Lab_1

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2 Theory

2.1 Surge Impedance

$$Z_0 = \sqrt{\frac{L}{C}} \tag{2.1}$$

Where L and C are the line capacitance and reactance. [1]

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[1] since this is given as a fraction it doesn't matter weather this is given as a per unit length value or as a total value

2.2 Electrical Length

This is effectively a measure of the amount of wavelengths of a particular frequency fit into a length of conductor. Electrical length is given by Equation 2.2.

$$\theta = \omega\sqrt{LC} \tag{2.2}$$

A value of $\theta = 2\pi$ would imply a single wavelength, however even for very long lines, typically values are $\ll 2\pi$.

2.3 Open Circuit Transmission line Voltage distribution

Voltage distribution along the line is given by Equation 2.3:

$$V(x) = V_s \frac{\cos(\theta(1 - x/a))}{\cos\theta} \tag{2.3}$$

Where x is defined as the distance from the sending end, a is the line length, and V_s is the phasor voltage at the sending end. setting $x = a$ and expression is derived for the voltage at the receiving end.

$$V_r = V(x = a) = \frac{V_s}{\cos\theta} \tag{2.4}$$

Since we assume that typical values of angle are $\ll 2\pi$ we know that as θ grows we expect V_r to increase from being exactly equal to V_s to a value $\geq V_s$

2.4 Matched Impedance Transmission line Voltage Distribution

The voltage profile for a line terminated in a matched impedance Z_0 would yield a perfectly flat voltage distribution i.e. $V(x) = V_s = V_r$. For any impedance greater than the surge impedance (Z_0) the voltage will tend to rise at the end of the transmission line while lower load impedance will cause the voltage profile in the line to sag leading to lower V_r. [2]

2.4.1 Reactive Power Consumption

When the load impedance is matched to the surge impedance ($Z_0 = Z_l$), the reactive power consumption of the line is zero. When $Z_l > Z_0$ the line generates reactive power whereas when $Z_l < Z_0$ the line consumes reactive power.

3 Experiment

3.1 Line Parameters

Line parameters are given by Table 3.1:

Table 3.1: *Per section model transmission line parameters*

C_{Sect} (μ F)	C_{Tot} (μ F)	L_{Sect} (mH)	L_{tot} (mH)	N_{Sections}	f (Hz)	ω (Rad/s)
0.02	0.02	7.29	7.29	10	45.80307	287.78069

3.2 Surge Impedance (Part a)

Line surge impedance is calculated according to Equation 2.1 and the line parameters given in Table 3.1. Table shows the resulting surge impedance:

[2] this can be expressed also as higher voltage for loads lower than the surge load where *surge load* $\propto 1/Z_l$

Table 3.2: *Calculated Surge Impedance based on Equation 2.1 and Line Parameters in Table 3.1*

Surge impedance Z_0 (Ω)
1.6563467e-3

3.3 Electrical length (Part b)

Electrical length is calculated from Equation 2.2 and the line parameters given in Table 3.1