ECE 320: Lecture 28
Examples

1 .For the shunt dc motor described below:

Prated := 30hp	ILrated := 110A
VT := 240V	N_F := 2700 turns/pole
n_rated := 1200'M	N_SE := 12turns/pole
R_A := 0.19ohm	R_F := 75ohm
Rs := 0.02ohm	Radj ranges from 100 to 400 ohm

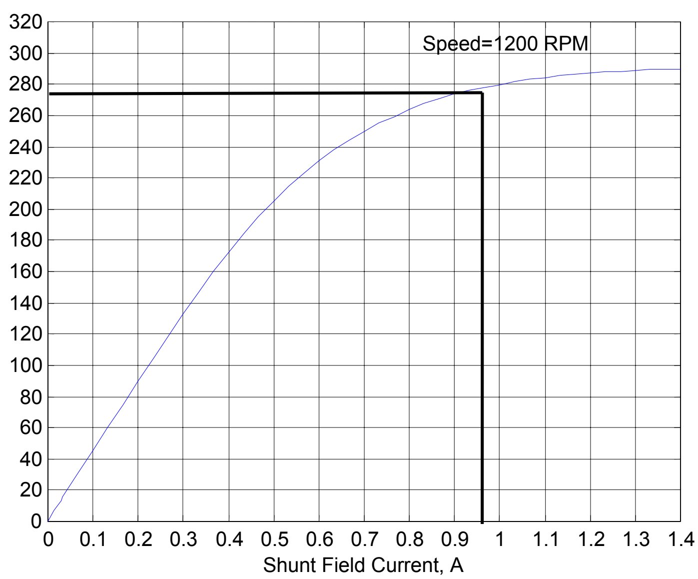
(a) If the resistor, Radj is adjusted to 175 ohms, what is the rotational speed of the motor at no load conditions?

R_adj1 := 175ohm

E_A1 := VT   Therefore, IA=0 (as expected for no-load)

$$I\_F1 := \frac{VT}{R\_F + R\_adj1} \qquad I\_F1 = 0.96\,A$$

Using the voltage characteristic below, determine the E_A resulting from I_F1 at 1200 RPM



From the curve, we see that:

Ea1200 := 277V

Find no-load speed for this case:

$$n\_noload := 1200 \cdot \frac{E\_A1}{Ea1200} \qquad n\_noload = 1040 \quad \text{RPM}$$

(b) For the shunt dc motor described in the last problem:

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

$$I\_Afl := ILrated - I\_F1 \qquad I\_Afl = 109.04\,A$$

$$EA\_fl := VT - I\_Afl \cdot R\_A \qquad EA\_fl = 219.28\,V$$

Since the field current hasn't changed (same terminal voltage), Ea1200=277V as before

$$n\_fl := 1200 \cdot \frac{EA\_fl}{Ea1200} \qquad n\_fl = 950 \quad \text{RPM}$$

$$SpeedRegulation := \frac{n\_noload - n\_fl}{n\_fl} \qquad SpeedRegulation = 9.448\,\%$$

2. Series motor:

$Rtot := 0.08ohm$ this is Ra + Rse

$Vt := 250V$ $\quad n\_base := \frac{1200}{1sec}$ RPM $\quad \omega\_base := n\_base \cdot \left(\frac{2\pi}{60}\right)$

$Nse := 25$ turns $\quad \omega\_base = 125.66 \frac{rad}{sec}$

(a) Find torque if Ia = 50A

$$Ia := 50A$$

$$Ea := Vt - Ia \cdot Rtot \qquad Ea = 246\,V$$

$$MMF := Nse \cdot Ia \qquad MMF = 1250\,A \ -turns$$

From the magnetization characteristic, determined at 1200 RPM, 1250 A-turns corresponds

$$Ea\_eff := 80V$$

$$n\_actual := n\_base \cdot \frac{Ea}{Ea\_eff} \qquad n\_actual = 3690\,Hz\,RPM$$

$$\omega\_actual := n\_actual \cdot \left(\frac{2\cdot\pi}{60}\right) \qquad \omega\_actual = 386.42\,\frac{rad}{sec}$$

$$\tau := \frac{Ea\cdot Ia}{\omega\_actual} \qquad \tau = 31.83\,N\cdot m$$

We can repeat this for additional operating points and get a torque-speed characteristic.

3. The machine below is connected as a shunt generator. The shunt field resistor Radj is adjusted to 10 ohm, and the generator's speed is 1800 RPM.

$Ra := 0.18ohm \qquad Vf := 120V \qquad Rf := 24ohm$

$Nf := 1000$ turns/pole

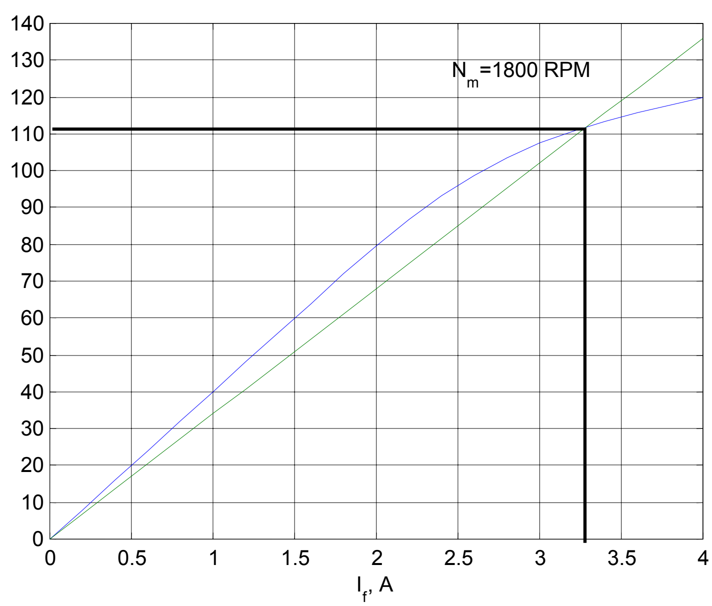
Radj ranges from 0 to 30 Ohm

(a) What is the no-load terminal voltage of the generator?

Add the plot of V_T vs I_f on the no-load magnetization curve.

$Radj := 10ohm \qquad Rshunt := Rf + Radj \qquad Rshunt = 34\,ohm$

The generator is operating at no-load, so the intersection between the V_T line and the magnetization curve is the no load voltage.



$T\_noload := 112V$

(b) Assuming no armature reaction, what is the terminal voltage of the generator with an armature current of 20A? 40A?

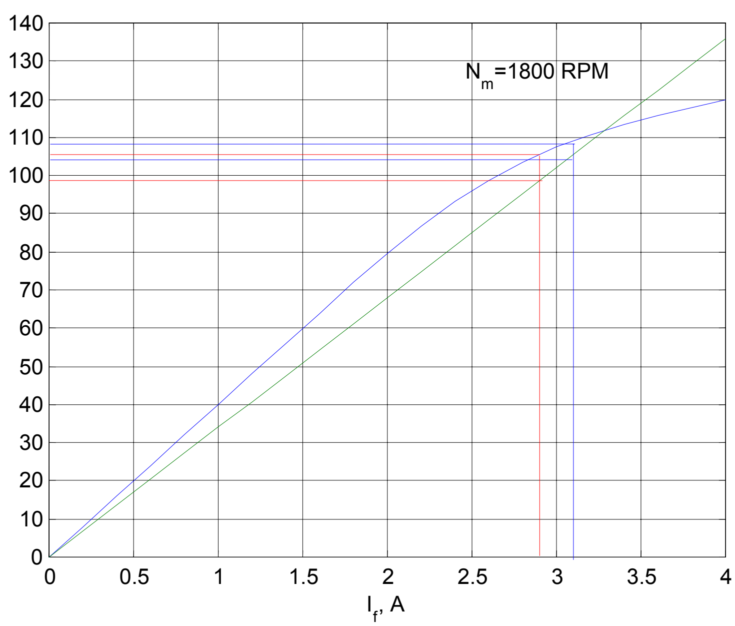
$IA1 := 20A$

Voltage Drop: $V\_ra1 := IA1 \cdot Ra \quad V\_ra1 = 3.6\,V$

$IA2 := 40A$

Voltage Drop: $V\_ra2 := IA2 \cdot Ra \quad V\_ra2 = 7.2\,V$

Find the point on the characteristic wherethe difference between Ea and Vt is equal to the voltage drop



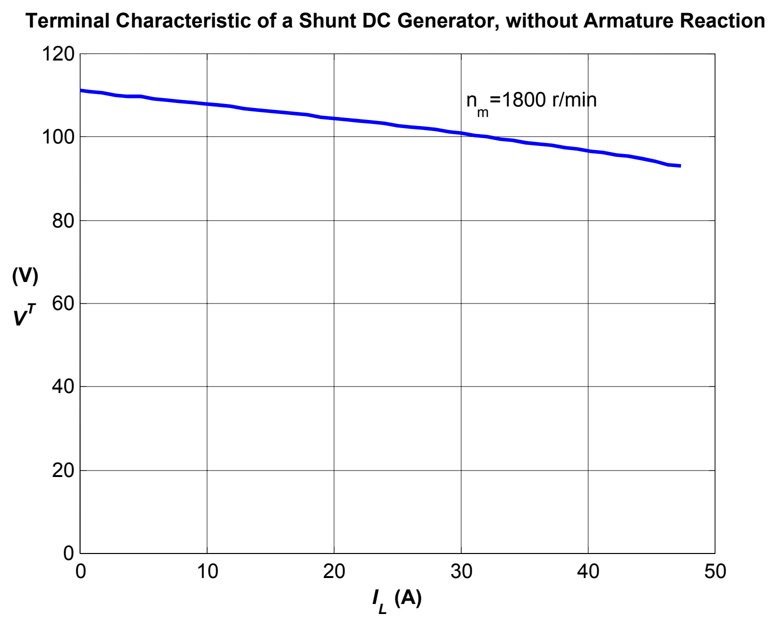
The answer will depend on your reading of the graph.

A voltage difference of 3.6V occurs when Ea=110V and Vt=106.4V, as shown with the blue lines.

A voltage difference of 7.2V occurs when Ea=106V and Vt=98.8V, as shown with the red lines.

(d) Calculate and plot the terminal characteristics of this generator with and without armature reaction

Basically repeat this process of part b over the full range of desired currents. The resulting plot is shown below.



4. A 120-V, 50-A cumulatively compounded dc generator has the following characteristics:

Rseries := 0.20ohm Ra + Rse

Nse := 15 turns

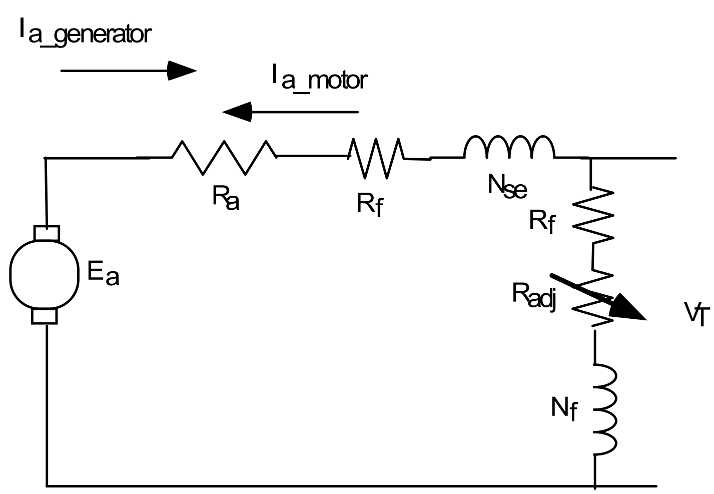
Rf_27 := 20ohm

Nf_27 := 1000 turns

Radj_27 := 10ohm Ranges from 0 to 30 ohms

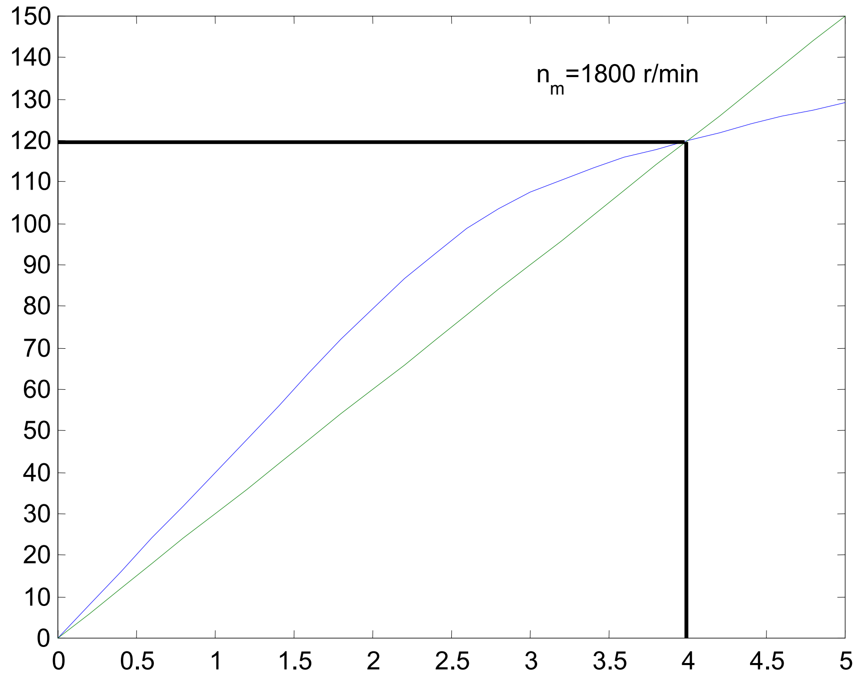
nm := 1800 RPM

The machine has the magnetization curve shown in below. Its equivalent circuit is below. Answer the following questions about this machine assuming no armature reaction.



(a) If the generator is operating at no load, what is its terminal voltage?

Vt = If *(Rf_27+Radj) = If*30



From the graph, Vt_noload = EA_noload = 120V

(b) If the generator has an armature current of 20A, what is its terminal voltage?

Ia_27 := 20A

Determine MMF from series winding, and then find the equivalent field current

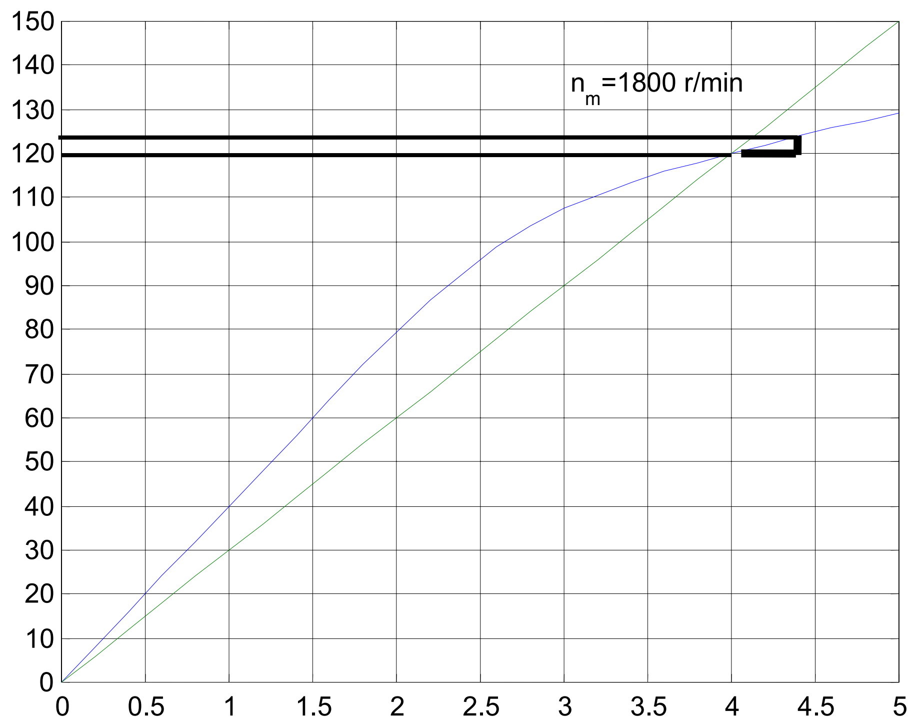
MMF_se := Nse·Ia_27 MMF_se = 300 Aturns

$$\text{If\_se} := \frac{\text{MMF\_se}}{\text{Nf\_27}} \qquad \text{If\_se} = 0.3\,\text{A}$$

Voltage drop, due to Ia*(Ra+Rse)

V_ra20 := Ia_27·(Rseries) V_ra20 = 4 V

Find a triangle that has sides with voltage equal to voltage drop and current equal to If_se. Notice that the If_se extends from the Vt line, not the Ea line. In this case the triangle will have a plus sign, If_se since cumulative compounded.



From the figure we see: Vt=119V and Ea= 123V

(c) If the generator has an armature current of 40A, what is its terminal voltage?

Ia_27c := 40A

Determine MMF from series winding, and then find the equivalent field current

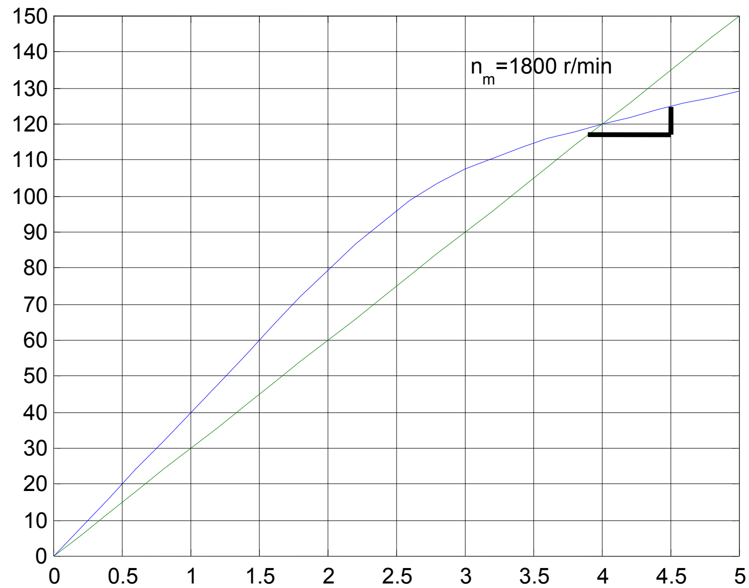
MMF_sec := Nse·Ia_27c   MMF_sec = 600 A·turns

$$\text{If\_sec} := \frac{\text{MMF\_sec}}{\text{Nf\_27}} \qquad \text{If\_sec} = 0.6\,\text{A}$$

Voltage drop, due to Ia*(Ra+Rse)

V_ra20c := Ia_27c·(Rseries V_ra20c = 8 V

Find a triangle that has sides with voltage equal to voltage drop and current equal to If_se. Notice that the
If_se extends from the Vt line, not the Ea line. In this case the triangle will have a plus If_se since cumulative compounded.



From the figure we see: Vt=117V and Ea= 125V

(d) Calculate and plot the terminal characteristics of this machine.

Basically repeat this process over the full range of desired currents. The resulting plot is shown below.