EE 5223 - Lecture 24 Fri Mar 3, 2023

Ongoing List of Topics:

- URL: https://pages.mtu.edu/~bamork/EE5223/index.htm
- Term Project - all proj/team topics have been approved.
  - Follow timeline, see posting on web page (posted in week 5)
  - Weeks 7 thru 9 - develop formal outline w/complete reference list
- Homework set 9 to be completed by after break
- Protection fundamentals for 87T (finish up topic from Monday's Lecture 22)
  - a) must connect CT secondaries to provide proper phase shift so that restraint currents flowing through restraint elements are in phase;
  - Following topics will be discussed in depth in a future lecture: b) relay settings are used to compensate for pri voltage ratio and CT ratios. c) Mismatch problems - due to being forced to use less than full CT ratio, and having Pri and Sec CTs with different accuracy levels. Differential slope of trip characteristic can be 10%, 15%, 25% to allow for mismatch.

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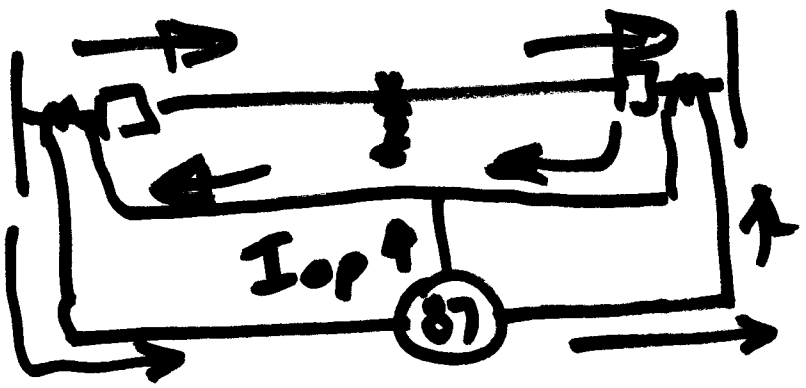
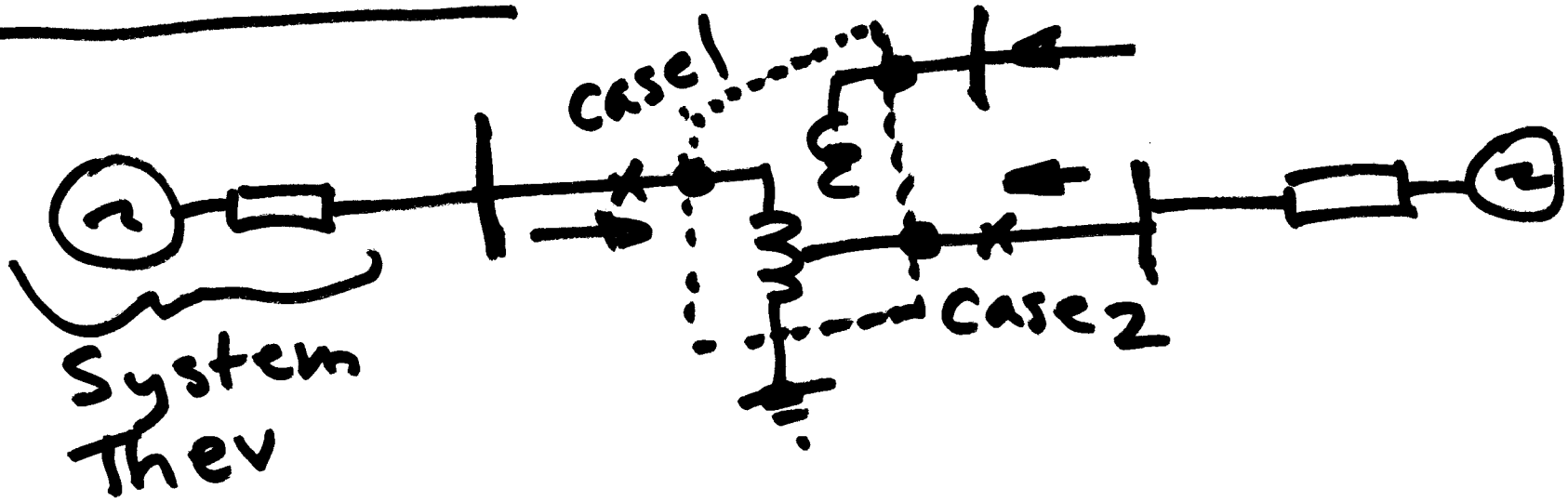
- 3 Winding Xfmrs
- Distance Relaying
- Differential Schemes
  - Buses
  - Xfmrs - Phase Shift, CT ratios
  - Generators
  - Lines



3-WDG Xfmr



L-G fault
or
L-L-G fault..... how can we take advantage of gnd polarizing source?

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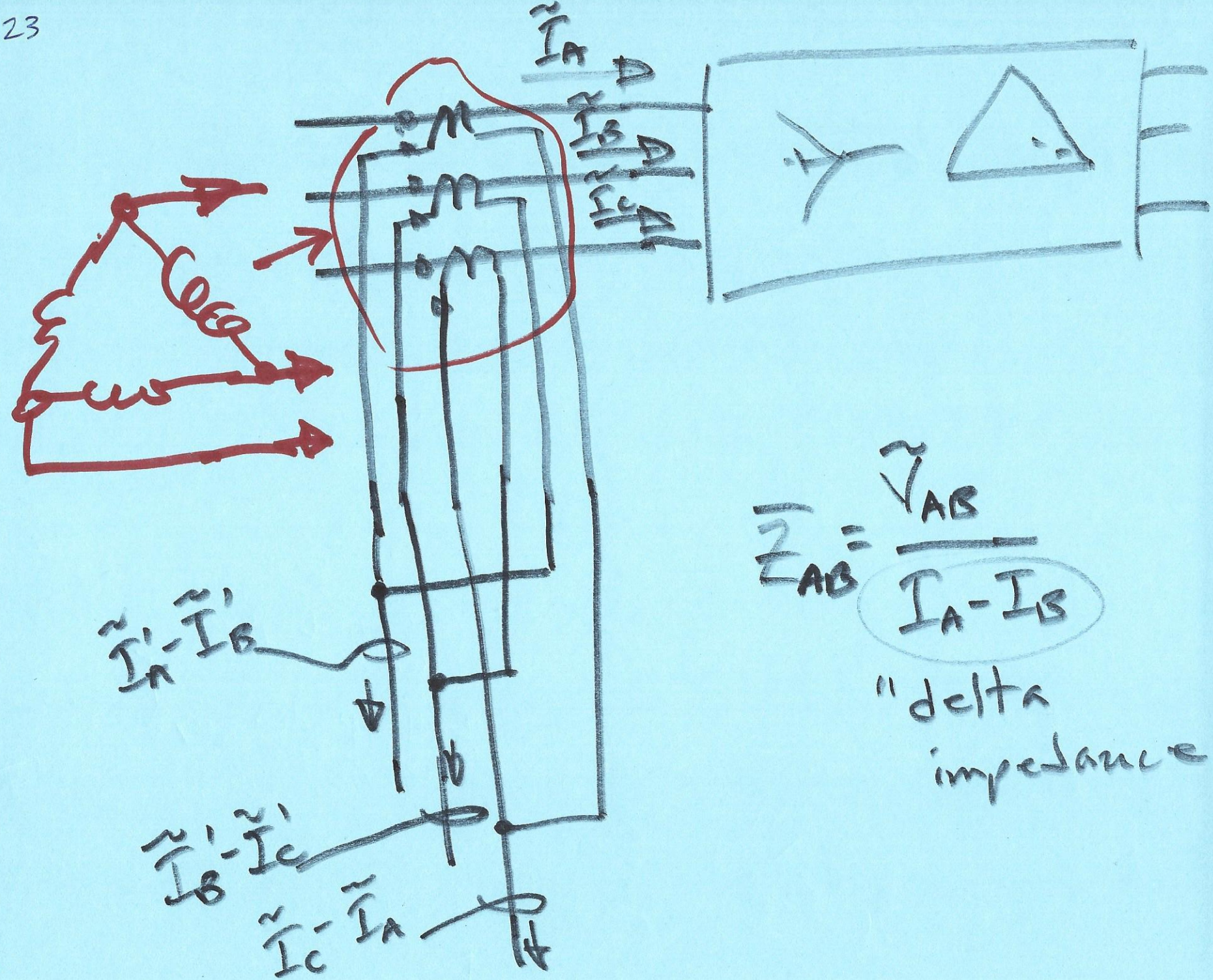
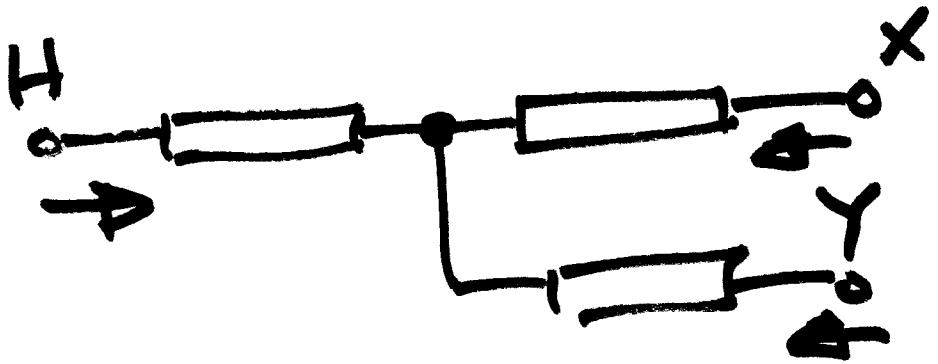


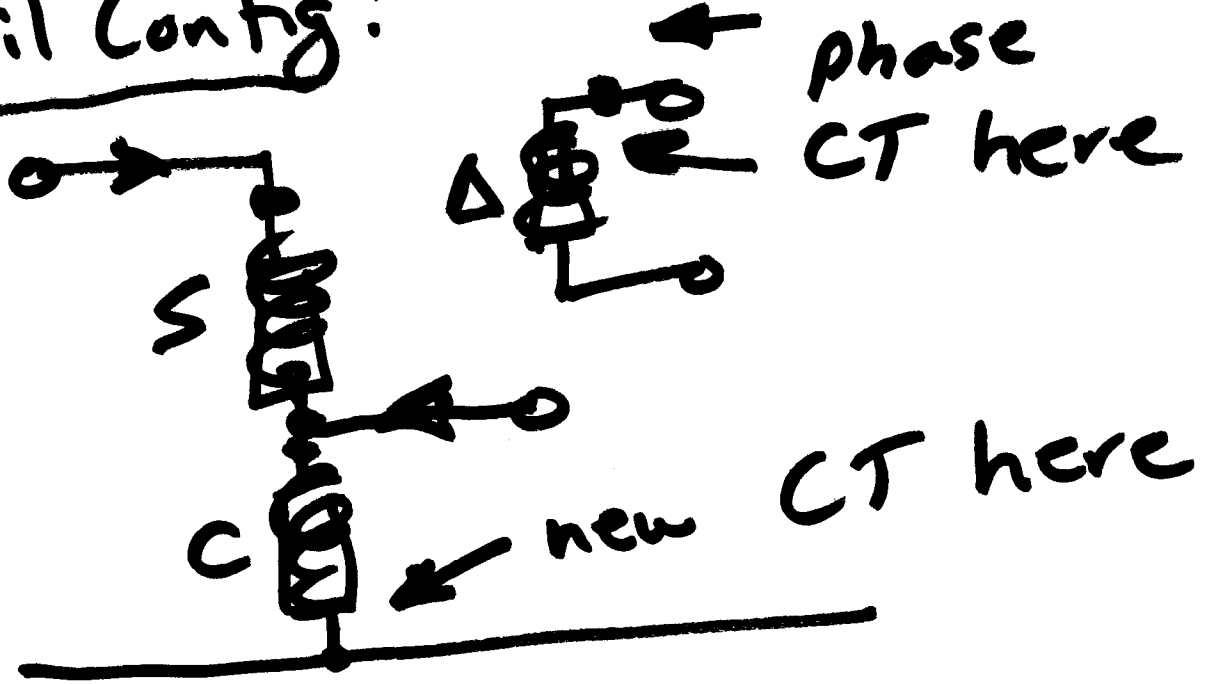
$$\tilde{Z}_{AB} = \frac{\tilde{V}_{AB}}{\tilde{I}_A - \tilde{I}_B}$$

"delta impedance



"star equiv" in seq. networks.

Actual Coil Config:



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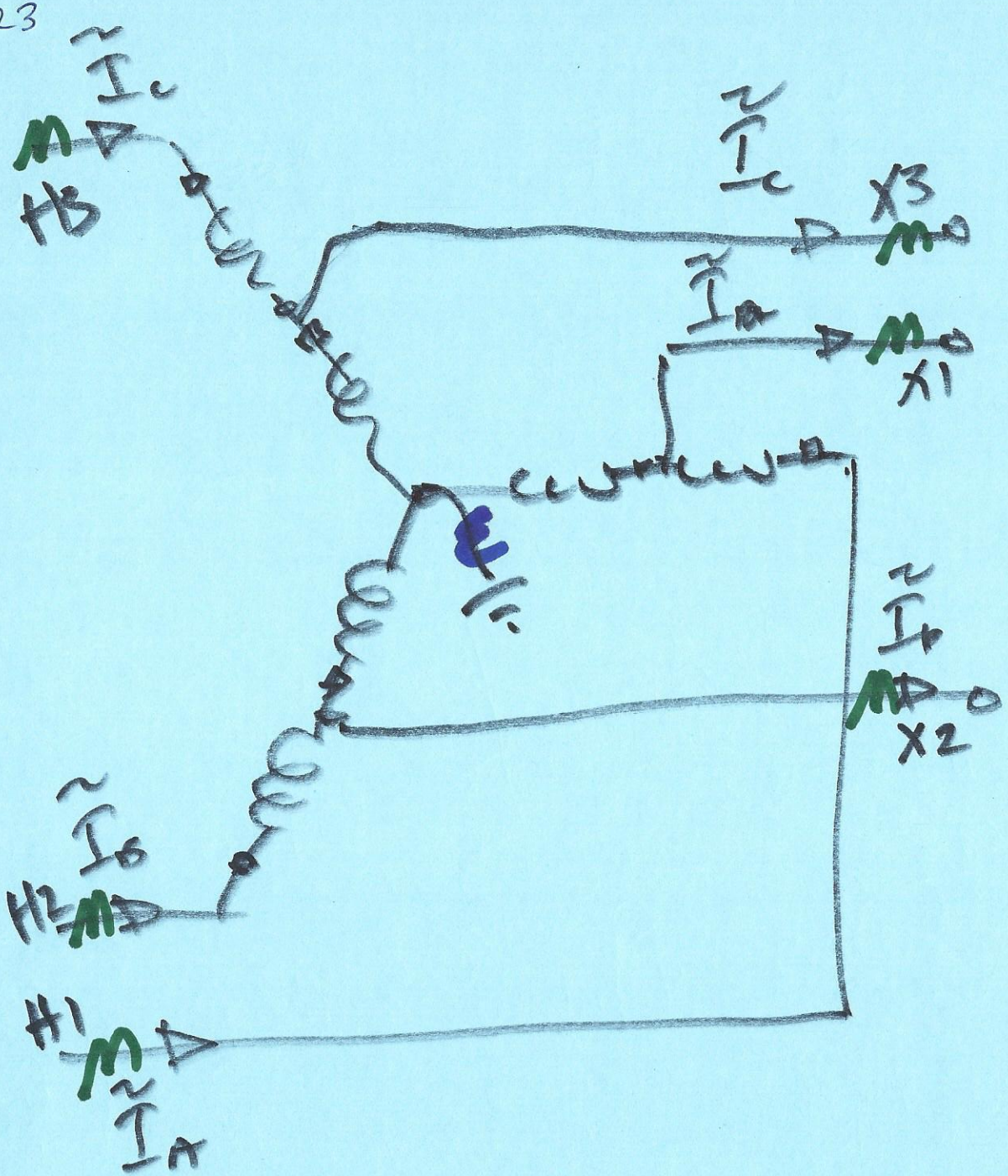
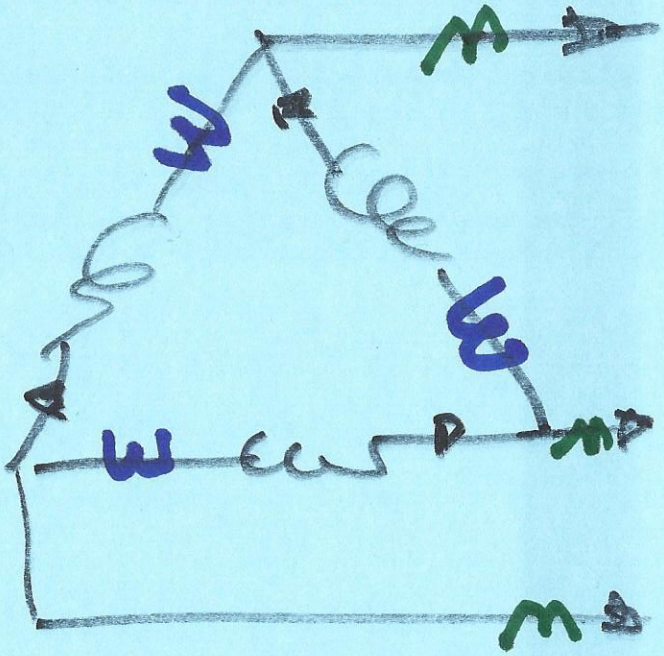
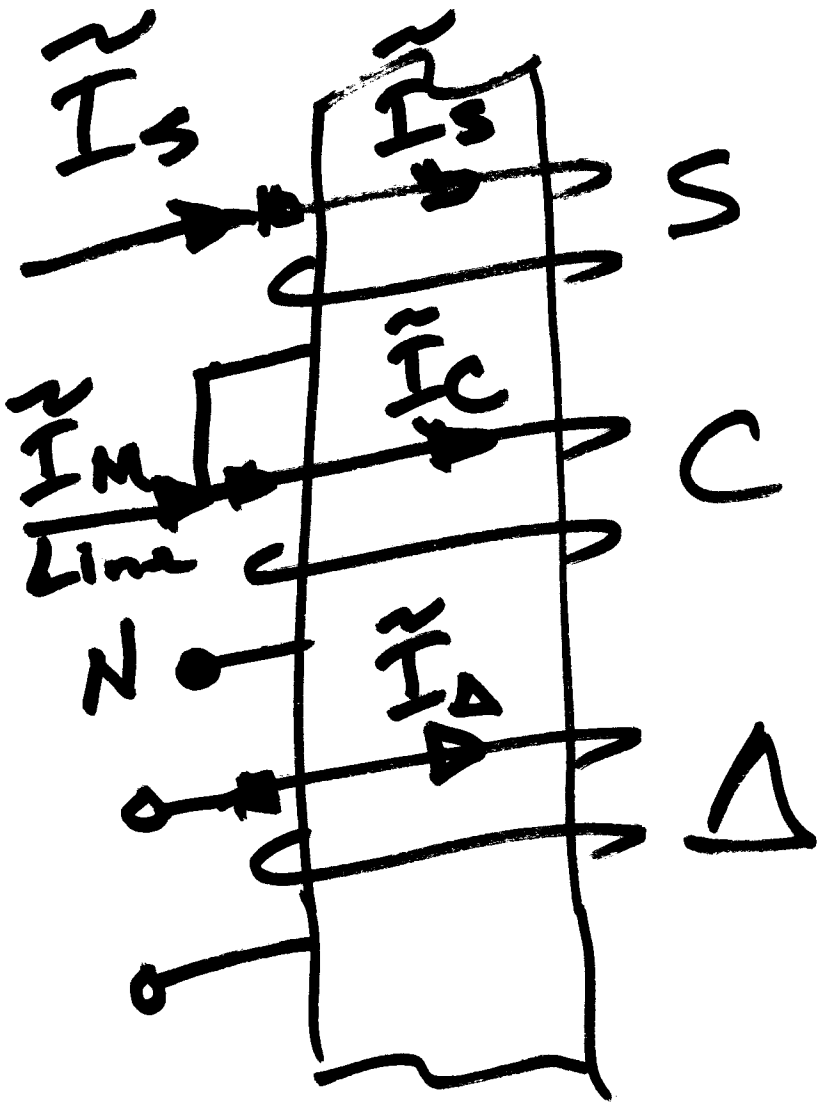
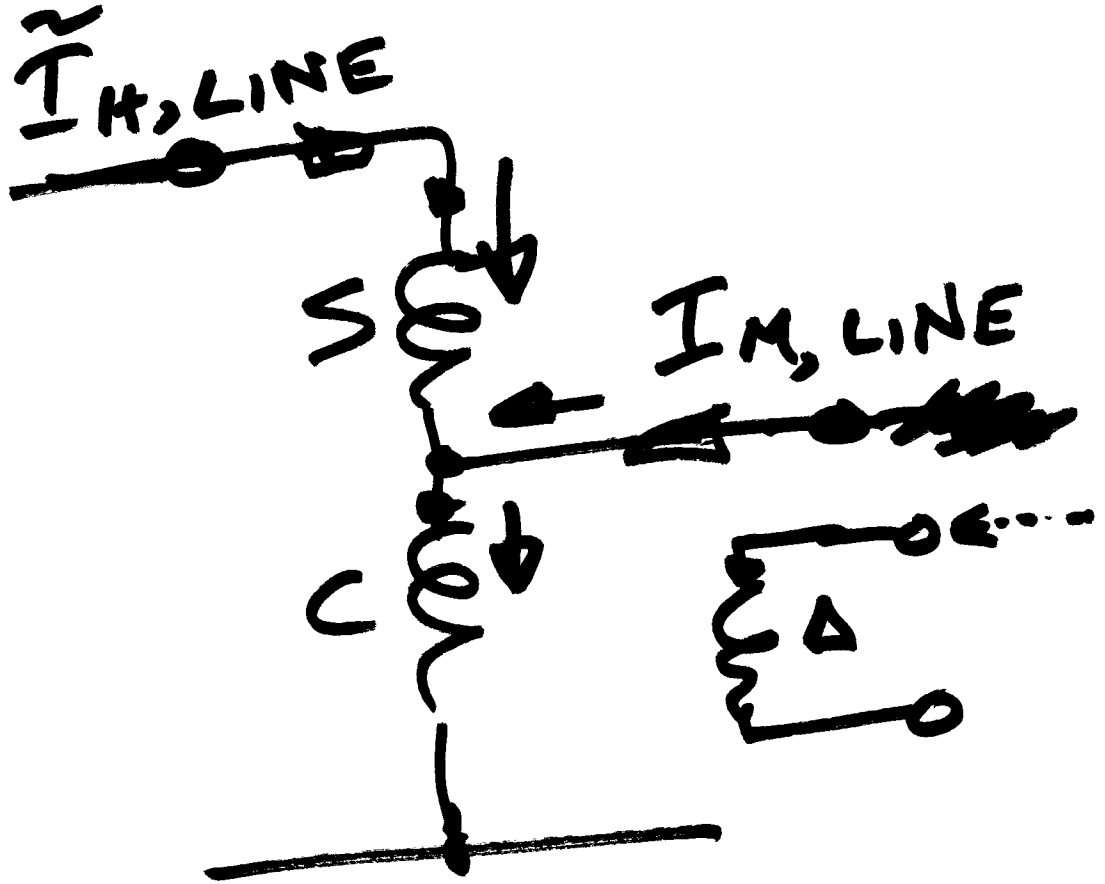

$\tilde{I}_c$
H3
$\tilde{I}_c$
X3
$\tilde{I}_a$
X1
$\tilde{I}_b$
$\tilde{I}_b$
X2
$\tilde{I}_a$
H2
H1







$|\tilde{I}_\Delta|$:

$$\sum \bar{S}_{IN} = 0 = \sum \tilde{V} I^*_{IN}$$

Pos Seq: $= |\tilde{I}_L|/\sqrt{3}$

Neg Seq: $= |\tilde{I}_L|/\sqrt{3}$

Zero Seq:

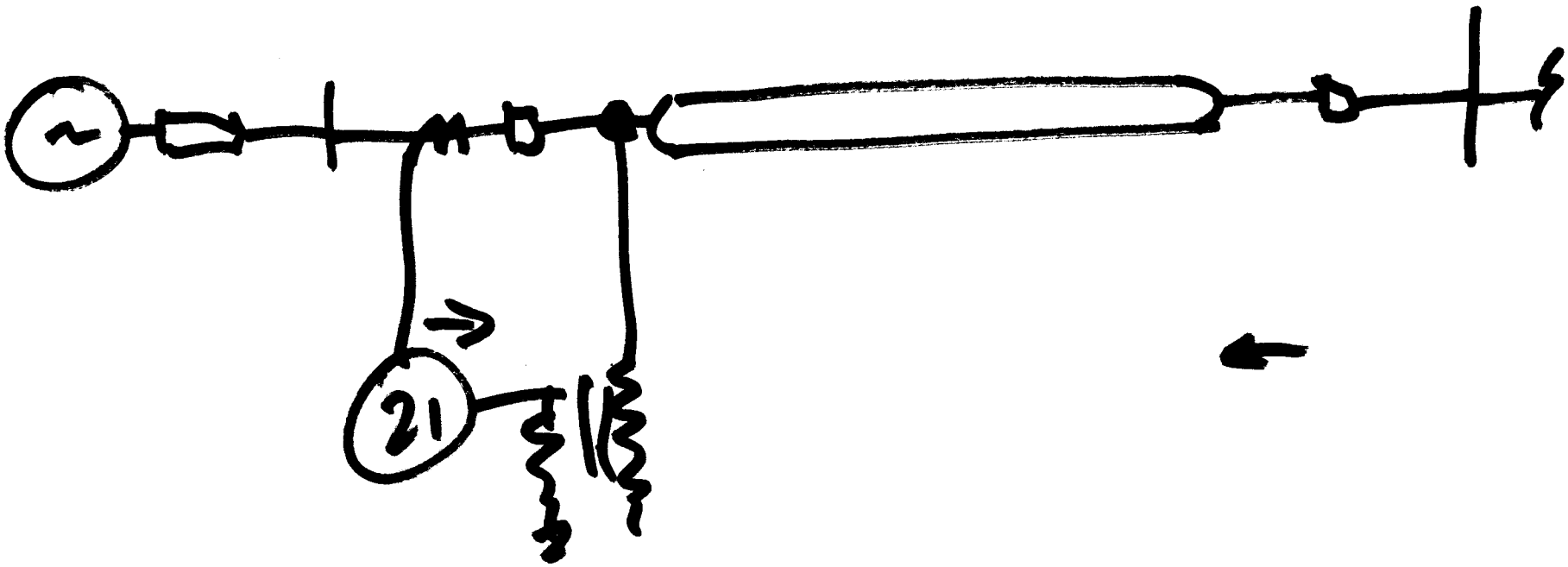
Using Actual Amps & Volts (NOT PER UNIT!)

evaluate $\Sigma S_{IN} = 0$

$$\tilde{V}_S \tilde{I}_S^* + \tilde{V}_C \tilde{I}_C^* + \tilde{V}_\Delta \tilde{I}_\Delta^* = 0$$

Can solve for $\tilde{I}_\Delta$!

Problem: 4.4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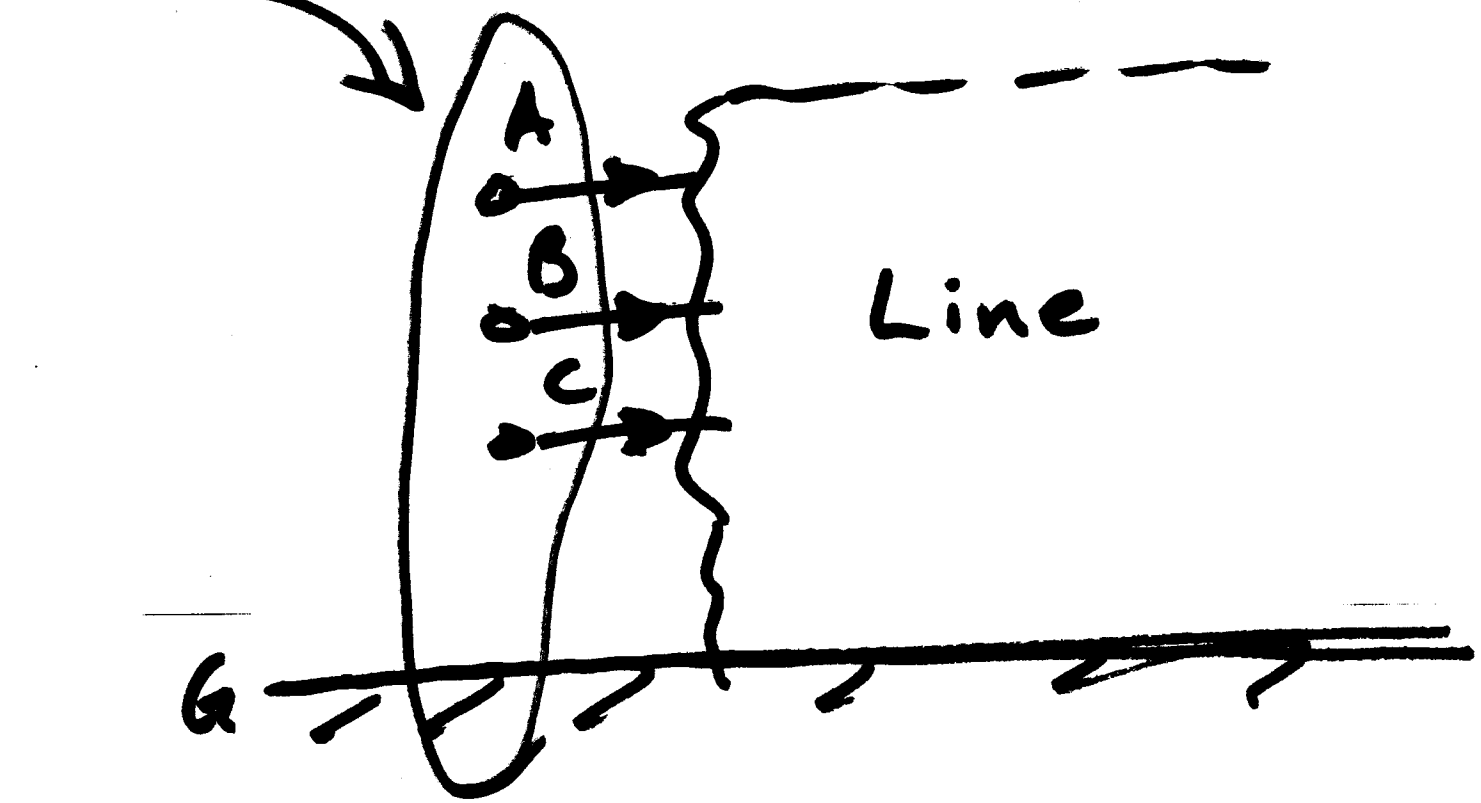
Relay "sees" $\tilde{V}_{AG}, \tilde{V}_{BG}, \tilde{V}_{CA}$
$\tilde{I}_A, \tilde{I}_B, \tilde{I}_C$



What Z's can be calculated?

$$\bar{Z} = \frac{\tilde{V}}{\tilde{I}}$$

$$\bar{Z}(\omega) = \frac{\tilde{V}(\omega)}{\tilde{I}(\omega)}$$

Phase Impedances:

$$\bar{Z}_A = \frac{\tilde{V}_{AG}}{\tilde{I}_A}$$

$$\bar{Z}_B = \frac{\tilde{V}_{BG}}{\tilde{I}_B}$$

$$\bar{Z}_C = \frac{\tilde{V}_{CG}}{\tilde{I}_C}$$

SEQ IMPEDANCES

$$\bar{Z}_0 = \frac{\tilde{V}_{A0}}{\tilde{I}_{A0}}$$

$$\bar{Z}_1 = \frac{\tilde{V}_{A1}}{\tilde{I}_{A1}}$$

$$\bar{Z}_2 = \frac{\tilde{V}_{A2}}{\tilde{I}_{A2}}$$

"DELTA IMPEDANCES"

$$\bar{Z}_{AB} = \frac{\tilde{V}_{AB}}{(\tilde{I}_A - I_B)}$$

$$\bar{Z}_{BC} = \frac{\tilde{V}_{BC}}{(\tilde{I}_A - \tilde{I}_B)}$$

$$\bar{Z}_{CA} = \frac{\tilde{V}_{CA}}{(\tilde{I}_C - \tilde{I}_A)}$$

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→ "Literature"

→ Impedance Meas.

"Incremental Impedances"