EXPERIMENT NO. 3

Study of variation in dipole lengths on radiation pattern and performance

Aim:

To study the effect of variation in dipole lengths on radiation pattern and performance.

Software requirements:

Software- 4nec2 (Numeric Electromagnetic Coder)
Operating System- Windows XP, windows 7 and above

Theory:

Linear wire antennas are one of the oldest, simplest, and most basic configurations. Such radiating structures are oldest, simplest, cheapest, and in many cases the most versatile for many practical applications.
For a very thin dipole (ideally zero diameter), the current distribution can be written, to a good approximation, as-

$$\mathbf{I}_e(x'=0, y'=0, z') = \begin{cases} \hat{\mathbf{a}}_z I_0 \sin\left[k\left(\frac{l}{2} - z'\right)\right], & 0 \le z' \le l/2 \\ \hat{\mathbf{a}}_z I_0 \sin\left[k\left(\frac{l}{2} + z'\right)\right], & -l/2 \le z' \le 0 \end{cases}$$

This distribution assumes that the antenna is center-fed and the current vanishes at the end points ($z' = \pm l/2$). Experimentally it has been verified that the current in a center-fed wire antenna has sinusoidal form with nulls at the end points.
For such a finite-length dipole configuration, the typical far-field radiations are characterized as-

$$\boxed{E_\theta \simeq j\eta \frac{I_0 e^{-jkr}}{2\pi r}\left[\frac{\cos\left(\frac{kl}{2}\cos\theta\right) - \cos\left(\frac{kl}{2}\right)}{\sin\theta}\right]}$$

$$\boxed{H_\phi \simeq \frac{E_\theta}{\eta} \simeq j \frac{I_0 e^{-jkr}}{2\pi r}\left[\frac{\cos\left(\frac{kl}{2}\cos\theta\right) - \cos\left(\frac{kl}{2}\right)}{\sin\theta}\right]}$$

The associated radiation intensity is then given by-

$$U = r^2 W_{av} = \eta \frac{|I_0|^2}{8\pi^2}\left[\frac{\cos\left(\frac{kl}{2}\cos\theta\right) - \cos\left(\frac{kl}{2}\right)}{\sin\theta}\right]^2$$

The typical normalized (to 0 dB) elevation power patterns, for l = λ/4, λ/2, 3λ/4, λ and an infinitesimal dipole are shown plotted in Figure 1 below:

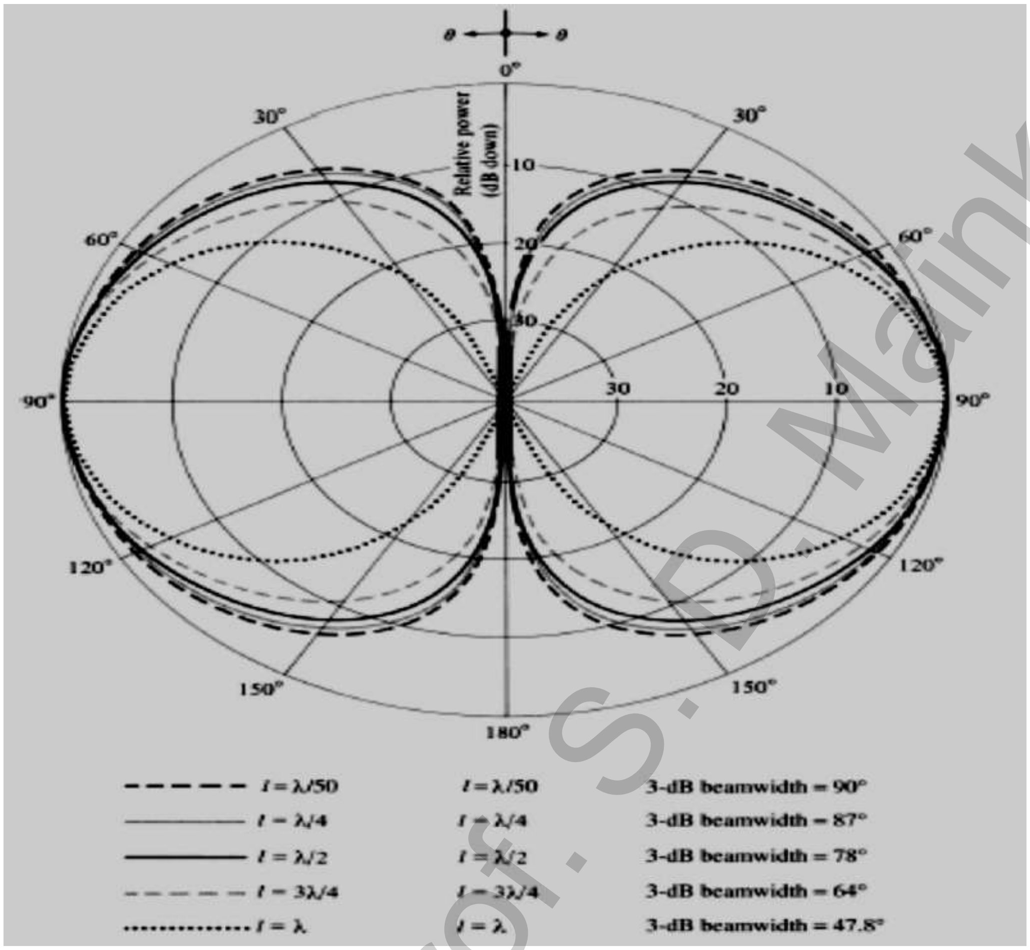

Fig. 1: Elevation plane amplitude patterns for a thin dipole with sinusoidal current distribution (l = λ⁄50, λ⁄4, λ⁄2, 3λ⁄4, λ).

Observation Table:

Operating frequency = 300 MHz

Sr. No.	Length of linear wire element	3-dB Beamwidth (HPBW)		Antenna Gain
		Theoretical	Practical	
1.	**l = λ/4**	**87^0**		
2.	**l = λ/2**	**78^0**		
3.	**l = 3λ/4**	**64^0**		
4.	**l = λ**	**47.8^0**		
5.	**l = 1.25λ**	**---**		

Conclusions:

1. As the length of the linear wire antenna increases, the beam becomes narrower. Because of that, the directivity and antenna gain should increase with length.
2. As the length of the dipole increases beyond one wavelength (l > λ), the number of lobes begin to increase.