Department of Electrical and Computer Engineering

Transmission Line Models

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Outline

- Lecture 1:
  - Review of lectures on transmission line parameters
  - Representation of transmission lines
  - The short transmission line model
  - Voltage regulation
  - In-class example
  - The medium transmission line model (if we have time)
- Lecture 2:
  - Review of lectures on short line and medium line models
  - The long transmission line model
  - Equivalent pi-model

- Lecture 3:
  - Review of lectures 1 and 2.
  - Peer grading
  - Tutorial

Review of last lectures

Previous Homework

1. An 18 km three-phase overhead line in Calgary Downtown is composed of drake conductors equilaterally spaced. Manufacturer tables list the drake conductor as having a resistance of 0.2357 ohm/km, and an inductive reactance of 0.4139 ohm/km. If the line delivers 2500 kW at 11 kV to a balanced star-connected load at Suncor Towers, determine

(a) The per-phase series impedance of the line.

(b) The sending-end voltage when the load power factor is 0.9 lagging.

(c) The percent voltage regulation of the line

Redo the (b) and (c) when the power factor is 0.9 leading and unity.

Quick Questions

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Quick question 11:

(a) Name the line parameters usually considered for the short line model? Why are other parameters neglected for the short line model?

(b) Name the line parameters used in modeling medium transmission lines? Are these parameters considered lumped or distributed?

Answer:

(a) Resistance and Inductance. Capacitance is neglected because as the short lines are usually less than 80 km, the line charging current is small and thus can be neglected.

(b) The parameters considered for medium lines are resistance, inductance and capacitance. The parameters are considered lumped.

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Quick question 12:

(a) What happens to the percent V.R. when the load power factor is lagging?
(b) What happens to the percent V.R. when the load power factor is leading?
(c) Do electricity utility operators (e.g. AESO, ENMAX) prefer a smaller or larger value for the percent voltage regulation?

Answer:

(a) The percent V.R. will become larger
(b) The percent V.R. will become smaller
(c) Electricity utility operators prefer smaller percent V.R. as it entails lesser voltage drop (and by extension power loss) occurs along the line. It is for this reason that utility operators incentivize people with lower power factor equipment to install capacitors to improve their power factor.

Quick question 13: *Do the ABCD constants for a medium line satisfy the equation: AD-BC=1?*

Answer:

For a medium line, the ABCD constants are as follows:

$$A = D = 1 + (YZ)/2; \quad B = Z; \; C = Y(1 + \frac{YZ}{4})$$

Then, $AD - BC$ is given by:

$$AD - BC = \left(1 + \frac{YZ}{2}\right)\left(1 + \frac{YZ}{2}\right) - ZY(1 + \frac{YZ}{4})$$

$$= 1 + YZ + (\frac{YZ}{2})^2 - YZ - (\frac{YZ}{2})^2$$

Thus, $AD - BC = 1$ Proved.

Homework

1. Read up the notes and ask one question about what you don't understand in the next class.
2. The sending-end voltage, current, and power factor of a three-phase transmission line spanning from Red Deer to Calgary are found to be 260 kV, 300 A, and 0.9 lagging, respectively. The *ABCD* constants are:

$$A = D = 0.8904\angle 1.34^o$$

$$B = 186.82\angle 79.45^o\ \Omega$$

$$C = 1.131 \times 10^{-3}\angle 90.41^o\ \mathrm{S}$$

(i) Find the shunt admittance and series impedance of the line

(ii) Using the answers from in-class exercise, compute the percentage voltage regulation