Rochester Institute of Technology

# EE629 Antenna Theory

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**Due Date:** 09/22/2020

**Re:** PROJECT #1: Linear Dipole Antenna

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## Abstract

This project contains the analysis for the radiation pattern for the thin linear Antenna for different lengths. The graphs are plotted using MATLAB code. Analysis of the graphs are done in the discussion section.


## Theory

The Antenna which has less diameter compare to the wavelength is commonly known as thin linear antenna. The antenna wires considered so much thin so that tangential current considered to be nearly zero. Basic structure of the antenna is shown in the figure 1.

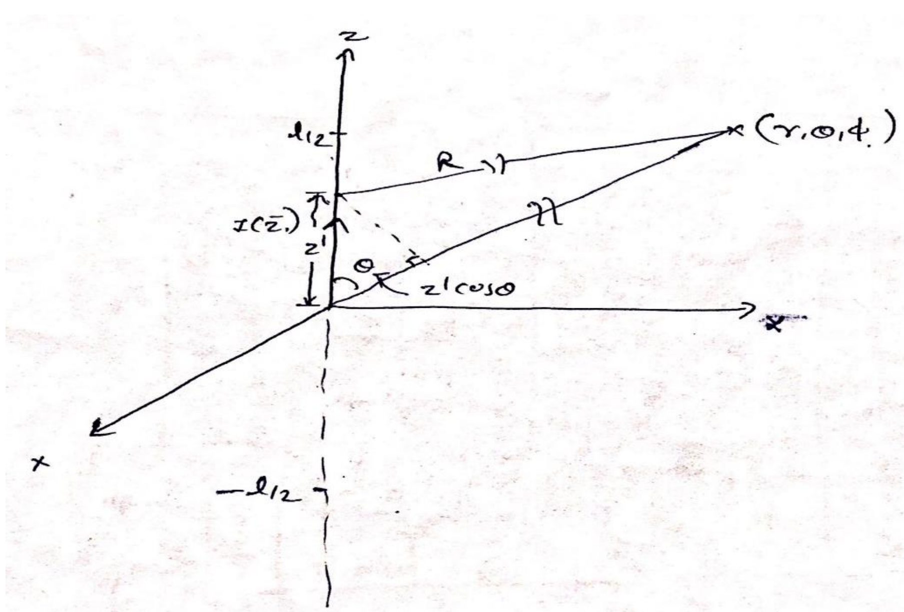


*Figure 1. Thin linear Antenna with Length L*

For the elemental dipole of length(L), electric field at distance $z'$ can be as,

$$\widehat{dE} = \frac{j\, K_0\, \eta_0\, \hat{I}\, \sin\theta\, e^{-jkR}}{4\pi R}\, dz' \tag{1}$$

After solving the equation, final formula for the electric field can be written as:

$$E(\theta) = \frac{j\, K_0\, \eta_0\, \hat{I}\, \sin\theta\, e^{-jkR}}{2\pi r}\, [\frac{\cos(\frac{K_0 l}{2}\cos\theta) - \cos\frac{K_0 l}{2}}{\sin\theta}] \tag{2}$$

Where $\theta$ is the variable and direction of the wave is positive r.

Radiation pattern distribution for the wave can be defined as :

$$F(\theta) = \frac{\cos(\frac{K_0 l}{2}\cos\theta) - \cos\frac{K_0 l}{2}}{\sin\theta} \tag{3}$$

Where l is the length of the antenna.

$K_0$ is the constant = $\frac{2\pi}{\lambda}$

Using the radiation pattern equation 3, graphs are plotted between $F(\theta)\ vs\ (\theta)$.

**Results**

| No | Antenna length | Normalize maximum value |
|---|---|---|
| 1 | 0.25 λ | 0.29 |
| 2 | 0.5 λ | 1 |
| 3 | 0.75 λ | 1.7 |
| 4 | 1 λ | 2 |
| 5 | 1.25 λ | 1.7 |
| 6 | 2 λ | 2.3 |

*Table. 1*

- Table 1 indicates the normalize maximum value of the radiation pattern captured from the plots.
- Figure 2 and 3 contains the MATLAB code for the rectangular and polar wave form. Only difference between the code is the way of plotting the graph which can be clearly seen from the line 11 of the both codes.
- For the polar plots, polarplot() is used where for rectangular plots, plot() is used.

## MATLAB code for the rectangular plot

```
 % v is taken as Wavelength and assigned one for simplisity of calculation. It will cancel out eventually.
 v = 1;
%Linear Dipole antanna , L is the length of antenna
for L = 0.25*v:0.25*v:2*v
% K is defined as constant
K = 2*pi/v;
x = 0:0.01:2*pi;
% equation for radiation pattern
F = abs((cos(K*L/2*cos(x))-cos(K*L/2))./sin(x));
figure()
plot(x,F)
end
```

*Figure 2. MATLAB code for rectangular waveform*

## MATLAB code for the polar plot

```
 % v is taken as Wavelength and assigned one for simplisity of calculation. It will cancel out eventually.
 v = 1;
%Linear Dipole antanna , L is the length of antenna
for L = 0.25*v:0.25*v:2*v
% K is defined as constant
K = 2*pi/v;
x = 0:0.01:2*pi;
% equation for radiation pattern
F = abs((cos(K*L/2*cos(x))-cos(K*L/2))./sin(x));
figure()
polarplot(x,F)
end
```

*Figure 3. MATLAB code for polar waveform*

Radiation patten graphs for different lengths in rectangular coordinate system.

**1) L = 0.25 λ**

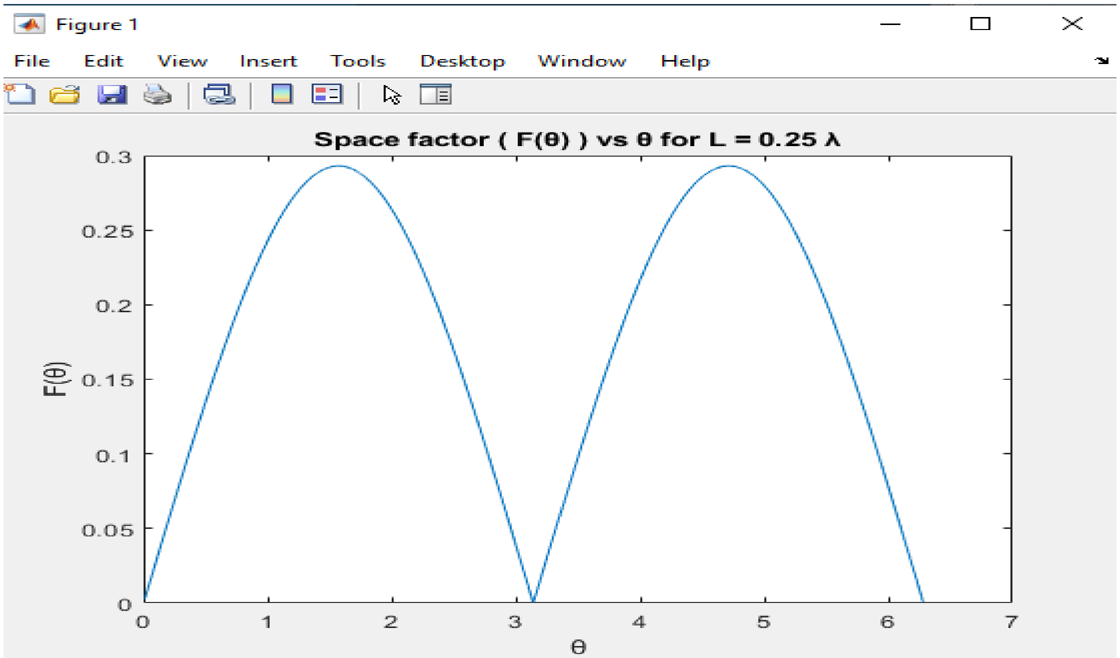


*Figure 4. Waveform for L = 0.25 λ ( Rectangular)*

**2) L = 0.5 λ**

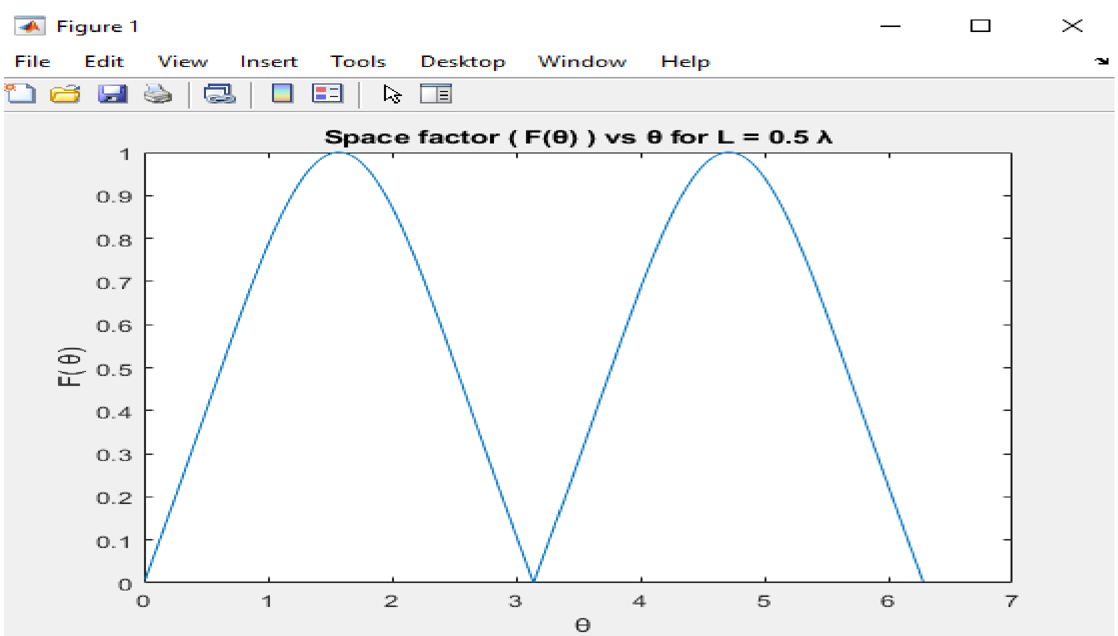


*Figure 5. Waveform for L = 0.5 λ ( Rectangular)*

**3) L = 0.75 λ**

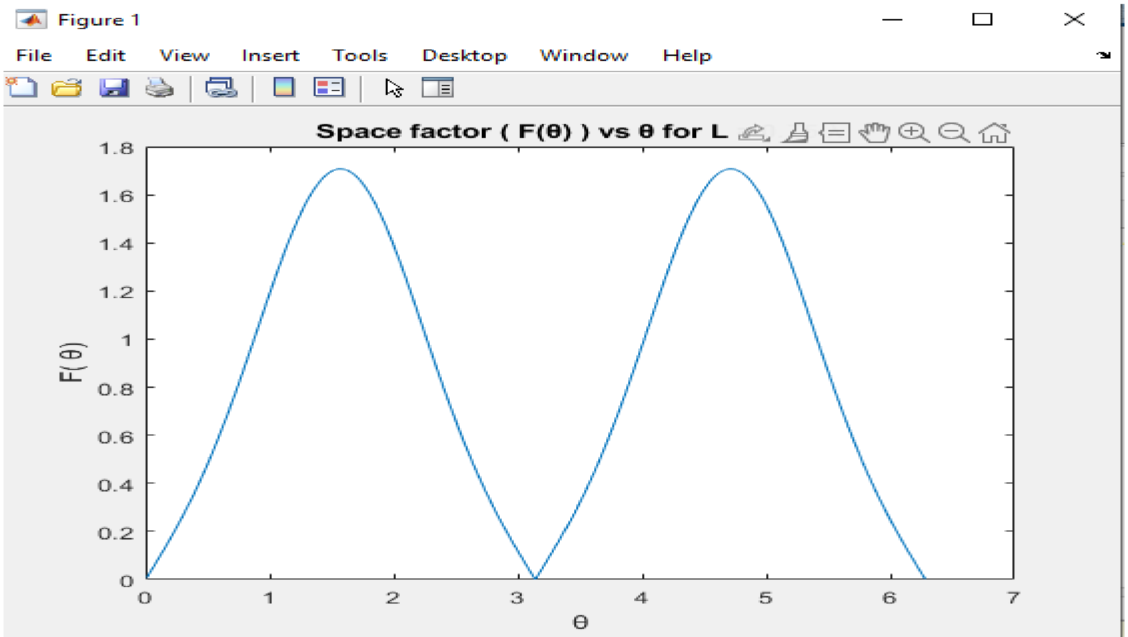


*Figure 6. Waveform for L = 0.75 λ ( Rectangular)*

**4) L = λ**

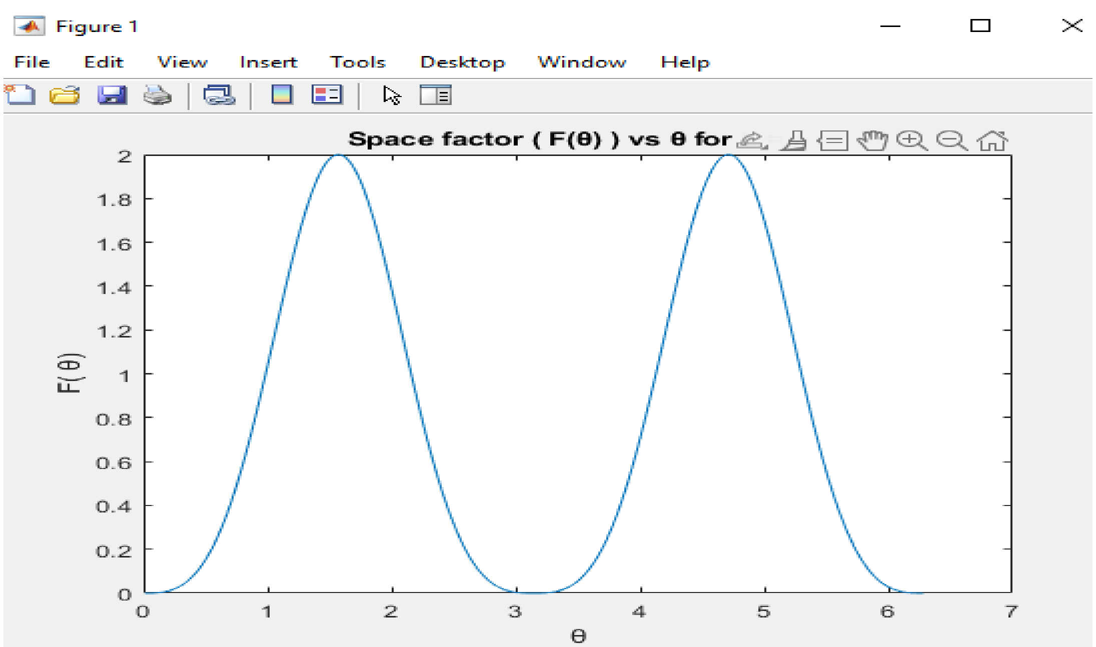


*Figure 7. Waveform for L = λ ( Rectangular)*

**5) L = 1.25 λ**

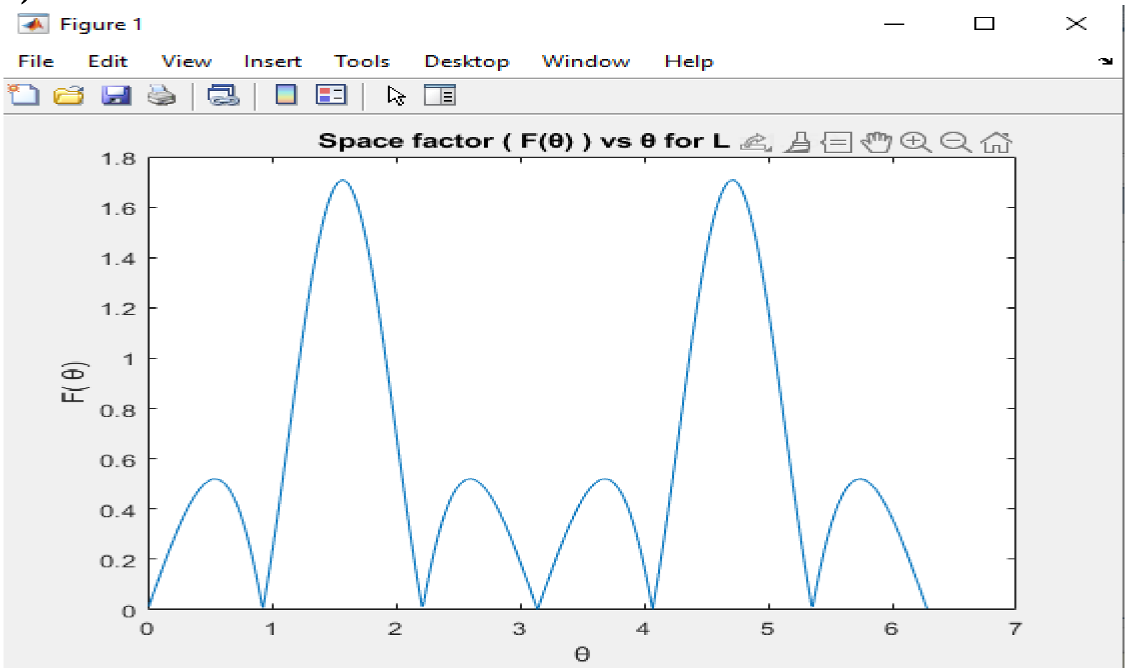


*Figure 8. Waveform for L = 1.25 λ ( Rectangular)*

**6) L = 2 λ**

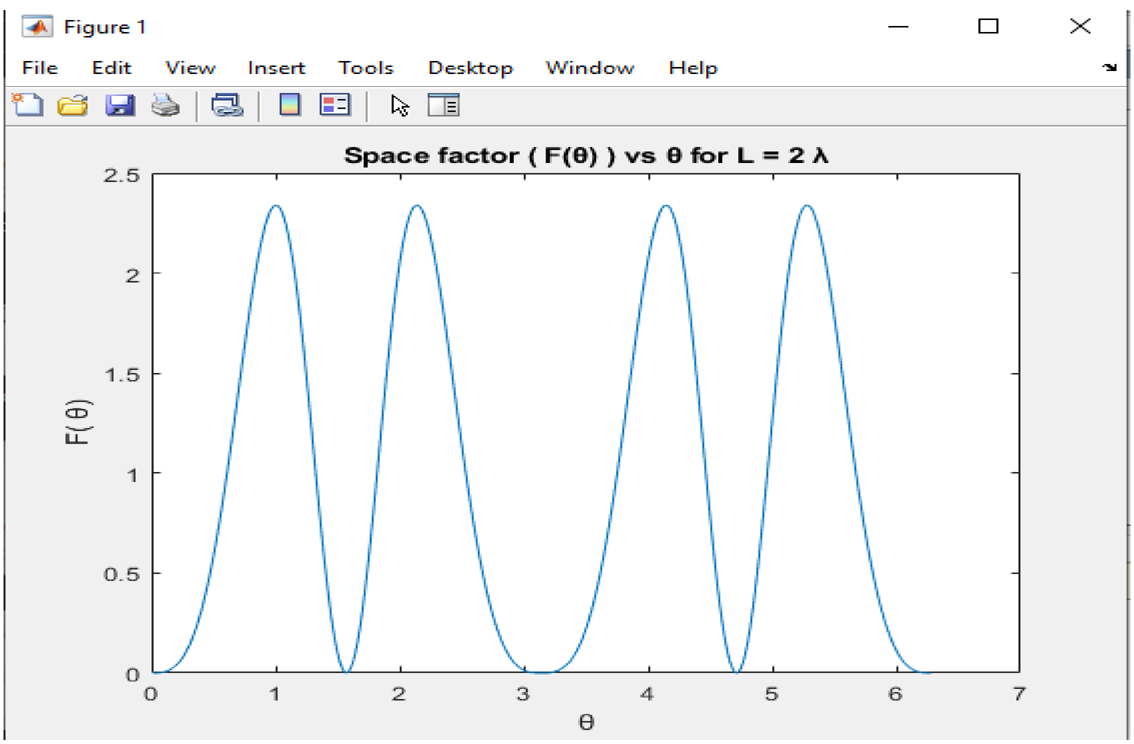


*Figure 9. Waveform for L = 2 λ ( Rectangular)*

Radiation patten graphs for different lengths in polar coordinate system.

**1) L = 0.25 λ**

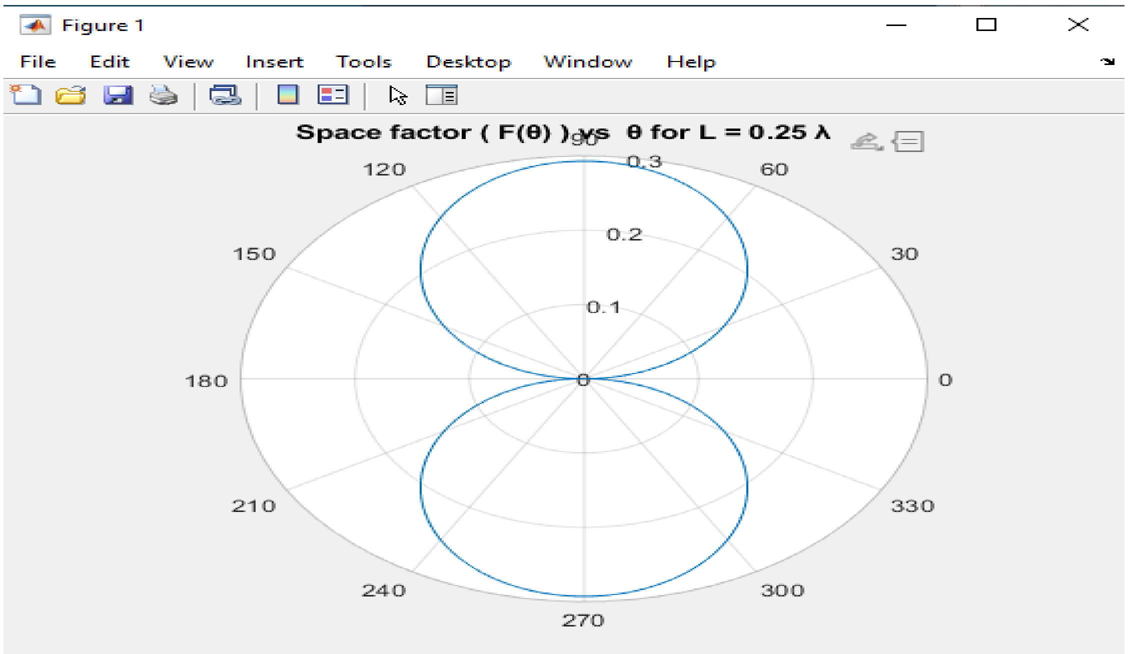


*Figure 10. Waveform for L = 0.25 λ ( Polar)*

**2) L = 0.5 λ**

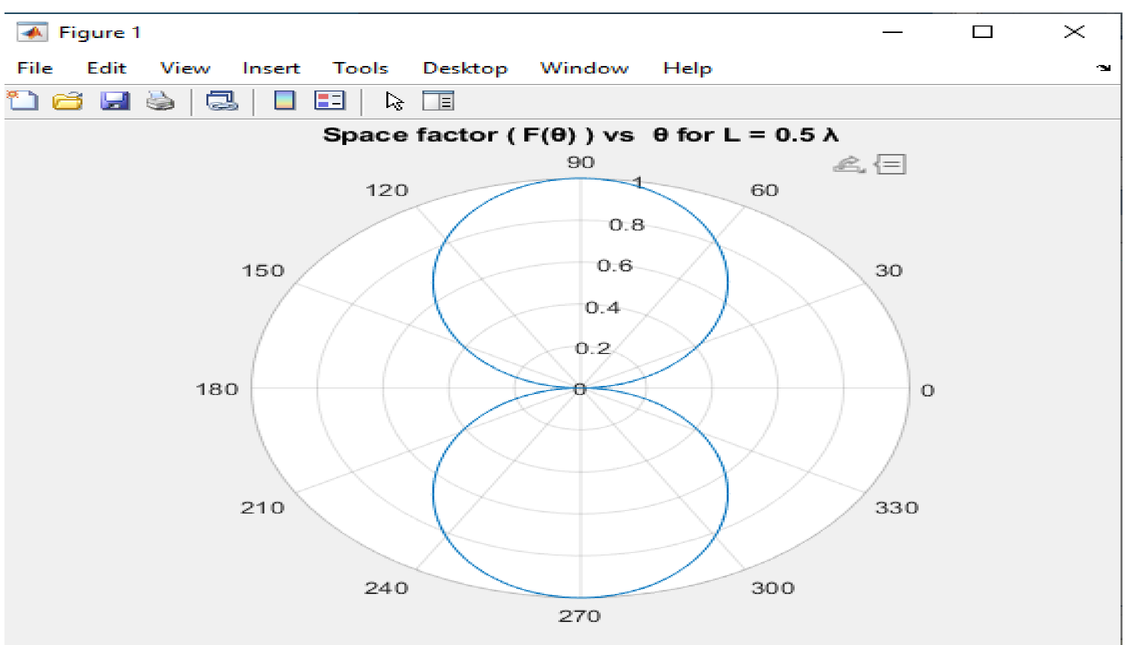


*Figure 11. Waveform for L = 0.5 λ ( Polar)*

**3)** **L = 0.75 λ**

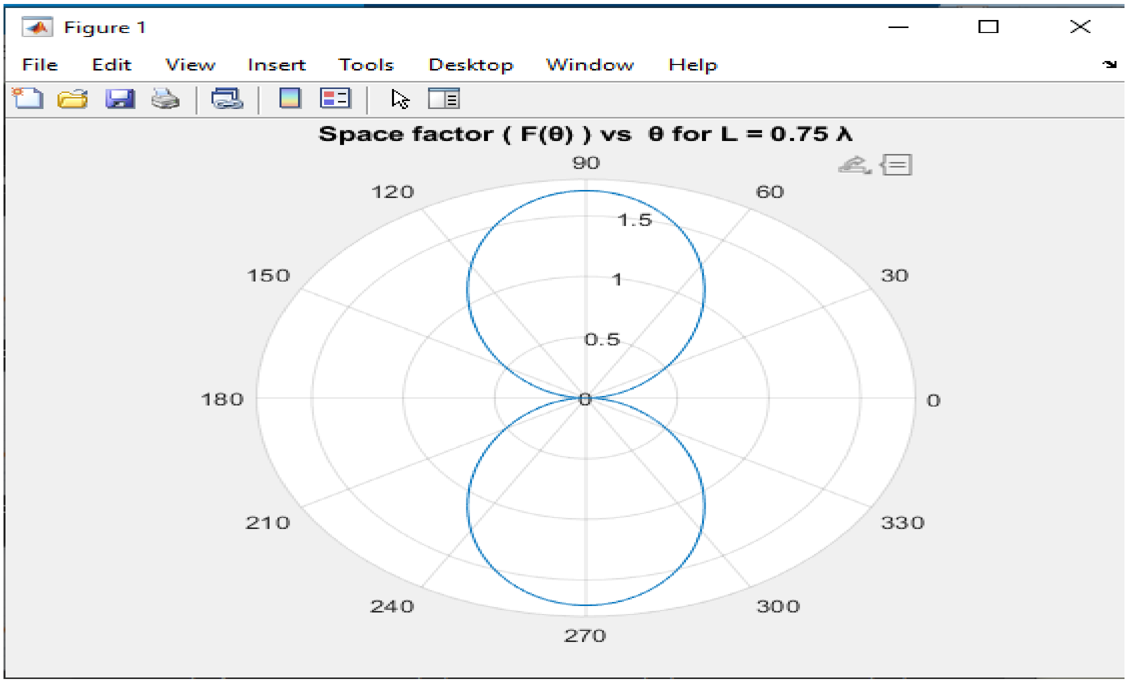


*Figure 12. Waveform for L = 0.75 λ ( Polar)*

**4)** **L = λ**

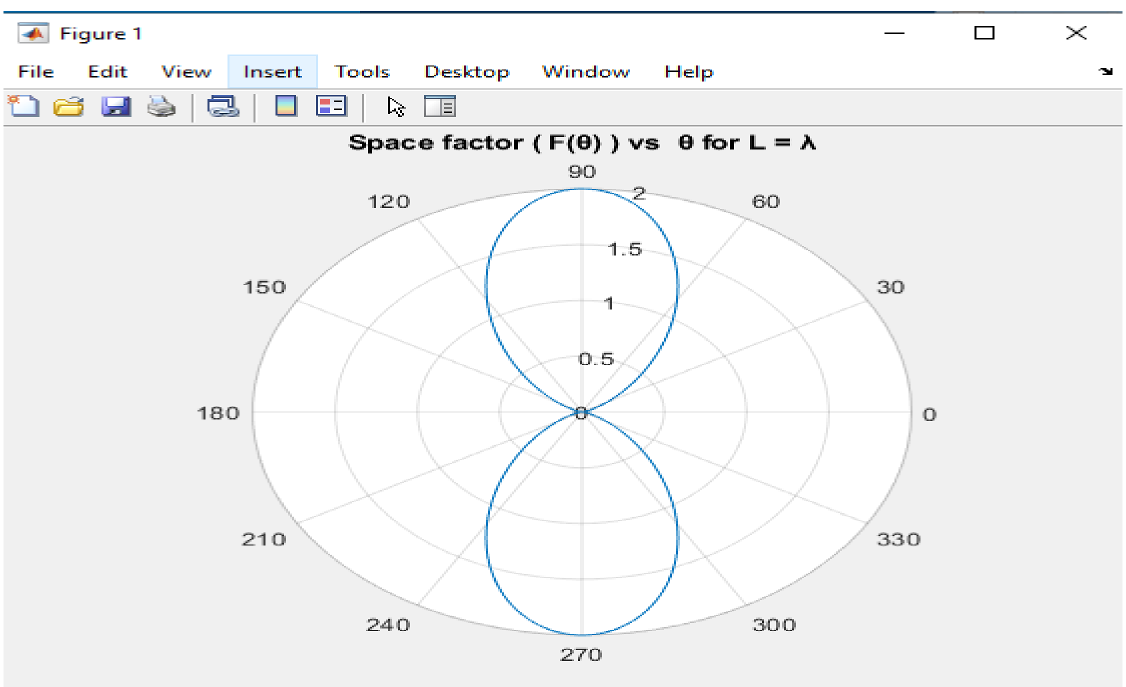


*Figure 13. Waveform for L = λ ( Polar)*

## 5) L = 1.25 λ

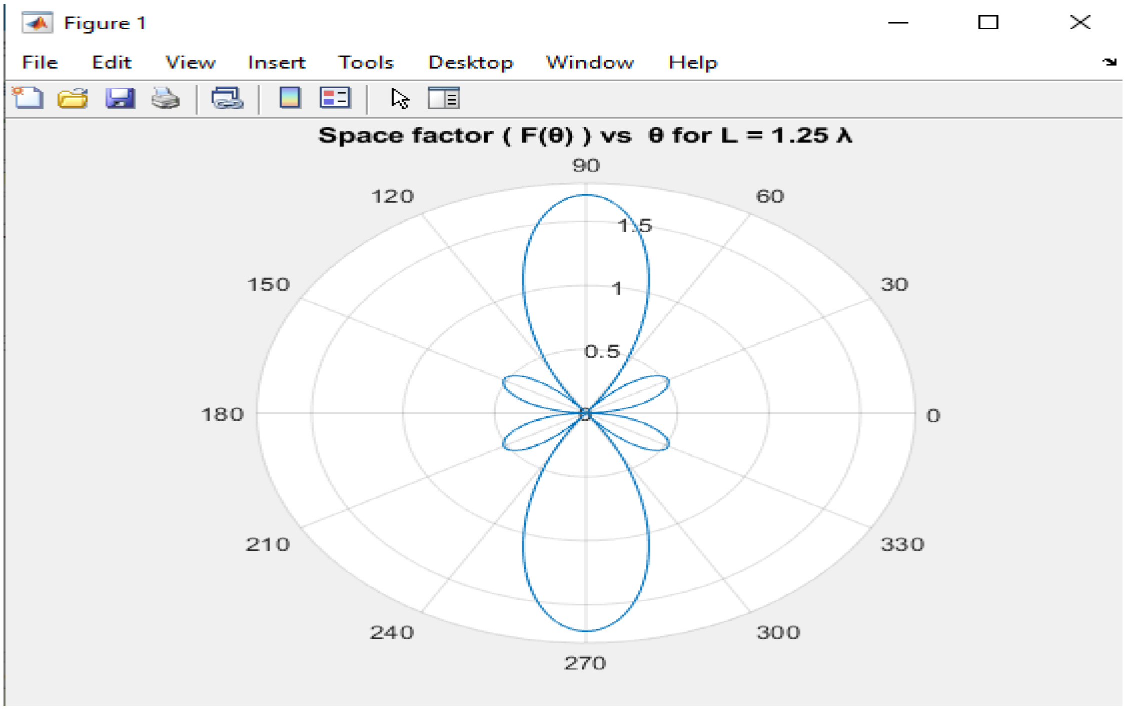


*Figure 14. Waveform for L = 1.25 λ ( Polar)*

## 6) L = 2 λ

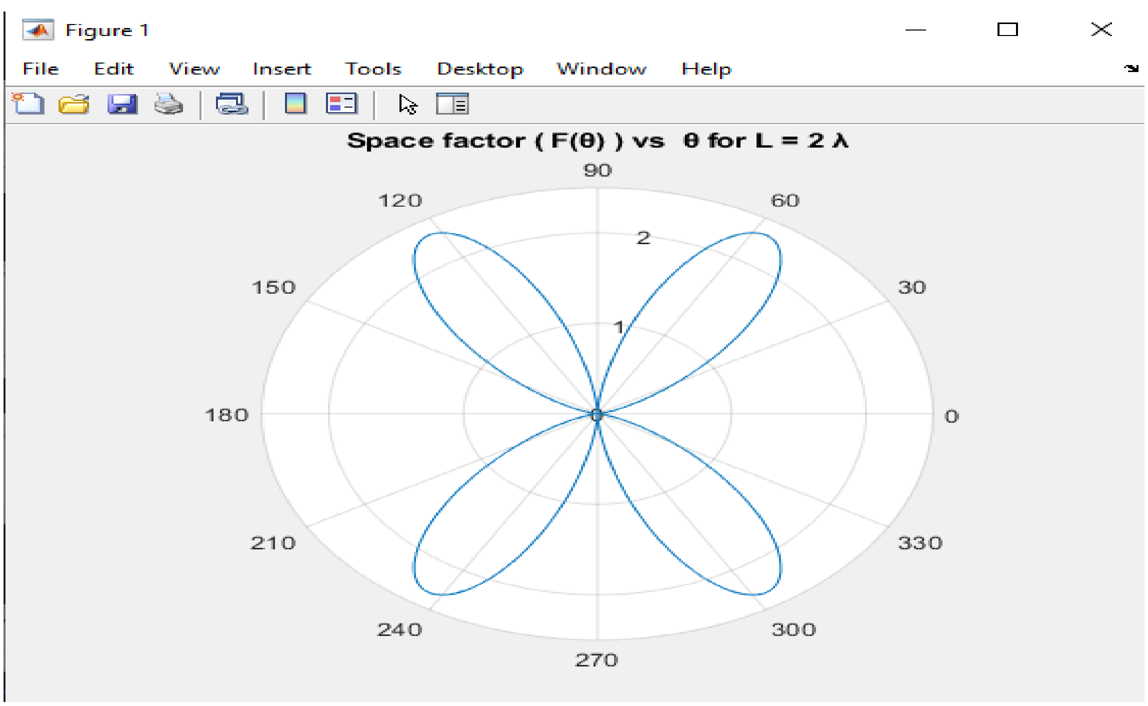


*Figure 15. Waveform for L = 2 λ ( Polar)*

## Discussion

- As the length of linear thin antenna increase, beam becomes narrower as can be observed from the rectangular graphs (figure 4 -9).
- If the length of the dipole increases beyond the wavelength, number of lobes begin to increase which can be easily observed from polar graphs (figure 10–15).
- Normalized values of the radiation pattern also increase with increase in the length as can be observed from the table.1