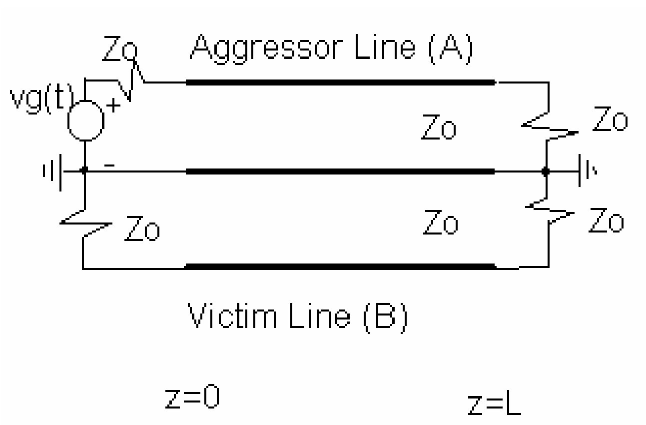
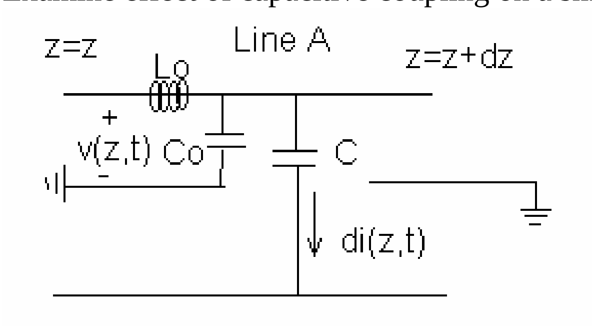
**ECE 6130 Cross Talk**

Portfolio:
What is cross talk? What causes it? How do you maximize, minimize it?
Given a pair of coupled lines, what signals do you receive from the forward and reverse cross talk?
Read Chapter 5 in Black Magic textbook.

**CROSS TALK**



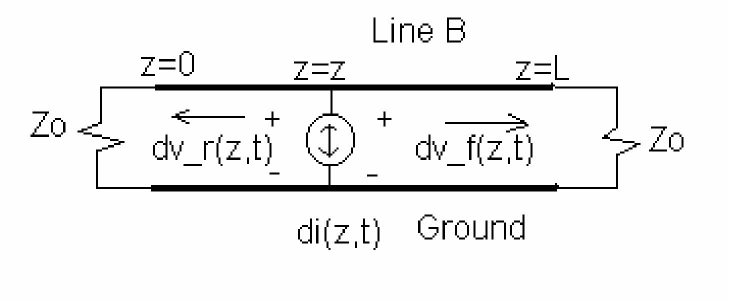

Examine effect of capacitive coupling on a small segment of line (dz) starting at z.




From capacitor equation:

$$di(z,t) = (C)\,(dz)\,(dv(z,t)/dt)$$

This differential cross talk current feeds the victim line. We can model the current as either direction.



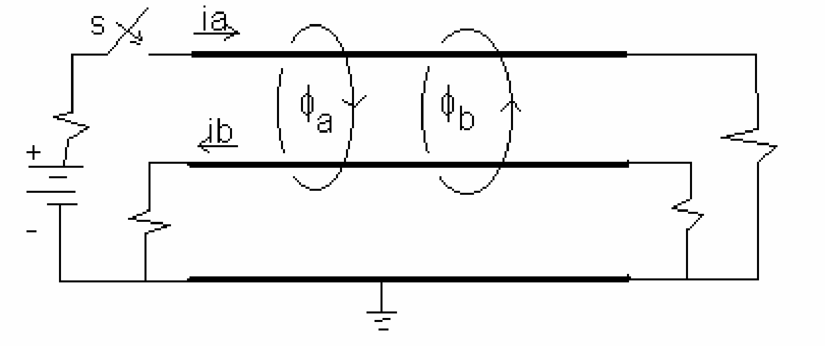

Differential Forward Voltage:

dv_f(z,t) = ( di(z,t) /2) (Zo) = (C) (dz) (dv(z,t) /dt) (Zo) /2

Differential Reverse Voltage:

dv_r(z,t) = dv_f(z,t)

Analysis of Inductive Coupling:




Lenz's Law:

(1) When the switch is closed, a transient (changing) current $i_a$ appears on line A.

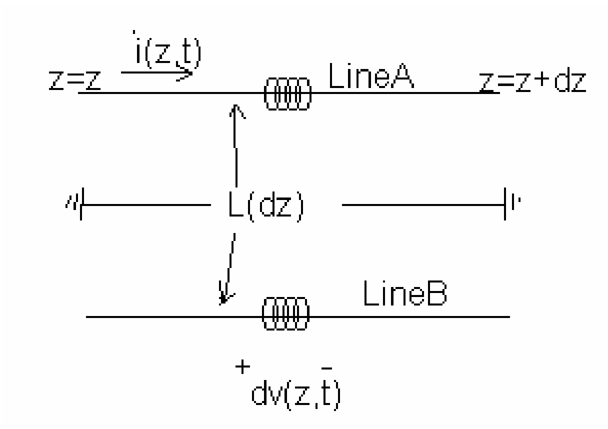
(2) This induces a changing magnetic flux density, $\phi_a$ around line A.

(3) Flux $\phi_a$ also wraps around (couples to) line B.

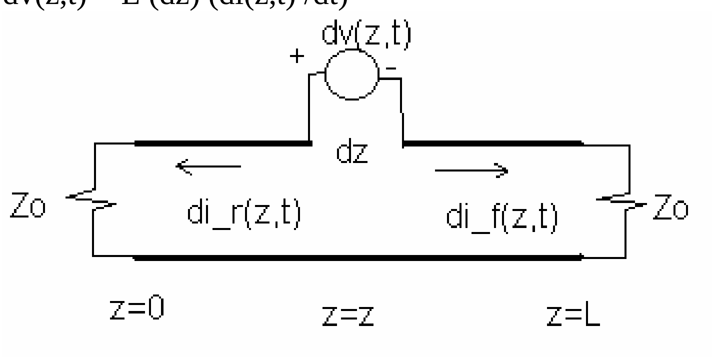
(4) Lenz Law states that line B will try to oppose the CHANGE in $\phi_a$ . So, Line B produces a current $i_b$ in the opposite direction.

(5) Current $i_b$ creates an opposing magnetic flux $\phi_b$ .

(6) After the transient has died away flux $\phi_b$ will be gone.




dv(z,t) = L (dz) (di(z,t) /dt)




Differential Forward Current:

di_f(z,t) = (L) (dz) (di(z,t)/dt) / (2 Zo)

Differential Reverse Current:

di_r(z,t) = - di_f(z,t)

Differential Forward Voltage:

dv_f(z,t) = -(Zo) di_f(z,t) = -(L) (dz) (di(z,t)/dt) / 2

Differential Reverse Voltage:

dv_r(z,t) = - dv_f(z,t) = (L) (dz) (di(z,t)/dt) / 2

Add components from Inductive and Capacitive Coupling:

dv_f(z,t) = ( C Zo – L / Zo) (dv(z,t) /dt) (dz) /2

dv_r(z,t) = ( C Zo + L / Zo) (dv(z,t) /dt) (dz) /2

Cross talk Coefficients::

K_f = ( C Zo – L / Zo)/2 (seconds/meter)

K_r = $v_p$( C Zo + L / Zo)/4 (dimensionless)

<u>Forward Cross Talk Equation:</u>

Assume voltage starts at z=0 at time t=0. It propagates down the line to z=z at time t=t + dt, where dt = z/$v_p$

dv_f(z,t) = (K_f) (dv(t – dt) /dt) (dz)

$= (K\_f)\ (dv(z,\ t - z/v_p)\ /dt)\ (dz)$

This cross talk voltage will propagate down the line to an observer located at zo. It is then given by:

$dv\_f(zo,t) = (K\_f)\ (dv(\ t - z/v_p - (zo - z)/\ v_p)\ /dt)\ (dz)$
$= (K\_f)\ (dv(\ t - zo\ /\ v_p)\ /dt)\ (dz)$

In the limit as (dz) goes to zero:
$v\_f(zo,t) \quad = (K\_f)$ int (0 to zo) $(dv(\ t - zo\ /\ v_p)\ /dt)\ (dz)$

Integrand is not a function of dz, so:
$V\_f(zo,t) = (K\_f)\ (z)\ (dv\ (t- z\ /\ v_p)\ /dt)$

<u>Reverse Cross Talk Equation:</u>
$dv\_r(z,t) = (2/\ v_p)\ (K\_r)\ (dv\ (t- z\ /\ v_p)\ /dt)\ (dz)$

Wave travels to the left to zo.
$dv\_r(z,t) = (2/\ v_p)\ (K\_r)\ (dv\ (t- z\ /\ v_p - (z - zo)/\ v_p))\ /dt)\ (dz)$
$=(2/\ v_p)\ (K\_r)\ (dv\ (t + (zo-2z)/\ v_p)\ /dt)\ (dz)$

In the limit as (dz) goes to zero:
$v\_r(z,t) =(2/\ v_p)\ (K\_r)$ integral (zo to L) $(dv\ (t + (zo-2z)/\ v_p)\ /dt)\ (dz)$
$= -K\_r\ v(t + (zo - 2z)/\ v_p)$ from z to L

$v\_r(z,t) = (K\_r)\ [\ v(t-z/\ v_p) - v(t - 2T + z/\ v_p)\ ]$