PERFORMANCE COPARISION OF INVERTED L AND F-SHAPE DUAL BAND MICROSTRIP ANTENNA

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ABSTRACT

Wireless Local Area Network (WLAN) application nowadays has become more popular, since it allows users to access network services without being tethered to a wired infrastructure. In high performance point to point and point to multipoint application where size, weight, cost, performance, ease of installation are constraints, low profile antenna is very much required. To meet these requirements, microstrip antenna is preferred. In this work two dual bands inverted L and F-shape geometry microstrip antennas using probe feeding operating at 2.45GHz and 5.8 GHz for WLAN application was designed and simulated. The simulation process has been done through EMPIRE software. The properties of antenna such as bandwidth, S parameter, VSWR were investigated. The simulation results show the bandwidth is maximum for dual band F-shape antenna at 5.8 GHz frequency that is 244. The return losses are better for inverted L-shape antenna at 2.45 GHz that is -25.62dB.

Keywords- Dual band, Microstrip Antenna, Probe Feeding, WLAN

INTRODUCTION

Communications has become the key to momentous changes as it conveys information between the source and destination. Information is indeed the lifeblood of modern economies and antennas provide mother earth a solution to a wireless communication system (Abu *et al*., 2009).

Antennas are the most important components required to create a communication link and be defined as the structure associated with the region of transition between a guided wave and a free space wave, (Constantine A. Balanis., 1997). The demand for antennas, capable to be embedded in portable devices which serve a wireless land mobile or terrestrial network. With time and requirements, these devices become smaller in size and hence the antennas required for transmit and receive signals have also to be smaller and light weight.

The current trend in commercial and government communication systems has been to develop low cost, minimal weight, low profile antennas that are capable of maintaining high performance over a large spectrum of frequencies. This technology has focused much effort into the design of micro strip (patch) antennas. Micro strip antennas appeared as a by-product of micro strip circuits, which by then had become a mature technology. Their design and realization took advantage of the techniques developed for micro strip circuits and used micro strip circuit substrates with a simple geometry, this antenna offer many advantages not commonly exhibited in other antenna configurations (Ramesh *et al*., 2001).In principle, dual-band antennas should operate with similar features, both in terms of radiation and impedance matching, at two or more separate frequencies. It is known that a simple rectangular micro strip patch can be regarded as a cavity with magnetic walls on the radiating edges.

The first three modes with the same polarization can be indicated by $TM_{10,}TM_{20}$ and TM_{30}. TM_{10} Is the mode typically used in practical applications whereas TM_{20} and TM_{30} are associated with a frequency approximately twice and triple of that of the mode.

This provides the possibility to operate at multiple frequencies. The simplest way to operate at dual frequencies is to use the first resonance of the two orthogonal dimensions of the rectangular patch, i.e., $TM_{10,}$ and $TM_{01,}$modes. In this case, the frequency ratio is approximately equal to the ratio between the two orthogonal sides of the patch. The obvious limitation of this approach is that the two different frequencies excite two orthogonal polarizations.

The most popular technique for obtaining a dual-frequency behavior is to introduce a reactive loading to a single patch, including stubs (Richards *et al*., 1985), notches (Rod and Waterhouse, 1999), pins (Hammerstad, 1975), (S. Zhong *et al*., 1983), capacitors and slots (Ramesh *et al*., 2001). By reactive-loading approaches, one can modify the resonant mode of the patch, so that the radiation pattern of the higher order mode could be similar to that of the fundamental mode. This indicates that the use of a single feed for both frequencies on a single radiating element can be realized.

In rectangular patch with two narrow slots etched close to and parallel to the radiating edge was used to obtain the dual-frequency operation proposed by (Maci *et al*., 1993). In this dual-frequency design, the two operating frequencies are associated with the $TM_{01,}$ and $TM_{30,}$ modes of the un-slotted rectangular patch. In addition, this two operating frequencies have the same polarization planes and broadside radiation patterns, with a frequency ratio within the range of 1.6-2.0 for the inset feed case.

The above approach characterizes dual-frequency patch antennas, which will be identified as orthogonal mode dual-frequency patch antenna (Ramesh *et al*., 2001). This can be extended to any kind of patch shape that offers two cross-polarized resonant modes.

Misran *et al*., **(**2008**)** present a coaxially-fed single-layer compact micro strip patch antenna for achieving dual-polarized radiation suitable for applications in the IEEE Radar band C and X. Simultaneous use of both frequencies should dramatically improve data collection and knowledge of the targets in an airborne synthetic aperture radar system.

The designed antenna consists of three rectangular patches that are overlapped along their diagonals. The design and simulation of the antenna were performed using 3D full wave electromagnetic simulator IE3D. The measured results show that the designed antenna achieves VSWR less than 2 and a bandwidth of 154 MHz.

Abu et al., (2009) have also proposed a slotted e-shape rectangular patch antenna with dual-frequency operation. The patch dimension of 34×23 mm, FR4 substrate material having thickness of 1.6 mm and permittivity of 4.8 were used. The measured results show that the designed antenna achieves a VSWR less than 2 with bandwidth of 3.02% (2.45-2.525 GHz) at lower frequency and 1.65% (6.125 - 6.025 GHz) at upper frequency and measured gain of this antenna is 3 dB for both working frequencies.

Wideband and dual-band characteristics of single and double notched rectangular patch antennas are also presented by Palit S.K. and Hamadi A., (1999)**.** A comparative study of the experimental results employing coax, microstrip aperture-coupled and electromagnetically coupled feed techniques have been made for increased bandwidth and improved cross-polar level that is a measure of how an antenna is purely polarized. It is determined by the difference in decibels between the maximum radiation intensity of the co and cross polarizations.

The experimental radiation patterns were compared with simulated and theoretical patterns found to be in good agreement. Thus, the maximum measured impedance bandwidths of 26.6% in band 1 and 31.7% in band 2 have been achieved for coax-fed single-notched patches. A double-layered double-notched aperture coupled (composite) patch antenna was also designed, and further improvement in impedance bandwidth of 39% was achieved without significant degradation in radiation characteristics.

Tlili, (2010) a double C-slot microstrip antenna is designed and simulated for the WiMAX frequency range of 2.5-2.69 GHz. This antenna presents an extension to the single C slot antenna. The proposed antenna has a gain of 6.46 dBi and a size reduction of 37% when compared to a conventional square microstrip patch antenna.

Gupta, (2012) proposed design and fabrication of dual and triple band microstrip patch antennas using proximity feeding for wireless applications. The geometry shape used was an inverted T shaped slot that resonates at 2.45 and 5.8 GHz frequencies. In this design stacking and Defected Ground Structure (DGS) are used where, the size of stacked substrate is different from the main substrates. The design of the antenna has patch width and length of 29.036mm and 25.054mm respectively. The substrates used were same material having dielectric constant of 4.4 and the height of the substrate was 1.57mm. The simulation results of the designed antenna indicated that return loss and bandwidth of -16dB and 88MHz at 2.4GHz and -17.5dB and 67MHz at 5.8GHz respectively. Similarly, VSWR is 1.4 and 1.3 at frequencies of 2.4 GHz and 5.8GHz respectively.

Thus, from the reviewed literatures different types of Microstrip antenna were designed for different application and their performances are described. The design of an efficient dual frequency small size patch antenna for recent wireless applications is a major challenge so that in this work significant size reduction, enhancement of antenna bandwidth and design of dual band frequencies with geometry of Inverted L-shape and F-Shape antennas for wireless application is proposed.

MATERIALS AND METHODS

In this thesis work dual bands inverted L and F-shape geometry microstrip antennas have been designed and simulated. Probe feeding technique was used for excitation of the designed dual band microstrip antennas. Probe feed was used to couple microwave energy to the antenna and feed point can be located on anywhere within the patch but, the feed location inside the patch was properly selected to obtain good impedance match at both resonances since the antenna resonates at two frequencies one corresponding to the width and the other corresponding to the length. The center of the patch was taken as the origin and the feed point location was given by the coordinates $\left(X_{f,}Y_f\right)$ from the origin. The feed point must be located on the patch at a point where the input impedance is 50 ohms for the resonant frequency. For different locations of the feed point, the return loss was compared and that feed point was selected where the return loss is most negative.

Design of Dual Band Proposed Micro strip Antennas

Significant reduction of antenna size was realized by using inverted L-shaped patch geometry instead of the conventional rectangular micro strip patch antenna. The inverted-L shape antenna shown in Figure 1 consists of patch of width and lengths etched on a Rogers RT/Droid 5870 substrate of thickness h =1.160mm and dielectric constant ε_r = 2.330. The different parameters of the patch were varied and the optimum results and their effects in the radiation characteristics were studied.

Figure 1: Inverted L shape antenna geometry at 2.45 and 5.8 GHz

As shown in Table 1 the dimensions of Inverted L-shape microstrip patch antenna at operating frequency 2.45GHz and 5.8 GHz are listed. The slot length Ls and slot width Ws are selected in such a way that it helps to get the optimized performance of the antenna. The Second antenna geometry developed for attaining dual frequency operation was having the shape of F- shape geometry, Which was consisted of patch of width and length etched on a Rogers RT/Droid 5870 substrate of thickness h =1.160mm and dielectric constant ε_r = 2.330.

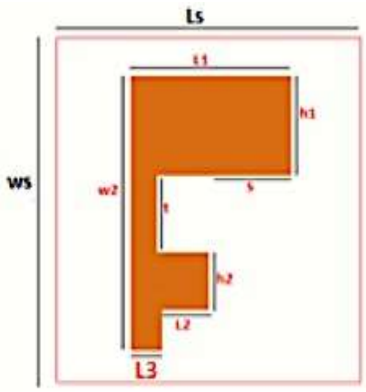

Figure 2: F-antenna geometry at 2.45 and 5.8 GHz.

RESULTS AND DISCUSSSION

In this section the simulation results was demonstrated to show the performance of our proposed micro strip antenna shapes.

Results for return loss, bandwidth, radiation pattern, and far field radiation for both inverted L and F shape dual band antennas was discussed.

Inverted L-Shape Antenna

The probe feed is used to excite the designed dual inverted L-shaped antenna and the center frequency is selected at which the return loss is minimum. The designed antenna resonates at 2.45 GHz and 5.8 GHz frequencies. The return loss for 2.45 GHz and 5.8 GHz are -25.62 dB -23.29 dB respectively that satisfies the minimum required value of return loss of -10 dB and these values are shown in Figure 3 that presents the S_{11} parameters (return loss in dB) frequency.

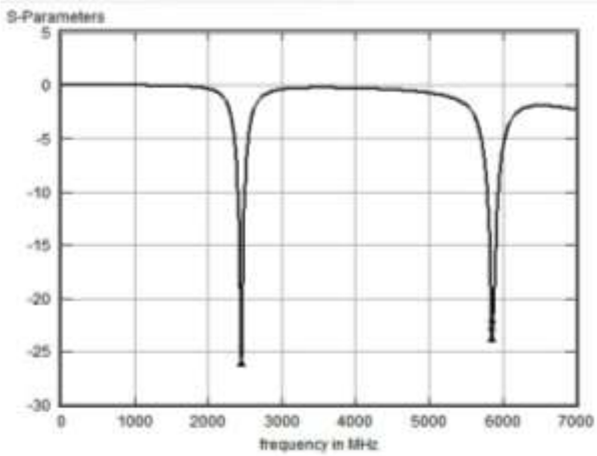

Figure 3: S-Parameter versus frequency for dual band inverted L micro strip antenna.

The bandwidth of inverted L- shape antenna can be calculated from return loss versus frequency plot. Based on this, the -10 dB and 3 dB bandwidth of the designed inverted L shape antenna are 144 MHz and 63 MHZ for 2.45 GHz frequency, 190 MHz and 90 MHZ for 5.8 GHz frequency respectively. -10 dB and 3dB bandwidth for 2.45 GHz and 5.8 GHz frequency has been shown in Figure 4 and 5 respectively.

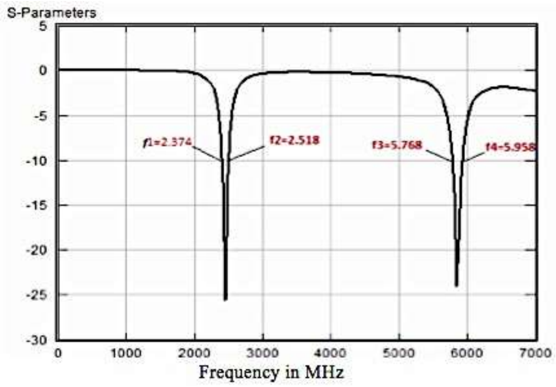

Figure 4**:** -10dB bandwidth of dual band inverted L antenna at 2.45 and 5.8 GHz.

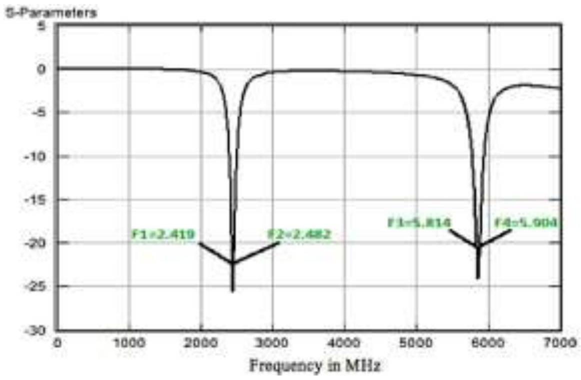

Figure 5: 3dB bandwidth of dual band inverted L antenna at 2.45 and 5.8 GHz.

Figure 5 shows the 3dB Bw, which describes the point where the power output is half than the input power. It is conventions that the power at output drops to half, performance could be tolerated. As shown in Figure 4 and 5, the -10 dB and 3 dB bandwidth of the designed inverted L shape antenna are 144 MHz and 63 MHZ for 2.45 GHz frequency, 190 MHz and 90 MHZ for 5.8 GHz respectively.

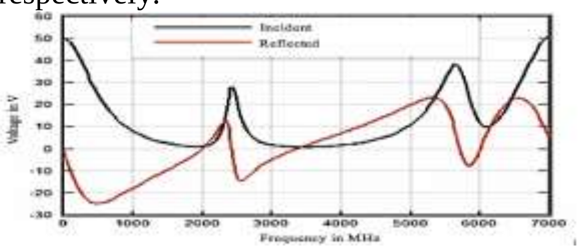

Figure 6: Frequency domain voltage radiation Pattern

can be seen from the Figure 6, the reflected voltage amplitude was smaller than the incident voltage amplitude, giving a larger return loss. From the frequency domain voltage, one can also observe that the incident voltage was stronger than the reflected voltage that gives larger return loss at the expected operating frequencies of the antenna.

The Far field radiation pattern of inverted L-shape microstrip antenna shown in Figure 7 indicates the E and H-plane pattern at 2.45GHz and 5.8GHz center frequency and it can be observed that the designed antenna has stable radiation pattern throughout the whole operating frequency band.

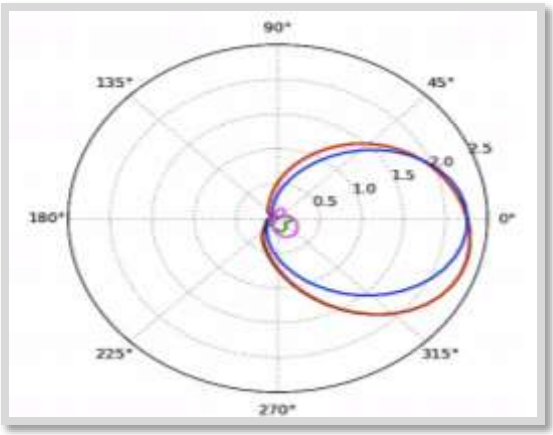

Figure 7: Far field radiation pattern polar plot (Linear).

Efficiency is defined as the ratio of the radiated power (Prad) to the input power (Pi). The input power is transformed into radiated power and surface wave power while a small portion is dissipated due to conductor and dielectric losses of the materials used. From this the radiation efficiency and the gain of the proposed L-shape geometry are 72.22% and 2.25dBi respectively. Where power into Excitation port (Pi) = 1.829W, incident power into excitation port (pinc) = 2.356W, and radiated power = 1.321W.

F-Shape Antenna

Similarly the simulation result for F-geometry of dual band microstrip antenna that resonates at 2.45 GHz and 5.8 GHz frequencies are presented and discussed in detail. As shown in Figure 8 the return loss for 2.45 GHz and 5.8GHz are -23.51 dB and -25.05dB respectively in which the minimum required return loss value, -10 dB, is satisfied.

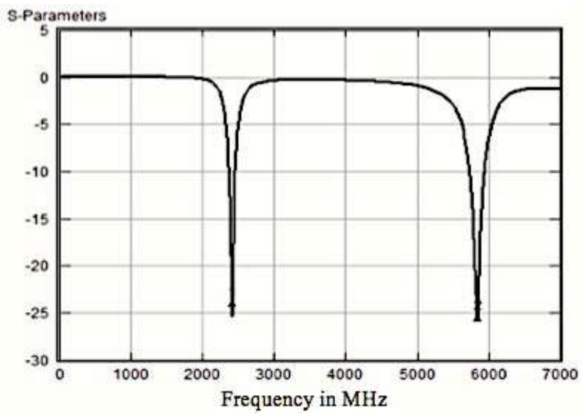

Figure 8: S-parameter versus frequency for dual band F shape microstrip antenna

Since the bandwidth of antenna can be calculated from return loss, the obtained values are shown in Figure 9 and 10. The -10dB and 3dB bandwidth of the designed F-shape antenna are 136 MHz and 72 MHz for 2.45 GHz frequency and 244 MHz and 81MHz for 5.8 GHz frequencies respectively.

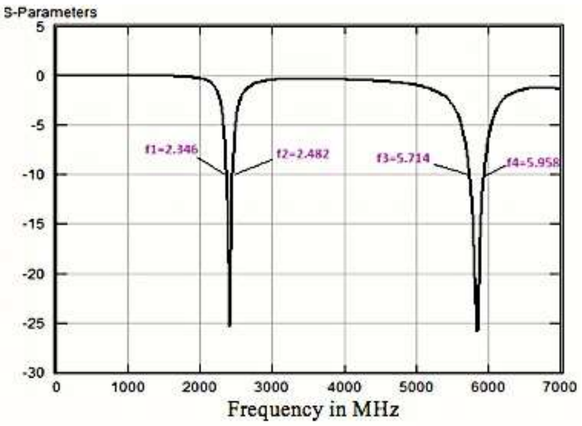

Figure 9: -10 dB band width of dual band F shape antenna at 2.45 and 5.8 GHZ

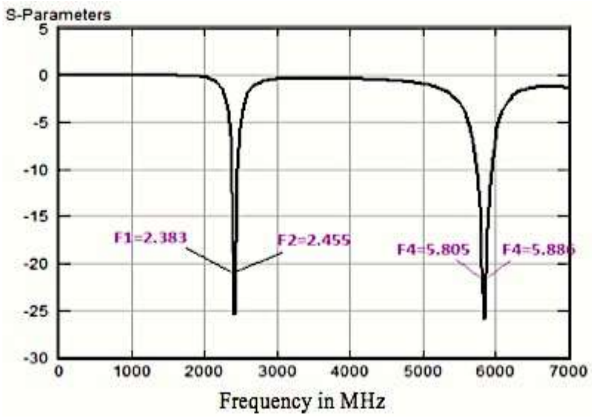

Figure 10: 3dB band width of dual band F shape antenna at 2.45 and 5.8 GHZ

As can be seen from the Figure 11, the reflected voltage amplitude is smaller than that of the incident voltage amplitude, giving a larger return loss. From the frequency domain voltage cure, one can identify that the incident voltage is stronger than the reflected voltage and this assures that the return loss at the expected operating frequencies of the antenna is large.

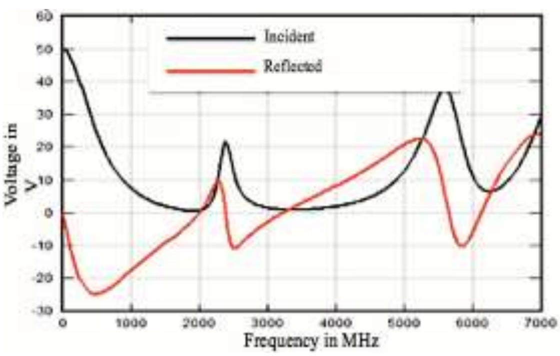

Figure 11: Frequency domain voltage radiation Pattern

Figure 12 presents the E and H- plane pattern of F-shape microstrip antenna at 2.45GHz and 5.8GHz center frequencies and this indicates that the antenna radiates power in all directions for the entire operating band.

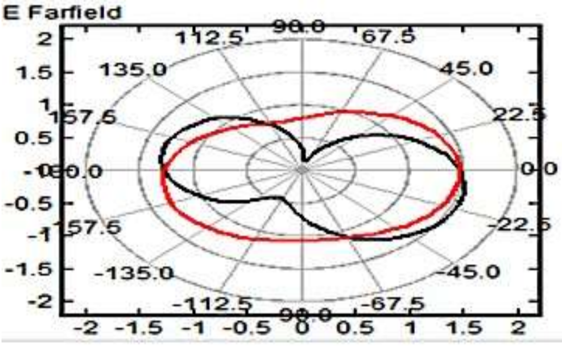

Figure 12: Far field radiation pattern (linear).

Finally, the comparison table based on different parameters that have been mention above for the two proposed geometries of microstrip antenna is shown in Table 3. Finally, the comparison table based on different parameters that have been mention above for the two proposed geometries of microstrip antenna is shown in Table 3.

Table 4 shows surface area for both proposed geometry. From the table we observe that the surface area of the radiating patch obtained for each type of antennas are $176mm^2$ and $129mm^2$ respectively with respect to the operating frequency of the antennas.

The result shows that the F-shaped antenna has small surface area which achieved a size reduction of 0.47% when compared with that of an inverted L-shaped antenna, Generally the performance parameters like bandwidth, return loss, and gain of the designed antenna in this work are better and there was a significant surface area reduction, so that the cost for fabricating for F-shape antenna is more cheaper than inverted L-shape antenna.

CONCULUSIONS

This work presents design and simulation of different shapes of microstrip antenna intended to be used for WLAN application at 2.45GHz and 5.8 GHz operating frequencies. The results report dual band inverted L-shape and F-shape microstrip antenna using probe feeding technique and comparison made with antenna parameters like: return loss, bandwidth, and Gain. As stated in results section physical parameters affects the results and performances of the antennas and it can be observed that varying these parameters in the right manner gives optimized results for a desired resonant frequency operation of Microstrip Antenna. Thus, the designed antennas give efficient results resonating at 2.45 GHz and 5.8 GHz that could be applicable for WLAN. Based on the parameters, the bandwidth is maximum for F-shape antenna at 5.8 GHz frequency that is 244 MHz for which 100 MHz is acceptable whereas the return losses are better for inverted L-shape antenna at 2.45 GHz that is -25.62dB. The VSWR of both antennas lie between 1 and 2 so that all the designs are acceptable. In General, the obtained performance values achieved the need of microstrip patch antenna.

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Table 1. Dimensions of designed inverted L- antenna geometry

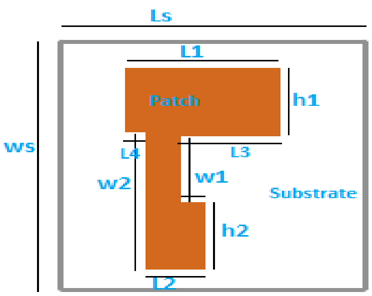
Antenna Geometry	Antenna Parameter	Value (mm)	Dimensions (mm^2)
	L_1	16.25	21.93*22.00
	L2	6.00	
	L_3	10.50	
	L4	2.25	
	w_1	10.00	
	w_2	16.54	
	h_1	5.00	
	h_2	10.00	
	L_s	21.93	
	W_s	22.00	

Table 2: Dimension of designed F –antenna Geometry

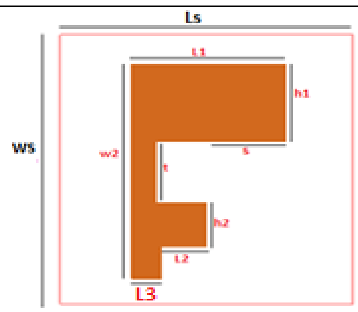
Antenna Geometry	Antenna Parameter	Value(mm)	Dimensions (mm^2)
 F- Antenna	L1	10.50	16*24.50
	t	6.68	
	h_1	8.50	
	h_2	4.81	
	L_3	2.60	
	s	7.0	
	L_s	16	
	W_s	24.50	
	W2	22.50	

Table 3. Comparison of simulated Antenna

Antenna Configuration	Resonating Frequency	Return Loss	Bandwidth	VSWR	Gain
Dual Band Inverted L-shape Antenna	2.45 GHz	-25.62dB	144MHz	1.004	2.25dBi
	5.8 GHz	-23.29dB	190MHz	1.083	
Dual Band F-shape Antenna	2.45 GHz	-23.51dB	136MHz	1.009	1.4dBi
	5.8 GHz	-25.05dB	244MHz	1.007	

Table 4. Surface area comparisons of the proposed geometries

Antenna Configuration	Resonating Frequency	Patch Area (mm^2)
Dual Band Inverted L-shape Antenna	2.45 GHz & 5.8 GHz	$176mm^2$
Dual Band F-shape Antenna	2.45 GHz & 5.8 GHz	$129mm^2$