Bounce Diagram

A graphic tool to help us do the bookkeeping. Using it, we can construct $v(z, t)$ at arbitrary $z$.

Assuming $\Gamma_c > 0$ and $\Gamma_g > 0$

Similarly, you can construct a plot for $i(z,t)$. That will look a bit different. It is not monotonic, due to the – signs.

The $v$ and $i$ each converge to their respective steady-state values.
A step delivers only 1 bit of information.

We send pulses to deliver lots of bits.

What we really care is how a pulse, not a step, will bounce back and forth.

A pulse is the superposition of two steps:

$$\text{Pulse}(t) = V_o \left[ u(t) - u(t - \tau) \right]$$

The transmission line system is linear.

The response to the superposition of two steps is the superposition of the two responses.

This justifies what we will do next.
A specific example (with numeric values) to show how we trace the echoes of a pulse using the bounce diagram:

\[ \Gamma_i = 0.5, \quad \Gamma_q = -0.6, \quad \tau = \frac{T}{2}, \quad v_i^+ = 4V \]

Plot \( v_L(t) \)

Pay attention to the value

What is the steady-state value?

Review textbook Section 2-12.2. Finish Homework 6.
Let’s consider some real-world situations.

\[ v_p = \frac{2}{3}c = 2 \times 10^8 \text{ m/s} \]

\[ R_L = R_g = 3Z_0 \implies \Gamma_L = \Gamma_g = 1/2 \]

\[ v(l, (2n + 1)T) = V_1^+ \left(1 + \frac{1}{2}\right) \left[1 + \frac{1}{4} + \frac{1}{4^2} + \frac{1}{4^3} + \cdots + \frac{1}{4^n}\right] \]

\[ 4^5 = 1024 \]

After \((2 \times 5 + 1)T = 11T\), the voltage load is already almost settled to the steady state.

\[ l = 2 \text{ m} \implies T = 10^{-8} \text{ s} = 10 \text{ ns} \implies 11T = 0.11\mu s \]

\[ l = 200 \text{ m} \implies T = 10^{-6} \text{ s} = 1 \mu s \implies 11T = 11\mu s \]

The transient happens “fast”!

But if you are sending “bits” of information (pulses), the voltage of the \(n\)th echo, which is at \(t = (2n + 1)T\), is \((2/3)V_1^+/4^n\). You would say the echoes die down too slowly!