Solutions for EE461 Midterm Exam2 26/5/21

1- Considering the following equations that are used in DC machines,

$T = K\phi I_a$, $E_g = K\phi\omega$

ω : rad/sec $\Rightarrow K\phi$: $\frac{V.sec}{rad}$

In question 1, $K\phi = 0.042$ V/rpm

0.042 V/rpm is converted to $\frac{V.sec}{rad}$ as,

$\frac{30}{\pi} \times 0.042 = 0.4$ $\frac{V.sec}{rad}$

Therefor, $K\phi = 0.4$ will be used in solving the problem.

a) At no-load (when the rotational losses are neglected) $\Rightarrow I_a = 0$

$KV_d = R_a I_a + E_g = 1.2 \times 0 + E_g = 120$

$K\phi\omega = 120 \Rightarrow \omega = \frac{120}{0.4} = 300$ rad/sec

$n = \omega \times \frac{30}{\pi} = 2865$ rpm

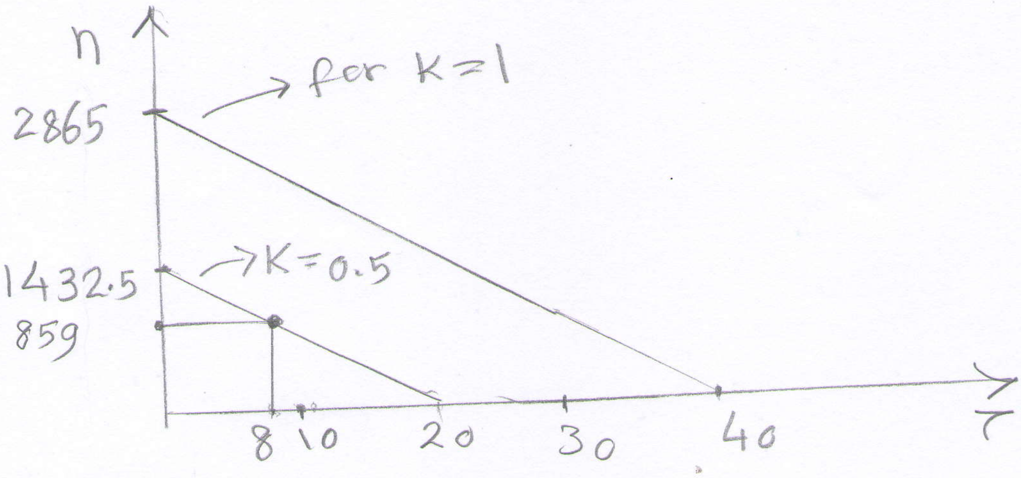
At the time of starting $n = \omega = 0 \Rightarrow E_g = 0$

$KV_d = R_a I_a + 0 \Rightarrow I_{ast} = \frac{1 \times 120}{1.2} = 100$ A

$T = K\phi I_a = 0.4 \times 100 = 40$ A

b– $n\ (T=0) = 2865\ rpm$

$T\ (n=0) = 40\ N.m.$



c– $KV_d = R_a I_a + K\Phi\omega$

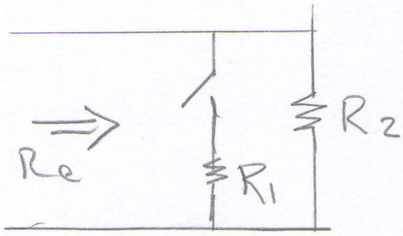
$0.5 \times 120 = 1.2 \times \frac{T}{K\Phi} + K\Phi\omega$

$60 = 1.2 \times \frac{8}{0.4} + 0.4\omega \Rightarrow \omega = 90\ rad/sec$

$n = 90 \times \frac{30}{\pi} = 859\ rpm$

2-

Firstly, We derive the equivalent resistance



During on state the input resistance $= R_1 \| R_2$

" off " " " " $= R_2$

$$\Rightarrow R_e = K\, R_1 \| R_2 + (1-K) R_2 = \frac{K R_1 R_2}{R_1 + R_2} + \frac{(1-K) R_2}{1}$$

$$R_e = \frac{\cancel{K R_1 R_2} + R_1 R_2 + R_2^2 - \cancel{K R_1 R_2} - K R_2^2}{R_1 + R_2}$$

$$R_e = \frac{R_2^2 (1-K) + R_1 R_2}{R_1 + R_2}$$

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a) $\omega_m = 850 \times \frac{\pi}{30} = 89$ rad/sec

$T_L = 780 \left(\frac{850}{1200}\right)^2 = 391.17$ N.m

$\omega_s = 2 \times 377/4 = 188.5$

$$I_d = \frac{T_L\, \omega_s}{2.3394 V_s \eta_m}$$

$$I_d = \frac{391.17 \times 188.5}{2.3394 \times 275 \times 0.95} = 120.65$$

$$\omega_m = \omega_s (1-S) = \omega_s \left[1 - \frac{I_d R_e}{2.3394 V_s \eta_m}\right]$$

$$S = \frac{I_d R_e}{2.3394 V_s \eta_m}$$

The speed is min when K = 0
(switch is open circuit)

$$89 = 188.5\left(1 - \frac{124.93 R_2}{2.3394 \times 275 \times 0.95}\right)$$

$$\Rightarrow R_2 = 2.5823\,\Omega$$

b)

At $n_m = 1100$

$$T_L = 780\left(\frac{1100}{1200}\right)^2 = 655.42 \text{ N.m}$$

$$I_d = \frac{655.42 \times 188.5}{2.3394 \times 275 \times 0.95} = 202.15$$

c)

$$\omega_m = \frac{1100 \times \pi}{30} = 115.19 \text{ rad/sec}$$

$$115.19 = 188.5\left[1 - \frac{209.32 \times R_e}{2.3394 \times 275 \times 0.95}\right]$$

$R_e = 1.136\,\Omega$ 1.097

$$1.136 = \frac{2.5823^2(1-K) + 0.01 \times 2.5823}{0.01 + 2.5823}$$

$K = 0.5623$