ECE320: Fields and Waves

Lab 1 Report: Waves on Transmission Lines

Alp Tarım, Pranshu Malik

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1 Introduction

This laboratory focused on investigating the characteristics of transmission lines, studying voltage and current propagation along them, as well as its depedance on the nature of load impedance.

2 Determining the Characteristic Impedance, Z_0

We varied the load on the switch box until we saw little or no traces of reflected waves. This was at $Z_L = 50\Omega$ which is also equal to the charactertic impedance since we know that the reflections nullify when $Z_L = Z_0$. The corresponding waveforms captured at the generator input (channel 1, top) and the transmission line input (channel 2, bottom) are shown in Figure 1.

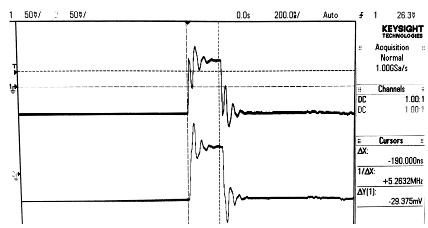


Figure 1: Transmission line terminated with load equal to Z_0

3 Determining Z_0 using $\frac{\tilde{V}^+(z=0)}{\tilde{I}^+(z=0)}$

Find something below:

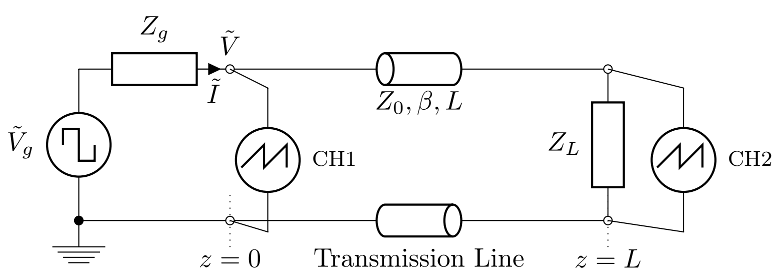


Figure 2: Laborartory setup for studying characteristcs of tranmission lines

As seen in the picture the voltage at v_g is 154mV and v_1 is equal to 51mV. Assuming the resistance in between is 100Ω $i_l = \frac{0.154-0.051}{100} = 1.03 * 10-3$A. Which means $Z_0 = \frac{v_1}{i_l} = \frac{0.051}{1.03*10-3} = 49.51\Omega$ 50Ω

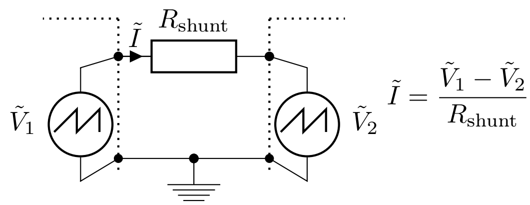
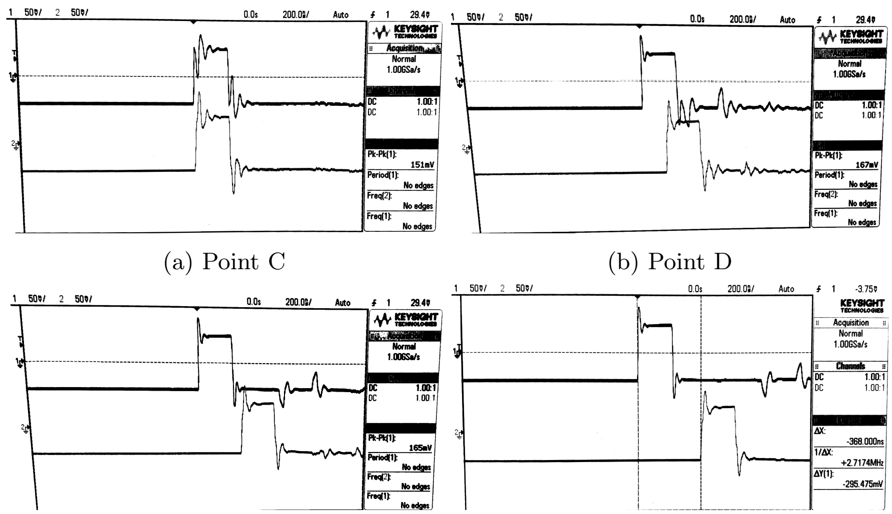


Figure 3: Measuring $\tilde{I}^{+}(z=0)$ through a shunt resistor

Thus, we can see something there. We know that $\tilde{V}_2 = \tilde{V}(z=0)$ and thus, we can confirm the value of Z_0 through the following relation: $\frac{\tilde{V}^{+}(z=0)}{\tilde{I}^{+}(z=0)}$.

4 Observation of Travelling Waves

We observed the following waveforms at different points, C = 0m, D = 30m, E = 60m, F = 90m along the



(a) Point C

(b) Point D

(c) Point E

(d) Point F

Figure 4: Observed waveforms, $V(t)$, at different loactions along the transmission line

The table of delays are:

Point	**Δt (ns)**
D	130
E	244
F	368

Table 1: Time delay for pulses

5 Determination of Velocity of Propagation

The velocity of propagation of the signal can be calculated by the relation $v_p = \frac{\Delta L}{\Delta t}$, given that we are able to track the same point on the waveform at both places. Using the data from table 1, we get that the average velocity of propagation is $v_{p,\text{avg}} = 2.44 \cdot 10^8 \text{m/s}$.

We know that the phase velocity of an electromagentic wave in space with magnetic permeability, μ, and electric permittivitty, ϵ is given by:

$$v_p = \frac{1}{\sqrt{\mu\epsilon}}$$

6 Simple Reflection

We know that

7 Multiple Reflections

8 Input Impedance and Transmission Line Length

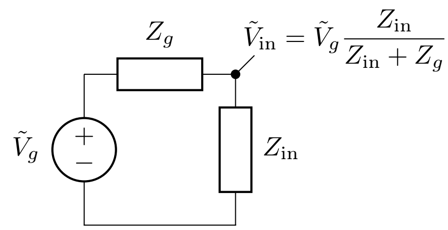


Figure 5: Voltage division over net input impedance, Z_{in}

We know that the impedance changes.

$$Z_{\text{in}} = Z_0 \frac{1 + \Gamma_d}{1 - \Gamma_d} = Z_0 \frac{Z_0 + jZ_L \tan \beta L}{Z_L + jZ_0 \tan \beta L}$$

9 Conclusion

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10 Notes

All pictures taken during the lab were post-processed in a batch using a custom script that bit-wise inverted the pixels and the thresholded to produce a binarized image. No adjustments or modifications were made to the readings, for which the oscilloscope's measurements are also shown alongside the waveforms. All work can be found at `github.com/pranshumalik14/ece320-labs`.