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A Novel Triple-notched Circular-shaped UWB Monopole Antenna for Rejecting WLAN, WiMAX and X Bands

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Abstract

A modified semicircular ground plane with a slotted circular UWB monopole antenna designed for notched applications. The proposed antenna comprises the semicircular partially ground plane and three rectangular slots with a circular patch. Certain narrow-band wireless communication systems, such as those operating at 3.6–4.9 GHz, 5.6–6.4 GHz and 8.4–9.6 GHz for satellite communication, coexist throughout the whole UWB operational bandwidth. The suggested antenna's obtained impedance bandwidth is 7.6 GHz (3-10.6 GHz). This antenna's other benefits include its small size (18 × 24 × 1.6 mm^3), realized gain, directivity and uniform radiation properties across the entire passbands.

Keywords: FSS • Angular stability • Single band • Surface wave

Introduction

The most fundamental requirement for an Ultra-Wide Band (UWB) system is an antenna that can take in all signal elements spread over the whole UWB-employed band without signal distortion in the phase of these received components. The radiation patterns and matching features should be consistent over the UWB spectrum. The design of printed monopole UWB antenna is popular for wireless communication due to their low cost and small size, making it possible for simple integration with other equipment. UWB technology has features such as deficient power levels for communication over short distances and high information distributed over a broad spectrum [1]. Microstrip patch antennas are among the best options for use with UWB because of their compact, planar design and ease of integration with other types of electronic equipment [2].

The front end of a UWB communication system can be made more efficient and less expensive by rejecting interferences. As a consequence, UWB antennas with certain frequency-notched bands are quite significant. Several studies have also been attempted to design UWB band-notched antennas. Several approaches for notched-band design have been suggested in this study, etching slots, integrating parasitic elements to the radiators, utilizing Electromagnetic-Band Gap (EBG) design and inserting resonant cells in a microstrip line [3-7]. However, the processes for etching slots and integrating parasitic elements may have an important effect on the current distributions of pass-band frequency ranges and also the pass-band radiation patterns [8].

An antenna which having enhanced L-shaped notches with modified ground and the patch's bottom-side magnetism while also enhancing the impedance bandwidth at intermediate bands [9]. An operating bandwidth of 2-11 GHz can be achieved for a reflection coefficient of less than about -10 dB. At the lower 3.25 GHz and higher 7.98 GHz bands of frequencies, accordingly. On the ground plane, a reversed T-shaped slot and a thin strip included to a U-shaped patch are used to create further resonances. This antenna design operates between 3.1 to 10.75 GHz [10]. A rectangular aperture on the radiator and a step cut in the partially ground plane improve the bandwidth to around 61.34%, or 5.73 to 10.84 GHz [11].

A rectangular slit and an additional L-shaped stub in the modified ground plane increase the impedance bandwidth, which is between 3 and 12 GHz. Its dimension is relatively modest and it has good electrical efficiency [12]. The antenna comprises a partial ground plane, a microstrip line for feeding and multiple circular radiators having truncated segments. This structure offers WLAN and UWB bands an operational bandwidth of 2.13–12.4 GHz. A U-shaped slot with the patch is designed using the center notch frequency of 3.7 GHz. WiMAX (3.2–4.2 GHz) interference band has been rejected by this U-shaped slot in patch [13].

Two miniature UWB antennas with partial ground plane and band-notches on microstrip feeding have been demonstrated in another work. To improve impedance bandwidth, especially at the upper frequency side ranging the (3.1–10.6 GHz) UWB range, the patch is designed as a semicircle with steps. To remove interference from the lower Wireless LAN band (5.15–5.35 GHz), two U-shaped inverted resonators, each having a half-wavelength electrical length, are inserted around the feedline. This prevents interference from the upper WLAN (5.7–5.8 GHz) band [14].

The demonstrated UWB antenna is a triple-band notched design with multi-type slots. The antenna is made up of a microstrip line for feeding, a four-step trapezoidal patch, three steps and a slit on a partial ground plane that modifies the impedance resulting in a 3–16.5 GHz bandwidth [15]. Using a Circular Split Ring Slot (CSRS) on a patch eliminates the 3.3–3.7 GHz band; another notched band for the X–band (7.5–8.5 GHz) has been created by connecting double strips to this CSRS; and an L-shaped slot on a segmental ground plane creates a stopband for the WLAN band (5.1-5.8 GHz). A steady group delay has been observed along with a peak gain of 6.5 dBi. Three half-wavelength resonators in combination with a single parasitic element above the ground plane suppress the 3.4 GHz –3.6 GHz (Wireless MAX), 5.15 GHz –5.39 GHz (lower Wireless LAN) and 5.75 GHz –5.96 GHz (higher Wireless LAN) bands [16].

A comprehensive investigation is performed on a slotted circular-shaped UWB that has three notched-band characteristics. In order to realize 3.6 GHz - 4.7 GHz for Wireless MAX, 5.6 GHz - 6.4 GHz for Wireless LAN and 8.4 GHz - 9.6 GHz for satellite communication in X-band communication services, three half-guided wavelength long notching components are etched on three slots. This slotted circular antenna is a useful competitor for UWB applications because of its improved matching of the simulated S11 features, good omnidirectional radiation patterns and high peak gain, except for three notched bands.

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Materials and Methods

Proposed antenna design

Figure 1 exhibits the detailed evolution of the suggested circular patch antenna. The top and bottom layers of this proposed modified circular-shaped UWB antenna are made of copper material and have been changed to provide an appropriate slot-inspired circular patch which is fed by a strip line feed to receive signals and a modified ground plane, respectively. The size of the full antenna measures 18 × 24 mm². The microstrip feeding has a width of 2.2 mm, resulting in a 50 Ω impedance.

Stage 1 gives a single narrow band at 5 GHz and a circular patch with a full ground plane (Figure 1(i)). Stage 2 comprises the etching of three modified rectangular slots in a circular patch (Figure 1(ii)), which improves the reflection coefficients |S11| and also increases bandwidth. The obtained bandwidth is 6.7 GHz with frequencies covering from 2.9 GHz to 9.7 GHz. To obtain higher frequencies, the ground plane is reduced to a semicircular form. The proposed antenna achieved good gain throughout the entire operating band. This slot-inspired modified circular-shaped antenna is shown in Figure 2. The optimum dimensions and values are listed in Table 1.

Results and Discussion

At the whole UWB band, the proposed antenna's reflection coefficient is investigated and simulated with CST Microwave Studio. Since the suggested antenna is almost exactly matched to a 50-Ω impedance, better impedance matching has been achieved and the reflection coefficient is -38.4 dB obtained at the bandwidth of 9.4 GHz (3.1 to 12.5 GHz) with an acceptable gain. Figure 3 displays the simulated reflection coefficient of the suggested antenna.

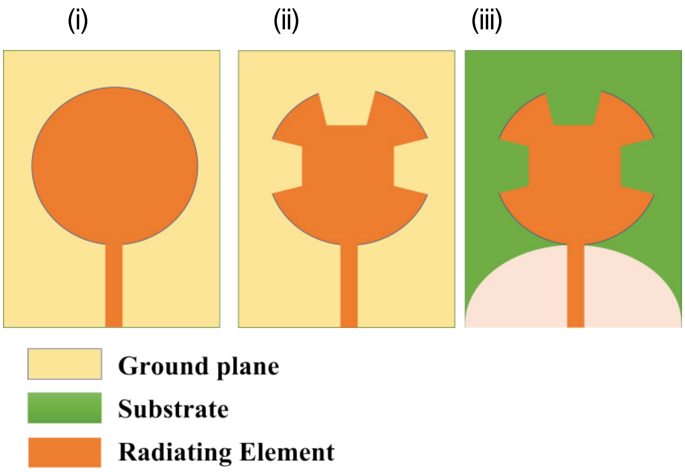

Figure 1. Parametric iterations of the proposed antenna at different stages.

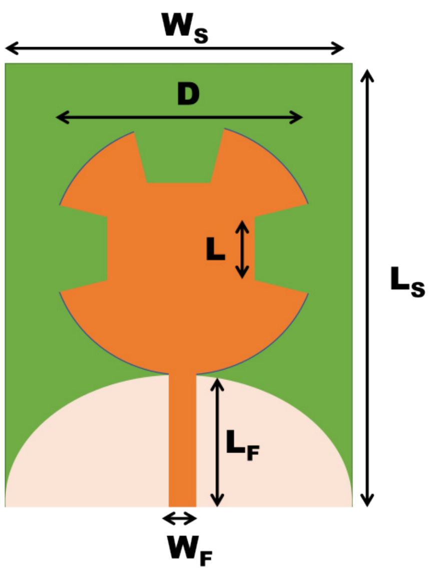

Figure 2. Total geometry and configuration of the proposed antenna.

Table 1. Parameter of the proposed antenna.

Parameter	Size (mm)	Parameter	Size (mm)
WS	18	L	3
LS	24	WF	2.2
D	14	LF	6.5

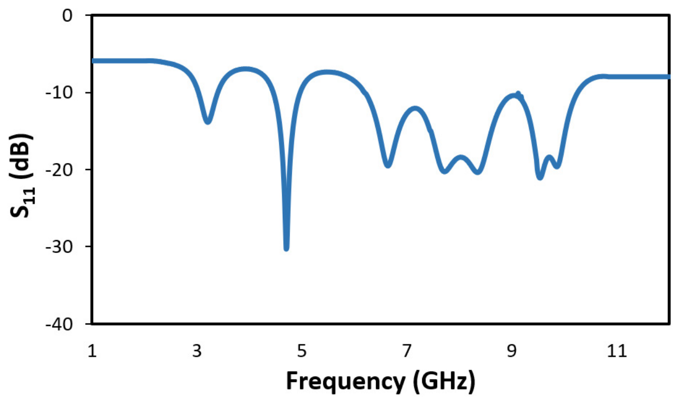

Figure 3. Simulated reflection coefficients of the proposed antenna.

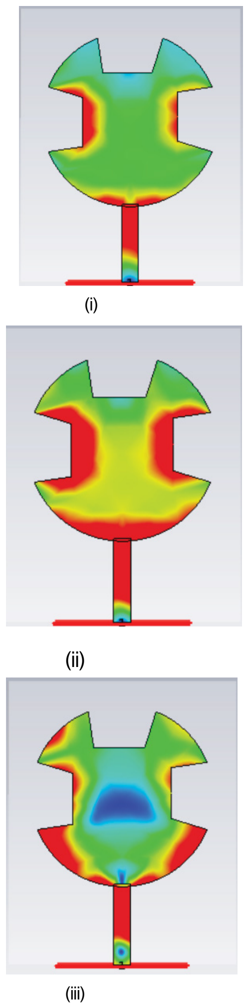

Figure 4. The analysed current density of the suggested circular patch antenna. **i)** 3.2 GHz **ii)** 7.2 GHz and **iii)** 10.2 GHz.

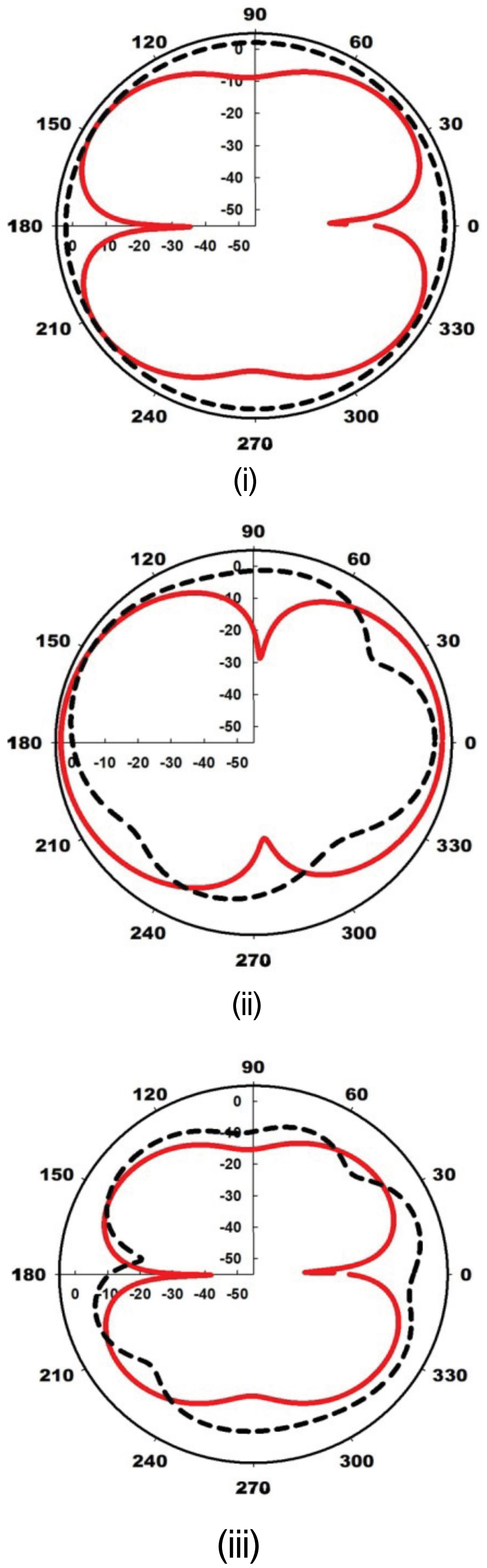

Figure 5. Simulated radiation patterns of the antenna. **i)** 3.2 GHz **ii)** 7.2 GHz and **iii)** 10.2 GHz.

Figure 4 illustrate the current distribution at each frequency to help in understanding the parameters of the this antenna. Because it can show the surface current distribution at 3.2, 7.2 and 10.2 GHz, respectively. Surface currents operating around the outer area of the rectangular slots and feed structure, which take up additional resonant frequencies, are responsible for the greater benefit about the greater electrical length of the slots. It has been proposed that this is the reason for the UWB characteristics. It is evident from Figure 4(i) that currents are mostly flowing through the patch's lower portion at lower frequencies. Figures 4(ii) and 4(iii) demonstrate the most significant distribution along the outer circular patch boundaries, which is responsible for the wider bandwidth at the centre and higher frequencies. The surface current distributions indicate that most of the current concentrates in the outside regions of the feed and patch.

The obtained radiation properties of this antenna are examined all over the full achieved UWB band. The resonant frequencies in the E- and H-planes, which have been chosen for 3.2 GHz, 7.2 GHz and 10.2 GHz are plotted in Figure 5 H and E planes of the antenna are displayed together to show the results. The antenna covers the whole frequency range with approximately bidirectional and omnidirectional E-plane and H-plane radiation patterns.

It is greater performance from the antenna across its operating frequencies. The suggested antenna achieved 3.6 dB gain and 82% maximum radiation efficiency at a higher frequency of 9.7 GHz. Therefore, this antenna is a good solution for UWB-notch applications because of its simple layout, small dimensions, improved gain and radiation efficiency.

Conclusion

The article provides a small, circular Monopole UWB antenna with three-notch bands. The antenna has been created using FR4-Lossy material. A semi-circular ground plane, three rectangular slots and a circular monopole antenna have been investigated as UWB characteristics. Complementary shape slots with discontinuities are incorporated to the circular patch to notch bands. It can be seen that two notch bands that include the frequency bands of 3.6–4.7 GHz for WiMAX, 5.6–6.4 GHz for WLAN and 8.4–9.6 GHz were developed with the addition of three slots in the circular patch. These notch bands will remove interference from the WiMAX and WLAN frequency bands.

Acknowledgement

None.

Conflict of Interest

None.

References

1. Arslan, Huseyin, Zhi Ning Chen and Maria-Gabriella Di Benedetto, eds. “Ultra wideband wireless communication.” John Wiley & Sons (2006).
2. Galvan-Tejada, Giselle M., Marco Antonio Peyrot-Solis and Hildeberto Jardón Aguilar. “Ultra wideband antennas: Design, methodologies and performance.” CRC Press (2017).
3. Guha, Debatosh and Yahia MM Antar, eds. “Microstrip and printed antennas: New trends, techniques and applications.'' John Wiley & Sons (2011).
4. Yazdandoost, K. Yekeh and Ryuji Kohno. “Ultra wideband antenna.” *IEEE Commun Mag* 42 (2004): S29-S32.
5. Awan, Wahaj A., Abir Zaidi, Niamat Hussain and Amjad Iqbal, et al. “Stub loaded, low profile UWB antenna with independently controllable notch-bands.” *Microw Opt Technol Lett* 61 (2019): 2447-2454.
6. Bong, Han-Ul, Minjoo Jeong, Niamat Hussain and Seung-Yeop Rhee, et al. “Design of an UWB antenna with two slits for 5G/WLAN-notched bands.” *Microw Opt Technol Lett* 61 (2019): 1295-1300.
7. Zheng, Xuemei and Tao Jiang. “Triple notches bandstop microstrip filter based on archimedean spiral electromagnetic bandgap structure.” Electronics 8 (2019): 964.
8. Naji, Dhirgham Kamal. “Miniature slotted semi-circular dual-band antenna for WiMAX and WLAN applications.” *J Electromagn Eng Sci* 20 (2020): 115-124.

9. Chinnasamy, Mohan, Esther Florence Sundarsingh and Priyadharshini Sankaran. "Design of a novel compact modified-circular printed antenna for high data rate wireless sensor networks." *J RF Microwave Comput Aided Eng* 30 (2020): e22375.

10. George, Neeba and B. Lethakumary. "A compact microstrip antenna for UWB applications." *Microw Opt Technol Lett* 57 (2015): 621-624.

11. Bekasiewicz, A. and S. Koziel. "Compact UWB monopole antenna for internet of things applications." *Electron Lett* 52 (2016): 492-494.

12. Sefidi, Moein, Yashar Zehforoosh and Shahram Moradi. "A novel monopole antenna for wireless communication systems and UWB application." *Microw Opt Technol Lett* 55 (2013): 1856-1860.

13. Priyadharshini, S. and C. Mohan. "Design of compact-circular monopole UWB antenna with dual notch bands." In 2019 1st ICIICT IEEE (2019): 1-5.

14. Tang, Zhi-jun, Jie Zhan, Zai-Fang Xi and Shi-Gang Wu, et al. "A compact triple band-notched UWB printed antenna with multistep patches integrated by multitype slots." *Microw Opt Technol Lett* 59 (2017): 270-275.

15. Arshed, Talha and Farooq A. Tahir. "A miniaturized triple band-notched UWB antenna." *Microw Opt Technol Lett* 59 (2017): 2581-2586.

16. Satyanarayana, Boya and Shivasharanappa Mulgi. "Design of planar band-notched monopole antenna for 2.4 GHz WLAN and UWB applications." *Microw Opt Technol Lett* 57 (2015): 2496-2501.

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