Excelsior College – ELEC350
Module 6, Assignment 2
Chapter 8, Problem 8.5

Student Name: Daniel Scrobe **Date: 7/28/2019**

Problem 11.4 – A permanent-magnet dc motor has the following parameters: $R_a = 0.3\ \Omega$ and $k_E = k_T = 0.5$ in MKS units. For a torque of up to 10 Nm, plot its steady state torque-speed characteristics for the following values of V_a: 100 V, 75 V, and 50 V.

Key Idea: When providing more electrical-magnetic torque output for a set supply voltage to the brushes of a permanent-magnet DC motor (PMDC), the motor will spin slower. This torque-speed characteristic curve can be raised higher on the plot by providing a higher supply voltage.

Solve:

V_a (V)	ω_{rated} (rad/s)	$\omega_{full\ \mathrm{load}}$ (rad/s)
100	200	188
75	150	138
50	100	88

Module 6 - Assignment 2

Problem 11.4 - Permanent-magnet DC motor

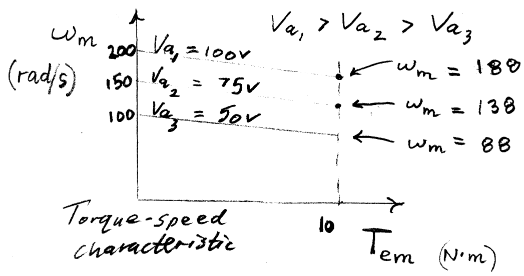
Plot steady-state characteristics for:

$V_a = 100V, 75V, 50V$

$R_a = 0.3\,\Omega$

$k_E = k_T = 0.5$ in MKS units

Torque output max = 10 N·m



rated $V_a = 100v$

ϕ_F constant at rated value

$$\omega_m = \frac{V_a - R_a(T_{em}/k_t)}{k_e} \quad \text{eq. 11.7}$$

$$\omega_m = \frac{100v - .3\Omega(T_{em}/.5)}{.5}$$

→ plotted into graphing calcutor with diff values for V_a.

Instructor's Way:

$e_a = k_E \omega_m$ eq. 11.2

when $e_a = 100V$ $\quad \omega_m = \frac{e_a}{k_e} = \frac{100v}{.5} = 200\,rad/s$ (at no load)

at a torque of 10 N·m $\quad i_a = \frac{T_{em}}{k_t} = \frac{10\,N\cdot m}{.5} = 20\,A$

ignoring L_a, $\quad e_a = V_a - R_a i_a$ (eq. 11.4) and $\omega_m = \frac{e_a}{k_e}$

$e_a = 100v - (.3\Omega)(20A)$ $\quad \omega_m = \frac{94v}{.5} = 188\,rad/s$

$= 94v$

Since a motor can vary its output torque, I can solve i_a for ½ rated torque:

$i_a = \frac{\frac{1}{2}(10\,N\cdot m)}{.5} = 10A$ $\quad \omega_m = \frac{97v}{.5} = 194\,rad/s$

$e_a = 100V - (.3\Omega)(10A)$

$= 97v$

This agree with my curves above!

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Problem 11.5 – Consider the dc motor of Problem 11.4 whose moment-of-inertia $J_m = 0.02$ kg-m^2. Its armature inductance L_a can be neglected for slow changes. The motor is driving a load of inertia $J_L = 0.04$ kg-m^2. The steady state operating speed is 400 rad/s. Calculate and plot the terminal voltage $v_a(t)$ that is required to bring this motor to a halt as quickly as possible, without exceeding the armature current of 12 A.

Key Idea: At steady state conditions, the power processing unit will have to output a voltage slightly higher than the back-emf of the motor. This causes current to flow to the motor. To stop the motor, the motor needs to decelerate its rotational movement. This requires a negative current or away from the motor. This can be done by making the terminal voltage slightly less than the back emf.

Solve:

$v_a(t) = -50t + 196.4$ (at t=0 seconds when the PPU lowers the terminal voltage)

Problem 11.5 -

Calculate & plot $v_a(t)$ required to halt the motor as quickly as possible, without exceeding armature current = 12 A

$J_m = 0.02\ Kg \cdot m^2$

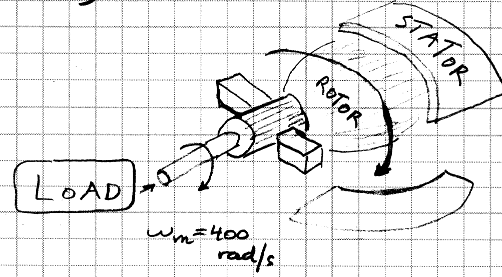
(moment-of-inertia of motor)

Neglect L_A for slow changes

$J_L = 0.04\ kg \cdot m^2$

(moment-of-inertia of load)

$\omega_{m\ (steady\ state)} = 400\ rad/s$



At steady state:

$$\frac{d\omega_m}{dt} = 0 = \frac{1}{J_{eq}}(T_{em} - T_L) = \frac{0}{J_m + J_L}$$

To stop motor, load torque = 0 and T_{em} = negative

$i_a = -12A$ opposite direction

$T_{em} = (.5)(-12A)$

$= -6$

To make i_a negative, you need a lower v_a

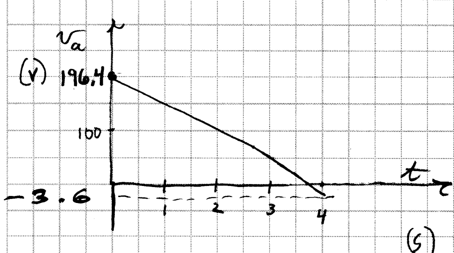
at $t=0$

$v_a = e_a + R_a i_a$ (neglect L_a)

$= 200V + (.3)(-12A)$

$= 196.4V$

$$\frac{d\omega_m}{dt} = -\frac{6}{.02 + .04} = \frac{-100\ rad/s}{s}$$ → Motor will stop in 4 seconds

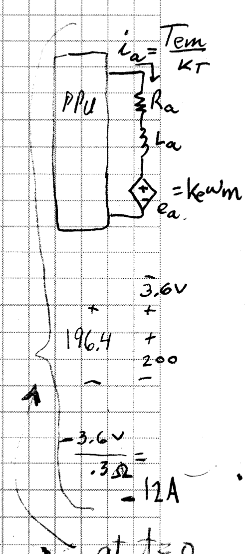


at $t=0$

$e_a = K_E\ \omega_m$

$= (.5)(400\ rad/s)$

$e_a = 200V$



$y = mx + b$

$y = -\frac{200}{4}x + 196.4$

$y = -50x + 196.4$

$v_a(t) = -50t + 196.4$

at $t=4s$: there is no induced emf since the motor has stopped.

$v_a = e_a + R_a i_a$

$= 0V + (.3)(-12A)$

$= -3.6V$