## 1. Find the received power using Free Space Propagation Model

```
clc;
close all;
clear all;
f=input('Enter the frequency in Mhz');
L=300/f;
disp('Thus the wavelength is:');
L
%displaying wave length
d=input('Enter the distance in km:');
Gt=input('Enter the transmitting antenna gain:');
Gr=input('Enter the receiving antenna gain:');
pt=input('Enter the transmitted power:');
do=input('Enter the free space distance in meter:');
LF=input('Enter the system loss factor:');
%ls= 32.44+20*log10(d)+20*log10(f);
%disp(sprintf('%s %d %s','the path loss is:',ls,'db')); %displaying path
%loss
pr_do=(pt*Gt*Gr*l^2)/(16*3.14^2*do^2*LF);
%calculating recieved power at free space distance in W
disp(sprintf('%s %d %s','the recieved power at free space distance is :',pr_do,'watts'));
pr=10^(pr_do/10); %calculating recieved power in watts
pr_dbm=10*log10((pr_do)/(10^-3));
disp(sprintf('%s %d %s','the recieved power is:',pr_dbm,'dbm'));
pr_d=pr_dbm+20*log10(do/d);
disp(sprintf('%s %d %s','the received power at distance d is :',pr_d,'dbm'));
```

## **Output**

Enter the frequency in MHz 900

Thus the wavelength is:

L =

0.3333

Enter the distance in km:10000

Enter the transmitting antenna gain:1

Enter the receiving antenna gain:1

Enter the transmitted power:50

Enter the free space distance in meter:100

Enter the system loss factor:1

the recieved power at free space distance is : 3.521666e-06 watts

the recieved power is: -2.453252e+01 dbm

the recieved power at distance d is : -6.453252e+01 dbm

## 2. Find the received power using Okumura

```
clc;
clear all;
close all;
Lfsl= input('enter the free space loss=');
Amu=input('enter the median attenuation value=');
Hmg=input('enter the mobile station antenna height gain factor=');
Hbg=input('enter the Base station antenna height gain factor=');
Kc=input('enter the correction factor gain=');
L=Lfsl+Amu-Hmg-Hbg-Kc;
disp(sprintf('%s %f %s','the median path loss:',L,'dB'));
EIRP=input('enter the effective isotropic radiated power:');
Gr=input('enter the receiving antenna gain=');
Pr=EIRP-L+Gr;
disp(sprintf('%s %f %s','the median received power:',Pr, ‘dBm'));
```

## Output

enter the free space loss= 125.5

enter the median attenuation value=43

enter the mobile station antenna height gain factor=10.46

enter the Base station antenna height gain factor=-6

enter the correction factor gain=9

the median path loss: 155.040000 dB

enter the effective isotropic radiated power:60

enter the receiving antenna gain=0

the median received power : -95.040000 dBm

## 3. Find the received power using Hata model

```
clc;

clear all;

close all;

f=input('enter the frequency of transmission in Hz:');

Hb=input('enter the height of base station antenna in meter:');

Hm=input('enter the height of mobile station antenna in meter:');

d=input('enter the distance between the base and mobile station:');

n=input('enter 0 for small city and 1 for large city:');

if n==0

   ch=0.8+(1.1*log10(f)-0.7)*Hm-1.56*log10(f);

else

   if f>=150*10^6&&f<=300*10^6

      ch=8.29*(log10(1.54*Hm))^.2-1.1;

   else

      if f>=300*10^6&&f<=1500*10^6

         ch=3.2*(log10(11.75*hm))^.2-4.97;

      end;

   end;

end;

lu=69.55+26.26*log10(f)-13.82*log10(Hb)-ch+(44.9-6.55*log10(Hb))*log10(d);

LS=lu-2*[log(f/28)]^.2-5.4;
```

```
LR=lu-4.78*log(f)^.2+18.33*log(f)-40.94;

disp(sprintf('%s%f%s','correction factor=',ch,'db'));

disp(sprintf('%s%f%s','poth loss in urban area=',lu,'db'));

disp(sprintf('%s%f%s','suburban area =',LS,'dB'));

disp(sprintf('%s%f%s','rural area =',LR,'db'));
```

## Output

```
enter the frequency of transmission in Hz:900*10^6
enter the height of base station antenna in meter:100
enter the height of mobile station antenna in meter:5
enter the distance between the base and mobile station:50000
enter 0 for small city and 1 for large city:1
correction factor=-1.383293db
poth loss in urban area=427.858947db
suburban area =418.922498dB
rural area =756.089735db
```

## 4. Orthogonal code generation using Walsh code in CDMA

```
clc;
clear all;
close all;
s=input('enter the number of code words you want: ');
if(s==1)
   z=[1];
else if(s==2)
      z=[1 1;1 -1];
   else
      x=[1 1;1 -1];
      z=[];
      s=log(s)/log(2);
      for i=1:s-1
         z=[x x;x -x];
         x = z;
      end
   end
end
```

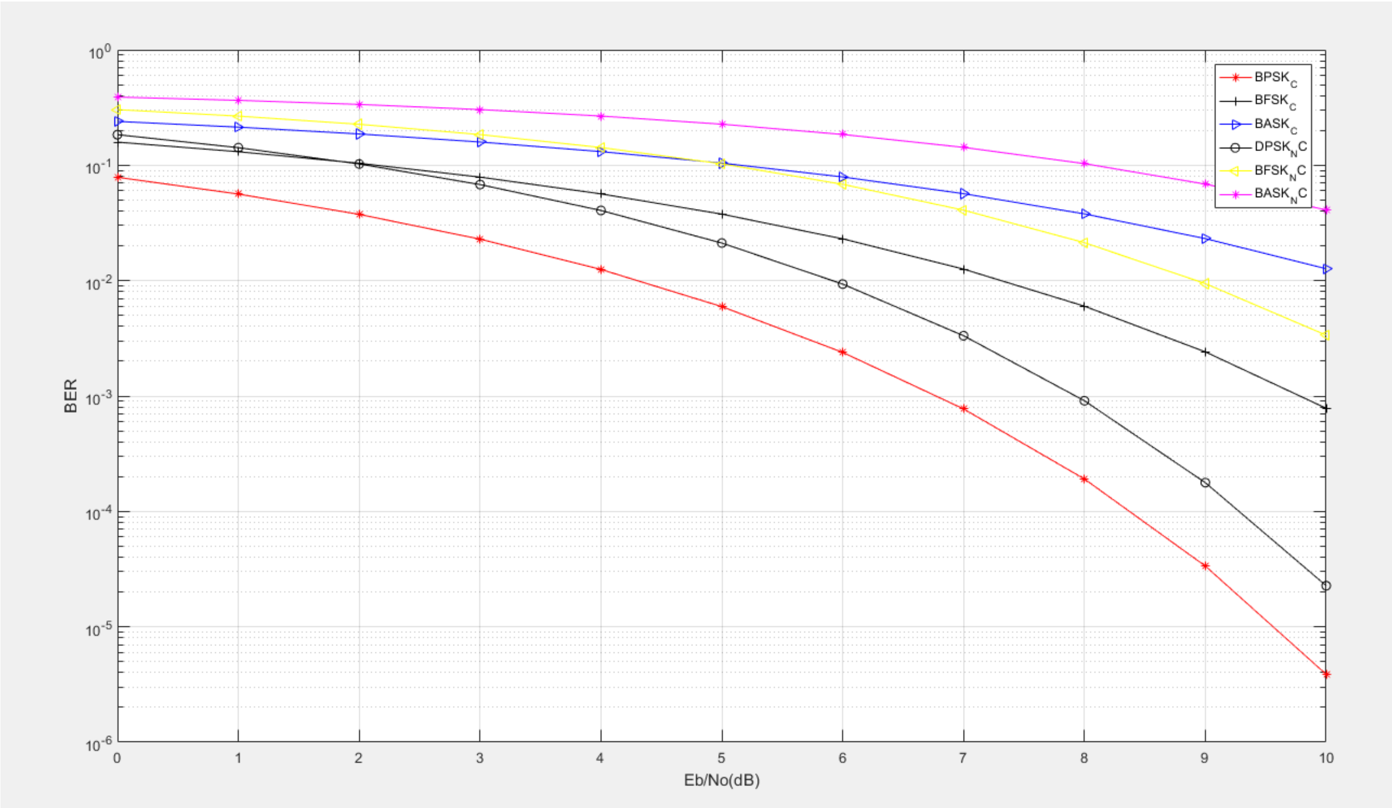
## Output

```
enter the number of code words you want: 8
>> z

z =

     1     1     1     1     1     1     1     1
     1    -1     1    -1     1    -1     1    -1
     1     1    -1    -1     1     1    -1    -1
     1    -1    -1     1     1    -1    -1     1
     1     1     1     1    -1    -1    -1    -1
     1    -1     1    -1    -1     1    -1     1
     1     1    -1    -1    -1    -1     1     1
     1    -1    -1     1    -1     1     1    -1

>> z(1,:).*z(3,:)

ans =

     1     1    -1    -1     1     1    -1    -1

>> sum(ans)

ans =

     0
```

## 5. Comparison of Bit Error Rate between Coherent and Non Coherent modulation technique

```
clc;
close all;
clear all;
EbNodB=0:10;
EbNo=10.^(EbNodB/10);
pe_bpsk=0.5*erfc(sqrt(EbNo));
pe_bfsk=0.5*erfc(sqrt(EbNo/2));
pe_bask=0.5*erfc(sqrt(EbNo/4));
pe_dpsk=0.5*exp(-EbNo);
pe_bfsk_nc=0.5*exp(-EbNo/2);
pe_bask_nc=0.5*exp(-EbNo/4);
semilogy(EbNodB,pe_bpsk,'r*-',EbNodB,pe_bfsk,'k+-',EbNodB,pe_bask,'b>-',
EbNodB,pe_dpsk,'ko-',EbNodB,pe_bfsk_nc,'y<-',EbNodB,pe_bask_nc,'m*-');
legend('BPSK_C','BFSK_C','BASK_C','DPSK_NC','BFSK_NC','BASK_NC');
xlabel('Eb/No(dB)');
ylabel('BER');
grid on
```

## Output



BPSK_C
BFSK_C
BASK_C
DPSK_NC
BFSK_NC
BASK_NC
BER
Eb/No(dB)
10^0
10^-1
10^-2
10^-3
10^-4
10^-5
10^-6
0
1
2
3
4
5
6
7
8
9
10

# 6. Simulation of Rayleigh Fading channel

```
%....Rayleigh Fading....
% ....Input Section....
N=1000000;%number of samples to generate
variance=0.2;%variance of underlying Gaussian random variable
%Independent Gaussian random variables with zero mean and unit variance
x=randn(1,N);
y=randn(1,N);
%Rayleigh fading envelop with the desired variance
r=sqrt(variance*(x.^2+y.^2));
%define bin steps and range of histogram plotting
step=0.1;range=0:step:3;
%Get histogram values and approximate it to get the pdf curve
h=hist(r,range);
approxPDF=h/(step*sum(h));%simulated PDF from x and y samples
%Theoritical PDF from the Rayleigh fading equation
theoritical=(range/variance).*exp(-range.^2/(2*variance));
plot(range,approxPDF,'b*',range,theoritical,'r');
title('Simulated and theoritical Rayleigh PDF for variance=0.5')
legend('Simulated PDF','theoritical PDF')
xlabel('r>');
ylabel('P(r)>');
grid;
%PDF of phase of Rayleigh envelope
theta=atan(y./x);
figure(2)
hist(theta) %Plot histogram of the phase part
% Approximate the histogram of the phase part to a nice PDF curve
[counts,range]=hist(theta,100);
step=range(2)-range(1);
```

```
approxPDF=counts/(step*sum(counts)); % Simulated PDF from the x and y samples
bar(range,approxPDF,'b');
hold on
plotHandle=plot(range,approxPDF,'r');
set(plotHandle,'LineWidth',3.5);
axis([-2 2 0 max(approxPDF)+0.2])
hold off
title('Simulated PDF of phase of Rayleigh Distribution');
xlabel('\theta>');
ylabel('P(\theta)>');
grid;
```

## Output

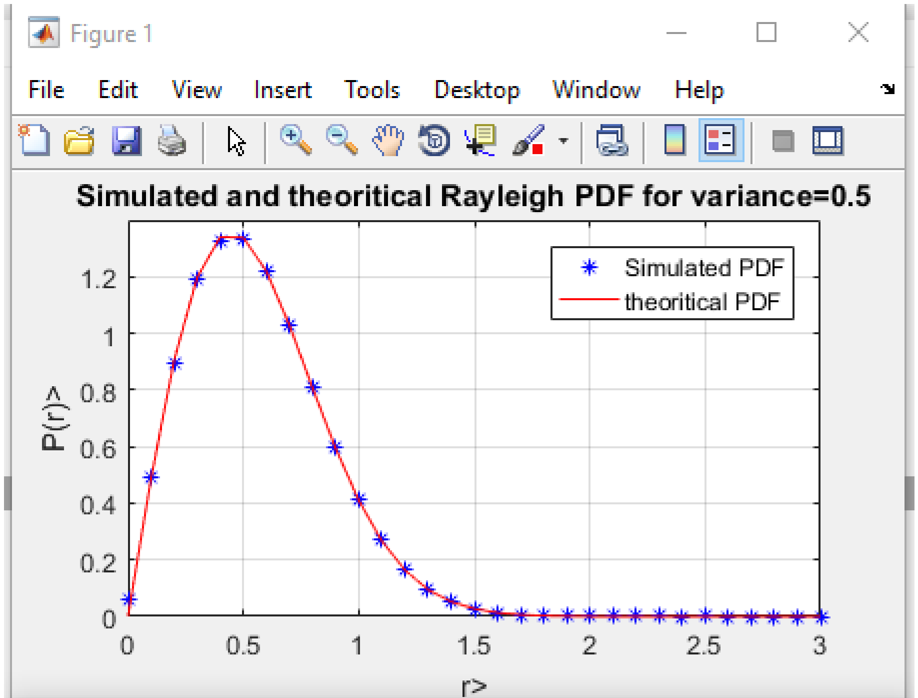


Figure 1
File Edit View Insert Tools Desktop Window Help
Simulated and theoritical Rayleigh PDF for variance=0.5
Simulated PDF
theoritical PDF
P(r)>
r>
0 0.2 0.4 0.6 0.8 1 1.2
0 0.5 1 1.5 2 2.5 3

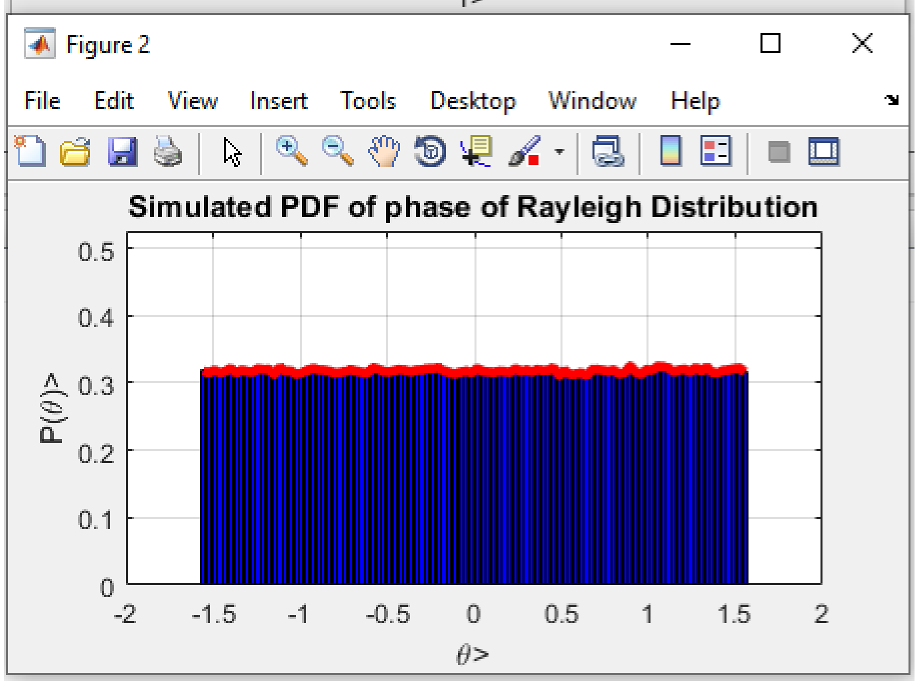


Figure 2
File Edit View Insert Tools Desktop Window Help
Simulated PDF of phase of Rayleigh Distribution
P(θ)>
θ>
0 0.1 0.2 0.3 0.4 0.5
-2 -1.5 -1 -0.5 0 0.5 1 1.5 2

# 7. Simulation of Wireless Channel Equalization

```
clc;

clear all;

close all;

n=10^6;

Eb_No_dB=(0:15);

nTx=2;

nRx=2;

for ii=1:length(Eb_No_dB)

    ip=rand(1,n)>0.5;

    s=2*ip-1;

    sMod=kron(s,ones(nRx,1));

    sMod=reshape(sMod,[nRx,nTx,n/nTx]);

    h=1/sqrt(2)*[randn(nRx,nTx,n/nTx)+j*randn(nRx,nTx,n/nTx)];

    N=1/sqrt(2)*[randn(nRx,n/nTx)+j*randn(nRx,n/nTx)];

    y=squeeze(sum(h.*sMod,2))+10^(-Eb_No_dB(ii)/20)*N;

    hCof=zeros(2,2,n/nTx);

    hCof(1,1,:)=sum(h(:,2,:).*conj(h(:,2,:)),1);

    hCof(2,2,:)=sum(h(:,1,:).*conj(h(:,1,:)),1);

    hCof(2,1,:)=-sum(h(:,2,:).*conj(h(:,1,:)),1);

    hCof(1,2,:)=-sum(h(:,1,:).*conj(h(:,2,:)),1);

    hDen=((hCof(1,1,:).*hCof(2,1,:))-(hCof(1,2,:).*hCof(2,1,:)));
```

```
    hDen=reshape(kron(reshape(hDen,1,n/nTx),ones(2,2)),2,2,n/nTx);
    hlnv=hCof./hDen;
    hMod=reshape(conj(h),nRx,n);
    yMod=kron(y,ones(1,2));
    yMod=(sum(hMod.*yMod,1));
    yMod=kron(reshape(yMod,2,n/nTx),ones(1,2));
    yHat=sum(reshape(hlnv,2,n).*yMod,1);
    ipHat=real(yHat)>0;
    nErr(ii)=size(find([ip-ipHat]),2);
end
simBer=nErr(ii)/n;
EbNoLin=10.^(Eb_No_dB/10);
theoryBer_nRx1=0.5.*(1-1*(1+1./EbNoLin).^(-0.5));
p=1/2-1/2*(1+1./EbNoLin).^(-1/2);
theoryBerMRC_nRx2=p.^2.*(1+2*(1-p));
close all;
figure
semilogy(Eb_No_dB,theoryBer_nRx1,'bp-','Linewidth',2);
hold on
semilogy(Eb_No_dB,theoryBerMRC_nRx2,'kd-','Linewidth',2);
semilogy(Eb_No_dB,simBer,'mo-','Linewidth',2);
axis([0 15 10^-5 0.5])
```

grid on

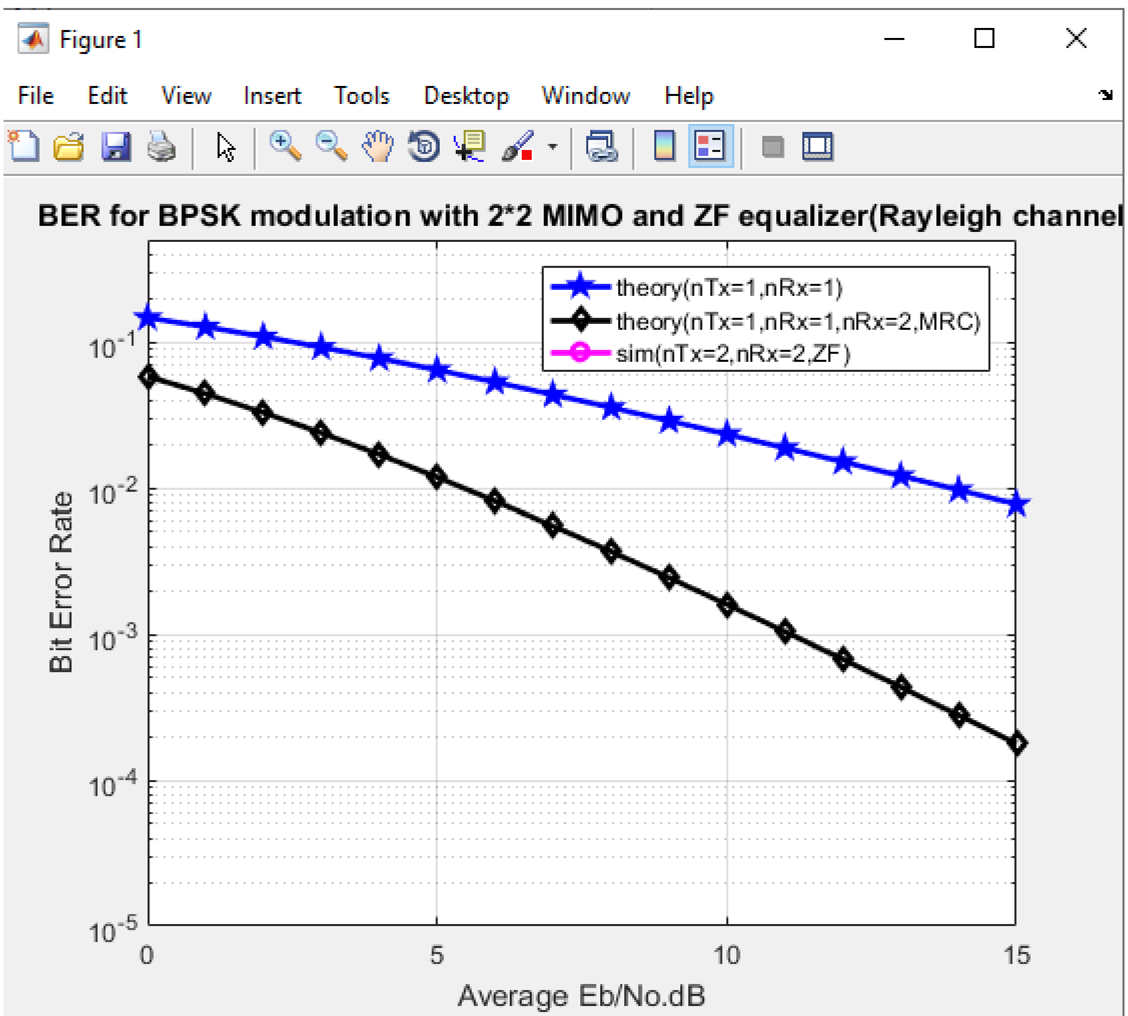
legend('theory(nTx=1,nRx=1)','theory(nTx=1,nRx=1,nRx=2,MRC)','sim(nTx=2,nRx=2,ZF)');

xlabel('Average Eb/No.dB');

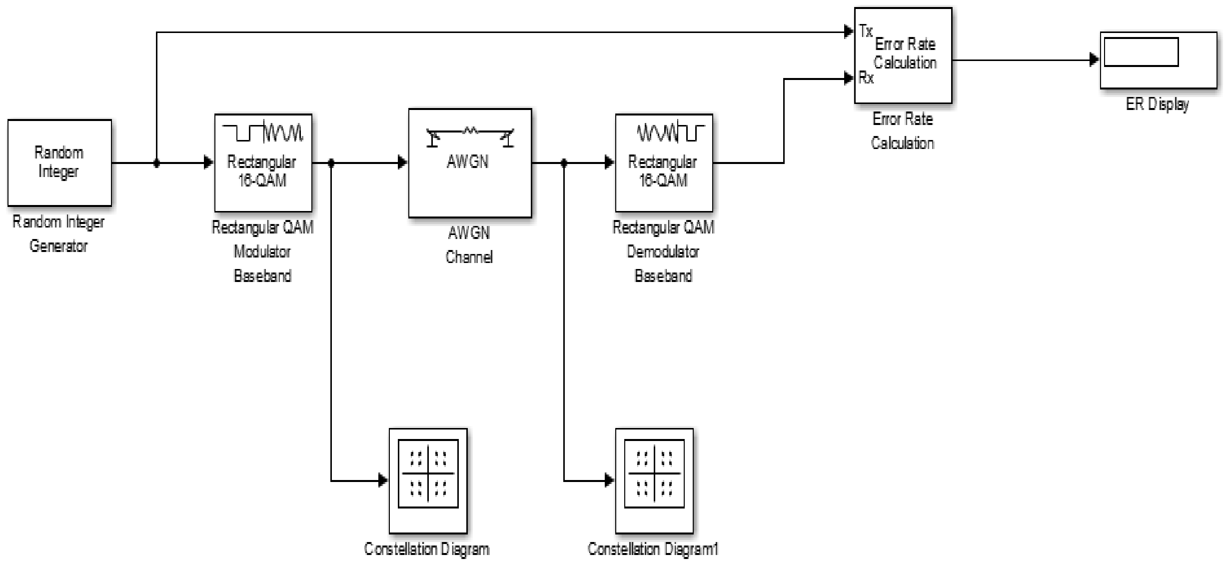
ylabel('Bit Error Rate');

title('BER for BPSK modulation with 2*2 MIMO and ZF equalizer(Rayleigh channel');

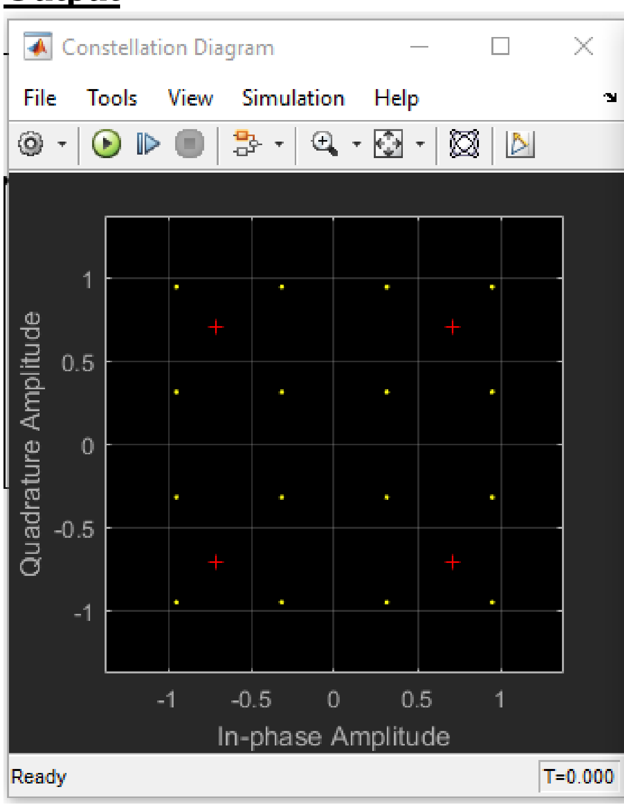
## Output

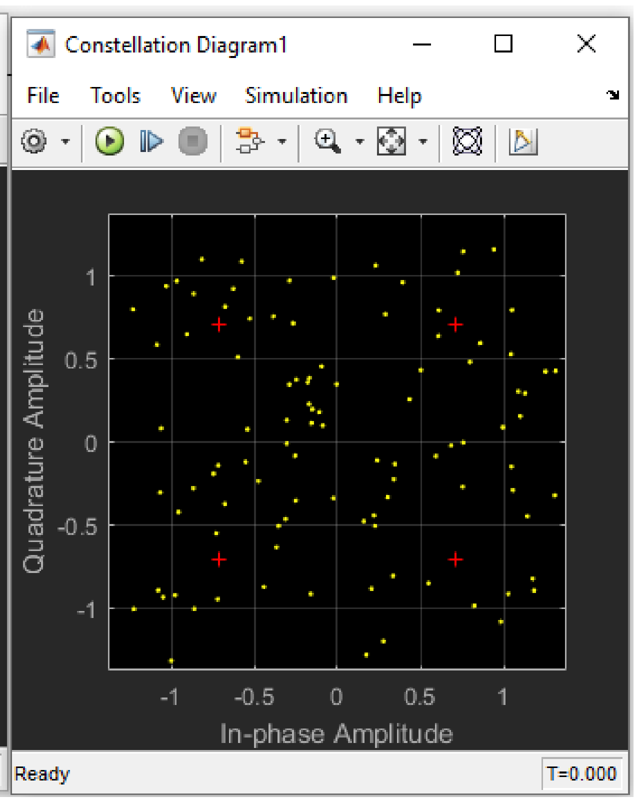


# 8. Quadrature Amplitude Modulation (QAM) technique using MATLAB SIMULINK.




## Output



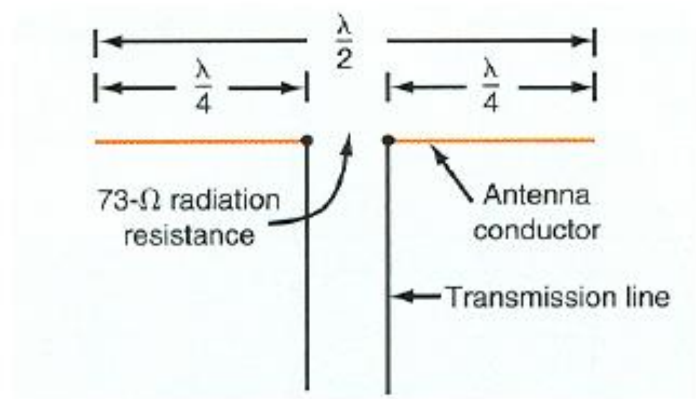
# PART B

# 4NEC2

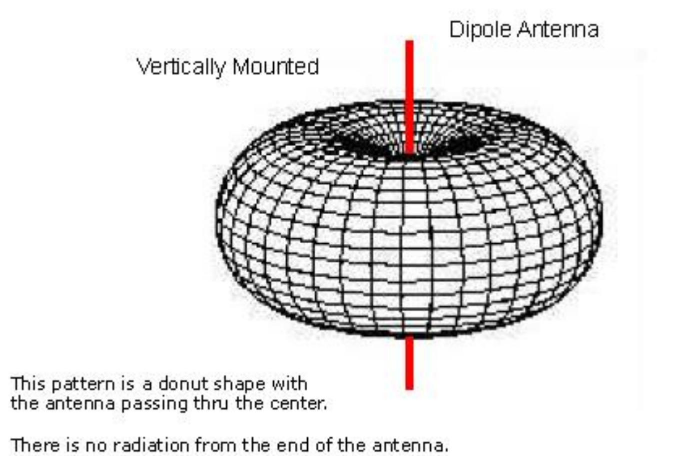
The Numerical Electromagnetics Code, or NEC, is a popular antenna modelling system for wire and surface antennas. It was developed by Lawrence Livermore Laboratory in 1981 for the Navy. 4nec2 is a completely free Nec2, Nec4 and windows based tool for creating, viewing, optimizing and checking 2D and 3D style antenna geometry structures and generate, display and/or compare near/far-field radiation patterns. Line-chart visualization for frequency-sweep Gain, F/B, F/R, SWR and impedance data. Drag and drop style Geometry Editor to assist the starting antenna modeller.

## 9. Dipole Antenna

**One of the most widely used antenna types is the half-wave dipole.**




**Three-dimensional radiation pattern for a dipole.**



Objective: - To design a dipole antenna at the given frequency (300MHz) and to verify,

- Radiation Pattern in 2D
- Radiation Pattern in 3D
- Standing Wave Ratio (SWR)
- Reflection Coefficient (min)

**Design**

Length + diameter = 0.48 λ

Consider f = 300MHz

λ = C/f = 3*10^8/ 300M = 1meter

Dia = λ/100 = 0.01m

Thus length = 0.48 λ – dia

= 0.48 (1) – 0.01

= 0.47m.

**Steps: -**

1. Open 4NEC2 -> Settings -> NEC editor (new) -> Click icon edit NEC input_file
2. A new Window will open. In that
    - Symbols: Enter the Dimension Calculated
        1. Lambda=1
        2. Length=0.47
        3. Dia=0.01
    - Geometry:
      Type: wire
      Tag: 1
      Seg's: 11(odd number so that center can be selected)
      X1: 0
      Y1: -Length/2
      Z1: 0
      X2: 0
      Y2: Length/2
      Z2: 0
      Radius: Dia/2
    - Source/Load:
      Type: Voltage_src
      Tag: 1

Seg: 6(Middle value)
opt: -- (NO entry)
Real: 1(Normalized Voltage Value=1+0j)
Imag: 0
Magn: 1
Phase: 0

- Freq/Ground:
  Frequency: 300MHz

3.Save as Any File Name [File -> Save as]

4.Run NEC -> A Window will Appear

- Choose far field Pattern -> Generate -> 2D radiation Pattern Window will appear -> use space bar, up and down arrow keys see the radiation Pattern in two planes.

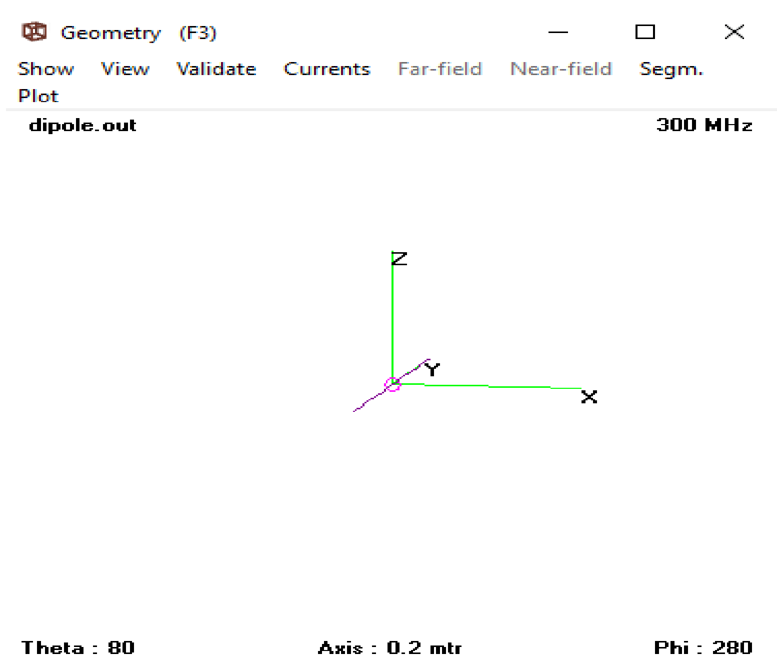
5.Again Run NEC -> a Window will pop-up

- Choose frequency Sweep -> O Ver -> FR: Start[290] stop[310] step[1]

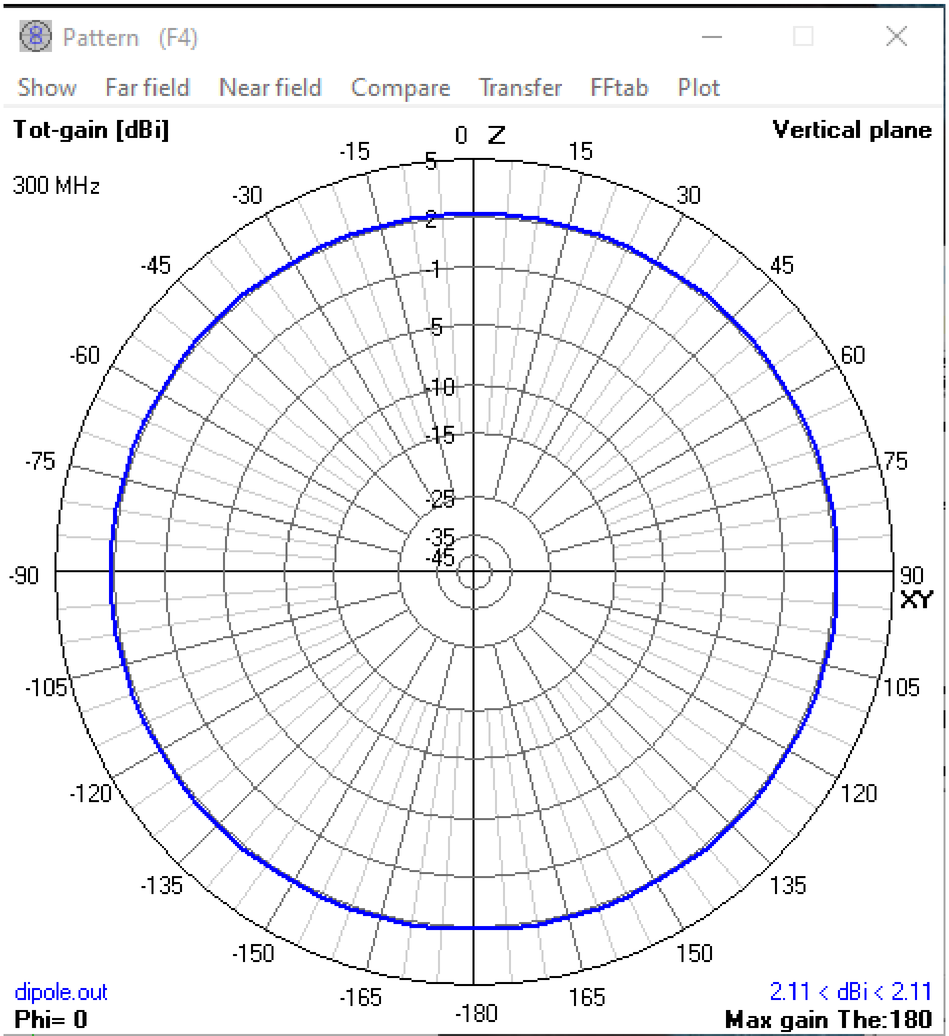
-> Generate

Plots of SWR and Reflection Coefficient will Appear.

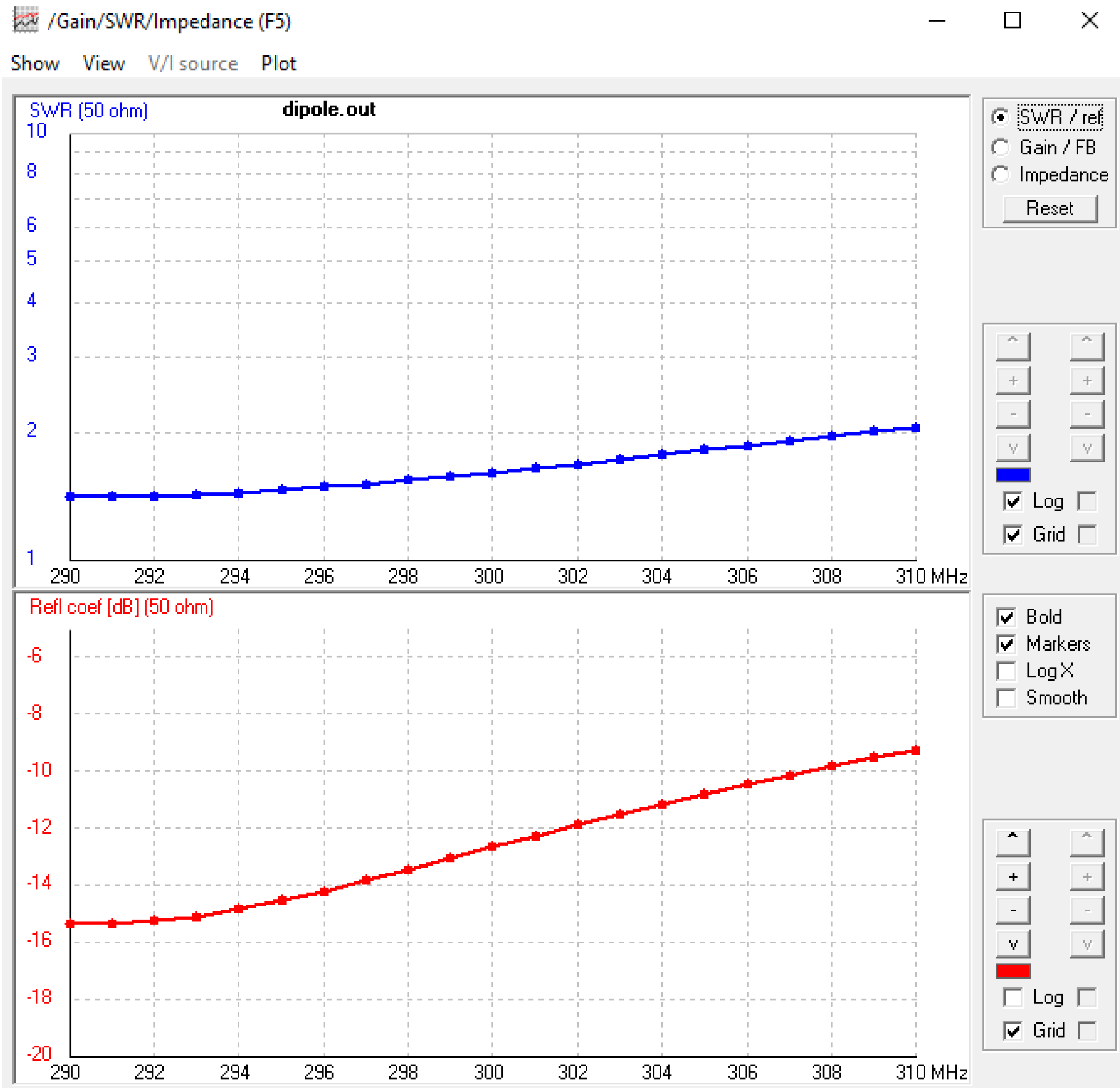
## a) 2D view:-



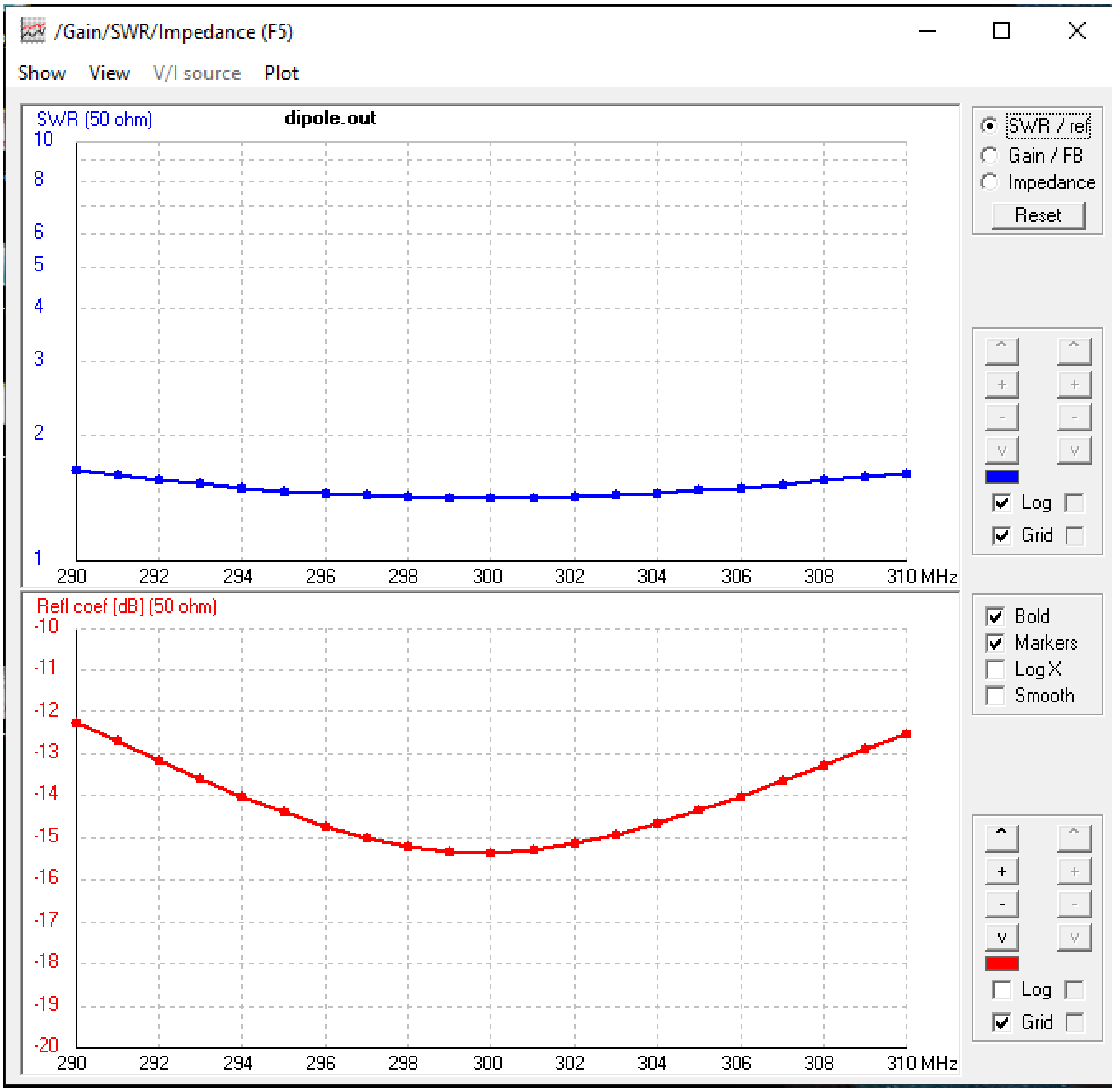
## b) 2D Radiation pattern:-



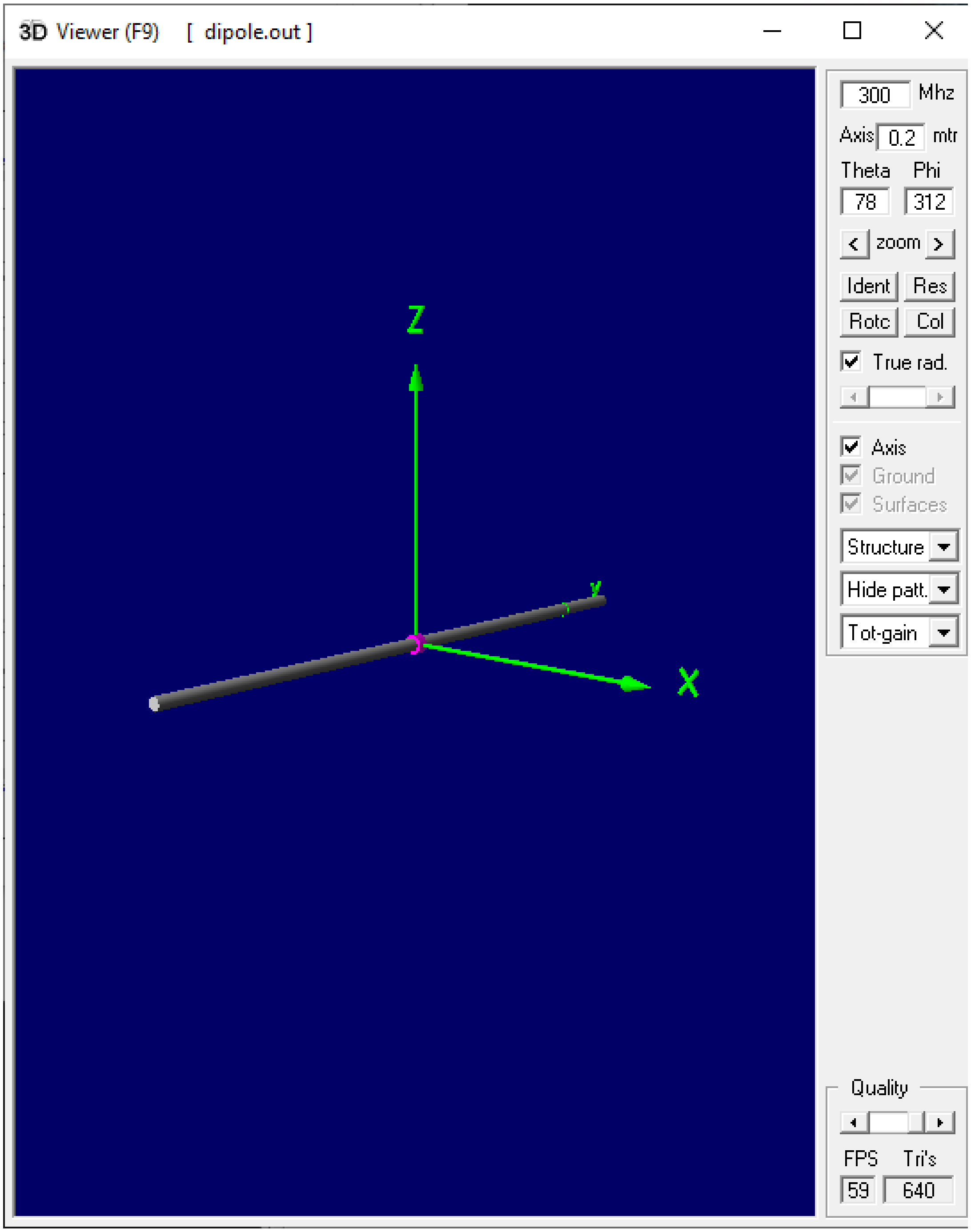
## c)Frequency_sweep of length 0.47:-



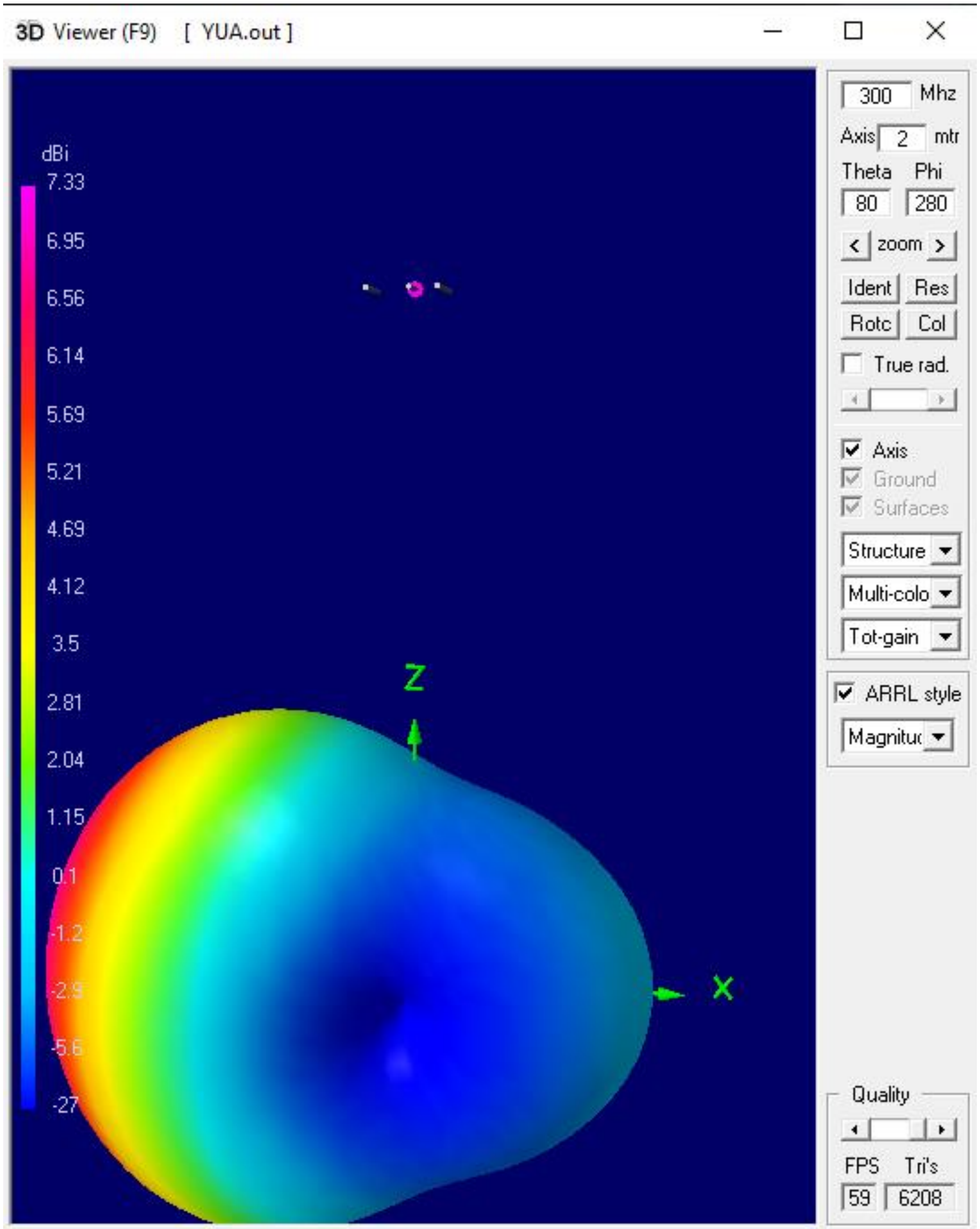
## d) Frequency_sweep of Length 0.455:-



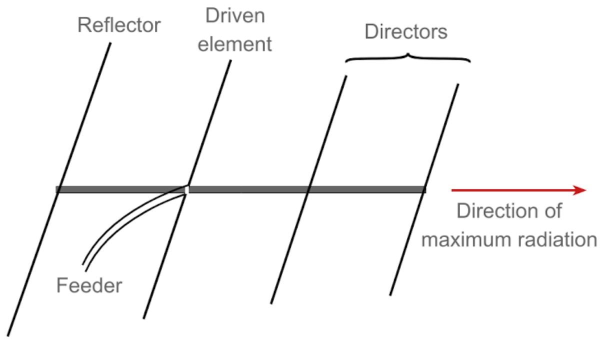
## e) 3D view of Dipole antenna:-



## f) 3D Radiation pattern of Dipole antenna:-



## 10. YAGI_UDA Antenna – 3 Element




Steps: -

1.Open 4NEC2 -> Settings -> NEC editor (new) -> Click icon edit NEC input_file

2.A new Window will open. In that

- Symbols: Enter the Dimension Calculated

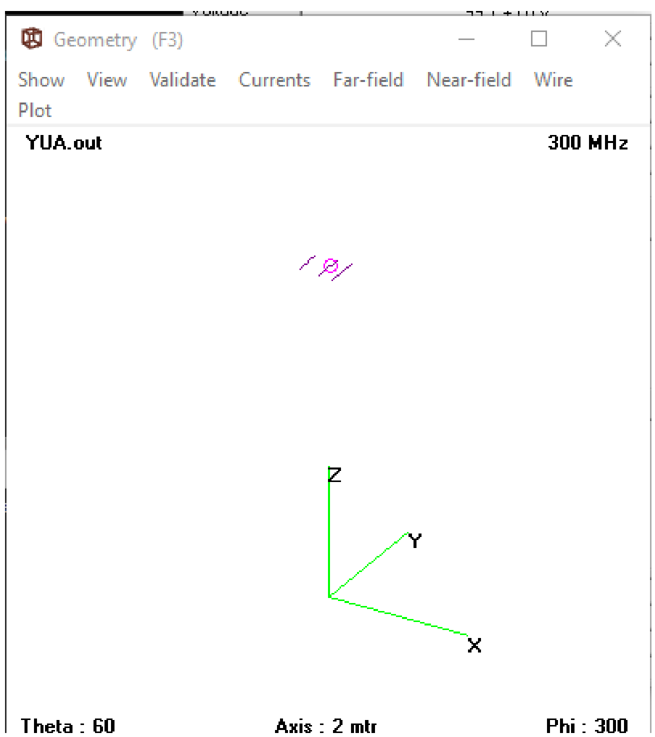
  Lambda=1

  Act=0.48*Lambda

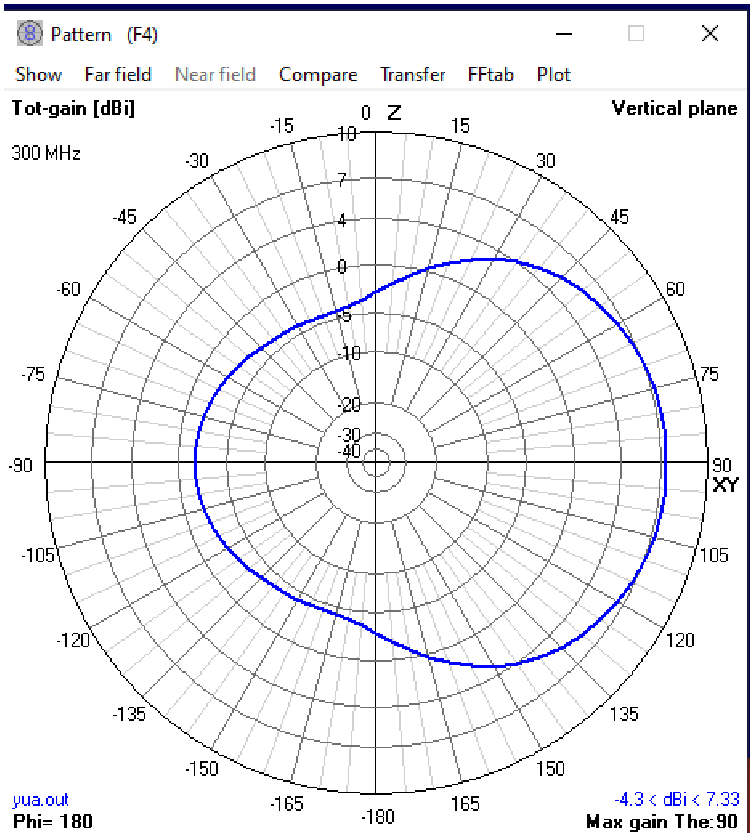
| Dimension | Value |
|---|---|
| Active | 0.47λ -0.49λ |
| Reflector | 0.5λ – 0.525λ |
| Director | 0.4λ – 0.45λ |
| S1 | 0.2λ – 0.25λ |
| S2 | 0.3λ – 0.4λ |

| Dimensions | Value | Starting Coordinate | Ending Coordinate |
|---|---|---|---|
| Act | 0.48λ | (0,-Act/2,H) | (0,Act/2,H) |
| Ref | 0.525λ | (S1,-Ref/2,H) | (S1,Ref/2,H) |
| Dir | 0.42λ | (-S2,-Dir/2,H) | (-S2,Dir/2,H) |
| S1 | 0.2λ | NA | NA |
| S2 | 0.3λ | NA | NA |
| H | 5λ | NA | NA |

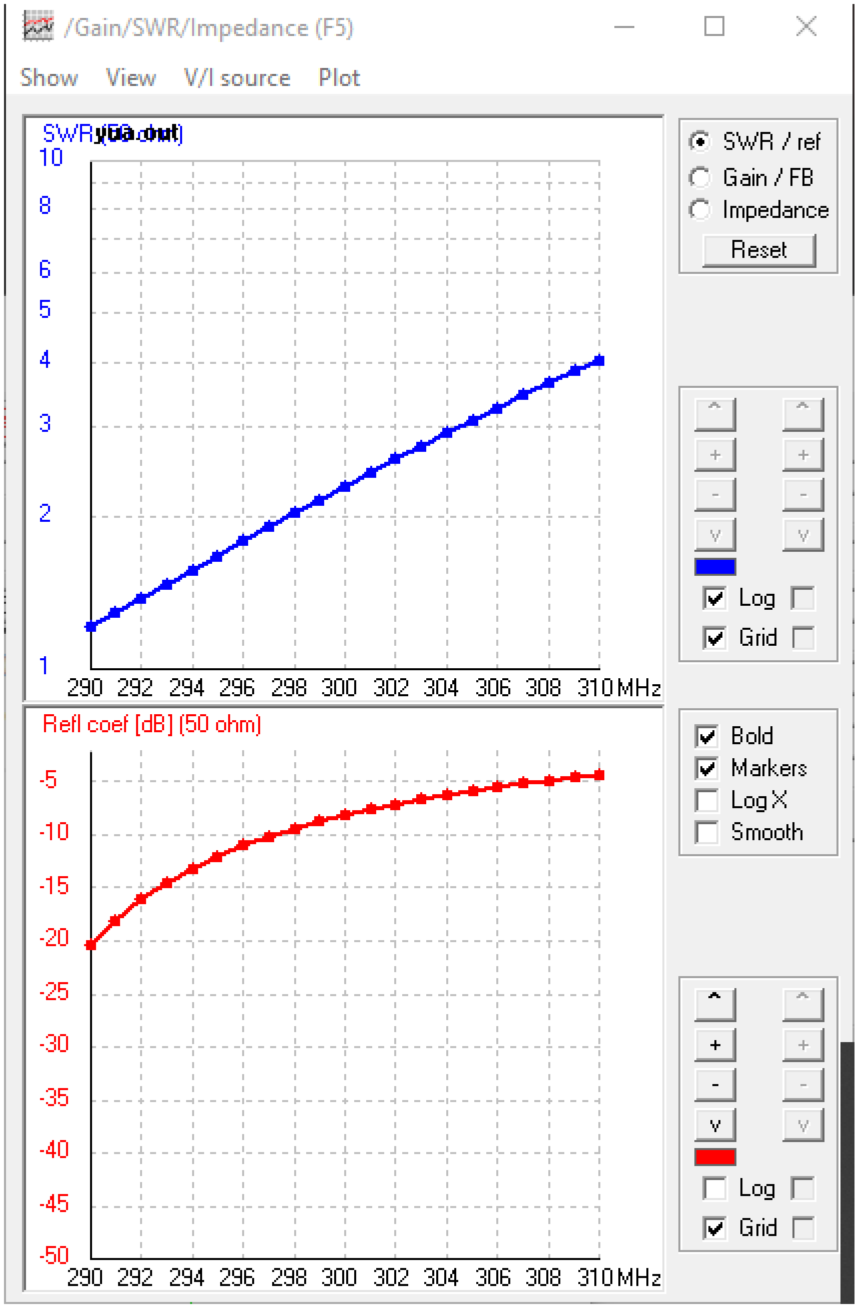
## a) 2D View:-



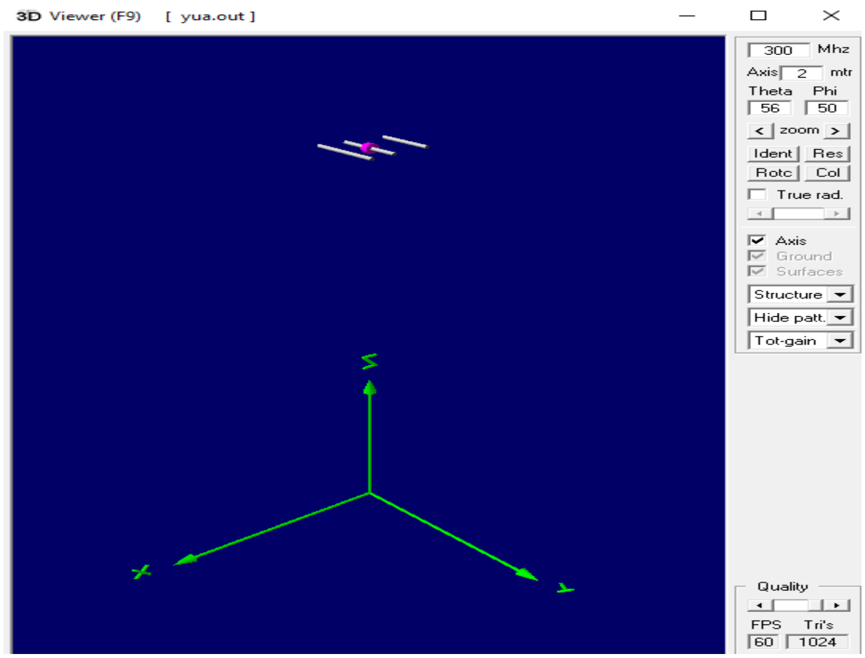
## b) 2D Radiation Pattern:-



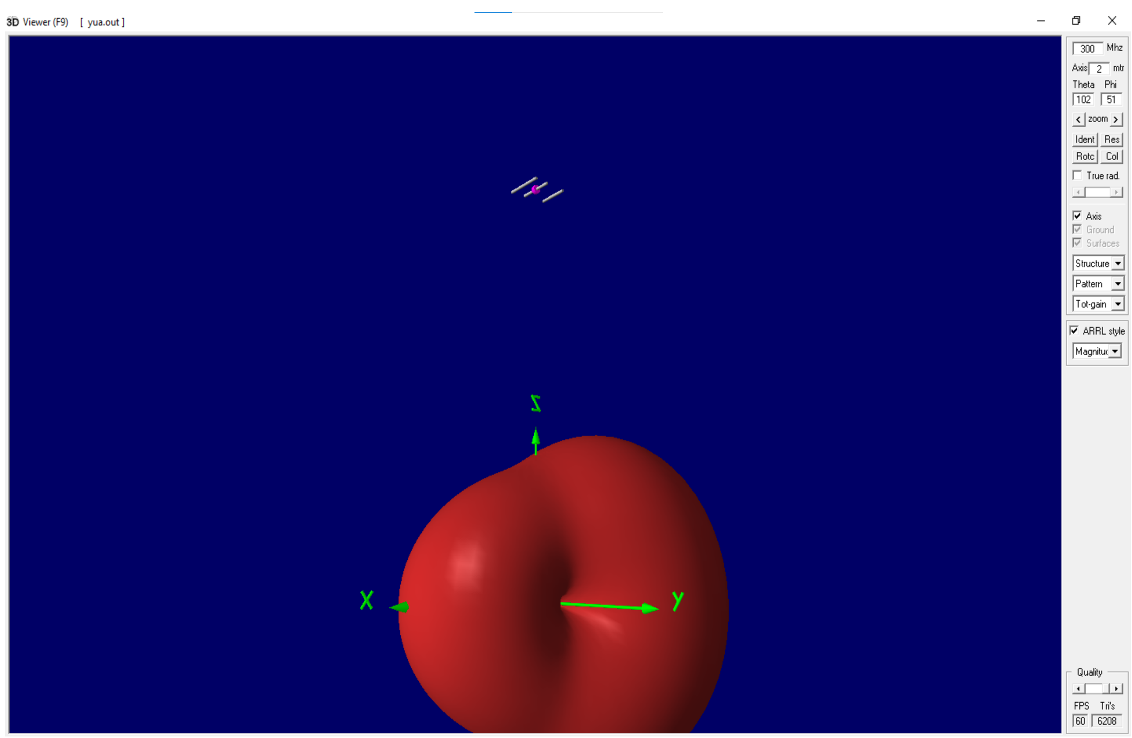
## c) Frequence_sweep:-



## d) 3D view:-




## e)3D Radiation pattern of Yagi Uda:-



## 11. Yagi Uda Antenna - 5 Element

It consists of 1 active element, 1 reflector and 3 directors.

Considering the basic dimensions of 3-element yagi-uda antenna, the 5-element can be designed:

- Dir_1 = 0.42λ
- Length of director 2(Dir_2) = Dir_1 – 5% 0f Dir_1

  = 0.42 – 5% of 0.42

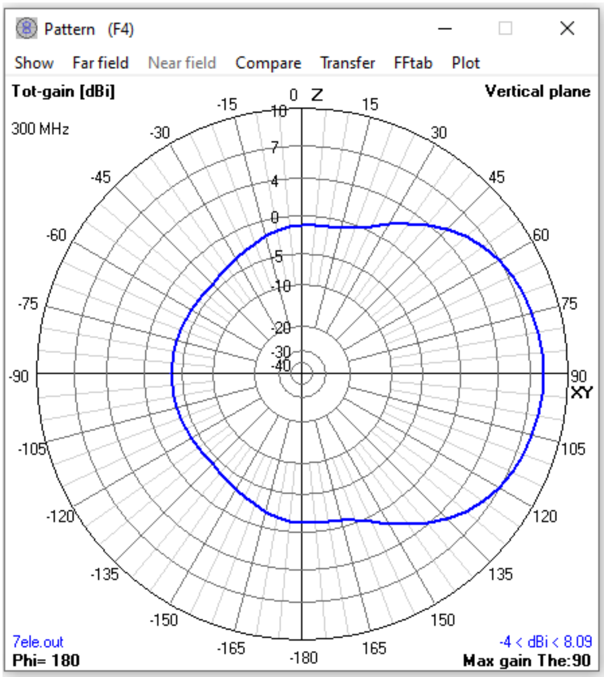
  = 0.399.
- Length of director 3(Dir_3) = Dir_2 – 5% 0f Dir_1

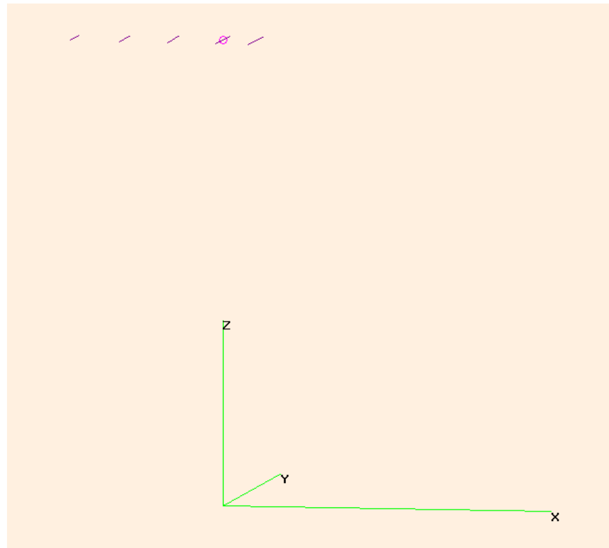
  = 0.399 – 5% of 0.399

  = 0.379.

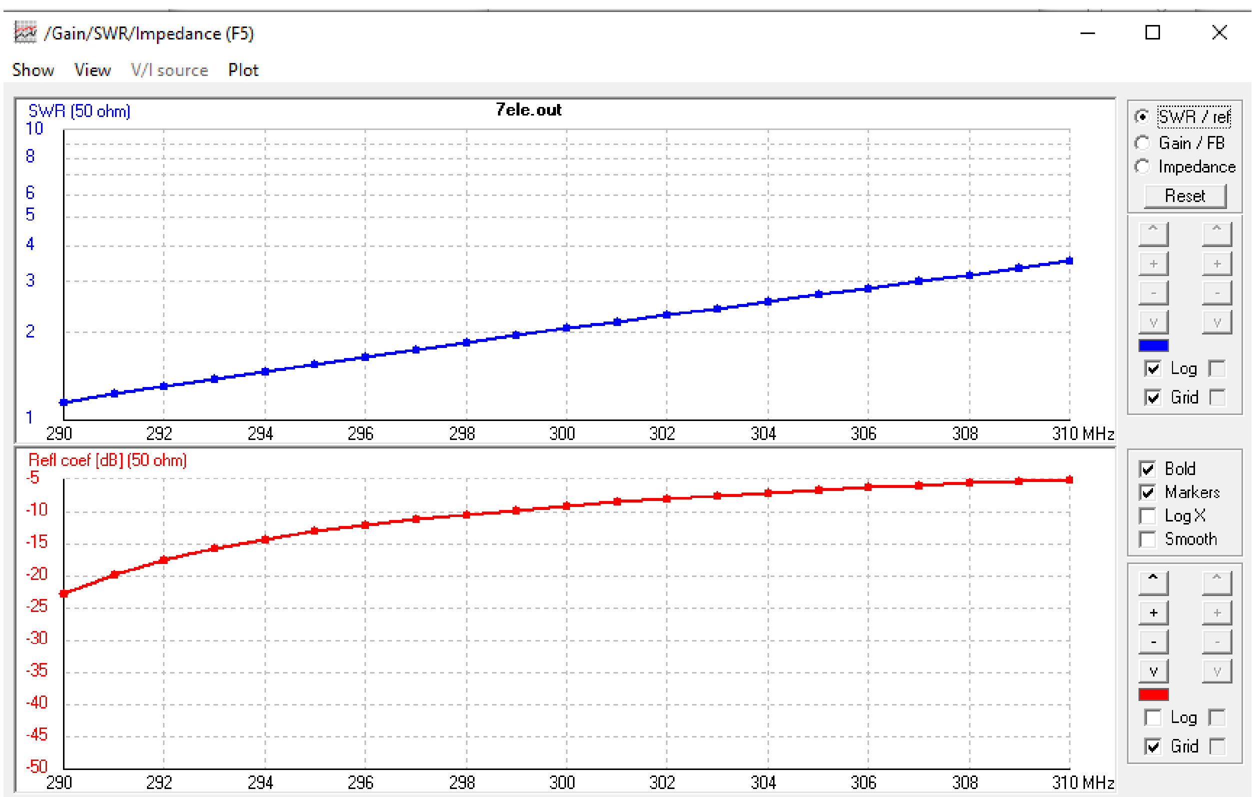
| Dimensions | Value | Starting Coordinate | Ending Coordinate |
|---|---|---|---|
| Act | 0.48λ | (0,-Act/2,H) | (0,Act/2,H) |
| Ref | 0.525λ | (S1,-Ref/2,H) | (S1,Ref/2,H) |
| Dir_1 | 0.42λ | (-S2,-Dir_1/2,H) | (-S2,Dir_1/2,H) |
| Dir_2 | 0.399λ | (-S3,-Dir_2/2,H) | (-S3,Dir_2/2,H) |
| Dir_3 | 0.379λ | (-S4,-Dir_3/2,H) | (-S4,Dir_3/2,H) |
| S1 | 0.2λ | NA | NA |
| S2 | 0.3λ | NA | NA |
| S3 | 0.6λ | NA | NA |
| S4 | 0.9λ | NA | NA |
| H | 5λ | NA | NA |

# Radiation Pattern And 2D View:

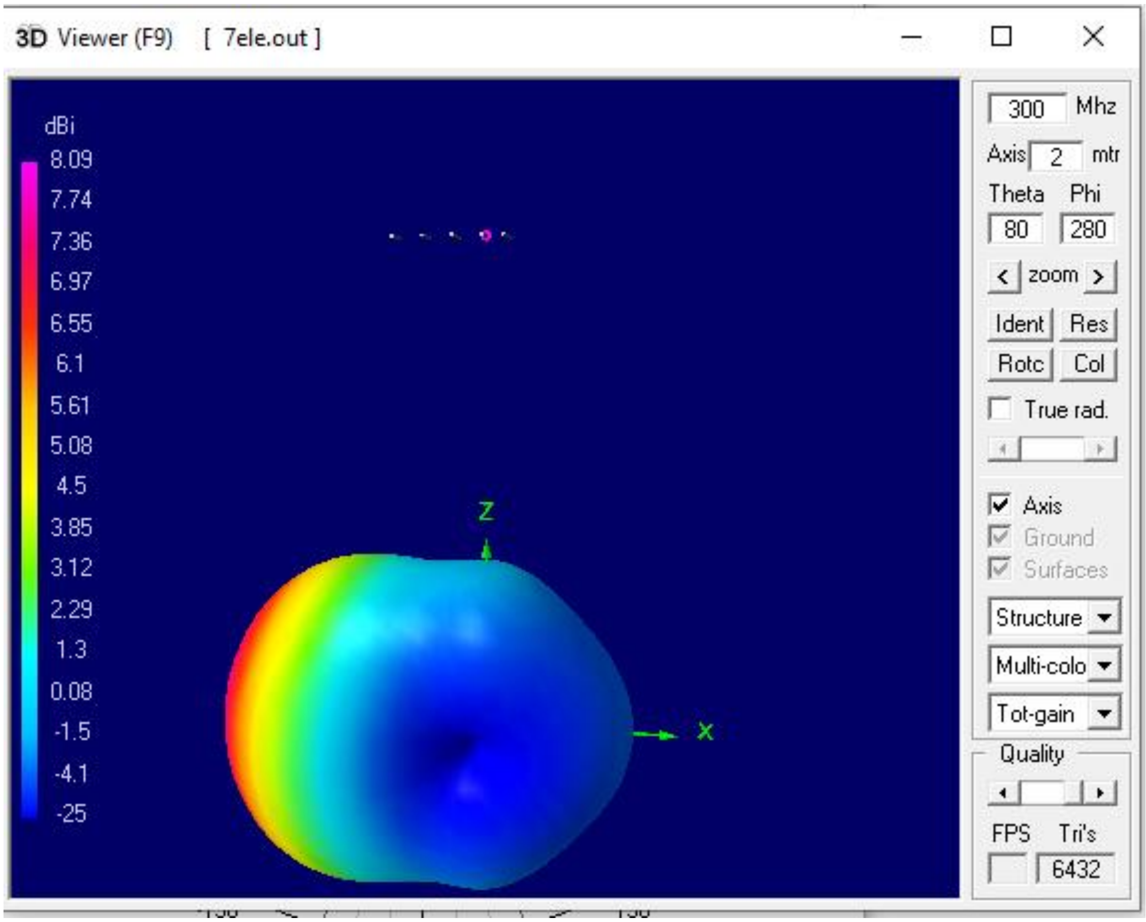



# Frequency Sweep



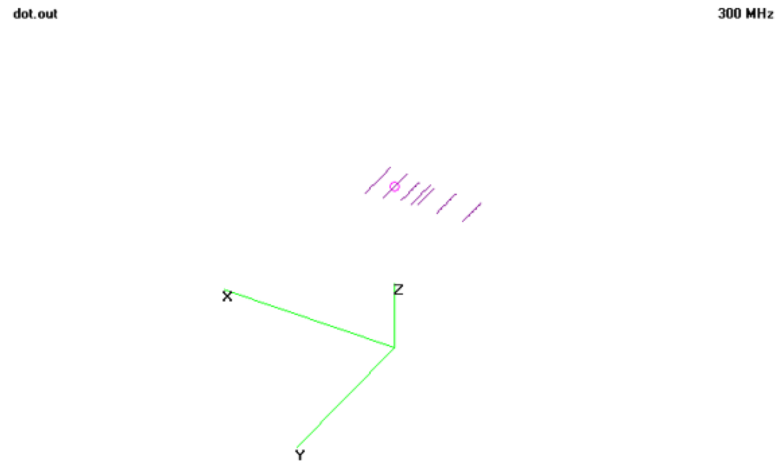
# 3D Radiation pattern



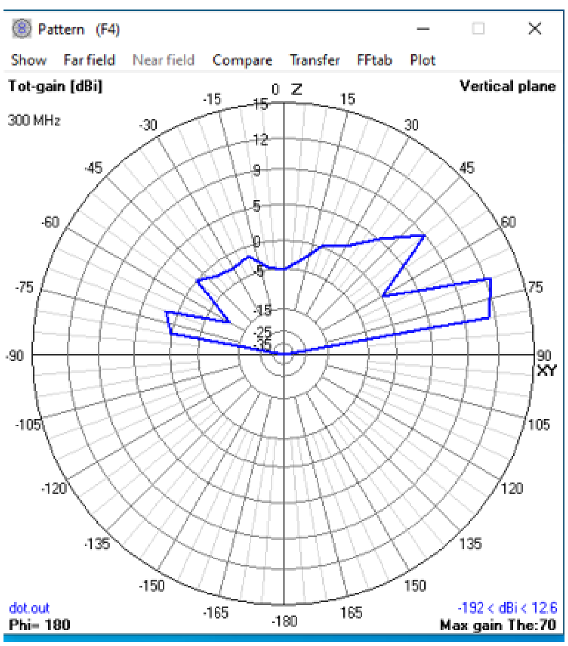
## 12. Yagi-Uda Antenna - 7 Element

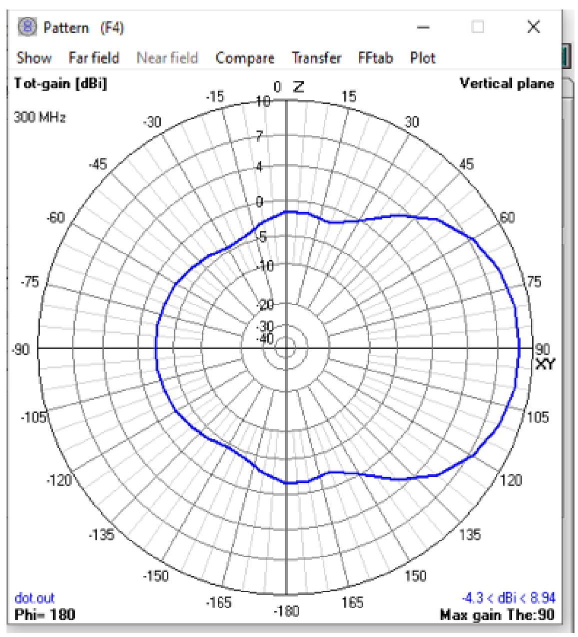
| Dimensions | Value | Starting Coordinate | Ending Coordinate |
|---|---|---|---|
| Act | 0.48λ | (0,-Act/2,H) | (0,Act/2,H) |
| Ref | 0.525λ | (S1,-Ref/2,H) | (S1,Ref/2,H) |
| Dir_1 | 0.42λ | (-S2,-Dir_1/2,H) | (-S2,Dir_1/2,H) |
| Dir_2 | 0.399λ | (-S3,-Dir_2/2,H) | (-S3,Dir_2/2,H) |
| Dir_3 | 0.379λ | (-S4,-Dir_3/2,H) | (-S4,Dir_3/2,H) |
| Dir_4 | 0.360 λ | (-S5,-Dir_4/2,H) | (-S5,Dir_4/2,H) |
| Dir_5 | 0.342λ | (-S6,-Dir_5/2,H) | (-S6,Dir_5/2,H) |
| S1 | 0.2λ | NA | NA |
| S2 | 0.3λ | NA | NA |
| S3 | 0.6λ | NA | NA |
| S4 | 0.9λ | NA | NA |
| S5 | 1.8λ | NA | NA |
| S6 | 2.7 λ | NA | NA |
| H | 5λ | NA | NA |

# 2D-View

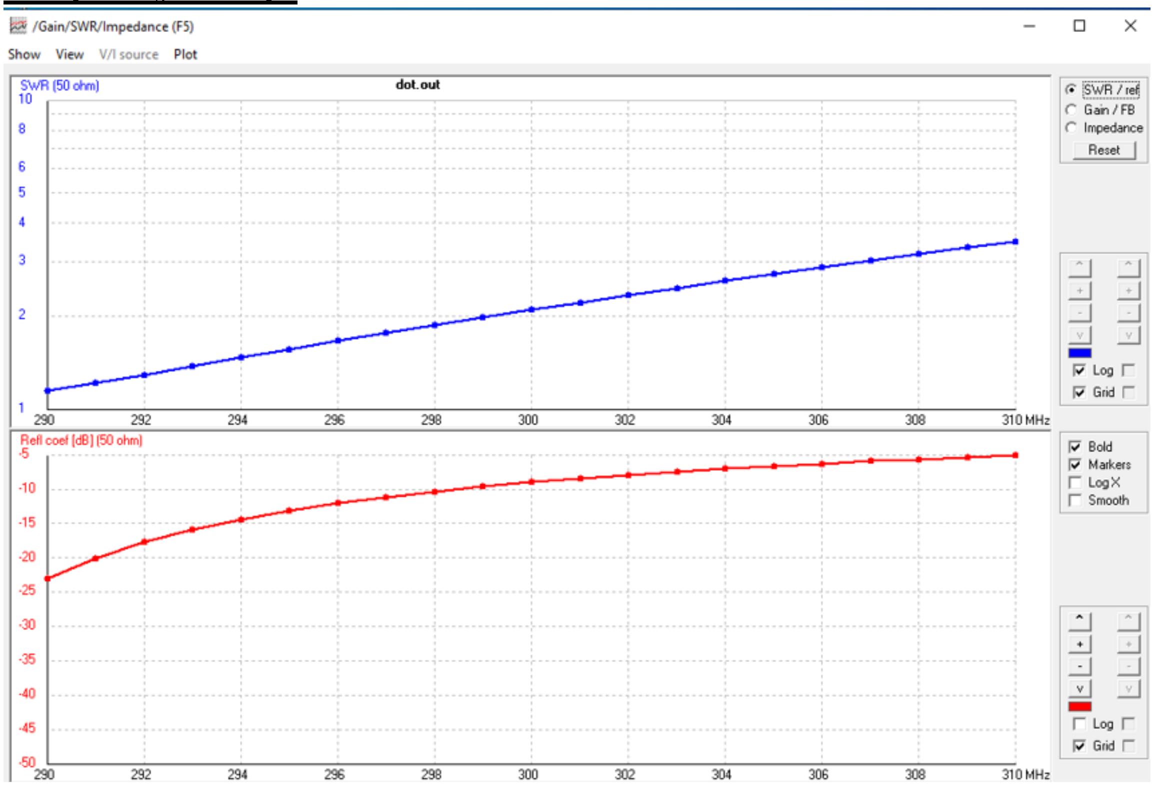



# 2D-Radiation Pattern:

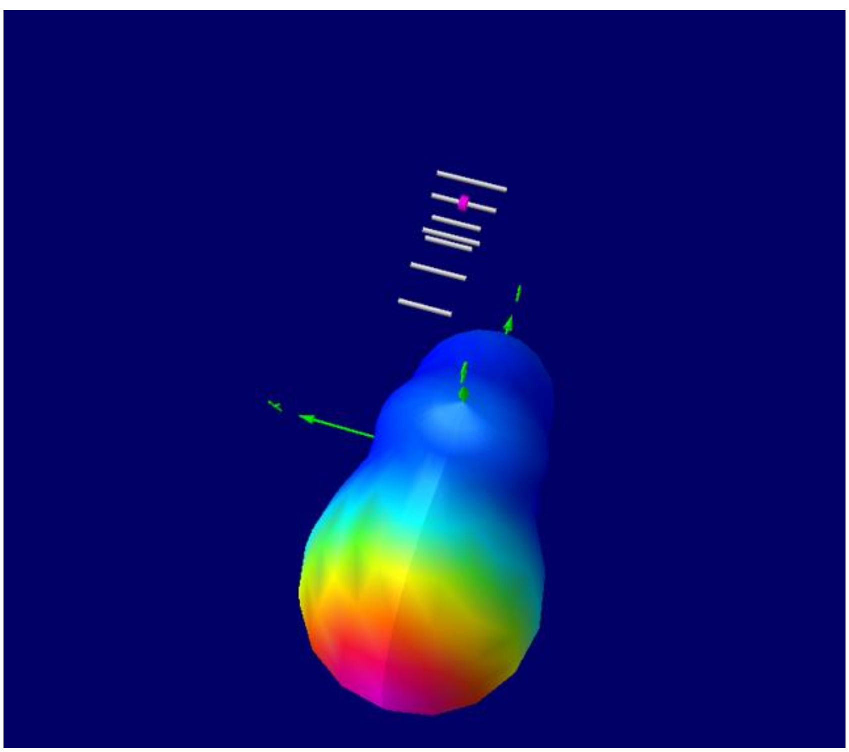


## Frequency Sweep:




## 3D Radiation Pattern



# WC Lab Question Bank

1) Write MATLAB code to generate Walsh codes and check the orthogonality of codes.

2) Write MATLAB code to determine the received power using Free space propagation model. Given the operating frequency _____ MHz, transmitter power ____ W, at distance d _____ m Assume necessary parameter.

3) Write MATLAB code to determine the received power using Okumura model for outdoor radio propagation. Given the following data, Free space loss ______ , mobile station antenna height gain factor ______, base station antenna height gain factor _______, correction factor gain ________, effective isotropic radiated power ________, median attenuation value _____ and receiving antenna gain _____.

4) Write MATLAB code to determine the received power using HATA model for outdoor radio propagation. Given the following data base station antenna height _____ m, mobile station antenna height _______ m and distance between the base and mobile station _______m.

5) Write MATLAB code to compare and analyze bit error rate or coherent and non coherent digital modulation techniques.

6) Write MATLAB code to obtain the PDF of Rayleigh fading effect for magnitude and phase response.

7) Simulate and build the block diagram of 16-Quadrature Amplitude Modulation using Matlab Simulink to obtain the constellation diagram and BER.

8) Write Matlab code to obtain BER performance of ZF-Equalizer for BPSK modulation technique.

9) Design a dipole antenna for an operating frequency of ______ MHz and obtain the following

i. 2D and 3D radiation pattern
ii. Standing Wave Ratio
iii. Reflection Co-efficient
iv. Gain value

10) Design a 3 element Yagi Uda antenna for an operating frequency of _____ MHz and obtain the following

i. 2D and 3D radiation pattern
ii. Standing Wave Ratio
iii. Reflection Co-efficient
iv. Gain value

11) Design a 5 element Yagi Uda antenna for an operating frequency of _____ MHz and obtain the following

i. 2D and 3D radiation pattern
ii. Standing Wave Ratio
iii. Reflection Co-efficient
iv. Gain value

12) Design a 7 element Yagi Uda antenna for an operating frequency of _____ MHz and obtain the following

i. 2D and 3D radiation pattern
ii. Standing Wave Ratio
iii. Reflection Co-efficient
iv. Gain value