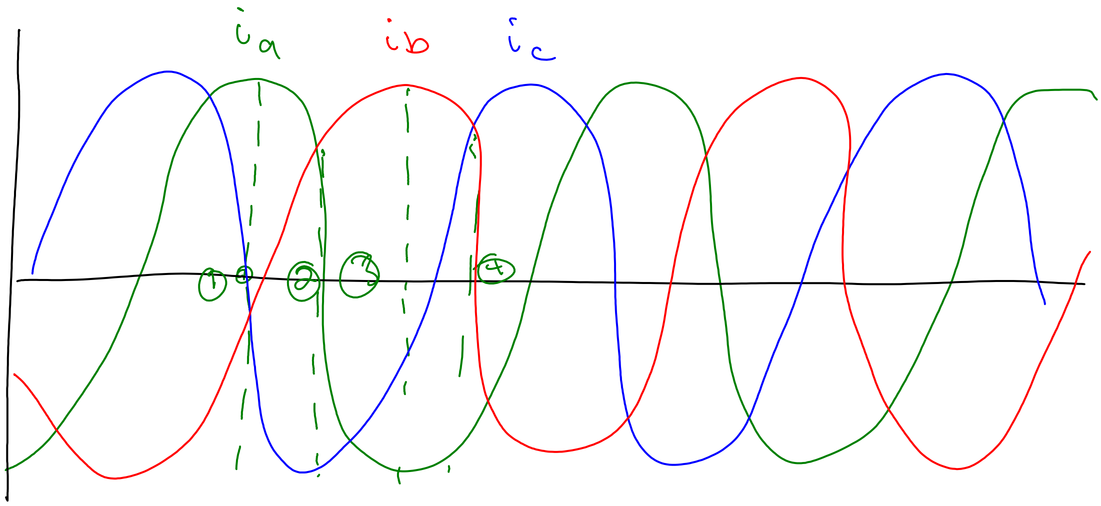
$$= N_s i_p \sin(\gamma - \theta)$$

$$\mathcal{F}_{sg}(\theta) = \frac{N_s i_p}{2} \sin(\gamma - \theta)$$

Now consider 3 windings placed on the

Now consider 3 windings placed on the stator, each sinusoidally distributed and each displaced mechanically by $2\pi/3$ $(120)^\circ$ from the next




Note that in one full cycle of the supply frequency, the flux pattern makes a complete revolution of the stator

Note that in each of the instants ①, ② and ③, the resultant mmf is

$$1.5 \times \frac{N_s i_p}{2}$$

Note that this is a 2-pole machine.

$$\text{mmf}: \mathcal{F}_{sg} = \frac{3 N_s I_p}{4} \cos \omega_s t$$

If $\theta$ varies as $\omega_s t$ turns then

$$(\omega_s t + \alpha_s - \theta) = \text{constant.}$$

$\Rightarrow$ the resultant mmf consititutes a travelling wave in the air gap.

The direction of travel of the mmf may be reversed by reversing the phase sequence of the stator currents.