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Design a new notched UWB antenna to rejected unwonted band for wireless communication

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ABSTRACT

This paper presents a slotted design for ultra-wideband (UWB) antenna. Design of a rectangular UWB antenna covering the frequency range 3.1-10.6 GHz, to achieve notch characteristics in the bands at 3.1-8.4 GHz and 8.6-10.6 GHz. By changing the direction of distribution of current to apply this technique by inserting three C-shaped holes and two pairs of rectangular notches below the antenna. The simulation results reveal that the proposed structure is in good accord with the simulation results. The proposed UWB antenna size is (100x90x1.6 mm)^3. This proposed design could provide a solution to eliminating bands that interfere in a UWB band depending on the aperture design. The simulated findings reveal that the UWB antenna operates in the 8.5 GHz center frequency range and rejects all frequency bands utilizing slits. This antenna design can provide a solution to remove UWB bands from 3.1-10.6 except for 8.5 GHz which only works. By using the notch, we got a large increase in the gain. makes to be a suitable candidate for X-band-UWB applications.

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1. INTRODUCTION

Due to their traditional frequency band assignments, many overlapping radio systems are crowded due to the proliferation of wireless communications and the increasing demand for operating frequency bands. The ultra-wideband (UWB) systems' wide frequency ranges, which the Federal Communications Commission (FCC) distributes through 3.11-10.6 GHz, will cause interference in current wireless communication systems such as the IEEE 802.11a wireless local area network (WLAN) operating in the 5.15-5.35 GHz and 5.725-5.825 GHz bands UWB antenna with single band-stop performance is required for (WiMAX) operating in 3.3-3.6 GHz and C-band running in 3.7-4.2 GHz [1]-[3]. To improve the quality of communication by preventing unwanted frequencies, we use filters. However, the utilization of filters increases the value and volume of the system also as insertion losses [4], [5].

As a result, a lot of research has gone into developing UWB antennas with band rejection capabilities to avoid any interference from existing bands. Many notched band UWB antennas have been designed in recent studies utilizing multiple approaches to prevent interference concerns. These approaches for band rejection on the patch, include etching slots [6]-[8]. Fixing resonance slots in the radiating patch or its ground plane is the most typical way [9]. By cutting two slots with modified dimensions on the patch, the antenna can show a dual-band notch function in the integrated frequency ranges. The slots on the radiating stub distinguish extra surface current pathways and vary the current flow direction, resulting in the necessary notched frequency attenuations [10]. The type and location of the resonant structure to be employed are taken into account while configuring notch attributes. Slot resonators are the most commonly utilized resonator kinds [11]-[13]. Microstrip [14], [15] coplanar waveguide (CPW) [16] and metamaterial [17]-[19] resonators. The patch within the antenna is made of a conducting material such as Cu (Copper) or Au (Gold) and comes in a variety of shapes, including rectangular, circular, triangular, elliptical, and other variations [20]. Two pairs of L-shaped resonators are introduced with the design to remove the WLAN at 5.2 GHz and 5.8 GHz domains, respectively [21]. With wire-tape feed, complementary slotted ring resonators (CSRRs) are loaded into a UWB antenna patch. The helical gap is put onto the feeder, while the J gap is symmetrically loaded onto the bottom plate. At 3.22-3.97 GHz, 4.94-5.84 GHz, and 7.25-7.86 GHz, the triple band is obtained [22]. By drilling an S-shaped slot in the tiny tape feed line and an asymmetric C-shaped parasite above the defective ground structure (DGS), two rejected bands 5.02-5.97 GHz and 7.23-7.72 GHz are obtained, respectively [23].

The proposed antenna consists of a rectangular patch with a slot and two symmetrical slits in the patch plane also cutting ground structure will produce a single band to prevent interference with all other bands. According to the size of the slot rectangular resonator and its signal rejection showing, it is etched in the rectangular patch of the UWB printed rectangular antenna to achieve band-notched characteristics at the center frequency 8.5 GHz band. The slit resonator is placed close to the feed line. By enrollment of the equal slits in the patch, the plane provides rejection of all interfering signals.

2. PROPOSED ANTENNA DESIGN

The antenna consists of basic components length (L) and width (W), an insulating substrate of fixed (ε r), patch height (h), and width (t) supported by a ground plane. The rectangular patch antenna is made to operate at a resonant frequency. The length to be patched consists of the height, width, and insulating substrate. In the Table 1, look at the specific values of each factor.

Table 1. Limits of the parameter in rectangular patch antenna

Parameters	Specified Values
Length of the patch	$0.333\lambda < L < 0.5\ \lambda$
The wideness of the patch	under $t << \lambda$
Height h of the dielectric substrate	among 0.003 λ & 0.05λ
The dielectric constant, (ε_r)	among 2.19 & 12

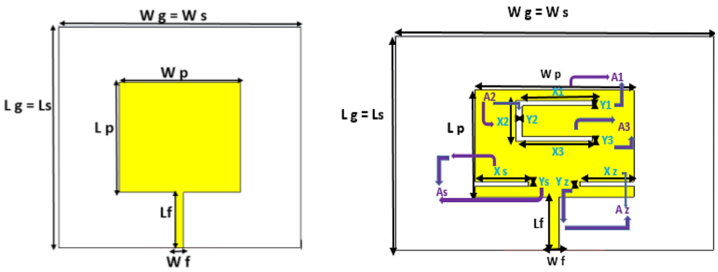
Different microstrip antenna structures exist in a wide range of antenna models, but in general, an antenna has four essential elements [24]. They are (patch, an insulating substrate, ground level, feed line). The region where the ground level is usually of the same material is the thin metal zone with various shapes and sizes. The RF supply of power to the patch is a common process that we must be aware of. The insulating material is sometimes referred to as the substrate' [25]. One of the most important difficulties in ultra-wideband (UWB) communication systems is the creation of low-cost, small-size components [26]. The cost of the material, the dielectric loss tangent, the conductor coatings' surface adhesion qualities, and the ease of production are all factors to consider [27]. For the planar and conformal antenna orders, there are numerous types of materials available for the substrate option. The materials' dielectric constants ranging from 1.17 to 25 [28].

The rectangular antenna without notch on the patch is shaped UWB antenna is shown in Figure 1 (a) which operates within a bounded frequency range between 3.1-10.6 GHz. It is fed by using a waveguide port (WGP). On the patch plane, two small, shallow slits and C-slots are integrated is shown in Figure 1 (b). Finally, change the dimensions of the ground plane results in the single-band antenna. The antenna is simulated using (CST) where an FR4-lossy substrate with relative permittivity *(ε_r)* of 4.3 hight of the substrate (H) and thickness of groud (t). area of slots, (A1, A2, A3), slits (As, Az) respectively all dimensions are illustrated in Table 2. The simulated reflection coefficients of the antenna are shown in Figure 2.

2.1. Notch design

To produce band-notched characteristics, the UWB antenna discussed in the previous section is modified by adding a resonant structure to the patch plane. This is accomplished by inserting two symmetrical slits with area (As and Az) and dimensions (xs, ys) (xz, yz) at the patch's bottom edge. Except for the core frequency 8.5 GHz, the two slits are designed to notch out all frequencies between 3.1 and 10.6 GHz. The slots have three regions (A1, A2, A3) their dimensions (x1, y1), (x2, y2), and (x3, y3), respectively. Figure 3 shows the reflection coefficient of the band-notched UWB rectangular antenna. In addition, a single band frequency at the center frequency 8.5 GHz is achieved, as demonstrated by comparison in Figure 4, entirely notching out all frequency bands.

During the design, processes such as cutting a rectangular slot and a side slit on the patch are utilized to produce a large bandwidth. The slots and slits website has been made bandwidth-friendly. The current path and input impedance are changed to achieve this. While cutting any slot, we check at the existing distribution in the patch to get the required band. We can trim the patch's slot if we only want single frequencies.



(a) (b)

Figure 1. Rectangular antenna: (a) prototype antenna and (b) rectangular notch-band antenna

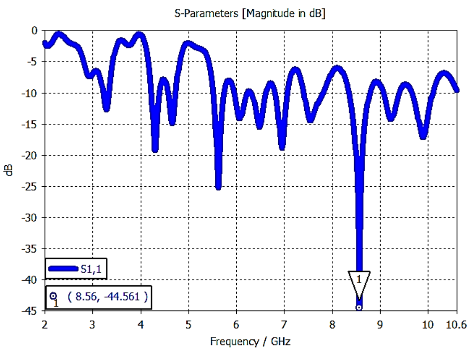


Figure 2. The reflection coefficient versus frequency without the notch

Table 2. Design parameters

Parameters	Values in mm	Parameters	Values in mm	Parameters	Values in mm
Wg=Ws	100	Lg=Ls	90	H	1.6
wf	3.2	Lf	22.5	t	0.035
wp	50	Lp	45	A3	44
A1	44	A2	34	Xz	17
As	34	Az	34	Yz	2
Ys	2	Xs	17	Y2	2
Y1	2	X1	22	Y3	2
X2	7	X3	22		

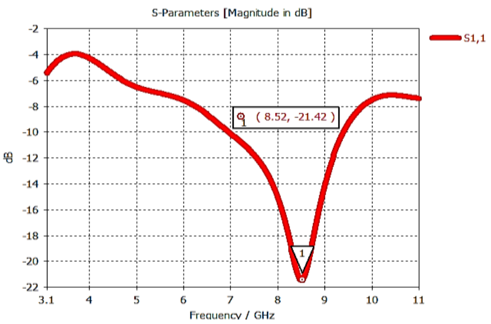


Figure 3. The reflection coefficient versus with notch

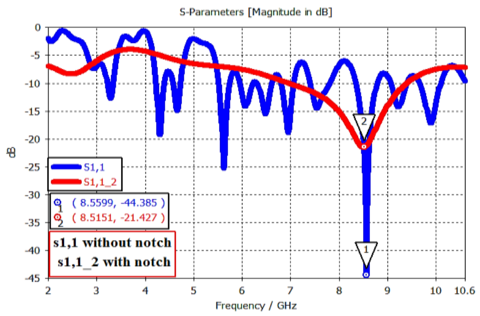


Figure 4. Compere reflection coefficient frequency versus with and without the notch

2.2. The size and position of the slots

To choose the size and position of the slits and slots we derive the following equations. In the beginning the area of the rectangle patch (A_{patch}) is equal to the side area of the cylinder ($A_{cylinder}$).

$$A_{patch} = A_{cylinder} \tag{1}$$

$$A_{cylinder} = 2\pi hr \tag{2}$$

$$A_{patch} = w_p\, l_p \tag{3}$$

where w_p& l_p width and length of patch.

By subtracting the sum both of the area of slit and slot from an area of patch and substitutein to the (1) we get;

$$A_{patch} - (A_{\mathrm{slit}} + A_{\mathrm{slot}}) = A_{cylinder} \tag{4}$$

where A_{slit}& A_{slot} is the the area of slit and slot respectively we can find the area of slit from the (5).

$$A_{\mathrm{slit}} = A_s + A_z \tag{5}$$

Where A_s & A_z is the area of right and left slit in Figure 1 (b)

$$A_{\mathrm{slit}} = x_s y_s + x_z y_z \tag{6}$$

$$A_s = x_s y_s \tag{7}$$

where x_s & y_s are the width and length of (A_s)

$$A_z = x_z y_z \tag{8}$$

where x_z *and* y_z are the width and length of (A_z). Also, the area of the slot is;

$$A_{\mathrm{slot}} = A_1 + A_2 + A_3 \tag{9}$$

where A_1 & A_2 & A_3 are the area of slots which is shown in Figure 1 (b)

$$A_1 = x_1 y_1 \tag{10}$$

x_1 & y_1 are the width and length of A_1

$$A_2 = x_2 y_2 \tag{11}$$

where x_2 and y_2 are the width and length of A_2

$$A_3 = x_3 y_3 \tag{12}$$

where x_3 *and* y_3 are the width and length of A_3. When substituting these (10), (11) and (12) in (9) we get

$$A_{slot} = x_1 y_1 + x_2 y_2 + x_3 y_3 \tag{13}$$

to find the ratio of the slit area to the patch area substituting these (3), (5) and (9) in (4) we get

$$w_p l_p - (A_s + A_z + A_1 + A_2 + A_3) = 2\pi hr \tag{14}$$

$$w_p l_p - (x_s y_s + x_z y_z + x_1 y_1 + x_2 y_2 + x_3 y_3 \tag{15}$$

we can find the area of patch (A_{patch}) from (3) we get A_{patch} is 2250 mm^2 also we can find both areas of the slit (A_{slit})and *slot* (A_{slot}) from (5) and (9) respectively we get A_{slit} *is* 68 mm^2 and A_{slot} *is* 122 mm^2.

The ratio between the area of the patch to the total area of slit and slot are;

$$\frac{A_{patch}}{A_{slit}+A_{slot}} = 11.8 \tag{16}$$

So

$$A_{patch} = 11.8(A_{slit} + A_{slot}) \tag{17}$$

substitute (17) in (4) we get

$$11.8(A_{slit} + A_{slot}) - (A_{slit} + A_{slot}) \quad = 2\pi hr \tag{18}$$

$$10.8(A_{slit} + A_{slot}) = 2\pi\text{hr} \tag{19}$$

$$(A_{slit} + A_{slot}) \quad = \frac{2\pi hr}{10.5} \tag{20}$$

from (6) $A_{\text{slit}} = 68$ mm^2 substitute in (20) weget the area of slot

$$(68 + A_{slot}) \quad = \frac{2\pi hr}{10.5} \tag{21}$$

So, the area of the slot is;

$$A_{slot} \quad = \frac{2\pi hr}{10.5} \ - 68 \tag{22}$$

from (13) $A_{slot} = 122$ mm^2 substitute in (20) weget the area of the slit

$$(A_{slit} + 122) \quad = \frac{2\pi hr}{10.5} \tag{23}$$

Also, the area of the slit is;

$$A_{slit} \quad = \frac{2\pi hr}{10.5} \ - 122 \tag{24}$$

from (22) we can determine the area of the specified slots that can be clipped from patch. Also, from (24) we can determine the area of the specified slits that can be clipped from patch. the area of slits (As, Az) rejected frequency band 3.1-5.2 GHz and the area of slots (A1, A2, A3) removing frequency band at 5.3-8.4 GHz, 8.6-10.6 GHz.

3. RESULTS AND DISCUSSION

In this section Antenna design results refer to working with a single band that operates within a single frequency without any interference with the specified frequencies from 3.1-8.4 GHz and 8.6-10.6 GHz also, there is a significant increase in the antenna gain at value 4.4 dBi when using notch and without using notch as shown in Figures 5 and 6 respectively.

Figure 7 shows the voltage standing wave ratio (VSWR), which is less than 2 of the band necessary so that the VSWR is the current at any point it considers as a measure of the line-to-load mismatch. At center frequency 8.5 GHz, the final antenna has a single bandwidth. The parameters sweeps are used to discover the best slit and slot placement on a patch for both circumstance and size as shown in Figure 8.

Surface current distributions for the UWB planar antenna for the center frequency 2 GHz are shown in Figure 9 (a) (see Appendix) to get rid of the unwanted frequencies, we go to the distribution of the current, where the concentration of the current is high. Put the slot to block the passage of the current and change the direction of the current, the current concentration is reduced and concentrated at the edges by adding rectangular slots (A 1, A2, A3). Both of the slots are designed to notch out all frequencies from 3.1-10.6 GHz except center frequency, the area of slots removes frequency band at 5.3-8.4 GHz, 8.6-10.6 GHz and the area of slits rejected frequency band 3.1-5.2 GHz. In Figure 9 (b) (see Appendix) showing the current concentration is higher at frequency 8.5 GHz.

The radiation patterns for the E and H fields are stable but have asymmetry throughout the frequency range. The asymmetry could be due to the structure in the correction plane and the ground. The E-plane is omnidirectional as shown in Figure 9 (c) (see Appendix) while for the H field, electromagnetic waves can be easily attached to the structure as the dimensions of the antenna are reduced, as shown in Figure 9 (d) (see Appendix) and therefore, while more often, the waves change to distort, a stepwise pattern of the radiation due to a change in the flow of current at the edge of the structure, as shown in Figure 9 (e) (see Appendix) and simulated radiation patterns of the proposed antenna in the 8.5 GHz case, including H-plane and E-plane.in Figure 9 (f) (see Appendix). The overall gain pattern with 3 dB angular width is 4.4 dBi, 0.227 dBi in Figure 9 (g) (see Appendix) at f=8.5 GHz and at Figure 9 (h) (see Appendix) at f=2 GHz, respectively. Also, with a 3 dB angular width, the total gain pattern is 4.11 dB. Figure 10 depicts the proposed antenna's far-field broadband. Also, the comparition reults with others work as showen in Table 3.

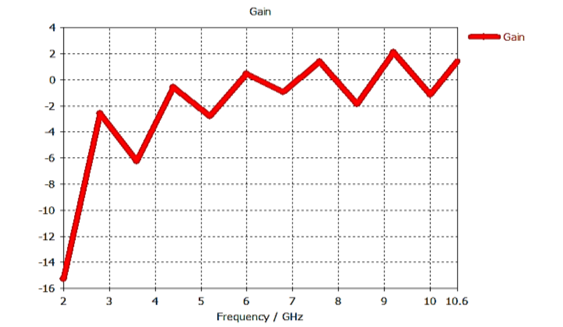


Figure 5. Variation of gain with the frequency of the proposed antenna without the notch

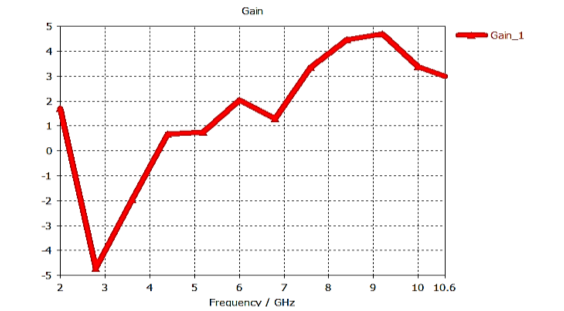


Figure 6. Variation of gain with the frequency of the proposed antenna with the notch

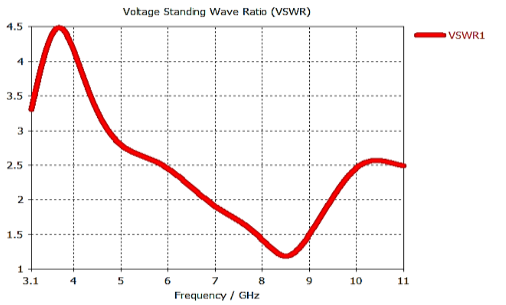


Figure 7. The VSWR of the proposed antenna

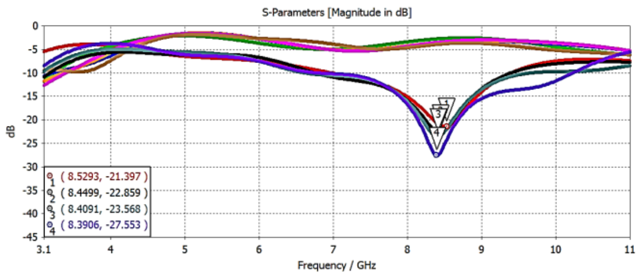


Figure 8. The parameters sweep with using notch

Table 3. Copmpartion result with other work

Ref	dimension (mm)^3	Band Notching structure	Removed band (GHz)
[29]	20×20×0.8	On the radiating patch, cut two slots and embed two (PIN)diodes	3.15-3.85 5.13-6.1
[30]	40×35×1.5	Complementary Split ring resonators	3.3-3.7 5.15-5.35
[31]	34×27×0.787	Strips that are rectangular and U-shaped	2.97-4.7 4.97-6.62
[32]	40×30×0.787	U-Shaped slot etched on the feedline	5.1-5.8
[33]	72×23×1.6	Square and circular rings with a split phi form	5.1–6.2 4.9-5.9
[34]	12×19×1.6	split ring resonator slot & two L-shaped	3.3-3.8, 5.1-5.825, 7.25-7.75
[35]	37.8×27.1×1.6	inverted pi-slot & double split ring resonators (DSRRs)	3.2-3.67 4.32-5.81
This work	100×90×1.6	Rectangular notches	3.1-8.4 8.6-10.6

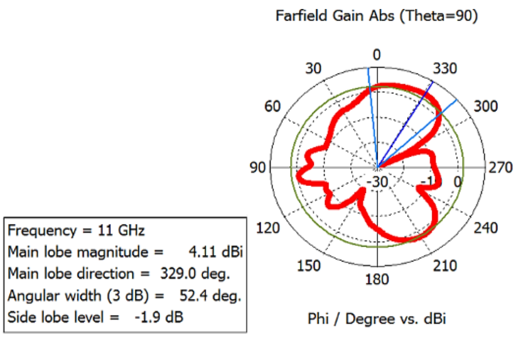


Figure 10. The proposed antenna's gain pattern for fairfield broadband

4. CONCLUSION

New design notchd-band UWB antenna with single-band selection between bands for large gain in the range 2.2-4.4 dB. The first part of design model is simple and works with S11 requirements below -10 dBm in the range 3.1-10.6 GHz. The simulated data shows that the proposed antenna can produce a relatively single frequency. at second part of design we got slots for rejecting the frequency range 3.1-8.4 GHz and 8.6-10.6 GHz. The center frequency of the grooved band 8.5 GHz by changing the slit position. the position of slits dependent on distribution technique for current where the current is at edge of the slots thus,we remove the unwanted frequencies. Simulation results for antenna reflection coefficient using computer simulation technology (CST). From the simulation we get anew antenna of low cost, with the ability to reject any unwanted frequency. This antenna works with UWB applications. Hence, we can operate at one frequency without interfering with other bands in the rang 3.1-10.6 GHz.

APPENDIX

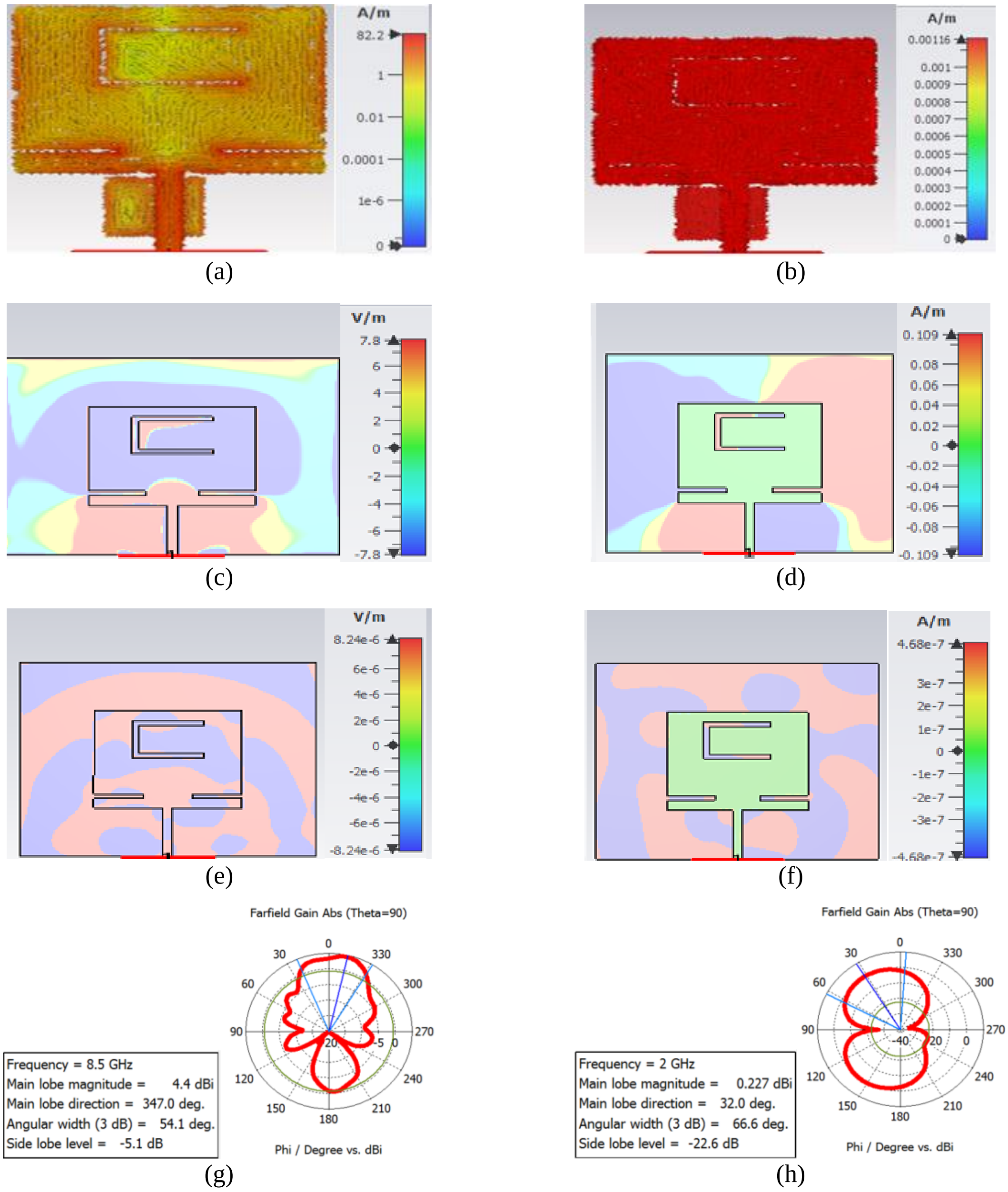


Figure 9. Current surface distribution at ((a) current surface distribution at f=2 GHz, (b) current surface distribution at f=8.5 GHz) and farfield 2D/3D results at ((c) E-Field at f=2 GHz, (d) H-field at f=2 GHz) Farfield 2D/3D results at ((e) E-Field at f=8.5 GHz, (f) H-field at f=8.5 GHz, (g) farfield polar form at f=8.5 GHz, (h) farfield polar form at f=2 GHz) respectively

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REFERENCES

[1] H. Schantz, "The art and science of ultrawideband antennas," *Artech House, Inc, MA*, 2005.
[2] G. Kumar and K. P. Ray, "Broadband microstrip antennas," *Artech house*, 2003.
[3] E. Erfani, J. Nourinia, C. Ghobadi, M. Niroo-Jazi, and T. A. Denidni, "Design and implementation of an integrated UWB/reconfigurable-slot antenna for cognitive radio applications," *IEEE Antennas Wirel. Propag. Lett.*, vol. 11, pp. 77–80, 2012, doi: 10.1109/LAWP.2011.2182631.
[4] P. Kim and Y. Jeong, "A coupled line impedance transformer for high termination impedance with a bandpass filtering response," *J. Electromagn. Eng. Sci.*, vol. 18, no. 1, pp. 41–45, 2018, doi: 10.26866/jees.2018.18.1.41.
[5] T. L. Wu, Y. M. Pan, P. F. Hu, and S. Y. Zheng, "Design of a low profile and compact omnidirectional filtering patch antenna," *IEEE Access*, vol. 5, pp. 1083–1089, 2017, doi: 10.1109/ACCESS.2017.2651143.
[6] J. Park, M. Jeong, N. Hussain, S. Rhee, P. Kim, and N. Kim, "Design and fabrication of triple‐ band folded dipole antenna for GPS/DCS/WLAN/WiMAX applications," *Microw. Opt. Technol. Lett.*, vol. 61, no. 5, pp. 1328–1332, 2019, doi: 10.1002/mop.31739.
[7] R. H. Thaher, "Design and analysis microstrip antenna with reflector to enhancement gain for wireless communication," *Bulletin of Electrical Engineering and Informatics (BEEI)*, vol. 9, no. 2, pp. 652–660, 2020, doi: 10.11591/eei.v9i2.1696.
[8] Y. Zhang, W. Hong, C. Yu, Z.-Q. Kuai, Y.-D. Don, and J.-Y. Zhou, "Planar ultrawideband antennas with multiple notched bands based on etched slots on the patch and/or split ring resonators on the feed line," *IEEE Trans. Antennas Propag.*, vol. 56, no. 9, pp. 3063–3068, 2008, doi: 10.1109/TAP.2008.928815.
[9] T. Dissanayake and K. P. Esselle, "Prediction of the notch frequency of slot loaded printed UWB antennas," *IEEE Trans. Antennas Propag.*, vol. 55, no. 11, pp. 3320–3325, 2007, doi: 10.1109/TAP.2007.908792.
[10] S. Nikolaou, N. D. Kingsley, G. E. Ponchak, J. Papapolymerou, and M. M. Tentzeris, "UWB elliptical monopoles with a reconfigurable band notch using MEMS switches actuated without bias lines," *IEEE Trans. Antennas Propag.*, vol. 57, no. 8, pp. 2242–2251, 2009, doi: 10.1109/TAP.2009.2024450.
[11] Y. Kim and D.-H. Kwon, "CPW-fed planar ultra wideband antenna having a frequency band notch function," *Electron. Lett.*, vol. 40, no. 7, pp. 403–405, 2004, doi: 10.1049/el:20040302.
[12] A. K. Jassim and R. H. Thaher, "Calculate the optimum slot area of the elliptical microstrip antenna for mobile applications," *Indones. J. Electr. Eng. Comput. Sci.*, vol. 16, no. 3, pp. 1364–1370, 2019, doi: 10.11591/ijeecs.v16.i3.pp1364-1370.
[13] Y. J. Cho, K. H. Kim, S. H. Hwang, and S.-O. Park, "A miniature UWB planar monopole antenna with 5 GHz band-rejection filter," in *The European Conference on Wireless Technology, 2005.*, pp. 511–514, 2005, doi: 10.1109/ECWT.2005.1617769.
[14] T.-G. Ma, R.-C. Hua, and C.-F. Chou, "Design of a multiresonator loaded band-rejected ultrawideband planar monopole antenna with controllable notched bandwidth," *IEEE Trans. Antennas Propag.*, vol. 56, no. 9, pp. 2875–2883, 2008, doi: 10.1109/TAP.2008.928778.
[15] S.-J. Wu, C.-H. Kang, K.-H. Chen, and J.-H. Tarng, "Study of an ultrawideband monopole antenna with a band-notched open-looped resonator," *IEEE Trans. Antennas Propag.*, vol. 58, no. 6, pp. 1890–1897, 2010, doi: 10.1109/TAP.2010.2046839.
[16] S.-W. Qu, J.-L. Li, and Q. Xue, "A band-notched ultrawideband printed monopole antenna," *IEEE Antennas Wirel. Propag. Lett.*, vol. 5, pp. 495–498, 2006, doi: 10.1109/LAWP.2006.886303.
[17] J. Kim, C. S. Cho, and J. W. Lee, "5.2 GHz notched ultra-wideband antenna using slot-type SRR," *Electron. Lett.*, vol. 42, no. 6, pp. 315–316, 2006, doi: 10.1049/el:20063713.
[18] A. A. Jabber, A. K. Jassim, and R. H. Thaher, "Compact reconfigurable PIFA antenna for wireless applications," *TELKOMNIKA Telecommunication, Computing, Electronics and Control*, vol. 18, no. 2, pp. 595–602, 2020, doi: 10.12928/TELKOMNIKA.v18i2.13427.
[19] J. Liu, S. Gong, Y. Xu, X. Zhang, C. Feng, and N. Qi, "Compact printed ultra-wideband monopole antenna with dual band-notched characteristics," *Electron. Lett.*, vol. 44, no. 12, pp. 710–711, 2008, doi: 10.1049/el:20080931.
[20] R. Garg, P. Bhartia, I. J. Bahl, and A. Ittipiboon, "Microstrip antenna design handbook," *Artech house*, 2001.
[21] S. W. Yik, Z. Zakaria, and N. A. Shairi, "A Compact Design of Reconfigurable Dual Band-Notched UWB Antenna," in *2018 IEEE International Workshop on Electromagnetics: Applications and Student Innovation Competition (iWEM)*, 2018, pp. 1–2, doi: 10.1109/iWEM.2018.8536707.
[22] Y. Lv, J. Zhang, and H. Hou, "A novel triple band-notched UWB printed monopole antenna," *Prog. Electromagn. Res.*, vol. 81, pp. 85–95, 2019, doi:10.2528/PIERM19022201.
[23] V. N. K. R. Devana and A. M. Rao, "Design and Analysis of Dual Band-Notched UWB Antenna Using a Slot in Feed and Asymmetrical Parasitic stub," *IETE J. Res.*, pp. 1–11, 2020, doi: 10.1080/03772063.2020.1816226
[24] Y. T. Lo and S. W. Lee, "Antenna Handbook-Theory, Applications and Design Chap. 11," *Van Nostrand Reinhold Co., NY*, 1988.
[25] F. Di Paulo, "Networks and Devices Using Planar Transmission Lines," *CRC Press LLC*, pp. 490–491, Boca Raton, 2000.
[26] L. Zhu, S. Sun, and W. Menzel, "Ultra-wideband (UWB) bandpass filters using multiple-mode resonator," *IEEE Microw. Wirel. components Lett.*, vol. 15, no. 11, pp. 796–798, 2005, doi: 10.1109/LMWC.2005.859011.

[27] I. G. Kiani, “Coplanar Microstrip Active Integrated Antenna for Dual Band Low Noise Amplifier,” M. Sc Thesis, Department of Electronic Engineering. GIK Institute, 2003.
[28] M. Olyphant Jr and T. E. Nowicki, “Microwave substrates support MIC technology. I,” *MicWa*, vol. 19, pp. 74–76, 1980.
[29] B. Badamchi, J. Nourinia, C. Ghobadi, and A. V. Shahmirzadi, “Design of compact reconfigurable ultra-wideband slot antenna with switchable single/dual band notch functions,” *IET Microwaves, Antennas Propag.*, vol. 8, no. 8, pp. 541–548, 2014, doi: 10.1049/iet-map.2013.0311.
[30] D. Zhao, L. Lan, Y. Han, F. Liang, Q. Zhang, and B.-Z. Wang, “Optically controlled reconfigurable band-notched UWB antenna for cognitive radio applications,” *IEEE Photonics Technol. Lett.*, vol. 26, no. 21, pp. 2173–2176, 2014, doi: 10.1109/LPT.2014.2349961.
[31] M.-C. Tang, H. Wang, T. Deng, and R. W. Ziolkowski, “Compact planar ultrawideband antennas with continuously tunable, independent band-notched filters,” *IEEE Trans. Antennas Propag.*, vol. 64, no. 8, pp. 3292–3301, 2016, doi: 10.1109/TAP.2016.2570254.
[32] A. Alhegazi, Z. Zakaria, N. A. Shairi, A. Salleh, and S. Ahmed, “Compact UWB filtering-antenna with controllable WLAN band rejection using defected microstrip structure,” *Radioengineering*, vol. 27, no. 1, pp. 110–117, 2018, doi: 10.13164/re.2018.0110.
[33] K. V Ajetrao and A. P. Dhande, “Phi shape UWB antenna with band notch characteristics,” *Eng. Technol. Appl. Sci. Res.*, vol. 8, no. 4, pp. 3121–3125, 2018.
[34] S. Doddipalli and A. Kothari, “Compact UWB antenna with integrated triple notch bands for WBAN applications,” *IEEE Access*, vol. 7, pp. 183–190, 2018, doi: 10.1109/ACCESS.2018.2885248.
[35] P. Mayuri, N. D. Rani, N. B. Subrahmanyam, and B. T. P. Madhav, “Design and analysis of a compact reconfigurable dual band notched UWB antenna,” *Prog. Electromagn. Res.*, vol. 98, pp. 141–153, 2020, doi: 10.2528/PIERC19082903.

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