ISSN: 0974-5823 Vol. 7 No. 2 February, 2022

International Journal of Mechanical Engineering

Realizing the design of dual faced hooked antenna for WLAN applications

[1]Dr. Sivasankari Narasimhan, [2]Shrivarshni G, and [3]Surendra Kumar Vyas

[1]Assistant Professor (Sr), Mepco Schlenk Engineering College, Anna University, Chennai

[2,3]Undergraduate Students, Mepco Schlenk Engineering College, Anna University, Chennai

Abstract - In the development of low-cost high-resolution applications, more patch antenna designs have been introduced. In wireless devices, small size of RFID tags requires lightweight antennas for signal reception and transmission. In this paper, a simple dual band antenna in hooked type has been proposed. This shows better improvement in radiation intensity and directivity. The dimension of the antenna is 40 mm × 15 mm. This antenna has two distinct operating bands 2.57GHz(2.49GHZ-2.68GHz) and 5.81GHz (5.33GHz-6.3GHz). FR4 epoxy substrates with relative permittivity of 4.4 is utilized in this antenna design. The desired antenna works at wireless local area network frequency of about 2.57 to5.81GHz and the parameters like return loss, gain, radiation pattern and VSWR (Voltage Standing Wave Ratio) are analyzed and implemented ANSYS HFSS software. The return loss obtained are -13.317 dB and -8858 dB respectively for the two bands and having the gain of -11.5 dB and -23 dB.

INTRODUCTION

Wireless communication devices definitely depend on antennas. The most commonly used antennas for wireless applications are patch antennas, slot antennas, and folding dipole antennas. The attributes and applications of these types are distinct. A slot antenna is a form of antenna with a specific aperture cut in a metallic conductor that is activated using a two-wire transmission line or coaxial cable. It's usually made by cutting an vertical slot in a metallic conductive sheet with a length of around λ/2 and a width of less than λ/2. The slot is stimulated either at the centre or off the centre. A horizontal slot antenna transmits a signal that is vertically polarised. A horizontally polarised signal is received via a vertical slot antenna. Energy is radiated from the slot when a high-frequency field is present in the slot. Electric and Magnetic field from the antenna will be perpendicular to each other. More conductive slots can be produced from a large metal sheet. They are acting as an array antenna. Each λ/2 slots are behaving as one λ/2 dipole antenna. The only variation is the direction of polarization. According to Babinet's principle, the slot antenna and the half-wave dipole structure creates complements for each other. They are related in their impedance values as per equation 1

$$Z_s Z_d = \frac{\eta^2}{4} \qquad (1)$$

Where Z_s impedance of slot antenna and Z_d impedance of dipole antenna; η intrinsic impedance of medium approximately equal to 377 Ω.

For dual slot it is expected to have the similar characteristics at two frequencies. Usually, wireless communication is taken place at 2.4 GHz and 5 GHz frequencies, either simultaneously or one at a time. Dual-band systems are meant to ensure constant performance by allowing users to choose between two frequency bands and switching between them quickly and automatically. Dual-band routers are often used with smartphones, laptops, and tablets, and they operate on the 2.5GHz and 5.8GHz bands.

The proposed antenna has two hook shaped antenna slot structure. The resonant frequency of the antenna can be adjusted by changing the length of the slot. The remaining sections are arranged as follows: Section II describes some related works. Section III narrates the proposed work. Section IV discusses the results followed by conclusion.

RELATED WORKS

Sourav Nandi and Akhilesh Mohan, [1] discussed about microstrip fed antenna with two λ/4 slots of different lengths, at dual band frequencies of 2.5GHz and 5.6GH. In the work of Pomsathit, and Benjangkaprasert, [2] a unique small and light weight dual band/dual polarisation right angle slot antenna supplied by microstrip line has been proposed for application in wireless technology.

J. Zhang et al. [3] presented, and it recommends that a folded dual-band slot antenna with even smaller dimensions, that is, the folded slot antenna only takes up around 28mm x 90mm x 4.8mm for wireless communication applications. Proposed antenna by Ren et al., [4] contains radiating elements which are made up of a square ring slot and a circular ring slot that operate in the 2.4 GHz and 5 GHz bands, respectively. But these kinds of antenna experience more design complexity.

To achieve dual band functioning, instead of designing the patch, feeding techniques can also be changed. The antenna proposed by Sahar Chagharyand et al, [5] is fed by a coplanar waveguide (CPW) with two inverted C-shaped resonators. The antenna is mostly made up of a patch with a modified open U-shaped slot and a T-shaped feed line, according to the design.

By folding some sections of patch, dual band characteristics can be obtained without slots. This method is described in reference [6].

PROPOSED METHODOLOGY

Design of antenna starts with normal designing of substrate and patch. Length is calculated as

$$L = \frac{c}{2f\sqrt{\varepsilon r_{eff}}} - 2\Delta L \qquad (2)$$

Effective dielectric constant is calculated as

$$\varepsilon r_{eff} = \frac{\varepsilon_r+1}{2} + \frac{\varepsilon_r-1}{2}\left(1+12\frac{h}{w}\right)^{(-0.5)} \qquad (3)$$

Due to fringing effect, how much the length increased is given as

$$\frac{\Delta L}{h} == 0.412\frac{(\varepsilon r_{eff}+0.3)(\frac{W}{h}+0.264)}{(\varepsilon r_{eff}-0.258)(\frac{W}{h}+0.8)} \qquad (4)$$

Width of the slot is given as $W = \frac{C}{2f}\sqrt{\frac{2}{\varepsilon_r+1}}$ (5)

From this the dimensions for the proposed antenna is designed as given in Table 1.

Table 1: Dimensions of the proposed antenna

L1	L2	L3	L4	Lg	Ws	Wa
17.5mm	8.0mm	12.0mm	18.0mm	8mm	2.0mm	1.0mm

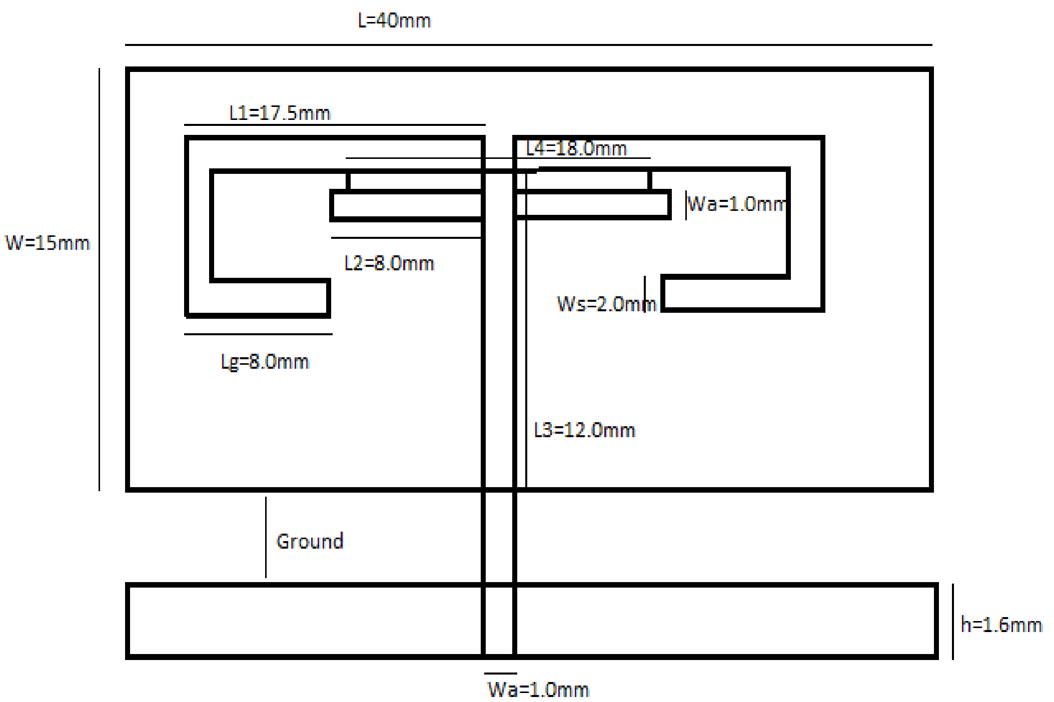


Figure 1: Proposed antenna Design

From the above equations designing parameters of antenna are tabulated in Table 2.

Table 2: Design Parameters for the antenna

Parameters	values
Dimensions of the substrate	40 mm× 15 mm× 1.6 mm
Material of the substrate	FR-4 Epoxy
Dimension of the ground	40mm ×15mm
Dimension of the patch	Specified in Table 1.

RESULTS AND DISCUSSION

The above design is implemented in ANSYS HFSS 2021 version. Obtained dual band frequencies are 2.54 and 5.74 GHz. Return loss result is given in Figure 2. At these frequencies, return return loss must lie between -10dB to -20dB, hence the plot obtained is -13.317dB at 2.57GHz and -9.58 dB at 5.8GHz. For a good antenna, the return loss must be greater than 10 dB, then only 90% of the power will be within antenna. From Figure 2, it is clear that, around 14 dB of return loss at 2.54 GHz and 8.4 dB return loss at 5.8 GHz.

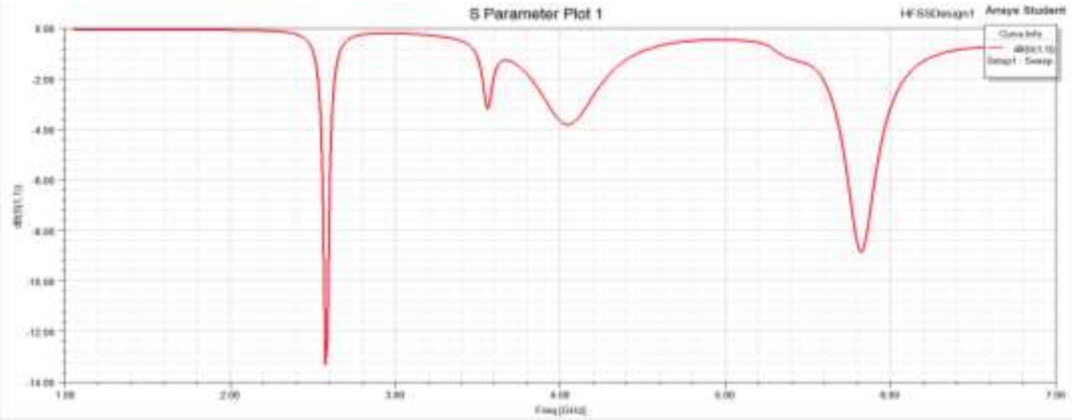


Figure 2: Return Loss curve

Smith chart analysis is done to infer the impedence matching of the antenna. Aroud the value of VSWR 3 is achieved. It is verified in smith chart and VSWR plot given in Figure 2 and 3.

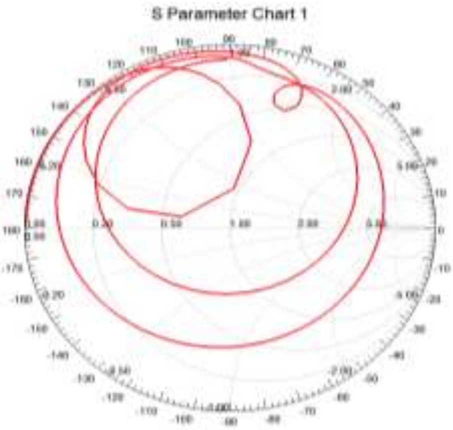


Figure 2: Smith Chart

VSWR is the measure of loss at the feeder because of mismatch. It should be less than 2dB

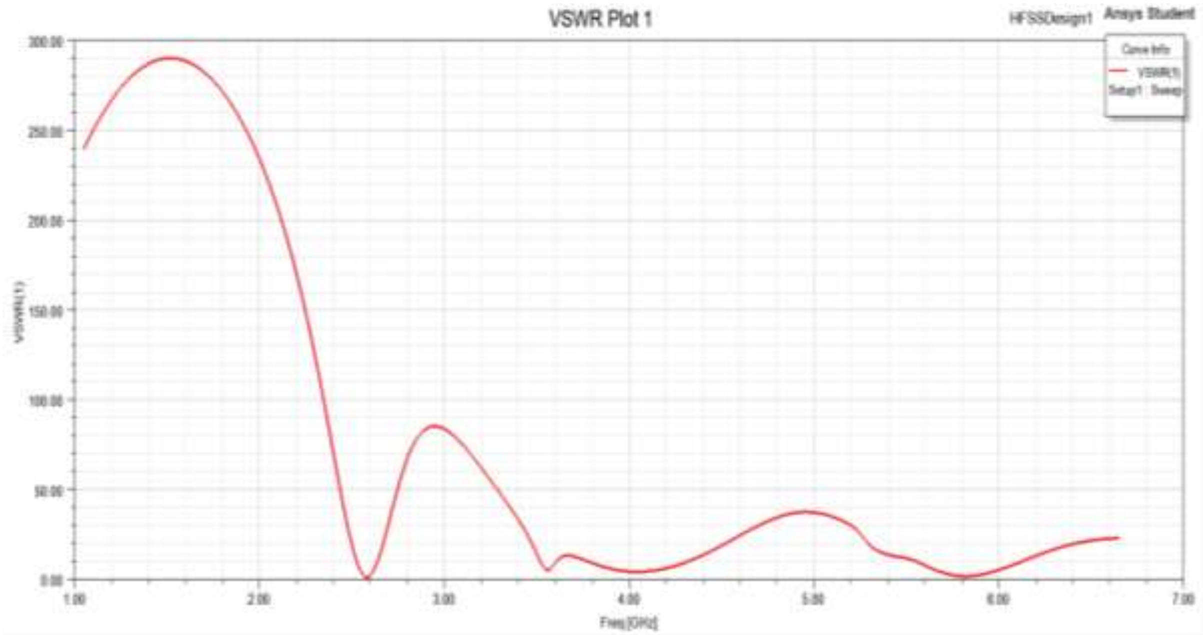
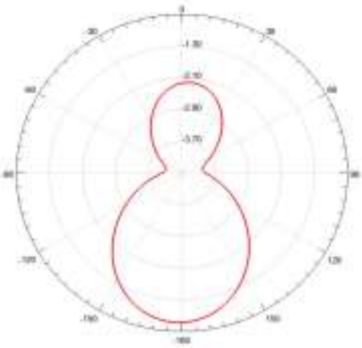
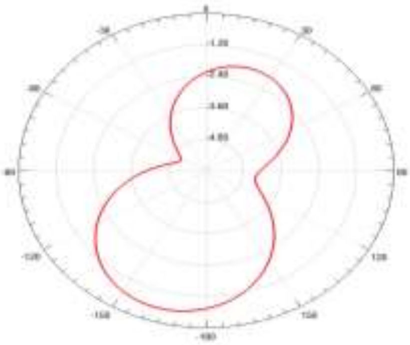
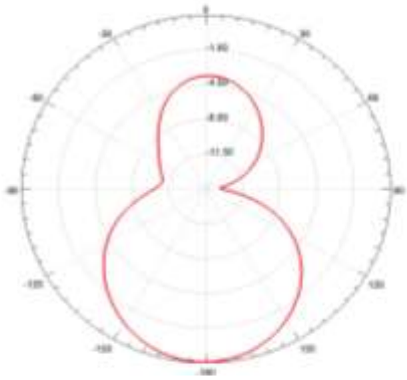


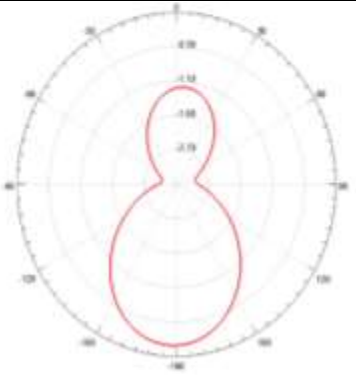
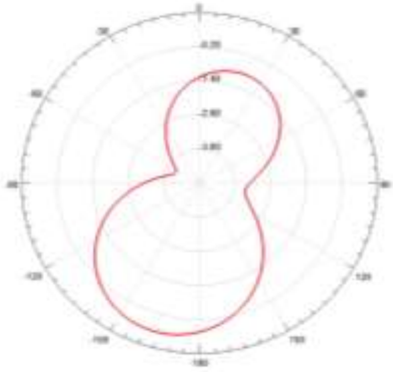
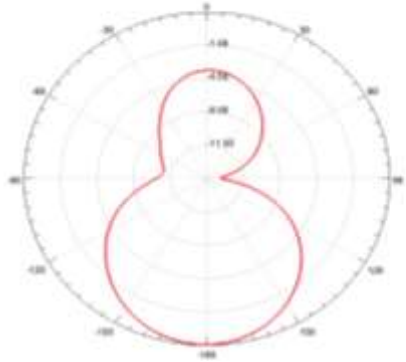
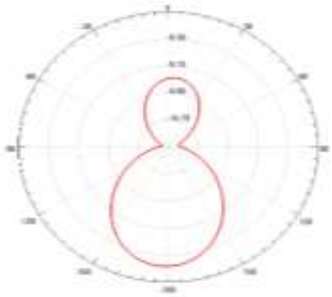
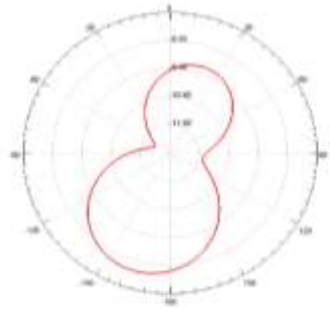
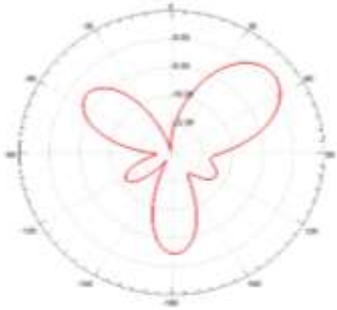
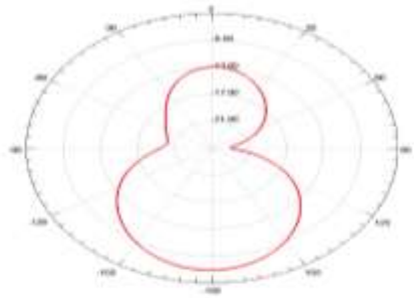
Figure 3: VSWR Plot

ANTENNA PARAMETER ANALYSIS

Some other parameters such as gain, directivity in E field and H field in these two different frequencies are given in Table 3.

Table 3: Radiation Pattern, Gain and Directivity Plot for 2.57GHz and 5.81GHz

Antenna parameters	**With E Field**	**With H field**
1.Radiation pattern **2.57GHz**		
5.81GHz		

2.Directivity $$D = \frac{U}{U_0} = \frac{4\pi U}{P_{rad}}.$$ **2.57GHZ**		
5.81GHz		
3.Gain(dB) **G=KD** (G-gain K-Efficiency D-directivity) **2.57GHz**		
5.81GHz		

The radiation pattern, Directivity and Gain for the antenna design 40mmx15mmx1.6mm is obtained and tabulated above for the frequency of 2.57GHz and 5.81GHz for the E-plane and H-plane.

DIMENSIONAL ANALYSIS

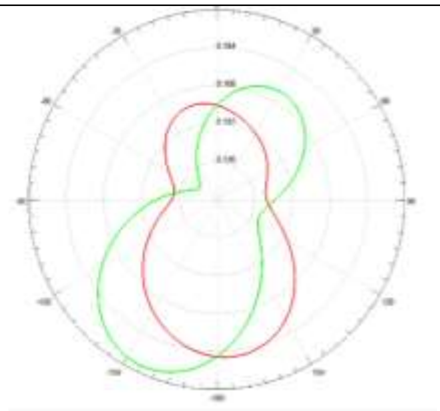
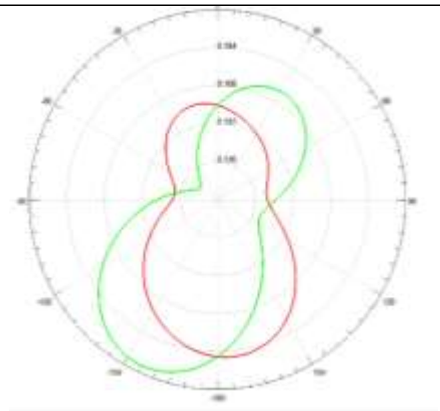
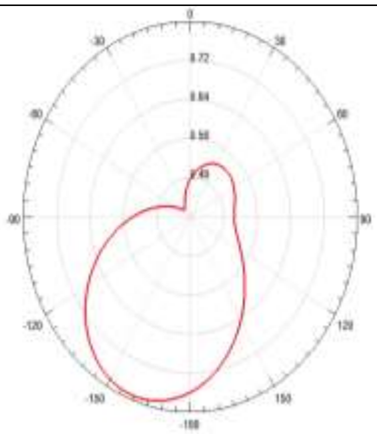
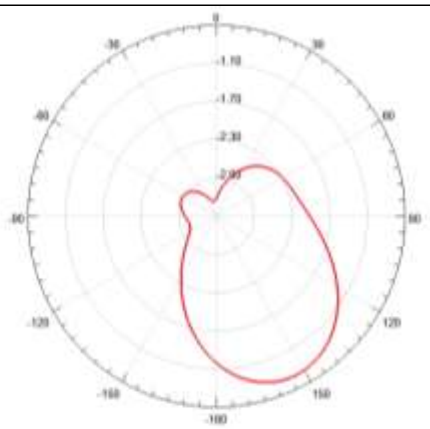
With various dimensions, the above process is repeated with various dimensions and the bandwidth ranges for both the dual band, range of bandwidth is given in Table 4. From this table, it is inferred that the optimum return loss is obtained at the dimension 40mm x15mm x 1.6mm that is 11.5dB at 2.57GHz and 12.9dB at 5.81GHz.

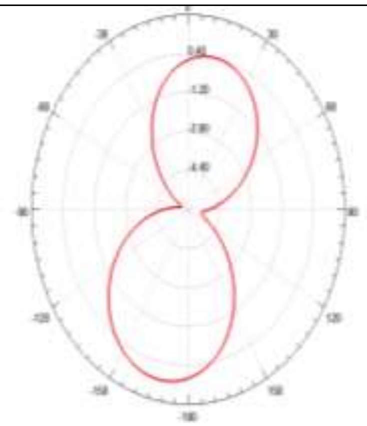
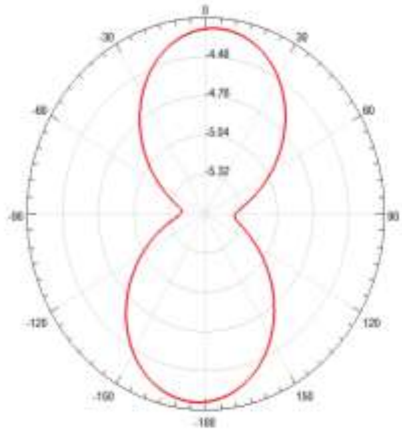
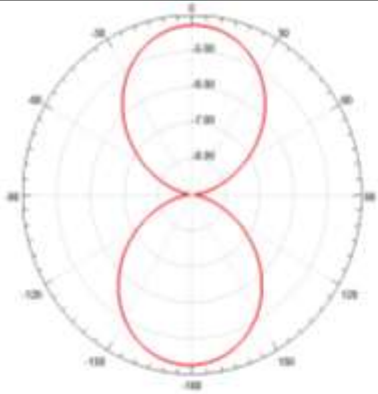
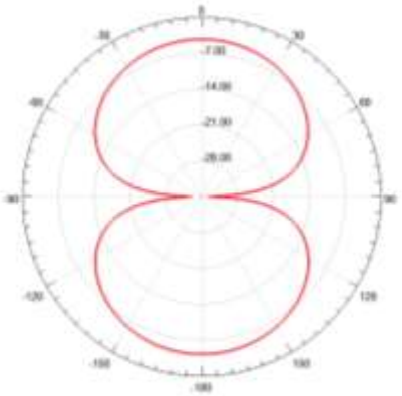
Table 4: Antenna Parameters for dimensional analysis

S.No.	Antenna size (mm2)	Bandwidth (GHz)		Return Loss (dB)
		I band frequency range	II band frequency range	
1	70x30 x 1.6	2.26-2.51	5.41-5.79	-11.2
2	65x27 x 1.6	2.3-2.42	4.9-5.52	-10.56
3	65x25 x 1.6	2.37-2.53	5.10-5.9	-9.28
4	56x20 x 1.6	2.40-2.5	4.9-5.75	-8.84
5	50x18 x 1.6	2.43-2.62	5.25-5.65	-6.94

Radiation Pattern gain and directivity plots are considered to see the direction or the pattern of radiation of the antenna in all directions and given in Table 5.

Table 5: Radiation Pattern for variations in antenna parameters

DIMENSIONS	**WITH E FIELD (Phi =0 degree)**	**WITH H FIELD (Phi=90 degree)**
L =70mm W=30mm H=1.6mm		
L =65mm W=25mm H=1.6mm		

L =55mm W=20mm H=1.6mm		
L =50mm W=18mm H =1.6mm		

From these radiation patterns infer that the dimension of antenna and slot selected has better radiation pattern when L =50mm; W=18mm; H =1.6mm.

Table 6: Antenna Parameters Table

Frequency (GHz)	Peak Realized Gain(dB)	Peak System Gain(dB)	Beam Area (mm^2)	Radiated Power (W)	Accepted Power (W)
2.57	7.766027	18.310673	10.548144	18.754732	10.544646
5.81	4.821594	13.255988	6.475094	17.773095	8.434395

CONCLUSION

A double hooked slot antenna was proposed and analyzed. Its frequency band characteristics were achieved at 2.57GHz and 5.81 GHz bands. Various radiation plots are obtained for the antenna with some dimensions. Better radiation pattern, return loss, gain, peak directivity has been achieved for the dimension L =50mm; W=18mm; h =1.6mm. This design of slot antenna is very useful in WLAN applications. It can be used for long distance communication. Due to its gain and radiation efficiency, it can also be used for satellite communication and also used in aircrafts skin which receives and signals. It has good impedance, compact size..

REFERENCES

1. Qing-Xin Chu, and Ying-Ying Yang, “A Compact Ultrawideband Antenna With 3.4/5.5 GHz Dual Band-Notched Characteristics,” IEEE Trans. Antennas Propag., vol. 56, pp. 3637–3644, Dec. 2008.
2. T. H. Kim and D. C. Park, “Compact dual-band antenna with double Lslits for WLAN operations,” IEEE Antennas Wireless Propag. Lett., vol. 4, pp. 249–252, 2005.
3. H. Ma, Q.-X. Chu, and Q. Zhang, “Compact dual-band printed monopole antenna for WLAN application,” Electron. Letters, vol. 44, no. 14, pp. 834-835, Jul. 9 2008.
4. T.-Y. Wu, S.-T. Fang, and K.-L. Wong, “Printed diversity monopole antenna for WLAN operation,” Electron. Letters, vol. 38, no. 25, pp. 1625–1626, Dec. 5 2002.

5. Zhijun Zhang, Magdy F. Iskander, Jean-Christophe Langer, and Jim Mathews, “Dual-band WLAN dipole antenna using an internal matching circuit,” IEEE Trans. Antennas Propag., vol. 53, pp. 1813–1818, May. 2005.

6. N. Behdad and K. Sarabandi. 2004. Bandwidth Enhancement and Further Size Reduction of a Class of Miniaturized Slot Antennas. IEEE Transactions on Antennas and Propagation. 52: 1928–1935.

7. C. Wen-Shan and K. Kuang-Yuan. 2008. Band-Rejected Design of the Printed Open Slot Antenna for WLAN/WiMAX Operation. Antennas and Propagation, IEEE Transactions on. 56:116:193