Topics for Today:

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

• Hmwk 10 (Probs. 5.7 & 14.5) due Mon Apr 19th 5pm.
• Term Project - Final Report - completed by Fri April 23rd
• Term Project - On-campus teams present on Wed Apr 28th (alt. Apr. 27th ?)
• Insulation design and coordination - Chapter 16
  • Shielding design for overhead lines
  • CB ratings in general
  • NESC tables for conductor separation, corona discharge
  • BIL and BSL levels vs. nominal voltage ratings
  • Comments on L-G vs. L-L overvoltages
  • Corona characteristic - nonlinear capacitance.
Chapter 16

Fig. 16.1

Strike Distance \( S = 10I^{0.6} \)
\( I = kA \)
\( S = \text{meters} \)

Quite likely to hit if it gets within \( S \) meters of conductor.

\( \beta = 0.8 \text{ - EHV} \)
0.67 - UHV

Shielding Failure Occurs over arc P-Q.

At some current value \( I_{\text{max}} \), P & Q will coincide.
No shielding failure above \( I_{\text{max}} \).
Often need to know \( P \) of \( V_r \) falling within a range of values. 

\[
P(820 < V_r < 880 \text{ KV}) = \quad ? \quad \Rightarrow \quad 1922 \cdot 0.0148
\]

\[
z_1 = \frac{820 - 980}{46} = -2.174
\]

\[
z_2 = \frac{880 - 920}{46} = 0.8696
\]

\[
17.7\%
\]
## Typical Spacings and Clearances in a Substation

*See up-to-date NESC to verify!*

<table>
<thead>
<tr>
<th>Voltage Level (KV (L-L))</th>
<th>Min Conductor Spacing</th>
<th>Min Switch Spacing Ph-Ph</th>
<th>Min L-L Phase Clearance</th>
<th>Min No. Bells at Deadend</th>
<th>Min Cable Size</th>
<th>Min Bus Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>7.5</td>
<td>1'6&quot;</td>
<td>7½&quot;</td>
<td>3'</td>
<td>18&quot;</td>
<td>2'6&quot;</td>
<td>7&quot;</td>
</tr>
<tr>
<td>15</td>
<td>2'</td>
<td>10&quot;</td>
<td>3'</td>
<td>2'</td>
<td>2'6&quot;</td>
<td>12&quot;</td>
</tr>
<tr>
<td>23</td>
<td>2'-6&quot;</td>
<td>12&quot;</td>
<td>4'</td>
<td>2'-6&quot;</td>
<td>3&quot;</td>
<td>15&quot;</td>
</tr>
<tr>
<td>34.5</td>
<td>3'</td>
<td>15&quot;</td>
<td>5'</td>
<td>3'</td>
<td>4&quot;</td>
<td>18&quot;</td>
</tr>
<tr>
<td>46</td>
<td>4'</td>
<td>1'-6&quot;</td>
<td>6'</td>
<td>4'</td>
<td>5&quot;</td>
<td>21&quot;</td>
</tr>
<tr>
<td>69</td>
<td>5'</td>
<td>2'-5&quot;</td>
<td>7'</td>
<td>5'</td>
<td>6&quot;</td>
<td>31&quot;</td>
</tr>
<tr>
<td>115</td>
<td>7'</td>
<td>3'-7½&quot;</td>
<td>10'</td>
<td>7'</td>
<td>9&quot;</td>
<td>53&quot;</td>
</tr>
<tr>
<td>138</td>
<td>8'</td>
<td>4'-1&quot;</td>
<td>12'</td>
<td>8'</td>
<td>11&quot;</td>
<td>63&quot;</td>
</tr>
<tr>
<td>161</td>
<td>9'</td>
<td>4'-10&quot;</td>
<td>14'</td>
<td>14'</td>
<td>9&quot;</td>
<td>72&quot;</td>
</tr>
<tr>
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<td>11'</td>
<td>6'-½&quot;</td>
<td>15'</td>
<td>16'</td>
<td>11'</td>
<td>89&quot;</td>
</tr>
<tr>
<td>230</td>
<td>13'</td>
<td>7'-3&quot;</td>
<td>16'</td>
<td>18'</td>
<td>13'</td>
<td>105&quot;</td>
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<tr>
<td>345</td>
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<td>8'-5½&quot;</td>
<td>18'</td>
<td>20'</td>
<td>15'</td>
<td>119&quot;</td>
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<tr>
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<td>---</td>
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</tbody>
</table>

*Corona*
Another Issue...
Secondary effects.
Voltage Levels vs. Insulation ratings

\[
\text{Y}_{\text{II}} \left( I - G \right)
\]

\[
\left( I + H \right)
\]
if corona occurs, C becomes nonlinear.