Scilab Textbook Companion for Electronics Fundamentals and Applications by D. Chattopadhyay and P. C. Rakshit[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

Basic Ideas Energy Bands In Solids

Scilab code Exa 1.7.1 To find the final velocity of electron

```

//scilab 5.4.1
//windows 7 operating system
//chapter 1:Basic Ideas:Energy Bands In Solids
clc
clear
//given
Ek=1.6*(10^-19)*100;//Ek=final kinetic energy of
    electron in Joules
m0=9.11*(10^-31);//m0=rest mass of the electron in
    kg
//solving final velocity of the electron
v=sqrt((2*Ek)/m0)//v=final velocity of the electron
disp("m/s",v,"v=")
```

Scilab code Exa 1.7.2 To find the velocity and kinetic energy of ion

```
//scilab 5.4.1
//windows 7 operating system
//chapter 1:Basic Ideas:Energy Bands In Solids
clc
clear
//given data
m=7360*9.11*(10^-31);//m=mass of the ion in kg
q=2*1.6*(10^-19);//q=charge of the ion in Coulomb
V=2000;//V=potential difference in Volt
//solving velocity & kinetic energy of the ion
v=sqrt((2*q*V)/m)//v=velocity of the ion
disp("m/s",v,"v=")
Ek=(1/2)*m*(v^2)//Ek=kinetic energy of the ion
disp("J",Ek,"Ek=")
```

Chapter 2

Electron Emission from Solid

Scilab code Exa 2.7.1 to calculate the number of electrons emitted per unit area per second

```

//scilab 5.4.1
//windows 7 operating system
//chapter 2:Electron Emission from Solids
clc
clear
//given
A=6.02*(10^5)//A=thermionic emission constant in A(m^(-2))(K^(-2))
Ew=4.54//Ew=work function in eV
T=2500//T=temperature in Kelvin
kB=1.38*10^(-23)//kB=Boltzmann's constant in J/K
e=1.6*10^(-19)//e=charge of anelectron in C
b=(e*Ew)/kB//b=thermionic emission constant in K
disp("K",b,"b=")
Jx=A*(T^2)*exp(-b/T)//Jx=emission current density in A/m^(2)
disp("A/(m^2)",Jx,"Jx=")
n=Jx/e//n=number of electrons emitted per unit area per second in (m^-2)(s^-1)
```

```
disp("(m^-2)(s^-1)",n,"n=")
```

Scilab code Exa 2.7.2 To find the percentage change in emission current

```

//scilab 5.4.1
//windows 7 operating system
//chapter 2:Electron Emission from Solids
clc
clear
//given
T=2673//T=temperature in Kelvin
dT=10//dT=change in temperature in Kelvin
Ew=4.54//Ew=work function in eV
e=1.6*10^(-19)//e=charge of anelectron in C
kB=1.38*10^(-23)//kB=Boltzmann's constant in J/K
//I=(S*A*(T^2))*exp(-((e*Ew)/(kB*T))//I=emission
    current,S=surface area of the filament,dI=change
    in emission current
d=((2*dT)/T)+(((e*Ew)/(kB*(T^2))*dT))//d=change in
    emission current
disp("",d,"d=")
d*100//percent change in emission current
disp("%",d*100,"d*100=")
```

Scilab code Exa 2.7.3 difference between thermionic work function of the two emitters

```

//scilab 5.4.1
//windows 7 operating system
//chapter 2:Electron Emission from Solids
clc
```

```
clear
//given
kB=1.38*10^(-23)//kB=Boltzmann's constant in J/K
//A=6.02*(10^5)//A=thermionic emission constant in A(m^(-2))(K^(-2))
//Ew1,Ew2=thermionic work function of 2 emitters in eV
e=1.6*10^(-19)//e=charge of anelectron in C
T=2000//T=temperature in Kelvin
//Jx1=A*(T^2)*exp(-(a/(kB*T)))//Jx=emission current density in A/m^(2)
//Jx2=A*(T^2)*exp(-(b/(kB*T)))
//(Jx1/Jx2)=2
//(Jx1/Jx2)=exp((Ew2-Ew1)/(kB*T))
//exp((Ew2-Ew1)/(kB*T))=2
d=(kB*T*log(2))//d=(Ew2-Ew1)=difference in thermionic work functions of 2 emitters
disp("J",d,"d=")
d/e
disp("eV",d/e,"d/e=")
```

Scilab code Exa 2.7.4 to find the anode voltage

```

//scilab 5.4.1
//windows 7 operating system
//chapter 2:Electron Emission from Solids
clc
clear
//given
//Ia=(K*(Va^(3/2)));Ia=space charge limited current,Va=anode voltage,K=proportionality constant
Ia1=300//Ia1=space charge limited current of 1st anode in A
Ia2=200//Ia2=space charge limited current of 2nd
```

```
   anode in A
Va1=200//Va=anode voltage of 1st anode in V
Va2=(Va1*((Ia2/Ia1)^(2/3)))//Va2=anode voltage of 2
   nd anode in V
disp("V",Va2,"Va2=")
```

Chapter 3

PROPERTIES OF SEMICONDUCTORS

Scilab code Exa 3.11.1 To find the conductivity and resistivity

```

//scilab 5.4.1
//WINDOWS 7 Operating System
//chapter 3 PROPERTIES OF SEMICONDUCTORS
//example 1

clc
//Given data
T=300;  //K
ni=1.5*10^16;    //Intrinsic carrier concentartion
   per m^3
yn=0.13;    //Electron mobility in m^2/(V*s)
yp=0.05;   //Hole mobility in m^2/(V*s)
e=1.6*10^-19;   //Charge of electron in C

//Required Formula
Gi=e*ni*(yn+yp);    //Intrinsic conductivity

Ri=1/Gi;    //Intrinsic resistivity
```

```

disp('S/m',Gi,'Intrinsic conductivity=');

disp('ohm*meter',Ri,'Intrinsic resistivity=');
//End
```

Scilab code Exa 3.11.2 To find Concentration of donor atoms

```

//scilab 5.4.1
//WINDOWS 7 Operating Systems
//chapter 3 PROPERTIES OF SEMICONDUCTORS

//example 2
clc
//Given data
Sn=480;      //Conductivity in S/m
yn=0.38;     //Electron mobility in m^2/(V*s)
e=1.6*10^-19;    //Charge of electron in C

//Required Formula
Nd=Sn/(e*yn);    //Concentration of donor atoms per m
   ^3
 disp('m^-3',Nd,'Concentration of donor atoms');
 //End
```

Scilab code Exa 3.11.4 To find intrinsic conductivity and resistance required

```

//scilab 5.4.1
//OS-WINDOWS 7
//chapter 3 PROPERTIES OF SEMICONDUCTORS
```

```
//example 4

clc
//Given data
T=300;  //K
ni=1.5*10^16;     //Intrinsic carrier concentartion
   per m^3
yn=0.13;     //Electron mobility in m^2/(V*s)
yp=0.05;    //Hole mobility in m^2/(V*s)
e=1.6*10^-19;    //Charge of electron in C
l=0.01;     //length in m
a=10^-6;     //cross sectional area in m^2

//Required Formula
Gi=e*ni*(yn+yp);     //Intrinsic conductivity

Ri=l/(Gi*a);     //Required resistance

disp('S/m',Gi,'Intrinsic conductivity=');

disp('ohm',Ri,'required resistance');
//End
```

Scilab code Exa 3.11.5 To find the conductivity and current density of doped sample

```

//scilab 5.4.1
//windows 7 operating system
//chapter 3:Properties of Semiconductors
clc
clear
//given
z=(100/60);//z=conductiarrier concentration in /(m
   ^3)
```

```
ni=2.5*10^(19);//ni=intrinsic conductivity of
    intrinsic material in S/m
//(P/N)=(1/2);//(P/N)=ratio of hole mobility(P) to
    electron mobility(N)
e=1.6*(10^-19);//e=charge of electron in Coulomb
N=(z/(e*ni*(1+(1/2))))
disp("(m^2)/(V.s)",N,"N=")
P=(N/2)
disp("(m^2)/(V.s)",P,"P=")
//Nd+p=Na+n;n=electron concentration;p=hole
    concentration
//np=(ni^2)
Nd=(10^20)//Nd=donor concentration in /(m^3)
Na=5*(10^19)//Na=acceptor concentration in /(m^3)
n=(1/2)*((Nd-Na)+sqrt(((Nd-Na)^2)+(4*(ni^2))))
disp("/(m^3)",n,"n=")
p=(ni^2)/n
disp("/(m^3)",p,"p=")
Z=e*((n*N)+(p*P))//Z=conductivity of doped sample in
     S/m
disp("S/m",Z,"Z=")
F=200//F=applied electric field in V/cm
J=Z*F//J=total conduction current density in A/(m^2)
disp("A/(m^2)",J,"J=")
```

Scilab code Exa 3.11.6 To find the electron and hole concentration and conductivity of doped sample

```

//scilab 5.4.1
//windows 7 operating system
//chapter 3:Properties of Semiconductors
clc
clear
//given
```

```
ni=2.5*10^(19);//ni=intrinsic conductivity of intrinsic material in S/m
Nd=5*(10^19)//Nd=donor concentration in /(m^3)
n=(1/2)*(Nd+sqrt((Nd^2)+(4*(ni^2))))//n=electron concentration
disp("/(m^3)",n,"n=")
p=(ni^2)/n//p=hole concentration
disp("/(m^3)",p,"p=")
N=0.38//N=electron mobility in (m^2)/(V.s)
P=0.18//P=hole mobility in (m^2)/(V.s)
e=1.6*(10^-19)//e=electronic charge in Coulomb
Z=e*((n*N)+(p*P))//Z=conductivity of doped sample in S/m
disp("S/m",Z,"Z=")
```

Scilab code Exa 3.11.7 To find the required wavelength

```

//scilab 5.4.1
//windows 8 operating system
//chapter 3:Properties of Semiconductors
clc
clear
//given
c=3*(10^8);//c=velocity of light in vacuum in m/s
h=6.6*(10^-34);//h=Planck's constant in J.s
Eg=1.98*1.6*(10^-19)//Eg=band gap in J
//calculating Y=required wavelength
Y=((c*h)/Eg)/(10^-9)
disp("nm",Y,"Y=")
```

Scilab code Exa 3.11.8 To find the magnetic and hall field

```

//scilab 5.4.1
//windows 7 operating system
//chapter 3:Properties of Semiconductors
clc
clear
//given
RH=(10^-2);//RH=Hall coefficient in (m^3)/C
VH=(10^-3);//VH=Hall Voltage in V
b=2*(10^-3);//b=width in m
I=(10^-3);//I=current in A
//RH=(VH*b)/(I*B)
B=(VH*b)/(I*RH)//B=magnetic field
disp("T",B,"B=")
t=(10^-3)//t=thickness in m
FH=(VH/t)//FH=Hall field
disp("V/m",FH,"FH=")
```

Chapter 4

Metal Semiconductor Contacts

Scilab code Exa 4.7.1 to find barrier height and depletion region width and maximum electric field

```

//scilab 5.4.1
//windows 7 operating system
//chapter 4:Metal-Semiconductor Contacts
clc
clear
//given
Qm=4.55//Qm=work function of tungsten in eV
X=4.01//X=electron affinity of silicon in eV
eQb=(Qm-X)//eQb=barrier height as seen from the
    metal
disp("eV",eQb,"eQb=")
a=0.21//a=(Ec-Ef)=forbidden gap in eV
eVbi=eQb-a//eVbi=barrier height from semiconductor
    side
disp("eV",eVbi,"eVbi=")
Es=11.7*8.854*(10^-12)//Es=permittivity of
    semiconductor;11.7=dielectric constant of silicon
e=1.6*10^(-19)//e=charge of an electron
Nd=10^22//Nd=donor concentration in m^-3
```

```
W=((2*Es*eVbi)/(e*Nd))^(1/2)//W=width of the depletion region
disp("m",W,"W=")
Fm=((e*Nd*W)/Es)//Fm=maximum electric field in V/m
disp("V/m",Fm,"Fm=")
```

Scilab code Exa 4.7.2 to find the barrier height and concentration

```

//scilab 5.4.1
//windows 7 operating system
//chapter 4:Metal-Semiconductor Contacts
clc
clear
//given
// as per given data barrier height =Vbi=intercept on Vr axis=0.4 V
Es=11.7*8.854*(10^-12)//Es=permittivity of semiconductor;11.7=dielectric constant of silicon
e=1.6*10^(-19)//e=charge of an electron
m=4.4*10^(15)//m=slope of (1/C^2) vs Vr plot of a Schottky contact in(cm^4)(F^-2)(V^-1)
//m=2/(e*Es*Nd)
Nd=(2*10^8)/(e*Es*m)//Nd=donor concentration in silicon in m^-3
disp("m^-3",Nd,"Nd=")
```

Scilab code Exa 4.7.3 to calculate barrier lowering and the position of the maximum barrier height

```

//scilab 5.4.1
//windows 7 operating system
```

```
//chapter 4:Metal-Semiconductor Contacts
clc
clear
//given
e=1.6*10^-19//e=charge of an electron in C
Fa=7*10^6//Fa=reverse bias field in V/m
Es=13.1*8.854*10^-12//(Es/Eo)=13.1;Eo=8.854*10^-12
dQ=((e*Fa)/(4*%pi*Es))^(1/2)//dQ=barrier lowering in V
disp("V",dQ,"dQ=")
Xm=(dQ)/(2*Fa)//Xm=position of the maximum barrier height
disp("m",Xm,"Xm=")
```

Scilab code Exa 4.7.4 to determine the effective richardson constant

```

//scilab 5.4.1
//windows 7 operating system
//chapter 4:Metal-Semiconductor Contacts
clc
clear
//given
//Js=A*(T^2)*exp(-((e*Qbn)/(kB*T)))
kB=1.38*10^(-23)//kB=Boltzmann's constant in J/K
T=300//T=temperature in Kelvin
e=1.6*10^-19//e=charge of an electron in C
Js=6*10^-5//Js=emission current density in A/cm^2
Qbn=0.668//Qbn=barrier height in V
A=(Js/(T^2))*exp((e*Qbn)/(kB*T))//A=Richardson constant
disp("(cm^-2)(K^-2)",A,"A=")
```

Scilab code Exa 4.7.5 to calculate current in a Schottky diode

```

//scilab 5.4.1
//windows 7 operating system
//chapter 4:Metal-Semiconductor Contacts
clc
clear
//given
e=1.6*10^-19//e=charge of an electron in C
V=0.32//V =applied forward bias in V
kB=1.38*10^(-23)//kB=Boltzmann's constant in J/K
T=300//T=Temperature in Kelvin
Js=0.61//Js=reverse saturation current density in A/
    m^2
J=Js*(exp((e*V)/(kB*T))-1)//J=current density in A/m
    ^2
disp("A/m^2",J,"J=")
A=4*10^-8//A=cross sectional area in m^2
I=(J*A)*10^3//I=current
disp("mA",I,"I=")
```

Chapter 5

Semiconductor Junction Diodes

Scilab code Exa 5.7.1 To find the voltage to be applied across the junction

```

//scilab 5.4.1
//windows 7 operating system
//Chapter 5:Semiconductor Junction Diodes
clc
clear
//I=Is*(exp((e*V)/kB*T)-1)
I=50*10^(-3)//I=Forward current in ampere
Is=5*10^(-6)//Is=Reverse saturation current in
   ampere
e=1.6*10^(-19)//e=charge of electron in coulomb
//V=voltage
kB=1.38*10^(-23)//kB=Boltzmann's constant in Joule/
   kelvin
T=300//T=Temperature in kelvin
a=(I/Is)+1
//exp((e*V)/kB*T)=a
V=((kB*T)/e)*log(10^4)
disp("V",V,"V=")
```

Scilab code Exa 5.7.2 To calculate the ratio of current for forward bias to that of reverse bias

```

//scilab 5.4.1
//windows 7 operating system
//chapter 5:Semiconductor Junction Diodes
clc
clear
//given
e=1.6*10^-19//e=charge of an electron in C
V1=0.06//V1=applied forward bias in V
V2=(-0.06)//V2 =applied reverse bias in V
kB=1.38*10^(-23)//kB=Boltzmann's constant in J/K
T=300//T=Temperature in Kelvin
//Is=reverse saturation current in A
//I1=Is*(exp((e*V1)/(kB*T))-1)//I1=current for
   forward bias
//I2=Is*(exp((e*V2)/(kB*T))-1)//I2=current for
   reverse bias
a=((exp((e*V1)/(kB*T))-1))/((exp((e*V2)/(kB*T))-1))
   //a=(I1/I2)
disp("",abs(a),"a")
```

Scilab code Exa 5.7.3 To determine the static and dynamic resistance of the diode

```

//scilab 5.4.1
//windows 7 operating system
//Chapter 5:Semiconductor Junction Diodes
clc
```

```
clear
V=0.9//V=forward bias voltage
I=60*10^(-3)//I=Current in ampere
rdc=(V/I)//rdc=static resistance in ohm
n=2//n=emission coefficient
rac=((26*n*10^(-3))/I)//rac=dynamic resistance
disp("ohm",rdc,"rdc=")
disp("ohm",rac,"rac=")
```

Scilab code Exa 5.7.4 To calculate the increase in the bias voltage

```

//scilab 5.4.1
//windows 7 operating system
//chapter 5:Semiconductor Junction Diodes
clc
clear
e=1.6*10^(-19)//e=charge of an electron in C
kB=1.38*10^(-23)//kB=Boltzmann's constant in J/K
//V,V1=forward bias voltagesin V
n=2//n=emission coefficient for silicon pn junction
    diode
T=300//T=Temperature in kelvin
//Is=Reverse saturation current in A
//I=Is*(exp((e*V)/(n*kB*T)))//I=current for forward
    bias voltage V
//2I=Is*(exp((e*V1)/(n*kB*T)))//2I=current for
    forward bias voltage V1
//exp((e*(V1-V)/(n*kB*T)))=2
a=(((n*kB*T)/e)*log(2))*10^3//a=(V1-V)=increase in
    the bias voltage in V
disp("mV",a,"V1-V")
```

Scilab code Exa 5.7.5 To find the bias voltage of pn junction diode

```
//scilab 5.4.1
//windows 7 operating system
//chapter 5:Semiconductor Junction Diodes
clc
clear
e=1.6*10^(-19)//e=charge of an electron in C
kB=1.38*10^(-23)//kB=Boltzmann's constant in J/K
n=2//n=emission coefficient for silicon pn junction diode
T=300//T=Temperature in kelvin
//Is=Reverse saturation current in A
//V=bias voltage in V
//I=Is*(exp((e*V)/(n*kB*T))-1)//I=reverse current in A
//I=(-(Is/2))
a=(((n*kB*T)/e)*log(1/2))*10^3//a=bias for reverse current in silicon pn junction diode
disp("mV",a,"V")
disp("The negative sign suggests diode in reverse bias")
```

Scilab code Exa 5.7.6 To calculate the rise in temperature

```
//scilab 5.4.1
//windows 7 operating system
//chapter 5:Semiconductor Junction Diodes
clc
clear
//T1,T2=Temperature in kelvin
//Is1=Reverse saturation current at temperature T1 in ampere
```

```
//Is2=Reverse saturation current at temperature T2
    in ampere
//Is2=Is1*2^((T2-T1)/10)
//((T2-T1)/10)*log(2)=log(Is2/Is1)
//b=(Is2/Is1)
b=50
a=((10*log(b))/log(2))//a=(T2-T1)=rise in
    temperature in degree celcius
disp("C",a,"T2-T1")
```

Scilab code Exa 5.7.7 To calculate the maximum permissible battery voltage

```

//scilab 5.4.1
//windows 7 operating system
//chapter 5:Semiconductor Junction Diodes
clc
clear
V=0.6//V=cutin voltage in V
r=150//r=forward resistance in ohm
P=200*(10^-3)//P=maximum power in Watt
//P=(i^2)*r where i=maximum safe diode current
i=(sqrt(P/r))*10^3
disp("mA",i,"i=")
//i=((Vb/3)-V)/3 by applying KCL
Vb=((3*i)+V)*3//Vb=maximum permissible battery
    voltage
disp("V",Vb,"Vb=")
```

Scilab code Exa 5.7.8 To calculate series resistance and the range over which load resistance can be varied

```
//scilab 5.4.1
//windows 7 operating system
//chapter 5:Semiconductor Junction Diodes
clc
clear
V=15//V=supply voltage
Vz=12//Vz=Zener voltage
P=0.36//P=power of Zener diode
//P=Vz*I
I=(P/Vz)//I=maximum allowable Zener current
disp("A",I,"I=")
Vr=V-Vz//Vr=voltage drop across series resistance R
disp("V",Vr,"Vr=")
R=Vr/I//R=series resistance
disp("ohm",R,"R=")
//I=Iz+Il
Iz=2*(10^-3)//Iz=minimum diode current
Il=I-Iz//Il=current through load resistance Rl
disp("A",Il,"Il=")
Rlm=Vz/Il//Rlm=minimum value of Rl
disp("ohm",Rlm,"Rlm=")
disp("The allowable range of variation of Rl is
    428.6ohm<=Rl<infinite")
```

Scilab code Exa 5.7.9 To determine the limits between which the supply voltage can vary

```
//scilab 5.4.1
//windows 7 operating system
//chapter 5:Semiconductor Junction Diodes
clc
clear
V=15//V=supply voltage
```

```
Vz=12//Vz=Zener voltage
P=0.36//P=power of Zener diode
//P=Vz*I
I=(P/Vz)//I=maximum allowable Zener current
disp("A",I,"I=")
Iz=2*10^(-3)//Iz=minimum value attained by the zener
    current
Rl=1000//Rl=load resistance
i=Vz/Rl//i=load current
disp("A",i,"i=")
Imin=Iz+i//Imin=minimum allowable value of current
R=100//R=series resistance
Vr=Imin*R//Vr=voltage drop across R
disp("V",Vr,"Vr=")
Vmin=Vz+Vr//Vmin=minimum value of V
disp("V",Vmin,"Vmin=")
I1=I+i
disp("A",I1,"I1=")
VR=I1*R
disp("V",VR,"VR=")
Vmax=Vz+VR//Vmax=maximum value of V
disp("V",Vmax,"Vmax=")
disp("V can vary between Vmin & Vmax")
```

Scilab code Exa 5.7.10 To find whether power dissipated exceeds the maximum power limit

```

//scilab 5.4.1
//windows 7 operating system
//chapter 5:Semiconductor Junction Diodes
clc
clear
Vz=3//Vz=breakdown voltage of zener diode
Vi=12//Vi=input voltage
```

```
V=[12;-3]//V=[Vi:-Vz]
R1=1000
R2=1000
R3=500//R1,R2,R3=resistances
R=[R1+R2 -R2;-R2 R2+R3]
I1=inv(R)*V//solving this matrix on the basis of
    application of KCL & KVL,we get the values of
    branch currents I & Iz as I1=[I;Iz]
disp("A",I1(1),"I=")
disp("A",I1(2),"Iz=")
Pz=Vz*I1(2)//Pz=power dissipated in zener diode
disp("W",Pz,"Pz=")
disp("Power dissipated does not exceed the maximum
    power limit of 20mW")
```

Scilab code Exa 5.7.11 To determine the range of variation of the output voltage

```

//scilab 5.4.1
//windows 7 operating system
//chapter 5:Semiconductor Junction Diodes
clc
clear
Vs1=15
Vs2=30//Vs=supply voltage varying from 15(Vs1) to
    30(Vs2) Volt
Vzo=9//Vzo=knee voltage
rZ=5//rZ=dynamic resistance in ohms
R=800//R=series resistance in ohms
Izmin=(Vs1-Vzo)/(R+rZ)//Izmin=current through zener
    diode when Vs is 15 V
disp("A",Izmin,"Izmin=")
Vomin=(rZ*Izmin)+Vzo//Vomin=corresponding minimum
    output voltage
```

```
disp("V",Vomin,"Vomin=")
Izmax=(Vs2-Vzo)/(R+rZ)//Izmax=current through zener
    diode when Vs is 30 V
disp("A",Izmax,"Izmax=")
Vomax=(rZ*Izmax)+Vzo//Vomax=corresponding maximum
    output voltage
disp("V",Vomax,"Vomax=")
disp("Output voltage Vo varies in the range Vomin to
    Vomax")
```

Scilab code Exa 5.7.12 To find the value of resistance R

```

//scilab 5.4.1
//windows 7 operating system
//chapter 5:Semiconductor Junction Diodes
clc
clear
V=35//V=supply voltage
Iz=25*10^(-3)//Iz=diode current
Il=5*10^(-3)//Il=load current
Vzo=7//Vzo=knee voltage of zener diode
rZ=6//rZ=dynamic resistance in ohms
Vz=Vzo+(rZ*Iz)//Vz=zener voltage
disp("V",Vz,"Vz=")
I=Iz+Il//I=current through resistance R
disp("A",I,"I=")
R=(V-Vz)/I
disp("ohm",R,"R=")
```

Chapter 6

Diode Circuits

Scilab code Exa 6.11.1 To find various currents voltages power conversion efficiency and percentage regulation

```

//scilab 5.4.1
//windows 7 operating system
//chapter 6:Diode Circuits
clc;
clear;
//given data
Vrms=20;     //in volts
Vm=20*1.41;  //in volts
Rf=50;  //forward resistance in ohms
RL=1200;     //load resistance in ohms

Im=Vm/(Rf+RL);  //peak load current
format("v",7)
disp('A',Im,'Im=');

Idc=Im/%pi;      //dc load current
format("v",8)//to set the current printing format
    with the specified parameter type
disp('A',Idc,'Idc=');
```

```
Irms=Im/2;//rms load current
Irms1=sqrt((Irms^2)-(Idc^2))//rms ac load current
format("v",8)
disp('A',Irms1,'rms ac load current is=');

Vdc=Idc*Rf;      //Dc voltage across the diode
format("v",6)
disp('V',Vdc,'Dc voltage across the diode=');

Pdc=Idc*Idc*RL;      //Dc output power
format("v",6)
disp('W',Pdc,'Dc output power=');

n=40.6/(1+(Rf/RL));      //conversion efficiency
format("v",5)
disp('%',n,'conversion efficiency=');

s=Rf*100/RL;          //Pertcentage regulation
format("v",5)
disp('%',s,'Pertcentage regulation=');

//end
```

Scilab code Exa 6.11.2 To find various currents power ripple voltage percentage regulation and effiiciency of rectification

```

//scilab 5.4.1
//windows 7 operating system
//chapter 6:Diode Circuits
clc;
clear;
//given data
Rf=100; //forward resistance in ohms
```

```
Rl=1000; //load resistance in ohms
n=10;   //Primary to secondary turns ratio
Vp=240; //Primary input V(rms)

Vm=24*(2^(1/2))/2;   //secondary peak voltage from cenre tap
Vs=Vp/n;    //Secondary input voltage
Im=Vm/(Rf+Rl);  //peak current through the resistance in A
Idc=(2*Im)/%pi;  //DC Load current in A
format("v",8)
disp('A',Idc,'DC load current Idc=',);
I=Idc/2;    //Direct current supplied by each diode in A
format("v",7)
disp('A',I,'Direct current supplied by each diode Idc=',);
Pdc=Idc*Idc*Rl; //DC power output
format("v",6)
disp('W',Pdc,'Pdc=');
Irms=Im/(2^(1/2));
Vrp=sqrt((Irms*Irms)-(Idc*Idc))*Rl;   //Ripple voltage in V
format("v",7)
disp('V',Vrp,'Ripple voltage Vrp=');


M=(Rf*100)/Rl;    //percentage regulation
disp('%',M,'Percentage regulation=');
n=81.2/(1+(Rf/Rl));  //Efficiency of rectification
format("v",5)
disp('%',n,'Efficiency of rectification');

//end
```

Scilab code Exa 6.11.3 To calculate the dc load voltage ripple voltage and the percentage regulation

```

//scilab 5.4.1
//windows 7 operating system
//chapter 6:Diode Circuits
clc;
clear;
//given data
Rf=50;  //forward resistance in ohms
Rl=2500; //load resistance in ohms
Vp=30;   //Primary input V(rms)
Vm=30*sqrt(2);

Im=Vm/(2*Rf+Rl);     //peak load current in A
Idc=2*Im/%pi;

Vdc=Idc*Rl;      //DC load voltage
disp('V',Vdc,'Vdc=');
Irms=Im/sqrt(2);
Vrp=Rl*sqrt(((Irms*Irms)-(Idc*Idc)));    //Ripple
    voltage in V
disp('V',Vrp,'Ripple voltage Vrp=');

M=(2*Rf/Rl)*100;     //Percentage regulation
disp('%',M,'Percentage regulation=');

//end
```

Scilab code Exa 6.11.4 To calculate ripple voltage and the percentage ripple

```

//scilab 5.4.1
```

```
//windows 7 operating system
//chapter 6:Diode Circuits
clc;
clear;
//given data

Vdc=20;  //DC value in V
Vpp=1;  //Peak to peak ripple voltage in V

Vp=Vpp/2;   //Peak ripple voltage in V
Vrms=Vp/sqrt(2);    //Vrms voltage in V
S=Vrms/Vdc;     //Ripple Factor
format("v",7)
disp(S,'Ripple factor=')
T=S*100;
format("v",5)
disp("%",T,'Percentage Ripple=')
//end
```

Scilab code Exa 6.11.5 To design a full wave rectifier with L type LC filter

```
//scilab 5.4.1
//Windows 7 operating system
//chapter 6 Diode Circuits
clc
clear
//For a full wave rectifier
//L-type LC filter
f=50//f=line frequency in Hz
w=2*%pi*f
Vdc=10//Vdc=dc output voltage
Idc=100*10^-3//Idc=load current in Amperes
y=0.02//y=allowable ripple factor
//y=sqrt(2)/(12*(w^2)*L*C)
```

```
//Let L*C=a................(1)
a=sqrt(2)/(y*12*(w^2))
RL=Vdc/Idc//RL=load resistance
//Lc=critical inductance
//Lc=RL/(3*w)
//For line frequency of 50Hz,Lc=RL/(300*%pi)
//Lc=RL/950
Lc=RL/950
format("v",4)
L=0.1//Assumed inductance in henry
C=a/L//C=capacitance calculated from equation (1)
format("v",4)
L1=1//Assumed inductance in henry
C1=a/L1//C1=capacitance calculated from equation (1)
format("v",4)
Rb=950*L1//Rb=bleeder resistance for good voltage regulation
disp("The designed values of the components for a full wave rectifier with L-type LC filter are")
disp("ohm",RL,"The load resistance RL is =")
disp("H",Lc,"The critical inductance Lc is =")
disp("H",L,"The inductance L is=")
disp("  F ",C/10^-6,"The capacitance C is")//C is converted in terms of microfarad
//In textbook 957  F  is approximately taken as 600  F
disp("H",L1,"But if the inductance L designed is of the value =")
disp("  F ",C1/10^-6,"the capacitance C will be of the value =")//C1 is converted in terms of microfarad
disp("So,a standard value of 50  F  can be used in practice")
disp("ohm",Rb,"The bleeder resistance Rb for good voltage regulation is=")
disp("As Rb is much greater than RL,little power is wasted in Rb.This reflects the advantage of selecting L>Lc")
```

Chapter 7

Junction Transistor Characteristics

Scilab code Exa 7.13.1 To find the voltage gain and power gain of a transistor

```

//scilab 5.4.1
//windows 7 operating system
//chapter 7:Junction Transistor Characteristics
clc;
clear;
//given data
a=0.99;//a=fraction of the emitter current
    contributed by the carriers injected into the
    base and reaching the collector
Rl=4500;      //Load resistance in ohms
rd=50;       //dynamic resistance in ohms

Av=a*Rl/rd;      //Voltage gain
Ap=a*Av;//Power gain

disp(Av,'Av=');
disp(Ap,'Ap=');
```

Scilab code Exa 7.13.2 To find the base and collector current of a given transistor

```

//scilab 5.4.1
//windows 7 operating system
//chapter 7:Junction Transistor Characteristics
clc;
clear;
//given data
a=0.98;//a=fraction of the emitter current contributed by the carriers injected into the base and reaching the collector
Ie=0.003;   //emitter current in A
Ico=10*10^-6;   //reverse saturation current in A

Ic=a*Ie+Ico;      //collector current in A
format("v",8)
disp('mA',Ic/10^-3,'Ic=');//Ic is converted in terms of mA

Ib=Ie-Ic;       //base current in A
format("v",8)
disp(' A ',Ib/10^-6,'Ib=');//Ib is converted in terms of  A
```

Scilab code Exa 7.13.3 To calculate the emitter and collector current of a given transistor

```

//scilab 5.4.1
```

```
//windows 7 operating system
//chapter 7:Junction Transistor Characteristics
clc;
clear;
//given data
a=0.975;//a=fraction of the emitter current
    contributed by the carriers injected into the
    base and reaching the collector
Ico=10*10^-6;   //reverse saturation current in A
Ib=250*10^-6;   //base current in A

b=a/(1-a);       //transistor gain
disp(b,'gain B=');
Ic=b*Ib+(b+1)*Ico;        //collector current in A
format("v",5)
disp('mA',Ic/10^-3,'Ic=');//Ic is converted in terms
     of mA
Ie=(Ic-Ico)/a;       //emitter current in A
format("v",5)
disp('mA',Ie/10^-3,'Ie=');//Ie is converted in terms
     of mA
```

Scilab code Exa 7.13.4 To calculate the voltage between collector and emitter terminals

```

//scilab 5.4.1
//windows 7 operating system
//chapter 7:Junction Transistor Characteristics
clc;
clear;
//given data
b=125;//b=forward current transfer ratio or dc
    current gain
Vbe=0.6;    //base to emitter voltage in V
```

```
Ib=(10-Vbe)/(310*10^3);      //base current in A
disp('mA',Ib*10^3,'Ib=');
Ic=b*Ib;          //collector current in A
disp('mA',Ic*10^3,'Ic=');
Vce=20-(Ic*5000);        //collector to emitter
    voltage
disp('V',Vce,'Vce=');
```

Scilab code Exa 7.13.5 To check what happens if resistance Rc is indefinitely increased

```
//scilab 5.4.1
//Windows 7 operating system
//chapter 7 Junction Transistor Characteristics
clc
clear
disp("As the base is forward biased,transistor is
    not cut off.")
disp("Assuming the transistor in active region ")
VBB=5//VBB=base bias voltage
VBE=0.7//VBE=voltage between base and emitter
    terminal
RB=220//RB=base circuit resistor in kilo ohms
IB=(VBB-VBE)/RB//IB=base current in mA(By applying
    Kirchhoff's voltage law)
format("v",7)
disp("mA",IB,"IB=")
disp("Ico<<IB")//Ico=reverse saturation current and
    is given as 22nA
B=100//B=dc current gain
IC=B*IB
format("v",5)
disp("mA",IC,"IC=")
Vcc=12//Vcc=collector supply voltage
```

```
Rc=3.3//Rc=collector circuit resistor in kilo ohms
VCB=Vcc-(IC*Rc)-VBE//VCB=voltage between collector
    and base terminal (by applying Kirchhoff's
    voltage law to the collector circuit)
disp("V",VCB,"VCB=")
disp("A positive value of VCB implies that for n-p-n
     transistor,the collector junction is reverse
    biased and hence the transistor is actually in
    active region")
IE=-(IB+IC)//IE=emitter current
disp("mA",IE,"IE=")
format("v",7)
disp("The negative sign indicates that IE actually
    flows in the opposite direction.")
disp("IB and IC do not depend on the collector
    circuit resistance Rc.So if it is increased, at
    one stage VCB becomes negative and transistor
    goes into saturation region ")
```

Scilab code Exa 7.13.6 To check whether transistor is operating in the saturation region for the given hFE

```
//scilab 5.4.1
//Windows 7 operating system
//chapter 7 Junction Transistor Characteristics
clc
clear
disp("Applying Kirchhoff voltage law to the base &
    collector circuit respectively")
//(R1*IB)+VBE+(RE*(Ic+IB))=VBB..........(1)
//(R2*Ic)+VCE+(RE*(Ic+IB))=Vcc..........(2)
R1=47//R1=value of base circuit resistance in kilo
    ohms
RE=2.2//RE=emitter circuit resistance in kilo ohms
R2=3.3//R2=collector circuit resistance in kilo ohms
```

```
VBE=0.85//VBE=voltage between base and emitter
    terminals
VBB=5//VBB=base supply voltage
Vcc=9//Vcc=collector supply voltage
VCE=0.22//VCE=voltage between collector and emitter
    terminals
R=[(R1+RE) RE;RE (R2+RE)];
V=[(VBB-VBE);(Vcc-VCE)];
I=inv(R)*V
disp("mA",I(1),"IB=")
disp("mA",I(2),"IC=")
hFE=110//hFE=dc current gain
disp("The minimum base current required for
    saturation is")
IBmin=I(2)/hFE
disp("mA",IBmin,"IBmin=")
if (I(1)<IBmin) then
    disp("As IB<IBmin transitor is not in the
        saturation region.It must be in the active
        region.")
end
```

Scilab code Exa 7.13.7 To calculate the output resistance along with the current gain

```
//scilab 5.4.1
//Windows 7 operating system
//chapter 7 Junction Transistor Characteristics
clc
clear
IB=(30*10^-3)//IB=base current (in mA) of transistor
    in CE mode
IC1=3.5
IC2=3.7
VCE1=7.5
```

```
VCE2=12.5//IC1 and IC2 are the change found in collector current IC in mA when collector emitter voltage VCE changes from VCE1 to VCE2(in volts)
VCE=VCE2-VCE1
IC=IC2-IC1
disp("Output resistance is")
Ro=VCE/IC
disp("kilo ohm",Ro,"The output resistance is =")
b=IC2/IB//b=forward current transfer ratio or dc current gain
disp(b,"b=")
a=b/(b+1)//a=fraction of the emitter current contributed by the carriers injected into the base and reaching the collector
//b=a/(1-a) Hence a=b/(b+1)
disp(a,"a=")
```

Scilab code Exa 7.13.8 To find the resistance R1 R2 and the range of RL

```
//scilab 5.4.1
//Windows 7 operating system
//chapter 7 Junction Transistor Characteristics
clc
clear
b=100//b=forward current transfer ratio or dc current gain
Vz=4//Vz=Zener diode voltage
IL=2//IL=load current in mA
Iz=5//Iz=Zener current in mA
VCC=12//VCC=collector supply voltage
VEB1=0.7
VEB2=VEB1//VEB1,VEB2=emitter-to-base voltage for both transistors Q1 and Q2 respectively
//Since IL is the collector current of transistor Q1
IB=IL/b//IB=base current of transistor Q1
```

```
IE=IB+IL//IE=emitter current of transistor Q1
VR1=VCC-VEB2-Vz//VR1=voltage drop across resistor R1
R1=VR1/(IB+Iz)
format("v",5)
disp("kilo ohm",R1,"The resistance R1 is =")
VR2=VEB2+Vz-VEB1//VR2=voltage drop across resistor R2
R2=VR2/IE
format("v",5)
disp("kilo ohm",R2,"The resistance R2 is =")
//VBC=VCC-VR2-VEB1-(IL*RL) where VBC=base-collector voltage drop for transistor Q1
//VBC=7.3-(2*RL) where RL=load resistance for transistor Q1 in terms of kilo ohm
disp("For Q1 to remain in the active region,VBC 0, i.e.")
disp("RL (7.3/2) kilo ohm")
disp("RL 3.65 kilo ohm")
disp("So the range of RL for Q1 to remain in the active region is 0 RL 3.65 kilo ohm")
```

Chapter 8

Junction Transistors Biasing and Amplification

Scilab code Exa 8.14.1 To find the Q point and stability factors

```

//scilab 5.4.1
//windows 7 operating system
//chapter 8:Junction Transistors:Biasing and
   Amplification
clc;
clear;
//given data
b=99;
Vbe=0.7;     //Volatge between base and emitter in V
Vcc=12;      //Volatge source applied at collector in
    V4
Rl=2*10^3;       //load resistance in ohms
Rb=100*10^3;        //Resistance at base in ohms
Ib=(12-0.7)/((100*Rl)+Rb);         //Base current in
   micro Ampere
format("v",7)
disp('mA',Ib*10^3,'Ib=');

```

```
Ic=b*Ib;
format("v",7)
disp('mA',Ic*10^3,'Ic=');
Vce=4.47;          //Voltage between collector and emitter in V

S=(b+1)/(1+b*Rl/(Rl+Rb));         //stabilty factor 1
disp(S,'S=');
S1=b/(Rb+Rl*(1+b));       //stabilty factor 2 in A/V
disp('A/V',S1,'S1=');
S2=(Vcc-Vbe-(Ic*Rl))/(Rb+Rl*(1+b));         //stability factor 3 in A
disp('A',S2,'S2=');
```

Scilab code Exa 8.14.2 To find the resistances R1 R2 and Re

```
//scilab 5.4.1
//windows 7 operating system
//chapter 8:Junction Transistors:Biasing and Amplification
clc;
clear;
//given data
b=49;//b=dc current gain of the common emitter transistor
Vbe=0.2;     //Volatge between base and emitter in V
Vcc=10;      //Volatge source applied at collector in V4
Vce=5;       //Collector to emitter voltage in V
Ic=4.9;      //collector current in mA
Rl=1;       //load resistance in kilo ohms
S=10;        //stability factor

Ib=Ic/b;     //base current in mA
```

```
Re=((Vcc-Vce-(Ic*Rl))/(Ic+Ib))*1000;          //Resistance at emitter in ohms
disp('ohms',Re,'Re=');
//S=((1+b)*(1+(RT/Re)))/(1+b+(RT/Re))
RT=((S-1)*Re)/(1-(S/(1+b)))//RT=Thevenin resistance=(R1*R2)/(R1+R2)
VT=(Ib*(10^-3)*RT)+Vbe+((Ib+Ic)*(10^-3)*Re)//VT=Thevenin voltage=(R2*Vcc)/(R1+R2)
// R2/(R1+R2)=VT/Vcc
R1=(RT*Vcc)/VT
format("v",6)
disp("kilo ohm",R1/10^3,"R1=")
R2=((VT/Vcc)*R1)/(1-(VT/Vcc))
disp("ohm",R2,"R2=")
```

Scilab code Exa 8.14.3 To calculate the input and output resistances and current voltage and power gain

```

//scilab 5.4.1
//windows 7 operating system
//chapter 8:Junction Transistors:Biasing and Amplification
clc;
clear;
//given data
hib=30;     //h parameter of CB a transistor
hrb=4*10^-4;         //h parameter of CB a transistor
hfb=-0.99;         //h parameter of CB a transistor
hob=0.9*10^-6;          //h parameter of CB a transistor in S
Rl=6*10^3;        //Load resistance in ohms

AI=-hfb/(1+(hob*Rl));          //Current gain
disp(AI,'AI=');
```

```

Ri=hib-((hfb*hrb*Rl)/(1+(hob*Rl)));     //Input resistance in ohms
disp('ohms',Ri,'Ri=');

Ro=hib/((hib*hob)-(hfb*hrb));        //Output Resistance in kohms
disp('kilo ohms',Ro*10^-3,'Ro=');

AV=AI*Rl/Ri;          //Voltage gain
disp(AV,'AV=');

AP=AI*AV;         //Power gain
disp(AP,'AP=');
```

Scilab code Exa 8.14.4 To find the input and output resistance

```

//scilab 5.4.1
//windows 7 operating system
//chapter 8:Junction Transistors:Biasing and Amplification
clc;
clear;
//given data
Rg=1*10^3;       //internal resistance in ohms
Rl=20*10^3;      //Load resistance in ohms
hie=1*10^3;      //h parameter of the transistor in terms of ohms
hre=2.5*10^-4;      //h parameter of the transistor
hfe=150;      //h parameter of the transistor
hoe=1/(40*10^3);       //h parameter of the transistor in terms of mho

AI=(-hfe)/(1+(hoe*Rl));       //Current gain
```

```
disp(AI,'AI=');

Ri=hie+(AI*hre*Rl);        //input resistance in ohms
disp('ohms',Ri,'Ri=');
Ro=(Rg+hie)/((Rg*hoe)+(hie*hoe)-(hfe*hre));        //output resistance in ohms
disp('kilo ohms',Ro*10^-3,'Ro=');
```

Scilab code Exa 8.14.5 To find the current amplification and voltage and power gains

```

//scilab 5.4.1
//windows 7 operating system
//chapter 8:Junction Transistors:Biasing and Amplification
clc;
clear;
//given data
Rl=5*10^3;       //Load resistance in ohms
hie=1*10^3;      //h parameter of the transistor in terms of ohms
hre=5*10^-4;       //h parameter of the transistor
hfe=100;       //h parameter of the transistor
hoe=25*10^-6;        //h parameter of the transistor in terms of mho
Rg=1*10^3;        //source reistance in ohms

AI=(-hfe)/(1+(hoe*Rl));        //Current gain
disp(AI,'AI=');

Ri=hie+(AI*hre*Rl);        //input resistance in ohms
disp('ohms',Ri,'Ri=');

AVo=AI*Rl/(Rg+Ri);        //Overall voltage gain
```

```
   including source resistance
disp(AVo,'AVo=');

APo=AVo*AI;      //Overall voltage gain including
   source resistance
disp(APo,'APo=');
```

Scilab code Exa 8.14.6 To determine the current and voltage gain as well as the input and output resistances

```

//scilab 5.4.1
//windows 7 operating system
//chapter 8:Junction Transistors:Biasing and
   Amplification
clc;
clear;
//given data
hoe=25*10^-6;        //h parameter in A/V
hie=4000;        //h paramater in ohms
hfe=135;         //h paramater of transistor
hre=7*10^-4;         //h paramater of transistor
Re=100;      //emitter resistance in ohms
Rl=3*10^3;       //Load resistance in ohms

//Here hoe*Rl is less than 0.1. So we can simplify
   the circuit and according to it the current gain
   is AI=Ic/Ib. here Ic=-hfe*Ib.

AI=-hfe;         //current gain
disp(AI,'AI=');

Ri=hie+(1+hfe)*Re;       //input resistance in ohms
disp('kilo ohms',Ri*10^-3,'Ri=');

```

```
AV=AI*Rl/Ri;          //voltage gain
disp(AV,'AV=');

disp("The output resistance of the transistor
   excluding RL is infinite.")
disp("kilo ohm",Rl/10^3,"The output resistance of
   the transistor including RL is =.")
```

Scilab code Exa 8.14.7 To determine the input and output resistances as well as the voltage gain and Q point

```

//scilab 5.4.1
//windows 7 operating system
//chapter 8:Junction Transistors:Biasing and
   Amplification
clc;
clear;
//given data

hfe=100;          //h parameter of transistor
hie=560;          //h parameter of transistor in ohms
Rc=2*10^3;        //collector resistance in ohms
Re=10^3;          //emitter resistance in ohms
Rb=600*10^3;          //Base resistance in ohms

//Since hoe is neglected we can use the simplified
   equivalent circuit hence the Ri is

Ri=hie+(1+hfe)*Re;        //Input resistance in ohms
disp('kilo ohms',Ri*10^-3,'Ri=');

Rib=(Ri*Rb)/(Ri+Rb);          //Input resistance
   including Rb in ohms
disp('kilo ohms',Rib*10^-3,'Input resistance (
```

```
    including Rb)=');

disp("The output resistance excluding load is
    infinita")
Ro=Rc;
disp(" kilo ohms",Ro*10^-3,"Output resistance
    including load =")

AV=-(hfe*Ro)/(hie+((1+hfe)*Re));          //voltage
    gain
disp(AV,'AV=');
disp("Small signals are used,since otherwise the
    output waveform will be distorted.Also,the
    equivalent circuit will not hold.")

//Taking DC emitter current and collector current
    nearly equal

Ib=20/(Rb+Re*101);        //base current in mA
disp('mA',Ib*10^3,'Ib=');

disp("The Q-point is defined by")
Ic=hfe*Ib;        //collector current in mA
disp('mA',Ic*10^3,'Ic=');

VCE=20-(3*Ic*10^3)
disp('V',VCE,'VCE=');
```

Scilab code Exa 8.14.8 To design a CE transistor amplifier

```
//scilab 5.4.1
//Windows 7 operating system
//chapter 8 Junction Transistors:Biasing and
    Amplification
clc
```

```
clear
//For a CE transistor amplifier circuit with self-bias
f=1000//f=frequency in Hz
AV=-200//AV=voltage gain
hfe=100//hfe=current gain
hie=1//hie=input impedance in kilo ohms
Pcmax=75*10^-3//Pcmax=maximum collector dissipation in Watt
//hre and hoe are to be neglected
VCC=12//VCC=collector supply voltage
//AV=-(hfe*RL)/hie where RL is the load resistance
RL=-(AV*hie)/hfe
format("v",5)
disp("The designed values of the components of a CE transistor amplifier are:")
disp("kilo ohm",RL,"The load resistance RL is =")
//For the amplifier to be linear,the quiescent point is chosen to lie in the middle of the DC load line
VCG=VCC/2  //VCG=DC collector to ground voltage
//VCC=(IC*RL)+VCG where IC=DC collector current
IC=(VCC-VCG)/RL
format("v",5)
disp("mA",IC,"Ihe DC collector current is =")
Pr=(IC^2)*RL//Pr=power dissipation in RL
//Pc=the collector dissipation is set at 14.5 mW which is below the value of Pcmax
//Pc=VCE*IC
Pc=14.5
VCE=Pc/IC//VCE=collector-to-emitter voltage drop
format("v",4)
VEG=VCG-VCE//VEG=DC voltage drop across resistance Re
IE=IC//IE=emitter current
Re=VEG/(IC)
disp("ohm",Re*1000,"The resistance Re is =")//Re is converted in terms of ohms
```

```
Pe=(IC^2)*Re//Pe=power dissipation in Re
VBE=0.7//VBE=assumed DC base-to-emitter voltage drop
VBG=VBE+(IE*Re)//VBG=DC voltage across resistance R2
//VT=(VCC*R2)/(R1+R2) where VT=Thevenin equivalent voltage
//RT=(R1*R2)/(R1+R2).............(1) where RT=Thevenin equivalent resistance
//VBG=VT-(IB*RT)
//VBG=((VCC*R2)/(R1+R2))-(IB*((R1*R2)/(R1+R2)))...................(2)
//Let (R2/(R1+R2))=x ..............(3)
x=VBG/VCC//neglecting the second term on the right hand side of equation (2)
a=(1-x)/x    //a=R1/R2
//S=((1+b)*(1+RT/Re))/(1+b+(RT/Re)) where S=stability factor and b=current gain=hfe
//b>>1 hence S=(hfe*(1+RT/Re))/(1+b+(RT/Re))
//For good stability we choose S=hfe/20
RT=((hfe-20)/19)*Re
R1=RT/x//from equation (1) and (3)
format("v",5)
disp("kilo ohm",R1,"The resistance R1 is=")
R2=R1/5.33
format("v",4)
disp("kilo ohm",R2,"The resistance R2 is =")
Pr2=(VBG^2)/R2//Pr2=power dissipation in R2
Pr1=((VCC-VBG)^2)/R1 //Pr1=power dissipation in R1
Ce=1/(2*%pi*f*((Re*1000)/10))//Ce=bypass capacitor
format("v",2)
disp("micro farad",Ce/10^-6,"The bypass capacitance Ce is =")//Ce is converted in terms of micro farad
C1=2/(2*%pi*f*100)//C1=coupling capacitor
format("v",4)
disp("micro farad",C1/10^-6,"The coupling capacitance C1 is =")//C1 is converted in terms of micro farad
Rin=20*1000//Rin=assumed input impedance in ohms
```

```
C2=1/(2*%pi*f*0.1*Rin)//C2=coupling capacitor
format("v",4)
disp("micro farad",C2/10^-6,"The coupling
    capacitance C2 is =")//C2 is converted in terms
    of micro farad
```

Scilab code Exa 8.14.9 To find the resistance R1

```
//scilab 5.4.1
//Windows 7 operating system
//chapter 8 Junction Transistors:Biasing and
    Amplification
clc
clear
VCC=12//VCC=collector supply voltage
a=0.98//a=dc current gain of the common base
    transistor
VBE=0.7//VBE=base emitter voltage
IE=2//IE=emitter current in mA
//Ico is to be neglected
b=a/(1-a)//b=dc current gain of the common emitter
    transistor
//IC=b*IB where IC=collector current and IB=base
    current
//IE=IC+IB
//IE=(b+1)*IB
IB=IE/(b+1)
IC=b*IB
RE=0.1//RE=resistance in kilo ohms connected to the
    emitter terminal
R2=20//R2=resistance in kilo ohms
RC=3.3//RC=resistance in kilo ohms connected to the
    collector terminal
//Let I be the current in the resistance R2
//Applying Kirchhoff's voltage law in the base-
```

```
    emitter circuit
//VBE+(RE*IE)=R2*I
I=(1/R2)*(VBE+(RE*IE))
//Applying Kirchhoff's voltage law
//((I+IB+IC)*RC)+((I+IB)*R1)+(I*R2)=VCC
R1=(VCC-((I+IB+IC)*RC)-(I*R2))/(I+IB)
format("v",5)
disp("kilo ohm",R1,"The resistance R1 is =")
```

Scilab code Exa 8.14.10 To find the quiescent values of IE and VCE

```
//scilab 5.4.1
//Windows 7 operating system
//chapter 8 Junction Transistors:Biasing and
    Amplification
clc
clear
VBE=0.7//VBE=base emitter voltage
b=90//b=dc current gain of the common emitter
    transistor
VCC=10//VCC=collector supply voltage
RE=1.2//RE=resistance in kilo ohms connected to the
    emitter terminal
RC=4.7//RC=resistance in kilo ohms connected to the
    collector terminal
RB=250//RB=resistance in kilo ohms connected to the
    base terminal
//Applying Kirchhoff's voltage law
//VCE=(RB*IB)+VBE where VCE=collector emitter
    voltage
//Also VCC=((IB+IC)*RC)+VCE+(IE*RE)
//IC=b*IB where IC=collector current and IB=base
    current
//IE=IC+IB where IE=emitter current
//IE=(b+1)*IB
```

```
IB=(VCC-VBE)/(((b+1)*(RC+RE))+RB)
format("v",6)
IE=(b+1)*IB
format("v",5)
VCE=(RB*IB)+VBE
format("v",5)
IC=b*IB
format("v",5)
disp("mA",IE,"The quiescent value of IE is =")
disp("V",VCE,"The quiescent value of VCE is =")
disp("mA",IC,"When dc current gain=90,IC=")
//b is increased by 50%
b1=((50*b)/100)+b
IB1=(VCC-VBE)/(((b1+1)*(RC+RE))+RB)
IC1=b1*IB1
disp("mA",IC1,"When dc current gain is increased by
    50%,IC=")
x=((IC1-IC)/IC)*100//x=increase in the collector
    current
disp("%",x,"The increase in the collector current IC
     is =")
disp("The percentage increase of IC being less than
    that of the dc current gain,the circuit provides
    some stabilization against the changes in the dc
    current gain.")
disp("VCE does not depend on dc current gain and
    hence it is not affected when the dc current gain
     changes.")
```

Scilab code Exa 8.14.11 To calculate the quiescent values of IB IC IE and VCE

```
//scilab 5.4.1
//Windows 7 operating system
//chapter 8 Junction Transistors:Biasing and
```

```
Amplification
clc
clear
VBE=0.7//VBE=base emitter voltage
b=99//b=dc current gain of the common emitter transistor
VCC=15//VCC=collector supply voltage
RE=7//RE=resistance in kilo ohms connected to the emitter terminal
RC=4//RC=resistance in kilo ohms connected to the collector terminal
RB=5//RB=resistance in kilo ohms connected to the base terminal
VEE=(-15)//VEE=emitter supply voltage
//Applying Kirchhoff's voltage law in the base emitter loop
//-VEE=(RB*IB)+VBE +(IE*RE)
//IC=b*IB where IC=collector current and IB=base current
//IE=IC+IB where IE=emitter current
//IE=(b+1)*IB
IB=(-VEE-VBE)/(RB+((b+1)*RE))
format("v",7)
disp("mA",IB,"The quiescent value of IB is =")
IC=b*IB
format("v",5)
disp("mA",IC,"The quiescent value of IC is =")
IE=(b+1)*IB
format("v",5)
disp("mA",IE,"The quiescent value of IE is =")
//Applying Kirchhoff's voltage law in the output circuit
//(IC*RC)+VCE+(IE*RE)=VCC-VEE
VCE=(VCC-VEE)-(IE*RE)-(IC*RC)
format("v",5)
disp("V",VCE,"The quiescent value of VCE is =")
//b is increased by 20%
b1=((20*b)/100)+b
```

```
IB1=(-VEE-VBE)/(RB+((b1+1)*RE))
format("v",10)
IC1=b1*IB1
format("v",6)
disp("mA",IC1,"When dc current gain is increased by 20%,IC=")
x=((IC1-IC)/IC)*100//x=increase in the collector current
disp("%",x,"The increase in the collector current IC is =")
disp("Since a 20% increase in current gain produces a mere 0.284% enhancement of IC,the circuit provides a good stabilization against the changes in the current gain")
//In textbook the increase in the collector current is given as 0.5% which is actually coming as 0.284% approximately
```

Scilab code Exa 8.14.12 To determine the operating point

```
//scilab 5.4.1
//Windows 7 operating system
//chapter 8 Junction Transistors:Biasing and Amplification
clc
clear
//For a self-bias circuit
VBE=0.7//VBE=base emitter voltage
b=100//b=dc current gain of the common emitter transistor
VCC=22//VCC=collector supply voltage
R1=82//R1=resistance in kilo ohms
R2=16//R2=resistance in kilo ohms
RL=2.2//RL=load resistance in kilo ohms
Re=0.750//Re=resistance in kilo ohms connected to
```

```
   the emitter terminal
//ICO is to be neglected
VT=(R2*VCC)/(R1+R2)//VT=Thevenin equivalent voltage
RT=(R1*R2)/(R1+R2)//RT=Thevenin equivalent
   resistance
//Applying Kirchhoff's voltage law to the base
   circuit
//(IB*(RT+Re))+(IC*Re)=VT-VBE
//IC=b*IB
IB=(VT-VBE)/(RT+Re+(b*Re))//IB=base current
IC=b*IB//IC=collector current
format("v",8)
//Applying Kirchhoff's voltage law to the collector
   circuit
//(IC*(RL+Re))+(IB*Re)+VCE=VCC
VCE=VCC-((IC*(RL+Re))+(IB*Re))//VCE=collector
   emitter voltage
format("v",5)
disp("The operating point is specified by")
disp("mA",IC,"IC=")
disp("V",VCE,"VCE=")
```

Scilab code Exa 8.14.13 To determine the operating point

```
//scilab 5.4.1
//Windows 7 operating system
//chapter 8 Junction Transistors:Biasing and
   Amplification
clc
clear
RE=0.680//RE=resistance in kilo ohms connected to
   the emitter terminal
RC=2.7//RC=resistance in kilo ohms connected to the
   collector terminal
//RB=resistance connected to the base terminal
```

```
VCE=7.3//VCE=collector emitter voltage
VBE=0.7//VBE=base emitter voltage
Vre=2.1//Vre=voltage across RE resistance
IB=0.02//IB=base current in mA
IE=Vre/RE//IE=emitter current in mA
IC=IE-IB//IC=collector current in mA
b=IC/IB//b=current gain
format("v",6)
disp(b,"The current gain    is =")
VCC=(IC*RC)+VCE+Vre//VCC=collector supply voltage
format("v",5)
disp("V",VCC,"The collector supply voltage VCC is ="
   )
//Voltage across RB (Vrb)resistance is given by
Vrb=VCC-(VBE+Vre)
RB=Vrb/IB
format("v",5)
disp("kilo ohm",RB,"The resistance RB is =")
//To draw the DC load line,we neglect the base
   current in RE resistance
//Equation for DC load line is:
//VCE=VCC-(RC+RE)*IC
disp("For the DC load line")
disp("V",VCC,"The intercept of the load line on the
   VCE-axis(X-axis) is =")
disp("mA",VCC/(RC+RE),"The intercept of the load
   line on the IC axis(Y-axis) is =")
disp("The DC load line is the straight line joining
   above two intercepts.")
disp("The co-ordinates of the operating point Q on
   the load line are (7.3V,3.07mA)")
```

Scilab code Exa 8.14.14 To determine the ac as well as dc load line and the amplitude of the output voltage

```
//scilab 5.4.1
//Windows 7 operating system
//chapter 8 Junction Transistors:Biasing and Amplification
clc
clear
VBE=0.7//VBE=base emitter voltage
b=120//b=dc current gain of the common emitter transistor
VCC=15//VCC=collector supply voltage
R1=72//R1=resistance in kilo ohms
R2=8//R2=resistance in kilo ohms
RL=2//RL=load resistance in kilo ohms
Re=0.700//Re=resistance in kilo ohms connected to the emitter terminal
RC=2//RC=resistance in kilo ohms connected to the collector terminal
Rin=1.5//Rin=input resistance in kilo ohms of the amplifier
vi=1//vi=amplitude of the ac input signal in mV
VT=(R2*VCC)/(R1+R2)//VT=Thevenin equivalent voltage
RT=(R1*R2)/(R1+R2)//RT=Thevenin equivalent resistance
//Applying Kirchhoff's voltage law to the base circuit
//(IB*(RT+Re))+(IC*Re)=VT-VBE
//IC=b*IB
IB=(VT-VBE)/(RT+Re+(b*Re))//IB=base current
IC=b*IB//IC=collector current
format("v",5)
//Applying Kirchhoff's voltage law to the collector circuit
//(IC*(RL+Re))+(IB*Re)+VCE=VCC
VCE=VCC-((IC*(RL+Re)))//VCE=collector emitter voltage(neglecting small term IB*RE)
format("v",5)
//Equation for DC load line is:
//VCE=VCC-(RL+Re)*IC
```

```
disp(" 1. For the DC load line")
disp("The operating point Q is specified by")
disp("mA",IC,"IC=")
disp("V",VCE,"VCE=")
disp("V",VCC,"The intercept of the dc load line on
    the VCE-axis(X-axis) is =")
disp("mA",VCC/(RC+Re),"The intercept of the dc load
    line on the IC axis(Y-axis) is =")
disp("The DC load line is the straight line joining
    above two intercepts.")
Rac=(RL*RC)/(RL+RC)//Rac=ac load resistance
disp(" 2. For the AC load line")
disp("V",VCE+(IC*Rac),"The intercept of the ac load
    line on the VCE-axis(X-axis) is =")
disp("The line joining the above intercept and the
    operating point Q extended to meet the IC axis(Y-
    axis) gives the AC load line")
AV=-(b*Rac)/Rin//AV=voltage gain of the amplifier
vo=abs(AV)*vi//vo=amplitude of the output voltage
    signal
disp("mV",vo," 3. The amplitude of the output
    voltage vo is =")
```

Chapter 9

Basic Voltage and Power Amplifiers

Scilab code Exa 9.12.1 To determine the lower and upper half power frequencies

```
//scilab 5.4.1
//Windows 7 operating system
//chapter 9 Basic Voltage and Power Amplifiers
clc
clear
AVm=120//AVm=mid-band gain of an RC-coupled
    amplifier
fm=100//fm=frequency in Hz corresponding to the mid-
    band gain
AVl=60//AVl=reduced gain
AVh=AVl
f=100*10^3//f=frequency in Hz corresponding to the
    reduced gain
//|AVl|=(|AVm|)/sqrt(1+(fl/fm)^2) where fl=lower
    half power frequency
fl=sqrt((abs(AVm)/abs(AVl))^2 -1)*fm
format("v",6)
disp("Hz",fl,"The lower half-power frequency is =")
```

```
//|AVh|=(|AVm|)/sqrt(1+(f/fh)^2) where fh=upper half
    power frequency
fh=f/sqrt((abs(AVm)/abs(AVh))^2 -1)
format("v",5)
disp("kHz",fh/10^3,"The upper half-power frequency
    is =")//fh is converted in terms of kHz
```

Scilab code Exa 9.12.2 To determine the lower and upper half power frequencies

```
//scilab 5.4.1
//Windows 7 operating system
//chapter 9 Basic Voltage and Power Amplifiers
clc
clear
//For two identical transistors employed by an RC-
    coupled amplifier
hfe=100//hfe=current gain
hie=2*10^3//hie=input impedance in ohm
Cob=2*10^-12//Cob=capacitance in farad quoted by the
    transistor manufacturers
C=0.4*10^-6//C=coupling capacitance in farad
RL=8*10^3//RL=load resistance in ohms for each
    transistor
CW=10*10^-12//CW=wiring capacitance in farad
fl=1/(2*%pi*C*(hie+RL))//fl=lower half power
    frequency
format("v",5)
disp("Hz",fl,"The lower half-power frequency is =")
hfb=-hfe/(1+hfe)//hfb=current gain for common base
    transistor
Coc=Cob/(1+hfb)//Coc=transistor collector
    capacitance in farad
Cs=Coc+CW//Cs=shunt capacitance in farad
Ro=(hie*RL)/(hie+RL)//Ro=equivalent resistance of
```

```
the parallel combination of hie and RL
fh=1/(2*%pi*Cs*Ro)//fh=upper half power frequency
format("v",5)
disp("kHz",fh/10^3,"The upper half-power frequency is =")//fh is converted in terms of kHz
```

Scilab code Exa 9.12.3 To find the gain relative to the mid frequency gain

```
//scilab 5.4.1
//Windows 7 operating system
//chapter 9 Basic Voltage and Power Amplifiers
clc
clear
//AVm=mid-band gain of an RC-coupled amplifier
fm=60//fm=frequency in Hz corresponding to the mid-band gain
//AVl=reduced gain
//AVh=AVl
f=600*10^3//f=frequency in Hz corresponding to the reduced gain
fl=30// fl=The lower half-power frequency in Hz
fh=300*10^3//fh=The upper half-power frequency in Hz
//|AVl|=(|AVm|)/sqrt(1+(fl/fm)^2)
//Suppose (AVl/AVm)=a=low frequency gain with respect to the mid frequency gain
//a=1/sqrt(1+(fl/fm)^2)//a=magnitude of the low frequency gain
a=1/sqrt(1+(fl/fm)^2)
format("v",5)
o=atand(fl/fm)//o=phase angle in degree of the low frequency gain
format("v",5)
disp("For the low frequency gain with respect to the mid frequency gain ")
disp(a,"Magnitude=")
```

```
disp("degree",o,"Phase angle=")
//|AVh|=(|AVm|)/sqrt(1+(f/fh)^2)
//Suppose (AVh/AVm)=b=high frequency gain with respect to the mid frequency gain
//b=1/sqrt(1+(f/fh)^2)//b=magnitude of the high frequency gain
b=1/sqrt(1+(f/fh)^2)
format("v",6)
O=-atand(f/fh)//O=phase angle in degree of the high frequency gain
format("v",6)
disp("For the high frequency gain with respect to the mid frequency gain ")
disp(b,"Magnitude=")
disp("degree",O,"Phase angle=")
```

Scilab code Exa 9.12.4 To calculate the output power

```
//scilab 5.4.1
//Windows 7 operating system
//chapter 9 Basic Voltage and Power Amplifiers
clc
clear
//In a CE class A power amplifier
RL=12//RL=load resistance in ohms
n=8//n=primary-to-secondary turns ratio of a transformer
//Peak-to-peak swing of the signal current is 250mA
Im=(250*10^-3)/2//Im=ac collector current in Ampere
RL1=(n^2)*RL//RL1=RL'=resistance reflected to the primary for the resistance RL in presence of an ac signal
//Pac=(1/2)*Vm*Im where Pac=ac output power
//Pac=(1/2)*(Im^2)*RL1
Pac=(1/2)*(Im^2)*RL1
```

```
disp("W",Pac,"The output power is =")
```

Scilab code Exa 9.12.5 To calculate dc input and ac output power along with the collector dissipation and the efficiency

```
//scilab 5.4.1
//Windows 7 operating system
//chapter 9 Basic Voltage and Power Amplifiers
clc
clear
VCQ=6//VCQ=quiescent collector voltage
ICQ=50*10^-3//ICQ=quiescent collector current
VCmin=1
VCmax=11//VCmin,VCmax=output signal voltage variation
ICmin=10*10^-3
ICmax=90*10^-3//ICmin,ICmax=output signal current variation in Ampere
Ps=VCQ*ICQ//Ps=dc input power to the transistor
disp("W",Ps,"The dc input power is =")
Pac=(1/8)*(ICmax-ICmin)*(VCmax-VCmin)//Pac=ac output power delivered to the load
disp("W",Pac,"The ac output power is =")
PT=(VCQ*ICQ)-Pac//PT=the collector dissipation
disp("W",PT,"The collector dissipation is =")
n=(Pac/Ps)*100//n=the efficiency of the active device
format("v",5)
disp("%",n,"The efficiency is =")
```

Scilab code Exa 9.12.6 To determine the maximum dc power and the maximum output power along with the efficiency

```
//scilab 5.4.1
//Windows 7 operating system
//chapter 9 Basic Voltage and Power Amplifiers
clc
clear
//In a class B push pull circuit
//Transformer winding resistances are to be ignored
n=3//n=primary-to-secondary turns ratio of a transformer
RL=9//RL=load resistance in ohms
VCC=15//VCC=collector supply voltage
RL1=((n/2)^2)*RL//RL1=reflected load resistance for one transistor
Pactot=(VCC^2)/(2*RL1)//Pactot=maximum output power
format("v",5)
disp("W",Pactot,"The maximum output power is =")
Pstot=(2*VCC^2)/(%pi*RL1)//Pstot=the maximum dc power supplied to the two transistors
format("v",5)
disp("W",Pstot,"The maximum dc power supplied is =")
n=(Pactot/Pstot)*100//n=efficiency
format("v",5)
disp("%",n,"The efficiency is =")
```

Scilab code Exa 9.12.7 To calculate the resonant frequency along with the bandwidth and the maximum voltage gain

```
//scilab 5.4.1
//Windows 7 operating system
//chapter 9 Basic Voltage and Power Amplifiers
clc
clear
//In a single tuned amplifier
L=120*10^-6//L=inductance in henry
C=100*10^-12//C=capacitance in farad
```

```
R=10//R=resistance in ohms
hoe=50*10^-6//hoe=output impedance in mho(or S)
hfe=100//hfe=current gain
hie=2.5*10^3//hie=input impedance in ohm
RT=10*10^3//RT=equivalent resistance of RB and Ri in parallel
fo=1/(2*%pi*sqrt(L*C))//fo=resonant frequency
format("v",5)
disp("MHz",fo/10^6,"The resonant frequency is =")//fo is converted in terms of MHz
Qo=(1/R)*sqrt(L/C)//Qo=Q-factor of the resonant frequency
Ro=(Qo^2)*R//Ro=maximum impedance Zm
Rp=1/(hoe+(1/Ro)+(1/RT))//Rp=equivalent resistance of the parallel combination of Ro,ro and RT
Qe=(Qo*Rp)/Ro//Qe=effective Q-factor
B=fo/Qe//B=bandwidth
format("v",6)
disp("kHz",B/10^3,"The bandwidth is =")//B is converted in terms of kHz
AVm=-(hfe*Rp)/hie//AVm=maximum voltage gain
format("v",6)
disp(AVm,"The maximum voltage gain is =")
```

Scilab code Exa 9.12.8 To find out the decibel change in the output power level

```
//scilab 5.4.1
//Windows 7 operating system
//chapter 9 Basic Voltage and Power Amplifiers
clc
clear
V=10//V=voltage at frequency 5kHz
Vr=7.07//Vr=voltage at frequency 25kHz
//x=10*log10(P/Pr) where x=change in decibel(dB) of
```

```
power P from some standard power Pr
//P=V^2/R=I^2*R
//Also Pr=Vr^2/R=Ir^2*R
//x=10*(log10(V/Vr))^2=20*log10(V/Vr)
x=20*log10(V/Vr)//x=change in decibel(dB) of voltage
    V from some standard voltage Vr
format("v",4)
disp("dB",x,"The decibel change in the output power
    level is =")
```

Scilab code Exa 9.12.9 To find the rms output voltage and rms input voltage along with the output power in the midband region

```
//scilab 5.4.1
//Windows 7 operating system
//chapter 9 Basic Voltage and Power Amplifiers
clc
clear
Vorms=2//Vorms=rms output voltage in the midband
    region of an amplifier
Pa=42//Pa=power gain in dB
Pol=0.4//Pol=power output in W at the lower cut-off
    frequency 100Hz
Ri=10^3//Ri=input resistance in ohms
VOrms=2/sqrt(2)//VOrms=rms output voltage at 100Hz
format("v",6)
disp("V",VOrms,"1. The rms output voltage at 100Hz,
    which is the lower cutoff frequency, is =")
Po=2*Pol//Po=output power in the midband region
disp("W",Po,"2. The output power in the midband
    region is =")
//Let Pi=input power
//10*log10(Po/Pi)=Pa
Pi=Po/(10^(Pa/10))
//Pi=(Vi^2)/Ri where Vi=rms input voltage
```

```
Vi=sqrt(Pi*Ri)
format("v",7)
disp("V",Vi,"3. The rms input voltage is =")
```

Chapter 10

Feedback In Amplifiers

Scilab code Exa 10.7.1 To find the voltage gain with feedback the amount of feedback in dB the output voltage of the feedback amplifier the feedback factor the feedback voltage

```
//scilab 5.4.1
//windows 7 operating system
//chapter 10:Feedback In Amplifiers
clc
clear
A=(-100)//A=voltage gain of an amplifier
B=(-0.04)//B=feedback ratio
Af=A/(1+(A*B))//Af=voltage gain with feedback
disp("",Af,"1.Voltage gain with feedback Af=")
F=20*log10(abs(Af/A))//F=amount of feedback
format("v",6)
disp("dB",F,"2.Amount of feedback F=")
Vi=40*(10^-3)//Vi=input voltage
Vo=Af*Vi//Vo=output voltage
disp("V",Vo,"3.Output voltage Vo=")
f=(-A*B)//f=feedback factor
disp("",f,"4.Feedback factor f=")
Vf=B*Vo//Vf=feedback voltage
disp("mV",Vf/10^-3,"5.Feedback voltage is Vf=")//Vf
```

is converted in terms of mV
```

**Scilab code Exa 10.7.2** To find the minimum value of the feedback ratio and the open loop gain

```
//scilab 5.4.1
//windows 7 operating system
//chapter 10:Feedback In Amplifiers
clc
clear
disp("Negative feedback has to be applied for gain
    stability")
//A=open loop gain of an amplifier
//B=feedback ratio
Af=10//Af=voltage gain with feedback
//dAf/Af=(1/(1+(A*B)))*(dA/A)
y=2//(dAf/Af)=y=percent change of gain that is
    allowable
x=20//(dA/A)=x=percent change in open loop gain of
    an amplifier
a=(x/y)//(1+(A*B))=a
disp("",a,"(1+(A*B))=")
//Af=A/((1+(A*B)))
A=(Af*a)
disp("",A,"Open loop gain A=")
//1+(A*B)=a
B=(a-1)/A
disp("",B,"Minimum value of feedback ratio B=")
```

Scilab code Exa 10.7.3 To find the reverse transmission factor

```
//scilab 5.4.1
//windows 7 operating system
```
```

```
//chapter 10:Feedback In Amplifiers
clc
clear
VD=0.1//VD=outputdistortion voltage
VDf=0.05//VDf=output distortion voltage with feedback
A=-80//A=open loop gain of an amplifier
//VDf=VD/(1+(A*B))
B=((VD/VDf)-1)/A//B=reverse transmission factor
format("v",10)
disp("",B,"Reverse transmission factor B=")
```

Scilab code Exa 10.7.4 To find voltages current and power dissipation of a given transistor circuit

```
//scilab 5.4.1
//windows 7 operating system
//chapter 10:Feedback In Amplifiers
clc
clear
B=50//B=reverse transmission factor for silicon transistor T1
VB=((640)*10)/(640+360)//calculating voltage at point B i.e VB by applying voltage divider rule in the given circuit
format("v",4)
disp("V",VB,"VB=")
VBE=VB-5.6//VBE=base emitter voltage drop for silicon transistors T1 and T2 both
disp("V",VBE,"VBE=")
VA=10-0.8//VA=voltage at point A in the given circuit
disp("V",VA,"VA=")
I1=10/(360+640)//I1=current through resistor of 360 ohm
```

```
format("v",5)
disp("A",I1,"I1=")
IE1=I1+1//IE1=emitter current of transistor T1
format("v",5)
disp("A",IE1,"IE1=")
//IC1=-IB1+IE1
IB1=IE1/(B+1)//IB1=base current of transistor T1
disp("mA",IB1/10^-3,"IB1=")//IB1 is converted in terms of mA
I2=(20-VA)/300//I2=current through resistor of 300 ohm
disp("mA",I2/10^-3,"I2=")//I2 is converted in terms of mA
IC2=I2-IB1//IC2=collector current of transistor T2
disp("mA",IC2/10^-3,"IC2=")//IC2 is converted in terms of mA
//Assuming the base current IB2 of transistor T2 is negligibly small
IE2=IC2//IE2=emitter current of transistor T2
disp("mA",IE2/10^-3,"IE2=")//IE2 is converted in terms of mA
I3=(20-5.6)/1000//I3=current through 1000 ohm resistor
disp("mA",I3/10^-3,"I3=")//I3 is converted in terms of mA
IZ=I3+IE2//IZ=current through zener diode
disp("mA",IZ/10^-3,"IZ=")//IZ is converted in terms of mA
VCE=20-10//VCE=collector emitter voltage drop for transistor T1
disp("V",VCE,"VCE=")
IC1=B*IB1
P=VCE*IC1//P=power dissipation in transistor T1
disp("W",P,"P=")
```

Scilab code Exa 10.7.5 To calculate the voltage gain and input output resistances

```
//scilab 5.4.1
//windows 7 operating system
//chapter 10:Feedback In Amplifiers
clc
clear
A=50//A=voltage gain of transistor amplifier
Ri=1000//Ri=input resistance of transistor amplifier
    without feedback
Ro=40*1000//Ro=output resistance of transistor
   amplifier feedback
//Vf=0.1*Vo (given) where Vf=feedback voltage and Vo
   =output voltage
B=0.1//B=(Vf/Vo)=feedback fraction
Af=A/(1+(A*B))//Af=gain of the feedback amplifier
format("v",5)
disp("",Af,"Gain of feedback amplifier Af=")
Rif=Ri*(1+(A*B))//Rif=input resistance of the
   feedback amplifier
Rof=Ro/(1+(A*B))//Rof=output resistance of the
   feedback amplifier
format("v",5)
disp("kilo ohm",Rif/10^3,"Input resistance with
   feedback Rif=")//Rif is converted in terms of
   kilo ohm
disp("kilo ohm",Rof/10^3,"Output resistance with
   feedback Rof=")//Rof is converted in terms of
   kilo ohm
```

Chapter 11

Sinusoidal Oscillators and Multivibrators

Scilab code Exa 11.12.1 To calculate the frequency of oscillation and mutual inductance

```
//scilab 5.4.1
//Windows 7 operating system
//chapter 11 Sinusoidal oscillator and
    multivibrators
clc
clear
L=50*10^-3//L=primary inductance of a transformer in
     henry
C=(200*10^-12)//C=capacitor connected across
    transformer in farad
R=50//dc resistance of primary coil in ohm
hie=2000//hie=input impedance in ohm
hre=10^(-4)//hre=reverse voltage amplification
    factor
hfe=98//hfe=current gain
hoe=(0.5*10^(-4))//hoe=output impedance in mho
RB=50000//RB=resistance
f=1/(2*%pi*sqrt(L*C))//f=frequency of oscillation
```

```
format("v",5)
g=((hie*hoe)-(hfe*hre))//g=dhe=delta he
//M=mutual inductance in henry between the transformer primary and the secondary coils for sustained oscillations
M=((RB/hfe)*((C*R)+(hoe*L)))+((C*R*hie)/hfe)+((L*g)/hfe)
format("v",5)
disp("kHz",f/10^3,"Frequency of oscillation is =")//f is converted in terms of kHz
disp("mH",M/10^-3,"Mutual inductance is =")//M is converted in terms of mH
```

Scilab code Exa 11.12.2 To find the values of the inductances

```
//scilab 5.4.1
//Windows 7 operating system
//chapter 11 Sinusoidal oscillator and multivibrators
clc
clear
//L1 and L2=inductances in henry in a Hartley oscillator
//Suppose L1=a
//L2=b
f=60*10^3//f=frequency in Hz
C=400*10^(-12)//C=capacitance in Farad
//Also tuning capacitance varies from 100 pF to 400 pF
//f=1/(2*%pi*sqrt((L1+L2)*C)) where f=frequency of a Hartley oscillator which varies from 60 kHz to 120 kHz
//d=L1+L2=a+b
//d=1/(((2*%pi*f)^2)*C)
d=1/(((2*%pi*f)^2)*C)//.......(1)
```

```
format("v",10)
//e=L2/L1=hfe/dhe
hfe=90//hfe=current gain
dhe=0.2//dhe=delta he
e=hfe/dhe//..........(2)
//From equation (1) and (2)
//L*x=y
x=[1 1 ; e -1]
y=[d ; 0]
L=inv(x)*y
format("v",6)
disp("micro Henry",(L(1))/10^-6,"Inductance L1 is ="
   )//converting L(1) in terms of micro Henry
disp("mH",(L(2))/10^-3,"Inductance L2 is =")//
   converting L(2) in terms of mH
```

Scilab code Exa 11.12.3 To calculate the frequency of oscillation

```
//scilab 5.4.1
//Windows 7 operating system
//chapter 11 Sinusoidal oscillator and
   multivibrators
clc
clear
L=20*10^-3//L=inductance in henry
C1=(200*10^(-12))//C1=capacitance in farad
C2=(300*10^(-12))//C2=capacitance in farad
Cs=((C1*C2)/(C1+C2))
f=1/(2*%pi*sqrt(L*Cs))
disp("kHz",f/10^3,"Frequency of oscillation is =")//
   converting f in terms of kHz
```

Scilab code Exa 11.12.4 To determine the frequency of oscillation

```
//scilab 5.4.1
//Windows 7 operating system
//chapter 11 Sinusoidal oscillator and
    multivibrators
clc
clear
R=4700//R=resistance in a phase−shift oscillator in
    ohm
C=(0.01*10^(-6))//C=capacitance in a phase−shift
    oscillator in farad
f=1/(2*%pi*sqrt(10)*R*C)
disp("kHz",f/10^3,"Frequency of oscillation f is =")
    //converting f in terms of kHz
```

Scilab code Exa 11.12.5 To find the resistances needed to span the frequency range and to find the ratio of the resistances

```
//scilab 5.4.1
//Windows 7 operating system
//chapter 11 Sinusoidal oscillator and
    multivibrators
clc
clear
f=30//f=frequency of oscillation of a Wien−bridge
    oscillator in Hz
C=(500*10^(-12))//C=capacitance in farad
//f=1/2*%pi*R*C//R=resistance in ohm
R=1/(2*%pi*f*C)
disp("Mega ohms",R/10^6,"Resistance needed to span
    the frequency range,R=")//converting R in terms
    of Mega ohms
//C1=50pF C2=500pF where C1,C2 are variable
    capacitances in a Wien bridge oscillator
//ratio of capacitance=(1:10)
//frequency range is 30 Hz to 300 Hz with R=10.6
```

```
Megaohms
//for the next frequency range from 300 Hz to 3 kHz,new R=(10.6/10)=1.06 Megaohm
//for frequency range 3 kHz to 30kHz,R=1.06/10=106 Kilo-ohm
//So,three values of R are 10.6 Megaohm,1.06 Megaohm,106 Kilo ohm
A=6//A=gain of amplifier
//R2/(R1+R2)=(1/3)-(1/A)=(1/3)-(1/6)
//1+(R1/R2)=6
//Hence R1/R2=5
//R3=(R1/R2)
R3="5:1"
disp(R3,"The ratio of the resistances in the other arms of the bridge,R1/R2 is =")
```

Scilab code Exa 11.12.6 To find the quality factor of the crystal

```
//scilab 5.4.1
//Windows 7 operating system
//chapter 11 Sinusoidal oscillator and multivibrators
clc
clear
//Q=Quality factor
L=3.5//L=inductance in henry
f=450000//f=frequency in Hz
R=9050//R=resistance in ohm
Q=(2*%pi*f*L)/R
format("v",5)//format() sets the current printing format
disp(Q,"Quality factor is")
```

Chapter 12

Modulation and Demodulation

Scilab code Exa 12.9.1 To find the percentage modulation and the amplitude of the unmodulated carrier

```
//scilab 5.4.1
//Windows 7 operating system
//chapter 12 Modulation and Demodulation
clc
clear
Vmax=8//Vmax=maximum peak to peak value of an AM
   voltage
Vmin=2//Vmin=minimum peak to peak value of an AM
   voltage
ma=(Vmax-Vmin)/(Vmax+Vmin)//ma=percentage modulation
disp("%",(ma*100),"Percentage modulation ma=")
//ma=(Vmax-Vmin)/(2*VC) where VC=amplitude of the
   unmodulated carrier
VC=(Vmax-Vmin)/(2*ma)
disp("V",VC,"Amplitude of the unmodulated carrier is
    VC=")
disp("In the textbook answer given is incorrect as
   they have further divided by 2 which is not the
   part of given formula.")
```

Scilab code Exa 12.9.2 To find the frequency span of each sideband and maximum upper and minimum lower side frequency along with the channel-width

```
//scilab 5.4.1
//Windows 7 operating system
//chapter 12 Modulation and Demodulation
clc
clear
fc=1000*(10^3)//fc=frequency of the carrier wave in
    Hz(hertz)
fmin=400
fmax=1600//fmin and fmax represent the frequency
    range of audio signals by which the carrier wave
    is amplitude modulated.
fs=fmax-fmin//fs=frequency span of each sideband
disp("Hz",fs,"1.Frequency span of each sideband is "
    )
fumax=(fc+fmax)/1000//fumax=maximum upper side
    frequency
disp("kHz",fumax,"2.The maximum upper side frequency
     is ")
flmin=(fc-fmax)/1000//flmin=minimum lower side
    frequency
disp("kHz",flmin,"3.The minimum lower side frequency
     is ")
Wc=fumax-flmin//Wc=channelwidth
disp("kHz",Wc,"4.The channelwidth is ")
```

Scilab code Exa 12.9.3 To calculate the power developed by an AM wave

```
//scilab 5.4.1
```

```
//Windows 7 operating system
//chapter 12 Modulation and Demodulation
clc
clear
R=100//R=load resistance in ohms
Vc=100//Vc=peak voltage of the carrier in volts
ma=0.4//ma=modulation factor
Pc=(Vc^2)/(2*R)//Pc=unmodulated carrier power
    developed by an AM wave
disp("W",Pc,"The unmodulated carrier power is Pc= ")
Pt=Pc*(1+((ma^2)/2))//Pt=total power developed
disp("W",Pt,"The total power developed by the AM
    wave is Pt=")
```

Scilab code Exa 12.9.4 To determine the necessary audio power

```
//scilab 5.4.1
//Windows 7 operating system
//chapter 12 Modulation and Demodulation
clc
clear
ma=0.5//ma=modulation factor
Pc=20//Pc=unmodulated carrier power in kilowatts(kW)
Ps=(1/2)*(ma^2)*Pc//Ps=total sideband power
disp("kW",Ps,"The total sideband power is Ps=")
//modulator system efficiency is given as 70 per
    cent
Pa=Ps/0.7//Pa=audio power necessary toamplitude
    modulate a given carrier wave
format("v",5)
disp("kW",Pa,"The required audio power is ")
```

Scilab code Exa 12.9.5 To find the modulation index three pairs of side frequency and the channelwidth

```
//scilab 5.4.1
//Windows 7 operating system
//chapter 12 Modulation and Demodulation
clc
clear
df=30//df=maximum frequency deviation in kilohertz(kHz)
fm=15//fm=modulation frequency of a sinusoidal audio signal in kilohertz(kHz)
mf=df/fm//mf=frequency modulation index
disp(mf,"1.The modulation index is mf=")
fc=100//fc=carrier wave frequency in megahertz(MHz)
disp("2.The three significant pairs of side frequencies are 100MHz+-15kHz(fc+-fm);100MHz+-30kHz(fc+-2fm);100MHz+-45kHz(fc+-3fm)")
wc=mf*3*fm//wc=channelwidth required for 3 above mentioned side frequency pairs
disp("kHz",wc,"3.The required channelwidth is ")
```

Scilab code Exa 12.9.6 To find the highest modulation frequency

```
//scilab 5.4.1
//Windows 7 operating system
//chapter 12 Modulation and Demodulation
clc
clear
R=0.2*(10^6)//R=load resistance in ohms in a diode detector
C=150*(10^-12)//C=capacitance in farad in a diode detector
//fmh=wmh/(2*%pi)where fmh=highest modulation frequency that can be detected with tolerable
```

```
   distortion and wmh=corresponding angular
   frequency
ma=0.5//ma=modulation factor or depth of modulation
fmh=(1/(2*%pi*ma*R*C))/1000
format("v",6)
disp("kHz",fmh,"The required frequency is fmh=")
```

Scilab code Exa 12.9.7 To find the depth of modulation and the total radiated power

```
//scilab 5.4.1
//Windows 7 operating system
//chapter 12 Modulation and Demodulation
clc
clear
Pc=10//Pc=unmodulated carrier power in kilowatts(kW)
Pt=12.5//Pt=total power in kilowatts(kW)
//Pt=Pc*(1+((ma^2)/2))
ma=sqrt(2*((Pt/Pc)-1))//ma=depth of modulation of
   the first signal
disp(ma,"The depth of modulation is ma=")
mb=0.6//mb=depth of modulation of the second signal
PT=Pc*(1+((ma^2)/2)+((mb^2)/2))//PT=the total
   radiated power
disp("kW",PT,"The total radiated power is PT=")
```

Chapter 13

Field Effect Transistors

Scilab code Exa 13.16.1 To find the pinch off voltage and the saturation voltage

```
//scilab 5.4.1
//Windows 7 operating system
//chapter 13 Field-Effect Transistors
clc
clear
ND=2*10^21//ND=donor concentration in m^-3 of an n-
   channel silicon JFET
e=1.6*10^-19//e=charge of an electron
E=12*8.854*10^-12//E=permittivity of the material
   where 12=dielectric constant of silicon(given)
a=(4*10^-6)/2//2*a=channel width in metres and 2*a
   =4*10^-6
Vp=(e*ND*(a^2))/(2*E)
format("v",5)
disp("V",Vp,"The pinch-off voltage is =")
VGS=-2//VGS=gate source voltage
//Vp=VDsat-VGS where VDsat=saturation voltage
VDsat=Vp+VGS
format("v",5)
disp("V",VDsat,"The saturation voltage is =")
```

Scilab code Exa 13.16.2 To find the resistance RS

```
//scilab 5.4.1
//Windows 7 operating system
//chapter 13 Field-Effect Transistors
clc
clear
VGS=-1.5//VGS=gate-to-source voltage of a JFET
IDsat=5*10^-3//IDsat=drain saturation current in
    Ampere
RS=(abs(VGS))/(abs(IDsat))//RS=resistance to be
    calculated=|VGS| / |IDsat|
disp("ohm",RS,"Resistance to be calculated is =")
```

Scilab code Exa 13.16.3 To find the transconductance of the FET along with the amplification factor

```
//scilab 5.4.1
//Windows 7 operating system
//chapter 13 Field-Effect Transistors
clc
clear
VGS1=-1
VGS2=-1.5//VGS1,VGS2=change in VGS(gate-to-source
    voltage) from VGS1 to VGS2 keeping VDS(drain-to-
    source voltage) constant
ID1=7*10^-3
ID2=5*10^-3//ID1,ID2=change in ID(drain current) in
    Ampere from ID1 to ID2
//gm=(id/vgs)|VDS=constant where gm=transconductance
id=ID1-ID2
```

```
vgs=VGS1-VGS2
gm=id/vgs
disp("mA/V",gm*10^3,"The transconductance of the FET
    is =")
rd=200*10^3//rd=ac drain resistance in ohms
u=rd*gm//u=amplification factor
disp(u,"The amplification factor of the FET is =")
```

Scilab code Exa 13.16.4 To calculate the voltage gain and the output resistance

```
//scilab 5.4.1
//Windows 7 operating system
//chapter 13 Field-Effect Transistors
clc
clear
RL=250*10^3//RL=load resistance in ohms in a FET
    amplifier
rd=100*10^3//rd=ac drain resistance in ohms
gm=0.5*10^-3//gm=transconductance in A/V
u=rd*gm//u=amplification factor
AV=-(u*RL)/(rd+RL)//AV=voltage gain
disp(AV,"The voltage gain of FET amplifier is =")
disp("kilo ohm",rd/1000,"The output resistance
    excluding RL is rd=")
ro=(rd*RL)/(rd+RL)//ro=output resistance including
    RL
disp("kilo ohm",ro/1000,"Including RL,the output
    resistance is=")
```

Scilab code Exa 13.16.5 To find the drain current and the pinch off voltage

```
//scilab 5.4.1
//Windows 7 operating system
//chapter 13 Field-Effect Transistors
clc
clear
//For n-channel JFET
IDSS=12*10^-3//IDSS=saturation drain current in Ampere when VGS(gate-to-source voltage)=0V
Vp=-4//Vp=pinch-off voltage
VGS=-2//VGS=gate-to-source voltage
//By Shockley's equation
IDS=IDSS*(1-(VGS/Vp))^2//IDS=saturation drain current to be calculated for given value of VGS
disp("mA",IDS/10^-3,"The drain current for given value of VGS is=")
gmo=4*10^-3//gmo=transconductance in A/V of a JFET when VGS=0V
//gmo=-(2*IDSS)/Vp
Vp=-(2*IDSS)/gmo//Vp=pinch-off voltage to be calculated for given value of transconductance
disp("V",Vp,"The pinch-off voltage for given value of gmo is =")
```

Scilab code Exa 13.16.6 To determine drain current along with drain source voltage along with gate source voltage

```
//scilab 5.4.1
//Windows 7 operating system
//chapter 13 Field-Effect Transistors
clc
clear
IDSS=12*10^-3//IDSS=saturation drain current in Ampere when VGS(gate-to-source voltage)=0V
Vp=-4//Vp=pinch-off voltage
VDD=30//VDD=drain supply voltage
```

```
RL=5*10^3//RL=load resistance in ohms
Rs=600//Rs=resistance connected to source terminal in ohms
Rg=1.5*10^6//Rg=resistance connected to gate terminal in ohms
//By Shockley's equation
//IDS=IDSS*(1-(VGS/Vp))^2 where IDS=saturation drain current to be calculated for given value of VGS
//Substituting VGS=(-ID*Rs) we get ID=IDS
//ID=IDSS*(1+((ID*Rs)/Vp))^2
//ID=12*(1+((0.6*ID)/-4))^2 where ID is obtained in mA
//(0.27*ID^2)-(4.6*ID)+12=0.........(1)
ID1=(4.6+sqrt((4.6^2)-(48*0.27)))/(2*0.27)
format("v",5)
ID2=(4.6-sqrt((4.6^2)-(48*0.27)))/(2*0.27)//ID1,ID2 are the 2 roots of the above equation (1)
format("v",5)
disp("mA",ID1,"ID1=")
disp("mA",ID2,"ID2=")
if (ID1>(IDSS/10^-3)) then//IDSS is converted in terms of mA
    disp("mA",ID1,"As ID1>IDSS ,the value rejected is ID1=")
end
if (ID2>(IDSS/10^-3)) then//IDSS is converted in terms of mA
    disp("mA",ID2,"As ID2>IDSS ,the value rejected is ID2=")
end
disp("mA",ID2,"Therefore,the drain current is =")
ID=ID2*10^-3//converting ID2 in terms of Ampere
VDS=VDD-ID*(RL+Rs)//VDS=drain-to-source voltage
disp("V",VDS,"The value of drain-to-source voltage VDS is =")
VGS=-ID*Rs//VGS=gate-to-source voltage
disp("V",VGS,"The value of gate-to-source voltage VGS is=")
```

```
if(Vp<0 & VDS>(VGS-Vp))
    disp("As Vp=(-4)<VGS<0V and VDS=12V>(VGS-Vp),it
        is verified that the JFET is in the
        saturation region of the drain
        characteristics")
end
```

Scilab code Exa 13.16.7 To calculate the drain current

```
//scilab 5.4.1
//Windows 7 operating system
//chapter 13 Field-Effect Transistors
clc
clear
IDSS=10*10^-3//IDSS=saturation drain current in
   Ampere when VGS(gate-to-source voltage)=0V
Vp=-2//Vp=pinch-off voltage
VDD=20//VDD=drain supply voltage
RL=1*10^3//RL=load resistance in ohms
Rs=2*1000//Rs=resistance connected to source
   terminal in ohms
R1=12*10^6//R1=resistance in the voltage divider
   network in ohms
R2=8*10^6//R2=resistance in the voltage divider
   network in ohms
VT=(R2/(R1+R2))*VDD//VT=Thevenin voltage
//VGS=VT-(ID*Rs)
//By Shockley's equation
//IDS=IDSS*(1-(VGS/Vp))^2 where IDS=saturation drain
    current to be calculated for given value of VGS
//Substituting VGS=(VGS-ID*Rs) we get ID=IDS
//(10*ID^2)-(101*ID)+250=0.........(1) where ID is
   obtained in mA
ID1=(101+sqrt((101^2)-(40*250)))/(2*10)
format("v",5)
```

```
ID2=(101-sqrt((101^2)-(40*250)))/(2*10)//ID1,ID2 are
    the 2 roots of the above equation (1)
format("v",5)
disp("mA",ID1,"ID1=")
disp("mA",ID2,"ID2=")
//For ID1
VGS=VT-(ID1*Rs)//VGS=gate-to-source voltage
   calculated for ID1
if (Vp>VGS) then
    disp("mA",ID1,"As Vp>(VGS calculated using ID1),
        the value rejected is ID1=")
end
disp("mA",ID2,"Therefore,the drain current is =")
ID=ID2*10^-3//converting ID2 in terms of Amperes
VGS=VT-(ID*Rs)//VGS=gate-to-source voltage
disp("V",VGS,"VGS=")
VDS=VDD-(ID*(RL+Rs))//VDS=drain-to-source voltage
format("v",2)
disp("V",VDS,"VDS=")
if(Vp<VGS & VDS>(VGS-Vp))
    disp("As Vp=(-2)<(VGS=-0.68V) and VDS=7V>(VGS-Vp
       ),it is checked that the JFET operates in the
        saturation region ")
end
```

Scilab code Exa 13.16.8 To find the saturation drain current and the minimum value of drain source voltage

```
//scilab 5.4.1
//Windows 7 operating system
//chapter 13 Field-Effect Transistors
clc
clear
//For a n-channel JFET
IDSS=10*10^-3//IDSS=saturation drain current in
```

```
Ampere when VGS(gate-to-source voltage)=0V
Vp=(-4)//Vp=pinch-off voltage
VGS=(-2.5)//VGS=gate-to-source voltage
//By Shockley's equation
IDS=IDSS*(1-(VGS/Vp))^2//IDS=saturation drain current to be calculated for given value of VGS
format("v",5)
disp("mA",IDS/10^-3,"The drain current for given value of VGS is=")//converting IDS in terms of mA
VDSmin=VGS-Vp//VDSmin=minimum value of drain-to-source voltage for the onset of the saturation region
format("v",5)
disp("V",VDSmin,"The minimum value of VDS for saturation is=")
```

Scilab code Exa 13.16.9 To determine gate source voltage and the transconductance

```
//scilab 5.4.1
//Windows 7 operating system
//chapter 13 Field-Effect Transistors
clc
clear
VDD=20//VDD=drain supply voltage
IDS=0.9//IDS=drain saturation current in terms of mA
Vp=-3//Vp=pinch-off voltage
IDSS=8//IDSS=saturation drain current in mA when VGS (gate-to-source voltage)=0V
//By Shockley's equation
//IDS=IDSS*(1-(VGS/Vp))^2
VGS=Vp*(1-sqrt(IDS/IDSS))//VGS=gate-to-source voltage
disp("V",VGS,"The gate-to-source voltage VGS is=")
//gm=(dIDS/dVGS)|VDS=constant where gm=
```

```
   transconductance
gm=-((2*IDSS)/Vp)*(1-(VGS/Vp))
format("v",5)
disp("mS",gm,"The value of transconductance is=")
```

Scilab code Exa 13.16.10 To find the gate source voltage

```
//scilab 5.4.1
//Windows 7 operating system
//chapter 13 Field−Effect Transistors
clc
clear
IDS=-15//IDS=drain saturation current in terms of mA
Vp=5//Vp=pinch−off voltage
IDSS=-40//IDSS=saturation drain current in mA when
   VGS(gate−to−source voltage)=0V
//By Shockley's equation
//IDS=IDSS*(1−(VGS/Vp))^2
VGS=Vp*(1-sqrt(IDS/IDSS))//VGS=gate−to−source
   voltage
disp("V",VGS,"The gate−to−source voltage VGS is=")
```

Scilab code Exa 13.16.11 To calculate Rs and the channel resistance

```
//scilab 5.4.1
//Windows 7 operating system
//chapter 13 Field−Effect Transistors
clc
clear
IDSS=10*10^-3//IDSS=saturation drain current in
   Ampere when VGS(gate−to−source voltage)=0V
Vp=-5//Vp=pinch−off voltage
VDD=24//VDD=drain supply voltage
```

```
VDS=8//VDS=drain-to-source voltage
ID=4*10^-3//ID=drain current in Ampere
R1=2*10^6//R1=resistance in the voltage divider
    network in ohms
R2=1*10^6//R2=resistance in the voltage divider
    network in ohms
VT=(R2/(R1+R2))*VDD//VT=Thevenin voltage
//By Shockley's equation
//ID=IDS=IDSS*(1-(VGS/Vp))^2
VGS=Vp*(1-sqrt(ID/IDSS))//VGS=gate-to-source voltage
//VGS=VT-(ID*Rs) where Rs=resistance connected at
    the source terminal
Rs=(VT-VGS)/ID
disp("kilo ohm",Rs/10^3,"The value of Rs =")//
    converting Rs in terms of kilo-ohm
Rch=VDS/ID//Rch=channel resistance at the Q-point
disp("kilo ohm",Rch/10^3,"The channel resistance at
    the Q-point is=")//converting Rch in terms of
    kilo-ohm
```

Scilab code Exa 13.16.12 To find the saturation drain current

```
//scilab 5.4.1
//Windows 7 operating system
//chapter 13 Field-Effect Transistors
clc
clear
ID=5//ID=saturation drain current in terms of mA in
    an n-channel enhancement mode MOSFET
VGS=8//VGS=gate-to-source voltage
VT=4//VT=Threshold voltage
VGS2=10//VGS2=gate-to-source voltage for which
    saturation drain current is to be calculated
//ID=K*(VGS-VT)^2 where K=(IDSS/(Vp^2)) and Vp=pinch
    -off voltage ,IDSS=drain saturation current for
```

```
    VGS=0 V
K=ID/((VGS-VT)^2)
ID1=K*(VGS2-VT)^2//ID1=The saturation drain current for gate-source voltage of 10V i e VGS2
disp("mA",ID1,"The saturation drain current for gate-source voltage of 10V is =")
```

Scilab code Exa 13.16.13 To calculate drain current along with gate source voltage and drain source voltage

```
//scilab 5.4.1
//Windows 7 operating system
//chapter 13 Field-Effect Transistors
clc
clear
//For n-channel enhancement mode MOSFET operating in active region
VT=2//VT=Threshold voltage
K=0.5//K=(IDSS/(Vp^2)) in terms of mA/V^2
VDD=15//VDD=drain supply voltage
RL=1//RL=load resistance in kilo ohm
R1=200*10^3//R1=resistance in the voltage divider network in terms of ohms
R2=100*10^3//R2=resistance in the voltage divider network in terms of ohms
VGS=(R2/(R1+R2))*VDD//VGS=gate-to-source voltage
disp("V",VT,"Threshold voltage is =")
disp("V",VGS,"The gate-to-source voltage VGS is =")
ID=K*(VGS-VT)^2//ID=drain current in mA
disp("mA",ID,"The value of drain current ID is =")
VDS=VDD-(ID*RL)//VDS=drain-to-source voltage
disp("V",VDS,"The value of drain-to-source voltage VDS is=")
if (VDS>(VGS-VT)) then
    disp("As VDS>(VGS-VT),(i.e. 10.5>(5-2)),the
```

```
operation is indeed in the active region ")
end
```

Scilab code Exa 13.16.14 To calculate K along with drain current and drain source voltage

```
//scilab 5.4.1
//Windows 7 operating system
//chapter 13 Field-Effect Transistors
clc
clear
//For n-channel MOSFET operating in the depletion mode
VDD=18//VDD=drain supply voltage
VGS=0//VGS=gate-to-source voltage
RL=600//RL=load resistance in ohms
IDSS=18//IDSS=drain saturation current in mA for gate-to-source voltage (VGS)=0V
Vp=-5//Vp=pinch-off voltage
//Assuming that the operation is in the active region
//ID=IDS=IDSS*(1-(VGS/Vp))^2
//ID=(IDSS/Vp^2)(VGS-Vp)^2
K=IDSS/(Vp^2)
disp("mA/V^2",K,"The value of K is =")
ID=IDSS//ID=drain current
disp("mA",ID,"Since VGS=0,the value of ID=IDSS is=")
VDS=VDD-(ID*(RL/10^3))//VDS=drain-to-source voltage and also converting RL in terms of kilo ohm
disp("V",VDS,"The value of VDS is =")
disp("V",Vp,"Pinch off voltage Vp is =")
disp("V",VGS,"Gate to source voltage VGS is =")
if (VDS>(VGS-Vp)) then
    disp("As VDS>(VGS-Vp),(i.e.7.5>(0-(-5))),the MOSFET is actually in the active region")
```

```
end
```

Scilab code Exa 13.16.15 To calculate the voltage gain and the output resistance

```
//scilab 5.4.1
//Windows 7 operating system
//chapter 13 Field-Effect Transistors
clc
clear
//r given in textbook is taken as rd afterwards.
   Hence r=rd
rd=100*10^3//rd=drain resistance in ohms
gm=3500*10^-6//gm=transconductance in terms of A/V (
   or S)
RL=5*10^3//RL=load resistance in ohms
u=rd*gm//u=amplification factor
AV=(u*RL)/(((u+1)*RL)+rd)//AV=voltage gain
format("v",6)
disp(AV,"The voltage gain is=")
Ro=rd/(u+1)//Ro=output resistance excluding RL
format("v",5)
disp("ohm",Ro,"The output resistance excluding RL is
   =")
Ro1=(rd*RL)/(rd+((u+1)*RL))//Ro1=Ro'=output
   resistance including RL
format("v",6)
disp("ohm",floor(Ro1),"The output resistance
   including RL is=")//floor function is used to
   round down the value
```

Scilab code Exa 13.16.16 To find the small signal voltage gain

```
//scilab 5.4.1
//Windows 7 operating system
//chapter 13 Field-Effect Transistors
clc
clear
//In a FET used in a CS amplifier
IDSS=4//IDSS=drain saturation current in mA for gate
    -to-source voltage (VGS)=0V
Vp=-3//Vp=pinch-off voltage
RL=10//RL=load resistance in kilo ohms
VGS=-0.7//VGS=gate-to-source voltage
gmo=-(2*IDSS)/Vp//gmo=transconductance in A/V of a
    JFET when VGS=0V
gm=gmo*(1-(VGS/Vp))//gm=transconductance
AV=-gm*RL//AV=the small signal voltage gain
disp(AV,"The small signal voltage gain is =")
//Decimal term in the answer displayed in textbook
    is incorrect as 2.04*10=20.4 and not 20.04.
```

Chapter 14

Integrated Circuits and Operational Amplifiers

Scilab code Exa 14.12.1 To determine the output voltage along with input resistance and the input current

```
//scilab 5.4.1
//Windows 7 operating system
//chapter 14 Integrated Circuits and Operational
    Amplifiers
clc
clear
R1=1000//R1=input resistance in ohms in the
    inverting amplifier circuit
Rf=3*1000//Rf=feedback resistance in ohms
v1=2//v1=input voltage in the inverting terminal of
    an amplifier circuit
vo=-(Rf/R1)*v1//vo=output voltage
disp("V",vo,"Output voltage is=")
disp("Output voltage is negative as it is the
    circuit of inverting amplifier")
disp("kilo ohm",R1/1000,"Input resistance Rin=R1 is
    =")
i=v1/R1//i=input current
```

```
disp("mA",i*1000,"The input currrent is =")
```

Scilab code Exa 14.12.2 To calculate the voltage gain

```
//scilab 5.4.1
//Windows 7 operating system
//chapter 14 Integrated Circuits and Operational
    Amplifiers
clc
clear
R1=2*1000//R1=input resistance in ohms in the non-
    inverting amplifier circuit
Rf=5*1000//Rf=feedback resistance in ohms
AV=1+(Rf/R1)//AV=voltage gain of the non-inverting
    amplifier circuit
disp(AV,"The voltage gain of the given non-inverting
     amplifier circuit is =")
```

Scilab code Exa 14.12.3 To calculate the voltage gains for difference and common mode signals along with CMRR

```
//scilab 5.4.1
//Windows 7 operating system
//chapter 14 Integrated Circuits and Operational
    Amplifiers
clc
clear
//First case
v1=40*10^-6//v1=voltage applied to the non-inverting
     input terminal
v2=-40*10^-6//v2=voltage applied to the inverting
    input terminal
```

```
vo=100*10^-3//vo=output voltage for the above inputs v1 and v2
//Second case
V1=40*10^-6//V1=voltage applied to the non-inverting input terminal
V2=40*10^-6//V2=voltage applied to the inverting input terminal
Vo=0.4*10^-3//Vo=output voltage for the above inputs V1 and V2
disp("In first case:")
vd=v1-v2//vd=difference signal voltage
disp(" V ",vd/10^-6,"vd=")
vc=(v1+v2)/2//vc=common mode signal voltage
format("v",5)
disp(" V ",vc/10^-6,"vc=")
//Output voltage is vo=(Ad*vd)+(Ac*vc) where Ad and Ac are the voltage gains for the difference signal and the common-mode signal,respectively
Ad=vo/vd//Ad calculated in first case as common mode signal vc=0
disp(Ad,"Voltage gain for the difference signal is Ad =")
disp("In second case:")
Vd=V1-V2//Vd=difference signal voltage
disp(" V ",Vd/10^-6,"Vd=")
Vc=(V1+V2)/2//Vc=common mode signal voltage
format("v",5)
disp(" V ",Vc/10^-6,"Vc=")
Ac=Vo/Vc//Ac calculated in second case as difference signal Vc=0
disp(Ac,"Voltage gain for the common-mode signal is Ac =")
CMRR=abs(Ad/Ac)//CMRR=Common Mode Rejection Ratio=|Ad/Ac|
disp(CMRR,"Common Mode Rejection Ratio is CMRR=")
```

Scilab code Exa 14.12.4 To find the output voltage of the three input summing amplifier

```
//scilab 5.4.1
//Windows 7 operating system
//chapter 14 Integrated Circuits and Operational Amplifiers
clc
clear
R1=1*1000//R1=input resistance in ohms in the inverting terminal of the amplifier circuit
R2=200//R2=input resistance in ohms in the inverting terminal of the amplifier circuit
R3=400//R3=input resistance in ohms in the inverting terminal of the amplifier circuit
Rf=500//Rf=feedback resistance in ohms
v1=-5//v1=input voltage in the inverting terminal of an amplifier circuit at R1 resistor
v2=3//v2=input voltage in the inverting terminal of an amplifier circuit at R2 resistor
v3=4//v3=input voltage in the inverting terminal of an amplifier circuit at R3 resistor
vo=-(((Rf/R1)*v1)+((Rf/R2)*v2)+((Rf/R3)*v3))//vo=output voltage for inverting summing summing amplifier circuit
disp("V",vo,"Output voltage of the 3-input summing amplifier circuit is =")
disp("Output voltage is negative as it the circuit of inverting summing amplifier")
```

Scilab code Exa 14.12.5 To find the voltage gain along with the output voltage

```
//scilab 5.4.1
//Windows 7 operating system
//chapter 14 Integrated Circuits and Operational Amplifiers
clc
clear
R1=1*1000//R1=input resistance in ohms in the inverting amplifier circuit
Rf=50*1000//Rf=feedback resistance in ohms
A=-(Rf/R1)//AV=voltage gain of the inverting amplifier circuit
disp(A,"The voltage gain of the given inverting amplifier circuit is =")
//vin=0.5*sin(100*%pi*t)
//vout=A*vin=-50*0.5*sin(100*%pi*t)=-25*sin(100*%pi*t)
disp("If the operation were entirely linear ,the output voltage would have been -25*sin(100*%pi*t)")
disp("But since the voltage supply is +-12V ,the op-amp is saturated when |vout| attains 12V")
//Let at time t=to,vout=-12V
//-12=-25*sin(100*%pi*to)
to=(1/(100*%pi))*asin(12/25)
format("v",8)
disp("s",to,"to=")
disp("Thus over the entire cycle,")
disp("vout=-25*sin(100*%pi*t) V when 0<=t<=to")
disp("vout=-12V when to<=t<=(0.01-to)")
disp("vout=-25*sin(100*%pi*t) V when (0.01-to)<=t<=(0.01+to)")
disp("vout=+12V when (0.01+to)<=t<=(0.02-to)")
disp("vout=-25*sin(100*%pi*t) V when (0.02-to)<=t<=0.02 seconds")
```

Scilab code Exa 14.12.6 To find the output voltage of the differentiator

```
//scilab 5.4.1
//Windows 7 operating system
//chapter 14 Integrated Circuits and Operational Amplifiers
clc
clear
R=2*1000//R=feedback resistance in ohms in the differentiator circuit
C=0.01*10^-6//C=input capacitance in farad in the differentiator circuit
//dvi/dt=1.5V/1ms for 0<t<1ms (given ramp input signal)
//output voltage of a differentiator is given as vo=-RC(dvi/dt)
d=1.5/(10^-3)//d=dvi/dt=1.5V/1ms
vo=-R*C*d
disp("V",vo,"Output voltage of a differentiator is ")
disp("Hence for <t<1 ms,vo=-0.03V=-30mV.Otherwise,vo=0V")
```

Scilab code Exa 14.12.8 To calculate the output voltage

```
//scilab 5.4.1
//Windows 7 operating system
//chapter 14 Integrated Circuits and Operational Amplifiers
clc
clear
R1=5*1000//R1=input resistance in ohms in the given op-amp circuit
Rf=10*1000//Rf=feedback resistance in ohms
vi=5//vi=input voltage at the inverting terminal of
```

```
    an op−amp
V=4//V=voltage at the non−inverting terminal of an
    op−amp
//By applying superposition theorem
Vo=((1+(Rf/R1))*V)+(-(Rf/R1)*vi)
disp("V",Vo,"Output voltage Vo of the circuit is =")
```

Scilab code Exa 14.12.9 To find the differential mode gain

```
//scilab 5.4.1
//Windows 7 operating system
//chapter 14 Integrated Circuits and Operational
    Amplifiers
clc
clear
R1=10*1000//R1=resistance in ohms
R2=100//R2=resistance in ohms
R3=10*1000//R3=resistance in ohms
R4=10*1000//R4=resistance in ohms
R5=10*1000//R5=resistance in ohms
//Since the voltage gains of the OP AMPs are
    infinite,the voltages of the points X and Y in
    the given figure are V1 and V2 respectively
//Applying Kirchhoff's current law at X
//(V1/R1)+((V1−V)/R3)+((V1−V2)/R2)=0
//Applying Kirchhoff's current law at Y
//((V2−V)/R4)+((V2−V1)/R2)+((V2−Vo)/R5)=0
//Eliminating V from the above equations
//V2*((1/R2)+(1/R4)+(1/R5)+(R3/(R2*R4)))−V1*((1/R2)
    +(1/R4)+((R3/R4)*((1/R1)+(1/R2))))=Vo/R5
//V2*R−V1*r=Vo/R5...................(1)
R=((1/R2)+(1/R4)+(1/R5)+(R3/(R2*R4)))
r=((1/R2)+(1/R4)+((R3/R4)*((1/R1)+(1/R2))))
disp(R,"R=")
disp(r,"r=")
```

```
//R=r from above calculation and its answer displayed
//Hence from the above equation (1) A=Vo/(V1-V2)=-(R5*R)=-(R5*r)
disp(-R5*r,"Differential mode gain A=Vo/(V1-V2)=")
```

Chapter 15

Active Filters

Scilab code Exa 15.7.1 To design a Butterworth low pass filter

```
//scilab 5.4.1
//Windows 7 operating system
//chapter 15 Active Filters
clc
clear
fc=1000//fc=given cut-off frequency in Hz
A=-56//A=required gain to be dropped by this much amount in dB
//Also,A=normalized gain of Butterworth filter=|A(jw)/Ao|
f=10*1000//f=given frequency in Hz where the normalized gain is dropped by given amount
//|A(jw)/Ao|=(-20)*n*log10(w/wc) where n=order of the filter
//|A(jw)/Ao|=(-20)*n*log10(f/fc)
n=A/((-20)*log10(f/fc))//n=order of Butterworth low-pass filter
disp(ceil(n),"Order of given filter to be designed is (n)=")
//As n=3 (from above calculation) we need cascading of first-order section and second-order section
```

```
//For n=3
k=0.5//k=damping factor
Ao=3-(2*k)//Ao=DC gain for each op-amp in a given
    Butterworth Filter to be designed
R1=10*1000//R1=Assumed resistance in ohms
//Ao=(R1+R2)/R1
R2=(Ao*R1)-R1
//fc=1/(2*%pi*R*C)
R=1000//R=Assumed resistance in ohms
C=1/(2*%pi*R*fc)
format("v",5)
disp("The designed values of resistance and
    capacitance for a low-pass Butterworth filter are
    :")
disp("kilo ohm",R1/1000,"R1=")
disp("kilo ohm",R2/1000,"R2=")
disp("kilo ohm",R/1000,"R=")
disp("micro Farad",C/10^-6,"C=")
```

Scilab code Exa 15.7.2 To design a first order Butterworth active High Pass filter

```
//scilab 5.4.1
//Windows 7 operating system
//chapter 15 Active Filters
clc
clear
Ao=5//Ao=high frequency gain of a given first-order
    Butterworth active HP filter
//Ao=(R1+R2)/R1
R1=1000//R1=Assumed resistance in ohms
R2=(Ao*R1)-R1
fc=200//fc=given cut-off frequency in Hz
//fc=1/(2*%pi*R*C)
R=5*1000//R=Assumed resistance in ohms
```

```
C=1/(2*%pi*R*fc)
disp("The designed values of resistance and
   capacitance for a high−pass Butterworth filter
   are:")
disp("kilo ohm",R1/1000,"R1=")
disp("kilo ohm",R2/1000,"R2=")
disp("kilo ohm",R/1000,"R=")
disp("micro Farad",C/10^-6,"C=")
```

Scilab code Exa 15.7.3 To design a second order band pass Butterworth filter

```
//scilab 5.4.1
//Windows 7 operating system
//chapter 15 Active Filters
clc
clear
fo=1000//fo=centre frequency in Hz
f=100//f=bandwidth in Hz
//Q=wo/w=Quality factor
Q=(2*%pi*fo)/(2*%pi*f)
C1=0.02*10^-6
C2=0.02*10^-6//C1=C2=Assumed Capacitances in Farad
Ao=2//Ao=gain at the centre frequency
//R1*C1=Q/(wo*Ao) for active band pass Butterworth
   filter
wo=2*%pi*fo
R1=Q/(Ao*wo*C1)
R3=Q/(wo*((C1*C2)/(C1+C2)))
Rp=1/((wo^2)*R3*C1*C2)
R2=(R1*Rp)/(R1-Rp)
disp("The designed values of resistance and
   capacitance for a second order band−pass
   Butterworth filter are:")
disp("kilo ohm",ceil(R1/1000),"R1=")//floor() and
```

```
    ceil() functions are used in order to get
    truncated floating values as per the requirement
disp("ohm",floor(R2),"R2=")
disp("kilo ohm",ceil(R3/1000),"R3=")
disp("micro Farad",C1/10^-6,"C1=")
disp("micro Farad",C2/10^-6,"C2=")
```

Scilab code Exa 15.7.4 To design a notch filter

```
//scilab 5.4.1
//Windows 7 operating system
//chapter 15 Active Filters
clc
clear
fo=400//fo=centre frequency in Hz
Q=10//Q=wo/w=Quality factor
C1=0.1*10^-6
C2=0.1*10^-6//C1=C2=Assumed Capacitances in Farad
Ao=2//Ao=gain at the centre frequency
//R1*C1=Q/(wo*Ao) for active band pass Butterworth
    filter
wo=2*%pi*fo
R1=Q/(Ao*wo*C1)
format("v",6)
R3=Q/(wo*((C1*C2)/(C1+C2)))
Rp=1/((wo^2)*R3*C1*C2)
R2=(R1*Rp)/(R1-Rp)
//Assuming arbitrarily (R6/R5)=10=a
a=10
R6=10*1000//R6=Assumed resistance in ohms
R5=R6/a
R4=R5/Ao
disp("The designed values of resistance and
    capacitance for a notch filter are:")
disp("kilo ohm",(R1/1000),"R1=")
```

```
disp("ohm",(R2),"R2=")
disp("kilo ohm",(R3/1000),"R3=")
disp("ohm",R4,"R4=")
disp("kilo ohm",(R5/1000),"R5=")
disp("kilo ohm",(R6/1000),"R6=")
disp("micro Farad",C1/10^-6,"C1=")
disp("micro Farad",C2/10^-6,"C2=")
```

Chapter 16

Special Devices

Scilab code Exa 16.10.1 To determine the time period of the sawtooth voltage across capacitor C

```
//scilab 5.4.1
//Windows 7 operating system
//chapter 16 Special Devices
clc
clear
Vp=15//Vp=firing voltage of a unijunction transistor
    in Volts
VBB=40//VBB=source voltage in Volts
n=(Vp/VBB)//n=intrinsic stand-off ratio
disp(n,"The intrinsic stand-off ratio is ")
R=50*(10^3)//R=resistance in ohms
C=2000*(10^-12)//c=capacitance in farad
T=(R*C*log(1/(1-n)))*(10^6)//T=time period of the
   sawtooth voltage across C
format("v",7)
disp("microseconds",T,"The time period is ")
```

Chapter 17

Number Systems Boolean Algebra and Digital Circuits

Scilab code Exa 17.17.1 To determine the binary equivalents

```
//scilab 5.4.1
//Windows 7 operating system
//chapter 17 Number Systems,Boolean Algebra,and
   Digital Circuits
clc
clear
x=25
s=dec2bin(x)
disp(,s,"1 Binary equivalent of 25 is ")
y=576
s1=dec2bin(y)
disp(,s1,"2 Binary equivalent of 576 is ")
```

Scilab code Exa 17.17.2 To determine the decimal equivalent

```
//scilab 5.4.1
```

```
//Windows 7 operating system
//chapter 17 Number Systems,Boolean Algebra,and
    Digital Circuits
clc
clear
s='1111'
x=bin2dec(s)
disp(,x,"Decimal equivalent of 1111 is ")
```

Scilab code Exa 17.17.3 To convert from binary system to decimal system

```
//scilab 5.4.1
//Windows 7 operating system
//chapter 17 Number Systems,Boolean Algebra,and
    Digital Circuits
clc
clear
p=1;
//initialising variables
q=1;
z=0;
b=0;
w=0;
f=0;
format('v',18);//increasing the precision to 18 .
bin=11.1101;
d=modulo(bin,1);//separating the decimal part and
    the integer part
d=d*10^10;
a=floor(bin);//removing the decimal part
while(a>0)//loop to take the binary bits of integer
    into a matrix
r=modulo(a,10);
b(1,q)=r;
```

```
a=a/10;
a= floor(a);
q=q+1;
end
for m=1:q-1//multiplying the bits of integer with
   their position values and adding
c=m-1;
f=f+b(1,m)*(2^c);
end
while(d>0)//loop to take the binary bits of decimal
   into a matrix
e=modulo(d,2)
w(1,p)=e
d=d /10;
d=floor(d)
p=p+1;
end
for n=1:p-1//multiplying the bits of decimal with
   their position values and adding
z=z+w(1,n) *(0.5) ^(11-n);
end
z=z*10000;
//rounding of to 4 decimal values
z=round(z);
z=z/10000;
printf("The decimal equivalent of 11.1101 is = %f" ,
   f+z)
```

Scilab code Exa 17.17.4 To convert from decimal system to binary system

```
//scilab 5.4.1
//Windows 7 operating system
//chapter 17 Number Systems,Boolean Algebra,and
   Digital Circuits
```

```
clc
clear
q=0;
b=0;
s=0;
format('v',18);//increasing the precision to 18 .
a=4.625;
d=modulo(a,1);//separating the decimal part and the integer part
a=floor(a);//removing the decimal part
while(a>0)//taking integer part into a matrix and converting into equivalent binary
x=modulo(a,2);
b=b+(10^q)*x;
a=a/2;
a=floor(a);
q=q+1;
end
for i=1:10//for values after decimal point converting into binary
d=d*2;
q=floor(d);
s=s+q/(10^i);
if d>=1 then
d=d-1;
end
end
k=b+s;
printf ("The binary equivalent of 4.625 is = %f" ,k);
```

Scilab code Exa 17.17.5 To find the equivalent of given number in a code base 5

```
//scilab 5.4.1
```

```
//Windows 7 operating system
//chapter 17 Number Systems,Boolean Algebra,and
   Digital Circuits
clc
clear
dec=263
base=5
s=dec2base(dec,base)
disp(,s,"Equivalent of 263 in a code base 5 is ")
```

Scilab code Exa 17.17.6 To perform binary addition corresponding to decimal addition

```
//scilab 5.4.1
//Windows 7 operating system
//chapter 17 Number Systems,Boolean Algebra,and
   Digital Circuits
clc
clear
x=2
s=x+x
s1=dec2bin(s)
disp(,s1,"Binary addition corresponding to decimal
   addition 2+2 is ")
```

Scilab code Exa 17.17.7 To perform binary addition and also to show the corresponding decimal addition

```
//scilab 5.4.1
//Windows 7 operating system
//chapter 17 Number Systems,Boolean Algebra,and
   Digital Circuits
clc
```

```
clear
x='11111'
y='1011'
z='101'
w='10'
v='1'
s1=bin2dec(x)
s2=bin2dec(y)
s3=bin2dec(z)
s4=bin2dec(w)
s5=bin2dec(v)
a=s1+s2+s3+s4+s5
b=dec2bin(a)
disp(,b,"Binary addition of 11111+1011+101+10+1 is "
    )
disp(,a,"Decimal equivalent corresponding to above
    binary addition is ")
```

Scilab code Exa 17.17.8 To perform the binary subtraction

```
//scilab 5.4.1
//Windows 7 operating system
//chapter 17 Number Systems,Boolean Algebra,and
    Digital Circuits
clc
clear
x='1101'
y='111'
s1=bin2dec(x)
s2=bin2dec(y)
a=s1-s2
s=dec2bin(a)
disp(,s,"Binary subtraction 1101-111 is =")
```

Scilab code Exa 17.17.9 To obtain the output levels of a silicon transistor for given input levels and to show that circuit has performed NOT operation using positive logic

```
//scilab 5.4.1
//Windows 7 operating system
//chapter 17 Number Systems,Boolean Algebra,and Digital Circuits
clc
clear
hFE=30//hFE=dc current gain of given silicon transistor
VBE=0.8//VBE=base-emitter voltage drop at saturation
VCE=0.2//VCE=collector-emitter voltage drop at saturation
R1=15*1000//resistance at the base side of the transistor in ohms
R2=100*1000//another resistance at the base side of the transistor in ohms
RL=2*1000//load resistance at the collector side of the transistor in ohms
VCC=10//VCC=collector supply voltage
VBB=-10//VBB=base supply voltage
//If the input level is 0 volt i e vi=0,the open-circuited base voltage is given as
VB=VBB*(R1/(R1+R2))
disp("For input level 0 V:")
disp("As a bias of approximately 0 V is sufficient to cut off a silicon emitter junction ,it follows that transistor is cut off when vi=0")
disp("V",VCC,"When vi=0,the output voltage is vo=VCC=")
disp("This indicates that the output is in state 1 when the input is in state 0")
```

```
//When the input level is 10 volt i e vi=10, we have to show that the transistor is in saturation
//The minimum base current for saturation is given by iB(min)=iC/hFE
iC=(VCC-VCE)/RL//collector current when the transistor saturates
iB=iC/hFE//iB=iB(min)=minimum base current for saturation in mA
i1=(10-VBE)/R1//i1=current through R1 resistor connected at the base side and here vi=10 is taken
i2=(VBE-VBB)/R2//i2=current through R2 resistor connected at the base side
iB1=i1-i2//iB1=actual base current
disp("For input level 10 V:")
if (iB1>iB) then
    disp("Since iB>iB(min),it is verified that the transistor is in saturation")//iB indicates actual base current & iB(min) indicates minimum base current for saturation
    disp("V",VCE,"When vi=10,the output voltage is vo=VCE(sat)=")
    disp("This indicates that the output is in state 0 when the input is in state 1")
end
disp("Overall it has been thus verified that the circuit has performed the NOT operation")
```

Scilab code Exa 17.17.10 To solve the Boolean expression

```
//scilab 5.4.1
//Windows 7 operating system
//chapter 17 Number Systems,Boolean Algebra,and Digital Circuits
clc
```

```
clear
A=0
B=0
C=bitor(A,B)//bitwise OR operation is performed
disp(C,"Boolean expression C=A+B for inputs A=0 and
    B=0 is")
A=1
B=0
C=bitor(A,B)
disp(C,"Boolean expression C=A+B for inputs A=1 and
    B=0 is")
A=1
B=1
C=bitor(A,B)
disp(C,"Boolean expression C=A+B for inputs A=1 and
    B=1 is")
```

Chapter 19

VLSI Technology and Circuits

Scilab code Exa 19.29.1 To find the value of inverse of aspect ratio along with power dissipated and load resistance

```
//scilab 5.4.1
//Windows 7 operating system
//chapter 19 VLSI Technology and Circuits
clc
clear
ID=50*10^-6//ID=drain current in amperes
k=25*10^-6//k=ue/D in A/V^2
VDS=0.25//VDS=drain-to-source voltage
VGS=5//VGS=gate-to-source voltage
VTH=1.5//VTH=threshold voltage
w=ID/(k*(VGS-VTH)*VDS)//w=W/L
format("v",5)
disp(w,"W/L=")
P=VDS*ID//P=power dissipated by the transistor
disp("micro Watt",P*10^6,"The dissipated power is=")
VDD=5//VDD=drain supply voltage of given NMOS
    transistor
R=(VDD-VDS)/ID//R=load resistor to be connected in
    series with the drain
disp("kilo ohm",R/1000,"The load resistance is=")
```

Scilab code Exa 19.29.2 To find the pull up and pull down aspect ratio

```
//scilab 5.4.1
//Windows 7 operating system
//chapter 19 VLSI Technology and Circuits
clc
clear
ID=50*10^-6//ID=drain current in amperes
k=25*10^-6//k=ue/D in A/V^2
VDEP=3
l=(k*((-VDEP)^2))/(2*ID)//l=(L/W)=aspect ratio of the pull-up
disp(l,"Pull-up (L/W)=")
VGS=5//VGS=gate-to-source voltage
VTH=1//VTH=threshold voltage
VDs=4.75//VDs=the drain source voltage of the depletion mode pull-up in saturation
VDD=5//VDD=drain supply voltage of given NMOS inverter
//L/W=(k*(VGS-VTH)*VDS)/ID where L/W=pull down aspect ratio
l1=(k*(VGS-VTH)*(VDD-VDs))/ID//l1=L/W
disp(l1,"Pull-down (L/W)=")
```

Scilab code Exa 19.29.3 To find the value of inverse of aspect ratio of the PMOS transistor for a symmetrical inverter

```
//scilab 5.4.1
//Windows 7 operating system
//chapter 19 VLSI Technology and Circuits
clc
```

```
clear
w=10//w=W/L value of the NMOS transistor in a CMOS inverter
un=1350//un=electron mobility for NMOS transistor in cm^2/V s
up=540//up=electron mobility for PMOS transistor in cm^2/V s
//(Wpu/Lpu)*up*(VINV-VDD-VTHP)^2=(Wpd/Lpd)*un*(VINV-VTHN)^2
//For a symmetrical inverter VINV=(VDD/2) and VTHN=(-VTHP)
//Also for input voltage=VDD/2 both transistors operate in saturation region
//Therefore,up*(Wpu/Lpu)=un*(Wpd/Lpd)
w1=(un*w)/up//w1=Wpu/Lpu=W/L value of the PMOS for a symmetrical inverter
disp(w1,"W/L value of the PMOS transistor in a CMOS inverter is =")
```

Scilab code Exa 19.29.4 To determine the maximum permissible number of fan outs

```
//scilab 5.4.1
//Windows 7 operating system
//chapter 19 VLSI Technology and Circuits
clc
clear
f=2*10^9//f=clock frequency in Hz
VDD=3//VDD=drain supply voltage
Cl=1*10^-12//Cl=load capacitance in Farad
P=50*10^-3//P=maximum power dissipation capability in W/stage
N=P/(f*Cl*VDD^2)//N=maximum permissible number of fan outs
format("v",5)
```

```
disp(N,"N=")
disp(floor(N),"The maximum permissible number of fan
   -outs is(integer just below actual value)=")
```

Scilab code Exa 19.29.5 To calculate the channel transit time

```
//scilab 5.4.1
//Windows 7 operating system
//chapter 19 VLSI Technology and Circuits
clc
clear
L=3*10^-6//L=length of an NMOS pass transistor in
   metres
VDS=0.5//VDS=drain-source voltage
u=1400*10^-4//u=electron mobility in m^2/V s
t=L^2/(VDS*u)//t=channel transit time
format("v",5)
disp("nanoseconds",t/10^-9,"The transit time is=")
```

Scilab code Exa 19.29.6 To calculate the required metal line width

```
//scilab 5.4.1
//Windows 7 operating system
//chapter 19 VLSI Technology and Circuits
clc
clear
y=2//y=length unit in micrometres
W=3*y//W=mimimum metal linewidth in micrometres
disp("micrometres",W,"W=")
n=80//n=number of driven inverters
i=0.07//i=average current ratings in milliamperes
I=n*i//I=total currrent drawn by n inverters
disp("mA",I,"I=")
```

```
//1mA per micrometre of aluminium line width is the
   maximum safe average current an aluminium wire
   can carry.
disp("This needs a line at least width of")
disp("micrometres",I)
if (W>I) then
    disp("Above calculated minimum metal line-width
       (W) is thus the safe width of the metal line
       driving 80 inverters.")
end
f=5//f=number of fanout lines
w=f*W//w=required metal line width
disp("micrometres",w,"The metal line-width required
   to supply a fan-out of 5 lines is=")
```

Chapter 20

Cathode Ray Oscilloscope

Scilab code Exa 20.9.1 To determine the transit time along with transverse acceleration and spot deflection

```
//scilab 5.4.1
//Windows 7 operating system
//chapter 20 Cathode Ray Oscilloscope
clc
clear
e=1.6*10^-19//e=charge of an electron
Va=1000//Va=potential difference in volts
m=9.11*10^-31//m=mass of an electron
v=sqrt((2*e*Va)/m)//v=axial velocity of an electron
l=2*10^-2//l=axial length of deflecting plates in metre
t=l/v//t=transit time of the beam through the deflecting plates
format("v",9)
disp("s",t,"The transit time is =")
Vd=20//Vd=potential difference applied between the deflecting plates in volts
s=5*10^-3//s=separation between the plates in metre
ta=(e*Vd)/(s*m)//ta=the traverse acceleration imparted to the electrons by the deflecting
```

```
voltage
format("v",10)
disp("m/s^2",ta,"Traverse acceleration is =")
L=25*10^-2//L=distance of the CRT screen from the centre of the deflecting plates in metre
d=(l*L*Vd)/(2*s*Va)//d=deflection of the spot on the CRT screen
format("v",13)
disp("cm",d*100,"Spot deflection is =")//d is converted in terms of cm
S=d/Vd//S=deflection sensitivity
format("v",10)
disp("mm/V",S/10^-3,"Deflection sensitivity is =")//S is converted in terms of mm/V
```

Scilab code Exa 20.9.2 To calculate the highest frequency of the deflecting voltage

```
//scilab 5.4.1
//Windows 7 operating system
//chapter 20 Cathode Ray Oscilloscope
clc
clear
e=1.6*10^-19//e=charge of an electron
Va=1000//Va=potential difference in volts
m=9.11*10^-31//m=mass of an electron
v=sqrt((2*e*Va)/m)//v=axial velocity of an electron
l=1.5*10^-2//l=axial length of deflecting plates in metre
t=l/v//t=transit time of the beam through the deflecting plates
//T=time period of the sinusoidal deflecting voltage
//tmax=maximum transit time
//(0.1/360)*T=tmax,since 1 cycle corresponds to 360 degrees
```

```
T=(t*360)/0.1
f=1/T//f=highest frequency of the deflecting voltage
format("v",5)
disp("kHz",f/1000,"The highest frequency of the deflecting voltage is =")
```

Scilab code Exa 20.9.3 To find the deflection of the spot and the magnetic deflection sensitivity

```
//scilab 5.4.1
//Windows 7 operating system
//chapter 20 Cathode Ray Oscilloscope
clc
clear
V=1000//V=potential difference in volts
//B=150 gauss (given)
B=1.5*10^-2//B=magnetic field in tesla
l=1*10^-2//l=axial length of deflecting plates in metre
L1=20*10^-2//L1=(L+(l/2))=distance of the fluorescent screen from the centre of the deflection system in metre
e=1.6*10^-19//e=charge of an electron
m=9.11*10^-31//m=mass of an electron
d=B*sqrt(e/(2*V*m))*l*L1//d=deflection of the spot
format("v",5)
disp("cm",d*100,"The deflection of the spot is=")
Sm=d/B//Sm=magnetic deflection sensitivity
format("v",5)
disp("mm/gauss",Sm/10,"The magnetic deflection sensitivity is=")
```

Scilab code Exa 20.9.4 To calculate the frequency of the signal

```
//scilab 5.4.1
//Windows 7 operating system
//chapter 20 Cathode Ray Oscilloscope
clc
clear
sw=10//sw=sweep width in cm
n=5/2//n=number of cycles given by vertical
    deflection plates
c=sw/n//c=centimetres occupied by one cycle of
    signal
ct=0.1//ct=calibrated time base of CRO in ms/cm
t=ct*c//t=time interval corresponding to centimetres
     occupied by one cycle of signal
T=t/5//T=time period of the signal,since the scale
    is 5 times magnified
f=1/T//f=frequency of the signal
disp("kHz",f,"The frequency of the signal is =")
```

Scilab code Exa 20.9.5 To find the frequency of the vertical signal

```
//scilab 5.4.1
//Windows 7 operating system
//chapter 20 Cathode Ray Oscilloscope
clc
clear
//Let fv=frequency of the vertical signals in kHz
//fh=frequency of the horizontal signals
//Number of horizontal tangencies=nh
//Number of vertical tangencies=nv
//fv/fh=nh/nv
fh=1
nh=3
nv=4
fv=(nh/nv)*fh
disp("Hz",fv*1000,"The frequency of the vertical
```

```
signal is =")
```

Scilab code Exa 20.9.6 To find the phase difference between the voltages

```
//scilab 5.4.1
//Windows 7 operating system
//chapter 20 Cathode Ray Oscilloscope
clc
clear
//slope of the major axis is negative (given)
A=2.6//A=The maximum y-displacement
vyo=1.1//vyo=the vertical displacement
sino=(vyo/A)//o=phase difference between the two
   voltages
x=asind(sino)
disp("As the major axis of the ellipse has a
   negative slope,phase difference between the two
   voltages must lie between 90 degree and 180
   degree")
disp("degree",180-x,"Therefore,phase difference
   between the voltages is =")
```

Chapter 21

Communication Systems

Scilab code Exa 21.13.1 To calculate the critical frequencies and the maximum frequencies

```
//scilab 5.4.1
//Windows 7 operating system
//chapter 21 Communication Systems
clc
clear
Npe=6*10^10//Npe=peak electron concentration for the E layer in m^-3
Npf=10^12//Npf=peak electron concentration for the F layer in m^-3
fCE=9*sqrt(Npe)//fCE=critical frequency for the E layer
format("v",5)
disp("MHz",fCE/10^6,"Critical frequency for the E layer is =")
fCF=9*sqrt(Npf)//fCF=critical frequency for the F layer
format("v",5)
disp("MHz",fCF/10^6,"Critical frequency for the F layer is =")
R=6400//R=radius of the earth in km
```

```
He=110//He=height of the E layer above the earth
    surface in km
ime=asind(R/(R+He))//ime=angle corresponding to
    maximum frequency fmE for E layer in degrees
format("v",3)
fmE=fCE*secd(ime)//fmE=maximum frequency reflected
    from the E layer
disp("MHz",fmE/10^6,"The maximum frequency reflected
     from the E layer is =")
Hf=250//Hf=height of the F layer above the earth
    surface in km
imf=asind(R/(R+Hf))//imf=angle corresponding to
    maximum frequency fmF for F layer in degrees
format("v",3)
fmF=fCF*secd(imf)//fmF=maximum frequency reflected
    from the F layer
disp("MHz",fmF/10^6,"The maximum frequency reflected
     from the F layer is =")
```

Scilab code Exa 21.13.2 To find the maximum distance between the transmitting and receiving points

```
//scilab 5.4.1
//Windows 7 operating system
//chapter 21 Communication Systems
clc
clear
R=6400//R=radius of the earth in km
He=110//He=height of the E layer above the earth
    surface in km
ime=asin(R/(R+He))//ime=angle corresponding to
    maximum frequency fmE for E layer in radian
format("v",10)
o=(%pi/2)-ime//o=angle made by the incident ray at
    the centre of the earth in degrees
```

```
format("v",5)
L=2*o*R//L=maximum distance between the transmitting
     and the receiving points on the earth surface
    for single hop transmission of the radiowave
    reflected from the E layer
format("v",5)
disp("km",L,"The maximum distance for single hop
    transmission is =")
//Answer given in textbook is 2459 km which is
    incorrect as it is actually around 2356 km.
```

Scilab code Exa 21.13.3 To find the height of the point above the ground from which the wave is reflected back

```
//scilab 5.4.1
//Windows 7 operating system
//chapter 21 Communication Systems
clc
clear
//fc=9*sqrt(Np)
fc=3*10^6//fc=critical frequency in Hz
Np=(fc^2)/81//Np=electron concentration at the
    reflecting point
//h=height of the reflecting point from the bottom
    of the layer
//Np=(5*10^10)+(10^9*h)....(given)
h=(Np-(5*10^10))/10^9
H=100//H=height above the surface of the earth in km
disp("km",h+H,"The required height above the ground
    is =")
```

Chapter 23

Lasers Fibre Optics and Holography

Scilab code Exa 23.31.1 To calculate the number of photons emitted per second

```
//scilab 5.4.1
//Windows 7 operating system
//chapter 23 Lasers,Fibre Optics,and Holography
clc
clear
y=630*10^(-9)//y=emitted wavelength in meters
c=3*10^8//c=velocity of light in free space in m/s
v=c/y//v=frequency of the emitted radiation
format("v",9)
disp("The frequency of the emitted radiation is")
disp("Hz",v,"v=")
h=6.62*10^(-34)//h=Planck's constant
P=1*10^(-3)//P=output power of gas laser(given)
n=P/(h*v)
format("v",9)
disp("s^-1",n,"The number of photons emitted per
    second is=")
```

Scilab code Exa 23.31.2 To calculate the coherence time and the longitudinal coherence length

```
//scilab 5.4.1
//Windows 7 operating system
//chapter 23 Lasers,Fibre Optics,and Holography
clc
clear
V=500//V=bandwidth of a He-Ne laser in Hz
t=1/V//t=coherence time
disp("ms",(t*(10^3)),"The coherence time is =")
c=3*10^8//c=velocity of light in m/s
Lc=c/V//Lc=longitudinal coherence length
disp("km",(Lc/1000),"The longitudinal coherence
    length is=")
```

Scilab code Exa 23.31.3 To calculate the minimum difference between two arms of a Michelson interferometer

```
//scilab 5.4.1
//Windows 7 operating system
//chapter 23 Lasers,Fibre Optics,and Holography
clc
clear
//To obtain interference fringes of good visibility
    the path difference for the central fringe must
    be an integral multiple of each of the 2
    wavelengths.
//2*d=(n1*y1)=(n2*y2)where y1 & y2 are 2 wave-
    lengths and d=path difference and n1 and n2 are 2
     integers
```

```
//(2*d)*((1/y2)-(1/y1))=(n2-n1)=m where m is another integer
//Now m=(-2*d*Y)/(y^2)=(2*d*V)/(v*y)=(2*d*V)/c=(2*d)/Lc
Lc=600//Lc=coherence length in km
d=(Lc/2)//d=minimum difference between the 2 arms of the Michelson interferometer
disp("km",d,"The minimum difference between the two arms of the Michelson interferometer is=")
```

Scilab code Exa 23.31.4 To show that emission for a normal optical source is predominantly due to spontaneous transitions

```
//scilab 5.4.1
//Windows 7 operating system
//chapter 23 Lasers,Fibre Optics,and Holography
clc
clear
h=6.62*10^(-34)//h=Planck's constant
v=3*10^8//v=velocity of light(as normal optical source is mentioned) in m/s
kB=1.38*10^-23//kB=Boltzmann's constant
T=1000//T=temperature in Kelvin
w=6000//w=wavelength in Armstrong
R=(exp((h*v)/(w*(10^-10)*kB*T)))-1//R=the ratio of the number of spontaneous to stimulated transitions
disp(,R,"R=")
if (R>1) then

    disp("As the ratio of the number of spontaneous to stimulated transitions (R) is >> 1 the emission is predominantly due to spontaneous transitions and is thus incoherent")
end
```

Scilab code Exa 23.31.5 To determine coherence time and the coherence length

```
//scilab 5.4.1
//Windows 7 operating system
//chapter 23 Lasers,Fibre Optics,and Holography
clc
clear
u=8/(10^14)//u=(V/v)=the short term frequency
    stability of a He-Ne gas laser
//v=c/y where c=velocity of light in vacuum  and y=
    wavelength
c=3*10^8//c=velocity of light in m/s
y=1153*10^(-9)//y=emitted wavelength in meters
V=(u*c)/y
t=1/V//t=coherence time
disp("ms",(t*(10^3)),"The coherence time is =")
format("v",9)
Lc=c/V//Lc=coherence length
disp("m",Lc,"The coherence length is=")
format("v",3)
```

Scilab code Exa 23.31.6 To find the line width and the coherence length

```
//scilab 5.4.1
//Windows 7 operating system
//chapter 23 Lasers,Fibre Optics,and Holography
clc
clear
//y0=vacuum wavelength for the frequency v
//c=(v*y0)
```

```
//The deviation in the wavelength is Y0=(c*V)/(v^2)
//Y0=((y0^2)*V)/c
//V being spread in frequency over the linewidth.
//V=(1/tc)
c=3*(10^8)//c=velocity of light in m/s
tc=10^(-8)//tc=coherence time in seconds
y0=650*(10^(-9))//y0=vacuum wavelength in m
Y0=(y0^2)/(c*tc)
format("e",9)
disp("nm",Y0/(10^-9),"Line width is =")//Y0 is
    converted in terms of nm
Lc=c*tc//Lc=coherence length
format("v",5)
disp("m",Lc,"The coherence length Lc is=")
```

Scilab code Exa 23.31.7 To find the radius along with the power density of the image and the coherence length

```
//scilab 5.4.1
//Windows 7 operating system
//chapter 23 Lasers,Fibre Optics,and Holography
clc
clear
o=5*10^-5//o=angular spread in radians
f=10//f=focal length in cm
D=f*o//D=diameter of the image
r=(D/2)//r=image radius
format("v",15)
disp("cm",r,"The image radius is =")
a=%pi*(r^2)//a=cross sectional area of the image in
    cm^2
P=10*10^-3//P=power in Watts
PD=P/a//PD=power density
format("v",10)
disp("W/cm^2",PD,"Power density is =")
```

```
y=6000*10^-8//y=wavelength in cm
d=y/o//d=coherent width
disp("cm",d,"The lateral coherent width is =")
```

Scilab code Exa 23.31.8 To find the amount of pumping energy required for transition from 3s to 2p

```
//scilab 5.4.1
//Windows 7 operating system
//chapter 23 Lasers,Fibre Optics,and Holography
clc
clear
h=6.62*10^-34//h=Planck's constant
c=3*10^8//c=velocity of light in vacuum in m/s
y=632.8*10^-9//y=emitted wavelength in m
E=(h*c)/y//E=emitted photon energy in Joules
e=15.2*10^-19//e=energy of 2p level in Joules
P=E+e//P=Pumping energy required for transition from
    3s to 2p level in a He-Ne laser
disp("eV",P/(1.6*10^-19),"The desired pumping energy
    is =")
format("v",10)
```

Scilab code Exa 23.31.9 To calculate the probability of stimulated emission

```
//scilab 5.4.1
//Windows 7 operating system
//chapter 23 Lasers,Fibre Optics,and Holography
clc
clear
h=6.62*10^-34//h=Planck's constant
v=2.4*10^15//v=frequency of emitted radiation in Hz
```

```
c=3*10^8//c=velocity of light in vacuum in m/s
A21=1/(1.66*10^-8)//A21=mean spontaneous life time
B21=((c^3)*A21)/(8*%pi*h*(v^3))//B21=probability of
    stimulated emission
disp("m^3/(J.s^2)",B21,"The desired probability is =
    ")
```

Scilab code Exa 23.31.10 To calculate the NA and the acceptance angle along with number of reflections per metre

```
//scilab 5.4.1
//Windows 7 operating system
//chapter 23 Lasers,Fibre Optics,and Holography
clc
clear
u1=1.55//u1=refractive index of the core of the
    fibre
u2=1.50//u2=refractive index of the cladding
oa=asind(sqrt((u1^2)-(u2^2)))//oa=acceptance angle
format("v",5)
disp("degree",oa,"The acceptance angle is =")
NA=sind(oa)//NA=numerical aperture
disp(,NA,"NA=")
oc=asind(u2/u1)//oc=critical angle
disp("degree",oc,"Critical angle=")
d=50*10^-6//d=core diameter in meters
x=d*tand(oc)//x=axial distance traversed by the ray
    between two consecutive reflections
n=1/x//n=number of reflections per metre
disp(,n,"The number of reflections per metre is =")
```