POLARA

DESIGN CONSIDERATIONS FOR PASSIVE DELAY LINES

Electromagnetic delay lines are passive networks consisting of iterative capacitive and inductive elements that exhibit, in a relatively small package, the same general delay characteristics as a conventional transmission line. An ideal delay line, or transmission line, would provide:

1. Linear phase shift versus frequency when properly terminated.
2. Zero insertion loss.
3. Infinite bandwidth.

Any compromise with the foregoing ideal characteristics will cause an unfaithful reproduction of an applied step function. An actual transmission line most nearly approaches the ideal case. It has the following typical characteristics:

1. Very linear phase shift versus frequency.
2. Low insertion loss.
   a. Low resistance.
   b. Low dielectric losses.
3. Good high frequency response.
4. Short time delay per foot of length. (Approximately 1.5 nsec for 50 ohm cable.)

The design of a delay line involves a choice of certain parameters, such as impedance, delay and size, but with some compromise to be accepted in performance when comparing it with the ideal transmission line. Generally, electromagnetic delay lines fall into two basic categories — Lumped Constant and Distributed Constant — the design choice depending on such trade off factors as performance, cost, size, impedance and total delay.

The lumped constant approach simulates a transmission line by lumping the distributed inductance and capacitance into series inductors and shunt capacitors in the configuration of a low pass ladder filter. The greater the number of these discrete elements, for a given delay, the more closely the delay line will resemble the performance of an equivalent transmission line having the same total inductance and capacitance.

Typical applications for lumped delay lines involve delays ranging from less than one nsec to several msecs. Delay to rise time ratios available depend on several factors. Delays in the higher μsec range can be supplied with ratios as high as 100:1. Characteristic impedances ranging from 20 ohms to a practical limit of 5K ohms can be supplied. Temperature coefficient of delays of approximately zero to plus or minus 100 ppm/ C are possible. The attenuation per μsec of delay can be held much lower than for an equivalent distributed delay line.

A distributed constant line has the capacitance distributed uniformly between the inductance winding and the ground plane. The longer the inductance winding for a given delay, the more closely the delay line will resemble the performance of a transmission line.

Distributed delay lines usually have less ringing distortion than lumped constant delay lines, for delays in the range of 1 nsec to 1 μsec when the delay to rise time ratio requirement is less than 12:1. The temperature coefficient of delay for distributed lines will range from 300 to 500 ppm/ C. Impedance values of 200 to 2K are available.

DELAY TIME

Total delay is expressed as $T_D = \sqrt{LC}$

where T_D = Total time in μsec or nsec

L = Total inductance in μH

C = Total capacitance in μF or pF

Tap delays are expressed as a % of T_D.

4115 ARTESIA AVENUE • FULLERTON, CALIFORNIA 92633 • (714) 521-0900 • FAX (714) 522-8001