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# Design and Analysis of Ultra Wide Band log-periodic Planar Dielectric Antenna in Wireless Communications

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## ABSTRUCT

The ultra wide band planar dielectric antennas developed give almost omni directional radiation pattern along with a huge impedance bandwidth. These antennas are investigated from 6 GHz to 14 GHz ( in case of planar log periodic dielectric antenna ) and 3 GHz to 8 GHz ( for the planar spiral dielectric antenna ). All these antennas are very useful in blue-tooth, WI-FI, personal wireless communications equipment, as all these antennas give good omnidirectional radiation patterns with ultra wide band impedance bandwidth. For wireless mobile or blue tooth applications at the higher end of the spectrum, small Omni directional antennas are required which are capable of providing almost equal radiation to all directions over a very wide frequency range. Though micro strip, PIFA and other planar antennas can provide rather broad radiation pattern at these frequency ranges, they suffer from extremely narrow bandwidth of operation

**KEYWORDS**: Dielectric Antenna, Ultra wide band, Log periodic , Radiating Slab.

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## INTRODUCTION

Frequency independent antennas had been proposed and devised for working over huge band widths. According to Rumsay [1], solely angle dependent geometries are amenable to such operation. This principle had so far been applied to metallic antennas only. Here we report theoretical and experimental investigations on novel planar dielectric antennas like, ultra wide band log-periodic and spiral angle dependent dielectric antennas. The first dielectric log periodic planar antennas is of the form of two arms forming a bowtie and then the spiral dielectric antenna is of the form of two arms forming an angle dependent equiangular structure, whose dimensions vary exponentially with constant periodicity. Planar antennas can provide rather broad radiation pattern at these frequency ranges, they suffer from extremely narrow bandwidth of operation [2-4]. Moreover, another limitation of such antennas is hemispherical radiation pattern. To eliminate these problems, we investigate a planar dielectric toothed log periodic antenna and a dielectric spiral antenna, which are defined by angle dependent geometry and hence are suitable for frequency independent operation. The feeding is done by a 50 ohm coaxial type SMA connector at the centre.

### *Ultra wide band log-periodic dielectric antenna*

We investigate a dielectric dipole structure within which notches are cut, whose dimensions vary with logarithmic periodicity. It is found that the antenna offers ultra wide 3:1 VSWR bandwidth of about 6.48 GHz. Further, the experimentally measured radiation patterns show rather broad nature suitable for omni directional coverage. Varying the plane of polarization, it is also observed to have an almost polarization independent behavior. All these characteristics make this new antenna ideally suited for numerous emerging fields of wireless and mobile communications.

### *Designing Methodology*

In spherical co-ordinates ($r$, $\theta$, $\Phi$) the shape of a typical log periodic structure can be written as [5-7]

$\theta$ = periodic function of [$b \ln(r)$] where b is a constant.

An example may be cited as $\theta = \theta_0 \sin [b \ln (r/r_o)]$

It is evident that the value of $\theta$ is repeated whenever the logarithm of the radial frequency $\ln(\omega) = \ln(2.\pi.f)$ differs by ($2\pi / b$). The performance of the system is then periodic as a function of the logarithm of the frequency, thus the name logarithmic-periodic or log periodic. Photograph of the planar log periodic structure investigated is shown in Figure 5.1(a). It consists of a dielectric strip whose edges are specified by the angle $\alpha / 2$ as shown in its top view depicted in Figure 5.1(b). It consists of two coplanar arms (forming a dipole) with notches cut within whose dimensions vary in successive cells according to a common ratio. With reference to Figure 5.1(b), we choose $\tau = \frac{R_{n+1}}{R_n}$ , $\sigma = \frac{r_n}{R_n}$ and $\sigma = (\tau)^{\frac{1}{2}}$, thus equalizing the width of the teeth and the gap between them and at the same time, we consider $\alpha + \beta = 90^0$ with $\alpha = \beta = 45^0$ and $\tau = 0.85$, so as to maintain symmetry of the dielectric structure. If the dielectric toothed log periodic antenna has certain properties (e.g. impedance, gain etc.) at any particular frequency f, it follows that the antenna will have the exactly the same properties at frequencies $\tau f$, $\tau^2 f$, $\tau^3 f$…. and $f/\tau$, $f/\tau^2$, $f/\tau^3$….and so on, provided that these frequencies are within the cut-off limits.

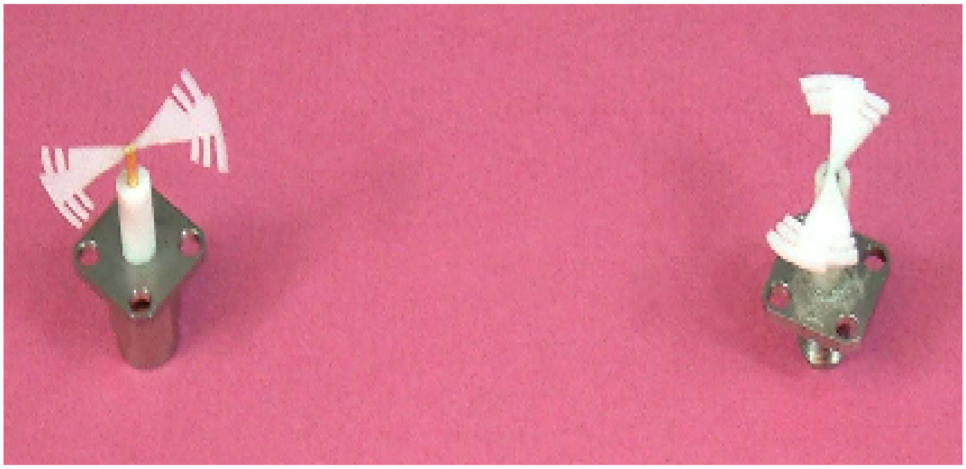

**Figure 5.1(a) Dielectric log- periodic antenna**

For the experimental purpose, dielectric material chosen is Teflon [7] with dielectric constant ($\varepsilon_r$) = 2.4.

R3 = 0.78 cm. r3 = 0.719 cm.

R2 = 0.92 cm. r2 = 0.848 cm.

R1 = 1.08 cm. r1 = 0.996 cm.

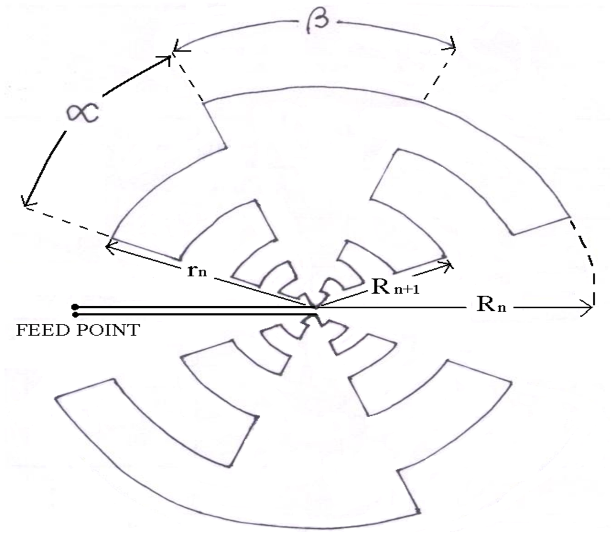


**Figure 5.1(b) Top view of dielectric log periodic antenna**

## RESULTS:

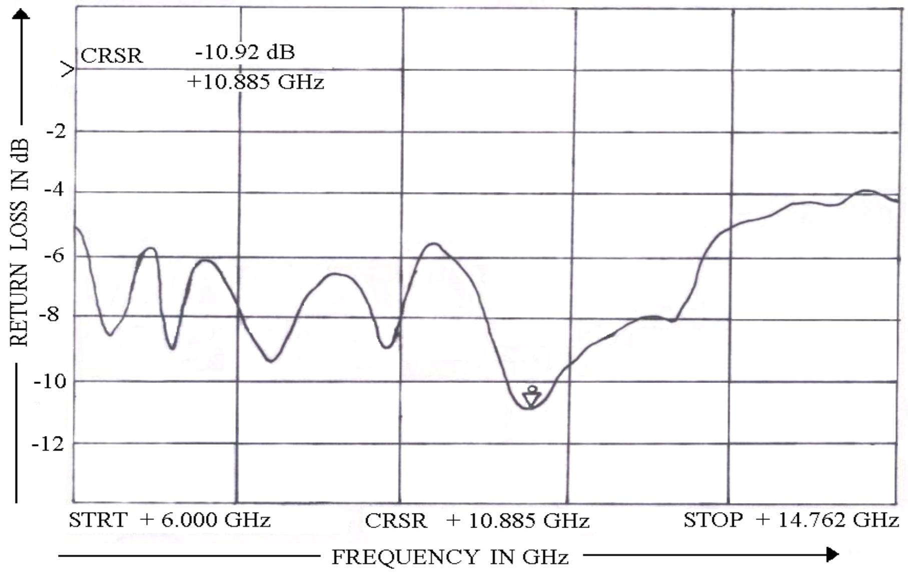


**Figure 5.2 Return loss vs. frequency plot**

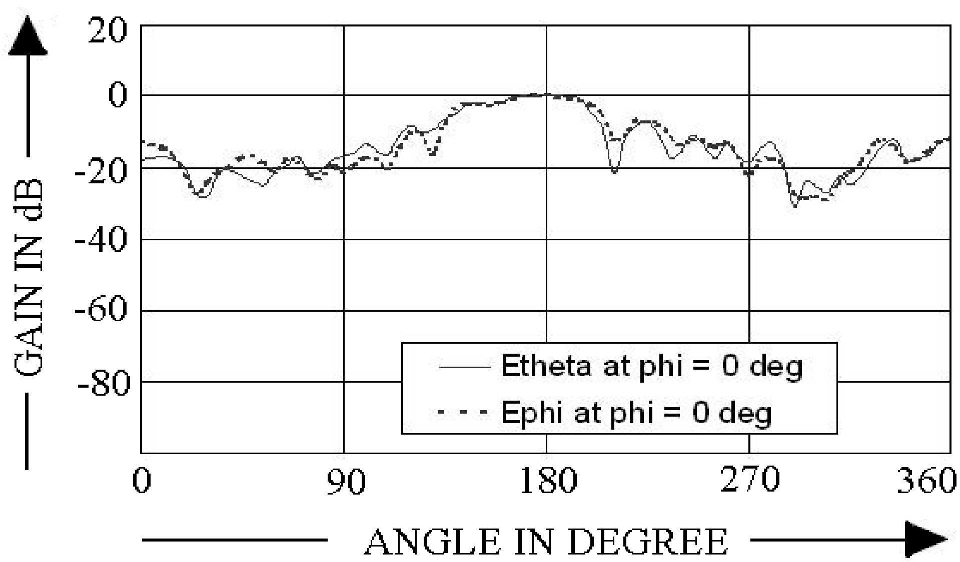


**Figure 5.3 Radiation patterns for $E_{theta}$ and $E_{phi}$ vs. theta at phi = 0 deg.**

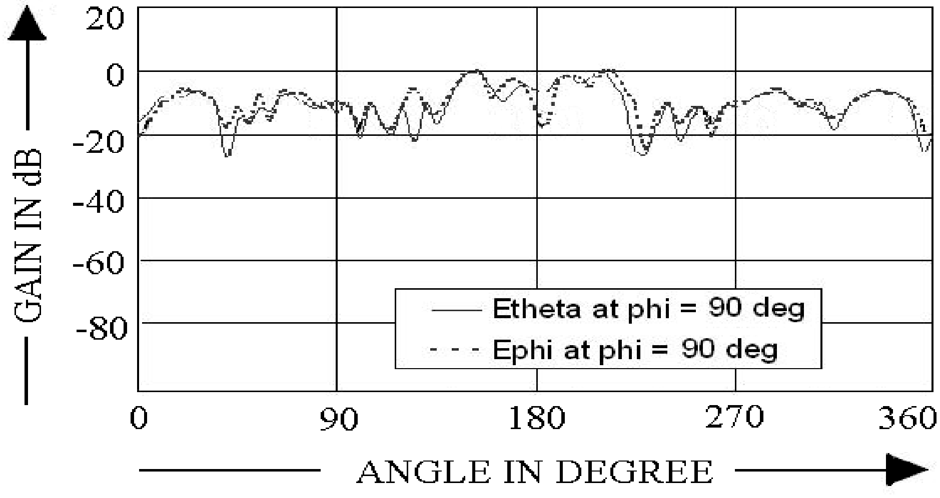


**Figure 5.4 Radiation patterns for $E_{theta}$ and $E_{phi}$ vs. theta at phi = 90 deg**

Experimentally measured return loss plot against frequency is shown in Figure 5.2. It shows that the minimum return loss of about –10.92 dB occurs at 10.885 GHz. In addition, it maintains ultra wide band spectrum with nearly 3:1 VSWR bandwidth extending from 6.1752 GHz to 12.66 GHz. It is to be noted that this is the standard definition used for ultra wide band antennas. Within this frequency range, it provides less than 2.5:1 V.S.W.R. for more than five bands of operation. The bands are of width 219.05 MHz about 6.329 GHz, 219.05 MHz about 6.767 GHz, 584.133 MHz about 8.044 GHz, 292.067 MHz about 9.359 GHz and 2044.467 MHz about 10.885 GHz and even <2:1 V.S.W.R. for 701 MHz extending from 10.555 GHz to 11.256 GHz.

Experimental radiation patterns had been also measured and are shown in Figures (5.3 and 5.4). In all four principal planes the patterns are almost omni directional and as a whole the antenna gives an almost isotropic pattern.

## CONCLUSION

Measured results indicate suitability of these wide band dielectric antenna for wireless and mobile applications with good omni directional pattern coverage over extremely wide spectral ranges. Another interesting observation has been the small size of the antenna, which makes them ideal for handheld mobile applications where space and weight are at premium.

It is found experimentally that ultra wide 3:1 VSWR impedance bandwidth of about 4.23 GHz (from 3.08 to 7.31 GHz) with the best return loss within the operating band being about -11 dB is obtained for the dielectric spiral antenna and nearly 3:1 VSWR bandwidth extending from 6.1752 GHz to 12.66 GHz is obtained for the dielectric log-periodic antnna. Further, the experimentally measured radiation patterns show rather broad nature suitable for omni directional coverage. Varying the plane of polarization, they are also observed to have an almost polarization independent behavior.

All these characteristics make these new antennas developed ideally suited for numerous emerging fields of wireless, blue tooth and mobile communications.

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