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A 6 : 1 Unequal Wilkinson Power Divider with EBG CPW

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Power dividers are widely used in various microwave communications and high frequency applications. The standard 2-way Wilkinson divider has the equal power dividing ratio. However, if N>2 in 1:N unequal dividing ratio, a microstrip line having very high characteristic impedance is required. For instance, the 6:1 power divider requires a 207 Ω microstrip line, which is difficult to realize due to PCB process limitations, as shown in Fig. 1. In order to enhance the microstrip line impedance, it needs to employ a narrow microstrip trace that eventually leads to a reduction of its power handling capability and an increase of its insertion loss. Moreover, the narrow strip width cannot be easily fabricated in a conventional PCB process. Some studies have been reported to overcome this problem. The microstrip lines with the defected ground structure (DGS) patterns were proposed to increase the realizable line impedance by increasing the equivalent inductance. However, these methods are neither uniplanar nor truly one-dimensional (1-D) structures because their defected ground planes are on the backside of substrate. Moreover, the DGS patterns should be kept far from the other conductors of the ground plane. Thus, the design procedure is relatively complex, inducing a degraded manufacturing yield. To avoid these drawbacks, a fully integrated coplanar waveguide (CPW) with electromagnetic bandgap (EBG) structures for microwave integrated circuits was proposed to design a transmission line with high characteristic impedance. It is a pity that the design needs extra bonding wires in order to remove other modes, except for the CPW mode which requires extra cost and also suffers extra yield loss. In this work, a 6:1 unequal Wilkinson power divider that combines the advantages of a coplanar waveguide with an electromagnetic bandgap (EBG CPW) and microstrip line structures suitable for a PCB circuit design is proposed. The proposed EBG CPW structure with a wider strip width can accomplish high characteristic impedance. Furthermore, the proposed divider also performs true 1-D structures by incorporating the EBG CPW and microstrip line structures without any bonding wire.

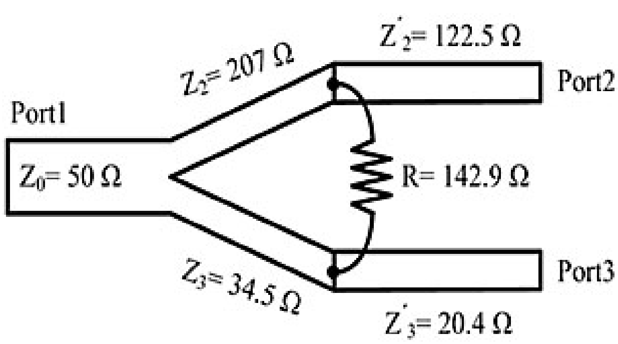

Figure 1. Topology of a 6:1 unequal Wilkinson power divider, including the required characteristic impedance, isolation resistor, and termination impedances.

The configuration of the proposed divider is illustrated in Fig. 2, which consists of the EBG CPW and microstrip line structures. The design concept of the circuit uses a CPW with EBG structures to realize the highly characteristic impedance of Z_2, and the ground planes can be connected to each other using via holes, thus avoiding the undesired waveguide modes generated. The EBG structure is symmetrically etched on both sides of the ground planes of the CPW. The characteristic impedance of the proposed EBG CPW structure can be evaluated by several design parameters as shown in Fig. 2, namely: 1) the rectangular region (h and b) and 2) the separation between the rectangle and the edge of the ground (d). The slot gap (g) is fixed. The characteristic impedance (Z_2) can be enhanced by increasing the rectangular region (h and b) and decreasing the separation between the rectangle and the edge of the ground (d). After calculating the maximum reflection coefficient (S_{11}) of the EBG CPW, the EBG CPW dimensions for a 207 Ω line could be found.

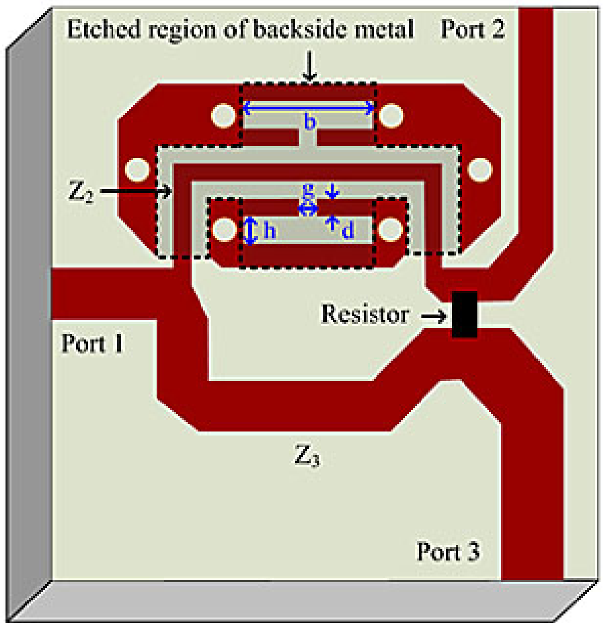

Figure 2. Schematic diagram of the proposed 6:1 unequal Wilkinson power divider.

To validate the design structure, a Rogers RT/Duroid 5880 with a relative permittivity of 2.2 and a 31 mil-thick substrate was used to implement the 6:1 unequal Wilkinson power divider at the center frequency of 1.5 GHz. The optimal dimensions are optimized using the Zeland IE3D EM software, which is considered to be a good simulator for microwave circuits, in order to obtain the exact dividing ratios. The final dimensions of the proposed EBG CPW structure are found and implemented as follows: g=0.3 mm, d=0.8 mm, b=13.7 mm, h=5.4 mm, G/W/G=2/0.55/2 mm, and length=38.4 mm. An isolation resistor equal to 150 Ω is selected instead of one equal to 142.9 Ω due to the unavailability of a precise resistor value. In addition, the fabricated conductor width of the 207 Ω transmission line was 0.55 mm, 0.085 mm for the conventional microstrip line, and 0.28 mm for the CPW in EM simulation. The simulated and measured results of insertion loss, isolation, and return loss are plotted in Figs. 3 and 4. From the measured results, the S_{21} and S_{31} are approximately 8.46 dB and 0.7 dB at 1.5 GHz, respectively. The measured isolation between port 2 and port 3 is also better than 38.6 dB. It shows that the two output ports have good isolation from each other. The measured return losses are better than 34 dB at 1.5 GHz.

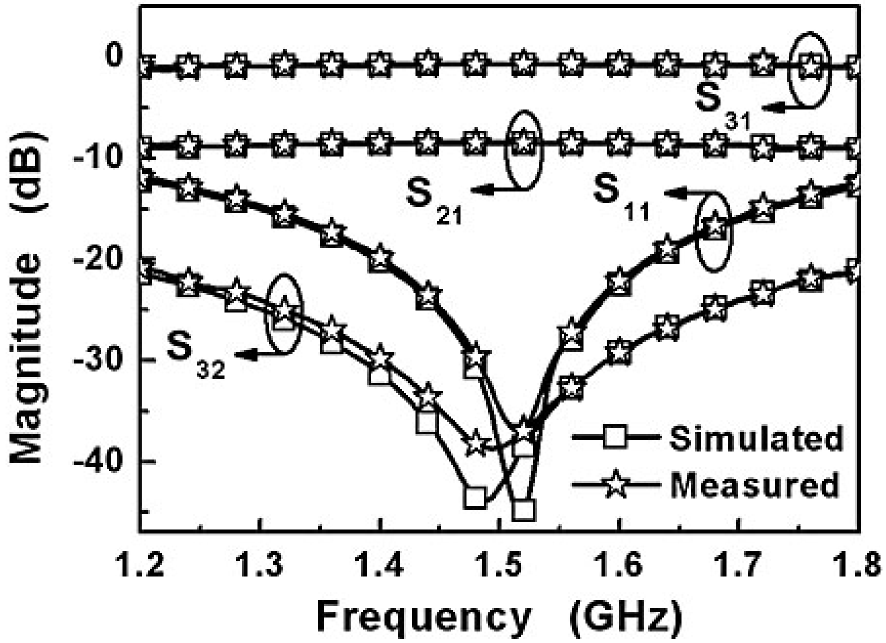

Figure 3. The simulated and measured results of the insertion loss, isolation, and input return loss as a function of frequency.

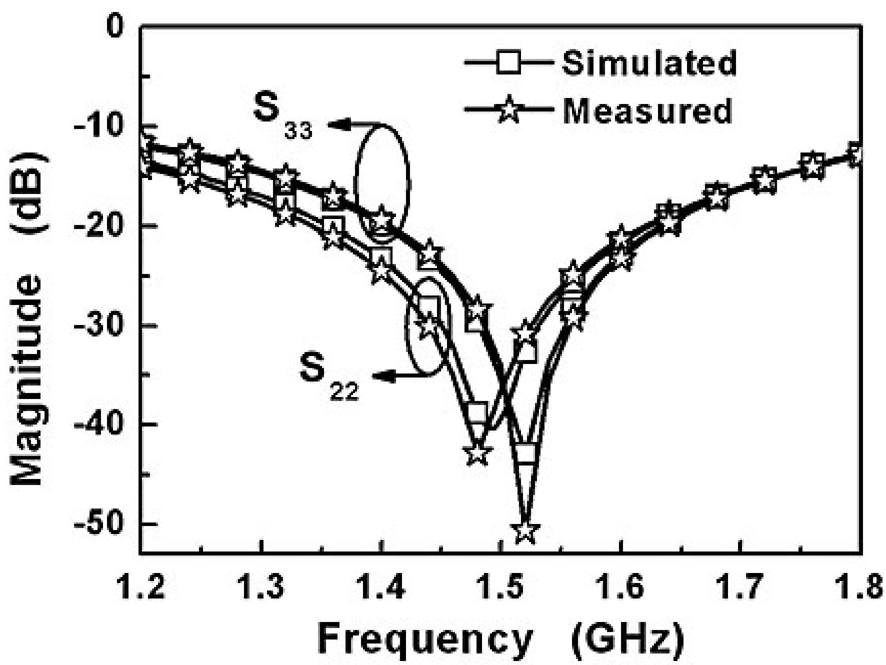

Figure 4. The simulated and measured results of the output return loss as a function of frequency.

In summary, a 6:1 unequal Wilkinson power divider with EBG CPW structure has been proposed and implemented. The proposed EBG CPW structure eliminates the main difficulty of a narrow strip width of a 6:1 unequal power divider. The proposed EBG structure enabled the CPW with very high characteristic impedance to be easily designed on PCB without using the backside patterns and extra bonding wires. On the other hand, additional processes are not needed when using the proposed structures. The proposed technique can be widely used in many RF and microwave circuits to provide more desirable flexibility.