# 3 dB Hybrid Coupler

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**Abstract:** In this work a 3dB stripline broadside coupler is designed and simulated. Various combinations were tried and final geometry is simulated with a 3-D planar electromagnetic simulation software, Sonnet Suites [1]. Simulation results are satisfactory and presented detaily in figures. The coupler can be used in some of L-band and S-band applications.

**Keywords:** Coupler, Stripline, 3dB, broadside.

## 1. Introduction

Recently, the demands for high frequency and broadside transmission are increased. To satisfy these market demands, the concern of passive microwave elements with small size and high performance is also increasing. In order to achieve the splitting, combining and phase-shifting of microwave, it costs many efforts and time for the development of microwave devices, such as hybrid couplers. In addition, the system working at microwave band requires low-profile, compact, low-loss devices, and advanced packaging technology [2]. There are several 3dB couplers in literature. Some of them are ring type and microstrip, some of them are similar to the design in this work [3]. This technology can be applied to construct highly integrated in the WiFi/WiMAX RF applications in order to save valuable PCB space[4]. Directional couplers are key components in many wireless communication systems for realizing components such as baluns, balanced mixers, balanced amplifiers, power dividers and butler matrices [5-9].

## 2. Simulation Results

In this work, the main purpose was to design and simulate a 3 dB stripline coupler. In this desing, high performance (The isolation is more than 16dB; the amplitude balance is ±0.8dB; the phase differance is 90°) and small size (1.07cm× 2.53cm× 0.16cm) are achieved within 2.3-4.3GHz frequency band. A stripline broadside coupled lines are used to design a 3dB hybrid coupler. The dielectric heights are 30-5.2-30 mils. Dielectric constant is 2, dielectric name is Rogers RT6002. Figure 1 shows the top view of the coupler. Figure 2 has the 3-D view. Figure 3 and 4 has the S-parameter data.

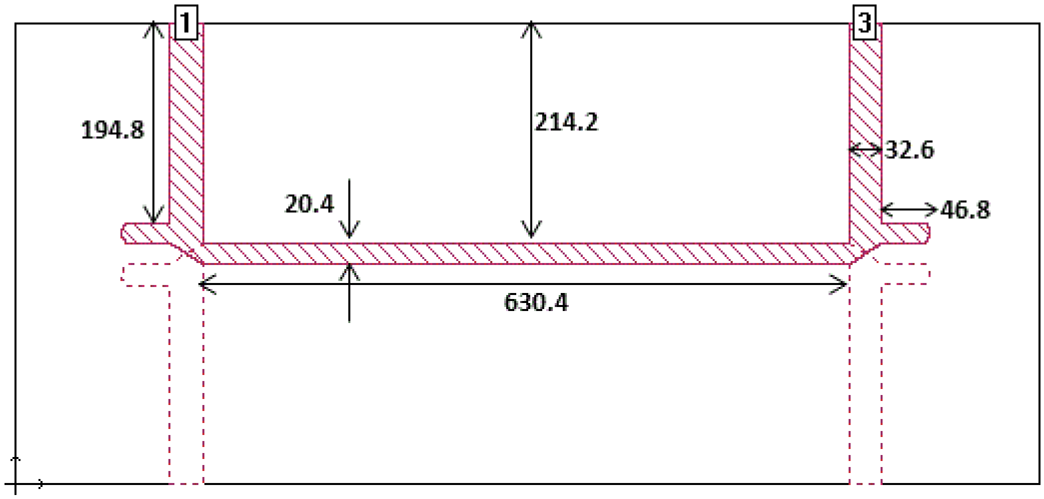


Fig. 1. Top view and dimensions of the coupler (mils).

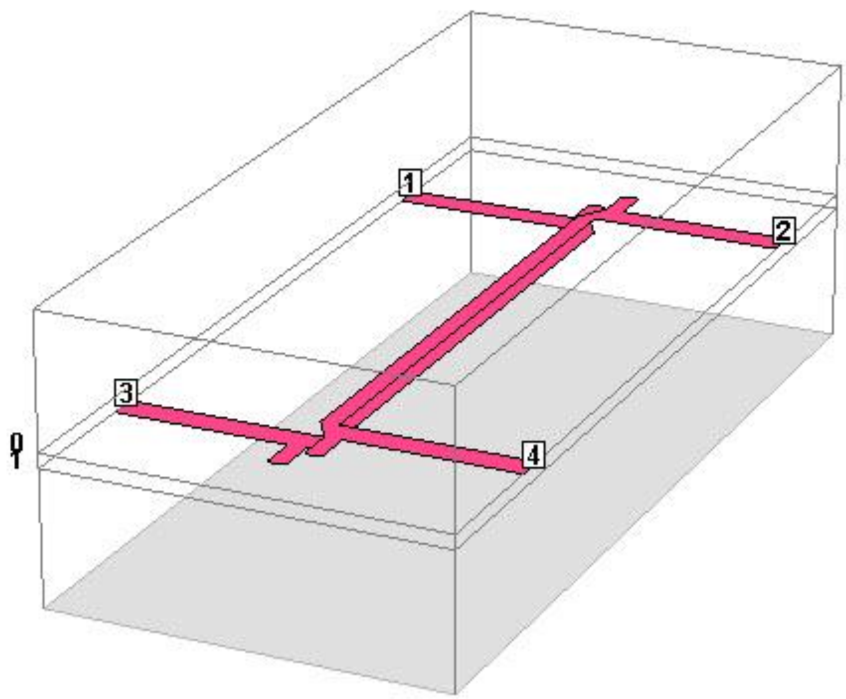


Fig. 2. 3-D view of the Coupler.

Figure 3 shows that coupling and thru ports are -3.16 dB and -3.25 dB at the start and the stop bands, respectively. The isolation and the return losses are almost -18 dB and -16 dB at the start and the stop bands.

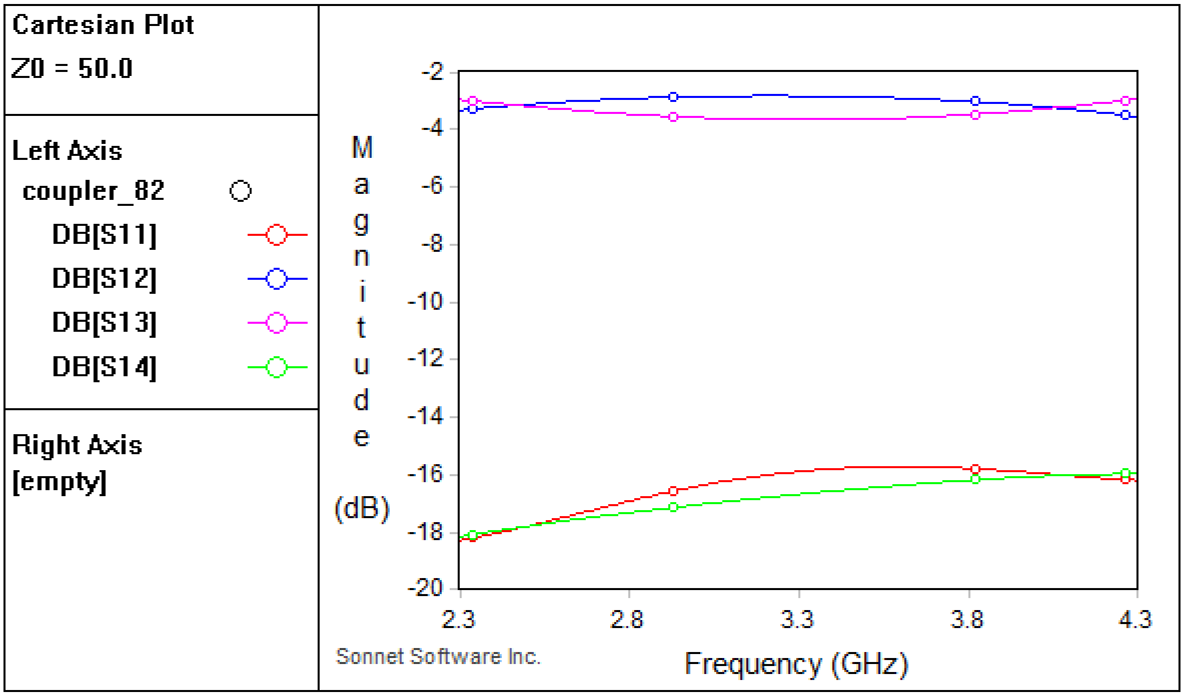


Fig. 3. S-parameters of the Coupler.

Figure 4 is a close-up on coupling and the through ports. It shows the amplitude balance of the coupling is 0.8 dB.

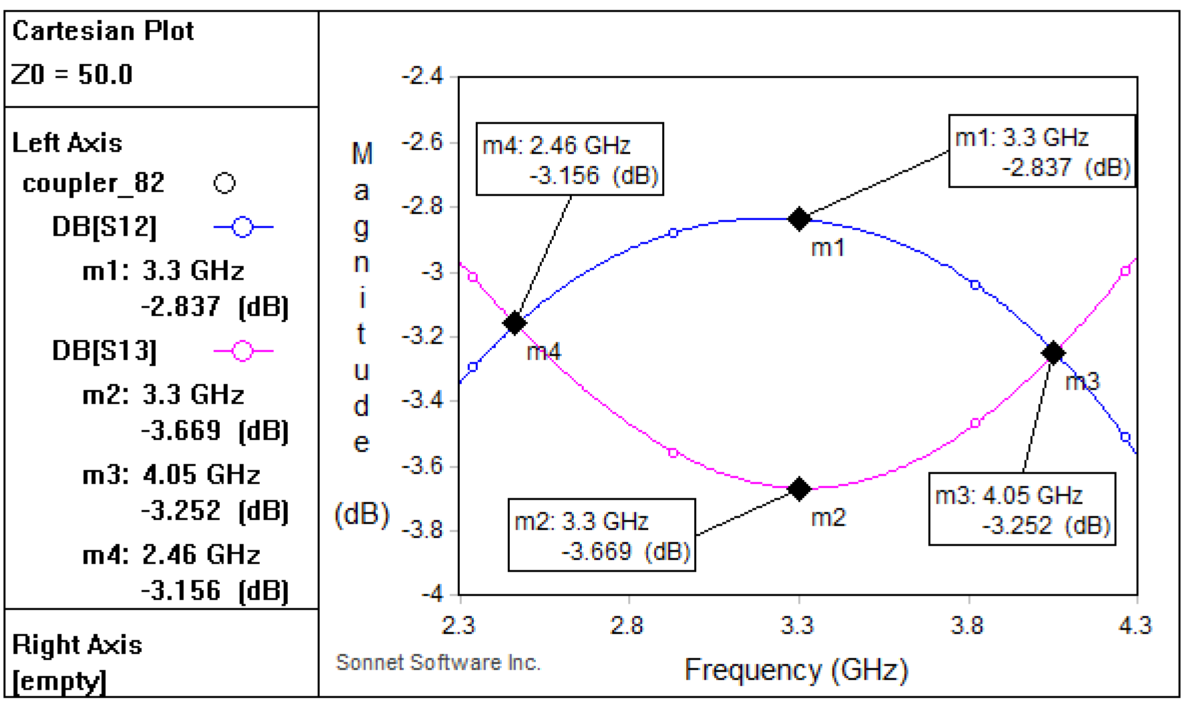


Fig. 4. A close-up view to show the Amplitude Balance.

The phase difference of the coupled port and the thru port is 90º along the frequency band as seen in Figure 5.

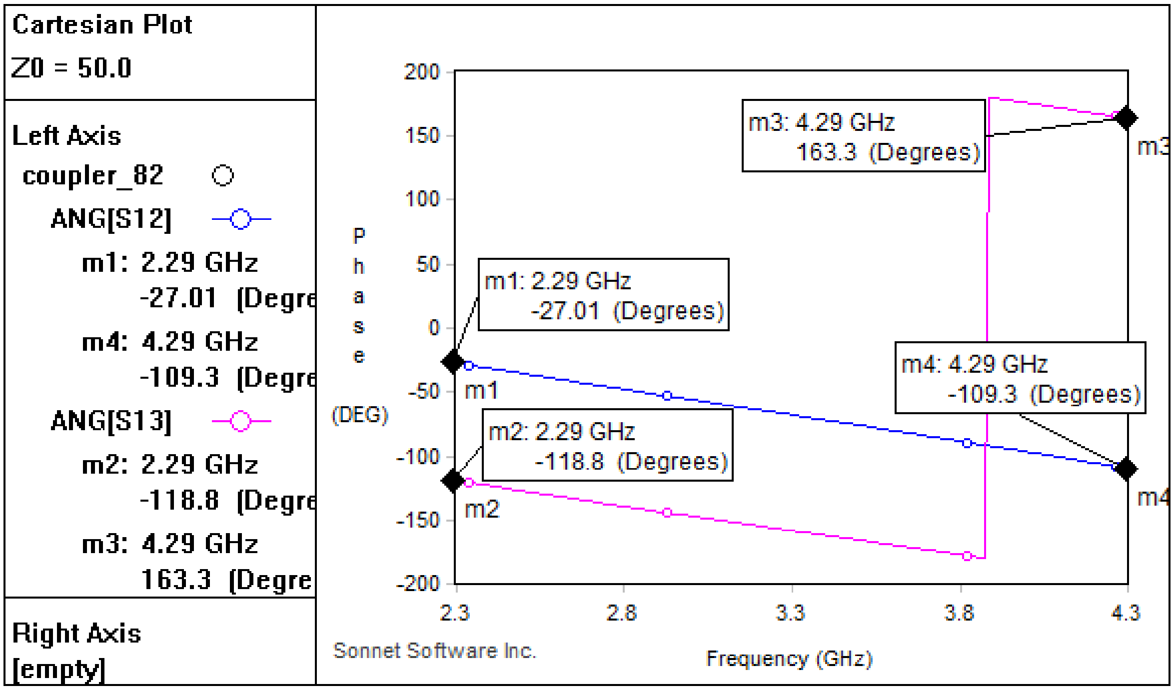


Fig. 5. Phase difference between the coupled and thru port.

**Table 1. Tolerance analysis on dielectric thickness**

| Thickness (mils) | Frequency (GHz) | Coupling Port (dB) | Thru Port (dB) | Isolation Port (dB) | Return Loss Port (dB) | Amplitude Balance |
|---|---|---|---|---|---|---|
| 20, 5.2, 20 | 2.46 | -3.67 | -2.47 | -27.72 | -28.52 | 0 |
| | 4.05 | -3.71 | -2.47 | -26.30 | -27.74 | |
| 25, 5.2, 25 | 2.46 | -3.31 | -2.88 | -20.80 | -21.19 | 0.29 |
| | 4.05 | -3.35 | -2.93 | -19.00 | -19.36 | |
| **30, 5.2, 30** | **2.46** | **-3.16** | **-3.16** | **-18.03** | **-18.09** | **0.83** |
| | **4.05** | **-3.25** | **-3.25** | **-16.03** | **-15.99** | |
| 35, 5.2, 35 | 2.46 | -2.91 | -3.63 | -16.05 | -15.62 | 1.6 |
| | 4.05 | -3.01 | -3.84 | -14.10 | -13.52 | |
| 40, 5.2, 40 | 2.46 | -2.79 | -3.97 | -14.87 | -14.13 | 2.2 |
| | 4.05 | -2.94 | -4.27 | -12.98 | -12.00 | |

**Table 2. Tolerance analysis on spacing thickness**

| Thickness (mils) | Frequency (GHz) | Coupling Port (dB) | Thru Port (dB) | Isolation Port (dB) | Return Loss Port (dB) | Amplitude Balance |
|---|---|---|---|---|---|---|
| 30, 5.0, 30 | 2.46 | -3.03 | -3.31 | -17.89 | -17.78 | 1.12 |
| | 4.05 | -3.14 | -3.39 | -15.85 | -15.74 | |
| **30, 5.2, 30** | **2.46** | **-3.16** | **-3.16** | **-18.03** | **-18.09** | **0.83** |
| | **4.05** | **-3.25** | **-3.25** | **-16.03** | **-15.99** | |
| 30, 5.4, 30 | 2.46 | -3.24 | -3.09 | -17.59 | -17.77 | 0.41 |
| | 4.05 | -3.30 | -3.22 | -15.81 | -15.92 | |

**Table 3. Tolerance analysis on dielectric constant**

| Thickness (mils) | Dielectric constant | Frequency (GHz) | Coupling Port (dB) | Thru Port (dB) | Isolation Port (dB) | Return Loss Port (dB) | Amplitude Balance |
|---|---|---|---|---|---|---|---|
| 30, 5.2, 30 | 1.8 | 2.46 | -3.26 | -3.15 | -16.63 | -16.77 | 1.16 |
| | | 4.05 | -3.00 | -3.71 | -14.88 | -14.31 | |
| 30, 5.2, 30 | 1.9 | 2.46 | -3.16 | -3.21 | -17.23 | -17.30 | 1.08 |
| | | 4.05 | -3.09 | -3.52 | -15.36 | -15.07 | |
| **30, 5.2, 30** | **2.0** | **2.46** | **-3.16** | **-3.16** | **-18.03** | **-18.09** | **0.83** |
| | | **4.05** | **-3.25** | **-3.25** | **-16.03** | **-15.99** | |
| 30, 5.2, 30 | 2.1 | 2.46 | -3.00 | -3.29 | -18.43 | -18.30 | 0.96 |
| | | 4.05 | -3.29 | -3.18 | -16.36 | -16.48 | |
| 30, 5.2, 30 | 2.2 | 2.46 | -2.95 | -3.32 | -18.96 | -18.78 | 0.91 |
| | | 4.05 | -2.99 | -3.43 | -16.97 | -17.12 | |

## 3. Conclusion

In this work, a 3 dB 90º hybrid broadside coupled stripline coupler is designed and simulated. The design covers a frequency range of 2.3 – 4.3 GHz. The simulated results are an input return loss of 18 dB, an isolation of 18 dB, and phase difference of 90º, with a maximum amplitude balance of 0.8 dB. According to the simulation results of Sonnet software, all results are satisfactory.

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