SESSION no. 18

PROTECTION OF POWER SYSTEMS II

ECE 526
Change to match this system

Default Line Impedance and angle Settings

Quantities requiring setting have a green background.

Directional element settings for Relay I

Level 1: 0.5
Level 2: 0.5
Level 3: 0.5
Level 4: 0.5

Underneath on D1 & D2 fault on level 2.

Relay I Overturter Settings

Relay I Overurrent Settings

Phase Elements will overreach on 3 phase fault on level 1 and

Relay I Quad Distance Elements

Relay I Directional Elements

Enable the relay elements you want to use (1 means enabled, 0 means disabled).

Relay Settings

Relay Model:
Ground (zero sequence) element (use calculated instead of measured currents):

\[ 10.0' \leq \frac{1}{0.1 - \frac{1}{\text{freq}}} \leq 1 \]

\[ 1 \leq \text{freq} \leq \frac{1}{100} \]

\[ \text{freq} \leq \frac{1}{100} \]

\[ \text{freq} \geq \frac{1}{100} \]

\[ 10.0' \geq \frac{1}{0.1 - \frac{1}{\text{freq}}} \geq 1 \]

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\[ \text{freq} \leq \frac{1}{100} \]

\[ \text{freq} \geq \frac{1}{100} \]

Negate sequence element (modified to leave and stay one, no drop out for now):

Relay 2 pickup logic and trip equations:

\[ 0 = A_{\text{pickup}} - \frac{1}{\text{freq}} \]

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Initialize Relay Elements (use 12 and 10, not 3*12 and 3*10):

Relay Element Pick Up Logic

- Define cycles: Level 2 Delay 1:
- Define cycles: Level 1 Delay 2:
- Define cycles: Level 1 Delay 3:
- Define cycles: Level 1 Delay 1:
\[ Z_{\text{REMOTE}} = 3(1 + j10) \]

\[ Z_{\text{SOURCE}} = 0.5 + j5 \]

Avoid divide by 0

Calculate negative sequence impedance and zero sequence impedance

Negative sequence and Zero sequence directional elements

Default setting - captures most negative values

Forward threshold (set at 0.5z line)

Minimum Negative Sequence Current (as a percentage of I1) to enable directional element

<table>
<thead>
<tr>
<th>Negative Sequence Directional Element</th>
<th>Negative Sequence Directional Element</th>
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<tbody>
<tr>
<td>0</td>
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</tbody>
</table>
\[ P_{AV} - Z_1 = 22.5 \, \text{dB} \]

\[ X_{AV} - Z_1 = 11.26 \, \text{dB} \]

Multiples \( X \) set

Percentage of line length

Zone 1 and Zone 2 Quad Settings:

\[ P_{220} \, R_{24} > \lambda \]

\[ X_{22} = 0.80 \% \]

\[ R_{52} = 0.10 - 3 \]

\[ \frac{RS}{\lambda} \]

\[ |Z_{REMOTE}| \]

\[ |Z_{SOURCE}| \]

\[ \lambda Z_{24} \]
Transmission of Signals

Communication Time Delay: T_{Delay} = 0.5s (Do not change the T_{Delay})

(2) Direct Undercurrent Transfer Trip (DUVT) Scheme

Remote Relay  Local Relay

RS

RS

TR_{T2}  TR_{T1}
- electrical interaction between lines
- capacitive coupling
- magnetic coupling between the lines
Characteristics

Zero

\[
\begin{align*}
\text{Characteristic:} & \\
X_{0L1} &= 2.01 \text{ mH} \\
X_{L1} &= 2.54 \text{ mH} \\
Y_{0L1} &= 3.47 \text{ mH} \\
Y_{L1} &= 6.04 \text{ mH} \\
R_{0L1} &= 1.38 \text{ ohm} \\
R_{L1} &= 1.42 \text{ ohm} \\
V_{0L1} &= 1.8123 \text{ V} \\
V_{L1} &= 1.6996 \text{ V} \\
I_{0L1} &= 1.9237 \text{ A} \\
I_{L1} &= 2.5078 \text{ A} \\
&
\end{align*}
\]

Problem

APT Line Constants

Characteristics

Conductor GMR = 0.4760 in
DC Resistance = 0.15 ohm/mile
Conductor outside diameter = 1.0 in
Bundle spacing = 1.5 inches
Number of conductors per bundle = 4, positioned as shown above
Horizontal spacing between adjacent phases = 35 ft
Height at midpoint = 35 ft
Height at lower = 77 ft
Height at upper = 77 ft

Conductor GMR = 0.3876 in
DC Resistance = 0.15 ohm/mile
Conductor outside diameter = 0.995 in
Bundle spacing = 1.5 inches
Number of conductors per bundle = 4, positioned as shown above
Horizontal spacing between adjacent phases = 35 ft
Height at midpoint = 35 ft
Height at lower = 76 ft
Height at upper = 76 ft

Mutually Coupled Transmission Lines

ECF 326: Lecture 18

Protection of Power Systems II
The text appears to be a mathematical or engineering document, possibly related to electrical systems or circuit analysis. The symbols and expressions suggest calculations involving matrices or linear algebra. The text is not entirely legible due to the quality of the image.
Instead look at an impedance matrix

\[
\begin{bmatrix}
6.89 + 38.0 \Omega & 6.89 + 38.0 \Omega \\
6.89 + 38.0 \Omega & 9.65 + 38.0 \Omega \\
9.65 + 76.7 \Omega & 9.65 + 38.0 \Omega \\
9.65 + 76.7 \Omega & 6.89 + 38.0 \Omega
\end{bmatrix}
\]

\[
\begin{bmatrix}
V_{\text{in 1}} \\
V_{\text{in 2}} \\
V_{\text{in 3}} \\
V_{\text{in 4}}
\end{bmatrix}
\]

\[
\begin{bmatrix}
Z_{121} & 0 & 0 \\
0 & Z_{122} & 0 \\
0 & 0 & Z_{123}
\end{bmatrix}
\]
$$\begin{align*}
\text{Ohm} & : 0.04 \\
2.71 \times 10^{-5} + 4.67 \times 10^{-5} \\
2.86 \times 10^{-5} + 3.56 \times 10^{-5} \\
3.41 \times 10^{-5} + 1.09 \times 10^{-5} \\
1.74 \times 10^{-5} + 3.04 \times 10^{-5} \\
1.51 \times 10^{-4} + 1.51 \times 10^{-4}
\end{align*}$$
500 kV line currents

Both 500 kV lines appear electrically A Close 1/29
Case 1: Add a third line:

\[
Z_{m0} = \frac{R_{01212} + jX_{01212}}{Z_{m0} = (0.27 + 1.13)} \Omega
\]

Now for the zero sequence mutual coupling:

\[
X_{01212} = 2.04 \Omega
\]

\[
X_{111} = 0.52 \Omega
\]

\[
X_{01212} = 0.52 \Omega
\]

\[
X_{01212} = 0.52 \Omega
\]

\[
X_{01212} = 0.52 \Omega
\]

\[
X_{01212} = 0.52 \Omega
\]

\[
X_{01212} = 0.52 \Omega
\]

\[
X_{01212} = 0.52 \Omega
\]

\[
X_{01212} = 0.52 \Omega
\]
Now the system with 2 parallel lines:
Sequence out circuit elements
- Supersize with negative
- Conversion share
- Directed and enough
- Use negative sequence

 Preferred solution

\[ -170 \times 21 + 7 \times 21 - 21 \]
I \text{ft} = 1.25 \text{fL} - \text{m}\text{ax}

- \text{at open end of parallel linn}
- \text{within parallel linn in a cut}
  - with cut perpendicular to ground connected
  - 516 at remote bus
- Exteme short circuit studies
- IC 506 of element

62/52 817
Distance elements

\[ AG = \frac{V_A}{I_A + k_0 I_m} \]

\[ k_0 = \frac{Z_0 - Z_1}{3Z_1} \]

\[ V_A = mZ_1c (I_A + k_0 3I_0) + mZ_0m I_m \]

- Underreach if \( I_0 \) \& \( I_m \) in some direction
- Overreach if \( I_m \) opposite \( I_0 \) + \( I_m \)
Not widely used

\[ V_a = \frac{M}{2} \left( I_a + I_b \right) \]

For I_m and I_m as a measurement

Some possible solutions

Zone 2 should never under read

Zone 1 should never over read
\[ \frac{3z_1}{2} \]

\[ \frac{3z_1}{z_1 - 2z_1 + 2a_1} \]

\[ K_0 = \frac{z_1 - 2z_1 - z_0}{2a_1} \]

What if open surrounded on east end? When it is open, \( K_0 = \frac{z_1 - z_0}{2a_1} \).

Potential \((\text{electrical} \oplus \text{coarse})\):\[ V_{\text{vario} \oplus \text{dynamic}} \]

\( K_0 \)
Use Live Current differentials.