ECE 524

TRANSIENTS IN POWER SYSTEMS

SESSION no. 39
Checking transformer model?

1. Simulate: Open circuit / short circuit tests
   - Calculate parameters
     - Should match what started with

2. No load voltage waveform
   - Check voltage transformation ratio
     - Phase shift
     - Polarity
Ground transformer resistor current for a three phase fault:
Ground Transformer Resistor Current for SLG fault

Phase currents to the transformer for SLG fault (note all in phase):
\[ \sum_{GR} \rightarrow \text{size to limit} \\
\text{SLG current} \]

\[ V = \frac{X_{oc} || 3R_0}{R_1 + R_2 + (X_{oc} || R_0)} \]

\[ \sum_{GR} \rightarrow \text{RG not 3RG in calculation} \]
Saturation was not enabled. So the only line that means anything here is the magnetizing current.

Note that unless the transformer is specified as ideal the magnetizing current cannot be set to zero.

**Autotransformer case:**

- Using default transformer parameters other than turns ratio
  
  $V_{\text{prim}} := 240\text{kV}$
  
  $V_{\text{sec}} := 120\text{kV}$
Winding Impedance calculations for three winding transformer

MVA := 1000kW \quad pu := 1

Useful Constants

\[ V_h := \frac{500\text{-kV}}{\sqrt{3}} \quad V_m := \frac{230\text{-kV}}{\sqrt{3}} \quad V_1 := 34.5\text{-kV} \quad S_b := 100\text{-MVA} \]

- Test Impedances, found at bases listed next to numbers (in percent)

\[ X_{hm} := 7.9\% \quad 448 \text{ MVA} \]
\[ X_{hl} := 3.4\% \quad 25 \text{ MVA} \]
\[ X_{ml} := 2.8\% \quad 25 \text{ MVA} \]

- Convert test impedances to 100 MVA Base (answers still in percent), based on the data from data sheets regarding H/L and H/M

\[ X_{hl\text{new}} := \frac{100}{25} \cdot X_{hl} \quad X_{hl\text{new}} = 0.136\cdot pu \]
\[ X_{hm\text{new}} := \frac{100}{448} \cdot X_{hm} \quad X_{hm\text{new}} = 0.018\cdot pu \]
\[ X_{ml\text{new}} := \frac{100}{25} \cdot X_{ml} \quad X_{ml\text{new}} = 0.112\cdot pu \]

- Find \( X_H, X_M, \) and \( X_L \)

\[
\begin{align*}
X_H := (0.5)\cdot(X_{hl\text{new}} + X_{hm\text{new}} - X_{ml\text{new}}) & \quad X_H = 0.021\cdot pu \\
X_M := (0.5)\cdot(X_{hm\text{new}} + X_{ml\text{new}} - X_{hl\text{new}}) & \quad X_M = -0.0032\cdot pu \\
X_L := (0.5)\cdot(X_{ml\text{new}} + X_{hl\text{new}} - X_{hm\text{new}}) & \quad X_L = 0.115\cdot pu
\end{align*}
\]

- Now we need impedance bases.

\[
\begin{align*}
Z_{BH} := \frac{(500\text{-kV})^2}{100\text{MVA}} \\
Z_{BM} := \frac{(230\text{-kV})^2}{100\text{MVA}} \\
Z_{BL} := \frac{(34.5\text{-kV})^2}{100\text{MVA}}
\end{align*}
\]
- Find inductances

\[ X_{H\_ohm} := X_H Z_{BH} \]
\[ L_H := \frac{X_{H\_ohm}}{2 \cdot \pi \cdot 60\text{Hz}} \]
\[ L_H = 138.047\text{mH} \]

\[ X_{M\_ohm} := X_M Z_{BM} \]
\[ L_M := \frac{X_{M\_ohm}}{2 \cdot \pi \cdot 60\text{Hz}} \]
\[ L_M = -4.466\text{mH} \]

\[ X_{L\_ohm} := 3X_L Z_{BL} \]
\[ L_L := \frac{X_{L\_ohm}}{2 \cdot \pi \cdot 60\text{Hz}} \]
\[ L_L = 10.91\text{mH} \]

- Saturable Transformer Model Window:

For zero sequence calculations (in per unit):

\[ X_{H0} = X_{H0} + X_{L0} \]
\[ X_{M0} = X_{M0} + X_{L0} \]

\[ X_{H0} + \left( \frac{1}{X_{M0}} + \frac{1}{X_{L0}} \right)^{-1} \]

\[ \frac{X_{m0} - X_{L0}}{X_{m0} + X_{L0}} \]