My artifact of choice is a skeletal report from PHYS 333 on a measurement of coaxial transmission line impedance. Figure 1 of this report shows data collected on the impedance of the transmission line linearized and fit to a model to extract parameters. Applying linear fits to data through computer algorithm is an essential tool for data analysis and enables a more complete understanding of the system than manual approximation. In this particular experiment a linear model first had to be derived from non-linear data, then corresponding values re-calculated. This was done through Excel sheet and column equations. The corresponding linear fit was also done by calculating the slope, intercept, then using those values to create model data shown in the dashed line. Determining the slope of the fit represented the impedance of the coax line, which was the goal of the experiment. We compared this experimental measurement to a theoretical impedance calculated from other measured characteristics and found close agreement to 0.490%. This agreement from two independent sources indicates the linearized model and subsequent fit was preformed correctly. Learning to preform a successful linear fit has benefited nearly every research project I have been involved in, and my methods have become more sophisticated from Excel sheets to Python notebooks.

Characterization of the Impedance of a Coaxial Cable Skeletal Report

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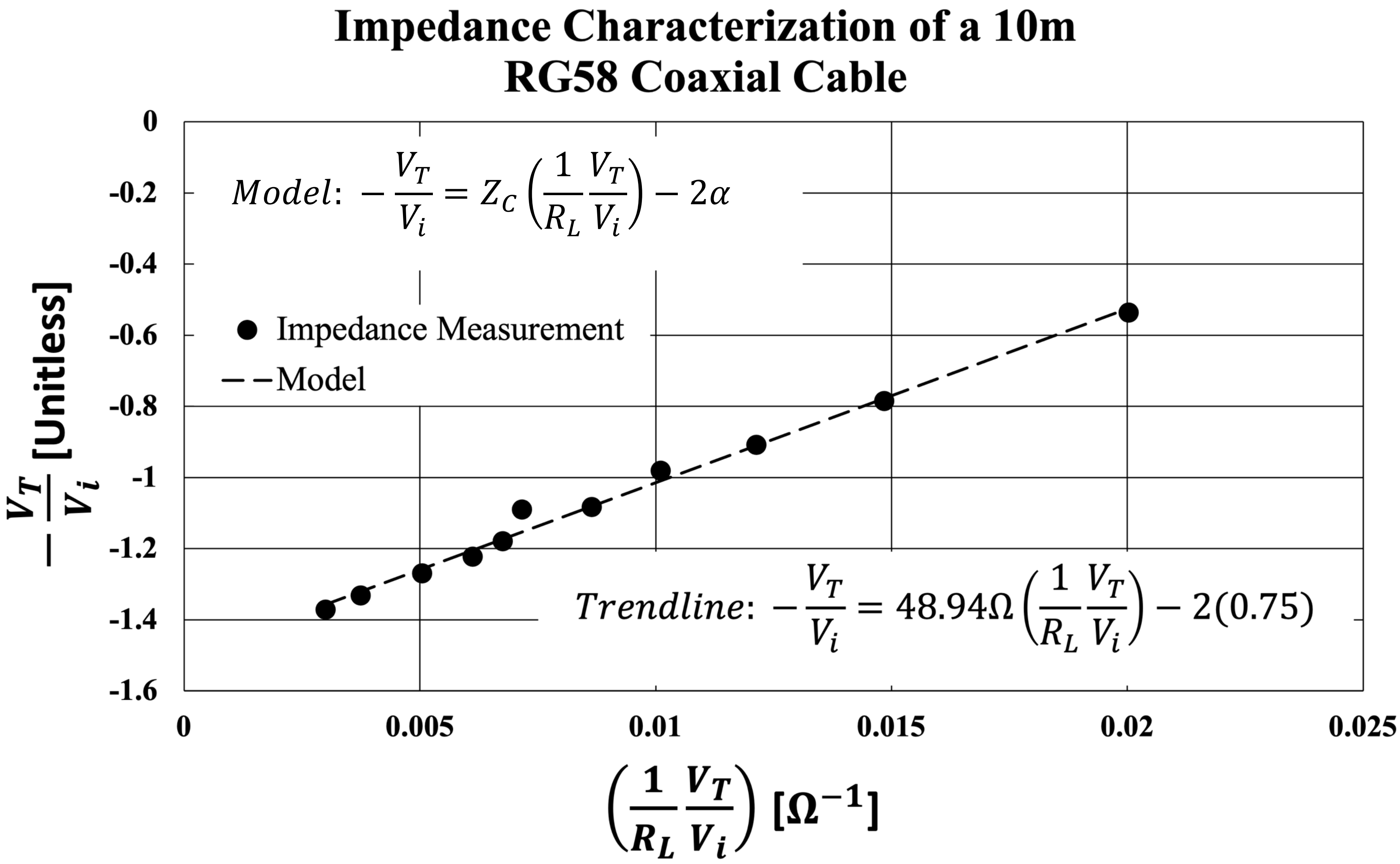

Figure 1. Impedance measurements taken for a distribution of load resistances. The slope of the trendline is the experimental value of characteristic impedance. The intercept of the trendline is two times an attenuation parameter of current into the coaxial cable and current out of the coaxial cable.

Results and Analysis

Collected data was transferred from the logbook into an *Excel* spreadsheet. The input peak voltages V_i, terminal peak voltages V_T, and load resistance R_L, were placed in separate columns. From these columns $-\frac{V_T}{V_i}$ and $\frac{1}{R_L}\frac{V_T}{V_i}$ were calculated in separate columns. These columns represent the y and x values respectively in a linear equation of the form $y = mx + b$ and are shown graphically in Figure 1. The uncertainties associated with these measurements were not evaluated or estimated.

A qualitative analysis of Figure 1 reveals a linear trend in the calculated values. The data is consistent with the model behavior described by Equation 1:

$$-\frac{V_T}{V_i} = \left(\frac{1}{R_L}\frac{V_T}{V_i}\right) Z_C - 2\alpha \qquad \text{Equation 1}$$

where Z_C is the characteristic impedance of the coaxial cable and α is a unitless attenuation coefficient relating the current into the transmission line to the current out of the transmission line.

Figure 1 was analyzed by a linear trend line done in *Excel* and from this analysis the experimental values $Z_C = 48.94\Omega$ and $\alpha = 0.75$ were obtained. The uncertainties associated with these values were not evaluated or estimated.

Another value of the characterstic impedance of the transmission line was found by Equation 2:

$$Z_C = \frac{1}{2\pi}\sqrt{\frac{\mu}{\epsilon}}\ln\left(\frac{b}{a}\right) \qquad \text{Equation 2}$$

where μ is the magnetic permeability of the dielectric, ϵ is the electric permittivity of the dielectric, b is the outer diameter of the conductor, and a is the inner diameter of the conductor.

μ	$1.2500 * 10^{-6}\ Hm^{-1}$
ϵ	$6.5077 * 10^{-11}\ Fm^{-1}$
b	$2.95\ mm$
a	$0.850\ mm$

Table 1. A collection of physical values for the coaxial cable with an inner dielectric composed of Polyethylene.[1][2]

A measurement of characteristic impedance is obtained by evaluating Equation 2 with the parameters listed in Table 1 of $Z_C = 48.7\Omega$, with associated uncertainties not evaluated or estimated. This measured value of characteristic impedance differs from the previous experimentally measured characteristic impedance by 0.490% not accounting for uncertainties or error in measurement.

From the manufacturer datasheet the RG58 AWG Type C coaxial cable used in this experiment has a nominal characteristic impedance of 54Ω[1]. The characteristic impedance measured by Equation 2 differs by 9.81% and the characteristic impedance measured by Equation 1 differs by 9.37% not accounting for uncertainties or error in measurements.

References

[1] Belden Wire & Cable. *50 Ohm Wireless Transmission Coax, RG-58, 20 AWG Str TC, 95% TC Braid, PVC Jkt, CM*. 2022. https://www.mouser.com/datasheet/2/46/8219_techdata-1393977.pdf.

[2] Professional Plastics. *Electrical Properties of Plastic Materials*. 2022. https://www.professionalplastics.com/professionalplastics/ElectricalPropertiesofPlastics.pdf.