20 dB Hybrid Stripline Coupler

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Abstract: Stripline couplers are widely used in communication systems due to their cost effective and easy fabrication features [1]. In this work a 20dB 90º hybrid stripline coupler is designed. Hybrid means, a 4-port device which seperates the input signal into two output ports and isolates the 4th port. If there is a 90º phase difference between the through and the coupling ports, the coupler is named as 90º hybrid. The design is simulated by an electromagnetic simulation program called Sonnet software [2]. The results taken from Sonnet are presented as; current distribution, smith chart and S-parameters.

Keywords: Coupler, stripline, 90º hybrid, 20dB.

1. Introduction

According to the frequencies and modulation methods that are used on some circuits, microstrip lines are used as one layer or more than one layer [3]. Furthermore they are commonly used because one can implement empedance matching circuits, narrow or wide band filters, power dividers, directional couplers and passive RLC components with these unique curcuits [4]. In Figure 1, electric field vectors are shown for different type of circuits in cross section view. Electric field is captivated inside due to the outer conductor except for the two-wire line and the microstrip line. For example, in coaxial line, there is no electromagnetic leaking to the outside and no coupling from the outside since the energy is transmitted between the inner and the outer conductors. That's why those are named as "shielded transmission lines". On the contrary, microstrip lines are exposed to leaking and coupling [1]. Stripline technique has some advantages such as design easiness but, also has some drawbacks such as fabrication losses. Especially broadside-coupled stripline structures have some restrictions about lamination thickness so that after fabrication sensitivity is important on tight couplers, such as 3-dB couplers. In this work, edge-coupled stripline structure is used, since designed coupler is not a tight coupler.

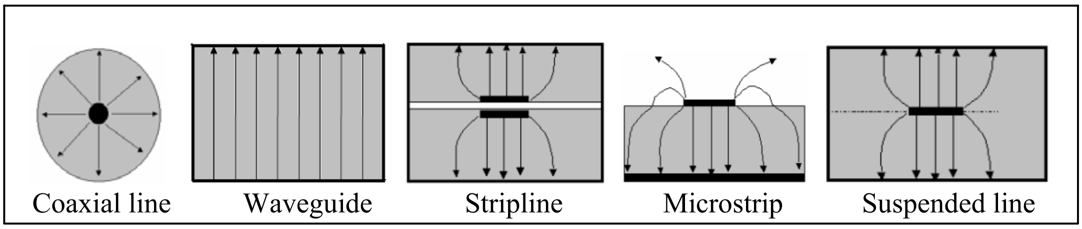

Fig. 1. Various transmission line cross sections.

2. Design of the coupler

Couplers are mostly used for seperating the incident wave and the reflected wave in a transmission line. For example, in Figure 2, there is backward wave coupler. When it is excited from Port 1, port 2 is the coupling port, port 4 is the thru port and the port 3 is the isolation port. In an ideal coupler, most of the incident power is divided between the coupling and the thru port and there is no power reflected back to the incident port and transmitted to the isolated port. In another saying, ideal coupler is lossless, reciprocal and matched 4-port device, and the S-parameters are shown in equation 1 below;

$$S = \begin{bmatrix} 0 & S_{12} & 0 & S_{14} \\ S_{21} & 0 & S_{23} & 0 \\ 0 & S_{32} & 0 & S_{34} \\ S_{41} & 0 & S_{43} & 0 \end{bmatrix} \qquad (1)$$

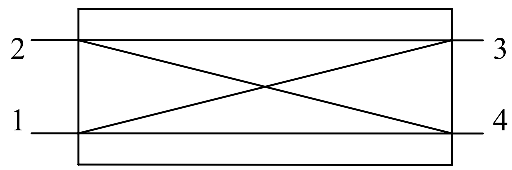

Fig. 2. Directional Coupler

Some of the parameters are "zero" because of the reflections and the isolation. Coupler is defined with 2 parameters; coupling and directivity. They can be formulized as;

$$\text{Coupling (dB)} = 10\log(\text{Pi} / \text{Pc}) \qquad (2)$$

$$\text{Directivity (dB)} = 10\log(\text{Pc} / \text{Pd}) \qquad (3)$$

where

Pi = Input port power
Pc = Coupled port power
Pd = Decoupled ''isolated'' port power.

Coupling is a measure of how much of incident power is being sampled at the coupling port and directivity is a measure of how well the coupler distinguishes between forward and the backward traveling waves [5].

3. Simulation Results

In this work, main purpose is to design and simulate a 20 dB stripline 90º hybrid coupler. As an electromagnetic simulation program, Sonnet software is used. Discontinuities on the transmission lines ensures less power to the isolated port. Since this is not a tight coupler, edge-coupling technique is being used. Port 2 and port 4 are on the other side of the wall according to the port 1 and port 3 because of the fabrication easiness. Figure 3 has the top view and Figure 4 shows the 3 dimensional view of the coupler.

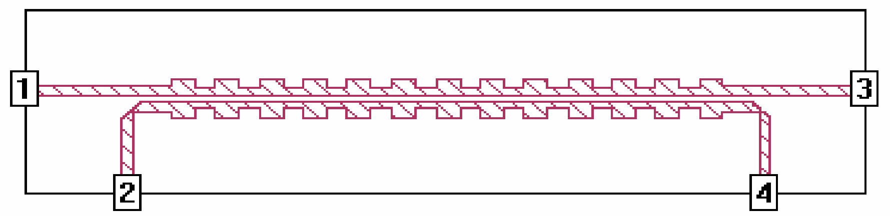

Fig. 3. Top view of the Coupler

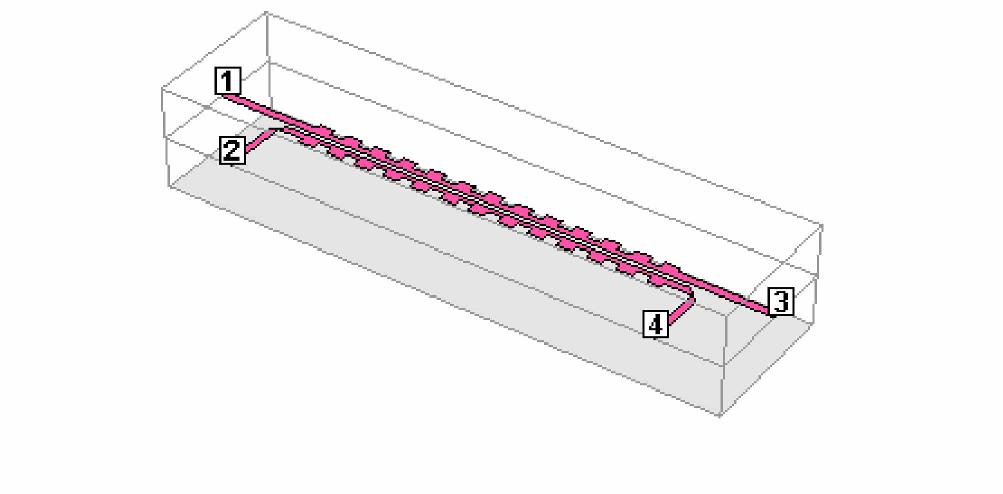

Fig. 4. 3D view of the Coupler

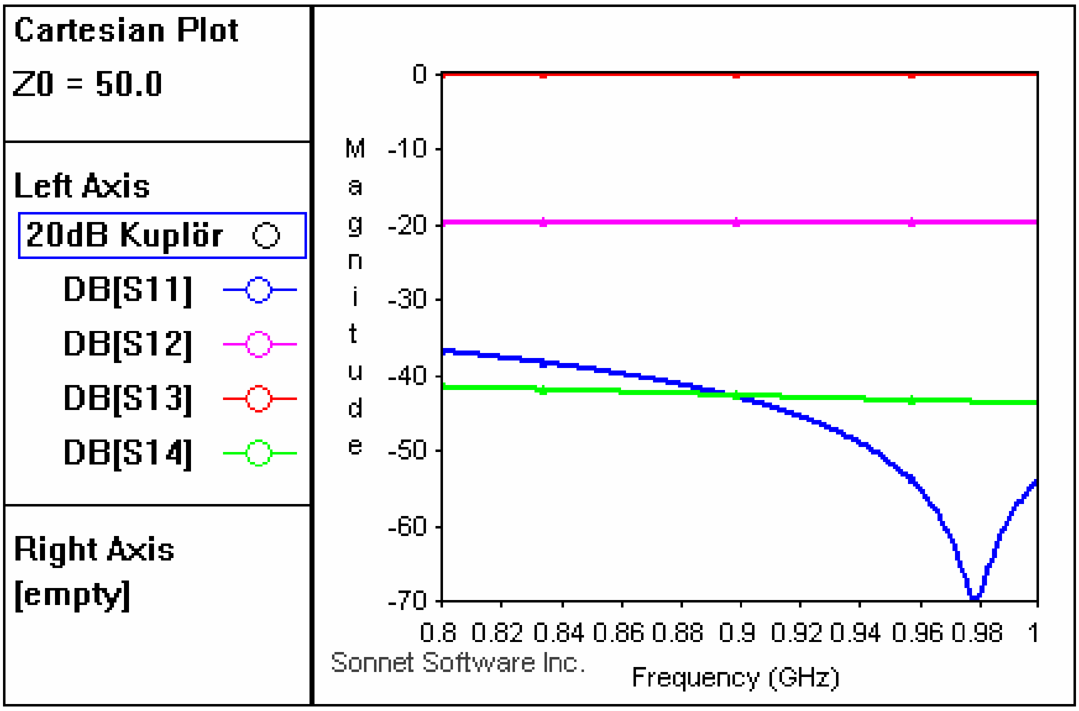

Fig. 5. S-parameters of the Coupler

It is clearly seen in Figure 4 that, coupling is exactly -20 dB, thru port is < −1dB and the isolation is < − 41 dB. Input reflection coefficient is better than −37 db in the beginning but decreases to − 70 dB at the end of the frequency band.

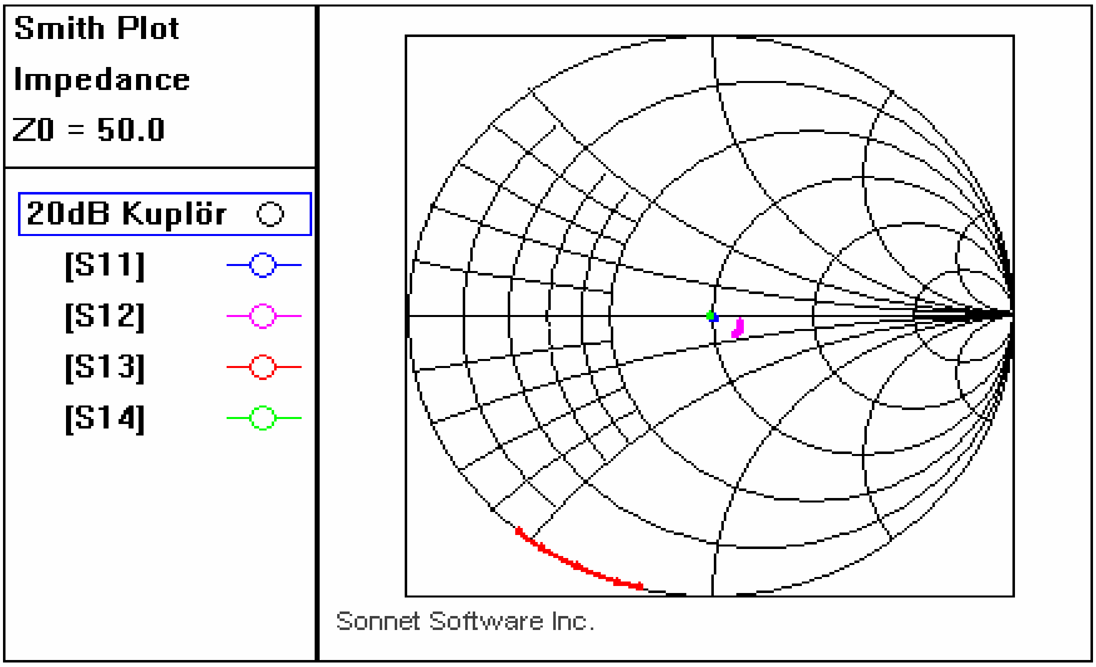

Fig. 6. S-parameters on the Smith Chart

Figure 6 shows that, input reflection coefficient (S11) and isolation (S14) are almost at the center of the smith chart as expected.

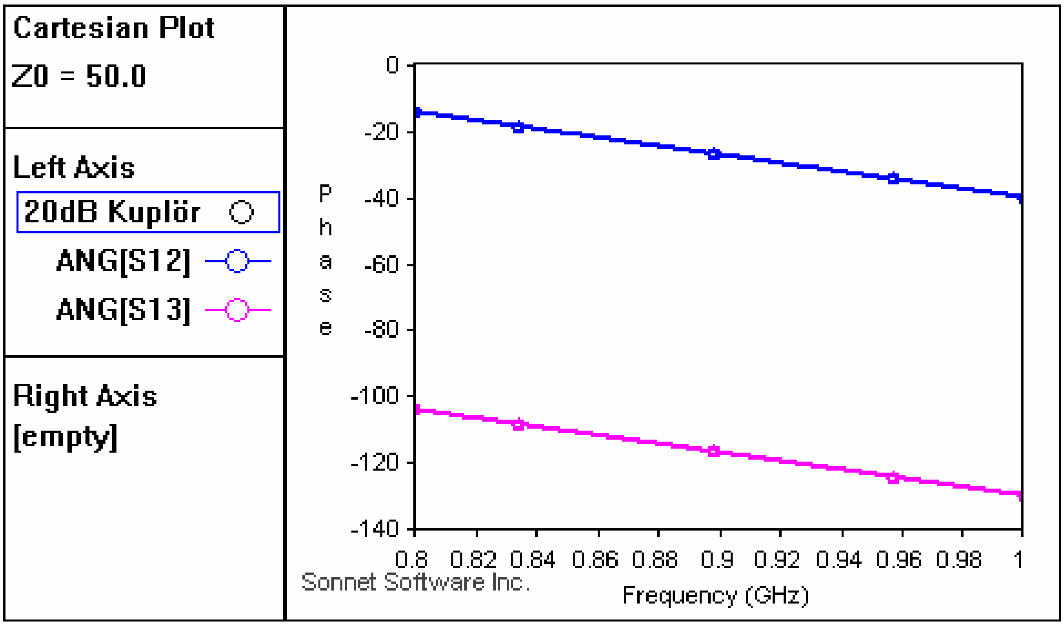

Fig. 7. Phase difference between the coupled and thru ports

The phase difference is 90º through the frequency band as it is seen on Figure 7.

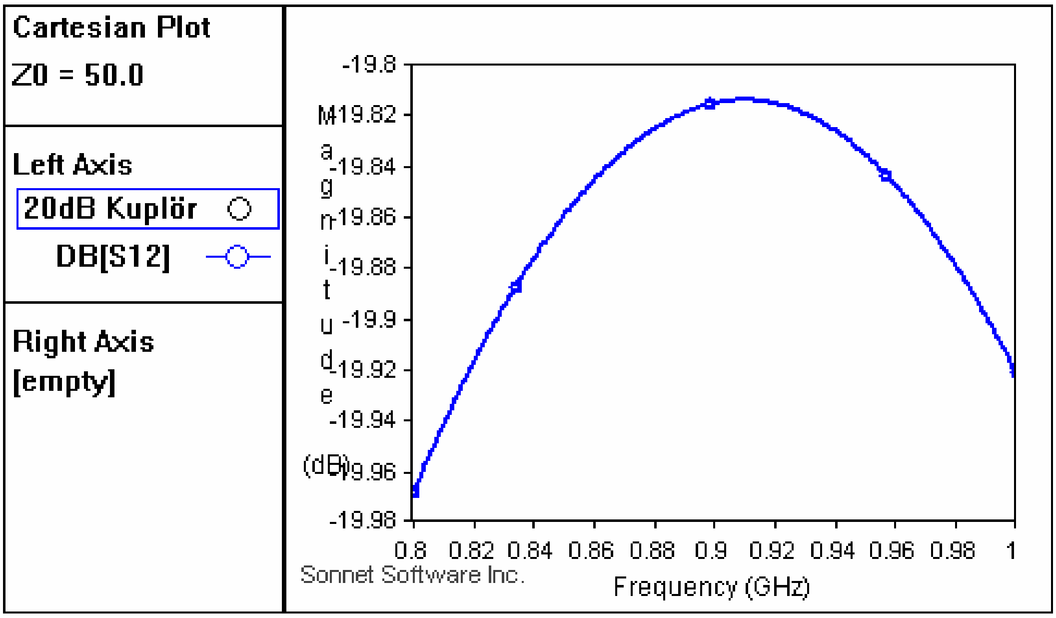

Fig. 8. Amplitude Balance of coupling port.

Figure 8 is a close-up on coupling port. It shows the amplitude balance of the coupling, which is 0.2 dB.

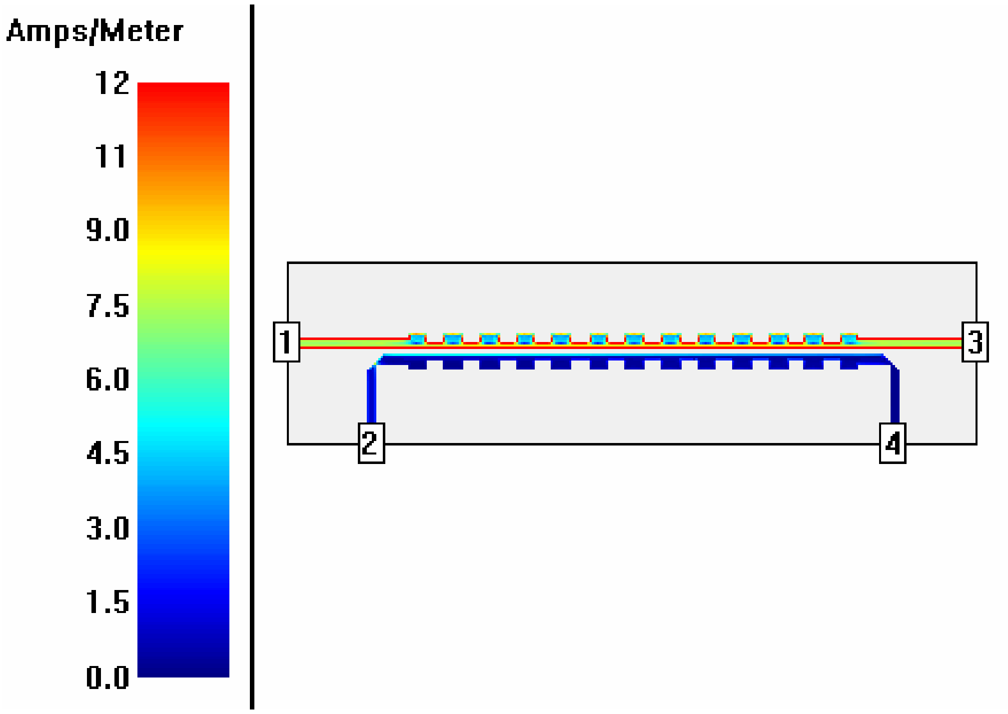

Fig. 9. Current distribution on the coupler

Current distribution on Figure 9 clearly shows that current is crowded on the main line (between 1 and 3) and almost no current goes to the isolation port(4), but less power goes to the coupled port(2).

7. Conclusions

In this work a 20dB 90º hybrid stripline coupler is designed and simulated. According to the simulation results of Sonnet software, all results are satisfactory. Design started with a little error (a slight deviation from 20 dB at first) but, after reducing the cell size and the distance between the lines an exact value of 20 dB coupling is achieved.

8. Acknowledgments

Special thanks are due for Greg Alton from Sonnet software who has promptly issued licenses for Haliç University.

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