Transmission Line

- Transfer equation:

$$V_1 = V_2 \cosh(\gamma \ell) + Z_c I_2 \sinh(\gamma \ell)$$

$$I_1 = I_2 \cosh(\gamma \ell) + \frac{V_2}{Z_c} \sinh(\gamma \ell)$$

- Propagation constant:

$$\gamma = \sqrt{yz}$$

- Characteristic impedance:

$$Z_c = \sqrt{\frac{z}{y}} = \frac{z}{\gamma} = \frac{\gamma}{y}$$

- Transmission matrix for Π equivalent circuit:

$$T = \begin{bmatrix} 1 + \frac{ZY}{2} & Z \\ Y(1 + \frac{ZY}{4}) & 1 + \frac{ZY}{2} \end{bmatrix}$$

Per Unit System

- Impedance base conversion

$$Z_{new,p.u.} = Z_{old,p.u.} \left(\frac{V_{B,old}^{l}}{V_{B,new}^{l}} \right)^2 \left(\frac{S_{B,new}^{3\phi}}{S_{B,old}^{3\phi}} \right)$$

Problem 1 [40]

1. A 60Hz 50MVA 138kV three-phase transmission line is 300 km-long. The distributed line parameters are

$$r = 0.2\Omega/km, l = 2\ mH/km, c = 0.01\mu F/km, g = 0$$

The transmission line delivers its rated power at its rated voltage and at power factor 0.9 lagging.

- Treat the line as "long" transmission line.
  a. [15] What is the sending-end current?

- Treat the line in question 1 as "medium-length" line.
  b. [10] What is the sending-end voltage and current?
  c. [5] What is the transmission line efficiency?

- Consider it is Surge Impedance Loaded (SIL) (i.e. the line is loaded with its characteristic impedance)
  d. [6] What are the voltage gain $|V_2|/|V_1|$ and current gain $|I_2|/|I_1|$?
  e. [4] What is the driving point impedance $|V_1|/|I_1|$ of the transmission line?

Problem 2 [35]

Consider a power system shown in the figure has the following parameters

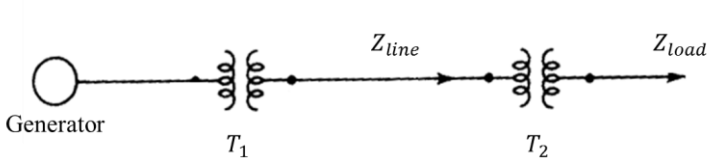
Generator: $30MVA, 13.8kV, X_s = 0.1p.u.$

Load: $Z_{load} = 40 + j30\Omega$ at each leg of wye connected load

T_1: $30MVA, 13.2/132kV, X_l = 0.1\ p.u.$

T_2: $20MVA, 138/13.8kV\ , X_l = 0.08p.u.$

Line: $j100\Omega$



a. [15] The power base for the system is chosen as $30MVA$, and voltage base of the transmission line is $132kV$. Using the chosen power and voltage base, define other basis as needed and find the impedance diagram of the power system.

- If the generator's ***terminal voltage*** is $13.2kV$, find the **actual** values of

b. [5] current on transmission line
c. [5] voltage at load
d. [6] real power delivered to the load and its power factor
e. [4] power delivery efficiency of this power system