Comparison of Various Contact Feeding Techniques for Triangular Microstrip Patch Antenna

Dr.M.Arulaalan#1, Dr. L.Nithyanandan#2, P.Prabakaran#3, G.Manikannan#4

[1] *Associate Professor, Department of ECE, CK College of Engineering and Technology, Cuddalore, Anna University*
[2] *Professor, Department of ECE, Pondicherry Engineering College, Pondicherry University*
[3] *Assistant Professor, Department of ECE, CK College of Engineering and Technology, Cuddalore, Anna University*
[4] *Assistant Professor, Department of ECE, CK College of Engineering and Technology, Cuddalore, Anna University*

[1]arulaalan@gmail.com , [2]nithi@pec.edu, [3]1984.praba@gmail.com, [4]Kannan.gr18@gmail.com

Abstract: This paper presents a comparison between various contact feeding techniques of triangular Microstrip patch antenna (TMSA) for Wireless local area Network (WLAN) application (2.4GHz). The proposed TMSA is composed of a triangular Microstrip patch antenna printed on an fr4 substrate, with thickness of 1.6 mm .The TMSA antenna is designed, simulated and tested for coaxial feed, inset feed and Microstrip line feed for WLAN applications. The inset fed ETMSA provides better matching and performance in terms of gain and return loss (S_{11}). Due to better performance the inset fed antenna is fabricated and tested. The overall size of the antenna is 46 mm × 61 mm × 1.6 mm.

Keywords — Microstrip Antenna, WLAN, ETMSA, Inset feed, S_{11}

I. INTRODUCTION

WLAN or Wi-Fi is a technology that combines computer system, laptops and personal digital assistant with wireless communication technology to exchange data using radio waves. Wireless LANs refer to any local area network (LAN) that a mobile user can connect to through a wireless connection; Wi-Fi is a term for certain types of WLANs that use specifications in the 802.11 wireless protocol family. There are five noticeable frequency ranges for WLAN: 2.4 GHz, 3.6 GHz, and 4.9 GHz, 5 GHz, and 5.9 GHz bands. Of those, other than telecommunication application, the 2.4 GHz and 5 GHz frequency ranges are set aside globally for industrial, scientific and medical (ISM band) purposes also. For transfer of data in the ISM band over a computer network it requires a compact, low cost and a high profile antenna. In recent years WLAN antennas with simplicity, ease of integration and compactness post the major challenge along with reflection loss, gain and radiation performance. There are a wide variety of antennas used for WLAN application like helix, bi-quad, cubic quad, helical antenna and Yagi WLAN antennas. These antennas do not assure the constraint of compactness and ease of integration. The antenna which solves the problem of compactness is Microstrip antenna. There are numerous Microstrip antennas designed for WLAN application. Planar inverted F-antenna designed for WLAN application requires a wide ground plane, which increases the size of the antenna [1, 2]. A coaxial fed plate antenna with an inverted L-slit designed for 2.4 GHz has a gain of 3 dB [3]. Due to their compactness, high gain, low cost and volume, Equilateral Triangular Microstrip Antenna (ETMSA) antenna is chosen for the development of WLAN antenna (2.4GHz).

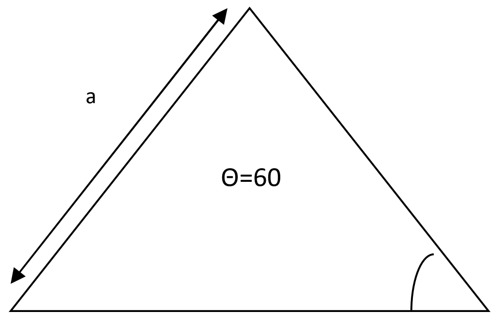
In this paper, design and analysis of contact feeding technique for ETMSA is discussed for WLAN (2.4GHz). The non-contact feeding scheme has several drawbacks of requiring two substrates to design the antenna which increases the production cost, volume and proper alignment is needed. The two substrates that do not suit the necessity of compactness and ease of integration is not preferred and in turn non- contact feeding scheme in not considered here. The types of contact feeding techniques considered for ETMSA are

- Microstrip line feed
- Coaxial feed
- Inset fed Line feed

The advantage of using contact feeding techniques is that it requires a single substrate to design the antenna i.e. both the feed line and patch are held on the same substrate. So the cost and volume of the contact feeding TMSA are reduced than Non Contacting feeding technique [4].

II. DESIGN OF ETMSA

Of the different patch shapes like circular and rectangular, the patch antenna designed with a triangular patch occupies a less area on the substrate [5]. The dielectric substrate material used is of FR4, that has a thickness of t = 1.6 mm and $\varepsilon_r = 4.4$. The substrate material chosen has an inherent advantage of low cost, easy availability with high mechanical strength and its resistance to water. The formula for the calculation of an ETMSA with sides 'a' is given in Equation 1 and the pictorial representation is shown in Fig. 1 [6].



$$a = \frac{2c}{3f\sqrt{\varepsilon_r}} \quad (1)$$

Where a = Triangular side in mm, c = velocity or speed of light (m/s)

A. Microstrip Line-Fed TMSA:

As shown in Fig. 2, the ETMSA structure is connected with a conducting strip at the base of the triangle that acts as a feeding for excitation, and the technique or scheme is Microstrip line feeding technique [7-11]. The breadth or width of the conducting feed line strip is smaller in dimension as that of the base of the patch i.e. ETMSA. This technique has an advantage of the triangular patch and the feed line lying in the same plane above the substrate and can be etched easily during fabrication. The linearly polarized ETMSA antenna is intended for 2.4 GHz frequency of operation. The feed line width and length is 3 mm and 24.3 mm respectively. A gain of 6.2 dB is obtained for the 2.4 GHz frequency of operation which is shown in Fig. 3(b) and has a return loss value of -12.57 dB and is represented in Fig. 3(a). The overall size of the antenna is 39.5 mm × 56.4 mm × 1.6 mm. The proposed ETMSA is linearly polarized with vertical polarization since the electric field varies in one direction as shown in Fig. 4(a) and 4(b).The efficiency of 92% is achieved for microstrip line fed ETMSA which is represented in Fig. 5

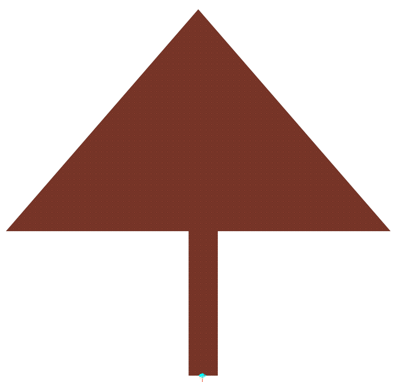


Fig. 2 Layout of Line fed ETMSA

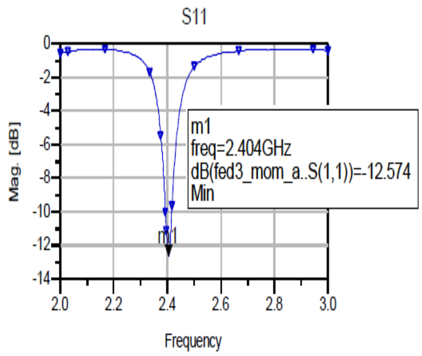
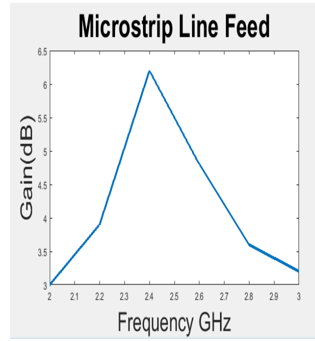


Fig.3 (a) S_{11} of line fed ETMSA



(b) Gain of line fed ETMSA

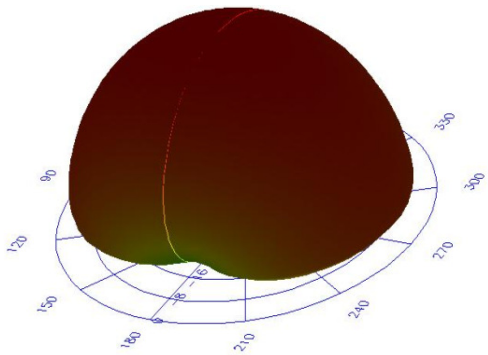
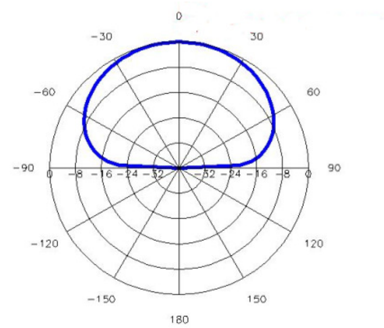


Fig. 4 (a) 3D - E-Plane Radiation Pattern of Line fed ETMSA



(b) 2D E-Plane Radiation Pattern of Line Fed ETMSA

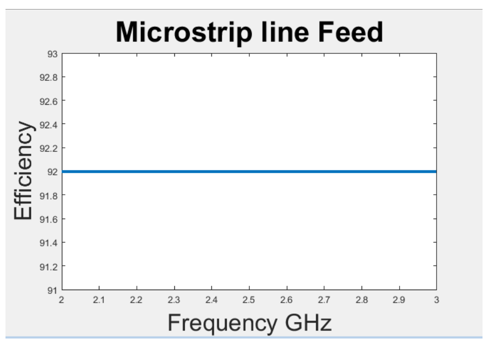


Fig. 5 Frequency versus efficiency of Line fed ETMSA

B. Inset Fed TMSA

The triangular patch antenna with inset feed triangular patch is shown in Fig. 6. The feed technique plays a crucial role in the design of TMSA [12-16]. To attain a 50Ω impedance matching, the inset-fed (Contact) feeding technique is preferred due to its flexibility. The inset cut provided can be easily accustomed by changeable feed line position and helps to achieve good matching.

The feed length (Y_0) of the inset cut is calculated for the rectangular Microstrip antenna using the formula given [17-19], and is chosen to be around inset fed width W_i = 3mm and Y_o = 8mm as shown in Fig. 6. The overall size of the antenna is 39.5 mm × 61 mm × 1.6 mm. The dimensions of the Inset fed TMSA antenna are listed in Table I

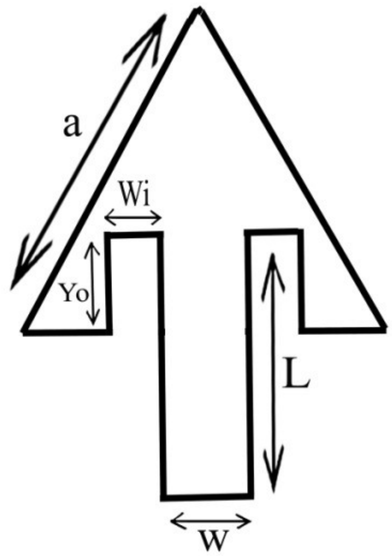


Fig.. 6 Outline of the Inset fed ETMSA

Table I Dimensions of Inset Fed Triangular Patch Antenna at 2.4 GHz

Patch antenna Parameters	**L**	**W**	**a**	**Yo**	**Wi**
Units in mm	32.3	3	39.5	8	3

C. Simulated Results of Inset Fed ETMSA

The inset fed ETMSA simulated by considering an infinite ground plane using ADS is shown in Fig. 7. The scale of the ETMSA is same for all the feeding techniques. The return loss of S_{11} of -30.01 dB for inset fed ETMSA with infinite ground plane is shown in Fig. 8 (a). The ETMSA resonates at 2.36 GHz with a gain of 6.4 dB is shown in Fig. 8 (b). The proposed ETMSA is linearly polarized with vertical polarization since the electric field varies in one direction as shown in Fig. 9 (a) and 9 (b) .Fig. 10 represents the frequency versus efficiency graph. The antenna was designed for 2.4 GHz but the antenna resonated at 2.363 GHz .The difference in error may due to port excitation and mesh generation by the ADS software.

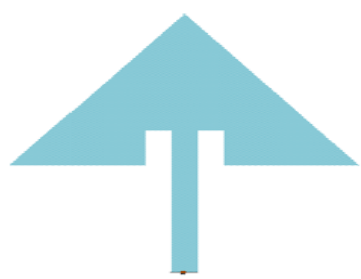
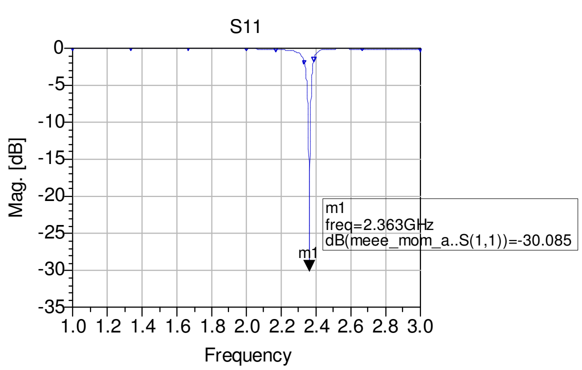


Fig.. 7 Layout of Inset fed ETMSA



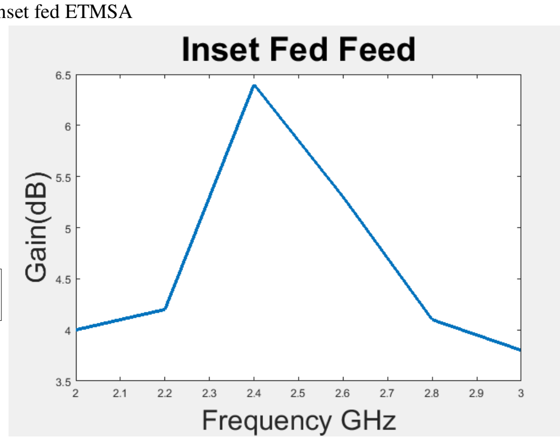


Fig. 8 (a) S_{11} of Inset fed ETMSA (b) Gain of Inset fed ETMSA

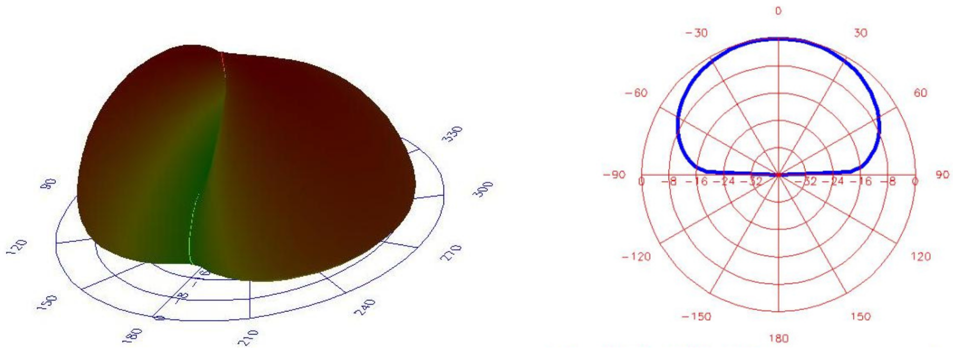


Fig. 9 (a) 3D – E-Plane Radiation Pattern of Inset fed ETMSA (b) 2D- E-Plane Radiation pattern of Inset fed ETMSA

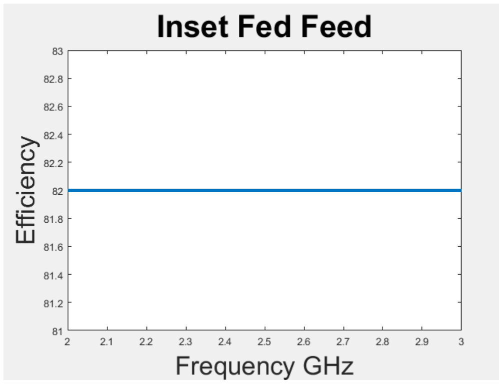


Fig. 10 Frequency versus efficiency of Inset fed ETMSA

D. Coaxial Fed TMSA

In general, one of the most popularly used feeding techniques for excitation of ETMSA is the coaxial feed. Here, the outer conductor of the coaxial cable is connected to the ground plane of the antenna, but the inner conductor pierces through the substrate material to reach the patch that lies at the top of the substrate. It is then soldered with the patch at the top to make physical as well as electrical connection between them [20-24]. Thus, the position of the coaxial cable can be located at any desired place on the triangular patch to attain a good impedance matching to the maximum level and provides a major flexible merit than that of the other feeding techniques. This scheme also provides an advantage of ease of fabrication and, results in low spurious radiation since the radiation is from the patch alone. The layout of this structure is shown in Fig. 11. The S_{11} plot of coaxial fed TMSA with infinite ground plane is shown in Fig. 12(a). The antenna operates at 2.39 GHz with S_{11} of -25.52 dB and gain of 5.65 dB as shown in Fig. 12(b). The proposed TMSA is linearly polarized with vertical polarization since the electric field varies in one direction as shown in Fig. 13(a) and 13(b). Fig. 14 represents the frequency versus gain of coaxial fed ETMSA. The overall size of the antenna is 39.5 mm × 33.7 mm × 1.6 mm.

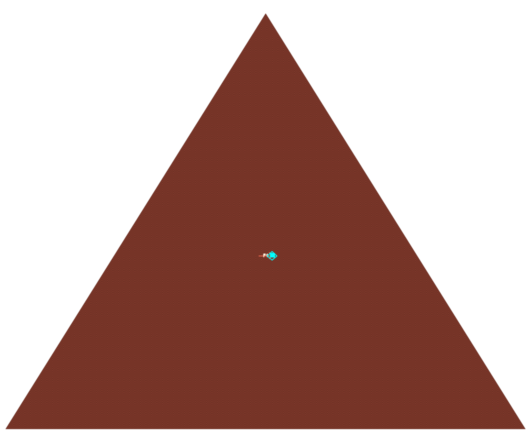
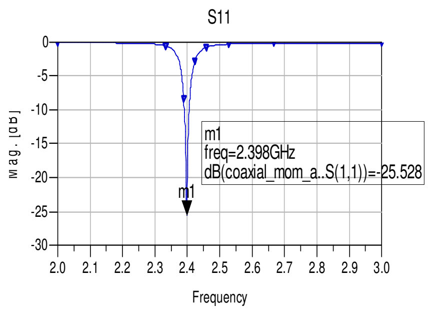


Fig. 11 Layout of Coaxial fed ETMSA



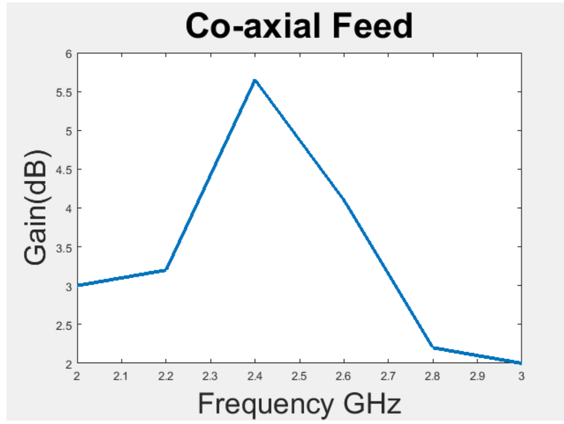
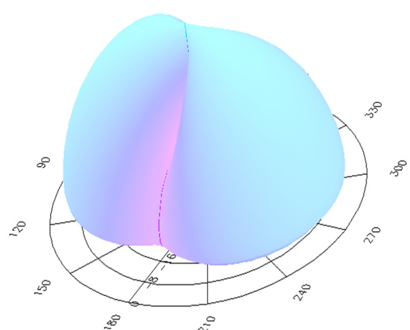


Fig. 12 (a) S_{11} of Coaxial fed ETMSA (b) Frequency versus Gain of coaxial Feed



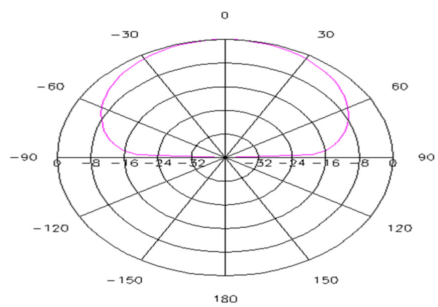


Fig. 13 (a) 3D- E-Plane Radiation pattern of coaxial fed ETMSA (b) 2D- E-Plane Radiation pattern of coaxial fed ETMSA

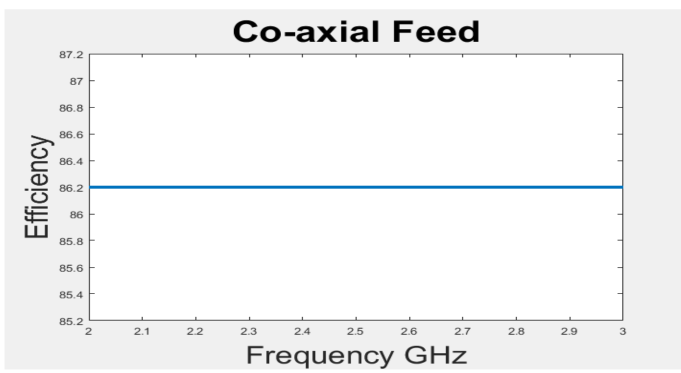


Fig. 14 Frequency versus Efficiency of coaxial fed ETMSA

III. COMPARISON OF VARIOUS FEEDING TECHNIQUES

A comparison among the contact feeding techniques for ETMSA in terms of S_{11}, gain, and resonant frequency is given in Table II

Table II Comparison of Contact Feeding Techniques

Contact feeding technique	Resonant Frequency (GHz)	Return loss (dB)	Gain (dB)
Microstrip Line Feed	2.4	-12.57	6.2
Inset fed Feed	2.36	-30	6.4
Coaxial Feed	2.39	-25.52	5.65

IV. MEASURED RESULTS OF INSET TRIANGULAR PATCH ANTENNA

The designed inset fed ETMSA is simulated for finite ground plane of size 46 mm × 61 mm × 1.6 mm using ADS and it is fabricated using FR4 substrate. The designed antenna covers the ISM band i.e. 2.4 GHz (IEEE 802.11b). Fig. 15 shows the fabricated Inset fed ETMSA with a finite ground plane. The antenna measurement is carried out using Rohde & Schwarz VNA. The measured VSWR value is 1.39 at 2.51 GHz resonant frequency as shown in Fig. 16. The simulated results show the operating frequency to be 2.37 GHz and the fabricated antenna results with a resonant frequency of 2.51 GHz. The measured impedance (terminal) of the antenna is of 51 Ω and the antenna gain is of 5.6dB. Fig. 17 shows the 2-D radiation pattern of the ETMSA. The difference in measured and simulated results may be due to SubMiniature version A Connector, the feed position error in software, automatic adaptive mesh refinement in software and fabrication inaccuracies. When the ETMSA is designed with finite ground plane the return loss and gain degrades compared to infinite ground plane, with shift in the resonant frequency. The return loss and gain are the major requirement for ETMSA and it is improved by the addition of fractal boundary. The shift in frequency may be due *fabrication* inaccuracies, surface roughness, the measurements are carried out in open space, substrate parameter tolerances and modeling inaccuracies

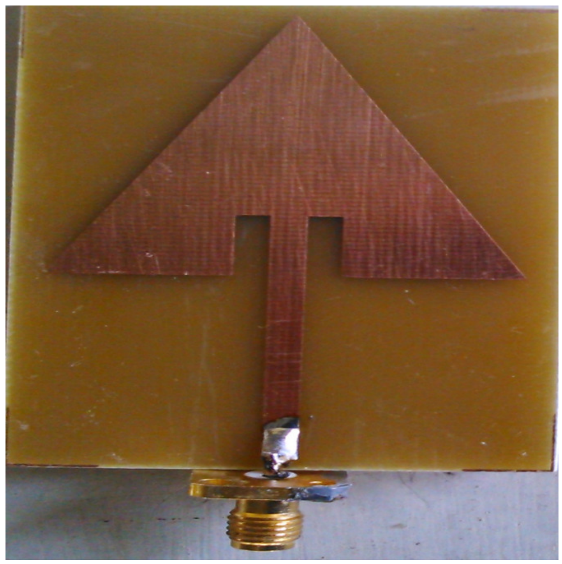


Fig. 15 Fabricated Prototype of Inset-fed ETMSA

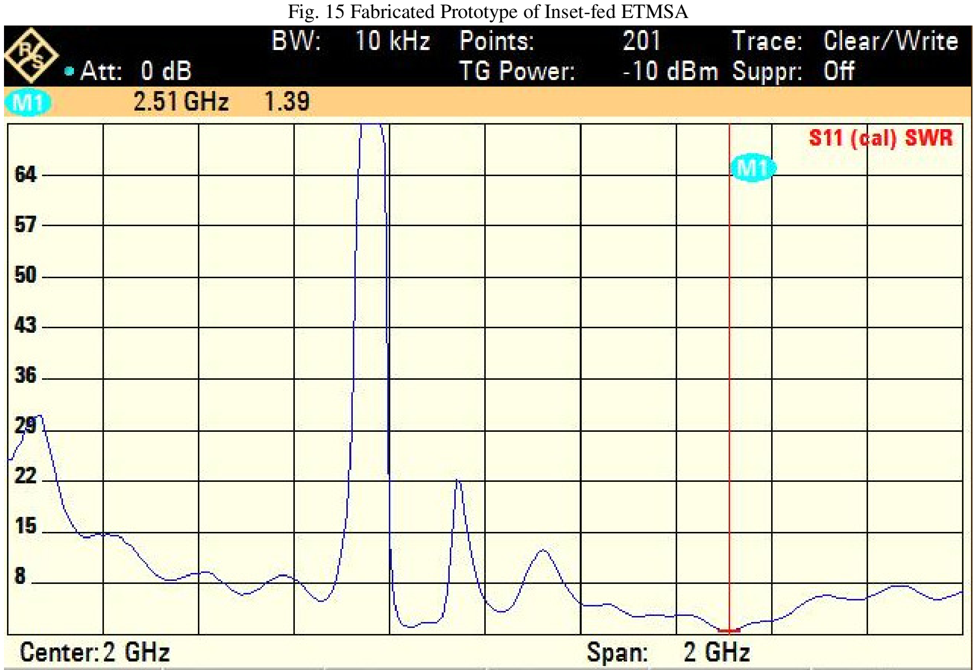


Fig. 16 Measured VSWR for Inset Microstrip Antenna

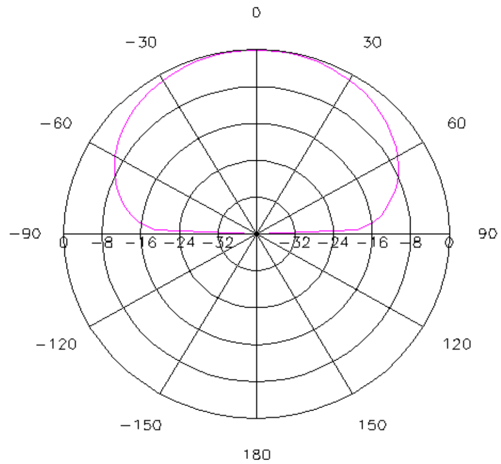


Fig. 17 2D E-plane Radiation pattern of Inset-fed ETMSA

V CONCLUSION

A comparison of various contact feeding techniques of Equilateral triangular Microstrip Antenna has been analyzed. The performance of inset fed ETMSA in terms of return loss and gain is best compared to that of coaxial feed and Microstrip line feed. The fabricated antenna is well suited for WLAN applications.

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