EE160 Lab Assignment-8

Lab section 1A

Synchronous Generator

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Objectives:

Create and execute a Matlab Program that models the Synchronous Generator operating alone.

Description:

The provided MATLAB code is used to calculate and visualize the terminal characteristic for a 0.8 power factor lagging load. It begins by initializing various variables such as the range of current amplitudes (0 to 60 A), phase voltage, voltage magnitude, electrical phase angle, line impedance, and reference voltage.

Next, the code proceeds to iterate over each current level and calculates the corresponding phase voltage based on the given formulas. Using this phase voltage, it determines the terminal voltage while considering the phase relationship between the current and voltage in a three-phase system.

Finally, the code plots the terminal characteristic by creating a graph where the x-axis represents the line current and the y-axis represents the terminal voltage. It also adds appropriate labels to the axes, a title to the plot, and sets the desired axis limits. This resulting plot provides a visual representation of the relationship between the line current and terminal voltage for the specified load condition.

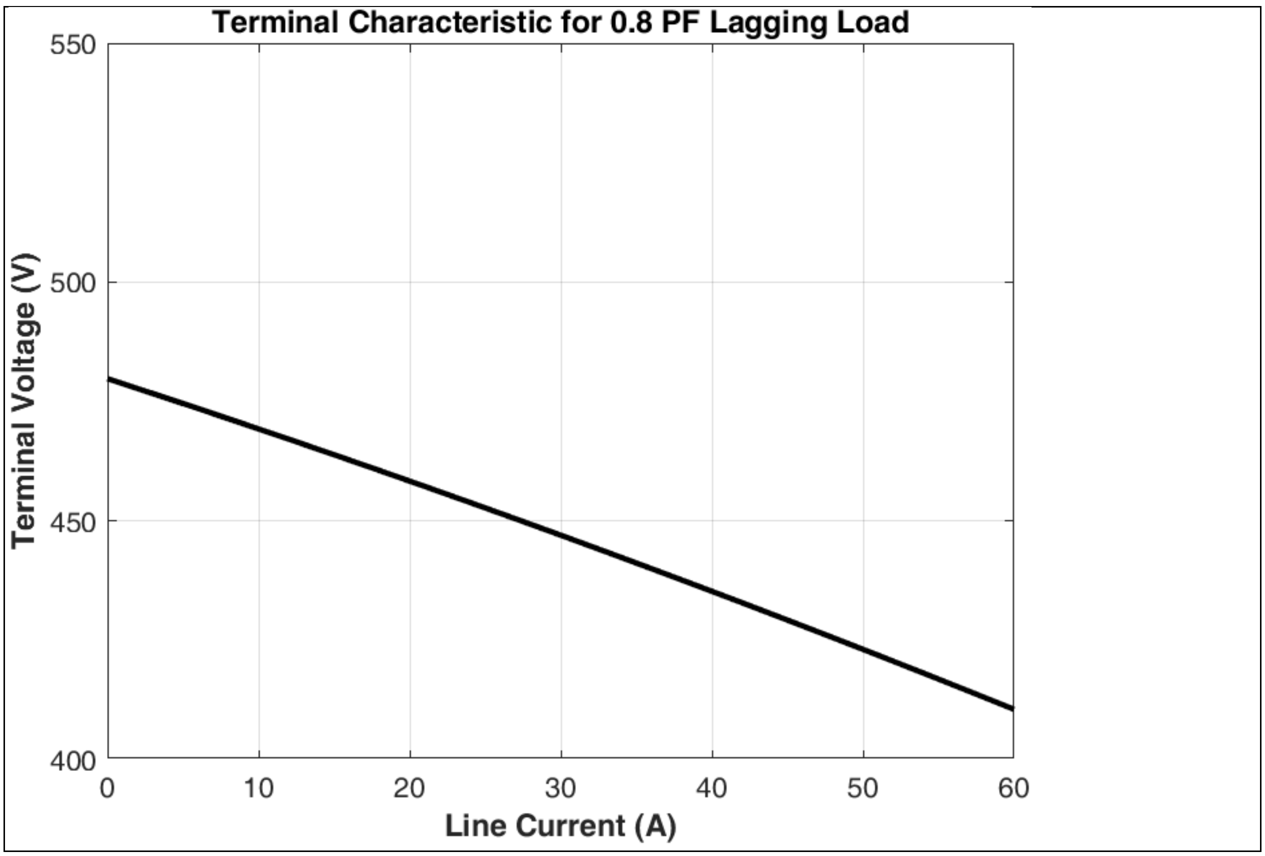
Program Code:

For Lagging

```
% Initialize current amplitudes (21 values in the range 0-60 A)
i_a = (0:20) * 3;
% Initialize other values
v_phase = zeros(1, 21);
e_a = 277.0;
x_s = 1.0;
theta = 36.57 * (pi / 180); % Converted to radians
% Calculate v_phase for each current level
for ii = 1:21
v_phase(ii) = sqrt(e_a^2 - (x_s * i_a(ii) * cos(theta))^2) - (x_s * i_a(ii) *
sin(theta));
end
% Calculate terminal voltage from the phase voltage
```

```
v_t = v_phase * sqrt(3);
% Plot the terminal characteristic, remembering the line current is the same
as i_a
plot(i_a, v_t, 'Color', 'k', 'Linewidth', 2.0);
xlabel('Line Current (A)', 'Fontweight', 'Bold');
ylabel('Terminal Voltage (V)', 'Fontweight', 'Bold');
title('Terminal Characteristic for 0.8 PF Lagging Load', 'Fontweight',
'Bold');
grid on;
axis([0 60 400 550]);
```

Graph :-

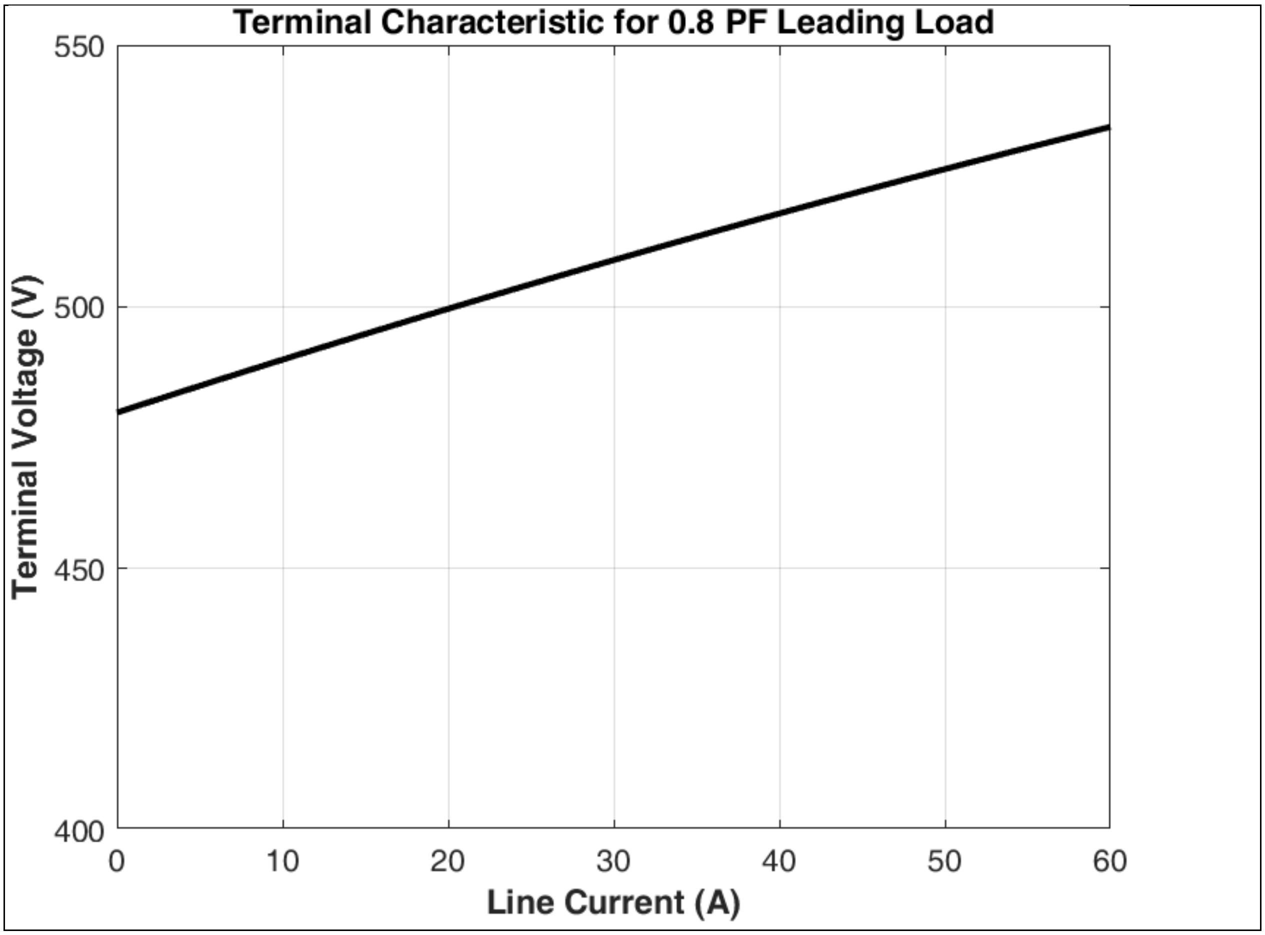


For leading:

Change

```
theta = - 36.57 * (pi / 180);
```

Graph:



Observations:

Based on the observations made and the characteristics of power factor variations, there are three possible graphs that can be generated to illustrate the relationship between generator loads, power factor, and terminal voltage:

1) Lagging power factor:
When the generator operates with a lagging power factor, an increase in the connected load results in a decrease in the terminal voltage. This reduction is primarily caused by the increased demand for reactive power from the load. The generator compensates for this demand by supplying additional reactive power, leading to a voltage drop across its internal reactance and subsequently lowering the terminal voltage.

2) Unity power factor:
At unity power factor, where the load consumes only real power, an increase in the connected load leads to a slight decrease in the terminal voltage. This decrease is mainly attributed to the voltage drop across the generator's internal impedance, consisting of resistive and inductive components. However, since there is no reactive power component involved at unity power factor, the change in terminal voltage is relatively small compared to the lagging power factor scenario.

3) Leading power factor:
In the case of a leading power factor, where the load produces reactive power, an increase in the connected load results in an increase in the terminal voltage. As the load generates reactive power, the demand for reactive power from the generator decreases. Consequently, the generator reduces its output of reactive power, leading to a diminished voltage drop across its internal reactance. Ultimately, this decrease in voltage drop contributes to an increase in the terminal voltage.

Based on the graph you mentioned, it can be inferred that the plotted graph represents the relationship between line current and terminal voltage for a leading power factor. This conclusion is supported by the fact that the terminal voltage increases as the line current increases, aligning with the characteristics described for a leading power factor scenario.

Figures :

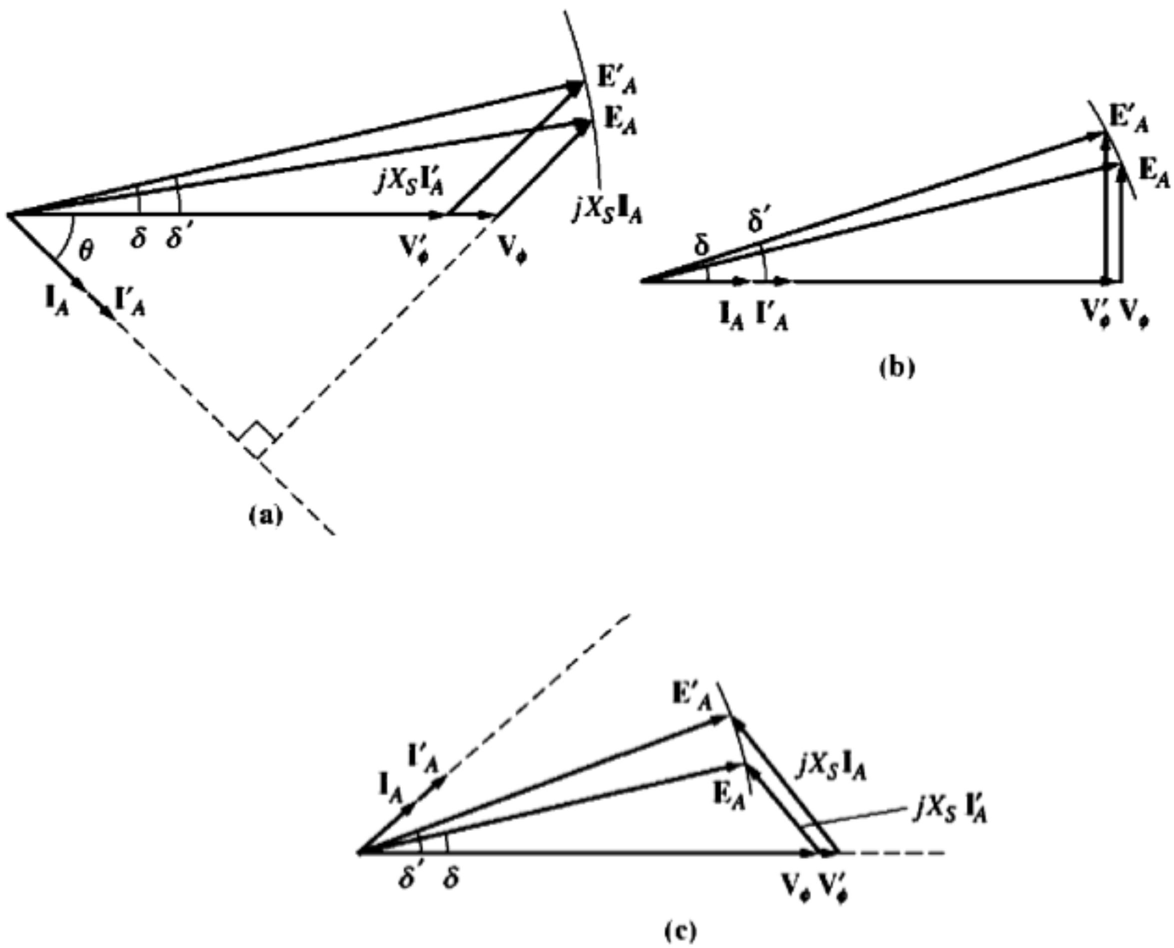


FIGURE 5–22
The effect of an increase in generator loads at constant power factor upon its terminal voltage. (a) Lagging power factor; (b) unity power factor; (c) leading power factor.

Conclusion :

1. When lagging loads, such as inductive reactive power loads, are connected to a generator, it causes a notable reduction in both the phase voltage (V phase) and terminal voltage. This decrease occurs due to the increased demand for reactive power from the load, which requires the generator to supply additional reactive power. Consequently, there is a voltage drop across the generator's internal reactance, resulting in lower phase voltage and terminal voltage.
2. The introduction of unity-power-factor loads, which consume only real power without any reactive power, to a generator results in a slight decrease in both the phase voltage and terminal voltage. This decrease can be attributed to the voltage drop across the generator's internal impedance, which includes resistive and inductive components. However, since there is no reactive power component involved at unity power factor, the change in phase voltage and terminal voltage is relatively small compared to scenarios with lagging loads.
3. When leading loads, such as capacitive reactive power loads, are added to a generator, it leads to an increase in both the phase voltage and terminal voltage. As the load produces reactive power, there is a reduced demand for reactive power from the generator. Consequently, the generator responds by reducing its output of reactive power, resulting in a diminished voltage drop across its internal reactance. This reduction in voltage drop contributes to an overall increase in both the phase voltage and terminal voltage.