50 dB Hybrid Stripline Coupler

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Abstract: This paper describes a 50 dB ,an edge coupled 90º hybrid stripline coupler is designed and simulated. The coupler is analized using Sonnet, a planar 3D electromagnetic simulation software. The results taken from Sonnet are presented as, current distribution, smith chart, phase difference between the coupled and through ports and S-parameters. Commercial application of the work is in wireless 3G networks

Keywords: Coupler, Stripline, Hybrid, 50 dB.

1. Introduction

Hybrids are classified according to the phase shift between the two outputs. There are two basic types: 180° hybrids and 90° (quadrature) hybrids. The latter are also called 3-dB directional couplers.[1] Directional couplers are critical devices in many RF/microwave systems to combine or divide signals. In addition, they are commonly employed in microwave circuitries such as balanced mixer and amplifiers, and antenna array feeds [2]. In particular, directional couplers with 90º phase difference, such as branch line couplers, are essential for image rejection mixers, Doherty amplifiers, circularly polarized antennas and so on. However, the conventional branch line coupler offers very limited bandwidth (~10%),which is suitable only for limited applications. By cascading multisections of the couplers, the bandwidth can be improved [2]. However, it results in large circuit occupation and very high characteristics impedance line, which makes the fabrication difficult.

In this work, a 50 dB single section edge coupled line directional coupler is designed and simulated. As a stripline dielectric thickness of B = 60 mm, characteristic impedance of 50 Ω is chosen. The substrate is Arlon AD250 with dielectric constant of $\varepsilon_r = 2.5$. A frequency range of coupler from 1.8 GHz to 2.4 GHz with 0.31 dB amplitude balance and 90º phase difference were achieved experimentally with coupler dimensions: 788 x 36 mils [3]. A 20 dB coupler which also uses edge-coupled technique can be found in [4]. Design consists of step by step changes on the geometry in order to meet the specifications. 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[4]. The port definitions used in this paper; Ports 1 and 4 are the isolated input ports, port 3 is port 1's direct output, and port 2 is port 4's direct output. The coupling and isolation ports of the proposed design are reversed the conventional one, but the same as the coupled line coupler. The entire coupler is implemented using parallel-strip line.

2.Simulation Results

In this work, main purpose was to design and simulate a 50 dB stripline 90º hybrid coupler. Figure 1 has the top view of the coupler. Since this is not a tight coupler, edge-coupling technique is being used. Figure 2 has the 3-D view. Figure 3 shows the simulated scattering parameters and the amplitude balance is seen on Figure 4. The return loss is around –13.53 dB at the low end of band, while it reduces to –14.68 dB, at the high and of the band.

Coupling of almost exact value of 50 dB is achieved. Very satisfactory isolation value of under -65 dB is also achieved throughout the entire frequency band.

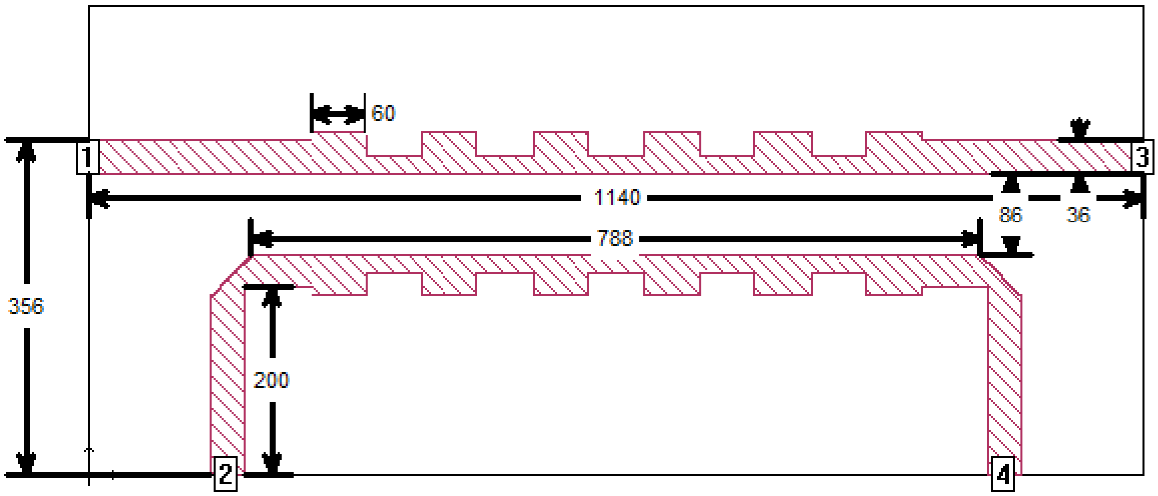

Fig. 1. Top view and dimensions of the coupler (mils).

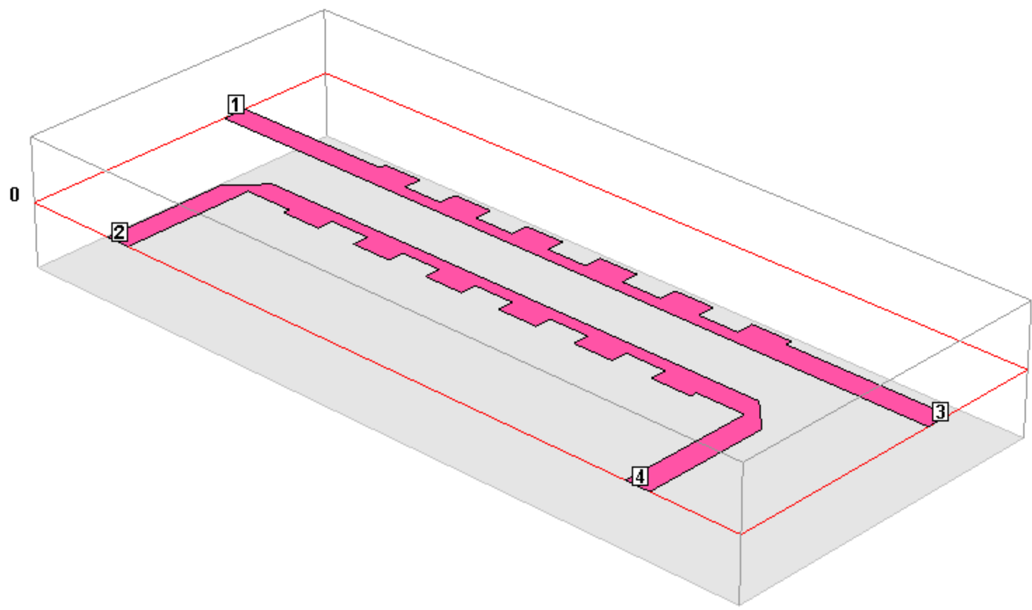

Fig. 2. 3-D view of the Coupler.

It is clearly seen in Figure 4 that, the coupling is – 49.52 dB and – 49.83 dB at the lowend and high end of the band, respectively. It shows the amplitude balance of the coupling is 0.31 dB. The phase difference between the coupled port and the thru port is almost 90º along the frequency band as it is seen in Figure 5.

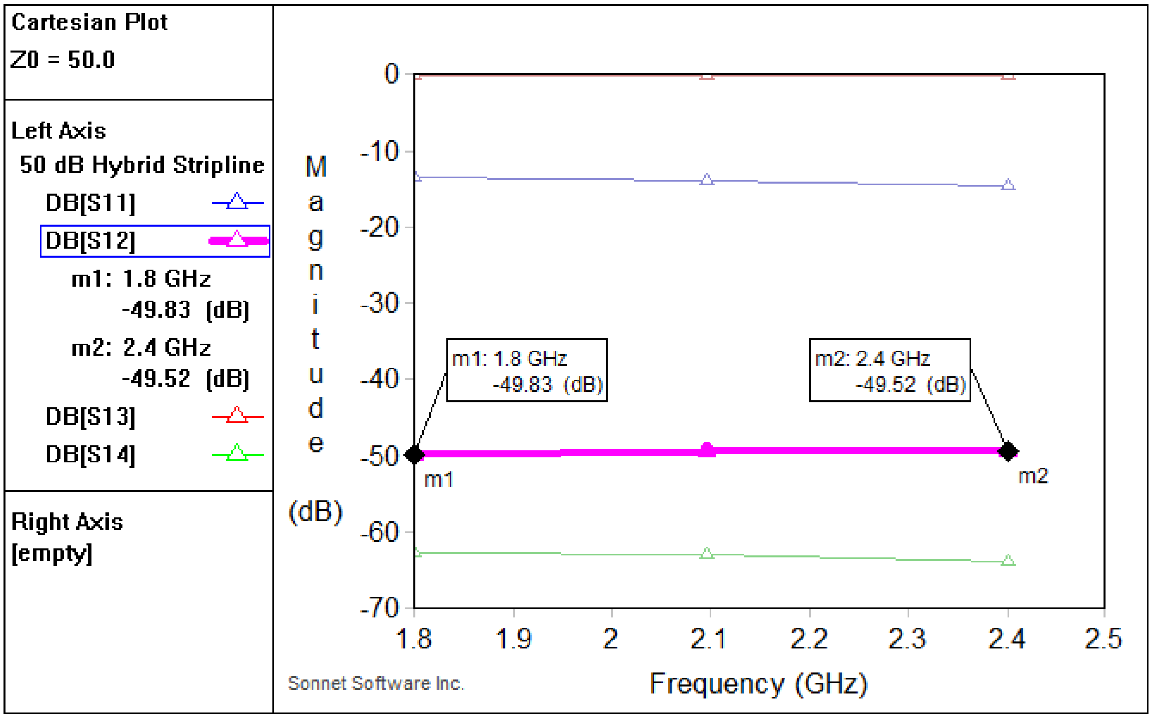

Fig. 3. S-parameters of the Coupler

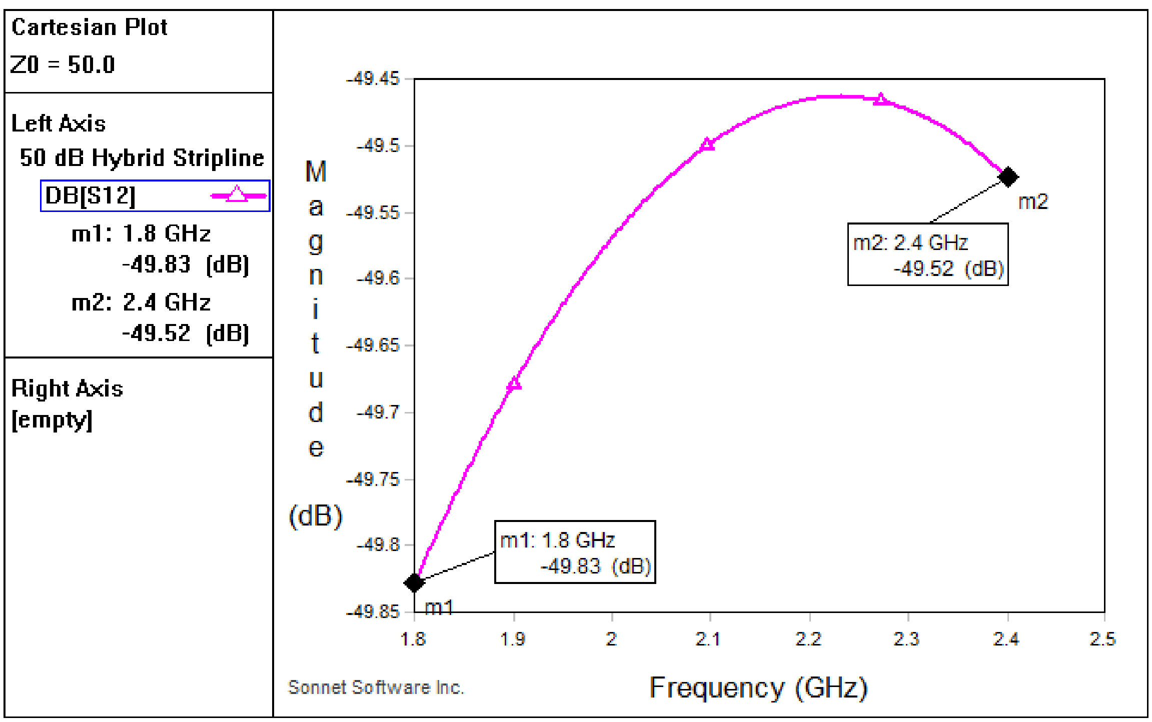

Fig. 4. Amplitude Balance.

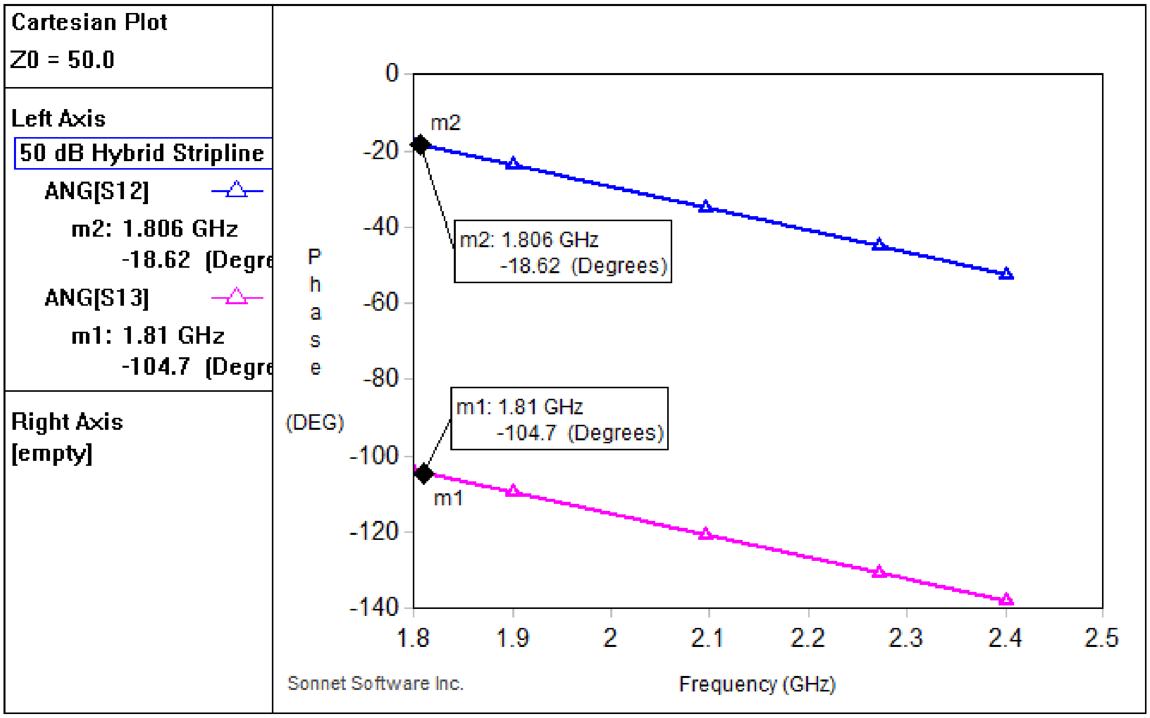

Fig. 5. Phase difference between the coupled and thru ports.

Table 1,2,3 and 4 shows the tolerance analysis of some parameters in case of a fabrication error.

Table 1: Comparison of the dielectric constant

Spacing Between the Lines (mils)	Dielectric Constrant	Frequency (Ghz)	Coupling Port	Thru Port	Isolation Port (dB)	Return Loss Port (dB)	Amplitude Balance (dB)
86	2.4	1.8	-49.97	-0.25	-62.16	-12.78	-0.44
		2.4	-49.53	-0.20	-63.08	-13.91	
86	2.45	1.8	-49.90	-0.23	-62.47	-13.15	-0.38
		2.4	-49.52	-0.18	-63.52	-14.30	
86	**2.5**	**1.8**	**-49.83**	**-0.21**	**-62.78**	**-13.53**	**-0.31**
		2.4	**-49.52**	**-0.17**	**-63.96**	**-14.68**	
86	2.6	1.8	-49.69	-0.18	-63.42	-11.32	-0.15
		2.4	-49.54	-0.15	-64.85	-15.49	

Table 2: Comparison of the distance between the lines

Distance Between the Lines (mils)	Frequency (Ghz)	Coupling Port	Thru Port	Isolation Port (dB)	Return Loss Port (dB)	Amplitude Balance (dB)
84	1.8	-48.77	-0.31	-60.46	-11.89	-0.55
	2.4	-48.22	-0.19	-61.07	-14.19	
85	1.8	-49.22	-0.30	-60.91	-11.89	-0.55
	2.4	-48.67	-0.19	-61.52	-14.15	
86	**1.8**	**-49.83**	**-0.21**	**-62.78**	**-13.53**	**-0.31**
	2.4	**-49.52**	**-0.17**	**-63.96**	**-14.68**	
87	1.8	-50.14	-0.31	-61.82	-11.89	-0.56
	2.4	-49.58	-0.19	-62.43	-14.19	

Table 3: Comparison of the dielectric thickness

Dielectric Thickness (mils)	Frequency (Ghz)	Coupling Port	Thru Port	Isolation Port (dB)	Return Loss Port (dB)	Amplitude Balance (dB)
25, 25	1.8	-58.14	-0.07	-74.43	-18.70	-0.17
	2.4	-57.98	-0.09	-75.26	-18.16	
30, 30	**1.8**	**-49.83**	**-0.21**	**-62.78**	**-13.53**	**-0.31**
	2.4	**-49.52**	**-0.17**	**-63.96**	**-14.68**	
32, 32	1.8	-47.27	-0.28	-59.09	-12.32	-0.40
	2.4	-46.87	-0.21	-60.02	-13.77	
40, 40	1.8	-39.66	-0.56	-48.34	-49.32	-0.78
	2.4	-38.88	-0.36	-48.38	-11.24	

Table 4: Comparison of the coupler length

Coupler length (mils)	Frequency (Ghz)	Coupling Port	Thru Port	Isolation Port (dB)	Return Loss Port (dB)	Amplitude Balance (dB)
780	1.8	-49.86	-0.21	-62.80	-13.53	-0.36
	2.4	-49.50	-0.17	-63.88	-14.70	
784	1.8	-49.85	-0.21	-62.81	-13.53	-0.34
	2.4	-49.51	-0.17	-63.94	-14.70	
788	**1.8**	**-49.83**	**-0.21**	**-62.78**	**-13.53**	**-0.31**
	2.4	**-49.52**	**-0.17**	**-63.96**	**-14.68**	
792	1.8	-49.78	-0.22	-62.67	-13.46	-0.28
	2.4	-49.50	-0.17	-63.99	-14.62	

Current distribution in Figure 6 clearly shows that current is crowded on the main line (between 1 and 3) and almost no current goes to the isolation port(4), and very less power goes to the coupled port(2).

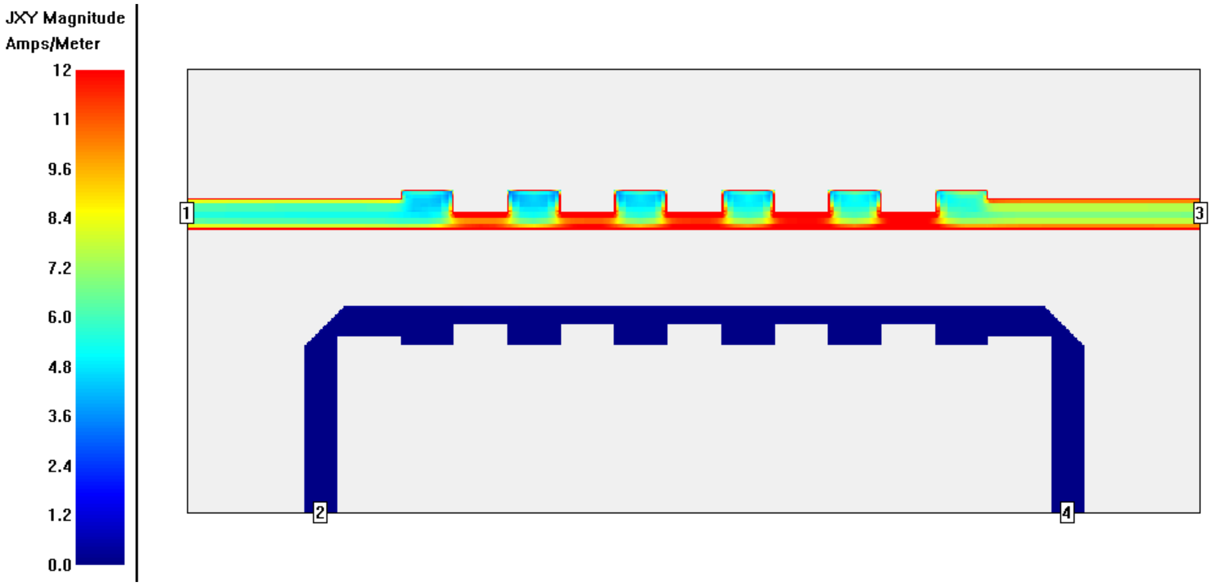

Fig. 6. Current distribution on the coupler

3. Conclusions

In this work a four-port stripline hybrid coupler is designed and simulated. Coupling is almost 50 dB over a frequency range of 1.8–2.4 GHz. An isolation of 63 dB is achieved. Tolerance analysis of dielectric thicknesses, dielectric constant and coupler length and distance between the lines are performed. According to the simulation results of Sonnet software, all results are satisfactory. Design started with a little error (a slight deviation from 50 dB at first) but, after reducing the cell size and the distance between the lines, an exact value of 50 dB coupling is achieved.

4. References

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