Topics for Today:

- Distributed-Parameter Transmission Lines:
  - Multi-phase transmission lines models.
  - ATPDraw LINE CONSTANTS example
  - Verifying validity over required range of frequencies that the model must work.
- Modal domain (Bergeron, Marti, Semlyen) vs. phase domain (Noda) vs. time domain (Mork/Gopakumar).
- Duality Transforms for Transformer models (Cooper Class Projects)

ATP Simulation Pointer for the day:

When running the "Verify" routine for your transmission line, keep in mind that there are several steps involved:

- Save the binary *.ALC line-data file
- Create ATP LINE CONSTANTS text input file
- Run ATP LINE CONSTANTS supporting routine which creates the actual line model, associates it the icon, and saves it in the library
- Creates and runs an ATP frequency scan simulation to determine the open-circuit frequency response.

What is a “Frequency Scan?”

Fig. 1. Traditional method to calculate driving point impedance using EMTP
Procedure -
- Inject 1 amp peak
- Repeat at discrete values of $f$.

$$Z_k(f) = \frac{V(f)_k}{I(f)_k} = V(f)_k$$

Diagram:
- Graph with $Z(f)$ on the y-axis and $f$ on the x-axis.
- Points marked at $f_1$ and $f_2$.
- Labels for "o.c." and "s.c."
at \( f_1 \) - O.C.

"parallel resonant"

\[
f_1 = \frac{1}{2\pi\sqrt{LC}}
\]

at \( f_2 \) - S.C.

"series resonant"

\[
f_2 = \frac{1}{2\pi\sqrt{LC}}
\]
For T-Line Verification, we can also use freq. scan.

Check complete range of frequency.

- POS SEQ, Ph. 1, 2, 3... N
- ZERO
- NEG SEQ, Ph. 1, 2, 3... N

In-class demo
- Bergeron
- Marti
- Lumped Coupled Pi
Bergeron - "Constant Param" (Snelson, Meyer)

Pi - Lumped Coupled Pi

Earth Resistivity = 

Conductivity = 6.000 Ohm-Meters

\[ R = \frac{\log P}{A} = \frac{m \cdot \text{m}}{m^2} = \sigma \]

Impacts: Zero-Sequence Parameters \((R_0, L_0)\)
Figure 3.1 Detailed Representation of a transmission line element
consisting of three sections as shown in Figure 3.2. In this case the line is energized at one end and open at the far end. For this example we consider the very first time step when \( t = t_1 \) and \( t - \Delta t = t_0 = 0 \).

![Diagram of a transmission line divided into three sections](image)

**Figure 3.2** Transmission line divided into three sections.

Equations (3.18)-(3.23) are a set of six equations (two for each section) which describe the current and voltage relations along the line. They are listed here as follows:
size in the stable range is much larger than required for most transient studies.

![Graph showing variation of matrix condition number with time step size.](image)

**Figure 4.4** Variation of the coefficient matrix condition number with time step size.