ElecEng 2CF4
Assignment 6 Report 1

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EXERCISE #1: LOW-LOSS TRANSMISSION LINE IN HARMONIC REGIME

1. Calculations

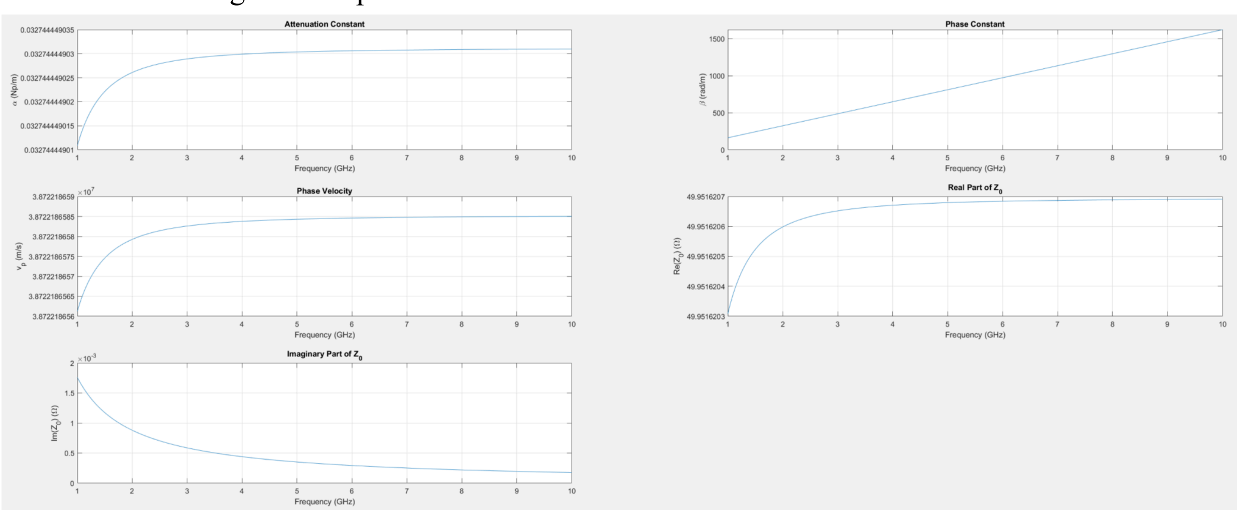
$$\frac{L'}{C'} = Z_0^2, \quad L'C' = \mu_0\varepsilon_0\varepsilon_r = \frac{\varepsilon_r}{c^2}$$

$Z_0 = 50\,\Omega$
$\varepsilon_r = 6$
$\mu_0 = 4\pi \times 10^{-7}\ \mathrm{H/m}$
$\varepsilon_0 = 8.854187817 \times 10^{-12}\ \mathrm{F/m}$

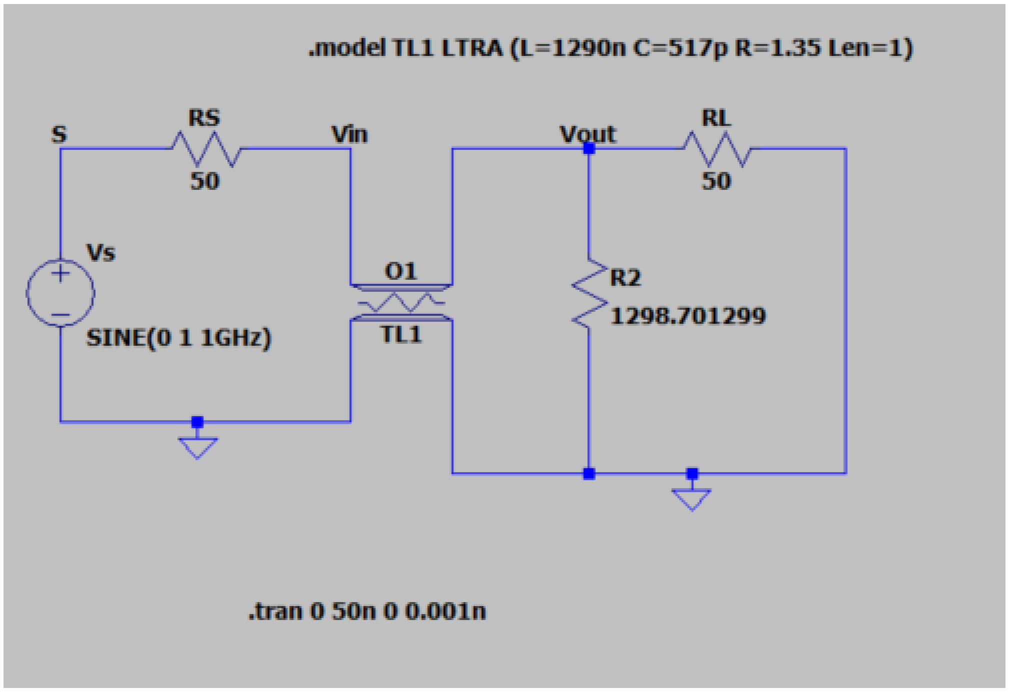
Manipulating the above 2 formulas, we see:
$L' = 1.29 \times 10^{-6}\ \mathrm{F/m}$
$C' = 5.17 \times 10^{-10}\ \mathrm{H/m}$

$R' = 1.35\,\Omega/\mathrm{m}$
$G' = 0.77\,\mathrm{mS/m}$

2. MATLAB-generated plots



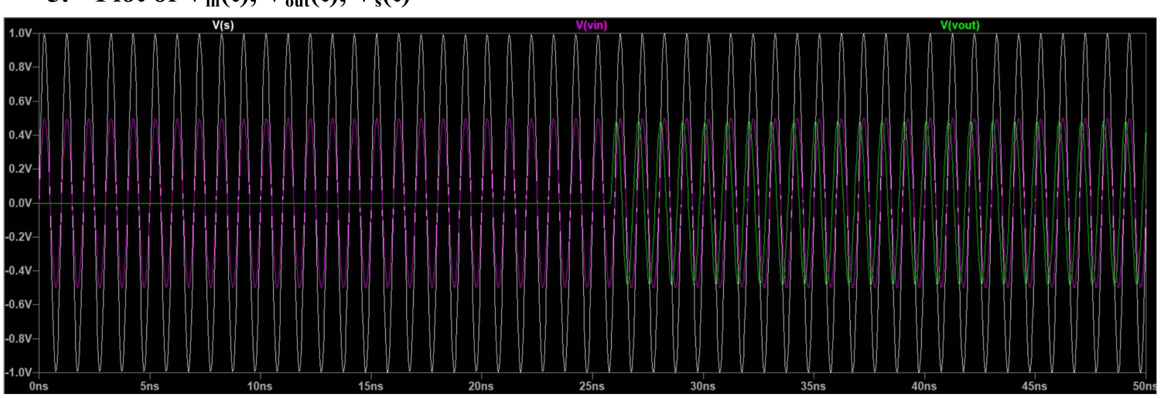
3. **LTspice schematic**



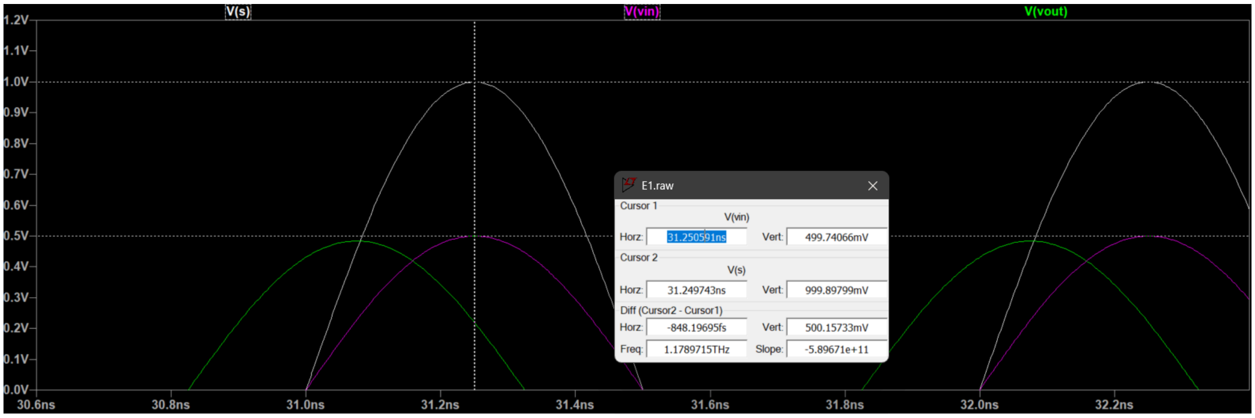
4. **Spice Netlist**

```
* C:\Users\Josh\Documents\COMPENG\Y2S2\2CF3\Assignment6\E1.asc
Vs S 0 SINE(0 1 1GHz)
RS Vin S 50
O1 Vin 0 Vout 0 TL1
R2 Vout 0 1298.701299
RL 0 Vout 50
.model TL1 LTRA (L=1290n C=517p R=1.35 Len=1)
.tran 0 50n 0 0.001n
.backanno
.end
```

5. **Plot of $V_{in}(t)$, $V_{out}(t)$, $V_s(t)$**

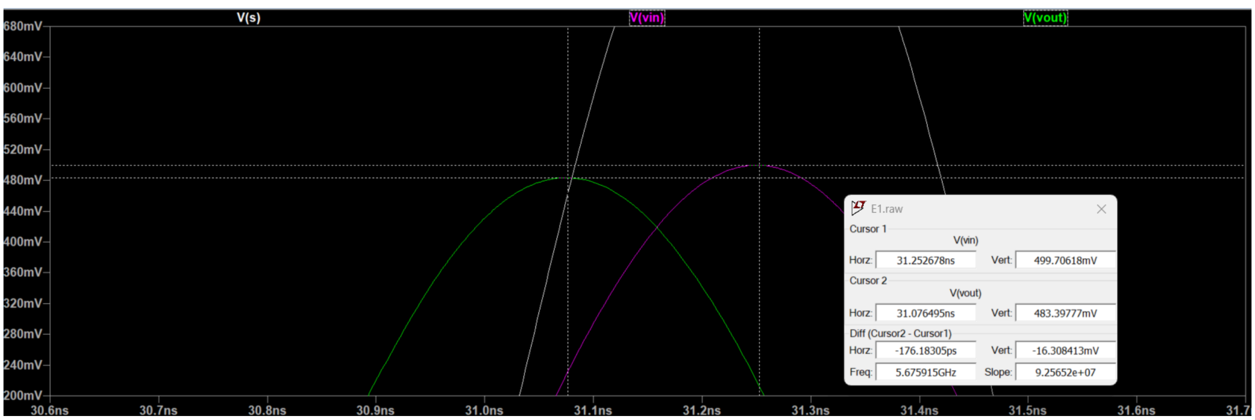


6. **How does the magnitude of $V_{in}(t)$ compare to the magnitude of $V_s(t)$? Explain your observation.**



The magnitude of $v_{in}(t)$ is approximately 0.4997 V = 0.5V, while the source voltage $v_s(t)$ is 999.8 V = 1.00 V. This result is expected due to the voltage divider effect created by the source resistance R_s=50 Ω and the input impedance of the matched transmission line (Z_0=50 Ω). Since both impedances are equal, the voltage at the line input is approximately half of the source voltage.

7. **How does the magnitude of $V_{out}(t)$ compare to the magnitude of $V_{in}(t)$? Explain your observation**



The output voltage magnitude $v_{out}(t)$ is approximately 0.4834 V, which is slightly less than $v_{in}(t)$=0.4997 V. This small drop in amplitude is due to the attenuation caused by the transmission line's per-unit-length resistance R′ and conductance G′. Since the line is low-loss and only 1 m long, this attenuation is minor and consistent with theoretical expectations.

8. **Calculate the attenuation constant α (in Np/m) of the TL using the peak values of $V_{in}(t)$ and $V_{out}(t)$ that you determined in questions 6 and 7. Does this value agree with the value obtained with your MATLAB code?**

The attenuation constant is calculated using the formula:

$$\alpha = \frac{1}{d} \ln\left(\frac{V_{\text{in}}}{V_{\text{out}}}\right)$$

Substituting the measured values:

$$\alpha = \ln\left(\frac{0.4997}{0.4834}\right) = 0.03316\,\mathrm{Np/m}$$

From MATLAB, the attenuation constant at 1GHz was:

$$\alpha_{\mathrm{MATLAB}} = 0.0327\,\mathrm{Np/m}$$

These values are in the same range and show reasonable agreement. The difference is likely due to limited resolution when reading waveform peaks in LTspice or numerical approximation in the MATLAB model. Overall, the results confirm the expected low-loss behavior. The **% difference is 1.3969%**, demonstrating that they are in agreement with each other.