Topics for Today:

- Course Info:
  - Web page: http://www.ee.mtu.edu/faculty/bamork/ee5220/
  - 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%)
  - See ATPDMan56p.pdf for user’s manual and many examples.

- HW#7 - due after break
- Term Project - Mar 17th - complete reference list and fully-detailed table of contents, via e-mail to Dr. Mork.
- Use of Line Constants .lis output
  - Double-circuit lines: Phase matrices; Sequence matrices; B; Z
  - Zero sequence coupling
- Basics for lines vs. cables; traveling wave model (See Feb 20th video/ATP)
  - HW#7
- Multi-conductor line models for transient and traveling wave behaviors
  - Traveling wave equations for multi-conductor system
  - Modal transformations
    - Symmetrical components, Park’s, Clarke, Karrenbauer
Double-Circuit Lines

Transposition

Look in "EMTP Theory Book"
\[ [Z] = \sqrt{\frac{2m}{C + 2}} \]

\[ \text{ERA} \]

\[ \text{ECC} \]

\[ \text{LOB} \]
Sequence: B, Z

$Z_5 = \begin{bmatrix} \text{ckt 1} \\
\text{ckt 2} \\
\text{ckt + 2} \\
\end{bmatrix}

\begin{bmatrix}
\text{ckt + 1} \\
\text{ckt 1} \\
\text{ckt 2} \\
\end{bmatrix}

\begin{bmatrix}
\text{ckt + 2} \\
\text{ckt 1} \\
\text{ckt 2} \\
\end{bmatrix}

All zeros if ckt + 1 is decoupled from ckt 2.

$Z_m = Z_00 = \text{zero}$

© Transposition

"Continuous Transposition"
Assumes full transposition (or nearly so).

\[ Z_s = \]

\[ \begin{array}{cccc}
  200 & 0 & 0 & 222 \\
  0 & 0 & 0 & 0 \\
  0 & 211 & 0 & 0 \\
  200 & 0 & 0 & 0 \\
\end{array} \]
Skin Effect

Skin Depth "δ"

Rin vs. Rout

Fe

Al

Rin

Rout

Rdc

Rdc vs. f
\[ NB = 3 \]
\[ \alpha = 90^\circ = \frac{360^\circ}{NB} \]
\[ Z(f) = \frac{\tilde{V}(f)}{\tilde{I}(f)} \]

Verify

Actual Model vs. True