RIS - LAB 2
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Lab 2 - (Task 1.4 - 1.9)

Task 1.4

We are given the following equations in the task to estimate K_t the motor torque constant:

$$\tau_m = \hat{k}_t \, i$$

$$\tau_g = \eta \, \hat{k}_t \, i \triangleq k_t \, i$$

T_m is the torque generated outside shaft without gears. Given stall current i = 5A and small torque t_m= 0.5329m we can calculate that:

$$k_t = \frac{0.5932Nm}{5A} = 0.11864NmA^{-1}$$

Task 1.5

We are given the upper limit for K_e to be;

$$k_e \leq \frac{v_a}{\omega_0}$$

Given w_0= 52.36rad/sec and V_a= 12V, we can calculate that

$$k_e \leq \frac{12V}{52.36radsec^{-1}}, \; k_e \leq 0.22918V.sec.rad^{-1}$$

With this, it is eminent that maximum K_e = 0.22918V.sec/rad

Task 1.6

We are given the equation :

$$b = \frac{k_t \, i_0}{\omega_0}$$

From the previous tasks, we have k_t= 0.11864Nm/A, the no-load speed w_o = 52.36rad/s and the no-load current i_o = 0.3A so, we can make the calculation for b as follows:

$$b = \frac{0.11864 Nm.A^{-1} \cdot 0.3A}{52.36 rad.s^{-1}} = 6.798 \cdot 10^{-4} Nms.rad^{-1}$$

Task 1.7

We are given the equation from 1.19 to be :

$$R_a = \frac{v_a}{i_s}$$

Given i_s = 5A and V = 12V in Table 1.1,

$$R_a = \frac{12V}{5A} = 2.4\Omega$$

We are given the equation from 1.18 to be :

$$v_a - iR_a - L_a\frac{di}{dt} = e \overset{(1.6)}{=} k_e\dot{\theta}_g.$$

Given Θ = w_o, i=i_o and di/dt=0, we can change the equation above as follows for k_e :

$$k = \frac{v_a - i_o \cdot R_a}{w_o}$$

Using V = 12V, i = 0.3A, w = 52.36rad/s and R = 2.4Ω, we can calculate k to be:

$$k_e = \frac{12V - 0.3A \cdot 2.4\Omega}{52.36 rad.s^{-1}} = 0.21543 sec.rad^{-1}$$

which is more accurate than the previous value k_e = 0.22918V.sec/rad from Task 1.5

Task 1.8

Using the Equation 1.17 in Laplace Domain and solving for I(s), we get the new equation to be as follows:

$$I(s) = \frac{(Js^2 + bs) \cdot \Theta g(s) + T_L(s)}{k_t}$$

Using the Equation 1.20 and solving for I(s), we get the equation to be:

$$I(s) = \frac{V_a(s) - k_e s\, \Theta g(s)}{R + L_a(s)}$$

Using the equations above from Eq. 1.17 and 1.20, we can re-arrange the equations as follows:

$$s.\Theta g(s) \cdot ((Js + b) \cdot (R_a + L_a s) + (k_e \cdot k_t)) = V_a(s) \cdot k_t - T(R_a + L_a s)$$

Given Equation 1.21a,

$$D(s) = (R_a + L_a(s)) \cdot (Js + b) + k_e \cdot k_t$$

Substituting Equation 1.21a into the cross multiplied Equations 1.17 and 1.20, we can solve and simplify Θg(s) by dividing it over sD(s) to get the final equation as follows:

$$\Theta g(s) \cdot sD(s) = V_a s \cdot k_t - T_L(R_a + L_a s)$$

$$\Theta g(s) = \frac{V_a(s)k}{sD(s)} - \frac{T_L(s) \cdot (R_a + L_a s)}{sD(s)}$$

Hence, this derivation is equal to the equation in 1.21b which was to be proved.

Task 1.9

To prove Equation 1.23 and finding parameters a and K in terms of other variables, we first take into account the Equation from 1.22a and 1.22b for $H_{wv}(s)$ and Equation 1.21a for D(s)

$$H_{wv}(s) = \frac{k_t}{D(s)}$$

$$D(s) = (R_a + L_a(s)) \cdot (Js + b) + k_e \cdot k_t$$

Substituting D(s) and considering $L_a s = 0$, we get:

$$H_{wv}(s) = \frac{k_t}{(R_a + L_a s) \cdot (Js + b) + k_e \cdot k_t}$$

$$= \frac{\frac{k_t}{RJ}}{s + \frac{b}{J} + \frac{k_e \cdot k_t}{RJ}}$$

Comparing the equation above with the original Equation from 1.23, we get K and a to be as follows with their parameters:

$$K = \frac{k_t}{R_a J} \qquad and \qquad a = \frac{b}{J} + \frac{k_e \cdot k_t}{R_a J}$$