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Enhancement of Bandwidth of Equilateral Triangular Microstrip Antenna using Nanoparticles

Mahesh C P[1], Pooja Mali[2], Maheshwar Sharon[3], Madhuri Sharon[4]
[1, 2, 3, 4]*Department of Nanotechnology, Walchand Centre for Research in Nanotechnology and Bionanotechnology, Solapur, Maharashtra, India,*

Abstract: This paper presents equilateral triangular microstrip antenna for wireless applications. The antenna consist of glass epoxy substrate material with relative permittivity 4.2 and thickness (h) is 0.16cm. The proposed antenna is resonates at 6.6 GHz with bandwidth of 4.54%, after loading the iron nanoparticles on the radiating patch of the antenna resonates for 4.1 GHz, 6.1Ghz, 7.3GHz and 11.3 GHz respectively, with enhancement of bandwidth up to 26.02%. The proposed antenna is suitable for Wi-Fi, radar and satellite communication applications. The experimentally measured and calculated antenna parameters such as return loss, VSWR, radiation pattern and gain are presented.
Keywords: Equilateral microstrip antenna, Iron nanoparticles, Bandwidth, Return loss, Gain and VSWR

I. INTRODUCTION

The microstrip antenna is one of the most basic building blocks of wireless applications like cellular communications, wireless fidelity (Wi-Fi), worldwide interoperability for microwave access (Wi-max), wireless sensor networks (WSN), wireless local area networks (WLAN) etc. The mirostrip antenna have advantages such as low profile, light weight, low cost. The limitations of mirostrip antenna are narrow bandwidth, low gain, low efficiency and low power handling capacity [1]. Nowadays, there is a continuous expansion of wireless system applications that demands higher bandwidth for high data rate transmission. The utilizations of microstrip antennas are more over the microwave frequency because of their geometry and sharp resonance [2]. a metallic layers in a specific shape is reinforced on a dielectric substrate which frames a transmitting component and another persistent metallic layer on the opposite side of as ground plane [3].The basic shape of the microstrip antenna can be square, rectangular, dipole, triangular, curved or some fundamental shapes [4]. For the ease of design and simplicity, rectangular shape is chosen in this paper. The main aim of this research is to discuss the usability of iron nanoparticles (around 100 nm) on radiating patch of equilateral triangualr microstrip antenna for bandwidth enhancement in wireless communication. In this research work, our study originates from previous work done in [5], where aperture coupled microstrip antenna with different nanofilm metals like Aluminum, Chromium, Titanium and Nickel patch were used. In this paper, we have considered other antenna structure with different nanoparticles.

II. ANTENNA DESIGN CONSIDERATION

To achieve multi band frequencies and increase the bandwidth of microstrip antenna there were so many different methods are adopted like increasing in the substrate thickness, making use of a low dielectric constant substrate, using different feeding techniques and impedance matching and usage of slot antenna geometry. This work, proposed antenna is designed for the frequency of 5.5GHz utilizing the relations currently present in the literature of the design of equilateral triangular microstrip antenna using economy cost glass epoxy substrate having dielectric constant εr = 4.2. The shape of the equilateral triangular microstrip antenna(ETMSA) is shown in Figure 1.The making of equilateral triangular microstrip patch antenna is side of length ‘a’ cm over a substrate with substrate thickness ‘h’ cm. The value of ‘a’ is calculated by the equation (1),

$$a = \frac{2C}{3 f_r \sqrt{\varepsilon_r}} \quad (1)$$

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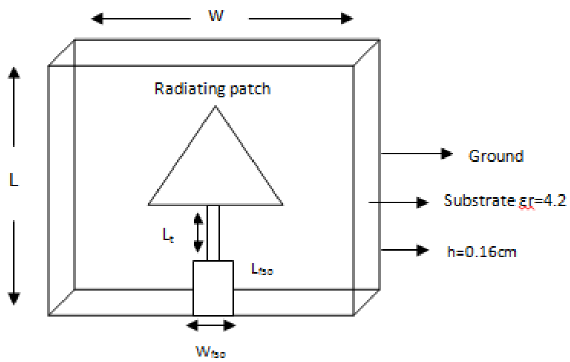

Figure. 1: Geometry of ETMSA

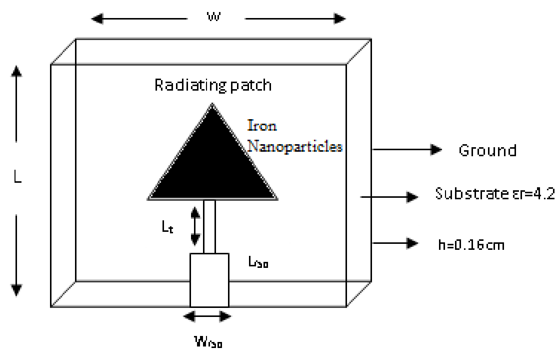

Figure. 2: Top View of INETMSA

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

TABLE 1 Designed Specifications of the Proposed Antennas

Antenna Specifications	Dimensions in Cm
Side length of equilateral triangle (a)	2.24
Substrate thickness, h	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 ETMSA and INETMSA antennas are shown in Figure 3 and Figure 4. The experimental impedance bandwidth is calculated using the equation (2),

$$\text{Bandwidth}(\%) = \left[\frac{f_2 - f_1}{f_c}\right] \text{x}100\% \quad \textbf{(2)}$$

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 ETMSA resonates at 6.6GHz with impedance bandwidth of 4.54% (6.4GHz –6.7GHz). From the Figure 4, it is found that the INETMSA resonates at quad bands of frequencies i.e, f_1, f_2, $f_3$and f_4 with their corresponding bandwidths BW_1= 3.65% (3.9GHz – 4.05GHz), BW_2= 6.55% (5.9GHz –6.3GHz), BW_3= 26.02% (6.9GHz -8.8GHz) and BW_4= 22.12% (9.5GHz-12GHz) respectively.

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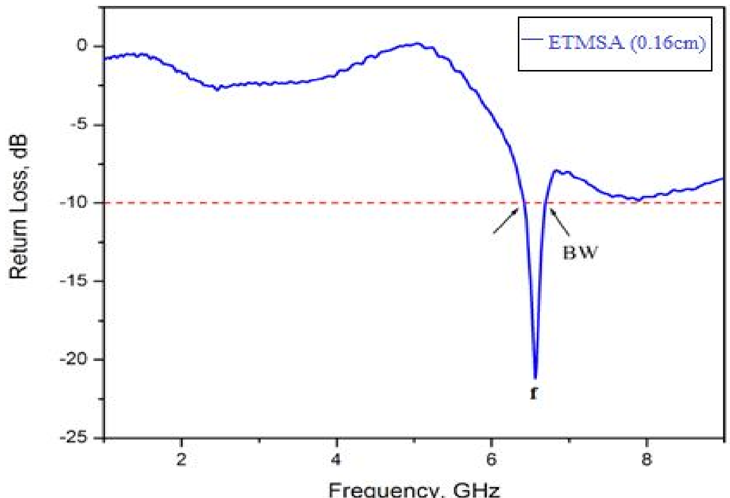


Figure 3: Variation of Return Loss v/s Frequency of ETMSA

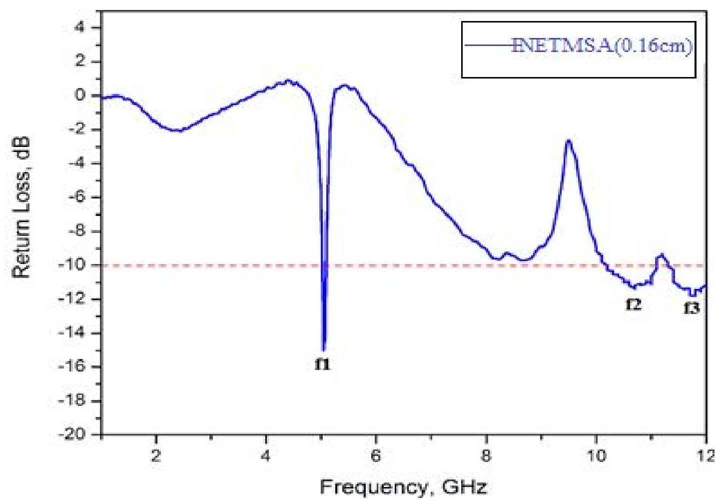
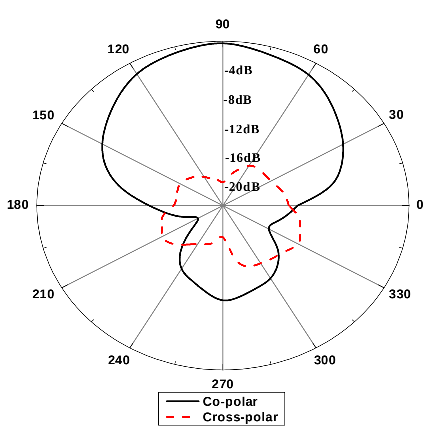
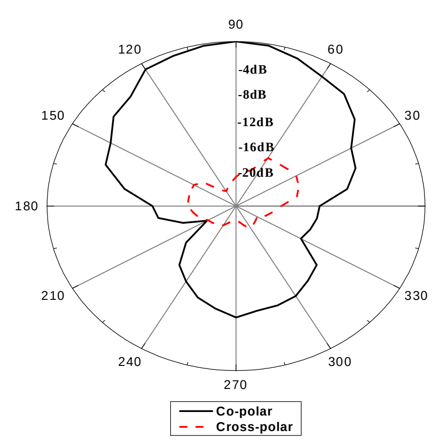


Figure 4: Variation of Return Loss v/s Frequency of INETMSA

The X-Y plane co-polar and cross-polar radiation patterns of ETMSA and INETMSA 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.



Radiation Pattern at 6.6 GHz



Radiation Pattern at 4.1 GHz

The gain of proposed antenna is calculated using absolute gain method given by the equation (3),

$$(G)_{dB} = 10\log\left(\frac{P_r}{P_t}\right) - (G_t)_{dB} - 20\log\left(\frac{\lambda_0}{4\pi R}\right)_{dB} \quad dB \tag{3}$$

where, P_t and P_r 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 and 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
ETMSA	6.6	-22	4.01	1.15
INETMSA	4.1	-15.5	5.12	1.10

IV. CONCLUSIONS

This paper concludes from the above figures and tables that after loaded iron nanoparticles on the radiating patch of an antenna has improved characteristics like gain, enhancement bandwidth and multiband frequencies and due to these improved parameters maximum output is achieved. The Proposed antenna for Wi-max, Wi-Fi and Radar applications.

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