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Design of Microstrip Coupledline Bandpass Filter

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ABSTRACT: Microstrip Bandpass Filter simulations are included in this project paper. It has a graph, a design, a top view, and a 3D projection. The Coupled-Line Microstrip Filter is built of FR-4 material with a permittivity of 4.4 and is designed for a center frequency of 2.4 GHz. The ground is 1.55mm thick, and the air is 11mm thick. 50 ohms is the characteristic impedance. This filter is attached to the two ports and is made up of parallel coupled lines linking the two ports. All of the dimensions have been put down. S11 values should be less than -10dB, while S12 values should be more than -2dB. The filter gives an insertion of -1.7 dB, return loss of -23 dB and bandwidth of 1.5 GHz. Designed Microstrip Coupled Line Bandpass Filter can be used for wireless and high frequency applications. All the design and simulations of this filter are done using Sonnet Suites Software.

1. INTRODUCTION

Microstrip filters are created on a PC board using a well defined design. They are one of the crucial parts of the microwave system and any communication system. Resonant modes are used to create a wide passband, which is a frequency range that can be transmitted without being blocked or distorted. These modes are coupled together in order to increase the efficiency of the filter [1]. Microwave Coupled Lines (MCL) are a type of microwave-coupled in modern radars, microwave radio links, and satellite communication systems, band pass filters are essential components. Coupled lines, which are two parallel transmission lines situated near together, are used in these filters. The coupled line filters have an advantage in that the gaps between the coupled lines are larger, thus making them less critical and easier to manufacture [2]. In current wireless communication systems, band-pass filters (BPFs) with high frequency selectivity and out-of-band rejection levels are essential. By inserting numerous transmission zeros (TZs) or correctly modifying their position, frequency selectivity and stopband suppression can be increased. The data and simulations used to validate the design idea are valid [3]. An analytical design of a microstrip parallel-coupled line bandpass filter is presented in this paper. The circuit topology consists of two coupled lines that are connected to the two ends of a microstrip transmission line. The purpose of using the coupled lines is to increase the inductance and decrease the capacitance from both components, which helps to achieve a higher impedance [4]. Aside from the compactness requirement, other characteristics demand further attention in order to achieve effective filter features such as high return loss and large rejection band levels. These filters are commonly employed in a variety of communication systems, including satellite, mobile, and radar. Designing these filters is accomplished by using one or more resonators that are coupled to each other [5]. Solid performance, good and easy design will show us an example of a RF filter, as well as its low cost [6]. In the present advances of the modern wireless communication system, broadband wireless access (BWA) is an important topic. Signals transmitted and received must be filtered at a specific center frequency with a specific bandwidth [7]. In recent years, the wireless communication systems has increased the demand of band-pass filters with higher accuracy because new technology is looking for more accuracy. The demand for précised, narrow bandwidth and low loss had led to the innovative design of a band-pass filter content due to the advancement in technology, there is an increase in the number of cell phone [8]. Frequency responses of the filters were measured by the electromagnetic simulator program Sonnet [9]. Both simulation and measurement results are provided and shown below [10]. The operating principle is explained, and simulated examples are illustrated [11]. Resonators are devices that generate sharp rejection and wide bandwidth. With the increasing improvements of wireless communication systems, the attractive qualities of millimeter-wave frequencies such as a wide frequency band, minimal circuit size, and repeating use of the same frequency band in tiny zones are gaining more and more attention [12]. The majority of filter structures are complicated and difficult to understand and discuss. For some filters, creating an analogous circuit for analysis is problematic. Furthermore, most filters necessitate a high level of manufacturing precision. A suggested broadband band-pass filter made up of linked lines and a cross-shaped resonator that improves the band-pass filter's frequency selection properties and increase a transmission zero point [13].

2. MATERIALS AND METHODS

The design of the microstrip bandpass is fabricated on FR-4 material with relative permittivity $\varepsilon r = 4.4$ and the thickness of 1.55 mm, while the characteristic impedance is chosen as $Z0 = 50\Omega$. The unit of the dimensions is represented in millimeters.

Since two ports are used, S11 and S12 are needed for the result.
In the picture below top view of the filter is shown:

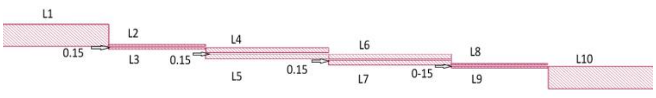

Figure 1: Top view of the filter

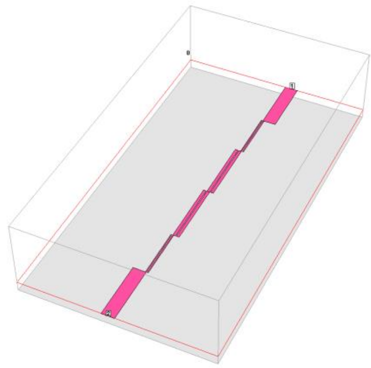

Figure 2: 3D of the filter

It is seen that top metal is free space and the ground metal is lossless.
Bandwidth of the final Figure is 1.5, which is clearly shown in the figure below:

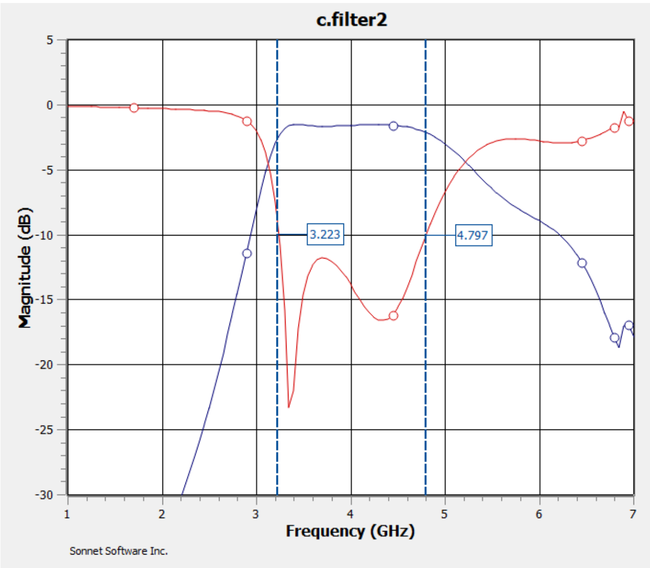

Figure 3: Graph

As it is shown, S11 needs to be under -10dB and S12 above -2dB. To accomplish that, only small changes were made.
The filter has one passing frequency regions, which starts from 3.2 and ends at 4.8.
First and last coupled line's size have been increased and others lines are decreased. To avoid error, gaps between these lines are reduced to the minimum.

Next figure shows current graph with the center frequency of 4.01 GHz:

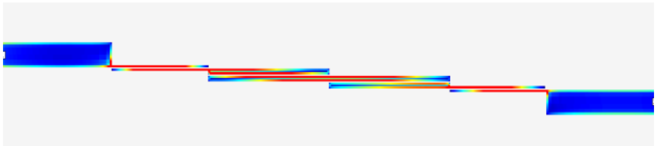

Figure 4: Current graph

Next, some more changes were made to compare the results.

3. PARAMETRIC STUDY

This analysis of the Coupled Line Filter was done in Sonnet Software, which produces very precise results with a simple design process.

To keep wanted results in the graph but with few changes, small changes were made.

Box Size	55.8 mm x 30.75 mm
Dielectric constant ε_r	4.4
Ground thickness	1.55
Cell size	0.15 mm
Material at 0	Air
Material at GND	Substrate

After doing many simulations, first graph's parameters are shown below:

Table 1: Changes in separation

Separation	S11/Ghz	S12/Ghz	Bandwidth
0.13	-17.5 / 3.4	-1.2 / 4	1.6
0.15	-20 / 3.5	-1.4 / 3.8	1.5
0.17	-18 / 3.2	-1.5 / 4.2	1.55
0.20	-22 / 3.5	-1.3 / 4	1.8
0.12	-12 / 3.8	-1.7 / 3.5	1.85

Table 2: Changes in diel.constant

Diel.const	S11/GHz	S12/GHz	Bandwidth
4.44	-19.2 / 3.4	-1.3 / 3.8	1.55
4.43	-21 / 4.5	-1.2 / 3.9	1.6
4.45	-22 / 3.2	-1.3 / 4	1.65
4.37	-21 / 3	-1.7 / 4	1.7
4.35	-22.5 / 4	-1.5 / 4.1	1.75

Table 3: Changes in length 1

Length	Width	S11 / Ghz	S12 / Ghz	Bandwith
9.39	2.1	-19.3 / 3.9	-1.3 / 4	1.5
9.4	2.17	-18 / 4	-1.3 / 4.2	1.55
9.391	2.21	-17.3 / 3.9	-1.4 / 3.9	1.65
9.38	2.14	-20 / 3.8	-1.5 / 4	1.8
9.39	2.24	-21 / 3.5	-1.7 / 4.2	1.85

Table 4: Changes in length 2

Length	Width	S11 / Ghz	S12 / Ghz	Bandwith
8.1	0.15	-12.3 / 3.8	-1.5 / 4.1	1.6
8.1	0.1	-13 / 3.85	-1.6 / 4.1	1.65
8.1	0.12	-15.2 / 3.6	-1.2 / 4	1.5
8.1	0.11	-12 / 3.75	-1.2 / 4.2	1.5
8.1	0.16	-13 / 3.55	-1.7 / 4.4	1.7

Table 5: Changes in thickness

Thickness	S11/GHz	S12/GHz	Bandwidth
1.55	-19.2 / 3.4	-1.2 / 3.9	1.65
1.53	-20.25 / 4.3	-1.4 / 4	1.7
1.57	-22.5 / 3.3	-1.3 / 4	1.55
1.5	-21.7 / 3.3	-1.5 / 4.75	1.8

4. CONCLUSION

In this paper, a procedure for building a microstrip bandpass coupled line filter is used. The filter is connected to the two ports and coupled lines marked as L1, L2, L3 etc. have certain length and width size. At the center frequency, the insertion loss and reflection factor has the values about -2dB and better than -10dB. Coupled Line filter gives an insertion of -1.7 dB, return loss of -23 dB and bandwidth of 1.5 GHz. To accomplish wanted results, gaps between coupled lines were minimized and changed later for noticing differences in results. Microstrip substrate is FR4, and dielectric constant is of 4.4. At the end of the paper, all the dimensions, dielectric layers and frequencies are shown using tables.

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