TDT10: Coupling Between Transmission Lines

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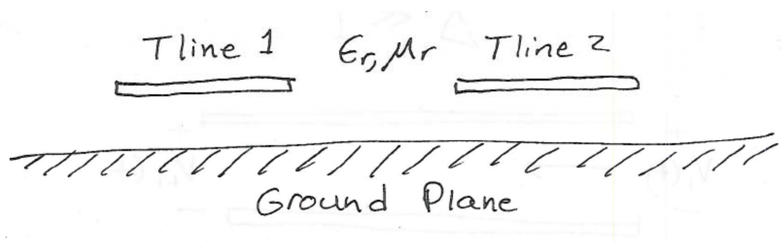
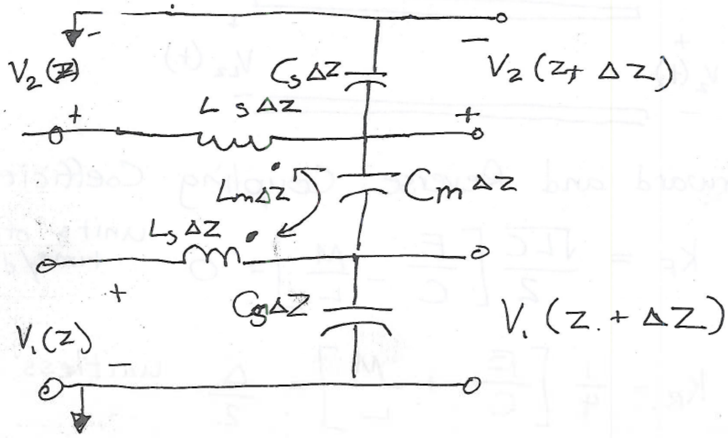
Physics of Coupling



- Occurs when lines are either close and/or have very poor field confinement
- Magnetic coupling through Faraday's law
- Electric coupling through Coulomb's law

Per Unit Length Circuit Model



$$L = L_s \qquad C = C_s + C_m$$

$$E = C_m \qquad M = L_m$$

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Measure of Coupling

$$L = L_s \qquad C = C_s + C_m$$

$$E = C_m \qquad M = L_m$$

If line is embedded in a homogeneous medium.

① $$\frac{M}{L} = \frac{E}{C} \Longrightarrow \Delta = \frac{M}{L} = \frac{E}{C}$$

② $$LC - ME = LC(1-\Delta^2) = \mu\epsilon$$

$\Delta = 0 \longrightarrow$ no coupling in the system

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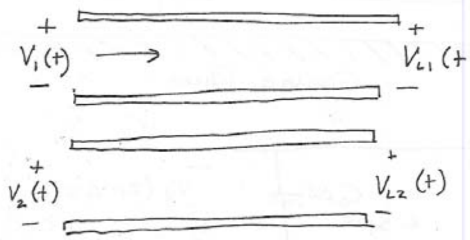
Forward and Backward Crosstalk Coefficients



A Signal in Line 1 will cause:

① Forward propagation in line 2

$$\Delta V_2^+ = K_F \, \Delta z \, \frac{\partial V_1(z,t)}{\partial t}$$ Forward Crosstalk

② Backwards propagation in line 2

$$\Delta V_2^- = K_R \, 2\sqrt{LC} \, \Delta z \, \frac{\partial V_1(z,t)}{\partial t}$$ Reverse Crosstalk

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Ideal, Weakly-Coupled Lines

Weakly Coupled Assumption:

$$\Delta \ll 1$$

Forward and Reverse Coupling Coefficients

$$K_F = \frac{\sqrt{LC}}{2}\left[\frac{E}{C} - \frac{M}{L}\right] = 0$$ units of time/distance

$$K_R = \frac{1}{4}\left[\frac{E}{C} + \frac{M}{L}\right] = \frac{\Delta}{2}$$ unitless

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