where:

ε_r = Dielectric Constant of the Board Material

Again, the propagation delay of the trace is dependent only on the relative dielectric constant of the PCB substrate. Using Equation 4 the delay of the line can be plotted vs dielectric constant (Figure 3.8).

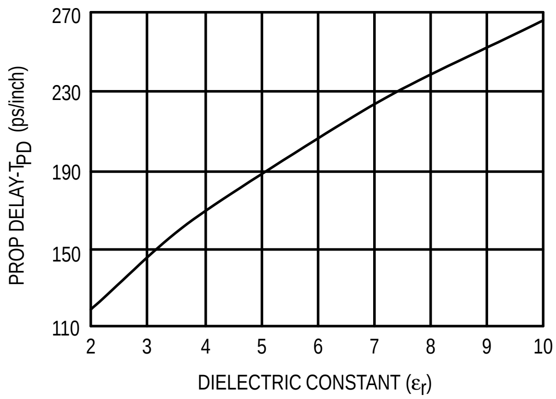

Figure 3.8. Stripline Propagation Delay vs Dielectric Constant

General Information

Since fiberglass-epoxy is by far the most widely used substrate in the industry, two important considerations should be mentioned:

1. The propagation delay for microstrip is ≈145ps per inch, whereas that for stripline is ≈185ps per inch. Since the propagation delay is governed by the dielectric of the substrate, a board material with a lower dielectric constant than glass-epoxy is required if a lower propagation delay is desired.

2. Cross coupled noise due to board geometries may require a substrate material with a lower dielectric constant. For example, the distance from the signal trace to the ground plane is a function of the substrate dielectric constant for a specified line characteristic impedance. Hence, the switching energy coupled into adjacent traces on the same signal plane is also a function of the dielectric constant. If the dielectric thickness and trace width must be maintained for a given line impedance, the spacing between traces must be increased to maintain the noise margin. Since the dielectric constant of glass-epoxy is relatively large, the increase in spacing between the traces may be unacceptable. So, a substrate material with a lower dielectric constant may be desirable. Generally, if the distance between traces is maintained at twice the distance to the ground plane, coupling between traces will be minimal.

Finally, printed circuit signal line shape variations play a significant role in modulating both the capacitance and inductance per unit length for a transmission line; in other words, shape variations cause reflections. Bends in printed circuit traces cause an increase in the capacitance per unit length and a decrease in the inductance per unit length with a pronounced effect for angles of 90° or more. Two techniques available to compensate for shape changes are:

1. Maintain a uniform trace width.
2. Cut the corners of the trace such that the length of the diagonal cut is in the range of 1.6 to 2.0 times the trace width.

Figure 3.9 illustrates these two techniques.

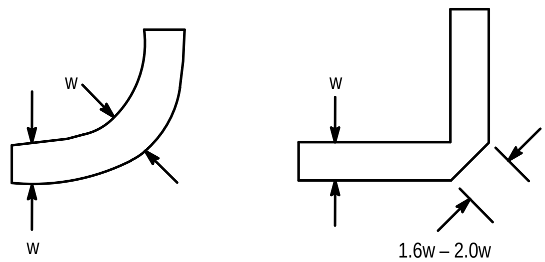

Figure 3.9. Compensation for Capacitive Effects of Trace Angles

Coaxial Cable

Coaxial cable is a two conductor transmission line consisting of a concentric inner conductor surrounded by a dielectric which in turn is surrounded by a tubular outer conductor (Figure 3.10). It is ideal for transmitting high frequency signals over long distances because of its well defined and uniform characteristic impedance. Moreover, crosstalk is minimized by the ground shield provided by the outer conductor.

The propagation delay is derived in the same way as a stripline interconnect and, thus, is described by Equation 4. Therefore, as with stripline structures, the delay is a function of only the dielectric constant. The characteristic impedance and capacitance per unit length are parameters specified by the coaxial cable manufacturer; hence, the designer should look to the cable manufacturer for these parameters.

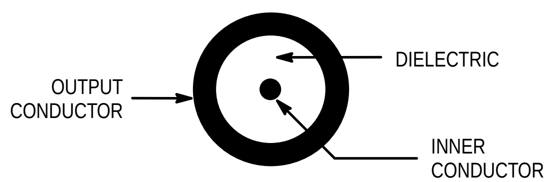

Figure 3.10. Cross Section of Coaxial Cable