Scilab Textbook Companion for Antenna and Wave Propagation by A. K. Gautam[1]

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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

Eletromagnetic Field Radiation

Scilab code Exa 1.1 What is the strength of a magnetic field H in free space

```
1 //Ex:1.1
2 clc;
3 clear;
4 close;
5 E=2;// electriv field strength in V/m
6 n=120*%pi;
7 H=E/n;// strength of a magnetic field H
8 printf("The strength of a magnetic field H = %f mA/
      meter", H*10^3);
```

Scilab code Exa 1.2 Find out the field strength

```
1 //Ex:1.2
2 clc;
```

```
3  clear ;
4  close ;
5  W =625*10^3; // power in W
6  r =30*10^3; // in m
7  Erms =( sqrt (90*W))/r; // the field strength in V/m
8  printf (" The field strength = %d mV/meter", Erms
       *10^3) ;
```

Scilab code Exa 1.3 Calculate the radiation resistance

```
1  //Ex:1.3
2  clc ;
3  clear ;
4  close ;
5  f =10; // frequency in MHz
6  le =60; // height of antenna in m
7  y =300/f; // wavelength in m
8  Rr =(160*%pi^2*le^2)/y^2; // radiation resistance in
       ohm
9  printf (" The radiation resistance = %f K–ohm", Rr
       /1000) ;
```

Scilab code Exa 1.4 What is the power radiated and also what is the efficiency of the antenna

```
1  //Ex:1.4
2  clc;
3  clear;
4  close;
5  f=40000;// frequency in Hz
6  f1=0.040;// frequency in MHz
7  le=100;// height of antenna in m
8  Irms=450;// current in Amp
9  Rt=1.12;// total resistance in ohm
10 y=300/f1;// wavelength in m
11 Rr=(160*%pi^2*le^2)/y^2;// radiation resistance in
       ohm
12 W=Irms^2*Rr;// power radiated in Watts
13 n=Rr/Rt;// efficiency of the antenna
14 printf("The power radiated = %f KW", W/1000);
15 printf("\n The efficiency of the antenna = %f %%", n
       *100);
```

Scilab code Exa 1.5 How much power will an antenna having a radiation rasistance of fifty ohms

```
1  //Ex:1.5
2  clc;
3  clear;
4  close;
5  I=20;// current in amp
6  Rr=50;// radiation resistance in ohm
7  Wr=I^2*Rr;// radiated power in W
8  printf("The radiated power = %d W", Wr);
```

Scilab code Exa 1.6 What is the radiation resistance of an antenna

```
1  //Ex:1.6
2  clc;
3  clear;
4  close;
5  I=15;// current in amp
6  W=5000;// radiated power in W
7  Rr=W/I^2;// radiation resistance in ohm
8  printf("The radiation resistance = %f ohm", Rr);
```

Scilab code Exa 1.7 How much current flows into the antenna

```
1  //Ex:1.7
2  clc;
3  clear;
4  close;
5  W=10*1000;// radiated power in W
6  Rr=75;// radiation resistance in ohm
7  I=sqrt(W/Rr);// current in amp
8  printf("The current = %f Amp", I);
```

Scilab code Exa 1.8 Calculate the strength of electric field

```
1 //Ex:1.8
2 clc;
3 clear;
4 close;
5 W=100*1000;// radiated power in W
6 r=100*1000;// distance in m
7 Erms=(sqrt(90*W))/r;// strength of electric field in
     V/m
8 printf("The strength of electric field = %f V/m",
    Erms);
```

Scilab code Exa 1.9 Estimate the effective height of the antenna

```
1 //Ex:1.9
2 clc;
3 clear;
4 close;
5 Irms=25;// current in Amp
6 f=0.150;// frequency in MHz
7 y=2000;
8 Erms=1.5*10^-3;// strength of electric field in V/m
9 r=25*1000;// distance in m
```

```
10  le=(Erms*y*r)/(60*%pi*Irms);// effective height of
        antenna in m
11  printf("The effective height of antenna = %f m", le)
        ;
```

Scilab code Exa 1.10 Find the field strength and the power radiated

```
1  //Ex:1.10
2  clc;
3  clear;
4  close;
5  le=100;// effective height of antenna in m
6  Irms=100;// current in Amp
7  f=0.300;// frequency in MHz
8  r=10*1000;// distance in m
9  y=300/f;// in m
10 Erms=(120*%pi*Irms*le)/(y*r);// strength of electric
        field in V/m
11 Rr=160*(%pi^2)*(le/y)^2;// radiation resistance in
        ohm
12 W=Irms^2*Rr;// radiated power in Watt
13 printf("The strength of electric field = %f mV/m",
        Erms*1000);
14 printf("\n The radiated power = %f KW", W/1000);
```

Scilab code Exa 1.11 Calculate the power radiated

```
1  //Ex:1.11
2  clc;
3  clear;
4  close;
5  le=10;// effective height of antenna in m
6  Irms=50;// current in Amp
7  f=0.600;// frequency in MHz
8  y=300/f;// in m
9  Rr=160*(%pi^2)*(le/y)^2;// radiation resistance in
       ohm
10 W=Irms^2*Rr;// radiated power in Watt
11 printf("The radiated power = %f KW", W/1000);
```

Scilab code Exa 1.12 Calculate the radiation resistance of current elements

```
1  //Ex:1.12
2  clc;
3  clear;
4  close;
5  // dl=y/50
6  // then dl/y=((y/50)/y=1/50)
7  dl_y=1/50;// the value of dl/y
8  Rr=80*%pi^2*(dl_y^2);// Radiation resistance in ohm
9  printf("The radiation resistance = %f ohm", Rr);
```

Scilab code Exa 1.13 Calculate the power radiated and what is its radiation resistance

```
1 //Ex:1.13
2 clc;
3 clear;
4 close;
5 // Prad=n(pi/3)*(Io*dl/y)^2, where n=120pi & y is
      wavelength
6 // Prad=120*pi*(pi/3)*(100*y/16*y)
7 Prad=120*3.14*(3.14/3)*(100/16)^2;// power radiated
      in Watts
8 // Rr=80*pi*(y/16y)^2
9 Rr=80*3.14^2*(1/16)^2;// the radiation resistance in
      ohm
10 printf("The power radiated = %f watts", Prad);
11 printf("\n The radiation resistance = %f ohm", Rr);
```

Scilab code Exa 1.14 what is the electric field

```
1 //Ex:1.14
2 clc;
3 clear;
4 close;
```

```
5  r=5*1000;// distance in m
6  r1=10*1000;// distance in m
7  W=1;
8  Erms=(sqrt(90*W))/r;// electric field strength at a
       distanve 5 km
9  Erms1=(sqrt(90*W))/r1;// electric field strength at
       a distanve 10 km
10 E_E1=Erms/Erms1;// the ratio of electric field
       strengths
11 Erms=10;// electric field strength in mV/m
12 Erms2=Erms/E_E1;// electric field strength in mV/m
       at a distance of 10 km
13 printf("The electric field strength in mV/m at a
       distance of 10 km = %d mV/m", Erms2);
```

Scilab code Exa 1.15 Calculate the antenna current at a distance of five eight wavelength away from the feed point

```
1  //Ex:1.15
2  clc;
3  clear;
4  close;
5  Irms=10;// rms value of current in amp
6  // Erms=(120*pi*Irms*le)/y*r, where y= wavelength
7  // Erms=(120*pi*10*(3y/2))/y*r=1200*pi*3/2*r=1800*pi
       /r V/m
8  // now, Erms1=120*pi*Irms1*5y/(8*y*r)=75*pi*Irms1/r
9  // now equate these two Erms, we have
10 // 1800*pi/r=75*pi*Irms1/r i.e., Irms1=1800/75
11 Irms1=1800/75;// antenna current in amp
12 printf("The antenna current = %d amp", Irms1);
```

Scilab code Exa 1.16 Determine the field strength of the radiated field produced

```
1  //Ex:1.16
2  clc;
3  clear;
4  close;
5  r=1000;// distance in m
6  l=1;// length in m
7  Irms=5;// current in Amp
8  f=1;// frequency in MHz
9  y=300/f;// Wavelength in m
10 le=(2/%pi)*l;// effective length in m
11 Erms=(120*%pi*le*Irms)/(y*r);// field strength in V/
       m
12 printf("The field strength = %d mV/m", Erms*1000);
```

Scilab code Exa 1.17 Calculate the effective height of the antenna in meters

```
1  //Ex:1.17
2  clc;
3  clear;
4  close;
```

```
 5  r=100;// distance in m
 6  Irms=32;// current in Amp
 7  y=300*1000;// Wavelength in m
 8  Erms=9*10^-3;// field strength in V/m
 9  le=(Erms*y*r)/(120*3.14*Irms);// effective height of
        antenna in m
10  printf("The effective height of antenna = %f m", le)
        ;
```

Scilab code Exa 1.18 Calculate the radiation resistance

```
1  //Ex:1.18
2  clc;
3  clear;
4  close;
5  I=10;// current in Amp
6  Wt=(10*I)^2/30;// power in Watt
7  Rt=Wt/I^2;// Radiation resistance in ohm
8  printf("The Radiation resistance = %f ohm", Rt);
```

Scilab code Exa 1.19 Find the radiation resistance and power radiated and also antenna efficiency

```
1  //Ex:1.19
2  clc;
```

```
3 clear;
4 close;
5 le=61.4;// effective height in m
6 Irms=50;// current in amp
7 y=625;// wavelength in m
8 Rr=160*(%pi*le)^2/(y^2);// Radiation resistance of
      an antenna in ohm
9 W=(Irms^2)*Rr;// power radiated in Watt
10 Rt=50;// total antenna resistance in ohm
11 n=Rr/Rt;// efficiency
12 printf("The Radiation resistance of an antenna = %f
      ohm", Rr);
13 printf("\n The power radiated = %f KW", W/1000);
14 printf("\n The efficiency = %f %%", n*100);
```

Scilab code Exa 1.20 What is the power radiated

```
1 //Ex:1.20
2 clc;
3 clear;
4 close;
5 le=49.12;// effective height in m
6 Irms=220;// current in amp
7 f=37.5;// frequency in KHz
8 f1=f/1000;// frequency in MHz
9 y=300/f1;// wavelength in m
10 Rr=160*(%pi^2)*(le/y)^2;// Radiation resistance in
      ohm
11 W=Irms^2*Rr;// power radiated in watts
12 printf("The power radiated = %f kW", W/1000);
```

Scilab code Exa 1.21 Find out the field strength

```
1 //Ex:1.21
2 clc;
3 clear;
4 close;
5 W=35*10^3;// power in Watts
6 r=60*10^3;// in m
7 Erms=(sqrt(90*W))/r;// field strength in mV/m
8 printf("The field strength = %f mV/m", Erms*1000);
```

Scilab code Exa 1.22 At what distance from a sixty cycle circuit is the radiation field approximately

```
1 //Ex:1.22
2 clc;
3 clear;
4 close;
5 f=60*10^-6;// frequency in MHz
6 y=300/f;// wavelength in m
7 r=y/(2*3.14);// distance in m
8 printf("The distance = %f*10^6 m", r/10^6);
```

Scilab code Exa 1.23 Find out the field strength

```
1  //Ex:1.23
2  clc;
3  clear;
4  close;
5  W=1*10^3;// power in Watts
6  r=10^3;// in m
7  Erms=(sqrt(30*W))/r;// field strength in mV/m
8  printf("The field strength = %f mV/m", Erms*1000);
```

Scilab code Exa 1.24 Find the velocity of a plane wave in a loss less medium

```
1  //Ex:1.24
2  clc;
3  clear;
4  close;
5  Er=15;// relative permittivity
6  ur=5;// relative mobility
7  B=1/sqrt(Er*ur);
8  A=3*10^8;// the value of 1/sqrt(Eo*uo)
9  V=A*B;// velocity of propagation in volt
10  printf("The field strength = %f*10^7 m/s", V/10^7);
```

Scilab code Exa 1.25 What is the strength of a magnetic field H in free space

```
1 //Ex:1.25
2 clc;
3 clear;
4 close;
5 E=6;// electric field strength in V/m
6 n=120*%pi;// efficiency
7 H=E/n;// magnetic field strength in Amp/m
8 printf("The magnetic field strength = %f mA/m", H
    *1000);
```

Scilab code Exa 1.26 Calculate the field strength at a distance of twenty five km

```
1 //Ex:1.26
2 clc;
3 clear;
4 close;
5 l=70;// antenna height in m
6 le=2*l/%pi;// effective length in m
7 Irms=25;// current in amp
```

```
 8 f=10;// frequency in MHz
 9 y=300/f;// wavelength in m
10 r=25*10^3;// distance in m
11 Erms=(120*%pi*le*Irms)/(y*r);// field strength in mV
     /m
12 printf("The field strength = %d mV/m", Erms*10^3);
```

Scilab code Exa 1.27 Calculate the radiation resistance

```
1 //Ex:1.27
2 clc;
3 clear;
4 close;
5 le=50;// effective height of antenna in m
6 f=10;// frequency in MHz
7 y=300/f;// wavelength in m
8 Rr=160*(%pi^2)*(le/y)^2;// Radiation resistance in
     ohm
9 printf("The Radiation resistance = %f k-ohm", Rr
     /1000);
```

Scilab code Exa 1.28 Derive an expression for the gain of a half wave antenna

```
1 //Ex:1.28
```

```
 2  clc ;
 3  clear ;
 4  close ;
 5  //  G=Pr/pi
 6  //  G=Pr/(Wi/4*%pi*r^2)
 7  //  G=4*%pi*r^2*Pr/Wi
 8  //  Pr=(30*Irms^2/%pi*r^2)*((cos(%pi/2*(cos(x))))^2/(
        sin(x)^2)
 9  //  this  is  max  when  x=90  degree
10  //  then  Pr=(30*Irms^2/(%pi*r^2))
11  //  Wi=73.14*Irms^2
12  //  then  G=(4*%pi*r^2*30*Irms^2)/(73.14*Irms^2*%pi*r
        ^2)
13  //  G=120/73.14
14  G=120/73.14;//  Gain
15  g=10*log(G)/log(10);//  Gain  in  dB
16  printf("The  Gain  =  %f  dB", g);
```

Scilab code Exa 1.29 Calculate the antenna current at a distance of seventh eighth wavelength away from the feed point

```
 1  //Ex:1.29
 2  clc ;
 3  clear ;
 4  close ;
 5  Irms=15;//  current  in  Amp
 6  //  Erms=(120*%pi*Irms*le)/(y*r)
 7  //  here  Irms=15  amp  and  le=3y/2
 8  //  then
 9  //  Erms=(120*%pi*15*3y/2)/(y*r)
10  //  Erms=2700*%pi/r
```

```
11  // Now, le=7y, then
12  // Erms1=(120*%pi*Irms1*7y)/(y*r)
13  // Erms1=105*%pi/r
14  // and Erms=Erms1
15  // 2700*%pi/r=105*%pi*Irms1/r
16  // Irms1=2700/105
17  Irms1=2700/105;// current in Amp
18  printf("The current = %f Amp", Irms1);
```

Scilab code Exa 1.30 Find the average energy density

```
1  //Ex:1.30
2  clc;
3  clear;
4  close;
5  Pr=15;// poynting vector in W/m^2
6  v=3*10^8;// average velocity ( the speed of light)
7  dav=Pr/v;// average energy density in W S/m^3 or J/m
       ^3
8  dav1=dav*10^9;// average energy density in nJ/m^3
9  printf("The average energy density = %d nJ/m^3",
       dav1);
```

Scilab code Exa 1.31 Determine the radiation resistance

```
1 //Ex:1.31
2 clc;
3 clear;
4 close;
5 le_y=1/10;// the ratio of le to y
6 Rr=160*(%pi^2)*(le_y)^2;// radiation resistance in
     ohm
7 printf("The radiation resistance = %f ohm", Rr);
```

Scilab code Exa 1.32 What is the value of electric field strength at a point twenty five away in the same direction

```
1 //Ex:1.32
2 clc;
3 clear;
4 close;
5 r=15*10^3;// distance in m
6 r1=25*10^3;// distance in m
7 Erms_Erms1=r1/r;// the ratio of Erms to Erms1
8 Erms=25;// mV/m;// electric field strength in mV/m
9 Erms1=Erms/Erms_Erms1;// electric field strength in
     mV/m at a point 25 away in the same direction
10 printf("The electric field strength = %d mV/meter",
     Erms1);
```

Scilab code Exa 1.33 Find the velocity of propogation and the wavelength and the impedence of the medium and also the rms electric field E

```
1  //Ex:1.33
2  clc;
3  clear;
4  close;
5  f=20*10^6;// frequency in Hz
6  P=10;// poynting vector in W/m^2
7  u=4;// relative mobility
8  Er=5;// relative permeability
9  c=3*10^8;// the speed of light= 1/sqrt(uo*Eo)
10 V=c/sqrt(u*Er);// the velocity of propagation in m/s
11 y=V/f;// wavelength in m
12 E=sqrt(P*120*%pi*sqrt(4/5));// electric field in V/m
13 Erms=sqrt(E^2/sqrt(2));// rms electric field
14 E=sqrt(2)*Erms;// electric field
15 n=E^2/P;// impedance of the medium in ohm
16 printf("The velocity of propagation = %f*10^8 m/s",
      V/10^8);
17 printf("\n The wavelength = %f m", y);
18 printf("\n The impedance of the medium = %f ohm", n)
      ;
19 printf("\n The rms electric field = %f V/m", Erms);
```

Scilab code Exa 1.34 At what distance in wavelength is the radiation component of magnetic field three times the induction components

```
1  //Ex:1.34
2  clc;
3  clear;
```

```
4  close ;
5  //  3*(1/ r ^2)=w/( r *c )
6  //  3/ r =(2*%pi* f / c )
7  //  r =(1/(2*%pi)) *3
8  r =(1/(2* %pi )) *3; // distance  in  terms  of  y ( wavelength
       )
9  r1 =(1/(2* %pi )) *50; // distance  in  terms  of  y (
       wavelength )
10 printf ("The  distance  when  component  of M−field  three
        times  the  induction  field  = %f*y" , r );
11 printf ("\n  The  distance  when  component  of M−field  50
        times  the  induction  field= %f*y" , r1 );
```

Scilab code Exa 1.35 Find out the field strength

```
1  // Ex : 1 . 3 5
2  clc ;
3  clear ;
4  close ;
5  W =50*1000; // radiated  power  in W
6  r =90*1000; // distance  in  m
7  Erms =( sqrt (90* W ))/ r ; // strength  of  electric  field  in
       V/m
8  printf ("The  strength  of  electric  field  = %f mV/m" ,
      Erms *1000) ;
```

Scilab code Exa 1.36 Find the velocity of a plane wave in a loss less medium

```
1 //Ex:1.36
2 clc;
3 clear;
4 close;
5 c=3*10^8; // the speed of light in m/s
6 ur=1; // relative permittivity
7 Er=4; // relative permeability
8 vp=c/sqrt(ur*Er); // velocity of a plane wave
9 printf("The velocity of a plane wave = %f*10^8 m/s",
      vp/10^8);
```

Scilab code Exa 1.37 Calculate the antenna current at a distance of seventh eighth wavelength away from the feed point

```
1 //Ex:1.37
2 clc;
3 clear;
4 close;
5 Irms=15; // current in Amp
6 // Erms=(120*%pi*Irms*le)/(y*r)
7 // here Irms=15 amp and le=7y/2
```

```
 8  //  then
 9  //  Erms=(120*%pi*15*7y/2)/(y*r)
10  //  Erms=6300*%pi/r
11  //  Now,  le=7y,  then
12  //  Erms1=(120*%pi*Irms1*7y)/(y*r)
13  //  Erms1=105*%pi/r
14  //  and  Erms=Erms1
15  //  6300*%pi/r=105*%pi*Irms1/r
16  //  Irms1=6300/105
17  Irms1=6300/105;// current in Amp
18  printf("The current = %d Amp", Irms1);
```

Scilab code Exa 1.38 Determine the radiation resistance

```
1  //Ex:1.38
2  clc;
3  clear;
4  close;
5  le_y=1/150;// the ratio of le to y
6  Rr=16*(%pi^2)*(le_y)^2;// radiation resistance in
      ohm
7  printf("The radiation resistance = %f*10^-3 ohm", Rr
      *1000);
```

Scilab code Exa 1.39 What is the radiation resistance of an antenna

```
1  //Ex:1.39
2  clc;
3  clear;
4  close;
5  Pr=10*10^3;// power in Watts
6  I=18;// current in Amp
7  R=Pr/I^2;// radiation resistance of an antenna in
      ohm
8  printf("The radiation resistance of an antenna = %f
      ohm", R);
```

Scilab code Exa 1.40 What is the bandwidth

```
1  //Ex:1.40
2  clc;
3  clear;
4  close;
5  fo=25*10^6;// frequency in Hz
6  Q=40;
7  B_W=fo/Q;// bandwidth in Hz
8  printf("The bandwidth = %d KHz", B_W/1000);
```

Scilab code Exa 1.41 Define radiation resistance and also Calculate the radiation resistance and efficiency

```
1  //Ex:1.41
2  clc;
3  clear;
4  close;
5  Rl=1.5;// loss resistance in ohm
6  le_y=1/50;// the ratio of le to y
7  Rr=80*(%pi^2)*(le_y)^2;// radiation resistance in
       ohm
8  Rt=Rl+Rr;// total resistance in ohm
9  n=Rr/Rt;// effeciency
10 printf("The effeciency = %f %%", n*100);
```

Scilab code Exa 1.42 What is the significance of electrostatic field and induction field and also radiation field of the antenna and at what distance in wavelength the radiation component of magnetic field is hundred times of the induction component

```
1  //Ex:1.42
2  clc;
3  clear;
4  close;
5  // 100*(1/r^2)=w/(r*c)
6  // 100/r=(2*%pi*f/c)
7  // r=(1/(2*%pi))*100
8  r=(1/(2*%pi))*100;// distance in terms of y(
       wavelength)
9  printf("The distance when component of M-field three
        times the induction field = %f*y", r);
```

Scilab code Exa 1.43 Define retarded vector potential

```scilab
1 //Ex:1.43
2 clc;
3 clear;
4 close;
5 printf("Retarded vector potential- The vector
      potential expression represents the super
      positions of various current elements I.dl, at a
      distant point P at a distance of r. If these are
      simply added up, it means an assumption is made
      that these field effects which are super imposed
      at time t, all started from the current elements
      of the same value of current and even though they
       have travelled different. Varying distances in
      other words finite time of propagation has been
      ignored which is not correct. This would have
      been correct provided the velocity of propagation
       would have been infinite which is actually not."
      );
6 printf("\n If the expression for vector potential in
       Integrated it follows thet potential due to
      various current element are added up let us
      suppose that current (I) is istantaneous current
      (I) in the element be Sinusoidal function of time
       as");
7 printf("\n I=Im.sin(wt), where Im= max current");
8 printf("\n I=Instantaneous current");
9 printf("\n w=2hf, angular frequency");
```

Scilab code Exa 1.44 What is the power radiated and what is the efficiency of the antenna

```
1  //Ex:1.44
2  clc;
3  clear;
4  close;
5  c=3*10^8;// the speed of light in m/s
6  Irms=450;// current in Amp
7  dl=100;// effective length in m
8  f=40*10^3;// frequency in Hz
9  y=c/f;// wavelength in m
10 w=80*%pi^2*Irms^2*(dl/y)^2;// power radiated in
       Watts
11 Rr=0.14;// radiation resistance in ohm
12 Rt=1.12;// total resistance in ohm
13 n=Rr/Rt;// effeciency
14 printf("The power radiated = %f kW", w/1000);
15 printf("\n The effeciency = %f %%", n*100);
```

Scilab code Exa 1.45 Calculate the radiation resistance power radiated and the efficiecy of an antenna

```
1  //Ex:1.45
```

```
2  clc ;
3  clear ;
4  close ;
5  le =69.96; // effective length in m
6  Irms =50; // current in Amp
7  Rt =50; // total resistance in ohm
8  c =3*10^8; // the speed of light in m/s
9  f =0.480*10^6; // frequency in Hz
10 y=c/f ; // wavelength in m
11 Rr =160*%pi^2*(le/y)^2; // radiation resistance in ohm
12 w= Irms^2*Rr; // power radiated in Watts
13 n= Rr/Rt ; // effeciency
14 printf ("The radiation resistance = %f ohm", Rr );
15 printf ("\n The power radiated = %f kW", w/1000) ;
16 printf ("\n The effeciency = %f %%", n*100) ;
```

Scilab code Exa 1.46 Find the radiation resistance and efficiency

```
1  //Ex:1.46
2  clc ;
3  clear ;
4  close ;
5  Rl =1.5; // loss resistance in ohm
6  dl_y =1/15; // the ratio of dl to y( wavelength )
7  Rr =80*(%pi^2)*(dl_y)^2; // radiation resistance in
      ohm
8  Rt = Rl+Rr ; // total resistance in ohm
9  n= Rr/Rt ; // effeciency
10 printf ("The radiation resistance = %f ohm", Rr );
11 printf ("\n The effeciency = %d %%", n*100) ;
```

Scilab code Exa 1.47 What is the power radiated

```
1  //Ex:1.47
2  clc;
3  clear;
4  close;
5  I=10;// peak current in Amp
6  Irms=I/sqrt(2);// rms current in Amp
7  A=80*Irms^2;
8  printf("The the value of A = %f", A);
9  printf("\n power radiated=4000(pi*dl)^2/y^2");
10 printf("\n Where, y=wavelength & pi=3.14");
```

Scilab code Exa 1.48 What is the strength of magnetic field H in free space

```
1  //Ex:1.48
2  clc;
3  clear;
4  close;
5  E=60;// electric field strength in V/m
6  n=120*%pi;// efficiency
7  H=E/n;// magnetic field strength in Amp/m
8  printf("The magnetic field strength = %f A/m", H);
```

Scilab code Exa 1.49 Calculate the radiated field strength and the total power radiated and also the radiation resistance

```
1 //Ex:1.49
2 clc;
3 clear;
4 close;
5 c=3*10^8;// speed of the light in m/s
6 f=10*10^6;// frequency in Hz
7 y=c/f;// wavelength in m
8 I=1;// current in amp
9 l=1;// length in m
10 r=500*10^3;// distance in m
11 n=120*%pi;
12 Ex=(n*I*l*sin(%pi/2))/(2*r*y);// the magnitude of
       electric field in uV/m
13 Hx=(I*l*sin(%pi/2))/(2*r*y);// the magnitude of
       magnetic field in AT/m
14 Pm=(80*%pi^2*I^2*l^2)/(y^2);// the maximum power
       radiated in watts
15 Pav=(1/2)*Pm;// the average power radiated in watts
16 Rr=80*%pi^2*(l/y)^2;// the radiation resistance in
       ohm
17 printf("The magnitude of electric field = %f uV/m",
       Ex*10^6);
18 printf("\n The magnitude of magnetic field = %f
       *10^-8 AT/m", Hx*10^8);
19 printf("\n The maximum power radiated = %f watts",
       Pm);
20 printf("\n The average power radiated = %f watts",
```

```
      Pav ) ;
21  printf (" \n The radiation resistance = %f ohm", Rr ) ;
```

Scilab code Exa 1.50 Show the total far field electric field amplitude and also Calculate the power that could be fed into a dipole antenna

```
1  //Ex:1.50
2  clc ;
3  clear ;
4  close ;
5  V=5*10^-3; // rms value in volt
6  r=3*10^3; // in meter
7  Rr=73; // the radiation resistance in ohm
8  // The electric field in the far region may be given
       by
9  // Ex=(60. pi . Im . sin ( x )/y . r )* e ^(− jko . r )* integrate ( '(
      cos ( koz )* e ^( jko . z . cos ( x ) ) ) , ' z ' , − y /4 , y /4)
10 // Ex=(60. pi . Im . sin ( x )/y . r )* e ^(− jko . r )* integrate
      ( '(2. cos ( ko ) ( cos ( ko . z ) . cos ( x )+j . sin ( ko . z ) . cos ( x ) )
      ' , ' z ' ,0 , y /4)
11 // Ex=(60. pi . Im . sin ( x )/y . r )* e ^(− jko . r )* integrate
      ( '(2. cos ( ko . z ) . cos ( ko . z . cos ( x ) ) ) ' , ' z ' ,0 , y /4)
12 // on integrating , we get ,
13 // Ex=(60* Im /r )*( cos ( pi /2. cos ( x ) )/ sin ( x ) )
14 Emax=V* sqrt (2) ; // the peak value of field in V/m
15 // on putting x=90 degree in Ex=(60* Im /r )*( cos ( pi /2.
      cos ( x ) )/ sin ( x ) ) , we get
16 // Emax=60* Im /r , then
17 Im=Emax *r /60; // max current in amp
18 Pav =( Im ^2/2) *( Rr ) ; // the average power in watts
19 printf (" The expression of total electric field
```

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```
      amplidude , Ex=(60∗Im/ r ) ∗( cos ( pi /2. cos ( x ) ) / sin ( x ) )
      ")
20 printf ("\n The  value  of  the  average  power= %f  watts"
      , Pav ) ;
```

Scilab code Exa 1.51 Calculate the loss resistance and also Calculate the power radiated and the ohmic loss and loss resistance

```
1 //Ex:1.51
2 clc ;
3 clear ;
4 close ;
5 I =4;// peak  current  in  Amp
6 Irms =I/sqrt(2) ;// rms  current  in  Amp
7 Rr =18;// radiation  resistance  in  ohm
8 Pr=Irms^2*Rr ;// power  radiated  in  Watts
9 Rl =(0.1*Rr)/0.9;// loss  resistance  in  ohm
10 Pl=Irms^2*Rl ;// ohmic  loss  in  Watt
11 printf ("The  power  radiated  =  %f  Watts", Pr ) ;
12 printf ("\n The  loss  resistance  =  %d  ohm", Rl ) ;
13 printf ("\n The  ohmic  loss  =  %f  watts", Pl ) ;
```

Chapter 2

Antenna Terminology

Scilab code Exa 2.1 What is the wavelength

```
1 //Ex:2.1
2 clc;
3 clear;
4 close;
5 c=3*10^8;// the speed of light in m/s
6 f=1000000;// frequency in Hz
7 y=c/f;// wavelength in m
8 printf("The wavelength = %d meter", y);
```

Scilab code Exa 2.2 What is the actual velocity of EM energy

```
1 //Ex:2.2
2 clc;
3 clear;
4 close;
```

```
5  c=3*10^8; // the speed of light in m/s
6  f=0.75; // propagation fector
7  v=c*f; // actual veloity in m/s
8  printf("The actual veloity = %f*10^8 meter/sec", v
       /10^8);
```

Scilab code Exa 2.3 What is the wavelength in vaccum and in air

```
1  //Ex:2.3
2  clc;
3  clear;
4  close;
5  c=3*10^8; // the speed of light in m/s
6  f=60*1000000; // frequency in Hz
7  y=c/f; // wavelength in vaccum in m
8  y1=y*0.98; // wavelength in air in m
9  printf("The wavelength in vaccum = %d meter", y);
10 printf("\n The wavelength in air = %f meter", y1);
```

Scilab code Exa 2.4 What is the directicity

```
1  //Ex:2.4
2  clc;
3  clear;
4  close;
```

```
5  Rr=80;// radiation resistance in ohm
6  Rl=10;// loss−resistance in ohm
7  n=Rr/(Rr+Rl);// effeciency
8  G=20;// Power Gain
9  D=G/n;// directivity
10 printf("The directivity = %f", D);
```

Scilab code Exa 2.5 Calculate the radiation resistance

```
1  //Ex:2.5
2  clc;
3  clear;
4  close;
5  dl_y=1/20;// the ratio of dl to y(wavelength)
6  Rr=80*(%pi^2)*(dl_y)^2;// radiation resistance in
      ohm
7  printf("The radiation resistance = %f ohm", Rr);
```

Scilab code Exa 2.6 Find the max directivity and compare it with its exact value

```
1  //Ex:2.6
2  clc;
3  clear;
4  close;
```

```
 5  x1r =2*%pi /3;// in radian
 6  x2r =2*%pi /3;// in radian
 7  D=4*%pi /( x1r )^2;//  the max directivity
 8  // Now, let us find the exact value of the max
        directivity and compare the result
 9  // y=Bo. cos(x)
10  // ymax=Bo
11  // Prad=integration of (Bo. cos(x). sin(x)) with limit
         0 to 2*pi
12  P=integrate('sin(2*x)','x',0,2*3.14);
13  // Prad=%pi*Bo*integration of (Bo. cos(x). sin(x))
        with limit 0 to 2*pi
14  // then we get Prad=%pi*Bo
15  // Do=(4*pi*ymax)/Prad=4*pi*Bo/%pi*Bo
16  Do =4;// exact value of the max directivity
17  printf("The max directivity = %f (dimensionless)", D
        );
18  printf("\n The exact value of the max directivity =
        %d (dimensionless)", Do);
19  printf("\n The exact max directivity is 4 and its
        approx. value is 2.84. Better approximations can
        be obtained if the patterns have much narrower
        beamwidths.");
```

Scilab code Exa 2.7 What is the bandwidth and also bandwidth ratio

```
 1  //Ex:2.7
 2  clc;
 3  clear;
 4  close;
 5  fc =220;// center frequency in Hz
```

```
 6  f3db =190;// 3 db frequency in Hz
 7  f3db1 =240;// 3 db frequency in Hz
 8  Bl=(fc-f3db)/fc;// lower band width
 9  Bu=(f3db1-fc)/fc;// upper band width
10  R=f3db1/f3db;// max to min ratio
11  printf("The lower band width = %f %%", Bl*100);
12  printf("\n The upper band width = %f %%", Bu*100);
13  printf("\n The max to min ratio = %f to 1 ", R);
```

Scilab code Exa 2.8 Calculate the max effective aperture of an antenna

```
1  //Ex:2.8
2  clc;
3  clear;
4  close;
5  y=2;// wavelength in m
6  D=100;// directivity
7  Aem=(D*y^2)/(4*%pi);// max efeective aperture in m^2
8  printf("The max efeective aperture = %f m^2", Aem);
```

Scilab code Exa 2.9 Find out the radiation resistance

```
1  //Ex:2.9
2  clc;
3  clear;
```

```
4 close ;
5 dl_y =1/8;// the ratio of dl to y(wavelength)
6 Rr =80*(%pi^2)*(dl_y)^2;// radiation resistance in
     ohm
7 printf("The radiation resistance = %f ohm", Rr);
```

Scilab code Exa 2.10 How much power does a fifty ohms antenna radiate
when fed a current five amp

```
1 //Ex:2.10
2 clc ;
3 clear ;
4 close ;
5 Irms =5;// current in Amp
6 Rr =50;// radiation resistance in m
7 W= Irms^2*Rr;// power in Watts
8 printf("The power = %d Watts", W);
```

Scilab code Exa 2.11 Calculate the radiation resistance

```
1 //Ex:2.11
2 clc ;
3 clear ;
4 close ;
5 G =20;// Power Gain
```

```
6  D =22; // directivity
7  n=G/D; // effeciency
8  Rl =10; // loss-resistance in ohm
9  Rr =( n*Rl )/(1 -n ); // radiation resistance in ohm
10 printf (" The radiation resistance = %f ohm", Rr );
```

Scilab code Exa 2.12 Calculate the front to back ratio of an antenna in dB

```
1  // Ex :2.12
2  clc ;
3  clear ;
4  close ;
5  P1 =3000; // in Watts
6  P2 =500; // in Watts
7  Gdb =10* log ( P1 / P2 )/ log (10); // front to back ratio of
       an antenna in dB
8  printf (" The front to back ratio of an antenna = %f
       dB", Gdb );
```

Scilab code Exa 2.13 Find the received power

```
1  // Ex :2.13
2  clc ;
3  clear ;
```

```
4 close;
5 G=40;// power gain in dB
6 Gt=40;// power gain in dB
7 Gr=40;// power gain in dB
8 G1=10^(G/10);// power gain
9 Gt1=10^(Gt/10);// power gain
10 Gr1=10^(Gr/10);// power gain
11 f=10*10^3;// frequency in MHz
12 y=300/f;// wavelength in m
13 Wt=1;// Transmitter in Watts
14 r=30*10^3;// range of link in m
15 Wr=(Wt*G1^2*y^2)/(4*%pi*r)^2;// receive power in
      Watts
16 printf("The receive power = %f*10^-6 Watts", Wr
      *10^6);
```

Scilab code Exa 2.14 How much is the new signal picked up by the receiving station

```
1 //Ex:2.14
2 clc;
3 clear;
4 close;
5 V2=50;// in micro volt
6 G=5;// voltage gain in dB
7 G1=10^(G/20);// voltage gain
8 V1=V2*G1;// signal at receiving station in volt
9 printf("The signal at receiving station = %f micro
      volts", V1);
```

Scilab code Exa 2.15 Calculate the power gain

```
1  //Ex:2.15
2  clc;
3  clear;
4  close;
5  Pi=400*10^-3;// input power to reference Antenna
6  Pt=100*10^-3;// input power to test antenna
7  Gdb=10*log(Pi/Pt)/log(10);// power gain in dB
8  printf("The power gain = %f dB", Gdb);
```

Scilab code Exa 2.16 Calculate the approximate gain and beamwidth of a paraboloidal reflector antenna

```
1  //Ex:2.16
2  clc;
3  clear;
4  close;
5  D=20;// directivity
6  A=%pi*(D/2)^2;
7  f=4*10^3;// frequency in MHz
8  y=300/f;// wavelength in meter
9  n=0.55;// effeciency
10 G=(4*%pi*n*A)/y^2;// gain
```

```
11  Gdb =10* log (G) / log (10) ;// gain in dB
12  B_W =(70* y/D) ;// beamwidth of a paraboloidal
        reflector antenna
13  printf ("The gain = %f dB", Gdb);
14  printf ("\n The beamwidth of a paraboloidal reflector
        antenna = %f degree", B_W);
```

Scilab code Exa 2.17 Find out the quality factor Q of an antenna

```
1  //Ex:2.17
2  clc ;
3  clear ;
4  close ;
5  df =0.600;// bandwidth in MHz
6  fr =30;// frequency in MHz
7  Q=fr/df ;// quality factor
8  printf ("The quality factor = %d", Q);
```

Scilab code Exa 2.18 Calculate the bandwidth of an antennas

```
1  //Ex:2.18
2  clc ;
3  clear ;
4  close ;
5  fr =110*10^6;// frequency in Hz
```

```
6 Q=70;// quality factor
7 df=fr/Q;// bandwidth in MHz
8 printf("The bandwidth= %f MHz", df/10^6);
9 printf("\n The answer is wrong in the textbook");
```

Scilab code Exa 2.19 Calculate the directivity of isotropic antenna

```
1 //Ex:2.19
2 clc;
3 clear;
4 close;
5 A=4*%pi;// for isotropic antenna
6 D=4*%pi/A;// directivity
7 printf("The directivity= %d", D);
```

Scilab code Exa 2.20 Calculate the max effective aperture of a microwave antenna

```
1 //Ex:2.20
2 clc;
3 clear;
4 close;
5 D=900;// directivity
6 // Aem=(D.y^2)/(4*%pi), where y= Wavelength
7 Aem=(D/(4*%pi));// max effective aperture
```

```
8  printf("The max effective aperture= %f*y^2, where y=
        wavelength", Aem);
```

Scilab code Exa 2.21 Find the equivalent temperature

```
1  //Ex:2.21
2  clc;
3  clear;
4  close;
5  FdB=0.2;// noise figure in dB
6  F=10^(FdB/10);// noise figure
7  To=290;// temperature in k
8  Te=(F-1)*To;// equivalent temperature in k
9  printf("The equivalent temperature= %f k", Te);
10  printf("\n The answer is wrong in the textbook");
```

Scilab code Exa 2.22 Find the noise factor

```
1  //Ex:2.22
2  clc;
3  clear;
4  close;
5  Te=20;// equivalent temperature in k
6  To=290;// temperature in k
7  F=1+Te/To;// noise figure
```

```
8 printf(" The noise figure = %f", F);
```

Scilab code Exa 2.23 what is the effective noise temperature

```
1 //Ex:2.23
2 clc;
3 clear;
4 close;
5 FdB=1.1; // noise figure in dB
6 F=10^(FdB/10); // noise figure
7 To=290; // temperature in k
8 Te=(F-1)*To; // equivalent temperature in k
9 printf(" The equivalent temperature= %f k", Te);
```

Scilab code Exa 2.24 Calculate the available noise power per unit bandwidth and also Calculate the available noise power for a noise bandwidth

```
1 //Ex:2.24
2 clc;
3 clear;
4 close;
5 Ta=15; // effective temperature in k
6 Tn=20; // effective noise temperature in k
7 B=4*10^6; // noise bandwidth in Hz
8 k=1.38*10^-23; // boltzmann's constant
```

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```
9  Ps_Bn=k*(Ta+Tn);// noise power per unit bandwidth in
       Watts/Hz
10 Ps=Ps_Bn*B;// the total available noise power in
       Watts
11 printf("The noise power per unit bandwidth= %f
       *10^-23 Watts/Hz", Ps_Bn*10^23);
12 printf("\n The total available noise power= %f
       *10^-17 Watts", Ps*10^17);
```

Scilab code Exa 2.25 How much is the new signal picked up by the receiving station

```
1  //Ex:2.25
2  clc;
3  clear;
4  close;
5  V2=50;// in u volt
6  G=5;// voltage gain in dB
7  G1=10^(G/20);// voltage gain
8  V1=V2*G1;// signal at receiving station in volt
9  printf("The signal at receiving station = %f u-volts
       ", V1);
```

Scilab code Exa 2.26 Calculate the max effective aperture of an antenna

```
1 //Ex:2.26
2 clc;
3 clear;
4 close;
5 y=5;// wavelength in m
6 D=75;// directivity
7 Aem=(D*y^2)/(4*%pi);// max efeective aperture in m^2
8 printf("The max efeective aperture = %f m^2", Aem);
```

Scilab code Exa 2.27 Find the equivalent temperature

```
1 //Ex:2.27
2 clc;
3 clear;
4 close;
5 FdB=0.5;// noise figure in dB
6 F=10^(FdB/10);// noise figure
7 To=290;// temperature in k
8 Te=(F-1)*To;// equivalent temperature in k
9 printf("The equivalent temperature= %f k", Te);
```

Scilab code Exa 2.28 Find the noise factor

```
1 //Ex:2.28
2 clc;
```

```
3  clear;
4  close;
5  Te=40;// equivalent temperature in k
6  To=290;// temperature in k
7  F=1+Te/To;// noise figure
8  printf("The noise figure = %f", F);
```

Scilab code Exa 2.29 What is the effective noise temperature

```
1  //Ex:2.29
2  clc;
3  clear;
4  close;
5  FdB=1.5;// noise figure in dB
6  F=10^(FdB/10);// noise figure
7  To=290;// temperature in k
8  Te=(F-1)*To;// equivalent temperature in k
9  printf("The equivalent temperature= %f k", Te);
```

Scilab code Exa 2.30 Calculate the available noise power per unit bandwidth and also Calculate the available noise power for a noise bandwidth

```
1  //Ex:2.30
2  clc;
3  clear;
```

```
4  close;
5  Ta=25;// effective temperature in k
6  Tn=45;// effective noise temperature in k
7  B=7*10^6;// noise bandwidth in Hz
8  k=1.38*10^-23;// boltzmann's constant
9  Ps_Bn=k*(Ta+Tn);// noise power per unit bandwidth in
       Watts/Hz
10 Ps=Ps_Bn*B;// the total available noise power in
      Watts
11 printf("The noise power per unit bandwidth= %f
       *10^-23 Watts/Hz", Ps_Bn*10^23);
12 printf("\n The total available noise power= %f
       *10^-17 Watts", Ps*10^17);
```

Scilab code Exa 2.31 Calculate the gain and beam width of the antenna

```
1  //Ex:2.31
2  clc;
3  clear;
4  close;
5  f=7.375*10^3;// frequency in MHz
6  y=300/f;// wavelength in m
7  D=2.7;// directivity
8  Ae=%pi*(D/2)^2*0.65;// effective aperture
9  G=(4*%pi/y^2)*Ae;// gain
10 BW=70*y/D;// Beamwidth in A
11 printf("The gain = %f ", G);
12 printf("\n The Beamwidth = %f A", BW);
```

Scilab code Exa 2.32 How much is the new signal picked up by the receiving station

```
1 //Ex:2.32
2 clc;
3 clear;
4 close;
5 V2=60;// in u volt
6 G=15;// voltage gain in dB
7 G1=10^(G/20);// voltage gain
8 V1=V2*G1;// signal at receiving station in volt
9 printf("The signal at receiving station = %f u-volts
     ", V1);
```

Scilab code Exa 2.33 Calculate the radiation resistance

```
1 //Ex:2.33
2 clc;
3 clear;
4 close;
5 G=30;// Power Gain
6 D=42;// directivity
7 n=G/D;// effeciency
8 Rl=25;// loss-resistance in ohm
```

```
9  Rr =( n * Rl ) /(1 - n ) ;// radiation resistance in ohm
10 printf ( " The radiation resistance = %f ohm " , Rr ) ;
```

Scilab code Exa 2.34 Determine the total radited power

```
1  // Ex : 2 . 3 4
2  clc ;
3  clear ;
4  close ;
5  // For a closed surface , a sphere of radius r is
      choosen . To find the total radiated power , the
      radiated component of the power density is
      integrated over its surface . therefore ,
6  // Wt=double integration of ( ar . Ao .( sin ( x )/ r ^2)) *( ar
      . r ^2. sin ( x )) with limits from 0 to 2* pi and from
      0 to pi , and on integration we get , pi ^2* Ao
      watts
7  printf ( " The total radiated power= pi ^2* Ao watts " ) ;
```

Scilab code Exa 2.35 Find the max directivity of the antenna and write an expression for the directivity

```
1  // Ex : 2 . 3 5
2  clc ;
3  clear ;
```

```
 4 close ;
 5 // The max radiation is directed along x=pi/2.
      Therefore, Ymax=Ao
 6 // radiation intensity in example 2.34 is , Wt=pi^2*
      Ao
 7 // then , max directivity , Do=4*pi*Ymax/Wt=4*pi*Ao/pi
      ^2*Ao=4/pi
 8 Do =4/%pi ;// the max directivity
 9 // since the radiation intensity is only a function
      of angle x, the directivity as a function of the
      directional angles is represented by, D=Do*sin(x)
10 printf ("The max directivity = %f", Do);
11 printf ("\n The directivity as a function of the
      directional angles is represented by, D=Do*sin(x)
      , where Do is the max value of directivity");
```

Scilab code Exa 2.36 Find the max directivity of the antenna and write an expression for the directivity

```
 1 //Ex:2.36
 2 clc ;
 3 clear ;
 4 close ;
 5 // The radiation intensity is given by, F=r^2*Wr=Ao
      *(sin(x))^2
 6 // The max radiation is directed along x=pi/2.
      therefore, Ymax=Ao
 7 // the total radiated power is given by,Wt= Ao(8*pi
      /3)
 8 // then the max directivity is equal to
 9 // Do=4*pi*Ymax/Wt=4*pi*Ao/(8*pi*Ao/3)=3/2
```

```
10  Do =3/2;// the max directivity
11  printf(" The max directivity = %f", Do);
12  printf("\n The directivity as a function of the
        directional angles is represented by, D=1.5*(sin(
        x))^2");
```

Scilab code Exa 2.37 Show the max effective aperture of a short dipole antenna

```
1  //Ex:2.37
2  clc;
3  clear;
4  close;
5  // It is assume that
6  // 1. short dipole is coincide with x-axis
7  // 2. Plane polarized wave in travelling along y-
        axis and including current along the x-axis of
        antenna which constant throughout the length of
        the dipole and in the same phase
8  // 3. Length of the short dipole is small in
        comparison to wavelength i.e. dl<<y
9  // 4. Antenna losses are zero.
10  // i.e.,        RL=Rr+Rl
11  // or           RL=Rr,        Rl=0
12  // As we know max-effective aperture is given by
13  // (Ae)max=V^2/(4*pi*P*Rr)
14  // where, V=induced voltage, P=poynting vector, Rr=
        radiation resistance
15  // As we here, V=E*dl, P=E^2/n W/m^2, where, n=
        intrinsic impedence of free space and E=Electric
        field intensity
```

```
16  // the radiation Resistance of short dipole antenna
        is given by
17  // Rr=80*pi^2*(dl/y)^2 in ohm
18  // then (Ae)max=(E*dl)^2/(4*(E^2/n)*(80*pi^2)*(dl/y)
        ^2)
19  //        (Ae)max=(n*y^2)/(80*pi^2*4)=(120*pi*y^2)
        /(320*pi^2)
20  //                =(3*y^2)/(8*pi)=0.119*y^2
21  printf("The maximum effective aperture of a short
        dipole antenna, (Ae)max=0.119*y^2, where y is
        wavelength");
```

Scilab code Exa 2.38 Show the field strength at adistance r meters from an antenna of gain G and radiating power P

```
1  //Ex:2.38
2  clc;
3  clear;
4  close;
5  // Power at point P, i.e., distance r meters
6  // w=wt/4*pi*r^2
7  // here, wt=PG
8  // now, w=EH and E/H=n then w=E^2/n where n=120*pi
9  // E^2=wn=(wt/4*pi*r^2)n=(PG/4*pi*r^2)n=120*pi*PG/4*
        pi*r^2=30*PG/r^2
10 printf("The field strength is, E=sqrt(30*P*G)/r^2 V/
        m");
```

Scilab code Exa 2.39 Define effective aperture and scattering aperture

```
1  //Ex:2.39
2  clc;
3  clear;
4  close;
5  printf("Effective aperture and scattering aperture-
       Resides effective aperture, there are other
       aperture also like scattering aperture (As) and
       loss aperture (Al). Corresponding to considerable
        losses in radiation or re-radiation Resistance (
       Rr) and antenna losses resistance (Rl)
       respectively and accordingly they are called as
       scattering apertures.");
6  // The scattering aperture, As=((Irms)^2*Rr)/P
7  printf("The scattering aperture, As=(V^2*Rr)/((RL+RA
       )^2+(XL+XA)^2)*P) ");
```

Scilab code Exa 2.40 Calculate the power density and magnetic and electric field strength

```
1  //Ex:2.40
2  clc;
3  clear;
```

```
 4 close;
 5 Irms=4;// rms current in Amp
 6 Rr=70;// radiation resistance in ohm
 7 Pmax=(sqrt(2)*Irms)^2*Rr;// max power in Watts
 8 Pav=Pmax/2;// average power in Watts
 9 d=60*10^3;// distance in m
10 Pd=(Pav*1.6)/(4*%pi*d^2);// power density
11 n=120*%pi;// efficiency
12 E=sqrt(n*Pd);// electric field in V/m
13 H=E/n;// magnetic field A/m
14 printf("The power density = %f micro Watt/m^2", Pd
      *10^6);
15 printf("\n The electric field = %f mV/m", E);
16 printf("\n The magnetic field = %f*10^-5 AT/m ", H
      *10^5);
```

Scilab code Exa 2.41 Calculate the antenna gain

```
1 //Ex:2.41
2 clc;
3 clear;
4 close;
5 Pt=120;// transmitting power in Watt
6 Pd=160*10^-6;// power density in W/cm^2
7 d=10*100;// distance in cm
8 Gt=(Pd*4*%pi*d^2)/Pt;// the antenna gain
9 printf("The antenna gain = %f ", Gt);
```

Scilab code Exa 2.42 Calculate the effective aperture and what will the power received

```
1  //Ex:2.42
2  clc;
3  clear;
4  close;
5  f=1.2*10^9;// freqyency in Hz
6  c=3*10^8;// the speed of light in m/s
7  y=c/f;// wavelength in m
8  D=1.5;// directivity
9  Ae=(D*y^2)/(4*%pi);// effective aperture area
10 Pd=2*10^-3;// power density in W/m^2
11 Pr=Pd*Ae;// power received in Watts
12 printf("The power received = %f*10^-6 Watts", Pr
       *10^6);
```

Scilab code Exa 2.43 Find the directivity and gain and effective aperture and beam solid angle and radiation resistance and also terminal resistance

```
1  //Ex:2.43
2  clc;
3  clear;
4  close;
```

```
5  Rl=1.5;// loss resistance in ohm
6  // Rr=80*pi^2*(l/y)^2=(80*pi^2*(y/15)^2)/y^2=80*pi
       ^2/225
7  Rr=80*%pi^2/225;// the radiation resistance of the
       antenna in ohm
8  n=Rr/(Rr+Rl);// the efficiency factor
9  // the effective aperture of the antenna is given by
10 // Ae=V^2/4*S*Rr
11 // max emf induced, V=E*l volt
12 // Poynting vector, S=E^2/zo W/m^2, where zo=120*pi
       ohm
13 // Ae=(E*l)^2/(4*(E^2/zo)*Rr)=l^2*zo/(4*Rr), l=y/15
14 // Ae=((y/15)^2*120*pi)/(4*3.5)=0.1196*y^2
15 // the directivity, D=4*pi*Ae/y^2=(4*pi/y^2)*0.1196*
       y^2
16 D=4*%pi*0.1196;// the directivity
17 G=n*D;// the gain of the dipole
18 Rt=Rr+Rl;// the terminal resistance in ohm
19 x=4*%pi/D;// the beam solid angle in sreradian
20 printf("The radiation resistance of the anteenna =
       %f ohm", Rr);
21 printf("\n The effective aperture, Ae=0.1196*y^2,
       where y is wavelength");
22 printf("\n The directivity = %f", D);
23 printf("\n The gain of the dipole = %f", G);
24 printf("\n The terminal resistance = %d ohm", Rt);
25 printf("\n The beam solid angle = %f sreradian", x);
```

Scilab code Exa 2.44 Find the beam width

```
1  //Ex:2.44
```

```
 2 clc;
 3 clear;
 4 close;
 5 GdB=44;// gain in dB
 6 G=10^(44/10);// gain
 7 XB=(4*%pi)/G;// beam solid angle in sreradian
 8 X3dB=sqrt(4/%pi)*sqrt(XB);// beam width in radian
 9 X3dB1=X3dB*180/%pi;// beam width in degree
10 printf("The beam width = %f degree", X3dB1);
```

Scilab code Exa 2.45 what is the size of spot illuminated by the antenna

```
 1 //Ex:2.45
 2 clc;
 3 clear;
 4 close;
 5 X3dB=0.1;// beam width in degree
 6 X3dB1=X3dB*%pi/180;// beam width in radian
 7 XB=(%pi/4)*(X3dB1^2);// beam solid angle
 8 r=36000*1000;// distance from earth surface in m
 9 A=XB*r^2;// area of spot in m^2
10 printf("The area of spot = %f*10^9 m^2", A/10^9);
```

Scilab code Exa 2.46 Find the power density

```
1  //Ex:2.46
2  clc;
3  clear;
4  close;
5  Gt=36;// the antenna gain in dB
6  Gt1=10^3.6;// the antenna gain
7  Pt=5*10^3;// transmitting power in Watt
8  R=25*10^3;// distance in m
9  Pd=(Pt*Gt1)/(4*%pi*R^2);// power density in W/cm^2
10 printf("The power density = %f*10^-3 W/m^2 ", Pd
       *1000);
```

Scilab code Exa 2.47 Find the max radiated electric field and what is the max power density

```
1  //Ex:2.47
2  clc;
3  clear;
4  close;
5  l=1.2/100;// length in m
6  Im=2.8;// peak current in Amp
7  f=1*10^9;// frequency in Hz
8  c=3*10^8;// the speed of light in m/s
9  y=c/f;// wavelength in m
10 x=90;// angle in degree
11 x1=x*%pi/180;// angle in radian
12 r=10;// in m
13 n=120*%pi;// efficiency
14 Emax=(n*Im*l*sin(x1))/(2*r*y);// max radiated
       electric field in V/m^2
15 Pmax=Emax^2/n;// max power density in W/m^2
```

```
16  printf("The max radiated electric field = %f V/m",
        Emax);
17  printf("\n The max power density = %f W/m", Pmax);
```

Scilab code Exa 2.48 Find the peak poynting vector and the average poynting vector and also the peak value of magnetic field H

```
1  //Ex:2.48
2  clc;
3  clear;
4  close;
5  E=10;// peak electric field in V/m
6  n=120*%pi;// efficiency
7  H=E/n;// peak magnetic field At/m
8  Ppeak=E*H;// peak poynting vector in W/m^2
9  Pav=(E^2)/(2*n);// average poynting vector in W/m^2
10 printf("The peak magnetic field = %f At/m", H);
11 printf("\n The peak poynting vector = %f W/m^2",
        Ppeak);
12 printf("\n The average poynting vector = %f W/m^2",
        Pav);
```

Scilab code Exa 2.49 Find the magnitude of magnetic and electric fields

```
1  //Ex:2.49
```

```
2  clc;
3  clear;
4  close;
5  Pav=100;// power density in W/m^2
6  E=8.85*10^-12;
7  V=3*10^8;// velocity in m/s
8  Eo=sqrt((2*Pav)/(E*V));// peak value of electric
       field in V/m
9  n=120*%pi;// efficiency
10 H=Eo/n;// magnetic field in AT/m
11 printf("The peak value of electric field = %f V/m",
       Eo);
12 printf("\n The magnetic field = %f AT/m", H);
```

Scilab code Exa 2.50 Find the rms electric and magnetic field and the average value of poynting vector and the average energy density and also the time it takes a signal to reach earth

```
1  //Ex:2.50
2  clc;
3  clear;
4  close;
5  R=3.8*10^5;// earth moon distance in km
6  R1=3.8*10^5*10^3;// earth moon distance in m
7  Pt=1;// transmitter power in Watts
8  Pd=Pt/(4*%pi*R^2);// power density at earth in W/m^2
9  n=120*%pi;// efficiency
10 pn=5.513*10^-13;// multiplication of P(poynting
       vector) and n(efficiency)
11 E=sqrt(2*Pd*n);// electric field in V/m
12 Erms=E/sqrt(2);// rms value of E
```

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```
13  Hrms=Erms/n ;// rms value of H
14  c=3*10^8;// the speed of light in m/s
15  t=R1/c ;// time taken by the signal to reach earth
16  printf("The power density at earth = %f*10^-13 W/m^2
        ", Pd*10^13);
17  printf("\n The rms value of E = %f*10^-5 V/m", Erms
        *10^5);
18  printf("\n The rms value of H = %f*10^-8 AT/m", Hrms
        *10^8);
19  printf("\n The time taken by the signal to reach
        earth = %f sec", t);
```

Chapter 3

Antenna Arrays

Scilab code Exa 3.1 Calculate the half power beam width of the major lobes of the array in horizontal plane

```
1  //Ex:3.1
2  clc;
3  clear;
4  close;
5  // the path difference , x=dcos(a)
6  // therefore , phase difference , w=(2*%pi/y)*dcos(a)
       =Bdcos(a)
7  // from the geometry of the figure in the far field
       r>>d
8  // r1=r+x=r+dcos(a)
9  // r2=r-x=r-dcos(a)
10 // Hence , Et=I1exp^(-jB(r+dcos(a)))+I2exp^(-jB(r-
       dcos(a)))
11 // Et=exp^(-jBr)(I1exp^(-jBdcos(a))+I2exp^(-jBdcos(a
       )))
12 // case (a): in case I, we have I1=I2=I
13 // Hence , Et=Iexp^(-jBr)*(exp^(-jBdcos(a))+exp^(-
       jBdcos(a)))=2exp^(-jBr)*cos(Bdcos(a))
14 // Et will be max when cos(Bdcos(a)) will be max.
       therefore
```

```
15  //  cos(Bd*cos(a))=1
16  //  Bd*cos(a)=0
17  //  a_max=n*%pi/2, where n=1,2,3,........
18  //  hence , for the half power point a_HPPD
19  //  cos(Bd*cos(a))=1/(sqrt(2))
20  //  Bd*cos(a)=%pi/4
21  //  cos(a_HPPD)=%pi/4Bd= %pi/(4*2%pi*0.75y/y)=1/6
22  //  a_HPPD=acos(1/6)
23  a_HPPD=(acos(1/6)*180/%pi);// the half power point
        in degree
24  a_m=2*a_HPPD;// the half power beam width in degree
25  //  In case I1=I and I2=Iexp^(j540)=Iexp^(j180)=-I
26  //  therefore , Et2=Iexp^(-jBr)*(exp^(-jBdcos(a))+exp
        ^(-jBdcos(a)))
27  //  =2j*I*exp^(-jBd)*sin(Bdcos(a))
28  //  The max value of sin(Bdcos(a)) is at a=%pi. When
29  //  sin(Bd*cos(a))=sin(Bd*cos(%pi))=sin(-Bd)=sin(-2*
        %pi*3y/(y*4))=sin(-3%Pi/2)=1
30  //  Hence at the half power point a_HPPD2
31  //  sin(Bd*cos(a))=1/(sqrt(2))
32  //  Bd*cos(a_HPPD2)=%pi/4
33  //  cos(a_HPPD2)=%pi/(4*2%pi*0.75y/y)=1/6
34  a_HPPD2=(acos(1/6)*180/%pi);// the half power point
        in degree
35  a_m2=2*a_HPPD2;// the half power beam width in
        degree
36  printf("The half power beam width for broad side
        array = %f degree", a_m);
37  printf("\n The half power beam width for end fire
        array = %f degree", a_m2);
```

Scilab code Exa 3.2 Calculate the progressive phase shifts and also Calculate the angle at which the main beam is placed for this phase distribution

```
1  //Ex:3.2
2  clc;
3  clear;
4  close;
5  // The phase difference w=Bd*cos(a)=(2%pi/y)*(y/4)*
      cos(a)=(%pi/2)*cos(a)
6  // Therefore, Et=Io(exp^(-j(%pi/2*cos(a)+k))+1+exp^(
      j(%pi/2*cos(a)+infinite)))=Eo(1+2*cos(%pi/2*cos(a
      +k)))
7  // the null appear, when, 1+2*cos((%pi/2)*cos(a_n)+k
      ), a_n is equal to 33.56
8  // therefore , 1+2*cos((%pi/2)*cos(33.56)+k)=0
9  // cos((%pi/2)*cos(33.56)+k)=-1/2
10 // (%pi/2)*cos(33.56)+k= 2%pi/3
11 // k=(2%pi/3)-((%pi/2)*cos(33.56))
12 k=(2*%pi/3)-((%pi/2)*cos(33.56*%pi/180));//
      progressive phase shift in radian
13 k1=k*180/%pi;// progressive phase shift in degree
14 // The position of main beam a_m occurs when
15 // ((%pi/2)*cos(a_m))+B=0
16 // cos(a_m)= -B*2/%pi=-(%pi/4)*(2/%pi)=-1/2
17 a_m=(acos(-1/2)*180/%pi);// the position of main
      beam width in degree
18 printf("The progressive phase shift = %d degree", k1
      );
19 printf("\n The position of main beam width in degree
       = %d degree", a_m);
```

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Scilab code Exa 3.3 Discuss the radiation pattern of a linear array

```
1  //Ex:3.3
2  clc;
3  clear;
4  close;
5  // The phase difference, w=Bd*cos(a)+k
6  // In this case, d=y/2, k=0, therefore
7  // w= (2%pi/y)*(y/2)*cos(a)+0= %pi*cos(a)
8  // The total far field at distance point P is given
       by
9  // Et=Eo(exp^(-jw)+2+exp^(jw))=Eo*(2+2*cos(w))=2*Eo
       (1+cos(%pi*cos(a)))
10 // Maximum value mode of Et=4*Eo
11 // so the normal value Enor=Et/(mode of Et)=(1+cos(
       %pi*cos(a)))/2
12 // For the max value (1+cos(%pi*cos(a))) should be
       max , therefore
13 // 1+cos(%pi*cos(a))=1
14 // cos(%pi*cos(a))=0
15 // %pi*cos(a)=%pi/2( in both sign plus & minuse)
16 a_m1=(acos(1/2))*(180/%pi);// when take + sign ,
       angle will be in degree
17 a_m2=(acos(-1/2))*(180/%pi);//when take - sign ,
       angle will be in degree
18 // For the max value (1+cos(%pi*cos(a))) should be
       max , therefore
19 // 1+cos(%pi*cos(a))=0
20 // cos(%pi*cos(a))=-1
21 // %pi*cos(a)=%pi( in both sign plus & minuse)
22 a_m3=(acos(1))*(180/%pi);// when take + sign , angle
       will be in degree
23 a_m4=(acos(-1))*(180/%pi);//when take - sign , angle
       will be in degree
24 // for HPPD (1+cos(%pi*cos(a))) should be 1/sqrt(2)
25 // 1+cos(%pi*cos(a))=1/sqrt(2)
26 // cos(%pi*cos(a))=(1/sqrt(2))-1=-0.293
27 // %pi*cos(a)=107 degree    ( in both sign plus &
```

```
         minuse )
28  //  cos ( a_HPPD )=0.595    (  in  both  sign  plus  &  minuse )
29  a_HPPD1 =( acos (0.595) ) *(180/%pi ) ;// when  take  +  sign ,
        the  value  of  a_HPPD  in  degree
30  a_HPPD2 =( acos ( -0.595) ) *(180/%pi ) ;// when  take  −  sign
        ,  the  value  of  a_HPPD  in  degree
31  printf ( "when  take  +  sign ,  angle  for  maxima  = %d
        degree" ,  a_m1 ) ;
32  printf ( "\n  when  take  −  sign ,  angle  for  maxima= %d
        degree" ,  a_m2 ) ;
33  printf ( "\n  when  take  +  sign ,  angle  for  minima= %d
        degree" ,  a_m3 ) ;
34  printf ( "\n  when  take  −  sign ,  angle  for  minima= %d
        degree" ,  a_m4 ) ;
35  printf ( "\n  when  take  +  sign ,  the  value  of  HPPD= %d
        degree" ,  a_HPPD1 ) ;
36  printf ( "\n  when  take  −  sign ,  the  value  of  HPPD= %d
        degree" ,  a_HPPD2 ) ;
37  printf ( "\n  The  Radiation  pattern  of  the  3−element  is
         shown  in  figure  in  the  given  text  book" ) ;
```

Scilab code Exa 3.4 Design a eight element broad side array

```
1  //Ex:3.4
2  clc ;
3  clear ;
4  close ;
5  dB =26;
6  n =8; // eight  element  array
7  r1 =10^( dB /20) ; // because  dB=20 log ( r )
8  r = ceil ( r1 ) ; // round  off  value  of  r1
```

```
9  // Tchebyscheff polynomial of degree (n-1)=8-1=7
10 // T7(xo)=r
11 // 64Xo^7-112xo^5+56xo^3-7xo=20
12 // then using ulternate formula, we get the value of
       xo
13 m=n-1;// degree of the equation
14 a=sqrt(r^2-1);
15 A=(r+a)^(1/m);
16 B=(r-a)^(1/m);
17 xo1=.5*(A+B);
18 xo=1.15;// approx. value of xo1
19 // eight element array is shown in figure in the
       given textbook
20 // Thus Et, i.e., E8 from the equation
21 // E8=aoz+a1(4z^3-3z)+a2(16z^5-20z^3+5z)+a3(64z
       ^7-112z^5+56z^3-7z)=64x^7-112x^5+56x^3-7x, where
       z=(x/xo)
22 // Then on putting z=(x/xo), we get
23 // ao(x/xo)+a1(4(x/xo)^3-3(x/xo))+a^2(16(x/xo)^5-20(
       x/xo)^3+5(x/xo))+a^3(64(x/xo)^7-112(x/xo)^5+56(x/
       xo)^3-7(x/xo))=64x^7-112x^5+56x^3-7x
24 // Now equating terms, we have
25 a3=xo^7;
26 a2=(112*a3-112*xo^5)/16;
27 a1=14*xo^3+5*a2-14*a3;
28 ao=3*a1-5*a2+7*a3-7*xo;
29 // Therefore the relative amplitude of the array are
30 a33=a3/a3;// the ratio of the a3 to a3
31 a23=a2/a3;// the ratio of the a2 to a3
32 a13=a1/a3;// the ratio of the a1 to a3
33 ao3=ao/a3;// the ratio of the ao to a3
34 printf("The value of the parameter r= %d", r);
35 printf("\n The value of the parameter xo= %f", xo);
36 printf("\n The value of the current amplitude
       parameter ao= %f", ao);
37 printf("\n The value of the current amplitude
       parameter a1= %f", a1);
38 printf("\n The value of the current amplitude
```

```
        parameter a2= %f", a2 );
39  printf ("\n The value of the current amplitude
        parameter a3= %f", a3 );
40  printf ("\n The value of the relative amplitude
        parameter a33= %f", a33 );
41  printf ("\n The value of the relative amplitude
        parameter a23= %f", a23 );
42  printf ("\n The value of the relative amplitude
        parameter a13= %f", a13 );
43  printf ("\n The value of the relative amplitude
        parameter ao3= %f", ao3 );
44  printf ("\n The five element array is shown in figure
         in the given textbook")
```

Scilab code Exa 3.5 Design a five element broad side array which has the optimum pattern

```
1  //Ex:3.5
2  clc ;
3  clear ;
4  close ;
5  dB =20;
6  n =5;// five element array
7  r =10^(dB/20);// because dB=20log(r)
8  // Tchebyscheff polynomial of degree (n−1)=5−1=4
9  // T4(xo)=r
10 // 8xo^4−8xo^2+1=10
11 // then using ulternate formula, we get the value of
        xo
12 m =4;// degree of the equation
13 a =sqrt (r^2-1);
```

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```
14  A=(r+a)^(1/m);
15  B=(r-a)^(1/m);
16  xo=.5*(A+B);
17  // five element array is shown in figure in the
        given textbook
18  // Thus Et, i.e., E5 from the equation
19  // E5=aoz+a1(2z^2-1)+a2(8z^4-8z^2+1), where z=(x/xo)
20  // E5=T4(xo)
21  // ao(x/xo)+a1(2(x/xo)^2-1)+a2(8(x/xo)^4-8(x/xo)
        ^2+1)=8x^4-8x^2+1
22  // Now equating terms, we have
23  // a2(x/xo)^4=x^4
24  a2=xo^4;
25  // a1*2(x/xo)^2-a2*8(x/xo)^2=-8x^2
26  a1=4*a2-4*xo^2;
27  // ao-a1+a2=1
28  ao=1+a1-a2;
29  // Therefore the relative amplitude of the array are
30  a11=a1/a1;// the ratio of the a1 to a1
31  a12=a1/a2;// the ratio of the a1 to a2
32  a02=2*ao/a2;// the ratio of the 2ao to a2
33  printf("The value of the parameter r= %d", r);
34  printf("\n The value of the parameter xo= %f", xo);
35  printf("\n The value of the current amplitude
        parameter 2*ao= %f", 2*ao);
36  printf("\n The value of the current amplitude
        parameter a1= %f", a1);
37  printf("\n The value of the current amplitude
        parameter a2= %f", a2);
38  printf("\n The value of the relative amplitude
        parameter a11= %f", a11);
39  printf("\n The value of the relative amplitude
        parameter a12= %f", a12);
40  printf("\n The value of the relative amplitude
        parameter a02= %f", a02);
41  printf("\n The five element array is shown in figure
        in the given textbook")
```

Scilab code Exa 3.6 Design a four element broad side array

```
 1 //Ex:3.6
 2 clc;
 3 clear;
 4 close;
 5 dB=18;
 6 n=4;// five element array
 7 r1=10^(dB/20);// because dB=20log(r1)
 8 r=ceil(r1);
 9 // Tchebyscheff polynomial of degree (n-1)=4-1=4
10 // T3(xo)=r
11 // 4xo^3-3xo=8
12 // then using ulternate formula, we get the value of
      xo
13 m=3;// degree of the equation
14 a=sqrt(r^2-1);
15 A=(r+a)^(1/m);
16 B=(r-a)^(1/m);
17 xo1=.5*(A+B);
18 xo=1.46;// approx. value of xo1 is 1.46 because xo1
      =1.456957
19 // four element array is shown in figure in the
      given textbook
20 // Thus Et, i.e., E4 from the equation
21 // E4=aoz+a1(4z^3-3z), where z=(x/xo)
22 // E4=T3(xo)
23 // ao(x/xo)+a1(4(x/xo)^3-3(x/xo))=4x^3-3x
24 // Now equating terms, we have
25 // 4a1(x/xo)=4x^3
```

```
26  a1 = xo ^3 ;
27  // ao−3a1=−3a1
28  ao =3* a1 -3* xo ;
29  // Therefore the relative amplitude of the array are
30  a11 = a1 / a1 ;// the ratio of the a1 to a1
31  ao1 = ao / a1 ;// the ratio of the ao to a1
32  printf ("The value of the parameter r= %d", r);
33  printf ("\n The value of the parameter xo= %f", xo);
34  printf ("\n The value of the current amplitude
        parameter ao= %f", ao);
35  printf ("\n The value of the current amplitude
        parameter a1= %f", a1);
36  printf ("\n The value of the relative amplitude
        parameter a11= %f", a11);
37  printf ("\n The value of the relative amplitude
        parameter ao1= %f", ao1);
38  printf ("\n The five element array is shown in figure
        in the given textbook")
```

Scilab code Exa 3.7 Determine Dolph Tchebyscheff current distribution and also determine the half power beam width

```
1  //Ex:3.7
2  clc ;
3  clear ;
4  close ;
5  dB =21 ;
6  n =5 ;// five element array
7  r1 =10^( dB /20) ;// because dB=20 log ( r1 )
8  r = floor ( r1 ) ;
9  // Tchebyscheff polynomial of degree (n−1)=5−1=4
```

```
10  //  T4(xo)=r
11  //  8xo^4-8xo^2+1=20
12  //  then using ulternate formula, we get the value of
         xo
13  m=4;// degree of the equation
14  a=sqrt(r^2-1);
15  A=(r+a)^(1/m);
16  B=(r-a)^(1/m);
17  xo1=.5*(A+B);
18  xo=1.3132;// approx. value of xo1 is 1.3132 because
       xo1=1.313295
19  // Thus Et, i.e., E5 from the equation
20  // E5=aoz+a1(2z^2-1)+a2(8z^4-8z^2+1), where z=(x/xo)
21  // E5=T4(xo)
22  // ao(x/xo)+a1(2(x/xo)^2-1)+a2(8(x/xo)^4-8(x/xo)
       ^2+1)=8x^4-8x^2+1
23  // Now equating terms, we have
24  // a2(x/xo)^4=x^4
25  a2=xo^4;
26  // a1*2(x/xo)^2-8(x/xo)^2*a2=-8x^2
27  // a1-4a2=-4x^2
28  a1=4*a2-4*xo^2
29  // ao-a1+a2=1
30  ao=a1-a2+1;
31  a22=a2/a2;// the ratio of the a2 to a2
32  a12=a1/a2;// the ratio of the a1 to a2
33  ao2=2*ao/a2;// the ratio of the 2ao to a2
34  R=r/sqrt(2);
35  // Y=acos(R/sqrt(2))= log(R+sqrt(R^2-1))
36  Y=log(R+sqrt(R^2-1))/log(10);
37  //  cosh(Y/4)=cosh(1.19/4)=cosh(0.2975)
38  //  because  cosh(x)= 1+(x^2/2)+(x^4/24)+.....
39  //  cosh(0.2975)=1+(0.2975^2/2)+(0.2975^4/24)
40  A=1+(0.2975^2/2)+(0.2975^4/24);
41  // HPBW= 2*asin((y/180*d)*acos(1/x0*cosh(Y/4)))
42  // HPBW= 2*asin((y*2/180*y)*acos(1/x0*cosh(0.2975)))
43  // HPBW= 2*asin((2/180)*acos(1/x0*A))
44  HPBW=2*(asin((2/180)*(acos(A/xo))*(180/%pi)))*180/
```

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```
       %pi ;// half power bandwidth in degree
45 printf (" The value of the parameter r= %d" , r );
46 printf (" \n The value of the parameter xo= %f" , xo );
47 printf (" \n The value of the current amplitude
       parameter ao= %f" , ao );
48 printf (" \n The value of the current amplitude
       parameter a1= %f" , a1 );
49 printf (" \n The value of the current amplitude
       parameter a2= %f" , a2 );
50 printf (" \n The value of the relative amplitude
       parameter a22= %f" , a22 );
51 printf (" \n The value of the relative amplitude
       parameter a12= %f" , a12 );
52 printf (" \n The value of the relative amplitude
       parameter ao2= %f" , ao2 );
53 printf (" \n The half power bandwidth= %f degree" ,
       HPBW );
54 printf (" \n The five element array is shown in figure
        in the given textbook" )
```

Scilab code Exa 3.8 Design an array to yield an optimum pattern

```
1 // Ex :3.8
2 clc ;
3 clear ;
4 close ;
5 m =5;// number of elements
6 xn =45/2;// mean beamwidth in degree
7 xn1 = xn *%pi /180;// mean beamwidth in radian
8 x = cos ((180/(2*( m -1)))*(%pi /180));
9 a = sin ( xn1 );
```

```scilab
10  p=cos(90*a*(%pi/180));
11  xo=x/p;
12  // E5=aoz+a1(2z^2-1)+a2(8z^4-8z^2+1), where z=(x/xo)
13  // E5=T4(xo)
14  //  ao(x/xo)+a1(2(x/xo)^2-1)+a2(8(x/xo)^4-8(x/xo)
       ^2+1)=8x^4-8x^2+1
15  // Now equating terms, we have
16  //  a2(x/xo)^4=x^4
17  a2=xo^4;
18  //  a1*2(x/xo)^2-8(x/xo)^2*a2=-8x^2
19  //  a1-4a2=-4x^2
20  a1=4*a2-4*xo^2
21  //  ao-a1+a2=1
22  ao=a1-a2+1;
23  a22=a2/a2;// the ratio of the a2 to a2
24  a12=a1/a2;// the ratio of the a1 to a2
25  ao2=2*ao/a2;// the ratio of the 2ao to a2
26  printf("The value of the parameter xo = %f um", xo);
27  printf("\n The value of the current amplitude
       parameter ao= %f", ao);
28  printf("\n The value of the current amplitude
       parameter a1= %f", a1);
29  printf("\n The value of the current amplitude
       parameter a2= %f", a2);
30  printf("\n The value of the relative amplitude
       parameter a22= %f", a22);
31  printf("\n The value of the relative amplitude
       parameter a12= %f", a12);
32  printf("\n The value of the relative amplitude
       parameter ao2= %f", ao2);
33  printf("\n The five element array is shown in figure
        in the given textbook")
```

Scilab code Exa 3.9 Calculate the directivity of a given linear broad side

```
1  //Ex:3.9
2  clc;
3  clear;
4  close;
5  n=20;// number of isotropic array
6  // d=y/8, where y is wavelength
7  // then, D=2n(d/y)=2n((y/8)(1/y))=2n(1/8)
8  D=2*n*(1/8);// directivity of a linear broad-side
       array
9  printf("The directivity of a linear broad-side array
        = %d dimensionless", D);
```

Scilab code Exa 3.10 Calculate the Dolph Tchebysceff distribution which yield the optimum pattern

```
1  //Ex:3.10
2  clc;
3  clear;
4  close;
5  xnp=35;// beam width in degree
6  xnp1=(xnp/2)*(%pi/180);// half beam width in degree
7  // T(m-1)(x)=0 or T(8-1)(x)=0, or T(7)(x)=0
```

```
8   //  cos ((m-1)*acos(x))=0
9   //  (8-1)*acos(x)=cos(2k-1)*(%pi/2)
10  //  acos(x)=(2k-1)*pi/14
11  //  for   first  nulls , k=1
12  //  acos(x)=pi/14;
13  x=cos(%pi/14);
14  //  but  z=x/xo=cos(p/2)
15  //  p=Bd*sin(xnp1)
16  //  p/2=Bd*sin(xnp1)/2
17  //  x/xo=cos(Bd*sin(xnp1)/2)
18  //  and  Bd*sin(a)=(2*%pi/y)*(y/2)*(1/2)*sin(xnp1)
19  //  and  Bd*sin(xnp1)=90*sin(xnp1)
20  xo=x/(cos((90*sin(xnp1)*(%pi/180))));
21  //  aoz+a1(4z^3-3z)+a2(16z^5-20z^3+5z)+a3(64z^7-112z
        ^5+56z^3-7z)=64x^7-112x^5+56x^3-7x, where  z=(x/xo
        )
22  //  Then  on  putting  z=(x/xo), we  get
23  //  ao(x/xo)+a1(4(x/xo)^3-3(x/xo))+a2(16(x/xo)^5-20(x
        /xo)^3+5(x/xo))+a3(64(x/xo)^7-112(x/xo)^5+56(x/xo
        )^3-7(x/xo))=64x^7-112x^5+56x^3-7x
24  //  on  comparing  the  terms , we  get  ao=3.339,a1=2.919,
        a2=2.191,a3=1.886
25  ao=3.339;
26  a1=2.919;
27  a2=2.191;
28  a3=1.886;
29  a33=a3/a3;//  the  ratio  of  the  a3  to  a3
30  a23=a2/a3;//  the  ratio  of  the  a2  to  a3
31  a13=a1/a3;//  the  ratio  of  the  a1  to  a3
32  ao3=ao/a3;//  the  ratio  of  the  ao  to  a3
33  printf("The  value  of  the  parameter  xo = %f", xo);
34  printf("\n The  value  of  the  amplitude  parameter  ao=
        %f", ao);
35  printf("\n The  value  of  the  amplitude  parameter  a1=
        %f", a1);
36  printf("\n The  value  of  the  amplitude  parameter  a2=
        %f", a2);
37  printf("\n The  value  of  the  amplitude  parameter  a3=
```

```
      %f " ,  a3 ) ;
38  printf ( " \n  The  value  of  the  relative  amplitude
         parameter  a33=  %f " ,  a33 ) ;
39  printf ( " \n  The  value  of  the  relative  amplitude
         parameter  a23=  %f " ,  a23 ) ;
40  printf ( " \n  The  value  of  the  relative  amplitude
         parameter  a13=  %f " ,  a13 ) ;
41  printf ( " \n  The  value  of  the  relative  amplitude
         parameter  ao3=  %f " ,  ao3 ) ;
42  printf ( " \n  The  five  element  array  is  shown  in  figure
           in  the  given  textbook " )
```

Scilab code Exa 3.11 Design an array that will produce approximately a pattern of the given figure

```
1  //Ex:3.11
2  clc ;
3  clear ;
4  close ;
5  //  The  given  pattern  is  defined  as
6  //  f ( x )=1,    0<x<pi /3
7  //  f ( x )=0,    pi /3<x<2*pi /3
8  //  f ( x )=1,    2*pi /3<x<pi
9  //  It  will ,  of  course ,  by  symmetrical  about  the  line
           of  the  array  x=0.  If  the  spacing  is  closer  to  be
           y /2 ,  then  p=pi*cos ( x )+a
10  //  f ( p )=1,       pi+a  >  p  >  pi /2+a
11  //  f ( p )=0,       pi /2+a  >  p  >  −pi /2+a
12  //  f ( p )=1,       −pi /2+a  >  p  >  −pi+a
13  //  choosing  a=−pi  for  an  end  fire  array  results  in
           the  function  shown  in  figure  in  the  given  text
```

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```
        book . The fourier series expansion for this
        function is
14  //  F(p)=(1/2)+((2/ pi )* sigma (1/k* sin (k* pi /2)* cos (kp))
        ) , k varies from 1 to infinite
15  //  Therefore the coefficient
16  //  ao=1/2
17  //  ak=(1/ pi *k) *( sin ( pi *k/2) )
18  //  bk=0, k not equal to 0
19  //  The pattern obtained using the value of m=4 is
        given as
20  //  mode (E)= (1/ pi )*( -(1/3) *z ^ -3)+z ^ -1+ pi /2+z -(1/3) *z
        ^3
21  printf (" The fire element array having the current
        ratios indicated and an overall length of three
        wavelength ( the apparent spacing between elements
         is one half wavelength , but four of the elements
         are missing ) . The pattern produced by this array
         is shown in figure in the given textbook ")
```

Scilab code Exa 3.12 Prove that the directivity of an end fire array

```
1  // Ex : 3.12
2  clc ;
3  clear ;
4  close ;
5  //  D=4*%pi *E(x , y )max /( double integration of ( f (x , y )*
        sin (x)) with limit from 0 to 2* pi & other from 0
        to pi )
6  //  E(x)=Eo*( sin (n* si /2) )/ sin ( si /2)=E( x )=( sin (2* si /2)
        )/ sin ( si /2)=E( x )=( sin ( si ) )/ sin ( si /2) ,      for=Eo
        =1, n=2
```

```
7  // E(x)=2*cos(si/2)
8  // (E(x))^2=2*(1+cos(si))
9  // si=Bd*cos(x)+a, and a=-Bd
10 // then, si=Bd*cos(x)-Bd
11 A=2*(1+cos(0));// the value of (E(x))^2max
12 // Now on putting the value of (E(x))^2max and (E(x)
       )^2, we get
13 // D=4*pi*4/(2*pi)*integrate('2(1+cos(y)*sin(x))','x
       ',0,pi)
14 // then D=4/(integrate('(1+cos(y)*sin(x))','x',0,pi)
       )
15 // D=4/(integrate('sin(x)+cos(y)*sin(x)','x',0,pi))
16 // On solving this, we get,
17 // D=4/(2+sin(2Bd)/Bd)=2/(1+sin(2Bd)/2Bd)
18 printf("The directivity of an end fire array, D
       =2/(1+sin(2Bd)/2Bd)");
```

Scilab code Exa 3.13 Prove that directivity for a broadside array of two identical isotropic

```
1 //Ex:3.13
2 clc;
3 clear;
4 close;
5 // D=4*%pi*E(x,y)max/(double integration of (f(x,y)*
       sin(x)) with limit from 0 to 2*pi & other from 0
       to pi)
6 // E(x)=Eo*(sin(n*si/2))/sin(si/2)=E(x)=(sin(2*si/2)
       )/sin(si/2)=E(x)=(sin(si))/sin(si/2), for=Eo
       =1, n=2
7 // E(x)=2*cos(si/2)
```

```
8  // (E(x))^2=2*(1+cos(si))
9  // si=Bd*cos(x)+a, and a=-Bd
10 // then, si=Bd*cos(x)-Bd
11 A=2*(1+cos(0)); // the value of (E(x))^2max
12 // Now on putting the value of (E(x))^2max and (E(x)
      )^2, we get
13 // D=4*pi*4/(2*pi)*integrate('2(1+cos(y)*sin(x))','x
      ',0,pi)
14 // then D=4*pi*4/(integrate('(1+cos(y)*sin(x))','x
      ',0,pi))
15 // D=4*pi*4/(integrate('(1+cos(y)*sin(x))','x',0,pi)
      )
16 // D=4*pi*4/(integrate('sin(x)+cos(y)*sin(x)','x',0,
      pi))
17 // On solving this, we get, D=4*pi*4/(2*pi(2+2.sin(
      Bd)/Bd))=4/2*(1+sin(Bd)/Bd)
18 // and finally, D=2/(1+sin(Bd)/Bd)
19 printf("The directivity for a broadside array, D
      =2/(1+sin(Bd)/Bd)");
```

Scilab code Exa 3.14 Calculate the Dolph Tchebyscheff distribution which yield the optimum pattern

```
1 //Ex:3.14
2 clc;
3 clear;
4 close;
5 xnp=45; // beam width in degree
6 xnp1=(xnp/2)*(%pi/180); // half beam width in degree
7 // T(n-1)(x)=0 or T(8-1)(x)=0, or T(7)(x)=0
8 // cos((m-1)*acos(x))=0
```

```
9  //  (8−1)∗acos(x)=cos(2k−1)∗(%pi/2)
10  //  acos(x)=(2k−1)∗pi/14
11  //  for  first  nulls ,  k=1
12  //  acos(x)=pi/14;
13  x=cos(%pi/14);
14  //  but  z=x/xo=cos(p/2)
15  //  p=Bd∗sin(xnp1)
16  //  p/2=Bd∗sin(xnp1)/2
17  //  x/xo=cos(Bd∗sin(xnp1)/2)
18  //  and  Bd∗sin(a)=(2∗%pi/y)∗(y/2)∗(1/2)∗sin(xnp1)
19  //  and  Bd∗sin(xnp1)=90∗sin(xnp1)
20  xo=x/(cos((90*sin(xnp1)*(%pi/180))));
21  //  aoz+a1(4z^3−3z)+a^2(16z^5−20z^3+5z)+a^3(64z^7−112
       z^5+56z^3−7z)=64x^7−112x^5+56x^3−7x,  where  z=(x/
       xo)
22  //  Then  on  putting  z=(x/xo),  we  get
23  //  ao(x/xo)+a1(4(x/xo)^3−3(x/xo))+a^2(16(x/xo)^5−20(
       x/xo)^3+5(x/xo))+a^3(64(x/xo)^7−112(x/xo)^5+56(x/
       xo)^3−7(x/xo))=64x^7−112x^5+56x^3−7x
24  //  on  comparing  the  terms ,  we  get  ao=12.3858,a1
       =10.0506,a2=6.4106,a3=3.223
25  ao=12.3858;
26  a1=10.0506;
27  a2=6.4106;
28  a3=3.223;
29  a33=a3/a3;//  the  ratio  of  the  a3  to  a3
30  a23=a2/a3;//  the  ratio  of  the  a2  to  a3
31  a13=a1/a3;//  the  ratio  of  the  a1  to  a3
32  ao3=ao/a3;//  the  ratio  of  the  ao  to  a3
33  printf("The  value  of  the  parameter  xo =  %f", xo);
34  printf("\n The  value  of  the  current  amplitude
       parameter  ao=  %f", ao);
35  printf("\n The  value  of  the  current  amplitude
       parameter  a1=  %f", a1);
36  printf("\n The  value  of  the  current  amplitude
       parameter  a2=  %f", a2);
37  printf("\n The  value  of  the  current  amplitude
       parameter  a2=  %f", a3);
```

```
38  printf(”\n The value of the relative amplitude
        parameter a33= %f”, a33);
39  printf(”\n The value of the relative amplitude
        parameter a23= %f”, a23);
40  printf(”\n The value of the relative amplitude
        parameter a13= %f”, a13);
41  printf(”\n The value of the relative amplitude
        parameter ao3= %f”, ao3);
42  printf(”\n The five element array is shown in figure
         in the given textbook”)
```

Scilab code Exa 3.15 Determine Dolph Tchebyscheff current distribution
for the minimum beamwidth of a linear in phase broad side array of eight
isotropic source

```
1   //Ex:3.15
2   clc;
3   clear;
4   close;
5   dB=40;
6   n=8;// five element array
7   r1=10^(dB/20);// because dB=20log(r1)
8   r=floor(r1);
9   // Tchebyscheff polynomial of degree (n−1)=8−1=4
10  //  T7(xo)=r
11  //  64xo^7−112xo^5+56xo^3−7xo=r
12  // then using ulternate formula, we get the value of
         xo
13  m=7;// degree of the equation
14  a=sqrt(r^2-1);
15  A=(r+a)^(1/m);
```

```
16  B=(r-a)^(1/m);
17  xo1=.5*(A+B);
18  xo=1.3244;// approx. value of xo1
19  // Thus Et, i.e., E8 from the equation
20  // E8=aoz+a1(4z^3-3z)+a^2(16z^5-20z^3+5z)+a^3(64z
      ^7-112z^5+56z^3-7z)=64x^7-112x^5+56x^3-7x, where
      z=(x/xo)
21  // Then on putting z=(x/xo), we get
22  // ao(x/xo)+a1(4(x/xo)^3-3(x/xo))+a^2(16(x/xo)^5-20(
      x/xo)^3+5(x/xo))+a^3(64(x/xo)^7-112(x/xo)^5+56(x/
      xo)^3-7(x/xo))=64x^7-112x^5+56x^3-7x
23  // Now equating terms, we have
24  a3=xo^7;
25  a2=7*a3-7*xo^5;
26  a1=14*xo^3+5*a2-14*a3;
27  ao=-7*xo+3*a1-5*a2+7*a3;
28  a33=a3/a3;// the ratio of the a3 to a3
29  a23=a2/a3;// the ratio of the a2 to a3
30  a13=a1/a3;// the ratio of the a1 to a3
31  ao3=ao/a3;// the ratio of the ao to a3
32  R=r/sqrt(2);
33  // Y=acos(R/sqrt(2))= log(R+sqrt(R^2-1))
34  Y=(1/7)*log(R+sqrt(R^2-1))/log(10);
35  // cosh(Y/4)=cosh(1.19/4)=cosh(0.2975)
36  // because cosh(x)= 1+(x^2/2)+(x^4/24)+....
37  // cosh(0.3072)=1+(0.3072^2/2)+(0.3072^4/24)
38  K=1+(0.3072^2/2)+(0.3072^4/24);
39  // HPBW= 2*asin((y/180*d)*acos(1/x0*cosh(Y/4)))
40  // HPBW= 2*asin((y*4/180*3y)*acos(1/x0*cosh(0.3072))
      )
41  // HPBW= 2*asin((4/3*180)*acos(1/x0*K))
42  HPBW=2*(asin((4/540)*(acos(K/xo))*(180/%pi)))*180/
      %pi;// half power bandwidth in degree
43  printf("The value of the parameter r= %d", r);
44  printf("\n The value of the parameter xo= %f", xo);
45  printf("\n The value of the current amplitude
      parameter ao= %f", ao);
46  printf("\n The value of the current amplitude
```

```
     parameter  a1= %f", a1);
47  printf("\n The value of the current amplitude
     parameter a2= %f", a2);
48  printf("\n The value of the current amplitude
     parameter a3= %f", a3);
49  printf("\n The value of the relative amplitude
     parameter a33= %f", a33);
50  printf("\n The value of the relative amplitude
     parameter a23= %f", a23);
51  printf("\n The value of the relative amplitude
     parameter a13= %f", a13);
52  printf("\n The value of the relative amplitude
     parameter ao3= %f", ao3);
53  printf("\n The half power bandwidth= %f degree",
     HPBW);
54  printf("\n The five element array is shown in figure
      in the given textbook")
```

Scilab code Exa 3.16 Find the directivity of linear broad side

```
1  //Ex:3.16
2  clc;
3  clear;
4  close;
5  n=10;// number of isotropic elements
6  // d=y/4
7  // Do=2n*(d/y)
8  // Do=2n*(y/4y)=2n(1/4)
9  Do=2*n*(1/4);
10 D0=10*log(Do)/log(10);// Directivity in db
11 printf("the Directivity = %f dB", D0);
```

Scilab code Exa 3.17 Find the directivity of linear end fire

```
1  //Ex:3.17
2  clc;
3  clear;
4  close;
5  n=10;// number of isotropic elements
6  // d=y/4
7  // Do=4n*(d/y)
8  // Do=4n*(y/4y)=2n(1/4)
9  Do=4*n*(1/4);
10 D0=10*log(Do)/log(10);// Directivity in db
11 printf("the Directivity = %d dB", D0);
```

Scilab code Exa 3.18 Find the directivity of a linear end fire

```
1  //Ex:3.18
2  clc;
3  clear;
4  close;
5  n=10;// number of isotropic elements
6  // d=y/4
7  // Do=1.789(4n*(d/y))
8  // Do=1.789(4n*(y/4y)=2n(1/4))
```

```
9  Do=1.789*(4*n*(1/4));
10 D0=10*log(Do)/log(10);// Directivity in db
11 printf("the Directivity = %f dB", D0);
```

Scilab code Exa 3.19 Define antenna gain and directivity

```
1  //Ex:3.19
2  clc;
3  clear;
4  close;
5  printf("Gain: gain is define as the ratio of max
       radiation. Intensity in a given direction  to the
        max radiation intensity from the reference
       antenna produced in the same direction with same
       power input.");
6  printf("\n Gain=max radiation intensity from test
       antenna/max radiation intensity from reference
       antenna with same power input ");
7  printf("\n Directivity: The max directivity gain is
       called as directivity of an antenna. We can
       defined directivity of antenna as follows. It is
       the ratio of max radiotion intensity to  its
       average raiotion intensity.");
8  printf("\n directivity= max radiation intensity from
        test antenna/average radiation intensity of test
        antenna");
```

Scilab code Exa 3.20 Find the array length and width and what will be these value for a broad side array

```
 1  //Ex:3.20
 2  clc;
 3  clear;
 4  close;
 5  D=30;// directive gain
 6  l=D/4;
 7  // array length L=l*y, where y is wavelength
 8  y=1.5;//
 9  Bw=114.6*sqrt(2/(5*y));// beamwidth of the major
        lobe in degree
10  // for Broadside case
11  // L=(D/2)*y=(30/2)*y=15y=array length
12  y1=15/4;
13  BWFN=114.6/(4*y1);// beamwidth for a broadside array
         in degree
14  printf("The array length = %f*y, where y is
        wavelength", l);
15  printf("\n The beamwidth of the major lobe = %f
        degree", Bw);
16  printf("\n The beamwidth for a broadside array = %f
        degree", BWFN);
```

Scilab code Exa 3.21 Derive the expression for beam width

```
1  //Ex:3.21
2  clc;
3  clear;
4  close;
5  // For N array elements
6  // Etr/Eo=sin(ny/2)/sin(y/2), where y=Bdcos(x)+dl=
       Bdcos(x), because dl=0
7  // The null in the pattern occur when, ny/2=k*%pi
8  // (nBdcos(x))/2=%pi, for the first nulls
9  // or      cos(x)=2*%pi/(nBd)=2*%pi/(n*(2*%pi/L)*(L
       /4))=(4/n)
10 // In the broadeside array main beam is directed in
       x=90 degree. Therefore half beam width will be
11 // a=90-x1
12 // or x1=90-a
13 // Thus   cos(x1)=cos(90-a)=sin(a)
14 // or sin(a)=(4/n)
15 // Now the beam width for n elements array will be 2
       a=2.asin(4/n)
16 // Thus
17 BW1=2*(asin(4/5)*180/%pi);// Bandwidth for n=5
18 BW2=2*(asin(4/6)*180/%pi);// Bandwidth for n=6
19 BW3=2*(asin(4/7)*180/%pi);// Bandwidth for n=7
20 BW4=2*(asin(4/8)*180/%pi);// Bandwidth for n=8
21 BW5=2*(asin(4/9)*180/%pi);// Bandwidth for n=9
22 BW6=2*(asin(4/10)*180/%pi);// Bandwidth for n=10
23 printf("The Bandwidth for n=5 = %f degree", BW1);
24 printf("\n TheBandwidth for n=6 = %f degree", BW2);
```

```
25  printf("\n The Bandwidth for n=7 = %f degree", BW3);
26  printf("\n The Bandwidth for n=8 = %f degree", BW4);
27  printf("\n The Bandwidth for n=9 = %f degree", BW5);
28  printf("\n The Bandwidth for n=10 = %f degree", BW6)
       ;
```

Scilab code Exa 3.22 Find the FNBW and HPBW for a broad side linear array

```
1   //Ex:3.22
2   clc;
3   clear;
4   close;
5   n=20;
6   // d=y/2, where y is wavelength
7   // FNBW=2y/nd, then
8   // FNBW=2y/(n*y/2)=4/n radian
9   FNBW=4/n;// beam width for broad side array in
       radian
10  Fnbw=(180*FNBW)/%pi;// beam width for broad side
       array in degree
11  HPBW=Fnbw/2;// the half power beam width for broad
       side array in degree
12  // d1=y/4, for end fire array
13  // then FNBW1=2*sqrt(2y/nd1)
14  // FNBW1=2*sqrt(2y/(n*y/4))=2*sqrt(8/n)
15  FNBW1=2*sqrt(8/n);// beam width for end fire array
       in radian
16  Fnbw1=(180*FNBW1)/%pi;// beam width for end fire
       array in degree
17  HPBW1=(2/3)*Fnbw1;// the half power beam width for
```

```
          end fire array in degree
18  printf("The beamwidth for a broad side array = %f
        degree", Fnbw);
19  printf("\n The half power beam width for broad side
        array = %f degree", HPBW);
20  printf("\n The beam width for end fire array = %f
        degree", Fnbw1);
21  printf("\n The half power beam width for end fire
        array = %f degree", HPBW1);
```

Scilab code Exa 3.23 Find the location of the first nulls on a either side of beam center

```
1  //Ex:3.23
2  clc;
3  clear;
4  close;
5  n=80;
6  //  sinx=y/(nd)
7  //  sinx=y/(n*y/2)=2/n
8  sinx=2/n;
9  x=asin(sinx)*(180/%pi);// in degree
10 dx=2*x;// the first nulls beam width in degree
11 printf("The first nulls beam width = %f degree",dx);
```

Scilab code Exa 3.24 Calculate the radiated power and also FNBW of the array

```
1  //Ex:3.24
2  clc;
3  clear;
4  close;
5  f=300*10^6;// frequency in Hz
6  c=3*10^10;// the speed of light in cm/sec
7  y=c/f;// wavelength in cm
8  d=y/2;// in cm
9  n=4;
10 I=0.5;// element current in amp
11 Rr=73;// resistence in ohm
12 Prad=n*Rr*I^2;// radiated power in watt
13 // sinx=y/(nd)
14 // sinx=y/(n*y/2)=2/n
15 sinx=2/n;
16 x=asin(sinx)*(180/%pi);// in degree
17 dx=2*x;// the FNBW of the array in degree
18 printf("The radiated power = %d watt",Prad);
19 printf("\n The FNBW of the array = %d degree",dx);
```

Scilab code Exa 3.25 Find the array length and width of the major lobe and what will be these values for broadside array

```
1  //Ex:3.25
2  clc;
3  clear;
4  close;
5  D=30;// directive gain
```

```
6  // D=4L/y=4Nd/y, where L=Nd
7  // then 30=4L/y
8  // L=7.5y
9  L=30/4;
10 // FNBW=2*sqrt(2y/Nd)=2*sqrt(2y/7.5y)
11 // =2*sqrt(2/7.5)
12 FNBW=2*sqrt(2/7.5);// FNBW for end fire array in
      radian
13 Fnbw=FNBW*180/%pi;// FNBW for end fire array in
      degree
14 // FNBW1=2y/Nd=2y/7.5y=2/7.5
15 FNBW1=2/7.5;// FNBW for broad side array in radian
16 Fnbw1=FNBW1*180/%pi;// FNBW for broad side array in
      degree
17 printf("The array length= %f*y, where y is
      wavelength", L);
18 printf("\n The FNBW for end fire array = %f degree",
       Fnbw);
19 printf("\n The FNBW for broad side array = %f degree
      ", Fnbw1);
```

Chapter 4

Practical Antennas

Scilab code Exa 4.1 Design a log periodic antenna for a broadcast band

```
1  //Ex:4.1
2  clc;
3  clear;
4  close;
5  c=3*10^8;// the speed of light in m/s
6  f=88*10^6;// frequency in Hz
7  r=0.95;// in m
8  y=c/f;// wavelength in m
9  l1=y/2;
10 l2=r*l1;
11 l3=r*l2;
12 l4=r*l3;
13 l5=r*l4;
14 d1=0.08*y;
15 d2=r*d1;
16 d3=r*d2;
17 d4=r*d3;
18 d=d1+d2+d3+d4;// overall length of the antenna
       support boom in m
19 printf("The wavelength = %f meter", y);
20 printf("\n The overall length of the antenna support
```

```
boom = %f meter", d);
```

Scilab code Exa 4.2 Find the dimenssions of a three element

```
1  //Ex:4.2
2  clc;
3  clear;
4  close;
5  c=3*10^8;// the speed of light in m/s
6  f=100*10^6;// frequency in Hz
7  y=c/f;// wavelength in m
8  de=y/2;// drive element in m
9  Rf=de+(de*5/100);// reflector in m
10 Df=de-(de*5/100);// director in m
11 sp=0.2*y;// spacing between the elements in m
12 printf("The wavelength = %d meter", y);
13 printf("\n The drive element = %f meter", de);
14 printf("\n The reflector = %f meter", Rf);
15 printf("\n The director = %f meter", Df);
16 printf("\n The spacing between the elements = %f
       meter", sp);
```

Scilab code Exa 4.3 What is the gain in dB and the beam width of a helical antenna

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```
1  //Ex:4.3
2  clc;
3  clear;
4  close;
5  y=3;// wavelength in m
6  d=1;// in m
7  N=10;// no. of turns
8  s=0.75;// in m
9  Gp=15*(%pi^2*(1/y)^2*(10*(s/y)));// power gain
10 GdB=10*log(Gp)/log(10);// power gain in dB
11 Bw=52/(%pi*(1/y)*sqrt(10*(s/y)));// beamwidth in
       degree
12 BW=70/20;// beamwidth when d=20*y(wavelength)
13 printf("The power gain = %f dB", GdB);
14 printf("\n The beamwidth = %f degree", Bw);
15 printf("\n The beamwidth when d is 20*y = %f degree"
       , BW);
```

Scilab code Exa 4.4 How large is the dish diameter

```
1  //Ex:4.4
2  clc;
3  clear;
4  close;
5  f=300*10^6;// frequency in Hz
6  c=3*10^8;// the speed of light in m/s
7  y=c/f;// wavelength in m
8  GdB=60;// gain in dB
9  G=10^(GdB/10);// gain
10 D=sqrt(G/6)*y;// diameter in m
11 D1=3.28*D;// diameter in m
```

```
12  printf("The  dish  diameter  =  %d  meter" , D);
13  printf("\n  The  dish  diameter  =  %d  ft." , D1);
```

Scilab code Exa 4.5 What is the change in gain and beam width

```
1  //Ex:4.5
2  clc;
3  clear;
4  close;
5  printf("By  the  formula ,  gain  increases  with  the
        square  of  D,  so  new  diameter  =2D  will  have  gain
        2*2=4  compared  to  diameter  D.  The  increase  in
        gain  is  4  times  or  6dB.");
6  printf("\n  Similarly ,  the  beamwidth  varies  with  the
        inverse  of  D,  so  the  new  D  causes  beamwidth  to
        one  half  its  previous  value  ");
```

Scilab code Exa 4.6 what is the change in gain

```
1  //Ex:4.6
2  clc;
3  clear;
4  close;
5  printf("The  formula  for  the  gain  shows  that  it  is
        proportional  to  1/y^3,  a  new  y(wavelength)  is
```

```
        half of the previous value will therefore
        increase the gain by");
6   printf(" \n 1/(1/2)^3=8 times ")
```

Scilab code Exa 4.7 Calculate the beamwidth and gain as a power ratio and in dB

```
1   //Ex:4.7
2   clc;
3   clear;
4   close;
5   Vc=3*10^10;// the speed of light in m/cm
6   f=5*10^9;// frequency in Hz
7   y=Vc/f;// wavelength in cm
8   hw=9*8;// aperture dimensions in cm
9   D=(7.5*hw)/y^2;// beamwidth in degree
10  Ap=(4.5*hw)/y^2;
11  G=10*log(Ap)/log(10);// gain as a power ratio and in
        dB
12  printf("The beamwidth = %d degree", D);
13  printf(" \n The gain as a power ratio and in dB = %f
        dB", G);
```

Scilab code Exa 4.8 What are the dimensions of the elements

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```scilab
1  //Ex:4.8
2  clc;
3  clear;
4  close;
5  Vc=3*10^8;// the speed of light in m/cm
6  f=100*10^6;// frequency in Hz
7  y=Vc/f;// wavelength in cm
8  de=(y/2)+(y/2)*(5/100);// driven element length in m
9  l1=(y/2)-(y/2)*(5/100);// first director length in m
10 l2=l1-(l1*5/100);// second director length in m
11 l3=l2-(l2*5/100);// third director length in m
12 l_s=0.2*y*4;// support boom length in m
13 L_s=l_s*3.28;// support boom length in ft.
14 printf("The first director length = %f meter", l1);
15 printf("\n The second director length = %f meter",
      l2);
16 printf("\n The third director length = %f meter", l3
      );
17 printf("\n The support boom length in m = %f meter",
      l_s);
18 printf("\n The support boom length in ft. = %d ft.",
      L_s)
```

Scilab code Exa 4.9 Calculate the power gain of an optimum horn antenna

```scilab
1  //Ex:4.9
2  clc;
3  clear;
4  close;
5  printf("Aperture=10y*10y");
```

```
6  printf("\n then, G=(4.5*10y*10y)/(y^2)");
7  printf("\n and finally, G=4.5*100");
8  G=4.5*100;// power gain of optimum horn antenna
9  printf("\n The power gain of optimum horn antenna =
       %d", G);
```

Scilab code Exa 4.10 Calculate the peak value of the magnetic field intensity H of the RF wave

```
1  //Ex:4.10
2  clc;
3  clear;
4  close;
5  N=10;// number of turns
6  A=1;// area in m^2
7  f=1*10^6;// frequency in Hz
8  V=100*10^-6;// in volt
9  x=1;// the value of cos(Angle)
10 u=4*%pi*10^-7;
11 H=(sqrt(2)*V)/(2*%pi*f*u*A*N);// peak value of the
       magnetic field intensity H
12 printf("The peak value of the magnetic field
       intensity H  = %f uA/m", H*10^6);
```

Scilab code Exa 4.11 Calculate the radiation resistance

```
1  //Ex:4.11
2  clc;
3  clear;
4  close;
5  printf("A=pi*a^2=pi(y/25)^2=pi*y^2/625");
6  printf("\n  Rr=31171.2*(A/y^2)^2");
7  printf("\n and finally,  Rr=(31171.2*pi^2)/(625^2)");
8  Rr=(31171.2*%pi^2)/(625^2);// radiation resistance
       for single turn
9  N2=82;
10 Rr1=Rr*N2;// radiation resistance for turn loop
11 printf("\n The radiation resistance for single turn
       = %f ohm", Rr);
12 printf("\n The radiation resistance for turn loop =
       %f ohm", Rr1);
13 printf("\n The answer is wronge in the given
       textbook");
```

Scilab code Exa 4.12 Estimate the diameter of the mouth and the half power beam width of the antenna

```
1  //Ex:4.12
2  clc;
3  clear;
4  close;
5  y=0.1;// wavelength in m
6  GP=1000;// power gain
7  D=y*(sqrt(GP/6));// diameter of the mouth in m
8  printf("The diameter of the mouth = %f meter", D);
```

Scilab code Exa 4.13 Find the terminal resistance of complementary slot

```
1 //Ex:4.13
2 clc;
3 clear;
4 close;
5 Zs=35476/710;// terminal resistance in ohm
6 L_D=28;// the ratio of L to D
7 L=0.925;// length in m in terms of wavelength y
8 D=L/L_D;// diameter in m in terms of wavelength y
9 W=2*D;// width in m in terms of wavelength y
10 printf("The terminal resistance = %f ohm", Zs);
11 printf("\n The diameter in m in terms of wavelength
      = %f*y meter", D);
12 printf("\n The width in m in terms of wavelength =
      %f*y meter", W);
```

Scilab code Exa 4.14 Estimate the diameter and the effective aperture of a paraboloidal reflector antenna

```
1 //Ex:4.14
2 clc;
3 clear;
4 close;
```

```
5  f =3*10^3; // frequency in MHz
6  y =300/ f; // wavelength in m
7  BW =10; // beamwidth in degree
8  D =140* y/ BW; // diameter of a paraboidal reflector
        antenna in m
9  printf ("The diameter of a paraboidal reflector
        antenna = %f meter", D);
```

Scilab code Exa 4.15 Calculate the antenna gain in dB

```
1  // Ex :4.15
2  clc ;
3  clear ;
4  close ;
5  D =20; // diameter in m
6  r =10; // radius in m
7  f =6*10^3; // frequency in MHz
8  y =300/ f; // wavelength in m
9  K =0.54; // illumination efficiency
10 A =% pi * r ^2; // area in m^2
11 G =(4*% pi * K * A )/ y ^2; // antenna gain
12 G1 =10* log ( G )/ log (10) ; // antenna gain in dB
13 printf ("The antenna gain = %f dB", G1);
```

Scilab code Exa 4.16 Determine the gain beamwidth and capture area for a parabolic antenna

```
1  //Ex:4.16
2  clc;
3  clear;
4  close;
5  f=10*10^3;// frequency in MHz
6  y=300/f;// wavelength in m
7  D=10;// diameter in m
8  Gp=6*(D/y)^2;// gain of a parabolic antenna
9  BW=140*y/D;// beamwidth in degree
10 Dr=6*Gp;// directivity
11 A=(Dr*y^2)/(4*%pi);// capture area in m^2
12 printf("The gain of a parabolic antenna = %f", Gp);
13 printf("\n The beamwidth = %f degree", BW);
14 printf("\n The capture area in m^2 of a parabolic
       antenna = %f meter^2", A);
```

Scilab code Exa 4.17 Calculate the gain of the horn antenna

```
1  //Ex:4.17
2  clc;
3  clear;
4  close;
5  r=0.45;// distance in m
6  f=10*10^3;// frequenc in MHz
7  y=300/f;// wavelength in m
8  Wtr=8.9;
9  wtr=10^(Wtr/10);
10 wrt=1/wtr;
```

```
11  D=(4*%pi*r/y)*(sqrt(wrt));// gain of the horn
        antenna
12  d=10*log(D)/log(10);// gain of the horn antenna in
        dB
13  printf("The gain of the horn antenna = %f dB", d);
```

Scilab code Exa 4.18 Estimate the diameter of the paraboloidal reflector

```
1  //Ex:4.18
2  clc;
3  clear;
4  close;
5  BW=15;// beamwidth in degree
6  f=1.5*10^3;// frequenc in MHz
7  y=300/f;// wavelength in m
8  D=(140*y)/(BW);// diameter of the paraboloidal
        reflector in m
9  printf("The diameter of the paraboloidal reflector =
        %f meter", D);
```

Scilab code Exa 4.19 Estimate the diameter and effective aperture

```
1  //Ex:4.19
2  clc;
3  clear;
```

```
4 close ;
5 BW =15; // beamwidth in degree
6 f =3*10^3; // frequenc in MHz
7 y =300/ f ; // wavelength in m
8 D =(140* y ) /( BW ) ; // diameter of the paraboloidal
      reflector in m
9 printf (" The diameter of the paraboloidal reflector =
      %f meter ", D ) ;
```

Scilab code Exa 4.20 Estimate the diameter of the mouth and the half power beamwidth

```
1 // Ex :4.20
2 clc ;
3 clear ;
4 close ;
5 y =0.1; // wavelength in m
6 GP =1000; // power gain
7 D = y *( sqrt ( GP /6) ) ; // diameter of the mouth in m
8 HPBW =(70* y ) / D ; // half power beamwidth in degree
9 printf (" The diameter of the mouth = %f meter ", D ) ;
10 printf ("\ n The half power beamwidth of the antenna =
      %f degree ", HPBW ) ;
```

Scilab code Exa 4.21 What is the directivities of these two antennas

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```
1 //Ex:4.21
2 clc;
3 clear;
4 close;
5 r=5000;// in m
6 F=1.9;// propagation factor
7 f=150;// frequenc in MHz
8 y=300/f;// wavelength in m
9 wr=2*10^-3;// receiving power in watt
10 wt=25;// transmitting power in watt
11 D=(4*%pi*r/(2*F))*(sqrt(wr/wt));// directivities of
       these antenna
12 printf("The directivity of antenna = %f", D);
```

Scilab code Exa 4.22 Calculate the directivity in dB

```
1 //Ex:4.22
2 clc;
3 clear;
4 close;
5 a=15*%pi/180;// angle in radian
6 N=35;// number of turns
7 s_c=tan(a);// the ratio of s to c and c=y
8 D=(15*N*s_c);// directivity of 35 turn helix
9 d=10*log(D)/log(10);// directivities of 35 turn
       helix in dB
10 printf("The directivity of 35 turn helix = %f dB", d
       );
```

Scilab code Exa 4.23 Find out the length and width and half flare angles

```
1  //Ex:4.23
2  clc;
3  clear;
4  close;
5  // dl=0.23y, value of dl in E-plane
6  // dL=0.375y, value of dl in H-plane
7  // h=15y, height in terms of wavelength y
8  // L=h^2/8*dl in   E-plane
9  // L=(15*y)^2/8*0.2y=225y^2/1.6y;=140.625y
10 printf("The value of length L in terms of wavelength
        y=140.625y");
11 // OE=atan(h/2L)=atan(15y/2*140.625y)=atan
        (15/2*140.625)
12 OE=(atan(15/(2*140.625))*180/%pi);// half flare
        angle in E-plane in degree
13 // OH=acos(L/(L+dL))=acos(140.625y/(140.625y+0.375y)
        )=acos(140.625/(140.625+.375))
14 OH=(acos(140.625/(140.625+0.375))*(180/%pi));// half
         flare angle in H-plane in degree
15 //w=2*L*tan(OH)=2*140.625y*tan(4.18)=20.56y, width
        interms of wavelength y
16 printf("\n The half flare angle in E-plane = %f
        degree", OE);
17 printf("\n The half flare angle in H-plane = %f
        degree", OH);
18 printf("\n The width interms of wavelength y= 20.56y
        ");
```

Scilab code Exa 4.24 Calculate the angular aperture for paraboloidal reflector antenna

```
 1  //Ex:4.24
 2  clc;
 3  clear;
 4  close;
 5  D=20;// diameter of the reflector mouth in m
 6  // As we know, f=(D/4)*cot(x/2)
 7  // f/D=0.25*cot(x/2)
 8  f_d1=0.30;// ratio of f to D or aperture number
 9  f_d2=0.55;// aperture number
10  f_d3=0.80;// aperture number
11  // 0.30=0.25*cot(x/2)
12  // tan(x/2)=0.25/0.30
13  x1=2*(atan(0.25/f_d1))*(180/%pi);
14  x2=2*(atan(0.25/f_d2))*(180/%pi);
15  x3=2*(atan(0.25/f_d3))*(180/%pi);
16  Aa1=2*x1;// angular aperture in degree
17  Aa2=2*x2;// angular aperture in degree
18  Aa3=2*x3;// angular aperture in degree
19  f1=f_d1*D;// position of focal point for aperture
        number 0.30
20  f2=f_d2*D;// position of focal point for aperture
        number 0.30
21  f3=f_d3*D;// position of focal point for aperture
        number 0.30
22  printf("The angular aperture for aperture number
        0.30 = %f degree", Aa1);
23  printf("\n The angular aperture for aperture number
```

```
     0.55 = %f degree", Aa2);
24 printf("\n The angular aperture for aperture number
       0.80 = %f degree", Aa3);
25 printf("\n The position of focal point for aperture
       number 0.30 = %f meter", f1);
26 printf("\n The position of focal point for aperture
       number 0.55 = %f meter", f2);
27 printf("\n The position of focal point for aperture
       number 0.80 = %f meter", f3);
```

Scilab code Exa 4.25 Calculate the peak value of the magnetic field intensity H of the radio wave

```
1  //Ex:4.25
2  clc;
3  clear;
4  close;
5  N=15;// number of turns
6  A=1;// area in m^2
7  f=10*10^6;// frequency in Hz
8  Vrms=200*10^-6;// e.m.f in volt
9  x=1;// the value of cosine angle
10 u=4*%pi*10^-7;
11 H=(Vrms*sqrt(2))/(2*%pi*f*u*A*N);// peak value of
       the magnetic field intensity
12 printf("The peak value of the magnetic field
       intensity = %f uA/m", H*10^6);
```

Scilab code Exa 4.26 Calculate the input voltage to the receiver

```
1  //Ex:4.26
2  clc;
3  clear;
4  close;
5  N=500;// number of turns
6  A=1;// area in m^2
7  f=10;// frequency in MHz
8  y=300/f;// wavelength in m
9  x=60*%pi/180;// angle in radians
10 Erms=20*10^-6;// field strength in volt
11 Vrms=(2*%pi*Erms*A*N*cos(x))/y;// e.m.f in volt
12 Q=150;// quality factor
13 Vr=Vrms*Q;// voltage to the receiver in volt
14 printf("The voltage to the receiver = %d mV", Vr
       *10^3);
```

Scilab code Exa 4.27 Estimate the voltage across the capacitor

```
1  //Ex:4.27
2  clc;
3  clear;
4  close;
```

125

```
5  N =10; // number of turns
6  r =0.4; // radius in m
7  E =200*10^-6; // E-field in V/m
8  L =50*10^-6; // inductance in Henry
9  R =2; // resistance in ohm
10 f =1.5; // frequency in MHz
11 f1 =1.5*10^6; // frequency in Hz
12 y =300/f; // wavelength in m
13 A =%pi*r^2; // area in m^2
14 Vrms =(2*%pi*E*A*N)/y; // e.m.f in volt
15 Q =(2*%pi*f1*L)/R; //
16 Vc =Vrms*Q; // voltage across the capacitor in volt
17 printf("The voltage across the capacitor = %f mV",
       Vc*1000);
```

Scilab code Exa 4.28 Calculate the max emf in the loop

```
1  //Ex:4.28
2  clc;
3  clear;
4  close;
5  A =5; // area in m^2
6  w =25*10^-3; // power in watt
7  f =15; // frequency in MHz
8  y =300/f; // wavelength in m
9  Rr =31171*(A/y^2)^2; // radiation resistance in ohm
10 V =sqrt(w*4*Rr); // max emf in volts
11 printf("The max emf = %f Volts", V);
```

Scilab code Exa 4.29 Calculate the beamwidth between first null and what will be its gain in dB

```
1  //Ex:4.29
2  clc;
3  clear;
4  close;
5  f=10*1000; // frequency in MHz
6  y=300/f; // wavelength in m
7  D=5; // in m
8  BW=(140*y)/D; // beamwidth in degree
9  Gp=6*(D/y)^2; // gain
10 Gp1=10*log(Gp)/log(10); // gain in dB
11 printf("The beamwidth = %f degree", BW);
12 printf("\n The gain in dB = %f dB", Gp1);
```

Scilab code Exa 4.30 What should be minimum distance between primary and secondary antenna

```
1  //Ex:4.30
2  clc;
3  clear;
4  close;
5  f=5000; // frequency in MHz
```

```
6  y=300/f;// wavelength in m
7  d=30*0.3048;// aperture dimension in m
8  r=(2*d^2)/y;// min distance in m
9  printf("The min distance = %f meter", r);
```

Scilab code Exa 4.31 Calculate the directivity in dB

```
1  //Ex:4.31
2  clc;
3  clear;
4  close;
5  a=14*%pi/180;// angle in radian
6  N=25;// number of turns
7  s_c=tan(a);// the ratio of s to c and c=y
8  D=(15*N*s_c);// directivity of 35 turn helix
9  d=10*log(D)/log(10);// directivities of 35 turn
       helix in dB
10 printf("The directivity of 35 turn helix = %f dB", d
     );
```

Scilab code Exa 4.32 Find the received power

```
1  //Ex:4.32
2  clc;
3  clear;
```

```
4 close;
5 wt=1;// transmitted power
6 Gt=10^4;// transmitter gain
7 Gr=10^4;// receiver gain
8 f=10000;// frequency in MHz
9 r=30000;// range of the link in m
10 y=300/f;// wavelength in m
11 wr=wt*Gt*Gr*(y/(4*%pi*r))^2;// received power in
     Watt;
12 printf("The received power = %f uW", wr*10^6);
```

Scilab code Exa 4.33 Find the dimensions of three element

```
1 //Ex:4.33
2 clc;
3 clear;
4 close;
5 f=100;// frequency in MHz
6 y=300/f;// wavelength in m
7 dr=y/2;// the driven element in m
8 Rf=dr+(5*dr/100);// reflective in m
9 Df=dr-(5*dr/100);// deflective in m
10 Sp=0.2*y;// the spacing between terminal
11 printf("The reflective = %f m", Rf);
12 printf("\n The director = %f m", Df);
13 printf("\n The spacing between terminal = %f m", Sp)
     ;
```

Scilab code Exa 4.34 How large is the dish diameter

```
1 //Ex:4.34
2 clc;
3 clear;
4 close;
5 G=80;// gain in dB
6 G1=10^(G/10);// gain
7 f=300;// frequency in MHz
8 y=300/f;// wavelength in m
9 D=sqrt(G1/6)*y;// the dish parameter in m
10 printf("The dish parameter = %f m", D);
```

Scilab code Exa 4.35 What is the change in gain and beamwidth

```
1 //Ex:4.35
2 clc;
3 clear;
4 close;
5 printf("new diameter=2D ");
6 printf("\n Gain=2*2=3 times compared to D");
7 printf("\n the increase in gain is 4 times or 6 dB")
     ;
8 printf("\n Bw varies inverse of D");
```

```
9 printf("\n Bw is half of previous value");
```

Scilab code Exa 4.36 Calculate the beamwidth and gain as a power ratio in dB

```
1 //Ex:4.36
2 clc;
3 clear;
4 close;
5 f=5000;// frequency in MHz
6 y=300/f;// wavelength in m
7 h=9/100;// height in m
8 w=8/100;//  width in m
9 D=(7.5*h*w)/y^2;// beamwidth in degree
10 Ap=(4.5*h*w)/y^2;
11 Ap1=10*log(Ap)/log(10);// gain as a power ratio in
      dB
12 printf("The beamwidth = %f degree", D);
13 printf("\n The gain as a power ratio in dB = %f dB",
       Ap1);
```

Scilab code Exa 4.37 Calculate the gain of the horn antenna

```
1 //Ex:4.37
2 clc;
```

```
3  clear ;
4  close ;
5  r=0.35;// distance in m
6  f=9*10^3;// frequenc in MHz
7  y=300/f;// wavelength in m
8  Wtr=8.9;
9  wtr=10^(Wtr/10);
10 wrt=1/wtr;
11 D=(4*%pi*r/y)*(sqrt(wrt));// gain of the horn
       antenna
12 d=10*log(D)/log(10);// gain of the horn antenna in
       dB
13 y1=10;// in m
14 Gp=1000;
15 D=sqrt((Gp*y1^2)/6);// diameter in m
16 HPBW=(58*y1)/D;// the half power band width in
       degree
17 printf("The gain of the horn antenna = %f dB", d);
18 printf("\n The half power band width = %f degree",
       HPBW);
```

Scilab code Exa 4.38 Define folde dipole antenna and drive its input impedance

```
1  //Ex:4.38
2  clc ;
3  clear ;
4  close ;
5  // Equation of Input impedence− Let V be the emf
       applied at the end of terminals. This is being
       divided equally in each dipole. Hence voltage in
       each dipole V/2 as shown and by nodal analysis
```

```
6  // V/2=I1.z11+I2z.12
7  // where I1 , I2 are the currents flowing at
      terminals of dipole no. 1 and 2 and z11 & z12 are
       self impedance between dipole 1 & 2 respectively
8  // But , I1=I2
9  // Then , V/2=I1 ( z11+z12 )
10 // The two dipole in system are very close to each
      other . The spacing between two dipoles is of the
      order of y/100 , i.e., z11=z12
11 // Then , V/2=I1 *( 2 z11 )
12 // z=V/I1 then , z=4*z11 ,        z11=73 for a dipole
13 z11 =73; // for a dipole
14 z=4*z11 ; // input impedance in ohm
15 printf ( "The input impedance = %d ohm" , z );
```

Scilab code Exa 4.39 Calculate the capture area of antenna

```
1  //Ex:4.39
2  clc ;
3  clear ;
4  close ;
5  G =75; // gain in dB
6  G1 =10^( G /10) ; // gain
7  f =15000; // frequency in MHz
8  y =300/ f ; // wavelength in m
9  ca =( G1 * y^2 ) /(4* %pi ) ; // the capture area in m^2
10 D=sqrt ( G1 /6) * y ; // the dish parameter in m
11 BWFN =(140* y ) /D ; // 3−dB beamwidth
12 printf ( "The capture area = %f m^2" , ca );
13 printf ( "\n The 3−dB beamwidth = %f degree" , BWFN );
```

Scilab code Exa 4.40 What is the antenna gain in decibels

```
1 //Ex:4.40
2 clc;
3 clear;
4 close;
5 f=6000;// frequency in MHz
6 y=300/f;// wavelength in m
7 A=%pi*100*0.54;// aperture area in m^2
8 G=(4*%pi*A)/y^2;// gain of the reflector antenna
9 G1=10*log(G)/log(10);// gain of the reflector
      antenna in dB
10 printf("The gain of the reflector antenna = %f dB",
      G1);
```

Scilab code Exa 4.41 What is the corresponding value of illumination efficiency

```
1 //Ex:4.41
2 clc;
3 clear;
4 close;
5 // G=4*piAn/y^2=7.4ab/y^2", where y is wavelength
6 n=7.4/(4*%pi);// illumination efficiency
```

```
7 printf("The illumination efficiency = %f%%", n*100);
```

Scilab code Exa 4.42 What is its gain

```
1  //Ex:4.42
2  clc;
3  clear;
4  close;
5  D=10;// beam width
6  y=30.54;// wavelength in cm
7  X=(58*y)/D;// 3-dB beam width
8  Ar=(%pi*X^2)/4;// area of the cross section in m^2
9  G=(4*%pi*Ar)/y^2;// the gain for y=30.54 cm
10 G1=10*log(G)/log(10);// the gain for y=30.54 cm in
       dB
11 y1=3.054;// wavelength in cm
12 X1=(58*y1)/D;// 3-dB beam width
13 Ar1=(%pi*X1^2)/4;// area of the cross section in m^2
14 G2=(4*%pi*Ar1)/y1^2;// the gain for y=3.054 cm
15 G3=10*log(G2)/log(10);// the gain for y=3.054 cm in
       dB
16 printf("The gain for y=30.54 cm = %f dB", G1);
17 printf("\n The gain for y=3.054 cm = %f dB", G3);
```

Scilab code Exa 4.43 Calculate the power gain and half power point beam width

```
1  //Ex:4.43
2  clc;
3  clear;
4  close;
5  f=8*10^3;// frequency in MHz
6  y=300/f;// wavelength in m
7  BW=6;// beamwidth in degree
8  D=(70*y)/BW;// in m
9  hpbw=(58*y)/D;// the half power point beam width in
        degree
10 Ap=(6*D^2)/y^2;// power gain
11 Ap1=10*log(Ap)/log(10);// power gain in dB
12 printf("The half power point beam width = %f degree"
        , hpbw);
13 printf("\n The power gain = %f", Ap);
14 printf("\n The power gain in dB = %f dB", Ap1);
```

Scilab code Exa 4.44 Calculate the diameter of antenna and half power point beam width

```
1  //Ex:4.44
2  clc;
3  clear;
4  close;
5  f=3*10^3;// frequency in MHz
6  y=300/f;// wavelength in m
7  Ap=26;// power gain in dB
8  Ap1=10^(Ap/10);// power gain
```

```
9  D=sqrt((Ap1*y^2)/6);// diameter of antenna in m
10 hpbw=(58*y)/D;// the half power point beam width in
      degree
11 printf("The diameter of antenna = %f cm", D*100);
12 printf("\n The half power point beam width = %f
      degree", hpbw);
```

Scilab code Exa 4.45 Calculate the directivity and power gain as a ratio and in dB

```
1  //Ex:4.45
2  clc;
3  clear;
4  close;
5  f=8*10^3;// frequency in MHz
6  y=300/f;// wavelength in m
7  A=8*4/100^2;// Area in m^2
8  D=(7.5*A)/y^2;// directivity of the horn antenna
9  Ap=(4.5*A)/y^2;// power gain
10 Ap1=10*log(Ap)/log(10);// power gain in dB
11 printf("The directivity of the horn antenna = %f
      degree", D);
12 printf("\n The power gain = %f", Ap);
13 printf("\n The power gain in dB = %f dB", Ap1);
```

Scilab code Exa 4.46 Calculate the aperture height

```
1  //Ex:4.46
2  clc;
3  clear;
4  close;
5  f=4*10^3;// frequency in MHz
6  y=300/f;// wavelength in m
7  w=10/100;// width in m
8  Ap=25;// power gain in dB
9  Ap1=10^(Ap/10);// power gain
10 h=(Ap1*y^2)/(4.5*w);// aperture height in m
11 printf("The aperture height in m = %f m", h);
12 printf("\n The aperture height in cm = %f cm", h
       *100);
```

Scilab code Exa 4.47 Determine the dimensions of the horn mouth and the directive gain

```
1  //Ex:4.47
2  clc;
3  clear;
4  close;
5  Y1=10;// the half power beam width in E-plane in
       degree
6  Y2=10;// the half power beam width in H-plane in
       degree
7  // Y1=51y/b, where y= wavelength
8  // b=51y/10=5.1y
9  // Y2=67y/a, then a=67y/10=6.7y
10 // the directive gain, G=4.5*l*h/y^2=4.5*6.7y*5.1y/y
```

```
      ^2 =4.5*6.7*5.1
11  G=4.5*6.7*5.1;// the directive gain over the y/2
      antenna
12  G1=10*log(G)/log(10);// the directive gain over the
      y/2 antenna in dB
13  printf("The dimension of the horn mouth, a=6.7*y,
      where y is wavelength in m");
14  printf("\n The dimension of the horn mouth, b=5.1*y,
      where y is wavelength in m");
15  printf("\n The directive gain over the y/2 antenna =
      %f", G);
16  printf("\n The directive gain over the y/2 antenna
      in dB = %f dB", G1);
```

Scilab code Exa 4.48 Calculate the gain of the transmitting antenna

```
1  //Ex:4.48
2  clc;
3  clear;
4  close;
5  f=9*10^3;// frequency in MHz
6  y=300/f;// wavelength in m
7  Pr=5.4*10^-3;// received power in watt
8  Pt=20;// transmitted power in watt
9  Gr=15;// receiver gain in dB
10 Gr1=10^(Gr/10);// receiver gain
11 d=10;// distance in m
12 Gt=(Pr*(4*%pi*d)^2)/(Pt*Gr1*(y^2));// transmitter
      antenna gain
13 Gt1=10*log(Gt)/log(10);// transmitter antenna gain
      in dB
```

```
14  printf("The transmitter antenna gain = %f", Gt);
15  printf("\n The transmitter antenna gain in dB = %f
        dB", Gt1);
```

Scilab code Exa 4.49 Calculate the gain and half power beam widths

```
1  //Ex:4.49
2  clc;
3  clear;
4  close;
5  f=10*10^3;// frequency in MHz
6  y=300/f;// wavelength in m
7  a=5.2/100;// height in m
8  b=3.8/100;// width in m
9  A=a*b;// area in m^2
10  G=(4*%pi*A)/y^2;// the gain of the horn
11  G1=10*log(G)/log(10);// the gain of the horn in dB
12  he=(51*y)/b;// the half power point beam width in E-
        plane in degree
13  hh=(67*y)/a;// the half power point beam width in H-
        plane in degree
14  printf("The gain of the horn = %f", G);
15  printf("\n The the gain of the horn in dB = %f dB",
        G1);
16  printf("\n The half power point beam width in E-
        plane = %f degree", he);
17  printf("\n The half power point beam width in H-
        plane = %f degree", hh);
```

Scilab code Exa 4.50 Calculate the HPBW and directivity

```
1  //Ex:4.50
2  clc;
3  clear;
4  close;
5  N=30;// number of turns
6  // Diameter, d=y/3, where, y= wavelength
7  // spacing, S=y/5
8  // hpbw=52/((pi*d/y)*sqrt(NS/y))=52/((pi*y/3y)*sqrt
       (30y/5y))
9  hpbw=53*3/(%pi*sqrt(30/5));// half power point beam
        width in degree
10 // the directivity, D=15*NS*(pi*d)^2/y^3=((15*30*y)
       /(5y^3))*(pi*y/3)^2
11 D=15*30*%pi^2/(5*3^2);// the directivity
12 D1=10*log(D)/log(10);// the directivity in dB
13 printf("The half power point beam width = %f degree"
       , hpbw);
14 printf("\n The directivity = %f", D);
15 printf("\n The directivity in dB= %f dB", D1);
```

Scilab code Exa 4.51 Calculate the number of turns and directivity in dB
and the half power point beam width in degree and axial ratio of the helix

```scilab
1  //Ex:4.51
2  clc;
3  clear;
4  close;
5  f=1.7*10^3;// frequency in MHz
6  y=300/f;// wavelength in m
7  D=4.84/100;// diameter in m
8  a=11.7*%pi/180;// angle in radian
9  C=%pi*D;// circumference of the helix in m
10 S=C*tan(a);// in m
11 L=78.7/100;// length in m
12 N=L/S;// the number of turns
13 Dr=(15*N*S*(%pi*D)^2)/y^3;// the directivity of the
       antenna
14 Dr1=10*log(Dr/10);// the directivity of the antenna
       in dB
15 h_3dB=52/((%pi*D/y)*sqrt(N*S/y));// half power point
        beam width in degree
16 Ar=(2*N+1)/(2*N);// the axial ratio
17 printf("The number of turns = %f", N);
18 printf("\n The directivity of the antenna = %f", Dr)
       ;
19 printf("\n The directivity of the antenna in dB = %f
        dB", Dr1);
20 printf("\n The half power point beam width in degree
        = %f degree", h_3dB);
21 printf("\n The axial ratio = %f", Ar);
```

Chapter 5

Propagation

Scilab code Exa 5.1 Calculate max line of sight range and the field strength and also calculate the distance

```
1  //Ex:5.1
2  clc;
3  clear;
4  close;
5  ht=100;// transmitter height in m
6  hr=9;// receiver height in m
7  D=3550*(sqrt(ht)+sqrt(hr));// distance to horizon in
        m
8  f=60;// frequency in MHz
9  y=300/f;// wavelength in m
10 p=10*1000;// power in watt
11 d=10*1000;// distance in m
12 h=5;
13 Et=(88*sqrt(p)*hr*ht)/(h*d^2);// the field strength
        in V/m
14 et=10^-3;// field strength in V/m
15 d2=(88*sqrt(p)*hr*ht)/(h*et);
16 d1=sqrt(d2);// distance at which the field strength
        reuces to 1 mV/meter
17 printf("The field strength = %f mV/m", Et*1000);
```

```
18 printf("\n The distance at which the field strength
      reuces to 1 mV/meter = %f*10^3 meter", d1/1000);
```

Scilab code Exa 5.2 Calculate the field strength

```
1 //Ex:5.2
2 clc;
3 clear;
4 close;
5 p=100;// power in kW
6 d=10;// distance in km
7 Eo=(300*sqrt(p))/d;/// the field strength in mV/m
8 printf("The field strength = %d mV/m", Eo);
```

Scilab code Exa 5.3 What will be the range for which the MUF is ten MHz

```
1 //Ex:5.3
2 clc;
3 clear;
4 close;
5 u=0.9;// refractive index
6 f=10*10^6;// frequency in Hz
7 h=400;// height in km
8 Nmax=((1-0.81)*f^2)/81;
```

```
9  fc=9*sqrt(Nmax);// frequency in Hz
10 Ds=(2*h)*(sqrt((f/fc)^2-1));// range in km
11 printf("The range = %f km", Ds);
```

Scilab code Exa 5.4 Calculate the max electron concentrations of the layers

```
1  //Ex:5.4
2  clc;
3  clear;
4  close;
5  fc1=2.5*10^6;// critical frequency in Hz of E layer
6  fc2=8.4*10^6;// critical frequency in Hz of F layer
7  Nmax1=fc1^2/81;// maximum electron concentration of
       E layer
8  Nmax2=fc2^2/81;// maximum electron concentration of
       F layer
9  printf("The maximum electron concentration of E
       layer = %f*10^11 per cubic meter", Nmax1/10^11);
10 printf("\n The maximum electron concentration of F
       layer = %f*10^11 per cubic meter", Nmax2/10^11);
```

Scilab code Exa 5.5 What is the critical frequency for the reflection at vertical incidence

```
1 //Ex:5.5
2 clc;
3 clear;
4 close;
5 Nm=1.24*10^6/10^6;// electron density in per m^3
6 fc=9*sqrt(Nm);// critical frequency in MHz
7 printf("The critical frequency = %f MHz", fc);
```

Scilab code Exa 5.6 What is the max distance and what is the radio horizon in this case

```
1 //Ex:5.6
2 clc;
3 clear;
4 close;
5 ht=169;// transmeter height in m
6 hr=16;// receiver height in m
7 d=4.12*(sqrt(ht)+sqrt(hr));// in km
8 Rh=4.12*(sqrt(ht));/// radio horizon in km
9 printf("The radio horizon = %f km", Rh);
```

Scilab code Exa 5.7 Find the basic path loss

```
1 //Ex:5.7
2 clc;
```

```
3  clear ;
4  close ;
5  f =3000; // frequency in MHz
6  d =384000; // distance in km
7  Lp =32.45+20* log (f)/ log (10) +20* log (d)/ log (10) ;// path
        loss in dB
8  printf (" The path loss = %f dB", Lp );
```

Scilab code Exa 5.8 Find the max range of a tropospheric transmission

```
1  // Ex :5.8
2  clc ;
3  clear ;
4  close ;
5  ht =100; // transmeter height in m
6  hr =50; // receiver height in m
7  d =1.4142*( sqrt (ht )+ sqrt (hr )) ;// max range in miles
8  printf (" The max range = %f miles", d );
```

Scilab code Exa 5.9 Find the range of LOS system

```
1  // Ex :5.9
2  clc ;
3  clear ;
4  close ;
```

```
5  ht =100; // transmeter height in m
6  hr =10; // receiver height in m
7  d =4.12*( sqrt ( ht )+ sqrt ( hr ) ) ; // line of sight range in
      km
8  printf ( " The line of sight range = %f km " , d ) ;
```

Scilab code Exa 5.10 At what frequency a wave must propagate for the D region

```
1  // Ex :5.10
2  clc ;
3  clear ;
4  close ;
5  u =0.5; // refractive index
6  N =400; // electron / cc
7  f = sqrt (81* N /(1 - u ^2) ) ; // frequency in KHz
8  printf ( " The frequency = %f KHz " , f ) ;
```

Scilab code Exa 5.11 What will be the range for which the MUF is twelve MHz

```
1  // Ex :5.11
2  clc ;
3  clear ;
4  close ;
```

```
5  u=0.75;// refractive index
6  f=10*10^6;// frequency in Hz
7  fmuf=12*10^6;// frequency in Hz
8  h=350;// height in km
9  Nmax=((1-u^2)*f^2)/81;
10 fc=9*sqrt(Nmax);// frequency in Hz
11 Ds=(2*h)*(sqrt((fmuf/fc)^2-1));// range in km
12 printf("The range = %f km", Ds);
13 printf("\n The ans is wronge in the given textbook")
     ;
```

Scilab code Exa 5.12 What is the max distance and the radio horizon in this case

```
1  //Ex:5.12
2  clc;
3  clear;
4  close;
5  ht=256;// transmeter height in m
6  hr=25;// receiver height in m
7  d=4.12*(sqrt(ht)+sqrt(hr));// in km
8  Rh=4.12*(sqrt(ht));/// radio horizon in km
9  printf("The radio horizon = %f km", Rh);
```

Scilab code Exa 5.13 What is the critical frequency for the reflection at vertical incidence

```
1 //Ex:5.13
2 clc;
3 clear;
4 close;
5 Nm=2.58*10^6/10^6;// electron density in m^-3
6 fc=9*sqrt(Nm);// critical frequency in MHz
7 printf("The critical frequency = %f MHz", fc);
```

Scilab code Exa 5.14 Find the basic path loss

```
1 //Ex:5.14
2 clc;
3 clear;
4 close;
5 f=4000;// frequency in MHz
6 d=384000;// distance in km
7 Lp=32.45+20*log(f)/log(10)+20*log(d)/log(10);// path
      loss in dB
8 printf("The path loss = %f dB", Lp);
```

Scilab code Exa 5.15 Find the field strength at a distance of twenty km

```
1  //Ex:5.15
2  clc;
3  clear;
4  close;
5  p=150;// power in kW
6  d=20;// distance in km
7  Eo=(300*sqrt(p))/d;// field strength mV/m
8  printf("The field strength = %f mV/m", Eo);
```

Scilab code Exa 5.16 Determine the ground range for which this frequency is the MUF

```
1  //Ex:5.16
2  clc;
3  clear;
4  close;
5  u=0.9;// refractive index
6  f=10*10^6;// frequency in Hz
7  h=400;// height in km
8  Nmax=((1-0.81)*f^2)/81;
9  fmuf=10*10^6;// in Hz
10 fc=9*sqrt(Nmax);// frequency in Hz
11 R=6370;// in km
12 d=1651.76;
13 D=2*(h+(d^2/(8*R)))*(sqrt((fmuf/fc)^2-1));// skip
       distance in km
14 printf("The skip distance = %f km", D);
```

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Scilab code Exa 5.17 Determine the transmitter power required

```
1  //Ex:5.17
2  clc;
3  clear;
4  close;
5  f=1690*1000;// frequency in Hz
6  d=16*1000;// distance in m
7  E=15;// dielectric constant
8  k=5*10^-5;// conductivity in ohms/cm
9  Eg=0.5*10^-3;// V/m
10 c=3*10^8;// the speed of ligth in m/s
11 y=c/f;// wavelength in m
12 // tan(b)=(E+1)/x=(E+1)/(1.8*10^12*k/f=f*(E+1))
       /(1.8*10^12*k)
13 // then b=atan(f*(E+1))/(1.8*10^12*k))
14 x=1.8*10^12*k/f;
15 b=(atan((f*(E+1))/(k*1.8*10^12)))*(180/3.14);// in
       degree
16 p=((%pi*d)/(x*y))*cos(b*%pi/180);
17 p1=5.1;// approx. value of p
18 A=(2+0.3*p1)/(2+p1+0.6*p1^2);
19 A1=0.15
20 ps=(Eg*d)/(300*A1);
21 P=ps^2;// transmitter power in KW
22 P1=P*1000;// transmitter power in watts
23 printf("The transmitter power = %f watts", P1);
24 printf("\n since antenna efficiency is 50 percent,
       the transmitter must deliver 31.6049*2=63.2098
       watts to the antenna.");
```

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Scilab code Exa 5.18 Determine the strength of its ground wave

```
1  //Ex:5.18
2  clc;
3  clear;
4  close;
5  f=900*1000;// frequency in Hz
6  c=10^-4;// conductivity in mhos/cm
7  p=10;// power in kw
8  d=100*1000;// distance in m
9  d1=100;// distance in km
10 Er=20;// relative dielectric constant
11 y=3*10^8/f;// wavelength in m
12 w=2*%pi*f;
13 Eo=(10^-9)/(36*%pi);
14 x=c/(w*Eo);
15 b=(atan((Er+1)/x))*180/3.14;// in degree
16 P=(%pi*d*cos(b*%pi/180))/(x*y);
17 A1=(2+0.3*P)/(2+P+0.6*P^2);
18 // tower efficiency is 80% so effective power is
         10/.80=12.5kW=Pef
19 Pef=12.5;// effective power in kW
20 Eg=(1.1*300*A1*sqrt(Pef))/d1;// strength of ground
         wave in mV/meter
21 printf("The strength of ground wave= %f mV/meter",
         Eg);
```

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Scilab code Exa 5.19 Calculate the transmission path distance for an iono-spheric transmission

```
1  //Ex:5.19
2  clc;
3  clear;
4  close;
5  h=200;// height in km
6  B=20;// angle of elevation in degree
7  B1=B*3.14/180;// angle of elevation in radians
8  R=6370;// radius of earth in km
9  D=2*h/tan(B1);// in km
10 D1=2*R*((3.14/2)-(B1)-asin((R*cos(B1))/(R+h)));//
      transmission-path distance in km
11 printf("The transmission-path distance= %f km", D1);
```

Scilab code Exa 5.20 Find the effective area

```
1  //Ex:5.20
2  clc;
3  clear;
4  close;
5  d=10*1000;// distance in m
6  wt=500;// transmeter power in Watt
```

```
 7  wr =2*10^ -6;// receiver power in Watt
 8  Gt =10;// antenna gain
 9  Ae =( wr *4* %pi *d^2)/( wt *Gt );// effective area in m^2
10  printf (" The effective area = %f m^2", Ae );
```

Scilab code Exa 5.21 Calculate the open circuit voltage

```
 1  //Ex:5.21
 2  clc ;
 3  clear ;
 4  close ;
 5  f =150;// frequency in MHz
 6  y =300/ f;// in m
 7  wt =10;// transmeter power in Watt
 8  Gt =1.641;// antenna gain
 9  d =50*10^3;// in m
10  E= sqrt (30* wt * Gt )/d ;// electric field strength in V/m
11  Voc =E* y/ %pi ;// open circuit voltage in mV
12  printf (" The open circuit voltage = %f mV", Voc *1000)
        ;
```

Scilab code Exa 5.22 Calculate the field strength at a receiving antenna

```
 1  //Ex:5.22
 2  clc ;
```

```
3  clear;
4  close;
5  f=150;// frequency in MHz
6  y=300/f;// wavelength in m
7  ht=20;// transmeter height in km
8  hr=2;// receiver height in km
9  d=40*10^3;// distance in m
10 p=100;// power in watt
11 Er=(88*sqrt(p)*ht*hr)/(y*d^2);// field strength in
      uV/m
12 printf("The field strength = %d uV/m", Er*10^6);
```

Scilab code Exa 5.23 Calculate the the attenuation

```
1  //Ex:5.23
2  clc;
3  clear;
4  close;
5  Gt=20;// transmeter gain in dB
6  Gr=20;// receiver gain in dB
7  d=40;// distance in km
8  f=600;// frequency in MHz
9  Ls=32.45+20*log(f)/log(10)+20*log(d)/log(10);// loss
       in dB
10 at=Gt+Gr-Ls;// attenuation in dB
11 printf("The attenuation = %f dB", at);
12 printf("\n Negative sign shown attenuation");
```

Scilab code Exa 5.24 Explain what is meant by the gyro frequency and Calculate the max range obtain able in a single hop transmission utilizing

```
1 //Ex:5.24
2 clc;
3 clear;
4 close;
5 R=6370;// radius of earth in km
6 hm=400;// height of the ionospheric layer in km
7 d=2*R*(acos(R/(R+hm)));// max range in a single hop
     transmission in km
8 printf("The max range in a single hop transmission =
     %f km", d);
```

Scilab code Exa 5.25 Calculate the max range obtainable in single hop transmission utilizing E layer

```
1 //Ex:5.25
2 clc;
3 clear;
4 close;
5 R=6370;// radius of earth in km
6 hm=140;// height of the ionospheric layer in km
```

```
7  d=2*R*(acos(R/(R+hm)));// max range in a single hop
       transmission in km
8  printf("The max range in a single hop transmission =
       %f km", d);
```

Scilab code Exa 5.26 Calculate the max range obtainable in single hop transmission utilizing D layer

```
1  //Ex:5.26
2  clc;
3  clear;
4  close;
5  R=6370;// radius of earth in km
6  hm=90;// height of the ionospheric layer in km
7  d=2*R*(acos(R/(R+hm)));// max range in a single hop
       transmission in km
8  printf("The max range in a single hop transmission =
       %f km", d);
```

Scilab code Exa 5.27 Find the virtual heightof the reflected layer

```
1  //Ex:5.27
2  clc;
3  clear;
4  close;
```

```
5  T=5/1000;// period in sec
6  c=3*10^8;// the speed of the light in m/s
7  h=c*T/2;// virtual height in m
8  printf("The virtual height = %f km", h/1000);
```

Scilab code Exa 5.28 Calculate the max line of sight range and the field strength and also distance

```
1  //Ex:5.28
2  clc;
3  clear;
4  close;
5  ht=120;// transmeter height in m
6  hr=16;// receiver height in m
7  Los=4.12*(sqrt(ht)+sqrt(hr));// line of sight range
      in km
8  f=50;// frequency in MHz
9  y=300/f;// wavelength in m
10 d=12*10^3;// distance in m
11 p=15000;// power in watt
12 Er=(88*sqrt(p)*ht*hr)/(y*d^2);// field strength in v
      /m
13 Er1=1/1000;// field strength in V/m
14 d1=sqrt((88*sqrt(p)*ht*hr)/(y*Er1));// distance in
      km
15 printf("The line of sight range = %f km", Los);
16 printf("\n The field strength = %f mV/m", Er*1000);
17 printf("\n The distance = %d km", d1);
```

Scilab code Exa 5.29 Calculate the power density reating the moon surface

```
1 //Ex:5.29
2 clc;
3 clear;
4 close;
5 wt=10*10^6;// power in Watt
6 Gt=65;// antenna gain in dB
7 Gt1=10^(Gt/10);// antenna gain
8 d=4000000*100;// distance in m
9 Pd=(wt*Gt1)/(4*%pi*d^2);// power density in uW
10 printf("The power density = %f uW", Pd*10^6);
```

Scilab code Exa 5.30 What is the max disance along the surface of the earth

```
1 //Ex:5.30
2 clc;
3 clear;
4 close;
5 ht=4000;// transmeter height in m
6 hr=7000;// receiver height in m
```

```
7  Los =4.12*( sqrt ( ht )+ sqrt ( hr ) ) ;// line of sight range
        in km
8  printf (" The line of sight range = %f km" , Los ) ;
```

Scilab code Exa 5.31 What will be the range for which the MUF is twenty MHz

```
1   // Ex :5.31
2   clc ;
3   clear ;
4   close ;
5   u =0.8;// refractive index
6   f =15*10^6;// frequency in Hz
7   fmuf =20*10^6;// MUF in Hz
8   h =350;// height in km
9   Nmax =((1 - u ^2) * f ^2) /81;
10  fc =9* sqrt ( Nmax ) ;// frequency in Hz
11  Ds =(2* h ) *( sqrt (( fmuf / fc ) ^2 -1) ) ;// range in km
12  printf (" The range = %f km" , Ds ) ;
```

Scilab code Exa 5.32 Calculate the power received by an antenna

```
1   // Ex :5.32
2   clc ;
3   clear ;
```

```
4 close ;
5 wt =35;// transmeter power in Watt
6 wt1 =10* log(wt)/log(10) ;// transmeter power in dB
7 Gt =40;// transmeter gain in dB
8 Gr =40;// receiver gain in dB
9 d =150;// distance in km
10 y =6/100 ;// wavelength in m
11 f =300/ y ;// frequency in MHz
12 Ls =32.45+20* log(f)/log(10) +20* log(d)/log(10) ;// loss
      in dB
13 wr = wt1 + Gt + Gr - Ls ;// receive power in dB
14 WR =10^( wr /10) ;// receive power in watt
15 printf ("The receive power = %f dB", wr);
16 printf ("\n The receive power = %f uW", WR*10^6);
```

Scilab code Exa 5.33 What is the max power received by the receiver

```
1 //Ex :5.33
2 clc ;
3 clear ;
4 close ;
5 wt =2*10^3;// transmeter power in Watt
6 Gt =1.64;// directivity of transmeter
7 Gr =1.64;// directivity of receiver
8 d =200*10^3;// distance in m
9 f =150;// frequency in MHz
10 y =300/ f ;// wavelength in m
11 wr =( wt * Gt * Gr)*(y/(4*%pi*d))^2;// max received power
      in Watt
12 printf ("The max received power = %f*10^-9 Watts", wr
      *10^9) ;
```

Scilab code Exa 5.34 Calculate the MUF for the given path

```
1 //Ex:5.34
2 clc;
3 clear;
4 close;
5 D=400;// depth in km
6 h=300;// height in km
7 f=5;// critical frequency in MHz
8 fmuf=f*sqrt(1+(D/(2*h))^2);// MUF in MHz
9 printf("The MUF in MHz = %d MHz", fmuf);
```

Scilab code Exa 5.35 Calculate the value of frequency at which an electromagnetic wave must be propagate

```
1 //Ex:5.35
2 clc;
3 clear;
4 close;
5 u=0.6;// refractive index
6 N=4.23*10^4;// electron/m^3
7 f=sqrt(81*N/(1-u^2));// frequency in Hz
8 printf("The frequency = %f Hz", f);
```

Scilab code Exa 5.36 Determine the ground range for which this frequency is MUF

```
1  //Ex:5.36
2  clc;
3  clear;
4  close;
5  h=300;// height in km
6  fmuh=15*10^6;// in Hz
7  // we know that u=sqrt(1-81N/f^2)
8  u=0.8;// refractive index
9  //then 0.8^2=1-81N/f^2");
10 // fc=9*sqrt(Nmax)
11 // 0.36=fc^2/fmuh^2
12 fc=sqrt(0.36*fmuh^2);// in Hz
13 fc1=fc/10^6;// cut off frequancy in MHz
14 printf("The cut off frequancy, fc= %d MHz", fc1);
15 // skip distance D=2*(h+D^2/8R^2)*sqrt((fmuh/fc)
       ^2-1)
16 // D=2*(300+D^2/8*6370)*sqrt((15/9)^2-1)
17 // D^2-19.11*10^3D+15.29*10^16=0
18 // after solve this equation, we get D=18.27*10^6
       meter
19 D=18.27*10^3;// skip distance in meter
20 printf("\n The skip distance = %f*10^3 meter", D
       /10^3);
```

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Scilab code Exa 5.37 At what frequency a wave must propogate for the D regions

```
1 //Ex:5.37
2 clc;
3 clear;
4 close;
5 u=0.6;// refractive index
6 N=500;// electron/cc
7 f=sqrt(81*N/(1-u^2));// frequency in KHz
8 printf("The frequency = %f KHz", f);
```

Scilab code Exa 5.38 Find the received power

```
1 //Ex:5.38
2 clc;
3 clear;
4 close;
5 u=0.5;// refractive index
6 N=500;// electron/cc
7 f=sqrt(81*N/(1-u^2));// frequency in KHz
8 printf("The frequency = %f Hz", f);
```

Scilab code Exa 5.39 Explain the Directivity polarization and virtual height

```
1 //Ex:5.39
2 clc;
3 clear;
4 close;
5 printf("Directivity: The max directive gain is
     called directivity of an antenna.");
6 printf("\n Directivity= max radiation intensity of
     test antenna/average radiation intensity of test
     antenna ");
7 printf("\n Polarization: Polarization of an antenna
     means the direction of electric field of the
     electromagnetic wave being radiated by the
     transmitting syatem.");
8 printf("\n Virtual Height: Virtual height of an
     ionospheric layer may be defined as the height to
      which short pulse of energy sent vertically
     upward and travelling with speed of light would
     reach taking the same ways travel time as does
     the actual pulse reflected from the layer.");
9 printf("\n Practically the virtual height is alway
     greater than actual height");
```

Scilab code Exa 5.40 Calculate the LOS range and field strength

```
1  //Ex:5.40
2  clc;
3  clear;
4  close;
5  ht=120;// height of transmitting antenna in m
6  hr=16;// height of receiving antenna in m
7  d=4.12*(sqrt(ht)+sqrt(hr));// line of sight range in
       km
8  p=15*1000;// power in watts
9  f=50;// frequency in MHz
10 y=300/f;// wavelenght in m
11 r=12*1000;// distance in m
12 E=(88*sqrt(p)*ht*hr)/(y*r^2);// field strength at a
       receiving antenna
13 printf("The line of sight range = %f km", d);
14 printf("\n The field strength at a receiving antenna
        = %f mV", E*1000);
```

Scilab code Exa 5.41 Find the field strenght

```
1  //Ex:5.41
2  clc;
3  clear;
4  close;
5  f=500/1000;// frequency in MHz
6  A=1;// area in m^2
7  y=300/f;// wavelength in m
8  Vrms=2/1000;// potential difference in Volt
9  N=10;// no. of turns
```

```
10  Erms=(Vrms*y)/(2*%pi*A*N);// field strength in v/m
11  printf("The field strength = %f mV/m", Erms*1000);
```

Scilab code Exa 5.42 What is standing wave ratio and explain how it is measured experimentally

```
1  //Ex:5.42
2  clc;
3  clear;
4  close;
5  printf("SWR may be defined as ratio of max to min
       current on voltage on a line having standing
       waves. ");
6  printf("\n VSWR=Vmax/Vmin");
7  printf("\n S=Vmax/Vmin=Imax/Imin");
8  printf("\n The SWR is a measure of mismatch between
       load of transmission line and is first and
       foremost quantity calculated for a particular
       load. Its value is always greater than unity when
        termination is not correct. But when termination
        is correct, its value is equal to unity, if
       termination is perfectly matched.");
```

Scilab code Exa 5.43 Calculate the value of the frequency

```
1  //Ex:5.43
2  clc;
3  clear;
4  close;
5  u=0.5;// refractive index
6  N=3.25*10^4;// electron/m^3
7  f=sqrt(81*N/(1-u^2));// frequency in Hz
8  printf("The frequency = %f KHz", f/1000);
```

Scilab code Exa 5.44 What will be the effects of earth magnetic field on refractive index of th eionosphere

```
1  //Ex:5.44
2  clc;
3  clear;
4  close;
5  printf("Effect of Earth Magnetic Field on Refractive
        Index of the Ionosphere: The theory which deals
        with the propagation of Radio wave through
        Ionosphere in presence of earth magnetic field is
         known as Magneto-Ionic-theory. ");
6  printf("\n The phenomenon of propagation of radio
        waves through Ionosphere in the presence of earth
         magnetic field is changed.");
7  printf("\n because is the presence of earth magnetic
        field, the formula of refractive Index u is
        changed,");
8  printf("\n u=sqrt(1-81N/f^2)");
9  printf("\n i.e.,");
10 printf("\n u^2=sqrt(1-(2/(2a-(yt^2/a-1)+sqrt(yt^2/(a
        -1)^2+4yL^2))))");
```

```
11  printf("\n where");
12  printf("\n    a=(EoMw^2)/(Ne^2)=d^2/dc^2");
13  printf("\n    yt=aBt.e/wm");
14  printf("\n    yL=aBL.e/wm and y=sqrt(yt^2+yL^2)");
15  printf("\n    BL=component of earth magnetic field
        intensity B along the direction of propagation.")
        ;
16  printf("\n    Bt=component of earth magnetic field
        intensity traverse to the direction of
        propagation.");
17  printf("\n    B=uo.H");
18  printf("\n    M=mass of electron=9.1*10^-31 kg");
19  printf("\n    e=charge of electron=1.6*10^-19c");
20  printf("\n    w=2*3.14*d=angular frequency");
21  printf("\n    N=electron density");
22  printf("\n    Eo=dielectric constant=8.854*10^-12 F/M
        ");
23  printf("\n    u=refractive index of Ionosphere.");
```

Scilab code Exa 5.45 At what frequency a wave must propogate for D region and what is the critical frequency

```
1  //Ex:5.45
2  clc;
3  clear;
4  close;
5  u=0.5;// refractive index
6  N=400;// electron/cc
7  f=sqrt(81*N/(1-u^2));// frequency in Hz
8  N1=1.24*10^6;// in per cm^3
9  fc=9*sqrt(N1);// critical frequency in Hz
```

```
10  printf("The  frequency  =  %f  KHz",  f/1000);
11  printf("\n  The  critical  frequency  =  %d  KHz",  fc
        /1000);
```

Scilab code Exa 5.46 Find the skip distance

```
1   //Ex:5.46
2   clc;
3   clear;
4   close;
5   h=300;//  height  in  km
6   fmuh=15*10^6;//  in  Hz
7   //  we  know  that  u=sqrt(1−81N/f^2)
8   u=0.8;//  refractive  index
9   //then  0.8^2=1−81N/f^2");
10  //  fc=9*sqrt(Nmax)
11  //  0.36=fc^2/fmuh^2
12  fc=sqrt(0.36*fmuh^2);//  in  Hz
13  fc1=fc/10^6;//  cut  off  frequancy  in  MHz
14  printf("The  cut  off  frequancy,  fc=  %d  MHz",  fc1);
15  //  skip  distance  D=2*(h+D^2/8R^2)*sqrt((fmuh/fc)
        ^2−1)
16  //  D=2*(300+D^2/8*6370)*sqrt((15/9)^2−1)
17  //  D^2−19.11*10^3D+15.29*10^16=0
18  //  after  solve  this  equation,  we  get  D=18.27*10^6
        meter
19  D=18.27*10^6;//  skip  distance  in  meter
20  printf("\n  The  skip  distance  =  %f*10^6  meter",  D
        /10^6);
```

Scilab code Exa 5.47 What is the max power thet can be received

```
1  //Ex:5.47
2  clc;
3  clear;
4  close;
5  Gt=25;// transmitter gain in dB
6  gt=10^(Gt/10);// transmitter gain
7  Gr=30;// receiver gain in dB
8  gr=10^(Gr/10);// receiver gain
9  f=1.5*1000;// frequency in MHz
10 R=1.5*1000;// distance in m
11 y=300/f;// wavelength in m
12 pt=200;// transmitted power in watt
13 pr=(pt*gt*gr)*(y/(4*%pi*R))^2;// received power in
       watt
14 printf("The received power = %f mW", pr*1000);
```

Scilab code Exa 5.48 Find the max range of the radar and also the max range when frequency is doubled

```
1  //Ex:5.48
2  clc;
3  clear;
```

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```
 4  close;
 5  A=12.5;// cross section area of the target in m^2
 6  pr=10^-13;// max received power in Watt
 7  Gr=2000;// receiver gain
 8  Gt=2000;// transmitter gain
 9  y=16/100;// wavelength in m
10  pt=250*10^3;// transmitted power in Watts
11  Rmax=((pt*Gt^2*y^2*A)/((4*%pi)^3*pr))^(1/4);// max
       range in m
12  Rmax2=sqrt(2)*Rmax;// max range in m
13  printf("The max range Rmax1 = %f km", Rmax/1000);
14  printf("\n The max range Rmax2 = %f km", Rmax2/1000)
       ;
```

Scilab code Exa 5.49 Find the max allowable distance between the two antennas

```
 1  //Ex:5.49
 2  clc;
 3  clear;
 4  close;
 5  f=30;// frequency in MHz
 6  y=300/f;// wavelength in m
 7  l=y/2;// in m
 8  I=10;// current in amp
 9  Gt=1.5;// gain
10  Gr=1.5;// gain
11  Pr=10^-3;// receiver power in Watts
12  Ptmax=(80*%pi^2*I^2*l^2)/y^2;// max transmitter
       power in watts
13  Ptav=Ptmax/2;// average power in Watts
```

```
14  d=(Ptav*Gt*Gr*y^2)/(16*%pi*%pi*Pr);// max allowable
        distance in m
15  printf("The max allowable distance = %f km", d/1000)
        ;
16  printf("\n The answer is wronge in the textbook");
```

Scilab code Exa 5.50 What is the voltage available at the terminals

```
1   //Ex:5.50
2   clc;
3   clear;
4   close;
5   f=2*10^9;// frequency in Hz
6   c=3*10^8;// speed of light in m/s
7   R1=50;// lengt in km
8   R=50*1000;// lengt in meter
9   y=c/f;// wavelength in m
10  GT=20;// gain in db
11  GR=20;// gain in db
12  Gt=10^(GT/10);// gain
13  Gr=10^(GR/10);// gain
14  pt=1;// power in watt
15  pr=(pt*Gt*Gr)*(y/(4*%pi*R))^2;// the received power
        in watt
16  V=sqrt(pr*R1);// voltage available at the terminals
        in micro volt
17  printf("voltage available at the terminals in micro
        volt = %f uV", V*10^6);
```

Scilab code Exa 5.51 What transmitter power is required for a received signal

```
1  //Ex:5.51
2  clc;
3  clear;
4  close;
5  f=4*10^9;// frequency in Hz
6  c=3*10^8;// speed of light in m/s
7  y=c/f;// wavelength in m
8  D=1.22;// in meter
9  A=(%pi*D*D)/4;// area in m^2
10 d=96*1000;// in m
11 Pr=(10^-3)*(10^(-90/10));// received power in watt
12 //the received power is given by
13 //Pr=Pt*Gt*Gr*(y/4*%pi*d)
14 //antennas are symmetrical, Gt=Gr=G
15 //Pr/Pt=G^2*(y/4*%pi*d)^2
16 //  =A^2/(y*d)^2
17 // then
18 //Pt=Pr*(y*d/A)^2
19 Pt=Pr*(y*d/A)^2;// the transmitted power in watts
20 printf("the transmitted power = %f micro watt", Pt
       *10^6);
```