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Design and Analysis of Microwave Filters for Satellite Communication

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Abstract - Designing of a filter that satisfies the required criterion of lowest insertion loss and highest return loss is desirable. There are several methods of designing a filter such as using Triple mode resonator, Micro strip quarter-wave resonator, stub-loaded resonator and Substrate Integrated Waveguide (SIW). In addition with the specification, reduced size and cost are also desirable factor in the designing of filter. Substrate Integrated Waveguides (SIWs) are planar structures which are fabricated by using two periodic rows of metallic cylindrical slots implanted in a dielectric substrate that electrically unite both parallel conducting plates Substrate integrated waveguide is a type of dielectric filled waveguide SIW structures maintain most of the benefits of classical metallic waveguides. It has high Q- factor, better capacity to handle the power with better electrical shielding as applies to classical waveguide.

Key Words: SIW, Waveguide, substrate, resonator, field.

1.Introduction

filter is designed for the frequency range from 19.2 to 21.2 GHz. Different input/output topologies of the filter are discussed for wide stop band applications. The transmission zeros in the insertion loss response of a microwave filter can be used to improve the selectivity and stop band attenuation. In general, the implementation of transmission zeros can be obtained using the well known “extracted pole” technique or by introducing coupling between nonadjacent resonators (cross-coupling). However, the transmission zeros cannot be far away from the desired pass band due to the limitation of the physical structure. An alternative approach is the use of other modes, propagating or evanescent, as separate paths for energy flow. In this paper, multiple transmission zeros generated by the nonphysical cross-coupling of higher order modes are used to improve the s to p band attenuation of patent-pending SIW filters. Nonphysical cross-coupling was utilized to generate transmission zeros distant from the pass band for good stop band performance of SIW filters for the first time in and a novel millimeter-wave SIW filter using -mode cavities was also presented in . At lower microwave frequencies planar technology (micro strip, strip lines and coplanar waveguide) found very useful but these devices are prevented at high frequency (>30GHz) due to high transmission losses. On the other hand waveguides having high-Q values and high power handling capability and low losses but they are bulky and not suitable for high density integration hence ultimately increases the cost and size of the system . So it becomes difficult to design the filter with reduced size and cost. To find the possibility of miniaturization, filter is designed using substrate integrated waveguide (SIW) technology.

2. Microwave Filters

An infinite transmission line or waveguide periodically loaded with reactive elements is an example of a *periodic structure*. As shown in Figure 2, periodic structures can take various forms, depending on the transmission line media being used. Often the loading elements are formed as discontinuities in the line itself, but in any case they can be modeled as lumped reactance in shunt (or series) on a transmission line, as shown in Figure 2.1. Periodic structures support slow-wave propagation (slower than the phase velocity of the unloaded line), and have pass band and stop band characteristics similar to those of filters; they find application in traveling-wave tubes, masers, phase shifters, and antennas.

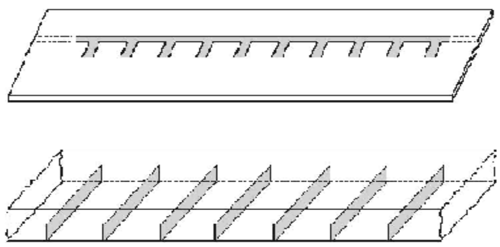

Fig 2: periodic stubs in microstrip lines

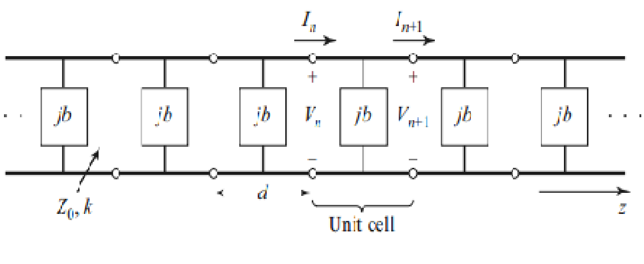

Fig 2.1: periodic diaphragms in waveguide

3.Comoposite Filters

By combining in cascade the constant-k, m -derived sharp cutoff and the m -derived matching sections we can realize a filter with the desired attenuation and matching properties. This type of design is called a composite filter . The sharp-cutoff section, with m < 0.6, places an attenuation pole near the cutoff frequency to provide a sharp attenuation response; the constant-k section provides high attenuation further into the stop band. The bisected-π sections at the ends of the filter match the nominal source and load impedance, R_0, to the internal image impedances, ZiT, of the constant-k and m -derived sections. Notice that once the cutoff frequency and impedance are specified, there is only one degree of freedom (the value of m for the sharp-cutoff section) left to control the filter response.

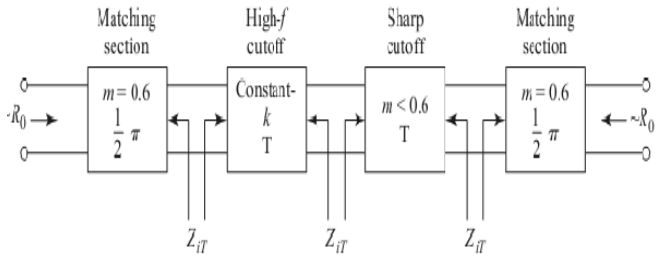

Fig 3: Four stage composite filter

4.Filter design by insertion loss method

The image parameter method of the previous section may yield a usable filter response for some applications, but there is no methodical way of improving the design. The insertion loss method, however, allows a high degree of control over the passband and stopband amplitude and phase characteristics, with a systematic way to synthesize a desired response. The necessary design trade-offs can be evaluated to best meet the application requirements. If, for example, a minimum insertion loss is most important, a binomial response could be used; a Chebyshev response would satisfy a requirement for the sharpest cutoff. If it is possible to sacrifice the attenuation rate, a better phase response can be obtained by using a linear phase filter design. In addition, in all cases, the insertion loss method allows filter performance to be improved in a straightforward manner, at the expense of a higher order filter. For the filter prototypes to be discussed below, the order of the filter is equal to the number of reactive elements.

5. Method used to design filter

Filters with FTZs located on the imaginary axis or symmetrically on the real axis or in all four quadrants of the complex frequency plane are known to have better out-of-band frequency selectivity and/or in-band phase response. The FTZs on the imaginary axis of the complex frequency plane will lead to high selectivity performance and excellent stopband characteristics, while FTZs on the real axis or in all the four quadrants are used for achieving a linear phase response in the passband. There are two methods that have been used to produce FTZs. The first method makes use of cross couplings with nonphysical couplings by higher-order modes or physical coupling structures to produce multiple paths for signal flow. If two different signal pathsyield the same magnitude but opposite phase, they would cancel each other out, and an FTZ on the imaginary axis is then produced. However, positive and negative couplings must be simultaneously realized for the opposite phases. On the other hand, if two signal paths generate the same magnitude and phase, an FTZ on the real axis is then produced. In this case, all of the couplings can have the same sign. The second method involves FTZs on the imaginary axis that can be extracted to realize bandstop resonators. In an extracted-pole filter, it is not necessary to simultaneously realize both types of coupling because the FTZ on the imaginary axis is produced by the bandstop resonator that can also produce a transmission pole in the passband.

6. Design procedure

Due to the fact that the generated transmission zeros are not close enough to the edge of the desired passband to significantly interact with the transmission poles of the filters (insertion loss minima), a pure Chebyshev response in the desired passband can still be achieved. Initially, we can obtain the inter-resonator coupling and the external quality factor from the generalized element values g_i of a Chebyshev filter.

$$k_{i,i+1} = \frac{FBW}{\sqrt{\epsilon_r}}$$

$$f_o = \frac{c_0}{2\sqrt{\epsilon_r}} \sqrt{\left(\left(\frac{1}{a_{eff}}\right)^2 + \left(\frac{1}{l_{eff}}\right)^2\right)}$$

$$a_{eff} = \text{a} - \frac{d^2}{0.95p},\ l_{eff} = \text{l} - \frac{d^2}{0.95p},$$

7. Conclusions

Proposed K-band bandpass Filter using Substrate Integrated Waveguide Technology (SIW) is easy to fabricate, More Compact and simpler in design. Simulated results shows that the proposed filter has better Frequency Response with insertion loss of 0.33dB at the center frequency of 20.3 GHz, its bandwidth is about 2GHz. Other parameter of filter (such as Group Delay and VSWR) also satisfying the desired criterion of Filter. This Bandpass filter of frequency ranges from 19.3GHz to 21.3 GHz found application for the satellite Ground terminal.Designed K-band bandpass filter is used for satellite ground terminal. Proposed filter can be used to predict precipitation (Tropical rainfall measurement by using TMI).

There are several reasons of using substrate integrated waveguide technology for designing the filter such as compact filter designing is possible. There are two parameters that can be varied when designing a filter that is diameter and pitch of the vias. Hence by changing diameter and and pitch of filter one can change the specification of the filter. Proposed filter can also be used in transceiver for microwave communication and for radar applications.

REFERENCES

1. Xiao-Ping Chen, Ke Wu, “Substrate IntegrateWaveguide Filters,” IEEE Microwave Magazine, pp.121-133, Oct 2014.

2. Lee, J-R., Cho, J-H., and Yun, S.-W, "New Compact Bandpass Filter Using Microstrip V4-Resonators with Open Stub Inverter," IEEE Microwave And Guided Wave Letters, vol. 10, no.12, December 2000.

3. S. Amari, K. Hamed, Y Antar, and A Freundorfer, "New elliptic microstrip V4-resonator filters," Proc. Asia-Pacific Microw. Conf. pp. 755-758,2001.

4. Yang Huang, Mengkui Shen, Zhenhai Shao, Xiang li, “A Novel Ku-band BandPass Filter Using Triple Mode Resonator,” IEEE Communication Problem Solving (ICCP) .Conf. pp. 470-472, 2015.

5. Peng Li, Hui Chu, Ru-Shen Chen, “Design of Bandpass Filters Using Quarter-Mode and Eight-Mode SIW Cavities,” IEEE Trans. on component packaging and Manufacturing Tech. 2017.

6. Nitin Muchhal, Shweta Srivastava, “Review of Recent Trends on Miniaturization of Substrate Integrated Waveguide (SIW) Components,” IEEE Computational Intelligence and Communication Technology, Conf. 2017.

7. Hong, J S., S. Hussein, and Y.-H. Chun, "Dual-mode microstrip openloop resonators and filters," IEEE Trans. Microw. Theory Tech., vol. 55, no. 8, 1764-1770,2007.

8. L. Zhang, Z.-Y Yu, and Shao-Guo, Mo, "Design of compact triplemode bandpass filter using double center stub-loaded resonator ", Microwave and Optical Technology Letters, vol. 52, no. 9, September 2010.

9. ZHU Wensi, ZHANG Junru, YU Mengxia, "A novel Ku-band microstrip triple-mode filter using stub-loaded resonator," Proc. Electronics, Communications and Control, pp.1847-1849, Sept .2011.

10. L. Han, K. Wu, and X.-P, Chen, "Compact ultra-wideband bandpass filter using stub-loaded resonator," Electron. Lett., vol.45, no.lO, pp. 504-506, May. 2009.