 ISBN: 978-93-86005-02-1

Study of UWB Circular and Square Monopole Antenna

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Abstract

Various configuration of printed ultra wideband monopole antenna namely circular and square monopole has been studied in this paper. The characteristics of these antennas have been investigated in order to compare their performance. It has been found that all the studied antennas can provide very wide bandwidth with satisfactory radiation patterns. Role of antenna configurations and ground plane size on antenna bandwidth has been studied.

Keywords: Broadband Planar Monopole Antenna, Circular Disc Monopole, Square Planar Monopole, -10db Return Loss, Ultra-Wide Bandwidth

1. Introduction

Now a day's ultra wide band printed monopole antennas have created a great impact due its Omni directional radiation pattern, wide bandwidth[1,2]. To make a broadband monopole antenna as a planar structure, a ground plane perpendicular to the radiator is required. Two types UWB planar antenna feeding techniques, namely microstrip fed[3] and CPW fed[4,5] have been reported recently. Also various monopole radiator shape like circular[3,5], square[6], triangle has been reported. In this paper we have studied the characteristics of two types of antenna namely CPW fed antennas with circular and square radiator.

1.1 Circular Disc Monopole Antenna Design and Performance

Here we have studied the circular disc monopole configuration proposed by Liang et al[5]. The CPW fed monopole antenna has been simulated using FR4 substrate with relative permittivity of $\varepsilon_r = 4.4$. Thickness of the substrate (H) is chosen to be 1.6 mm. The gap between strip and ground plane and the width of the metal strip (W_f) is chosen to be 0.3 mm and 2.3 mm respectively in order to achieve 50Ω impedance. The studied circular disc monopole antenna is shown in Figure 1. The radius r of the circular disc monopole antennas has been varied in order to see the effect of disc radius on antenna resonance frequency.

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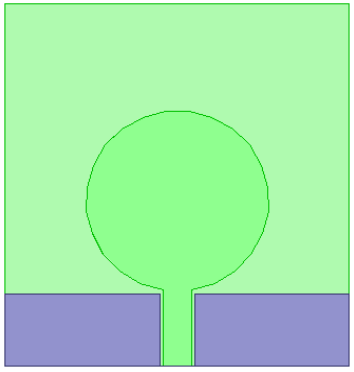

Figure 1. Circular disc monopole antenna.

Also the width W of the ground plane has been varied in order to see the effect of ground plane dimension on antenna bandwidth. The circular disc monopole antenna has been found to provide a very wide bandwidth.

1.2 Effect of the Design Parameters

Simulation results shows that the operating bandwidth of the antenna is dependent on the width of the ground plane **W** and the radius of the disc **r**. That's why for maximum bandwidth these parameters should be optimized.

1.3 Effect of the Width of the Ground Plane W

To investigate the effect of ground plane width W, we have kept the radius **r** of the antenna to be 12.5 mm and varied the ground plane width. Simulation results shows that return loss curves changes substantially for different ground plane width. So ground plane dimension have significant role in impedance matching. We have seen from the simulation that for the changes in **W** the higher resonance frequencies changes significantly, but the first resonant does not change so much. Similar results have been reported by Liang et al[5]. Simulated return-loss curves for different ground plane dimensions are shows in the Figures 2 to 5.

1.4 The Effect of the Dimensions of the Disc

From the return loss curves we have seen that for different **W** the first resonance always occurs at around 3 GHz when **r** = 12.5 mm. So, we can see that the quarter wavelength at this first resonant frequency is just equals to the diameter of the disc. Similar results have been reported by Liang et al[5]. So, we can say that this resonant frequency is mostly determined by the circular disc. From the return loss curves we can say, when we increase the dimensions of the disc the first resonant

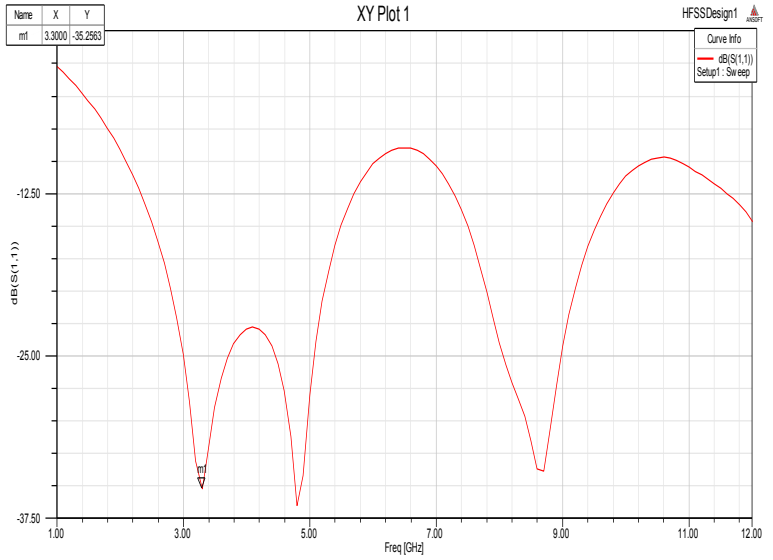

Figure 2. Return loss curves for r = 12.5 mm and W = 40 mm.

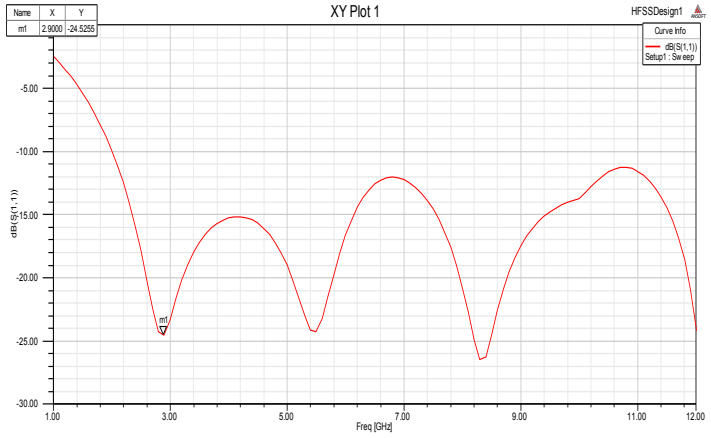

Figure 3. Return loss curves for r = 12.5 mm and W = 47 mm.

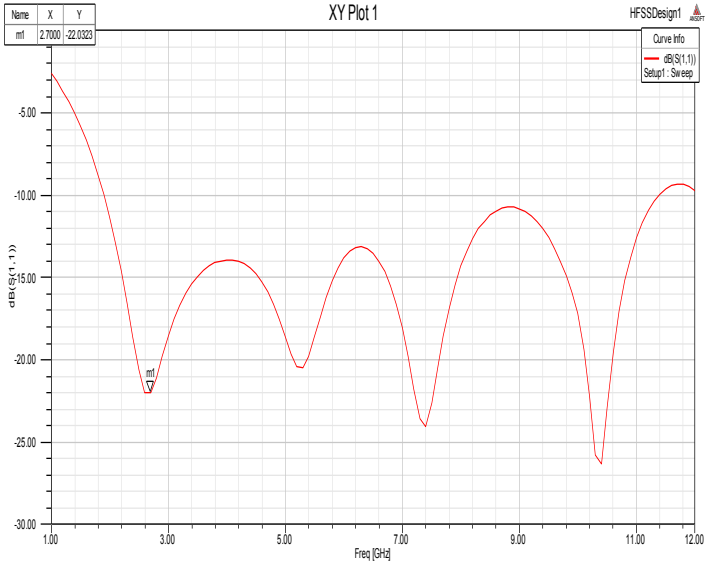

Figure 4. Return loss curves for r = 12.5 mm and W = 52 mm.

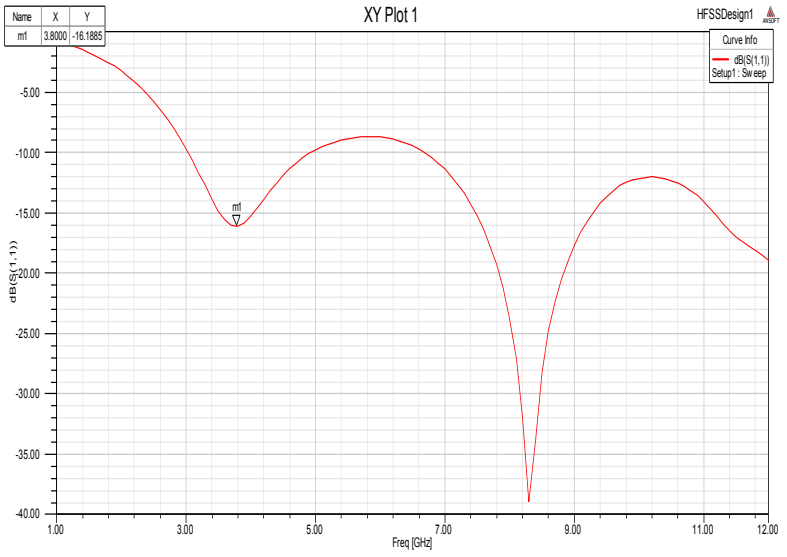

Figure 5. Return loss curves for r = 12.5 mm and W = 60 mm.

frequency decreases as shown in the Figure 6 to Figure 8 and the relationship between the diameter of the circular disc monopole and the first resonances frequency is given in Table 1.

1.5 Radiation Patterns

In the conventional monopole antenna the radiation patterns are Omni-directional. In the studied CPW fed disc antenna the radiation pattern is Omni-directional at lower frequencies of the operational band. This is evident from Figures 9, 10 and 11. However as evident from Figures 12 and 13, the pattern becomes more and more directive at higher frequencies. This is due to the fact that the antenna operates as a travelling wave antenna at higher frequencies. The simulated radiation patterns at 3 GHz and 9 GHz are plotted in Figures 9 to 13.

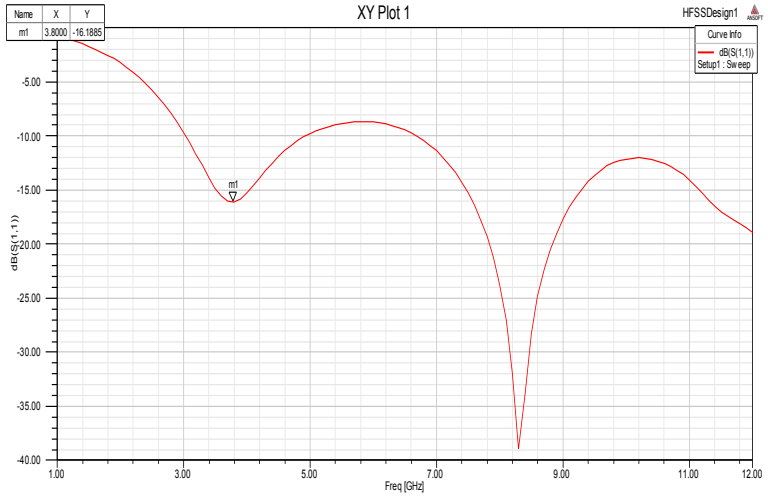

Figure 6. Return-loss curves for r = 7.5 mm.

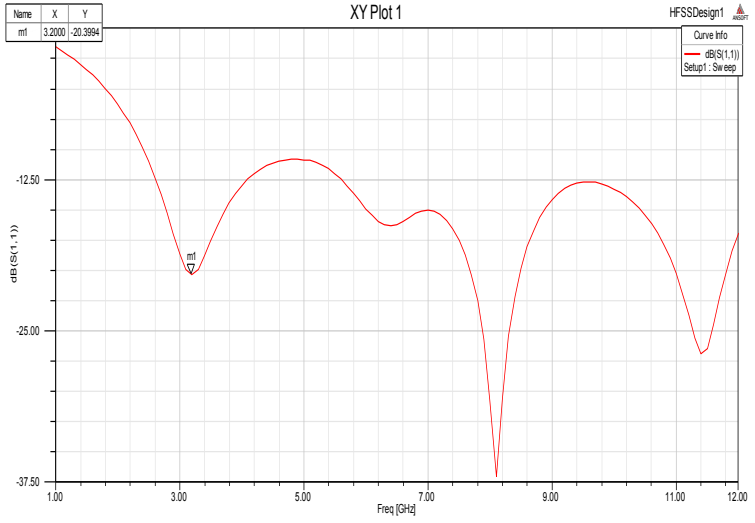

Figure 7. Return-loss curves for r = 10 mm.

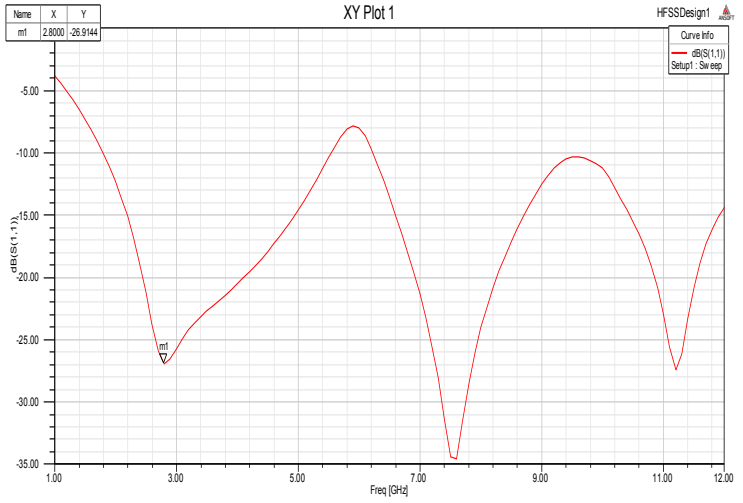

Figure 8. Return-loss curves for r = 15 mm.

Table 1. First resonances frequency

Table I	Relationship between diameters and the first resonance		
	Diameter 2r(mm)	First resonance f1 (GHz)	Wavelength λ at f1 (mm)
1.	15	3.8	78.95
2.	20	3.2	93.75
3.	25	2.9	103.45
4.	30	2.8	107.14

1.6 Square Planar Monopole Antenna Design and Performance

Here we have studied the square printed monopole configuration proposed by Ammann et al.[6]. A Square printed monopole with CPW feeding has been simulated using FR4 substrate with relative permit-

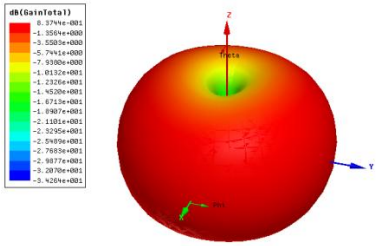

Figure 9. 3-D radiation pattern at 3 GHz.

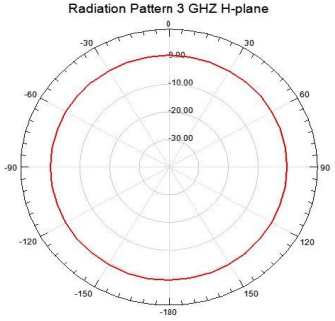

Figure 10. Radiation pattern at 3 GHz in H-plane.

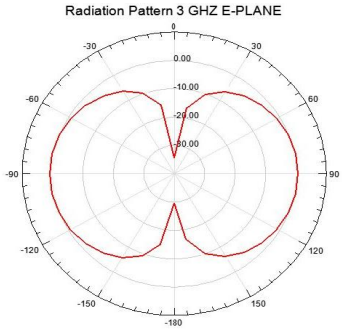

Figure 11. Radiation pattern at 3 GHz in E-plane.

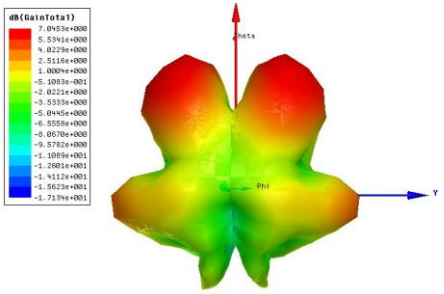

Figure 12. 3-D Radiation Pattern at 9 GHz.

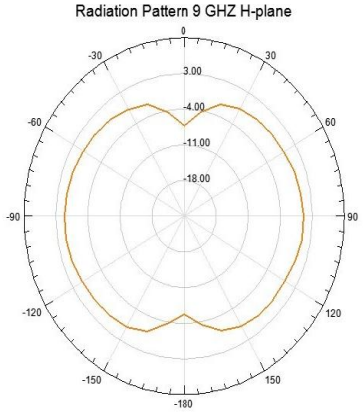

Figure 13. Radiation pattern 9 GHz at H-plane.

tivity of ε_r = 4.4. Thickness of the substrate (H) is chosen to be 1.6 mm. In order to achieve 50Ω impedance, the gap between strip and ground plane and the width of the metal strip (W_f) is chosen to be 0.3 mm and 2.3 mm respectively. The studied square monopole antenna is shown in Figure 14. The length of square monopole antennas has been varied in order to see the effect of square side length on antenna resonance frequency.

We have taken the length of each ground planes to be 20 mm and we have varied the square monopole dimension in order to find the effect on resonance frequency. The simulated return loss for square side length 25 mm and 15 mm are shown in Figures 15 and 16. Table 2 illustrates that square dimension is one fourth that of resonant wavelength.

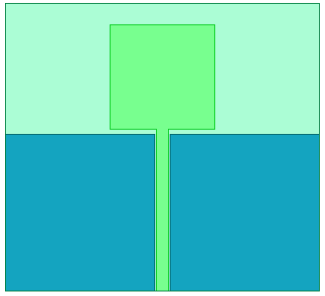

Figure 14. Square planar monopole antenna.

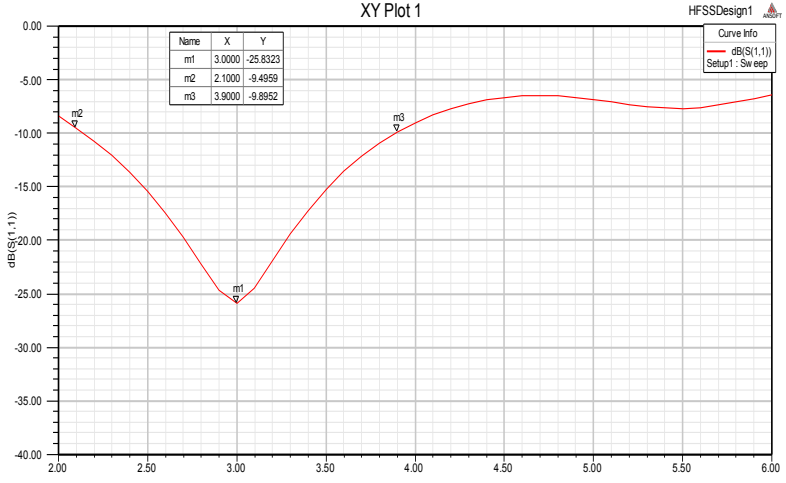

Figure 15. Return loss curve for square planar antenna when square length is 25 mm.

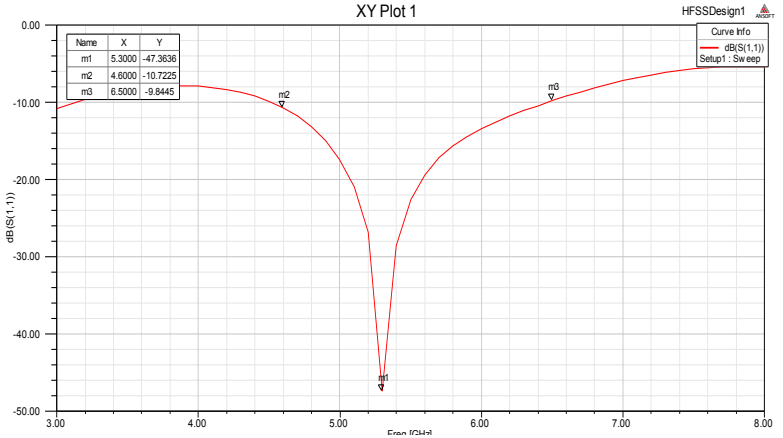

Figure 16. Return loss curve for square planar antenna when square length is 15 mm.

Table 2. Square dimension is one fourth that of resonant wavelength

Table II	Bandwidth for different square size				
	Square side length	Resonant Frequency	Wavelength	–10 dB frequency limits	Bandwidth
1.	25 mm	3 GHz	100 mm	2.1 GHz – 3.9 GHz	1.8 GHz
2.	15 mm	5.3 GHz	56 mm	4.6 GHz –6.5 GHz	1.9 GHz

2. Conclusion

A wideband circular and square monopole antenna has been investigated. Effect of various parameters on its performance has been studied. So from these we can say that for future UWB application this antenna is very suitable. Time domain analysis to get an estimate of signal dispersion could be a done in future.

3. References

1. Agrwall NP, Kumar G, Ray KP. Wideband planar monopole antennas. IEEE Trans. 1998 Feb; 46(2):294–5.
2. Hammoud M. et al. Matching the input impedance of Broadband disc monopole. Electronics Letters. 1993 Feb; 29(4):406–7.
3. Liang J, Chaiau CC, Chen X, Parini CG. Printed circular disc monopole antenna for ultra wideband application. Electron Left. 2004; 40(20):1246–8.
4. Kim Y, Kwon DH. CPW-fed planar ultra wideband antenna having a frequency band notch function. Electron Left. 2004; 40(7):403–5.
5. Liang J, Guo L, Chiau CC, Chen X, Parini CG. Study of CPW-fed circular disc monopole antenna for ultra wideband applications. IEE Proceedings - Microwaves, Antennas and Propagation. 2005; 152(6):520–6.
6. Ammann MJ. Square planar monopole antenna. IEE National Conference on Antennas and Propagation; York, UK. 1999, p. 37–40.
7. Wang W, Zhong SS, Chen SB. A novel wideband coplanar-fed monopole antenna. Microw Opt Technol Lett. 2004; 43(1):50–2.
8. Wang SBT, Niknejad AM, Borderson RW. Modeling omnidirectional small antennas for UWB applications. IEEE Antenna and Propagation International Symposium; 2004 Jun. p. 1295–8.
9. Munier F, Eriksson T, Svensson A. On the effect of antennas in UWB systems. Proceedings of 28th URSI General Assembly in India; 2005. P. 1–6.
10. Lu G, Greenstien L. Antenna and pulse designs for Meting UWB spectrum density requirements. IEEE Conference on Ultra-Wideband Systems and Technologies; 2003 Nov. p. 162–6.
11. Liang J, Chaiau CC, Chen X, Parini CG. Analysis and design of UWB disc monopole antennas. IEE Seminar on Ultra Wideband Commun Technol Syst Design; 2004 Jul. p. 103–6.