EE 5200 - Lecture 11

Topics for Today:

- Announcements
  - Matlab - last reminder to purchase (online students).
  - Office hrs: 2:00-3:00pm M,W,F
  - Office: EERC 614. Phone: 906.487.2857
  - Recommended problems from Ch.3, solutions posted

- Transformers and circuits w/transformers
  - Paralleling of transformers
    - Proportioning of MVA flow for unequal MVA size, unlike impedances
    - Circuit calculations for above cases
  - Design and operations issues
  - Phase shifting transformers
  - Remaining topics will be covered in context of system operation & analysis, i.e. Chapters 7 and 8.
    - Per phase Pi-equivalent for off-nominal turns ratio, phase shifts, etc.
    - Incorporation in system admittance matrix for short-circuit and load flow
Next Lecture: Synchronous Machines - Chapter 3

- Recommended problems & solns for Ch.3 are posted.
- Phasor diagrams - unity, lag, lead
- Salient rotor machines - calculation with Xd and Xq.
- Calculation Example(s)
- P & Q flows thru transmission lines
- More on admittance matrix [Y] construction

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MONDAY

"Intro" to Synch Machines - L13

- Dr. Bohmann
- Physical structure
- A-B-C-Rotor $\Rightarrow$ d-q per phase analysis.
CASE 1

69 kV paralleling
- "Unlike" impedances.
- Equal turns ratios which match VBASE of system.

KEY: Zsc of T1 & T2 equal on base of respective xfurs

A \( jX_L, \rho, R_m \) \( A' \)

115 kV

T1

T2

115 kV
CASE 1

\[
\frac{2Z_s, n}{\text{p.u.}} \quad \rightleftharpoons \quad \frac{2Z_s, n}{\text{p.u.}}
\]

CASE 2

\[
\frac{2Z_s, n}{\text{p.u.}} \quad \rightleftharpoons \quad \frac{2Z_s, n}{\text{p.u.}}
\]
CASE 2

- Turns ratio (voltage ratio) of xfmr is not equal to ratio of VBASE of system.

\[ V_B = 115KV_{LL} \]
\[ 118KV \] \( \frac{3}{5} \) \( \frac{3}{5} \) \[ 69KV \] \[ V_B = 69KV_{LL} \]
What happens if \( \frac{N_1'}{N_2'} \neq \frac{N_1}{N_2} \)?

Per Unit Gain is thus:

\[ Z_{T1} \]

3 Methods:
1) Ckt+ Theory
2) [Y] method
3) Circulating Current method.
Circuit theory

\[ I_1 = I_{1a} + I_{1b} \]

\[ I_2 = I_{1a} + I_{1b} = \frac{160^\circ - \tilde{V}_2}{j \cdot 2} + \frac{(160^\circ - \frac{\tilde{V}_2}{1.05})}{1.05} \]

KCL:

\[ \Rightarrow \tilde{V}_2 = 0.963 \angle 51^\circ \text{ p.u.} \]
Method:

\[
\begin{bmatrix}
\bar{I}_1 \\
\bar{I}_2
\end{bmatrix}
= \begin{bmatrix}
\bar{Y}_{11} & \bar{Y}_{12} \\
\bar{Y}_{21} & \bar{Y}_{22}
\end{bmatrix}
\begin{bmatrix}
\bar{V}_1 \\
\bar{V}_2
\end{bmatrix}
\]

\[
\begin{bmatrix}
\bar{Y}_{bus}
\end{bmatrix}
\begin{bmatrix}
\bar{V}
\end{bmatrix}
= \begin{bmatrix}
\bar{I}_{inj}
\end{bmatrix}
\]