

Scilab Textbook Companion for
Antenna and Wave Propagation
by S. Wali¹

Created by
Rajkumar
B.Tech
Electrical Engineering
Uttarakhand Technical University
College Teacher
Vinesh Saini
Cross-Checked by
Prathan Mehta

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Book Description

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Scilab numbering policy used in this document and the relation to the above book.

Exa Example (Solved example)

Eqn Equation (Particular equation of the above book)

AP Appendix to Example(Scilab Code that is an Appednix to a particular Example of the above book)

For example, Exa 3.51 means solved example 3.51 of this book. Sec 2.3 means a scilab code whose theory is explained in Section 2.3 of the book.

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Chapter 1

Review of Electromagnetics and Transmission Lines

Scilab code Exa 1.1.1 Find the wavelengths

```
1 //Example No. 1.1.1
2 clc;
3 clear;
4 close;
5 format('v',7);
6
7 f1=100; //kHz
8 f2=1; //MHz
9 f3=10; //MHz
10 c=3*10^8; //m/s
11 lambda1=c/(f1*10^3); //m
12 lambda2=c/(f2*10^6); //m
13 lambda3=c/(f3*10^6); //m
14 disp(lambda1/1000,"At 100kHz, wavelength(km) : ");
15 disp(lambda2,"At 1MHz, wavelength(m) : ");
16 disp(lambda3,"At 10MHz, wavelength(m) : ");
```

Chapter 3

Fundamental parameters of Antenna

Scilab code Exa 3.3.1 Half Power Beam Width

```
1 //Example No. 3.3.1
2 clc;
3 clear;
4 close;
5 format('v',7);
6 E_theta=1/sqrt(2); //Electric Field at half power
7 //theta=thetaHP/2; //E(thetaHP/2)=cosd(thetaHP/2)
8 thetaHP=2*acosd(E_theta); //degree(Half power beam
   width)
9 disp(thetaHP,"Half power beam width(degree) : ");
```

Scilab code Exa 3.3.2 HPBW and FNBW

```
1 //Example No. 3.3.2
2 clc;
3 clear;
```

```

4 close;
5 format('v',7);
6 E_theta=1/sqrt(2); // Electric field at theta=90-
    thetaHP/2
7 //E(90-thetaHP/2)=sind(90-thetaHP/2)
8 thetaHP=2*(90-asind(E_theta)); // degree (HPBW)
9 disp(thetaHP,"HPBW( degree) : ");
10 theta1=0;theta2=180; // degree (Pattern angles)
11 FNBW=theta2-theta1; //degree (FNBW) //as E is zero at
    these points
12 disp(FNBW,"FNBW( degree) : ");

```

Scilab code Exa 3.3.3 Half Power Beam width

```

1 //Example No. 3.3.3
2 clc;
3 clear;
4 close;
5 format('v',7);
6 E_theta=1/sqrt(2); // Electric field at half power
    point
7 //E(thetaHP/2)=(cosd(thetaHP/2))^2
8 thetaHP=2*(acosd(sqrt(E_theta))); // degree (HPBW)
9 disp(thetaHP,"Half Power Beam Width( degree) : ");

```

Scilab code Exa 3.8.1 Exact and Approximate Directivity

```

1 //Example No. 3.8.1
2 clc;
3 clear;
4 close;
5 format('v',6);
6 theta1=0;theta2=%pi/2; //radian (Angles)

```

```

7 fi1=0;fi2=2*%pi;//radian (Angles)
8 //Prad=integrate('integrate('U','thheta',theta1,
    theta2) ','fi',fi1,fi2);
9 Prad_BY_Um=%pi*(1/2)*(cos(2*theta1)-cos(2*theta2));
    //(Power radiated/Max intensity)
10 Do=4*%pi/Prad_BY_Um;//Exact Directivity
11 disp(Do,"Exact Directivity : ");
12 //Um*Cosd(thetaHP/2)=0.5*Um
13 thetaHP=2*acosd(0.5);//degree (HPBW)
14 fiHP=thetaHP;//degree (HPBW)
15 Do=41253/(thetaHP*fiHP);//Approximate Directivity
16 disp(Do,"Approximate Directivity : ");

```

Scilab code Exa 3.10.1 Power radiated

```

1 //Example No. 3.10.1
2 clc;
3 clear;
4 close;
5 format('v',6);
6
7 K=90;//%//radiation efficiency
8 Pin=10;//W
9 Prad=(K/100)*Pin;//W
10 disp(Prad,"Radiated power in Watts : ");

```

Scilab code Exa 3.11.1 Gain in dB

```

1 //Example No. 3.11.1
2 clc;
3 clear;
4 close;
5 format('v',6);

```

```

6
7 D=20; // Directivity
8 K=90; // % radiation efficiency
9 G=(K/100)*D; // Gain
10 GdB=10*log10(G); // dB
11 disp(GdB, "Gain in dB : ");
12 // Answer is not calculated in the book.

```

Scilab code Exa 3.11.2 Directivity in dB

```

1 // Example No. 3.11.2
2 clc;
3 clear;
4 close;
5 format('v',7);
6 Rr=72; //
7 RL=8; //
8 G=16; // Gain
9 K=Rr/(Rr+RL)*100; // % radiation efficiency
10 D=G/(K/100); // Directivity
11 DdB=10*log10(D); // dB
12 disp(DdB, "Directivity in dB : ");

```

Scilab code Exa 3.13.1 Radiation Resistance

```

1 // Example No. 3.13.1
2 clc;
3 clear;
4 close;
5 format('v',6);
6 Irms=15; // A (Current Drawn)
7 Prad=5; // kW (Radiated Power)
8 Rr=Prad*10^3/Irms^2; // (Radiation Resistance)

```

```
9 disp(Rr," Radiation resistance in : ");
```

Scilab code Exa 3.13.2 Current Drawn

```
1 //Example No. 3.13.2
2 clc;
3 clear;
4 close;
5 format('v',4);
6 Prad=1000; //W(Radiated Power)
7 Rr=300; // (Radiation Resistance)
8 Irms=sqrt(Prad/Rr); //A(Current Drawn)
9 disp(Irms," Current drawn in A : ");
```

Scilab code Exa 3.13.3 Maximum Effective Aperture

```
1 //Example No. 3.13.3
2 clc;
3 clear;
4 close;
5 format('v',5);
6 Rr=73; // (Radiation Resistance)
7 Z=120*%pi; // (For free space)
8 //le=lambda/%pi
9 AemBYlambda_sqr=(1/%pi)^2*Z/(4*Rr);
10 disp("Maximum effective aperture in m is "+string(
    AemBYlambda_sqr)+"*lambda ");
```

Scilab code Exa 3.13.4 Effective length

```

1 //Example No. 3.13.4
2 clc;
3 clear;
4 close;
5 format('v',7);
6
7 Rr=73; //
8 Z=120*%pi; // (For free space)
9 //Aem=0.13*lambda
10 AemBylambda_sqr=0.13;
11 leBYlambda=2*sqrt(AemBylambda_sqr*Rr)/sqrt(Z);
12 disp("Effective length in meter is "+string(
    leBYlambda)+"*lambda");

```

Scilab code Exa 3.15.1 Polarization Loss factor

```

1 //Example No. 3.15.1
2 clc;
3 clear;
4 close;
5 format('v',4);
6
7 cos_si_p=1/sqrt(2);
8 PLF=cos_si_p^2; //Polarization Loss factor
9 PLFdB=10*log10(PLF); //dB
10 disp(PLFdB,"Power loss factor in dB : ");

```

Scilab code Exa 3.16.1 Maximum effective aperture and power

```

1 //Example No. 3.16.1
2 clc;
3 clear;
4 close;

```

```

5 format('v',9);
6
7 Do_dB=20; //dB
8 f=10; //GHz
9 Wi=2*10^-3; //W/ m
10 c=3*10^8; //m/s
11 lambda=c/(f*10^9); //m
12 Do=10^(Do_dB/10); // unitless
13 Aem=lambda^2/(4*%pi)*Do; // m
14 disp(Aem,"Maximum effective aperture in m : ");
15 Pr=Aem*Wi; //W
16 disp(Pr*10^6,"Maximum received power in W : ");

```

Scilab code Exa 3.16.2 Directivity of Antenna

```

1 //Example No. 3.16.2
2 clc;
3 clear;
4 close;
5 format('v',6);
6 ecd=1; //for lossless antenna
7 Aem=2.147; //m (Maximum Effective aperture)
8 Zin=75; // (Input impedance)
9 Zo=50; // (Output impedance)
10 f=100; //MHz(Operating frequency)
11 c=3*10^8; //m/s(speed of light)
12 aw_aa=1; //For no polarization loss
13 lambda=c/(f*10^6); //m(Wavelength)
14 Tau=(Zin-Zo)/(Zin+Zo); //(Reflection Coefficient)
15 Do=Aem/(ecd*(1-Tau^2)*lambda^2/(4*%pi)/aw_aa^2); //
    unitless(Directivity)
16 disp(Do,"Directivity of antenna : ");

```

Scilab code Exa 3.17.1 Find the power delivered

```
1 //Example No. 3.17.1
2 clc;
3 clear;
4 close;
5 format('v',11);
6 PT=15; //W(Transmitted Power)
7 AeT=0.2; // m (Effective aperture)
8 AeR=0.5; // m (Effective aperture)
9 f=5; //GHz(frequency)
10 r=15; //km(line of sight distance)
11 c=3*10^8; //m/s(Speed of light)
12 lambda=c/(f*10^9); //m(Wavelength)
13 PR=PT*AeT*AeR/((r*1000)^2*lambda^2); //Watts(Power
    delivered to reciever)
14 disp(PR,"Power delivered to receiver in Watts : ");
15 //Answer is wrong in the book. lambda is 0.6 instead
    of 0.06 and lambda^2 is 0.06 instead of 0.0036
```

Scilab code Exa 3.17.2 Calculate the power

```
1 //Example No. 3.17.2
2 clc;
3 clear;
4 close;
5 format('v',6);
6 DT=20; //dB(Transmitter Directivity)
7 DR=20; //dB(Reciever Directivity)
8 PT=10; //W(Transmitted Power)
9 ecdT=1; ecdR=1; //(For lossless antenna)
10 aT_aR=1; //(For polarization match)
11 DT=10^(DT/10); //unitless(Transmitter Directivity)
12 DR=10^(DR/10); //unitless(Reciever Directivity)
13 Tau_T=0; Tau_R=0; //(Reflection coefficient)
```

```

14 rBYlambda=50; //m
15 PR=PT*ecdT*ecdR*(1-Tau_T^2)*(1-Tau_R^2)/(4*pi*
    rBYlambda)^2*DT*DR*aT_aR^2; //Watts(Power
    delivered to reciever)
16 disp(PR,"Power at receiving antenna in Watts : ");

```

Scilab code Exa 3.17.3 Power delivered to load

```

1 //Example No. 3.17.3
2 clc;
3 clear;
4 close;
5 format('v',9);
6 f=3; //GHz
7 c=3*10^8; //m/s(Speed of light)
8 lambda=c/(f*10^9); //m(wavelength)
9 r=500; //m(distance)
10 PT=100; //W(Transmitted Power)
11 GT=25; //dB(Transmitter Gain)
12 GR=20; //dB(Reciever Gain)
13 GT=10^(GT/10); //unitless(Transmitter Gain)
14 GR=10^(GR/10); //unitless(Reciever Gain)
15 PLF=1; aT_aR=1; //(For polarization match)
16 PR=PT*(lambda/4/pi/r)^2*GT*GR*aT_aR^2; //Watts(Power
    delivered to reciever)
17 disp(PR,"Power delivered to load in Watts : ");

```

Chapter 4

Linear Wire Antennas

Scilab code Exa 4.2.1 Er Etheta and Hfi

```
1 //Example No. 4.2.1
2 clc;
3 clear;
4 close;
5 format('v',7);
6 l=5;//cm(length of antenna)
7 f=100;//MHz(operating frequency)
8 Io=120;//mA(Terminal current)
9 t=1;//s(time)
10 theta=45;//degree(Angle)
11 r=3;//m(radius)
12 c=3*10^8;//m/s////Speed of light
13 omega=2*%pi*f*10^6;//rad/sec(rotation)
14 k=omega/c;//rad/m(Phase constant)
15 kr=2*%pi*r/3;//degree(Phase constant)
16 Er=Io*10^-3*1*10^-2/(2*%pi*r^2)*cosd(theta)*120*%pi
    *[1+1/(%i*kr)]*exp(-%i*kr+%i*omega*t);//V/m(
    Electric field)
17 Er=Er*1000;//mV/m(Electric field)
18 Er_mag=abs(Er);//mV/m(magnitude of Er)
19 Er_angle=atand(imag(Er),real(Er));//degree(angle of
```

```

Er)
20 disp(Er_angle,Er_mag," Value of Er : magnitude(mV/m)
    and angle in degree : ");
21 Etheta=Io*10^-3*1*10^-2/(4*%pi*r)*sind(theta)*120*
    %pi*i*k*[1+1/(%i*kr)+1/(%i*kr)^2]*exp(-%i*kr+%i*
    omega*t); //V/m(Electric field)
22 Etheta_mag=abs(Etheta); //V/m(magnitude of Etheta)
23 Etheta_angle=atand(imag(Etheta),real(Etheta)); //
    degree(angle of Etheta)
24 disp(Etheta_angle,Etheta_mag," Value of Etheta :
    magnitude(V/m) and angle in degree : ");
25 Hfi=Io*10^-3*1*10^-2/(4*%pi*r)*sind(theta)*%i*k
    *[1+1/(%i*kr)]*exp(-%i*kr+%i*omega*t); //A/m(
    Magnetic field)
26 Hfi_mag=abs(Hfi); //A/m(magnitude of Hfi)
27 Hfi_angle=atand(imag(Hfi),real(Hfi)); //degree(angle
    of Hfi)
28 disp(Hfi_angle,Hfi_mag," Value of H : magnitude(A/m
    ) and angle in degree : ");
29 //Answer is not accurate in the book.

```

Scilab code Exa 4.5.1 Effective area

```

1 //Example No. 4.5.1
2 clc;
3 clear;
4 close;
5 format('v',6);
6 f=500; //MHz(Operating Frequency)
7 Do=1.643; //for half wave dipole
8 c=3*10^8; //m/s////Speed of light
9 lambda=c/(f*10^6); //m(Wavelength)
10 Aem=lambda^2/(4*%pi)*Do; //m (Effective area)
11 disp(Aem," Effective area in m : ");

```

Scilab code Exa 4.6.1 Current required

```
1 //Example No. 4.6.1
2 clc;
3 clear;
4 close;
5 format('v',6);
6
7 l=1; //m
8 Prad=4; //W
9 f=1.5; //MHz
10 c=3*10^8; //m/s////Speed of light
11 lambda=c/(f*10^6); //m
12 //here l/lambda<1/50 tells us it is a Hertzian
    monopole antenna
13 h=1; //m
14 Rr=40*%pi^2*(h/lambda)^2; // m
15 Io=sqrt(2*Prad/Rr); //A
16 disp(Io,"Current required in A : ");
```

Scilab code Exa 4.9.1 Power radiated

```
1 //Example No. 4.9.1
2 clc;
3 clear;
4 close;
5 format('v',6);
6
7 le=100; //m
8 Irms=450; //A
9 f=40000; //Hz
10 c=3*10^8; //m/s////Speed of light
```

```

11 lambda=c/f; //m
12 P=160*%pi^2*(le/lambda)^2*Irms^2; //mW
13 Rr=160*%pi^2*(le/lambda)^2; //
14 disp(P*10^-3,"Power radiated in W : ");
15 disp(Rr,"Radiation resistance in      : ");
16 //Answer wrong for radiation resistance in the book.

```

Scilab code Exa 4.9.2 Radiation resistance and power

```

1 //Example No. 4.9.2
2 clc;
3 clear;
4 close;
5 format('v',6);
6
7 le=61.4; //m
8 Irms=50; //A
9 lambda=625; //m
10 P=160*%pi^2*(le/lambda)^2*Irms^2; //kW
11 Rr=160*%pi^2*(le/lambda)^2; //
12 disp(P*10^-3,"Power radiated in kW : ");
13 disp(Rr,"Radiation resistance in      : ");

```

Scilab code Exa 4.9.3 Power radiated and efficiency

```

1 //Example No. 4.9.3
2 clc;
3 clear;
4 close;
5 format('v',5);
6 le=10; //m(effective length)
7 Irms=450; //A(rms current)
8 Rl=1.5; // (resistance)

```

```

9 f=50; //kHz(Operating frequency)
10 c=3*10^8; //m/s////Speed of light
11 lambda=c/(f*10^3); //m(Wavelength)
12 P=160*%pi^2*(le/lambda)^2*Irms^2; //kW(Power)
13 P=P*1000; //W(Power)
14 Rr=160*%pi^2*(le/lambda)^2; // (Radiation resistance
    )
15 Eta=Rr/(Rr+Rl)*100; //%(Efficiency)
16 disp(Eta,"Efficiency of antenna in % : ");

```

Scilab code Exa 4.9.4 Radiation Resistance

```

1 //Example No. 4.9.4
2 clc;
3 clear;
4 close;
5 format('v',6);
6 //l=lambda/8
7 lBYlambda=1/8; //(length/Wavelength)
8 Rr=80*%pi^2*(lBYlambda)^2; // (Radiation resistance)
9 disp(Rr,"Radiation resistance in : ");

```

Scilab code Exa 4.9.5 Radiation Resistance

```

1 //Example No. 4.9.5
2 clc;
3 clear;
4 close;
5 format('v',6);
6 L=1; //m(Length of element)
7 f=10; //MHz(Operating frequency)
8 c=3*10^8; //m/s////Speed of light
9 lambda=c/(f*10^6); //m(Wavelength)

```

```
10 Rr=80*%pi^2*(L/lambda)^2; // (Radiation resistance)
11 disp(Rr,"Radiation resistance in      : ");
```

Chapter 6

Antenna Arrays

Scilab code Exa 6.2.1 Relative field pattern

```
1 //Example No. 6.2.1
2 clc;
3 clear;
4 close;
5 format('v',5);
6 n=2; //(No. of point source)
7 //E=E0*{exp(%i*pi/2)-exp(-%i*si/2)} where exp(-%i*
    si)=-1
8 //si=Beta*d*cosd(fi)=2*pi*cosd(fi)
9 //E=2*i*E0*sind(%pi*cosd(fi)); But 2*i*E0=1
10 fi=[0 30 60 90 120 150 180 210 240 270 300 330]; //
    degree(angle)
11 En=sin(%pi*cosd(fi)); //Normalized field
12 disp("Different values of fi : ");
13 disp(string(fi));
14 disp("Corresponding normalized field is : ");
15 disp(string(abs(En)));
```

Scilab code Exa 6.2.2 Radiation patern

```

1 //Example No. 6.2.2
2 clc;
3 clear;
4 close;
5 format('v',5);
6 n=2; //(No. of point source)
7 //E=E0*{exp(i*(%pi/4+ si /2))-exp(-i*(%pi/4+ si /2))}
  as exp(i*theta)+exp(-i*theta)=2*cos(theta)
8 //E=2*E0*cos(%pi/4+ si /2);
9 // si=Beta*d*cosd(fi)=2*%pi*cosd(fi)
10 //En=cos(%pi/4+Beta*d*cosd(%pi/4)); But 2*E0=1
11 fi=[0 30 60 90 120 150 180 210 240 270 300 330]; //
  degree(angle)
12 En=cos(%pi/4+%pi/4*cosd(fi)); //Normalized field
13 disp("Different values of fi : ");
14 disp(string(fi));
15 disp("Corresponding normalized field is : ");
16 disp(string(abs(En)));

```

Scilab code Exa 6.2.3 Field pattern

```

1 //Example No. 6.2.3
2 clc;
3 clear;
4 close;
5 format('v',5);
6 //E=cos(fi)+sin(fi)<si;
7 //En=cos(%pi/4+%pi*cosd(fi)) as 2*E0=1
8 fi=[0 30 60 90 120 150 180 210 240 270 300 330]; //
  degree(Angle)
9 si=%pi/2*(cosd(fi)+1); //(Phase)
10 En=cos(%pi/4+%pi*cosd(fi)); //Normalized field
11 disp("Different values of fi : ");
12 disp(string(fi));
13 disp("Corresponding normalized field is : ");

```

```
14 disp(string(abs(En)));
15 //Answer in the book is wrong.
```

Scilab code Exa 6.6.1 Location of first null

```
1 //Example No. 6.6.1
2 clc;
3 clear;
4 close;
5 format('v',5);
6 n=80; //(no. of elements)
7 N=1; //for first null
8 //d=lambda/2;(spacing)
9 dBYlambda=1/2; //(spacing/wavelength)
10 fi01=acosd(N/n/dBYlambda); //degree(Angle)
11 Null_1st=(%pi/2*180/%pi)-fi01; //degree(First Null)
12 disp(Null_1st,"Location of 1st null from maxima in
    degree : ");
```

Scilab code Exa 6.6.2 Various parameters of isotropic array

```
1 //Example 6.6.2
2 clc;
3 clear;
4 close;
5 n=4; //(No. of elements)
6 //d=lambda/2;(Spacing)
7 dBYlambda=1/2; //(Spacing/wavelength)
8 alfa=0; //degree(angle)
9 N=1; //(For first null)
10 disp("Part (i)");
11 theta01=[acosd(+N/2) acosd(-N/2)]; //degree(Angle)
12 N=2; //(For second null)
```

```

13 theta02=[acosd(+N/2) acosd(-N/2)];//degree(angle)
14 //N=3;//not possible as N/2 is greater than 1
15 disp(theta01,"Null directions for N=1 : theta01(
    degree) ");
16 disp(theta02,"Null directions for N=2 : theta02(
    degree) ");
17 disp("Part (ii)");
18 m=0;//for maxima
19 theta_m=acosd(m/dBYlambda);//degree(angle)
20 disp(theta_m,"Direction of maxima : theta_m(degree)
    ");
21 disp("Part (iii)");
22 S=1;//for side lobe maxima
23 //S=2 & onwards not possible
24 theta_S=[acosd((2*S+1)/2/n/dBYlambda) acosd(-(2*S+1)
    /2/n/dBYlambda)];//degree(angle for side lobe)
25 disp(theta_S,"Side lobe maxima : theta_S(degree) ");
26 disp("Part (iv)");
27 HPBW=2*[90-acosd(1.391/%pi/n/dBYlambda)];//degree(
    HPBW)
28 disp(HPBW,"HPBW(degree) ");
29 disp("Part (v)");
30 FNBW=2*[90-acosd(1/n/dBYlambda)];//degree(FNBW)
31 disp(FNBW,"FNBW(degree) ");
32 disp("Part (vi)");
33 SLL=-13.46;//dB////for isotropic sources array(Side
    lobe level)
34 disp(SLL,"Side lobe level(dB) ");

```

Scilab code Exa 6.8.1 Ordinary endfire array

```

1 //Example No. 6.8.1
2 clc;
3 clear;
4 close;

```

```

5 format('v',5);
6 n=4; //(No. of elements)
7 //d=lambda/2;(spacing)
8 dBYlambda=1/2; //(spacing/wavelength)
9 theta=0; //degree(angle)
10 //Beta=2*pi/lambda
11 disp("Part (i)");
12 Beta_into_lambda=2*pi; //(Coefficient)
13 //alfa=-Beta*d
14 alfa=-Beta_into_lambda*dBYlambda; //radian(
    Progressive phase shift)
15 alfa=alfa*180/pi; //degree(Progressive phase shift)
16 disp(alfa,"Progressive phase shift(degree) ");
17 disp("Part (ii)");
18 N=1:3; //as N=4 is not allowed
19 theta01=acosd(1-N(1)/n/dBYlambda); //degree(angle)
20 theta02=acosd(1-N(2)/n/dBYlambda); //degree(angle)
21 theta03=acosd(1-N(3)/n/dBYlambda); //degree(angle)
22 disp(theta03,theta02,theta01,"Null directions ,
    theta01, theta02 & theta03 in degree are : ");
23 disp("Part (iii)");
24 m=0:1; //as m=2 & onwards is not allowed
25 theta0=acosd(1-m(1)/dBYlambda); //degree(angle)
26 theta1=acosd(1-m(2)/dBYlambda); //degree(angle)
27 disp(theta1,theta0,"Maxima directions , theta0 ,
    theta1 in degree are : ");
28 disp("Part (iv)");
29 FNBW=2*acosd(1-1/n/dBYlambda); //degree(FNBW)
30 disp(FNBW,"FNBW in degree : ");
31 disp("Part (v)");
32 HPBW=2*acosd(1-1.391/n/pi/dBYlambda); //degree(HPBW)
33 disp(HPBW,"HPBW in degree : ");

```

Scilab code Exa 6.8.2 Half Power Beam Width

```

1 //Example No. 6.8.2
2 clc;
3 clear;
4 close;
5 format('v',6);
6 n=16;//no. of point source
7 //d=lambda/4;(spacing)
8 dBYlambda=1/4;//(Spacing/wavelength)
9 HPBW=2*acosd(1-1.391/n/%pi/dBYlambda);//degree(HPBW)
10 disp(HPBW,"HPBW in degree : ");

```

Scilab code Exa 6.10.1 Find the Directivity

```

1 //Example No. 6.10.1
2 clc;
3 clear;
4 close;
5 format('v',6);
6 n=10;//no. of elements
7 //d=lambda/4;(spacing)
8 dBYlambda=1/4;//(Spacing/wavelength)
9 //Broadside array
10 D=2*n*dBYlambda;//unitless(Directivity)
11 D=10*log10(D);//dB(Directivity)
12 disp(D,"Directivity for broadside array in dB : ");
13 //Endfire array
14 D=4*n*dBYlambda;//unitless(Directivity)
15 D=10*log10(D);//dB(Directivity)
16 disp(D,"Directivity for Ordinary endfire array in dB
: ");

```

Scilab code Exa 6.10.2 Design ordinary endfire array

```

1 //Example No. 6.10.2
2 clc;
3 clear;
4 close;
5 format('v',6);
6 D=20; //dB(Directivity)
7 //d=lambda/4;(spacing)
8 dBYlambda=1/4; //(spacing/wavelength)
9 D=10^(D/10); //unitless(Directivity)
10 n=D/4/dBYlambda; //no. of elements
11 disp(n,"(i) No. of elements : ");
12 LBYlambda=(n-1)*dBYlambda; //(length/wavelength)
13 disp("(ii) Length of the array is "+string(LBYlambda
    )+"*lambda");
14 HPBW=2*acosd(1-1.391/%pi/n/dBYlambda); //degree(HPBW)
15 disp(HPBW,"(iii) HPBW in degree : ");
16 SLL=-13.46; //dB(Side lobe level)
17 disp(SLL,"(iv) SLL in dB : ");
18 Beta_into_lambda=2*%pi; //(temporary calculatuion)
19 //alfa=-Beta*d; //for theta=0
20 //alfa=Beta*d; //for theta=180
21 alfa1=-Beta_into_lambda*dBYlambda; //radian////for
    theta=0
22 alfa1=alfa1*180/%pi; //degree(angle)
23 alfa2=Beta_into_lambda*dBYlambda; //radian////for
    theta=180
24 alfa2=alfa2*180/%pi; //degree(angle)
25 disp(alfa2,alfa1,"(v) Progressive phase shift ,
    for theta equals to 0 & 180 are : ");

```

Scilab code Exa 6.14.1 Four Element broadside array

```

1 //Example No. 6.14.1
2 clc;
3 clear;

```

```

4 close;
5 format('v',6);
6 SLL=19.1; //dB(Side Lobe Level)
7 //d=lambda/2;(spacing)
8 dBYlambda=1/2; //(Spacing/wavelength)
9 n=4; //(no. of elements)
10 r=round(10^(SLL/20)); //(ratio of main lobe to side
    lobe)
11 m=n-1; //(degree )
12 //T3(x0)=r=4*x0^3-3*x0;
13 x0=roots([4 0 -3 -r]); //(Coefficient)
14 x0=x0(1); //taking real value(Coefficient)
15 //E4(z)=T3(x)=4*x^3-3*x=4*a1*z^3-3*a1*z+a0*z
16 //4*a1*z^3=4*x^3 where z^3=(x/x0)^3
17 a1=4*x0^3/4; //(Coefficient)
18 //a0*z-3*z*a1=-3*x
19 a0=(3/x0*a1-3)*x0; //(Coefficient)
20 disp(a0,a1,"Coefficients of array polynomial a1 & a0
    are : ");
21 disp(a0/a1,a1/a1,"Relative current amplitudes are :")
    );

```

Chapter 7

Loop Antenna

Scilab code Exa 7.10.1 Input Voltage

```
1 //Example No. 7.10.1
2 clc;
3 clear;
4 close;
5 format('v',6);
6 A=1;//m (Area of loop)
7 N=400;//no. of turns
8 Q=100;//Quality factor
9 theta=60;//degree(angle)
10 Erms=10;// V /m(field strength)
11 f=1;//MHz(tuned frequency)
12 c=3*10^8;//m/s////Speed of light
13 lambda=c/(f*10^6);//m(Wavelength)
14 Vr=Q*2*%pi*A*N*cosd(theta)*Erms*10^-6/lambda;//V(
    reciever input voltage)
15 disp(Vr*1000,"Input voltage to the receiver in mV :
    ");
```

Scilab code Exa 7.10.2 Voltage induced in lop

```

1 //Example No. 7.10.2
2 clc;
3 clear;
4 close;
5 format('v',7);
6 N=12;//no. of turns
7 A=1;// m (Area of loop)
8 Erms=100;// V /m(field strength)
9 f=10;//MHz(tuned frequency)
10 theta=0;//degree(angle)
11 c=3*10^8;//m/s////Speed of light
12 lambda=c/(f*10^6);//m(Wavelength)
13 Vr=2*%pi*A*N*cosd(theta)*Erms*10^-6/lambda;//V(
    reciever input voltage)
14 disp(Vr*10^6,"Voltage induced in loop in V /m : ");

```

Scilab code Exa 7.10.3 Find the field strength

```

1 //Example No. 7.10.3
2 clc;
3 clear;
4 close;
5 format('v',6);
6 N=25;//no. of turns
7 Vrms=150;// V (emf induced)
8 f=500;//kHz(tuned frequency)
9 A=0.5^2;// m (Area of loop)
10 theta=0;//degree(angle)
11 c=3*10^8;//m/s////Speed of light
12 lambda=c/(f*10^3);//m(Wavelength)
13 Erms=lambda/(2*%pi*A*N*cosd(theta))*Vrms*10^-6;//V/m
    (maximum emf induced)
14 disp(Erms*10^3,"Field strength in mV/m : ");

```

Scilab code Exa 7.10.4 Radiation Resistance

```
1 //Example No. 7.10.4
2 clc;
3 clear;
4 close;
5 format('v',7);
6 N1=1;//no. of turns in primary
7 N2=8;//no. of turns in secondary
8 //a=lambda/25;
9 aBYlambda=1/25;//(temporary calculation)
10 //A=%pi*a^2
11 A_BY_lambda_sqr=%pi*aBYlambda^2;//(temporary
    calculation)
12 Rr1=31200*(N1*A_BY_lambda_sqr)^2;// (Radiation
    resistance for single turn)
13 disp(Rr1,"Radiation resistance for single turn loop
    in : ");
14 Rr2=31200*(N2*A_BY_lambda_sqr)^2;// (Radiation
    resistance for 8 turn)
15 disp(Rr2,"Radiation resistance for 8 turn loop in
    : ");
```

Scilab code Exa 7.10.5 Radiation Efficiency

```
1 //Example No. 7.10.5
2 clc;
3 clear;
4 close;
5 format('v',6);
6 f=100;//MHz(Operating frequency)
7 c=3*10^8;//m/s////Speed of light
```

```

8 lambda=c/(f*10^6); //m(Wavelength)
9 a=lambda/25; //m(radius)
10 C=2*%pi*a; //m(Circumference)
11 d=2*10^-4*lambda; //m(Spacing)
12 disp("For single turn : ");
13 N=1; //n. of turns
14 RL_BY_Rr=3430/(C^3*f^(3.5)*N*d); //(temporary
    calculation)
15 K=1/(1+RL_BY_Rr)*100; //%(Radiation efficiency)
16 disp(K,"Radiation efficiency of single turn in % : ")
    );
17 disp("For Eight turn : ");
18 N=8; //no. of turns
19 RL_BY_Rr=3430/(C^3*f^(3.5)*N*d); //(temporary
    calculation)
20 K=1/(1+RL_BY_Rr)*100; //%(Radiation efficiency)
21 disp(K,"Radiation efficiency of eight turn in % : ")
    ;

```

Scilab code Exa 7.10.6 Directivity

```

1 //Example No. 7.10.6
2 clc;
3 clear;
4 close;
5 format('v',6);
6 a=0.5; //m(radius)
7 f=0.9; //MHz(OPERating frequency)
8 c=3*10^8; //m/s////Speed of light
9 lambda=c/(f*10^6); //m(wavelength)
10 C=2*%pi*a; //m(Circumference)
11 if C/lambda<1/3 then
12     D=3/2; //Directivity
13 elseif C/lambda>1/3 then
14     D=0.682*C/lambda; //Directivity

```

```
15 end
16 disp(D," Directivity : ");
```

Chapter 8

Slot Antenna

Scilab code Exa 8.3.1 Input Impedence

```
1 //Example No. 8.3.1
2 clc;
3 clear;
4 close;
5 format('v',7);
6 Zcs=73+%i*42.5; // (Impedence of complementary
   structure)
7 Eta=120*%pi; //(Constant for free space)
8 ZS=Eta^2/4/Zcs; // (Input Impedence)
9 disp(ZS,"Input impedance in      : ");
10 //At resonance
11 Zcs=73; // (Impedence of complementary structure)
12 Eta=120*%pi; //(Constant for free space)
13 ZS=Eta^2/4/Zcs; // (Input Impedence)
14 disp(ZS,"At resonance , Input impedance in      : ");
15 disp("ZS can be rounded to 500      ");
```

Chapter 9

Horn Antenna

Scilab code Exa 9.6.1 Capture Area

```
1 //Example No. 9.6.1
2 clc;
3 clear;
4 close;
5 format('v',7);
6 f=2; //GHz(Frequency)
7 G=12; //dBi(Gain)
8 D=12; //dBi(Gain)
9 D=10^(D/10); //unitless(Directivity)
10 c=3*10^8; //m/s(speed of light)
11 lambda=c/(f*10^9); //m(wavelength)
12 Ap=D*lambda^2/7.5; //m (capture area)
13 disp(Ap,"Required capture area in m : ");
```

Scilab code Exa 9.6.2 Various parameters of horn

```
1 //Example No. 9.6.2
2 clc;
```

```

3 clear;
4 close;
5 format('v',7);
6 aEBylambda=10; //(Aperture/wavelength)
7 del_EBylambda=0.2; //in E-plane
8 del_HBylambda=0.375; //in H-plane
9 LBylambda=aEBylambda^2/8/del_EBylambda; //(Length/
    wavelength)
10 disp("Length of the horn is "+string(LBylambda)+"*
    lambda");
11 aHBylambda=sqrt(LBylambda*8*del_HBylambda); //(
    Aperture/wavelength)
12 disp("H-plane aperture, aH is "+string(aHBylambda)+"
    *lambda");
13 theta_E=2*atand(aEBylambda/2/LBylambda); //degree(
    Angle)
14 theta_H=2*atand(aHBylambda/2/LBylambda); //degree(
    Angle)
15 disp(theta_H,theta_E,"Flare angles theta_E & theta_H
    (in degree) are : ");
16 HPBW_E=56/aEBylambda; //degree(HPBW for E-plane)
17 disp(HPBW_E,"HPBW(E-plane) in degree : ");
18 HPBW_H=67/aHBylambda; //degree(HPBW for H-plane)
19 disp(HPBW_H,"HPBW(H-plane) in degree : ");
20 FNBW_E=102/aEBylambda; //degree(FNBW for E-plane)
21 disp(FNBW_E,"FNBW(E-plane) in degree : ");
22 FNBW_H=172/aHBylambda; //degree(FNBW for F-plane)
23 disp(FNBW_H,"FNBW(H-plane) in degree : ");
24 D=10*log10(7.5*aEBylambda*aHBylambda); //(Directivity
    )
25 disp(D,"Directivity in dB : ");

```

Chapter 10

Broadband and frequency independent antenna

Scilab code Exa 10.5.1 Five turn helical antenna

```
1 //Example No. 10.5.1
2 clc;
3 clear;
4 close;
5 format('v',6);
6 N=5;//no. of turns
7 f=400;//MHz(Frequency)
8 c=3*10^8;//m/s(Speed of light)
9 lambda=c/(f*10^6);//m(Wavelength)
10 disp("Part (i)");
11 S=lambda/50;//m(Spacing between turns)
12 S_BY_lambda=1/50;//(Spacing/wavelength)
13 C_BY_lambda=sqrt(2*S_BY_lambda);//(Circumference/
    wavelength)
14 disp("Circumference is "+string(C_BY_lambda)+"*
    lambda");
15 C=sqrt(2*lambda*S);//m(Circumference)
16 disp(C,"Circumference in meter : ");
17 disp("Part (ii)");
```

```

18 Lo_BY_lambda=sqrt(S_BY_lambda^2+C_BY_lambda^2);//(
    Length/wavelength)
19 disp("Length of single turn is "+string(Lo_BY_lambda
    )+"*lambda");
20 Lo=sqrt(S^2+C^2);//m(Length of single turn)
21 disp(Lo,"Length of single turn in meter : ");
22 disp("Part (iii)");
23 Ln_BY_lambda=N*Lo_BY_lambda; //(Overall length/
    wavelength)
24 disp("Overall Length is "+string(Ln_BY_lambda)+"*
    lambda");
25 Ln=N*Lo; //m(Overall length)
26 disp(Ln,"Overall Length in meter : ");
27 disp("Part (iv)");
28 alfa=atand(S/C); //degree(Pitch angle)
29 disp(alfa,"Pitch angle ,      in degree : ");

```

Scilab code Exa 10.5.2 Five turn helical antenna

```

1 //Example No. 10.5.2
2 clc;
3 clear;
4 close;
5 format('v',6);
6 N=5; //no. of turns
7 f=300; //MHz(Frequency)
8 c=3*10^8; //m/s(speed of light)
9 disp("Part (i)");
10 lambda=c/(f*10^6); //m(Wavelength)
11 C_BY_lambda=1; //(Circumference/wavelength)
12 disp("Near optimum circumference is "+string(
    C_BY_lambda)+"*lambda");
13 C=lambda; //m(Circumference)
14 disp(C,"Near optimum circumference in meter : ");
15 disp("Part (ii)");

```

```

16 alfa=14;//degree//(Pitch angle)//for near optimum
17 S_BY_lambda=C_BY_lambda*tand(alfa);
18 disp("Spacing is "+string(S_BY_lambda)+"*lambda");
19 S=C*tand(alfa);//m(Spacing)
20 disp(S,"Spacing in meter : ");
21 disp("Part (iii)");
22 Rin=140*C/lambda;// (Input impedance)
23 disp(Rin,"Input impedance in : ");
24 disp("Part (iv)");
25 HPBW=52/(C/lambda*sqrt(N*S/lambda));//degree(HPBW)
26 disp(HPBW,"HPBW in degree : ");
27 disp("Part (v)");
28 FNBW=115/(C/lambda*sqrt(N*S/lambda));//degree(FNBW)
29 disp(FNBW,"FNBW in degree : ");
30 disp("Part (vi)");
31 Do=15*(C/lambda)^2*N*(S/lambda);//unitless/////
    Directivity
32 disp(Do,"Directivity(unitless) : ");
33 Do_dB=10*log10(Do);//dB(Directivity)
34 disp(Do_dB,"Directivity in dB : ");
35 disp("Part (vii)");
36 AR=(2*N+1)/2/N;//axial ratio
37 disp(AR,"Axial ratio : ");
38 disp("Part (viii)");
39 Rin=140*(C/lambda);// (Input impedance)
40 //50 line
41 Zo=50;// (Output impedance)
42 Tau=(Rin-Zo)/(Rin+Zo);//Scaling factor
43 VSWR=(1+Tau)/(1-Tau);//(VSWR)
44 disp(VSWR,"VSWR for 50 line : ");
45 //75 line
46 Zo=75;// (Output impedance)
47 Tau=(Rin-Zo)/(Rin+Zo);//Scaling factor
48 VSWR=(1+Tau)/(1-Tau);//(VSWR)
49 disp(VSWR,"VSWR for 75 line : ");

```

Scilab code Exa 10.5.3 Various parameters of helix array

```
1 //Example No. 10.5.3
2 clc;
3 clear;
4 close;
5 format('v',6);
6 HPBW=39; //degree(HPBW)
7 alfa=12.5; //degree(Pitch angle)
8 f=475; //MHz(Frequency)
9 c=3*10^8; //m/s(Speed of light)
10 lambda=c/(f*10^6); //m(Wavelength)
11 C=lambda; //m(Circumference)
12 disp("Part (i)");
13 //it is in axial mode as  $3/4*\lambda < C < 4/3*\lambda$ 
14 S=C*tand(alfa); //meter(Spacing)
15 N=52^2/HPBW^2/(S/lambda)/(C/lambda)^2; //turns
16 disp(round(N),"Number of turns : ");
17 disp("Part (ii)");
18 N=round(N); //turns
19 Do=15*(C/lambda)^2*N*(S/lambda); //unitless(
    Directivity)
20 Do_dB=10*log10(Do); //dB(Directivity)
21 disp(Do_dB,"Directivity in decibels : ");
22 disp("Part (iii)");
23 AR=(2*N+1)/2/N; //axial ratio
24 disp(AR,"Axial ratio : ");
25 disp("Part (iv)");
26 //  $3/4*\lambda < C < 4/3*\lambda$ 
27 lambda1=C/(3/4); //meter(Wavelength)
28 lambda2=C/(4/3); //meter(Wavelength)
29 f1=c/lambda1; //Hz(Frequency)
30 f2=c/lambda2; //Hz(Frequency)
31 disp("Frequency range is "+string(f1/10^6)+" MHz to
```

```

    "+string(f2/10^6)+" MHz.")
32 disp(" Part (v)");
33 //At design frequency
34 Rin=140*C/lambda;// (Input impedance)
35 disp(Rin,"At design frequency , Input impedance in
    is : ");
36 //3/4*lambda<C<4/3*lambda
37 //At high frequency end
38 Rin=140*C/lambda2;// (Input impedance)
39 disp(Rin,"At high frequency end, Input impedance in
    is : ");
40 //At low frequency end
41 Rin=140*C/lambda1;// (Input impedance)
42 disp(Rin,"At low frequency end, Input impedance in
    is : ");

```

Scilab code Exa 10.5.4 Input Impedance HPBW and Axial ratio

```

1 //Example No. 10.5.4
2 clc;
3 clear;
4 close;
5 format('v',6);
6 Do_dB=14;//dB(Directivity)
7 f=2.4;//GHz(Frequency)
8 c=3*10^8;//m/s(Speed of light)
9 lambda=c/(f*10^6);//m(Wavelength)
10 Do=10^(Do_dB/10);//unitless(Directivity)
11 C=lambda;//m////for optimum result(Circumference)
12 alfa=14;//degree/////for optimum result(Pitch angle)
13 S=C*tand(alfa);//m(Spacing)
14 N=Do/15/(C/lambda)^2/(S/lambda);//turns
15 N=round(N);//turns
16 Rin=140*C/lambda;// (Input impedance)
17 disp(Rin,"Input impedance in is : ");

```

```

18 HPBW=52/(C/lambda*sqrt(N*S/lambda)); //degree
19 disp(HPBW,"HPBW in degree : ");
20 format('v',4);
21 FNBW=115/(C/lambda*sqrt(N*S/lambda)); //degree
22 disp(FNBW,"FNBW in degree : ");
23 AR=(2*N+1)/2/N; //(Axial ratio)
24 disp(AR," Axial ratio : ");

```

Scilab code Exa 10.8.1 Symmetrical two wire spiral

```

1 //Example No. 10.8.1
2 clc;
3 clear;
4 close;
5 format('v',8);
6 f=10; //MHz(Frequency)
7 c=3*10^8; //m/s(Speed of light)
8 lambda=c/(f*10^6); //m(Wavelength)
9 d0=10^-3*lambda; //m(spacing)
10 Lo=1*lambda; //m(Length)
11 fi=%pi; fi0=0; //radian
12 r0=d0/2; //m
13 disp("Part (i)");
14 //R=r0*exp(a*fi-a*fi0); //m
15 //a=sqrt(1/Lo^2/(R-r0)^2-1); //per adian
16 a=1.166; //rad^-1(by above equation)
17 disp(a,"Rate of spiral in rad^-1 : ");
18 R_BY_lambda=r0/lambda*exp(a*2*%pi); //m(Radius/
    wavelength)
19 disp("Radius of terminal point is "+string(
    R_BY_lambda)+"*lambda");
20 disp("Part (ii)");
21 R=r0*exp(a*2*%pi); //m(Radius)
22 disp(R,"Radius at terminal point in meter : ");

```

Scilab code Exa 10.8.2 Design Equiangular spiral Antena

```
1 //Example No. 10.8.2
2 clc;
3 clear;
4 close;
5 format('v',5);
6 fU=900;//MHz(Upper frequency)
7 fL=450;//MHz(Lower frequency)
8 c=3*10^8;//m/s(Speed of light)
9 lambdaU=c/(fU*10^6);//m(Upper wavelength)
10 lambdaL=c/(fL*10^6);//m(Lower wavelength)
11 Exp_ratio=4;//expansion ratio
12 a=log(Exp_ratio)/(2*%pi);//rad^-1////rate of spiral
13 Beta=atand(1/a);//degree
14 r0=lambdaU/4;//meter////minimum radius
15 disp(r0*100,"Minimum radius in cm : ");
16 R=lambdaL/4;//meter////minimum radius
17 disp(R*100,"Maximum radius in cm : ");
18 fi_m=log(R/r0)/a;//radian
19 fi_m=fi_m*180/%pi;//degree
20 disp(fi_m," m in degree is ");
21 N=1/2;//for m =180;//degree
22 disp(N,"Number of turns , N is ");
```

Scilab code Exa 10.10.1 Elements length and spacing

```
1 //Example No. 10.10.1
2 clc;
3 clear;
4 close;
5 format('v',7);
```

```

6 Gain=8.5; //dB(Gain)
7 tau=0.822; sigma=0.149; //for given gain
8 alfa=2*atand((1-tau)/4/sigma); //degree
9 fL=54; //MHz(Lower frequency)
10 fU=216; //MHz(Upper frequency)
11 c=3*10^8; //m/s(Speed of light)
12 lambdaU=c/(fU*10^6); //m(Upper wavelength)
13 lambdaL=c/(fL*10^6); //m(Lower wavelength)
14 l1=lambdaU/2; //m(Length of element1)
15 lN=lambdaL/2; //m(Length of longest element)
16 l2=l1/tau; l3=l2/tau; l4=l3/tau; l5=l4/tau; l6=l5/tau; l7
    =l6/tau; l8=l7/tau; l9=l8/tau; //m(Length of
    elements)
17 d1=2*sigma*l1; d2=2*sigma*l2; d3=2*sigma*l3; d4=2*sigma
    *l4; d5=2*sigma*l5; d6=2*sigma*l6; d7=2*sigma*l7; d8
    =2*sigma*l8; d9=2*sigma*l9; //meter(Spacing between
    elements)
18 d=d1+d2+d3+d4+d5+d6+d7+d8+d9; //meter(total spacing)
19 disp(lN,"Length(m) of longest element : ");
20 disp(l1,"Length(m) of element1 : ");
21 disp(l2,"Length(m) of element2 : ");
22 disp(l3,"Length(m) of element3 : ");
23 disp(l4,"Length(m) of element4 : ");
24 disp(l5,"Length(m) of element5 : ");
25 disp(l6,"Length(m) of element6 : ");
26 disp(l7,"Length(m) of element7 : ");
27 disp(l8,"Length(m) of element8 : ");
28 disp(l9,"Length(m) of element9 : ");
29 disp(d1,"Spacing(m) of element1 : ");
30 disp(d2,"Spacing(m) of element2 : ");
31 disp(d3,"Spacing(m) of element3 : ");
32 disp(d4,"Spacing(m) of element4 : ");
33 disp(d5,"Spacing(m) of element5 : ");
34 disp(d6,"Spacing(m) of element6 : ");
35 disp(d7,"Spacing(m) of element7 : ");
36 disp(d8,"Spacing(m) of element8 : ");
37 disp(d9,"Spacing(m) of element9 : ");
38 disp(d,"Total Spacing length(m) : ");

```


39 //Answer is not accurate in the book.

Scilab code Exa 10.10.2 Design a log periodic dipole

```
1 //Example No. 10.10.2
2 clc;
3 clear;
4 close;
5 format('v',7);
6 tau=0.895;//scale factor
7 sigma=0.166;//(spacing factor)
8 fU=30;//MHz(Upper frequency)
9 fL=10;//MHz(Lower frequency)
10 c=3*10^8;//m/s(Speed of light)
11 lambdaU=c/(fU*10^6);//m(Upper wavelength)
12 lambdaL=c/(fL*10^6);//m(Lower wavelength)
13 l1=lambdaU/2;//m(Length of shortest element)
14 disp(l1,"Length of shortest element, l1 in meter is
      : ");
15 l2=l1/tau;l3=l2/tau;l4=l3/tau;l4=l3/tau;l5=l4/tau;l6
      =l5/tau;l7=l6/tau;l8=l7/tau;l9=l8/tau;l10=l9/tau;
      l11=l10/tau;//m(Length of element)
16 disp(l11,l10,l9,l8,l7,l6,l5,l4,l3,l2,"Other elements
      length(m) l2 , l3 , l4 , l5 , l6 , l7 , l8 , l9 , l10 ,
      l11 are : ");
17 alfa=17.97;//degree(angle)
18 R1=(l1/2)/tand(alfa/2);//m(Spacing between elements)
19 R2=R1/tau;R3=R2/tau;R4=R3/tau;R4=R3/tau;R5=R4/tau;R6
      =R5/tau;R7=R6/tau;R8=R7/tau;R9=R8/tau;R10=R9/tau;
      R11=R10/tau;//m
20 disp(R11,R10,R9,R8,R7,R6,R5,R4,R3,R2,R1,"Spacing
      between elements in meter R1, R2, R3, R4, R5, R6,
      R7, R8,R9, R10, R11 are : ");
21 //Answer is not accurate in the book.
```

Chapter 11

Microstrip Antennas

Scilab code Exa 11.9.1 Determine physical dimensions

```
1 //Example No. 11.9.1
2 clc;
3 clear;
4 close;
5 format('v',7);
6 fr=10;//GHz(center frequency)
7 fr=fr*10^9;//Hz(center frequency)
8 epsilon_r=10.2;//(constant)
9 h=0.127;//cm(height of sustrate)
10 c=3*10^10;//cm/s(Speed of light)
11 W=c/2/fr*sqrt(2/(epsilon_r+1));//cm(Physical
    dimension)
12 epsilon_reff=(epsilon_r+1)/2+(epsilon_r-1)/2*[1+12*h
    /W]^(-1/2);//(effective constant)
13 delta_L=h*0.412*(epsilon_reff+0.3)*(W/h+0.264)/[(
    epsilon_reff-0.258)*(W/h+0.8)];//cm(distance)
14 L=c/2/fr/sqrt(epsilon_reff)-2*delta_L;//cm(distance)
15 disp(L,W,"Design values of W & L(in cm) are : ");
```

Chapter 12

Reflector Antennas

Scilab code Exa 12.9.1 First null beam width and power gain

```
1 //Example No. 12.9.1
2 clc;
3 clear;
4 close;
5 format('v',6);
6 D=2; //m(Diameter)
7 f=6000; //MHz(Frequency)
8 c=3*10^8; //m/s////speed of light
9 lambda=c/(f*10^6); //m(Wavelength)
10 FNBW=140*lambda/D; //degree
11 disp(FNBW,"First null beam width(FNBW in degree) : ")
12 );
13 GP=6*(D/lambda)^2; //unitless(Power gain)
14 GP_dB=10*log10(GP); //dB(Power gain)
15 disp(GP_dB,"Power Gain in dB : ");
16 //Ans in the book is not accurate.
```

Scilab code Exa 12.9.2 Diameter of mouth and HPBW

```

1 //Example No. 12.9.2
2 clc;
3 clear;
4 close;
5 format('v',5);
6 GP=1000;//unitless(Power gain)
7 lambda=10;//cm(Wavelength)
8 D=sqrt(GP/6)*(lambda/100);//m(Diameter)
9 disp(D,"Diameter of mouth in meter : ");
10 HPBW=58*(lambda/100)/D;//degree(HPBW)
11 disp(HPBW,"Half power beam width(HPBW in degree) : ")
    );

```

Scilab code Exa 12.9.3 Gain Beamwidth and capture area

```

1 //Example No. 12.9.3
2 clc;
3 clear;
4 close;
5 format('v',6);
6 D=6;//meter(Diameter)
7 f=10;//GHz(Frequency)
8 c=3*10^8;//m/s////speed of light
9 lambda=c/(f*10^9);//m(Wavelength)
10 GP=6*(D/lambda)^2;//unitless(Power gain)
11 GP_dB=10*log10(GP);//dB(Power gain)
12 disp(GP_dB,"Gain in dB : ");
13 FNBW=140*lambda/D;//degree(FNBW)
14 disp(FNBW,"FNBW in degree : ");
15 HPBW=58*lambda/D;//degree(HPBW)
16 disp(HPBW,"HPBW in degree : ");
17 K=0.65;//constant
18 Ao=K*pi/4*D^2;// m (Capture area)
19 disp(Ao,"Capture area in m : ");

```

Chapter 13

Antenna Measurement

Scilab code Exa 13.4.1 Gains of Antennas

```
1 //Example No. 13.4.1
2 clc;
3 clear;
4 close;
5 format('v',7);
6 Pr1=0.0297/1000; //W(Recieved power)
7 Pr2=0.0471/1000; //W(Recieved power)
8 Pr3=0.0374/1000; //W(Recieved power)
9 Pt=1; //W(Transmitted power)
10 R=10; //m(Radius)
11 f=980; //MHz(Frequency)
12 f=f*10^6; //Hz(Frequency)
13 c=3*10^8; //m/s(Speed of light)
14 lambda=c/f; //m(Wavelength)
15 A=20*log10(4*%pi*R/lambda)+10*log10(Pr1/Pt); //(A=
    G1dB+G2dB)
16 B=20*log10(4*%pi*R/lambda)+10*log10(Pr2/Pt); //(B=
    G1dB+G3dB)
17 C=20*log10(4*%pi*R/lambda)+10*log10(Pr3/Pt); //(C=
    G2dB+G3dB)
18 G1dB=(A+B-C)/2;
```

```
19 G2dB=(A-B+C)/2;
20 G3dB=(-A+B+C)/2;
21 disp(round(G3dB),round(G2dB),round(G1dB),"Gain of
    antennas , G1db, G2dB & G3dB(in dB) are : ");
```

Chapter 14

Ground Wave Propagation

Scilab code Exa 14.6.1 Loss and power received

```
1 //Example No. 14.6.1
2 clc;
3 clear;
4 close;
5 format('v',7);
6 d=36000;//km(height of satellite)
7 f=4000;//MHz(frequency)
8 GT=20;//dB(Transmitter gain)
9 GR=40;//dB(Receiver gain)
10 PT=200;//W(Transmitted power)
11 PT_dB=10*log10(PT);//dB(Transmitted power)
12 disp("Part (i)");
13 Ls=32.44+20*log10(f)+20*log10(d);//dB(Free space
    transmission loss)
14 disp(Ls,"Free space transmission loss in dB : ");
15 disp("Part (ii)");
16 PT=200;//W(Transmitted power)
17 PT_dB=10*log10(PT);//dB(Transmitted power)
18 PR_dB=PT_dB+GT+GR-Ls;//dB(Received power)
19 PR=10^(PR_dB/10);//W(Received power)
20 disp(PR*10^12,"Received power in pW : ");
```

Scilab code Exa 14.6.2 Open circuit voltage

```
1 //Example No. 14.6.2
2 clc;
3 clear;
4 close;
5 format('v',7);
6 f=150; //MHz(frequency)
7 c=3*10^8; //m/s(speed of light)
8 GT=1.64; //dB(Transmitter gain)
9 PT=20; //W(Transmitted power)
10 d=50; //km(distance)
11 lambda=c/(f*10^6); //m(Wavelength)
12 E=sqrt(30*GT*PT)/(d*1000); //V/m(emf induced)
13 le=lambda/%pi; //m(Effective length)
14 Voc=E*le; //V/m(Open circuit voltage)
15 disp(Voc*10^6,"Open circuit voltage in micro Volt :
    ");
```

Scilab code Exa 14.10.1 Calculate the range

```
1 //Example No. 14.10.1
2 clc;
3 clear;
4 close;
5 format('v',7);
6 ht=100; //m(transmitter height)
7 hr=100; //m(receiver height)
8 d=3.57*[sqrt(ht)+sqrt(hr)]; //km(Range)
9 disp(d,"Range of space wave propagation in km : ");
```

Scilab code Exa 14.10.2 Radio horizon

```
1 //Example No. 14.10.2
2 clc;
3 clear;
4 close;
5 format('v',6);
6 ht=100;//feet(transmitter height)
7 hr=50;//feet(receiver height)
8 d=1.4142*[sqrt(ht)+sqrt(hr)]; //miles(Range)
9 disp(d,"Radio horizon in miles : ");
```

Scilab code Exa 14.10.3 Maximum covered distance

```
1 //Example No. 14.10.3
2 clc;
3 clear;
4 close;
5 format('v',6);
6 ht=80;//m(transmitter height)
7 hr=50;//m(receiver height)
8 d=4.12*[sqrt(ht)+sqrt(hr)]; //km(Range)
9 disp(d,"Maximum distance in km : ");
```

Scilab code Exa 14.10.4 Required height of antenna

```
1 //Example No. 14.10.4
2 clc;
3 clear;
```

```

4 close;
5 format('v',6);
6 ht=100;//m(transmitter height)
7 d=80;//km(receiver height)
8 hr=(d/4.12-sqrt(ht))^2;//m(range)
9 disp(hr,"Required height of receiving antenna in
meter : ");

```

Scilab code Exa 14.10.5 Radio horizon distance

```

1 //Example No. 14.10.5
2 clc;
3 clear;
4 close;
5 format('v',6);
6 ht=100;//m(transmitter height)
7 d=4.12*sqrt(ht);//km(Horizon distance)
8 disp(d,"Horizon distance in km : ");

```

Scilab code Exa 14.10.6 Find Distance and field strength

```

1 //Example No. 14.10.6
2 clc;
3 clear;
4 close;
5 format('v',6);
6 P=35;//W(Transmitter power)
7 ht=45;//m(transmitter height)
8 hr=25;//m(receiver height)
9 f=90;//MHz(frequency)
10 c=3*10^8;//m/s(Speed of light)
11 d=4.12*[sqrt(ht)+sqrt(hr)];//km(line of sight
distance)

```

```
12 disp(d," Distance of line of sight communication in
    km : ");
13 lambda=c/(f*10^6); //m(Wavelength)
14 ER=88*sqrt(P)*ht*hr/(lambda*(d*1000)^2); //V/m(Field
    strength)
15 disp(ER*10^6," Field strength in micro Volt/meter : ")
    );
16 //Answer is wrong in the textbook.
```

Chapter 15

Ionospheric Propagation

Scilab code Exa 15.8.1 Maximum electron density

```
1 //Example No. 15.8.1
2 clc;
3 clear;
4 close;
5 format('v',11);
6 fc_E=2.5; //MHz(critical frequency of E-layer)
7 fc_F=8.4; //MHz(critical frequency of F-layer)
8 disp("For E-layer : ");
9 Nm=(fc_E*10^6)^2/81; //per m^3(Maximum electron
    density)
10 disp(Nm,"Maximum electron density in per m^3 : ");
11 disp("For F-layer : ");
12 Nm=(fc_F*10^6)^2/81; //per m^3(Maximum electron
    density)
13 disp(Nm,"Maximum electron density in per m^3 : ");
```

Scilab code Exa 15.8.2 Critical Frequency

```

1 //Example No. 15.8.2
2 clc;
3 clear;
4 close;
5 format('v',6);
6 Nm_D=400; //electron/cm^3(Maximum electron density)
7 Nm_E=5*10^5; //electron/cm^3(Maximum electron density
8 Nm_F=2*10^6; //electron/cm^3(Maximum electron density
9 fc_D=9*sqrt(Nm_D); //kHz(critical frequency of D-
10 disp(fc_D,"Critical frequency for D-layer in kHz : ")
11 fc_E=9*sqrt(Nm_E); //kHz(critical frequency of E-
12 disp(fc_E/1000,"Critical frequency for E-layer in
13 fc_F=9*sqrt(Nm_F); //kHz(critical frequency of F-
14 disp(fc_F/1000,"Critical frequency for F-layer in

```

Scilab code Exa 15.8.3 Calculate frequency

```

1 //Example No. 15.8.3
2 clc;
3 clear;
4 close;
5 format('v',7);
6 Eta=0.5; //(refractive index)
7 N=400; //electron/cm^3(Electron density)
8 f=sqrt(81*N/(1-Eta^2)); //kHz(frequency)
9 disp(f,"Frequency in kHz : ");

```

Scilab code Exa 15.9.1 Find the virtual height

```
1 //Example No. 15.9.1
2 clc;
3 clear;
4 close;
5 format('v',7);
6 T=5; //milli-seconds(time period)
7 c=3*10^8; //m/s///speed of light
8 H=1/2*c*T*10^-3; //m(Virtual height)
9 disp(H/1000,"Virtual height in km : ");
```

Scilab code Exa 15.12.1 Calculate MUF

```
1 //Example No. 15.12.1
2 clc;
3 clear;
4 close;
5 format('v',7);
6
7 d=2000; //km
8 H=200; //km
9 fc=6; //MHz
10 f_MUF=fc*sqrt(1+(d/2/H)^2); //MHz
11 disp(f_MUF,"MUF in MHz : ");
```

Scilab code Exa 15.13.1 Calculate the range

```
1 //Example No. 15.13.1
```

```
2  clc;
3  clear;
4  close;
5  format('v',8);
6
7  Eta=0.9; //refractive index
8  f_MUF=10; //MHz
9  H=400; //km
10 Nm=(1-Eta^2)*(f_MUF*10^6)^2/81; //per m^3
11 fc=9*sqrt(Nm); //Hz
12 Dskip=2*H*sqrt((f_MUF*10^6/fc)^2-1); //km
13 disp(Dskip,"Skip distance or range in km : ");
```
