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Wideband Balanced Filter with High Common Mode Rejection

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Abstract

A wideband balanced filter with high common mode rejection is presented. T-shaped resonator is adopted to generate differential mode (DM) wideband performance, while the high common mode (CM) rejection is achieved by loading branches connecting the differential output pairs. Transmission line theory analysis and corresponding simulations are carried out to explain the operating mechanism and to verify the proposed idea.

Keywords: *High CM rejection, Microstrip balanced filters, wideband filters*

1. Introduction

The filter is one of the fundamental components in many microwave circuits and systems, such as GPS, wireless local area networks (WLANs), wireless medical monitoring, and mobile communications [1]. Increasing interest of balanced filter has also been gained in filter research community due to its advantage of CM rejection [2], [3]. Reviewing the literature reveals a great effort in implementing various methods and techniques for achieving wideband balanced filters [4], [5]. However, most of these feature unsatisfied CM rejection level. Since wider bandwidth is the key factor to increase communications speed and capacity, it is highly necessary to propose a novel filter structure both with wide bandwidth and high CM rejection level.

Microstrip (MS) filter is one of popular antenna structures because of its inherent merits, i.e., easiness to integrate with other circuit components, low cost fabrication, etc. Many wideband balanced filters with MS structure have been reported [6], [7].

In this paper, a wideband MS filter having high CM rejection level is presented. By using multiple branches with different width connecting differential port pairs, wideband filtering feature and high CM rejection level are achieved. Compared with reference [8], the proposed structure adds another rectangular stub which improves CM rejection level. EM full-wave simulation is carried out to verify the proposed idea.

2. Design of the Wideband Balanced Filter

The schematic of the proposed filter is shown in Fig. 1. The proposed structure is designed on a substrate RO4350B with a relative dielectric constant of 3.66, loss tangent of 0.04 and thickness of 0.508 mm. It consists of two perpendicular branches with different width connecting with the differential ports.

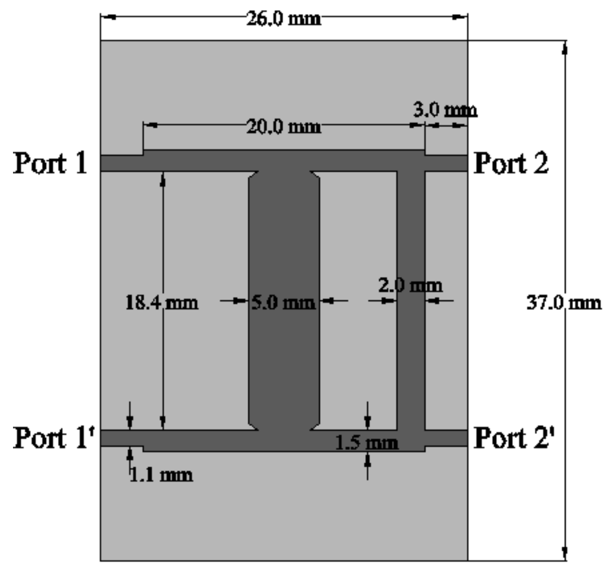

Figure1. Layout of the proposed filter as well as the physical dimensions.

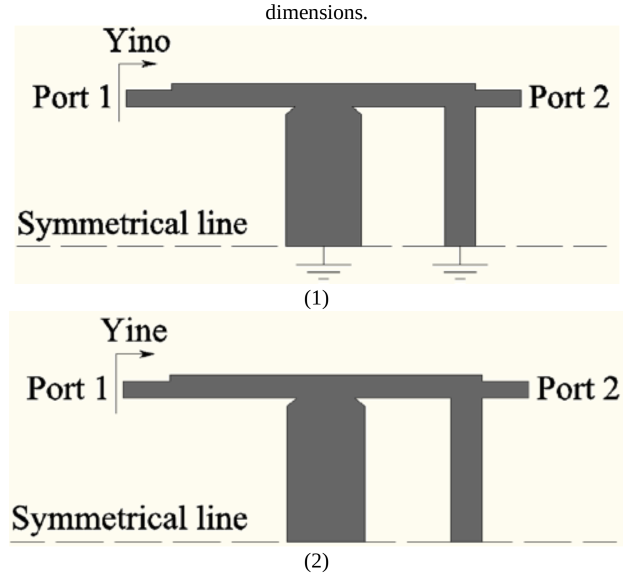

Figure2. (1) Odd- and (2) even-mode equivalent circuits of the proposed filter.

Since it is symmetrical, odd- and even-mode method is applied to analyze the DM and CM performance. The odd- and even-mode equivalent circuits are presented in Fig. 2 when electrical and magnetic wall is applied to the symmetrical line, respectively. The DM and CM circuit resonate when the corresponding input admittance equals to zero. The resonance conditions are shown below:

$$Yine = 0 \quad (1)$$
$$Yino = 0 \quad (2)$$

where Yine and Yino are the input admittance of the even- and odd-mode equivalent circuits as shown in Fig. 2, respectively.

The whole design process is demonstrated in Fig. 3. Once desired DM and CM resonant frequencies are determined, the physical dimensions of the proposed structure can be deduced from (1) and (2). The resonant conditions feature multi-outcomes for fixed resonant frequencies. Different physical dimensions are substituted into (3) as shown below. Since high CM rejection is achieved by moving the CM resonant frequencies far from DM bandpass range, the index value H_m can be used to evaluate the CM rejection level. The higher the index value H_m, the higher the CM rejection level will be. The highest index value is determined after optimization as well as the corresponding physical parameters.

$$H_m = \left| \sum_i f_{cm}^i - \sum_k f_{dm}^k \right| \quad (3)$$

where f_{cm}^i and f_{dm}^k denote CM and DM resonant frequencies, respectively.

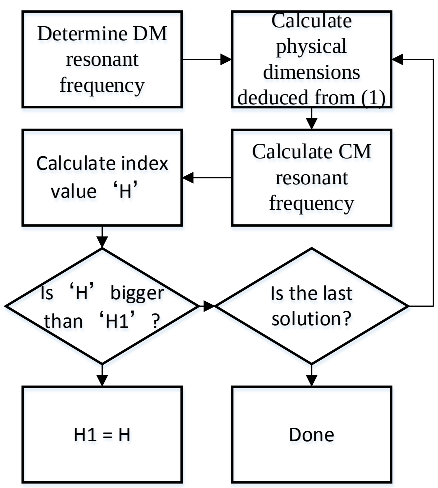

Figure3. Design process of the proposed filter.

3. Simulated Results

In order to verify the balanced filtering performance of the proposed structure, full-wave model is built by commercial EM simulation tool HFSS. EM results are illustrated in Fig. 4 by carrying out the full-wave simulation. The simulated DM S21 shows a bandpass response of 3.01-6.49 GHz (3-dB DM S21), while the simulated CM S21 presents high rejection level over in-band range. The highest CM rejection level reaches 51 dB at 4.9 GHz. DM bandpass filtering is achieved while CM signals are attenuated largely. Additionally, the in-band return loss is approximately as high as 20 dB showing good impedance matching.

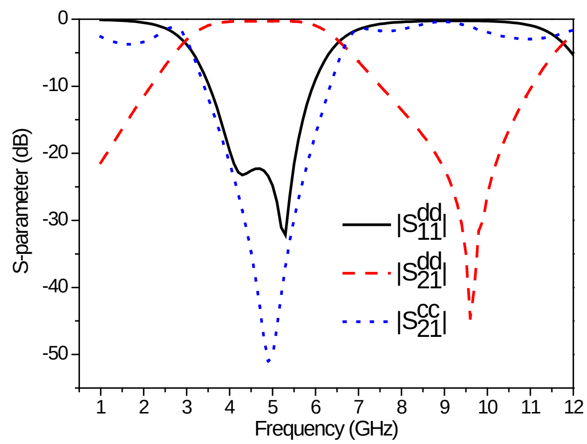

Figure4. EM simulated results of the proposed filter..

4.Conclusions

In this paper, wideband balanced filter with high CM rejection level is designed and simulated. Simulated results including DM insertion losses, DM return losses, and CM insertion losses are presented to show the wideband balanced filtering as well as CM rejection and finally to verify the proposed idea. 3-dB DM S21 bandwidth reaches 53.6%. The proposed filter is an excellent candidate for applications such as high speed wireless communications and satellite systems that require high communication capacity.

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