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Research, design and fabrication of a high-power combiner using Wilkinson bridge of L-band

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Abstract. In this paper, we are dealing with a L-band power combiner method using the Wilkinson bridge. This is a modern power combination technique in the microwave technology. The design and simulink of the basic power moduls and Wilkinson bridge were performed using the ADS soflware. We have researched, designed and fabricated the power combination from the basic 200W moduls. The experimental results showed that power combination method using the Wilkinson bridge may be applicable in the L-band transmission.

Keyword: Microware, Wilkinson, power combination….

1. Introduction

The assemble of the L-band high-power amplifier is usually difficult, therefore the search for the power combination methods is important. The power combination method using the Wilkinson bridge is one of methods that have been taken into account. We have studied and aplied this method for combining power from the basic modules. Wilkinson power divider was proposed by E. J. Wilkinson [1], as a method of distributing power to attain equiphase and equiamplitude condition.

2. Theories

The Wilkinson power divider can use as combiner or divider. It is a simple power divider cannot simultaneously have all the properties of lossless, reciprocal, and matched. Hence, the Wilkinson power divider was developed. Here, an isolation resistor is placed between the output ports to help achieve the properties. Dissipation of energy occurs only in isolation resistor when signal enters the network from any output port. However, it should not affect Wilkinson network efficiency. Besides, this isolation resistor provides perfect isolation to protect output ports at the operating frequency.

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Generally, Wilkinson power divider can have any number of output ports. A basic three port Wilkinson power divider of port characteristic impedance Z_0 is schematically shown in Figure 1.

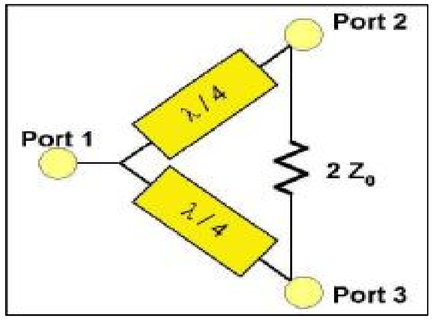


Fig. 1. Schematic diagram of aWilkinson power divider [1].

This is a such network that the lossless and resistive T-junction power dividers have no isolation between the outputs of port 2 and port 3, and the lossless divider is not matched at all ports, and the resistive power divider is lossy. The Wilkinson power divider has all ports matched and has isolation between output ports, but is lossy [1]. The Wilkinson power divider is a 3-port device with a scattering matrix of:

$$\bar{\bar{S}} = \begin{bmatrix} 0 & -j/\sqrt{2} & -j/\sqrt{2} \\ -j/\sqrt{2} & 0 & 0 \\ -j/\sqrt{2} & 0 & 0 \end{bmatrix} \tag{1}$$

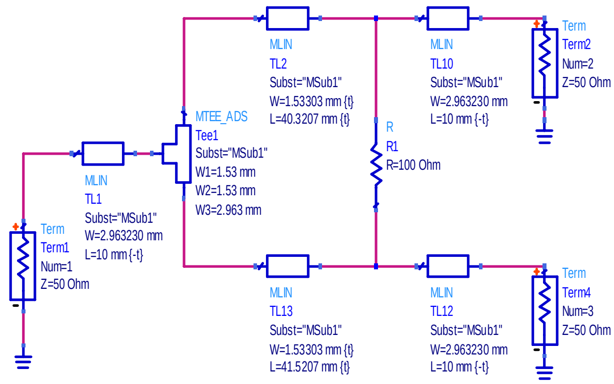
Note this device is matched at port 1 ($S_{11} = 0$), and we find that magnitude of column 1 is:

$$|S_{11}|^2 + |S_{21}|^2 + |S_{31}|^2 = 1 \tag{2}$$

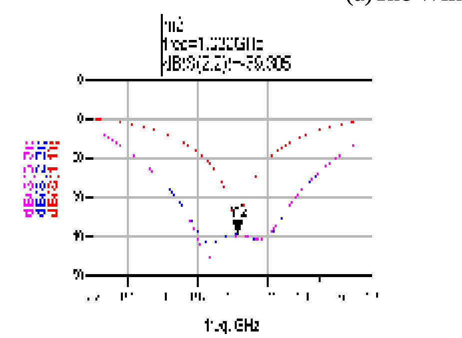
Thus, just like the lossless divider the incident power on port 1 is evenly and efficiently divided between the outputs of port 2 and port 3. But now look closer at the scattering matrix. We also note that the ports 2 and 3 of this device are matched. It looks a lot like a lossless 3dB divider, only with an additional resistor between ports 2 and 3 .

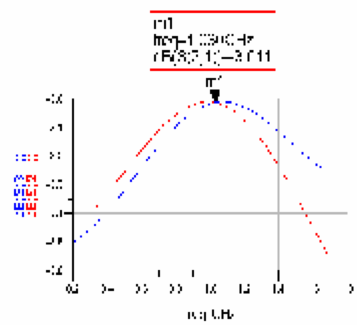
3. Design Wilkinson power divider

We simulate the Wilkinson brigde by ADS solfware (figure 2a), the frequency of transmission signal is 1030 MHz, we retrieve the S-matrix parameter magnitudes depicted in Figure 2b, 2c. The 1030 MHz frequency was studied because this frequency will application in our the next reseach for design and fabrication of a transmitter system for the phase identification code.



(a)The Wilkinson by ADS solfware





(b) S parameter magnitude

(c) S parameter magnitude

Fig. 2. The semulink results.

Base on Wilkinson brigde methods, we propose a combination methods from the medium power modul and the small power modul (Figure 3).

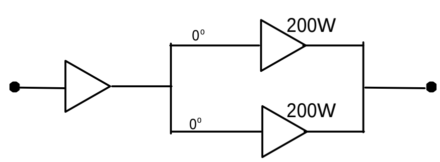
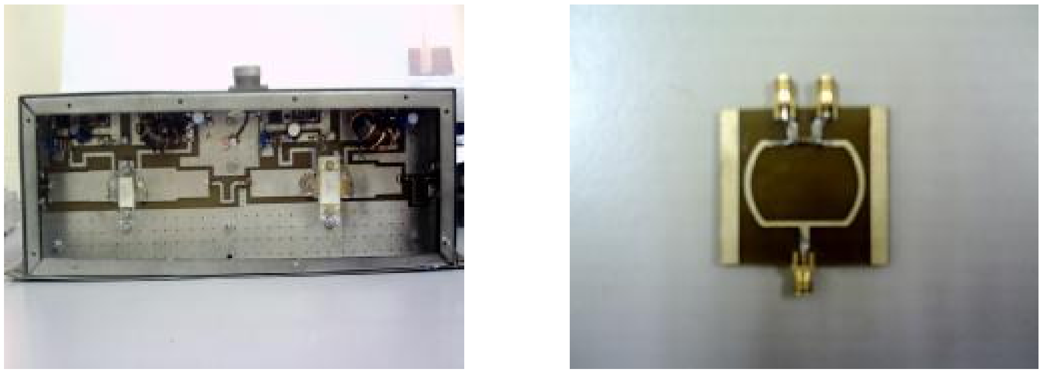


Fig. 3. The power combining use Wilkinson brigde.

4. Experiments result

We have designed and fabricated the 200W amplifier modules from the smaller ones. The basic modules were designed by using the microtrip technology [4], which are small and portable (figure 4a). After simulink modelling, the Wilkinson bridge was designed using the modern accurate circuit imprint technology [2,3](figure 4b)



(a) (b)

Fig. 4. The 200W power amplifier (a) The Wilkinson bridge (b).

From the basic amplifier moduls and Wilkinson bridge divider we have fabricated the high-power combination circuit as illustrated in figure5.

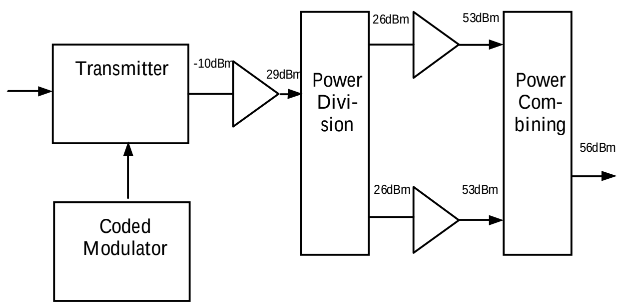
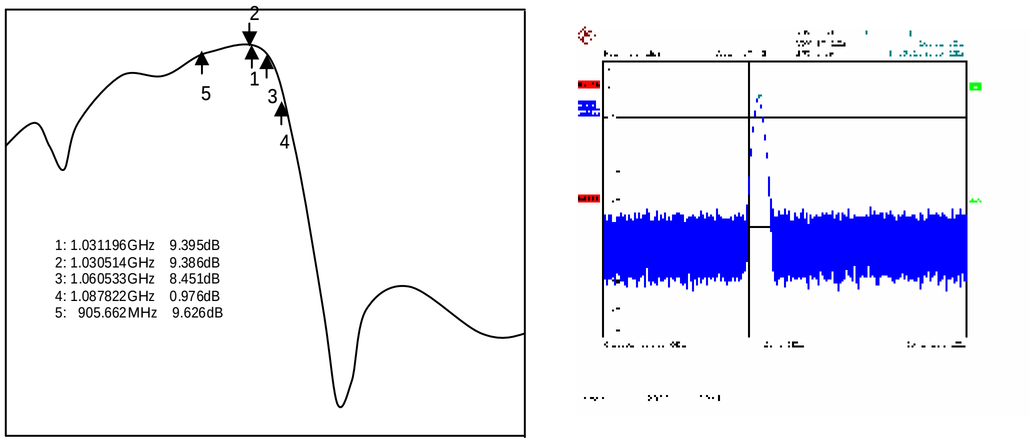


Fig. 5. The integration of the frequency combination circuit.

The amplifier modules were carefully checked to assure the compatibility so that the risk of malfuction after the integration is minimal. Observing the working of the 200W amplifier by the network analyzer (Rolde & Schwarz ESPI, 9 KHz-3GHz, test receiver), we revealed that the band-width was quite wide and the amplifying coefficient has achieved the high value within the frequency range 905MHz-1060MHz (Fig. 6a)[4]. The signal at 1030 MHz was inputed into the amplifying module and observed on the spectrum analyzer (Advantest R3765CG (300 KHz-3.8 GHz)), the result showed that at 1030 MHz the amplifying coefficient reached high value, the input amplitude was set at -10dB and the output one was above 16dB. The adjustment of current regime may increase the amplifying coefficient even more. We have also investigated the S_{11} factor of the power divider Wilkinson on network analyzer, the result was relatively similar to that of the simulink model.

Afterthat we have measured the characteristics of the power combiner using the Winkinson bridge. The input amplitude from the generator was set at -10dB and was directed to the amplifier module before the divider. This power amplifier was composed from the three modules having the power 1W, 45W and 200W. The output amplitude reached 29dB. The signal was then transmitted to the divider, the two outputs also reached 26dB and were synchronized. The outputs were inputed to the 200W amplifier modules. These modules were set to work in the AB regime with amplifying coefficient G=27 and the output amplitude reached 53dB. Afterthat we utilized the Wilkinson bridge to combine the two output signals. The final amplitude was 56dB when measured with the Watt Meter Model 43-S/N286070



(a) (b)

Fig. 6. (a) The frequency characteristics; (b) Spectrum at 1030MHz.

5. Conclusion

We have designed, successfully fabricated and tested the power combination unit using the Wilkinson bridge. The experimental results demonstrated the efficiency of this method in manufacturing the larger modules from the smaller ones and we anticipate to applicate this method for raising the output power in near future.

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