A Printed Elliptical Disc Monopole Antenna for UWB Communications

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1. Introduction

There is a growing need for broadband antennas which can satisfy the entire frequency range of future ultra wideband (UWB) systems with a reasonable performance. Most UWB applications require an antenna with the following features: a light weight, a low profile, relatively low cost and easy to manufacture. It has been reported that a circular disc monopole antenna has a very large impedance bandwidth [1-4]. However, it also seems that the circular disc monopole antenna is not particularly easy to integrate into handsets or mobile terminal cases.

In this paper, a novel wideband printed monopole antenna which has an elliptical disc radiator fed by microstrip line is proposed. The characteristics of the antenna are evaluated by experiments and computer simulations based on the FDTD method. It is shown that bandwidth of VSWR ≤ 2 can be achieved over the FCC approved UWB frequency range of 3.1 to 10.6 GHz.

2. Antenna Design

Figure 1 shows the geometry of the printed elliptical disc monopole antenna on a dielectric substrate (thickness = 0.8 mm, $\varepsilon_r = 2.25$). An elliptical radiator connected with a microstrip line is on the top surface of a dielectric substrate and a rectangular ground is on the bottom surface. The diameter of the elliptic radiator in the y direction is fixed at $a = 50$ mm, and the diameter b in the z direction is varied for different ellipticity ratios. The feed gap d_f is the width between the lower edge of the elliptic radiator and the upper edge of the ground. The other edge of the microstrip line is connected by a 50 Ω coaxial cable through a SMA connector.

3. Numerical and Experimental Results

Figures 2 (a) and (b) show the calculated VSWR characteristics of the printed circular disc monopole antenna when $d_f = -1$ mm to 0 and $d_f = 0$ to 1 mm, respectively ($a = b = 50$ mm). In the case of $d_f \leq 0$, a part of the elliptical radiator laps over the ground. As the feed gap d_f increases, the VSWR increases near the frequencies of 5 GHz and 11 GHz and decreases near the near the frequencies of 3

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GHz and 7 GHz. These figures show that the feed gap $d_f = 0$ gives a maximum bandwidth for VSWR ≤ 2.

Figure 3 shows the calculated and measured VSWR characteristics of the printed elliptical disc monopole antenna for the frequency range of 0 to 20 GHz (a = 50 mm, b = 40 mm, $d_f = 0$). It can be seen that the calculated data agree almost exactly with the measured data in the frequency range lower than 11 GHz. Furthermore, the measured VSWR ≤ 2 is obtained in the frequency range from 1.7 to 15.4 GHz, which corresponds to a bandwidth ratio of 1 : 9.1.

The antennas for five different ellipticity ratios of radiator were fabricated and experiments were then carried out. The dimensions and measured VSWR bandwidths in the frequency range of 1 to 20 GHz are summarized in Table 1. The maximum bandwidth ration of 1 : 11.3 is obtained for the circular disc monopole antenna ($a = b$ = 50mm, $d_f = 0$). It is observed that the higher edge of the frequency bandwidth increases as the diameter b of the elliptical radiator increases.

Figures 4 (a) and (b) respectively show the calculated current distributions on the top surface of the printed circular disc monopole antenna at frequencies of 3 GHz and 10 GHz ($a = b$ = 50mm, $d_f = 0$). The magnitude of current is seen to be strong at edge of the circular radiator at both frequencies.

Figures 5 and 6 show the measured results of radiation patterns for the printed circular disc monopole antenna at 3 GHz and 10 GHz, respectively ($a = b$ = 50mm, $d_f = 0$). As indicated in Figure 5, the radiation patterns are similar to those of the monopole antenna on the finite ground plane. It is found that the E_ϕ level is very low at frequency of 3 GHz. On the other hand, it can be seen that the E_ϕ level increased at a frequency of 10 GHz from Figure 6.

4. Conclusion

In this paper, a novel printed disc monopole antenna has been proposed. This low profile antenna had an elliptical disc radiator fed by microstrip line. Both computed and measured results have been presented. The bandwidth for VSWR ≤ 2 has been obtained for the frequency band between 1.5 to 17.0 GHz, which corresponds to a bandwidth ratio of 1 : 11.3.

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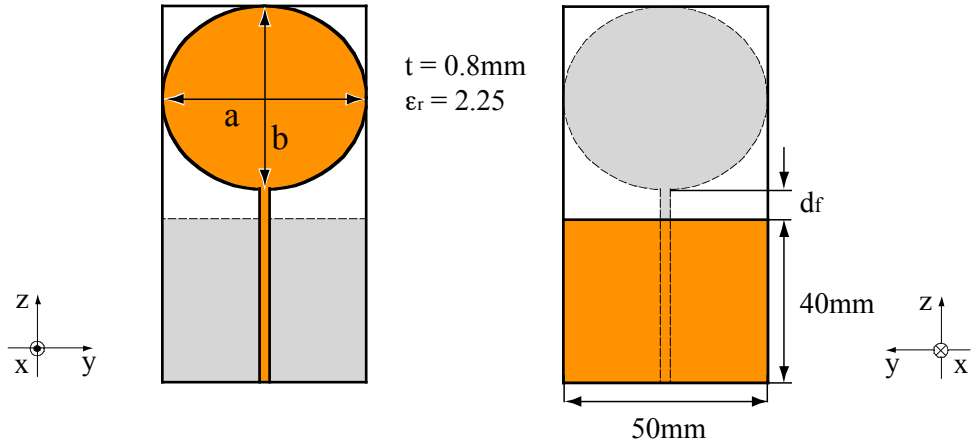
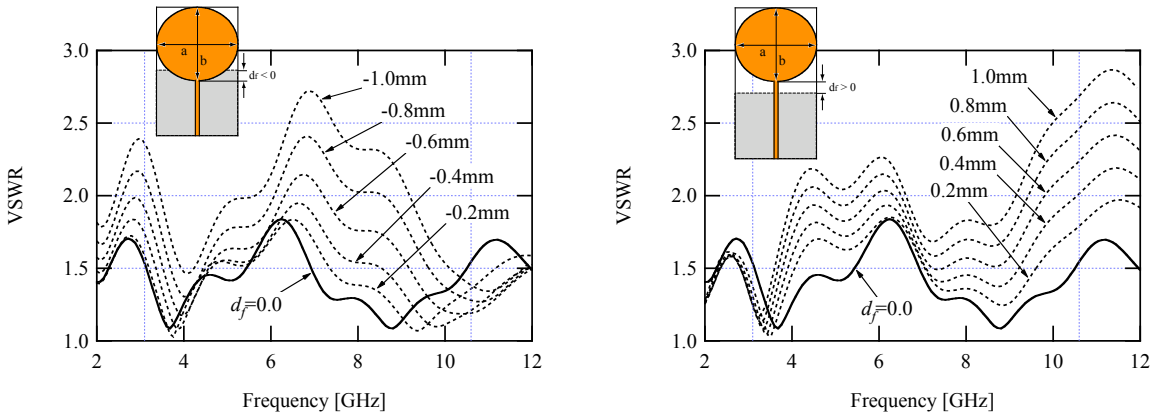


(a) Top view (b) Bottom view

Fig. 1 Geometry of the printed elliptical disc monopole antenna.



(a) $d_f \le 0$ (b) $d_f \ge 0$

Fig. 2 VSWR of the printed circular disc monopole antenna with different feed gap d_f ($a = b = 50$ mm).

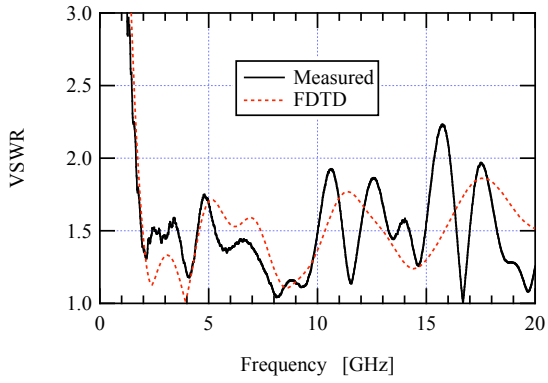
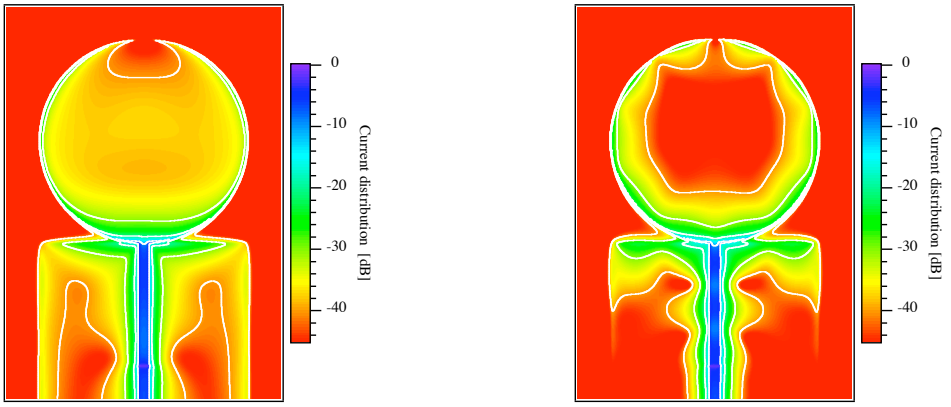


Fig. 3 VSWR of the printed elliptical disc monopole antenna ($a = 50$ mm, $b = 40$ mm, $d_f = 0$).

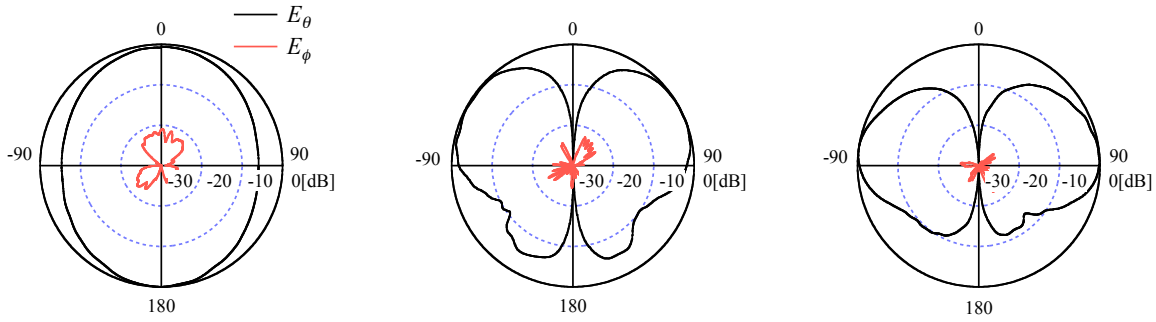
Table 1 VSWR and bandwidth of the elliptical disc monopole antenna.

b	Freq. range for VSWR ≤ 2 [GHz]	Bandwidth ratio
0.8*a*	1.7 to 15.4	1:9.1
0.9*a*	1.6 to 15.4	1:9.6
1.0*a*	1.5 to 17.0	1:11.3
1.1*a*	2.3 to 20.0*	1:8.7
1.2*a*	2.4 to 20.0*	1:8.3



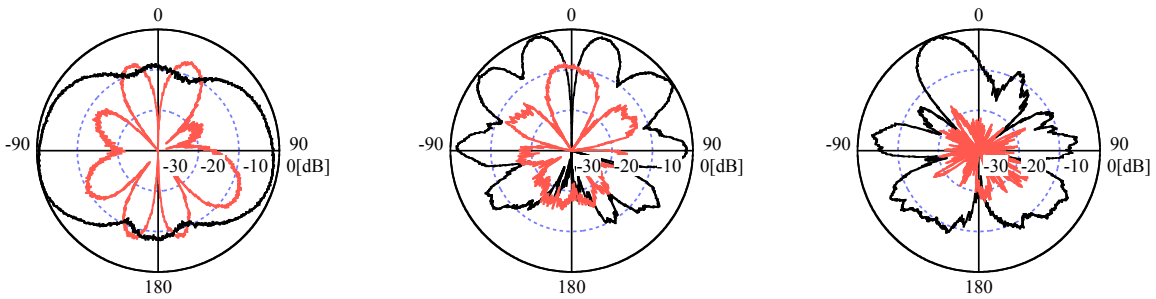
(a) 3 GHz (b) 10 GHz

Fig. 4 Current distribution of the printed circular disc monopole antenna ($a = b = 50$ mm, $d_f = 0$).



(a) *xy*-plane (b) *yz*-plane (c) *zx*-plane

Fig. 5 Radiation patterns of the printed circular disc monopole antenna at 3 GHz.



(a) *xy*-plane (b) *yz*-plane (c) *zx*-plane

Fig. 6 Radiation patterns of the printed circular disc monopole antenna at 10 GHz.