Oscillations at Transmission Line Interfaces[1]

Figure 1 is a transmission line of 1000 ohms surge impedance mating with a short length of line of surge impedance of 200 ohms. This in turn is mated with a continuation of the 1000 ohm transmission line. The time required for a wave to travel the length of the 200 ohm line is Δt. Coming into the junction from the left is a current wave of amplitude 1.0. At this junction the transmission coefficient is γ = 1.667 and the reflection coefficient is δ = 0.667. Accordingly, a transmitted wave of 1.667 amplitude enters the 200-ohm line and a reflected wave is launched from right to left of amplitude 0.667. On either side of the vertical separation lines, the voltage must be equal. The incident voltage (to the left of the separation line) is equal to the sum of the incident and reflected components for 1.667 amplitude. The wave that is transmitted into the 200 ohm section of line then propagates to the right to the next transition point where a reflection of amplitude -1.111 occurs, and a transmitted wave of amplitude 0.556 is propagated to the right and out of the paper.

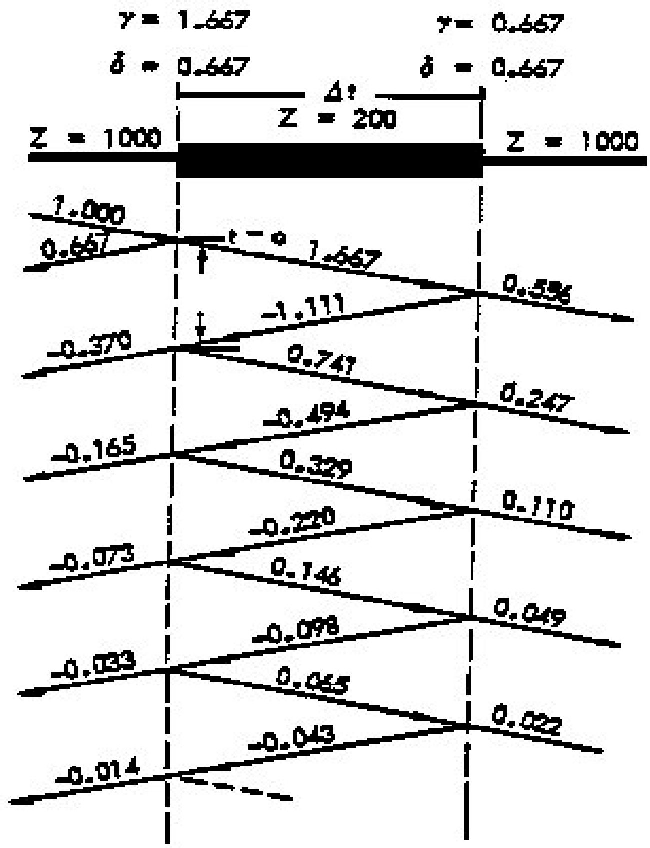

Figure 0 - Three Section Transmission Line Showing Amplitude of Reflections

The first reflection traveling right to left then meets the first transition point at a time 2Δt after the incident wave hit the first junction. At that time, there is generated a second reflection traveling right to left of amplitude 0.741 and a transmitted wave going right to left of 0.370. At any time, the magnitude of the wave at the first transition is the sum of all of the wave components on either side of the first vertical demarcation line. Accordingly, at time 2Δt the amplitude at the first transition point is 1.0 + 0.667 - 0.370 or 0.1297. The amplitude at any other point and at any other time is likewise the sum of all the transmitted and reflected wave components above that point at that time. For instance, at the midpoint of the 200-ohm line, the current is zero until a time 1Δt. This time, the amplitude jumps to 1.667 and remains there until a time 3Δt, when the amplitude becomes 1.667 - 1.111 or 0.556. This bookkeeping process of keeping track of the transmitted and reflected wave components may be continued as long as necessary.

The total pattern of development of these waves for the conditions of Figure 1 (and assuming Δt equals 0.1 microseconds) is shown on Figure 2. The voltage at the input of the 200-ohm line is

[1] *The majority of this paper derived from General Electric Aircraft Lightning Protection Note 75-1.*

seen to rise to an amplitude of 0.167 and decay in a series of steps reaching essentially its final amplitude after about 1 microsecond. Current does not begin to come out of the line until 0.1 microsecond, at which time it begins to jump to its final value in a series of steps. The current at the midpoint of the 260 ohm line oscillates bark and forth with a period $2\Delta t = 0.2$ microseconds, or a frequency of 5 MHz.

Figure 3 shows types of voltage and current distribution produced on a transmission line by different load impedances for the case of a transmission line having low attenuation and a characteristic impedance that is resistive.

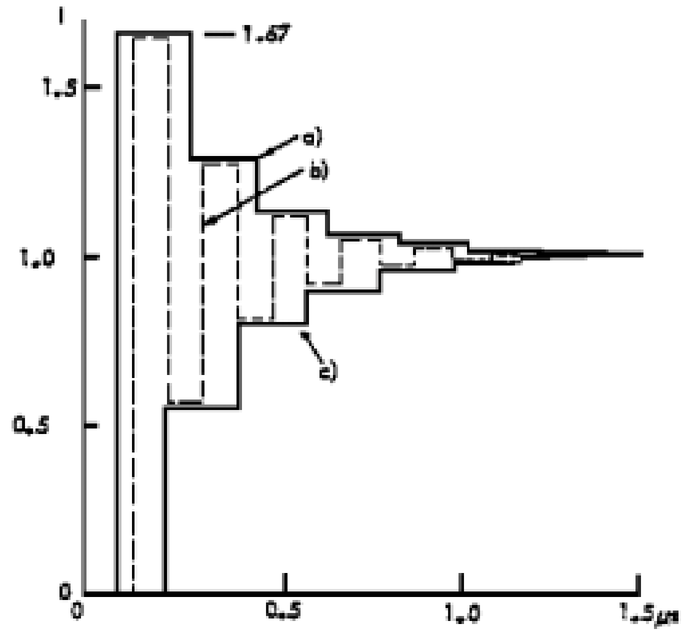

Figure 2 - Response to Step Function Current

A) Input Current
B) Current at Center of 200 ohm Line
C) Output Current

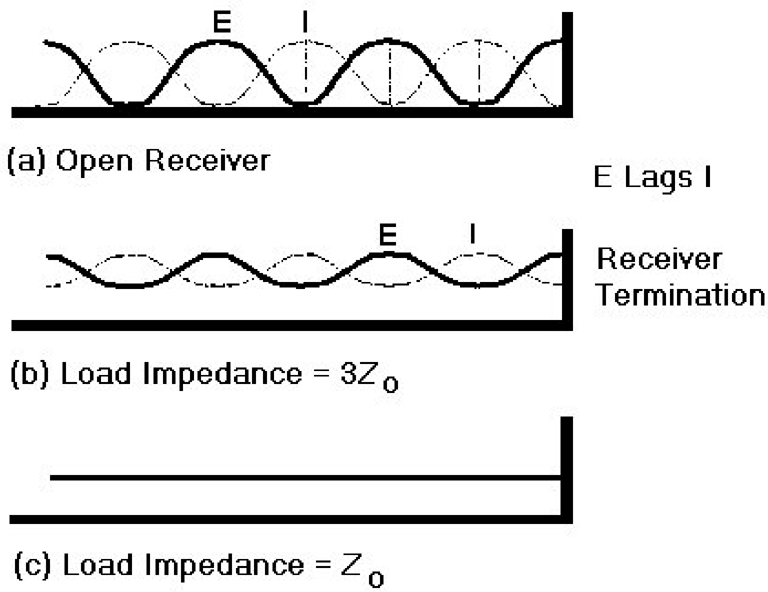

Figure 3 - Effects of Transmission Line Loading