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Design Simulation Analysis and Comparison of 2-Way Wilkinson Power Divider with Different Topologies

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ABSTRACT: This paper presents 2 way Wilkinson power divider (WPD) on microstrip line proposed designed and analysed for 650 MHz operating frequency. This Wilkinson power divider use elliptical as well as circular split design. First an optimized 2 way elliptical splitWilkinson power divider is designed and the output response of this power divider needs to be improved for equal and unequal both type of Wilkinson power divider applications. Then a circular split designWilkinson power divider is presented that yields acceptable input and output responses for equal and unequal Wilkinson power divider. This study shows the improvement of output simulation responses, this WPD have a better isolation and insertion loss, and also give a better return loss of input and output ports for operating frequency at 650 MHz.All simulations are carried out by AWR simulator.

KEYWORDS: Wilkinson power divider(WPD), elliptical splitWilkinson power divider, circular split Wilkinson power divider,Advancing the wireless revolution (AWR)

I. Introduction

Power divider and combiner is passive device that divide RF input power among several output and vice versa. The power divider and power combiner are very popular components for a microwave power combining system. High power solid state RF power divider/combiner are essential due to modest power of solid state devices. As such, most of the popular powers combining schemes have emerged from communication system requirement; generally, a passive power divider can work as a power combiner without any modification due to the reciprocity Hence concepts developed for the power divider equally applies to a combiner. In case of power division, an input signal is divided into two (or more) output signals of lesser power, while a power combiner as name suggests do reverse operation and combines them at an output port. Power dividers usually provide equal and unequal power division ratio. In many applications, there is a need to use microstrip Wilkinson power divider with unequal power division ratio. However, for the unequal Wilkinson power divider with high power dividing ratio,the characteristic impedance of one of the microstrip lines becomes high.

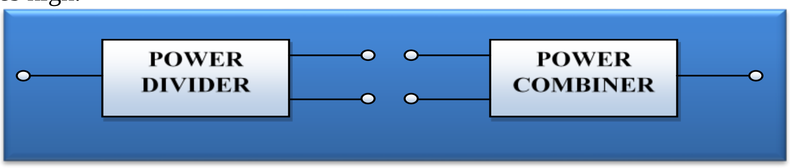

Figure 1 Basic Diagram of Power Divider/Combiner

II. Related work

The most popular and widely adopted power combining structure was proposed by E.J. Wilkinson in, 1960 and it is consequently referred to as Wilkinson splitter/combiner.Up to now, many new power dividers are still being proposed.

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These can reduce the dimensions of the divider and have a better return loss, insertion loss and isolation.In [1] author designs a 4:1 unequal Wilkinson power divider using a microstrip. The conventional Wilkinson topology is used for design with the defected ground structure (DGS) which can obtain the 4:1 power dividing ratio easily without any problem. Author in [2] investigated different type of microwave combining techniques like chain and tree combining and n-way combining structures. In the work of [3] focus of author was on the design, fabrication, and testing of feeding the networks individually and within an array system. In the design of Wilkinson power divider, three topologies, viz. straight split section, a circular split section, and an elliptical split section for the quarter-lambda split transmission line section were discussed. The elliptical split transmission line design results the most reduced size, but was rejected, due to close spacing of the lines did not allow themselves to be sufficiently decoupled from each other, and the circular and straight line quarter lambda split sections are designed, analysed and compared from simulation results. Ansoft HFSS simulator is used to compare these two topologies by simulation results.Another scheme was presented in [4] a uniform asymmetrical microstrip coupled lines was introduced to overcome the narrow strip width in unequal Wilkinson power divider with high dividing ratio. A comprehensive analytical design scheme is given in [5]; author has generalized unequal Wilkinson power divider operating at dual-frequency. Here, the parallel and series RLC structures are chosen to obtain effective isolation between the two output ports according to different operating frequencies. Paper [6] presents design and fabrication of 2way Wilkinson power divider (WPD) for dual operating Frequencies; 2.4GHz and 4.928GHz. This power divider has two branches of impedance transformer and parallel connection at the output ports of this divider with RLC lumped element.The report [7] discusses both equal and unequal power split cases. That is a power division ratio of 1:1, 3:2, 2:1 are discussed here. The circuits of 3 ports Wilkinson power divider are analysed by the author to reduce the size of it by replacing the $\lambda/4$ transmission line with a compact stepped impedance transmission line using even and odd mode analysis. The results show that matching at all the ports are good. And good isolation between output ports is achieved at designed frequencies.

Here, we describe a new topology to design power divider. The analysis of Wilkinson power divider and comparison between Both topologies elliptical as well as circular split design are also presented. To demonstrate that circular split design of Wilkinson circuit has a good performance in the equal, unequal both case, the proposed Wilkinson power divider has been analysed and simulated. The simulated results indicate reasonable agreement with the designed results.

III. PROPOSED ALGORITHM

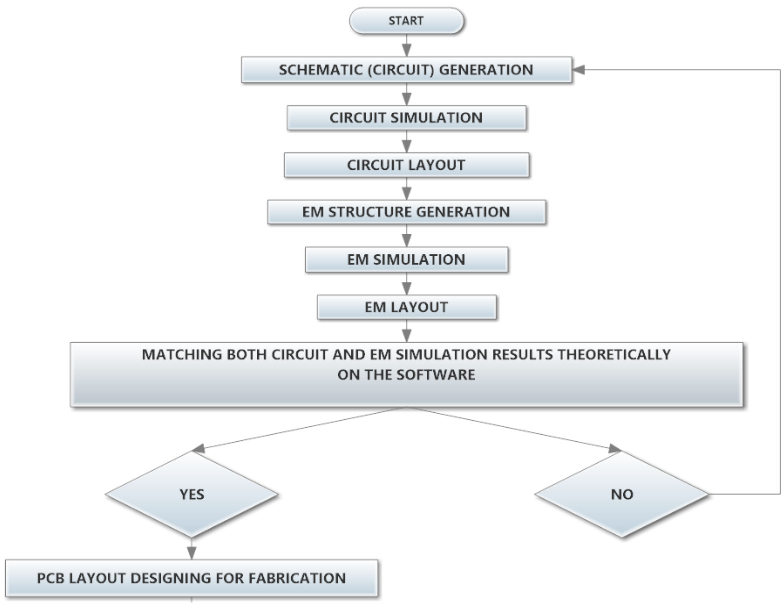

Figure 2 Design Step for Simulation Of RF Power Dividers

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IV. DESCRIPTION OF THE DESIGN ALGORITHM

Aim of the proposed algorithm is to Design simulate analyse and compare of 2-Way Wilkinson Power Divider with different topologies; elliptical as well as circular split design. Two design topologies were simulated for the equal and 1:2 unequal WPD by, the elliptical split design and circular split design section. The design algorithm is consists of three main steps.

Steps to be followed:

1) Design the power divider for the power division ratio K^2 using design formula.
2) Calculate the Physical length and width of each microstrip line
3) Construct circuit and measure the performance parameters such as Input Return loss Insertion loss to port – 2 Insertion loss to port – 3, Isolation between two output ports

V. SIMULATION RESULTS AND DISCUSSION

A. TWO WAY EQUAL POWER DIVIDERS

STEP 1:- Calculation of Equal Power Divider

(i) $K^2 = 1/1$, K=1

(ii) $Z_{02} = Z_{03}$, $Z_{02} = Z_{03} = 70.71$ohm

(iii) R = 100 ohm

Where:-

K = Coupling factor

Z_{02} =impedance of port 2, Z_{03}=impedance of port 3

STEP 2:- Calculation Of Width And Length Of Microstrip

AWR provides a TXLINE Calc utility to calculate the width, w and length, l in mm, according to your specifications. Using TXLINE Calc:

For Z_0=50 Ohm, at $\lambda/4$ W= 7.2 mm, L= 69.39 mm

For Z= $\sqrt{2}Z_0$=70.71 Ohm at $\lambda/4$ W= 3.9 mm, L= 71.08 mm

STEP 3:-Follow the Design Procedure

SCHEMATIC DESIGN

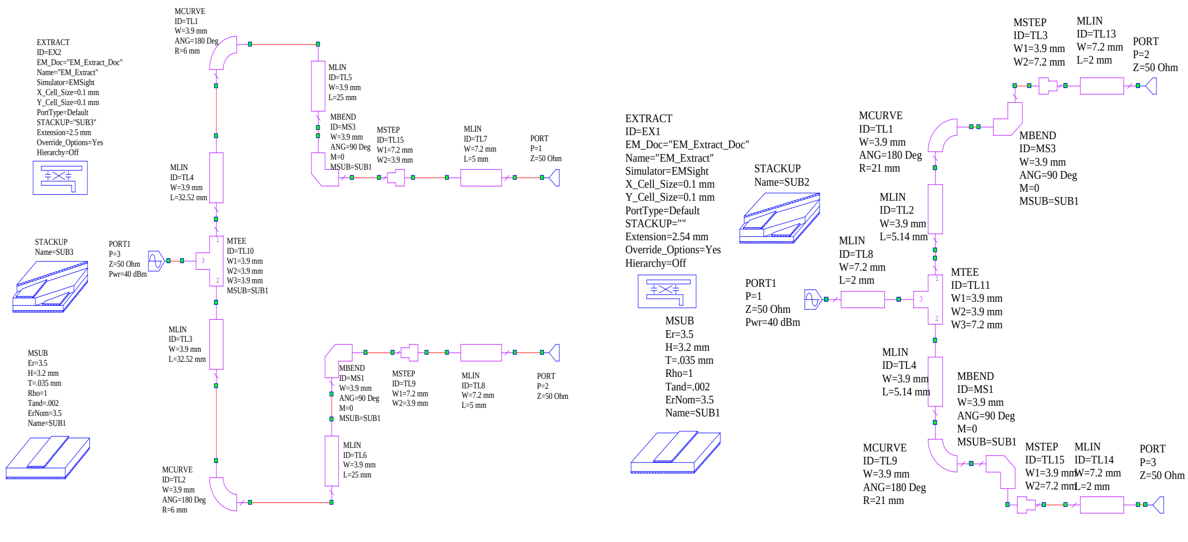

Figure 3 Schematic Diagram Of Equal (A) Elliptical And (B) Circular Spilt Power Divider

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EM LAYOUT

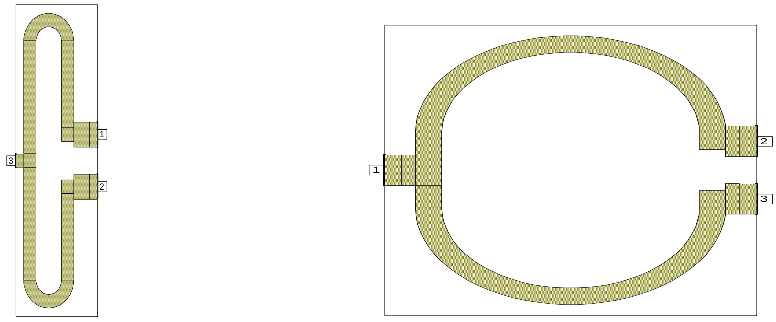

Figure 4 EM Layout Of Equal (A) Elliptical And (B) Circular Spilt Power Divider.

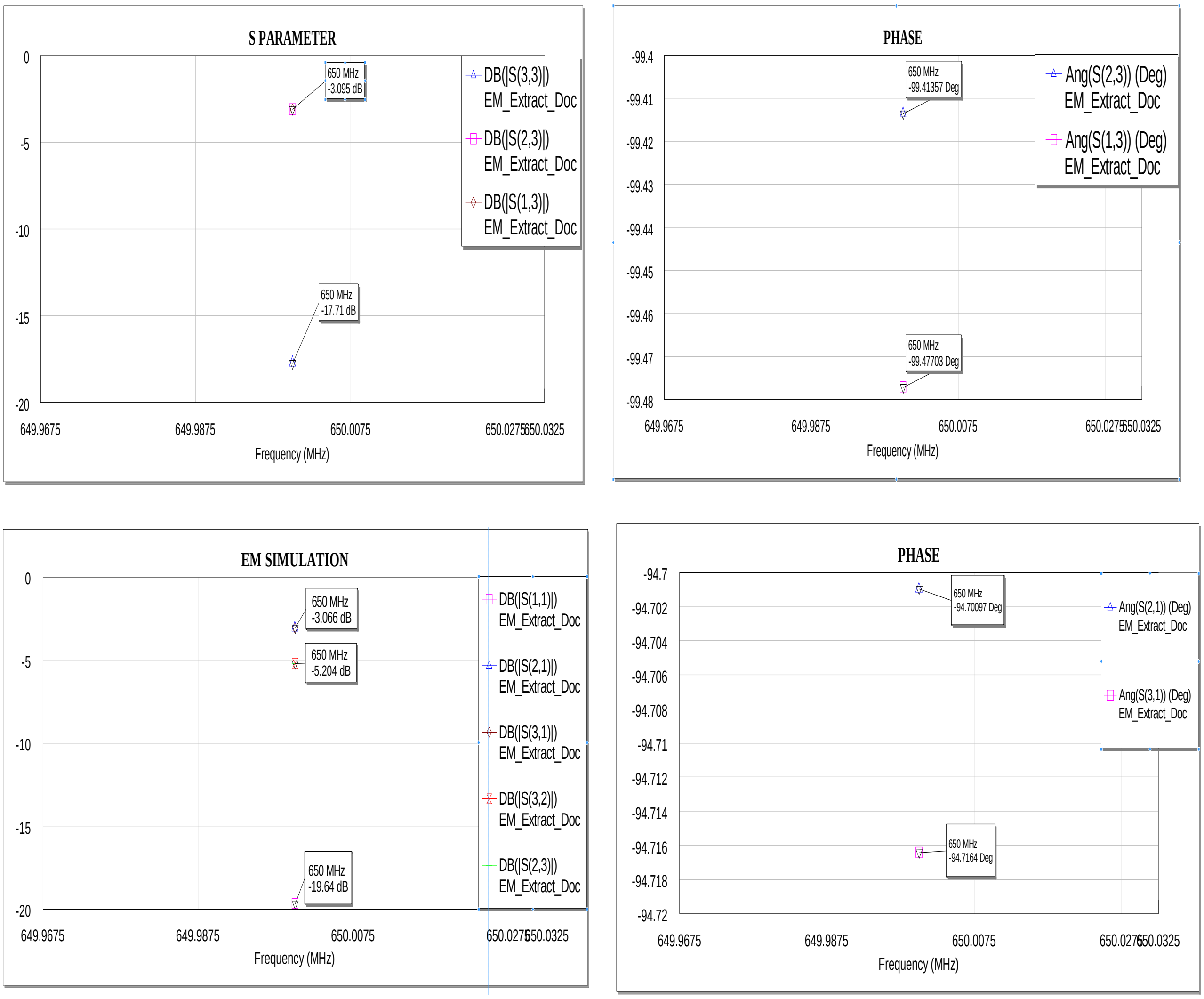

Figure 5: Graph of Equal (A) Elliptical and (B) Circular Spilt Power Divider.

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This divider is simulated using AWR simulators. Graphs shows the obtained scattering parameters achieved over the frequency of 650 MHz. An input return loss better than -20 dB is obtained over a frequency of 650 MHz. Moreover, the coupling coefficient equals to -3dB.

SIMULATION RESULTS OF EQUAL ELLIPTICAL SPLIT DESIGN VERSUS CIRCULAR SPLIT DESIGN

The following graph show the simulation result of return loss and insertion loss of elliptical as well as circular split equal power divider. From the graph, it is observed that circular split equal WPD return loss is highly desirable and the insertion loss is low when compared with elliptical split equal WPD. Figure (a),(b) shows the return loss of about -17.71dB and -19.64dB respectively.

ELLIPTICAL SPLIT DESIGN			CIRCULAR SPLIT DESIGN		
S PARAMETER	SIMULATION RESULT		S PARAMETER	SIMULATION RESULT	
650 MHz	MAGNITUDE(d**B**)	PHASE (Deg)	650 MHz	MAGNITUDE (d**B**)	PHASE (Deg)
S_{33}	-17.71 dB		S_{11}	-19.64 dB	
S_{23}	-3.095 dB	-99.41^0	S_{21}	-3.066 dB	94.700^0
S_{13}	-3.095 dB	-99.47^0	S_{31}	-3.066 dB	94.716^0

B. 1:2 UNEQUAL POWER DIVIDER

STEP 1:- Calculation and Simulation of 1:2 Unequal Power Divider

$K^2 = 1/2$

$K = .7071$

$Z_{02} = Z_{03} K^2$, $Z_{02} = 51.48$

$Z_{03} = Z_0\sqrt{\frac{1+k^2}{k^3}}$, $Z_{03} = 102.99$

$R = Z_0 (K+1/K)$, $R = 106.06$

$R_{02}= Z_0K$, $R_{02}= 35.35$

$R_{03}= Z_0/K$, $R_{03}= 70.71$

Where:K = Coupling factor,Z_{02} =impedance of port 2,Z_{03} =impedance of port 3,R_{02} = resistance of port 2,R_{03} = resistance of port 3

STEP 2:- Calculation of Width and Length of Microstrip:-

AWR to calculate the width, w and length, l in mm, according to our specifications. Using TXLINE Calc:

For Z_0=50 Ohm, at $\lambda/4$ W=7.2 mm, L= 69.39mm

For $Z_{02}= Z_{03} K^2$=51.48 Ohm at $\lambda/4$ W= 6.84 mm, L= 69.52mm

For $Z_{03}= Z_0\sqrt{\frac{1+k^2}{k^3}}$ = 102.99 Ohm at $\lambda/4$ W= 1.64 mm, L= 72.87 mm

STEP 3:-**Follow the Design Procedure**

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SCHEMATIC DESIGN:-

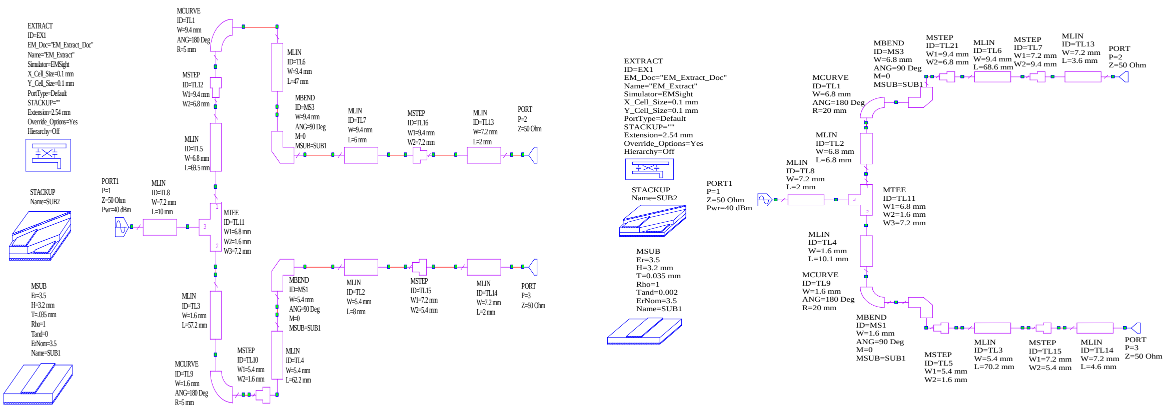


Figure6: Schematic Diagram of 1:2 Unequal (A) Elliptical and (B) Circular Spilt Power Divider

EM LAYOUT:

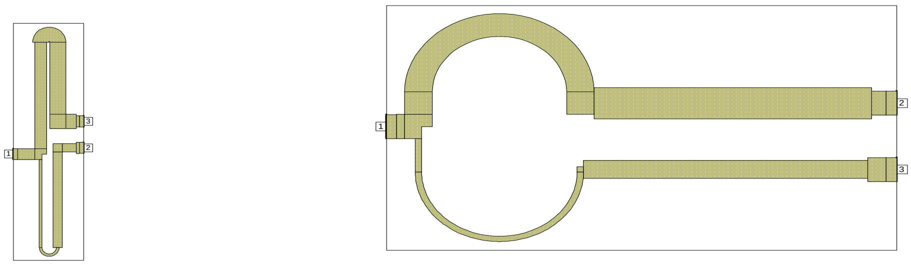
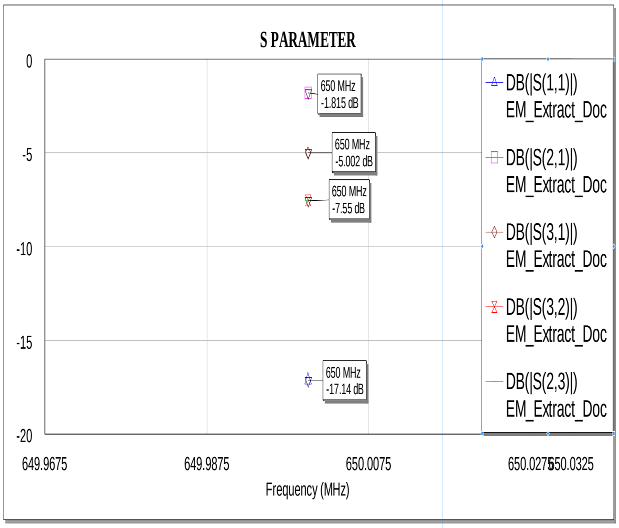
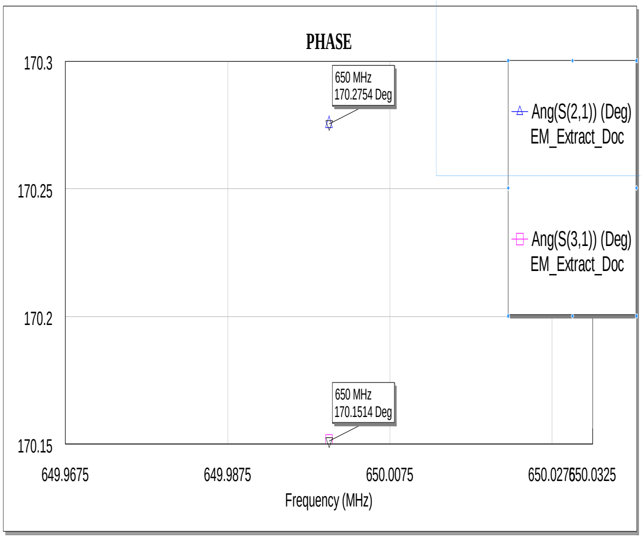


Figure 7: EM Layout of 1:2 Unequal (A) Elliptical and (B) Circular Spilt Power Divider.





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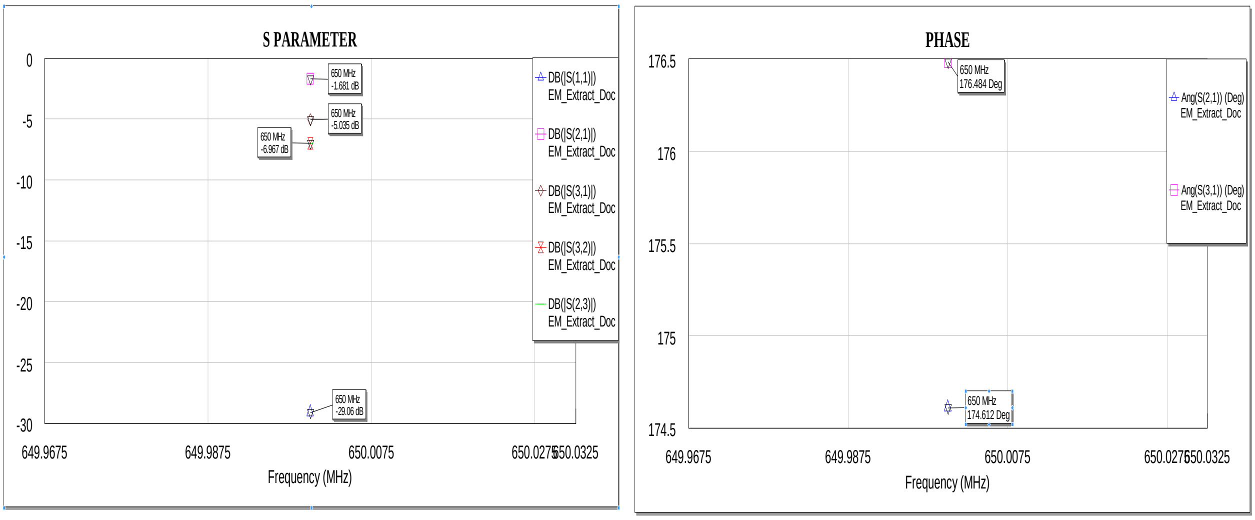

Figure 8: Graph of 1:2 Unequal (A) Elliptical and (B) Circular Spilt Power Divider

The results of the project were in agreement to the theoretical available results, so the various S parameters were plotted as shown above.The circuit's main S-parameters were plotted S11,S12,S23 and S31. These indicate matching, power division, and port isolation, respectively.

SIMULATION RESULTS OF UNEQUAL ELLIPTICAL SPLIT DESIGN VERSUS CIRCULAR SPLIT DESIGN

Table1 gives the performance analysis of circular split unequal WPD over elliptical split unequal WPD on the basis of insertion loss and return loss at the operating frequency. Elliptical split unequal WPD return loss is measured of about -17.14dB whereas circular split unequal WPD return loss is measured about 29.06dB. Hence the return loss of circular split unequal WPD is found to be lower about -17.14dB when compared with elliptical split unequal WPD.

	ELLIPTICAL SPLIT DESIGN		CIRCULAR SPLIT DESIGN	
S PARAMETER	SIMULATION RESULT		SIMULATION RESULT	
650 MHz	MAGNITUDE (d**B**)	PHASE (Deg)	MAGNITUDE (d**B**)	PHASE (Deg)
S_{11}	-17.14 dB		-29.06 dB	
S_{21}	-1.815 dB	170.2^0	-1.681 dB	174.6^0
S_{31}	-5.002 dB	170.1^0	-5.035 dB	174.4^0

VI. CONCLUSION

In this paper, the performance comparison of elliptical split design and circular split design are analysed in terms of return loss, coupling and isolation loss with the operating frequency of 650 MHz. The simulation result shows the reduction of losses between the two dividers using AWR microwave simulator. Thus, we conclude that circular split design overcomes the limitations and has better performance when compared to elliptical split design. Hence the circular split design is advantageous over elliptical split design.

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