Sonnet Modeling and Simulation of Wilkinson Power Divider with OhmegaPly Resistor

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Abstract: The power division is one of the main design problems in feeders used for distributing the microwave energy in transmit - receive modules. As a usual solution, various configurations of power dividers are used with different types of modifications compared to the basic one. One of these approaches is studied in this paper where the main emphasis is on the use of the lossy planar geometry acting as a resistor. This resistor is implemented as a thin layer placed between the copper and the substrate. The aim of the high resistive layer is to avoid the use of discrete resistor, and in that way to make the circuitry construction simpler. Also, the assembly and reliability issues of the component are reduced with this approach. The modeling of this type of Wilkinson divider is done in SONNET®.

Keywords: Wilkinson Power Divider, OhmegaPly Resistor, Resistive Layer

1. Introduction

In the field of microwave engineering, in order to divide input signal into two output copies [2], a special class of power dividers is being used, called the Wilkinson power divider. This device is capable of isolating its output ports [1] as well as preventing interference between external devices connected to these ports (e.g. antenna). Also, this is done so that mismatches and reflected signals from a port do not propagate through the system [2]. Typical solution used for solving the isolation problem on the outputs involves the use of a resistor placed between the output legs. Even though this solution is quite simple, the presence of the resistor parasitics makes the design process cumbersome to a certain extent. The higher the resistivity of the resistor used, the bigger is the parasitic effect. On the other hand, use of smaller resistors in high frequency applications increases coupling between quarter - wave arms again adding to the difficulty of the design process [2].

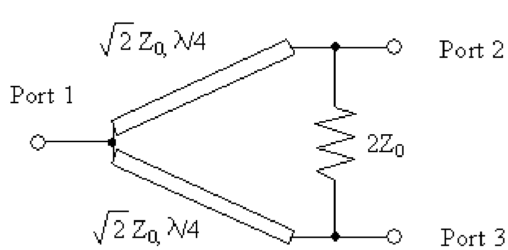

Fig. 1. Traditional 1-section 1-chip Wilkinson divider design.

This paper presents the method to overcome the problems described above. As a solution, a high resistive layer is introduced between the output ports. This layer is merged between the copper and the dielectric layer in the substrate and acts as a resistor.

2. Resistive Layer

The demand for making smaller and more compact Wilkinson power dividers pushed research in the direction of new high resistive materials that could be used as resistors in the circuit design. It has been shown that polytetrafluoroethylene (PTFE) based materials have the best electrical performance for high frequency applications. However, there still exist issues related to the limitations in the production process [3]. Combination of PTFE and ceramic filler, solved many of these circuit fabrication issues. As a result of this research, new materials have been commercialized, such as RT/duroid® 6002 material [3].

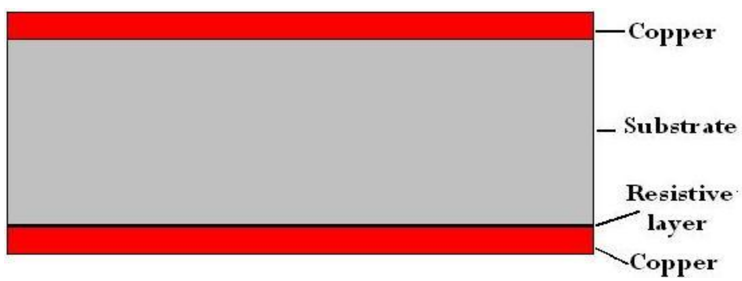

Fig. 2. Cross-sectional view of a substrate material using a copper in-plane resistive layer [3].

The new, improved substrate, RT/duroid 6202PR created by the same manufacturer is a material that, also, incorporates resistive foils [3]. These so-called OhmegaPly resistive layers improved production of in-plane resistors. When it comes to the production of the Wilkinson power divider with this kind of resistors, the part of resistive layer that is not used is being removed, so that only high resistive material which is being left is the one between output ports, and it runs under the copper sheet. Electromagnetic effects of OhmegaPly under copper can be neglected as the current is mostly concentrated in the copper layer.

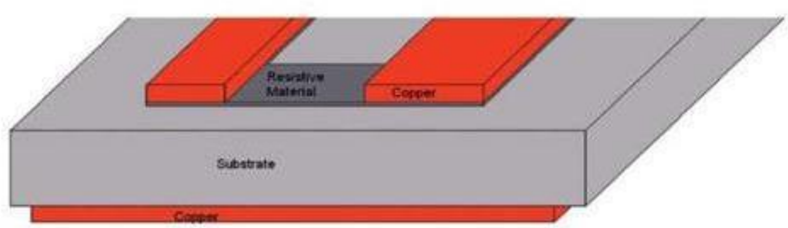

Fig. 3. Resistive material between two conductor [3].

The typical values of resistivity in commercial products are 25, 50 and 100 ohm/square. However, there are several dependencies to be mentioned here. One is the physical size of the resistor. A larger resistor will typically have much better resistance tolerance control. In recent studies, there have been extremely good results achieved with medium to large resistors and good results with relatively small resistors. As a benefit, the stability of this approach is also to be mentioned [3]. When a printed circuit board (PCB) becomes more complex, dimensional stability of the laminate will play a major role in how the various circuit layers can be aligned. In order to optimize the RT/duroid 6202PR substrate for planar resistor applications, many resources were applied to ensure that the dimensional stability of this laminate is stable.

3. Circuit Design

Using SONNET®, v12.56, the Wilkinson power divider with OhmegaPly resistor has been modeled. The circuit is realized in stripline techology using RO6002 substrate (2x30 mils). The frequency range is 1-3 Ghz. For this design, we have firstly used the divider without resistor in order to compare configuration with results of the simulation where it is used, and to be able to see the differences which are caused by the presence of OhmegaPly resistor.

When it comes to design of the power divider which has a resistive element between the output ports, after setting appropriate physical lengths and widths (impedance dependable), some modifications had to be done. Since OhmegaPly technology is not embedded in SONNET, we had to add a new metal type which will have the same functionality as OhmegaPly. The main problem with OhmegaPly is related to the tolerances in resistivity [Ohm/square] therefore, in order to make the design more robust, larger sizes of the resistive elements have been used.

4. Simulation and Results

After the circuit modeling has been completed, the next step was the analysis of the divider model created in SONNET. This section presents the results of the SONNET simulations. The first analysis was done based on the divider without the resistors. The results are shown in Figure 4. As can be observed, this design is characterized by a poor isolation performance due to the absence of the resistors.

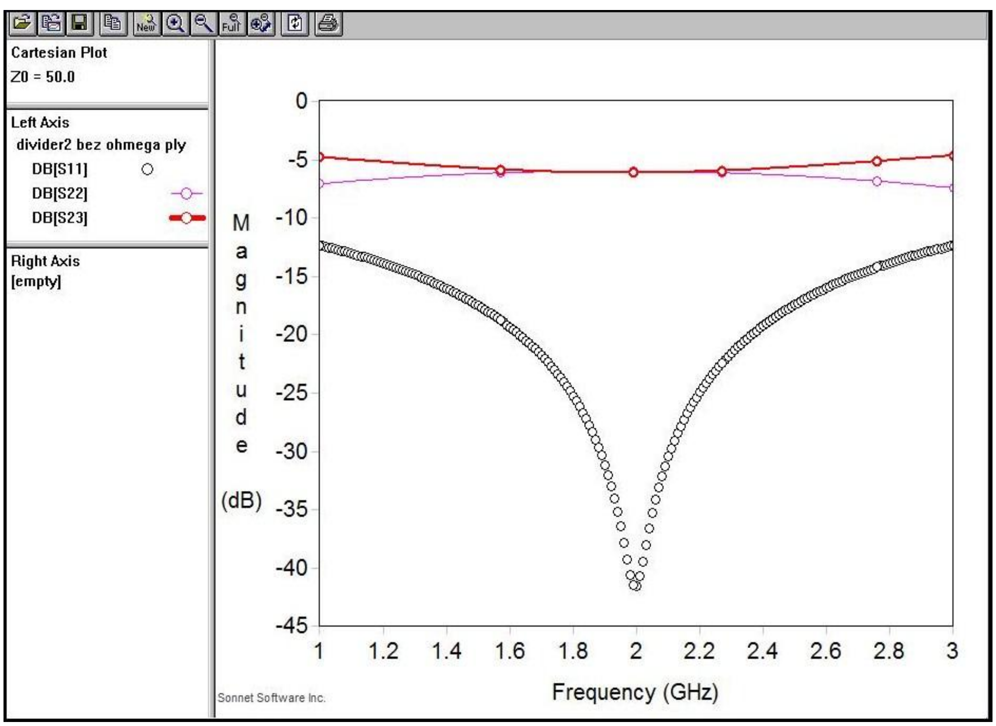

Fig. 4. S parameters (S11-input return loss, S22-output return loss, S23-isolation).

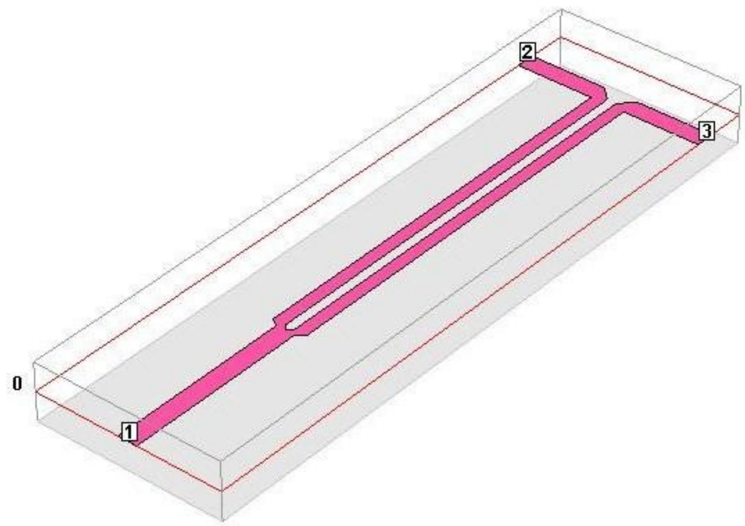

Fig. 5. 3D model without resistor.

Simulation of the divider with resistive element between the output ports shows a significantly better performance of the divider, especially when it comes to the isolation and output return loss. As seen in Figure 6, isolation which was previously -6dB (no resistor) improved to -45dB (presence of the resistor). Values similar to these apply to the output return loss as well.

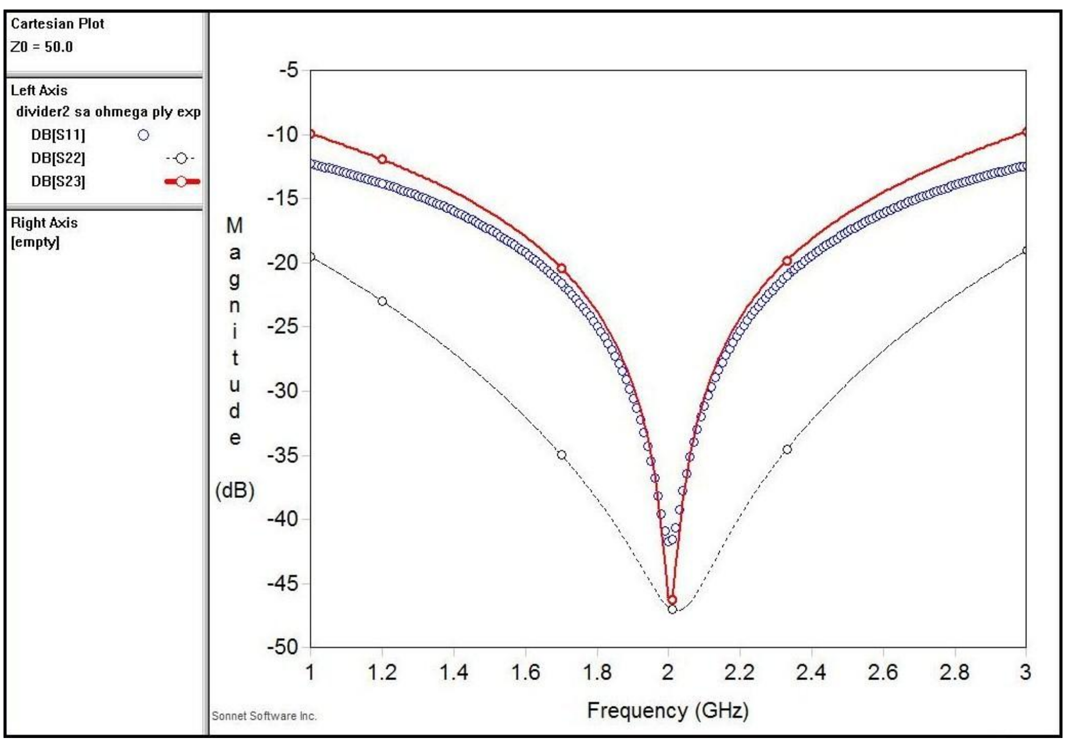

Fig. 6. S parameters (S11-input return loss, S22-output return loss, S23-isolation).

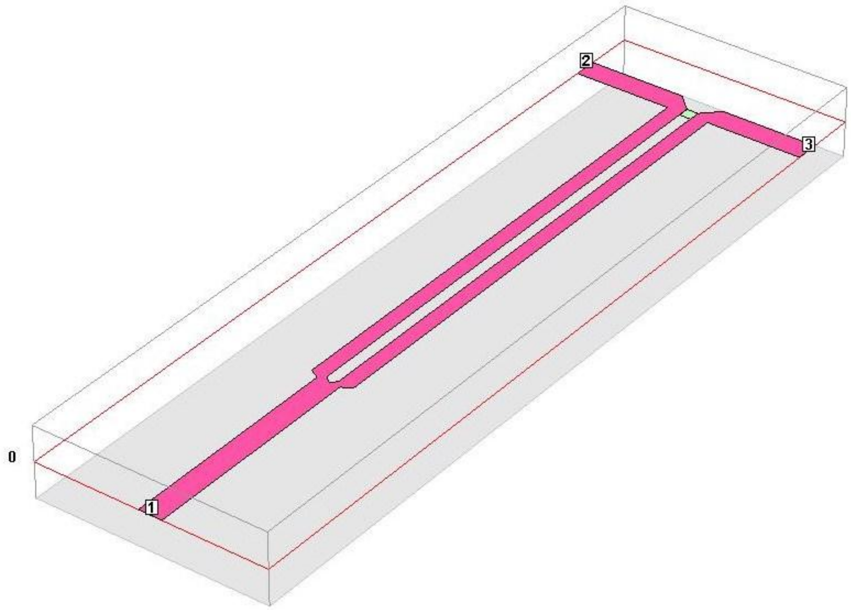

Fig. 7. 3D model with resistive element between the output ports.

5. Conclusion

This paper presents implementation of the Wilkinson power divider with OhmegaPly resistive elements. This type of resistor is formed by a thin and highly resistive layer placed between the copper and the substrate. This resistive layer acts as a lossy transmission line. One of the aims of this project is to compare the results of the divider without resistors to the one which uses resistive material. The paper also presents the tolerance analysis of the divider performance that takes into account the etch tolerances of the OhmegPly resistive element. This paper therefore gives basic directions to RF engineers on how to successfully use SONNET Suite to design, simulate, and optimize Wilkinson power dividers with OhmegaPly resistive elements.

References

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