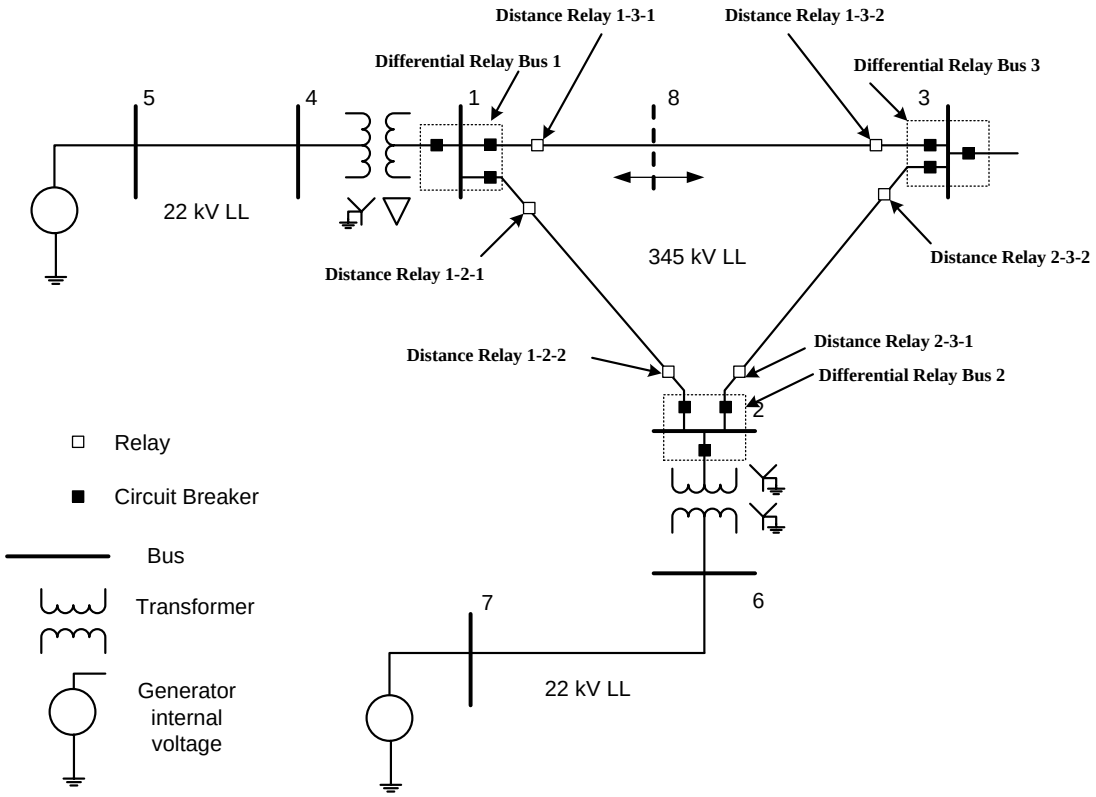
Laboratory Experiment 12A

Fault Analysis with Relay Settings

Objectives: To study a power system with faults and determine relay settings based on calculated fault currents

Laboratory Tasks and Report:

1. You are given the two generator system below. You will use the program to analyze relay settings. The network you are to solve is shown below:



2. You are going to run several faults on this system and then see what various relays would have as input given the fault voltages and currents that the program outputs. The program is in Matlab and is called **FaultAnalysis_RelaySettings.m** and the data describing the network is in a separate file called **NetworkData.m** and you will need both to run the program.
3. The program will print out the Line to Neutral and Line to Line voltages at all buses in the network, as well as the zero, positive and negative sequence currents and the abc currents on each branch of the network. (voltages are in kV currents in amperes)
4. The program allows you to select three phase or line to ground fault, it allows you to select a bus or line fault, and which bus the fault is on. If it is a line fault it

allows you to select how far down the line the fault appears and adds a new bus at that point where the fault takes place.

The positive sequence impedances in per unit for lines 1-3 and 2-3 are: Z13 = 0.005+0.044j and Z23=0.0025+0.022j the system has two voltages, 22 kV and 345 kV. The 22 kV is the voltage of the generators (buses 4, 5, 6 and 7 only) and buses 1, 2, and 3 are at 345 kV. When you run the program it prints out the Sbase, Vbase_LL and Vbase_LN, Ibase and Zbase for all regions. The 22 kV regions are considered region 1 (Vbase1_LL, Vbase1_LN, Ibase1 and Zbase1) and the 345 kV region is region 2 (Vbase2_LL, Vbase2_LN, Ibase2 and Zbase2).

You are going to capture the kV and ampere reading seen by the distance relays 1-3-1, 1-3-2, 2-3-1 and 2-3-2 as shown on the diagram. The program gives you kV LN and amperes flowing during a fault. You will use the following equation to calculate the impedance "seen" by each relay during a set of faults (given below), you will then divide the impedance seen by the actual impedance of each line to determine the distance to the fault. Note that you have to use the line impedance in ohms, not per unit, so use the Zbase2 to convert to actual impedance (use the impedance magnitude):

$$|Z_{measured}| \angle \theta_Z = \frac{|V| \angle \theta_V}{|I| \angle \theta_I}$$

Or

$$|Z_{measured}| = \frac{|V|}{|I|}$$

Where V is in volts (not kV not pu) and I is in amps (not pu) result is Z in ohms

Now calculate the distance to the fault as $d = \frac{Z_{measured}}{Z_{line}}$ where both $Z_{measured}$ and Z_{line} are in ohms, then d is the fraction of the total line's impedance as measured by the relay, which should be the same as the fraction of the line distance where the fault happens.

Task 1: Run the following faults in this order:

Three phase fault at 26 % of distance from bus 1 to bus 3 on line 1-3
Three phase fault at 50 % of distance from bus 1 to bus 3 on line 1-3
Three phase fault at 75 % of distance from bus 1 to bus 3 on line 1-3
Three phase fault on bus 3
Three phase fault at 75 % of distance from bus 2 to bus 3 on line 2-3 (i.e., 25 % of distance from bus 3 to bus 2 on line 2-3)
Three phase fault at 50 % of distance from bus 2 to bus 3 on line 2-3 (i.e., 50 % of distance from bus 3 to bus 2 on line 2-3)
Three phase fault at 25 % of distance from bus 2 to bus 3 on line 2-3 (i.e., 75 % of distance from bus 3 to bus 2 on line 2-3)

Calculate the distance to the fault as calculated by each relay for each case. Note that inline faults result in a new bus called bus 8, so the fault currents seen on relay 1-3-1 are calculated from the line to neutral voltage at bus 1 and the current on one of the phases as seen on line 1-8. Do these calculations for distance calculated at the other relays (1-3-2, 2-3-1, and 2-3-2) for all the faults. Are the faults measuring the distance correctly? Note that when the fault is in line 2-3 the relay at 1-3-1 sees the entire line impedance Z13 and part of the impedance of line 2-3 – so you need to add them together.

Task 2: Repeat the above with a single line to ground fault instead of a three phase fault, once again, calculate the distance measured using phase a(using Va_LN and Ia) as well as phases b and c using their respective LN voltages and phase currents). Can you still get the distance to the fault in the case of a single line to ground fault.