GROUND PLANE EFFECT ON THE MULTI-BAND MULTIPLE RING MONOPOLE ANTENNA

Ali Mirkamali[(1), (2)], Peter S. Hall[(1)], Mohammad Soleimani[(2)]

[(1)]School of Electronic, Electrical and Computer Engineering,
University of Birmingham,
Edgbaston, Birmingham, UK.
a.mirkamali@bham.ac.uk
P.S.Hall@bham.ac.uk

[(2)]Department of Electrical Engineering,
Iran University of Science and Technology,
Narmak, Tehran, Iran.
soleimani@iust.ac.ir

INTRODUCTION

Multi-band and wideband monopole antennas due to their merits such as near omni-directional radiation patterns, simple structure and low cost have attracted a great deal of attention for modern wireless communication systems. Among these are circular disk and multiple ring monopole antennas. The circular disk monopole antenna with a very large impedance bandwidth was introduced in [1] and [2]. In [3] the effect of changing the circular to an elliptical disk was investigated. The microstrip fed monopole disk antenna, which is suitable to connect to printed circuit boards, was presented in [4]. The multi-band multiple ring monopole antenna was introduced in [5] and [6]. This antenna consists of a set of self-similar circular rings that are superimposed to form the antenna. Comparison between the multiple ring monopole antenna characteristics and disk monopole antenna shows that radiation pattern of the multiple ring monopole antenna at higher frequencies is better than the disk monopole antenna. In [7] this antenna was investigated more and the effect of the ellipticity ratio on elliptical multiple ring antenna was proposed. It has been shown that the wider bandwidths can be obtained by decreasing the ellipticity ratio.

In this paper the effect of the changing the height from the ground plane perpendicular to the antenna plane and changing the position of the ground plane from perpendicular to parallel to the antenna plane, which leads to the microstrip fed multiple ring monopole antenna, on the multi-band multiple ring monopole antenna are presented. The results show that at higher frequency bands better matching can be obtained for smaller height from the perpendicular ground plane and it does not affect on the lower frequency bands. It is also shown that changing the position of the ground plane from perpendicular to parallel to the antenna plane improves the matching at the first band significantly. The microstrip fed multiple ring antenna can be integrated with printed circuit boards and used in low-profile applications.

DIFFERENT HEIGHTS FROM THE GROUND PLANE

In order to investigate the changing of the height from the ground plane a multiple ring monopole antenna was constructed. The antenna, shown in Fig. 1 has an overall height of 86mm and smaller ring heights of 43mm, 21.5mm, 10.75mm and 5.5mm. The antenna was fabricated using conventional printing techniques on a 0.5mm thick FR4 substrate (relative permittivity of 4.5) and was mounted perpendicularly over a metallic ground plane of 15cm×15cm. A 50 Ω SMA connector is used to feed the antenna at the centre of the ground plane. The thicknesses of the rings are: t_1=11mm, t_2=7mm, t_3=5mm, t_4=2.5mm. The constructed antenna is also depicted in Fig. 1. The return loss of the antenna with different heights from the ground of 2mm, 1mm and 0.3mm were measured. The measurement results are shown in Fig. 2. The results show that when the antenna is mounted over the ground with the height of 2mm the third band is not well matched and the fourth band is narrow. By decreasing the height of the antenna to 0.3mm from the ground the higher frequency bands matching become better (the third and fourth) and as it depicted the height of 0.3mm, the smallest height, has the best matching performance. In addition, by decreasing the height from the ground a

0-7803-9444-5/06/$20.00 © 2006 IEEE.

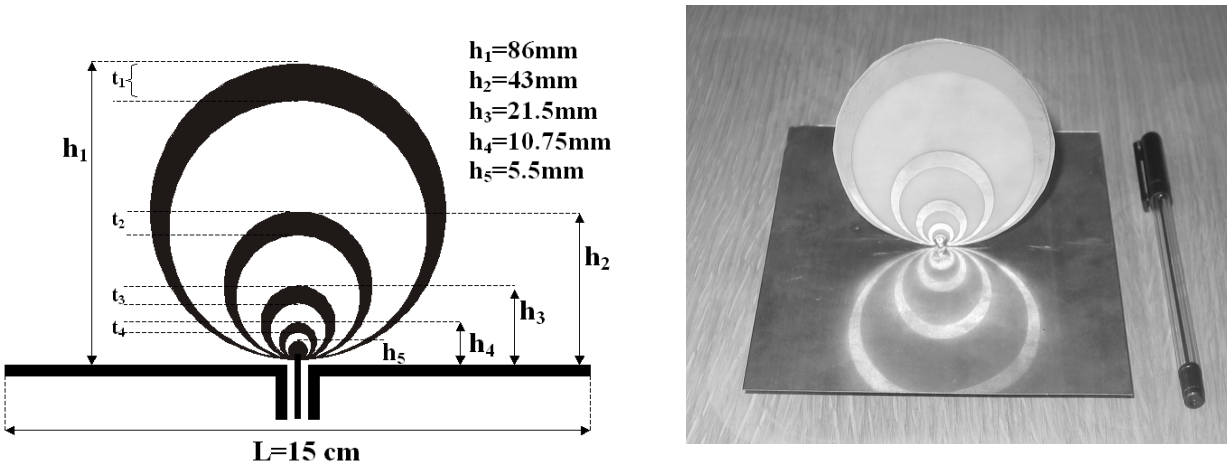


Fig. 1-the multiple ring monopole antenna

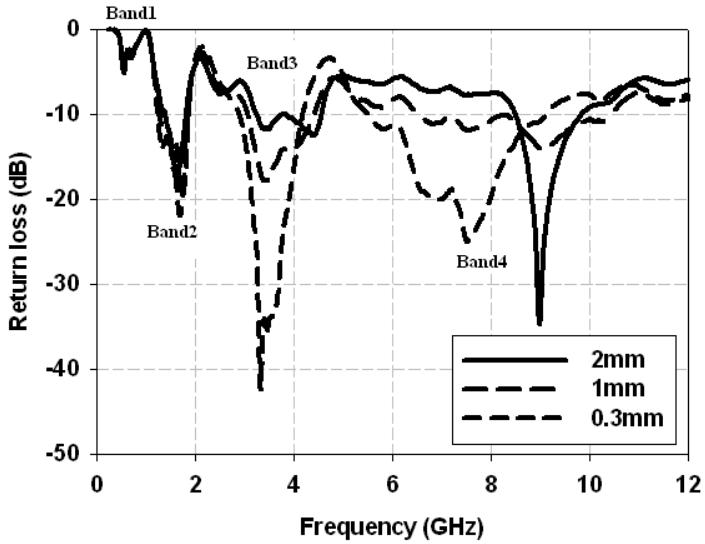
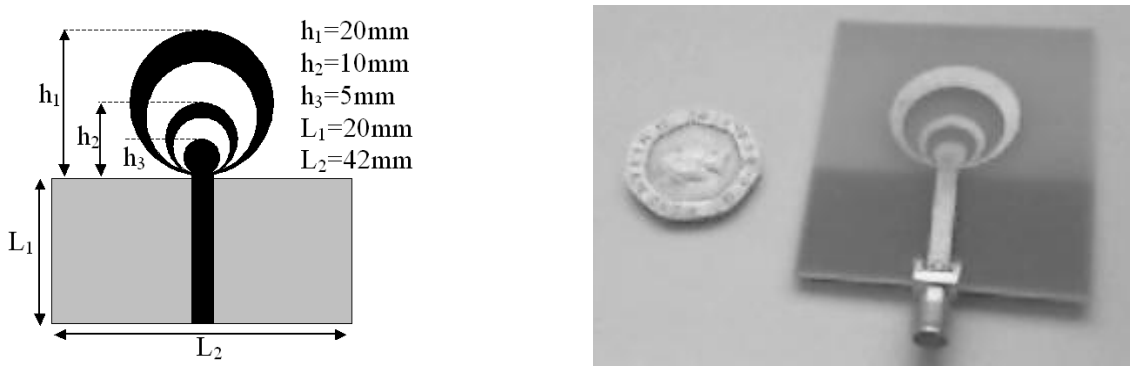


Fig. 2- the measured return loss of the multiple ring monopole antenna with different heights from the ground plane

frequency shift to lower frequencies occurs for the fourth band. This frequency shift can be observed by comparing the return loss of the antenna with heights of 2mm and 0.3mm.

MICROSTRIP FED MULTIPLE RING MONOPOLE ANTENNA

The effect of changing the height from the ground plane, which is perpendicular to the antenna structure, was explained above. In this section changing the position of the ground plane from perpendicular to parallel with the antenna plane is discussed. By changing the position of the ground to parallel with the antenna plane a microstrip fed multiple ring monopole antenna can be obtained. Fig. 3 shows the constructed microstrip fed multiple ring monopole antenna. The heights of the rings and disk are 20mm, 10mm and 5mm. And the thicknesses of the rings are 4mm and 2mm. The antenna is printed on a 1.6mm thick FR4 substrate and fed by a 50Ω microstrip line. The ground plane size is 42mm×20mm. The length of the microstrip line is 20mm and the height of the antenna from the ground plane is 1.5mm. Fig. 4 shows the measured return loss of the antenna. The return loss has three frequency bands and their best matching are at 2.4 GHz, 4.46GHz and 8.5 GHz for the first, second and the third band respectively. As it depicted in Fig. 4, the first band is well matched and the best matching occurs at 2.4GHz where the S_{11} is –22.5dB. The good matching at the first band is one of the advantages of the microstrip fed multiple ring antenna over the monopole with the perpendicular ground plane.



(a) (b)

Fig. 3- microstrip fed multiple ring monopole antenna a) top view, b) constructed antenna

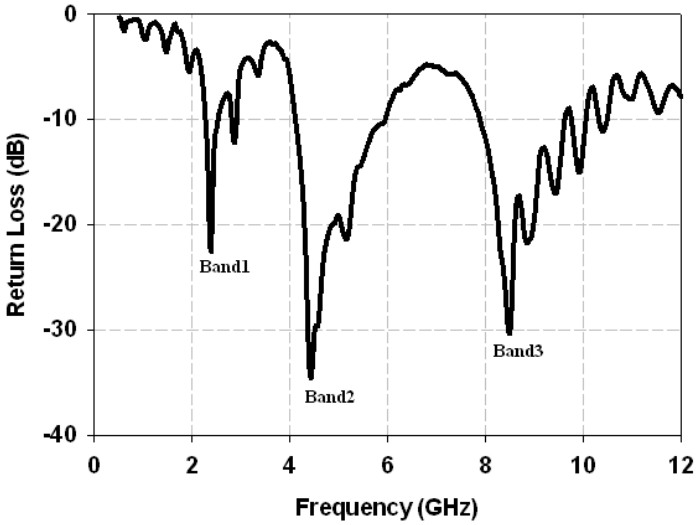
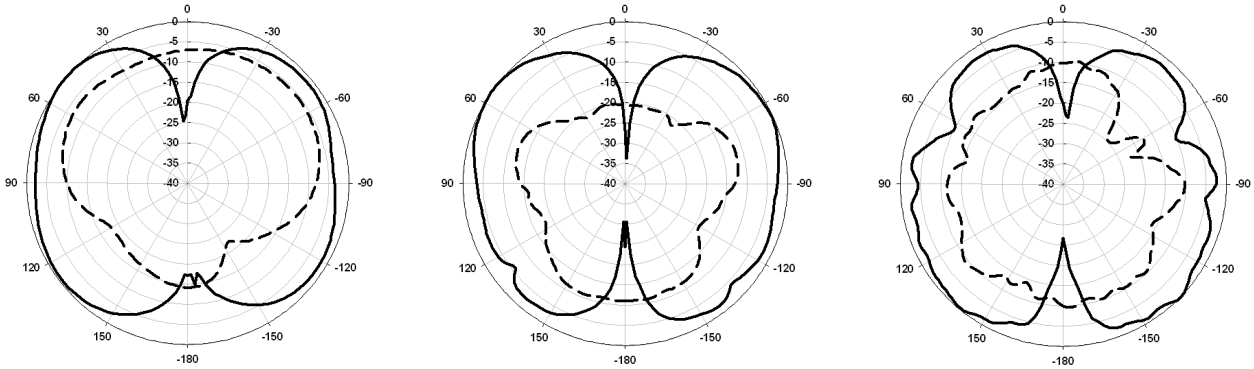


Fig. 4-the measured return loss of the microstrip fed multiple ring monopole antenna

In [6] it was shown that when the ground plane is perpendicular to the antenna plane the first band is inherently poor matched (the best matching of around S_{11}=-7dB at the first band). In addition, the microstrip fed multiple ring monopole antenna can be used in low profile applications and connected to the printed circuit boards.

The radiation patterns of the constructed microstrip fed multiple ring antenna were measured in E-plane and H-plane. Fig. 5 shows the results.



2.4 GHz 4.46 GHz 8.5 GHz

Fig. 5a

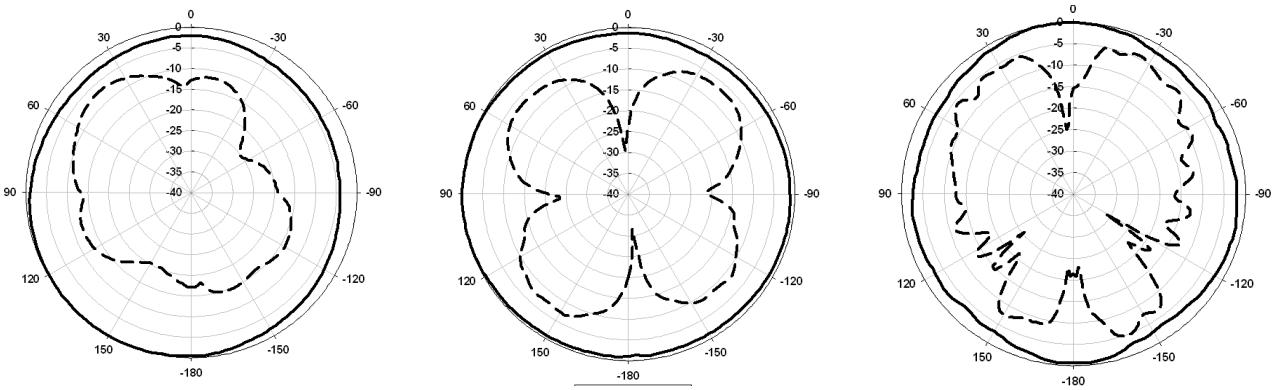


Fig. 5b

Fig. 5-the measured radiation patterns of microstrip fed multiple ring monopole antenna a) E-plane, b) H-plane, solid line is co-polarization and dashed line is cross-polarization

The measurement results show that some nulls occur in the E-plane of radiation pattern at the third band but H-plane patterns are smooth for all three bands.

CONCLUSION

In this paper the effect of the changing the height of the multi-band multiple ring monopole antenna from the ground plane perpendicular to the antenna plane and changing the position of the ground plane from perpendicular to parallel to the antenna plane, which leaded to microstrip fed multiple ring antenna design, were investigated. It was shown that by decreasing the height from the perpendicular ground plane better matching obtained specially in higher frequency bands. By using microstrip fed multiple ring antenna the matching at the first band was improved significantly. The microstrip fed multiple ring monopole antenna can be connected to printed circuit boards and used in low-profile applications.

REFERENCES

[1] S. Honda, M. Ito, H. Seki and Y. Jingo," A disk monopole antenna with 1:8 impedance bandwidth and omni-directional radiation pattern," in Proc. Int. Symp. Antennas Propagat., Sapporo, Japan, pp. 1145-1148, Sept. 1992.

[2] P. P. Hammoud and F. Colomel, "Matching the input impedance of a broadband disk monopole", Electron. Lett., vol. 29, pp. 406-407, Feb. 1993

[3] N. Prasad Agrawall, G. Kumar and K.P. Ray, "Wide-Band Planar Monopole Antennas" IEEE Trans. Antennas Propagat., Vol. 46, no. 2, pp. 294-295, 1998.

[4] J. Liang, C. C. Chiau, X. Chen and C. G. Parini, " Printed Circular Ring Monopole Antennas", Microwave and Optical Technology Letters, Vol. 45, No. 5, pp. 372-375, June 2005.

[5] C.T.P. Song, P.S. Hall, H. Ghafouri-Shiraz and D. Wake, "Multi-circular loop monopole antenna," Inst. Elect. Eng. Electron. Lett., vol. 36, no. 5, pp. 391-393, 2000.

[6] C.T.P. Song, P.S. Hall, H. Ghafouri-Shiraz, "Multiband Multiple Ring Monopole Antennas," IEEE Trans. Antennas Propagat., Vol. 51, no. 4, pp. 722-729, April 2003.

[7] A. Mirkamali, P. S. Hall and M. Soleimani, "Elliptical Multiple Ring Monopole Antennas", in press, Microwave and Optical Technology Letters in January 2006.