Scilab Textbook Companion for Solid State Electronics by J. P. Agrawal[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

Introduction to solid state electronics

Scilab code Exa 1.1 ne

```
//Example 1.1:
clc;
clear;
close;
//given data :
ni=1.5*10^16;// in m^-3
nh=4.5*10^22;// in m^-3
ne=ni^2/nh;
format('e',8)
disp(ne," ne in the doped silicon is ,(m^-3) = ")
```

Scilab code Exa 1.2 resistivity

```
//Example 1.2:
clc;
clear;
```

```
close;
//given data :
ne=8*10^19;// in m^-3
nh=5*10^18;// in m^-3
mu_e=2.3;// in m^2/V-s
mu_h=.01;// in m^2/V-s
e=1.6*10^-19;// in V
p=1/(e*((ne*mu_e)+(nh*mu_h)));
format('e',8)
disp(p,"(b) the resistivity ,p(ohm-m)=")
```

Scilab code Exa 1.3 density

```
//Example 1.3:
clc;
clear;
close;
//given data :
sigma=500;// in ohm^-1 m^-1
mu_e=.39;// m^2/V-s
e=1.6*10^-19;// in V
ne=sigma/(e*mu_e);
format('e',9)
disp(ne,"number density of donor,ne(m^-3) = ")
```

Scilab code Exa 1.4 density

```
//Example 1.4:
clc;
clear;
close;
//given data :
e=1.6*10^-19;// in V
```

```
Pp=10^-2;// p-type silicon in ohm-m
Pn=10^-2;// n-type silicon in ohm-m
mu_p=0.048;// holes mobilities in m^2/V-s
mu_n=0.135;// electrons mobilities in m^2/V-s
Na=1/(e*mu_p*Pp);
Nd=1/(e*mu_n*Pn);
format('e',8)
disp(Na,"(i). the density of impurity,Na (m^-3) = ")
format('e',9)
disp(Nd,"(ii). the density of impurity,Nd (m^-3) = ")
```

Scilab code Exa 1.5 resistivity

```
//Example 1.5:
clc;
clear;
close;
//given data :
format('v',5)
e=1.6*10^-19;// in V
n=2.5*10^19;//m^3
p=n;//
ni=n;//
mu_p=0.17;// holes mobilities in m^2/V-s
mu_n=0.36;// electrons mobilities in m^2/V-s
sgint=e*(ni*(mu_p+mu_n));//electrical conductivity in mho/metre
pint=1/sgint;//resistivity in ohm-meter
disp(sgint,"electrical conductivity is ,(mho/metre)=")
disp(pint,"resistivity is ,(ohm-metre)=")
```

Scilab code Exa 1.6 conductivity

```
//Example 1.6:
clc;
clear;
close;
//given data :
format('e',9)
e=1.6*10^-19;// in V
ni=1.5*10^16;//in m^3
mu_p=0.13;// holes mobilities in m^2/V-s
mu_n=0.05;// electrons mobilities in m^2/V-s
sgint=e*(ni*(mu_p+mu_n));//electrical conductivity in mho/m
siat=10^8;//number of silicon atoms
ta=5*10^28;//silicon atoms in atoms/m^3
Nd=ta/siat;// in atoms/m^3
p= ni^2/Nd;//holes concentration in holes/m^3
n=Nd;//
mu_n=0.13;// electrons mobilities in m^2/V-s
sntype=e*n*mu_n;// in mho/m
disp(sgint,"(i) electrical conductivity is ,(mhos/m)=")
format('e',8)
disp(p,"(ii) holes concentration is, (holes/m^3)=")
format('v',5)
disp(sntype,"(ii) conductivity is ,(mho/m)=")
siat=10^8;//number of silicon atoms
ta=5*10^28;//silicon atoms in atoms/m^3
Na=ta/siat;// in atoms/m^3
n= ni^2/Na;//holes concentration in holes/m^3
p=Na;//
mu_p=0.05;//holes mobilities in m^2/V-s
sptype=e*p*mu_p;// in mho/m
format('e',8)
disp(n,"(iii) electron concentration is, (holes/m^3)=")
format('v',3)
```

```
disp(sptype,"(iii) conductivity is ,(mho/m)=")
```

Scilab code Exa 1.7 fremi level

```
//Example 1.7:
clc;
clear;
close;
//given data :
format('v',6)
//Nd1=Nc*exp^-(Ec-Ef1)/kT ...Formula Used
Nc=1;//assume
kT=0.03;//eV
EcEf1=0.5;//position of Fermi level in V
Nd=1;//assume
Nd1=3*Nd;//After tripling the donor concentration
EcEf2=(EcEf1-(kT*(log(Nd1/Nd))));//in eV
disp(EcEf2,"new position of Fermi-level is ,(eV)=")
```

Scilab code Exa 1.8 density

```
//Example 1.8:
clc;
clear;
close;
//given data :
e=1.6*10^-19;// in V
Pp=10^-1;// p-type silicon in ohm-m
Pn=10^-1;// n-type silicon in ohm-m
mu_h=0.05;// holes mobilities in m^2/V-s
mu_e=0.13;// electrons mobilities in m^2/V-s
Na=1/(e*mu_h*Pp);
Nd=1/(e*mu_e*Pn);
```

```
format('e',9)
disp(Na,"(i). the density of impurity,Na (m^-3) = ")
format('e',8)
disp(Nd,"(ii). the density of impurity,Nd (m^-3) = ")
```

Scilab code Exa 1.9 current

```
//Example 1.9:
clc;
clear;
close;
//given data :
e=1.6*10^-19;// in V
Pp=10^-1;// p-type silicon in ohm-m
Pn=10^-1;// n-type silicon in ohm-m
mu_hsi=0.048;// holes mobilities in m^2/V-s
mu_esi=0.135;// electrons mobilities in m^2/V-s
nisi=1.5*10^16;//in m^-3
nesi=nisi;//
nhsi=nisi;//
mu_hge=0.19;// holes mobilities in m^2/V-s
mu_ege=0.39;// electrons mobilities in m^2/V-s
A=1*10^-4;//area in m^2
nige=2.4*10^19;//in m^-3
V=2;//in V
l=0.1;//in m
Isi= e*A*(V/l)*((nesi*mu_esi)+(nhsi*mu_hsi));//in A
format('e',8)
disp(Isi,"Total current for silicon is,(A)=")
//Current for silicon is calculated wrong in the textbook
nege=nige;//
nhge=nige;//
Ige= e*A*(V/l)*((nege*mu_ege)+(nhge*mu_hge));//in A
```

```
format('e',9)
disp(Ige,"Total current for germanium is,(A)=")
```

Scilab code Exa 1.10 hole concentration and conductivity

```
//Example 1.10:
clc;
clear;
close;
//given data :
nh=2*10^21;// acceptor atoms in atoms/m^3
Na=nh;
format('e',8)
disp(Na,"(i). hole concentration,Na(atoms/m^3) = ")
mu_h=0.17;// mobility of holes in m^2/V-s
e=1.6*10^-19;// in C
sigma=nh*mu_h*e;
format('v',6)
disp(sigma,"conductivity,(ohm^-1-m^-1) = ")
//conductivity is calculated wrong in the book
```

Scilab code Exa 1.11 donor concentration

```
//Example 1.11:
clc;
clear;
close;
//given data :
p=0.15;// in ohm-m
mu_e=0.39;// mobility of electron in m^2/V-s
e=1.6*10^-19;// in C
Na=1/(e*mu_e*p);
format('e',9)
```

```
disp(Na,"The value of donor concentration,Na(m^-3) = ")
```

Scilab code Exa 1.12 resistivity

```
//Example 1.12:
clc;
clear;
close;
//given data :
mu_n=0.13;// in m^2/V-s
mu_p=0.05;// in m^2/V-s
ni=1.5*10^16;// in m^-3
e=1.6*10^-19;// in C
p=1/((e*ni)*(mu_n+mu_p));
format('v',7)
disp(p,"The resistivity,p(ohm-m) = ")
```

Scilab code Exa 1.13 current

```
//Example 1.13:
clc;
clear;
close;
//given data :
e=1.6*10^-19;// electron charge in coulombs
k=1.38*10^-23;//Boltzmann constant in m^2-kg/s^2-K^-1
T=300;//in Kelvin
Vt=(k*T)/e;//in V
I=240;//in mA
eta=2;//
Ve=0.8;//in V
```

```
V=0.7;//in V
Id=I*exp((V-Ve)/(eta*Vt));//in mA
format('v',5)
disp(round(Id),"(i) Current is ,(mA)=")
Ir=(I/((exp(Ve/(eta*Vt)))-1))*10^6;//
format('v',4)
disp(round(Ir),"(ii) reverse saturation current is ,(nA)=")
//reverse saturation current is calculated wrong in the textbook
```

Scilab code Exa 1.14 diode current and voltage

```
//Example 1.14:
clc;
clear;
close;
//given data :
e=1.6*10^-19;// electron charge in coulombs
k=1.38*10^-23;//Boltzmann constant in m^2-kg/s^2-K^-1
T=300;//in Kelvin
Vt=(k*T)/e;//in V
Ir1=10^-10;//in A
Ir2=10^-12;//in A
V21=((Vt)*log10(Ir1/Ir2))*2.3026;//in V
V211=0.5;//in V
V2=(1/2)*(V21+V211);//in V
V1=(1/2)*(V211-V21);//in V
I1=Ir2*exp(V2/Vt)*10^6;//in micro-A
I2=I1;//
format('v',8)
disp(V2,"diode voltage V2 is ,(V)=")
disp(V1,"diode voltage V1 is ,(V)=")
format('v',7)
```

```
disp(I1,"diode current is ,(micro-A)=")
//diode current is calculated wrong in the textbook
```

Scilab code Exa 1.15 voltage

```
//Example 1.15:
clc;
clear;
close;
//given data :
e=1.6*10^-19;// electron charge in coulombs
k=1.38*10^-23;//Boltzmann constant in m^2-kg/s^2-K
   ^-1
T=300;//in Kelvin
Vt=(k*T)/e;//in V
Ir1=10^-12;//in A
Ir2=10^-10;//in A
I21=Ir2/Ir1;//
It=2;//mA
I1=It/(1+I21)*10^3;//in micro-A
I2=It*10^3-I1;//in micro-A
I1=I2/I21;//in micro-A
x=((I1*10^-6)/Ir1);//
V=Vt*log10(x)*2.3026;//in V
format('v',6)
disp(V,"diode voltage is ,(V)=")
```

Scilab code Exa 1.16 voltage

```
//Example 1.16:
clc;
clear;
close;
```

```
//given data :
format('v',5)
T=27;//degree Celsius
Tk=273+T;//in Kelvin
e=1.6*10^-19;// electron charge in coulombs
k=1.38*10^-23;//Boltzmann constant in m^2-kg/s^2-K^-1
J=10^4;//in Amp/m^2
Jo=200;//in mA/m^2
x=(J/(Jo*10^-3));//
Ve=((log(x))*k*Tk)/e;//in V
disp(Ve,"voltage to be applied is ,(V)=")
```

Scilab code Exa 1.17 resistance

```
//Example 1.17:
clc;
clear;
close;
format('v',5)
V=3;//in V
I=55;//in mA
Rdc=V/(I*10^-3);//in ohm
V2=26;//in mV
Rac=V2/I;//in ohm
disp(Rdc,"static resistance is ,(ohm)=")
disp(Rac,"dynamic resistance is ,(ohm)=")
```

Scilab code Exa 1.18 resistance

```
//Example 1.18:
clc;
clear;
```

```
close;
//given data :
format('v',5)
k=1.38*10^-23;// constant
T=27+273;// in K
eta=2;
e=1.6*10^-19;// in C
Vt=(k*T/e);// in V
V=0.5;// in V
Ir=10^-6;// in A
I=(Ir*10^3*(exp(V/(eta*Vt))-1));// in A
R_dc=V*10^3/I;
disp(R_dc,"static resistance,R_dc(ohm) = ")
R_ac=(eta*k*T)/(e*I*10^-3);
format('v',5)
disp(R_ac,"Dynamic resistance,R_ac(ohm) = ")
// answer is wrong in textbook
```

Scilab code Exa 1.19 resistance

```
//Example 1.19:
clc;
clear;
close;
//given data :
V=1.2;// in V
Vk=0.7;// in V
I_F=100;// in mA
R_B=(V-Vk)/(I_F*10^-3);
V_R=10;// in V
I_R=1;// in micro-A
R_R=V_R/I_R;
format('v',3)
disp(R_B,"the bulk resistance,R_B(ohm) = ")
disp(R_R,"the reverse resistance,R_R(M-ohm) = ")
```

```
eta=2;
I=5;// in  mA
R_ac=eta*26/I;
format('v',5)
disp(R_ac,"ac resistance,R_ac(ohm) = ")
```

Scilab code Exa 1.20 capacitance

```
//Example 1.20:
clc;
clear;
close;
//given data :
epsilon_0=8.85*10^-12;// in farada/m
K=12;// constant for silicon
epsilon=epsilon_0*K
A=1*10^-8;// in m^2
W=5*10^-7;// in m
Ct=epsilon*A*10^14/W;
format('v',6)
disp(Ct,"the transition capacitance,Ct(PF)  = ")
```

Scilab code Exa 1.21 resistance

```
//Example 1.21:
clc;
clear;
close;
//given data :
V=0.2;// in V
I=1;// in micro-A
R_dc=V*10^3/I;
R_ac=26/(I*10^3);
```

```
format('v',5)
disp(R_dc,"The static resistance,R_ac(k-ohm) = ")
format('v',6)
disp(R_ac,"the dynamic resistance,R_ac(ohm) = ")
```

Chapter 2

Special Purpose Diodes

Scilab code Exa 2.1 maximum current

```
//Example 2.1:
clc;
clear;
close;
//given data :
Pmax=364;//dissipation in milliwatt
Vz=9.1;//in V
Izmax=Pmax/Vz;//in mA
format('v',4)
disp(Izmax,"maximum current the diode can handle is
    ,(mA)=")
```

Scilab code Exa 2.2 resistance

```
//Example 2.2:
clc;
clear;
close;
```

```
//given data :
mip=15;//in volt
op=6.8;//output potential in volt
pd=mip-op;//potential difference across series resistor
Il=5;//load current in mA
nmip=20;//new maximum input voltage in volt
pd1=nmip-op;//new potential difference across series resistor
Il1=20;//new load current in mA
R=((pd1-pd)/((Il1-Il)*10^-3));//resistance in ohm
format('v',6)
disp(R,"value of series resistance is ,(ohm)=")
```

Scilab code Exa 2.3 current

```
//Example 2.3:
clc;
clear;
close;
//given data :
V=120;//in V
Vz=50;//in V
vd5=V-Vz;//voltage drop across 5 ohm resistor
R=5;// in ohm
I5=vd5/R;//current through 5 ohm resistor
Rl=10;// in k-ohm
Il=Vz/(Rl*10^3);//current through load resistor
Iz=I5-Il;//in A
format('v',7)
disp(Iz,"current through zener diode is ,(A)=")
```

Chapter 3

Bi Polar Junction Transistor

Scilab code Exa 3.1 varitation in alpha and value of beta

```
//Example 3.1:
clc;
clear;
close;
//given data :
Beta=50;//amlification factor
dbb=1;//percentage variation in degree celsius
daa=dbb/50;//variation in degree celsius
format('v',5)
disp(daa,"(i) variation in alpha for a silicon BJT
    is ,(%/degree-Celsius)=")
temp=325;//in K
t=25;//degree celsius
Beta1=dbb*t;//in %
nBeta=Beta+(Beta1/100)*t;//
format('v',6)
disp(nBeta,"new value of Beta is ,=")
```

Scilab code Exa 3.2 current amplification factor

```
//Example 3.2:
clc;
clear;
close;
format('v',4)
//given data :
del_Ic=1*10^-3;// in A
del_Ib=50*10^-6;// in A
Beta=del_Ic/del_Ib;
disp(Beta,"The current amplification factor,Beta = ")
```

Scilab code Exa 3.3 base current

```
//Example 3.3:
clc;
clear;
close;
format('v',5)
//given data :
alfa=0.88;
Ie=1;// in mA
Ic=alfa*Ie;// in mA
I_B=Ie-Ic;
disp(I_B,"Base current,(mA) = ")
```

Scilab code Exa 3.4 short circuit current gain

```
//Example 3.4:
clc;
clear;
close;
format('v',5)
```

```
//given data :
del_Ic=0.95*10^-3;// in A
del_Ie=1*10^-3;// in A
alfa=del_Ic/del_Ie;
disp(alfa,"the short circuit current gain, = ")
```

Scilab code Exa 3.5 collector and base current

```
//Example 3.5:
clc;
clear;
close;
//given data :
format('v',5)
Ie=5*10^-3;// in A
alfa=0.95;
I_co=10*10^-6;// in A
Ic=((alfa*Ie)+I_co)*10^3;
Ib=(Ie-(Ic*10^-3))*10^6;
disp(Ic,"Collector current,(mA) = ")
disp(Ib,"Base current,(micro-A) = ")
```

Scilab code Exa 3.6 Ic Ib and Iceo

```
//Example 3.6:
clc;
clear;
close;
//given data :
Ie=5;// in mA
alfa=0.99;
I_co=0.005;// in mA
Ic=((alfa*Ie)+I_co);
```

```
Ib=(Ie-Ic);
Beta=alfa/(1-alfa);
I_CEO=I_co/(1-alfa);
format('v',6)
disp(Ic,"Ic ,(mA) = ")
format('v',4)
disp(Ib*10^3,"Ib ,(micro-A) = ")
disp(Beta,"Beta = ")
format('v',6)
disp(I_CEO*10^3,"I_CEO(micro-A) = ")
```

Scilab code Exa 3.7 change in collector current

```
//Example 3.7:
clc;
clear;
close;
//given data :
alfa=0.9;// constant
Beta=alfa/(1-alfa);
Del_Ib=4;// in mA
Del_Ic=Beta*Del_Ib;
format('v',4)
disp(Del_Ic,"the change in the collector current ,(mA
    ) = ")
```

Scilab code Exa 3.8 emitter current

```
//Example 3.8:
clc;
clear;
close;
//given data :
```

```
Beta=40;
Ib=25;// base current in micro-A
Ic=Beta*Ib;
Ie=(Ib+Ic)*10^-3;
format('v',6)
disp(Ie,"Ie,(mA) = ")
```

Scilab code Exa 3.9 beta

```
//Example 3.9:
clc;
clear;
close;
//given data :
alfa=0.98;// constant
Beta=alfa/(1-alfa);
format('v',4)
disp(Beta,"Beta =  ")
```

Scilab code Exa 3.10 error

```
//Example 3.10:
clc;
clear;
close;
//given data :
Beta=100;// constant
Ib=20*10^-6;// in A
I_co=500*10^-9;// in A
Ic1=((Beta*Ib)+(1+Beta)*I_co)*10^3;
Ic2=(Beta*Ib)*10^3;
Error=(Ic1-Ic2)*100/Ic1;
format('v',5)
```

```
disp(Error,"The error,(%) = ")
//answer is wrong in the txtbook
```

Scilab code Exa 3.11 change in base current

```
//Example 3.11:
clc;
clear;
close;
//given data :
alfa=0.98;//
del_Ie=5;// in mA
del_Ic=alfa*del_Ie;// in mA
del_Ib=del_Ie-del_Ic;
format('v',4)
disp(del_Ib,"change in base current,(mA) = ")
```

Scilab code Exa 3.12 collector current base current and alfa

```
//Example 3.12:
clc;
clear;
close;
//given data :
Ie=8.4; // in mA
cr=0.8/100;// carriers recombine in base in %
Ib=cr*Ie;
format('v',6)
disp(Ib,"(a). The base current,Ib(mA) = ")
Ic=Ie-Ib;
format('v',5)
disp(Ic,"(b). The collector current,Ic(mA) = ")
alfa=Ic/Ie;
```

```
format('v',6)
disp(alfa,"(c). the value of alfa = ")
```

Scilab code Exa 3.13 ac current gain

```
//Example 3.13:
clc;
clear;
close;
//given data :
Ie1=20;// in mA
Ie2=15;// in mA
Ib1=0.48;// in mA
Ib2=0.32;// in mA
del_Ie=(Ie1-Ie2)*10^-3;// in A
del_Ib=(Ib1-Ib2)*10^-3;// in A
del_Ic=del_Ie-del_Ib;// in A
alfa=del_Ic/del_Ie;//
Beta=del_Ic/del_Ib;
format('v',5)
disp(alfa,"ac current gain in common base
    arrangement, = ")
format('v',4)
disp(Beta,"ac current gain in common emitter
    arrangement, = ")
```

Scilab code Exa 3.14 Beta Iceo and collector current

```
//Example 3.14:
clc;
clear;
close;
//given data :
```

```
alfa=0.992;// constant
Beta=alfa/(1-alfa);
format('v',5)
disp(Beta,"(a) Beta= ")
I_CBO=48*10^-9;// in A
I_CEO=(1+Beta)*I_CBO*10^6;
format('v',3)
disp(I_CEO,"(a) I_CEO (micro-A) = ")
Ib=30*10^-6;// in A
Ic=((Beta*Ib)+(1+Beta)*I_CBO)*10^3;
format('v',5)
disp(Ic,"(b) Collector current,Ic(mA) = ")
```

Scilab code Exa 3.15 collector current alfa and beta

```
//Example 3.15:
clc;
clear;
close;
//given data :
format('v',5)
Ie=9.6;//emitter current in mA
Ib=0.08;//base current in mA
Ic=Ie-Ib;//
format('v',5)
disp(Ic,"(a). collector current,Ic(mA) = ")
alfa=Ic/Ie;
format('v',5)
disp(alfa,"(b). alfa = ")
alfa=0.99;//
Beta=alfa/(1-alfa)
format('v',4)
disp(Beta,"(c). Beta = ")
```

Scilab code Exa 3.16 collector current

```
//Example 3.16:
clc;
clear;
close;
//given data :
Ib=68*10^-6;// in A
Ie=30*10^-3;// in A
Beta=440;// constant
alfa=Beta/(1+Beta);
Ic=alfa*Ie*10^3;
format('v',6)
disp(Ic,"Collector current,Ic(mA) = ")
```

Chapter 4

Small signal amplifiers

Scilab code Exa 4.1 voltage

```
//Example 4.1:
clc;
clear;
close;
//given data :
format('v',6)
Rc=4.7;// in ohm
Vcc=24;// in V
Ic=1.5;//in mA
//this is given as 15 mA in textbook which is wrong
Vce=Vcc-(Ic*Rc*10^-3*10^3);//in V
disp(Vce,"(i) Collector to emitter voltage,Vce(V) =
    ")
Ic1=0;//in A
Vce1=Vcc-Ic1*Rc;//in V
format('v',4)
disp(Vce1,"(ii) Collector to emitter voltage,Vce(V)
    = ")
```

Scilab code Exa 4.2 vce

```
//Example 4.2:
clc;
clear;
close;
//given data :
Beta=100;
Rb=200*10^3;// in ohm
Rc=1*10^3;// in ohm
Vcc=10;// in V
Ib=Vcc/Rb;// in A
Ic=Beta*Ib;//in A
Vce=Vcc-(Ic*Rc);
format('v',4)
disp(Vce,"Collector to emitter voltage,Vce(V) =  ")
```

Scilab code Exa 4.3 base resistance

```
//Example 4.3:
clc;
clear;
close;
//given data :
format('v',6)
Vcc=20;// in V
Vbe=0.7;// in V
Rc=2;//in kilo-ohm
Icsat= Vcc/Rc;//in mA
Beta=200;//
Ib=(Icsat/Beta)*10^3;//in micro-A
Rb=((Vcc-Vbe)/(Ib))*10^3;//in kilo-ohm
disp("Rb < "+string(Rb)+"  kilo-ohm")
```

Scilab code Exa 4.4 operating point

```
//Example 4.4:
clc;
clear;
close;
//given data :
Vcc=15;// in V
Rb=200;// in k-ohm
Rc=2;// in k-ohm
Beta=50;
Ib=(Vcc/(Rb*10^3+(Beta*Rc*10^3)))*10^6;//in micro-A
Ic=Beta*Ib*10^-3;//in mA
Vce=Vcc-(Ic*10^-3*(Rc*10^3));
format('v',4)
disp(Ic,"collector current,Ic(mA) = ")
disp(Vce,"Collector to emitter voltage,Vce(V) = ")
```

Scilab code Exa 4.5 resistor

```
//Example 4.5:
clc;
clear;
close;
//given data :
Vcc=15;// in V
Vce=6;// in V
Rc=3*10^3;// in ohm
Beta=50;
Ic=(Vcc-Vce)/Rc;
Ib=Ic/Beta;
Rb=((Vcc/Ib)-(Beta*Rc))*10^-3;
```

```
format('v',5)
disp(Rb,"The value of resistoe,Rb(k-ohm) = ")
```

Scilab code Exa 4.6 operating point

```
//Example 4.6:
clc;
clear;
close;
//given data :
Vcc=12;// in V
Rb1=70;// in k-ohm
Rb2=70;// in k-ohm
Beta=50;
Rc=2;// in k-ohm
Ib=Vcc/((Rb1+Rb2+(Beta*Rc))*10^3);
Ic=Beta*Ib*10^3;
Vce=Vcc-(Ic*Rc);
format('v',4)
disp(Ic,"collector current,Ic(mA) = ")
disp(Vce,"Collector to emitter voltage,Vce(V) = ")
```

Scilab code Exa 4.7 operating point

```
//Example 4.7:
clc;
clear;
close;
//given data :
Vcc=9;// in V
Rb=50;// in k-ohm
Rc=250;// in ohm
Re=500;// in ohm
```

```
Beta=80;
Ib=Vcc/(Rb*10^3+(Beta*Re));
Ic=Beta*Ib*10^3;
Vce=Vcc-(Ic*10^-3*(Rc+Re));
format('v',3)
disp(Ic,"collector current,Ic(mA) = ")
disp(Vce,"Collector to emitter voltage,Vce(V) = ")
```

Scilab code Exa 4.8 operating point

```
//Example 4.8:
clc;
clear;
close;
//given data :
R2=4;// in k-ohm
R1=40;// in k-ohm
Vcc=22;// in V
Rc=10;// in k-ohm
Re=1.5;// in k-ohm
Vbe=0.5;// in V
Voc=R2*10^3*Vcc/((R1+R2)*10^3);
Ic=(Voc-Vbe)/(Re*10^3);
Vce=Vcc-(Rc+Re)*Ic*10^3;
format('v',5)
disp(Vce,"Collector to emitter voltage,Vce(V) = ")
```

Scilab code Exa 4.9 maximum collector current

```
//Example 4.9:
clc;
clear;
close;
```

```
//given data :
Bv=12;//battery voltage in V
Cl=6;//collector load in k−ohm
CC=Bv/Cl;
format('v',4)
disp(CC,"Collector current,(mA) = ")
```

Scilab code Exa 4.10 maximum collector current

```
//Example 4.10:
clc;
clear;
close;
//given data :
format('v',6)
Bv=12;//battery voltage in V
P=2;// power in Watt
Ic=(P/Bv)*10^3;
disp(Ic,"The maximum collector current,Ic(mA) = ")
```

Scilab code Exa 4.11 gain

```
//Example 4.11:
clc;
clear;
close;
//given data :
del_ic=1;// in mA
del_ib=10;// in micro−A
del_Vbe=0.02;// in V
del_ib=10*10^-6;// in A
Rc=2;// in k−ohm
Rl=10;// in k−ohm
```

```
Beta=del_ic/(del_ib*10^3);//
format('v',5)
disp(Beta,"Current gain,Beta = ")
Ri=(del_Vbe/del_ib)*10^-3;
format('v',4)
disp(Ri,"Input impedence,Ri(k-ohm) = ")
Rac=Rc*Rl/(Rc+Rl);
format('v',5)
disp(Rac,"Effective load,Rac(k-ohm) = ")
Av=round(Beta*Rac/Ri);
format('v',4)
disp(Av,"Voltage gain,Av = ")
Ap=Beta*Av;
format('v',6)
disp(Ap,"power gain,Ap = ")
```

Scilab code Exa 4.12 output voltage

```
//Example 4.12:
clc;
clear;
close;
//given data :
Rc=10;// in k-ohm
Rl=10;// in k-ohm
Beta=100;
Ri=2.5;
Iv=2;// input voltage in mV
Rac=Rc*Rl/(Rc+Rl);
Av=round(Beta*Rac/Ri);
Ov=Av*Iv*10^-3;
format('v',4)
disp(Ov,"Output voltage,(V) = ")
```

Scilab code Exa 4.13 gain and resistance

```
//Example 4.13:
clc;
clear;
close;
//given data :
format('v',5)
I=1;
hfe=46;
hoe=80*10^-6;// in mho
hre=5.4*10^-4;
hie=800;// in ohm
RL=5*10^3;// in ohm
Aie=hfe/(I+(hoe*RL));
Zie=hie-(hre*RL*Aie);
Ave=(Aie*RL)/Zie;
Rg=500;// in ohm
Zoe=((hie+Rg)/(hoe*(hie+Rg)-(hfe*hre)))/10^3;
Ape=Aie*Ave;
disp(Aie,"Current gain, Aie = ")
format('v',6)
disp(Zie,"Input resistance, Zie(ohm) = ")
disp(Ave,"Voltage gain, Ave = ")
format('v',5)
disp(Zoe,"Output resistance, Zoe(k-ohm) = ")
format('v',7)
disp(Ape,"Power gain, Ape = ")
//voltage gain and power gain are calculated wrong
   in the textbook
```

Scilab code Exa 4.14 gain and voltage

```
//Example 4.14:
clc;
clear;
close;
//given data :
A=100;//gain without feedback
Beta=1/25;//feed back ratio
Af=(A/(1+(Beta*A)));//gain with feedback
disp(Af,"(i) gain with feedback is ,=")
ff=Beta*A;//feedback factor
disp(ff,"feedback factor is,=")
vi=50;//mV
Vo=Af*vi*10^-3;//in V
disp(Vo,"output voltage is ,(V)=")
fv=Beta*Vo;//in V
format('v',5)
disp(fv,"feedback voltage is ,(V)=")
vin=vi*(1+Beta*A);//mV
disp(vin,"new increased input voltage is ,(mV)=")
```

Scilab code Exa 4.15 voltage gain

```
//Example 4.15:
clc;
clear;
close;
//given data :
A=1000;//gain without feedback
fctr=0.40;//gain reduction factor
Af=A-fctr*A;//gain with feedback
Beta=((A/Af)-1)/A;//feed back ratio
A2=800 ;//redued gain
Af2=((A2)/(1+(Beta*A2)));//
format('v',6)
disp(Af2,"(i) voltage gain  is ,=")
```

```
prfb= ((A-A2)/A)*100;//percentage reduction without
    feedback
format('v',4)
disp(prfb,"(ii) percentage reduction without
    feedback is,(%)=")
prwfb= ((Af-Af2)/Af)*100;//percentage reduction
    without feedback
format('v',6)
disp(prwfb,"percentage reduction with feedback is,(%
    )=")
```

Scilab code Exa 4.16 small change in gain

```
//Example 4.16:
clc;
clear;
close;
//given data :
A=200;//gain without feedback
Beta=0.25;//feed back ratio
gc=10;//percent gain change
dA=gc/100;//
dAf= ((1/(1+Beta*A)))*dA;//
format('v',7)
disp(dAf,"small change in gain is,=")
```

Scilab code Exa 4.17 input voltage

```
//Example 4.17:
clc;
clear;
close;
//given data :
```

```
format('v',5)
A=200;//gain without feedback
Beta=0.05;//feed back ratio
Af=(A/(1+(Beta*A)));//gain with feedback
disp(Af," gain with negative feedback is ,=")
Dn=10;//percentage distortion
format('v',6)
Dn1=(Dn/(1+A*Beta));//percentage Distortion with
    negative feedback
ff=Beta*A;//feedback factor
vo=0.5;//initial output voltage
vi=A*vo;//in V
vin=vi/Af;//in V
disp(Dn1,"percentage Distortion with negative
    feedback is ,(%)=")
disp(vin,"new input voltage is ,(V)=")
//gain and input voltage are calculated wrong in the
     textbook
```

Scilab code Exa 4.18 percentage of feedback

```
//Example 4.18:
clc;
clear;
close;
//given data :
format('v',5)
A=50;//gain without feedback
Af=10;//gain with feedback
Beta=(((A/Af)-1)/A)*100;//feed back ratio
disp(Beta," percentage of feedback is ,(%)=")
```

Scilab code Exa 4.19 band width

```
//Example 4.19:
clc;
clear;
close;
//given data :
format('v',5)
Bw=200;//bandwidth in kHz
vg=40;//dB
fb=5;//percentage negetive feedback
A=40;//gain without feedback
Beta=fb/100;//feed back ratio
Af=(A/(1+(Beta*A)));//gain with feedback
Bwf= (A*Bw)/Af;//Bandwidth with feedback
disp(Bwf," new band-width is ,(kHz)=")
```

Scilab code Exa 4.20 percentage reduction

```
//Example 4.20:
clc;
clear;
close;
//given data :
format('v',5)
A=50;//gain without feedback
Af=25;//gain with feedback
Beta=(((A/Af)-1)/A);//feed back ratio
Ad=40;//new gain after ageing
Af1=(Ad/(1+(Beta*Ad)));//new gain with feedback
df=Af-Af1;// reduction in gain
pdf= (df/Af)*100;//percentage reduction in gain
disp(pdf," percentage reduction in gain is ,(%)=")
```

Scilab code Exa 4.21 Av and beta

```
//Example 4.21:
clc;
clear;
close;
//given data :
format('v',5)
Af=100;//gain with feeback
vi=50;//in mV
vi1=60;//in mV
AAf=vi1/vi;//
A=AAf*Af;//
Beta=(((A/Af)-1)/A);//feed back ratio
disp(A,"Av is ,=")
format('v',8)
disp(Beta," feedback factor is,=")
```

Chapter 5

Power Amplifiers

Scilab code Exa 5.1 efficiency

```
//Example 5.1:
clc;
clear;
close;
//given data :
Pac=0.1;//in W
Vcc=20;//in V
Ic=20;//in mA
Pdc=Vcc*Ic*10^-3;//in W
eta=(Pac/Pdc)*100;//efficiency
format('v',4)
disp(eta,"efficiency is ,(%)=")
```

Scilab code Exa 5.2 collector current

```
//Example 5.2:
clc;
clear;
```

```
close;
//given data :
Pac=2;//in W
Vcc=12;//in V
Ic=(Pac*sqrt(2)*sqrt(2))/Vcc;//in A
format('v',5)
disp(Ic,"maximum collector current is ,(A)=")
```

Scilab code Exa 5.3 collector efficiency and power rating

```
//Example 5.3:
clc;
clear;
close;
//given data :
Pac=3;//in W
Pdc=10;//in W
eta=(Pac/Pdc)*100;//percentage efficieny
format('v',4)
disp(eta,"collector efficiency is ,(%)=")
disp(Pdc,"power rating of transistor is ,(W)=")
```

Scilab code Exa 5.4 power

```
//Example 5.4:
clc;
clear;
close;
//given data :
dIc=100;//in mA
Rl=6;//in ohm
mv=dIc*Rl*10^-3;//in V
pd=mv*dIc;//in mW
```

```
disp(pd,"(i) power developed in loudspeaker is ,(mW)
   =")
dVc=10;//in V
oi=(dVc/dIc)*10^3;//in ohm
Rl=6;//in ohm
n=sqrt(oi/Rl);//turn ratio of transformer
tsv=dVc/n;//om V
Il=tsv/Rl;//in A
ptr= Il^2*Rl*10^3;//in mW
format('v',5)
disp(ptr,"(ii) power transferred to loudspeaker is
   ,(mw)=")
//in textbook in second case there is one point
   deviation in the answer.
```

Scilab code Exa 5.5 power

```
//Example 5.5:
clc;
clear;
close;
//given data :
n=10;//turn ratio
Rl=10;//ohm
Rld=n^2*Rl;//in ohm
Ic=100;//in mA
Irms=Ic/(sqrt(2));//in mA
P=Irms^2*Rld;//in W
format('v',3)
disp(P*10^-6,"maximum power output is ,(W)=")
```

Scilab code Exa 5.6 harmonic distortions and change in power

```
//Example 5.6:
clc;
clear;
close;
//given data :
//ie=15*sin 400*t+1.5*sin 800*t + 1.2*sin 1200*t +
    0.5*sin 1600*t  given equation
I2=1.5;//in A
I1=15;//in A
I3=1.2;//in A
I4=0.5;//in A
D2=(I2/I1)*100;//Second percentage harmonic
    distortion
D3=(I3/I1)*100;//Third percentage harmonic
    distortion
//in book I2 is mentioned wrongly in place of I1
D4=(I4/I1)*100;//Fourth percentage harmonic
    distortion
disp("part (i)")
disp(D2,"Second percentage harmonic distortion (D2)
    is ,(%)=")
disp(D3,"Third percentage harmonic distortion (D3)
    is ,(%)=")
format('v',5)
disp(D4,"Fourth percentage harmonic distortion (D4)
    is ,(%)=")
disp("part (ii)")
D=sqrt(D2^2+D3^2+D4^2)/100;//Distortion Factor
P1=1;//assume
P=(1+D^2)*P1;//in W
peri=((P-P1)/P1)*100;//percentage increase in power
    due to distortion
disp(peri,"percentage increase in power due to
    distortion is ,(%)=")
```

Scilab code Exa 5.7 power dissipated

```
//Example 5.7:
clc;
clear;
close;
//given data :
Vcc=15;//in V
Vpeak=24/2;//in V
Rl=100;//in ohm
Ipeak= Vpeak/Rl;//in A
Pdc=Vcc*(2/(%pi))*Ipeak;//in W
pad=(1/2)*(Vpeak^2)/Rl;//in W
pd=Pdc-pad;//in W
pde=pd/2;//in W
disp(pde*10^3,"power dissipated by each transistor
    is ,(mW)=")
```

Chapter 6

Field Effect Transistors

Scilab code Exa 6.1 drain resistance transconductance and amplification factor

```
//Example 6.1:
clc;
clear;
close;
//given data :
Vgs= [0;0;0.3];//in V
Vds=[5;10;10];//in V
Id=[8;8.2;7.6];//in mA
dVds=Vds(2)-Vds(1);//in V
dId=Id(2)-Id(1);//in mA
rd=(dVds/dId);//in kilo-ohm
format('v',4)
disp(rd,"(i) A.C. Drain resistance is ,(kilo-ohm)=")
dVgs=Vgs(3)-Vgs(2);//in V
dId1=Id(2)-Id(3);//in mA
gm=dId1/dVgs;//in mA/volt
format('v',3)
disp(gm,"(ii) Transconductance is ,(mS)=")
mu=gm*rd;//A/V
format('v',4)
```

```
disp(mu,"(iii) Amplification factor is ,=")
//Transconductance and Amplification factor are
   calculated wrong in the textbook
```

Scilab code Exa 6.2 mutual conductance

```
//Example 6.2:
clc;
clear;
close;
//given data :
I1=1;// in mA
I2=1.2;// in mA
del_ID=(I2-I1);
V1=-3;// in V
V2=-2.9;// in V
del_VGS=V2-V1;// in V
gm=del_ID/del_VGS;
format('v',4)
disp(gm,"mutual conductance ,gm(mS) = ")
```

Scilab code Exa 6.3 pinch off voltage

```
//Example 6.3:
clc;
clear;
close;
//given data :
format('v',4)
a=5.6*10^-6/2;// channel width in m
epsilon0=8.86*10^-12;// in F/m
epsilon=12*epsilon0;// in F/m
Nd=10^21;// in m^-3
```

```
e=1.6*10^-19;// in V
Vp=e*Nd*a^2/(2*epsilon);
disp(Vp,"Pinch off voltage,Vp(V) = ")
```

Scilab code Exa 6.4 ID gm and gmo

```
//Example 6.4:
clc;
clear;
close;
//given data :
I_DES=8.7;// in mA
V1=-3;// in V
V_GS=-1;// in V
ID=I_DES*(1-(V_GS/V1))^2;
format('v',6)
disp(ID,"(i). ID(mA) = ")
gmo=-(2*I_DES/V1);
format('v',4)
disp(gmo,"(ii). gmo(mS) = ")
gm=gmo*(1-(V_GS/V1));
format('v',6)
disp(gm,"(iii). gm(mA) = ")
```

Scilab code Exa 6.5 Vgs

```
//Example 6.5:
clc;
clear;
close;
//given data :
format('v',4)
ID=3;// in mA
```

```
I_DSS=9;// in mA
Vp=-4.5;// in V
Vgs=-Vp*(sqrt(ID/I_DSS)-1);
disp(Vgs,"Vgs(V) = ")
```

Scilab code Exa 6.6 voltage amplification

```
//Example 6.6:
clc;
clear;
close;
//given data :
gm=3;//Transconductance in mS
rl=10;//load resistance in kilo-ohm
av=gm*rl;//
format('v',4)
disp(av,"the voltage aplification is ,=")
```

Scilab code Exa 6.7 output voltage

```
//Example 6.7:
clc;
clear;
close;
//given data :
Rl=20;//in kilo-ohm
Rs=1;//in kilo-ohm
Rg=1;//in M-ohm
Cs=25;//in micro-F
mu=20;//amplification factor
rd=100;//in kilo-ohm
vi=2;//in V
f=1;//in kilo-Hz
```

```
Xc=((1/(2*%pi*f*10^3*Cs*10^-6)));//in ohm
A=((mu*Rl*10^3)/((rd+Rl)*10^3));//Voltage gain
Vo=A*vi;//in V
format('v',5)
disp(Vo,"amplifier output signal voltage is ,(V)=")
```

Chapter 9

Silicon Controlled Rectifier

Scilab code Exa 9.1 average voltage

```
//Example 9.1:
clc;
clear;
close;
//given data :
Vm=200;// in V
theta=30;//firing angle in degree
vdc=((Vm/%pi)*(1+cosd(theta)));//in V
format('v',5)
disp(round(vdc),"average value of voltage is ,(V)=")
```

Scilab code Exa 9.2 dc load current rms load current amd power dissipiated

```
//Example 9.2:
clc;
clear;
close;
```

```
//given data :
Va=300;// in V
Vm=300*sqrt(2);//in V
Rl=50;//in ohm
theta1=90;//firing angle in degree
idc=((Vm/(2*%pi*Rl))*(1+cosd(theta1)));//in A
format('v',6)
disp((idc),"(i) the dc load current is ,(A)=")
irms=Va/(2*Rl);//in A
format('v',4)
disp(round(irms),"(ii) the rms load current is ,(A)=")
P=irms^2*Rl;//in W
format('v',5)
disp(round(P),"(iii) the power dissipated by the load is ,(W)=")
```

Scilab code Exa 9.3 firing angle conducting angle and average current

```
//Example 9.3:
clc;
clear;
close;
//given data :
Ih=0;//in A
Vi=100;// in V
Vm=200;//in V
Rl=100;//in ohm
theta1=asind(Vi/Vm);//firing angle in degree
ca=180-theta1;//conducting angle in dehree
format('v',4)
disp(theta1,"(i) firing angle is ,(degree)=")
format('v',5)
disp(ca,"(ii) conducting angle is ,(degree)=")
av=((Vm/(2*%pi))*(1+cosd(theta1)));//in V
```

```
ac=av/Rl;//in A
format('v',7)
disp(ac,"(iii) average current is ,(A)=")
//average current is wrong in the textbook
```

Chapter 10

The Unijunction Transistor

Scilab code Exa 10.1 stand off and peak point voltage

```
//Example 10.1:
clc;
clear;
close;
//given data :
Vbb=20;// in V
eta=0.6;// instrinsic stand off ratio
Vb=0.7;// in V
sov=eta*Vbb;// Stand off voltage
format('v',4)
disp(sov,"(i). Stand off voltage,(V) = ")
Vp=(eta*Vbb)+Vb;
format('v',6)
disp(Vp,"(ii). Peak point voltage,Vp(V) = ")
```

Scilab code Exa 10.2 time period

```
//Example 10.2:
```

```
clc;
clear;
close;
format('v',6)
//given data :
Vbb=20;// in V
C=100;//in micro-farad
R=100;//in kilo-ohms
Vp=10;// in V
eta=Vp/Vbb;// instrinsic stand off ratio
T= ((C*10^-12*R*10^3 *log(1/(1-eta))))*10^7;//in micro-seconds
format('v',6)
disp(T,"time period of the saw  tooth waveform generated is ,(micro-seconds)=")
```

Scilab code Exa 10.3 resistance

```
//Example 10.3:
clc;
clear;
close;
//given data :
eta=0.6;// instrinsic stand off ratio
Rbb=10;// interbase resistance in k-ohm
Rb1=eta*Rbb;
Rb2=Rbb-Rb1;
format('v',4)
disp(Rb1,"Resistance,Rb1(k-ohm) = ")
disp(Rb2,"Resistance,Rb1(k-ohm) = ")
```