Lesson 17: Other Dc Motor Connections

ET 332a

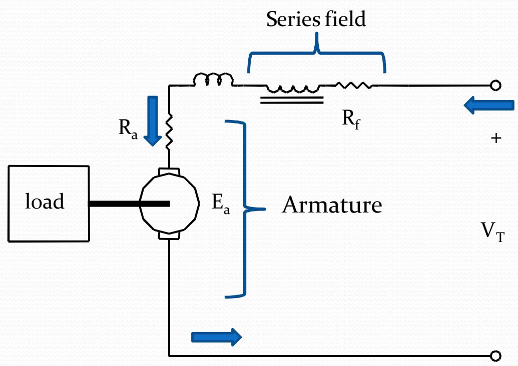
Dc Motors, Generators and Energy Conversion Devices

Learning Objectives

- Identify common connections of dc motors
- Explain how to connected various dc motors to reverse their rotation.
- Identify the circuit model of a series dc motor and use model equations to solve problems

Other Dc Motor Connections

Series dc motor- field excitation comes from armature current.

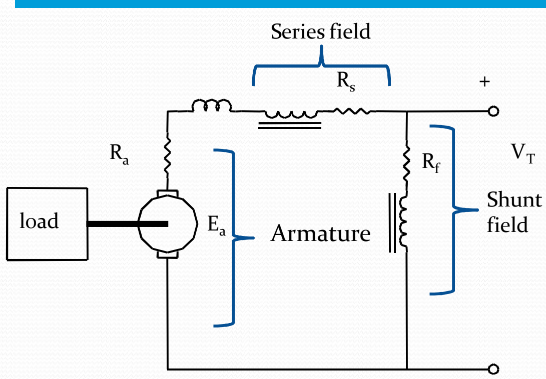


Field current equals armature current

Field winding constructed of few turns of large diameter wire

Other Dc Motor Connections

Compound motor - series and shunt windings in the same machine combine to make the field flux.



Type of compound motors

Commulatively compounded motors - series and shunt mmfs add to the flux produced in the field

Differentially compounded motors - series and shunt mmfs subtract - unstable connection.

Reversing Dc Motors

General theory - shunt and separately excited motors

Reverse the polarity of **<u>either</u>** the armature or the field connections. Changes the direction of armature/field flux which reverses the direction of the developed torque.

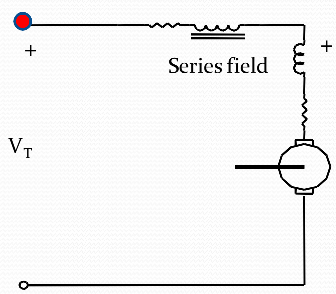
Reversing direction of Series or Compound motor

Same as other types- take care to avoid creating differentially compounded motor. series and shunt fields must change polarity together.

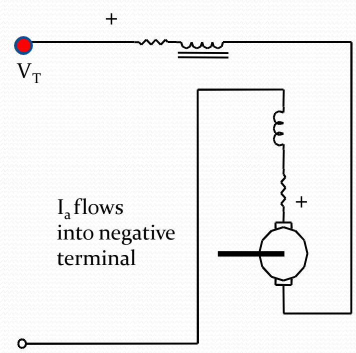
In series motor must only change the polarity of the field or armature. Reversing terminal voltage will reverse both field and armature polarity

Reversing Connections for Series and Compound Dc Motors

Series Motors



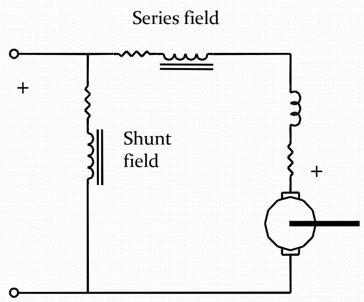
Forward connection



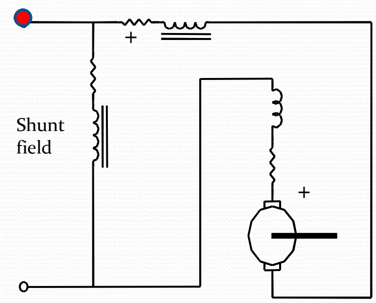
Reverse connection

Reversing Connections for Series and Compound Dc Motors

Compound Motors



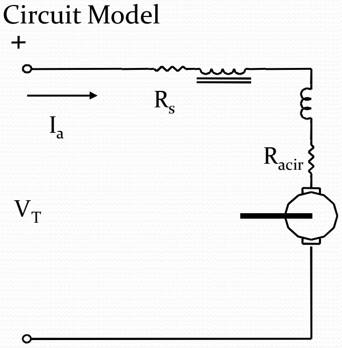
Forward connection



Reverse connection

Series Dc Motor Model and Equations

Circuit Model



Linear operation equations –assumes no magnetic saturation.

General Equations

$$E_a = k_G \cdot n \cdot \Phi_p$$

$$T_D = k_T \cdot I_f \cdot I_a$$

$$n = \frac{V_T - I_a \cdot R_{acir}}{k_G \cdot \Phi_p}$$

$$E_a = V_T - I_a \cdot R_{acir}$$

In series motor, $I_a = I_f$ so above equations become

$$E_a = k_G \cdot n \cdot \Phi_p$$

$$T_D = k_T \cdot I_a^2$$

Torque proportional to I_a squared

$$n = \frac{V_T - I_a \cdot (R_{acir} + R_s)}{k_G \cdot \Phi_p}$$

$$E_a = V_T - I_a \cdot (R_{acir} + R_s)$$

Include series field R

Series Dc Motor Model and Equations

Torque and speed characteristics of series motor

For linear operation, Φ_p proportional to I_a

$$T_D = k_T \cdot I_a^{\,2} \qquad \uparrow n = \frac{V_T - I_a \cdot (R_{acir} + R_s)}{k_G \cdot \Phi_p \downarrow}$$

As load torque decreases developed torque decreases causing I_a to decrease
This decreases field flux.
Motor speed, n, increases with decreasing field flux.

$T_D \downarrow$ $I_a \downarrow$ $\Phi_D \downarrow$ $n \uparrow$

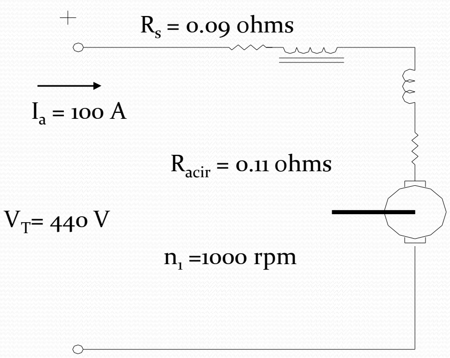
Series motors must operate with direct coupled mechanical loads to prevent centrifugal damage due to high speeds.

Series Dc Motor Example-Speed and Torque Calculations

<u>Example 17-1</u>: A 440 V series motor draws a current of 100 A at a speed of 1000 rpm The total armature circuit resistance is 0.11 ohms and the field resistance is 0.09 ohms. Assuming a linear magnetizing, curve calculate the speed and the torque when the current drops to 50 A.

Example 17-1 Solution (1)

Information from problem statement



Speed is inversely proportional to Φ_p. Reducing I_a reduces Φ_p linearly

$I_{a1} = 100\ A$

$I_{a2} = 50\ A$

$$\frac{\Phi_{p1}}{\Phi_{p2}} = \frac{I_{a1}}{I_{a2}} = \frac{100A}{50A} = 2$$

Example 17-1 Solution (2)

Find the motor speed at reduced armature current

$$\frac{n_1}{n_2} = \left[\frac{E_{a1}}{E_{a2}}\right]\left[\frac{\Phi_{p2}}{\Phi_{p1}}\right]$$

Solve for n_2

$$n_2 = \left[\frac{E_{a2}}{E_{a1}}\right]\left[\frac{\Phi_{p1}}{\Phi_{p2}}\right] n_1$$

$E_{a1} = V_T - I_{a1}(R_{acir} + R_s)$

$E_{a1} = 440V - 100A(0.11\Omega + 0.09\Omega)$

$E_{a1} = 420V$

$E_{a2} = V_T - I_{a2}(R_{acir} + R_s)$

$E_{a2} = 440V - 50A(0.11\Omega + 0.09\Omega)$

$E_{a2} = 430V$

$$n_2 = \left[\frac{430V}{420V}\right][2](1000 Rpm)$$

$n_2 = 2048\ Rpm$ ← Answer

Example 17-1 Solution (3)

Find T_{D1}, initial developed torque

$$T_{D1} = \frac{P_{em1}}{\omega_1} \qquad P_{em1} = E_{a1} I_{a1} \qquad P_{em1} = (420V)(100A) = 42{,}000W$$

$$T_{D1} = \frac{42{,}000W}{104.7\ N\text{-}m}$$

$$T_{D1} = 401.1\ N\text{-}m$$

Torque is proportional to I_a^2

$$\frac{T_{D1}}{T_{D2}} = \frac{K_T I_{a1}^2}{K_T I_{a2}^2} \Rightarrow T_{D2} = \left[\frac{I_{a2}^2}{I_{a1}^2}\right] T_{D1}$$

$$T_{D2} = \frac{(50A)^2}{(100A)^2}(401.1\ N\text{-}m)$$

$$\boxed{T_{D2} = 100.3\ N\text{-}m}$$

Answer

As load torque decreases developed torque decreases causing speed increase

End Lesson 17

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