

ECE 526: Lab 1

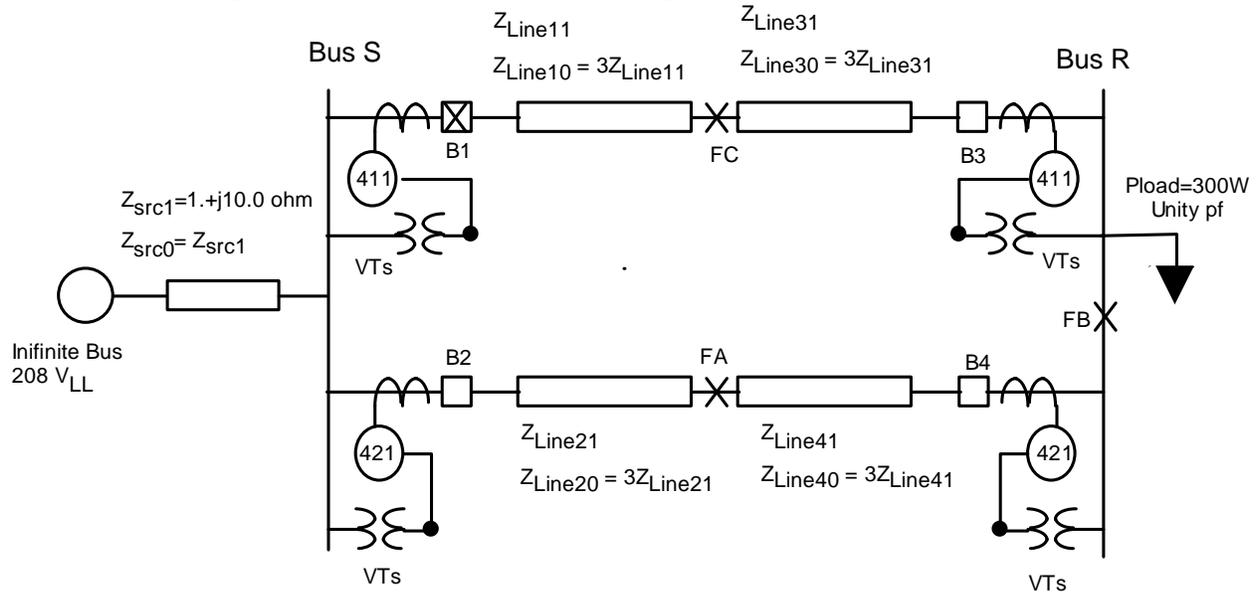
Due: Session 15 (March 2)

Lab Objective

- Learn the principles of distance protection and distance relays
- Learn the basic setting of SEL 421 relays for distance protection
- Perform relay co-ordination by properly setting relay parameters (impedance, time-delay)
- Physically connect the laboratory test setup and create faults (3-phase, LL, SLG, etc)
- Set and communicate with SEL 421 relays through serial port commands
- Observe the impact of fault resistance on Mho distance relay.

Lab Tasks

- Set distance relays and perform distance protection.
- MPS Setup (Notice that the Breaker B1 is open.)



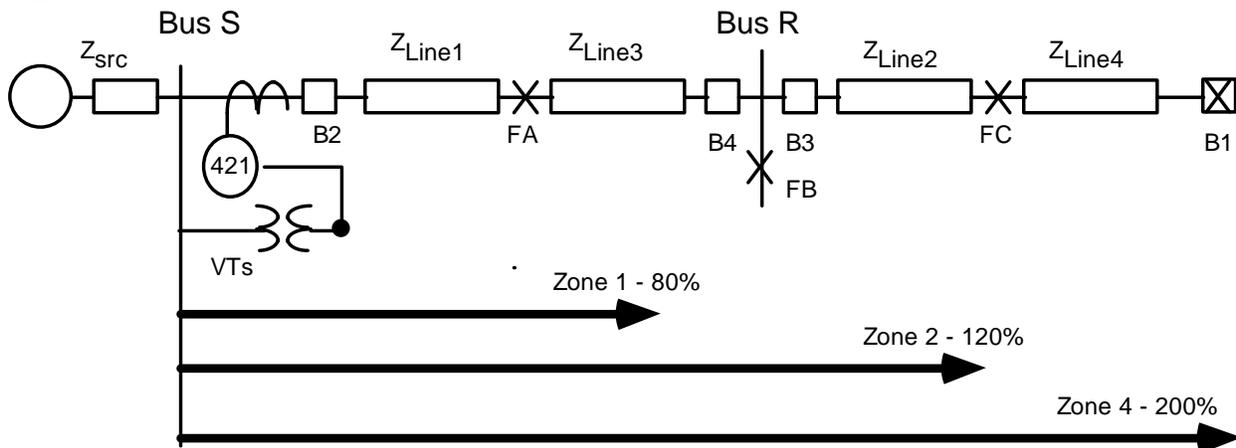
Set line impedances as follows

	Z_{line2}	Z_{line4}	Z_{line3}	Z_{line1}
Case 1	(0.8+j8.0) ohm	(0.2+j2.0) ohm	(0.5+j5.0) ohm	(0.5+j5.0) ohm
Case 2	(0.8+j8.0) ohm	(0.2+j2.0) ohm	(0.5+j5.0) ohm	(0.5+j5.0) ohm
Case 3	(0.8+j8.0) ohm	(0.2+j2.0) ohm	(0.9+j9.0) ohm	(0.1+j1.0) ohm
Case 4	(0.7+j7.0) ohm	(0.3+j3.0) ohm	(0.5+j5.0) ohm	(0.5+j5.0) ohm

Note: positive sequence impedances are: Between B2-B3: $Z_{line1} + Z_{line3} = (1.0+j10.0)$ ohm, Between B3-B1, $Z_{line2} + Z_{line4} = (1.0+j10.0)$ ohm, and source impedance: $Z_{src} = (1.0+j10.0)$ ohm

The relay SEL 421 at Bus S provides instantaneous distance protection for zone 1 which is set at 80% of line L1-L3. The relay should have two time delayed overreaching backup zones, zone2 which is set at 150% of the impedance of line L1-L3 (note in this case this is 100% of line L1-L3 plus 50% of line L2-L4), and zone 4 which is set at 200% of line L1-L3 (so 100% of line L1-L3 and 100% of line L2-L4). The zone 3 setting is optional in this lab.

Equivalent Circuit with Zone Reaches:



Case 1: Set the phase and ground distance elements in the SEL 421 at Bus S to provide instantaneous under-reaching tripping against faults (3-phase, LL, SLG) at FA.

Case 2: Set SEL 421 at Bus S to provide time-delayed overreaching backup tripping against faults (3-phase, LL, SLG) at FB and FC. Let's set 10-cycle time delay in this case.

Case 3: Test the setting of SEL 421 at Bus S such that relay will NOT response to faults at FC beyond the zone 2 reach setting (overreaching) in Zone 2. Zone 4 should still pick up.

Case 4: Test the response of SEL421 at Bus S with varying the fault resistance for SLG fault at FA. Use the single phase resistor bank. Record the resistance value where zone 1 fails to pick up.

Pre-lab Preparation

- (1) Calculate the relay impedance settings for each task and each case.
- (2) Please also calculate the fault current values for LL, SLG and 3-phase faults.
- (3) Possibly do computer simulations to verify your calculations and settings.

Relay Settings

The SEL 421 relay provides a large set of protection functions, we will use a small part of these. For your reference, a list of relevant settings is given below. For a complete reference, please visit www.selinc.com to download the SEL 421 relay manual in the lab.

- (1) Set CT and PT ratio
 CTR, PTR : CT ratio and PT ratio which are set as $CTR = 200.0$ and $PTR = 200.0$
- (2) Calculate Line Impedance
 - $Z1MAG, Z1ANG$: magnitude and angle of line positive-sequence impedance (secondary)
 - $Z0MAG, Z0ANG$: magnitude and angle of line zero-sequence impedance (secondary)
 - Let $k = PTR/CTR$
 - $Z1MAG(secondary) = Z1MAG(primary) / k$; $Z0MAG(secondary) = Z0MAG(primary) / k$.
- (3) Set **E21MP**: Enable Phase MHO protection. Set **E21MP** = 2 (or 3) for two (three)

protection zones.

(4) Set **E21MG**: Enable Ground MHO protection. Set **E21MG** = 2 (or 3) for two (three) protection zones.

(5) Set **M1P**, **M2P**, **M3P** : phase impedance setting for zone 1, zone 2 and zone 3.
For example: $M1P = 80\% \times Z1MAG(\text{secondary})$; $M2P = 150\% \times Z1MAG(\text{secondary})$

(7) Set **Z1G**, **Z2G**, **Z3G** : ground impedance setting for zone 1, zone 2 and zone 3.
Note: to use the ground distance protection, we have to set the Zero-Sequence Compensation Factor k_0 whose formula is $k_0 = (Z_0 - Z_1) / (3Z_1)$, where Z_0 is the zero-sequence line impedance and Z_1 is the positive-sequence line impedance.

(8) Set **Z2PT**, **Z3PT** : definite-time delay element for zone 2 and zone 3.

Report:

1. Your report should list your relay settings
2. Show summaries from the MathCAD results demonstrating that the relay settings operate correctly. Show the plots with the response of the trip equation as well as the pick up of the relay elements.