Lesson 16: Computing Resistive Starter Values

ET 332a

Dc Motors, Generators and Energy Conversion Devices

Learning Objectives

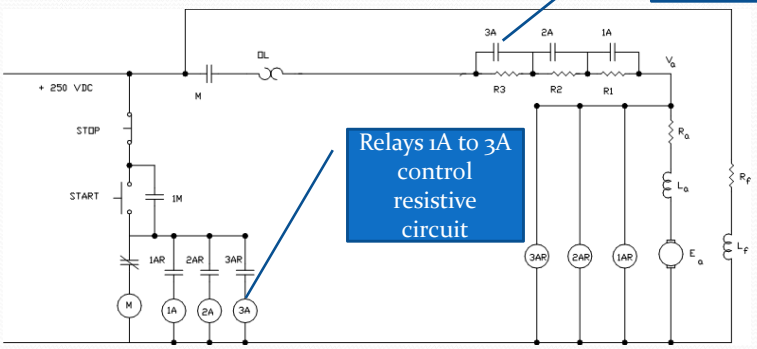
After this presentation you will be able to:

- Identify and utilize formulas for computing the values of resistance in a step resistive dc motor starter
- Work an example using the formulas
- Find individual resistor values based on the computations

Sizing Resistors in Step Resistor Starter

Three step resistive starter

Contacts short resistors as speed builds.



Relays 1AR to 3AR pickup based on motor terminal voltage, V_a

Sizing Resistors in Step Resistor Starter

Resistive starter equations

Current level determines the size of resistors. Set based on percentage of rated current allowed into machine during startup.

Compute starter R at step n.

$$R_{Tn} = \left[\frac{V_T - E_a}{\left[\frac{\%I}{100}\right] \cdot I_{rated}}\right] - R_a$$

Compute induced internal voltage at step n.

$$E_a = V_T - I_a(R_a + R_{Tn})$$

Compute relay n pick-up voltage at step n.

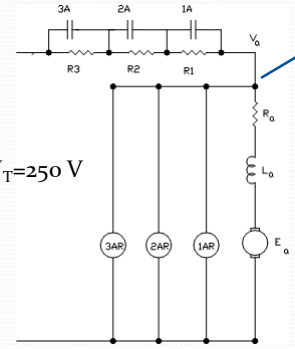
$$V_a = V_T - I_a(R_{Tn})$$

Where:

V_T = motor terminal voltage
R_a = total armature resistance
R_{Tn} = total starter R at step n
I_{rated} = rated motor current
%I = percentage of rated allowed
E_a = induced internal voltage

Repeat for all n steps of starter

Example 16-1: Sizing Starter Resistors



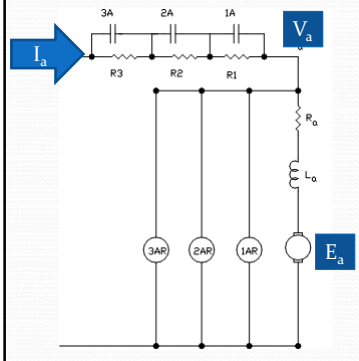
V_T=250 V

V_a

Example 16-1:
Dc motor has terminal voltage of 250 Vdc and rated current of 125 A. The total armature resistance is 0.15 ohms Find values of R1-R3 and pick-up voltage V_a for relays 1AR to 3AR to limit current to 200% of rated. Relays 1AR-3AR should activate when the armature current reaches rated motor current at each stage.

Example 16-1 Solution (1)

Define the values of R_{Tn}



$R_{T1} = R_1 + R_2 + R_3$
$R_{T2} = R_2 + R_3$
$R_{T3} = R_3$

Basic operational theory: I_a produces torque that Accelerates armature causing E_a to increase. Relays 1AR-3AR short out R's as V_a increases

Stage 1

$\%I = 200\%$ $R_a = 0.15\ \Omega$
$V_T = 250V$
$I_{rated} = 125A$

$n = 0$ $E_a = 0$

$$R_{T1} = \left[\frac{V_T - E_a}{\left[\frac{\%I}{100}\right] I_{rated}}\right] - R_a\ \Omega$$

Example 16-1 Solution (2)

$$R_{T1} = \left[\frac{250 - 0}{\left[\frac{200\%}{100}\right]125A}\right] - 0.15\Omega$$

$$R_{T1} = \frac{250V}{250A} - 0.15\Omega$$

$$R_{T1} = 1\Omega - 0.15\Omega = 0.85\Omega$$

Find V_{a1} and E_a drop at 125 A due to the starting R's in the circuit

$$V_{a1} = V_T - R_{TN} I_{rated}$$

$$V_{a1} = 250V - 0.85\Omega(125A) = 193.75V$$

answer — Voltage setting 1AR

$$E_{a1} = 250 - (125A)(0.85\Omega + 0.15\Omega) = 125V$$

$$E_{a1} = 125V$$

Example 16-1 Solution (3)

Stage 2

Compute stage 2 values with 1AR closed. Use E_{a1}=125 V

$$R_{T2} = \left[\frac{V_T - E_{a1}}{\left[\frac{\%I}{100}\right]I_{rated}}\right] - R_a$$

$$R_{T2} = \left[\frac{250V - 125V}{\frac{200\%}{100}(125)}\right] - 0.15\Omega$$

$$R_{T2} = \left[\frac{125V}{250A}\right] - 0.15\Omega$$

$$R_{T2} = 0.35\Omega$$

$$V_{a1} = V_T - I_{rated}(R_{T2})$$

$$V_{a1} = 250V - 125A(0.35)$$

$V_{a1} = 206.25V$ 2AR VOLTAGE SETTING

answer

$$E_{a2} = V_T - I_{rated}(R_{T2} + R_a)$$

$$E_{a2} = 250V - (125A)(0.35 + 0.15\Omega)$$

$$E_{a2} = 187.5V$$

Example 16-1 Solution (4)

Stage 3

1AR and 2AR are closed. Use E_{a2}=187.5 V

$$R_{T3} = \left[\frac{V_T - E_{a2}}{\left[\frac{\%I}{100}\right] I_{rated}}\right] - R_a$$

$$R_{T3} = \left[\frac{250 - 187.5\,V}{\left(\frac{200\%}{100}\right) 125A}\right] - 0.15\Omega$$

$$R_{T3} = \frac{62.5\,V}{250A} - 0.15\Omega$$

$$R_{T3} = 0.25 - 0.15\Omega$$

$$R_{T3} = 0.1\Omega$$

Compute the last relay pick up voltages

$$V_{a3} = V_T - I_{Rated} R_{T3}$$

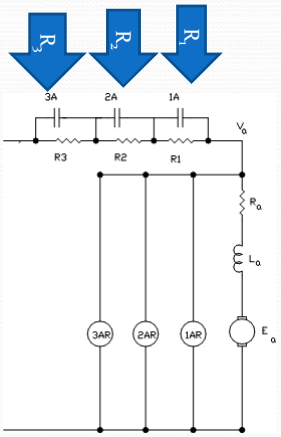
$$V_{a3} = 250V - (125A)(0.1\Omega)$$

$$V_{a3} = 237.5V$$

answer

Example 16-1 Solution (5)

Compute the individual resistor values



$$R_1 = R_{T1} - R_{T2}$$

$$R_1 = 0.85\Omega - 0.35\Omega$$

$$R_1 = 0.5\Omega$$

$$R_2 = R_{T2} - R_{T3}$$

$$R_2 = 0.35\Omega - 0.1\Omega$$

$$R_2 = 0.25\Omega$$

$$R_3 = R_{T3}$$

$$R_3 = 0.1\Omega$$

End Lesson 16

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