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Γ Shaped Slotted Compact Circular Crossover for Communication Applications at 2.45 GHz

Mert Yerli[1*], Merih Palandöken [2]

[1*] *Izmir Katip Celebi University, Faculty of Engineering and Architecture, Departmant of Electrical and Electronics Engineering, Izmir, Turkey, (ORCID: 0000-0003-2088-1776), eng.mertyerli@gmail.com*

[2] *Izmir Katip Celebi University, Faculty of Engineering and Architecture, Departmant of Electrical and Electronics Engineering, Izmir, Turkey, (ORCID: 0000-0003-3487-2467), merih.palandoken@ikc.edu.tr*

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***Abstract* –** Modern communication system technologies, crossover structures are widely used as one of the main elements in microwave circuits in different operating environments. Nowadays, microwave circuit elements provide continuity and development in these areas by triggering rapid transformation in terms of communication, protection and security. Innovative and contemporary solutions are becoming an important issue with increasing product demands and production capacities. This paper introduces valuable solutions in this direction of crossover design for microwave integrated circuits. A circular cross with symmetrical internal transmission line covering the frequency with WLAN (wireless local area network), WiMAX and GSM applications is proposed. The circular crossover bandwidth -10dB is between the frequencies 2.32 GHz and 2.58 GHz. The designed microwave circular crossover size is 40mm x 40mm x 1.6mm. The efficient compact microwave crossover design method in planar circuits promise to improve the performance and versatility of microwave circuits. The efficiency in 2.45 GHz frequency transitions brings closer to realizing efficient band applications for wireless communication and paves the way for future developments in this field.

Keywords – WLAN, Microwave Integrated Circuit, WiMAX, GSM, Crossover

I. INTRODUCTION

Microwave crossover structures are widely used in RF/Microwave circuits, which cover important technologies used in a wide range of advanced communication systems and industrial applications [1,2]. Various crossover topologies provide power transfer and signal switching in modern microwave circuits. These topologies are an effective transition way between two transmission lines with different methods because the system can perform better and is compact [1-3]. The methods mentioned in the literature all have their own methods for obtaining transitions, but the circular transition design using very few design schemes has been proposed. Circular structures with symmetrical inner transmission line covering WLAN, WiMAX [4] and GSM [5] applications that can operate at different frequencies produce valuable solutions for microwave integrated circuits. The basic operation of the crossover [6] circuit is that when all ports in the circuit match, the power and signal entering Port 1 must be transmitted to Port 3 without loss, and the phase from Port 1 to Port 3 must be transmitted one-to-one. It is necessary that the power and signal are not transferred (isolated) to Port 2 and Port 4 and there should be no transmission losses. To carry signals independently in both channels in the circuit, Butler matrix [7,8] is used to transmit in microwave circuits that provide high isolation between intersecting transmission lines. Microwave crossover connection should be provided in the circuit to provide isolation between transmission lines with the help of the matrix.

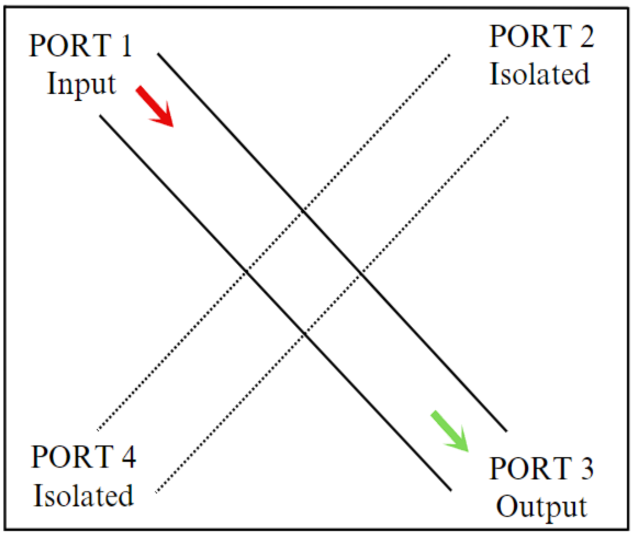

Fig. 1 Crossover structure

Fig.1 shows the proposed crossover general circuit [9] form used to construct the waveguide structure. Input/output ports are located using microstrip connection. The ideal scattering matrix [10] of the crossover described in (1),

$$[S] = \frac{1}{\sqrt{2}} \begin{bmatrix} 0 & 1 & j & 0 \\ 1 & 0 & 0 & j \\ j & 0 & 0 & 1 \\ 0 & j & 1 & 0 \end{bmatrix} \quad (1)$$

It can be shown that the output phase of the proposed crossover is decided by the output phase difference of the microwave circuits at 2.45 GHz frequency. Based on the design guidelines, design was carried out to validate the feasibility of this proposed concept.

II. Materials and Method

In this study, microwave circular crossover is designed. A structure consisting of eight identical X-shaped slots, a symmetrical Γ (gamma) slot in the center, and four-port network including an input & output port and two isolated ports has been designed. This structure was printed on the low-cost FR-4 substrate, which is a dielectric material. The substrate height (thickness) 1.6 mm, 40 mm wide and 40 mm long, and has a relative permittivity (ε_r) of 4.3 and a loss tangent of 0.025. Radius value for circular patch is L2=16.5 mm. The size of the proposed circuit is 40x40x1.6mm^3.

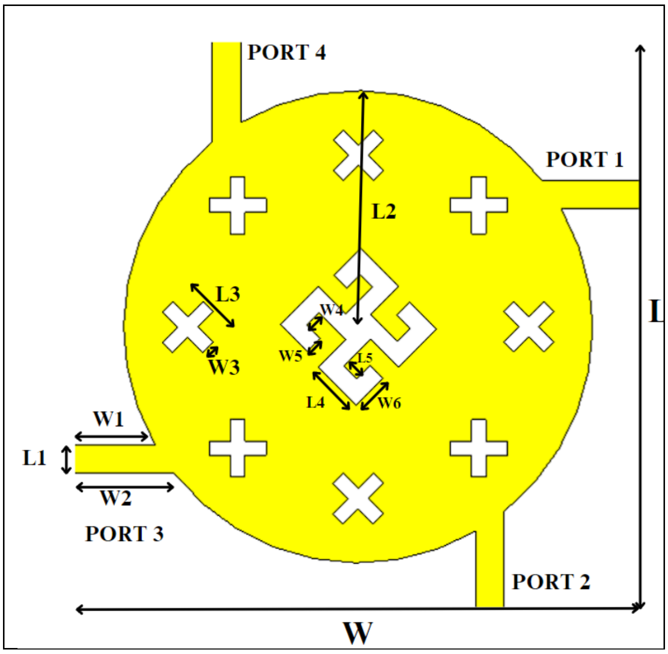

Fig. 2 Proposed circular crossover

The proposed structure is symmetrical by nature along both the x-axis and the y-axis. Simulations were made with CST Studio Suite. Obtained data were compared with parametric results. Table 1 shows the parameters of circular crossover.

Table 1. Parameters of the proposed circular crossover

Parameters	Value (mm)	Parameters	Value (mm)
W	40	L	40
W1	5.71	L1	1.6
W2	7.19	L2	16.5
W3	2	L3	10
W4	2.5	L4	5.5
W5	2.5	L5	2.5
W6	3		

The parameters are calculated numerically and simulated in the designed circuit.

III. Results

The simulation results show that the microwave crossover operates at a frequency of 2.45 GHz when examining the S_{11} , S_{21} and S_{31} properties. The dB values obtained for circular crossover and similar microwave design are very important. In microwave circuits, dB values below -10 dB are generally considered low return loss.

In Figure 3, the value of the return loss in the circular crossover structure is -18.71 dB at 2.45 GHz. This value know that there is almost no power reflected to the input.

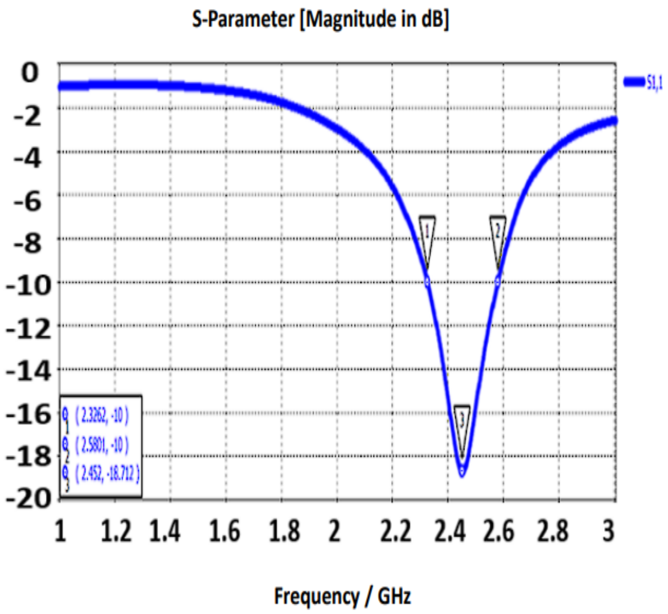

Fig. 3 S_{11} for proposed circular crossover

As seen in Figure 3, the circular crossover operates under -10 dB, between the 2.32 GHz and 2.58 GHz frequencies. The obtained values are electrically well-isolated for the two physically overlapping signal paths for ideal microwave circular crossover designs.

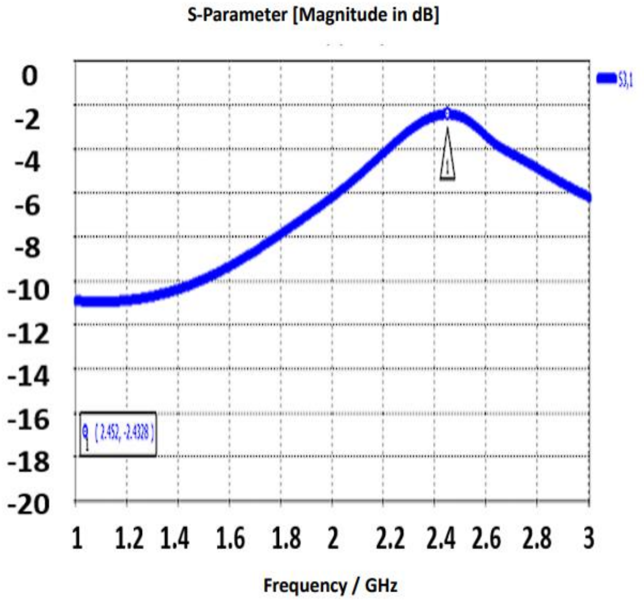

Fig. 4 S_{31} for proposed circular crossover

The Γ Shaped Slotted Compact Circular Crossover design is used for power and signal transfer from Port 1 to Port 3 and the S_{31} value is important. The current S_{31} value is -2.43 dB under 2.45 GHz in Fig. 4.

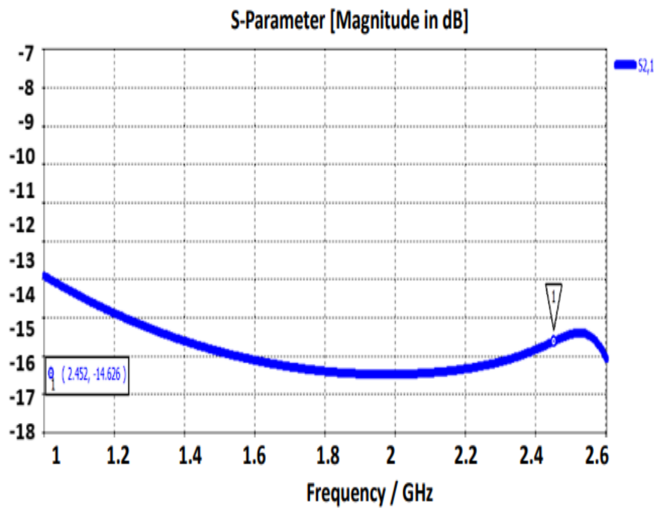

Fig. 5 S_{21} for proposed circular crossover

Parameter S_{21} the ratio of the power delivered to Port 2 to the input power applied at Port 1, when a microwave signal is applied to Port 1. In Fig. 5, the S_{21} parameter is measured as - 14.63 dB at 2.45 GHz, this value shows that it isolates Port 2. The power ratings of S_{11}, S_{21} and S_{41} are all below -10 dB. The power and signal from Port 1 are transferred to Port 3 without loss, in other words, it indicates that there is no reflected signal. Port 2 and Port 4 remained isolated.

IV. DISCUSSION

Microwave crossover used as circuit elements in many RF/Microwave research interests are insufficient in terms of cost, use and supply. Therefore, modern and innovative solutions are required.

With the circuit structure designed in this study, power and signal transfer was provided with the help of a microwave crossover with two isolated ports at 2.45 GHz as in Figure 6, and a circular structure was created unlike the circuit structures made before. Thanks to the circular structure, return losses are reduced compared to linear and strip structures.

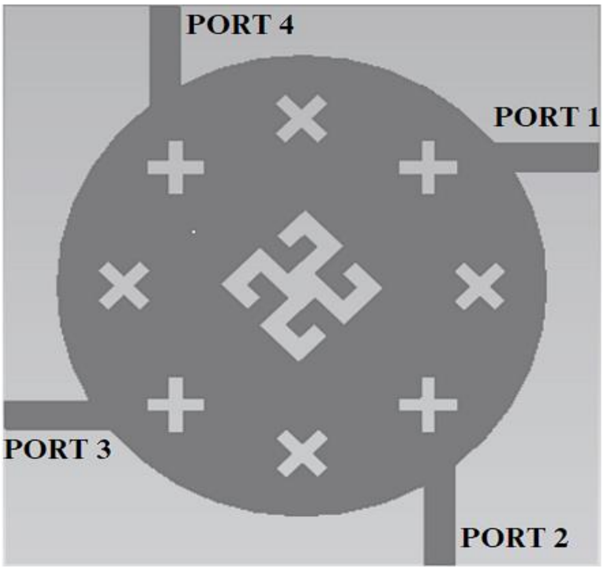

Fig. 6 Proposed circular crossover

Microwave circular crossover use in industrial and academic research areas can be increased. As a result, microwave crossover circuits are alternative circuit method for RF/Microwave systems operating in different conditions.

V. CONCLUSION

In this article, Γ Shaped Slotted Compact Circular Crossover circuit that can operate at 2.45 GHz is designed. Circular structure and gamma slot effects observed by numerical calculations were performed at the frequency adjusted with parametric changes and in five steps, including change parameters and slots. However, the measured results of the gamma-slot design showed good transmission, return loss and isolation values compared to the results below -10 dB, considering the values according to the circuits with different slots and structures at 2.45 GHz. Based on the results, the presented structure can be used in WLAN, WiMAX, and GSM applications. The presented structure has a new configuration and is still easy to fabricate.

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