LECTURE 5

OVERVIEW OF SINGLE PHASE IM

- Construction : similar to 3ϕ induction motor
- A single-phase motor is a rotating machine that has both main and auxiliary windings and a squirrel-cage rotor.
- Supplying of both main and auxiliary windings enables the single-phase machine to be driven as a two-phase machine.

OVERVIEW OF SINGLE PHASE IM

- Home air conditioners
- Kitchen fans
- Washing machines
- Industrial machines
- Compressors
- Refrigerators

OVERVIEW OF SINGLE PHASE IM

- Types of 1ϕ induction Motor
  - Split Phase Motor
  - Capacitor Start Motors
  - Capacitor Start, Capacitor Run
  - Shaded Pole Induction Motor
  - Universal Motor (ac series motors)

Note:

<u>*At stator*</u>: $n_s = \frac{120f}{p}$

$$\therefore f = \frac{n_s p}{120} \qquad .....(i)$$

<u>*At Rotor*</u>: $n_s - n_r = \frac{120f}{p}$

$$\therefore f = \frac{(n_s - n_r)p}{120} \qquad .....(ii)$$

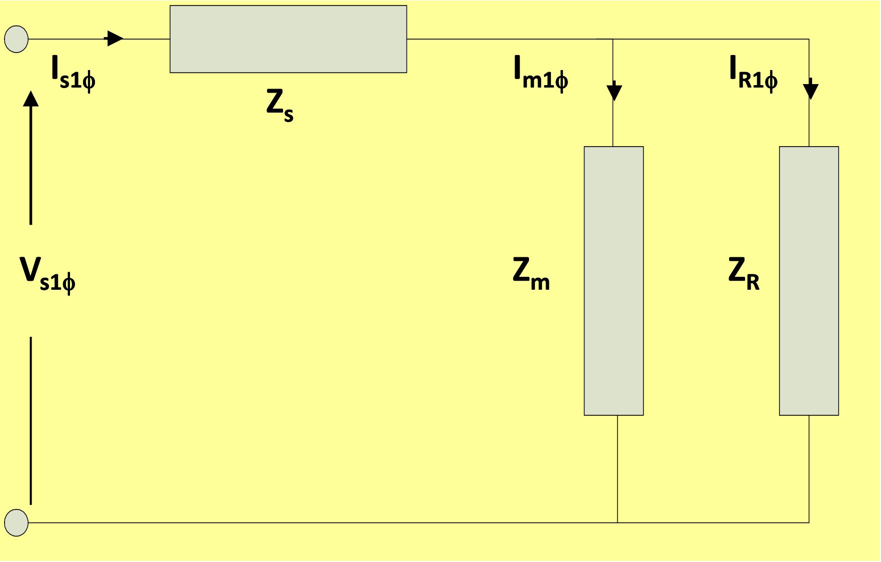
<u>$(ii) \div (i)$</u>: $f_r = s.f$

Analysis of Induction Machines

- For simplicity, let assume

$$I_s = I_1 \quad , \quad I_R = I_2$$

(s=stator, R=rotor)



$$Z_R = \frac{R_R'}{s} + jX_R' \quad ;$$

$$Z_m = R_c \, // \, jX_m \quad ; R_c \neq neglected$$

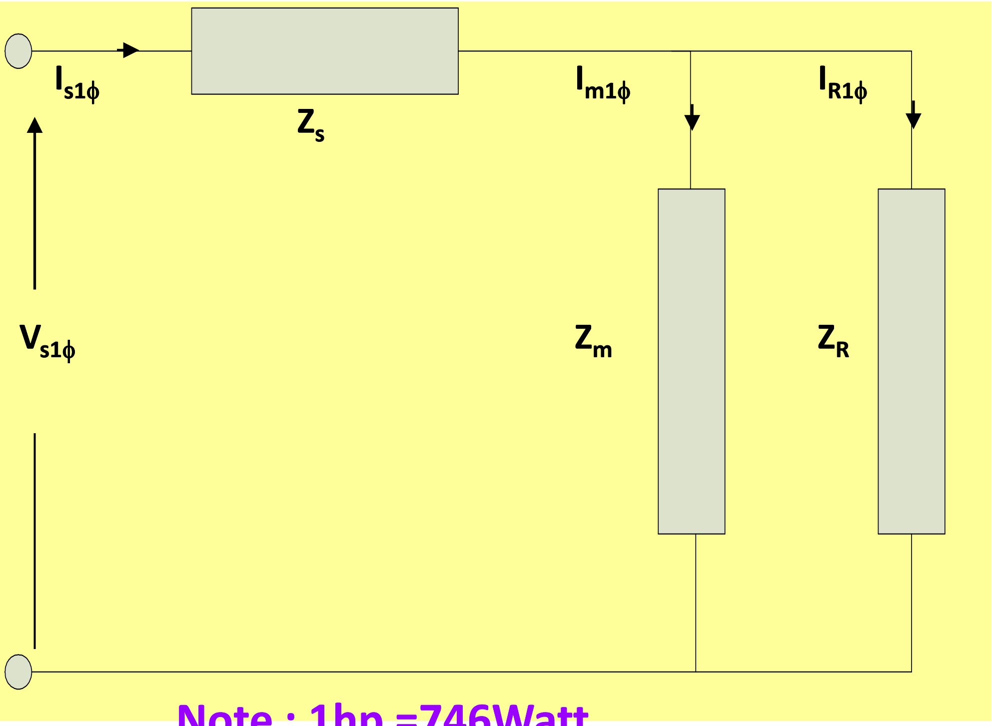
$$Z_m = jX_m \quad ; R_c = neglected$$

$$Z_s = R_s + jX_s \quad ;$$

$$Z_{Total} = Z_s + \left[Z_m \, // \, Z_R \right]$$

$$I_{s1\phi} = \frac{V_{s\,1\phi}}{Z_T}$$

Analysis of Induction Machines



Note : 1hp =746Watt

Current Dividing Rules,

$$I_{m1\phi} = \left[\frac{Z_R}{Z_m + Z_R} \right] I_{s1\phi}$$

$$I_{R1\phi} = \left[\frac{Z_m}{Z_m + Z_R} \right] I_{s1\phi}$$

OR

Voltage Dividing Rules,

$$V_{RM\,1\phi} = \left[\frac{Z_R \,//\, Z_m}{Z_T} \right] V_{s1\phi}$$

Hence,

$$I_{R1\phi} = \left[\frac{V_{RM\,1\phi}}{Z_R} \right]$$

$$I_{m1\phi} = \left[\frac{V_{RM\,1\phi}}{Z_m} \right]$$

EXAMPLE 1

A 4 poles, 3ϕ Induction Motor operates from a supply which frequency is 50Hz. Calculate:

a. The speed at which the magnetic field is rotating
b. The speed of the rotor when slip is 0.04
c. The frequency of the rotor when slip is 3%.
d. The frequency of the rotor at standstill

EXAMPLE 2

A 500hp, 3ϕ 6 poles, 50Hz Induction Motor has a speed of 950rpm on full load. Calculate the slip.

EXAMPLE 3

A 440V, 50Hz, 6 poles, Y connected induction motor is rated at 135hp. The equivalent circuit parameters are :

$R_s = 0.084\Omega$ $R_R' = 0.066\Omega$

$X_s = 0.2\Omega$ $X_R' = 0.165\Omega$

$s = 5\%$ $X_m = 6.9\Omega$

Determine the stator current, magnetism current and rotor current.

Solution

Given V=440V, p=6, f=50Hz, 135hp

$$[177.6\angle -24.34^o\,A, 170.44\angle -13.76^o\,A, 32.85\angle -96.63^o\,A]$$

Efficiency

$$\eta = \frac{P_{out}}{P_{in}} \times 100\%$$

$$if\ \ P_{losses}\ are\ given,$$

$$P_o = P_{in} - P_{losses}$$

$$P_o = P_m - P_\mu$$

$$otherwise,$$

$$P_{in} = \sqrt{3}\, V_s I_s \cos\theta$$

$$P_{out} = x\,hp \times 746W = 746x\ Watt$$