Rochester Institute of Technology

# EE629 Antenna Theory


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**Due Date:** 11/3/2020

**Re:** PROJECT #3: Design of Linear Dipole Antenna and a linear Array of λ/2 Dipoles in GNEC

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## Abstract

This project contains the analysis of Linear Dipole Antenna and a linear Array of λ/2 Dipoles in Graphical Numerical Electromagnetic Code (GNEC ) software. Exporting the data from GNEC and plotting using MTALB code. Comparing the GNEC and MATLAB results.


## Theory

Graphical Numerical Electromagnetic Code ( GNEC ) software is widely used for antenna modeling for wire and surface antenna. Mainly used for television and radio antenna analysis. The data of electric field can be easily exported as .txt file. Utilizing the data, algorithms in the MTLAB can be generated to plot the different waveform.

Using GNEC software, Modeling for linear dipole antenna for different lengths and 10 Element uniform linear array are generated.

Different commands used in GNEC software:

- ✓ CM – To do any comments in the program. Mainly used to provide more details about the program. To do inline comment, '!' can be used.
- ✓ CE – End of the comment.
- ✓ GW – To generate the wire and dimensions
- ✓ GS – Provides units for a wire dimension.
- ✓ GE – To end the Geometry
- ✓ FR – Frequency specification
- ✓ EX - Provides structure excitation
- ✓ RP – Set up sweeps of the radiation pattern
- ✓ EN - End of data flag

## Results

### ❖ GNEC code and Diagram

### 1. Thin linear dipole antenna

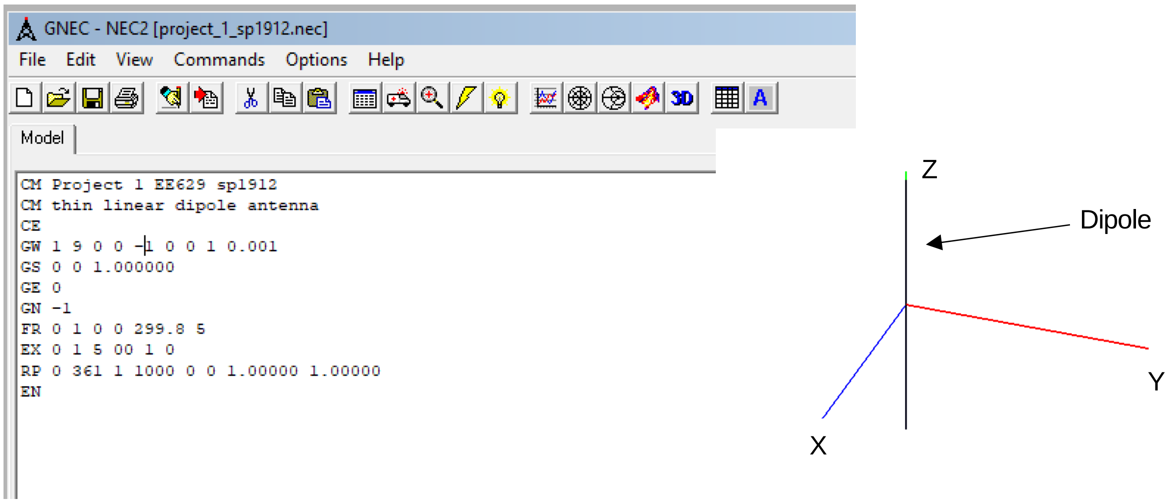



Figure 1. GNEC code for thin linear dipole and Diagram

### 2. Linear array

- While generating code for different **β** values, only excitation parameter will be changed every time since the location of Linear array will remain same.

**a. β = 0**

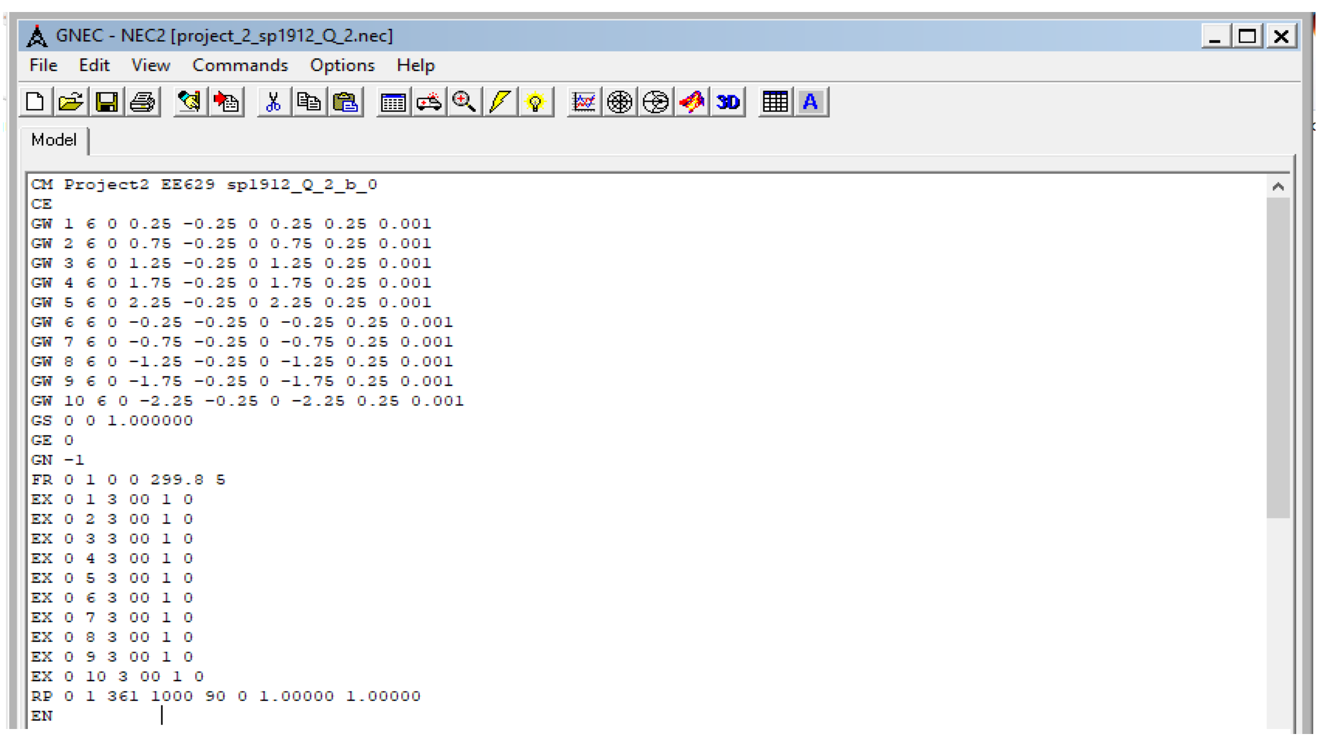
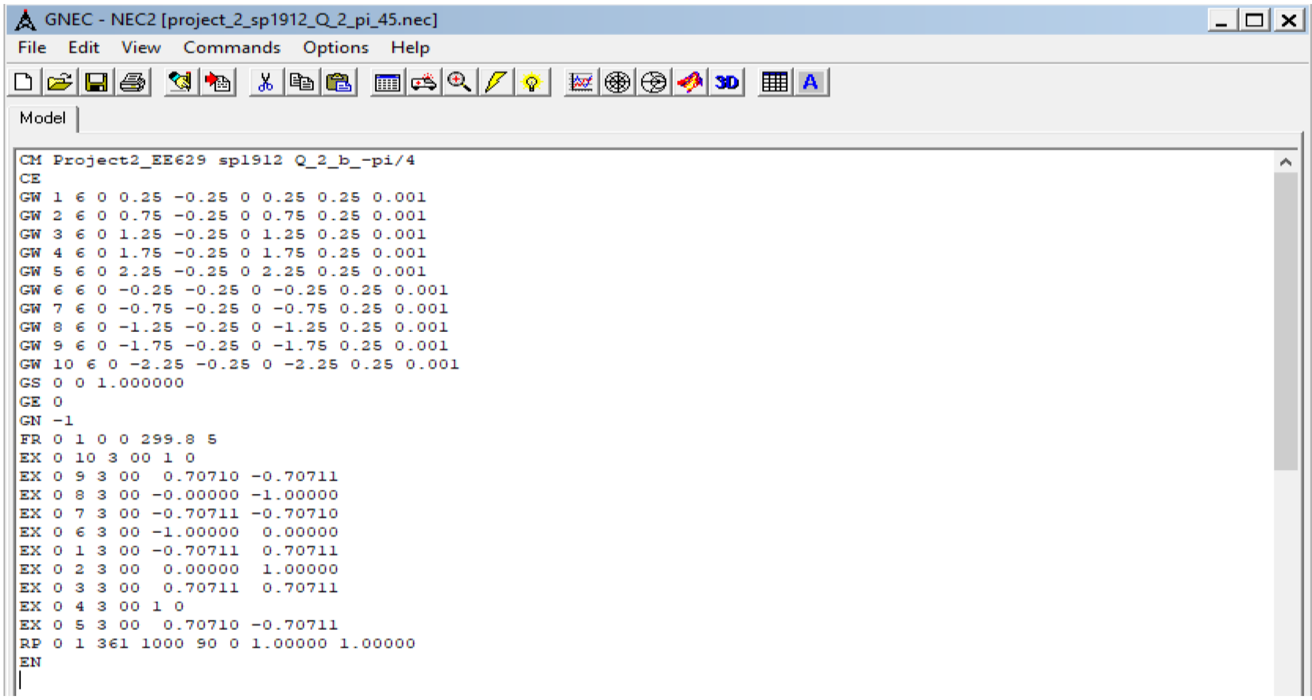



Figure 2. GNEC code for β = 0

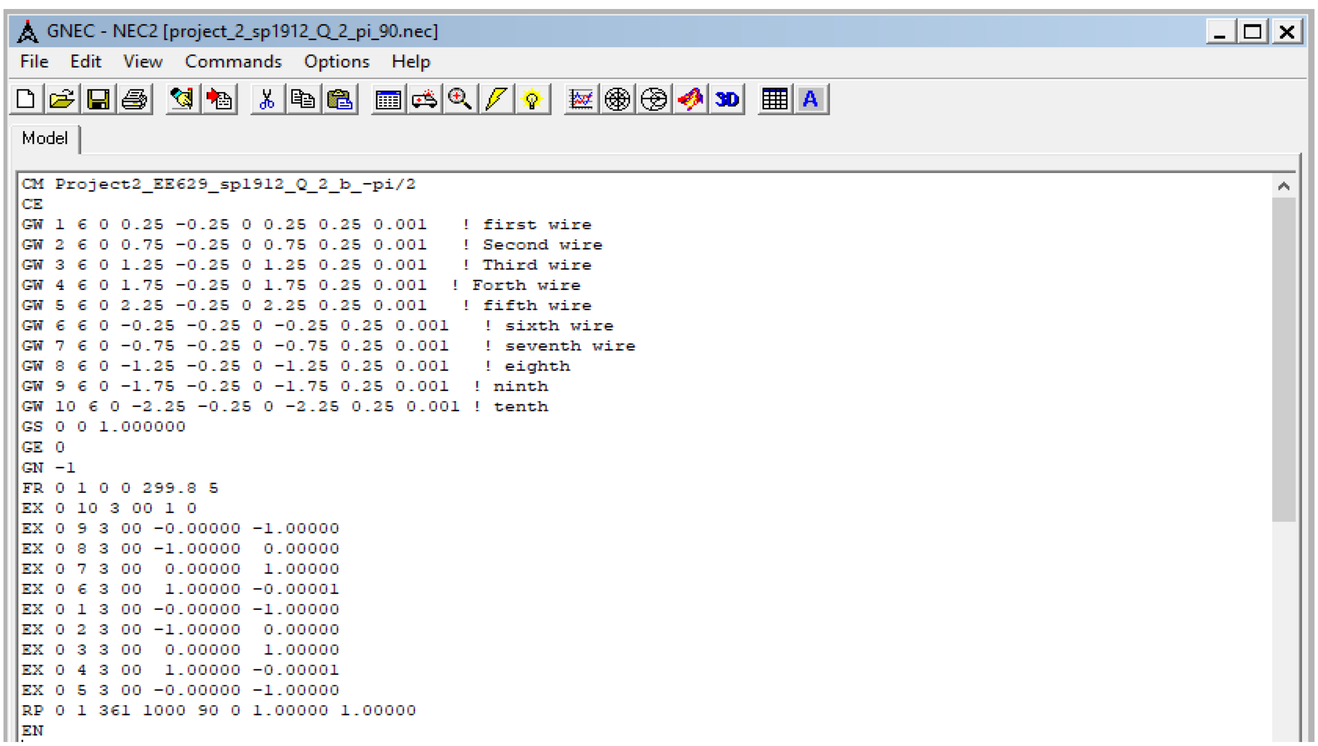
### b. β = -π/4




```
CM Project2_EE629 sp1912 Q_2_b_-pi/4
CE
GW 1 6 0 0.25 -0.25 0 0.25 0.25 0.001
GW 2 6 0 0.75 -0.25 0 0.75 0.25 0.001
GW 3 6 0 1.25 -0.25 0 1.25 0.25 0.001
GW 4 6 0 1.75 -0.25 0 1.75 0.25 0.001
GW 5 6 0 2.25 -0.25 0 2.25 0.25 0.001
GW 6 6 0 -0.25 -0.25 0 -0.25 0.25 0.001
GW 7 6 0 -0.75 -0.25 0 -0.75 0.25 0.001
GW 8 6 0 -1.25 -0.25 0 -1.25 0.25 0.001
GW 9 6 0 -1.75 -0.25 0 -1.75 0.25 0.001
GW 10 6 0 -2.25 -0.25 0 -2.25 0.25 0.001
GS 0 0 1.000000
GE 0
GN -1
FR 0 1 0 0 299.8 5
EX 0 10 3 00 1 0
EX 0 9 3 00  0.70710 -0.70711
EX 0 8 3 00 -0.00000 -1.00000
EX 0 7 3 00 -0.70711 -0.70710
EX 0 6 3 00 -1.00000  0.00000
EX 0 1 3 00 -0.70711  0.70711
EX 0 2 3 00  0.00000  1.00000
EX 0 3 3 00  0.70711  0.70711
EX 0 4 3 00 1 0
EX 0 5 3 00  0.70710 -0.70711
RP 0 1 361 1000 90 0 1.00000 1.00000
EN
```

Figure 3. GNEC code for β = -π/4

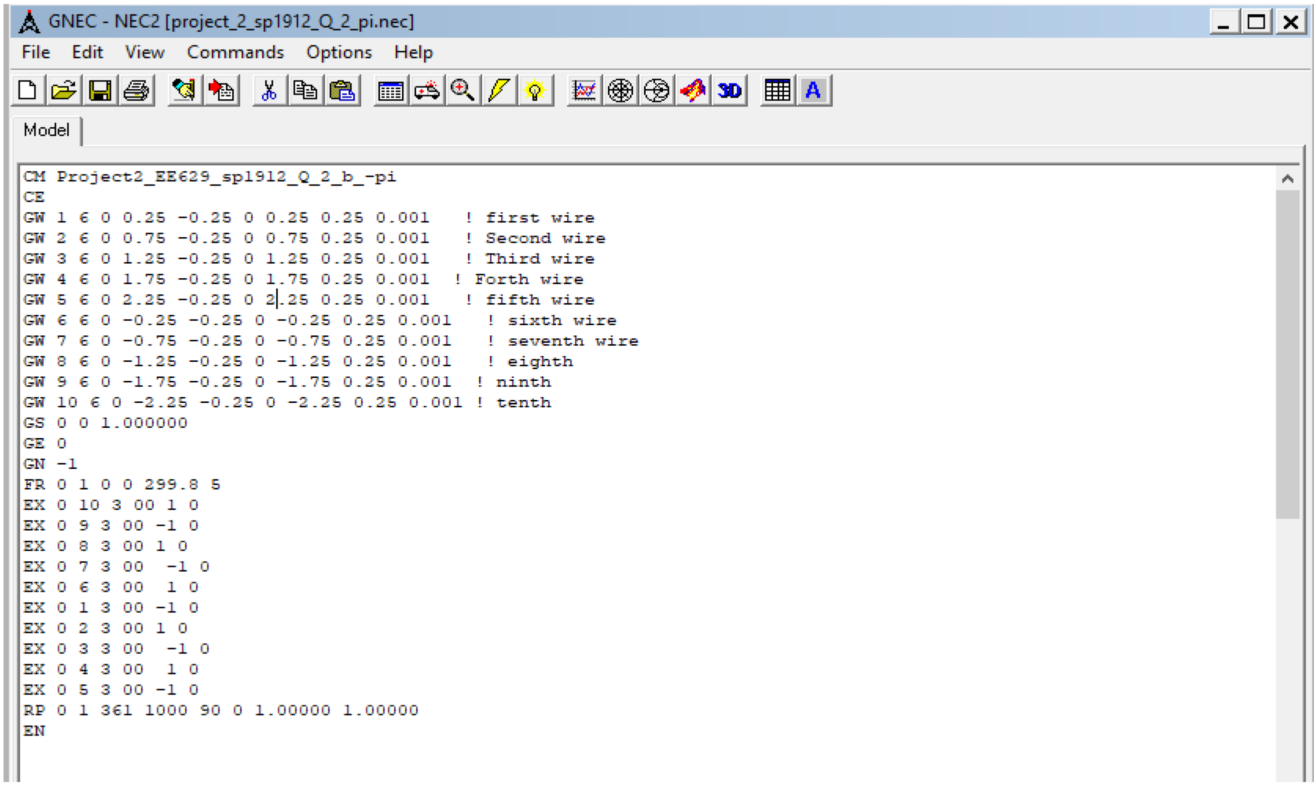
### c. β = - π/2




```
CM Project2_EE629_sp1912_Q_2_b_-pi/2
CE
GW 1 6 0 0.25 -0.25 0 0.25 0.25 0.001   ! first wire
GW 2 6 0 0.75 -0.25 0 0.75 0.25 0.001   ! Second wire
GW 3 6 0 1.25 -0.25 0 1.25 0.25 0.001   ! Third wire
GW 4 6 0 1.75 -0.25 0 1.75 0.25 0.001  ! Forth wire
GW 5 6 0 2.25 -0.25 0 2.25 0.25 0.001   ! fifth wire
GW 6 6 0 -0.25 -0.25 0 -0.25 0.25 0.001   ! sixth wire
GW 7 6 0 -0.75 -0.25 0 -0.75 0.25 0.001   ! seventh wire
GW 8 6 0 -1.25 -0.25 0 -1.25 0.25 0.001   ! eighth
GW 9 6 0 -1.75 -0.25 0 -1.75 0.25 0.001  ! ninth
GW 10 6 0 -2.25 -0.25 0 -2.25 0.25 0.001 ! tenth
GS 0 0 1.000000
GE 0
GN -1
FR 0 1 0 0 299.8 5
EX 0 10 3 00 1 0
EX 0 9 3 00 -0.00000 -1.00000
EX 0 8 3 00 -1.00000  0.00000
EX 0 7 3 00  0.00000  1.00000
EX 0 6 3 00  1.00000 -0.00001
EX 0 1 3 00 -0.00000 -1.00000
EX 0 2 3 00 -1.00000  0.00000
EX 0 3 3 00  0.00000  1.00000
EX 0 4 3 00  1.00000 -0.00001
EX 0 5 3 00 -0.00000 -1.00000
RP 0 1 361 1000 90 0 1.00000 1.00000
EN
```

Figure 4. GNEC code for β = -π/2

**d. $\beta = -\pi$**




```
CM Project2_EE629_sp1912_Q_2_b_-pi
CE
GW 1 6 0 0.25 -0.25 0 0.25 0.25 0.001   ! first wire
GW 2 6 0 0.75 -0.25 0 0.75 0.25 0.001   ! Second wire
GW 3 6 0 1.25 -0.25 0 1.25 0.25 0.001   ! Third wire
GW 4 6 0 1.75 -0.25 0 1.75 0.25 0.001  ! Forth wire
GW 5 6 0 2.25 -0.25 0 2.25 0.25 0.001   ! fifth wire
GW 6 6 0 -0.25 -0.25 0 -0.25 0.25 0.001   ! sixth wire
GW 7 6 0 -0.75 -0.25 0 -0.75 0.25 0.001   ! seventh wire
GW 8 6 0 -1.25 -0.25 0 -1.25 0.25 0.001   ! eighth
GW 9 6 0 -1.75 -0.25 0 -1.75 0.25 0.001  ! ninth
GW 10 6 0 -2.25 -0.25 0 -2.25 0.25 0.001 ! tenth
GS 0 0 1.000000
GE 0
GN -1
FR 0 1 0 0 299.8 5
EX 0 10 3 00 1 0
EX 0 9 3 00 -1 0
EX 0 8 3 00 1 0
EX 0 7 3 00  -1 0
EX 0 6 3 00  1 0
EX 0 1 3 00 -1 0
EX 0 2 3 00 1 0
EX 0 3 3 00  -1 0
EX 0 4 3 00  1 0
EX 0 5 3 00 -1 0
RP 0 1 361 1000 90 0 1.00000 1.00000
EN
```

Figure 5.GNEC code for $\beta = -\pi$

- **Linear array Diagram**
  - All the dipoles are placed on the Y – axis parallel to Z axis.

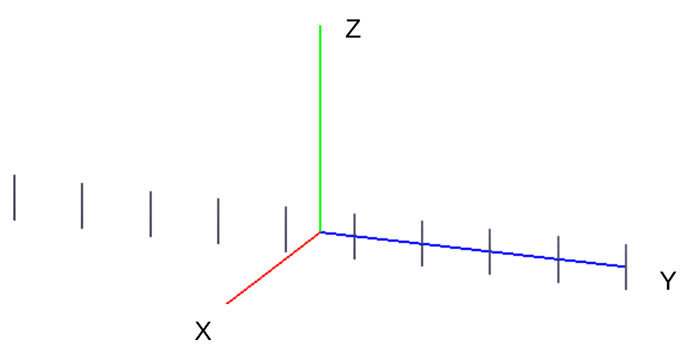



Figure 6. Linear array Diagram 10 dipole

- **MATLAB code to utilize GNEC data and using it to plot in MATLAB**

Editor - C:\Users\sp1912\Documents\MATLAB\gnec.m

gnec.m

```matlab
% Importing radition pattern data from GNEC and plotting polar graphs
clear all;
close all;
% For elevation plane phi=0
rp_data=importdata('b_180.txt'); % assuming the data is in current directory
rp_data=rp_data.data;
degrees=rp_data(:,1); % grabbing the values of phase from data
dB=rp_data(:,3); %the radiation pattern for vertical radiation is 3nd column. It is Power gains.
theta_radians=degrees/180*pi;  % Converting phase from degree to radians
field_magnitude=db2mag(dB);  % COnverting dB to real value of field.
figure
polarplot(theta_radians,field_magnitude);  % Plotting polar wave
rlim([min(field_magnitude),max(field_magnitude)]) % IMP: to get negative values of plot
```

Figure 7. MATLAB code to Plot GNEC data

- **Polar plots for thin linear dipole antenna**

**i. L = 0.25 λ**

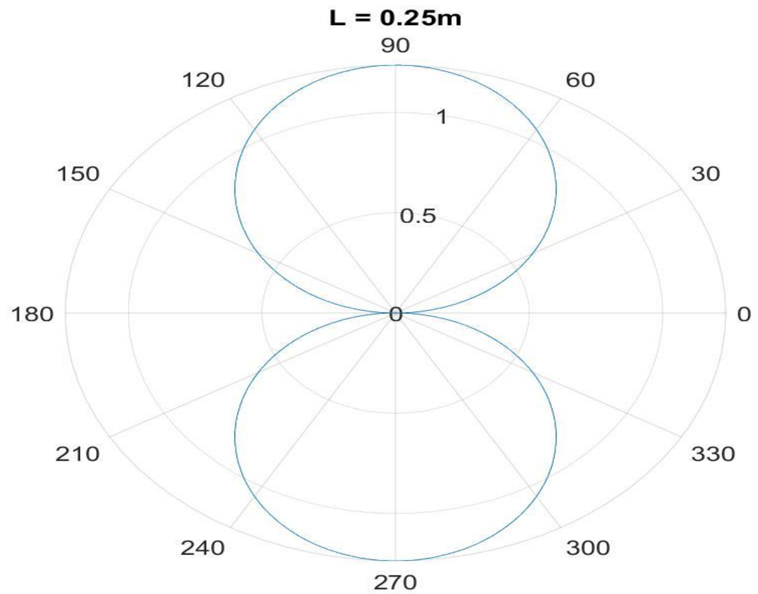



Figure 9. GNEC polar plot L = 0.25 λ

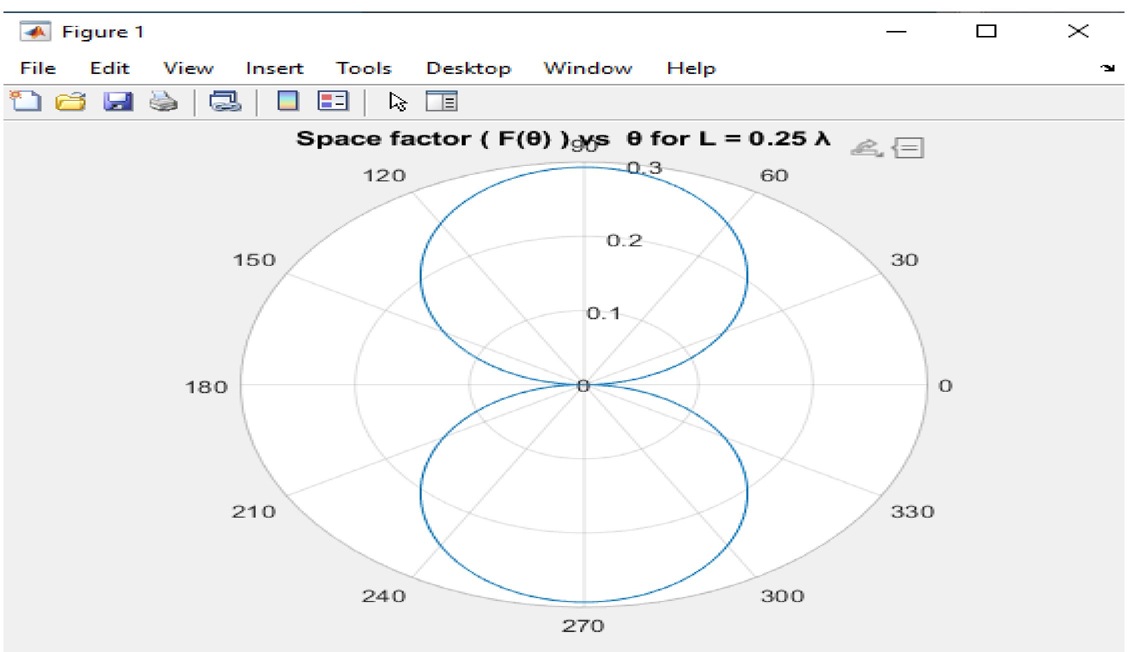



Figure 8. MATLAB polar plot L = 0.25 λ

**ii. L = 0.5 λ**

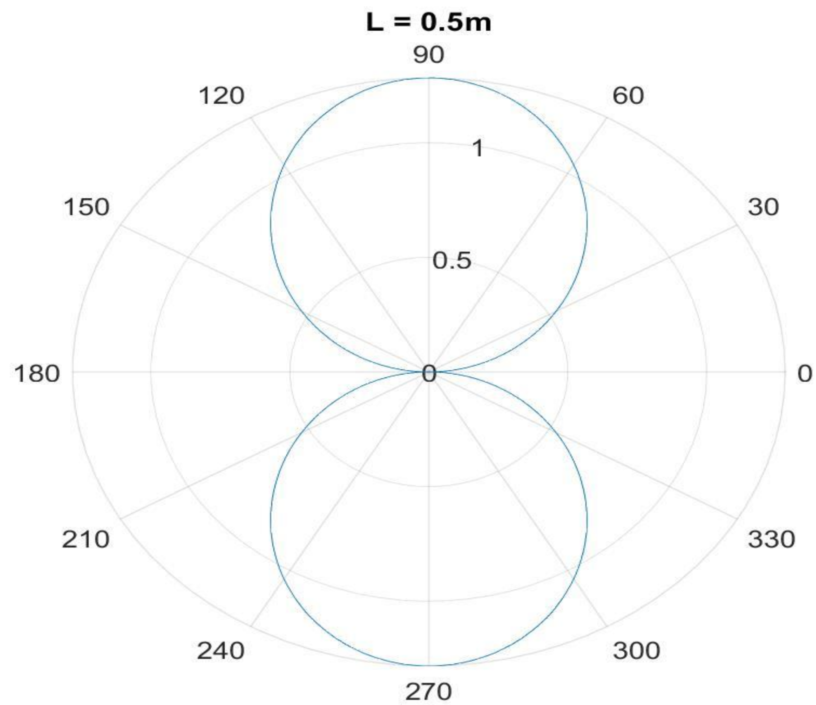



Figure 10. GNEC polar plot L = 0.5 λ

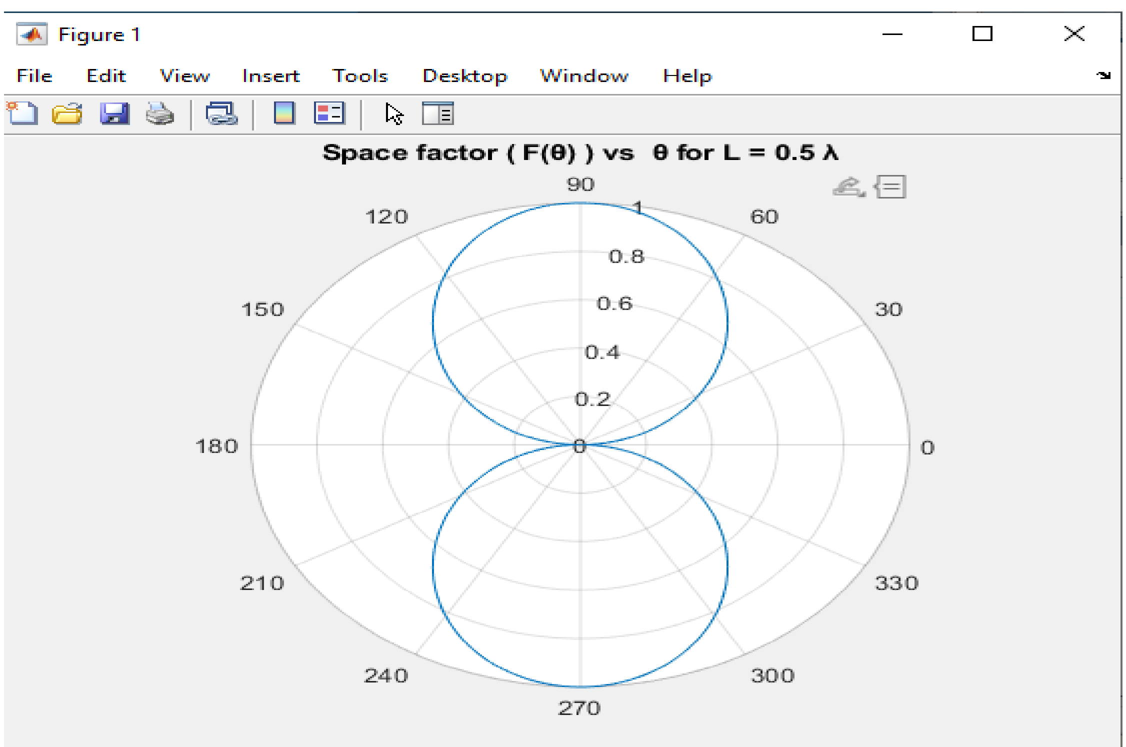



Figure 11. MATLAB polar plot L = 0.5 λ

**iii. L = 0.75 λ**

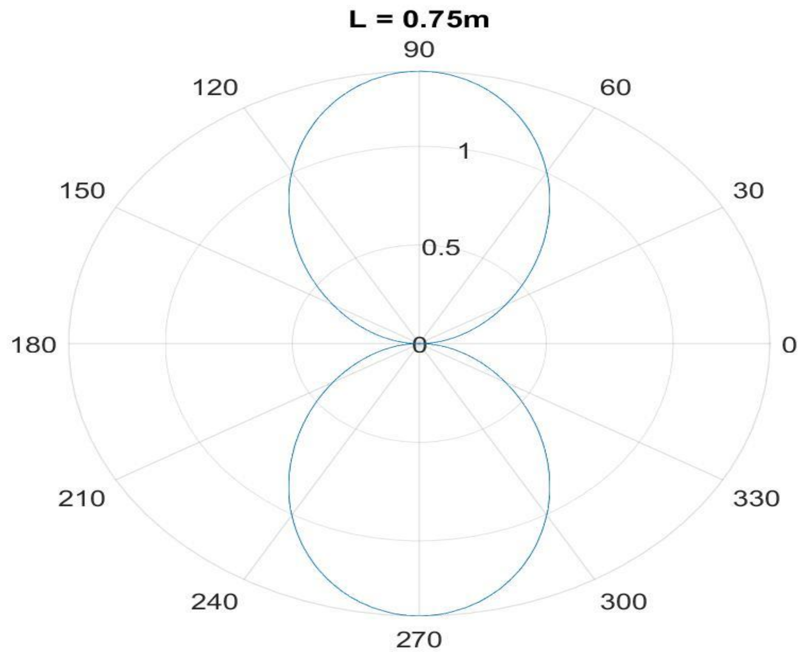



Figure 12. GNEC polar plot L = 0.75 λ

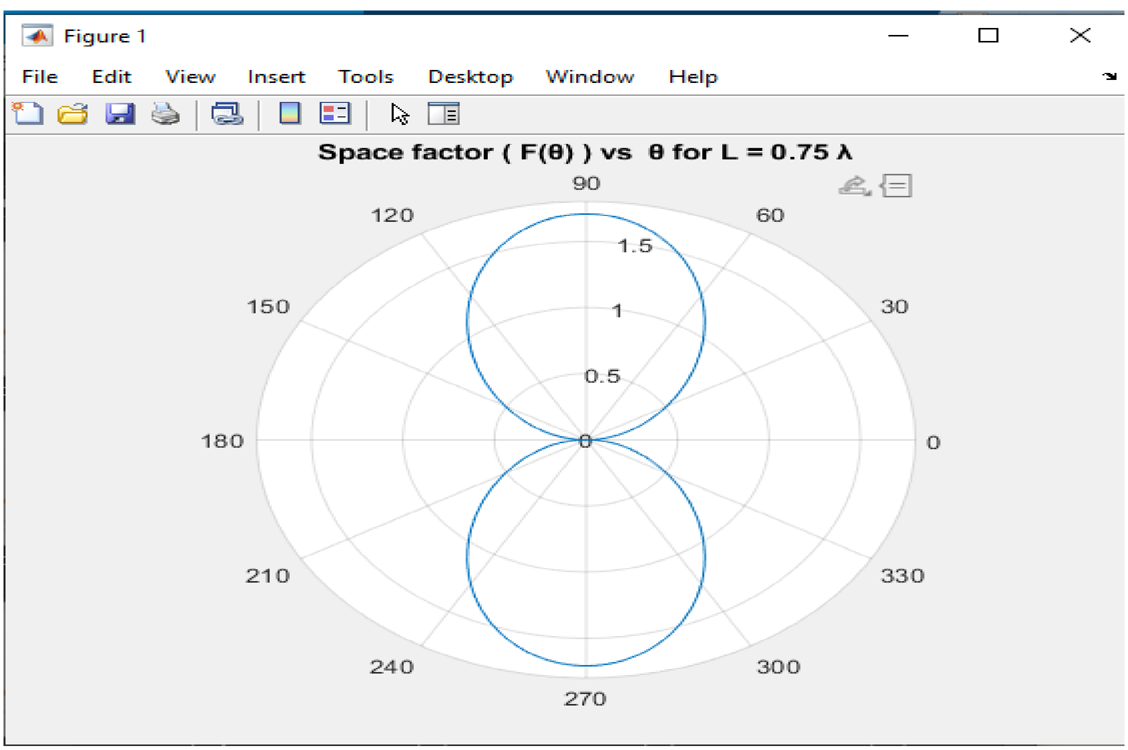



Figure 13. MATLAB polar plot L = 0.75 λ

**iv.** **L = λ**

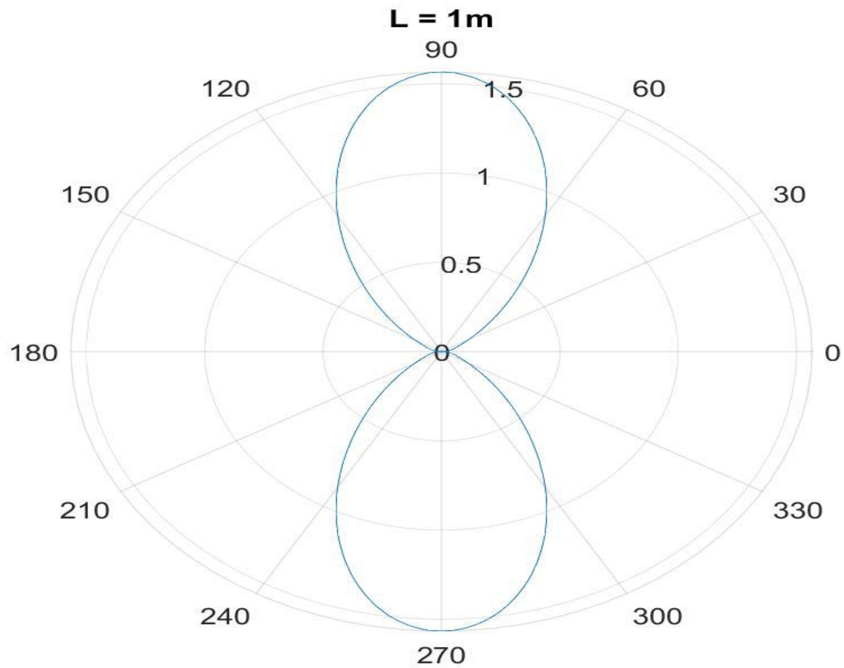



Figure 14. GNEC polar plot L = λ

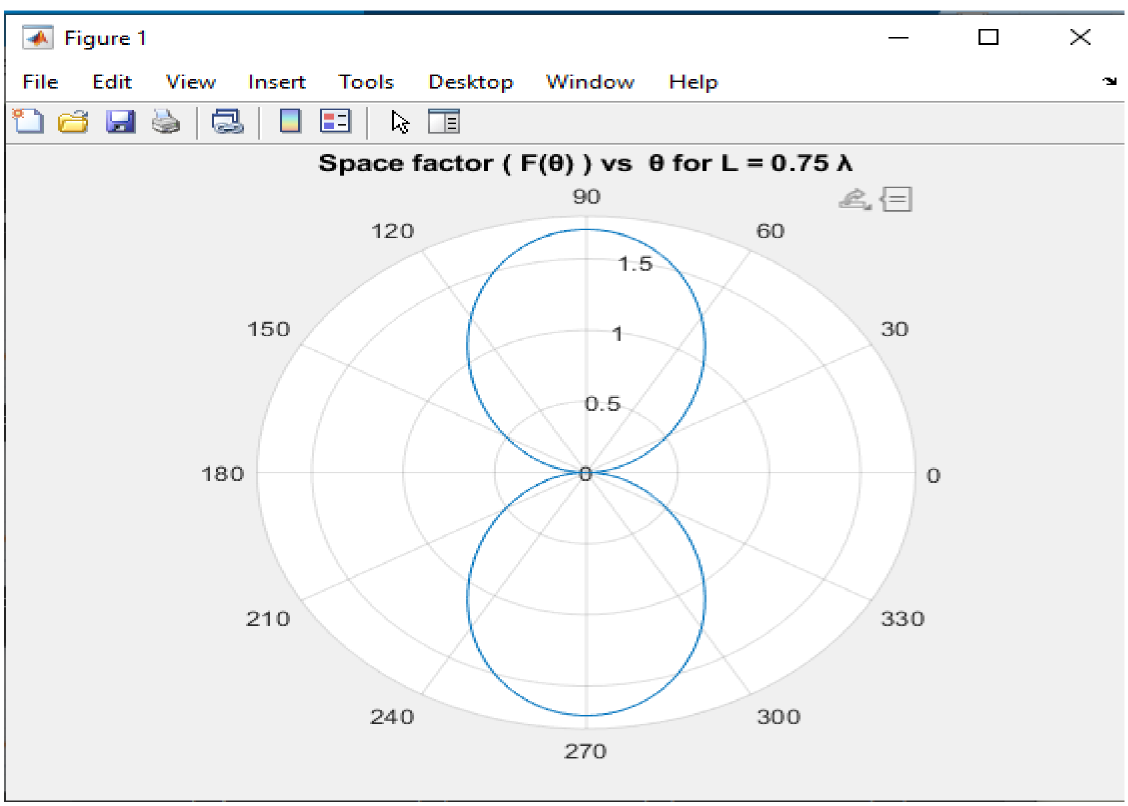



Figure 15. MATLAB polar plot L = λ

**v. L = 1.25 λ**

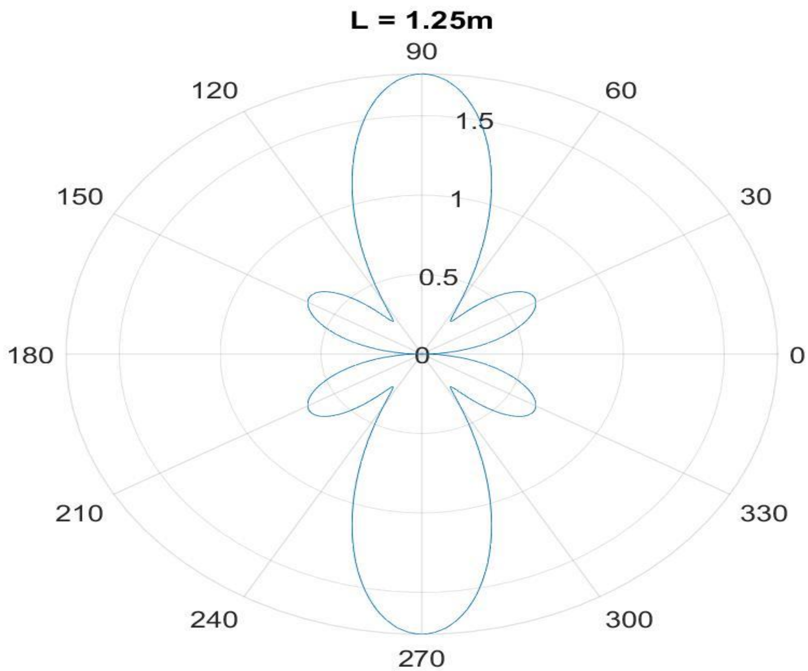



Figure 16. GNEC polar plot L = 1.25 λ

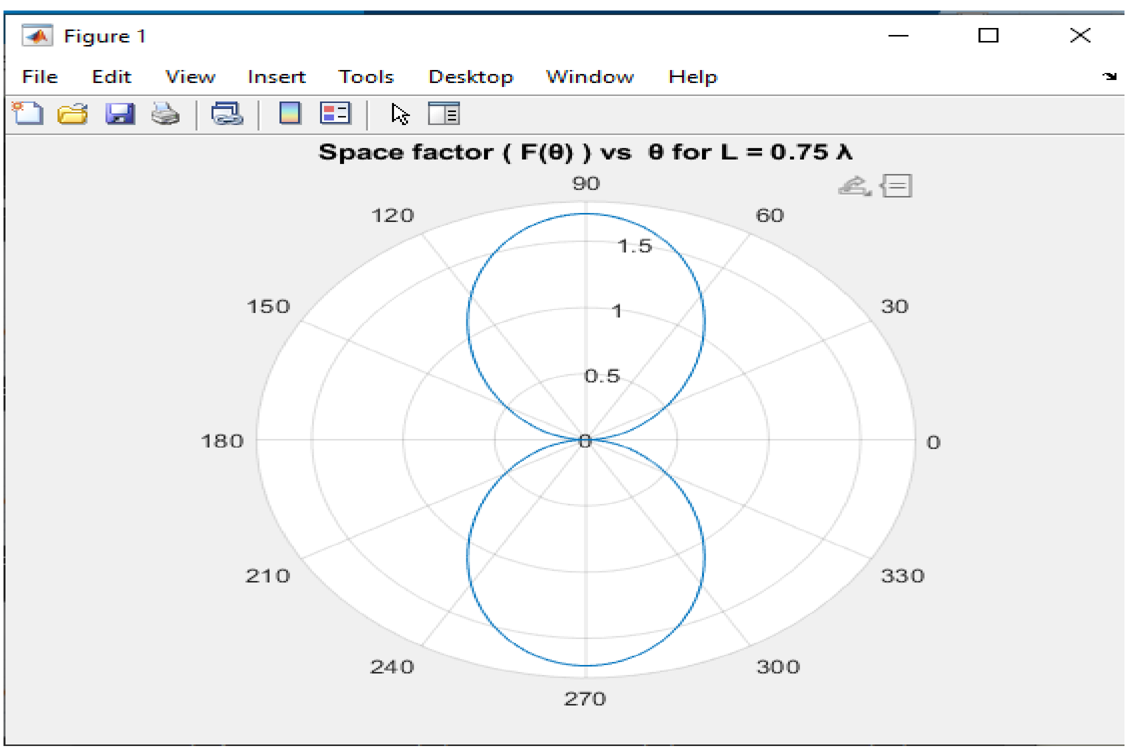



Figure 17. MATLAB polar plot L = 1.25 λ

**vi. L = 2 λ**

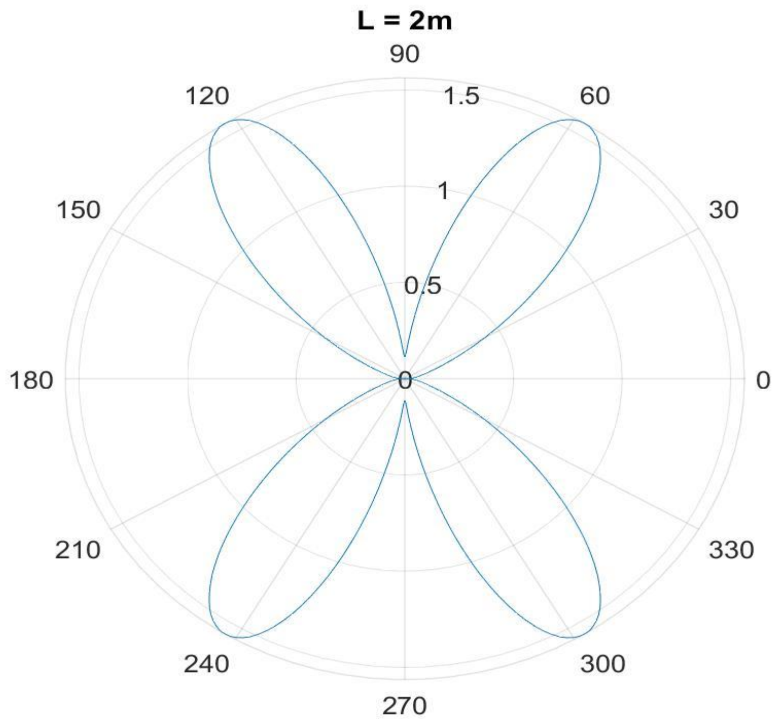



Figure 18. GNEC polar plot L = 2 λ

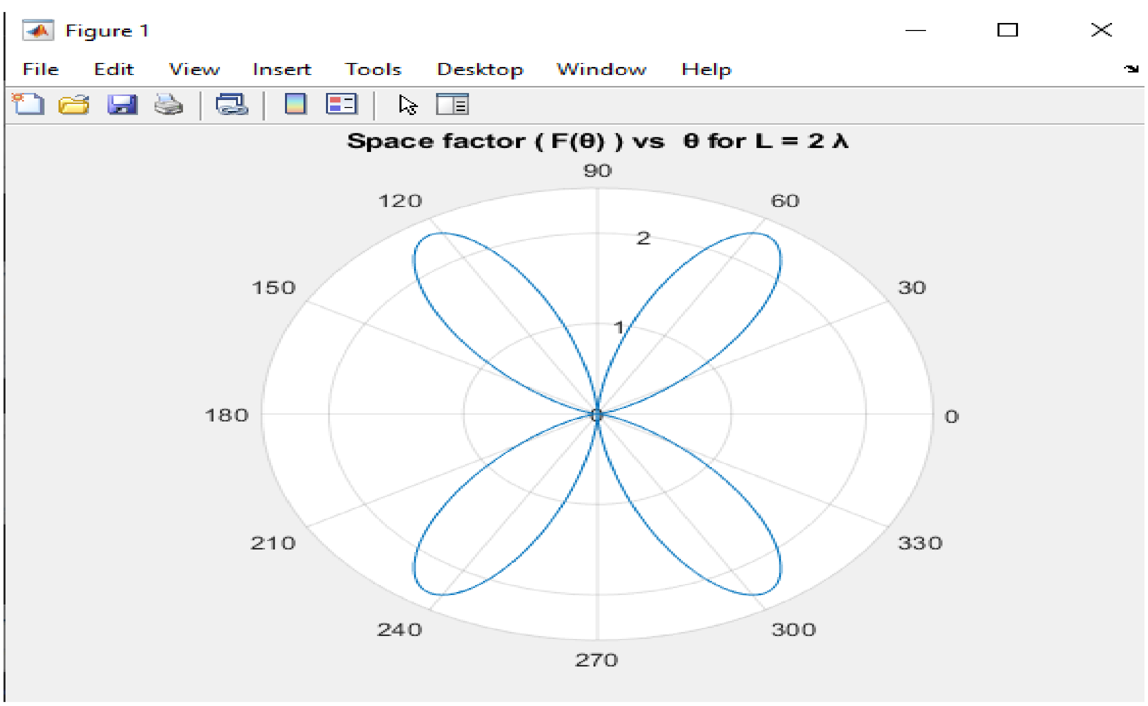



Figure 19. MATLAB polar plot L = 2 λ

## 3. Linear array

### MATLAB code for Total pattern for N dipoles

Editor - C:\Users\sp1912\Documents\MATLAB\total_ep_af.m

gnec.m | total_ep_af.m

```matlab
 %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 b = 0:-pi/4:-pi
L = 0.5*v;
N = 10;   % 10 element uniform linear array
% K is defined as constant
K = 2*pi/v;
x = pi/2;  % Theta
y = 0:0.01:2*pi;  % Phi
q = sin(x).*sin(y);
si = K*L*q+ b;
% equation for radiation pattern
F = abs(((cos(K*L/2*cos(x))-cos(K*L/2))/sin(x))*((sin(N*si/2))./(N*sin(si/2))));
figure()
polarplot(y,F)
end
```

Figure 20. MATLAB code for Total pattern ( Linear array )

**Comparison between the graph obtained from GNEC and Direct total plot**

**i. β = 0**

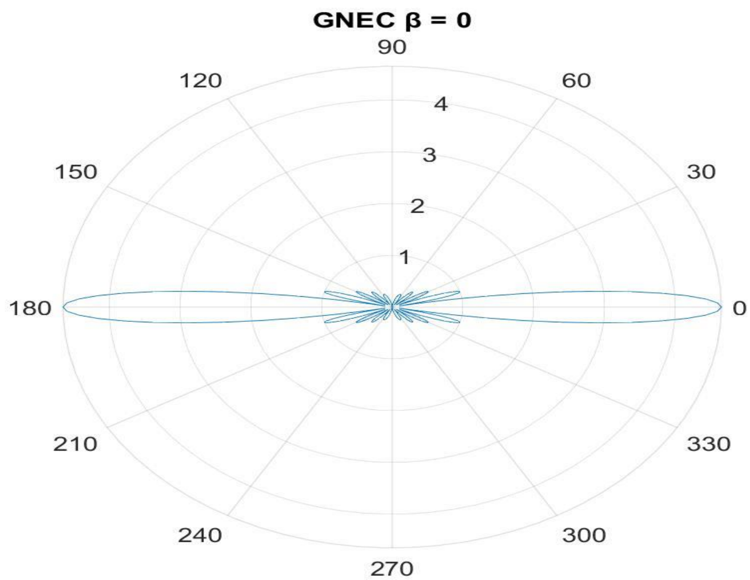



Figure 21. GNEC polar plot for β = 0

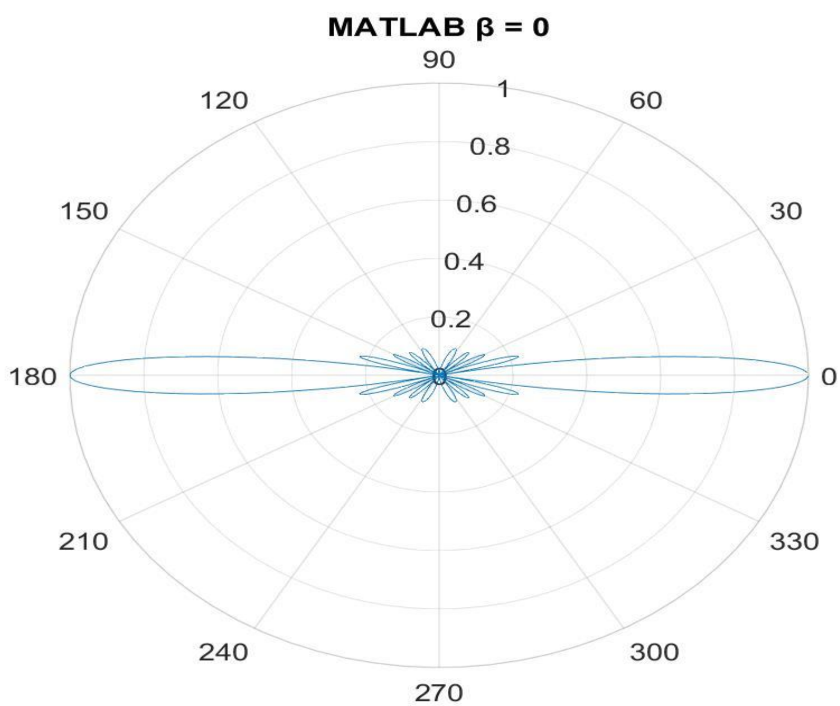



Figure 22. MATLAB polar plot for β = 0

**ii. $\beta = -\pi/4$**

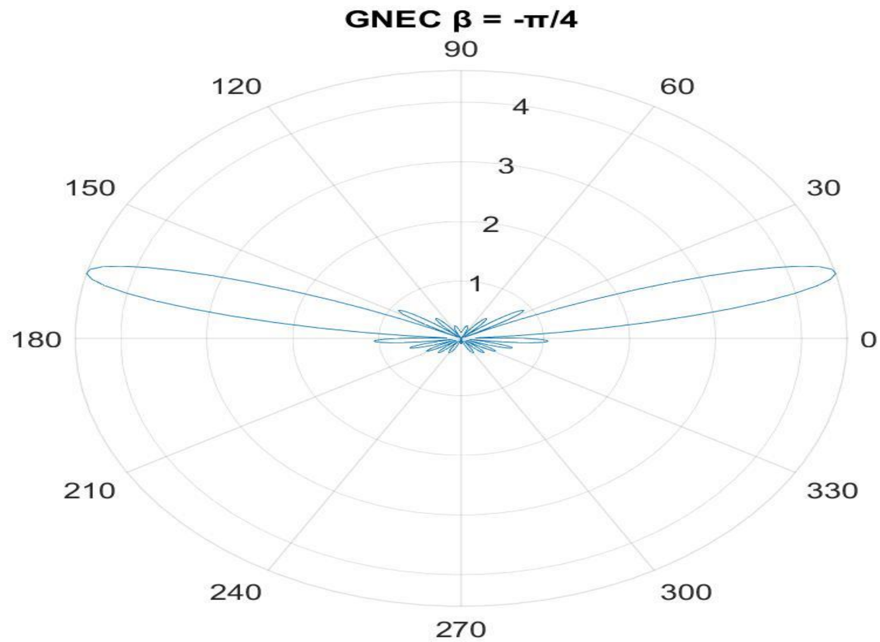



Figure 23. GNEC polar plot for $\beta = -\pi/4$

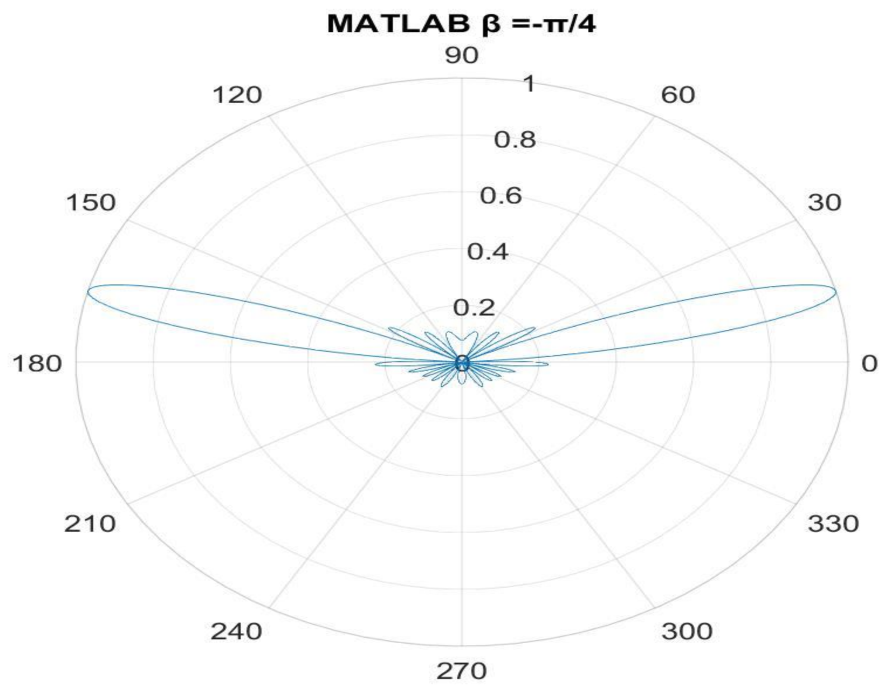



Figure 24. MATLAB polar plot for $\beta = -\pi/4$

**iii.** **β = - π/2**

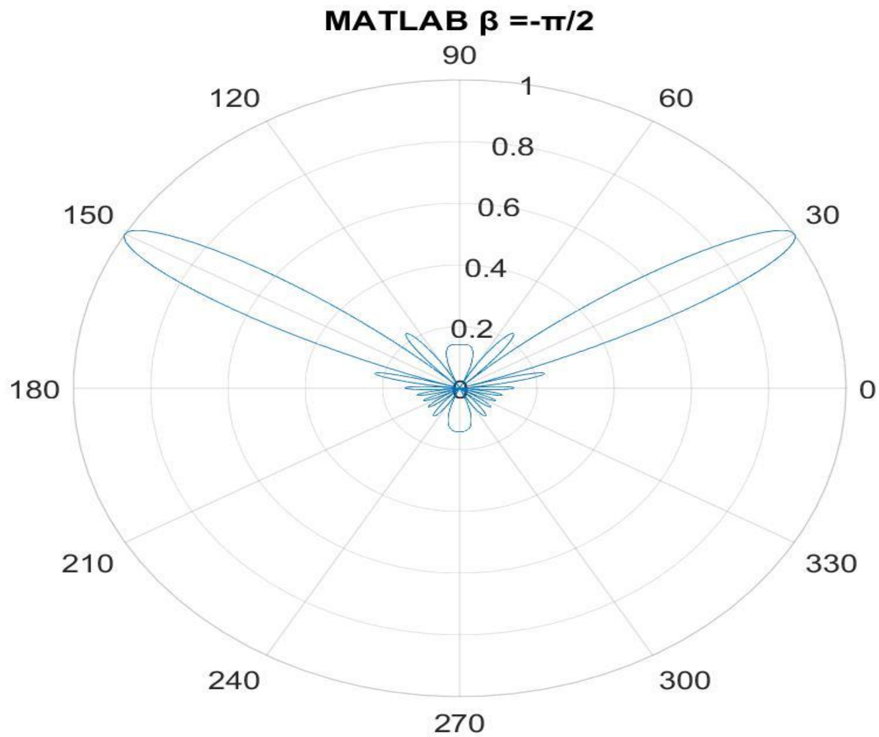



Figure 25. MATLAB polar plot for β = -π/2

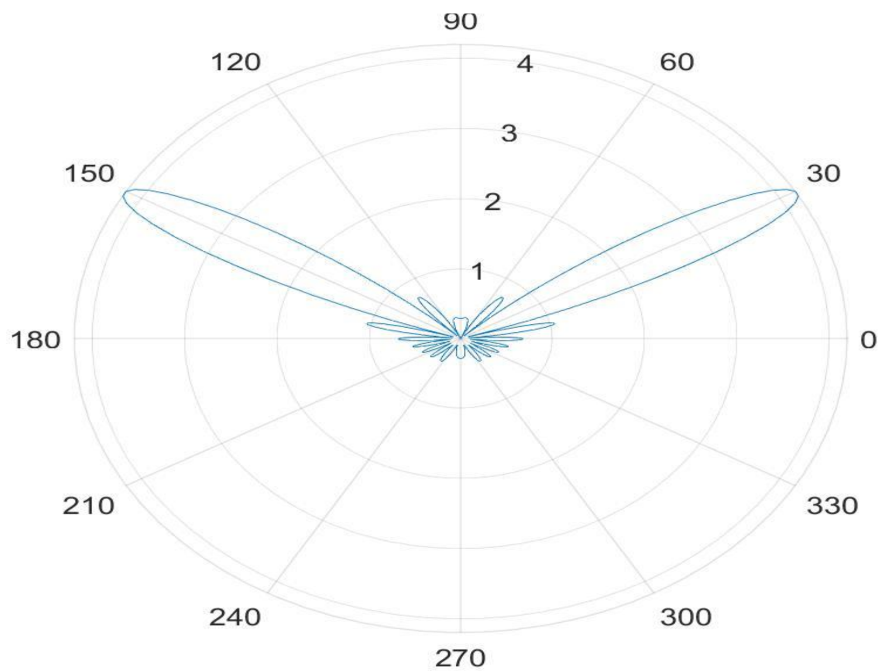



Figure 26. GNEC polar plot for β = -π/2

**iv. $\beta = -\pi$**

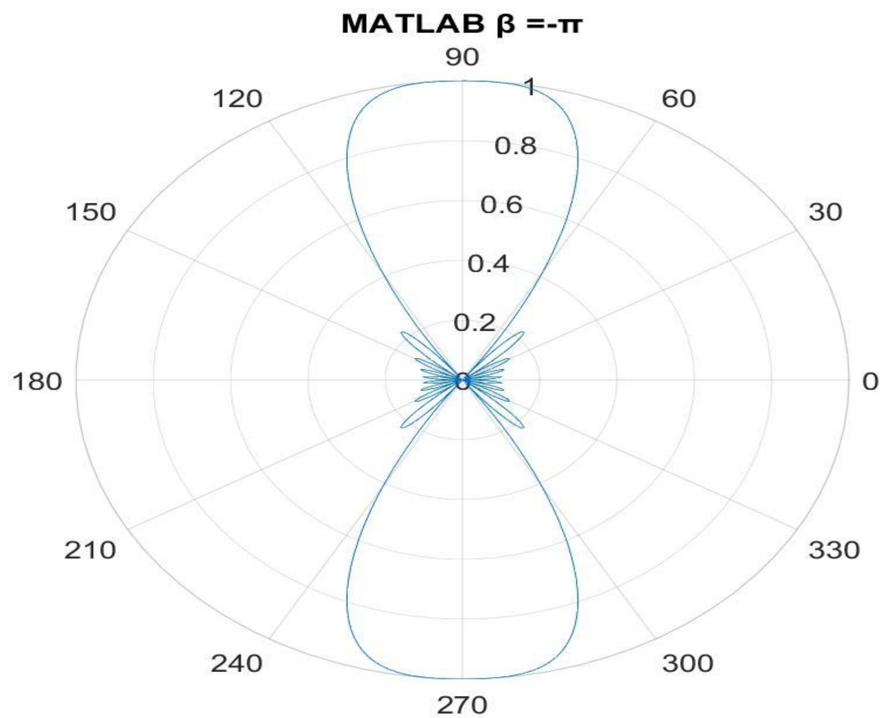



Figure 27. MATLAB polar plot for $\beta = -\pi$

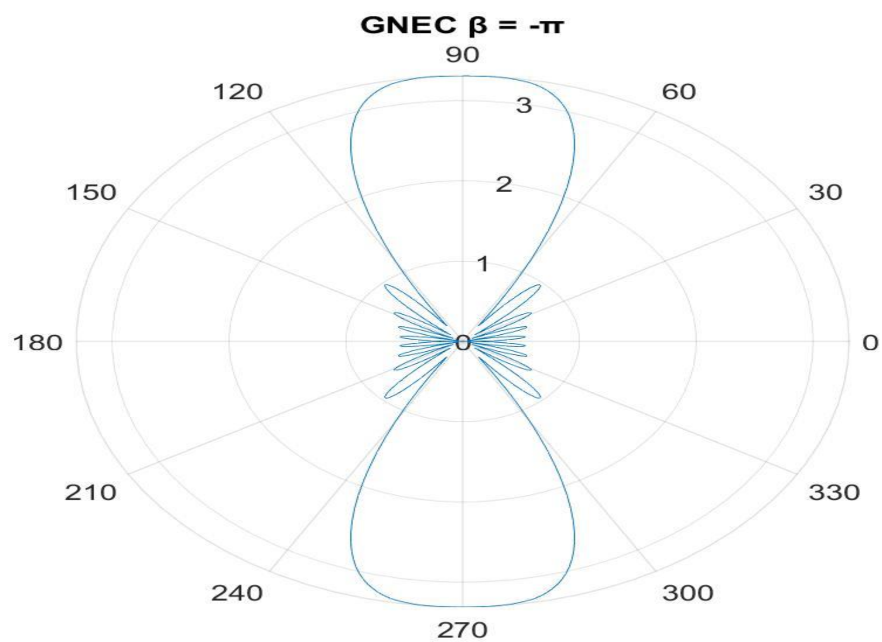



Figure 28. GNEC polar plot for $\beta = -\pi$

## Discussion

- For thin linear dipole antenna, results obtain from GNEC as well as from direct MATLAB simulations matches with minor variations( figures 10-19).
- For linear array, comparing the results obtain from the direct MATLAB simulations and obtained from GNEC software are very similar as can be observed from the plots shown in results( figures 21-28).