Professor: Chuck Bland

EE 375 Section 02

12:10 - 3:00 PM Tuesday

Lab #6

Transmission Line Parameters

Written By:

John Gharib

Aria Amini

Austin Ma

May 24, 2021

# 1. Sample calculation of one frequency for α, β, vp and Velocity factor @ 35MHz

# 2. Summary table for all frequency according to meter and Np

| Frequency(MHZ) | Initial Short Impedance | Trip count | Impedance @ Stop | Initial Open Impedance | Trip count | Impedance @ F | Zo | x | alpha (Np/m) | alpha (db/100') | Beta (rad/m) | Vp (m/s) | Velocity factor | L(H/m) | L(nH/m) | L(nH/ft) | C(pF/m) | C(pF/ft) |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 35 | 1.18-70.4j |  |  | 0.958+39.7j |  |  | 52.8776736678195-0.194762728494759j | -0.284350125268948-0.979384392441684j | 0.00236857079104729 | 0.6271 | 1.231 | 178716287 | 0.5957 | 0.0000002958769636 | 295.88 | 90.206 | 105.82 | 32.262 |
| 500 |  | 10 | 2.87+14.8j |  | 10 | 26-155j | 48.6723796468734-0.616879639291044j | 0.917177984271462+0.618377105521485j | 0.0121724293373779 | 3.2226 | 17.618 | 178316468.5 | 0.5944 | 0.0000002729769668 | 272.98 | 83.225 | 115.21 | 35.125 |
| 600 |  | 14 | 3.42+19.2j |  | 14 | 21.8-125j | 49.7449904464066-0.0898582944711953j | 0.831671873196605+0.758833924157141j | 0.0142986633953034 | 3.7855 | 24.640 | 152999247.3 | 0.5100 | 0.0000003251327865 | 325.13 | 99.126 | 131.39 | 40.058 |
| 700 |  | 15 | 3.98+22.3j |  | 15 | 20-107j | 49.656229473508+0.202794294024528j | 0.758427905089698+0.859570331844389j | 0.0164749773056405 | 4.3617 | 26.415 | 166502190.9 | 0.5550 | 0.0000002982341752 | 298.23 | 90.925 | 120.95 | 36.875 |
| 800 |  | 16 | 5.71+24.5j |  | 16 | 25.1-96.7j | 50.128467737346+0.626320759782758j | 0.739455890933309+0.963109618395174j | 0.0234177781818291 | 6.1998 | 28.180 | 178374694.3 | 0.5946 | 0.0000002810509669 | 281.05 | 85.686 | 111.83 | 34.094 |
| 900 |  | 18 | 6.29+27.9j |  | 18 | 21.7-91.3j | 51.8059205362662+0.300670267775588j | 0.658556928498272+1.01890502352663j | 0.0233149836520154 | 6.1725 | 31.693 | 178427091.3 | 0.5948 | 0.0000002903527298 | 290.35 | 88.522 | 108.18 | 32.982 |
| 1000 |  | 20 | 6.81+28.5j |  | 20 | 23.3-94.8j | 53.4836684320107+0.172594742855656j | 0.671583906628974+1.02192147805117j | 0.0242697784947071 | 6.4253 | 35.181 | 178593871.4 | 0.5953 | 0.000000299472465 | 299.47 | 91.303 | 104.69 | 31.918 |

3. Derivation of α and β according to meter and Np

it is possible beta is just to represent negative cases of x

, where n is an integer

# 

# 4. Derive conversion of Np/m to dB/100ft

(Np/m)

# 

# 5. Compare α(dB/100ft), β (rad/m), L (μH/ft), C (pF/ft), velocity factor values to the datasheet (Belden). Table them according to frequency.

| Nominal inductance = .065uH/ft |
| --- |
| Nominal capacitance conductor to shield = 26pF/ft |
| nominal velocity of propagation = .78 or 78% |

Data from Datasheet

| **Frequency(MHZ)** | **Attenuation (dB/100ft)** | **Beta (rad/m)** | **L (nH/ft)** | **C (pF/ft)** | **Velocity Factor** |
| --- | --- | --- | --- | --- | --- |
| 1 | 0.1 | 0.015 | 65 | 26 | 0.78 |
| 10 | 0.5 | 0.148 | 65 | 26 | 0.78 |
| 50 | 1.2 | 0.740 | 65 | 26 | 0.78 |
| 100 | 1.7 | 1.479 | 65 | 26 | 0.78 |
| 200 | 2.6 | 2.959 | 65 | 26 | 0.78 |
| 400 | 3.9 | 5.917 | 65 | 26 | 0.78 |
| 700 | 5.6 | 10.355 | 65 | 26 | 0.78 |
| 900 | 6.5 | 13.314 | 65 | 26 | 0.78 |
| 1000 | 7 | 14.793 | 65 | 26 | 0.78 |

Data from Experiment

| **Frequency(MHZ)** | **Attenuation (dB/100ft)** | **Beta (rad/m)** | **L (nH/ft)** | **C (pF/ft)** | **Velocity Factor** |
| --- | --- | --- | --- | --- | --- |
| 35 | 0.6085 | 1.239 | 88.111 | 33.462 | 0.592 |
| 500 | 3.1878 | 17.626 | 87.239 | 33.538 | 0.594 |
| 600 | 3.7941 | 24.648 | 103.124 | 38.529 | 0.510 |
| 700 | 4.2970 | 26.424 | 94.634 | 35.453 | 0.555 |
| 800 | 6.2118 | 28.181 | 86.036 | 33.958 | 0.595 |
| 900 | 6.2298 | 31.694 | 88.874 | 32.853 | 0.595 |
| 1000 | 6.6036 | 35.181 | 91.132 | 31.977 | 0.595 |

# 

# 6. Question: Why does the trace rotate in the clockwise direction with increasing frequency?

As the frequency increases, the electrical length of the transmission line, , increases significantly as the wavelength is < 1 and going towards 0, causing the electrical length to go towards infinity. As seen in the S11 forward reflected data for the short and open load, the trace rotates in the clockwise direction as the wavelengths (electrical length) towards the generator increase!

# 

# 7. Comparison of data 35MHz(or 500MHz) and 1GHz

Though we are doing low-loss calculations for this transmission line RG-8/U, we are seeing a kind of distortionless behavior with the attenuation constant not linearly dependent with the increasing frequency, but rather almost logarithmically correlated with an increasing frequency. The alpha seemed dependent on the linearly increasing frequency and then realized that the attenuation constant began to change at its own rate, plateauing towards 7 as the frequency increased. The beta values also prove to be linearly and directly related to the increasing frequency (as the jump from 35MHz to 500MHz is the biggest increment going from 1.239 rads/m to 17.626 rads/m, while the rest of the increments in frequency are by 100MHz so the changes in beta by the even increments prove to be more steadily increasing 2-3 rads/m), proving the line to be more distortionless as alpha is also not linearly related to frequency.

CONCLUSION:

Aria Amini: In this lab, we studied and experimentally measured the transmission line parameters for an RG-8/U cable to compare to the manufacturer’s datasheet. From the measured and calculated data, we observed that the line’s impedance, capacitance, and velocity factor remained approximately constant over the range of tested frequencies, with values that remained around 90 nH/ft, 35 pf/ft, and 0.59, respectively. However, values for attenuation and beta did show some frequency dependence, thus implying that the line follows more of a distortionless model rather than a lossless one. When compared to the manufacturer’s nominal values, our experimental values for attenuation were fairly similar to expected. Values for inductance and capacitance were slightly higher than the expected values of 65 nH/ft and 26 pf/ft. Additionally, measured values for beta were nearly double what was expected, and velocity factor was around 25% lower than expected. Possible causes for these discrepancies could be due to differences in the actual dielectric constant and permeability of the transmission line due to the geometry of the line and environmental factors such as temperature and humidity.

John Gharib: In lab 6, experiments were conducted to collect data on an RG-8/U cable to compare nominal values to measured and calculated values of the line. In the lab, the measured characteristic impedance was within a tolerable amount of the nominal value, as the furthest measured value from nominal was ~3.5 + j0.17 Ω, and the attenuation constant in dB/100’ was close to the nominal values. However, with the rest of the calculations, there were discrepancies between what was measured and what is nominally expected to be measured.The beta values we measured from the lines were off by about a factor of 2, our velocity factor was off by about 75%, and our inductance and capacitance per foot values were both higher than expected. The reason for these values not being nominal could be from the environment they were in, as there could be RF interference (Dissipating microwave energy along a wire could cause some interference if there are 18 lines of the same length being tested at the same time, in the same room).

Austin Ma: This was a very hard lab, there were a lot of calculations and we had to catch a lot of our own mistakes. We saw a large change in the output parameters of the actual RG-8/U despite the manufacturer’s data. We tried to account for the number of wavelengths around a trip in the smith chart (2 trips = 1 wavelength) for the beta, but ended up with a velocity factor above the speed of light. It makes me feel uncertain to know that accounting for discrepancies in real life distortion and loss in a transmission line may require taking manufacturer specifications with a grain of salt.