Scilab Textbook Companion for Optical Fiber Communication by R. R. Dudeja[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.

Contents

List of Scilab Codes

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Chapter 2

OPTICAL FIBER

Scilab code Exa 2.1 critical angle

```
1  // Example  2.1: Critical  angle
2  clc;
3  clear;
4  close;
5  n2=1.402;//Waveguide  Refractive  Index
6  n1=1.495;//Cladding  Refractive  Index
7  no=1;//  for  air
8  Oc=asind(n2/n1);//  Critical  Angle
9  disp(Oc,"Critical  angle  in  degree")
```

Scilab code Exa 2.2.a critical angle

```
1  // Example  2.2.a:  Critical  Angle
2  clc;
3  clear;
4  close;
5  n1=1.50;//Waveguide  Refractive  Index
6  n2=1.47;//Cladding  Refractive  Index
```

```
7  Oc=asind(n2/n1);//Critical  Angle
8  oc=floor(Oc);//
9  x=Oc-oc;//
10 disp("CRITICAL  ANGLE  IS  "+string(oc)+"  DEGREE  AND  "+
        string(round((60*(x))))+"  MINUTES  ")
11 //answer  is  wrong  in  the  textbook
```

Scilab code Exa 2.2.b NA

```
1  // Example  2.2.b:Numerical  Aperture
2  clc;
3  clear;
4  close;
5  n1=1.50;//Waveguide  Refractive  Index
6  n2=1.47;//Cladding  Refractive  Index
7  NA=sqrt(n1^2-n2^2);// Numerical  Aperture
8  disp(NA,"Numerical  Aperture  is")
```

Scilab code Exa 2.2.c acceptance angle

```
1  // Example  2.2.c:  Acceptance  Angle
2  clc;
3  clear;
4  close;
5  n1=1.50;//Waveguide  Refractive  Index
6  n2=1.47;//Cladding  Refractive  Index
7  h= 1.3;// Wavelenght  in  micrometers
8  NA=sqrt(n1^2-n2^2);// Numerical  Aperture
9  Oa=asind(NA);//ACCEPTANCE  ANGLE
10 oa=floor(Oa);//
11 x=Oa-oa;//
12 disp("ACCEPTANCE  ANGLE  IS  "+string(oa)+"  DEGREE  AND
        "+string(round((60*(x))))+"  MINUTES  ")
```

```
13 // answer is wrong in the textbook
```

Scilab code Exa 2.3 NA solid acceptance angle and critical angle

```
1 // Example 2.3: Numerical Aperture , Acceptance Angle
     and criticle angke
2 clc;
3 clear;
4 close;
5 n1=1.46;// core Refractive Index
6 d=1;// refractive index differnce in percentage
7 NA=n1*(sqrt(2*(d/100)));// Numerical Aperture
8 Sa= %pi*(NA)^2;// solid accepance angle in strad
9 r=1-(d/100);// ratio of refractive index
10 Oc=asind(r);// criticle angle in degree
11 oc=floor(Oc);//
12 x=Oc-oc;//
13 disp(NA,"numerical aperture is")
14 disp(Sa,"solid acceptance angle in air in stard is")
15 disp("CRITICAL ANGLE IS "+string(oc)+" DEGREE AND "+
     string(round((60*(x))))+" MINUTES ")
```

Scilab code Exa 2.4 critical angle

```
1 // Example 2.4; Critical Angle
2 clc;
3 clear;
4 close;
5 n1=1.48;// Waveguide Refractive Index
6 n2=1.46;// Cladding Refractive Index
7 Oc=asind(sqrt((1-(n2/n1)^2)));// Critical Angle
8 disp(Oc,"critical angle in degree is")
```

Scilab code Exa 2.5 refrative index

```
1  // Example 2.5: Core and Cladding Index
2  clc;
3  clear;
4  close;
5  NA=0.3;// numerical aperture
6  d= 0.01;// Cange in core-cladding refractive index
7  r=(1-d);//ratio
8  n1=sqrt(((NA)^2)/(1-r^2));//core refrative index
9  n2= n1-(d*n1);
10 disp(n1,"refrative index of core is")
11 disp(n2,"Refradctive index of cladding is")
```

Scilab code Exa 2.6 compare acceptance angle

```
1  // Example 2.6: compare acceptance angle
2  clc;
3  clear;
4  close;
5  NA=0.4;// numerical aperture
6  r2=100;//angle at which rays change dirction
7  r=r2/2;//in degree
8  Oa=asind(NA);//ACCEPTANCE ANGLE
9  oa=floor(Oa);//
10 x=Oa-oa;//
11 Oas=asind(NA/cosd(r));//ACCEPTANCE ANGLE for skew
      rays in degree
12 oas=floor(Oas);//
13 xs=Oas-oas;//
14 disp("ACCEPTANCE ANGLE IS "+string(oa)+" DEGREE AND
      "+string(round((60*(x))))+" MINUTES ")
```

```
15  disp("ACCEPTANCE ANGLE FOR MEIDONAL RAYS IS "+string
        (oas)+" DEGREE AND "+string(round((60*(xs))))+"
        MINUTES ")
```

Scilab code Exa 2.7 number of modes

```
1  // Example 2.7: Number of the modes
2  clc ;
3  clear ;
4  close ;
5  a=50;;// Radius in meter
6  NA=0.29;// Numerical Aperture
7  h=0.85;// Wavelength in meter
8  M=round((2*%pi^2*a^2*NA^2)/(h)^2);//
9  disp(M,"Number of modes")
10 // answer is wrong in the textbook
```

Scilab code Exa 2.8 normalised frequency and number of modes

```
1  // Example 2.8: Number of modes
2  clc ;
3  clear ;
4  close ;
5  n1=1.5;// Waveguide Refractive Index
6  d= 0.015;// Cange in core-cladding refractive index
7  a=40;// core radius in micro meters
8  h=0.85;// wavelngth in micro meters
9  v=(2*%pi*a*n1*sqrt(2*d))/h;// Normalised wavelngth
10 m= round (v^2/2);// number of modes
11 disp(m,"number of modes")
12 // answer is wrong in the textbook
```

Scilab code Exa 2.9 radius

```
1  // Example 2.9: Maximum Core Readius
2  clc;
3  clear;
4  close;
5  n1=1.55;//Waveguide Refractive Index
6  n2=1.52;//
7  d= n1-n2;// Cange in core-cladding refractive index
8  h=1550;//wavelngth in nano meters
9  a=((2.405*h*10^-9)/(2*%pi*sqrt(n1^2-n2^2)));//Core
      Radius
10 disp(a*10^6,"maximum core radius in micro meters")
```

Scilab code Exa 2.10 number of modes

```
1  // Example 2.10: Number of modes
2  clc;
3  clear;
4  close;
5  NA=0.2
6  a=40;// core radius in micro meters
7  h=1;//wavelngth in micro meters
8  v=(2*%pi*(a/2)*NA)/h;//Normalised wavelngth
9  m= round (v^2/4);// number of modes
10 disp(m,"number of modes")
```

Scilab code Exa 2.11 core diameter

13

```
1  // Example  2.11: diameter
2  clc;
3  clear;
4  close;
5  v1=1.2;//
6  v2=2.4;//
7  h=0.85;//in  micro  meter
8  n1=1.5;//refrative  index
9  d1=0.015;//
10 a1=((v1*h)/(2*%pi*n1*sqrt(2*d1)));//in  micro  meter
11 d2=0.0015;//
12 a2=((v2*h)/(2*%pi*n1*sqrt(2*d2)));//in  micro  meter
13 disp(2*a1,"diameter  (case  1)  in  micro  meters  is")
14 disp(2*a2,"diameter  (case  2)  in  micro  meters  is")
15 //answer  is  wrong  in  the  textbook
```

Scilab code Exa 2.12 core diameter

```
1  // Example  2.12: diameter
2  clc;
3  clear;
4  close;
5  v=2.4*sqrt(2);//
6  h=1.3;//in  micro  meter
7  n1=1.5;//refrative  index
8  d1=0.01;//
9  a1=((v*h)/(2*%pi*n1*sqrt(2*d1)));//in  micro  meter
10 disp(a1,"radius  in  micro  meters  is")
```

Scilab code Exa 2.13 cut off wavelength

```
1  // Example  2.13: Cutoff  Wavelength
2  clc;
```

```
3  clear;
4  close;
5  n1=1.48;//Waveguide Refractive Index
6  a=4.8;// core radius in micro meters
7  d= 0.0025;// Cange in core−cladding refractive index
8  Hc= (2*%pi*a*sqrt(2*d)*n1)/2.4;
9  disp(round(Hc*10^3),"Cutoff wavelength in nano
      meters")
10 //answer is wrong in the textbook
```

Scilab code Exa 2.15 core diameter

```
1  // Example 2.15:diameter
2  clc;
3  clear;
4  close;
5  mfd=11.6;//in micro meter
6  a=mfd/2;//in micro meters
7  v=2.2;//
8  alpha=((a*10^-6)/(0.65+1.619*sqrt(v)+2.879*((v)^-6))
      );//
9  disp(2*alpha*10^6,"core diameter in micro meter ")
10 //answer is wrong in the textbook
```

Scilab code Exa 2.16 ESI refractive index difference

```
1  // Example 2.16:ESI relative refractive index
2  clc;
3  clear;
4  close;
5  h=1.190;//micro meter
6  sp=5.2;//in micro meter
7  n=1.5;//refractive index
```

```
 8  alpha2 =1.820* sp ;// in  micro  meter
 9  desi1 =(0.293/( n )^2) ;//
10  desi2 = desi1 *(1.19/ alpha2 )^2 ;//
11  disp ( desi2 *100 ,"ESI  relative  refrative  index
        difference  in  percentage  is")
12  // answer  is  wrong  in  the  textbook
```

Chapter 3

OPTICAL FIBER FABRICATION

Scilab code Exa 3.1.a fracture stress

```
1  // Example 3.1.a: fracture stress
2  clc;
3  clear;
4  close;
5  la=0.16;//bond length in nm
6  st=2.6*10^6;//psi
7  psi=6894.76;//Nm^-2
8  e=9*10^10;//NM^-2
9  yp=((4*la*10^-9*(st*psi)^2)/(e));//in joules
10 c=10^-8;//
11 sf=sqrt((2*e*yp)/(%pi*c));//N/m^2
12 sf1=sf/(psi);//psi
13 disp(sf1,"fracture stress in psi is")
```

Scilab code Exa 3.1.b percentage strain

```
1  // Example 3.1.b:percentage strain
2  clc;
3  clear;
4  close;
5  la=0.16;//bond length in nm
6  st=2.6*10^6;//psi
7  psi=6894.76;//Nm^-2
8  e=9*10^10;//NM^-2
9  yp=((4*la*10^-9*(st*psi)^2)/(e));//in joules
10 c=10^-8;//
11 sf=sqrt((2*e*yp)/(%pi*c));//N/m^2
12 sf1=sf/(psi);//psi
13 e=(sf/e)*100;//
14 disp(round(e),"percentage strain (%) is")
```

Scilab code Exa 3.2 loss

```
1  //Example 3.2 // The loss
2  clc;
3  clear;
4  close;
5  //given data :
6  format('v',5)
7  n1=1.5;
8  n2=1;
9  r=((n1-n2)/(n1+n2))^2;
10 L_f= (-10*log10(1-r));
11 disp(L_f,"The optical loss at one end ,(dB) = ")
12 Lt=2*L_f;
13 disp(Lt,"Total loss at both joints ,(dB) = ")
```

Scilab code Exa 3.3.a insertion loss and lateral misalignment

18

```
1  // Example 3.3.a:insertion loss
2  clc;
3  clear;
4  close;
5  n12=1.5;//refractive index
6  y=5;//lateral misalignment in micro meter
7  a2=50;//dia in micro meter
8  nlat=((16*n12^2)/(%pi*(1+n12)^4))*((2*acos(y/a2))-(y
       /a2)*sqrt(1-(y/a2)^2));//
9  loss=-10*log10(nlat);//loss in dB
10 disp(loss,"insertion loss in dB is")
11 //answer is wrong in the textbook
```

Scilab code Exa 3.3.b insertion loss and lateral misalignment

```
1  // Example 3.3.b:insertion loss
2  clc;
3  clear;
4  close;
5  n12=1.5;//refractive index
6  y=5;//lateral misalignment in micro meter
7  a2=50;//dia in micro meter
8  nlat=(1/(%pi))*((2*acos(y/a2))-(y/a2)*sqrt(1-(y/a2)
       ^2));//
9  loss=-10*log10(nlat);//loss in dB
10 disp(loss,"insertion loss in dB is")
11 //answer is wrong in the textbook
```

Scilab code Exa 3.4.a insertion loss

```
1  //Example 3.4.a // insertion loss
2  clc;
3  clear;
```

```
4 close;
5 //given data :
6 y=3;// in micro-m
7 alfa=2;
8 d=50;// in micro-m
9 a=d/alfa;
10 Lt=0.85*(y/a);
11 eta_lat=1-Lt;
12 L_lat=-10*log10(eta_lat);
13 disp(L_lat,"The insertion loss ,(dB) = ")
```

Scilab code Exa 3.4.b insertion loss

```
1 //Example 3.4.b // insertion loss
2 clc;
3 clear;
4 close;
5 //given data :
6 y=3;// in micro-m
7 alfa=2;
8 d=50;// in micro-m
9 a=d/alfa;
10 Lt=0.75*(y/a);
11 eta_lat=1-Lt;
12 L_lat=-10*log10(eta_lat);
13 disp(L_lat,"The insertion loss ,(dB) = ")
```

Scilab code Exa 3.5 insertion loss

```
1 //Example 3.5 // insertion loss
2 clc;
3 clear;
4 close;
```

```
 5  //given data :
 6  n1BYn2=1.48;
 7  NA1=0.2;
 8  n2theta=(5*%pi)/180;
 9  NA2=0.4;
10  eta1=((16*(n1BYn2)^2)/(1+n1BYn2)^4)*(1-((n2theta/(
      %pi*NA1))));
11  L_ang1=-10*log10(eta1);
12  eta2=((16*(n1BYn2)^2)/(1+n1BYn2)^4)*(1-((n2theta/(
      %pi*NA2))));
13  L_ang2=-10*log10(eta2)
14  disp(L_ang1,"the insertion loss ,(dB) = ")
15  disp(L_ang2,"the insertion loss ,(dB) = ")
```

Scilab code Exa 3.6 total insertion loss

```
 1  //Example 3.6 //total insertion loss
 2  clc;
 3  clear;
 4  close;
 5  //given data :
 6  a=8/2;// in micro-m
 7  V=2.4;
 8  w=a*((0.65+(1.62*V^(-3/2))+(2.88*V^-6))/sqrt(2));
 9  y=1;
10  NA=0.1;
11  theta=%pi/180;
12  n1=1.46;
13  T_lat=2.17*(y/w)^2;
14  T_ang=2.17*((theta*w*n1*V)/(a*NA))^2;
15  T=T_lat+T_ang;
16  disp(T,"Total insertion loss ,(dB) = ")
```

Scilab code Exa 3.7 loss

```
1  //Example 3.7 //The loss
2  clc;
3  clear;
4  close;
5  //given data :
6  a=9.2;// in micro-m
7  b=8.4;// in micro-m
8  wo2=b/2;
9  wo1=a/2;
10 L=-10*log10(4*((wo2/wo1)+(wo1/wo2))^-2);
11 disp(L,"The loss ,L(dB) = ")
12 // answer is wrong in textbook
```

Scilab code Exa 3.8 excess loss insertion loss cross talk and split ratio

```
1  //Example 3.8.a // Excess loss
2  clc;
3  clear;
4  close;
5  //given data :
6  P1=60;// in micro-W
7  P3=26;// in micro-W
8  P4=27.5;// in micro-W
9  P2=0.004;// in micro-W
10 E_loss=10*log10((P1/(P3+P4)));
11 disp(E_loss,"(a). The excess loss ,(dB) = ")
12 I_loss=10*log10(P1/P4);
13 disp(I_loss,"(b).i. insertion loss port 1 to port
       4,(dB) = ")
14 I_loss1=10*log10(P1/P3);
15 disp(I_loss1,"(b).ii. insertion loss port 1 to port
       3,(dB) = ")
16 C_talk=10*log10(P2/P1);
```

```
17  disp(C_talk,"Cross talk ,(db) = ")
18  sr=(P3/(P3+P4))*100;
19  disp(sr,"Split ratio ,(%) = ")
```

Scilab code Exa 3.9 total loss and average insertion loss

```
1  //Example 3.9 // Total loss and Average insertion
       loss
2  clc;
3  clear;
4  close;
5  //given data :
6  N=32;
7  Pin=10^3;
8  a=14;// in micro-W
9  pf=a*N;
10  s_loss=10*log10(N);
11  e_loss=10*log10(Pin/pf);
12  T_loss=s_loss+e_loss;
13  disp(T_loss,"Total loss ,(dB) = ")
14  I_loss=10*log10(Pin/a);
15  disp(I_loss,"The insertion loss ,(dB) = " )
```

Chapter 4

TRANSMISSION CHARACTERSTICS OF OPTICAL FIBERS

Scilab code Exa 4.1.a overall signal attenuation

```
1 // Example 4.1.a:signal attenuation
2 clc;
3 clear;
4 close;
5 L=8;// Length of fiber in km
6 Pi=120*10^-6;// input power in Watt
7 Po=4*10^-6;//Output power in Watt
8 alpha=(10*(log10(Pi/Po)));//Loss in dB
9 disp(alpha,"signal attenuation in dB")
```

Scilab code Exa 4.1.b signal attenuation per km

```
1 // Example 4.1.b:signal attenuation per km
2 clc;
```

```
 3 clear;
 4 close;
 5 L=8;// Length of fiber in km
 6 Pi=120*10^-6;// input power in Watt
 7 Po=4*10^-6;//Output power in Watt
 8 alpha=(10*(log10(Pi/Po)));//Loss in dB
 9 alphal=alpha/L
10 disp(alphal,"signal attenuation per km in dB/km is")
```

Scilab code Exa 4.1.c overall signal attenuation

```
 1 // Example 4.2.c:Loss for 10Km
 2 clc;
 3 clear;
 4 close;
 5 L=8;// Length of fiber in km
 6 Pi=120*10^-6;// input power in Watt
 7 Po=4*10^-6;//Output power in Watt
 8 alpha= round(10*(log10(Pi/Po)));//Loss in dB
 9 alphadb= alpha/L;//Loss in dB/Km
10 alphadb2=alphadb*10;// Loss along 10Km fiber length
      in dB
11 Ds=alphadb2+9;// Due to splices at 1km Interval
12 disp(Ds,"Atenuation Due to splices at 1km Interval
      in dB")
```

Scilab code Exa 4.1.d ratio of input power to output power

```
 1 // Example 4.1.d:Ratio of powers
 2 clc;
 3 clear;
 4 close;
 5 L=8;// Length of fiber in km
```

```
6  Pi =120*10^ -6;// input  power  in  Watt
7  Po =4*10^ -6;//Output  power  in  Watt
8  alpha= round (10*( log10 (Pi/Po)));//Loss  in  dB
9  alphadb= alpha/L;//Loss  in  dB/Km
10 alphadb2=alphadb *10;// Loss  along  10Km  fiber  length
      in  dB
11 Ds=alphadb2 +9;// Due  to  splices  at  1km  Interval
12 rt= 10^(Ds/10);// Ratio  of  input  to  output  power
13 disp (rt,"Ratio  of  input  to  output  power")
14 //answer  is  wrong  in  the  textbook
```

Scilab code Exa 4.2 attenuation

```
1  // Example  4.2: Attenuation
2  clc ;
3  clear ;
4  close ;
5  L=1;//in  km
6  h1 =0.63;//in  micro  meter
7  h2 =1;//in  micro  meter
8  h3 =1.3;//in  micro  meter
9  Tf =1400;//Temperature  in  Kelvin
10 p=0.286;//photoelastic  coefficient  of  silica
11 n=1.46;//Refractive  index  of  silica
12 Bc =7*10^ -11;//isothermal  compersebility  in  in  Metere
       square  per  N
13 K=1.38*10^ -23;// boltzman  constt.  in  julian  per
      Kelvin
14 x1= (h1 *10^ -6);
15 x2= (h2 *10^ -6);
16 x3= (h3 *10^ -6);
17 Yr1 =(8*%pi^3*n^8*p^2*Bc*K*Tf)/(3*(x1)^4);//ray  leigh
       scattering  coefficient
18 Ekm1= exp(-Yr1*L*10^3)
19 alpha1 =10*( log10 (1/Ekm1));//Attenuation  in  dB/km
```

```
20  Yr2=(8*%pi^3*n^8*p^2*Bc*K*Tf)/(3*(x2)^4);//ray leigh
       scattering coefficient
21  Ekm2= exp(-Yr2*L*10^3)
22  alpha2=10*(log10(1/Ekm2));//Attenuation in dB/km
23  Yr3=(8*%pi^3*n^8*p^2*Bc*K*Tf)/(3*(x3)^4);//ray leigh
       scattering coefficient
24  Ekm3= exp(-Yr3*L*10^3)
25  alpha3=10*(log10(1/Ekm3));//Attenuation in dB/km
26  disp(alpha1,"Attenuation in dB/km for (h=0.63 micro
       meter)")
27  disp(alpha2,"Attenuation in dB/km for (h=1 micro
       meter)")
28  disp(alpha3,"Attenuation in dB/km for (h=1.30 micro
       meter)")
```

Scilab code Exa 4.3 threshold stimulated Brillouin and Raman scattering powers

```
1  // Example 4.3: Optical Powers
2  clc;
3  clear;
4  close;
5  h=1.5;//Wavelength in micro meter
6  d=6;//Core diameter in micro meter
7  v=600;//frequency in Mega Hertz
8  alpha=0.4;//Attenuation in dB/km
9  Pb=(4.4*10^-3*d^2*h^2*alpha*v*10^-3)*10^3;//
       Threshold optical power for brillouin scattering
       in milli Watt
10 Pr=(5.9*10^-2*d^2*alpha*h);//Threshold optical power
       for Raman scattering in Watt
11 disp(Pb,"Threshold optical power for Brillouin
       scattering in milli Watt")
12 disp(Pr,"Threshold optical power for Raman
       scattering in Watt")
```

```
13  // Pb is calculated wrong in the text book
```

Scilab code Exa 4.4.a critical radius

```
1  // Example  4.4.a: Critical  Radius
2  clc;
3  clear;
4  close;
5  d=0.03;//Refractive  index  difference
6  n1=1.5;//Core  refractive  index
7  h= 0.85*10^-6;//Wavelength  in  meters
8  x=2*n1^2*d;//
9  Rc=(3*n1^2*h)/(4*%pi*sqrt(x))*10^6;//  Critical
       Radius  in  micro  meters
10 disp(Rc,"Critical  Radius  in  micro  meters")
11 //answer  is  calculated  wrong  in  the  textbook
```

Scilab code Exa 4.4.b critical radius

```
1  // Example  4.4.b: Critical  Radius  of  curvature
2  clc;
3  clear;
4  close;
5  a=4;// core  radius  in  micro  meters
6  d=0.003;//Refractive  index  difference
7  n1=1.5;//Core  refractive  index
8  h= 1.55*10^-6;//Wavelength  in  meters
9  x=2*n1^2*d;//
10 hc= ((2*%pi*a*10^-6*sqrt(2*d)*n1)/2.405)*10^6;//cut
       off  wavelength  in  micro  meters;
11 x1=(20*h)/(sqrt(x));
12 y=((2.748-0.996*((h*10^6)/hc)))^-3;
13 Rcs=x1*y*10^6;
```

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```
14 disp(Rcs,"Critical Radius of curvature in micro
      meters")
15 //answer is calculated wrong in the textbook
```

Scilab code Exa 4.5.a bandwidth

```
1 // Example 4.5.a:Maximum possible optical bandwidth
2 clc;
3 clear;
4 close;
5 t=0.1*10^-6;//Time in second
6 L=15;//Distance in km
7 Bt=(1/(2*t))*10^-6;//Maximum possible optical
      bandwidth in Mega Hertz
8 disp(Bt,"Maximum possible optical bandwidth in Mega
      Hertz")
```

Scilab code Exa 4.5.b pulse dispersion

```
1 // Example 4.5.b:Despersion per unit length
2 clc;
3 clear;
4 close;
5 t=0.1*10^-6;//Time in second
6 L=15;//Distance in km
7 dp=(t/L)*10^6;//Despersion per unit length in micro
      second per Km
8 disp(dp*10^3,"Despersion per unit length in nano
      second per km")
```

Scilab code Exa 4.5.c bandwidth length product

```
1 // Example 4.5.c:Bandwidth legth product
2 clc;
3 clear;
4 close;
5 t=0.1*10^-6;//Time in second
6 L=15;//Distance in km
7 Bt=(1/(2*t))*10^-6;//Maximum possible optical
     bandwidth in Mega Hertz
8 BL=Bt*L;// bandwidth length product in km
9 disp(BL,"bandwidth length product in MHz km")
```

Scilab code Exa 4.6 material dispersion parameter and pulse broadning

```
1 // Example 4.6;/Pulse broadning due to material
     dispersion
2 clc;
3 clear;
4 close;
5 c=3*10^5;// speed of light in km/s
6 Dh=0.025;//Material dispersion
7 L=1;//distance in km
8 h=0.85;//Wavelength micro meters
9 Sh=20;// Spectral width in nano meter
10 M=Dh/(c*h*10^3);//
11 Sm=M*L*Sh//Pulse broadning due to material
     dispersion in nano second per kilometer
12 disp(Sm*10^9,"Pulse broadning due to material
     dispersion in nano second per kilometer")
```

Scilab code Exa 4.7 rms pulse broadning

```
1  // Example 4.7// Pulse broadning due to material
       dispersion
2  clc;
3  clear;
4  close;
5  c=3*10^5;// speed of light in km/s
6  Dh=0.03;// Material dispersion
7  L=1;// distance in km
8  h=0.85;// Wavelength in micro meters
9  Sh=0.0012*h;// Spectral width in nano meter
10 M=Dh/(c*h*10^3);//
11 Sm=M*L*Sh// Pulse broadning due to material
       dispersion in nano second per kilometer
12 disp(Sm*10^12,"Pulse broadning due to material
       dispersion in nano second per kilometer")
```

Scilab code Exa 4.8 pulse spreading

```
1  // Example 4.8// Pulse broadning due to material
       dispersion
2  clc;
3  clear;
4  close;
5  ho=1343;// nm
6  h=850;// in nm
7  so=0.097;// in ps/nm^2
8  m(h)=((so*(h/4))*(1-(h/ho))^4);// in ps/nm-km
9  tgmat=m(h)*70;// in ns/km
10 dt=tgmat*100;// in ns
11 disp(dt,"total pulse spread in ns is")
12 // answer is wrong in the textbook
```

Scilab code Exa 4.9.a delay difference

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```
1  // Example 4.9.a //delay
2  clc;
3  clear;
4  close;
5  d=0.01;// Change in refractive index
6  n1=1.5;//Core refrctive index
7  L=6*10^3;//Length in meter
8  C=2.998*10^8;//Speed of light in m/s
9  dts=round(((L*n1*d)/C)*10^9);//delay in ns
10 disp(dts,"delay in ns")
```

Scilab code Exa 4.9.b rms pulse broadning

```
1  // Example 4.9.b;//Pulse broadning due to intermodal
       dispersion
2  clc;
3  clear;
4  close;
5  d=0.01;// Change in refractive index
6  n1=1.5;//Core refrctive index
7  L=6*10^3;//Length in meter
8  C=2.998*10^8;//Speed of light in m/s
9  Ss=(L*n1*d)/(2*sqrt(3)*C)*10^9;//Pulse broadning due
       to intermodal dispersion in ns
10 disp(Ss,"Pulse broadning due to intermodal
     dispersion in ns")
```

Scilab code Exa 4.9.c bit rate

```
1  // Example 4.9.c//Bit Rate
2  clc;
3  clear;
4  close;
```

```
5  d=0.01;// Change in refractive index
6  n1=1.5;//Core refrctive index
7  L=6*10^3;//Length in meter
8  C=2.998*10^8;//Speed of light in m/s
9  dts=round(((L*n1*d)/C)*10^9);//Delay in ns
10 Bt=(1/(2*dts*10^9))*10^12;//Bit rate in Mbits/sec
11 Ss=(L*n1*d)/(2*sqrt(3)*C);//Pulse broadning due to
       intermodal dispersion in ns
12 Btimp=0.2/Ss;//
13 disp(Bt,"Bit rate in M bit per seconds")
14 disp(Btimp*10^-6,"improved estimate of bit rate in M
        bit per seconds")
```

Scilab code Exa 4.9.d bandwidth length product

```
1  // Example 4.9.d//BANDWIDTH LENGTH PRODUCT
2  clc;
3  clear;
4  close;
5  d=0.01;// Change in refractive index
6  n1=1.5;//Core refrctive index
7  L=6*10^3;//Length in meter
8  C=2.998*10^8;//Speed of light in m/s
9  dts=round(((L*n1*d)/C)*10^9);//Delay in ns
10 Bt=(1/(2*dts*10^9))*10^12;//Bit rate in Mbits/sec
11 Ss=(L*n1*d)/(2*sqrt(3)*C);//Pulse broadning due to
       intermodal dispersion in ns
12 Btimp=0.2/Ss;//
13 BL=Btimp*L*10^-9;// bandwidth length product in km
14 disp(BL,"bandwidth length product MHz km")
```

Scilab code Exa 4.10.a rms pulse broadning

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```
1  // Example 4.10.a;//TOTAL RMS Pulse broadning
2  clc;
3  clear;
4  close;
5  M=250;//dispersion parametr picosecond per nano
      meter per kilometer
6  Sa=50;//spectral width in nm
7  NA=0.3;//numerical aperture
8  n1=1.45;// Core refractibve index
9  C=2.998*10^8;//Speed of light in m/s
10 L=1;//length in Km
11 Sm=M*L*Sa*10^-3;//rms pulse broadning due to
      material dispersion
12 Ss=(L*10^3*NA^2)/(4*sqrt(3)*C*n1)*10^9;//Pulse
      broadning due to intermodal dispersion in ns/km
13 St=sqrt(Sm^2+Ss^2);// Total broadning
14 disp(St,"Total broadning ns per km is")
```

Scilab code Exa 4.10.b bandwidth length product

```
1  // Example 4.10.b;//bandwidth length product
2  clc;
3  clear;
4  close;
5  M=250;//dispersion parameter picosecond per nano
      meter per kilometer
6  Sa=50;//spectral width in nm
7  NA=0.3;//numerical aperture
8  n1=1.45;// Core refractibve index
9  C=2.998*10^8;//Speed of light in m/s
10 L=1;//length in km
11 Sm=M*L*Sa*10^-3;//rms pulse broadning due to
      material dispersion
12 Ss=(L*10^3*NA^2)/(4*sqrt(3)*C*n1)*10^9;//Pulse
      broadning due to intermodal dispersion in ns/km
```

```
13  St=sqrt(Sm^2+Ss^2);// Total broadning
14  BL= (0.2/(St*10^-9))*10^-6;// Bandwidth length
       product in Mega hertz km
15  disp(BL,"Bandwidth length product is ,(MHz-km)")
```

Scilab code Exa 4.11 compare first order dispersion

```
1  // Example 4.11 //compare the total first order
       dispersion
2  clc;
3  clear;
4  close;
5  so=0.095;//ps nm^-2 km^-1
6  h=1270;//in nm
7  ho=1320;//in nm
8  dt1=((h*so)/4)*((1-(ho/h)^4));// in ps nm^-1 km^-1
9  h1=1520;//in nm
10 dt21=((h1*so)/4)*((1-(ho/h1)^4));// in ps nm^-1 km
       ^-1
11 dt2=dt21-(13.5+4.1);// in ps nm^-1 km^-1
12 disp(dt1,"first order dispersion at wavelength 1270
       nm in ps nm^-1 km^-1")
13 disp(dt2,"first order dispersion at wavelength 1320
       nm in ps nm^-1 km^-1")
14 //answer is wrong in the textbook
```

Scilab code Exa 4.12 bit rate

```
1  // Example 4.12;// bit rate
2  clc;
3  clear;
4  close;
5  dx=2;//in ps/nm-km
```

```
 6  L=100;//in  km
 7  h1 =1310;//  in  nm
 8  h2 =1300;//in  nm
 9  dh=h1 - h2;//in  nm
10  brl =(1/(4* dx *( dh /10)));//in  Gbps-km
11  br=brl/L;//in  Gbps
12  disp ( br *10^3 ," bit  rate  in  Gbps ")
```

Scilab code Exa 4.13 bit rate

```
1  // Example  4.13;//Maximum  bit  rate
2  clc ;
3  clear ;
4  close ;
5  L=20;//Length  in  km
6  Dt2 =300*10^ -12;//Birefringent  in  second  per
       kilometer
7  B=(0.9)/( Dt2 *L*10^3);//
8  Btm=  round (( B /0.55)*10^ -3);// maximum  bit  rate  in
       kilo  bit  per  second
9  disp (Btm ," maximum  bit  rate  in  kilo  bit  per  second ")
```

Scilab code Exa 4.14 modal birefringence

```
1  // Example  4.14  // birefringence
2  clc ;
3  clear ;
4  close ;
5  Lbc1 =0.7;// beat  length  micro  meter
6  h=1.3;// wavelength  in  micro  meter
7  Bf1 =(( h *10^ -6)/( Lbc1 *10^ -3));// birefringence  when
       beat  length  =  0.5mm
8  Lbc2 =80;// beat  length  meter
```

```
9  Bf2=((h*10^-6)/(Lbc2));// birefringence when beat
       length = 60 meter
10 disp(Bf1 ,"birefringence (high birefringent fiber)
       when beat length = 0.7 micro meter")
11 disp(Bf2 ,"birefringence (lower birefringent fiber)
       when beat length = 80 meter")
```

Scilab code Exa 4.15 modal birefringence cohrence length and propogation difference

```
1  // Example 4.15// Bifringence and differnce between
       the propogation constt.
2  clc;
3  clear;
4  close;
5  Lb=0.09;// Birefringent Coherence over length in
       meter
6  h=0.9;// wavelength in micro meter
7  df=1;// spectral width in nano meter
8  Bf=((h*10^-6)/(Lb));//modal bifringence
9  Lbc= (((h*10^-6)^2)/(Bf*df*10^-9));//Coherance
       length in meter
10 Bxy=(2*%pi)/(Lb);//Diff in the propogation constant
11 disp(Bf ,"modal bifringence  is")
12 disp(Bxy ,"Difference in the propgation constants. is
       ")
```

Scilab code Exa 4.16 bit rate

```
1  // Example 4.16// bit rate
2  clc;
3  clear;
4  close;
```

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```
5 pmc =0.5; // ps / s q r t (km)
6 l =100; //km
7 br =(1/(4* pmc * sqrt (l)));//
8 disp ( br *10^3 ," bit  rate  is  ,( Gbps )=")
```

Chapter 5

OPTICAL SOURCES LASER

Scilab code Exa 5.1 number of longitudinal modes and their frequency separation

```
1  // Example 5.1 //number of longitudinal modes and
       frequency spacing
2  clc;
3  clear;
4  close;
5  h=0.55*10^-6; //Wavelength in meter
6  n=1.78; //refractive index
7  L=4*10^-2; //Length in meter
8  C=3*10^8; //Speed of light in m/s
9  q=(2*n*L)/(h); //Number of logitudinal modes
10 df=((C)/(2*n*L))*10^-9; //frequency sepration in Gega
       Hertz
11 disp(q,"Number of longitudinal modes are ")
12 disp(df,"frequency spacing in Gega Hertz is ")
```

Scilab code Exa 5.2 radiative minority carrier lifetimes

```
1  // Example 5.2;// wavelength spacing and frequency
       spacing
2  clc;
3  clear;
4  close;
5  Br1=7.21*10^-10;//Bit rate
6  n=10^18;//hole concentration
7  Trg=((Br1*n)^-1)*10^9;//radiative minority carrier
       lifetime in GaAs in ns
8  Br2=1.79*10^-15;//Bit rate
9  Trs=((Br2*n)^-1)*10^3;//radiative minority carrier
       lifetime in Si in ms
10 disp(Trg,"radiative minority carrier lifetime in
       GaAs in ns")
11 disp(Trs,"radiative minority carrier lifetime in Si
       in ms")
```

Scilab code Exa 5.3 threshold current density

```
1
2  // Example 5.3 //threshold density and threshold
       current
3  clc;
4  clear;
5  close;
6  B=21*10^-3;//Gain factor in ampere per centimeter
       cube
7  alpha=10;// in per cm
8  L=250*10^-4;//length in meter
9  w=100;//in micro meter
10 r=0.32;
11 Jth=(1/B)*(alpha+(1/L)*log(1/r));//Threshold current
        in ampere per centimeter cube
12 ith=Jth*L*w*10^-4;//
13 disp(Jth,"threshold density in Ampere per centimeter
```

```
      square")
14 disp(ith*10^3,"threshold current in mA is")
```

Scilab code Exa 5.4 slope efficiency

```
1 // Example 5.4 //slope efficiency
2 clc;
3 clear;
4 close;
5 eg=1242;//
6 e=1300;//in nm
7 n=0.1;//efficiency
8 s=((eg/e)*n);//
9 disp(s,"slope efficiency is")
```

Scilab code Exa 5.5 external power efficiency

```
1 // Example 5.5//external power efficiency
2 clc;
3 clear;
4 close;
5 eg=1.44;//
6 v=2.8;//in volts
7 an=0.20;;//efficiency
8 nep=((an*(eg/v))*100);//external power efficiency
9 disp(nep,"external power efficiency in percentage is
      ")
```

Scilab code Exa 5.6 compare ratio of threshold current densities

```
1 // Example 5.6;//ratio of threshold current at
      differnt temperatures
2 clc;
3 close;
4 clear;
5 To1=160;//Absolute temperature in Kelvin
6 To=55;//in Kelvin
7 T1=293;//T=20 in Kelvin
8 T2=353;//T=80 in Kelvin
9 J1=exp((T2-T1)/To1);//threshold current ration for
      AlGaAs laser
10 J2=exp((T2-T1)/To);//threshold current RATIO FOR
      InGaAs laser
11 disp(J1,"ratio of the threshold current densities
      for AlGaAs laser")
12 disp(J2,"ratio of current densities for InGaAs laser
      ")
```

Scilab code Exa 5.7.a rms value of power fluctuation

```
1 // Example 5.7.a;//rms value of power fluctuation
2 clc;
3 close;
4 clear;
5 op=10^-15;//outputin dB Hz^-1
6 bw=100;//in MHz
7 h=1.55;//in micro meter
8 ef=0.6;//quantum efficiency
9 pi=2;//in mW
10 rrmf=op*bw*10^6;//
11 rmf=sqrt(rrmf);//
12 disp(rmf,"rms value of power fluctuation is")
```

Scilab code Exa 5.7.b rms noise current

```
1  // Example 5.7.b;// rms noise current
2  clc;
3  close;
4  clear;
5  op=10^-15;//outputin dB Hz^-1
6  bw=100;//in MHz
7  h=1.55;//in micro meter
8  ef=0.6;//quantum efficiency
9  pi=2;//in mW
10 rrmf=op*bw*10^6;//
11 rmf=sqrt(rrmf);//
12 e=1.6*10^-19;//
13 hc=6.63*10^-34;//
14 c=3*10^8;//in m/s
15 x=((e*ef*h*10^-6*pi*10^-3*10^4*3.16*10^-8)/(hc*c));
       //
16 disp(x,"rms noise current in A is")
```

Chapter 6

OPTICAL SOURCES LEDs

Scilab code Exa 6.1 internal quantum efficiency

```
1 // Example 6.1 //inernal quantum efficiency
2 clc;
3 clear;
4 close;
5 tr=2.5;//radiative recombination time in milli
    second
6 tnr=50;//non radiative recombination time in milli
    second
7 t=(tr*tnr)/(tr+tnr);//Bulk recombination life time
    in millisecond
8 nint= (t/tr)
9 disp(nint*100,"inernal quantum efficiency is(%) ")
```

Scilab code Exa 6.2 total carrier recombination lifetime and power

```
1 // Example 6.2//internal power level
2 clc;
3 clear;
```

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```scilab
4  close;
5  e=1.6*10^-19;//Electronic charge
6  ht=6.62*10^-34;//Constt
7  C=3*10^8;//speed light in m/s
8  h=0.87*10^-6;//wavelength in meter
9  tr=80;//radiative recombination time in nano second
10 tnr=120;//non radiative recombination time in nano
       second
11 t=(tr*tnr)/(tr+tnr);//Bulk recombination life time
       in nano second
12 nint= (t/tr)
13 i=40;//injected current in milli ampere
14 Pint= (nint*((ht*C*i*10^-3)/(e*h)))*10^3;//internal
       power level in milli Watt
15 disp(Pint,"internal power level in milli Watt")
```

Scilab code Exa 6.3.a optical power

```scilab
1  // Example 6.3.a//optical power emitted
2  clc;
3  clear;
4  close;
5  F=0.62;//transmission factore
6  nx=3.6;//refractive index
7  n=1;//refractive index of air
8  Px=((F*n^2)/(4*nx^2));//optical power emitter
9  disp("emiiter power in terms of power generated
       internally is "+string(Px)+" Pint")
```

Scilab code Exa 6.3.b external efficiency

```scilab
1  // Example 6.3.b //external power efficiency
2  clc;
```

```
3  clear;
4  close;
5  F=0.62;//transmission factore
6  nx=3.6;//refractive index
7  n=1;//refractive index of air
8  Px=((F*n^2)/(4*nx^2));//optical power emitter
9  Pint=0.5;//
10 NEP=(Px*Pint)*100;//
11 disp(NEP,"external power efficiency in (%) is")
```

Scilab code Exa 6.4.a coupling efficiency

```
1  // Example 6.4.a //coupling efficiency
2  clc;
3  clear;
4  close;
5  NA=0.2;//numerical aperture
6  n=1.4;//refractive index
7  nc=(NA)^2;//coupling efficiency
8  disp(nc,"coupling efficiency is")
```

Scilab code Exa 6.4.b optical loss

```
1  // Example 6.4.b //optical power loss
2  clc;
3  clear;
4  close;
5  NA=0.2;//numerical aperture
6  n=1.4;//refractive index
7  nc=(NA)^2;//coupling efficiency
8  Loss=round(-(10*log10(nc)));//optical loss in dB
9  disp(Loss,"optical loss in dB is")
```

Scilab code Exa 6.4.c loss

```
1  // Example 6.4.c //optical loss
2  clc;
3  clear;
4  close;
5  NA=0.2;//numerical aperture
6  n=1.4;//refractive index
7  nc=(NA)^2;//coupling efficiency
8  pe=0.012;//
9  pc1=pe*nc;//
10 Loss=round(-(10*log10(pc1)));//optical loss in dB
11 disp(Loss,"optical loss in dB is")
12 //answer is wrong in the text book
```

Scilab code Exa 6.5 optical power

```
1  // Example 6.5 //optical power
2  clc;
3  clear;
4  close;
5  r=0.01;//fresenel reflection coefficient
6  NA=0.15;//numeical apertrure
7  Rd=30;//radiance in W sr-1 cm-2
8  R=30*10^-4;//radis in centi meter
9  A=(%pi*R^2);//area
10 Pc=(%pi*(1-r)*A*Rd*NA^2)*10^6;//optical power
      coupled in mincro watt
11 disp(Pc,"optical power coupled in micro Watt is")
12 // answer is wrong in the textbook
```

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Scilab code Exa 6.6 overall power conversion efficiency

```
1
2 // Example 6.6 //overall power conversion efficiency
3 clc;
4 clear;
5 close;
6 Pc=200*10^-6;//Optical power in Watt
7 If=25;//forward current in milli Ampere
8 Vf=1.5;//forward voltage in Volts
9 P=If*10^-3*Vf;//power in Watt
10 npc=((Pc/P));//overall power conversion efficiency
11 disp(npc*100,"overall power conversion efficiency in
        percentage")
12 //answer is wrong in the textbook
```

Scilab code Exa 6.7 compare electrical and optical bandwidth

```
1 // Example 6.7:compare
2 clc;
3 clear;
4 close;
5 ioi=1/sqrt(2);//given
6 ioi1=1/(2);//given/
7 disp(ioi,"-3 dB electrical bandwidth point occur
      when Iout/Iin,=")
8 disp(ioi1,"-3 dB optical bandwidth point occur when
      Iout/Iin,=")
```

Scilab code Exa 6.8 optical power and optical bandwidth

```
1  // Example 6.8 // find output power and bandwidth
2  clc;
3  clear;
4  close;
5  Pdc=320*10^-6;//d.c. power in Watt
6  f1=20*10^6;//frequency in hertz
7  Ti=5*10^-9;// recombination life time in nano second
8  Pe1=(Pdc/sqrt(1+(2*%pi*f1*Ti)^2))*10^6;
9  f2=100*10^6;//frequency in hertz
10 Pe2=(Pdc/sqrt(1+(2*%pi*f2*Ti)^2))*10^6;
11 f=((sqrt(3))/(2*%pi*Ti));//in MHz
12 fele=f*0.707;//
13 disp(Pe1,"overall power in micro Watt when frequecy
       is 20 MHz")
14 disp(Pe2,"overall power in micro Watt when frequecy
       is 80 MHz")
15 disp(f*10^-6,"optical bandwidth in MHz is")
16 disp(round(fele*10^-6),"electrical bandwidth in MHz
       is")
```

Scilab code Exa 6.9 operating lifetime

```
1  // Example 6.9;//CW operating lifetime
2  clc;
3  clear;
4  close;
5  d=0.67;//
6  bo=1.86*10^7;//in h^-1
7  ea=1.67*10^-19;//
8  k=1.38*10^-23;//
9  t=290;//Kelvin
10 x=((-ea)/(k*t));//
11 be=((bo)*exp(-40));//in h^-1
```

```
12  t=((-log(d))/be);//in hours
13  disp(t,"CW operating lifetime in hours is")
```

Scilab code Exa 6.10 power coupled

```
1  // Example 6.10 //power coupled
2  clc;
3  clear;
4  close;
5  tha=15;//in degree
6  po=1;//in micro watt
7  nc=(sind(tha))^2;//
8  pf=nc*po*10^-6;//in watts
9  disp(pf*10^9,"power coupled in nW is")
```

Scilab code Exa 6.11 power coupled

```
1  // Example 6.11 //power coupled
2  clc;
3  clear;
4  close;
5  If=1.5;//in mA
6  Vf=20;//in volts
7  pin=If*Vf;//in Watts
8  nint=2;//efficiency
9  tha=20;//in degree
10 po=((nint/100)*pin);//in Watt
11 nc=(sind(tha))^2;//
12 pf=nc*po;//in Watts
13 disp(pf*10^3,"power coupled in micro watts is")
```

Scilab code Exa 6.12 bandwidth

```
1  // Example 6.12;//bandwidth
2  clc;
3  clear;
4  close;
5  tr=10;//in ns
6  bw=(0.35/tr);//in MHz
7  disp(bw*10^3,"bandwidth in MHz is")
```

Scilab code Exa 6.13 coupling efficiency

```
1  // Example 6.13 //coupling efficiency
2  clc;
3  clear;
4  close;
5  t=1;//
6  no=1;//
7  na=0.3;//
8  x=1;//assume
9  y=1;//
10 nc1=(t*(na/no)^2*(x/y)^2)*100;//
11 alpha=2;//
12 nc2=((t*(na/no)^2*(x/y)^2*(alpha/(alpha+2))))*100;//
13 disp(nc1,"coupling efficiency for step index fiber
       in (%)")
14 disp(nc2,"coupling efficiency for graded index fiber
        in (%)")
```

Scilab code Exa 6.14 coupling efficiency

```
1  // Example 6.14 //coupling efficiency
2  clc;
```

```
3  clear ;
4  close ;
5  t =1; //
6  no =1; //
7  na =0.3; //
8  x =1; // assume
9  y =3/4; //
10 alpha =2; //
11 nc1 =((t*(na/no)^2)*(alpha+(1-(y/x)^2)))/(alpha+2)
      *100; //
12 disp(nc1 ,"coupling efficiency for graded index fiber
      in (%)")
```

Scilab code Exa 6.15 power coupled

```
1  // Example 6.15; // power coupled
2  clc ;
3  clear ;
4  close ;
5  n1 =1.48; //
6  n2 =1.46; //
7  po =100; // in micro watts
8  pin =((po*((n1^2-n2^2)))); // in micro watts
9  disp(pin ,"power coupled in micro watts is")
```

Chapter 7

OPTICAL DETECTORS

Scilab code Exa 7.1 cut off wavelength

```
1  // Example 7.1 //WAVELENGTH
2  clc;
3  clear;
4  close;
5  E=1.35//energy gap in electron-volt
6  e=1.6*10^-19;//elecronic charge
7  C=3*10^8;//Speed of light in meter per second
8  ht=6.63*10^-34;//plank constt.
9  h=((ht*C)/(E*e))*10^6;//Wavelength
10 disp(h,"wavelength in micro meter")
```

Scilab code Exa 7.2 quantum efficiency and responsivity

```
1
2  // Example 7.2 //quantum efficiency and responsivity
3  clc;
4  clear;
5  close;
```

```
 6  e=1.6*10^-19;//elecronic  charge
 7  re=1.2*10^12;// Average  no.  of  electron  hole  pair
        generated
 8  rp=3*10^12;//no.  of  photons
 9  h=0.85;//wavelength  in  micro  meter
10  E=0.75;//energy  gap  in  electron  volt
11  C=3*10^8;//SPEED  of  light  in  meter  per  second
12  n=round((re/rp)*100);//quantum  efficiency
13  ht=6.62*10^-34;//plank  constt.
14  R=((n/100)*e*h*10^-6)/(ht*C);
15  disp(n,"quantum  efficiency  (%)")
16  disp(R,"Responsivity  is  in  Ampere  per  Watt")
```

Scilab code Exa 7.3 wavelength and optical power

```
 1  // Example  7.3  //Wavelength  and  Incident  optical
        power
 2  clc;
 3  clear;
 4  close;
 5  E=1.5*10^-19;//energy  in  joule
 6  e=1.6*10^-19;//elecronic  charge
 7  If=3*10^-6;//forward  current  in  ampere
 8  C=3*10^8;//Speed  of  light  in  meter  per  second
 9  n=0.6;//quantum  efficiency
10  ht=6.62*10^-34;//plank  constt.
11  h=((ht*C)/E)*10^6;//Wavelength
12  R=(n*e)/(E);//Responsivity  in  ampere  per  watt
13  Po=(If/R)*10^6;//Output  power  in  micro  watt
14  disp(h,"wavelength  in  micro  meter")
15  disp(Po,"Output  power  in  micro  Watt")
```

Scilab code Exa 7.4 responsivity

```
 1
 2 // Example 7.4 //responsivity
 3 clc;
 4 clear;
 5 close;
 6 n=20;//efficiency
 7 e=1.6*10^-19;//elecronic charge
 8 h=0.80;//wavelength in micro meter
 9 C=3*10^8;//SPEED of light in meter per second
10 ht=6.62*10^-34;//plank constt.
11 R=((n/100)*e*h*10^-6)/(ht*C);
12 disp(R,"Responsivity is in Ampere per Watt")
```

Scilab code Exa 7.5.a photocurrent

```
1 // Example 7.5.a //photocurrent
2 clc;
3 clear;
4 close;
5 R=0.85;//in AW^-1
6 pi=1.5;//in mW
7 po=1;//in mW
8 ip=po*R;//in mA
9 disp(ip,"photocurrent in mA is")
```

Scilab code Exa 7.6 responsivity

```
1 // Example 7.6 // responsivity
2 clc;
3 clear;
4 close;
5 e=1.6*10^-19;//elecronic charge
6 eg=0.75;//eV
```

```
7  n=0.7;//
8  R=(n*e)/(eg*e);//
9  disp(R,"Responsivity  is  in  Ampere  per  Watt")
```

Scilab code Exa 7.7 width

```
1  // Example  7.7  //width    of  deplition  region
2  clc;
3  clear;
4  close;
5  n=70;// efficinecy
6  absc=10^5;//cm^−1
7  W=(2.303*-log10(1-(n/100)))/(absc);//in  meter
8  disp(round(W*10^6),"deplition  width  in  micro  meter
        is")
```

Scilab code Exa 7.8 response time

```
1  //Example  7.8  //  Maximum  response  time
2  clc;
3  clear;
4  close;
5  //given  data  :
6  Vd=3*10^4;//  in  m/s
7  W=30*10^-6;//  in  m
8  Bm=Vd/(2*%pi*W);
9  M=(1/Bm)*10^9;
10 disp(M,"Maximum  response  time ,( ns )  =  ")
```

Scilab code Exa 7.9 NEP and specific detectivity

```
1  //Example 7.9 // NEP and specific detectivity
2  clc;
3  clear;
4  close;
5  //given data :
6  h=6.63*10^-34;
7  c=3*10^8;
8  Id=9*10^-9;// in A
9  e=1.6*10^-19;
10 eta=60/100;
11 lamda=1.3*10^-6;// in m
12 A=100*50*10^-12;// in m^2
13 NEP=(h*c*sqrt(2*Id*e))/(eta*e*lamda);
14 disp(NEP,"NEP,(W) = ")
15 D=sqrt(A)/NEP;
16 disp(D,"Specific detectivity ,(MHz^(-1/2) W^-1) = ")
```

Scilab code Exa 7.10 bandwidth

```
1  //Example 7.10 // Bandwidth
2  clc;
3  clear;
4  close;
5  //given data :
6  t_tr=100;// in ps
7  tau_rc=100;// in ps
8  BW=(1/(2*%pi*(t_tr+tau_rc)*10^-12))*10^-9;
9  disp(BW,"Bandwidth ,BW(G bit/s) = ")
```

Scilab code Exa 7.11 multiplication factor

```
1  //Example 7.11 // Multiplication factor
2  clc;
```

```
 3  clear;
 4  close;
 5  //given data :
 6  eta=80/100;// quantum efficiency
 7  e=1.6*10^-19;
 8  lamda=.88*10^-6;// in m
 9  h=6.63*10^-34;//
10  c=3*10^8;
11  I=12;// in micro-A
12  R=(eta*e*lamda)/(h*c);
13  P0=0.6*10^-6;// in W
14  Ip=P0*R*10^6;
15  M=I/Ip;
16  disp(M,"Multiplication factor ,M = ")
```

Scilab code Exa 7.12 optical gain and hfe

```
 1  //Example 7.12 // Optical gain and hFE
 2  clc;
 3  clear;
 4  close;
 5  //given data :
 6  h=6.63*10^-34;
 7  c=3*10^8;
 8  e=1.6*10^-19;
 9  Ic=15*10^-3;// in A
10  P0=140*10^-6;// in W
11  lamda=1.3*10^-6;// in m
12  eta=45/100;// quantum efficiency
13  G0=(h*c*Ic)/(e*P0*lamda);
14  disp(G0,"The optical gain ,G0 = ")
15  h_FE=G0/eta;
16  disp(h_FE,"hFE = ")
17  // answer is wrong in the textbook
```

Scilab code Exa 7.13 maximum 3 dB bandwidth

```
1  //Example 7.13 // Maximum 3dB bandwidth
2  clc;
3  clear;
4  close;
5  //given data :
6  tF=5*10^-12;// in sec
7  G=60;// photoconductive gain
8  Bm=(1/(2*%pi*tF*G))*10^-6;
9  disp(Bm,"The maximum 3dB bandwidth ,Bm(MHz) = ")
10 // answer is wrong in textbook
```

Scilab code Exa 7.14 SNR

```
1  //Example 7.14 // SNR
2  clc;
3  clear;
4  close;
5  r=1;//responsivity
6  p=0.1;//micro watt
7  ins=910;//nA
8  snr=((r^2*(p*10^3)^2)/(ins^2));//
9  disp(snr,"SNR is , =")
```

Chapter 8

OPTICAL FIBER COMMUNICATION SYSTEM

Scilab code Exa 8.1 compare shot noise and thermal noise current

```
1
2 // Example 8.1 //compare shot noise and thermal
      current
3 clc;
4 clear;
5 close;
6 T=293;//Temperature in Kelvin
7 K=1.38*10^-23;//boltzman constt
8 C=3*10^8;//Speed of light in meter per second
9 e=1.6*10^-19;//elecronic charge
10 ht=6.62*10^-34;//plank constt.
11 Id=3;//dark current in nano ampere
12 n=0.60;//efficiency
13 Rl=4;//load resistance in kilo-ohms
14 h=0.9;//wavelength in micro meter
15 Po=200;// ouput power in nano Watt
16 B=5;// bandwidth in mega hertz
17 Ip= ((n*h*10^-6*Po*10^-9*e)/(ht*C))*10^9;//Photo
      current in Ampere
```

```
18  its=(2*e*B*10^6*(Id+Ip)*10^-9);//total shot noise
19  itsr=sqrt(its);//RMS shot noise
20  disp(itsr,"RMS shot noise current in Ampere is")
21  T=293;//Temperature in Kelvin
22  K=1.38*10^-23;//boltzman constt
23  C=3*10^8;//Speed of light in meter per second
24  e=1.6*10^-19;//elecronic charge
25  ht=6.62*10^-34;//plank constt.
26  Id=3;//dark current in nano ampere
27  n=0.60;//efficiency
28  Rl=4;//load resistance in killo ohms
29  h=0.9;//wavelength in micro meter
30  Po=200;// ouput power in nano wat
31  B=5;// bandwidth in mega hertz
32  it=(((4*K*T*B*10^6)/(Rl*10^3)));//thermal noise
33  itr=sqrt(it);//rms thermal noise
34  disp(itr,"RMS thermal noise current in Ampere is")
```

Scilab code Exa 8.2.a quantum limit

```
1  // Example 8.2.a //threshold quantum limit
2  clc;
3  clear;
4  close;
5  en=10^-9;//
6  n=-log(en);//
7  disp(round(n),"quantum limit is (photons per pulse
      required )")
```

Scilab code Exa 8.2.b incident power

```
1  // Example 8.2.b //minumum incident optical power
2  clc;
```

```
3  clear;
4  close;
5  en=10^-9;
6  n=-log(en);//
7  c=3*10^8;//m/s
8  ht=6.62*10^-34;//plank constt.
9  B=10^7;//NO. OF BITS
10 h=0.85*10^-6;//wavelength in meter
11 Po=((20.7*ht*B*c)/(2*h));//pulse energy in pico Watt
12 Podb=10*(log10(Po));//pulse energy in dB when
        refrence level is one Watt
13 Podb1=10*(log10(Po*10^3));//pulse energy in dB when
        refrence level is one mili Watt
14 disp(Po, "minimum incident optical power in Watts is
        ")
15 disp(Podb1 , "pulse energy in dB when refrence level
         is one miiliwatt in dBm")
```

Scilab code Exa 8.3.a bit rate for the system

```
1  // Example 8.3.a;//bit rate for the system
2  clc;
3  clear;
4  close;
5  wd=8;//bit wide
6  ts=32;//time slots
7  nb=ts*wd;//no. of bits in a frame
8  nf=8*10^3;//no. of frames
9  tr=nf*nb;//transmission rate
10 disp(tr*10^-6,"transmission rate for the system in M
        -bits-s^-1")
```

Scilab code Exa 8.3.b duration of time slot

```
1  // Example 8.3.b //duration of time slot
2  clc;
3  clear;
4  close;
5  wd=8;//bit wide
6  ts=32;//time slots
7  nb=ts*wd;//no. of bits in a frame
8  nf=8*10^3;//no. of frames
9  tr=nf*nb;//transmission rate
10 bdr1=1/tr;//bit duration
11 bdr=bdr1*wd;//
12 disp(bdr*10^6,"duration of time slot in micro
      seconds")
```

Scilab code Exa 8.3.c duration of a frame and multiframe

```
1  // Example 8.3.c //duration of a frame and
      multiframe
2  clc;
3  clear;
4  close;
5  wd=8;//bit wide
6  ts=32;//time slots
7  nb=ts*wd;//no. of bits in a frame
8  nf=8*10^3;//no. of frames
9  tr=nf*nb;//transmission rate
10 bdr1=1/tr;//bit duration
11 bdr=bdr1*wd;//
12 df=bdr*10^6*ts;//duration of frame
13 dmf=df*(ts/2);//ms
14 disp(df,"duration of frame in micro seconds")
15 disp(dmf*10^-3,"duration of multiframe in milli
      seconds")
```

Scilab code Exa 8.4 average number of photons

```
1 //Example 8.4 // Average nummber of photon
2 clc;
3 clear;
4 close;
5 //given data :
6 format('v',5)
7 M=80;// multiplication factor
8 K=0.02;// carrier ionization rates
9 eta=85/100;// quntum efficiency
10 Bt=0.6;// assuming a raised cosine signal spectrum
11 SbyN=144;
12 FM=(K*M)+(2-(1/M))*(1-K);
13 eta_max=(2*Bt*FM*SbyN)/(eta);
14 disp(eta_max,"The average number of photon,(photon)
     = ")
15 // answer is wrong in a textbook
```

Scilab code Exa 8.5 incident optical power

```
1 // Example 8.5;//minumum incident optical power
2 clc;
3 clear;
4 close;
5 nmax=732;//
6 c=3*10^8;//m/s
7 ht=6.62*10^-34;//plank constt.
8 B=10^7;//NO. OF BITS
9 h=1*10^-6;//wavelength in meter
10 Po=((nmax*ht*B*c)/(2*h))*10^12;//pulse energy in
     pico Watt
```

```
11  Podb =10*( log10 (Po ));// pulse energy in dB when
        refrence level is one Watt
12  Podb1 =10*( log10 (Po *10^ -9));// pulse energy in dB when
        refrence level is one mili Watt
13  disp (Podb1 , "pulse energy at bit rate of 10 M bit s
        ^ -1 in dBm")
14  B1 =14*10^7;//NO. OF BITS
15  Po1 =(( nmax *ht *B1 *c )/(2*h )) *10^12;// pulse energy in
        pico Watt
16  Podb1 =10*( log10 (Po1 ));// pulse energy in dB when
        refrence level is one Watt
17  Podb2 =10*( log10 (Po1 *10^ -9));// pulse energy in dB
        when refrence level is one mili Watt
18  disp (Podb2 , "pulse energy at bit rate of 140 M bit
        s^ -1 in dBm")
19  //at 10 M bit s^ -1 power is calc ulated wrong in the
        book
```

Scilab code Exa 8.6 channel loss

```
1  // Example 8.6;// total channel loss
2  clc ;
3  clear ;
4  close ;
5  afc =5;// attenuation in dB/km
6  aj =2;// splice loss in dB/km
7  l =5;// length in km
8  ac =3;//dB
9  ac1 =4.5;//dB
10 cl =( afc + aj )*l+ ac + ac1 ;//dB
11 disp (cl ,"tota channel loss in dB is")
```

Scilab code Exa 8.7.a dispersion equalization penalty

```
1  // Example 8.7.a //dispersion equalization penalty
2  clc;
3  clear;
4  close;
5  sg=0.65;// ns km^-1
6  l=8;//km
7  st=sg*l;//ns
8  bt=20;//M bit s^-1
9  dlw=2*(2*st*10^-9*bt*10^6*sqrt(2))^4;//dB
10 st1=sg*sqrt(l);//ns
11 dlw1=2*(2*st1*10^-9*bt*10^6*sqrt(2))^4;//dB
12 disp(dlw,"dispersion equalization penalty in dB
       without mode coupling at bit rate of 20 M bit s
       ^-1")
13 disp(dlw1,"dispersion equalization penalty in dB
       with mode coupling at bit rate of 20 M bit s^-1")
14 //penalty with mode coupling is calculated wrong in
       the book
```

Scilab code Exa 8.7.b dispersion equalization penalty

```
1  // Example 8.7.b;//dispersion equalization penalty
2  clc;
3  clear;
4  close;
5  sg=0.65;// ns km^-1
6  l=8;//km
7  st=sg*l;//ns
8  bt=140;//M bit s^-1
9  dlw=2*(2*st*10^-9*bt*10^6*sqrt(2))^4;//dB
10 st1=sg*sqrt(l);//ns
11 dlw1=2*(2*st1*10^-9*bt*10^6*sqrt(2))^4;//dB
12 disp(dlw,"dispersion equalization penalty in dB
       without mode coupling at bit rate of 20 M bit s
       ^-1")
```

```
13  disp(dlw1 ,"dispersion  equalization  penalty  in  dB
       with  mode  coupling  at  bit  rate  of  20 M  bit  s^-1")
14  //answer  is  calculated  wrong  in  the  book
```

Scilab code Exa 8.8 bit rate

```
1
2   // Example  8.8  //bit  rate
3   clc ;
4   clear ;
5   close ;
6   ts =8; //ns
7   l =8; //km
8   tn =4; //ns
9   tn1=tn*l ; //ns
10  tc =1; //
11  tc1=tc*l ; //ns
12  td =5; //ns
13  tsys =1.1* sqrt ( ts ^2+ tn1 ^2+ tc1 ^2+ td ^2) ; //ns
14  btmax =(0.7/( tsys *10^ -9) )*10^ -6; //M  bit /s
15  bt = btmax /2; //
16  disp ( bt ,"maximum  bit  rate  for  NRZ  format  in  MHz")
```

Scilab code Exa 8.9.a lonk length

```
1   // Example  8.9. a  //Link  length
2   clc ;
3   clear ;
4   close ;
5   pi = -3; //dBm
6   po = -56; //dBm
7   ac =2; //dBm
8   ma =8; //dBm
```

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```
9  afc =0.4; //dBm
10 aj=0.1; //dBm
11 l=((pi-po-ac-ma)/(afc+aj)); //km
12 disp(l,"link length when operating at 50 M bit/s in
      km is")
```

Scilab code Exa 8.9.b link length

```
1  // Example 8.9.b;//Link length
2  clc;
3  clear;
4  close;
5  pi=-3; //dBm
6  po=-42; //dBm
7  ac=2; //dBm
8  ma=8; //dBm
9  afc=0.4; //dBm
10 aj=0.1; //dBm
11 l=((pi-po-ac-ma)/(afc+aj)); //km
12 disp(l,"link length when operating at 500 M bit/s in
       km is")
```

Scilab code Exa 8.9.c link length

```
1  // Example 8.9.c;//Link length
2  clc;
3  clear;
4  close;
5  pi=-3; //dBm
6  po=-42; //dBm
7  ac=2; //dBm
8  ma=8; //dBm
9  afc=0.4; //dBm
```

```
10  aj =0.1;//dBm
11  dl =1.5;//dbm
12  l=((pi-po-ac-ma-dl)/(afc+aj));//km
13  disp(l,"link length when dispersion equalisation
        penalty is included in km is")
```

Scilab code Exa 8.10 optical power budget

```
1  // Example 8.10 //optical power budget
2  clc;
3  clear;
4  close;
5  mip=-10;//dBm
6  mop=-41;//dBm
7  tsm=mip-mop;//dB
8  disp(tsm,"total system margin in dB is")
9  l=7;//km
10  fcl=2.6;//dB
11  lfc=l*fcl;//fiber cable loss in dB
12  sl=0.5;//dBm
13  slc=sl*(l-1);//dB
14  cl=1.5;//dB
15  sm=6;//dB
16  tsm1=lfc+slc+cl+sm;//dB
17  disp(tsm1,"total system margin in dB is")
18  epm=tsm-tsm1;//dB
19  disp(epm,"excess power margin in dB is")
```

Scilab code Exa 8.12 average incident power

```
1  // Example 8.12 //optical power
2  clc;
3  clear;
```

```
4  close;
5  e=1.6*10^-19;//electron charge
6  sndb=55;//signal to noise ration in dB
7  sn=(10^(sndb/10));//
8  bw=5;//Mhz
9  r=0.5;//responsivity
10 cs=0.7;//signal attenuation
11 k=1.38*10^-23;//bolzman constant
12 tc=20;//degree celsius
13 tk=tc+273;//Kelvin
14 fdb=1.5;//
15 f=10^(fdb/10);//
16 rl=1;//mega ohms
17 x=((sn*4*k*tk*bw*10^6*f)/(rl*10^6));//
18 y=((2*sn*e*bw*10^6*r));//
19 ma=9/8;//
20 z=(2*ma*r^2*cs^2);//
21 s=poly(0,"s");//
22 p=-x-y*s+z*s^2;//
23 m=roots(p);//
24 disp(m(1,1)*10^6,"average incident power in micro
       Watts is")
```

Scilab code Exa 8.13 average incident power

```
1  // Example 8.13 //optical power
2  clc;
3  clear;
4  close;
5  fdb=6;//
6  f=10^(fdb/10);//
7  e=1.6*10^-19;//electron charge
8  sndb=45;//signal to noise ration in dB
9  sn=(10^(sndb/10));//
10 h=6.63*10^-34;//planck constant
```

```
11  c=3*10^8; //m/s
12  e=1.6*10^-19; //
13  n=0.6; //efficneicny
14  ma=0.5*10^-3; //
15  k=1.38*10^-23; //boltzman constant
16  tk=300; //degree celcius
17  bw=8; //MHz
18  rl=50; //kilo ohms
19  po=((h*c)/(e*n*ma^2))*sqrt((8*k*tk*bw*10^6*f)/(rl
        *10^3))*sqrt(sn); //
20  disp(po*10^6,"average power incident in micro Watts
        is")
```

Scilab code Exa 8.14.a optical power budget

```
1  // Example 8.14.a //optical power budget
2  clc;
3  clear;
4  close;
5  mip=-10; //dBm
6  mop=-25; //dBm
7  tsm=mip-mop; //dB
8  disp(tsm,"total system margin in dB is")
9  l=2; //km
10 fcl=3.2; //dB
11 lfc=l*fcl; //fiber cable loss in dB
12 sl=0.8; //dBm
13 slc=sl*l; //dB
14 cl=1.6; //dB
15 sm=4; //dB
16 tsm1=lfc+slc+cl+sm; //dB
17 disp(tsm1,"total system margin in dB is")
18 epm=tsm-tsm1; //dB
19 disp(epm,"excess power margin in dB is")
```

Scilab code Exa 8.14.b link length

```
1  // Example 8.14.b //possible increase in link length
2  clc;
3  clear;
4  close;
5  mip=-10;//dBm
6  mop=-25;//dBm
7  tsm=mip-mop;//dB
8  disp(tsm,"total system margin in dB is")
9  l=2;//km
10 fcl=3.2;//dB
11 lfc=l*fcl;//fiber cable loss in dB
12 sl=0.8;//dBm
13 slc=sl*l;//dB
14 cl=1.6;//dB
15 sm=4;//dB
16 tsm1=lfc+slc+cl+sm;//dB
17 disp(tsm1,"total system margin in dB is")
18 epm=tsm-tsm1;//dB
19 ma=8;//dB
20 l1=((-mop-cl-ma)/(fcl+sl));//km
21 eil=l1-l;//
22 disp(eil,"possible increase in length in km")
```

Scilab code Exa 8.15 time

```
1  //Example 8.15 //
2  clc;
3  clear;
4  close;
5  //given data :
```

```
6  B=5*10^6;// in Hz
7  Ts=10;// in ns
8  Td=4;// in ns
9  a=9;// in ns/km
10 b=2;// in ns/km
11 l=6;// in km
12 Tn=a*l;// in ns
13 Tc=b*l;// in ns
14 Ts_max=(0.35/B)*10^9;
15 disp(Ts_max,"T system_maxmum,(ns) = ")
16 Tsys=1.1*sqrt(Ts^2+Tn^2+Tc^2+Td^2);
17 disp(Tsys,"T system,(ns) = ")
18 //answer is wrong in the textbook
```

Scilab code Exa 8.16.b improvement in SNR and bandwidth

```
1  // Example 8.16.b //SNR improvement and bandwidth
2  clc;
3  clear;
4  close;
5  fd=400;//KHz
6  ba=4;//kHz
7  df1=fd/ba;//
8  snri=(1.76+20*log10(df1));//dB
9  disp(snri,"SNR improvement in dB is")
10 bm=2*ba*(df1+1);//kHz
11 disp(bm,"bandwidth in kHz is")
```

Scilab code Exa 8.17 ration of SNR

```
1  // Example 8.17;//ration of SNR
2  clc;
3  clear;
```

```
 4 close ;
 5 fa =1;//
 6 pa =1;//
 7 r =1;//
 8 po =1;//
 9 ac =1;//
10 ba =1;//
11 no =1;//
12 snr1 =((3* fa ^3* po *( r * po )^2*(( ac ^2) /2) )/(2* ba ^3* no ));
      // SNR output FM
13 snr2 =(( fa ^3* po *( r * po )^2*(( ac ^2) /2) )/(2* ba ^3* no ));//
      SNR output FM
14 rt = snr1 / snr2 ;//
15 disp ( rt ," ratio of output SNR ( in dB ) in two system
      is ")
```

Scilab code Exa 8.18 bandwidth and SNR

```
 1 // Example 8.18 // Optimum receiver bandwidth and
      peak to peak signal power to noise ratio
 2 clc ;
 3 clear ;
 4 close ;
 5 // given data :
 6 Tr =12*10^ -9;// in sec
 7 f0 =20*10^6;// in Hz
 8 fD =5*10^6;// in Hz
 9 Mr =80;// multiplication factor
10 Pp =.75*10^ -7;
11 B =5*10^6;// in Hz
12 i2N =10^ -17;// in A^2
13 fr =(1/ Tr )*10^ -6;
14 disp ( fr ," Optimum receiver bandwidth , fr ( MHz ) = ")
15 T0 =1/ f0 ;
16 SbyN =10* log10 ((3*( T0 * fD * Mr * Pp )^2) /((2*% pi * Tr * B )^2*
```

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```
     i2N) ) ;
17 disp(SbyN,"signal power to noise ratio ,(dB) = ")
```

Scilab code Exa 8.19 loss for star and bus distribution system

```
1  // Example 8.19:compare
2  clc;
3  clear;
4  close;
5  cl=1;//dB
6  actr=10;//dB
7  acl=1;//dB
8  fcl=4.5;//dB/km
9  sl=2.5;//dB
10 cel=2;//dB
11 dl=100;//m
12 x=cel*cl-fcl*dl*10^-3+(cel*cl+cl)*-(cel+cl)+(cel*cl+
       actr)+sl+cl;//
13 x1=(fcl*dl*10^-3)+(cel*cl+cl);//
14 disp("total loss for bus distribution system is "+
       string(x1)+"N + "+string(x)+"")
15 x3=(cel*2*cl)+cel+(fcl*dl*10^-3);//
16 disp("total loss for star distribution system is "+
       string(x3)+"+ 10log10(N)")
```

Scilab code Exa 8.20 length

```
1  // Example 8.20;//maximum length of the system
2  clc;
3  clear;
4  close;
5  af=0.20;//dB/km
6  ac1=0.05;//dB/km
```

```
 7  k=4;//
 8  b=1.2;//G bit/s
 9  c=3*10^8;//m/s
10  h=1.55;//micro meter
11  sndb=17
12  sn=10^(sndb/10);//
13  l=100;//km
14  hc=6.63*10^-34;//
15  lt=((10^-3*h*10^-6*(10^-((af+ac1)*(l/10)))*l*10^3)/(
       k*hc*c*b*10^12*sn));//
16  disp(lt,"maximum length of the system in km is")
17  //answer is wrong in the textbook
```

Chapter 9

OPTICAL FIBER SYSTEM II

Scilab code Exa 9.1 temperture

```
1 // Example 9.1;//maximum termperature change
2 clc;
3 clear;
4 close;
5 f=0.15;//GHz
6 fc=18;//GHz/degree celsius
7 ta=f/fc;//
8 disp(ta,"maximum temperature change alowed in degree
      celsius is")
```

Scilab code Exa 9.2 bandwidth

```
1 // Example 9.2;//bandwidth
2 clc;
3 clear;
4 close;
5 snl=-55.45;//dBm
6 ps=10^(snl/10);//
```

```
 7  n=0.8;//
 8  h=1.54;//micro meter
 9  hc=6.63*10^-34;//
10  c=3*10^8;//m/s
11  sndb=12;//
12  sn=10^(sndb/10);//
13  b=((n*ps*10^-3*h*10^-6)/(hc*c*sn));//
14  disp(b*10^-9,"bandwidth in GHz is")
15  //answer is wrong in the textbook
```

Scilab code Exa 9.3 number of recieved photons

```
 1  // Example 9.3;//number of received photos
 2  clc;
 3  clear;
 4  close;
 5  ber=10^-9;//
 6  x=-2*log10(ber);//
 7  np1=4*x;//no. of received photons for ASK heterodyne
         sysnchronous detection
 8  np2=-4*log(2*ber);//no. of received photons for ASK
       heterodyne non-sysnchronous detection
 9  np3=x/2;//no. of received photons for PSK homodyne
       detection
10  disp(round(np1),"no. of received photons for ASK
       heterodyne sysnchronous detection")
11  disp(round(np2),"no. of received photons for ASK
       heterodyne non-sysnchronous detection")
12  disp(round(np3),"no. of received photons for PSK
       homodyne detection")
```

Scilab code Exa 9.4 incoming power level

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```
1  // Example 9.4 //minimum incoming power level
2  clc;
3  clear;
4  close;
5  ber=10^-9;//
6  x=-2*log10(ber);//
7  hc=6.63*10^-34;//
8  c=3*10^8;//m/s
9  bt=500;//Mbits/s
10 h=1.55;//micro meter
11 ps=((x*2*hc*c*bt*10^6)/(h*10^-6));//nW
12 disp(ps*10^9,"minimum incoming power level in nano
       Watts is")
```

Scilab code Exa 9.5.a repeater spacing

```
1  // Example 9.5.a;//maximum repeater spacing
2  clc;
3  clear;
4  close;
5  ber=10^-9;//
6  x1=-2*log10(ber);//
7  hc=6.63*10^-34;//
8  c=3*10^8;//m/s
9  bt=50;//Mbits/s
10 h=1.55;//micro meter
11 ps=((x1*2*hc*c*bt*10^6)/(h*10^-6));//nW
12 psdb=10*log10(ps*10^3);//
13 cl=0.25;//dB/km
14 x=4;//dBm
15 y=x-psdb;//
16 mrs1=y/cl;//km
17 disp(mrs1,"maximum repeater spacing in km at 50 M-
       bit/s  system (ASK) in km is")
18 bt1=1;//Gbit/s
```

```
19  ps1 =(( x1 *2* hc *c* bt1 *10^9) /( h *10^ -6) ); //nW
20  psdb1 =10* log10 ( ps1 *10^3) ; //
21  cl =0.25; //dB/km
22  x =4; //dBm
23  y1 =x - psdb1 ; //
24  mrs2 = y1 / cl ; //km
25  disp ( mrs2 ," maximum  repeater  spacing  in  km  at  1  G—bit
        /s   system  (ASK)  in  km  is ")
```

Scilab code Exa 9.5.b repeater spacing

```
 1  // Example  9.5.B; //maximum  repeater  spacing
 2  clc ;
 3  clear ;
 4  close ;
 5  ber =10^ -9; //
 6  x1 = -2* log10 ( ber ) ; //
 7  hc =6.63*10^ -34; //
 8  c =3*10^8; //m/s
 9  bt =50; //Mbits/s
10  h =1.55; //micro  meter
11  ps =((( x1 /2) * hc *c* bt *10^6) /( h *10^ -6) ); //nW
12  psdb =10* log10 ( ps *10^3) ; //
13  cl =0.25; //dB/km
14  x =4; //dBm
15  y =x - psdb ; //
16  mrs1 = y / cl ; //km
17  disp ( mrs1 ," maximum  repeater  spacing  in  km  at  50  M—
        bit /s   system  (PSK)  in  km  is ")
18  bt1 =1; //Gbit/s
19  ps1 =((( x1 /2) *2* hc *c* bt1 *10^9) /( h *10^ -6) ); //nW
20  psdb1 =10* log10 ( ps1 *10^3) ; //
21  cl =0.25; //dB/km
22  x =4; //dBm
23  y1 =x - psdb1 ; //
```

```
24 mrs2=y1/cl;//km
25 disp(mrs2,"maximum repeater spacing in km at 1 G-bit
       /s  system  (PSK) in km is")
26 //for 1 Gbit/s systme answer is wrong in the
       textbook
```

Scilab code Exa 9.6 refractive index and bandwidth

```
1 //Example 9.6 // refractive index and 3dB spectral
       bandwidth
2 clc;
3 clear;
4 close;
5 //given data :
6 lamda=1.5*10^-6;// in m
7 L=300*10^-6;// in m
8 del_lamda=10^-9;// in m
9 n=lamda^2/(2*del_lamda*L);
10 disp(n,"refractive index , n = ")
11 R1=0.3;
12 R2=R1;
13 a=4.8;// in dB
14 Gs=10^(4.8/10);
15 c=3*10^8;
16 B=(c/(%pi*n*L)*asin((1-sqrt(R1*R2)*Gs)/(2*sqrt(sqrt(
       R1*R2)*Gs))))*10^-9;
17 disp(B," Spectral bandwidth,(GHz) = ")
```

Scilab code Exa 9.7 cavity gain

```
1 //Example 9.7// cavity gain
2 clc;
3 clear;
```

```
4 close;
5 x=0.5; //
6 y=(1-(sqrt(x)))/(1+sqrt(x)); //
7 g=(y/(1-y)^2); //
8 disp(" cavity  gain  is "+string(g)+"/( sqrt (R1*R2))")
```