1. Consider a T.L. with characteristic impedance $Z_o = 100\,\Omega$, length $l = 600$ m, and propagation velocity $v = \frac{1}{\sqrt{\mathcal{LC}}} = c = 3\times10^8$ m/s. A voltage source $f(t)$ with an internal resistance $R_g = Z_o$ is connected to one end of the T.L. (at $z = 0$) and the other end ($z = l$) is terminated by a load resistance $R_L = Z_o/2$.

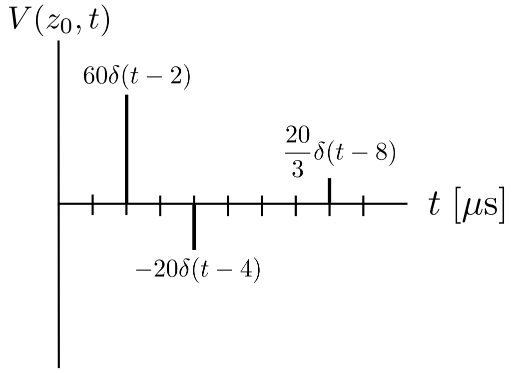
   a) Construct two "bounce diagrams" to determine the voltage, $V(z,t)$, and current, $I(z,t)$, variations on the line for $0 < z < l$ and $t > 0$ for $f(t) = \delta(t)$.

   b) Write the expressions for $V(\frac{l}{4},t)$ and $I(\frac{l}{4},t)$ as weighted sums of appropriately delayed impulses $\delta(t)$.

   c) Plot $V(\frac{l}{4},t)$ as a function of t for $0 < t < 13\,\mu$s for $f(t) = 10u(t)$ V. — **Hint:** use the convolution of the result of part (b) with $30u(t)$.

   d) Determine the steady state voltage and current on the line for the excitation from part (c).

2. A generator with internal resistance $R_g = 50\,\Omega$ and an open circuit output voltage $f(t) = 90\delta(t)$ feeds a T.L. that has an unknown characteristic impedance Z_o and an unknown resistive load termination R_L at an unknown distance, L, from the generator. At a distance $z_0 = 300$ m from the generator, smaller than L, the voltage waveform as a function of time for $0 < t < 9\,\mu$s is found to be $V(z_0,t) = 60\delta(t-2) - 20\delta(t-4) + \frac{20}{3}\delta(t-8)$ V, which is plotted below.



   a) Determine the injection coefficient τ_g and the impedance of the transmission line, Z_o.

   b) Determine the load reflection coefficient Γ_L and the load resistance, R_L.

   c) Determine the transmission time, $T = L/v_p$, of the impulse propagating on the transmission line.

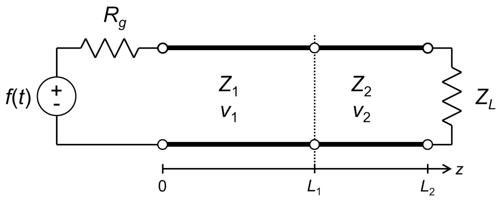
   d) Determine the speed of wave propagation on the line, v_p, in m/s and the length of the transmission line, L in meters.

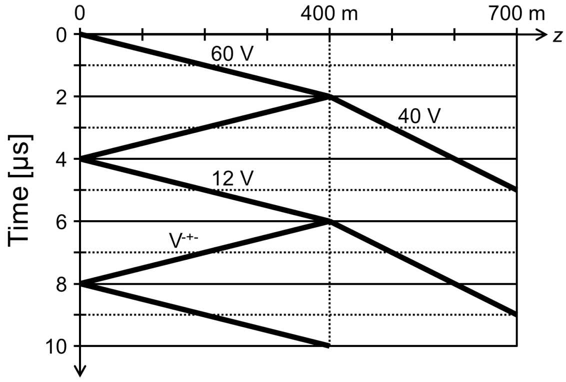
   e) Determine the next two voltage impulses (magnitudes and time delays) that will be measured at z_0 on the line for $t > 9\,\mu$s.

   f) Sketch a bounce diagram for the *current* waveform $I(z,t)$ — not the voltage waveform as we have often done — for $0 < t < 12\,\mu$s. Be sure to mark the numerical values for the amplitude of the current in the diagram.

   g) What is the algebraic expression for the current waveform as a function of (z,t) for the domain $0 < z < L$ and $0 < t < 12\,\mu$s?

3. A system of two transmission lines connected in series are driven by a voltage source $f_i(t) = V_0 u(t)$ and terminated by a resistive load of $60\,\Omega$ as shown in the figure below. A switch is closed at $t = 0$ and the positive voltages are measured for 5 μs giving the bounce diagram shown in the figure — the voltage values indicated in the diagram correspond to delta function weights times the source voltage V_o, products such as $V_o\tau_g$, $V_o\tau_g(1 + \Gamma_{12})$, etc.





The impedance and transmission time of line 1 are Z_1 and T_1 and those of line 2 are Z_2 and T_2. Using the figures, identify the following parameters in appropriate units:

a) Transmission times T_1 and T_2

b) Propagation velocity v_{p1} on line 1, and propagation velocity v_{p2} on line 2

c) Impedance Z_2

d) Reflection coefficient Γ_{12} between lines 1 and 2

e) Impedance Z_1

f) Source resistance R_g

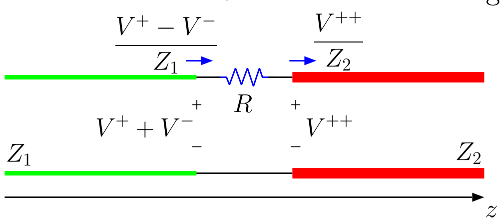
g) Source voltage V_o

h) Reflected voltage V^{-+-} on line 1 (see the diagram for this notation)

i) Steady state voltage V_1 on line 1 as $t \to \infty$

j) Steady state voltage V_2 on line 2 as $t \to \infty$

4. Two T.L.'s with characteristic impedances Z_1 and Z_2 are joined at a junction that also includes a series resistance R as shown in the diagram below.

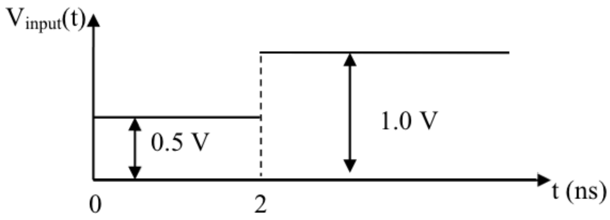


a) Write the pertinent KVL and KCL equations at the junction that relate $V^+(t - \frac{z}{v_{p1}})$, $V^-(t + \frac{z}{v_{p1}})$ and $V^{++}(t - \frac{z}{v_{p2}})$.

b) Solve the KVL and KCL equations above to obtain the reflection and transmission coefficients $\Gamma_{12} \equiv \frac{V^-}{V^+}$ and $\tau_{12} = \frac{V^{++}}{V^+}$ for the junction.

c) Calculate $\Gamma_{12} \equiv \frac{V^-}{V^+}$ and $\tau_{12} = \frac{V^{++}}{V^+}$ for $Z_1 = 50\,\Omega,\ Z_2 = 25\,\Omega$, and $R = 100\,\Omega$.

5. A defect in one of the wires of a transmission line manifests itself as an effective series resistance at a distance d from the input. The transmission line is lossless, of length 4 m, and propagation speed $v = 2 \times 10^8$ m/s. The load impedance is 50 Ω. When the line is driven by a unit step voltage source with internal (Thevenin) source impedance of 50 Ω, the voltage response at the input of the line, $V(0,t)$, is depicted in the figure below (where time is denoted in ns):



a) Calculate the characteristic impedance of the transmission line;

b) Calculate the distance d from the source where the defect occurs;

c) Calculate the defect resistance;

d) Plot the voltage response at the load.