Design & Parameters Analysis of Microstrip Patch Antenna for Ultra wide band Application

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Abstract –

Microstrip patch antennas being popular because of light weight, low volume, thin profile configuration which can be made conformal. This paper presents antenna designs for ultra wide band applications. UWB is a short distance radio communication technology that can perform high speed communications with speeds of more than 100Mbps. Modern communication system requires single antenna to cover several wireless bands. The UWB systems have received great attention in indoor and handheld wireless communication. The first is the design and parametric analysis of Inset fed rectangular micro-strip antenna which operates at the central frequency of 6.57GHz.The second aspect is the design and parametric analysis of slot cut E-shaped micro-strip antenna. The simulation process has been done through high frequency structure simulator (HFSS). The properties of antenna such as bandwidth, return loss, VSWR has been investigated and comparison between these two micro-strip antenna. The presented antenna simulated and various parameters such as return loss, VSWR, gain and radiation pattern has been investigated.

Keywords -- *HFSS(High frequency structured simulator), MPA(Micro-strip Patch Antenna), FEM(Finite Element Method) etc.*

I. INTRODUCTION

Antenna "The eyes and ears in space" is experiencing a various changes from earlier long wire type for radio broadcast, communication links to the military applications, aircraft, radars, missiles, space applications in the second half of last century. This scenario is fast changing with the evolution of Cellular mobile personal communication in the form of Global System for Mobile communications (GSM), Code Division Multiple Access (CDMA), Digital Communication System (DCS) 1800 systems, North American dual-mode cellular system Interim Standard (lS)-54, North American IS-95 system, and Japanese Personal Digital Cellular (PDC) system etc. Satellite communication and Wireless communication has been developed rapidly in the past decades and it has already a dramatic impact on human life. In the last few years, the development of wireless local area networks (WLAN) represented one of the principal interests in the information and communication field. Micro-strip patch antennas being popular because of light weight, low volume, thin profile configuration which can be made conformal. Wireless communication systems applications circular polarization antenna is placing vital role. In this study we introduce a new technique to produce circular polarization. Hybrid coupler is directly connected to micro-strip antenna to get circular polarization[11]. The common shapes of the micro-strip patch are rectangular, square, circular, triangular, etc.

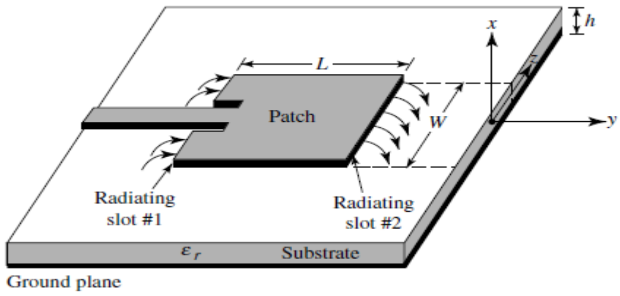

Fig 1 Micro-strip Patch Antenna

The length of the connecting strip is maintained to be λ/4. However, the width of the strip is treated as a variable. The four strips are placed symmetrically at four points. Micro-strip feeding techniques is preferred in this design. The length of the feed is again considered to be multiples of λ/4 for proper impedance matching at the end. The patch antenna shape is etched from the double side printed dielectric substrate FR4-Epoxy with dielectric constant (Ɛr) of 4.4. The backside of the substrate is used as the ground portion. The dimensions are determined based on selected resonant frequencies 6.57 and 9.5 GHz.

A micro-strip patch antenna can be fed either by coaxial probe or by an inset micro-strip line. Coaxial probe feeding is sometimes advantageous for applications like active antennas, while micro-strip line feeding is suitable for developing high-gain micro-strip array antennas. In both cases, the probe position or the inset length determines the input impedance[10].

$$\varepsilon_r eff = \frac{\varepsilon_r+1}{2} + \frac{\varepsilon_r-1}{2}\left(1+12\frac{h}{w}\right)^{-\frac{1}{2}} \quad (1)$$

$$\frac{\Delta l}{h} = 0.412 \frac{(\varepsilon_r eff+0.3)(\frac{W}{h}+0.264)}{(\varepsilon_r eff-0.258)(\frac{W}{h}+0.8)} \quad (2)$$

This ΔL value mainly depends on the effective dielectric constant and the width to height ratio. Due to this length extension length of patch is about 0.48λ rather than 0.5λ. Therefore to get the actual physical length of the patch equal to λ/2 we have consider the extension on both the ends and that is,

$$L = L_{eff} - 2\Delta L \quad (3)$$

As we know for dominant mode TM_{010} the length patch is equal to λ/2 therefore the L_{eff} is given by

$$L_{eff} = c/f_r \quad (4)$$

$$Leff = \frac{c_o}{2f_r\sqrt{\varepsilon_{r\theta}ff}} \quad (5)$$

Where C_o is the velocity of light in free space and f_r is the resonance frequency for which antenna is to be design.

For the dominant mode TM_{010} there is no fringing field along the width therefore there is no need to consider the effective dielectric constant Width of the patch can be calculator by the formula

$$W = \frac{c_o}{2f_r}\left(\frac{\varepsilon_r+1}{2}\right)^{-1/2} \quad (6)$$

For the dominant mode TM_{010} the antenna resonates (without taking fringing into account) at the frequency given by

$$f_r = \frac{c_o}{2(L+2\Delta L\sqrt{\varepsilon_r eff}} \quad (7)$$

II. DESIGN METHODOLOGY

The invention of Micro-strip patch antennas has been attributed to several authors, but it was certainly dates in the 1960s with the first works published by Deschamps, Greig and Engleman, and Lewin, among others. After the 1970‟s research publications started to flow with the appearance of the first design equations. Since then different authors started investigations on Micro-strip patch antennas like James Hall and David M. Pozar and there are also some who contributed a lot. HFSS from Ansoft are very popular computer software that are used for antenna models design. Before building antennas, people can use these softwares to help them for finding the results they want. There are lots of different types of antennas in the world. And, there are different theories behind these antennas and different methods behind these two computer softwares. In this project, we will use HFSS to build structures and simulate for different type of antennas, which are mushroom cell antenna, patch antenna, dielectric antenna, and spiral antenna

III. DESIGN AN INSET FED PATCH ANTENNA FOR UWB APPLICATION

A rectangular Patch antenna has been in the process of design, it is easy in the fabrication analysis and also in the prediction of the performance. The design of the antenna is being under process at 6.57GHz frequency using the Dielectric material with εr = 4.4 with a dielectric loss tangent (tan δ) = 0.009 with a height of 1.5mm. The feed mechanism plays an important role in the design of microstrip patch antennas. A microstrip patch antenna can be fed either by coaxial probe or by an inset microstrip line.

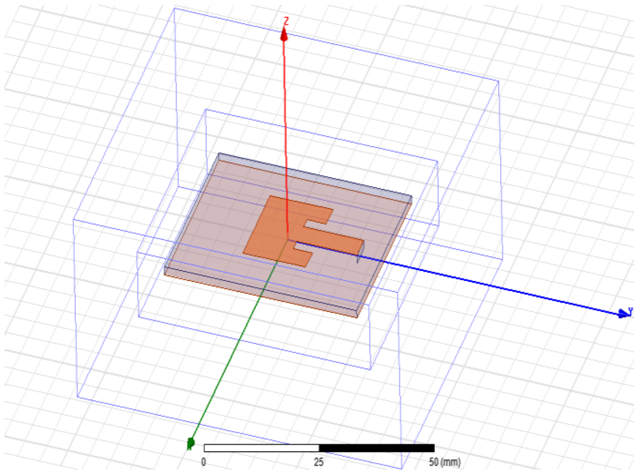

Fig.2 Proposed Inset Fed Micro-strip Patch Antenna.

Table 1 Design Parameter of Inset Fed Patch Antenna

Antenna	**Parameters**	**Dimensions**
	Resonant frequency	6.5GHz ,9.5G Hz
	Dielectric constant	2.2
	Loss tangent	0.009
Rectangular patch	Length of patch	18.24mm
	Width of patch	14.66mm
Feed	Feed length	14.06mm
	Feed width	4.62mm
Ground / Substrate plane	Length of plane	36.4mm
	Substrate Thickness	44.91mm
	Width of plane	27.20mm
Inset	Inset Distance	4.48mm
	Inset gap	2.31mm

A. Parametric Study of Inset Fed Microstrip Antenna

The simulated result of S11 scattering parameter (return loss) of single element rectangular microstrip antenna is presented in Fig.3 From the Fig.3 the antenna has almost 6.5GHz resonant frequency and it has 42MHz bandwidth at -9 dB (the difference of 6.5GHz and 6.6 GHz) and it has -

13.01dB return loss. The value of VSWR at 6.5 GHz resonant frequency is 1.7. The simulation result for Gain (dB) is shown in the Fig 7 and Fig 8. The measured Gain is 7.11dB.

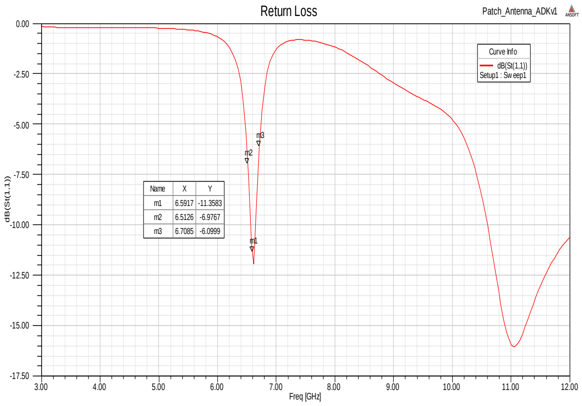

Fig 3 Return Loss For Patch Antenna

The performance of the antenna is described in terms of gain. It gives overall performance of the antenna .Gain refers to the direction of maximum radiation. The Fig.4 shows the gain of the designed antenna. The maximum measured Gain of antenna is 7.11dB .

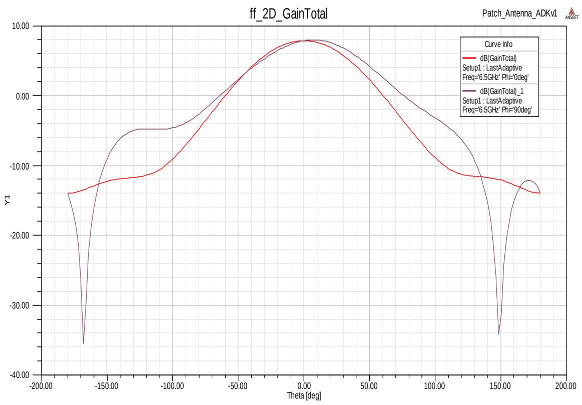

Fig 4 Total 2-D Gain of Inset Fed Patch Antenna

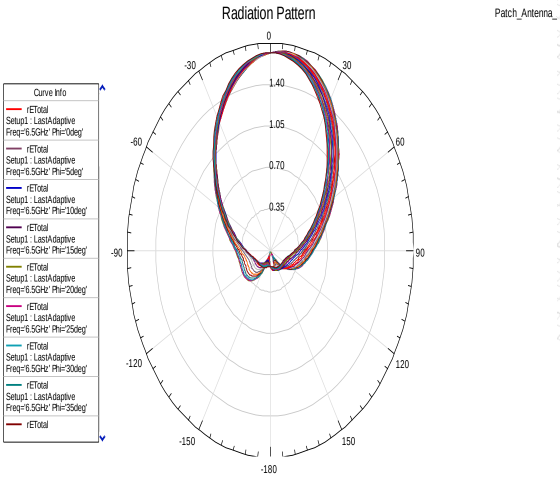

Fig 5 Total Radiation Pattern of Inset Fed Patch

The VSWR is an important characteristic of communication devices. It gives the measurement of how well an antenna is matched with it feed impedances where the reflection coefficient will be 0. The simulation result for VSWR is shown in Fig.6. The antenna radiate efficiently At 6.5GHz the VSWR value is 1.74.

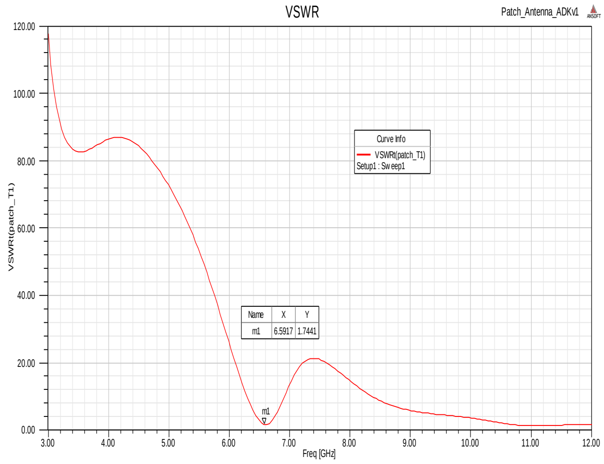

Fig 6 VSWR of Inset Fed Patch Antenna

IV. DESIGN E-SHAPED PATCH ANTENNA FOR ULTRA WIDE BAND APPLICATION

The simulated result of S11 scattering parameter (return loss) of E-shaped microstrip antenna is presented in Fig.7. From the Fig, the antenna has almost 6.57GHz resonant frequency and it has 440MHz bandwidth at -15 dB (the difference of 7.03 GHz and 6.59 GHz) and it has -17.50 dB return loss. The value of VSWR at 6.57GHz resonant frequency is 1.07. The simulation result for Gain (dB) is shown in the Fig.10. The measured Gain is 7.97dB. The design parameter of E-shape antenna is shown in Table 2.

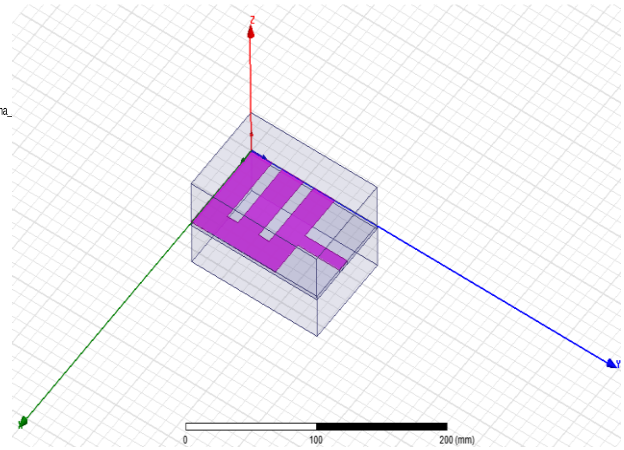

Fig 7 Showing Proposed E-Shape Patch Antenna

Table 2 Design Parameter of Inset Fed Patch Antenna

Antenna	Parameters	Dimensions
	Resonant frequency	6.5GHz ,9.5 GHz
	Dielectric constant	2.2
	Loss tangent	0.009
Rectangular patch	Length of patch	18.24mm
	Width of patch	14.66mm
Feed	Feed length	14.06mm
	Feed width	4.62mm
Ground / Substrate plane	Length of plane	36.4mm
	Substrate Thickness	44.91mm
	Width of plane	27.20mm
Middle slot	Slot length	21mm
Side slot	Slot length	25mm
	Slot width	7.2mm
Inset	Inset Distance	4.48mm
	Inset gap	2.31mm

A. Parametric study of E-shape Antenna

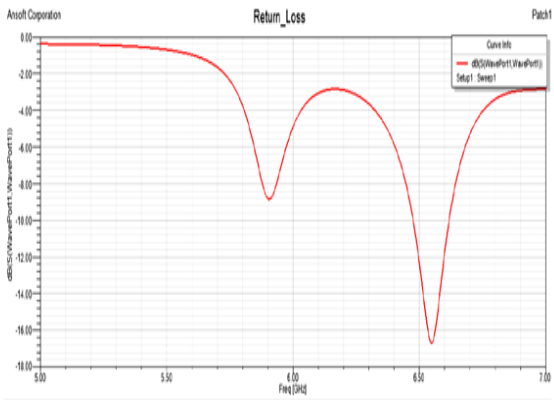

Fig 8 Return Loss of E-Shape Patch Antenna

The simulation result for Return loss and VSWR is shown in Fig.8 and Fig.9. Hence, the antenna radiate efficiently at 6.5GHz the VSWR value is 1.74

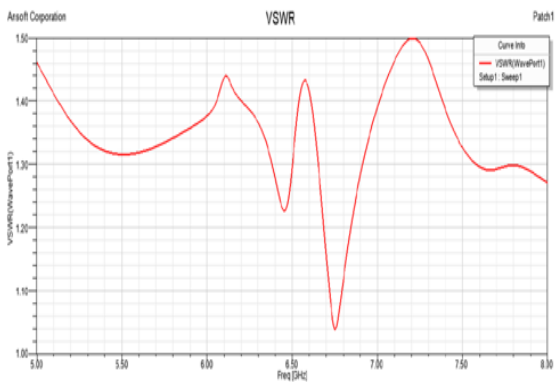

Fig 9 VSWR of E-Shape Patch Antenna

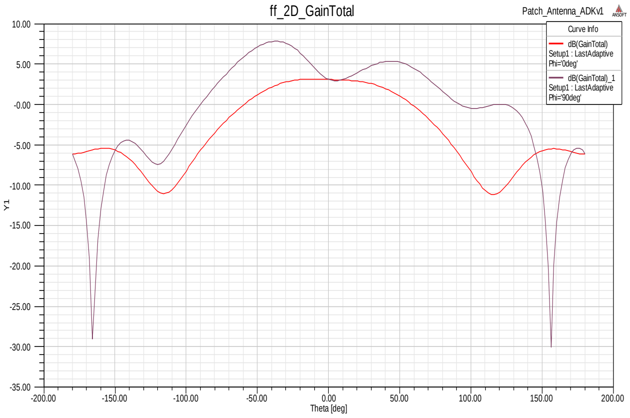

Fig 10 2D Gain of E-Shape Patch Antenna

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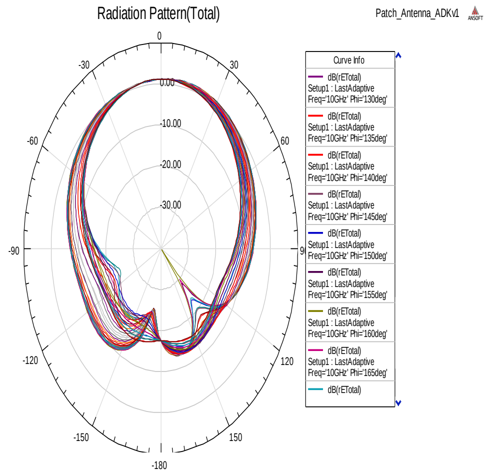

Fig 11 Radiation Pattern of E-Shape Patch Antenna

Table 3 Comparison Between Inset Fed and E-Shaped Patch Antenna

Parameter	Rectangular inset Fed Patch Antenna	E-shape patch Antenna
Resonant Frequency	6.5GHz	6.57GHz
Bandwidth	40MHz	440MHz
Return loss	-11.35dB	-17.50
VSWR	1.74	1.07
Gain	7.11dB	7.97dB

V. CONCLUSION

In this paper, Ultra wide band antenna geometries are designed and implemented After the parametric study it is concluded that multi resonance characteristics of MPA such as Return loss, VSWR, Radiation pattern, can be improved by changing the parameters such as operating frequency, ground plane structure dimensions, feeding techniques Can be made usable new structure defined MPA within UWB ranges for many wireless devices communication applications. From the table it is clear that the antennas are designed at the resonant frequency of 6.5GHz and 6.57GHz. In rectangular inset fed the bandwidth is 40MHz, gain and Return loss is 7.11dB and -11.35.The E-shaped patch antenna enhances bandwidth 440MHz, Gain 7.97dB and good return loss (S11 parameters) of -17.50dB and excellent value of VSWR be 1.07 is achieved as compare to inset microstrip patch antenna.

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