

Revisit: open
reflection

- doubling @ end
- 2 waves on line

calculate Γ^t
in odd S₁₁ function

- open/short
- R
- LC
- ∞ line

Revisit waves
& propagation

VSWR

- Talking about transmission lines ~ homes for TEM waves
 - ↳ waveguides house TE/TM waves
- Characteristic impedance Lets us describe waves in their homes
 - relates I & V. @ one point → $Z_0 = \sqrt{\frac{L}{C}}$
- Propagation coefficient lets us relate waves @ 2 points
 - $\gamma = \alpha + j\beta$
 - $V(z) = V_0 e^{-\gamma z}$
 - $t_{delay} = \frac{d\phi}{d\omega}$
 - if you know voltage anywhere then you can "freeze time" & find it elsewhere.
- Recall a plane wave complex exponential is $A e^{j(\omega t - kz)}$
- (2) - Generalized this V(z) equation to define variable reflection coeff and impedance Z(z) & $\Gamma(z)$
- (3) - Reflection coefficient discusses how a finite line interacts with a load

$$\Gamma_L = \frac{Z_L - Z_0}{Z_L + Z_0} \quad \text{pronounce: } \text{en suus } Z_0 = \frac{V_i(z=0)}{V_r(z=0)}$$
 - Generates a reflection b/c extra current has to go somewhere
- Can use this σ wave description to write voltage on line

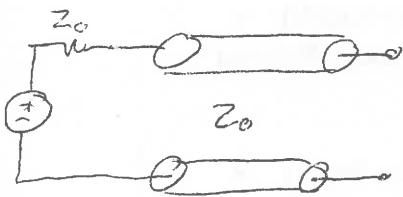
$$V(z) = V_{i0} e^{-\gamma z} + V_{r0} e^{\gamma z}$$

$$= V_{i0} e^{j(\omega t - kz - \gamma z)} + V_{r0} e^{j(\omega t - kz + \gamma z)}$$

From this we've learned 3 key skills we want to practice

- transmission line propagation modeling } practice today
- calculating reflection coefficients }
- calculating line properties from geometry } -HW b/c hard to do by hand
 - but $Z_0 = \sqrt{\frac{L}{C}}$ & $V \approx \frac{1}{\sqrt{LC}}$
 - know how to sketch fields + E/V

Calculate Γ for these situations:

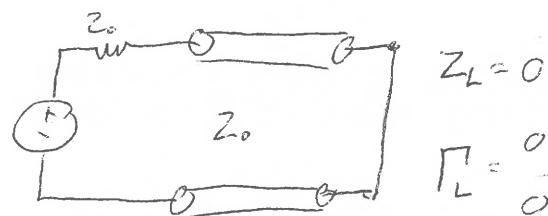


$$Z_L = \infty$$



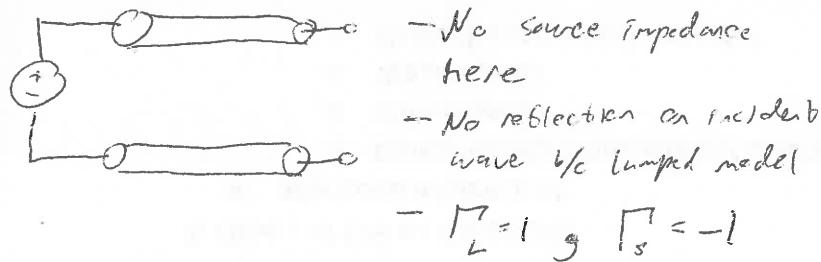
$$\Gamma = \frac{\infty - Z_0}{\infty + Z_0} = 1$$

- Note input voltage is $V/2$



$$Z_L = 0$$

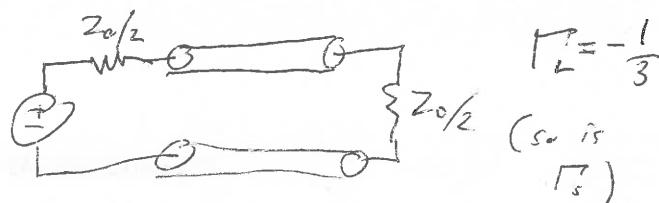
$$\Gamma_L = \frac{0 - Z_0}{0 + Z_0} = -1$$



- No source impedance here

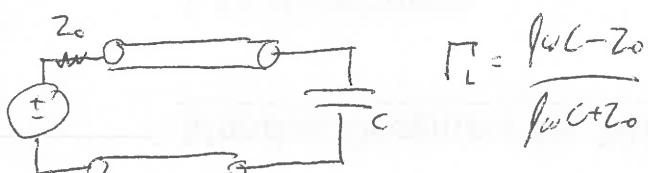
- No reflection on incident wave b/c lumped model

$$\Gamma_L = 1 \text{ and } \Gamma_s = -1$$



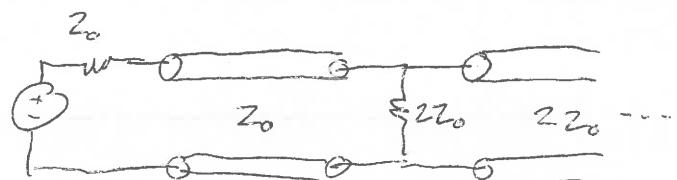
$$\Gamma_L = -\frac{1}{3}$$

(s_0 is Γ_s)



$$\Gamma_L = \frac{I_{wC} - Z_0}{I_{wC} + Z_0}$$

- Frequency dependent
- Complex, results in phase
- Both ok ... harder for S-parameters



- Load impedance is $2Z_0 \parallel Z_{line} = Z_0$

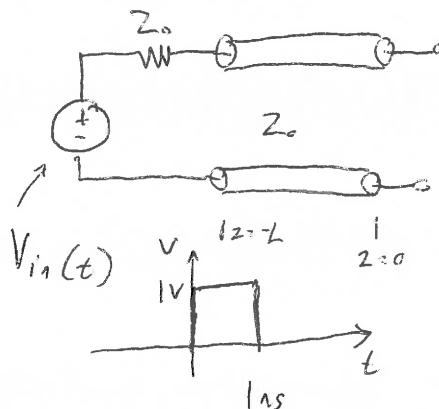
$$\Gamma_L = 0$$

- And line is ∞ , what about reflections?

$\hookrightarrow Z_{(2)}$ describes impedance of terminated line away from load

Modeling propagation

- revisit last class example, lossless line w/ open term



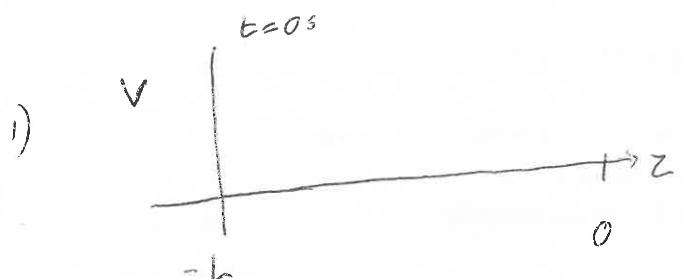
- V_m is boundary cond. to wave eq¹
on t-line

- per custom, set $z=0$ to be load location

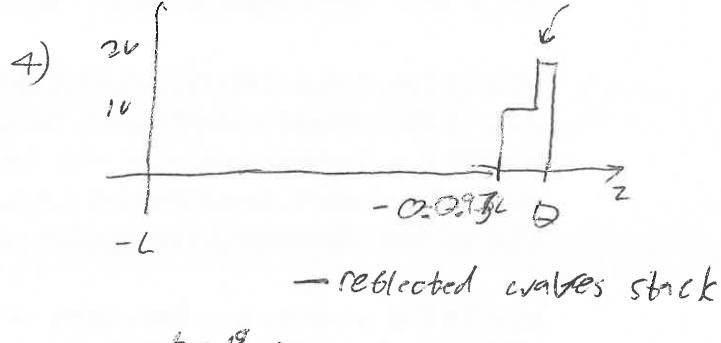
- Let ~~defn~~ $v = L/p_0 \cdot \frac{1}{n^5}$

$$z = 10^{15} \text{ ns}$$

$$-0.97L$$

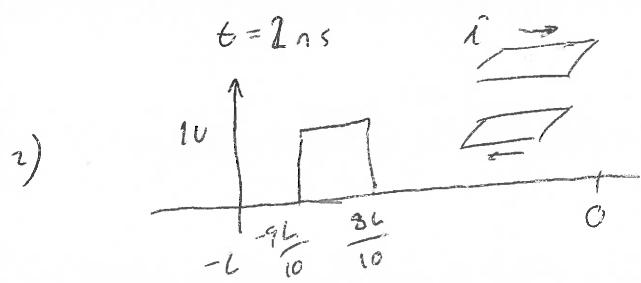


- Nothing asserted yet, no wave



- reflected waves stack

$$t = 18\text{ ns}$$

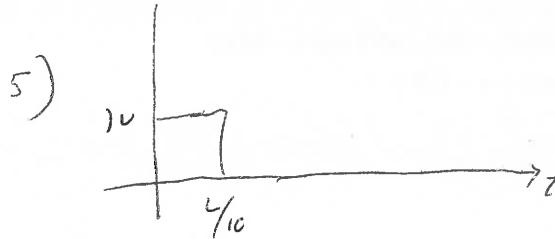


- rising edge propagates then falling edge

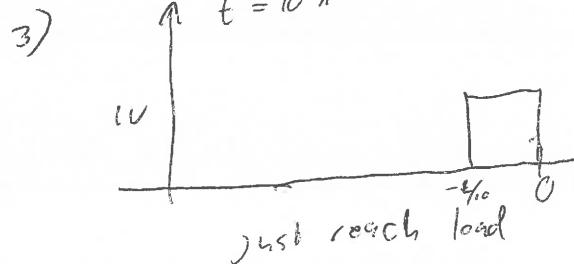
- sol² is $V_m(t-z/v_f)$

- No reflected wave, can imagine it at $2L$

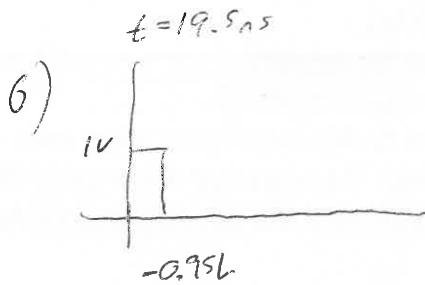
- Not using $V_0 e^{-j\omega z}$ b/c phase tricky



- goes back, reflected wave +ve



just reach load



- wave just gets eaten by input term.