Pseudo-Interdigital Bandpass filters

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Abstract

A new type of bandpass filter that will meet the requirements of small size and planar fabrication is designed. It is a microstrip pseduo interdigital bandpass filter of size less than quarter wavelength at the operating midband frequency of 1.15 GHz. The simplicity and compactness of this design are no constraints for planar fabrication unlike the conventional interdigital band pass filters that have short circuit vias for the quarter wavelength resonators. The simulation results are presented.

INTRODUCTION

Miniaturization of microwave bandpass filters has much demand in the rapid changing cellular communication world. Even though there are end-coupled bandpass filters [1] and parallel-coupled bandpass filters [2] with the half wavelength resonators are prevalent, they are much larger in size. Microstrip Interdigital bandpass filter [3] is even though small in size, it is not quite compatible with the IC technology and not simple in fabrication due to short circuit connections.

This paper describes a technique to further reduce the size of interdigital bandpass filters known as microstrip pseudo-interdigital bandpass filters without the complication of vias connections to the ground. This filter uses the resonators of quarter wavelength but with no short circuit connections to the ground via holes. Hence such filters are simple to design and can be fabricated easily using planar fabrication techniques. A microstrip pseudo-interdigital filter whose layout as shown in Figure 1 (front view with the dimensions) and Figure 2 (3-D view) was designed and simulated results using High Frequency Structure Simulator are shown in Figure 3.

PSEUDO-INTERDIGITAL BANDPASS FILTERS

Microstrip pseudo-interdigital filters are similar to interdigital bandpass filters with small change about the short circuit (grounding) connections. Interdigital bandpass filter is of small size because of quarter wavelength resonators used. Interdigital filter contains quasi-TEM mode transmission line resonators. One end of these resonators will be short-circuited and the other end will be open circuited with alternative orientation. Coupling achieved by way of fields between resonators. The input and output port admittances are set equal to source and load characteristic admittance respectively. The short-circuited ends are connected to ground with via holes for interdigital bandpass filters. Interdigital filters are compact but require grounding microstrip resonators through vias. However because the resonators are quarter wavelength resonators the second passband of filter is centered at three times midband frequency for which filter was designed so no spurious response occur in between. Parallel-coupled filters with half wavelength resonators have the spurious passband at twice the midband frequency of filter operation. The short circuit ends of microstrip resonators are usually grounded with via holes connection in interdigital bandpass filter. Without affecting bandpass frequency response severely, grounding resonators short circuit ends can be realized by short circuit connections as shown in Figure 1. Grounds are at the same potential they may be so connected. At the midband frequency there is an electrical short circuit at the position where the two-grounded ends are joined even without via holes grounding. This results in the pseudo-interdigital filter.

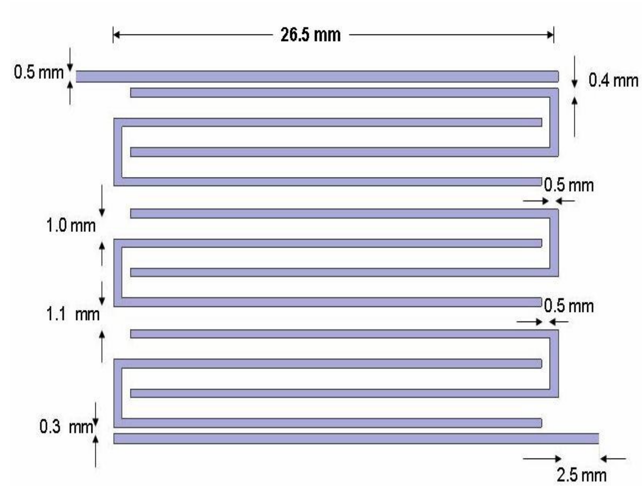

Figure 1 Filter layout diagram (front view with dimensions)

Here to get the bandpass response we have taken the doubly periodic structures. The wave interaction in a doubly periodic structure will exhibit both passband and stopband behaviors.

Pseudo-interdigital filter gains compactness from the fact that it is similar in size to that of the interdigital bandpass filters and attains simplicity because of no grounding of short circuit ends with via holes. So these filters are compact and simple to be fabricated using planar fabrication techniques. There will be some loss in passband due to conductor loss due finite conductivity of the metallic strip, which can be minimized by using wider resonator lines or using a superconductor [4].

A pseudo-interdigital bandpass filter was designed with substrates RT/Duroid of thickness 1.27mm in z-direction and relative permittivity (ε_r) of 10.2. Figure 1 illustrates front view of the layout of the filter designed. The feeding lines are of equal in size with thickness of 0.5mm and length of 29mm. All quarter wavelength resonators are also of same size with thickness of 0.4mm and length of 25.5mm. Gap between the feeding lines and resonator lines is 0.3mm. Short circuit connections are of thickness 0.5mm. The spacing between short circuit connections and the resonator lines is 0.5mm. Spacing between resonator lines of one periodic structure is 1.0mm. Spacing between two periodic structures is 1.1mm. Feeding lines are extended 2.5mm out of filter structure at input and output. This layout is designed on the substrate using two lumped port connections one at input and the other at output with matched admittance as shown on Figure 2.

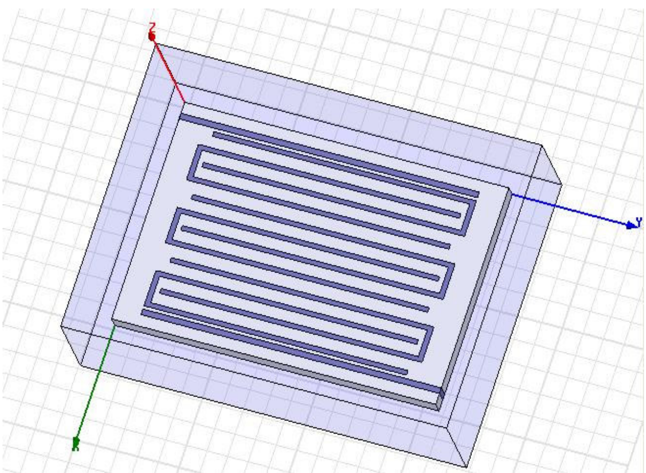

Figure 2 3-D view of the Pseudo Interdigital Bandpass Filter

Figure 2 is the design to simulate the pseudo-interdigital bandpass filter in the powerful high frequency simulation tool Ansoft HFSS version 9 [5]. Air medium of box of thickness less than $\lambda/4$ was created around the filter structure and five faces excluding the lower face are assigned the radiation boundary for proper propagation of EM waves of the band pass filter designed. The simulated bandpass filter response at a mid band frequency of 1.15GHz of the pseudo-interdigital bandpass filter designed is shown in the plot given in Figure 3. Scattering parameters S_{11} and S_{12} are plotted against frequency in GHz at midband frequency of 1.15GHz. The scattering parameters S_{11} and S_{12} represents return loss and insertion loss respectively in db. The sum of the squares of both return loss and insertion loss ($S_{11}^2 + S_{12}^2$) is always equal to 1 for a lossless bandpass filter. The bandpass frequency response is obtained from 1.08GHz to 1.24GHz with a –10dB return loss bandwidth of 160MHz.

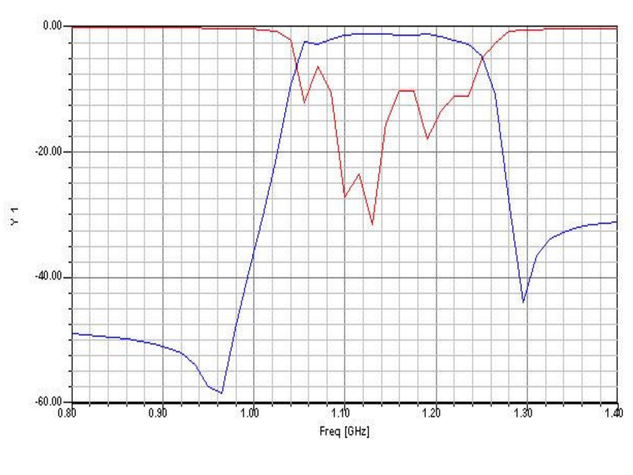

Figure 3 Scattering parameters of the bandpass filter Insertion loss (S_{11}-----), Return loss(S_{12}-----)

CONCLUSION

Microstrip bandpass filter is designed and simulated using HFSS. Scattering parameters of the simulated results are reported as shown in Figure 3. Using this design a more compact microstrip bandpass filter can be designed and can be fabricated using the planar fabrication techniques because of simplicity achieved through this design due to grounding connections with via holes of interdigital band pass filters are replaced by short circuit connections at the short circuit ends. The pseudo interdigital bandpass filter designed with a 14% bandwidth at 1.15 GHz is very compact and has size smaller than quarter wavelength at the midband operating frequency. It is achieves the simplicity with out short circuit connections in the bandpass filter unlike the conventional interdigital bandpass filters. It would seem that this type of filter structure provides a very attractive means for developing very compact filters with fully planar fabrication techniques. This is especially of benefit for the growing numbers of microwave circuits for IC technology and wireless communications.

REFERENCES

[1]. J.-S. Hong and M. J. Lancaster, "End-coupled microstrip slow-wave resonator filter," Electronics Letters, 32, 16, 1996, pp. 1494-1496.

[2]. M. Makimoto and S. Yamashita, "Bandpass filters using parallel coupled stripline stepped impedance resonators," IEEE Trans., MTT-28, 1980, 1413-1417.

[3] J.-S. Hong and M. J. Lancaster, Microstrip Filters for RF/Microwave Applications, John Wiley and Sons, NY, 2001.

[4]. D. M. Pozar, Microwave Engineering, 3rd Edition, John Wiley and Sons, New York, 2005.

[5] Ansoft, High Frequency Structure Simulator version 9,

Pittsburgh, PA.