Scilab Textbook Companion for Fundamentals Of Electronic Devices by J. B. Gupta[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

Chapter 1

Semiconductor materials and crystal properties

Scilab code Exa 1.3 Calculate Density of Copper Crystal

```scilab
1  //Exa 1.3
2  clc;
3  clear;
4  close;
5  //given data
6  r=1.278;//in Angstrum
7  AtomicWeight=63.5;//constant
8  AvogadroNo=6.023*10^23;//constant
9  //For FCC structure a=4*r/sqrt(2)
10 a=4*r*10^-10/sqrt(2);//in meter
11 V=a^3;//in meter^3
12 //mass of one atom = m
13 m=AtomicWeight/AvogadroNo;//in gm
14 m=m/1000;//in Kg
15 n=4;// no. of atoms per unit cell for FCC structure
16 rho=m*n/V;//in Kg/m^3
17 disp(rho,"Density of crystal in Kg/m^3: ");
```

Scilab code Exa 1.4 Obtain volume density of Si atoms

```
1  //Exa 1.4
2  clc;
3  clear;
4  close;
5  //given data
6  n=4;// no. of atoms per unit cell of silicon
7  AtomicWeight=28;//constant
8  AvogadroNo=6.021*10^23;//constant
9  m=AtomicWeight/AvogadroNo;//in gm
10 m=m/1000;//in Kg
11 a=5.3;//lattice constant in Angstrum
12 a=a*10^-10;//in meter
13 V=a^3;//in meter^3
14 rho=m*n/V;//in Kg/m^3
15 disp(rho,"Density of silicon crystal in Kg/m^3: ");
```

Scilab code Exa 1.5 Calculate surface density of atoms

```
1  //Exa 1.5
2  clc;
3  clear;
4  close;
5  //given data
6  a=4.75;//lattice constant in Angstrum
7  a=a*10^-10;//in meter
8  disp("Surface density in FCC on (111) Plane : dp =
      2.31/a^2");
9  dp=2.31/a^2;//in atom/m^2
10 dp=dp/10^6;//in atom/mm^2
```

```
11  disp(dp,"Surface density in FCC on (111)Plane in
       atoms/mm^2: ");
```

Scilab code Exa 1.6 Determine Interplanar Distance

```
1  //Exa 1.6
2  clc;
3  clear;
4  close;
5  //given data
6  lambda=1.539;//in Angstrum
7  theta=22.5;//in degree
8  n=1;//order unitless
9  d=n*lambda/(2*sin(theta*%pi/180));//in Angstrum
10  disp(d,"Interpolar distance in Angstrum : ")
```

Scilab code Exa 1.7 Determine Wavelength of X rays

```
1  //Exa 1.7
2  clc;
3  clear;
4  close;
5  //given data
6
7  theta=16.8/2;//in degree
8  n=2;//order unitless
9  d=0.4;//in nm
10  lambda=(2*d*sin(theta*%pi/180))/n;//in Angstrum
11  disp(lambda,"wavelength of X-rays in Angstrum : ");
12  //Note: Ans in the book is not correct
```

Chapter 2

Energy Bands and Charge Carriers in Semiconductor

Scilab code Exa 2.1 Calculate the velocity of electron at fermi level

```
1 //Exa 2.1
2 clc;
3 clear;
4 close;
5 //given data
6 E=2.1;//in eV
7 E=E*1.602*10^-19;//in Joule
8 m=9.107*10^-31;//in Kg
9 //Formula : E= (m*v^2)/2
10 v=sqrt(2*E/m);//in m/s
11 disp(v,"Velocity of electron at fermi level in m/s :
        ");
```

Scilab code Exa 2.2 Determine Drift Velocity of Electrons

```
1 //Exa 2.2
```

```
 2  clc ;
 3  clear ;
 4  close ;
 5  // given data
 6  J =2.4; // in A/mm^2
 7  J = J *10^6; // in A/m^2
 8  n =5*10^28; // electrons /m^3
 9  e =1.6*10^ -19; // constant
10  // Formula : J=e*n*v
11  v = J /( e * n ) ; // in m/s
12  disp ( v *10^3 ," Velocity of electron at fermi level in
         mm/s : ") ;
```

Scilab code Exa 2.3 Calculate magnitude of currrent

```
 1  // Exa 2.3
 2  clc ;
 3  clear ;
 4  close ;
 5  // given data
 6  n =10^24; // electrons /m^3
 7  e =1.6*10^ -19; // constant
 8  v =1.5*10^ -2; // in m/s
 9  A =1; // in cm^2
10  A =1*10^ -4; // in m^2
11  I = e * n * v * A ; // in Ampere
12  disp ( I ," Magnitude of current in Ampere : ") ;
```

Scilab code Exa 2.4 Find electron and hole densities

```
 1  // Exa 2.4
 2  clc ;
 3  clear ;
```

```
 4 close;
 5 //given data
 6 ni=2.5*10^13;//in atoms/cm^3
 7 rho=0.039;//in ohm-cm
 8 SIGMAn=1/rho;//in (ohm-cm)^-1
 9 e=1.6*10^-19;//constant
10 MUe=3600;//in cm^2/V-s
11 //formula : SIGMAn=n*e*MUe=Nd*e*MUe
12 Nd=SIGMAn/(e*MUe);//in atoms/cm^3
13 n=Nd;//in atoms/cm^3
14 p=ni^2/n;//in atoms/cm^3
15 disp(n,"Electron density in atoms/cm^3 : ");
16 disp(p,"Hole density in atoms/cm^3 : ");
```

Scilab code Exa 2.5 Calculate concentrations in semiconductor

```
 1 //Exa 2.5
 2 clc;
 3 clear;
 4 close;
 5 //given data
 6 DonorImpurity=1/10^6;;//impurity per atom
 7 SiAtomCon=5*10^22;//in cm^-3
 8 ni=1.45*10^10;//in cm^-3
 9 MUe=1300;//in cm^2/V-s
10 e=1.6*10^-19;//constant
11 //part (i)
12 Nd=SiAtomCon*DonorImpurity;//in cm^-3
13 disp(Nd,"Donor atom concentration in cm^-3 : ");
14 //part (ii)
15 n=Nd;//in cm^-3
16 disp(n,"Mobile electron concentration in cm^-3: ");
17 //part (iii)
18 p=ni^2/Nd;//in cm^-3
19 disp(p,"Hole concentration in cm^-3 : ");
```

```
20 //part (iv)
21 SIGMA=n*e*MUe; //in (ohm–cm)^-1
22 disp(SIGMA,"Conductivity of doped silicon sample in
      (ohm–cm)^-1 : ");
23 //part (v)
24 rho=1/SIGMA; //in ohm–cm
25 l=0.5; //in cm
26 A=(50*10^-4)^2; //in cm^2
27 R=rho*l/A; //in ohm
28 disp(rho,"Resistivity in ohm–cm : ");
29 disp(R,"Resistance in ohm : ")
```

Scilab code Exa 2.6 Find ratio of electron to hole concentration

```
1 //Exa 2.6
2 clc;
3 clear;
4 close;
5 //given data
6 ni=1.4*10^18; //in atoms/m^3
7 Nd=1.4*10^24; //in atoms/m^3
8 n=Nd; //in atoms/m^3
9 p=ni^2/n; //in atoms/m^3
10 ratio=n/p; //unitless
11 disp(p,"Concentration of holes in per m^3 : ");
12 disp(ratio,"Ratio of electron to hole concentration
      : ");
```

Scilab code Exa 2.7 Calculate relaxation time resistivity and velocity of electron

```
1 //Exa 2.7
2 clc;
```

```
3 clear;
4 close;
5 //given data
6 Ef=5.5;//in eV
7 MUe=7.04*10^-3;//in m^2/V-s
8 n=5.8*10^28;//in m^-3
9 e=1.6*10^-19;//constant
10 m=9.1*10^-31;//in Kg
11 //part (i)
12 tau=MUe*m/e;//in sec
13 disp(tau,"Relaxation time in sec : ");
14 rho=1/(n*e*MUe);//in ohm-m
15 disp(rho,"Resistivity of conductor in ohm-m : ")
16 vF=sqrt(2*Ef*1.6*10^-19/m);
17 disp(vF,"velocity of electron with fermi energy in m
      /s : ");
```

Scilab code Exa 2.8 Find conductivity and resistivity

```
1 //Exa 2.8
2 clc;
3 clear;
4 close;
5 //given data
6 ni=2.5*10^13;//in cm^-3
7 e=1.6*10^-19;//in coulamb
8 MUh=1800;//in cm^2/V-s
9 MUe=3800;//in cm^2/V-s
10 SIGMAi=ni*e*(MUe+MUh);//in (ohm-cm)^-1
11 RHOi=1/SIGMAi;//in ohm-cm
12 disp(SIGMAi,"Intrinsic conductivity in (ohm-cm)^-1 :
      ");
13 disp(RHOi,"Intrinsic resistivity in ohm-cm : ");
```

Scilab code Exa 2.9 Calculate density of electron

```
1  //Exa 2.9
2  clc;
3  clear;
4  close;
5  //given data
6  SIGMAi=2.12766;//in S/m
7  RHOi=0.47;//in ohm-m
8  MUh=0.19;//in m^2/V-s
9  MUe=0.39;//in m^2/V-s
10 e=1.6*10^-19;//in coulamb
11 //Formula : SIGMAi=ni*e*(MUe+MUh)
12 ni=SIGMAi/(e*(MUe+MUh));//in m^-3
13 E=10^4;//in V/m
14 vn=MUe*E;//in m/s
15 vh=MUh*E;//in m/s
16 disp(ni,"Density of electron in intrinsic material
       in m^-3 : ");
17 disp(vn,"Drift velocity for electrons in m/s : ");
18 disp(vh,"Drift velocity for holes in m/s : ");
```

Scilab code Exa 2.10 Find conductivity of Si

```
1  //Exa 2.10
2  clc;
3  clear;
4  close;
5  //given data
6  ni=1.5*10^10;//in cm^-3
7  e=1.6*10^-19;//in coulamb
8  MUh=450;//in cm^2/V-s
```

```
9  MUe=1300;//in cm^2/V-s
10 SIGMAi=ni*e*(MUe+MUh);//in (ohm-cm)^-1
11 disp(SIGMAi,"Conductivity of silicon(intrinsic) in (
      ohm-cm)^-1 ");
12 Na=10^18;//in cm^-1
13 SIGMAp=e*Na*MUh;//in (ohm-cm)^-1
14 disp(SIGMAp,"Conductivity of resulting P-type si
      semiconductor in (ohm-cm)^-1 : ");
```

Scilab code Exa 2.11 Find conductivity of intrinsic Ge

```
1  //Exa 2.11
2  clc;
3  clear;
4  close;
5  //given data
6  ni=2.5*10^13;//in cm^-3
7  e=1.6*10^-19;//in coulamb
8  MUh=1800;//in cm^2/V-s
9  MUe=3800;//in cm^2/V-s
10 SIGMAi=ni*e*(MUe+MUh);//in (ohm-cm)^-1
11 GeAtoms=4.41*10^22;//in cm^-1
12 DonorImpurity=1/10^7;//in per Ge Atom
13 Nd=4.41*10^22*DonorImpurity;//in cm^-1
14 n=Nd;//in cm^-1
15 p=ni^2/Nd;//in cm^-3
16 SIGMAn=e*Nd*MUe;//in (ohm-cm)^-1
17 disp(SIGMAi,"Conductivity of Ge(intrinsic) in (ohm-
      cm)^-1 ");
18 disp(SIGMAn,"Conductivity of resulting N-type Ge
      semiconductor in (ohm-cm)^-1 : ");
```

Scilab code Exa 2.12 Find drift velocity of electron and hole Conductivity and current

```
1  //Exa 2.12
2  clc;
3  clear;
4  close;
5  //given data
6  e=1.6*10^-19;//in coulamb
7  MUh=0.18;//in m^2/V-s
8  MUe=0.38;//in m^2/V-s
9  V=10;//in Volts
10 l=25;//in mm
11 w=4;//in mm
12 t=1.5;//in mm
13 E=V/(l*10^-3);//in
14 //part (i)
15 ve=MUe*E;//in m/s
16 vh=MUh*E;//in m/s
17 disp(ve,"Drift velocity for electrons in m/s : ");
18 disp(vh,"Drift velocity for holes in m/s : ");
19
20 ni=2.5*10^19;//in m^-3
21 //part (ii)
22 SIGMAi=ni*e*(MUe+MUh);//in (ohm-m)^-1
23 disp(SIGMAi,"Conductivity of Ge(intrinsic) in (ohm-m
       )^-1 ");
24 //part (iii)
25 I=SIGMAi*E*w*10^-3*t*10^-3;//in Ampere
26 disp(I*10^3,"Total current in mili ampere : ");
```

Scilab code Exa 2.13 Find diffusion coefficient of electron and hole

```
1  //Exa 2.13
2  clc;
```

```
3  clear;
4  close;
5  //given data
6  e=1.6*10^-19;//in coulamb
7  T=300;//in Kelvin
8  MUh=1700;//in cm^2/V-s
9  MUe=3600;//in cm^2/V-s
10 k=1.38*10^-23;//in J/K
11 De=MUe*k*T/e;//in cm^2/s
12 Dh=MUh*k*T/e;//in cm^2/s
13 disp(De,"Diffusion constant of electron(in cm^2/s) :
      ");
14 disp(Dh,"Diffusion constant of hole(in cm^2/s) : ");
```

Scilab code Exa 2.14 Find mobility and density of charge carriers

```
1  //Exa 2.14
2  clc;
3  clear;
4  close;
5  //given data
6  e=1.6*10^-19;//in coulamb
7  resistivity=9*10^-3;//in ohm-m
8  RH=3.6*10^-4;//in m^3-coulamb^-1
9  SIGMA=1/resistivity;//in (ohm-m)^-1
10 rho=1/RH;//in cooulamb/m^3
11 n=rho/e;//in m^-3
12 disp(n,"Density of charge carriers in m^-3 : ");
13 MU=SIGMA*RH;//in m^2/V-s
14 disp(MU,"Mobility in m^2/V-s : ");
```

Scilab code Exa 2.15 Determine current density

```
1  //Exa  2.15
2  clc;
3  clear;
4  close;
5  //given  data
6  e=1.6*10^-19;//in  coulamb
7  E=100;//in  V/m
8  RH=0.0145;//in  m^3-coulamb^-1
9  MUn=0.36;//in  m^2/V-s
10 J=MUn*E/RH;//in  A/m^2
11 disp(J,"Current  density  in  A/m^2  :  ");
```

Scilab code Exa 2.16 Calculate Hall coefficients

```
1  //Exa  2.16
2  clc;
3  clear;
4  close;
5  //given  data
6  e=1.6*10^-19;//in  coulamb
7  n=2.05*10^22;//in  m^-3
8  RH=1/(n*e);//in  m^3-coulamb^-1
9  disp(RH,"Hall  coefficient  in  m^3-coulamb^-1  :  ");
```

Scilab code Exa 2.17 Find magnitude of hall voltage

```
1  //Exa  2.17
2  clc;
3  clear;
4  close;
5  //given  data
6  e=1.6*10^-19;//in  coulamb
7  ND=10^17;//in  cm^-3
```

```
8  Bz=0.1; //in Wb/m^2
9  w=4; //in mm
10 d=4; //in mm
11 Ex=5; //in V/cm
12 MUe=3800; //in cm^2/V-s
13 v=MUe*Ex; //in cm/s
14 v=v*10^-2; //in m/s
15 VH=Bz*v*d; //in mV
16 disp(VH,"Magnitude of hall voltage in mV : ");
```

Scilab code Exa 2.18 Determine mobility of holes

```
1  //Exa 2.18
2  clc;
3  clear;
4  close;
5  //given data
6  e=1.6*10^-19; //in coulamb
7  w=3; //in mm
8  d=3; //in mm
9  rho=200; //in Kohm-cm
10 rho=rho*10^3*10^-2; //in ohm-m
11 VH=50; //in mV
12 VH=VH*10^-3; //in Volts
13 I=10; //in uA
14 I=I*10^-6; //in Ampere
15 Bz=0.1; //in Wb/m^2
16 RH=VH*w*10^-3/(Bz*I)
17 MUh=RH/rho; //in m^2/V-s
18 disp(MUh,"Mobility of holes in p-type Si bar in m^2/
       V-s : ");
```

Scilab code Exa 2.19 Determine Hall Voltage

```
1  //Exa 2.19
2  clc;
3  clear;
4  close;
5  //given data
6  e=1.6*10^-19;//in coulamb
7  ND=10^21;//in m^-3
8  Bz=0.2;//in T
9  d=4;//in mm
10 d=d*10^-3;//in meter
11 J=600;//in A/m^2
12 n=ND;//in m^-3
13 //formula : VH*w/(B*I)=1/(n*e)
14 VH=Bz*J*d/(n*e);//in V
15 disp(VH*10^3,"Magnitude of hall voltage in mV : ");
```

Scilab code Exa 2.20 Calculate Hall angle

```
1  //Exa 2.20
2  clc;
3  clear;
4  close;
5  //given data
6  e=1.6*10^-19;//in coulamb
7  rho=0.00912;//in ohm-m
8  B=0.48;//in Wb/m^2
9  RH=3.55*10^-4;//in m^3-coulamb^-1
10 SIGMA=1/rho;//in (ohm-m)^-1
11 THETAh=atand(SIGMA*B*RH);//in Degree
12 disp(THETAh,"Hall angle in degree : ");
```

Chapter 3

Excess Carriers in Semiconductors

Scilab code Exa 3.2 Find minimum Energy

```
1  //Exa  3.2
2  clc ;
3  clear ;
4  close ;
5  //given  data
6  lambda =6000; //in  Angstrum
7  h=6.6*10^(-34); //Planks  constant
8  c=3*10^8; //speed  of  light  in  m/s
9  e=1.602*10^(-19); //Constant
10 phi=c*h/(e*lambda*10^(-10));
11 disp (phi ,"Minimum  required  energy  in  eV  is  :");
12 //Note  :  Ans  in  the  book  is  n ot  correct
```

Scilab code Exa 3.3 Calculate work function

```
1  //Exa  3.3
```

```
 2  clc;
 3  clear;
 4  close;
 5  //given data
 6  Emax=2.5;//maximum energy of emitted electrons in eV
 7  lambda=2537;//in Angstrum
 8  EeV=12400/lambda;//in eV
 9  disp(EeV,"The eV equivalent of the energy of
        incident photon : ");
10  phi=EeV-Emax;//in eV
11  disp(phi,"Work function of the cathode material is "
        );
```

Scilab code Exa 3.4 Determine power absorbed and rate of excess thermal energy

```
 1  //Exa 3.4
 2  clc;
 3  clear;
 4  close;
 5  //given data
 6  t=0.46*10^-6;//in meters
 7  hf=2;//in ev
 8  Pin=10;//in mW
 9  alpha=50000;// in per cm
10  e=1.6*10^-19;//constant
11  Io=10^-2;//in mW
12  It=Io*e^(-alpha*t);//in mW
13  //Part (i)
14  disp("Thus power absorbed = 10-1 = 9 mW or 0.009 J/s
        ");
15  disp((2-1.43)/2,"The fraction of each photon energy
        unit which is converted into heat");
16  //Part (ii)
17  disp(((2-1.43)/2)*0.009,"Energy converted into heat
```

```
        in  J/s : " ) ;
18  // Part  ( i i i )
19  disp (0.009/( e *2) ," Number  of  photons  per  second  given
        off  from  recombination  events  : " ) ;
```

Scilab code Exa 3.5 Determine electron transit time and photoconductor gain

```
1  // Exa  3 . 5
2  clc ;
3  clear ;
4  close ;
5  // given  data
6  L =100; // in  uM
7  A =10& -7; // in  cm ^2
8  th =10^ -6; // in  sec
9  V =12; // in  Volts
10 ue =0.13; // in  m ^2/V−s
11 uh =0.05; // in  m ^2/V−s
12 E = V /( L *10^ -6) ; // in  V/m
13 tn =( L *10^ -6) /( ue * E ) ;
14 disp ( tn ," Electron  transit  time  in  sec  is  " ) ;
15 Gain =(1+ uh / ue ) *( th / tn ) ;
16 disp ( Gain ," Photoconductor  gain  is  " ) ;
```

Scilab code Exa 3.6 Determine current through diode

```
1  // Exa  3 . 6
2  clc ;
3  clear ;
4  close ;
5  // given  datex
6  Io =0.15; // in  uA
```

```
7  V =0.12; //in mVolt
8  Vt =26; //in mVolt
9  I = Io *10^ -6*( exp (V /( Vt *10^ -3) ) -1) ; //in A
10 disp ( I *10^6 ,"Current flowing through diode in uA is
       ");
```

Scilab code Exa 3.7 Find forward voltage

```
1  //Exa 3.7
2  clc ;
3  clear ;
4  close ;
5  //given data
6  Io =2.5; //in uA
7  I =10; //in mA
8  Vt =26; //in mVolt
9  n =2; //for silicon
10 V = n * Vt *10^ -3* log (( I *10^ -3) /( Io *10^ -6) )
11 disp (V ,"Forward voltage in volts is ");
```

Scilab code Exa 3.8 Find reverse saturation current density

```
1  //Exa 3.8
2  clc ;
3  clear ;
4  close ;
5  //given data
6  ND =10^21; //in m^-3
7  NA =10^22; //in m^-3
8  De =3.4*10^ -3; //in m^2-s^-1
9  Dh =1.2*10^ -3; //in m^2-s^-1
10 Le =7.1*10^ -4; //in meters
11 Lh =3.5*10^ -4; //in meters
```

```
12  ni =1.6*10^16; //in m^-3
13  e =1.602*10^-19; // constant
14  IoA = e * ni^2*(Dh/(Lh*ND)+De/(Le*NA));
15  disp (IoA *10^6 ,"Reverse saturation current density in
        uA/m2 is ")
```

Chapter 4

Junction Properties

Scilab code Exa 4.2 Calculate electron and hole concentration at thermal equilibrium

```
1  //Exa4.2
2  clc;
3  clear;
4  close;
5  //given data
6  T=300;//in Kelvin
7  ND=10^16;//in cm^-3
8  NA=0;//in cm^-3
9  ni=1.5*10^10;//in cm^-3
10 no=ND/2+sqrt((ND/2)^2+ni^2);//in cm^-3
11 po=ni^2/no;//in cm^-3
12 disp(no,"Majority carrier electron concentration in
      cm^-3 : ");
13 disp(po,"Minority carrier hole concentration in cm
      ^-3 : ");
```

Scilab code Exa 4.3 Calculate electron and hole concentration at thermal equilibrium

```
1  //Exa4.3
2  clc;
3  clear;
4  close;
5  //given data
6  T=300;//in Kelvin
7  ND=3*10^15;//in cm^-3
8  NA=10^16;//in cm^-3
9  ni=1.6*10^10;//in cm^-3
10 po=(NA-ND)/2+sqrt(((NA-ND)/2)^2+ni^2);//in cm^-3
11 no=ni^2/po;//in cm^-3
12 disp(po,"Majority carrier hole concentration in cm
       ^-3 : ");
13 disp(no,"Minority carrier electron concentration in
       cm^-3 : ");
```

Scilab code Exa 4.4 determine built in potential barrier

```
1  //Exa4.4
2  clc;
3  clear;
4  close;
5  //given data
6  T=300;//in Kelvin
7  ND=10^15;//in cm^-3
8  NA=10^18;//in cm^-3
9  ni=1.5*10^10;//in cm^-3
10 VT=T/11600;//in Volts
11 Vbi=VT*log(NA*ND/ni^2);//in Volts
12 disp(Vbi,"Built in potential barrier in volts : ");
```

Scilab code Exa 4.5 Obtain value of contact potential

```
1  //Exa4.5
2  clc;
3  clear;
4  close;
5  //given data
6  T=300;//in Kelvin
7  ND=10^21;//in m^-3
8  NA=10^21;//in m^-3
9  ni=1.5*10^16;//in m^-3
10 VT=T/11600;//in Volts
11 Vo=VT*log(NA*ND/ni^2);//in Volts
12 disp(Vo,"Contact p;otential in volts : ");
```

Scilab code Exa 4.6 Determine space charge width and electric field

```
1  //Exa4.6
2  clc;
3  clear;
4  close;
5  //given data
6  T=300;//in Kelvin
7  ND=10^15;//in cm^-3
8  NA=10^16;//in cm^-3
9  ni=1.5*10^10;//in cm^-3
10 VT=T/11600;//in Volts
11 e=1.6*10^-19;//in Coulamb
12 epsilon=11.7*8.854*10^-14;//constant
13 Vbi=VT*log(NA*ND/ni^2);//in Volts
14 SCW=sqrt((2*epsilon*Vbi/e)*(NA+ND)/(NA*ND));//in cm
15 SCW=SCW*10^4;//in uMeter
16 disp(SCW,"Space charge width in uMeters : ");
17 xn=0.864;//in uM
18 xp=0.086;//in uM
19 Emax=-e*ND*xn/epsilon;//in V/cm
20 disp(Emax,"At metallurgical junction , i.e for x=0
```

```
        the electric field is peak i.e. Emax in volts : "
        );
21  //Note : Ans in the book is wrong
```

Scilab code Exa 4.7 Obtain value of contact potential

```
1  //Exa4.7
2  clc;
3  clear;
4  close;
5  //given data
6  T=300;//in Kelvin
7  ND=10^21;//in m^-3
8  NA=10^21;//in m^-3
9  ni=1.5*10^16;//in m^-3
10  VT=T/11600;//in Volts
11  Vo=VT*log(NA*ND/ni^2);//in Volts
12  disp(Vo,"Contact potential in volts : ");
```

Scilab code Exa 4.8 Calculate height of potential barrier

```
1  //Exa4.8
2  clc;
3  clear;
4  close;
5  //given data
6  T=300;//in Kelvin
7  ND=8*10^14;//in cm^-3
8  NA=8*10^14;//in cm^-3
9  ni=2*10^13;//in cm^-3
10  k=8.61*10^-5;//in eV/K
11  Vo=k*T*log(NA*ND/ni^2);//in Volts
12  disp(Vo,"Contact potential in volts : ");
```

Scilab code Exa 4.9 Find current in the circuit

```
1 //Exa4.9
2 clc;
3 clear;
4 close;
5 //In given circuit :
6 V=5;//in volts
7 Vo=0.7;//in Volts
8 R=100;//in Kohm
9 disp("Since diode is silicon one, and the barrier
      potential for Si diode is 0.7 volt, Vo = 0.7
      volts ");
10 disp("This barrier potential acts in opposite
      direction to the applied voltage. The diode
      forward resistance is being assumed to be zero.")
      ;
11 I=(V-Vo)/R;//in Ampere
12 disp(I*1000,"Current flowing through the circuit in
      Amperes :")
```

Scilab code Exa 4.10 Determine voltage VA in the circuit

```
1 //Exa4.10
2 clc;
3 clear;
4 close;
5 //In given circuit :
6 V=15;//in volts
7 Vo=0.7;//in Volts
8 R=7;//in Kohm
```

```
 9  I=(V-2*Vo)/R
10  disp("Since diode is silicon one, and the barrier
        potential for Si diode is 0.7 volt, Vo = 0.7
        volts ");
11  disp("This barrier potential acts in opposite
        direction to the applied voltage. The diode
        forward resistance is being assumed to be zero.")
        ;
12  I=(V-2*Vo)/R;//in mAmpere
13  disp("Barrier potential of Si diode, Vo = 0.7 Volts"
        );
14  disp("Potential VA = Voltage drop across 7 Kohm
        resistor");
15  VA=I*R;//in Volts
16  disp(VA,"Voltagee VA in volts : ");
```

Scilab code Exa 4.12 Determine temperature coefficients

```
 1  //Exa4.12
 2  clc;
 3  clear;
 4  close;
 5  //given data
 6  Vz=5;//in volts
 7  to=25;//in degree centigrade
 8  t=100;//in degree centigrade
 9  Vdrop=4.8;//in Volts
10  delVz=Vdrop-Vz;//in Volts
11  delt=t-to;//in degree centigrade
12  TempCoeff=delVz*100/(Vz*delt);
13  disp(TempCoeff,"Temperature coefficient f zener
        diode in %  : ");
```

Scilab code Exa 4.13 Find output voltage and current through Zener diode

```
1  //Exa4.13
2  clc;
3  clear;
4  close;
5  //given data
6  Vz=8;//in volts
7  VS=12;//in volts
8  Vout=8;//in volts
9  RL=10;//in Kohm
10 Rs=5;//in Kohm
11 //part (a)
12 disp("Output voltage will be equal to Vz i.e "+
        string(Vz)+" Volts");
13 //part (b)
14 Vrs=VS-Vout;//in volts
15 disp(Vrs,"Voltage across Rs in volts : ");
16 IL=Vout/RL;//in mAmpere
17 Is=(VS-Vout)/Rs;//in mAmpere
18 Iz=Is-IL;//in mAmpere
19 disp(Iz,"Current through zener diode in mA : ");
```

Scilab code Exa 4.14 Find maximum and minimum values of zener diode current

```
1  //Exa4.14
2  clc;
3  clear;
4  close;
5  //given data
6  Vz=50;//in volts
7  VSmax=120;//in volts
8  VSmin=80;//in volts
9  RL=10;//in Kohm
```

```
10  Rs=5;//in Kohm
11  Vout=Vz;//in Volts
12  disp("Output voltage will be equal to Vz i.e "+
        string(Vz)+" Volts");
13  IL=Vout/RL;//in mAmpere
14  disp("The zener current will be maximum when input
        voltage is maximum i.e. 120V.");
15  ISmax=(VSmax-Vout)/Rs;//in mAmpere
16  Izmax=ISmax-IL;//in mA
17  disp(Izmax,"Maximum zener diode current in mA : ");
18  disp("The zener current will be minimum when input
        voltage is minimum i.e. 80V.");
19  Ismin=(VSmin-Vout)/Rs;//in mAmpere
20  Izmin=Ismin-IL;//in mA
21  disp(Izmin,"Minimum zener diode current in mA : ");
```

Scilab code Exa 4.15 Design a regulator

```
 1  //Exa4.15
 2  clc;
 3  clear;
 4  close;
 5  //given data
 6  Vz=15;//in volts
 7  Izk=6;//in mA
 8  Vout=15;//in Volts
 9  Vs=20;//in Volts
10  ILmin=10;//in mA
11  ILmax=20;//in mA
12  disp("the zener current will be minimum i.e. Izk = 6
        mA when load current is maximum i.e. ILmax = 20mA
        ");
13  RS=(Vs-Vout)/(Izk+ILmax);//in ohm
14  disp("when the load current will decrease and become
        10 mA, the zener current will increase and
```

become 6+10 i.e. 16 mA. Thus the current through
series resistance Rs will remain unchanged at
6+20 i.e. 26 mA. Thus voltage drop in series
resistance Rs will remain constant. Consequently,
the output voltage will also remain constant. ")
;

Scilab code Exa 4.16 Determine VL IZ and PZ

```
1  //Exa4.16
2  clc;
3  clear;
4  close;
5  //given data
6  Vs=16;//in volts
7  RL=1.2;//in Kohm
8  Rs=1;//in Kohm
9  //If zener open circuited
10 VL=Vs*RL/(Rs+RL);//in Volts
11 disp(VL,"When zener open circuited Voltage across
       load in volts : ");
12 disp("Since voltage across load VL is less than
       breakdown voltage of zener diode i.e. VL < Vz.
       The zener diode will not conduct and VL = 8.73
       Volt");
13 Iz=0;//in mA
14 disp(Iz,"Zener current in mA : ");
15 Pz=VL*Iz;//in watts
16 disp(Pz,"Power in watts : ");
```

Scilab code Exa 4.17 Comment on operation of circuit

```
1  //Exa4.17
```

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```
 2  clc;
 3  clear;
 4  close;
 5  //given data
 6  Vin=20;//in volts
 7  Rs=220;//in Kohm
 8  Vz=10;//in volts
 9  // part (i) RL=50;//in Kohm
10  disp("For RL=50ohm :");
11  RL=50;//in Kohm
12  VL=Vin*RL/(RL+Rs)
13  disp("Since voltage across load, VL is less than
         breakdown voltage of zener diode. Zener will not
         conduct.")
14  IR=Vin/(Rs+RL);//in mA
15  IL=IR;//in mA
16  IZ=0;//in mA
17  disp(VL,"VL in volt : ");
18  disp(IL*1000,"IL in mA :");
19  disp(IZ,"Iz in mA: ");
20  disp(IR*1000,"IR in mA :");
21
22  // part (ii) RL=200;//in Kohm
23  disp("For RL=200ohm : ")
24  RL=200;//in Kohm
25  VL=Vin*RL/(RL+Rs)
26  disp("voltage across load, if zener diode is open
         circuited.")
27  IR=Vin/(Rs+RL);//in mA
28  IL=IR;//in mA
29  IZ=0;//in mA
30  disp(VL,"VL in volt : ");
31  disp(IL*1000,"IL in mA :");
32  disp(IZ,"Iz in mA: ");
33  disp(IR*1000,"IR in mA :");
```

Scilab code Exa 4.18 Find voltage drop across the resistance

```
1  //Exa4.18
2  clc;
3  clear;
4  close;
5  //given data
6  RL=10;//in Kohm
7  Rs=5;//in Kohm
8  Vin=100;//in Volts
9  disp("Removing the zener diode from the circuit , We
       have : V = Vin*RL/(RL+Rs)");
10 V=Vin*RL/(RL+Rs);//in Volt
11 disp(V,"Voltage V in volts = ");
12 disp("V > Vz So zener diode is in ON stste.");
13 VZ=50;//in Volts
14 VL=VZ;//in volts
15 //Apply KVL
16 VR=100-50;//in Volts
17 VR=50;//in Volts
18 disp(VR,"Hence the voltage dropp across the 5 Kohm
       resistor in Volts is : ");
```

Scilab code Exa 4.19 Find Ri so that VL remain 12V

```
1  //Exa4.19
2  clc;
3  clear;
4  close;
5  //given data
6  RL=120;//in ohm
7  Izmin=20;//in mA
```

```
 8  Izmax =200; //in mA
 9  VL =12; //in  Volts
10  VDCmin =15; //in  Volts
11  VDCmax =19.5; //in  Volts
12  Vz =12; //in  Volts
13  IL=VL/RL; //in  Ampere
14  IL=IL *1000; //in  mAmpere
15  //For VDCmin = 15  volts
16  VSmin =VDCmin -Vz; //in  Volts
17  //For VDCmax = 19.5  volts
18  VSmax =VDCmax -Vz; //in  Volts
19  ISmin =Izmin +IL; //in mA
20  Ri=VSmin /ISmin; //in  Kohm
21  Ri=Ri *10^3; //in  ohm
22  disp (Ri ,"The  resistance  Ri  in  ohm  :  ");
```

Scilab code Exa 4.20 Determine range of RL and IL

```
 1  //Exa4.20
 2  clc ;
 3  clear ;
 4  close ;
 5  //given  data
 6  VRL =10; //in  Volts
 7  Vi =50; //in  Volts
 8  R=1; //in  Kohm
 9  Vz =10; //in  Volts
10  VL=Vz; //in  Volts
11  Izm =32; //in mA
12  IR=(Vi -VL)/R; //in mA
13  disp ("Load  current  IL  will  be  maximum  when  Iz  =  0  ")
      ;
14  Izmin =0; //in mA
15  ILmax =IR -Izmin; //in mA
16  disp (ILmax ,"Maximum  load  current  in  mA  :  ");
```

```
17  RLmin=VL/ILmax;//in Ohm
18  disp("Load current IL will be minimum when Iz =
        maximum i.e. 32 mA ");
19  Izmax=32;//in mA
20  ILmin=IR-Izmax;//in mA
21  disp(ILmin,"Minimum load current in mA : ");
22  VL=Vz;//in Volts
23  RLmax=VL/ILmin;//in Ohm
24  disp("Hence range of RL and IL are as follows :");
25  disp("Range of RL in Kohm : From "+string(RLmin)+"
        to "+string(RLmax));
26  disp("Range of IL in mA : From "+string(ILmin)+" to
        "+string(ILmax));
```

Chapter 5

Junction Properties Continued

Scilab code Exa 5.1 Estimate junction width

```
1 //Exa 5.1
2 clc;
3 clear;
4 close;
5 //given data
6 ND=10^17;//in atoms/cm^3
7 NA=0.5*10^16;//in atoms/cm^3
8 Vo=0.7;//in Volts
9 V=-10;//in Volts
10 ND=ND*10^6;//in atoms/m^3
11 NA=NA*10^6;//in atoms/m^3
12 epsilon=8.85*10^-11;//in F/m
13 e=1.6*10^-19;//coulamb
14 //part (i)
15 disp("When no external voltage is applied i.e. V=0")
    ;
16 disp("VB = 0.7 volts");
17 VB=0.7;//in Volts
18 W=sqrt(2*epsilon*VB*(1/NA+1/ND)/e);//in m
19 disp(W,"When no external voltage is applied,
    Junction width in meter : ");
```

```
20 //part (ii)
21 disp("When external voltage of −10 volt is applied")
      ;
22 disp("VB = Vo−V volts");
23 VB=Vo-V;//in Volts
24 W=sqrt(2*epsilon*VB*(1/NA+1/ND)/e);//in m
25 disp(W,"When external voltage of −10 Volt is applied
      , Junction width in meter : ");
```

Scilab code Exa 5.3 Find new position of fermi level

```
1 //Exa 5.3
2 clc;
3 clear;
4 close;
5 //given data
6 Ecf=0.3;//in Volts
7 T=27+273;//in Kelvin
8 delT=55;//in degree centigrade
9 //formula : Ecf=Ec−Ef=K*T*log(nc/ND)
10 //let K*log(nc/ND)=y
11 //Ecf=Ec−Ef=T*y
12 y=Ecf/T;//assumed
13 Tnew=273+55;//in Kelvin
14 EcfNEW=y*Tnew;//in Volts
15 disp(EcfNEW,"New position of fermi level is(eV) : ")
      ;
```

Scilab code Exa 5.4 Calculate height of potential barrier

```
1 //Exa 5.4
2 clc;
3 clear;
```

```scilab
 4 close ;
 5 //given data
 6 ND=8*10^14;//in cm^-3
 7 NA=8*10^14;//in cm^-3
 8 ni=2*10^13;//in cm^-3
 9 T=300;//in Kelvin
10 k=8.61*10^-5;//in eV/K
11 e=1.6*10^-19;//coulamb
12 Vo=k*T*log(ND*NA/ni^2);//in Volts
13 disp(Vo,"Potential barrier in volts : ");
```

Scilab code Exa 5.5 Find electron and hole concentration

```scilab
 1 //Exa 5.5
 2 clc;
 3 clear;
 4 close;
 5 //given data
 6 ND=2*10^16;//in cm^-3
 7 NA=5*10^15;//in cm^-3
 8 Ao=4.83*10^21;//constant
 9 T=300;//in Kelvin
10 EG=1.1;//in eV
11 kT=0.026;//in eV
12 ni=Ao*T^(3/2)*exp(-EG/(2*kT));//in m^-3
13 ni=ni*10^-6;//in cm^-3
14 p=(ni^2)/ND;//in cm^-3
15 n=(ni^2)/NA;//in cm^-3
16 disp(p,"Hole concentration in cm^-3 : ");
17 disp(n,"electron concentration in cm^-3 : ");
18 disp("Since elctron concentration is mote than hole
      concentration , the given Si is of N-type.");
19 //Note : Ans in the book is wrong. Mistake in value
      putting.
```

Scilab code Exa 5.6 Determine junction capacitance

```
1  //Exa 5.6
2  clc;
3  clear;
4  close;
5  //given data
6  CTzero=50;//in pF
7  VR=8;//in Volt
8  VK=0.7;//in Volt
9  n=1/3;//for Si
10 CT=CTzero/((1+VR/VK)^n);//in pF
11 disp(CT,"Junction capacitance in pF : ");
```

Chapter 6

Bipolar Junction Transistors

Scilab code Exa 6.1 Determine emitter current

```
1  //Exa 6.1
2  clc;
3  clear;
4  close;
5  //given data
6  IC=20;//in mA
7  Beta=50;//Unitless
8  IB=IC/Beta;//in mA
9  IE=IC+IB;//in mA
10 disp(IE,"Emitter current in mA : ");
```

Scilab code Exa 6.2 Determine emitter current amplification factor and gain factor

```
1  //Exa 6.2
2  clc;
3  clear;
4  close;
```

```
5  //given data
6  IC=0.98;//in mA
7  IB=20;//in uA
8  IB=IB*10^-3;//in mA
9  //part (i)
10 IE=IB+IC;//in mA
11 disp(IE,"Emitter current in mA :");
12 //part (ii)
13 alfa=IC/IE;//unitless
14 disp(alfa,"Current amplification factor : ");
15 //part (iii)
16 Beta=IC/IB;//unitless
17 disp(Beta,"Current gain factor : ");
```

Scilab code Exa 6.3 Determine emitter current and collector current

```
1  //Exa 6.3
2  clc;
3  clear;
4  close;
5  //given data
6  alfaDC=0.98;//unitless
7  ICBO=4;//in uA
8  ICBO=ICBO*10^-3;//in mA
9  IB=50;//in uA
10 IB=IB*10^-3;//in mA
11 //Formula : IC=alfaDC*(IB+IC)+ICBO
12 IC=alfaDC*IB/(1-alfaDC)+ICBO/(1-alfaDC);//in mA
13 IE=IC+IB;//in mA
14 disp(IE,"Emitter current in mA : ");
15 disp(IC,"Collector current in mA : ");
```

Scilab code Exa 6.4 Determine collector current

```
1  //Exa  6.4
2  clc;
3  clear;
4  close;
5  //given  data
6  IB=10;//in  uA
7  IB=IB*10^-3;//in  mA
8  Beta=99;//Unitless
9  ICO=1;//in  uA
10 ICO=ICO*10^-3;//in  mA
11 //Formula  :  IC=alfa*(IB+IC)+ICO
12 IC=Beta*IB+(1+Beta)*ICO;//in  mA
13 disp(IC,"Collector  current  in mA : ");
```

Scilab code Exa 6.5 Calculate dynamic input resistance

```
1  //Exa  6.5
2  clc;
3  clear;
4  close;
5  //given  data
6  delVEB=200;//in  Volts
7  delIE=5;//in  mA
8  rin=delVEB/delIE;//in  ohm
9  disp(rin,"Dynamic  input  resistance  in  ohm : ");
```

Scilab code Exa 6.6 Determine base and collector current

```
1  //Exa  6.6
2  clc;
3  clear;
4  close;
5  //given  data
```

```
6  alfao =0.98; // unitless
7  ICO =10; // in uA
8  ICO = ICO *10^ -3; // in mA
9  IE =2; // in mA
10 IC = alfao * IE + ICO ; // in mA
11 IB = IE - IC ; // in mA
12 disp (IC ," Collector current in mA : ");
13 disp (IB *1000 ," Base current in uA : ");
```

Scilab code Exa 6.7 Determine current gain and base current

```
1  // Exa 6.7
2  clc ;
3  clear ;
4  close ;
5  // given data
6  ICBO =12.5; // in uA
7  ICBO = ICBO *10^ -3; // in mA
8  IE =2; // in mA
9  IC =1.97; // in mA
10 alfa =( IC - ICBO )/ IE ; // unitless
11 IB = IE - IC ; // in mA
12 disp ( alfa ," Current gain : ");
13 disp (IB ," Base current in mA : ");
```

Scilab code Exa 6.8 Determine base current

```
1  // Exa 6.8
2  clc ;
3  clear ;
4  close ;
5  // given data
6  RL =4; // in Kohm
```

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```
7  VL=3;//in volt
8  alfa=0.96;//unitless
9  IC=VL/RL;//in mA
10 IE=IC/alfa;//in mA
11 IB=IE-IC;//in mA
12 disp(IB,"Base current in mA : ");
```

Scilab code Exa 6.9 Determine base current

```
1  //Exa 6.9
2  clc;
3  clear;
4  close;
5  //given data
6  RL=1;//in Kohm
7  VL=1.2;//in volt
8  Beta=60;//unitless
9  IC=VL/RL;//in mA
10 IB=IC/Beta;//in mA
11 disp(IB*1000,"Base current in uA : ");
```

Scilab code Exa 6.10 Determine collector emitter voltage and base current

```
1  //Exa 6.10
2  clc;
3  clear;
4  close;
5  //given data
6  VCC=10;//in volt
7  RL=800;//in ohm
8  VL=0.8;//in volt
9  alfa=0.96;//unitless
```

```
10 //VR=IC*RL
11 VCE=VCC-VL;//in Volt
12 disp(VCE,"Collector-emitter Voltage in volts : ");
13 IC=VL*1000/RL;//in mA
14 Beta=alfa/(1-alfa);//unitless
15 IB=IC/Beta;//in mA
16 disp(IB*1000,"Base current in uA : ");
```

Scilab code Exa 6.11 Determine collector current

```
1 //Exa 6.11
2 clc;
3 clear;
4 close;
5 //given data
6 alfao=0.98;//unitless
7 ICO=10;//in uA
8 ICO=ICO*10^-3;//in mA
9 IB=0.22;//in mA
10 IC=(alfao*IB+ICO)/(1-alfao);//in mA
11 disp(IC,"Collector current in mA : ");
```

Scilab code Exa 6.12 Calculate dynamic input resistance

```
1 //Exa 6.12
2 clc;
3 clear;
4 close;
5 //given data
6 delVEB=250;//in mVolts
7 delIE=1;//in mA
8 rin=delVEB/delIE;//in ohm
9 disp(rin,"Dynamic input resistance in ohm : ");
```

Scilab code Exa 6.13 Calculate dynamic output resistance

```
1  //Exa 6.13
2  clc;
3  clear;
4  close;
5  //given data
6  delVCE=10-5;//in Volts
7  delIC=5.8-5;//in mA
8  rin=delVCE/delIC;//in Kohm
9  disp(rin,"Dynamic output resistance in Kohm : ");
```

Scilab code Exa 6.14 Determine operating point

```
1  //Exa 6.14
2  clc;
3  clear;
4  close;
5  //given data
6  VCC=10;//in volt
7  RC=8;//in Kohm
8  Beta=40;//unitless
9  IB=15;//in uA
10 IB=IB*10^-3;//in mA
11 // For VCE = 0 Volts
12 IC=VCC/RC;//in mA
13 disp(IC,"VCE=0V and IC in mA = ");
14 disp("This gives a point on loasd line.");
15 //For IC=0 VCE=VCC=10V :
16 disp("For IC=0, VCE=VCC=10V :")
17 disp("This gives another point on load line.");
```

```
18  IC=Beta*IB;//in mA
19  VCE=VCC-IC*RC;//in Volts
20  disp("Operating point Q is ("+string(VCE)+"V,"+
        string(IC)+"mA)");
```

Scilab code Exa 6.15 Find VCE at cut off point

```
1  //Exa 6.15
2  clc;
3  clear;
4  close;
5  //given data :
6  VCC=20;//in Volt
7  RC=3.3*10^3;//in ohm
8  disp("Applying Kirchoffs Voltage Law : ");
9  disp("VCC=IC*RC+VCE");
10 disp("For cut-off point , IC=0");
11 disp("Therefore , VCC=VCE");
12 VCE=VCC;//in volt
13 disp(VCE,"VCE at cut-off point : ");
14 disp("For Saturation point , VCE = 0");
15 VCE=0;//in volts
16 IC=VCC/RC;//in A
17 disp(IC,"IC at saturation point in mA ; ");
18 disp("Therefore Load line coordinates are given as :
        ");
19 disp("("+string(20)+"V,"+string(0)+"mA)");
20 disp("("+string(VCE)+"V,"+string(IC*1000)+"mA)");
```

Scilab code Exa 6.16 Determine VC and VB

```
1  //Exa 6.16
2  clc;
```

```scilab
3 clear;
4 close;
5 //given data :
6 Beta=45;//Unitless
7 VBE=0.7;//in Volt
8 VCC=0;//in Volt
9 RB=10^5;//in ohm
10 RC=1.2*10^3;//in ohm
11 VEE=-9;//in Volt
12 disp("Applying Kirchoffs Voltage Law in input loop
     we have : ");
13 disp("IB*RB+VBE+VEE=0");
14 IB=-(VBE+VEE)/RB;//in mA
15 IC=Beta*IB;//in mA
16 VC=VCC-IC*RC;//in Volts
17 VB=VBE+VEE;//in Volts
18 disp(VC,"VC in volts : ");
19 disp(VB,"VB in volts : ");
```

Scilab code Exa 6.17 Find IB and IC

```scilab
1 //Exa 6.17
2 clc;
3 clear;
4 close;
5 //given data :
6 Beta=100;//Unitless
7 hfe=Beta;//Unitless
8 VBB=5;//in Volt
9 VBE=0.8;//in Volt
10 RB=50*10^3;//in ohm
11 RE=2*10^3;//in ohm
12 VCE=0.2;//in Volt
13 disp("Applying Kirchoffs Voltage Law in input loop
     we have : ");
```

```
14  disp("VBB=IB*RB+VBE+IE*RE=IB*RB+VBE+(1+Beta)*IB*RE")
        ;
15  disp("IB=(VBB-VBE)/(RB+(1+Beta)*RE)");
16  IB=(VBB-VBE)/(RB+(1+Beta)*RE);//in A
17  disp(IB*1000,"IB in mA : ");
18  disp("Applying Kirchoffs Voltage Law in output loop
        we have : ");
19  disp("10-IC(3*10^3)-VCE-IE(2*10^3)=0");
20  IC=(10-0.2)/(5*10^3);//in A
21  disp(IC*1000,"IC in mA : ");
22  disp(Beta*IB,"Beta*Ib in mA = ");
23  disp(IC,"IC = ");
24  disp("IC > Beta*IB. Hence the transistor is in
        saturation with the values of IB = 0.0166 mA and
        IC = 1.96 mA.")
```

Chapter 7

Field Effect Transistors

Scilab code Exa 7.1 Determine resistance between gate and source

```
1  //Exa 7.1
2  clc;
3  clear;
4  close;
5  //given data :
6  VGS=10;//in Volt
7  IG=0.001;//in uA
8  IG=IG*10^-6;//in A
9  RGS=VGS/IG;//in ohm
10 disp(RGS/10^6,"Resistance between gate and source in
       Mohm ; ");
```

Scilab code Exa 7.2 Calculate AC drain resistance

```
1  //Exa 7.2
2  clc;
3  clear;
4  close;
```

```
5  // given data :
6  delVDS =1.5; // in Volt
7  delID =120; // in uA
8  delID =120*10^ -6; // in A
9  rd= delVDS / delID ; // in Ohm
10 disp ( rd *10^ -3 ,"AC drain resistance of JFET in Kohm :
        ") ;
```

Scilab code Exa 7.3 Determine Transconductance

```
1  // Exa 7.3
2  clc ;
3  clear ;
4  close ;
5  // given data :
6  VP = -4.5; // in Volt
7  IDSS =10; // in mA
8  IDS =2.5; // in mA
9  disp (" From shockleys equation , drain source current ,
        IDS=IDSS*(1−VGS/VP)^2 ") ;
10 VGS = VP *(1 - sqrt ( IDS / IDSS ) ) ;// in Volt
11 gm =( -2* IDSS / VP ) *(1 - VGS / VP ) ;// in mA/ Volt
12 disp ( gm ,"Transconductance in mA/ Volt : ") ;
```

Scilab code Exa 7.4 Calculate VGS

```
1  // Exa 7.4
2  clc ;
3  clear ;
4  close ;
5  // given data :
6  gm =10; // in mS
7  IDSS =10; // in uA
```

```
8  IDSS=IDSS-10^-6;//in Ampere
9  disp("VGS(OFF) : VGS=VP");
10 disp("gm=gmo=-2*IDSS/VP=-2*IDSS/VGS(OFF)");
11 VGS_OFF=-2*IDSS/gm
12 disp(round(VGS_OFF),"VGS(OFF) in mV :");
```

Scilab code Exa 7.5 Determine minimum value of VDS

```
1  //Exa 7.5
2  clc;
3  clear;
4  close;
5  //given data :
6  VP=-4;//in Volt
7  IDSS=10;//in mA
8  IDSS=IDSS*10^-3;//in Ampere
9  VGS=-2;//in Volt
10 ID=IDSS*(1-VGS/VP)^2;//in mA
11 disp(ID*1000,"Drain current in mA : ");
12 disp("The minimum value of VDS for pinch-OFF region
       is equal to VP. Thus the minimum value of VDS : "
       );
13 disp(VP,"VDS(min) in volt : ");
```

Scilab code Exa 7.6 Findd values of ID gmo and gm

```
1  //Exa 7.6
2  clc;
3  clear;
4  close;
5  //given data :
6  VP=-3;//in Volt
7  IDSS=8.7;//in mA
```

```
8  IDSS=IDSS*10^-3;//in mA
9  VGS=-1;//in Volt
10 ID=IDSS*(1-VGS/VP)^2;//in Ampere
11 disp(ID*1000,"ID in mA : ")
12 gmo=-2*IDSS/VP;//in mS
13 disp(gmo*1000,"gmo in mS : ");
14 gm=gmo*(1-VGS/VP);//in mS
15 disp(gm*1000,"gm in mS : ");
```

Scilab code Exa 7.7 Findd values of ID and gm

```
1  //Exa 7.7
2  clc;
3  clear;
4  close;
5  //given data :
6  VP=-3;//in Volt
7  IDSS=8.4;//in mA
8  VGS=-1.5;//in Volt
9  ID=IDSS*(1-VGS/VP)^2;//in mA
10 disp(ID,"Drain current in mA : ");
11 gmo=-2*IDSS/VP;//in mS
12 gm=gmo*(1-VGS/VP);//in mS
13 disp(gm,"gm in mS : ");
```

Scilab code Exa 7.8 Find value of VGS and gm

```
1  //Exa 7.8
2  clc;
3  clear;
4  close;
5  //given data :
6  VP=-4.5;//in Volt
```

```
7  IDSS =9;//in  mA
8  IDSS = IDSS *10^ -3;//in  Ampere
9  IDS =3;//in  mA
10 IDS = IDS *10^ -3;//in  Ampere
11 VGS = VP *(1 - sqrt ( IDS / IDSS ));//in  Volt
12 disp ( VGS ," IDS  =  3  mA  when  VGS( in  Volt )  is  :   ");
13 gm =( -2* IDSS / VP ) *(1 - VGS / VP );//in  mS
14 disp ( gm *1000 ," IDS  =  3  mA  when  gm( in  mS)  is  :   ");
```

Scilab code Exa 7.9 Sketch the transfer Characteristics

```
1  // Exa  7.9
2  clc ;
3  clear ;
4  close ;
5  // given  data  :
6  VP = -4;//in  Volt
7  IDSS =10;//in  mA
8  VGS =[0  1  -1  -2  -4];
9  ID = zeros (1 ,5) ;
10 for  i =1:5
11     ID ( i )= IDSS *(1 - VGS ( i )/ VP )^2;//in  mA
12 end
13 plot2d ( VGS , ID ) ;
```

Scilab code Exa 7.10 Determine Drain current

```
1  // Exa  7.10
2  clc ;
3  clear ;
4  close ;
5  // given  data  :
6  ID_on =5;//in  mA
```

```
 7  VGS=6;//in Volt
 8  VGS_on=8;//in Volt
 9  VGST=4;//in Volt
10  K=ID_on/(VGS_on-VGST)^2;//in mA/V^2
11  ID=K*(VGS-VGST)^2;//in mA
12  disp(ID,"When VGS=6V the drain current in mA : ");
```

Chapter 8

Photonic Devices

Scilab code Exa 8.1 Determine steady state photo current density

```
1  //Exa 8.1
2  clc;
3  clear;
4  close;
5  //given data :
6  NA=10^22;//in atoms/m^3
7  ND=10^22;//in atoms/m^3
8  De=25*10^-4;//in m^2/s
9  Dh=10^-3;//in m^2/s
10 TAUeo=500;//in ns
11 TAUho=100;//in ns
12 ni=1.5*10^16;//in atoms/m^3
13 VR=-10;//in Volt
14 epsilon=11.6*8.854*10^-12;//in F/m
15 e=1.6*10^-19;//in Coulamb
16 VT=26;//in mV
17 GL=10^27;//in m^-3 s^-1
18
19 Le=sqrt(De*TAUeo*10^-9);//in um
20 Le=Le*10^6;//in um
21 Lh=sqrt(Dh*TAUho*10^-9);//in um
```

```
22 Lh=Lh*10^6;//in um
23 Vbi=VT*10^-3*log(NA*ND/ni^2);//in Volt
24 Vo=Vbi;//in Volt
25 VB=Vo-VR;//in Volt
26 W=sqrt((2*epsilon*VB/e)*(1/NA+1/ND));//in um
27 W=W*10^6;//in um
28 JL=e*(W+Le+Lh)*10^-6*GL;//in A/cm^2
29 disp(JL/10^4,"Steady state photocurrent density in A
      /cm^2 : ");
```

Scilab code Exa 8.2 Determine photo current density

```
1 //Exa 8.2
2 clc;
3 clear;
4 close;
5 //given data :
6 W=25;//in um
7 PhotonFlux=10^21;//in m^2s^-1
8 alfa=10^5;//in m^-1
9 e=1.6*10^-19;//in Coulambs
10 GL1=alfa*PhotonFlux;//in m^-3s^-1
11 GL2=alfa*PhotonFlux*exp(-alfa*W*10^-6);//in m^-3s^-1
12 JL=e*PhotonFlux*(1-exp(-alfa*W*10^-6));//in mA/cm^2
13 disp(JL/10,"Steady state photocurrent density in mA/
      cm^2 : ");
```

Scilab code Exa 8.3 Determine open circuit voltage

```
1 //Exa 8.3
2 clc;
3 clear;
4 close;
```

```
5  //given data :
6  NA=7.5*10^24;//in atoms/m^3
7  ND=1.5*10^22;//in atoms/m^3
8  De=25*10^-4;//in m^2/s
9  Dh=10^-3;//in m^2/s
10 TAUeo=500;//in ns
11 TAUho=100;//in ns
12 ni=1.5*10^16;//in atoms/m^3
13 VR=-10;//in Volt
14 epsilon=11.6*8.854*10^-12;//in F/m
15 e=1.6*10^-19;//in Coulamb
16 VT=26;//in mV
17 GL=10^27;//in m^-3 s^-1
18
19 Le=sqrt(De*TAUeo*10^-9);//in um
20 Le=Le*10^6;//in um
21 Lh=sqrt(Dh*TAUho*10^-9);//in um
22 Lh=Lh*10^6;//in um
23 JS=e*(ni^2)*(De/(Le*10^-6*NA)+De/(Lh*10^-6*ND));//in
       A/cm^2
24 JL=12.5;//in mA/cm^2
25 VOC=VT*log(1+JL/JS);//in Volt
26 disp(VOC,"Open circuit voltage in Volt : ");
27 //Note : Answer in the book is wrong.
```

Scilab code Exa 8.4 Determine approximate no of solar cell required

```
1  //Exa 8.4
2  clc;
3  clear;
4  close;
5  //given data :
6
7  disp("Each cell supplies 50 mA at 0.45V. Allowing
       for the voltage drop across the rectifier and
```

```
       series resistor, a maximum output voltage of
       approximately 28V is required. Thus, ");
 8  disp("n = Vout/Vcell");
 9  Vout=28;//in Volts
10  Vcell=0.45;//in Volt
11  n=Vout/Vcell;//Unitless
12  disp(n,"No. of series connected- cells = ");
13  disp("the charge taken from the batteries over a
       period of 24 hour is 24*0.5 =  12 Ah. thus, the
       charge delivered by the solar cells must be 12
       ampere Hours");
14  disp("Since the solar cells are illuminated only 12
       hours a day, the necessary charging current from
       the solar cell is 12Ah/12h i.e. 1 A");
15  Iout=1;//in A
16  Icell=50;//in mA
17  m=Iout/(Icell*10^-3);//unitless
18  disp(m,"Hence total no. of group of cells in
       parallel, m ");
19  disp(round(m*n),"The total no. of cells required : "
       );
20  //Note : Answer in the book is wrong.
```