Available online at www.ijarbest.com
International Journal of Advanced Research in Biology, Ecology, Science and Technology (IJARBEST)
Vol. 1, Issue 2, May 2015

Design and Development of branch line coupler using split ring resonator cell

R.Gayathri
Final year-M.E Communication System
K. Ramakrishnan College of Engineering,
Trichy, Tamilnadu

U.Surendar
Assistant professor,K.Ramakrishnan College of engineering,
Trichy, Tamilnadu

***Abstract*- In this paper, microwave element is designed using the concept of split ring resonator. In this branch line coupler is loaded with ring resonator structure to reduce overall size than conventional element and to have excellent stop band characteristics. The proposed coupler has good performance than conventional element and also hasharmonic suppression in addition.**

***Index terms*- Branch line coupler, Split ring resonator, negative effect,S-parameter.**

I INTRODUCTION

In the recent decade, artificial materials have become a topic of great interest in physics and microwave engineering. The electromagnetic properties are determined by the material parameters which in turn are decided by the microscopic structures. To change certain electromagnetic properties of such a material, changes have to be made at the microscopic level. This is highly difficult and requires great precision. In case of artificial media, the structuring is done at macroscopic level and the electromagnetic properties are altered for a particular range of frequencies. This is a huge advantage when compared to making changes at microscopic level in terms of cost and precision required. Examples of such artificial materials are Electromagnetic bandgap structures (EBG), Photonic bandgap structures (PBG) and left-handed media (Metamaterials).

EBG and PBG are periodic structures mostly used for suppressing surface waves and require signal, ground planes. The frequency selectivity in EBG is based on the periodicity and requires cascading of many cells for significant rejection levels. The EBG period scales with the operating wavelength and when designed for low frequencies, the size of the structure becomes considerably huge. One more factor is EBG structures do not provide easy control. The same applies for PBG structures.

Electromagnetic Metamaterials are periodically arranged artificial structures that show peculiarbehaviors such as negative refraction not seen in natural materials. The photonic atoms or the element

structures of the metamaterials, are typically much smaller in size than the working wavelengths such that the metamaterials can be considered to be homogeneous and macroscopic parameters such aselectrical permittivity and magnetic permeability can be used to describe the electromagnetic properties of the metamaterials. By carefully examining thephotonic atoms, both the permittivity and permeability can be made negative such that negative
refraction can be achieved from the metamaterial. The most widely used structures forthis purpose is the composite of short metallic wires and split-ring resonators (SRRs).

While the array of short wires gives a negative permittivity in the wide frequency range belowthe effective plasma frequency, the array of SRRs gives a negative permeability in the narrowfrequency range just above the resonance frequency so that the effective index of refraction canbe negative in a narrow frequency band. While most of the research in this area is in a linearregime, where the electromagnetic responses are independent of the external fields, some efforthas been made to study the nonlinear effects of the metamaterials, especially the nonlinear tenability of the SRRs. The SRRs are essentially LC resonators and the resonance frequencyis determined by the geometry of the rings. To tune the magnetic responses of the SRRs, extracomponents or materials need to be introduced into the SRRs.Unlike the EBG/PBG structures, left-handed materials can operate at $1/10^{th}$ of the operating wavelength making the device more compact. Higher rejection levels can be achieved with less unit cells. One more advantage is it can be

Available online at www.ijarbest.com
International Journal of Advanced Research in Biology, Ecology, Science and Technology (IJARBEST)
Vol. 1, Issue 2, May 2015

realized as planar structures without vias unlike certain EBG structures.Left-handed materials are used in wide range of applications including electromagnetics, optics, MEMS, acoustics and more. In applications pertaining to microwaves, left-handed materials are used for enhancement of bandwidth, designing of dual band components, improving the radiation characteristics, design of miniaturized coupler and improving their response.

II FREQUENCY RESPONSE OF SRR

Recently, there has been a growing interest in using the split-ring resonator (SRR) and the complementary split-ring resonator (CSRR) as constituent particles for the design of novel planar microwave components. Split ring resonators (SRRs) consist of a pair of concentric metallic rings, etched on a dielectric substrate, with slits etched on opposite sides.The geometry parameters of the SRRs (Fig 1) consist of ring width *c*, space between the rings*d*, and the ring radius *r* and *l*, which affect the electric performance deeply.

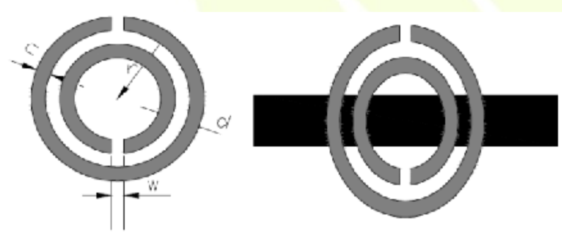

Fig 1. Geometry dimension of SRR Cell

SRRscan produce an effect of being electrically smaller when responding to an oscillating electromagnetic field. These resonators have been used for the synthesis of left handed and negative refractive index media, where the necessary value of the negative effective permeability is due to the presence of the SRRs. A single cell SRR has a pair of enclosed loops with splits in them at opposite ends. The loops are made of nonmagnetic metal like copper and have a small gap between them. The loops can be concentric, or square, and gapped as needed. A magnetic flux penetrating the metalrings will induce rotating currents in the rings, which produce their own flux to enhance or opposethe incident field.The small gaps between the rings produces large capacitance values which lower the resonating frequency. The dimensions of the structure are small compared to the resonant wavelength. This results in low radiative losses, and very high quality factors.

Fig 2 shows by properly coupling SRRs to a host planar microstrip transmission line, planar structures with effective negative constituent parameters can be obtained. SRRs also exhibit cross-polarization effects (magneto electric coupling) so that excitation by a properly polarized time-varying external electric field is also possible and its parameters values are depicted in table 1.

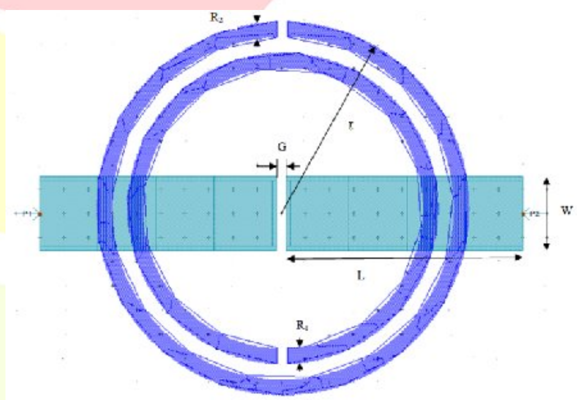

Fig 2. Layout of SRR Cell

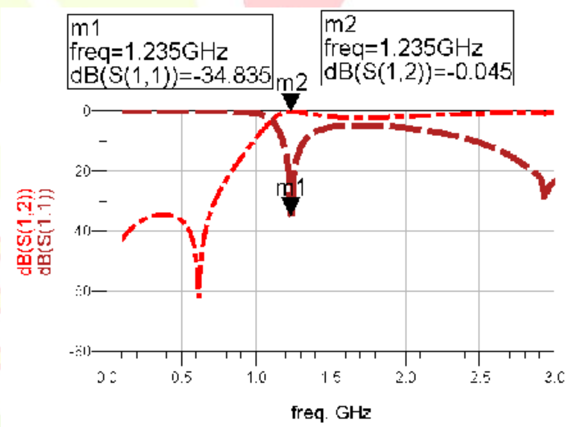

Fig 3.Simulated results

Simulated frequency responses of the designed metamaterial structure are depicted in Fig 3. The measured insertion losses at the design frequencyare close to the value corresponding to an ideal losslessdevice, measured return losses are better than 20 dB. Thus, device miniaturizationis achieved, maintaining device performance at the design frequency.

Table 1. Parameter Specifications

Available online at www.ijarbest.com
International Journal of Advanced Research in Biology, Ecology, Science and Technology (IJARBEST)
Vol. 1, Issue 2, May 2015

Parameters	Values(mm)
Length(L)	6.16
Width(W)	1.23
Gap(G)	0.16
Centre Radius(r)	4.76
Ring Width(R_1)	0.53
Ring Width(R_2)	0.48

III DESCRIPTION OF COUPLER WITH SRR

The splitting and recombining of electromagnetic signals is a fundamental signal processing functionality in electronics. Many circuits exist in the RF and microwave designer's toolbox to facilitate effective signal splitting and recombination. The proper choice of circuit depends on the application and requirements. Couplers and power dividers arestraightforward passive components. A coupler is a passive device which couples part of the transmission power by a known amount out through another port, often by using two transmission lines set close enough together such that energy passing through one is coupled to the other. Branch line coupler or hybrid couplers are basically 3dB directional couplers in which the phase of the coupled output signal and the output signal are 90° apart. A 3 dB coupler divides the power equally (within a certain tolerance) between the output and coupled output ports. The 90° phase difference between the outputs makes hybrids useful in the design of electronically variable attenuators, microwave mixers, modulators and many other microwave components and systems. It is also called quadrature hybrids because the phase of the two outputs is a quadrant (90°) apart.Branch line coupler is one of the most popular passive circuits used for microwave and millimeter wave applications.

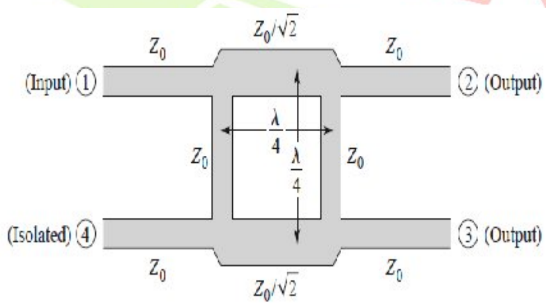

Fig 4 . Geometry of branch line coupler

The geometry of the branch-line coupler is shown in Fig 4. A branch-line coupler is made by two main transmission lines shunt-connected by two secondary (branch lines). As it can be seen from the figure, it has a symmetrical four port. First port is named as input port, second and third ports are output ports and the fourth port is the isolated port. The second port is also named as direct or through port and the third port is named as coupled port.

It is obvious that due to the symmetry of the coupler any of these ports can be used as the input port but at that time the output ports and isolated port changes accordingly. This symmetry is reflected in the scattering matrix, as coupler each row can be obtained as a transposition of the first row.Figure 5 shows single band branch line coupler with Z_o and $Z_o/\sqrt{2}$ impedance of λ/4 transmission line.Branch Line Coupler is designed using microstrip technology on FR4 substrate, operating at a frequency of 2.4GHz. The analysis of this system shows improved insertion loss and return loss. Branch line coupler designed at 2.4 GHZ is used for ISM band and wireless LAN applications.

At microwave frequency the logical variables used are travelling waves with associated powers, rather than total voltages and total currents. These logical variables are called as S-parameters. So in microwave analysis, the power relationship between the various ports of microwave junction is defined in terms of parameters, called as S-parameters or scattering parameters.

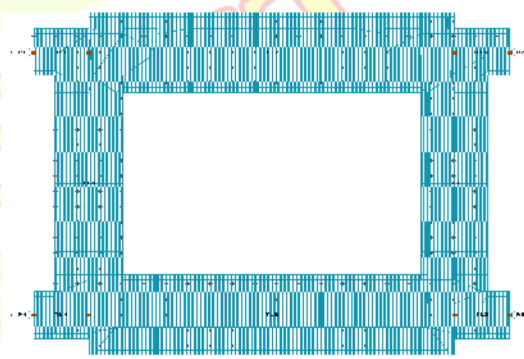

Fig 5.Single band branch line coupler

Return loss is a convenient way to characterize the input and output of signal sources The above fig 6 shows the measurement of return loss -27.803 dB where ideal value of return loss is less than -15 dB.Since branch line coupler also called as 3dB coupler fig 6 observes insertion loss of single band branch line coupler as -3 dB.

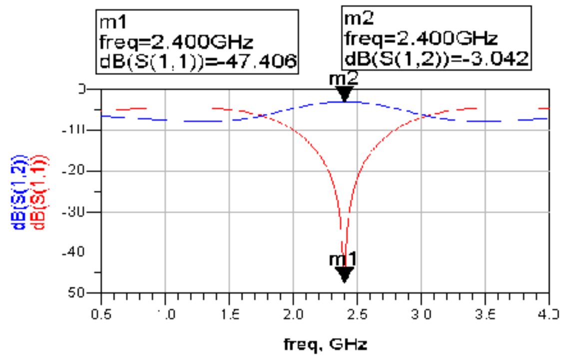

Fig 6. Simulated results

Table 2.Specification of coupler

Parameters	Specifications (Z_o impedance)	Specifications ($Z_o/\sqrt{2}$ impedance)
Length	17.124mm	17.124mm
Width	1.9118mm	3.2728mm
λ/4	0.0684	0.0684

In addition by using SRRs in coupler design, their performance is improved compared to conventional structure as shown in fig 7.It Provides an effective negative permittivity, rather than permeability.The dominant mode of excitation of SRRs is by applying an axial time varying electric field parallel to the axis of the rings.

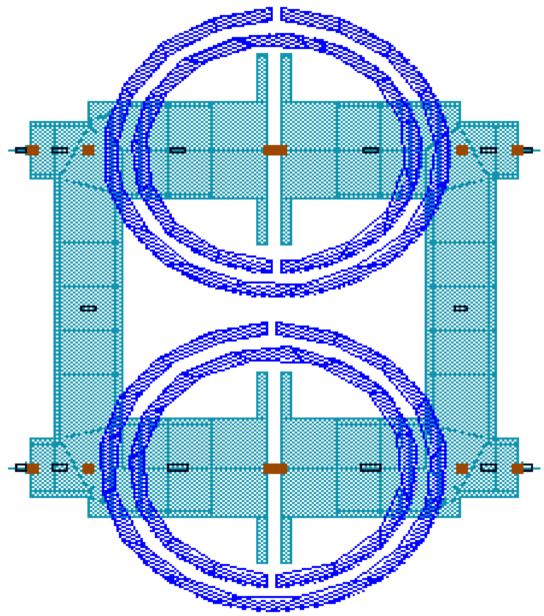

Fig 7. 90º coupler with SRR

Layout (Fig 8.) shows return and isolation loss. For example, it is desirable to drive power splitter with its characteristic impedance for maximum port-to-port isolation and therefore it may be desirable to check return loss of an oscillator or other source. The output return loss is measured by applying a test signal to the oscillator through a directional coupler or circulator. From this fig 8 at 920 MHz and 2.4 GHz return loss observed to be -29 dB and -16 dB. S_{21} is observed as -3 dB.

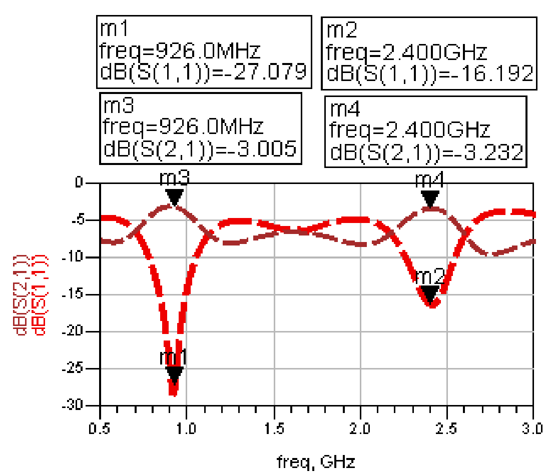

Fig 8.Simulated response

IV CONCLUSION

This paper presented the design method for microstrip passive circuitusing SRR cell. The frequency selective propertiesof the SRR cell shows the considerable relation with its geometryparameters, which has been analyzed detailedly in the paper. Asdemonstration branch-line hybrid coupler operatingat desired frequency was realized by common PCB process. With couplersloaded with SRR cells, branch-line couplerhas insertion loss comparable to the conventional one, while, the 3rd harmonic signals have been deeply suppressed due to the stop-bandeffect of SRR cell. The above newly design method can be used invarious hybrid microwave integrated circuit (HMIC) and monolithicmicrowave integrated circuit (MMIC) without any additional process. By adding up it is suitable for Power splitting and combining, Monitoring and Power measurements.

ACKNOWLEDGMENT

First of all i thank the God almighty for strengthening me throughout this project and helping me to complete it successfully. I wish to express our profound gratitude to my guides **Mr. U. SURENDAR M.E.** for his invaluable guidance, immense help, encouragement and providing me necessary facilities throughout this project. His insightful comments and suggestions have continually helped me to improve my understanding. My project would be incomplete if i fail to thank my **PARENTS** for the constant encouragement and advice, i have received from them.

References

[1]J. Zhang / and X.-W. Sun,**"**Harmonic suppression of branch-line and Rat-race coupler using complementary Spilt ring resonators (CSRR) cell",*Progress In Electromagnetics Research Letters,* Vol. 2, 73–79, 2008.

[2] Volkan Öznazlı Vakur B. Ertürk, "On the use of split-ring resonators and complementarySplit-ring resonators for novel printed microwaveElements: simulations, experiments and discussions".

[3] Metamaterials with negative parameters theory,design and microwave applications by Mario Sorolla.

[4] http://en.wikipedia.org/wiki/split ring resonator.

[5] http://en.wikipedia.org/wiki/decibel.

[6] *International Journal of Soft Computing and Engineering (IJSCE)* ISSN: 2231-2307, Volume-3, Issue-1, March 2013.

[7] K. Cheng and F. L. Wong, "A novel approach to the design and implementation of dual-band compact 90 branch-line coupler," *IEEE Trans. Microw. Theory Tech.,* vol. 52, no. 11, pp. 2458–2463, Nov. 2004.

[8]Youn-Kwon Jung and Bomson Lee "Dual-Band Circularly Polarized Microstrip RFID Reader Antenna Using Metamaterial Branch-Line Coupler" *IEEE transactions on antennas and propagation*, vol. 60, no. 2, February 2012.

[9] "Microwave Engineering" by David M. Pozar.

Author's Profile

R.Gayathri obtained her Bachelor Degree specialized in Electronics and Communication Engineering at PSNA college of engineering under Anna University Chennai. Currently, she is pursuing Master degree in Communication Systems at K.Ramakrishnan College of Engineering under Anna University, Chennai, Tamilnadu, India. Her research areas includes microwave passive devices, microstrip patch, network security.
E-mail: gayathriyaso@gmail.com

U.SURENDAR. completed Bachelors degree in Electronics and Communication Engineering and Masters in Communication Systems from Anna University in 2011 and 2014 respectively. Presently working as Assistant Professor, ECE Dept. in K. Ramakrishnan College of Engineering, Trichy. He has published papers related to RF devices in international Journals and presented papers in International Conferences.His research areas includes RF antennas and devices, Metamaterials.
E-mail: surendarsuriya@outlook.com