Design of High Isolation Diplexer with Source-load Coupling

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Abstract— A microstrip diplexer with very high isolation is proposed. The diplexer comprises two third-order CT filters and a connecting line between them. The improved CT filter has three adjustable transmission zeros through leading in the coupling coefficient between the source and load. By locating the transmission zero of one channel at the passband of the other channel, very high isolation of the diplexer can be achieved. Good agreements are also achieved between measurement and simulation.

1. INTRODUCTION

Planar diplexer with compact circuit size, low insertion loss, high isolation and controllable channel frequencies is an important component in wireless communication systems. For the design of planar diplexers, the traditional approach is to design two different filters individually and then to design the matching network. The most straightforward method is to combine two bandpass filters with a T-junction Y-junction [1, 2]. The method, which features one filter an open-circuited line shunted to the other filter at the frequency of the latter, is adopted to reduce the mutual loading effect between the filters. In [3–5], the common resonator technology is proposed to remove the input junction in the diplexer designs and reduces the size to a great degree. Some novel diplexer designs without distribution networks have appeared in the recent literatures [6–9]. A new topology of the diplexer with common port directly connected to two filters was proposed and synthesized in [6]. A design procedure for coupled resonator diplexers that does not employ any external junctions was also proposed in [7].

In this paper we presented a novel type of microstrip diplexer structure with center frequencies at 1.8 and 2.3 GHz High isolation large than 37 dB from 1 to 5 GHz is obtained. Two cascaded triplet (CT) filters are employed in parallel configurations to obtain the dual-channel response, and the center frequency and bandwidth of each passband can be controlled independently. The source-load coupling is also introduced to provide two additional transmission zeros, which improve the selectivity greatly.

2. DIPLEXER DESIGN

Figure 1 shows the structure of the proposed diplexer using quarter-wavelength resonators. The proposed diplexer consists of two cascaded triplet (CT) unit Three quarter-wavelength resonators are combined together to form a typical CT unit. Some resonators are folded to reduce the size. The via holes that connect the microstrip line and the ground plane are denoted by circles. To improve the selectivity of the diplexer, the coupling between the source and load is introduced to add two

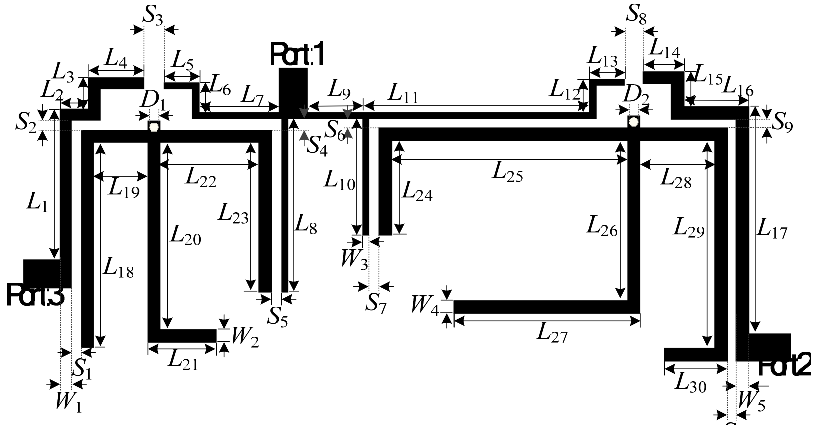

Figure 1: Layout of the proposed diplexer filter.

transmission zeros. Figure 2 shows the coupling diagram of the dual-band filter, which contain two CT filter with source-load coupling. Both the direct couplings between the adjacent resonators and cross coupling between the first and third resonators are magnetic, so the filter presented in this paper is a special case of CT filter. The cross-coupling is inductive, so one transmission zero can only be located at the upper stopband of each channel.

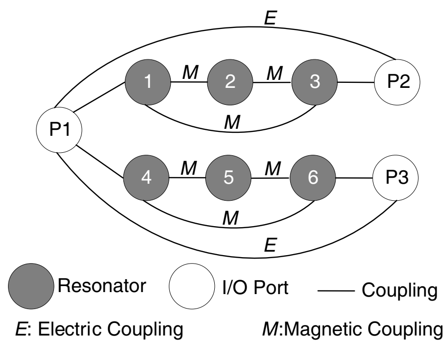

Figure 2: Coupling and routing scheme of the diplexer.

The proposed dual-band filter is to be designed on a substrate with dielectric constant = 2.55, loss tangent = 0.0029, and thickness $h = 0.8$ mm. In this study, IE3D is employed for simulating and optimizing the filter design. A trial diplexer centering at 1.8 and 2.3 GHz is design for demonstration. Figure 3 shows the simulated insertion loss responses under different situations. Each passband can be designed separately. To obtain a dual-channel response, a novel matching network with four open-circuited stubs is designed.

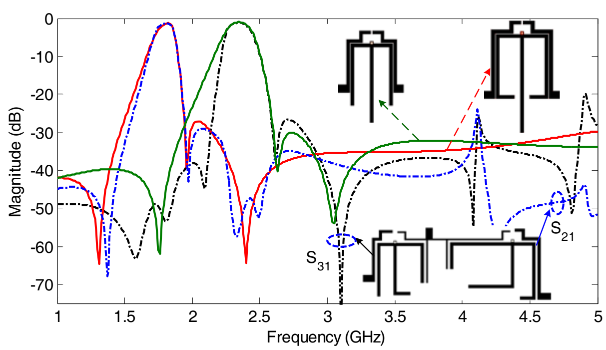

Figure 3: Diplexer design based on CT bandpass filters.

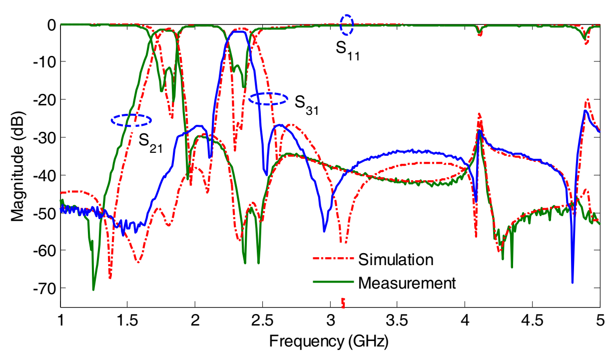

Figure 4: Simulated and measured reflection and transmission coefficients of the designed diplexer.

3. SIMULATION AND MEASUREMENT RESULTS

Based on the foregoing design process, a diplexer with high isolation is presented. The dimensions for the diplexer are: $S_1 = 0.2$ mm, $S_2 = 0.2$ mm, $S_3 = 0.5$ mm, $S_4 = 0.2$ mm, $S_5 = 0.2$ mm, $S_6 = 0.5$ mm, $S_7 = 0.35$ mm, $S_8 = 0.55$ mm, $S_9 = 0.2$ mm, $S_{10} = 0.2$ mm, $L_1 = 12.6$ mm, $L_2 = 3.5$ mm, $L_3 = 2.4$ mm, $L_4 = 3.15$ mm, $L_5 = 2.75$ mm, $L_6 = 2.3$ mm, $L_7 = 6.4$ mm, $L_8 = 11.4$ mm, $L_9 = 4.9$ mm, $L_{10} = 8.65$ mm, $L_{11} = 18.15$ mm, $L_{12} = 2.5$ mm, $L_{13} = 2.7$ mm, $L_{14} = 3.4$ mm, $L_{15} = 2.65$ mm, $L_{16} = 5.2$ mm, $L_{17} = 18.1$ mm, $L_{18} = 16.35$ mm, $L_{19} = 4.3$ mm, $L_{20} = 16.65$ mm, $L_{21} = 4.5$ mm, $L_{22} = 7.9$ mm, $L_{23} = 11.3$ mm, $L_{24} = 7.15$ mm, $L_{25} = 18.8$ mm, $L_{26} = 12.9$ mm, $L_{27} = 14.1$ mm, $L_{28} = 6$ mm, $L_{29} = 17$ mm, $L_{30} = 4.35$ mm, $W_1 = 0.9$ mm, $W_2 = 1$ mm, $W_3 = 0.5$ mm, $W_4 = 1$ mm, $W_5 = 1.15$ mm, $D_1 = D_2 = 0.8$ mm. The simulated and measured S parameters are shown in Figures 4 and 5. The full-wave simulation is carried out by IE3D, and the diplexer is measured using Agilent vector network analyzer 5230A. The center frequencies of the diplexer are 1.8 and 2.3 GHz. The insertion losses are 1.7 and 1.8 dB, and the isolations among channels are larger than 37.5 dB. The fractional bandwidths of the two passbands are 10% and 7%. The photograph of the proposed diplexer is shown in Figure 6, and the circuit size of the proposed diplexer is $58\,\text{mm} * 25\,\text{mm} = 0.50\lambda_g * 0.22\lambda_g$, where λ_g is the guided wavelength on the substrate at the center frequency of the first channel.

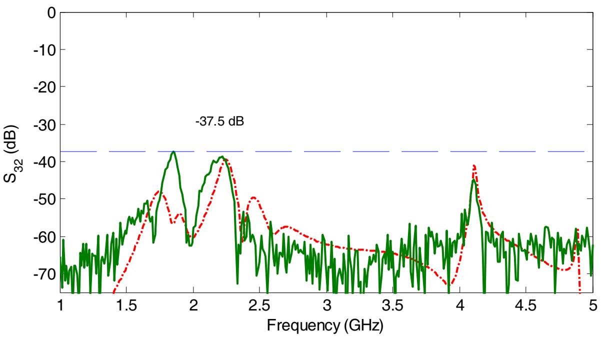

Figure 5: Simulated and measured isolation of the designed diplexer.

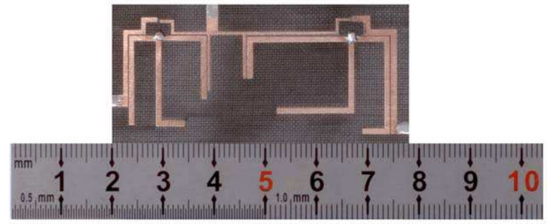

Figure 6: Photograph of the fabricated diplexer.

4. CONCLUSION

A new type of diplexer based on a microstrip CT filter with source-load coupling is presented. The implemented CT filter has the merits of compact size and high selectivity. The positions of the transmission zeros can be easily controlled by source-load coupling. This feature is applied to improve the isolation of the diplexer successfully. A trial diplexer centering at 1.8 and 2.3 GHz is presented to prove the efficiency of this design method.

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