ECE 331 - Solution to Homework #7

AC Synchronous Generator

1) Assume an AC synchronous generator: 75kW, 3 phase, 2-pole, 60Hz, $240V_{LN}$, Xs = 7.0 Ohms, Ef = 350V.

Find the slip angle, δ, to generate 10kW:

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

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

$$-10000 = 3\left(\frac{-(240V)(350V)}{7.0\Omega}\right) \cdot \sin(\delta)$$

$$\delta = +16.13^0$$

The rotor leads the rotating field by 16.13 degrees (as opposed to homework #6 where it lagged by 10 degrees).

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

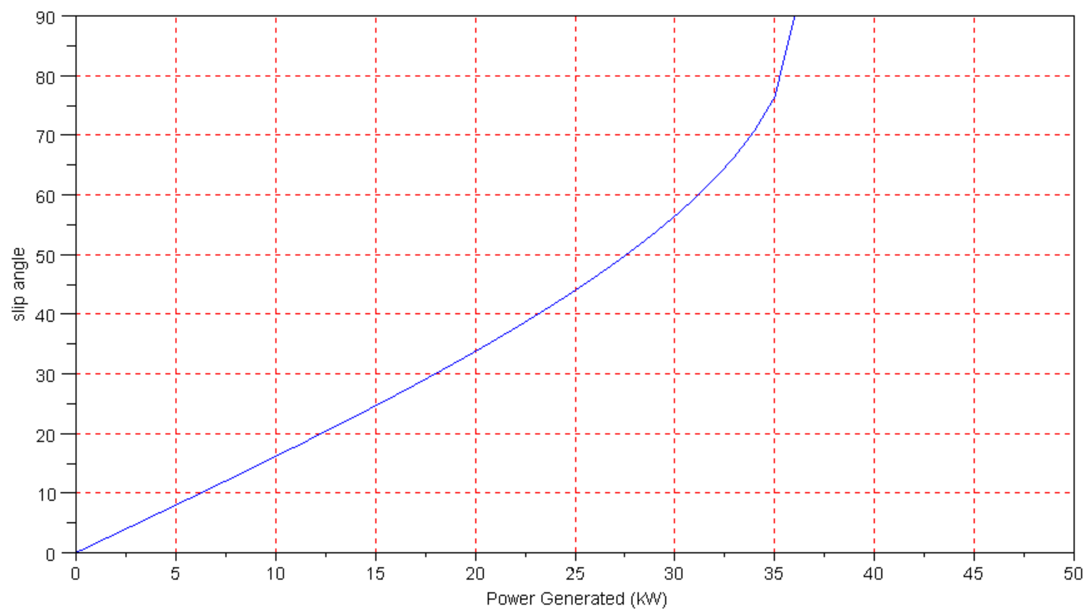
```
function [delta] = sm_slip(P)

delta = -asin(P*7 / (3*240*350));

endfunction
```

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

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



Note that the maximum power you can generate is 36kW.

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

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

j = sqrt(-1);
Xs = 7;
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 power generated of 75kW. Plot the per-phase source curent, Ia, and the phase of Ia as the excitation voltage, Ef, varies from 0V to 500V. (V curve)

Compute the minimum excitation voltage required to generate 75kW:

```
-->P = -75000;
-->Xs = 7;
-->Vt = 240;
-->P*Xs/3/Vt
  - 729.16667
```

There is no solution.

You need at least 729V to produce 75kW.

5) Assume a power generated of 20kW. Plot the per-phase source curent, Ia, and the phase of Ia as the excitation voltage, Ef, varies from 0V to 500V. (V curve)

```
-->P = -20000;

-->P*Xs/3/Vt

  - 194.44444
```

You need at least 194.4V to produce 20kW. Sweep the excitation voltage from 195V .. 500V.

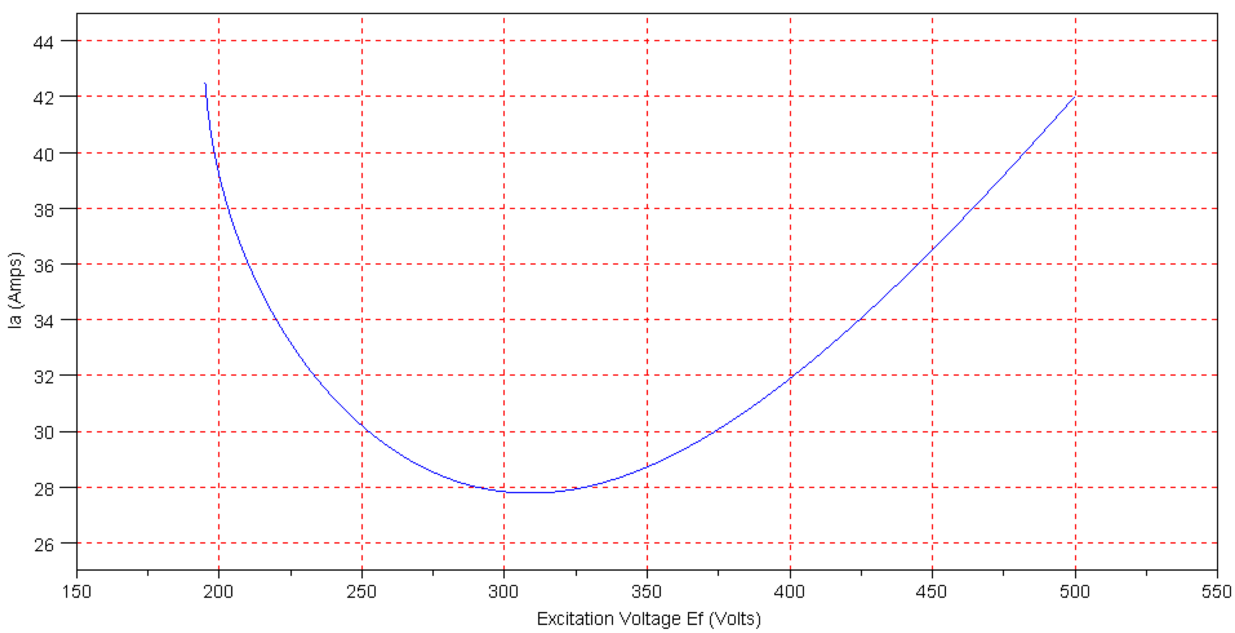
```
 -->Ef5 = [209:500]';
```

Compute the slip angle and current:

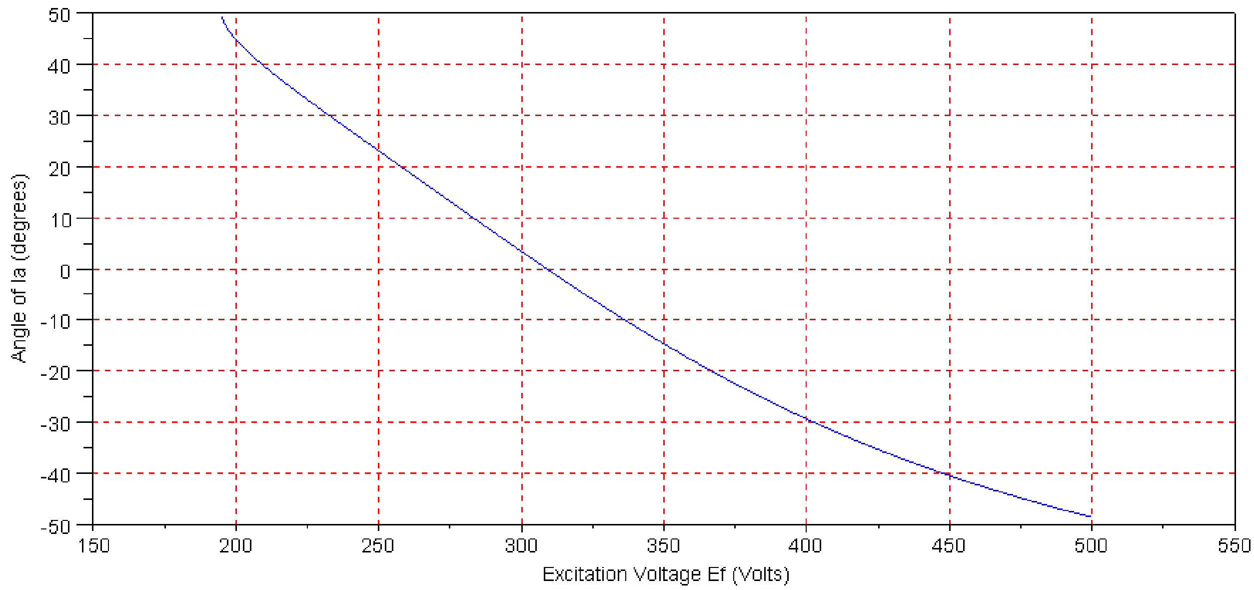
```
-->delta5 = -asin(P*Xs ./ (3*Vt*Ef5));
-->Ef5 = Ef5 .* exp(j*delta5);
-->Ia5 = (Vt - Ef5) / (j*Xs);
```

Plotting the results:

```
-->plot(abs(Ef5),abs(Ia5));
-->xlabel('Excitation Voltage Ef (Volts)');
-->xgrid(5);
-->ylabel('Ia (Amps)')
```



```
-->plot(abs(Ef5),angle(-Ia5));
-->xlabel('Excitation Voltage Ef (Volts)');
-->xgrid(5);
-->ylabel('Angle of Ia (degrees)')
```



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6) Assume a power generated of 10kW. Plot the per-phase source curent, Ia, and the phase of Ia as the excitation voltage, Ef, varies from 0V to 500V. (V curve)

Compute the minimum excitation voltage to generate 10kW:

```
-->P = -10000;

-->P*Xs/3/Vt
  - 97.222222
```

Sweep the excitation voltage from 98V to 500V:

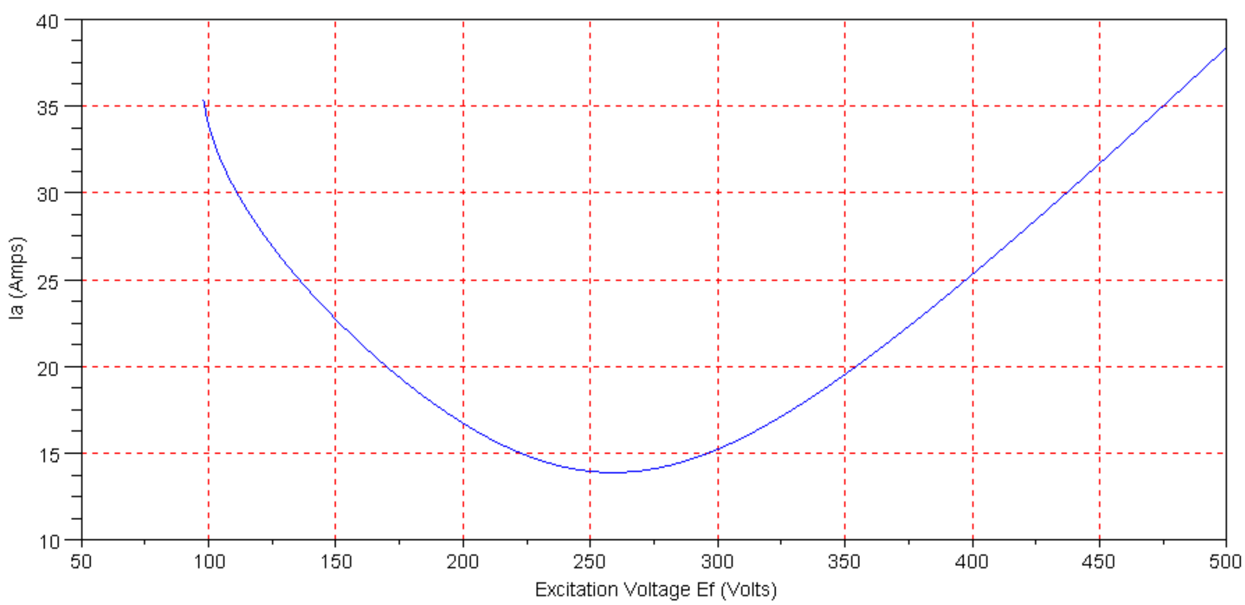
```
-->Ef6 = [70:500]';
```

Compute the slip angle and current

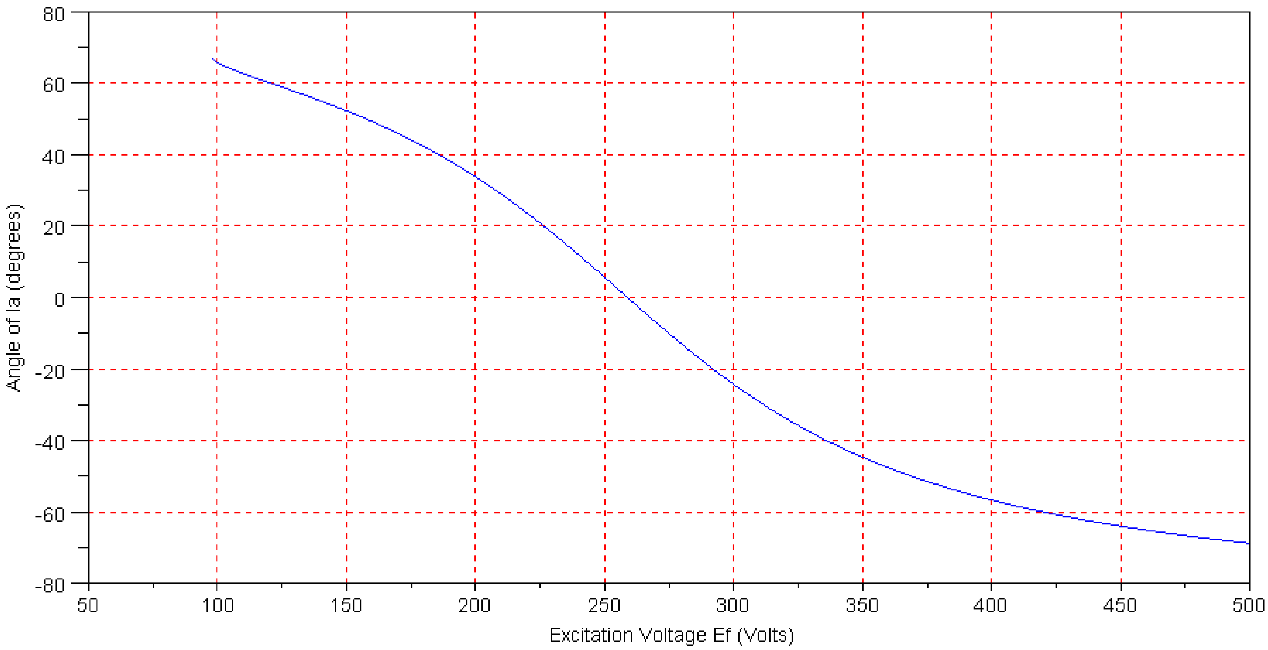
```
-->delta6 = -asin(P*Xs ./ (3*Vt*Ef6) );
-->Ef6 = Ef6 .* exp(j*delta6);
-->Ia6 = (Vt - Ef6) / (j*Xs);
```

Plot the results:

```
-->plot(abs(Ef6),abs(Ia6));
-->xlabel('Excitation Voltage Ef (Volts)');
-->xgrid(5);
-->ylabel('Ia (Amps)')
```




```
-->plot(abs(Ef6),angle(-Ia6));
-->xgrid(5);
-->xlabel('Excitation Voltage Ef (Volts)');
-->ylabel('Angle of Ia (degrees)')
```



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