Medbiotech Journal

MBTJ, 1(4): 159-164, 2017

Research Paper

Directional UWB Microstrip Antenna for Radar Applications

A. A. Kalteh[1*], S. Nikmeh[2], Atila Eskandarnejad[1]

[1]Department of Electrical Engineering, Faculty of Engineering, Aliabad katoul branch, Islamic Azad University, Aliabad katoul, Iran (P. O Box: 14155-4933)

[2]Faculty of Electrical & Computer Engineering, University of Tabriz, Tabriz, Iran

Received: 13 September 2017 Accepted: 24 October 2017 Published: 01 December 2017

Abstract

The design and analysis of a directional microstrip ultra wideband antenna is presented. The proposed antenna consists of a circular ring exciting stub on the front side and a curved L-shaped ground plane. The curved L-shaped ground plane can simultaneously satisfy the requirement of impedance matching with 50-ohm transmission line and also give directivity. The proposed antenna is fabricated and measured. Measured results show that this antenna operates from 3 GHz to upper 9.35 GHz for voltage standing wave ratio less than 2. Moreover, the experimental results show that the proposed antenna exhibit low return loss, high directivity and flat gain in band of interest.

Keywords: Ultra-wideband Antennas; Microstrip Antenna; Radar Application

How to cite the article:
A. A. Kalteh, S. Nikmeh, Atila Eskandarnejad, Directional UWB Microstrip Antenna for Radar Applications, Medbiotech J. 2018; 1(4): 159-165, DOI: 10.22034/mbt.2017.87066

Introduction

Ultra-wideband (UWB) technology is now becoming widely used in a variety of applications such as radar, short-range communications and positioning systems. This is because this technology offers advantages of large channel capacity, multipath propagation performance and potential for ultralow-power implementation of transmitting-only devices. As is the case in conventional wireless communication systems, an antenna plays a crucial role in UWB systems. However, there are more challenges in designing a UWB antenna than a narrow band one. In particular, a suitable UWB antenna should be capable of operating over an ultra-wide bandwidth as allocated by the FCC, that is, 3.1–10.6 GHz. Recent UWB antenna research tends to focus on ultra compact planar antennas as they are more practical in terms of manufacturing, integration with the system electronic board and form factor. Typical configurations exhibit radiation similar to traditional monopole antennas with quasi-omni-directional patterns [1-3]. This feature is desirable for UWB communication systems, whereas it is a strong limitation in the case of radar applications [4]. In the past few years, several planar broadband monopole-like configurations have been reported for UWB applications [5,6]. None the less, very few efforts have been made to increase directionality of printed UWB antennas to be employed, for example, in radar applications [7].

In this article, we present a novel ultra-wideband microstrip antenna with highly directional radiation characteristics. The proposed directional antenna composed of circular ring resonator fed by a 50-Ohm microstrip line printed on a FR4 substrate. In order to increase both directivity and bandwidth of the antenna the shape of the ground plane is carefully designed for a UWB radar transceiver operating at a central frequency of 7.5GHz with more than 110 percent bandwidth. Performance simulations of the antenna were performed with Ansoft HFSS10.0 CST Microwave

* Corresponding Author Email: aziz_kalteh@ yahoo.com

Studio, which utilize numerical methods for electromagnetic computations. Designed antenna with optimal dimensions was fabricated and measured. An extensive comparison between experimental and simulation results is made, which demonstrates good agreement over approximately the entire operating frequency range.

The remaining of this article organized as follows: Section II presents the configuration of proposed antenna, the simulated and measured results are discussed in section III, and finally the conclusion is provided in section IV.

Antenna configuration

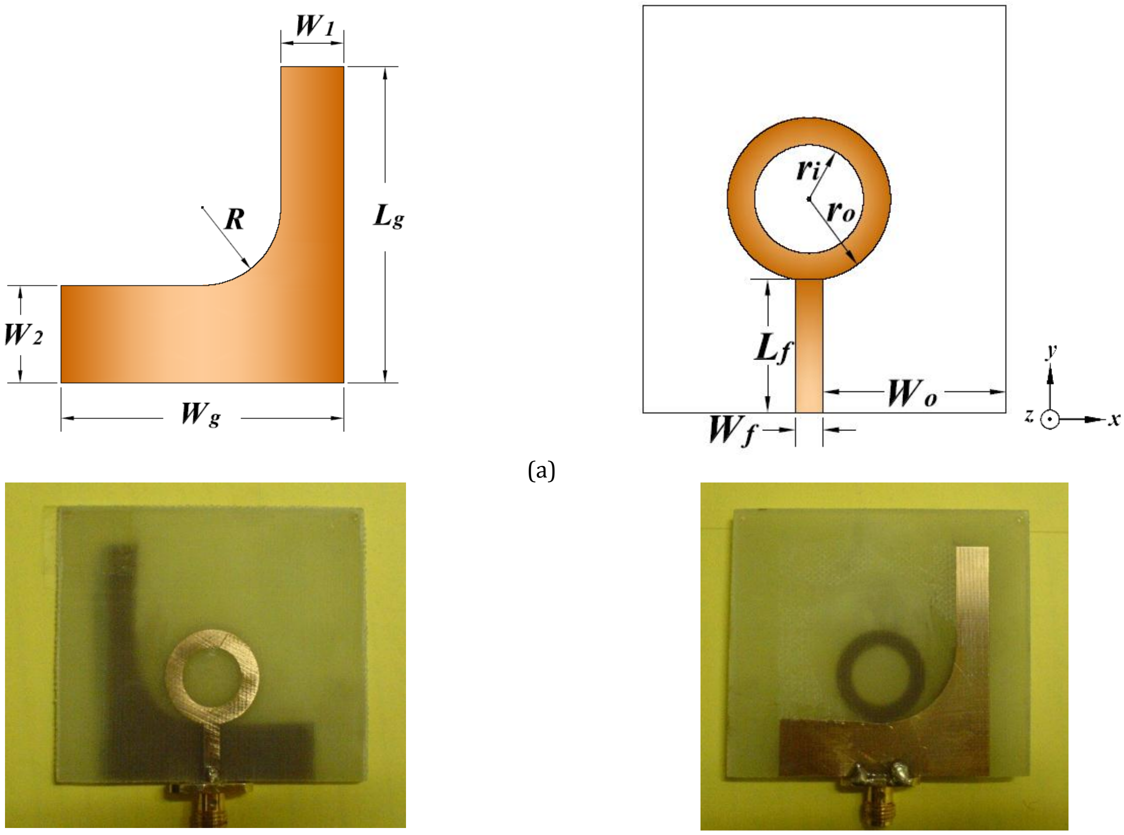
The geometry of the proposed directional UWB antenna is depicted in figure 1 along with its characterizing parameters. The antenna is located on the x-y plane and the normal direction is parallel to z-axis. The proposed antenna is fabricated on a dielectric substrate of FR4 epoxy substrate with relative permittivity (ε_r) of 4.4, thickness of 1.6 mm, and with dimensions $L_g \times W_g$ = 45 mm×40 mm. On one side of the board we have a 50-Ohm microstrip feeding line with W_f = 3mm, and a circular ring resonator with inner radius of r_i and outer radius of r_o that is centered in the nearly middle of the board. On the other side of the substrate we have an L-shaped ground plane with curved corner to achieve high directivity and wide band width (see figure. 1(a)).

Results and Discussion

The simulated and measured results of VSWR, radiation patterns, Directivity, Group delay and Phase variation of the proposed directional UWB antenna are presented in this section. The simulations were performed using Ansoft HFSS and CST Microwave Studio, which utilize numerical methods for electromagnetic computations. The VSWR and input impedance of antenna was measured by the Agilent 8722ES network analyzer and radiation characteristics measurements were performed in anechoic chamber at the antenna laboratory of Iran Research Institute for ICT (ITRC).

VSWR

The simulated and measured VSWR curves of the proposed directional UWB antenna, whose dimensions are given in Table I, are shown in figure. 2. This figure shows the simulated bandwidth of the proposed antenna for which VSWR ≤ 2.1 is from 2.4 GHz to greater than 10.6 GHz. The measured 3-dB bandwidth of fabricated antenna is from 3 GHz to greater than 9.35 GHz with VSWR ≤ 2. The correlation between the numerical and experimental results is considered to be excellent.



(a)

(b)

Figure 1. Geometry of proposed directional UWB antenna. (a) Schematic and, (b) photograph of fabricated antenna.

Table 1. Dimensions of the proposed directional UWB antenna.

Parameter	Value (mm)
W_g	40
L_g	45
R	11.1
W_1	8.9
W_2	13.9
W_o	21
W_f	3
L_f	14.3
r_i	6
r_o	9

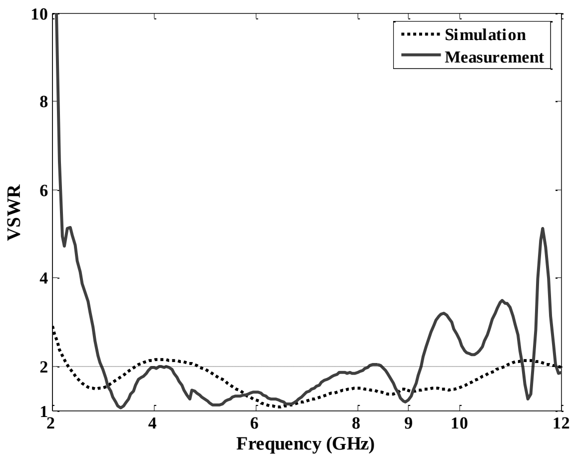


Figure 2. The VSWR response of the proposed directional UWB antenna with dimensions given in Table I.

Radiation Pattern and Directivity

The directivity curves of both conventional circular ring UWB monopole antenna and proposed directional UWB antenna are depicted in figure 3. This is a clear signature of the increased directivity of the antenna with structured ground plane. It is clear that, in the case of the conventional circular ring monopole directivity is slightly oscillating around 3.7 dBi, whereas the introduction of an L-shaped ground plane with curved corner nearly permits to double the directivity, with small variation around the value of 6.3 dBi in the band of interest.

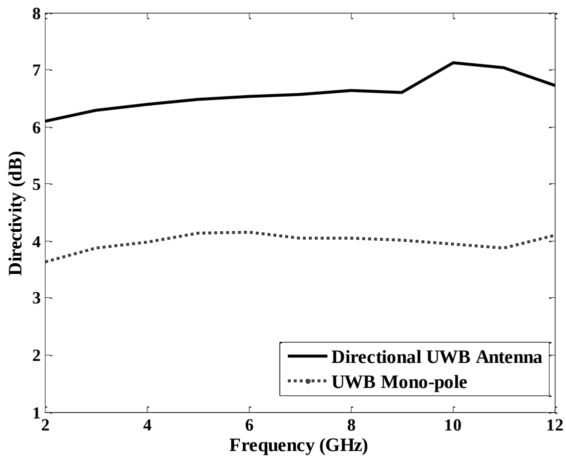
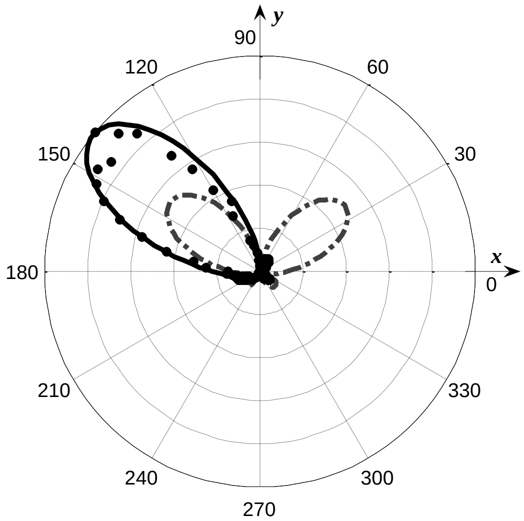


Figure 3. Antenna directivity of conventional UWB monopole (dotted line) and proposed directional UWB antenna.

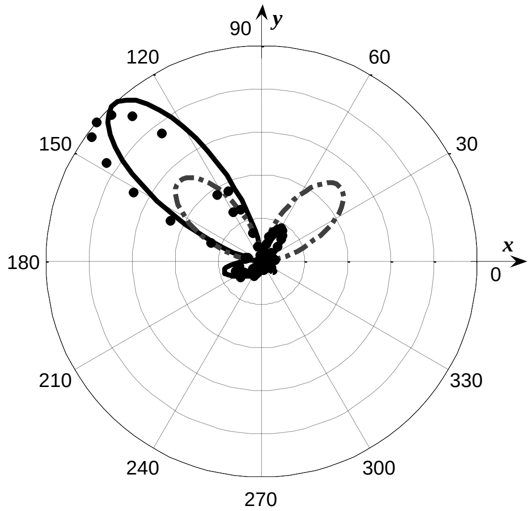
The measured and simulated radiation patterns of the proposed directional UWB antenna in the xy-plane are shown in figure 4 at three different spot frequencies, that is, 5.5, 7.5 and 8.5 GHz. By comparison of radiation patterns for conventional circular ring monopole and proposed directional antenna, it is straightforward to note that the conventional circular ring monopole has two radiation lobes around 45 and 135 degrees from the x-axis, whereas in the case of proposed directional UWB antenna with corner curved L-shaped ground plane the lobe at 45 degrees is suppressed, and the magnitude of the other lobe is increased. The agreement between the measured and simulated radiation patterns is very good.

Time-Domain Characteristics

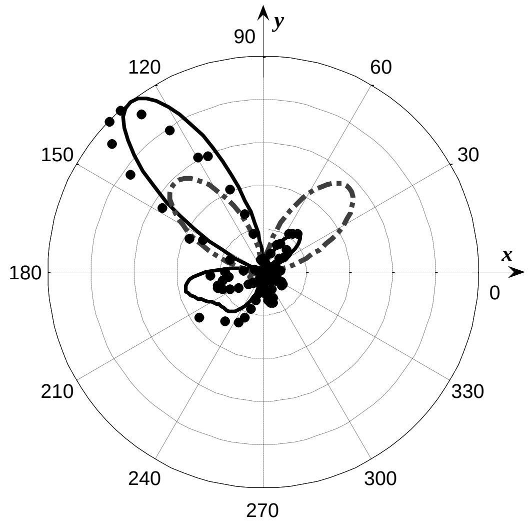
Apart from the consideration of the 10 dB return loss bandwidth and radiation pattern, as studied in the previous section, a good impulse response, i.e., time domain characteristic, is an essential requirement for an UWB antenna. To studding the time domain behavior of the proposed UWB antenna, one pair of this antenna in two different orientations, namely face to face and side by side, as shown in figure 5, is investigated. One of them plays as transmitter antenna (RX) and other plays as receiver antenna (TX). The phase of S_{21} and group delay of UWB antenna system is investigated here. Ideally, a linear phase response (constant group delay) is desirable.



(a) f= 5.5 GHz

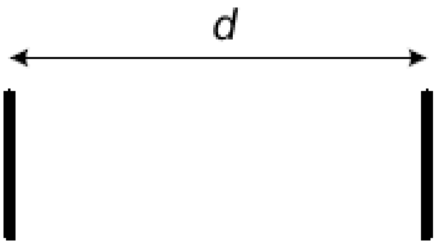


(b) f= 7.5 GHz

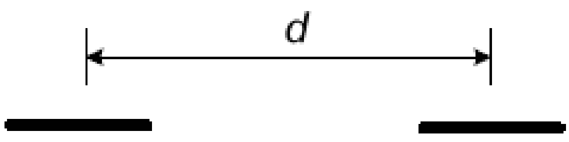


(c) f= 8.5 GHz

Figure 4. Simulated radiation pattern of the proposed directional UWB antenna (solid line) and of the conventional circular ring UWB monopole (dash-dotted line) in the x-y plane at three different spot frequencies. The measured radiation pattern of the proposed antenna represented with black circles. Results are reported in linear scale.

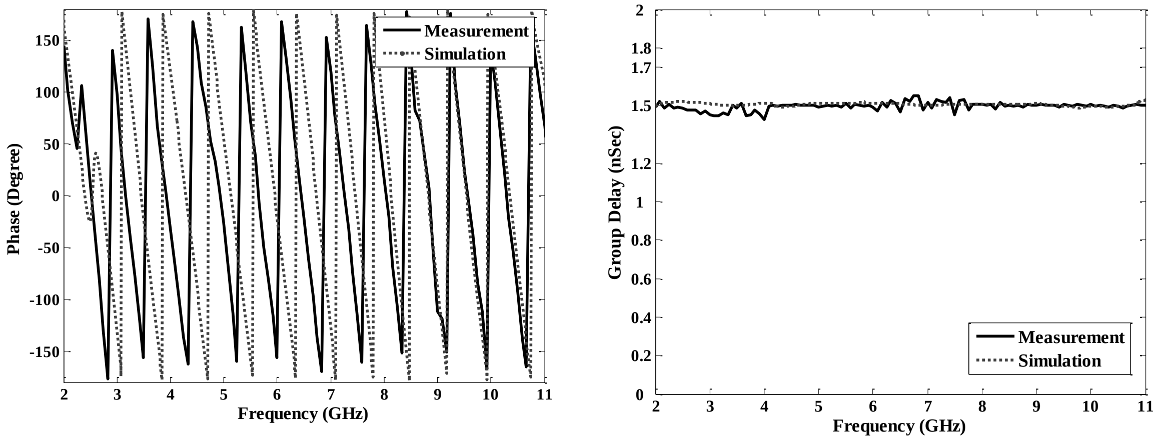


(a) face-to-face



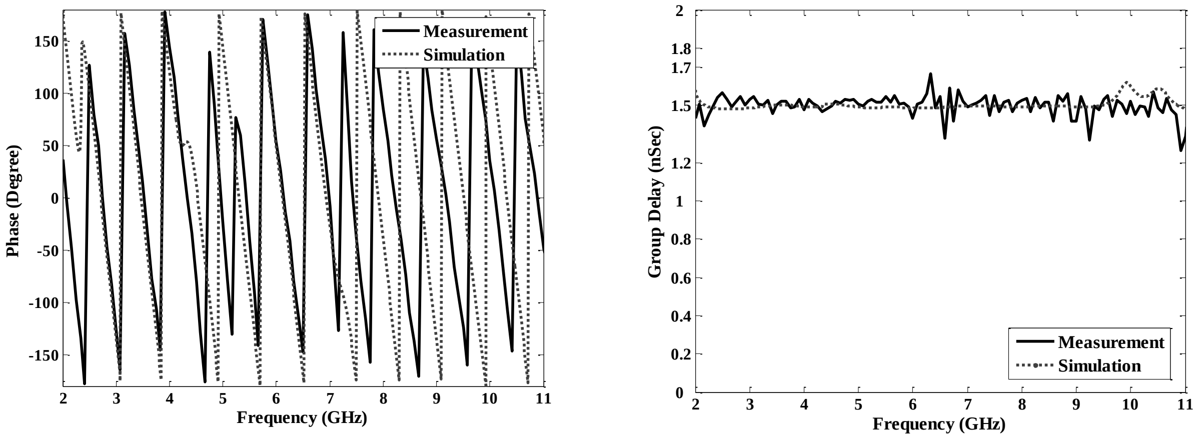
(b) side-by-side

Figure 5. Antenna orientations for time domain measurements.



(a) (b)

Figure 6. The simulated and measured (a) phase of transfer function, and (b) group delay of proposed Directional UWB antenna system at face-to-face orientation.



(a) (b)

Figure 7. The simulated and measured (a) phase of transfer function, and (b) group delay of proposed directional UWB antenna system at side-by-side orientation.

For group delay and phase measurement two identical directional UWB antennas with separation of 30cm exited using an Agilent 8722ES Network Analyzer.

The simulated and measured phase curves of the transfer functions for both face to face and side by side cases are depicted in figures 6 and 7. As shown in these figures, they are nearly linear over an ultra wide frequency range from about 3 GHz to upper than 10 GHz. The simulated and measured group delays for the two orientations, as given in figures 6 and 7, are quite stable with variation less than 0.2 ns within the frequency range from 3 GHz to 10 GHz, which corresponds well to the phase curves of the transfer functions.

Conclusion

A directional ultra-wideband antenna with highly directional radiation characteristics has been proposed and fabricated. Here, an L-shaped ground plane with curved corner is introduced in antenna structure to achieve high directivity and wide band width. The measurements show that VSWR is below 2 within the desired frequency bandwidth from 3 GHz to greater than 9.35 GHz. The stable directional radiation patterns and flat directivity in the UWB band are obtained. The time-domain behavior of proposed UWB antenna in two different orientations has been investigated, also. The linear phase variation and quite stable group delay over an ultra wide frequency range from about 3 GHz to upper than 10 GHz are obtained. Accordingly, the proposed antenna is expected to be a good candidate in various UWB radar systems.

Acknowledgment

The authors are thankful to Aliabad Katoul Branch Islamic Azad University and Iran Telecommunication Research Center (ITRC) for bracing this research.

References

1. Telzhensky, N. Leviathan. 2006. Novel method of UWB antenna optimization for specified input

signal forms by means of genetic algorithm. *IEEE Transactions on Antennas and Propagation* 54(8): 2216–2225.
2. Moghadasi, N., M. DadashZadeh, G. R. Kalteh, A. A. Virdee. 2010. Design of a novel band-notched slot patch antenna for UWB communication systems. Microw. *Opt. Technol. Lett.* 52(7): 1599–1603.
3. Fallahi, R., A. A. Kalteh, M. G. Roozbahani. 2008. A novel UWB elliptical slot antenna with band-notched characteristics. *Progress in Electromagnetics Research* 82: 127-136.
4. Li, X., S. C. Hagness, M. K. Choi, D. van der Weide. 2003. Numerical and experimental investigation of an ultra-wideband ridged pyramidal horn antenna with curved launching plane for pulse radiation. *IEEE Antennas Wireless Propag. Lett.* 2: 259-262.
5. Kim, J., T. Yoon, J. Kim, J. Choi. 2005. Design of an ultra-wideband printed monopole antenna using FDTD and genetic algorithm. *IEEE Microwave Wireless Compon. Lett.* 15: 395-397.
6. Liang, J. X., C. C. Chian, X. D. Chen, C. G. Parini. 2005. Study of a printed circular disc monopole antenna for UWB systems. *IEEE Transactions on Antennas and Propagation* vol. 53: 3500-3504.
7. Klemm, M., I. Z. Kovacs, G. F. Pedersen, G. Troster. 2005. Novel smallsize directional antenna for UWB WBAN/WPAN applications. *IEEE Transactions on Antennas and Propagation* 53: 3884-3896.