Performance Analysis of microstrip antenna and its array for 2.4ghz application

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Abstract- *In this Paper Performance Analysis Of Microstrip Patch Antenna at f=2.4Ghz for Wireless LAN Application is studied and results are analyzed using HFSS v15 software. The FR4 epoxy with relative permittivity 4.4 is used as substrate material. Our goal here is to obtain high gain and reduced losses, to be especially used for WLAN applications. Using an array 1*3 rectangular patch we obtain gain of 7.1dB and return loss of -10.3dB.*

Key words - WLAN, Microstrip Patch, HFSS, Gain, Return Loss

1. INTRODUCTION

Today wireless communication has become more of a dire necessity in various applications. In many scenarios where the wired systems are impractical or almost impossible to be implemented, wireless systems have readily replaced them. Many systems are actually required to actually transmit a message and receive it with minimal error in a wireless systems. Such blocks like transmitter, receiver, coders etc. are required to pass information both over short and long distances. Take the example of the unlicensed spectrum of 2.4 GHz for interconnecting Wi-Fi devices such as connecting laptops or mobile devices for people in transit. This spectrum in small range is used for communicating multiple devices in various networks thereby generating requirement of various kinds of specialised antenna for the suitable purpose. One more use for wireless systems is one that connect the mobile network to connect to the satellites. Take the example of GPS systems where devices need to be within the range of three or more satellites. The location is transmitted from the satellites in range via the communicating channels. So practically the antenna needs to be designed in such a manner that the signals can be detected in any orientation. So a circularly polarised antenna is the requirement for such an application which overcomes the orientation problem. In this Paper Performance Analysis Of Microstrip Patch Antenna at f=2.4Ghz for Wireless LAN Application is studied and results are analyzed using HFSS v15 software. The FR4 epoxy with relative permittivity 4.4 is used as substrate material.

2. Theory And Methodology

For simplified analysis and better performance of the WLAN Systems, a rectangular-shaped microstrip patch antenna operating at 2.4 GHz has been proposed. While designing an array, the most important parameter which must be accommodate very carefully is adjustment of distance between the radiating elements of an array in order to keep it compact as well as efficient.

In our proposed work:

$$\text{Frequency} = f = 2.4GHz \text{, as}$$

$$c = f\lambda \text{ , } \lambda = \frac{3\times10^{8}}{2.4\times10^{9}}$$

$$\text{Wavelength} = \lambda = 0.122GHz \text{, so}$$

$$\frac{\lambda}{2} \approx 61mm$$

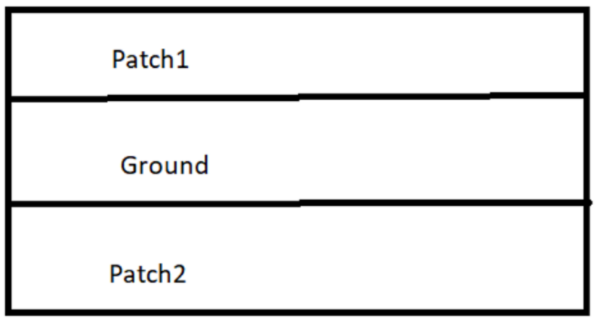

Fig-1:Structure of patch antenna

It's the sandwich of the two patches with ground plane in between as shown in figure above.

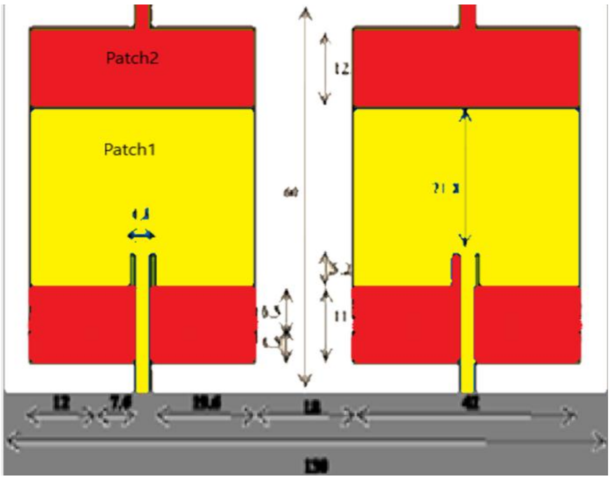

Fig-2:Dual Elements in Array without slots

It consists of two rectangular patches placed side by side with an overall dimension of 60mm x 130mm x 1.5 mm to give directive radiation pattern and maximum gain. Each element has individual ground plane to make further separation among them and is fed independently by transmission line with an impedance matching of 50 Ω. The distance between both the transmission lines is 60mm approximately equal to the one calculated mathematically. The distance between radiating elements set is 18 mm and is adjusted in such a way that the operational frequency remains at 2.4 GHz with improved directivity and gain.

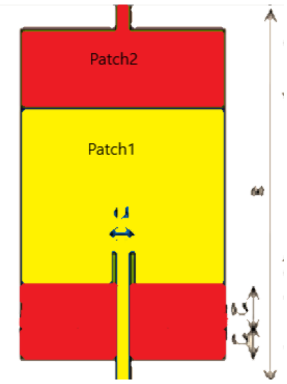

Fig-3:1*1 Rectangular Patch without slots

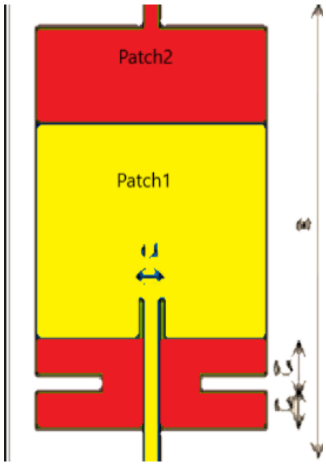

Fig-4:1*1 Rectangular Patch with slots in patch2

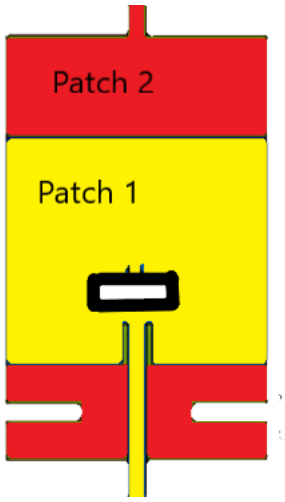

Fig-5:1*1 Rectangular Patch with slots in patch 1 and patch 2

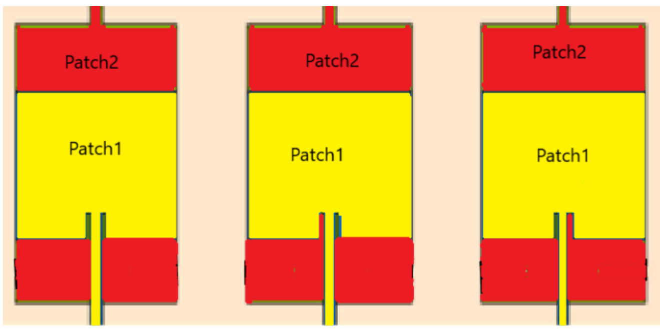

Fig-6:Triple Elements in an array without slots

To enhance the gain and directivity obtained from single element, a linear triple array of 162mm* 60mm*1.5 mm was simulated in HFSS.

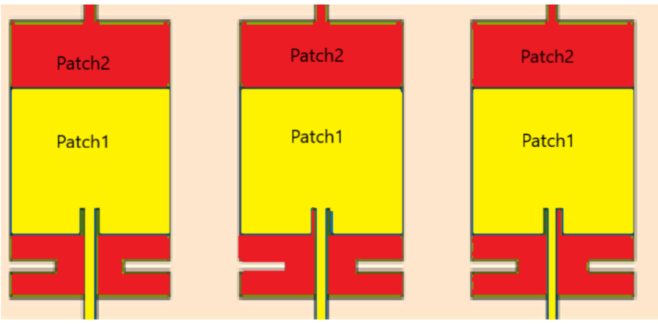

Fig-7:Triple elements in array with slots in Patch2

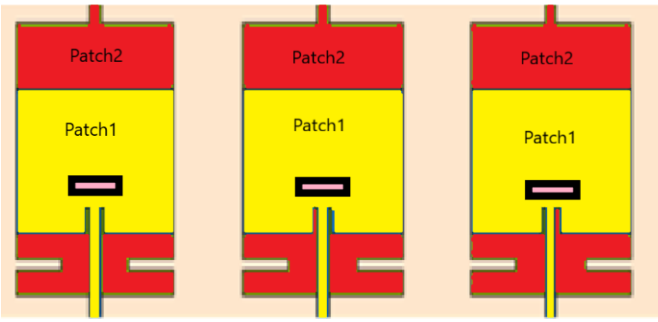

Fig-8:Triple elements in array with slots in Patch1 and Patch2

3. Design Specification

The parameters that have been used in this proposed rectangular microstrip patch antenna are given below:

Parameter Descriptions along with their symbols	**Dimension(mm)**
Width of Patch1, W	27
Length of Patch1,L	42
Width of Patch 2,W	52
Length of Patch2,L	42
Width of the Ground plane,Wg	70
Length of the Ground plane,Lg	70
Height of Substrate,hs	1.6

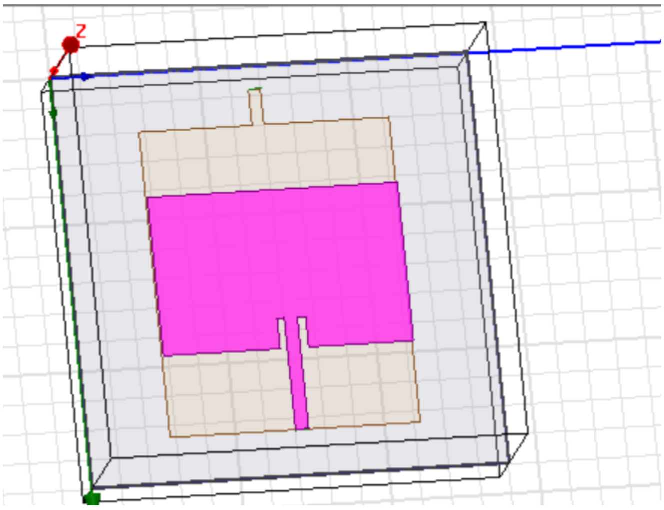

Fig-9:1*1 Rectangular Patch without Slots

Table-1:Dimensions of Slot in Patch2

Parameter	Dimension
Width of Slot	14mm
Length of Slot	2mm

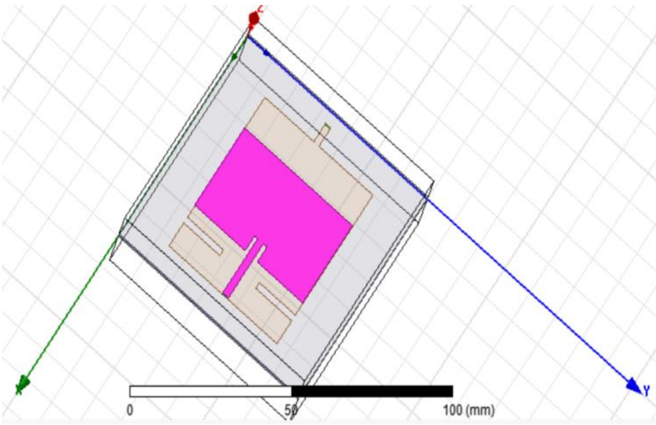

Fig-10:1*1 Rectangular Patch with Slots

Table-2:Dimensions of Slot in Patch1

Parameter	Dimension
Width of Slot	12mm
Length of Slot	0.8mm

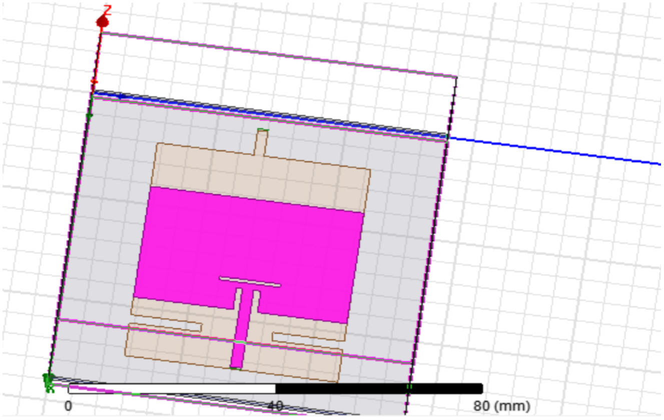

Fig-11:Modified 1*1 Rectangular Patch with Slots

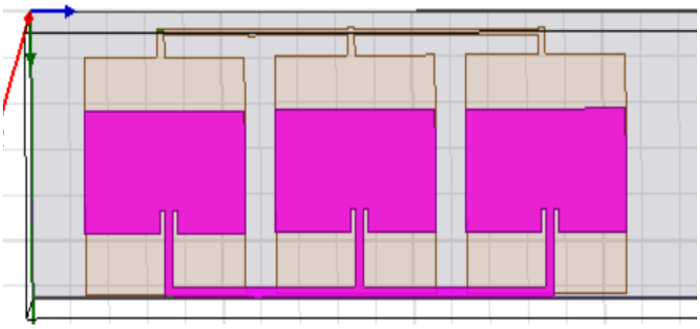

Fig-12:1*3 Rectangular Patch without Slots

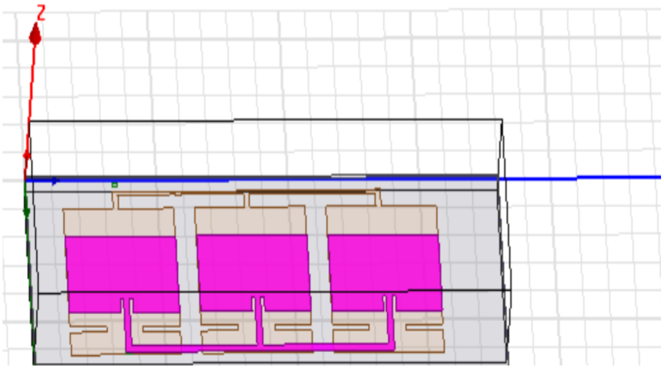

Fig-13:1*3 Rectangular Patch with Slots

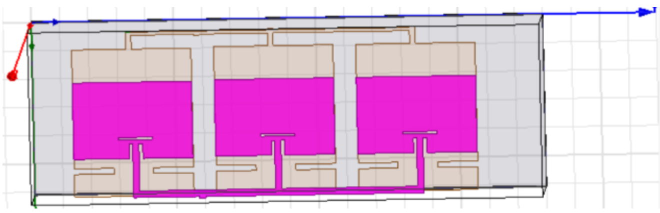

Fig-14:Modified 1*3 Rectangular Patch with Slots

4. Simulations And Results

All the simulation results of the implemented rectangular microstrip patch antenna for WLAN Systems have been successfully carried out. Simulations includes the Return Loss, Voltage Standing Wave Ratio (VSWR), Directivity and Gain.

4.1 Gain

As per Antenna specification, gain parameter is one of the most common measurements to realise the ability of the antenna for the effective transmission and reception. Gain value with 1*1 rectangular patch without slots using Fr4 substrate is 2.16 dB. Gain value with 1*1 rectangular patch with slots is 4.14dB and for the modified rectangular patch is 5.1dB.Also considering its array i.e 1*3 without slots shows a gain of 3.24dB also 1*3 with slots shows gain of 5.13dB and the modified one has the gain of 7.13dB.

Fig-15:3D Polar plot for gain of 1*1 rectangular patch without slots

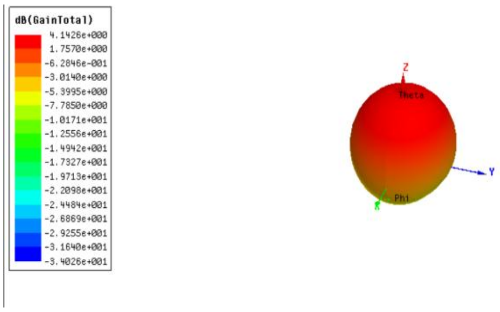

Fig-16:3D Polar plot for gain of 1*1 rectangular patch with slots

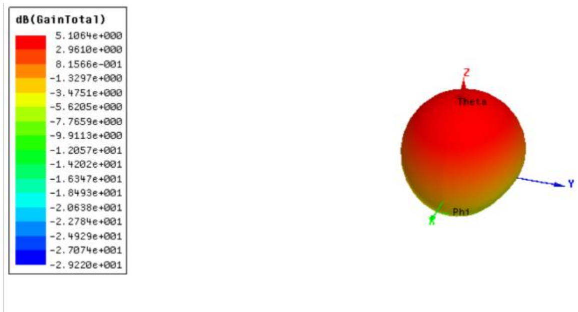

Fig-17:3D Polar plot for gain of modified 1*1 rectangular patch with slots

Fig18:3D Polar plot for gain of 1*3 rectangular patch without slots

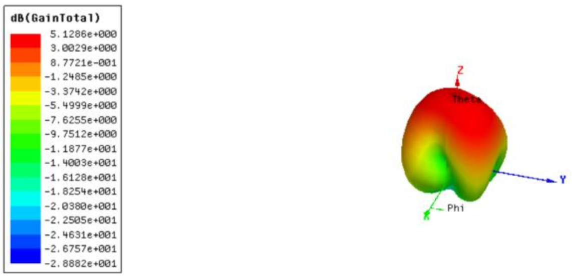

Fig-19:3D Polar plot for gain of 1*3 rectangular patch with slots

Fig-20:3D Polar plot for gain of modified 1*3 rectangular patch with slots

4.2 Return Loss

S11 represents how much power is reflected from the antenna, and hence is known as the reflection coefficient . Return loss value with 1*1 rectangular patch without slots using Fr4 substrate is -4.8 dB.Return loss value with 1*1 rectangular patch with slots is -5.8dB and for the modified rectangular patch is -7.3 dB.Also considering its array i.e 1*3 without slots shows return loss of -8.8dB also 1*3 with slots shows return loss of -9.6dB and the modified one has the return loss of -10.3dB.

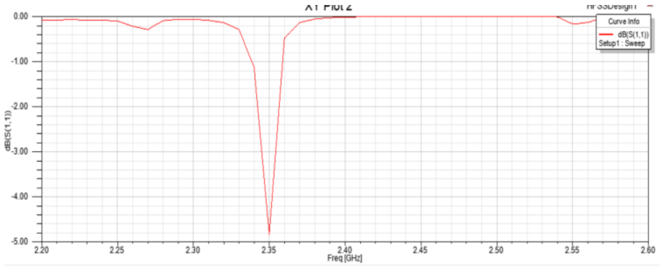

Fig-21: Return Loss plot for 1*1 rectangular patch without slots

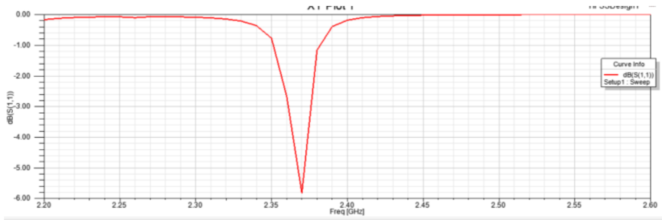

Fig-22: Return Loss plot for 1*1 rectangular patch with slots

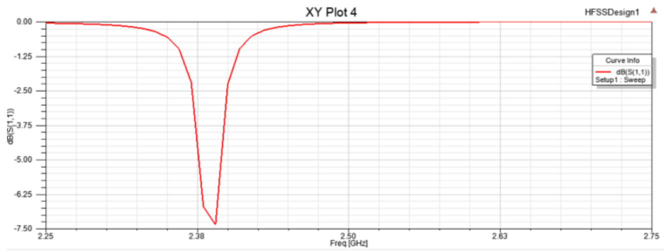

Fig-23:Return Loss plot for modified 1*1 rectangular patch with slots

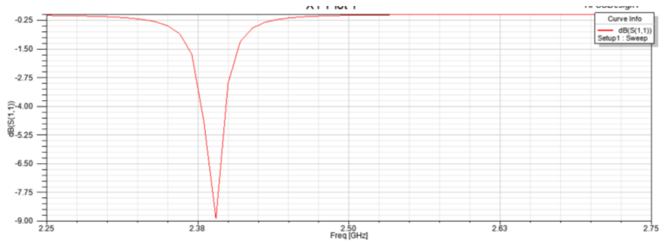

Fig-24: Return Loss plot for 1*3 rectangular patch without slots

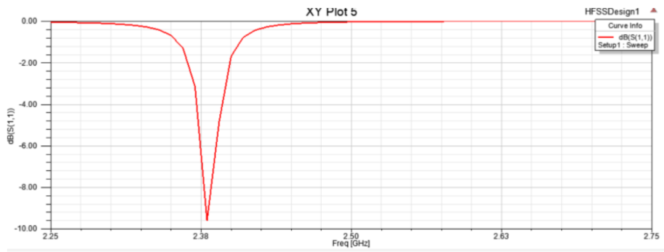

Fig-25: Return Loss plot for 1*3 rectangular patch with slots

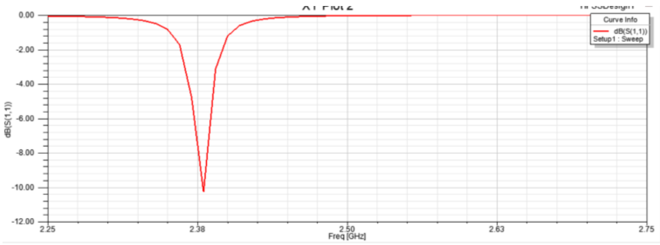

Fig-26: Return Loss plot for modified 1*3 rectangular patch with slots

4.3 VSWR

Voltage standing wave ratio (VSWR) is defined as the ratio between transmitted and reflected voltage standing waves in a radio frequency (RF) electrical transmission system. It is a measure of how efficiently RF power is transmitted from the power source, through a transmission line, and into the load. VSWR value with 1*1 rectangular patch without slots using Fr4 substrate is 10dB.VSWR value with 1*1 rectangular patch with slots is 10 dB and for the modified rectangular patch is 5dB.Also considering its array i.e 1*3 without slots shows VSWR of 5dB also 1*3 with slots shows VSWR of 5dB and the modified one has VSWR of 5dB.

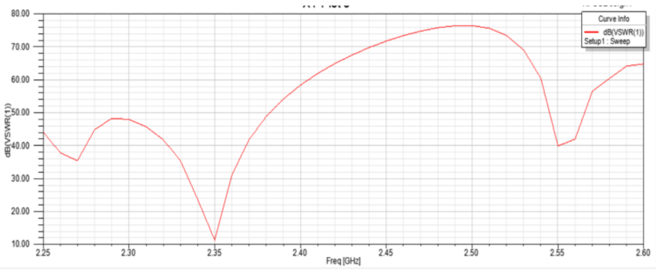

Fig-27: VSWR plot for 1*1 rectangular patch without slots

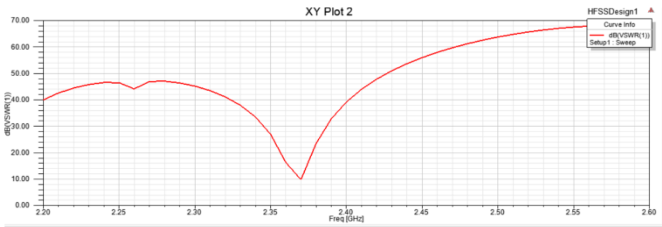

Fig-28: VSWR plot for 1*1 rectangular patch with slots

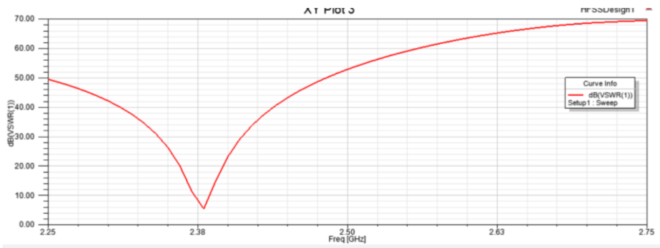

Fig-29: VSWR plot for modified 1*1 rectangular patch with slots

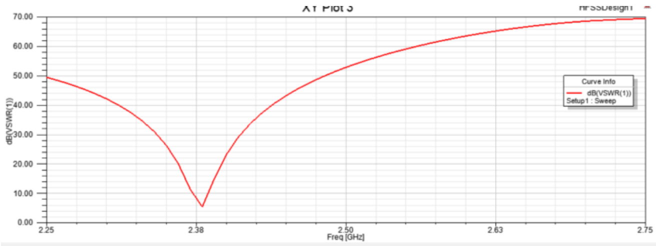

Fig-30: VSWR plot for 1*3 rectangular patch without slots

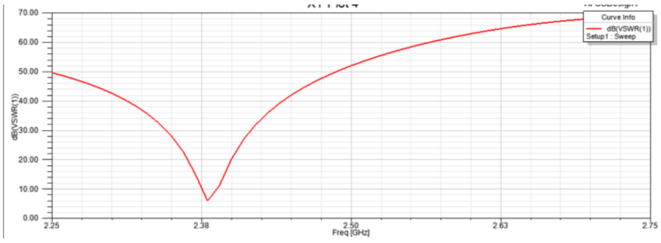

Fig-31: VSWR plot for 1*3 rectangular patch with slots

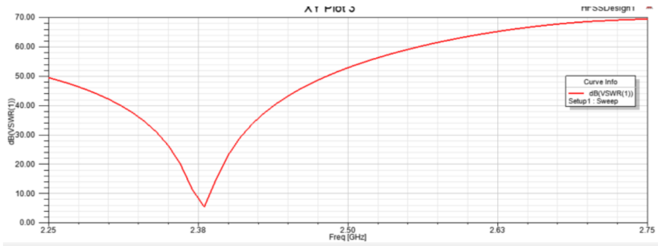

Fig-32: VSWR plot for modified 1*3 rectangular patch with slots

5.Result

This study has proposed a design for a 2.4 GHz rectangular microstrip patch antenna for the WLAN applications. At first, rectangular patch antenna is designed without slots. After that, rectangular patch antenna was designed with slots. Later rectangular patch antenna was modified in such a way that there was improvement in antenna parameters .Also using same patch design array was formed with 3 elements. It was found that antenna array has better performance in terms of Gain ,return loss and VSWR parameters.

6. Comparative Study

Table-3: Performance Parameters

1*1 Rectangular Patch

Type of Antenna	Size of patch	Gain (dB)	Return Loss	VSWR
1*1 without slots	42mm*60 mm*1.5m m	2.16	-4.8	10

1*1 with slots in patch2	42mm*60 mm*1.5mm	4.14	-5.8	10
1*1 with slot in patch 1	42mm*60 mm*1.5mm	5.1	-7.3	5

1*3 Rectangular Patch

Type of Antenna	Size of patch	Gain(dB)	Return Loss	VSWR
1*3 without slots	162mm*60 mm*1.5mm	3.24	-8.8	5
1*3 with slots in patch2	162mm*60 mm*1.5mm	5.12	-9.6	5
1*3 with slot in patch1	162mm*60 mm*1.5mm	7.1	-10.3	5

In this paper, various parameters of antenna such as Gain, Return Loss (S11) and VSWR were analyzed. Comparing single element with its array, a better Gain and S11 parameter was obtained performing the simulation on HFSS at 2.4 GHz resonant frequency. For high-speed protocols, the S11 parameter is the most vital part. Also, since this research's primary focus is the WLAN systems, the necessity of high-speed data transmission is also required.

9. Conclusion

The necessity of high gain and adequate protection from path loss will be necessary considering the expansion of modern technology in WLAN Systems . Considering the demand and numerous advantageous applications of WLAN systems, in this paper, using the HFSS 15 software, a rectangular shaped microstrip patch model antenna has been proposed to operate at a resonant frequency 2.4GHz. Moreover, it has also been deduced numerous parameters of the proposed antenna model, considering all the requirements and effectiveness. The designed model has a S11 value of -10.3 dB, a gain magnitude of 7.1 dB. However, considering the future demand, these parameters can be upgraded as per the requirements for overcoming the WLAN Systems challenges and enhancing the antenna's performance.

REFERENCES

[1] Priya Upadhyay, Vivek Sharma, Richa Sharma, ``Design of Microstrip Patch Antenna Array for WLAN Application'', IJEIT, Volume 2, Issue 1, July 2012.

[2]Naresh Kumar Poonia, Krishan Kumar Sherdia, ``Microstrip Antenna Array for WiMAX & WLAN Applications'', IJARCCE, Vol. 2, Issue 9, September 2013.

[3]Anusury, K., Dollapalli, S., Survi, H., Kothari, A. and Peshwe, P., 2019, July. ``Microstrip Patch Antenna For 2.4 GHz Using Slotted Ground Plane''. In 2019 10th International Conference on Computing, Communication and Networking Technologies (ICCCNT) (pp. 1-6). IEEE.

[4]Ali, Y.E.M. and Jasim, K.A.S., 2015. ``Design of Broadband Microstrip Patch Antenna for WLAN/WiMAX Applications''. AL Rafdain Engineering Journal, 23(1), pp.154-163.

[5]Shantwng He and Jidong Xie, "Analysis and Novel Design of a Novel Dual Band Array Antenna with a Low Profile for 2400/5800 MHz WLAN Systems", IEEE Transactions on Antennas and Propagation, Vol. 58, No. 2, pp. 391-396, 2010.

[6]Casu, G., Moraru, C. and Kovacs, A., 2014, May. ``Design and implementation of microstrip patch antenna array''. In *2014 10th International Conference on Communications (COMM)* (pp. 1-4). IEEE.

[7]Ramya, B., C. Supratha, and S. Robinson. "Design and Analysis of microstrip patch array antenna for WLAN applications." *ICTACT Journal on Microelectronics* 3.4 (2018): 457-461.

[8] Asokan, V., S. Thilagam, and K. Vinoth Kumar. "Design and analysis of microstrip patch antenna for 2.4 GHz ISM band and WLAN application." *2015 2nd International Conference on Electronics and Communication Systems (ICECS)*. IEEE, 2015.

[9] Bala, B. D., et al. "Microstrip patch antenna array with gain enhancement for wlan applications." *Bayero Journal Of Engineering And Technology (Bjet)* 12.2 (2017): 18-25.

[10]Ayush Arora, Arpit Rana, Abhimanyu Yadav and R.L.Yadava.``Design of microstrip patch antenna at 2.4 GHz for Wi-Fi and Bluetooth applications''.``Journal of Physics(2021)''.