A New Ultra wideband Omni directional Antenna

Behrouz Heydari [1], Ali Afzali [2], Hossein Rabiee Goodarzi [3]

[1] Asian Elite Co., P.O.Box: 14155-4735, Tehran, Iran, behrouzheydari@gmail.com

1. Introduction

The necessity to ultra wideband and omni directional antennas, have caused to increase the use of these kinds of antennas in military and industrial applications. The primaries of these antennas are the dipole and monopole (if a half-space is to be illuminated). The problem of these omni directional antennas is their narrow bandwidth that we can use a plate instead of a string of wire in order to solve this problem [1]. After that circular-disc antennas (figure 1) [2], half-disc antennas (figure 2) [3] and planar inverted cone antenna (PICA) (figure 3) were propounded [4].

Figure 1: Circular-disc   Figure 2: Half-disc   Figure 3: PICA

Although the above antennas have the preference of being ultra wideband and have simple structure, but are able to get just one kind of polarization .In this essay is tried to introduce a new sample of omni directional antenna with frequency bandwidth of 4:1 and acceptable VSWR which is able to get all kind of polarization by changing in the structure of PICA antenna and the related Ground plane. Also we have tried to have maximum directivity in angels 0° to 30° to axis z which will be preceded in the following.

2. Preamble of the plan

Before getting through the whole structure of antenna and its performance, it's better to pay attention to its designing thought. In order to increase the frequency bandwidth of omni directional antenna, we can use a plate instead of a string of wire [1] and a special form of omni directional antennas with the favorable radiation pattern is obtainable by a few changes in this plate.
Before the changes, in the first step, the frequency bandwidth of the antenna is set to 1GHz to 4GHz, so:

$$f_l = 1GHz \Rightarrow \lambda_h = c / f_l \Rightarrow \lambda_h = 300mm$$

$$f_h = 4GHz \Rightarrow \lambda_l = c / f_h \Rightarrow \lambda_l = 75mm$$

After identifying the frequency bandwidth, the represented plate in figure 3 which is called Radiator from now on, is designed that as rule its sizes will be a multiple of wavelength λ (table 1) if another frequency of operation is needed.
It's noticeable that the distance of radiator to the ground has important effect on the VSWR of the antenna. After using sizes of table 1 and simulating the designed antenna(figure 4) with HPHFSS, the radiation pattern at 1GHz and return loss will be like the following form (figure 5&6).

Table 1: Dimensions of PICA Antenna

Description	Symbol	Size
Length L1	L1	37.5 mm
Length L2	L2	37.5 mm
Height of the element	L	75 mm
Width of the element	L3	75 mm
Cone angle	a	90 Degree
Feed length	h	0.7 mm
Radius of Ground Plane	Ground Plane	300 mm

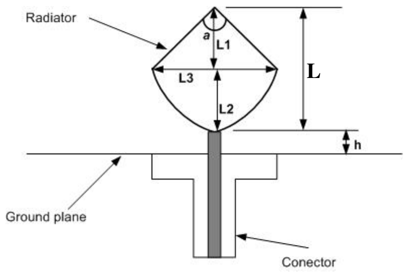

Figure 4: PICA

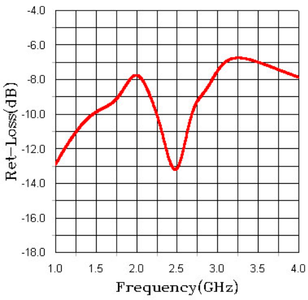

Figure 5: Return Loss

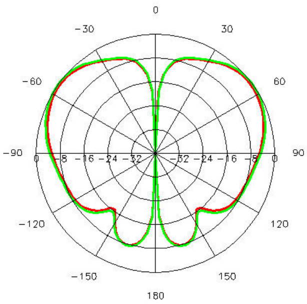
Figure 6: Elevation Pattern at 1GHz

In the second step, in order to approach the main and discussed antenna specifications, we must flip the radiator to axis x (figure 7). With this variation the angle of maximum directivity take place in 0° to 30° range and the proper VSWR is obtained. Although the sizes in the table 1 will be changed as follows (table 2):

Table 2: Dimensions of Inverted PICA Antenna

Description	Symbol	Size
Length L1	L1	37.5 mm
Length L2	L2	37.5 mm
Height of the element	L	75 mm
Width of the element	L3	75 mm
Cone angle	a	90 Degree
Feed length	h	4.396 mm
Radius of Ground Plane	Ground Plane	300 mm

By using the mentioned changes and simulating it with software HPHFSS, we can see some changes in return loss and radiation pattern of antenna (figure 8&9).

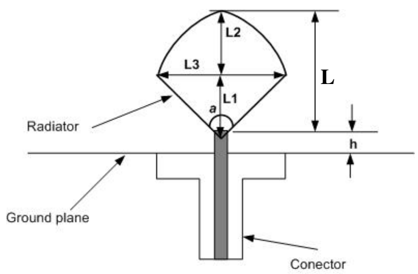

Figure 7: Inverted PICA

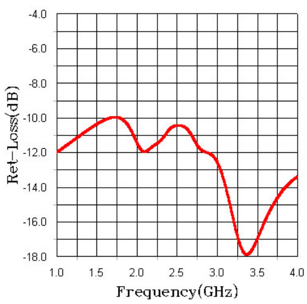

Figure 8: Return Loss

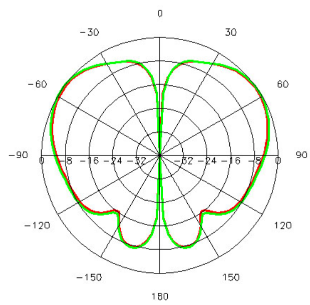
Figure 9: Elevation Pattern at 1GHz

3. The main structure of antenna

By doing step 1 and step 2 that we got through them before, we approached to the main goal which is designing the omni directional antenna in the desired frequency bandwidth.

Also it is supposed to design the antenna in a way to have maximum directivity in angles 0°to 30° to the axis z. so first we rotate the radiator to the axis x and then to the axis z about 45° and we suppose the ground as a cone that its big base radius is 150mm and its small base radius equals 10mm and its vertical in 56.2mm (Figure 10). the changes in angle of radiation to the axis's x and z causes to have different kinds of polarizations in addition to omni directional and the optimized pattern in angles 0° to 30° to the axis z.

In order to prevent the connection between radiator and the ground which is 2.3 mm of the bottom of disc, we put a plate of teflon between them. Input Impedance here is 50Ω. The obtained antenna has a fan shape beam which has the maximum directivity in angles 0° to 30° but it hasn't omni directional pattern(figure11 & 12).

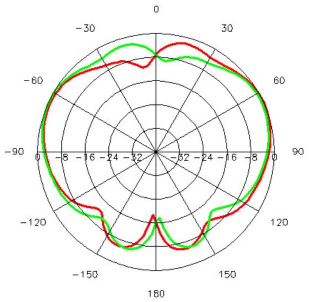

Figure 11: Elevation Pattern at 1GHz

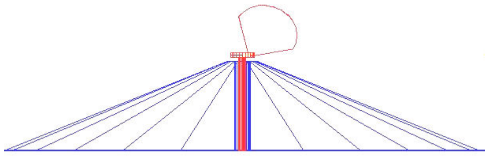

Figure 10: Single Rotated Invert PICA with new Ground

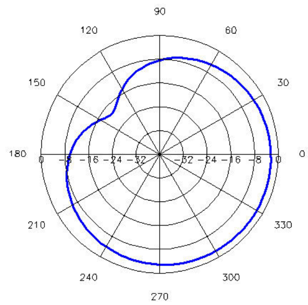

Figure 12: Azimuth Pattern at 1GHz`at $\theta = 15°$

For making an omni directional pattern in the desired frequency bandwidth, mean while changing in sizes of radiator, we use 8 radiators that are arranged with an equal angle around a disc with 7.5 mm in radius and 3 mm in vertical, in this way the final structure of antenna will be formed (figure 13).

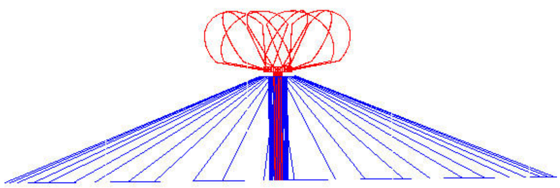

Figure 13: Antenna with 8 Radiators

With this structure, we can see the production of 8 fan shape beams which totally include 360° in azimuth and 0° to 30 ° in elevation.

By changing the angle of radiators to the axis z or changing the angle of cone gradient (ground) we can change the covering angle in elevation as we like. The plots of radiation pattern and return loss of final antenna often simulating with HPHFSS in different frequencies will come out like this:

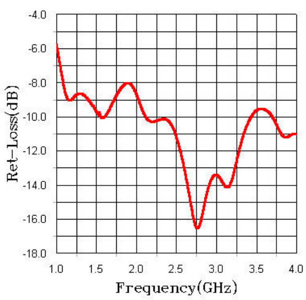

Figure 14: Return Loss

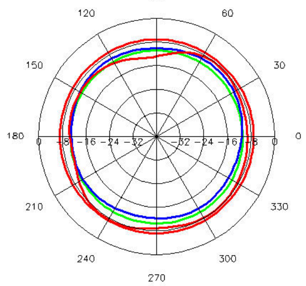

Figure 15: Azimuth Pattern at 1, 2, 3&4GHz at $\theta = 15°$

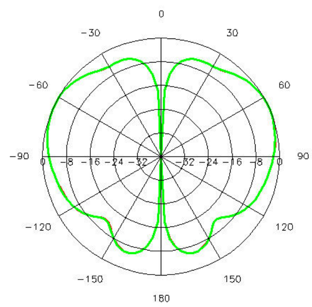

Figure 16: Elevation Pattern at 1GHz

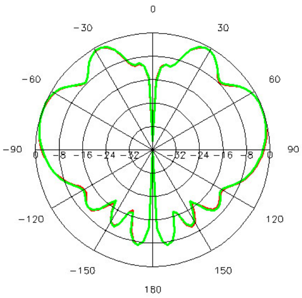

Figure 17: Elevation Pattern at 2GHz

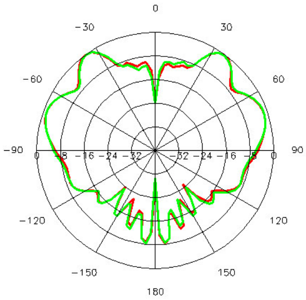

Figure 18: Elevation Pattern at 3GHz

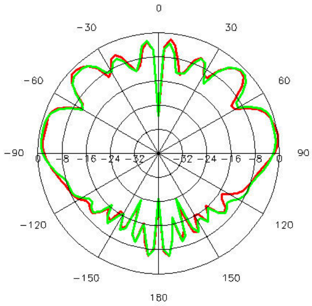

Figure 19: Elevation Pattern at 4GHz

After the above process and optimizing it with HPHFSS we make the antenna (figure 20).
The measured return loss (figure 21) indicates the conformity of structured antenna with simulated sample.

Figure 20: Final Antenna

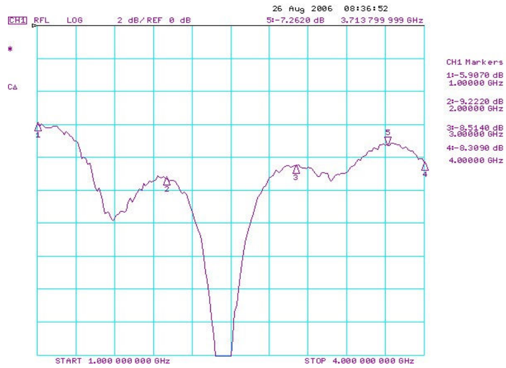

Figure 21: Return Loss

References

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

[2]N.PAgramall, G.Kummar, and K.P.Ray, “Wide-band Planar Monopole Antenna” ,IEEE Transactions on Antennas and Propagation, Vol. 46, No. 2, pp. 294-295, Feb 1998.

[3]R.M.Taylor, “A broadband Omni-directional Antenna”, IEEE Antenna and Propagation Society International Digest (Seattle), Vol.2, pp.1294-1297, June1994.

[4]Seong-Youp Suh, “A Comprehensive Investigation of new planar wideband Antenna”, PHD thesis, Black burg Virginia, Electrical and Computer Eng. pp. 123-156, July 2002.