A Novel Patch Antenna With A U-Shape Parasitic Strip For 2.4/5.4 GHz WLAN Applications

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Abstract

A Novel Dual-Band Design Of Patch Antenna is presented in this paper. The design of the original Antenna has been optimized to yield better results in terms of Gain, Bandwidth and Radiation Efficiency. The T-Shape Parasitic Strip has been changed to U-Shape Strip, which resulted in Higher gain, better radiation efficiency, and bandwidth. The U-Shape strip has been given finite conductivity, and thus improved gain and return loss characteristics are obtained. The ultimate antenna resonated in two resonant frequencies viz.2.45Ghz(S11<-10db) and 5.42Ghz(S11<-10db), and a Gain of 4.2db and 5.01 db are obtained respectively. The frequency domain characteristics of the Antenna has been studied thoroughly, and is presented in this paper. The Antenna is simulated using High Frequency Structure Simulator(HFSS) software.

Keywords: Patch Antenna, Microstrip Antenna, Wireless Local Area Network(WLAN)

1. Introduction

In recent years, there has been a lot of developments in the area of Wireless Local Area Network(WLAN). A patch antenna is a wide-beam, narrowband antenna that is fabricated by etching the antenna element pattern in metal trace using an insulating dielectric substrate with a continuous metal layer bonded to the opposite side of the substrate forming the ground plane. Common microstrip antenna shapes are square, rectangular, circular and elliptical, but any continuous shape is possible. To benefit the use of Mobile WLAN devices, multi-band and wide-band antennas are being developed to operate in multi-band/dual-bands.

In this paper, a dual-band patch antenna which has been modified to provide better results is presented. The proposed Antenna consists of a U-Shape parasitic strip, and a rectangle shaped ground plane parallel to the 50Ω Microstrip feed line that is electromagnetically coupled to provide excitation. The best values of W3 and l3 are taken, and has been simulated for different values of d1 and d2(Associated with the 50Ω transmission line. The optimized values of d1 and d2 are obtained as d1=11mm, and d2=5.2mm, which then yielded better Gain, Bandwidth and Radiation efficiency. Good impedance bandwidth is achieved in dual resonant frequencies of 2.4Ghz and 5.4Ghz with S11<-10db. Design details of the proposed antenna along with results and detailed explanations are given and discussed in this paper.

2. Antenna Design:

Microstrip Patch Antennas generally has very narrow frequency bandwidth because of high quality factor. The Bandwidth of such Antennas can further be improved either by altering the values of design parameters through parametric study, or by changing the existing design. In the proposed antenna, the ground plane and U-Shape parasitic strip are printed on the same side of the substrate(FR4 substrate is used here, which has thickness of 1.6mm, and relative permittivity of 4.4). The width of the microstrip feed line has been made as 3mm(W1), and width of the two rectangles forming the U-Shape structures are made to be fixed as W4=W5=2mm. Current paths of two resonant frequencies are being formed, which in turn induces dual resonant modes. The original Antenna with T-Shape parasitic strip has been modified with a U-Shape strip by joining two rectangles of similar dimensions(Length=7mm, and Breadth=2mm) at the extreme edges of the T-Shape strip. By varying the dimensions of d1 and d2, we can obtain improved characteristics of the Antenna at the same frequency range.

Figure 2 denotes the general depiction of the Antenna with U-Shaped Parasitic Strip, and Figure 3 denotes the simulated antenna. The Antenna is designed using HFSS(High Frequency Structure Simulator) Software.

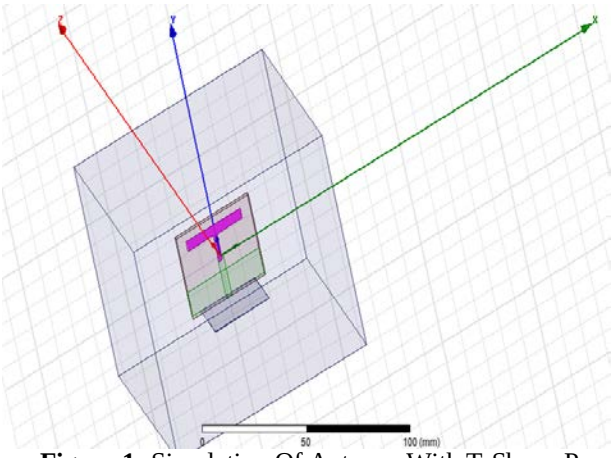

Figure 1: Simulation Of Antenna With T-Shape Parasitic Strip

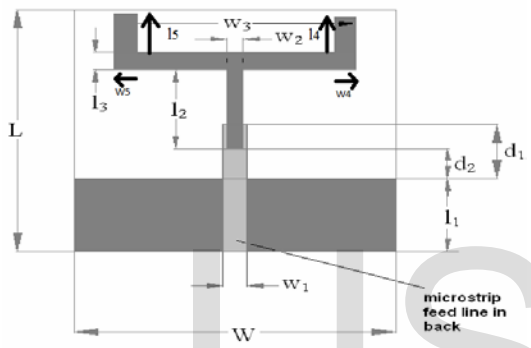

Figure 2: Geometry Of The Antenna(Proposed)

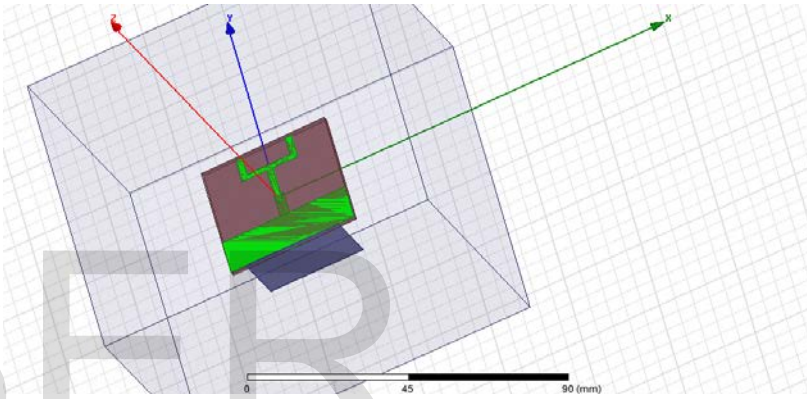

Figure 3: Simulated Antenna(Proposed)

Dimensions Of The Proposed Antenna:
[L=40mm,l1=12mm,l2=13mm,W=40mm,W1=3mm,W2=2mm,W3=18mm,l3=2mm,d1=11mm,d2=5.2mm,Length of Rectangle 3= 7mm, Width of Rectangle 3=2mm, Length of Rectangel4= 7mm, Width=2mm,W4=W5=2mm and l4=l5=7mm]

The substrate length and dimension is 40mm x 40mm, and Ground Plane is made to be of dimension 12mm x 40mm. 'W' denotes the width of both substrate and the Ground. The Antenna can operate in the bands that cover the required bandwidths of IEEE 802.11 WLAN standards in the bands 2.4Ghz(2400-2484Mhz) and 5.4Ghz(5725-5825Mhz). For the proposed antenna, two parameters that are being varied to achieve the best values of Gain and Bandwidth are 'd1' and 'd2'. First of all, 'd1' and 'd2' of the original antenna with T-Shape parasitic strip has been varied by taking best values of W3 and l3 as W3=18mm, and l3=2mm from the simulated return loss by taking various values of W3 and l3. Good Antenna performances of the operating frequencies over the operating band are being obtained. The resultant graphs and tables are illustrated below.

3. Observation And Results:

Observations:

- **Parametric Study Of T-Shaped Parasitic Strip Antenna:**

The table is depicted in Figure 4. 'd1' and 'd2' are being varied here, and all the other parameters are being kept constant. From the table, the following observations are being made:

- When d1=9.2mm, and d2= 5.2mm, considerable return loss (S11)is obtained as -27.00db.
- Considerable characteristics are obtained at d1=11mm, d2=7mm, and d1=9.2mm, and d2=5.2mm. So, to choose a perfect value out of them, we have chosen d1=11mm, and d2=5.2mm.
- Also it is observed that good characteristics are obtained at other values of d1 and d2 viz. d1=9.2mm, d2=5.2mm, d1=9.4mm, d2=5.4mm, d1=10.6mm, d2=6.6mm. So, by taking all these values we simulated it for U-Shape Patch. In all the cases, solution frequency as been made fixed to **2.45Ghz.**

Parametric Study Of U-Shaped Parasitic Strip Antenna:

The table is depicted in Table-2. The optimized values from Table-1 has been taken and four set of values are obtained, which are then further simulated by Changing the T-Shape patch to U-Shaped patch with W4=W5=2mm and l4=l5=7mm. Set of values(optimized) that are being obtained from Table-1 are depicted below[All are in mm]:

- d1=11, and d2=5.2
- d1=9.2, and d2=5.2
- d1=9.4, and d2=5.4
- d1=10.6, and d2=6.6

These values are then taken, and simulated for U-Shaped patch. Both the Tables are illustrated below.

Table 1: Antenna Parameters Of T-Shaped Patch Antenna For Varying 'd1' & 'd2' values

Parametric Study Of Original Antenna:
Here constant Parameters are:

L=40mm, l1=12mm, l2=13mm, W=40mm, W1=3mm, W2=2mm, W3=18mm, l3= 2mm, d1=varied from 9mm to 11mm, and d2=varied from 5mm to 7mm:

d1 mm	d2 mm	F1 GHz	F2 GHz	S11 F1 db	S11F2 db	G1 db	G2 db	BW1 GHz	BW2 Ghz	Peak Gain	Radiation Efficiency
9	5	2.47	5.86	-16.28	-31.85	2.49	4.69	0.43	0.75	1.53	0.90
9.2	5.2	2.84	5.81	-16.96	-27.00	2.41	4.61	0.43	0.67	0.66	1.27
9.4	5.4	2.83	5.78	-17.32	-24.50	2.30	3.36	0.45	0.63	1.06	2.64
9.6	5.6	2.81	5.72	-17.81	-22.36	2.41	2.48	0.45	0.60	0.86	1.08
9.8	5.8	2.80	5.69	-18.26	-20.88	2.36	4.39	0.45	0.57	1.24	1.63
10	6.0	2.78	5.65	-18.92	-19.63	2.34	2.64	0.45	0.52	0.88	1.30
10.2	6.2	2.77	5.62	-19.01	-18.32	2.42	2.87	0.43	0.52	0.88	1.48
10.4	6.4	2.76	5.57	-19.30	-17.80	2.38	2.42	0.46	0.48	0.99	1.46
10.6	6.6	2.75	5.54	-20.25	-16.89	2.42	2.04	0.46	0.43	1.10	1.53
10.8	6.8	2.72	5.50	-20.54	-16.33	2.42	2.46	0.45	0.42	1.74	3.95
11	7.0	2.72	5.47	-21.33	-15.69	2.36	2.64	0.40	0.40	1.80	2.47
11	5.2	2.69	5.69	-26.25	-18.22	2.35	2.20	0.49	0.49	1.10	1.22
9.2	7	2.95	5.56	-13.26	-18.80	2.38	2.15	0.54	0.54	1.53	2.31

Table 2: Parametric Study Of U-Shape Patch Antenna With Optimized Values

U-Shape Patch Simulation Results:

d1 mm	d2mm	F1 GHz	F2 GHz	S11 F1 db	S11 F2 db	G1 db	G2 db	B.W1	B.W2	Peak Gain(db)	Radiation Efficiency
9.2	5.2	2.59	5.54	-16.6	-21.0	2.78	2.70	0.24	0.55	2.17	2.29
9.4	5.4	2.59	5.51	-16.9	-19.1	3.9	4.6	0.34	0.56	6.52	6.94
10.6	6.6	2.57	5.35	-19.7	-15.0	3.80	4.70	0.38	0.42	1.57	1.73
11	5.2	2.45	5.42	-26.6	-15.5	4.2	5.01	0.44	0.60	1.27	1.27

Results:

From Table Number 2, d1=11mm, and d2=5.2mm are being taken as optimum values. So, the ultimate optimized values for U-Shape parasitic strip is obtained. The graphs for return losses are depicted below in figure number 6 and figure 7. The Antenna is designed using HFSS(High Frequency Structure Simulator) Software.

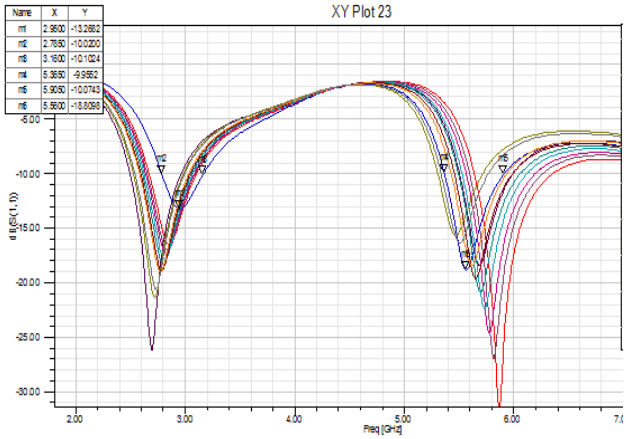

Figure 6: Combined Return Loss Graphs(TShape)

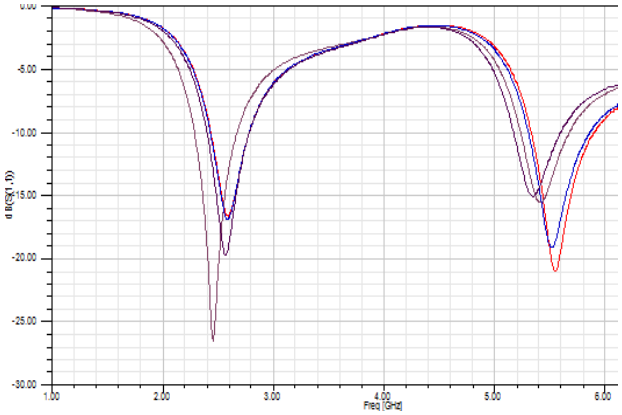

Figure 7: Combined Return Loss Graphs(UShape)

Thus after choosing the optimum values, the resultant antenna is simulated with all the optimum values combined. The return loss of the final proposed antenna is shown in figure 8.

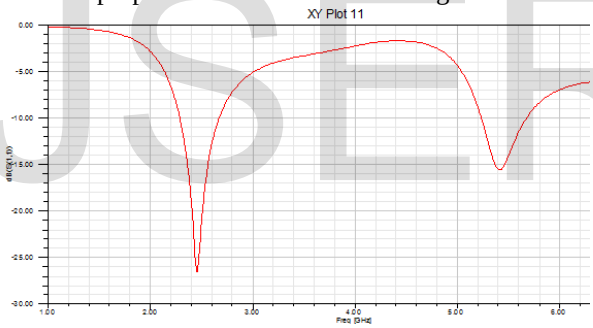

Figure 8: Return Loss Of The Proposed Antenna

From the return loss graph in Figure 8, resonant frequencies and Gains of the proposed antenna are calculated. The final values of U-Shaped Novel Patch Antenna are depicted below:

[F1=2.45Ghz, F2=5.42Ghz, S11(F1)=-26.60db, S11(F2)=-15.56db, Gain(F1)= 4.2db, Gain(F2)= 5.01db, Bandwidth(F1)= 0.44GHz, Bandwidth(F2)= 0.75GHz, Radiation Efficiency= 1.27]

Inference:

Thus, the U-Shape Parasitic strip Antenna has better Gain, Bandwidth and Radiation Efficiency than the T-Shape patch Antenna. The Radiation Pattern of the proposed antenna is shown in figure 9 below.

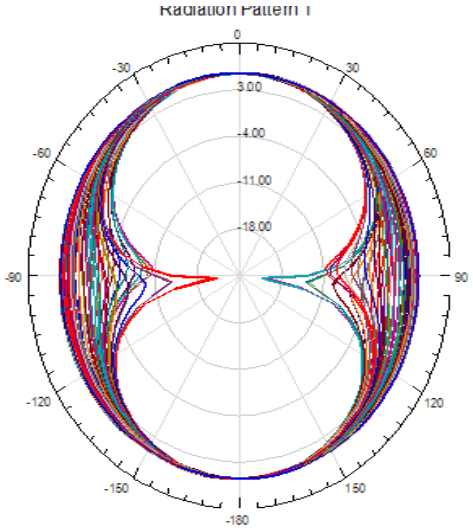

Figure 9: Radiation Pattern Of Proposed Antenna(At 2.45Ghz)

From the radiation pattern, it is clearly observed that there is much more larger cross polarization radiation in the higher band, and thus this Antenna can receive the signals that travels for large distances due to large cross-polarization.

4. Conclusion:

A novel dual band patch antenna with a U-Shape parasitic strip has been presented in this paper. Two discrete operating bands are being provided by this antenna viz. 2.4Ghz and 5.4Ghz covering (2.4-2.484)GHz and (5725-5825)MHz bands. Good Antenna performance in terms of Gain, Bandwidth and Radiation efficiency has been obtained. Numerical study of the antenna is then being carried out in order to analyze the antenna in details.

5. References:

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