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Design and Fabrication of Rectangular Microstrip Antenna using Zinc Nanoparticles for Wireless Applications and Enhancement of Bandwidth

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Abstract: This Paper presents enhancement of bandwidth of the rectangular microstrip antenna. The proposed antenna is simpler in design with low fabrication cost. The main objective of this paper is to design microstrip antenna for wireless applications by loading zinc nanoparticles on rectangular patch of the proposed antenna. The antenna consists of substrates made up of glass epoxy material with thickness as 0.16cm. The experimentally measured and calculated antenna parameters such as bandwidth, return loss, VSWR, radiation pattern and gain are presented.
Keywords: Zinc nanoparticles, Rectangular microstrip antenna, Bandwidth, Gain, Return loss and VSWR.

I. INTRODUCTION

The microstrip antenna plays an important role in telecommunication industry and is used to transmit and receive electromagnetic (EM) waves. Microstrip antenna is one of the most basic building blocks of wireless applications. Microstrip antenna is a metallic device acts as transducers, which transfers and also receives EM waves. Antennas are present everywhere; at homes, automobiles, roads, houses, police stations, radar system, parks, satellite communications buildings, and military devices.

The microstrip antenna technology began its rapid development in the late 1970s. By the early 1980s basic microstrip antenna elements and arrays were fairly well establish in term of design and modeling. In the last decades printed antennas have been largely studied due to their advantages over other radiating systems, which include: light weightiness, reduced size, low cost, conformability and the ease of integration with active device [1]. The radiating patch and the feed lines are usually photo etched on the dielectric substrate [2]. But use of rectangular microstrip patch Antenna alone is very difficult because of its low gain and narrow bandwidth. So to overcome these problems an artificial material called Metamaterial is incorporates. In this paper, a great interest in wideband antenna for use in wireless communication has been presented. The wideband antenna Preferred over narrow band antennas because of the usage in various applications [3]. For last few years researchers exploiting nanotechnology for antenna on developing new substrate and conductive part of the antenna to overcome size reduction and narrow bandwidth problem [4]. Recently F. Urbani and co-workers have successfully fabricated and demonstrated use of conducting nanofilm for enhancement of radiation properties of patch antennas [5]. In this paper we reported enhancement in bandwidth and multiband operation of antenna by employing zinc nanoparticles on the radiating patch of the proposed antenna.

II. ANTENNA DESIGN CONSIDERATION

The proposed antenna is designed for the frequency of 5.5GHz utilizing the relations currently present in the literature of the design of rectangular microstrip antenna using economy cost glass epoxy substrate having dielectric constant $\varepsilon r = 4.2$.The shape of the rectangular microstrip antenna (RMSA) is shown in Figure 1.The making of rectangular microstrip patch antenna is side of length ‘l’ cm and width ‘w’ cm, over a substrate with substrate thickness ‘h’ cm (0.16cm). The essential parameters for the design of a rectangular microstrip patch antenna are:

Calculation of width (W):

$$W = \frac{c}{2f_0\sqrt{\frac{(\varepsilon_r + 1)}{2}}} \quad (1)$$

Calculation of effective Dielectric constant (ε_{reff}):

$$\varepsilon_{reff} = \frac{\varepsilon_r + 1}{2} + \frac{\varepsilon_r - 1}{2}[1 + 12\frac{h}{W}]^{\frac{1}{2}} \quad (2)$$

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Calculation extension Length: It is used for calculating resonant frequency of micostrip antenna:

$$\Delta L = 0.412\frac{\left(\frac{W}{h} + 0.264\right)(\varepsilon_{reff} + 0.3)}{(\varepsilon_{reff} - 0.258)(\frac{W}{h} + 0.8)} \quad (3)$$

Calculation of Length (L), Effective Length (Leff):

$$L_{eff} = \frac{c}{2f_o\sqrt{\varepsilon_{reff}}} \quad (4)$$

and

$$L = L_{eff} - 2\Delta L \quad (5)$$

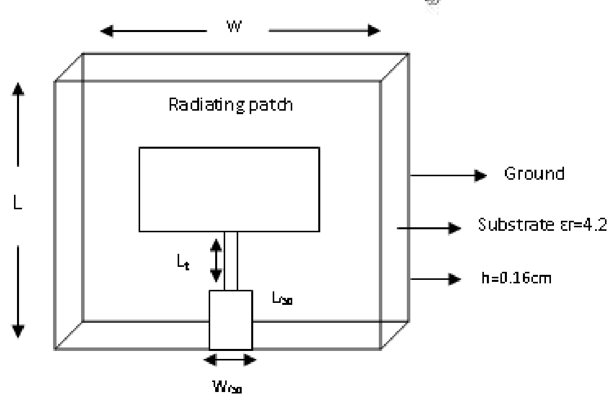

Figure 1: Geometry of RMSA

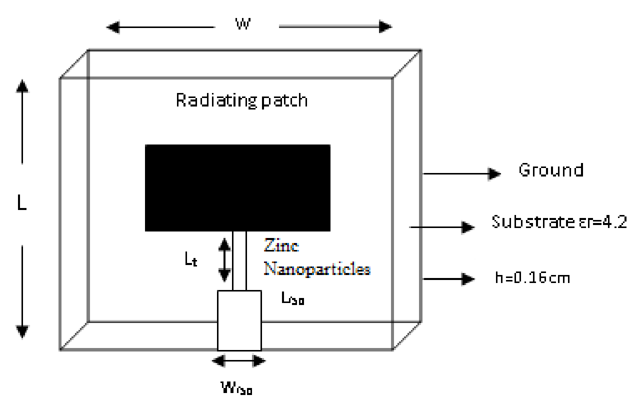

Figure 2: Top View of ZNRMSA

Further, the study is made by loading zinc nanoparticles on the radiating patch which provides extent to achieve multiband frequencies and high enhancement in bandwidth. The top view of zinc nanoparticles loaded rectangular microstrip antenna (ZNRMSA) is shown in Figure 2. The proposed antenna work is constructed using the computer software AUTOCAD to gain the best accuracy. The antenna is fabricated using the photolithography process. All the parameters of proposed antenna are given in Table 1.

TABLE 1
Designed Specifications of the Proposed Antennas

Antenna Specifications	Dimensions in Cm
Length of the rectangular patch	0.91
Width of the rectangular patch	1.52
Thickness of the substrate	0.16
L_{f50}	0.629
W_{f50}	0.306
L_t	0.63
W_t	0.046
L_g	3.35
W_g	2.48

III.EXPERIMENTAL RESULTS

The impedance bandwidths over return loss less than -10 dB for the proposed antennas are measured. The measurements are taken on Vector Network Analyzer (Rohde & Schwarz, German make ZVK Model No. 1127.8651). The variations of return loss versus frequency of RMSA and ZNMSA antennas are shown in Figure 3 and Figure 4. The experimental impedance bandwidth is calculated using the equation (6),

$$\text{Bandwidth}(\%) = \left[\frac{f_2 - f_1}{f_c}\right] \text{x}100\% \quad (6)$$

where, f_1 and f_2 are the upper and lower cut off points of resonating frequency when its return loss reaches -10 dB and f_c is a center frequency between f_1 and f_2. The RMSA resonates at 5.8GHz with impedance bandwidth of 2.24% (5.75GHz –5.88GHz). From the Figure 4, it is found that the ZNRMSA resonates at penta bands of frequencies i.e, f_1, f_2, f_3, $f_4$and f_5 with their corresponding bandwidths BW_1= 13.88% (3.4GHz – 3.9GHz), BW_2= 22.22% (4.2GHz –5.2GHz), BW_3= 26.44% (5.5GHz -7.1GHz), BW_4= 16.00% (7.6GHz-8.8GHz) and BW_5= 4.97% (8.95GHz-9.4GHz) respectively.

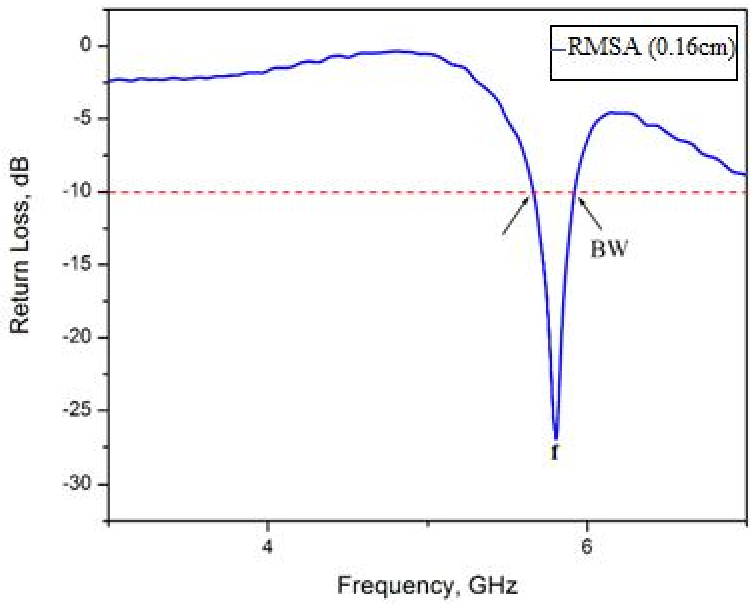

Figure 3: Variation of Return Loss v/s Frequency of RMSA

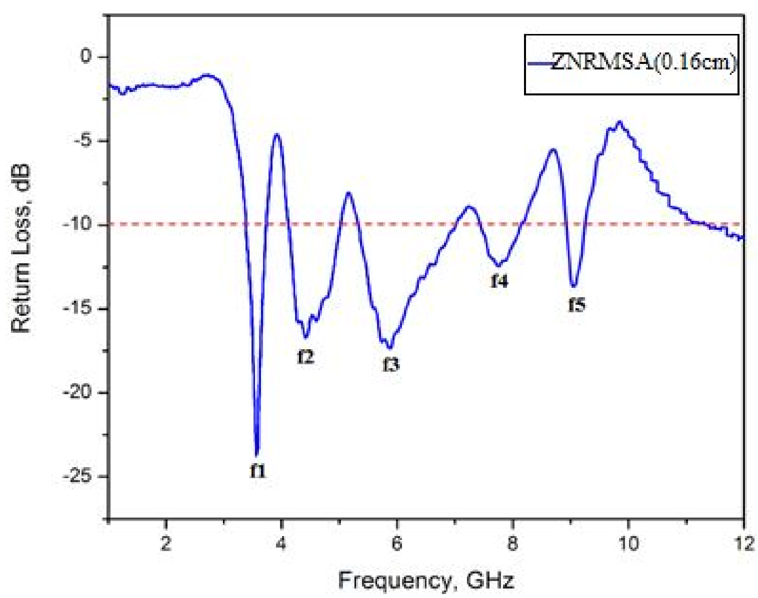

Figure 4: Variation of Return Loss v/s Frequency of ZNRMSA

The X-Y plane co-polar and cross-polar radiation patterns of RMSA and ZNRMSA are measured at their resonating frequencies and are shown in Figure 5 to Figure 6. These figures indicate that the antennas show broad side radiation characteristics.

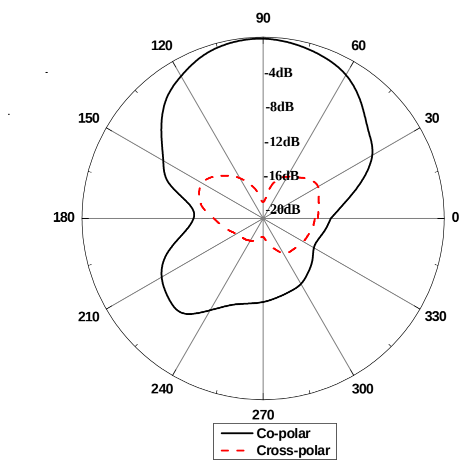

Figure 5: Radiation Pattern at 5.8 GHz

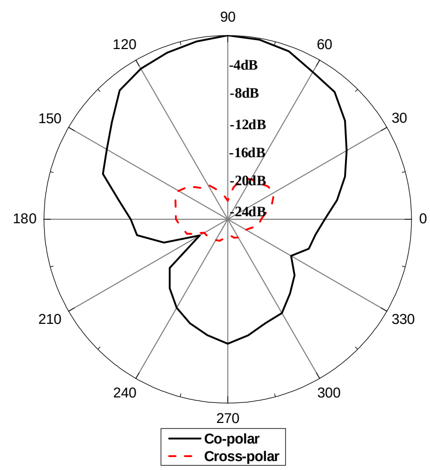

Figure 6: Radiation Pattern at 3.6 GHz

The gain of proposed antenna is calculated using absolute gain method given by the equation (7),

$$(G)_{dB} = 10\log\left(\frac{P_r}{P_t}\right) - (G_t)_{dB} - 20\log\left(\frac{\lambda_0}{4\pi R}\right)_{dB} \quad dB \qquad (7)$$

where, Pt and Pr are transmitted and received powers respectively, G_t is the gain of the pyramidal horn antenna and R is the distance between transmitting antenna and antenna under test. The return loss, gain and VSWR of the antennas are also tabulated in Table 2.

TABLE.2

Calculated Return loss, Gain and VSWR

Antennas	Frequency in GHz	Return loss in dB	Gain in dB	VSWR
RMSA	5.8	-26.9	3.05	1.02
ZNRMSA	3.6	-24	5.00	1.13

IV. CONCLUSIONS

In this paper we design a rectangular microstrip antenna using zinc nanoparticles for wireless applications. The conventional antenna achieves gain of 3.05 dB at 5.8GHz and after loading zinc nanoparticles on radiating patch its maximum gain in one direction is 5.00dB and also enhancement in bandwidth. All these performance measure results make this antenna suitable for Wi-Fi, Wlan, ISM, Mobile Wi-max and Radar applications.

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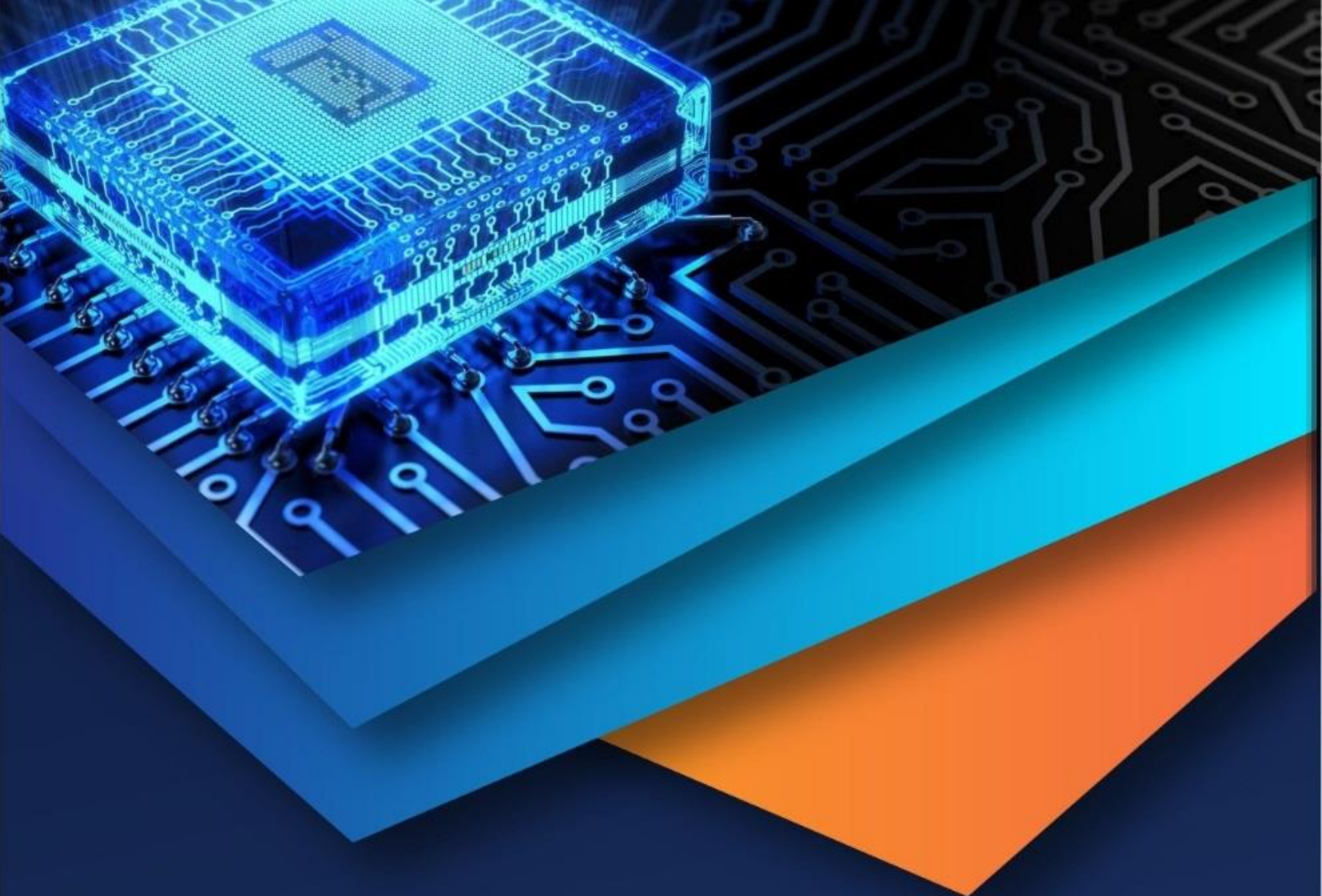

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