

Scilab Textbook Companion for
Electronics Fundamentals and Applications
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Book Description

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Scilab numbering policy used in this document and the relation to the above book.

Exa Example (Solved example)

Eqn Equation (Particular equation of the above book)

AP Appendix to Example(Scilab Code that is an Appednix to a particular Example of the above book)

For example, Exa 3.51 means solved example 3.51 of this book. Sec 2.3 means a scilab code whose theory is explained in Section 2.3 of the book.

Contents

List of Scilab Codes	4
1 Basic Ideas Energy Bands In Solids	5
2 Electron Emission from Solid	7
3 PROPERTIES OF SEMICONDUCTORS	11
4 Metal Semiconductor Contacts	17
5 Semiconductor Junction Diodes	21
6 Diode Circuits	30
7 Junction Transistor Characteristics	36
8 Junction Transistors Biasing and Amplification	44
9 Basic Voltage and Power Amplifiers	63
10 Feedback In Amplifiers	71
11 Sinusoidal Oscillators and Multivibrators	76
12 Modulation and Demodulation	81

13 Field Effect Transistors	86
14 Integrated Circuits and Operational Amplifiers	100
15 Active Filters	107
16 Special Devices	112
17 Number Systems Boolean Algebra and Digital Circuits	113
19 VLSI Technology and Circuits	122
20 Cathode Ray Oscilloscope	127
21 Communication Systems	132
23 Lasers Fibre Optics and Holography	135

List of Scilab Codes

Exa 1.7.1	To find the final velocity of electron	5
Exa 1.7.2	To find the velocity and kinetic energy of ion	5
Exa 2.7.1	to calculate the number of electrons emitted per unit area per second	7
Exa 2.7.2	To find the percentage change in emission cur- rent	8
Exa 2.7.3	difference between thermionic work function of the two emitters	8
Exa 2.7.4	to find the anode voltage	9
Exa 3.11.1	To find the conductivity and resistivity . . .	11
Exa 3.11.2	To find Concentration of donor atoms	12
Exa 3.11.4	To find intrinsic conductivity and resistance required	12
Exa 3.11.5	To find the conductivity and current density of doped sample	13
Exa 3.11.6	To find the electron and hole concentration and conductivity of doped sample	14
Exa 3.11.7	To find the required wavelength	15
Exa 3.11.8	To find the magnetic and hall field	15
Exa 4.7.1	to find barrier height and depletion region width and maximum electric field	17
Exa 4.7.2	to find the barrier height and concentration	18
Exa 4.7.3	to calculate barrier lowering and the position of the maximum barrier height	18
Exa 4.7.4	to determine the effective richardson constant	19
Exa 4.7.5	to calculate current in a Schottky diode . .	19
Exa 5.7.1	To find the voltage to be applied across the junction	21

Exa 5.7.2	To calculate the ratio of current for forward bias to that of reverse bias	22
Exa 5.7.3	To determine the static and dynamic resistance of the diode	22
Exa 5.7.4	To calculate the increase in the bias voltage	23
Exa 5.7.5	To find the bias voltage of pn junction diode	23
Exa 5.7.6	To calculate the rise in temperature	24
Exa 5.7.7	To calculate the maximum permissible battery voltage	25
Exa 5.7.8	To calculate series resistance and the range over which load resistance can be varied . .	25
Exa 5.7.9	To determine the limits between which the supply voltage can vary	26
Exa 5.7.10	To find whether power dissipated exceeds the maximum power limit	27
Exa 5.7.11	To determine the range of variation of the output voltage	28
Exa 5.7.12	To find the value of resistance R	29
Exa 6.11.1	To find various currents voltages power conversion efficiency and percentage regulation	30
Exa 6.11.2	To find various currents power ripple voltage percentage regulation and efficiency of rectification	31
Exa 6.11.3	To calculate the dc load voltage ripple voltage and the percentage regulation	32
Exa 6.11.4	To calculate ripple voltage and the percentage ripple	33
Exa 6.11.5	To design a full wave rectifier with L type LC filter	34
Exa 7.13.1	To find the voltage gain and power gain of a transistor	36
Exa 7.13.2	To find the base and collector current of a given transistor	37
Exa 7.13.3	To calculate the emitter and collector current of a given transistor	37
Exa 7.13.4	To calculate the voltage between collector and emitter terminals	38

Exa 7.13.5	To check what happens if resistance R_c is indefinitely increased	39
Exa 7.13.6	To check whether transistor is operating in the saturation region for the given h_{FE} . . .	40
Exa 7.13.7	To calculate the output resistance along with the current gain	41
Exa 7.13.8	To find the resistance R_1 R_2 and the range of R_L	42
Exa 8.14.1	To find the Q point and stability factors . . .	44
Exa 8.14.2	To find the resistances R_1 R_2 and R_e	45
Exa 8.14.3	To calculate the input and output resistances and current voltage and power gain	46
Exa 8.14.4	To find the input and output resistance . . .	47
Exa 8.14.5	To find the current amplification and voltage and power gains	48
Exa 8.14.6	To determine the current and voltage gain as well as the input and output resistances . . .	49
Exa 8.14.7	To determine the input and output resistances as well as the voltage gain and Q point	50
Exa 8.14.8	To design a CE transistor amplifier	51
Exa 8.14.9	To find the resistance R_1	54
Exa 8.14.10	To find the quiescent values of I_E and V_{CE}	55
Exa 8.14.11	To calculate the quiescent values of I_B I_C I_E and V_{CE}	56
Exa 8.14.12	To determine the operating point	58
Exa 8.14.13	To determine the operating point	59
Exa 8.14.14	To determine the ac as well as dc load line and the amplitude of the output voltage . . .	60
Exa 9.12.1	To determine the lower and upper half power frequencies	63
Exa 9.12.2	To determine the lower and upper half power frequencies	64
Exa 9.12.3	To find the gain relative to the mid frequency gain	65
Exa 9.12.4	To calculate the output power	66
Exa 9.12.5	To calculate dc input and ac output power along with the collector dissipation and the efficiency	67

Exa 9.12.6	To determine the maximum dc power and the maximum output power along with the efficiency	67
Exa 9.12.7	To calculate the resonant frequency along with the bandwidth and the maximum voltage gain	68
Exa 9.12.8	To find out the decibel change in the output power level	69
Exa 9.12.9	To find the rms output voltage and rms input voltage along with the output power in the midband region	70
Exa 10.7.1	To find the voltage gain with feedback the amount of feedback in dB the output voltage of the feedback amplifier the feedback factor the feedback voltage	71
Exa 10.7.2	To find the minimum value of the feedback ratio and the open loop gain	72
Exa 10.7.3	To find the reverse transmission factor	72
Exa 10.7.4	To find voltages current and power dissipation of a given transistor circuit	73
Exa 10.7.5	To calculate the voltage gain and input output resistances	74
Exa 11.12.1	To calculate the frequency of oscillation and mutual inductance	76
Exa 11.12.2	To find the values of the inductances	77
Exa 11.12.3	To calculate the frequency of oscillation	78
Exa 11.12.4	To determine the frequency of oscillation	78
Exa 11.12.5	To find the resistances needed to span the frequency range and to find the ratio of the resistances	79
Exa 11.12.6	To find the quality factor of the crystal	80
Exa 12.9.1	To find the percentage modulation and the amplitude of the unmodulated carrier	81
Exa 12.9.2	To find the frequency span of each sideband and maximum upper and minimum lower side frequency along with the channelwidth	82
Exa 12.9.3	To calculate the power developed by an AM wave	82
Exa 12.9.4	To determine the necessary audio power	83

Exa 12.9.5	To find the modulation index three pairs of side frequency and the channelwidth	83
Exa 12.9.6	To find the highest modulation frequency . . .	84
Exa 12.9.7	To find the depth of modulation and the total radiated power	85
Exa 13.16.1	To find the pinch off voltage and the saturation voltage	86
Exa 13.16.2	To find the resistance RS	87
Exa 13.16.3	To find the transconductance of the FET along with the amplification factor	87
Exa 13.16.4	To calculate the voltage gain and the output resistance	88
Exa 13.16.5	To find the drain current and the pinch off voltage	88
Exa 13.16.6	To determine drain current along with drain source voltage along with gate source voltage	89
Exa 13.16.7	To calculate the drain current	91
Exa 13.16.8	To find the saturation drain current and the minimum value of drain source voltage	92
Exa 13.16.9	To determine gate source voltage and the transconductance	93
Exa 13.16.10	To find the gate source voltage	94
Exa 13.16.11	To calculate Rs and the channel resistance . .	94
Exa 13.16.12	To find the saturation drain current	95
Exa 13.16.13	To calculate drain current along with gate source voltage and drain source voltage	96
Exa 13.16.14	To calculate K along with drain current and drain source voltage	96
Exa 13.16.15	To calculate the voltage gain and the output resistance	97
Exa 13.16.16	To find the small signal voltage gain	98
Exa 14.12.1	To determine the output voltage along with input resistance and the input current	100
Exa 14.12.2	To calculate the voltage gain	101
Exa 14.12.3	To calculate the voltage gains for difference and common mode signals along with CMRR	101
Exa 14.12.4	To find the output voltage of the three input summing amplifier	102

Exa 14.12.5	To find the voltage gain along with the output voltage	103
Exa 14.12.6	To find the output voltage of the differentiator	104
Exa 14.12.8	To calculate the output voltage	105
Exa 14.12.9	To find the differential mode gain	106
Exa 15.7.1	To design a Butterworth low pass filter . . .	107
Exa 15.7.2	To design a first order Butterworth active High Pass filter	108
Exa 15.7.3	To design a second order band pass Butterworth filter	109
Exa 15.7.4	To design a notch filter	110
Exa 16.10.1	To determine the time period of the sawtooth voltage across capacitor C	112
Exa 17.17.1	To determine the binary equivalents	113
Exa 17.17.2	To determine the decimal equivalent	113
Exa 17.17.3	To convert from binary system to decimal system	114
Exa 17.17.4	To convert from decimal system to binary system	115
Exa 17.17.5	To find the equivalent of given number in a code base 5	116
Exa 17.17.6	To perform binary addition corresponding to decimal addition	117
Exa 17.17.7	To perform binary addition and also to show the corresponding decimal addition	117
Exa 17.17.8	To perform the binary subtraction	118
Exa 17.17.9	To obtain the output levels of a silicon transistor for given input levels and to show that circuit has performed NOT operation using positive logic	118
Exa 17.17.10	To solve the Boolean expression	120
Exa 19.29.1	To find the value of inverse of aspect ratio along with power dissipated and load resistance	122
Exa 19.29.2	To find the pull up and pull down aspect ratio	123
Exa 19.29.3	To find the value of inverse of aspect ratio of the PMOS transistor for a symmetrical inverter	123

Exa 19.29.4	To determine the maximum permissible number of fan outs	124
Exa 19.29.5	To calculate the channel transit time	125
Exa 19.29.6	To calculate the required metal line width	125
Exa 20.9.1	To determine the transit time along with transverse acceleration and spot deflection	127
Exa 20.9.2	To calculate the highest frequency of the deflecting voltage	128
Exa 20.9.3	To find the deflection of the spot and the magnetic deflection sensitivity	129
Exa 20.9.4	To calculate the frequency of the signal	129
Exa 20.9.5	To find the frequency of the vertical signal	130
Exa 20.9.6	To find the phase difference between the voltages	131
Exa 21.13.1	To calculate the critical frequencies and the maximum frequencies	132
Exa 21.13.2	To find the maximum distance between the transmitting and receiving points	133
Exa 21.13.3	To find the height of the point above the ground from which the wave is reflected back	134
Exa 23.31.1	To calculate the number of photons emitted per second	135
Exa 23.31.2	To calculate the coherence time and the longitudinal coherence length	136
Exa 23.31.3	To calculate the minimum difference between two arms of a Michelson interferometer	136
Exa 23.31.4	To show that emission for a normal optical source is predominantly due to spontaneous transitions	137
Exa 23.31.5	To determine coherence time and the coherence length	138
Exa 23.31.6	To find the line width and the coherence length	138
Exa 23.31.7	To find the radius along with the power density of the image and the coherence length	139
Exa 23.31.8	To find the amount of pumping energy required for transition from 3s to 2p	140
Exa 23.31.9	To calculate the probability of stimulated emission	140

Exa 23.31.10 To calculate the NA and the acceptance angle
along with number of reflections per metre . 141

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

```
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 concentration
    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*1016; //Intrinsic carrier concentration
    per m3
11 yn=0.13; //Electron mobility in m2/(V*s)
12 yp=0.05; //Hole mobility in m2/(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 m2
16
17 //Required Formula
18 Gi=e*ni*(yn+yp); //Intrinsic conductivity
19
20 Ri=1/(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 sample

```

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=conductiarrrier 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 conductivity

```

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
```

```

    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

```

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(104)
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 voltages in 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)*103//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


```

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)=rise in
    temperature in degree celcius
15 disp("C",a,"T2-T1")

```

Scilab code Exa 5.7.7 To calculate the maximum permissible battery voltage

```

1
2 //scilab 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 resistance in ohm
9 P=200*(10^-3)//P=maximum power in Watt
10 //P=(i^2)*r where i=maximum safe 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 //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 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 Vomn=(rZ*Izmin)+Vzo//Vomn=corresponding minimum
    output voltage
15 disp("V",Vomn,"Vomn=")
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=")

```

```
20 disp("Output voltage Vo varies in the range Vom in 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 I1=5*10^(-3)//I1=load current
10 Vz=7//Vz=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+I1//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; //Percentage regulation
39 format("v",5)
40 disp('%',s,'Percentage 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
    centre 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 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=0.975; //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*103, '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 R_c 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 transistor 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, VBC 0 ,
    i.e.")
27 disp("RL (7.3/2) kilo ohm")
28 disp("RL 3.65 kilo ohm")
29 disp("So the range of RL for Q1 to remain in the
    active region is 0 RL 3.65 kilo ohm")
```

Chapter 8

Junction Transistors Biasing and Amplification

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

```
1
2 //scilab 5.4.1
3 //windows 7 operating system
4 //chapter 8:Junction Transistors:Biassing 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*R1/(R1+Rb));          //stabilty factor 1
23 disp(S,'S=');
24 S1=b/(Rb+R1*(1+b));          //stabilty factor 2 in A/V
25 disp('A/V',S1,'S1=');
26 S2=(Vcc-Vbe-(Ic*R1))/(Rb+R1*(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 R1=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*R1))/(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:Biassing 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 R1=6*10^3;       //Load resistance in ohms
13
14 AI=-hfb/(1+(hob*R1));           //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 gain.

```

1
2 //scilab 5.4.1
3 //windows 7 operating system
4 //chapter 8:Junction Transistors:Biassing 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:Biassing 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",R1/10^3,"The output resistance of
      the transistor including RL is =.")

```

Scilab code Exa 8.14.7 To determine the input and output resistances as well as the

```

1
2 //scilab 5.4.1
3 //windows 7 operating system
4 //chapter 8:Junction Transistors:Biassing 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")

```

```

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:Biassing 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,"The DC collector current is =")
25 Pr=(IC2)*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=(IC2)*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=(VBG2)/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 Kirchoff'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 Kirchoff'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 Kirchoff's voltage law to the base
    circuit
18 //  $(I_B * (R_T + R_e)) + (I_C * R_e) = V_T - V_{BE}$ 
19 //  $I_C = \beta * I_B$ 
20  $I_B = (V_T - V_{BE}) / (R_T + R_e + (\beta * R_e))$  //  $I_B =$  base current
21  $I_C = \beta * I_B$  //  $I_C =$  collector current
22 format("v" ,8)
23 //Applying Kirchoff's voltage law to the collector
    circuit
24 //  $(I_C * (R_L + R_e)) + (I_B * R_e) + V_{CE} = V_{CC}$ 
25  $V_{CE} = V_{CC} - ((I_C * (R_L + R_e)) + (I_B * R_e))$  //  $V_{CE} =$  collector
    emitter voltage
26 format("v" ,5)
27 disp("The operating point is specified by")
28 disp("mA" ,  $I_C$  , "IC=")
29 disp("V" ,  $V_{CE}$  , "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",0," 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

```
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

```
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

```

```

    V from some standard voltage Vr
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 feedback

```
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 open loop gain

```
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
```

```

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/103,"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/106,"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 upper

```
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

```
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

```
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")

```

Scilab code Exa 13.16.7 To calculate the drain current

```
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 resistance

```
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 current 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= $|A(j\omega)/A_o|$ 
9 f=10*1000//f=given frequency in Hz where the
   normalized gain is dropped by given amount
10 // $|A(j\omega)/A_o|=(-20)*n*\log_{10}(\omega/\omega_c)$  where n=order of
   the filter
11 // $|A(j\omega)/A_o|=(-20)*n*\log_{10}(f/f_c)$ 
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 across

```
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*1010;
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

```

```

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 addition

```

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

```

```

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  $i_B(\text{min})=i_C/hFE$ 
22  $i_C=(VCC-VCE)/RL$ //collector current when the
   transistor saturates
23  $i_B=i_C/hFE$ // $i_B(\text{min})$ =minimum base current for
   saturation in mA
24  $i_1=(10-VBE)/R1$ // $i_1$ =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(1," 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(11," 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 C1=1*10^-12//C1=load capacitance in Farad
9 P=50*10^-3//P=maximum power dissipation capability
  in W/stage
10 N=P/(f*C1*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 current 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 acceleration

```
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 transverse 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=(1*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=1/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 frequency

```
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 which

```

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 coherence

```
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 predom

```

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=(y02)/(c*tc)
16 format("e",9)
17 disp("nm",Y0/(10-9),"Line width is =")//Y0 is
    converted in terms of mm
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*(r2)//a=cross sectional area of the image in
    cm2
13 P=10*10-3//P=power in Watts
14 PD=P/a//PD=power density
15 format("v",10)
16 disp("W/cm2",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 =")

```

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

```
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 =")
```
