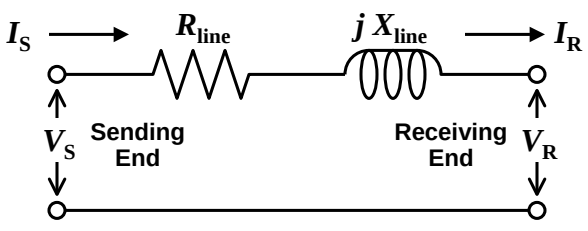
T-Line Equivalent Circuits

- **Three general models for equivalent transmission line circuits**
  - Choice influenced by the line length, type (cable or overhead line), and operating voltage level
  - Choice based on the analysis (e.g., short circuit or voltage drop)
- **Models**
  - Short Length Line
  - Medium Length Line
  - Long Length Line

Short Length Line Model

- **Used for**
  - low- and medium-voltage overhead lines
  - high-voltage lines with lengths less than ~50 miles
  - low-voltage cable circuits
- **Neglects the effect of the line shunt capacitance**
- **Lumps the line series impedance into a resistance and inductance equivalent**



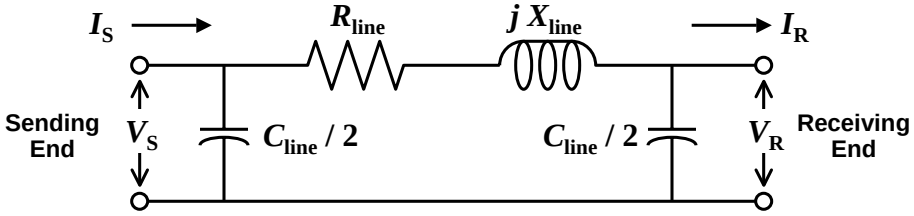
$X_{line} = X' \cdot d$

$R_{line} = R' \cdot d$

Length of line

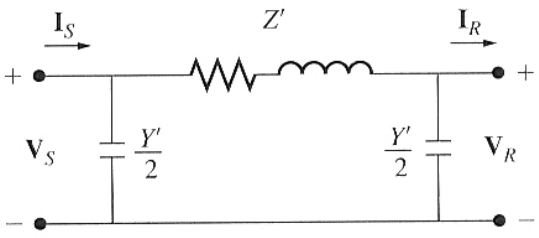
Medium Length Line Model

- **Used for**
  - high-voltage overhead lines longer than ~50 mi & less than ~150 mi
  - medium- and high-voltage cable circuits
- **Lump parameter model using a pi-equivalent**
  - Lumps the line series impedance into a resistance and inductance equivalent
  - Lumps the line shunt capacitance into two capacitors at each end of the line



Long Length Line Model

- **Used for**
  - high-voltage overhead lines longer than ~150 mi
  - traveling wave calculations (e.g. lightning strike)
- **Lump parameter model using a modified pi-equivalent**
  - Derived from traveling wave equations for transmission lines
  - Uses propagation constant calculated from z and y (parameters per length)

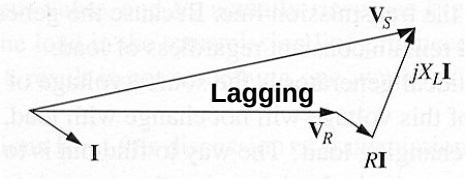


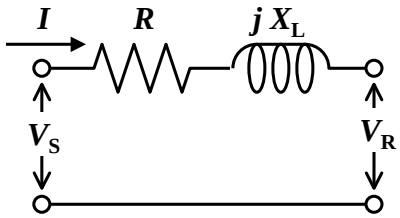
$$\gamma = \sqrt{zy}$$

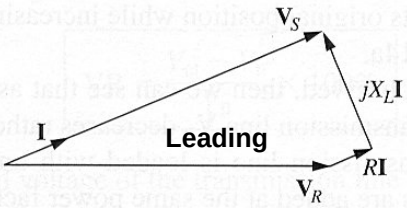
$$Z' = Z\,\frac{\sinh \gamma d}{\gamma d}$$

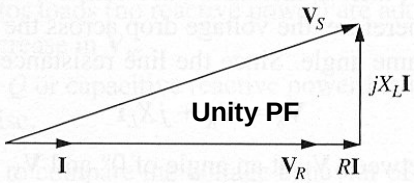
$$Y' = Y\,\frac{\tanh(\gamma d/2)}{\gamma d/2}$$

T-Line Phasor Diagrams



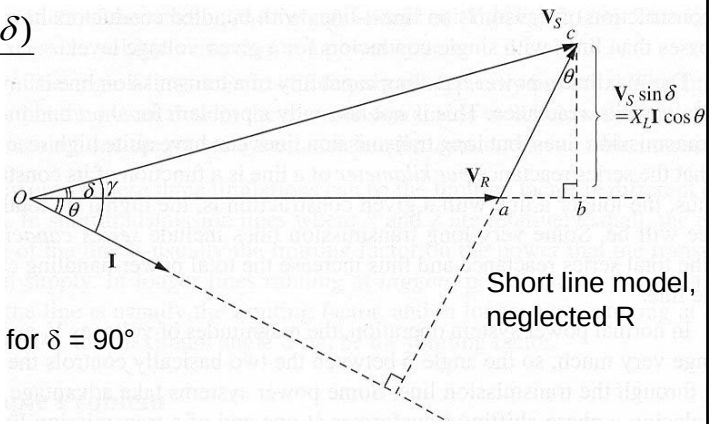






T-Line Loading Characteristics

$$P = \frac{3V_S V_R \sin(\delta)}{X_L}$$

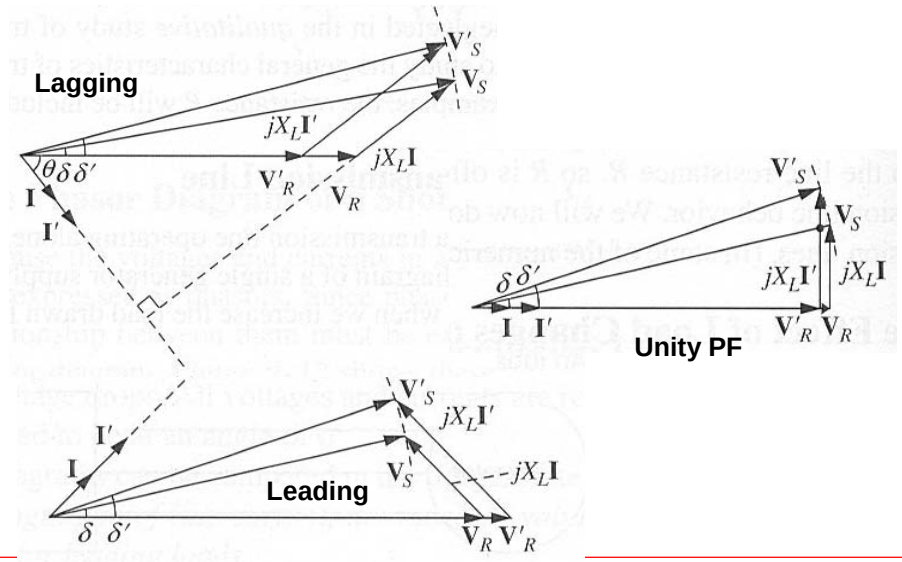


Short line model, neglected R

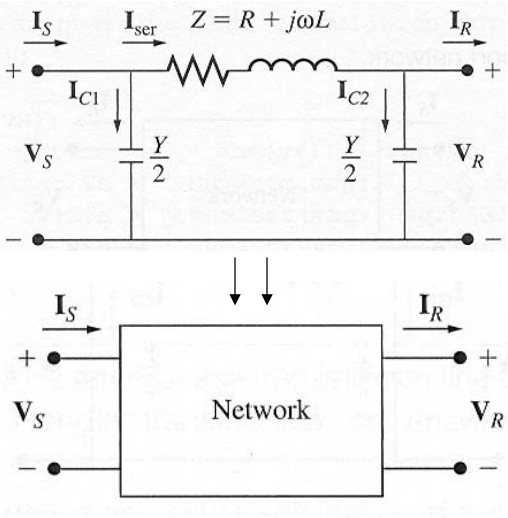
$$P_{MAX} = \frac{3V_S V_R}{X_L}$$ for δ = 90°

Typical operation: δ ≤ 25°

T-Line Loading Characteristics



ABCD Two-Port Network Model



$$\mathbf{V}_S = A\mathbf{V}_R + B\mathbf{I}_R$$
$$\mathbf{I}_S = C\mathbf{V}_R + D\mathbf{I}_R$$

HW 9

Problems 9-6, 9-11, 9-15 in book

Additional question for 9-6: what is the voltage on the receiving end?

Tips:
- No need for using tables
- Ignore shunt admittance for problem 9-15