



#### POWER SYSTEM ANALYSIS

#### UNIT - I

#### PERMANENT MAGNET BRUSHLESS DC MOTOR

**Torque Equation of PMLDC Motor**  
**Starting Condition.**

Under starting condition, speed is zero.  
and back emf also zero.

$$I_{st} = \frac{V}{2R_{ph}} \quad (\text{starting current})$$

If  $V_{dd}$  is given, then

$$I_{st} = \frac{V + V_{dd}}{2R_{ph}}$$

**No load Condition**

Under no load, current is negligible

$$V = 2 e_{ph0}$$

where  $e_{ph0}$  = back emf generated under no load condition.

$$V = 2 [2 B_g r l T_{ph}] \omega_{m0}$$
$$V = [4 B_g r l T_{ph}] \omega_{m0}$$

$$V = k_m \omega_{m0}$$

From the above equations, The no load speed is given by

$$\omega_{m0} = \frac{V}{k_m}$$

ON-load Condition

$$V = 2e_{ph} + 2I R_{ph}$$

$$I = \frac{V - 2e_{ph}}{2R_{ph}}$$

$$\begin{aligned} 2e_{ph} &= 2 [2 B_g r l T_{ph}] \omega_m \\ &= [4 B_g r l T_{ph}] \omega_m \\ &= k_m \omega_m \end{aligned}$$

$$I = \frac{V - k_m \omega_m}{2R_{ph}}$$

From the above equations,  $\omega_m$  is given by

$$I 2R_{ph} = V - k_m \omega_m$$

$$I 2R_{ph} - V = -k_m \omega_m$$

$$\omega_m = \frac{V - I 2R_{ph}}{k_m}$$

$$T_{\text{torque}} = \frac{P_m}{\omega_m}$$

Power input to the motor is given by  $VI$

$$VI = [2E_{ph} + 2I R_{ph} + 2V_{dd}] I$$

$$= 2IE_{ph} + 2I^2 R_{ph} + 2IV_{dd}$$

Where

$VI$  = Electrical I/p power

$2IE_{ph}$  = Power converted as mechanical

$2I^2 R_{ph}$  = Resistive loss (or copper loss)

$2V_{dd} I$  = Power loss in device

$$P_m = 2 [2 B_g r l T_{ph} \omega_m] I$$

$$= 4 B_g r l T_{ph} \omega_m I \quad \text{--- (1)}$$

$$T_{\text{torque developed}} = \frac{4 B_g r l T_{ph} \omega_m I}{\omega_m}$$

$$T = 4 B_g r l T_{ph} I$$

$$T = k_m I$$

Under starting condition

$$T_{st} = k_m I_{st}$$

### Speed Ratio

Defined as ratio between Under load speed to no-load speed.

$$SR = \frac{\omega_m}{\omega_{no}}$$

$$= \frac{V - 2IR_{pa}}{V}$$

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$$SR = 1 - \frac{2IR_{pa}}{V}$$

### Torque Ratio (TR)

$$TR = \frac{T}{T_{st}} = \frac{k_m I}{k_m I_{st}}$$

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