Topics for Today:

EE 5220 - Lecture 24
- Creates and runs an ATP frequency scan simulation to determine the open-circuit frequency response.

What is a “Frequency Scan?”

\[ \tilde{Z}(\omega) = \frac{\tilde{V}(\omega)}{\tilde{I}(\omega)} \]

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

\[
\bar{Z}_k(f) = \frac{\bar{V}(f)_k}{\bar{I}(f)_k} = V(f)_k
\]
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
- NEG SEQ, Ph. 1, 2, 3...N
- ZERO

In-Class Demo
- Bergeron - Const. $Z_c$
- Marti - $Z_c(F)$
- Lumped Coupled Pi -
Bergeron - "Constant Param" (Snelson, Meyer)

Pi - Lumped Coupled Pi

Earth Resistivity: \( \rho \text{ Ohm-Meters} \)

Conductivity: \( \sigma \)

\( \frac{\pi \cdot m^2}{m} = p \)

Impacts:

Zero-Sequence Parameters \( (R_0, L_0) \)
Figure 3.1 Detailed Representation of a transmission line element

1999 MS Thesis - MORK/ GOPAKUMAR
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 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:
\[ E = \frac{V}{4} \]

near-singular

How does \( \Delta t \) affect \( G^2 \).

\[ \frac{\Delta t}{\Delta E} \]

function of \( \Delta t \)
size in the stable range is much larger than required for most transient studies.

Figure 4.4 Variation of the coefficient matrix condition number with time step size.
Prob 9.2 - "double-exponential"

\[ v(t) = 750 (e^{-2.3 \times 10^8 t} - e^{-10^8 t}) \text{ kV} \]
Waveshapes:
- "Double Exponential"

\[ V(t) = V_{\text{MAX}} (e^{-\alpha t} - e^{-\beta t}) \]

**CRUDE APPROX:**
Actual Lightning or Switching Surges:

Standard Reference:

$t_f \times t_t$

$t_f = 1.6(X_2 - X_3)$

$t_t = (X_4 - X_0)$

Stds: 1.2 $\times$ 50 ms (Lightning Surges)

5 $\times$ 200 ms (Impulse)
Name: SURGE - Surge function. Two exponentials. TYPE 15.
Card: SOURCE
Data:  U/I= 0: Voltage source.
       -1: Current source.
       Amp= Constant in [A] or [V].
       Does not exactly correspond to the peak value of surge.
       A= Negative number specifying falling slope.
       B= Negative number specifying rising slope.
       Tsta= Starting time in [sec.]. Source value zero for T<Tsta.
       Tsto= Ending time in [sec]. Source value zero for T>Tsto.
Node:  SU= Positive node of exponential surge function.
       Negative node is grounded.
       SU=Amp*(exp(A*t)-exp(B*t))
RuleBook: VII.C.5