ECE 526: Engineering Outreach Lab 3  
Due: Session 29, April 27

Lab Objective
- Observe the effect of series capacitors on distance elements and line current differential elements
- Apply the principles of setting the distance and line current differential elements using the MathCAD relay models of the distance elements and the line current differential elements.
- Test these elements using COMTRADE files (from ATP/EMTP simulations)
- Analyze the simulation results

The Power System Configuration

The simulated power system is configured as shown below, with two sources, two transmission lines and series capacitors in the first line. The system parameters as follows:

\[
V_S := 69.5V \cdot e^{j \cdot 0 \text{deg}} \\
V_R := 69.5V \cdot e^{-j \cdot 2.5 \text{deg}} \\
Z_{S1} := j \cdot 1 \text{ohm} \\
Z_{cap1} := -j \cdot 0.8 \text{ohm} \\
Z_{1L1} := j \cdot 1 \text{ohm} \\
Z_{1L2} := j \cdot 1 \text{ohm} \\
Z_{R1} := j \cdot 0.4 \text{ohm} \\
Z_{S0} := j \cdot 3 \text{ohm} \\
Z_{cap0} := -j \cdot 0.8 \text{ohm} \\
Z_{0L1} := j \cdot 3 \text{ohm} \\
Z_{0L2} := j \cdot 3 \text{ohm} \\
Z_{R0} := j \cdot 1.2 \text{ohm}
\]

Power System Configuration
Lab Procedure:

- Set the relays at Bus S and Bus R to provide protection to line 1 by using the MathCAD relay models for distance elements and line current differential elements.
- Set Zone 1 of the line and time delayed back up Zone 2 of this line as well as the line current differential elements.
- For the setting of CT ratio and PT ratio: they are set as CTR = 1 and PTR = 1.
- Download the COMTRADE files for SLG faults for four cases. These will be placed on the web page as zip files (each with a *.hdr, *.cfg, *.dat) file.
- Load each of the COMTRADE files into the MathCAD relay model and test your setting for the following cases:

  - **Case 1:** without series capacitors
    Suppose the SLG fault occurs at 10% of the way from bus 2 to bus 3. Test your settings and observe the response of the distance elements and the line currents differential elements for this fault.

  - **Case 2:** with series capacitors (50% of the line 1 impedance)
    Suppose the SLG fault occurs at 10% of the way from bus 2 to bus 3. Observe the response of the distance elements and the line currents differential elements for this fault.

  - **Case 3:** with series capacitors (80% of the line 1 impedance)
    For this case suppose the SLG fault occurs at 20% of the way from bus 1 to bus 2. Observe the response of the distance elements and the line currents differential elements for this fault. For distance elements, the COMTRADE files are provided for bus side and line side measurement.

  - **Case 4:** with series capacitors (90% of the line 1 impedance)
    For this case suppose the SLG fault occurs at 20% of the way from bus 1 to bus 2 and the sending end source impedance is equal to \( Z_{S1} = (j.0.3) \) ohm. Notes the response of the distance elements and line currents differential elements for this fault. For distance elements, the COMTRADE files are provided for bus side and line side measurement.

Report:
1. Your report should list your relay settings
2. Compare the response of the distance elements versus the response of the line current differential elements for each case.
3. Comment on your results and determine the challenges of using series capacitor in each case for the distance elements and the line current differential elements.