TRANSIENT-DOMAIN ANALYSIS OF T. L. CIRCUITS

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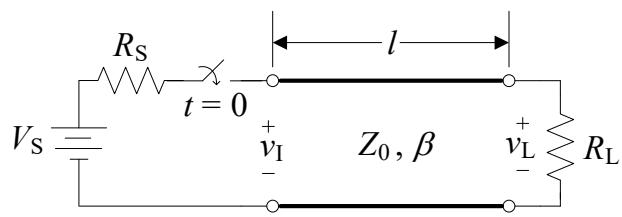
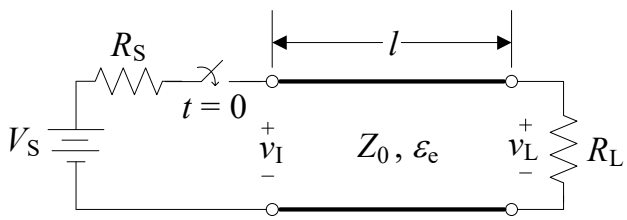
PROBLEMS

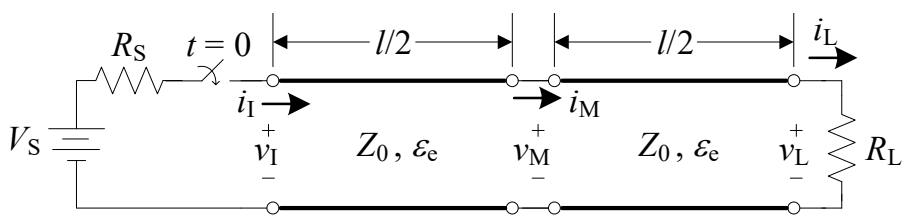
1. The following circuit uses a transmission line with an inductance per-unit length L = 333.325 nH/m, a capacitance per-unit length C = 133.33 pF/m, and a physical length l = 1 m. A DC voltage V_S = 3 V is applied to the transmission line at t = 0 s. Using bouncing diagrams, plot the voltage at the input of the line (v_I) and at the load (v_L), from 0 to 80 ns, when: a) R_S = 50 Ω, R_L = 50 Ω; b) R_S = 5 Ω, R_L = 50 Ω; c) R_S = 50 Ω, R_L = 10 KΩ; and d) R_S = 5 Ω, R_L = 10 KΩ.



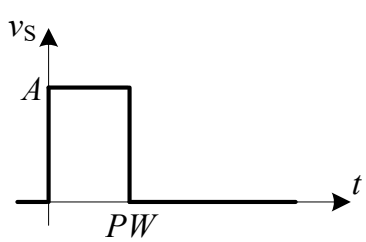
2. The following circuit uses V_S = 2 V, R_S = 20 Ω, R_L = 200 Ω, Z_0 = 50 Ω, ε_e = 4, and l = 15 cm. a) Using a voltage bouncing diagram, plot the voltage at the input of the line (v_I), and at the load (v_L), from 0 to 10 ns. b) Using a current bouncing diagram, plot the current at the input of the line (i_I), and at the load (i_L), from 0 to 10 ns.

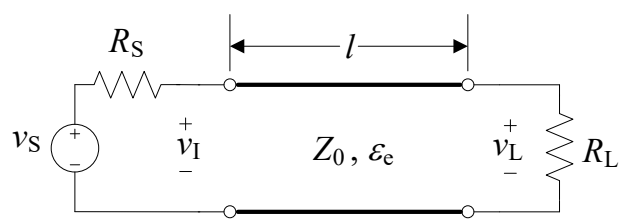


3. The following circuit uses V_S = 1.5 V, R_S = 15 Ω, R_L = 150 Ω, Z_0 = 50 Ω, ε_e = 2.2, and l = 20 cm. Using a bouncing diagram, plot the voltage at the input of the line (v_I), at the middle of the line (v_M), and at the load (v_L), from 0 to 6 ns.

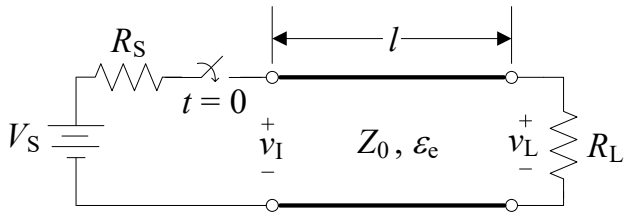


4. An ideal positive voltage pulse v_S with amplitude A = 5 V and pulse width PW = 2.5 ns is applied to the following transmission line circuit. Using bouncing diagrams, plot v_I and v_L from 0 to 8ns. Assume R_S = 15 Ω, R_L = 150 Ω, Z_0 = 50 Ω, ε_e = 9, and l = 10 cm.

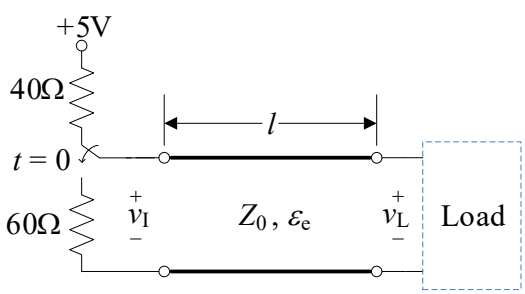


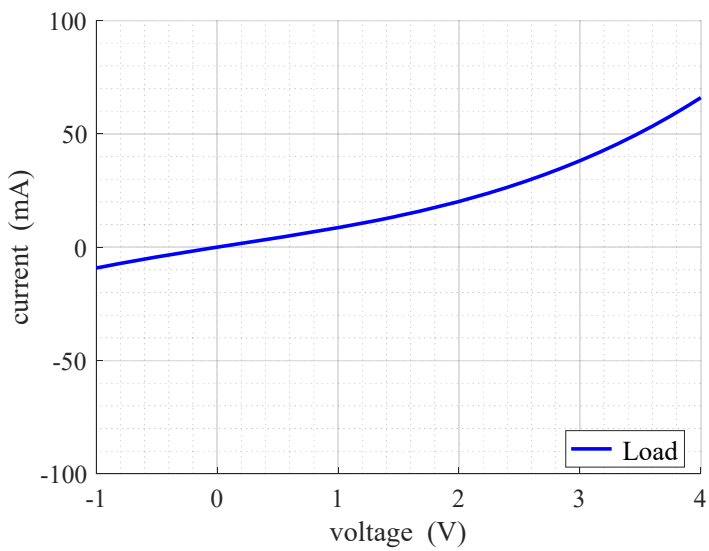


5. The following circuit uses V_S = 2 V, R_S = 20 Ω, R_L = 200 Ω, Z_0 = 50 Ω, as in the previous Problem 2. Using a Bergeron diagram, plot the following waveforms in time delays t_d (from 0 to $9t_d$): the voltage at the input of the line (v_I) and at the load (v_L), as well as the current at the input of the line (i_I) and at the load (i_L). Confirm that you get the same results as in Problem 2. Calculate the steady state voltage V_{ss} and current I_{ss} along the line.



6. El siguiente circuito utiliza un driver y una carga como se indica abajo. Si Z_0 = 50 Ω, a) dibujar el diagrama de Bergeron correspondiente; b) dibujar las formas de onda del voltaje en la entrada, v_I, y del voltaje en la carga, v_L, de 0 a 5 retardos de tiempo.

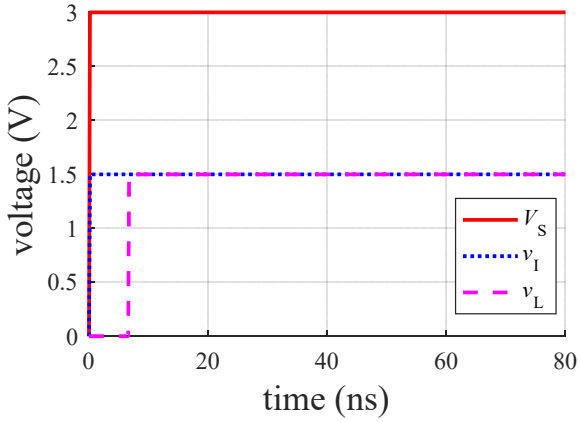




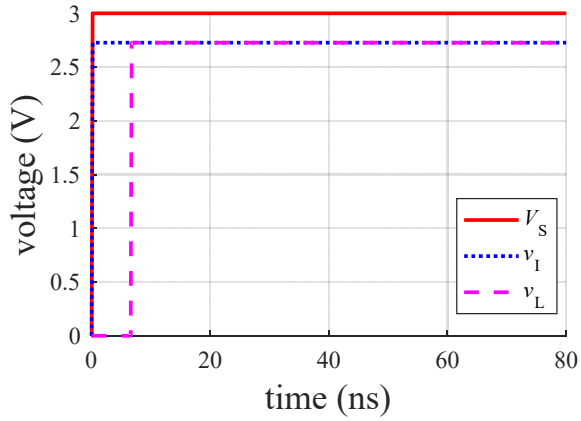
SOLUTIONS

1.

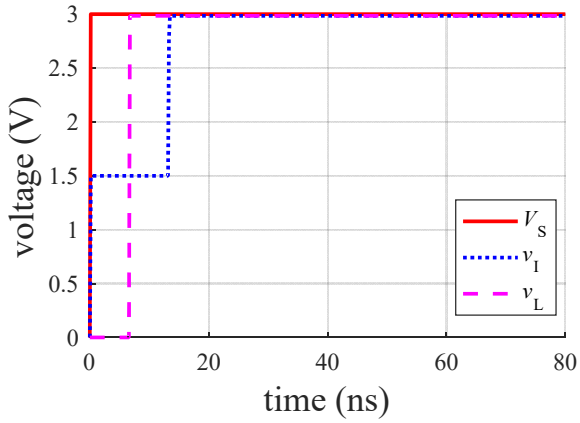
a) $R_S = 50\Omega$, $R_L = 50\Omega$



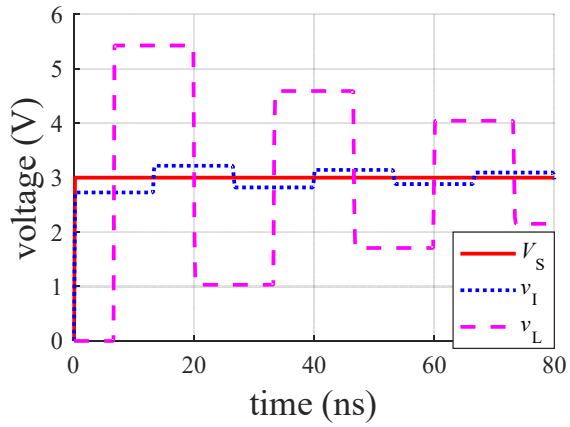
b) $R_S = 5\Omega$, $R_L = 50\Omega$



c) $R_S = 50\Omega$, $R_L = 10K\Omega$

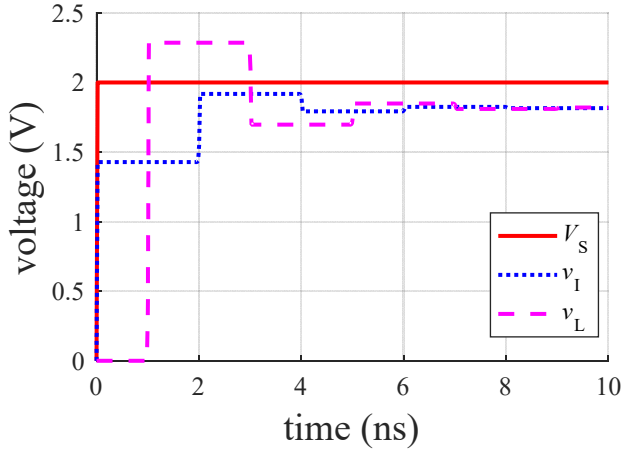


d) $R_S = 5\Omega$, $R_L = 10K\Omega$



2.

a)



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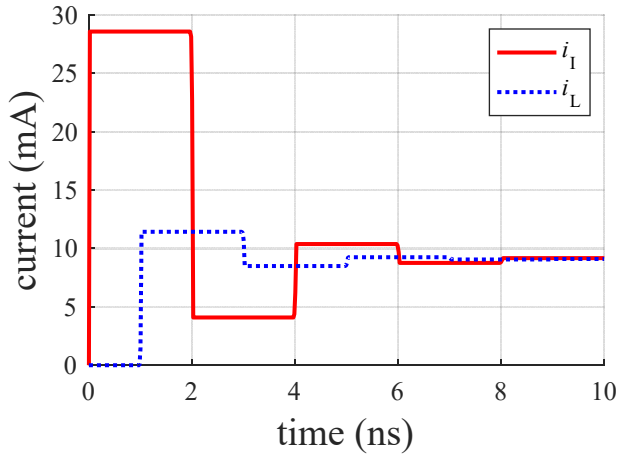

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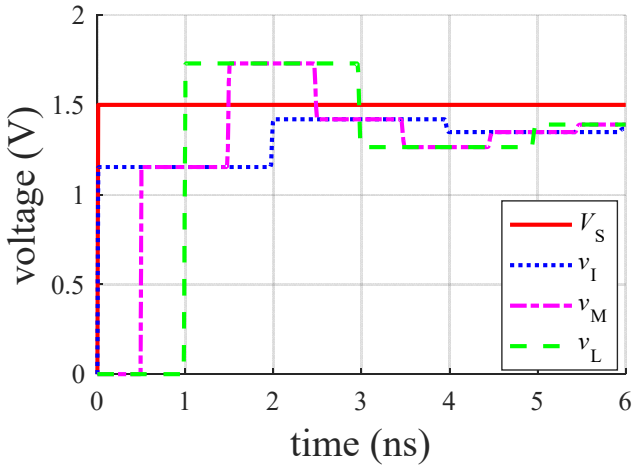

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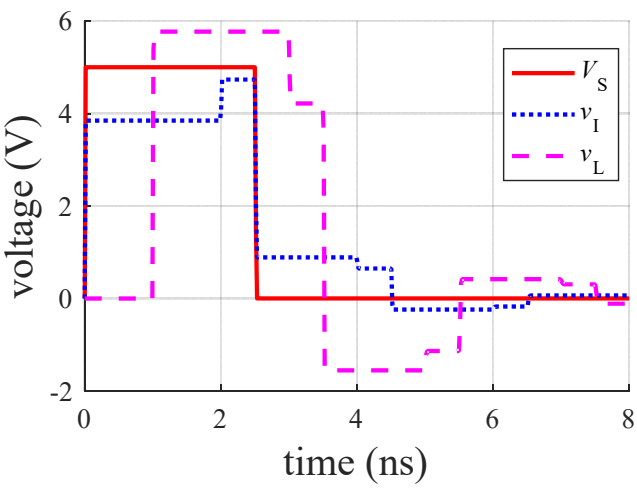

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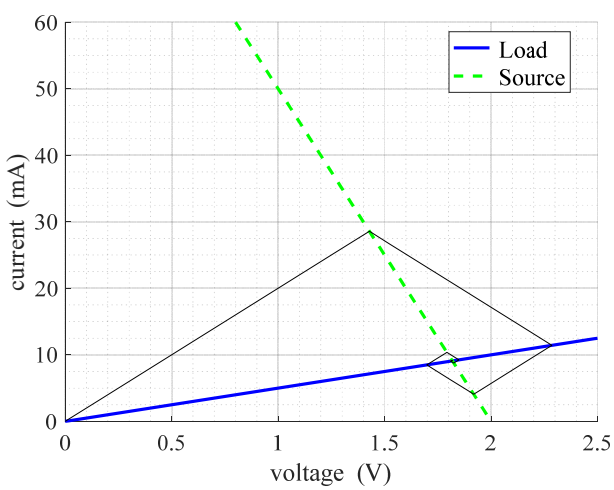
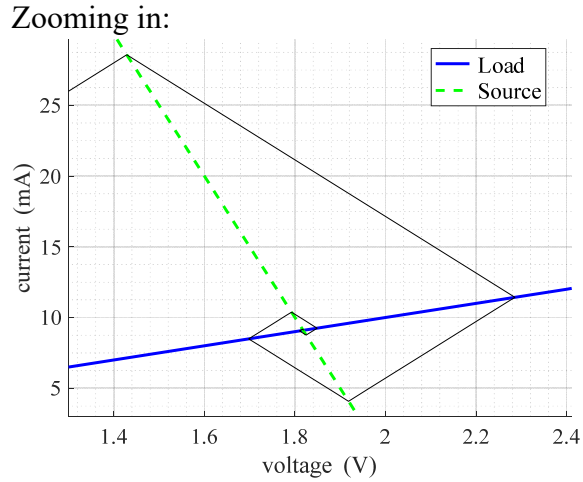
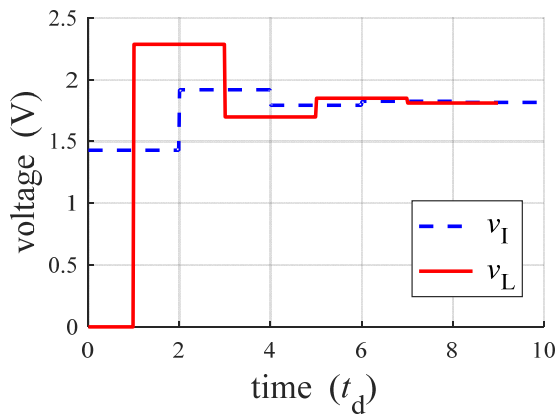


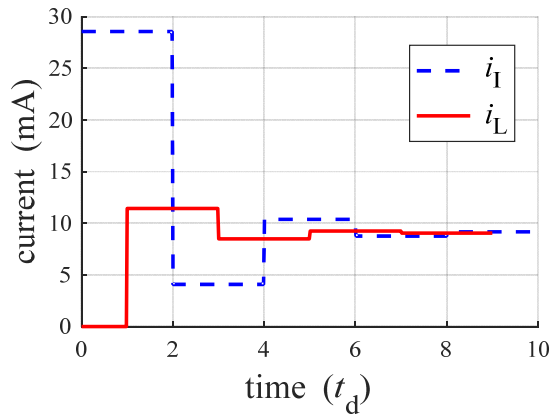
Zooming in:



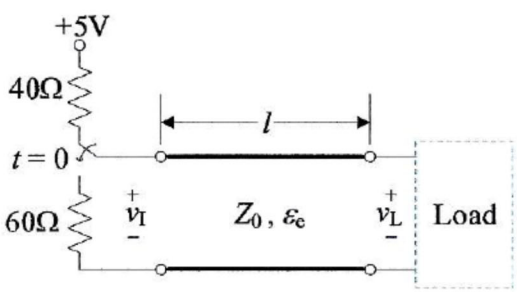
Steady state voltage and current:
V_{ss} = 1.82 V
I_{ss} = 9.09 mA

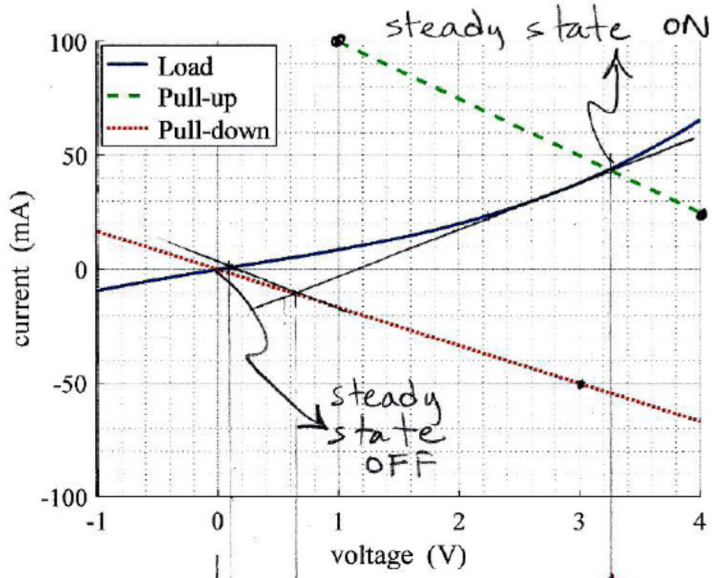
Numerical readouts:
i_I (mA) = [28.57 4.08 10.38 8.76 9.18]
i_L (mA) = [0.00 11.43 8.49 9.25 9.05]
v_I (V) = [1.43 1.92 1.79 1.82 1.82]
v_L (V) = [0.00 2.29 1.70 1.85 1.81]



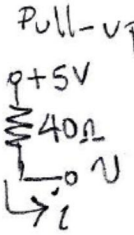


6.





Pull-up:



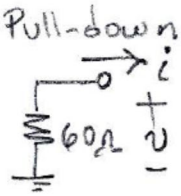
Si $v = 4\,V$,

$$i = \frac{1V}{40\Omega} = 25mA$$

Si $v = 1V$,

$$i = \frac{4V}{40\Omega} = 100mA$$

Pull-down:



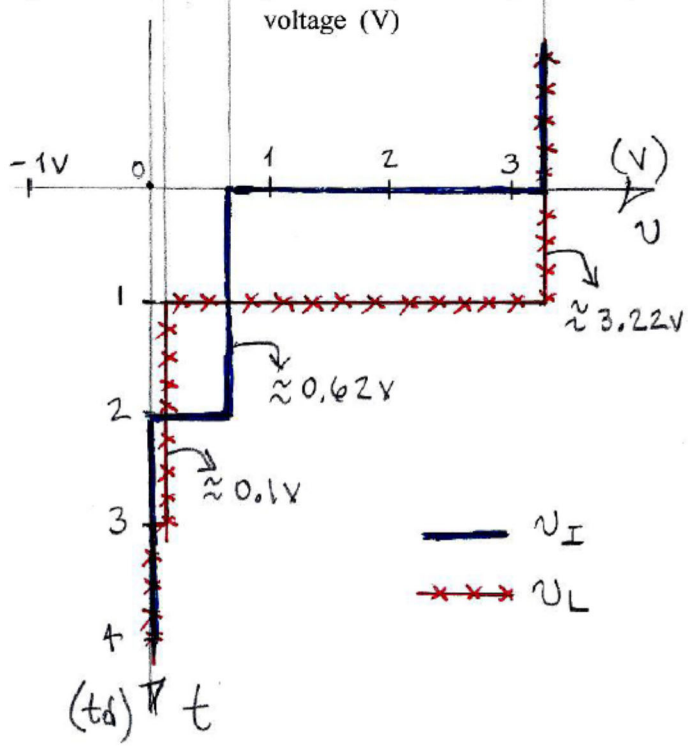
Si $v = 0V$,

$i = 0A$

Si $v = 3V$,

$$i = \frac{-3V}{60\Omega} = -50mA$$

TL:

$$\frac{1V}{Z_0} = \frac{1V}{50\Omega} = 20mA$$

$$\frac{0.5V}{Z_0} = \frac{0.5V}{50\Omega} = 10mA$$