Scilab Textbook Companion for Optoelectronics an Introduction by J. Wilson and J .F. B. Hawkes[1]

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Book Description

Title: Optoelectronics an Introduction

Author: J. Wilson and J .F. B. Hawkes

Publisher: Prentice

Edition: 2

Year: 2001

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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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List of Scilab Codes

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Chapter 1

Light

Scilab code Exa 1.1 1

```
//Optoelectronics - An Introduction, 2nd Edition by
    J. Wilson and J.F.B. Hawkes
//Example 1.1
//OS=Windows XP sp3
//Scilab version 5.5.2
clc;
clear;

//given
n1=1;//refractive index of air medium
n2=1.5;//refractive index of glass medium

thetaB=atand(n2/n1);//brewster angle for glass in
    degrees
mprintf("Brewster Angle = %.1f degrees",thetaB);
```

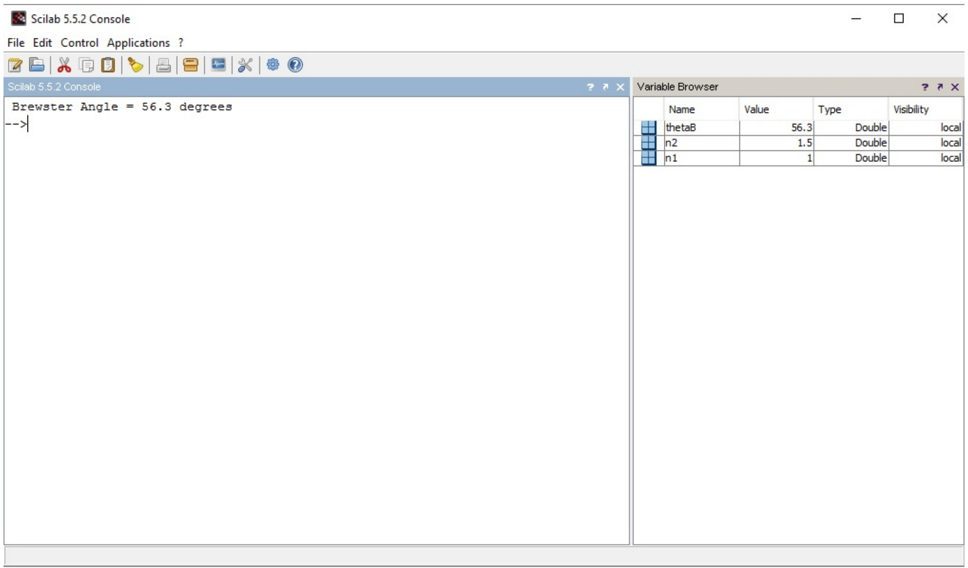


Figure 1.1: 1

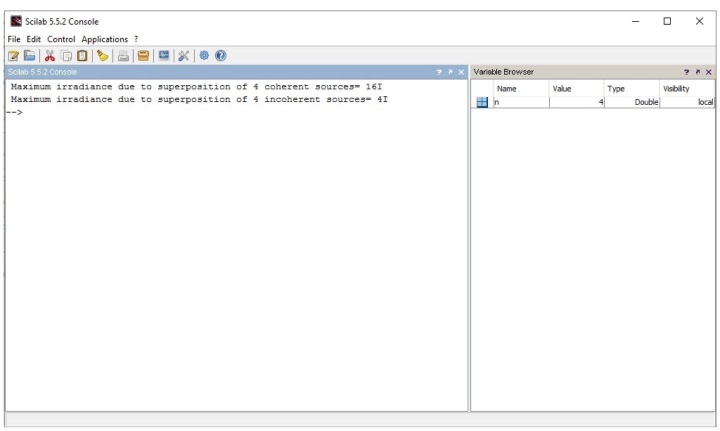


Figure 1.2: 2

Scilab code Exa 1.2 2

```
//Optoelectronics - An Introduction, 2nd Edition by
    J. Wilson and J.F.B. Hawkes
//Example 1.2
//OS=Windows XP sp3
//Scilab version 5.5.2
clc;
clear;

//given
n=4;//number of sources
//Let 'I' be the intensity of the sources

//Case (1) :
//For coherent sources
mprintf("Maximum irradiance due to superposition of
    %d coherent sources Imax= %dI",n,n^2);

//Case (2) :
//For incoherent sources
mprintf("\n Maximum irradiance due to superposition
    of %d incoherent sources Imax= %dI",n,n);
```

Scilab code Exa 1.3 3

```
//Optoelectronics - An Introduction, 2nd Edition by
    J. Wilson and J.F.B. Hawkes
//Example 1.3
//OS=Windows XP sp3
```

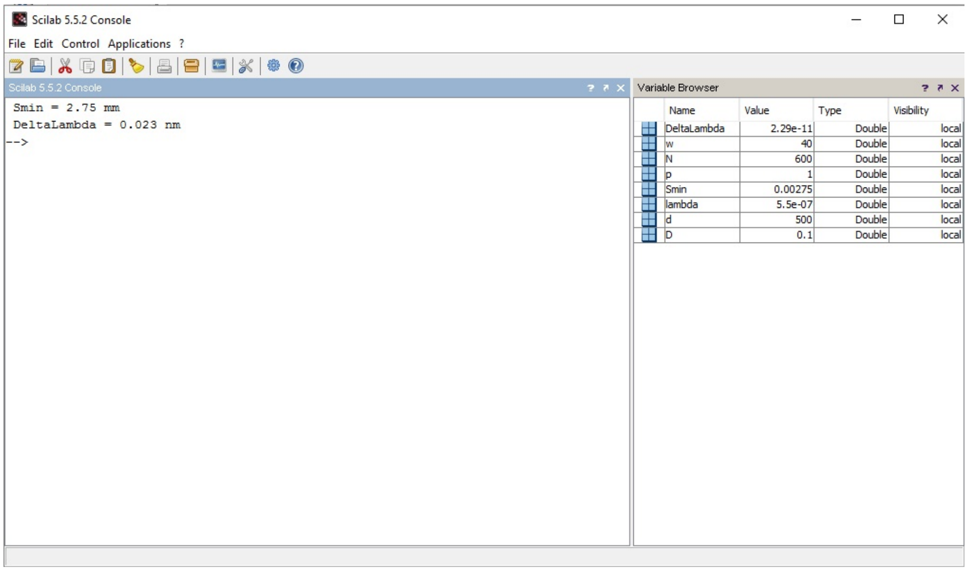


Figure 1.3: 3

```
//Scilab version 5.5.2
clc;
clear;

//given - Case(1)
D=0.1;//diameter of an objective lens in m
d=500;//distance of the lens from the sources in m
lambda=550e-9;//wavelength of the light used in m

Smin=d*lambda/D;//minimum separation of two point
    sources that can just be resolved in m
mprintf("Smin = %.2f mm",Smin/1e-3);//division by
    10^(-3) to convert into mm


//given - Case(2)
p=1;//order of the fringe
N=600;//number of lines used per mm
lambda=550e-9//wavelength of the light used in m
w=40//width of the diffraction grating in mm
```

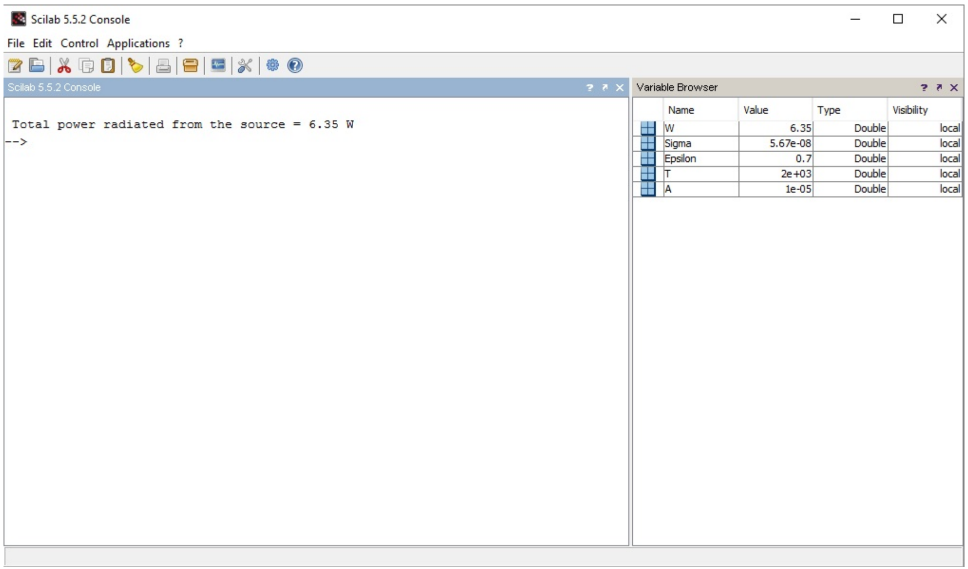


Figure 1.4: 4

```

DeltaLambda=lambda/(p*N*w);//minimum wavelength difference that can be resolved in m
mprintf("\n DeltaLambda = %.3f nm",DeltaLambda/1e-9);//division by 10^(-9) to convert in nm
```

Scilab code Exa 1.4 4

```
//Optoelectronics - An Introduction, 2nd Edition by J. Wilson and J.F.B. Hawkes
//Example 1.4
//OS=Windows XP sp3
//Scilab version 5.5.2
clc;
clear;
```

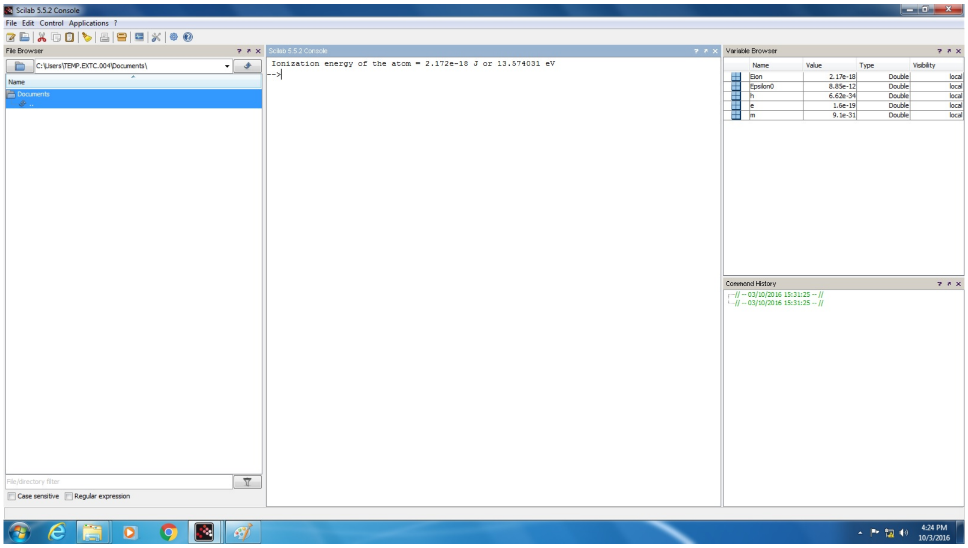


Figure 1.5: 5

```
//given
A=1e-5;//source area in m^2
T=2e3;//temperature of the source in K
Epsilon=0.7//emissivity of the surface
Sigma=5.67e-8//value of Stefan's constant in SI
    Units

W=Epsilon*Sigma*A*T^4//total power radiated from the
     source in W
mprintf("\n Total power radiated from the source = %
    .2f W",W);
```

Scilab code Exa 1.5 5

```
//Optoelectronics - An Introduction, 2nd Edition by J. Wilson and J.F.B. Hawkes
//Example 1.5
//OS=Windows XP sp3
//Scilab version 5.5.2
clc;
clear;

//given
m=9.1e-31;//rest mass of electrons in kg
e=1.6e-19;//charge of electrons in C
h=6.62e-34;//Planck's constant in SI Units
Epsilon0=8.85e-12;//permittivity of vaccuum in SI Units

Eion=m*(e^4)/(8*(h*Epsilon0)^2);//Ionization energy of the atom in J
mprintf("Ionization energy of the atom = %.3e J or %f eV",Eion,Eion/1.6e-19);//The answers vary due to round off error
```

Scilab code Exa 1.6 6

```
//Optoelectronics - An Introduction, 2nd Edition by J. Wilson and J.F.B. Hawkes
//Example 1.6
//OS=Windows XP sp3
//Scilab version 5.5.2
clc;
clear;

//given
v0=1.1e15;//threshold frequency of light in Hz
```

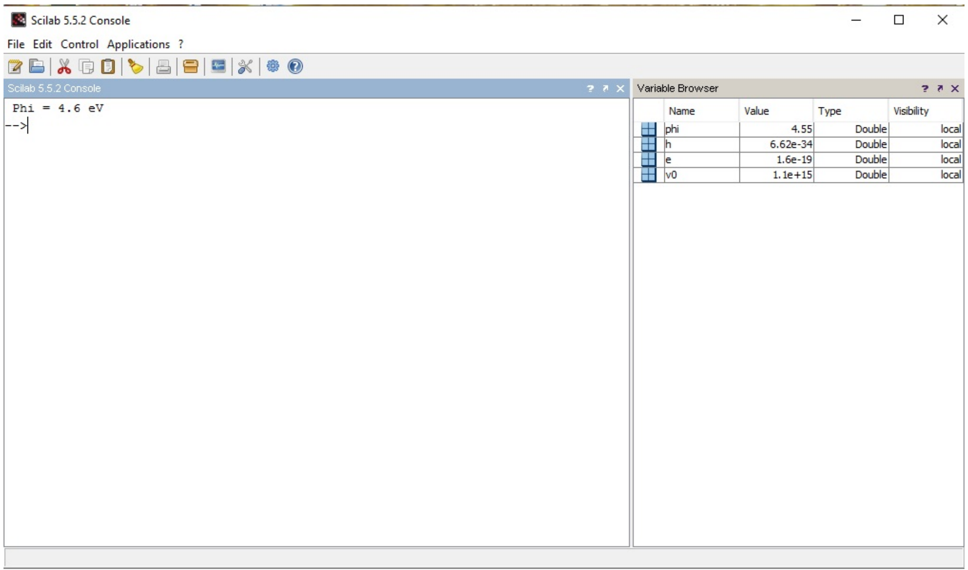


Figure 1.6: 6

```
e=1.6e-19;//charge of electrons in C
h=6.62e-34;//Planck's constant in SI Units

phi=h*v0/e;//work function of the metal in eV
mprintf("Phi = %.1f eV",phi);//The answers vary due to round off error
```

Chapter 2

Elements of solid state physics

Scilab code Exa 2.1 1

```
//Optoelectronics - An Introduction, 2nd Edition by J. Wilson and J.F.B. Hawkes
//Example 2.1
//OS=Windows XP sp3
//Scilab version 5.5.2
clc;
clear;

//given - Case(1)
NA=6e26;//Avagadro's number
rho=8.93e3;//density of copper in SI Units
A=63.54;//Atomic mass number of Cu
e=1.6e-19;//charge of electrons in C
m=9.1e-31;//rest mass of electrons in kg
T=2.6e-14;//mean free time between collisions in s

n=NA*rho/A;//number of atoms per unit volume in m^(-3)
mprintf("n = %.1e m^(-3)",n);
```

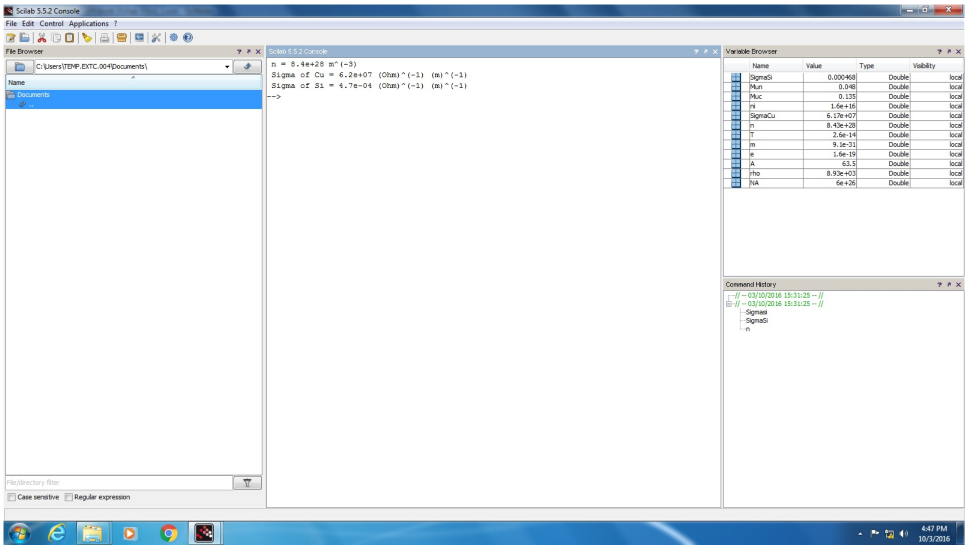


Figure 2.1: 1

```
SigmaCu=n*(e^2)*T/m;//electrical conductivity of Cu
    in SI Units
mprintf("\n Sigma of Cu = %.1e (Ohm m)^(-1)",SigmaCu
    );//The answers vary due to round off error

//given - Case(2)
ni=1.6e16;//number of holes or electrons per unit
    volume of intrinsic silicon in m^(-3)
e=1.6e-19;//charge of electrons in C
Muc=0.135;//electron mobility in SI Units
Mun=0.048;//hole mobility in SI Units

SigmaSi=ni*e*(Muc+Mun);//electrical conductivity of
    Si in SI Units
mprintf("\n Sigma of Si = %.1e (Ohm m)^(-1)",SigmaSi
    );
```

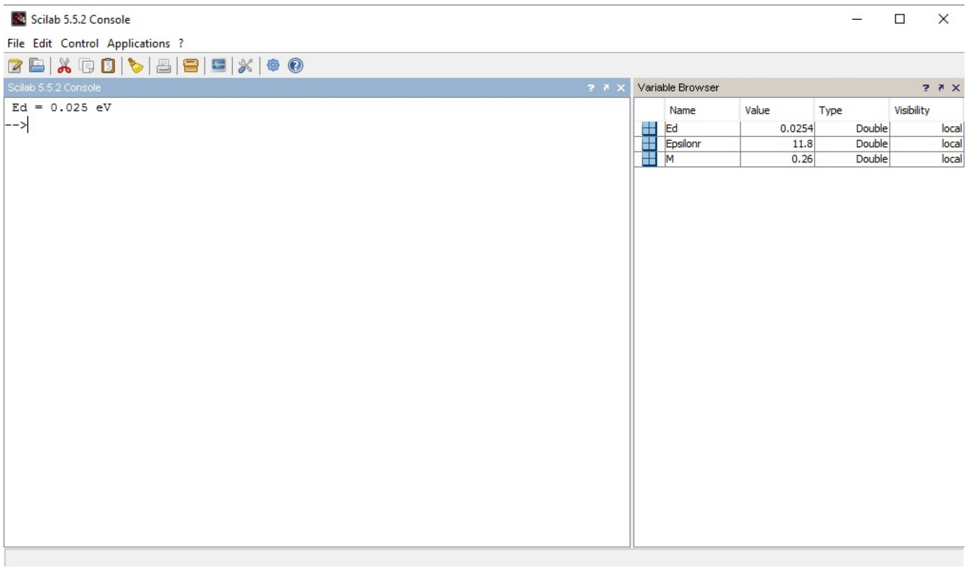


Figure 2.2: 2

Scilab code Exa 2.2 2

```
//Optoelectronics - An Introduction, 2nd Edition by
    J. Wilson and J.F.B. Hawkes
//Example 2.2
//OS=Windows XP sp3
//Scilab version 5.5.2
clc;
clear;

//given
//Let the quanity 'me/m' be denoted by M
M=0.26;
Epsilonr=11.8//relative permittivity of Si

Ed=13.6*M/(Epsilonr^2);//Energy required to excite
    the electrons from donor levels to the conduction
```

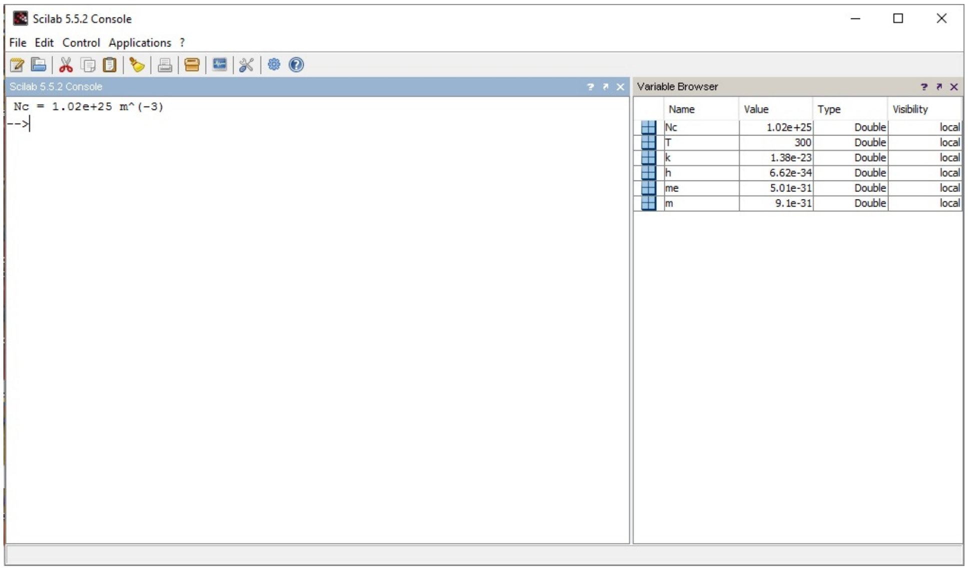


Figure 2.3: 3

```
    band in eV
mprintf("Ed = %.3f eV", Ed);
```

Scilab code Exa 2.3 3

```
//Optoelectronics - An Introduction, 2nd Edition by
    J. Wilson and J.F.B. Hawkes
//Example 2.3
//OS=Windows XP sp3
//Scilab version 5.5.2
clc;
clear;

//given
m=9.1e-31;//rest mass of electrons in kg
```

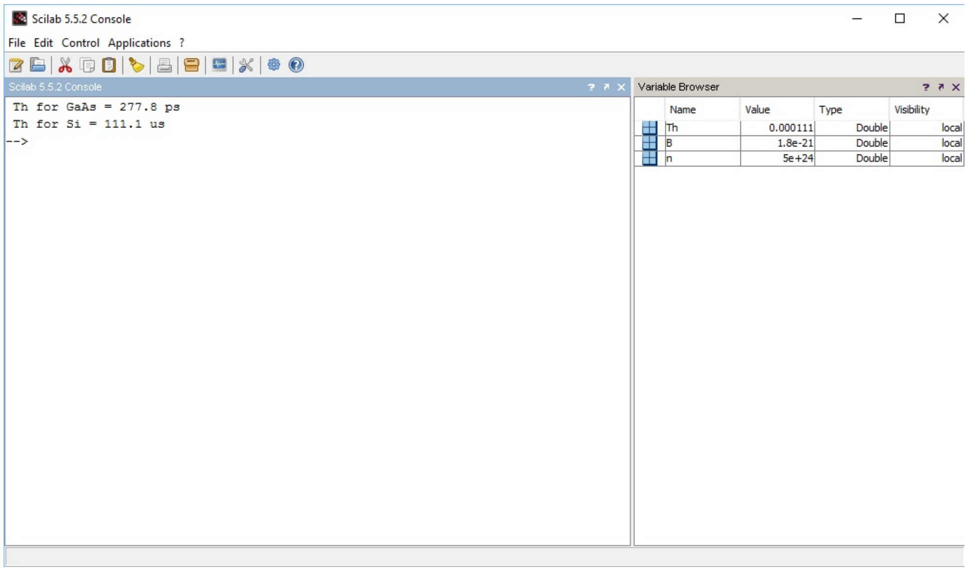


Figure 2.4: 4

```
me=0.55*m;//effective mass of electrons in kg
h=6.62e-34;//Planck's constant in SI Units
k=1.38e-23;//Boltzmann's constant in SI Units
T=300;//temperature of the source in K

Nc=2*(2*%pi*me*k*T/(h^2))^(3/2);//effective density of states in the conduction band
mprintf("Nc = %.2e m^(-3)",Nc);//The answers vary due to round off error
```

Scilab code Exa 2.4 4

```
//Optoelectronics - An Introduction, 2nd Edition by J. Wilson and J.F.B. Hawkes
//Example 2.4
```

```
//OS=Windows XP sp3
//Scilab version 5.5.2
clc;
clear;

//given
n=5e24;//Donor concentration in m^(-3)

//Case (i)
B=7.2e-16;//Recombination constant for GaAs in m^3 s
    ^(-1)
Th=1/(B*n);//Hole lifetime in s
mprintf("Th for GaAs = %.1f ps",Th/1e-12);//Dividing
    by 10^(-12) to convert to ps
//The answers vary due to round off error

//Case (i)
B=1.8e-21;//Recombination constant for Si in m^3 s
    ^(-1)
Th=1/(B*n);//Hole lifetime in s
mprintf("\n Th for Si = %.1f us",Th/1e-6);//Dividing
    by 10^(-6) to convert to us
//The answers vary due to round off error
```

Scilab code Exa 2.5 5

```
//Optoelectronics - An Introduction, 2nd Edition by
    J. Wilson and J.F.B. Hawkes
//Example 2.5
//OS=Windows XP sp3
//Scilab version 5.5.2
clc;
clear;
```

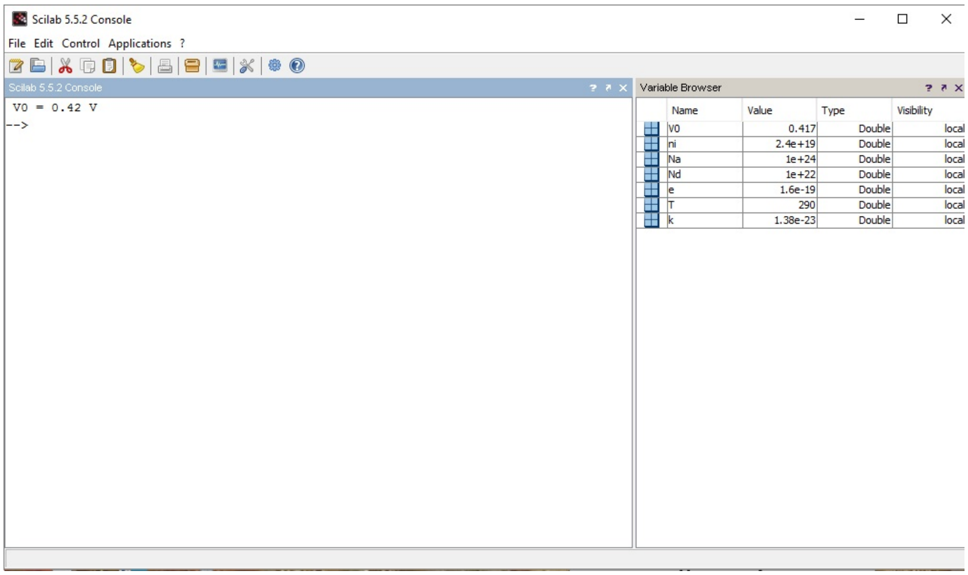


Figure 2.5: 5

```

//given
k=1.38e-23;//Boltzmann's constant in SI Units
T=290;//room temperature in K
e=1.6e-19;//charge of electrons in C
Nd=1e22;//donor impurity level in m(-3)
Na=1e24;//acceptor impurity level in m(-3)
ni=2.4e19;//intrinsic electron concentration in m
    ^(-3)

V0=k*T/e*log(Na*Nd/(ni^2));//contact potential
    difference in V
mprintf("V0 = %.2f V",V0);
```

Scilab code Exa 2.6 6

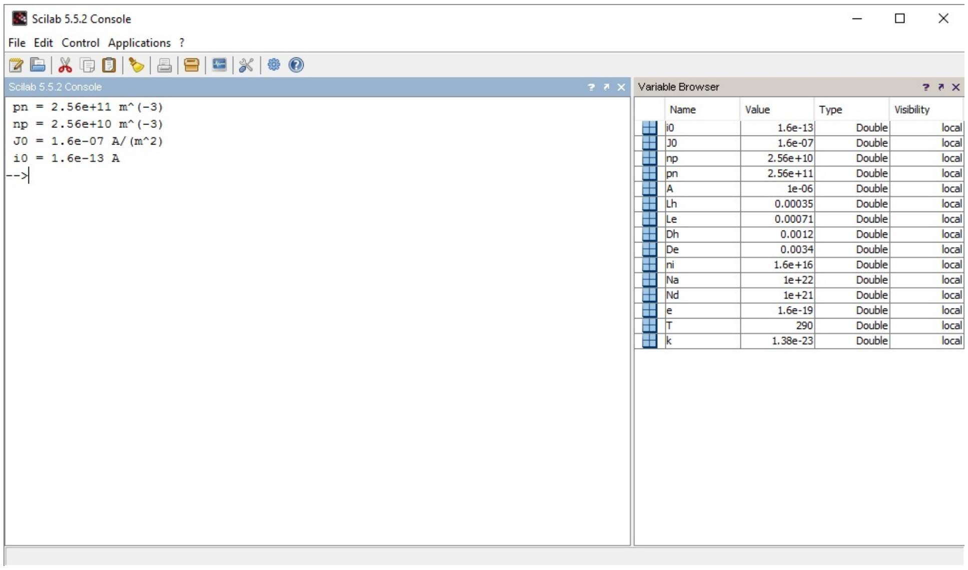


Figure 2.6: 6

```
//Optoelectronics - An Introduction, 2nd Edition by J. Wilson and J.F.B. Hawkes
//Example 2.6
//OS=Windows XP sp3
//Scilab version 5.5.2
clc;
clear;

//given
V=-4;//reverse bias voltage applied to a Si diode in V
//The negative sign indicates reverse bias
Nd=4e21;//donor impurity level in m^(-3)
V0=0.8;//potential barrier of the diode in V
Epsilon0=8.85e-12;//permittivity of free space in SI Units
Epsilonr=11.8;//relative permittivity of the diode
A=4e-7;//junction area of the diode in m^2
e=1.6e-19;//charge of electrons in C

```

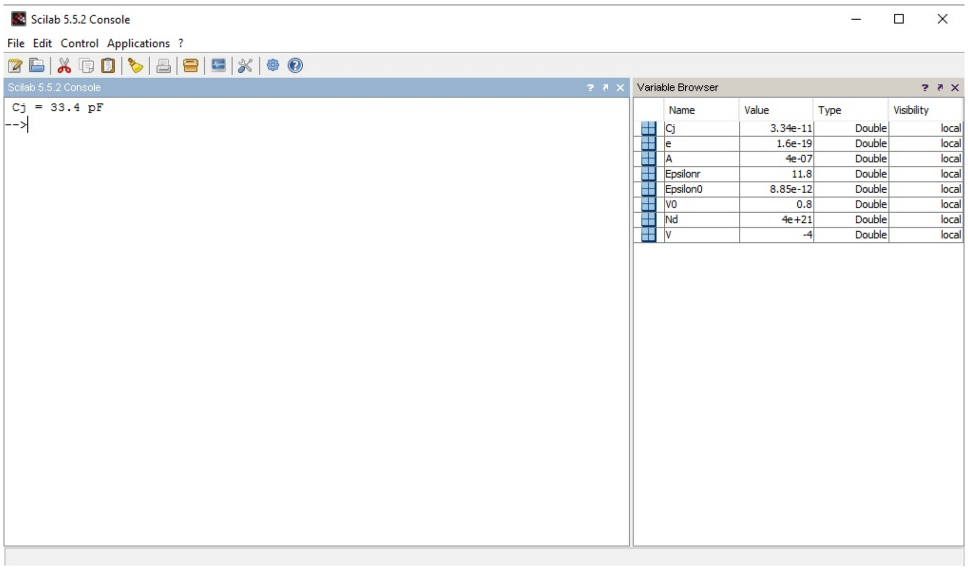


Figure 2.7: 7

```
Cj=A/2*(2*e*Epsilon0*Epsilonr*Nd/(V0-V))^(1/2);//
    junction capacitance of the diode in F
mprintf("Cj = %.1f pF",Cj/1e-12);//division by
    10^(-12) to convert into pF
```

Scilab code Exa 2.7 7

```
//Optoelectronics - An Introduction, 2nd Edition by
    J. Wilson and J.F.B. Hawkes
//Example 2.7
//OS=Windows XP sp3
//Scilab version 5.5.2
clc;
clear;

```

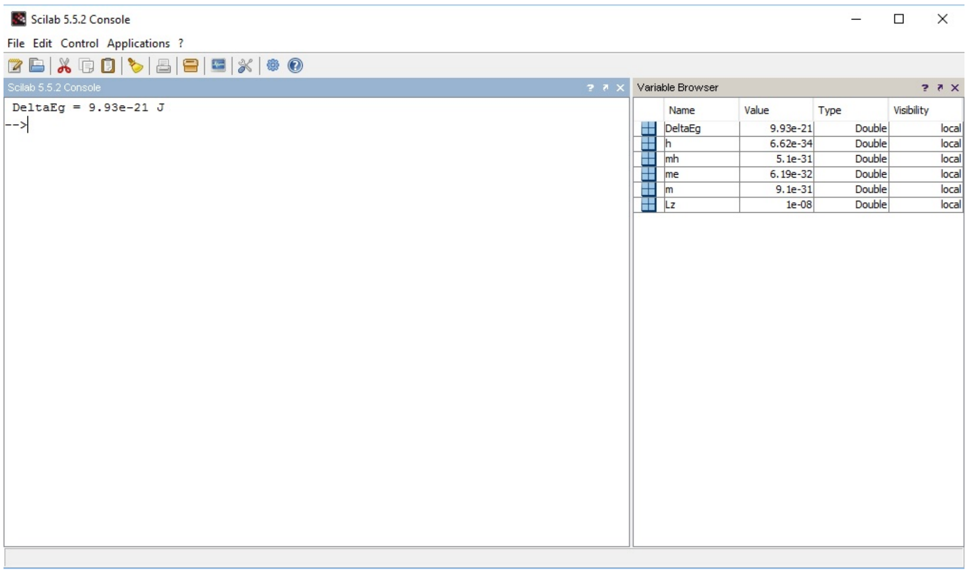


Figure 2.8: 8

```
//given
V=-4;//reverse bias voltage applied to a Si diode in V
//The negative sign indicates reverse bias
Nd=4e21;//donor impurity level in m^(-3)
V0=0.8;//potential barrier of the diode in V
Epsilon0=8.85e-12;//permittivity of free space in SI Units
Epsilonr=11.8;//relative permittivity of the diode
A=4e-7;//junction area of the diode in m^2
e=1.6e-19;//charge of electrons in C

Cj=A/2*(2*e*Epsilon0*Epsilonr*Nd/(V0-V))^(1/2);//junction capacitance of the diode in F
mprintf("Cj = %.1f pF",Cj/1e-12);//division by 10^(-12) to convert into pF
```

Scilab code Exa 2.8 8

```
//Optoelectronics - An Introduction, 2nd Edition by J. Wilson and J.F.B. Hawkes
//Example 2.8
//OS=Windows XP sp3
//Scilab version 5.5.2
clc;
clear;

//given
Lz=10e-9;//Thickness of a GaAs quantum well in m
m=9.1e-31;//Rest mass of an electron in kg
me=0.068*m;//Mass of electrons in conduction band
mh=0.56*m;//Mass of electrons in valence band
h=6.62e-34;//Planck's constant in SI Units

DeltaEg=(h^2)/(8*(Lz)^2)*(1/me+1/mh);//Energy gap in the GaAs quantum well
mprintf("DeltaEg = %.2e J",DeltaEg);
```

Chapter 3

Modulation of Light

Scilab code Exa 3.1 1

```
//Optoelectronics - An Introduction, 2nd Edition by
   J. Wilson and J.F.B. Hawkes
//Example 3.1
//OS=Windows XP sp3
//Scilab version 5.5.2
clc;
clear;

//given
w=10e-3;//Width of the KD*P crystal in m
r=26.4e-12;//Linear electro-optic coefficient of the
    crystal in m/V
n0=1.51;//refractive index of the crystal
E=4000;//Applied voltage in V

//Let the change in refractive index be Deltan = |n-
   n0|
Deltan=(1/2)*r*E*(n0^3)/w;//Dimensionless change in
   refractive index of the crystal
```

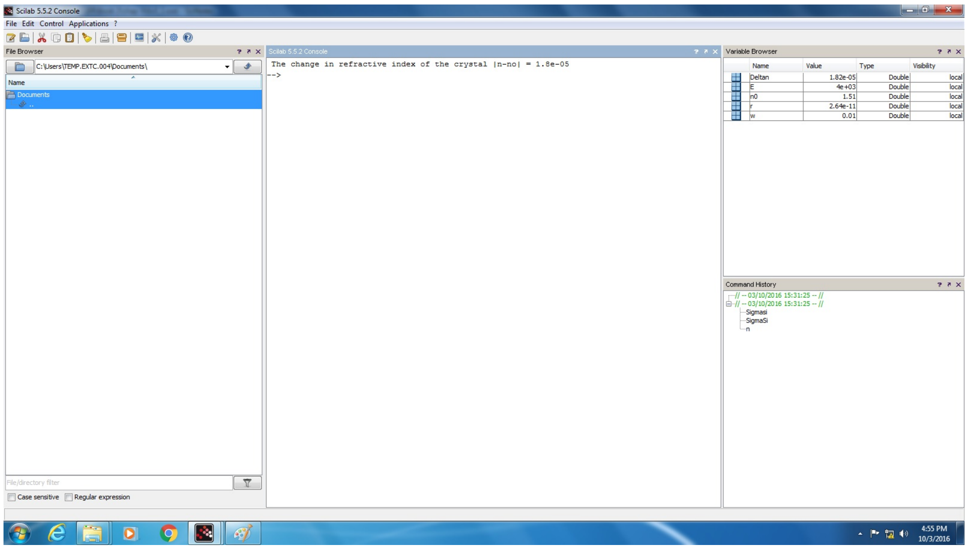


Figure 3.1: 1

```
mprintf("The change in refractive index of the
    crystal = %.1e",Deltan);
```

Scilab code Exa 3.2 2

```
//Optoelectronics - An Introduction, 2nd Edition by
    J. Wilson and J.F.B. Hawkes
//Example 3.2
//OS=Windows XP sp3
//Scilab version 5.5.2
clc;
clear;

//given
lambda=1.06e-6;//Wavelength at which half-wave
    voltage is to be calculated, in m
```

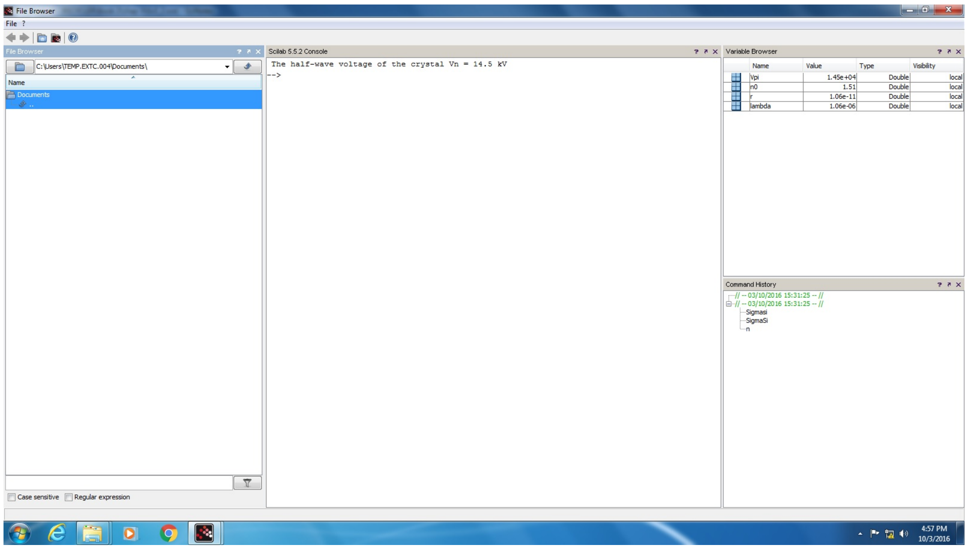


Figure 3.2: 2

```
r=10.6e-12;//Linear electro-optic coefficient of KDP
    crystal in m/V
n0=1.51;//refractive index of the crystal

Vpi=lambda/(2*r*(n0^3));//Half-wave voltage for the
    crystal in V
mprintf("The half-wave voltage of the crystal = %.1f
    kV",Vpi/1e3);//Division by 10^3 to convert into
    kV
```

Scilab code Exa 3.3 3

```
//Optoelectronics - An Introduction, 2nd Edition by
    J. Wilson and J.F.B. Hawkes
//Example 3.3
//OS=Windows XP sp3
```

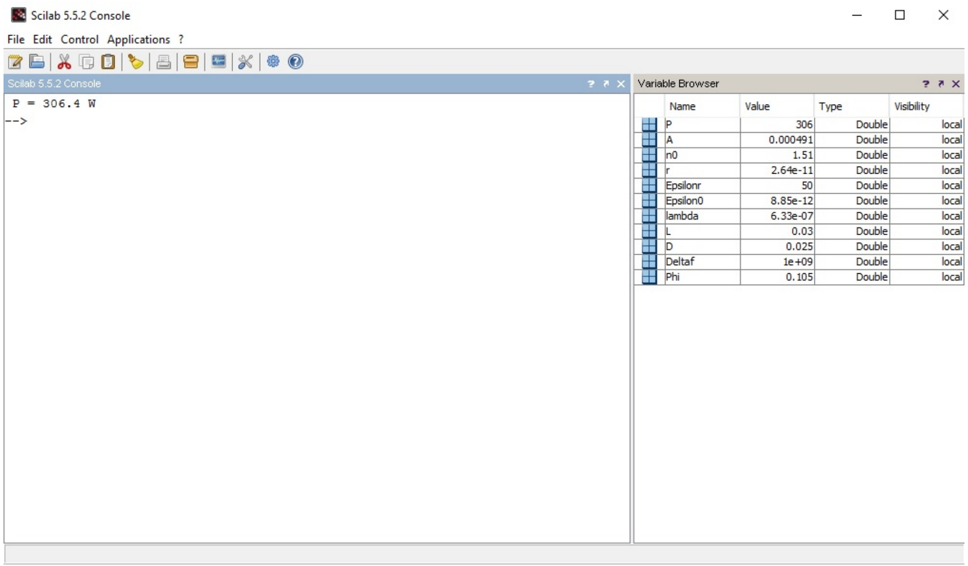


Figure 3.3: 3

```
//Scilab version 5.5.2
clc;
clear;

//given
Phi=%pi/30;//Given phase retardation
Deltaf=1e9;//Frequency bandwidth in Hz
D=25e-3;//Diameter of the circular aperture of a KD*
   P Pockels cell in m
L=30e-3;//Length of the cell in m
lambda=633e-9;//Wavelength in m
Epsilon0=8.85e-12;//Permittivity of free space in SI
    Units
Epsilonr=50;//Dimensionless Relative permittivty of
   the crystal
r=26.4e-12;//Linear electro-optic coefficient of KD*
   P crystal in m/V
n0=1.51;//refractive index of the crystal

A=%pi*((D/2)^2);//Cross-sectional area of the
```

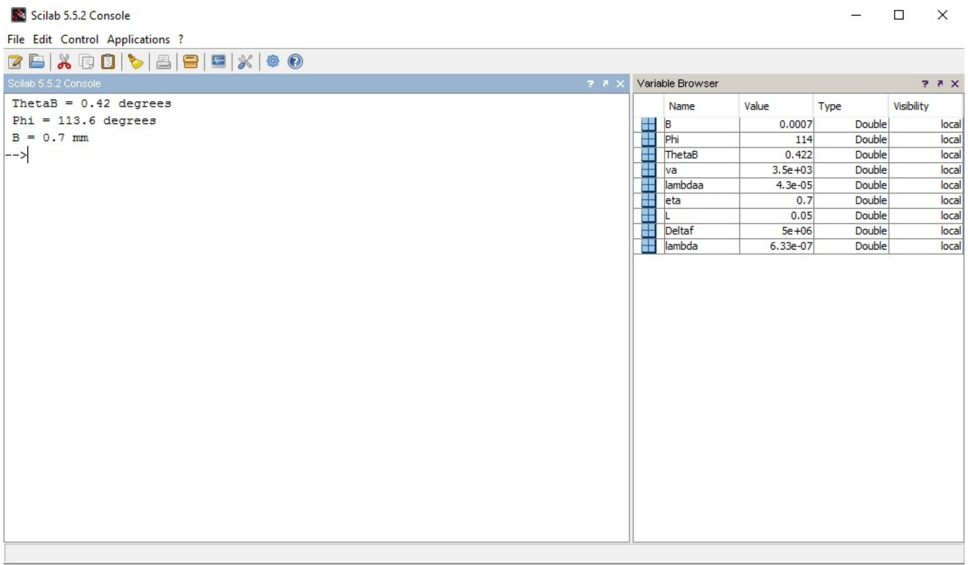


Figure 3.4: 4

```
    crystal in m^2
P=(Phi^2)*(lambda^2)*A*Epsilon0*Epsilonr*Deltaf/(4*
    %pi*(r^2)*(n0^6)*L);//Power required for the
    desired phase retardation in W
mprintf("P = %.1f W",P);
```

Scilab code Exa 3.4 4

```
//Optoelectronics - An Introduction, 2nd Edition by
    J. Wilson and J.F.B. Hawkes
//Example 3.4
//OS=Windows XP sp3
//Scilab version 5.5.2
clc;
clear;
```

```

//given
lambda=633e-9;//Wavelength in m
Deltaf=5e6;//Frequency bandwidth in Hz
L=50e-3;//Length of the modulator in m
eta=0.7;//diffraction efficiency
lambdaa=4.3e-5;//Acoustic wavelength in m
va=3500;//Acoustic velocity in m/s

ThetaB=asind(lambda/(2*lambdaa));//Angle of diffraction in degrees
mprintf("ThetaB = %.2f degrees",ThetaB);

//As eta=(sin(Phi/2))^2, Rearranging the terms we get:
Phi=2*asind(sqrt(eta));
mprintf("\n Phi = %.1f degrees",Phi);

B=va/Deltaf;//Maximum optical beamwidth in m
mprintf("\n B = %.1f mm",B/1e-3);//Division by 10^(-3) to convert into mm
```

Scilab code Exa 3.5 5

```
//Optoelectronics - An Introduction, 2nd Edition by J. Wilson and J.F.B. Hawkes
//Example 3.5
//OS=Windows XP sp3
//Scilab version 5.5.2
clc;
clear;

//given appropriate refractive indices for ADP :-
```

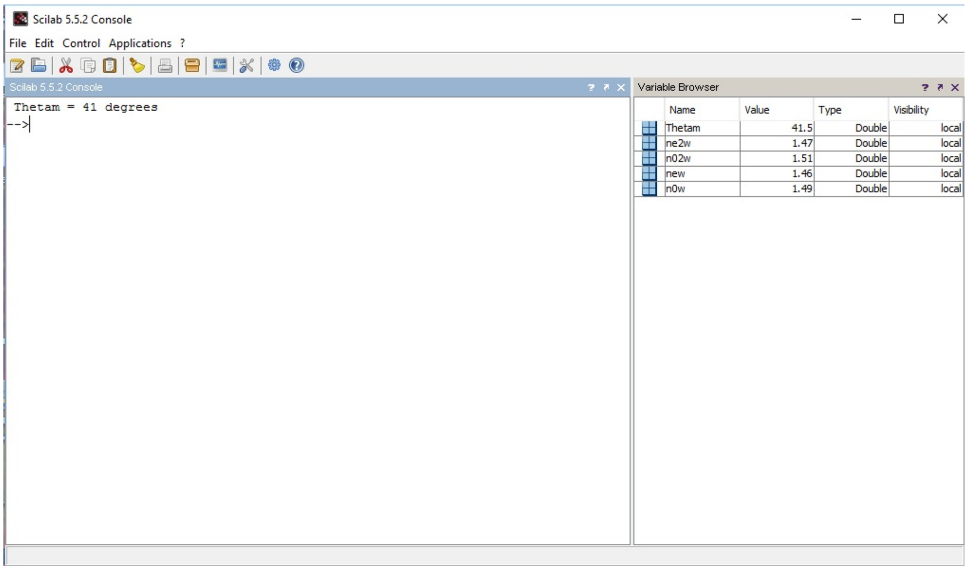


Figure 3.5: 5

```
n0w=1.4943;
new=1.4603;
n02w=1.5132;
ne2w=1.4712;

Thetam=asind(sqrt((n0w^(-2)-n02w^(-2))/(ne2w^(-2)-n02w^(-2))));//Phase matching angle for the ADP
mprintf("Thetam = %d degrees", Thetam);//The answer provided in the textbook is wrong
```

Scilab code Exa 3.6 6

```
//Optoelectronics - An Introduction, 2nd Edition by J. Wilson and J.F.B. Hawkes
//Example 3.5
```

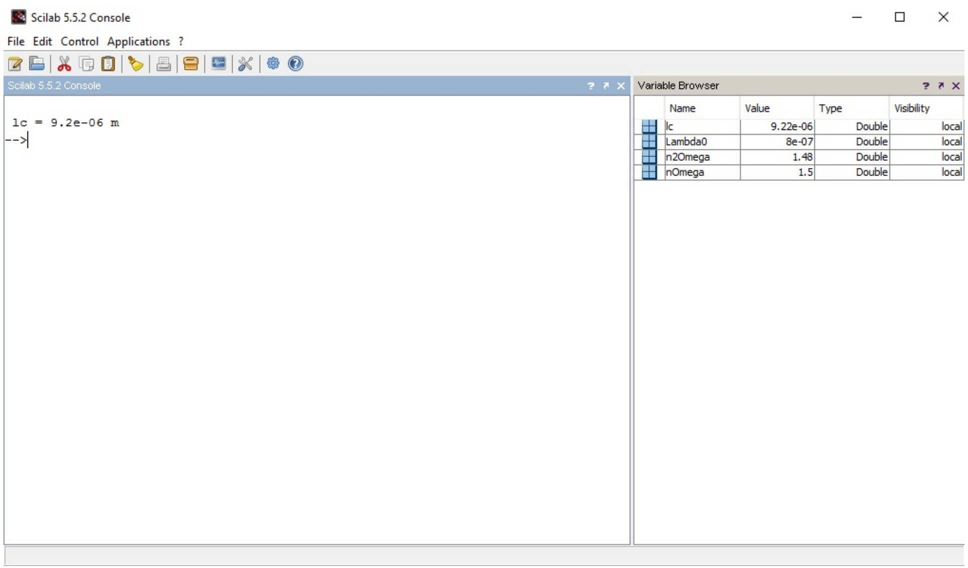


Figure 3.6: 6

```
//OS=Windows XP sp3
//Scilab version 5.5.2
clc;
clear;

//given
nOmega=1.5019;//refractive index corresponding to
    the ray of frequency Omega
n2Omega=1.4802;//refractive index corresponding to
    the ray of frequency 2*Omega
Lambda0=0.8e-6;//vacuum wavelength at the
    fundamental frequency in m

lc=Lambda0/(4*(nOmega-n2Omega));//Coherence length
    in m
mprintf("\n lc = %.1e m",lc);//The answers vary due
    to round off error
```

Chapter 4

Display Devices

Scilab code Exa 4.1 1

```
//Optoelectronics - An Introduction, 2nd Edition by
    J. Wilson and J.F.B. Hawkes
//Example 4.1
//OS=Windows XP sp3
//Scilab version 5.5.2
clc;
clear;

//given
//Let DeltaE = Ec - Ed
DeltaE=0.4;//Depth of the conduction band below the
    conduction band in eV
kT=0.025;//Value of k*T for room temperature in eV
Q=1e8;//Constant value in s^(-1)

//Let the probability of escape of a trapped
    electron per second be p
p=Q*exp(-DeltaE/kT);
mprintf("\n Probability of escape of a trapped
```

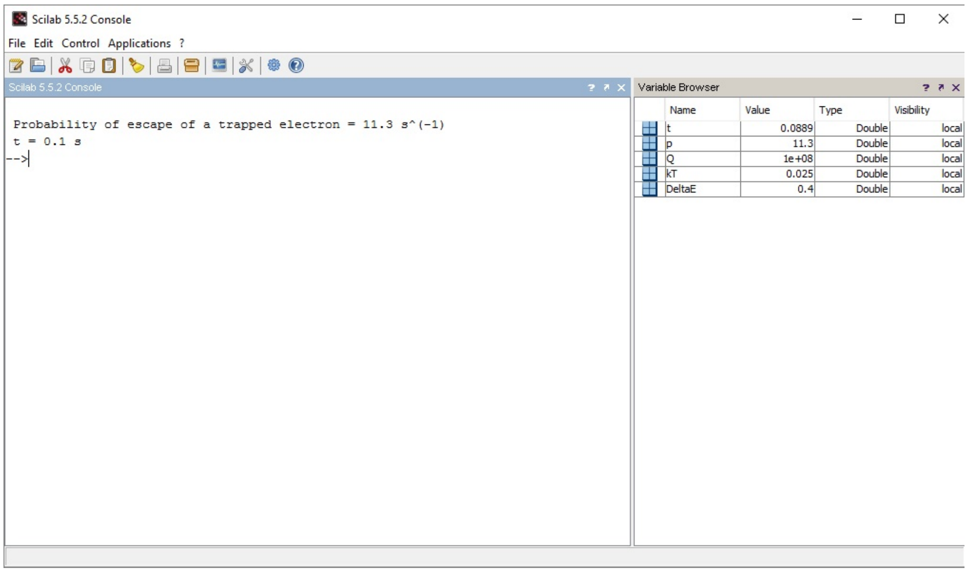


Figure 4.1: 1

```
    electron = %.1f s^(-1)",p);//The answers vary due
     to round off error

//Let the corresponding luminescence lifetime in sec
     be t
t=1/p;
mprintf("\n t = %.1f s",t);
```

Scilab code Exa 4.2 2

```
//Optoelectronics - An Introduction, 2nd Edition by
    J. Wilson and J.F.B. Hawkes
//Example 4.2
//OS=Windows XP sp3
//Scilab version 5.5.2
```

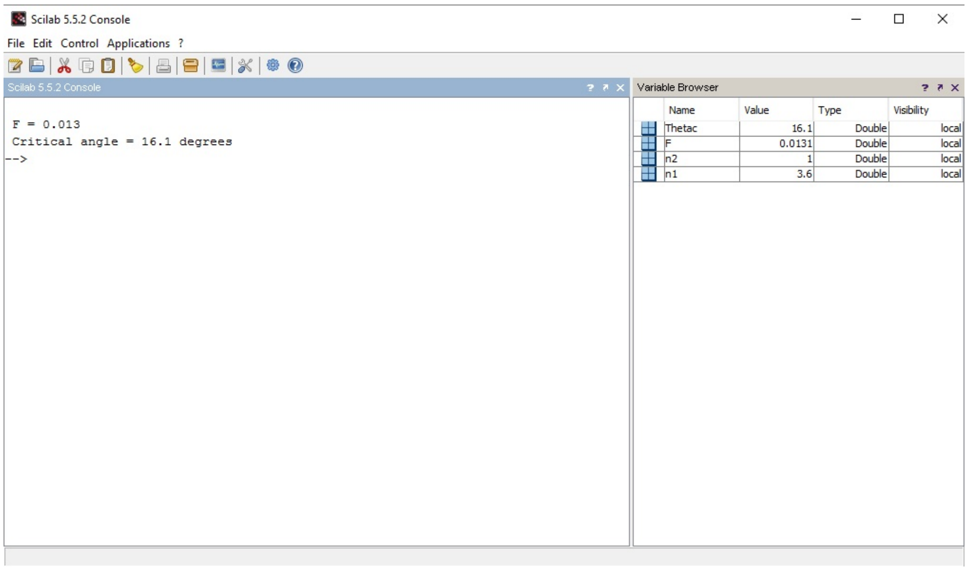


Figure 4.2: 2

```
clc;
clear;

//given
n1=3.6;//Refractive index of 1st medium (GaAs)
n2=1;//Refractive index of 2nd medium (air)

F=(1/4)*(n2/n1)^2*(1-((n1-n2)/(n1+n2))^2);//
    Dimensionless Fractional transmission for
    isotropic radiation
mprintf("\n F = %.3f",F);

Thetac=asind(n2/n1);//critical angle in degrees
mprintf("\n Critical angle = %.1f degrees",Thetac);
    //The answers vary due to round off error
```

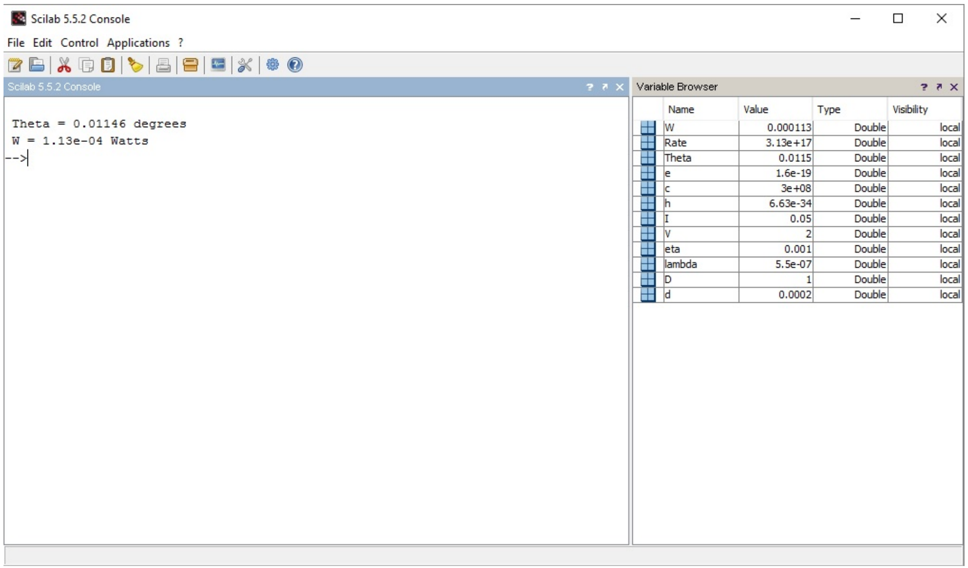


Figure 4.3: 3

Scilab code Exa 4.3 3

```
//Optoelectronics - An Introduction, 2nd Edition by
    J. Wilson and J.F.B. Hawkes
//Example 4.3
//OS=Windows XP sp3
//Scilab version 5.5.2
clc;
clear;

//given
d=0.2e-3;//Chip diameter of LED in m
D=1;//Distance between LED and the viewer in m
lambda=550e-9;//Wavelength emitted in m
eta=0.001;//Quantum efficiency of LED
V=2;//Operating voltage in V
I=50e-3;//Operating current in A
h=6.626e-34;//Planck's constant in SI Units
c=3e8;//Speed of light in air in m/s
e=1.6e-19;//Electronic charge in C
```

```
Theta=2*atand(d/(2*D));//Angle subtended by the
    emitting area in degrees
mprintf("\n Theta = %.5f degrees",Theta);
//As Theta is less than 0.01667, LED acts as a point
    source

//Let the photon emission rate be denoted by 'Rate'
Rate=I/e;//Number of photons emitted per second

W=(h*c/lambda)*eta*Rate;//Total radiant power in W
mprintf("\n W = %.2e Watts",W);
```

Chapter 5

Lasers I

Scilab code Exa 5.1 1

```
//Optoelectronics - An Introduction, 2nd Edition by
   J. Wilson and J.F.B. Hawkes
//Example 5.1
//OS=Windows XP sp3
//Scilab version 5.5.2
clc;
clear;

//given
h=6.6e-34;//Planck's constant in SI Units
nu=5e14;//Average frequency in Hz
k=1.38e-23;//Boltzmann constant in SI Units
T=2000;//Operating temperature in K

R=exp(h*nu/(k*T))+1;//Dimensionless ratio of rates
   of spontaneous and stimulated emissions
mprintf("\n R = %.1e",R);//The answers vary due to
   round off error
```

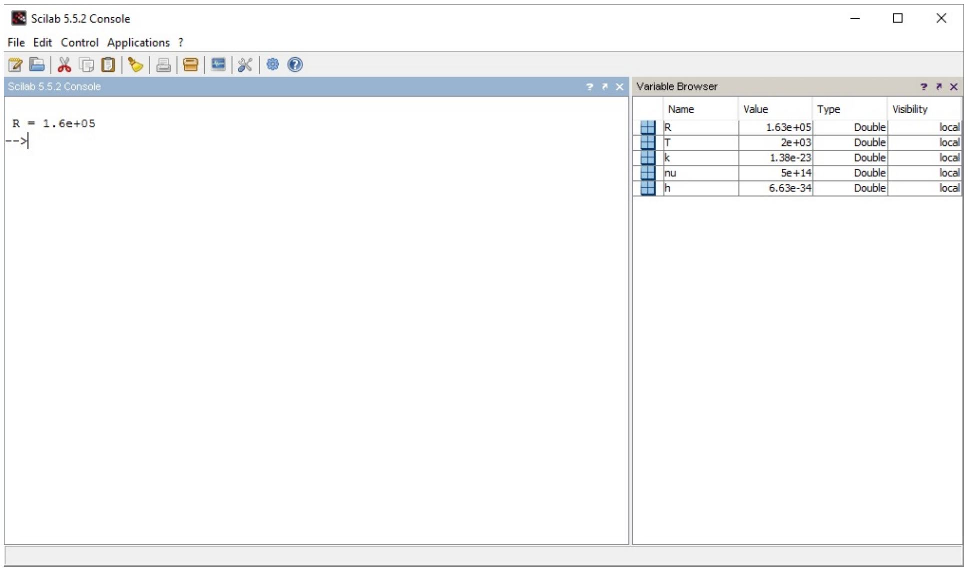


Figure 5.1: 1

Scilab code Exa 5.2 2

```
//Optoelectronics - An Introduction, 2nd Edition by
   J. Wilson and J.F.B. Hawkes
//Example 5.2
//OS=Windows XP sp3
//Scilab version 5.5.2
clc;
clear;

//given
h=6.6e-34;//Planck's constant in SI Units
c=3e8;//Speed of light in m/s
lambda=550e-9;//Average wavelength in m
k=1.38e-23;//Boltzmann constant in SI Units
```

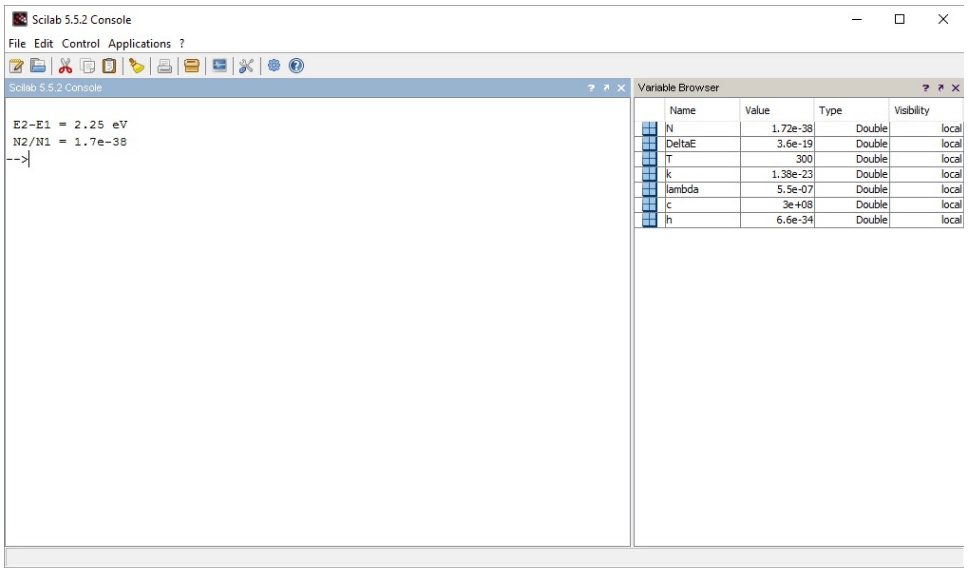


Figure 5.2: 2

```
T=300;//Operating temperature in K

//Let the difference between the two energy levels
    be DeltaE
DeltaE=h*c/lambda;//Difference in energy levels in J
mprintf("\n E2-E1 = %.2f eV",DeltaE/1.6e-19);//
    Division by 1.6*10^(-19) to convert into eV

//Let the relative population of the energy levels '
    N2/N1' be N
N=exp(-DeltaE/(k*T));
mprintf("\n N2/N1 = %.1e",N);//The answer provided
    in the textbook is wrong
```

Scilab code Exa 5.3 3

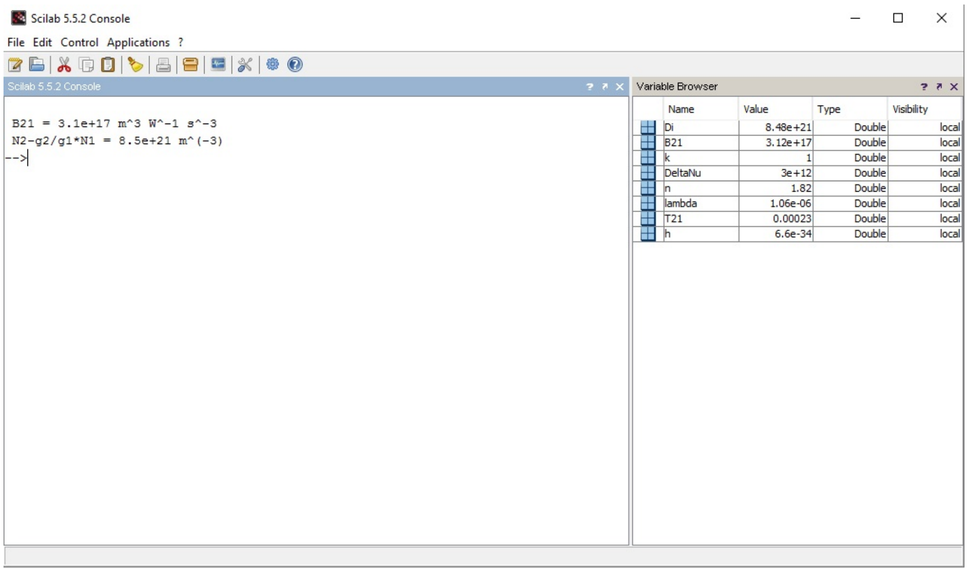


Figure 5.3: 3

```
//Optoelectronics - An Introduction, 2nd Edition by
    J. Wilson and J.F.B. Hawkes
//Example 5.3
//OS=Windows XP sp3
//Scilab version 5.5.2
clc;
clear;

//given
h=6.6e-34;//Planck's constant in SI Units
T21=230e-6;//Spontaneous lifetime in s
lambda=1.06e-6;//Wavelength in m
n=1.82;//Refractive index of medium
DeltaNu=3e12;//Linewidth in Hz
k=1;//Given value of gain coefficient in m^(-1)

B21=(lambda^3)/(8*%pi*h*T21);
mprintf("\n B21 = %.1e m^3 W^-1 s^-3",B21);

//Let the inversion density (N2-g2/g1*N1) be Di
```

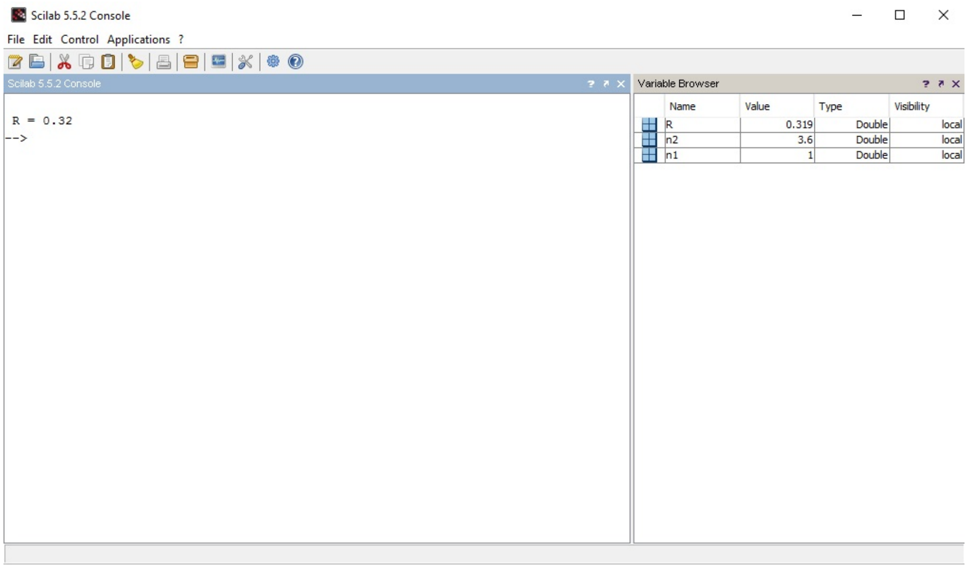


Figure 5.4: 4

```
Di=k*lambda*DeltaNu/(B21*h*n);
mprintf("\n N2−g2/g1*N1 = %.1e m^(−3)",Di);//The
    answer provided in the textbook is wrong
```

Scilab code Exa 5.4 4

```
//Optoelectronics − An Introduction , 2nd Edition by
    J. Wilson and J.F.B. Hawkes
//Example 5.4
//OS=Windows XP sp3
//Scilab version 5.5.2
clc;
clear;

//given
```

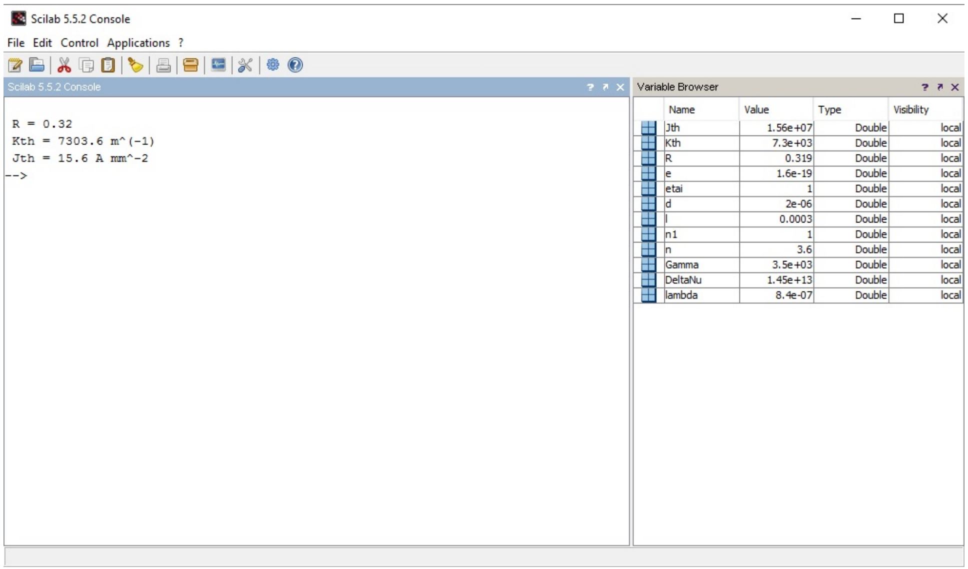


Figure 5.5: 5

```
n1=1;//Refractive index of air medium
n2=3.6;//Refractive index of GaAs medium

R=((n2-n1)/(n2+n1))^2;//Reflectance at GaAs/air
    interface by Fresnel equation
mprintf("\n R = %.2f",R);
```

Scilab code Exa 5.5 5

```
//Optoelectronics - An Introduction, 2nd Edition by
    J. Wilson and J.F.B. Hawkes
//Example 5.5
//OS=Windows XP sp3
//Scilab version 5.5.2
clc;
```

```
clear;

//given
lambda=0.84e-6;//wavelength in m
DeltaNu=1.45e13;//Transition linewidth in Hz
Gamma=3.5e3;//Loss coefficient in m^(-1)
n=3.6;//Refractive index of GaAs medium
n1=1;//Refractive index of air medium
l=300e-6;//Length in m
d=2e-6;//Diameter in m
etai=1;//Internal quantum efficiency
e=1.6e-19;//Electronic charge in C

R=((n-n1)/(n+n1))^2;//Reflectance at GaAs/air interface by Fresnel equation
mprintf("\n R = %.2f",R);

Kth=Gamma+1/(2*l)*log(1/R^2);//Threshold gain in m^(-1)
mprintf("\n Kth = %.1f m^(-1)",Kth);//The answers vary due to round off error

Jth=8*%pi*e*d*DeltaNu*(n^2)/(etai*(lambda^2))*Kth;//Threshold current density in A m^(-2)
mprintf("\n Jth = %.1f A mm^-2",Jth/1e6);//Dividing by 10^6 to convert into A mm^(-2)
//The answers vary due to round off error
```

Scilab code Exa 5.6 6

```
//Optoelectronics - An Introduction, 2nd Edition by J. Wilson and J.F.B. Hawkes
//Example 5.6
```

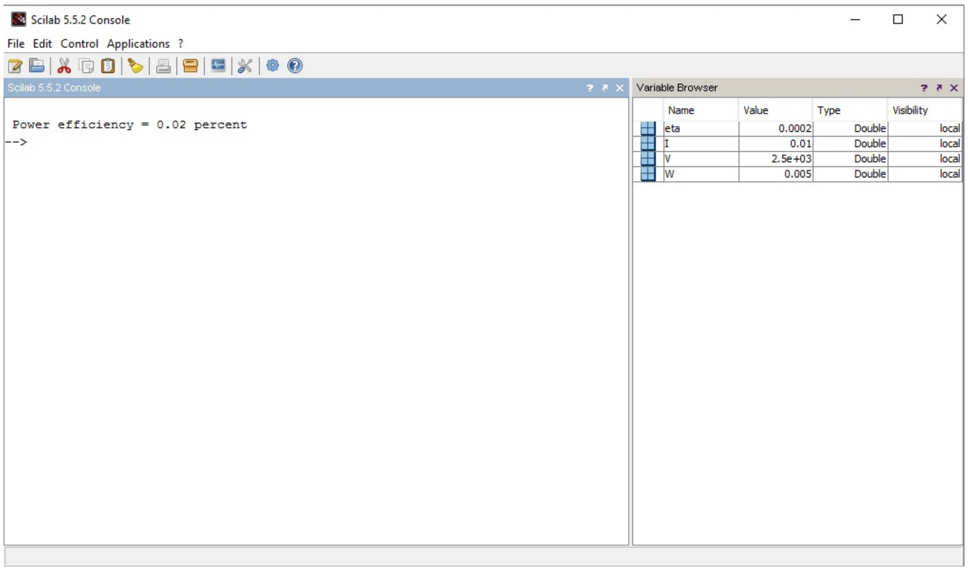


Figure 5.6: 6

```
//OS=Windows XP sp3
//Scilab version 5.5.2
clc;
clear;

//given
W=5e-3;//Optical output power of laser in W
V=2500;//Operating voltage in V
I=10e-3;//Operating current in A

eta=W/(V*I);//Overall power efficiency
mprintf("\n Power efficiency = %.2f percent",eta
    *100);//Multiplying by 100 to convert in
    percentage
```

Chapter 6

Lasers II

Scilab code Exa 6.1 1

```
//Optoelectronics - An Introduction, 2nd Edition by
   J. Wilson and J.F.B. Hawkes
//Example 6.1
//OS=Windows XP sp3
//Scilab version 5.5.2
clc;
clear;

//given
DeltaNu=1.1e11;//Fluorescent linewidth in Hz
L=0.1;//Length of the laser rod in m
c=3e8;//Speed of light in m/s

//Let the mode separation be 'M'
M=c/(2*L);//Mode separation in Hz
mprintf("\n Mode separation = %.1e Hz",M);

//Let the number of modes oscillating be 'N'
N=DeltaNu/M;
```

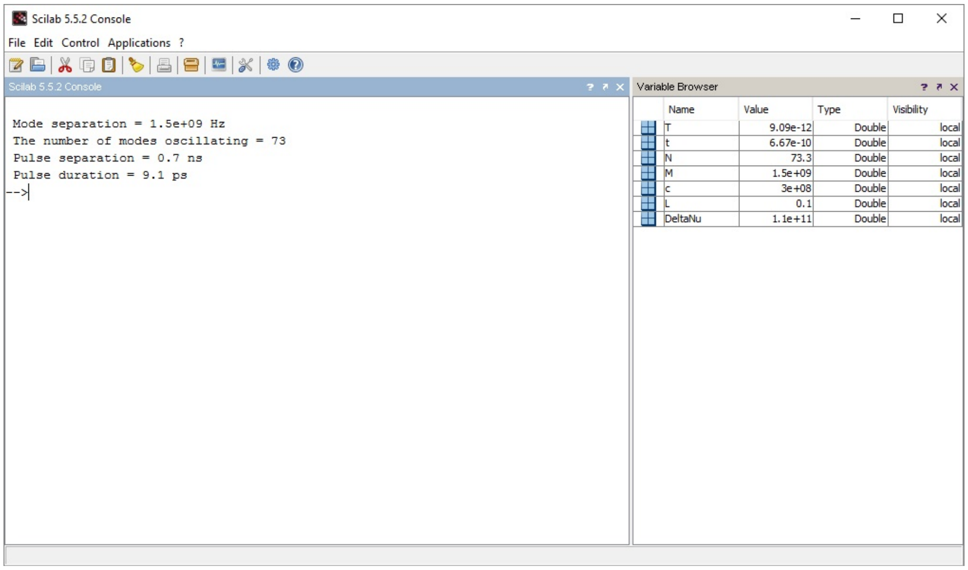


Figure 6.1: 1

```
mprintf("\n The number of modes oscillating = %d",N)
    ;

//Let the pulse separation in seconds be 't'
t=2*L/c;
mprintf("\n Pulse separation = %.1f ns",t/1e-9);//
    Dividing by 10^(-9) to convert into ns

//Let the pulse duration be 'T'
T=t/N;
mprintf("\n Pulse duration = %.1f ps",T/1e-12);//
    Dividing by 10^(-12) to convert into ps
//The answers vary due to round off error
```

Scilab code Exa 6.2 2

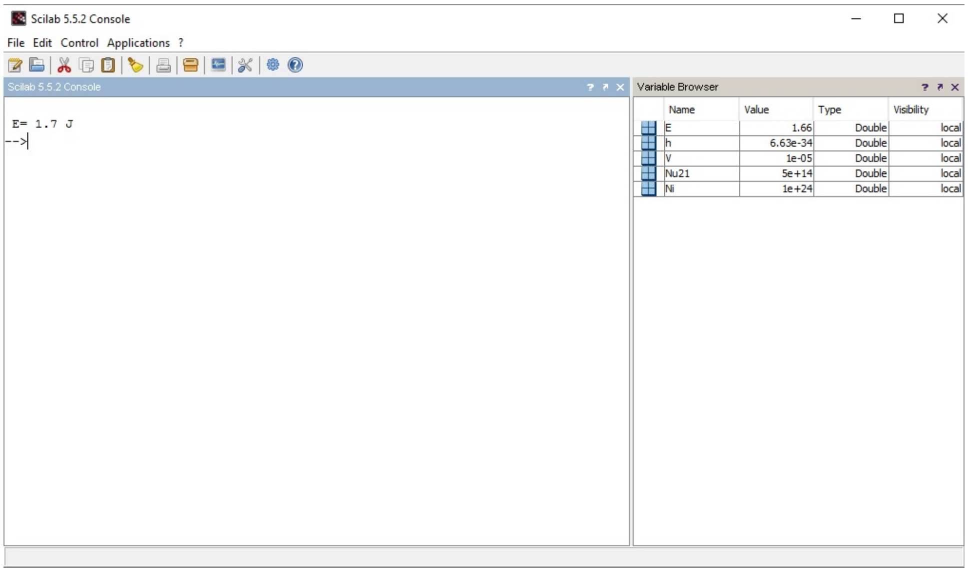


Figure 6.2: 2

```
//Optoelectronics - An Introduction , 2nd Edition by J. Wilson and J.F.B. Hawkes
//Example 6.2
//OS=Windows XP sp3
//Scilab version 5.5.2
clc;
clear;

//given
Ni=1e24;//Population Inversion in m^-3
Nu21=5e14;//Frequency of laser in Hz
V=1e-5;//Volume in m^3
h=6.63e-34;//Planck's constant in SI Units

//Assuming Nf<<Ni, we get
E=(1/2)*h*Nu21*Ni*V;//Total energy emitted in the pulse in J
mprintf("\n E= %.1f J",E)
```

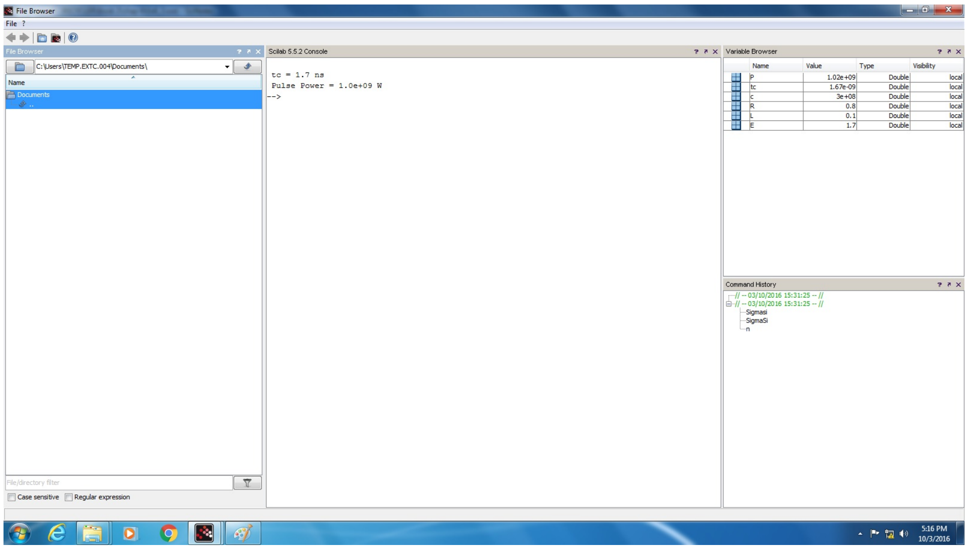


Figure 6.3: 3

Scilab code Exa 6.3 3

```
//Optoelectronics - An Introduction, 2nd Edition by
    J. Wilson and J.F.B. Hawkes
//Example 6.3
//OS=Windows XP sp3
//Scilab version 5.5.2
clc;
clear;

//given
E=1.7;//Total energy emitted in the pulse in J (From
    previous example)
L=0.1;//Cavity length of the laser in m
R=0.8;//Mirror reflectance of the laser
```

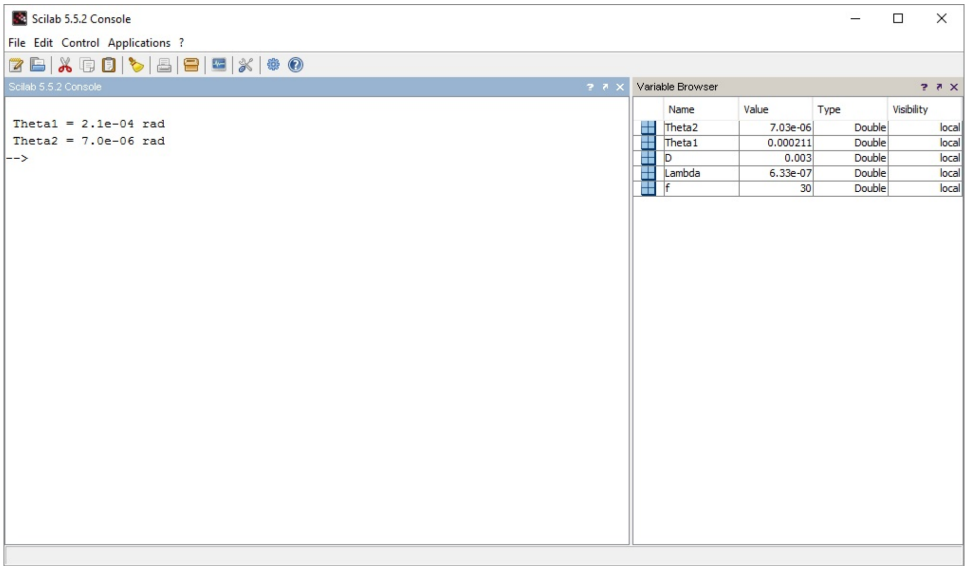


Figure 6.4: 4

```
c=3e8;//Speed of light in air in m/s

tc=L/((1-R)*c);//Cavity lifetime of the laser in s
mprintf("\n tc = %.1f ns",tc/1e-9);//Dividing by
    10^(-9) to convert in ns

P=E/tc;//Pulse power in W
mprintf("\n P = %.1e W",P);
```

Scilab code Exa 6.4 4

```
//Optoelectronics - An Introduction, 2nd Edition by
    J. Wilson and J.F.B. Hawkes
//Example 6.4
//OS=Windows XP sp3
```

```
//Scilab version 5.5.2
clc;
clear;

//given
//Let the focal length ratio of objective lens to eyepiece lens of a telescope be f2/f1 = 'f'
f=30;
Lambda=633e-9;//wavelength of the laser beam in m
D=3e-3;//Diameter of the plasma tube in m

Theta1=Lambda/D;//Divergence of the beam in radians
mprintf("\n Theta1 = %.1e rad",Theta1);

Theta2=Theta1/f;//Divergence of the beam after collimation in radians
mprintf("\n Theta2 = %.1e rad",Theta2);
```

Scilab code Exa 6.5 5

```
//Optoelectronics - An Introduction, 2nd Edition by J. Wilson and J.F.B. Hawkes
//Example 6.5
//OS=Windows XP sp3
//Scilab version 5.5.2
clc;
clear;

//given - Case(i)
Lambda=589e-6;//wavelength of the sodium lamp in m
DeltaNu=5.1e11;//Linewidth of the sodium D lines in Hz
c=3e8;//Speed of light in air in m/s
```

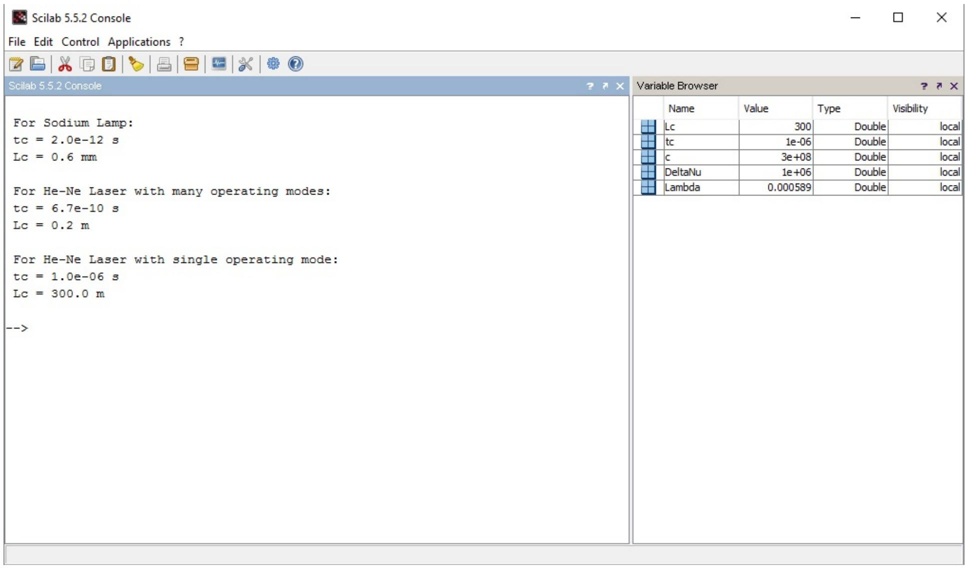


Figure 6.5: 5

```

mprintf("\n For Sodium Lamp:");
tc=1/DeltaNu;//Coherence time in s
mprintf("\n tc = %.1e s",tc);

Lc=tc*c;//length of emitted wave in m
mprintf("\n Lc = %.1f mm\n",Lc/1e-3);//Division by
    10^(-3) to convert into mm


//given - Case(ii)
DeltaNu=1500e6;//Linewidth of He-Ne laser in Hz
c=3e8;//Speed of light in air in m/s

mprintf("\n For He-Ne Laser with many operating
    modes:");
tc=1/DeltaNu;//Coherence time in s
mprintf("\n tc = %.1e s",tc);

Lc=tc*c;//length of emitted wave in m
```

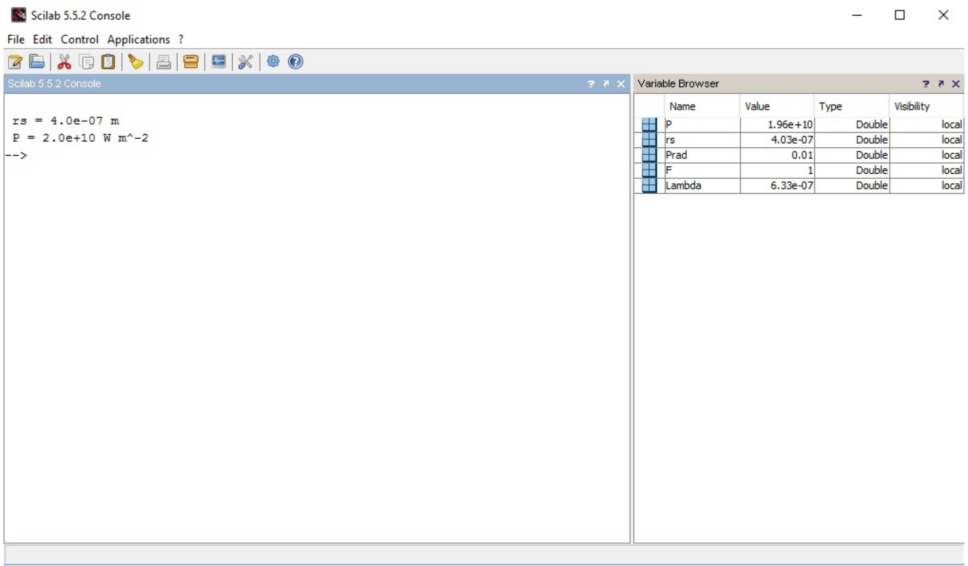


Figure 6.6: 6

```
mprintf("\n Lc = %.1f m\n",Lc);


//given - Case(iii)
DeltaNu=1e6;//Linewidth of He-Ne laser in Hz
c=3e8;//Speed of light in air in m/s

mprintf("\n For He-Ne Laser with single operating mode:");
tc=1/DeltaNu;//Coherence time in s
mprintf("\n tc = %.1e s",tc);

Lc=tc*c;//length of emitted wave in m
mprintf("\n Lc = %.1f m\n",Lc);
```

Scilab code Exa 6.6 6

```
//Optoelectronics - An Introduction, 2nd Edition by
   J. Wilson and J.F.B. Hawkes
//Example 6.6
//OS=Windows XP sp3
//Scilab version 5.5.2
clc;
clear;

//given
Lambda=632.8e-9;//Wavelength of the laser in m
F=1;//Focal ratio of the lens
Prad=10e-3;//Power radiated by the laser in W

rs=2*Lambda*F/%pi;//Radius of the focused spot in m
mprintf("\n rs = %.1e m",rs);

//Let the power per unit area in W m^-2 be P
P=Prad/(%pi*(rs)^2);
mprintf("\n P = %.1e W m^-2",P);
```

Scilab code Exa 6.7 7

```
//Optoelectronics - An Introduction, 2nd Edition by
   J. Wilson and J.F.B. Hawkes
//Example 6.7
//OS=Windows XP sp3
//Scilab version 5.5.2
clc;
clear;

//given
```

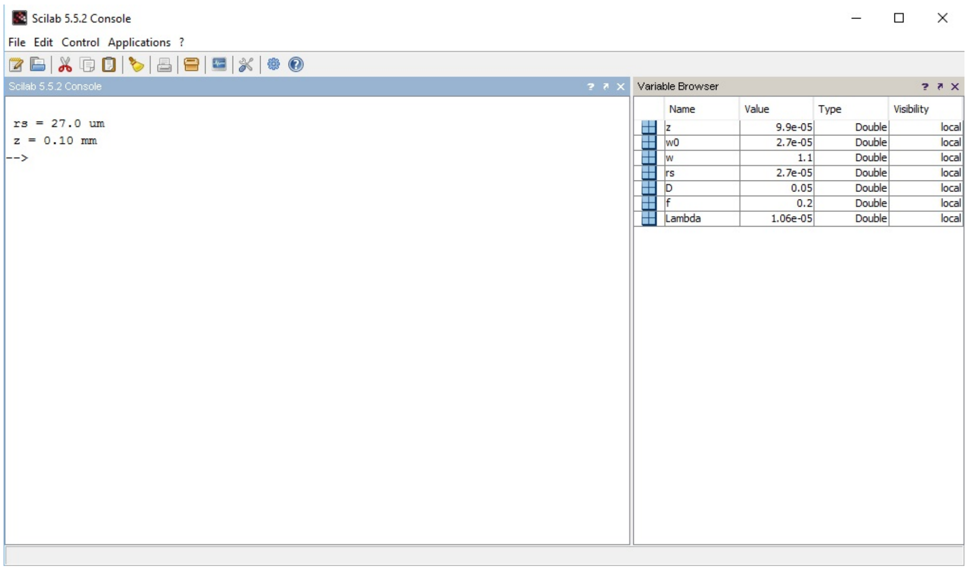


Figure 6.7: 7

```
Lambda=10.6e-6;//Wavelength of the laser in m
f=200e-3;//Focal length of the lens in m
D=50e-3;//Diameter of aperture of focusing lens

rs=2*Lambda*f/(%pi*D);//Radius of the focused spot in m
mprintf("\n rs = %.1f um",rs/1e-6);//Dividing by 10^(-6) to convert to um
//The answers vary due to round off error

//Let the ratio w(z)/w0 be w
w=1.1;
w0=rs;//Also given

z=%pi*w0^2/Lambda*sqrt((w^2)-1);//Depth of focus in m
mprintf("\n z = %.2f mm",z/1e-3);//Dividing by 10^(-3) to convert to mm
//The answers vary due to round off error
```

Chapter 7

Photodetectors

Scilab code Exa 7.1 1

```
//Optoelectronics - An Introduction, 2nd Edition by J. Wilson and J.F.B. Hawkes
//Example 7.1
//OS=Windows XP sp3
//Scilab version 5.5.2
clc;
clear;

//given
D=1e9;//Specific detectivity of detector in  m Hz^(1/2) W^(-1)
Lambda=2e-6;//Wavelength in m
A=25e-6//Detector area in m^2
Deltaf=10e3;//Detection bandwidth in Hz

NEP=sqrt(A*Deltaf)/D;//Detector sensitivity in W
mprintf("\n NEP = %.1e W",NEP);
```

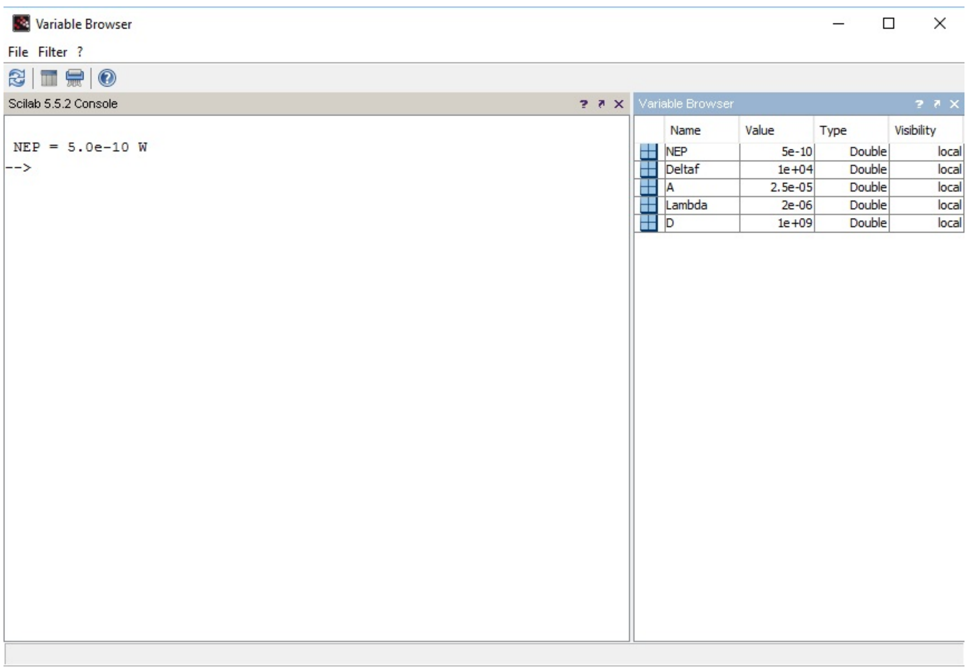

Variable Browser
File Filter ?
Scilab 5.5.2 Console
NEP = 5.0e-10 W
-->
Variable Browser
Name
Value
Type
Visibility
NEP
5e-10
Double
local
Deltaf
1e+04
Double
local
A
2.5e-05
Double
local
Lambda
2e-06
Double
local
D
1e+09
Double
local

Figure 7.1: 1

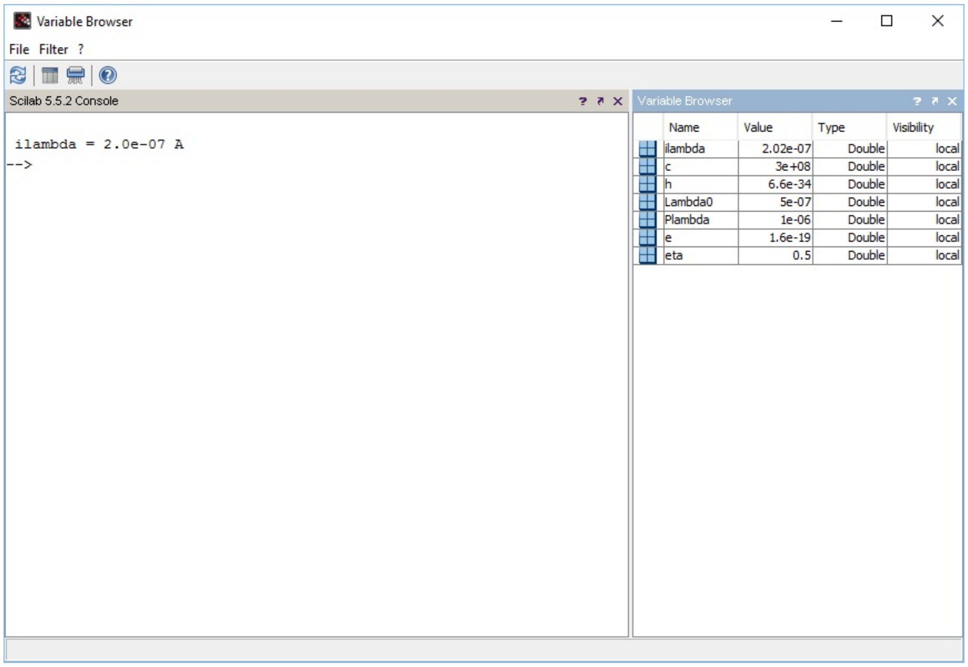


Figure 7.2: 2

Scilab code Exa 7.2 2

```
//Optoelectronics - An Introduction, 2nd Edition by
    J. Wilson and J.F.B. Hawkes
//Example 7.2
//OS=Windows XP sp3
//Scilab version 5.5.2
clc;
clear;

//given
eta=0.5;//Dimensionless Quantum efficiency of
```

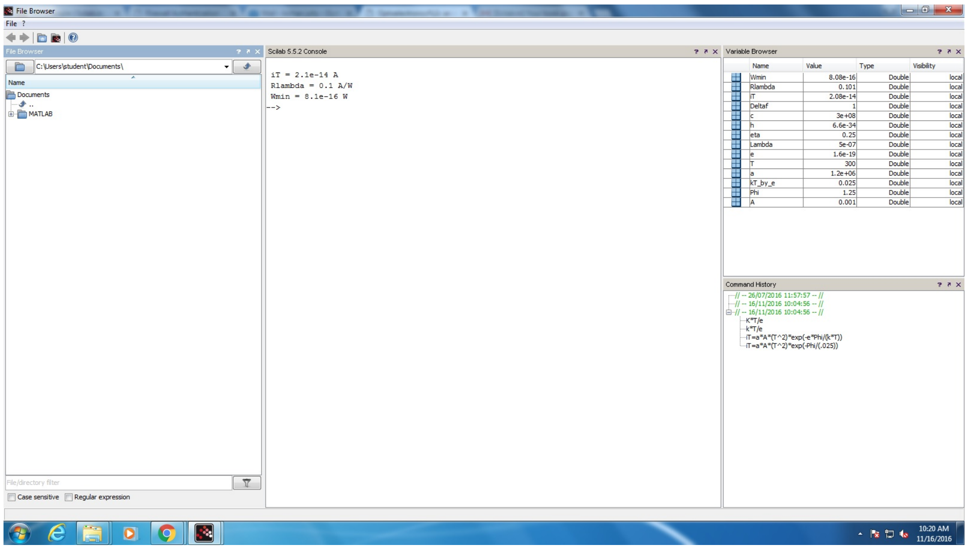


Figure 7.3: 3

```
    photocathode
e=1.6e-19;//Electronic charge in C
Plambda=1e-6;//Radiation power incident on the
    photodiode in W
Lambda0=500e-9;//Wavelength of incident light in m
h=6.6e-34;//Planck's constant in SI Units
c=3e8;//Speed of light in vacuum in m/s

ilambda=eta*e*Plambda*Lambda0/(h*c);//Corresponding
    current generated in A
mprintf("\n ilambda = %.1e A",ilambda);
```

Scilab code Exa 7.3 3

```
//Optoelectronics - An Introduction, 2nd Edition by
    J. Wilson and J.F.B. Hawkes
```

```
//Example 7.3
//OS=Windows XP sp3
//Scilab version 5.5.2
clc;
clear;

//given
A=1000e-6;//Cathode area in m^2
Phi=1.25;//Work function of the metal in eV
kT_by_e=0.025;//constant term =product of Boltzmann constant with Ambient temperature divided by charge of an electron in SI Units
a=1.2e6;//Constant value for pure metals in A m^-2 K^-2
T=300;//Temperature in K
e=1.6e-19;//Electronic charge in C
Lambda=0.5e-6;//wavelength in m
eta=0.25;//Dimensionless Quantum efficiency
h=6.6e-34;//Planck's constant in SI Units
c=3e8;//Speed of light in air in m/s
Deltaf=1;//Bandwidth in Hz

iT=a*A*(T^2)*exp(-Phi/kT_by_e);//Thermionic emission current in A
mprintf("\n iT = %.1e A",iT);//The answer provided in the textbook varies due to roundingoff

Rlambda=eta*e*Lambda/(h*c);//Responsivity of the photomultiplier in A W^-1
mprintf("\n Rlambda = %.1f A/W",Rlambda);

Wmin=sqrt(2*iT*e*Deltaf)/Rlambda;//Minimum detectable signal power in presence of dark current iT in W
mprintf("\n Wmin = %.1e W",Wmin);//The answer provided in the textbook varies due to roundingoff
```

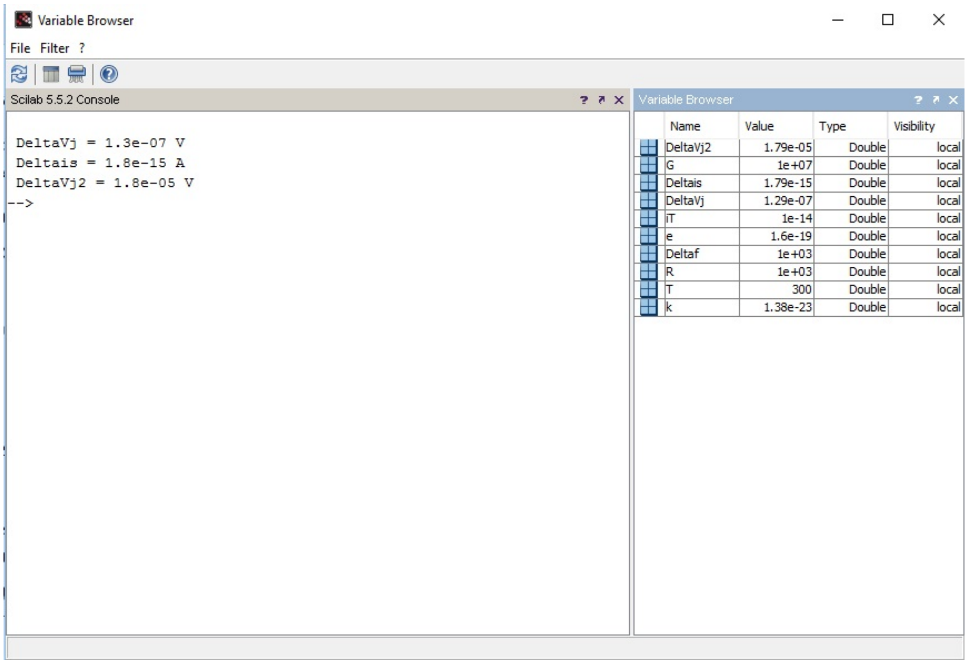


Figure 7.4: 4

Scilab code Exa 7.4 4

```
//Optoelectronics - An Introduction, 2nd Edition by
    J. Wilson and J.F.B. Hawkes
//Example 7.4
//OS=Windows XP sp3
//Scilab version 5.5.2
clc;
clear;

//given
k=1.38e-23;//Boltzmann constant in SI Units
```

```
T=300;//Absolute temperature in K
R=1e3;//Load resistance in Ohms
Deltaf=1e3;//Bandwidth of the photo multiplier in Hz
e=1.6e-19;//Electronic charge in C
iT=1e-14;//Dark current in A


DeltaVj=sqrt(4*k*T*R*Deltaf);
mprintf("\n DeltaVj = %.1e V",DeltaVj);
//The answer provided in the textbook is wrong

Deltais=sqrt(2*iT*e*Deltaf);//Corresponding magnitude of rms current fluctuations in A
mprintf("\n Deltais = %.1e A",Deltais);

//Let the photomultiplier gain be G
G=1e7;//Given
//Let the shot noise voltage signal across R be DeltaVj2
DeltaVj2=Deltais*G*R;
mprintf("\n DeltaVj2 = %.1e V",DeltaVj2);
```

Scilab code Exa 7.5 5

```
//Optoelectronics - An Introduction, 2nd Edition by J. Wilson and J.F.B. Hawkes
//Example 7.5
//OS=Windows XP sp3
//Scilab version 5.5.2
clc;
clear;

//given
```

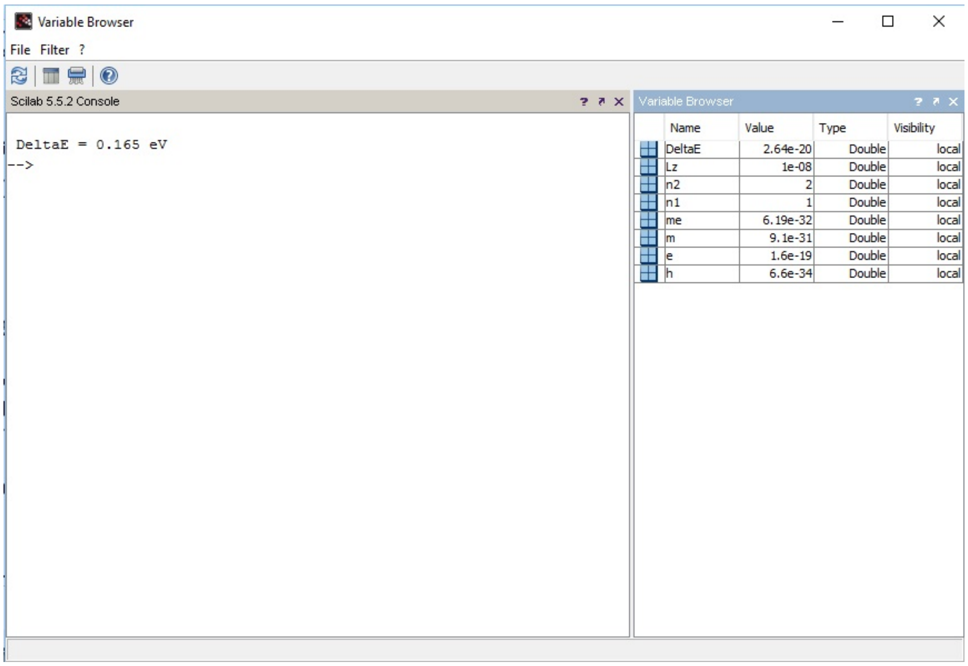


Figure 7.5: 5

```
h=6.6e-34;//Planck's constant in SI Units
e=1.6e-19;//Electronic charge in C
m=9.1e-31;//Rest mass of electron in kg
me=0.068*m;//Relative mass of electron in conduction band
n1=1;//Initial state of electron
n2=2;//Final state of electron
Lz=10e-9;//Width of the quantum well in m

DeltaE=(h^2)/(8*me)*((n2/Lz)^2-(n1/Lz)^2);//Energy difference between the two states in J
mprintf("\n DeltaE = %.3f eV",DeltaE/e);//Dividing by 'e' to convert to eV
```

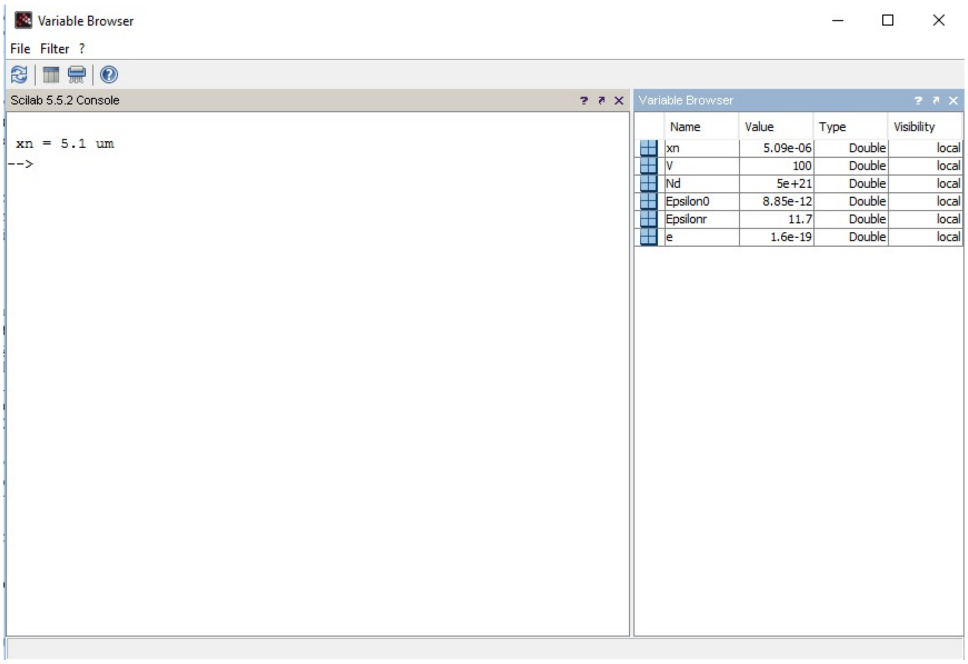


Figure 7.6: 6

Scilab code Exa 7.6 6

```
//Optoelectronics - An Introduction, 2nd Edition by
    J. Wilson and J.F.B. Hawkes
//Example 7.6
//OS=Windows XP sp3
//Scilab version 5.5.2
clc;
clear;

//given
e=1.6e-19;//Electronic charge in C
Epsilonr=11.7;//Relative permittivity of medium
Epsilon0=8.85e-12;//Permittivity of free space in SI
```

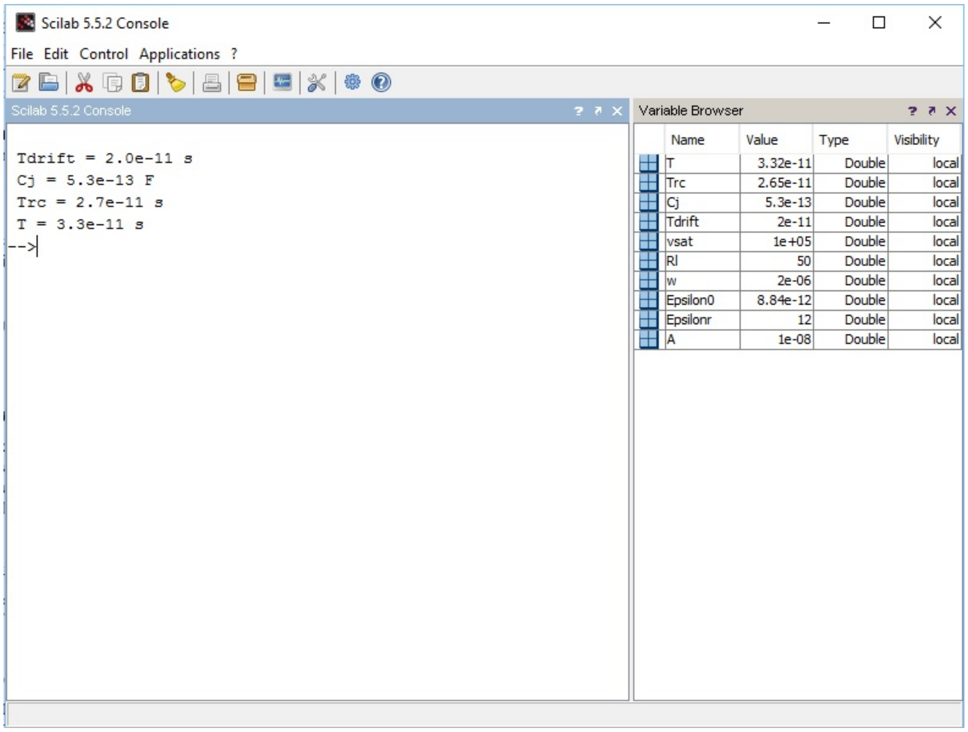


Figure 7.7: 7

```
    Units
Nd=5e21;//Doping level of the diode in m^-3
V=100;//Reverse bias voltage in V

xn=sqrt(2*Epsilon0*Epsilonr*V/(e*Nd));//Depletion
    region thickness in m
mprintf("\n xn = %.1f um",xn/1e-6);//Dividing by10
    ^(-6) to convert to um
```

Scilab code Exa 7.7 7

```
//Optoelectronics - An Introduction, 2nd Edition by
    J. Wilson and J.F.B. Hawkes
//Example 7.7
//OS=Windows XP sp3
//Scilab version 5.5.2
clc;
clear;

//given
A=100e-6*100e-6;//Junction area of the photodiode in
     m^2
Epsilonr=12;//Relative permittivity of InGaAs
Epsilon0=8.84e-12;//Permittivity of free space in SI
     Units
w=2e-6;//Thickness of the i region
Rl=50;//Load resistance in Ohms
vsat=1e5;//Saturation velocity of electrons in
    InGaAs

Tdrift=w/vsat;//Transit time of electrons through
    the depletion region in s
mprintf("\n Tdrift = %.1e s",Tdrift);

Cj=A*Epsilon0*Epsilonr/w;//Diode capacitance in F
mprintf("\n Cj = %.1e F",Cj);

Trc=Rl*Cj;//Response time associated with the
    detector RC network in s
mprintf("\n Trc = %.1e s",Trc);//The answers vary
    due to round off error

T=sqrt((Tdrift)^2+(Trc)^2);//Total time response in
    s
mprintf("\n T = %.1e s",T);
//The answers vary due to round off error
```

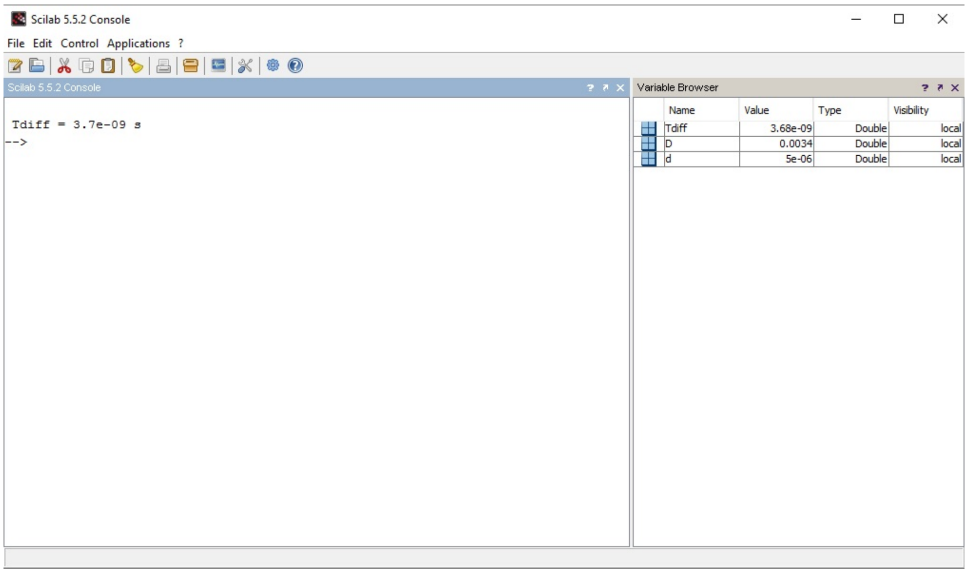


Figure 7.8: 8

Scilab code Exa 7.8 8

```
//Optoelectronics - An Introduction , 2nd Edition by
    J. Wilson and J.F.B. Hawkes
//Example 7.8
//OS=Windows XP sp3
//Scilab version 5.5.2
clc;
clear;

//given
d=5e-6;//Thickness of Si layer in m
D=3.4e-3;//Minority carrier diffusion coefficient in
     m^2 s^-1

```

```
Tdiff=(d^2)/(2*D);//Diffusion time of carriers in s
mprintf("\n Tdiff = %.1e s",Tdiff);
```

Chapter 8

Fiber optical waveguides

Scilab code Exa 8.1 1

```
//Optoelectronics - An Introduction, 2nd Edition by
   J. Wilson and J.F.B. Hawkes
//Example 8.1
//OS=Windows XP sp3
//Scilab version 5.5.2
clc;
clear;

//given
n1=1.5;//Dimensionless refractive index of glass
n2=1;//Dimensionless refractive index of air
Theta_i=60;//Angle of incidence in degrees
Tan_Sai=sqrt(sind(Theta_i)^2-(n2/n1)^2)/(cosd(
   Theta_i))//Tan of phase shift in incident and
   reflected ray
Sai=atand(Tan_Sai)//phase shift in perpendicular
   component ofincident and reflected ray in degrees
delta=atand((n1/n2)^2*Tan_Sai)//phase shift in
   parallel component of incident and reflected ray
   in degrees

```

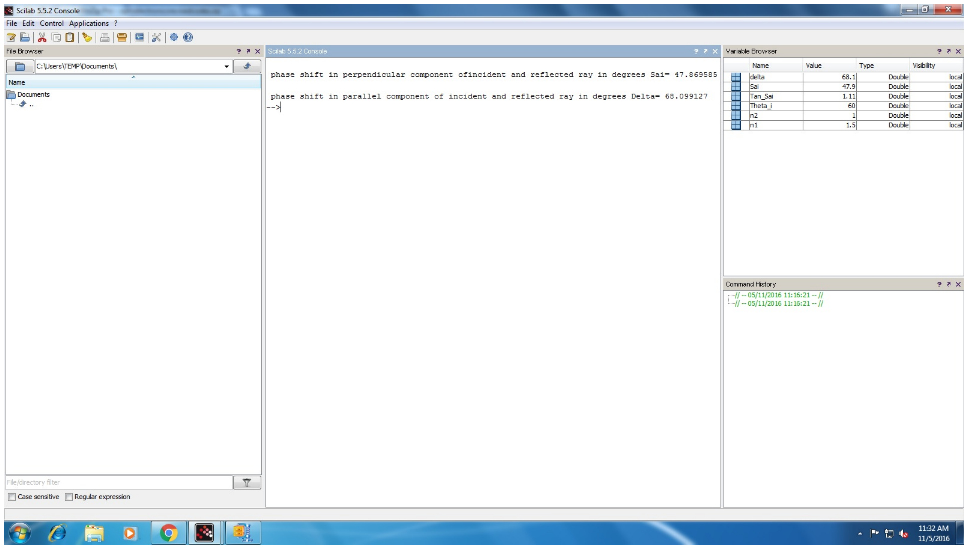


Figure 8.1: 1

```
mprintf("\n phase shift in perpendicular component
    ofincident and reflected ray in degrees Sai= %f",
    Sai);
mprintf("\n\n phase shift in parallel component of
    incident and reflected ray in degrees Delta= %f",
    delta);
// the difference in answer is becoause of
    roundingoff
```

Scilab code Exa 8.2 2

```
//Optoelectronics - An Introduction, 2nd Edition by
    J. Wilson and J.F.B. Hawkes
```

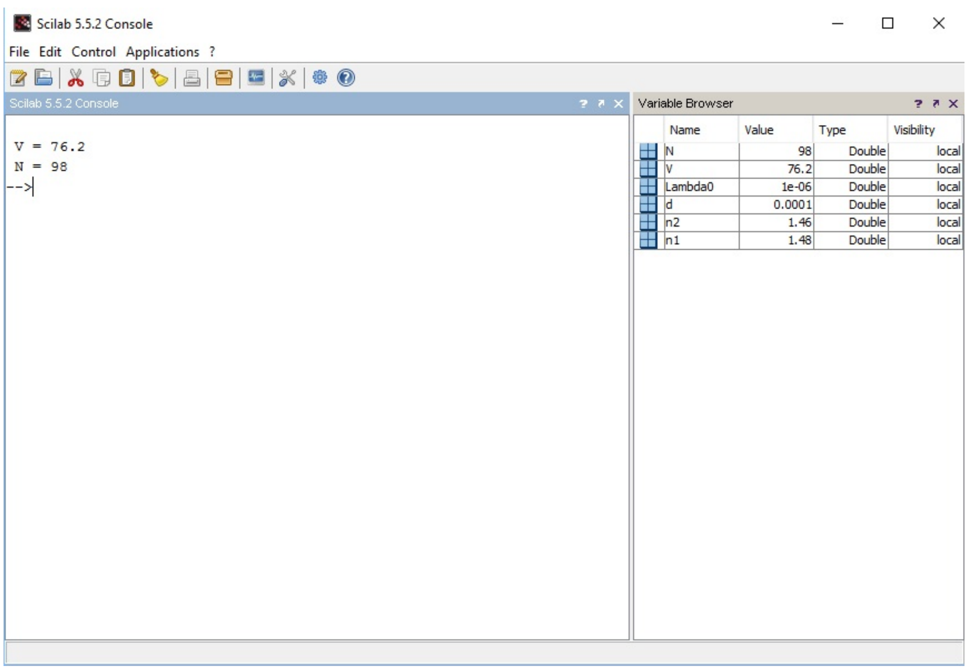

Scilab 5.5.2 Console
File Edit Control Applications ?
Scilab 5.5.2 Console
V = 76.2
N = 98
-->
Variable Browser
Name
Value
Type
Visibility
N 98 Double local
V 76.2 Double local
Lambda0 1e-06 Double local
d 0.0001 Double local
n2 1.46 Double local
n1 1.48 Double local

Figure 8.2: 2

```
//Example 8.2
//OS=Windows XP sp3
//Scilab version 5.5.2
clc;
clear;

//given
n1=1.48;//Dimensionless refractive index of core
n2=1.46;//Dimensionless refractive index of cladding
d=100e-6;//Width of the waveguide in m
Lambda0=1e-6;//Vacuum wavelength in m

V=%pi*(d/Lambda0)*sqrt((n1^2)-(n2^2));//
    Dimensionless normalized film thickness
mprintf("\n V = %.1f",V);

//Let the total number of possible modes be 'N'
N=2*(1 + floor(2*V/%pi));
mprintf("\n N = %d",N);
```

Scilab code Exa 8.3 3

```
//Optoelectronics - An Introduction, 2nd Edition by
    J. Wilson and J.F.B. Hawkes
//Example 8.3
//OS=Windows XP sp3
//Scilab version 5.5.2
clc;
clear;

//given
n1=1.48;//Dimensionless refractive index of fiber
    core
```

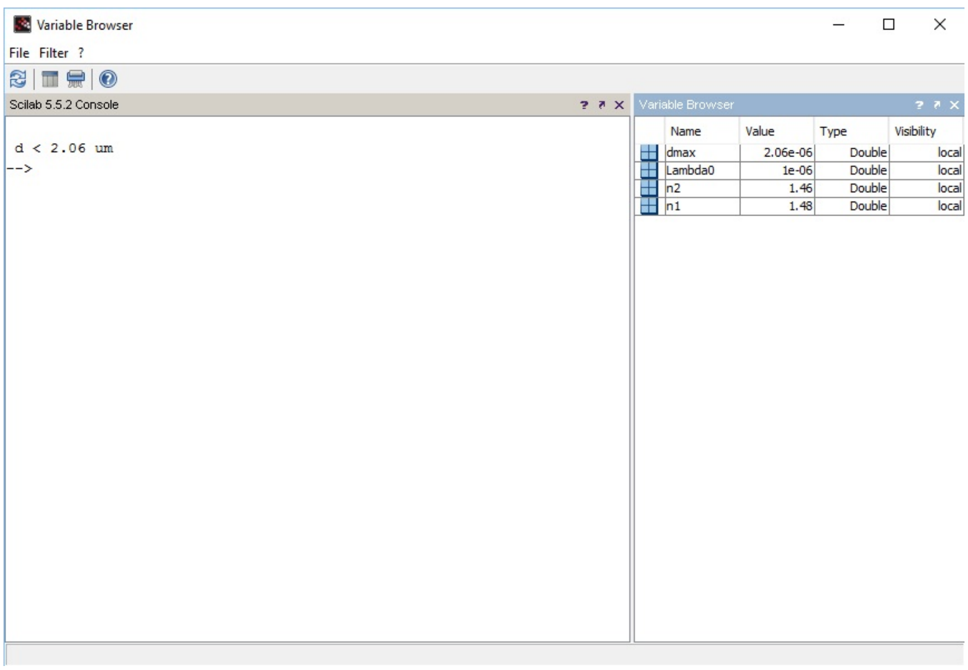

Variable Browser
File Filter ?
Scilab 5.5.2 Console
d < 2.06 um
-->
Variable Browser
Name Value Type Visibility
dmax 2.06e-06 Double local
Lambda0 1e-06 Double local
n2 1.46 Double local
n1 1.48 Double local

Figure 8.3: 3

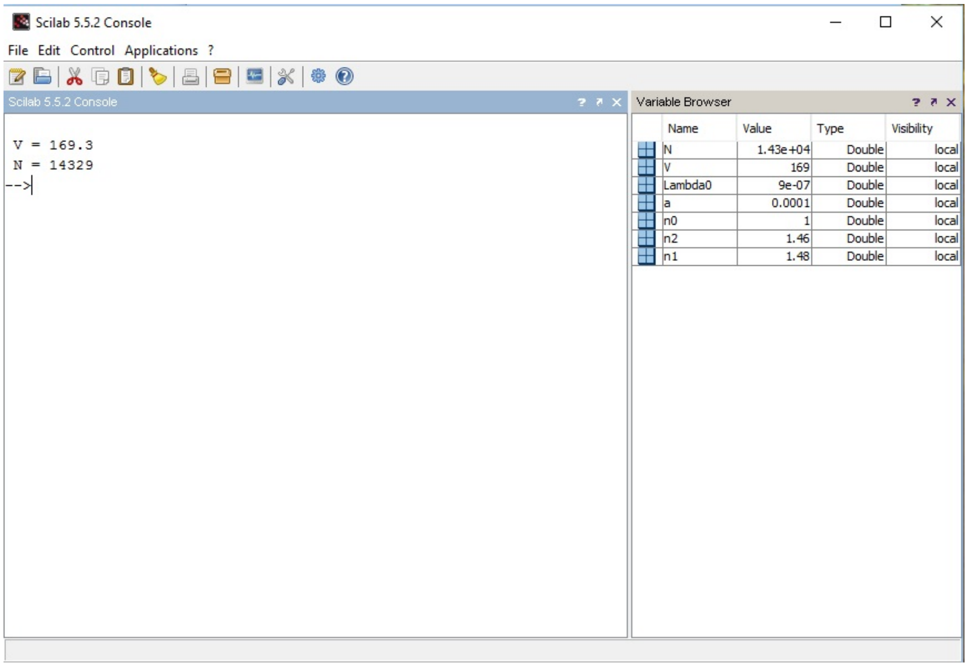


Figure 8.4: 4

```
n2=1.46; //Dimensionless refractive index of fiber cladding
Lambda0=1e-6; //Wavelength in m

//For single mode guide, let the core thickness be less than dmax
dmax=Lambda0/(2*sqrt(n1^2 - n2^2));
mprintf("\n d < %.2f um",dmax/1e-6); //Dividing by 10^(-6) to convert to um
```

Scilab code Exa 8.4 4

```
//Optoelectronics - An Introduction, 2nd Edition by
   J. Wilson and J.F.B. Hawkes
//Example 8.4
//OS=Windows XP sp3
//Scilab version 5.5.2
clc;
clear;

//given
n1=1.48;//Dimensionless refractive index of fiber
   core
n2=1.46;//Dimensionless refractive index of fiber
   cladding
n0=1;//Dimensionless refractive index of air
a=100e-6;//Core radius in m
Lambda0=900e-9;//Vacuum wavelength in m

V=2*%pi*(a/Lambda0)*sqrt((n1^2)-(n2^2));//
   Dimensionless normalized film thickness
mprintf("\n V = %.1f",V);

N=(V^2)/2;//Number of modes of propagation
mprintf("\n N = %d",N);
```

Scilab code Exa 8.5 5

```
//Optoelectronics - An Introduction, 2nd Edition by
   J. Wilson and J.F.B. Hawkes
//Example 8.5
//OS=Windows XP sp3
//Scilab version 5.5.2
clc;
clear;
```

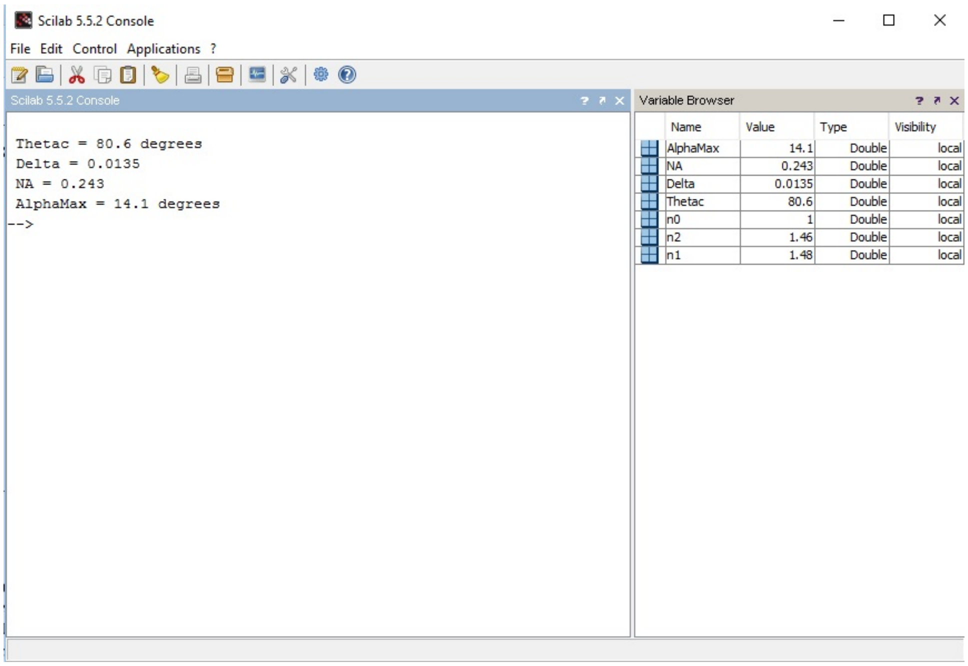


Figure 8.5: 5

```

//given
n1=1.48;//Dimensionless refractive index of fiber
    core
n2=1.46;//Dimensionless refractive index of fiber
    cladding
n0=1;//Dimensionless refractive index of air

Thetac=asind(n2/n1);//critical angle in degrees
mprintf("\n Thetac = %.1f degrees",Thetac);//The
    answers vary due to round off error

Delta=(n1-n2)/n1;
mprintf("\n Delta = %.4f",Delta);//The answers vary
    due to round off error

NA=n1*sqrt(2*Delta);//Dimensionless Numerical
```

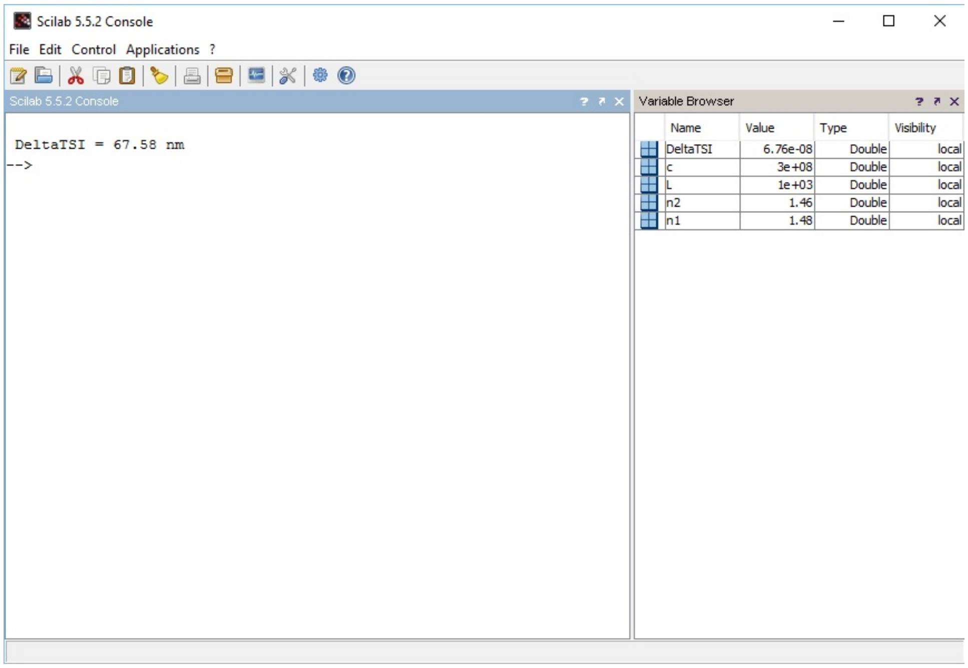


Figure 8.6: 6

```
    aperture of fiber
mprintf("\n NA = %.3f",NA);//The answers vary due to
     round off error

AlphaMax=asind(NA);//Fiber acceptance angle in
    degrees
mprintf("\n AlphaMax = %.1f degrees",AlphaMax);//The
     answers vary due to round off error
```

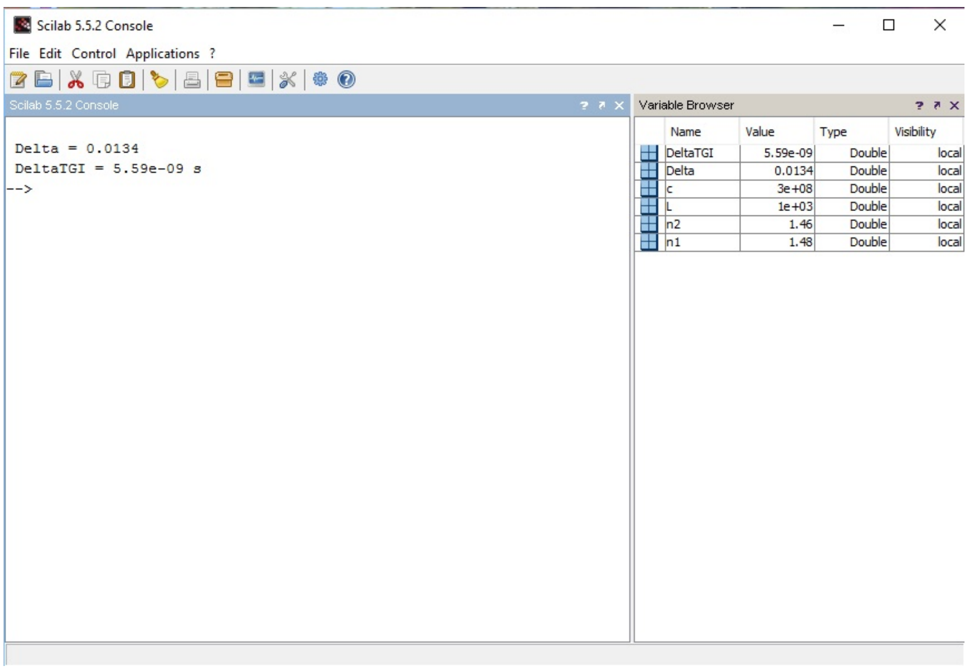
Scilab code Exa 8.6 6

```
//Optoelectronics - An Introduction, 2nd Edition by
    J. Wilson and J.F.B. Hawkes
```

```
//Example 8.6
//OS=Windows XP sp3
//Scilab version 5.5.2
clc;
clear;

//given
n1=1.48;//Dimensionless refractive index of fiber core
n2=1.46;//Dimensionless refractive index of fiber cladding
L=1e3;//Length of fiber in m
c=3e8;//Speed of light in vacuum in m/s

DeltaTSI=L/c*(n1/n2)*(n1-n2);//Intermodal dispersion in s
mprintf("\n DeltaTSI = %.2f ns",DeltaTSI/1e-9);//Dividing by 10^(-9) to convert to ns
//The answers vary due to round off error
```

Scilab code Exa 8.7 7

```
//Optoelectronics - An Introduction, 2nd Edition by J. Wilson and J.F.B. Hawkes
//Example 8.7
//OS=Windows XP sp3
//Scilab version 5.5.2
clc;
clear;

//given
n1=1.48;//Dimensionless refractive index of fiber core
```



Scilab 5.5.2 Console
File Edit Control Applications ?
Scilab 5.5.2 Console
Delta = 0.0134
DeltaTGI = 5.59e-09 s
-->
Variable Browser
Name Value Type Visibility
DeltaTGI 5.59e-09 Double local
Delta 0.0134 Double local
c 3e+08 Double local
L 1e+03 Double local
n2 1.46 Double local
n1 1.48 Double local

Figure 8.7: 7

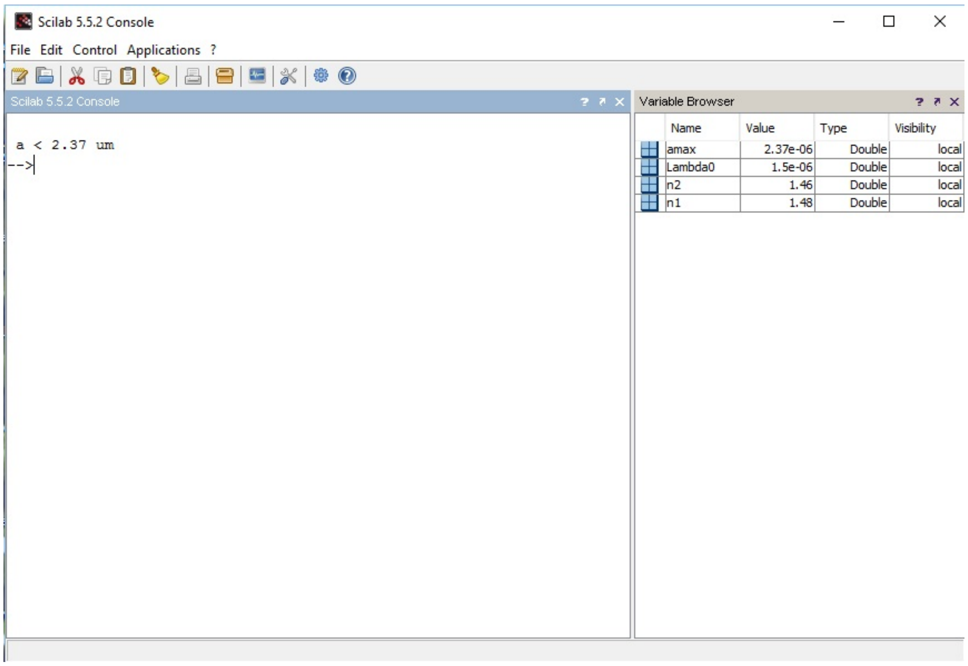


Figure 8.8: 8

```
n2=1.46;//Dimensionless refractive index of fiber
    cladding
L=1e3;//Length of fiber in m
c=3e8;//Speed of light in vacuum in m/s

Delta=(n1^2 - n2^2)/(2* n1^2);
mprintf("\n Delta = %.4f",Delta);

DeltaTGI=L/c*Delta/8;//Intermodal dispersion in s
mprintf("\n DeltaTGI = %.2e s",DeltaTGI);
//The answers vary due to round off error
```

Scilab code Exa 8.8 8

```
//Optoelectronics - An Introduction, 2nd Edition by
   J. Wilson and J.F.B. Hawkes
//Example 8.8
//OS=Windows XP sp3
//Scilab version 5.5.2
clc;
clear;

//given
n1=1.48;//Dimensionless refractive index of fiber
   core
n2=1.46;//Dimensionless refractive index of fiber
   cladding
Lambda0=1.5e-6;//Wavelength in m

//Let the maximum core radius in m for single mode
   operation be 'amax'
amax=2.405*Lambda0/(2*%pi*sqrt((n1^2)-(n2^2)));
mprintf("\n a < %.2f um",amax/1e-6);//Dividing by
   10^(-6) to convert into um
```

Scilab code Exa 8.9 9

```
//Optoelectronics - An Introduction, 2nd Edition by
   J. Wilson and J.F.B. Hawkes
//Example 8.9
//OS=Windows XP sp3
//Scilab version 5.5.2
clc;
clear;

//given - Case (i)
k=1.38e-23//boltzman constant
Lambda0=1e-6;//Wavelength in m
n=1.46;//Dimensionless refractive index of core
```

```
p=0.286;//photelastic coefficient
Beta=7e-11//isothermal compressibility at T_F which
    is fictive temperature in m^2N^-1
T_F=1400//fictive temperature in K
alpha_r=8*(%pi^3)*(n^8)*p^2*Beta*k*T_F/(3*Lambda0^4)
    //absorption coefficient in per Km
L=1e3//length in m
Loss=-10*log10(exp(-alpha_r*L))//loss in dB Km^-1
mprintf("\n absorption coefficient =%fx10^-4 m^-1\n
    Loss in dB Km^-1= %f dB Km^-1",alpha_r*1e4,Loss);
    //multiplication by 1e4 to just represent the
    answer in proper form
//The answers vary due to round off error

//given - Case (ii)
Lambda0=1550e-9;//Wavelength in m
n=1.46;//Dimensionless refractive index of core
p=0.286;//photelastic coefficient
Beta=7e-11//isothermal compressibility at T_F which
    is fictive temperature in m^2N^-1
T_F=1400//fictive temperature in K
alpha_r=8*(%pi^3)*(n^8)*p^2*Beta*k*T_F/(3*Lambda0^4)
    //absorption coefficient in per Km
L=1e3//length in m
Loss=-10*log10(exp(-alpha_r*L))//loss in dB Km^-1
mprintf("\n absorption coefficient =%fx10^-5 m^-1\n
    Loss in dB Km^-1= %f dB Km^-1",alpha_r*1e5,Loss);
    //multiplication by 1e5 to just represent the
    answer in proper form
//The answers vary due to round off error
```

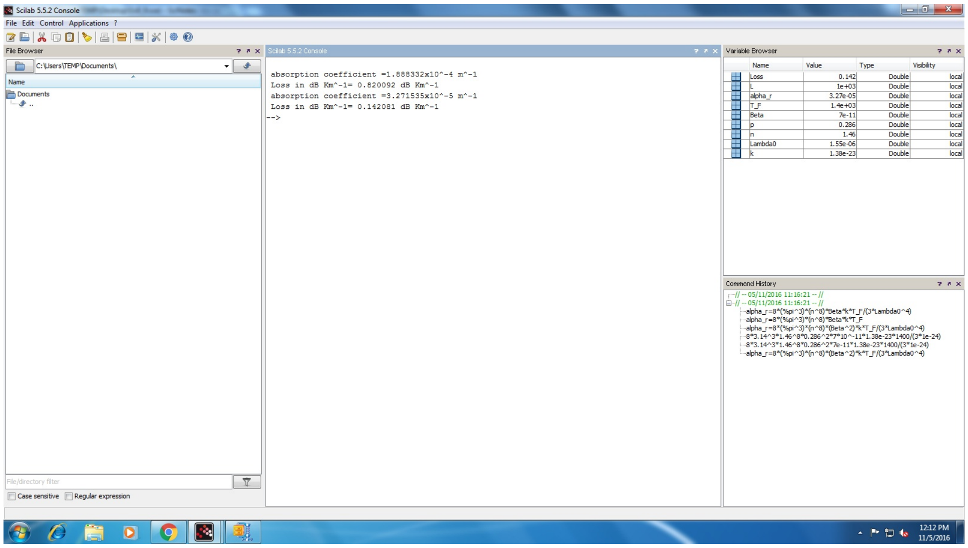


Figure 8.9: 9

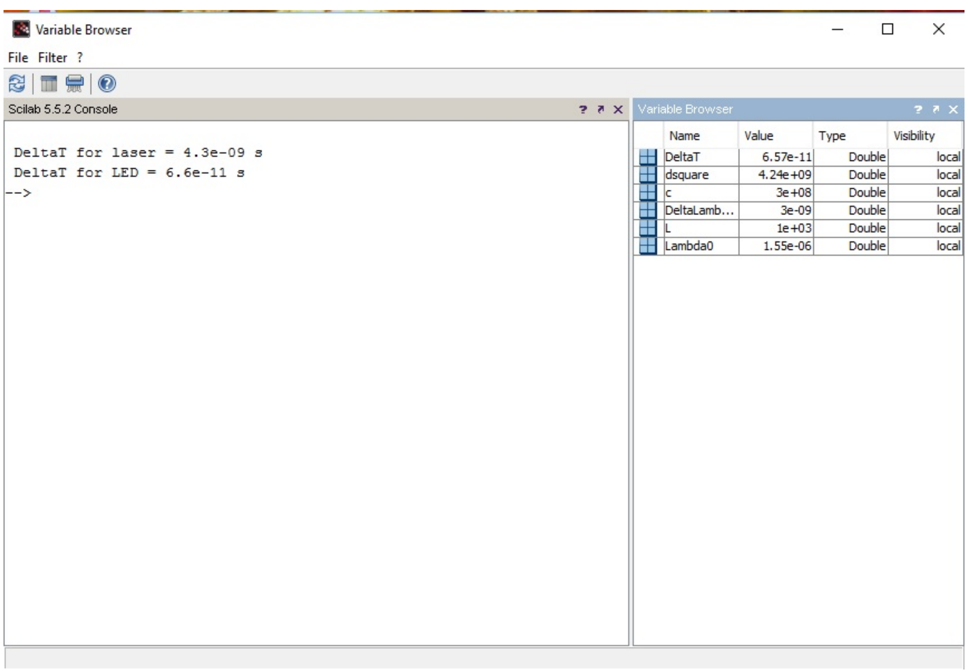


Figure 8.10: 10

Scilab code Exa 8.10 10

```
//Optoelectronics - An Introduction, 2nd Edition by
    J. Wilson and J.F.B. Hawkes
//Example 8.10
//OS=Windows XP sp3
//Scilab version 5.5.2
clc;
clear;

//given - Case (i)
Lambda0=850e-9;//Wavelength in m
L=1e3;//Length of the silica based fiber in m
DeltaLambda0=50e-9;//Linewidth of the fiber in m
c=3e8;//Speed of light in m/s
//Let the term '((d^2)n)/(dLambda0)^2' in m^-2 be
    denoted by dsquare
dsquare=3e10;

DeltaT=L*Lambda0*dsquare*DeltaLambda0/c;//Material
    dispersion for laser in s
mprintf("\n DeltaT for laser = %.1e s",DeltaT);//The
     answers vary due to round off error

//given - Case (ii)
Lambda0=1550e-9;//Wavelength in m
L=1e3;//Length of the silica based fiber in m
DeltaLambda0=3e-9;//Linewidth of the fiber in m
c=3e8;//Speed of light in m/s
//Let the term '((d^2)n)/(dLambda0)^2' in m^-2 be
    denoted by dsquare
dsquare=4.24e9;

DeltaT=L*Lambda0*dsquare*DeltaLambda0/c;//Material
    dispersion for LED in s
mprintf("\n DeltaT for LED = %.1e s",DeltaT);
```

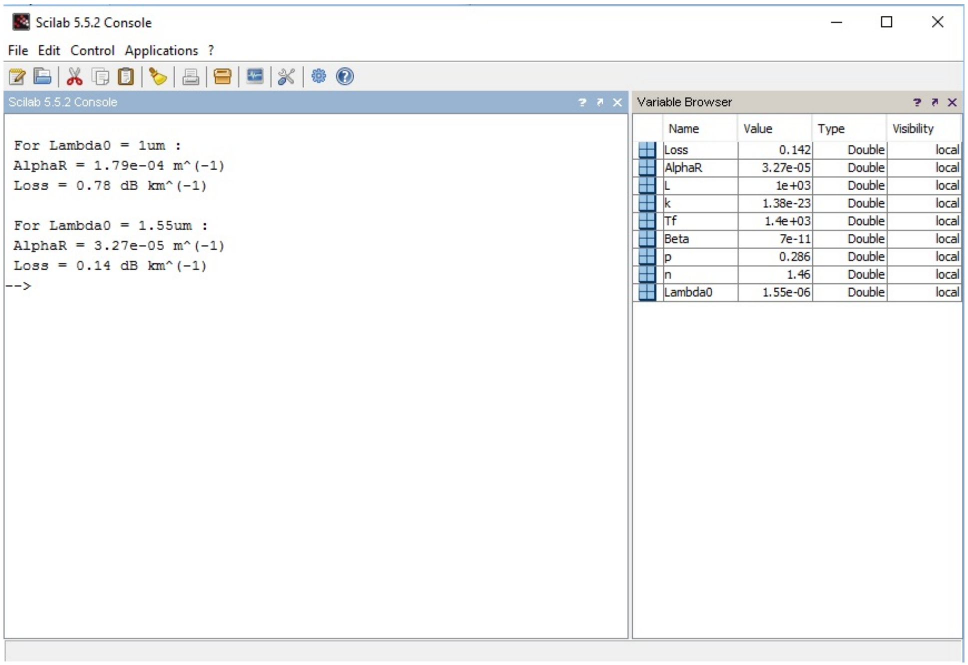


Figure 8.11: 11

Scilab code Exa 8.11 11

```
//Optoelectronics - An Introduction, 2nd Edition by
    J. Wilson and J.F.B. Hawkes
//Example 8.11
//OS=Windows XP sp3
//Scilab version 5.5.2
clc;
clear;

//given - Case(i)
Lambda0=1e-6;//Wavelength in m
```

```
n=1.45;//Dimensionless Refractive index of the fiber
p=0.286;//Dimensionless Photoelastic coefficient of the fiber
Beta=7e-11;//Isothermal compressibility of the fiber in m^2 N^-1
Tf=1400;//Temperature in K
k=1.38e-23;//Boltzmann constant in SI Units
L=1e3;//Length of fiber in m

mprintf("\n For Lambda0 = 1um :");
AlphaR=8*((%pi)^3)/(3*(Lambda0^4))*(n^8)*(p^2)*Beta*k*Tf;//Absorption coefficient due to Rayleigh scattering in m^-1
mprintf("\n AlphaR = %.2e m^(-1)",AlphaR);

Loss=-10*log10(exp(-AlphaR*L));
mprintf("\n Loss = %.2f dB km^(-1)\n",Loss);


//given - Case(ii)
Lambda0=1.55e-6;//Wavelength in m
n=1.46;//Dimensionless Refractive index of the fiber
p=0.286;//Dimensionless Photoelastic coefficient of the fiber
Beta=7e-11;//Isothermal compressibility of the fiber in m^2 N^-1
Tf=1400;//Temperature in K
L=1e3;//Length of fiber in m

mprintf("\n For Lambda0 = 1.55um :");
AlphaR=8*((%pi)^3)/(3*(Lambda0^4))*(n^8)*(p^2)*Beta*k*Tf;//Absorption coefficient due to Rayleigh scattering in m^-1
mprintf("\n AlphaR = %.2e m^(-1)",AlphaR);//The answers vary due to round off error

Loss=-10*log10(exp(-AlphaR*L));
mprintf("\n Loss = %.2f dB km^(-1)",Loss);//The
```

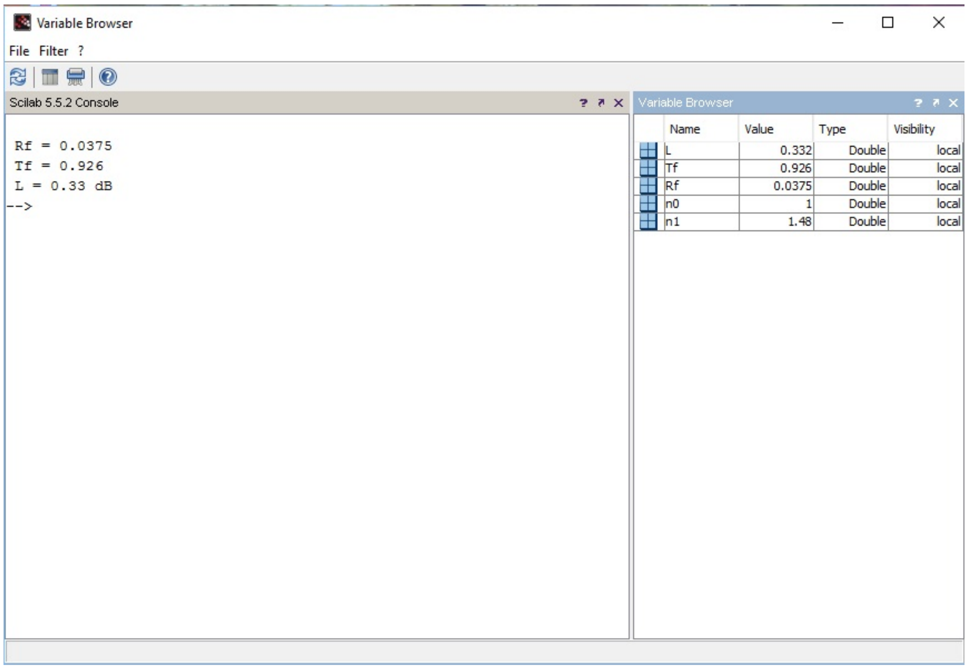


Figure 8.12: 12

```
answers vary due to round off error
```

Scilab code Exa 8.12 12

```
//Optoelectronics - An Introduction, 2nd Edition by
    J. Wilson and J.F.B. Hawkes
//Example 8.12
//OS=Windows XP sp3
//Scilab version 5.5.2
clc;
clear;

//given
```

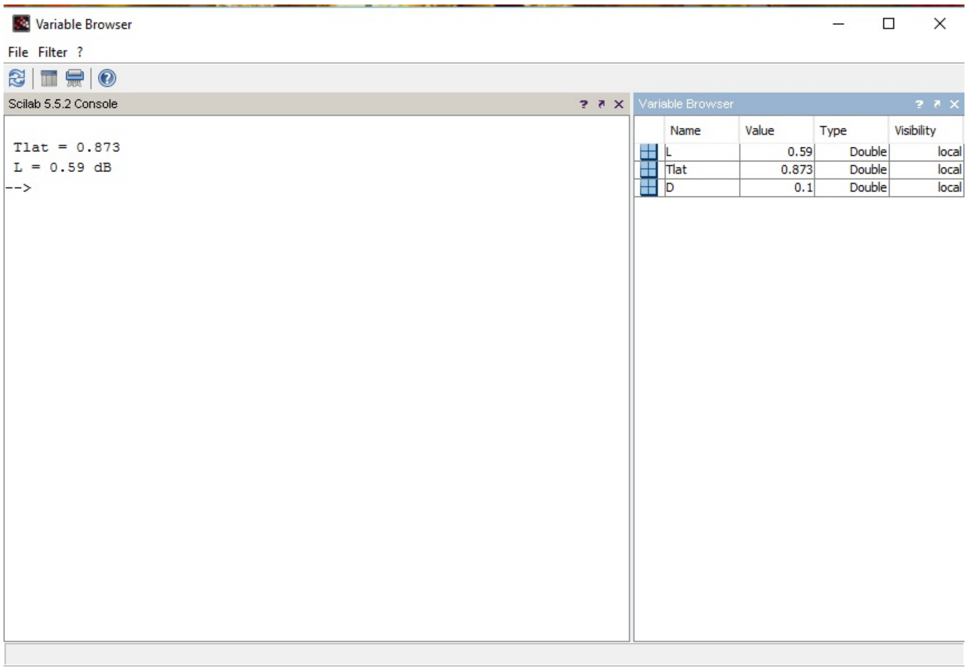


Figure 8.13: 13

```
n1=1.48;//Dimensionless refractive index of fiber
    core
n0=1;//Dimensionless refractive index of air

Rf=((n1-n0)/(n1+n0))^2;//Fraction of light reflected
     at each fiber end
mprintf("\n Rf = %.4f",Rf);

Tf=(1 - Rf)^2;
mprintf("\n Tf = %.3f",Tf);

L=-10*log10(Tf);//Corresponding total loss in dB
mprintf("\n L = %.2f dB",L);
```

Scilab code Exa 8.13 13

```
//Optoelectronics - An Introduction, 2nd Edition by J. Wilson and J.F.B. Hawkes
//Example 8.13
//OS=Windows XP sp3
//Scilab version 5.5.2
clc;
clear;

//given
//Let the quantity 'D/2a' be 'D'
D=0.1;//Dimensionless Ratio of lateral displacement to fiber core radius

Tlat=2/%pi*(acos(D) - D*sqrt(1 - D^2));//Transmission losses from misalignment
mprintf("\n Tlat = %.3f",Tlat);//The answers vary due to round off error

L=-10*log10(Tlat);//Corresponding Transmission loss in dB
mprintf("\n L = %.2f dB",L);
```

Scilab code Exa 8.14 14

```
//Optoelectronics - An Introduction, 2nd Edition by J. Wilson and J.F.B. Hawkes
//Example 8.14
//OS=Windows XP sp3
```

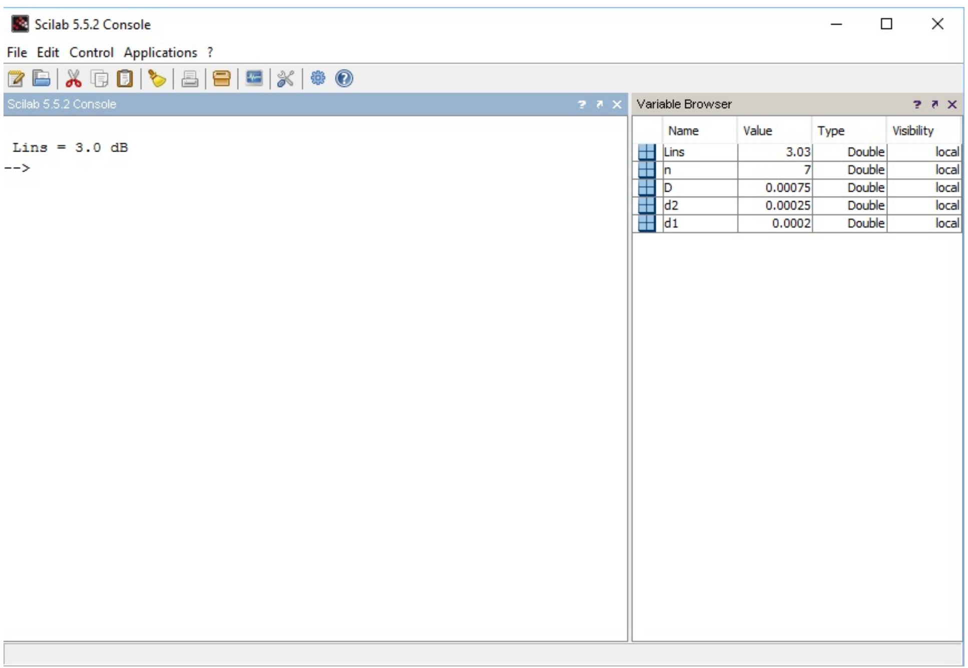


Figure 8.14: 14

```
//Scilab version 5.5.2
clc;
clear;

//given
d1=200e-6;//Diameter of core in m
d2=250e-6;//Diameter of 'core+cladding' in m
//Let the Diameter of mixing rod be D
D=3*d2;
n=7;//Number of input and output fibers in the rod
    type coupler

//As B is a constant, it will be cancelled from the
    numerator & the denominator of expression of Lins
//So the simplified expression for Li becomes:
Lins=-10*log10((n*%pi*(d1^2)/4)/(%pi*(D^2)/4));//
    Insertion loss in dB
mprintf("\n Lins = %.1f dB",Lins);
```

Chapter 9

Optical Communication syatems

Scilab code Exa 9.1 1

```
//Optoelectronics - An Introduction, 2nd Edition by
    J. Wilson and J.F.B. Hawkes
//Example 9.1
//OS=Windows XP sp3
//Scilab version 5.5.2
clc;
clear;

//given
eta=0.6;//Dimensionless Quantum Efficiency of
    photodiode
Lambda0=1.3e-6;//Wavelength in m
e=1.6e-19;//Electronic charge in C
P=10e-6;//Optical power in W
h=6.6e-34;//Planck's constant in SI Units
c=3e8;//Speed of light in m/s
iD=3e-9;//Reverse bias leakage current in A
```

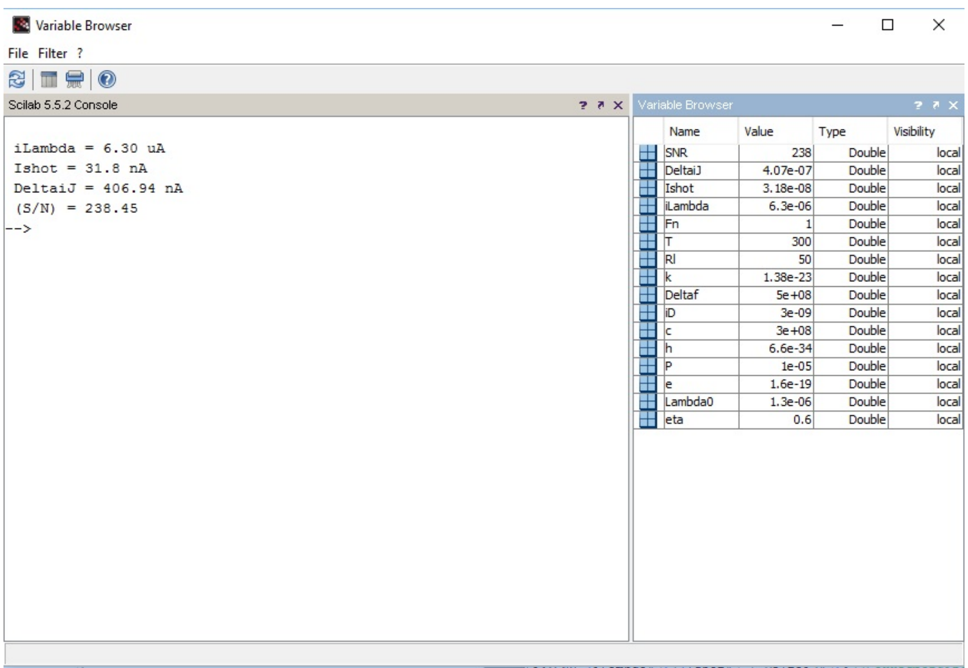

Variable Browser
File Filter ?
Scilab 5.5.2 Console
iLambda = 6.30 uA
Ishot = 31.8 nA
DeltaiJ = 406.94 nA
(S/N) = 238.45
-->
Variable Browser
Name Value Type Visibility
SNR 238 Double local
DeltaiJ 4.07e-07 Double local
Ishot 3.18e-08 Double local
iLambda 6.3e-06 Double local
Fn 1 Double local
T 300 Double local
Rl 50 Double local
k 1.38e-23 Double local
Deltaf 5e+08 Double local
iD 3e-09 Double local
c 3e+08 Double local
h 6.6e-34 Double local
P 1e-05 Double local
e 1.6e-19 Double local
Lambda0 1.3e-06 Double local
eta 0.6 Double local

Figure 9.1: 1

```
Deltaf=500e6;//Bandwidth of system in Hz
k=1.38e-23;//Boltzmann constant in SI Units
Rl=50;//Load resistor in Ohms
T=300;//Absolute temperature in K
Fn=1;//Assumption

iLambda=eta*P*e*Lambda0/(h*c);//Corresponding
    photogenerated current in A
mprintf("\n iLambda = %.2f uA",iLambda/1e-6);//
    Dividing by 10^(-6) to convert to uA
//The answers vary due to round off error

//Let the total shot noise be Ishot
Ishot=sqrt(2*(iLambda+iD)*e*Deltaf);
mprintf("\n Ishot = %.1f nA",Ishot/1e-9);//Dividing
    by 10^(-9) to convert to nA

DeltaiJ=sqrt(4*k*T*Fn*Rl*Deltaf)/Rl;//Corresponding
    Johnson noise in A
mprintf("\n DeltaiJ = %.2f nA",DeltaiJ/1e-9);//
    Dividing by 10^(-9) to convert to nA
//The answers vary due to round off error

SNR=(iLambda^2)/(Ishot^2 + DeltaiJ^2);//
    Corresponding Dimensionless Signal to Noise Ratio
mprintf("\n (S/N) = %.2f",SNR);//The answers vary
    due to round off error
```

Scilab code Exa 9.2 2

```
//Optoelectronics - An Introduction, 2nd Edition by
    J. Wilson and J.F.B. Hawkes
//Example 9.2
```

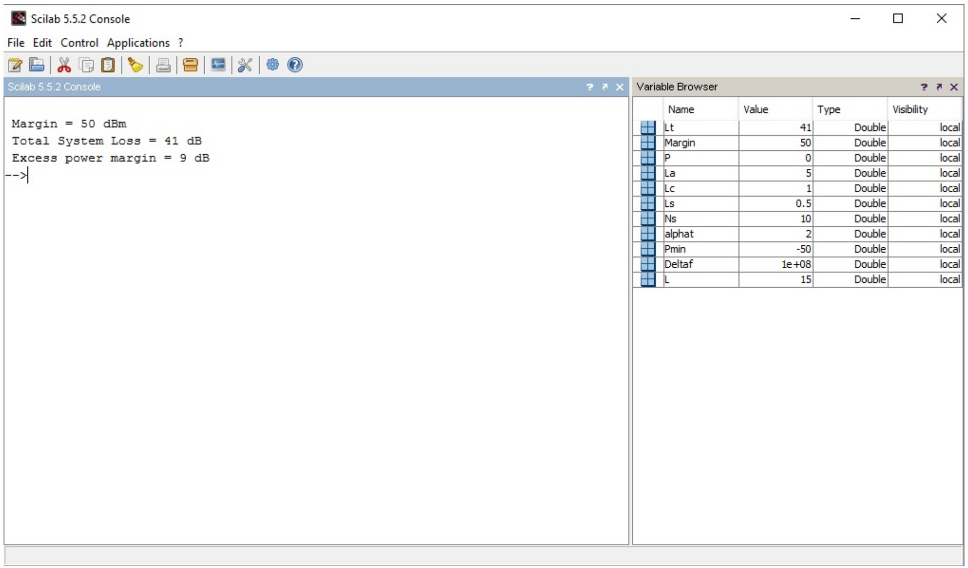


Figure 9.2: 2

```
//OS=Windows XP sp3
//Scilab version 5.5.2
clc;
clear;

//given
L=15;//Length of link in km
Deltaf=100e6;//Bandwidth in b/s
Pmin=-50;//Receiver sensitivity in dBm is the minimum power received by receiver
alphat=2;//Fiber transmission loss in dB/km
Ns=10;//Number of splices contributing to loss
Ls=0.5;//Loss of each splice in dB
Lc=1;//Detector coupling loss in dB
La=5;//Additional Losses due to various factors in dB;
//Let the transmitter launch power in dBm be 'P'
P=0;

Margin=P-Pmin;//Power Margin in dBm
```

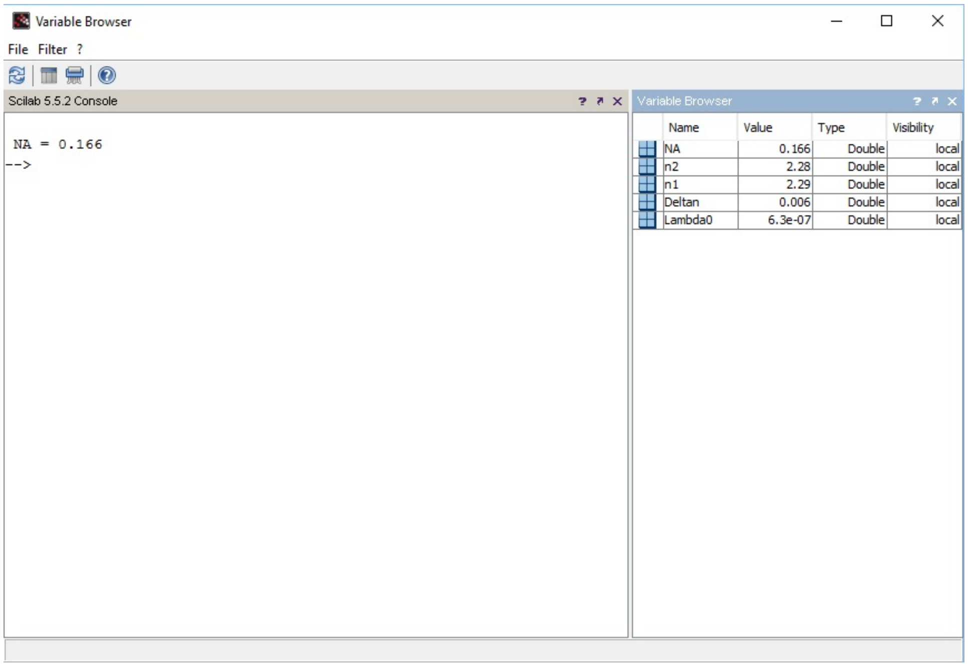


Figure 9.3: 3

```
mprintf("\n Margin = %d dBm",Margin);

//Let the total system loss in dB be 'Lt'
Lt=alphat*L+Lc+Ns*Ls+La;
mprintf("\n Total System Loss = %d dB",Lt);
mprintf("\n Excess power margin = %d dB",Margin-Lt);
    //Excess power margin in dB
```

Scilab code Exa 9.3 3

```
//Optoelectronics - An Introduction, 2nd Edition by
    J. Wilson and J.F.B. Hawkes
//Example 9.3
```

```
//OS=Windows XP sp3
//Scilab version 5.5.2
clc;
clear;

//given
Lambda0=0.63e-6;//Wavelength in m
Deltan=6e-3;//Dimensionless Change in refractive
    index of titanium
n1=2.286;//Ordinary dimensionless refractive index
    of Titanium

n2=n1-Deltan;//Changed dimensionless refractive
    index of titanium
NA=sqrt(n1^2 - n2^2);//Corresponding dimensionless
    numerical aperture
mprintf("\n NA = %.3f",NA);
```

Chapter 10

Noncommunications applications of fibers

Scilab code Exa 10.1 1

```
//Optoelectronics - An Introduction, 2nd Edition by
   J. Wilson and J.F.B. Hawkes
//Example 10.1
//OS=Windows XP sp3
//Scilab version 5.5.2
clc;
clear;

//given
d=50e-6;//Core diameter in m
a=d/2;//Core radius in m
n1=1.48;//Dimensionless maximum refractive index of
   the core
n2=1.46;//Dimensionless maximum refractive index of
   cladding

Delta=(n1-n2)/n1;
```

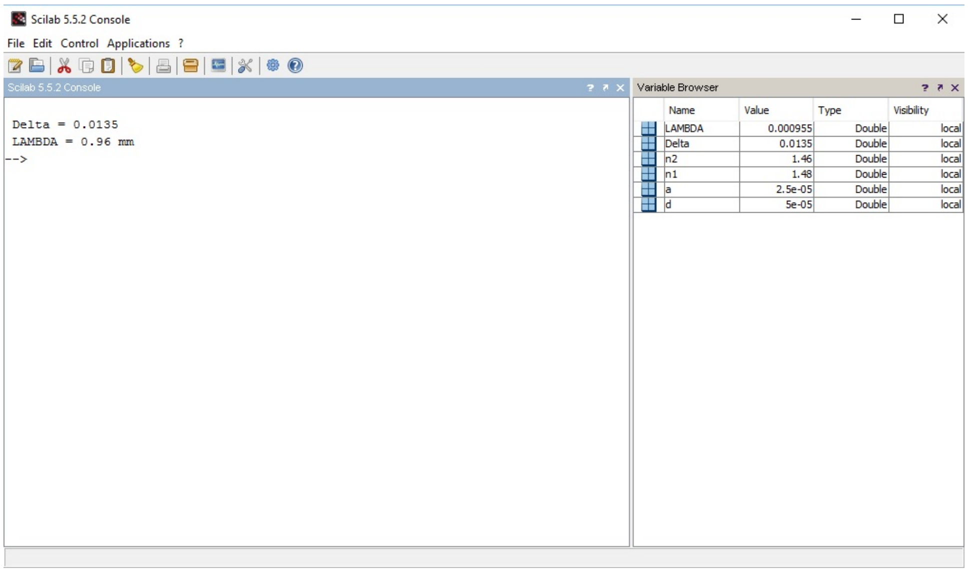


Figure 10.1: 1

```
mprintf("\n Delta = %.4f",Delta);

LAMBDA=2*%pi*a/sqrt(2*Delta);//Condition for
    coupling of all the modes together for a graded
    index fiber
mprintf("\n LAMBDA = %.2f mm",LAMBDA/1e-3);//
    Dividing by 10^(-3) to convert into mm
```

Scilab code Exa 10.2 2

```
//Optoelectronics - An Introduction, 2nd Edition by
    J. Wilson and J.F.B. Hawkes
//Example 10.2
//OS=Windows XP sp3
//Scilab version 5.5.2
```

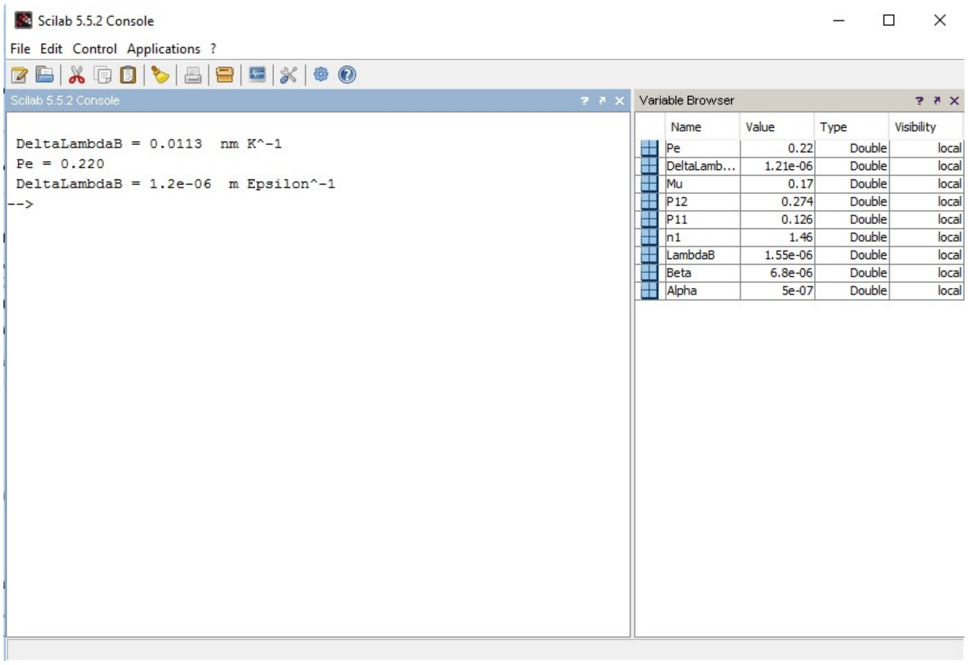


Figure 10.2: 2

```
clc;
clear;

//given
Alpha=5e-7;//Coefficient of expansion of pure silica
    in K^(-1)
Beta=6.8e-6;//Value for pure silica in K^(-1)
LambdaB=1.55e-6;//Wavelength in m
n1=1.46;//Dimensionless Refractive index of Silica
P11=0.126;//Value of 1st Pockels coefficient
P12=0.274;//Value of 2nd Pockels coefficient
Mu=0.17;//Poisson's ratio

DeltaLambdaB=LambdaB*(Alpha+Beta);//Wavelength
   sensitivity to temperature changes of the fiber
   in  m K^(-1)
mprintf("\n DeltaLambdaB = %.4f  nm K^-1",
```

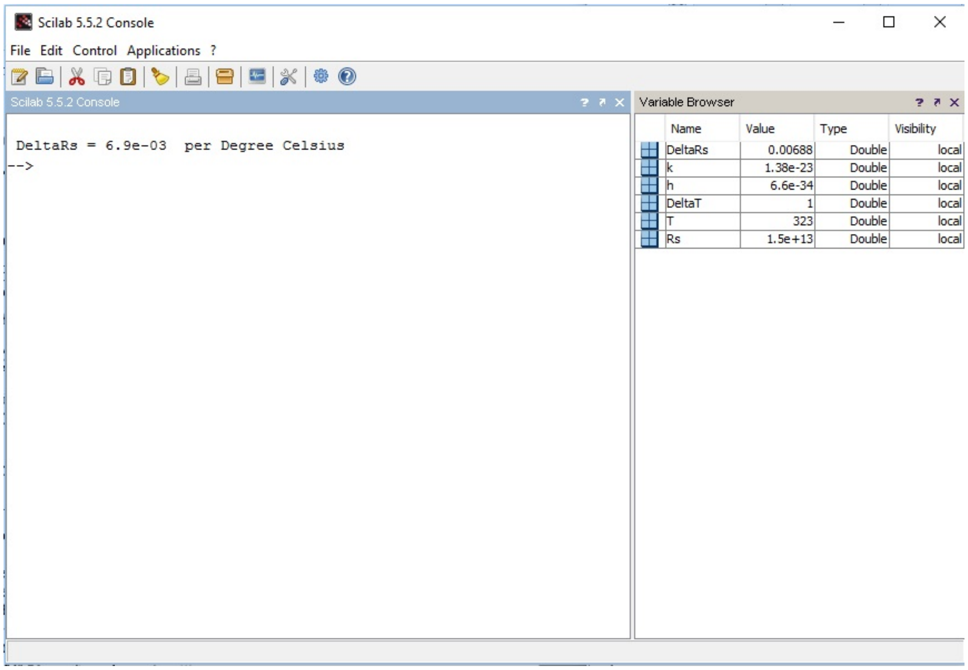


Figure 10.3: 3

```
    DeltaLambdaB/1e-9);//Dividing by 10^(-9) to
    convert to nm K^(-1)

Pe=(n1^2)/2*((1-Mu)*P12-Mu*P11);//Corresponding
    effective photoelastic coefficient
mprintf("\n Pe = %.3f",Pe);//The answers vary due to
     round off error

DeltaLambdaB=LambdaB*(1-Pe);//Wavelength sensitivity
     as far as sensitivity is concerned in  m Epsilon
    ^(-1)
mprintf("\n DeltaLambdaB = %.1e  m Epsilon^-1",
    DeltaLambdaB);
```

Scilab code Exa 10.3 3

```
//Optoelectronics - An Introduction, 2nd Edition by
    J. Wilson and J.F.B. Hawkes
//Example 10.3
//OS=Windows XP sp3
//Scilab version 5.5.2
clc;
clear;

//given
Rs=1.5e13;//Raman shift in Silica in Hz
T=323;//Absolute temperature in K
DeltaT=1;//Change in Temperature in Degree Celsius
    or K
h=6.6e-34;//Planck's constant in SI Units
k=1.38e-23;//Boltzmann constant in SI Units

DeltaRs=h*Rs*DeltaT/(k*(T^2));
mprintf("\n DeltaRs = %.1e  per Degree Celsius",
    DeltaRs);
```

Scilab code Exa 10.4 4

```
//Optoelectronics - An Introduction, 2nd Edition by
    J. Wilson and J.F.B. Hawkes
//Example 10.4
//OS=Windows XP sp3
//Scilab version 5.5.2
clc;
```

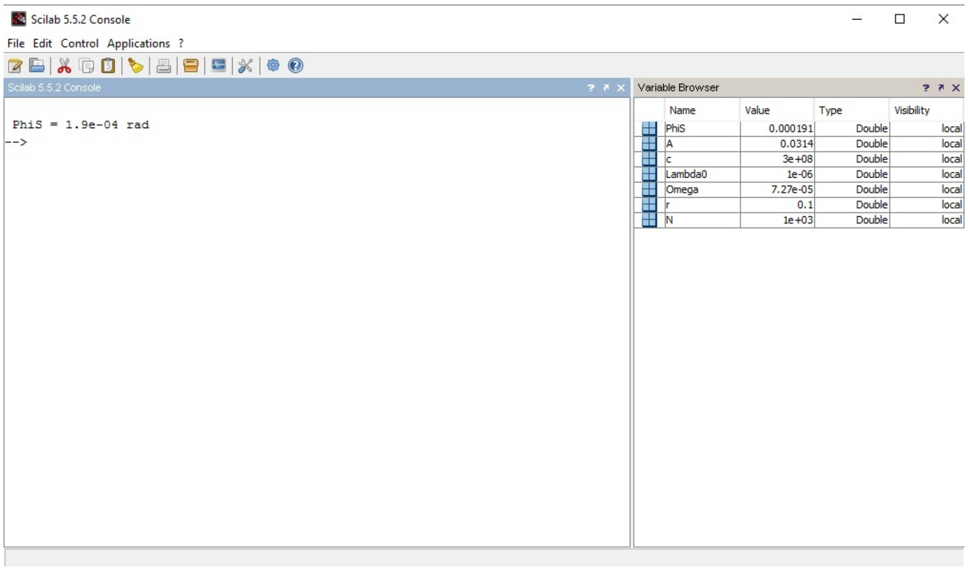


Figure 10.4: 4

```
clear;

//given
N=1000;//Number of turns of fiber
r=0.1;//Radius of fiber in m
Omega=15*%pi/(180*3600);//Multiplying by %pi/180 & Dividing by 3600 to convert the earth's rotation rate unit into rad/s
Lambda0=1e-6;//Wavelength of beam in m
c=3e8;//Speed of light in m/s

A=%pi*(r^2);//Area of the fiber ring in m^2
PhiS=8*%pi*Omega*A*N/(Lambda0*c);//Corresponding Phase shift in the beam in radians
mprintf("\n PhiS = %.1e rad",PhiS);
```

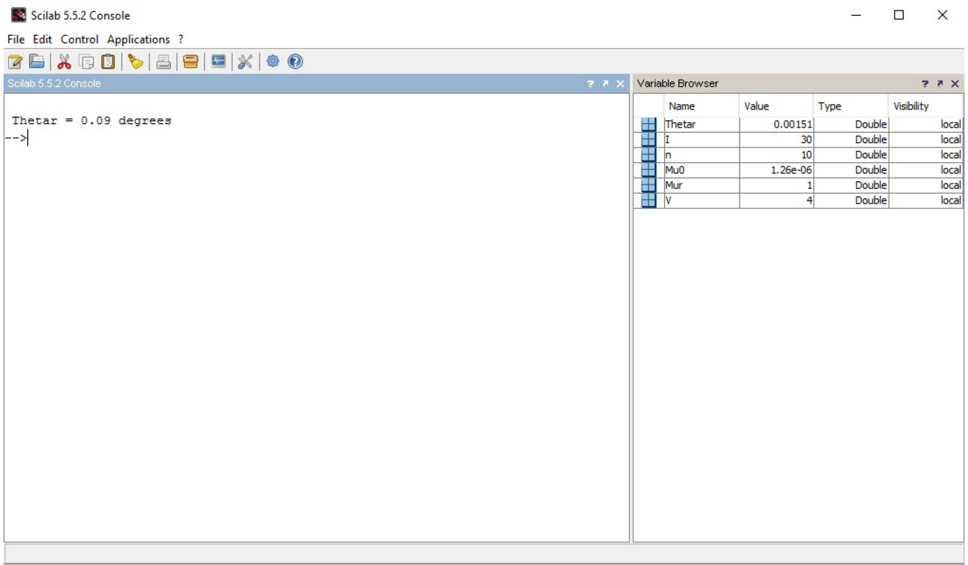


Figure 10.5: 5

Scilab code Exa 10.5 5

```
//Optoelectronics - An Introduction, 2nd Edition by
    J. Wilson and J.F.B. Hawkes
//Example 10.5
//OS=Windows XP sp3
//Scilab version 5.5.2
clc;
clear;

//given
V=4;//Value of Verdet constant in rad m^-1 T^-1
Mur=1;//Relative permeability of Silica
Mu0=4*%pi*1e-7;//Permeability of free space in SI
    Units
n=10;//Number of turns of the fiber coil
I=30;//Current flowing through the fiber in A

Thetar=Mu0*Mur*n*V*I;//Corresponding polarization
    rotation in radians
```

```
mprintf("\n Thetar = %.2f degrees",Thetar*180/%pi);
    //Multiplying by '180/%pi' to convert in degrees
```