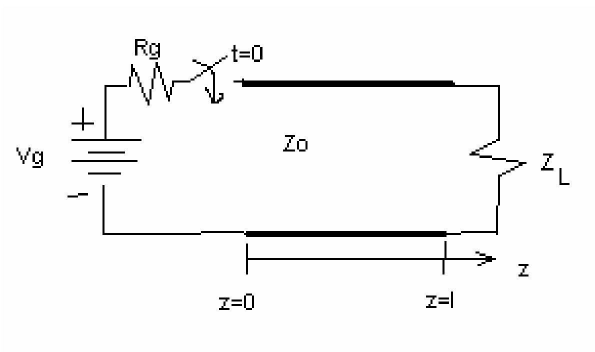
ECE 6130 LECTURE 5

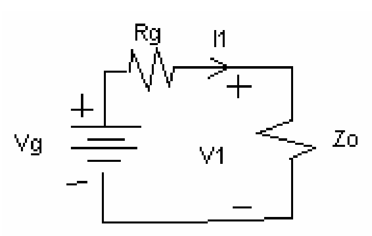
Text Section: 2.5,6

Portfolio: For a terminated lossless transmission line:
1) Describe how to find the voltage at any point on the line as a function of time
2) Describe how to find the voltage along the line at any point in time.

TRANSIENTS ON TRANSMISSION LINES

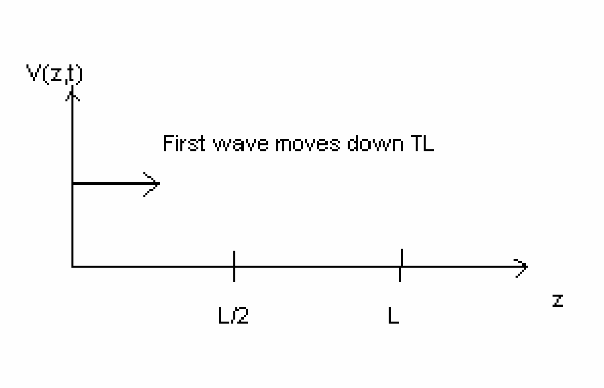


Note definition of z axis is different from previous work.

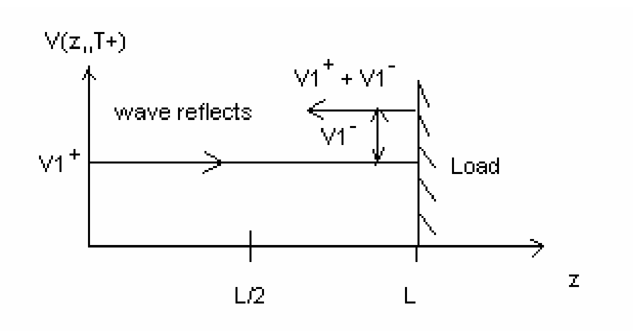


Equivalent circuit at initial time (t=0)
The switch is closed, no voltage has moved down the transmission line.
All the generator "sees" is Zo … Z_L is too far away.

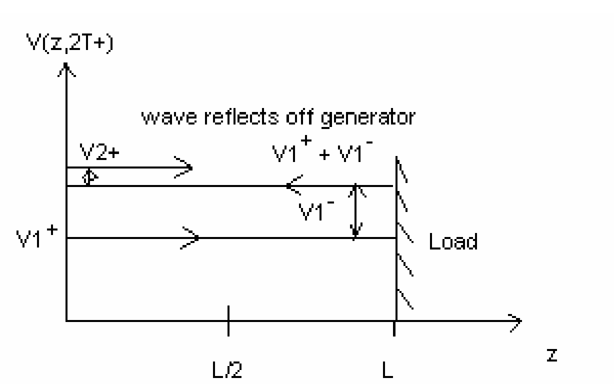
$I_1^+ = Vg / (Rg + Zo)$ ← + means positive-traveling wave, "1" means first wave
$V_1^+ = I_1^+ Zo = Vg\, Zo / (Rg + Zo)$



Velocity of wave vp = 1/ sqrt(εμ)
Wave moves down TL with no reflections until it reaches the load …
Time to reach load: T = L / vp



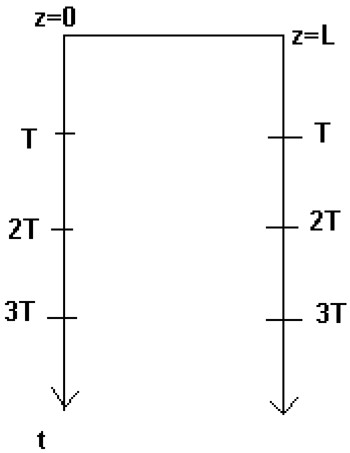
Wave reflects off load and starts back.
$V_1^- = \Gamma_L V_1^+$
$\Gamma_L = (Z_L - Zo) / (Z_L + Zo)$
(For $Z_L = 2$ Zo, $\Gamma_L = 1/3$ ← This is real … what happens if it is complex? Get phase change as well as reflection.)



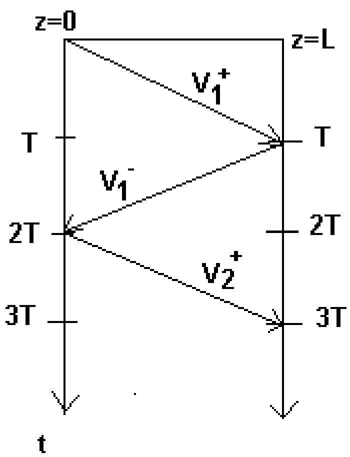
Wave V_1^- now reflects off generator.
New +-traveling wave is produced:
$V_2^+ = = \Gamma_g V_1^-$
$\Gamma_g = (Z_g - Zo) / (Z_g + Zo)$
Notice that reflections are getting progressively smaller.

Waves keep reflecting until STEADY STATE is reached:
(additional reflections are negligibly small)
$V\infty = Vg\, Z_L / (Rg + Z_L)$ ← Voltage on line at steady state.
This is the SAME as we would have observed in the DC case!
$I\infty = V\infty / Z_L = Vg / (Rg + Z_L)$

BOUNCE DIAGRAMS



Axes: Time and distance



$V_1^- = \Gamma_L V_1^+$

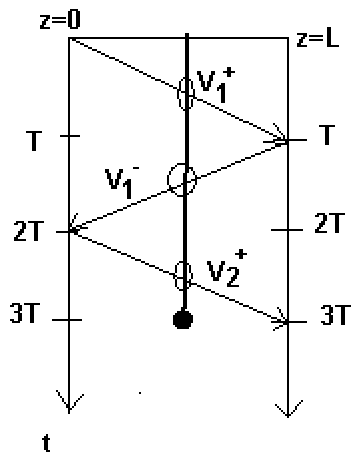
$V_2^+ = \Gamma g\, V_1^- = \Gamma g\, \Gamma_L V_1^+$

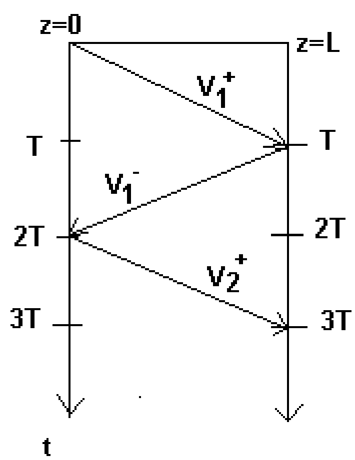
$V_2^- = \Gamma_L V_2^+ = \Gamma g\, \Gamma_L^2 V_1^+$

How to find V(z,t) for any z and t:

1. Find the point (z,t) on the bounce diagram (eg. Z= L/2, t = 3T)
2. Draw a line back to T=0

3. Add up all of the V traces you cross





$V(L/2,3T) = V_1^+ + V_1^- + V_2^+$

Example : Handout