University of Idaho

ECE 525

POWER SYSTEM PROTECTION AND RELAYING

SESSION no. 4

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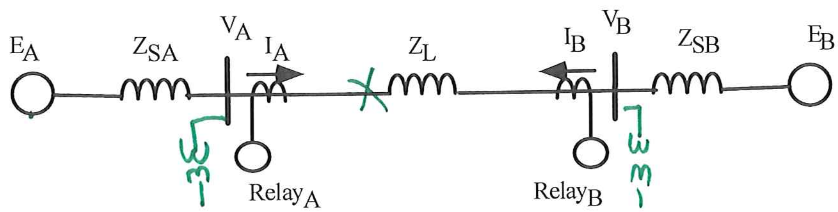
ECE 525: Homework #1

Due Session 6 (Sept. 6)

1. Given the power system below:



Where the following are given as CT and VT secondary quantities::

$E_{SA} := 70V \cdot e^{j \cdot 0deg}$ $\qquad E_{SB} := 70V \cdot e^{-j \cdot 30deg}$

$Z_{SA1} := 1.5ohm \cdot e^{j \cdot 87deg}$ $\qquad Z_{SA2} := Z_{SA1}$ $\qquad Z_{SA0} := 5ohm \cdot e^{j \cdot 87deg}$

$Z_{SB1} := 0.8ohm \cdot e^{j \cdot 83deg}$ $\qquad Z_{SB2} := Z_{SB1}$ $\qquad Z_{SB0} := 2.5ohm \cdot e^{j \cdot 83deg}$

$Z_{L1} := 5ohm \cdot e^{j \cdot 82deg}$ $\qquad Z_{L0} := 18ohm \cdot e^{j \cdot 82deg}$

The current trransformer ratios are: $CTR := \frac{1200}{5}$

The voltage transformer ratios are: $VTR := \frac{132.8kV}{70V}$ Line-to-neutral

A. Calculate the source voltages, line and source impedances and line current referred to primary values based on the information given above. Also find the line currents in secondary Amps accounting for CT polarity.

B. Repeat part A in per unit

C. Calculate real and reactive power flow at Bus A and Bus B based on the CT polarity using primary values

D. For the conditions of part A, calculate the effective imedance measured by Relay A and Relay B in terms of secondary values. $Z_{AG} = V_{AG} / (I_A + k_0 3I_0)$ $\quad Z_{AB} = \frac{V_{AG} - V_{BG}}{I_A - I_B}$

E. Suppose a 3 phase fault occurs 30% of the way from Bus A to Bus B, do the following:

(1) Calculate the total fault current and the current seen at Relay A and Relay B in primary and secondary quantities.

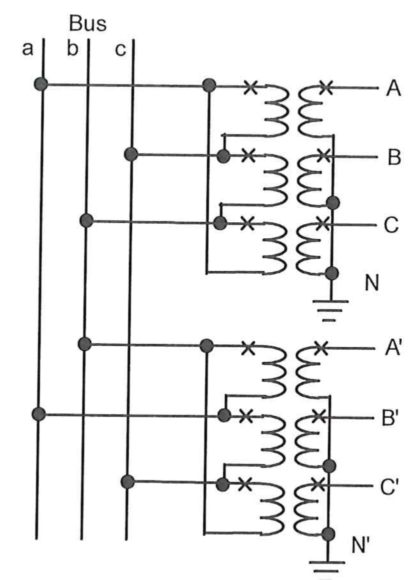
(2) Compare the fault currents to the load currents calculated earlier with load currents

(3) Calculate the effective impedances distance elements at Relay A and Relay B would calculate in secondary and primary ohms.

(4) What Iop and Irt be for a differential element (assume a charging current of 100 A capacitive divided equally between each end.
- load condition
- fault condition

you can ignore load flow ($\angle E_{SB} = 0$)

2. Sketch the winding connections for a Yg-Δ transformer following the ANSI/IEEE connection standard if (a) the Y-connected winding is the HV winding and (b) if the Δ-connected winding is the HV winding.

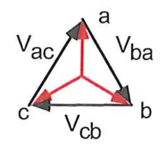


Note the phase sequence reversal through each transfomer.

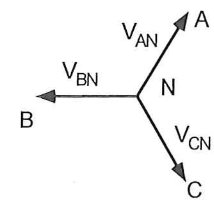
Phase relationships:

$V_{A'N'}$ lags V_{AN} by 120 degrees
$V_{B'N'}$ lags V_{BN} by 120 degrees
$V_{C'N'}$ lags V_{CN} by 120 degrees

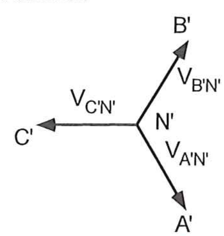
Phasors on Bus Side

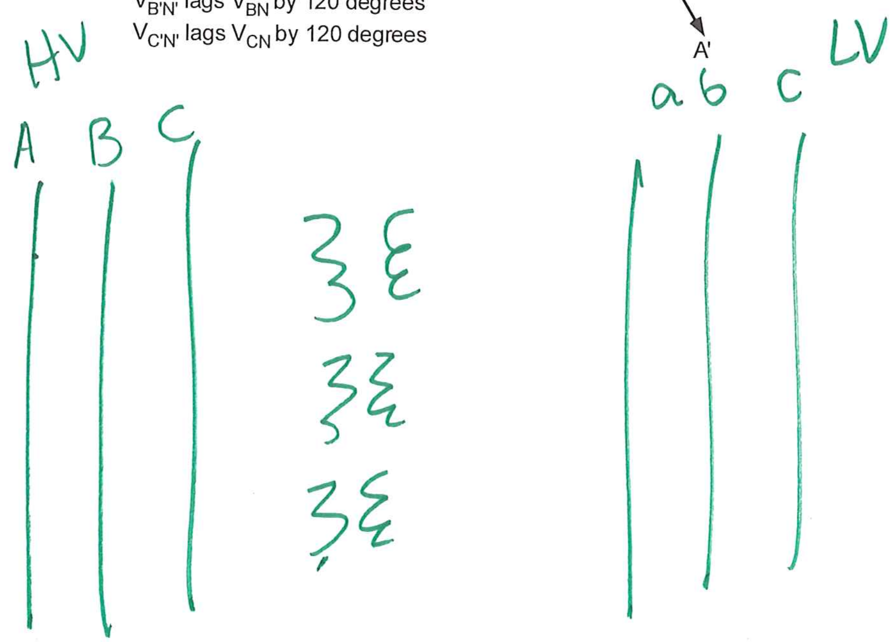


Use these to create Wye side voltages for top transformer.



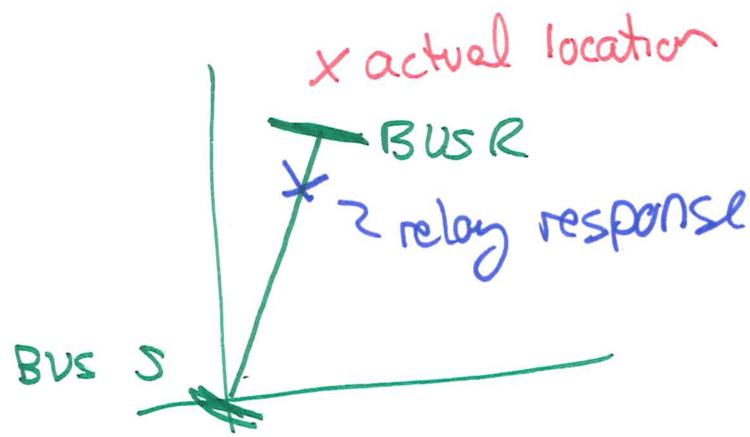
Now create the Wye side voltages for the bottom transformer





Protection response (and sometimes used in settings)

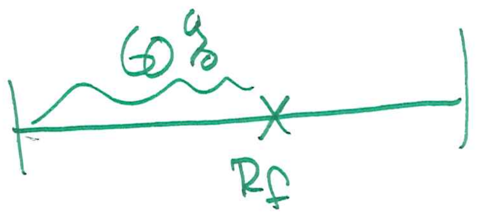
- Over-reaches
  → we have a response beyond (or more than) the setting

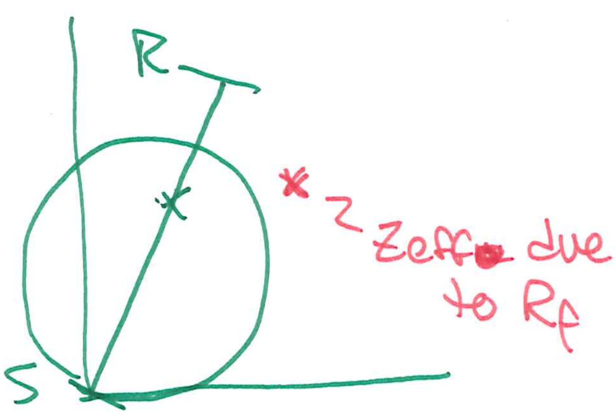


- Zone 2 elements over reach ~~end~~ end the line

- In relay response to a fault
  - over reach if the element thinks fault is closer than actual location

Under reach: ① setting less than length of line (example, a zone 1 is an underreaching element since set less than line length)





② Relay response
- protection element ~~thing~~ thinks fault farther away than actual.

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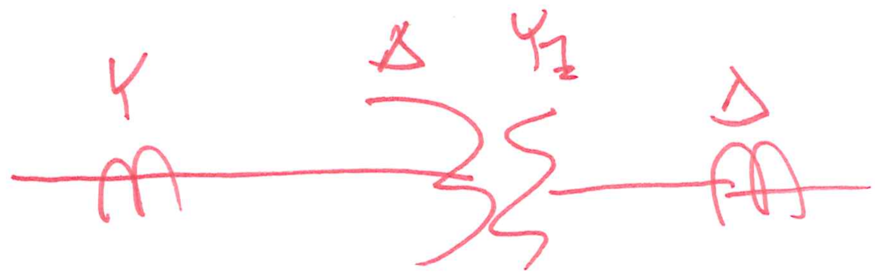
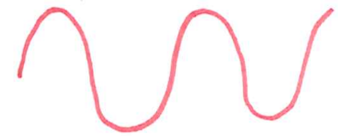
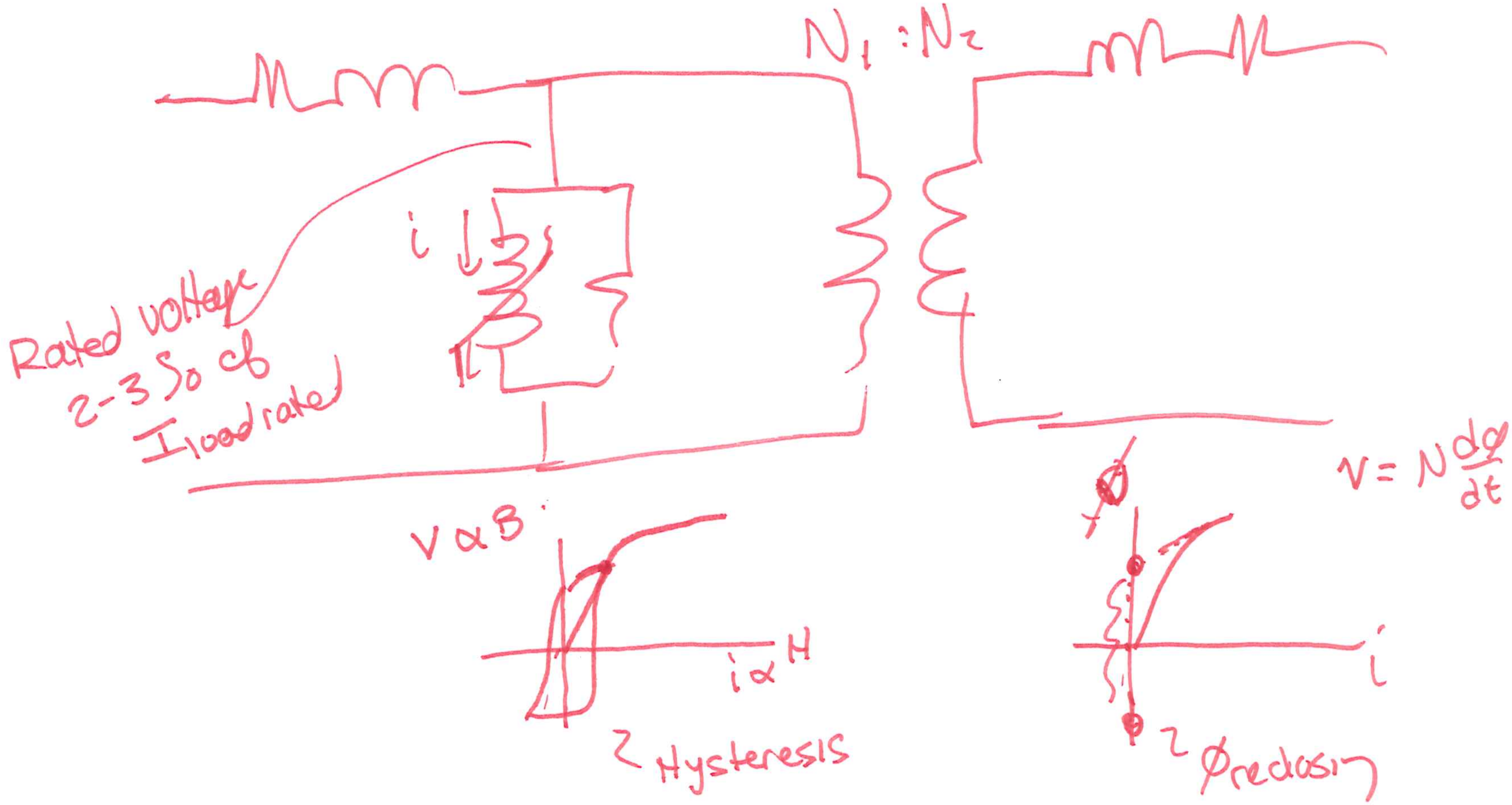






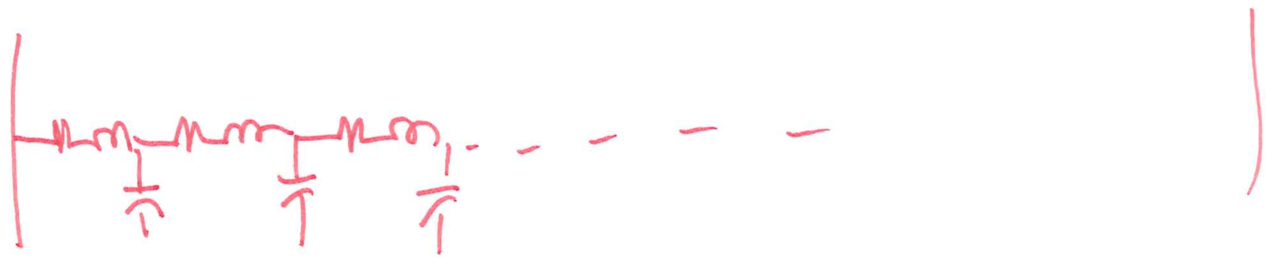
in rush current ~ 8-10pu worst case

harmonic spectrum

- 2nd, 5th harmonic

↳ harmonic blocking

Line charging current



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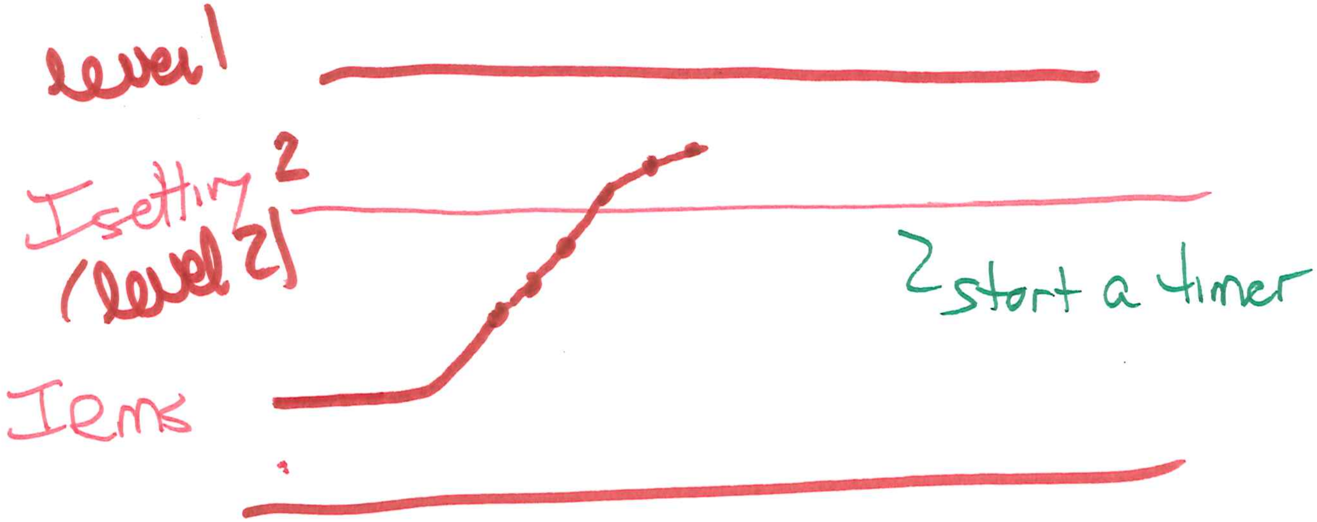
- Overcurrent or overvoltage (undervoltage)

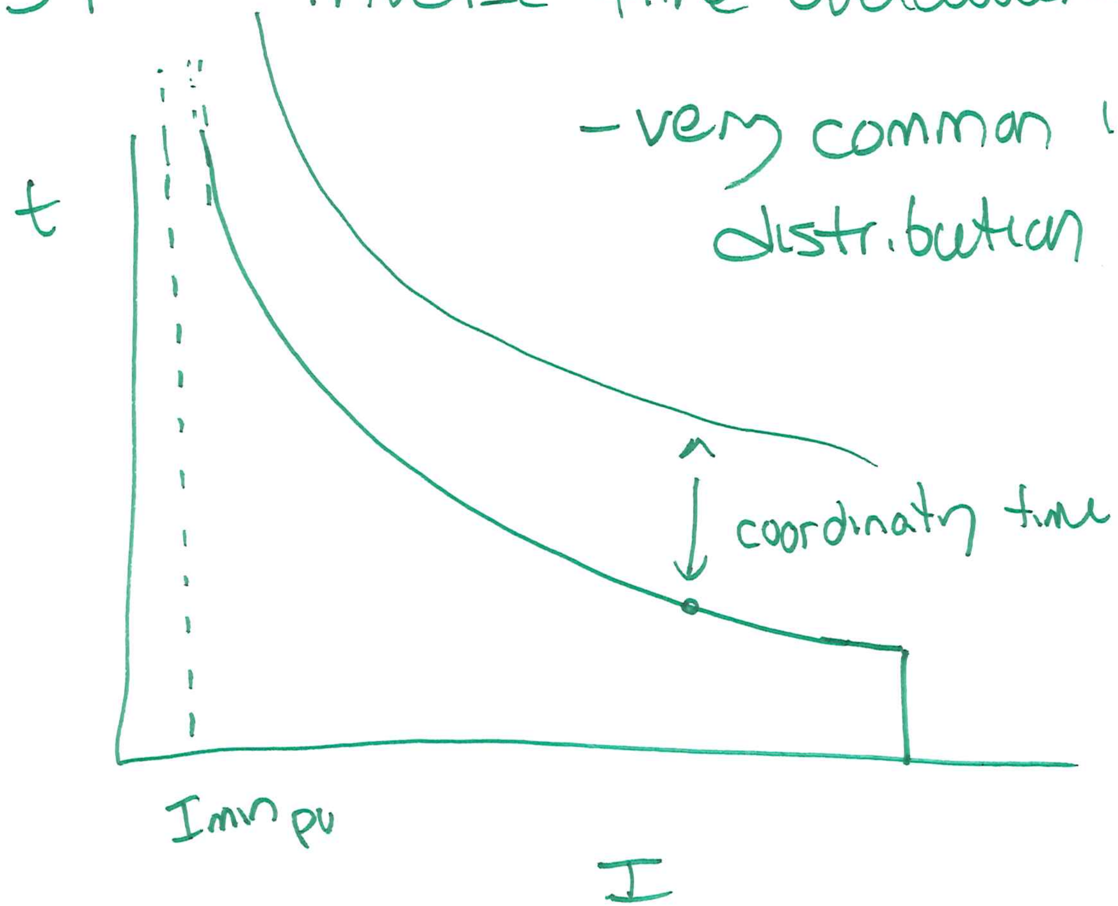
(Threshold comparison)

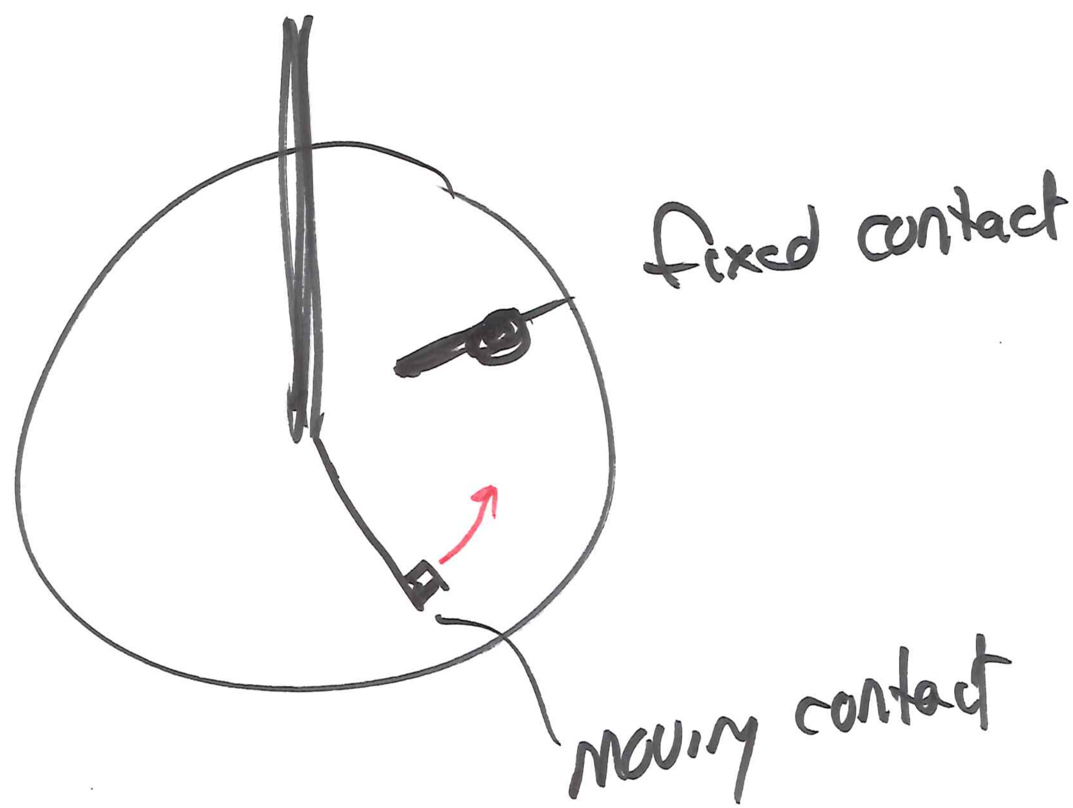
50 - overcurrent (instantaneous)



51 — inverse time overcurrent

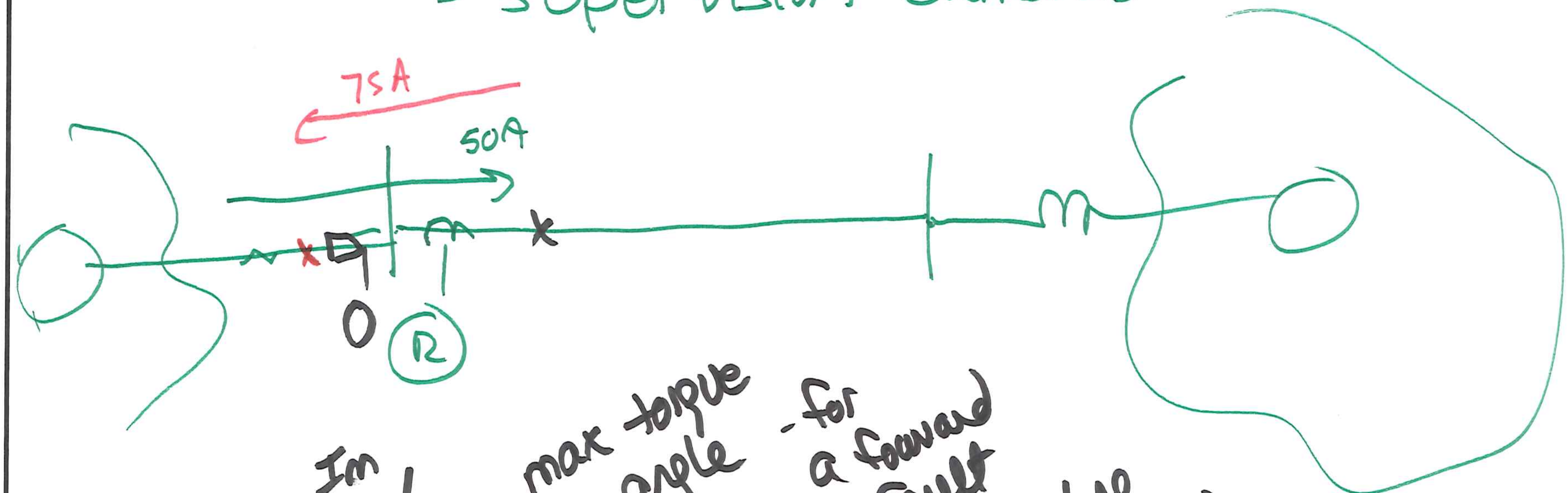
- very common in distribution systems

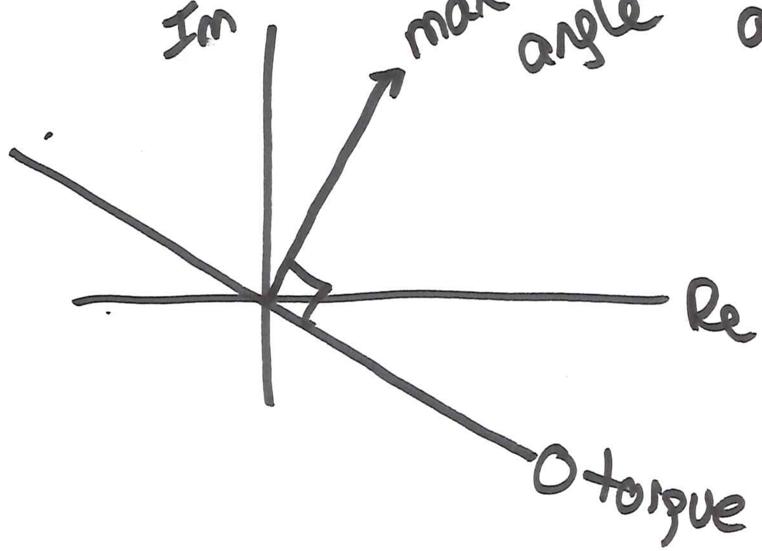



fixed contact
moving contact

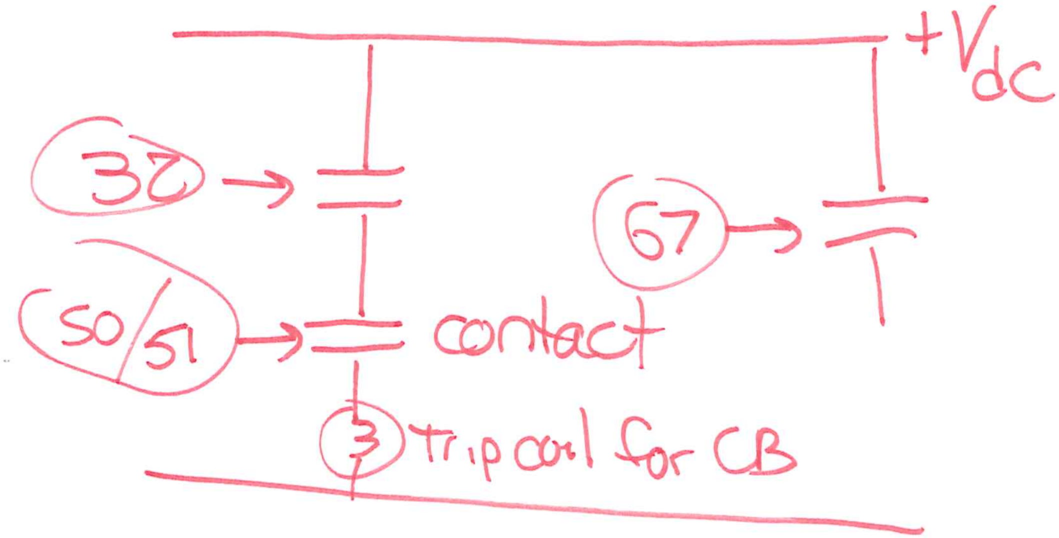
Directional Elements

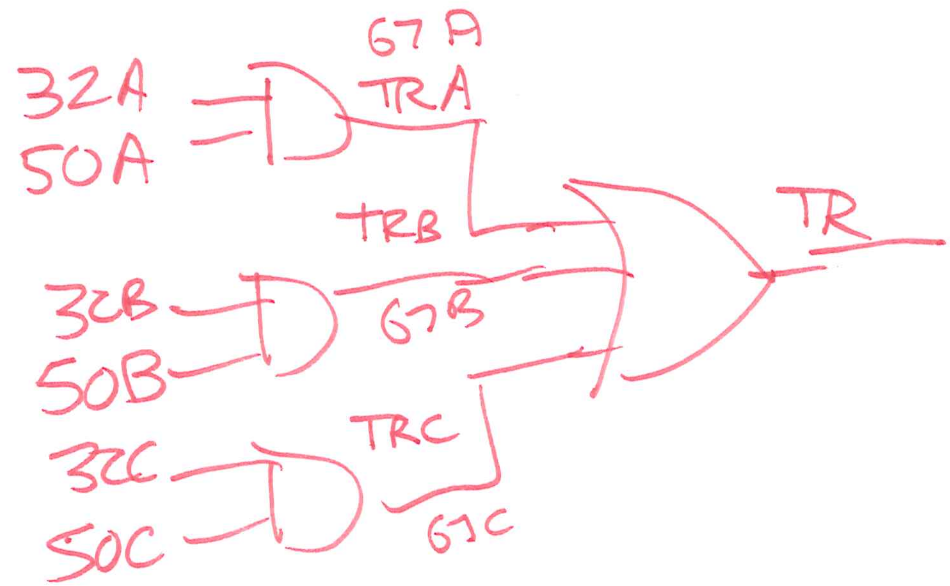
- supervision elements





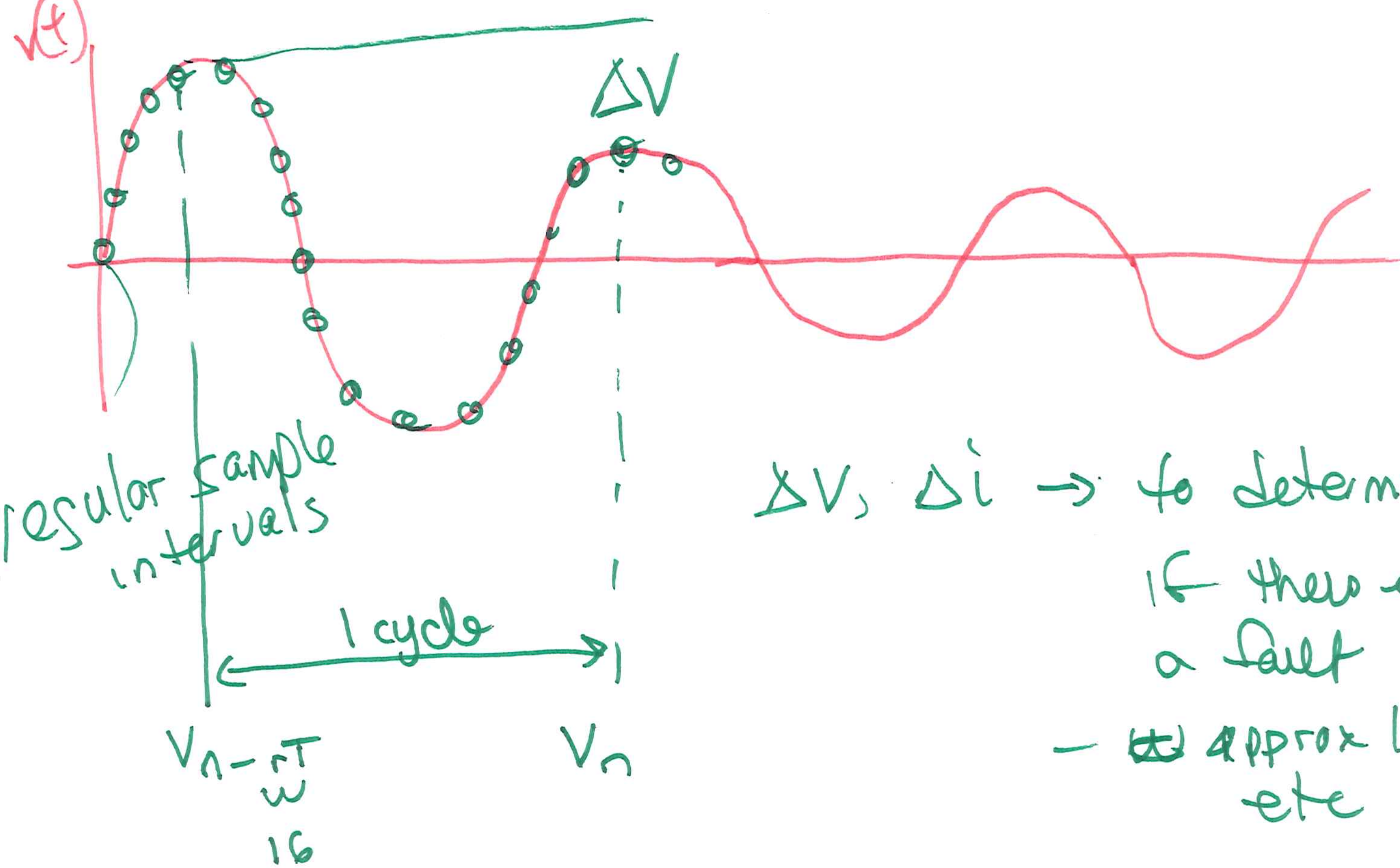
- E-M


+V_{dc}
32
50/51
contact
67
3 Trip coil for CB


32A
50A
67A
TRA
TRB
32B
50B
67B
TRC
32C
50C
67C
TR

TRANSIENT ELEMENTS

- Delta Quantities (superimposed quantities)



$\Delta V, \Delta i$ → to determine if there is a fault

– approx locat etc

Traveling Waves