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A COMPACT UWB BANDPASS FILTER WITH IMPROVED OUT-OF-BAND PERFORMANCE USING MODIFIED COUPLING STRUCTURE

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Abstract—A compact ultra-wideband (UWB) bandpass filter (BPF) with improved harmonic suppression using a modified coupling structure is presented in this paper. The modified coupling structure is constructed by taper-connecting two folded open stubs to the traditional parallel-coupled lines, which shows an improved characteristic in harmonic suppression. By integrating the proposed coupling and the stepped-impedance stub loaded resonator (SISLR), a UWB BPF is finally built and tested. The simulated and measured results are in good agreement with each other, exhibiting good wideband filtering characteristic and improved out-of-band performance.

1. INTRODUCTION

Since the release of ultra-wideband (UWB: 3.1–10.6 GHz) frequency in 2002 [1], a great effort has been made in the exploration of a variety of UWB BPFs using different approaches [2–19]. In [2], a UWB BPF comprised a composite lowpass-highpass topology was proposed. In [3], pseudo-interdigital structure was developed to construct a UWB BPF. UWB BPFs using multiple-mode resonator (MMR) have been reported in [4–6]. In [7, 8], fractal technologies were used to reduce the sizes of UWB BPFs, another intuitive ideas of constructing UWB BPFs were to use composite right-/left-handed (CRLH) transmission line structures [9, 10]. However, it is still a challenge to design a UWB BPF with good in-band and out-of-band performance at compact size. To eliminate the spurious passband, defected ground structures (DGS) were adopted in [11–13], which suffered from fabricated complication.

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In [14], electromagnetic bandgap was introduced to UWB filter design for a wider upper-stopband. Harmonic-suppressed multiple-mode resonators were developed in [15–18] to push harmonics to high frequencies. However, the lower stopband still exhibited unexpected poor roll-off rejection performance. In [19], capacitive-ended coupled lines were presented to suppress the first spurious passband. But this approach can only raise the upper-stopband from 13.8 to 15.9 GHz.

In this paper, a UWB BPF with improved out-of-band performance is presented based on the SISLR mentioned in our previous work [20]. To suppress the spurious passband, the proposed coupling structure is constructed by taper-connecting two folded open stubs to the traditional parallel-coupled lines, which can weaken the coupling efficient at the higher order harmonics of the SISLR and suppress the spurious passband with the desired passband response nearly unchanged. After optimization, the proposed UWB BPF is fabricated and the experimental results agree well with the simulation to demonstrate good filtering characteristic and a wide upper-stopband with more than 20 dB attenuation from 11.5 GHz up to 30 GHz.

2. FILTER DESIGN

The configuration of the proposed UWB BPF with modified coupling structure is depicted in Fig. 1. It can be observed that the UWB BPF is constructed by stepped-impedance stub loaded resonator (SISLR) and the proposed coupling structure. The SISLR used in the UWB BPF has been presented and analyzed in [20]. The first three resonances

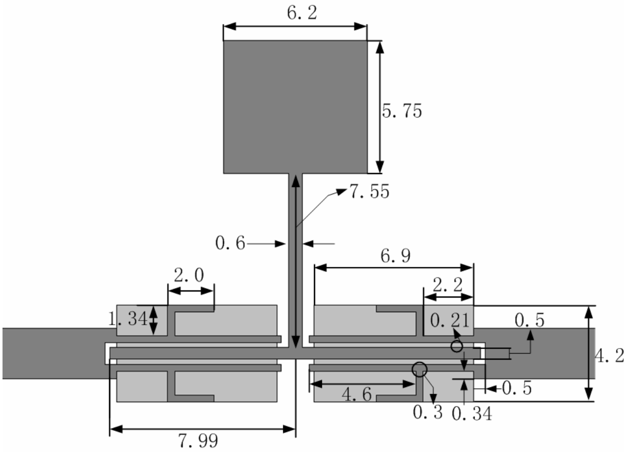

Figure 1. Configuration of the proposed UWB BPF (all in mm).

of the SISLR are utilized to make up a UWB passband with other higher order harmonics located at the upper-stopband which may cause spurious passband. An improvement is developed in this work by introducing the modified coupling structure for harmonic suppression. The proposed coupling structure is formed by taper-connecting two folded open stubs to the traditional aperture-back parallel-coupled lines.

As shown in Figs. 2(a) and (b), structural parameters of the traditional aperture-back parallel-coupled lines and the proposed modified coupling structure are all the same except the extra taper-connecting folded open stubs. To investigate the characteristics of the modified coupling structure, simulations have been carried out, as shown in Fig. 3. It can be observed obviously that the coupling efficient at the upper stopband is weakened and spurious passband response of the traditional parallel-coupled lines can be greatly suppressed by the folded open stubs. Moreover, by adjusting the length of the open stubs, spurious passband response can be properly tuned with the desired passband response nearly unchanged.

A UWB BPF can be constructed by integrating the modified coupling structure and the SISLR. Meanwhile, at the higher order harmonics of the SISLR, because of the low coupling efficient provided by the modified coupling structure, harmonics in the unwanted passband can be suppressed effectively. Comparison of simulated frequency responses of the UWB BPFs with traditional aperture-

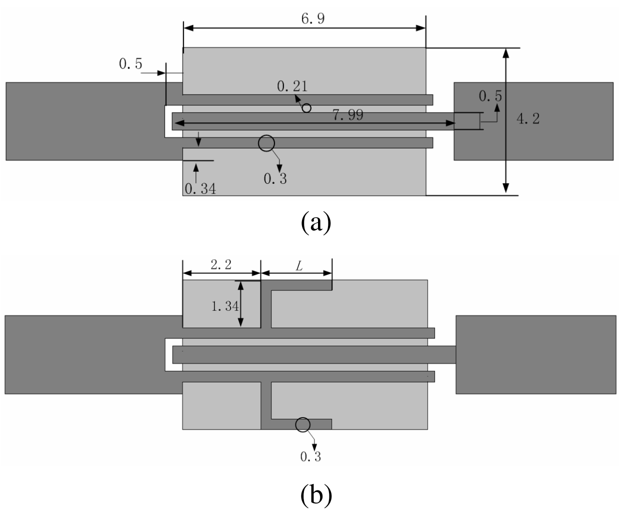

Figure 2. (a) Traditional aperture-back parallel-coupled lines, (b) The modified coupling structure (all in mm).

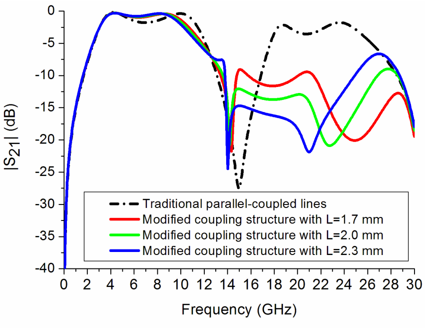

Figure 3. Frequency responses of the traditional parallel-coupled lines and the modified coupling structure.

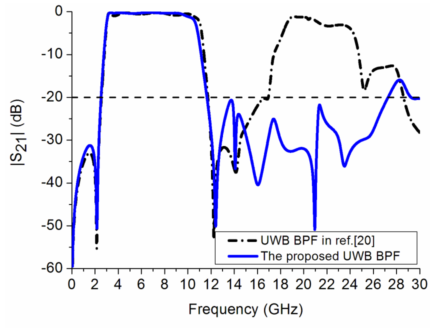

Figure 4. Comparison of the frequency responses of the UWB BPFs with traditional aperture-back parallel-coupled lines and the modified coupling structure.

back parallel-coupled lines [20] and the modified coupling structure is presented in Fig. 4. It is clearly demonstrated that upper-stopband is significantly widened up to 27 GHz with attenuation level of higher than 20 dB in simulation. Moreover, there is little influence on the desired passband response which exhibits very good in-band performance and high selectivity.

3. SIMULATED AND MEASURED RESULTS

To verify the proposed approach, the UWB BPF with harmonic-suppressed coupling structure is optimally designed and fabricated on the substrate with relative dielectric constant of 2.55 and thickness of 0.8 mm. The photographs of the top layer and bottom layer of fabricated UWB BPF are demonstrated in Fig. 5. Experiment has been carried out and Fig. 6 shows the S-parameters and group delay of the UWB BPF. Good agreement between simulation and measurement is obtained. Some slight discrepancies may due to unexpected tolerances in fabrication, material parameters. It can be observed from Fig. 6 that the measured 3-dB passband ranges from 2.8 to 10.4 GHz against the counterpart frequency of 3.0 to 10.7 GHz in simulation. The in-band group delay is flat and small. As expected, the spurious passband has been greatly suppressed due to the modified coupling structure. The measured attenuation level is higher than 20 dB in a wide upper-stopband from 11.5 up to 30 GHz. In addition, the filter has a compact size of 16.4 mm × 15.65 mm.

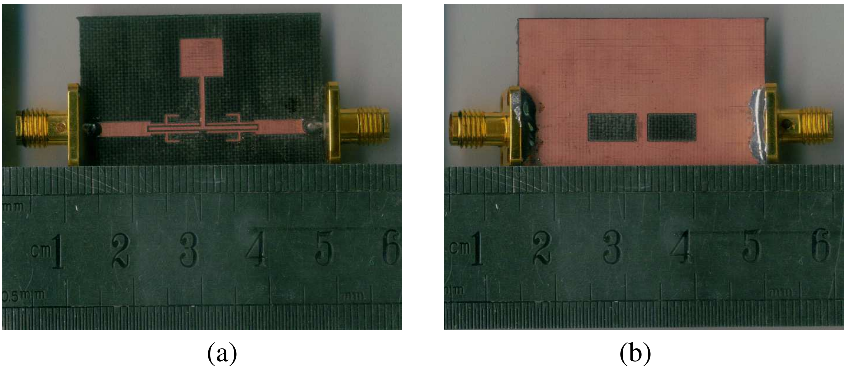

Figure 5. Photographs of the fabricated UWB BPF, (a) top layer, (b) bottom layer.

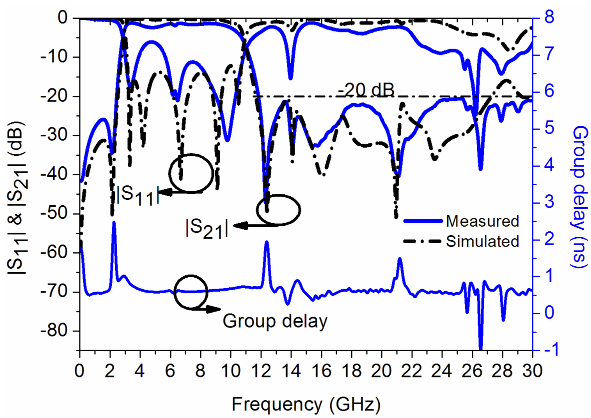

Figure 6. Simulated and measured results of the proposed UWB BPF.

4. CONCLUSION

A compact UWB BPF with improved out-of-band performance using modified coupling structure is presented and implemented in this paper. Both simulated and measured results validate the predicted design with good agreement, demonstrating that the proposed modified coupling structure has an improved characteristic in harmonic suppression and the upper-stopband of the proposed UWB BPF has been significantly widened up to 30 GHz with attenuation level higher than 20 dB.

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