1. A transmission line is used to model a circuit interconnect on a high-speed logic board. The speed-of-propagation is \( u = 20 \text{ cm/ns} \), and the characteristic resistance is \( R_c = 50 \text{ ohms} \). The transmission line is 20 cm long and is terminated in a “matched” load, so there is no reflected voltage on the line.

![Diagram of a transmission line](image)

The voltage generator has the waveform shown in the figure, with a rise time of 0.05 ns and a fall time of 0.03 ns.

(a) An oscilloscope probe is connected at \( z = 7 \text{ cm} \), that is, 7 cm from the generator. Draw the graph of the voltage on the transmission line as a function of time that appears on the ‘scope face.

(b) Draw a graph of the voltage on the transmission line as a function of distance \( z \) at time \( t = 0.15 \text{ ns} \) and at time 0.25 ns.

2. A transmission line with characteristic resistance 50 ohms and speed of propagation 14 cm/ns is driven by a step-function generator with internal resistance \( R_s = 50 \text{ ohms} \). The open-circuit voltage across the generator is zero volts for \( t < 0 \) and 10 volts for \( t > 0 \).

![Diagram of transmission line with generator](image)
The transmission line is 2 cm in length. The transmission line is terminated with load resistor $R_L$.

(a) If the load is matched ($R_L = R_c$), draw a bounce diagram for the transmission line from $t = 0$ to $t = 0.5$ ns. Draw a graph of the voltage across the load as a function of time.

(b) Repeat question (a) if the load is an open circuit ($R_L \to \infty$).

(c) Download program BOUNCE from the course web site and run the program to solve the problems in part (a) and (b) above. Verify that your paper-and-pencil solution agrees with the simulation using the BOUNCE program.

3. A transmission line is 10 cm long. It has speed-of-propagation $u = 20$ cm/ns, and characteristic resistance $R_c = 50$ ohms. The internal resistance of the generator is 20 ohms. The load resistor is 1000 ohms.

(a) The voltage generator is a step function from 0 volts to 10 volts starting at $t=0$. Draw the bounce diagram for $0 < t < 3.1$ ns. Draw a graph of the voltage across $R_L$ as a function of time.

(b) The voltage generator is a pulse function. At $t=0$, the voltage generator steps up from 0 volts 10 to volts. At $t=0.4$ ns, the voltage generator steps down from 10 volts back to zero volts. Draw the bounce diagram for $0 < t < 3.1$ ns. Draw a graph of the voltage across $R_L$ as a function of time.

(c) Explain how to use the “step response” from part (a) to calculate the “pulse response” in part (b).

(d) Download program BOUNCE from the course web site and run the program to solve the problems in part (a) and (b) above. Verify that your paper-and-pencil solution agrees with the simulation using the BOUNCE program.