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COMPACT UWB BANDPASS FILTER WITH NOTCHED BAND

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Abstract—A compact ultra-wideband (UWB) band-pass filter (BPF) with highly rejected notched band is proposed in this paper. The proposed UWB BPF is composed of two cascaded interdigital hairpin resonator units. Interdigital hairpin resonator unit with different coupling is theoretically analyzed. The working frequency of the proposed UWB BPF is 3.1–10.6 GHz and notched band is 5.7–5.8 GHz. Finally, measured results are presented, which are in good agreement with the simulation results.

1. INTRODUCTION

Ultra-wideband (UWB) technology has risen dramatically since U.S. Federal Communications Commission (FCC) authorized the frequency band of 3.1 to 10.6 GHz for commercial purposes [1, 2]. Different methods have been used to develop UWB band-pass filters (BPFs), e.g., nonperiodical shunt-stub loading [3, 4], composite lowpass-highpass topology [5], cascaded broadside-coupling [6–11], circular

resonator [12–19] and multiple-mode resonator (MMR) [20–23]. Due to the existing radio signals such as wireless local-area network (WLAN), a small band-pass filter with a notched band is urgent requirement in UWB radio system to suppress the interferes by the WLAN radio signals. UWB BPF with a notched band is realized by an embedded open-circuited stub [24], which is an effective way to reject any undesired radio signal. However this structure has relatively complex form and large size.

Based on our previous works, a new structure is proposed and implemented in this paper, which has wide pass-band and relatively small size. Notched band-stop filtering effect is achieved by adding coupling interdigital finger to reject the undesired WLAN radio signals. Interdigital hairpin resonator unit with different coupling is theoretically analyzed. The newly designed UWB BPF is composed of two cascaded interdigital hairpin resonator units along with the transmission line. By appropriately choosing the dimensions of the hairpin resonator units, the filter can obtain wideband pass-band and notched band simultaneously. Measured results show that the working frequency is 3.1–10.6 GHz and notched band with 15 dB attenuation is 5.7–5.8 GHz. The return losses are less than −15 dB in pass-band. Measured results agree well with the simulated results.

2. ANALYSIS AND DESIGN OF THE UWB BPF

The proposed microstrip interdigital hairpin resonator is shown in Figure 1, which is composed of three parallel coupling interdigital fingers with the same size. The width of the finger is $W2$ and the distance between the adjacent coupling fingers is $W3$. In order to investigate the frequency characteristics, interdigital hairpin resonator

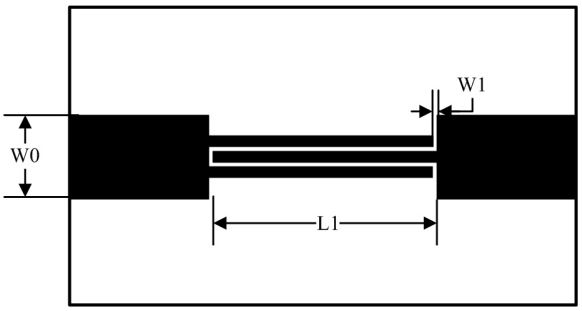

Figure 1. Geometry of the interdigital hairpin resonator unit with three fingers.

is simulated by HFSS 10.0. The simulation results show that interdigital hairpin resonator have bandpass performance, as shown in Figure 2.

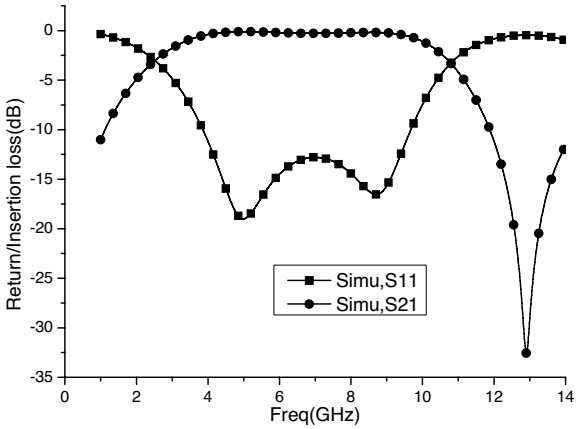

Figure 2. Simulated S-parameters of the interdigital hairpin resonator unit with three fingers ($W0 = 3.0\,\text{mm}$, $W1 = 0.15\,\text{mm}$, $L1 = 8.0\,\text{mm}$, $W2 = 0.3\,\text{mm}$, $W3 = 0.15\,\text{mm}$, ε_r of substrate = 2.2, thickness of substrate = 1.0 mm).

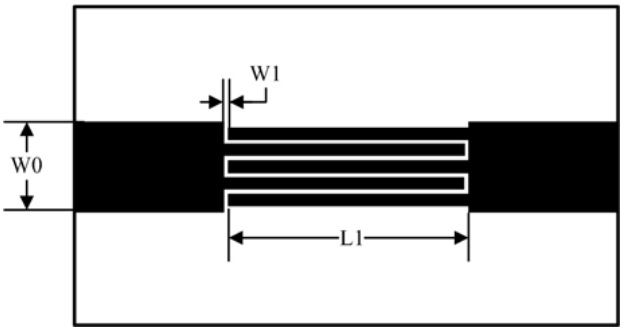

Figure 3. Geometry of the interdigital hairpin resonator unit with five fingers.

Figure 3 show the geometry of the proposed interdigital hairpin resonator unit with five identical fingers. The simulation results show that notched band is introduced by adding two fingers, as shown in Figure 4. It can be seen that the frequency response of the upper side band and lower side band of the proposed interdigital hairpin resonator

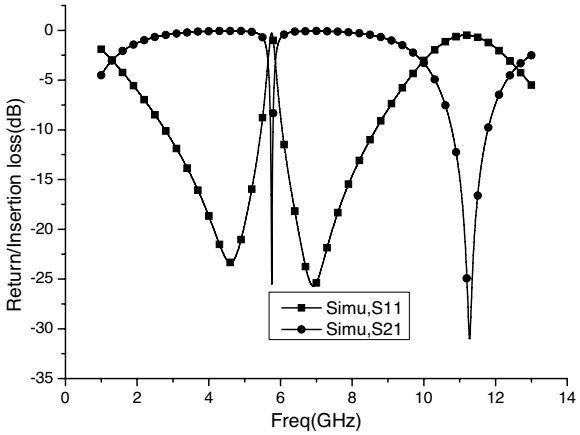

Figure 4. Simulated S-parameters of the interdigital hairpin resonator unit with five fingers ($W0 = 3.0\,\text{mm}$, $W1 = 0.15\,\text{mm}$, $L1 = 9.4\,\text{mm}$, $W2 = 0.4\,\text{mm}$, $W3 = 0.15\,\text{mm}$, ε_r of substrate = 2.2, thickness of substrate = 1.0 mm).

unit is not good.

For the design of UWB BPF with the highly rejected notched band and good performance in pass-band, two interdigital hairpin resonator units with the same dimensions are cascaded along with the transmission line. The configuration of the proposed UWB BPF is shown in Figure 5. The simulation is performed by using HFSS V.10.0. The substrate is RT/Duorid 5880 with the thickness of 1.0 mm and the dielectric constant of 2.2. The characteristic impedance of the microstrip line is assumed to be 50-Ω. All the parameters of dimensions are determined as follows: $W0 = 3.0\,\text{mm}$, $W1 = 0.15\,\text{mm}$, $L1 = 9.4\,\text{mm}$, $L2 = 5.0\,\text{mm}$, $W2 = 0.4\,\text{mm}$, $W3 = 0.15\,\text{mm}$. Figure 6 shows simulated S-parameters of the proposed UWB BPF. It can be seen that the transitional band is greatly improved.

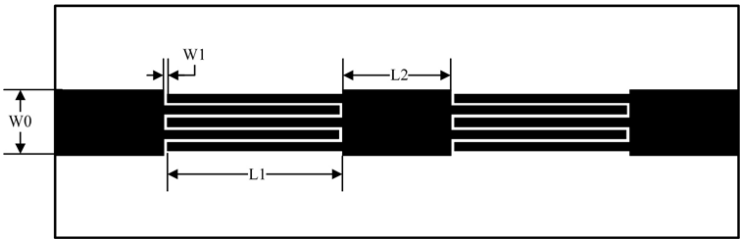

Figure 5. Geometry of the proposed UWB BPF.

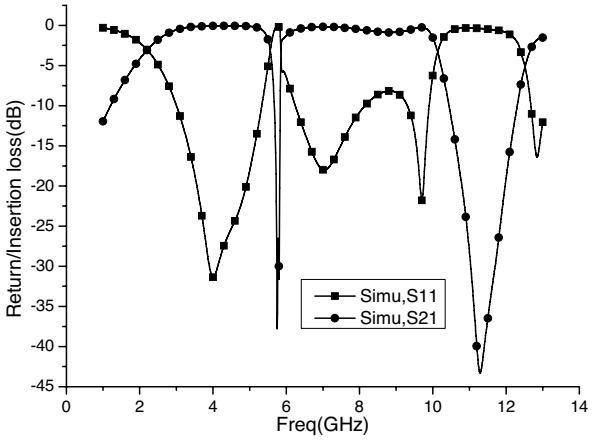

Figure 6. Simulated S-parameters of the proposed UWB BPF.

3. RESULTS AND DISCUSSION

Finally, the designed UWB BPF is measured with an Agilent N5230A vector network analyzer. The comparison of the simulated and measured results is shown in Figure 7. It is found that the working frequency of the proposed UWB BPF is 3.1–10.6 GHz and notched band is 5.7–5.8 GHz. The insertion loss is less than 1.0 dB in pass-band. The measured rejection loss is more than −30 dB at he midband

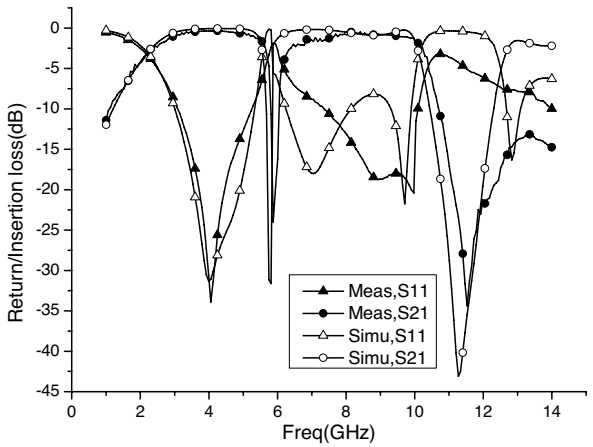

Figure 7. Simulated and measured S-parameters of the designed UWB BPF.

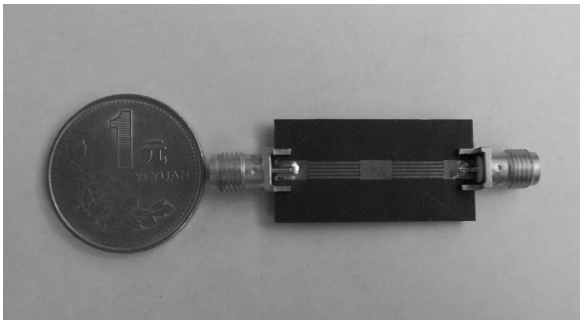

Figure 8. Photograph of the fabricated UWB BPF.

frequency of notched band. Figure 8 shows the photograph of the fabricated UWB BPF.

4. CONCLUSION

A compact UWB BPF with highly rejected notched band has been proposed in this paper. The proposed BPF is composed of two cascaded interdigital hairpin resonator units. By tuning the parameters of the interdigital hairpin resonator unit, the proposed UWB BPF can have wideband pass-band in the meantime effectively introduce a narrow notched band. The measured results are in good agreement with the simulated results.

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