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Conception of Passive Meander Coupler With Microstrip Waveguide Structure

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Abstract— ***The new passives structures of a microstrip coupler was proposed and studied numerically in this work. The structure under study was made from a FR4 substrate (1mm thick). The HFSS is used to simulate the coupler and to generate accurate estimation of the transmission characteristics at operating frequency. The goal of this work is to design a «3 dB hybrid coupler. Two prototypes are proposed to get a better performance.*** **These** ***improvements*** **include a** ***reduction of insertion losses which should be around 2 dB and a larger bandwidth. The best circulation performance is obtained with an insertion loss of -2.80 dB, coupling loss and an isolation of -22.81 dB has been achieved by optimizing the structure at 2.30 GHz.***

Keywords— **meander** ***Coupler, microwave, S-parameters,*** **passive components, microstrip, hybrid coupler** ***bi-band***

1. INTRODUCTION

A miniaturization of civilian and military devices has imposed itself, particularly in the field of aeronautics and telecommunications, and has continued ever since. The devices must therefore be developed miniaturized, low-cost products, while operating at higher frequency ranges and multiple-band operation mode [1,2].

The objective of our work is to model a component commonly used in microwave design : the directional Coupler [3].

The coupler is a passive four port component. Each access is adapted, the power injected into an input port 1 (incident path) is distributed between the two output ports 2 and 3(direct, coupled), as indicated in Fig. 1. The remaining access is isolated port, which means that no power will be transferred to it.

An ideal directional coupler is reciprocal, matched and lossless. A reciprocal directional coupler is also known under the name 3-dB quadrature hybrid.

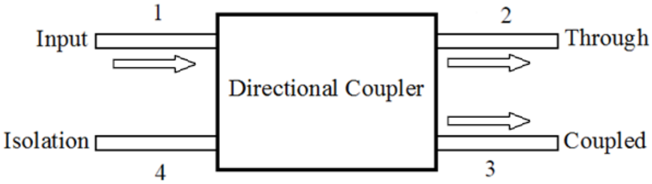


Figure 1 : Four-port directional coupler.

❖ Performance of a Directional Coupler :

The directional coulpler performance isusually characterized in terms of the following parameters [4] :

A. *The coupling*

$C(dB)=10\log(P1/P2) = -20\log|S_{31}|$

B. *The isolation*

$I(dB)=10\log(P1/P4) = -20\log|S_{41}|$

C. *The directivity*

$D(dB)=10\log(P3/P4) = -20\log(|S_{41}|/|S_{31}|)$

P_1 is the input power, P_2 and P_3 are the output normalized power and P_4 is The normalized power the isolated port.
These quantities can be linked by the following relationship :

$I= D + C$ (en dB)

An ideal coupler must have directivity and an isolation of the order of infinity. Generally, the coupling C varies from 3 dB to 6 dB In a wide variety of microwave applications. The directivity D varies from 15 to 20 dB for the microstrip lines and from 30 to 50 dB for rectangular waveguides [5].

D. *Losses*

- Insertion losses

Insertion losses $(dB)=10\log(P1/P2) = -20\log|S_{21}|$

- Coupling losses

Coupling Losses $(dB)=10\log(1- P3/P1)$

- Bandwidth

Relative bandwidth $= (f_2 - f_1 / f_0) \times 100\ \%$

Where f_0, f_1 and f_2 are respectively the central, minimum and maximum frequencies.
In this work, thow prototypes of the coupler are studied on an ordinary FR-4. The optimization component is accomplished through a parametric study in HFSS simulator that provides a satisfactory structures.

2. 3 DB HYBRIDE COUPLER DESIGN

The symbolic design of a Branch-Line Coupler [4, 6] is illustrated in Fig. 2.

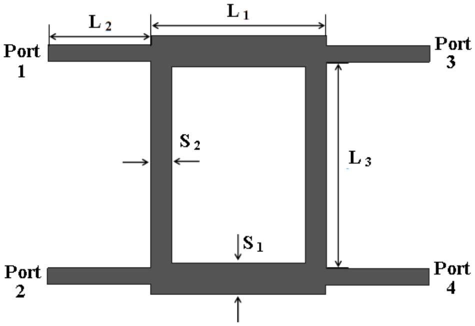


Figure 2 : Conventional 3 dB branch line coupler.

The basic topology of this coupler integrates two length transmission lines, it have a phase difference of 90° between the transmitted input and coupled output [4].
This type of coupler is often fabricated using microstrip or CPW technology.

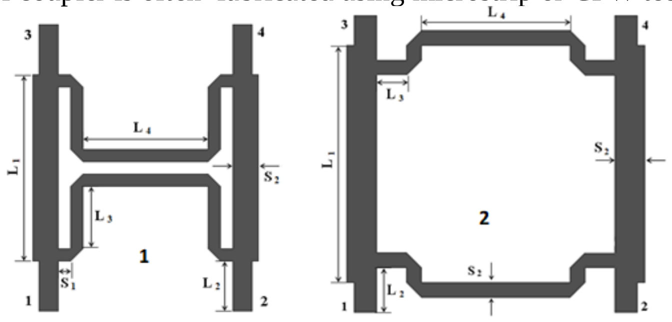


Figure 3: Proposed prototypes of the 3 dB branch line coupler 1 and 2.

The figure 3 shows the top view layout of proposed couplers with its dimensions.
This hybrid couplers was designed to operate at 2.3 GHz and 2.6 GHz frequency. The dimensions of the proposed couplers are displayed in Table 1.

TABLE 1: DIMENSIONS OF THE MEANDER BRANCH LINE COUPLER

	L_1 mm	**L_2 mm**	**L_3 mm**	**L_4 mm**	**S_1 mm**	**S_2 mm**	**Z Ω**
prototype 1	15	4	6	10	1	2	50.49
prototype 2	16	3.5	2	10	1	2	50.26
Conventional coupler	17	10	20	____	3	2	49.57

The first proposed structure operate at 2.3 GHz, has dimensions 18×23 mm, the other is 20×20 mm in size, and it operate at 2.6 GHz. The Conventional coupler has dimensions of 24.2×37 mm, at 2.3 GHz.

3. SIMULATION OF THE COUPLER

The commercial software ANSOFT-HFSS was employed. To start the simulation, it is necessary to excite the two structures. We use Wave-Ports that are specified for the excitation signal is not fully enclosed in the slot and extend into the air above the substrat.

The dielectric used is FR4 substrate dielectric constant of 4.7 with substrate height of 0.8 mm and loss tangent of 0.0197.

The resulting characteristic impedance is equal to 50 Ω for the tow prototypes for its ports (see the Table 1).

The performance of the two prototypes are presented in the (Fig. 6), and summarized in Table 2.

3.1 Conventional Branch Line Coupler

The results of the simulation parameters of the conventional branch line coupler are illustrated in (Fig. 4).

The directivity transmission characteristics represented by S_{31}=-4.31 dB, is observed at 2.3 GHz. The signal propagates from port 1 to port 4 with insertion losses is -2.97dB, in the direction of the port 2, the signal is blocked with an isolation rate of the order of -30.56 dB and the return loss at the port 1 is -28.75dB. , the phase difference response result of conventional branch line coupler is 90.43° at 2.3 GHz is shown in (Fig. 5).

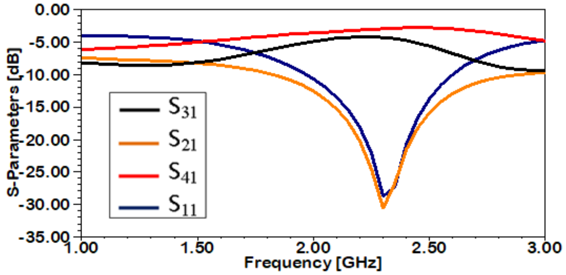


Figure 4: S- Parameter results of conventional branch line.

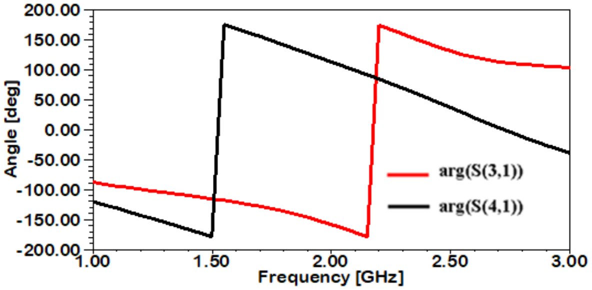
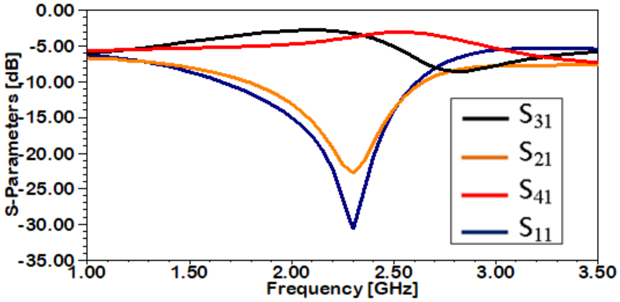


Figure 5: Phase difference result of conventional branch line coupler.

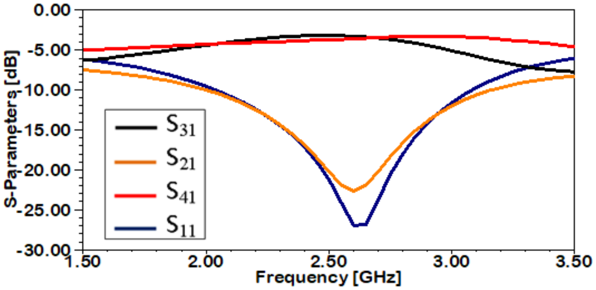
3.2 A Proposed Compact 3-dB Coupler

Figure 6 shows the S-parameter results for the tow prototypes. The best coupling and through results given by the prototype 1, shows those values are -3.75 dB and -2.80 dB, respectively at 2.3 GHz The return loss is -30.65 dB and isolation performance is -22.81dB at 2.3 GH. The phase differences of simulated result are shown in (Fig. 7).

Based on the graph, phase difference between port 3 and port 4 is approximately 90.25° at operated frequency of 2.45 GHz for the prototype 1 and 89.88° at 2.6 GHz for the prototype 2.

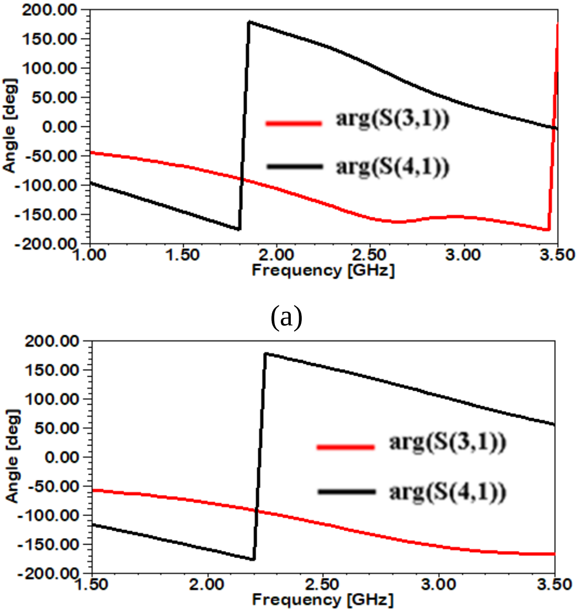


(a)



(b)

Figure 6: S- parameter results of the proposed coupler, a) prototype 1, b) prototype 2.



(a)

(b)

Figure 7: Phase difference response between the output ports of proposed couplers; a) prototype 1, b) prototype 2.

The comparison results of the the conventional with proposed couplers are summarized as Table 2. The comparison showed that the size on proposed coupler (prototype 1) is reduced by 46 % compared to a conventional coupler and 44.6 % for the prototype 2.

The simulated bandwidth result of proposed coupler is 39.13 % which covers from 1.65 GHz to 2.55 GHz and other from 2 GHz to 3 GHz with a relative bandwith= 38.46 %.

TABLE 2: COMPARISON RESULTS OF CONVENTIONAL COUPLER AND PROPOSED COUPLERS

		Proposed Coupler		**Conventional Coupler**
		1	**2**	
S-Parameter dB	**S31**	-2.80	-3.28	-4.31
	S41	-3.75	-3.58	-2.97
	S21	-22.81	-22.63	-30.56
	S11	-30.65	-26.91	-28.75
Operating frequency (GHz)		2.3	2.6	2.3
Phase difference	**(deg)**	90.25	89.88	90.43
Size	**(mm)**	18×23	20×20	24.2×37

3.3 Effect of Changing Substrate Material on Transmission Characteristics

We conducted a new simulation to quantify the effect of changing material on performance coupler (prototype 1) using a massive YIG ferrite instead of an FR4 substrate.

The thickness of the YIG layer is 100 µm. The magnetic material (the Yig) is detrmined in [7] by the following features: a relative permittivity εr = 15.3, a dielectric loss tangent $\tan\delta = 10^{-2}$, a saturation magnetization Ms=178 mT and the damping factor α = 0.0175. An internal magnetic field polarization Hi = 447 KA/m was applied in a direction perpendicular to the YIG layer.

These device are designed and simulated by using the ANSOFT HFSS simulator based on the finite element methods.

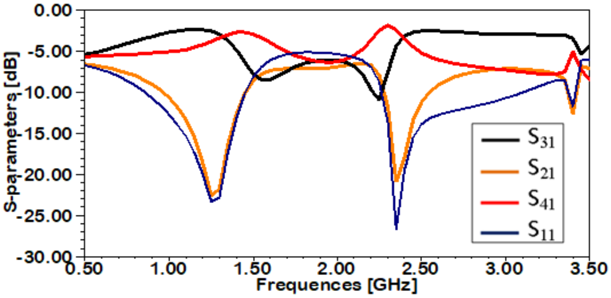


Figure 8: Evolution of *S*-parameters of a new coupler.

For the new substrate material we determined the coupler performance parameters like return loss, isolation, coupling, throug, and bandwidth with the same geometric dimensions of the coupler given in the Fig. (2.a). The S parameters is which shown in (Fig. 8).

We noticed, during the simulation of the new coupler, the appearance of a second passband in the left-hand portion of the operating frequency of the proposed coupler, prototype 1, at 2.3 GHz.

The simulation result shows that the reflections, isolations, direct transmissions (throug) and couplings have sufficient values for efficient operation of the device in two different frequency bands at the operating frequncy 1.25 GHz for the fisrt band and 2.3 GHz for the second.

With the yig as substrate, the coupler can operate at dual band frequency.

4. CONCLUSION

In this work, we have presented a numerical study of a Passive meandeer coupler with microstrip Waveguide Structure, based on FR4 substart. The structure, the geometric dimensions and the different characteristics transmissions were presented. The results obtained from the simulation in HFSS show the functioning of the coupler.

From the above analysis, we can conclude that the use of the YIG substrate material can improve the performance of the component.

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