

Scilab Manual for
Optical Fiber Communication
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Contents

List of Scilab Solutions	3
1 To compute the Thermal noise,Signal to noise ratio and Shot noise power for a PIN photodiode	4
2 To compute the responsivity,received optical power & the number of photons received by a pn photodiode	6
3 Compute the resulting output voltage of a photodetector	8
4 Compute the acceptance angle for the optical fiber in water	10
5 Compute the numerical aperture and the critical angle at the core cladding interface for the step index fiber	12
6 Computation of maximum bit rate for RZ & NRZ encoding for the pulse spreading constants certain cable lengths	14
7 Computing overall signal attenuation,signal attenuation/km,overall signal attenuation for 20km link with splices at 2km interval	16
8 To compute the maximum link span for 4,8,16 channel; 2.5Gb/s channel optical link.	18
9 Compute the numerical aperture & the acceptance angle for the fiber in air	20
10 Compute the absorption loss taking place in an optical fiber	22

List of Experiments

Solution 1.1	Experiment Number 1	4
Solution 2.1	Experiment Number 2	6
Solution 3.1	Experiment Number 3	8
Solution 4.1	Experiment Number 4	10
Solution 5.1	Experiment Number 5	12
Solution 6.1	Experiment Number 6	14
Solution 7.1	Experiment Number 7	16
Solution 8.1	Experiment Number 8	18
Solution 9.1	Experiment Number 9	20
Solution 10.1	Experiment Number 10	22

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
```

```

14 k=1.38*(10^-23); //k=Boltzmann constant
15 e=1.6*(10^-19); //E=Electron
16 RL=2000; //RL=Load resistance
17 //PNT=4*k*T*delF where PNT=Thermal noise
18 //If shot noise is equal to thermal noise ,then PNT=
    PNS
19 //PNS is the shot noise power
20 //So, 4*k*T*delF=2*e*iS*delF*RL
21 //Hence iS=(2*k*T)/(e*RL)
22 iS=(2*k*T)/(e*RL); //iS=signal photocurrent
23 disp('Amp',iS,'iS=')
24 R=0.5; //R=responsivity=0.5
25 PR=iS/R;
26 disp('Watts',PR,'Received optic power PR=');
27 PNT=4*k*T*delF;
28 disp(PNT,'Thermal noise PNT=')
29
30 //(b) Signal to noise ratio:
31 //Since PNS=PNT;
32 //Total noise;N=PNS+PNT
33 //So,N=2*PNS
34 //But PNS=2*e*iS*delF*RL
35 S_by_N=(iS)/(4*e*delF);
36 disp(S_by_N,'Signal to noise ratio (S/N)=')
37
38 //(c) Shot noise power:
39 PNS=2*e*iS*delF*RL;
40 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)
14 e=1.6*(10^-19);
15 h=6.6*(10^-34);
16 c=3*(10^8);
17 R=(n*e*lambda)/(h*c);
18 disp('AW^-1',R,'R=')
19
20 //(b):Received optical power:
21 //R=Ip/P0
22 Ip=10^-6;
23 P0=Ip/R;
24 disp('Watts',P0,'Received optical power (P0)=')
25
26 //No. of received photons :
27 E=(h*c)/(lambda);
28 disp('Watts',E,'E=')
29 //Optical power=No. of photons*Energy of a photon
30 NOP=P0/E;
31 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=')
```

```
15 h=(6.625)*(10^(-34)); //h=Planck's constant
16 c=(3)*(10^8); //c=Speed of light
17 e=(1.6)*(10^(-19)); //Electron
18 I=(n*e*lambda*Pi)/(h*c); //Computing current I
19 disp('Amp',I,'Current(I)=')
20 //Voltage across resistor of 50 ohms
21 R1=50;
22 V1=I*R1; //Basic relation: Voltage=Current*Resistance
23 disp('Volts',V1,'V1=')
24
25 //Voltage across resistor of ohms
26 R2=1000;
27 V2=I*R2; //Basic relation: Voltage=Current*Resistance
28 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 lmm=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 lm=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 lm=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  $2.998 \times 10^8$ 
   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  $2.01 \times 10^8$  m/sec
9
10 c= $2.998 \times 10^8$ ; //c=velocity of light in vacuum
11 v1= $2.01 \times 10^8$ ; //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  $\sin(\theta_c) = n_2/n_1$ 
16  $n_2 = \sin(\theta_c) * n_1$ ;
17 disp( $n_2$ , 'n2=')
18  $NA = \sqrt{(n_1^2) - (n_2^2)}$ 
19 disp( $NA$ , 'Numerical aperture (NA)=')
20 //Computing the acceptance angle
21  $\theta_a = \text{asin}(NA)$ 
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
14 Vop=165*(10^(-6)); //Vop=Voltage level corresponding
    to unscattered light
15 //Computing the scattering loss :
16 alpha_sc=(4.343/1)*(Vsc/Vop);
17 disp('dB/km',alpha_sc,'Scattering loss (alpha_sc)=')
18 //Computation of total attenuation:
19 L1=1; //L1=Length of the original fiber
20 L2=0.002; //L2=Length of cutback optical fiber
21 V2=22; //V2=Voltage level for cutback optical fiber
22 V1=5.20; //V1=Voltage level for original optical
    fiber
23 alpha_T=(1/(L1-L2))*(10*log10(V2/V1)); //alpha_T=
    total attenuation
24 disp('dB/km',alpha_T,'Total attenuation (alpha_T) =')
    )
25 //Computing the absorption loss :
26 AL=alpha_T-alpha_sc; //AL=Absorption loss
27 disp('dB/km',AL,'Absorption loss=')

```
