Reducing the Insertion Loss of a Shunt PIN Diode

Application Note 957-2

A shunt PIN diode is often used as a switch or attenuator. The upper frequency limitation is determined by the increase in insertion loss as the diode capacitance starts to short out the load. Figure 1 shows a symmetrical matching circuit that extends this frequency limitation by incorporating the diode capacitance, C, into a low pass filter. Figure 2 shows the filter response when the inductance value, L, is chosen to form a Chebyshev equal ripple filter.

$$L = R^2C \times g(1) / g(2)$$

The constants g(1) and g(2) are low pass prototype element values, available in the literature [1,2] as a function of the ripple value shown in Figure 2. This filter is designed to operate between equal generator and load resistances, R.

The cutoff frequency, f_c, shown in Figure 2, is determined by the diode capacitance, the ripple value, and R.

$$f_c = g(2) / 2\pi RC$$

For convenience in design, inductance and cutoff frequency are plotted in Figure 3 in terms of VSWR and in Figure 4 in terms of insertion loss. For example, the HP 5082-0001 PIN diode has a zero bias capacitance of 0.18 pF. If a cutoff frequency of 16 GHz is desired, the insertion loss ripple will be 0.007 dB and the VSWR ripple will be 1.072, corresponding to $f_cC = 2.88$. The value of L is 0.28 nH corresponding to

$$L / C = 1.54$$

Higher cutoff frequencies or lower ripple may be obtained by lowering the diode capacitance with reverse bias. The capacitance of the 5082-0001 PIN diode is reduced to 0.12 pF with a reverse bias of 20 volts. This increases the cutoff frequency for the same ripple to 24 GHz.

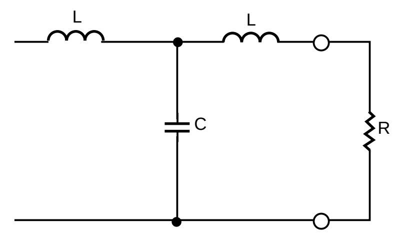

Figure 1. Low Pass Matching Circuit

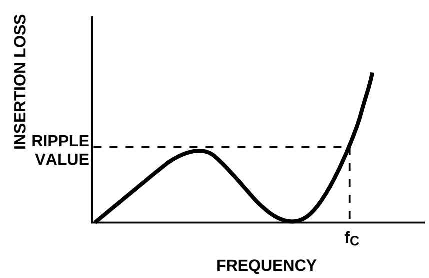

Figure 2. Chebyshev Response

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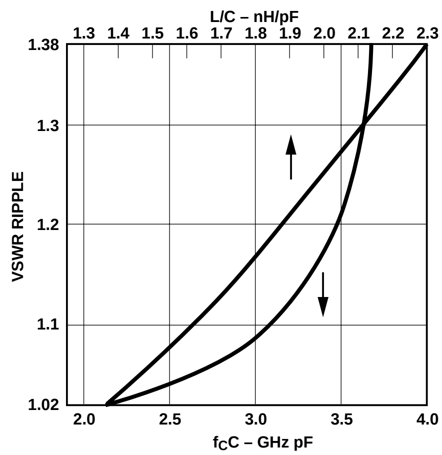

Figure 3. Filter Design Curves

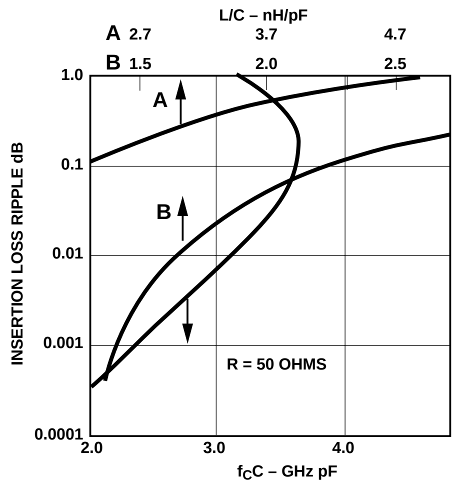

Figure 4. Filter Design Curves

References

1. L.Weinberg,“Network Analysis and Synthesis”, McGraw-Hill, 1962.

2. N. Chitre and M. O’Donovan, “A Unified Design Chart for Small VSWR Filters”, Microwave Journal, April 1967, pp 79-84.

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