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E-Shape Microstrip Patch Antenna Design for Wireless Applications

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Abstract— A E-shape microstrip patch antenna proposed system design for wireless application. An microstrip patch antenna operated at microwave frequencies and also called microwave antenna are mainly used for long distance mobile communication. The microstrip patch antenna will provide broad bandwidth which is required in various application like remote sensing, biomedical application, mobile radio and satellite communication etc., The high frequency antenna designed microwave laboratory and it is simulated using HFSS (High Frequency Structure Simulator) version 13 software. Coaxial feed or probe feed technique is used in this experiment. Parametric study was included to determine effect of design towards the antenna performance. The microwave antenna design performance was analyzed in term of bandwidth, gain, return loss, VSWR and radiation pattern. The microwave antenna results show operate from 12.50 GHz to 25.49 GHz frequency band with optimum frequency at 18.73 GHz. The design was optimized to meet the best possible result. Substrate used was air which has a dielectric constant of 1.0006.

Index Terms— E-shape microstrip patch antenna, HFSS (High Frequency Structure Simulator) version 13 software, wideband.

I. INTRODUCTION

The concept of micro strip antennas was first demonstrate in 1886 by Heinrich Hertz and its practical application by Guglielmo Marconi in 1901 and it can be newly proposed by Decamps in 1953. Howell and Munson developed the first practical antennas in the early 1970‟s. Since then, extensive research and development of micro strip antennas and arrays, exploiting their advantages such as low weight, low volume, low cost, conformal configuration, compatibility with integrated circuits, mechanically robust when mounted on rigid surfaces, capability of dual and triple frequency operations all these features, attract many researchers to investigate the performance of patch antenna in various ways and also have led to many diversified applications. In genaral Micro strip antennas are also known as “ Printed Antennas ” The basic configuration of a micro strip antenna is a metallic patch printed on a thin, grounded dielectric substrate. Microstrip patch antenna is a key building in wireless communication and Global Positioning system. Future trend in communication design is towards compact devices. Microstrip patch antenna have been well known for several techniques have been applied to overcome this problem such as increasing the substrate thickness, introducing parasitic elements i.e. co-planar or stack configuration, or modifying the patch's shape itself. Modifying patch's shape includes designing an E-shaped patch antennas. This proposed systems provide broad bandwidth when compare to the other research system.

These antennas can be integrated with printed strip-line feed networks and active devices. This is a relatively new area of antenna engineering. This proposed system of E-shape only adjust length, width and position of slot. The main objective of this paper is to optimize the base design in to obtain higher bandwidth. This single patch antenna operates at voltage standing wave ratio of less than 2 (VSWR < 2). Our proposed system designed and simulated using HFSS (High Frequency Structure Simulator) version 13 software shown in fig.1.

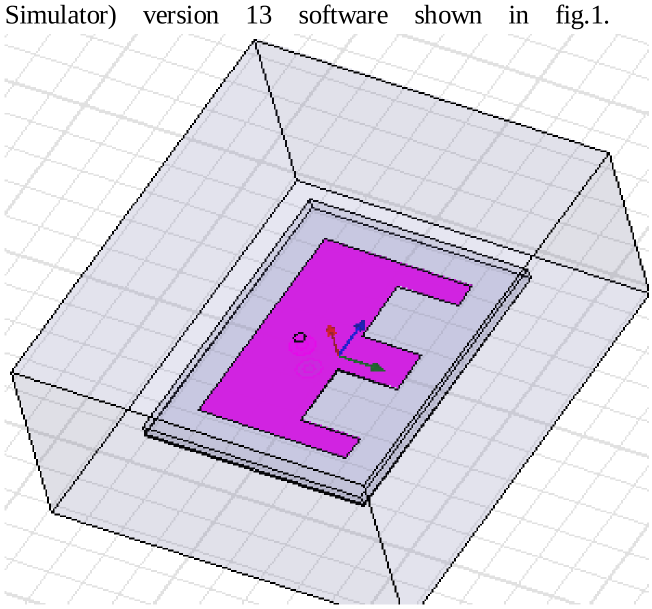

Fig.1 Proposed E-Shaped Patch Antenna

II. DESIGN METHODOLOGY OF RADIATING ELEMENT

The radiation properties of micro strip structures have been known since the mid 1950‟s.The application of this type of antennas started in early 1970‟s when conformal antennas were required for missiles. Originally, the element was fed with either a coaxial line through the bottom of the substrate, of by a coplanar microstrip line. This latter type of excitation allows feed networks and other circuitry to be fabricated on the same substrate as the antenna element, as in the corporate- fed microstrip array. The microstrip antenna radiates a relatively broad beam broadside to the plane of the substrate. Rectangular and circular micro strip resonant patches have been used extensively in a variety of array configurations. A major contributing factor for recent advances of microstrip antennas is the current revolution in electronic circuit miniaturization brought about by developments in large scale integration. As conventional antennas is often bulky and costly part of an electronic system, micro strip antennas based on photolithographic technology.

In our proposed system increase thickness the bandwidth increases accordingly. The input impedance of about 42% is achieved. The slots making it to look alike inverted E shape; it demonstrated a bandwidth enhancement by 30 %.In this design an air-filled or foam has been essential to realize broadband characteristics. This proposed system design use the substrate material will gives air and the patch shape is the combination of inverted E.

II.A. Design Setup A microstrip patch antenna consists of a radiating patch on one side of a dielectric substrate which has a ground plane on the other side. The antenna's resonant properties were predicted and optimized using High Frequency Structure simulation software Ansoft version 13. The design procedure begins with determining the length, width and the type of dielectric substance for the given operating frequency as shown in flow diagram Fig.2. Then using the measurements obtained above simulation has been setup for the basic rectangular microstrip antenna and the parameters are optimized for the best impedance matching. Furthermore two parallel slots are incorporated and optimized such that it closely resembles E shape this increases the gain of the antenna. After that introducing two more parallel slots and one perpendicular slot are incorporated and optimized such that it closely resembles its shape. Then dielectric substrate of dielectric constant of 1.0006 introduces to decrease the size of the antenna and to further enhance the bandwidth. At last the probe feeding is introduced for attaining a required bandwidth, resonating frequency and gain value. The proposed design methodology of the antenna given in Fig 2.

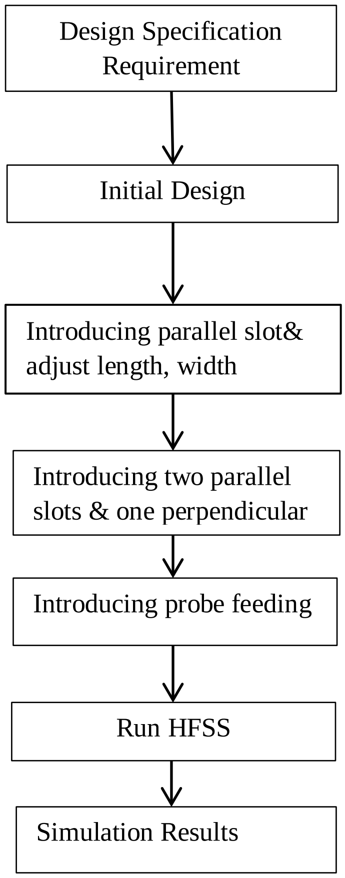

Fig.2 Antenna Design Procedure

II.B. Geometry of the antenna

The geometry of the designed antenna is shown in the Fig. 3.The antenna is made of a single patch on top, one layers of dielectric (air) and a vertical probe connected from ground to the upper patch. The basic antenna element is a strip conductor of length L and width W on a dielectric substrate with constant ε_r; thickness or height of the patch being h with a height and thickness t is supported by a ground plane. The rectangular patch antenna is designed so as it can operate at the resonance frequency. The length that is for the patch does depend on the height, width of the patch and the dielectric substrate. The patch is generally made of conducting material such as copper or gold and can take any possible shape. The radiating patch and the feed lines are usually photo etched on the dielectric substrate. The E-shaped radiating patch antenna can propagate at high frequency range it will also improve the performance of greater bandwidth than existing systems.

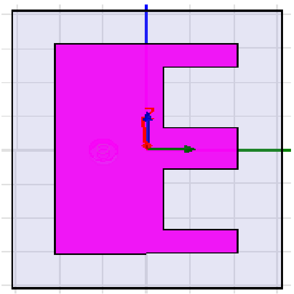

Fig.3 Geometry of Proposed Antenna(Top view)

The length of the patch for a rectangular patch antenna normally would be $0.333\lambda < L < 0.5\lambda$, λ being the free space wavelength. The thickness of the patch is selected to be in such a way that is $t << \lambda$

The length of the patch can be calculated by the simple calculation

$$L \approx 0.49\,\lambda_d = 0.49\lambda_0/\sqrt{\varepsilon_r}$$

L – Resonate length.

$\lambda 0$ – wave length of the free space.

λd – wavelength of the PC board.

εr – dielectric constant.

As we know that the dimensions of the patch antenna effects in the results as the main part, especially length (L) and the width (W).

The width of the patch can be calculated by the formula

$$W = (c/\,2f_r\,)\sqrt{2/\,\varepsilon_r+1}$$

c – The speed of light,

fr – the resonant frequency which is equal to 1GHz

The height h of the dielectric substrate that supports the patch usually ranges between $0.003\,\lambda$ & 0.05λ so as the dielectric constant, εr of the substrate ranging between 2.19 and 12.

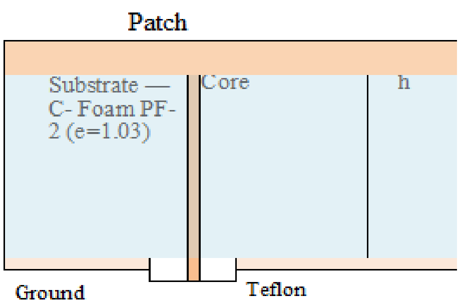

Fig.4 Cut Plane View of Antenna

III. PARAMETRIC STUDY

The default value of dimension for this antenna is presented in Table 1. Dimension that are kept constant in this paper are Main Patch, Outer Patch, Substrate's thickness, LsB and SMA parameter is allowed to change at a time while other variables remain constant as default except ground and substrate that will varied together. All dimension mentioned in graphs are in millimeter (mm).

Table 1: Microstrip patch antenna specifications

Parameter		Label	Dimension (mm)
Main Patch	Length	La	10.9
	Width	Wa	15.7
Outer Patch	Length	Lb	13.2
	Width	Wb	21.7
Slot	Main slot width	WsB	17.7
	Slot Width	Sa,Sb	1.0
	Slot A length	LsA	8.4
	Slot B length	LsB	10.9
Centre Arm	Width	Wc	5.2
Feed point	Width	Wc/2	2.6
	Length	Lf	1.8
Substrate Air	Thickness	H	3.2
	Dielectric constant	STS	1.0006
Substrate and Ground	Width and Length	Wsub, Lsu Wg, Lg	60
	Core Diameter	Dc	1.275

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SMA	Teflon Diameter	Dt	4.17
	Teflon Dielectric constant	Sit	2.08

Parallel slots in this design are responsible for the excitation of next resonant mode i.e. main parallel slot excite 2nd resonant frequency while outer slot excite 3rd resonant frequency. Slots length (LsA and LsB), slot width (S), main slot width (WsB) and center arm (Wc) controls the frequency of the next resonant mode. Figure 4 shows the cut plane view of the antenna. The patch and ground are separated by closed-cell low loss air of thickness 3.2 mm. Dielectric constant for this foam is 1.0006, and it benefits to obtain wider bandwidth and higher gain.

Air gap was used as substrate and infinite ground was assumed. This paper design a finite set of ground dimension which is defined by Wg × Lg. SMA connector design is according to specification in using Teflon of dielectric constant = 2.08. The default value of this antenna design is shown in Table 1.

IV RESULTS AND DISCUSSION

The rectangular antenna design are finished and appropriate various rectangular antenna performance are carried out by using simulation (HFSS) result. These results are plotted such graph as polar, smith chart,3D radiation pattern, XYZ plot and their different characteristics are plotted using HFSS simulation software. The varied parameters specification after optimization and the frequency band for the optimized wideband antenna range from 12.59 GHz up to 25.99 GHz. When Compared to original default bandwidth (using Air), the bandwidth is expanded from 4.68 GHz to 5.4 GHz which is a 15.38% bandwidth improvement.

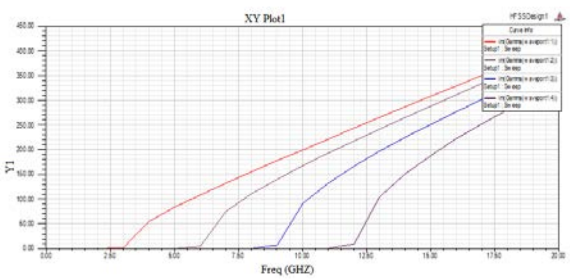

Fig.5 Optimized Patch Antenna's

The impedance bandwidth of 21.6% from 4.68GHz to 5.4 GHz is achieved at VSWR ≤ 2. In this proposed system performance of the broad bandwidth is increases and frequency range also increases from 12.50 GHz to 25.49 GHz frequency band with optimum frequency at 18.73 GHz shown in fig.5.This results shows that improvement from previous research . The wideband characteristic is due to large separation between the radiating patch and the ground plane and due to the use of low permittivity substrate with the proposed design. The maximum achievable gain is 11.31 dBi at the frequency of 18.45 GHz and the gain shows stable performance in the entire operating band. Fig.7 shows that the smith chart performances are plotted. The designed antenna displays good broadband radiation patterns. The antenna shows better cross-polarization. It is notable that the radiation characteristic of the proposed microstrip antenna are better to those of the conventional microstrip antenna due to good cross polarization level in both planes are achieved over the impedance bandwidth.

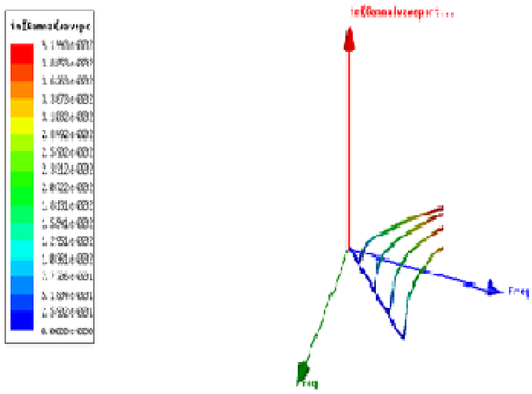

Fig.6 3D Pattern of Optimized Patch Antenna's

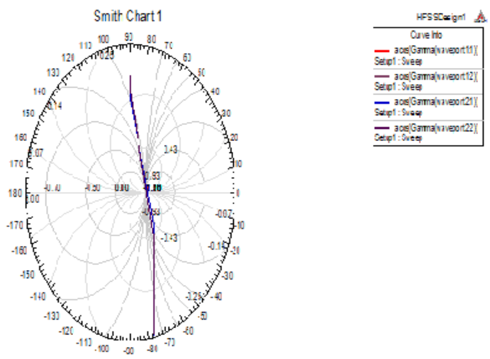

Fig.7 Performance of antenna using Smith chart

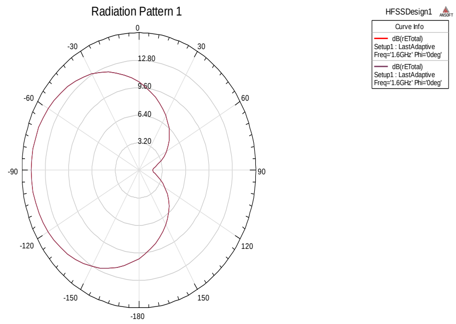

Fig.8 2D Radiation Pattern

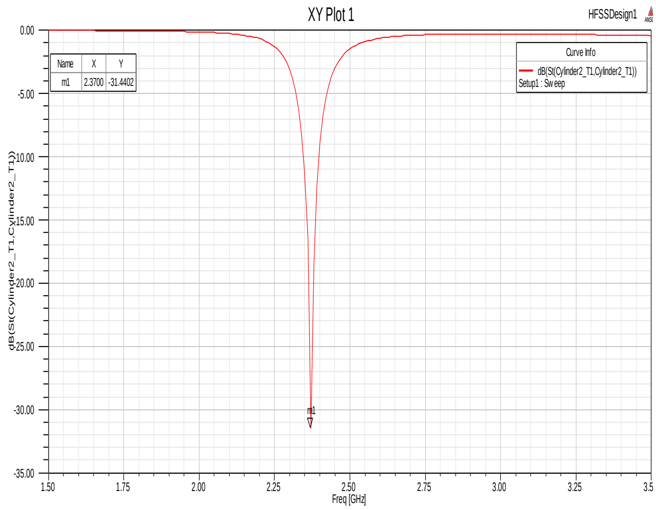

Fig.9 S-Parameter of optimized antenna

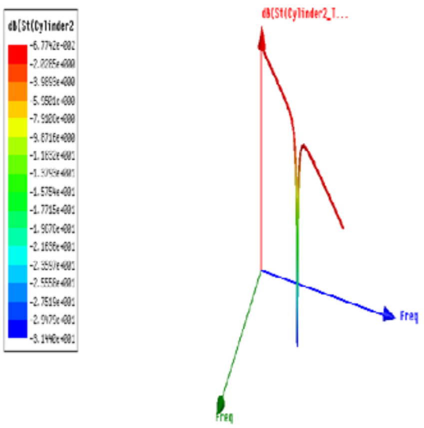

Fig.10 3D View of S-Parameter

S11 parameter for the original air gap substrate, the original foam substrate, and the optimized wideband antenna. The frequency band for the optimized wideband antenna range from 12.50 GHz up to 25.49 GHz. Compared to original default bandwidth (using Air), the bandwidth is expanded from 4.68 GHz to 5.4 GHz which is a 15.38% bandwidth improvement. The obvious improvement is the position of low cut-off frequency.Fig.10 shows that VSWR(Voltage Standing Wave Ratio) comparison of optimized antenna and the lowest VSWR value is 1.67 for 13.24GHz while for optimized antenna which uses Air substrate acquires the lowest VSWR of 0.217. The antenna operates optimally at 1st resonant frequency which is 12.50 GHz, followed by 2nd resonant at 18.45 GHz and finally 3rd resonant at 25.49 GHz.The gain measured for default design at its most optimum frequency (18.45 GHz) is 11.31 dB and the gain using air substrate at 12.50 GHz, the gain is .

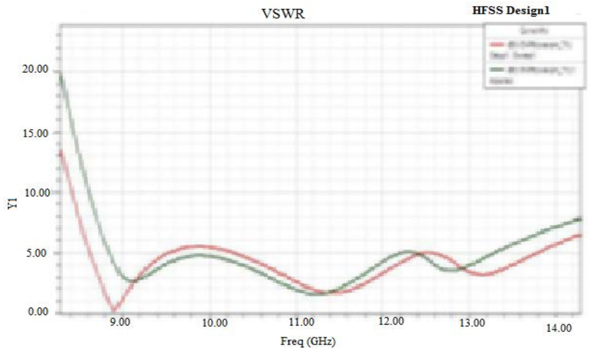

Fig.11 VSWR of optimized antenna

Fig.11 shows that radiation pattern of 3D view and it only contain main lobe(major lobe) doesn't have any side lobe. So there is no losses and doesn't occurs any reflection or errors. The radiation pattern for the antenna at 18.45 GHz. HPBW is the angular separation which the magnitude of the radiation pattern from the peak of the main beam decreases by 50% or -3 dB. HPBW (angle) is 70˚ for Optimum Frequency of 18.45 GHz. our results performance show that improvement from previous research.

Fig.12 3D View of Radiation Pattern.

V. CONCLUSION

Antenna can be designed for an each parameter give an accurate value by doing continues changing value to get an different output can be viewed and based on the different input data to get an different output using this HFSS(High Frequency Structure Simulator) its helpful for 2Dimensional as well as 3Dimensional radiation pattern can be viewed to get an accurate output. The maximum achievable gain is 11.31 dBi at the frequency of 18.45 GHz and the gain shows stable performance in the entire operating band. The measured total efficiency of the proposed antenna is an average of 90% over the operational frequency. The designed antenna displays rectangular design bandwidth, gain, band of frequency range will be improved. In future fully completed the E-shape patch and rectangular patch surely achieved higher bandwidth, high frequency range (12.50 GHz up to 25.49 GHz) and it will helpful for long distance communication in real time wireless applications.

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good broadband radiation patterns. This proposed system should be extend the frequency in the range of 12.50 GHz up to 25.49 GHz in future and up to r

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