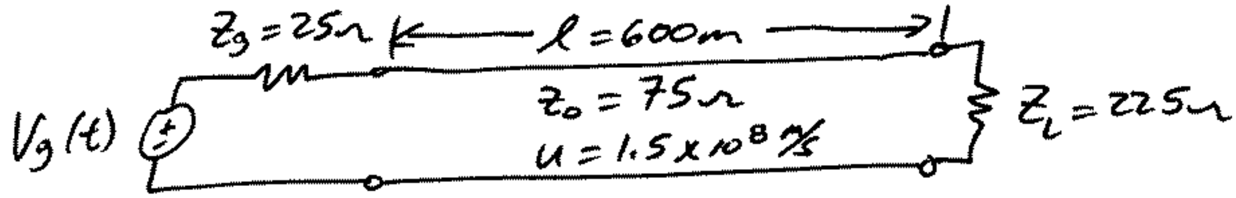
Step voltage input into transmission line

⇒ let $V_g(t) = 100\, u(t)$ V



$$T = \frac{\ell}{u} = \frac{600\text{m}}{1.5\times10^{8}\,\text{m/s}} = \underline{4\,\mu s}$$

$$\Gamma_L = \frac{Z_L - Z_0}{Z_L + Z_0} = \frac{225-75}{225+75} = \underline{0.5}$$

$$\Gamma_g = \frac{Z_g - Z_0}{Z_g + Z_0} = \frac{25-75}{25+75} = \underline{-0.5}$$

@ z=0

$$V_{init}(t) = V_g(t)\frac{Z_0}{Z_g + Z_0} = 100\,u(t)\frac{75}{25+75} = \underline{75\,u(t)\text{ V} = V_1^+}$$

$$I_{init}(t) = \frac{V_g(t)}{Z_g + Z_0} = \frac{100\,u(t)}{25+75} = \underline{1\,u(t)\text{ A} = I_1^+}$$

@ S.S. $(t\to\infty)$

$$V_{SS} = V_g(t\to\infty)\frac{Z_L}{Z_g+Z_L} = 100\frac{225}{25+225} = \underline{90\text{V}}$$

$$I_{SS} = \frac{V_g(t\to\infty)}{Z_g+Z_L} = \frac{100}{25+225} = \underline{0.4\text{A}}$$

answers should converge to these values

Find $v(z, t_1 = 3.5T) = V(z, 14\mu s)$

→ Draw horizontal line on voltage bounce diagram at $3.5T = 14\mu s$.

→ Draw vertical line from where the horizontal line crosses the bounce diagram down to the z-axis. This value of z is where there will be a discontinuity. Call it z_1.

$z_1 = 300\,m = \ell/2$

→ Add up voltage, on either side of z_1 below the horizontal line

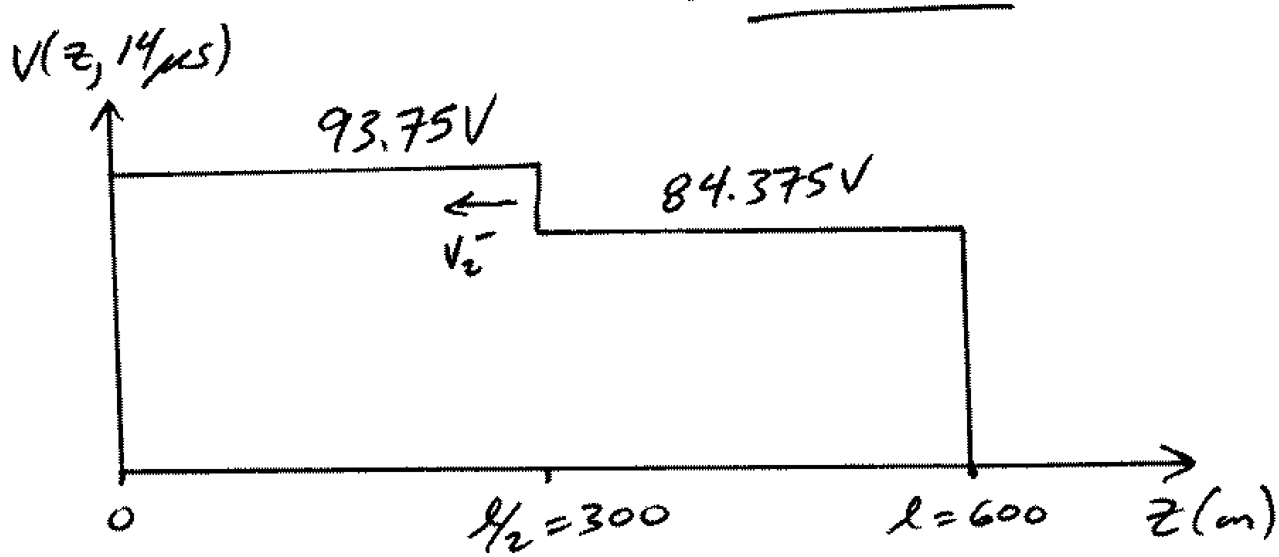
$0 \le z < z_1 \quad V(z, 14\mu s) = V_2^+ + V_1^- + V_1^+$

$= -18.75 + 37.5 + 75$

$= 93.75V$

$z_1 \le z \le \ell \quad V(z, 14\mu s) = V_2^- + V_2^+ + V_1^- + V_1^+$

$= 84.375V$



Find $i(z, t_2 = 4.75T) = i(z, 19\mu s)$

→ Draw horizontal line at $t_2 = 4.75T = 19\mu s$ on the current bounce diagram

→ Draw a vertical line from where the horizontal line crosses the bounce diagram down to the z-axis. This value of z is where there will be a discontinuity at

$z_2 = 450\,m = 3\ell/4$

→ Add up the currents on either side of z_2 below the horizontal line

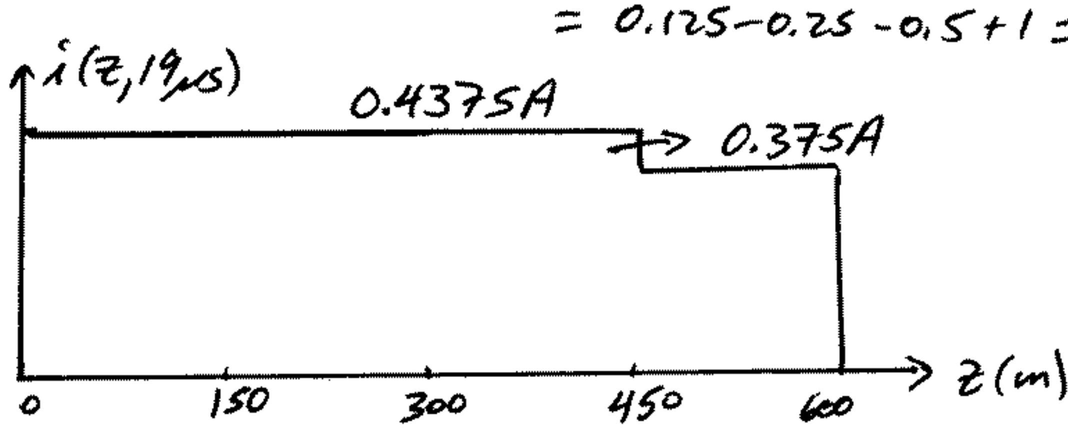
$0 \le z < z_2 \qquad i(z, 19\mu s) = I_3^+ + I_2^- + I_2^+ + I_1^- + I_1^+$

$= 0.0625 + 0.125 - 0.25 - 0.5 + 1$

$= \underline{0.4375A}$

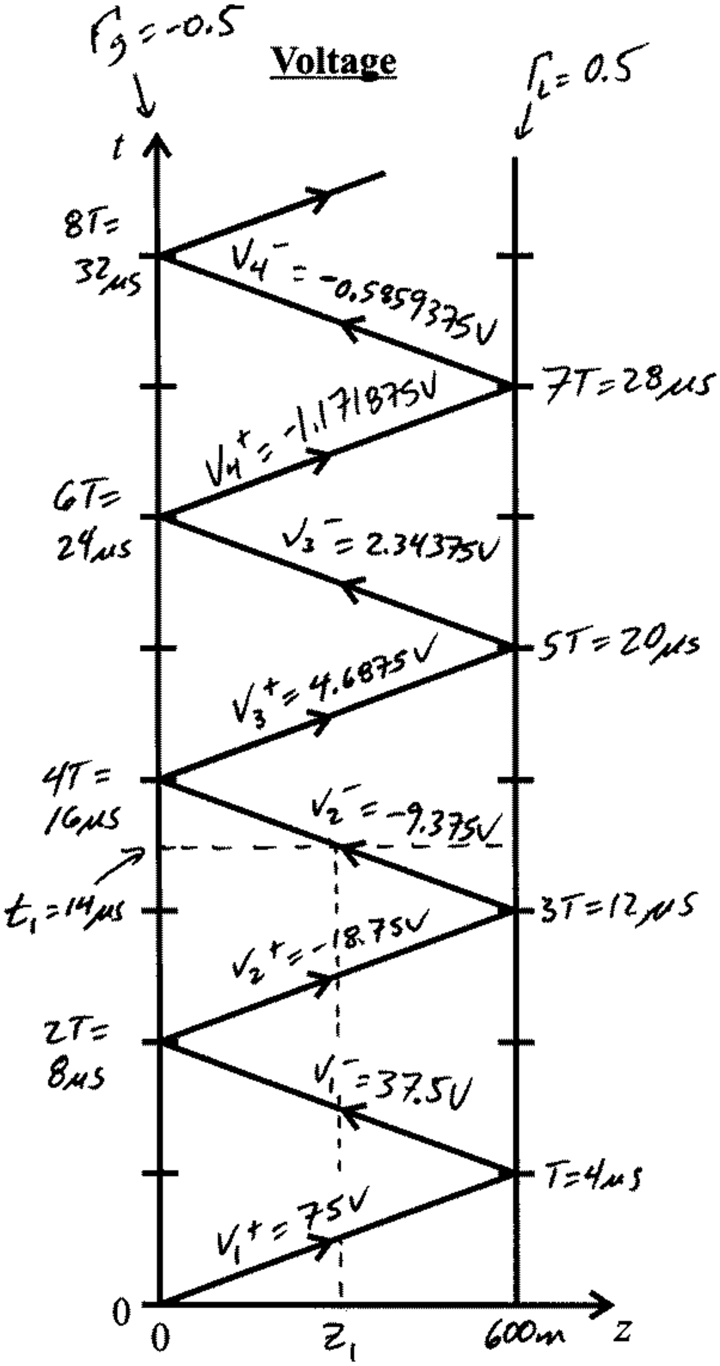
$z_2 \le z \le \ell \qquad i(z, 19\mu s) = I_2^- + I_2^+ + I_1^- + I_1^+$

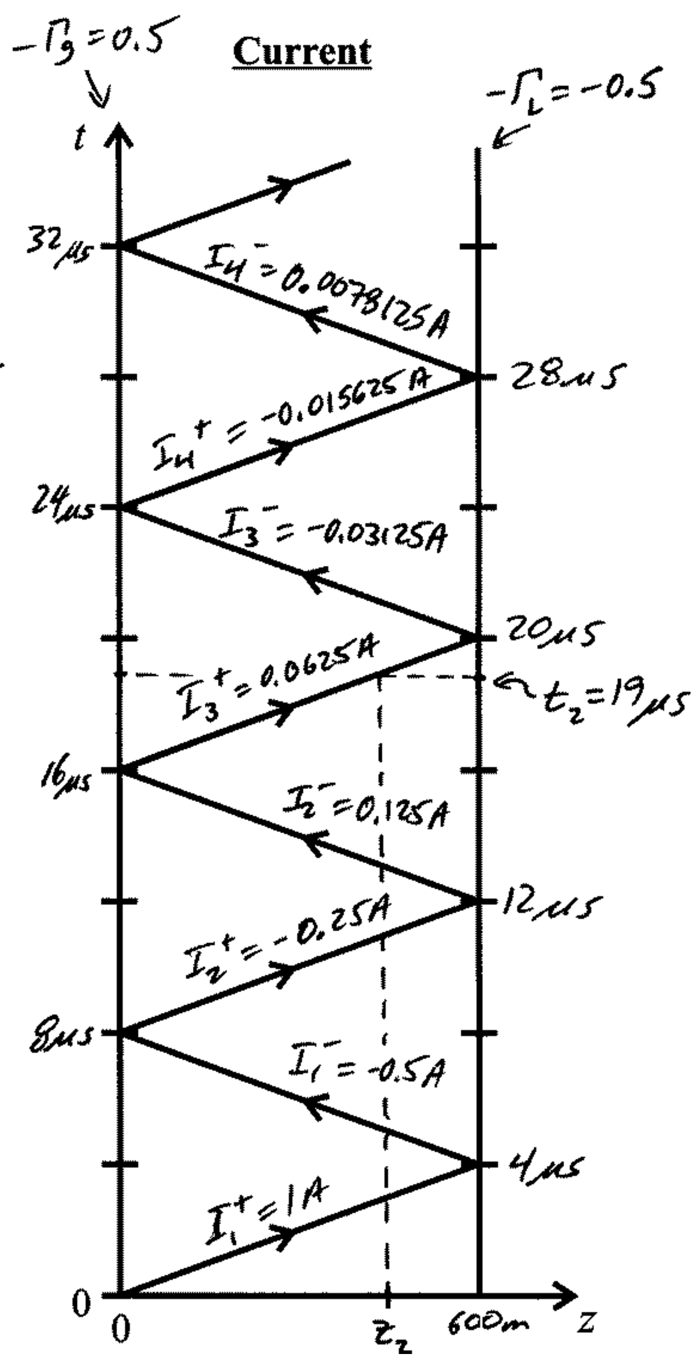
$= 0.125 - 0.25 - 0.5 + 1 = \underline{0.375A}$



Bounce diagrams

$V(z,\ t_1 = 3.5T = 14\,\mu s)$ $I(z,\ t_2 = 4.75T = 19\,ms)$





Find $V(z = \ell/2, t) = V(300\text{m}, t)$

→ Draw a vertical line up from $z = 300$m on the voltage bounce diagram

→ add up voltages as the vertical line crosses the bounce diagram, draw horizontal lines over to the time axis to note times where voltage level changes

$0 \le t < 2\mu s \quad V(300,t) = 0$

$2\mu s \le t < 6\mu s \quad V(300,t) = 75V$

$6\mu s \le t < 10\mu s \quad V(300,t) = 75 + 37.5 = 112.5V$

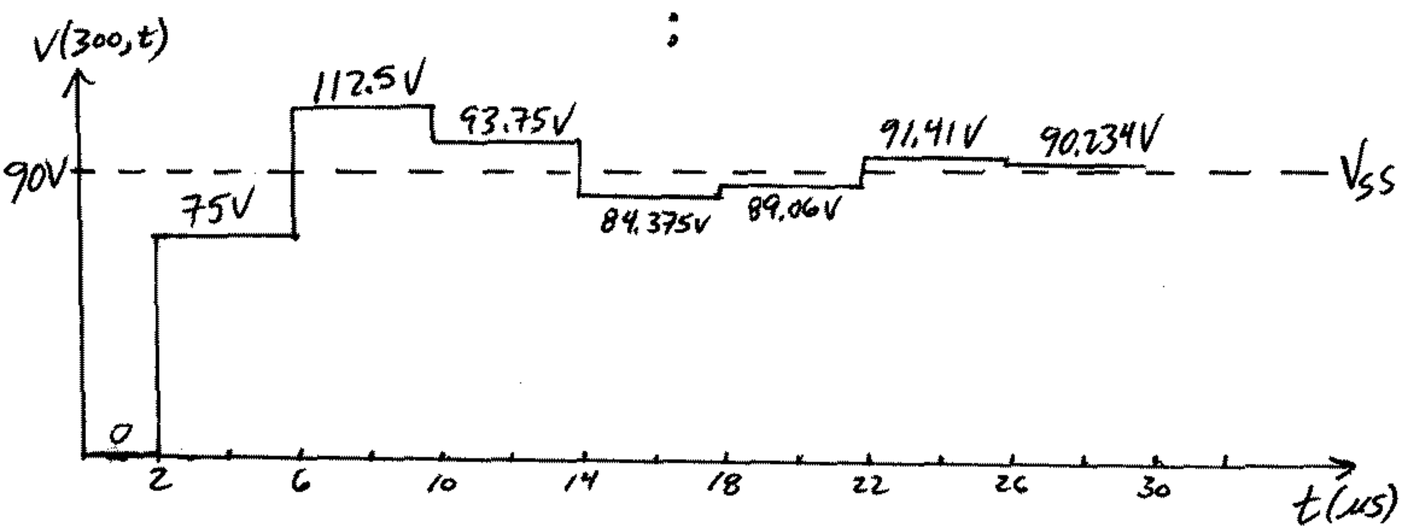
$10\mu s \le t < 14\mu s \quad V(300,t) = 112.5 + (-18.75) = 93.75V$

$14\mu s \le t < 18\mu s \quad V(300,t) = 93.75 - 9.375 = 84.375V$

$18\mu s \le t < 22\mu s \quad V(300,t) = 84.375 + 4.6875 = 89.0625V$

$22\mu s \le t < 26\mu s \quad V(300,t) = 89.0625 + 2.34375 = 91.40625V$

⋮



Find $i(z=\ell, t) = i(600m, t)$

→ use existing vertical line & time marks on current bounce diagram

→ add up currents as the vertical line at $z=\ell$ contacts bounce diagram & note times

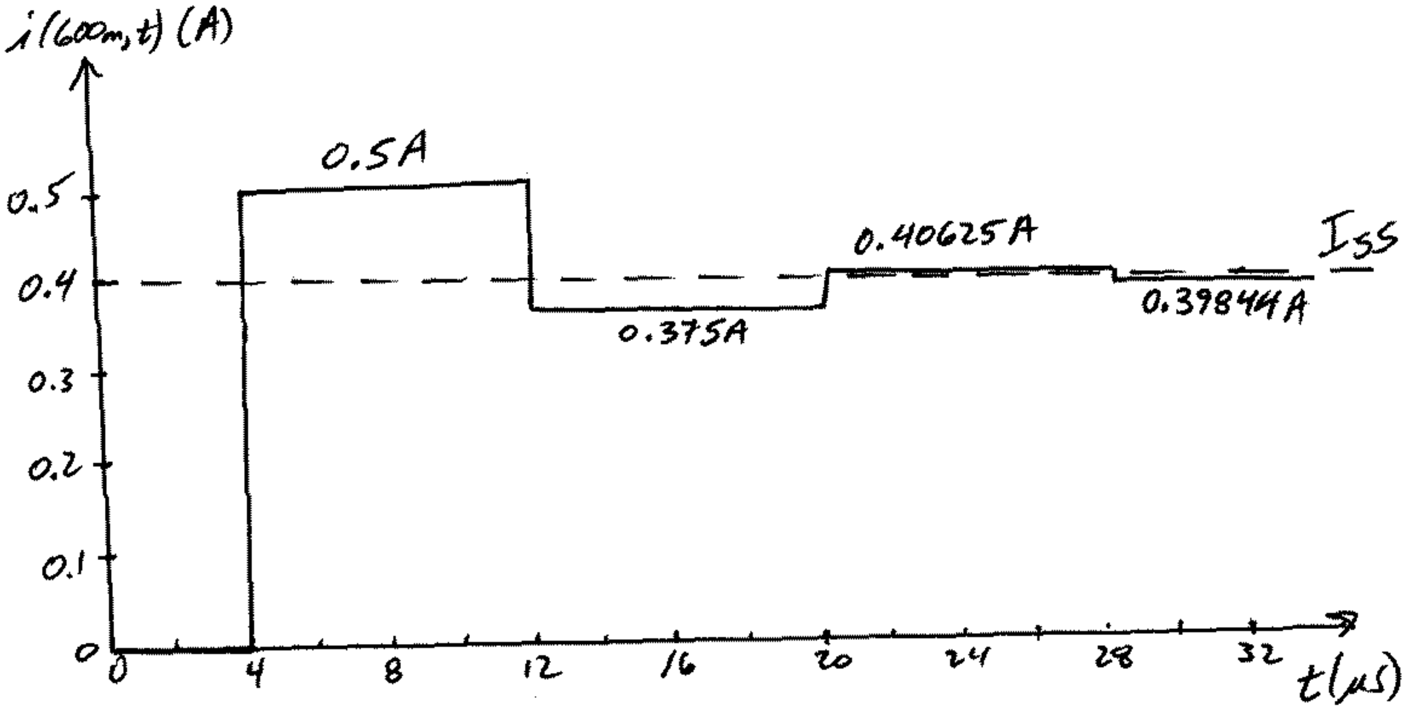
$0 \le t < 4\mu s$ $\quad i(600,t) = \underline{0}$

$4\mu s \le t < 12\mu s$ $\quad i(600,t) = 1 + (-0.5) = \underline{0.5A}$

$12\mu s \le t < 20\mu s$ $\quad i(600,t) = 0.5 + (-0.25 + 0.125) = \underline{0.375A}$

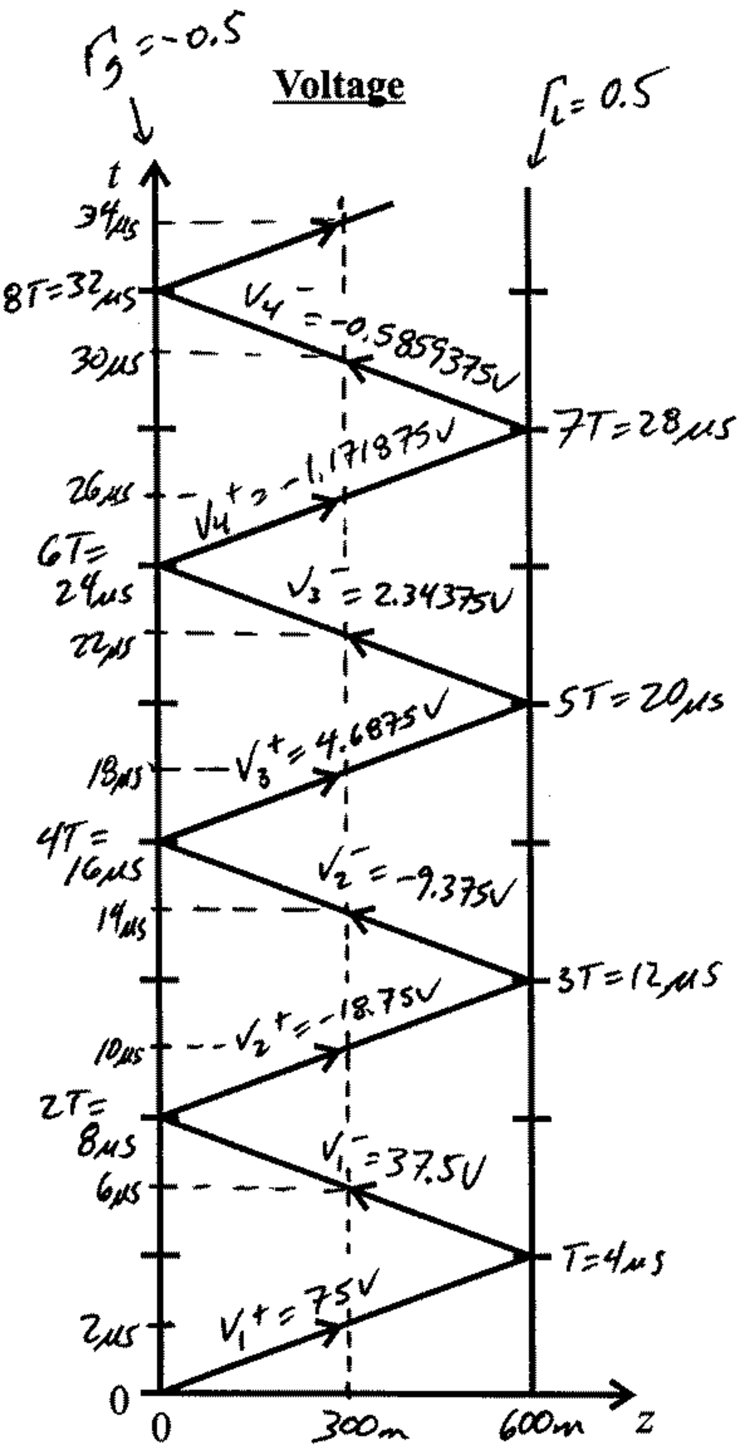
$20\mu s \le t < 28\mu s$ $\quad i(600,t) = 0.375 + (0.0625 - 0.03125) = \underline{0.40625\,A}$

$28\mu s \le t < 36\mu s$ $\quad i(600,t) = 0.40625 + (-0.015625 + 0.0078125) = \underline{0.3984375A}$



Bounce diagrams

$V(z=l/2=300\text{m}, t)$



$I(z=l=600\text{m}, t)$