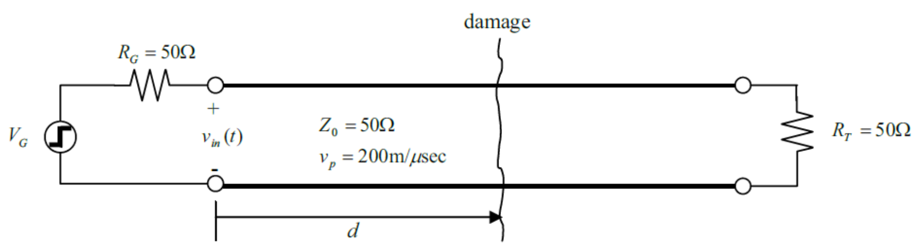
ECE 391: Transmission Lines

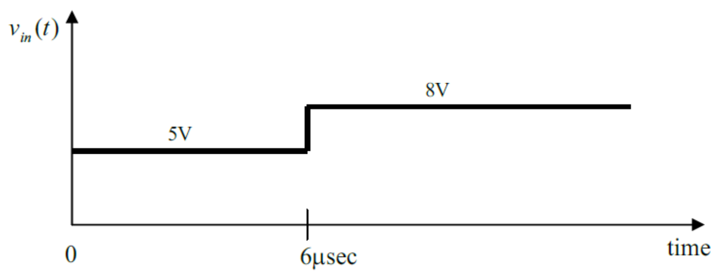
Spring Term 2020

Homework Assignment #3

Friday, May. 8 Online (Canvas)

1. A lossless transmission line cable ($Z_0 = 50$, $v_p = 200\text{m}/\mu\text{sec}$) is suspected to be damaged at an unknown distance d from the input. The cable is terminated in a matched resistance $R_T = 50$. In order to find the location of the damaged cable, a step voltage is applied at the input at time t = 0, and the voltage waveform is observed at the input of the cable (time-domain reflectometry). The step-voltage generator is matched to the transmission line ($R_G = 50$).

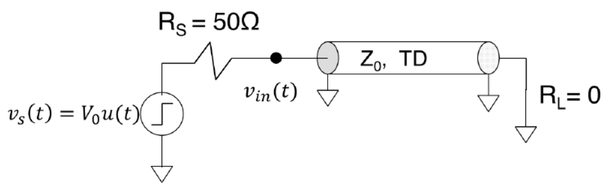


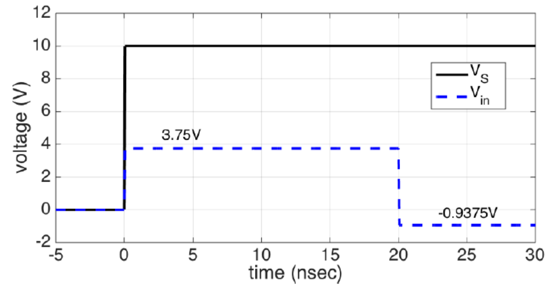


(a) What are the voltage and current amplitudes of the first outgoing wave?
(b) Determine the generator voltage.
(c) Determine distance d at which the cable is damaged.
(d) Determine the voltage of the returning wave (reflected at the damaged location).
(e) What is the reflection coefficient at the location of the damaged cable?

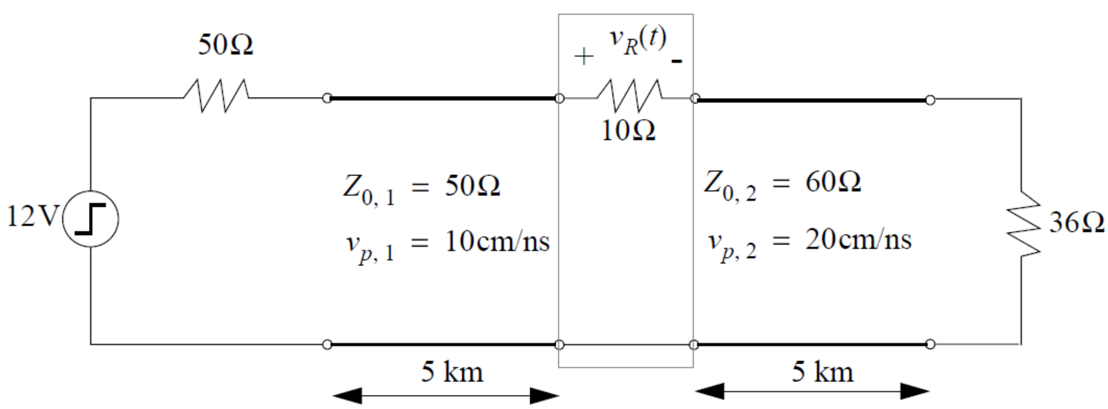
2. You have found a piece of 2m long piece of coaxial cable of unknown characteristic impedance, Z_0. To characterize the cable, you connect one end of the cable to the TDR instrument in your lab and short-circuit the other end, as illustrated in the figure below. The open circuit voltage of the TDR system is $V_0 = 10\text{V}$ and the output impedance is $R_S = 50\Omega$. The recorded step response $v_{in}(t)$ at the input of the coaxial cable is shown below for $-5 \leq t \leq 30$ nsec (dashed curve).
(a) Determine the delay time (TD) of the coaxial transmission line.

(b) Determine the propagation velocity on the coaxial cable.
(c) Determine the characteristic impedance of the coaxial cable.
(d) Determine the reflection coefficient at the source (Γ_S) and the load (Γ_L).
(e) Draw lattice diagram and show the numerical values for voltage and current for the first 5 wave components.
(f) Determine the voltage at the input of the coaxial cable, v_{in}, at time t = 45nsec.
(g) Determine the current into the coaxial cable (source side) at t = 5nsec and t = 25nsec.
(h) What are the steady-state voltage and current at the input of the coaxial cable?





3. Two lossless transmission lines are connected in tandem through a series resistance, as shown below.
(a) Determine the delay time of each line.
(b) Determine the reflection and transmission coefficients at the junction between the two lines.
(d) Draw a lattice diagram and specify the voltage and current of each wave component up to t = 80μsec.
(e) Plot the voltage across the 10Ω series resistance as a function of time for 0 ≤ t ≤ 80μsec;
(f) Determine the steady-state voltage across the 36Ω load resistor.



4. An ideal coaxial line with characteristic impedance $Z_0 = 50\Omega$ is connected to a source having $V_S = 18V$ and $R_S = Z_0 = 50$. The termination of the coaxial line at the far end is unknown. At time t = 0 the source is turned on and the transient response at the near end (z = 0) is observed on an oscilloscope (see figure below).

(a) Determine the delay time t_d of this transmission line.

(b) Determine the unknown lumped-element termination (show the terminating circuit and include the lumped-element values with appropriate units).