A New Broadband Trapezoidal Flat Monopole Antenna

#Behrouz Heydari[1], Alireza Islamdoost[2]
[1]Asian Elite Co., P.O.Box: 14155-4735, Tehran, Iran, behrouzheydari@gmail.com
[2]Asian Elite Co., P.O.Box: 14155-4735, Tehran, Iran, alirezaislamdoost@gmail.com

1. Introduction

Before getting through the structure of the antenna in this article, first we consider the process of changes in flat monopole antenna. The first flat monopole antenna was proposed by Mr.B.J. Lamberty in 1958 Fig. 1. After that, from 1992 till now, other shapes of that antenna have been introduced that you can see in Fig. 2, 3and4. [1]

Figure 1: Rectangular Plate Antenna
B.J. Lamberty, 1958

Figure 2: Circular Disc Antenna
S. Honda, M. Lto, H. Seki and Y. Jinbo, 1992

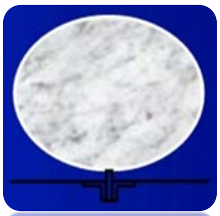

Figure 3: Elliptical Disc Antenna
N. P. Agrawall, G. Ku and K. P. Ray, 1998

Figure 4: Trapezoidal Disc Antenna
J. A. Evans and M.J. Ammann, 1999

The reason of using a flat instead of a bar in monopole antennas is to increase the bandwidth [2] though all of the mentioned antennas have some advantages and disadvantages. For example, in circular flat antenna, increasing frequency, the radiation pattern of the antenna will worsen the condition, although it has a greater wideband (about 10:1).

In designing the circular flat antenna which its working limitation has defined between 2.25 to 17.25 GHz, the result is VSWR< 2, but the maximum radiation of antenna in E-plane with frequency changes from 2.5 to 9 GHz varies from 30° to 60° or in H-plane we have some changes in radiation pattern from 4 dB to 7 dB. [1], [3]

Although elliptical flat antenna has a better condition than circular flat which was proposed in 1998, tried to decrease the mentioned defects, but the problem of changes in the title of pattern angle in E-plane has remained as well. [1], [4]

In trapezoidal flat antenna which was proposed in 1999, tried to decrease the mentioned defects, but the problem of changes in the title of pattern angle in E-plane remained as well. [1], [5]

With these explanations we get through the configuration of the mentioned antenna.

2. Antenna Configuration

The configuration of the antenna is trapezoidal flat monopole that has the following changes comparing to the same antenna presented in 1999(Fig. 4): a. The change in flat radiator of trapezoidal. b. The change in impedance transformer. c. The change in ground plane.

By doing the above changes, it seems, it better an extended frequency bandwidth and radiation pattern of antenna in E & H-plane.

Note: In the following of improving radiation pattern of antenna in E & H-plane some holes on radiator can be used. [1]

To see desirable condition that is resulted from designing monopole antenna in this way, we start to design it to work at 0.7 to 8GHz. You can see some sizes of this antenna in Fig. 5.

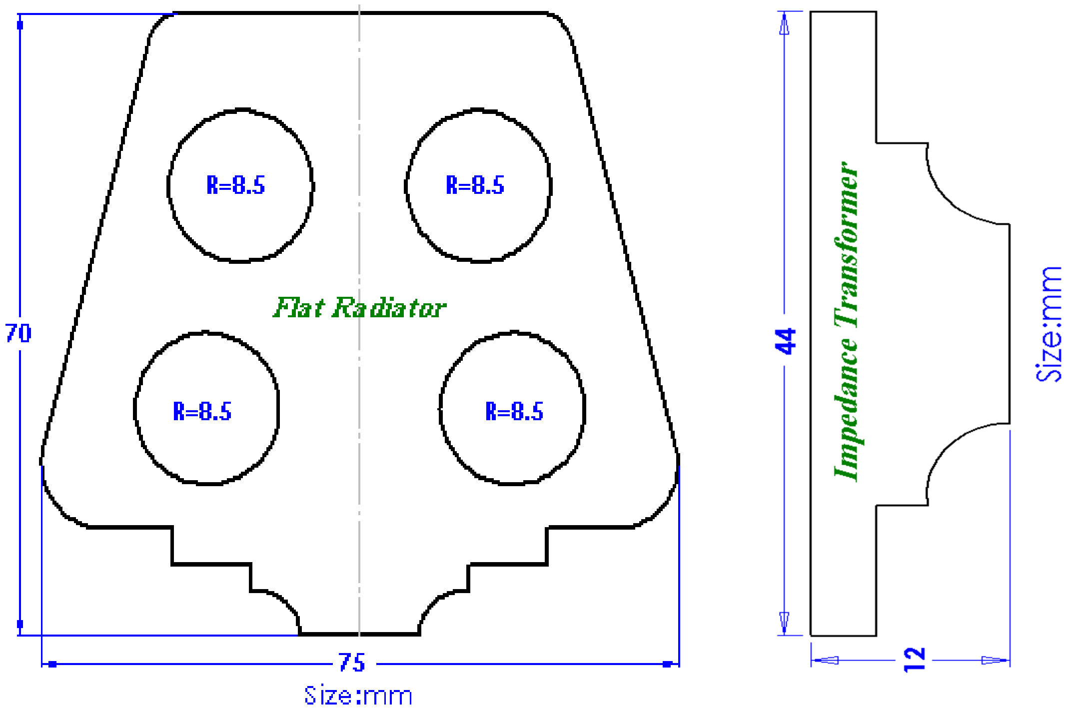

Figure 5: The new trapezoidal disc antenna cutaway drawing

After simulating antennas with sizes which shown in Fig. 5 with ground plane 420*420*0.5mm (which, in the lowest working range, is almost equivalent to λ_L) and the input impedance of 50 ohm, the following results were obtained reflecting return loss and radiation pattern. See Fig. 6 to 19.

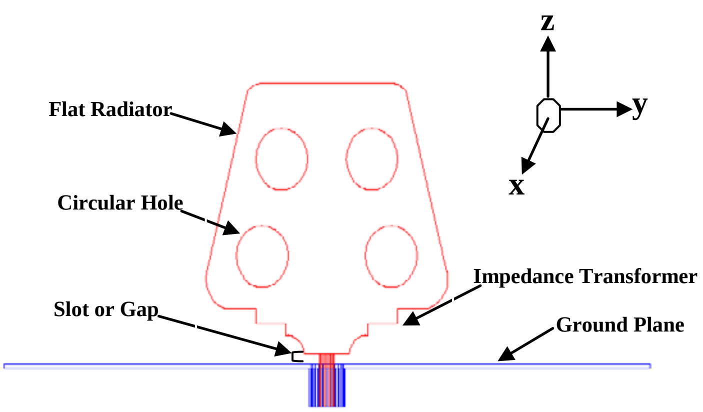

Figure 6: New trapezoidal disc antenna above the ground plane

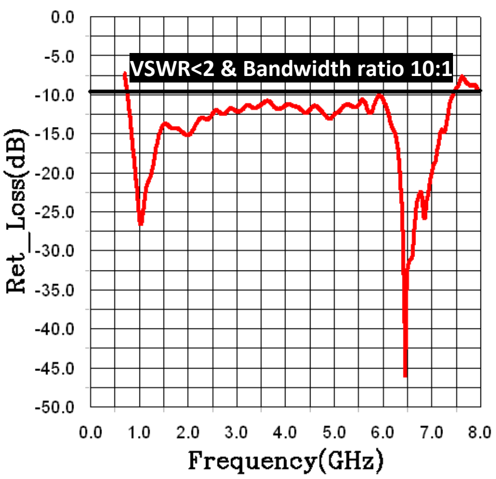

Figure7: Return loss

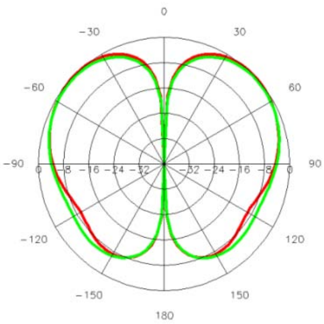

Figure 8: Elevation pattern at 0.75GHz

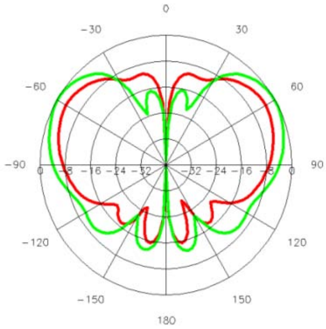

Figure 9: Elevation pattern at 1.7GHz

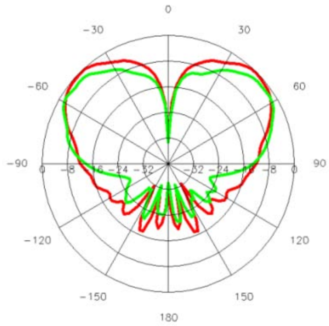

Figure 10: Elevation pattern at 2.7GHz

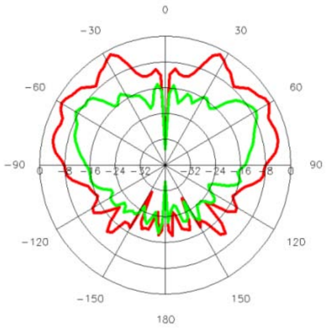

Figure 11: Elevation pattern at 3.7GHz

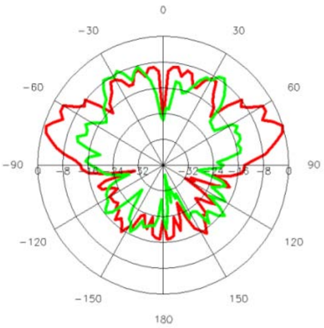

Figure 12: Elevation pattern at 4.7GHz

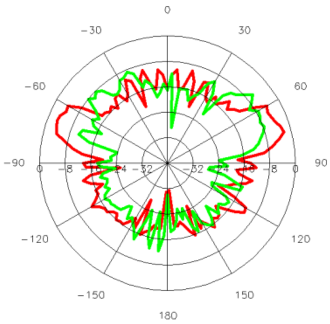

Figure 13: Elevation pattern at 5.2GHz

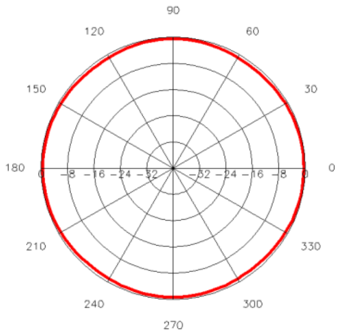

Figure 14: Azimuth pattern at 0.75GHz at θ=60 ˚

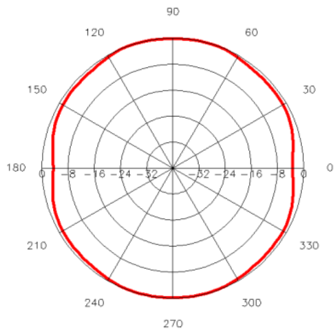

Figure 15: Azimuth pattern at 1.7GHz at θ=60 ˚

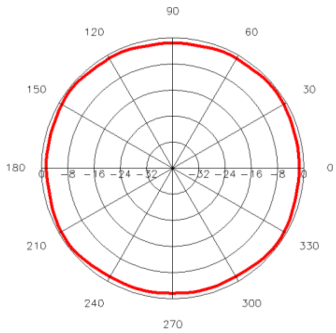

Figure 16: Azimuth pattern at 2.7GHz at θ=60 ˚

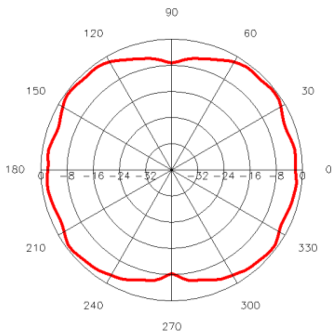

Figure 17: Azimuth pattern at 3.7GHz at θ=60 ˚

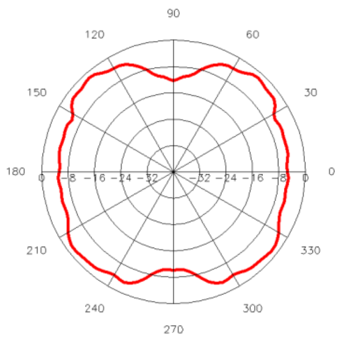

Figure 18: Azimuth pattern at 4.7GHz at θ=60 ˚

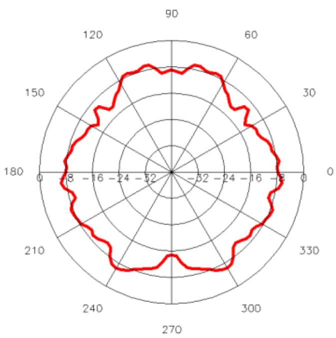

Figure 19: Azimuth pattern at 5.2GHz at θ=60 ˚

Radiation pattern were simulation at several frequencies over the bandwidth from 0.7 to 8GHz. The elevation patterns are presented for two principal planes of Φ=0°(xz-plane) and Φ=90°(yz-plane).

The azimuth patterns are presented at an angle of θ=60° azimuth angle corresponds to the x-axis direction. When the change the curve in impedance transformer and the size between flat radiator and ground plane (slot) and size of the ground plane we obtain reasonably match well, So the trapezoidal flat monopole antenna tends to radiate energy Omni-directional for 6:1 portion of the bandwidth, but beyond the initial 6:1 bandwidth, the antenna tend to radiate more in the direction of Φ=90°(yz-plane).

A slot between the radiator and ground plane contributes to radiate the high frequency. The simulation radiation pattern show that at the low end of operating band, the currents are well distributed over the trapezoidal antenna plate, so the pattern are Omni-directional, but at high end of the operating band, the currents are concentrated near the slot, so the fields radiate in the direction of Φ=90°(yz-plane) mainly through the slot.

The simulation show that to use 4-circular holes in trapezoidal flat monopole antenna help to enhance the radiation patterns in the direction of Φ=0°(xz-plane) which is the direction of the plane of the metal the radiation patterns in the direction of Φ=90°(yz-plane) , however, are not change by the holes.

Investigation results of the trapezoidal antenna with 4-circular holes show that the holes control the flow of the current in the metal plate so that the frequency response of the element improved without deteriorating the impedance performance. Another shape of holes in this antenna can be applied the extend radiation performance for Omni-direction in azimuth at high frequency.

3. Conclusion

The presented antenna in this article is a new shape of trapezoidal monopole antenna resulting from changes in flat radiator, impedance transformer and ground plane, which led to a better radiation pattern bandwidth(above 6:1) in working limitation of antenna and acceptable impedance bandwidth(10:1) for VSWR< 2 too.

The antenna capability and flexibility scaled in different frequency limitations has made it possible to use it in various transmitting/receiving stations, aircraft, helicopters, and automobiles.

References

[1]Seong-Youpsuh, “A Comprehensive investigation Of New Planar Wide Band Antenna”, PHD Thesis, Black Burg Virginia, Electrical and Computer Eng .pp.21-23, 146-154, July 2002.

[2] W.L.Stutzman and G.A.Thiele, Antenna Theory and Design, second edition, John Wiley and Sons, New York, 1981.

[3] P.P.Hammoud and F.Colomel, “Matching the input Impedance of a broad band disc Monopole,” Electronic letters, Vol.29, PP.406-407, Feb 1993.

[4]N.P.Agrawall, G.Kumar and K.P.Ray, “wideband planar Monopole Antenna”, IEEE Transaction on Antenna and propagation, Vol46, N0.2, PP.294-295, Feb 1998.

[5]J.A Evance and M.J.Ammann, “planar Trapezoidal and Pentagonal Monopole with Impedance Bandwidth in excess of 10:1,” IEEE International Symposium Digest (Orlandy), Vol3, PP.1558-1559, 1999.