c) $I_L = 300A \Rightarrow I_A = 300 - 5 = 295A$

$E_A = 250 - 0.06 \times 295 = 232.3V$

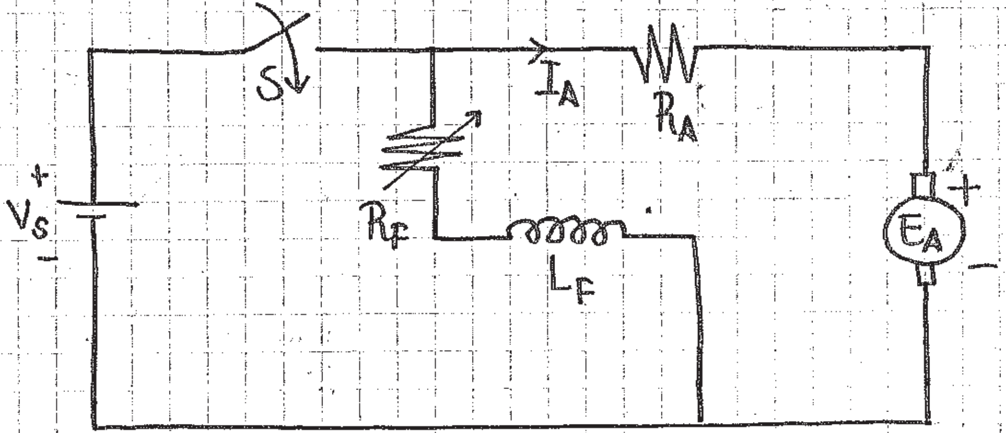
$$\frac{1200}{n_2} = \frac{250}{232.3} \Rightarrow n_2 = 1115 rpm$$

	n(rpm)
$I_A = 0$ (no load)	1200
$I_A = 100$	1173
$I_A = 200$	1144
$I_A = 300$	1115

6 Nisan Çarşamba 2011

Starters in DC Motors:

The starting current of DC motors is very high and should be limited to obtain a proper operation.



Switch S is closed at $t = 0$

$$V_S = R_A I_A + E_A \Rightarrow I_A = \frac{V_S - E_A}{R_A}$$

$$E = K\phi\omega \Rightarrow I_A = \frac{V_S - K\phi\omega}{R_A}$$

At starting $n = 0$ or $\omega = 0 \Rightarrow E_A(t = 0^+) = 0$

** $I_A = \frac{V_S}{R_A} \Longrightarrow I_A$(starting)

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Example: for a shunt DC Motor with armature resistance of 0.[redacted]2 Ω find the starting current.

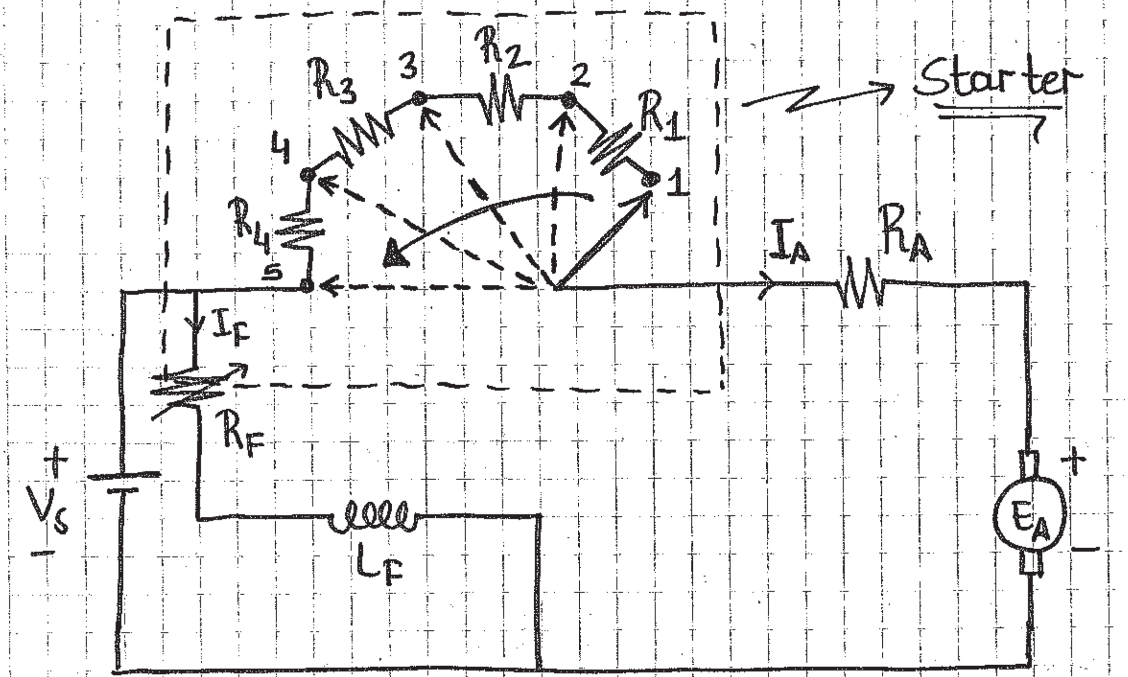
The motor is supply from a 200Vdc source

$$\left.\begin{array}{l} V_S = 200 \\ R_A = 0.[redacted]2 \end{array}\right\} \quad I_A(\text{starting}) = \frac{200}{0.2} = \underline{1000A}$$

Staters ⇒ DC motorlarda motorun başlangıç akımı çok yüksek olduğu için, bu durumun önüne geçmeye yarayan cihazlardır...

ex: DC motorun nominal akım değeri ⇒ 50A iken
starting akım değeri ⇒ 1000A

Starting akım değerini düşürmeye yarayan şey ⇒ starters



At $t=0$ → $I_A = \dfrac{V_S - K\phi\omega}{R_A + [R_1 + R_2 + R_3 + R_4]}$

$\omega(t=0) = 0$ → $I_A(t=0) = \dfrac{V_S}{R_A + R_1 + R_2 + R_3 + R_4}$

Chapter 8: *DC Motors*

8-1. The following information is given about the simple rotating loop shown in Figure 8-6:

$B = 0.4\text{ T}$ $\qquad$ $V_B = 48\text{ V}$

$l = 0.5\text{ m}$ $\qquad$ $R = 0.4\ \Omega$

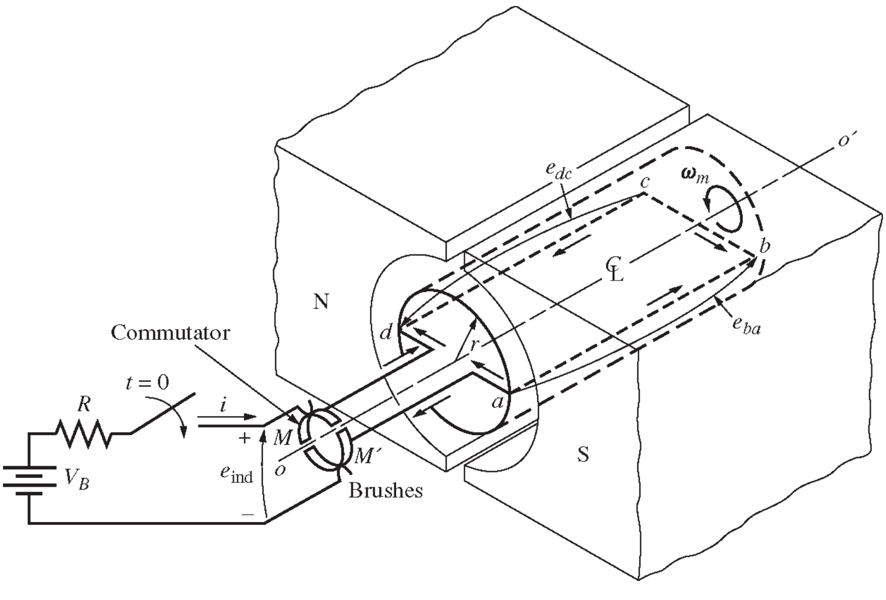
$r = 0.25\text{ m}$ $\qquad$ $\omega = 500\text{ rad/s}$

(a) Is this machine operating as a motor or a generator? Explain.

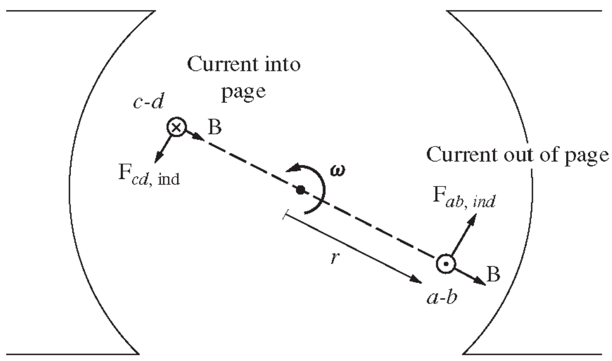
(b) What is the current *i* flowing into or out of the machine? What is the power flowing into or out of the machine?

(c) If the speed of the rotor were changed to 550 rad/s, what would happen to the current flow into or out of the machine?

(d) If the speed of the rotor were changed to 450 rad/s, what would happen to the current flow into or out of the machine?



(*a*)



(*b*)

SOLUTION

(a) If the speed of rotation ω of the shaft is 500 rad/s, then the voltage induced in the rotating loop will be

$$e_{\text{ind}} = 2rlB\omega$$
$$e_{\text{ind}} = 2(0.25\ \text{m})(0.5\ \text{m})(0.4\ \text{T})(500\ \text{rad/s}) = 50\ \text{V}$$

Since the external battery voltage is only 48 V, this machine is operating as a *generator*, charging the battery.

(b) The current flowing out of the machine is approximately

$$i = \frac{e_{\text{ind}} - V_B}{R} = \left(\frac{50\ \text{V - 48 V}}{0.4\ \Omega}\right) = 5.0\ \text{A}$$

(*Note* that this value is the current flowing while the loop is under the pole faces. When the loop goes beyond the pole faces, e_{ind} will momentarily fall to 0 V, and the current flow will momentarily reverse. Therefore, the *average* current flow over a complete cycle will be somewhat less than 5.0 A.)

(c) If the speed of the rotor were increased to 550 rad/s, the induced voltage of the loop would increase to

$$e_{\text{ind}} = 2rlB\omega$$
$$e_{\text{ind}} = 2(0.25\ \text{m})(0.5\ \text{m})(0.4\ \text{T})(550\ \text{rad/s}) = 55\ \text{V}$$

and the current flow out of the machine will increase to

$$i = \frac{e_{\text{ind}} - V_B}{R} = \left(\frac{55\ \text{V - 48 V}}{0.4\ \Omega}\right) = 17.5\ \text{A}$$

(d) If the speed of the rotor were decreased to 450 rad/s, the induced voltage of the loop would fall to

$$e_{\text{ind}} = 2rlB\omega$$
$$e_{\text{ind}} = 2(0.25\ \text{m})(0.5\ \text{m})(0.4\ \text{T})(450\ \text{rad/s}) = 45\ \text{V}$$

Here, e_{ind} is less than V_B, so current flows into the loop and the machine is acting as a motor. The current flow into the machine would be

$$i = \frac{V_B - e_{\text{ind}}}{R} = \left(\frac{48\ \text{V - 45 V}}{0.4\ \Omega}\right) = 7.5\ \text{A}$$

8-2. The power converted from one form to another within a dc motor was given by

$$P_{\text{conv}} = E_A I_A = \tau_{\text{ind}}\omega_m$$

Use the equations for E_A and τ_{ind} [Equations (8-30) and (8-31)] to prove that $E_A I_A = \tau_{\text{ind}}\omega_m$; that is, prove that the electric power disappearing at the point of power conversion is exactly equal to the mechanical power appearing at that point.

SOLUTION

$$P_{\text{conv}} = E_A I_A$$

Substituting Equation (8-30) for E_A

$$P_{\text{conv}} = (K\,\phi\,\omega)\,I_A$$

$$P_{\text{conv}} = (K \phi I_A)\omega$$

But from Equation (8-31), $\tau_{\text{ind}} = K \phi I_A$, so

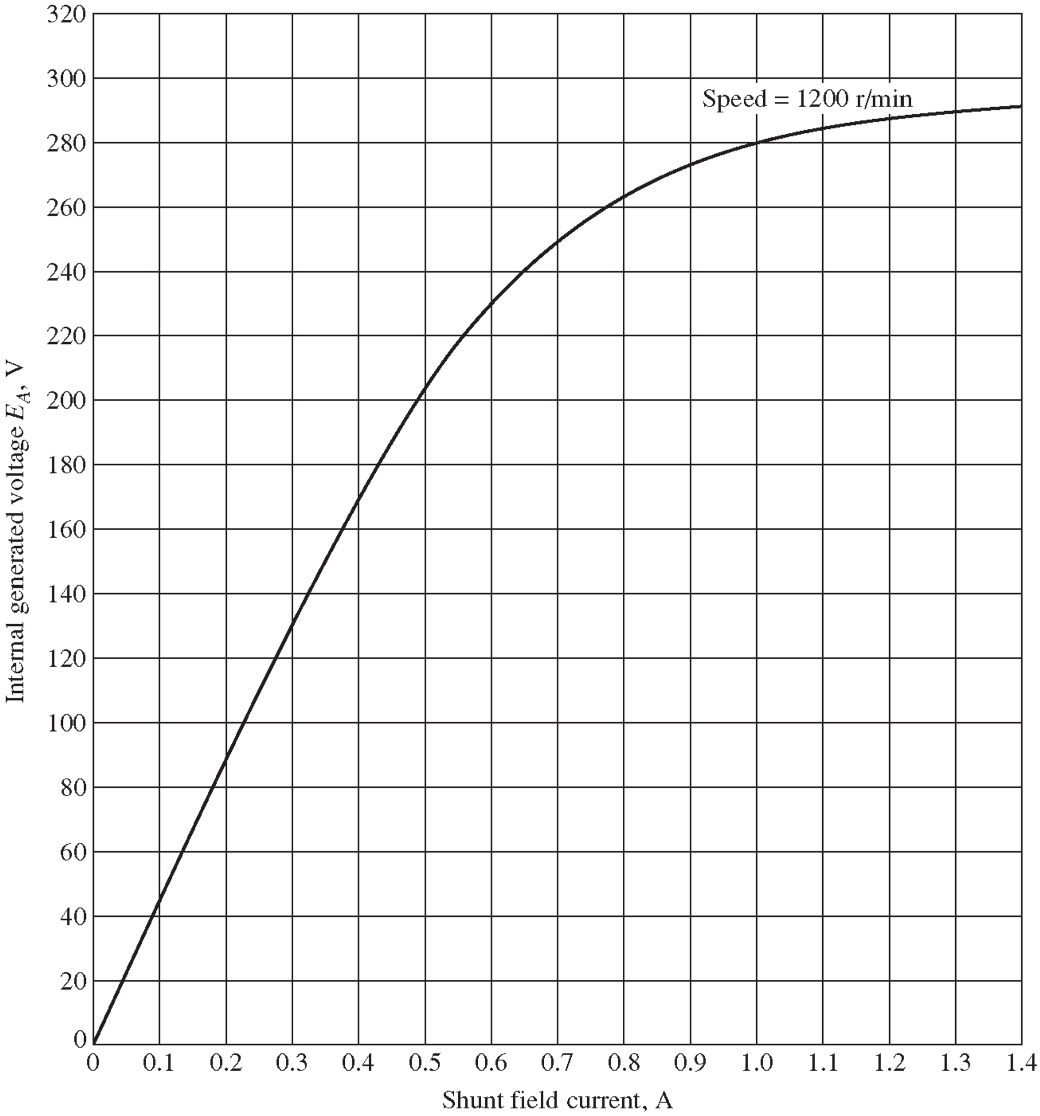
$$P_{\text{conv}} = \tau_{\text{ind}} \omega$$

Problems 8-3 to 8-14 refer to the following dc motor:

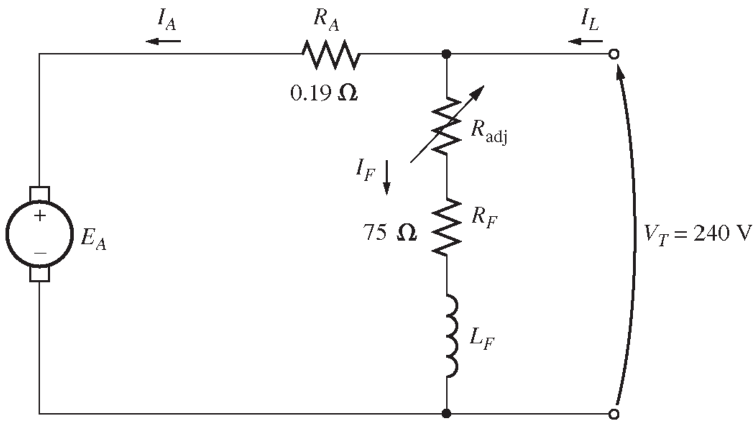
$P_{\text{rated}} = 30$ hp	$I_{L,\text{rated}} = 110$ A
$V_T = 240$ V	$N_F = 2700$ turns per pole
$n_{\text{rated}} = 1200$ r/min	$N_{\text{SE}} = 12$ turns per pole
$R_A = 0.19\ \Omega$	$R_F = 75\ \Omega$
$R_S = 0.02\ \Omega$	$R_{\text{adj}} = 100$ to $400\ \Omega$

Rotational losses = 3550 W at full load

Magnetization curve as shown in Figure P8-1



In Problems 8-3 through 8-9, assume that the motor described above can be connected in shunt. The equivalent circuit of the shunt motor is shown in Figure P8-2.



8-3. If the resistor R_{adj} is adjusted to 175 Ω what is the rotational speed of the motor at no-load conditions?

SOLUTION At no-load conditions, $E_A = V_T = 240\text{ V}$. The field current is given by

$$I_F = \frac{V_T}{R_{\text{adj}} + R_F} = \frac{240\text{ V}}{175\,\Omega + 75\,\Omega} = \frac{240\text{ V}}{250\,\Omega} = 0.96\text{ A}$$

From Figure P8-1, this field current would produce an internal generated voltage E_{Ao} of 277 V at a speed n_o of 1200 r/min. Therefore, the speed *n* with a voltage of 240 V would be

$$\frac{E_A}{E_{Ao}} = \frac{n}{n_o}$$

$$n = \left(\frac{E_A}{E_{Ao}}\right) n_o = \left(\frac{240\text{ V}}{277\text{ V}}\right)(1200\text{ r/min}) = 1040\text{ r/min}$$

8-4. Assuming no armature reaction, what is the speed of the motor at full load? What is the speed regulation of the motor?

SOLUTION At full load, the armature current is

$$I_A = I_L - I_F = 110\text{ A - }0.96\text{ A} = 109\text{ A}$$

The internal generated voltage E_A is

$$E_A = V_T - I_A R_A = 240\text{ V} - (109\text{ A})(0.19\ \Omega) = 219.3\text{ V}$$

The field current is the same as before, and there is no armature reaction, so E_{Ao} is still 277 V at a speed n_o of 1200 r/min. Therefore,

$$n = \left(\frac{E_A}{E_{Ao}}\right) n_o = \left(\frac{219.3\text{ V}}{277\text{ V}}\right)(1200\text{ r/min}) = 950\text{ r/min}$$

The speed regulation is

$$\text{SR} = \frac{n_{\text{nl}} - n_{\text{fl}}}{n_{\text{fl}}} \times 100\% = \frac{1040\text{ r/min - }950\text{ r/min}}{950\text{ r/min}} \times 100\% = 9.5\%$$

8-5. If the motor is operating at full load and if its variable resistance R_{adj} is increased to 250 Ω, what is the new speed of the motor? Compare the full-load speed of the motor with R_{adj} = 175 Ω to the full-load speed with R_{adj} = 250 Ω. (Assume no armature reaction, as in the previous problem.)

SOLUTION If R_{adj} is set to 250 Ω, the field current is now

$$I_F = \frac{V_T}{R_{adj} + R_F} = \frac{240\text{ V}}{250\,\Omega + 75\,\Omega} = \frac{240\text{ V}}{250\,\Omega} = 0.739\text{ A}$$

Since the motor is still at full load, E_A is still 219.3 V. From the magnetization curve (Figure P8-1), this current would produce a voltage E_{Ao} of 256 V at a speed n_o of 1200 r/min. Therefore,

$$n = \left(\frac{E_A}{E_{Ao}}\right) n_o = \left(\frac{219.3\text{ V}}{256\text{ V}}\right)(1200\text{ r/min}) = 1028\text{ r/min}$$

Note that R_{adj} has increased, and as a result the speed of the motor n increased.

8-6. Assume that the motor is operating at full load and that the variable resistor R_{adj} is again 175 Ω. If the armature reaction is 1200 A·turns at full load, what is the speed of the motor? How does it compare to the result for Problem 8-5?

SOLUTION The field current is again 0.96 A, and the motor is again at full load conditions. However, this time there is an armature reaction of 1200 A·turns, and the *effective* field current is

$$I_F^{\,*} = I_F - \frac{\text{AR}}{N_F} = 0.96\text{ A} - \frac{1200\text{ A}\cdot\text{turns}}{2700\text{ turns}} = 0.516\text{ A}$$

From Figure P8-1, this field current would produce an internal generated voltage E_{Ao} of 210 V at a speed n_o of 1200 r/min. The actual internal generated voltage E_A at these conditions is

$$E_A = V_T - I_A R_A = 240\text{ V} - (109\text{ A})(0.19\,\Omega) = 219.3\text{ V}$$

Therefore, the speed n with a voltage of 240 V would be

$$n = \left(\frac{E_A}{E_{Ao}}\right) n_o = \left(\frac{219.3\text{ V}}{210\text{ V}}\right)(1200\text{ r/min}) = 1253\text{ r/min}$$

If all other conditions are the same, the motor with armature reaction runs at a higher speed than the motor without armature reaction.

8-7. If R_{adj} can be adjusted from 100 to 400 Ω, what are the maximum and minimum no-load speeds possible with this motor?

SOLUTION The minimum speed will occur when R_{adj} = 100 Ω, and the maximum speed will occur when R_{adj} = 400 Ω. The field current when R_{adj} = 100 Ω is:

$$I_F = \frac{V_T}{R_{adj} + R_F} = \frac{240\text{ V}}{100\,\Omega + 75\,\Omega} = \frac{240\text{ V}}{175\,\Omega} = 1.37\text{ A}$$

From Figure P8-1, this field current would produce an internal generated voltage E_{Ao} of 289 V at a speed n_o of 1200 r/min. Therefore, the speed n with a voltage of 240 V would be

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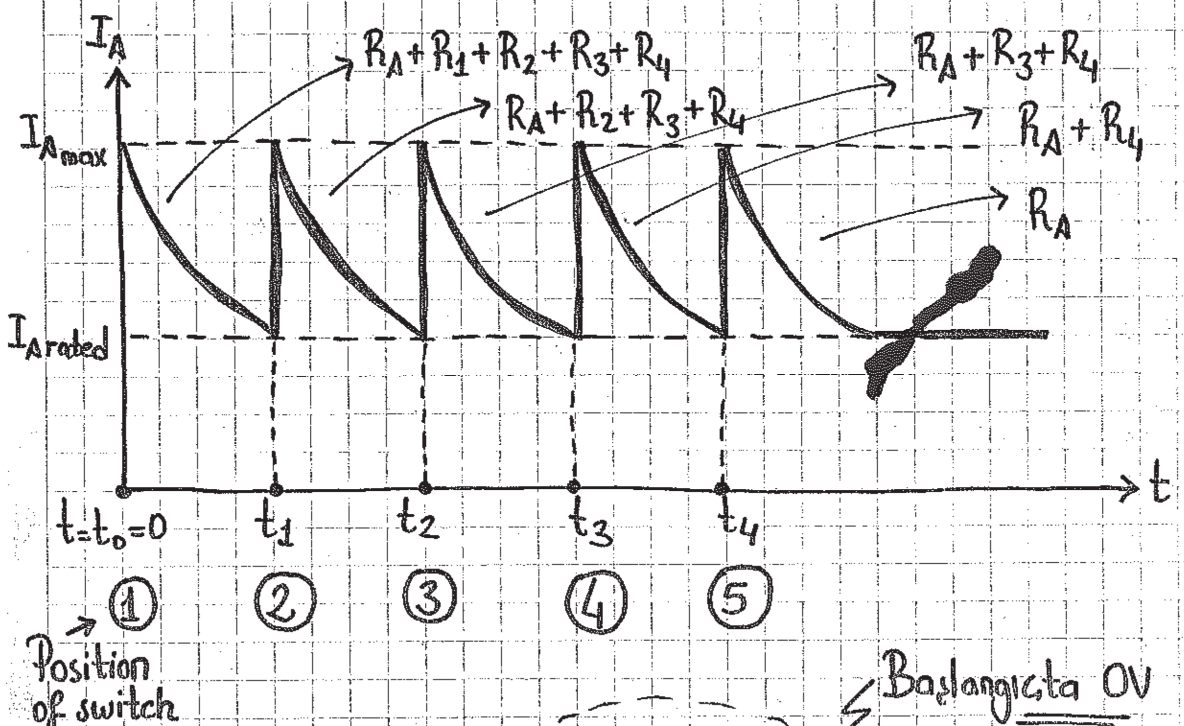
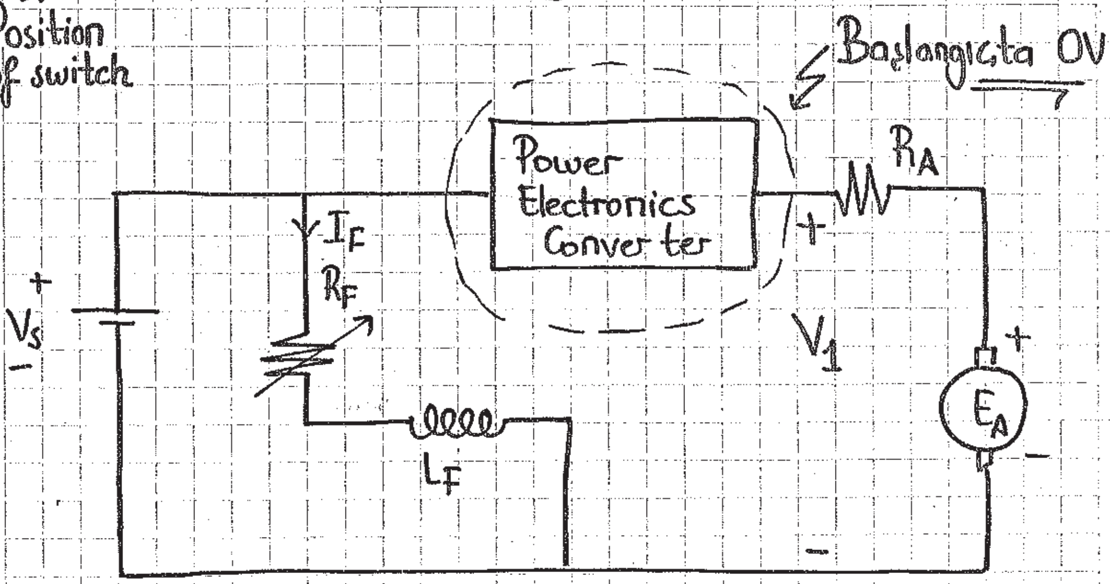
$\omega \uparrow \Rightarrow E_A \uparrow \Rightarrow I_A \downarrow$

with increasing of motor speed the armature current decreases

$$I_A = \frac{V_S - K\phi\omega}{(\text{------})}$$





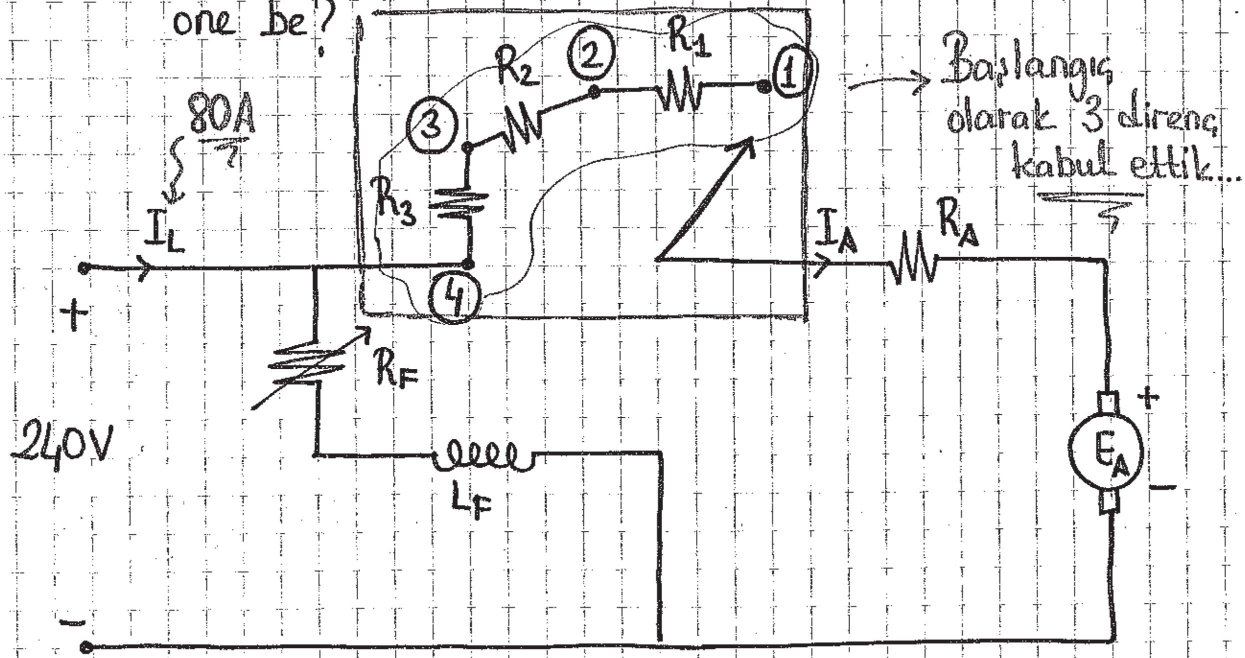
V_1 (voltage applied to motor) is adjusted using a converter.

V_1 is increased from zero up to voltage rating of motor.

4/5 Soru Vize için
1 - ... (cut off)
2 - DC Machine (1 yada 2 soru)
3 - Tanım
4 - Trafo

39-a

Example: An automatic starter circuit is to be designed for a shunt motor at 20hp, 240V and 80A. The armature resistance of the motor is 0.12Ω and the shunt field resistance is 40Ω. The motor is to start with no more than 250 percent of its rated armature current, and as soon as the current falls to rated value, a starting resistor stage is be cut out. How many stages of starting resistance are needed and how big should each one be?



$R_A = 0.12\Omega$

$R_F = 40\Omega$

$$V_T = E_A + I_A R_A$$

$$V_T = K\phi\omega + I_A R_A$$

$$I_A = \frac{V_T - K\phi\omega}{R_A}$$

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$$I_A(t=0) = \frac{V_T - 0}{R_A}$$

$$I_A = \frac{V_T - E_A}{R_A + \sum R_{start}}$$

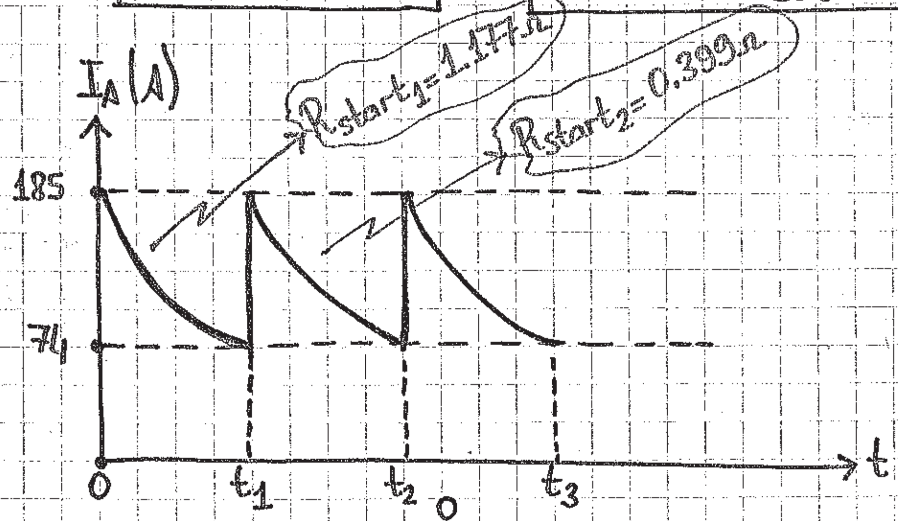
Without starter

$$I_A(t=0) = \frac{240}{0.12} = \underline{2000\,A}$$

$$80 = I_L = I_A + I_F = I_A + \frac{V_T}{R_F} = I_A + \frac{240}{40} = \underline{I_A + 6}$$

$$I_A = 80 - 6 = 74\,A$$

$\Rightarrow$ $I_{A\,rated} = 74\,A$ $\qquad$ $I_{A\,max} = \frac{250}{100} \times 74 = 185\,A$



Motor hızlandıkça $E_A \uparrow$

$E_A \uparrow$ aradaki fark azalıp akım $\downarrow$

$E_{A\,min}$, R_{max}

$$185 = \frac{240 - \overbrace{E_A(t=0)}^{0}}{R_A + R_{start_1}} = \frac{240}{\underbrace{R_A}_{0.12\,\Omega} + R_{start_1}} \Rightarrow R_{start_1} = 1.177\,\Omega$$

↳ toplam seri direnç

$$185 = \frac{240 - E_A(t_1)}{R_A + R_{start_2}}$$

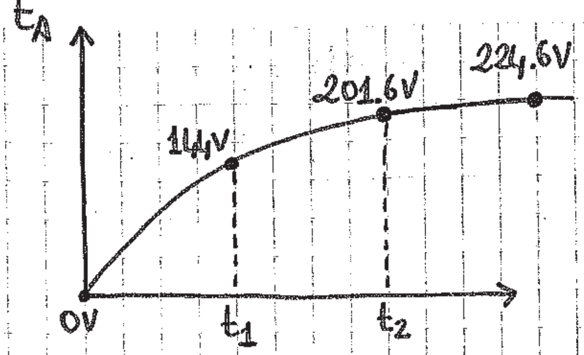
$\rightarrow$ 1. direnç devre dışı bırakıldı, geriye 2 direnç kaldı...

$$E_A(t=t_1) = V_T - (R_A + 1.177) \times 74 = 144\,V$$

$\longrightarrow$

40-a

97



$$I_A = \frac{V_T - 144}{R_A + R_{start_2}}$$

$$I_A = \frac{240 - 144}{0.12 + R_{start_2}} = 185\,A$$

$$R_{start_2} = \underline{0.399\,\Omega}$$

At t_2 : $E_A(t = t_2) = V_T - I_{A rated}(R_A + R_{start_2})$

$$= 240 - 74(0.12 + 0.399) = 201.6V$$

$$I_A = \frac{V_T - 201.6V}{R_A + R_{start_3}} \Rightarrow 185 = \frac{240 - 201.6}{0.12 + R_{start_3}} \Rightarrow R_{start_3} = \underline{0.088\,\Omega}$$

$$E_A(t = t_3) = V_T - I_{A rated}(R_A + R_{start_3})$$

$$= 240 - 74(0.12 + 0.088) = 224.6V$$

$$I_A = \frac{V_T - 224.6V}{R_A} = \underline{128.3 < 185\,A} \Rightarrow I_A = \frac{240 - 224.6}{0.12} = \underline{128.3}$$

$$R_1 = R_{start_1} - R_{start_2}$$

$$= 1.177\,\Omega - 0.399 = \underline{0.778\,\Omega}$$

$$R_2 = R_{start_2} - R_{start_3}$$

$$= 0.399 - 0.088 = \underline{0.311\,\Omega}$$

$$R_3 = \underline{0.088\,\Omega}$$

hesaplanan I_A değeri 185 üzerindeyse R hesabına devam et

ex 190 ise işleme devam et R sayısı = 4 olur o zaman