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Iron Oxide Nanoparticles Loaded Equilateral Triangular Microstrip Antenna for Triple Band Operation

Mahesh C P¹, S G Holikatti², P M Hadalgi³

Department of Electronics, Walchand College of Arts and Science, Solapur, Maharashtra, India¹

Department of Physics, Walchand College of Arts and Science, Solapur, Maharashtra, India²

Professor, Department of PG studies and Research in Applied Electronics, Gulbarga University, Kalaburagi, Karnataka, India³

ABSTRACT: A novel technique for the triple band operation of equilateral triangular microstrip antenna is proposed. 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 oxide nanoparticles on the radiating patch of the antenna which resonates for a triple band frequency operation can be achieved between 3.18 GHz to 7.57 GHz, with enhancement of bandwidth up to 15.37%. This antenna is suitable for Wi-Fi, radar and satellite communication applications. The experimentally measured and calculated antenna parameters such as VSWR, radiation pattern and gain are presented.

KEYWORDS:Equilateral Triangular microstrip antenna, Iron oxide nanoparticles, Bandwidth, Gain and VSWR.

I. INTRODUCTION

The microstrip antennas have achieved popular position in today's communication system because of their inherent attractive features like light weight, planar structure, ruggedness, different geometries and shapes, easy installation, low fabrication cost etc., [1].The present era of wireless communication possess many desirable features such as wide bandwidth, light weight, low cost and compactness with microwave circuitry [2]. It is need of the hour to select the antenna that uses single antenna for transmit/receive purpose. The microstrip antenna designers worked hard to put forth many methods and techniques such as cutting slots of different geometries like rectangular narrow slot, ellipse, circular ring, square slot on the radiating patch [3-7] etc. The equilateral triangular radiating patch was found to exhibit good radiation characteristics, simple to design and compact in size when compared to other microstrip patch shapes [8] and loading oxide nanoparticles on patch it is gives good results when compared to conventional microstrip antenna.

II. ANTENNA DESIGN CONSIDERATION

The proposed antenna is designed for the frequency of 5.5 GHz using the relations present in the literature for the design of equilateral triangular microstrip antenna. A low cost glass epoxy substrate material with dielectric constant $\epsilon_r = 4.2$ is used fabricate microstrip antenna. 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),

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

where, C is the velocity of light and f_r is the resonating frequency. The microstripline feed of length L_f and width W_f is etched on the top of the substrate. The dimensions of the ground plane L_g and W_g are calculated from equation (2),

$$W_g = L_g = 6h+a \quad (2)$$

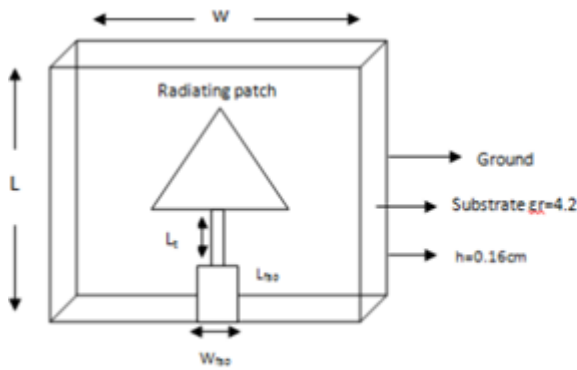


Fig-1: Geometry of ETMSA,

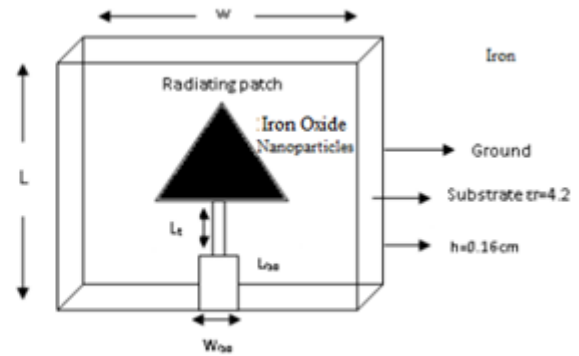


Fig-2: Geometry of IONETMSA,

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 oxide nanoparticles on the radiating patch which provides extent to achieve triple band frequencies and high enhancement in bandwidth. The geometry of the iron oxide nanoparticles equilateral triangular microstrip antenna (IONETMSA) is shown in Figure 2.

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 IONETMSA antennas are shown in Figure 3 and Figure 4. The experimental impedance bandwidth is calculated using the equation (3),

$$BW = \left[\frac{f_2 - f_1}{f_c} \right] \times 100\% \quad (3)$$

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 .

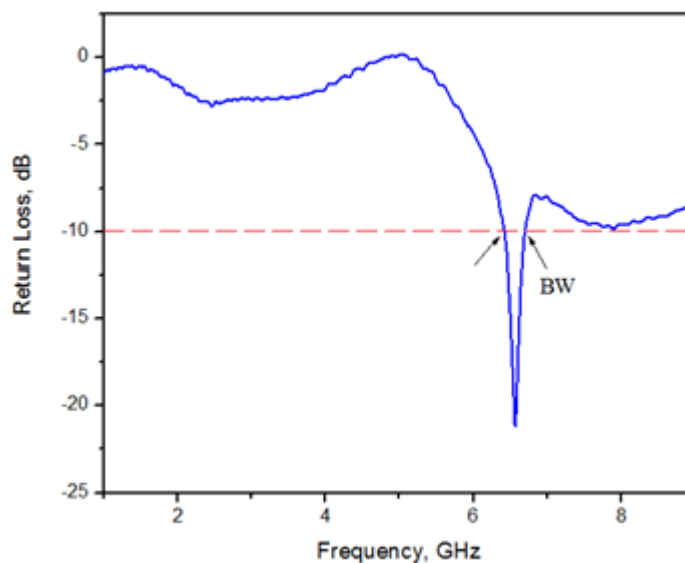


Fig.3. Return loss versus frequency of ETMSA

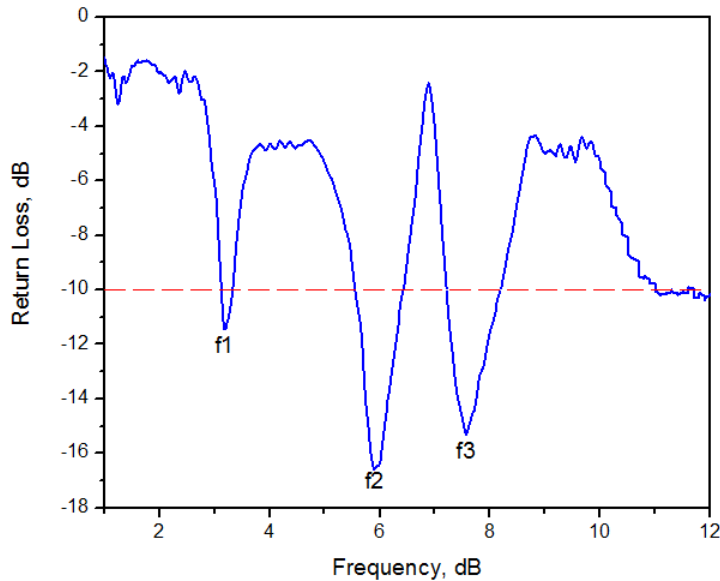


Fig.4. Return loss versus frequency of IONETMSA

The above graphs show that, the antenna resonates very close to its designed frequency. From the Fig. 3 and 4 it is observed that, the ETMSA resonates at 6.66 GHz with impedance bandwidth of 4.54%, whereas after loading the iron oxide nanoparticles on the radiating patch by keeping all the specifications constant, the antenna resonates at three different frequency i.e., 3.18GHz, 5.92GHz and 7.57GHz with impedance bandwidth 7.54%, 15.37% and 12.68% respectively as shown in Fig. 4. The VSWR is found to be 1.32 (6.66GHz), 1.07 (3.18GHz), 1.87 (5.92GHz) and 1.57 (7.57GHz) respectively. The proposed antenna is compared with ETMSA.

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

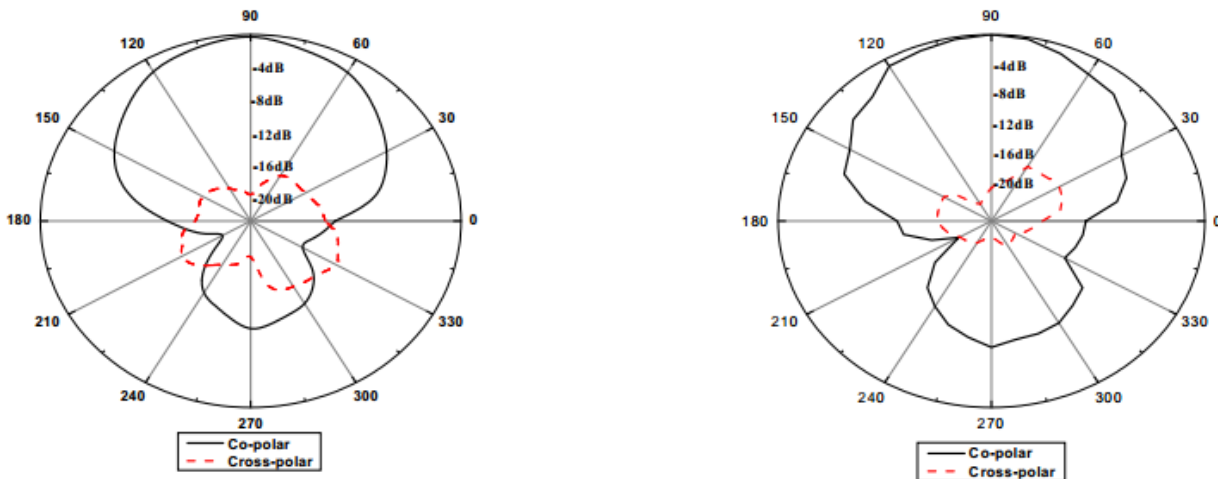


Figure 5. Radiation pattern at 6.66 GHz Figure 6. Radiation pattern at 5.92 GHz

The gain of proposed antenna is calculated using absolute gain method given by the equation (4),

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

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 gain of the antennas are also tabulated in Table 1.



Antennas	Frequency in GHz	Gain in dB
ETMSA	6.66	4.01
IONETMSA	5.92	6.02

IV. CONCLUSION

From the detailed study, it is clear that the ETMSA antenna gives a single frequency band but after loading the iron oxide nanoparticles on slot i.e. IONETMSA resonates for three operating frequency bands with enhancement in the bandwidth with better broadside radiation pattern at their resonating frequency points. This antenna may find applications in modern communication systems such as Wi-Fi, radar and in satellite communications.

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