Topics for Today:

• Announcements
  • Software: online students - apply for ATP/ATPDraw license, verify licensing when you receive it by e-mail, and we will mail you the install CD.
  • Office hrs: 2-3pm M,W,F
  • Office: EERC 614. Phone: 906.487.2857
  • Book exercises from Ch.6,7 solutions posted

Chapter 6 - Shunt Capacitance Transmission Lines

• Using the T-Line models
  • Short Transmission Lines - up to 50 miles (80 km)
  • Voltage Regulation, phasor diagrams
  • Per-phase impedance diagrams (positive seq only)
  • Medium-Length Lines (50 - 150 miles)
  • ABCD parameters for Medium-lines, power flow
  • Long Lines - more than 150 miles (240 km)
  • Derivation of long-line equations, meaning of equations
  • Characteristic Impedance $Z_C$
  • Propagation Constant $\gamma = \alpha + j\beta$
  • Surge-Impedance Loading (SIL)
  • Wavelength, velocity, Traveling waves, reflections
\[ S = V_i^* I_i^* \]

\[ Q = V_i^2 \frac{B_{dc}}{2} \]

\[ \tilde{I} = \frac{\tilde{V}_3 - \tilde{V}_1}{R + jX_L} = I/I_m \]

\[ \Delta P = 4.66 \quad \Delta Q = 8.79 \]

\[ 1 \rightarrow 3 \quad -174.88 \quad -40.45 \]

\[ 3 \rightarrow 1 \quad 179.54 \quad 49.24 \]
\[ Q = V_1^2 B_c \]
\[ I_{12} = \frac{V_1 - V_2}{R + jX} \]
\[ S_1' = S_1 + V_1^2 B_c \]
\[ S_2' = S_1' - P_R - Q_x \]
\[ = S_1' - (I_{12})_R^2 - (I_{12})_X^2 \]
Generic 2-Port Network

ABCD Parameters (T-Lines)
H Parameters (Electronics)
Many others
TABLE A.5
ABCD constants for various networks

Series impedance

\[ I_s \quad I_r \]
\[ V_s \quad V_r \]
\[ A = 1 \]
\[ B = 0 \]
\[ C = Y \]
\[ D = 1 \]

Shunt admittance

\[ I_s \quad I_r \]
\[ V_s \quad Y \]
\[ A = 1 + YZ_1 \]
\[ B = Z_1 + Z_2 + YZ_2 Z_3 \]
\[ C = Y \]
\[ D = 1 + YZ_1 \]

Unsymmetrical T

\[ I_s \quad I_r \]
\[ V_s \quad Y_1 \]
\[ A = 1 + YZ \]
\[ B = Z \]
\[ C = Y_1 + Y_2 + ZY_1 Y_2 \]
\[ D = 1 + YZ \]

Unsymmetrical π

\[ I_s \quad I_r \]
\[ V_s \quad A_1 B_1 C_1 D_1 \]
\[ A_2 B_2 C_2 D_2 \]
\[ V_r \]
\[ A = A_1 A_4 + B_2 C_2 \]
\[ B = A_1 B_4 + B_4 D_4 \]
\[ C = A_2 C_1 + C_2 D_1 \]
\[ D = B_2 C_1 + D_2 D_4 \]

Networks in cascade

\[ I_s \quad I_r \]
\[ V_s \quad A_1 B_1 C_1 D_1 \]
\[ A_2 B_2 C_2 D_2 \]
\[ V_r \]
\[ A = (A_1 B_4 + A_4 B_1)/(B_1 + B_4) \]
\[ B = B_2 B_4/(B_1 + B_4) \]
\[ C = C_1 + C_4 + (A_1 - A_4)(D_2 - D_1)/(B_1 + B_4) \]
\[ D = (B_2 D_1 + B_4 D_4)/(B_1 + B_4) \]

Networks in parallel

\[ I_s \quad I_r \]
\[ V_s \quad A_1 B_1 C_1 D_1 \]
\[ A_2 B_2 C_2 D_2 \]
\[ V_r \]
\[ A = (A_1 B_4 + A_4 B_1)/(B_1 + B_4) \]
\[ B = B_2 B_4/(B_1 + B_4) \]
\[ C = C_1 + C_4 + (A_1 - A_4)(D_2 - D_1)/(B_1 + B_4) \]
\[ D = (B_2 D_1 + B_4 D_4)/(B_1 + B_4) \]
Voltage Regulation

\[ V_{drop} = \pi j \omega L \rightarrow V_R \]

\[ V_{load} = \frac{V_{NL} - V_{FL}}{V_{FL}} \]

Most loads are lagging PF \( \Rightarrow V_{NL} > V_{FL} \)

IF load is leading PF \( \Rightarrow V_{NL} < V_{FL} \Rightarrow VR < 0 \.)
\[ \vec{V}_s = \vec{I}_R (R + jX) + \vec{V}_R = \frac{V_{NL}}{2} \]

Assume \[ \vec{V}_R = 1.1 \text{ p.u.} \]

\[ = V_{FL} \]

VR is neg if \( V_s < V_R \).

\( (V_{NL} < V_{FL}) \)
\[ \vec{V}_s = \vec{V}_R + \vec{I}_R jX_L \]

\[ \vec{V}_R = \vec{V}_s + \vec{I}_R jX_L \]