SRR Loaded Multiband Patch Antenna for Wireless Transmission

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Abstract

The proposed rectangular SRR loaded patch antenna designed for operation in the frequency band of 2 GHz to 5GHz increases the gain and directivity of the antenna in comparison to conventional microstrip patch antenna. It consists of two rectangular spilt rings with microstrip line feed. The effect of this structure on the antenna parameters such as return loss, radiation pattern, Smith chart, is also investigated and is improved compared to the conventional rectangular patch antenna without loaded with SRR's. The proposed antenna is simulated using HFSS software and fabricated with satisfactory results.

Keywords — SRR, Metamaterial, Return loss, Smith chart

Introduction

The microstrip patch antenna is widely used in wireless communication have numerous advantages such as low profile, weight and cost etc. (Balanis, 2012). But it suffers from low gain, directivity.. The concept of metamaterial was proposed theoretically by Veselago, 1968 but it was realized experimentally by D. R. Smith et al. in 2000. Metamaterials has unusual electromagnetic properties, which is usually not present in natural substrates (Shen *et al.,* 2001; Chen, *et al.,*1997). Based on the theoretical analysis of microstrip antenna and taking into consideration the size and design parameters, the antenna is simulated, return loss at resonant frequencies are calculated using HFSS . Smith chart provides information about major lobe and its variation. The simulated results are found to be in close agreement with each other in nature. In most basic form, a microstrip patch antenna consists of a radiating patch on one side of a dielectric substrate which has a ground plane on the other side. For good antenna performance a thick dielectric substrate having a low dielectric constant is desirable since this provides better efficiency, larger bandwidth and better radiation (Williams, 1992). The patch usually fed along the centerline to the symmetry and thus minimizes the excitation of undesirable modes.

This paper presented a new design of rectangular patch antenna which is able to improve the antenna performance. The technique that is used in the suppression of harmonics are inserting of two rectangular SRR (Split Ring Resonator) in the patch (McLean and Tatsuo, 1992; Pozar, *et al.,* 2000). The patch antenna shows return loss values of 11.5 dB at 2.32 GHz, 11.5 dB at 3.11 GHz and 11 dB at frequency of 4.62 dB and suppress all the harmonics up to -1dB. The proposed antenna is fabricated on FR4 substrate with the two rectangular split rings.

Antenna Design

The proposed rectangular metamaterials based antenna with microstrip line feed is shown in Figure 4.The microstrip patch antenna consists of three layers named ground plane, patch, and feed port. The proposed microstrip patch antenna is realized on FR4 substrate with å =0.9 and thickness of 2.8 mm and ground plate and radiating patch is made of copper. The dimension of radiating patch is calculated in the following equations, where L, W is length and width of radiating patch. Here, f0 is the Resonance frequency, år is the relative permittivity of the dielectric substrate, 'c' is defined as the speed of light: 3 x 108 m/sec and h is the thickness,

a) Calculation of the Width (W)

$$W = \frac{c}{2 f_o \sqrt{\frac{(\varepsilon_r + 1)}{2}}}$$

b) Calculation of the Effective Dielectric Constant-

$$\varepsilon_{eff} = \frac{\varepsilon_r + 1}{2} + \frac{\varepsilon_r - 1}{2}\left[1 + 12\frac{h}{W}\right]^{-\frac{1}{2}}$$

c) Calculation of the Effective length

$$L_{eff} = \frac{c}{2 f_o \sqrt{\varepsilon_{eff}}}$$

d) Calculation of the Effective Extended length

$$\Delta L = 0.412h \frac{(\varepsilon_{eff} + 0.3)\left(\frac{W}{h} + 0.264\right)}{(\varepsilon_{eff} - 0.258)\left(\frac{W}{h} + 0.8\right)}$$

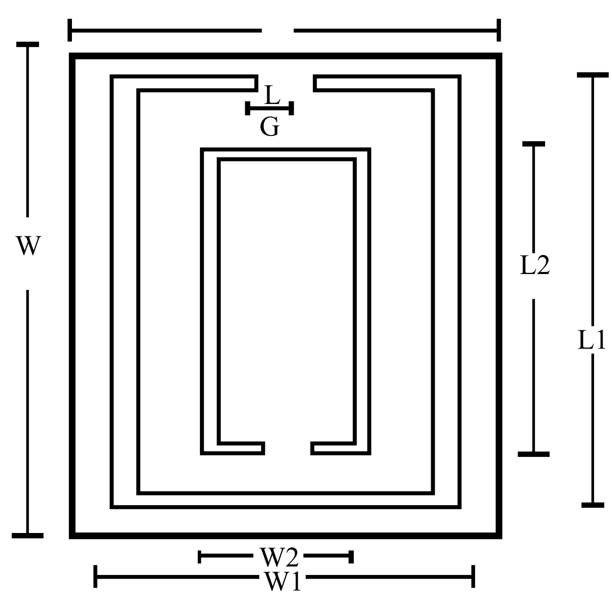

Figure 1: Dimensions of SRR loaded patch antenna

The rectangular patch is designed using two split rings and a feed line is attached to the patch. The two patches reduces the desired frequency. The patch antenna have been calculated by (W×L) as (23.69mm × 30.71mm) which represents the outer patch 10 polylines are used to make the two split rings which has different properties of its own. The dimensions of the entire microstrip patch antenna are-

Table 1: Dimensions of SRR loaded patch antenna

L	W	L1	W1	L2	W2	G
30.71 mm	23.69 mm	25.357 mm	0.72 mm	15.00 mm	4.28 mm	0.7 mm

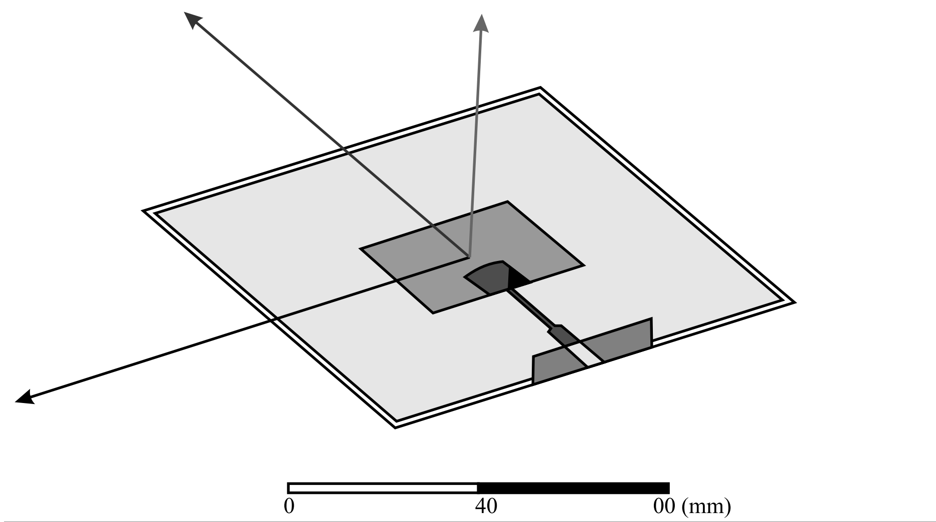

Figure 2: Design of rectangular patch with feed line

Results and Discussion

Split Ring Resonators (SRR) are resonance structures that are used widely in electromagnetic. For example, these structures are used in periodic configurations to design metamaterial structures. Also, because of their resonance behavior SRRs and CSRRs can be used to design slow wave transmission lines, phase shifters, various kinds of microstrip filters, etc. (Mathaei et al., 1980; Bozzeti et al., 2003; Huang, et al., 2005) The circuit model of SRR elements in the waveguide is parallel capacitance and inductance, placed in series in the transmission line and, therefore, these elements can be used to design patch antennas for wireless applications. Split Ring Resonators (SRR) and Complementary Split Ring Resonators (CSRR) are widely used to design metamaterial structures. These structures when excited by suitable electromagnetic fields have resonance behavior and show unusual properties such as negative permeability and permittivity near the resonance frequency region.

The following are results and analysis the each result. The gain of the proposed multiple-layer with partial substrate removal patch was found to be 4.035 dB. Back lobe of the radiation pattern is quite large due to small ground planes. These can be improved by increasing the area of the ground plane. The gain of a rectangular microstrip patch antenna with air dielectric can be very roughly estimated as follows. Since the length of the patch, half a wavelength, is about the same as the length of a resonant dipole, we get about 2 dB of gain from the directivity relative to the vertical axis of the patch.

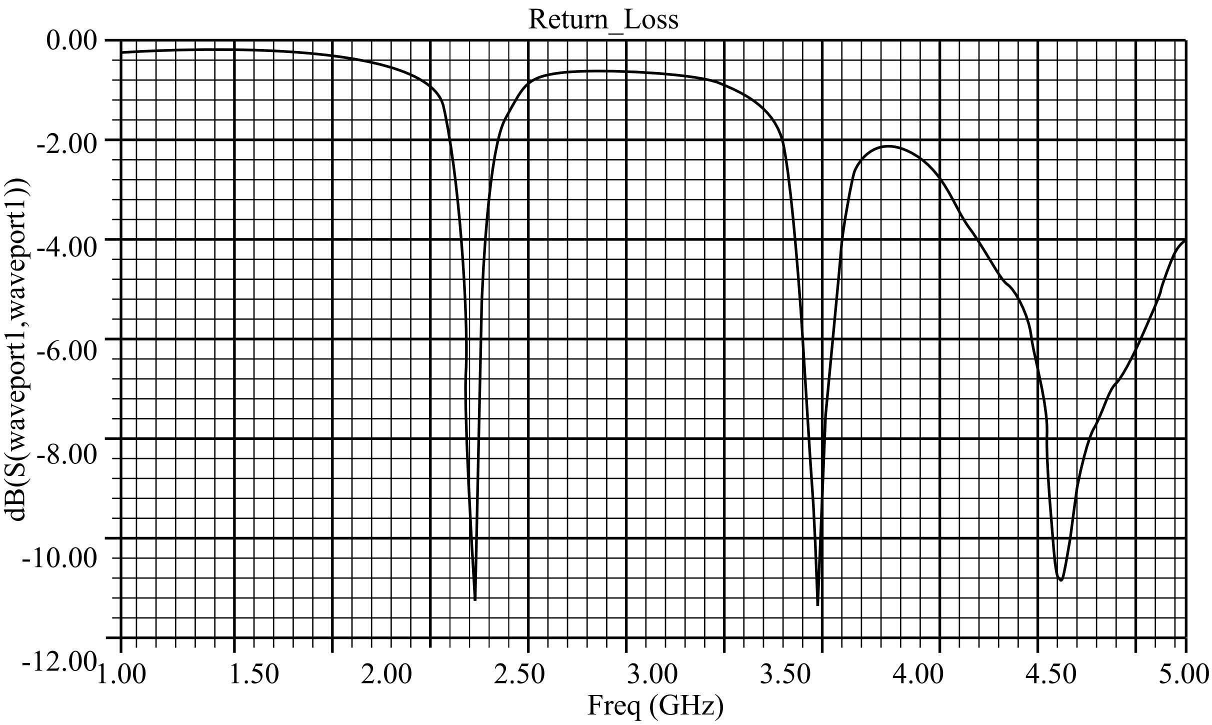

Figure 3 : Return Loss SRS Patch Antenna

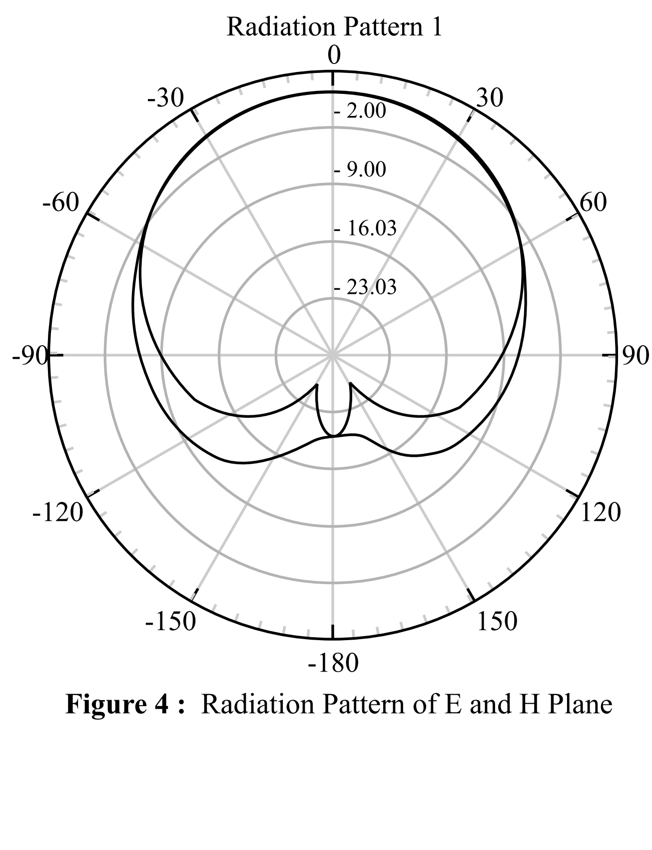

Figure 4 : Radiation Pattern of E and H Plane

In particular, SRR and CSRR structures have been used in the design of antenna because each propagation mode operates as a transmission line and it is possible to use such resonance structures as radiating elements. CSRRs will use to design a exciters in the L-band. The circuit model of these elements in the waveguide is similar to parallel L and C components that are placed in parallel form in a transmission line. Resonance frequency and bandwidth of LC resonance circuit are adjusted by proper choice of the CSRR geometrical dimensions. Then, to design the miniaturized patch antenna these structures are combined with proper admittance inverter. The admittance inverter is designed such that its electric length is very smaller than the conventional $\lambda/4$ transmission line.

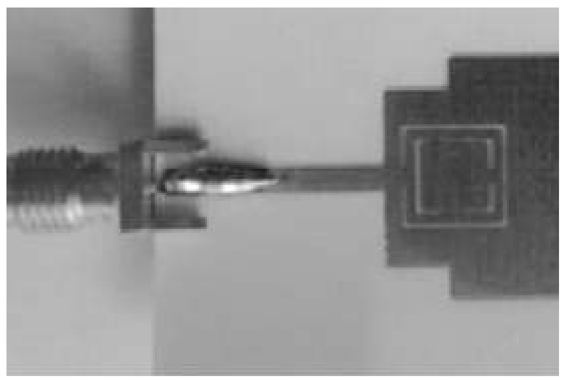

Figure 5 : Fabricated Antenna with two spit rings

Conclusion

Based on the theoretical analysis of the rectangular shape microstrip antenna and taking into consideration the size and design parameters, the antenna is simulated, return loss at resonant frequencies are calculated using HFSS. VSWR found to be less than 2 dB. Smith chart provides information about major lobe and its variation. The proposed antenna is fabricated on FR4 substrate with the two rectangular split rings. The return loss can be measured with network analyzer. The return loss value can be further increase by introducing a U shape slot in the ground plane or multiband antenna can also be realized by any other technique such as fractals.

References

Balanis, C.A., 2012. Antenna theory: Analysis and Design. John Wiley & Sons.

Bozzeti, M., D'Orazio, A., Petruzzelli, V., Prudenzano, F., Renna, F. 2003. Tapered photonic bandgap microstrip low pass filter:design and realization, Microwaves, Antenna and Propagation, IEEE proceedings, 150 (6), 459-462.

Chen, E., Stephen, Y., Chou, L. 1997. Characteristics of Coplanar Transmission Lines on Multilayer Substrate: Modeling and Experiments, IEEE Trans. Microwave Theory Tech. MTT-45,939-945.

Huang, H., Mao, J., Li, Xiao-Chun, Zhengfan Li, 2005. A photonic bandgap microstrip filter based on YBCO superconducting film", Applied Superconductivity, IEEE transactions, 15(3), 3827-3830.

IE3D Software Release – 8, Developed by M/S Zeland Software Inc.

Mathaei, G., L., Young, L., Jones, E., M., T. 1980. Microwave Filter, impedance matching networks and coupling structures, Artech House, Dedham, Mass.

McLean, J., S., Tatsuo, I. 1992. Analysis of a New Configuration of Coplanar Stripline, IEEE Trans. Microwave Theory Tech. MTT-40, 772-774.

Pozar, D., M. 2000. Microwave Engineering (2/e), John Wiley.

Shen, J., Hong, G., Lancaster, M., J. 2001. Microstrip Filters for RF/ Microwave Applications. John Wiley & Sons Inc.

Veselago, G. 1968. The Electrodynamic Of Substances With Simultaneously Negative Values Of And M, Physics-uspekhi, 10(4), 509-514.

Williams, F., 1992. Novel Coplanar Stripline: Design, Characterization and Applications, IEEE Trans. Microwave Theory Tech Symposium, MTT-S, Digest, 214.