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A PLANAR MONOPOLE UWB ANTENNAS WITH ROUNDED PATCH AND GROUND PLANE POSSESSING IMPROVED IMPEDANCE MATCHING

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ABSTRACT: *A planar monopole UWB antenna with rounded patch and rounded truncated ground plane for ultra-wideband applications is investigated. The geometry of the antenna is optimized to obtain a minimum return loss. The antenna provides the return loss better than −15 dB in almost the entire (3.1–10.6) GHz frequency band and good radiation characteristics. The simulated and experimental results are in a good agreement.* © 2011 Wiley Periodicals, Inc. Microwave Opt Technol Lett 54:335–338, 2012; View this article online at wileyonlinelibrary.com. DOI 10.1002/mop.26544

Key words: *planar monopole microstrip-fed antenna; truncated ground plane; ultra-wideband antenna*

1. INTRODUCTION

With the establishment by the Federal Communication Commission of the frequency band from 3.1 to 10.6 GHz for commercial ultra-wideband (UWB) systems in 2002 [1], great efforts have been dedicated to the development of more suitable antennas for portable applications [2–4]. Providing high data transmission rates with ultra low power spectral densities for short range communications, the UWB technology can be used in a wide range of wireless applications such as in personal area network, in connecting printed circuit (PC) peripherals, etc. [5, 6].

Planar monopole antennas are very suitable for UWB applications due to their simple structures, wide operating bandwidth, satisfactory radiation properties, easy fabrication and integration with printed circuit boards, low cost, and lightweight [3, 5–9]. An interesting variant of such antennas is presented in Ref. 2, where the antenna consists of a rectangular truncated ground plane and a circular patch printed on a dielectric substrate.

One of the important characteristics of the antennas is their impedance matching with the feeding line. The low

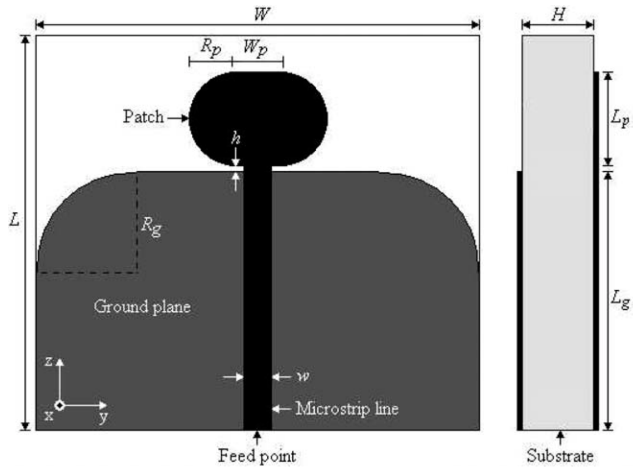

Figure 1 Geometry of the proposed UWB antenna

return loss of the antennas is very desirable as this provides higher tolerances in the fabrication process and allows one to mitigate the environment influences such as the installation box, nearby printed circuit boards and other electromagnetic components.

In this article, we suggest and analyze a planar monopole antenna similar to that presented in Ref. 2. The main difference is the geometry of the patch and the ground plane which in our case have rounded corners (Fig. 1). Because of high concentration of currents in the corners, these simple geometrical modifications followed by parametric optimization allowed us to diminish the return loss from −10 dB for the original antenna [2] to −15 dB for our variant in almost (3.1–10.6) GHz frequency band. Thus we improved significantly the impedance matching of the antenna and the feeding microstrip line. Notice that the suggested here method is efficient also for other types of planar UWB antennas as we have shown earlier [10]. In electromagnetic simulations, we used the commercial software CST MWS [11].

2. ANTENNA DESCRIPTION

The analyzed antenna (Fig. 1) is printed on the substrate with the dielectric permittivity $\varepsilon = 2.55$ and the loss

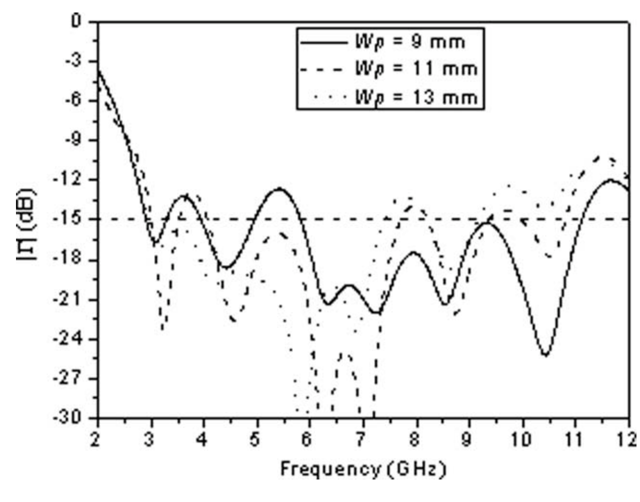

Figure 2 Simulated returns loss for different W_p parameters, $R_g = 18$, $h = 0.2$ mm

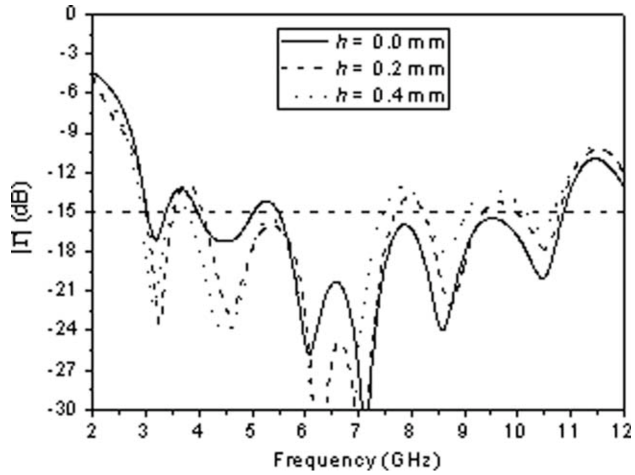

Figure 3 Simulated returns loss for different h parameters, $R_g = 18$, $W_p = 11$ mm

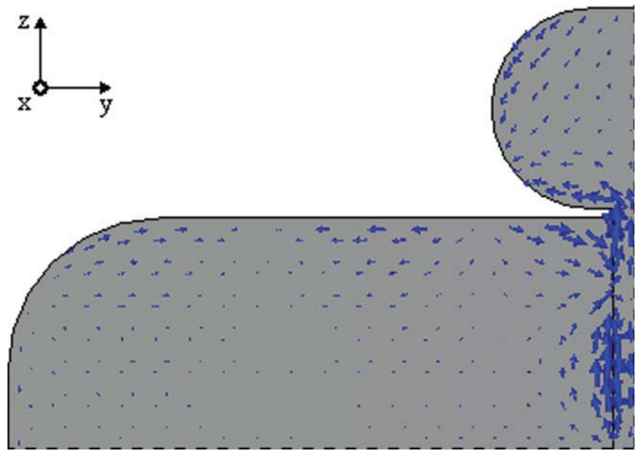

Figure 5 Surface current distribution at 7 GHz. [Color figure can be viewed in the online issue, which is available at wileyonlinelibrary.com]

tangent tg $\delta = 0.0022$. The dimensions of the substrate are L and W and its thickness is H. The antenna is composed of two radiation elements: the patch and the truncated ground plane. The patch is fed by 50-Ω microstrip line on one side of the dielectric substrate. The truncated ground plane is on the other side. The patch is formed by a rectangle of dimensions W_p and L_p, and two semi-circles of the radius R_p. The truncated ground plane is $L_g \times W$ of area. The rounded corners of metallization in the ground plane are one-quarter of a circumference with the radius R_g (notice that $R_g = 0$ corresponds to the rectangular corners). The parameter h represents the feed gap between the patch and the truncated ground plane. During the optimization process, the parameters $L = 70$, $L_g = 50$, $W = 90$, $R_p = 8$, $L_p = 16$, $w = 4.6$, and $H = 1.524$ mm were fixed while the parameters W_p, R_g, and h were optimized.

3. PARAMETRIC OPTIMIZATION

The return loss curves for some values of the parameters R_g, W_p, and h which greatly affect the antenna characteristics are shown in Figures 2–4 to illustrate the optimization process. In the simulations, the coaxial microstrip line connector SMA was considered.

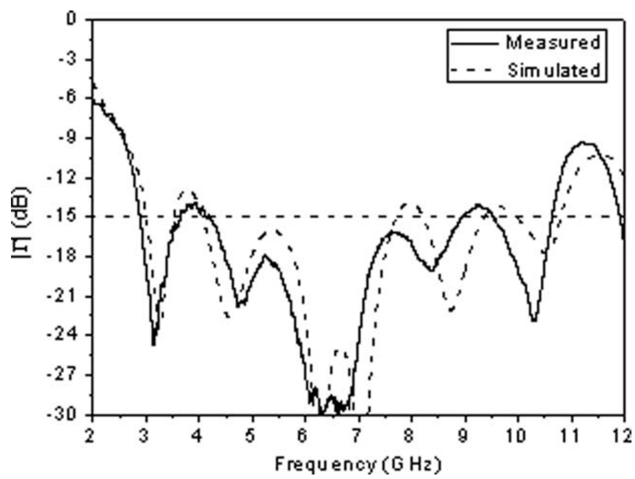

Figure 4 Simulated and measured antenna returns loss for optimized antenna

3.1. Return Loss

During the optimization process, we discovered that the return loss |Γ| is decreased (mainly at high frequencies) when the corner radius R_g of the ground plane is increased from 0 to 18 mm. For values of R_g larger than 18 mm, the return loss is not improved significantly, therefore we have chosen the parameter $R_g = 18$ mm as the optimum value.

In Figure 2, we show the returns loss curves for three different values of the parameter W_p with $R_g = 18$ mm and $h = 0.2$ mm fixed. When the parameter W_p is increased from 9 to 13 mm, the input impedance matching is improved significantly in the region of the second and the third resonances. We have chosen $W_p = 11$ mm as the optimum value.

We present in Figure 3 the returns loss curves for different values of the parameter h. One can see that for the chosen $R_g = 18$ mm and $W_p = 11$ mm, the better choice of the parameter h is 0.2 mm.

Figure 4 shows the simulated (dotted line) and measured (solid line) returns loss of the optimized antenna with $R_g = 18$, $W_p = 11$, and $h = 0.2$ mm. It can be seen from this figure that the return loss of both simulated and measured curves are below −15 dB practically in the entire UWB frequencies from 3.1 to 10.6 GHz. Notice that in the published results [2], the return loss is at the level of −10 dB. The simulated results agree well with the experimental ones.

3.2. Surface Current Distribution

The surface current distribution of the proposed antenna at frequency 7 GHz is shown in Figure 5. It can be seen that there is a significant concentration of the current in the rounded parts of the patch and of the ground plane. Thus, the cuts of the corners of the ground plane and of the patch are mainly responsible for the great improvement in the impedance matching of the antenna.

3.3. Radiation Patterns and Gain

The radiation patterns of the proposed antenna were simulated in the x–y and y–z planes and measured in the x–y plane at 4, 7, and 10 GHz, as shown in Figures 6(a)–6(f). Because of the operational difficulties as setting of the coaxial cable and SNA connector when they are attached in the prototype, it

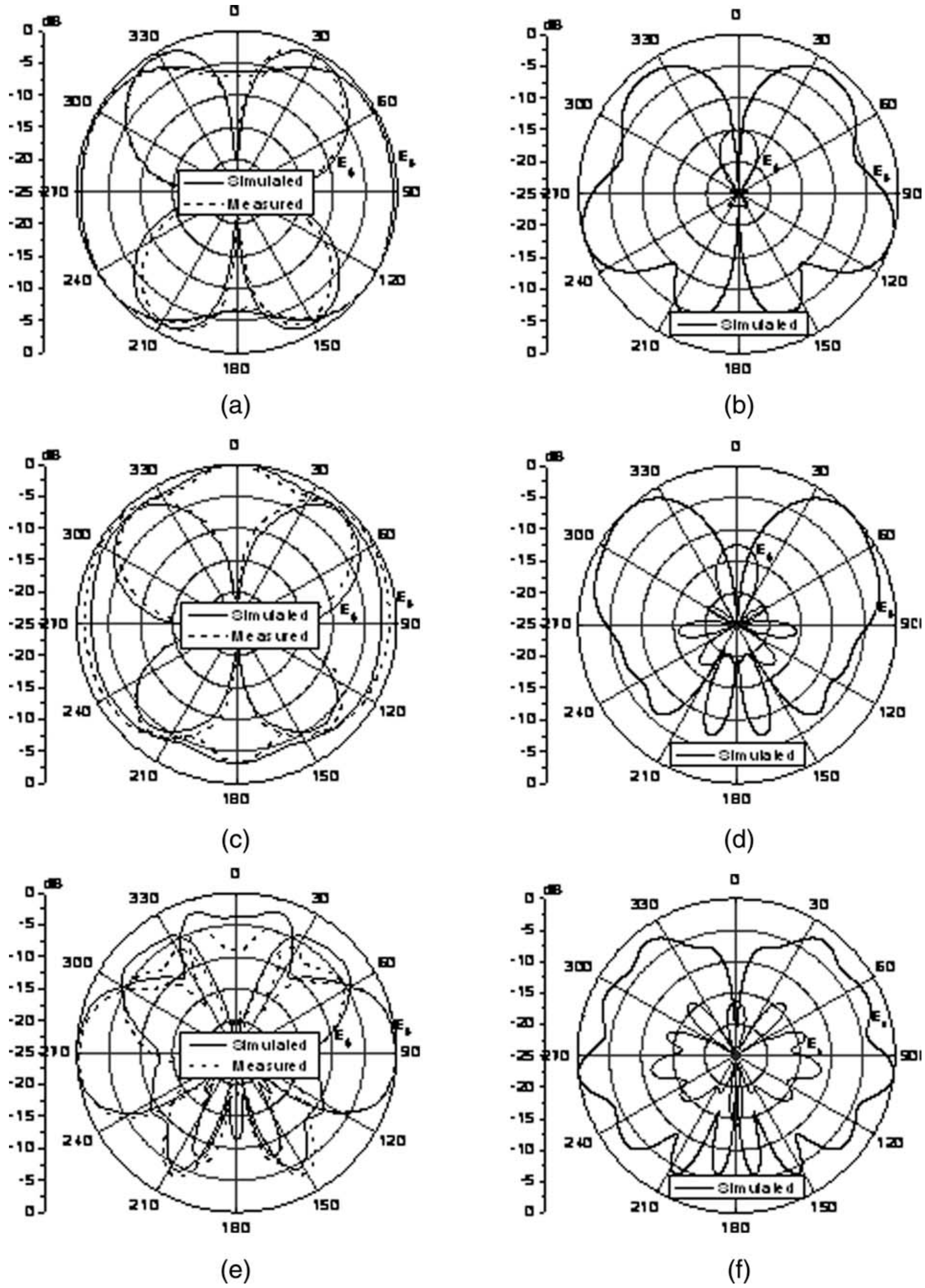

Figure 6 Radiation patterns at 4, 7, and 10 GHz for *x–y* and *y–z* planes

was not possible to measure the radiation patterns in the *y–z* plane. The antenna has an omnidirectional pattern in the *H*-plane *x–y* [Figs. 6(a), 6(c), and 6(e)], and dipole-like radiation patterns in the *E*-plane *y–z* [Figs. 6(b), 6(d), and 6(f)]. When the frequency is increased over 10 GHz, the radiation patterns characteristics become distorted in both *x–y* and *y–z* planes, as shown in Figures 6(e) and 6(f). A good agreement is achieved between the simulated and the experimental radiation pattern characteristics.

The simulated gain of the optimized antenna computed in the *y*-direction is shown in Figure 7. Excluding the range of frequencies of 4–5 GHz and 7–9 GHz where the gain is around −3.5 and −0.5 dBi, respectively, the simulated gain is about 0 dBi with the maximums in the upper and lower parts of the UWB region. These variations are typical for these types of UWB antennas.

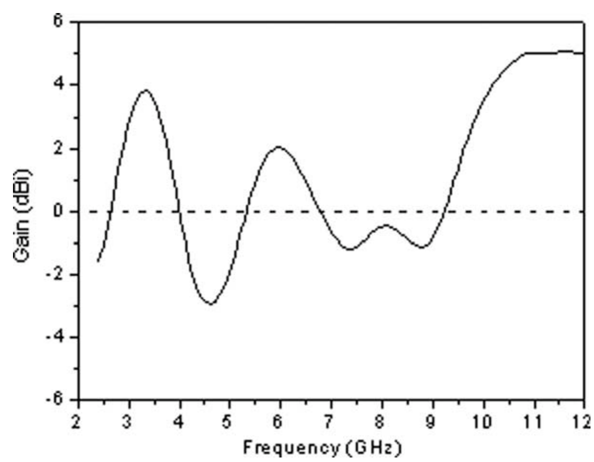

Figure 7 Simulated antenna gain in the *y*-direction

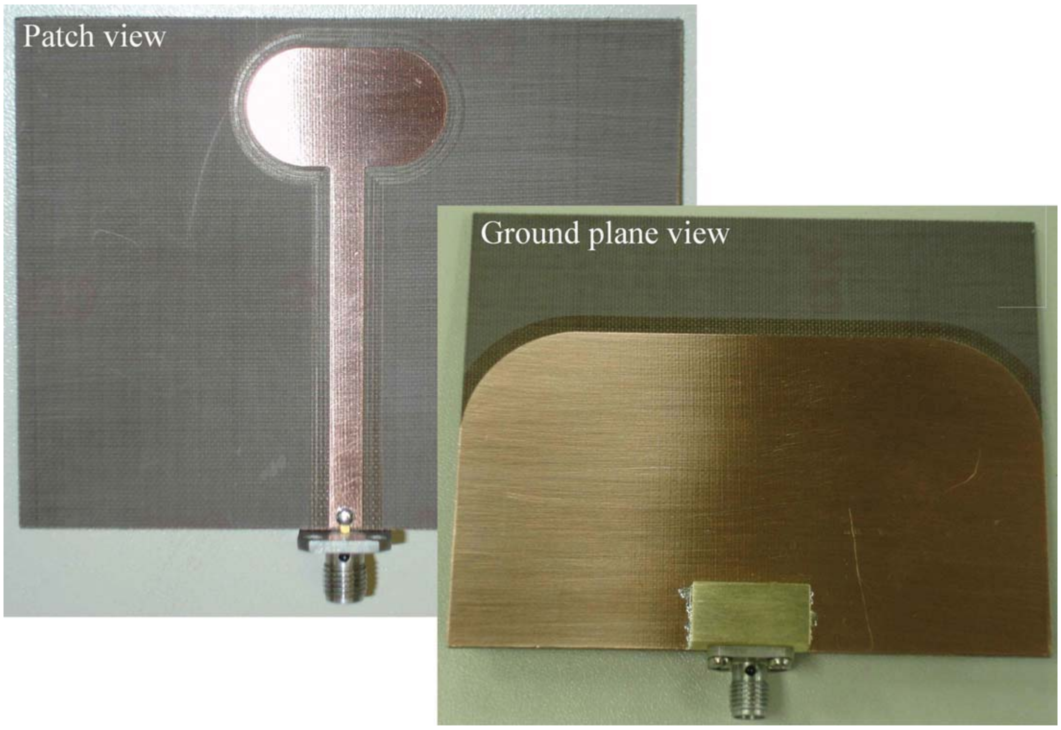

Figure 8 Top and bottom view photos of the constructed prototype. [Color figure can be viewed in the online issue, which is available at wileyonlinelibrary.com]

The top and bottom view photos of the constructed prototype are shown in Figure 8. The return loss and radiation pattern measurements were made in an anechoic chamber with Agilent PNA N5230A network analyzer.

4. CONCLUSIONS

A planar monopole UWB antenna with rounded patch and rounded truncated ground plane was investigated. It was shown that the level of the return loss of the antenna can be improved significantly by using the rounded patch and rounded ground plane and optimizing the feed gap h, and the other two geometrical parameters R_g and W_p. The proposed antenna has return loss around of -15 dB in the entire UWB frequency band. The radiation patterns of the antenna are nearly omnidirectional in the x–y plane and dipole-like in the y–z plane for frequencies at 4 and 7 GHz. In the ends of range frequency, over 10 GHz, these radiation patterns characteristics are distorted in both x–y and y–z planes.

The calculated variation of the antenna gain is acceptable for UWB application. A good agreement is achieved between the simulated and the experimental results. The low level of the return loss -15 dB of the antenna can mitigate tolerances in the fabrication and environment influences such as the installation box, nearby printed circuit boards and other electromagnetic components.

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