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CSRR Loaded Microstrip Transmission Line with Stop band Characteristics

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Abstract – In this project, square shape vaselogo material also known as metamaterials is used to design the proposed microstrip transmission line. The metamaterials are artificial materials reflected by characteristics generally not present in nature. Metamaterial elements particularly used Split ring resonator and Complementary split ring resonator for simulation. A Complementary Split Ring Resonator (CSRR) Defected Ground Structure (DGS) is designed and etched on the ground plane mainly to reduce the coupling effect. The proposed CSRR loaded antenna is designed at height of 1.6 from ground plane for the operating frequency of 1-10GHz. The structure is designed on FR4 substrate and simulated using CST Microwave Studio. The simulated output of proposed structure produces three stop bands such as from 2.19GHz to 2.35GHz, 3.47 GHz to 3.8 GHz and 5.89 GHz to 6.33 GHz with resonant frequencies of 2.27GHz, 3.67GHz and 6.11GHz and insertion loss of -14.24 dB, -33 dB and -37 dB respectively. The proposed antenna is fabricated and analyzed with network analyser which found applications in filters with enhanced performance and miniaturization.

Index Terms – Metamaterials, SRR, CSRR, Vaselego Materials, CST Software, Microstrip line.

1. INTRODUCTION

Printed circuit board technology is used to design Microstrip line, a type of electrical transmission line. It is used to transmit microwave frequency signals. It consists of three layers namely conducting strip, dielectric substrate and ground. Dielectric layer called the substrate separates the conducting strip from a ground plane. Microstrip transmission line have unique characteristics and attractive features such as low profile configuration , light weight, compact in weight and low fabrication cost. This has major drawback of low power capacity, higher losses, low gain and narrow bandwidth. The drawback of microstrip line is overcome by using metamaterial.

Metamaterials are artificial structures designed to have unique properties not found in common materials. The electromagnetic properties of Metamaterials can be changed to something beyond one which is found in future. This word is a combination of "Meta" and "Material", Meta is a Greek word which means something beyond, altered, or changed. Metamaterials with negative permeability (μ) and permittivity (ε), are called as left handed materials. Metamaterial was first introduced by Victor Veselago in 1940. He discovered the negative permeability and negative permeability property of metamaterials. Prof. John Pendry(1943) suggested the practical method for making metamaterials in 1999. Wireless communication systems widely used Planar metamaterial structure based microstrip antennas . The end result produced here is good radiation pattern of the antenna with reduced size, increase in bandwidth and multiple resonant frequency.

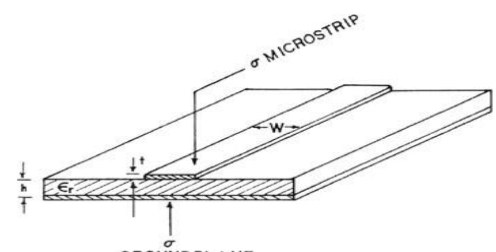

Fig: 1. Microstrip line structure

Split ring resonator and Complementary split ring resonator are mostly used for metamaterial elements simulation. A split ring resonator is an artificially produced structure common to metamaterials. Desired magnetic susceptibility (magnetic response) can be produced in many types of metamaterials up to 200 terahertz. The SRR was first proposed by J. B. Pend for achieving negative value of permeability in resonant particle type matematerial substrate. The Split Ring Resonator (SRR) and its complementary structure, known as Complimentary Split Ring Resonator (CSRR) are widely used in this design. F. Falcon, at first reported about CSRR. Duality and complementary principles were used to obtain negative value of the permittivity(E) in a planar structure at a finite narrow band to derive CSRR from SRR.

2. LITERATURE SURVEY

In the year 1943 J. B. Pendry, A. J. Holden, proposed "Magnetism from Conductors and Enhanced Nonlinear Phenomena", which describes the theory of non magnetic conducting sheet exhibits an effective permeability. This investigation also reveals the effect of metallic rod and split rings on the patch or conducting medium.

Amir. Bazrkar et al proposed, "Miniaturization of Rectangular Patch Antennas partially loaded with μ-Negative Metamaterials". It describes a partially loaded rectangular patch antenna by a metamaterial which operate as μ–negative metamaterials (MNG). The parameters like radiation pattern and return loss of the conventional rectangular patch antenna and the μ-Negative Metamaterials loaded Patch antenna are measured. The antenna that was to be operated at 6.35GHz made to operate at 1.73 GHz. Thus, the antenna size was reduced by 77%.

H.Nornikman, B.H.Ahmad, " Effect of single complementary split ring resonator structure on microstrip patch antenna design", describes the CSRR on the ground plane for different positions are analyzed.

Y.Lee and Y.Hao,"Characterization of microstrip patch antennas on Metamaterial substrates loaded with complementary split-ring resonator, " A novel design for microstrip patch antenna to operate at dual frequency with complementary split ring resonators (CSRRs). Three CSRR were etched in the conventional patch antenna ground plane to yield the dual frequency. The antenna showed good performance at both the frequencies with major contribution at first operating frequency and minor contribution at second operating frequency. The CSRR is incorporated on the patch to excite the antenna.

3. PROPOSED DESIGN

In the proposed design, a metamaterial-implemented microstrip transmission line is introduced. The metamaterial Antenna is designed for 1-10 GHz with the predetermined formula. Then, a unit cell of CSRR is designed for 1-10 GHz and structure CSRR which acts as metamaterial were introduced in the ground to yield the desired frequencies.

In proposed method, the conventional patch antenna are compared with metamaterial loaded antenna. And the performance is analyzed. In this project, the structure of split ring resonator and Complementary Split Ring Resonator are embedded on the ground. The metamaterial loaded antenna gives the better performance compare with the conventional path antenna. The Return loss, bandwidth, VSWR and radiation pattern are observed for the metamaterial loaded antenna. The proposed antenna design is easy to fabricate, cheap, small size and can easily avoid the problems of microstrip patch antenna at operating frequency.

CSRRs, the complementary of the basic unit cells of metamaterials, are taken out from the ground plane to resonate at 2.27 GHz, 3.64GHz and 6.15 GHz.

The microstrip transmission line antenna is designed by using CST-MWS (computer simulation Technology) software with 1.6 mm height from the ground plane

4. DESIGN ASPECTS

The CSRR loaded transmission is designed with characteristic impedance 50 ohm on dielectric substrate. The microstrip line is designed using commercial software.The Parameters selected for the design are W=3.3mm and L=22.9mm. The dimensions of CSRR are a= 14.315mm, b= 11.45, c= 3.675mm, d= 5.475mm and e=0.5mm.

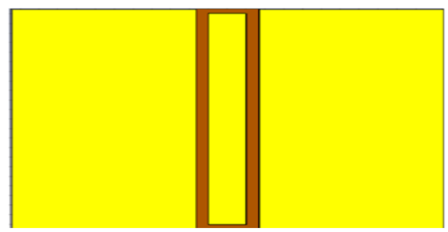

Fig. 2 CSRR loaded transmission line Top view (microstrip line)

After the designing of microstrip line, Complementary split ring resonator (CSRR) on ground plane is designed with the chosen parameters. The open or split part of square shape CSRR is kept parallel to the axis of microstrip transmission Line.

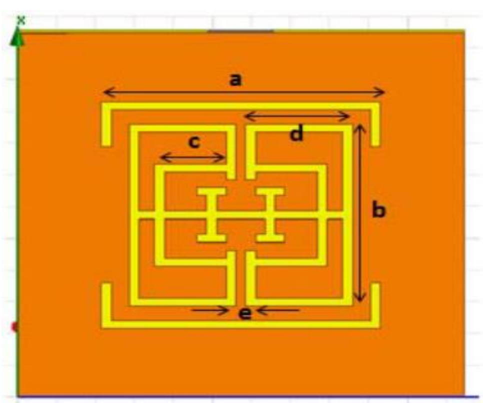

Fig. 3 Modified CSRR loaded transmission line Bottom view (CSRR)

5. SIMULATED RESULTS

After getting the simulated output, the scattering parameters i.e. S(1,1) and S(2,1) were measured and plotted on a graph by the software. Complex SRR structures are used to improve the inference of magnitude response because it increases the capacitance as well as inductance of the resultant equivalent circuit for SRR.The simulation of modified CSRR is done in CST. CSRR results in multi-band out of which bands 2.19 GHz to 2.35 GHz, 3.47 GHz to 3.8 GHz and 5.89 GHz to 6.33 GHz are stop bands. The CSRR structure provides good results with proper bandwidth.

The simulated results indicate the modified CSRR structure resonates at three different frequencies because of its complicated structure and design providing the peak rejection of -14.24 dB, -33 dB and -42 dB respectively. Network analyser is used for testing the fabricated prototype of CSRR.

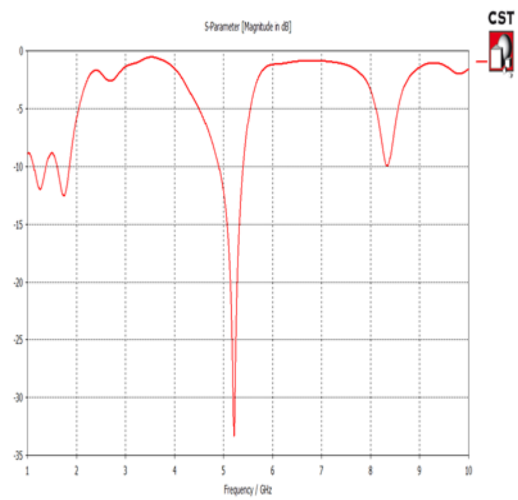

Fig. 4 Graph of S11 parameter

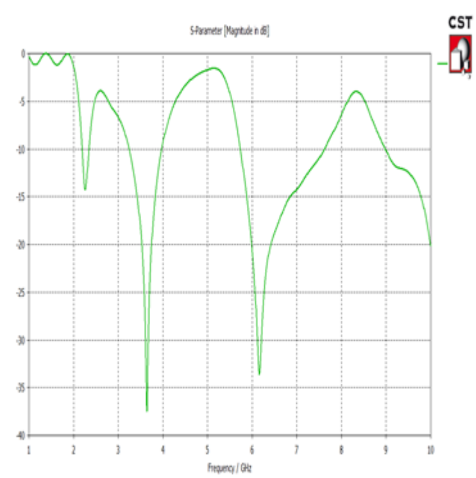

Fig. 5 coupling coefficient

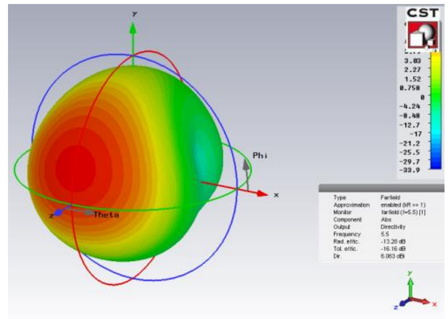

Fig. 6 Radiation pattern of modified CSRR

Fabricated prototype of the microtrip line and the modified CSRR structure

Fig.7 Fabricated CSRR loaded transmission line (a)Top view (microstrip line) (b) Bottom view (CSRR)

Performance is better in the metamaterial loaded antenna compare with the conventional path antenna. The Return loss, bandwidth, VSWR and radiation pattern are measured for the metamaterial loaded antenna. The metamaterial loaded antenna is fabricated and paramaters are compared with simulated results. The proposed microstrip antenna design structure have been analyzed with a commercial software where the measured and simulated radiation characteristics, such as, return loss, VSWR, input impedance, radiation patterns and the surface current density have been taken to study about anenna performance. Also, it should be noted that the proposed antenna size was relatively small to fit in the limited space available in communication system applications circuit board.

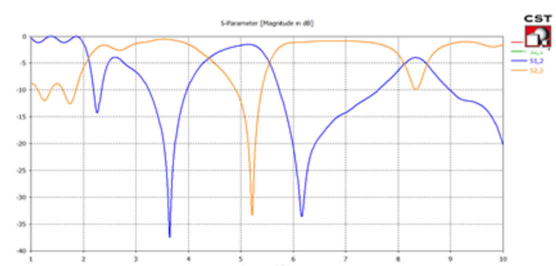

Fig. 8 Magnitude response of Fabricated Modified CSRR

6. CONCLUSION

A highly miniaturized metamaterial antenna design methodology is presented.The proposed design may be implemented in many microwave circuits such as phased array antenna, monopulse comparators and switching circuit. The modified or proposed CSRR produced a multi frequency characteristic which includes three stop bands resonating at 2.27 GHz, 3.61 GHz and 5.71 GHz and two pass bands resonating at 4.97 GHz and 8.1 GHz. The corresponding applications of CSRR transmission line are also used while designing notch filter, stopband and passband filter, diplexer, rat-race coupler and phase shifter.

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