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.

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Chapter 1

Basic Ideas Energy Bands In Solids

Scilab code Exa 1.7.1 To find the final velocity of electron

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

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

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

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

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

```
1
2  //scilab 5.4.1
3  //windows 7 operating system
4  //chapter 2:Electron Emission from Solids
5  clc
6  clear
7  //given
8  T=2673//T=temperature in Kelvin
9  dT=10//dT=change in temperature in Kelvin
10 Ew=4.54//Ew=work function in eV
11 e=1.6*10^(-19)//e=charge of anelectron in C
12 kB=1.38*10^(-23)//kB=Boltzmann's constant in J/K
13 //I=(S*A*(T^2))*exp(-((e*Ew)/(kB*T)))//I=emission
       current,S=surface area of the filament,dI=change
       in emission current
14 d=((2*dT)/T)+(((e*Ew)/(kB*(T^2))*dT))//d=change in
       emission current
15 disp("",d,"d=")
16 d*100//percent change in emission current
17 disp("%",d*100,"d*100=")
```

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

```
1
2  //scilab 5.4.1
3  //windows 7 operating system
4  //chapter 2:Electron Emission from Solids
5  clc
6  clear
```

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

Scilab code Exa 2.7.4 to find the anode voltage

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

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

Chapter 3

PROPERTIES OF SEMICONDUCTORS

Scilab code Exa 3.11.1 To find the conductivity and resistivity

```
1
2  // scilab  5.4.1
3  //WINDOWS 7  Operating  System
4  // chapter  3 PROPERTIES  OF  SEMICONDUCTORS
5  // example  1
6
7  clc
8  // Given  data
9  T=300;   //K
10 ni=1.5*10^16;     // Intrinsic  carrier  concentartion
        per  m^3
11 yn=0.13;      // Electron  mobility  in  m^2/(V*s)
12 yp=0.05;     // Hole  mobility  in  m^2/(V*s)
13 e=1.6*10^-19;    // Charge  of  electron  in  C
14
15 // Required  Formula
16 Gi=e*ni*(yn+yp);     // Intrinsic  conductivity
17
18 Ri=1/Gi;     // Intrinsic  resistivity
```

```
19
20  disp('S/m',Gi,'Intrinsic conductivity=');
21
22  disp('ohm*meter',Ri,'Intrinsic resistivity=');
23  //End
```

Scilab code Exa 3.11.2 To find Concentration of donor atoms

```
1
2   //scilab 5.4.1
3   //WINDOWS 7 Operating Systems
4   //chapter 3 PROPERTIES OF SEMICONDUCTORS
5
6   //example 2
7   clc
8   //Given data
9   Sn=480;       //Conductivity in S/m
10  yn=0.38;      //Electron mobility in m^2/(V*s)
11  e=1.6*10^-19;    //Charge of electron in C
12
13  //Required Formula
14  Nd=Sn/(e*yn);    //Concentration of donor atoms per m
       ^3
15   disp('m^-3',Nd,'Concentration of donor atoms');
16   //End
```

Scilab code Exa 3.11.4 To find intrinsic conductivity and resistance required

```
1
2   //scilab 5.4.1
3   //OS--WINDOWS 7
4   //chapter 3 PROPERTIES OF SEMICONDUCTORS
5   //example 4
```

```
 6
 7  clc
 8  //Given data
 9  T=300;   //K
10  ni=1.5*10^16;       //Intrinsic  carrier  concentartion
        per  m^3
11  yn=0.13;      //Electron  mobility  in  m^2/(V*s)
12  yp=0.05;    //Hole  mobility  in  m^2/(V*s)
13  e=1.6*10^-19;     //Charge  of  electron  in  C
14  l=0.01;      //length  in  m
15  a=10^-6;       //cross  sectional  area  in  m^2
16
17  //Required  Formula
18  Gi=e*ni*(yn+yp);       //Intrinsic  conductivity
19
20  Ri=l/(Gi*a);      //Required  resistance
21
22  disp('S/m',Gi,'Intrinsic  conductivity=');
23
24  disp('ohm',Ri,'required  resistance');
25  //End
```

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

```
 1
 2  //scilab  5.4.1
 3  //windows  7  operating  system
 4  //chapter  3:Properties  of  Semiconductors
 5  clc
 6  clear
 7  //given
 8  z=(100/60);//z=conductiarrier  concentration  in  /(m
        ^3)
 9  ni=2.5*10^(19);//ni=intrinsic  conductivity  of
        intrinsic  material  in  S/m
```

```
10  //(P/N)=(1/2);//(P/N)=ratio  of  hole  mobility (P)  to
        electron  mobility (N)
11  e =1.6*(10^ -19) ;//e=charge  of  electron  in  Coulomb
12  N=(z/(e*ni*(1+(1/2)))))
13  disp (" (m^2) /(V. s )" ,N ," N=")
14  P=(N/2)
15  disp (" (m^2) /(V. s )" ,P ," P=")
16  //Nd+p=Na+n;n=electron  concentration ;p=hole
        concentration
17  //np=(ni^2)
18  Nd =(10^20)//Nd=donor  concentration  in  /(m^3)
19  Na =5*(10^19)//Na=acceptor  concentration  in  /(m^3)
20  n =(1/2) *((Nd -Na)+sqrt (((Nd -Na)^2)+(4*(ni^2))))
21  disp (" /(m^3)" ,n ," n=")
22  p =(ni^2)/n
23  disp (" /(m^3)" ,p ," p=")
24  Z=e *((n*N)+(p*P))//Z=conductivity  of  doped  sample  in
        S/m
25  disp (" S/m" ,Z ," Z=")
26  F=200//F=applied  electric  field  in  V/cm
27  J=Z*F//J=total  conduction  current  density  in  A/(m^2)
28  disp (" A/(m^2)" ,J ," J=")
```

Scilab code Exa 3.11.6 To find the electron and hole concentration and conductivit

```
1
2  //scilab  5.4.1
3  //windows  7  operating  system
4  //chapter  3:Properties  of  Semiconductors
5  clc
6  clear
7  //given
8  ni =2.5*10^(19) ;//ni=intrinsic  conductivity  of
        intrinsic  material  in  S/m
9  Nd =5*(10^19)//Nd=donor  concentration  in  /(m^3)
```

```
10  n=(1/2)*(Nd+sqrt((Nd^2)+(4*(ni^2))))//n=electron
       concentration
11  disp("/(m^3)",n,"n=")
12  p=(ni^2)/n//p=hole concentration
13  disp("/(m^3)",p,"p=")
14  N=0.38//N=electron mobility in (m^2)/(V.s)
15  P=0.18//P=hole mobility in (m^2)/(V.s)
16  e=1.6*(10^-19)//e=electronic charge in Coulomb
17  Z=e*((n*N)+(p*P))//Z=conductivity of doped sample in
       S/m
18  disp("S/m",Z,"Z=")
```

Scilab code Exa 3.11.7 To find the required wavelength

```
1
2  //scilab 5.4.1
3  //windows 8 operating system
4  //chapter 3:Properties of Semiconductors
5  clc
6  clear
7  //given
8  c=3*(10^8);//c=velocity of light in vacuum in m/s
9  h=6.6*(10^-34);//h=Planck's constant in J.s
10  Eg=1.98*1.6*(10^-19)//Eg=band gap in J
11  //calculating Y=required wavelength
12  Y=((c*h)/Eg)/(10^-9)
13  disp("nm",Y,"Y=")
```

Scilab code Exa 3.11.8 To find the magnetic and hall field

```
1
2  //scilab 5.4.1
3  //windows 7 operating system
```

```
 4 //chapter  3:Properties  of  Semiconductors
 5 clc
 6 clear
 7 //given
 8 RH=(10^-2);//RH=Hall  coefficient  in  (m^3)/C
 9 VH=(10^-3);//VH=Hall  Voltage  in  V
10 b=2*(10^-3);//b=width  in  m
11 I=(10^-3);//I=current  in  A
12 //RH=(VH*b)/(I*B)
13 B=(VH*b)/(I*RH)//B=magnetic  field
14 disp("T",B,"B=")
15 t=(10^-3)//t=thickness  in  m
16 FH=(VH/t)//FH=Hall  field
17 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

```
1
2  //scilab 5.4.1
3  //windows 7 operating system
4  //chapter 4:Metal-Semiconductor Contacts
5  clc
6  clear
7  //given
8  Qm=4.55//Qm=work function of tungsten in eV
9  X=4.01//X=electron affinity of silicon in eV
10 eQb=(Qm-X)//eQb=barrier height as seen from the
       metal
11 disp("eV",eQb,"eQb=")
12 a=0.21//a=(Ec-Ef)=forbidden gap in eV
13 eVbi=eQb-a//eVbi=barrier height from semiconductor
       side
14 disp("eV",eVbi,"eVbi=")
15 Es=11.7*8.854*(10^-12)//Es=permittivity of
       semiconductor;11.7=dielectric constant of silicon
16 e=1.6*10^(-19)//e=charge of an electron
17 Nd=10^22//Nd=donor concentration in m^-3
18 W=((2*Es*eVbi)/(e*Nd))^(1/2)//W=width of the
```

25

```
         depletion region
19  disp("m",W,"W=")
20  Fm=((e*Nd*W)/Es)//Fm=maximum  electric  field  in  V/m
21  disp("V/m",Fm,"Fm=")
```

Scilab code Exa 4.7.2 to find the barrier height and concentration

```
1
2  //scilab 5.4.1
3  //windows 7 operating system
4  //chapter 4:Metal−Semiconductor Contacts
5  clc
6  clear
7  //given
8  // as per given data barrier height =Vbi=intercept
       on Vr axis=0.4 V
9  Es=11.7*8.854*(10^-12)//Es=permittivity of
       semiconductor;11.7=dielectric constant of silicon
10  e=1.6*10^(-19)//e=charge of an electron
11  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)
12  //m=2/(e*Es*Nd)
13  Nd=(2*10^8)/(e*Es*m)//Nd=donor concentration in
       silicon in m^−3
14  disp("m^−3",Nd,"Nd=")
```

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

```
1
2  //scilab 5.4.1
3  //windows 7 operating system
4  //chapter 4:Metal−Semiconductor Contacts
5  clc
```

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

Scilab code Exa 4.7.4 to determine the effective richardson constant

```
 1
 2  //scilab 5.4.1
 3  //windows 7 operating system
 4  //chapter 4:Metal−Semiconductor Contacts
 5  clc
 6  clear
 7  //given
 8  //Js=A*(T^2)*exp(−((e*Qbn)/(kB*T)))
 9  kB=1.38*10^(-23)//kB=Boltzmann's constant in J/K
10  T=300//T=temperature in Kelvin
11  e=1.6*10^-19//e=charge of an electron in C
12  Js=6*10^-5//Js=emission current density in A/cm^2
13  Qbn=0.668//Qbn=barrier height in V
14  A=(Js/(T^2))*exp((e*Qbn)/(kB*T))//A=Richardson
        constant
15  disp("(cm^−2)(K^−2)",A,"A=")
```

Scilab code Exa 4.7.5 to calculate current in a Schottky diode

```scilab
1
2  //scilab 5.4.1
3  //windows 7 operating system
4  //chapter 4: Metal−Semiconductor Contacts
5  clc
6  clear
7  //given
8  e=1.6*10^-19//e=charge of an electron in C
9  V=0.32//V =applied forward bias in V
10  kB=1.38*10^(-23)//kB=Boltzmann's constant in J/K
11  T=300//T=Temperature in Kelvin
12  Js=0.61//Js=reverse saturation current density in A/
       m^2
13  J=Js*(exp((e*V)/(kB*T))-1)//J=current density in A/m
       ^2
14  disp("A/m^2",J,"J=")
15  A=4*10^-8//A=cross sectional area in m^2
16  I=(J*A)*10^3//I=current
17  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

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

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

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

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

```
1
2  //scilab 5.4.1
3  //windows 7 operating system
4  //Chapter 5:Semiconductor Junction Diodes
5  clc
6  clear
7  V=0.9//V=forward bias voltage
```

```
8  I=60*10^(-3)//I=Current in ampere
9  rdc=(V/I)//rdc=static resistance in ohm
10 n=2//n=emission coefficient
11 rac=((26*n*10^(-3))/I)//rac=dynamic resistance
12 disp("ohm",rdc,"rdc=")
13 disp("ohm",rac,"rac=")
```

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

```
1
2  //scilab 5.4.1
3  //windows 7 operating system
4  //chapter 5:Semiconductor Junction Diodes
5  clc
6  clear
7  e=1.6*10^(-19)//e=charge of an electron in C
8  kB=1.38*10^(-23)//kB=Boltzmann's constant in J/K
9  //V,V1=forward bias voltagesin V
10 n=2//n=emission coefficient for silicon pn junction
      diode
11 T=300//T=Temperature in kelvin
12 //Is=Reverse saturation current in A
13 //I=Is*(exp((e*V)/(n*kB*T)))//I=current for forward
      bias voltage V
14 //2I=Is*(exp((e*V1)/(n*kB*T)))//2I=current for
      forward bias voltage V1
15 //exp((e*(V1-V)/(n*kB*T)))=2
16 a=(((n*kB*T)/e)*log(2))*10^3//a=(V1-V)=increase in
      the bias voltage in V
17 disp("mV",a,"V1-V")
```

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

31

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

Scilab code Exa 5.7.6 To calculate the rise in temperature

```
 1
 2  //scilab 5.4.1
 3  //windows 7 operating system
 4  //chapter 5:Semiconductor Junction Diodes
 5  clc
 6  clear
 7  //T1,T2=Temperature in kelvin
 8  //Is1=Reverse saturation current at temperature T1
        in ampere
 9  //Is2=Reverse saturation current at temperature T2
        in ampere
```

```
10  // Is2=Is1 * 2 ^ ( ( T2−T1 ) / 10)
11  // ( ( T2−T1 ) / 10) * log ( 2 )=log ( Is2 / Is1 )
12  //b=(Is2 / Is1 )
13  b=50
14  a = ( ( 10* log ( b ) ) / log ( 2 ) ) // a=(T2−T1)=r i s e  in
        temperature  in  degree  c e l c i u s
15  disp ( ”C” , a , ”T2−T1” )
```

Scilab code Exa 5.7.7 To calculate the maximum permissible battery voltage

```
1
2   // s c i l a b  5 . 4 . 1
3   // windows 7 operating  system
4   // chapter  5: Semiconductor  Junction  Diodes
5   clc
6   clear
7   V =0.6// V=cutin  voltage  in V
8   r =150// r=forward  r e s i s t a n c e  in ohm
9   P =200*(10^ -3)// P=maximum power  in Watt
10  //P=(i ^2)* r  where  i=maximum  s a f e  diode  current
11  i = ( sqrt (P/ r ) )*10^3
12  disp ( ”mA” , i , ” i=” )
13  // i =((Vb/3)−V)/3 by applying KCL
14  Vb = ( ( 3* i )+V )*3// Vb=maximum  permissible  battery
        voltage
15  disp ( ”V” , Vb , ”Vb=” )
```

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

```
1
2   // s c i l a b  5 . 4 . 1
3   // windows 7 operating  system
4   // chapter  5: Semiconductor  Junction  Diodes
```

```
5 clc
6 clear
7 V=15//V=supply voltage
8 Vz=12//Vz=Zener voltage
9 P=0.36//P=power of Zener diode
10 //P=Vz*I
11 I=(P/Vz)//I=maximum allowable Zener current
12 disp("A",I,"I=")
13 Vr=V-Vz//Vr=voltage drop across series resistance R
14 disp("V",Vr,"Vr=")
15 R=Vr/I//R=series resistance
16 disp("ohm",R,"R=")
17 //I=Iz+Il
18 Iz=2*(10^-3)//Iz=minimum diode current
19 Il=I-Iz//Il=current through load resistance Rl
20 disp("A",Il,"Il=")
21 Rlm=Vz/Il//Rlm=minimum value of Rl
22 disp("ohm",Rlm,"Rlm=")
23 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

```
1
2 //scilab 5.4.1
3 //windows 7 operating system
4 //chapter 5:Semiconductor Junction Diodes
5 clc
6 clear
7 V=15//V=supply voltage
8 Vz=12//Vz=Zener voltage
9 P=0.36//P=power of Zener diode
10 //P=Vz*I
11 I=(P/Vz)//I=maximum allowable Zener current
12 disp("A",I,"I=")
```

```
13 Iz=2*10^(-3)//Iz=minimum value attained by the zener
       current
14 Rl=1000//Rl=load resistance
15 i=Vz/Rl//i=load current
16 disp("A",i,"i=")
17 Imin=Iz+i//Imin=minimum allowable value of current
18 R=100//R=series resistance
19 Vr=Imin*R//Vr=voltage drop across R
20 disp("V",Vr,"Vr=")
21 Vmin=Vz+Vr//Vmin=minimum value of V
22 disp("V",Vmin,"Vmin=")
23 I1=I+i
24 disp("A",I1,"I1=")
25 VR=I1*R
26 disp("V",VR,"VR=")
27 Vmax=Vz+VR//Vmax=maximum value of V
28 disp("V",Vmax,"Vmax=")
29 disp("V can vary between Vmin & Vmax")
```

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

```
1
2 //scilab 5.4.1
3 //windows 7 operating system
4 //chapter 5:Semiconductor Junction Diodes
5 clc
6 clear
7 Vz=3//Vz=breakdown voltage of zener diode
8 Vi=12//Vi=input voltage
9 V=[12;-3]//V=[Vi:-Vz]
10 R1=1000
11 R2=1000
12 R3=500//R1,R2,R3=resistances
13 R=[R1+R2 -R2;-R2 R2+R3]
14 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]
15  disp("A",I1(1),"I=")
16  disp("A",I1(2),"Iz=")
17  Pz=Vz*I1(2)//Pz=power dissipated in zener diode
18  disp("W",Pz,"Pz=")
19  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

```
1
2  //scilab 5.4.1
3  //windows 7 operating system
4  //chapter 5:Semiconductor Junction Diodes
5  clc
6  clear
7  Vs1=15
8  Vs2=30//Vs=supply voltage varying from 15(Vs1) to
        30(Vs2) Volt
9  Vzo=9//Vzo=knee voltage
10 rZ=5//rZ=dynamic resistance in ohms
11 R=800//R=series resistance in ohms
12 Izmin=(Vs1-Vzo)/(R+rZ)//Izmin=current through zener
        diode when Vs is 15 V
13 disp("A",Izmin,"Izmin=")
14 Vomin=(rZ*Izmin)+Vzo//Vomin=corresponding minimum
        output voltage
15 disp("V",Vomin,"Vomin=")
16 Izmax=(Vs2-Vzo)/(R+rZ)//Izmax=current through zener
        diode when Vs is 30 V
17 disp("A",Izmax,"Izmax=")
18 Vomax=(rZ*Izmax)+Vzo//Vomax=corresponding maximum
        output voltage
19 disp("V",Vomax,"Vomax=")
```

36

```
20  disp("Output voltage Vo varies in the range Vomin to
        Vomax")
```

Scilab code Exa 5.7.12 To find the value of resistance R

```
1
2  //scilab 5.4.1
3  //windows 7 operating system
4  //chapter 5:Semiconductor Junction Diodes
5  clc
6  clear
7  V=35//V=supply voltage
8  Iz=25*10^(-3)//Iz=diode current
9  Il=5*10^(-3)//Il=load current
10 Vzo=7//Vzo=knee voltage of zener diode
11 rZ=6//rZ=dynamic resistance in ohms
12 Vz=Vzo+(rZ*Iz)//Vz=zener voltage
13 disp("V",Vz,"Vz=")
14 I=Iz+Il//I=current through resistance R
15 disp("A",I,"I=")
16 R=(V-Vz)/I
17 disp("ohm",R,"R=")
```

Chapter 6

Diode Circuits

Scilab code Exa 6.11.1 To find various currents voltages power conversion efficien

```
1
2  // scilab  5.4.1
3  // windows  7  operating  system
4  // chapter  6: Diode  Circuits
5  clc ;
6  clear ;
7  // given  data
8  Vrms =20;       // in  volts
9  Vm =20*1.41;  // in  volts
10  Rf =50;   // forward  resistance  in  ohms
11  RL =1200;       // load  resistance  in  ohms
12
13  Im = Vm /( Rf + RL ) ;   // peak  load  current
14  format ( ” v ” ,7)
15  disp ( ’A ’ , Im , ’Im= ’ ) ;
16
17  Idc = Im /%pi ;        // dc  load  current
18  format ( ” v ” ,8) // to  set  the  current  printing  format
       with  the  specified  parameter  type
19  disp ( ’A ’ , Idc , ’ Idc= ’ ) ;
20
```

```
21  Irms = Im/2; //rms load current
22  Irms1 = sqrt((Irms^2) -(Idc^2))//rms ac load current
23  format("v" ,8)
24  disp('A', Irms1 ,'rms ac load current is=');
25
26  Vdc = Idc * Rf;        // Dc voltage across the diode
27  format("v" ,6)
28  disp('V', Vdc ,'Dc voltage across the diode=');
29
30  Pdc = Idc * Idc * RL;        // Dc output power
31  format("v" ,6)
32  disp('W', Pdc ,'Dc output power=');
33
34  n =40.6/(1+(Rf/RL));        // conversion efficiency
35  format("v" ,5)
36  disp('%',n ,'conversion efficiency=');
37
38  s = Rf *100/ RL;        // Pertcentage regulation
39  format("v" ,5)
40  disp('%',s ,'Pertcentage regulation=');
41
42  // end
```

Scilab code Exa 6.11.2 To find various currents power ripple voltage percentage re

```
1
2  // scilab 5.4.1
3  // windows 7 operating system
4  // chapter 6: Diode Circuits
5  clc;
6  clear;
7  // given data
8  Rf =100; // forward resistance in ohms
9  Rl =1000; // load resistance in ohms
10 n =10;     // Primary to secondary turns ratio
```

```
11  Vp=240;  //Primary input V(rms)
12
13  Vm=24*(2^(1/2))/2;    //secondary peak voltage from
       cenre tap
14  Vs=Vp/n;    //Secondary input voltage
15  Im=Vm/(Rf+Rl);  //peak current through the
       resistance in A
16  Idc=(2*Im)/%pi;  //DC Load current in A
17  format("v",8)
18  disp('A',Idc,'DC load current Idc=',);
19  I=Idc/2;    //Direct current supplied by each diode
       in A
20  format("v",7)
21  disp('A',I,'Direct current supplied by each diode
       Idc=',);
22  Pdc=Idc*Idc*Rl; //DC power output
23  format("v",6)
24  disp('W',Pdc,'Pdc=');
25  Irms=Im/(2^(1/2));
26  Vrp=sqrt((Irms*Irms)-(Idc*Idc))*Rl;   //Ripple
       voltage in V
27  format("v",7)
28  disp('V',Vrp,'Ripple voltage Vrp=');
29
30
31  M=(Rf*100)/Rl;    //percentage regulation
32  disp('%',M,'Percentage regulation=');
33  n=81.2/(1+(Rf/Rl));  //Efficiency of rectification
34  format("v",5)
35  disp('%',n,'Efficiency of rectification');
36
37  //end
```

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

```
1
2  //scilab 5.4.1
3  //windows 7 operating system
4  //chapter 6:Diode Circuits
5  clc;
6  clear;
7  //given data
8  Rf=50;   //forward resistance in ohms
9  Rl=2500; //load resistance in ohms
10 Vp=30;    //Primary input V(rms)
11 Vm=30*sqrt(2);
12
13 Im=Vm/(2*Rf+Rl);     //peak load current in A
14 Idc=2*Im/%pi;
15
16 Vdc=Idc*Rl;      //DC load voltage
17 disp('V',Vdc,'Vdc=');
18 Irms=Im/sqrt(2);
19 Vrp=Rl*sqrt(((Irms*Irms)-(Idc*Idc)));   //Ripple
       voltage in V
20 disp('V',Vrp,'Ripple voltage Vrp=');
21
22 M=(2*Rf/Rl)*100;     //Percentage regulation
23 disp('%',M,'Percentage regulation=');
24
25 //end
```

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

```
1
2  //scilab 5.4.1
3  //windows 7 operating system
4  //chapter 6:Diode Circuits
5  clc;
6  clear;
```

```
7  //given data
8
9  Vdc=20;  //DC value in V
10 Vpp=1;  //Peak to peak ripple voltage in V
11
12 Vp=Vpp/2;  //Peak ripple voltage in V
13 Vrms=Vp/sqrt(2);  //Vrms voltage in V
14 S=Vrms/Vdc;  //Ripple Factor
15 format("v",7)
16 disp(S,'Ripple factor=')
17 T=S*100;
18 format("v",5)
19 disp("%",T,'Percentage Ripple=')
20 //end
```

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

```
1  //scilab 5.4.1
2  //Windows 7 operating system
3  //chapter 6 Diode Circuits
4  clc
5  clear
6  //For a full wave rectifier
7  //L-type LC filter
8  f=50//f=line frequency in Hz
9  w=2*%pi*f
10 Vdc=10//Vdc=dc output voltage
11 Idc=100*10^-3//Idc=load current in Amperes
12 y=0.02//y=allowable ripple factor
13 //y=sqrt(2)/(12*(w^2)*L*C)
14 //Let L*C=a..............(1)
15 a=sqrt(2)/(y*12*(w^2))
16 RL=Vdc/Idc//RL=load resistance
17 //Lc=critical inductance
18 //Lc=RL/(3*w)
```

```
19  //For line frequency of 50Hz,Lc=RL/(300*%pi)
20  //Lc=RL/950
21  Lc=RL/950
22  format("v",4)
23  L=0.1//Assumed inductance in henry
24  C=a/L//C=capacitance calculated from equation (1)
25  format("v",4)
26  L1=1//Assumed inductance in henry
27  C1=a/L1//C1=capacitance calculated from equation (1)
28  format("v",4)
29  Rb=950*L1//Rb=bleeder resistance for good voltage
       regulation
30  disp("The designed values of the components for a
       full wave rectifier with L-type LC filter are")
31  disp("ohm",RL,"The load resistance RL is =")
32  disp("H",Lc,"The critical inductance Lc is =")
33  disp("H",L,"The inductance L is=")
34  disp(" F ",C/10^-6,"The capacitance C is")//C is
       converted in terms of microfarad
35  //In textbook 957 F  is approximately taken as 600
        F
36  disp("H",L1,"But if the inductance L designed is of
       the value =")
37  disp(" F ",C1/10^-6,"the capacitance C will be of
       the value =")//C1 is converted in terms of
       microfarad
38  disp("So,a standard value of 50 F  can be used in
       practice")
39  disp("ohm",Rb,"The bleeder resistance Rb for good
       voltage regulation is=")
40  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

```
1
2  // scilab  5.4.1
3  // windows  7  operating  system
4  // chapter  7: Junction  Transistor  Characteristics
5  clc;
6  clear;
7  // given  data
8  a=0.99; //a=fraction  of  the  emitter  current
      contributed  by  the  carriers  injected  into  the
      base  and  reaching  the  collector
9  Rl=4500;        // Load  resistance  in  ohms
10 rd=50;          // dynamic  resistance  in  ohms
11
12 Av=a*Rl/rd;        // Voltage  gain
13 Ap=a*Av; // Power  gain
14
15 disp(Av, 'Av=');
16 disp(Ap, 'Ap=');
```

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

```
1
2  //scilab 5.4.1
3  //windows 7 operating system
4  //chapter 7:Junction Transistor Characteristics
5  clc;
6  clear;
7  //given data
8  a=0.98;//a=fraction of the emitter current
       contributed by the carriers injected into the
       base and reaching the collector
9  Ie=0.003;    //emitter current in A
10  Ico=10*10^-6;    //reverse saturation current in A
11
12  Ic=a*Ie+Ico;       //collector current in A
13  format("v",8)
14  disp('mA',Ic/10^-3,'Ic=');//Ic is converted in terms
       of mA
15
16  Ib=Ie-Ic;       //base current in A
17  format("v",8)
18  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 t

```
1
2  //scilab 5.4.1
3  //windows 7 operating system
4  //chapter 7:Junction Transistor Characteristics
5  clc;
```

```
 6  clear;
 7  //given data
 8  a=0.975;//a=fraction of the emitter current
       contributed by the carriers injected into the
       base and reaching the collector
 9  Ico=10*10^-6;    //reverse saturation current in A
10  Ib=250*10^-6;    //base current in A
11
12  b=a/(1-a);       //transistor gain
13  disp(b,'gain B=');
14  Ic=b*Ib+(b+1)*Ico;        //collector current in A
15  format("v",5)
16  disp('mA',Ic/10^-3,'Ic=');//Ic is converted in terms
        of mA
17  Ie=(Ic-Ico)/a;      //emitter current in A
18  format("v",5)
19  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 term

```
 1
 2  //scilab 5.4.1
 3  //windows 7 operating system
 4  //chapter 7:Junction Transistor Characteristics
 5  clc;
 6  clear;
 7  //given data
 8  b=125;//b=forward current transfer ratio or dc
       current gain
 9  Vbe=0.6;     //base to emitter voltage in V
10
11  Ib=(10-Vbe)/(310*10^3);      //base current in A
12  disp('mA',Ib*10^3,'Ib=');
13  Ic=b*Ib;          //collector current in A
```

```
14  disp ( 'mA' , Ic *10^3 , 'Ic=' ) ;
15  Vce =20 -( Ic *5000) ;        // collector  to  emitter
       voltage
16  disp ( 'V' , Vce , 'Vce=' ) ;
```

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

```
1  // scilab  5.4.1
2  // Windows  7  operating  system
3  // chapter  7  Junction  Transistor  Characteristics
4  clc
5  clear
6  disp ( "As  the  base  is  forward  biased , transistor  is
       not  cut  off ." )
7  disp ( "Assuming  the  transistor  in  active  region  " )
8  VBB =5 // VBB=base  bias  voltage
9  VBE =0.7 // VBE=voltage  between  base  and  emitter
       terminal
10  RB =220 // RB=base  circuit  resistor  in  kilo  ohms
11  IB =( VBB - VBE ) / RB // IB=base  current  in  mA( By  applying
       Kirchhoff 's  voltage  law )
12  format ( " v " ,7)
13  disp ( "mA" , IB , "IB=" )
14  disp ( " Ico <<IB" ) // Ico=reverse  saturation  current  and
       is  given  as  22nA
15  B =100 // B=dc  current  gain
16  IC =B* IB
17  format ( " v " ,5)
18  disp ( "mA" , IC , " IC=" )
19  Vcc =12 // Vcc=collector  supply  voltage
20  Rc =3.3 // Rc=collector  circuit  resistor  in  kilo  ohms
21  VCB =Vcc -( IC * Rc ) - VBE // VCB=voltage  between  collector
       and  base  terminal  ( by  applying  Kirchhoff 's
       voltage  law  to  the  collector  circuit )
22  disp ( "V" , VCB , "VCB=" )
```

```
23  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")
24  IE=-(IB+IC)//IE=emitter current
25  disp("mA",IE,"IE=")
26  format("v",7)
27  disp("The negative sign indicates that IE actually
        flows in the opposite direction.")
28  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

```
1  //scilab 5.4.1
2  //Windows 7 operating system
3  //chapter 7 Junction Transistor Characteristics
4  clc
5  clear
6  disp("Applying Kirchhoff voltage law to the base &
        collector circuit respectively")
7  //(R1*IB)+VBE+(RE*(Ic+IB))=VBB..........(1)
8  //(R2*Ic)+VCE+(RE*(Ic+IB))=Vcc..........(2)
9  R1=47//R1=value of base circuit resistance in kilo
        ohms
10 RE=2.2//RE=emitter circuit resistance in kilo ohms
11 R2=3.3//R2=collector circuit resistance in kilo ohms
12 VBE=0.85//VBE=voltage between base and emitter
        terminals
13 VBB=5//VBB=base supply voltage
14 Vcc=9//Vcc=collector supply voltage
15 VCE=0.22//VCE=voltage between collector and emitter
        terminals
```

```
16  R=[(R1+RE)  RE;RE  (R2+RE)];
17  V=[(VBB-VBE);(Vcc-VCE)];
18  I=inv(R)*V
19  disp("mA",I(1),"IB=")
20  disp("mA",I(2),"IC=")
21  hFE=110//hFE=dc  current  gain
22  disp("The  minimum  base  current  required  for
        saturation  is")
23  IBmin=I(2)/hFE
24  disp("mA",IBmin,"IBmin=")
25  if  (I(1)<IBmin)  then
26      disp("As  IB<IBmin  transitor  is  not  in  the
            saturation  region.It  must  be  in  the  active
            region.")
27  end
```

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

```
1  //scilab  5.4.1
2  //Windows  7  operating  system
3  //chapter  7  Junction  Transistor  Characteristics
4  clc
5  clear
6  IB=(30*10^-3)//IB=base  current  (in  mA)  of  transistor
        in  CE  mode
7  IC1=3.5
8  IC2=3.7
9  VCE1=7.5
10  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)
11  VCE=VCE2-VCE1
12  IC=IC2-IC1
13  disp("Output  resistance  is")
14  Ro=VCE/IC
```

```
15  disp(" kilo ohm",Ro,"The output resistance is =")
16  b=IC2/IB//b=forward current transfer ratio or dc
        current gain
17  disp(b,"b=")
18  a=b/(b+1)//a=fraction of the emitter current
        contributed by the carriers injected into the
        base and reaching the collector
19  //b=a/(1-a) Hence a=b/(b+1)
20  disp(a,"a=")
```

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

```
 1  //scilab 5.4.1
 2  //Windows 7 operating system
 3  //chapter 7 Junction Transistor Characteristics
 4  clc
 5  clear
 6  b=100//b=forward current transfer ratio or dc
        current gain
 7  Vz=4//Vz=Zener diode voltage
 8  IL=2//IL=load current in mA
 9  Iz=5//Iz=Zener current in mA
10  VCC=12//VCC=collector supply voltage
11  VEB1=0.7
12  VEB2=VEB1//VEB1,VEB2=emitter-to-base voltage for
        both transistors Q1 and Q2 respectively
13  //Since IL is the collector current of transistor Q1
14  IB=IL/b//IB=base current of transistor Q1
15  IE=IB+IL//IE=emitter current of transistor Q1
16  VR1=VCC-VEB2-Vz//VR1=voltage drop across resistor R1
17  R1=VR1/(IB+Iz)
18  format("v",5)
19  disp(" kilo ohm",R1,"The resistance R1 is =")
20  VR2=VEB2+Vz-VEB1//VR2=voltage drop across resistor
        R2
```

```
21  R2=VR2/IE
22  format("v",5)
23  disp("kilo ohm",R2,"The resistance R2 is =")
24  //VBC=VCC-VR2-VEB1-(IL*RL) where VBC=base-collector
        voltage drop for transistor Q1
25  //VBC=7.3-(2*RL) where RL=load resistance for
        transistor Q1 in terms of kilo ohm
26  disp("For Q1 to remain in the active region, V B C 0 ,
        i.e.")
27  disp(" R L (7.3/2) kilo ohm")
28  disp(" R L 3 .65 kilo ohm")
29  disp("So the range of RL for Q1 to remain in the
        active region is 0   RL3   .65 kilo ohm")
```

Chapter 8

Junction Transistors Biasing and Amplification

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

```
1
2 // scilab  5.4.1
3 // windows  7  operating  system
4 // chapter  8: Junction  Transistors : Biasing  and
      Amplification
5 clc ;
6 clear ;
7 // given  data
8 b =99;
9 Vbe =0.7;      // Volatge  between  base  and  emitter  in  V
10 Vcc =12;       // Volatge  source  applied  at  collector  in
       V4
11 Rl =2*10^3;        // load  resistance  in  ohms
12 Rb =100*10^3;        // Resistance  at  base  in  ohms
13 Ib =(12 -0.7) /((100* Rl )+ Rb );        // Base  current  in
      micro  Ampere
14 format (" v " ,7)
15 disp ( 'mA ' , Ib *10^3 , ' Ib = ' );
16
```

```
17  Ic=b*Ib;
18  format("v",7)
19  disp('mA',Ic*10^3,'Ic=');
20  Vce=4.47;          //Voltage between collector and
        emitter in V
21
22  S=(b+1)/(1+b*Rl/(Rl+Rb));          //stabilty factor 1
23  disp(S,'S=');
24  S1=b/(Rb+Rl*(1+b));          //stabilty factor 2 in A/V
25  disp('A/V',S1,'S1=');
26  S2=(Vcc-Vbe-(Ic*Rl))/(Rb+Rl*(1+b));          //
        stability factor 3 in A
27  disp('A',S2,'S2=');
```

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

```
1
2  //scilab 5.4.1
3  //windows 7 operating system
4  //chapter 8:Junction Transistors:Biasing and
        Amplification
5  clc;
6  clear;
7  //given data
8  b=49;//b=dc current gain of the common emitter
        transistor
9  Vbe=0.2;      //Volatge between base and emitter in V
10 Vcc=10;       //Volatge source applied at collector in
        V4
11 Vce=5;        //Collector to emitter voltage in V
12 Ic=4.9;       //collector current in mA
13 Rl=1;         //load resistance in kilo ohms
14 S=10;         //stability factor
15
16 Ib=Ic/b;      //base current in mA
```

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

Scilab code Exa 8.14.3 To calculate the input and output resistances and current v

```
1
2  //scilab  5.4.1
3  //windows  7  operating  system
4  //chapter  8:Junction  Transistors:Biasing  and
        Amplification
5  clc;
6  clear;
7  //given  data
8  hib=30;       //h  parameter  of  CB  a  transistor
9  hrb=4*10^-4;          //h  parameter  of  CB  a  transistor
10  hfb=-0.99;          //h  parameter  of  CB  a  transistor
11  hob=0.9*10^-6;          //h  parameter  of  CB  a
        transistor  in  S
12  Rl=6*10^3;          //Load  resistance  in  ohms
13
14  AI=-hfb/(1+(hob*Rl));          //Current  gain
15  disp(AI,'AI=');
16
```

```
17  Ri=hib -(( hfb*hrb*Rl )/(1+( hob*Rl )));      //Input
        resistance  in  ohms
18  disp ( 'ohms ', Ri , 'Ri= ');
19
20  Ro=hib /(( hib*hob )-( hfb*hrb ));          //Output
        Resistance  in  kohms
21  disp ( 'kilo  ohms ', Ro*10^ -3 , 'Ro= ');
22
23  AV = AI*Rl / Ri ;              //Voltage  gain
24  disp (AV , 'AV= ');
25
26  AP = AI*AV ;          //Power  gain
27  disp (AP , 'AP= ');
```

Scilab code Exa 8.14.4 To find the input and output resistance

```
1
2  //scilab  5.4.1
3  //windows  7  operating  system
4  //chapter  8:Junction  Transistors : Biasing  and
        Amplification
5  clc ;
6  clear ;
7  //given  data
8  Rg =1*10^3;         //internal  resistance  in  ohms
9  Rl =20*10^3;        //Load  resistance  in  ohms
10  hie =1*10^3;          //h  parameter  of  the  transistor  in
        terms  of  ohms
11  hre =2.5*10^ -4;       //h  parameter  of  the  transistor
12  hfe =150;        //h  parameter  of  the  transistor
13  hoe =1/(40*10^3);          //h  parameter  of  the
        transistor  in  terms  of  mho
14
15  AI =( -hfe )/(1+( hoe*Rl ));        //Current  gain
16  disp (AI , 'AI= ');
```

```
17
18  Ri=hie+(AI*hre*Rl);        //input  resistance  in  ohms
19  disp('ohms',Ri,'Ri=');
20  Ro=(Rg+hie)/((Rg*hoe)+(hie*hoe)-(hfe*hre));        //
        output  resistance  in  ohms
21  disp('kilo  ohms',Ro*10^-3,'Ro=');
```

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

```
1
2  //scilab  5.4.1
3  //windows  7  operating  system
4  //chapter  8:Junction  Transistors:Biasing  and
        Amplification
5  clc;
6  clear;
7  //given  data
8  Rl=5*10^3;        //Load  resistance  in  ohms
9  hie=1*10^3;        //h  parameter  of  the  transistor  in
        terms  of  ohms
10  hre=5*10^-4;        //h  parameter  of  the  transistor
11  hfe=100;        //h  parameter  of  the  transistor
12  hoe=25*10^-6;        //h  parameter  of  the  transistor
        in  terms  of  mho
13  Rg=1*10^3;        //source  reistance  in  ohms
14
15  AI=(-hfe)/(1+(hoe*Rl));        //Current  gain
16  disp(AI,'AI=');
17
18  Ri=hie+(AI*hre*Rl);        //input  resistance  in  ohms
19  disp('ohms',Ri,'Ri=');
20
21  AVo=AI*Rl/(Rg+Ri);        //Overall  voltage  gain
        including  source  resistance
22  disp(AVo,'AVo=');
```

```
23
24  APo = AVo * AI ;        // Overall  voltage  gain  including
        source  resistance
25  disp ( APo , 'APo=') ;
```

Scilab code Exa 8.14.6 To determine the current and voltage gain as well as the in

```
1
2  // scilab  5.4.1
3  // windows  7  operating  system
4  // chapter  8: Junction  Transistors: Biasing  and
        Amplification
5  clc ;
6  clear ;
7  // given  data
8  hoe =25*10^ -6;        //h  parameter  in  A/V
9  hie =4000;        //h  paramater  in  ohms
10  hfe =135;          //h  paramater  of  transistor
11  hre =7*10^ -4;          //h  paramater  of  transistor
12  Re =100;      // emitter  resistance  in  ohms
13  Rl =3*10^3;        // Load  resistance  in  ohms
14
15  // 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 .
16
17  AI = - hfe ;          // current  gain
18  disp ( AI , 'AI=') ;
19
20  Ri = hie +(1+ hfe ) * Re ;        // input  resistance  in  ohms
21  disp ( 'kilo  ohms ', Ri *10^ -3 , 'Ri=') ;
22
23  AV = AI * Rl / Ri ;          // voltage  gain
24  disp ( AV , 'AV=') ;
25
```

```
26  disp("The output resistance of the transistor
        excluding RL is infinite.")
27  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 th

```
1
2   //scilab 5.4.1
3   //windows 7 operating system
4   //chapter 8:Junction Transistors:Biasing and
        Amplification
5   clc;
6   clear;
7   //given data
8
9   hfe=100;            //h parameter of transistor
10  hie=560;            //h parameter of transistor in ohms
11  Rc=2*10^3;          //collector resistance in ohms
12  Re=10^3;            //emitter resistance in ohms
13  Rb=600*10^3;           //Base resistance in ohms
14
15  //Since hoe is neglected we can use the simplified
        equivalent circuit hence the Ri is
16
17  Ri=hie+(1+hfe)*Re;      //Input resistance in ohms
18  disp('kilo ohms',Ri*10^-3,'Ri=');
19
20  Rib=(Ri*Rb)/(Ri+Rb);          //Input resistance
        including Rb in ohms
21  disp('kilo ohms',Rib*10^-3,'Input resistance (
        including Rb)=');
22
23  disp("The output resistance excluding load is
        infinita")
```

58

```
24  Ro=Rc ;
25  disp (" kilo ohms" ,Ro*10^-3 ," Output resistance
        including load =")
26
27  AV=-(hfe*Ro)/(hie+((1+hfe)*Re));          // voltage
        gain
28  disp (AV, 'AV=');
29  disp (" Small signals are used , since otherwise the
        output waveform will be distorted . Also , the
        equivalent circuit will not hold .")
30
31  // Taking DC emitter current and collector current
        nearly equal
32
33  Ib=20/(Rb+Re*101);          // base current in mA
34  disp ('mA',Ib*10^3 ,'Ib=');
35
36  disp (" The Q-point is defined by")
37  Ic=hfe*Ib;          // collector current in mA
38  disp ('mA',Ic*10^3 ,'Ic=');
39
40  VCE=20-(3*Ic*10^3)
41  disp ('V',VCE,'VCE=');
```

Scilab code Exa 8.14.8 To design a CE transistor amplifier

```
1  // scilab 5.4.1
2  // Windows 7 operating system
3  // chapter 8 Junction Transistors : Biasing and
        Amplification
4  clc
5  clear
6  // For a CE transistor amplifier circuit with self −
        bias
7  f =1000 // f=frequency in Hz
```

```
 8  AV=-200//AV=voltage gain
 9  hfe=100//hfe=current gain
10  hie=1//hie=input impedance in kilo ohms
11  Pcmax=75*10^-3//Pcmax=maximum collector dissipation
        in Watt
12  //hre and hoe are to be neglected
13  VCC=12//VCC=collector supply voltage
14  //AV=-(hfe*RL)/hie where RL is the load resistance
15  RL=-(AV*hie)/hfe
16  format("v",5)
17  disp("The designed values of the components of a CE
        transistor amplifier are:")
18  disp("kilo ohm",RL,"The load resistance RL is =")
19  //For the amplifier to be linear,the quiescent point
         is chosen to lie in the middle of the DC load
        line
20  VCG=VCC/2  //VCG=DC collector to ground voltage
21  //VCC=(IC*RL)+VCG where IC=DC collector current
22  IC=(VCC-VCG)/RL
23  format("v",5)
24  disp("mA",IC,"Ihe DC collector current is =")
25  Pr=(IC^2)*RL//Pr=power dissipation in RL
26  //Pc=the collector dissipation is set at 14.5 mW
        which is below the value of Pcmax
27  //Pc=VCE*IC
28  Pc=14.5
29  VCE=Pc/IC//VCE=collector-to-emitter voltage drop
30  format("v",4)
31  VEG=VCG-VCE//VEG=DC voltage drop across resistance
        Re
32  IE=IC//IE=emitter current
33  Re=VEG/(IC)
34  disp("ohm",Re*1000,"The resistance Re is =")//Re is
        converted in terms of ohms
35  Pe=(IC^2)*Re//Pe=power dissipation in Re
36  VBE=0.7//VBE=assumed DC base-to-emitter voltage drop
37  VBG=VBE+(IE*Re)//VBG=DC voltage across resistance R2
38  //VT=(VCC*R2)/(R1+R2) where VT=Thevenin equivalent
```

```
        voltage
39  //RT=(R1*R2)/(R1+R2) .............(1)  where RT=
        Thevenin equivalent resistance
40  //VBG=VT-(IB*RT)
41  //VBG=((VCC*R2)/(R1+R2))-(IB*((R1*R2)/(R1+R2)))
        ..................(2)
42  //Let (R2/(R1+R2))=x .............(3)
43  x=VBG/VCC//neglecting the second term on the right
        hand side of equation (2)
44  a=(1-x)/x      //a=R1/R2
45  //S=((1+b)*(1+RT/Re))/(1+b+(RT/Re))  where S=
        stability factor and b=current gain=hfe
46  //b>>1 hence S=(hfe*(1+RT/Re))/(1+b+(RT/Re))
47  //For good stability we choose S=hfe/20
48  RT=((hfe-20)/19)*Re
49  R1=RT/x//from equation (1) and (3)
50  format("v",5)
51  disp("kilo ohm",R1,"The resistance R1 is=")
52  R2=R1/5.33
53  format("v",4)
54  disp("kilo ohm",R2,"The resistance R2 is =")
55  Pr2=(VBG^2)/R2//Pr2=power dissipation in R2
56  Pr1=((VCC-VBG)^2)/R1 //Pr1=power dissipation in R1
57  Ce=1/(2*%pi*f*((Re*1000)/10))//Ce=bypass capacitor
58  format("v",2)
59  disp("micro farad",Ce/10^-6,"The bypass capacitance
        Ce is =")//Ce is converted in terms of micro
        farad
60  C1=2/(2*%pi*f*100)//C1=coupling capacitor
61  format("v",4)
62  disp("micro farad",C1/10^-6,"The coupling
        capacitance C1 is =")//C1 is converted in terms
        of micro farad
63  Rin=20*1000//Rin=assumed input impedance in ohms
64  C2=1/(2*%pi*f*0.1*Rin)//C2=coupling capacitor
65  format("v",4)
66  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

```
1  //scilab 5.4.1
2  //Windows 7 operating system
3  //chapter 8 Junction Transistors:Biasing and
      Amplification
4  clc
5  clear
6  VCC=12//VCC=collector supply voltage
7  a=0.98//a=dc current gain of the common base
      transistor
8  VBE=0.7//VBE=base emitter voltage
9  IE=2//IE=emitter current in mA
10 //Ico is to be neglected
11 b=a/(1-a)//b=dc current gain of the common emitter
      transistor
12 //IC=b*IB where IC=collector current and IB=base
      current
13 //IE=IC+IB
14 //IE=(b+1)*IB
15 IB=IE/(b+1)
16 IC=b*IB
17 RE=0.1//RE=resistance in kilo ohms connected to the
      emitter terminal
18 R2=20//R2=resistance in kilo ohms
19 RC=3.3//RC=resistance in kilo ohms connected to the
      collector terminal
20 //Let I be the current in the resistance R2
21 //Applying Kirchhoff's voltage law in the base−
      emitter circuit
22 //VBE+(RE*IE)=R2*I
23 I=(1/R2)*(VBE+(RE*IE))
24 //Applying Kirchhoff's voltage law
```

```
25  //((I+IB+IC)*RC)+((I+IB)*R1)+(I*R2)=VCC
26  R1=(VCC-((I+IB+IC)*RC)-(I*R2))/(I+IB)
27  format("v",5)
28  disp("kilo ohm",R1,"The resistance R1 is =")
```

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

```
1   //scilab 5.4.1
2   //Windows 7 operating system
3   //chapter 8 Junction Transistors:Biasing and
        Amplification
4   clc
5   clear
6   VBE=0.7//VBE=base emitter voltage
7   b=90//b=dc current gain of the common emitter
        transistor
8   VCC=10//VCC=collector supply voltage
9   RE=1.2//RE=resistance in kilo ohms connected to the
        emitter terminal
10  RC=4.7//RC=resistance in kilo ohms connected to the
        collector terminal
11  RB=250//RB=resistance in kilo ohms connected to the
        base terminal
12  //Applying Kirchhoff's voltage law
13  //VCE=(RB*IB)+VBE where VCE=collector emitter
        voltage
14  //Also VCC=((IB+IC)*RC)+VCE+(IE*RE)
15  //IC=b*IB where IC=collector current and IB=base
        current
16  //IE=IC+IB where IE=emitter current
17  //IE=(b+1)*IB
18  IB=(VCC-VBE)/(((b+1)*(RC+RE))+RB)
19  format("v",6)
20  IE=(b+1)*IB
21  format("v",5)
```

```
22  VCE=(RB*IB)+VBE
23  format("v",5)
24  IC=b*IB
25  format("v",5)
26  disp("mA",IE,"The quiescent value of IE is =")
27  disp("V",VCE,"The quiescent value of VCE is =")
28  disp("mA",IC,"When dc current gain=90,IC=")
29  //b is increased by 50%
30  b1=((50*b)/100)+b
31  IB1=(VCC-VBE)/(((b1+1)*(RC+RE))+RB)
32  IC1=b1*IB1
33  disp("mA",IC1,"When dc current gain is increased by
        50%,IC=")
34  x=((IC1-IC)/IC)*100//x=increase in the collector
        current
35  disp("%",x,"The increase in the collector current IC
         is =")
36  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.")
37  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

```
1  //scilab 5.4.1
2  //Windows 7 operating system
3  //chapter 8 Junction Transistors:Biasing and
       Amplification
4  clc
5  clear
6  VBE=0.7//VBE=base emitter voltage
7  b=99//b=dc current gain of the common emitter
```

```
        transistor
 8  VCC=15//VCC=collector supply voltage
 9  RE=7//RE=resistance in kilo ohms connected to the
        emitter terminal
10  RC=4//RC=resistance in kilo ohms connected to the
        collector terminal
11  RB=5//RB=resistance in kilo ohms connected to the
        base terminal
12  VEE=(-15)//VEE=emitter supply voltage
13  //Applying Kirchhoff's voltage law in the base
        emitter loop
14  //-VEE=(RB*IB)+VBE +(IE*RE)
15  //IC=b*IB where IC=collector current and IB=base
        current
16  //IE=IC+IB where IE=emitter current
17  //IE=(b+1)*IB
18  IB=(-VEE-VBE)/(RB+((b+1)*RE))
19  format("v",7)
20  disp("mA",IB,"The quiescent value of IB is =")
21  IC=b*IB
22  format("v",5)
23  disp("mA",IC,"The quiescent value of IC is =")
24  IE=(b+1)*IB
25  format("v",5)
26  disp("mA",IE,"The quiescent value of IE is =")
27  //Applying Kirchhoff's voltage law in the output
        circuit
28  //(IC*RC)+VCE+(IE*RE)=VCC-VEE
29  VCE=(VCC-VEE)-(IE*RE)-(IC*RC)
30  format("v",5)
31  disp("V",VCE,"The quiescent value of VCE is =")
32  //b is increased by 20%
33  b1=((20*b)/100)+b
34  IB1=(-VEE-VBE)/(RB+((b1+1)*RE))
35  format("v",10)
36  IC1=b1*IB1
37  format("v",6)
38  disp("mA",IC1,"When dc current gain is increased by
```

```
      20% , IC=" )
39  x=((IC1-IC)/IC)*100//x=increase in the collector
       current
40  disp("%",x,"The increase in the collector current IC
        is =")
41  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")
42  //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

```
1  //scilab 5.4.1
2  //Windows 7 operating system
3  //chapter 8 Junction Transistors:Biasing and
       Amplification
4  clc
5  clear
6  //For a self-bias circuit
7  VBE=0.7//VBE=base emitter voltage
8  b=100//b=dc current gain of the common emitter
       transistor
9  VCC=22//VCC=collector supply voltage
10 R1=82//R1=resistance in kilo ohms
11 R2=16//R2=resistance in kilo ohms
12 RL=2.2//RL=load resistance in kilo ohms
13 Re=0.750//Re=resistance in kilo ohms connected to
       the emitter terminal
14 //ICO is to be neglected
15 VT=(R2*VCC)/(R1+R2)//VT=Thevenin equivalent voltage
16 RT=(R1*R2)/(R1+R2)//RT=Thevenin equivalent
       resistance
```

```
17  //Applying Kirchhoff's voltage law to the base
       circuit
18  //(IB*(RT+Re))+(IC*Re)=VT-VBE
19  //IC=b*IB
20  IB=(VT-VBE)/(RT+Re+(b*Re))//IB=base current
21  IC=b*IB//IC=collector current
22  format("v",8)
23  //Applying Kirchhoff's voltage law to the collector
       circuit
24  //(IC*(RL+Re))+(IB*Re)+VCE=VCC
25  VCE=VCC-((IC*(RL+Re))+(IB*Re))//VCE=collector
       emitter voltage
26  format("v",5)
27  disp("The operating point is specified by")
28  disp("mA",IC,"IC=")
29  disp("V",VCE,"VCE=")
```

Scilab code Exa 8.14.13 To determine the operating point

```
1  //scilab 5.4.1
2  //Windows 7 operating system
3  //chapter 8 Junction Transistors:Biasing and
      Amplification
4  clc
5  clear
6  RE=0.680//RE=resistance in kilo ohms connected to
      the emitter terminal
7  RC=2.7//RC=resistance in kilo ohms connected to the
      collector terminal
8  //RB=resistance connected to the base terminal
9  VCE=7.3//VCE=collector emitter voltage
10 VBE=0.7//VBE=base emitter voltage
11 Vre=2.1//Vre=voltage across RE resistance
12 IB=0.02//IB=base current in mA
13 IE=Vre/RE//IE=emitter current in mA
```

```
14  IC=IE-IB//IC=collector current in mA
15  b=IC/IB//b=current gain
16  format("v",6)
17  disp(b,"The current gain     is =")
18  VCC=(IC*RC)+VCE+Vre//VCC=collector supply voltage
19  format("v",5)
20  disp("V",VCC,"The collector supply voltage VCC is ="
        )
21  //Voltage across RB (Vrb)resistance is given by
22  Vrb=VCC-(VBE+Vre)
23  RB=Vrb/IB
24  format("v",5)
25  disp("kilo ohm",RB,"The resistance RB is =")
26  //To draw the DC load line,we neglect the base
        current in RE resistance
27  //Equation for DC load line is:
28  //VCE=VCC-(RC+RE)*IC
29  disp("For the DC load line")
30  disp("V",VCC,"The intercept of the load line on the
        VCE-axis(X-axis) is =")
31  disp("mA",VCC/(RC+RE),"The intercept of the load
        line on the IC axis(Y-axis) is =")
32  disp("The DC load line is the straight line joining
        above two intercepts.")
33  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 amplit

```
1  //scilab 5.4.1
2  //Windows 7 operating system
3  //chapter 8 Junction Transistors:Biasing and
        Amplification
4  clc
5  clear
```

```
 6  VBE=0.7//VBE=base emitter voltage
 7  b=120//b=dc current gain of the common emitter
       transistor
 8  VCC=15//VCC=collector supply voltage
 9  R1=72//R1=resistance in kilo ohms
10  R2=8//R2=resistance in kilo ohms
11  RL=2//RL=load resistance in kilo ohms
12  Re=0.700//Re=resistance in kilo ohms connected to
       the emitter terminal
13  RC=2//RC=resistance in kilo ohms connected to the
       collector terminal
14  Rin=1.5//Rin=input resistance in kilo ohms of the
       amplifier
15  vi=1//vi=amplitude of the ac input signal in mV
16  VT=(R2*VCC)/(R1+R2)//VT=Thevenin equivalent voltage
17  RT=(R1*R2)/(R1+R2)//RT=Thevenin equivalent
       resistance
18  //Applying Kirchhoff's voltage law to the base
       circuit
19  //(IB*(RT+Re))+(IC*Re)=VT-VBE
20  //IC=b*IB
21  IB=(VT-VBE)/(RT+Re+(b*Re))//IB=base current
22  IC=b*IB//IC=collector current
23  format("v",5)
24  //Applying Kirchhoff's voltage law to the collector
       circuit
25  //(IC*(RL+Re))+(IB*Re)+VCE=VCC
26  VCE=VCC-((IC*(RL+Re)))//VCE=collector emitter
       voltage(neglecting small term IB*RE)
27  format("v",5)
28  //Equation for DC load line is:
29  //VCE=VCC-(RL+Re)*IC
30  disp(" 1. For the DC load line")
31  disp("The operating point Q is specified by")
32  disp("mA",IC,"IC=")
33  disp("V",VCE,"VCE=")
34  disp("V",VCC,"The intercept of the dc load line on
       the VCE-axis(X-axis) is =")
```

```
35  disp("mA",VCC/(RC+Re),"The intercept of the dc load
        line on the IC axis(Y−axis) is =")
36  disp("The DC load line is the straight line joining
        above two intercepts.")
37  Rac=(RL*RC)/(RL+RC)//Rac=ac load resistance
38  disp(" 2. For the AC load line")
39  disp("V",VCE+(IC*Rac),"The intercept of the ac load
        line on the VCE−axis(X−axis) is =")
40  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")
41  AV=-(b*Rac)/Rin//AV=voltage gain of the amplifier
42  vo=abs(AV)*vi//vo=amplitude of the output voltage
        signal
43  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

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

```
              power frequency
16  fh=f/sqrt((abs(AVm)/abs(AVh))^2 -1)
17  format("v",5)
18  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

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

```
21  format("v",5)
22  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

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

```
24  //Suppose (AVh/AVm)=b=high frequency gain with
        respect to the mid frequency gain
25  //b=1/sqrt(1+(f/fh)^2)//b=magnitude of the high
        frequency gain
26  b=1/sqrt(1+(f/fh)^2)
27  format("v",6)
28  O=-atand(f/fh)//O=phase angle in degree of the high
        frequency gain
29  format("v",6)
30  disp("For the high frequency gain with respect to
        the mid frequency gain ")
31  disp(b,"Magnitude=")
32  disp("degree",O,"Phase angle=")
```

Scilab code Exa 9.12.4 To calculate the output power

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

Scilab code Exa 9.12.5 To calculate dc input and ac output power along with the co

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

Scilab code Exa 9.12.6 To determine the maximum dc power and the maximum output po

```scilab
1  //scilab 5.4.1
2  //Windows 7 operating system
3  //chapter 9 Basic Voltage and Power Amplifiers
```

```
4  clc
5  clear
6  //In a class B push pull circuit
7  //Transformer winding resistances are to be ignored
8  n=3//n=primary-to-secondary turns ratio of a
      transformer
9  RL=9//RL=load resistance in ohms
10 VCC=15//VCC=collector supply voltage
11 RL1=((n/2)^2)*RL//RL1=reflected load resistance for
      one transistor
12 Pactot=(VCC^2)/(2*RL1)//Pactot=maximum output power
13 format("v",5)
14 disp("W",Pactot,"The maximum output power is =")
15 Pstot=(2*VCC^2)/(%pi*RL1)//Pstot=the maximum dc
      power supplied to the two transistors
16 format("v",5)
17 disp("W",Pstot,"The maximum dc power supplied is =")
18 n=(Pactot/Pstot)*100//n=efficiency
19 format("v",5)
20 disp("%",n,"The efficiency is =")
```

Scilab code Exa 9.12.7 To calculate the resonant frequency along with the bandwidth

```
1  //scilab 5.4.1
2  //Windows 7 operating system
3  //chapter 9 Basic Voltage and Power Amplifiers
4  clc
5  clear
6  //In a single tuned amplifier
7  L=120*10^-6//L=inductance in henry
8  C=100*10^-12//C=capacitance in farad
9  R=10//R=resistance in ohms
10 hoe=50*10^-6//hoe=output impedance in mho(or S)
11 hfe=100//hfe=current gain
12 hie=2.5*10^3//hie=input impedance in ohm
```

```
13  RT=10*10^3//RT=equivalent resistance of RB and Ri in
        parallel
14  fo=1/(2*%pi*sqrt(L*C))//fo=resonant frequency
15  format("v",5)
16  disp("MHz",fo/10^6,"The resonant frequency is =")//
        fo is converted in terms of MHz
17  Qo=(1/R)*sqrt(L/C)//Qo=Q-factor of the resonant
        frequency
18  Ro=(Qo^2)*R//Ro=maximum impedance Zm
19  Rp=1/(hoe+(1/Ro)+(1/RT))//Rp=equivalent resistance
        of the parallel combination of Ro,ro and RT
20  Qe=(Qo*Rp)/Ro//Qe=effective Q-factor
21  B=fo/Qe//B=bandwidth
22  format("v",6)
23  disp("kHz",B/10^3,"The bandwidth is =")//B is
        converted in terms of kHz
24  AVm=-(hfe*Rp)/hie//AVm=maximum voltage gain
25  format("v",6)
26  disp(AVm,"The maximum voltage gain is =")
```

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

```
1  //scilab 5.4.1
2  //Windows 7 operating system
3  //chapter 9 Basic Voltage and Power Amplifiers
4  clc
5  clear
6  V=10//V=voltage at frequency 5kHz
7  Vr=7.07//Vr=voltage at frequency 25kHz
8  //x=10*log10(P/Pr) where x=change in decibel(dB) of
        power P from some standard power Pr
9  //P=V^2/R=I^2*R
10  //Also Pr=Vr^2/R=Ir^2*R
11  //x=10*(log10(V/Vr))^2=20*log10(V/Vr)
12  x=20*log10(V/Vr)//x=change in decibel(dB) of voltage
```

```
13  format("v",4)
14  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

```
1   //scilab  5.4.1
2   //Windows  7  operating  system
3   //chapter  9  Basic  Voltage  and  Power  Amplifiers
4   clc
5   clear
6   Vorms=2//Vorms=rms  output  voltage  in  the  midband
        region  of  an  amplifier
7   Pa=42//Pa=power  gain  in  dB
8   Pol=0.4//Pol=power  output  in  W at  the  lower  cut-off
        frequency  100Hz
9   Ri=10^3//Ri=input  resistance  in  ohms
10  VOrms=2/sqrt(2)//VOrms=rms  output  voltage  at  100Hz
11  format("v",6)
12  disp("V",VOrms,"1.  The  rms  output  voltage  at  100Hz,
        which  is  the  lower  cutoff  frequency ,is  =")
13  Po=2*Pol//Po=output  power  in  the  midband  region
14  disp("W",Po,"2.  The  output  power  in  the  midband
        region  is  =")
15  //Let  Pi=input  power
16  //10*log10(Po/Pi)=Pa
17  Pi=Po/(10^(Pa/10))
18  //Pi=(Vi^2)/Ri  where  Vi=rms  input  voltage
19  Vi=sqrt(Pi*Ri)
20  format("v",7)
21  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 feedba

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

```
1  //scilab 5.4.1
2  //windows 7 operating system
3  //chapter 10:Feedback In Amplifiers
4  clc
5  clear
6  disp("Negative feedback has to be applied for gain
        stability")
7  //A=open loop gain of an amplifier
8  //B=feedback ratio
9  Af=10//Af=voltage gain with feedback
10 //dAf/Af=(1/(1+(A*B)))*(dA/A)
11 y=2//(dAf/Af)=y=percent change of gain that is
        allowable
12 x=20//(dA/A)=x=percent change in open loop gain of
        an amplifier
13 a=(x/y)//(1+(A*B))=a
14 disp("",a,"(1+(A*B))=")
15 //Af=A/((1+(A*B)))
16 A=(Af*a)
17 disp("",A,"Open loop gain A=")
18 //1+(A*B)=a
19 B=(a-1)/A
20 disp("",B,"Minimum value of feedback ratio B=")
```

Scilab code Exa 10.7.3 To find the reverse transmission factor

```
1  //scilab 5.4.1
2  //windows 7 operating system
3  //chapter 10:Feedback In Amplifiers
4  clc
```

```
5  clear
6  VD=0.1//VD=outputdistortion voltage
7  VDf=0.05//VDf=output distortion voltage with
       feedback
8  A=-80//A=open loop gain of an amplifier
9  //VDf=VD/(1+(A*B))
10 B=((VD/VDf)-1)/A//B=reverse transmission factor
11 format("v",10)
12 disp("",B,"Reverse transmission factor B=")
```

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

```
1  //scilab 5.4.1
2  //windows 7 operating system
3  //chapter 10:Feedback In Amplifiers
4  clc
5  clear
6  B=50//B=reverse transmission factor for silicon
       transistor T1
7  VB=((640)*10)/(640+360)//calculating voltage at
       point B i.e VB by applying voltage divider rule
       in the given circuit
8  format("v",4)
9  disp("V",VB,"VB=")
10 VBE=VB-5.6//VBE=base emitter voltage drop for
       silicon transistors T1 and T2 both
11 disp("V",VBE,"VBE=")
12 VA=10-0.8//VA=voltage at point A in the given
       circuit
13 disp("V",VA,"VA=")
14 I1=10/(360+640)//I1=current through resistor of 360
       ohm
15 format("v",5)
16 disp("A",I1,"I1=")
17 IE1=I1+1//IE1=emitter current of transistor T1
```

```
18  format (" v " ,5)
19  disp ("A" , IE1 ," IE1=")
20  //IC1=−IB1+IE1
21  IB1=IE1/(B+1)//IB1=base current of transistor T1
22  disp ("mA" ,IB1/10^-3 ," IB1=")//IB1 is converted in
        terms of mA
23  I2=(20-VA)/300//I2=current through resistor of 300
        ohm
24  disp ("mA" ,I2/10^-3 ," I2=")//I2 is converted in terms
        of mA
25  IC2=I2-IB1//IC2=collector current of transistor T2
26  disp ("mA" ,IC2/10^-3 ," IC2=")//IC2 is converted in
        terms of mA
27  //Assuming the base current IB2 of transistor T2 is
        negligibly small
28  IE2=IC2//IE2=emitter current of transistor T2
29  disp ("mA" ,IE2/10^-3 ," IE2=")//IE2 is converted in
        terms of mA
30  I3=(20-5.6)/1000//I3=current through 1000 ohm
        resistor
31  disp ("mA" ,I3/10^-3 ," I3=")//I3 is converted in terms
        of mA
32  IZ=I3+IE2//IZ=current through zener diode
33  disp ("mA" ,IZ/10^-3 ," IZ=")//IZ is converted in terms
        of mA
34  VCE=20-10//VCE=collector emitter voltage drop for
        transistor T1
35  disp ("V" ,VCE ," VCE=")
36  IC1=B*IB1
37  P=VCE*IC1//P=power dissipation in transistor T1
38  disp ("W" ,P ," P=")
```

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

```
1  //scilab 5.4.1
```

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

```
1  //scilab 5.4.1
2  //Windows 7 operating system
3  //chapter 11 Sinusoidal oscillator and
      multivibrators
4  clc
5  clear
6  L=50*10^-3//L=primary inductance of a transformer in
      henry
7  C=(200*10^-12)//C=capacitor connected across
      transformer in farad
8  R=50//dc resistance of primary coil in ohm
9  hie=2000//hie=input impedance in ohm
10 hre=10^(-4)//hre=reverse voltage amplification
      factor
11 hfe=98//hfe=current gain
12 hoe=(0.5*10^(-4))//hoe=output impedance in mho
13 RB=50000//RB=resistance
14 f=1/(2*%pi*sqrt(L*C))//f=frequency of oscillation
15 format("v",5)
```

```
16  g=((hie*hoe)-(hfe*hre))//g=dhe=delta he
17  //M=mutual inductance in henry between the
        transformer primary and the secondary coils for
        sustained oscillations
18  M=((RB/hfe)*((C*R)+(hoe*L)))+((C*R*hie)/hfe)+((L*g)/
        hfe)
19  format("v",5)
20  disp("kHz",f/10^3,"Frequency of oscillation is =")//
        f is converted in terms of kHz
21  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

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

```
17  //e=L2/L1=hfe/dhe
18  hfe=90//hfe=current gain
19  dhe=0.2//dhe=delta he
20  e=hfe/dhe//..........(2)
21  //From equation (1) and (2)
22  //L*x=y
23  x=[1 1 ; e -1]
24  y=[d ; 0]
25  L=inv(x)*y
26  format("v",6)
27  disp("micro Henry",(L(1))/10^-6,"Inductance L1 is ="
        )//converting L(1) in terms of micro Henry
28  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

```
1   //scilab 5.4.1
2   //Windows 7 operating system
3   //chapter 11 Sinusoidal oscillator and
        multivibrators
4   clc
5   clear
6   L=20*10^-3//L=inductance in henry
7   C1=(200*10^(-12))//C1=capacitance in farad
8   C2=(300*10^(-12))//C2=capacitance in farad
9   Cs=((C1*C2)/(C1+C2))
10  f=1/(2*%pi*sqrt(L*Cs))
11  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

```
1  // scilab 5.4.1
2  //Windows 7 operating system
3  //chapter 11 Sinusoidal oscillator and
       multivibrators
4  clc
5  clear
6  R=4700 //R=resistance in a phase-shift oscillator in
       ohm
7  C=(0.01*10^(-6))//C=capacitance in a phase-shift
       oscillator in farad
8  f=1/(2*%pi*sqrt(10)*R*C)
9  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

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

```
14  // for  the  next  frequency  range  from  300  Hz  to  3  kHz
       , new  R=(10.6/10)=1.06  Megaohm
15  // for  frequency  range  3  kHz  to  30kHz , R=1.06/10=106
       Kilo−ohm
16  //So , three  values  of  R  are  10.6  Megaohm , 1.06  Megaohm
       , 106  Kilo  ohm
17  A=6//A=gain  of  amplifier
18  //R2/(R1+R2)=(1/3)−(1/A)=(1/3)−(1/6)
19  //1+(R1/R2)=6
20  //Hence  R1/R2=5
21  //R3=(R1/R2)
22  R3=" 5:1 "
23  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

```
 1  // scilab  5.4.1
 2  //Windows  7  operating  system
 3  // chapter  11  Sinusoidal  oscillator  and
       multivibrators
 4  clc
 5  clear
 6  //Q=Quality  factor
 7  L=3.5//L=inductance  in  henry
 8  f=450000//f=frequency  in  Hz
 9  R=9050//R=resistance  in  ohm
10  Q=(2*%pi*f*L)/R
11  format ("v" ,5)//format ()  sets  the  current  printing
       format
12  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

```
1  // scilab 5.4.1
2  // Windows 7 operating system
3  // chapter 12 Modulation and Demodulation
4  clc
5  clear
6  Vmax=8 // Vmax=maximum peak to peak value of an AM
        voltage
7  Vmin=2 // Vmin=minimum peak to peak value of an AM
        voltage
8  ma=(Vmax-Vmin)/(Vmax+Vmin) // ma=percentage modulation
9  disp("%",(ma*100),"Percentage modulation ma=")
10 // ma=(Vmax-Vmin)/(2*VC) where VC=amplitude of the
        unmodulated carrier
11 VC=(Vmax-Vmin)/(2*ma)
12 disp("V",VC,"Amplitude of the unmodulated carrier is
        VC=")
13 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 upp

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

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

```
1 //scilab 5.4.1
2 //Windows 7 operating system
3 //chapter 12 Modulation and Demodulation
```

```
4 clc
5 clear
6 R=100//R=load resistance in ohms
7 Vc=100//Vc=peak voltage of the carrier in volts
8 ma=0.4//ma=modulation factor
9 Pc=(Vc^2)/(2*R)//Pc=unmodulated carrier power
     developed by an AM wave
10 disp("W",Pc,"The unmodulated carrier power is Pc= ")
11 Pt=Pc*(1+((ma^2)/2))//Pt=total power developed
12 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

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

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

```
1 //scilab 5.4.1
```

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

Scilab code Exa 12.9.6 To find the highest modulation frequency

```
1  //scilab 5.4.1
2  //Windows 7 operating system
3  //chapter 12 Modulation and Demodulation
4  clc
5  clear
6  R=0.2*(10^6)//R=load resistance in ohms in a diode
      detector
7  C=150*(10^-12)//C=capacitance in farad in a diode
      detector
8  //fmh=wmh/(2*%pi)where fmh=highest modulation
      frequency that can be detected with tolerable
      distortion and wmh=corresponding angular
      frequency
9  ma=0.5//ma=modulation factor or depth of modulation
10 fmh=(1/(2*%pi*ma*R*C))/1000
```

```
11  format("v",6)
12  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

```
1  //scilab 5.4.1
2  //Windows 7 operating system
3  //chapter 12 Modulation and Demodulation
4  clc
5  clear
6  Pc=10//Pc=unmodulated carrier power in kilowatts(kW)
7  Pt=12.5//Pt=total power in kilowatts(kW)
8  //Pt=Pc*(1+((ma^2)/2))
9  ma=sqrt(2*((Pt/Pc)-1))//ma=depth of modulation of
       the first signal
10  disp(ma,"The depth of modulation is ma=")
11  mb=0.6//mb=depth of modulation of the second signal
12  PT=Pc*(1+((ma^2)/2)+((mb^2)/2))//PT=the total
       radiated power
13  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

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

Scilab code Exa 13.16.2 To find the resistance RS

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

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

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

```
14  disp("mA/V",gm*10^3,"The transconductance of the FET
        is =")
15  rd=200*10^3//rd=ac drain resistance in ohms
16  u=rd*gm//u=amplification factor
17  disp(u,"The amplification factor of the FET is =")
```

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

```
1  //scilab 5.4.1
2  //Windows 7 operating system
3  //chapter 13 Field-Effect Transistors
4  clc
5  clear
6  RL=250*10^3//RL=load resistance in ohms in a FET
        amplifier
7  rd=100*10^3//rd=ac drain resistance in ohms
8  gm=0.5*10^-3//gm=transconductance in A/V
9  u=rd*gm//u=amplification factor
10 AV=-(u*RL)/(rd+RL)//AV=voltage gain
11 disp(AV,"The voltage gain of FET amplifier is =")
12 disp("kilo ohm",rd/1000,"The output resistance
        excluding RL is rd=")
13 ro=(rd*RL)/(rd+RL)//ro=output resistance including
        RL
14 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

```
1  //scilab 5.4.1
2  //Windows 7 operating system
3  //chapter 13 Field-Effect Transistors
4  clc
```

```
5  clear
6  //For n-channel JFET
7  IDSS=12*10^-3//IDSS=saturation drain current in
       Ampere when VGS(gate-to-source voltage)=0V
8  Vp=-4//Vp=pinch-off voltage
9  VGS=-2//VGS=gate-to-source voltage
10 //By Shockley's equation
11 IDS=IDSS*(1-(VGS/Vp))^2//IDS=saturation drain
       current to be calculated for given value of VGS
12 disp("mA",IDS/10^-3,"The drain current for given
       value of VGS is=")
13 gmo=4*10^-3//gmo=transconductance in A/V of a JFET
       when VGS=0V
14 //gmo=-(2*IDSS)/Vp
15 Vp=-(2*IDSS)/gmo//Vp=pinch-off voltage to be
       calculated for given value of transconductance
16 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

```
1  //scilab 5.4.1
2  //Windows 7 operating system
3  //chapter 13 Field-Effect Transistors
4  clc
5  clear
6  IDSS=12*10^-3//IDSS=saturation drain current in
       Ampere when VGS(gate-to-source voltage)=0V
7  Vp=-4//Vp=pinch-off voltage
8  VDD=30//VDD=drain supply voltage
9  RL=5*10^3//RL=load resistance in ohms
10 Rs=600//Rs=resistance connected to source terminal
       in ohms
11 Rg=1.5*10^6//Rg=resistance connected to gate
       terminal in ohms
```

```
12  //By Shockley's equation
13  //IDS=IDSS*(1-(VGS/Vp))^2 where IDS=saturation drain
        current to be calculated for given value of VGS
14  //Substituting VGS=(-ID*Rs) we get ID=IDS
15  //ID=IDSS*(1+((ID*Rs)/Vp))^2
16  //ID=12*(1+((0.6*ID)/-4))^2 where ID is obtained in
     mA
17  //(0.27*ID^2)-(4.6*ID)+12=0.........(1)
18  ID1=(4.6+sqrt((4.6^2)-(48*0.27)))/(2*0.27)
19  format("v",5)
20  ID2=(4.6-sqrt((4.6^2)-(48*0.27)))/(2*0.27)//ID1,ID2
     are the 2 roots of the above equation (1)
21  format("v",5)
22  disp("mA",ID1,"ID1=")
23  disp("mA",ID2,"ID2=")
24  if (ID1>(IDSS/10^-3)) then//IDSS is converted in
     terms of mA
25      disp("mA",ID1,"As ID1>IDSS ,the value rejected
         is ID1=")
26  end
27  if (ID2>(IDSS/10^-3)) then//IDSS is converted in
     terms of mA
28      disp("mA",ID2,"As ID2>IDSS ,the value rejected
         is ID2=")
29  end
30  disp("mA",ID2,"Therefore ,the drain current is =")
31  ID=ID2*10^-3//converting ID2 in terms of Ampere
32  VDS=VDD-ID*(RL+Rs)//VDS=drain-to-source voltage
33  disp("V",VDS,"The value of drain-to-source voltage
     VDS is =")
34  VGS=-ID*Rs//VGS=gate-to-source voltage
35  disp("V",VGS,"The value of gate-to-source voltage
     VGS is=")
36  if(Vp<0 & VDS>(VGS-Vp))
37      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")
```

38 `end`

Scilab code Exa 13.16.7 To calculate the drain current

```scilab
1  //scilab 5.4.1
2  //Windows 7 operating system
3  //chapter 13 Field-Effect Transistors
4  clc
5  clear
6  IDSS=10*10^-3//IDSS=saturation drain current in
       Ampere when VGS(gate-to-source voltage)=0V
7  Vp=-2//Vp=pinch-off voltage
8  VDD=20//VDD=drain supply voltage
9  RL=1*10^3//RL=load resistance in ohms
10 Rs=2*1000//Rs=resistance connected to source
       terminal in ohms
11 R1=12*10^6//R1=resistance in the voltage divider
       network in ohms
12 R2=8*10^6//R2=resistance in the voltage divider
       network in ohms
13 VT=(R2/(R1+R2))*VDD//VT=Thevenin voltage
14 //VGS=VT-(ID*Rs)
15 //By Shockley's equation
16 //IDS=IDSS*(1-(VGS/Vp))^2 where IDS=saturation drain
        current to be calculated for given value of VGS
17 //Substituting VGS=(VGS-ID*Rs) we get ID=IDS
18 //(10*ID^2)-(101*ID)+250=0.........(1) where ID is
       obtained in mA
19 ID1=(101+sqrt((101^2)-(40*250)))/(2*10)
20 format("v",5)
21 ID2=(101-sqrt((101^2)-(40*250)))/(2*10)//ID1,ID2 are
       the 2 roots of the above equation (1)
22 format("v",5)
23 disp("mA",ID1,"ID1=")
24 disp("mA",ID2,"ID2=")
```

```
25  //For ID1
26  VGS=VT -( ID1*Rs )//VGS=gate−to−source  voltage
        calculated  for  ID1
27  if (Vp>VGS) then
28      disp("mA",ID1,"As Vp>(VGS calculated  using  ID1) ,
            the  value  rejected  is  ID1=")
29  end
30  disp("mA",ID2 ,"Therefore , the  drain  current  is  =")
31  ID=ID2*10^-3//converting  ID2  in  terms  of  Amperes
32  VGS=VT -( ID*Rs )//VGS=gate−to−source  voltage
33  disp("V",VGS ,"VGS=")
34  VDS=VDD -( ID*(RL+Rs ))//VDS=drain−to−source  voltage
35  format("v" ,2)
36  disp("V",VDS ,"VDS=")
37  if(Vp<VGS & VDS >(VGS -Vp ))
38      disp("As Vp=(−2)<(VGS=−0.68V)  and  VDS=7V>(VGS−Vp
            ) , it  is  checked  that  the  JFET  operates  in  the
            saturation  region  ")
39  end
```

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

```
1  //scilab  5.4.1
2  //Windows 7 operating  system
3  //chapter 13 Field−Effect  Transistors
4  clc
5  clear
6  //For a n−channel JFET
7  IDSS=10*10^-3//IDSS=saturation  drain  current  in
        Ampere  when  VGS(gate−to−source  voltage )=0V
8  Vp=(-4)//Vp=pinch−off  voltage
9  VGS=(-2.5)//VGS=gate−to−source  voltage
10 //By Shockley 's  equation
11 IDS=IDSS*(1-(VGS/Vp ))^2//IDS=saturation  drain
        current  to  be  calculated  for  given  value  of  VGS
```

```
12  format("v",5)
13  disp("mA",IDS/10^-3,"The drain current for given
        value of VGS is=")//converting IDS in terms of mA
14  VDSmin=VGS-Vp//VDSmin=minimum value of drain-to-
        source voltage for the onset of the saturation
        region
15  format("v",5)
16  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

```
1  //scilab 5.4.1
2  //Windows 7 operating system
3  //chapter 13 Field-Effect Transistors
4  clc
5  clear
6  VDD=20//VDD=drain supply voltage
7  IDS=0.9//IDS=drain saturation current in terms of mA
8  Vp=-3//Vp=pinch-off voltage
9  IDSS=8//IDSS=saturation drain current in mA when VGS
        (gate-to-source voltage)=0V
10  //By Shockley's equation
11  //IDS=IDSS*(1-(VGS/Vp))^2
12  VGS=Vp*(1-sqrt(IDS/IDSS))//VGS=gate-to-source
        voltage
13  disp("V",VGS,"The gate-to-source voltage VGS is=")
14  //gm=(dIDS/dVGS)|VDS=constant where gm=
        transconductance
15  gm=-((2*IDSS)/Vp)*(1-(VGS/Vp))
16  format("v",5)
17  disp("mS",gm,"The value of transconductance is=")
```

Scilab code Exa 13.16.10 To find the gate source voltage

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

Scilab code Exa 13.16.11 To calculate Rs and the channel resistance

```
1  //scilab  5.4.1
2  //Windows  7  operating  system
3  //chapter  13  Field-Effect  Transistors
4  clc
5  clear
6  IDSS=10*10^-3//IDSS=saturation  drain  current  in
      Ampere  when  VGS(gate-to-source  voltage)=0V
7  Vp=-5//Vp=pinch-off  voltage
8  VDD=24//VDD=drain  supply  voltage
9  VDS=8//VDS=drain-to-source  voltage
10 ID=4*10^-3//ID=drain  current  in  Ampere
11 R1=2*10^6//R1=resistance  in  the  voltage  divider
      network  in  ohms
12 R2=1*10^6//R2=resistance  in  the  voltage  divider
      network  in  ohms
13 VT=(R2/(R1+R2))*VDD//VT=Thevenin  voltage
```

```
14  //By Shockley 's equation
15  //ID=IDS=IDSS*(1-(VGS/Vp))^2
16  VGS=Vp*(1-sqrt(ID/IDSS))//VGS=gate-to-source  voltage
17  //VGS=VT-(ID*Rs) where Rs=resistance  connected  at
        the  source  terminal
18  Rs=(VT-VGS)/ID
19  disp("kilo  ohm",Rs/10^3,"The  value  of  Rs  =")//
        converting  Rs  in  terms  of  kilo-ohm
20  Rch=VDS/ID//Rch=channel  resistance  at  the  Q-point
21  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

```
1  //scilab  5.4.1
2  //Windows  7  operating  system
3  //chapter  13  Field-Effect  Transistors
4  clc
5  clear
6  ID=5//ID=saturation  drain  current  in  terms  of  mA in
        an  n-channel  enhancement  mode  MOSFET
7  VGS=8//VGS=gate-to-source  voltage
8  VT=4//VT=Threshold  voltage
9  VGS2=10//VGS2=gate-to-source  voltage  for  which
        saturation  drain  current  is  to  be  calculated
10  //ID=K*(VGS-VT)^2  where  K=(IDSS/(Vp^2))  and  Vp=pinch
        -off  voltage  ,IDSS=drain  saturation  current  for
        VGS=0 V
11  K=ID/((VGS-VT)^2)
12  ID1=K*(VGS2-VT)^2//ID1=The  saturation  drain  current
        for  gate-source  voltage  of  10V i  e VGS2
13  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

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

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

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

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

```
1  //scilab 5.4.1
2  //Windows 7 operating system
```

```
3  //chapter 13 Field-Effect Transistors
4  clc
5  clear
6  //r given in textbook is taken as rd afterwards.
       Hence r=rd
7  rd=100*10^3//rd=drain resistance in ohms
8  gm=3500*10^-6//gm=transconductance in terms of A/V (
       or S)
9  RL=5*10^3//RL=load resistance in ohms
10 u=rd*gm//u=amplification factor
11 AV=(u*RL)/(((u+1)*RL)+rd)//AV=voltage gain
12 format("v",6)
13 disp(AV,"The voltage gain is=")
14 Ro=rd/(u+1)//Ro=output resistance excluding RL
15 format("v",5)
16 disp("ohm",Ro,"The output resistance excluding RL is
       =")
17 Ro1=(rd*RL)/(rd+((u+1)*RL))//Ro1=Ro'=output
       resistance including RL
18 format("v",6)
19 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

```
1  //scilab 5.4.1
2  //Windows 7 operating system
3  //chapter 13 Field-Effect Transistors
4  clc
5  clear
6  //In a FET used in a CS amplifier
7  IDSS=4//IDSS=drain saturation current in mA for gate
       -to-source voltage (VGS)=0V
8  Vp=-3//Vp=pinch-off voltage
```

```
 9  RL =10 //RL=load  resistance  in  kilo  ohms
10  VGS = -0.7 //VGS=gate−to−source  voltage
11  gmo = -(2* IDSS )/ Vp //gmo=transconductance  in  A/V  of  a
        JFET  when  VGS=0V
12  gm = gmo *(1 -( VGS / Vp )) //gm=transconductance
13  AV = -gm * RL //AV=the  small  signal  voltage  gain
14  disp ( AV ,"The  small  signal  voltage  gain  is  =")
15  // 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 resistanc

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

Scilab code Exa 14.12.2 To calculate the voltage gain

```
1 //scilab 5.4.1
2 //Windows 7 operating system
3 //chapter 14 Integrated Circuits and Operational
      Amplifiers
4 clc
5 clear
6 R1=2*1000//R1=input resistance in ohms in the non-
      inverting amplifier circuit
7 Rf=5*1000//Rf=feedback resistance in ohms
8 AV=1+(Rf/R1)//AV=voltage gain of the non-inverting
      amplifier circuit
9 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 m

```
1 //scilab 5.4.1
2 //Windows 7 operating system
3 //chapter 14 Integrated Circuits and Operational
      Amplifiers
4 clc
5 clear
6 //First case
7 v1=40*10^-6//v1=voltage applied to the non-inverting
       input terminal
8 v2=-40*10^-6//v2=voltage applied to the inverting
      input terminal
9 vo=100*10^-3//vo=output voltage for the above inputs
       v1 and v2
```

```
10  //Second case
11  V1=40*10^-6//V1=voltage applied to the non−inverting
        input terminal
12  V2=40*10^-6//V2=voltage applied to the inverting
        input terminal
13  Vo=0.4*10^-3//Vo=output voltage for the above inputs
        V1 and V2
14  disp("In first case:")
15  vd=v1-v2//vd=difference signal voltage
16  disp(" V ",vd/10^-6,"vd=")
17  vc=(v1+v2)/2//vc=common mode signal voltage
18  format("v",5)
19  disp(" V ",vc/10^-6,"vc=")
20  //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
21  Ad=vo/vd//Ad calculated in first case as common mode
        signal vc=0
22  disp(Ad,"Voltage gain for the difference signal is
        Ad =")
23  disp("In second case:")
24  Vd=V1-V2//Vd=difference signal voltage
25  disp(" V ",Vd/10^-6,"Vd=")
26  Vc=(V1+V2)/2//Vc=common mode signal voltage
27  format("v",5)
28  disp(" V ",Vc/10^-6,"Vc=")
29  Ac=Vo/Vc//Ac calculated in second case as difference
        signal Vc=0
30  disp(Ac,"Voltage gain for the common−mode signal is
        Ac =")
31  CMRR=abs(Ad/Ac)//CMRR=Common Mode Rejection Ratio=|
        Ad/Ac|
32  disp(CMRR,"Common Mode Rejection Ratio is CMRR=")
```

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

```
1  // scilab 5.4.1
2  //Windows 7 operating system
3  //chapter 14 Integrated Circuits and Operational
       Amplifiers
4  clc
5  clear
6  R1=1*1000//R1=input resistance in ohms in the
       inverting terminal of the amplifier circuit
7  R2=200//R2=input resistance in ohms in the inverting
        terminal of the amplifier circuit
8  R3=400//R3=input resistance in ohms in the inverting
        terminal of the amplifier circuit
9  Rf=500//Rf=feedback resistance in ohms
10 v1=-5//v1=input voltage in the inverting terminal of
        an amplifier circuit at R1 resistor
11 v2=3//v2=input voltage in the inverting terminal of
       an amplifier circuit at R2 resistor
12 v3=4//v3=input voltage in the inverting terminal of
       an amplifier circuit at R3 resistor
13 vo=-(((Rf/R1)*v1)+((Rf/R2)*v2)+((Rf/R3)*v3))//vo=
       output voltage for inverting summing summing
       amplifier circuit
14 disp("V",vo,"Output voltage of the 3−input summing
       amplifier circuit is =")
15 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

```
1  // scilab 5.4.1
2  //Windows 7 operating system
3  //chapter 14 Integrated Circuits and Operational
       Amplifiers
4  clc
5  clear
```

```
6  R1=1*1000//R1=input resistance in ohms in the
       inverting amplifier circuit
7  Rf=50*1000//Rf=feedback resistance in ohms
8  A=-(Rf/R1)//AV=voltage gain of the inverting
       amplifier circuit
9  disp(A,"The voltage gain of the given inverting
       amplifier circuit is =")
10 //vin=0.5*sin(100*%pi*t)
11 //vout=A*vin=-50*0.5*sin(100*%pi*t)=-25*sin(100*%pi*
       t)
12 disp("If the operation were entirely linear ,the
       output voltage would have been -25*sin(100*%pi*t)
       ")
13 disp("But since the voltage supply is +-12V ,the op-
       amp is saturated when |vout| attains 12V")
14 //Let at time t=to,vout=-12V
15 //-12=-25*sin(100*%pi*to)
16 to=(1/(100*%pi))*asin(12/25)
17 format("v",8)
18 disp("s",to,"to=")
19 disp("Thus over the entire cycle ,")
20 disp("vout=-25*sin(100*%pi*t) V when 0<=t<=to")
21 disp("vout=-12V when to<=t<=(0.01-to)")
22 disp("vout=-25*sin(100*%pi*t) V when (0.01-to)<=t
       <=(0.01+to)")
23 disp("vout=+12V when (0.01+to)<=t<=(0.02-to)")
24 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

```
1  //scilab 5.4.1
2  //Windows 7 operating system
3  //chapter 14 Integrated Circuits and Operational
       Amplifiers
```

```
4  clc
5  clear
6  R=2*1000//R=feedback resistance in ohms in the
       differentiator circuit
7  C=0.01*10^-6//C=input capacitance in farad in the
       differentiator circuit
8  //dvi/dt=1.5V/1ms for 0<t<1ms (given ramp input
       signal)
9  //output voltage of a differentiator is given as vo
       =-RC(dvi/dt)
10 d=1.5/(10^-3)//d=dvi/dt=1.5V/1ms
11 vo=-R*C*d
12 disp("V",vo,"Output voltage of a differentiator is "
       )
13 disp("Hence for <t<1 ms,vo=-0.03V=-30mV.Otherwise,vo
       =0V")
```

Scilab code Exa 14.12.8 To calculate the output voltage

```
1  //scilab 5.4.1
2  //Windows 7 operating system
3  //chapter 14 Integrated Circuits and Operational
       Amplifiers
4  clc
5  clear
6  R1=5*1000//R1=input resistance in ohms in the given
       op-amp circuit
7  Rf=10*1000//Rf=feedback resistance in ohms
8  vi=5//vi=input voltage at the inverting terminal of
       an op-amp
9  V=4//V=voltage at the non-inverting terminal of an
       op-amp
10 //By applying superposition theorem
11 Vo=((1+(Rf/R1))*V)+(-(Rf/R1)*vi)
12 disp("V",Vo,"Output voltage Vo of the circuit is =")
```

Scilab code Exa 14.12.9 `To find the differential mode gain`

```
1  //scilab 5.4.1
2  //Windows 7 operating system
3  //chapter 14 Integrated Circuits and Operational
       Amplifiers
4  clc
5  clear
6  R1=10*1000//R1=resistance in ohms
7  R2=100//R2=resistance in ohms
8  R3=10*1000//R3=resistance in ohms
9  R4=10*1000//R4=resistance in ohms
10 R5=10*1000//R5=resistance in ohms
11 //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
12 //Applying Kirchhoff's current law at X
13 //(V1/R1)+((V1-V)/R3)+((V1-V2)/R2)=0
14 //Applying Kirchhoff's current law at Y
15 //((V2-V)/R4)+((V2-V1)/R2)+((V2-Vo)/R5)=0
16 //Eliminating V from the above equations
17 //V2*((1/R2)+(1/R4)+(1/R5)+(R3/(R2*R4)))-V1*((1/R2)
       +(1/R4)+((R3/R4)*((1/R1)+(1/R2))))=Vo/R5
18 //V2*R-V1*r=Vo/R5 . . . . . . . . . . . . . . . . . . . ( 1 )
19 R=((1/R2)+(1/R4)+(1/R5)+(R3/(R2*R4)))
20 r=((1/R2)+(1/R4)+((R3/R4)*((1/R1)+(1/R2))))
21 disp(R,"R=")
22 disp(r,"r=")
23 //R=r from above calculation and its answer
       displayed
24 //Hence from the above equation (1) A=Vo/(V1-V2)=-(
       R5*R)=-(R5*r)
25 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

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

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

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

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

```
14  disp("The designed values of resistance and
        capacitance for a high−pass Butterworth filter
        are:")
15  disp("kilo ohm",R1/1000,"R1=")
16  disp("kilo ohm",R2/1000,"R2=")
17  disp("kilo ohm",R/1000,"R=")
18  disp("micro Farad",C/10^-6,"C=")
```

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

```
1  //scilab 5.4.1
2  //Windows 7 operating system
3  //chapter 15 Active Filters
4  clc
5  clear
6  fo=1000//fo=centre frequency in Hz
7  f=100//f=bandwidth in Hz
8  //Q=wo/w=Quality factor
9  Q=(2*%pi*fo)/(2*%pi*f)
10  C1=0.02*10^-6
11  C2=0.02*10^-6//C1=C2=Assumed Capacitances in Farad
12  Ao=2//Ao=gain at the centre frequency
13  //R1*C1=Q/(wo*Ao) for active band pass Butterworth
        filter
14  wo=2*%pi*fo
15  R1=Q/(Ao*wo*C1)
16  R3=Q/(wo*((C1*C2)/(C1+C2)))
17  Rp=1/((wo^2)*R3*C1*C2)
18  R2=(R1*Rp)/(R1-Rp)
19  disp("The designed values of resistance and
        capacitance for a second order band−pass
        Butterworth filter are:")
20  disp("kilo ohm",ceil(R1/1000),"R1=")//floor() and
        ceil() functions are used in order to get
        truncated floating values as per the requirement
```

```
21 disp("ohm",floor(R2),"R2=")
22 disp("kilo ohm",ceil(R3/1000),"R3=")
23 disp("micro Farad",C1/10^-6,"C1=")
24 disp("micro Farad",C2/10^-6,"C2=")
```

Scilab code Exa 15.7.4 To design a notch filter

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

```
27  disp("ohm",R4,"R4=")
28  disp("kilo ohm",(R5/1000),"R5=")
29  disp("kilo ohm",(R6/1000),"R6=")
30  disp("micro Farad",C1/10^-6,"C1=")
31  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 acros

```
1  // scilab 5.4.1
2  // Windows 7 operating system
3  // chapter 16 Special Devices
4  clc
5  clear
6  Vp=15//Vp=firing voltage of a unijunction transistor
       in Volts
7  VBB=40//VBB=source voltage in Volts
8  n=(Vp/VBB)//n=intrinsic stand-off ratio
9  disp(n,"The intrinsic stand-off ratio is ")
10 R=50*(10^3)//R=resistance in ohms
11 C=2000*(10^-12)//c=capacitance in farad
12 T=(R*C*log(1/(1-n)))*(10^6)//T=time period of the
       sawtooth voltage across C
13 format("v",7)
14 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

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

Scilab code Exa 17.17.2 To determine the decimal equivalent

```
1  // scilab 5.4.1
```

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

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

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

```
22  a= floor(a);
23  q=q+1;
24  end
25  for m=1:q-1//multiplying the bits of integer with
        their position values and adding
26  c=m-1;
27  f=f+b(1,m)*(2^c);
28  end
29  while(d>0)//loop to take the binary bits of decimal
        into a matrix
30  e=modulo(d,2)
31  w(1,p)=e
32  d=d /10;
33  d=floor(d)
34  p=p+1;
35  end
36  for n=1:p-1//multiplying the bits of decimal with
        their position values and adding
37  z=z+w(1,n) *(0.5) ^(11-n);
38  end
39  z=z*10000;
40  //rounding of to 4 decimal values
41  z=round(z);
42  z=z/10000;
43  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

```
1  //scilab 5.4.1
2  //Windows 7 operating system
3  //chapter 17 Number Systems ,Boolean Algebra ,and
        Digital Circuits
4  clc
5  clear
```

```
6  q=0;
7  b=0;
8  s=0;
9  format('v',18);//increasing the precision to 18 .
10  a=4.625;
11  d=modulo(a,1);//separating the decimal part and the
      integer part
12  a=floor(a);//removing the decimal part
13  while(a>0)//taking integer part into a matrix and
      converting into equivalent binary
14  x=modulo(a,2);
15  b=b+(10^q)*x;
16  a=a/2;
17  a=floor(a);
18  q=q+1;
19  end
20  for i=1:10//for values after decimal point
      converting into binary
21  d=d*2;
22  q=floor(d);
23  s=s+q/(10^i);
24  if d>=1 then
25  d=d-1;
26  end
27  end
28  k=b+s;
29  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

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

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```
4 clc
5 clear
6 dec =263
7 base =5
8 s= dec2base ( dec , base )
9 disp (,s ," Equivalent of 263 in a code base 5 is ")
```

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

```
1 // scilab 5.4.1
2 // Windows 7 operating system
3 // chapter 17 Number Systems , Boolean Algebra , and
      Digital Circuits
4 clc
5 clear
6 x=2
7 s=x+x
8 s1= dec2bin ( s )
9 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 correspond

```
1 // scilab 5.4.1
2 // Windows 7 operating system
3 // chapter 17 Number Systems , Boolean Algebra , and
      Digital Circuits
4 clc
5 clear
6 x= '11111 '
7 y= '1011 '
8 z= '101 '
9 w= '10 '
```

```
10  v = '1 '
11  s1 = bin2dec ( x )
12  s2 = bin2dec ( y )
13  s3 = bin2dec ( z )
14  s4 = bin2dec ( w )
15  s5 = bin2dec ( v )
16  a = s1 + s2 + s3 + s4 + s5
17  b = dec2bin ( a )
18  disp ( ,b ," Binary  addition  of  11111+1011+101+10+1  is  "
        )
19  disp ( ,a ," Decimal  equivalent  corresponding  to  above
        binary  addition  is  ")
```

Scilab code Exa 17.17.8 To perform the binary subtraction

```
1  // scilab  5.4.1
2  // Windows  7  operating  system
3  // chapter  17  Number  Systems , Boolean  Algebra , and
       Digital  Circuits
4  clc
5  clear
6  x = '1101 '
7  y = '111 '
8  s1 = bin2dec ( x )
9  s2 = bin2dec ( y )
10  a = s1 - s2
11  s = dec2bin ( a )
12  disp ( ,s ," Binary  subtraction  1101 −111  is  =")
```

Scilab code Exa 17.17.9 To obtain the output levels of a silicon transistor for gi

```
1  // scilab  5.4.1
2  // Windows  7  operating  system
```

```scilab
3  //chapter 17 Number Systems,Boolean Algebra,and
       Digital Circuits
4  clc
5  clear
6  hFE=30//hFE=dc current gain of given silicon
       transistor
7  VBE=0.8//VBE=base-emitter voltage drop at saturation
8  VCE=0.2//VCE=collector-emitter voltage drop at
       saturation
9  R1=15*1000//resistance at the base side of the
       transistor in ohms
10 R2=100*1000//another resistance at the base side of
       the transistor in ohms
11 RL=2*1000//load resistance at the collector side of
       the transistor in ohms
12 VCC=10//VCC=collector supply voltage
13 VBB=-10//VBB=base supply voltage
14 //If the input level is 0 volt i e vi=0,the open-
       circuited base voltage is given as
15 VB=VBB*(R1/(R1+R2))
16 disp("For input level 0 V:")
17 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")
18 disp("V",VCC,"When vi=0,the output voltage is vo=VCC
       =")
19 disp("This indicates that the output is in state 1
       when the input is in state 0")
20 //When the input level is 10 volt i e vi=10, we have
        to show that the transistor is in saturation
21 //The minimum base current for saturation is given
       by iB(min)=iC/hFE
22 iC=(VCC-VCE)/RL//collector current when the
       transistor saturates
23 iB=iC/hFE//iB=iB(min)=minimum base current for
       saturation in mA
24 i1=(10-VBE)/R1//i1=current through R1 resistor
       connected at the base side and here vi=10 is
```

```
       taken
25  i2=(VBE-VBB)/R2//i2=current through R2 resistor
       connected at the base side
26  iB1=i1-i2//iB1=actual base current
27  disp(" For input level 10 V:")
28  if (iB1>iB) then
29      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
30      disp("V",VCE,"When vi=10,the output voltage is
            vo=VCE(sat)=")
31      disp(" This indicates that the output is in state
             0 when the input is in state 1")
32  end
33  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

```
 1  //scilab 5.4.1
 2  //Windows 7 operating system
 3  //chapter 17 Number Systems,Boolean Algebra,and
       Digital Circuits
 4  clc
 5  clear
 6  A=0
 7  B=0
 8  C=bitor(A,B)//bitwise OR operation is performed
 9  disp(C," Boolean expression C=A+B for inputs A=0 and
     B=0 is")
10  A=1
11  B=0
12  C=bitor(A,B)
13  disp(C," Boolean expression C=A+B for inputs A=1 and
```

```
       B=0 is")
14  A=1
15  B=1
16  C=bitor(A,B)
17  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 po

```
1  // scilab  5.4.1
2  // Windows  7  operating  system
3  // chapter  19  VLSI  Technology  and  Circuits
4  clc
5  clear
6  ID=50*10^-6//ID=drain  current  in  amperes
7  k=25*10^-6//k=ue/D  in  A/V^2
8  VDS=0.25//VDS=drain-to-source  voltage
9  VGS=5//VGS=gate-to-source  voltage
10 VTH=1.5//VTH=threshold  voltage
11 w=ID/(k*(VGS-VTH)*VDS)//w=W/L
12 format("v",5)
13 disp(w,"W/L=")
14 P=VDS*ID//P=power  dissipated  by  the  transistor
15 disp("micro  Watt",P*10^6,"The  dissipated  power  is=")
16 VDD=5//VDD=drain  supply  voltage  of  given  NMOS
         transistor
17 R=(VDD-VDS)/ID//R=load  resistor  to  be  connected  in
         series  with  the  drain
18 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

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

Scilab code Exa 19.29.3 To find the value of inverse of aspect ratio of the PMOS t

```
1  //scilab 5.4.1
2  //Windows 7 operating system
3  //chapter 19 VLSI Technology and Circuits
4  clc
5  clear
```

```
6  w=10//w=W/L value of the NMOS transistor in a CMOS
        inverter
7  un=1350//un=electron mobility for NMOS transistor in
        cm^2/V s
8  up=540//up=electron mobility for PMOS transistor in
        cm^2/V s
9  //(Wpu/Lpu)*up*(VINV-VDD-VTHP)^2=(Wpd/Lpd)*un*(VINV-
        VTHN)^2
10 //For a symmetrical inverter VINV=(VDD/2) and VTHN
        =(-VTHP)
11 //Also for input voltage=VDD/2 both transistors
        operate in saturation region
12 //Therefore ,up*(Wpu/Lpu)=un*(Wpd/Lpd)
13 w1=(un*w)/up//w1=Wpu/Lpu=W/L value of the PMOS for a
        symmetrical inverter
14 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

```
1  //scilab 5.4.1
2  //Windows 7 operating system
3  //chapter 19 VLSI Technology and Circuits
4  clc
5  clear
6  f=2*10^9//f=clock frequency in Hz
7  VDD=3//VDD=drain supply voltage
8  Cl=1*10^-12//Cl=load capacitance in Farad
9  P=50*10^-3//P=maximum power dissipation capability
        in W/stage
10 N=P/(f*Cl*VDD^2)//N=maximum permissible number of
        fan outs
11 format("v",5)
12 disp(N,"N=")
13 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

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

Scilab code Exa 19.29.6 To calculate the required metal line width

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

```
13 //1mA per micrometre of aluminium line width is the
      maximum safe average current an aluminium wire
      can carry.
14 disp("This needs a line at least width of")
15 disp("micrometres",I)
16 if (W>I) then
17     disp("Above calculated minimum metal line−width
            (W) is thus the safe width of the metal line
            driving 80 inverters.")
18 end
19 f=5//f=number of fanout lines
20 w=f*W//w=required metal line width
21 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 acceler

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

```
17 format("v",10)
18 disp("m/s^2",ta,"Traverse acceleration is =")
19 L=25*10^-2//L=distance of the CRT screen from the
      centre of the deflecting plates in metre
20 d=(l*L*Vd)/(2*s*Va)//d=deflection of the spot on the
       CRT screen
21 format("v",13)
22 disp("cm",d*100,"Spot deflection is =")//d is
      converted in terms of cm
23 S=d/Vd//S=deflection sensitivity
24 format("v",10)
25 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

```
1 //scilab 5.4.1
2 //Windows 7 operating system
3 //chapter 20 Cathode Ray Oscilloscope
4 clc
5 clear
6 e=1.6*10^-19//e=charge of an electron
7 Va=1000//Va=potential difference in volts
8 m=9.11*10^-31//m=mass of an electron
9 v=sqrt((2*e*Va)/m)//v=axial velocity of an electron
10 l=1.5*10^-2//l=axial length of deflecting plates in
      metre
11 t=l/v//t=transit time of the beam through the
      deflecting plates
12 //T=time period of the sinusoidal deflecting voltage
13 //tmax=maximum transit time
14 //(0.1/360)*T=tmax,since 1 cycle corresponds to 360
      degrees
15 T=(t*360)/0.1
16 f=1/T//f=highest frequency of the deflecting voltage
```

```
17 format("v",5)
18 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 deflect

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

Scilab code Exa 20.9.4 To calculate the frequency of the signal

```
 1 //scilab 5.4.1
 2 //Windows 7 operating system
```

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

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

```
1  //scilab 5.4.1
2  //Windows 7 operating system
3  //chapter 20 Cathode Ray Oscilloscope
4  clc
5  clear
6  //Let fv=frequency of the vertical signals in kHz
7  //fh=frequency of the horizontal signals
8  //Number of horizontal tangencies=nh
9  //Number of vertical tangencies=nv
10 //fv/fh=nh/nv
11 fh=1
12 nh=3
13 nv=4
14 fv=(nh/nv)*fh
15 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

```
1 //scilab 5.4.1
2 //Windows 7 operating system
3 //chapter 20 Cathode Ray Oscilloscope
4 clc
5 clear
6 //slope of the major axis is negative (given)
7 A=2.6//A=The maximum y-displacement
8 vyo=1.1//vyo=the vertical displacement
9 sino=(vyo/A)//o=phase difference between the two
      voltages
10 x=asind(sino)
11 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")
12 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 freq

```
1  // scilab 5.4.1
2  // Windows 7 operating system
3  // chapter 21 Communication Systems
4  clc
5  clear
6  Npe=6*10^10//Npe=peak electron concentration for the
        E layer in m^-3
7  Npf=10^12//Npf=peak electron concentration for the F
        layer in m^-3
8  fCE=9*sqrt(Npe)//fCE=critical frequency for the E
        layer
9  format("v",5)
10 disp("MHz",fCE/10^6,"Critical frequency for the E
        layer is =")
11 fCF=9*sqrt(Npf)//fCF=critical frequency for the F
        layer
12 format("v",5)
13 disp("MHz",fCF/10^6,"Critical frequency for the F
        layer is =")
14 R=6400//R=radius of the earth in km
15 He=110//He=height of the E layer above the earth
```

```
        surface  in  km
16  ime = asind ( R /( R + He ))// ime = angle  corresponding  to
        maximum  frequency  fmE  for  E  layer  in  degrees
17  format ( " v " ,3)
18  fmE = fCE * secd ( ime )// fmE = maximum  frequency  reflected
        from  the  E  layer
19  disp ( " MHz " , fmE /10^6 , " The  maximum  frequency  reflected
         from  the  E  layer  is  =")
20  Hf =250// Hf = height  of  the  F  layer  above  the  earth
        surface  in  km
21  imf = asind ( R /( R + Hf ))// imf = angle  corresponding  to
        maximum  frequency  fmF  for  F  layer  in  degrees
22  format ( " v " ,3)
23  fmF = fCF * secd ( imf )// fmF = maximum  frequency  reflected
        from  the  F  layer
24  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

```
 1  // scilab  5.4.1
 2  // Windows  7  operating  system
 3  // chapter  21  Communication  Systems
 4  clc
 5  clear
 6  R =6400// R = radius  of  the  earth  in  km
 7  He =110// He = height  of  the  E  layer  above  the  earth
        surface  in  km
 8  ime = asin ( R /( R + He ))// ime = angle  corresponding  to
        maximum  frequency  fmE  for  E  layer  in  radian
 9  format ( " v " ,10)
10  o =(% pi /2) - ime // o = angle  made  by  the  incident  ray  at
        the  centre  of  the  earth  in  degrees
11  format ( " v " ,5)
12  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
13  format("v",5)
14  disp("km",L,"The maximum distance for single hop
        transmission is =")
15  //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 whic

```
1  //scilab 5.4.1
2  //Windows 7 operating system
3  //chapter 21 Communication Systems
4  clc
5  clear
6  //fc=9*sqrt(Np)
7  fc=3*10^6//fc=critical frequency in Hz
8  Np=(fc^2)/81//Np=electron concentration at the
        reflecting point
9  //h=height of the reflecting point from the bottom
        of the layer
10  //Np=(5*10^10)+(10^9*h)....(given)
11  h=(Np-(5*10^10))/10^9
12  H=100//H=height above the surface of the earth in km
13  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

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

```
1  //scilab 5.4.1
2  //Windows 7 operating system
3  //chapter 23 Lasers, Fibre Optics, and Holography
4  clc
5  clear
6  V=500//V=bandwidth of a He-Ne laser in Hz
7  t=1/V//t=coherence time
8  disp("ms",(t*(10^3)),"The coherence time is =")
9  c=3*10^8//c=velocity of light in m/s
10 Lc=c/V//Lc=longitudinal coherence length
11 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

```
1  //scilab 5.4.1
2  //Windows 7 operating system
3  //chapter 23 Lasers, Fibre Optics, and Holography
4  clc
5  clear
6  //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.
7  //2*d=(n1*y1)=(n2*y2)where y1 & y2 are 2 wave-
      lengths and d=path difference and n1 and n2 are 2
       integers
8  //(2*d)*((1/y2)-(1/y1))=(n2-n1)=m where m is another
       integer
```

```
9  //Now m=(-2*d*Y)/(y^2)=(2*d*V)/(v*y)=(2*d*V)/c=(2*d)
       /Lc
10 Lc=600//Lc=coherence length in km
11 d=(Lc/2)//d=minimum difference between the 2 arms of
        the Michelson interferometer
12 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 predo

```
1  //scilab 5.4.1
2  //Windows 7 operating system
3  //chapter 23 Lasers, Fibre Optics, and Holography
4  clc
5  clear
6  h=6.62*10^(-34)//h=Planck's constant
7  v=3*10^8//v=velocity of light(as normal optical
       source is mentioned) in m/s
8  kB=1.38*10^-23//kB=Boltzmann's constant
9  T=1000//T=temperature in Kelvin
10 w=6000//w=wavelength in Armstrong
11 R=(exp((h*v)/(w*(10^-10)*kB*T)))-1//R=the ratio of
       the number of spontaneous to stimulated
       transitions
12 disp(,R,"R=")
13 if (R>1) then
14
15     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")
16 end
```

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

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

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

```
1  // scilab 5.4.1
2  // Windows 7 operating system
3  // chapter 23 Lasers , Fibre Optics , and Holography
4  clc
5  clear
6  // y0=vacuum wavelength for the frequency v
7  // c=(v*y0)
8  // The deviation in the wavelength is Y0=(c*V)/(v^2)
9  // Y0=((y0^2)*V)/c
10 // V being spread in frequency over the linewidth.
11 // V=(1/tc)
12 c=3*(10^8)//c=velocity of light in m/s
```

```
13  tc=10^(-8)//tc=coherence  time  in  seconds
14  y0=650*(10^(-9))//y0=vacuum  wavelength  in  m
15  Y0=(y0^2)/(c*tc)
16  format("e",9)
17  disp("nm",Y0/(10^-9),"Line  width  is  =")//Y0  is
        converted  in  terms  of  nm
18  Lc=c*tc//Lc=coherence  length
19  format("v",5)
20  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 ima

```
1  //scilab  5.4.1
2  //Windows  7  operating  system
3  //chapter  23  Lasers,Fibre  Optics,and  Holography
4  clc
5  clear
6  o=5*10^-5//o=angular  spread  in  radians
7  f=10//f=focal  length  in  cm
8  D=f*o//D=diameter  of  the  image
9  r=(D/2)//r=image  radius
10  format("v",15)
11  disp("cm",r,"The  image  radius  is  =")
12  a=%pi*(r^2)//a=cross  sectional  area  of  the  image  in
        cm^2
13  P=10*10^-3//P=power  in  Watts
14  PD=P/a//PD=power  density
15  format("v",10)
16  disp("W/cm^2",PD,"Power  density  is  =")
17  y=6000*10^-8//y=wavelength  in  cm
18  d=y/o//d=coherent  width
19  disp("cm",d,"The  lateral  coherent  width  is  =")
```

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Scilab code Exa 23.31.8 To find the amount of pumping energy required for transiti

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

Scilab code Exa 23.31.9 To calculate the probability of stimulated emission

```
1  //scilab 5.4.1
2  //Windows 7 operating system
3  //chapter 23 Lasers,Fibre Optics,and Holography
4  clc
5  clear
6  h=6.62*10^-34//h=Planck's constant
7  v=2.4*10^15//v=frequency of emitted radiation in Hz
8  c=3*10^8//c=velocity of light in vacuum in m/s
9  A21=1/(1.66*10^-8)//A21=mean spontaneous life time
10 B21=((c^3)*A21)/(8*%pi*h*(v^3))//B21=probability of
        stimulated emission
11 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 n

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