Printed Anchor Shaped Monopole Antenna

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ABSTRACT
This paper presents a printed anchor shaped antenna with a rectangular ground plane which belongs to the class of printed monopole antenna and is small ($20.25cm^2$), compact, conformal and provides an ultra wide band performance giving very good omnidirectional radiation pattern similar to monopole antenna. It has an impedance bandwidth of more than 1:7 and a constant group delay over this range.

General Terms
Printed monopole antenna, UWB antenna.

Keywords
Group delay, 3D radiation pattern, gain.

1. INTRODUCTION
Ultra wide band technology is the most promising solution to achieve high speed data communication. The Federal Communication Commission (FCC) regulated the emission limits of -41.3dBm/Hz for an allocated spectrum ranging from 3.1GHz to 10.6 GHz. Conventional communications involves modulation of the message signal over a high frequency carrier and then transmitting it over a channel. This is a narrowband communication scheme. UWB technology transmits message signal as pulses in time domain which occupies a large bandwidth in frequency domain. Hence the devices that would have antennas in them that can cover a wide range of frequencies are required. Moreover in UWB the messages have to be transmitted with low power to avoid interference with previously existing narrowband systems. Hence the antenna that would operate in an UWB device must be highly efficient so as to minimize the losses. As technology advances the size of devices are becoming smaller. Hence the antenna unit in these devices must be small and compact. Moreover to avoid dispersion of pulses these antennas must have a constant group delay. A constant group delay involves less dispersion in time domain. Moreover these antennas have to provide omnidirectional radiation pattern throughout the entire bandwidth.

Monopole antenna which is a modified version of the dipole provides omnidirectional radiation pattern but these are three dimensional antennas and cannot be incorporated into smaller devices [3]. If the thickness of the monopole antenna is reduced to that of a plane the resultant antennas are called planar antennas [1]-[5]. These provide a larger bandwidth than their monopole counterparts but still these are not compact enough to be incorporated into smaller devices.

Microstrip patch antennas are compact and conformal but these are inherently narrow band antennas because of their resonant nature [24]. Several techniques have been proposed in literature to enhance the bandwidth of microstrip patch antennas but these would either increase the size of the antenna or the impedance match throughout the UWB range will not be perfect [22],[24].

Printed antennas have the design of patch antennas but envisage characteristics similar to that of a monopole antenna. These are small, conformal and have a wide impedance bandwidth. Many printed antennas have been discussed in literature [6]-[22].

This paper discusses a anchor shaped printed antenna which belongs to a class of printed monopole antennas that meets the above UWB requirements. All the simulations are carried out using Ansoft HFSS software.

2. STRUCTURE
The geometry and coordinate system for the proposed printed monopole antenna fed by a 50 Ω microstrip feed line is shown in Figure 1. It is printed on a Roger RT/ Duroid 5880(tm) substrate with a thickness of 1.6mm, relative permittivity of 2.2 and a dielectric loss tangent of 0.0009. The length of the patch is L=20 mm and width is W= 24mm.The width of the microstrip feed line is fixed at W_1=4.01 mm for 50 Ω impedance. A rectangle of cross section 3.2 mm × 15 mm is connected between the patch and the 50 Ω feed line for impedance matching (quarter wave transformer). The dimensions of the feed line are shown in Figure 2.

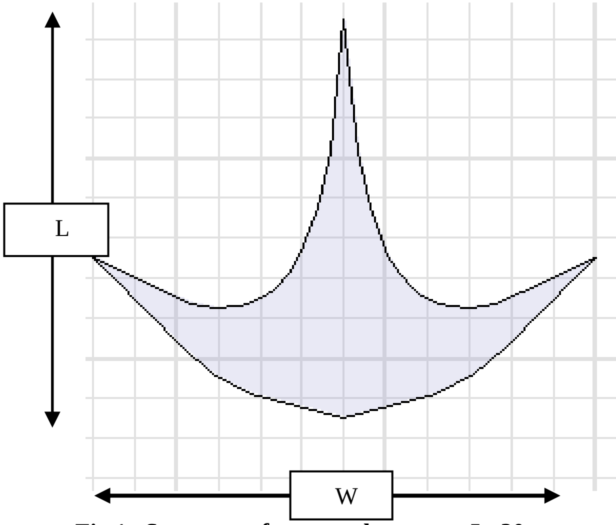


Fig 1. Structure of proposed antenna. L=20mm. W=24mm.

The substrate is of length 45 mm and width 45 mm. The dimensions of the ground plane are 45 mm × 14 mm. The bottom edge of the patch is located at 3.420 mm above the ground plane. The above dimensions of the antenna are for optimum performance got as a result of extensive simulations. We found that when the patch is not center fed, for an offset feed (offset distance f =2mm) better impedance match is obtained. This can be well understood from Figure 3 and the impedance bandwidth curves of Figure 4.

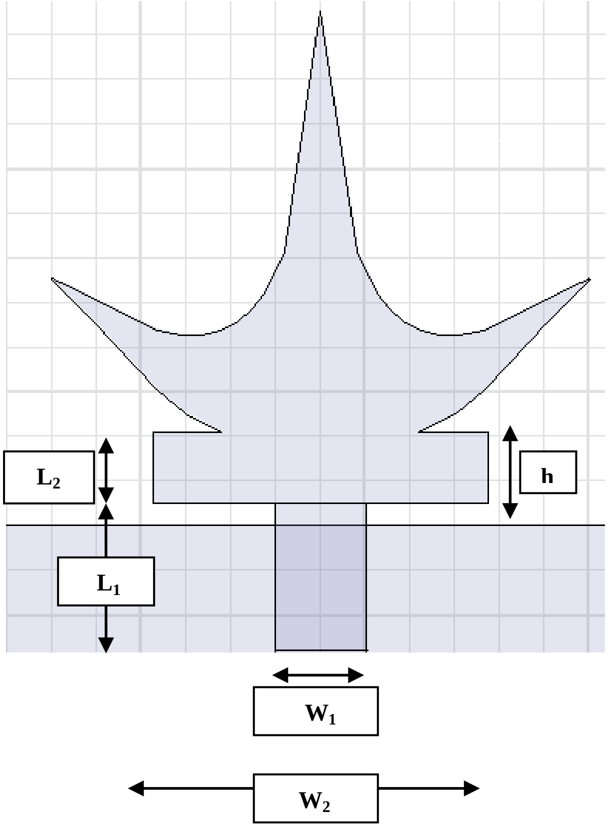


Fig 2. Dimensions of feed. L_1=15 mm, L_2=3,2mm ,W_1=4.01mm, W_2=15mm , h=4.2 mm.

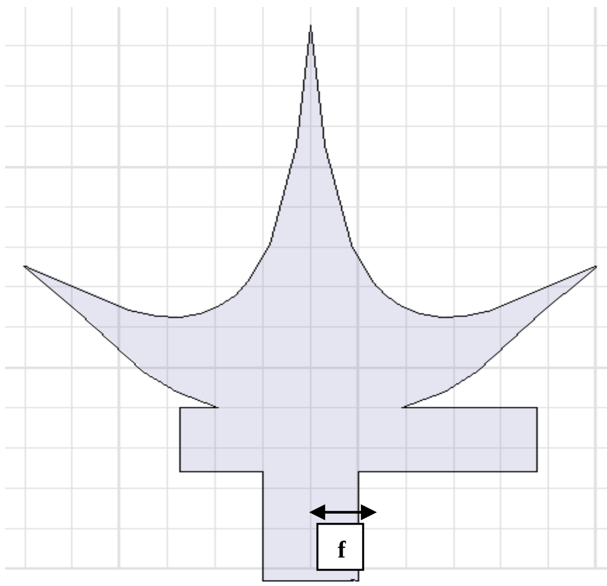


Fig 3. Offset length f= 2mm.

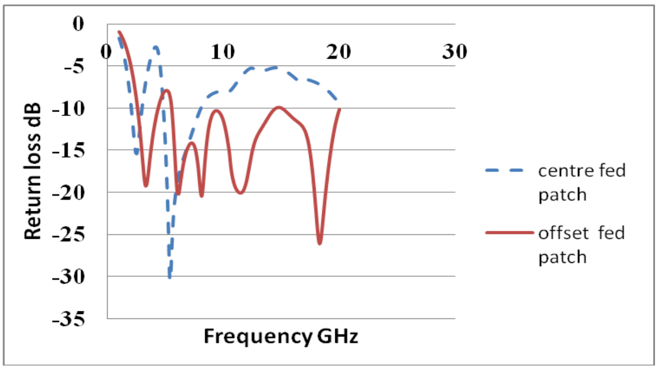


Figure 4. Impedance bandwidth curves for centre fed and offset fed patch.

3. IMPEDANCE BANDWIDTH

The impedance curve for the proposed antenna in which the patch is offset fed is shown in Figure 4. This Figure shows that our proposed antenna provides very good impedance match throughout the UWB range. The minima occurring in the UWB range are listed in Table 1.

Table 1. The minima occurring within the UWB range.

Minimum	f (GHz)	Return loss (dB)
First	3.28	-19.258
Second	6.23	-20.22
Third	8.12	-20.475

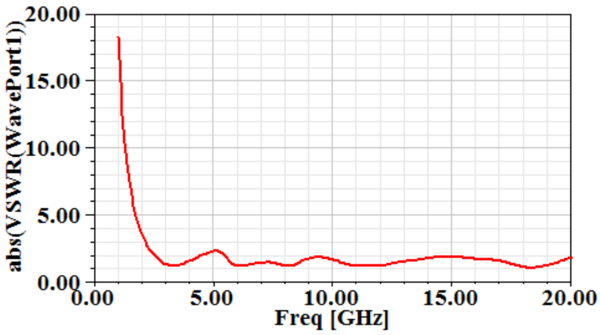


Figure 5. VSWR curve.

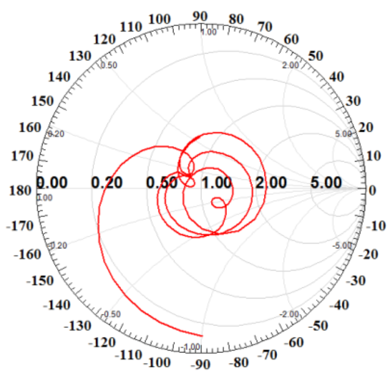


Figure 6. Smith chart showing impedance match.

The impedance bandwidth in terms of VSWR (VSWR < 2) for is shown if Figure 5 and in terms of smith chart in Figure 6. In both the plots we see that for the UWB range there is a good impedance matching between the patch and the feed as the VSWR value is noted to be less than 2. This is also indicated by the closely packed coils in the smith chart.

4. GROUP DELAY

A constant group delay which ensures low dispersion in time domain is required for an UWB antenna. This is an important characteristic of an UWB antenna. The group delay graph is shown in Figure 7. From the graph we observe that the proposed antenna gives reasonably constant group delay over the UWB range.

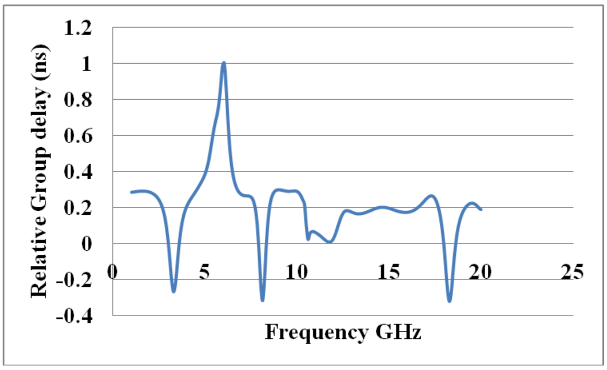


Figure 7. Relative Group delay.

5. RADIATION PATTERN

The radiation pattern for the various minimums listed in Table 1 is shown in Figure 11. At lower frequencies the cross polarization levels are low. As the frequency increases the cross polarization levels increase since the proposed antenna is not rotationally symmetrical. From Figure 11 we observe that this antenna provides very good omnidirectional radiation pattern throughout the UWB. The 3D radiation pattern is shown in Figure 10.

6. GAIN

The peak gain of the antenna for various frequencies is plotted in Figure 8. From the graph we observe that the gain gradually increases with frequency. There is a sharp increase in gain in the initial part of the graph, when the frequency reaches around 3 GHz the sharp increase vanishes and we see a gradual increase in the peak gain value.

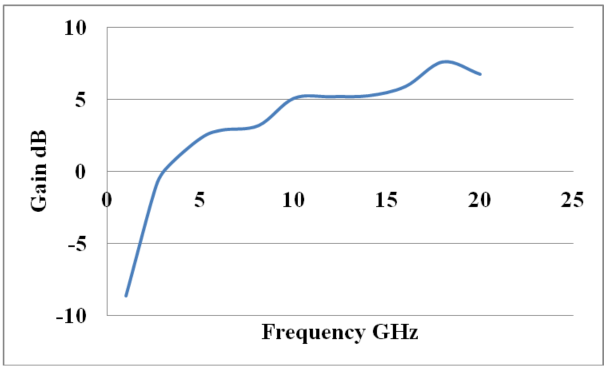


Figure 8. Gain Vs Frequency.

Gradual increase in gain indicates that there is also a gradual increase in directivity as they are directly proportional which means there is slow degradation of omnidirectional radiation pattern as the frequency increases. If there is a sharp increase in gain it would mean a sharp increase in directivity which means quick degradation of the omnidirectional radiation pattern. Our proposed antenna achieves a gradual increase in the peak gain value as shown in Figure 8.

7. DIRECTIVITY

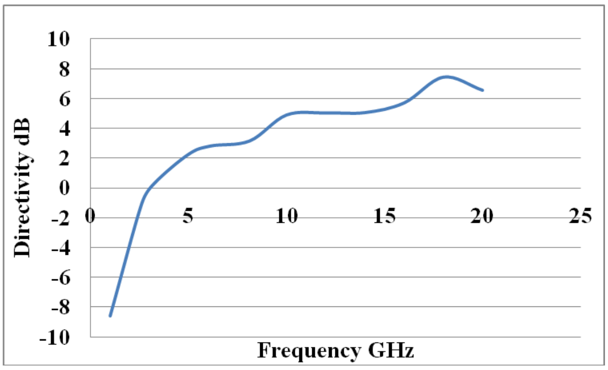


Figure 9. Directivity Vs Frequency.

High directivity means that the antenna is highly directional. Hence to get a very good omnidirectional radiation pattern the directivity value must be low. Since printed antennas are not rotationally symmetrical we would have degradation in the omnidirectional radiation pattern as the frequency increases. But the rate of degradation can be controlled. If by some mechanism we slow down the rate at which this degradation takes place then we would be getting very good omnidirectional pattern. The peak directivity for this antenna is shown in Figure 9.

From the graph we see that there is a gradual increase in directivity in the UWB region. We have a sharp increase in the directivity in the initial part of the graph, as the frequency approaches around 3 GHz the steep increase in directivity vanishes and we have a gradual increase.

8. 3D RADIATION PATTERN

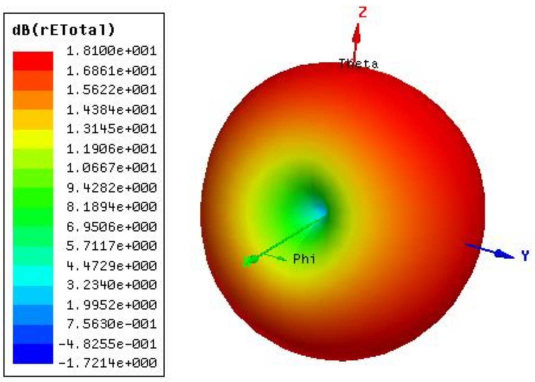
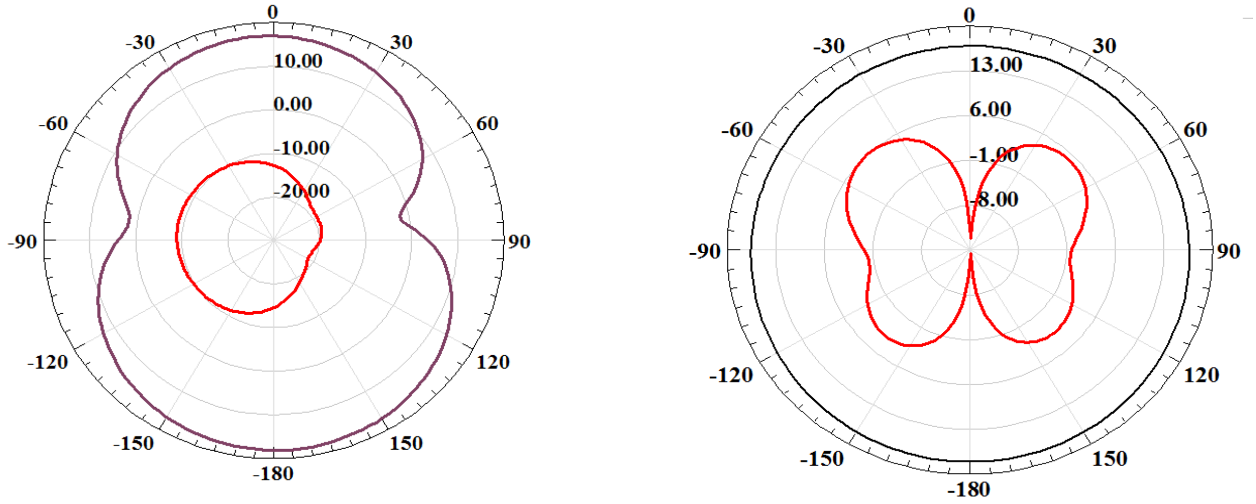
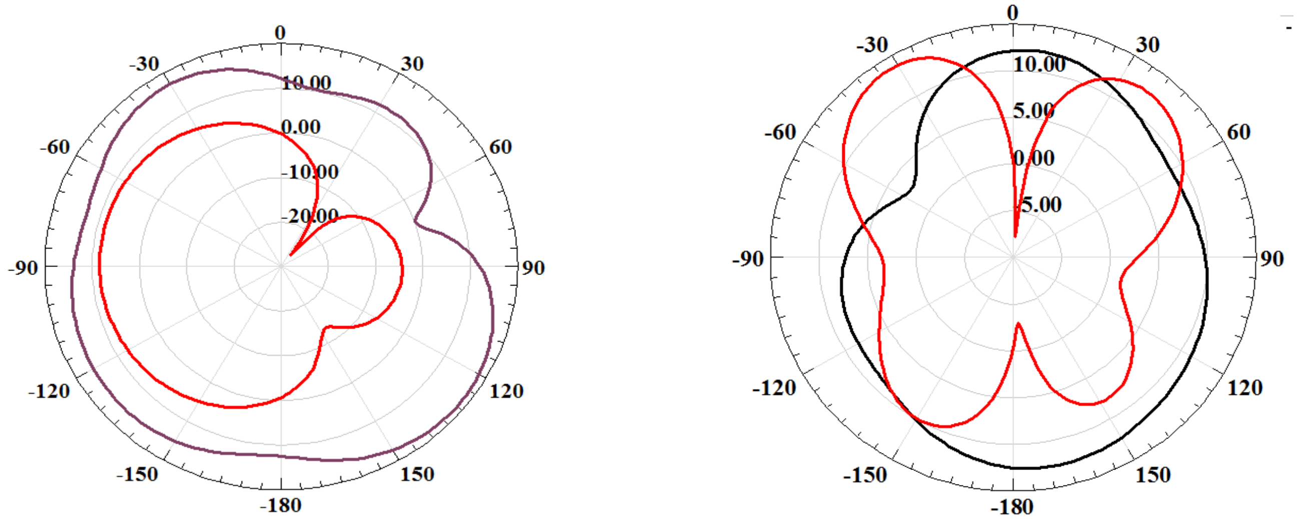


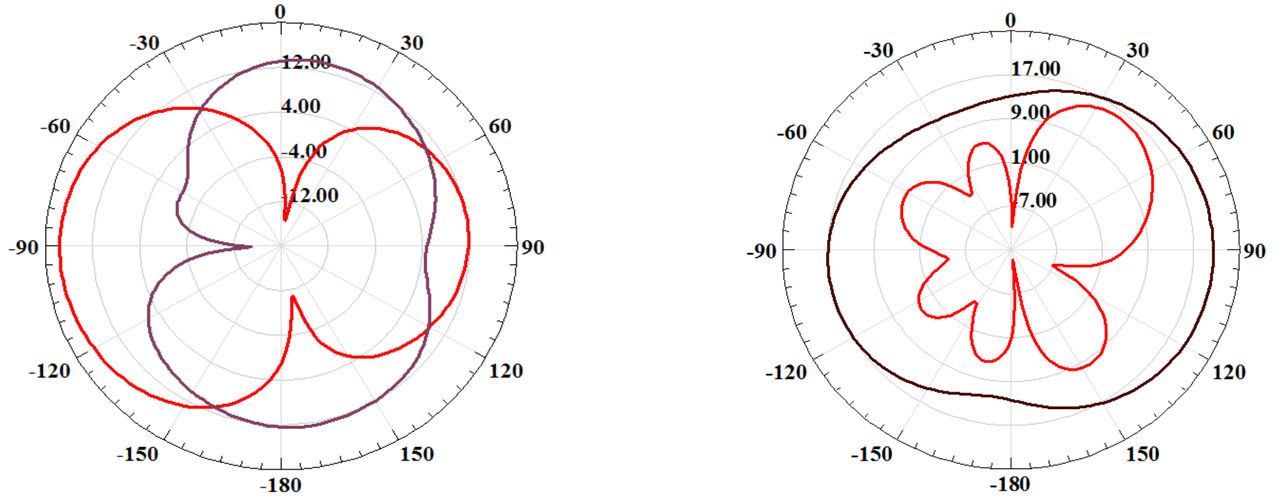
Figure 10. Three dimensional radiation pattern at 3.28Ghz.



a)



b)



c)

YZ plane **XZ plane**

Figure 11. Elevation pattern in XZ and YZ plane at a) 3.28 GHz b) 6.13 GHz c) 8.12 GHz.

9. CONCLUSION

A printed antenna that has a shape of an anchor belonging to the class of printed monopole antenna was discussed. Its radiation pattern, impedance bandwidth, gain and directivity were analyzed. The proposed antenna is compact (45 mm×45 mm) and hence can be incorporated into smaller devices that operate in the UWB range. Since the proposed antenna operates in a very high frequency range it can be used for military purposes.

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