Shunt motor: terminal characteristic – Example

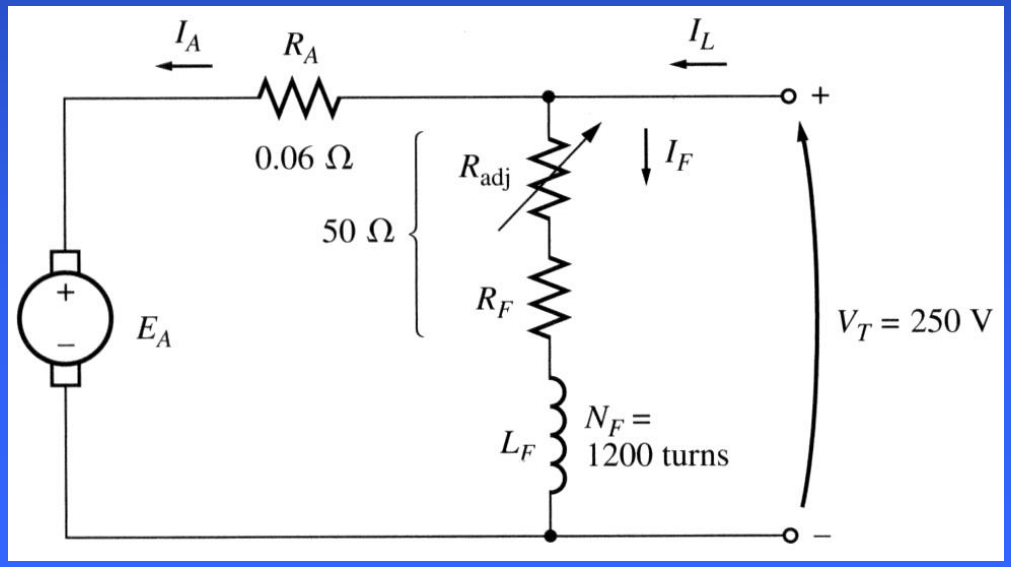
Example 9.1: A 50 hp, 250 V, 1200 rpm DC shunt motor **with** compensating windings has an armature resistance (including the brushes, compensating windings, and interpoles) of 0.06 Ω. Its field circuit has a total resistance $R_{adj} + R_F$ of 50 Ω, which produces a no-load speed of 1200 rpm. The shunt field winding has 1200 turns per pole.

a) Find the motor speed when its input current is 100 A.

b) Find the motor speed when its input current is 200 A.

c) Find the motor speed when its input current is 300 A.

d) Plot the motor torque-speed characteristic.



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The internal generated voltage of a DC machine (with its speed expressed in rpm):

$$E_A = K\phi\omega$$

Since the field current is constant (both field resistance and V_T are constant) and since there are no armature reaction (due to compensating windings), we conclude that the flux in the motor is constant. The speed and the internal generated voltages at different loads are related as

$$\frac{E_{A2}}{E_{A1}} = \frac{K\phi\omega_2}{K\phi\omega_1} = \frac{n_2}{n_1}$$

Therefore:

$$n_2 = \frac{E_{A2}}{E_{A1}} n_1$$

At no load, the armature current is zero and therefore $E_{A1} = V_T = 250$ V.

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a) Since the input current is 100 A, the armature current is

$$I_A = I_L - I_F = I_L - \frac{V_T}{R_F} = 100 - \frac{250}{50} = 95\ A$$

Therefore: $$E_A = V_T - I_A R_A = 250 - 95 \cdot 0.06 = 244.3 V$$

and the resulting motor speed is:

$$n_2 = \frac{E_{A2}}{E_{A1}} n_1 = \frac{244.3}{250} 1200 = 1173\ rpm$$

b) Similar computations for the input current of 200 A lead to n_2 = 1144 rpm.

c) Similar computations for the input current of 300 A lead to n_2 = 1115 rpm.

d) To plot the output characteristic of the motor, we need to find the torque corresponding to each speed. At no load, the torque is zero.

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Since the induced torque at any load is related to the power converted in a DC motor:

$$P_{conv} = E_A I_A = \tau_{ind} \omega$$

the induced torque is $$\tau_{ind} = \frac{E_A I_A}{\omega}$$

For the input current of 100 A: $$\tau_{ind} = \frac{2443 \cdot 95}{2\pi \cdot 1173/60} = 190\ N\text{-}m$$

For the input current of 200 A: $$\tau_{ind} = \frac{2383 \cdot 195}{2\pi \cdot 1144/60} = 388\ N\text{-}m$$

For the input current of 300 A: $$\tau_{ind} = \frac{2323 \cdot 295}{2\pi \cdot 1115/60} = 587\ N\text{-}m$$

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The torque-speed characteristic of the motor is: