UWB Monopole Antenna with Compact Polygon-Shaped Patch for Portable Devices

T. Sedghi [1], V. Rafii [2], and M. Moosazadeh [1]

[1] Department of Electrical Engineering, Urmia Branch, Islamic Azad University, Urmia, Iran

[2] Young Researchers and Elite Club, Urmia Branch, Islamic Azad University, Urmia, Iran
sedghi.tohid@gmail.com, vhdrafiei@gmail.com

Abstract **─** In this paper, a small ultra wideband (UWB) antenna with co-planar waveguide (CPW) feed, consisting of a polygon-shaped design on the patch and a ground plane truncated with two mirror rectangular–shaped notches is designed for ultra wideband (UWB) applications. In this proposed antenna, through increasing the number of cuts inside the initial patch, a proper control on the upper frequency of the band can be achieved. The overall dimension of the antenna is 19×19 ×1 mm^3 and fed by 50 Ω coplanar waveguide. The proposed antenna is developed and its VSWR is compared with the simulated result. The proposed antenna operates in the adopted bandwidth (3.1 GHz-10.6 GHz) with VSWR < 2, and covers it very well from 3 GHz to 14.9 GHz, which provides fractional bandwidths of more than 132%. The effect of the ground plane notch on the optimization of the VSWR is discussed in detail.

Index Terms - CPW-fed, small monopole antenna, truncated ground plane, and ultra wideband (UWB) antenna.

I. INTRODUCTION

The requirement for high data rates wireless communication becomes more and more vital and various solutions have been recommended. With the rapid development of these wireless systems, the design of the UWB antennas has been given lots of concentration, since they are the key elements to radiate and receive the signals [1]. There have been great progresses in the design of ultra wideband antennas and devices in recent years. Several impedance variation techniques are applied to previous works such as [2-4], wide rectangular slots and circular slots with hexagonal forms [2]. One of the major challenges in the design of ultra wideband antennas is how to achieve small size antennas with low weight and desired radiation pattern characteristics and electrical properties in the band of interest [3]. The numerous number of slots causes to more bandwidth and the optimum feed structure gives the good impedance matching [4]. Recently, some coplanar waveguide (CPW)-fed printed monopole antenna have been reported [5-11].

In this letter the polygon-shaped form on the patch has been used for increasing impedance bandwidth and better impedance matching. By using this design and the numerous numbers of cuts inside the patch the impedance matching is increased. Proposed antenna is designed with a mirror of rectangular-shaped slots on the ground plane, so impedance matching is desirable due to both these slots. The antenna has outstanding properties such as small size, desirable VSWR level, simple structure, and good omni-directional radiation pattern.

II. MONOPOLE ANTENNA DESIGN

The geometry of the CPW-fed antenna is shown in Fig. 1. The antenna is constructed with a substrate made of FR4, with the thickness of 1 mm and the relative dielectric constant ε_r = 4.4. The CPW feed-line has a center width W_c =2.4 mm and a g_c = 0.3 mm for 50 Ω impedance. A polygon-shaped patch with the radius of R is connected to the rectangular – shaped patch with width of W_p. For the impedance matching, the

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distance between the patch and the CPW- ground plane is indicated with a Gap = L_c - L. For increasing the upper frequency band, a pair of mirror rectangular-shaped notches is located on the ground plane. In most of the reported antennas so far, the slots on the patch are designed horizontally and vertically in the form of different geometric shapes. In this proposed antenna, for increasing the path of surface current, we use some cuts on the patch, which results in both the production of additional resonance and an increase in the bandwidth. The simulated results are obtained using the Ansoft simulation software high-frequency structure simulator (HFSS). The optimal parameters of the constructed antenna are as follows: W_{sub} = 19 mm, L_{sub} = 19 mm, R = 8 mm, NC = 10, W_p = 4 mm, L_c = 2.8 mm, g_c = 0.3 mm, W_c = 2.4 mm, L = 1 mm, and Gap = 0.4 mm.

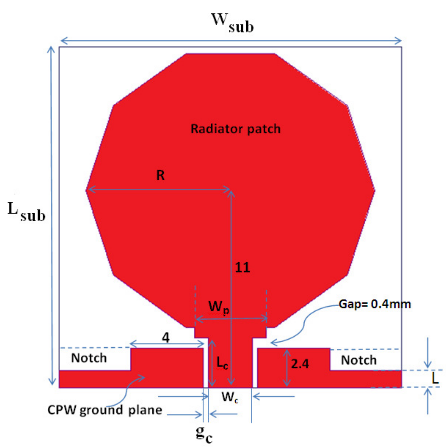

Fig. 1. Configuration of the proposed antenna with a pair of rectangular-shape notches on the ground plane and a polygon-shaped design on the patch.

III. SIMULATION AND MEASUREMENT RESULTS

After introducing the proposed antenna, we investigate the difference value of L, W_p, L_c, and NC parameters. With fixed value of R, we investigate the effective NC (number of cut) parameter. Figure 2 indicates the simulated VSWR characteristics with the difference values for NC. This figure clearly shows that sensitivity of upper frequency band in Fig. 2 is more. In other words, with increasing of NC, upper frequency band increases widely. In this simulation, the optimized value of 10 for the NC (number of cut) has been selected. Figure 3 indicates the simulated VSWR characteristics with the difference values for L. It can be observed that by decreasing the length of the L notch, the upper frequency is increased. The CPW ground plane plays an important role in the proposed antenna impedance matching. Figure 4 shows the simulated VSWR curves with difference values for W_p, while R is fixed in 8 mm. With doing several experiments, Wp is fixed in 4 mm. Figure 5 indicates distribution of currents at 10 GHz for polygon-shaped form. This figure shows that by inserting numbers of cuts around patch, currents are regularly concentrated around this polygon form. The printed monopole antenna, whose physical prototype is shown in Fig. 6, was tested in the antenna measurement laboratory at Iran Telecommunication Research Center (ITRC). The simulated and measured VSWR of the proposed antenna is plotted in Fig. 7. The figure clearly shows that the constructed antenna very well covers the intended VSWR of < -10 dB for 3.1 GHz - 10.6 GHz from 3 GHz to 14.9 GHz. Also, it is obvious that a little difference occurred between the two curves results in the position of resonance about 9 GHz, which is caused by SMA port effects in laboratory.

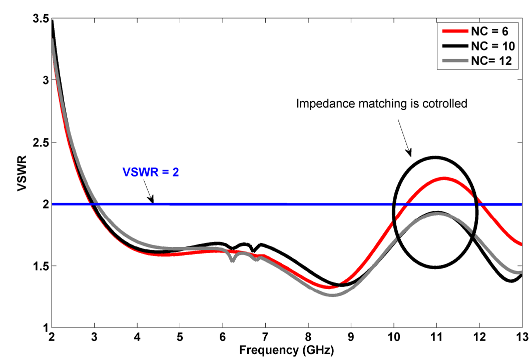

Fig. 2. Simulated VSWR characteristics for various values of NC.

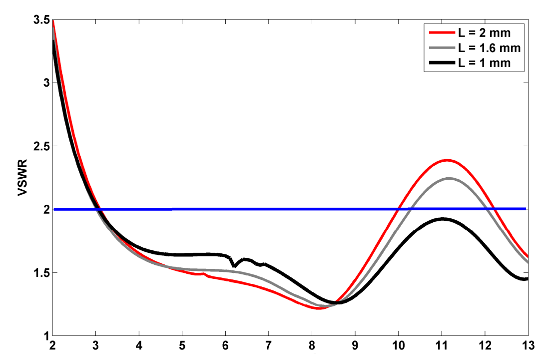

Fig. 3. Simulated VSWR characteristics of the proposed antenna with various values of L.

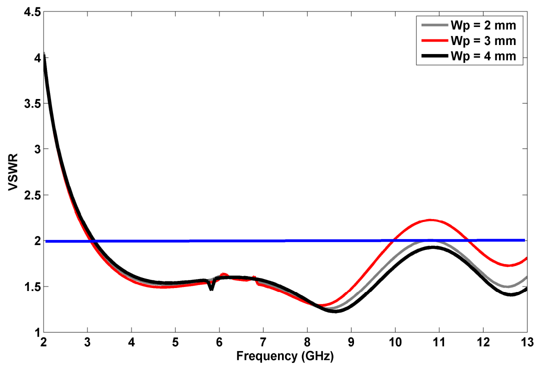

Fig. 4. Simulated VSWR characteristics of the proposed antenna with various values of Wp (L in 1 mm and NC in 10 is fixed).

Figure 8 shows the measured antenna gain from 3 GHz to 11 GHz for the proposed antenna. From this figure, we can find that, in different frequencies, the whole tendency of the antenna gains enhance with the frequency increases from 3 GHz to 11 GHz. Figure 9 shows the measured radiation pattern in frequencies 3.5 GHz, 5.5 GHz, 7.5 GHz, and 9.5 GHz, in H-plane (xz-plane), and E-plane (yz-plane). From Fig. 9 it can be realized that the proposed antenna acts similarly as a printed monopole antennas in the middle and lower frequency bands. Also, the figure is approximately indicative of omni-directional radiation pattern in the xz-plane.

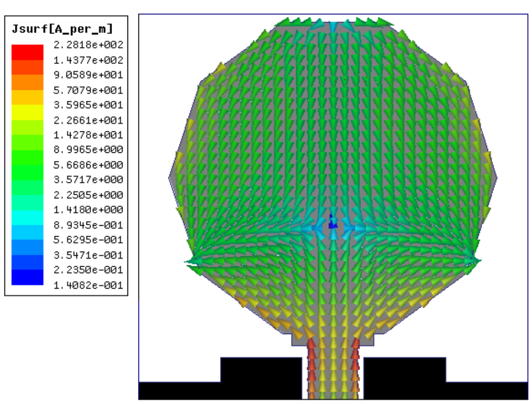

Fig. 5. Simulated current distributions on the patch with polygon-shaped form at 10 GHz.

IV. CONCLUSION

In this study, a small CPW-fed antenna with a polygon-shaped design with the numbers of cuts around the patch is proposed for ultra wideband (UWB) applications. This antenna has been designed with equal cuts on the circular patch and generating a polygon-shaped form and also a pair of mirror rectangular-shaped notches in the CPW ground plane. By inserting the numbers of cuts around the patch, we can achieve a proper control on the upper frequencies of the band. The antenna exhibits a simple structure and good VSWR level. Proposed antenna is suitable for ultra wideband systems with proper dimensions and aforementioned characteristics.

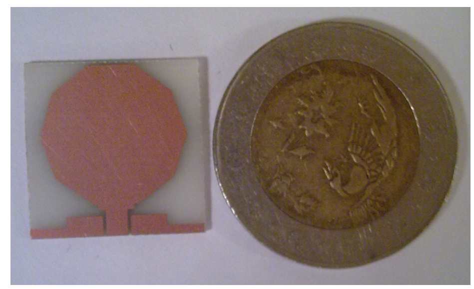

Fig. 6. Photograph of the proposed antenna.

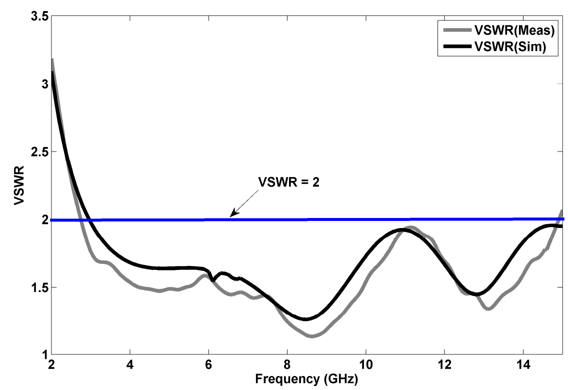

Fig. 7. Comparison between measured and simulated VSWR for the proposed antenna.

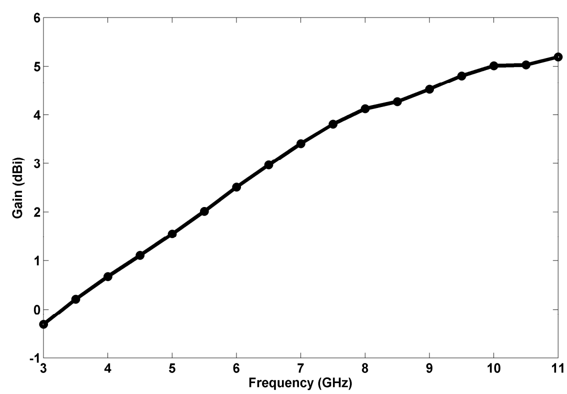

Fig. 8. Measured antenna gain of the proposed antenna.

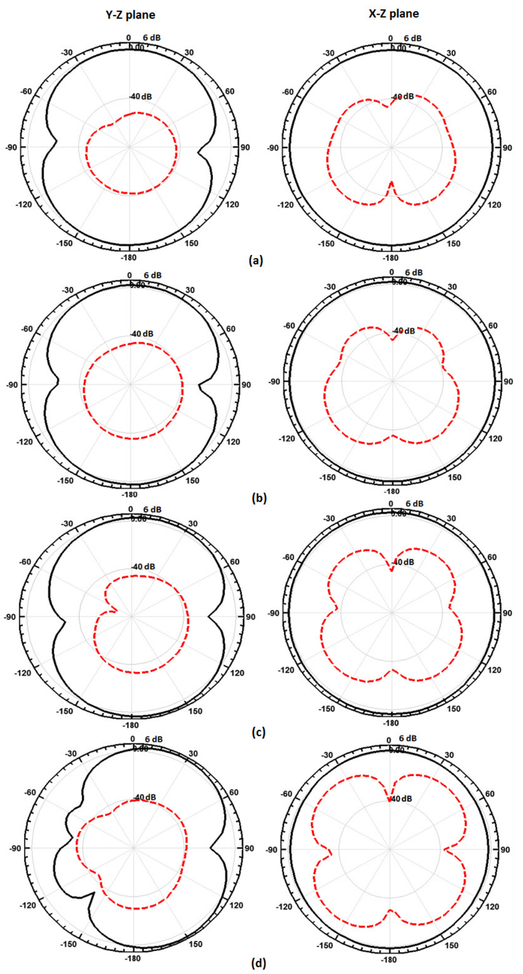

Fig. 9. Measured radiation pattern of the proposed antenna, (a) 3.5 GHz, (b) 5.5 GHz, (c) 7.5 GHz, and (d) 9.5 GHz. The solid line and red dash line are co-polar and cross-polar, respectively.

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Tohid Sedghi received the B.S degree in Electronic Engineering from IAU, Urmia Branch, Urmia, Iran, in 2007. He graduated from M.Sc. in Electrical Engineering at University of Urmia, Iran in 2009. Now he is working toward Ph.D. He is the author or coauthor of several refereed journal articles and conference papers. His research interests include, antenna miniaturization, optimization, method, monopole antennas, slot antennas, hybrid antennas, circular polarization antennas, diversity antennas, mobile phone and wireless local-area net work antennas, and antenna applications.

Vahid Rafii was born in Urmia, Iran, in 1986. He received the B.Sc. degree in Communication Engineering from the Urmia Azad University, in 2008 and M.Sc. degree in Communication Engineering from Urmia University, Urmia, Iran, in 2013. His research interests include antenna array, array feed networks, and their antenna applications.

Mahdi Moosazadeh received the B.Sc. degree in Electronic Engineering from IAU, Urmia Branch, Urmia, Iran, in 2005. He graduated from M.Sc. in Electrical Engineering at IAU, science research branch, Tehran, Iran in 2008. Now he is working toward Ph.D. His research interests include, monopole antennas, slot antennas, circular polarization antennas, diversity antennas, mobile phone and metamaterials.