Induction Machines: 1-phase Induction Motors

- Construction
- Principle of Operation
- Equivalent Circuit
- Power and Torque
- Motor Types
- Starting Winding Design
- Testing

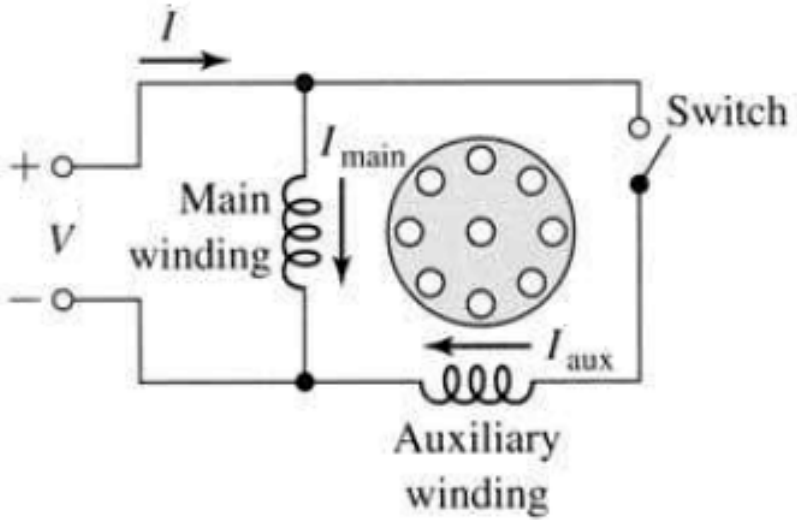
Induction Machines: 1-phase Induction Motors

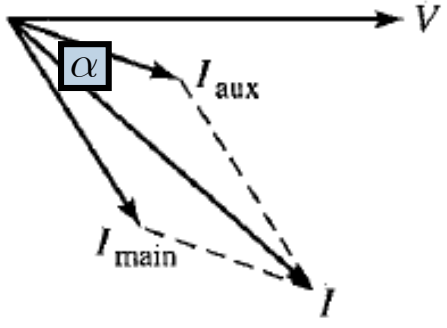
- Video

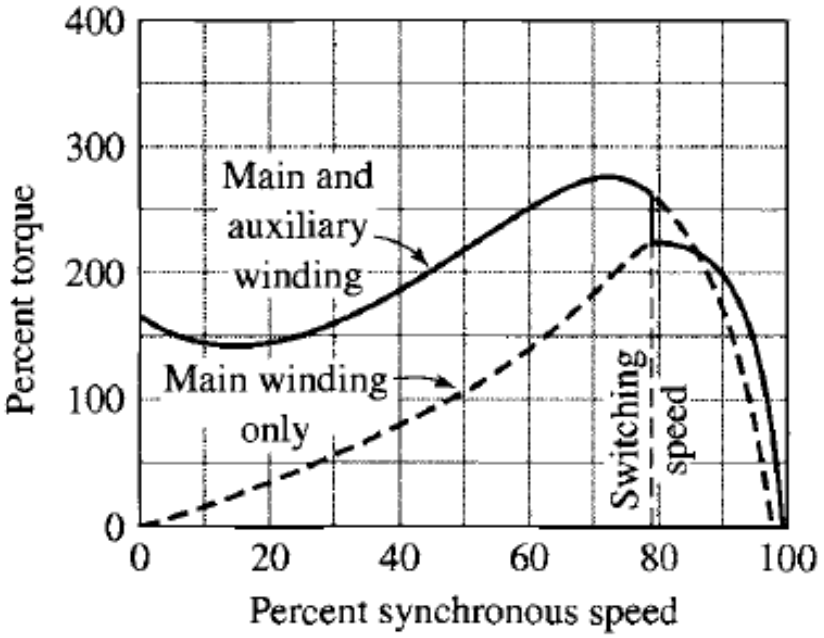
Induction Machines: 1-phase Induction Motors

Motor Types

1. Split-phase (resistance-start) Motor



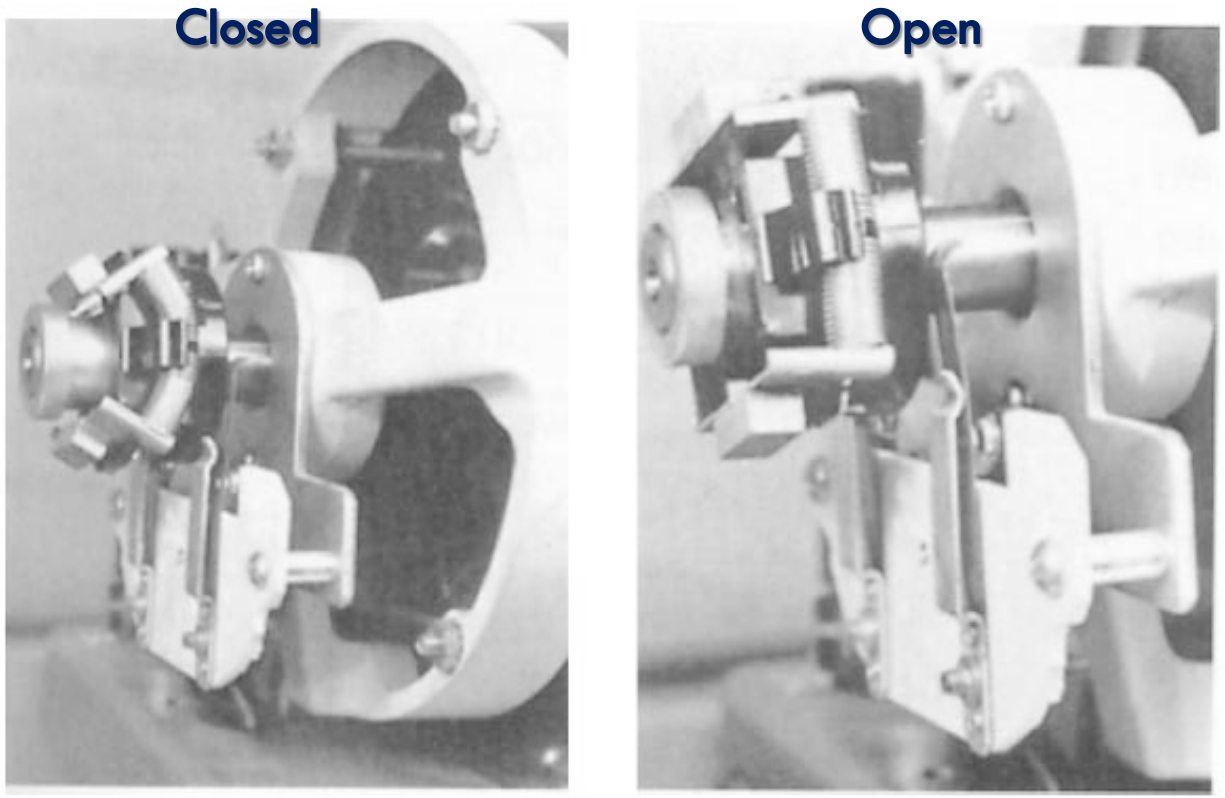




Induction Machines: 1-phase Induction Motors

Motor Types

1. Split-phase (resistance-start) Motor

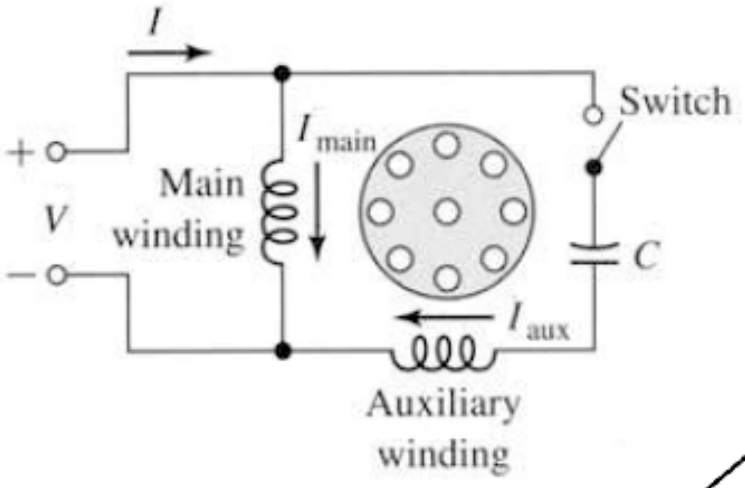


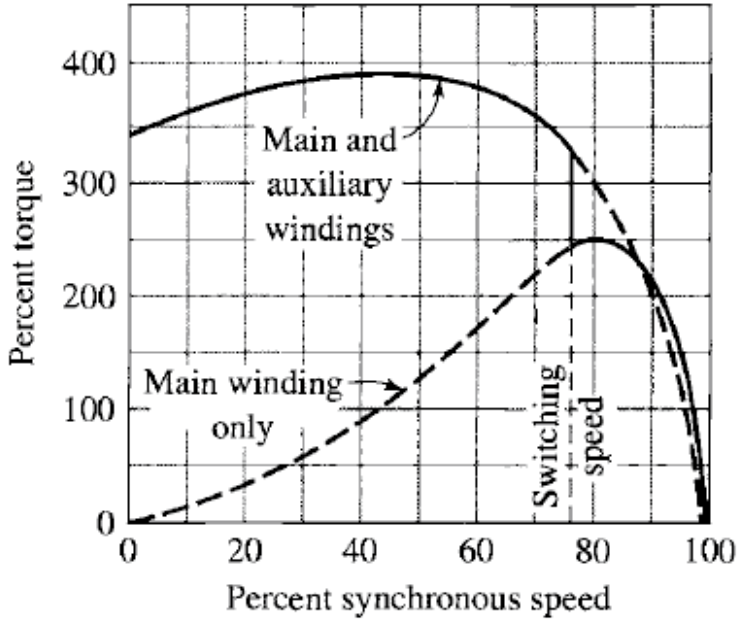
Centrifugal Switch

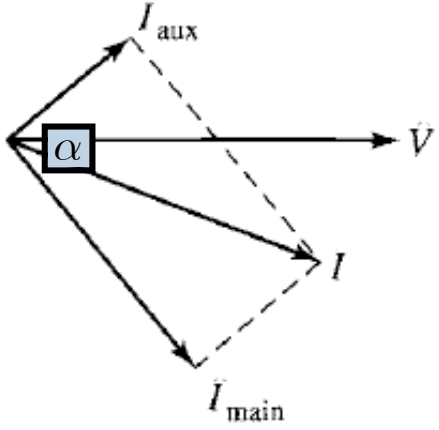
Induction Machines: 1-phase Induction Motors

Motor Types

2. Capacitor-Start Motor





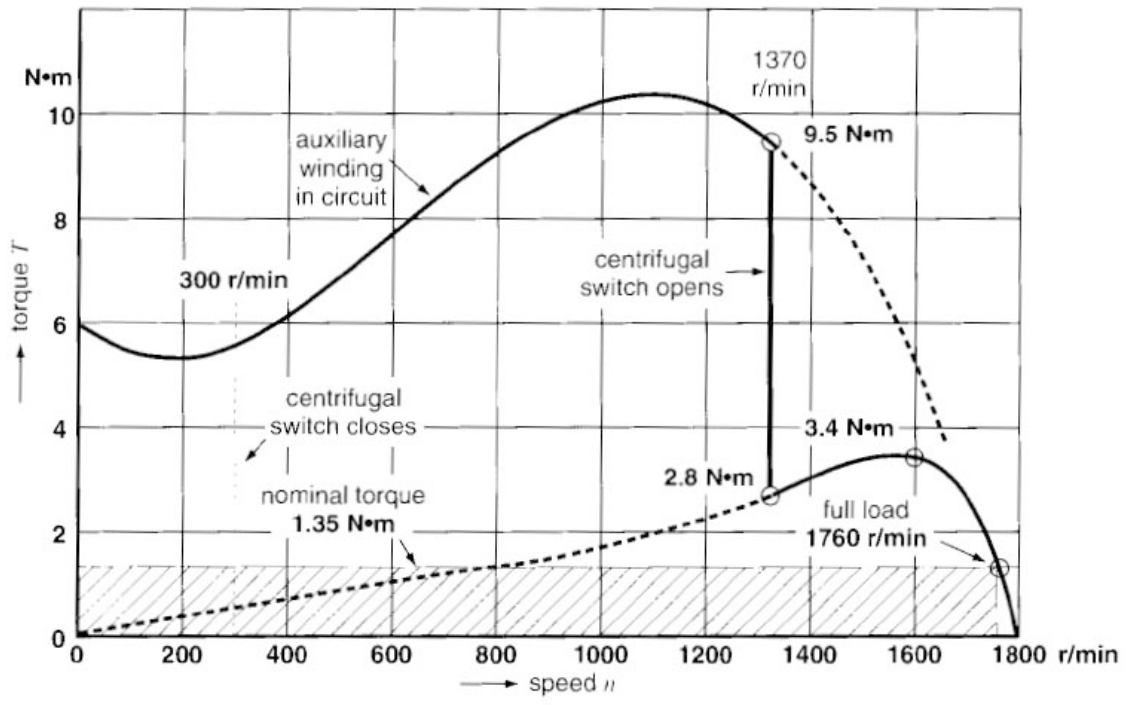


Induction Machines: 1-phase Induction Motors

Motor Types

2. Capacitor-Start Motor

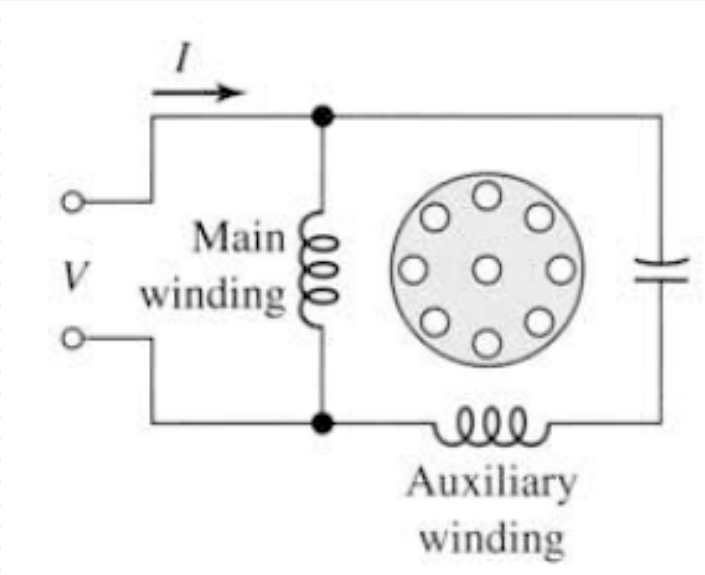
250 W (1/3 hp) motor, 4-poles, 110 V, 60 Hz

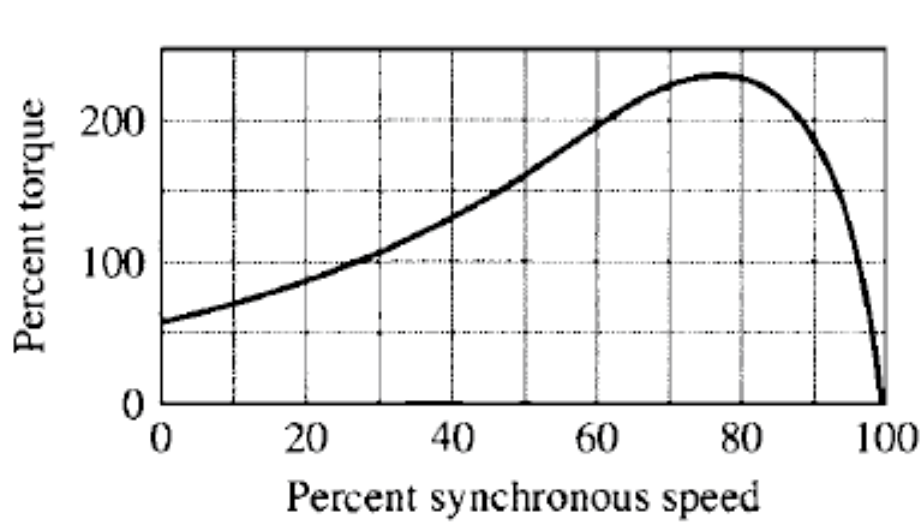


Induction Machines: 1-phase Induction Motors

Motor Types

3. Capacitor-Run Motor

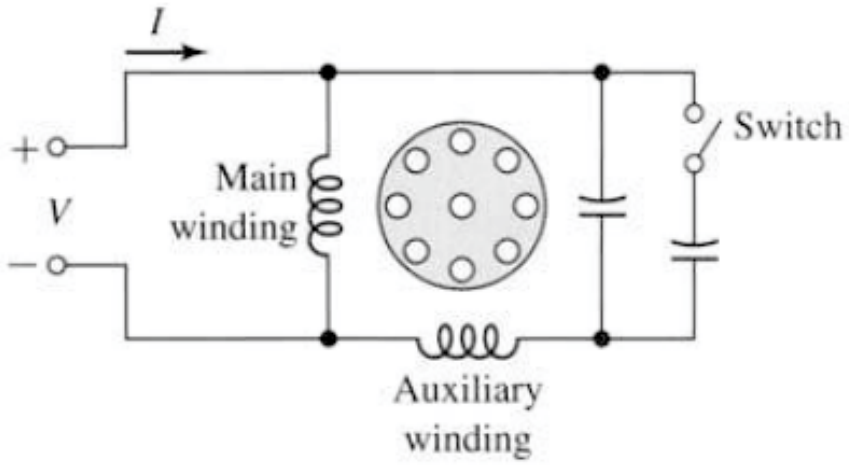


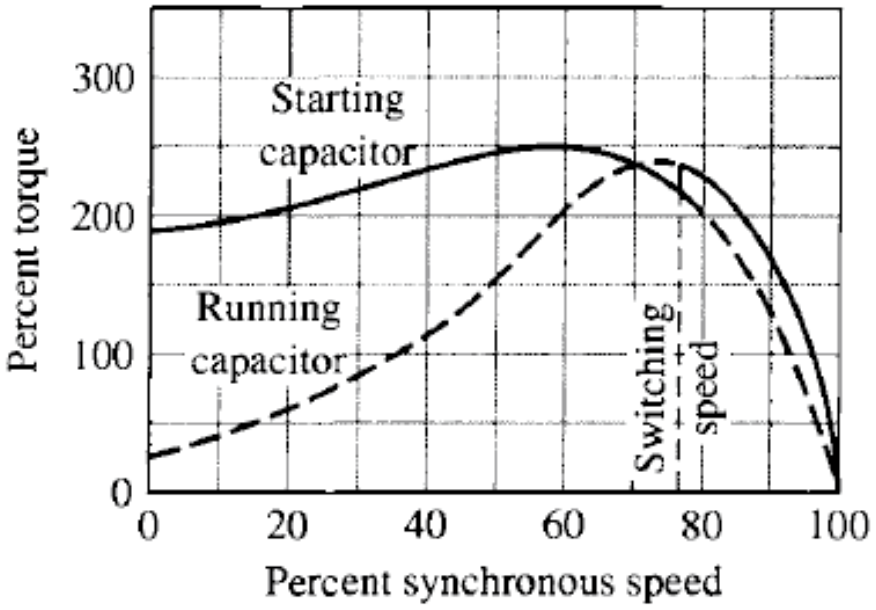


Induction Machines: 1-phase Induction Motors

Motor Types

4. Capacitor-Start, Capacitor-Run Motor

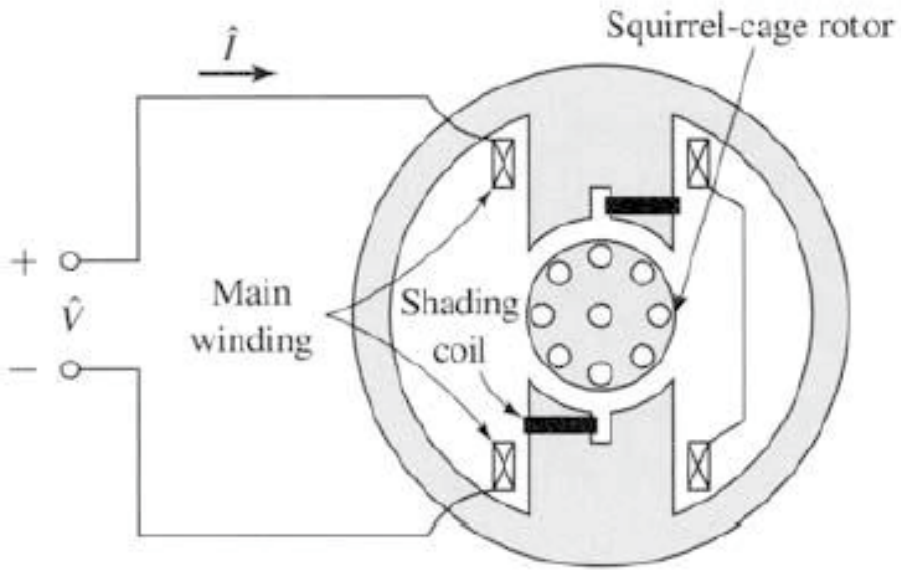


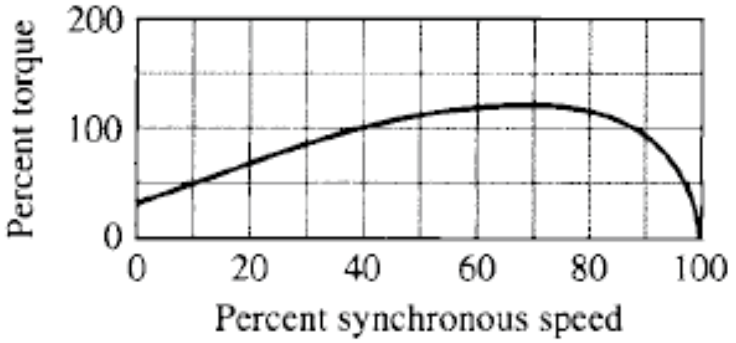


Induction Machines: 1-phase Induction Motors

Motor Types

5. Shaded-pole Motor

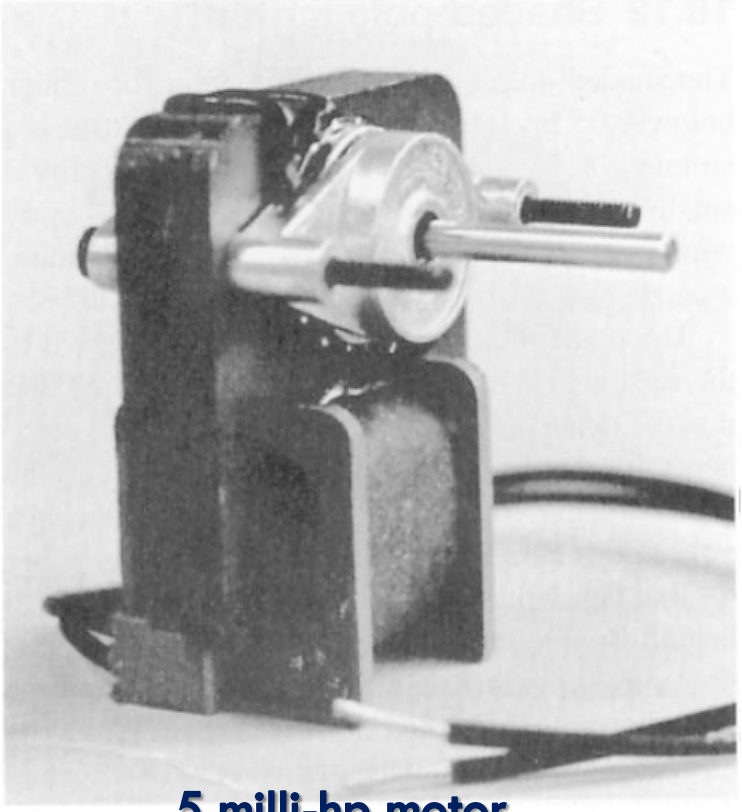




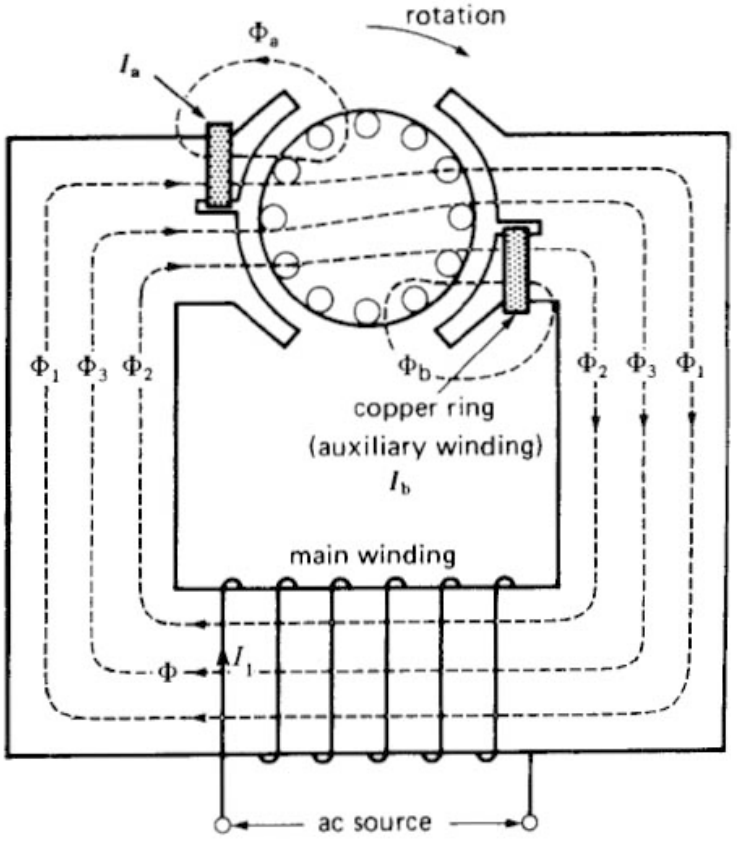
Induction Machines: 1-phase Induction Motors

Motor Types

5. Shaded-pole Motor



5 milli-hp motor

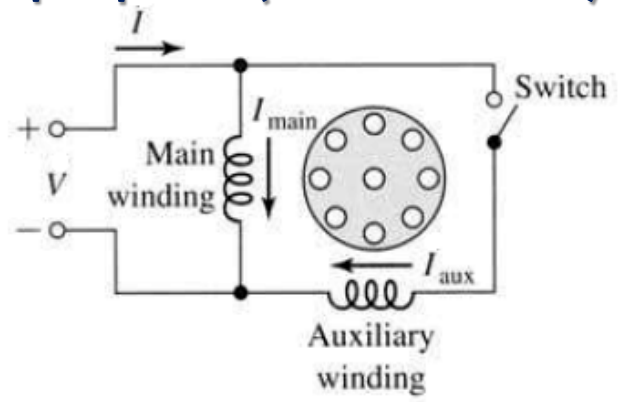


Induction Machines: 1-phase Induction Motors

Starting Winding Design

At starting (n=0, s=1)

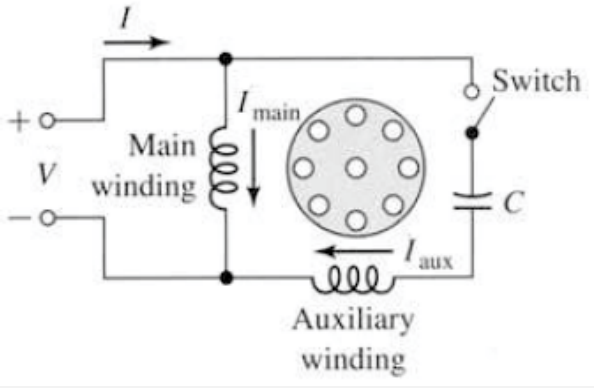
Split-phase (resistance start)



$$I_M = \frac{V}{Z_M}$$

$$I_A = \frac{V}{Z_A + R_{add}}$$

Capacitor-start



$$I_M = \frac{V}{Z_M}$$

$$I_A = \frac{V}{Z_A - jX_C}$$

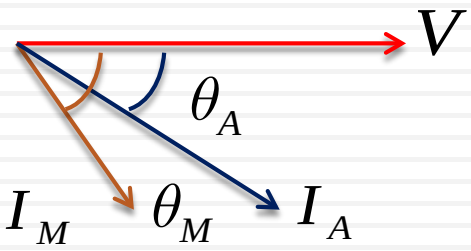
Z_M = *standstill impedance of the main winding*

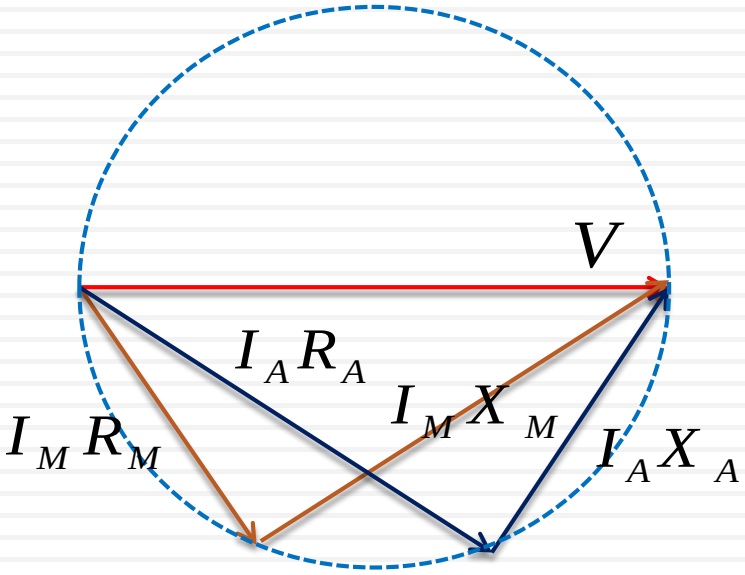
Z_A = *standstill impedance of the auxiliary winding*

Induction Machines: 1-phase Induction Motors

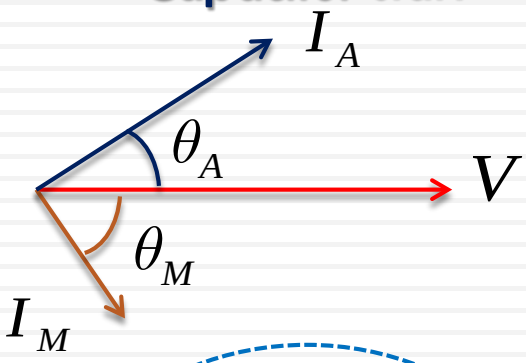
Starting Winding Design

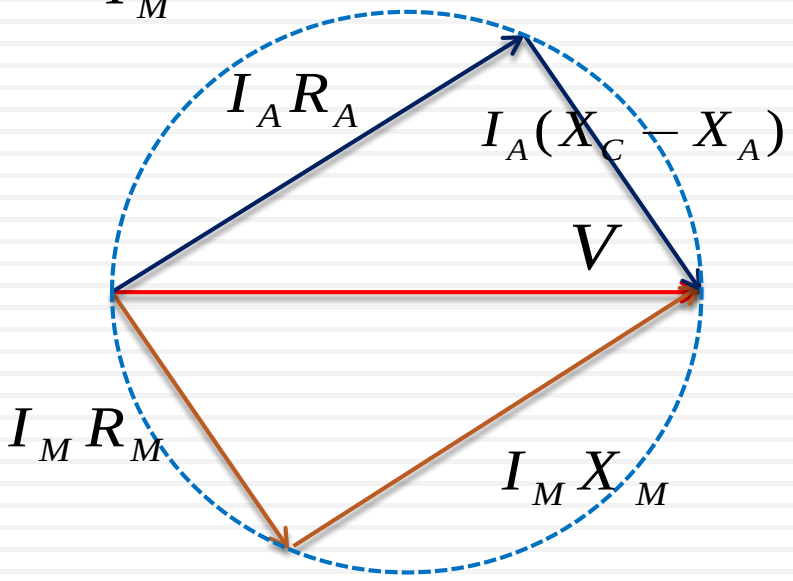
Split-phase (resistance start)





Capacitor-start





Induction Machines: 1-phase Induction Motors

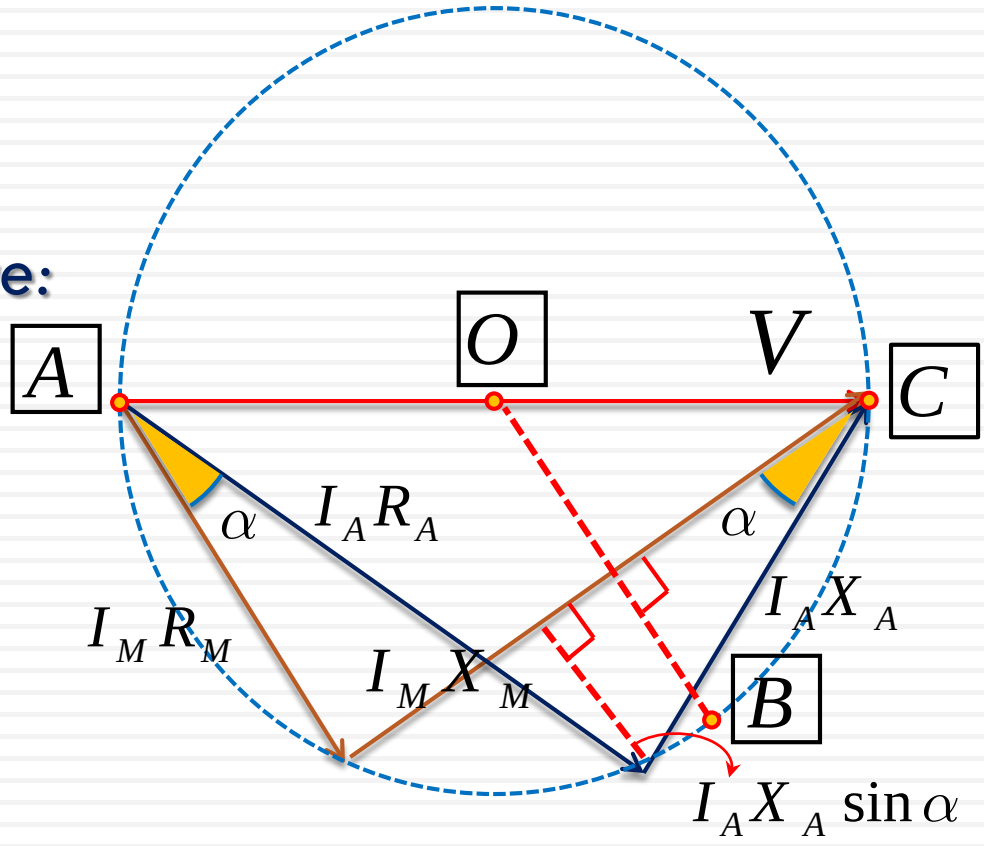
Starting Winding Design

1. Design of Resistance-Start Motors

$$T_{st} \propto I_A \sin\alpha$$

For max. starting torque:

$$\frac{AB}{BC} = \frac{R_A + R_{Add}}{X_A}$$



Induction Machines: 1-phase Induction Motors

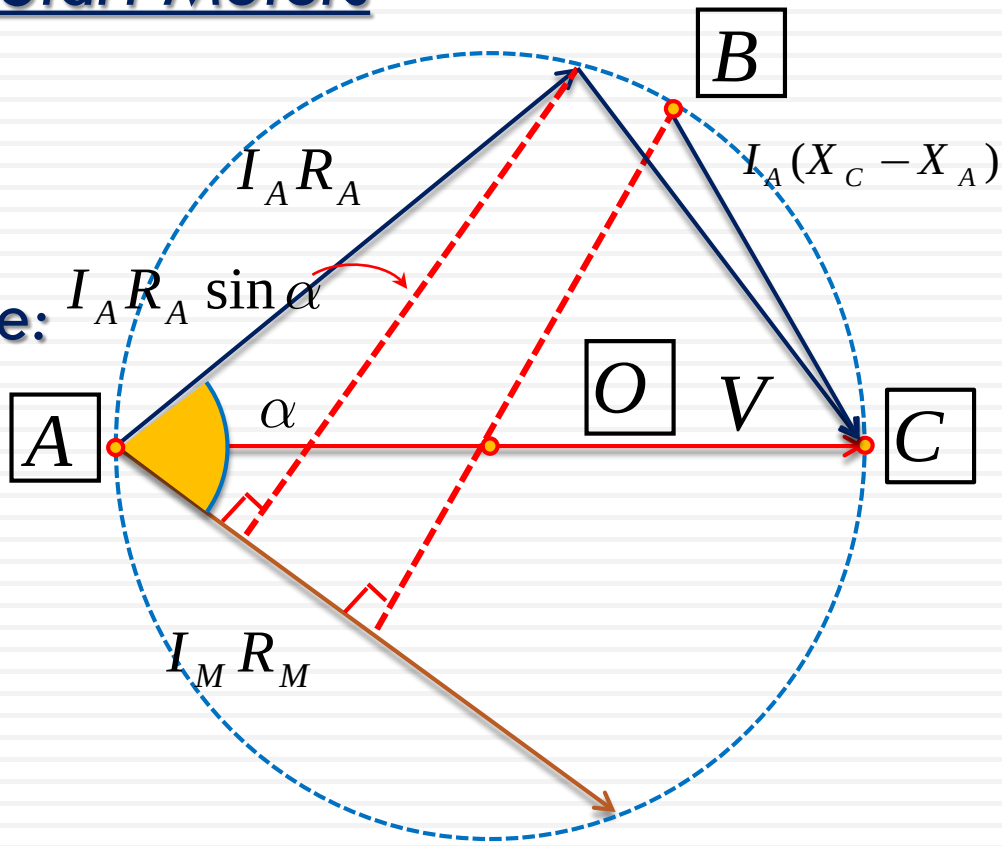
Starting Winding Design

2. Design of Capacitor-Start Motors

$$T_{st} \propto I_A \sin\alpha$$

For max. starting torque:

$$\frac{BC}{AB} = \frac{X_C - X_A}{R_A}$$



Induction Machines: 1-phase Induction Motors

Testing: 1. Locked Rotor (Standstill) Test

Voltage is adjusted such that stator current ≤ full load current

Main winding only is connected

Reduced Voltage

W_{LR}

$$W_{LR} = P_{cu1} + P_{cu2}$$

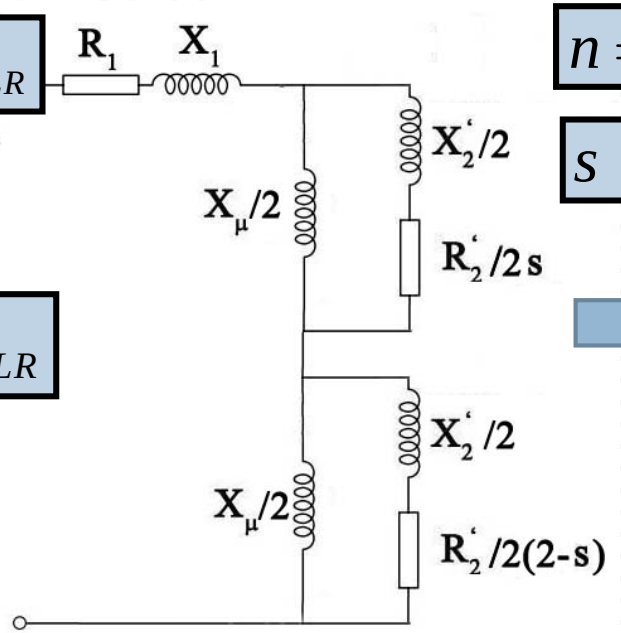
$$W = I_{LR}^2 R_{LR}$$

$$R_{LR} = R_1 + R_2^{'}$$

$$R_1 = R_2^{'} = \frac{R_{LR}}{2}$$

I_{LR}

V_{LR}

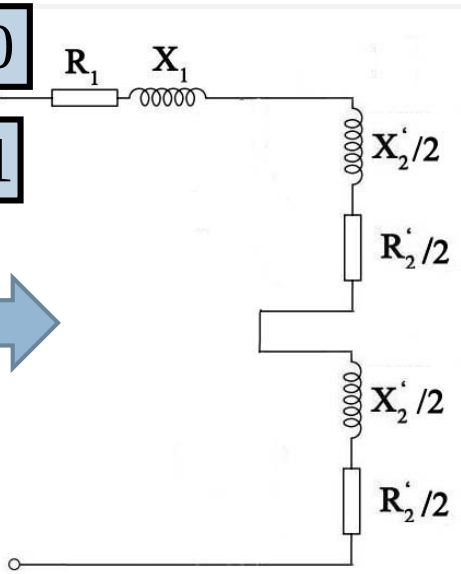


$$Z_{LR} = \frac{V_{LR}}{I_{LR}}$$

$$Z_{LR} = \sqrt{R_{LR}^2 + X_{LR}^2}$$

$n = 0$

$s = 1$



$$X_{LR} = X_1 + X_2^{'}$$

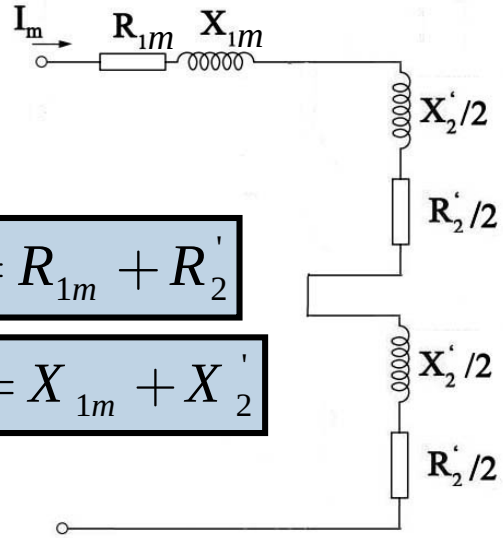
$$X_1 = X_2^{'} = \frac{X_{LR}}{2}$$

Induction Machines: 1-phase Induction Motors

Testing: 1. Locked Rotor (Standstill) Test

To get the standstill impedances of the main and auxiliary windings, this test is performed on each winding individually.

Main Winding only connected to the supply

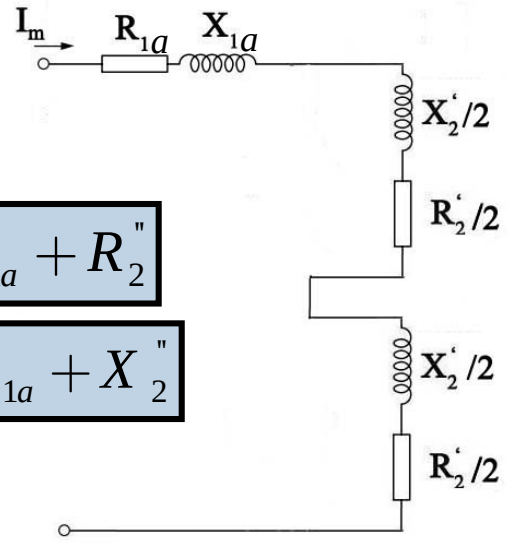


$$R_M = R_{1m} + R_2'$$

$$X_M = X_{1m} + X_2'$$

$$Z_M = R_M + jX_M$$

Aux.Winding only connected to the supply



$$R_A = R_{1a} + R_2''$$

$$X_A = X_{1a} + X_2''$$

$$Z_A = R_A + jX_A$$

Induction Machines: 1-phase Induction Motors

Testing: 2. No-Load Test

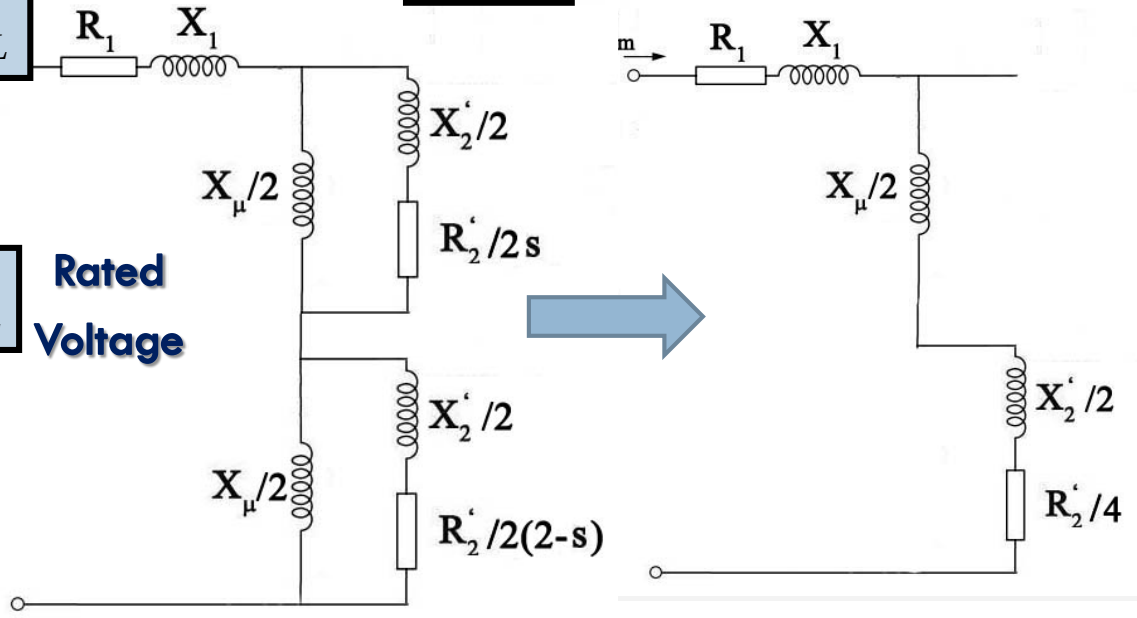
$$W_{NL} = P_{mech} + P_{cu1}$$

I_{NL}

W_{NL}

V_{NL} Rated Voltage

$s \approx 0$



$$P_{cu1} = I_{NL}^2 (R_1 + \frac{R_2^{'}}{4})$$

P_{mech}

$$Z_{NL} = \frac{V_{NL}}{I_{NL}}$$

$$Z_{NL} = \sqrt{R_{NL}^2 + X_{NL}^2}$$

$$X_{NL} = X_1 + \frac{X_2^{'}}{2} + \frac{X_\mu}{2}$$

$$X_\mu = 2 \times (X_{NL} - X_1 - \frac{X_2^{'}}{2})$$