

Compact UWB Antenna with Hiperlan/2 Band-Notched Characteristics for Wireless Applications

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Abstract— In this paper a three iteration smiley face fractal UWB antenna with notch band filter is presented. The designed antenna has very large bandwidth covering frequency band from 2.1 GHz to 15 GHz ($VSWR \leq 2$). The proposed antenna is modified then to reject 5.1 to 6.8 GHz band assigned for IEEE802.11a and HIPERLAN/2 ($VSWR > 2$) with maximum rejection at 5.8 GHz ($VSWR = 6.51$) by embedding an 'U' shaped slot in the central conductor of planar feed line near the radiating patch. The proposed antenna has a compact size of 32 mm × 34 mm, peak antenna gain of 4.42 dBi which remain constant for almost all the frequencies and maximum radiation efficiency of 95.93 %. The fabricated prototype gives good agreement between simulated and tested results.

Keywords— UWB Antenna; Notch Band Antenna; Microstrip Antenna; Planar Antenna.

I. INTRODUCTION

Development of components in ultra wideband (UWB) range has received tremendous momentum, when the Federal Communications Commission (FCC) agreed the rules for the commercial use of an ultra wideband technology in 2002 [1]. Designing an UWB antenna is exigent as it pertains to achieving compact size of antenna, proper impedance matching, omnidirectional radiation pattern and low manufacturing cost for consumer electronics applications. As there are different standards exists for different wireless narrowband like 5.8 GHz is assigned for IEEE 802.11a and HIPERLAN/2, 2.4/5.5 GHz is assigned for WLAN bands and 3.5/5.5 GHz for WiMAX bands, there is an additional requirement for UWB antennas to reject certain frequencies within the ultra-wide band and pass the remaining.

Various techniques has mentioned in literature like etching thin slots of different widths from the radiating patch [2], [3], [4] or ground plane, use of fractal tuning stub [5] or by the means of electromagnetic band gap structures[6]. In this paper a novel design for a compact, planar fed, human face shaped, fractal UWB antenna with circular boundary and slotted rectangular ground is presented. An embedded 'U' shaped slot in feed-line is used to realize notch characteristics covering HIPERLAN/2 and IEEE 802.11a bands. In the following sections, details of the antenna design and experimental results are discussed in detail.

II. ANTENNA DESIGN AND PARAMETRIC STUDY

A. Geometry of Radiating Patch And Fractal Design

The proposed circular boundary, human face shaped, fractal UWB monopole antenna is constructed by using

circular monopole antenna with three iterations. The Circular geometry is used to represent human face and eye. The reason for selecting the circular shape rather than any other is because circle has maximum circumference as compared to any other shape. Also with this shape maximum electrical length can be achieved with less number of iterations. Like in our proposed design, the desired UWB characteristic are achieved by using three numbers of iterations. Because of the fractal geometry, maximum current flows around the circumferences and centre that provides good radiation characteristic with wider bandwidth. An FR-4 substrate with relative permittivity $\epsilon_r = 4.4$ and dielectric loss tangent $\tan \delta = 0.02$ of dimension 34 × 32 × 1.6 mm³ is used to simulate and fabricate the optimized design. A circular patch of radius 8.5 mm and resonant frequency of 4.68 GHz is used to obtain UWB with multiple resonant frequencies and omnidirectional radiation pattern. The resonant frequency can be calculated by using equation 1 as:

$$a = \frac{F}{\sqrt{\left\{1 + \frac{2h}{\pi \epsilon F} \left[\ln \left(\frac{\pi F}{2h} \right) + 1.78 \right] \right\}}} \quad (1)$$

The patch is excited by using planar micro strip line of 12.64 mm longer and 3.08 mm wider as shown in Figure 1. The dimensions for the feed-line are calculated by using transmission line model equation to match 50Ω impedance. A simple rectangular patch of 32 mm x 12 mm is used as ground plane. The simulated result (return loss: S11) for the same is shown in figure 3 with blue color. The simulation result indicates that antenna is capable to transmit frequencies from 2.4 GHz to 15 GHz.

To obtain the first iteration, the two circles of radius 4mm with their centers on the diameter of the main patch (8.5 mm) circle are removed and then an arc of thickness 0.5 mm and perimeter of 8.374 mm is subtracted from main patch as shown in figure 1 (b). The return loss for the same is analyzed (shown in figure 3 with black trace) for further optimization.

To obtaining the second iteration, the procedure of iteration 1 is repeated one more time for smaller circles of radius 2.1 mm, an arc of width 0.33 mm and perimeter 1.875 mm as shown in figure 1 (c). The simulation results of same is obtained (shown in figure 3 with dotted pink trace) and analyzed for further optimization. A 'U' shaped slot is made in feed line to implement notch filter. Design of this slot is discussed in next section.

The final iteration is then obtained by repeating the same procedure four more times with different spacing as shown in figure 1 (d) in order to obtain the desired UWB characteristics. Final dimensions for optimized design are listed in table I.

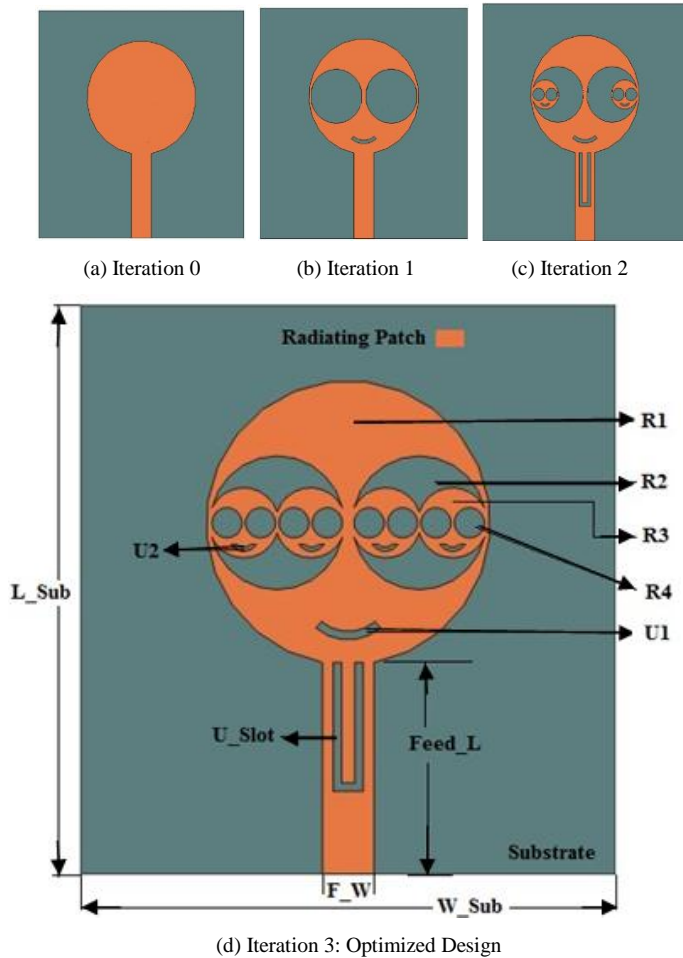


Fig. 1. Iteration wise designing the geometry of proposed antenna

TABLE I: GEOMETRICAL PARAMETERS OF THE PROPOSED ANTENNA

Parameter	Dimensions (mm)
R1	8.50
R2	4.00
R3	2.10
R4	0.90
U1	4.189x0.9011, width=0.5
U2	1.767x0.9011, width=0.33
U_Slot	7.7 x 1.8, width=0.5
Feed_L	12.64
F_W	3.08
W_Sub	32
L_Sub	34

B. Introducing Notch filter and design of Ground plane:

In Figure 5, the graph gives the simulated result for designed fractal shape with rectangular ground. In order to

introduce a band reject filter rejecting HIPERLAN/2 band a ‘U’ shape slot is made in the feed line with vertical length 7.7 mm, horizontal length 1.8 mm and width 0.5 mm as shown in figure2.

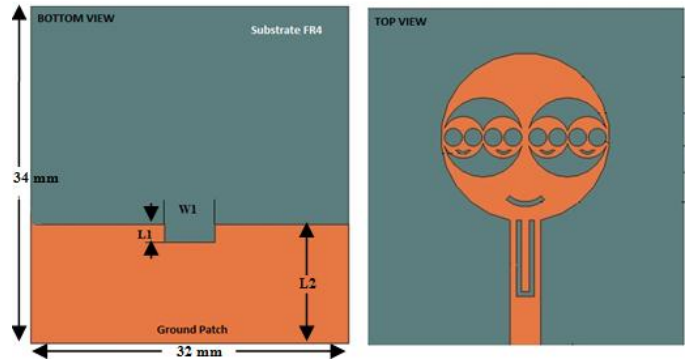


Fig. 2. Designing the ground plane

The dimensions for the same are obtained after having considerable number of simulations. To reduce the bandwidth of notch filter and to obtain the maximum rejection at 5.8 GHz, a small rectangular slit of 1.8 X 5.08 mm² is introduced in ground plane. The dimensions of the slits are obtained after performing good number of simulations. Finally the optimized design prototype contains a smiley shaped radiating patch, 50 Ω planar stripline with ‘U-Slot’, and rectangular ground plane with small rectangular slit at the centre.

III. RESULTS AND DISCUSSIONS

The antenna is designed using ANSOFT HFSS: The figure 4 and 5 gives the return loss for iteration 3 with and without notch filter. It is observed that, the designed antenna without U slot in feed line operates at Ultra wide band from 2.1GHz to 15 GHz. With the insertion of U slot of optimized dimensions in feedline, the antenna rejects the IEEE 802.11a and HIPERLAN/2 bands (5.1 GHz-6.8Hz) with notch band width of 1.7 GHz. Antenna also gives maximum rejection at desired frequency (5.8 GHz) with return loss of -2.68 dB.

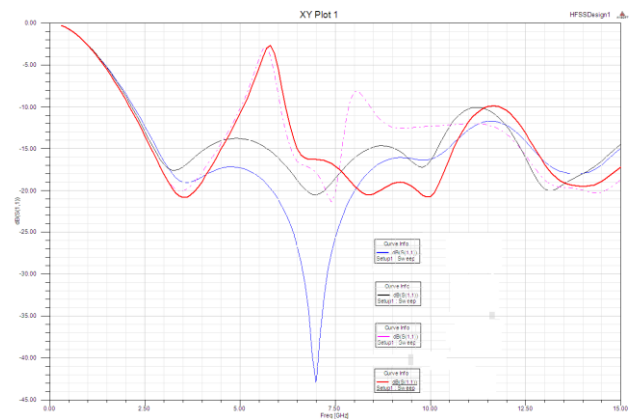


Fig. 3. Iterationwise Return loss (S11)

Figure 6 gives the return loss for band rejected antenna. In pass band, the value of VSWR is close to one (VSWR<2) whereas in stop band, the VSWR is greater than 2 and maximum at 5.8 GHz indicating the maximum rejection for HIPERLAN/2 band.

Figure 7 gives radiation gain for band rejected antenna. The maximum radiation gain is 4.42 dBm and is remain constant for almost all frequencies from pass band. Gain is low for HIPRLAN/2 band.

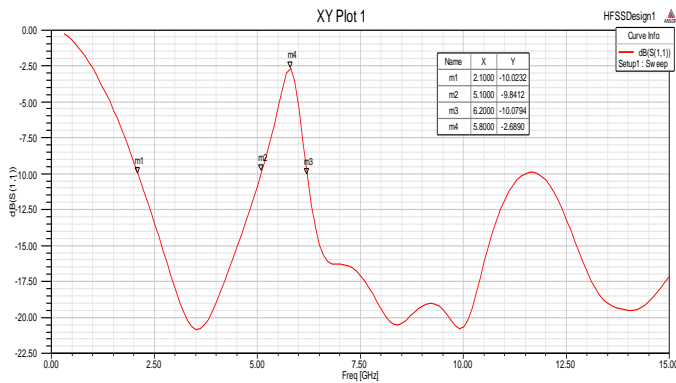


Fig. 4. Return loss for iteration 3 with U slot and ground slit.

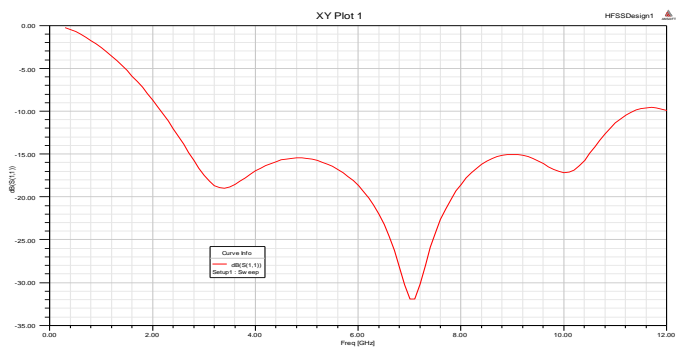


Fig. 5. Return loss for iteration 3 without U slot and ground slit.

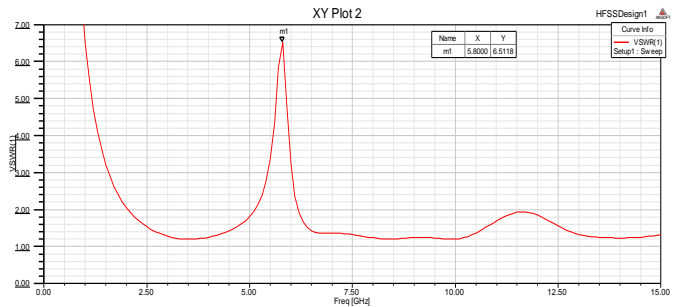


Fig. 6. VSWR for iteration 3 with U slot.

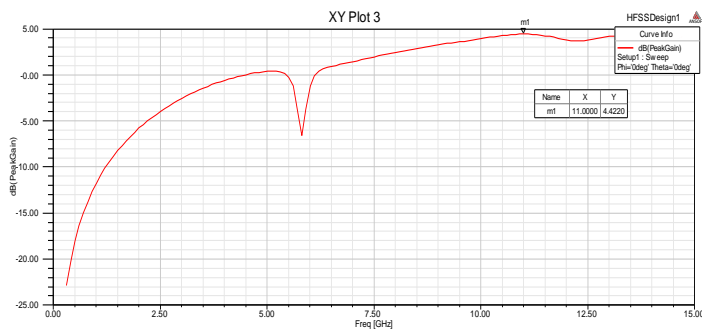


Fig. 7. Radiation Gain of proposed antenna

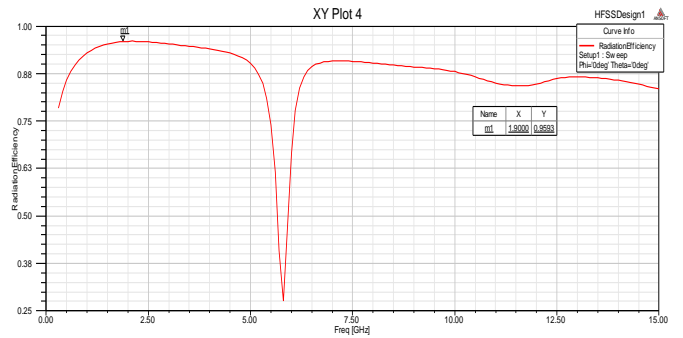


Fig. 8. Radiation Efficiency of proposed antenna

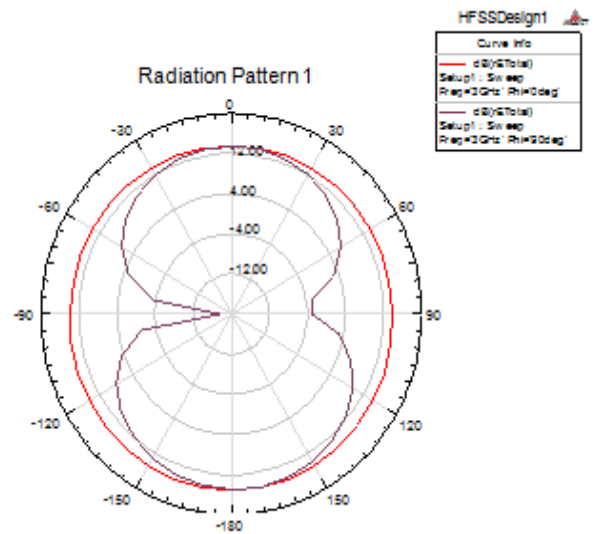


Fig. 9. Measured radiation patterns of the proposed antenna

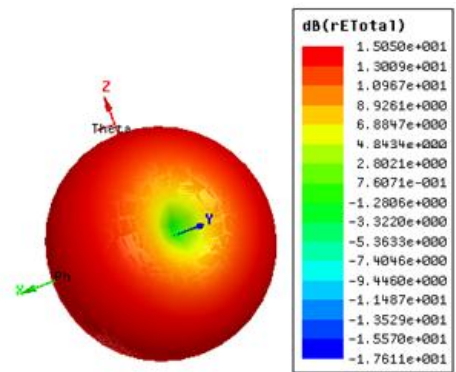


Fig. 10. 3D radiation patterns of the proposed antenna

Figure 8 gives radiation efficiency for band rejected antenna. The maximum radiation efficiency is 95.93 % .

Radiation Pattern: The antenna is designed in xy-plane and it is y-polarized because the monopole is in the y-direction.



Fig. 11. Fabricated antenna

Therefore, the E -plane for the antenna is the yz -plane and the H -plane is the xz-plane.

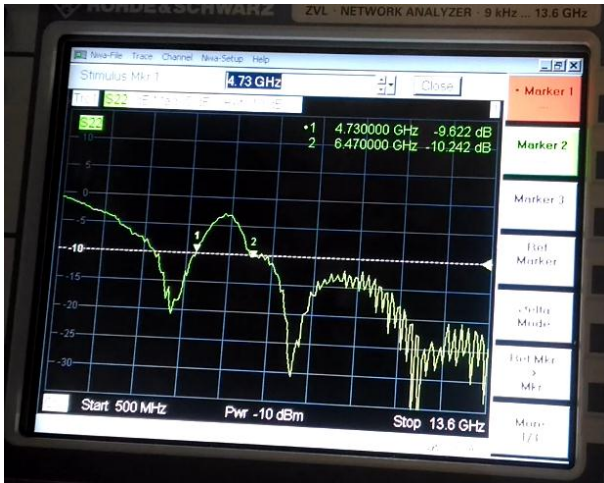


Fig. 12. Measured return loss of fabricated antenna.

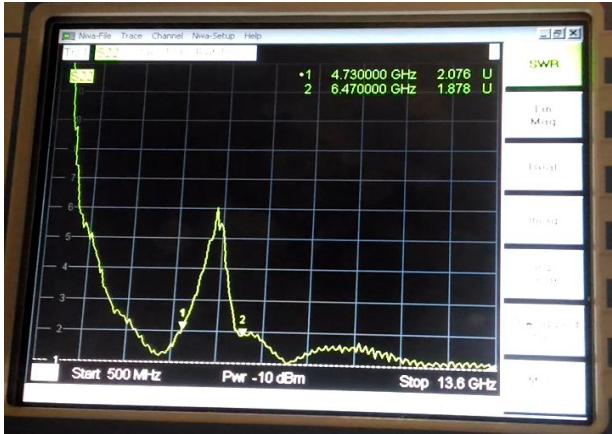


Fig. 13. Measured VSWR of fabricated antenna.

It can be notice from the figure 9 and 10 that nearly dipole-like radiation patterns in the E-plane and omni-directional radiation patterns in the H-plane are obtained for the proposed antenna. Figure 11, 12 and 13 gives the fabricated antenna structure, and its return loss and VSWR tested by using Vector Network Analyzer (9 KHz-13.6GHz). The results obtained for fabricated prototype gives good agreement with simulated results.

CONCLUSIONS

In this paper a three iteration smiley face fractal UWB antenna with notch band filter is presented. The designed antenna has very large bandwidth covering frequency band from 2.1 GHz to 15 GHz ($VSWR \leq 2$). The proposed antenna is modified then to reject 5.1 to 6.8 GHz band assigned for IEEE802.11a and HIPERLAN/2 ($VSWR > 2$) with maximum rejection at 5.8 GHz ($VSWR=6.51$) by embedding an ‘U’ shaped slot in the central conductor of planar feed line near the radiating patch. The proposed antenna has a compact size of 32 mm × 34 mm, peak antenna gain of 4.42 dBi which remain constant for almost all the frequencies and maximum radiation efficiency of 95.93 %. The fabricated prototype gives good agreement between simulated and tested results.

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