Antennas using Tapered Nylon Rods: Experiments

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Abstract

In this paper experimental studies were presented using tapered Nylon rod antennas of length $6\lambda_0$ with different taper angles. The Half Power Beam width (HPBW), Side Lobe Level (SLL) is measured for each taper angle of the antenna. The objective of the experimental study is to find the optimum taper angle of the antenna. The principle plane patterns are measured for each taper angle and the principle plane pattern are presented for optimum taper angle of the antenna.

Keywords: Taper angle, Half Power Beam Width (HPBW), Side Lobe Level (SLL), Nylon.

Introduction

Extensive studies on dielectric rod antennas like, Perspex, Polystyrene, Wood, Teflon, and Ebonite are reported in the literature [1] - [5]. The radiation characteristics of dielectric rod antennas mainly depend on the dielectric constant of the material, length, diameter and taper angle of the antenna. Hence the design of dielectric rod antenna includes length, diameter, taper angle of the rod and making provision for exciting the dielectric rod in HE_{11} mode. The tapered dielectric rod antennas are used to reduce amplitude and number of side lobes and these are also used to minimize standing waves caused by reflection at the free end of the rod [6]. The choice of Nylon rod antenna of length $6\lambda_0$ is made on the basis of results of computational studies carried out on the radiation patterns of tapered Nylon rod antennas reported in [7]. In this paper the experimental results of Nylon dielectric rod antennas with different taper angles and principle plane patterns for optimum taper angle are presented.

Design and Fabrication

A dielectric rod of uniform circular crossection may be excited in the HE_{11} mode, by inserting it into a cylindrical wave guide operating in the TE_{11} mode. The transition from metal to dielectric wave guide is achieved by means of tapering the end of the dielectric rod, inserted into the metal guide, to a point. The portion of the dielectric rod radiating into space is given a small taper to obtain matching between the dielectric rod and surrounding space.

In the present work, Nylon tapered dielectric rod antennas are fabricated for a length of $6\lambda_0$ with different taper angles. The dielectric rod antenna is designed to work at a frequency of 10

GHz. The corresponding free space wave length (λ_0) becomes 3cm and therefore the length of the radiating portion is 18cm. In addition to this length, an extra length of 6cm is used for tapering the rod to a point at the feedend to provide impedance matching with the guide, and another 3cm length is used to insert the dielectric rod into the metal wave guide to fit tightly. Therefore, the total length of Nylon rod becomes 27cm. The diameter of the rod at the feed end is equal to the inner diameter of the circular wave guide which for a WC94 wave guide is 2.383cm.

Diameter at free end (d_{min}) for a given taper angle (θ_0) is calculated using the expression [8]:

$$\tan(\theta_\circ) = \frac{(d_{max} - d_{min})}{2L}$$

The values of d_{min} are shown tabulated in table.1, for θ_0 = 0°, 1°, 1.5°, 2°, 2.5°, and 3°. The dimensions of tapered nylon rod antenna are shown in Fig.1. The Nylon rod purchased from the supplier has a length of approximately 30cm. This is cut and facedon a lathe to obtain the required length, that is, 27cm. The rod is tapered from d_{max} at one end to d_{min} at the other end on a lathe by setting the tool to the required angle. Thefabricated Tapered Nylon rod antenna for optimum taper angle is shown in Fig .2.

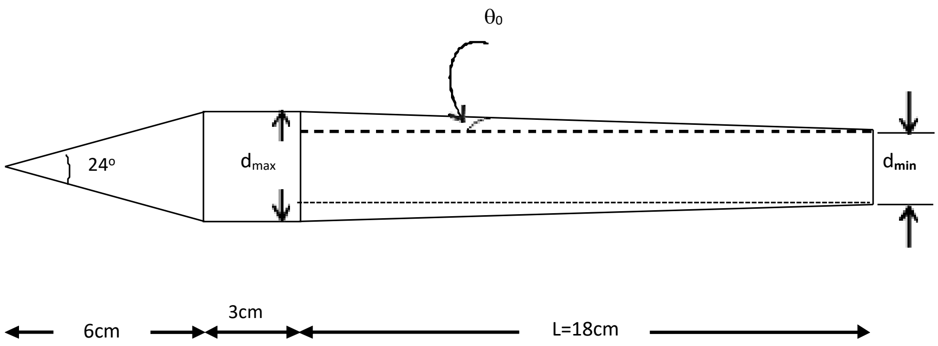


Figure 1: Dimensions of tapered Nylon rod antenna.

Table 1: d_{min} for different θ_0.

S.No.	θ_0 (Deg)	d_{min} (cm)
1	0°	2.37
2	1°	1.74
3	1.5°	1.43
4	2°	1.11
5	2.5°	0.8
6	3°	0.5

Figure 2: Tapered Nylon dielectric rod antenna (θ_0= 2.5°).

Results and Discussions

Tapered Nylon rod antennas of length $6\lambda_0$ is considered to measure the principle plane patterns at a frequency of 10GHz. The patterns are measured with taper angles equalto 0°, 1°, 1.5°, 2°, 2.5°, and 3°. With each taper angle the Half Power Beam Width (HPBW) and Side Lobe Level (SLL) are measured and results are presented in table

2. From the measured values the directivity (D_0) may be computed using Kraus formula [9].

$$\text{Directivity}\,(D_0) = 41253/\,(\theta_E \times \theta_H)$$

Where (2)

θ_E = HPBW in E-Plane (degrees)
θ_H = HPBW in H-Plane (degrees)

Table 2: variation of HPBW and SLL with taper angle.

S.No	θ_0 (Deg.)	HPBW(Deg.)		SLL (dB)		D_0 (dB)
		$\phi=0^0$	$\phi=90^0$	$\phi=0^0$	$\phi=90^0$	
1	0°	25	40	-3.7	-5	16.15
2	1°	26	27	-1.2	-1.5	17.69
3	1.5°	50	38	-3	-2	13.36
4	2°	30	19	-8	-2.5	18.59
5	2.5°	42	44	-12	-19	13.7
6	3°	40	38	-8	-15	14.33

From the results presented in Table.2, it may be observed that the Nylon rod antenna of length $6\lambda_0$ with 2.5° taper angle may be considered as an optimum choice, because in this case directivity is 13.7 dB and side lobe level is -19dB. In all other cases even though directivity is high, the SLL is slightly higher compared with 2.5°, taper angle. The principle plane patterns for 2.5°, taper angle are presented in Fig.3.

With a directivity of 13.7 dB and side lobe level of -19dB, this tapered nylon rod antenna may be an attractive choice as an element of planar arrays to produce a narrow broad-side radiation pattern.

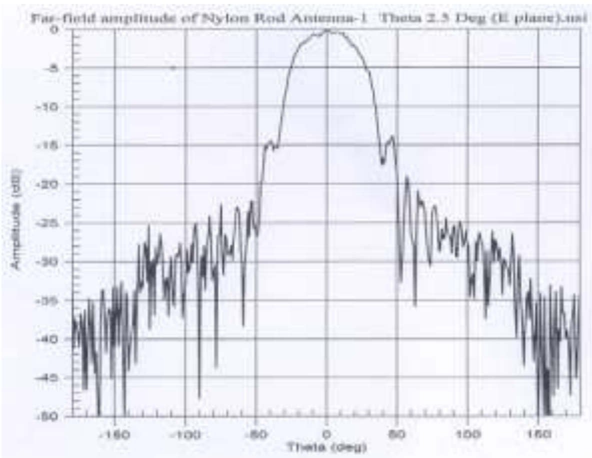
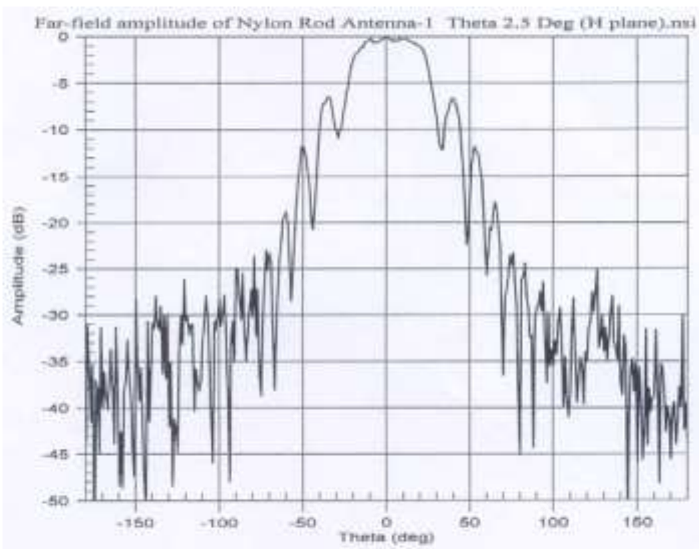


Figure 3: Principle plane patterns of Tapered Nylon rod antenna (θ_0 =2.5°).



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