

Chapter 17

Optimization of Band Notch Characteristic in Ultra-Wideband Microstrip Patch Antenna for Wireless Power Transfer



Ashish Mathur, Geetika Mathur, and Abhijit kulshrestha

1 Introduction

Federal communications commission (FCC) allocated a block of radio spectrum from 3.1 to 10.6 GHz for UWB operations [1]. UWB systems can support more than 500 Mbps data transmission within 10 m [1]. Compact size, low-cost printed antennas with Wideband and Ultra-wideband characteristic are desired in modern communications. The Ultra-wideband antennas can be classified as directional and omni-directional antennas [2]. A directional antenna has high gain and is relatively large in size. It has narrow field of view. Whereas the omni-directional antenna has low gain and relatively small in size. It has wide field of view as it radiates in all the directions [2]. The UWB antennas have broad band. There are many challenges in UWB antenna design. One of the challenges is to achieve wide impedance bandwidth. UWB antennas are typically required to attain a bandwidth, which reaches greater than 100% of the centre frequency to ensure a sufficient impedance match is attained throughout the band such that a power loss less than 10% due to reflections occurs at the antenna terminals. The bandwidth of the microstrip antenna can be enhanced by modifying the ground plane [3]. Many designers have tried various ways to improve the structure of the traditional circular antennas, and many valuable results have been obtained [4–8].

A. Mathur (✉) · A. kulshrestha
JIET Group of Institution-Jodhpur, Jodhpur, Rajasthan, India
e-mail: ashish.mathur@jietjodhpur.ac.in

A. kulshrestha
e-mail: abhijit.kulshrestha@jietjodhpur.ac.in

G. Mathur
Jagannath University Jaipur, Jaipur, Rajasthan, India
e-mail: geetika.mathur@jietjodhpur.ac.in

2 Antenna Configuration and Design

For the calculation of length and width of the patch antenna, we used basic formulas for length and width of patch. The ground plane is modified to enhance the bandwidth of the antenna. The proposed antenna designed on a FR4 substrate with dielectric constant $\epsilon_r = 4.4$ and height of the substrate is $h = 1.6$ mm. The substrate has length $L = 50$ mm and width $W = 50$ mm. The substrate is mounted on ground of 18 mm length and 50 mm width (Figs. 1 and 2).

The proposed design is capable of passing four bands in the range of 2.1–3.25 GHz in the range of ISM (2.4–2.4835 GHz), Bluetooth (2.4–2.484 GHz) and rejection of Wi max IEEE 802.16 (3.3–3.7 GHz) band at absolute bandwidth in GHz below return loss of -10 dB is 2.1 to 3.25 GHz = 1.25 GHz, Second 5.2 to 6.2 GHz = 1.0 GHz, third 7.8 GHz to 9.0 GHz and fourth 9.10 to 11.1 GHz. This antenna is resonant at four centre frequencies. First is 2.5 GHz with absolute bandwidth 1.0 GHz, second is 5.5 GHz with absolute bandwidth 2.0 GHz, third is 8.5 GHz and fourth is 10.5 GHz for UWB applications.

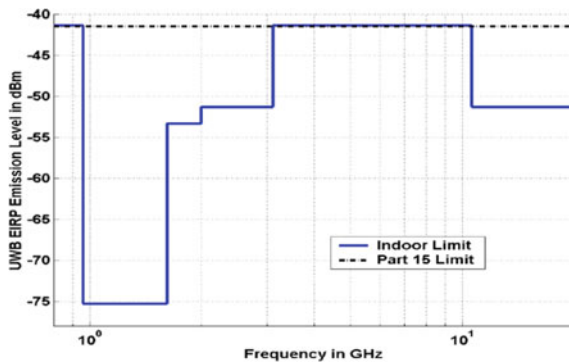


Fig. 1 UWB spectral mask per FCC (Modified) part 15 rules [1]

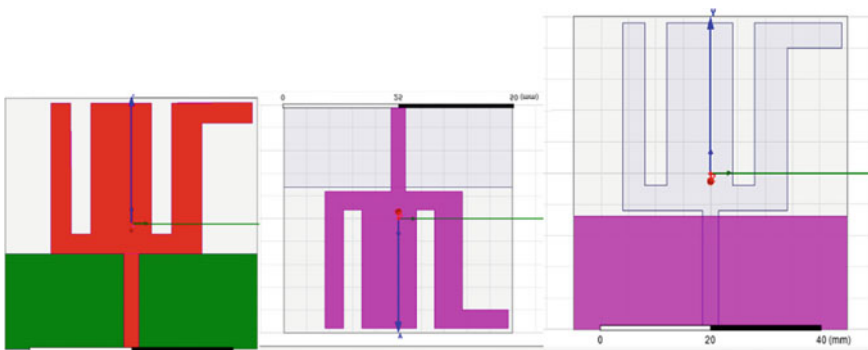


Fig. 2 Geometry of rectangular patch top view & bottom view

3 Simulation Results

Figures 3 and 4 show parametric study of S11 parameter for multiband patch antenna with optimized ground length $L_g = 18$ mm. This antenna is suitable for operating frequency of 2.1–3.25 GHz, 5.2–6.2 GHz, 7.8–9.0 GHz and 9.10–11.1 GHz in UWB. It is shown that return loss of the antennas is better than -10 dB. The VSWR obtained is less than 1.5 and the patch antenna is found to have the compact size. The return loss value of first, second, third and fourth band is -16 dB, -45 dB, -24 dB and -20.1 dB, respectively.

Figure 5 shows the relationship between VSWR with frequency for the proposed design. In this, the value of VSWR is ≤ 2 for four different centre frequencies. First is 2.5 GHz with absolute bandwidth 1.0 GHz and second is 5.5 GHz with absolute bandwidth 1.0 GHz and third is 8.5 GHz with absolute bandwidth 1.2 GHz and fourth is 10.5 GHz with absolute bandwidth 2.1 GHz for UWB applications.

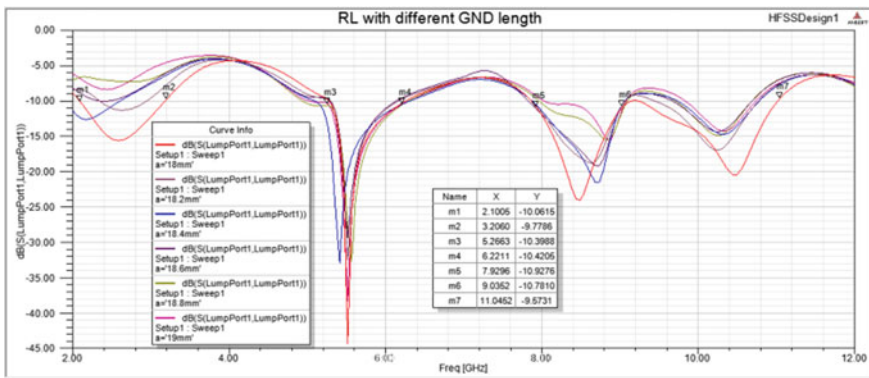


Fig. 3 S₁₁ of Patch antenna with different ground plane effects L_g

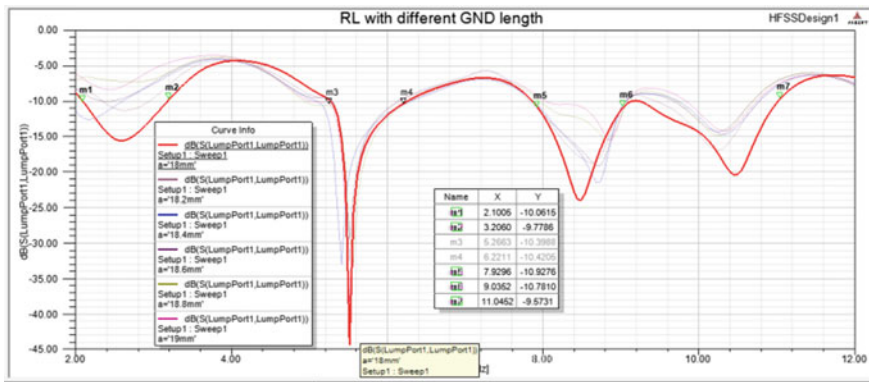


Fig. 4 S₁₁ of patch antenna with L_g = 18 mm

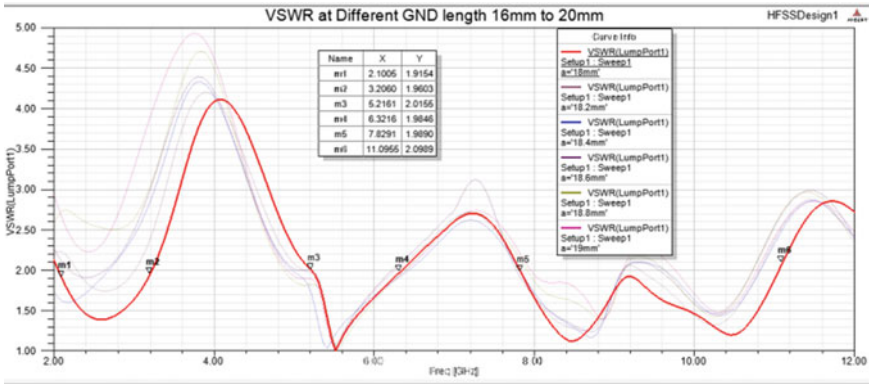


Fig. 5 VSWR of multiband notch patch antenna

The Plot curve of Directivity, Gain in 3D Polar are shown in Figs. 6 and 7, Radiation efficiency and radiation pattern are shown in Figs. 8 and 9, the current distribution of the proposed design is shown in Fig. 10. The simulated values of directivity are 3.65 dB with 2.64 dB antenna gain and 82% radiation efficiency is calculated for the proposed geometry. The uniformly current distribution and bidirectional radiation pattern are obtained for proposed geometry at 7 GHz.

Ground—Plane/Substrate—Related effect: The three important points can be observed after the parametric analysis of ground plane with FR4 substrate. First, it is seen that the impedance matching is very sensitive to the feed gap, especially

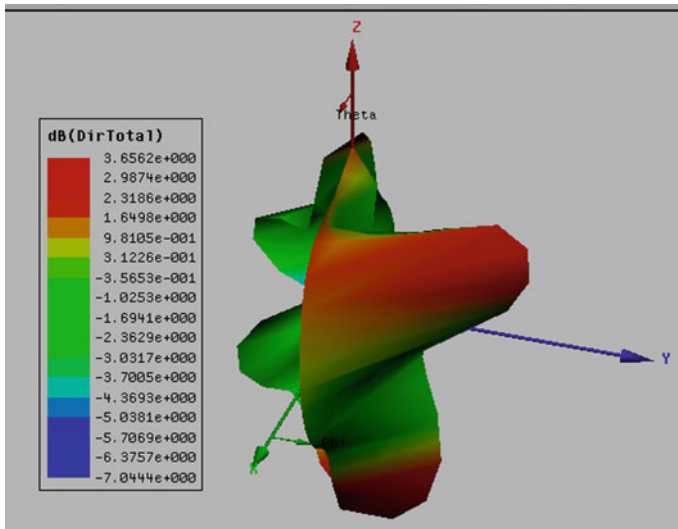


Fig. 6 Directivity of patch antenna at 7 GHz

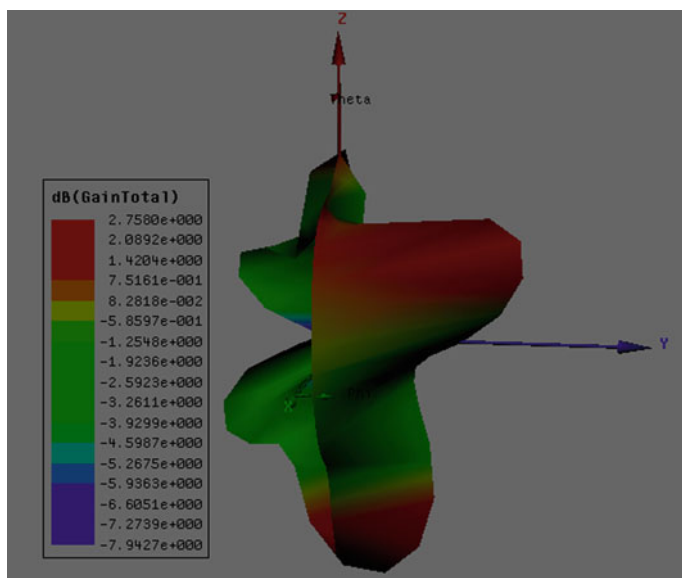


Fig. 7 3D Polar gain of patch antenna at 7 GHz

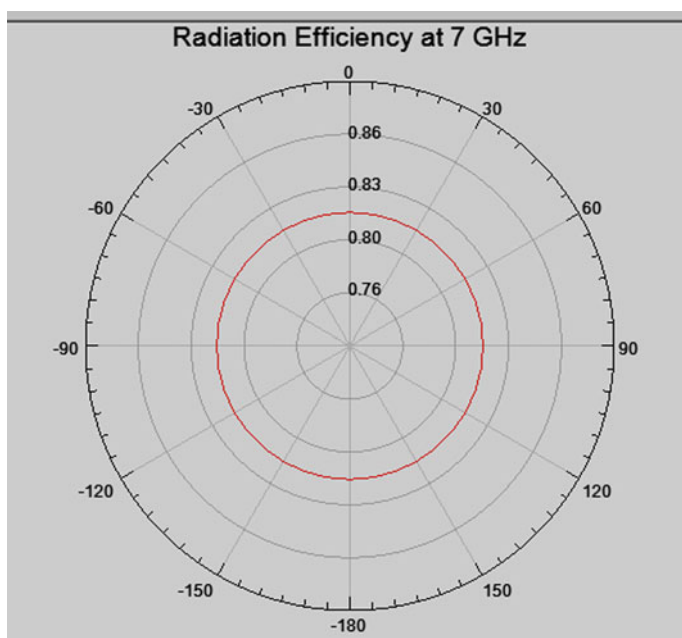


Fig. 8 Radiation efficiency at 7 GHz

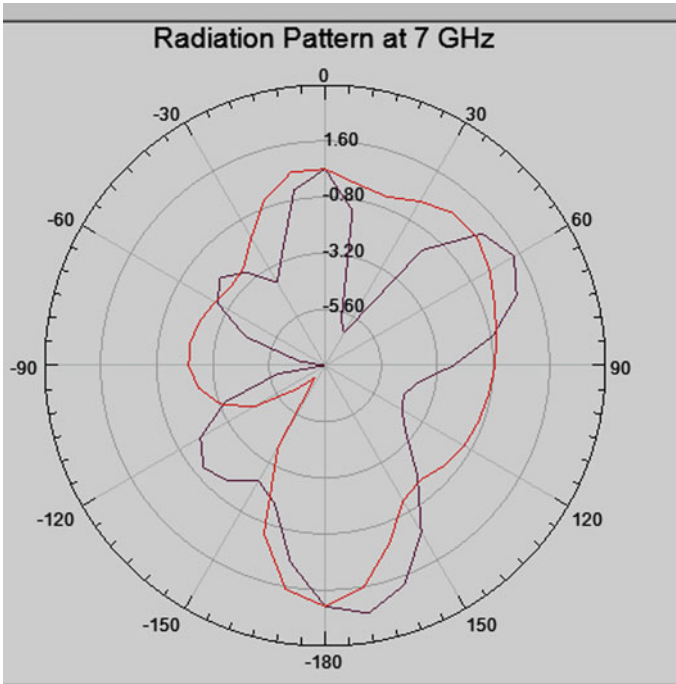


Fig. 9 Radiation patten at 7 GHz

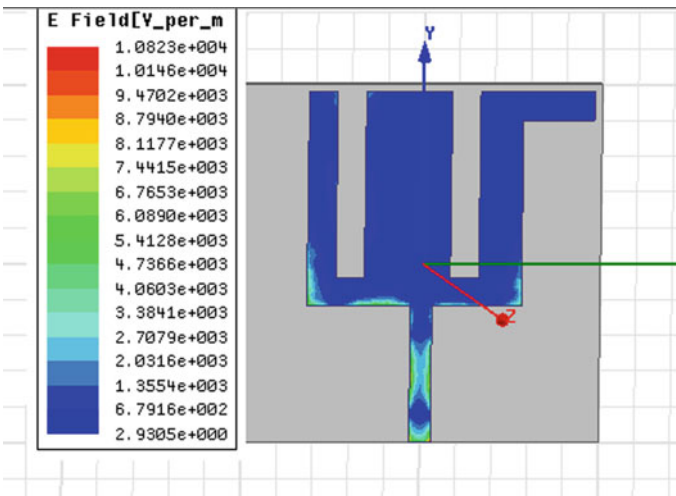


Fig. 10 Measurement of E field distribution at 7 GHz

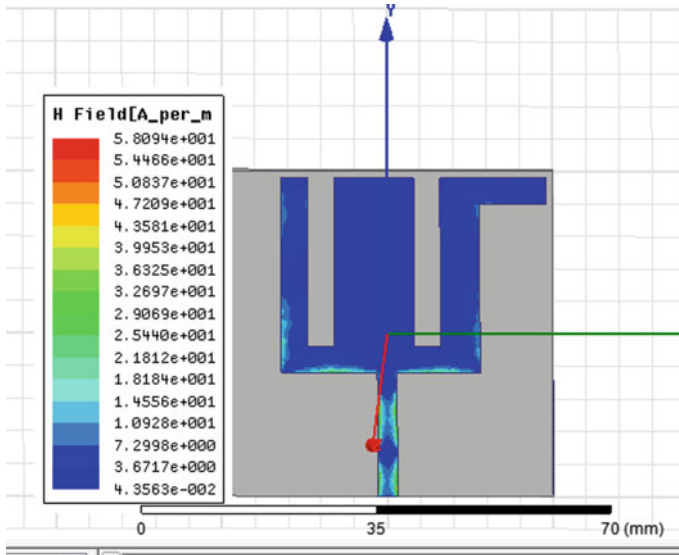


Fig. 11 Measurement of H field distribution at 7 GHz

at higher frequencies. Second, the length of the ground plane affects the impedance matching more significantly at higher frequencies than at lower frequencies [9]. This finding is consistent with the current distributions where more current is concentrated on the ground plane at the higher frequencies than at lower frequencies [10]. Last, the impedance response is also affected by the dielectric constant [11]. In this study, a change in the dielectric constant leads to a shift in the characteristic impedance of the feeding strip from 50 (Fig. 11).

4 Fabrication, Measurement Setup and Testing

The antenna structure is fabricated on FR 4 substrate using Photolithography technique. The proposed design is tested on vector network analyzer. The top view and measurement setup of fabricated antenna are shown in Figs. 12 and 13 (Table 1).

The measured result of S_{11} for the proposed design is calculated by vector network analyzer and on the basis of measured results, we conclude that this antenna is suitable for frequency band of 7.4–10.2 GHz with resonant frequency at 8.25 GHz with good return loss and VSWR values (Figs. 14 and 15).

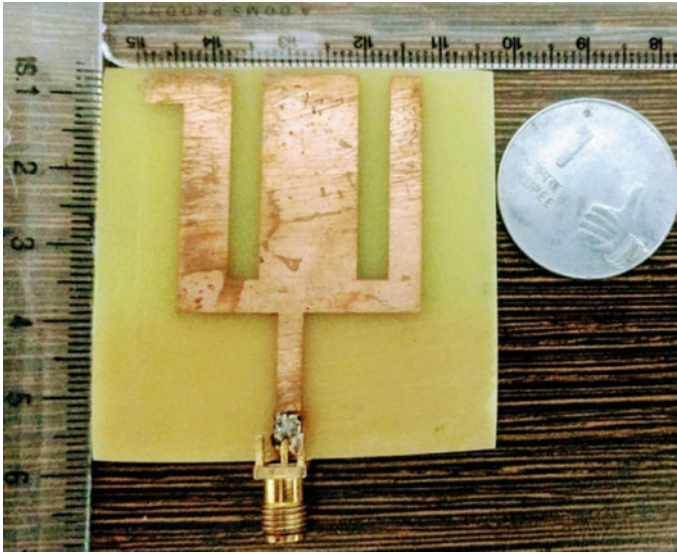


Fig. 12 Fabricated design of proposed antenna

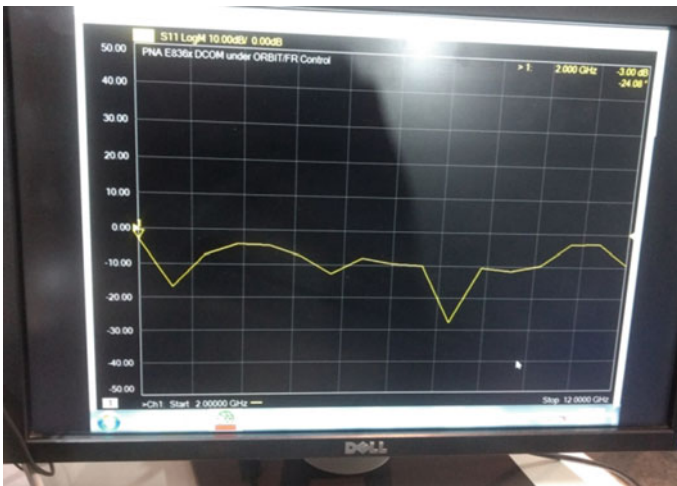


Fig. 13 Measurement setup of S_{11} at 7 GHz

Table 1 Antenna designing parameters

W sub	L sub	Wg	Lg	Ws	Ls	Wp	Lp
50	50	50	18	12	4	30	30



Fig. 14 Measurement setup of VSWR at 7 GHz



Fig. 15 Measurement setup of Input Impedance at 7 GHz

5 Conclusion

In this paper, multiband patch antenna with band Notch Characteristic in UWB is simulated using HFSS-13. The proposed antenna has advantages of small size, easy fabrication and simple construction. The simulated results of the proposed antenna show that return loss is less than -10 dB and VSWR is less than 1.5. The measured results of this antenna show that the antennas can be good candidates for the four operating frequency of 2.3–3.2 GHz, 5.4–6.2 GHz, 7.4–9.0 GHz and 9.1–10.2 GHz with four resonant frequencies and good return loss values. The gain of antenna is 2.64 dB and radiation efficiency 82% calculated. Microstrip line feeding is used for transmission of EM wave.

Acknowledgements The authors thank Prof. (Dr.) J. P. Agarwal Department of Electronics & Communication Engineering GIT Jaipur, India and Prof. R.K. Malviya Sectary ATMS for providing antenna design, fabrication and characterization facilities.

References

1. Ashtankar PS, Deth CG (2012) Design and modification of circular monopole UWB antenna for WPAN application. *Comput Eng Intell Syst* ISSN 2222-1719 (Paper) ISSN 2222-2863 (Online) 3(5)
2. Barba Qirino S (2010) UWB circular slot antenna provided with an inverted-l notch filter for the 5Ghz WLAN band. *Progr Electromag Res PIER* 104, 1–13
3. Chang CC, Watanable F, Inamura H (2006) Potential of UWB technology for the next generation wireless communications. In: *IEEE ninth international symposium on spread spectrum techniques and applications*, pp 422–429
4. Behdad N, Sarabandi K (2005) A compact antenna for Ultrawide- Band applications. *IEEE Trans Antennas Propag* 53(7)
5. Balanis C (1997) *Antenna theory: analysis and design*. John Wiley & Sons Inc, New York
6. Hassanien MA, Hamad EKI (2010) Compact rectangular u-shaped slot microstrip patch antenna for UWB applications. In: *IEEE APS, middle east conference on antennas and propagation (MECAP)*, Cairo, Egypt
7. Bhomia Y, Kajla A, Yadav D (2010) V-slotted triangular microstrip patch antenna. *Int J Electron Eng* 2(1): 21–23
8. Kaur N, Sharma N, Singh N (2017) A study of different feeding mechanisms in microstrip patch antenna. *Int J Microwave Appl* 6(1)
9. Chen ZN, See SP, Qing X (2007) Small printed ultrawidwband antenna with reduced ground plane effect. *IEEE Trans Antennas Propag* 55(2)
10. Xi D, Wen LH, Yin YZ, Zang Z, Mo YN (2010) A compact dual inverted c-shaped slots antenna for WLAN applications. *Progr Electromag Res Lett* 17:115–123
11. Prombutr N, Kirawanich P, Akkaraekthal P (2009) Bandwidth enhancement of UWB micro strip antenna with a modified ground plane. *Int J Microwave Sci Technol*