INDUCTION MOTOR-I (ASYNCHRONOUS MOTOR)

UNIT-III

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CONTENTS

Equivalent circuit

Lecture No. 4

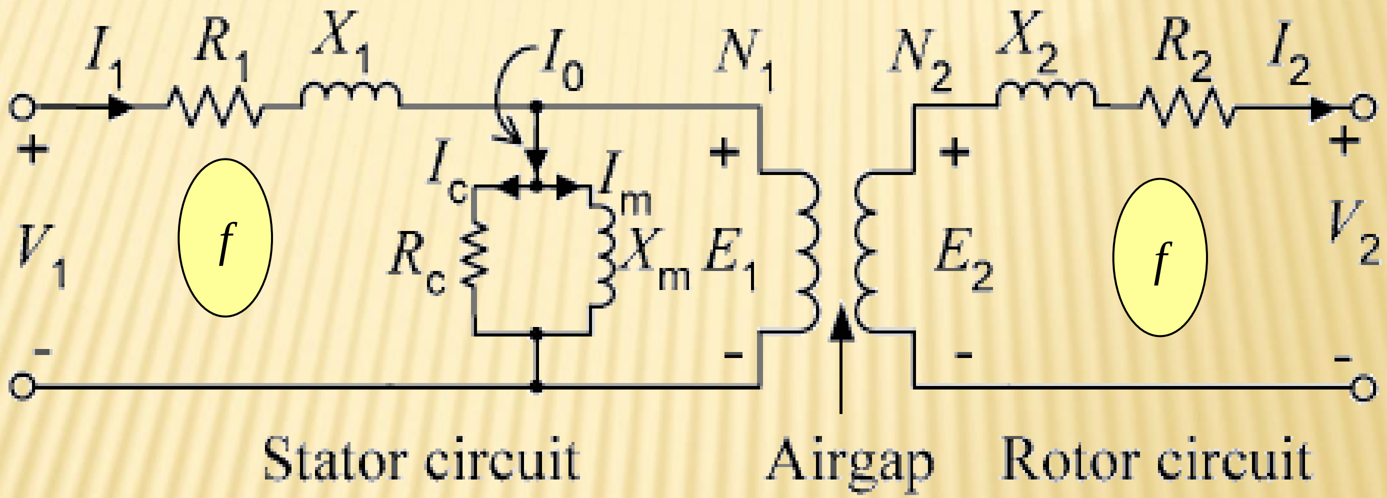
EQUIVALENT CIRCUIT OF INDUCTION MACHINES

- **Conventional equivalent circuit**
  - *Note:*
    - *Never use three-phase equivalent circuit. Always use per-phase equivalent circuit.*
    - *The equivalent circuit always bases on the Y connection regardless of the actual connection of the motor.*
    - *Induction machine equivalent circuit is very similar to the single-phase equivalent circuit of transformer. It is composed of stator circuit and rotor circuit*

EQUIVALENT CIRCUIT OF INDUCTION MACHINES

- **Step1 Rotor winding is open**

(The rotor will not rotate)



- Note:
  - The frequency of E_2 is the same as that of E_1 since the rotor is at standstill. At standstill s=1.

EQUIVALENT CIRCUIT OF INDUCTION MACHINES

V_1 – stator voltage, per phase ($V_1 = V_{LL}/\sqrt{3}$)

R_1, R_2 – stator and rotor winding resistance

$X_1 = 2\pi f_1 L_1$ – stator leakage reactance

$X_2 = 2\pi f_1 L_2$ – rotor leakage reactance

R_c – resistance representing core loss, per phase

X_m – magnetizing reactance, per phase

N_1, N_2 – effective number of turns of stator and rotor windings.

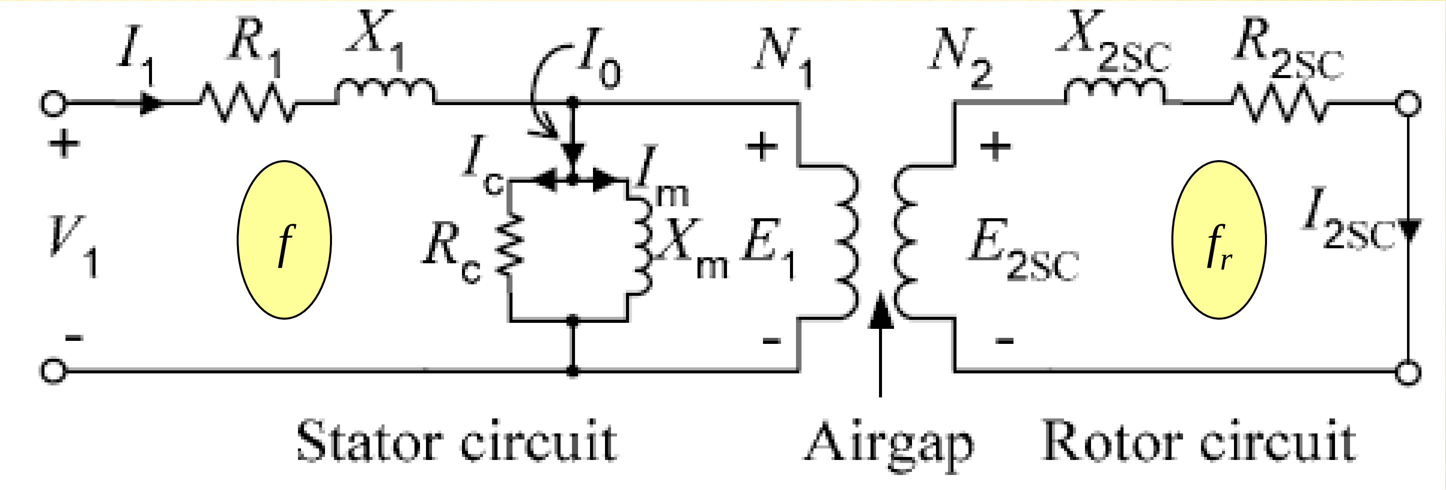
$E_1 = 4.44 f_1 N_1 \Phi$, where Φ is flux per pole

$E_2 = 4.44 f_1 N_2 \Phi$

EQUIVALENT CIRCUIT OF INDUCTION MACHINES

- **Step2: Rotor winding is shorted**

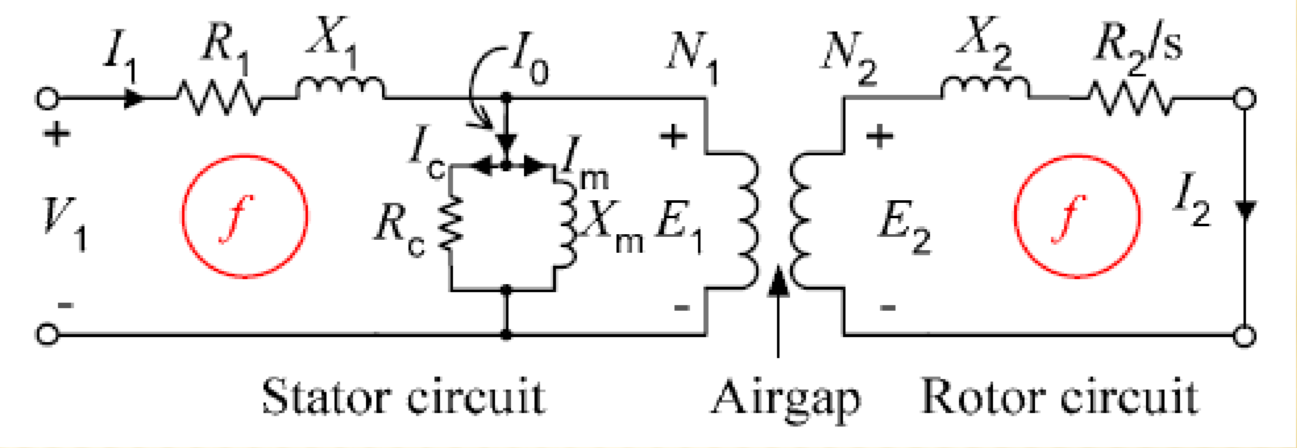
  (Under normal operating conditions, the rotor winding is shorted. The slip is *s*)



- Note:
  - The frequency of E_2 is $f_r = sf$ because rotor is rotating.

EQUIVALENT CIRCUIT OF INDUCTION MACHINES

- **Step3: Eliminate f_2**

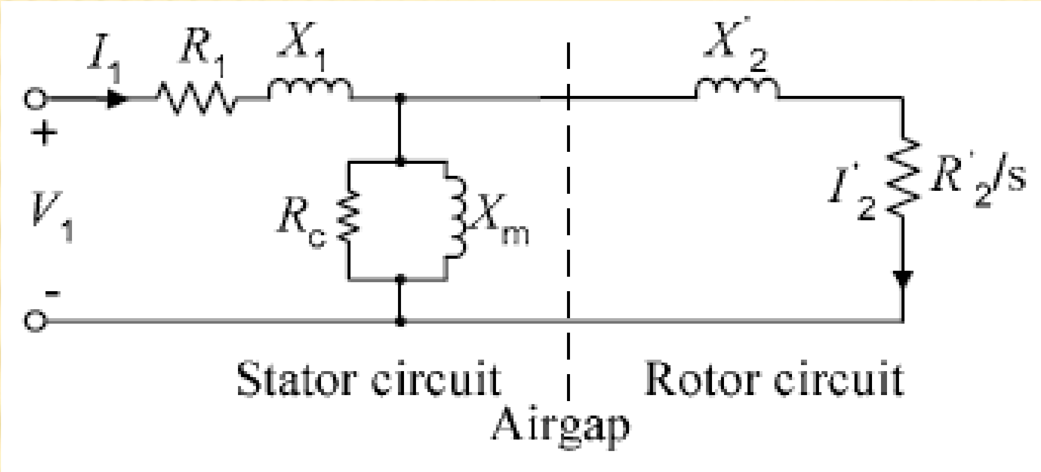


Keep the rotor current same:

$$I_{2sc} = \frac{E_{2sc}}{R_{2sc} + jX_{2sc}} = \frac{sE_2}{R_2 + jsX_2} = \frac{E_2}{\frac{R_2}{s} + jX_2} = I_2$$

EQUIVALENT CIRCUIT OF INDUCTION MACHINES

- **Step 4: Referred to the stator side**



$$X_2' = a^2 X_2,$$

$$R_2' = a^2 R_2,$$

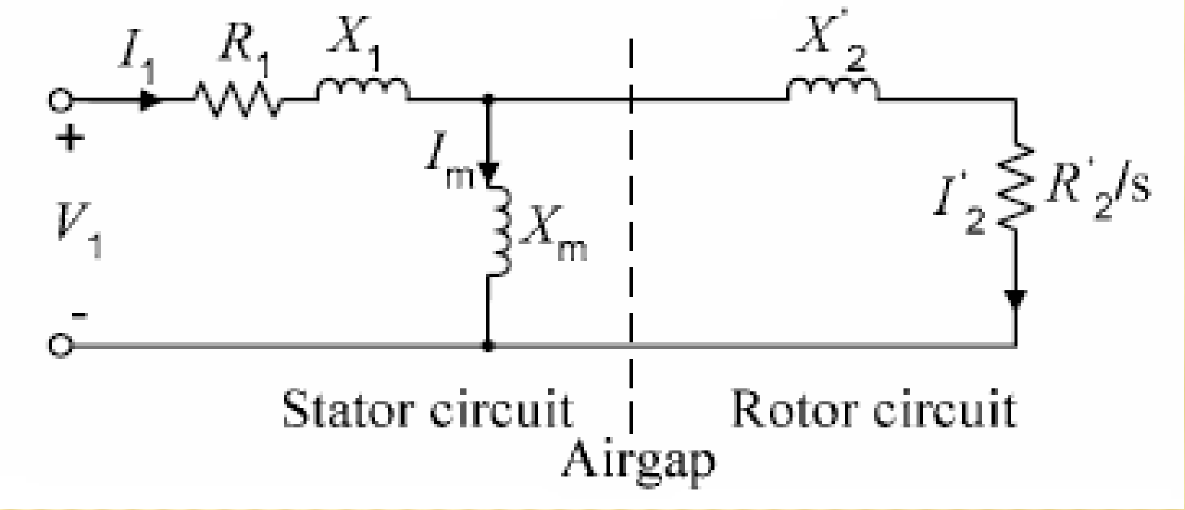
$$I_2' = \frac{1}{a} I_2,$$

$$\text{where } a = \frac{N_1}{N_2}$$

- Note:
  - X'_2 and R'_2 will be given or measured. In practice, we do not have to calculate them from above equations.
  - Always refer the rotor side parameters to stator side.
  - R_c represents core loss, which is the core loss of stator side.

EQUIVALENT CIRCUIT OF INDUCTION MACHINES

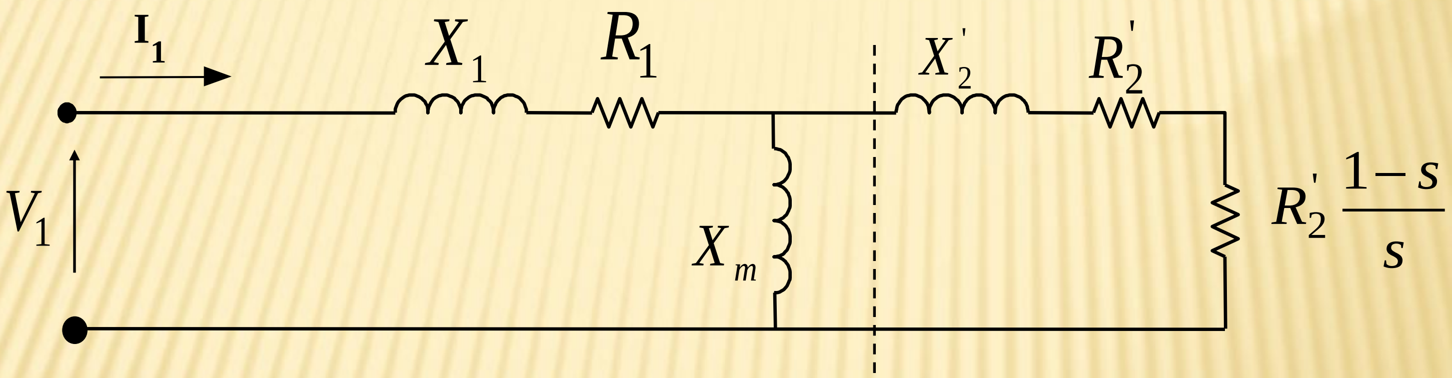
- **IEEE recommended equivalent circuit**



- Note:
  - R_c is omitted. The core loss is lumped with the rotational loss.

EQUIVALENT CIRCUIT OF INDUCTION MACHINES

- **IEEE recommended equivalent circuit**



- **Note: $\frac{R_2}{s}$ can be separated into 2 PARTS**

$$\frac{R_2}{s} = R_2 + \frac{R_2(1-s)}{s}$$

- **Purpose :**
  - **to obtain the developed mechanical torque**

EQUIVALENT CIRCUIT

We can rearrange the equivalent circuit as follows