GAIN ENHANCEMENT OF MICROSTRIP PATCH ANTENNA BY USING H-SLOTTED PATCH IN COMPARISON WITH RECTANGULAR PATCH

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Abstract :Aim : In this work, a rectangular microstrip patch antenna is designed by using H-slotted patch in comparison with rectangular patch for gain enhancement.**Materials and Methods :** The microstrip patch antenna using H-slotted patch uses a total of 40 samples in comparison with rectangular patch with 2mm substrate thickness. **Results :** Simulation is done by using HFSS (High Frequency Structure Simulator)software. The performance of the antenna is analysed in terms of Gain,Directivity,Return loss and VSWR. The enhanced gain is by 1.75 dB. Based on statistical analysis, it is observed that the significance value is 0.030 for gain. **Conclusion :**Microstrip patch antenna with H-slotted patch performs appears to be better in terms of Gain.

KEYWORDS: Microstrip patch antenna,Novel H-slot patch,AntennaDesign,Gain, Directivity, Return loss, VSWR.

1. INTRODUCTION :

The research is about inserting a novel H-slot patch to enhance the gain of the microstrip patch antenna. The importance of using H-slot in the microstrip patch antenna is to retain the additional resonance and to improve the performance of the antenna in terms of Gain(Tarbouch, El Amri, and Terchoune 2017).Microstrip patch antennas are most suitable for many applications because of their unique properties such as planar low profile configuration, fabrication simplicity and ease of integration with circuits(Karmokar et al. 2015).Due to the advancements in technology, wireless communication plays a major role in mobile phones, other hand held devices. Because of the good properties of microstrip patch antennas, these are used in Wide band communication systems such as Wimax and 5G communications(Panusa and Kumar 2014b).
Similar to this study, 4,450 journal papers are available in Google Scholar and 228 journals published in Sciencedirect from the last 5 years.Due to the rapid development of wireless communication technology, there is always a need for high gain and wide bandwidth antennas(Aravindraj and Ayyappan 2017).By using the gain enhancement techniques such as increasing substrate thickness,gap coupling and various feeding techniques, microstrip patch antennas are most suitable for wide band communications(Das, Mohanty, and Mishra 2015). Antenna is the essential component for communications across different systems. The antenna needs to be well designed for effective signal reception and transmission of various communication devices, thus the complexity is reduced(Panusa and Kumar 2014a).The microstrip patch antennas also have some limitations such as low efficiency, complex feed structures,low power handling capacity(Mishra and Sonkusare 2017).The design structure of the antenna need to be considered for effective performance in wireless signal transmission such as satellite communications, global positioning systems and wireless networks(Malisuwan et al. 2014).Our team has extensive knowledge and research experience that has translate into high quality publications(Patturaja and Pradeep 2016; Ramesh Kumar et al. 2011; Krishnan, Pandian, and Kumar S 2015; Felicita 2017b, [a] 2017; Kumar 2017; Sivamurthy and Sundari 2016; Sathivel et al. 2008; Sekar et al. 2019)

The unanswered problem in the existing research work is low gain. To improve the gain of microstrip patch antenna different techniques are available such as by slotting patch with different slots, shorting pins, different

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feeding techniques(coaxial, proximity coupled, microstrip line feed)and by using different substrate materials. This research work focuses on the design of high gain antennas by inserting novel H-slot in a rectangular patch.

2. MATERIALS AND METHODS :

This study was conducted at Electronics and Communication Department,Antenna and Wave propagation lab in Saveetha School of Engineering,SIMATS,Chennai.This study was based on the improvement of microstrip patch antenna using H-slotted patch in comparison with regular rectangular patch. Sample size was calculated by using previous study results(Bangash et al. 2019) using clinicalc.com by keeping alpha error-threshold by 0.05, 95% confidence interval, power 80%. In this study we compare the parameter such as gain with one sample group from previous literature(Bangash et al. 2019).
The first group refers to the microstrip patch antenna with a rectangular patch[dielectric constant is 4 with 2mm substrate thickness] containing 20 samples and the second group containing 20 samples by inserting the H-slot on the patch with rectangular patch.

Design of Microstrip Patch Antenna without Slot in patch :
The un-slotted rectangular patch consists of Flame Retardant(FR-4) as a substrate material. The dielectric constant of FR-4 is 4 with 2mm substrate thickness. The rectangular patch contains radiating metallic fields on one side of the patch and the other side is the ground plane. The substrate using FR-4 material has good insulation properties which is responsible for excellent mechanical properties(Reis and Virani 2020).The dimensions of the FR-4 substrate are 60 mm and width of 40 mm.
Fig.1 represents the design setup of a microstrip patch antenna without a slot in rectangular patch using Ansoft HFSS software.The length and width of the patch are used as[Patch length of 30.41 mm and width of 23.24 mm].

Design of Microstrip Patch Antenna using H-slot :
The H-slot is used to improve the gain of the proposed antenna. The novel H slot antenna is designed by combining three rectangular slots with slot length of 14 mm and width of 18 mm. The H-slot is mounted on the main rectangular patch.
Fig.2 represents the Design of microstrip patch antenna with H-slotted patch[dielectric constant of 4 with 2mm substrate thickness]with patch length of 30.41 mm and width of 23.24 mm.
The testing setup used to design the microstrip patch antenna is Ansoft HFSS software.The system configuration used to set up the testing procedure is Intel Core i3 10th gen processor. Microstrip patch antenna is designed at a frequency of 3 GHz. To obtain the dimensions of the designing antenna, it requires a resonant frequency which is fixed at a certain value. Antenna variables such as L,W,H,F are defined to construct the antenna in Ansoft HFSS Software. Excitations,boundaries and radiation fields are assigned to the antenna. Analysis setup has been done to add the frequency sweep to the antenna. After Validation,Simulation results are analysed in the HFSS simulation tool.

Statistical analysis :
SPSS version 21 was used for statistical comparison of parameters such as gain,directivity.The independent variables are width, height of substrate(width of 40 mm,height of 2mm) length and width of the patch(length of 30.41mm and width of 23.24 mm),operating frequency.The dependent variables are gain, directivity, return loss and VSWR.

3. RESULTS :

Microstrip patch antenna by using H-slotted patch has been designed and simulated results have been obtained by using AnsoftHFSS(High Frequency Structure Simulator)tool.
Fig.3 represents the Gain(dB) vs Frequency(GHz) plot. From Fig.3 it was observed that the value of gain at different frequencies. The plot shows the variation of gain at different frequencies in Wave shaped patterns . The red colour indicates the maximum gain obtained for the designed antenna and the other colour indicates the lower values away from the resonance. The maximum gain obtained for Parasitic patch is 9.04 dB
Fig.4 represents the Directivity(dB) vs Frequency(GHz) plot. The plot shows the variation of directivity at different frequencies in Wave shaped patterns. The red colour indicates the maximum directivity obtained for

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the designed antenna and the other colour indicates the lower values away from the resonance. The maximum directivity obtained for Parasitic patch is 6.03 dB

Fig.5 represents the Return loss(dB) vs Frequency(GHz) plot. From Fig.5 it was observed that the value of return loss obtained for H-slotted patch is -28.76 dB. This value indicates the power loss is less in the designed antenna. Always return loss value should be more negative(<-10 dB) for better performance of the antenna.

Fig.6 represents the VSWR VsFrequency(GHz)plot.The VSWR obtained for H-slotted patch is 0.63 which is minimal and real. For effective performance of the antenna the value should be 0 to 2.

From Table-1 it was observed that the data set is collected for values of Gain for two different groups. Group 1 refers to the data obtained from the H slotted patch and group 2 refers to the rectangular patch without a slot.

From Table-2 it was observed that comparative analysis of simulation results such as Gain, Directivity, Return loss and VSWR for H slotted patch and rectangular patch without slot obtained from HFSS software.

From Table-3 it was observed that by performing the statistical analysis with 20 samples for H slotted patch the mean is 4.0845, standard error is 0.50927 and the deviation is 2.27752.

The significance value is smaller than 0.05 shows that the design is good with respect to the output values(Table-4).

From Fig.7, the bar graph shows the Independent sample t-test used to compare the gain values between rectangular patch without slot and H slotted patch and it is statistically significant difference was noticedP < 0.05. When compared to the rectangular patch without a slot the gain improvement using the H slotted patch appears to be improved(Gain improvement of 1.75 dB)

4. DISCUSSIONS :

From the results (Fig.3) obtained it is clear that gain value appears to be improved for H slotted patch compared to rectangular patch without slot(Gain improvement of 1.75dB)and it is statistically significant p(0.03)for H slotted patch.

The maximum gain obtained for H slotted patch (Fig.3)is 9.04 dB when compared to 7.29 dB using rectangular patch without slot [Gain improvement of 1.75dB] and also the other findings like maximum directivity obtained for H slotted patch is 6.03 dB(Fig.4) when compared to 7.07 dB using rectangular patch without slot.The return loss value obtained for H slotted patch is -28.76 dB (Fig.5)indicates less power loss in signal when compared with rectangular patch without slot (-15.42 dB).The VSWR value of the designed antenna is 0.63(Fig.6 which is less when compared to rectangular patch without slot (1.61). From the above results the performance of the proposed microstrip patch antenna with H slotted patch appears to be improved.

To enhance the gain of the microstrip patch antenna H-slot is added by combining the three rectangular slots in the patch(Bharath, ArunVarma, and Sheeba 2017).Gain is the essential factor in rectangular microstrip patch antennas. It depends on various factors such as if the thickness of the dielectric substrate is reduced then the gain increases.So there is a conflict between the dielectric thickness and the antenna parameters such as gain and directivity(Deepika et al. 2017). The antenna gain describes how much input power is converted into radio waves that travel in a particular direction. Feed position to the patch of the antenna also plays an important role to analyse the performance of an antenna. The impedance needs to be correctly matched for the minimal power loss of the designed antenna(Jamali and Cook 2013).The performance of the antenna depends on the design structure,feed positions, boundaries, excitations and radiating fields. By inserting H-slot in the patch, gain appears to be improved(Nakmouche et al. 2020).The maximum gain obtained for H-slotted patch is 9.04 dB when compared to 7.29 dB using rectangular patch without slot [Gain improvement of 1.75 dB]. There is no previous literature with opposing findings in our design .

Increment in the dimensions of the patch due to Fringing Effect ,to avoid this the quality factor should be within the limit of microstrip patch antenna.

The present work can be extended for multi band frequencies in wireless communication applications,Militaryapplications,and Global positioning systems.

5. CONCLUSION :

Thus, the Microstrip patch antenna with H-slotted patch is designed and analysed.The gain obtained by using rectangular patch without slot is 7.29 dB. Gain of H-slotted patch is 9.04 dB. Which appears to be improved by 1.75dB.

Declarations :
Conflict of interests

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No conflict of interest in this manuscript.

Author Contributions
Author SR was involved in data collection , data analysis, manuscript writing.Author SWR was involved in conceptualization, data validation and critical review of manuscript.

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Figures and Tables :

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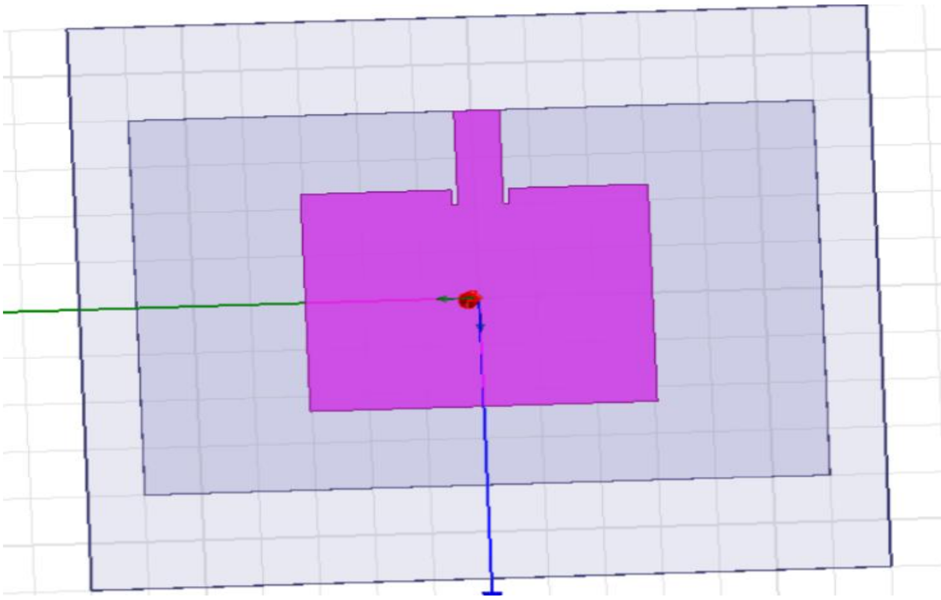

Fig. 1 : Design of microstrip patch antenna using rectangular patch [Dielectric constant of 4 with 2mm substrate thickness]with Patch length of 30.41 mm and width of 23.24 mm

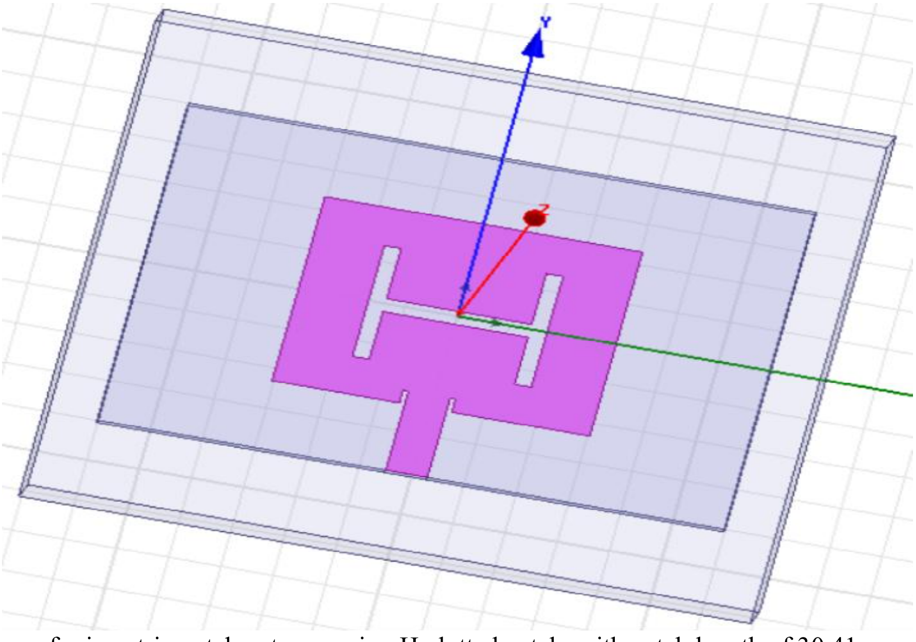

Fig. 2 : Design of microstrip patch antenna using H-slotted patch with patch length of 30.41 mm and width of 23.24 mm, H-Slot of length 14 mm and width is 18 mm.

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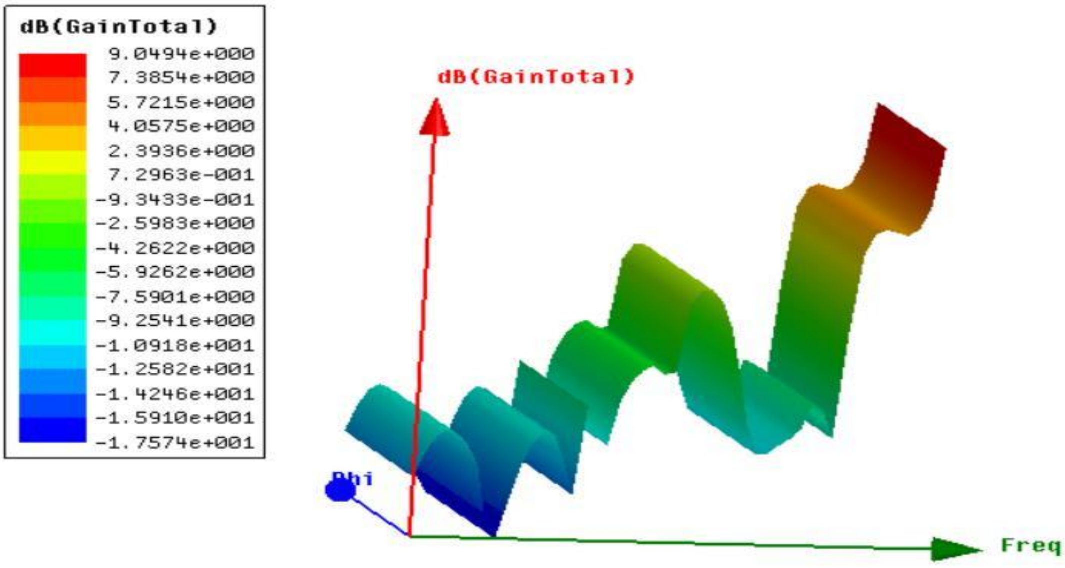

Fig. 3 : Gain(dB) Vs Frequency(GHz) is plotted and the maximum gain obtained for the Air substrate at a frequency of 3 GHz. Red colour indicates the maximum gain and other colours indicate the reduction of gain from maximum resonance of the antenna.

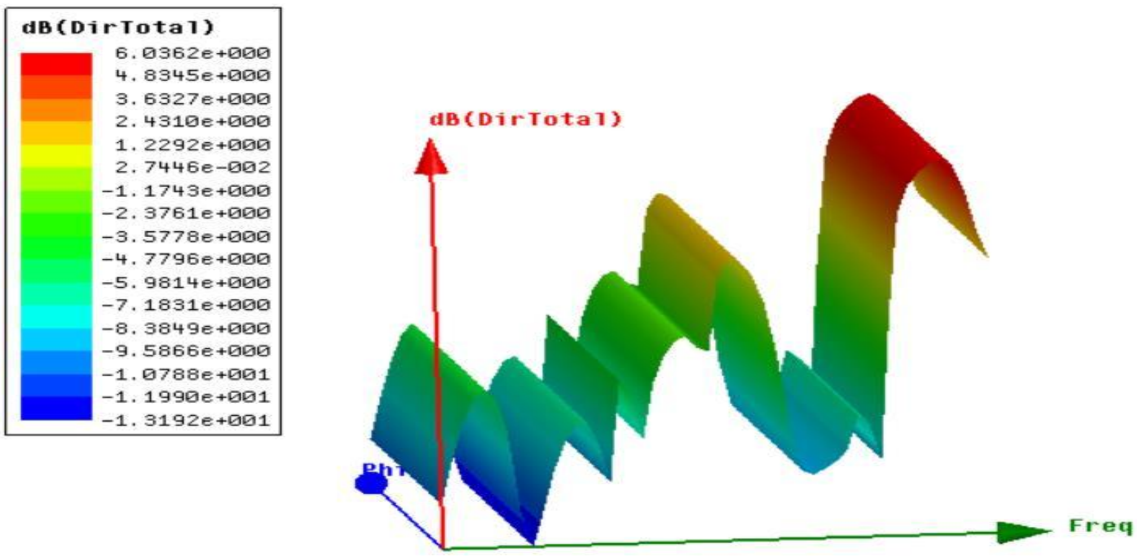

Fig. 4 : Directivity(dB) Vs Frequency(GHz) is plotted and the maximum Directivity obtained for Air substrate at a frequency of 3 GHz. Red colour indicates the maximum directivity and other colours indicate the reduction in directivity from maximum resonance of the antenna.

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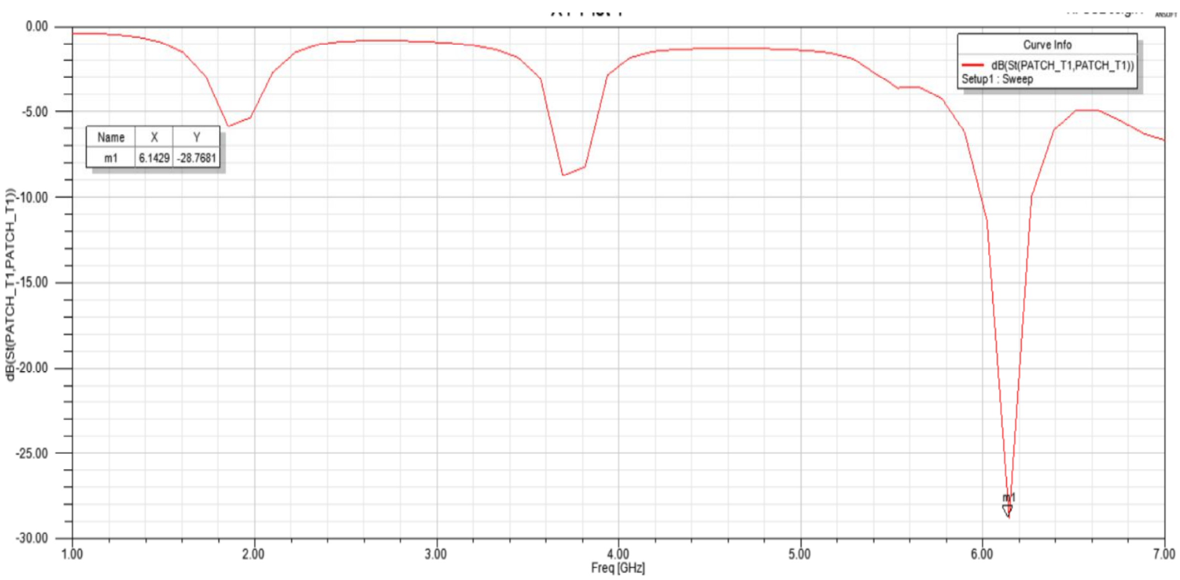

Fig. 5 : Return loss(dB) Vs Frequency(GHz) is plotted and it shows that the power loss is minimum at resonant frequency.

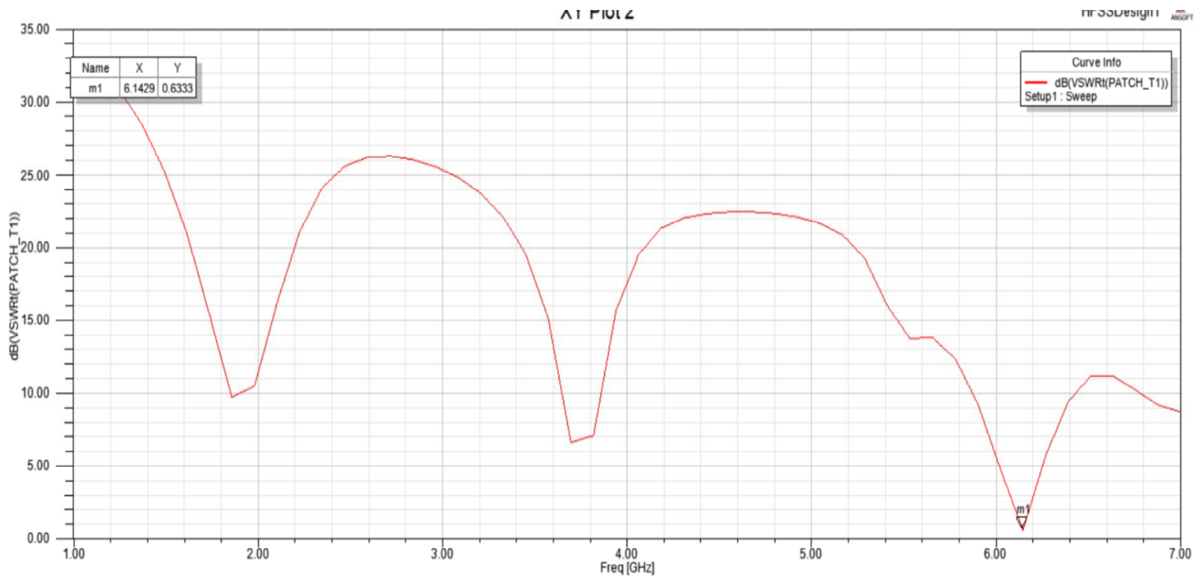

Fig. 6 : VSWR Vs Frequency(GHz) is plotted and the minimum value of VSWR is obtained for Air substrate.

Table 1 : Data set is collected for the values of Gain(dB) in two groups. Group 1 refers to the rectangular patch without a slot containing 20 samples and group 2 refers to the H-slotted patch of 20 samples.

Group [without slot]	Gain (dB)	Group [H-slot]	Gain (dB)
1	0.21	2	9.04
1	1.18	2	5.02
1	2.20	2	3.59
1	3.28	2	3.14
1	4.38	2	3.31

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1	5.47	2	3.51
1	6.45	2	3.23
1	7.16	2	1.87
1	7.29	2	3.30
1	6.64	2	3.18
1	5.39	2	1.40
1	3.90	2	0.76
1	2.22	2	0.80
1	0.11	2	1.81
1	4.28	2	6.13
1	0.84	2	6.25
1	0.70	2	6.43
1	0.05	2	5.85
1	0.36	2	6.17
1	0.42	2	6.90

Table 2 : Comparison of H-slotted patch and rectangular patch without slot values of Gain, Directivity, Return loss and VSWR at 3 GHz for microstrip patch antenna

Group	Gain	Directivity	Return loss	VSWR
Rectangular	7.29 dB	7.07 dB	-15.42 dB	1.61
H-slot patch	9.04 dB	6.03 dB	-28.76 dB	0.63

Table 3 : Group statistics results reveal that mean, standard deviation and standard mean error for the H-slotted patch. It states that the mean is higher for H-slotted patches compared with a rectangular patch without a slot.

	GROUP	N	Mean	Std. Deviation	Std. Error Mean
GAIN	RECTANGULAR	20	3.1267	2.61321	.58433

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	H SLOT	20	4.0845	2.27752	.50927

Table 4 : Independent sample T-test for significance and standard error determination. P value is less than 0.05 considered to be statistically significant

Independent Samples Test										
		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Gain	Equal variances assumed	1.13	.030	-1.23	38	.030	-0.957	0.77511	-2.5269	0.6113
	Equal variances not assumed			-1.23	37.3	.030	-0.957	0.77511	-2.5278	0.6122

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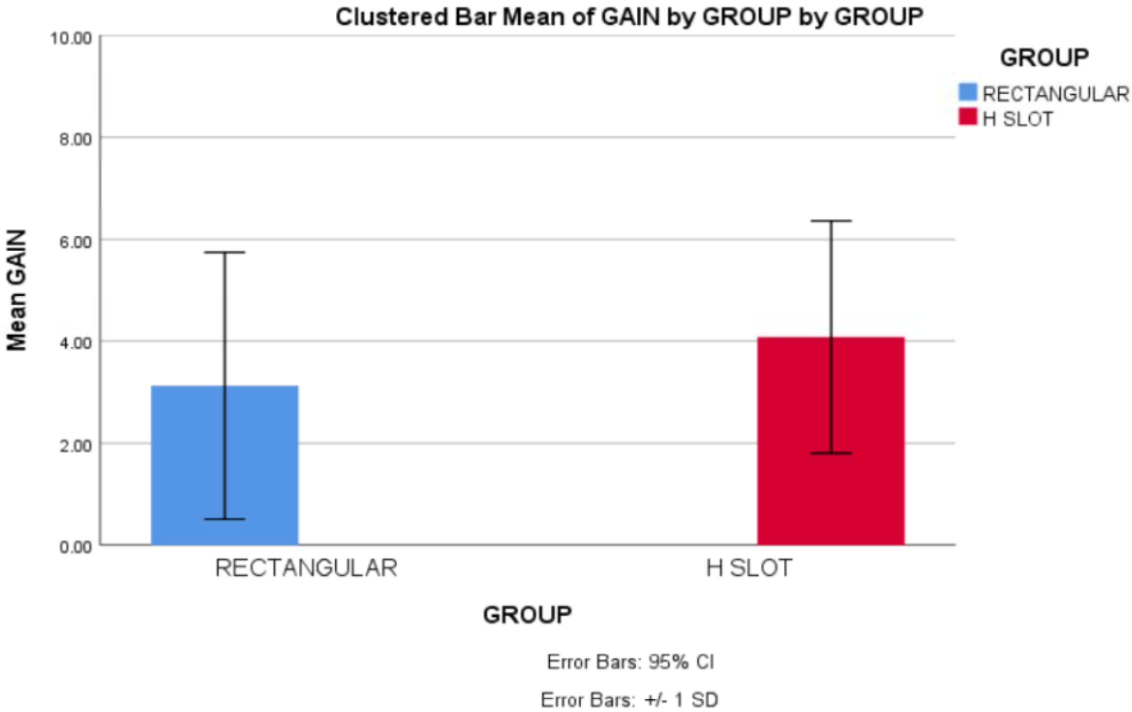

Fig-7 : Bar representing the gain comparison between rectangular path and H-slotted patch in terms of mean accuracy. The mean accuracy of H-slot is better than rectangular patch without slot. Mean accuracy of detection=+/-1SD.X Axis: Group (Patch Shapes) Y Axis: Mean Gain

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