Packaged Wideband Filtering Power Divider With Out-of-Phase on Multilayer Stripline

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Abstract—In this article, a novel packaged highly selective out-of-phase filtering power divider (FPD) with multilayer stacked stripline structure is presented, In this scheme, a looped double-coupled line (LDCL) is used to achieve power division and isolation functions. A pair of striplines are added after the LDCL to form a half-wavelength structure, and the two output ports are placed at the ends of the LDCL to achieve out-of-phase. To verify the results, the structure was built using a multilayer stacked strip printed circuit board (PCB) and subjected to electromagnetic simulation analysis. The research results show that the working frequency band of the proposed out-of-phase FPD is 2.1~3.7 GHz, with the insertion loss S21 and S31 are belw 5 dB and a return loss of less than -15 dB, 55.1% 3-dB FBW(center frequency 2.9 GHz)and the phase difference is within 10°. Compared with existing research on out-of-phase FPD, the proposed FPD has the advantages of miniaturization, simple structure, and high selectivity.

Keywords—FPD, multilayers, out-of-phase

I. Introduction

FPD is mainly used in signal processing, communication systems, and RF equipment, especially in scenarios that require high-precision signal allocation and phase control [1][2]. The current situation is constantly evolving with the development of 5G and the market's demand for high-performance and low loss filters is increasing, which promotes innovation and application expansion of related technologies.

In [3], a broadband inverse filtering power dividers was designed by utilizing the transition of microstrip slot lines and branch loaded resonators, but the filtering effect was average and the size was relatively large. In [4], a continuous phase shift phase was achieved by adding a loaded varactor diode to the annular stepped impedance resonator, but with high insertion loss and narrow bandwidth.Filtering power dividers designed based on Low Temperature Co fired Ceramic (LTCC) technology were proposed in [5], which have the characteristics of high frequency range, high integration, and miniaturization, but require high cost and manufacturing process requirements. Multilayer PCB circuits are receiving more attention from researchers due to their advantages of low manufacturing costs and ease of processing.

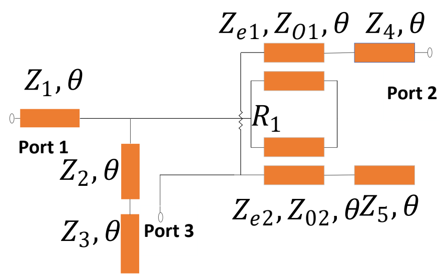

Fig. 1 Equivalent circuit schematic of out-of-phase FPD.

In this paper, an out-of-phase FPD based on a circular coupling line is proposed. To verify the feasibility of the principle, stacked stripline technology was chosen to design a self encapsulated inverted broadband FPD prototype for validation.

II. Design of Multilayer Out-of-Phase FPD

Fig. 1 describes the configuration of the proposed FPD prototype ($\theta = \pi/2$). The principle of inversion is shown in Fig. 2, which utilizes the half wavelength transmission line voltage characteristics to form an inverted standing wave voltage wave and electric field distribution on adjacent transmission lines. Specifically, (Z_1, θ) is used for circuit matching, and (Z_2, Z_3, θ) enhances passband selectivity. LDCL consists of (Z_{e1}, Z_{o1}, θ) (Z_{e2}, Z_{o2}, θ) and (R_1) is added at both ends of the LDCL to enable the entire structure to introduce TPs and TZs, power distribution, and port isolation. (Z_4, θ) and (Z_5, θ) form a half wavelength transmission line structure with the LDCL.

A pair of real TZs domain can be derived, that is,

$$f_{TZ1} = \frac{2}{\pi} arctan\sqrt{K}$$

$$f_{TZ2} = 2f_0 - \frac{2}{\pi} arctan\sqrt{K}$$

where K represents the impedance ratio Z_3/Z_2

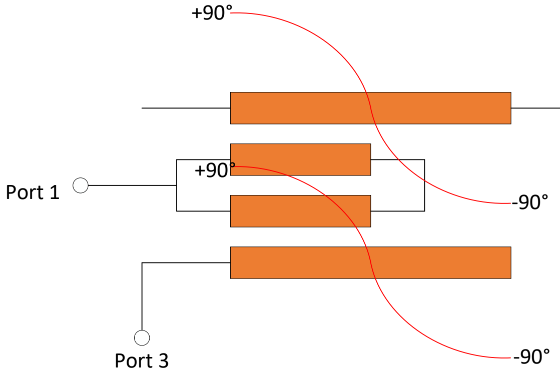

Fig. 2 Distribution diagram of output port feeder electric field.

III. Design of Filtering Power Divider

In this section, to verify the feasibility of the design principle, a prototype FPD was designed as shown in Fig. 3. This FPD is designed and manufactured in a self packaging form using multilayer PCB lamination technology. The substrate material of the designed circuit PCB is Arlon AD255C (tm) (ε_r=2.55, tan δ =0.001), and the substrates are bonded together by an insulating film with a thickness of 0.076mm (ε_r=4.2, tan δ =0.0025). The specific dimensions are shown in Fig. 4.

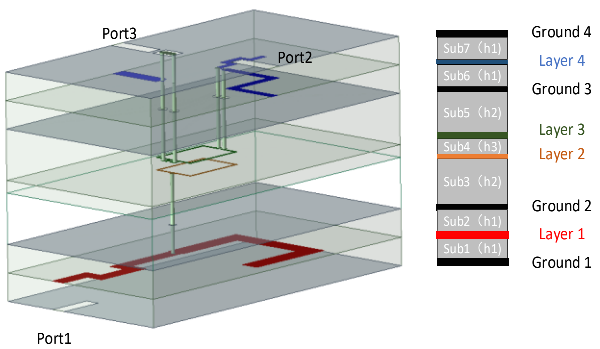

Fig. 3 3-D configuration.

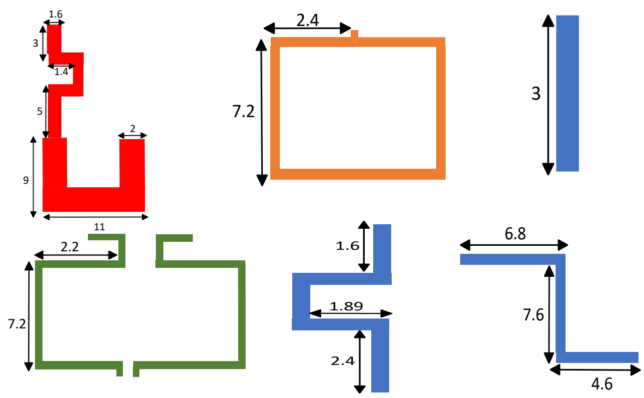

Fig. 4 Detailed plane dimensions.

The simulation results of out-of-phase FPD are shown in Fig. 5 and Fig. 6.The results show that in the frequency range of 2.1GHz-3.7GHz, the insertion loss S21 and S31 are belw 5 dB, the return loss is below 15dB, the relative bandwidth is 55.1%, the operating frequency band is relatively flat, and the phase deviation is controlled within 10° .

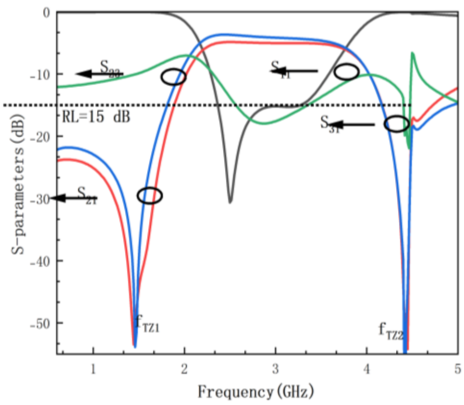

Fig. 5 Simulated S-parameters results of the proposed FPD.

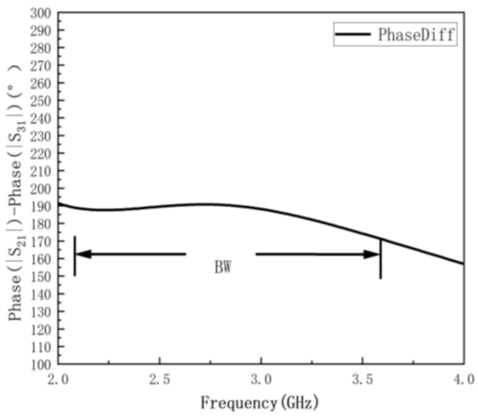

Fig. 6 ADS Simulated phase results of the proposed FPD.

IV. Conclusion

In this paper, a novel packaged highly selective out-of-phase FPD with multilayer stacked stripline structure is presented. The simulated results of the FPD show the frequency range of from 2.1GHz to 3.7GHz with bandwidths of 55.1% and ILs of 5 dB. The return loss and S23 is below 15dB, and the phase difference is within 10°. The good performance of the FPD shows that it is suitable for millimeter-wave devices for wireless systems.

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