1. Do the following for the circuit below using $Z_{bus}$ matrix methods assuming faults 33% of the way down line 2 (the lower of the two lines). No change of base calculations needed.

   a. Set the voltage source at Bus S is 1.0 at -30 degrees (this is to account for the transformer phase shift), and the voltage at Bus R to be 1.0 is -50 degrees. Calculate the prefault voltage magnitude and angle at each bus, including the fault point based on the prefault power flow. Check your results with a Powerworld or a similar program.

   b. Calculate the voltages and currents in the sequence domain and in the abc domain at RelayR1 and RelayR2, for 3 phase, SLG, LL, and DLG faults with $R_f = 0.3$ pu (for the DLG put the resistance in the ground path). Again, check your results with Powerworld or a similar program.

![Circuit Diagram]

- $V = 1.0\text{pu}$
- $Z_{S1} = j0.3\text{pu}$
- $Z_{S2} = Z_{S1}$
- $Z_{S0} = j0.01\text{pu}$

- $V = 1.0\text{pu}$
- $Z_{R1} = j0.3\text{pu}$
- $Z_{R2} = Z_{R1}$
- $Z_{R0} = j0.01\text{pu}$

- $Z_{L11} = 1.1\text{pu} / 85^\circ$
- $Z_{L12} = Z_{L11}$
- $Z_{L10} = 3*Z_{L11}$
- $Z_{L21} = 1.1\text{pu} / 85^\circ$
- $Z_{L22} = Z_{L21}$
- $Z_{L20} = 3*Z_{L21}$
- $Z_{L31} = 1.1\text{pu} / 85^\circ$
- $Z_{L32} = Z_{L31}$
- $Z_{L30} = 3*Z_{L31}$
- $Z_{L41} = 1.1\text{pu} / 85^\circ$
- $Z_{L42} = Z_{L41}$
- $Z_{L40} = 3*Z_{L41}$

- $13.8:345\text{kV}$
- $X = 10\%$
- $X/R = 15$
- $-Y_g$

- $345:24\text{kV}$
- $X = 10\%$
- $X/R = 15$
- $Y_g$
2. Given the system below do the following:
   (a) Sketch the sequence equivalent circuits series faults occurring on line 1 (Bus 2-Bus3) and reduce them to simplified equivalents. The voltages given are at BUS1 and BUS4, not the voltages behind the source impedances.
   (b) Determine the phase currents from Bus 1 to Bus 5 and from Bus 2 to Bus 3 if phase C is open on line 1 (treat it as the breakers at Bus 2 on phase C is open and phases A and B are closed).
   (c) Repeat part (b) if the transformer from Bus 1-Bus 2 is Y ungrounded on the HV side.
   (d) Determine the phase currents from Bus 1 to Bus 5 and from Bus 2 to Bus 3 if phases B and C are open on line 1 (treat this as the breaker having phase A closed and phases B and C open).
   (e) Repeat part (d) if the transformer from Bus 1-Bus 2 is Y ungrounded on the HV side.
   (f) Suppose that line 3 is series compensated, with each phase having a capacitive impedance of -j0.3pu. The capacitor on phase A is bypassed by a misoperating circuit breaker and phases B and C are inserted. Calculate the currents from Bus 1 to Bus 5 and from Bus 2 to Bus 3. Model Za and Zb as being the capacitor only. Do not lump in the line impedance.
   (g) Verify your results using transient simulation.