ECE 331 - Solutions to Homework #9

AC Synchronous Motors

1) Assume an AC synchronous motor: 50kW, 3 phase, 2-pole, 60Hz, $240V_{LN}$, Xs = 5.0 Ohms, Ef = 500V.

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

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

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

$$10000 = 3\left(\frac{-(240V)(500V)}{5.0\Omega}\right) \cdot \sin(\delta)$$

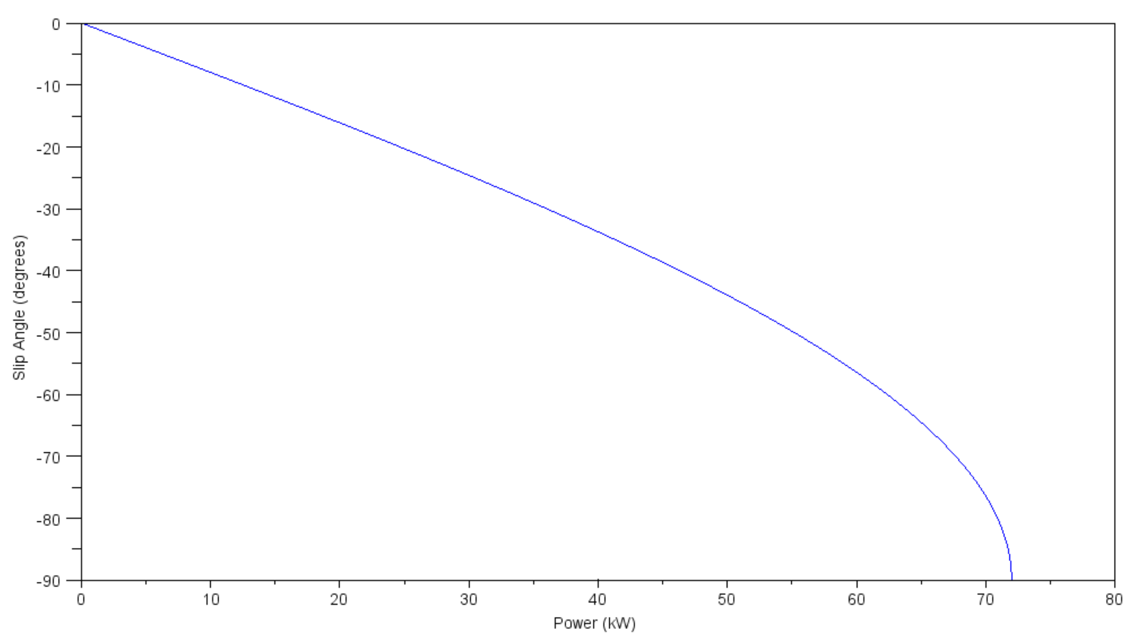
$$\delta = -7.89^0$$

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*500));
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');
-->xgrid(5)
```



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

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

j = sqrt(-1);
Xs = 5;
Vt = 240;
// Ef = 500;
// P = 50000;

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

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

endfunction
```

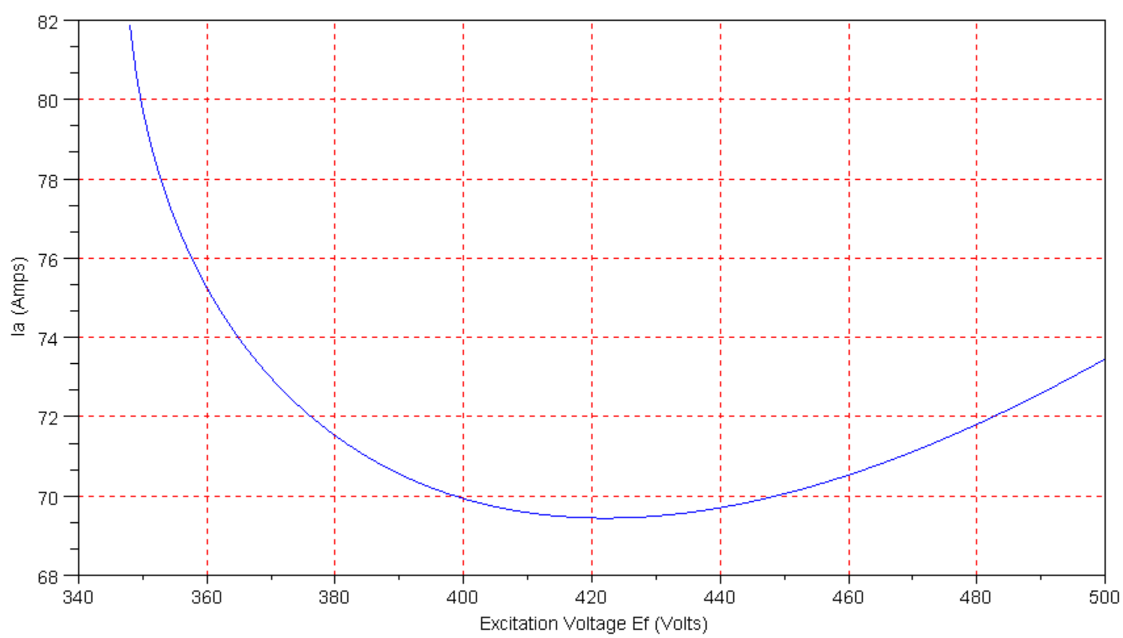
4) Assume a load of 50kW (100% load). Plot the per-phase source curent, Ia, and the phase of Ia as the excitation voltage, Ef, varies from 0V to 500V. (Voltage Load Line)

The min Ef is when

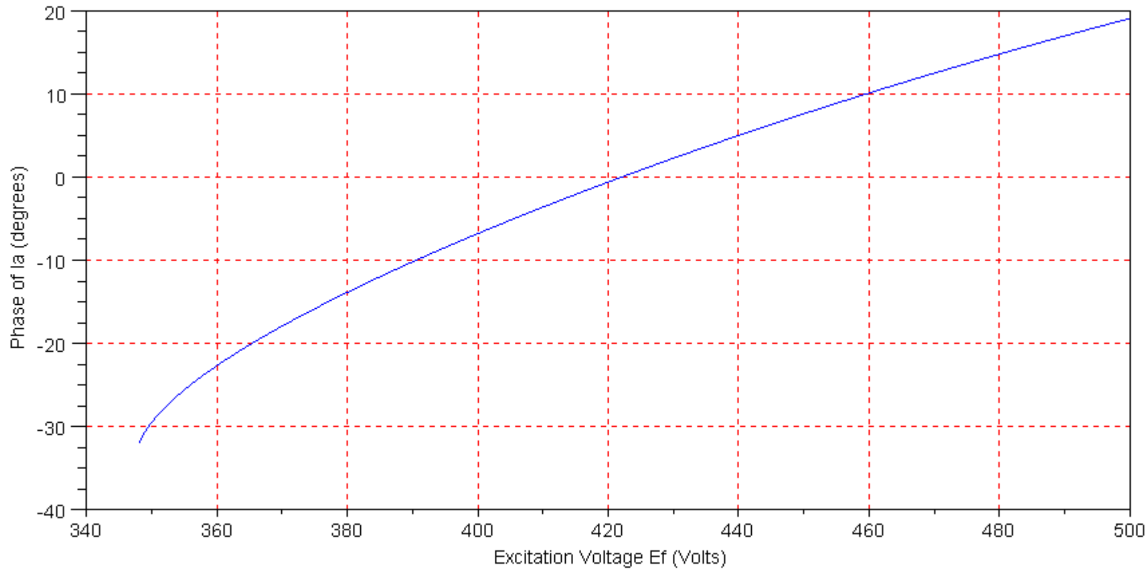
$$P \cdot X_s = 3V_tE_f$$

$$E_f = 347.2V$$

```
-->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)
```



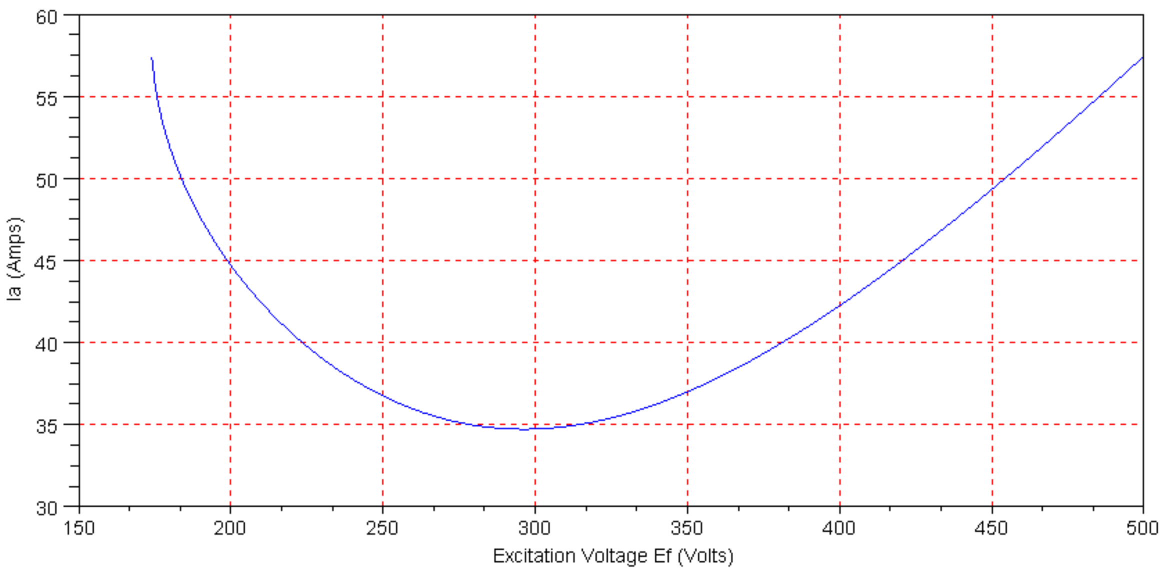
5) Assume a load of 25kW (50% load). Plot the per-phase source curent, Ia, and the phase of Ia as the excitation voltage, Ef, varies from 0V to 500V. (Voltage Load Line)

The min Ef is when

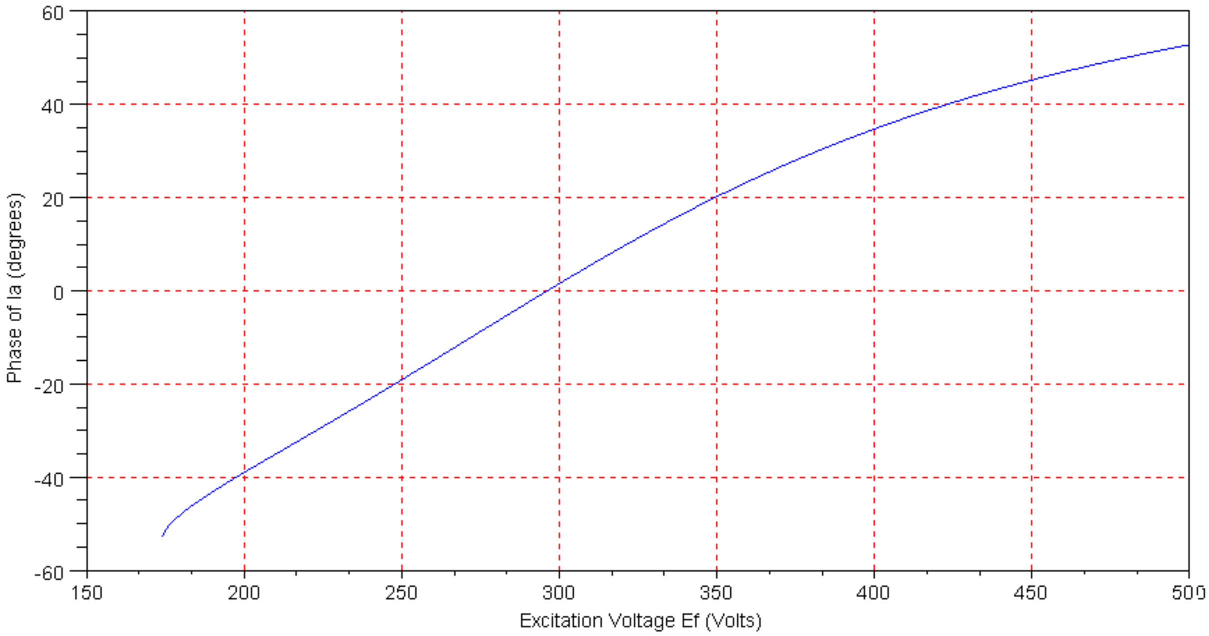
$$P \cdot X_s = 3V_t E_f$$

$$E_f = 173.6V$$

```
-->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)')
```

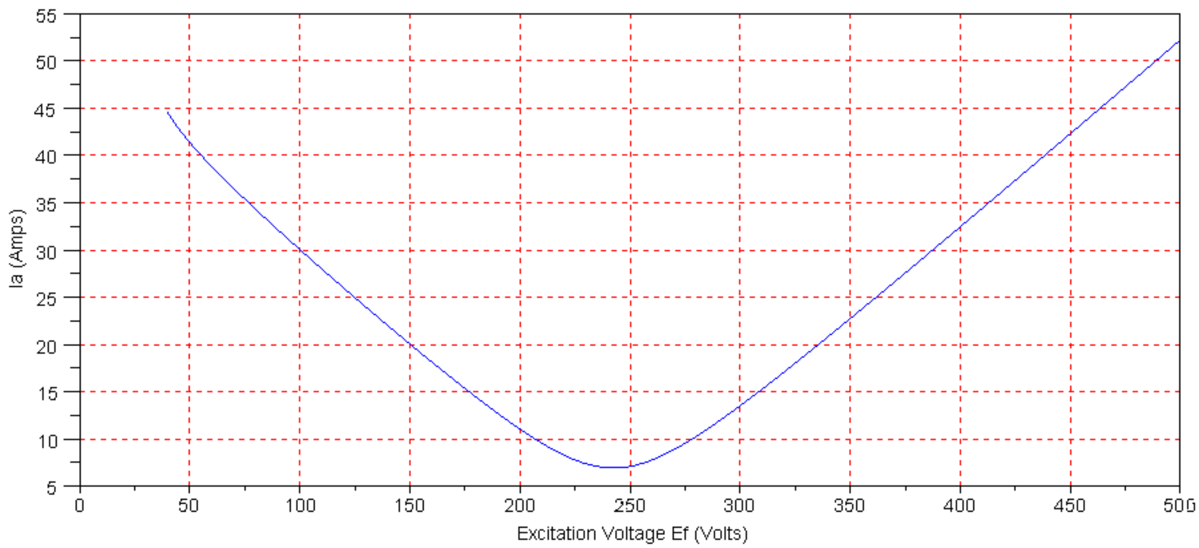


6) Assume a load of 5kW (10% load). Plot the per-phase source curent, Ia, and the phase of Ia as the excitation voltage, Ef, varies from 0V to 500V. (Voltage Load Line)

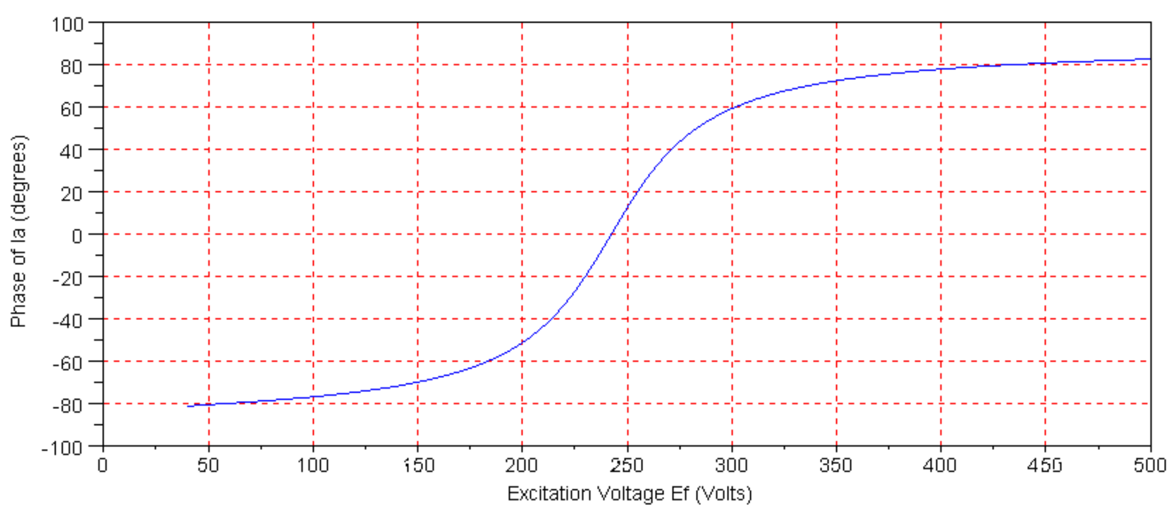
If the load is 10% of max load, the min excitation voltage is 10% as well:

Ef > 34.7 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: