Topics for Today:

- Announcements
  - Software: online students - apply for ATP/ATPDRAW license, verify licensing when you receive it by e-mail, and we will mail you the install CD.
  - Office hrs: 2-3pm M,W,F
  - Office: EERC 614. Phone: 906.487.2857
  - Book exercises from Ch.6,7 solutions posted

Chapter 6 - Shunt Capacitance Transmission Lines

- Using the T-Line models
  - Short Transmission Lines - up to 50 miles (80 km)
  - Voltage Regulation, phasor diagrams
  - Per-phase impedance diagrams (positive seq only)
  - Medium-Length Lines (50 - 150 miles)
  - ABCD parameters for Medium-lines, power flow
  - Long Lines - more than 150 miles (240 km)
  - Derivation of long-line equations, meaning of equations
  - Characteristic Impedance $Z_c$
  - Propagation Constant $\gamma = \alpha + j\beta$
  - Surge-Impedance Loading (SIL)
  - Wavelength, velocity, Traveling waves, reflections
EE 5200 - Term Projects

Time: Finals Week  Wednesday  12:45-2:45pm  
Room: EERC B45

Allotted Time: ~20 minutes per presentation; 4 mins between.

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<th>Start Time</th>
<th>Team Members</th>
<th>Topic</th>
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<td>Grimm</td>
<td>Mutual inductance of lines, fault calcs</td>
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<td>Pelon, Shauger, Bischoff</td>
<td>UG Cable faults - fault locating</td>
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<td>Stenvig</td>
<td>Wide Area Control - Dynamic Vars via SVC</td>
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<td>Krzeminski, Schoenherr</td>
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<td>Heidfeld, Van Singel</td>
<td>Lightning Surge Protection of T-Lines</td>
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<td>Prajapati, Ekneligoda, Guan</td>
<td>System Operation for Microgrids</td>
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<td>Ramamurthy, Vasireddy</td>
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<td>Load Flow?</td>
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<td>Brown</td>
<td>??</td>
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Generic circuit diagram and text:

- 2-Port + \( T \)-Lines
- \( Z \)-Parameters (electronics)
- \( H \)-Parameters (electronics)
- Many others.

Diagram:
- \( S \)
- \( \frac{1}{2} \)
- \( T \)
- \( R \)
- \( Z_s \)
- \( V_s \)
- Load
- \( V_L \)
- \( V_P \)
- \( P \)
### TABLE A.6

**ABCD constants for various networks**

<table>
<thead>
<tr>
<th>Circuit</th>
<th>Equations</th>
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</table>
| **Series impedance** | \[ A = 1 \]
|  | \[ B = Z \]
|  | \[ C = 0 \]
|  | \[ D = 1 \]  
|  | \[ \begin{bmatrix} A & B \\ C & D \end{bmatrix} \begin{bmatrix} V_R \\ I_R \end{bmatrix} = \begin{bmatrix} V_S \\ I_S \end{bmatrix} \]  
| **Shunt admittance** | \[ A = 1 \]
|  | \[ B = 0 \]
|  | \[ C = Y \]
|  | \[ D = 1 \]  
|  | \[ A = 1 + YZ \]
|  | \[ B = Z \]
|  | \[ C = Y \]
|  | \[ D = 1 + YZ \]  
| **Unsymmetrical T** | \[ A = 1 + Z \]
|  | \[ B = 1 \]
|  | \[ C = Y \]
|  | \[ D = 0 \]  
|  | \[ A = 1 + YZ \]
|  | \[ B = Z \]
|  | \[ C = Y \]
|  | \[ D = 1 + YZ \]  
| **Unsymmetrical π** | \[ A = 1 \]
|  | \[ B = 1 \]
|  | \[ C = Y \]
|  | \[ D = 1 \]  
|  | \[ A = 1 + YZ \]
|  | \[ B = Z \]
|  | \[ C = Y \]
|  | \[ D = 1 + YZ \]  
| **Networks in cascade** | \[ A = A_1A_2 + B_1C_1 \]
|  | \[ B = A_2B_1 + B_1D_1 \]
|  | \[ C = A_1C_1 + C_1D_1 \]
|  | \[ D = B_1C_1 + D_1D_1 \]  
|  | \[ A = (A_1B_1 + A_2B_1)/(B_1 + B_1) \]
|  | \[ B = B_1B_1/(B_1 + B_1) \]
|  | \[ C = C_1 + C_1 + (A_1 - A_2)(D_1 - D_1)/(B_1 + B_1) \]
|  | \[ D = (B_1D_1 + B_1D_1)/(B_1 + B_1) \]  
| **Networks in parallel** | \[ A = A_1I_1 + A_2I_1 \]
|  | \[ B = B_1I_1 + B_1I_1 \]
|  | \[ C = C_1 + C_1 + (A_1 - A_2)(D_1 - D_1)/(B_1 + B_1) \]
|  | \[ D = (B_1D_1 + B_1D_1)/(B_1 + B_1) \]
\[
\begin{bmatrix}
A & B \\
C & D
\end{bmatrix}
\begin{bmatrix}
V_s \\
I_s
\end{bmatrix}
= \begin{bmatrix}
V_r \\
I_r
\end{bmatrix}
\]

A = \frac{V_r}{I_s} (W/o. Load)  \\
B = \frac{I_r}{I_s} (v.o. (O.C. Receiving end))  \\
C = \frac{V_r}{I_s} (s.c.)  \\
D = \frac{I_r}{I_s} (s.c.)
**Voltage Regulation**

\[ VR = \frac{V_{NL} - V_{FL}}{V_{FL}} \]

Most loads are Lagging \( PF \Rightarrow V_{NL} > V_{FL} \)
\( VR > 0 \).

If load is leading \( PF \Rightarrow V_{NL} < V_{FL} \Rightarrow VR < 0 \).
\[ \bar{V}_s = \bar{I}_L (R+jX) + \bar{V}_R = \frac{V_{NL}}{V_{FL}} \]

Assume \( \bar{V}_R = 1 \text{ p.u.} \), then \( \bar{V}_s = \frac{V_{NL}}{V_{FL}} \)

\( \bar{V}_R \) is neg if \( V_s < V_R \).

( \( V_{NL} < V_{FL} \))
VOLTAGE PROFILE

\[ V_s \rightarrow \frac{1}{2}Y \rightarrow \frac{1}{2}Z \rightarrow \text{LOAD} \]

\[ x = l \quad x = 0 \]

Ferranti Rise
Open Receiving

"FLAT" LINE: \[ Z_L = Z_C \]
Full Load, LAG
S.C. LOAD
FERRANTI RISE

\[ \frac{X}{R} \approx 20 \text{ at } 345 \text{ kV} \]

\[ \bar{V}_s + I_{cha} jX - jXc - I_{cha} \bar{V}_s \]

\[ \bar{V}_s = I_{cha} \]

\[ V_{CAP} = \bar{V}_s - I_{cha} jX \]

\[ 0^\circ - (180^\circ) \]

hence the "negative voltage drop"

\[ \bar{V}_s - I_{cha} jXs \]