Design of High Coupling Microstrip Branch Directional Coupler

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Abstract: The directional coupler is a kind of microwave component, which has been widely used in the microwave field, and is mainly used in signal isolation, mixing and separation. The directional coupler is a combination of transmission lines directly. This design mainly uses ADS software to design a high-coupling microstrip branch directional coupler, and completes circuit simulation and layout simulation in ADS software. The designed high-coefficient microstrip branching directional coupler has a center frequency of 2.45 GHz. The simulation results are characterized by an isolation of -44.9 dB in the center band and a coupling degree of -3.05 dB in the center band.

1. Introduction

Microwave/electromagnetic wave technology is an important branch of radio research and has gradually become an important research topic in the fields of communication and radar [1, 2]. The microstrip branch directional coupler is a power coupling device, and its greatest feature is its power directivity. The microstrip branch directional coupler has four ports with two microstrip lines inside: a straight through line and a coupled line [3]. There is a certain coupling mechanism between the straight-through line and the coupled line, and then a part of the power on the straight-through line is directionally coupled into the coupled line by this special coupling mechanism. In theory, the power on the coupled line is all output at the coupled port, and the output power of the isolated port is zero. Microstrip directional couplers are widely used in microwave applications because of their several advantages, namely, manufacturability, repeatability, low cost, and the like [4].

At present, there are two kinds of couplers widely used: one is the Lange directional coupler, and the advantage of the Lange directional coupler is that it is compact and easy to integrate, but it has high requirements on the circuit fabrication process and cannot be widely applied; the other is a stripline directional coupler [5]. Although the stripline directional coupler is not as high as the Lange directional coupler, the stripline directional coupler structure is more complex and less integrated than a typical coupler [3]. The microstrip line directional coupler is characterized by compact structure, easy integration, and simple circuit fabrication process, and has gradually become the main development direction of directional couplers.

According to the brief introduction above, this paper designs a microstrip branching directional coupler. The operating frequency is 2.45 GHz and the working range is from 2.0 GHz to 3.0 GHz. The isolation is -45dB in the center band and the coupling is -3.0dB in the center band.

2. Simulation Structure

The directional coupler is a four-port component, so there are four Term ports in the schematic, as shown in Fig. 1. Among them, the "Term 1" port is designed as an input port, the "Term 2" port is designed as a straight-through port, the "Term 3" port is designed as a coupled port, and the "Term 4" port is designed as an isolated port. The start frequency "start" is set to 2.0 GHz, the termination frequency "stop" is set to 3.0 GHz, and the frequency interval "step-size" is set to 0.01 GHz.

Add the "VAR" control; select the "Optim" control and the "Goal" control in the component control panel of the schematic window to insert into the schematic. This high-coupling microstrip

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branch directional coupler sets three optimization targets S(2,1), S(3,1), and S(4,1), so three "Goal" controls are required. If the parameters at this time are still deviated from the parameters we want, then the parameters of the high-coupling microstrip branch directional coupler should be optimized.

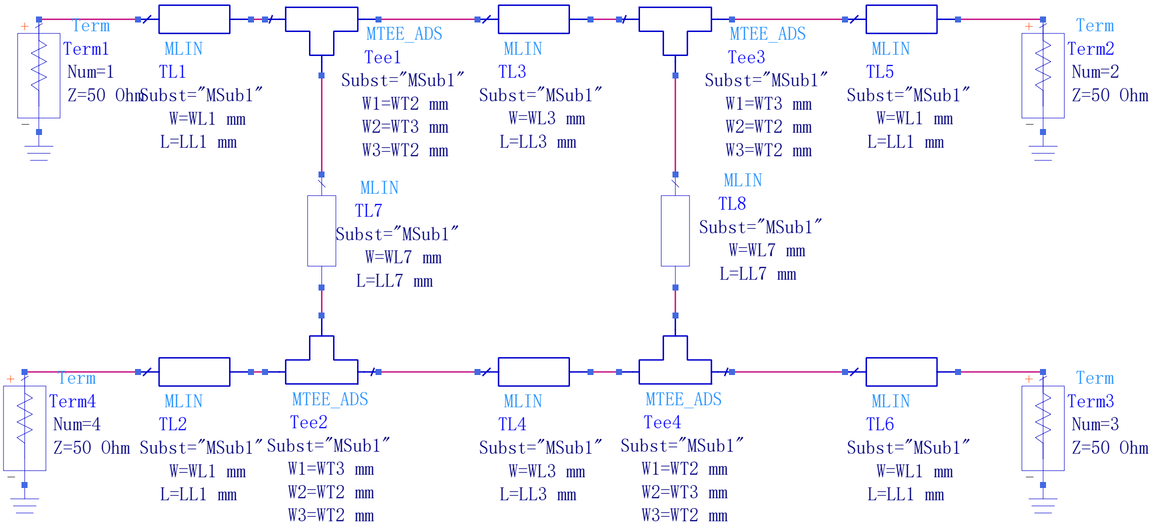

Fig. 1 High coupling degree microstrip branch directional coupler schematic

Then prepare to set the substrate parameters, generate a new dielectric board structure according to the schematic, and remove the unwanted conductors. The substrate structure is depicted in Fig. 2. The upper layer of the substrate metal is an air medium, and the lower layer is a dielectric substrate.

The dielectric constant of the dielectric substrate is set to 4.2;

The thickness of the microstrip substrate is set to 0.5 mm;

The thickness of the microstrip metal is set to 0.03 mm;

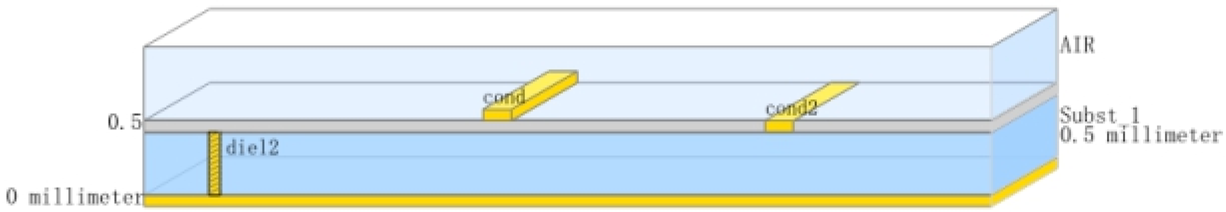

Fig. 2 Layout substrate structure

3. Simulation Results

Figure 3 show the schematic simulation results. As can be seen from Fig. 3, the value of the standing wave ratio for S(1,1) designed by the circuit is 1.018. Compared with the design requirements of general directional couplers, the value is already small enough, and the power reflected by the microwave during transmission is negligible. The values of dB(S(2,1)) and dB(S(3,1)) are also -3.757dB and -3.056dB, respectively, indicating that the attenuation from 1 port to 2 port and 1 port to 3 port meets us. Design the expected -3dB requirement. In terms of isolation, dB(S(4,1)) reaches -44.9dB, indicating that the isolated port has almost no power output, and the output power of the isolated port meets the power loss requirements in our design.

Compared with the circuit simulation, the data curve of the layout simulation, as illustrated in Fig. 4, has a slight offset. But numerically, the value of the standing wave ratio is at 1.035, and the peak value is about 1.01 at 2.47GHz, which is basically the same as the result of our circuit simulation. The values of dB(S(2,1)) and dB(S(3,1)) are also -3.157dB and -3.184dB, respectively, although they are incomparable with -.057dB and -3.056dB in circuit simulation, but It also meets the -3dB requirements of our design. In the isolation, the dB(S(4,1)) method has a large change, the isolation is reduced to -35.158dB, which is quite different from the -45dB in the circuit simulation. The peak value is about -46dB at 2.47GHz. Since the circuit simulation results themselves are subject to various requirements such as the manufacturing process, the slight shift of the peak value during the layout simulation often occurs. From the simulation results given in Fig. 3, the data basically meets our expected design requirements. However, it did not achieve the desired effect. In the later stage, it is still necessary to continuously optimize the design, and strive to optimize the peak value in the layout simulation results to 2.45GHz.

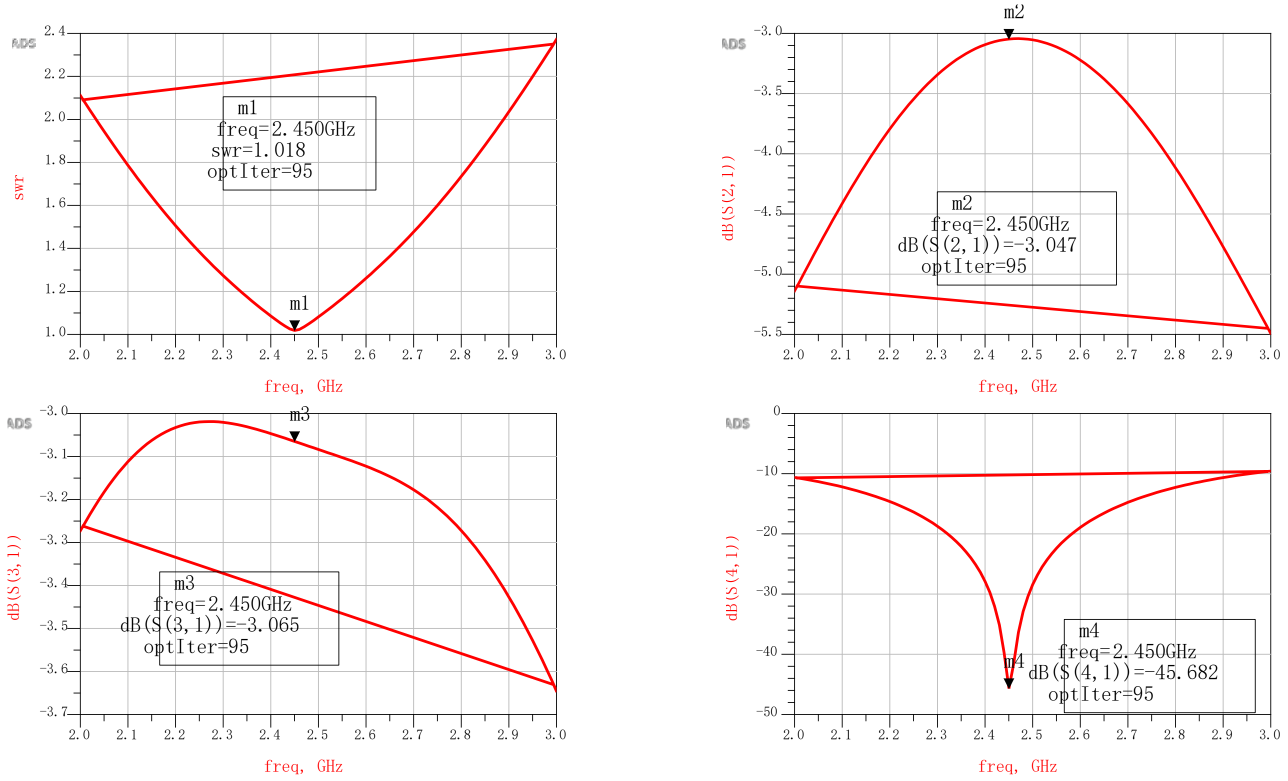

Fig. 3 Schematic simulation results

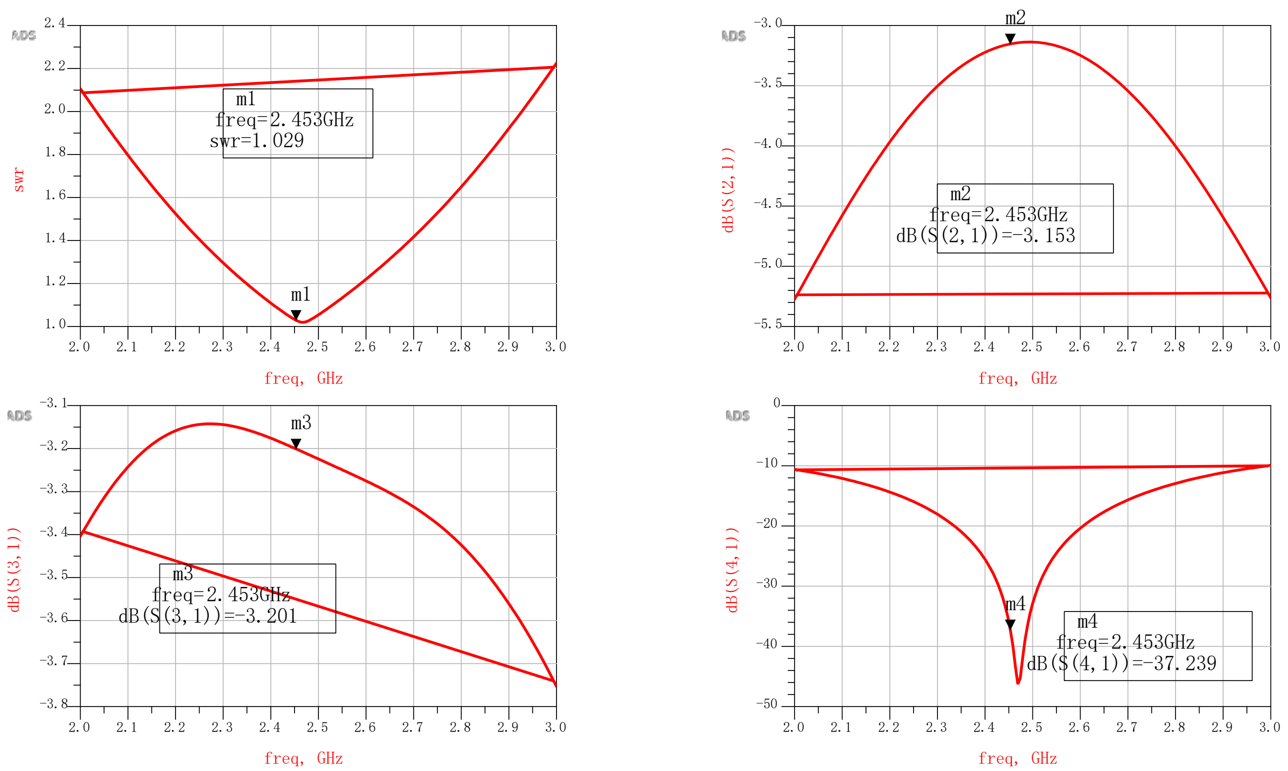

Fig. 4 Layout simulation results

4. Conclusion

Directional couplers are widely used in RF and microwave, and are an indispensable key component. Conventional directional couplers are relatively bulky and have a weak coupling, and have gradually been abandoned. The microstrip branch directional coupler occupies a small circuit area and has a strong coupling degree, and has been widely used in rapidly developing integrated circuits. This thesis is only theoretically analyzed. The ADS electromagnetic simulation platform is used to design and simulate the schematic diagram, and the layout is generated and the layout simulation is carried out. Further research is needed for actual production and application.

Acknowledgements

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