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| UNIVERSITY of Calgary |
| ENEL 476 |
| Laboratory #2: Transmission Lines |
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| This report covers the second laboratory in ENEL 476 and focuses on tests using the simulation software MEFiSTo and explores the topic of wave propagation along transmission lines. The results of the tests and commentary are contained herein. |

**Prelab:**

The following work outlines the prelab assignment.

**Part I:**

1. At 4Ghz, the wavelength in free space would be equal to:
2. Since, the cell size should be smaller than for better analysis, so this means:
3. If each cell was to be then the dimension of the cell would be:

This would result in a waveguide of the dimensions: (90 cells x 15 cells)

1. Our dimensions above all correspond with the requirements of the cell size, and our waveguide has a width of 15 cells which is greater than the required 10.

**Part II:**

1. The formula for calculating the reflection coefficient at any point along a line is:

1. The magnitude of the reflection coefficient varies only in its phase angle. The magnitude would be phase shifted as the wave propagates.
2. The range of values for the reflection coefficient is:
3. The range of values for the Standing Wave Ratio is:

**Part III:**

1. For a perfectly matched load:

and

1. For an unmatched load with then VSWR is:
2. At a distance of away from the load, the reflection coefficient is:
3. When the termination is shorted, the VSWR is infinite:
4. At a distance of away from a short, is:

**Experiment #1 – Lossless Transmission Line with Matched Termination:**

The first part of this laboratory focuses on lossless transmission line wave propagation when there is a matched load at the termination. All tests were done in MEFiSTo and following results were collected.

**Part I – Waveform Observation:**

1. After setting up and running MEFiSTo the following wave propagation was observed in the program:

**[\*\*\*\*\*SCREEN CAPTURE OF MATCHED TRANSMISSION LINE WAVEFORM\*\*\*\*\*]**

1. After analyzing the waveform it appears that 6 full wave-cycles can be observed from start to end. This appears to agree with what would be observed in free space as free space is lossless. This was setup during the part when we drew the calculation region which occurred in setup step c.
2. The amplitude of the wave did not change after reaching a steady-state. This corresponds with the expected results. Since it is a perfectly matched line and lossless, it neither reflects nor loses energy through transmission and as such it should remain constant in amplitude.
3. For matched termination the reflection coefficient is 0, and the VSWR is 1. This means that we have no reflection and this corresponds with a pure travelling wave. This is what was observed in the test.

**Part I – Reflection Coefficient:**

1. We observed a reflection coefficient of 0 at the location of interest for the probe. This was as expected as it relates to a wavelength away from the load and this is a perfectly matched system so magnitude shouldn’t change.

**Experiment #2 – Lossless Transmission Line with Unmatched Termination:**

The second part of the laboratory involves testing a lossless transmission line with a unmatched load at the end. The results from the tests follow.

**Part II – Waveform Observation:**

1. The observed waveform was a partial-standing wave. It showed some standing wave characteristics, but moved consistently in a rhythmic fashion.
2. We observed a value of around 0.6 for our reflection coefficient. This is relatively close to the value entered for our termination.

**Part II – Standing Wave Ratio:**

1. After running and testing the various different locations along the transmission line with the probe, the following amplitudes were observed:

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| --- | --- |
| Distance from Load (mm) | Voltage Amplitude (V) |
| 5 | 1.7 |
| 15 | 1.2 |
| 25 | 3.0 |
| 35 | 3.0 |
| 45 | 1.2 |
| 55 | 1.8 |
| 65 | 3.2 |
| 75 | 2.6 |
| 85 | 0.8 |
| 95 | 2.5 |
| 105 | 3.2 |

1. The following is the graph of the data above. As can be seen, it appears to be of a sine wave-like nature:
2. Based on the graph and the observed data, it would be fair to estimate VSWR as:

This value of is very close to that of our termination value of 0.65.

1. The distance between the maxima and minima relates to the wavelength of the wave. It appears to be about 40mm. This would be the wavelength of the partial standing wave, not the original source waveform.

**Experiment #3 – Lossless Transmission Line with Shorted Termination:**

**Part III – Waveform Observation:**

1. The waveform that was observed was a pure standing wave.

**Part III – Standing Wave Ratio:**

1. In the same fashion as was done for part II above, the VSWR was calculated for the pure standing wave as:

This value for our VSWR is practically okay, as it is still very much bigger than the partial standing wave, but it represents what would theoretically by infinity.