Available online at www.sciencedirect.com

ScienceDirect

Materials Today: Proceedings XX (2016) XXX–XXX

materialstoday: PROCEEDINGS

www.materialstoday.com/proceedings

PMME 2016

Compact Dual Band Monopole Antenna for RFID and WLAN Applications☆

Ashish Pandey[a,]*, Rajan Mishra[a]

[a]*Department of Electronics and Communication Engineering, Madan Mohan Malaviya University of Technology, Gorakhpur 273010, India*

Abstract

A compact dual band monopole antenna for application in portable devices covering wireless local area network (WLAN) and radio frequency identification (RFID) technologies at 2.4 and 5.0 GHz is presented in our paper. The antenna is fabricated on a relatively inexpensive dielectric material. The dimensions of FR4 substrate used is 38 x 30 x 1.6 mm^3. Experimental results provide omnidirectional radiation patterns, which is in agreement with requirement of both frequency bands. We obtain resonant frequencies of 2.45 and 5.20 GHz from the fabricated antenna. The proposed antenna is simple in design, compact in size and exhibits broadband impedance matching, appropriate gain characteristics (>2.5 dBi) and consistent omnidirectional radiation patterns in the RFID and WLAN frequency regions. All simulations have been carried out on HFSS ver. 15.0.

Selection and Peer-review under responsibility of International Conference on Processing of Materials, Minerals and Energy (July 29th – 30th) 2016, Ongole, Andhra Pradesh, India.

Keywords: Antenna systems; monopole antenna; RFID; WLAN

1. Main text

We are presently witnessing a very rapid growth in wireless communications and associated technologies. Antennas with wideband characteristics to cover several wireless technologies with a single antenna are in great demand. Planar Monopole antennas have found widespread applications in wireless mobile communication

* Corresponding author. Tel.: +91-9454300857.

E-mail address: ap1494@gmail.com

2214-7853
Selection and Peer-review under responsibility of International Conference on Processing of Materials, Minerals and Energy (July 29th – 30th) 2016, Ongole, Andhra Pradesh, India.

industry. Simple fabrication process, low cost and appropriate radiation characteristics have propelled their increased use in mobile communication systems stimulating popular research work in dual-frequency band design of monopole antennas. Reported designs for various types of dual-frequency monopole antennas include, center-fed monopole neighbored by multiple parasitic monopoles [1]-[2] or sleeves [3], a multi branch monopole [4]-[5], parallel line loaded monopole antenna [6], and a combination of the monopole and helix [7]–[8].

Currently two technologies are being popularized, each differing broadly with other, Wi-Fi and RFID. Wi-Fi being more popular has been the crux of research from various viewpoints. We have RFID systems which utilize resonant circuits with highly selective properties, operating at LF (30 - 500 kHz), HF (10 -15MHz) and UHF (850 - 950MHz, 2.4 - 2.5GHz, 5.8GHz) for application in tracking, logistics and supply chain inventory, materials management, access control and intelligent transportation system (ITS) [9-10].

Intention of this paper is to propose an antenna; whose area of application lies in UHF RFID and WLAN systems. Panda et al [11] proposed dual band antenna provides a chance to improve the bandwidth and return loss values. The paper proposes use of a compact dual-band printed monopole antenna resembling the shape of 9 for RFID UHF 2.45-GHz band (ISO 18000-4); IEEE 802.11 and WLAN standards of 2.4 GHz and 5.2 GHz frequency bands. The resonant frequencies obtained from fabricated antenna are 2.45 GHz and 5.20 GHz. A strip in the shape of 9 is printed on one side of it; microstrip line feeding has been provided for operation of antenna. Dual-band performance at requisite frequencies is provided by the longer and shorter strips of the nine shaped patch. Sections 2 and 3 of this paper discuss antenna geometry and results.

2. Antenna Design

Geometry and photograph of the proposed compact 9-shaped monopole antenna have been shown in Figure 1. Radiator of the proposed monopole antenna bears resemblance to the English number 'Nine' thus the name '9-shaped antenna'. FR4 substrate of relative permittivity εr= 4.4, tan ξ = 0.02 and thickness of 1.6 mm has been used in fabrication of the antenna. Width of microstrip line used for excitation is 3.06 mm. The antenna is designed to be compatible with 50 ohm systems. In order to provide proper impedance matching [12], width of the feed strip is fixed at 3.06 mm and the ground plane is truncated at a length of Lf. This truncation creates a capacitive load which neutralizes the inductive nature of the patch thus producing nearly pure resistive input impedance. Width of each section of 9 shaped strips is same as that of feed strip. The design consists of two main radiating elements which are responsible for simulated resonant frequencies of 2.50 and 5.15 GHz. Between the strips is placed a patch of Lp x Wp which couples the electric field. Equations 1 -4 given below equate proposed monopole antenna to an equivalent monopole antenna cylindrical in shape and of equivalent length Lcy and radius Rcy to calculate resonant frequencies

$$f = \left(\frac{7.2}{L_c + r_c + p}\right) \tag{1}$$

Where,

$$L_c = \{L2 + L3 + L4 + 2\,Wf\} \tag{2}$$

$$R_{cy} = \left(\frac{Wf(L1 + L2 + L3 + L4 + 4\,Wf)}{2\pi(L2 + L3 + L4 + 2\,Wf)}\right) \tag{3}$$

$$p = \{Lf - Wf - Wg\} \tag{4}$$

The two resonant frequencies obtained are multiple of each other. The first resonant frequency is 2.5 GHz which is produced due to the longer strip comprising of sections L2, L3 and L4. On adjusting length of section L1 to the value given in Table 1 we obtained a shifted second resonant frequency at 5.15 GHz. Without L1 second resonant frequency was obtained at 5 GHz. The design includes a small slot in the feed line to equalize the antenna for compatibility with 50 ohm systems at 2.5 GHz. A key shaped square slot of dimension 0.5 mm x 0.5 mm was incorporated at the end of longer strip during optimization. Geometrical parameters have been completely adjusted to provide best results. The final optimized dimensions of the antenna through EM simulations are given in Table 1. At each step of design process, the effect of change in antenna structure on antenna parameters (primarily reflection coefficient and bandwidth) was analyzed and the change incorporated only if it yielded improved results. Figure 2 compares reflection coefficient results between designs without key shaped square slot, without patch, final design and simulated antenna.

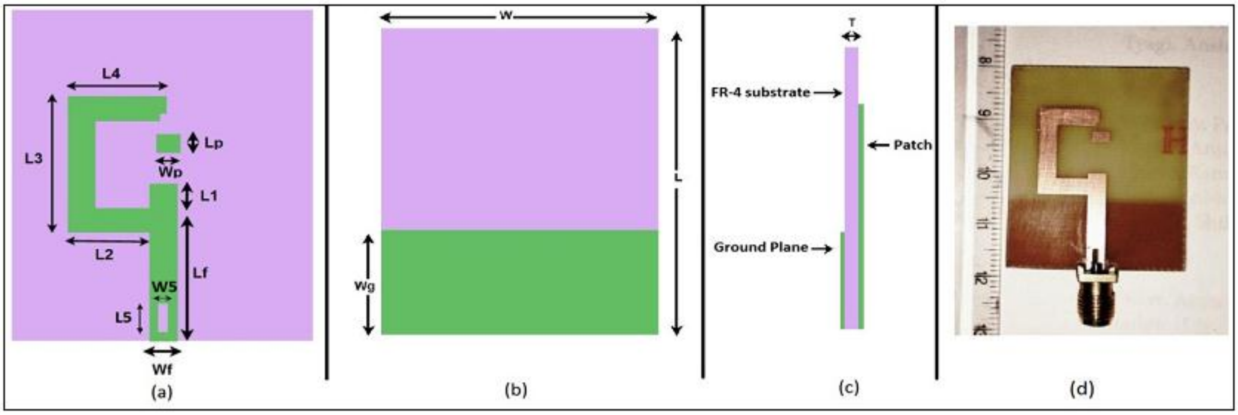

Fig. 1. Geometrical views of the antenna (a) Front view (b) Back view (c) Side view (d) Photograph of fabricated antenna.

Table 1. Dimensional values of various parameters of the proposed antenna.

PARAMETER	W	L	Wg	T	L1	L2	L3	L4	L5	W1	Wf	Lf	Wp	Lp
VALUE (mm)	30.0	38.0	13.0	1.6	1.0	8.46	16.12	10.06	3.0	1.0	3.06	17.06	3.0	2.0

3. Results and Discussion

Simulated results of the proposed antenna have been analyzed and optimized by using Ansoft's EM simulation tool HFSS version 15.0, which uses the FEM technique. Simulation and Measured results have been marked S and M in figure 2. We obtain two frequency bands with simulated resonant frequencies at 2.5 GHz and 5.15 GHz and return loss values of -18 dB and-41 dB respectively. Simulated impedance bandwidth of is 575 MHz and 2.70 GHz for first and second frequency bands respectively, which is 860 MHz more than in [11]. Measured results show resonant frequencies at 2.45 GHz and 5.20 GHz and frequency bands of bandwidth 600 MHz and 2.52 GHz.

From figure 3 we observe that the radiation pattern at both resonant frequencies is Omni-directional in E-Plane and H-Plane. As per maximum power transfer theorem, for an antenna to receive maximum power its impedance should be matched with the system, which is in this case 50 Ω. Figure 4 shows the variation in Z parameter of the antenna with frequency of operation. At resonant frequency of 2.50 GHz, imaginary part of Z parameter is Zero and the real part is nearly 55 Ω and at 5.15 GHz the imaginary part of Z parameter is Zero and the real part is nearly 50 Ω. This combination of real and imaginary values of Z parameter gives a pure resistive impedance of nearly 50 Ω for both frequency bands of operation. We obtain peak realized gain of 2.56 dBi at 2.5 GHz and 2.93 dBi at 5.15 GHz. It is found to increase slowly with frequency. An appropriate gain characteristic is provided by the proposed antenna which is required for operation in WLAN and RFID frequency bands. For both frequency bands, antenna has VSWR in the range of (1, 2).

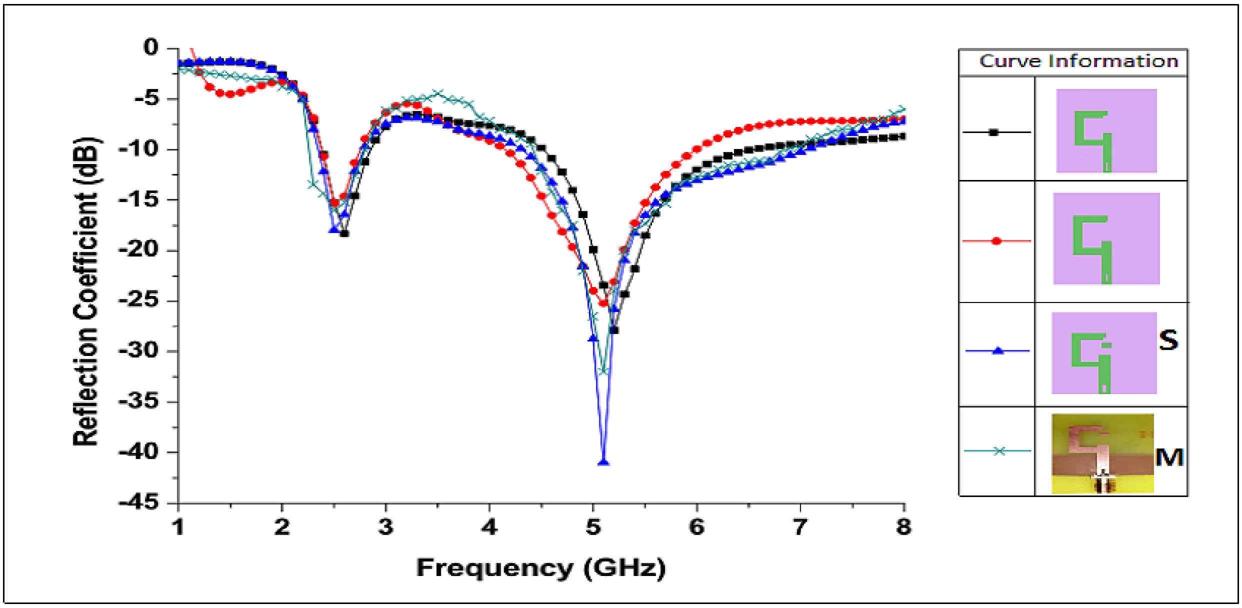

Fig. 2. Comparison between reflection coefficient results of the antenna at different stages.

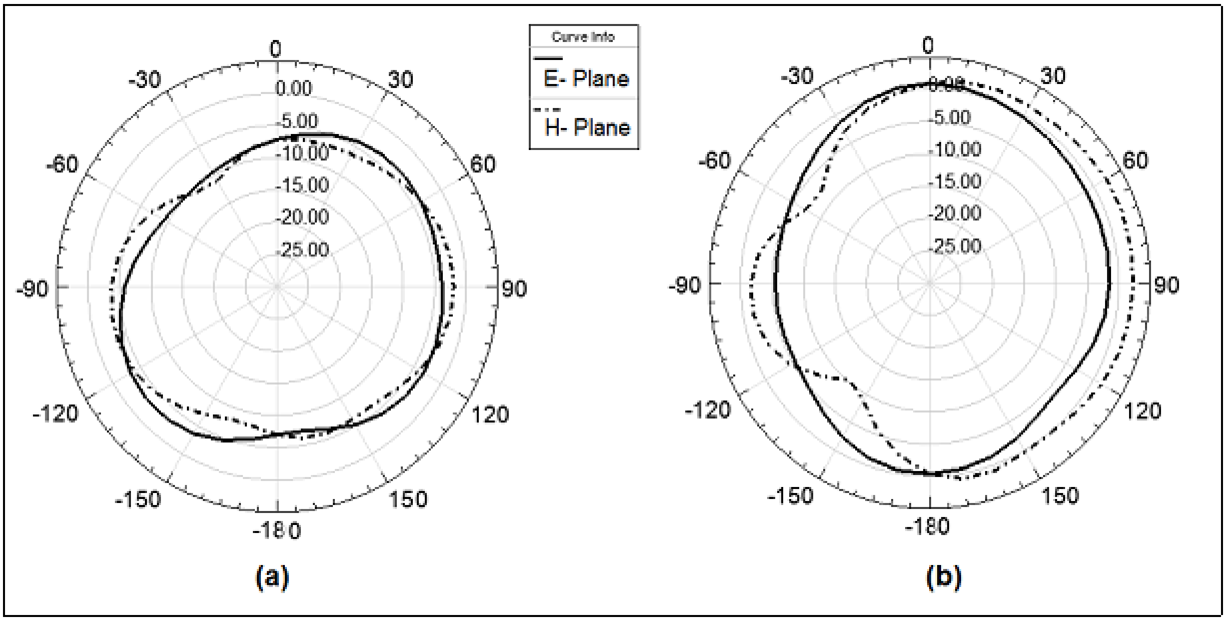

Fig. 3. E- Plane and H-Plane Simulated Radiation Pattern of proposed antenna at (a) 2.5 GHz (b) 5.15 GHz.

As discussed in section 2 of the paper, it has been observed that variation in length parameter L1 leads to shifting of second resonant frequency by 150 MHz from initially calculated 5.0 GHz. The variation discussed above is shown in figure 5. Appropriate result corresponding to second resonant frequency of 5.15 GHz was obtained for value of L1= 1.0 mm.

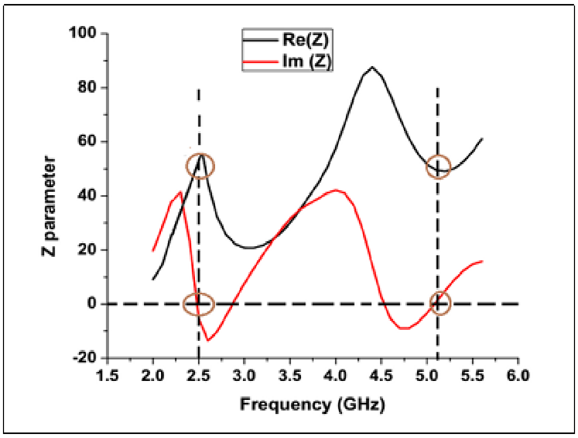

Fig. 4. Variation in Z parameter with frequency.

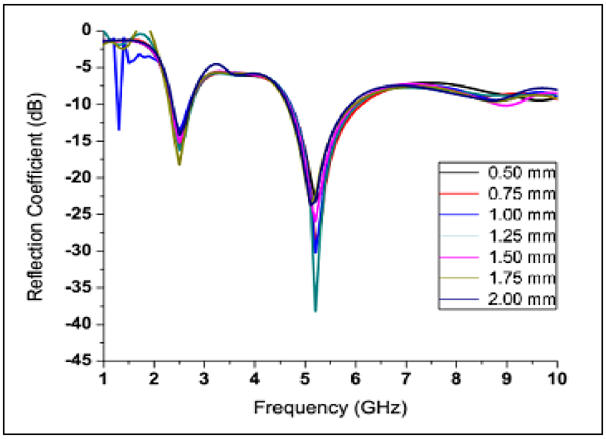

Fig. 5.Variation in reflection coefficient with L1.

4. Conclusion

In this paper a compact monopole antenna for applications in Wi-Fi and RFID enabled handheld devices has been presented. 9 shaped configuration of the proposed design provides results consistent with the intended application providing a gain greater than 2.5 dBi. Simple design and compact shape of the antenna are its prime features. Analysis and optimization of the design and its results was done on HFSS ver. 15.0 EM simulator tool which uses FEM technique. Simulation results are consistent with measured ones.

References

[1] D. Liu,"A dual-band antenna for cellular applications, "in Proc. IEEE Antennas Propagat. Soc. Int. Symp., vol. 2, June 21–26, 1998, pp.786–789.

[2] R. Schlub, D. V. Thiel, J. W. Lu, and S. G. O"Keefe,"Dual -band six-element switched parasitic array for smart antenna cellular communications systems," Electron. Lett., vol. 36, pp. 1342–1343, 2000.

[3] M. Ali, M. Okoniewski, M. A. Stuchly, and S. S. Stuchly, "Dual-frequency strip-sleeve monopole for laptop computers," IEEE Trans. Antennas Propagat., vol. 47, pp. 317–323, Feb. 1999.

[4] D. Liu ,"A multi-branch monopole antenna for dual-band cellular applications," in Proc. IEEE Antennas Propagation Soc. Int. Symp., vol. 3, July 11–16, 1999, pp. 1578–1581.

[5] C. T. P. Song, P. S. Hall, H. Ghafouri-Shiraz, and D. Wake ,"Multi-circular loop monopole antenna,"Electron. Lett., vol. 36, pp. 391–393,2000.

[6] T. Sukiji, Y. Kumon, and M. Yamasaki ,"Double folded monopole antenna using parallel line or co axial cable," Proc. Inst. Elect. Eng., vol.149, pp. 17–22, Feb. 2002.

[7] P. Eratuuli, P. Haapala, and P. Vainikainen , "Dual frequency wire antenna," Electron.Lett., vol. 32, pp. 1051–1052, 1996.

[8] Y. W. Chow, E. K. N. Yung, K. F. Tsang, and H. T. Hui, "An innovative monopole antenna for mobile-phone handsets," Microwave Opt.Technol.Lett., vol. 25, pp. 119–121, 2000.

[9] L. Qi, "Research on intelligent transportation system technologies and application," in Proc. Workshop Power Electron. Intell. Transport System, 2008, pp. 529-531.

[10] C. A. Valagiannopoulos, "High Selectivity and Controllability of a Parallel-plate component with a filled rectangular ridge," Progress In Electromagnetics Research, Vol. 119, 497-511, 2011.

[11] Jyoti Ranjan PANDA, Aditya Sri Ram SALADI, Rakhesh Singh KSHETRIMAYUM, "A Compact Printed Monopole Antenna for Dual-band RFID and WLAN Applications," Intl. Conf. on Computing Communication and Networking Techn, (ICCCNT), 29-31 July 2010, pp. 464-467.

[12] Y. C. Song, a J. Ding, and C. J. Guo," A semi-analytical numerical method for fast metamaterial absorber design," AIP Advances 5, 097108 , 2015.