

ECE 331 - Solutions to Homework #6

AC Synchronous Motors

1) Assume an AC synchronous motor: 50kW, 3 phase, 2-pole, 60Hz, 240V_{LN}, X_s = 5.0 Ohms, E_f = 400V.

Find the slip angle, δ , for a load of 10kW:

Speed: $n_s = (2\pi \cdot 60\text{Hz}) = 377 \text{ rad/sec}$

Slip Angle: $P = 3 \cdot \left(\frac{-V_t E_f}{X_s} \right) \cdot \sin(\delta)$

$$50000 = 3 \left(\frac{-(240\text{V})(400\text{V})}{5.0\Omega} \right) \cdot \sin(\delta)$$

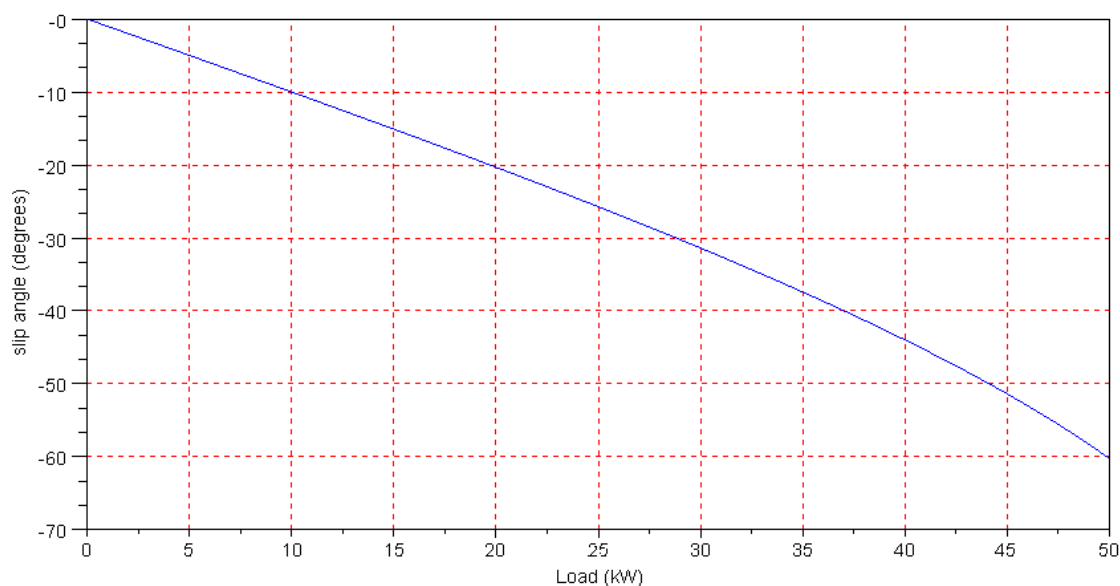
$$\delta = -60.23^\circ$$

2a) Write a MATLAB or SciLab program which computes the slip angle when given a load

```
function [delta] = sm_slip(P)
delta = -asin(P*5 / (3*240*400));
endfunction
```

2b) Using your MATLAB program, plot the slip angle for problem #1 as the load varies from 0kW to 50kW.

```
-->P = [0:1000:50000]';
-->delta = sm_slip(P);
-->plot(P,delta);
-->plot(P/1000,delta);
-->xlabel('Load (kW)');
-->ylabel('slip angle (degrees)');
-->xgrid(5)
```



3) Write a MATLAB or SciLab program which computes the per-phase source current, I_a , given the excitation voltage E_f and the load in kW.

```
function [Ia] = prob3(P, Ef)

j = sqrt(-1);
Xs = 5;
Vt = 240;
// Ef = 400;
// P = 50000;

delta = -asin(P*Xs / (3*Vt*Ef));
Ef = Ef*exp(j*delta);

Ia = (Vt - Ef) / (j*Xs);

endfunction
```

4) Assume a load of 50kW (100% load). Plot the per-phase source current, I_a , and the phase of I_a as the excitation voltage, E_f , varies from 0V to 500V. (Voltage Load Line)

The min E_f is when

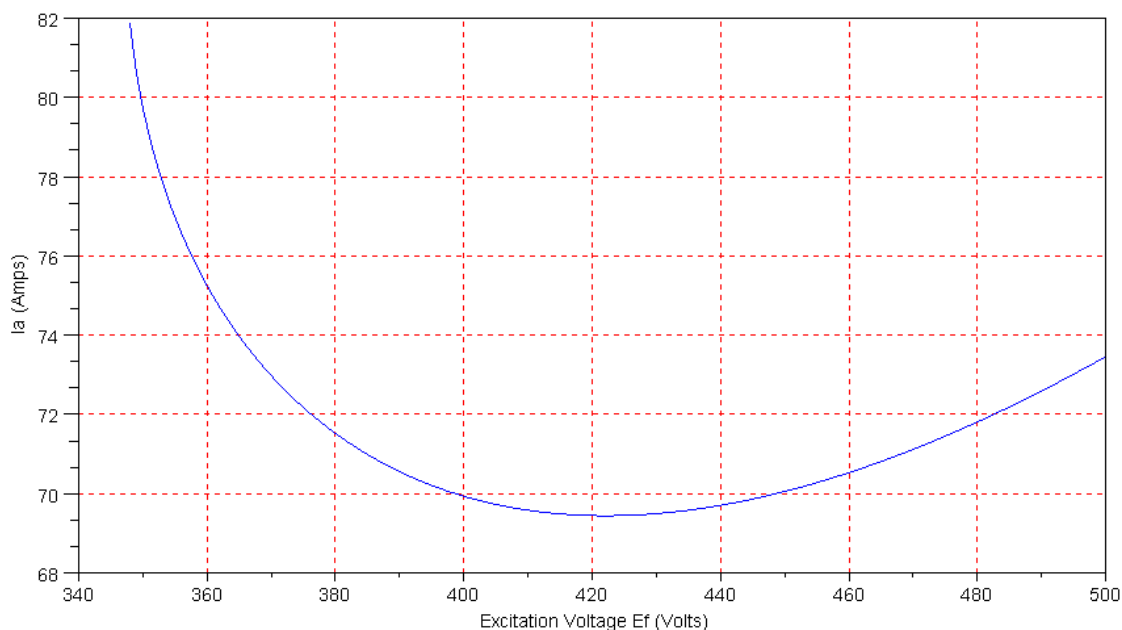
$$P \cdot X_s = 3V_t E_f$$

$$E_f = 347.2V$$

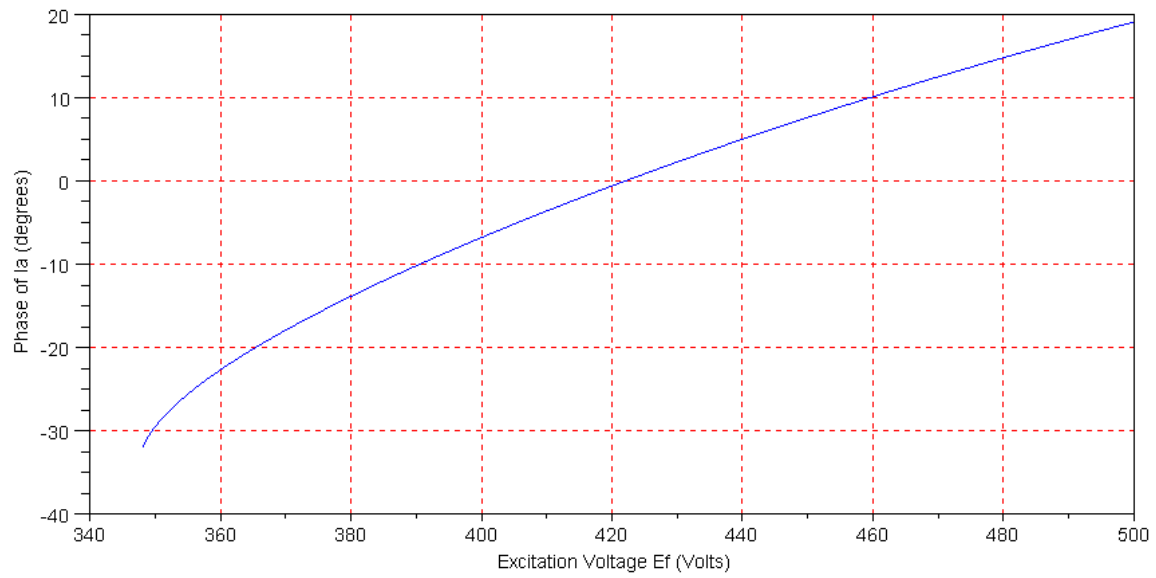
```
-->Ef4 = [348:500]';
-->Ia4 = 0*Ef4;

-->for i=1:length(Ef4)
-->    Ia4(i) = prob3(P,Ef4(i));
-->    end

-->plot(Ef4,abs(Ia4))
```



```
-->plot(Ef4,atan(imag(Ia4),real(Ia4))*180/%pi);  
-->xlabel('Excitation Voltage Ef (Volts)')  
-->ylabel('Phase of Ia (degrees)')  
-->xgrid(5)
```



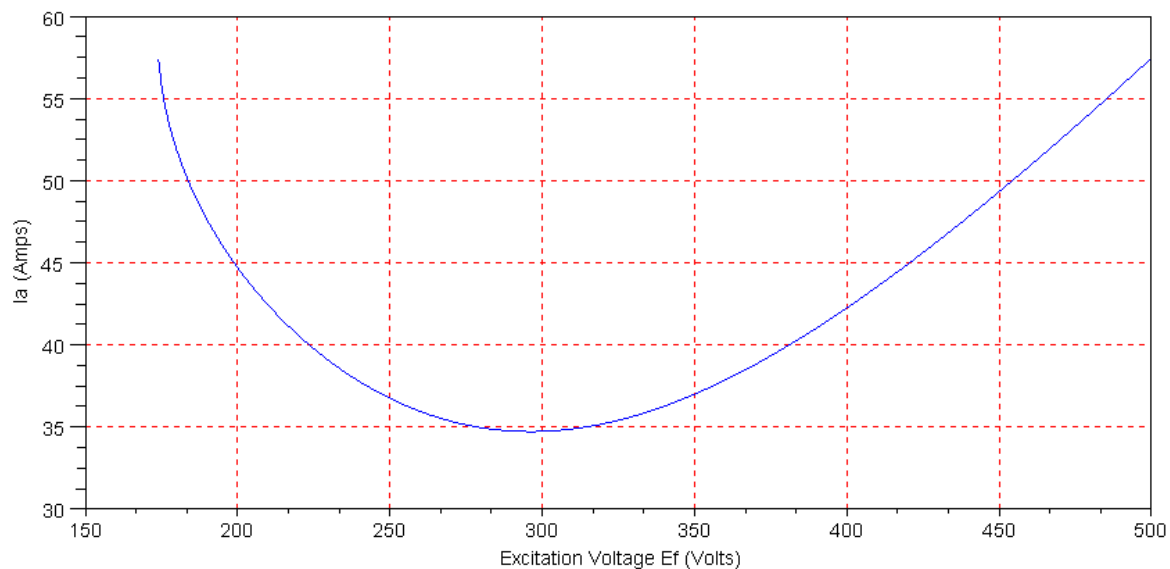
5) Assume a load of 25kW (50% load). Plot the per-phase source current, I_a , and the phase of I_a as the excitation voltage, E_f , varies from 0V to 500V. (Voltage Load Line)

The min E_f is when

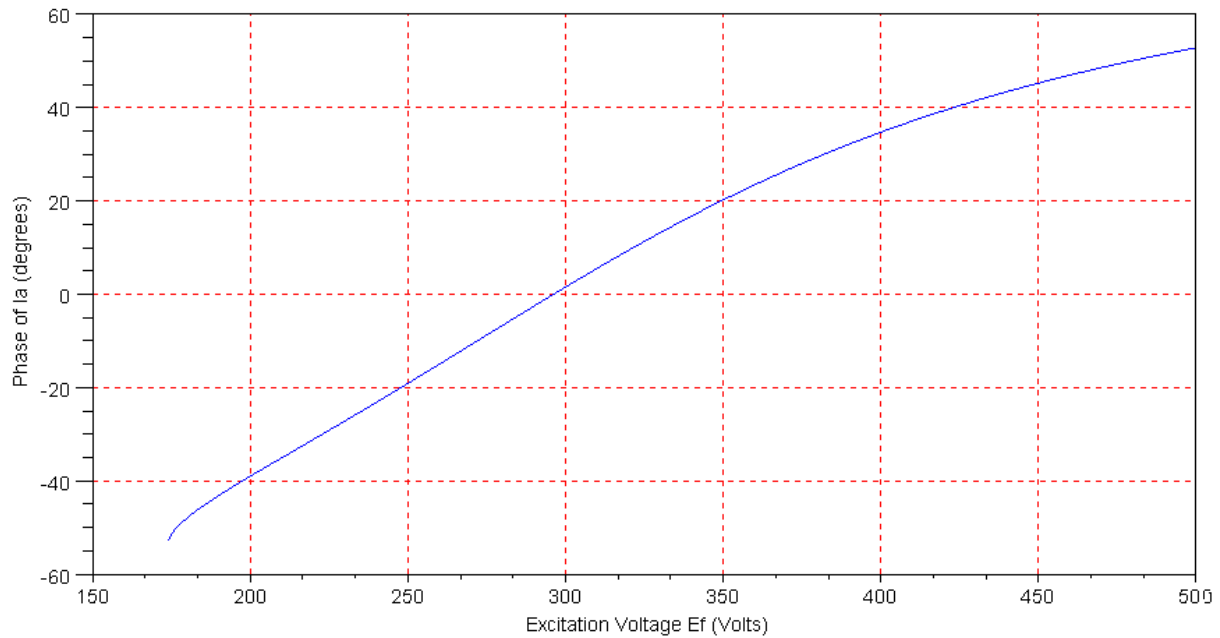
$$P \cdot X_s = 3V_t E_f$$

$$E_f = 173.6V$$

```
-->Ef5 = [174:500]';
-->Ia5 = 0*Ef5;
-->for i=1:length(Ef5)
-->    Ia5(i) = prob3(25000,Ef5(i));
-->    end
-->plot(Ef5,abs(Ia5))
-->xlabel('Excitation Voltage Ef (Volts)')
-->xgrid(5)
-->ylabel('Ia (Amps)')
```



```
-->plot(Ef5,atan(imag(Ia5),real(Ia5))*180/%pi);
-->xgrid(5)
-->xlabel('Excitation Voltage Ef (Volts)')
-->ylabel('Phase of Ia (degrees)')
```

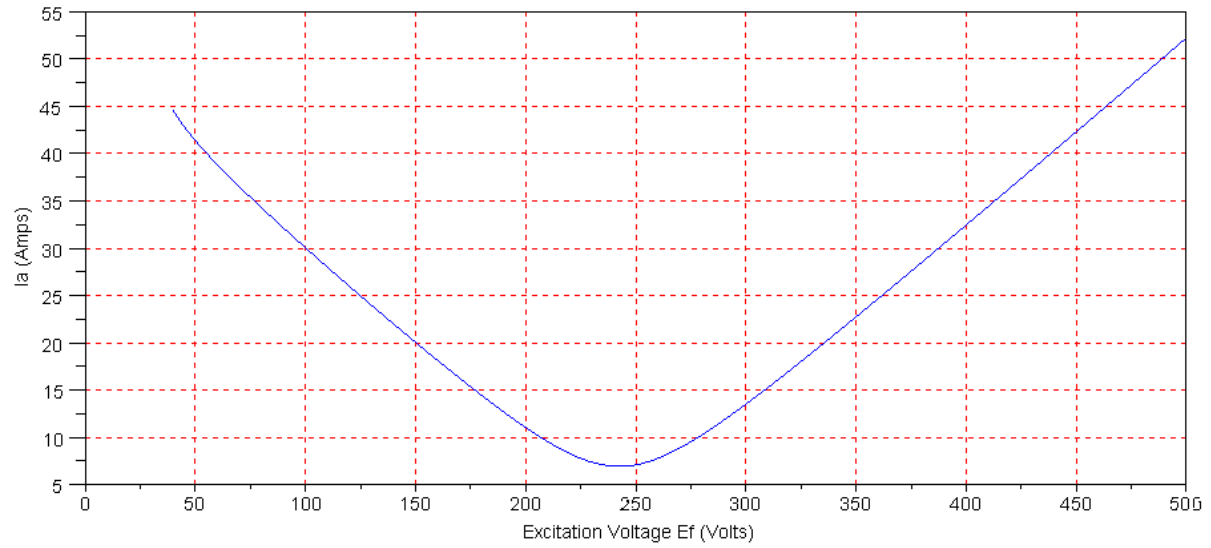


6) Assume a load of 5kW (10% load). Plot the per-phase source current, I_a , and the phase of I_a as the excitation voltage, E_f , varies from 0V to 500V. (Voltage Load Line)

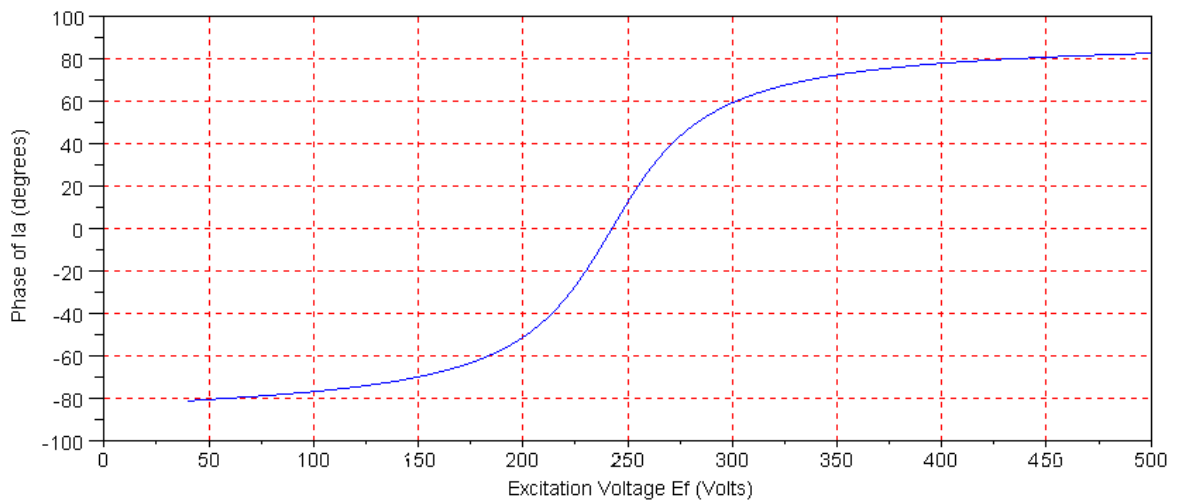
If the load is 10% of max load, the min excitation voltage is 10% as well:

$$E_f > 34.7 \text{ V}$$

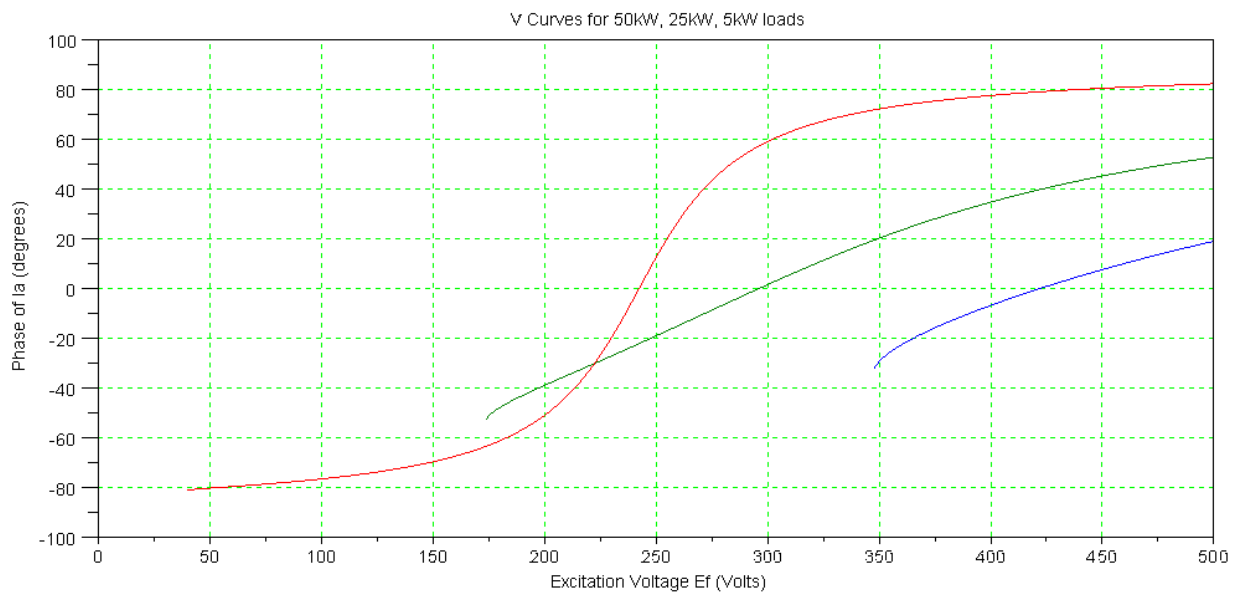
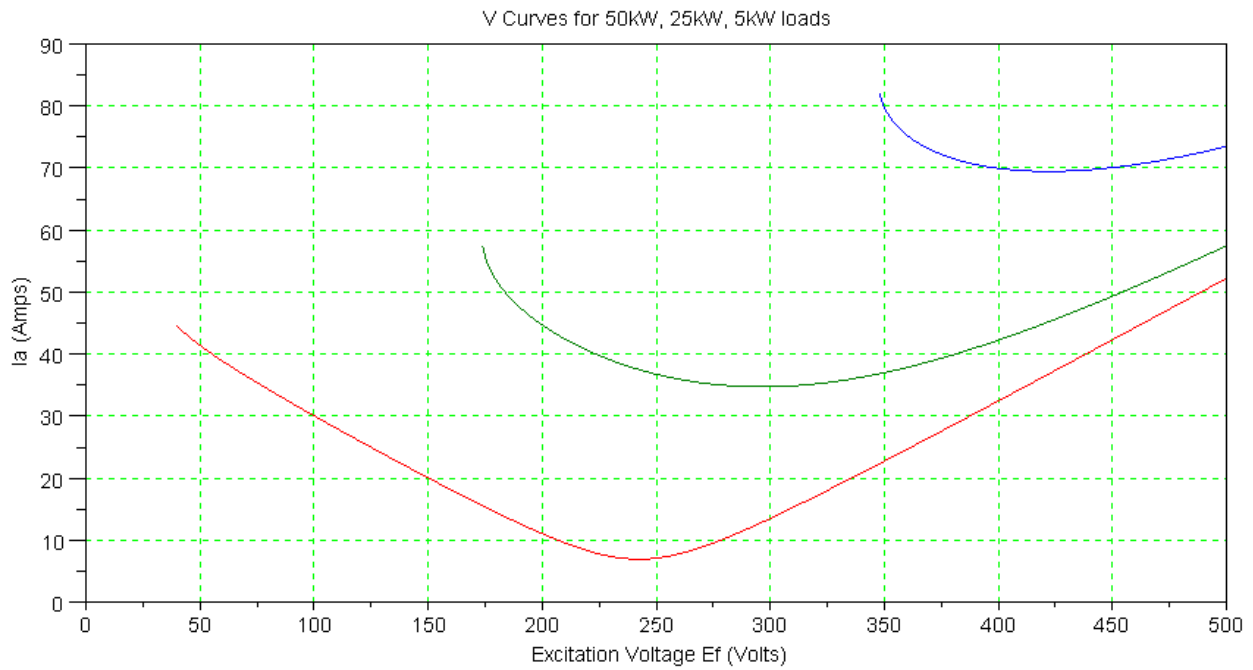
```
-->Ef6 = [40:500]';
-->Ia6 = 0*Ef6;
-->for i=1:length(Ef6)
-->    Ia6(i) = prob3(5000,Ef6(i));
--> end
-->plot(Ef6,abs(Ia6))
-->xlabel('Excitation Voltage Ef (Volts)')
-->xgrid(5)
-->ylabel('Ia (Amps)')
```



```
-->plot(Ef6,atan(imag(Ia6),real(Ia6))*180/%pi);
-->xgrid(5)
-->xlabel('Excitation Voltage Ef (Volts)')
-->ylabel('Phase of Ia (degrees)')
```



Combining problems 4,5,6:



(Lab Report)

7) Give the data you collected in the lab

8) Plot the Voltage Load Line for the AC synchronous motor in the lab.