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Antenna Design with Band Notched Characteristic for UWB Applications

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Abstract - In this paper, a small, low cost and light weight monopole antenna is presented with notched characteristic for Ultra Wideband application. The patch of the antenna consists of sides that are cut a half circle and a rectangle. A narrow rectangular slot has been made to notch the undesired frequency band. The ground plane of the proposed antenna has a rectangular cut which is useful for Impendence matching. The antenna is fed with 50 Ω micro-strip feedline. It has been printed on FR4 substrate which has the relative permittivity of ε_r =4.4 and the thickness of 1mm. The total size of the antenna is (26 ×20×1) mm^3. The proposed antenna is working at a larger frequency band from 2.9 GHz to 10.8 GHz and has notch band characteristic at 5 GHz to 5.9 GHz. C band notch can be achieved with a band width from 4GHz to 8GHz by increasing the slot size. Some of the simulation results and the characteristics of the proposed antenna are explained in this paper.

Keywords - *Monopole antenna, ultra wideband, notch band, rectangle slotted*

1. Introduction

The Ultra wide band technology got more attention from the time when the Federal Communication Commission (FCC) approved that the band Width 3.1GHz - 10.6GHz said to be Ultra Wideband UWB [1]. In the recent years, a significant development was achieved in Ultra Wideband technology and it has been widely used in some radars, wireless communication systems, medical and military applications. The main part of the Ultra wideband technology is the antenna; the printed monopole antenna is a better choice for Ultra wideband applications due to its simple structure, wide frequency range, omni-directional properties and low cost.

There are many different shapes and structures of monopole antennas and ultra-wide band was achieved [2-5], however the main problem in UWB antennas is that there are some standard narrow bands allocated in FCC frequency range such as Wireless Local Area Network (WLAN) which has the band Width of 5.1 GHz-5.8 GHz according to IEEE802.11a or C Band which has band width of 4GHz to 8GHz that may cause potential interference. For avoiding interference, filters can be used with Ultra Wideband antenna but it means more complexity and extra cost [6] so another option to avoid or minimize the interference is using Rejection techniques. There are commonly two main techniques used in antenna design to notch band of frequencies [7]. The first technique is very simple. In this technique, undesired band of frequencies can be notched or filtered by cutting different shapes of slots in radiator or ground plan or both [8-9] whereas in the second technique, notch band frequencies can be obtained by using different shapes of parasitic elements which are electromagnetically coupled with radiating patch and placed near the ground plane [10-11].

In this paper, we have discussed compact size, low profile, simple structure and omni-directional properties of the Ultra-Wide band antennas that have a band width from 2.9 GHz to 10.8 GHz which covers FCC's Ultra-wide band frequency range. This antenna has avoided the frequency range from 5 GHz to 5.9 GHz which is WLAN frequency range according to IEEE802.11a by simple narrow rectangle slot. or C band 4GHz to 8 GHz can be notched by making

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the slot wider. The Ansoft's (HFSS) software was used for designing the structure and analyzing the properties of the proposed antenna [12]. This paper was arranged as follows:

In Section II, the geometry of proposed antenna was explained; in Section III, C band notched antenna was explained; in Section IV, various results were shown and discussed and in Section V, we sum up with a brief conclusion.

2. Antenna Design

Figure 1 shows the design of the proposed antenna. The antenna is fabricated on FR4 substrate, the relative permittivity of FR4 substrate is ε_r =4.4 with loss tangent of δ = 0.02. The overall size of the proposed antenna is 20 × 26 × 1 mm^3, which shows the width W_s of antenna is 20mm, the length L_s of antenna is 26 mm and the thickness h of substrate is 1 mm. The radiating patch which is one of the important parts of the antenna, consists of sides cut a half circle with radius R and a rectangle with Width W_2 × Length L_2. The ground plane has the length L_g and width W_s. Rectangular cut was made for good impendence matching and for getting wide range of frequency band; that is why the rectangle cut in ground plane produces capacitive load which minimizes or cancels out the inductive nature of radiating patch to produce almost resistive input impendence [13]. The radiating patch is fed with 50Ω micro-strip feed line with width W_f.

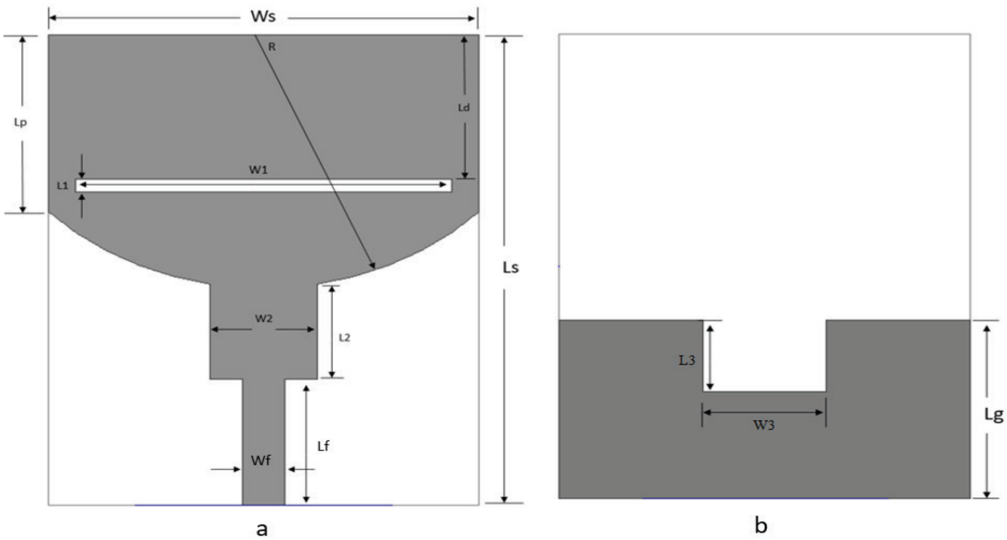


Figure 1. (a) Shows the front view of proposed antenna, (b) Shows the back view of proposed antenna

All the parameters which are shown in Figure 1 are listed in Table 1 and each of the parameters is measured in millimeters (mm).

Table 1. Parameters of Proposed Antenna

Parameters	Values (mm)	Parameters	Values (mm)
W_s	20	W2	5
L_s	26	L2	5
h	1	W_f	2
R	14	L_f	7
L_p	10	L_g	10
L_d	8.6	W_3	6
W_1	17.5	L_3	4
L_1	0.4		

Note: In order to notch the C Band, just increase the size of slot, change the value of L_1 from 0.4mm to 4.5mm and W_1 from 17.5mm to 19mm and change the position of slot L_d from 8.6mm to 3.4mm.

In Figure 2, all the phases were shown to get the proposed antenna. Simple antenna was shown in first phase (I) without any changes in its patch and ground plan. In the second phase (II), a rectangular cut was made in ground plane and no changes were made in radiating patch whereas in the third phase (III) we only added a rectangle shape to the radiating patch and Ultra wideband has been achieved in this phase. In the fourth phase (IV), a narrow rectangle slot was cut in radiating patch which helps us to notch undesired frequency band.

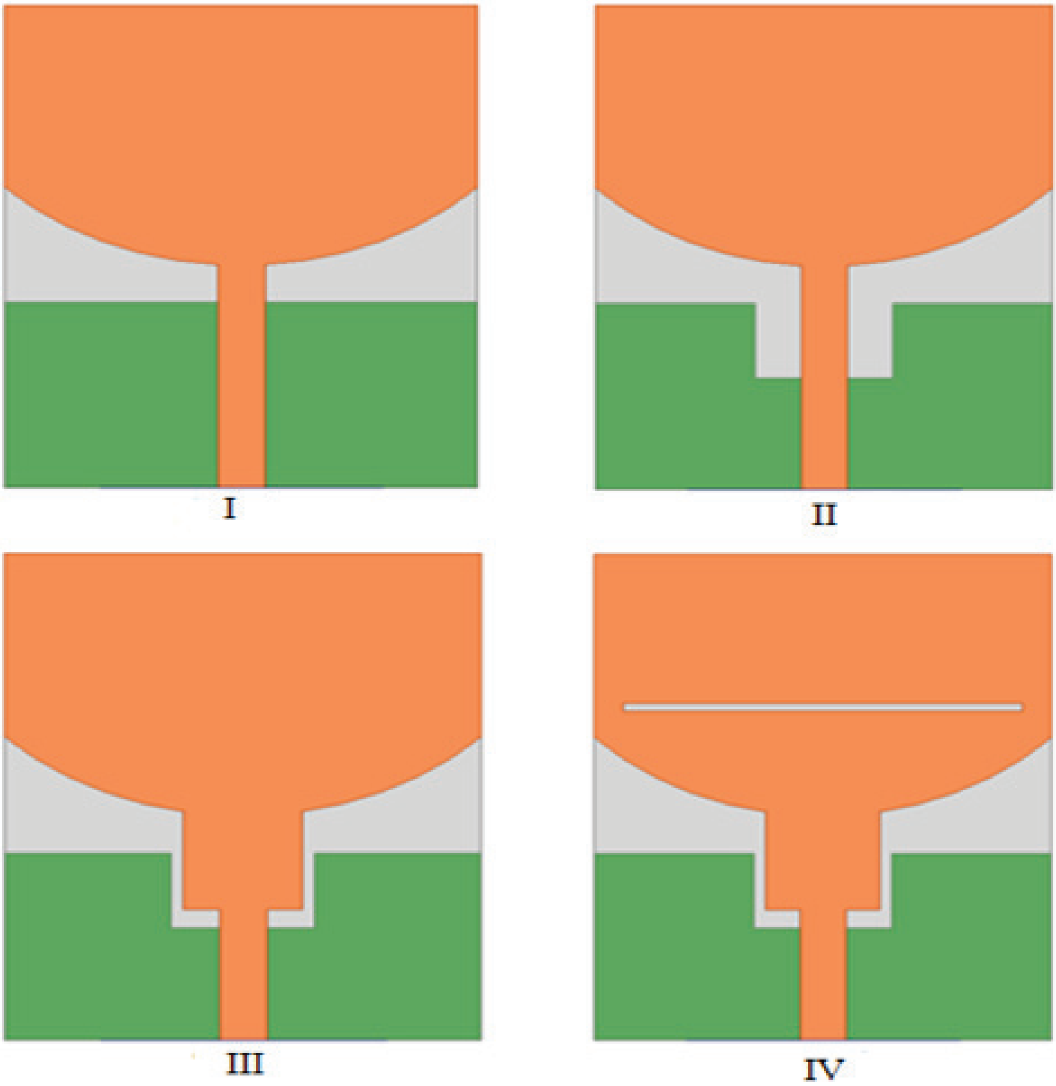


Figure 2. (I) Sample antenna, (II) Rectangle Cut in ground plan,(III) adding Rectangle to radiating Patch, (IV) Slot in Patch

The return losses or the S11 of all the phases (I to IV) were shown in Figure 3. The figure shows the variation that has occurred in each phase, and in phase (III) we have achived the Ultra wideband and in phase (IV) an undesired frequency band was notched.

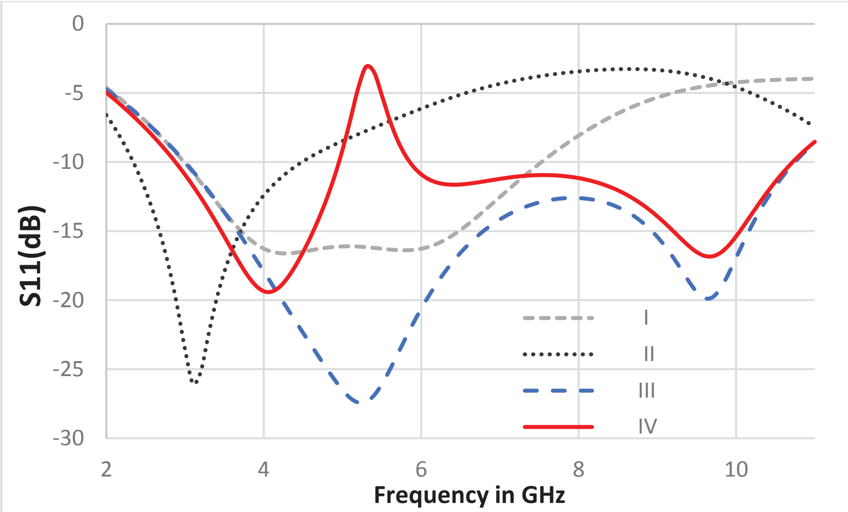


Figure 3. The variation that has occurred in S11 due to the changes made in the design antenna from (I),(II),(III) and (IV)

In Table 2, we compared our design with some other designs which are in References. We have compared the designs in terms of dimensions, gain, notched band, and bandwidth.

Table 2. Comparison of some Reference designs with proposed antenna in terms of Dimensions, Gain, Frequency Range and Notched Band

Reference No	dimensions (mm^3)	Frequency Range (GHz)	Gain	No0tched band (GHz)
[8]	26×35×1.6	2.8 ~ 11.4	6.7 dB	5.1 - 5.825
[14]	30×40×1.6	2.3 - 11.4	5.5 dB	4.9 – 6
[15]	26×32×1.6	2.8 – 11	2.7 dB	3.3 - 3.6
[16]	35×35×1.6	2.21 – 12.83	6.7dB	3.3 - 3.8, 5.15 - 5.8 & 7.9 - 8.4
[17]	48×48×0.8	2.5 – 12	6.7dB	5.1-6
[18]	50×45×0.787	2.7 - 10.9	4dB	5.1-5.9
[19]	32×38×1.6	2.8 - 14.9	6.5 dB	3.1-4.8 & 9.6-11.2
The proposed antenna	20×26×1	2.9-10.8	4.7 dB	5 - 5.9

3. C Band Notched Antenna

According to IEEE, C band has a bandwidth ranging from 4GHz to 8GHz, which is also allocated in FCC's Ultra wideband range and may cause potential interference. Therefore, rejection techniques that we have discussed can be used for avoiding the interference. In this paper, we have designed a C band notched antenna by making some changes in the slot of our proposed antenna. We have changed the width W_1 of the slot which was 17.5mm to 19mm, the length

L_1 of the slot which was 0.4mm to 4.5mm and we have also changed the position of the slot L_d from 8.6mm to 3.4mm. Figure 4 shows the design of C band notched Antenna.

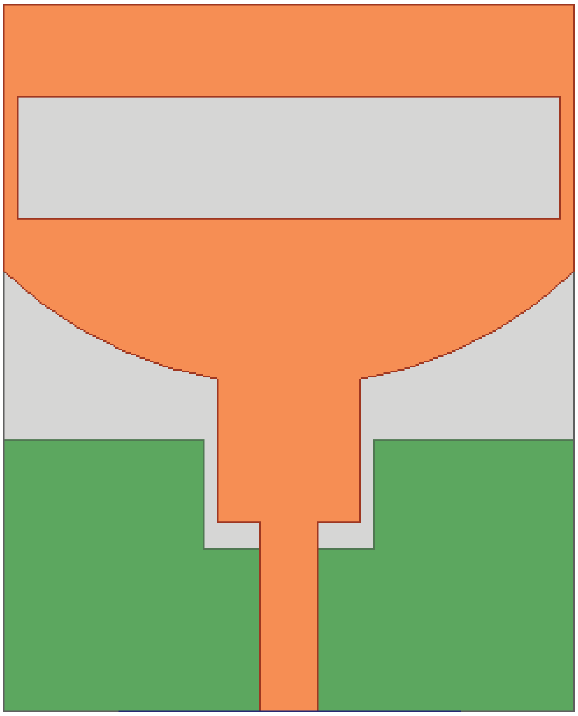


Figure 4. C Band Notched Antenna Design

The return loss or the S11 of the antenna is shown in Figure 5. The figure shows that the antenna is working from 2.9GHz to 10.7GHz with the notch band at 4GHz to 8GHz.

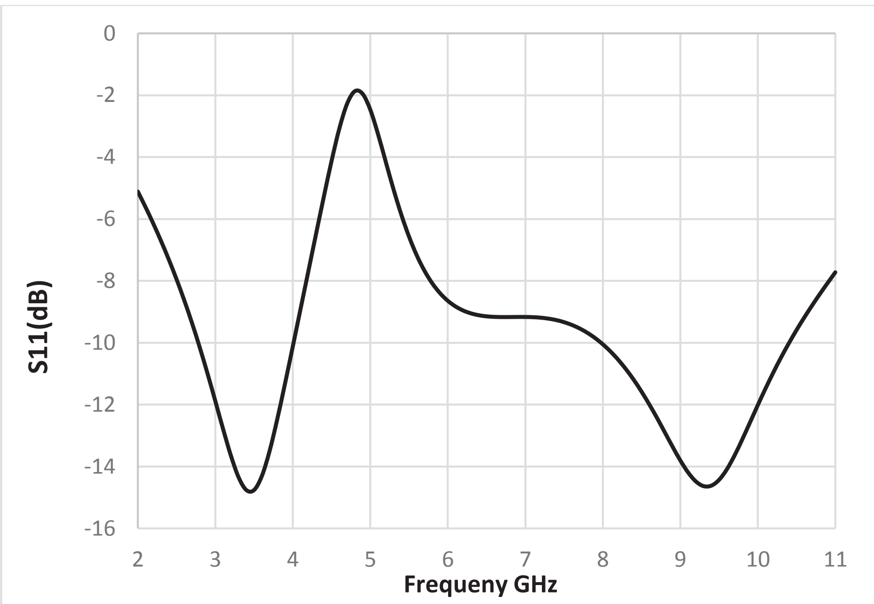


Figure 5. The Return loss S11 of C Band Notched antenna

4. Results and Discussions

The simulated results have been measured and analyzed in the Ansoft's High Frequency Structure Simulator (HFSS) software [12]. The proposed antenna has a bandwidth of 7.9GHz and it is working in the frequency range of 2.9GHz to 10.8GHz that covers the frequency range of Ultra-Wide band. The proposed antenna is notching the WLAN Band.

S11 or Return loss is one of the important parameters of the antenna, which is also called the refection coefficient. It shows how much power is reflected from the antenna. The S11 of proposed antenna is shown in Figure 6 which shows that the antenna is working from 2.9 GHz to 10.8 GHz with the notched band at 5 GHz to 5.9 GHz. Figure 7, shows that by changing the size of the slot, the performance of the notched band also changes. As we can see in Figure 7 (a), by keeping the Width of the slot W_1=17.5 and changing the Length L_1 of the slot, the performance of a notched band does not vary that much whereas in Figure 7 (b), some variation is observed in the performance of the notched band by keeping the Length of the slot L_1=0.4 and by changing the Width W_1 of the slot and at W_1 =17.5mm notch band can be observed to rise from 5GHz to 5.9GHz.

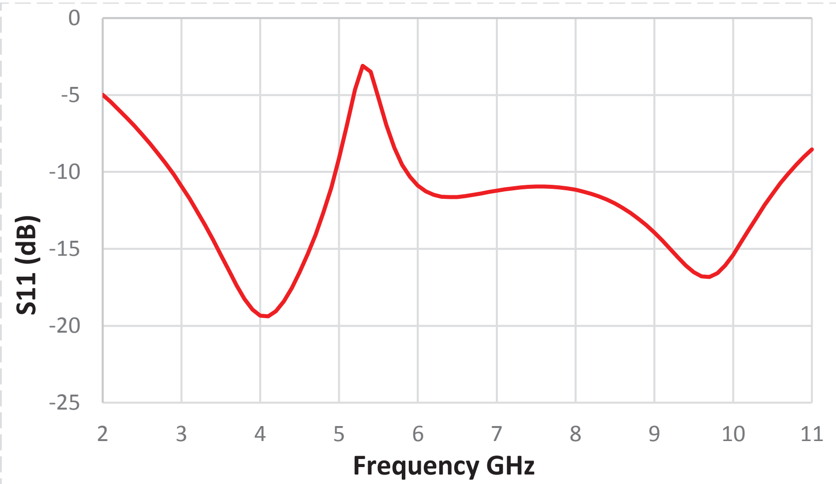
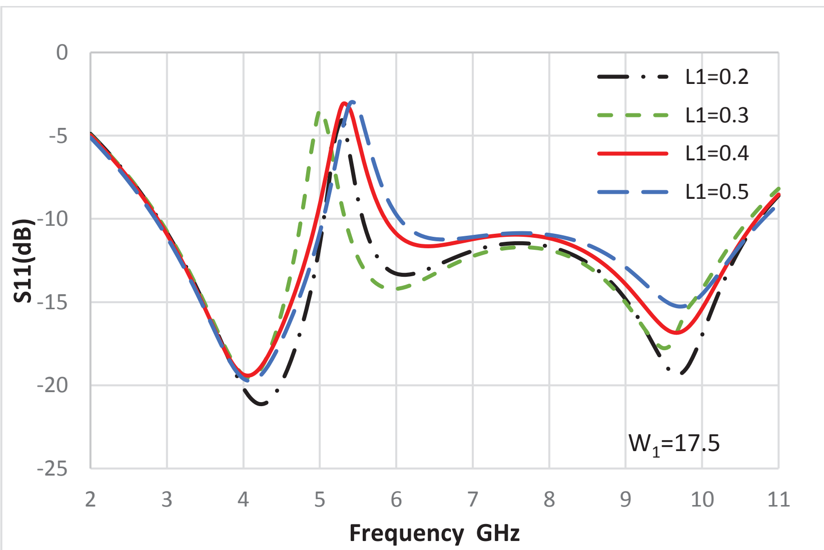


Figure 6. S11 of the Proposed Antenna



a

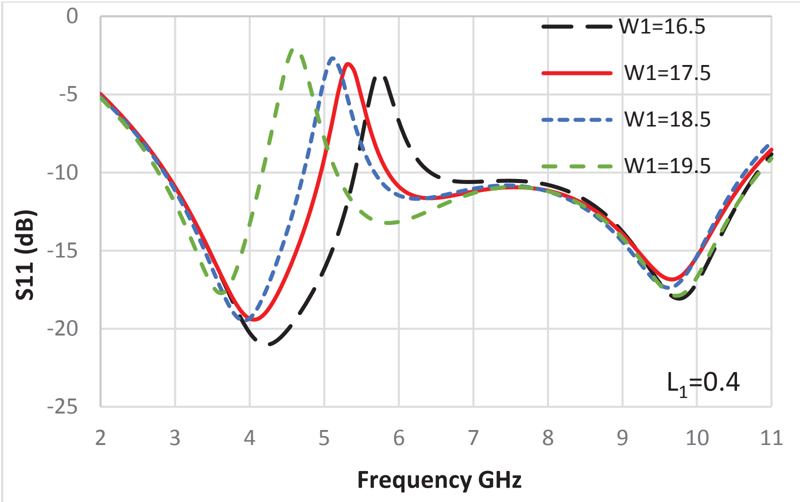


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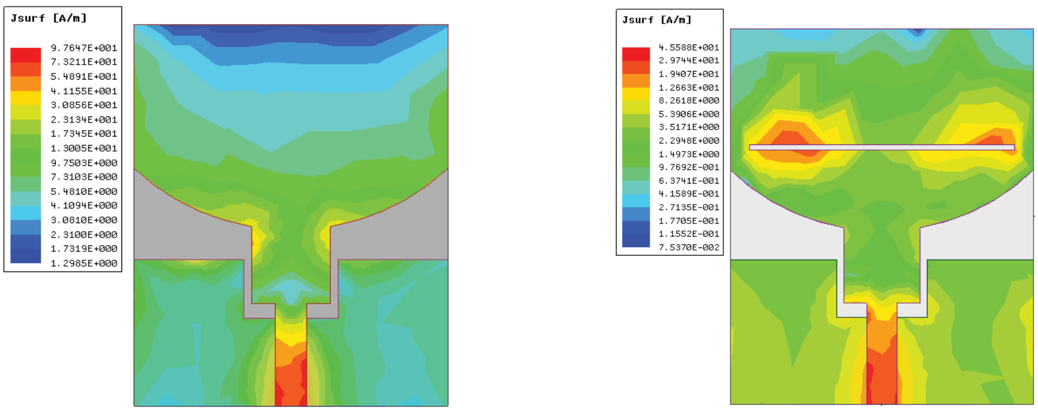
Figure 7. (a) shows the return Losses of the proposed antenna with different Length L_1 slot that is 0.2,0.3,0.4 and 0.5 with W_1 =17.5 and L_d =8.6 where all units are given in mm. While (b) shows the return losses of the proposed antenna with different Width W_1 of slot that is 16.5,17.5,18.5 and 19.5 with L_1 =0.4 and L_d =8.6 where all units are given in mm.



a b

Figure 8. Simulated Surface Current Distribution at Notched band 5.4GHz (a) without and b) with a slot

Figure 8 shows the simulated surface current distribution and compares at notched frequency 5.4GHz, the comparison was done on the basis of the slot. In Figure 8 (a), it is shown that the maximum current distribution is around the edges of the rectangular part of the patch when we have no slot in the antenna whereas in Figure 8 (b) we can see that maximum current distribution is around the slot. Figure 9 shows The Voltage Standing Wave Ratio (VSWR); VSWR describes the power reflected from the antenna. The value of VSWR should be less than 2 (VSWR<2). In Figure 9, we can see that the value of VSWR is less than 2 in the frequency range from 2.9GHz to 10.8GHz while in the notched frequency band from 5GHz to 5.9GHz, the value of VSWR is greater than 2 (VSWR>2). In Figure 10, the radiation pattern of the proposed antenna was measured and compared at notched frequency of 5.4GHz when there was no slot and when there is a slot. The gain of the proposed antenna is shown in Figure 11, which is another good measurement to describe the performance of the antenna. The gain of proposed antenna is sharply decreases at 5.41 GHz then it increases back and almost reaches to 4.7 dB.

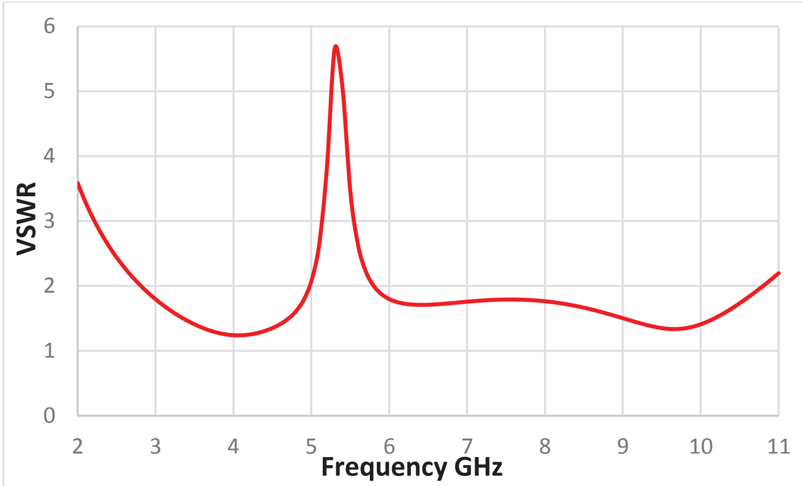
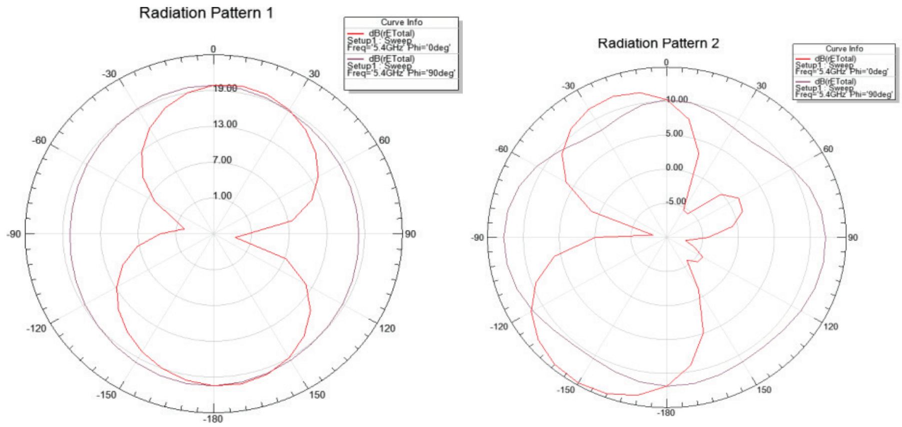


Figure 9. The VSWR of the proposed antenna



a

b

Figure 10. The Radiation pattern of Proposed antenna at notched frequency 5.4GHz (a)without a slot and (b) with a slot

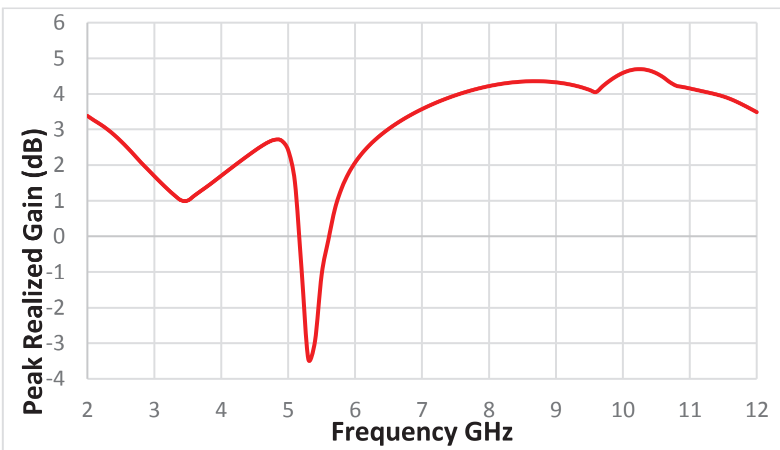


Figure 11. The Peak Realized Gain of Proposed antenna

5. Conclusion

A new micro strip fed monopole Ultra Wideband antenna was discussed in this paper. The proposed antenna has a frequency band width range from 2.9GHz to 10.8GHz and band rejected characteristic at 5GHz to 5. 9GHz.The band reject characteristic can be obtained by cutting a rectangular slot in its radiating patch. The rectangular cut in the ground plane is made for obtaining good impendence matching. The above mentioned results and discussions show that the proposed antenna is an appropriate choice for Ultra wideband applications.

References

[1] https://transition.fcc.gov/Bureaus/Engineering_Technology/Orders/2002/fcc02048.pdf
[2] Mehranpour, M., et al. "Dual band-notched square monopole antenna for ultrawideband applications." *ieee antennas and wireless propagation letters* 11 (2012): 172-175.
[3] Nouri, A., and G. R. Dadashzadeh. "A compact UWB band-notched printed monopole antenna with defected ground structure." *IEEE Antennas and Wireless Propagation Letters* 10 (2011): 1178-1181.
[4] Kundu, Suprio, Manisha Kundu, and Kaushiik Mandal. "Small monopole antenna with corner modified patch for UWB applications." *Automation, Control, Energy and Systems (ACES), 2014 First International Conference on*. IEEE, 2014.
[5] dVdvNioONAp, Barnypok, et al. "A holly-leaf-shaped monopole antenna with low RCS for UWB application." *Progress In Electromagnetics Research* 117 (2011): 35-50.
[6] Mishra, Sanjeev Kumar, and Jayanta Mukherjee. "Compact printed dual band-notched U-shape UWB antenna." *Progress in Electromagnetics Research C* 27 (2012): 169-181.
[7] Liu, Hao, and Ziqiang Xu. "Design of UWB monopole antenna with dual notched bands using one modified electromagnetic-bandgap structure." *The Scientific World Journal* 2013 (2013).
[8] Chen, Wen-Shan, and Kai-Cheng Yang. "CPW-fed planar ultra-wideband antenna having a frequency band-rejected function." *TENCON 2007-2007 IEEE Region 10 Conference*. IEEE, 2007.
[9] Abdollahvand, M., G. Dadashzadeh, and D. Mostafa. "Compact dual band-notched printed monopole antenna for UWB application." *IEEE Antennas and Wireless Propagation Letters* 9 (2010): 1148-1151.
[10] Ojaroudi, Mohammad, and Nasser Ojaroudi. "Ultra-wideband small rectangular slot antenna with variable band-stop function." *IEEE Transactions on Antennas and Propagation* 62.1 (2014): 490-494.
[11] Eshtiaghi, Raha, Javad Nourinia, and Changiz Ghobadi. "Electromagnetically coupled band-notched elliptical monopole antenna for UWB applications." *IEEE Transactions on Antennas and Propagation* 58.4 (2010): 1397-1402.
[12] http://anlage.umd.edu/HFSSv10UserGuide.pdf
[13] Zaker, Reza, Changiz Ghobadi, and Javad Nourinia. "A modified microstrip-FED two-step tapered monopole antenna for UWB and WLAN applications." *Progress In Electromagnetics Research* 77 (2007): 137-148.
[14] Pandey, Gaurav Kumar, et al. "Design of WLAN band notched UWB monopole antenna with stepped geometry using modified EBG structure." *Progress In Electromagnetics Research B* 50 (2013): 201-217.
[15] Jalil, Y. E., C. K. Chakrabarty, and B. Kasi. "A compact ultra wideband antenna with band-notched design." *Telecommunication Technologies (ISTT), 2014 IEEE 2nd International Symposium on*. IEEE, 2014.
[16] Sarkar, Debdeep, Kumar Vaibhav Srivastava, and Kushmanda Saurav. "A compact microstrip-fed triple band-notched UWB monopole antenna." *IEEE Antennas and Wireless Propagation Letters* 13 (2014): 396-399.
[17] Gao, Peng, et al. "Compact printed UWB diversity slot antenna with 5.5-GHz band-notched characteristics." *IEEE Antennas and Wireless Propagation Letters* 13 (2014): 376-379.
[18] Femina, Beegum S., and Sanjeev Kumar Mishra. "Compact WLAN Band-Notched Printed Ultrawideband MIMO Antenna with Polarization Diversity." *Progress In Electromagnetics Research C* 61 (2016): 149-159.
[19] Das, Avisikta, Sasmita Pahadsingh, and Sudhakar Sahu. "Compact microstrip fed UWB antenna with dual band notch characteristics." *Communication and Signal Processing (ICCSP), 2016 International Conference on*. IEEE, 2016.