ECE 526

PROTECTION OF POWER SYSTEMS II

SESSION no. 14

University of Idaho

$$\sqrt{\frac{X_C}{X_L}} = \sqrt{\frac{1}{\omega C \cdot \omega L}} \Rightarrow$$

~ 40-60 Hz is range of concern

→ In machine –

$$\left(\frac{60 + f_2}{2}\right), \left(\frac{60\,Hz - f_n}{2}\right)$$

steam turbine

SSR – sub synchronous ~~so~~ resonance

→ feedback to ~~mec~~ mechanical resonance of machine

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- In location prone to SSR
  - Relay on generator shaft
    - detect if subsynch oscillation, and it is growing
      - If no - record data
      - If yes - then take action
        - (1) Transfer command to by pass caps
        - (2) Trip generator unit (not entire station)

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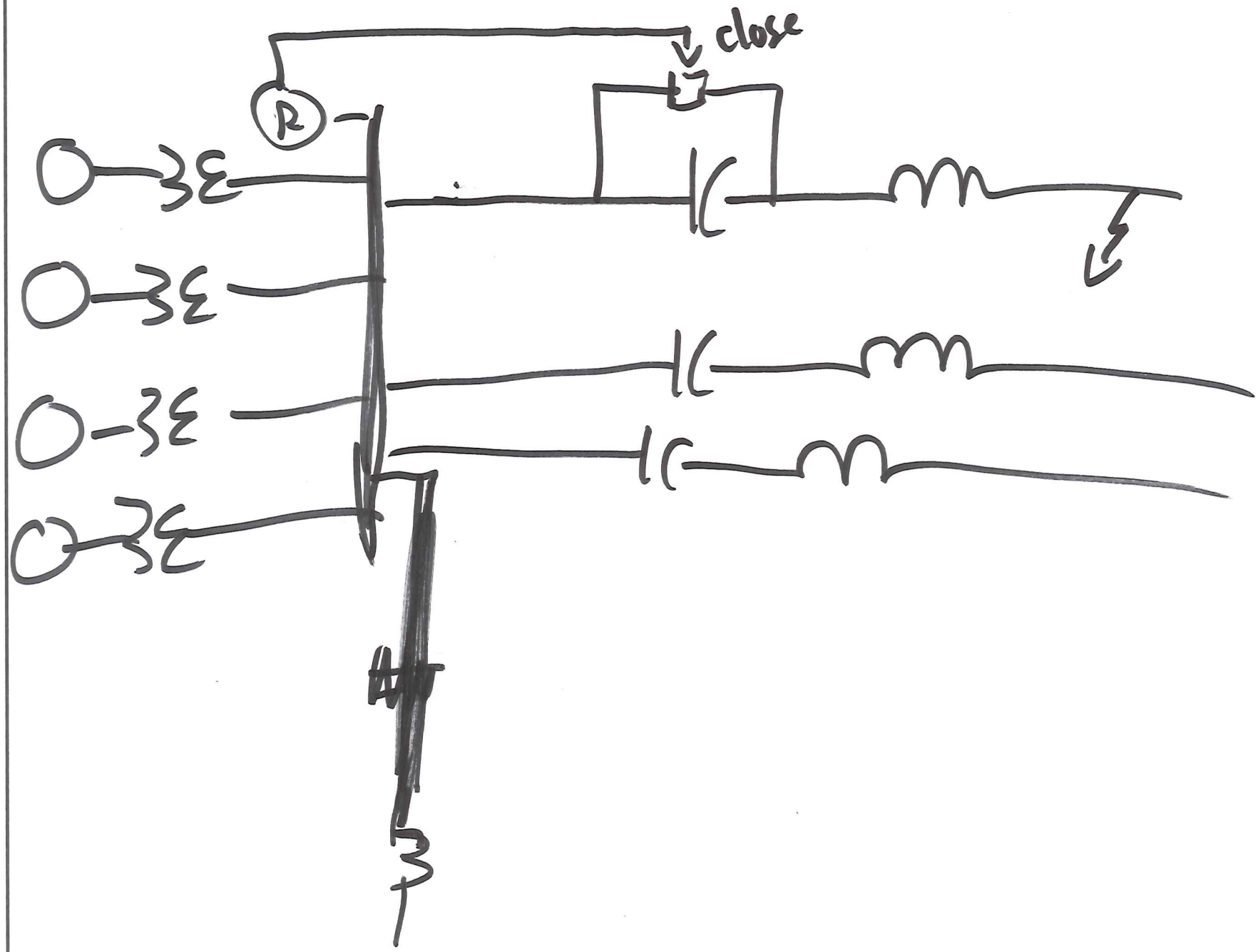

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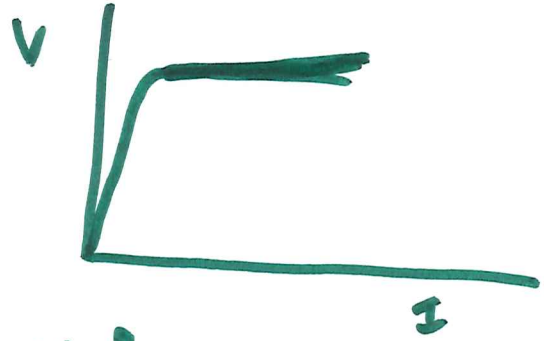
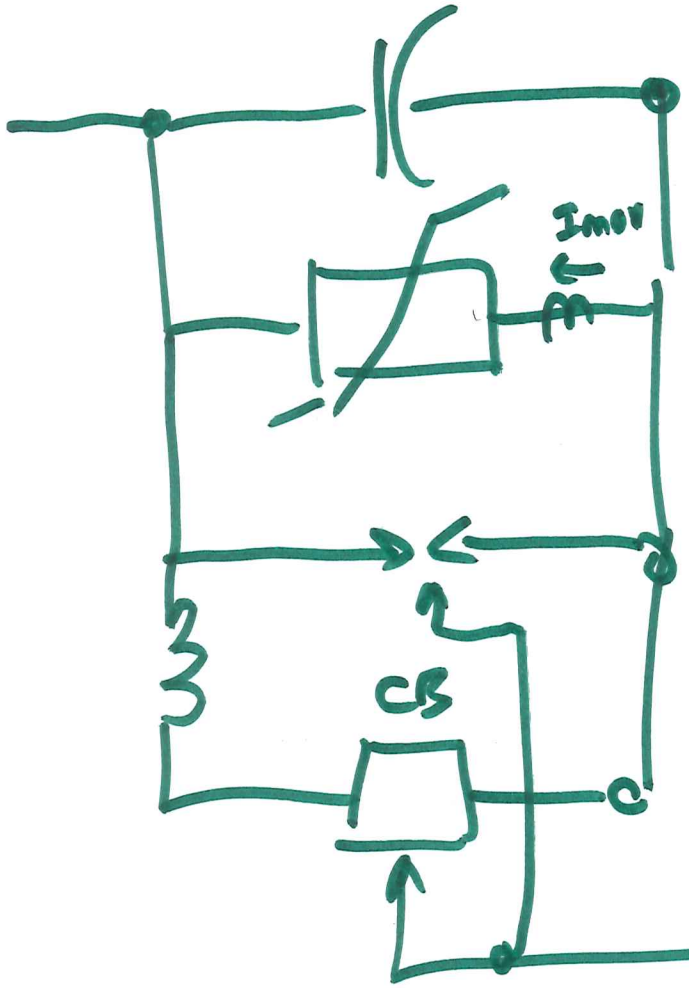
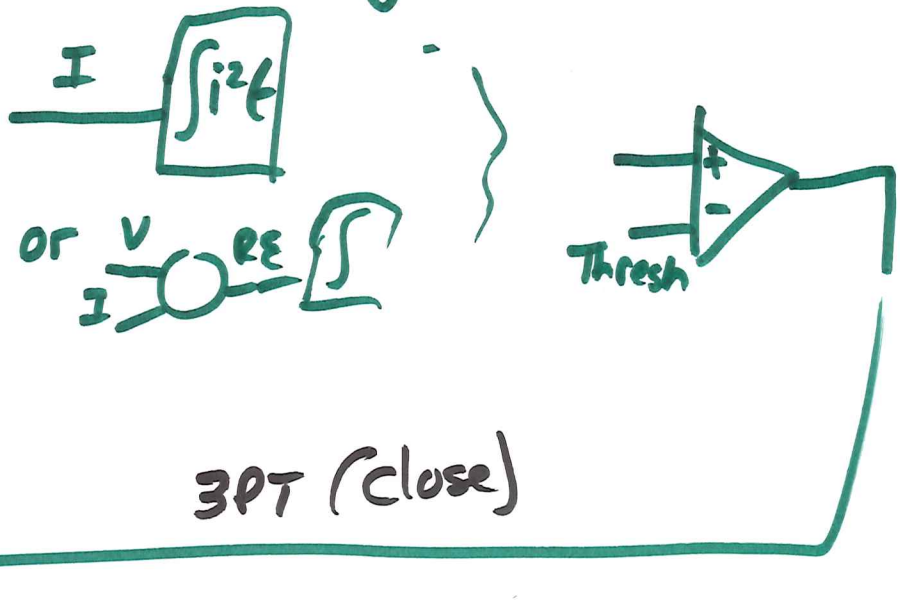




$E_{Thresh} \approx 5\text{-}15\,mJ$



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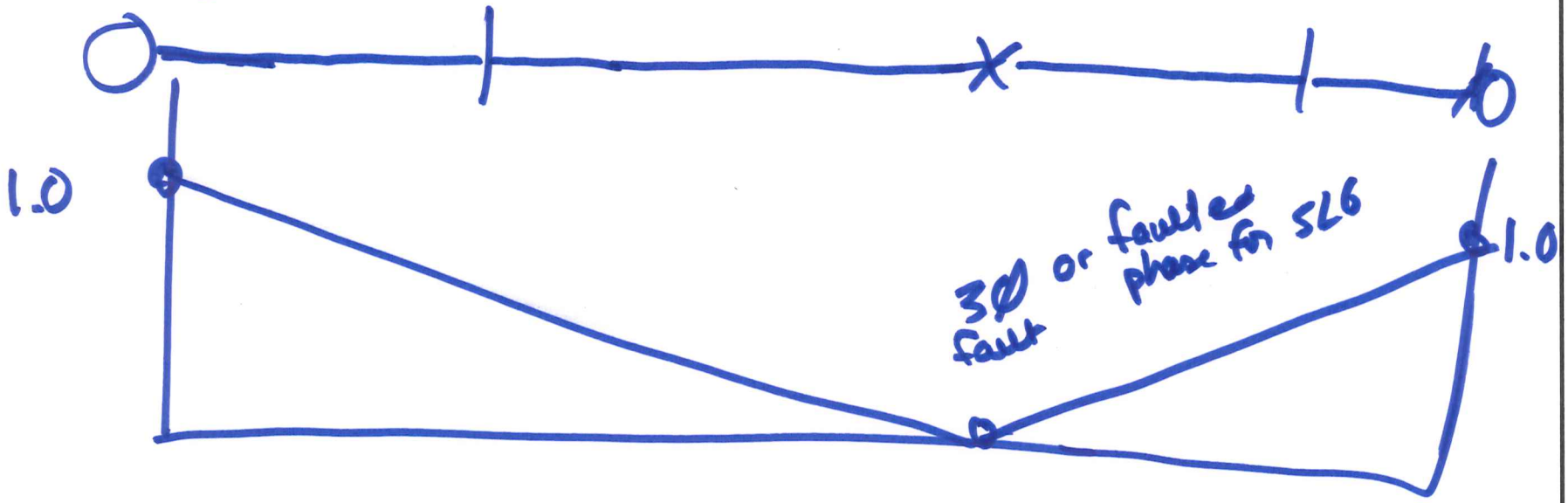
Voltage profile



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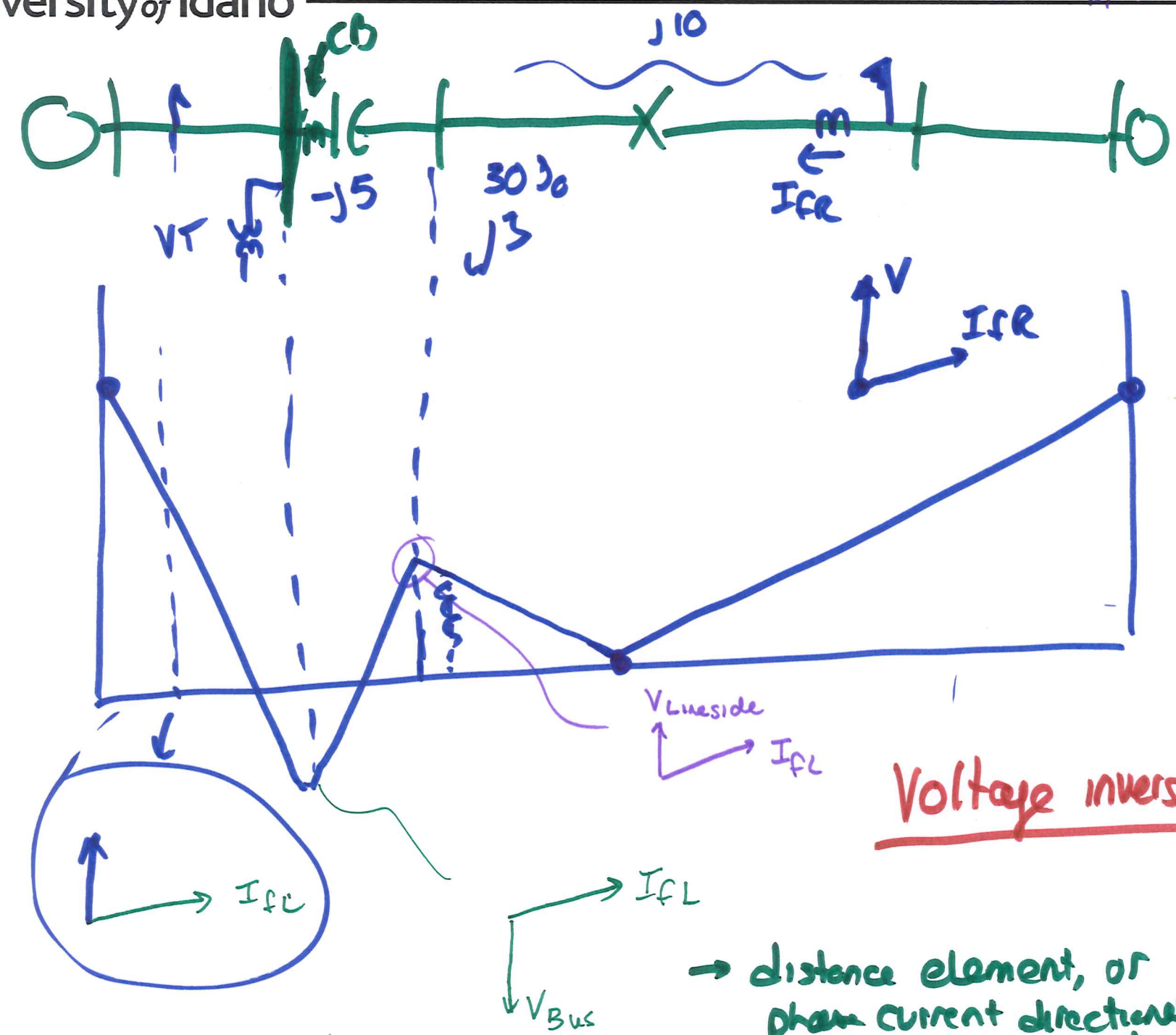

Voltage inversion

→ distance element, or phase current directional

→ (reverse fault)

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→ Possible ways to address this?

- Line current differential

→ Distance relay

(1) Relay that has ~~det~~ series capacitor compensation ...

- multiple options

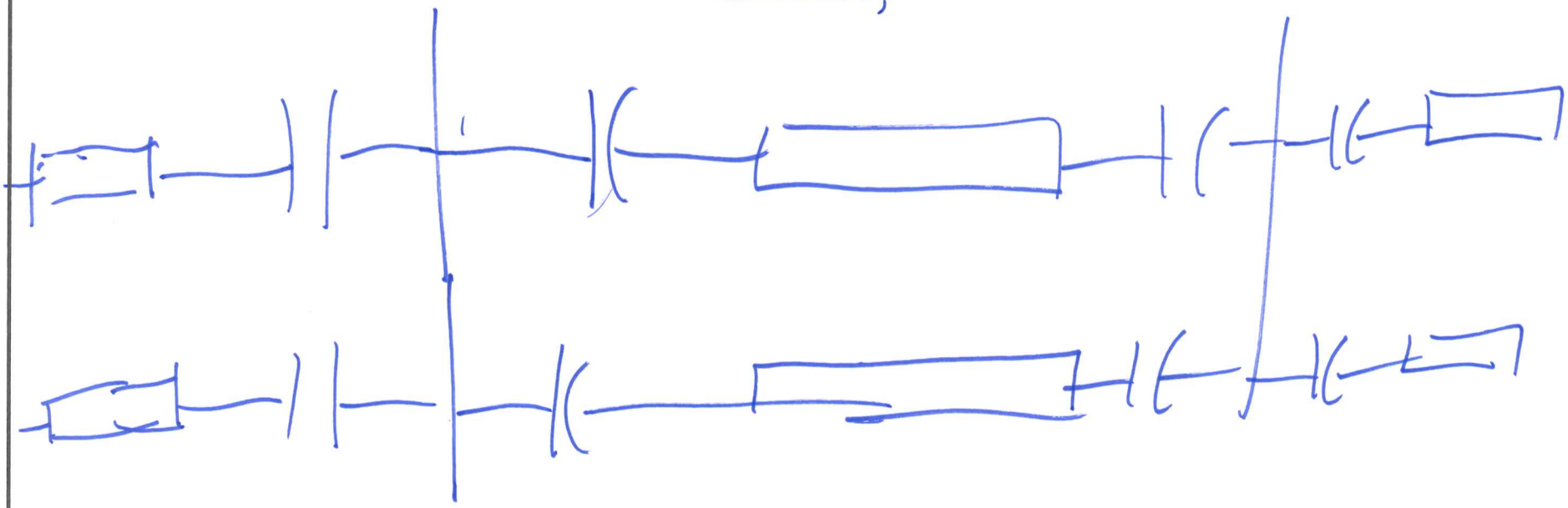
(A) use memory voltage if polarity changes

(B) Shift mho circle down
- directional supervision needed.

(2) Line side VTs

- what if there is a reverse fault?

500kV,



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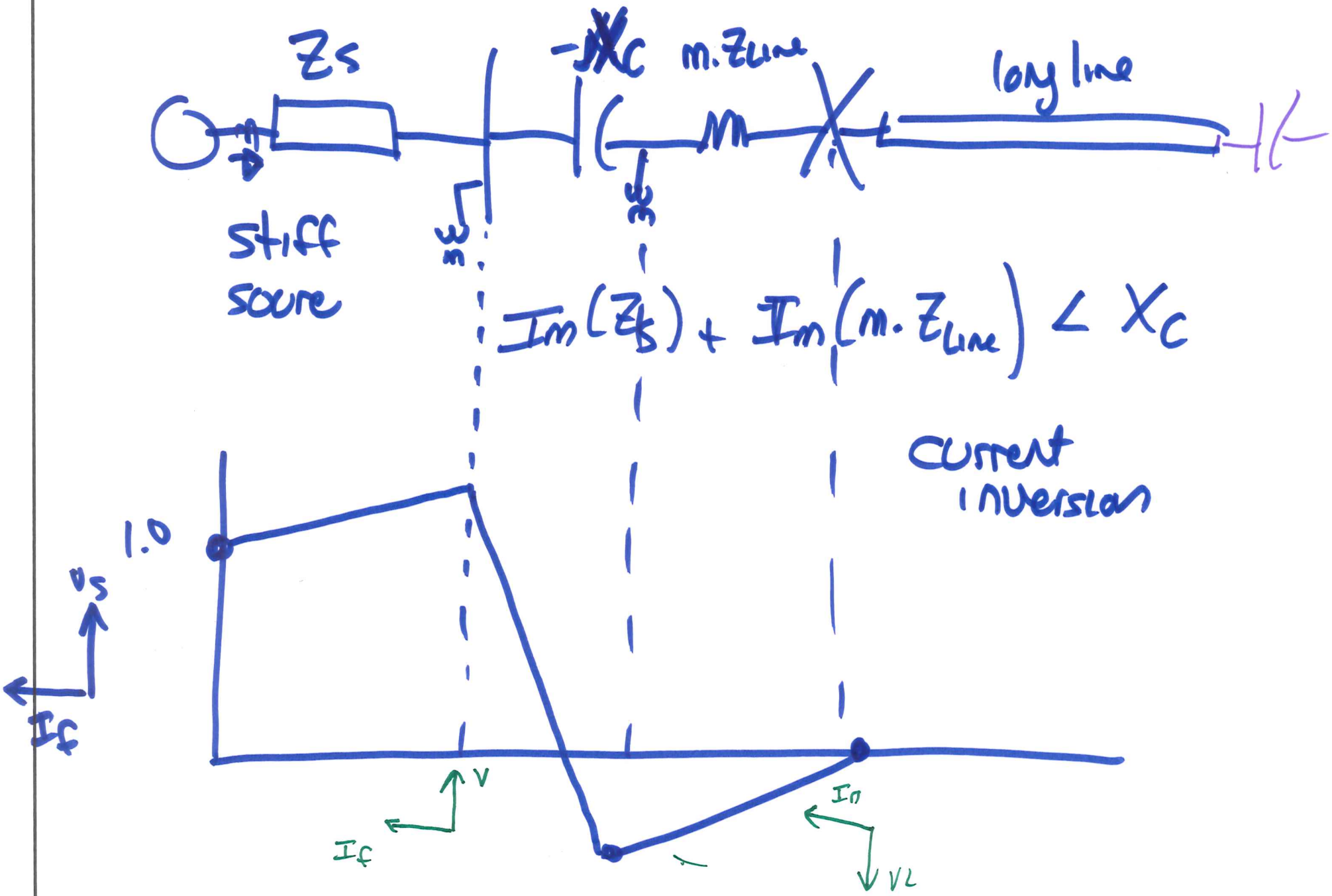
Zs
-jXc
m.Zline
long line
stiff
source
ω_m
ω_m
$Im(Z_s) + Im(m \cdot Z_{line}) < X_c$
current
inversion
1.0
v_s
I_f
V
I_f
I_n
VL

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- Current inversion is very rare
  - when does occur - often have $-X_C + X_{L_{equiv}} \approx 0$
  - <u>Big</u> current
    - MOV conducts quickly
      - energy accumulate quickly

- Line current differential?

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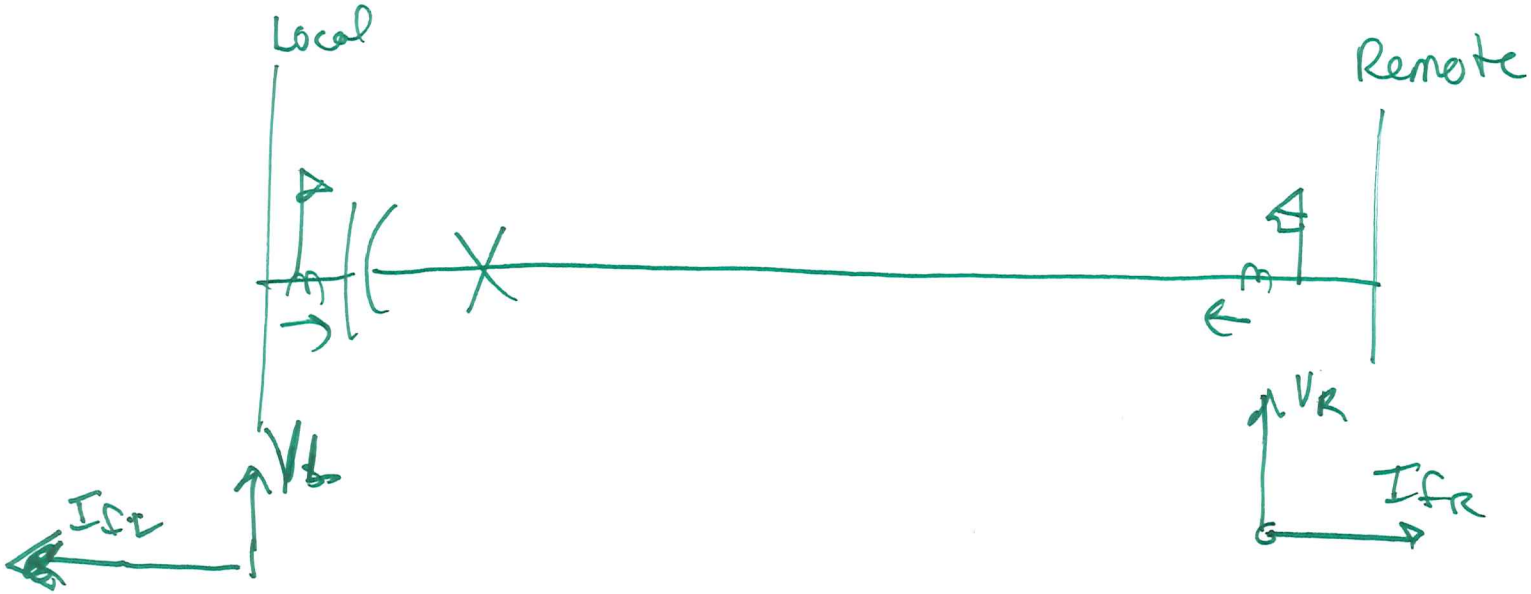
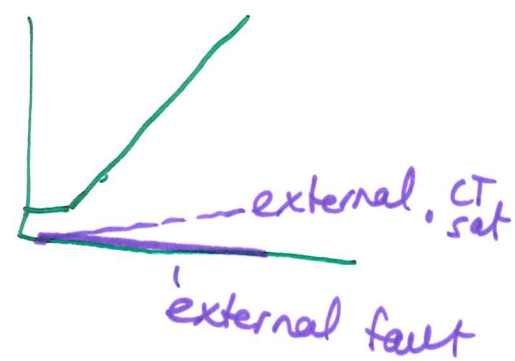


Percentage diff: $\left|\bar{I}_{fL} + \bar{I}_{fR}\right| = I_{op}$

- could have problems with percentage diff



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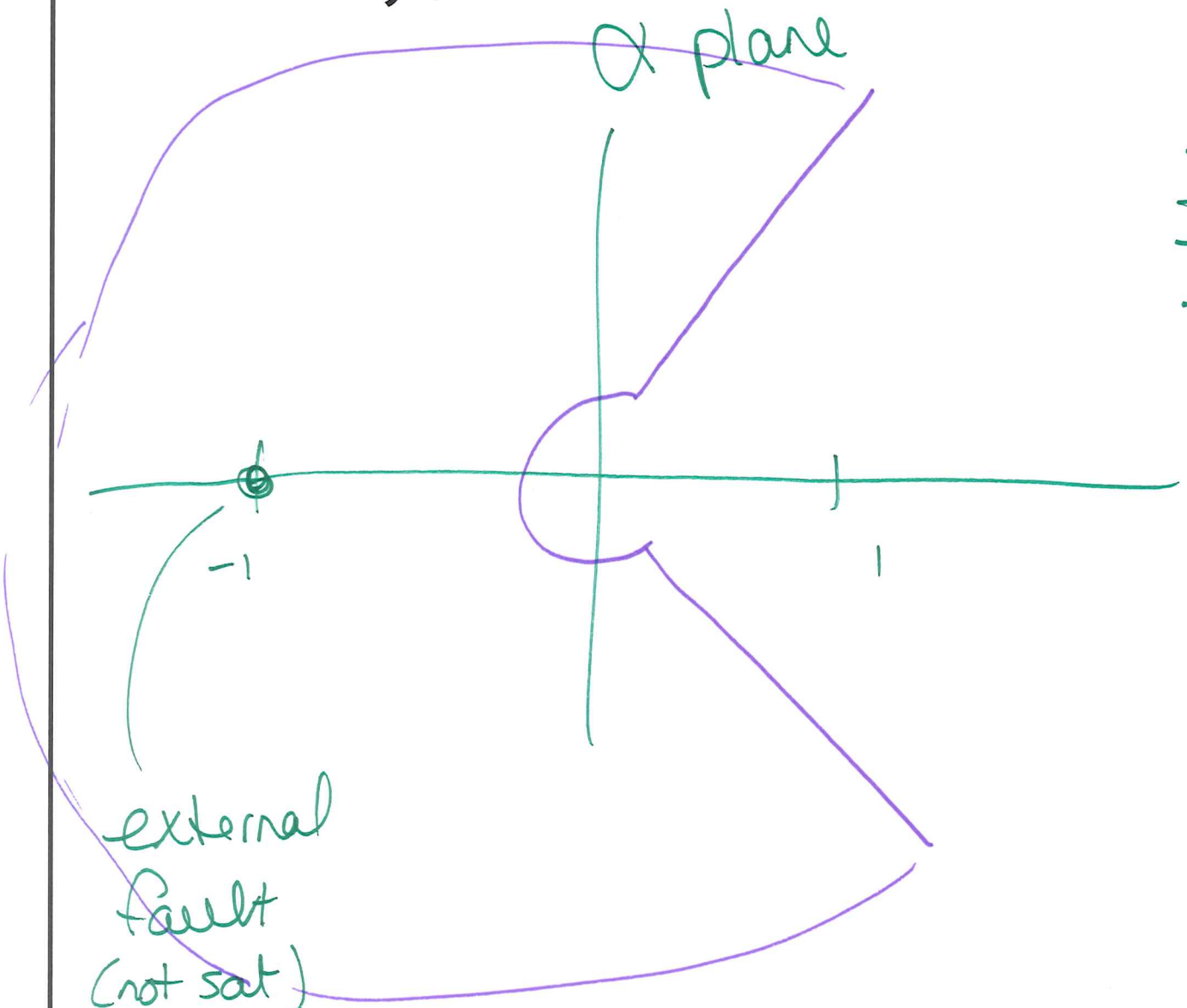

$$\frac{I_R}{I_L}$$

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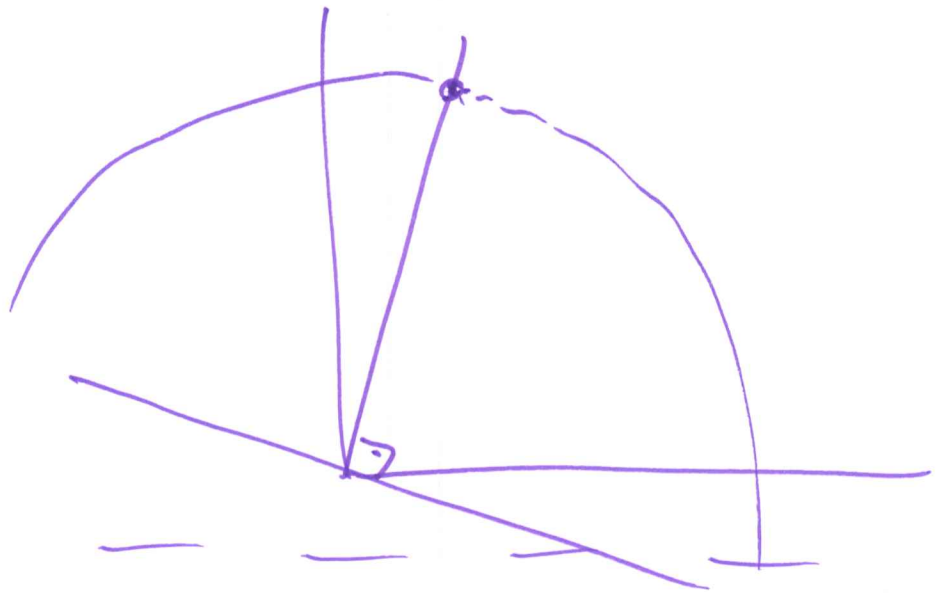
What does directional element do?

$$T = |V||I|\cos(\theta_V - (\theta_I + MTA))$$



$$\theta_{ZL1} < \theta_{V1} - \theta_{I1} < \theta_{ZL1}$$ } part of HW...

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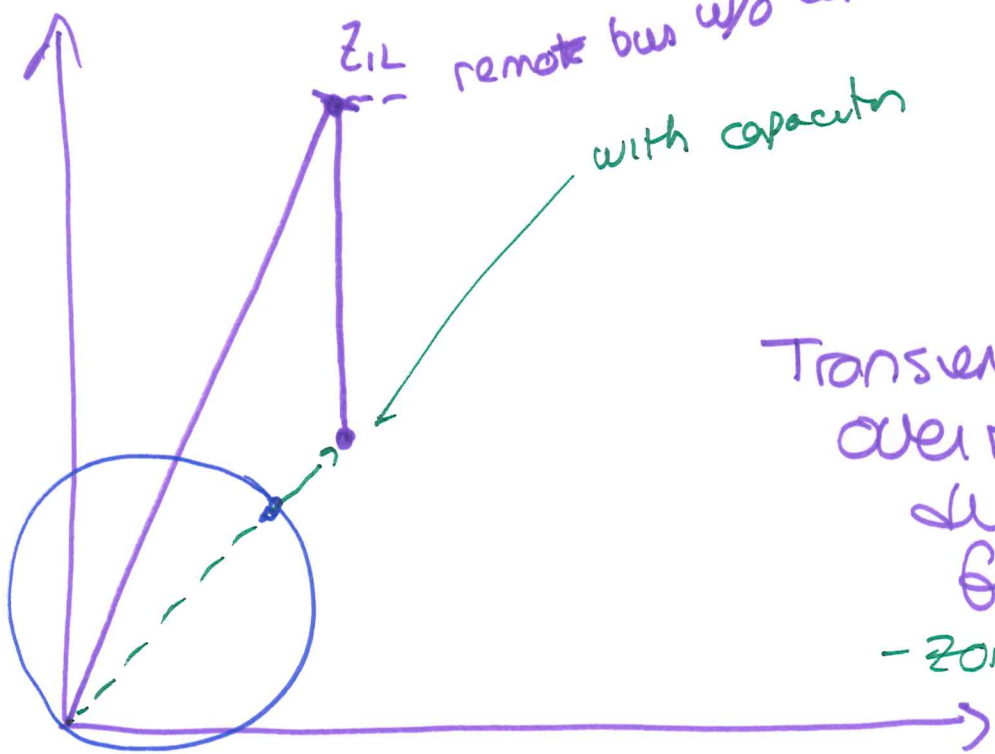
Setting distance elements

Zone 1 ....



Transient overreach due to low freq oscillation

- zone 1 - reduced

Earth schemes

Normal distance element

$$V_{op} = I \cdot r Z_{Line} - V_{relay}$$

but $V_{relay} = I Z_L - I(+jX_C)$

$$V_{op} = I \cdot r Z_{Lin} - (I \cdot Z_L - I \cdot jX_C)$$

$\approx I \cdot jX_C$ for faults at far end of ~~line~~ reach setting

where is Vmeas in this?

Another variant

$$V_{op} = V_{mov} \text{ or } V_{gap}$$

Better schemes next time