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Triple Band Inset Line Feed Hexagonal Microstip Patch Antennas with S-Slot and E- Slot for S, C and X–Bands Application

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ABSTRACT

This paper presents design, simulation and comparative study between S-shape slotted inset line feed hexagonal micro strip patch antenna and E-shape slotted inset line feed hexagonal micro strip patch antenna operating in the frequency range of 4GHz -11GHz with respect to an un-slotted inset line feed hexagonal micro strip patch antenna .The un-slotted hexagonal micro strip patch antenna resonated at 9.92 GHz with return loss-15.126189dB but with S-shaped slot and E- shaped slot it exhibited resonance at three different frequencies. The S-shape slotted hexagonal micro strip patch antenna resonated at three resonant frequencies 4.9GHz with return loss -12.765dB, 8.6GHz with return loss -14.553dB and 9.7 GHz with return loss-12.394dB, whereas E-shape slotted hexagonal micro strip patch antenna resonated at three frequencies 4.1GHz with return loss-12.765dB, 8.6GHz with return loss -13.926dB and 9.7GHz with return loss-12.178dB, covering S-Band, C-Band and X-Band. The design and simulation process has been carried out through C.S.T. Microwave Studio 2018. The characteristic properties of antenna such as bandwidth, return loss, VSWR have been investigated, analyzed and compared between S- shape slotted hexagonal micro strip patch antenna and E- shape slotted hexagonal micro strip patch antenna.

KEYWORDS: *E-SHAPE SLOTTED HEXAGONAL MICRO STRIP PATH ANTENNA, S-SHAPE SLOTTED HEXAGONAL MICRO STRIP PATCH ANTENNA, CST*

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INTRODUCTION

An antenna is the fundamental and key component of all kinds of the wireless networking and communication. Accordingto the IEEE standard, “Antenna is assumed as a device of transmission and reception of radio waves” [1]. Recently, the up growth in the wireless system leads to a lot of innovations in the micro strip patch antenna.Micro strip antenna technology achieved its rapid development in the late 1970s. By the early1980s basic micro strip antenna elements were fairly well established in terms of design and modeling. The micro strip patch antenna has more advantages over other microwave antennas in the area of portability because of its low profile, low cost fabrication, light weight, easy to install and integrate with feed networks. Due to simplicity and compatibility micro strip patch antennas are being used widely in different microwave frequency spectrum to cater commercial and scientific purposes [1-4]. But with these quantum merits patch antennas inherent major drawbacks of narrow band width, low efficiency and low gain [1-3]. Therefore these antennas have very narrow band width characteristics as it limits the frequency range over which the antenna can perform [1].However ,the bandwidth and the size of an antenna are self-contradictory properties, that is ,improvement of one of the characteristics normally results in degradation of the other. As a result, it captured the attention of investor and scientists to prompt and motivate more research into improvements in related fields. Researchers have made multiplex several efforts to overcome these challenges through various mechanisms. One ,out of these mechanism, to achieve desirable resonant frequency and improved band width, is modified configuration of different shapes of patch like L-shape, E-shape and half U- shape with various dimensions[5-7]. Another mechanism to improve band width is modification in the shape of patch by cutting slots in it, like U-Slot, V-Slot , E-Slot and S-Slot[8-10].Thus patch and slot are two parameters affectingoverall antenna’s performance fairly[11].Therefore, keeping these mechanism in view, patch of the proposed antennas is slotted properly in S and E shapes which have offered an appreciable increase in bandwidth over more than > 500 MHz.Inset line feed hexagonal patch antenna with S-shaped slot consist of S-slotted hexagonal patch, supported on a grounded dielectric FR-4 sheet of thickness h=1.6mm and dielectric constant 4.3 [12].Similarly, inset line feed hexagonal patch antenna with E

shaped slotconsist of E- slottedhexagonal patch, supported on a grounded dielectric FR-4 sheet of thickness h=1.6mm and dielectric constant 4.3[13].The prime object of this paper is comparison and analysis of band width (WB) characteristics under -10 dB return loss at resonant frequencies 4.1GHz /4.9GHz,8.6MHz /8.0GHz and 9.7GHz /9.7GHz and others characteristics such as voltage standing wave ratio (VSWR),directivity, gain , efficiency etc. of the proposed antennas which have been incorporated into two quietly different shapes of S-slot and E-slot.

1.1. ANTENNA DESIGN AND GEOMETRY

The circumscribed radius of the regular hexagonal patch antenna is 8.0 mm with thickness 0.036mm.Whereas length of its regular sides is 8.37mm.The dielectric constant of substrate FR-4 is 4.3 and its height is 1.6 mm. Vertical expansion of slots S and E is 7.0 mm whereas lateral expansion of S and E slots is 5.0 mm. Width of both the slots is 0.5 mm. Width of both the ground and substrate is 25 mm. whereas length of both is 25 mm. also. Thickness of ground is 0.036 mm while that of substrate is 1.6mm

Table -1 Design specifications of the proposed antennas

ANTENNA	DIMENSIONS	VALUE	MATERIAL
Hexagonal patch antenna	Circum radius of the hexagonal patch	r_o = 8.0mm	Copper
	Side length of regular hexagonal patch	8.37mm	Copper
	Patch thickness	t = 0.036mm	Copper
	Substrate height	h =1.6mm	FR-4
	Substrate width	2*W = 25mm	FR-4
	Substrate length	2*L =25mm	FR-4
	Ground width	2*W =25mm	Copper
	Ground length	2*L = 25mm	Copper
	Ground thickness	t = 0.036 mm	Copper
S- slot	Vertical expansion	7.0 mm	Air
	Lateral expansion	5.0 mm	Air
	Width	0.5 mm	Air
E-slot	Vertical expansion	7.0 mm	Air
	Lateral expansion	5.0 mm	Air
	Width	0.5 mm	Air

The perspective views of antennas design and geometry have been shown in fig (1), fig (2), fig (3) and fig (4).

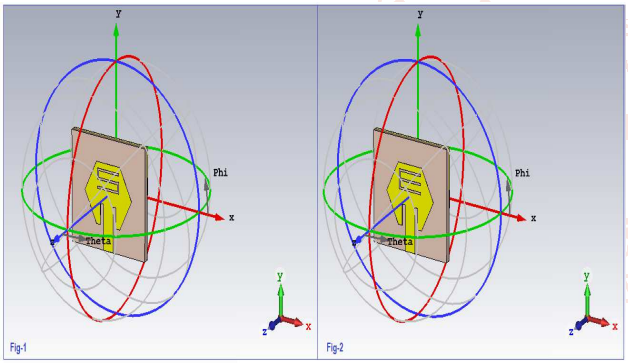

Fig.1- S-Shape Slotted Inset Line Feed Hexagonal Micro strip Patch Antenna

Fig.2- E-Shape Slotted Inset Line Feed Hexagonal Micro strip Patch Antenna.

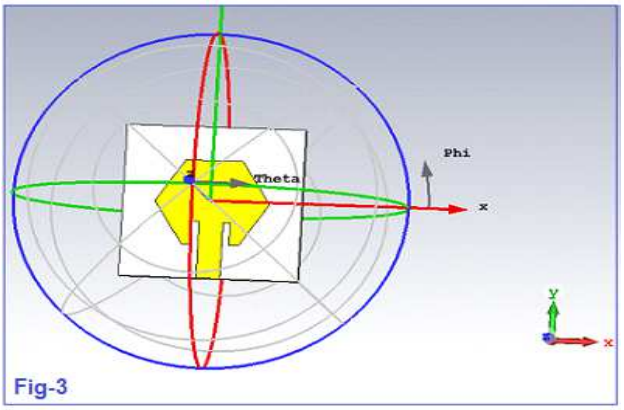

Fig.3- Un-Slotted Inset Line Feed Hexagonal Micro strip Patch Antenna

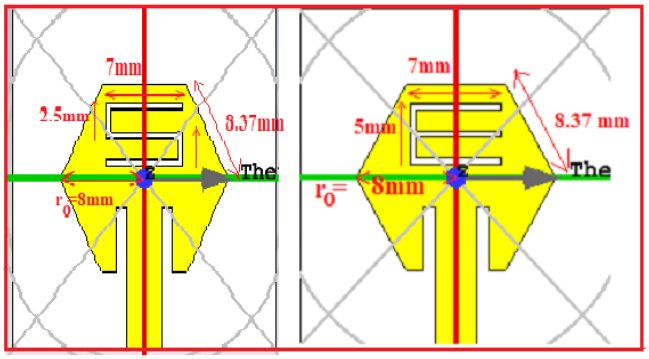

Fig.4- Layout dimensions of patch with S and E slots.

2. SIMULATIONS AND RESULTS:

A. RETURN LOSS:

After designing the antenna by CST Microwave Studio 2018, simulation process has been carried out.Plots for simulated return loss of un-slotted inset line feed hexagonal micro strip patch antenna, S-shaped slotted inset line feed hexagonal micro strip patch antenna and E-shaped slotted inset line feed hexagonal micro strip patch antenna have been shown in fig.5,fig.6 and fig.7 respectively. Magnitude of reflection coefficient has been found as -15.126189 dB at resonant frequency of 9.9 GHz of un-slotted inset line feed hexagonal microstirp patch antenna. Whereas, magnitudes of reflection coefficient for S-shape slotted inset line feed hexagonal micro strip patch antenna have been found to be -11.081dB,-13.926dB and -12.178 dB at resonant frequencies 4.1GHz,8.6GHz and 9.7GHz respectively and -12.765dB,-14.553dB and -12.394dB at resonant frequencies 4.9GHz ,8.6GHz and 9.7GHz respectively for E-shape slotted inset line feed hexagonal micro strip patch antenna. At -10 dB the bandwidth has been found as 606.2 MHz for un-slotted inset line feed hexagonal micro strip patch antenna at 9.9

GHz. And at -10 dB the bandwidth has been found to be 38.2 MHz, 224 MHz and 554.1 MHz corresponding to resonant frequencies 4.1GHz, 8.6GHz and 9.7GHz for S-shape slotted inset line feed hexagonal micro strip patch antenna whereas it, at -10 dB for E-shape slotted inset line feed hexagonal micro strip patch antenna has been found to be 99.9 MHz, 249 MHz and 559.4 MHz corresponding to resonant frequencies 4.9 GHz, 8.6GHz and 9.7 Ghz respectively.

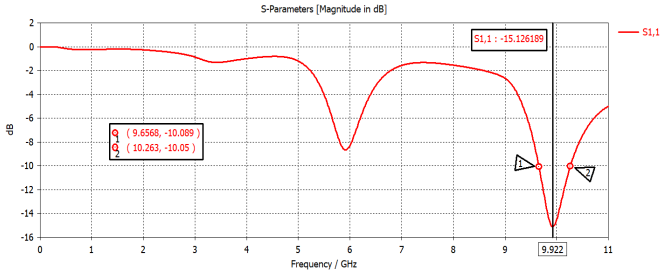

Fig-5: Return loss plot of un-slotted inset line feed hexagonal micro strip patch antenna

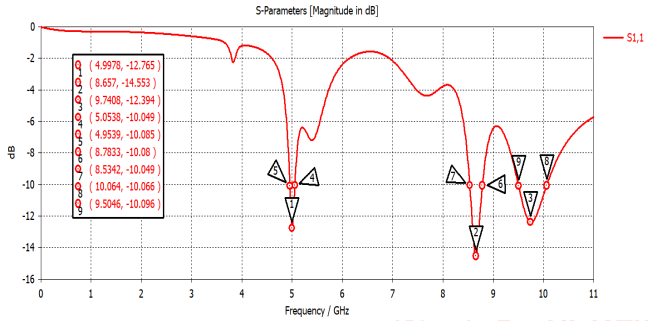

Fig-6: Return loss plot of S- shape slotted inset line feed hexagonal micro strip patch antenna

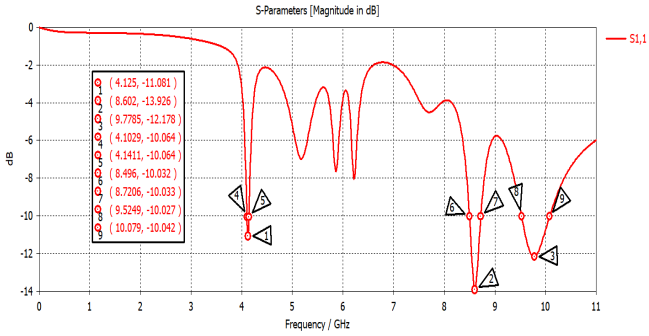

Fig-7: Return loss plot of E- shape slotted inset line feed micro strip patch antenna

B. VSWR:

Plots for VSWR of S-shape slotted inset line feed hexagonal micro strip patch antenna and E-shape slotted inset line feed hexagonal micro strip patch antenna have been shown in Fig -7 and fig-8 respectively. Magnitude of VSWR for S-shape slotted inset line feed hexagonal micro strip patch antenna has been found as 1.6021, 1.4608 and 1.6805 at the corresponding resonant frequencies 4.9GHz, 8.6GHz and 9.7GHz which are in good agreement and (< 2)less than value of 2 for an impedance matching.Whereas for E-shape slotted inset line feed hexagonal micro strip patch antenna , values of VSWR have been found to be 1.7747, 1.5055 and 1.6532 at corresponding resonant frequencies 4.1GHz, 8.6GHz and 9.7GHz which are in good agreement and (<2) less than value of 2 for an impedance matching also.

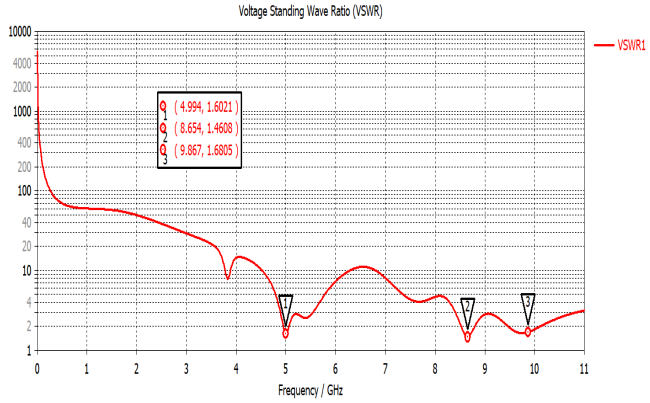

Fig-8: VSWR for S-shape slotted inets feed line hexagonal micro strip patch antenna

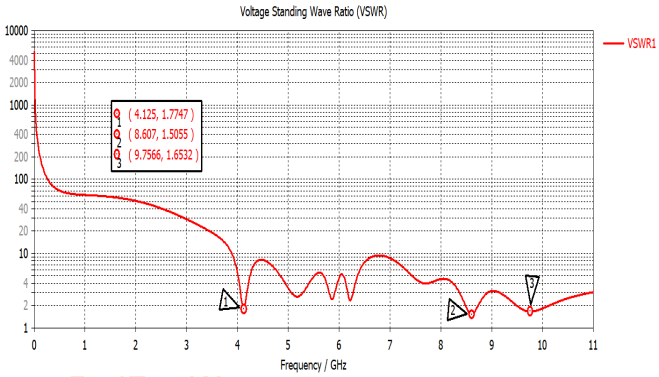

Fig-9: VSWR for E-shape slotted inset line feed hexagonal micro strip patch antenna

C. FARFIELD DIRECTIVITY:

Polar plots for farfield directivity of regular hexagonal micro strip patch antenna without slot , with S-slot and E-slot have been shown in fig-10,fig-11,fig-12,fig-13,fig-14,fig-15,fig-16,fig-17 and fig-18 respectively at reosnantfrequencies 9.95 GHz ,4.99GHz,8.6GHz, 9.7GHz,4.1GHz,8.6GHz and 9.7GHz. Main lobe magnidude is -2.58dBi and angulalar width is 112.2 degree for un- slotted hexagonal patch antenna. For S–shape slotted antenna main lobe magnitudes are -5.62dBi,-7.98 dBi,-8.43dBi respectively and angular widths are 114.2degree,72.5 degree,126.3 degree respectively.For E –shape slotted hexagonal patch antenna main lobe magnitudes are 5.91 dBi,7.95dBi,-8.7dBi respectively and angular widths are 112.9degree,71.7 degreeand124.2 degree respectively.Directivity of S-Shape slotted hexagonal patch antenna at resonant frequencies 4.9GHz ,8.6GHz and 9.7GHz are 5.645dBi,7.969dBi and 7.22dBi respectivily.Whereas directivity of E-shape slotted hexagonal micro strip patch antenna are 5.915dBi,7.891dBiand 7.394dBi respectively.

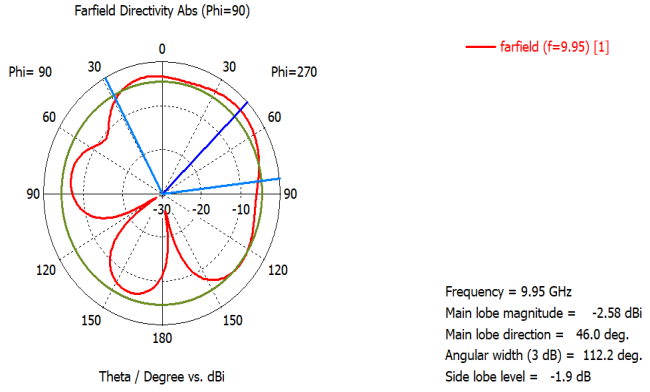

Fig-10: Far field directivity of Un-slotted inset line feed Hexagonal micro strip patch Antenna

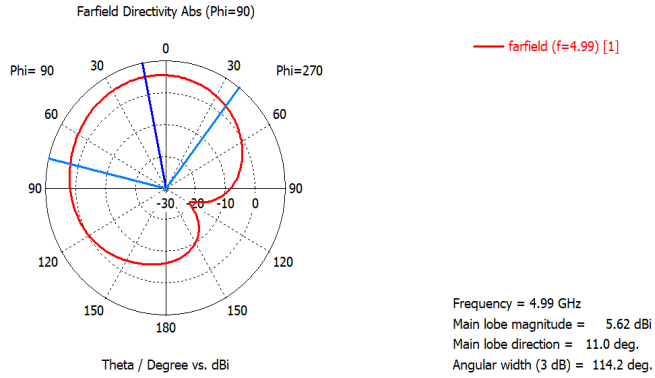

Fig-11: Far field directivity of S-shape slotted inset line feed hexagonal patch micro strip antenna at resonant frequency of 4.99GHz

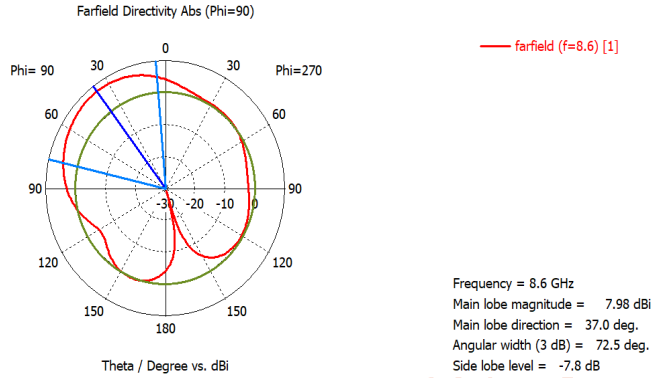

Fig-12: Far field directivity of S-shape slotted inset line feed hexagonal micro strip patch antenna at resonant frequency of 8.6 GHz

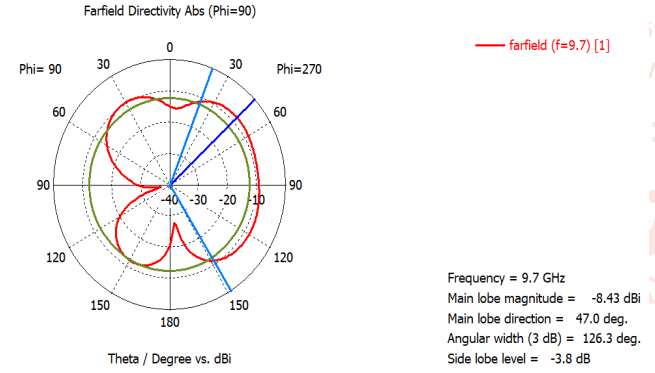

Fig-13: Far field directivity of S-shape slotted inset line feed micro strip patch antenna at 9.7 GHz

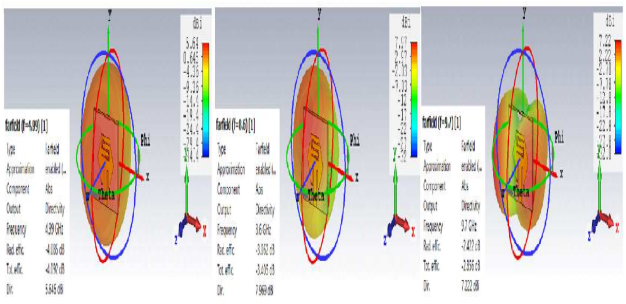

Fig-14: Showing directivity of S-Shape slotted hexagonal micro strip patch antenna at resonant frequencies of 4.9GHz,8.6GHz and 9.7GHz .

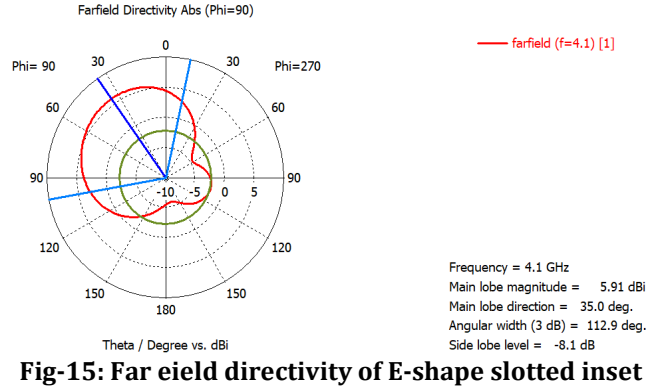

Fig-15: Far eield directivity of E-shape slotted inset line feed hexagonal micro strip patch antenna at resonant frequency of 4.1 GHz

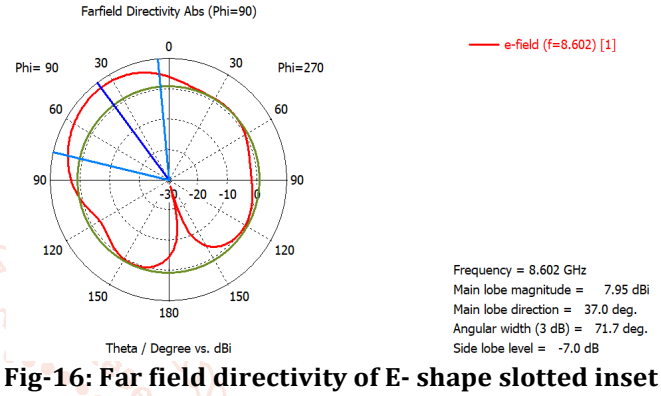

Fig-16: Far field directivity of E- shape slotted inset line feed hexagonal micro strip patch antenna at resonant frequency of 8.6 GHz.

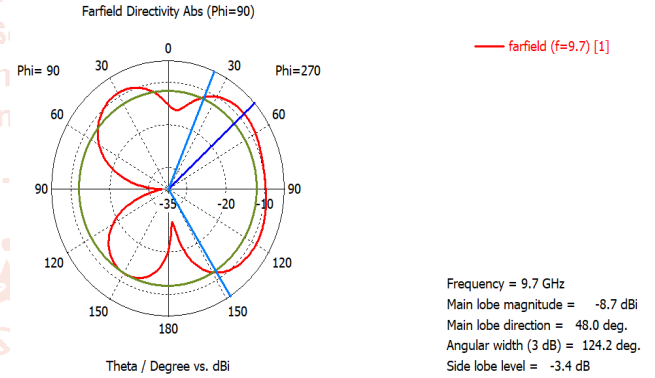

Fig-17: Far field directivity of E-shape slotted inset line feed micro strip patch antenna at resonant frequency of 9.7GHz.

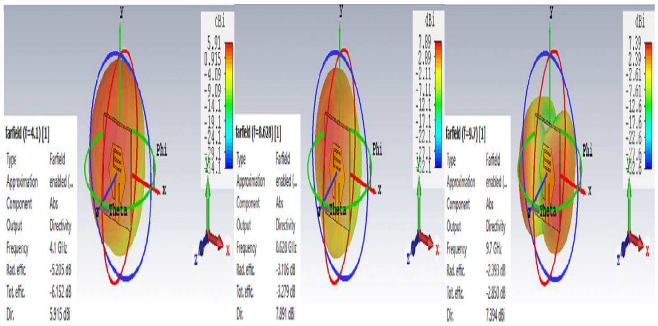

Fig-18: showing far field directivity of E-shape slotted hexagonal micro strip patch at resonant frequencies of 4.1GHz,8.6GHz and 9.7GHz.

D. RADIATION PATTERN:

The 3D –plots for radiation pattern of gain for regular hexagonal patch antenna without slot and with slot S and E have been shown by fig-19, fig- 20,fig-21,fig-22,fig-23,fig -24, and fig-25 respevtively. Gain for S-Shape slotted hexagonal patch micro strip patch antenna at resonant frequencies 4.9GHz,8.6GHz and 9.7GHz are 1.56dB,4.91dB and 4.8dB respectively and corresponding radiation efficiencies are 94%,89% and 85.8% respectively.Gain for E-Shape slotted hexagonal micro strip patch antenna at resonant frequencies 4.1GHz,8.6GHz and 9.7GHz are 0.71dB,4.84dB and5.0dB respectively and corresponding radiation efficiencies are 84.6%,93.8% and 83.9% respectively.

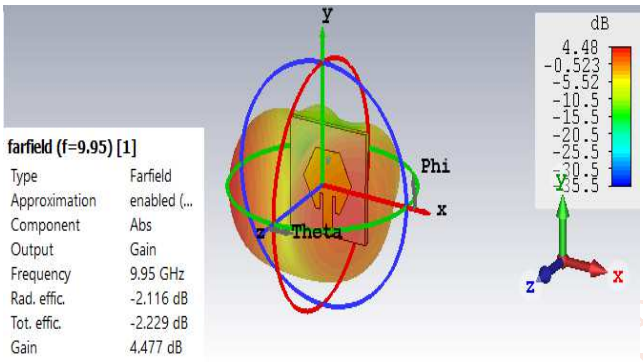

Fig-19: Gain of Unslotted inset line feed Hexagonal micro strip Patch Anteena

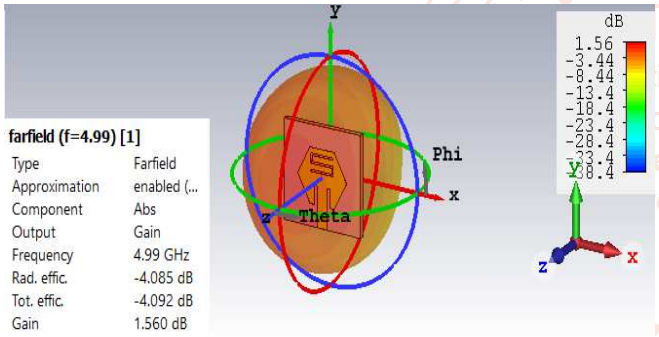

Fig- 20: Gain of S-shape slotted inset line feed hexagonal micro strip patch antenna at resonant frequency of 4.99GHz.

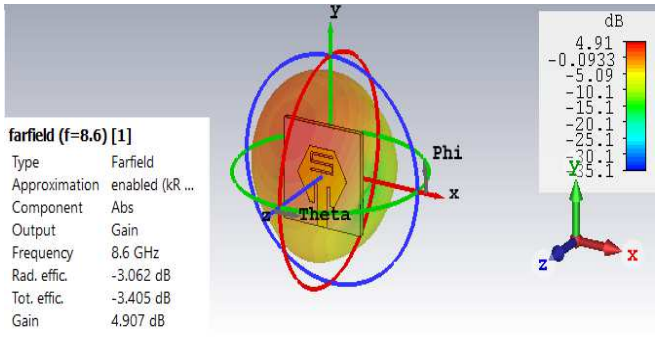

Fig-21: Gain of S- shape slotted inset line feed micro strip patch antenna at resonant frequency of 8.6GHz.

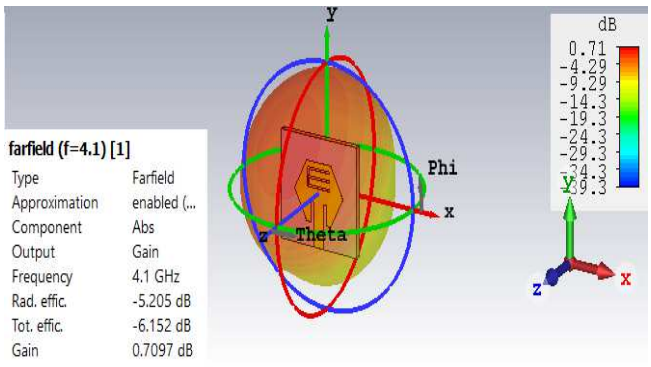

Fig-23: Gain of E –shape slotted inset line feed hexagonal micro strip patch antenna at resonant frequency of 4.1

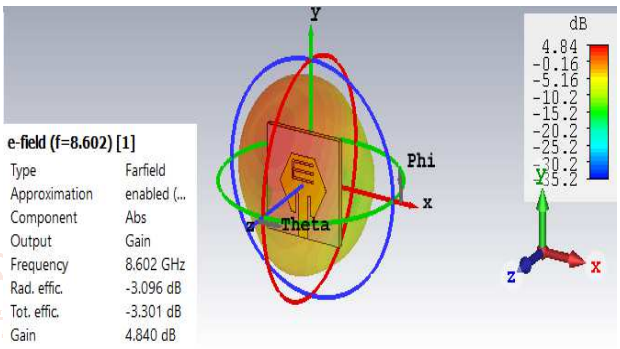

Fig-24: Gain of E-shape slotted inset line feed hexagonal miceostrip patch antenna at resonant frequency of 8.6 GHz.

Tbale-2 summary of simulated results

parameter	S-Shaped slotted hexagonal micostrip patch antenna			E-Shaped slotted microstrip hexagonal patch antenna		
Resonant frequency	4.9 GHz	8.6GHz	9.7GHz	4.1GHz	8.6GHz	9.7GHz
Return loss	-12.765dB	-14.553dB	-12.394dB	-11.081dB	-13.926dB	-12.178dB
Band width at -10dB	99.9MHz	249.1MHz	559.4MHz	38.2MHz	224.6MHz	554.1MHz
Band width %	2.4%	2.9%	5.8%	1%	2.6%	5.7%
VSWR	1.6021	1.4608	1.6805	1.7747	1.5055	1.6805
Gain	1.56dB	4.91dB	4.8dB	0.71dB	4.84dB	5.0dB
Directivity	5.645dBi	7.969dBi	7.22dBi	5.915dBi	7.891dBi	7.394dBI
Radiation efficiency	94%	89%	85%	84.6%	93.8%	83.9%
Main lobe direction	11.0deg.	37.0deg.	47.0deg.	35.0deg.	37.0deg.	48.0deg.
Main lobe magnitude	5.62dBi	7.98dBi	- 8.43dBi	5.91dBi	7.95dBi	-8.7dBi

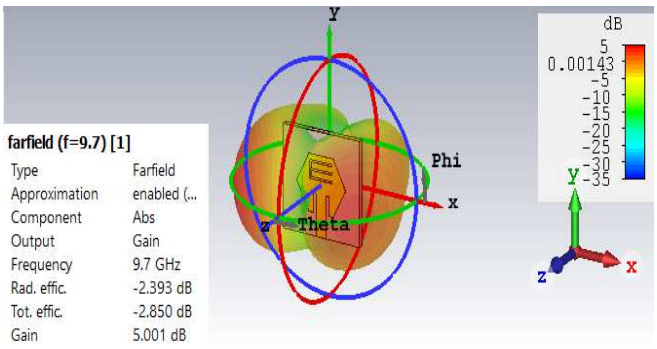

Fig- 25: Gain of E–shape slotted inset line feed hexagonal micro strip patch antenna at 9.7 GHz

From table 2, it is well vivid that S-Shape slotted inset line feed hexagonal micro strip patch antenna has overall better results than E-Shape slotted inset feed line hexagonal micro strip patch antenna. More negative value of return loss gives the better results. Hence S-Shape slotted hexagonal micro strip patch antenna show better results in comparison to E-Shape slotted hexagonal micro strip patch antenna. Less than value 2 and near to 1, better is the VSWR. Hence S-Shape slotted hexagonal micro strip patch antenna has better VSWR.S-Shape slotted hexagonal micro strip patch antenna has overall lesser directivity and more gain than E-Shape slotted hexagonal micro strip patch antenna. More the main lobe direction better is the radiation pattern; hence E-Shape slotted hexagonal micro strip patch antenna shows better radiation.

3. CONCLUSION:

The comparison between S-Shape slotted hexagonal micro strip patch antenna and E-Shape slotted hexagonal micro strip patch antenna has been carried out on the basis of simulation results obtained from CSTMW Studio. It, therefore ,concluded that both the antennas configuration show good results on perspective of Return loss, VSWR, Gain and Radiation efficiency for S ,C and X bands applications. However, in view of Return loss, Bandwidth, VSWR and Gain, S-Shape slotted hexagonal micro strip patch antenna shows better performance, whereas E-Shape slotted hexagonal micro strip patch antenna shows better performance in view of main lobe direction and radiation pattern.

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BIOGRAPHIES

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