ECE 526

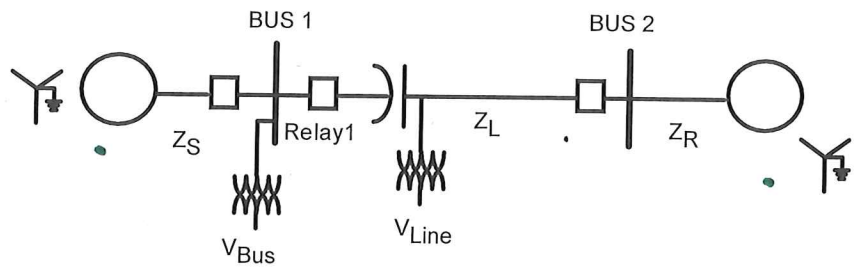
PROTECTION OF POWER SYSTEMS II

SESSION no. 15

ECE 526: Homework #3

Due Session 17 (March 9)

1. The impedances for the system below are given in secondary ohms.



$V_S := 69.5V \cdot e^{j \cdot 0deg}$ at 60Hz

$V_R := 69.5V \cdot e^{j \cdot 0deg}$ at 60Hz,

$Z_{S1} := j \cdot 1ohm$ $Z_{cap1} := -j \cdot 0.8ohm$ $Z_{L1} := j \cdot 1ohm$ $Z_{R1} := j \cdot 0.4ohm$

$Z_{S0} := j \cdot 3ohm$ $Z_{cap0} := -j \cdot 0.8ohm$ $Z_{L0} := j \cdot 3ohm$ $Z_{R1} := j \cdot 1.2ohm$

Suppose a SLG fault occurs at 30% of the way from BUS1 to BUS2, do the following:

1. Plot phase A voltage profile, Bus and Line side VTs are shown
2. Plot negative sequence voltage profile, Bus and Line side VTs are shown
3. Determine the negative sequence currents seen at BUS 1 and BUS 2
4. Determine settings for Z2F and Z2R for a negative sequence directional element
5. Calculate what a directional element based on the angle between V1 and I1 would calculate in this case?

Reference: see **http://www.ece.uidaho.edu/ee/power/ECE525/**
Especially lecture 20 and the handout included in lecture 19

2. Repeat problem 1, for a fault at 10% of the line and:

$Z_{S1} := j \cdot 0.3ohm$

$Z_{S0} := j \cdot 0.9ohm$

3. Repeat problems 1 part A and B if the angle of the remote source is -2.5 degrees

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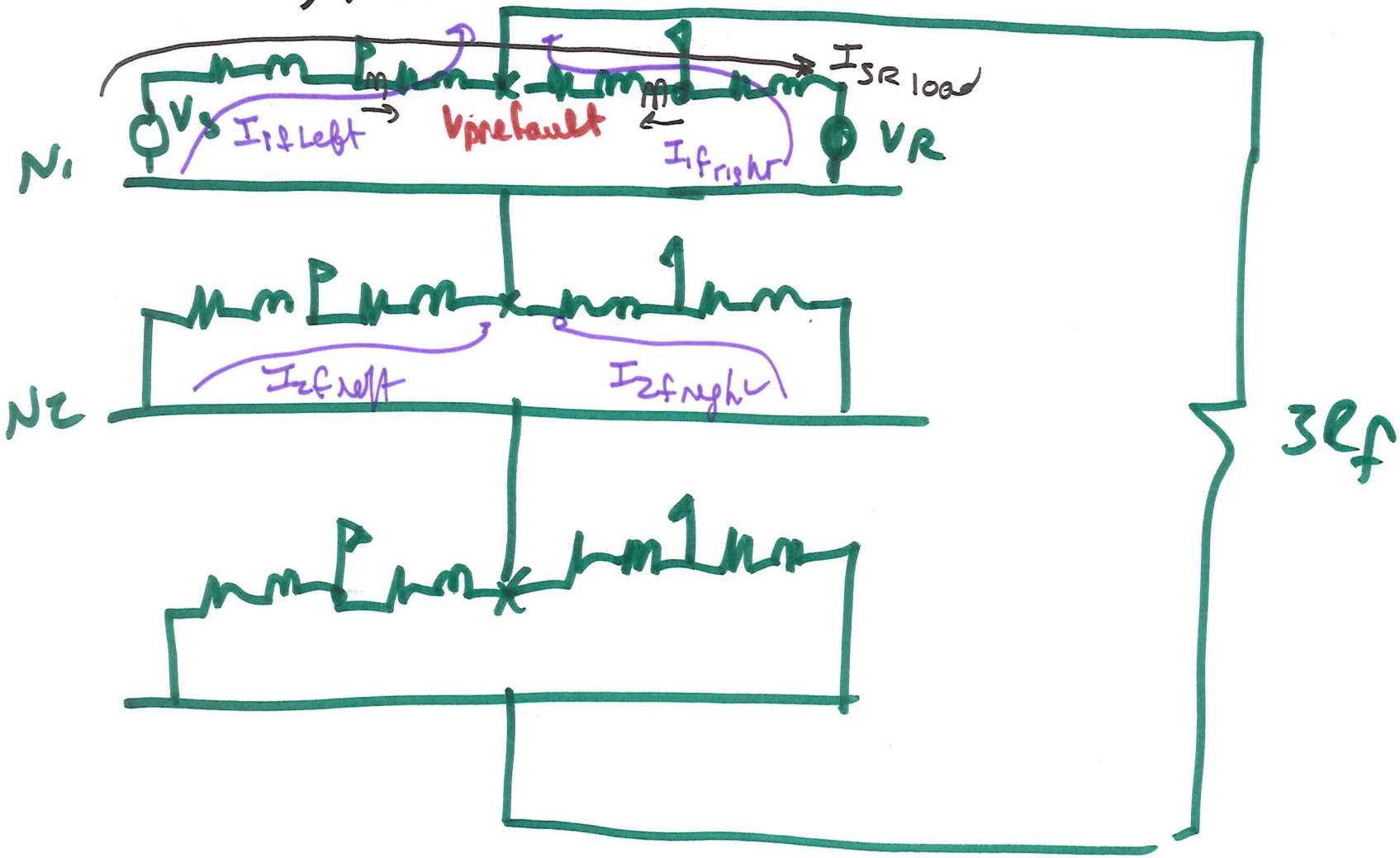
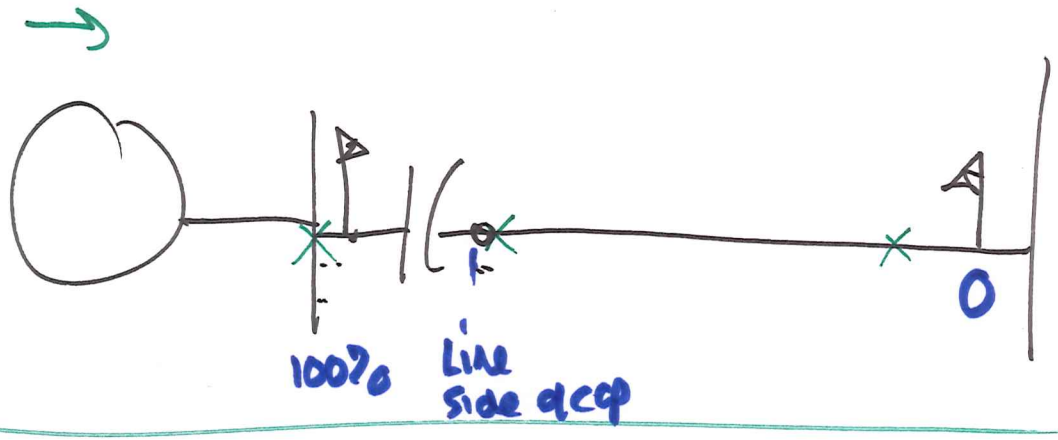


$$I_{1\,relay\,1} = \bar{I}_{1f\,left} + \bar{I}_{SR\,load}$$

$$I_{1\,relay\,2} = \bar{I}_{1f\,right} - \bar{I}_{SR\,load}$$

$$\underline{V}_{1\,fault} = \underline{V}_{1\,prefault} + \underline{\Delta V}_1$$

voltage at each bus in system ⇒ includes fault local



One option

Supervision Block 21 element until these calculations done...

- Relay calculates

$$V_{CALC_{AG}} = Z_{1L}(I_A + k_0 I_0) - jX_C I_A$$

from measured I_A, $3I_0$

$V_{R\,meas}$ =

calculate $V_{ratio} = \dfrac{V_R}{V_{CALC}}$

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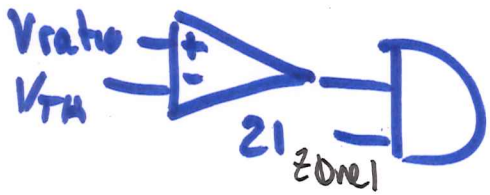

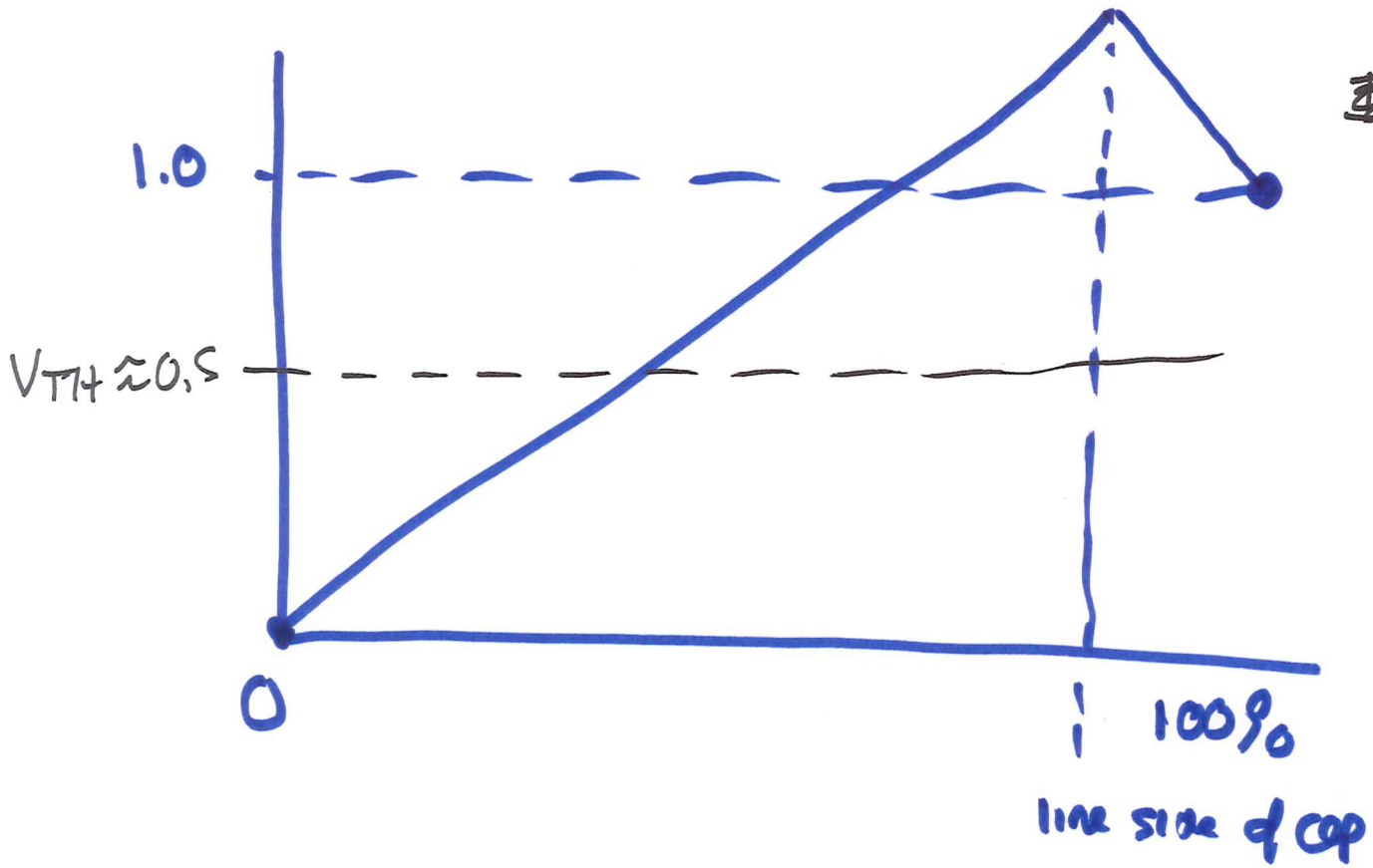

If $V_{ratio} < V_{TH}$

Z_1 is active

If $V_{ratio} > V_{TH}$

block Zone 1

for fault at far bus

$$V_{R_{AG}} = Z_{1L} \cdot (I_A + k_0 3I_0) - jX_C I_A$$

V_{relay}

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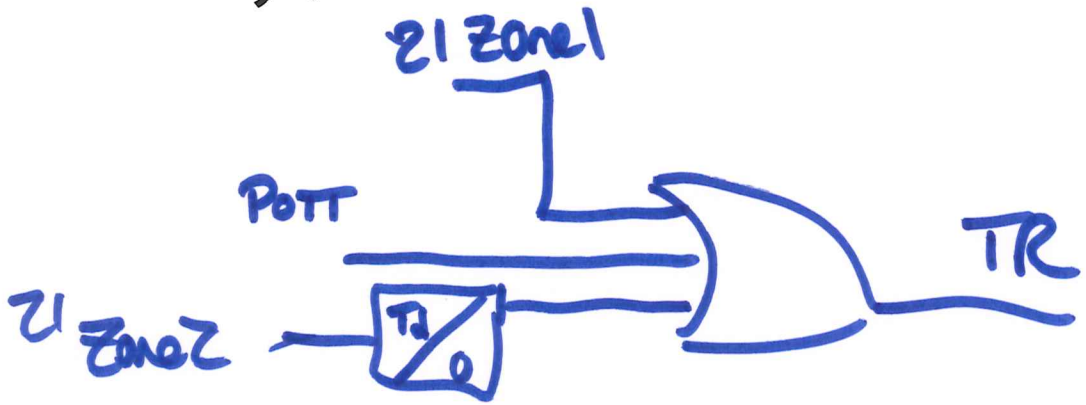
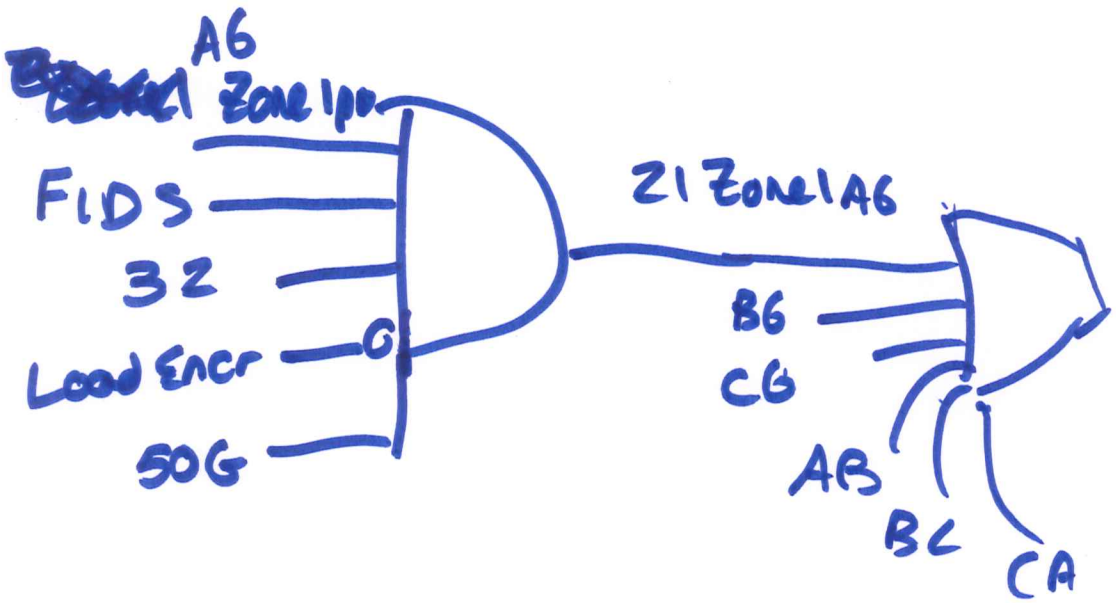

21 Zone1
POTT
21 Zone2
TR


A6
Zone1pu
F1DS
32
Load Encr
50G
21 Zone1A6
B6
C6
AB
BC
CA

Setting Zone 2

- completely cover entire length of line (Back up zone 2)
  - whether capacitor inserted or not
  - may end up reaching past end of next line..

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Zone 2 for comm aided distance?

- Don't need same Zone 2 as back up zone if relay has multiple zone available
  - more flexibility in reach setting

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Series capacitor protect-

- Account for uncertainty created by presence of $-jX_C$
- Take advantage of memory polarization & memory elements
- Pay attention to VT location
- If relay has series capacitor compensation available - use it
- → consider low freq oscillations
- Digital time domain solutions are essential... CATP, PSCAD/EMTDC/RTDS... OPAL/RT etc

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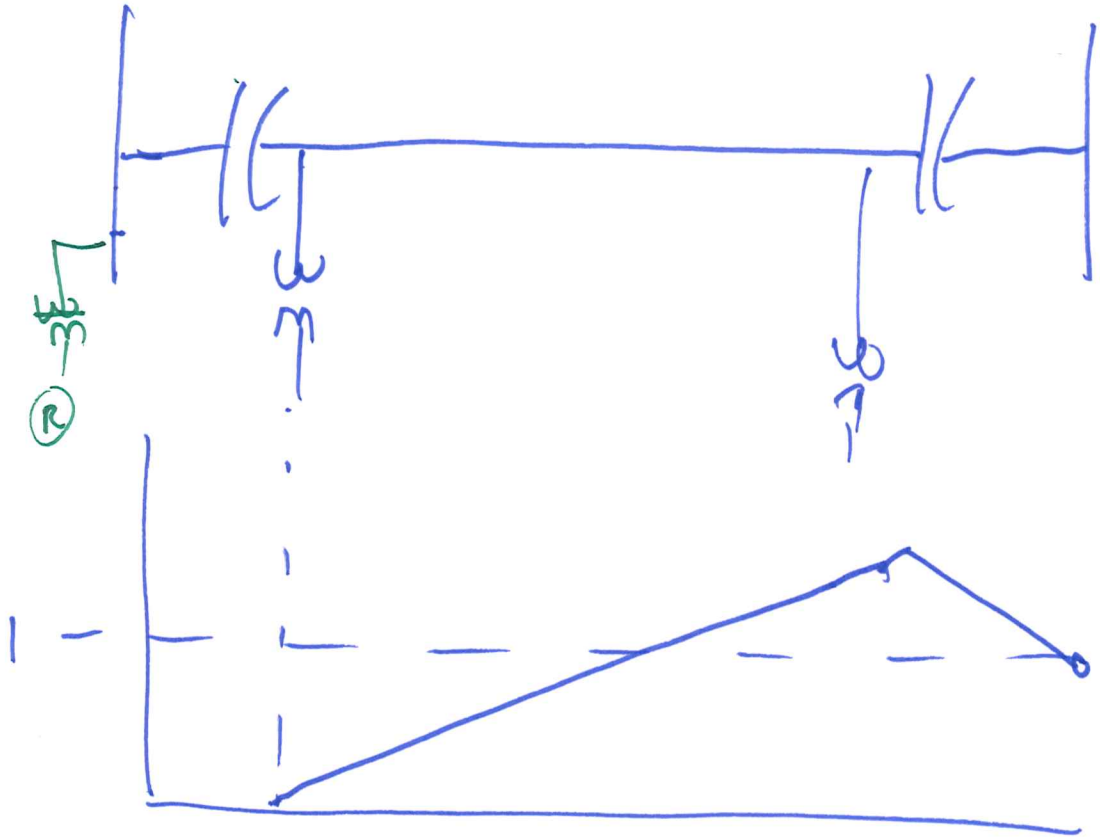

$$V_{CALC} = (I_A + 3I_0 h_0) Z_{1L} + I_A(-jX_C - jX_C)$$

$$V_R = (I_A + 3I_0 h_0) Z_{1L} + I_A(-jX_C)$$

for faults between caps

exercise for interested reader —

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Next Topic: Single Pole Tripping

→ Enabling with protection

→ Impacts on other elements

- SLG → Trip faulted phase only
  - Reclose only, phase faulted

How guaranteed fault has cleared?...
- longer reclose time