Lesson 14: Starting Dc Motors

ET 332a
Dc Motors, Generators and Energy Conversion Devices

Learning Objectives

- Explain why high armature currents are present when starting a dc motor
- List the types of dc motor starting given in the presentation
- Explain how high starting currents can damage a dc motor
- Compute the value of resistance to limit motor starting current to a specified value

Starting Separately Excited and Shunt Dc Motors– Resistor Dc Motor Starters

Blocked or locked rotor current depends on E_a and R_a

$$I_a = \frac{V_T - E_a}{R_a}$$

At start-up, $E_a = 0$ since n = 0 so,

$$I_{as} = \frac{V_T - 0}{R_a} = \frac{V_T}{R_a}$$

R_a low to minimize losses so I_a high at start

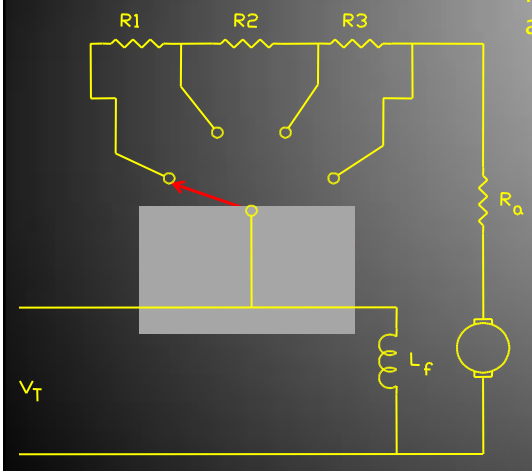
Dc motor starting methods:

1.) reduced armature voltage
2.) reduced current through starting resistors

Resistor Dc Motor Starters

In drawing below: R1, R2, R3 sized to limit I_a to 150–200% rated.

Resistance values switched out as armature speed increases



Damage due to high armature current:

1.) brush/commutator burning
2.) mechanical damage due to high torques. $T \alpha I_a$

Example 14-1: Motor Resistive Motor Starter

A 15 hp 230 V, 1750 rpm shunt motor has a terminal current of 56.2 A when delivering rated power at rated speed. The total armature circuit resistance, R_a, is 0.28 ohms and the field resistance, R_f, is 137 ohms. Compute:

1.) rated torque at the shaft (N-m)
2.) armature current for a locked rotor
3.) the value of external resistance required to limit I_a and developed torque to 200% of rated.
4.) the locked rotor torque when the terminal voltage drops to 215 V and the starting resistor is used to limit the armature current.

Example 14-1 Solution (1)

Part (1)

$P_o = (746\,W/hp)(15\,hp) = 11{,}190\,W$

$\omega = 1750\,rpm\left[\frac{2\pi}{60}\right] = 183.167\,rad/s$

$T_{rated} = \frac{P_o}{\omega} = \frac{11{,}190\,W}{183.167\,rad/s} = \boxed{61.1\,N\text{-}m}$

Part (2)

At start up $E_a = 0$ $n = 0$ $R_{ACIR} = 0.28\,\Omega$

Starting current

$I_{as} = \frac{V_T}{R_{ACIR}}$

$I_{as} = \frac{230V}{0.28\,\Omega}$

$I_{as} = 821.43\,A$

Compare to rated current

$\frac{I_{as}}{I_T} = \frac{821.43\,A}{56.2\,A} = 14.62 \times rated$

Example 14-1 Solution (2)

Part (3)

I_{a1} = armature I at rated output

I_{a2} = armature I at 200% rated torque

T_1 = Rated T

T_2 = 200% rated T

$I_{a1} = I_T - I_f$

$I_{a1} = 56.2A - \frac{230V}{137\Omega}$

$I_{a1} = 54.52A$

Torque proportional to I_a so

$T_1 = K_T I_{a1}$ $T_2 = K_T I_{a2}$

$\frac{T_1}{T_2} = \frac{K_T I_{a1}}{K_T I_{a2}}$ solve for I_{a2}

$T_2 = 2T_1$

Example 14-1 Solution (3)

$\frac{T_1}{2T_1} = \frac{54.52A}{I_{a2}} \Rightarrow I_{a2} = 109.04A$ Answer

$I_{a1} = 54.52A$

Find the value of the current limiting Resistance, R_x

$V_T = E_a + I_{a2}(R_{acir} + R_x)$ $\frac{V_T}{I_{a2}} = R_{acir} + R_x$

$E_a = 0$ $n = 0$

$R_x = \frac{V_T}{I_{a2}} - R_{acir}$ $R_x = \frac{230V}{109.04A} - 0.28\Omega$

Answer $R_x = 1.83\Omega$

Example 14-1 Solution (4)

Part (4)

Assume no saturation, V_T reduced to 215 V, which reduces field current and flux. Compute new I_f.

$$I_f = \frac{215\text{V}}{137\,\Omega} = 1.57\text{A}$$

Calculate I_{as} with reduced V_T

$$I_{as} = \frac{V_T}{R_{adj} + R_x} = \frac{215\text{V}}{0.28 + 1.83\,\Omega}$$

$$I_{as} = 101.9\text{ A}$$

Remember $T \propto I_a I_f$

Assume linear magnetic circuit

$$\frac{T_{230}}{T_{215}} = \frac{[I_f I_a]_{230}}{[I_f I_a]_{215}}$$

Example 14-1 Solution (5)

Solve for new torque at 215 V

$$T_{215} = \left[\frac{[I_f I_a]_{215}}{[I_f I_a]_{230}}\right] T_{230}$$

$$T_{215} = \left[\frac{(1.57\text{A})(101.9\text{A})}{(1.68\text{A})(84.52\text{A})}\right] 61.09\ \text{N-m}$$

$$T_{215} = 106.7\ \text{N-m}$$

Answer

Less than 200%

End Lesson 14

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