Scilab Textbook Companion for Basic Electronics by S. Biswas[1]

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Book Description

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

Exa Example (Solved example)

Eqn Equation (Particular equation of the above book)

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

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

Contents

List of Scilab Codes

Chapter 1

Introduction to Electronics

Scilab code Exa 1.1 Colour coding of resistors

```
//Tested on Windows 7 Ultimate 32-bit
//Chapter 1 Introduction to Electronics Pg no. 8
clear;
clc;

//Given Data

//Colour coding of four band resistor
//Given Sequence: [Gray Red Red Gold]
gray=8;
red=2;
gold=0.05;

//Solution

R=(gray*10+red)*(10^(red));//Base resistance in ohms
R_min=R*(1-0.05);//Least possible resistance in ohms
    using variance
R_max=R*(1+0.05);//Most possible resistance in ohms
    using variance

```

```
printf("Resistance should be in between %d ohms and
    %d ohms",R_min,R_max);
//Error in textbook as 5% of 8200 is 410 and not 41
```

Scilab code Exa 1.2 Colour coding of resistors

```
//Tested on Windows 7 Ultimate 32-bit
//Chapter 1 Introduction to Electronics Pg no. 9
clear;
clc;

//Given Data

//Colour coding of four band resistor
//Given Sequence: [Orange Orange Yellow Silver]
orange=3;
yellow=4;
silver=0.1;

//Solution

R=(orange*10+orange)*(10^(yellow));//Base resistance
    in ohms
R_min=R*(1-silver);//Least possible resistance in
    ohms using variance
R_max=R*(1+silver);//Most possible resistance in
    ohms using variance

printf("Resistance should be in between %d ohms and
    %d ohms",R_min,R_max);
//Error in textbook as 330K is not 33000 and is
    330000
```

Scilab code Exa 1.3 Colour coding of resistors

```
//Tested on Windows 7 Ultimate 32-bit
//Chapter 1 Introduction to Electronics Pg no. 9
clear;
clc;

//Given Data

//Colour coding of five band resistor
//Given Sequence: [Yellow Gray Violet Black Green]
yellow=4;
gray=8;
violet=7;
black=0;
green=0.005;

//Solution

R=(yellow*100+gray*10+violet)*(10^(black));//Base resistance in ohms
R_min=R*(1-green);//Least possible resistance in ohms using variance
R_max=R*(1+green);//Most possible resistance in ohms using variance

printf("Resistance should be in between %.2f ohms and %.2f ohms",R_min,R_max);//Upto 2 decimal points
//Decimal approximation error w.r.t. textbook
```

Scilab code Exa 1.4 Calculation of Parallel Plate Capacitance

```
//Tested on Windows 7 Ultimate 32-bit
//Chapter 1 Introduction to Electronics Pg no. 12
```

```
clear;
clc;

//Given Data

area=1;//meter squares
d=0.25;//distance between plates in centimeters
e=8.85D-12;//permittivity of air

//Solution

d=d*10^-2;//converting distance into meters
C=e*area/d;//Capacitance in Farads
C=C*10^12;//Coverting capacitance to pF from F
printf("C= %d pF\n",C);
printf("The capacitor can thus store a charge of %d
    *10^-12 C with 1 Volt.",C);
```

Scilab code Exa 1.6 Colour coding of Tantalum Capacitors

```
//Tested on Windows 7 Ultimate 32-bit
//Chapter 1 Introduction to Electronics Pg no. 17
clear;
clc;

//Given Data
//Fig. 1.16

//Solution
blue=6;
gray=8;
violet=50;
gold=0.05;

C=(blue*10+gray)*10^blue*10^-12;//Capacitance in
```

```
   Farads
C=C*10^6;//Converting from Farads to micro Farads

printf("The value of capacitance is %d uF \n and
   voltage rating is %d volts and tolerance of  %d
   percent.",C,violet,gold*100);
```

Scilab code Exa 1.7 Calculation of Output Voltage of an Amplifier equivalent circuit

```
//Tested on Windows 7 Ultimate 32-bit
//Chapter 1 Introduction to Electronics Pg no. 29
clear;
clc;

//Given Data
//Fig 1.33
vi=6D-3;//input volatage in volts
Rin=1200;//input resistance in ohms
Ai=100;//current gain
Ro=25000;//output resistance in ohms
Rl=1000;//load impedance

//Solution

is=vi/Rin;//Input current
i2=Ai*is;//Output circuit current source value
iL=i2*(Ro/(Ro+Rl));//Current divider to  find load
   current
Vout=iL*Rl;

printf("The output voltage is Vout=%.2f V",Vout);//
   Displaying upto 2 places of decimal
```

Scilab code Exa 1.8 Calculation of maximum current capacity

```
//Tested on Windows 7 Ultimate 32-bit
//Chapter 1 Introduction to Electronics Pg no. 33
//Solved Problem 1
clear;
clc;

//Given Data

wattage=100;//wattage in watts
voltage=220;//voltage in volts

//Solution

I=wattage/voltage;//current in amperes

printf("I=%.3f Amp.",I);//Displaying upto 3 places
    of decimal
//Error due to decimal approximations
```

Scilab code Exa 1.9 Calculation of Power in a Resistor

```
//Tested on Windows 7 Ultimate 32-bit
//Chapter 1 Introduction to Electronics Pg no. 33
//Solved Problem 2
clear;
clc;

//Given Data

I=6;//current in amperes
```

```
R=36;//resistance in ohms

//Solution

P=I^2*R;//power in watts

printf("P=%d W.",P);
```

Scilab code Exa 1.10 Calculation of Current rating of Resistor

```
//Tested on Windows 7 Ultimate 32-bit
//Chapter 1 Introduction to Electronics Pg no. 33
//Solved Problem 3
clear;
clc;

//Given Data

R=120;//resistance in ohms
P=1000;//power in watts

//Solution

I=sqrt(P/R);//current in amperes

printf("I=%.2f Amperes.",I);//Displaying upto 2 places of decimal
```

Scilab code Exa 1.11 Calculation of Current rating of Resistor

```
//Tested on Windows 7 Ultimate 32-bit
//Chapter 1 Introduction to Electronics Pg no. 33
//Solved Problem 4
```

```
clear;
clc;

//Given Data

R=10;//resistance in ohms
P=4;//power in watts

//Solution

I=sqrt(P/R);//current in amperes

printf("Maximum safe current is I=%.3f Amperes.",I);
   //Displaying upto 3 places of decimal
```

Scilab code Exa 1.12 Potentiometer for Motor Speed Control

```
//Tested on Windows 7 Ultimate 32-bit
//Chapter 1 Introduction to Electronics Pg no. 33
   and 34
//Solved Problem 5
clear;
clc;

//Given Data
//Figure 1.34

Rm=2;//resistance of motor in ohms
V=10;//battery voltage in volts
Rpot=10;//maximum resistance of potentiometer in
   ohms
Ppot=100;//maximum power rating of potentiometer in
   watts

//Solution
```

```

Ipot=sqrt(Ppot/(Rpot+Rm));//maximum safe current possible through potentiometer in amperes
printf("Current rating of potentiometer I = %.2f Amps\n\n",Ipot);

Rp=10;//Resistance of potentiometer set in ohms
I10=V/(Rp+Rm);//Current for corresponding resistance of potentiometer

printf("When the potentiometer is set to %d Ohms,\nthe total resistance of the circuit is %d ohms.\n",Rp,Rp+Rm);
printf("I = %.1f Amps\n",I10);

if(I10<Ipot)
    printf("\nThe amount of current is less than %.2f Amps and the potentiometer is safe.\n\n",Ipot);
end


Rp=2;//Resistance of potentiometer set in ohms
I2=V/(Rp+Rm);//Current for corresponding resistance of potentiometer

printf("When the potentiometer is set to %d Ohms,\nthe total resistance of the circuit is %d ohms\n",Rp,Rp+Rm);
printf("I = %.1f Amps\n",I2);

if(I10<Ipot)
    printf("\nThe amount of current is less than %.2f Amps and the potentiometer is safe \n",Ipot);
end

Rp=1;//Resistance of potentiometer set in ohms
```

```
I3=V/(Rp+Rm);//Current for corresponding resistance
    of potentiometer

printf("\n However when potentiometer resistance is
    %d ohms,  I= %d/%d = %.1f Amp.\nThis is greater
    than %.2f Amperes.\nThe potentiometer wire will
    get heated and temperature will rise.\nFor still
    lower values of potentiometer setting,\nI will be
     still higher and the potentiometer will be
    damaged.\nIt may even burn out.",Rp,V,(Rp+Rm),I3,
    Ipot)
```

Chapter 2

Fundamental Concepts Energy Bands in Solids

Scilab code Exa 2.1 KE PE and Total Energy of Electron

```
//Tested on Windows 7 Ultimate 32-bit
//Chapter 2 Fundamental Concepts: Energy Bands in
   Solids Pg no. 49
clear;
clc;

//Given Data
m0=9.1D-31;//mass of electron in kg
e=1.602D-19;//charge on a electron in Coulombs
e0=8.854D-12;//electric permittivity of air
h=6.625D-34;//planck's constant in Joules-sec
n=2;//index of the Bohr orbit

//Solution

KE=(m0*e^4)/(8*e0^2*n^2*h^2);//Kinetic Energy  of
   electron in Joules
KE=KE/(1.6D-19);//Converting it into electron volts
   eV
```

```

PE=-(m0*e^4)/(4*e0^2*n^2*h^2);//Potential Energy of electron in Joules
PE=PE/(1.6D-19);//Converting it into electron volts eV

TE=KE+PE;//Total energy is the sum of kinetic and potential energy of electron

printf("Kinetic Energy=%.1f eV \n Potential Energy=%.1f eV \n Total Energy=%.1f eV",KE,PE,TE);
```

Scilab code Exa 2.2 Total electrons in K L M shells

```
//Tested on Windows 7 Ultimate 32-bit
//Chapter 2 Fundamental Concepts: Energy Bands in Solids Pg no. 49
clear;
clc;

printf("According to Paulis principle no two electrons can possess same set of values for four quantum numbers.\n\n");
printf("Total electrons that can reside in eacvh shell is as follows\n");
printf("K shell: \n n=1,l=0,m=0,s= 1/2 \t\t\t 2 electrons Subshell:1s\n");
printf("\t\t\t\t   Total:2 electrons\n");
printf("L shell: \n n=2,l=0,m=0,s= 1/2 \t\t\t 2 electrons Subshell:2s\n");
printf(" n=2,l=1,m=-1,0,+1,s= 1/2 \t\t 6 electrons Subshell:2p\n");
printf("\t\t\t\t   Total:8 electrons\n");
printf("M shell: \n n=3,l=0,m=0,s= 1/2 \t\t\t 2 electrons Subshell:3s\n");
```

```
printf(" n=3,l=1,m=-1,0,+1,s= 1/2\t\t 6 electrons Subshell:3p\n");
printf(" n=3,l=2,m=-2,-1,0,+1,+2,s= 1/2 \t 10 electrons Subshell:3d\n");
printf("\t\t\t\t   Total:18 electrons\n");
```

Scilab code Exa 2.3 Calculation of KE and velocity of electron

```
//Tested on Windows 7 Ultimate 32-bit
//Chapter 2 Fundamental Concepts: Energy Bands in Solids Pg no. 50
clear;
clc;

//Given Data
m0=9.1D-31;//mass of electron in kg
e=1.602D-19;//charge on a electron in Coulombs
V1=100;//Accelerating potential difference in volts for case (i)
V2=500;//Accelerating potential difference in volts for case (ii)

//Solution
disp('case (i)')

KE1=e*V1;//Kinetic Energy  of electron in Joules
KE2=KE1/(1.6D-19);//Converting it into electron volts eV
v=sqrt(2*KE1/m0);//Velocity of electron in meters per second

printf("The Kinetic energy for V=%d volts is \n",V1);
printf("K.E.=%.3e Joules \nK.E.=%d eV\n",KE1,KE2);
printf("The corresponding velocity is %.2e m/sec\n",
```

```
    v);

disp('case (ii)')

KE1=e*V2;//Kinetic Energy  of electron in Joules
KE2=KE1/(1.6D-19);//Converting it into electron
    volts eV
v=sqrt(2*KE1/m0);//Velocity of electron in meters
    per second

printf("The Kinetic energy for V=%d volts is \n",V1)
    ;
printf("K.E.=%.3e Joules \nK.E.=%d eV\n",KE1,KE2);
printf("The corresponding velocity is %.2e m/sec\n",
    v);

//Decimal errors with respect to textbook due to
    approximations
```

Scilab code Exa 2.4 Calculation of KE and velocity of positively charged particle

```
//Tested on Windows 7 Ultimate 32-bit
//Chapter 2 Fundamental Concepts: Energy Bands in
    Solids Pg no. 50
clear;
clc;

//Given Data
m0=9.1D-31;//mass of electron in kg
e=1.602D-19;//charge on a electron in Coulombs
V=5000;//Accelerating potential difference in volts
    for case (ii)
m=3674*m0;//mass of positively charged particle in
    kg;
```

```
q=2*e;//charge of positively charged particle in
    Coulombs;


//Solution


KE1=q*V;//Kinetic Energy  of positively charged
    particle in Joules
KE2=KE1/(1.6D-19);//Converting it into electron
    volts eV

v=sqrt(2*KE1/m);//Velocity of positively charged
    particle in meters per second
v=v/1000;//Converting it into kilometers per second

printf("The Kinetic energy is %d eV\n",KE2);
printf("The corresponding velocity is %d km/sec\n",v
    );

//Error in kinetic energy due to approximations of
    decimals in textbook
```

Scilab code Exa 2.5 Calculation of mass of electron

```
//Tested on Windows 7 Ultimate 32-bit
//Chapter 2 Fundamental Concepts: Energy Bands in
    Solids Pg no. 50 and 51
clear;
clc;

//Given Data
m0=9.1D-31;//mass of electron in kg
v_to_c_ratio=0.2;

```

```
//Solution

m=m0/sqrt(1-v_to_c_ratio^2);//mass of electron in kg

printf("Mass of electron for v=0.2c is equal to m=%
    .2e kg",m);
```

Scilab code Exa 2.6 Determination of Balmer series for hydrogen atom

```
//Tested on Windows 7 Ultimate 32-bit
//Chapter 2 Fundamental Concepts: Energy Bands in
    Solids Pg no. 51
clear;
clc;

//Given Data

n=2;//orbit for Balmer series
h=6.625D-34;//planck's constant in Joules-sec
c=3D8;//speed of light in meter per second

//Solution

for k=3:6
    hf=-13.6*(1/(k^2)-1/(2^2));//radiated energy in
        eV
    hf2=hf*1.6D-19;//converting from eV to Joules
    f=hf2/h;//frequency of emitted radiation in Hz
    l=c/f;//wavelength of emitted radiation in
        meters
    u=l*10^6;//converting wavelength into micro
        meter
    A=l*10^10;//converting wavelength into angstroms

    printf("n=%d,hf%d2=%.2f eV,   =%.3f   m = %d     \
```

```
       n",k,k,hf,u,A);
end

hf=-13.6*(0-1/(2^2));//as k tends to infinity 1/k
   tends to zero
hf2=hf*1.6D-19;//converting from eV to Joules
f=hf2/h;//frequency of emitted radiation in Hz
l=c/f;//wavelength of emitted radiation in meters
u=l*10^6;//converting wavelength into micro meter
A=l*10^10;//converting wavelength into angstroms

    printf("n=    , hf  2 =%.2f eV,  =%.3f   m  = %d
          \n",hf,u,A);


//Errors with respect to book due to decimal
   approximations
```

Chapter 3

Semiconductor Diodes and Miscellaneous Devices

Scilab code Exa 3.1 Calculation of output voltage for half wave transformer rectifier

```
//Tested on Windows 7 Ultimate 32-bit
//Chapter 3 Semiconductor Diodes and Miscellaneous
   Devices Pg no. 71
clear;
clc;

//Given Data

//Figure 3.14
e1=4;//Relative emf of primary side
e2=1;//Relative emf of secondary side
vinp=220;//Input peak voltage in volts
Vd=0.7;//Forward voltage drop of diode

//Solution

tr=e2/e1;//turns ratio n2/n1
V2=tr*vinp;//as v2/v1=n2/n1
```

```
Voutp=V2-Vd;//Vout across Rl in volts

printf("The peak value of rectified output voltage
    is:\n(Vout)peak=%.1f V",Voutp);
```

Scilab code Exa 3.2 Calculation of important quantities for half wave rectifier

```
//Tested on Windows 7 Ultimate 32-bit
//Chapter 3 Semiconductor Diodes and Miscellaneous
    Devices Pg no. 89
clear;
clc;

//Given Data

r=1.0;//Diode resistance in ohms
Rl=100;//Load resistance in ohms
Ep=30;//Input supply voltage in volts peak

//Solution

disp("(a)");
Ip=Ep/(Rl+r)*1000;//peak current in milli-amperes
Irms=Ip/sqrt(2);//rms current in milli-amperes
Iavg=Ip/%pi;//average or d.c. value of current in in
     milli-amperes

printf("The peak value of current = Ip=%d mA\n",Ip);
printf("The rms value of current = Irms=%.1f mA\n",
    Irms);
printf("The average or d.c. value of current = Iav=%
    .1f mA\n",Iavg);

disp("(b)");
```

```
Pdc=(Iavg/1000)^2*Rl//d.c. output power in watts

printf("The d.c. output power = Pdc=%.3f watts\n",Pdc);

disp("(c)");
Pac=(Irms/1000)^2*(Rl+r);//input ac power in watts

printf("The a.c. input power = Pin=%.2f watts\n",Pac);

disp("(d)");
n=Pdc/Pac;//Rectification efficiency is output dc power over input ac power

printf("Rectification efficiency= %d percentage",n*100);


//Error in textbook as Irms=Ip/sqrt(2) and not Ip/2
```

Scilab code Exa 3.3 Calculation of important quantities for center tapped full wave rectifier

```
//Tested on Windows 7 Ultimate 32-bit
//Chapter 3 Semiconductor Diodes and Miscellaneous Devices Pg no. 89
clear;
clc;

//Given Data

Rl=470;//Load resistance in ohms
r=2;//Diodes dynamic resistance in ohms
esp=50;//Input signal voltage magnitude in volts
```

```
peak
esf=314/(2*%pi);//Input signal frequncy in hertz

//Solution

disp("(a)");
Ep=esp*sqrt(2);//peak voltage in volts
Ip=Ep/(Rl+r)*1000;//peak current in amperes

printf("The peak value of current = Ip=%.1f mA\n",Ip*1000);

disp("(b)");
Iavg=2*Ip/%pi;//average or d.c. value of current in in milli-amperes

printf("The average or d.c. value of current = Iav=%.2f mA\n",Iavg);

disp("(c)");
Irms=Ip/sqrt(2);//rms current in milli-amperes

printf("The rms value of current = Irms=%.2f mA\n",Irms);

disp("(d)");
RF=sqrt((Irms/Iavg)^2-1);//ripple factor

printf("The ripple factor = RF=%.4f\n",RF);

disp("(e)");
Pdc=(Iavg/1000)^2*Rl//d.c. output power in watts
Pac=(Irms/1000)^2*(Rl+r);//input ac power in watts
n=Pdc/Pac;//Rectification efficiency is output dc power over input ac power

printf("Rectification efficiency= %.2f percentage",n*100);
```

```
//Efficiency calculation error in textbook and also
   decimal errors due to approximations
```

Scilab code Exa 3.4 Calculation of capacitance for half wave rectifier with shunt capacitance filter

```
//Tested on Windows 7 Ultimate 32-bit
//Chapter 3 Semiconductor Diodes and Miscellaneous
   Devices Pg no. 90
clear;
clc;

//Given Data

Rl=2D3;//Load resistance in ohms
esp=50;//Input signal voltage magnitude in volts
   peak
esf=314/(2*%pi);//Input signal frequncy in hertz
Vr_to_Vdc=6/100;//Ratio of peak to peak ripple
   voltage to d.c. output voltage

//Solution

//Using figure E3.4
//From right angled triangle pqr

C=1/(esf*Rl*Vr_to_Vdc)*10^6;//Capacitance in micro
   faraday;

printf("The size of filter capacitor is C = %.1f   F
   ",C);

//Decimal errors in textbook due to approximations
```

Scilab code Exa 3.5 Calculation of output power in filter capacitor connected full wave rectifier

```
//Tested on Windows 7 Ultimate 32-bit
//Chapter 3 Semiconductor Diodes and Miscellaneous
    Devices Pg no. 90 and 91
clear;
clc;

//Given Data
//Taken as in Example 3.4
esp=50;//Input signal voltage magnitude in volts
    peak
esf=314/(2*%pi);//Input signal frequncy in hertz
Vr_to_Vdc=6/100;//Ratio of peak to peak ripple
    voltage to d.c. output voltage

//Solution

//Using figure E3.5

e0av=esp*(1-Vr_to_Vdc/2);//average value of d.c.
    output voltage in volts
printf("The average value of d.c. output voltage
    e0av = %.1f Volts",e0av);
```

Scilab code Exa 3.6 Calculation of ripple factor for full wave rectifier

```
//Tested on Windows 7 Ultimate 32-bit
//Chapter 3 Semiconductor Diodes and Miscellaneous
    Devices Pg no. 91
clear;
```

```
clc;

//Given Data

Rl=1D3;//Load resistance in ohms
esf=50;//Input signal frequncy in hertz
RF=4/100;//Ripple Factor

//Solution

//Using figure E3.6
//From right angled triangle pqr

C=1/(esf*Rl*2*RF)*10^6;//Capacitance in micro faraday;

printf("The size of filter capacitor is C = %d  F",C);

//Error in textbook as ripple factor is already given and capacitance is calculated
```

Scilab code Exa 3.7 Calculation of capacitance for full wave rectifier with shunt capacitance filter

```
//Tested on Windows 7 Ultimate 32-bit
//Chapter 3 Semiconductor Diodes and Miscellaneous Devices Pg no. 91
clear;
clc;

//Given Data

Rl=200;//Load resistance in ohms
esf=50;//Input signal frequncy in hertz
```

```
RF=5/100;//Ripple Factor

//Solution

C=1/(esf*Rl*2*RF)*10^6;//Capacitance in micro
    faraday;

printf("The size of shunt capacitor is C = %d  F",C
    );
```

Scilab code Exa 3.8 Calculation of turns ratio of a full wave rectifier with transformer

```
//Tested on Windows 7 Ultimate 32-bit
//Chapter 3 Semiconductor Diodes and Miscellaneous
    Devices Pg no. 91 and 92
clear;
clc;

//Given Data

Rl=220;//Load resistance in ohms
r=4;//Diodes dynamic resistance in ohms
esp=50*sqrt(2);//Input signal voltage magnitude in
    volts peak
esf=314/(2*%pi);//Input signal frequncy in hertz
Vdc=30;//output dc voltage in volts

//Solution

ne0dc=2*esp/%pi;//output dc voltage multiplied by
    turns ratio
i0dc=30/(2/%pi)/220;//output dc current
Vd=r*i0dc;//voltage across conducting diode
eout=i0dc*Rl;//output voltage across Rl
```

```
e0dc=(eout+Vd)*2/%pi;//output dc voltage of
    transformer
n=ne0dc/e0dc;//transformer ratio
printf("The transformer turns ratio = n = %.3f",n);

//Error in decimal places in textbook due to
    approximations
```

Scilab code Exa 3.9 Calculation of output voltages and regulation for a bridge rectifier

```
//Tested on Windows 7 Ultimate 32-bit
//Chapter 3 Semiconductor Diodes and Miscellaneous
    Devices Pg no. 92 and 93
clear;
clc;

//Given Data

Rl=1500;//Load resistance in ohms
Rf=10;//Diodes dynamic resistance in ohms
esp=110*sqrt(2);//Input signal voltage magnitude in
    volts peak
esf=314/(2*%pi);//Input signal frequncy in hertz

//Solution

disp("(a)");
Ip=esp/(Rl+2*Rf)*1000;//peak output current in milli
    -ampere
I0av=2*Ip/%pi;//average value of output current in
    milli-ampere
E0av=I0av*Rl/1000;//DC load voltage in volts

printf("DC load voltage (E0)dc = %.2f Volts",E0av);
```

```
disp("(b)");
IOrms=Ip/sqrt(2);//rms output current in milli-
    ampere
Vr=sqrt((IOrms/1000)^2-(IOav/1000)^2)*Rl;//output
    ripple voltage in volts

printf("Output ripple voltage Vr = %.1f Volts",Vr);

disp("(c)");
pr=2*Rf/Rl*100;//Percentage Regulation of voltage

printf("The percentage regulation is = %.2f
    percentage",pr);

//Error in textbook in calculation of average
    current
```

Scilab code Exa 3.10 Calculation of Vz for zener diode at given temperature

```
//Tested on Windows 7 Ultimate 32-bit
//Chapter 3 Semiconductor Diodes and Miscellaneous
    Devices Pg no. 95
clear;
clc;

//Given Data

Pz=0.5;//power dissipation of zener diode in watts
Vz=12;//zener breakdown voltage in volts
Tr=25;//reference temperature in degree celsius
T=90;//given temperature in degree celcius
Tc=0.075/100;//Temperature co-efficient in degree
    celcius inverse
```

```

//Solution

dVz=Vz*Tc*(T-Tr);//Change in Vz in volts
Vz90=Vz+dVz;//Zener voltage at T=90 degree celsius

printf("The value of Vz at T=90  C Vz=%.2f Volts",Vz90);
```

Scilab code Exa 3.11 Determination of bias for a zener diode

```
//Tested on Windows 7 Ultimate 32-bit
//Chapter 3 Semiconductor Diodes and Miscellaneous Devices Pg no. 96
clear;
clc;

//Given Data
//From Figure 3.27

V=15;//value of voltage source in volts
Vz=12;//zener breakdown voltage in volts
R=390;//series resistance in ohms
Izmax=10;//maximum zener current in milli-amperes

//Solution

//Assuming ideal diode Vz=12V and Rz=0 ohms
Vr=V-Vz;//voltage across resistor in volts
Iz=Vr/R*1000;//current through circuit in milli-amperes
printf("Iz max=%d mA\n Iz=%.2f mA\n",Izmax,Iz);

if Iz<Izmax then
    printf("The diode is properly biased.");
```

```
else printf("The diode is not properly biased.");
end
```

Scilab code Exa 3.12 Determination of bias for a zener diode and calculating power dissipation

```
//Tested on Windows 7 Ultimate 32-bit
//Chapter 3 Semiconductor Diodes and Miscellaneous Devices Pg no. 96
clear;
clc;

//Given Data
//From Figure 3.27

V=15;//value of voltage source in volts
Vz=12;//zener breakdown voltage in volts
R=390;//series resistance in ohms
rz=10;//diode resistance in ohms
Izmax=10;//maximum zener current in milli-amperes

//Solution

//Assuming ideal diode Vz=12V and Rz=0 ohms
Vr=V-Vz;//voltage across resistor in volts
Iz=Vr/(R+rz)*1000;//current through circuit in milli-amperes

if Iz<Izmax then
    printf("The diode is properly biased.\n");
else printf("The diode is not biased properly.\n");
end

Pz=Vz*Iz;//power dissipation in milli-watts

```

```
printf("The dissipated power = Pz = %d mW",Pz);
```

Scilab code Exa 3.13 Determination of bias for a zener diode and calculating power dissipation and Iz

```
//Tested on Windows 7 Ultimate 32-bit
//Chapter 3 Semiconductor Diodes and Miscellaneous Devices Pg no. 97
clear;
clc;

//Given Data
//From Figure 3.28

V=15;//value of voltage source in volts
Vz=10;//zener breakdown voltage in volts
Rs=300;//series resistance R in ohms
Rp=900;//shunt resistance R' in ohms
Izmax=10;//maximum zener current in milli-amperes

//Solution

//Assuming ideal diode Vz=12V and Rz=0 ohms
Vrs=V-Vz;//voltage across resistor in volts
Irs=Vrs/Rs*1000;//current through resistor R in milli-amperes
Irp=Vz/Rp*1000;//current through resistor R' in milli-amperes

Iz=Irs-Irp;//current through diode in milli-amperes

if Iz<Izmax then
    printf("The diode is properly biased.\n");
else printf("The diode is not biased properly.\n");
end
```

```

Pd=Vz*Iz;//power dissipation in milli-watts

printf("The dissipated power = Pd = %.1f mW",Pd);
```

Scilab code Exa 3.14 Calculation of output voltage for given zener circuit

```
//Tested on Windows 7 Ultimate 32-bit
//Chapter 3 Semiconductor Diodes and Miscellaneous
    Devices Pg no. 97 and 98
clear;
clc;

//Given Data

Vin=18;//input voltage in volts
Vz=10;//zener breakdown voltage in volts
Tr=20;//reference temperature in degree celsius
T=40;//given temperature in degree celcius
Tc=0.075/100;//Temperature co-efficient in degree
    celcius inverse
R=150;//value of resistor in ohms

//Solution

dVz=Vz*Tc*(T-Tr);//Change in Vz in volts
Vz40=Vz+dVz;//Zener voltage at T=40 degree celsius
Vr=Vin-Vz40;//voltage drop across resistor

printf("The output voltage Vo = Vr =%.2f Volts",Vr);
```

Scilab code Exa 3.15 Calculation of all branch currents for given zener circuit

```
//Tested on Windows 7 Ultimate 32-bit
//Chapter 3 Semiconductor Diodes and Miscellaneous Devices Pg no. 99 and 100
clear;
clc;

//Given Data

Vin1=50;//input voltage in volts
Vin2=75;//input voltage in volts
Vz=15;//zener breakdown voltage in volts
Pmax=1;//diode maximum power dissipation in watts
R=3.9D3;//value of resistor in ohms
Rload=3D3;//value of load resistance in ohms

//Solution
//With reference to Figure 3.32
disp("Case (a)");
disp("Vin=50V");
Vbc=Vz;//voltage across diode in volts
Vab=Vin1-Vbc;//voltage across resiston in volts
I=Vab/R*1000;//battery current in milli-amperes
Iload=Vbc/Rload*1000;//current through load in milli-amperes
Iz=I-Iload;//current through diode in milli-amperes
Izmax=Pmax/Vz*1000;//maximum current through diode in milli-amperes

printf("\n Battery current I = %.2f mA\n Zenner current Iz = %.2f mA\n Load current Iload = %d mA",I,Iz,Iload)

disp("Case (b)");
disp("Vin=75V");
Vbc=Vz;//voltage across diode in volts
Vab=Vin2-Vbc;//voltage across resiston in volts
I=Vab/R*1000;//battery current in milli-amperes
Iload=Vbc/Rload*1000;//current through load in milli
```

```
    -amperes
Iz=I-Iload;//current through diode in milli-amperes
Izmax=Pmax/Vz*1000;//maximum current through diode
    in milli-amperes

printf("\n Battery current I = %.2f mA\n Zenner
    current Iz = %.2f mA\n Load current Iload = %d mA
    ",I,Iz,Iload)

printf("\n\n Load current remains constant for any
    voltage input.");
```

Scilab code Exa 3.16 Calculation of zener current for different load resistances

```
//Tested on Windows 7 Ultimate 32-bit
//Chapter 3 Semiconductor Diodes and Miscellaneous
    Devices Pg no. 100
clear;
clc;

//Given Data

Vin=50;//input voltage in volts
Vz=30;//zener breakdown voltage in volts
R=2D3;//value of resistor in ohms

//Solution
//With reference to Figure 3.32

disp("Case (i)");
disp("Rload=30 kohm");
Rload=30D3;//load resistance in ohms
Vbc=Vz;//voltage across diode in volts
Vab=Vin-Vbc;//voltage across resiston in volts
```

```
I=Vab/R*1000;//battery current in milli-amperes
Iload=Vbc/Rload*1000;//current through load in milli-amperes
Iz=I-Iload;//current through diode in milli-amperes

printf("\n Zenner current Iz = %d mA\n",Iz)

disp("Case (ii)");
disp("Rload=10 kohm");
Rload=10D3;//load resistance in ohms
Vbc=Vz;//voltage across diode in volts
Vab=Vin-Vbc;//voltage across resiston in volts
I=Vab/R*1000;//battery current in milli-amperes
Iload=Vbc/Rload*1000;//current through load in milli-amperes
Iz=I-Iload;//current through diode in milli-amperes

printf("\n Zenner current Iz = %d mA\n",Iz)

disp("Case (iii)");
disp("Rload=3 kohm");
Rload=3D3;//load resistance in ohms
Vbc=Vz;//voltage across diode in volts
Vab=Vin-Vbc;//voltage across resiston in volts
I=Vab/R*1000;//battery current in milli-amperes
Iload=Vbc/Rload*1000;//current through load in milli-amperes
Iz=I-Iload;//current through diode in milli-amperes

printf("\n Zenner current Iz = %d mA\n",Iz)

printf("\n Since Iz=0 the diode will come out of breakdown region\n and diode will no longer act as a voltage regulator.");
```

Scilab code Exa 3.17 Calculation of resistor for construction a power supply and current when the supply voltage changes

```
//Tested on Windows 7 Ultimate 32-bit
//Chapter 3 Semiconductor Diodes and Miscellaneous
   Devices Pg no. 101
clear;
clc;

//Given Data

Vin1=24;//value of voltage source in volts
Vin2=20;//value of voltage source in volts
Vz=12;//zener breakdown voltage in volts
Izmax=20;//maximum zener current in milli-amperes

//Solution

disp("Vin=24V");
R=(Vin1-Vz)/Izmax*1000;//series resistance required
   for maximum safe current in ohms

printf("The minimum value of resistor required R=%d
   ohms.",R);
printf("Using R=680 ohms i.e. standaed value.")
R=680;//standard value of resistor selected
disp("Vin=20V");
Iz=(Vin2-Vz)/R*1000;//value of zener current in
   milli-amperes

printf("Current level at Vin=20V is Iz=%.1f mA",Iz);
```

Scilab code Exa 3.18 Design of a zener voltage regulator

```
//Tested on Windows 7 Ultimate 32-bit
```

```
//Chapter 3 Semiconductor Diodes and Miscellaneous Devices Pg no. 101 and 102
clear;
clc;

//Given Data

Vin=20;//supply input voltage in volts
Vz=9.1;//zener breakdown voltage in volts
Pmax=400D-3;//diode maximum power dissipation in watts
Izmin=5;//minimum current for diode to be in breakdown region in milli-amperes

//Solution

Izmax=Pmax/Vz;//maximum safe current through diode in milli-amperes
R=(Vin-Vz)/Izmax;

printf("Optimum value of resistor R=%.2f ohms.\n",R);
printf(" Standard value is 270 ohms.\n");

Iloadmax=Izmax*1000-Izmin;//maximum load current in milli-amperes
printf("Maximum load current in the circuit Iload max=%.2f mA",Iloadmax)
```

Scilab code Exa 3.19 Calculation of range of voltage for zener diode to be on

```
//Tested on Windows 7 Ultimate 32-bit
//Chapter 3 Semiconductor Diodes and Miscellaneous Devices Pg no. 102
```

```
clear;
clc;

//Given Data

Vz=18;//zener breakdown voltage in volts
Izmax=60;//maximum safe current through diode in
    milli-amperes
R=150;//series resistance in ohms
Rl=1D3;//load resistance in ohms

//Solution

Vinmin=((Rl+R)/Rl)*Vz;//minimum value of input
    voltage
Iload=Vz/Rl*1000;//load current in milli-amperes
Imax=Izmax+Iload;//maximum current through battery
    in milli-amperes
Vinmax=Vz+Imax/1000*R;//maximum value of input
    voltage

printf("So the input voltage ranges from %.1f volts
    to %.1f volts",Vinmin,Vinmax);
```

Scilab code Exa 3.20 Calculation of series resistance and dark current for given relay circuit

```
//Tested on Windows 7 Ultimate 32-bit
//Chapter 3 Semiconductor Diodes and Miscellaneous
    Devices Pg no. 119 and 120
clear;
clc;

//Given Data

```

```
Irelay=10;//relay current in milli-amperes
Int=400//light intensity in lm/m^2
Rc_d=100D3;//cell resistance in ohms when it is dark
Rc_i=1200;//cell resistance in ohms when
    illumination is 500lm/m^2
V=30;//source voltage in volts

//Solution

R=V/Irelay*1000-Rc_i;//series resistance in ohms
Id=V/(R+Rc_d)*1000;//dark current in milli-amperes

printf("Series resistance R = %d ohms\n Dark current
     = %.3f mA ",R,Id)
```

Chapter 4

Bipolar Junction Transistor

Scilab code Exa 4.1 Calculation of CE and CB current gains

```
//Tested on Windows 7 Ultimate 32-bit
//Chapter 4 Bipolar Junction transistors Pg no. 131
clear;
clc;

//Given Data

IB=40D-6;//base current in amperes
IC=4.25D-3;//collector current in amperes

//Solution

Bdc=IC/IB;//value of dc CE current gain
Adc=Bdc/(Bdc+1);//value of dc CB current gain

printf("The value of  dc = %.2f and  dc = %.4f",
   Bdc,Adc);

//Error in decimal places due to approximations in
   textbook
```

Scilab code Exa 4.2 Calculation of CB current gain and collector current

```
//Tested on Windows 7 Ultimate 32-bit
//Chapter 4 Bipolar Junction transistors Pg no. 131
clear;
clc;

//Given Data

Bdc=175;//value of dc CE current gain
IB=40D-6;//base current in amperes

//Solution

IC=IB*Bdc*1000;//collector current in milli-amperes
Adc=Bdc/(Bdc+1);//value of dc CB current gain

printf("The value of IC = %d mA and  dc = %.4f",IC,
   Adc);

//Error in decimal places due to approximations in
   textbook
```

Scilab code Exa 4.3 Calculation of CE current gain and base current

```
//Tested on Windows 7 Ultimate 32-bit
//Chapter 4 Bipolar Junction transistors Pg no. 131
clear;
clc;

//Given Data

```

```
IC=7.5D-3;//collector current in amperes
Adc=0.9914;//value of dc CB current gain

//Solution

IE=IC/Adc;//emitter current in amperes
IB=IE-IC;//base current in amperes
IB=IB*10^6;//converting base current to mICro-amperes
Bdc=Adc/(1-Adc);//value of dc CE current gain

printf("The value of IB = %d  A and  dc = %.2f",IB,Bdc);

//Error in decimal places due to approximations in textbook
```

Scilab code Exa 4.4 Determination of whether transistor is saturated

```
//Tested on Windows 7 Ultimate 32-bit
//Chapter 4 Bipolar Junction transistors Pg no. 133
clear;
clc;

//Given Data

VCEsat=0.25;//VCEsat in volts
VBB=4.5;//base driving source in volts
RB=20;//base resistance in kilo-ohms
RC=680;//collector resistance in ohms
VCC=9;//collector driving source in volts
VBE=0.7;//forward drop of emitter diode
Bdc=100;//dc current gain for CE configuration

//Solution
```

```
//Figure 4.12

ICsat=(VCC-VCEsat)/RC*1000;//value of collector
    saturation current in milli-amperes
printf("IC(sat)=%.2f mA\n\n",ICsat);
IB=(VBB-VBE)/RB;//value of base current in milli-
    amperes
printf("IB=%.2f mA\n\n",IB);
IC=Bdc*IB;//collector current for given IB in milli-
    amperes
printf("IC=%d mA\n\n",IC);

if IC>ICsat then
    printf("Since IC(calculated) = %d mA is greater
        than IC(sat),\nthe transistor is in
        saturation.\nThe collector current of %d mA
        is never reached.\nIf you increase IB further
        ,\nthe collector current is at the saturation
         value.",IC,IC);
end

//Error of 0.01 mA in textbook in the calculation of
     IC(sat)
```

Scilab code Exa 4.5 Determination of whether transistor is saturated

```
//Tested on Windows 7 Ultimate 32-bit
//Chapter 4 Bipolar Junction transistors Pg no. 133
    and 134
clear;
clc;

//Given Data

Bdc=50;//dc current gain for CE configuration
```

```
VBB=3;//base driving source in volts
RB=15;//base resistance in kilo-ohms
RC=1;//collector resistance in kilo-ohms
VCC=12;//collector driving source in volts
VCEsat=0.25;//VCEsat in volts
VBE=0.7;//forward drop of emitter diode


//Solution

ICsat=(VCC-VCEsat)/RC;//value of collector
    saturation current in milli-amperes
IB=(VBB-VBE)/RB;//value of base current in milli-
    amperes
IC=Bdc*IB;//collector current for given IB in milli-
    amperes

if IC>ICsat then
    printf("The transistor is in saturation and VCE=
        VCEsat=%.2f Volts",VCEsat);
else
    printf("The transistor is not in saturation and
        VCE=VCC-IC*Rc = %.2fVolts",(VCC-IC*RC));
end
```

Scilab code Exa 4.6 Calculation of voltage gain and output voltage for given amplifier figure

```
//Tested on Windows 7 Ultimate 32-bit
//Chapter 4 Bipolar Junction transistors Pg no. 135
clear;
clc;

//Given Data

```

```
Vin=50D-3;//rms value of input ac voltage in volts
Rl=1D3;//load resistance in ohms
re=40;//emitter diode resistance in ohms

//Solution
//Figure 4.16

Gv=Rl/re;//voltage gain
Vout=Gv*Vin;//output voltage in volts

printf("Voltage Gain Gv = %d and Output Voltage Vout
    = %.2f Vrms(Volts).",Gv,Vout);
```

Scilab code Exa 4.7 Calculation of input and output impedance and current and voltage gain at given load

```
//Tested on Windows 7 Ultimate 32-bit
//Chapter 4 Bipolar Junction transistors Pg no. 139
clear;
clc;

//Given Data

IE=2D-3;//emitter current in amperes
A=0.97;//dc current gain of CB configuration
Vi=1D-3;//rms value of input ac voltage in volts
Rl=500;//load resistance in ohms
VT=26D-3;//temperature equivalent voltage of pn
    junction

//Solution

disp("(a)");
re=VT/IE;//emitter diode resistance in ohms
Zi=re;//input impedance in ohms
```

```
printf("Input impedance of CB circuit = re = %d ohms
   \n",Zi);

disp("(b)");
Ii=Vi/Zi;//input current in amperes
Vo=A*Ii*Rl;//output voltage in volts
Gv=Vo/Vi;//voltage gain

printf("Voltage gain of CB circuit Gv = %.1f\n",Gv);

disp("(c)");
//as output cicuit contains reverse biased junction
   output impedance is infinite
Gi=-A;//current gain

printf("Output impedance Zo=    and Current Gain Gi
   = %.2f",Gi);
```

Scilab code Exa 4.8 Calculation of input impedance and current and voltage gain at given load

```
//Tested on Windows 7 Ultimate 32-bit
//Chapter 4 Bipolar Junction transistors Pg no. 139
clear;
clc;

//Given Data

B=140;//dc current gain of CE configuration
IE=2D-3;//emitter current in amperes
Rl1=2D3;//load resistance in ohms
Rl2=1.2D3;//load resistance in ohms
VT=26D-3;//temperature equivalent voltage of pn
   junction

```

```
//Solution

disp("(a)");
re=VT/IE;//emitter diode resistance in ohms
Zi=B*re;//input impedance in ohms
printf("Input impedance of CE circuit = re = %d ohms
   \n",Zi);

disp("(b)");
Gv=-Rl1/re;//voltage gain

printf("Voltage gain of CE circuit at 2k-ohm load =
   Gv = %.1f\n",Gv);

disp("(c)");
Gi=B;//current gain

printf("Current Gain Gi = %d",Gi);

//Error in voltage gain in part (b) as Rl is
   mistaken as 1.2 kilo-ohm instead of 2 kilo-ohm
```

Scilab code Exa 4.9 Determination of CE hybrid model and CB re model

```
//Tested on Windows 7 Ultimate 32-bit
//Chapter 4 Bipolar Junction transistors Pg no. 141
   and 142
clear;
clc;

//Given Data

hfe=120;//forward transfer current ratio of CE
   configuration
hoe=20D-6;//output conductance of CE configuration
```

```
   in siemens
hohfe=1D-6;//output conductance of Chfe
   configuration in siemens
IE=2D-3;//emitter current in amperes
VT=26D-3;//temperature equivalent voltage of pn
   junction

//Solution

disp("(a)");
re=VT/IE;//emitter diode resistance in ohms
hi=hfe*re/1000;//input impedance in kilo-ohms
ro=1/hoe/1000;//output impedance in kilo-ohms
printf("hi = %.2f kilo-ohms\nro = %d kilo-ohms\
   nValue of current source is %d*Ib",hi,ro,hfe);
//output circuit is given as Figure 4.24

disp("(b)");
hi=re;//input impedance in ohms
A=hfe/(hfe+1);//current gain alpha of Chfe circuit
A=round(A);//taking approximate value
ro=1/hohfe/10^6;//output impedance in mega-ohms
printf("hi = %d ohms\nro = %d mega-ohms\nValue of
   current source is %d*Ib",hi,ro,A);
//output circuit is given as Figure 4.25

//Error in decimal places due to approximations in
   textbook
```

Chapter 5

Bipolar Transistor Biasing

Scilab code Exa 5.1 Calculation of quantities for Q point for given figure

```
//Tested on Windows 7 Ultimate 32-bit
//Chapter 5 Bipolar Transistor Biasing Pg no. 147
clear;
clc;

//Given Data
//Figure 5.4

B=100;//current gain of CE configuration
VCC=15;//biasing voltage in volts
R=180D3;//biasing resistance in ohms
Rl=1.5D3;//load resistance in ohms
VBE=0.7;//forward drop of emitter diode in volts

//Solution

disp("(i)");
IB=(VCC-VBE)/R*10^6;//base current in micro-amperes
IC=B*IB/1000;//colelctor current in milli-amperes

printf("IB = %.2f   A \nIC = %.2f mA\n",IB,IC);
```

```
disp("(ii)");
VCE=VCC-IC*R1/1000;//volatage between collector and emitter in volts

printf("VCE = %.1f  Volts",VCE);

disp("(iii)");
VB=VBE;//base voltage w.r.t. ground in volts
VC=VCE;//coollector voltage w.r.t. ground in volts

printf("VB = %.1f Volts\nVC = %.1f Volts\n",VB,VC);

disp("(iv)");
VCB=VC-VB;//voltage between collector and base in volts
VBC=-VCB;//voltage between base and collector in volts

printf("VCB = %.1f Volts\n",VCB);
if VBC<0 then
    printf("Base collector junction is reverse biased.\n")
end
```

Scilab code Exa 5.2 Calculation of saturation current for given figure

```
//Tested on Windows 7 Ultimate 32-bit
//Chapter 5 Bipolar Transistor Biasing Pg no. 149
clear;
clc;

//Given Data
//Figure 5.4

```

```
VCC=15;//biasing voltage in volts
Rl=1.5D3;//load resistance in ohms

//Solution

//Assuming VCEsat=0 volts
ICsat=VCC/Rl*1000;//saturation current in milli-
    amperes

printf("ICsat = %d mA\n",ICsat);
```

Scilab code Exa 5.3 Calculation of Vcc and given resistances for the load line and Q point given

```
//Tested on Windows 7 Ultimate 32-bit
//Chapter 5 Bipolar Transistor Biasing Pg no. 151
clear;
clc;

//Given Data
//Figure 5.10

VCE=15;//voltage between collector and emitter in
    volts at IC = 0 mA
IC=15D-3;//collecotr current in amperes in VCE = 0
    Volts
IB=35D-6;//base current at Q point in amperes
VBE=0.7;//forward voltage drop of emitter diode in
    volts

//Solution

VCC=VCE;//biasing voltage in volts = VCE at IC = 0
    mA
R=(VCC-VBE)/IB/1000;//base biasing resistance in
```

```
    kilo-ohms
Rl=VCC/IC/1000;//load resistance in kilo-ohms

printf("VCC = %d Volts\n R = %.1f kilo-ohms\n Rl =
    %d kilo-ohm",VCC,R,Rl);
```

Scilab code Exa 5.4 Calculation of parameters for emitter biased circuit

```
//Tested on Windows 7 Ultimate 32-bit
//Chapter 5 Bipolar Transistor Biasing Pg no. 153
    and 154
clear;
clc;

//Given Data
//Figure 5.14

VCC=15;//supply voltage in volts
RB=330D3;//base resistance in ohms
RL=2D3;//load collector resistance in ohms
RE=820;//emitter resistance in ohms
B=75;//DC CE current gain beta
VBE=0.7;//forward voltage drop of emitter diode in
    volts
Cb=12D-6;//base coupling capacitor in farads
Ce=50D-6;//emitter bypass capacitor in farads

//Solution

disp("(i)");
IB=(VCC-VBE)/(RB+B*RE)*10^6;//base current in micro
    ampere
printf("IB = %.2f   A \n",IB);

disp("(ii)");
```

```
IC=B*IB/1000;//collector current in milli ampere
printf("IC = %.2f mA\n",IC);

disp("(iii)");
VCE=VCC-IC*(RL+RE)/1000;//collector to emitter voltage in volts
printf("VCE = %.1f Volts\n",VCE);

disp("(iv)");
VC=VCC-IC*RL/1000;//collector to ground voltage in volts
printf("VC = %.2f Volts\n",VC);

disp("(v)");
VE=VC-VCE;//emitter to ground voltage in volts
printf("VE = %.2f Volts\n",VE);

disp("(vi)");
VB=VBE+VE;//base to ground voltage in volts
printf("VB = %.2f Volts\n",VB);

disp("(vi)");
VCB=VC-VB;//collector to base voltage in volts
printf("VCB = %.1f Volts\n",VCB);

if VCB>0
    printf("VBC is less than zero indicating collector base juntion is reverse biased.")
end

//error in answers w.r.t. text book as BETA in figure is 75 and in calculations is 76
//here BETA is taken as 75
//also in (iv) answer is not printed in textbook
```

Scilab code Exa 5.5 Calculation of Q point for given dc bias circuit

```
//Tested on Windows 7 Ultimate 32-bit
//Chapter 5 Bipolar Transistor Biasing Pg no. 157 and 158
clear;
clc;

//Given Data
//Figure 5.19

VCC=20;//supply voltage in volts
R1=22D3;//bias resistance in ohms
R2=2.2D3;//bias resistance in ohms
RL=10D3;//load collector resistance in ohms
RE=820;//emitter resistance in ohms
B=100;//DC CE current gain beta
VBE=0.7;//forward voltage drop of emitter diode in volts
Cb=15D-6;//base coupling capacitor in farads
Ce=40D-6;//emitter bypass capacitor in farads
Cc=15D-6;//collector coupling capacitor in farads

//Solution

Rth=R1*R2/(R1+R2);//thevenin resistance of R1 and R2 at base in ohms
Vth=VCC*R2/(R1+R2);//thevenin voltage at base in volts

IB=(Vth-VBE)/(Rth+(B+1)*RE)*10^6;//base current in micro ampere
printf("IB = %.2f  A \n",IB);

IC=B*IB/1000;//collector current in milli ampere
printf("IC = %.2f mA\n",IC);

VCE=VCC-IC*(RL+RE)/1000;//collector to emitter
```

```
voltage in volts
printf("VCE = %.3f Volts\n",VCE);

//calculation error in textbook as Vth turns out to be 1.818 V instead of 1.67 V
```

Scilab code Exa 5.6 Calculation of stability factors for given circuit

```
//Tested on Windows 7 Ultimate 32-bit
//Chapter 5 Bipolar Transistor Biasing Pg no. 158 and 159
clear;
clc;

//Given Data
//Figure 5.19

VCC=20;//supply voltage in volts
R1=22D3;//bias resistance in ohms
R2=2.2D3;//bias resistance in ohms
RL=10D3;//load collector resistance in ohms
RE=820;//emitter resistance in ohms
B=100;//DC CE current gain beta
VBE=0.7;//forward voltage drop of emitter diode in volts
Cb=15D-6;//base coupling capacitor in farads
Ce=40D-6;//emitter bypass capacitor in farads
Cc=15D-6;//collector coupling capacitor in farads
ICO=1D-6;//leakage current in amperes

//Solution

Rth=R1*R2/(R1+R2);//thevenin resistance of R1 and R2 at base in ohms
Vth=VCC*R2/(R1+R2);//thevenin voltage at base in
```

```
volts
IB=(Vth-VBE)/(Rth+(B+1)*RE);//base current in ampere
IC=B*IB;//collector current in ampere

S1=(B+1)*(1+Rth/RE)/(1+B+Rth/RE);//Stability factor S of IC against ICO

S2=-B/(Rth+RE+B*RE);//Stability factor S' of IC against VBE

S3=1/(B*(1+B))*(IC*((Rth+RE)*(1+B)-B*S1*RE)/(RE+Rth)-S1*ICO);//Stability factor S'' of IC against BETA

printf("S= IC/ ICO=%.3f\n",S1);
printf("S''= IC/ VBE=%.3e\n",S2);
printf("S''''= IC/ B=%e\n",S3);

//error in calculation in textbook for IC and S''
```

Scilab code Exa 5.7 Calculation of Q point for given circuit

```
//Tested on Windows 7 Ultimate 32-bit
//Chapter 5 Bipolar Transistor Biasing Pg no. 161 and 162
clear;
clc;

//Given Data
//Figure 5.23

VCC=11;//supply voltage in volts
R=220D3;//base bias resistance in ohms
RL=5.6D3;//load collector resistance in ohms
RE=1.5D3;//emitter resistance in ohms
```

```
B=75;//DC CE current gain beta
VBE=0.7;//forward voltage drop of emitter diode in
    volts
Cb=12D-6;//base coupling capacitor in farads
Cc=12D-6;//collector coupling capacitor in farads

//Solution

IB=(VCC-VBE)/(B*(RL+RE)+R);//base current in ampere
ICQ=B*IB*1000;//quiscent collector current in milli
    ampere
VCEQ=VCC-ICQ*(RE+RL)/1000;//quiscent collector to
    emitter voltage in volts
printf("ICQ = %.2f mA\n",ICQ);
printf("VCEQ = %.2f Volts\n",VCEQ);

//decimal approximation error w.r.t textbook
```

Scilab code Exa 5.8 Calculation of Q point for given circuit and given beta

```
//Tested on Windows 7 Ultimate 32-bit
//Chapter 5 Bipolar Transistor Biasing Pg no. 162
clear;
clc;

//Given Data
//Figure 5.23

VCC=11;//supply voltage in volts
R=220D3;//base bias resistance in ohms
RL=5.6D3;//load collector resistance in ohms
RE=1.5D3;//emitter resistance in ohms
B=120;//DC CE current gain beta
VBE=0.7;//forward voltage drop of emitter diode in
```

```
   volts
Cb=12D-6;//base coupling capacitor in farads
Cc=12D-6;//collector coupling capacitor in farads

//Solution

IB=(VCC-VBE)/(B*(RL+RE)+R);//base current in ampere
ICQ=B*IB*1000;//quiscent collector current in milli
   ampere
VCEQ=VCC-ICQ*(RE+RL)/1000;//quiscent collector to
   emitter voltage in volts
printf("ICQ = %.2f mA\n",ICQ);
printf("VCEQ = %.2f Volts\n",VCEQ);

//decimal approximation error w.r.t textbook
```

Scilab code Exa 5.9 Calcualtion of dc level of IB and VC for given circuit

```
//Tested on Windows 7 Ultimate 32-bit
//Chapter 5 Bipolar Transistor Biasing Pg no. 162
   and 163
clear;
clc;

//Given Data
//Figure 5.24

VCC=20;//supply voltage in volts
R=270D3;//base bias resistance in ohms(60k+90k+120k)
RL=3.9D3;//load collector resistance in ohms
RE=410;//emitter resistance in ohms
B=100;//DC CE current gain beta
VBE=0.7;//forward voltage drop of emitter diode in
   volts
Cb=12D-6;//base coupling capacitor in farads
```

```
Cc=12D-6;//collector coupling capacitor in farads
Ce=60D-6;//emitter bypass capacitor in farads

//Solution

IB=(VCC-VBE)/(B*(RL+RE)+R);//base current in ampere
IC=B*IB*1000;//collector current in milli ampere
VC=VCC-IC*RL/1000;//collector to ground voltage in
    volts
printf("d.c. level of IB = %.1f  A \n",IB*10^6);
printf("d.c. level of VC = %.2f Volts\n",VC);

//decimal approximation error w.r.t textbook
```

Scilab code Exa 5.10 Design of a bias circuit for amplifier for given current IE

```
//Tested on Windows 7 Ultimate 32-bit
//Chapter 5 Bipolar Transistor Biasing Pg no. 164
    and 165
clear;
clc;

//Given Data

IE=1.5D-3;//emitter current in amperes
VCC=15;//supply voltage in volts
B=100;//DC CE current gain beta
VBE=0.7;//forward voltage drop of emitter diode in
    volts

//Solution

//Approximations
VR2=VCC/3;//voltage across R2 is 1/3rd of supply
```

```
   voltage
VRL=VCC/3;//voltage across RL is 1/3rd of supply
   voltage

VB=VR2;//voltage of base to ground in volts
VE=VB-VBE;//voltage of emitter to ground in volts
RE=VE/IE;//emitter resistance in ohms
I=0.1*IE;//setting voltage divider current as 0.1IE
   and neglecting base current
R1_plus_R2=VCC/I;//R1+R2 in ohms
R2=VR2/VCC*R1_plus_R2;//R2 in ohms
R1=R1_plus_R2-R2;//R1 in ohms

printf("RE = %.2f kilo-ohms\n",RE/1000);
printf("R1 = %.2f kilo-ohms\n",R1/1000);
printf("R2 = %.2f kilo-ohms\n",R2/1000);
//design is given in Figure E5.10
//IE for this circuit is 1.40 mA and more accuracy
   can be obtained by exact equations and
   eliminating approximations
```

Scilab code Exa 5.11 Calculation of stability factor for collector to base bias circuit

```
//Tested on Windows 7 Ultimate 32-bit
//Chapter 5 Bipolar Transistor Biasing Pg no. 165
clear;
clc;

//Given Data
//Figure 5.26

RL=470;//collector load resistance in ohms
R=20D3;//base collector parallel resistance in ohms
B=90;//DC CE current gain beta
```

```
//Solution

S=(B+1)/(1+(B*RL)/(RL+R));//stability factor S
printf("S = %.2f",S);

//decimal error as calculation is not accurate in
    textbook
```

Scilab code Exa 5.12 Calculation of stability factor for given circuit and load

```
//Tested on Windows 7 Ultimate 32-bit
//Chapter 5 Bipolar Transistor Biasing Pg no. 165
clear;
clc;

//Given Data
//Figure 5.26

RL=10;//load resistance in ohms which is dc
    resistance of primary coil of transistor
R=20D3;//base collector parallel resistance in ohms
B=90;//DC CE current gain beta

//Solution

S=(B+1)/(1+(B*RL)/(RL+R));//stability factor S
printf("S = %.2f",S);
```

Scilab code Exa 5.13 Calculation of stability factors for given circuit and parameters

```
//Tested on Windows 7 Ultimate 32-bit
//Chapter 5 Bipolar Transistor Biasing Pg no. 166
clear;
clc;

//Given Data
//Figure 5.27

IC=20D-3;//collector current in amperes
VCE=6;//collector to emitter voltage in volts
VCC=15;//supply voltage in volts
RL=390;//collector load resistance in ohms
IB=2D-3;//base bias current in amperes
B=90;//DC CE current gain beta
RE=82;//emitter resistance in ohms
C1=10D-6;//base coupling capacitance in farads
C2=10D-6;//collector coupling capacitance in farads
VBE=0.7;//forward voltage drop of emitter diode in volts

//Solution

R=(VCC-VBE-IC*RL-(IC+IB)*RE)/IB;//base collector parallel resistance in ohms
S=(B+1)/(1+(B*RE)/(RE+R));//stability factor S
printf("S = %.2f",S);

//calculation errors in textbook as KVL is incorrectly applied
```

Scilab code Exa 5.14 Calculation of Q point for given circuit

```
//Tested on Windows 7 Ultimate 32-bit
//Chapter 5 Bipolar Transistor Biasing Pg no. 166 and 167
```

```
clear;
clc;

//Given Data
//Figure 5.28

VCC=12;//supply voltage in volts
RL=6.8D3;//collector load resistance in ohms
B=75;//DC CE current gain beta
R=82D3;//base collector parallel resistance in ohms
VBE=0.7;//forward voltage drop of emitter diode in
    volts

//Solution

IC=(VCC-VBE)/(RL+R/B);//collector current in amperes
VCE=VCC-IC*RL;//collector to emitter voltage in
    volts and VCE = VC as VE = 0 V since emitter is
    grounded
printf("IC = %.2f mA\n",IC*1000);
printf("VCE = %.2f Volts\n",VCE);
```

Scilab code Exa 5.15 Calculation of Q point for given circuit and given beta

```
//Tested on Windows 7 Ultimate 32-bit
//Chapter 5 Bipolar Transistor Biasing Pg no. 167
    and 168
clear;
clc;

//Given Data
//Figure 5.28

VCC=12;//supply voltage in volts
```

```
RL=6.8D3;//collector load resistance in ohms
B=200;//DC CE current gain beta
R=82D3;//base collector parallel resistance in ohms
VBE=0.7;//forward voltage drop of emitter diode in volts

//Solution

IC=(VCC-VBE)/(RL+R/B);//collector current in amperes
VCE=VCC-IC*RL;//collector to emitter voltage in volts and VCE = VC as VE = 0 V since emitter is grounded
printf("IC = %.2f mA\n",IC*1000);
printf("VCE = %.2f Volts\n",VCE);

//error in textbooks as question is about Fig 5.27 and solved for Fig 5.28 , here solved as Fig 5.28
//decimal approximation error in textbook
```

Scilab code Exa 5.16 Calculation of Q point and stability factors for given circuit and parameters

```
//Tested on Windows 7 Ultimate 32-bit
//Chapter 5 Bipolar Transistor Biasing Pg no. 168
clear;
clc;

//Given Data
//Figure E5.15

VCC=15;//supply voltage in volts
RL=1.5D3;//collector load resistance in ohms
B=100;//DC CE current gain beta
R=82D3;//base collector parallel resistance in ohms
VBE=0.7;//forward voltage drop of emitter diode in
```

```
volts

//Solution

IC=(VCC-VBE)/(RL+R/B);//collector current in amperes
VCE=VCC-IC*RL;//collector to emitter voltage in volts and VCE = VC as VE = 0 V since emitter is grounded
disp("Q - point");
printf("IB = %.2f   A \n",IC*1D6/B);
printf("IC = %.2f mA\n",IC*1000);
printf("VCE = %.2f Volts\n",VCE);

disp("Stability factors");

S1=(B+1)/(1+(B*RL)/(RL+R));//stability factor S
printf("S = %.2f\n",S1);

S2=-B/(R+RL+B*RL);//Stability factor S'
printf("S'' = %.3f mA/V\n",S2*1000);

S3=(VCC-VBE-IC*RL)/(R+RL/(1+B));//Stability factor S''
printf("S'''' = %.2f   A \n",S3*1D6);

//decimal approximation error w.r.t textbook
```

Scilab code Exa 5.17 Calculation of unknown resistances for the given circuit and parameters

```
//Tested on Windows 7 Ultimate 32-bit
//Chapter 5 Bipolar Transistor Biasing Pg no. 168 and 169
clear;
clc;
```

```
//Given Data
//Figure E5.17

B=100;//DC CE current gain beta
VCC=15;//supply voltage in volts
RL=1D3;//collector load resistance in ohms
VCE=7.5;//collector to emitter voltage in volts
IC=6D-3;//collector current in amperes
VBE=0.7;//forward voltage drop of emitter diode in
    volts
S=12;//stability factor S


//Solution

IB=IC/B;//base current in amperes
RE=(VCC-VCE-IC*RL)/(IC+IB);//emitter resistance in
    ohms
Rth=RE*(S-1)/(1-S/(1+B));//thevenin resistance of
    divider network in ohms
R1=VCC*Rth/(IB*Rth+VBE+(IC+IB)*RE);//resistance R1
    in ohms
R2=R1*Rth/(R1-Rth);//resistance R2 in ohms

printf("RE = %.3f kilo-ohms\n",RE/1000);
printf("R1 = %.2f kilo-ohms\n",R1/1000);
printf("R2 = %.2f kilo-ohms\n",R2/1000);

//error in calculations in textbook for R1 and R2 as
     R2 cannot be less than Rth which is parallel
    resistance of R1 and R2
```

Scilab code Exa 5.18 Calculation of given parameters for circuit and stated parameters

```
//Tested on Windows 7 Ultimate 32-bit
//Chapter 5 Bipolar Transistor Biasing Pg no. 170 and 171
clear;
clc;

//Given Data
//Figure 5.30

B=100;//DC CE current gain beta
VCC=18;//collector supply voltage in volts
VEE=9;//emitter supply voltage in volts
VBE=0.7;//forward voltage drop of emitter diode in volts
RE=30D3;//emitter resistance in ohms
R=15D3;//base bias resistance in ohms
RL=15D3;//collector load resistance in ohms

//Solution

disp("(i)");
IE=(VEE-VBE)/(RE+R/B);//emitter current in amperes
printf("IE = %.3f mA\n",IE*1000);

disp("(ii)");
IC=IE;//collector current in amperes
printf("IE = %.3f mA\n",IC*1000);

disp("(iii)");
VC=VCC-IC*RL;//collector to groud voltage in volts
printf("VC = %.2f Volts\n",VC);

disp("(iv)");
VE=-(IC*R/B+VBE);//emitter to groud voltage in volts
printf("VE = %.2f Volts\n",VE);

disp("(v)");
VCE=VC-VE;//collector to emitter voltage in volts
```

```
printf("VCE = %.2f Volts\n",VCE);

disp("(vi)");
S=(1+R/RE)/(1+R/B/RE);//stability factor S
printf("S = %.4f\n",S);

//calculations are carried out taking RL=9 kilo-ohm instead of 15 kilo-ohm as in Figure 5.30 in textbook
//resulting in change in values of VC and VCE
```

Chapter 6

Single Stage BJT Amplifiers

Scilab code Exa 6.1 Plot of DC and AC load lines for given circuit

```
//Tested on Windows 7 Ultimate 32-bit
//Chapter 6 Single Staje BJT Amplifiers Pg no. 184
    and 185
clear;
clc;

//Given Data
//Figure 6.7

VCC=20;//collector supply voltage in volts
RC=1.5D3;//collector resistance in ohms
RE=1.8D3;//emitter resistance in ohms
R1=8.2D3;//divider network resistance R1 in ohms
R2=3.9D3;//divider network resistance R2 in ohms
VBE=0.7;//forward voltage drop of emitter diode in
    volts

//Solution

```

```
//For DC load line
VCEd=0:VCC;//as for load line maximum VCE is at IC=0 mA ie. VCE=VCC
ICd=(VCC-VCEd)/(RC+RE)*1000;//equation for DC load line
VB=VCC*R2/(R1+R2);//base to ground voltage in volts
VE=VB-VBE;//emitter to ground voltage in volts
IE=VE/RE;//emitter current in milli-amperes
IC=IE;//collector current is approximately equal to emitter current
VCE=VCC-IC*(RC+RE);//collector to emitter voltage in volts

//For AC load line
m=-1/RC;//slope of AC load line i.e. IC/VCE
c=IC-m*VCE;//load line passes through Q point
ICa=(m*VCEd+c)*1000;//AC load line equation

plot2d(VCEd,[ICd' ICa'],[1,2],leg="DC LOAD LINE@AC LOAD LINE",rect=[0,0,21,7]);
plot2d(VCE,IC*1000,-1);
xlabel("VCE (in Volts)");
ylabel("IC (in mA)");
xstring(VCE+.1,IC*1000+.1,"Q point");
xstring(VCC,.1,"R");
xstring(.1,VCC/(RC+RE)*1000,"P");
title("LOAD LINES FOR EXAMPLE 6.1")
```

Scilab code Exa 6.2 DC and AC analysis of given circuit

```
//Tested on Windows 7 Ultimate 32-bit
//Chapter 6 Single Staje BJT Amplifiers Pg no. 186,187 and 188
clear;
clc;
```

```
//Given Data
//Figure 6.9,6.10,6.11,6.12,6.13

VCC=15;//collector supply voltage in volts
RC=1D3;//collector resistance in ohms
RE=390;//emitter resistance in ohms
R1=18D3;//divider network resistance R1 in ohms
R2=3.9D3;//divider network resistance R2 in ohms
VBE=0.7;//forward voltage drop of emitter diode in volts
Bdc=120;//DC CE current gain beta
Bac=130;//AC CE current gain beta

//Solution

disp("DC analysis for Figure 6.10");
Rin_dc=Bdc*RE;//dc input resistance in ohms
if 0.1*Rin_dc>R2 then
    VB=VCC*R2/(R1+R2);//base to ground voltage in volts , since Rin>10*R2 it can be neglected
end
VE=VB-VBE;//emitter to ground voltage in volts
IE=VE/RE;//emitter current in amperes
IC=IE;//collector current is approximately equal to emitter current
VC=VCC-IC*RC;//collector to ground voltage in volts
VCE=VC-VE;//collector to emitter voltage in volts

printf("IC = %.2f mA\n",IC*1000);
printf("VCE = %.2f Volts\n",VCE);

disp("AC analysis for Figure 6.12");
printf("Rin'' = R1||R2||Rin where Rin=Vb/Ib\n");
printf("Vb=Ie*(re+RE)\n =Bac*Ib*(re+RE)\n");
printf("(Rin)''= Bac*(re+RE)\n");
printf("Rout = RC||rC = RC\n as rC>>RC\n");

```

```
//decimal error w.r.t. textbook due to approximations
```

Scilab code Exa 6.3 Calculation of base voltage for given circuit parameters

```
//Tested on Windows 7 Ultimate 32-bit
//Chapter 6 Single Staje BJT Amplifiers Pg no. 188
clear;
clc;

//Given Data
//Figure 6.11

VCC=15;//collector supply voltage in volts
RC=1D3;//collector resistance in ohms
RE=390;//emitter resistance in ohms
R1=18D3;//divider network resistance R1 in ohms
R2=3.9D3;//divider network resistance R2 in ohms
VBE=0.7;//forward voltage drop of emitter diode in volts
Bdc=120;//DC CE current gain beta
Bac=130;//AC CE current gain beta
VT=0.25D-3;//voltage equivalent of temperature in volts
Vs=5D-3;//source rms voltage in volts
Rs=600;//source internal impedance in ohms

//Solution

Rin_dc=Bdc*RE;//dc input resistance in ohms
if 0.1*Rin_dc>R2 then
    VB=VCC*R2/(R1+R2);//base to ground voltage in volts , since Rin>10*R2 it can be neglected
end
```

```
VE=VB-VBE;//emitter to ground voltage in volts
IE=VE/RE;//emitter current in amperes
IC=IE;//collector current is approximately equal to emitter current
VC=VCC-IC*RC;//collector to ground voltage in volts
VCE=VC-VE;//collector to emitter voltage in volts

re=VT/IE;//equivalent BJT model emitter resistance in ohms
Rin_dash=Bac*(RE+re);//internal resistance of BJT in ohms
Rin=1/(1/R1+1/R2+1/Rin_dash);//total internal resistance is Rin=R1||R2||Rin'
Vb=Rin/(Rs+Rin)*Vs;//signal voltage at base in volts
printf("Vb = %.2f mV",Vb*1000);
```

Scilab code Exa 6.4 Calculation of base to collector gain for given conditions of RE

```
//Tested on Windows 7 Ultimate 32-bit
//Chapter 6 Single Staje BJT Amplifiers Pg no. 190
clear;
clc;

//Given Data
//Figure 6.11

VCC=15;//collector supply voltage in volts
RC=1D3;//collector resistance in ohms
RE=390;//emitter resistance in ohms
R1=18D3;//divider network resistance R1 in ohms
R2=3.9D3;//divider network resistance R2 in ohms
VBE=0.7;//forward voltage drop of emitter diode in volts
Bdc=120;//DC CE current gain beta
```

```
Bac=130;//AC CE current gain beta
VT=25D-3;//voltage equivalent of temperature in volts

//Solution

Rin_dc=Bdc*RE;//dc input resistance in ohms
if 0.1*Rin_dc>R2 then
    VB=VCC*R2/(R1+R2);//base to ground voltage in volts , since Rin>10*R2 it can be neglected
end
VE=VB-VBE;//emitter to ground voltage in volts
IE=VE/RE;//emitter current in amperes
IC=IE;//collector current is approximately equal to emitter current
VC=VCC-IC*RC;//collector to ground voltage in volts
VCE=VC-VE;//collector to emitter voltage in volts
re=VT/IE;//equivalent BJT model emitter resistance in ohms

disp("(i)");
printf("Without emitter bypass capacitor.\n");
gain=RC/(re+RE);//base to collector voltage gain
printf("Base to collector voltage gain = %.2f\n",gain);

disp("(ii)");
printf("With RE shorted.\n");
gain=RC/re;//base to collector voltage gain
printf("Base to collector voltage gain = %d\n",gain);

//gain deviation due to approximations in textbook
```

Scilab code Exa 6.5 Calculations of specific gains for given circuit parameters

```
//Tested on Windows 7 Ultimate 32-bit
//Chapter 6 Single Staje BJT Amplifiers Pg no. 191 and 192
clear;
clc;

//Given Data
//Figure 6.9

VCC=15;//collector supply voltage in volts
RC=1D3;//collector resistance in ohms
RE=390;//emitter resistance in ohms
R1=18D3;//divider network resistance R1 in ohms
R2=3.9D3;//divider network resistance R2 in ohms
VBE=0.7;//forward voltage drop of emitter diode in volts
Bdc=120;//DC CE current gain beta
Bac=130;//AC CE current gain beta
VT=25D-3;//voltage equivalent of temperature in volts
Vs=5D-3;//source rms voltage in volts
Rs=600;//source internal impedance in ohms
re=5;//equivalent BJT model emitter resistance in ohms
RL=6.8D3;//load resistance in ohms
C2=50D-6;//emitter bypass capacitance in farads

//Solution

disp("(i)");
RL_dash=RC*RL/(RC+RL);//a.c. value of collector resistance in ohms
Gv=RL_dash/re;//a.c. voltage gain
printf("A.C. Voltage gain Gv = %.1f\n",Gv);

```

```
disp("(ii)");
Rin_dash=Bac*(RE+re);//internal resistance of BJT in
    ohms
Rin=1/(1/R1+1/R2+1/Rin_dash);//total internal
    resistance is Rin=R1||R2||Rin'
f=Rin/(Rs+Rin);//input attenuation factor
Gv_dash=f*Gv;//overall a.c. voltage gain
printf("Overall A.C. Voltage gain Gv'' = %.1f\n",
    Gv_dash);

//gain deviation due to approximations in textbook
```

Scilab code Exa 6.6 Calculation of output voltage for given circuit

```
//Tested on Windows 7 Ultimate 32-bit
//Chapter 6 Single Staje BJT Amplifiers Pg no.
    193,194 and 195
clear;
clc;

//Given Data
//Figure 6.18,6.19,6.20

VCC=15;//collector supply voltage in volts
RC=5.6D3;//collector resistance in ohms
RE0=390;//unbypassed emitter resistance in ohms
RE1=390;//bypased emitter resistance in ohms
R1=33D3;//divider network resistance R1 in ohms
R2=4.7D3;//divider network resistance R2 in ohms
VBE=0.7;//forward voltage drop of emitter diode in
    volts
Bdc=140;//DC CE current gain beta
Bac=160;//AC CE current gain beta
```

```
VT=25D-3;//voltage equivalent of temperature in volts
Vs=15D-3;//source rms voltage in volts
Rs=600;//source internal impedance in ohms
RL=68D3;//load resistance in ohms
C1=10D-6;//input coupling capacitance in farads
C2=50D-6;//emitter bypass capacitance in farads
C3=10D-6;//output coupling capacitance in farads


//Solution

//DC analysis
Rin_dc=Bdc*(RE0+RE1);//dc input resistance in ohms
if 0.1*Rin_dc>R2 then
    VB=VCC*R2/(R1+R2);//base to ground voltage in volts , since Rin>10*R2 it can be neglected
end
VE=VB-VBE;//emitter to ground voltage in volts
IE=VE/(RE0+RE1);//emitter current in amperes
IC=IE;//collector current is approximately equal to emitter current
VC=VCC-IC*RC;//collector to ground voltage in volts

//AC analysis
re=VT/IE;//equivalent BJT model emitter resistance in ohms
Rin_dash=Bac*(RE0+re);//internal resistance of BJT in ohms
Rin=1/(1/R1+1/R2+1/Rin_dash);//total internal resistance is Rin=R1||R2||Rin'
f=Rin/(Rs+Rin);//input attenuation factor
RL_dash=1/(1/RC+1/RL);//effective load resistance
Gv=RL_dash/(re+RE0);//a.c. voltage gain
Gv_dash=f*Gv;//overall a.c. voltage gain
vc=Gv_dash*Vs;//a.c voltage at collector in volts
printf("Output voltage will be a.c. signal of amplitude %d mV \nCollector voltage will be the
```

```
    same voltage mounted on a d.c. level of %.1f
    Volts",vc*1000,VC);
//plotting the curves
t=0:0.01:2*3.14;//one period
y1=VC+vc*sin(t);//total collector voltage
y2=vc*1000*sin(t);//output voltage

subplot(2,1,1);
plot(y1);
title("(a)Collector Voltage");
ylabel("Vc (volts)");
xlabel("time period");

subplot(2,1,2);
plot(y2);
title("(b)Output Voltage");
ylabel("Vc (milli-volts)");
xlabel("time period");
```

Scilab code Exa 6.7 Calculation of output voltage for given value of load resistances

```
//Tested on Windows 7 Ultimate 32-bit
//Chapter 6 Single Staje BJT Amplifiers Pg no. 195
    and 196
clear;
clc;

//Given Data
//Figure 6.18,6.19,6.20

VCC=15;//collector supply voltage in volts
RC=5.6D3;//collector resistance in ohms
RE0=390;//unbypassed emitter resistance in ohms
RE1=390;//bypased emitter resistance in ohms
```

```
R1=33D3;//divider network resistance R1 in ohms
R2=4.7D3;//divider network resistance R2 in ohms
VBE=0.7;//forward voltage drop of emitter diode in volts
Bdc=140;//DC CE current gain beta
Bac=160;//AC CE current gain beta
VT=25D-3;//voltage equivalent of temperature in volts
Vs=15D-3;//source rms voltage in volts
Rs=600;//source internal impedance in ohms
C1=10D-6;//input coupling capacitance in farads
C2=50D-6;//emitter bypass capacitance in farads
C3=10D-6;//output coupling capacitance in farads
RL=[3.3D3 10D3 33D3 100D3 500D3 %inf] ;//load resistances in ohms


//Solution

for i=1:6

printf("Case (%d)\n RL = %.1f kilo-ohms\n",i,RL(i)/1000);
Rin_dc=Bdc*(RE0+RE1);//dc input resistance in ohms
if 0.1*Rin_dc>R2 then
    VB=VCC*R2/(R1+R2);//base to ground voltage in volts , since Rin>10*R2 it can be neglected
end
VE=VB-VBE;//emitter to ground voltage in volts
IE=VE/(RE0+RE1);//emitter current in amperes
IC=IE;//collector current is approximately equal to emitter current
VC=VCC-IC*RC;//collector to ground voltage in volts
re=VT/IE;//equivalent BJT model emitter resistance in ohms
Rin_dash=Bac*(RE0+re);//internal resistance of BJT in ohms
Rin=1/(1/R1+1/R2+1/Rin_dash);//total internal
```

```
    resistance is Rin=R1||R2||Rin'
f=Rin/(Rs+Rin);//input attenuation factor
if RL(i)==%inf then
    RL_dash=RC;//effective load resistance
else
    RL_dash=1/(1/RC+1/RL(i));//effective load
        resistance
end
Gv=RL_dash/(re+RE0);//a.c. voltage gain
Gv_dash=f*Gv;//overall a.c. voltage gain
vc=Gv_dash*Vs;//a.c voltage at collector in volts

printf("Output voltage vc = %.2f mV\n",vc*1000);
end

//error in answers in textbook due to approximations
```

Scilab code Exa 6.8 Calculation of current gain and power gain for given circuit

```
//Tested on Windows 7 Ultimate 32-bit
//Chapter 6 Single Staje BJT Amplifiers Pg no. 197
clear;
clc;

//Given Data
//Figure 6.18,6.19,6.20

VCC=15;//collector supply voltage in volts
RC=5.6D3;//collector resistance in ohms
RE0=390;//unbypassed emitter resistance in ohms
RE1=390;//bypased emitter resistance in ohms
R1=33D3;//divider network resistance R1 in ohms
R2=4.7D3;//divider network resistance R2 in ohms
VBE=0.7;//forward voltage drop of emitter diode in
```

```
volts
Bdc=140;//DC CE current gain beta
Bac=160;//AC CE current gain beta
VT=25D-3;//voltage equivalent of temperature in volts
Vs=15D-3;//source rms voltage in volts
Rs=600;//source internal impedance in ohms
C1=10D-6;//input coupling capacitance in farads
C2=50D-6;//emitter bypass capacitance in farads
C3=10D-6;//output coupling capacitance in farads
RL=68D3;//load resistance in ohms

//Solution

Rin_dc=Bdc*(RE0+RE1);//dc input resistance in ohms
if 0.1*Rin_dc>R2 then
    VB=VCC*R2/(R1+R2);//base to ground voltage in volts , since Rin>10*R2 it can be neglected
end
VE=VB-VBE;//emitter to ground voltage in volts
IE=VE/(RE0+RE1);//emitter current in amperes
IC=IE;//collector current is approximately equal to emitter current
VC=VCC-IC*RC;//collector to ground voltage in volts

re=VT/IE;//equivalent BJT model emitter resistance in ohms
Rin_dash=Bac*(RE0+re);//internal resistance of BJT in ohms
Rin=1/(1/R1+1/R2+1/Rin_dash);//total internal resistance is Rin=R1||R2||Rin'
Vb=Rin/(Rs+Rin)*Vs;//signal voltage at base in volts
Ib=Vb/Rin_dash;//base current due to source
Is=Vs/(Rin+Rs);//current driven from source in amperes
Ic=Bac*Ib;//collector a.c. current
Gi_dash=Ic/Is;//overall a.c. current gain
RL_dash=RC*RL/(RC+RL);//a.c. value of collector
```

```
    resistance in ohms
Gv=RL_dash/re;//a.c. voltage gain
f=Rin/(Rs+Rin);//input attenuation factor
Gv_dash=f*Gv;//overall a.c. voltage gain
Gp_dash=Gv_dash*Gi_dash;//a.c. power gain

printf("Current gain Gi'' = %.2f and power gain Gp''
     = %.2f",Gi_dash,Gp_dash);


//error in calculation and missing calculation of
    power gain in textbook
```

Scilab code Exa 6.9 Calculations of specific gains and impedances for given CC amplifier

```
//Tested on Windows 7 Ultimate 32-bit
//Chapter 6 Single Staje BJT Amplifiers Pg no. 200
clear;
clc;

//Given Data
//Figure 6.25

VCC=15;//collector supply voltage in volts
RE=1.5D3;//emitter resistance in ohms
R1=12D3;//divider network resistance R1 in ohms
R2=10D3;//divider network resistance R2 in ohms
VBE=0.7;//forward voltage drop of emitter diode in
    volts
Bac=150;//AC CE current gain beta
VT=25D-3;//voltage equivalent of temperature in
    volts
Vs=1;//input rms a.c. voltage in volts
Rs=600;//source internal impedance in ohms
```

```
RL=12D3;//load resistance in ohms

//Solution

Req=RE*RL/(RE+RL);//equivalent output resistance in ohms
Rin_dash=Bac*Req;//base input resistance
Rin=1/(1/R1+1/R2+1/Rin_dash);//total input resistance in ohms
VB=VCC*R2/(R1+R2);//d.c. base to ground voltage in volts
VE=VB-VBE;//d.c. emitter to ground voltage in volts
IE=VE/RE;//d.c. emitter current in amperes
re=VT/IE;//equivalent BJT model emitter resistance in ohms
Gv=Req/(Req+re);//voltage gain of CC configuration
Ie=Gv*Vs/Req;//a.c. emitter current in amperes
Iin=Vs/Rin;//a.c. input current in amperes
Gi=Ie/Iin;//a.c. current gain
Gp=Gi*Gv;//a.c. power gain
printf("Voltage gain Gv = %.3f\n Current gain Gi = %.2f\n Power gain Gp = %.2f\n Total input resistance Rin = %.2f kilo-ohms",Gv,Gi,Gp,Rin/1000);

//decimal errors in textbook due to approximations
```

Scilab code Exa 6.10 Calculations of specific gains and impedances for given CB amplifier

```
//Tested on Windows 7 Ultimate 32-bit
//Chapter 6 Single Staje BJT Amplifiers Pg no. 202 and 203
clear;
clc;
```

```

//Given Data
//Figure 6.28

VCC=12;//collector supply voltage in volts
RC=1.5D3;//collector resistance in ohms
RE=1.5D3;//emitter resistance in ohms
R1=82D3;//divider network resistance R1 in ohms
R2=18D3;//divider network resistance R2 in ohms
VBE=0.7;//forward voltage drop of emitter diode in volts
VT=25D-3;//voltage equivalent of temperature in volts
RL=15D3;//load resistance in ohms

//Solution

VB=VCC*R2/(R1+R2);//d.c. base to ground voltage in volts
VE=VB-VBE;//d.c. emitter to ground voltage in volts
IE=VE/RE;//d.c. emitter current in amperes
re=VT/IE;//equivalent BJT model emitter resistance in ohms
Rin=re;//total input resistance in ohms
RL_dash=RC*RL/(RC+RL);//equivalent output resistance in ohms
Gv=RL_dash/re;//voltage gain of CC configuration
Gi=1;//current gain for a CB amplifier is almost equal to unity
Gp=Gi*Gv;//a.c. power gain
printf("Voltage gain Gv = %.1f\n Current gain Gi = %d\n Power gain Gp = %.1f\n Total input resistance Rin = %.2f ohms",Gv,Gi,Gp,Rin);
```

Scilab code Exa 6.11 Calculation of current gain for a superbeta transistor

```
//Tested on Windows 7 Ultimate 32-bit
//Chapter 6 Single Staje BJT Amplifiers Pg no. 204
clear;
clc;

//Given Data

B=190;//current gain of single transistor

//Solution

Bac=B^2;//current gain of superbeta transistor if B
    is the gain of each of the employed transistor
printf("Bac = %d",Bac);
```

Scilab code Exa 6.12 Calculation dc bias voltages and currents for given circuits

```
//Tested on Windows 7 Ultimate 32-bit
//Chapter 6 Single Staje BJT Amplifiers Pg no. 205
clear;
clc;

//Given Data
//Figure 6.31

VCC=18;//collector supply voltage in volts
RB=3.9D6;//base resistance in ohms
RE=470;//emitter resistance in ohms
VBE=1.6;//forward voltage drop of emitter diode of
    darlington pair in volts
Bac=10000;//DC current gain beta for darlington pair
```

```
//Solution

IB=(VCC-VBE)/(RB+Bac*RE);//base current in amperes
IE=Bac*IB;//emitter current in amperes
IC=IE;//collector current is almost equal to emitter
    current
VE=IE*RE;//emitter to ground voltage in volts
VB=VE+VBE;//base to ground voltage in volts
printf("IB = %.2f   A \n ",IB*10^6);
printf("IE = %.1f mA\n ",IE*10^3);
printf("IC = %.1f mA\n ",IC*10^3);
printf("VE = %.2f Volts\n ",VE);
printf("VB = %.2f Volts\n ",VB);

//error in calculation in textbook for VB
```

Scilab code Exa 6.13 Calculation of input impedances for given circuit

```
//Tested on Windows 7 Ultimate 32-bit
//Chapter 6 Single Staje BJT Amplifiers Pg no. 207
clear;
clc;

//Given Data
//Figure 6.31

VCC=18;//collector supply voltage in volts
RB=3.9D6;//base resistance in ohms
RE=470;//emitter resistance in ohms
VBE=1.6;//forward voltage drop of emitter diode of
   darlington pair in volts
Bac=10000;//DC current gain beta for darlington pair
ri=6D3;//emitter diode forward resistance

```

```
//Solution

Zin=1/(1/RB+1/(ri+Bac*RE));//input impedance of the circuit
printf("Zin = %.3f Mega-ohms",Zin/10^6);
```

Scilab code Exa 6.14 Calculation of base current and ac current gain for given circuit

```
//Tested on Windows 7 Ultimate 32-bit
//Chapter 6 Single Staje BJT Amplifiers Pg no. 207
clear;
clc;

//Given Data
//Figure 6.31

VCC=18;//collector supply voltage in volts
RB=3.9D6;//base resistance in ohms
RE=470;//emitter resistance in ohms
VBE=1.6;//forward voltage drop of emitter diode of darlington pair in volts
Bac=10000;//DC current gain beta for darlington pair

//Solution

Gi=RB/(RE+RB/Bac);//a.c. circuit current gain
printf("Gi = %d",Gi);

//error in question as base current can not be obtained without an input also not solved in textbook
```

Scilab code Exa 6.15 Calculation of ac output impedances and voltage gain for given circuit

```
//Tested on Windows 7 Ultimate 32-bit
//Chapter 6 Single Staje BJT Amplifiers Pg no. 207
clear;
clc;

//Given Data
//Figure 6.31

VCC=18;//collector supply voltage in volts
RB=3.9D6;//base resistance in ohms
RE=470;//emitter resistance in ohms
VBE=1.6;//forward voltage drop of emitter diode of
    darlington pair in volts
Bac=10000;//DC current gain beta for darlington pair
ri=6D3;//emitter forward resistance of darlington
    pair

//Solution

Zout=1/(1/RE+1/ri+1/(ri/Bac));//output impedance of
    the overall circuit in ohms
Gv=(RE+Bac*RE)/(ri+RE+Bac*RE);//a.c. voltage gain
printf("Zout = %.1f ohms\n ",Zout);
printf("Gv = %.4f",Gv);
```

Chapter 7

Field Effect Transistors

Scilab code Exa 7.1 Calculation of drain current for given circuit specifications

```
//Tested on Windows 7 Ultimate 32-bit
//Chapter 7 Field Effect Transistors Pg no. 220
clear;
clc;

//Given Data
//Figure 7.7

IDSS=15D-3;//drain saturation current in amperes
VGS_cutoff=-5;//gate to source cutoff voltage in volts
RD=300;//drain resistance in ohms

//Solution

VP=-VGS_cutoff;//pinch-off voltage in volts
VDS=VP;//drain to source voltage in volts should be equal to VP or more than that for constant current region
VGS=0;//gate to source voltage in volts
```

```
ID=IDSS;//drain current in amperes is saturation current because VGS=0 volts
VRD=ID*RD;//voltage drop across resistor
VD_dash_min=VRD+VDS;//minimum source voltage required for constant current region in volts
printf("Minimum VD'' required to place JFET into constant current region = %.1f Volts\n ",VD_dash_min);
VD_dash=15;//given value of VD'
if VD_dash>VD_dash_min then
    ID=IDSS;//drain current in equal to saturation current
end
printf("Drain current for VD'' = %d Volts , ID = %d mA\n And increased voltage will appear as drop in drain source terminals.",VD_dash,ID*1000);
```

Scilab code Exa 7.2 Calculation of drain current and transconductance for given circuit specifications

```
//Tested on Windows 7 Ultimate 32-bit
//Chapter 7 Field Effect Transistors Pg no. 224
clear;
clc;

//Given Data

IDSS=30D-3;//drain saturation current in amperes
VGS_cutoff=-10;//gate to source cutoff voltage in volts
gm0=5000D-6;//transconductance at VGS=0 Volts in Siemens
VGS=-5;//gate to source voltage in volts

//Solution
```

```

gm=gm0*(1-VGS/VGS_cutoff);//transconductance for given VGS in Siemens
ID=IDSS*(1-VGS/VGS_cutoff)^2;//drain current for given VGS in amperes
printf("gm = %d   S \n ",gm*10^6);
printf("ID = %.1f mA",ID*10^3);

//calculation of gm is incorrect in textbook as gm0 =5000  S and not 500  S
```

Scilab code Exa 7.3 Calculation of drain current and transconductances for given circuit specifications

```
//Tested on Windows 7 Ultimate 32-bit
//Chapter 7 Field Effect Transistors Pg no. 224 and 225
clear;
clc;

//Given Data

IDSS=10D-3;//drain saturation current in amperes
VP=6;//pinch-off voltage in volts
VGS=-3;//gate to source voltage in volts

//Solution

disp("(i)");
ID=IDSS*(1-VGS/(-VP))^2;//drain current for given VGS in amperes
printf("ID = %.1f mA",ID*10^3);

disp("(ii)");
gm0=-2*IDSS/(-VP);//transconductance for VGS=0 Volts
```

```
in Siemens
printf("gm0 = %.2f mS",gm0*10^3);

disp("(iii)");
gm=gm0*(1-VGS/(-VP));//transconductance for given VGS in Siemens
printf("gm = %.2f mS",gm*10^3);
```

Scilab code Exa 7.4 Calculation of drain current for given circuit specifications

```
//Tested on Windows 7 Ultimate 32-bit
//Chapter 7 Field Effect Transistors Pg no. 225
clear;
clc;

//Given Data

IDSS=15D-3;//drain saturation current in amperes
gm0=5D-3;//transconductance for VGS=0 Volts in Siemens
gm=2.5D-3;//transconductance in Siemens

//Solution

ID=IDSS*(gm/gm0)^2;//drain current in amperes
printf("ID = %.2f mA",ID*10^3);
```

Scilab code Exa 7.5 Calculation of circuit parameters for given circuit

```
//Tested on Windows 7 Ultimate 32-bit
//Chapter 7 Field Effect Transistors Pg no. 227
clear;
```

```
clc;

//Given Data
//Figure 7.14

VDD=15;//drain supply voltage in volts
IDSS=15D-3;//drain saturation current in amperes
VP=-6;//pinchoff voltage in volts
RD=1D3;//drain resistance in ohms
RG=2D6;//gate resistance in ohms
VGG=1.5;//gate supply voltage in volts

//Solution

disp("(i)");
VGS_Q=-VGG;//quiscent gate to source voltage in volts (since gate current is zero and drop across RG=0 Volts)
printf("VGS_Q = %.1f Volts",VGS_Q);

disp("(ii)");
IDQ=IDSS*(1-VGS_Q/VP)^2;//quiscent drain current in amperes
printf("IDQ = %.3f mA",IDQ*10^3);

disp("(iii)");
VDS=VDD-IDQ*RD;//drain to source voltage in volts
printf("VDS = %.3f Volts",VDS);

disp("(iv)");
VD=VDS;//drain to ground voltage in volts (since source is grounded)
printf("VD = %.3f Volts",VD);

disp("(v)");
VG=VGS_Q;//gate to ground voltage in volts (since source is grounded)
printf("VG = %.1f Volts",VG);
```

```

disp("(vi)");
VS=0;//source to ground voltage in volts (since source is grounded)
printf("VS = %d Volts",VS);
```

Scilab code Exa 7.6 Calculation of circuit parameters for given circuit

```
//Tested on Windows 7 Ultimate 32-bit
//Chapter 7 Field Effect Transistors Pg no. 229
clear;
clc;

//Given Data
//Figure 7.16

VDD=15;//drain supply voltage in volts
IDSS=10D-3;//drain saturation current in amperes
VP=-6;//pinchoff voltage in volts
RD=1D3;//drain resistance in ohms
RG=2D6;//gate resistance in ohms
RS=1D3;//source resistance in ohms

//Solution

disp("(i)");
ID_A=5D-3;ID_B=3D-3;//assuming two currents below and above the characteristic curve
VGS_A=ID_A*RS;VGS_B=ID_B*RS;//calculating corresponding gate to source voltages in volts
//constructing a line joining A and B. It intersects characteristic curve at Q point VGS_Q
VGS_Q=-3.2;//quiscent gate to source voltage in volts (solved using characteristic graph)
printf("VGS_Q = %.1f Volts",VGS_Q);
```

```
disp("(ii)");
IDQ=-VGS_Q/RS;//quiscent drain current in amperes
printf("IDQ = %.1f mA",IDQ*10^3);

disp("(iii)");
VDS=VDD-IDQ*(RD+RS);//drain to source voltage in volts
printf("VDS = %.1f Volts",VDS);

disp("(iv)");
VS=IDQ*RS;//source to ground voltage in volts
printf("VS = %.1f Volts",VS);

disp("(v)");
VG=0;//gate to ground voltage in volts (since gate current is almost zero,drop across RG is zero)
printf("VG = %d Volts",VG);

disp("(vi)");
VD=VDD-IDQ*RD;//drain to ground voltage in volts (since source is grounded)
printf("VD = %.1f Volts",VD);

//error in calculations in textbook as values are not taken as per the figure
```

Scilab code Exa 7.7 Calculation of circuit parameters for given circuit

```
//Tested on Windows 7 Ultimate 32-bit
//Chapter 7 Field Effect Transistors Pg no. 230 and 231
clear;
clc;

```

```
//Given Data
//Figure 7.18 and 7.19

VDD=18;//drain supply voltage in volts
IDSS=12D-3;//drain saturation current in amperes
VP=-2;//pinchoff voltage in volts
RD=1172;//drain resistance in ohms
RS=1028;//source resistance in ohms
VSS=9;//source supply voltage in volts

//Solution

disp("(i)");
VGS_a=9;//for ID=0 mA VGS=VSS volts
ID_a=8.754D-3;//for VGS=0 volts ID=VSS/RS amperes0
//a load line is constructed using these values and the intersection with charecteristic curve gives Q point
IDQ=9D-3;//quiscent drain current found graphically in amperes
printf("IDQ = %d mA",IDQ*10^3);

disp("(ii)");
VGS_Q=-0.25;//quiscent gate to source voltage in volts found graphically
printf("VGS_Q = %.2f Volts",VGS_Q);

disp("(iii)");
VDS=VDD-IDQ*(RD+RS)+VSS;//drain to source voltage in volts
printf("VDS = %.1f Volts",VDS);

disp("(iv)");
VD=VDD-IDQ*RD;//drain to ground voltage in volts (since source is grounded)
printf("VD = %.2f Volts",VD);

disp("(v)");
```

```
VS=VD-VDS;//source to ground voltage in volts
printf("VS = %.2f Volts",VS);
```

Scilab code Exa 7.8 Calculation of circuit parameters for given circuit

```
//Tested on Windows 7 Ultimate 32-bit
//Chapter 7 Field Effect Transistors Pg no. 232,233 and 234
clear;
clc;

//Given Data
//Figure 7.23 and 7.24

VDD=18;//drain supply voltage in volts
IDSS=10D-3;//drain saturation current in amperes
VP=-5;//pinchoff voltage in volts
RD=1.5D3;//drain resistance in ohms
RS=1D3;//source resistance in ohms
R1=1.5D6;//divider network resistance R1 in ohms
R2=180D3;//divider network resistance R2 in ohms
C1=5D-6;//gate coupling capacitance in farads
C2=25D-6;//source bypass capacitance in farads
C3=15D-6;//drain coupling capacitance in farads

//Solution

disp("(i)");
VG=VDD*R2/(R1+R2);//gate to ground voltage in volts
VGS_a=1.93;//for ID=0 mA VGS=VSS volts
ID_a=1.93D-3;//for VGS=0 volts ID=VG/RS amperes0
//a load line is constructed using these values and the intersection with charecteristic curve gives Q point
IDQ=3.64D-3;//quiscent drain current found
```

```
    graphically in amperes
printf("IDQ = %.2f mA",IDQ*10^3);

disp("(ii)");
VGS_Q=-1.85;//quiscent gate to source voltage in
    volts found graphically
printf("VGS_Q = %.2f Volts",VGS_Q);

disp("(iii)");
VD=VDD-IDQ*RD;//drain to ground voltage in volts (
    since source is grounded)
printf("VD = %.2f Volts",VD);

disp("(iv)");
VS=IDQ*RS;//source to ground voltage in volts
printf("VS = %.2f Volts",VS);

disp("(v)");
VDS=VDD-IDQ*(RD+RS);//drain to source voltage in
    volts
printf("VDS = %.1f Volts",VDS);
```

Scilab code Exa 7.9 Calculation of voltage gain for given circuit parameters

```
//Tested on Windows 7 Ultimate 32-bit
//Chapter 7 Field Effect Transistors Pg no. 237
clear;
clc;

//Given Data

gm=5D-3;//transconductance in Siemens
RD=1D3;//drain resistance in ohms
rd=7D3;//AC drain resistance in ohms
```

```
//Solution

GV=gm*RD*rd/(RD+rd);//voltage gain
printf("GV = %.3f",GV);
```

Scilab code Exa 7.10 Calculation of voltage gain for given circuit parameters

```
//Tested on Windows 7 Ultimate 32-bit
//Chapter 7 Field Effect Transistors Pg no. 237 and
   238
clear;
clc;

//Given Data

gm=5D-3;//transconductance in Siemens
RD=1D3;//drain resistance in ohms

//Solution

GV=gm*RD;//voltage gain
printf("GV = %d",GV);
```

Scilab code Exa 7.11 Calculation of voltage gain for given circuit parameters

```
//Tested on Windows 7 Ultimate 32-bit
//Chapter 7 Field Effect Transistors Pg no. 238
clear;
clc;

```

```
//Given Data
//Figure 7.30

gm=5D-3;//transconductance in Siemens
RD=1.2D3;//drain resistance in ohms
RS=330;//source resistance in ohms

//Solution

GV=gm*RD/(1+gm*RS);//voltage gain
printf("GV = %.2f",GV);
```

Scilab code Exa 7.12 Calculation of voltage gain for given circuit parameters

```
//Tested on Windows 7 Ultimate 32-bit
//Chapter 7 Field Effect Transistors Pg no. 241
clear;
clc;

//Given Data
//Figure 7.31

gm=5D-3;//transconductance in Siemens
RD=2.7D3;//drain resistance in ohms
RL=3.3D3;//load resistance in ohms

//Solution

RL_eq=RD*RL/(RD+RL);//equivalent load resistance in
    ohms
GV_dash=gm*RL_eq;//voltage gain for loaded circuit
GV=gm*RD;//voltage gain for unloaded circuit
printf("Voltage gain GV'' = %.2f\n Unloaded a.c.
    voltage gain GV = %.1f",GV_dash,GV);
```

```
//decimal approximation in textbook
```

Scilab code Exa 7.13 Calculation of circuit parameters for given circuit

```
clear;
clc;

disp("AS ON PAGE NUMBER 242");
//Tested on Windows 7 Ultimate 32-bit
//Chapter 7 Field Effect Transistors Pg no. 242,243
   and 244

//Given Data
//Figure 7.37

VGS_Q=-2.5;//quiscent gate to source voltage in
   volts
IDQ=5D-3;//quiscent drain current in amperes
VDD=12;//drain supply voltage in volts
IDSS=12D-3;//drain saturation current in amperes
VP=-5;//pinch off voltage in volts
YOS=20D-6;//AC drain admittance of JFET in Siemens
RS=1.5D3;//sourcce resistance in ohms
RG=1.5D6;//gate resistance in ohms
C1=0.1D-6;//gate coupling capacitance in farads
C2=0.1D-6;//drain coupling capacitance in farads

//Solution

disp("(i)");
gm0=2*IDSS/abs(VP);//transconductance for VGS=0
   Volts in Siemens
gm=gm0*(1-VGS_Q/VP);//transconductance in Siemens
printf("gm = %.1f mS\n",gm*10^3);
```

```

disp("(ii)");
rd=1/YOS;//AC drain resistance in ohms
printf("rd = %d kilo ohms\n",rd/10^3);

disp("(iii)");
Zin=RG;//input impedance in ohms
printf("Zin = %.1f Mega-ohms\n",Zin/10^6);

disp("(iv)");
Zout=1/(1/rd+1/RS+gm);//output impedance with rd connected in ohms
printf("Zout with rd = %d ohms\n",Zout);
Zout_dash=1/(1/RS+gm);//output impedance with rd disconnected in ohms
printf("Zout without rd = %.2f ohms\n",Zout_dash);

disp("(v)");
GV=gm*rd*RS/(rd+RS+gm*rd*RS);//voltage gain with rd connected
printf("GV with rd = %.2f\n",GV);
GV_dash=gm*RS/(1+gm*RS);//voltage gain with rd disconnected
printf("GV without rd = %.3f\n",GV_dash);

//decimal approximations in textbook

disp("AS ON PAGE NUMBER 245");

//Tested on Windows 7 Ultimate 32-bit
//Chapter 7 Field Effect Transistors Pg no. 245 and 246

//Given Data
//Figure E7.13

VDD=12;//drain supply voltage in volts
gm=4000D-6;//transconductance in Siemens
```

```
YOS=20D-6;//AC drain admittance of JFET in Siemens
RS=2.2D3;//sourcce resistance in ohms
RD=5D3;//drain resistance in ohms
RL=5D3;//load resistance in ohms

//Solution

RL_dash=RD*RL/(RD+RL);//equivalent load resistance
    in ohms
GV=gm*RL_dash;//voltage gain
Rin_source=1/gm;//input resistance at source
    terminal in ohms
Rin_net=Rin_source*RS/(Rin_source+RS);//net input
    resistance in ohms
Rout=1/(1/rd+1/RD+1/RL);//output resistance in ohms
printf("Voltage gain GV = %d\n",GV);
printf("Input resistance Rin = %.1f ohms\n",Rin_net)
    ;
printf("Output resistance Rout = %.2f kilo-ohms\n",
    Rout/10^3);
```

Scilab code Exa 7.14 Calculation of drain current for given circuit specifications

```
//Tested on Windows 7 Ultimate 32-bit
//Chapter 7 Field Effect Transistors Pg no. 251
clear;
clc;

//Given Data

IDSS=15D-3;//drain saturation current in amperes
VGS0=-6;//gate to source cutoff voltage in volts
VGS_1=-2;//gate to source voltage in volts
VGS_2=2;//gate to source voltage in volts
```

```
//Solution

ID_1=IDSS*(1-VGS_1/VGS0)^2;//drain current for VGS_1
    in amperes
ID_2=IDSS*(1-VGS_2/VGS0)^2;//drain current for VGS_2
    in amperes
printf("For VGS = %d Volts\nID = %.2f mA\n\n",VGS_1,
   ID_1*10^3);
printf("For VGS = %d Volts\nID = %.2f mA\n\n",VGS_2,
   ID_2*10^3);

//decimal are rounded off here
```

Scilab code Exa 7.15 Determination of n channel or p channel D MOSFET using circuit specifications

```
//Tested on Windows 7 Ultimate 32-bit
//Chapter 7 Field Effect Transistors Pg no. 251 and
   252
clear;
clc;

//Given Data

IDSS=20D-3;//drain saturation current in amperes
VGS0=6;//gate to source cutoff voltage in volts
VGS_1=3;//gate to source voltage in volts
VGS_2=-3;//gate to source voltage in volts

//Solution

ID_1=IDSS*(1-VGS_1/VGS0)^2;//drain current for VGS_1
    in amperes
ID_2=IDSS*(1-VGS_2/VGS0)^2;//drain current for VGS_2
```

```
in amperes
printf("For VGS = %d Volts\nID = %d mA\n\n",VGS_1,ID_1*10^3);
printf("For VGS = %d Volts\nID = %d mA\n\n",VGS_2,ID_2*10^3);
if VGS0>0 then
    printf("Since VGS0 is positive,this is an p-channel MOSFET");
else
    printf("Since VGS0 is negative,this is an n-channel MOSFET");
end
```

Scilab code Exa 7.16 Calculation of VGS and VDS for given circuit parameters

```
//Tested on Windows 7 Ultimate 32-bit
//Chapter 7 Field Effect Transistors Pg no. 253
clear;
clc;

//Given Data
//Figure 7.47

ID_ON=5D-3;//ON drain current in amperes
VGS_th=5;//threshold gate to source voltage in volts
VGS=9;//gate to source voltage in volts
VDD=20;//drain supply voltage in volts
RD=1D3;//drain resistance in ohms
R1=2.2D3;//voltage divider network resistance R1 in ohms
R2=3.3D3;//voltage divider network resistance R2 in ohms

//Solution
```

```
VGS_Q=VDD*R2/(R1+R2);//gate to source voltage in
    volts
C=ID_ON/(VGS-VGS_th)^2;//constant C in ampere/volt^2
ID=C*(VGS_Q-VGS_th)^2;//drain current in amperes
VDS=VDD-ID*RD;//drain to source voltage in volts
printf("VGS = %d Volts\n VDS = %.2f Volts",VGS_Q,VDS
    );
```

Scilab code Exa 7.17 Calculation of VDS for given D MOSFET circuit parameters

```
//Tested on Windows 7 Ultimate 32-bit
//Chapter 7 Field Effect Transistors Pg no. 254 and
    255
clear;
clc;

//Given Data
//Figure 7.50

IDSS=15D-3;//drain saturation current in amperes
VGS0=-6;//cut-off gate to source voltage in volts
VDD=20;//drain supply voltage in volts
RD=470;//drain resistance in ohms
RG=8.2D6;//gate resistance in ohms

//Solution

ID=IDSS;//drain current in amperes
VDS=VDD-ID*RD;//drain to source voltage in volts
printf("VDS = %.2f Volts",VDS);
```

Scilab code Exa 7.18 Calculation of VDS for given E MOSFET circuit parameters

```
//Tested on Windows 7 Ultimate 32-bit
//Chapter 7 Field Effect Transistors Pg no. 255 and
   256
clear;
clc;

//Given Data
//Figure 7.49(b)

R1=8.2D3;//divider network resistance R1 in ohms
R2=15D3;//divider network resistance R2 in ohms
RD=680;//drain resistance in ohms
RS=0;//source resistance in ohms
VDD=20;//drain supply voltage in volts
ID_ON=2D-3;//ON drain current in amperes
VGS=10;//gate to source voltage in volts
VGS_th=5;//threshold voltage in volts

//Solution

VGS_Q=VDD*R2/(R1+R2);//gate to source voltage in
   volts
C=ID_ON/(VGS-VGS_th)^2;//constant C in ampere/volt^2
ID=C*(VGS_Q-VGS_th)^2;//drain current in amperes
VDS=VDD-ID*RD;//drain to source voltage in volts
printf("VDS = %.2f Volts",VDS);
```

Scilab code Exa 7.19 Calculation of VDS for given circuit parameters

```
//Tested on Windows 7 Ultimate 32-bit
//Chapter 7 Field Effect Transistors Pg no. 255 and
   256
```

```
clear;
clc;

//Given Data
//Figure 7.49(b)

R1=8.2D3;//divider network resistance R1 in ohms
R2=15D3;//divider network resistance R2 in ohms
RD=680;//drain resistance in ohms
RS=0;//source resistance in ohms
VDD=20;//drain supply voltage in volts
ID_ON=2D-3;//ON drain current in amperes
VGS=10;//gate to source voltage in volts
VGS_th=5;//threshold voltage in volts

//Solution

VGS_Q=VDD*R2/(R1+R2);//gate to source voltage in
    volts
C=ID_ON/(VGS-VGS_th)^2;//constant C in ampere/volt^2
ID=C*(VGS_Q-VGS_th)^2;//drain current in amperes
VDS=VDD-ID*RD;//drain to source voltage in volts
printf("VDS = %.2f Volts",VDS);
```

Chapter 8

Power Amplifiers

Scilab code Exa 8.1 Calculation of maximum collector current for given VCC and PD

```
//Tested on Windows 7 Ultimate 32-bit
//Chapter 8 Power Amplifiers Pg no. 267
clear;
clc;

//Given Data

VCC=15;//battery voltage in volts
P_OUT=5;//output power in watts

//Solution

IC_MAX=P_OUT/VCC;//maximum collector current in
    amperes
printf("Maximum collector current IC = %d mA",IC_MAX
    *10^3);
```

Scilab code Exa 8.2 Calculation of ac output voltage and current for given circuit

```
//Tested on Windows 7 Ultimate 32-bit
//Chapter 8 Power Amplifiers Pg no. 267,268 and 269
clear;
clc;

//Given Data

p_out=32;//output power of speaker in watts
Z_speaker=8;//impedance of speaker in ohms

//Solution

v_out=sqrt(p_out*Z_speaker);//output a.c. voltage in
    volts
i_out=v_out/Z_speaker;//output a.c. current in
    amperes
printf("The a.c. output voltage V = %d Volts\n The a
    .c. output current I = %d Amperes",v_out,i_out);
```

Scilab code Exa 8.3 Calculation of effective resistance at primary of transformer

```
//Tested on Windows 7 Ultimate 32-bit
//Chapter 8 Power Amplifiers Pg no. 271 and 272
clear;
clc;

//Given Data

k=10;//turn ratio of transformer
RL=8;//load resistance in ohms

```

```
//Solution

RL_eq=k^2*RL;//equivalent resistance at primary in
    ohms
printf("RL'' = %d ohms",RL_eq);
```

Scilab code Exa 8.4 Calculation of turns ratio of a transformer for given parameters

```
//Tested on Windows 7 Ultimate 32-bit
//Chapter 8 Power Amplifiers Pg no. 272
clear;
clc;

//Given Data

RL=8;//load resistance in ohms
RL_eq=5D3;//equivalent resistance at primary in ohms

//Solution

k=sqrt(RL_eq/RL);//turns ratio N1/N2
printf("N1:N2 = %d:1",k);
```

Scilab code Exa 8.5 Calculation of power parameters and efficiency of transistor

```
//Tested on Windows 7 Ultimate 32-bit
//Chapter 8 Power Amplifiers Pg no. 277,278 and 279
clear;
clc;

//Given Data
```

```
//Figure 8.13

VCC=20;//collector supply voltage in volts
RC=270;//collector resistance in ohms
RE=150;//emitter resistance in ohms
R1=3.3D3;//divider network resistance R1 in ohms
R2=1.5D3;//divider network resistance R2 in ohms
VBE=0.7;//forward voltage drop of emitter diode in volts
B=100;//DC CE current gain beta
RL=470;//load resistance in ohms
C1=15D-6;//input coupling capacitance in farads
C2=15D-6;//output coupling capacitance in farads

//Solution

VB=VCC*R2/(R1+R2);//base to ground voltage in volts
VE=VB-VBE;//emitter to ground voltage in volts
IE=VE/RE;//emitter current in amperes
ICQ=IE;//neglecting base current, collector current is equal to emitter current in amperes
VC=VCC-ICQ*RC;//collector to ground voltage in volts
VCEQ=VC-VE;//collector to emitter quiscent voltage in volts
PD=VCEQ*ICQ;//power dissipation in watts
RL_dash=RC*RL/(RC+RL);//equivalent a.c. load resistance in ohms
IC_sat=ICQ+VCEQ/RL_dash;//saturation collector current in amperes
VCE_cutoff=VCEQ+ICQ*RL_dash;//cutoff collector to emitter voltage in volts
Pout=0.5*ICQ^2*RL_dash;//output a.c. power in watts
e=Pout/VCC/ICQ;//efficiency of circuit = Pout/Pin(dc)
printf("(a) The minimum transistor power rating required PD = %.3f Watts\n ",PD);
printf("(b) AC output power Pout = %d milli-Watts\n",Pout*10^3);
```

```
printf("(c) Efficiency of the amplifier     = %.2f\n
   ",e);

//decimal approximation taken here in efficiency
```

Scilab code Exa 8.6 Calculation of maximum load power of amplifier

```
//Tested on Windows 7 Ultimate 32-bit
//Chapter 8 Power Amplifiers Pg no. 279
clear;
clc;

//Given Data
//Figure 8.13

VCC=20;//collector supply voltage in volts
RC=270;//collector resistance in ohms
RE=150;//emitter resistance in ohms
R1=3.3D3;//divider network resistance R1 in ohms
R2=1.5D3;//divider network resistance R2 in ohms
VBE=0.7;//forward voltage drop of emitter diode in
   volts
B=100;//DC CE current gain beta
RL=470;//load resistance in ohms
C1=15D-6;//input coupling capacitance in farads
C2=15D-6;//output coupling capacitance in farads

//Solution

VB=VCC*R2/(R1+R2);//base to ground voltage in volts
VE=VB-VBE;//emitter to ground voltage in volts
IE=VE/RE;//emitter current in amperes
ICQ=IE;//neglecting base current, collector current
   is equal to emitter current in amperes
VC=VCC-ICQ*RC;//collector to ground voltage in volts
```

```
VCEQ=VC-VE;//collector to emitter quiscent voltage in volts
RL_dash=RC*RL/(RC+RL);//equivalent a.c. load resistance in ohms
VCEQ_midpt=(VCEQ+ICQ*RL_dash)/2;//collector to emitter voltage in Q point is set at midpoint of load line
Pout_max=0.5*VCEQ_midpt^2/RL_dash;//maximum output power for amplifier
printf("Maximum value of load power Pout(max) = %d milli-Watts",Pout_max*10^3);
```

Scilab code Exa 8.7 Calculation of input and output powers and efficiency for given amplifier circuit

```
//Tested on Windows 7 Ultimate 32-bit
//Chapter 8 Power Amplifiers Pg no. 279 and 280
clear;
clc;

//Given Data
//Figure 8.15

VCC=25;//collector supply voltage in volts
RL=25;//load collector resistance in ohms
RB=1.5D3;//base resistance in ohms
VBE=0.7;//forward voltage drop of emitter diode in volts
B=50;//DC CE current gain beta
Iin=12D-3;//input peak current in amperes

//Solution

IBQ=(VCC-VBE)/RB;//base quiscent current in amperes
ICQ=B*IBQ;//collector quiscent current in amperes
```

```
VCEQ=VCC-ICQ*RL;//quiscent collector to emitter voltage in volts
Ic_p=B*Iin;//peak collector current swing in amperes
Pout_ac=Ic_p^2*RL/2;//output a.c. power in watts
Pin_dc=VCC*ICQ;//input d.c. power in watts
e=Pout_ac/Pin_dc;//efficiency of amplifier
printf("(a) Input power = %.2f Watts\n",Pin_dc);
printf("(b) Output power = %.1f Watts\n",Pout_ac);
printf("(c) Efficiency of the amplifier    = %.2f %%\n",e*100);
```

Scilab code Exa 8.8 Calculation of harmonic distortion and increase in power due to it for an amplifier

```
//Tested on Windows 7 Ultimate 32-bit
//Chapter 8 Power Amplifiers Pg no. 288
clear;
clc;

//Given Data

vin_p=2;//input signal amplitude in volts
fin=50;//input signal frequency in hertz
I1=10;I2=1.5;I3=0.70;I4=0.3;//input current nth harmonic's amplitude in amperes

//Solution

D2=I2/I1;//second harmonic distortion
D3=I3/I1;//third harmonic distortion
D4=I4/I1;//fourth harmonic distortion
disp("(a)");
printf("Second harmonic distortion D2 = %.f %%\n",D2*100);
printf("Third harmonic distortion D3 = %.f %%\n",D3
```

```
    *100);
printf("Fourth harmonic distortion D4 = %.f %%\n ",
    D4*100);

D=sqrt(D2^2+D3^2+D4^2);//distortion factor
P=D^2;//percentage increase in power
disp("(b)");
printf("Percentage increase in power = %.2f %%",P
    *100);
```

Scilab code Exa 8.9 Calculation of output power for given amplifier circuit

```
//Tested on Windows 7 Ultimate 32-bit
//Chapter 8 Power Amplifiers Pg no. 288
clear;
clc;

//Given Data
//Figure 8.23

VCC=25;//collector supply voltage in volts
RL=220;//load resistance in ohms

//Solution

PCC=VCC^2/RL;//power developed in watts
printf("Power developed in amplifier PCC = %.2f
    Watts",PCC);
```

Scilab code Exa 8.10 Calculation of maximum efficiency for an inductor coupled amplifier

```
//Tested on Windows 7 Ultimate 32-bit
//Chapter 8 Power Amplifiers Pg no. 288
clear;
clc;

//Given Data

VCC=12;//collector supply voltage in volts
RL=220;//load resistance in ohms

//Solution

PL_max=(VCC/RL)^2*RL/2;//maximum load power in watts
Pin=VCC*VCC/RL;//power delivered to load in watts
e=PL_max/Pin;//efficiency of amplifier
printf("Efficiency of the amplifier    = %.f %%",e
    *100);
```

Scilab code Exa 8.11 Calculation of maximum load power of amplifier for given VCC and RL

```
//Tested on Windows 7 Ultimate 32-bit
//Chapter 8 Power Amplifiers Pg no. 289
clear;
clc;

//Given Data

VCC=12;//collector supply voltage in volts
RL=12;//load resistance in ohms

//Solution

PL_max=(VCC/RL)^2*RL/2;//power developed in watts
printf("Maximum value of load power = %.f Watts",
```

```
PL_max);
```

Scilab code Exa 8.12 Calculation of turns ratio of a transformer for given parameters

```
//Tested on Windows 7 Ultimate 32-bit
//Chapter 8 Power Amplifiers Pg no. 289 and 290
clear;
clc;

//Given Data

VCC=12;//collector supply voltage in volts
RL=16;//load resistance of loudspeaker in ohms
Pmax=1;//input power of loudspeaker
VCE_sat=0.7;//collector to emitter saturation
    voltage in volts

//Solution

k=(VCC-VCE_sat)/sqrt(2*RL*Pmax);//turns ratio
printf("Turns ratio    = %.3f or %.f turns",k,k);
```

Scilab code Exa 8.13 Calculation of supplied and collector dissipated power for an amplifier

```
//Tested on Windows 7 Ultimate 32-bit
//Chapter 8 Power Amplifiers Pg no. 290
clear;
clc;

//Given Data

```

```
VCC=12;//collector supply voltage in volts
RL=16;//load resistance of loudspeaker in ohms
Pmax=1;//input power of loudspeaker
VCE_sat=0.7;//collector to emitter saturation
    voltage in volts

//Solution

PCC=4/%pi*Pmax;//supplied power in watts
P=0.5*(PCC-Pmax);//collector dissipated power in
    watts
printf("Supplied power PCC = %.3f Watts\n ",PCC);
printf("Collector dissipated power = %.3f Watts",P);

//decimal approximations taken here
```

Scilab code Exa 8.14 Calculation of efficiency of complementary symmetry amplifier for given parameters

```
//Tested on Windows 7 Ultimate 32-bit
//Chapter 8 Power Amplifiers Pg no. 290
clear;
clc;

//Given Data
//Figure 8.21

VCC=12;//collector supply voltage in volts
RL=4;//load resistance in ohms
Pmax=15;//maximum load power in watts
IC_max=2.5;//maximum collector current in amperes

//Solution

P1=2/%pi*VCC*IC_max;//power supplied in watts
```

```
e=Pmax/P1;//maximum efficiency of the amplifier
printf("Maximum efficiency  max = %.2f %%",e*100);
```

Chapter 9

Frequency Response of Amplifiers

Scilab code Exa 9.1 Calculation of voltage and power gains in dB units

```
//Tested on Windows 7 Ultimate 32-bit
//Chapter 9 Frequency Response of Amplifier Pg no. 299
clear;
clc;

//Solution
disp("(i)");
Gp1=200;//power gain
Gp_dB1=10*log10(Gp1);//power gain in decibles
printf("Gp(dB) = %.2f dB",Gp_dB1);
disp("(ii)");
Gp2=100;//power gain
Gp_dB2=10*log10(Gp2);//power gain in decibles
printf("Gp(dB) = %.f dB",Gp_dB2);
disp("(iii)");
Gp3=50;//power gain
Gp_dB3=10*log10(Gp3);//power gain in decibles
printf("Gp(dB) = %.2f dB",Gp_dB3);
```

```
disp("(iv)");
Gp4=10;//power gain
Gp_dB4=10*log10(Gp4);//power gain in decibles
printf("Gp(dB) = %.f dB",Gp_dB4);
disp("(v)");
Gv5=20;//voltage gain
Gv_dB5=20*log10(Gv5);//voltage gain in decibles
printf("Gv(dB) = %.f dB",Gv_dB5);
disp("(vi)");
Gv6=0.707;//voltage gain
Gv_dB6=20*log10(Gv6);//voltage gain in decibles
printf("Gv(dB) = %.f dB",Gv_dB6);
disp("(vii)");
Gp7=0.5;//power gain
Gp_dB7=10*log10(Gp7);//power gain in decibles
printf("Gp(dB) = %.f dB",Gp_dB7);
disp("(viii)");
Gv8=0.25;//voltage gain
Gv_dB8=20*log10(Gv8);//voltage gain in decibles
printf("Gv(dB) = %.f dB",Gv_dB8);
disp("(ix)");
Gv9=0.125;//voltage gain
Gv_dB9=20*log10(Gv9);//voltage gain in decibles
printf("Gv(dB) = %.f dB",Gv_dB9);
disp("(x)");
Gv10=0.0625;//voltage gain
Gv_dB10=20*log10(Gv10);//voltage gain in decibles
printf("Gv(dB) = %.f dB",Gv_dB10);
disp("(xi)");
Gv11=2;//voltage gain
Gv_dB11=20*log10(Gv11);//voltage gain in decibles
printf("Gv(dB) = %.f dB",Gv_dB11);
disp("(xii)");
Gv12=4;//voltage gain
Gv_dB12=20*log10(Gv12);//voltage gain in decibles
printf("Gv(dB) = %.f dB",Gv_dB12);
disp("(xiii)");
Gv13=8;//voltage gain
```

```
Gv_dB13=20*log10(Gv13);//voltage gain in decibles
printf("Gv(dB) = %.f dB",Gv_dB13);
disp("(xiv)");
Gv14=16;//voltage gain
Gv_dB14=20*log10(Gv14);//voltage gain in decibles
printf("Gv(dB) = %.f dB",Gv_dB14);
```

Scilab code Exa 9.2 Calculation of input and output miller capacitances for given amplifier circuit

```
//Tested on Windows 7 Ultimate 32-bit
//Chapter 9 Frequency Response of Amplifier Pg no.
   299 and 300
clear;
clc;

//Given

Gv=-48;//voltage gain of amplifier
Cbc=2D-12;//base to collector capacitance in farads
Cbe=0.5D-12;//base to emitter capacitance in farads

//Solution

Cin_miller=Cbc*(1-Gv);//input miller capacitance in
   farads
Cout_miller=Cbc*(1-1/Gv);//output miller capacitance
    in farads
disp("(i)");
printf("Input Miller capacitance Cin(Miller) = %.f
   pF",Cin_miller*10^12);
disp("(ii)");
printf("Output Miller capacitance Cout(Miller) = %.f
    pF",Cout_miller*10^12);
```

Scilab code Exa 9.3 Calculation of input and output miller capacitances for given amplifier circuit

```
//Tested on Windows 7 Ultimate 32-bit
//Chapter 9 Frequency Response of Amplifier Pg no.
    300
clear;
clc;

//Given

Gv=-120;//voltage gain of amplifier
Cbc=2D-12;//base to collector capacitance in farads
Cbe=0.5D-12;//base to emitter capacitance in farads

//Solution

Cin_miller=Cbc*(1-Gv);//input miller capacitance in
    farads
Cout_miller=Cbc*(1-1/Gv);//output miller capacitance
     in farads
disp("(i)");
printf("Input Miller capacitance Cin(Miller) = %.f
    pF",Cin_miller*10^12);
disp("(ii)");
printf("Output Miller capacitance Cout(Miller) = %.f
     pF",Cout_miller*10^12);
```

Scilab code Exa 9.4 Calculation of gain magnitude from dB units

```
//Tested on Windows 7 Ultimate 32-bit
```

```
//Chapter 9 Frequency Response of Amplifier Pg no. 301
clear;
clc;

//Given

Gv_dB=75;//voltage gain of amplifier in dB units

//Solution

Gv=10^(0.1*Gv_dB);//voltage gain magnitude
printf("P2/P1 = %.f",Gv);
```

Scilab code Exa 9.5 Calculation of input voltage and power required for given amplifier parameters

```
//Tested on Windows 7 Ultimate 32-bit
//Chapter 9 Frequency Response of Amplifier Pg no. 301
clear;
clc;

//Given

P_rated=50;//wattage rating of amplifier
RL=16;//load resistance of speaker in ohms
Gp_dB=22;//power gain in dB units
Gv_dB=37;//voltage gain in dB units

//Solution

disp("(i)");
Pi=P_rated/10^(Gp_dB/10);//input power required in watts
```

```
printf("Pi = %.2f mW",Pi*10^3);

disp("(ii)");
Vin=sqrt(P_rated*RL)/10^(Gv_dB/20);//input voltage required in volts
printf("Vin = %.2f mV",Vin*10^3);

//calculation error in textbook as wattage mentioned in question is 50 W and in solution is 37 W
```

Scilab code Exa 9.6 Calculation of critical frequency for a given bypass network

```
//Tested on Windows 7 Ultimate 32-bit
//Chapter 9 Frequency Response of Amplifier Pg no. 307 and 308
clear;
clc;

//Given

VCC=15;//collector supply voltage in volts
RC=2.2D3;//collector resistance in ohms
RE=470;//emitter resistance in ohms
R1=33D3;//divider network resistance R1 in ohms
R2=10D3;//divider network resistance R2 in ohms
VBE=0.7;//forward voltage drop of emitter diode in volts
B=150;//DC CE current gain beta
Rs=600;//source internal impedance in ohms
RL=4.7D3;//load resistance in ohms
C1=0.1D-6;//input coupling capacitance in farads
C2=50D-6;//emitter bypass capacitance in farads
C3=0.1D-6;//output coupling capacitance in farads
re=4;//a.c. emitter resistance in ohms
```

```

//Solution

Rth=1/(1/R1+1/R2+1/Rs);//thevenin resistance at base
     in ohms
Rin_emitter=re+Rth/B;//resistance looking into the
    emitter in ohms
R=1/(1/Rin_emitter+1/RE);//resistance of the
    equivalent RC network in ohms
fc=1/(2*%pi*R*C2);//critical frequency of the bypass
     network in hertz

printf("critical frequency of the bypass network fc
    = %d Hz",fc);
```

Scilab code Exa 9.7 Calculation of corner frequency for a given bypass network

```
//Tested on Windows 7 Ultimate 32-bit
//Chapter 9 Frequency Response of Amplifier Pg no.
    308
clear;
clc;

//Given

VCC=12;//collector supply voltage in volts
RE=1D3;//emitter resistance in ohms
R1=47D3;//divider network resistance R1 in ohms
R2=15D3;//divider network resistance R2 in ohms
VBE=0.7;//forward voltage drop of emitter diode in
    volts
B=100;//DC CE current gain beta
Rs=1000;//source internal impedance in ohms
CE=100D-6;//emitter bypass capacitance in farads
```

```
re=11.5;//a.c. emitter resistance in ohms

//Solution

Rth=1/(1/R1+1/R2+1/Rs);//thevenin resistance at base
    in ohms
Rin_emitter=re+Rth/B;//resistance looking into the
   emitter in ohms
R=1/(1/Rin_emitter+1/RE);//resistance of the
   equivalent RC network in ohms
fc=1/(2*%pi*R*CE);//critical frequency of the bypass
    network in hertz

printf("critical frequency of the bypass network fc
   = %.2f Hz",fc);

//decimal approximation taken here
```

Scilab code Exa 9.8 Plot of total frequency response for given amplifier

```
//Tested on Windows 7 Ultimate 32-bit
//Chapter 9 Frequency Response of Amplifier Pg no.
   310
clear;
clc;

//Given

VCC=15;//collector supply voltage in volts
RC=2.2D3;//collector resistance in ohms
RE=470;//emitter resistance in ohms
R1=33D3;//divider network resistance R1 in ohms
R2=10D3;//divider network resistance R2 in ohms
```

```
VBE=0.7;//forward voltage drop of emitter diode in
    volts
B=150;//DC CE current gain beta
Rs=600;//source internal impedance in ohms
RL=4.7D3;//load resistance in ohms
C1=0.1D-6;//input coupling capacitance in farads
C2=50D-6;//emitter bypass capacitance in farads
C3=0.1D-6;//output coupling capacitance in farads
re=4;//a.c. emitter resistance in ohms

//Solution

Rin=1/(1/R1+1/R2+1/(B*re));//thevenised input
    network resistance in ohms
fc_input=1/(2*%pi*(Rs+Rin)*C1);//input cutoff
    frequency in hertz
Rth=1/(1/R1+1/R2+1/Rs);//thevenised bypass network
    resistance in ohms
Rin_emitter=7.7;//resistance looking into the
    emitter in ohms
fc_bypass=1/(2*%pi*1/(1/RE+1/Rin_emitter)*C2);//
    bypass cutoff frequency in hertz
Rout=RC+RL;//thevenised output network resistance in
     ohms
fc_output=1/(2*%pi*Rout*C3);//output cutoff
    frequency in hertz

s=poly(0,'s')
F=syslin('c',8*%pi^3*(fc_input*fc_bypass*fc_output)
    /(s+2*%pi*fc_output)/(s+2*%pi*fc_bypass)/(s+2*%pi
    *fc_input));
clf;
gainplot(F,100,10000,"Bode Plot for given amplifier
    in Example 9.8");
```

Scilab code Exa 9.9 Design of input RC network and calculation of cutoff frequency for a given amplifier

```
//Tested on Windows 7 Ultimate 32-bit
//Chapter 9 Frequency Response of Amplifier Pg no. 312 and 313
clear;
clc;

//Given

VCC=12;//collector supply voltage in volts
RC=2.7D3;//collector resistance in ohms
RE=560;//emitter resistance in ohms
R1=15D3;//divider network resistance R1 in ohms
R2=5.6D3;//divider network resistance R2 in ohms
VBE=0.7;//forward voltage drop of emitter diode in volts
VT=25D-3;//voltage equivalent of temperature in volts
B=100;//DC CE current gain bet
Rs=600;//source internal impedance in ohms
RL=2.7D3;//load resistance in ohms
Cbe=15D-12;//base to emitter capacitance in farads
Cbc=2D-12;//base to collector capacitance in farads
Cwi=5D-12;//wiring capacitance in farads


//Solution

VB=VCC*R2/(R1+R2);//base to ground voltage in volts
VE=VB-VBE;//emitter to ground voltage in volts
IE=VE/RE;//emitter current in amperes
re=VT/IE;//a.c. emitter resistance in ohms
RTH=1/(1/Rs+1/R1+1/R2+1/B/re);//thevenised input resistance in ohms
Gv_mid=RC*RL/(RC+RL)/re;//midrange gain of amplifier
Cin_miller=Cbc*(1+Gv_mid);//input miller capacitance
```

```
in farads
C=Cwi+Cbe+Cin_miller;//total input capacitance in farads
printf("The high frequency input R-C network consists of\n ");
printf("R = %.2f ohms\n ",RTH);
printf("C = %.1f pF\n\n ",C*10^12);

fc=1/2/%pi/RTH/C;//critical frequency in hertz
printf("fc = %.2f MHz",fc/10^6);

//calculation errors in textbook
```

Scilab code Exa 9.10 Calculation of phase shift of input RC network of a given amplifier

```
//Tested on Windows 7 Ultimate 32-bit
//Chapter 9 Frequency Response of Amplifier Pg no. 313 and 314
clear;
clc;

//Given

VCC=12;//collector supply voltage in volts
RC=2.7D3;//collector resistance in ohms
RE=560;//emitter resistance in ohms
R1=15D3;//divider network resistance R1 in ohms
R2=5.6D3;//divider network resistance R2 in ohms
VBE=0.7;//forward voltage drop of emitter diode in volts
VT=25D-3;//voltage equivalent of temperature in volts
B=100;//DC CE current gain bet
Rs=600;//source internal impedance in ohms
```

```
RL=2.7D3;//load resistance in ohms
Cbe=15D-12;//base to emitter capacitance in farads
Cbc=2D-12;//base to collector capacitance in farads
Cwi=5D-12;//wiring capacitance in farads
f=[1.19D6 2.38D6 4.76D6];//frequency values in hertz

//Solution

VB=VCC*R2/(R1+R2);//base to ground voltage in volts
VE=VB-VBE;//emitter to ground voltage in volts
IE=VE/RE;//emitter current in amperes
re=VT/IE;//a.c. emitter resistance in ohms
RTH=1/(1/Rs+1/R1+1/R2+1/B/re);//thevenised input resistance in ohms
Gv_mid=RC*RL/(RC+RL)/re;//midrange gain of amplifier
Cin_miller=Cbc*(1+Gv_mid);//input miller capacitance in farads
C=Cwi+Cbe+Cin_miller;//total input capacitance in farads

for i=1:3
    phi=atand(2*%pi*RTH*f(i)*C);
    printf("At f=%.2f MHz    = %.2f  \n\n",f(i)/10^6,phi);
end
```

Scilab code Exa 9.11 Design of output RC network and calculation of critical frequency for a given amplifier

```
//Tested on Windows 7 Ultimate 32-bit
//Chapter 9 Frequency Response of Amplifier Pg no. 314 and 315
clear;
clc;

```

```
//Given

VCC=12;//collector supply voltage in volts
RC=2.7D3;//collector resistance in ohms
RE=560;//emitter resistance in ohms
R1=15D3;//divider network resistance R1 in ohms
R2=5.6D3;//divider network resistance R2 in ohms
VBE=0.7;//forward voltage drop of emitter diode in volts
VT=25D-3;//voltage equivalent of temperature in volts
B=100;//DC CE current gain bet
Rs=600;//source internal impedance in ohms
RL=2.7D3;//load resistance in ohms
Cbe=15D-12;//base to emitter capacitance in farads
Cbc=2D-12;//base to collector capacitance in farads
Cwo=1D-12;//output wiring capacitance in farads
f=[1.19D6 2.38D6 4.76D6];//frequency values in hertz

//Solution

VB=VCC*R2/(R1+R2);//base to ground voltage in volts
VE=VB-VBE;//emitter to ground voltage in volts
IE=VE/RE;//emitter current in amperes
re=VT/IE;//a.c. emitter resistance in ohms
RTH=1/(1/Rs+1/R1+1/R2+1/B/re);//thevenised input resistance in ohms
Gv_mid=RC*RL/(RC+RL)/re;//midrange gain of amplifier
Cout_miller=Cbc*(1+Gv_mid)/Gv_mid;//output miller capacitance in farads
Cout_dash=Cout_miller+Cwo;//total output capacitance in farads
RL_dash=RL*RC/(RL+RC);//total output resistance in ohms
printf("The high frequency input R-C network consists of\n ");
printf("R = %.2f kilo-ohms\n ",RL_dash/10^3);
printf("C = %.f pF\n\n ",Cout_dash*10^12);
```

```
fc=1/2/%pi/RL_dash/Cout_dash;//critical frequency in
    hertz
printf("fc = %.1f MHz",fc/10^6);
```

Scilab code Exa 9.12 Calculation of bandwidth of an amplifier for given cutoff frequencies

```
//Tested on Windows 7 Ultimate 32-bit
//Chapter 9 Frequency Response of Amplifier Pg no.
    316
clear;
clc;

//Given

fch1=5D3;//higher cut-off frequency in hertz
fcl1=20;//lower cut-off frequency in hertz

//Solution

BW=fch1-fcl1;//bandwidth in hertz
printf("BW = %.f Hz",BW);
```

Scilab code Exa 9.13 Calculation of bandwidth of an amplifier for given transition frequency and midband gain

```
//Tested on Windows 7 Ultimate 32-bit
//Chapter 9 Frequency Response of Amplifier Pg no.
    316
clear;
clc;

```

```
//Given

fT=150D6;//transition frequency in hertz
Gv_mid=25;//midband voltage gain

//Solution

BW=fT/Gv_mid;//bandwidth in hertz
printf("BW = %.f MHz",BW/10^6);
```

Scilab code Exa 9.14 Determination of cutoff frequency for given input RC network

```
//Tested on Windows 7 Ultimate 32-bit
//Chapter 9 Frequency Response of Amplifier Pg no.
   318 and 319
clear;
clc;

//Given
//Figure 9.31

VGS=12;//gate to source voltage in volts
IGSS=40D-9;//gate saturation current in amperes
VDD=12;//drain supply voltage in volts
RD=6.8D3;//drain resistance in ohms
RG=15D6;//gate resistance in ohms
Cin=0.001D-6;//input coupling capacitance in farads
Cout=0.001D-6;//output coupling capacitance in
   farads

//Solution

Rin_gate=VGS/IGSS;//gate input resistance in ohms
Rin=Rin_gate*RG/(Rin_gate+RG);//input resistance in
```

```
   ohms
fc=1/(2*%pi*Rin*Cin);//cutoff frequency in hertz
printf("Cutoff frequency for input RC network fc = %
   .2f Hz",fc);
```

Scilab code Exa 9.15 Determination of cutoff frequency for given output RC network

```
//Tested on Windows 7 Ultimate 32-bit
//Chapter 9 Frequency Response of Amplifier Pg no.
   319
clear;
clc;
//Given
//Figure 9.31
//Given data is from Fig 9.31
VGS=12;//gate to source voltage in volts
IGSS=40D-9;//gate saturation current in amperes
RD=6.8D3;//drain resistance in ohms
RG=15D6;//gate resistance in ohms
Cout=0.001D-6;//output coupling capacitance in
   farads

//Solution

Rin_gate=VGS/IGSS;//gate input resistance in ohms
Rin=Rin_gate*RG/(Rin_gate+RG);//input resistance in
   ohms
RL=Rin;//load resistance is input resistance of next
   stage in ohms
CC2=Cout;//output RC network capacitance is equal to
   Cout
//The following equation is given as Equation 9.45
   in textbook
fc=1/(2*%pi*(RD+RL)*CC2);//cutoff frequency in hertz
```

```
printf("Critical frequency for output RC network fc'' = %.2f Hz",fc);

//Error in decimal approximation in textbook.
```

Scilab code Exa 9.16 Calculation of Cgd Cds and Cgs for 2N3796 using datasheet values

```
//Tested on Windows 7 Ultimate 32-bit
//Chapter 9 Frequency Response of Amplifier Pg no. 320
clear;
clc;

//Given

Ciss=5D-12;//FET input capacitance in farads
Crss=0.5D-12;//FET reverse transfer capacitance in farads
Coss=2D-12;//FET output capacitance in farads

//Solution

Cgd=Crss;//gate to drain capacitance in farads
Cgs=Ciss-Crss;//gate to source capacitance in farads
Cds=Coss-Crss;//drain to source capacitance in farads
printf("Cgd = %.1f pF\n ",Cgd*10^12);
printf("Cgs = %.1f pF\n ",Cgs*10^12);
printf("Cds = %.1f pF\n ",Cds*10^12);
```

Scilab code Exa 9.17 Design of input RC network and calculation of cut-off frequency for a given amplifier

```
//Tested on Windows 7 Ultimate 32-bit
//Chapter 9 Frequency Response of Amplifier Pg no.
    321
clear;
clc;

//Given
//Figure 9.35

Ciss=6D-12;//FET input capacitance in farads
Crss=2.5D-12;//FET reverse transfer capacitance in
    farads
gm=7500D-6;//transconductance in Siemens
Cwi=2D-12;//wiring capacitance in farads
VDD=12;//drain supply voltage in volts
Rs=50;//source resistance in ohms
RG=15D6;//gate resistance in ohms
RD=1.2D3;//drain resistance in ohms
RS=1D3;//source resistance in ohms
RL=15D6;//load resistance in ohms

//Solution

Cgd=Crss;//gate to drain capacitance in farads
Cgs=Ciss-Crss;//gate to source capacitance in farads
RL_dash=RD*RL/(RD+RL);//total load resistance in
    ohms
GV=gm*RL_dash;//total voltage gain
Cin_miller=Cgd*(1+GV);//input miller capacitance in
    farads
Cin_dash=Cgs+Cwi+Cin_miller;//total input
    capacitance in farads
fc=1/(2*%pi*Rs*Cin_dash);//cutoff frequency in hertz
printf("Cut-off frequency fc = %.2f MHz\n ",fc/10^6)
    ;
```

Scilab code Exa 9.18 Design of input RC network and calculation of cut-off frequency for a given amplifier

```
//Tested on Windows 7 Ultimate 32-bit
//Chapter 9 Frequency Response of Amplifier Pg no.
    321 and 322
clear;
clc;

//Given
//Figure 9.35

Ciss=6D-12;//FET input capacitance in farads
Crss=2.5D-12;//FET reverse transfer capacitance in
    farads
gm=5000D-6;//transconductance in Siemens
VDD=12;//drain supply voltage in volts
Rs=50;//source resistance in ohms
RG=15D6;//gate resistance in ohms
RD=1.2D3;//drain resistance in ohms
RS=1D3;//source resistance in ohms
RL=15D6;//load resistance in ohms

//Solution

Cgd=Crss;//gate to drain capacitance in farads
Cgs=Ciss-Crss;//gate to source capacitance in farads
RL_dash=RD*RL/(RD+RL);//total load resistance in
    ohms
GV=gm*RL_dash;//total voltage gain
Cin_miller=Cgd*(1+GV);//input miller capacitance in
    farads
Cin_dash=Cgs+Cin_miller;//total input capacitance in
     farads
```

```
fc=1/(2*%pi*Rs*Cin_dash);//cutoff frequency in hertz
printf("Critical frequency fc = %.2f MHz\n",fc
    /10^6);

//calculation error in textbook
```

Scilab code Exa 9.19 Design of output RC network and calculation of cut-off frequency for a given amplifier

```
//Tested on Windows 7 Ultimate 32-bit
//Chapter 9 Frequency Response of Amplifier Pg no.
    322
clear;
clc;

//Given
//Figure 9.35

Ciss=6D-12;//FET input capacitance in farads
Crss=2.5D-12;//FET reverse transfer capacitance in
    farads
gm=7500D-6;//transconductance in Siemens
VDD=12;//drain supply voltage in volts
Rs=50;//source resistance in ohms
RG=15D6;//gate resistance in ohms
RD=1.2D3;//drain resistance in ohms
RS=1D3;//source resistance in ohms
RL=15D6;//load resistance in ohms
Cwo=1D-12;//output wiring capacitance in farads

//Solution

Cgd=Crss;//gate to drain capacitance in farads
Cgs=Ciss-Crss;//gate to source capacitance in farads
RL_dash=RD*RL/(RD+RL);//total load resistance in
```

```
ohms
GV=gm*RL_dash;//total voltage gain
Cout_miller=Cgd*(1+GV)/GV;//output miller capacitance in farads
Cout_dash=Cwo+Cout_miller;//total output capacitance in farads
fc=1/(2*%pi*RL_dash*Cout_dash);//cutoff frequency in hertz
printf("Critical frequency fc = %.2f MHz\n",fc/10^6);
```

Chapter 10

Feedback in Amplifiers

Scilab code Exa 10.1 Calculation of closed loop gain and feedback factor for given amplifier

```
//Tested on Windows 7 Ultimate 32-bit
//Chapter 10 Feedback in Amplifiers Pg no. 330
clear;
clc;

//Given

Vi=2D-3;//input voltage in volts
Vo_dash=10;//output voltage with feedback in volts
BVo_dash=200D-3;//feedback voltage in volts

//Solution

A=Vo_dash/Vi;//open loop gain
Afb=Vo_dash/(Vi+BVo_dash);//closed loop gain
B=1/Afb-1/A;//feedback gain beta
printf("    = %.2f",B);
```

Scilab code Exa 10.2 Calculation of feedback parameters and output voltage for given amplifier

```
//Tested on Windows 7 Ultimate 32-bit
//Chapter 10 Feedback in Amplifiers Pg no. 330
clear;
clc;

//Given

Vi=25D-3;//input voltage in volts
A=300;//open loop gain
B=0.01;//feedback factor beta

//Solution

disp("(i)");
Afb=A/(1+A*B);//closed loop gain
printf("Afb = %d\n ",Afb);

disp("(ii)");
Vo_dash=Afb*Vi;//output voltage with feedback in volts
printf("Vo'' = %.3f Volts\n ",Vo_dash);

disp("(iii)");
AB=A*B;//feedback factor A
printf("Feedback factor A  = %d\n ",AB);

disp("(iv)");
BVo_dash=B*Vo_dash;//feedback voltage in volts
printf("Feedback voltage Vo'' = %.4f Volts",BVo_dash);
```

Scilab code Exa 10.3 Calculation of variation in closed loop gain with variation in open loop gain

```
//Tested on Windows 7 Ultimate 32-bit
//Chapter 10 Feedback in Amplifiers Pg no. 330 and
   331
clear;
clc;

//Given

A=500;//open loop gain
B=0.1;//feedback factor beta
dA_to_A=10/100;//variation in open loop gain

//Solution

dAfb_to_Afb=dA_to_A*1/(A*B);//variation in closed
   loop gain
printf("Percentage variation in closed loop gain = %
   .1f %%",dAfb_to_Afb*100);
```

Scilab code Exa 10.4 Calculation of variation in closed loop gain with variation in open loop gain

```
//Tested on Windows 7 Ultimate 32-bit
//Chapter 10 Feedback in Amplifiers Pg no. 331
clear;
clc;

//Given

A=70;//open loop gain
B=0.1;//feedback factor beta
A_dash=A+0.05*A;//open loop gain increases by 5%
```

```

//Solution

Afb=A/(1+A*B);//closed loop gain at A open loop gain
Afb_dash=A_dash/(1+A_dash*B);//closed loop gain at
    A_dash open loop gain
PC=(Afb_dash-Afb)/Afb*100;//percentage change in
    closed loop gain
printf("Percentage change in closed loop gain = %.1f
    %%",PC);

//approximations taken in textbook
```

Scilab code Exa 10.5 Calculation of output voltage and distortion voltage for given closed loop amplifier

```
//Tested on Windows 7 Ultimate 32-bit
//Chapter 10 Feedback in Amplifiers Pg no. 332
clear;
clc;

//Given

A=100;//open loop gain
D=0.05;//distortion
Vi=0.5;//input voltage in volts

//Solution

disp("(a)");
Vo=A*Vi;//output voltage in volts
printf("Output signal voltage = %d Volts",Vo);

disp("(b)");
DV=D*Vo;//distortion voltage in volts
```

```
printf("Distortion voltage = %.1f Volts",DV);

disp("(c)");
AOV=DV+Vo;//amplifier output voltage in volts
printf("Amplifier output voltage = %.1f Volts",AOV);
```

Scilab code Exa 10.6 Calculation of first stage gain and second harmonic distortion for a closed loop amplifier

```
//Tested on Windows 7 Ultimate 32-bit
//Chapter 10 Feedback in Amplifiers Pg no. 332
clear;
clc;

//Given

A2=200;//second stage open loop gain
B=0.1;//feedback gain beta
D2=0.02;//second harmonic distortion

//Solution

disp("(a)");
A2_dash=A2/(1+B*A2);//second stage closed loop gain
A1=A2/A2_dash;//gain of the first stage
printf("The gain of the first stage A1 = %d",A1);

disp("(b)");
D2_dash=D2/(1+B*A2);//total second harmonic distortion
printf("The second harmonic distortion D2''= %.1f %%",D2_dash*100);

//calculation error in textbook as A*B=20 and not 2
```

Scilab code Exa 10.7 Calculation of bandwidth after introduction of feedback in an amplifier

```
//Tested on Windows 7 Ultimate 32-bit
//Chapter 10 Feedback in Amplifiers Pg no. 333
clear;
clc;

//Given

A=250;//mid frequency open loop gain
f1=100;//open loop lower cutoff frequency in hertz
f2=25D3;//open loop higher cutoff frequency in hertz
B=0.025;//feedback gain beta
D2=0.02;//second harmonic distortion

//Solution

Afb=A/(1+A*B);//closed loop gain
f1_dash=f1/(1+A*B);//closed loop lower cutoff
    frequency in hertz
f2_dash=f2*(1+A*B);//closed loop higher cutoff
    frequency in hertz
BW=f2_dash-f1_dash;//closed loop bandwidth
printf("Closed loop gain Afb = %.2f\n ",Afb);
printf("Closed loop bandwidth BW = %.2f kHz",BW
    /10^3);
```

Scilab code Exa 10.8 Calculation of open and closed loop gain for given FET amplifier

```
//Tested on Windows 7 Ultimate 32-bit
```

```
//Chapter 10 Feedback in Amplifiers Pg no. 341
clear;
clc;

//Given
//Figure 10.13

RL=6.8D3;//load resistance in ohms
RD=6.8D3;//drain resistance in ohms
Rs=400;//source resistance in ohms
R1=400D3;//voltage divider resistance R1 in ohms
R2=100D3;//voltage divider resistance R2 in ohms
gm=5000D-6;//transconductance in Siemens

//Solution

RL_dash=RL*RD/(RL+RD);//total equivalent load
    resistance in ohms
A=-gm*RL_dash;//open loop gain
B=-R2/(R1+R2);//feedback factor beta
Afb=A/(1+A*B);//closed loop gain
printf("Gain without feedback A = %d\n ",A);
printf("Gain with feedback Afb = %.2f",Afb);
```

Scilab code Exa 10.9 Calculation of open and closed loop gain for given amplifier circuit

```
//Tested on Windows 7 Ultimate 32-bit
//Chapter 10 Feedback in Amplifiers Pg no. 343
clear;
clc;

//Given
//Figure 10.16

```

```
RD=4.7D3;//drain resistance in ohms
Rs=1D3;//source resistance in ohms
RF=10D6;//feedback resistance in ohms
gm=2D-3;//transconductance in Siemens

//Solution

A=-gm*RD;//open loop gain
Afb=A*RF/(RF-A*Rs);//closed loop gain
printf("Gain without feedback A = %.1f\n ",A);
printf("Gain with feedback Afb = %.1f",Afb);
```

Scilab code Exa 10.10 Calculation of open and closed loop gain for given amplifier circuit

```
//Tested on Windows 7 Ultimate 32-bit
//Chapter 10 Feedback in Amplifiers Pg no. 343 and
   344
clear;
clc;

//Given
//Figure 10.16

RD=4.7D3;//drain resistance in ohms
Rs=1D3;//source resistance in ohms
RF=15D3;//feedback resistance in ohms
gm=5D-3;//transconductance in Siemens

//Solution

A=-gm*RD;//open loop gain
Afb=A*RF/(RF-A*Rs);//closed loop gain
printf("Gain without feedback A = %.1f\n ",A);
printf("Gain with feedback Afb = %.2f",Afb);
```

Scilab code Exa 10.11 Calculation of closed loop gain for given amplifier circuit

```
//Tested on Windows 7 Ultimate 32-bit
//Chapter 10 Feedback in Amplifiers Pg no. 345
clear;
clc;

//Given
//Figure 10.18

VCC=15;//collector supply voltage in volts
RC=1.8D3;//collector resistance in ohms
RB=330;//base resistance in ohms
RE=390;//emitter resistance in ohms
hfe=150;//forward current gain
hie=1000;//input resistance of transistor in ohms
Vi=5D-3;//input rms voltage in volts

//Solution

A=-hfe/(hie+RE);//open loop gain
B=-RE;//feedback factor beta
Afb=A/(1+A*B);//closed loop gain
AVfb=Afb*RC;//closed loop voltage gain
printf("Voltage gain of the circuit (Av)fb = %.2f\n
    ",AVfb);
```

Scilab code Exa 10.12 Calculation of closed loop gain and feedback transfer ratio for given amplifier

```
//Tested on Windows 7 Ultimate 32-bit
//Chapter 10 Feedback in Amplifiers Pg no. 345
clear;
clc;

//Given

A0=200;//open loop midband gain
B=0.05;//feedback factor beta

//Solution

Afb=A0/(1+A0*B);//closed loop midband gain
printf("Voltage gain of the circuit (Av)fb = %.2f\n
   ",Afb);
```

Scilab code Exa 10.13 Calculation of lower cutoff frequency after introduction of negative feedback in an amplifier

```
//Tested on Windows 7 Ultimate 32-bit
//Chapter 10 Feedback in Amplifiers Pg no. 345 and
   346
clear;
clc;

//Given

A0=200;//open loop midband gain
B=0.05;//feedback factor beta
fL=25;//open loop lower cutoff frequency in hertz

//Solution

fLfb=fL/(1+A0*B);//closed loop lower cutoff
   frequency in hertz
```

```
printf("Closed loop lower cutoff frequency (fL)fb =
   %.2f Hz\n ",fLfb);
```

Scilab code Exa 10.14 Calculation of upper cutoff frequency after introduction of negative feedback in an amplifier

```
//Tested on Windows 7 Ultimate 32-bit
//Chapter 10 Feedback in Amplifiers Pg no. 346
clear;
clc;

//Given

A0=200;//open loop midband gain
B=0.05;//feedback factor beta
fH=100D3;//open loop higher cutoff frequency in
    hertz

//Solution

fHfb=fH*(1+A0*B);//closed loop higher cutoff
    frequency in hertz
printf("Closed loop higher cutoff frequency (fH)fb =
     %.1f MHz\n ",fHfb/10^6);
```

Chapter 11

Oscillators and Multivibrators

Scilab code Exa 11.1 Calculation of frequency of oscillations for Colpitts oscillator

```
//Tested on Windows 7 Ultimate 32-bit
//Chapter 11 Oscillators and Multivibrators Pg no.
   355 and 356
clear;
clc;

//Given
//Figure E 11.1

L=20D-3;//colpitts inductance in henry
C1=0.2D-6;//colpitts capacitor C1 in farads
C2=0.02D-6;//colpitts capacitor C2 in farads

//Solution

Ce=C1*C2/(C1+C2);//equivalent capacitance in farads
f0=1/(2*%pi*sqrt(L*Ce));//frequency of oscillations
   in hertz
printf("Frequency of oscillations f0 = %.2f kHz",f0
   /10^3);
```

Scilab code Exa 11.2 Calculation of frequency of oscillations for given circuit and Q values

```
//Tested on Windows 7 Ultimate 32-bit
//Chapter 11 Oscillators and Multivibrators Pg no. 356
clear;
clc;

//Given
//Figure E 11.1

L=20D-3;//colpitts inductance in henry
C1=0.2D-6;//colpitts capacitor C1 in farads
C2=0.02D-6;//colpitts capacitor C2 in farads
Qa=10;//Q point (a)
Qb=5;//Q point (b)

//Solution

Ce=C1*C2/(C1+C2);//equivalent capacitance in farads
disp("(a)");
f0=1/(2*%pi*sqrt(L*Ce))*sqrt(Qa^2/(Qa^2+1));//frequency of oscillations in hertz
printf("Q = %d\n",Qa);
printf("Frequency of oscillations f0 = %.f Hz",f0);

disp("(b)");
f0=1/(2*%pi*sqrt(L*Ce))*sqrt(Qb^2/(Qb^2+1));//frequency of oscillations in hertz
printf("Q = %d\n",Qb);
printf("Frequency of oscillations f0 = %.f Hz",f0);

//Round-off error in textbook
```

Scilab code Exa 11.3 Calculation of Q value for a crystal oscillator with given parameters

```
//Tested on Windows 7 Ultimate 32-bit
//Chapter 11 Oscillators and Multivibrators Pg no. 359
clear;
clc;

//Given

f=3.8D6;//frequency of oscillations in hertz
L=0.2;//equivalent inductance in henry
R=6000;//series resistance in ohms

//Solution

Q=2*%pi*f*L/R;//quality factor Q
printf("Q = %d\n",Q);
```

Scilab code Exa 11.4 Calculation of frequency of oscillations for given oscillator circuit

```
//Tested on Windows 7 Ultimate 32-bit
//Chapter 11 Oscillators and Multivibrators Pg no. 361
clear;
clc;

//Given

```

```
R=4.7D3;//R1,R2,R3 resistances in RC filter circuit in ohms
C=2.2D-9;//C1,C2,C3 resistances in RC filter circuit in farads

//Solution

f0=1/(2*%pi*R*C*sqrt(6));//frequency of oscillation in hertz
printf("Frequency of oscillation f0 = %.3f kHz",f0/10^3);
```

Scilab code Exa 11.5 Calculation of oscillation frequency and feedback resistance for given OPAMP oscillator

```
//Tested on Windows 7 Ultimate 32-bit
//Chapter 11 Oscillators and Multivibrators Pg no. 361
clear;
clc;

//Given

R=4.7D3;//R1,R2,R3 resistances in RC filter circuit in ohms
C=4.7D-9;//C1,C2,C3 resistances in RC filter circuit in farads
A=29;//voltage gain of RC phase shift oscillator

//Solution

f0=1/(2*%pi*R*C*sqrt(6));//frequency of oscillation in hertz
printf("Frequency of oscillation f0 = %.2f kHz\n ",f0/10^3);
```

```
Rf=A*R;//feedback resistance in ohms
printf("Feedback resistance Rf = %.1f kilo-ohms",Rf
    /10^3);
```

Scilab code Exa 11.6 Calculation of oscillation frequency for Wien Bridge oscillator

```
//Tested on Windows 7 Ultimate 32-bit
//Chapter 11 Oscillators and Multivibrators Pg no.
    367 and 368
clear;
clc;

//Given

f1=40;//lowest operating frequency in hertz
f2=40D3;//highest operating frequency in hertz
C1=40D-12;//lowest capacitance of variable capacitor
     in farads
C2=400D-12;//highest capacitance of variable
    capacitor in farads
A=10;//gain of amplifier
R2=7D3;//resistance of other arm of bridge in ohms

//Solution

R=1/(2*%pi*f1*C2);//resistance R of Wien bridge
    oscillator in ohms
printf("Since,capacitance can change in the ratio of
     10:1 only\n ");
printf("For R = %.2f Mega-ohms frequency range 40 Hz
     to 400 Hz\n ",R/10^6);
printf("For R = %.2f kilo-ohms frequency range 400
    Hz to 4 kHz\n ",R/10^5);
printf("For R = %.2f kilo-ohms frequency range 4 kHz
```

```
to 40 kHz\n\n ",R/10^6);

AB=1;//loop gain is unity for oscillator
B=AB/A;//feedback factor beta
R1_to_R2=1/(1/3-B)-1;//ratio of R1/R2 for wien bridge oscillator
R1=R1_to_R2*R2;//resistor R1 in ohms
printf("Resistance R1 = %d kilo-ohms",R1/10^3);
```

Scilab code Exa 11.7 Calculation of oscillation frequency for astable mutivibrator with given parameters

```
//Tested on Windows 7 Ultimate 32-bit
//Chapter 11 Oscillators and Multivibrators Pg no. 368
clear;
clc;

//Given
//Figure 11.18

R1=1.5D3;//resistance R1 in ohms
R2=1.5D3;//resistance R2 in ohms
R3=12D3;//resistance R3 in ohms
R4=12D3;//resistance R4 in ohms
C1=0.068D-6;//capacitance C1 in farads
C2=0.068D-6;//capacitance C2 in farads

//Solution

T1=0.693*R3*C1;//time period of initial part of waveform in seconds
T2=0.693*R4*C2;//time period of final part of waveform in seconds
T=T1+T2;//total time period of waveform in seconds
```

```
f=1/T;//frequency of wave in hertz
printf("Frequency of oscillations of astable
    multivibrator f = %d Hz",f);
```

Chapter 12

Modulation and Demodulation

Scilab code Exa 12.1 Calculation of percentage modulation and amplitude of carrier wave for given AM wave

```
//Tested on Windows 7 Ultimate 32-bit
//Chapter 12 Modulation and Demodulation Pg no. 378
clear;
clc;

//Given

Emax=10;//maximum peak to peak voltage of an AM
    signal
Emin=3;//minimum peak to peak voltage of an AM
    signal

//Solution

m=(Emax-Emin)/(Emax+Emin);//modulation index m
printf("Percent modulation = %.2f %%\n\n ",m*100);
Ac=(Emax-Emin)/(2*m);//amplitude of unmodulated
    carrier wave
printf("Amplitude of unmodulated carrier wave Ac = %
    .1f Volts",Ac);
```

Scilab code Exa 12.2 Calculations of sideband parameters and width for given AM wave

```
//Tested on Windows 7 Ultimate 32-bit
//Chapter 12 Modulation and Demodulation Pg no. 378 and 379
clear;
clc;

//Given

fc=1000D3;//frequency of carrier wave in hertz
fa1=450;//lowest audio frequency of modulating signal in hertz
fa2=1650;//highest audio frequency of modulating signal in hertz

//Solution

disp("(i)");
FS=fa2-fa1;//frequency span of each sideband in hertz
printf("Frequency span of each sideband = %d Hz",FS);

disp("(ii)");
FMAX=fc+fa2;//maximum upper side frequency in hertz
printf("Maximum upper side frequency = %.2f kHz",FMAX/10^3);

disp("(iii)");
FMIN=fc-fa2;//minimum upper side frequency in hertz
printf("Minimum upper side frequency = %.2f kHz",FMIN/10^3);
```

```
disp("(iv)");
CW=FMAX-FMIN;//channel width in hertz
printf("Channel width = %.1f kHz",CW/10^3);
```

Scilab code Exa 12.3 Calculation of power developed by AM wave

```
//Tested on Windows 7 Ultimate 32-bit
//Chapter 12 Modulation and Demodulation Pg no. 379
clear;
clc;

//Given

RL=180;//load resistance in ohms
Vc=90;//peak voltage of carrier wave in volts
m=0.5;//modulation index of AM wave

//Solution

Pc=Vc^2/(2*RL);//unmodulated carrier power in watts
Pt=Pc*(1+m^2/2);//total power developed by AM wave
    in watts
Pcs=Pc*m^2/2;//power in sideband in watts
printf("Total power developed by AM wave Pt = %.4f
    Watts\n ",Pt);
printf("Power in sideband Pc = %.4f Watts",Pcs);
```

Scilab code Exa 12.4 Calculation of the modulation index and side lengths ratio for given trapezoidal pattern AM wave

```
//Tested on Windows 7 Ultimate 32-bit
//Chapter 12 Modulation and Demodulation Pg no. 379
```

```
clear;
clc;

//Given

Vm=12;//modulating signal peak to peak voltage in
   volts
Vc=9;//carrier wave peak amplitude in volts

//Solution

Emax=Vc+Vm/2;//maximum amplitude of AM signal in
   volts
Emin=Vc-Vm/2;//minimum amplitude of AM signal in
   volts
m=(Emax-Emin)/(Emax+Emin);//depth of modulation
L1_to_L2=Emin/Emax;//ratio of side lengths
printf("Depth of modulation = %.2f %%\n ",m*100);
printf("Ratio of side-lengths L1/L2 = %.1f",L1_to_L2
   );
```

Scilab code Exa 12.6 Plot of frequency spectrum and calculation of modulation index for AM wave

```
//Tested on Windows 7 Ultimate 32-bit
//Chapter 12 Modulation and Demodulation Pg no. 380
clear;
clc;

//Given

fc=9D6;//frequency of carrier wave in hertz
Vc=9;//peak value of carrier wave in volts
```

```
fm=10D3;//frequency of modulating wave in hertz
Vm=4.5;//amplitude of modulating sine wave in volts

//Solution

m=Vm/Vc;//modulation index
printf("Modulation index m = %d %%",m*100);
fu=fc+fm;//upper side band frequency in hertz
fl=fc-fm;//lower side band frequency in hertz
f=[fc-2*fm fc-fm fc fc+fm fc+2*fm];//frequency range
for i=1:5
    if f(i)==fu | f(i)==fl then
        A(i)=m*Vc/2;//amplitude of side frequency in
            volts
    else
        A(i)=0;//amplitude of side frequency in
           volts
    end
end

bar(f/10^6,A,0.1,'red');
title("Frequency spectrum of AM wave");
xlabel("Frequency in MHz");
ylabel("Amplitude in volts");
xstring(8.988,2.3,"lower side band");
xstring(9.008,2.3,"upper side band");
```

Scilab code Exa 12.7 Calculation of the modulation index for given transmitter currents

```
//Tested on Windows 7 Ultimate 32-bit
//Chapter 12 Modulation and Demodulation Pg no. 380
   and 381
clear;
clc;
```

```
//Given

Ic=12;//rms current of unmodulated carrier in
    amperes
I=14;//rms current of modulated carrier in amperes

//Solution

m=sqrt(2*((I/Ic)^2-1));//modulation index of AM wave
printf("Modulation index m = %.2f %%",m*100);
```

Scilab code Exa 12.8 Calculation of required audio power for given AM signal

```
//Tested on Windows 7 Ultimate 32-bit
//Chapter 12 Modulation and Demodulation Pg no. 381
clear;
clc;

//Given

Pc=10D3;//carrier wave power in watts
m=0.75;//depth of modulation
e=0.65;//efficiency of modulator

//Solution

Ps=0.5*m^2*Pc;//total sideband power in watts
Pa=Ps/e;//required audio power in watts
printf("Required audio power P = %.3f kW",Pa/10^3);
```

Scilab code Exa 12.9 Calculation of maximum carrier power for given transmission of AM wave

```
//Tested on Windows 7 Ultimate 32-bit
//Chapter 12 Modulation and Demodulation Pg no. 381
clear;
clc;

//Given

Pc1=12D3;//carrier wave power in watts
m1=0.75;//maximum modulation index that can be
    achieved
m2=0.45;//modulation index for AM wave

//Solution

Pt=Pc1*(1+m1^2/2);//total power of AM wave in watts
Pc2=Pt/(1+m2^2/2);//carrier power in watts for m=m2
printf("Carrier power cane be raised to Pc = %.2f kW
    ",Pc2/10^3);
```

Scilab code Exa 12.10 Calculation of modulation index for given FM transmission

```
//Tested on Windows 7 Ultimate 32-bit
//Chapter 12 Modulation and Demodulation Pg no. 393
clear;
clc;

//Given

fc=150D6;//frequency of carrier wave in hertz
fm=10D3;//frequency of modulating wave in hertz
df=25D3;//maximum frequency deviation
```

```
//Solution

disp("(i)");
B=df/fm;//modulation index for FM wave
printf("Modulation index    = %.1f",B);
disp("(ii)");
printf("The three significant side frequency pairs are:\n ");
printf("%d MHz    %d kHz\n ",fc/10^6,fm/10^3);
printf("%d MHz    %d kHz\n ",fc/10^6,fm*2/10^3);
printf("%d MHz    %d kHz\n ",fc/10^6,fm*3/10^3);
```

Scilab code Exa 12.11 Calculation of bandwidth for given FM wave transmission

```
//Tested on Windows 7 Ultimate 32-bit
//Chapter 12 Modulation and Demodulation Pg no. 394
clear;
clc;

//Given

df=75D3;//maximum frequency deviation
fm=20D3;//frequency of modulating wave in hertz

//Solution

BW=2*(df+fm);//bandwidth for FM wave
printf("Bandwidth required in FM wave transmission B = %d kHz",BW/10^3);
```

Scilab code Exa 12.12 Calculation of average power output for a FM signal

```
//Tested on Windows 7 Ultimate 32-bit
//Chapter 12 Modulation and Demodulation Pg no. 394
clear;
clc;

//Given

df=6D3;//maximum frequency deviation
fm=1.5D3;//frequency of modulating wave in hertz
Pc=25;//carrier power in watts
J=[-0.4 -0.07 0.36 0.43 0.28 0.13 0.05 0.02];//
    Bessel function values required for given problem
    's modualtion index

//Solution

B=df/fm;//modulation index
PT=Pc*(J(1)^2+2*(J(2)^2+J(3)^2+J(4)^2+J(5)^2+J(6)^2+
    J(7)^2+J(8)^2));//total carrier power in watts
printf("Total carrier power PT = %.f Watts",PT);
```

Chapter 13

Integrated Circuits

Scilab code Exa 13.1 Design of diffused resistors of given value

```
//Tested on Windows 7 Ultimate 32-bit
//Chapter 13 Integrated Circuit Pg no. 414
clear;
clc;

//Given

R_a=0.5D3;//diffused resistor value in ohms
R_b=10D3;//diffused resistor value in ohms
Rs_n=10;//n-type emitter diffusion sheet resistance
    in ohms
Rs_p=250;//p-type emitter diffusion sheet resistance
     in ohms

//Solution

disp("(a)");
L_to_W_a=R_a/Rs_n;//length to width ratio of
    resistor
printf(" Thus a %d ohm resistor of n-type emitter
    diffusion ,\n can be fabricated by using a pattern
```

```
    of\n ",R_a);
printf("%d mils long by 1 mil wide",L_to_W_a);

disp("(b)");
L_to_W_b=R_b/Rs_p;//length to width ratio of
   resistor
printf(" Thus a %d kilo-ohm resistor of p-type
   emitter diffusion,\n can be fabricated by using a
    pattern of\n ",R_b/10^3);
printf("%d mils long by 1 mil wide",L_to_W_b);
```

Chapter 14

Operational Amplifiers

Scilab code Exa 14.1 Calculation of output voltage for a balanced differential amplifier

```
//Tested on Windows 7 Ultimate 32-bit
//Chapter 14 Operational Amplifiers Pg no. 418
clear;
clc;

//Given

vICM1=0;//input common mode vOltage in volts
vOCM1=5.4;//output common mode vOltage in volts
vICM2=1.05;//input common mode vOltage in volts
vOCM2=5.0;//output common mode vOltage in volts
vO2=5.4;//vOltage at collector of transistor Q2 in
    volts

//Solution

disp("vOCM=5.4 Volts");
vO1=2*vOCM1-vO2;//vOltage at collector of transistor
    Q1 in volts
printf("Voltage at collector of transistor Q1 vO1 =
```

```
%.1f volts\n ",vO1);

disp("vOCM=5.0 Volts");
vO1=2*vOCM2-vO2;//vOltage at collector of transistor Q1 in volts
printf("Voltage at collector of transistor Q1 vO1 = %.1f volts",vO1);

//calculation for vOCM=5 Volts not done in textbook
```

Scilab code Exa 14.2 Calculation of input and output common mode voltage for given balanced differential amplifier

```
//Tested on Windows 7 Ultimate 32-bit
//Chapter 14 Operational Amplifiers Pg no. 418
clear;
clc;

//Given

vI1=1.15;//voltage at base of transistor Q1 in volts
vI2=0.95;//voltage at base of transistor Q2 in volts
vO1=2;//voltage at collector of transistor Q1 in volts
vO2=8;//voltage at collector of transistor Q2 in volts

//Solution

vICM=(vI1+vI2)/2;//input common mode voltage in volts
vOCM=(vO1+vO2)/2;//output common mode voltage in volts
printf("Input common mode voltage vICM = %.2f Volts\n ",vICM);
```

```
printf("Output common mode voltage vOCM = %.1f Volts ",vOCM);
```

Scilab code Exa 14.3 Calculation of output common mode voltage for given balanced differential amplifier

```
//Tested on Windows 7 Ultimate 32-bit
//Chapter 14 Operational Amplifiers Pg no. 418 and 419
clear;
clc;

//Given

vI1=0;//voltage at base of transistor Q1 in volts
vI2p=5D-3;//peak voltage at base of transistor Q2 in volts
vI2w=0.2;//frequency of vI2 in hertz
vICM_a=0;//input common mode voltage in volts
vOCM_a=5;//output common mode voltage in volts
vICM_b=-2D-3;//input common mode voltage in volts
vOCM_b=5.01;//output common mode voltage in volts
vICM_c=2D-3;//input common mode voltage in volts
vOCM_c=4.99;//output common mode voltage in volts

//Solution

dvICMp=vI2p/2;//peak input common mode voltage in volts
dvICMw=vI2w;//input common mode frequency in hertz
printf("vICM = %.1f sin(%.1f pi t) mV\n ",dvICMp*10^3,dvICMw*2);
dvOCMp=(vOCM_b-vOCM_a)/vICM_b*dvICMp;//peak output common mode voltage in volts
dvOCMw=dvICMw;//output common mode frequency in
```

```
    hertz
printf("vOCM =5 V %.f sin(%.1f pi t) mV",dvOCMp
    *10^3,dvOCMw*2);

//error in calculation of vOCM in textbook
```

Scilab code Exa 14.4 Calculation of common mode gain for a balanced differential amplifier

```
//Tested on Windows 7 Ultimate 32-bit
//Chapter 14 Operational Amplifiers Pg no. 418
clear;
clc;

//Given

vI1=[-3.3 1.9];//voltage at base of transistor Q1 at
     instants T1 and T2 in volts
vI2=[-3.7 1.1];//voltage at base of transistor Q2 at
     instants T1 and T2 in volts
vO1=[4.3 2.7];//voltage at collector of transistor
    Q1 at instants T1 and T2 in volts
vO2=[4.5 3.1];//voltage at collector of transistor
    Q2 at instants T1 and T2 in volts

//Solution

vICM=((vI1(2)-vI1(1))+(vI2(2)-vI2(1)))/2;//input
    common mode voltage in volts
vOCM=((vO1(2)-vO1(1))+(vO2(2)-vO2(1)))/2;//output
    common mode voltage in volts
ACM=vOCM/vICM;//common mode gain
printf("Common mode gain ACM = %.2f",ACM);
```

Scilab code Exa 14.5 Calculation of CMRR in dB units for given operational amplifier

```
//Tested on Windows 7 Ultimate 32-bit
//Chapter 14 Operational Amplifiers Pg no. 423
clear;
clc;

//Given

Ad=15000;//differential gain
Ac=15;//common mode gain

//Solution

CMRR=Ad/Ac;//common mode rejection ratio
CMRR_dB=20*log10(CMRR);//common mode rejection ratio
    in dB units
printf("(CMRR)dB = %.f dB",CMRR_dB);
```

Scilab code Exa 14.6 Calculation of slew rate for given operational amplifier

```
//Tested on Windows 7 Ultimate 32-bit
//Chapter 14 Operational Amplifiers Pg no. 425 and
    426
clear;
clc;

//Given

V1=-10.8;//output at time instant t1 in volts
```

```
V2=10.8;//output at time instant t2 in volts
t2_t1=2D-6;//time gap between t1 and t2 in seconds

//Solution

SR=(V2-V1)/t2_t1/10^6;//slew rate in Volts/micro-seconds
printf("Slew Rate S.R. = %.1f V/ S",SR);
```

Scilab code Exa 14.7 Calculation of feedback resistance for given opamp closed loop amplifier

```
//Tested on Windows 7 Ultimate 32-bit
//Chapter 14 Operational Amplifiers Pg no. 428 and 429
clear;
clc;

//Given
//Figure E 14.7

Av_cl=50;//closed loop voltage gain
Ri=2.7D3;//resistance Ri in ohms

//Solution

Rf=Av_cl*Ri;//feedback resistance in ohms
printf("Feedback resistor Rf = %d kilo-ohms",Rf/10^3);
```

Scilab code Exa 14.8 Calculation of input and output impedances for given operational amplifier

```
//Tested on Windows 7 Ultimate 32-bit
//Chapter 14 Operational Amplifiers Pg no. 429
clear;
clc;

//Given
//Figure E 14.7

Av_ol=200000;//open loop voltage gain
Zin=5;//input impedance in ohms
Zout=50;//output impedance in ohms
Ri=2.7D3;//resistance Ri in ohms
Rf=135D3;//feedback resistance in ohms

//Solution

Zin=Ri;//input impedance of amplifier in ohms
Zout_miller=Rf*Av_ol/(1+Av_ol);//miller output
    impedance in ohms
Zout_total=1/(1/Zout+1/Zout_miller);//total output
    impedance of amplifier in ohms
printf("Input impedance Zin = %.1f kilo-ohms\n ",Zin
    /10^3);
printf("Output impedance Zout = %.f ohms",Zout_total
    );
```

Scilab code Exa 14.9 Calculation of closed loop voltage gain and input and output impedances for given operational amplifier

```
//Tested on Windows 7 Ultimate 32-bit
//Chapter 14 Operational Amplifiers Pg no. 431 and
    432
clear;
clc;

```

```
//Given

A=175000;//open loop voltage gain
Zin=1.5D6;//input impedance in ohms
Zout=70;//output impedance in ohms
Ri=8.2D3;//resistance Ri in ohms
Rf=180D3;//feedback resistance in ohms

//Solution

X=Ri/(Ri+Rf);//voltage divider ratio
Zin_n=Zin*(1+A*X);//input impedance in ohms
Zout_n=Zout/(1+A*X);//output impedance in ohms
Av_cl=1/X;//closed loop voltage gain
printf("Input impedance Zin = %.f Mega-ohms\n ",
    Zin_n/10^6);
printf("Output impedance Zout = %.4f ohms\n ",Zout_n
    );
printf("Closed loop voltage gain (Av)cl = %.f",Av_cl
    );
```

Scilab code Exa 14.10 Calculation of input and output impedances for given operational amplifier voltage follower

```
//Tested on Windows 7 Ultimate 32-bit
//Chapter 14 Operational Amplifiers Pg no. 432
clear;
clc;

//Given

Av_ol=175000;//open loop voltage gain
Zin=1.5D6;//input impedance in ohms
Zout=70;//output impedance in ohms

```

```
//Solution

Zi_vf=(1+Av_ol)*Zin;//input impedance of voltage follower in ohms
Zo_vf=Zout/(1+Av_ol);//output impedance of voltage follower in ohms
printf("Input impedance (Zi)VF = %.f Mega-ohms\n ",Zi_vf/10^6);
printf("Output impedance (Zo)VF = %.4f ohms\n ",Zo_vf);
```

Scilab code Exa 14.11 Calculation of oscillation frequency and feedback resistance for given phase shift oscillator

```
//Tested on Windows 7 Ultimate 32-bit
//Chapter 14 Operational Amplifiers Pg no. 435 and 436
clear;
clc;

//Given
//Figure 14.21

R=12D3;//resistances R1,R2,R3 in RC network in ohms
C=0.001D-6;//capacitances C1,C2,C3 in RC network in ohms
A=29;//gain for oscillator operation

//Solution

fr=1/(2*%pi*R*C*sqrt(6));//frequency of oscillations in hertz
Rf=A*R;//feedback resistance in ohms
printf("Frequency of oscillations fr = %.2f kHz\n ",fr/10^3);
```

```
printf("Feedback resistance Rf = %.f kilo-ohms\n ",
    Rf/10^3);
```

Scilab code Exa 14.13 Calculation of output voltage for given conditions in a summer circuit

```
//Tested on Windows 7 Ultimate 32-bit
//Chapter 14 Operational Amplifiers Pg no. 442
clear;
clc;

//Given
//Figure 14.32

V1=2;V2=1;V3=0.5;V4=0.2;//input voltages in volts
R=20D3;//input resistances R1,R2,R3,R4 in ohms
R5=20D3;//feedback resistance in ohms

//Solution

A=-R5/R;//gain for each input
disp("(a)");
Vo=A*(V1+V2+V3+V4);//output voltage in volts
printf("Normal output voltage Vo = %.1f Volts",Vo);
disp("(b)");
Vo=A*(V1+V2+V4);//output voltage in volts
printf("For R3 open, output voltage Vo = %.1f Volts"
    ,Vo);
disp("(c)");
printf("If resistor R5 opens output becomes -Vsat.")
```

Scilab code Exa 14.14 Calculation of output voltage for given conditions in a summer circuit

```
//Tested on Windows 7 Ultimate 32-bit
//Chapter 14 Operational Amplifiers Pg no. 442 and
    443
clear;
clc;

//Given
//Figure 14.33

V1=2;V2=1;V3=5.5;V4=2.2;V5=1.1//input voltages in
    volts
R=50D3;//input resistances R1,R2,R3,R4 in ohms
R5=10D3;//feedback resistance in ohms

//Solution

A=-R5/R;//gain for each input
disp("(a)");
Vo=A*(V1+V2+V3+V4+V5);//output voltage in volts
printf("Normal output voltage Vo = %.2f Volts",Vo);
disp("(b)");
Vo=A*(V1+V2+V4+V5);//output voltage in volts
printf("For R3 open, output voltage Vo = %.2f Volts"
    ,Vo);
```