Topics for Today:

- Announcements
  - Help session hrs: 4:05-5:55pm W,F - EERC 123
  - 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 again in context of system operation & analysis, i.e. Chapters 7 and 8. We can introduce main concepts here:
    - Per phase Pi-equivalent for off-nominal turns ratio, phase shifts, etc.
    - Incorporation in system admittance matrix for short-circuit and load flow
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
Screw moves into page.
**ABB POWER T & D COMPANY, INC.**

**THREE PHASE 138000 OGD. Y VOLS 69000 OGD. Y VOLS 65° C. AVG. RISE 50000/36666 KVA 50000/36666 KVA**

**TRANSFORMER CLASS DA/FA**

**GALLONS OIL TRANS. TANK**

**LOAD TAP CHANGER COMPARTMENT**

**SERIAL**

**RNP-11061 7/95**

**POLE SEG. IMPEDANCE 4.69 % AT 50000 KVA, 138000 TO 69000 VOLTS**

**ZERO SEG. IMPEDANCE 3.27 % AT 10311 KVA, 138000 TO 69000 VOLTS**

**ZERO SEG. IMPEDANCE 2.83 % AT 10311 KVA, 69000 TO 69000 VOLTS**

**FULL WAVE IMPULSE TEST LEVEL**

**H-WDG 650 KV, X-WDG 350 KV**

**HOXO NEUT. 110 KV, TERTIARY 110 KV**

**APPROX. WEIGHT IN LBS. CORE AND COILS**

**102200 CAS 88100 MUL 127200 TOTAL 317500**

**CAUTION: DO NOT ATTEMPT TO HANDLE, INSTALL, USE OR SERVICE THIS TRANSFORMER BEFORE READING INSTRUCTION BOOK XLL7952-12. TO DO SO MAY LEAD TO BODILY INJURY OR PROPERTY DAMAGE OR BOTH.**

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**H-WINDING**

**LIGHTNING ARRESTER (3-TOTAL)**

**2000% MOW (1-TOTAL)**

**TERTIARY VOLTAGE**

**REGULATING WINDING**

**PHASE A**

**PHASE B**

**PHASE C**

**X-WINDING**

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**CONNECTIONS**

**WINDING VOLS MAX. DE-ENERGIZED TAP CHANGER CONNECTS POSITION LOAD TAP CHANGER**

**HIGH VOLTAGE GRID. WYE 138000 16 4 4 4 A**

**LOW VOLTAGE GRID. WYE 5000 16 12 12 12 A**

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**REPAIRED IN ST. LOUIS MO. U.S.A.**

NP# XLL7952-10 SUB A
Admittance Approaches

\[
\begin{pmatrix}
\bar{y}_{11} & \bar{y}_{12} \\
\bar{y}_{21} & \bar{y}_{22}
\end{pmatrix}
\begin{pmatrix}
\bar{v}_1 \\
\bar{v}_2
\end{pmatrix}
= 
\begin{pmatrix}
\bar{I}_1 \\
\bar{I}_2
\end{pmatrix}
\]

injected!
\[ A = \begin{bmatrix} 1 & -1 & 0 \\ 2 & 3 & 0 \\ 0 & 0 & 2 \end{bmatrix} \]

\[ A^2 = \begin{bmatrix} 1 & -1 & 0 \\ 2 & 3 & 0 \\ 0 & 0 & 2 \end{bmatrix} \begin{bmatrix} 1 & -1 & 0 \\ 2 & 3 & 0 \\ 0 & 0 & 2 \end{bmatrix} = \begin{bmatrix} 1 & -1 & 0 \\ 2 & 3 & 0 \\ 0 & 0 & 2 \end{bmatrix} \begin{bmatrix} 1 & 2 & 0 \\ 2 & 3 & 0 \\ 0 & 0 & 2 \end{bmatrix} = \begin{bmatrix} 5 & * & * \\ 5 & * & * \\ * & * & * \end{bmatrix} \]
\[ \bar{y}_{21} = \bar{y}_{12}^{-1} \]

\[ \bar{y}_{11} = \frac{\bar{I}_1}{\bar{V}_1} \cdot \bar{V}_2 = 0 \]

\[ \bar{y}_{12} = \bar{y}_{21} = \frac{\bar{I}_1}{\bar{V}_1} \cdot \bar{V}_2 = 0 \]
2-port theory

- H param (electronics)
- ABCD params
- Admittance Matrix
\[
\begin{bmatrix}
-\bar{y}_{21} & \bar{y}_{12} \\
\bar{y}_{21} & \bar{y}_{22}
\end{bmatrix}
\begin{bmatrix}
\bar{I}_1 \\
\bar{I}_2
\end{bmatrix} =
\begin{bmatrix}
\bar{I}_{10} \\
\bar{I}_{20}
\end{bmatrix}
\]
Tap Changing XFMRs - Variations (p.u. representations)

From Bus

\[ y_{sc} \]

\( (R+jX) \)

\[ y_{sc} \]

C: 1

\[ y_{sc} \]

To Bus

\[ \frac{1}{R+jX} \]

- \( y_{sc} \) is off-nominal turns ratio. In general, \( C \) is complex.
- \( C \) is real for LTC.
- \( C \) is complex for PS.
- If \( |C| \neq 1 \) then magnitude change.
- If \( C \) is complex, phase shift.

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