ECE 523
Symmetrical Components

Session 21

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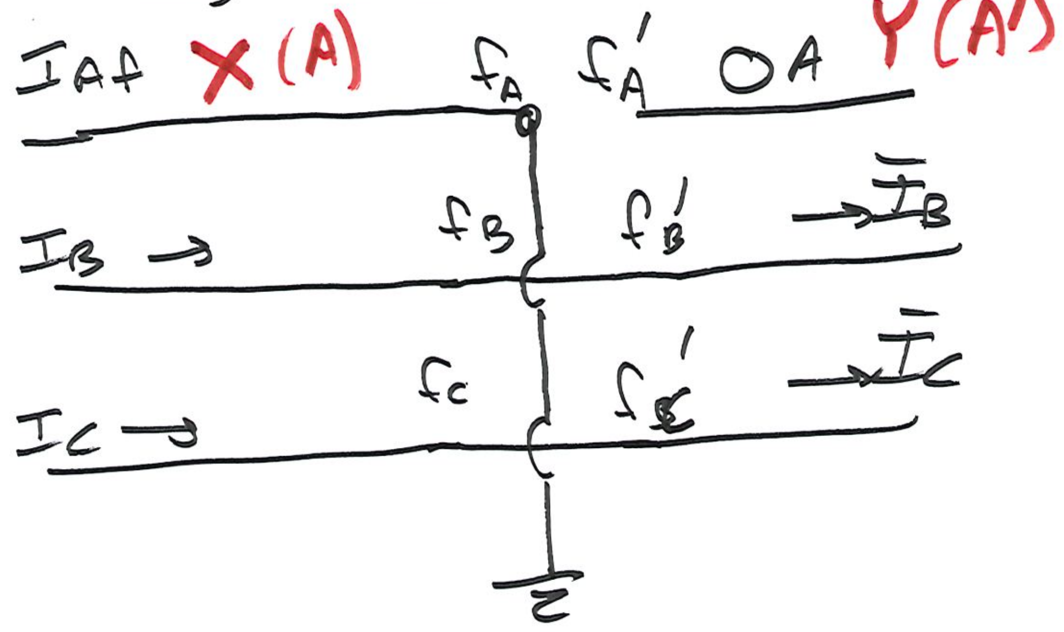
- Simultaneous SLG ~~or~~ with broken conductor

→ conductor fall to the ground



A - reference symmetrical components

Boundary conditions

phase A open: $Z_A = \infty$

$Z_B = Z_C = 0$

$I_{Af-f'} = 0$ (across open)

SLG $I_{Bf} = I_{Cf} = 0$

$I_{AG} = I_{Af} = I_{A1} + I_{A2} + I_{A0}$

$V_{AfG} = 0$ ($R_f = 0$

$V_{A'fG} = ?$

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SLG (x-side)

- $I_{A1x} = I_{A2x} = I_{A0}$ (fault itself)

$\uparrow$

But will also have pos sequence line current - load flow

- and I_2 + I_0 on line due to phase open

- $V_{A0x} + V_{A1x} + V_{A2x} = 0 = 3 I_0 R_f$

---

1 phase open

$V_{1ff'} = V_{2ff'} = V_{0ff'}$

$I_{1y} + I_{2y} + I_{0y} = 0$

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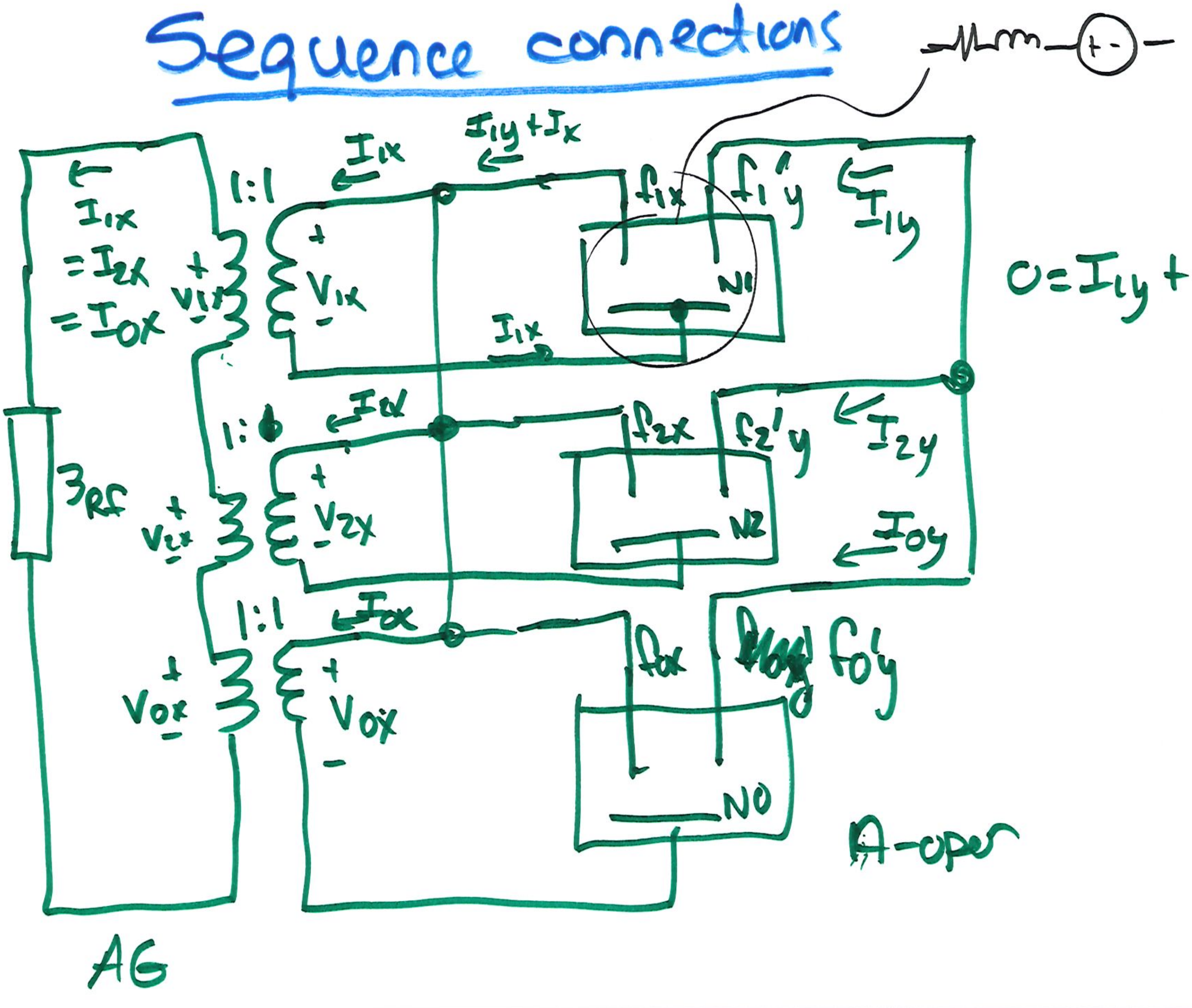
Sequence connections



$0=I_{1y}+I_{2y}+I_{0y}$

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Rest of Semester

- models of power apparatus in sequence domain for doing studies

- Transmission/distribution lines
  - ↳ mutual coupling
- cables
- Transformers (external faults) - specialized connection
  - 3 winding
  - Tap changers
  - grounding transformers
- Rotating machines - external faults
- Inverter based generation (wind, PV, storage) - impact on solution technique

Overhead Line Models / cable models

① models

② calculating model data

- $\underline{\underline{Z}}_0$

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<u>models</u> - Steady state
or quasi-steady state
<u>(phasor models)</u>

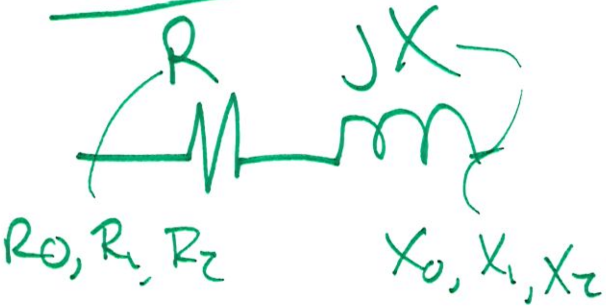
short, $\underbrace{\text{medium,}}_{\text{PI}}$ $\underbrace{\text{long}}_{\text{reduced to modified PI}}$

equal

$\Rightarrow$ can apply in pos, negative and
zero sequence

R, L, C per length

Short line model



- overhead lines for <u>power flow</u>
  ~5Ohm or less

- cables
  ~5hm of less
  (less L per lengh,
  more C perlength)

- fault analysis most likely used this unless system high resistance grounded or ungrounded

SLG

⟹ <u>If</u> that is case <u>must</u> use medium or long with capacitences

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medium length

OH : 50km – 150km

5 – 15 (20) for cables

(150km) based on frequency

PI model ↙ same as short lin

$j\frac{\omega C}{2}$ ~ C_0, C_1, C_2 $\left(C/_{\text{length}}\right)$ ·length

for longer underground cables this capacitance can impact fault currents

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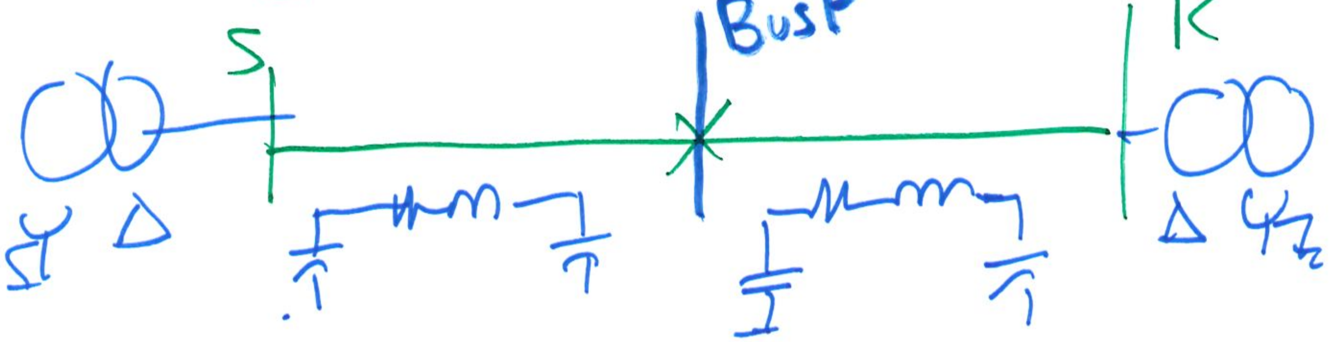
for fault studies with ~~[illegible]~~.
Ungrounded on high resistence
grounded systems...



T-model instead of PI

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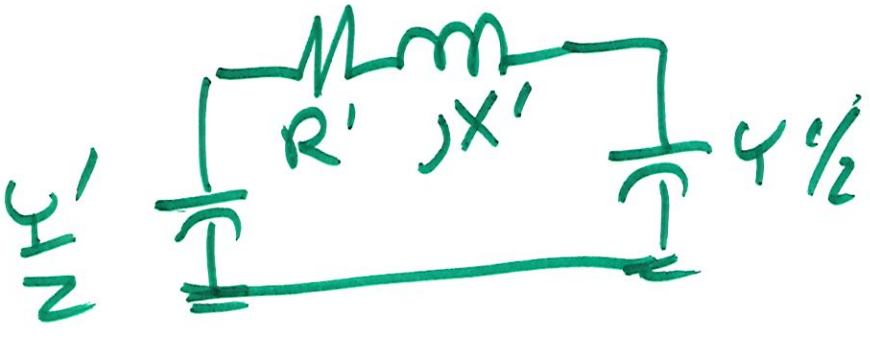
Long Line model



} correction factors for lengh effects

> 150km (rare in cables)

- If not an ungrounded system
  - → primarily want R', jX'

γl · length

$\sqrt{y'z'}$

$Z \frac{\cosh \gamma l}{\gamma l}$

$(R + j\omega L \cdot)$ Length

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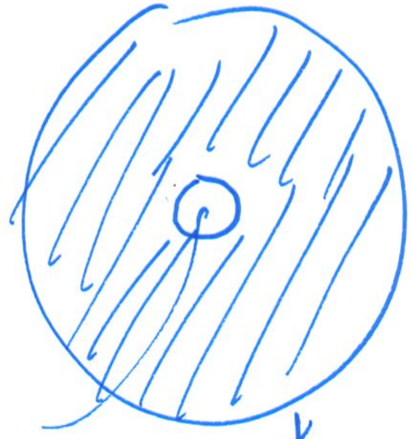
Calculating parameters for overhead lines

$r'_{AC} \rightarrow \Omega/\text{length}$

- accounts for skin effect

$$R_{dc} = \frac{\overset{\text{resistivity}}{\rho}\, l}{A}$$



get from tables
or test data

or
line constants
program that
calculates from
dimensional data

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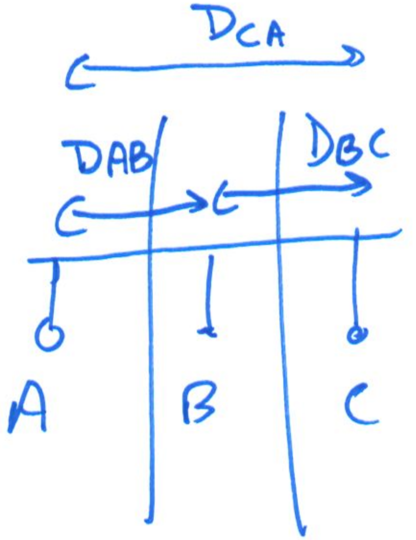
Intro to power systems course

$$L' = \frac{\mu_0}{2\pi} \ln\left(\frac{D_m}{R_b}\right)$$ in H/length



μ_0 = permeability of free space

$(\mu = \mu_r \mu_0)$

↑ relative permeability)

= 1 for overhead lines

$D_m = \sqrt[3]{D_{AB} \cdot D_{BC} \cdot D_{CA}}$ → Geometric mean distance

R_b ⇒ geometric mean radius → { single conductor, Bundled conductor

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single conductor

→ Geometric mean radius of conductor

⇒ - Accounts for skin effect

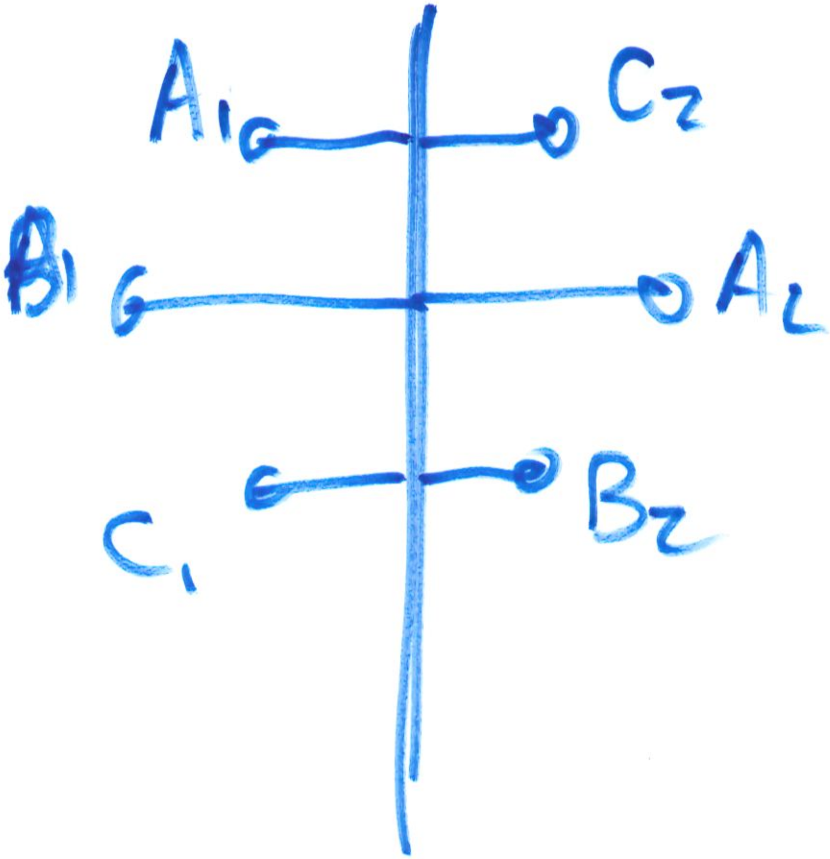
- Accounts for magnetic flux linkage

- Stranding

get from ~~datasheet~~ table

$$\omega L' \cdot \text{length} = \omega \cdot \text{Length} \cdot \frac{\mu_0}{2\pi} \ln\left(\frac{D_m}{R_b}\right)$$

$$\boxed{\bar{Z}_1 = R_{AC} \cdot \text{length} + j\omega L' \cdot \text{length}}$$



- mutual coupling

⇒ Dominated by zero Sequence