Design of a Compact UWB Wilkinson Power Divider with open stubs

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***Abstract*—In this work we present a Wilkinson power divider operating over an ultra wide frequency band (3.1GHz to 10.6GHz). The proposed power divider consists of two branches of impedance transformer, each consists of two sections of transmission lines with different characteristic impedances and different lengths. Two resistors of 100 ohm are set between the two sections and there are two stubs. The simulated and measured results of the proposed divider shows good insertion loss that is less than 0.4 dB, the role of skirts near both the cut off frequencies have been significantly sharpened, return loss of input port (S_{11}) and out ports (S_{22},S_{33}) are less than 12 dB and isolation is better than 11 dB for over UWB frequency range.**

***Index Terms*—Wilkinson power divider, ultra wideband, even mode, odd mode.**

I. INTRODUCTION

Since the release of commercial use of UWB technology in 2002 by FCC, significant research activities and interests have been aroused in academic and industrial circles toward exploring various UWB components and devices. Wilkinson's power divider's narrow bandwidth is a serious barrier for the UWB system applications. In a UWB system, a large number of papers have been published on the design of UWB antennas and UWB filters. But, as a key component in a variety of microwave systems, only few UWB dividers have been proposed, which are extensively being used in balanced mixers, phase shifters, and antenna array feed networks. The simplest type of power divider is a T junction operating over an ultra wide frequency band. It is a three-port network with one input port and two output ports.

In this paper, an ultra-wideband (UWB) power divider on microstrip line is proposed. The configuration of a compact Wilkinson power divider with two branches of impedance transformer, two resistors and two stubs are operating over an ultra wide frequency band. By employing the two-section transformer with different dimensions, the simulated and measured results of the proposed divider show equal power division with good return loss at the three ports, low insertion losses, and fine isolation between the two output ports across the UWB band from 3.1 GHz to 10.6 GHz.

II. PROPOSED UWB POWER DIVIDER

A schematic diagram of the proposed Wilkinson power divider, which realizes an equal power division over an ultra wide frequency band is shown in Fig. 1. In order to obtain high performance Wilkinson network, it is important to point out that dimensions of transmission line have to be carefully taken into account while defining the structure of the power divider. Each quarter-wave branch of a conventional Wilkinson power divider is replaced by two sections of transmission lines with different characteristic impedances Z_1 and Z_2 and the corresponding physical lengths l_1 and l_2, respectively. The isolation between the output ports is achieved by using resistors, as shown in Fig.1. The purpose of the present analysis is to determine the divider parameters: Z_1, Z_2,l_1 and l_2. Since this divider is symmetrical, the even- and odd-mode analysis has to be used to determine the divider parameters for ultra wide frequency operations.

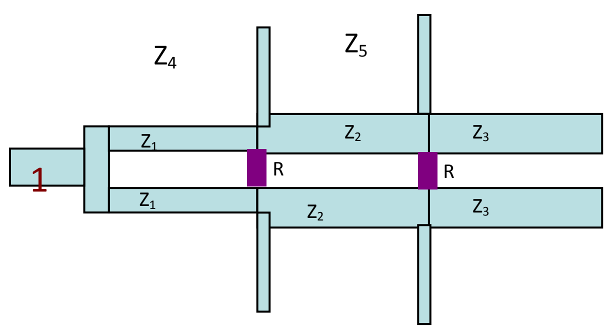

Fig.1 Schematic of the proposed UWB power divider on microstrip line

The first section Z_1 adjustment can control the lower cutoff frequency of the power divider and the second section Z_2 can control the upper cutoff frequency. The four short circuited stubs of Z_4 & Z_5 help to improve insertion loss and return loss in the mid band. This circuit has been designed on FR4 substrate and entire circuit has been fabricated which size 25.4mm x 30mm. Length and width of first section 4.20mm, 1.67mm, Length and width of middle section 5.82mm, 3.16mm, short circuited stub length and width 6.26 mm, 0.3mmand each resistance R = 100 Ohm. Fig. 2 shows the photograph of the fabricated power divider. The above dimensions of the power divider were simulated and fabricated to get the optimum performance. The divider is fabricated on the substrate with dielectric constant ε_r = 4.4, loss tangent δ= 0.0019, and thickness h =1.6 *mm.*

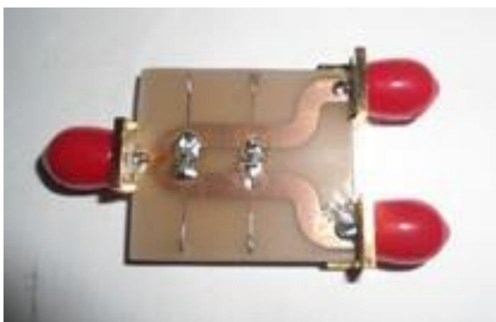

Fig. 2. Photograph of the fabricated Power divider

III. SIMULATION AND MEASUREMENT RESULTS

Entire design work has been mainly performed through Ansoft Serenade. Design software tools are very useful for design work to avoid real experimental work that in many cases consumes much time and costly. The numerical experiments were performed with a high frequency structure simulator (HFSS) serenade. To acquire a wide pass band in which the return loss at the input port and the output ports are less than 12 dB. The measured frequency response of the proposed UWB power divider is characterized in vector network analyzer (VNA). Results of the simulations are shown in Fig.3 to Fig.6.

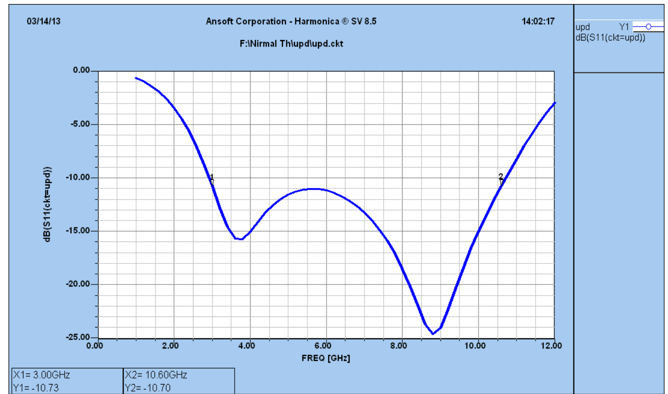

Fig.3 Simulated return loss S_{11}

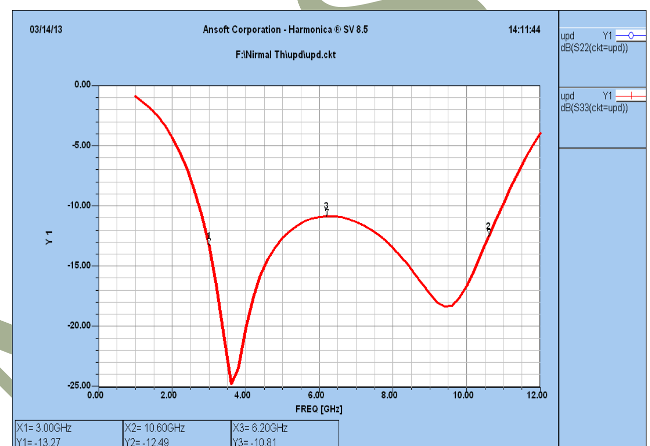

Fig.4 Simulated return loss S_{22}, S_{33}

The return loss at the input port is in the range of 10.70 dB for the whole band as shown in fig 3. At the same time, the return loss at the output ports is 10.80 dB for the same band as shown in fig. 4. The isolation between the two output ports is between 11dB across the band and 14 dB to 34 dB from 4.0GHz to 10.6 GHz. As shown in fig. 5.

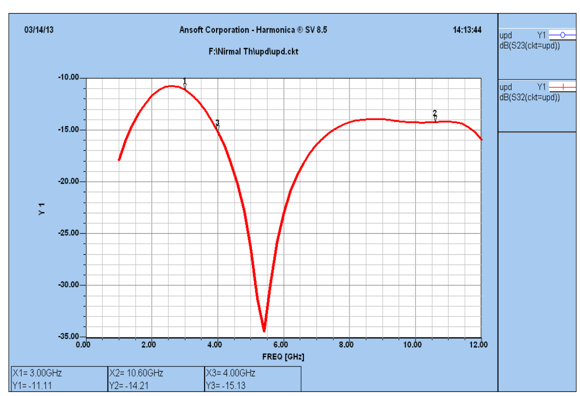

Fig.5 Simulated result of Isolation S_{32}, S_{23}

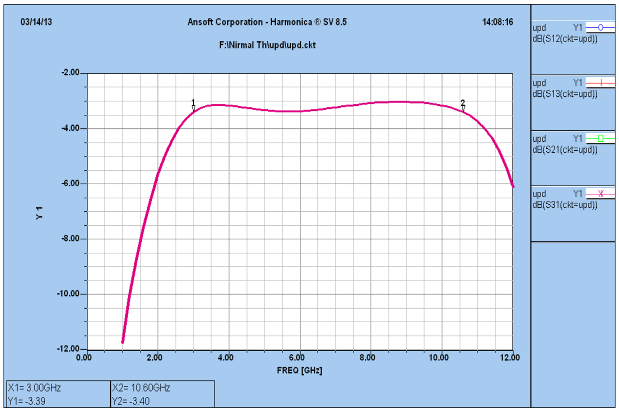

Fig.6 Simulated Insertion loss S_{12} , S_{13}, S_{31}, S_{21}

Those results reveal that the power is equally divided between the two output ports with insertion loss less than 0.4 dB across the band 3.1 GHz to 10.6 GHz. Fig.7 shows the measured S_{22} and S_{12}, S_{11} and S_{21}. The measured S_{11} is lower than -10 dB and S_{21} is close to -3.0 dB over the frequency range from 3.1 GHz to 10.6 GHz with 0.4 dB insertion loss for over UWB frequency range.

In particular, the roll-off skirts near the two cutoff frequencies are significantly sharpened as demonstrated in simulation as well as measured results. The measured S_{23} between port 2 and port 3 as well as S_{32} between port 3 and port 2 are all lower than -10 dB over the UWB band. Note that the presented measured results include losses of coaxial connectors that were used in the experimental testing they matched with each other.

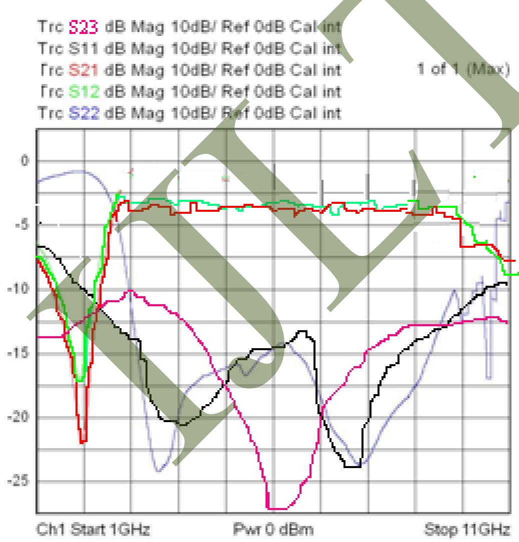

Fig.7 Measured results for S_{12}, S_{21}, S_{11}, S_{22},

IV. CONCLUSION

This paper has proposed a UWB power divider with good insertion loss, impedance matching and return loss. In particular, the roll-off skirts near the two cutoff frequencies are significantly sharpened as demonstrated in simulation as well as measured results. This divider is analyzed and designed based on a symmetrical three-port circuit model under even- and odd-mode excitations. The expected UWB performances of this proposed divider are found to be much better than previous work by using stubs. This is a matter of great satisfaction that the stimulated results matched with fabricated UWB power divider.

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