Module-4

Synchronous Generators (Salient Pole) and Performance of Synchronous Generators

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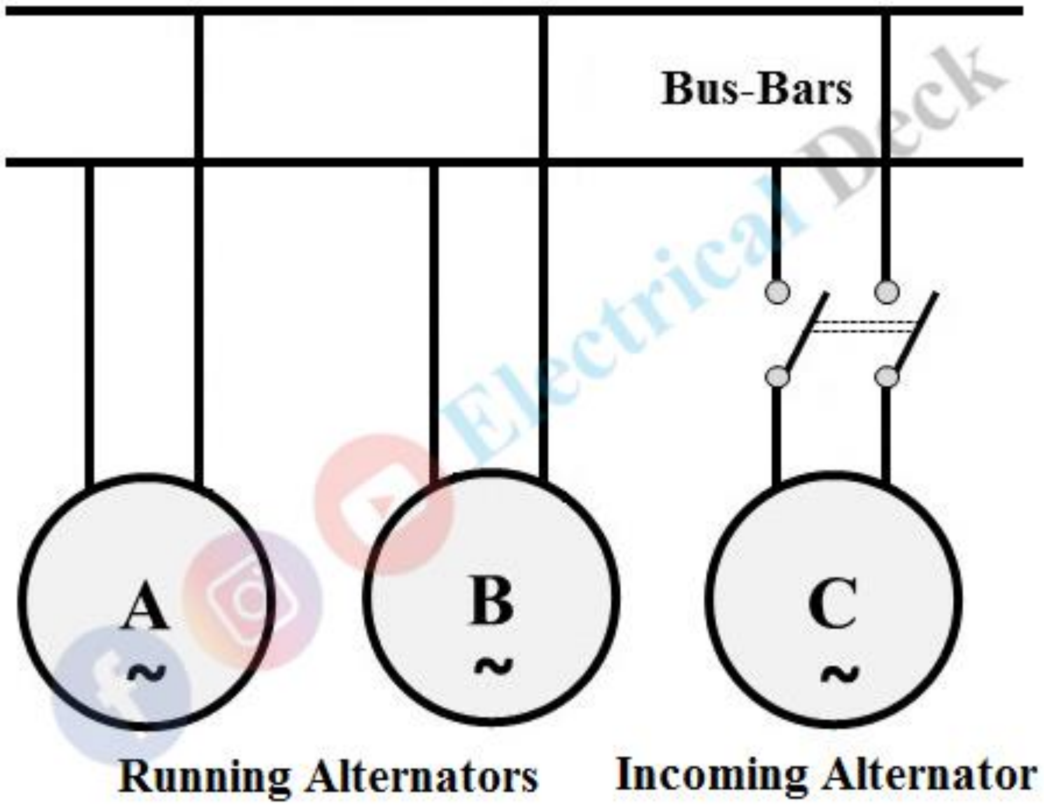
Module-4

Synchronous Generators (Salient Pole): Effects of saliency, two-reaction theory, Parallel operation of generators and load sharing. Methods of Synchronization, Synchronizing power.

Performance of Synchronous Generators: Power angle characteristic (salient and non-salientpole), power angle diagram, reluctance power, Capability curve for large turbo generators. Hunting and damper windings. Numerical.

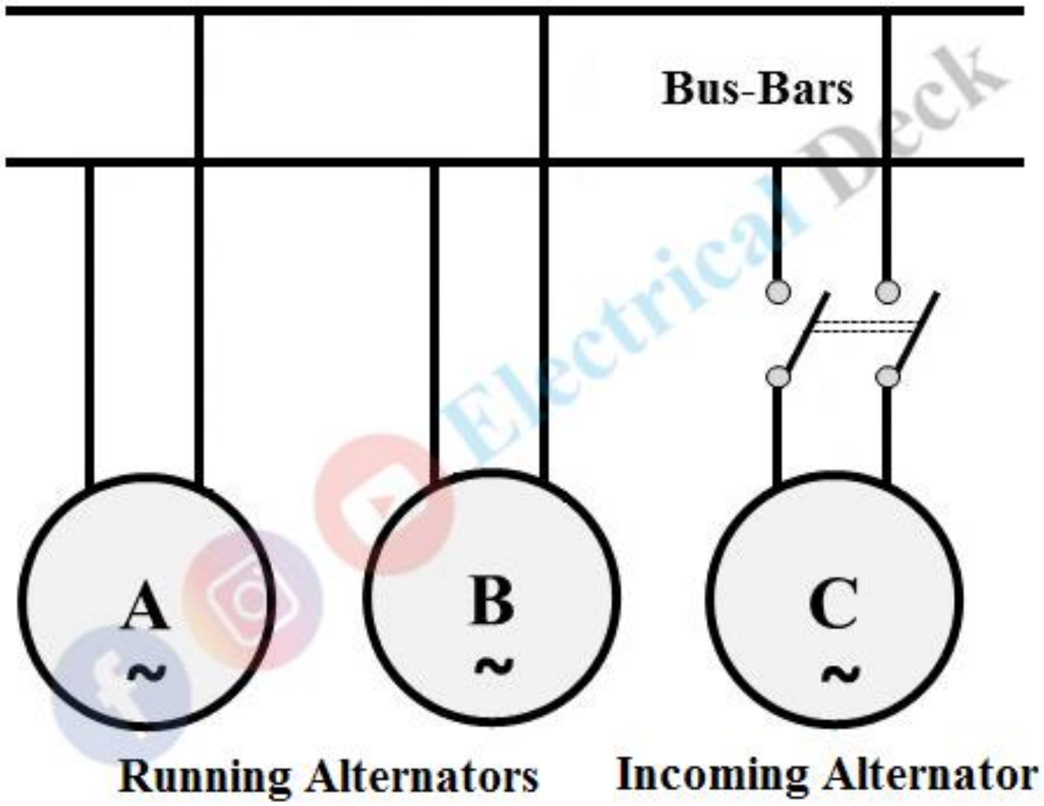
Parallel Operation of Alternators:



The method of connecting an alternator or synchronous generator in parallel with another alternator or synchronous generator or with common bus bars is known as parallel operation of alternators or synchronization of alternators.

Necessary condition for Synchronization:

1. The terminal voltage of the incoming machine must be same as that of the bus bar voltage.
2. The frequency must be same as that of the incoming machine as well as that of the bus bar
3. With respect to the external load, the phase of alternator voltage must be identical with that of the bus bar voltage

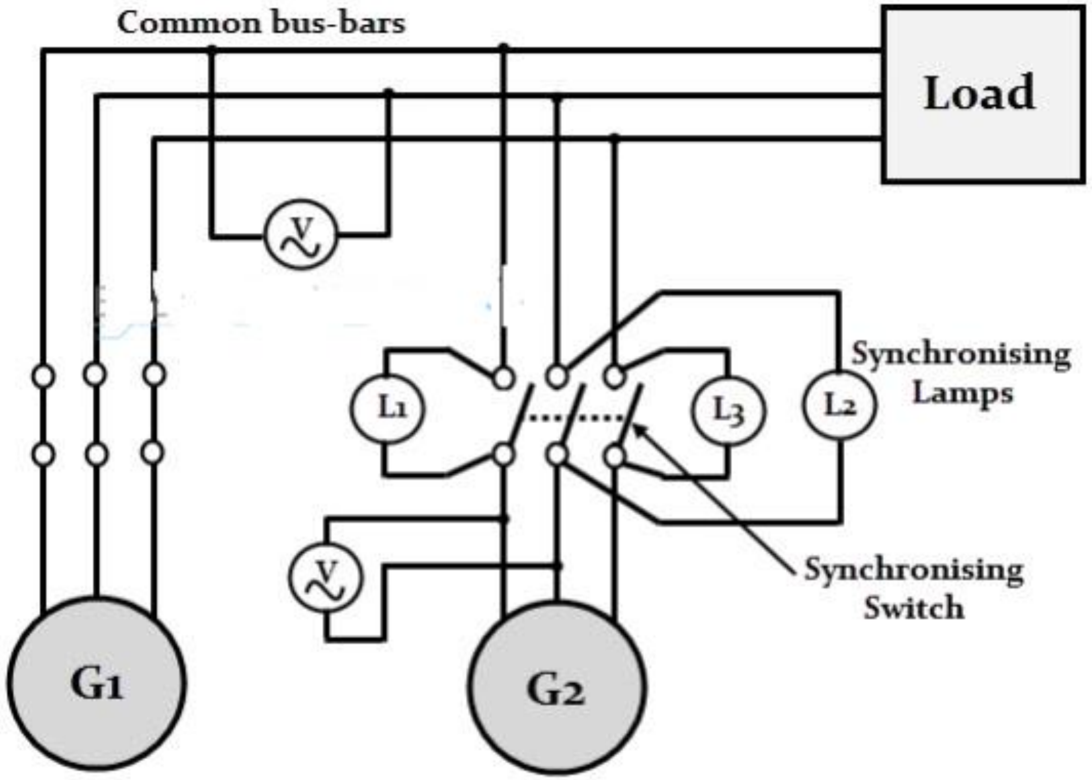


Different Techniques for Synchronization

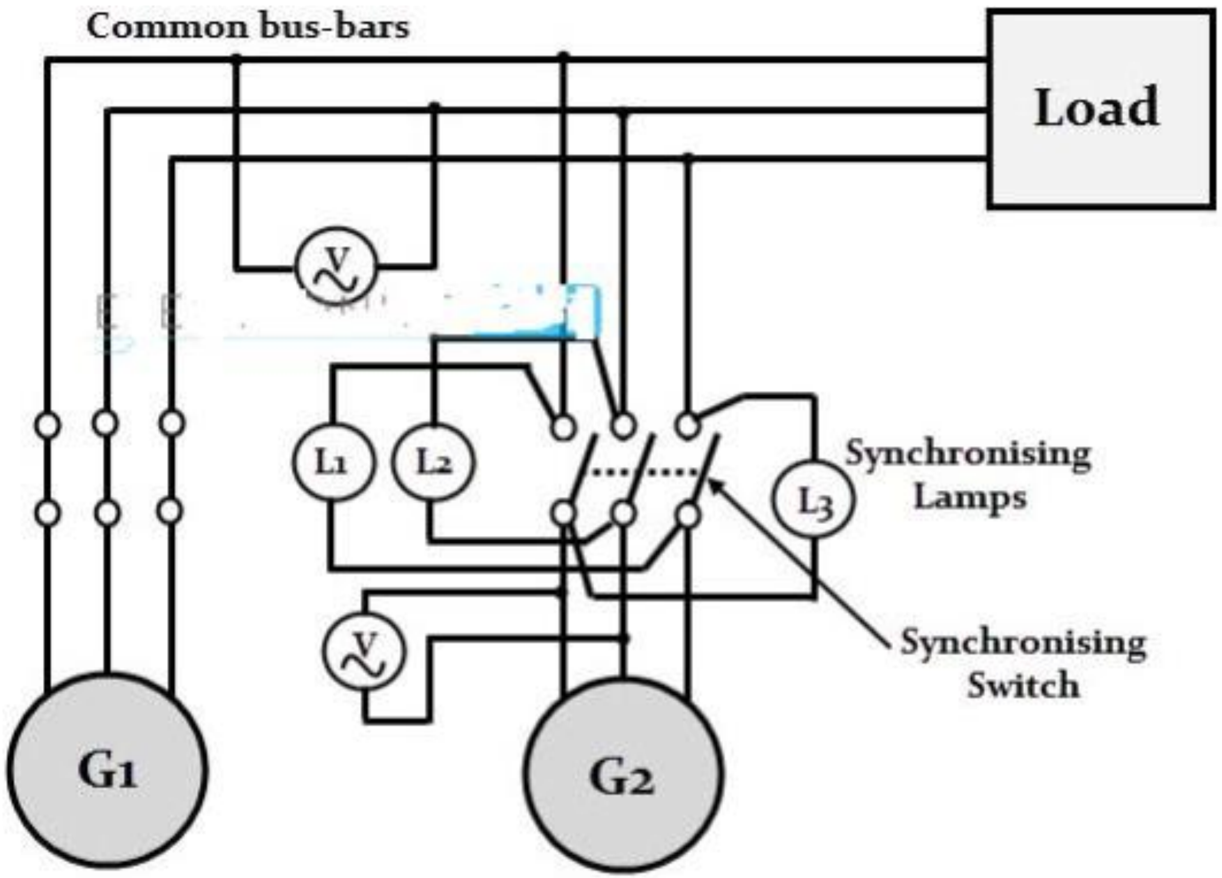
Different techniques are being available for the synchronization of alternators. The common methods used for
synchronizing the alternators are given below:

- Three Dark Lamps Method
- Two Bright, One Dark Method
- Synchroscope Method

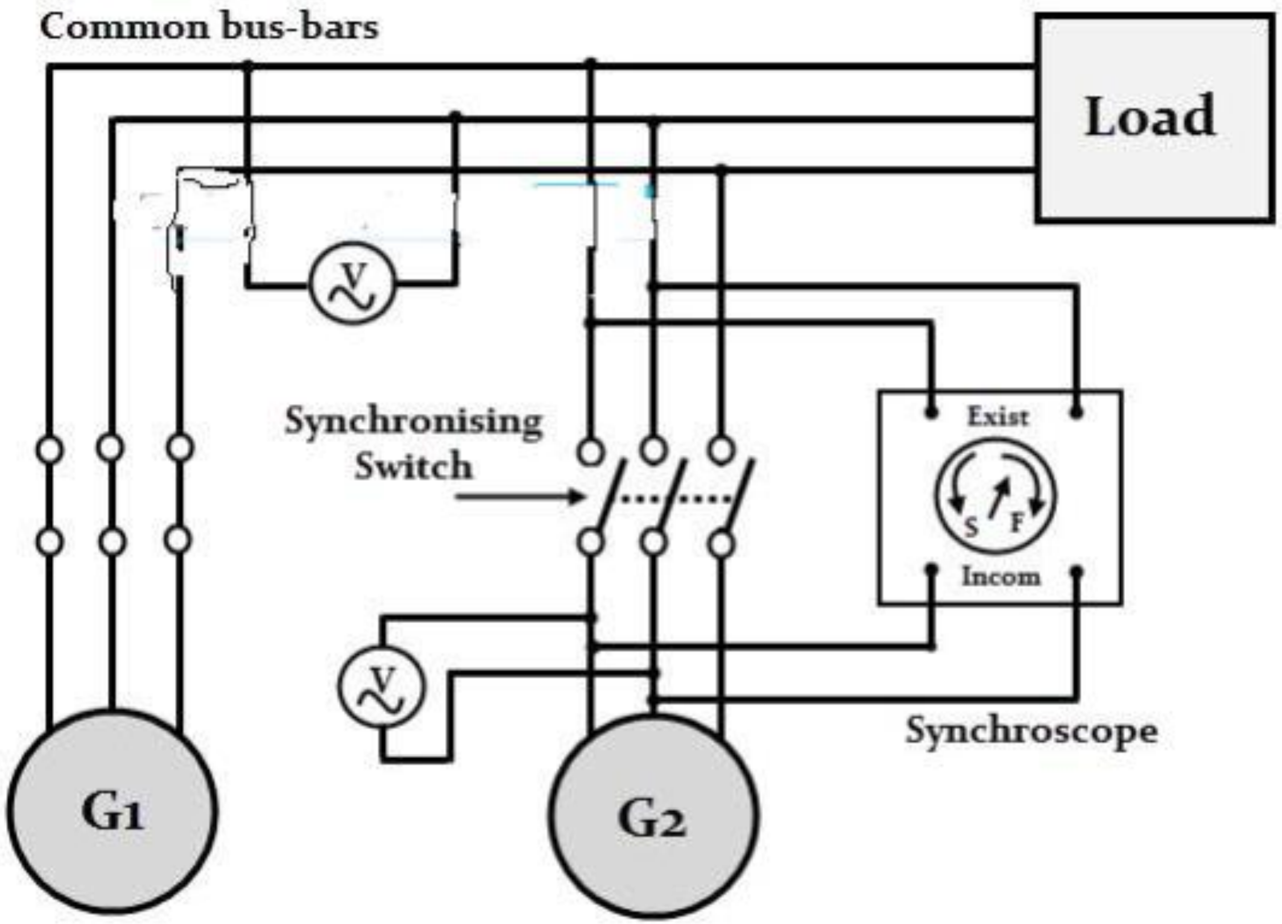
Three Dark Lamps Method



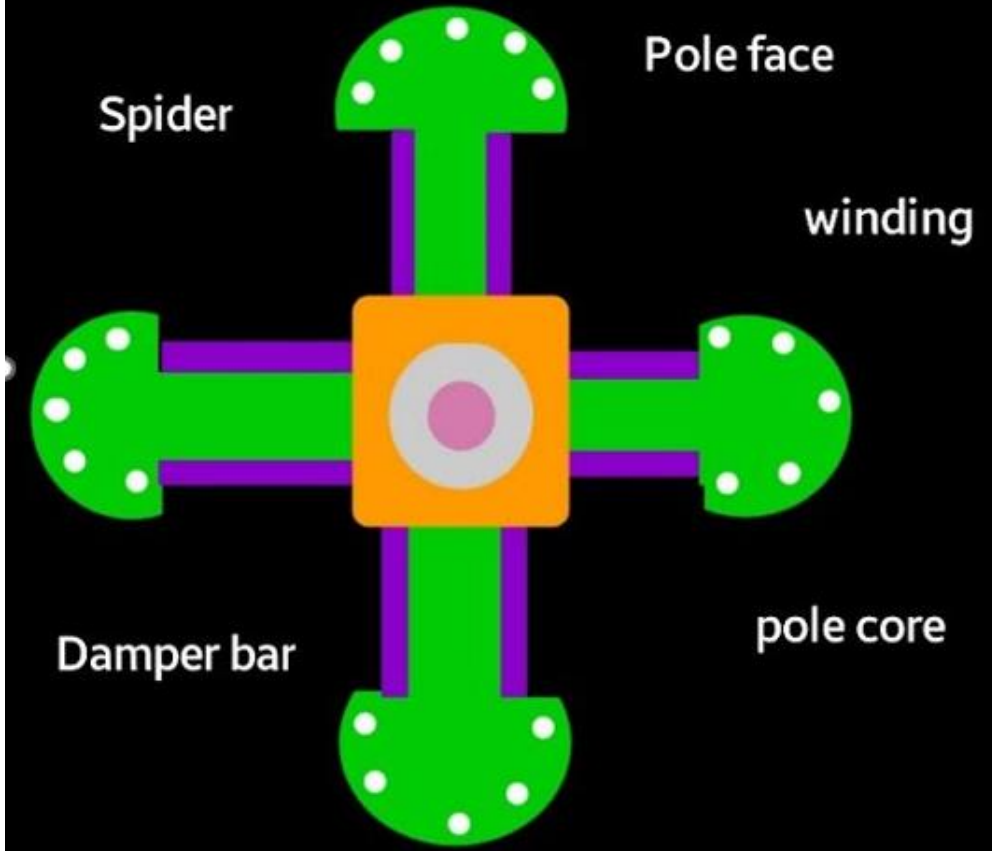
Two Bright and One Dark Lamp Method

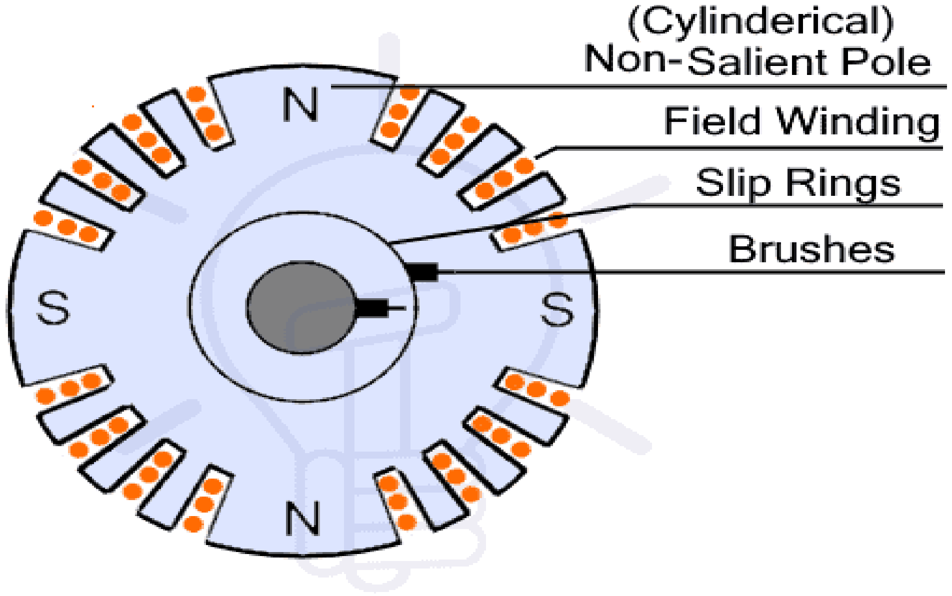


Synchroscope Method



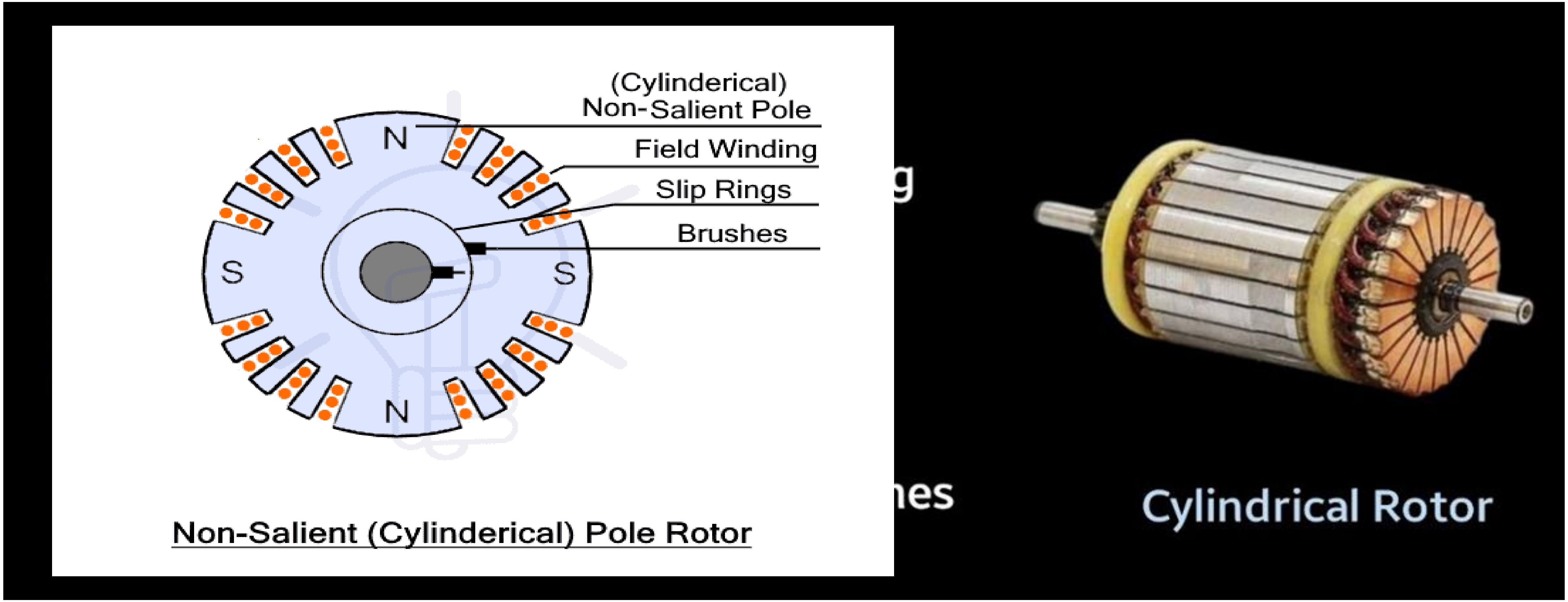
Salient Pole Rotor



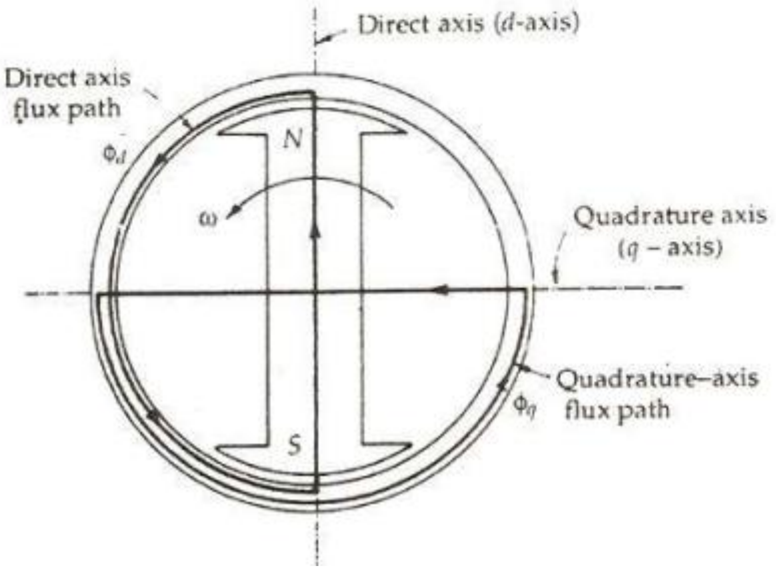


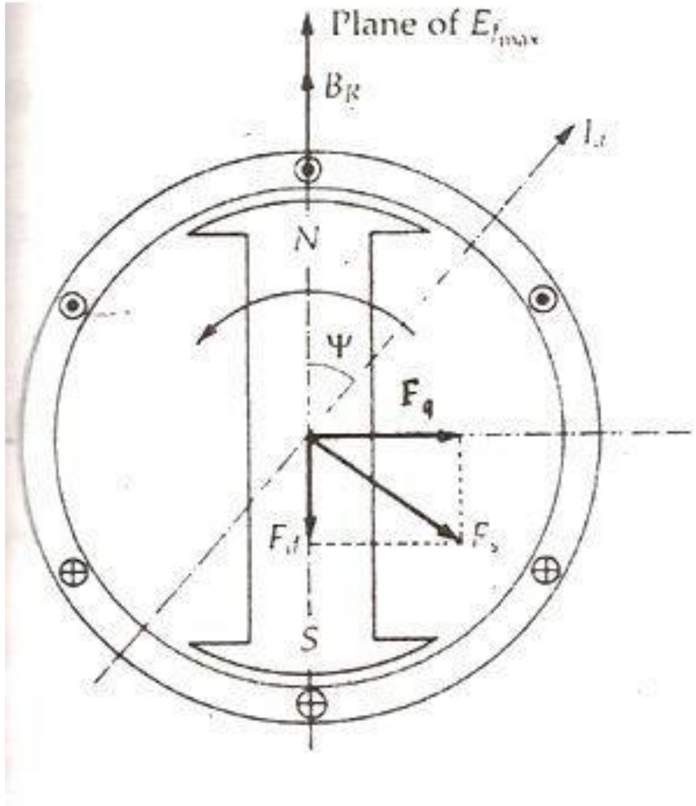
Non-Salient (Cylinderical) Pole Rotor

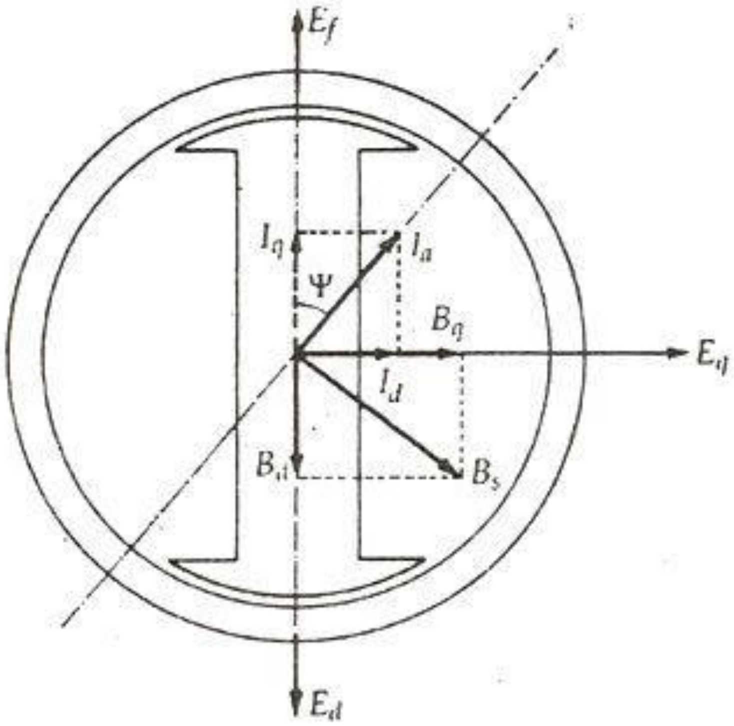
Cylindrical Rotor Construction



Two Reaction Theory – Salient Pole Synchronous Machine




Plane of $E_{f_{max}}$
B_R
I_a
N
Ψ
F_q
F_d
F_s
S


E_f
I_q
I_a
Ψ
B_q
E_q
I_d
B_d
B_s
E_d

$$\varphi_d = \frac{F_d}{R_d}$$

$$\varphi_q = \frac{F_q}{R_q}$$

$$E_{ad} = -j\,X_{ad}\,I_d \quad \dots\dots\dots (1)$$

$$E_{aq} = -j\,X_{aq}\,I_q \quad \dots\dots\dots (2)$$

$$E' = E_f + E_{ad} + E_{aq} \quad \dots\dots\dots (3) \quad \text{or}$$

$$E' = E_f - j\,X_{ad}I_d - j\,X_{aq}I_q \quad \dots\dots.(4)$$

$$E' = V + R_aI_a + j\,X_lI_a \quad \dots\dots.(5)$$

$$I_a = I_d + I_q \quad \dots\dots.(6)$$

$$E_f = V + R_aI_a + jX_lI_a + jX_{ad}I_d + jX_{aq}I_q \dots\dots\dots (7)$$

$$E_f = V + R_a(I_d + I_q) + j\,X_l(I_d + I_q) + jX_{ad}I_d + jX_{aq}I_q \dots\dots\dots (8)$$

$$E_f = V + R_a(I_d + I_q) + j(X_l + X_{ad})I_d + j(X_l + X_{aq})\,I_q \quad \dots\dots (9)$$

$$X_d \triangleq X_l + X_{ad} \dots\dots..(10)$$

$$X_q \triangleq X_l + X_{aq} \dots\dots..(11)$$


thank
you