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Design of Compact Monopole Antenna loaded with SRR for Wi-MAX/Wi-Fi/Satellite Communication

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ABSTRACT

A design and development of a simple monopole antenna based on metamaterial resonators for multiband operation is presented. The antenna operates in the frequency range of 2.97 GHz to 4.25GHz, 4.6 GHz to 5.24 GHz, 7.15 GHz to 10.41GHz, with impedance bandwidth of 35.45%, 13.01% and 37.13%, respectively. The split ring resonators (SRR) acts as metamaterial resonators which are embedded on the planar monopole that resonates for multiple frequency bands. The antenna shows the good impedance matching and radiation performance. The measured result is agreed well with the simulated result. The proposed antenna finds their application in the different wireless communications such as Wi-MAX, Wi-Fi and Satellite Communication.

I. Introduction

In the recent years, the multiband or broadband antennas have been in high demand for the modern communication systems such as worldwide interoperability for microwave access (Wi-MAX) , Wi-Fi, satellite applications. There is also another challenge to design a single antenna for different application. Planar microstrip patch antennas were used earlier for multiband as well as wideband operation by using various techniques like slot cutting [1], shortening pins [2], Meander line [3]. Although conventional microstrip antennas are low-profile and efficient, but possess narrow band-width. The monopole antennas are very popular candidates for the current communication system because of low cost and process simplicity [4, 5]. The multiband operation can also be obtained by use of metamaterial structure [6, 7]. In [8], a triple band very compact asymmetric monopole antenna with an electrically coupled split ring resonator (SRR) is presented. The operating frequencies cover the worldwide interoperability for microwave access (Wi-MAX), wireless local area network (WLAN), and Tagometry (Telemetry using RFID) applications. The asymmetric monopole is fed by a microstrip line, whereas the SRR is inductively coupled with the radiating element which gave triple band of resonances. The electric field-coupled SRR yields its resonance at 3.37 GHz in addition to the fundamental wideband resonances obtained by the asymmetric monopole. The simulated operating bands 3.37 GHz, 5.62 GHz, 8.26 GHz are suitable for Wi-MAX, WLAN and RFID bands respectively. Metamaterials are manmade, artificial and have the periodic structure with properties that do not exist in nature. The properties of metamaterials depend upon structure rather than composition. Use of Metamaterials can result in reduced size of antenna and helps the antenna to cover less area and also provides equal or better performance. One of the major advantages to this technology is that it can be easily printed on PCB board and costs significantly less in bulk production [9-10].

One of the most common elements of metamaterial is split ring resonator (SRR). SRR is a nonmagnetic conducting unit, in which and its periodic array yields negative effective magnetic permeability with an enhanced magnitude when the frequency of the incident electromagnetic field is close to the SRR resonance frequency. The resonance frequency of the SRR depends on its geometrical parameters.

SRR are electrically small LC resonant elements with a high quality factor at microwave frequency [11].In [12], a microstrip-fed compact multi-band slot antenna using a single split-ring resonator (SRR) is presented. The SRR acting as a loading element introduces multiple lower-order resonances in the antenna, which can be controlled by varying the SRR's dimensions as well as its position with respect to the arm of the slot, without altering the geometry of the radiating slot. A dual-band circularly polarized (CP) microstrip line fed slot antenna using a set of split ring resonators (SRRs) is proposed in [13] and the antenna operates at 3.1 and 4.7 GHz, which is fabricated and tested. The experimental results show the -10-dB impedance bandwidths of 400 MHz in both the bands.

This paper presents a simple method to design of an antenna by loading a pair of SRRs on the opposite surface of microstrip fed monopole antenna. The rectangular SRRs are placed symmetrically on the back side of the printed monopole antenna. It is acts as a notch frequency determined by the SRR's geometrical dimensions. The suppression of the radiation at the notch frequency is due to the effect of a strong magnetic coupling of the propagating EM signal with the SRR. By loading multiple SRR pairs with varying dimensions, the proposed antenna shows multiple resonances at different frequencies. The antenna shows the triple band behavior in the frequency range of 2.97 GHz to 4.25GHz, 4.6 GHz to 5.24 GHz, 7.15 GHz to 10.41GHz, with impedance bandwidth of 35.45%, 13.01% and 37.13%, respectively.

II. Antenna Structure

Figure1 shows the proposed antenna design and its dimensions. The overall size of the antenna is 34mm x 35 mm

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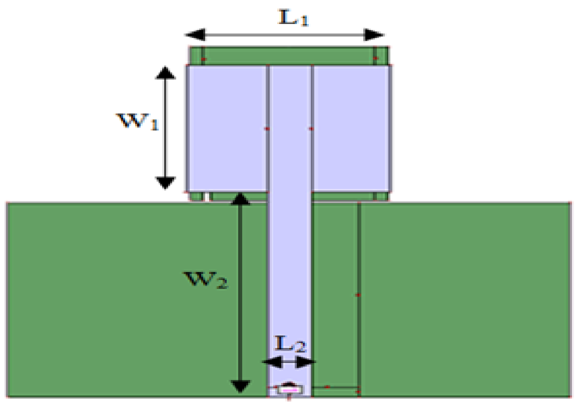
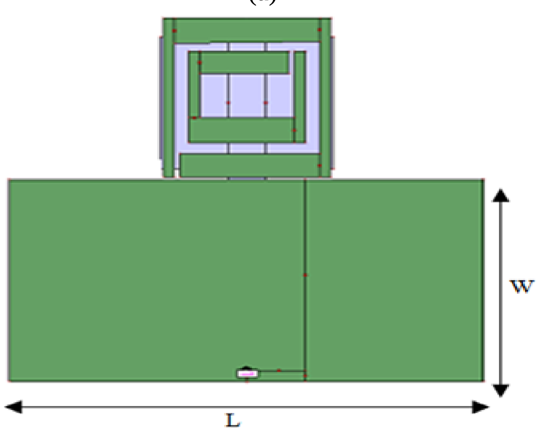
x0.8 mm. It is fabricated over FR4 epoxy with dielectric constant (ε_r) of 4.4 and loss tangent (tanδ) of 0.02. The rectangular monopole is printed on the lower side of substrate of the antenna. The rectangular patch is fed by microstrip line. Both, the patch and microstrip line are etched on the same side of the substrate. In the proposed antenna design, the fundamental band is obtained by the rectangular monopole and other resonant bands are obtained by embedding the two square shaped split ring resonators structure in the antenna. The antenna consists of a rectangular radiation patch and a rectangular ground plane that plays an important role in the broadband characteristics of this antenna because the electromagnetic coupling effects between the patch and the ground plane improve its impedance bandwidth. When the SRR is excited by an external time-varying magnetic field directed along the SRR axis, the cuts on each ring force the electric current to flow from one ring to another across the slot between them, taking the form of a strong displacement current. The slot between the rings therefore behaves as a distributed capacitance, and the whole SRR has the equivalent circuit shown in Figure 1(c), where Ls is the SRR self-inductance and Co/2 is the capacitance associated with each SRR half. The total capacitance of this circuit is the series connection of the capacitance of both SRR halves, that is, Co/4. Therefore, the resonance frequency ω_o is given by

$$\omega_0 = \frac{2}{\sqrt{L_s C_0}}$$

The size of the inner-square should be adjusted to determine the triple band frequency of antenna with other parameters being fixed. By properly tuning the dimensions of SRR and spacing to semi ground plane and SRR embedded plate, the proposed antenna gives three different operating bands. The optimized dimensions of the proposed antenna are given in table 1.



(a)



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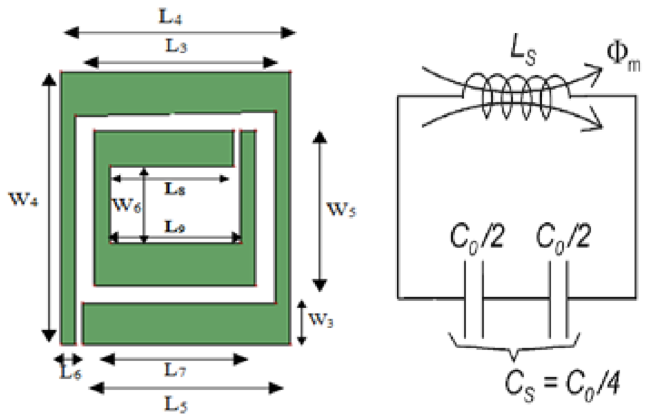
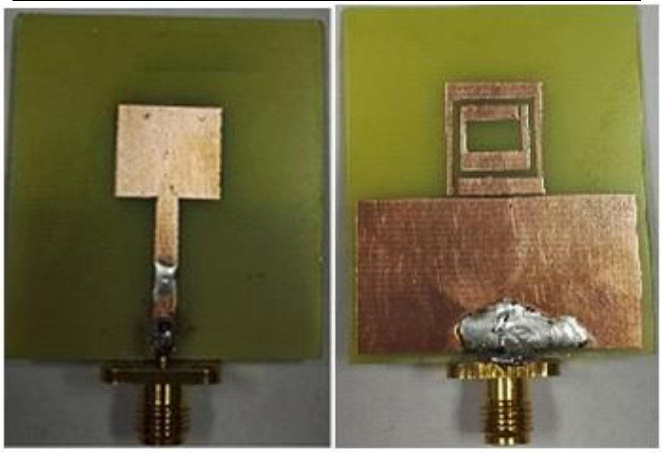


(c)

Fig1. Proposed antenna (a) top view (b) bottom view (c) equivalent circuit of SRR.

Table1.Antenna Parameters.

Parameter	**L**	**L_1**	**L_2**	**L_3**	**L_4**	**L_5**	**L_6**
Values(mm)	34	12.4	2.65	10.4	12	10.8	0.8
Parameter	L_7	L_8	L_9	L_9	L_{10}	W	W_1
Values(mm)	8.4	6.4	6.8			19	12.4
Parameter	W_2	W_3	W_4	W_5	W_6	W_7	
Values(mm)	20	2.2	15	8.6	4.2		



(a) (b)

Fig 2.Fabricated structure of the proposed antenna. (a) Top View (b) Bottom View.

III. Results and Discussions

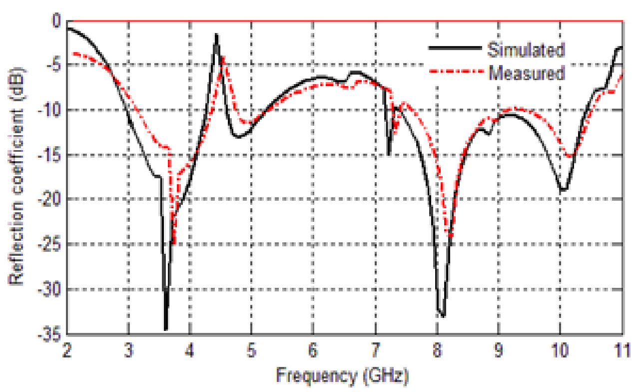


Fig3. Reflection coefficient versus frequency of the proposed antenna.

Figure 2 shows the fabricated multiband meta-material based monopole antenna. The multiband operation has been obtained due to the capacitances engendered by the voltage gradients between the SRR gaps and the inductance produced by the current flowing along SRR coils. The reduced ground structure has been employed so as to reduce harmonics.

It is noted that the inner opening ring and outer opening ring have just 180 degrees. Figure 3 shows the measured and simulated reflection coefficient versus frequency. The results show that the proposed antenna can offer triple band operation. From the figure, it is clear that first band operates in the frequency range of 2.97 GHz to 4.25GHz. This band can be used for the Wi-Max and for the downlink frequency of C- band satellite communication (3.7GHz-4.2GHz).The second band operates in the frequency range of 4.6 GHz to 5.24 GHz and this band is suitable for the 5 GHz Wi-Fi, while the third band operates in the frequency range of 7.15 GHz to 10.41GHz and can be used for the down link frequency (7.2GHz- 7.75GHz), uplink frequency (7.9GHz -8.4 GHz) of X-band satellite communication and traffic light detector at 10.4GHz.

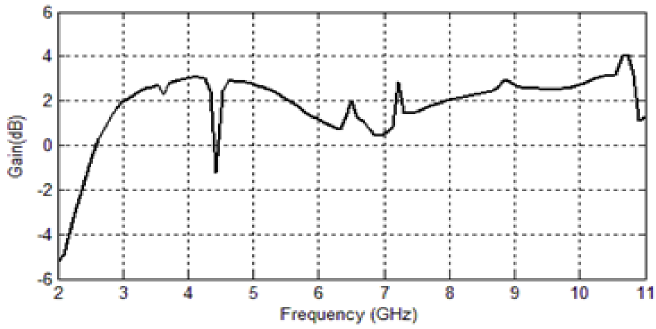
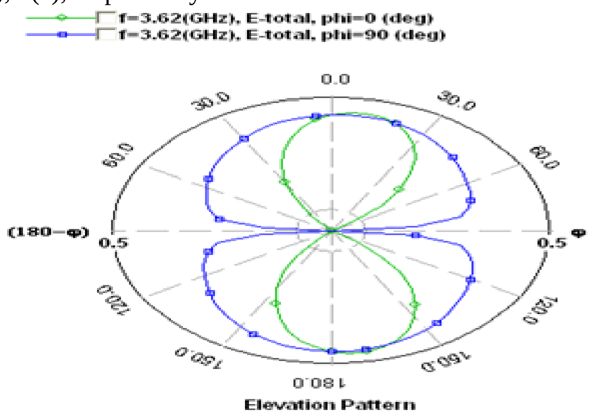
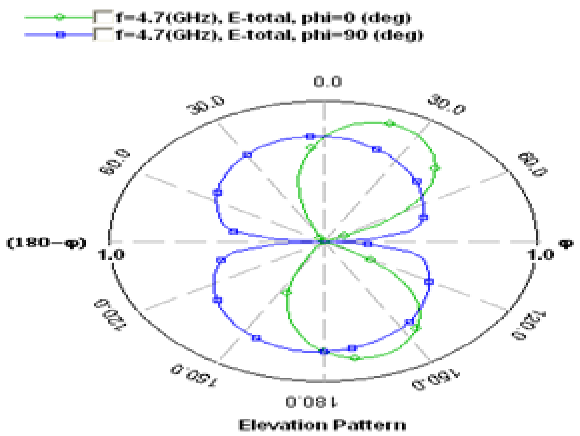


Fig4. Simulated gain versus frequency of the proposed antenna.

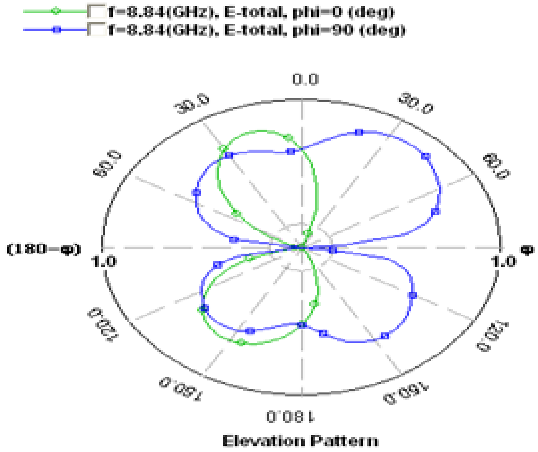
Figure 4 shows simulated gain the proposed antenna. It is observed that the antenna keeps a gain of about 2.8dBi, 2.75dBi and 2.0dBi at the Centre frequencies of the three bands, respectively. The radiation pattern at the Centre frequencies of the three bands are given in the figure 5(a), 5(b), 5(c), respectively.



(a)



(b)



(c)

Fig5.Radiation pattern at centre frequenciec of the proposed antenna .5(a) at 3.61GHz, 5(b) at 4.92 GHz, and 5(c) at 8.78GHz.

IV. Conclusions

Metamaterial embedded on the monopole plane with multiband operation for Wi-MAX/Wi-Fi/Satellite Communication has been presented. The use of SRR metamaterial structure produces the triple band operation out of which two bands show the wideband operation. The antenna operates in the frequency range of 2.97 GHz to 4.25GHz, 4.6 GHz to 5.24 GHz, 7.15 GHz to 10.41GHz, with impedance bandwidth of 35.45%, 13.01% and 37.13%, respectively. The proposed antenna is useful for the different applications such as Wi-MAX at 3.5 GHz, public safety WLAN (IEEE802.11y) at 4.9 GHz, IEEE 802.11ac Wi-Fi at 5 GHz has the expected WLAN throughput of at least 1 Gigabyte/s, C-band and X- satellite communications and for traffic light detector at 10.4GHz.

References

Lee, K. F., K. M. Luk, K.F. Tong and R. Q. Lee, “Experimental and Simulation studies of coaxially fed U-slot rectangular patch antenna”, *IEEE proc. Microwave antenna propagation*, Vol. 144 ,no 5, pp 354-358 ,1997.

Waterhouse, R. B.. Small microstrip patch antenna. Electron Letters, Vol. 31 No. 8, 604–605, 1995.

Kuo, J.-S., & Wong, K. L. A compact microstrip antenna with meandering slots in the ground plane. *Microwave and Optical Technology Letters*, Vol. *29 No.*2, 95–97, 2001.

Syed Muzahir Abbas, Yogesh Ranga, Anand K. Verma, and Karu P. Esselle, “A Simple Ultra Wideband Printed Monopole Antenna With High Band Rejection and Wide Radiation Patterns,” IEEE Transactions On Antennas And Propagation, Vol. 62, No. 9, September 2014.

Soheil Radiom, Hadi Aliakbarian, An Effective Technique for Symmetric Planar Monopole Antenna Miniaturization, IEEE Transactions On Antennas And Propagation, Vol. 57, No. 10, October 2009

Ajay Gummalla, Cheng-Jung Lee and Maha Achour, ‘Compact Metamaterial Quad-Band Antenna for Mobile Applications, Antennas and Propagation Society International Symposium, IEEE AP-S 2008.

S.C.Basaran, U.Olgun, K.Sertel, “Multiband monopole antennawith complementary split-ring resonators for WLAN and WiMAXapplications”, Electronics Letters, vol. 49, no. 10, pp. 636-638, 2013.

N.V.Rajasekhar; D.Sriramkumar, A triple band compact asymmetric monopole-SRR based antenna for Wi-Max, WLAN and RFID applications, 2015 International

Conference on Microwave, Optical and Communication Engineering (ICMOCE), IEEE, 2015

Dalia M. Elsheakh and Esmat A. Abdallah, 'Multiband Printed-IFA on Electromagnetic Band-Gap Ground Plane', IEEE, 2012.

Ari Sihvola, 'Metamaterials in Electromagnetics', Elsevier, pp.2-11, 2007

Baena, J.D., Bonache, J., Martín, F., Sillero, R.M., Falcone, F., Lopetegi, T., et al. (2005). Equivalent circuit models for split-ring resonators and complementary split-ring resonators coupled to planar transmission lines. *IEEE Transaction on Microwave Theory and Techniques*, *53*, 1451–1461

D.Sarkar, K.Saurav, K.V.Srivastava, Multi-band microstrip-fed slot antenna loaded with split-ring resonator, Electronics Letters Volume: 50, Issue: 21, October 9 2014

Krishnamoorthy Kandasamy; Basudev Majumder; Jayanta Mukherjee; Kamla Prasan Ray, Dual-Band Circularly Polarized Split Ring Resonators Loaded Square Slot Antenna, IEEE Transactions on Antennas and Propagation Volume: 64, Issue: 8, Aug. 2016.