CHARACTERISTICS OF A SYNCHRONOUS GENERATOR

Dt021A/3 Machine Lab 2
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A) Simulate OC test, SC test of a standalone Synchronous Generator, Typical graphs expected are OC curve, SC curve after the simulation.

Open Circuit test:

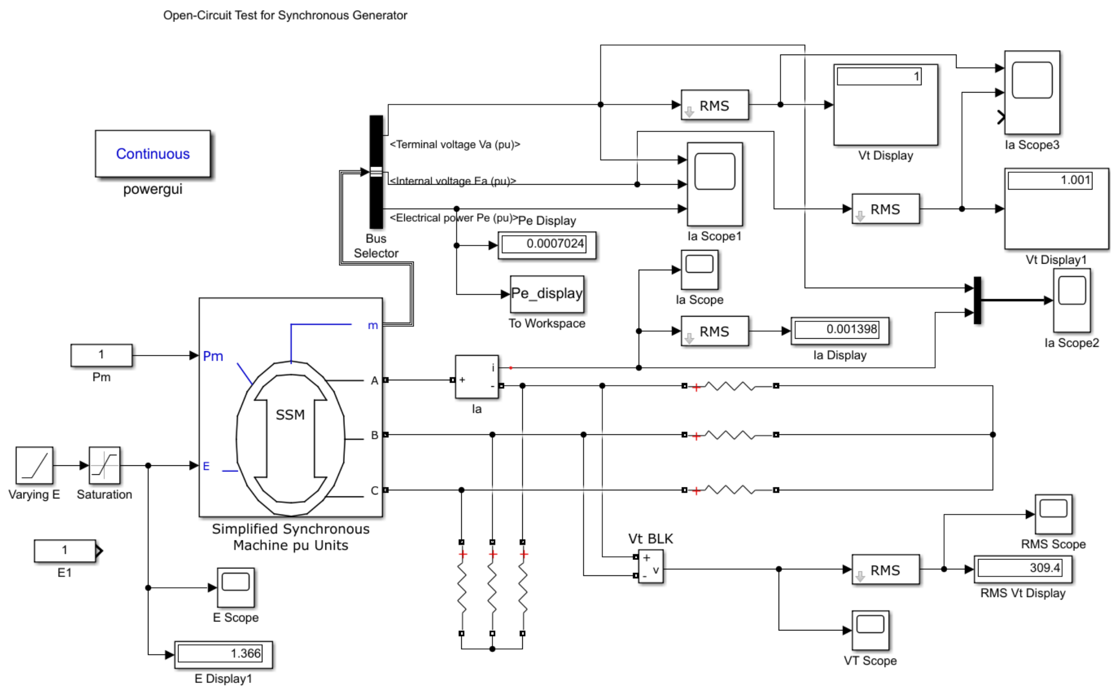

Figure 1 - Model of the open-circuit test for synchronous generator

In order to test the open circuit, the high resistor value of the RLOAD was chosen to be 200k Ohms to create an open circuit. As the resistance of the RLOAD increases the current reduces at A and which causes the Terminal and Internal voltages to be the same.
The circuit model is in power unit at which produces voltage displays 1 is the rated exited voltage.

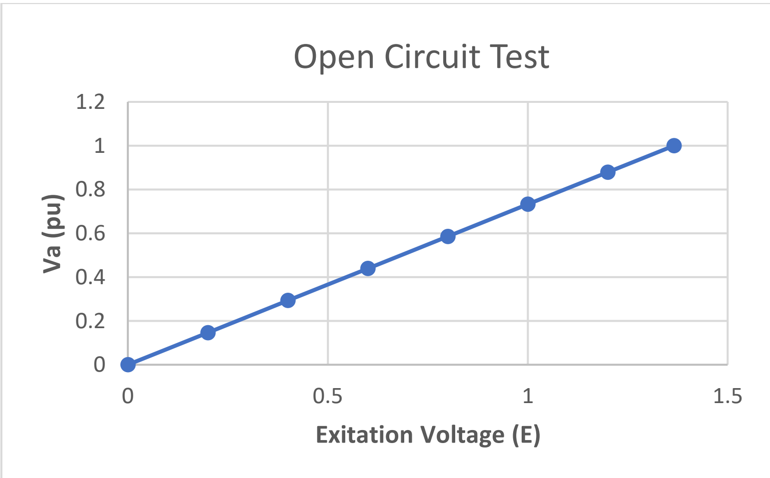

Figure 2 - Open circuit test graph

The Excitation voltage terminal voltage

Short Circuit test:

The rated excitation is given by the terminal voltage of 1 per unit. If any value that is below than 1.5 in the E considered as a under excitation condition, because the terminal voltage is less than 1. If the Terminal voltage is higher than 1 it is known as over excitation condition. To find the current in A the following equation is used:

$$I = \frac{Pn(VA)}{Vn(Vrms)}$$

$$I = \frac{1k}{\sqrt{3}\ \times 220} = 2.624A$$

In order to test the short circuit, the low resistor value of the RLOAD was chosen to be 100u Ohms to create a short circuit. As the resistance of the RLOAD decreases the current raises at A which causes the Terminal and Internal voltages to have different voltage amplitude. The circuit model is in power unit at which displays voltage 1 is the rated exited voltage shown in figure 1.

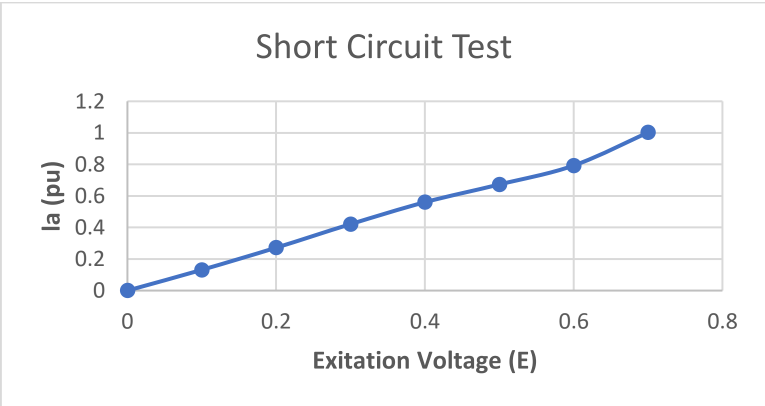

Figure 3 - Short circuit test

B) Simulate Load test on a Synchronous generator with R, L and C type load and plot the Terminal voltage vs stator current in the same graph load curve (Va vs Ia where If is constant);

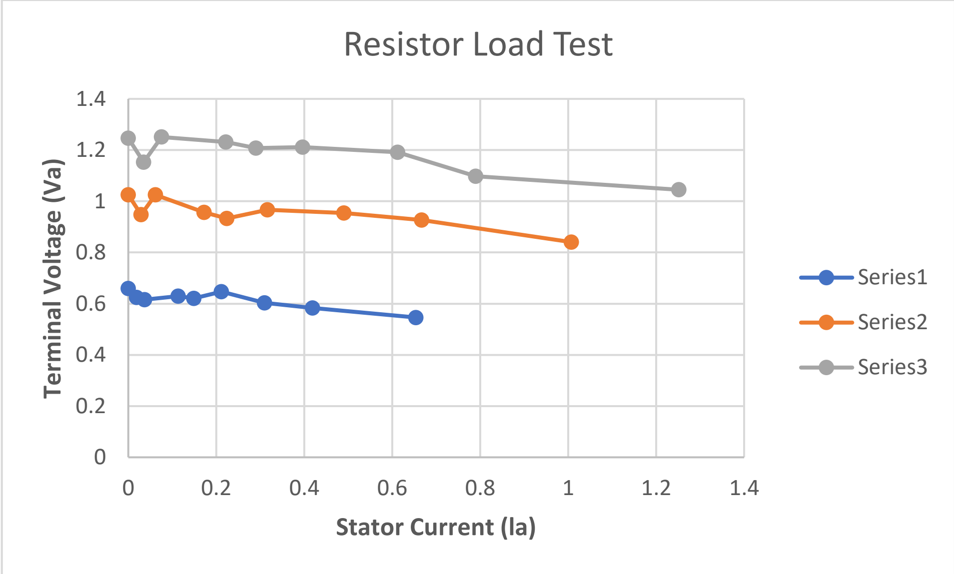

Figure 4 - Resistor Load Test

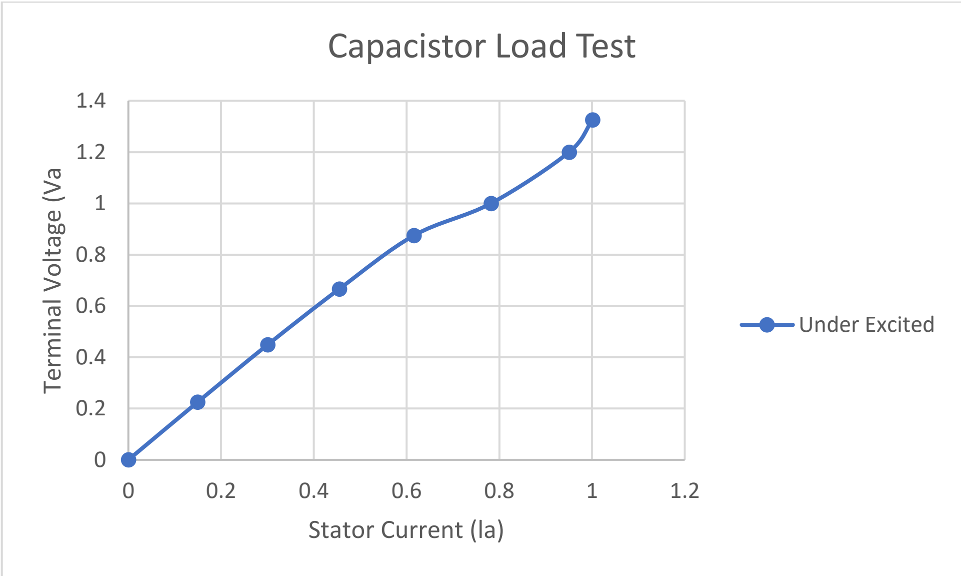

Figure 5 - Under exited graph for Capacitor load

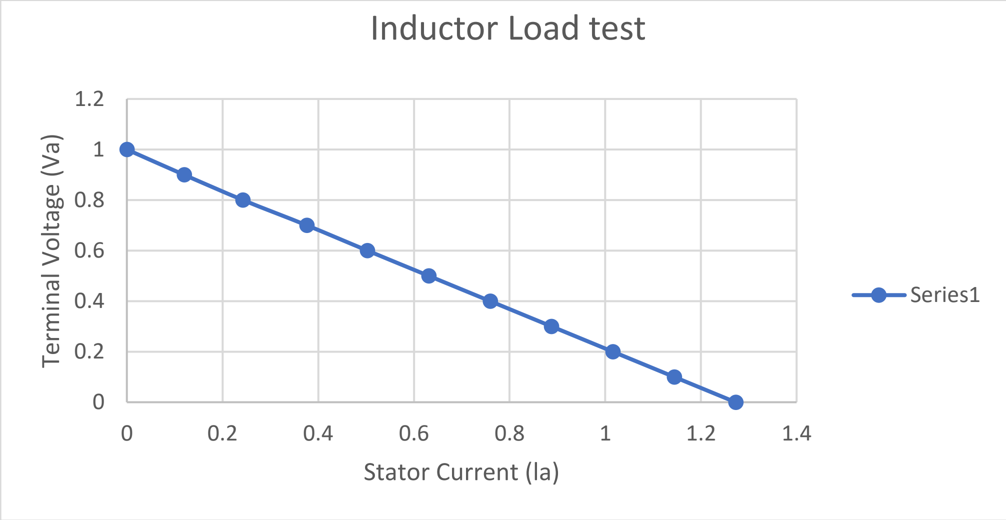

Figure 6 - Under excited graph for inductor

C) Find the Xs value from simulation results and check how close it is to input parameter you have selected

E = Vt + la * jXs

Xs = Ea/la , where (la=1)

Xs = 0.5373/1.002 = 0.536

1. What is a V- curve of a Synchronous Machine; show by drawing a v- curve how does the synchronous motor curve differ from a synchronous generator curve.

The power factor of the synchronous motor varying I_f. The I_a changes with the change in I_f. If the I_f is increased from the small value, the I_a decreases until the I_a becomes minimum when considering motor is operating at no load. The motor operates at unity power factor at minimum point. The motor operates at lagging power factor until it gets to point of operation.

If the current is increased even more, the I_a increases causes the motor to operate as a leading power factor. V curves consist of a stator current over field current for various constant loads. The graph shown below is the armature current I_a and field current I_f at no load the curve is formed known as a V curve. As the shape of the curve is like the letter “V”, therefore it is known as V curve of the synchronous motor.

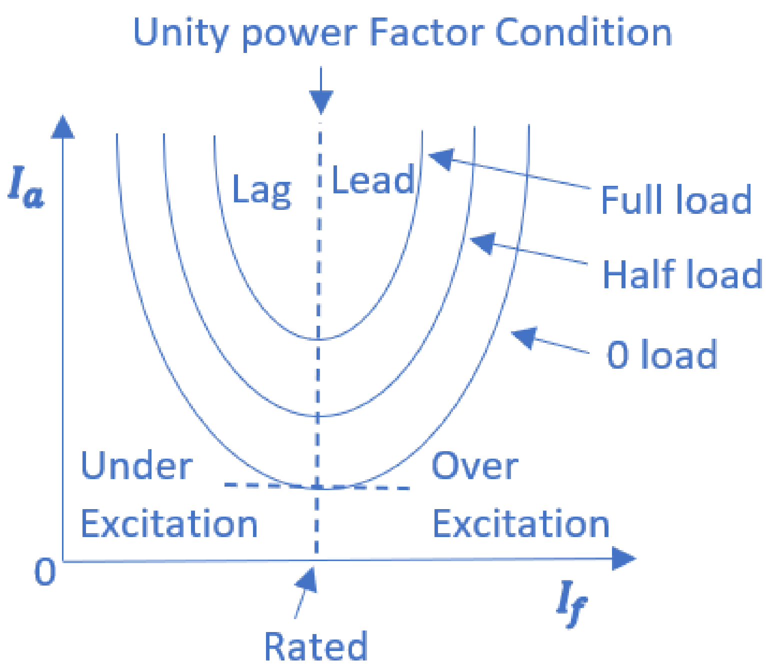

Figure 7 - V Curve of a Synchronous Motor

In Synchronous generator, if the power factor (pf) is plotted against excitation for various load condition, we get a set of curves known as Generator or Inverted V-Curves. The power factor is lags when the generator is under exited and leads when it is over excited.

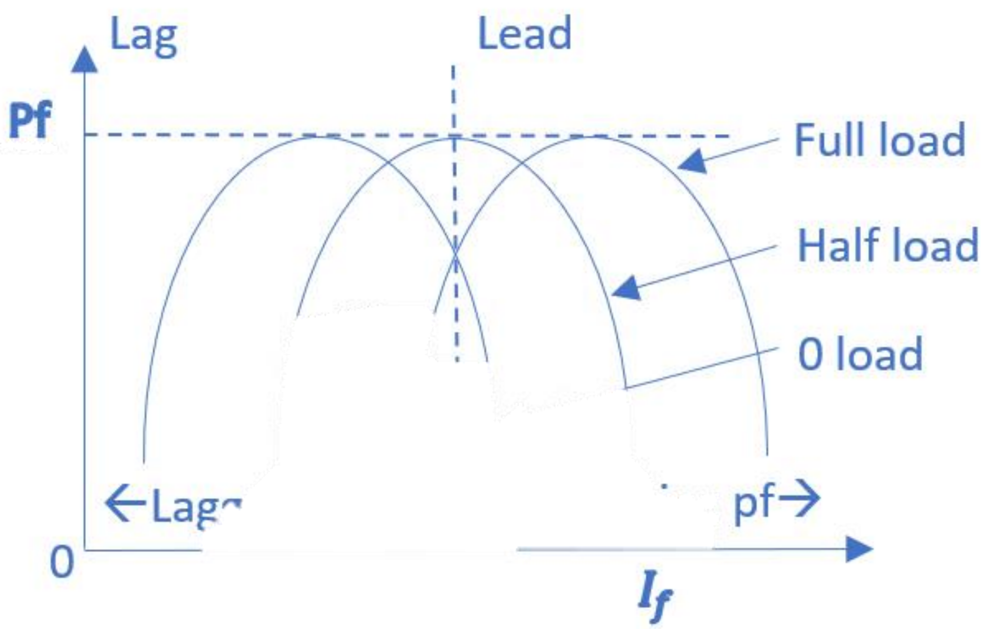

Figure 8 - V Curve of a Synchronous Generator

2. **Describe with a diagram what is a constant power locus of a synchronous machine? Will it be restricted by any specific power factor?**

3. Draw a phasor diagram of a cylindrical rotor synchronous motor when it is running at unity power factor condition.

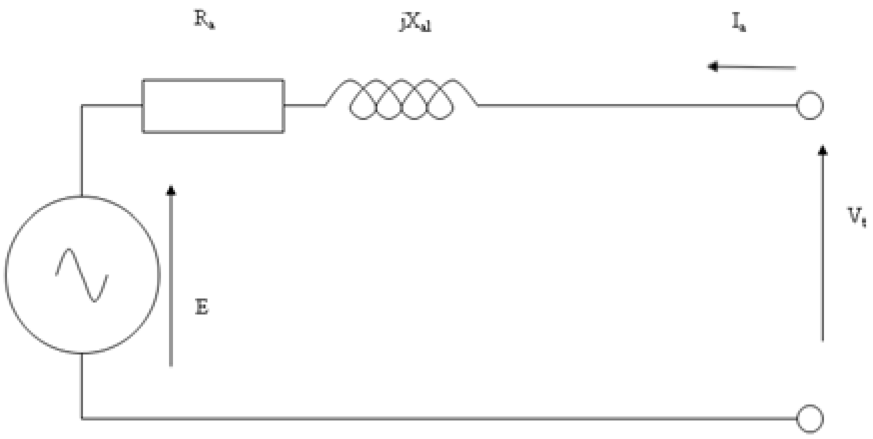

Figure 9 - Per phase equivalent circuit of a Synchronous generator

$$V_t = E_f + I_a R_a + jI_a X_s$$

Rearranging the equation to find the unity power factor of the synchronous motor.

$$E_f = V_t - I_a R_a - jI_a X_s$$

The phasor diagram of a cylindrical rotor synchronous when running a Unity power factor. As I is in phase with V.

$$\therefore\ V_i I_i \phi = 0$$

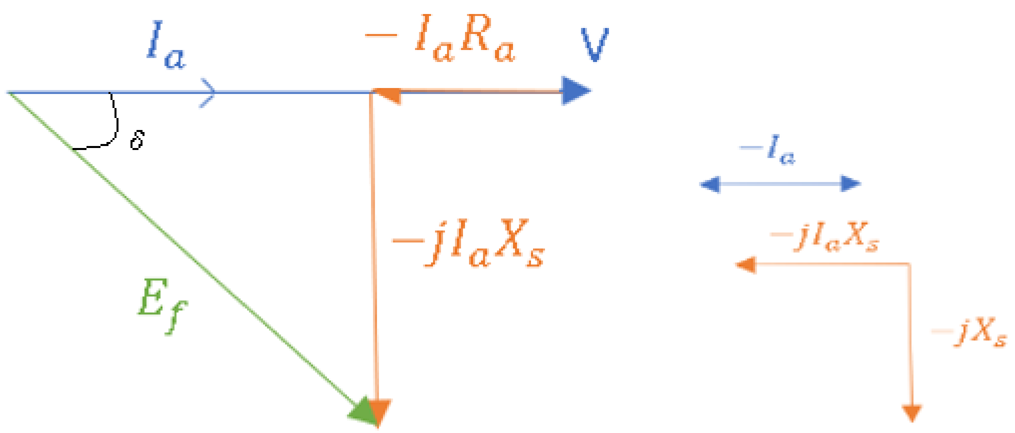

Figure 10 - Phasor diagram of a cylindrical rotor synchronous motor

4. How can you vary speed of a synchronous motor?

When Increasing the supply frequency of the current fed into the synchronous motor causes the motor to rotate faster as this is achieved by using the DC to AC invertor where the frequency can be adjusted to control the speed of the synchronous motor.
AC Motor Synchronous speed formula is given by:

$$n_s = \frac{120 * f}{p}$$

Where f is the frequency in Hz, p is the number of poles and n_s is the synchronous speed in rpm. As the frequency increases the speed of the motor increases as shown in the Table 1.

Table 1 - Calculating speed of the synchronous motor in rpm

p	f	n_s
20	100	600
	1000	6000
	1900	11400
	2800	16800
	3700	22200
	4600	27600