University of Idaho

ECE 525

POWER SYSTEM PROTECTION AND RELAYING

SESSION no. 26

University of Idaho

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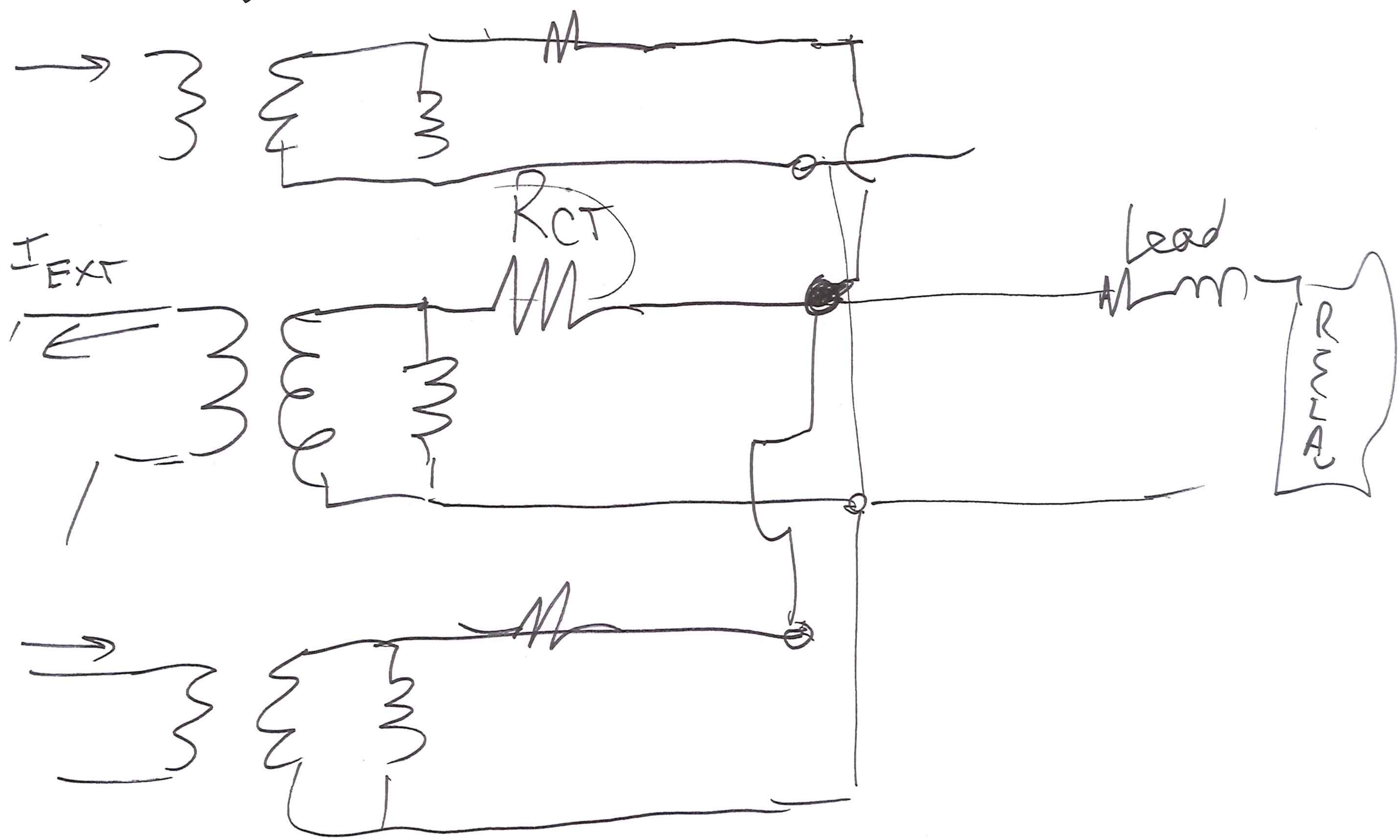

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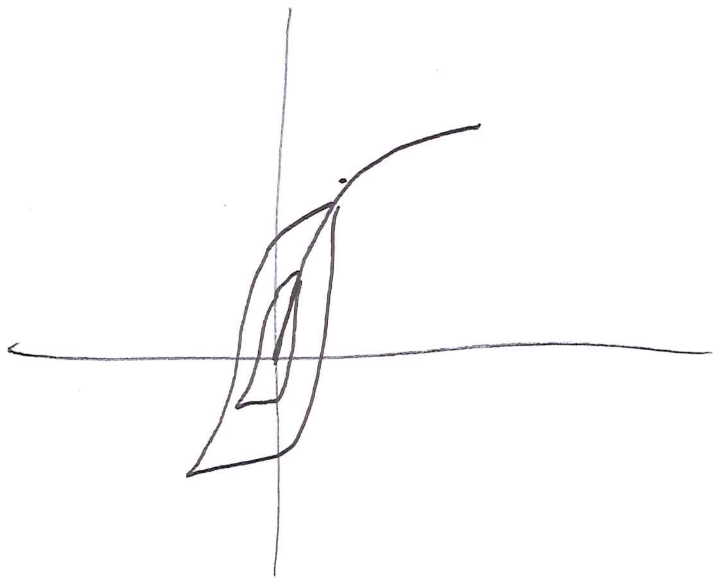
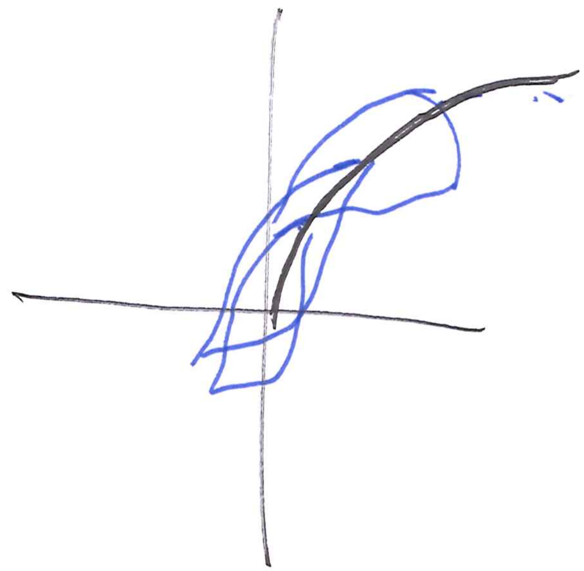




Transformer protection

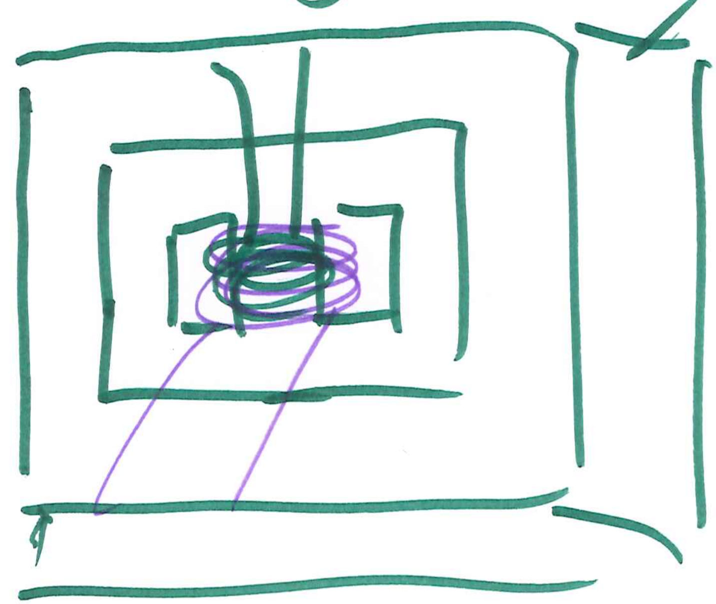
- Failure of transformer can have long time consequences
  → long Replacement time

→ Minimize impact of transformer faults

- reduce likelihood
  ⇒ Track external events that impact life of insulation

- heating of insulation has big impact on life
  - also transient overvoltages

Causes for heating:

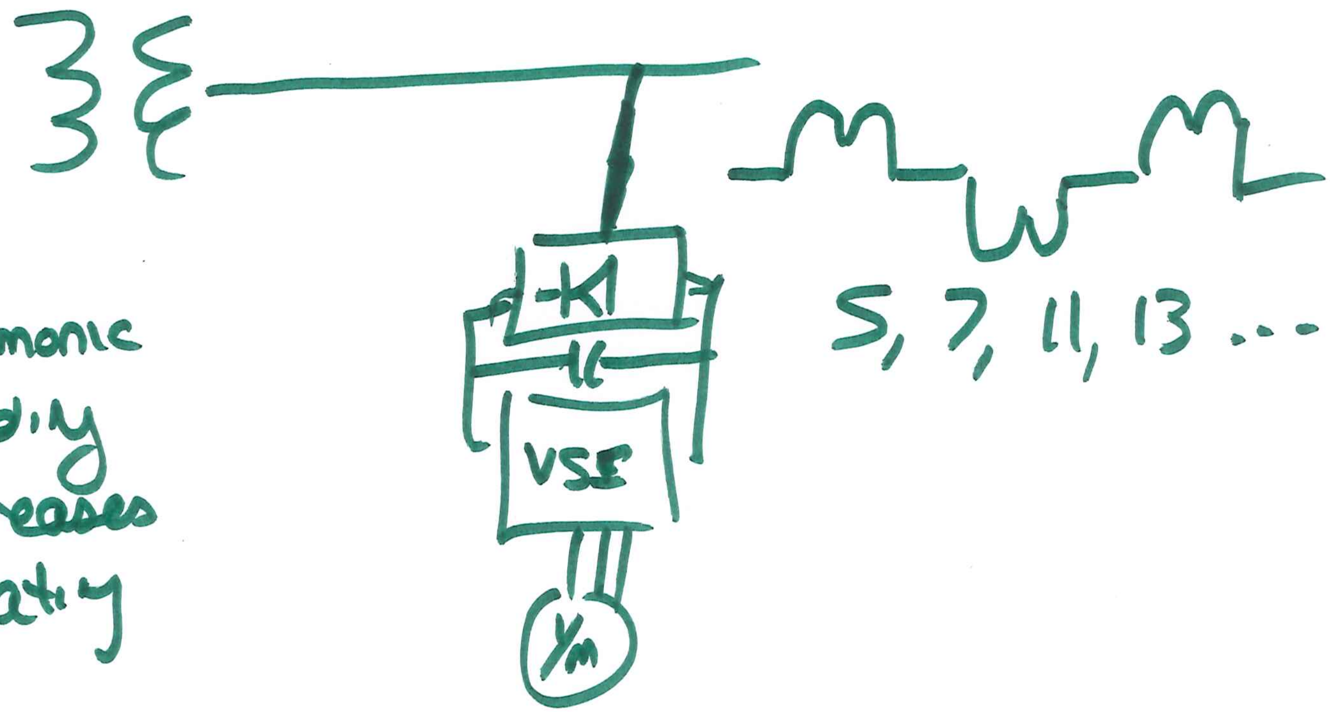


TANK
- oil filled
  - dielectric oil
  - also a coolant

15 MVA / 20 MVA / 25 MVA

- 15 MVA ← passive cooling
- 20 MVA ← circulating oil with pump
- 25 MVA ← pumps + fans

- Harmonic current loading due to external loads



- harmonic loading increases heating

- K factor rated transformers

- overexcitation
  - → steady state overvoltage
    - partial saturation
    - detect based on harmonics
      odd harmonics → 5th
  - ⇒ hysteresis losses
- Through faults (transformer is carrying current to a fault)
  - similar with frequent large motor starting or even xfmr energization,

Track sources of heating to
predict life span loss

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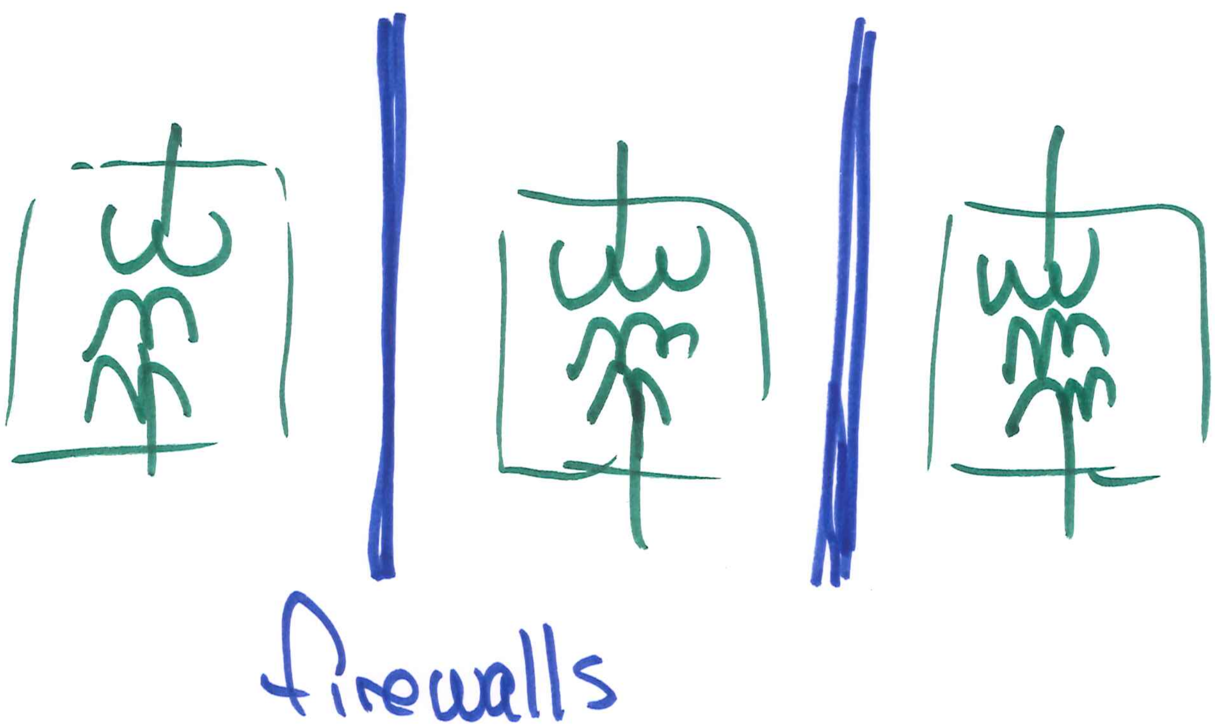
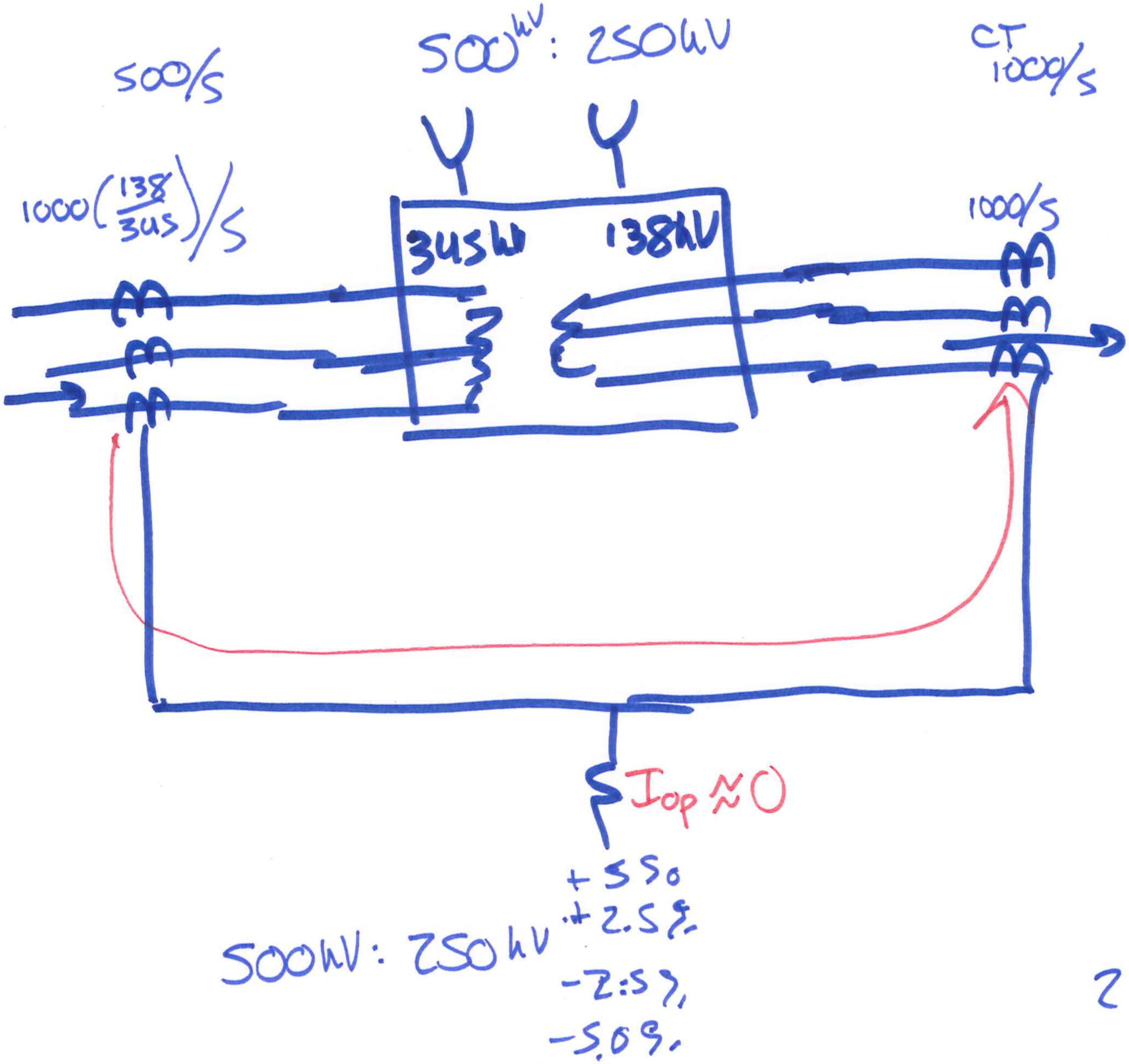
Protection for internal faults

- a fault that evolves to point where there is a fire can long repair times



→ First line: differential protection



complicating factors:

1. CT ratios may not cancel the Power Transformer ratio

⇒ TAPS on Relay

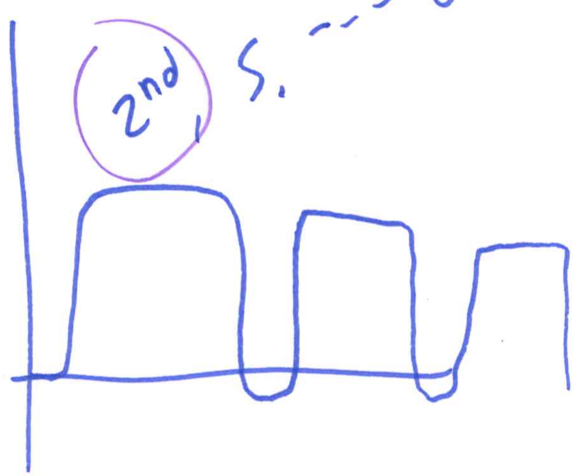
2. Power Transformer Taps

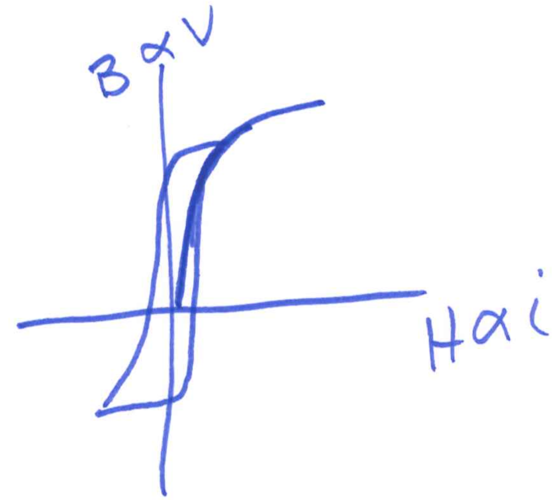
3: magnetizing current

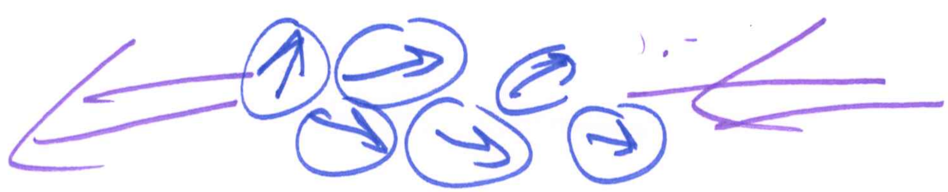
→ Transformer always draws

→ 2-4% of rated current in steady-state

→ magnetizing inrush current





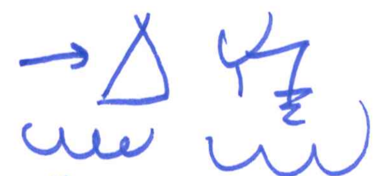


Transformer Phase Shift

ΔY, $(Y\Delta)$ ⇒ ANSI/IEEE Standard

⇒ V_{LN} on HV side leads V_{LN} on LV side by 30°

→ ΔY / → impact turns ratios

→ 

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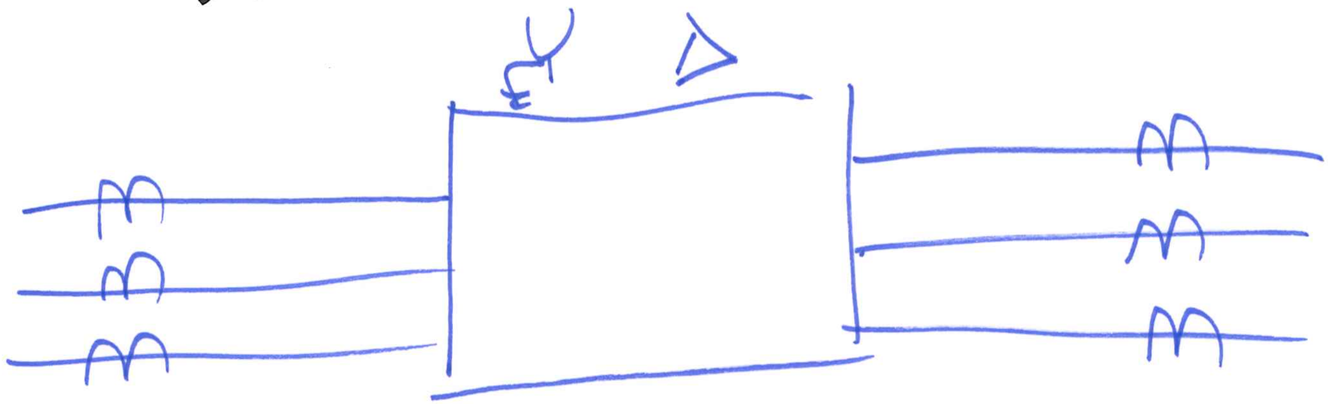
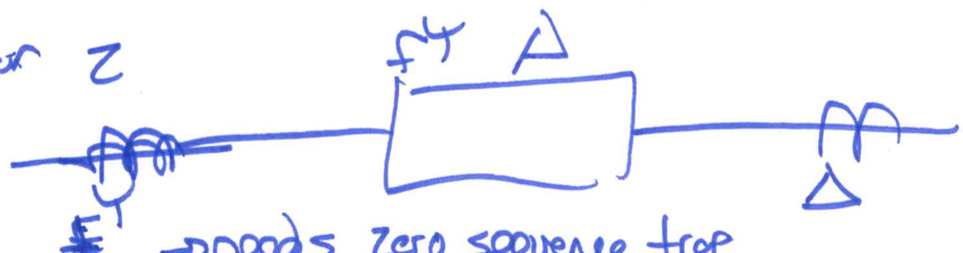


E-m relays

option: 1:

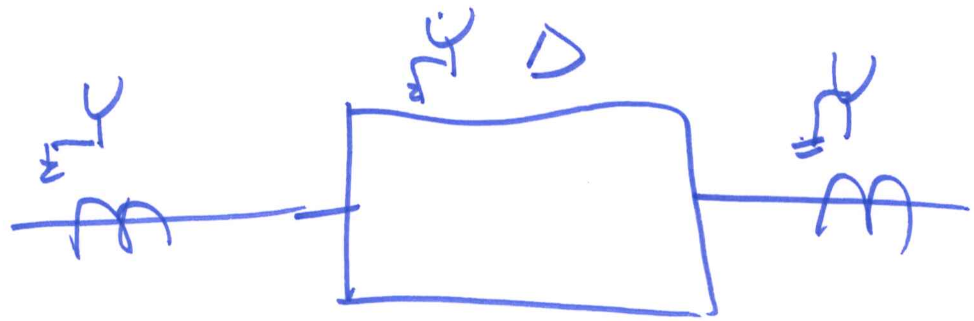
connect Δ properly to cancel shift

option 2



→ needs zero sequence trap

microprocessor relay



⇒ relay perform math to compensate for shift

– And remove I_0

} matrix multiplications

Compensation matrices for transformer differential protection

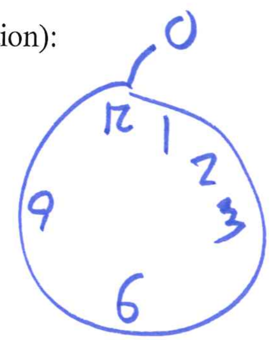
- Apply one for each winding of the transformer
- Typical usage is:

$$\begin{pmatrix} I_{A.sec\_cor} \\ I_{B.sec\_cor} \\ I_{C.sec\_cor} \end{pmatrix} = MAT_{correction} \cdot \frac{1}{Tap_{HV} \cdot CTR_{HV}} \cdot \begin{pmatrix} I_{A\_Primary} \\ I_{B\_Primary} \\ I_{C\_Primary} \end{pmatrix}$$

- Matrices for commonly used transformer connections in the North America

  - Standard Y Connected winding (Y_0 using IEC clock position notation):

$$MAT_0 := \begin{pmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{pmatrix}$$



- Δ connected winding, D_{AB} (D_1 using IEC clock position notation):

$$MAT_1 := \frac{1}{\sqrt{3}} \cdot \begin{pmatrix} 1 & -1 & 0 \\ 0 & 1 & -1 \\ -1 & 0 & 1 \end{pmatrix}$$

- Δ connected winding, D_{AC} (D_{11} using IEC clock position notation):

$$MAT_{11} := \frac{1}{\sqrt{3}} \cdot \begin{pmatrix} 1 & 0 & -1 \\ -1 & 1 & 0 \\ 0 & -1 & 1 \end{pmatrix}$$

- Zero sequence removal matrix:

$$MAT_{12} := \frac{1}{3} \cdot \begin{pmatrix} 2 & -1 & -1 \\ -1 & 2 & -1 \\ -1 & -1 & 2 \end{pmatrix}$$