Power Systems Lab

Experiment 7

Laboratory Report

Syed Alisamar Husain, 17BEE012
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Department of Electrical Engineering
Jamia Millia Islamia, New Delhi

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1 Objective

To verify the superposition theorem for a 3-phase radial electrical power system using Simulink Simscape Electrical.

2 Theoretical Background

The Superposition Theorem states that a linear circuit can be analyzed with only one source of power at a time, the corresponding component voltages and currents algebraically added to find the net effect of all power sources.

To negate all but one power source for analysis, replace any source of voltage (batteries) with a wire; replace any current source with an open (break).

It must be noted, that the Superposition Theorem works only for circuits that are reducible to series/parallel combinations for each of the power sources at a time. Thus, this theorem can't be used for analyzing an unbalanced bridge circuit, and it only works where the underlying equations are linear (no mathematical powers or roots).

2.1 Prerequisites for Applicablility

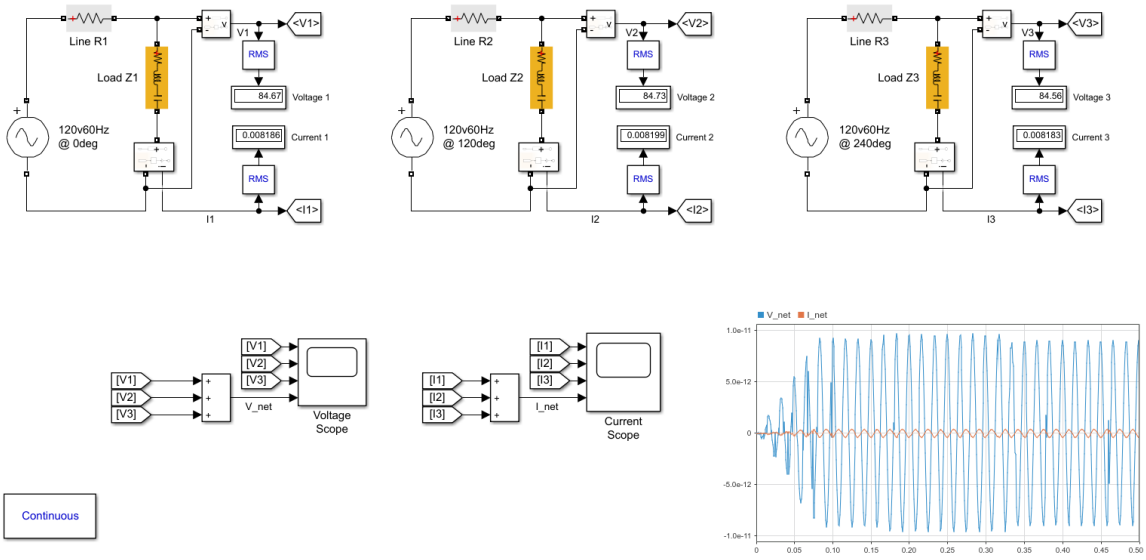
The requisite of linearity means that Superposition Theorem is only applicable for determining voltage and current, not power. Power dissipations, being nonlinear functions, do not algebraically add to an accurate total when only one source is considered at a time. The need for linearity also means this Theorem cannot be applied in circuits where the resistance of a component changes with voltage or current. Hence, networks containing components like lamps (incandescent or gas-discharge) or varistors could not be analyzed.

Another prerequisite for Superposition Theorem is that all components must be **bilateral**, meaning that they behave the same with electrons flowing in either direction through them. Resistors, inductors and capacitors being studied must have no polarity-specific behavior.

The Superposition Theorem finds use in the study of alternating current (AC) circuits, and semiconductor (amplifier) circuits, where sometimes AC is often mixed (superimposed) with DC. Because AC voltage and current equations (Ohms Law) are linear just like DC, we can use Superposition to analyze the circuit with just the DC power source, then just the AC power source, combining the results to tell what will happen with both AC and DC sources in effect.

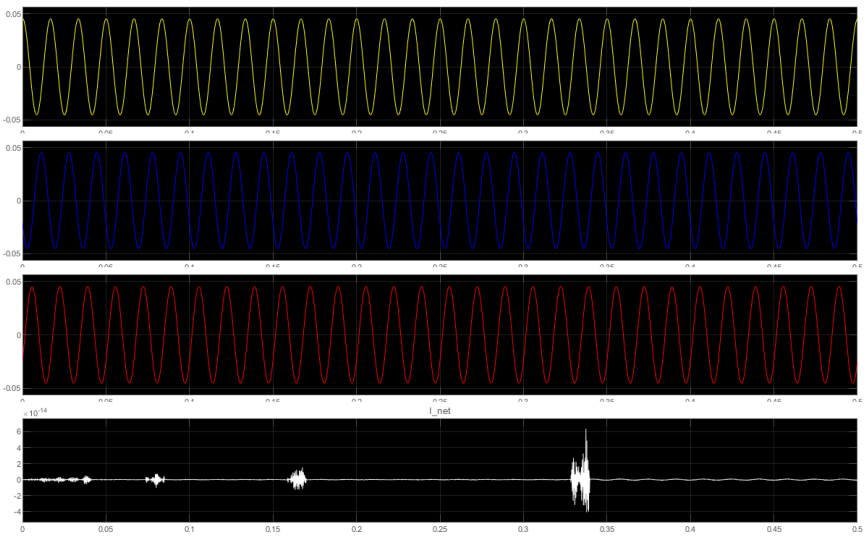
3 Implementation

For the verification of the superposition theorem, we build a model to represent the three phases of a 3-phase power system, each 120 degrees apart. Each phase has an independent voltage source and a **line resistance** in series with a **load impedance.** These resistances and impedances are equal for every phase, thus making the system balanced.



4 Observations

We measure the sum of voltages and currents which will give us the voltage at the null-point of a Y-connected load. For a three-phase system we expect that **the sum of currents at the null point should be zero**, since the sum of three sine waves 120 degrees out of phase with each other is zero at every point.



From the graph we can see that the currents at the null-point sum to zero, thus proving that the sum of currents of three independent phases is the same as the current of a 3-phase system. This means that each voltage source can be considered independently, **hence proving the superposition theorem.**

5 Result

We proved and verified that superposition theorem for a 3-phase power system using a Simulink model.