V_1 is the initial voltage

Fig.1 shows the coupled transmission line pair

The capacitive coupling induces a differential crosstalk current ΔI_{C2}, flowing into the ungrounded conductor of line 2, given by

$$\Delta I_{C2}(\xi,t) = C_m \Delta\xi \frac{\partial V_1(\xi,t)}{\partial t} \quad (1)$$

where $V_1(\xi,t)$ is the line-1 voltage

The inductive coupling induces a differential crosstalk voltage ΔV_{C2}, which is given by

$$\Delta V_{c2}(\xi,t) = L_m \Delta\xi \frac{\partial I_1(\xi,t)}{\partial t} \quad (2)$$

where $I_1 = \frac{V_1}{Z_0}$

Combining the contributions due to capacitive coupling and inductive coupling, we obtain the total differential voltages induced to the right and left of $z = \xi$ to be

$$\Delta V_2^+ = \frac{1}{2} Z_0 \Delta I_{c2} - \frac{1}{2}\Delta V_{c2}$$

$$\Delta V_2^- = \frac{1}{2} Z_0 \Delta I_{c2} + \frac{1}{2}\Delta V_{c2} \quad (3)$$

Substituting (1) and (2) into (3), we have

$$\Delta V_2^+(\xi,t) = \left[\frac{1}{2} C_m Z_0 \frac{\partial V_1(\xi,t)}{\partial t} - \frac{1}{2} L_m \frac{\partial I_1(\xi,t)}{\partial t}\right]\Delta\xi$$

$$= \frac{1}{2}\left(C_m Z_0 - \frac{L_m}{Z_0}\right)\frac{\partial V_1(\xi,t)}{\partial t}\Delta\xi \quad (4)$$

$$\Delta V_2^-(\xi,t) = \frac{1}{2}\left(C_m Z_0 + \frac{L_m}{Z_0}\right)\frac{\partial V_1(\xi,t)}{\partial t}\Delta\xi \quad (5)$$

Integrate (4) to obtain the induced voltage on line 2

$$V_2^+(z,t) = \int_0^z \frac{1}{2}\left(C_m Z_0 - \frac{L_m}{Z_0}\right)\frac{\partial}{\partial t}\left[V_1\left(t - \frac{\xi}{v_p} - \frac{z-\xi}{v_p}\right)\right]d\xi$$

$$= \frac{1}{2}\left(C_m Z_0 - \frac{L_m}{Z_0}\right)\int_0^z \frac{\partial V_1(t - z/v_p)}{\partial t}d\xi$$

or $V_2^+(z,t) = zK_f V_1^{'}(t - z/v_p)$

where K_f is the forward-crosstalk coefficient

$$K_f = \frac{1}{2}\left(C_m Z_0 - \frac{L_m}{Z_0}\right)$$

Since the effect of V_1 at $z = \xi$ at time t propagate to a location $z < \xi$ on line 2 at time $t + (\xi - z)/v_p$. Hence, by integrating (5) over proper integral, we have

$$V_2^-(z,t) = \int_z^l \frac{1}{2}(C_m Z_0 + \frac{L_m}{Z_0})\frac{\partial}{\partial t}\left[V_1\left(t - \frac{\xi}{v_p} - \frac{\xi - z}{v_p}\right)\right]d\xi$$

$$= \frac{1}{2}\left(C_m Z_0 + \frac{L_m}{Z_0}\right)\int_Z^l \frac{\partial}{\partial t}\left[V_1\left(t + \frac{z}{v_p} - \frac{2\xi}{v_p}\right)\right]d\xi$$

$$= -\frac{1}{4}v_p\left(C_m Z_0 + \frac{L_m}{Z_0}\right)\int_Z^l \frac{\partial}{\partial t}\left[V_1\left(t + \frac{z}{v_p} - \frac{2\xi}{v_p}\right)\right]d\xi$$

or $V_2^-(z,t) = K_b\left[V_1\left(t - \frac{z}{v_p}\right) - V_1\left(t - \frac{2l}{v_p} + \frac{z}{v_p}\right)\right]$

where K_b is the backward-crosstalk coefficient

$$K_b = \frac{1}{4}v_p\left(C_m Z_0 + \frac{L_m}{Z_0}\right)$$

In summary, the (+) wave on line 2 is

$$V_2^+(z,t) = zK_f V_1^{'}(t - z/v_p)$$

$$= \begin{cases} zK_f V_0 / T_0, & \text{for} \quad 0 < (t - z/v_p) < T_0 \\ V_0, & \text{otherwise} \end{cases}$$

$$= \begin{cases} zK_f V_0 / T_0, & \text{for} \quad (z/l)T < t < \left[(z/l)t + T_0\right] \\ V_0, & \text{otherwise} \end{cases}$$

The (-) wave on line 2 is

$$V_2^-(z,t) = K_b[V_1(t - z/v_p) - V_1(t - 2l/v_p + z/v_p)]$$

where

$$V_1(t - \frac{z}{v_p}) = \begin{cases} \frac{V_0}{T_0}\left(t - \frac{z}{l}T\right), & \text{for} \ \frac{z}{l}T < t < \left(\frac{z}{l}T + T_0\right) \\ V_0, & \text{for} \quad t > \left(\frac{z}{l}T + T_0\right) \end{cases}$$

$$V_1\left(t - \frac{2l}{v_p} + \frac{z}{v_p}\right) = \begin{cases} \frac{V_0}{T_0}\left(t - 2T + \frac{z}{l}T\right), & \text{for} \left(2T - \frac{z}{l}T\right) < t < \left(2T - \frac{z}{l}T + T_0\right) \\ Vo, & \text{for} \ t > \left(2T - \frac{z}{l}T + T_0\right) \end{cases}$$

The induced voltage on line 2 is

$$V = V_2^+ + V_2^-$$