

# ElecEng 2CF4

## Assignment 6 Report 2

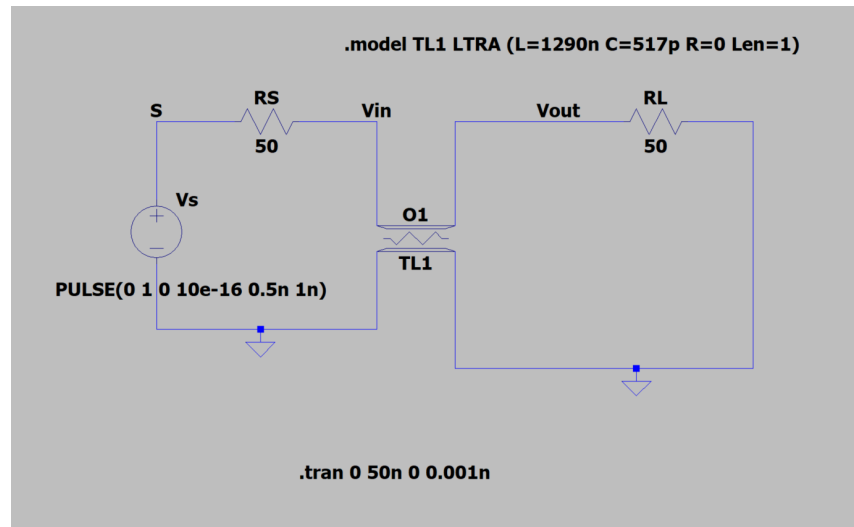
Joshua Obljubek-Thomas

400506256

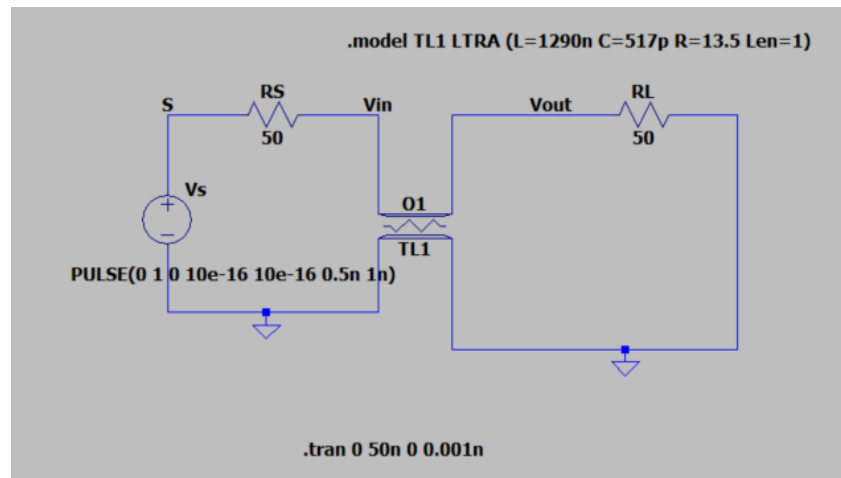
## EXERCISE #2: LOSSY TRANSMISSION LINE CARRYING PULSES

### 1. LTspice schematic

Loss Free



Lossy TL



### 2. Spice Netlist

Loss Free

\* C:\Users\Josh\Documents\COMPENG\Y2S2\2CF3\Assignment6\E2Loss-Free.asc

$V_s\ S\ 0\ PULSE(0\ 1\ 0\ 10e-16\ 10e-16\ 0.5n\ 1n)$

$R_S\ Vin\ S\ 50$

$O1\ Vin\ 0\ Vout\ 0\ TL1$

$RL\ 0\ Vout\ 50$

$.model\ TL1\ LTRA\ (L=1290n\ C=517p\ R=0\ Len=1)$

$.tran\ 0\ 50n\ 0\ 0.001n$

.backanno

.end

### Lossy

\* C:\Users\Josh\Documents\COMPENG\Y2S2\2CF3\Assignment6\E2Lossy.asc

Vs S 0 PULSE(0 1 0 10e-16 10e-16 0.5n 1n)

RS Vin S 50

O1 Vin 0 Vout 0 TL1

RL 0 Vout 50

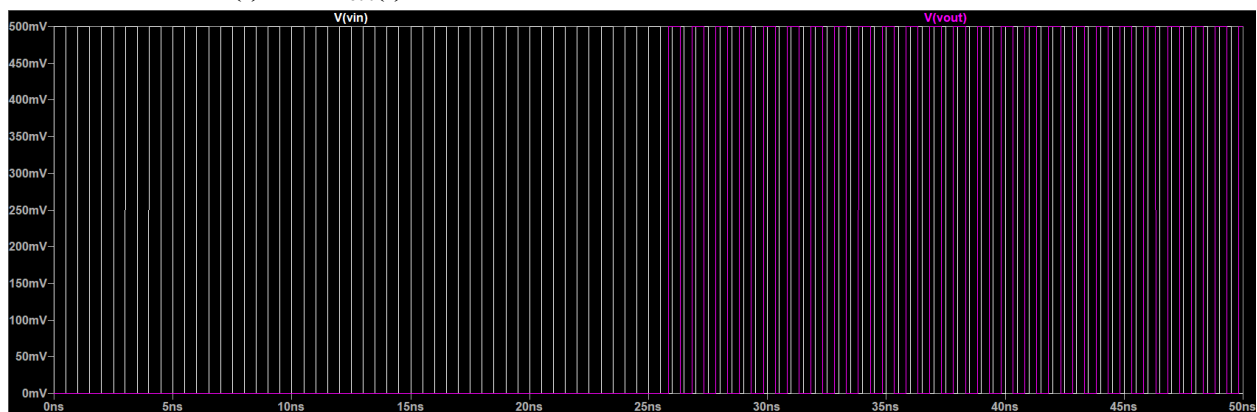
.model TL1 LTRA (L=1290n C=517p R=13.5 Len=1)

.tran 0 50n 0 0.001n

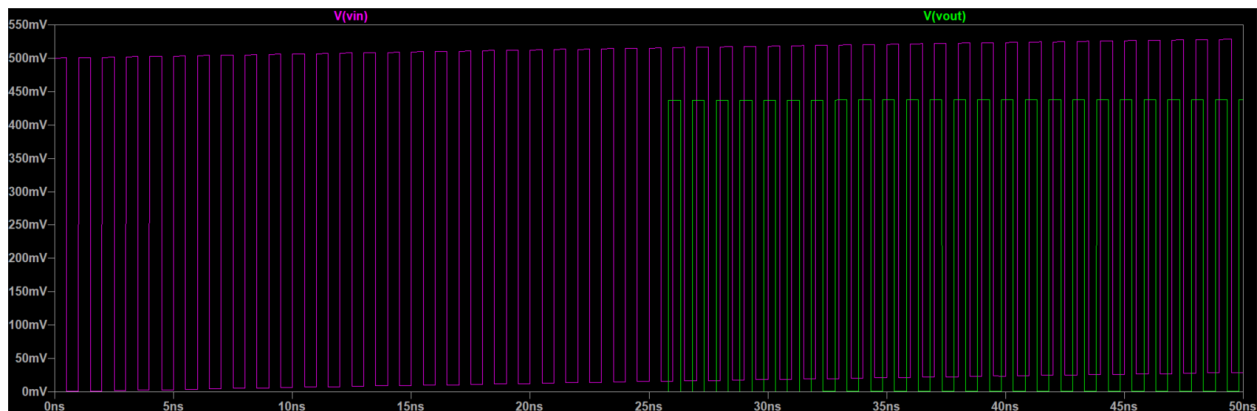
.backanno

.end

### 3. Plot of $V_{in}(t)$ and $V_{out}(t)$ waveforms from loss-free TL simulation.



### 4. Plot of $V_{in}(t)$ and $V_{out}(t)$ waveforms from lossy TL simulation.



- 5. Compare the magnitude of  $V_{\text{out}}$  in the loss-free TL compared to the magnitude of  $V_{\text{out}}(t)$  in the lossy TL. Based on these two values, calculate the attenuation of the lossy TL in dB/m. You do not need to compare this calculation with analytical calculations**

The attenuation in dB/m is calculated as:

$$\begin{aligned}\text{Attenuation (dB/m)} &= 20 \cdot \log_{10} \left( \frac{V_{\text{out,loss-free}}}{V_{\text{out,lossy}}} \right) \\ &= 20 \cdot \log_{10} \left( \frac{499.9999}{438.64} \right) \\ &= 1.73 \text{ dB/m}\end{aligned}$$

- 6. What is the time delay  $t_d$  between  $V_{\text{in}}(t)$  and  $V_{\text{out}}(t)$  in the lossy TL?**

The time delay is calculated from the difference between the rising edges of the input and output waveforms:

$$t_d = t_{\text{out}} - t_{\text{in}} = 25.823245 \text{ ns}$$

- 7. Calculate the phase velocity  $V_p$  in the lossy TL using the time delay  $t_d$  found in question 7. The length of the TL is 1m.**

The transmission line is 1 meter long, so the phase velocity is:

$$\begin{aligned}v_p &= \frac{\text{Distance}}{t_d} \\ v_p &= \frac{1}{25.823245 \times 10^{-9}} = 3.8722 \times 10^7 \text{ m/s}\end{aligned}$$

- 8. Compare the obtained phase velocity  $V_p$  with the analytical value, which you can compute using your MATLAB code at the repetition frequency  $f = 1/T$  where  $T = 1\text{ns}$  is the repetition period. The analytical calculation of  $V_p$  must take the losses into account, i.e., You cannot use the low-loss approximation. Include your analytical value of  $V_p$  in the report. Is there a good agreement? Please, state clearly the value of the simulation-based and the analytical phase velocities.**

From the LTspice simulation:

$$v_{p,\text{simulation}} = 3.8722 \times 10^7 \text{ m/s}$$

From the MATLAB analytical model (at 1 GHz, with losses included):

$$v_{p,\text{analytical}} = 3.8722 \times 10^7 \text{ m/s}$$

The simulation-based and analytical phase velocities match exactly. This indicates excellent agreement and confirms that the losses and delay are accurately captured by both the MATLAB model and the LTspice transient simulation.