A monopole antenna with rounded patch and slot for UWB applications

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***Abstract*—In this paper, three monopole antennas for ultra-wideband applications are analyzed and compared. They consist of a rounded patch and a rounded slot in the grounded plane, with the patch in one side of the substrate and a square ground plane with slot in the other. The antennas are fed with a 50Ω microstrip-line. One of the optimized antennas has return loss S_{11} less than about -13dB in the frequency band from 3.1 to 10.6GHz.**

***Keywords*—Ultra-wideband (UWB) antenna, planar monopole microstrip-fed antenna.**

I. INTRODUCTION

Ultra-wideband (UWB) technology has attracted much attention recently because of the high data transmission rates and low power radiation. This technology is adequate for short range applications such as wireless personal area networks. In UWB system, one of challenging issues is the design of small-size antennas while providing wide bandwidth, omnidirectional radiation pattern and flat gain in all range of operating frequencies band, [1]. Planar monopole antennas are preferable due to their low cost, light weight, ease fabrication, and omnidirectional radiation pattern [1]-[9]. In particular, rectangular [9], [10] and circular disc monopole antennas [2]-[7] have been widely studied because of their simple structure. The monopoles antennas are fed by coplanar waveguide (CPW) [2], [8] or microstrip lines [1]-[7], [9]-[10].

In this paper, wide-slot monopole antennas by 50Ω microstrip-line feeding for UWB applications are considered. Three different shapes of the antenna, shown in Fig. 1 and Fig. 2, were investigated. The patch and the slot have a same rounded geometry. The antenna with the shape 2 (circular) was discussed earlier in [6]. The new geometries, shapes 1 and 3, suggested in our work are modifications of the known antenna with the circular shape. The antennas were optimized in terms of input return loss bandwidth by varying some of the geometrical parameters. The simulations were carried out by CST Microwave Studio [11].

II. ANTENNA DESIGN

The proposed wide-slot monopole antennas are designed on a double printed circuit substrate with the patch on one side and the square ground plane with a slot on the other, as shown in Fig. 2. The size of the square substrate and the ground plane is $L \times W$. The rounded patch is described by the parameters L_{in} and R_{in} and the rounded slot by L_{out} and R_{out}. The substrate has the thickness h and the width of the microstrip-line feeding for achieve 50Ω characteristic impedance is w. The space between the rounded patch and slotted ground plane, the feed gap is g. The dielectric constant of the substrate is unchanged in 3.38. In the simulations, the parameters $L = W = 100$mm, $h = 1.524$mm and $w = 3.5$mm were fixed while the others, namely, L_{in}, R_{in}, L_{out}, R_{out} and g, were used as optimization parameters. The optimized parameters are shown in Table I.

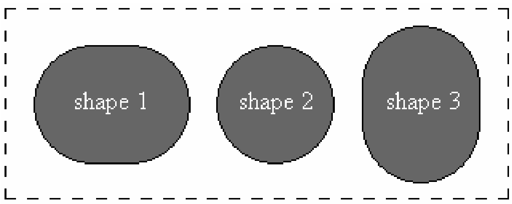


Fig. 1 Three different configurations of the radiation patch and slot structures.

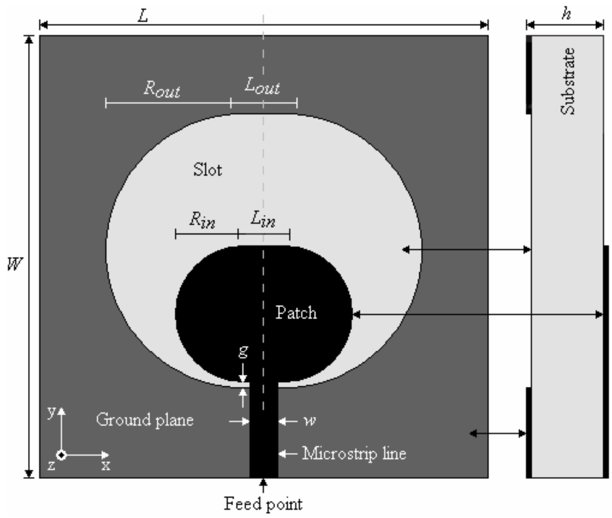


Fig. 2 Geometry of the wide-slot monopole antenna.

III. RESULTS

In Fig. 3 we show the curves of return losses versus frequency for the discussed antennas. The optimized geometrical parameters are shown in Table I. When the parameters $L_{in} = L_{out} = 0$ (shape 2) it means that the patch and the grounded plane are of circular outline. The antenna with shape 2 has the same characteristics presented in [6]. As it can be seen, the return loss of the antenna with shape 1 is lower than that for antennas with shapes 2 and 3 within the entire operating band. The difference is about -3dB. The low return loss of the antenna is very desirable since this gives more tolerances to fabrication deviations and environment influences such as the installation box and nearby printed circuit board and other electromagnetic components.

TABLE I
GEOMETRICAL PARAMETERS OF THE ANTENNAS INVESTIGATED

Parameters	L_{in}	R_{in}	L_{out}	R_{out}	g
shape 1 (mm)	6	5.5	6	13.5	0.5
shape 2 (mm)	0	7.5	0	14.963	0.225
shape 3 (mm)	6	5.5	6	13.5	0.5

Two possible explanations of the best performance of the antenna of shape 1 are as follows. Firstly, the capacitive coupling between the edges of the patch and the slot is stronger for antenna of shape 1. This compensates the inductive nature of the small patch which has a length shorter than one quarter of the wavelength at the upper edge of the operating band. The second factor is that the larger radiators normally result in the larger bandwidth.

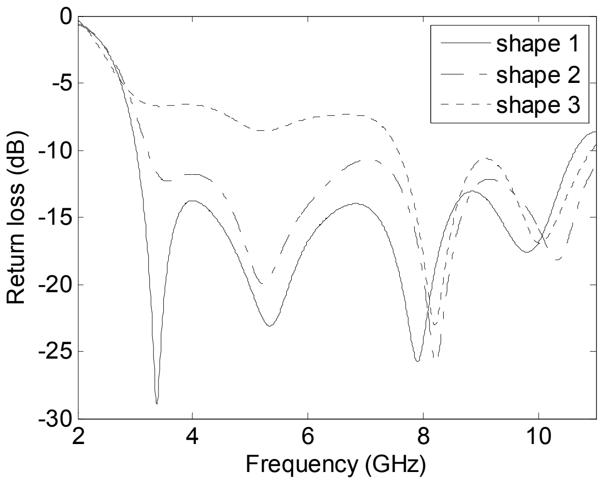
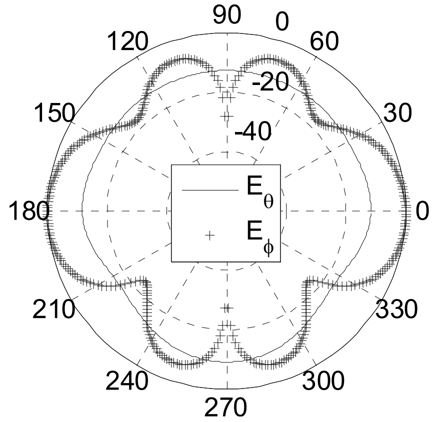


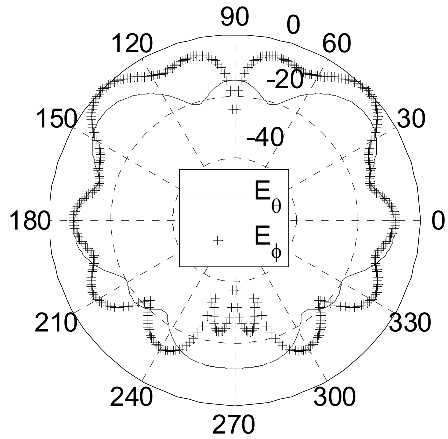
Fig.3 Return loss versus frequency of the antennas.

From our simulation results, the radiation patterns of antennas of shapes 1 and 2 have very similar characteristics, therefore, we will analyse only the radiation patterns of the proposed configuration (shape 1) in the following. In Fig. 4, the radiation patterns of the proposed configuration (shape 1) are shown for the x-y and x-z planes at 4, 7, and 10 GHz. In the x-y plane, Figs. 4(a) to 4(c), it can be seen that the number of deep attenuation directions and the oscillations are increased with frequency. In the x-z plane, Fig. 4(d) to 4(e), the antenna has a near omnidirectional pattern of the E_ϕ component and a dipole like pattern of the E_θ component at 4 GHz. As the frequency is increased these characteristics are distorted since the electrical length of the antenna is increased.

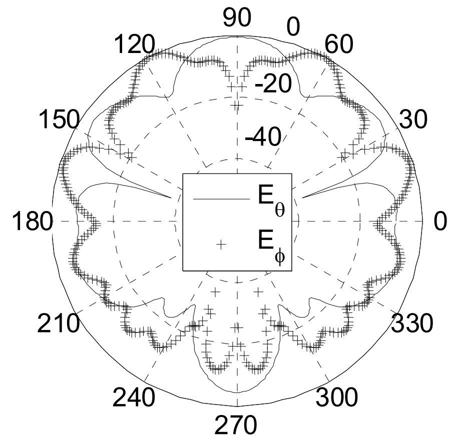
Fig. 5 shows the simulated gain of the optimized antenna (shape 1) in the direction θ = 45° (x-z plane). We can see, that the curve of antenna gain decreases from 4.5dBi (maximum gain) at around of middle frequency (7GHz) to -3.5dBi at 9GHz. At the end of frequency band the gain goes up to 2dBi.



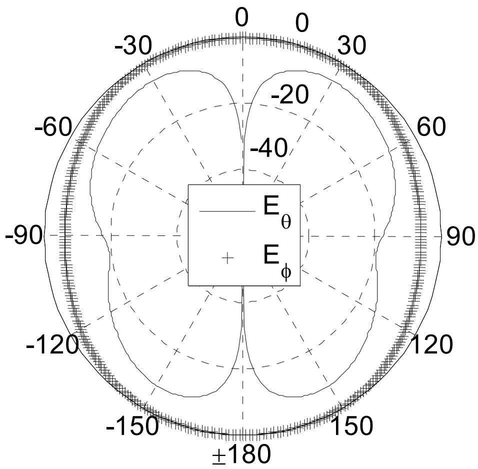
a) x-y at 4GHz



(b) x-y at 7GHz



(c) x-y at 10GHz



(d) x-z at 4GHz

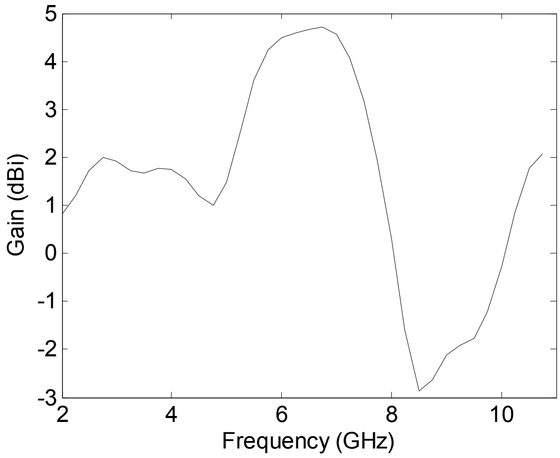
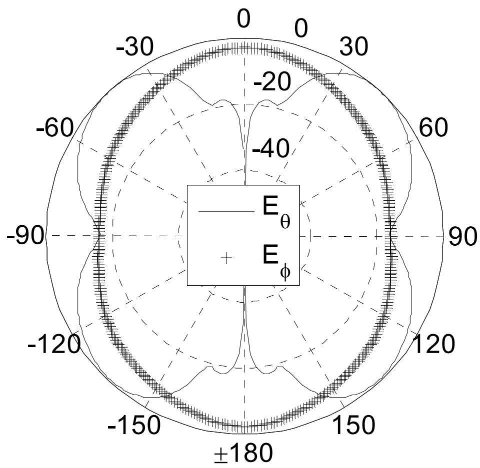
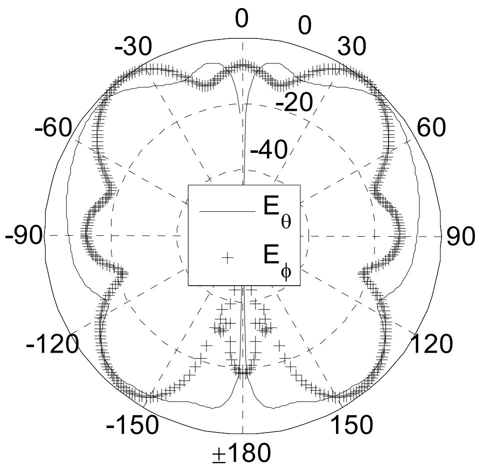


Fig. 5 Gain of the optimized antenna in the direction θ = 45° (x-z plane).



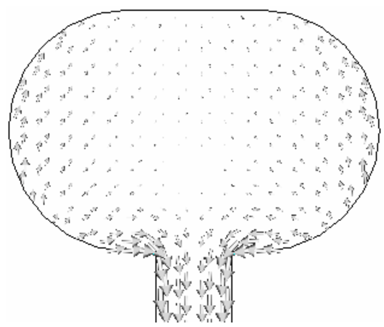
(e) x-z at 7GHz



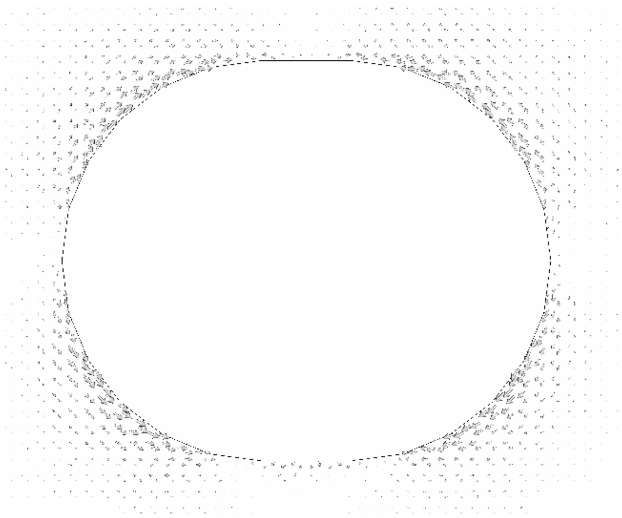
(e) x-z at 10GHz

Fig. 4 Radiation patterns of the optimized antenna (shape1) in the planes x-z and y-z at 4, 7, and 10GHz.

It is observed from Fig. 6 that the current is concentrated mainly on the edges of the patch and the slot. For frequencies higher than 7GHz, the slot has an electrical length greater than one wavelength which is responsible for the presence of various lobes in the radiation patterns.



(a)



(b)

Fig. 6 Current distribution at 7GHz on the patch (a) and near the edges of the slot (b) in logarithm scale.

IV. Conclusions

New geometries of wide-slot monopole antennas for UWB applications were investigated. They antennas consist of a rounded patch and a rounded slot in the grounded plane, with the patch in on side and a square ground plane with a slot in the other. The antenna is fed by a 50Ω microstrip-line. The optimized configuration has the bandwidth in all UWB frequency range with return loss less than -13dB which is better than published in the literature for circular antenna. The radiation pattern characteristics of this antenna are practically the same as those of the known one. The gain has a variation of about 7.5dBi within the entire operating band which is suitable for the UWB applications.

Acknowledgment

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