Design of novel stripline diplexer using frequency dependent couplings

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Abstract

A novel stripline diplexer design using frequency dependent couplings to achieve multiple transmission zeros is developed in this paper. The transmission zeros generated by the frequency dependent couplings are flexible and controllable, on the basis of the existing cross-coupled, more transmission zeros are introduced to improve the frequency selection characteristics. Based on this characteristic, we designed a 2.6G Hz diplexer, its transmitting channel filter is 5 order with 4 transmission zeros, and the receiving channel filter is 4 order with 5 transmission zeros. We fabricated and measured it, the synthesis results, simulation results, and the tested results are well matched with each other, which will provide more flexibility in the design of diplexers for wireless communication system.

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Abstract:A novel stripline diplexer design using frequency dependent couplings to achieve multiple transmission zeros is developed in this paper. The transmission zeros generated by the frequency dependent couplings are flexible and controllable, on the basis of the existing cross-coupled, more transmission zeros are introduced to improve the frequency selection characteristics. Based on this characteristic, we designed a 2.6G Hz diplexer, its transmitting channel filter is 5 order with 4 transmission zeros, and the receiving channel filter is 4 order with 5 transmission zeros. We fabricated and measured it, the synthesis results, simulation results, and the tested results are well matched with each other, which will provide more flexibility in the design of diplexers for wireless communication system.

Introduction: With the rapid development and wide application of modern communication technology, the limited spectrum resources are becoming more precious, in order to make full use of the electromagnetic spectrum resources, the operating frequency interval between various communication systems is getting smaller and smaller, and the anti-interference requirements between adjacent operating bands are also put forward higher requirements, the demand for highly selective RF front-end diplexers is also growing[1-2].

The finite transmission zeros are critical for diplexer design to enhance the rejection ratios, one of the prevalent methods for creating finite transmission zeros is the basic cross- coupling mechanism, and another popular mechanism to create finite transmission zeros is based on the frequency dependent coupling [3-5].

Metal stripline resonators have higher Q values, better harmonic suppression characteristics and higher reliability than dielectric waveguide resonators. Here we introduce a inverted E-type metal resonator, which can be regarded as an evolution of a 1/4 wavelength step impedance resonator, and they have similar field distribution and resonant characteristics. The upper space of the stripline resonator is mainly electric field distribution, and the lower space is mainly magnetic field distribution. When two stripline resonators are placed side by side, the electrical coupling E_c mainly exists through the upper half space coupling window, while the magnetic couplingM_c mainly exists through the lower half space coupling window. When there are coupling windows in the upper and lower spaces of both stripline resonators, that is, there are both electrical and magnetic coupling between the two resonators, the total coupling coefficient$k$ is frequency dependent, and the transmission zerof_{tz} produced by the frequency dependent coupling as follow[6-12]:

$k = \frac{(M_c - E_c)}{(1 - \text{M }_c E_c)}$ (1)

$f_{\text{tz}} = f_0 \sqrt{\frac{M_c}{E_c}}$(2)

As can be seen from (1) and (2), when the electric coupling in $E_c$is greater than magnetic couplingM_c, the transmission zero f_{tz} generated by the frequency dependent coupling will be at the lower end of the passband. While the magnetic coupling $M_c$is greater than the electric coupling E_c, the transmission zero f_{tz} will be at the higher end of the passband.

Diplexer design and measurement: Based on the frequency dependent coupling of the two stripline resonators described above, the frequency dependent coupling can generate transmission zero at the high frequency stopband or the low frequency stopband of filter, respectively, which can effectively improve the selection characteristics of the filter, while the asymmetric frequency response can greatly improve the isolation between channels in the diplexer applications. So here, we designed and fabricated a 2.6G cross-coupled diplexer with frequency dependent couplings, to verify the feasibility. The following specs have been assumed (return loss is 22dB for both channels).

Junction: Resonant node.

RX Filter: Band= [2495, 2575] MHz and f_{tz}= [2484, 2605, 2679] MHz, 4th order.

TX Filter: Band= [2615, 2695] MHz and f_{tz}= [2561, 2597, 2717] MHz, 5th order.

According to the above technical specifications, we carried out synthesis, modeling and simulation, the topology with synthesis results are shown in Fig. 1.

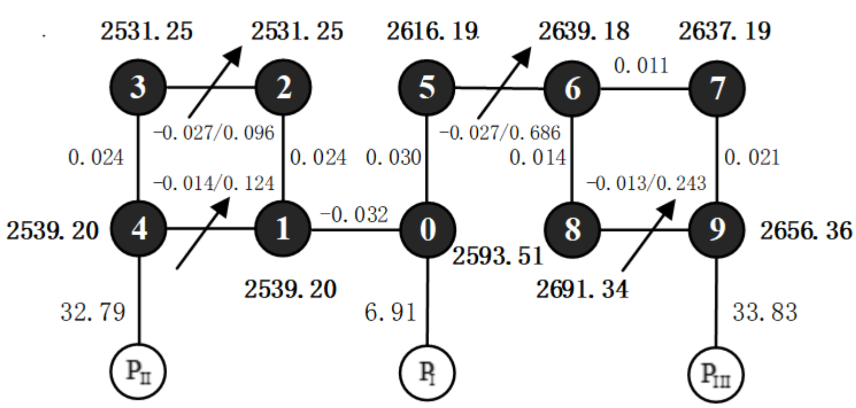

Fig 1 . Topology schematic of the duplexer with resonating frequencies, coupling coefficients and the external Q. (Black solid circle represent the resonators. Numbers next to the lines connecting the circles represent coupling coefficients or external Q . Solid line segments with arrows: FDC the pair $\frac{k_{0i,j}}{C_{i,j}}$.)

The diplexer simulation model is shown in Fig. 2, whose dimensions are 55mm×21mm×19mm, the simulation response and synthesis response are matched well as shown in Fig. 3.

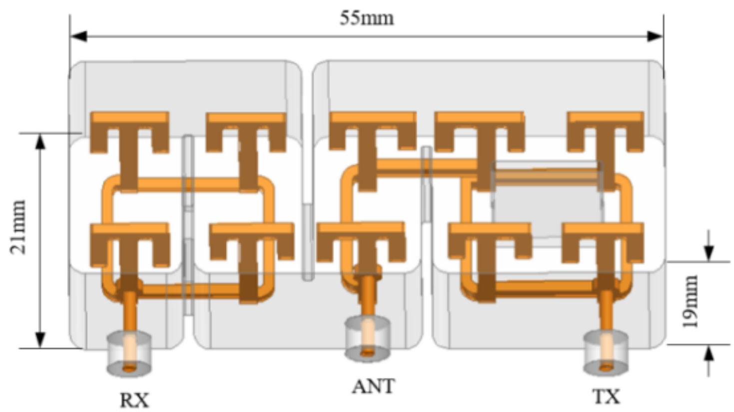

Fig 2 . The simulation model of the stripline duplexer

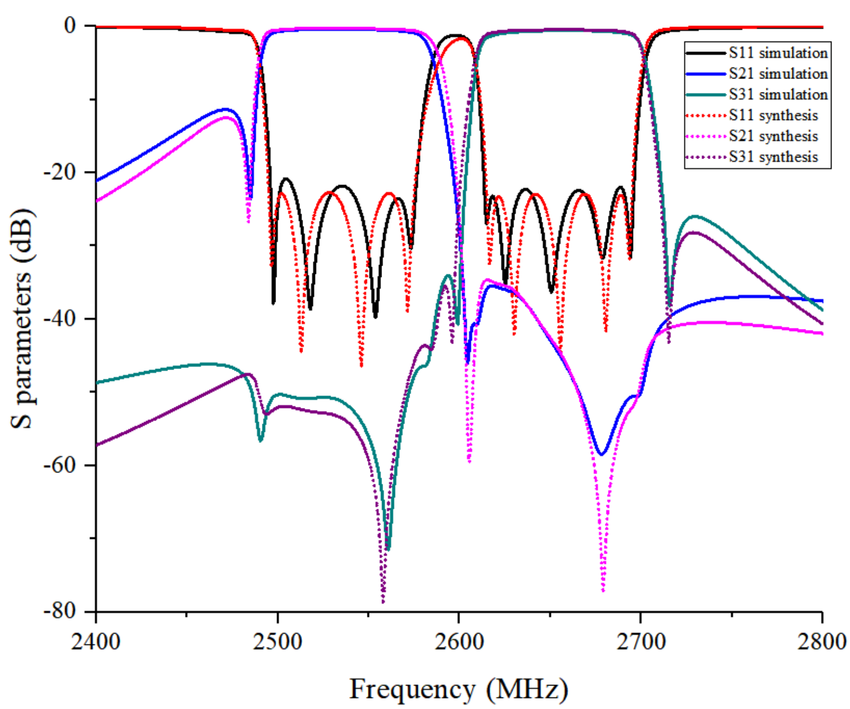

Fig 3 . The simulation response compared with the synthesis response of the stripline duplexer

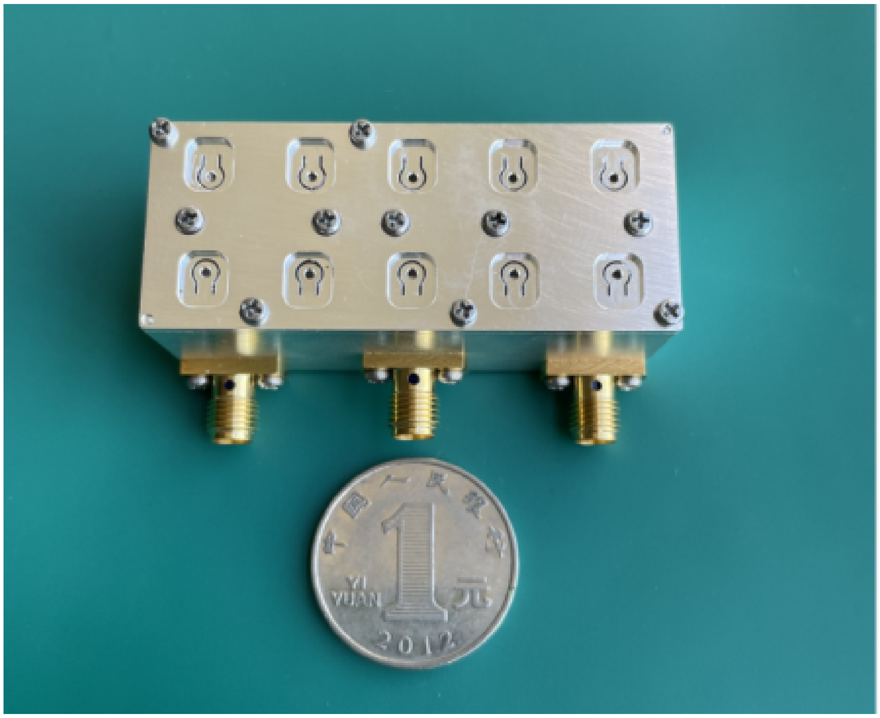

Fig 4. Photograph of the fabricated striplinediplexer

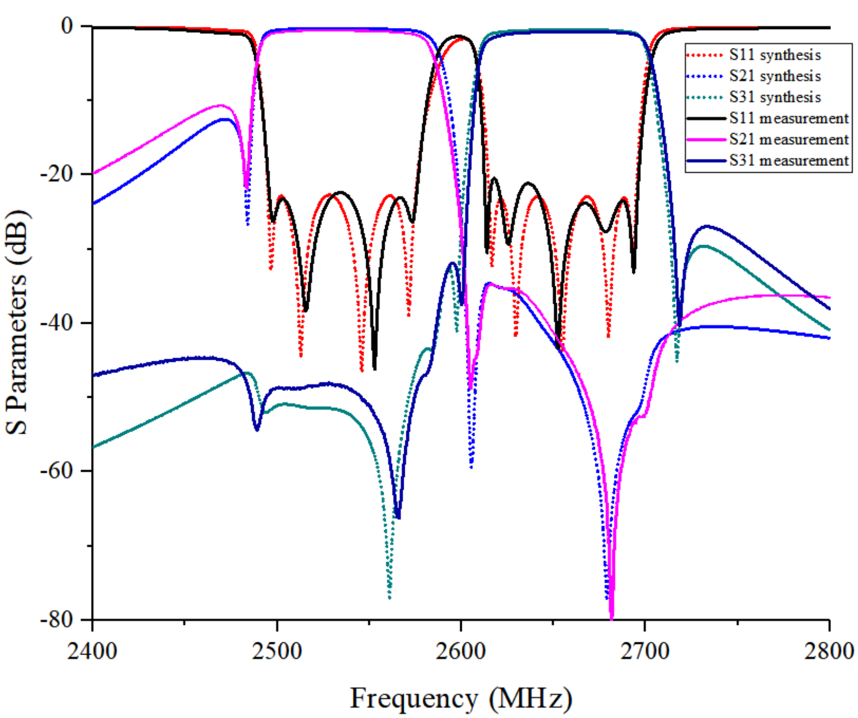

Fig 5 . The narrow band measurement results compared with the synthesis response of the duplexer

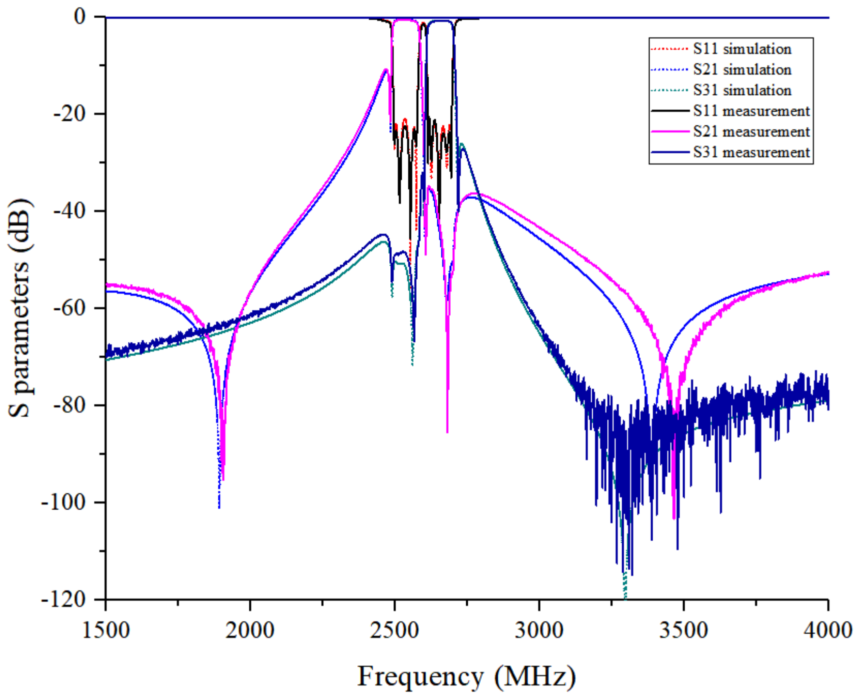

Fig 6. The wide band measuremen results compared with simulation response of the duplexer

The photograph of the fabricated diplexer is shown in Fig. 4, whose dimensions are 57mm×23mm×21mm (connector size is not included). In Fig. 6, the wide band response of the diplexer, there is one parasitic transmission zero of the transmitting channel, while there are two parasitic transmission zeros of the receiving channel. The parasitic transmission zeros can further enhance remote suppression. Combined with Fig. 3 and Fig. 5, we know the synthesis results, simulation results, and tested results are well matched with each other.

Conclusion: In this paper, a novel 2.6G stripline diplexer with multiple transmission zeros using frequency dependent couplings is developed. On the basis of the synthesis technique for cross-coupling filter, by introducing the frequency dependent couplings new transmission zeros are generated. The diplexer has better frequency selection characteristics, lower loss, better harmonic suppression characteristics and higher reliability, and it can be welded and integrated on the PCB board like the dielectric waveguide diplexer, it has broad application value.

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