International Refereed Journal of Engineering and Science (IRJES)
ISSN (Online) 2319-183X, (Print) 2319-1821
Volume 7, Issue 6 Ver. I (Jun 2018), PP. 41-44

A 12 Port Dual Bandwidth Exponential Taper Ring Coupler

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ABSTRACT:*A dual bandwidth exponential taper 12 port hybrid ring coupler is presented. The ability of this proposed ring coupler is demonstrated in this paper. This proposed coupler has some important applications such as a phase comparator circuit which is used in the mono-pulse radar in order to control both the azimuth and the elevation of the target. With the proper termination this proposed the 12 port network can be utilized as six port reflectometer, phase comparator and six-way power combiner/divider. Unique signal flow for this proposed 12 port network is developed in order to drive its scattering matrix at central frequency.*

Date of Submission:31-08-2018 Date of acceptance: 15-09-2018

I. INTRODUCTION

Non-uniform transmission lines have considerable applications in microwave circuits such as resonators, transformers, matching sections and filters. Normally the TEM mode of propagation in the non-uniform transmission line is described by its non-constant characteristic impedance which varies along the direction of propagation of electromagnetic waves [1]. This property makes the non-uniform transmission lines responses more superior than those of uniform ones. Uniform and non-uniform transmission lines could be isolated or coupled. Coupled uniform transmission lines are used in the realization of various types of microwave circuits i.e. filters, frequency discriminator, directional couplers, phase shifters and impedance transformers. Coupled non-uniform transmission line, by its nature of non-uniformity, offers additional design parameters to achieve the desired device performance, inherent impedance transformation capabilities and the possibility of the realization of a wide band component [2]. Therefore, non-uniform transmission line directional couplers can provide both, broad band capability and superior transmission responses than the uniform ones [3]. With proper terminations, the 12 port hybrid ring couplers may be served as building blocks for phase shifters, mixers, multiplexers, baluns and duplexers which are essential and required in multi-octave bandwidth antenna and broadband microwave systems. And also, can be used as a six-port reflectometer [4, 5].

Analysis of Hybrid Ring Coupler by using signal flow

The proposed 12-port hybrid ring coupler can be easily analyzed with the developed signal flow technique see fig 2. (a) and (b), while the computed scattering matrix is depicted as shown figure 3.

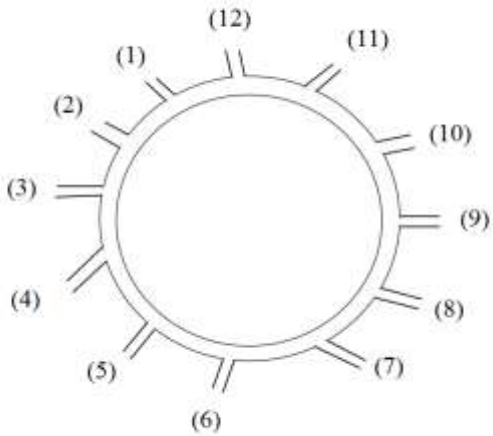
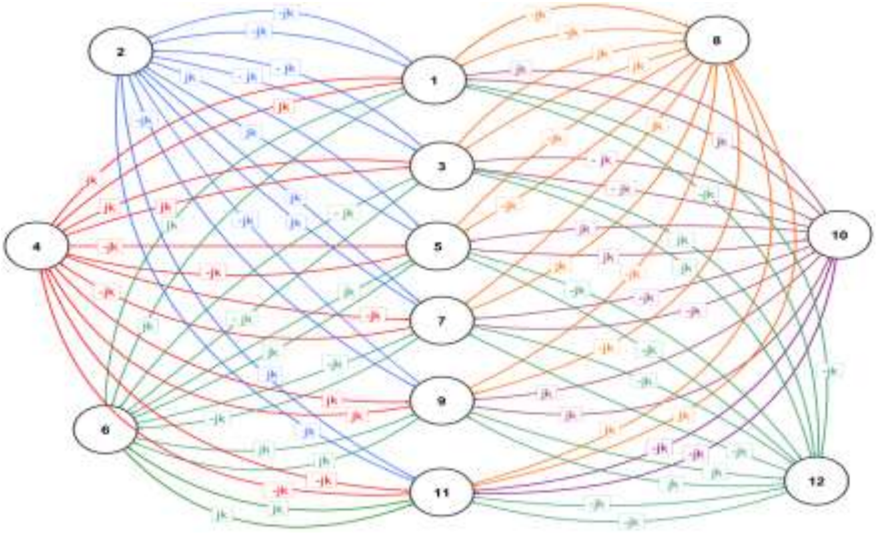
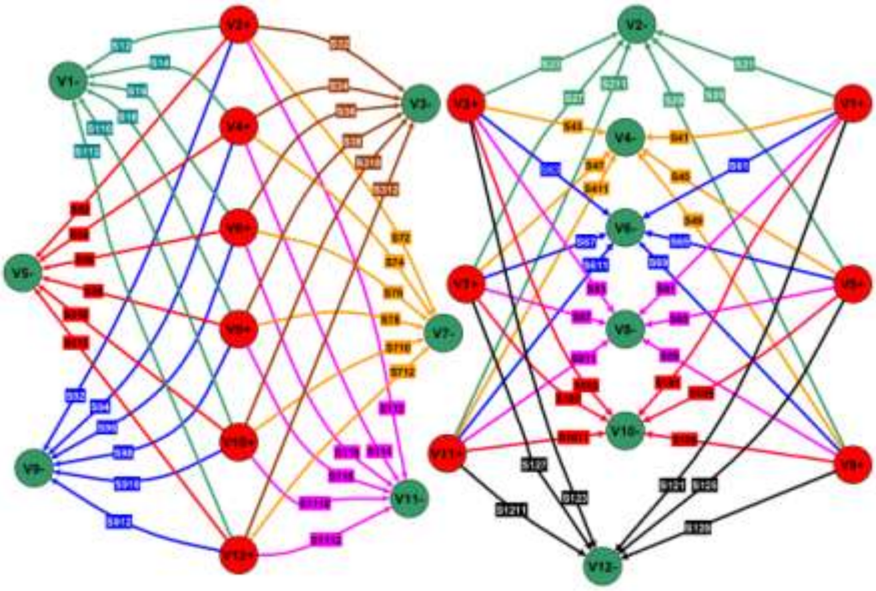


Fig. 1: 12-Port Hybrid Ring Coupler



(a)



(b)

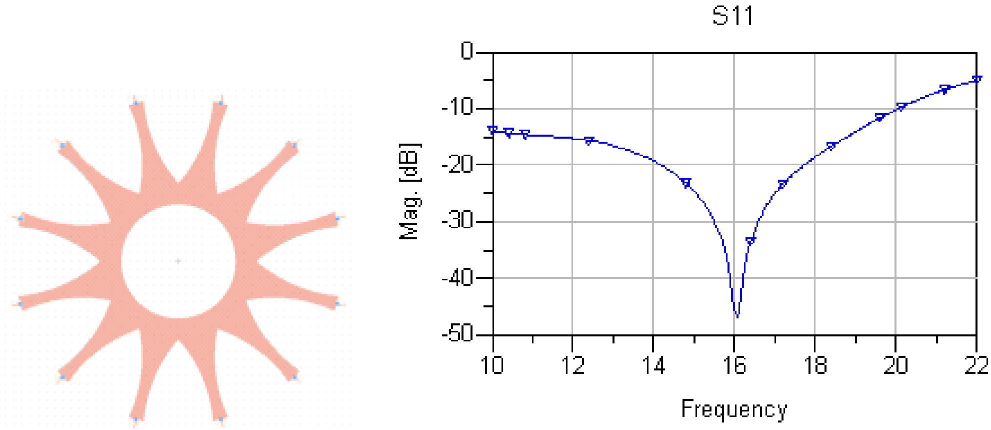
Fig. 2: The developed Signal Flow for 12-Port Hybrid Ring Coupler

$$S = K\begin{bmatrix} 0 & -j & 0 & j & 0 & -j & 0 & -j & 0 & j & 0 & -j \\ -j & 0 & -j & 0 & j & 0 & j & 0 & -j & 0 & j & 0 \\ 0 & -j & 0 & -j & 0 & j & 0 & j & 0 & -j & j & j \\ j & 0 & -j & 0 & j & 0 & j & 0 & j & 0 & -j & j \\ 0 & j & 0 & j & 0 & -j & 0 & -j & 0 & j & 0 & -j \\ -j & 0 & j & 0 & -j & 0 & j & 0 & -j & 0 & j & 0 \\ 0 & j & 0 & j & 0 & j & 0 & -j & 0 & j & 0 & -j \\ -j & 0 & j & 0 & -j & 0 & -j & 0 & -j & 0 & j & 0 \\ 0 & -j & 0 & j & 0 & -j & 0 & -j & 0 & -j & 0 & j \\ j & 0 & -j & 0 & j & 0 & j & 0 & -j & 0 & -j & 0 \\ 0 & j & j & -j & 0 & j & 0 & j & 0 & -j & 0 & -j \\ -j & 0 & j & j & -j & 0 & -j & 0 & j & 0 & -j & 0 \end{bmatrix}$$

Fig. 3: <u>The scattering matrix of 12 port hybrid ring Coupler</u>

Design and Implementation

Basically this 12 port coupler is a non-uniform implementation of a symmetric ring coupler. Initial design simulations yielded a very wide bandwidth of approximately 4 GHz with center frequency of 16 GHz as shown in fig. 4 (b).

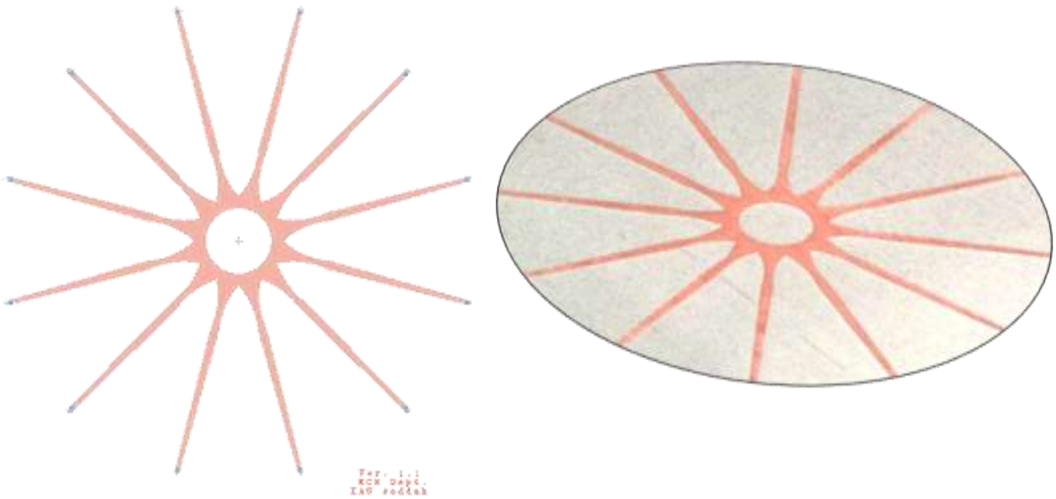


(a) (b)

Fig. 3: (a) 12-Port exponential taper ring coupler layout. (b) Return loss (S11) simulation using ADS.

Comments: It was found that the return loss of all ports having the same identical result, therefore the return loss of S11 has been selected see fig. 3 (b).

The circuit dimensions were small measuring 20 mm outer most radius making port connections almost impractical. Therefore, we modified the circuit to extend the ports to increase the outer radius up to 50 mm to enable the SMA connector to be properly connected. The layout and fabricated circuit of the 12-port exponential taper ring coupler is shown in fig. 4 below.

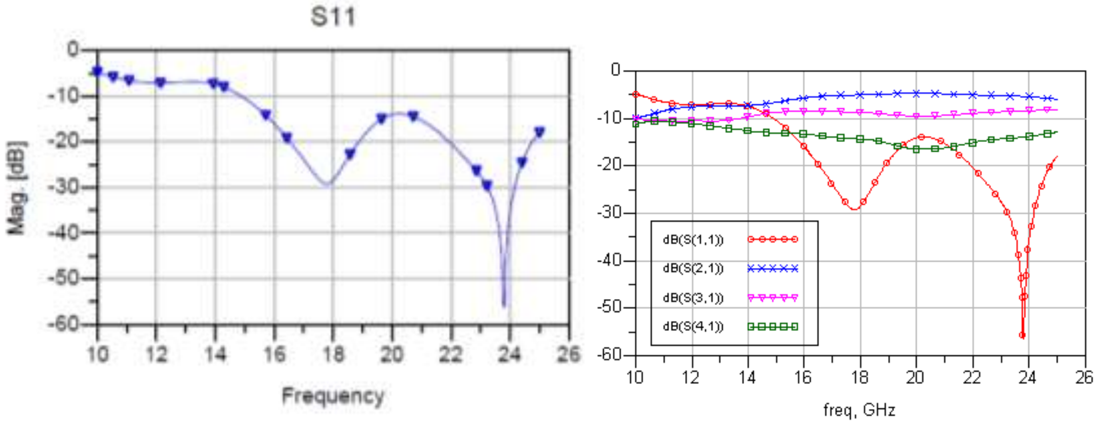


(a) (b)

Fig. 4: (a) Improved version of 12-Port exponential taper ring coupler layout.

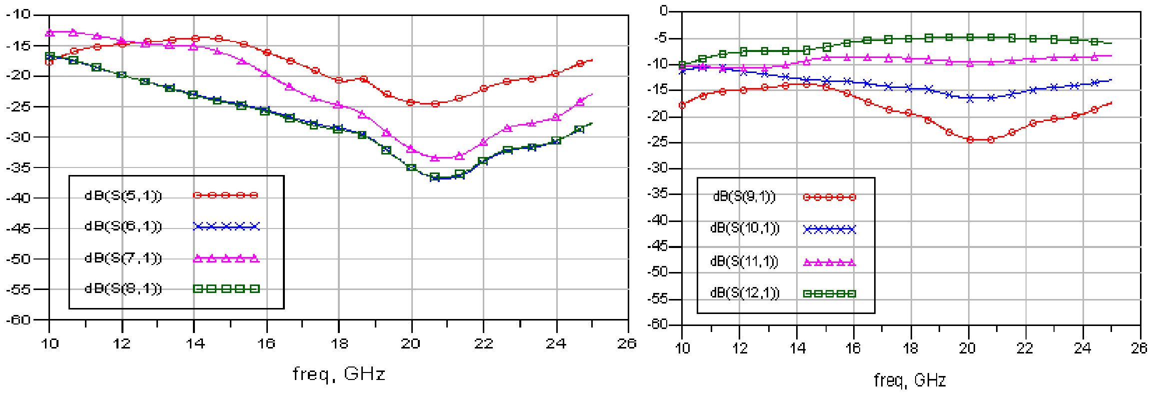
(b) Fabricated circuit by using LPKF laser etching machine on Roger 4003 substrate

The scattering parameters simulation using ADS 2009 shows a dual band operation under 20 dB reference with a bandwidth of approximately 2 GHz in each band.



(a) (b)

Fig. 5: (a) Reflection Coefficients (b) S-Parameters S(1,1), S(2,1), S(3,1) and S(4,1)



(a) (b)

Fig. 6: (a) S-Parameters S(5,1), S(6,1), S(7,1) and S(8,1)
(b) S-Parameters S(9,1), S(10,1), S(11,1) and S(12,1)

II. CONCLUSION

Fig. 5 & 6 show the frequency response of the optimized exponential taper ring coupler which was fabricated on roger substrate of dielectric constant ε_r = 3.38 and thickness of 0.2 mm. It is clear of the plot that this proposed ring coupler provides 2 GHz bandwidth for -20dB taken as a reference for both the return loss and isolation, working at center frequencies of 17.75 and 23.75 GHz. While the insertion loss of -5 dB for both and were observed over the same bandwidth. The signal flow which is used in driving scattering matrix of the 12 port hybrid ring is in full agreement with normal. The derived signal flow which is lead in computing the 12 port hybrid ring scattering matrix is utilized successfully

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Mohammed H. AlShehri "A 12 Port Dual Bandwidth Exponential Taper Ring Coupler "International Refereed Journal of Engineering and Science (IRJES), vol. 07, no. 06, 2018, pp. 41-44