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A Compact Design of Ultra Wide Band Antenna with 5.5GHz to 5.9GHz Dual Band Characteristics

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Abstract— ***An innovative and compact design of microstrip antenna is introduced and presented in this Paper. The proposed patch antenna in the present paper is embedded with the square split ring resonator, Which is placed inside the circular substrate. A co-axial probe feed is used to excite the patch antenna. The proposed patch antenna is designed, and simulated using ansoft HFSS simulation software. Incorporation of square SRR inside the substrate can produce sub-wave length resonant frequency. Various antenna parameters observed in this paper are VSWR, Return loss, Resonant frequency and gain. The proposed antenna produces improved results in the frequency band from 5.5GHz to 5.9GHZ. The results obtained are return loss-15dB, VSWR 1.8 and antenna gain 6.47dBi.***

Keywords: square SRR, gain, metamaterial, micro strip antenna, return loss, VSWR .

I. INTRODUCTION

Revolutionary increase in wireless communication demands high gain and large band width antennas, Covering all range of frequencies. The growth in technology needed compact yet high performance antennas. Antennas became an important link in today's communication world for effective information sharing. The information shared by armed forces using communication devices needs a compact patch antenna with good resolution. The proposed antenna works in C band. C band is a radio frequency band which extends from 4 to 8 GHz. The designed antenna works from 5.5 GHz to 5.9 GHZ which is highly suitable for military radio communication. Ultra wide band antennas have wide range of innovative applications such as sensor data collections, tracking applications, medical engineering fields etc. Metamaterials are having properties which are not usually found in natural materials. They have negative refractive index. Metamaterials along with the microstrip patch antenna can improve antenna radiation characteristics and reduce size of the antenna. Metamaterials are made from assembles of multiple elements fashioned from composite materials such as metals or plastics[1]. The materials are arranged in repeating patterns. Meta materials are designed as arrays of electrical conductive elements with suitable reactive element characteristics. Square split ring resonator is one type of metamaterial.

Table.1. Classification of material on the basis of μ and ε

ε<0,μ>0. Single negative metamaterial . Evanescent decaying waves.	Ɛ>0,μ>0 Conventional Material. Wave Propagates in forward direction
ε<0,μ<0 Double negative metamaterials. Backward wave is produced	ε>0,μ<0 split ring resonator. Evanescent decaying waves

A square split ring resonator is artificially produced material which acts as meta material. It can generate desired magnetic susceptibility. Unlike natural materials, square split ring resonator produces strong magnetic coupling to an applied electromagnetic field. Negative permeability can be obtained with a periodic arrangement of square split ring resonator. Microstrip patch antenna designed with a planer thin metamaterial based on a near zero refractive index results in a high gain antenna [2]. Microstrip antennas have wider chances in WLAN and WIMAX applications due to their compact design [3]. Many methods tested successfully and simulated to improve the gain of patch antenna. Gain can be improved by the addition of a superstrate over a substrate [4]. It is also found that the gain can be improved by the reduced surface wave antenna or parasitic element [5-7].An electromagnetic band gap structure is also one of the effective method to enhance the antenna parameters.

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This paper introduces insertion of square split ring resonator inside a circular substrate. This methodology allows the possibility of compact antenna design. The paper has different sections and their arrangement is as follows. Section II explains the model of antenna design. Section III discusses on results and its impacts and Section IV concludes the paper.

II. ANTENNA DESIGN

A rectangular microstrip antenna and with a square split ring resonator inside a circular substrate was designed using ansoft HFSS simulation software. A circular substrate with radius 23.1 mm and height 2mm was created on a rectangular patch with dimensions 15mm X 20mm was placed with co-ordinate position x=-7.5, y=-10 and z=2. Ground cut out with radius 1mm was created to feed the patch.

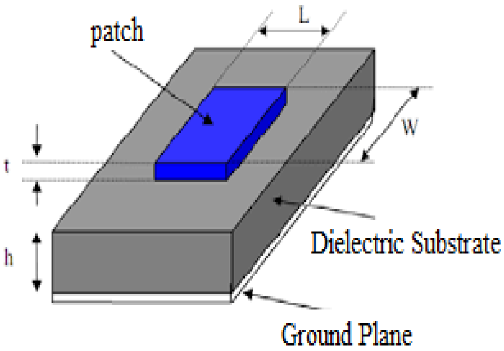
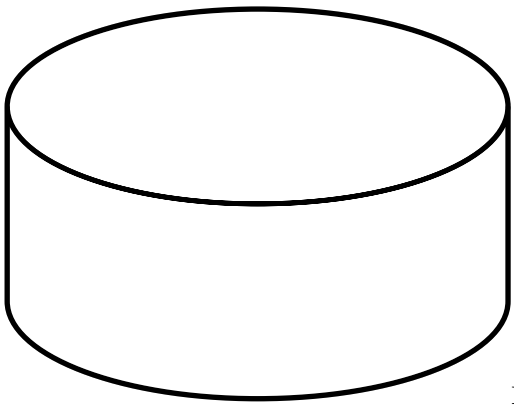


Fig. 1. Basic structure of Rectangular patch antenna

R = 23.1mm



H= 2 mm

Fig. 2. Substrate Dimensions

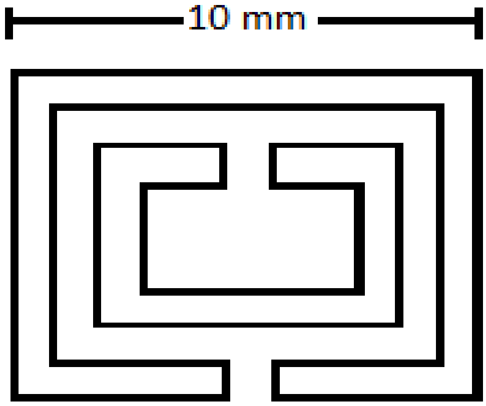


Fig. 3. Square Split Ring Resonator

Square split ring resonator was created with the co-ordinate entry fields x=5, y=-5 and z=1 with dimensions 10mm X 10mm in which slots were placed to complete square split ring resonator. In Fig 3 the gap between the slots and width of the slots is equal to 1mm.

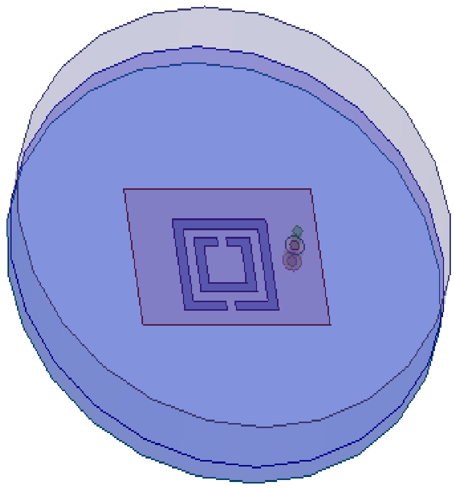


Fig. 4. Simulation Structure of the Patch antenna with SRR

2.1 Patch width calculation

$$W = \frac{u_0}{2 f_{rc}} \sqrt{\frac{2}{\varepsilon_r + 1}} \rightarrow (1)$$

Eq. 1 Explains the calculation of width of the patch. In this equation μ_o denotes speed of light, f_{rc} denotes the resonant frequency and ε_r denotes the value of dielectric constant of the substrate used.

$$f_r = \frac{u_o}{2L\sqrt{\varepsilon_r}} \rightarrow (2)$$

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Eq. 2 illustrates the calculation of resonant frequency without considering fringing effects. In this equation L indicates length of the patch.

$$f_{(rc)} = \frac{u_o}{2L_{eff}\sqrt{\varepsilon_{reff}}} \rightarrow (3)$$

Eq. 3 Represents the calculation of f_{rc} . In this equation f_{rc} is the resonant frequency. By considering fringing effects, L_{eff} denotes effective patch length and ε_{reff} indicates effective dielectric constant of the substrate.

$$L_{eff} = L + 2\Delta L \rightarrow (4)$$

Eq. 4 depicts the effective length of the patch. In this particular equation ΔL denotes incremental length of the patch due to fringing effects.

2.2 Calculation of ε reff

$$\varepsilon_{reff} = \frac{\varepsilon_r + 1}{2} + \frac{\varepsilon_r - 1}{2}\left(1 + 12\frac{h}{W}\right)^{-\frac{1}{2}} \rightarrow (5)$$

Using Eq. 5 effective dielectric constant (ε_{reff}) can be calculated. In this equation h denotes height of the substrate and w denotes width of the patch.

2.3 Calculation of ΔL

$$\Delta L = 0.412h\frac{(\varepsilon_{reff} + 0.3)(\frac{W}{h} + 0.264)}{(\varepsilon_{reff} - 0.258)(\frac{W}{h} + 0.264)} \rightarrow (6)$$

Eq. 6 depicts, the incremental length ΔL due to fringing effects. In microstrip antenna the radiation occurs due to fringing fields.

III. SIMULATION RESULTS

Proposed patch antenna was simulated using Ansoft HFSS tool and carried out experiments to verify antenna gain , return loss, and VSWR at both frequencies 5.6GHz and 5.9GHz.The patch antenna embedded with SRR was fabricated on RT duroid 5880.

3.1 Return Loss

Fig (5) demonstrates the variation of return loss of the proposed patch antenna. It is poor in the frequency range 1GHz to 5.4GHz and 6GHz to 7 GHz. Return loss is improved at the resonant frequencies 5.5GHz and 5.9GHz. Carried out experiments shows that the return loss is -15dB at the dual band frequencies 5.5GHz and 5.9GHz. S_{11} indicates return loss which defines reflected power.

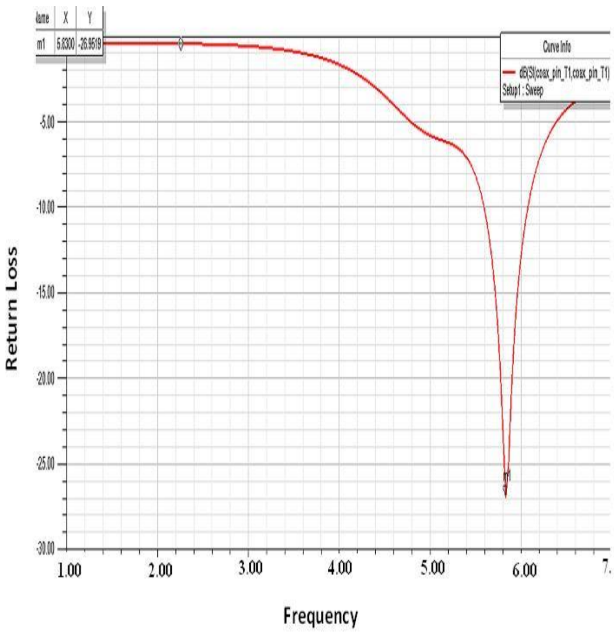

Fig. 5. Simulated Return loss

3.2 Radiation Pattern

The measured two dimensional (2D) radiation patterns are evaluated in azimuthal plane (x-y planes) at resonant frequencies. 2D radiation pattern explains E_θ and E_ϕ components separately. The 2D radiation characteristics are shown in fig (6). 3D radiation pattern indicates overall radiation power and it shows maximum possible gain is 6.47dBi.Radiation patterns demonstrates the spatial distribution of radiated energy.

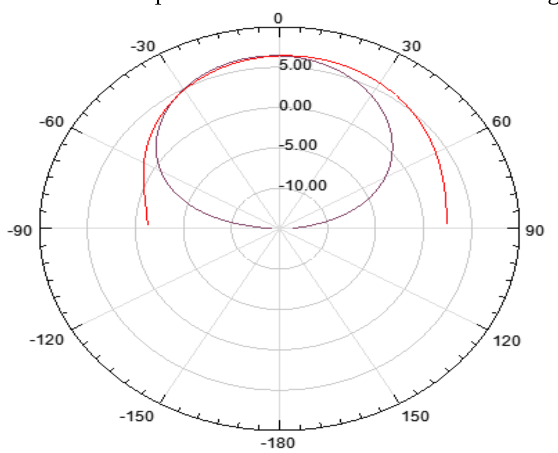

Fig. 6. Simulated E- and H-plane radiation patterns

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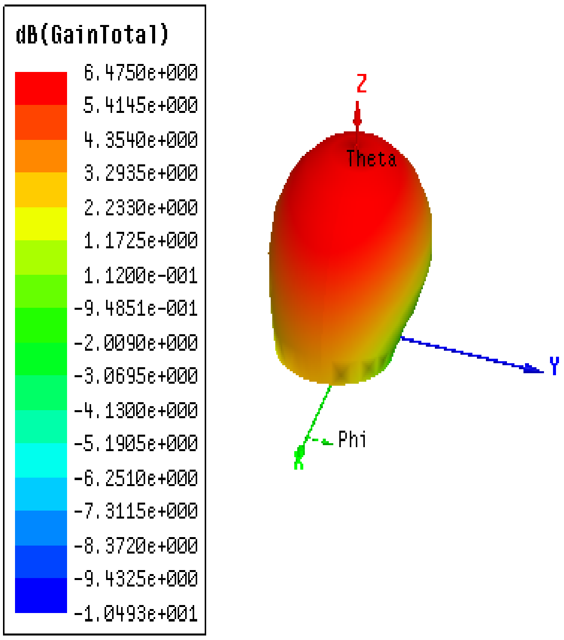

Fig .7. Three-dimensional radiation intensity pattern

The radiation pattern measurements shows that the gain is fairly constant over the frequencies 5.6GHz and 5.9GHz.

3.3 Voltage standing wave ratio

Fig (8) shows the variation of VSWR over frequency range 1GHz to 6GHz.

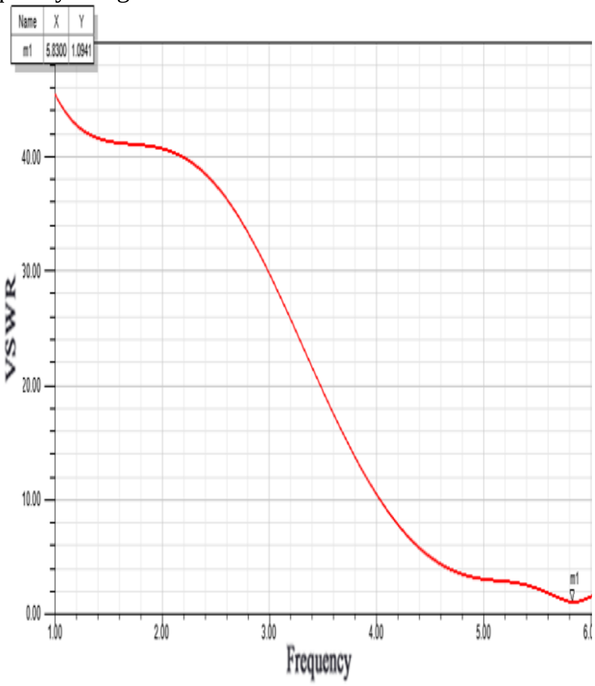

Fig .8. VSWR characteristics

Some energy of the signal is reflected due to impedance mismatches at the input and output of the antenna. The amount of energy reflection can be measured by calculating the value of VSWR. It is the measure of impedance matching of loads. Measurements carried out on VSWR shows that its value is in the acceptable range (VSWR<2). The value obtained for VSWR in the frequency range 5.5GHz to 5.9 GHz is 1.8.

IV. CONCLUSION

A compact design of ultra wide band antenna with 5.5GHz to 5.9GHz dual band characteristics is designed and simulated using ansoft HFSS tool. Incorporation of square SRR not only reduces the size of the antenna but also improves its performance in terms of return loss, VSWR and antenna gain. The proposed antenna shows very good characteristics in the frequency band 5.5GHz to 5.9GHz.The simulated results thus obtained are return Loss -15dB, VSWR 1.8, and Antenna Gain 6.47dBi.These results are found to be best for the proposed antenna in the frequency band 5.5GHz to 5.9GHz.

REFERENCES

1. Constantine A. Balanis, Antenna Theory analysis and design, John Wiley & Sons, Inc., Third Edition.
2. Raoul O.ovedraogo, EdwardJ.Rothwell, Alejandro R.diaz, Kazuko Funchi, Andrew Temme"Miniaturization of patch antennas using a metamaterial-Inspired Technique", IEEE transactions on antennas and propagation, VOL.60, NO.5, May2012.
3. Ji-jun Wanga, Lei-lei Gonga,∗, Yu-xin Sunb, Zhi-pan Zhua, Yan-rong Zhanga "High-gain composite microstrip patch antenna with the near-zero-refractive-index metamaterial",Optik 125 (2014) 6491–6495.
4. Jackson David R, Alexopoulos Nicolaos G. Gain enhancement methods for printed circuit antennas. IEEE Trans Antennas Propag 1987;33:976–87.
5. Kokotoff DM, Waterhouse RB, Britcher CR, Aberle JT. Annular ring coupled circular patch with enhanced performance. Electron Lett 1997;33:2000–1.
6. Llombart N, Neto A, Gerini G, de Maagt P. Planar circularly symmetric EBG structures for reducing surface waves in printed antennas. IEEE Trans Antennas Propag 2005;53: 3210–8.
7. Part Y-J, Herchlein A, Wiesbeck W. A photonic bandgap (PBG) structure for guiding and suppressing surface waves in millimeter-wave antennas. IEEE Trans Antennas Propag 2001;49:1854–7.
8. Seungbae Park, Cheolbok Kim, Youngho Jung, Hosang Lee, Dongki Cho, Munsoo Lee "Gain enhancement of a microstrip patch antenna using a circularly periodic EBG structure and air layer" Int. J. Electron. Commun. (AEÜ) 64 (2010) 607–613.
9. R. Best, "On the performance properties of the Koch fractal and other bent wire monopoles," *IEEE Trans. Antennas Propag.*, vol. 51, pp. 1292–1300, Jun. 2003.

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Journal Website: www.ijitee.org

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10. S. Xiao, B.-Z. Wang, W. Shao, and Y. Zhang, "Bandwidth-enhancing ultralow-profile compact patch antenna," *IEEE Trans. Antennas Prop.*, vol. 53, no. 11, pp. 3443-3447, 2005.
11. Y. Jia, Y. Liu, S. Gong, "Slot-coupled broadband patch antenna," *Electronics Letters*, vol. 51, no. 6, pp. 445-447, 2015.
12. F. Yang, X.-X. Zhang, X. Ye, and Y. Rahmat-Samii, "Wide-band E-shaped patch antennas for wireless communications," *IEEE Trans. Antennas Prop.*, vol. 49, no. 7, pp. 1094-1100, 2001.
13. G. Rama Krishna, Dr. N.Venkateswara Rao G. Anil Kumar a design of double swastika slot microstripAntenna for ultra wide band and WiMAX applications, International Journal on Cybernetics & Informatics (IJCI) Vol. 5, No. 4, August 2016
14. J.G.joshi, shyamS.pattnaik, and S.devi, "Metamaterial Embedded Wearable rectangular Microstrip Patch Antenna" Research Article, Hindawi publishing corporation, international journal of antennas and propagation, volume 2012, Article ID 974315.
15. R. W. Ziolkowski, "Design, fabrication, and testing of double negativemetamaterials," IEEE Transactions on Antennas and Propagation, vol. 51, no. 7, pp. 1516–1529, 2003.

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