A Size-Reduced CPW Balun using a "X"-Crossing Structure

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Abstract - A novel sized-reduced CPW balun is proposed. It has an 180° phase inverting structure, which is a "X"-crossing between signal line and ground planes of CPW transmission line. A 3λ/4 CPW transmission line can be reduced to λ/4 in physical length while the electrical length is preserved. One of previous Wilkinson baluns shown in [1] has a long 3λ/4 transmission section to form the Wilkinson structure having out of phase performance between output ports. The large Wilkinson balun is quite reduced by adopting the CPW phase inverting structure. Measured results show that the size-reduced CPW Wilkinson balun has better performances than the original Wilkinson balun.

I. INTRODUCTION

Balun is one of widely used circuits for high frequency applications. There have been a lot of types of baluns. Out of them, baluns having the basic Wilkinson structure, so called Wilkinson balun, are popular because of the familiarity with design and in-line structure.

Recently a CPW Wilkinson balun having two additional 2λ/4 transmission lines between port1 and port2, and port2 and the isolation resistor has been proposed at E-band [1]. In the previous work, because the proposed circuit as an instance was the Wilkinson balun at 77GHz, the size-problem was not considered. However, if the proposed topology is applied for low frequency application, the size may be very large and this will be a serious drawback.

In order to solve this problem, a 180° phase inverting section, which has a "X"-crossing structure between signal line and ground planes of CPW transmission line, is adopted.

II. THE PROPOSED SIZE-REDUCED CPW WILKINSON BALUN

Fig. 1(a) and (b) show the basic Wilkinson divider and previously presented E-band CPW Wilkinson balun. Fig. 1(b) can be designed easily from Fig. 1(a) by adding two λ/2 transmission lines. However it might have a bulky size at low frequencies because the physical 3λ/4 line is too long. So it is desirable to reduce the long transmission line, while the required electrical length (270°) is being kept. Fig. 1(c) is the proposed CPW Wilkinson balun in this work, whose 270° line section has only λ/4 in physical length due to a 180° phase inverting structure.

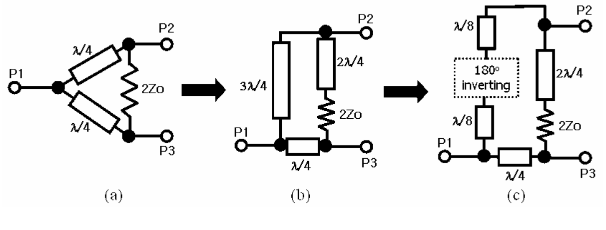


Fig. 1 Step for the proposed size-reduced CPW Wilkinson balun

(a) A Wilkinson divider (b) Previously proposed Wilkinson balun (c) Proposed size-reduced Wilkinson balun

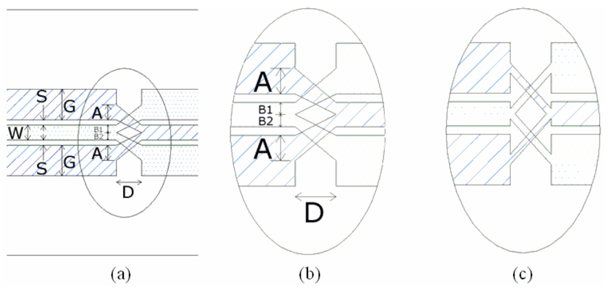


Fig. 2 The “X”-crossing structure for 180° phase converting in CPW transmission line

(a) Top view (b) Magnified “X”-crossing structure (c) A modified “X”-crossing structure

It is known that an additional 180° of phase is obtained if the signal line and ground planes cross each other in finite-grounded CPW and CPS transmission lines [2-4]. Fig. 2(a) and (b) show the "X"-crossing in CPW lines and its magnification. The "X"-crossing structure is formed within the widths of signal line and ground planes, i.e. W and G, respectively. There may be lots of modified layout for "X"-crossing such as Fig. 2(c). It is simply recommended that "B1+B2" ≤ “W” and “A” ≤ “G”. In the figure, “D” is the gap where the "X"-crossing structure exists.

The 3-dimensional "X"-crossing structure is formed by an air-bridged or bottom-bridged shape as shown in Fig. 3 and 4. In the case of bottom-bridge, lots of metallic via-holes and some pad patterns on the bottom side are required.

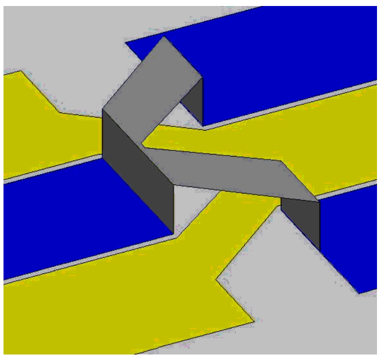


Fig. 3 Air-bridge structure

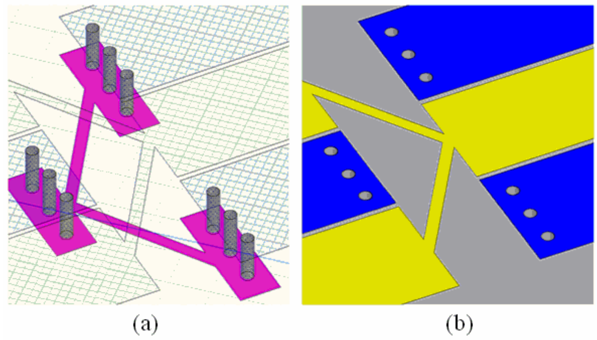


Fig. 4 Bottom-bridge structure

(a) 3-dimensional projection (b) CPW metal pattern on the top surface

III. Fabrication and Measured Performances

Fig. 5 shows the layouts of size-reduced CPW Wilkinson balun and normal one. The size of the proposed one is only half of the normal balun in Fig. 1(b). The balun layouts in Fig. 5 were designed for 2GHz of center frequency using the substrate of which dielectric constant and thickness are 2.2 and 31mils, respectively.

It should be noted that the proposed baluns in Fig. 1(b) and (c) are different from the commonly-used rat-race hybrids, even though they look similarly. Rat-race hybrids have four ports and do not require the isolation resistor. So, any one port out of four should be isolated or terminated in practical usage. However, the proposed baluns in Fig. 1(b) and (c) are 3-port devices which have the isolation resistor between output ports like Wilkinson dividers.

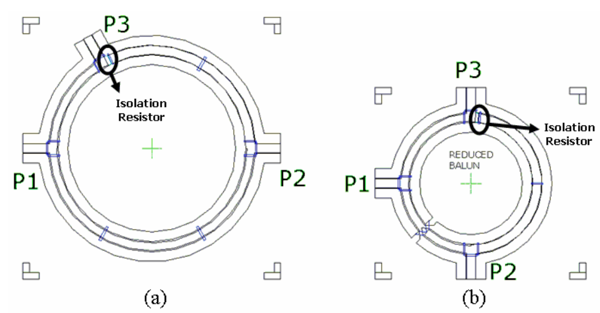


Fig. 5 Layouts of two baluns (a) before and (b) after size-reduction

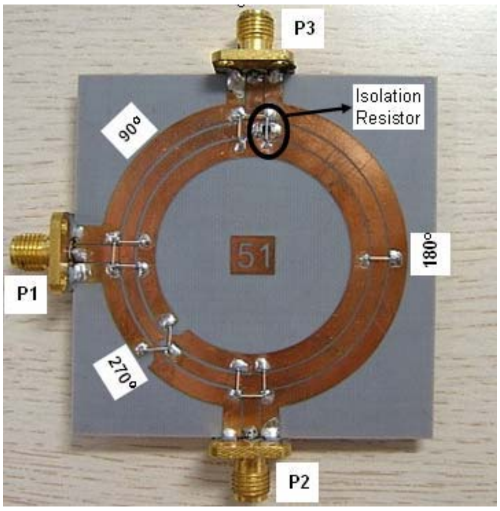


Fig. 6 Fabricated size-reduced CPW Wilkinson balun

Fig. 6 presents the photograph of the proposed balun. The simple air-bridge connections are used for the fast in-house fabrication. Three feeding sections are identical in order for their contribution such as electrical phase and loss to be the same. The characteristic impedance of two branches in Wilkinson structure is $\sqrt{2}Z_o$ while that of the additional 180o transmission line is Z_o. However in the design of conventional rat-race, the theoretical characteristic impedance of all transmission lines in the circle should be $\sqrt{2}Z_o$.

Fig. 7(a) and (b) show the measured S-parameters of the normal and size-reduced baluns, respectively. It is found that there is no critical cost in S-parameters in spite of size-reduction. To the contrary, the matching and isolation performances of the size-reduced balun are better than those of the normal balun. Additionally in Fig. 8(a) and (b), it is observed that the deviation from the ideal phase difference (180°) of the normal balun is more radical than the size-reduced balun. With the point of phase difference within 180°±10°, the bandwidths of the size-reduced and normal balun are 600 MHz and 300MHz, respectively.

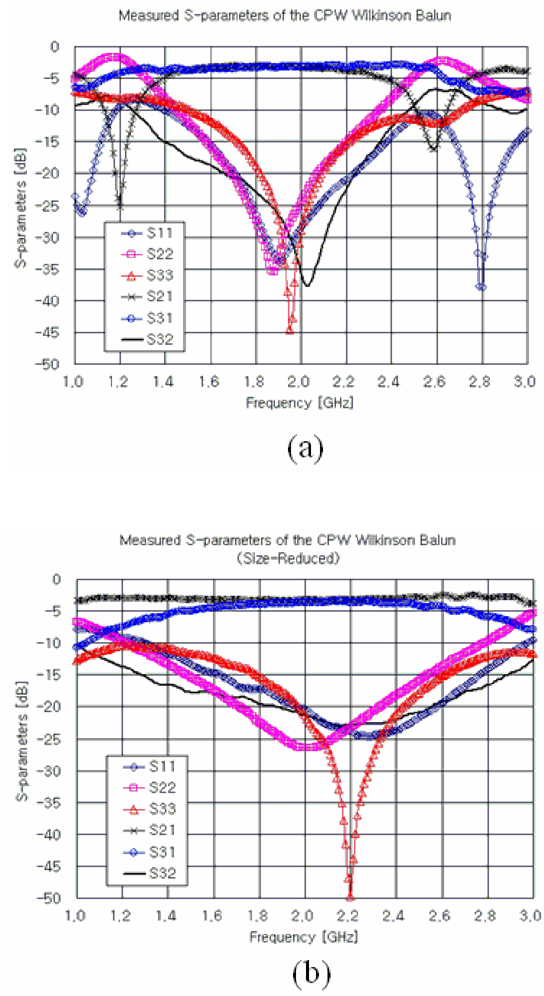
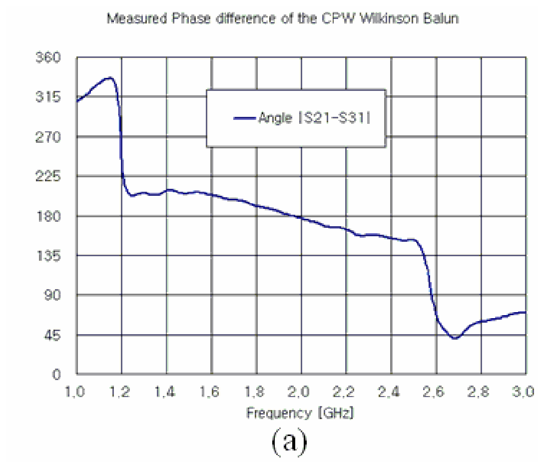


Fig. 7 The measured S-parameters (a) Normal size (b) Size-reduced



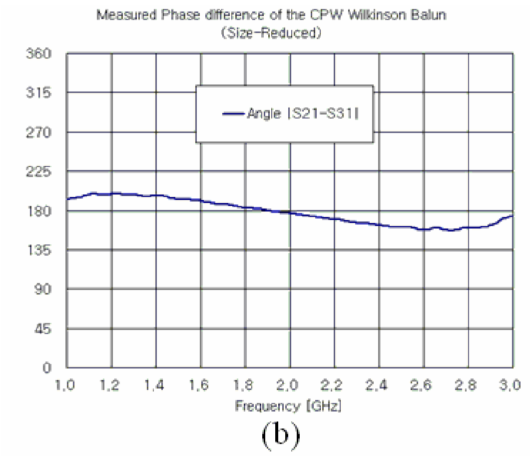


Fig. 8 The measured phase difference between output ports (a) Normal size (b) Size-reduced

IV. Conclusion

A size-reduced CPW Wilkinson balun having the "X"-crossing structure for 180^o phase inverting has been proposed. The size of the fabricated balun was only half of the normal one. The measured S-parameters and phase difference of the proposed balun were superior to the unreduced balun.

Acknowledgement

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References

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