ISSN(Online): 2320-9801
ISSN (Print): 2320-9798

International Journal of Innovative Research in Computer and Communication Engineering

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Vol. 4, Issue 1, January 2016

Design of Dual Band E-Shape Patch Antenna Suited for Wireless LAN Applications

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ABSTRACT: A Dual-Band Patch Antenna has been designed here. The E-Shape Patch(Strip) has been given finite conductivity, and thus improved gain and return loss characteristics are obtained. 2.41Ghz(S11<-10db) and 5.39Ghz(S11<-10db) are the two resonating frequencies and a Gain of 3.10db and 4.20db are obtained considerably at both these frequencies. 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, and it is found to be suitable for Wireless LAN Applications.

KEYWORDS: Microstrip Patch Antenna, E-Shape Patch, WLAN(Wireless Local Area Network), Dual-Band Patch Antenna, Microstrip Antenna

I. INTRODUCTION

Wireless Local Area Networks(WLAN) are being analyzed these days to a greater extent. A patch antenna is a low profile antenna(also called as rectangular microstrip patch antenna), that can be scaled on a flat surface, and usually consist of a patch of mental scaled on another large sheet of metal called as the Ground Plane. In this paper, a dual-band patch antenna has been presented, which consists of a E-Shape parasitic strip, and a rectangle shaped ground plane parallel to the 50Ω Microstrip feed line that is electromagnetically coupled to provide necessary excitations. 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 2.41Ghz and 5.31Ghz with S11<-10db. Design details of the proposed antenna along with results and detailed explanations are given and discussed in this paper.

II. ANTENNA DESIGN

In the proposed antenna, the ground plane and E-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 three rectangles forming the E-Shape structures are made to be fixed as W6=W4=W5=5mm. Current paths of two resonant frequencies are being formed, which in turn induces dual resonant modes. By varying the dimensions of d1 and d2, we can obtain improved characteristics of the Antenna at the same frequency range.

"Figure 1" denotes the general depiction of the Antenna with E-Shaped Parasitic Strip, and "Figure 2" denotes the Simulated Antenna(T-Shape), and "Figure 3" denotes the simulated proposed antenna with E-Shape patch. The Antenna is designed using HFSS(High Frequency Structure Simulator) Software.

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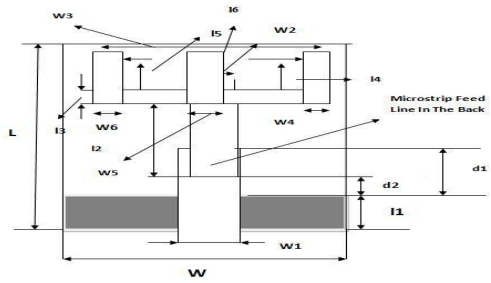

Figure 1: Geometry Of The Proposed Antenna

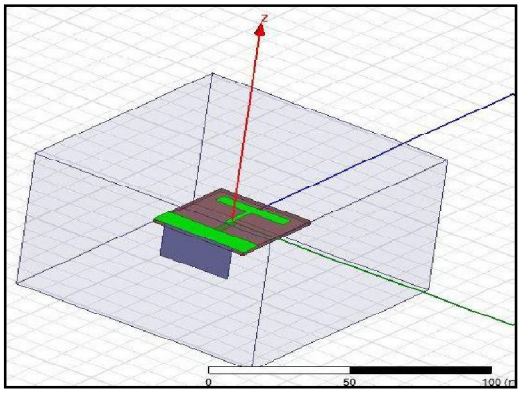

Figure 2: Antenna Simulation(T-Shape Patch)

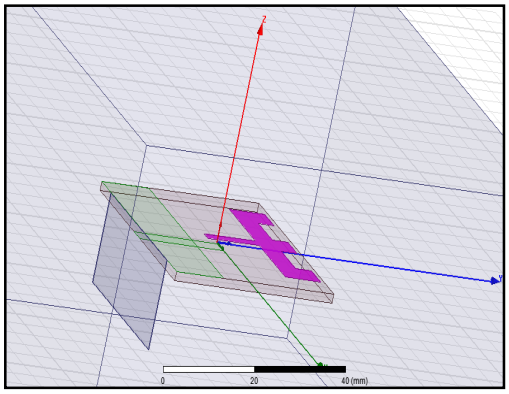

Figure 3: Simulated Antenna(Proposed)

A. *Dimensions Of The Proposed Antenna(Simulated):*

- **Lengths: [**L=40mm,l1=12mm,l2=13mm, l3=5mm, l4=l5=l6=4mm]
- **Widths:** [W=40mm,W1=3mm,W2=2mm,W3=30mm, d1=11mm,d2=5.2mm, W4=W5=W6=4mm]
- **Substrate Dimension:** [40mm x 40mm]
- **Ground Plane Dimension:** [12mm x 40mm]

B. *Notations Used In Antenna(Proposed Antenna):*

- W= Width of the Substrate
- L= Length Of The Substrate
- l1= Length Of The Ground Plane
- W3= Width Of T-Shape Patch
- W4, W5 & W6=Width Of Patch

C. *Operating Range Of The Proposed Antenna:*

- The Antenna can operate in the bands that cover the required bandwidths of IEEE 802.11 WLAN standards in the bands 2.4Ghz and 5.3Ghz(Two resonant frequencies).

III. OBSERVATIONS AND RESULTS

A. *Observations:*

- *Analysis Of T-Shaped Patch Antenna:* Various readings are being obtained by varying values of d1 and d2, and we can see from "Table 1" that sufficient values of gain and bandwidth are being obtained as we vary both the parameters from 9mm to 11mm.. The best values are then being taken, and using these values, the T-shape has been converted to E-Shape patch to yield more and more better results.

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d1 (mm)	d2 (mm)	F1 (GHz)	F2 (GHz)	S11(F1) (db)	S11(F2) (db)	B.W(F1) (GHz)	B.W(F2) (GHz)	G(F1) (db)	G(F2) (db)	Radiation Efficiency
9	5	2.48	5.65	-21.29	-20.67	0.33	0.69	2.53	3.74	1.95
9.4	5.4	2.47	5.57	-21.88	-18.02	0.33	0.60	2.57	3.27	3.1
9.8	5.8	2.43	5.42	-19.23	-17.63	0.44	0.55	2.43	4.01	3.2
10	6	2.76	5.32	-20.34	-18.93	0.45	0.50	2.43	2.52	2.46
10.6	6.6	2.73	5.3	-21.26	-16.43	0.46	0.41	2.56	2.02	3.23
11	5.2	2.68	5.32	-28.23	-17.33	0.46	0.44	2.40	2.18	2.01

Table No. 1: Analysis-(Antenna With T-Shaped Patch Antenna)

- *Data Obtained:*
  - **d1=9.4mm, and d2=5.4mm:** (S11)is equal to -21.88db.
  - **d1=10mm, d2=6mm, and d1=11mm and d2=5.2mm:** S11 for the first case: -20.34 db. S11 for the second case: -28.23db. So, optimum value that is chosen from these observations are: **d1=11mm, and d2=5.2mm**.
  - **Other optimal readings obtained at values:** d1=9.2mm, d2=5.2mm, d1=9.4mm, d2=5.4mm, d1=10.6mm, d2=6.6mm.
  - **Note:** In all the cases, solution frequency as been made fixed to **2.45Ghz.**

- *Analysis Of E-Shaped Patch Antenna:*

d1 (mm)	d2 (mm)	F1 (GHz)	F2 (GHz)	S11(F1) (db)	S11(F2) (db)	B.W(F1) (GHz)	B.W(F2) (GHz)	G(F1) (db)	G(F2) (db)	Radiation Efficiency
9.2	5.2	2.41	5.54	-19.77	-18.83	0.31	0.61	2.5	4.5	4.6
9.4	5.4	2.41	5.53	-19.74	-18.86	0.31	0.60	3.2	4.7	5.5
10.6	6.6	2.36	5.29	-24.67	-13.51	0.32	0.42	3.0	2.7	2.01
11	5.2	2.41	5.39	-45.39	-14.67	0.33	0.43	3.1	4.2	1.79

Table-2: Analysis-(Antenna With E-Shaped Strip Antenna)

- *Data Obtained:*
  - 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 E-Shaped patch with W4=W5=W6=5mm and l4=l5=l6=4mm. From "Table 2", it is observed that when d1=11 and d2=5.2mm, S11(f1) is highest, and Gain in both the resonating frequencies are also considerably large. So, out of these four readings, d1=11mm and d2=5.2mm is the dimension that is chosen by optimization or parametric study.
  - Short-Forms Used:

1. **F1 & F2:** First and Second Resonant Frequency in GHz.
2. **S11(F1) & S11(F2):** Return Loss in decibel(db) at first and second resonant frequency.
3. **G1(F1) & G2(F2):** Gain in db at first and second resonant frequency.
4. **BW(F1) & BW(F2):** Bandwidth in GHz at first and second resonant frequency

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B. *Results:*

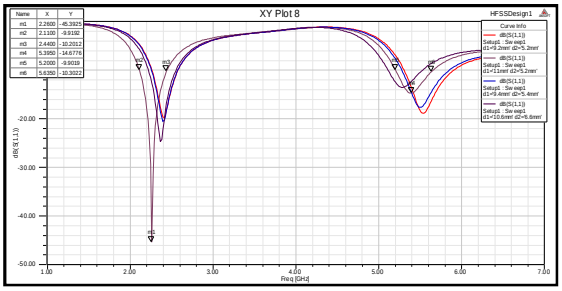

Figure 5:Combined Return Loss Graphs(E-Shape)

- "Fig. 5" denotes the combines return loss by choosing the optimum values of d1 and d2 in E-Shape Parasitic Strip Antenna. 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 "Fig. 6".
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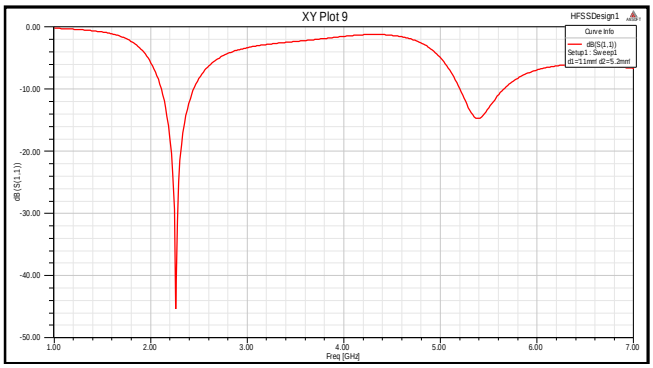

Figure 6: Return Loss Of The Proposed Antenna

- "Figure 6" denotes the return loss of the proposed antenna. It can be seen from the graph that, highest value of S11(in db) that 2.4GHz and 5.4GHz are the two frequencies where dip is present, and both of them are the resonant frequencies. The simulation was done by considering best value, ie. d1=11mm, nd d2=5.2mm.

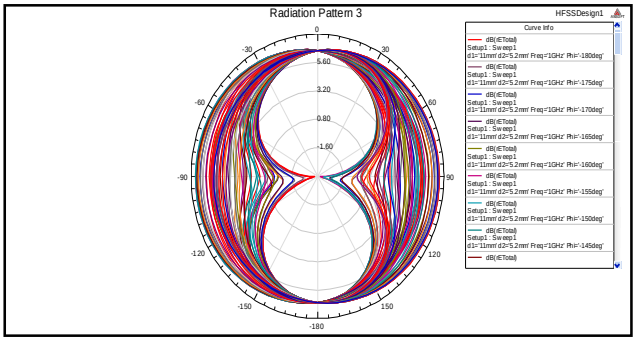

Figure 7: Radiation Pattern Of The Proposed Antenna

- From the return loss graph in "Figure 6", resonant frequencies and Gains of the proposed antenna are calculated. "Figure 7" denotes the radiation pattern of the proposed antenna, and it can be clearly seen that

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lower band achieves less polarization than the higher band, which makes this antenna suitable for wireless communication of longer distances. The radiation pattern is shown for various values of 'phi' in accordance with varying values of d1 and d2.

IV. CONCLUSION

A dual band patch antenna with a E-Shape strip has been presented in this paper. Two discrete operating bands are being provided by this antenna viz. 2.4Ghz and 5.3Ghz Covering the frequency band used for WLan applications. Good Antenna performance in terms of Gain, Bandwidth and Radiation efficiency has been obtained. The complete study of the antenna is presented in this paper, and numerical study of the antenna is then being carried out in order to analyze the antenna in details.

ACKNOWLEDGEMENT

I want to thank Dr. Subhrakanta Behera(Ass. Professor, School Of Electronics Engineering, KIIT University) for all his valuable suggestions and guidance. Also, I would like to thank all the faculty members in Electronics department of KIIT University whose valuable suggestions helped me in designing the Antenna.

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BIOGRAPHY

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