Electromagnetic System

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- Magneto motive force

$$\boxed{\text{MMF} = \text{Number of turns in the coil x current}}$$

- Magnetic flux

$$\boxed{\phi = \frac{\text{MMF}}{\text{Reluctance}}}$$

- Reluctance
  - Opposition offered by the magnetic flux is called Reluctance.

$$\boxed{Rl = \frac{l}{\mu A}}$$

where, Rl = Reluctance

l = Length of magnetic path, meter

A = Area of cross-section normal to flux path, m^2

$\mu = \mu_0\mu_r$ = Permeability of the magnetic material

μ_r = Relative permeability of the magnetic material

- Self inductance
  - The self-inductance L is defined as the magnetic flux-linkages per ampere

$$\boxed{L = \frac{\Psi}{I}}$$

- Magnetic flux density

$$\boxed{B = \frac{\text{Magnetic flux, } \phi}{\text{Cross-section area, } A}} \text{ Tesla or Wb/m}^2$$

- Magnetic field intensity

$$\boxed{H = \frac{\text{MMF}}{\text{mean length of magnetic circuits}}}$$

$$\boxed{H = \frac{\text{MMF}}{l}} \text{ AT/m}$$

- Relation between magnetic flux density and field intensity

$$\boxed{B = \mu H}$$

- Energy density in electric field

$$\boxed{\omega_{f/d} = \int_0^D E \cdot dD = \frac{1}{2}\frac{D^2}{\epsilon_0}}$$

where, D = Electric field flux density

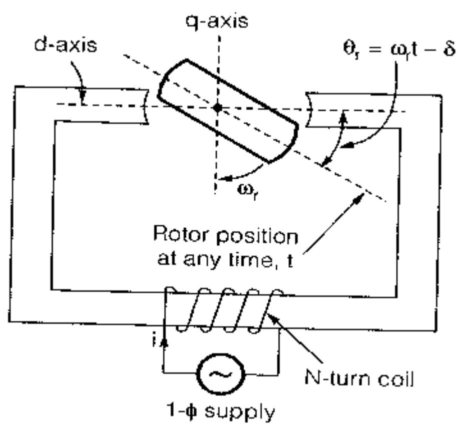
E = Electric field intensity or potential gradient

$$E = \frac{D}{\epsilon_0}$$

Reluctance Motor

- Reluctance at space angle θ_r

$$\boxed{\mathcal{R}l = \mathcal{R}l_q \sin^2\theta_r + \mathcal{R}l_d \cos^2\theta_r}$$



where, $\mathcal{R}l_q$ = quadrature-axis reluctance

$\mathcal{R}l_d$ = direct-axis reluctance

θ_r = space angle between stator d-axis and long rotor axis

- Torque

$$\boxed{T_e = -\frac{1}{2}\phi^2 \frac{d\mathcal{R}l}{d\theta_r}}$$

$$\boxed{T_e = -\frac{1}{2}\phi^2 (\mathcal{R}l_q - \mathcal{R}l_d)\sin 2\theta_r}$$

- Space angle

$$\boxed{\theta_r = \omega_r t - \delta}$$

where, δ = rotor position from stator d-axis at t = 0 or load angle

- Direct-axis inductance

$$\boxed{L_d = \frac{N^2}{\mathcal{R}l_d}}$$

- Quadrature-axis inductance

$$\boxed{L_q = \frac{N^2}{\mathcal{R}l_q}}$$

- Average torque

$$\boxed{T_{e(av)} = \frac{1}{8}\phi_{max}^2 (\mathcal{R}l_q - \mathcal{R}l_d)\sin 2\delta}$$

$$\boxed{T_{e(av)} = \frac{V_t^2}{4\omega}\left(\frac{1}{X_q} - \frac{1}{X_d}\right)\sin 2\delta}$$

$$\boxed{T_{e(av)} = \frac{V_t}{4\omega}(I_q - I_d)\sin 2\delta}$$

where, I_d, I_q = Current taken from the supply when the rotor is held in minimum and maximum reluctance position.

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