MINIATURIZED UNIPLANAR 180^o HYBRID-RING COUPLERS WITH $0.8\lambda_g$ AND $0.67\lambda_g$ CIRCUMFERENCES

Chih-Wai Kao and Chun Hsiung Chen
Department of Electrical Engineering and Graduate Institute of Communication Engineering,
National Taiwan University, Taipei 106, Taiwan
Tel: 886-2-23635251-221, FAX: 886-2-23638247
E-mail: chchen@ew.ee.ntu.edu.tw

Two miniaturized uniplanar 180^o hybrid-rings with $0.8\lambda_g$ and $0.67\lambda_g$ circumferences, respectively, are proposed. These hybrid-rings are implemented using the finite ground coplanar waveguide (FGCPW) structure. The sizes of these hybrid-rings are effectively reduced, and broadband performances are also achieved.

1 Introduction

Hybrid-ring couplers are fundamental components extensively used in a variety of microwave circuits such as balanced mixers, phase shifters, and feed networks in antenna arrays. The most common used hybrid ring is the rat-race hybrid ring coupler, but the $3\lambda_g/4$ transmission line occupies a large circuit area and also limits its bandwidth and applications. In recent years, uniplanar transmission lines such as coplanar waveguide (CPW), slotline, coplanar stripline (CPS), and finite ground coplanar waveguide (FGCPW) are widely used in microwave integrated circuit (MIC) and monolithic microwave integrated circuit (MMIC). Uniplanar transmission lines have the advantages such as easy realization of short circuited end, no need for via holes, low dispersion, and easy integration with active components or lump elements. Besides, the attractive feature of uniplanar transmission lines is that the signal strip and ground plane are on the same side of the substrate, so that crossover of signal strip and ground plane can easily be achieved. The crossover is essential in providing a 180°phase shift for a reverse-phase hybrid ring. Using this feature, many reduced-size uniplanar 180°hybrids have been reported [1-4]. In this work, two miniaturized uniplanar hybrid rings using FGCPW are proposed and examined. The circumferences of these two miniaturized hybrid rings are $0.8\lambda_g$ and $0.67\lambda_g$, respectively. These hybrid rings should have many applications in MIC and MMIC.

2 Circuit design

The miniaturized uniplanar 180^o hybrid-ring coupler under investigation which utilizes the FGCPW structure is shown in Fig.1. Here a crossover in FGCPW is introduced to implement a phase inverter for the reverse-phase hybrid-ring. This hybrid-ring is designed by the equation $z = z_0\sqrt{2(1-\cot^2\theta)}$, where z is the arm impedance, z_0 is the port impedance, and θ is the electrical length of each arm at the center frequency. The first design $\theta = 72^\circ$ leads to z = 1. 3375z_0 and the circumference of the hybrid ring is $0.8\lambda_g$. The second design $\theta = 60^\circ$ leads to z =1.1547z_0 and the circumference is further reduced to $0.67\lambda_g$.

3 Results

Two FGCPW hybrid-ring couplers are realized on FR4 substrate ($\varepsilon_r = 4.3$, $\tan\delta = 0.022$). The actual arm length is slightly longer than the design one so as to compensate the effect of T-junction. Figs.2 and 3 show the measured and simulated results of the $0.8\lambda_g$ hybrid-ring. Theoretically it is simulated by the software IE3D, which is based upon an integral-equation and method-of-moment algorithm. The in-phase and out-of-phase phase differences are less than 6^o and 10^o, respectively. Isolation between H-port and E-port is greater than 23dB from 0.5GHz to 3.5GHz and return loss is greater than 26dB at center frequency. The bandwidth of this hybrid-ring coupler is over one octave. The power dividing and phase difference performances of the 0.67 λ_g hybrid-ring coupler are similar to those of the 0.8 λ_g hybrid-ring coupler, the major difference between them is the return loss performance. Fig.4 shows the return loss of the 0.67 λ_g hybrid-ring coupler which is about 24dB at center frequency and is greater than 15dB from 1.7GHz to 2.6GHz. The return loss of 0.8 λ_g hybrid-ring is also shown in Fig.4 for comparsion. Note that size reduction is accompanied by poorer performance, thus there is a trade-off between size and return loss.

4 Conclusion

In this study, two reduced-size 180^o hybrid-rings using FGCPW structure with circumferences of 0.8 λ_g and 0.67 λ_g have been proposed. These two miniaturized hybrid-rings have good in-phase and out-of-phase phase differences and excellent H-port and E-port isolations. Its small size and broadband performances are very attractive in MIC/MMIC.

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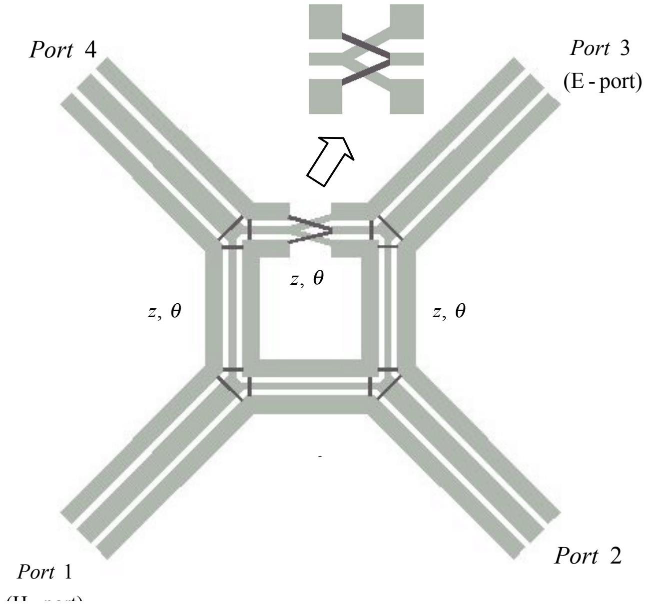

Fig.1 Configuration of miniaturized FGCPW hybrid-ring coupler.

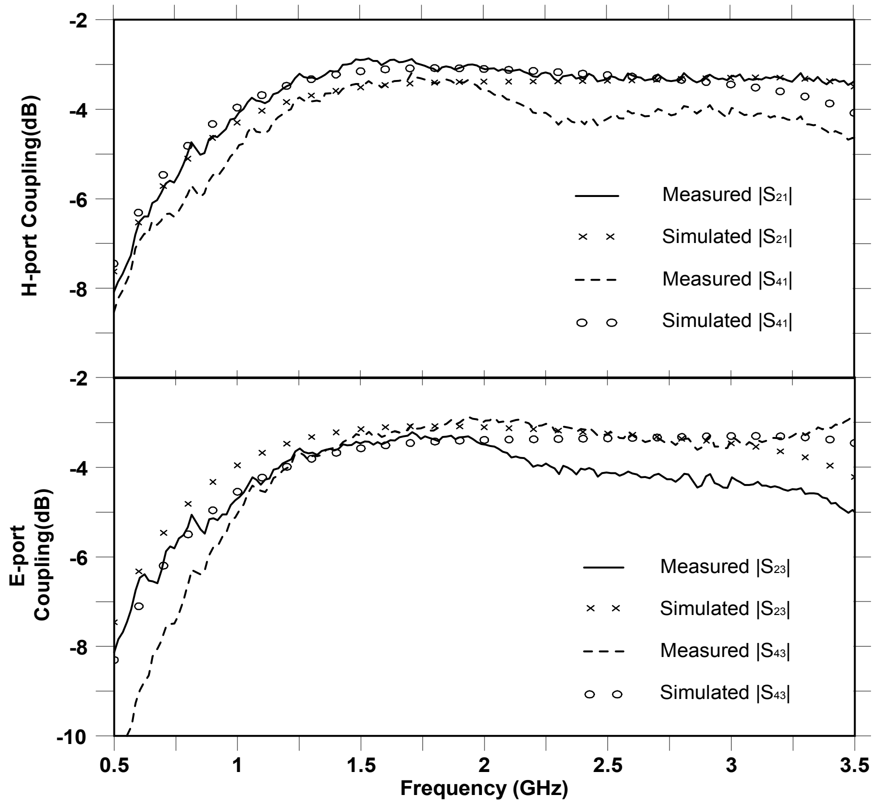

Fig.2 H-port and E-port power dividing for 0.8 λ_g hybrid-ring coupler.

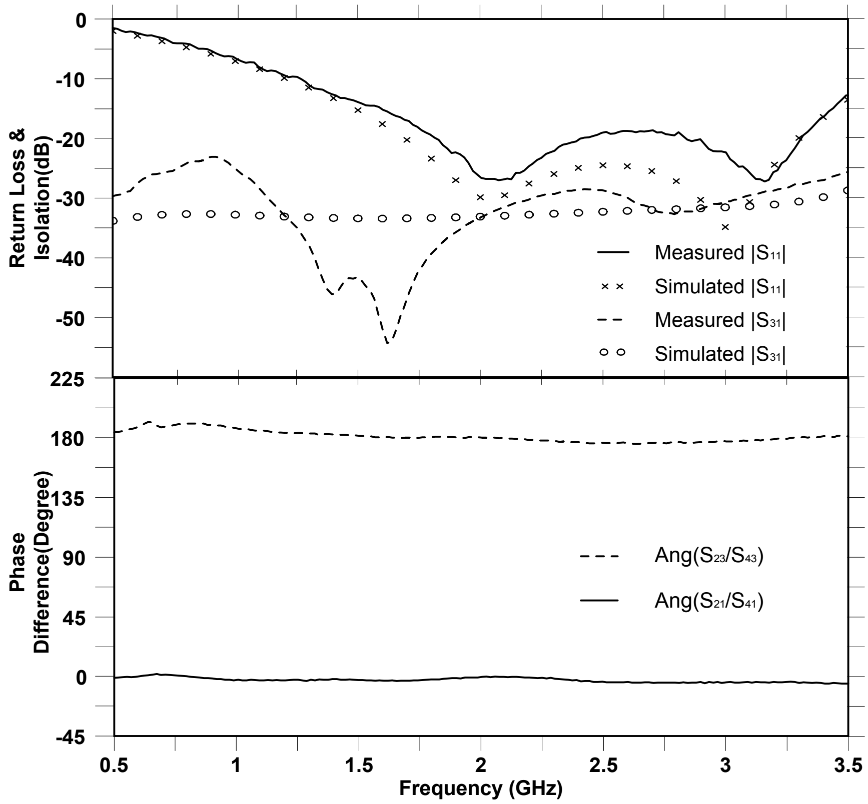

Fig.3 Return loss, isolation, and phase difference for 0.8 λ_g hybrid-ring coupler.

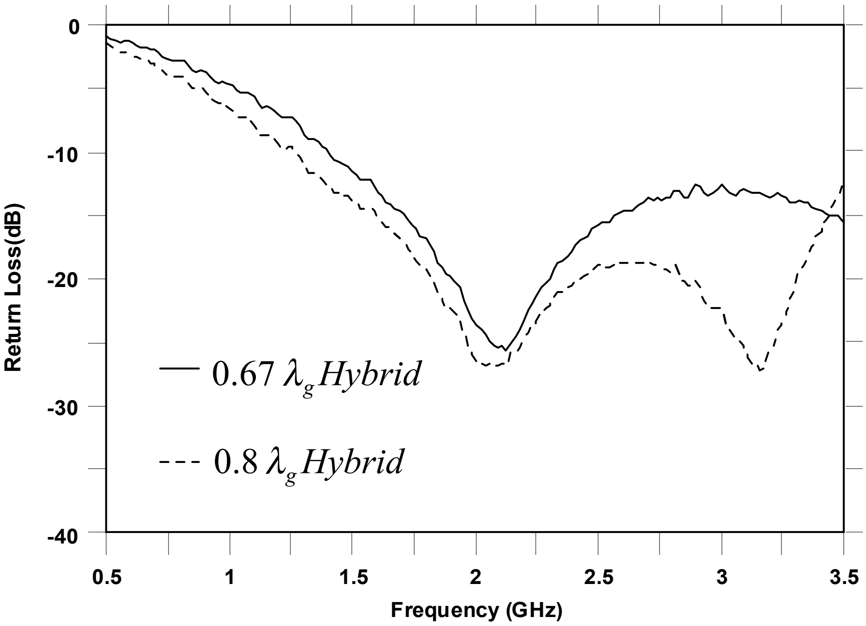

Fig.4 Return loss for 0.8 λ_g and 0.67 λ_g hybrid-ring couplers.