Wideband Out-of-Phase Filtering Power Divider with Arbitrary Power Dividing Ratio and High Selectivity

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***Abstract*—In this paper, a novel Filtering Power Divider(FPD) is proposed. This design consists of three parts: Marchand baluns constructed from two pairs of coupled lines and a terminal short-circuited stub, resonators loaded with two terminal short-circuited stubs, and two pairs of coupled resonators. This design generates four transmission zeros to improve selectivity. According to the design, good in-band isolation in the passband is achieved by connecting grounding resistors with two transmission lines at the central symmetry plane of the output ports of the baluns and coupled resonators. Simulation results show that this device achieves a 41% operating bandwidth, insertion losses of 9.57 dB and 0.52 dB, a power division ratio of 8:1, and a phase error of 1.8%, along with excellent in-band matching, out-of-band selectivity, and isolation.**

***Keywords*—FPD, arbitrary power division ratio, wideband**

I. INTRODUCTION

With the development of wireless communication technology, filtering power divider have become increasingly significant in fields such as microwave communications, radar, and phased array antennas. The Wilkinson power divider and the Gysel power divider are the most commonly used power division structures. However, they also have notable drawbacks. The power capacity of the Wilkinson [1][2] divider is limited by its internal resistors, which restricts its ability to handle high-power signals as the resistors absorb power and generate heat. On the other hand, the Gysel [3][4] dividers typically requires additional transmission lines and loads, leading to a larger circuit area, which is unsuitable for applications with strict space constraints. Due to the limited characteristic impedance of practical transmission lines, traditional Wilkinson and Gysel power dividers struggle to achieve power division ratios greater than 4:1.

This paper presents a high-selectivity, wideband inverted FPD with an arbitrary power division ratio. Its main advantages include: 1) a high power division ratio; 2) a relatively wide passband bandwidth; 3) excellent isolation performance; and 4) a flexible layout that can reduce parasitic effects and size. In Section 2, the design of the power divider is introduced, and the circuit parameters are discussed in detail.

II. DESIGN OF HIGH-SELECTIVITY WIDEBAND INVERTED FPD

The proposed FPD is shown in Fig 1. This asymmetric power divider uses a stepped impedance transmission line, coupled with two other transmission lines in the first two sections, forming two pairs of coupled lines. In the first pair of coupled lines, the signal is transmitted to the coupled port, while the isolated port is grounded; in the second pair, the signal is transmitted to the isolated port, with the coupled port grounded. The final transmission line section is grounded to create two transmission zeros. The signal then passes through two open stubs, which help support the passband, as well as an isolation unit. Finally, it goes through two pairs of coupled line resonators and is output, with both the through and isolated ports of the coupler grounded.

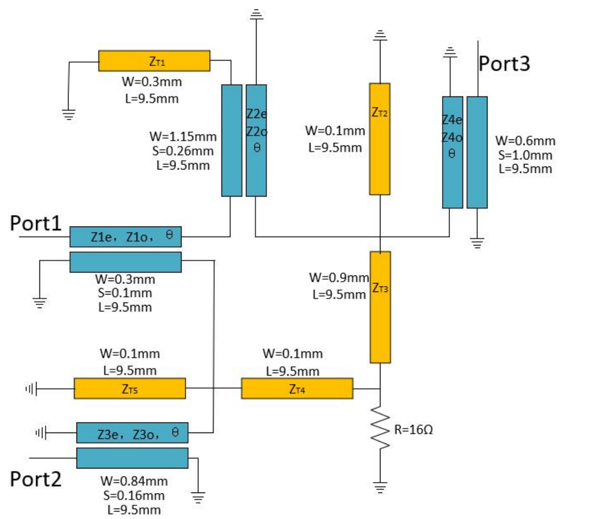


Fig. 1. Circuit diagram of the proposed FPD

III. Analysis of Filtering Response

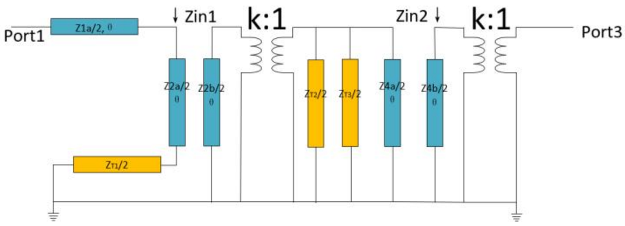


Fig. 2. Odd-mode equivalent circuit diagram.

The odd-mode equivalent circuit is shown in Fig 2. To determine the filtering response of this device, it is necessary to calculate the input impedances marked in Figure 1. Specifically, by setting $Z_{in1} = \infty$ or $Z_{in2} = 0$, the transmission zeros of the device can be derived, where

$$Z_{in1} = \frac{jZ_{2a}\left(Z_{T1}\tan\theta + Z_{2a}\tan\theta\right)}{2\left(Z_{2a} - Z_{T1}\left(\tan\theta\right)^{2}\right)} \tag{1}$$

$$Z_{in2} = jZ_{4b}\tan\theta \tag{2}$$

Thus, it can be calculated that

$$f_{Z1} = 0 \tag{3}$$

$$f_{Z2} = \frac{2f_0}{\pi}\arctan\sqrt{\frac{Z_a}{Z_S}} \tag{4}$$

$$f_{Z3} = 2f_0 - f_{Z2} \tag{5}$$

$$f_{Z4} = 2f_0 \tag{6}$$

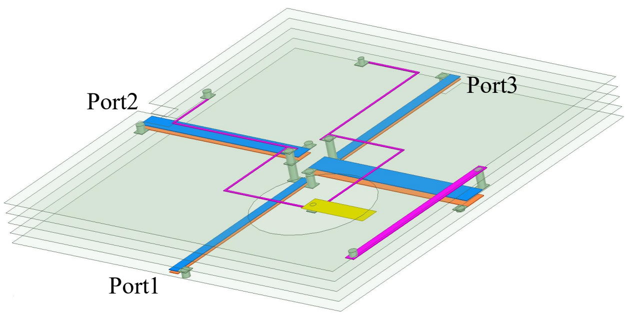
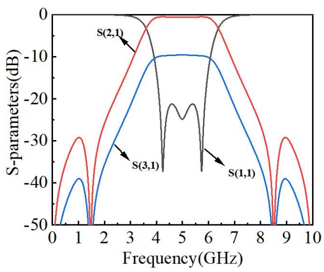


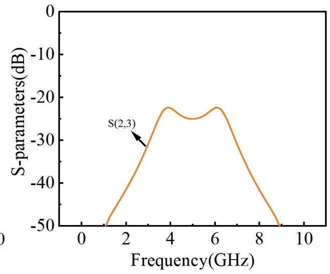
Fig. 3. Schematic diagram of the structure

IV. Simulation Results

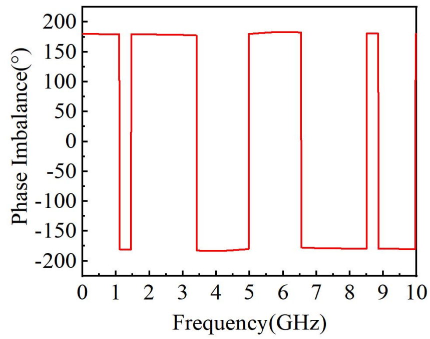
Fig 3 is the structural schematic diagram of the FPD designed in this work. The simulation results of the designed filter in ADS are shown in Fig 4. Fig 4(a) presents the S-parameter relationship between the input port Port1 and output ports Port2 and Port3, demonstrating the transmission performance and power division. Fig 4(b) shows the S-parameter relationship between output ports Port2 and Port3, illustrating the isolation between the two output ports. Fig 4(c) depicts the phase relationship between output ports Port2 and Port3, highlighting the inverted output effect. The designed FPD operates at f0=5 GHz, with a return loss (RL) of 20 dB and a fractional bandwidth (FBW) of 41%. The minimum in-band insertion losses are 0.5 (+3) dB and 9.5 (+3) dB, with an approximate power division ratio of 8:1. Two transmission zeros (TZs) are observed at 1.5 GHz and 8.48 GHz, significantly enhancing frequency selectivity. Additionally, a wideband isolation level above 14.3 dB is achieved in the range of 4.01 to 5.97 GHz. As shown in the figure, the phase and amplitude imbalances are better than 180◦ ±3.5◦ and ±0.5 dB, respectively.



(a)



(b)



(c)

Fig. 4. ADS simulation diagram. (a) Filtering performance, (b) Port isolation Performance, (c) Phase.

V. Conclusion

A high-selectivity, wideband inverted FPD with an arbitrary power division ratio, good isolation, and inverted characteristics was designed using a multilayer stripline structure. The transmission zeros were predicted using an odd-mode circuit. Finally, the transmission parameters, phase relationships, and isolation performance between the ports were simulated, showing favorable results.

Acknowledgment

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