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DESIGN OF A DUAL-BAND REJECTION PLANAR ULTRA-WIDEBAND (UWB) ANTENNA

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Abstract: A novel Slotted-Decagon-Shaped (SDS) antenna is presented for Ultra-Wide Band (UWB) applications. This antenna has two slots; the first one is printed on the lower side, and the second on the upper side of the conducting patch. The feeding technique used to feed this antenna is a 50Ω strip line. Return losses, bandwidth, radiation pattern, and, gain of the presented SDS antenna are tested. These characteristics denote it fitting for UWB wireless communication systems. The SDS antenna was fabricated and tested at the laboratories of the Iraqi-ministry of science and technology and the result shows a fine agreement between simulation and measured S_{11}. The SDS antenna has a compact size of 19.3mm×36mm×1.6mm. Measured results show that the SDS antenna has favorable properties of S_{11} less than −10 dB and a quasi-stable gain of 2 to 4.5 dB over UWB, with the exception of the notched WiMAX (3.3-3.7 GHz) & WLAN (5.1-5.8 GHz) bands.

Keywords: *WiMAX, WLAN, UWB, VSWR, PCB.*

1. Introduction

Ultra-Wideband (UWB) is a foundation for several different wireless communication technologies. In 1896, the first UWB Communications framework was made to interface two mailing stations in excess of a mile separated. Pulse Broadcasting was used by the United States armed forces in the 1950s to hide an image, radar, and stealth communication [1-3]. It's also why UWB has resulted in an increase in antenna design, with both new potential and difficulties. The Shannon-Hartley hypothesis affirms that channel limit is relative to data transfer capacity. The UWB can oblige many Mbps on account of its super wide recurrence transmission capacity. Moreover, UWB transmission rates are incredibly low. It gives a strong and secure interchanges framework in view of the energy thickness [3-5]. Since the motivation radio UWB signal transmission is at baseband, it is modest and easy to run. Between 3.1 GHz and 10.6 GHz, the FCC distributed UWB applications in February 2002. The FCC' Judgment has determined that UWB systems can employ any signal that occupies atamosco that, therefore, means UWB covers all impulse radios and everything else that meets all the UWB specifications [5]. Impulse radio-based UWB systems are capable of transferring data at a higher pace than narrowband frequency carriers.

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To avoid interference, certain UWB applications must reject unwanted frequency ranges employing discrete band-stop filters (EMI). The main challenge in building UWB radio wires is to give a wide transmission capacity while saving a high addition and extraordinary radiation productivity. Over the preceding decade, various scholarly approaches have been employed. Radiation patch or ground plane slot arrangements are the most often utilized ways for rejecting undesired frequency bands and lowering antenna size. In addition, the UWB antenna design introduces extra challenges [6-9].

The 5-6 GHz band, as appointed by the FCC, is additionally utilized by other existing narrowband administrations, for example, IEEE 802.11a WLAN and HIPERLAN/2 WLAN, which use UWB development. In general Interoperability for Microwave Access (WiMAX) is used in a couple of nations all through Europe and Asia. It is between 3.3 GHz and 3.7 GHz. Only one band will be ejected per notch structure. Many slot layouts are necessary to generate multiple notched bands [10]. The purpose of this letter is to present a compact UWB antenna with dual-band indents carved into the emanating patch to give scored band attributes. The radio wire is little in size-and ranges a UWB impedance transmission capacity of 3.1 to 10.6 GHz. WiMAX (3.3-3.7 GHz) and WLAN (5.1-5.8GHz) are two groups. A receiving wire model was planned, built, and estimated to demonstrate this notion, the experimental antenna was constructed on low-cost FR4 printed-circuit-board (PCB) material that exhibits relative permittivity (ε_r) of 4.3 and thickness of 1.6 mm. The suggested work is divided into components. Section 2 discusses the antenna geometry, Section 3 compares measured and simulated findings, and Section 4 closes the paper [11-12].

2. Design and Performance of Antennas:

A straightforward UWB antenna is developed, and the effect of key factors on the antenna's performance is investigated. Furthermore, Figure 1 illustrates the proposed UWB monopole radio wire with two indent channels. The fix radio wire was engraved on a standard FR4 substrate with a relative permittivity (εr) of 4.3, a dielectric setback deviation (tan δ) of 0.02, and a thickness of 1.6 mm. The radio wire substrate and ground plane have a combined area of 42x 36 mm2 and 19.3 x 36 mm2, respectively. The patch antenna is equipped with R (10) mm2 microstrip feed line that enables 50-ohm impedance matching between the fix radio wire and the SMA connector. The antenna parameter's optimal values were determined by parametric research, as shown in Table 1. The simulation results were generated using CST software.

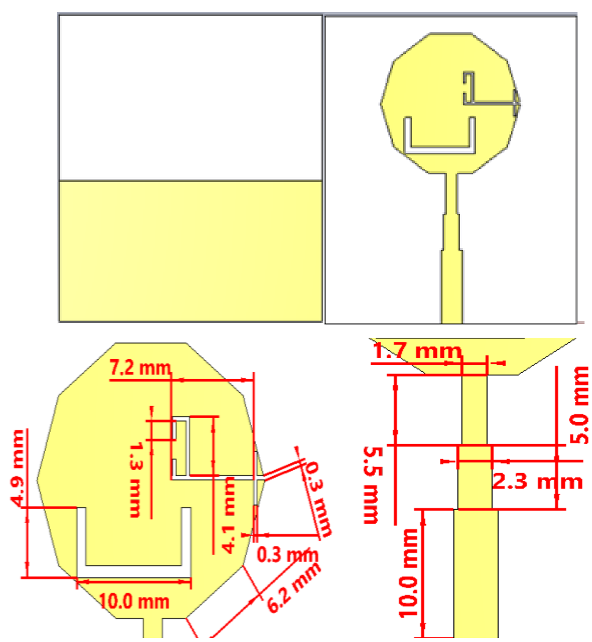

Figure 1. Proposed UWB antenna combinations

Table 1. The best value for antenna Parameters

Parameters	Value	Parameters	Value
L_S	42mm	W_f	3mm
W_s	36mm	t	0.035
L_g	19.3 mm	h	1.6mm
W_g	36mm	R	10mm
L_f	20.5mm	ε_r	4.3

The main problem in-band notching implementation is determining the optimal location of notching structures in the feed line, radiating patch, or ground plane in order to properly filter out the desired band. The proposed notching structures are oriented in order to generate the highest possible current density. With and without band notching functions, the antenna is analyzed. The first form UWB antenna is constructed, and the findings demonstrate that the suggested antenna covers a broad frequency range without requiring a single notch. Band notch functionality is accomplished by creating slots in the radiating patch. Figure 1 illustrates the proposed design featuring band notch functionality. Using the following formula, the band notch is implemented.

$$Fr = \frac{C}{4L\sqrt{\in eff}} \quad (1)$$

And

$$\in eff = \frac{(\in r + 1)}{2} \quad (2)$$

In the preceding equation, (L) represents the length of the opening , (Fr) addresses the indent recurrence, C addresses the speed of light, and ($\boldsymbol{\varepsilon r}$) addresses the substrate's successful dielectric consistent.

The length of the B slot the relationships listed below are used.

$$L_2 = \frac{\lambda g}{2} \quad (3)$$

$$\lambda g = \frac{c}{fr\sqrt{\varepsilon eff}} \quad (4)$$

Where λg - signifies the directed frequency of the ideal score recurrence and L2 indicates the B space's inexact length.

2.1. Structure with Notches for 3.5, 5.5 GHz

The suggested UWB patch antenna's performance has been extensively investigated. CST Microwave Studio software is used to create and model the antenna. To begin, we simulated the conventional UWB monopole antenna and obtained a VSWR of under 2 and a S11 worth of not exactly - 10 dB for the entire plan recurrence range (3.1 – 10.6 GHz). Second, the first structure is intended to create a notch on the main radiating element at 5.5 GHz. In Figure 2, the proposed structure's surface current density is depicted. As seen in the picture, the VSWR values obtained are greater than 2, indicating that the antenna demonstrated a notched band over WLAN. Additionally, lengthening the slot (5.5GHz) results in a frequency shift away from the ideal notch band.

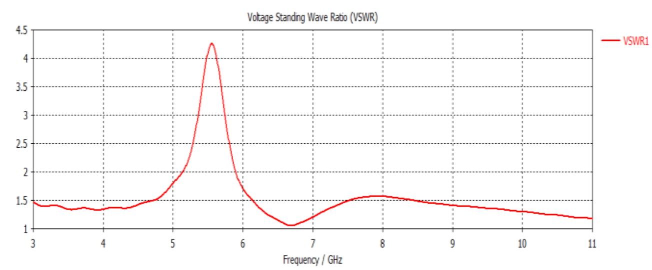

Figure 2. Demonstrates the influence of 5.5 slot length on VSWR.

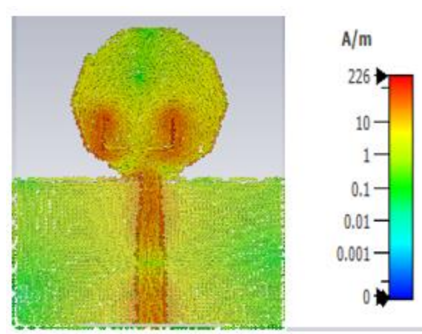

Figure 3. Surface Current Density for 5.5

Thirdly, the second structure is optimized for notch generation at 3.5 GHz. The developed antenna incorporates a notch to filter out undesirable frequencies centered on 3.5 GHz. The proposed structure's surface current density is depicted in Figure4. Figure 5 illustrates the intended antenna's simulated VSWR at various space lengths. Likewise, the outcomes show a VSWR more noteworthy than 2, demonstrating that the proposed radio wire showed score band execution over WiMAX (3.5 GHz)

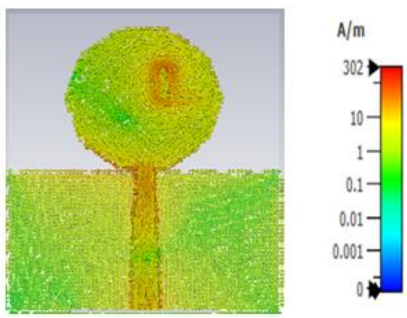

Figure 4. Surface Current Density for 3.5

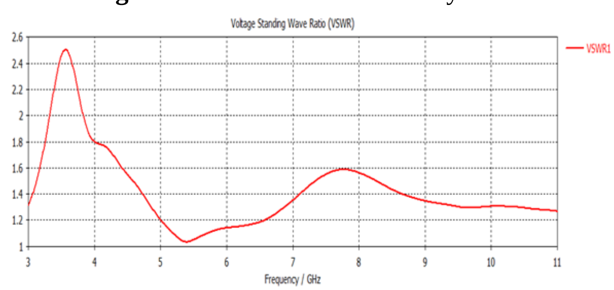

Figure 5. Demonstrates the influence of 3.5 slot length on VSWR.

3. Discussion of the Results

The proposed UWB radio wire configuration is talked about exhaustively in this part. In the accompanying segments, we will consider the recommended radio wire's appearance coefficient (S11), voltage standing wave proportion (VSWR), and gain.

3.1. Reflection Coefficient

The reflection coefficient (S_{11}) indicates the percentage of power reflected back from the antenna input to the excitation port. It is expressed as a decibel (dB) value and can be calculated as follows:

$$S11 =- 20\log_{10}\left|\frac{Zin - Zo}{Zin + zo}\right| \quad (5)$$

Where Z_{in} denotes the proposed antenna's driving point impedance and Z denotes the 50 SMA connector's characteristic impedance. The suggested UWB antenna's simulated outcome with and without notches is depicted in Figure 6.

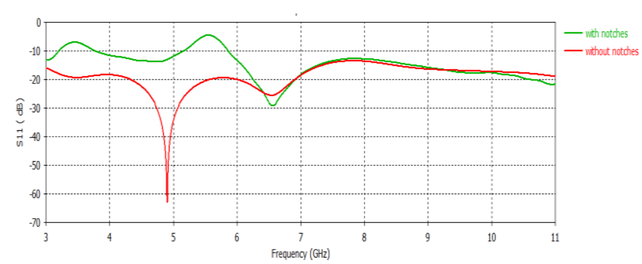

Figure 6. (S_{11}) return loss curves with and without notches.

3.2. Standing Wave Ratio of Voltage

The VSWR ratio is defined as the difference between the maximum and minimum voltages in the transmission feed line of the intended antenna. Figure 7 compares the simulated performance of the proposed UWB antenna with and without notches. Without notches, the proposed antennas have a VSWR of 2 across the whole 3.1 to 10.6 GHz frequency range. At 5.5 and 3.5 GHz, VSWR exceeds 2 due to the influence of the notches. This shows that the notch filter parameters have been adjusted to ensure sufficient spectrum rejection in the WLAN (5.1–5.8 GHz) and WiMAX bands (3.3-3.7GHZ).

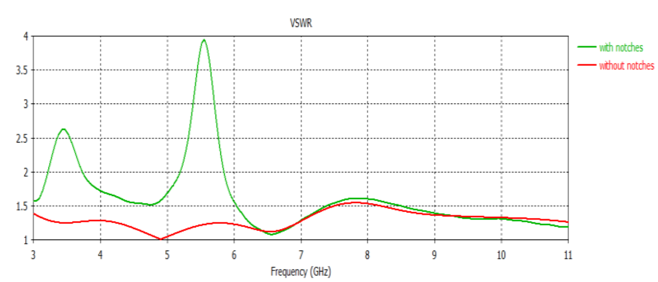

Figure 7. shows the VSWR curves (with and without notches).

3.3. The Gain

At 5 GHz, the addition of the UWB fix radio wire drops to 2 dB because of the indent impact. This shows that the indent channel boundaries were tuned to give an undeniable degree of band dismissal in the WLAN (5.1-5.8 GHz) and WiMAX (3.3-3.7 GHz) groups. After this band, the antenna gain increases dramatically. Figure 8 illustrates the proposed UWB antenna's projected maximum gain with and without dual-band notches.

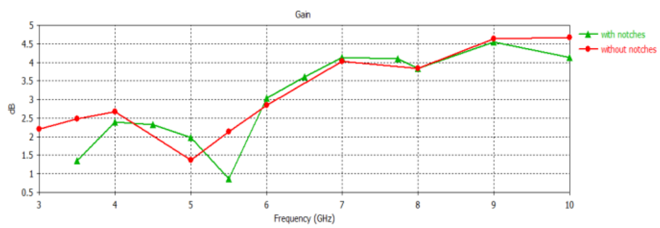

Figure 8. Gain of the UWB patch antenna with a band-notched pattern.

3.4. Density of Surface Current

Microwave studio programming is utilized to analyze the radiation properties of the double band indent UWB receiving wire at frequencies of 4 GHz, 6 GHz, and 8 GHz. Figure 9illustrates the radiation designs related with these frequencies. Fig .10 the 3D radiation example of the adjusted radio wire at frequencies 4, 8 GHz.

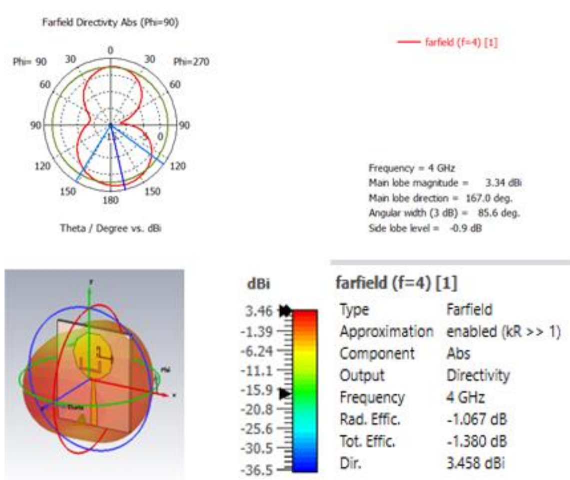

Figure 9. Radiation pattern at (4) GHz and (3D) view.

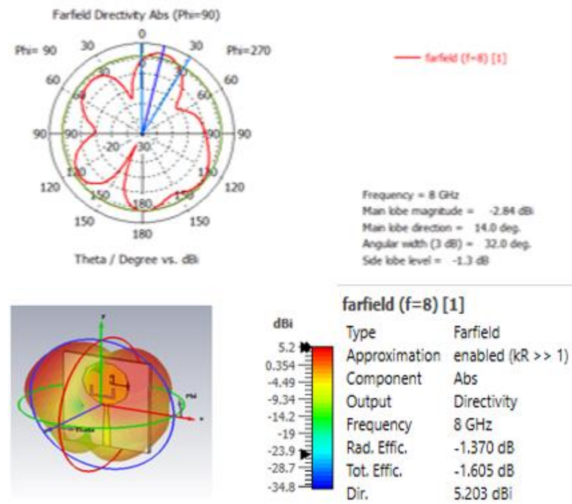

Figure 10. Radiation pattern at (8) GHz, and (3D) View.

4. Conclusion

We designed and measured a little size UWB fix radio wire with superb band dismissal execution. Two distinct slots were incorporated into the antenna's patch as notch filters. The dimensions of the slots have been tuned for Wimax and WLAN spectrum rejection. The obtained findings indicate that the proposed antenna exhibits favorable radiation patterns, gain, and reflection coefficient.

5. References

1- J. Kazim, A. Bibi, M. Rauf, and M. Tariq, “A compact planar dual band-notched monopole antenna for UWB application,” *Microwave and Optical Technology Letters*, vol. 56, no. 5, pp. 1095–1097, 2014.

2- N. Jaglan, S. D. Gupta, B. K. Kanaujia, and S. Srivastava, “Band notched UWB circular monopole antenna with inductance enhanced modified mushroom EBG structures,” *Wireless Networks*, vol. 24, no. 2, pp. 383–393, 2018.

3- K. G. Jangid, P. K. Jain, B. R. Sharma et al., "CPW fed UWB antenna with enhanced bandwidth and dual band notch characteristics," *AIP Conference Proceedings*, vol. 1953, article 140127, 2018.

4- J. Banerjee, A. Karmakar, R. Ghatak, and D. R. Poddar, "Compact CPW-fed UWB MIMO antenna with a novel modified Minkowski fractal defected ground structure (DGS) for high isolation and triple band-notch characteristic," *Journal of Electromagnetic Waves and Applications*, vol. 31, no. 15, pp. 1550–1565, 2017.

5- A. Alarifi, A. Al-Salman, M. Alsaleh, A. Alnafessah, S. Al-Hadhrami, M. A. Al-Ammar and H. S. Al-Khalifa," Ultra Wideband Indoor Positioning Technologies: Analysis and Recent Advances", Sensors, Vol. 16, 707; doi:10.3390/s16050707, pp.1-36, 2016.

6- A. Darvazehban, O. Manoochehri, M. A. Salari, P. Dehkhoda, and A. Tavakoli, "Ultra-wideband scanning antenna array with Rotman lens," *IEEE Transactions on Microwave Theory and Techniques*, vol. 65, no. 9, pp. 3435–3442, 2017.

7- S. Kundu and S. K. Jana, "Leaf-shaped CPW-fed UWB antenna with triple notch bands for ground penetrating radar applications," *Microwave and Optical Technology Letters*, vol. 60, no. 4, pp. 930–936, 2018.

8- A. Sharma and M. M. Sharma, "An UWB antenna design with dual band notched characteristic using U-shaped slots," in Proc. IEEE International Conference on Signal Processing and Communication, Noida, India, 2016.

9- A. R. Azeez, T. A. Elwi, and Z. A. A. AL-Hussain, "Design and Analysis of a Novel Concentric Rings based Crossed Lines Single Negative Metamaterial Structure," Elsevier, Engineering Science and Technology, an International Journal, vol. 20, no. 3, pp. 1140-1146, 2017.

10- R. Azim, M. T. Islam, and A. T. Mobashsher, "Design of a dual band-notches UWB slot antenna by means of simple parasitic slits," IEEE Trans. Antennas Propg., vol. 12, pp. 1412-1415, November. 2013.

11- Zhao, DS, Lan, LT, Han, YF, Liang, F, Zh ang, QL and Wang, BZ (2014) Optically controlled reconfigurable band-notched UWB antenna for cognitive radio applications. *IEEE Photonics Technology Letters* 26, 2173–2176.

12- M. Ojaroudi, N. Ojaroudi, N. Ghadi Dual band-notched small monopole antenna with novel coupled inverted U-ring strip and novel fork-shaped slit for UWB applications IEEE Antennas Wirel. Propag. Lett., 12 (2013), pp. 182-185.