EE331 – LECT. #6 JAN. 27, 2020

in last lecture:

$$\ell/\lambda \ll 1 \rightarrow \text{ignore TL}$$

$$\ell/\lambda \gtrsim 0.01 \rightarrow \text{may not be able to ignore}$$

for $\ell = 2.5$ cm, $f = 2$ kHz:

$$\ell/\lambda \cong 1.7 \times 10^{-7} \ll 1$$

for $\ell = 10$ km, $f = 2$ kHz:

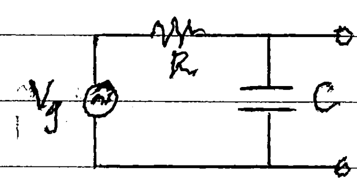
$$\ell/\lambda \cong 0.07 \gtrsim 0.01$$

power in U.S. → $f = 60$ Hz, for $u = c$ what is λ?

$$\lambda = u/f = 5 \times 10^6 \text{ m} \cong 3107 \text{ mi}$$

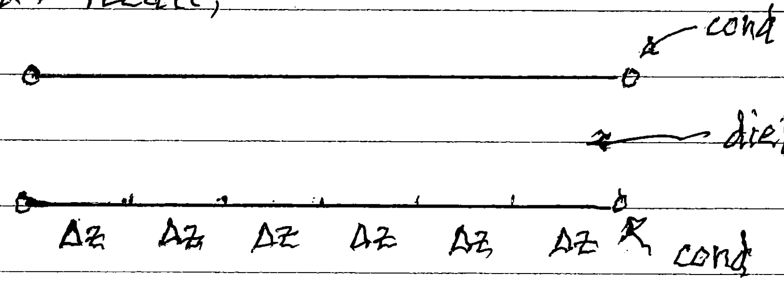
<u>lumped element model of TL</u>

consider:



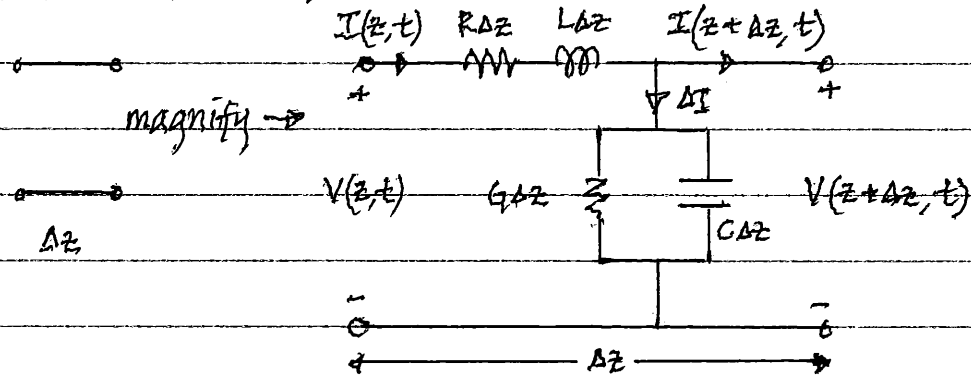
R, C, etc, are lumped elements

TL's have R, C, etc, but distributed throughout TL, not lumped. recall,



we break the line into tiny chunks Δz long.

consider one chunk:



lumped element model

TL parameters

1. R, L, G, C
2. funcs only of physical properties of a TL, i.e., the way they're made & for a fixed f (table 11.1)
3. units in per meter
   e.g., $R\,[\Omega/m]$ $\quad R\Delta z = [\Omega/m][m] = [\Omega]$
4. 2 conductors → R, L
   - R = resistance (loss in conductors) $[\Omega/m]$
   - L = inductance $[H/m]$
5. diel separating conductors → G
   - G = conductance (loss in dielectric) $[\mho/m]$
6. 2 conds + diel → C
   - C = capacitance $[F/m]$

derivation of TL eqs - want to find V & I

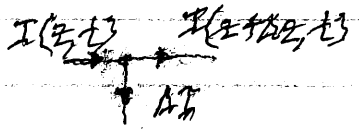
KVL: $V(z,t) = R\Delta z\, I(z,t) + L\Delta z \frac{\partial I(z,t)}{\partial t} + V(z+\Delta z, t)$

rearrange & take limit as $\Delta z \to 0$

$$\lim_{\Delta z \to 0} -\frac{V(z+\Delta z,t) - V(z,t)}{\Delta z} = RI(z,t) + L\frac{\partial I(z,t)}{\partial t}$$

$$\boxed{-\frac{\partial V(z,t)}{\partial z} = RI(z,t) + L\frac{\partial I(z,t)}{\partial t}}$$

KCL:



$$I(z,t) = \Delta I + I(z+\Delta z, t)$$

$$= G\Delta z\, V(z+\Delta z,t) + C\Delta z \frac{\partial V(z+\Delta z,t)}{\partial t} + I(z+\Delta z,t)$$

rearrange & take limit:

$$\lim_{\Delta z \to 0} -\frac{I(z+\Delta z,t) - I(z,t)}{\Delta z} = GV(z+\Delta z,t) + C\frac{\partial V(z+\Delta z,t)}{\partial t}$$

$$\boxed{-\frac{\partial I(z,t)}{\partial z} = GV(z,t) + C\frac{\partial V(z,t)}{\partial t}}$$

these are the TL eqs. also called telegrapher's eqs convert the TL eqs to phasor ~~form~~ form.

$$V(z,t) = Re\{V_s(z)e^{j\omega t}\}$$

$$I(z,t) = Re\{I_s(z)e^{j\omega t}\}$$

$$\frac{\partial}{\partial t} \to j\omega$$

then,

$$-\frac{dV_s}{dz} = (R + j\omega L)I_s \qquad (1)$$

$$-\frac{dI_s}{dz} = (G + j\omega C)V_s \qquad (2)$$