Scilab Manual for Optical Fiber Communication by Prof Harsha Sanap Others Padmabhushan Vasantdada Patil Pratishthan's College of Engineering/Mumbai University[1]

Solutions provided by
Prof RAJIV S. TAWDE
Others
Mumbai University/PVPPCOE

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Experiment: 1

To compute the Thermal noise,Signal to noise ratio and Shot noise power for a PIN photodiode

Scilab code Solution 1.1 Experiment Number 1

```
1 //AIM:To compute the Thermal noise,Signal to noise
     ratio and Shot noise power
2 //for a PIN photodiode
3
4 //Software version Scilab 5.5.2
5 //OS Windows 7
6 clc;
7 clear;
8 //Consider responsivity 0.5 A/W,load resistance=2000
     ohms,system
9 //bandwidth=50MHz,temperature=40 degrees centigrade
10 //(a) Thermal noise :
11 T=40+273;//T=Temperature
12 disp('K',T,'T=')
13 delF=50*(10^3);//delF=Bandwidth
```

```
k=1.38*(10^-23);//k=Boltzmann constant
e=1.6*(10^-19);//E=Electron
RL=2000;//RL=Load resistance
//PNT=4*k*T*delF where PNT=Thermal noise
//If shot noise is equal to thermal noise,then PNT=
   PNS
//PNS is the shot noise power
//So, 4*k*T*delF=2*e*iS*delF*RL
//Hence iS=(2*k*T)/(e*RL)
iS=(2*k*T)/(e*RL);//iS=signal photocurrent
disp('Amp',iS,'iS=')
R=0.5;//R=responsivity=0.5
PR=iS/R;
disp('Watts',PR,'Received optic power PR=');
PNT=4*k*T*delF;
disp(PNT,'Thermal noise PNT=')

//(b) Signal to noise ratio:
//Since PNS=PNT;
//Total noise;N=PNS+PNT
//So,N=2*PNS
//But PNS=2*e*iS*delF*RL
S_by_N=(iS)/(4*e*delF);
disp(S_by_N,'Signal to noise ratio (S/N)=')

//(c) Shot noise power:
PNS=2*e*iS*delF*RL;
disp('Watts',PNS,'Shot noise power PNS=')
```

Experiment: 2

To compute the responsivity,received optical power & the number of photons received by a pn photodiode

Scilab code Solution 2.1 Experiment Number 2

```
1 //AIM:To compute the responsivity,received optical
     power & the number of
2 //photons received by a pn photodiode
3
4 //Software version Scilab 5.5.2
5 //OS Windows 7
6 clc;
7 clear;
8 //Let us consider quantum efficiency of 50% at a
     wavelength of 0.9 micrometres
9 //& mean photocurrent is 10^-6 Amp
10 n=50/100;//n=Quantum efficiency=50%(given)
11 lambda=0.9*(10^-6);
12 //(a): Responsivity
13 //Responsivity R is related to the quantum
```

```
    efficiency n as R=(n*e*lambda)/(h*e)
e=1.6*(10^-19);
h=6.6*(10^-34);
c=3*(10^8);
R=(n*e*lambda)/(h*c);
disp('AW^-1',R,'R=')

//(b):Received optical power:
//R=Ip/P0
Ip=10^-6;
P0=Ip/R;
disp('Watts',P0,'Received optical power (P0)=')

//No. of received photons :
E=(h*c)/(lambda);
disp('Watts',E,'E=')
//Optical power=No. of photons*Energy of a photon
NOP=P0/E;
disp('photons/sec',NOP,'Number of photons=')
```

Experiment: 3

Compute the resulting output voltage of a photodetector

Scilab code Solution 3.1 Experiment Number 3

```
1 //AIM:Compute the resulting output voltage of a
    photodetector
2 //Software version Scilab 5.5.2
3 //OS Windows 7
4 clc;
5 clear;
6 //Let quantum efficiency=0.9,wavelength=1.3
    micrometre & incident power level
7 //of -37dBm
8 //Also we consider load resistance is 50 ohms and
    1000 ohms.
9 n=0.9;//n=Quantum efficiency
10 lambda=1.3*(10^(-6));//lambda=wavelength
11 //Incident optical power Pia=-37dBm
12 Pia=-37;//Pia=Incident power level
13 Pi=(10^(-3))*(10^(Pia/10));//Computing the incident
    optical power in Watts
14 disp('Watts',Pi,'Incident optical power (Pi) in
    Watts=')
```

```
h=(6.625)*(10^(-34));//h=Planck's constant
c=(3)*(10^(8));//c=Speed of light
e=(1.6)*(10^(-19));//Electron
I=(n*e*lambda*Pi)/(h*c);//Computing current I
disp('Amp',I,'Current(I)=')
//Voltage across resistor of 50 ohms
R1=50;
V1=I*R1;//Basic relation:Voltage=Current*Resistance
disp('Volts',V1,'V1=')

//Voltage across resistor of  ohms
R2=1000;
V2=I*R2;//Basic relation:Voltage=Current*Resistance
disp('Volts',V2,'V2=')
```

Experiment: 4

Compute the acceptance angle for the optical fiber in water

Scilab code Solution 4.1 Experiment Number 4

```
1 //AIM:Compute the acceptance angle for the optical
    fiber in water
2 //Software version Scilab 5.5.2
3 //OS Windows 7
4 clc;
5 clear;
6 //Let refractive index be 1.33,numerical aperture be
    0.20 and cladding
7 //refractive index be 1.59.
8 na=1.33;
9 n2=1.59;
10 NA=0.20;
11 //The refractive index of the core n1 is not given.
    So is has to be calculated.
12 //NA=sqrt((n1^2)-(n2^2))
13 n1=sqrt((NA^2)+(n2^2));
14 disp(n1,'n1=')
15 fiy_c = asin(n2/n1);
16 fiy_c_degrees=(fiy_c)*(180/%pi);
```

```
17 disp('degrees',fiy_c_degrees,'Critical angle at the
     core-cladding interface: fiy_c=')
18 //Computing the acceptance angle
19 theta_a=asin(NA/na);
20 theta_a_degrees=(theta_a)*(180/%pi);
21 disp('degrees',theta_a_degrees,'Acceptance angle :
     theta_a=')
```

Experiment: 5

Compute the numerical aperture and the critical angle at the core cladding interface for the step index fiber

Scilab code Solution 5.1 Experiment Number 5

```
1 //AIM:Compute the numerical aperture and the
     critical angle at the core
2 //cladding interface for the step index fiber
3
4 //Software version Scilab 5.5.2
5 //OS Windows 7
6 clc;
7 clear;
8 //Let the acceptance angle in air be 22 degrees and
     a relative refractive index
9 //difference of 3%
10 theta_a_degrees=22;
11 theta_a_radians=(theta_a_degrees)*(%pi/180);
12 del=0.03;
13 NA=sin(theta_a_radians);
```

```
14 disp(NA,'NA=')
15 n1=(NA)/(sqrt(2*del));
16 disp(n1,'n1=')
17 //Computing n2:
18 n2=n1-(del*n1);
19 disp(n2,'n2=')
20 //Computing the critical angle
21 fiy_c=asin(n2/n1);
22 fiy_c_degrees=(fiy_c)*(180/%pi);
23 disp('degrees',fiy_c_degrees,'Critical angle=')
```

Experiment: 6

Computation of maximum bit rate for RZ & NRZ encoding for the pulse spreading constants certain cable lengths

Scilab code Solution 6.1 Experiment Number 6

```
1 //AIM: Computation of maximum bit rate for RZ & NRZ
     encoding for the pulse
2 //spreading constants & certain cable lengths
3
4 //Software version Scilab 5.5.2
5 //OS Windows 7
6 clc;
7 clear;
8 //Consider pulse spreading constants & cable lengths
     as follows:
9 //(i): T =10ns/mm,L=100m;(ii): T =20ns/m,L=1000m ;(
     iii): T =2000ns/m,L=2km
10
11 //To find maximum bit rate for RZ & NRZ encoding
12 //(i):Since delT1=10ns/mm and 1mm=10^-6 km
```

```
13 delT1=10*(10^(-9))*(10^(6));
14 disp('sec/km',delT1,'delT1=')
15 tao1=0.1*delT1;//Computing total dispersion for 100
     m
16 disp('sec',tao1,'Total dispersion for 100 m=')
17 //Maximum possible optical bandwidth=maximum
     possible bit rate for RZ
18 Bopt1=1/(2*tao1)
19 disp('bits/sec',Bopt1,'Maximum possible bit rate for
     RZ=')
20 NRZ1=Bopt1/2;
21 disp('bits/sec',NRZ1,'Maximum possible bit rate for
     NRZ=')
22 //(ii):Since delT2=20ns/m and 1m=10^-3km
23 delT2=20*(10^(-9))/(10^(-3));
24 disp('sec',delT2,'Total dispersion for 1000 m or 1
     km =')
25 tao2=delT2;
26 Bopt2=1/(2*tao2)
27 disp('bits/sec',Bopt2,'Maximum possible bit rate for
     RZ=')
28 NRZ2=Bopt2/2;
29 disp('bits/sec',NRZ2,'Maximum possible bit rate for
     NRZ=')
30 //(iii):Since delT3=2000ns/m and 1m=10^-3km
31 delT3=2000*(10^(-9))/(10^(-3));
32 disp('sec/km',delT3,'delT3=')
33 tao3=delT3*2;
34 disp('sec',tao3,'Total dispersion over a length of 2
     km =')
35 Bopt3=1/(2*tao3)
36 disp('bits/sec',Bopt3,'Maximum possible bit rate for
     RZ=')
37 NRZ3=Bopt3/2;
38 disp('bits/sec',NRZ3,'Maximum possible bit rate for
     NRZ=')
```

Experiment: 7

Computing overall signal attenuation,signal attenuation/km,overall signal attenuation for 20km link with splices at 2km interval

Scilab code Solution 7.1 Experiment Number 7

```
1 //AIM:Computing overall signal attenuation,signal
    attenuation/km,overall
2 //signal attenuation for 20km link with splices at 2
    km interval
3
4 //Software version Scilab 5.5.2
5 //OS Windows 7
6 clc;
7 clear;
8 //Let us consider that each splice gives attenuation
     of 1.5dB for 10km long
9 //optical fiber having output optical power of 4 W
10 //and  input optical power of 100 W
```

```
11
12 Pin=100*(10^(-6));//Pin=Input optical power
13 Pout=4*(10^(-6));//Pout=Output optical power
14 alphaT=10*log10(Pin/Pout);//alphaT=Overall
      attenuation
15 disp('dB',alphaT,'Overall attenuation (alphaT)=')
16 //The length of the optical fiber is 10km
17 L1=10*(10^(3));
18 //Computing Signal attenuaion per km
19 alpha=alphaT/10;
20 disp('dB/km',alpha,'The signal attenuation per
      kilometer (alpha) =')
21 //Computation for 20kms length:
22 L2=20*(10^(3));
23 TSA=alpha/(10^(3))*L2;//TSA=Total signal attenuation
24 disp('dB',TSA,'Total signal attenuation=')
25 //A splice is connected at each 2km distance.Thus
      total 9 splices are used.
26 //Now each splice gives 1.5dB attenuation.
27 S=9;//S=Total No. of splices used
28 A=1.5;//A=Attenuation by each splice
29 TAFS=S*A;//TAFS=Total attenuation from splices
30 disp('dB',TAFS,'Total attenuation from splices=')
31 //Computing overall signal attenuation including
      attenuation due to splices
32 a=TAFS+TSA;
33 disp('dB',a,'Overall signal attenuation including
      attenuation due to splices=')
```

Experiment: 8

To compute the maximum link span for 4,8,16 channel; 2.5Gb/s channel optical link.

Scilab code Solution 8.1 Experiment Number 8

```
1 //AIM:To compute the maximum link span for 4,8,16
     channel; 2.5Gb/s channel
2 // optical link.
3
4 //Software version Scilab 5.5.2
5 //OS Windows 7
6 clc;
7 clear;
8 //(i):Computing maximum link span for 4-channel,2.5
     Gb/s per channel
9 //optical link
10
11 fb1=4*2.5;
12 Lmax1=(6.1*(10^3))/((fb1)^2);
13 disp('km',Lmax1,'Maximum link span for 4-channel,2.5
     Gb/s per channel optical link (i.e. Lmax1) =')
14
```

```
15 //(ii):Computing maximum link span for 8-channel,2.5
      Gb/s per channel
16 //optical link
17
18 fb2=8*2.5;
19 Lmax2=(6.1*(10^3))/((fb2)^2);
20 disp('km',Lmax2,'Maximum link span for 8-channel,2.5
      Gb/s per channel optical link (i.e.Lmax2) =')
21
22 //(iii):Computing maximum link span for 16-channel
      ,2.5Gb/s per channel
23 //optical link
24
25 fb3=16*2.5;
26 Lmax3=(6.1*(10^3))/((fb3)^2);
27 disp('km',Lmax3,'Maximum link span for 16-channel
      ,2.5Gb/s per channel optical link (i.e. Lmax3) ='
      )
```

Experiment: 9

Compute the numerical aperture & the acceptance angle for the fiber in air

Scilab code Solution 9.1 Experiment Number 9

```
1 //AIM:Compute the numerical aperture & the
    acceptance angle for the fiber in air
2 //Software version Scilab 5.5.2
3 //OS Windows 7
4 clc;
5 clear;
6 //Let the velocity of light in vacuum be 2.998*10^8
    m/sec,critical angle at the
7 // core-cladding interface be 80 degrees & velocity
    of light in the core
8 //of a step index fiber be 2.01*10^8 m/sec
9
10 c=2.998*10^8;//c=velocity of light in vacuum
11 v1=2.01*10^8;//v1=velocity of light in the core
12 theta_c=80*(%pi/180);//Expressing theta_c in radians
13 n1=c/v1;
14 disp(n1,'n1=')
```

```
15 //Since sin(theta_c)=n2/n1
16 n2=sin(theta_c)*n1;
17 disp(n2,'n2=')
18 NA=sqrt((n1^2)-(n2^2))
19 disp(NA,'Numerical aperture (NA)=')
20 //Computing the acceptance angle
21 theta_a=asin(NA)
22 theta_a_degrees=(theta_a)*(180/%pi);
23 disp('degrees',theta_a_degrees,'Acceptance angle (
   theta_a)=')
```

Experiment: 10

Compute the absorption loss taking place in an optical fiber

Scilab code Solution 10.1 Experiment Number 10

```
1 //AIM:Compute the absorption loss taking place in an
      optical fiber
2 //Software version Scilab 5.5.2
3 //OS Windows 7
4 clc;
5 clear;
6 //Let the length of the optical fiber be 3.5cm in an
      interference sphere,while
7 //the total length of the fiber be 1km.
8 //Also consider that it gives 5.1nV & 165 micro
     Volts corresponding to
9 //scattered & unscattered light respectively while
     for the cutback method,
10 //it gives 5.20V & 22V for original & cutback
     optical fibers respectively.
11
12 l=3.5*(10^(-5));//l=Length of optical in integrating
      sphere
13 Vsc=5.1*(10^(-9));//Vsc=Voltage level corresponding
```

```
    to scattered light
Vop=165*(10^(-6));//Vop=Voltage level corresponding
    to unscattered light
//Computing the scattering loss :
alpha_sc=(4.343/l)*(Vsc/Vop);
disp('dB/km',alpha_sc,'Scattering loss (alpha_sc)=')
//Computation of total attenuation:
L1=1;//L1=Length of the original fiber
L2=0.002;//L2=Length of cutback optical fiber
V2=22;//V2=Voltage level for cutback optical fiber
V1=5.20;//V1=Voltage level for original optical
    fiber
alpha_T=(1/(L1-L2))*(10*log10(V2/V1));//alpha_T=
    total attenuation
disp('dB/km',alpha_T,'Total attenuation (alpha_T) ='
    )
//Computing the absorption loss :
AL=alpha_T-alpha_sc;//AL=Absorption loss
disp('dB/km',AL,'Absorption loss=')
```