Development of Wilkinson Power Divider for UWB Application

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***Abstract*—This paper presents the development of Wilkinson power divider using circular stub and a L-type parasitic short line. The design of power divider is started with conventional design of Wilkinson power divider. To observe the significant performance enhancement, the performance of proposed power divider is compared with the conventional design of power divider. To validate the proposed design, all of designs are investigated using Ansoft HFSS simulation tool. The simulated results of the proposed Wilkinson power divider is compared and analyzed. The overall simulated percentage bandwidth of the proposed power divider is 59.73%, ranging from 6.27 to 11.61 GHz frequency band.**

Keywords—Wilkinson power divider; circular stub; L-type parasitic short line

I. Introduction

With the development of modern wireless communication, the UWB component become a necessary part in these systems. The UWB power divider is one of the most useful components that are used in various RF and microwave circuits. In recent years, many new types of power dividers for the application of UWB have been proposed. For example in [1], the wideband power divider is designed by adding butterfly radial stub as impedance matches. The implementation of butterfly radial stub is significantly improving the operating bandwidth. However, this design of butterfly radial stub involves more design parameters, therefore increase the complexity of the design. In [2], a compact wideband power divider is demonstrated using multilayer micro-strip technique, which may cost a lot.

Therefore, wideband power divider on single layer microstrip technique which is less expensive but has similar performances is introduced. The bandwidth of the power divider can be improved using circular stub matching network. The effects of the power divider parameters such as isolation, insertion loss and return loss are analyzed. In the design, a low loss Rogers 4003C substrate with a dielectric constant of 3.38, substrate height of 0.508mm.

II. DESIGN TECHNIQUE

The basic configuration for Wilkinson power divider is shown in Fig. 1.

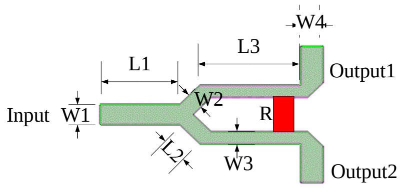

Fig. 1. Conventional Wilkinson power divider.

As shown in Fig.1, to match with the input port, the characteristic impedance of the each uncoupled lines is $\sqrt{2}Z0$, Z0 represents the characteristic impedance of transmission lines at the input port. L2 and L3 represent the length of the quarter wavelength transmission lines. Summary of the optimized dimensions are shown in Table I.

TABLE I. DIMENSIONS OF CONVENTIONAL WILKINSON POWER DIVIDER

Parameter	Dimension (mm)	Parameter	Dimension (mm)
W1	1.1	W3	0.66
L1	4.2	L3	5.4
W2	0.9	W4	1.1
L2	1.55		

Fig.2. shows the proposed UWB Wilkinson Power Divider with Circular Stub and L-type parasitic short line.

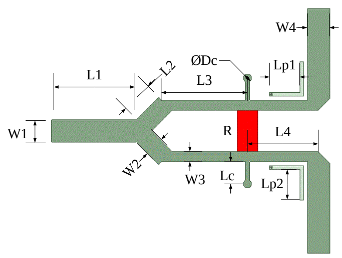

Fig. 2. The proposed UWB Wilkinson Power Divider

These additions will lead to changes in impedance matching and as results, will increases the bandwidth and directly increases the performance of UWB power divider as well. A shunt resistor, is then placed in the middle of circular stub and the value is two times the value of characteristic impedance such that R=2Z0=100Ω. The dimensions of the proposed UWB Wilkinson Power Divider are as shown below in Table II below.

TABLE II. DIMENSIONS OF THE PROPOSED WILKINSON POWER DIVIDER

Parameter	Dimension (mm)	Parameter	Dimension (mm)
W1	1.1	L4	2.88
L1	4.2	W4	1.1
W2	0.9	Lc	1.1
L2	1.55	Dc	0.4
W3	0.5	Lp1	1.53
L3	4.3	Lp2	1.53

III. RESULTS AND DISCUSSION

The results of S-Parameter corresponding to conventional and improved power divider are shown in the Fig. 3, Fig. 4 and Fig. 5 while the summary of the results are shown in Table III.

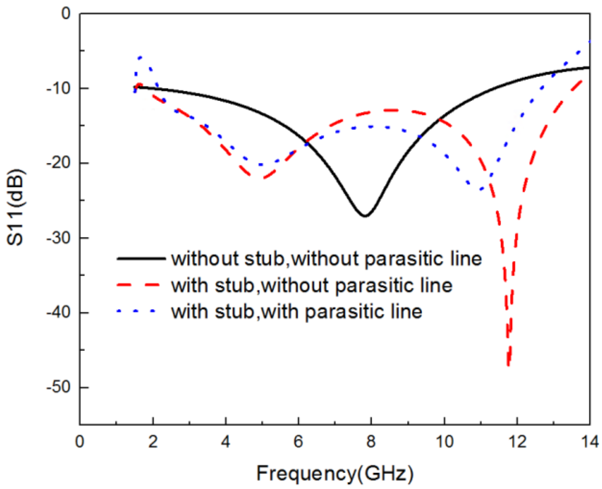

Fig. 3. S-parameters results of Input Return Loss, S11

Fig. 3 shows the effect of circular stub and L-type parasitic short line on input return loss result of the power divider. It shows that the circular stub can expand impedance bandwidth obviously. The L-type parasitic short line couples with powder divider, which slightly makes impedance matching at high frequencies badly.

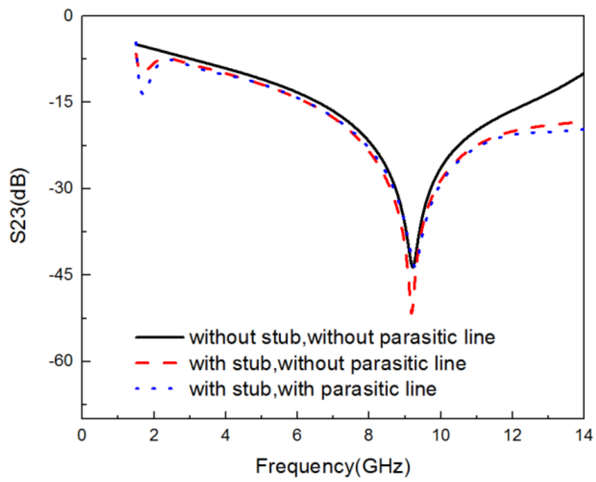

Fig. 4. S-parameters results of Isolation, S23

The isolation results are affected by circular stub and L-type parasitic short line, and its shown as in Fig.4. Both the circular stub and L-type parasitic short line can improve S-parameters results of isolation.

Fig.5 shows the graph pattern of power division. Both the circular stub and L-type parasitic short line can improve the performance of powder division, and further they can make the overall performance of powder divider better.

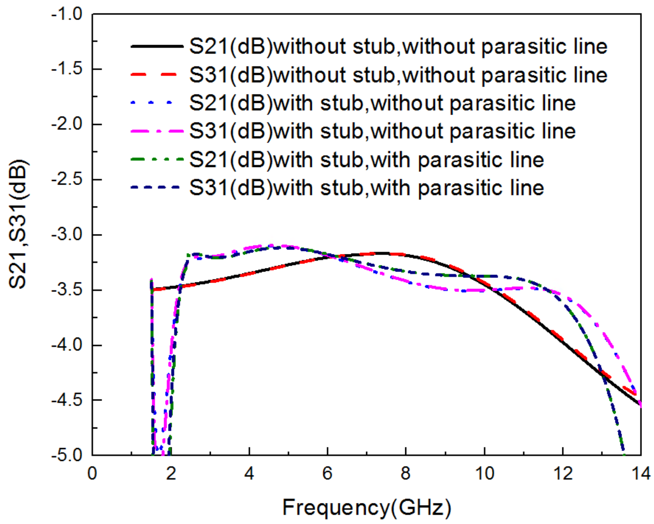

Fig. 5. S-parameters results of Power Division, S21 and S31

Table III shows the summary of simulated results of Wilkinson Power Divider without stub, with stub, without parasitic line and with parasitic line. The comparison will be made based on percentage bandwidth calculated using below equation (1), follow as:

$$\mathrm{BW} = 2\frac{f_H - f_L}{f_H + f_L} \times 100\% \qquad (1)$$

In order to writing easily, the Conventional Wilkinson power divider is called Divider, and the improved powder divider is called New Divider.

TABLE III. SUMMARY OF BANDWIDTH OF SIMUL-ATED OF CORRESPONDING S-PARAMETER

parameter	Frequency Range	Divider (GHz)	New Divider (GHz)
S11 (<-10dB)	f_L	2.03	2.15
	f_H	11.36	12.66
	Bw(%)	139.35	141.93
S23 (<-15dB)	f_L	6.58	6.27
	f_H	12.48	14
	Bw(%)	61.9	76.27
S21 (>3.5dB)	f_L	2	2.23
	f_H	10.3	11.61
	Bw(%)	134.95	135.55

As shown in Table III, percentage bandwidth of power divider with stub and parasitic line is better than without them for all parameter involved. This result is expected as adding additional stubs will change the circuit impedance matching and directly will change the bandwidth performance as well. A L-type parasitic short line can further improve isolation and power division. Considering parameter S11 until S21, overall bandwidth of the proposed power divider without improvement is covered from 6.58GHz to 10.3GHz with percentage bandwidth of 44%. In the other hand, the proposed power divider with circular stub and L-type parasitic short line achieved percentage bandwidth of 59.73% with the frequency ranging from 6.27 to 11.61GHz.

IV. CONCLUSION

In this paper, it presents two kinds of way to improve performance of Wilkinson power divider. Wilkinson power divider with circular stub and L-type parasitic short line are designed. The simulated S-parameters performances of the proposed power divider have been compared with the traditional Wilkinson power divider without improvement using Ansoft HFSS simulation tool.

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