Topics for Today:

- **Startup**
  - Web page: [http://www.ee.mtu.edu/faculty/bamork/ee5220/](http://www.ee.mtu.edu/faculty/bamork/ee5220/)
  - Book, references, syllabus, more are on web page.
  - Software - Matlab. ATP/EMTP [License - [www.emtp.org](http://www.emtp.org)]
    ATP tutorials posted on our course web page
  - **EE5220-L@mtu.edu** (participation = half letter grade, 5%)

- HW#4 posted. **Partnered** exercise. Due Wed Feb 10th.
- ATP Simulation pointers **time domain**
- Cap Bank Switching (continued)
  - Discussion - how to carry out HW#4
  - Parameters
    - Setup of this simple system simulation.
    - Cap Bank configurations
    - Transformer parameters
    - Rules of thumb for impedances
ATP Simulation Pointer for the day:

Always ground one point on your circuit. This avoids the problem of a "floating subnetwork." Essentially this is a situation where the admittance matrix that describes the circuit is singular. If the program would attempt to proceed with LU factorization there would be a divide by zero error and the program would crash.
\[ R = \frac{V_{IN}}{I_{SC}} \]

\[ Z_{TH} = \frac{V_{IN}}{I_{SC}} \]

\[ MVA_{cc} = \frac{1}{\sqrt{3} I_{SC}} \]

\[ \frac{P}{x} = \gamma \]

\[ X_{\text{cc}} = \text{Rectangular circuit diagram} \]
- Some parameters - vital
- """" - not important
- Some effects can be ignored.

Ex:

\[ L = (0.25)(100') = 25\text{mH} \]

\[ X_L = 2\pi f L \Omega \]

\[ = 377 \times 52 = 9.4\text{m}\Omega \text{ (60Hz)} \]

\[ = 78.5\text{m}\Omega \text{ 500Hz} \]

\[ = 785\Omega \text{ 5kHz} \]
\[ Z_B = \frac{115^2}{100} = 132.2 \Omega \]

\[ f_0 = \frac{1}{2\pi \sqrt{LC}} \]

\[ Z_0 = \sqrt{\frac{L}{C}} \]

\[ S.C. MVA = \sqrt{3} \times V_{ll} \times I_{sc} \]
Basic Series Impedances (Ohm/mi):

<table>
<thead>
<tr>
<th></th>
<th>Xo/Ro</th>
<th>Ro</th>
<th>Xo</th>
<th>R1</th>
<th>X1</th>
<th>X1/R1 (uH/ft)</th>
</tr>
</thead>
<tbody>
<tr>
<td>4/0 Cu</td>
<td>4.721323</td>
<td>0.5867</td>
<td>2.77</td>
<td>0.303</td>
<td>0.6008</td>
<td>2.64</td>
</tr>
<tr>
<td>556.5 Al</td>
<td>5.76318</td>
<td>0.4704</td>
<td>2.711</td>
<td>0.1871</td>
<td>0.7421</td>
<td>3.97</td>
</tr>
<tr>
<td>1590 Al</td>
<td>7.415819</td>
<td>0.3568</td>
<td>2.846</td>
<td>0.07313</td>
<td>0.677</td>
<td>9.26</td>
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<tr>
<td>5&quot; Al</td>
<td>8.11904</td>
<td>0.3041</td>
<td>2.469</td>
<td>0.0209</td>
<td>0.5005</td>
<td>23.95</td>
</tr>
</tbody>
</table>

Note: Z0 values seem to be typically 3x bigger than Z1. This compares to T-Line sections that have no shieldground wire.

\[ p = 1.2 \text{m} \]

**Damping:**

\[ E = \frac{1}{2} CV^2 \]

**Strain Bus - Overhead Conductor for bus conductor.**

**Tube/Pipe Bus - Al tube or channel**

Focus on \( X/R \) ratio and \( L/\text{ft} \).

Assume \( Z_0 = Z_1 = Z_2 \)

(Ground Grid!)

\[ 1.52 \text{m} \]
$V_s = \frac{\sqrt{2} \times V_{ll,\text{RMS}}}{\sqrt{3}} = V_p$

$Z_s = \text{From S.C. Study (CAPE, PSS/E)}$

or assume 57%, $\frac{x}{R} = \text{? Use Judgement}$

Bus Sections - Go to Sr. Power Book

$L = K \log \frac{D}{r}$

$R = \text{From Tables: } R_{ac@50^\circ C}$
Cap Bank Values

Equiv L-N Cap of a \( -MVAR\) Bank?

Typical Ratings: 100, 200, 400 KVAR
Low KV \(\rightarrow\) 24 KV
Losses: 0.05 - 0.3 W/KVAR

Each Can: \(K_s\) \(\frac{R}{R_{\text{Diss}}}\)
DAMPING

CBs - Switches

Spreadsheet Calcs:

Outrush:

STEP #2

\[ I_p + f_0 = 2 \times 10^7 \]

\[ I_p = \frac{\Delta V}{Z_0} = \frac{V_p}{\sqrt{L_B + L_{CC} \over C_{EQ}}} \]

\[ \frac{1}{(L_B + L_{CL}) \times C_{EQ}} \]