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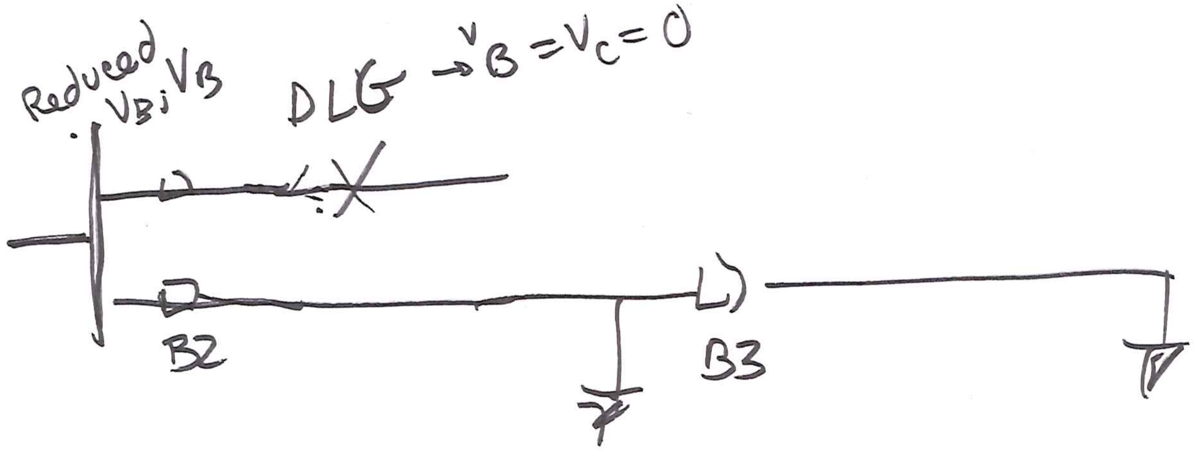
ECE 525

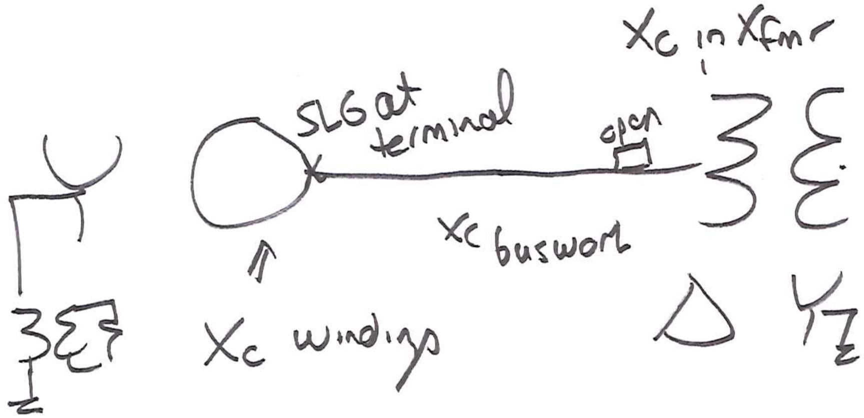
POWER SYSTEM PROTECTION AND RELAYING

SESSION no. 22


Reduced V_{B}; V_{B}
DLG → $V_{B} = V_{C} = 0$
B2
B3

High Resistance Ground (option)

$$3R_G = X_{C0}$$



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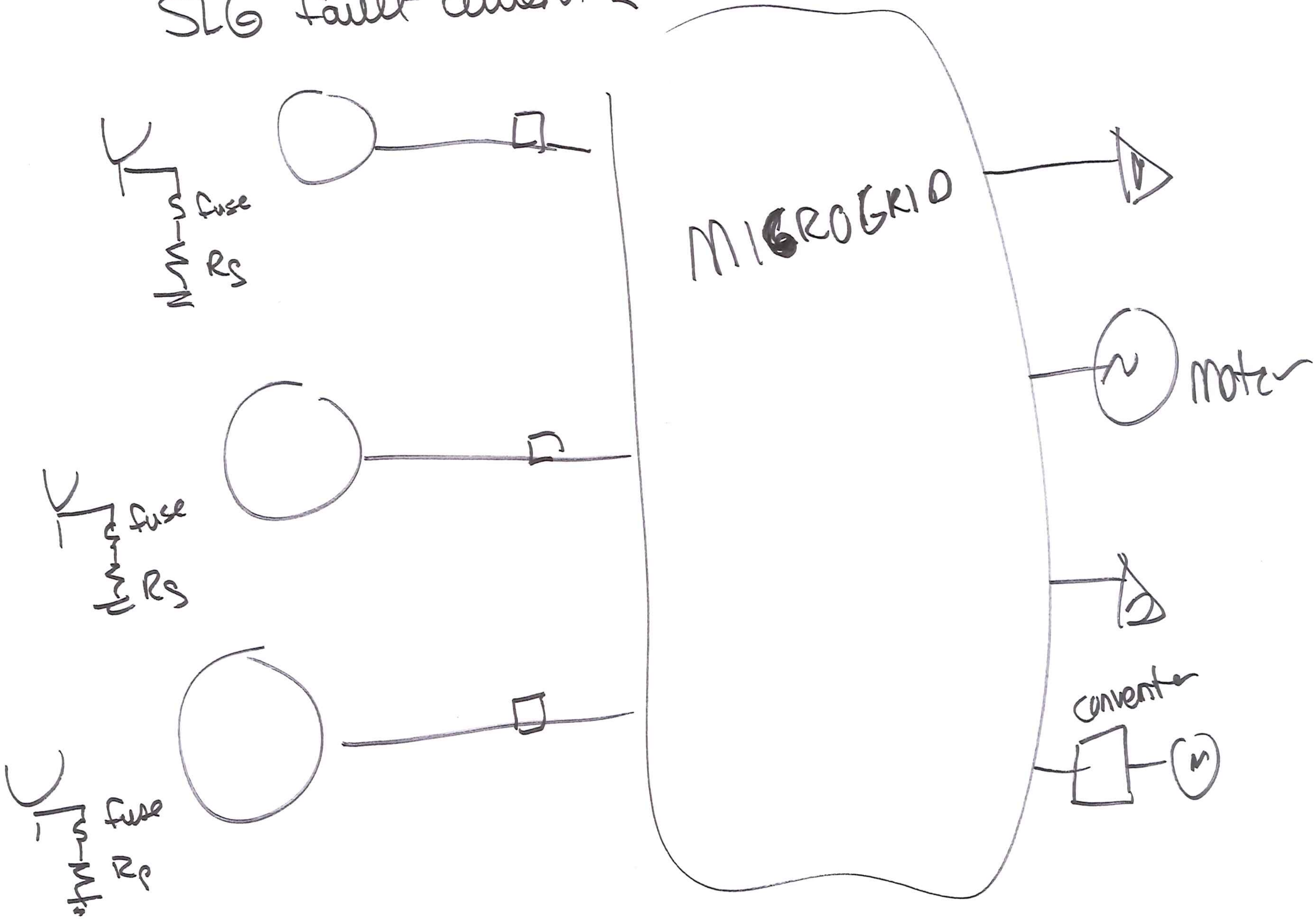
SLG fault current < 25A



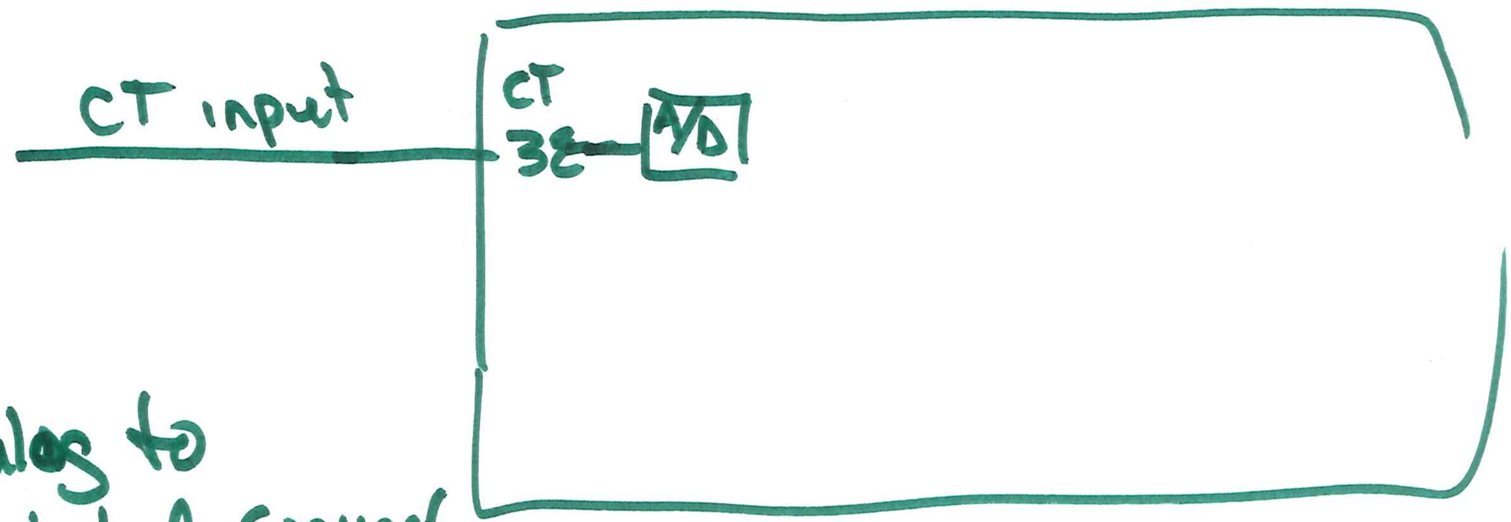
Ungrounded

Fault Detection

SLG : $V_{ng} = 3V_0$

LL, DLG, 3ϕ – overcurrent + Directional determination as earlier

- Directional Determination in ungrounded or high resistance grounded
  - → very small current
    - → $3I_0$
      - ↳ (1) Determine with $\bar{I}_A + \bar{I}_B + \bar{I}_C$
        - → (1) mathematical sum in relay



Analog to
Digital Converter

- fixed number of bits
  → if we have a 4 bit A/D
    1 bit is sign bit
    3 bits for the number
    ↳ 8 combinations
      → 0 to peak

111 - 200A
⋮
010
001
000 → 0A

→ 200A secondary (pk) → 1000/5 CT

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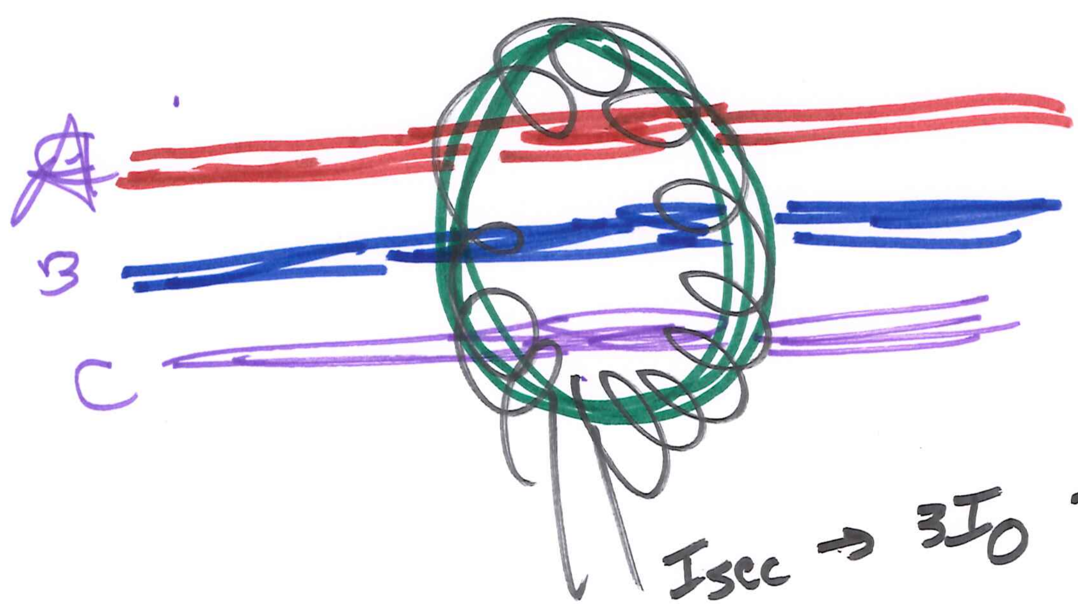
SLG → 20A primary

↓

$\frac{20\,A}{CTR} = 0.1\,A$ secondary

$\overline{}$

$I_A + I_B + I_C$ → magnetically



$I_{sec} \rightarrow 3I_0 \Rightarrow$ put this into a relay input with a scale for small currents

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If a system is high R grounded

→ I_n could be used in a similar fashion

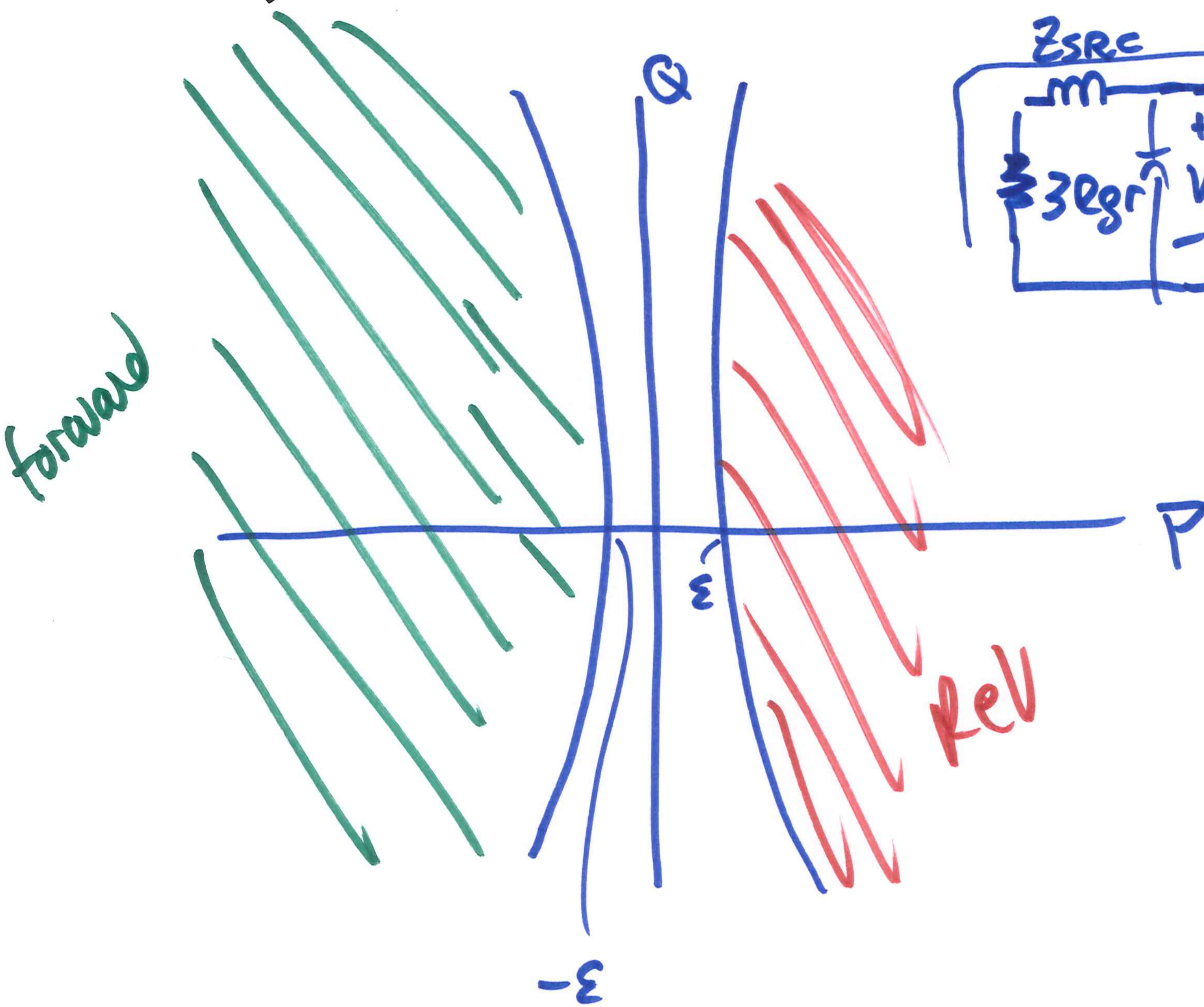
Directional Calculation Options

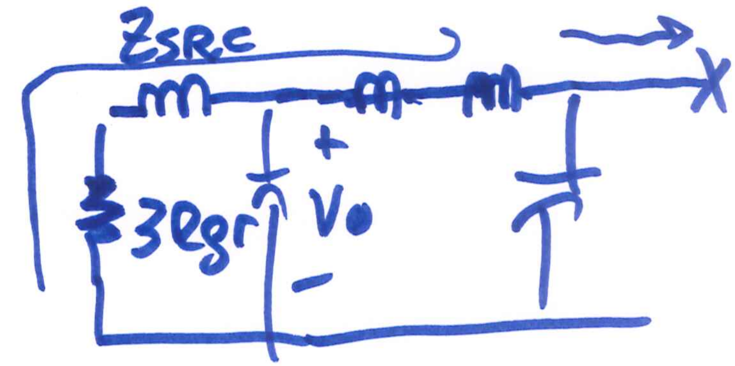
① Wattmetric Method

→ high resistance grounded

$$W_0 = Re\left[V_0 \cdot I_0^*\right]$$

$$\text{or } Re\left[3V_0 \cdot 3I_0^*\right]$$


forward
Q
P
ε
-ε
Rev


ZSRC
X
3egr
+
V₀
-

VARMETRIC METHOD

$$Q_0 = \mathrm{Im}\left(-3V_0 \cdot 3I_0^*\right)$$

↑

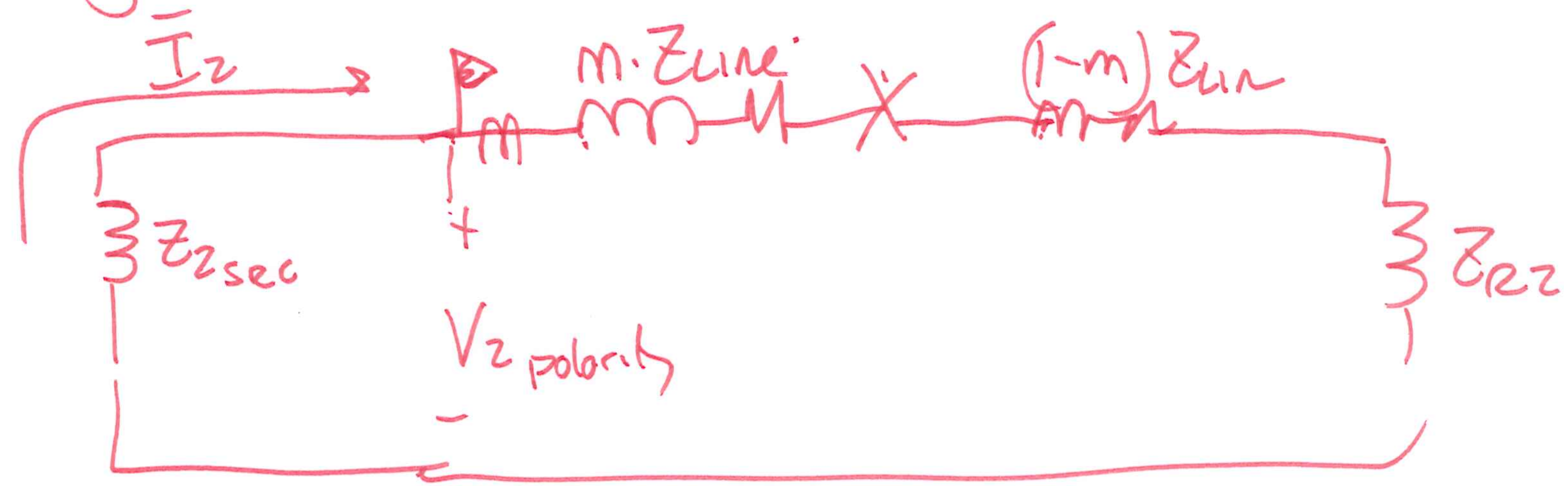
→ inductive grounded

- unsgrounded

Suscetance

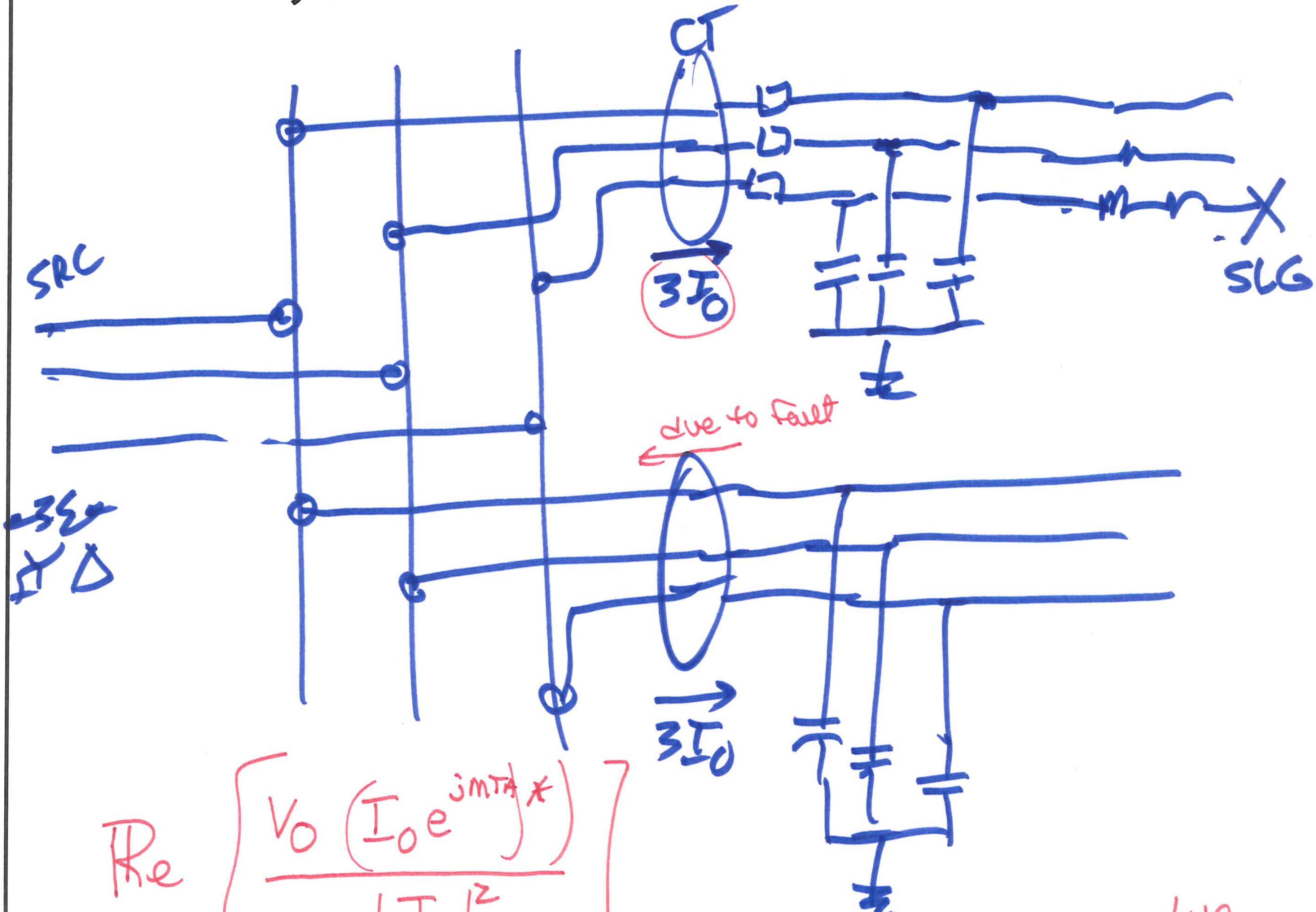
$$B_0 = \mathrm{Im}\left(I_0 / V_0\right)$$

Negative sequence directional element



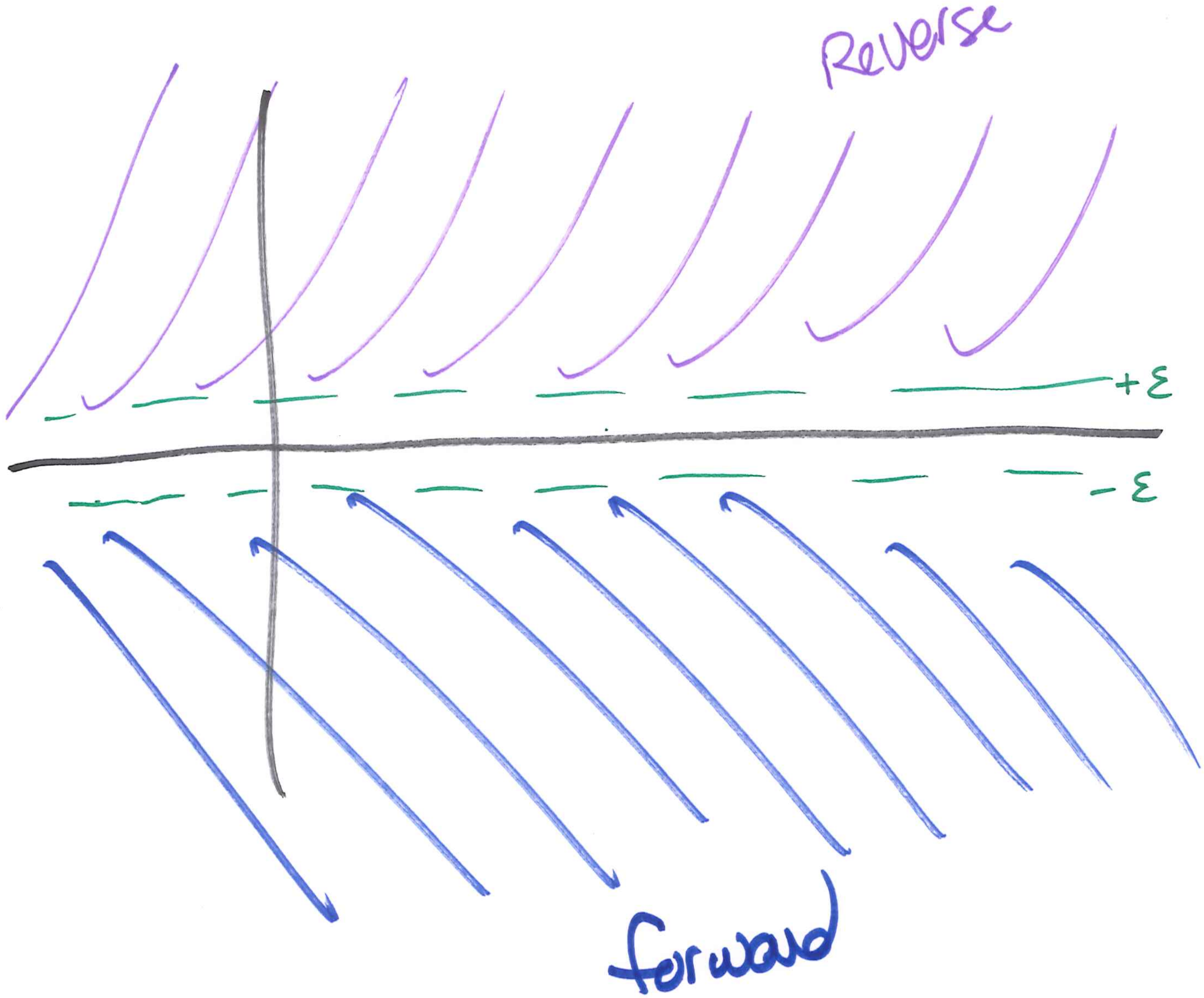
$V_{2_{rely}} = 0 - I_2 Z_{2SRC}$, θ_{ZLINE}

$\mathrm{Re}\left[\frac{V_2 (I_2 e^{jMTA})^*}{|I_2|^2}\right] = -|Z_{2SRC}|$ for forward fault



$$\mathrm{Re}\left[\frac{V_0\left(I_0 e^{jMTA}\right)^*}{|I_0|^2}\right]$$

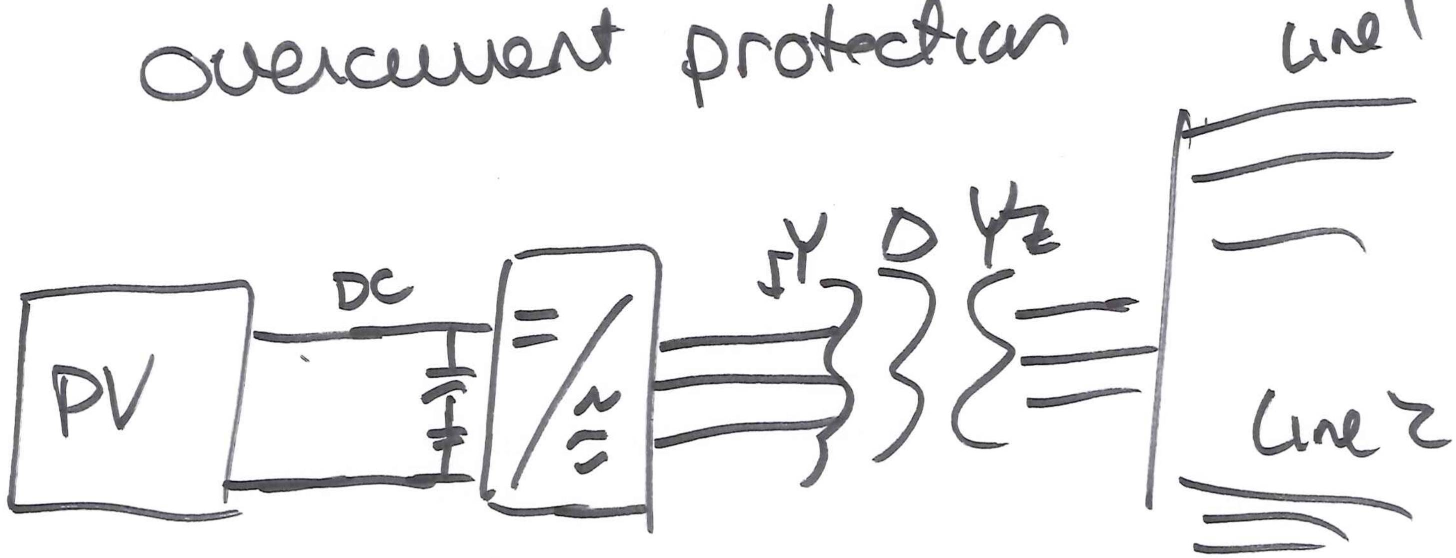
MTA = −90° → capacitive fault current


Reverse
+ε
-ε
forward

- If system is high resistance grounded - -

MTA → angle of fault current with $3R_G$ in parallel with X_{C0}

Challenges of voltage source converter generation for overcurrent protection



fast current regulator → limits $|I|$ to 1.2–1.5 pu

- some also regulate $I_2 = 0$

$I_0 = 0$

Regulates pf ⇒ unity

- some also have capacitive current to boost volt