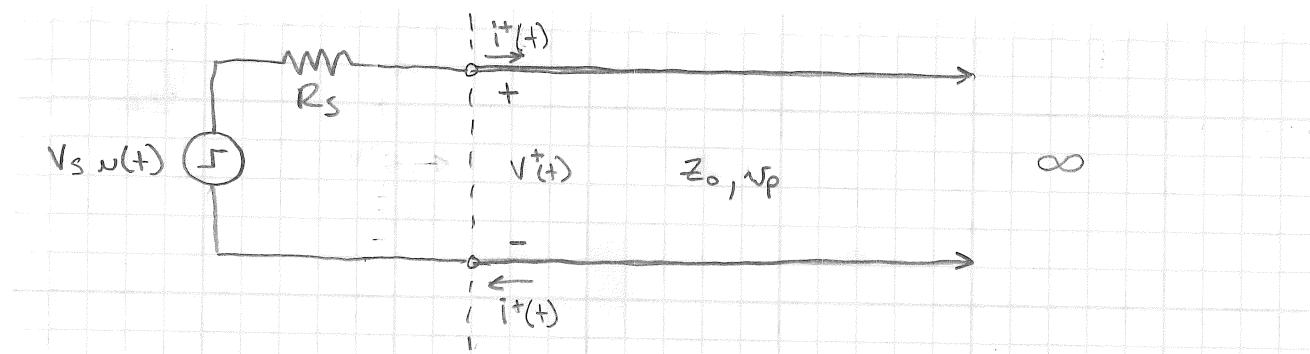


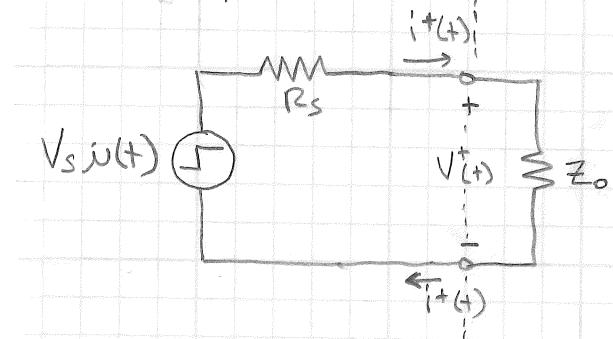
# LAUNCHING A WAVE ON AN INFINITELY LONG T-LINE



$V^+, i^+$  : VOLTAGE + CURRENT WAVE MOVING TOWARDS RIGHT

$V^-, i^-$  : VOLTAGE + CURRENT WAVE MOVING TOWARDS LEFT

An  $\infty$  length T-line can be modeled as a resistor of value  $Z_0$  at the T-line input.



The launched wave can not distinguish an  $\infty$  length line from a resistor of value  $Z_0$ .

$u(t)$  is the unit step function

$$u(t) = 0 \text{ for } t < 0$$

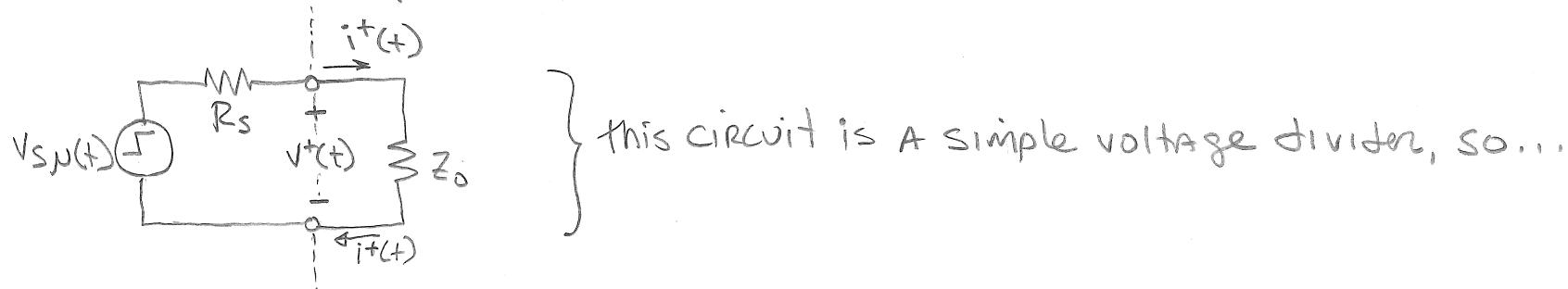
$$1 \text{ for } t > 0$$

undefined for  $t=0$

Note that  $V_s + R_s$  are considered lumped, not distributed.

## Launching A Wave, $\infty$ Length T-line

What is the Amplitude of the incident wave?



$$V^+(+) = V_{SP}(t) \left[ \frac{Z_0}{R_s + Z_0} \right] \quad \text{And} \quad i^+(+) = \frac{V^+(+)}{Z_0}$$

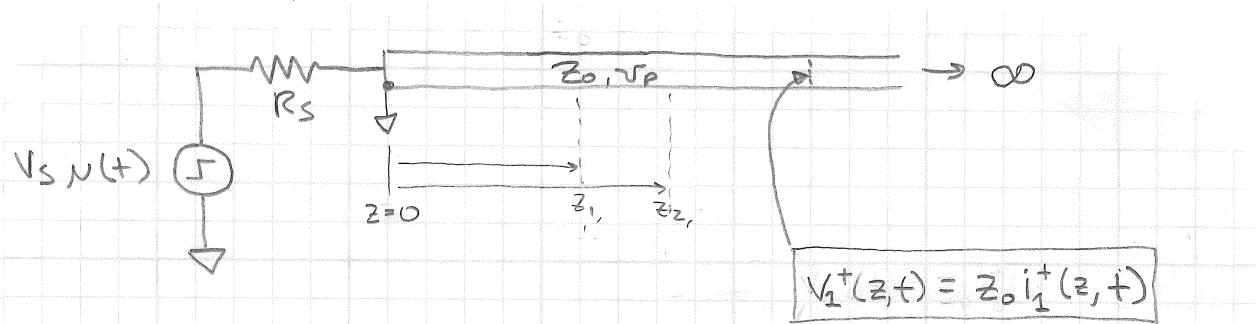
$$= \frac{V_{SP}(t)}{R_s + Z_0}$$

$$= \frac{1}{R_s + Z_0} V_{SP}(t)$$

What does this tell us about the Amplitude of the incident wave And the relative sizes of  $R_s$  &  $Z_0$ ? Is there A rule of thumb that we can remember?

# Launching A Wave on An $\infty$ Length T-Line

Additional Notation:  $V_1^+$  WAVE MOVING RIGHT  
 1<sup>ST</sup> wave that is moving right



First incident wave:

$$V_1^+(z, t) = V_s \left( \frac{Z_0}{Z_0 + R_s} \right) N \left( t - \frac{z}{v_p} \right)$$

1<sup>ST</sup> WAVE  
moving →

$$= V_s \left( \frac{Z_0}{Z_0 + R_s} \right) N(v_p t - z)$$

OR

$$i_1^+(z, t) = V_s \left( \frac{1}{Z_0 + R_s} \right) N \left( t - \frac{z}{v_p} \right)$$

$$= V_s \left( \frac{1}{Z_0 + R_s} \right) N(v_p t - z)$$

Go out a distance  $z$  and wait for the wavefront to reach you.  
 You will not see the wavefront until a time  $t > \frac{z}{v_p}$  has elapsed.

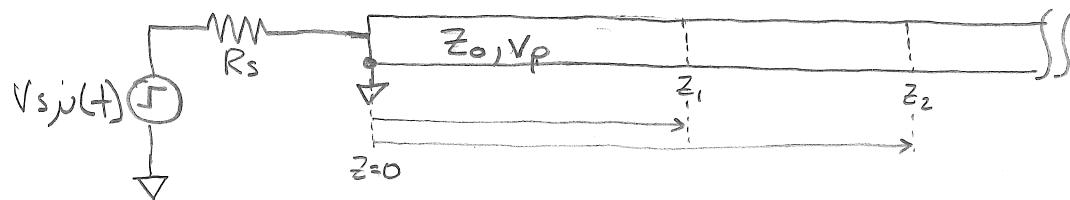
Let the edge travel down the T-line for a time  $t$  at velocity  $v_p$ .  
 Starting at  $z=0$ , travel down the T-line till you find the wavefront. It is found where  $z = v_p t$ . The voltage beyond this point is still zero, and behind you is  $V_s \left( \frac{1}{Z_0 + R_s} \right)$ .

A verbal narrative of the space/time relationship.

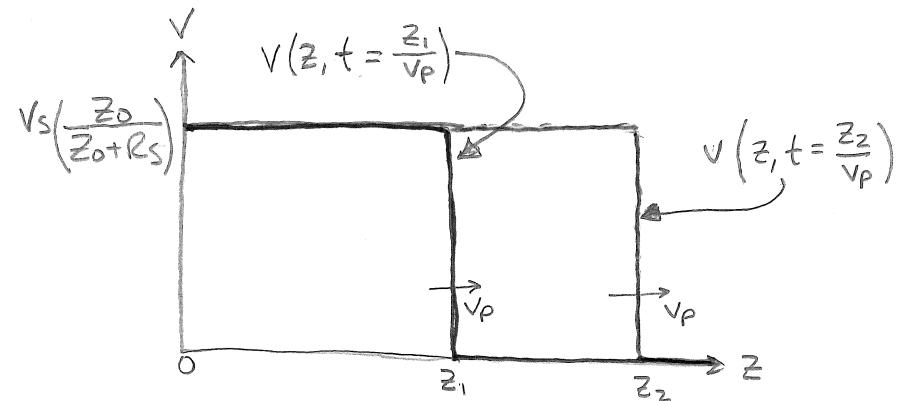
Remember that if the argument of the unit step function is  $< 0$  its zero

If the argument is  $> 0$ , its one

# Launching A Wave on An $\infty$ Length T-Line



$$\begin{aligned} v_1^+(z, t = \frac{z_1}{v_p}) &= V_s \left( \frac{Z_0}{Z_0 + R_s} \right) u\left(t_1 - \frac{z}{v_p}\right) \\ &= V_s \left( \frac{Z_0}{Z_0 + R_s} \right) u\left(\frac{(z - z_1)}{v_p}\right) \end{aligned}$$



Likewise for current,

$$\begin{aligned} i_1^+(z, t = \frac{z_1}{v_p}) &= V_s \left( \frac{1}{Z_0 + R_s} \right) N \left( t_1 - \frac{z}{v_p} \right) \\ &= V_s \left( \frac{1}{Z_0 + R_s} \right) N \left( \frac{(z - z_1)}{v_p} \right) \end{aligned}$$