International Journal of Electronics and Communication Engineering.
ISSN 0974-2166 Volume 7, Number 2 (2014), pp. 105-110

http://www.irphouse.com

Microstrip Coupler with High Isolation

S. Maheswari[1] and T. Jayanthy[2]

[1]Research Scholar, Sathyabama University, Chennai, India.
[2]Principal, Panimalar Insitute of Technology, Chennai, India.
E-mail: [1]maheswarisp@yahoo.co.in, [2]jayanthymd@rediffmail.com

Abstract

A method to improve the isolation of the microstrip coupler is presented. The pattern of the coupler is modified for phase velocity compensation which results in high isolation. Using this procedure, a 15 dB coupler is designed and fabricated at 0.9 GHz. A high isolation of 63.3 dB is measured. The validity of the design concept is verified by simulations and measurements.

Index Terms: Microstrip, directional coupler, coupled lines, microwave.

1. Introduction

Microstrip couplers are widely used in microwave applications such as antenna feeds, balanced mixers, modulators, phase shifters and so on. But, they suffer from poor isolation, due to the inequality between the odd and even mode phase velocities. Various compensation techniques have been reported to improve the isolation. The wiggly line coupler [1] improves the directivity and suffers due to lack of design equation. The capacitive compensation was used to improve the directivity [2-3]; however the capacitor has to be placed in the narrow spacing between the coupled lines. The inductive compensation improves the isolation and needs the iteration design process [4-6]. The coupled spur line [7], and reflected power canceller approach [8-10] work within a narrow band. The Epsilon negative transmission line [11] was used but it needs more number of unit cells to improve the accuracy, which leads to fabrication difficulty. Delay lines [12] were used, but the coupler occupies more space than the conventional one. The Re-entrant mode structure [13], periodic metallic cylinders [14], and metamaterial [15] were also reported to improve the isolation, where the coupler construction is complex. Periodic floating conductors [16] were used to improve the directivity for a wide bandwidth for a maximum directivity of 30 dB.

In this paper, the isolation of the coupler is improved, using the phase velocity compensation method. It is obtained by modifying the pattern of the coupler. The phase velocity of the even and odd modes can be varied by varying the distributed inductance and capacitance of microstrip lines of the coupler. These distributed parameters can be varied by modifying the pattern of the microstrip coupler structure. In the proposed coupler, inductance and capacitance of the microstrip lines are varied by varying the width of the microstrip lines. In one microstrip line, the width of the microstrip line is reduced by introducing slot at the center of microstrip line and increased at the other end. In another microstrip line, the width of the microstrip line is reduced by introducing slot at the center only. Even though the structure becomes asymmetric, the characteristic impedance of each microstrip line is maintained to be 50ohms by properly selecting the width of the microstrip line.

Using this method a 15dB microstrip coupler is designed, and isolation of the coupler is improved up to 63.3dB. Advantages of the proposed method are that the structure is planar, there is no special fabrication technique needed, construction is simpler and it does not require any iteration design process.

2. Design of Microstrip Coupler

The dimension ratios of the microstrip coupler are calculated using the design procedure given in [17] and the physical length of the coupler is calculated using

$$l = \frac{\lambda}{4} = \frac{c}{4f\sqrt{\varepsilon_{eff}}} \tag{1}$$

where ε_{eff} can be calculated using (2) as given in [18]

$$\varepsilon_{eff} = \frac{\varepsilon_r + 1}{2} + \frac{\varepsilon_r - 1}{2}\left\{F(w/h)\right\} - \frac{\varepsilon_r - 1}{4.6}\frac{t/h}{\sqrt{w/h}} \tag{2}$$

$$F(w/h) = \left(1 + \frac{12}{w/h}\right)^{-0.5} + 0.04[1-(w/h)]^2 \text{ for w/h} \leq 1 \tag{3}$$

$$F(w/h) = \left(1 + \frac{12}{w/h}\right)^{-0.5} \text{ for w/h} \geq 1 \tag{4}$$

where, $c=3*10^8$ m/ sec and f is operational frequency in Hz and ε_{eff} is the effective permittivity constant of the coupled structure and t is the thickness of the conductor.

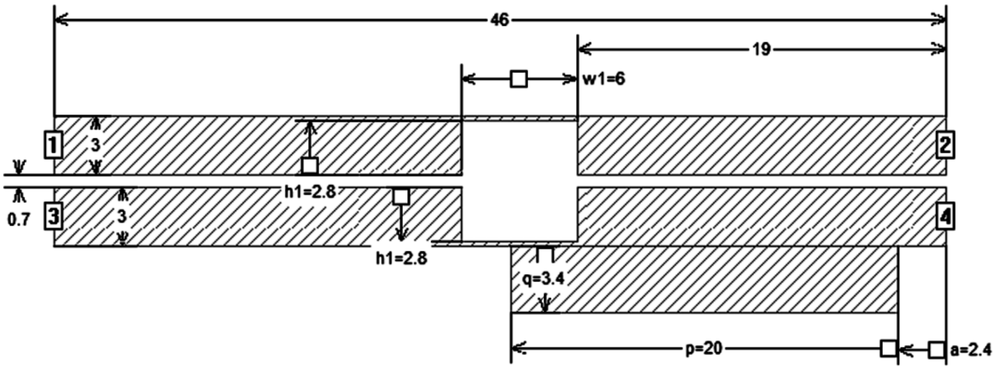

Fig. 1: Structure of proposed microstrip coupler.

The structure of the proposed coupler is shown in Fig 1. In the structure port 1 & 2 indicates the input and through port, port 3 & 4 indicates the coupled port and isolated port respectively.

3. Experimental Results

A 15 dB microstrip coupler is fabricated on FR4 substrate (ε_r = 4.4, h = 1.6 mm) with design values of: width of the microstrip line w = 3 mm, spacing between the lines s = 0.7mm and the length of the coupler *l* = 46 mm at 0.9 GHz. The slot is selected approximately at the center. The dimensions of depth and width of the slot are h1= 2.8 mm and w1 = 6 mm, and the additional increase in width is q = 3.4mm for a length of p=20mm. All the dimensions are shown in mm in Fig 1. The simulation is done using SONNET software. The fabricated proposed coupler is shown in Fig 2.

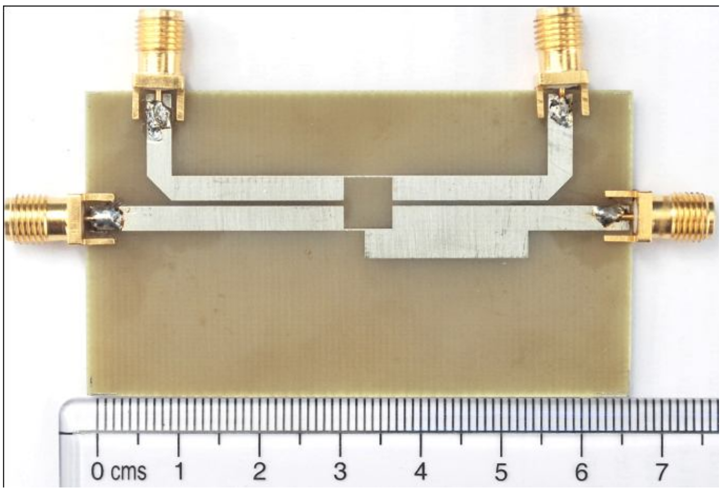

Fig. 2: Photograph of proposed microstrip coupler.

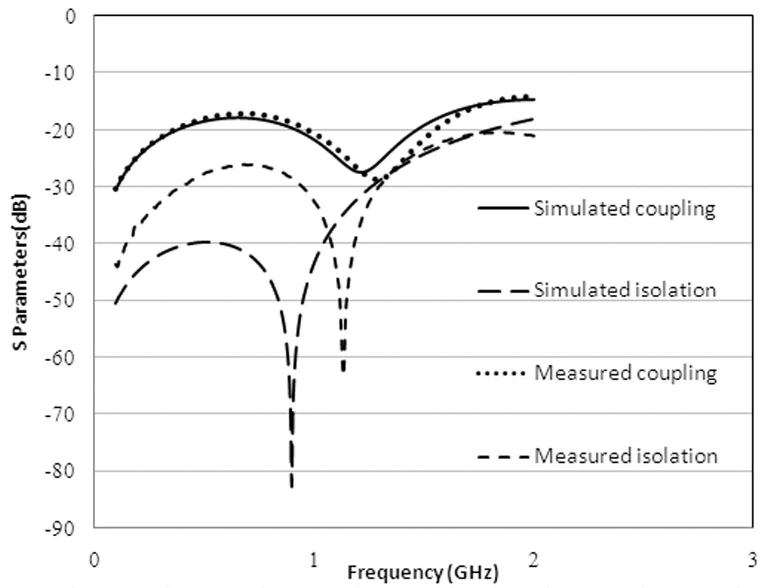

Fig. 3: Comparison of simulated & measured S31 & S41 of proposed coupler

The S parameters of the proposed coupler are measured using the Vector Network analyzer. The comparison between the simulated and measured results of the proposed coupler is shown in Fig 3&4. For the proposed coupler a maximum isolation of 82.7 dB is obtained for 0.9GHz in simulation and maximum isolation of 63.3B is obtained for 1.135GHz in measurement.

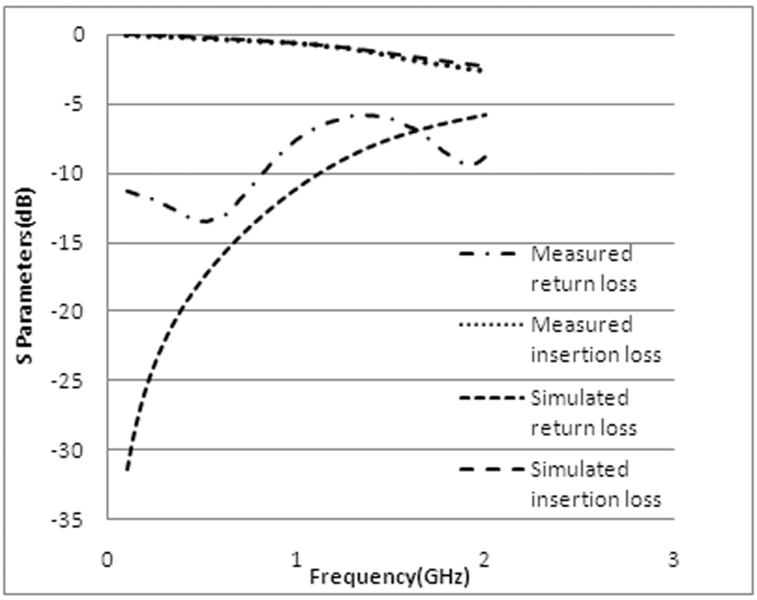

Fig. 4: Comparison of simulated & measured S11 & S21 of proposed coupler.

The simulated coupling is 19.6dB and measured coupling is 18.6dB at 0.9GHz. The simulated and measured value of insertion loss is 0.56dB.The simulated and measured values of return loss are 12dB and 8.7dB. In the proposed coupler, the measured values of coupling and insertion loss closely match the simulated result. Due to the discontinuity effect, there is a shift in the frequency at which the maximum isolation occurs in the measurement. The limitation of the proposed coupler is its narrow band.

4. Conclusion

In this paper, microstrip coupler with high isolation has been presented using phase velocity compensation. The width of the coupler is varied to reduce the phase velocity difference which improves the isolation of the coupler. Using this procedure a 15 dB microstrip coupler is designed and fabricated at 0.9GHz. A high isolation of 63.3dB is obtained. The simulation results are verified with measurements. The structure of the coupler is planar and construction is simpler and can be used for RFID applications.

References

[1] A. Podell, “A high directivity microstrip coupler technique,” in *IEEE MTT-S Int. Microw. Symp. Dig.*, pp.*33-36*, May, 1970.

[2] M. Dydyk, “Accurate design of microstrip directional couplers with capacitive compensation,” in *IEEE MTT-S Int. Dig.*, May 1990, pp.581–584.

[3] M. Dydyk, “Microstrip directional couplers with ideal performance via single-element compensation,” *IEEE Trans. Microw. Theory Tech.*, vol.47, no. 6, pp. 956–964, Jun. 1999.

[4] R. Phromloungsri, V. Chamnanphrai, and M. Chongcheawchamnan, “Design high-directivity parallel-coupled lines using quadrupled inductive-compensated technique,” in *Asia-Pacific Microw. Conf. Dig.*, 2006, pp. 1380–1383.

[5] R. Phromloungsri, M. Chongcheawchamnan, and I. D. Robertson, “Inductively compensated parallel coupled microstrip lines and their applications,” *IEEE Trans. Microw. Theory &Tech.*, vol.54, no.9, pp.3571–3582, Sep.2006.

[6] S. Lee and Y. Lee, “An inductor-loaded microstrip directional coupler for directivity enhancement,” *IEEE Microw. Wireless Compon. Lett.*, vol. 19, no. 6, pp. 362–364, Jun. 2009.

[7] S.-F. Chang, J.-L. Chen, Y.-H. Jeng and C.-T. Wu, “New high-directivity coupler design with coupled spurlines,” *IEEE Microw. Wireless Compon. Lett.*, vol. 14, no. 2, pp. 65–67, Feb. 2004.

[8] W.-K. Kim, M.-Q. Lee, J.-H. Kim, H. S. Lim, J.-W. Yu, B.-J. Jang and J.-S. Park, "A passive circulator with high isolation using a directional coupler for RFID," in *IEEE MTT-S Int. Microw. Symp. Dig.*, Jun. 2006, pp. 1177–1180.

[9] J. Muller and A. F. Jacob, "Complex compensation of coupled line structures in inhomogeneous media," in IEEE MTT-S Int. Microw. Symp. Dig., Jun. 2008, pp. 1007–1010.

[10] D.-Z. Chen, X.-W. Shi, Y.-Y. Yang, and F. Wei, "Compact microstrip parallel coupler with high isolation," Electron. Lett, vol. 44, no. 12, pp. 740–741, Jun. 2008.

[11] A. Pourzadi, A. Attari and M. Majedi, "A Directivity-Enhanced directional coupler using Epsilon Negative Transmission line," *IEEE Trans. Microw. Theory Tech.*, vol. 60, no. 11, pp. 3395–3402, Nov. 2012

[12] Y.-H. Chun, J.-Y. Moon, S.-W. Yun, and J.-K. Rhee, "Microstrip line directional couplers with high directivity," *Electron. Lett,* vol. 40, no. 5, pp. 317–318, Mar. 2004.

[13] C.-S. Kim, S.-W. Lee, P.-Y. Lee, H.-S. Kim, J.-S. Park & Dal Ahn, "Design of Re- entrant mode microstrip directional coupler for high directivity performance," in Asia-Pacific Microw. Conf. Dig., 2000, pp. 1286–1289.

[14] J. Shi, X.Y. Zhang, K.W. Lau, J.-X. Chen and Q. Xue, "Directional couplers with high directivity using metallic cylinders on microstrip line," Electron. Lett., vol. 45, no.8, pp. 415–417, Apr. 2009.

[15] Chun, Y.-H., and Hong, J.-S.: 'High directivity directional coupler using metamaterial'. *Eur. Microwave Conf.*, Manchester, UK, 2006, pp. 329–331.

[16] Takao Fujii, Yoshihiro Kokubo, and Isao Ohta, "High Directivity Quarter-Wave Microstrip Couplers with Periodic Floating-Conductors on Coupled Edges". *Proceedings of the 36th European Microwave Conference,* pp.32-35, Sept. 2006.

[17] Abdullah Eroglu & Jay Kynoon Lee, "The Completer Design of microstrip directional couplers using synthesis technique," IEEE Trans. Instrum. Meas., Vol.57, no.12,pp.2756-2761, Dec.2008

[18] I. Bahl and P. Bhartia, *Microwave Solid State Circuit Design*. New York, 1988, p.18.