Scilab Textbook Companion for Electronic Principles by A. Malvino And D. J. Bates[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

Scilab code Exa 1.1 example1

```
// For what load resistance is source stiff
// Electronic Principles
// By Albert Malvino , David Bates
// Seventh Edition
// The McGraw-Hill Companies
// Example 1-1, page 9

clear;clc; close;

// Given data
R(1)=50; //source resistance of ac voltage in ohms

// Calculations
R(2)=R(1)*100;// minimum load resistance
disp("ohms", R(2),"Load resistance =")

// Result
// As long as the load resistance is greater than
   5000 ohms , the ac voltage source is stiff and we
    can ignore the internal resistance of the source
   .
```

Scilab code Exa 1.2 example2

```
// For what range of load resistance is current
   source stiff
// Electronic Principles
// By Albert Malvino , David Bates
// Seventh Edition
// The McGraw-Hill Companies
// Example 1-2, page 12

clear;clc; close;

// Given data
i=2; // current source , in milli amperes
R=10*10^6; //internal source resistance , in ohms

// Calculations
Rlmin=0;// minimum load resistance in ohms
Rlmax=0.01*R; // maximum load resistance
disp("ohms", Rlmin,"Minimum Load resistance =")
disp("ohms", Rlmax,"Maximum Load resistance =")

// Result
// The stiff range for the current source is a load
   resistance from 0 to 100 Kohms.
```

Scilab code Exa 1.4 example4

```
// find thevenin voltage and resistance
// Electronic Principles
// By Albert Malvino , David Bates
// Seventh Edition
// The McGraw-Hill Companies
// Example 1-4, page 14

clear;clc; close;

// Given data
Vs=72;// source voltage in volts

// Calculations
// open load resistor to get thevenin voltage
Vth=24; // in volts as 8 mA flows through 6Kohms in series with 3Kohms,no current through 4Kohms
// reduce source to zero to get thevenin resistance
Rth=4+((3*6)/(3+6));// in Kohms

disp("Volts", Vth,"Thevenin Voltage =")
disp("ohms",Rth,"Thevenin Resistance =")

// Result
// Thevenin voltage is 24 volts
// Thevenin resistance is 6 Kohms
```

Scilab code Exa 1.6 example6

```
// convert into norton circuit
// Electronic Principles
// By Albert Malvino , David Bates
// Seventh Edition
// The McGraw-Hill Companies
```

```
// Example 1-6, page 19

clear;clc; close;

// Given data
Vth=10;// Thevenin voltage in volts
Rth=2000;// Thevenin resistance in ohms

// Calculations
In=Vth/Rth;// Norton current in amperes
disp("Amperes",In,"Norton Current=")

// Result
// Norton current is 5 milliAmperes
```

Chapter 2

Semiconductors

Scilab code Exa 2.5 example5

```
// to find barrier potential of a silicon diode at
   given temperature
// Electronic Principles
// By Albert Malvino , David Bates
// The McGraw-Hill Companies
// Example 2-5, page 49

clear;clc; close;

// Given data
V(1)=0.7;// barrier potential in volts at 25 degree
   celcius
T(1)=25; // temperature in degree celcius at which
   vbarrier potential is known
T(2)=100; T(3)=0; // temperature in degree celcius
   at which barrier potential has to be found

//Calculations
dT(2)=T(2)-T(1);// difference in temperature
dT(3)=T(3)-T(1);// difference in temperature
dV(3)=(-0.002)*dT(3);// barrier potential for
```

```
   silicon decreases by 0.002 volts for each degree
   celcius rise
dV(2)=(-0.002)*dT(2)// barrier potential for silicon
    decreases by 0.002 volts for each degree celcius
    rise
V(2)=V(1)+dV(2);// to find barrier potential at T(2)
V(3)=V(1)+dV(3);// to find barrier potential at T(3)
disp("Volts",V(2),"Barrier Potential at 100 Degree
   celcius =")
disp("Volts",V(3),"Barrier Potential at 0 Degree
   celcius =")

// Result
// barrier potential at 100 degree celcius is 0.55
   volts
// barrier potential at 0 degree celcius is 0.75
   volts
```

Scilab code Exa 2.6 example6

```
// to find saturation current if temperature is
   given
// Electronic Principles
// By Albert Malvino , David Bates
// Seventh Edition
// The McGraw-Hill Companies
// Example 2-6, page 51

clear;clc; close;

// Given data
I(1)=5;// saturation current at given temperature in
    nano amperes
```

```
T(1)=25;// temperature in degree celcius at which saturation current is known
T(2)=100;// temperature in degree celcius at which saturation current is to be found

// Calculations
I(2)=(2^7)*I(1);// 7 doublings between 25 and 95 degree celcius
I(3)=((1.07)^5)*I(2); // additional 5 degree between 95 and 100 degree celcius
disp("Amperes",I(3),"Saturation Current =")

// Result
// saturation current at 100 degree celcius is 898 nano amperes.
```

Scilab code Exa 2.7 example7

```
// to find surface leakage current if reverse voltage is given
// Electronic Principles
// By Albert Malvino , David Bates
// Seventh Edition
// The McGraw-Hill Companies
// Example 2-7, page 52

clear;clc; close;

// Given data
I(1)=2*10^-9;// surface leakage current in  amperes at given reverse voltage
V(1)=25;// reverse voltage in volts at which surface leakage is known
```

```
V(2)=35;// reverse voltage in volts at which surface leakage current is to be found

// Calculations
I(2)=V(2)*I(1)/V(1);// surface leakage current is directly proportional to reverse voltage
disp("Amperes",I(2),"Surface leakage Current =")

// result
// surface leakage current is 2.8 nano amperes.
```

Chapter 3

Diode Theory

Scilab code Exa 3.2 example2

```
// to find if diode will get destroyed
// Electronic Principles
// By Albert Malvino , David Bates
// Seventh Edition
// The McGraw-Hill Companies
// Example 3-2, page 63

clear;clc; close;

// Given data
v=1.2; // diode voltage in volts
i=1.75; // diode current in amperes
P(1)=5;// power rating in watts

// Calculations
P(2)=v*i; // power dissipation
disp("Watts",P(2),"Power dissipation")

// Result
// As power dissipation is lower than power rating
   the diode will not get destroyed.
```

Scilab code Exa 3.3 example3

```
// to find load voltage and load current using ideal diode
// Electronic Principles
// By Albert Malvino , David Bates
// Seventh Edition
// The McGraw-Hill Companies
// Example 3-3, page 65

clear;clc; close;

// Given data
// diode is forward biased , equivalent to a closed switch.

// Calculations
V=10;// load voltage in volts
R=1000;// load resistance in ohms
I=V/R;// all the source voltage appears across the load resistor
disp("Amperes",I,"Load Current=")
disp("Volts",V,"Load Voltage=")

// Result
// load current is 10 milliampears
// load voltage is 10 volts.
```

Scilab code Exa 3.4 example4

```
//to find the load voltage and load current using an
    ideal diode
// Electronic Principles
// By Albert Malvino , David Bates
// Seventh Edition
// The McGraw-Hill Companies
// Example 3-4, page 65'

clear;clc; close;

// Given data
// refer to the diagram, thevenize the circuit to
   the left of the diode.
// looking at the diode back toward the source,we
   see a voltage divider with 6 killo-ohms and 3
   killo-ohms.
R=2000;// thevenin resistance in ohms
V=12;// thevenin voltage in volts

// Calculations
disp("Using Thevenin Thm")
// we have a series circuit and the diode is forward
    biased.
// visualize the diode as a closed switch
I=V/3000; // load current in amperes
V(1)=I*1000;// load voltage
disp("Amperes",I,"Load Current=")
disp("Volts",V(1),"Load Voltage=")

// Results
// load current is 4 milliamperes
// load voltage is 4 volts
```

Scilab code Exa 3.5 example5

```
// using second approximation find load voltage ,load
    current ,diode power
// Electronic Principles
// By Albert Malvino , David Bates
// Seventh Edition
// The McGraw-Hill Companies
// Example 3-5, page 67‘

clear;clc; close;

// Given data
// the diode is forward biased , equivalent to a
   battery of 0.7 volts
V=10;// voltage of battery in volts
Vd=0.7;// diode drop in volts

// Calculations
Vl=V-Vd;// load voltage in volts
R=1000;// load resistance in ohms
Il=Vl/R;// load current in amperes
Pd=Il*Vd;// diode power in watts
disp("Amperes",Il,"Load Current=")
disp("Volts",Vl,"Load Voltage=")
disp("Watts",Pd,"Diode power=")


// Result
// load voltage is 9.3 volts
// load current is 9.3 milli amperes
// diode power is 6.51 milli watts
```

Scilab code Exa 3.6 example6

```
// to find the load voltage, load current,diode
    power using second approximation
// Electronic Principles
// By Albert Malvino , David Bates
// Seventh Edition
// The McGraw-Hill Companies
// Example 3-6, page 67`

clear;clc; close;

// Given data
// thevenize the circuit to the left of the diode.
// looking at the diode back toward the source,we
    see a voltage divider with 6 killo-ohms and 3
    killo-ohms.
R=2000;// thevenin resistance in ohms
V(1)=12;// thevenin voltage in volts

// Calculations
disp("Using Thevenin Thm")
V(2)=0.7;// diode voltage in volts
I=(V(1)-V(2))/3000// load current in amperes
P=V(2)*I // diode power in watts
V=I*1000// load voltage in volts
disp("Amperes",I,"Load Current=")
disp("Volts",V,"Load Voltage=")
disp("Watts",P,"Diode power=")

// Results
// load voltage is 3.77 volts
```

```
// load current is 3.77 milli amperes
// diode power is 2.64 milli watts
```

Scilab code Exa 3.7 example7

```
// to find the load voltage , load current ,diode power
// Electronic Principles
// By Albert Malvino , David Bates
// Seventh Edition
// The McGraw-Hill Companies
// Example 3-7, page 68

clear;clc; close;

// Given data
Vd=0.7;// diode drop  in volts
V=10;// source voltage
R=1000;// resistance in ohms

// Calculations
Vl=V-Vd;// load voltage in volts
I=Vl/R;// load current in amperes
P=(V-Vl)*I;// diode power in watts
disp("Amperes",I,"Load Current=")
disp("Volts",Vl,"Load Voltage=")
disp("Watts",P,"Diode power=")


// Result
// load voltage is 9.3 volts
// load current is 9.3 milli amperes
// diode power is 6.51 milli watt
```

Scilab code Exa 3.8 example8

```
// to find the load voltage , load current ,diode
   power
// Electronic Principles
// By Albert Malvino , David Bates
// Seventh Edition
// The McGraw-Hill Companies
// Example 3-8, page 69'

clear;clc; close;

// Given data
Rl=10;// load resistance in ohms
Rb=0.23;// bulk resistance in ohms
// diode drop=0.7 volts

// Calculations
Rt=Rl+Rb;// total resistance in ohms
Vt=10-0.7;// voltage of battery-diode drop
I=Vt/Rt;// load current
Vl=I*10;// load voltage
Vd=10-Vl;// source voltage-load voltage
P=Vd*I;
disp("Amperes",I,"Load Current=")
disp("Volts",Vl,"Load Voltage=")
disp("Watts",P,"Diode power=")

// Result
// load voltage is 9.09 volts
// load current is 0.909 amperes
// diode power is 0.826 watts
```

Chapter 4

Diode Circuits

Scilab code Exa 4.1 example1

```
// calculating of peak load voltage and dc load
   voltage
// Electronic Principles
// By Albert Malvino , David Bates
// Seventh Edition
// The McGraw-Hill Companies
// Example 4-1, page 92

clear;clc; close;

// Given data
Vrms=10;// voltage of source in volts
Vd=0.7;// diode drop in volts

// Calculations
Vp(1)=Vrms/0.707;// peak source voltage in volts
// with an ideal diode peak load voltage = peak
   source voltage
Vp(2)=Vp(1);// Vp(2) is peak load voltage in volts
Vdc=Vp(2)/%pi;// dc voltage in volts
disp("Volts",Vp(2),"Peak voltage =")
```

```
disp("Volts",Vdc,"dc load voltage=")

// with second approximation
Vp(2)=Vp(1)-Vd;// peak load voltage in volts
Vdc=Vp(2)/%pi;
disp("Volts",Vp(2),"Peak voltage =")
disp("Volts",Vdc,"dc load voltage=")

// Result
// for an ideal diode
// peak load voltage is 14.1 volts
// dc load voltage is 4.49 volts
// with second approximation
// peak load voltage is 13.4 volts
// dc load voltage is 4.27 volts
```

Scilab code Exa 4.2 example2

```
// calculating of peak load voltage and dc load
   voltage
// Electronic Principles
// By Albert Malvino , David Bates
// Seventh Edition
// The McGraw-Hill Companies
// Example 4-2, page 95

clear;clc; close;

// Given data
// refer to the diagram
// turns ratio 5:1
V1=120;// primary voltage in volts

```

```
// Calculations

V2=V1/5;// secondary voltage in volts
Vpin=V2/0.707;// peak secondary voltage in volts
// with ideal diode
Vpout=Vpin;
Vdc=Vpout/%pi;
disp("Volts",Vpout,"Peak voltage =")
disp("Volts",Vdc,"dc load voltage=")
// with second approximation

Vpout=Vpin-0.7;// peak load voltage in volts
Vdc=Vpout/%pi;
disp("Volts",Vpout,"Peak voltage =")
disp("Volts",Vdc,"dc load voltage=")


// Result

// for an ideal diode
// peak load voltage is 34 volts
// dc load voltage is 10.8 volts

// with second approximation
// peak load voltage is 33.3 volts
// dc load voltage is 10.6 volts
```

Scilab code Exa 4.3 example3

```
// calculating of peak input and output voltage
   value
// Electronic Principles
// By Albert Malvino , David Bates
```

```
// Seventh Edition
// The McGraw-Hill Companies
// Example 4-3, page 97

clear;clc; close;

// Given data
Vrms=120;// in volts
// 10:1 step down transformer

// Calculations

Vp1=Vrms/0.707;// peak primary voltage in volts
Vp2=Vp1/10;// peak secondary voltage in volts
// the full wave rectifier acts like 2 back-to-back
    half-wave rectifiers.because of the center tap,
    the input voltage to each half-wave rectifier is
    only half the secondary voltage
Vpin=0.5*Vp2;
disp("Volts",Vpin,"Peak input voltage =")

Vpout=Vpin;// ideally
disp("Volts",Vpout,"Peak voltage =")

Vpout=Vpin-0.7;// using second approximation
disp("Volts",Vpout,"Peak voltage =")


// Result

// peak input voltage is 8.5 volts
// ideally peak output voltage is 8.5 volts
// with second approximation  peak output voltage is
     7.8 volts.
```

Scilab code Exa 4.5 example5

```
// calculating of peak input and output voltage value
// Electronic Principles
// By Albert Malvino , David Bates
// Seventh Edition
// The McGraw-Hill Companies
// Example 4-5, page 102

clear;clc; close;

// Given data
Vrms=120;// in volts
// 10:1 step down transformer

// Calculations

Vp1=Vrms/0.707;// peak primary voltage in volts
Vp2=Vp1/10;// peak secondary voltage in volts
disp("Volts",Vp1,"Peak primary voltage =")
disp("Volts",Vp2,"Peak primary voltage=")
// with a bridge rectifier ,the secondary voltage is used as the input to the rectifier.
Vpout1=Vp2;// ideally
Vpout2=Vp2-1.4;// to a second approximation
disp("Volts",Vpout1,"Peak primary voltage =")
disp("Volts",Vpout2,"Peak primary voltage=")

// Result

// peak primary voltage is 170 volts
```

```
// peak secondary voltage is 17 volts
// ideally peak output voltage is 17 volts
// with second approximation  peak output voltage is 15.6 volts.
```

Scilab code Exa 4.6 example6

```
// calculating of dc load voltage and ripple
// Electronic Principles
// By Albert Malvino , David Bates
// Seventh Edition
// The McGraw-Hill Companies
// Example 4-6, page 108

clear;clc; close;

// Given data
V1=120;// rms input voltage in volts
Rl=5000;// dc load resistance in ohms
f=60;// frequency in hertz
C=100*10^-6// capacitance in farads
// 5:1 step down transformer

// Calculations
V2=V1/5;// rms secondary voltage in volts
Vp=V2/0.707;// peak secondary voltage
Vl=Vp;// dc load voltage if diode is ideal,small ripple
Il=Vl/Rl;// dc load current in amperes
Vr=Il/(f*C);// ripple in Vpp,half wave rectifier
disp("Volts",Vl,"dc load voltage =")
disp("Volts",Vr,"riple =")

```

```
// Result
// dc load voltage is 34 volts
// ripple is 1.1 Vpp
```

Scilab code Exa 4.7 example7

```
// calculating of dc load voltage and ripple
// Electronic Principles
// By Albert Malvino , David Bates
// Seventh Edition
// The McGraw-Hill Companies
// Example 4-7, page 109

clear;clc; close;

// Given data
V1=120;// rms input voltage in volts
Rl=5000;// dc load resistance in ohms
f=60;// frequency in hertz
C=100*10^-6// capacitance in farads
// 5:1 step down transformer

// Calculations
V2=V1/5;// rms secondary voltage in volts
Vp=V2/0.707;// peak secondary voltage
Vl=Vp/2;// half of peak secondary voltage is the
    input to each half-wave section
Il=Vl/Rl;// dc load current in amperes
Vr=Il/(2*f*C);// ripple in vpp, full wave rectifier
disp("Volts",Vl,"dc load voltage =")
disp("Volts",Vr,"riple =")

// Result
```

```
// dc load voltage is 17 volts
// ripple is 0.28 Vpp
```

Scilab code Exa 4.8 example8

```
// calculating of dc load voltage and ripple
// Electronic Principles
// By Albert Malvino , David Bates
// Seventh Edition
// The McGraw-Hill Companies
// Example 4-8, page 110

clear;clc; close;

// Given data
V1=120;// rms input voltage in volts
Rl=5000;// dc load resistance in ohms
f=60;// frequency in hertz
C=100*10^-6// capacitance in farads
// 5:1 step down transformer

// Calculations
V2=V1/5;// rms secondary voltage in volts
Vp=V2/0.707;// peak secondary voltage
Vl=Vp;// ideal diode and small ripple
Il=Vl/Rl;// dc load current in amperes
Vr=Il/(2*f*C);// ripple in vpp,bridge rectifier
disp("Volts",Vl,"dc load voltage =")
disp("Volts",Vr,"riple =")

// Result
// dc load voltage is 34 volts
// ripple is 0.57 Vpp
```

Scilab code Exa 4.9 example9

```
// calculating of dc load voltage and ripple
// Electronic Principles
// By Albert Malvino , David Bates
// Seventh Edition
// The McGraw-Hill Companies
// Example 4-9, page 111

clear;clc; close;

// Given data
V1=120;// rms input voltage in volts
Rl=500;// dc load resistance in ohms
f=60;// frequency in hertz
C=4700*10^-6// capacitance in farads
// 15:1 step down transformer

// Calculations
V2=V1/15;// rms secondary voltage in volts
Vp=V2/0.707;// peak secondary voltage
Vl=Vp-1.4;// using second approximation
Il=Vl/Rl;// dc load current in amperes
Vr=Il/(2*f*C);// ripple in vpp,bridge rectifier
disp("Volts",Vl,"dc load voltage =")
disp("Volts",Vr,"riple =")

// Result
// dc load voltage is 9.9 volts
// ripple is 35 mVpp
```

Scilab code Exa 4.10 example10

```
// calculating peak inverse voltage
// Electronic Principles
// By Albert Malvino , David Bates
// Seventh Edition
// The McGraw-Hill Companies
// Example 4-10, page 114

clear;clc; close;

// Given data
V1=120;// rms input voltage in volts
// turns ratio 8:1

// Calculations
V2=V1/8;// rms secondary voltage in volts
Vp=V2/0.707;// peak secondary voltage
PIV=Vp;// peak inverse voltage
disp(PIV)
disp("Volts",PIV,"Peak inverse voltage =")

// Result
// peak inverse voltage is 21.2 volts
```

Chapter 5

Special Purpose Diodes

Scilab code Exa 5.1 example1

```
// find minimum and maximum zener currents
// Electronic Principles
// By Albert Malvino , David Bates
// Seventh Edition
// The McGraw-Hill Companies
// Example 1-1, page 9

clear;clc; close;

// Given data
R=820;// resistance in ohms
V=10;// breakdown voltage of diode
Vinmin=20;// minimum input voltage in volts
Vinmax=40;// maximum input voltage in volts

// Calculations
// voltage across resistor=input voltage-breakdown
    voltage
Ismin=(Vinmin-V)/R;// minimum zener current in
    amperes
Ismax=(Vinmax-V)/R;// maximum zener current in
```

```
amperes
disp("Amperes",Ismin,"Minimum zener current =")
disp("Amperes",Ismax,"Maximum zener current =")

// results
// minimum zener current is 12.2 mAmperes
// maximum zener current is 36.6 mAmperes
```

Scilab code Exa 5.2 example2

```
// to check if zener diode shown in the figure is operating in the breakdown region
// Electronic Principles
// By Albert Malvino , David Bates
// Seventh Edition
// The McGraw-Hill Companies
// Example 5-2, page 149

clear;clc; close;

// Given data
Rl=1*10^3;// in ohms
Rs=270;// in ohms
Vs=18;// in volts
Vz=10;// zener voltage in volts

// Calculations
Vth=(Rl/(Rs+Rl))*Vs;// Thevenin voltage facing the diode
disp("Volts",Vth,"Thevenin voltage=")
disp("Vth>Vz")

// Result
```

```
// Since thevenin voltage is greater than zener voltage ,zener diode is operating in the breakdown region
```

Scilab code Exa 5.3 example3

```
// to find zener current
// Electronic Principles
// By Albert Malvino , David Bates
// Seventh Edition
// The McGraw-Hill Companies
// Example 5-3, page 149

clear;clc; close;

// Given data
Vl=10;// load voltage in volts
Rl=1*10^3;// in ohms
Rs=270;// in ohms
Vs=18;// in volts
Vz=10;// zener voltage in volts

// Calculations
Is=(Vs-Vz)/Rs; // current through series resistor in amperes
Il=Vl/Rl;// in amperes
Iz=Is-Il;// zener current in amperes
disp("Amperes",Iz,"zener current =")

// Result
// Zener current is 19.6 mAmperes
```

Scilab code Exa 5.7 example7

```
// using second approximation find load voltage
// Electronic Principles
// By Albert Malvino , David Bates
// Seventh Edition
// The McGraw-Hill Companies
// Example 5-7, page 153

clear;clc; close;

// Given data
Iz=20*10^-3;// zener current in amperes
Rz=8.5;// zener resistance in ohms
Vz=10;// breakdown voltage in volts

// Calculations
dVl=Iz*Rz;// change in load voltage in volts
Vl=Vz+dVl;// load voltage  in  volts
disp("Volts",Vl,"load voltage=")

// Result
// load voltage is 10.17 volts
```

Scilab code Exa 5.8 example8

```
// find approximate ripple voltage across load
// Electronic Principles
```

```
// By Albert Malvino , David Bates
// Seventh Edition
// The McGraw-Hill Companies
// Example 5-8, page 154

clear;clc; close;

// Given data
Rs=270; // series resistance in ohms
Vrin=2;// input ripple in volts
Rz=8.5;// zener resistance in ohms
Vz=10;// breakdown voltage in volts

// Calculations
Vrout=(Rz/Rs)*Vrin;// output ripple in volts
disp("Volts",Vrout,"load ripple=")

// Result
// approximate load ripple is 63 mVolts
```

Scilab code Exa 5.10 example10

```
// find maximum allowable series resistance
// Electronic Principles
// By Albert Malvino , David Bates
// Seventh Edition
// The McGraw-Hill Companies
// Example 5-10, page 157

clear;clc; close;

// Given data
Rlmin=140;// minimum load resistance in ohms
```

```
Vsmin=22;// minimum input voltage in volts
Vz=12;// zener voltage in volts

// Calculations
Rsmax=((Vsmin/Vz)-1)*Rlmin;// maximum series
   resistance in ohms
disp("ohms",Rsmax,"Series resistance=")

// Result
// maximum series resistance is 117 ohms
```

Scilab code Exa 5.11 example11

```
// find maximum allowable series resistance
// Electronic Principles
// By Albert Malvino , David Bates
// Seventh Edition
// The McGraw−Hill Companies
// Example 5−11, page 157

clear;clc; close;

// Given data
Ilmax=20*10^-3;// maximum load current in amperes
Vsmin=15;// minimum input voltage in volts
Vz=6.8;// zener voltage in volts

// Calculations
Rsmax=(Vsmin-Vz)/Ilmax;// maximum series resistance
   in ohms
disp("ohms",Rsmax,"Series resistance=")

// Result
```

```
// maximum series resistance is 410 ohms
```

Scilab code Exa 5.12 example12

```
// find approximate load current
// Electronic Principles
// By Albert Malvino , David Bates
// Seventh Edition
// The McGraw-Hill Companies
// Example 5-12, page 168

clear;clc; close;

// Given data
Vs=50;// dc input voltage in volts
Vd=2;// forward voltage in volts
Rs=2.2*10^3;// series resistance in ohms

// Calculations
Is=(Vs-Vd)/Rs;// load current in amperes
disp("Amperes",Is,"load current =")

// Result
// approximate load current is 21.8 mAmperes.
```

Scilab code Exa 5.13 example13

```
// find load current
// Electronic Principles
```

```
// By Albert Malvino , David Bates
// Seventh Edition
// The McGraw-Hill Companies
// Example 5-13, page 168

clear;clc; close;

// Given data
// input terminals are shorted
Vs=9;// dc input voltage in volts
Vd=2;// forward voltage in volts
Rs=470;// series resistance in ohms

// Calculations
Is=(Vs-Vd)/Rs;// load current in amperes
disp("Amperes",Is,"load current =")

// Result
// approximate load current is 14.9 mAmperes.
```

Scilab code Exa 5.14 example14

```
// find average LED current ,power dissipation in
   series resistor
// Electronic Principles
// By Albert Malvino , David Bates
// Seventh Edition
// The McGraw-Hill Companies
// Example 5-14, page 169

clear;clc; close;

// Given data
```

```
V=20;// ac source rms voltage in volts
Rs=680;// series resistance in ohms

// Calculations
Vp=sqrt(2)*V;// peak voltage in volts
Is1=Vp/Rs;// peak current in amperes
Is2=Is1/%pi;// average of the half-wave currnt through LED
P=(V)^2/Rs;// power dissipated in watts
disp("Amperes",Is2,"average LED current =")
disp("Watts",P,"dissipated power=")

// Result
// Average LED current is 13.1 mAmperes
// Power dissipated is 0.588 watts.
```

Scilab code Exa 5.15 example15

```
// find average LED current
// Electronic Principles
// By Albert Malvino , David Bates
// Seventh Edition
// The McGraw-Hill Companies
// Example 5-15, page 170

clear;clc; close;

// Given data
f=60;// frequency in hertz
C=0.68*10^-6;// capacitance in faradays
V=170;// voltage in volts

// Calculations
```

```
Xc=1/(2*%pi*f*C);// capacitive resistance in ohms
Is1=V/Xc;// peak current in amperes
Is2=Is1/%pi;// average of the half-wave currnt
    through LED
disp("Amperes",Is2,"average LED current =")

// Result
// Average LED current is 13.9 mAmperes
```

Chapter 6

Bipolar Junction Transistor

Scilab code Exa 6.1 example1

```
// to find current gain of the transistor
// Electronic Principles
// By Albert Malvino , David Bates
// Seventh Edition
// The McGraw-Hill Companies
// Example 6-1, page 194

clear;clc; close;

// Given data
Ic=10*10^-3;// collector current in amperes
Ib=40*10^-6;// base current in amperes

// Calculations
Bdc=Ic/Ib;// current gain
disp(Bdc)
disp(Bdc,"current gain =")

// Result
// current gain is 250.
```

Scilab code Exa 6.2 example2

```
// to find collector current of the transistor
// Electronic Principles
// By Albert Malvino , David Bates
// Seventh Edition
// The McGraw-Hill Companies
// Example 6-2, page 194

clear;clc; close;

// Given data
Bdc=175;// current gain
Ib=0.1*10^-3;// base current in amperes

// Calculations
Ic=Bdc*Ib;// collector current in amperes
disp("Amperes",Ic,"collector current =")

// Result
// Collector current is 17.5 mAmperes.
```

Scilab code Exa 6.3 example3

```
// to find base current of the transistor
// Electronic Principles
// By Albert Malvino , David Bates
// Seventh Edition
```

```
// The McGraw−Hill Companies
// Example 6−3, page 195

 clear;clc; close;

// Given data
Ic=2*10^-3;// collector current in amperes
Bdc=135;// current gain

// Calculations
Ib=Ic/Bdc;// collector current in amperes
disp("Amperes",Ib,"base current =")

// Result
// Base current is 14.8 micro Amperes.
```

Scilab code Exa 6.4 example4

```
// to find base current
// Electronic Principles
// By Albert Malvino , David Bates
// Seventh Edition
// The McGraw−Hill Companies
// Example 6−4, page 197

 clear;clc; close;

// Given data
Bdc=200;// current gain
Vbb=2;// base source voltage in volts
Vbe=0.7;// emitter diode in volts
Rb=100*10^3;// resistance in ohms

```

```
// Calculations
Ib=(Vbb-Vbe)/Rb;// current through base resistor in
   amperes
Ic=Ib*Bdc;// collector current in amperes
disp("Amperes",Ic,"collector current =")

// Result
// collector current is 2.6mAmperes
```

Scilab code Exa 6.5 example5

```
// find Ib,Ic,Vce,Pd
// Electronic Principles
// By Albert Malvino , David Bates
// Seventh Edition
// The McGraw-Hill Companies
// Example 6-5, page 201

clear;clc; close;

// Given data
Rc=2*10^3;// resistance in ohms
Bdc=300;// current gain
Vbb=10;// base source voltage in volts
Vbe=0.7;// emitter diode in volts
Rb=1*10^6;// resistance in ohms
Vcc=10;// in volts

// Calculations
Ib=(Vbb-Vbe)/Rb;// current through base resistor in
   amperes
Ic=Ib*Bdc;// collector current in amperes
Vce=Vcc-(Ic*Rc);// collector-emitter voltage in
```

```
   volts
Pd=Vce*Ic;// collector power dissipation in watts
disp("Amperes",Ib,"base current =")
disp("Amperes",Ic,"collector current =")
disp("Volts",Vce,"collector-emitter voltage =")
disp("watts",Pd,"dissipated power=")

// Result
// Ib is 9.3 microAmperes,Ic is 2.79 mAmperes,Vce is
    4.42 volts,Pd is 12.3 mWatts
```

Scilab code Exa 6.6 example6

```
// calculate current gain for 2N4424
// Electronic Principles
// By Albert Malvino , David Bates
// Seventh Edition
// The McGraw-Hill Companies
// Example 6-6, page 202

clear;clc; close;

// Given data
Rc=470;// resistance in ohms
Vbb=10;// base source voltage in volts
Vbe=0.7;// emitter diode in volts
Rb=330*10^3;// resistance in ohms
Vce=5.45;// collector-emitter voltage in volts

// Calculations
V=Vbb-Vce;// voltage across collector-resistance in
   volts
Ic=V/Rc;// collector current in amperes
```

```
Ib=(Vbb-Vbe)/Rb;// current through base resistor in amperes
Bdc=Ic/Ib;// current gain
disp(Bdc,"current gain")

// Result
// current gain is 343
```

Scilab code Exa 6.7 example7

```
// find collector-emmiter voltage
// Electronic Principles
// By Albert Malvino , David Bates
// Seventh Edition
// The McGraw-Hill Companies
// Example 6-7, page 204

clear;clc; close;

// Given data
Rb=470*10^3;// resistance in ohms
Vbe=0;// as emmiter diode is ideal
Bdc=100;// current gain
Vbb=15;// base source voltage in volts
Rc=3.6*10^3;// resistance in ohms
Vcc=15;// collector-supply voltage in volts

// Calculations
Ib=(Vbb-Vbe)/Rb;// current through base resistor in amperes
Ic=Ib*Bdc;// collector current in amperes
Vce=Vcc-(Ic*Rc);// collector-emitter voltage in volts
```

```
disp("Volts",Vce,"collector-emitter voltage =")

// Result
// collector-emmiter voltage is 3.52 Volts
```

Scilab code Exa 6.8 example8

```
// find collector-emmiter voltage
// Electronic Principles
// By Albert Malvino , David Bates
// Seventh Edition
// The McGraw-Hill Companies
// Example 6-8, page 205

clear;clc; close;

// Given data
Rb=470*10^3;// resistance in ohms
Vbe=0.7;// using second approximation
Bdc=100;// current gain
Vbb=15;// base source voltage in volts
Rc=3.6*10^3;// resistance in ohms
Vcc=15;// collector-supply voltage in volts

// Calculations
Ib=(Vbb-Vbe)/Rb;// current through base resistor in amperes
Ic=Ib*Bdc;// collector current in amperes
Vce=Vcc-(Ic*Rc);// collector-emitter voltage in volts
disp("Volts",Vce,"collector-emitter voltage =")

// Result
```

```
// collector-emmiter voltage is 4.06 Volts.
```

Scilab code Exa 6.9 example9

```
// find collector-emmiter voltage
// Electronic Principles
// By Albert Malvino , David Bates
// Seventh Edition
// The McGraw-Hill Companies
// Example 6-9, page 206

clear;clc; close;

// Given data
Rb=470*10^3;// resistance in ohms
Vbe=1;// voltage across emitter diode in volts
Bdc=100;// current gain
Vbb=15;// base source voltage in volts
Rc=3.6*10^3;// resistance in ohms
Vcc=15;// collector-supply voltage in volts

// Calculations
Ib=(Vbb-Vbe)/Rb;// current through base resistor in
    amperes
Ic=Ib*Bdc;// collector current in amperes
Vce=Vcc-(Ic*Rc);// collector-emitter voltage in
    volts
disp("Volts",Vce,"collector-emitter voltage =")

// Result
// collector-emmiter voltage is 4.27 Volts
```

Scilab code Exa 6.11 example11

```
// find power dissipation
// Electronic Principles
// By Albert Malvino , David Bates
// Seventh Edition
// The McGraw-Hill Companies
// Example 6-11, page 211

clear;clc; close;

// Given data
Vce=10;// collector-emmiter voltage in volts
Ic=20*10^-3;// collector-current in amperes
T=25;// ambient temperature
P=625*10^-3;// power rating in watts at 25 degree
   celcius

// Calculations
Pd=Vce*Ic;// power dissipation in watts
disp("watts",Pd,"dissipated power=")

// Result
// As power dissipation is less than rated power at
   ambient temperature,transistor(2N3904) is safe
```

Scilab code Exa 6.12 example12

```
// find if transistor is safe
// Electronic Principles
// By Albert Malvino , David Bates
// Seventh Edition
// The McGraw-Hill Companies
// Example 6-12, page 212

clear;clc; close;

// Given data
T1=100;// ambient temperature
T2=25;// in degree celcius
P=625*10^-3;// power rating in watts at 25 degree celcius
d=5*10^-3;// derating factor with respect to temperature

// Calculations
dT=T1-T2;// difference in temperature
dP=d*dT;// difference in power
Pd=P-dP;// maximum power dissipated in watts when ambient temperature is 100 degree celcius
disp("watts",Pd,"dissipated power=")

// Result
// If power dissipation is less than rated power at ambient temperatureor ambient temperature doesnt increase,transistor is safe
```

Chapter 7

Transistor Fundamentals

Scilab code Exa 7.1 example1

```
// calculate saturation current and cutoff voltage
// Electronic Principles
// By Albert Malvino , David Bates
// Seventh Edition
// The McGraw-Hill Companies
// Example 7-1, page 228

clear;clc; close;

// Given data
Vcc=30;// collector supply voltage in volts
Rc=3*10^3;// collector resistance in ohms

// Calculations
Icsat=Vcc/Rc;// saturation current in amperes
Vcecutoff=Vcc;// cutoff voltage in volts
disp("Amperes",Icsat,"Saturation Current")
disp("Volts",Vcecutoff,"cutoff voltage")

// Result
// saturation current is 10 mAmperes
```

```
// cutoff voltage is 30 Volts
```

Scilab code Exa 7.2 example2

```
// calculate saturation current and cutoff voltage
// Electronic Principles
// By Albert Malvino , David Bates
// Seventh Edition
// The McGraw-Hill Companies
// Example 7-2, page 228

clear;clc; close;

// Given data

Vcc=9;// collector supply voltage in volts
Rc=3*10^3;// collector resistance in ohms

// Calculations
Icsat=Vcc/Rc;// saturation current in amperes
Vcecutoff=Vcc;// cutoff voltage in volts
disp("Amperes",Icsat,"Saturation Current")
disp("Volts",Vcecutoff,"cutoff voltage")

// Result
// saturation current is 3 mAmperes
// cutoff voltage is 9 Volts
```

Scilab code Exa 7.3 example3

```
// calculate saturation current and cutoff voltage
// Electronic Principles
// By Albert Malvino , David Bates
// Seventh Edition
// The McGraw-Hill Companies
// Example 7-3, page 229

clear;clc; close;

// Given data

Vcc=15;// collector supply voltage in volts
Rc=1*10^3;// collector resistance in ohms

// Calculations
Icsat=Vcc/Rc;// saturation current in amperes
Vcecutoff=Vcc;// cutoff voltage in volts
disp("Amperes",Icsat,"Saturation Current")
disp("Volts",Vcecutoff,"cutoff voltage")


// Result
// saturation current is 15 mAmperes
// cutoff voltage is 15 Volts
```

Scilab code Exa 7.4 example4

```
// calculate saturation current and cutoff voltage
// Electronic Principles
// By Albert Malvino , David Bates
// Seventh Edition
// The McGraw-Hill Companies
// Example 7-4, page 229
```

```
clear;clc; close;

// Given data
Vcc=15;// collector supply voltage in volts
Rc=3*10^3;// collector resistance in ohms

// Calculations
Icsat=Vcc/Rc;// saturation current in amperes
Vcecutoff=Vcc;// cutoff voltage in volts
disp("Amperes",Icsat,"Saturation Current")
disp("Volts",Vcecutoff,"cutoff voltage")

// Result
// saturation current is 5 mAmperes
// cutoff voltage is 15 Volts
```

Scilab code Exa 7.5 example5

```
// calculate collector-emitter resistance voltage
// Electronic Principles
// By Albert Malvino , David Bates
// Seventh Edition
// The McGraw-Hill Companies
// Example 7-5, page 232

clear;clc; close;

// Given data
Bdc=100
Vbb=15;// in volts
Vcc=15;// collector supply voltage in volts
Vbe=0.7;// in volts
```

```
Rb=1*10^6;// base resistance in ohms
Rc=3*10^3;// collector resistance in ohms

// Calculations
Ib=(Vbb-Vbe)/Rb;// base current in amperes
Ic=Bdc*Ib;// collector current in amperes
Vce=Vcc-(Ic*Rc);// collector-emitter voltage in
   volts
disp("Volts",Vce,"collector-emitter voltage")

// Result
// collector-emitter voltage is 10.7 volts
```

Scilab code Exa 7.6 example6

```
// find whether transistor remains in saturated
   region
// Electronic Principles
// By Albert Malvino , David Bates
// Seventh Edition
// The McGraw-Hill Companies
// Example 7-6, page 235

clear;clc; close;

// Given data
Vcc=20;// collector supply voltage in volts
Vbb=10;// base voltage in volts
Rc=10*10^3;// collector resistance in ohms
Rb=1*10^6;// base resistance in ohms
Bdc=50;

// Calculations
```

```
Ib=Vbb/Rb;// base current in amperes
Ic=Bdc*Ib;// collector current in amperes
Vce=Vcc-(Ic*Rc);// collector-emitter voltage in
    volts
disp("Volts",Vce,"collector-emitter voltage")

// Result
// as Vce>0 ,the transistor is not saturated
```

Scilab code Exa 7.7 example7

```
// find whether transistor remains in saturated
    region
// Electronic Principles
// By Albert Malvino , David Bates
// Seventh Edition
// The McGraw-Hill Companies
// Example 7-7, page 235

clear;clc; close;

// Given data
Vcc=20;// collector supply voltage in volts
Vbb=10;// base voltage in volts
Rc=5*10^3;// collector resistance in ohms
Rb=1*10^6;// base resistance in ohms
Bdc=50;

// Calculations
Icsat=Vcc/Rc;// saturation current in amperes
Ib=Vbb/Rb;// base current in amperes
Ic=Bdc*Ib;// collector current in amperes
disp(Ic)
```

```
disp(Icsat)
disp("Ic>Icsat")

// Result
// as Ic>Icsat ,the transistor is saturated
```

Scilab code Exa 7.8 example8

```
// find the 2 values of output voltage
// Electronic Principles
// By Albert Malvino , David Bates
// Seventh Edition
// The McGraw-Hill Companies
// Example 7-8, page 236

clear;clc; close;

// Given data
Vcc=5;// collector supply voltage in volts
Vbb=10;// base voltage in volts
Rc=1*10^3;// collector resistance in ohms
Rb=10*10^3;// base resistance in ohms
Bdc=50;// current gain
Vcesat=0.15;// saturation voltage in volts
Iceo=50*10^-9;// collector leakage current in amperes

// Calculations
Vce=Vcc-(Iceo*Rc);// collector-emitter voltage in volts
disp("Volts",Vcesat,"Output voltage")
disp("Volts",Vce,"Output voltage")

```

```
// Result
// the 2 output voltages are 5 volts and 0.15 volts
```

Scilab code Exa 7.9 example9

```
// find voltage between collector and ground and
   between collector and emitter
// Electronic Principles
// By Albert Malvino , David Bates
// Seventh Edition
// The McGraw-Hill Companies
// Example 7-9, page 239

clear;clc; close;

// Given data
Vcc=15;// collector supply voltage in volts
Vbb=5;// base voltage in volts
Rc=2*10^3;// collector resistance in ohms
Re=1*10^3;// emitter resistance in ohms

// Calculations
Ve=Vbb-0.7;// emitter voltage in volts
Ie=Ve/Re;// emitter current in amperes
Ic=Ie;// collector current is equal to emitter
   current
Vc=Vcc-(Ic*Rc);// collector voltage in volts
Vce=Vc-Ve;// collector-emitter voltage in volts
disp("Volts",Vce,"collector-emitter voltage")
disp("Volts",Vc,"collector-ground voltage")

// Result
// collector-to-ground voltage is 6.4 volts
```

```
// collector-emitter voltage is 2.1 volts
```

Chapter 8

Transistor Biasing

Scilab code Exa 8.1 example1

```
// calculate the collector-emmitter voltage
// Electronic Principles
// By Albert Malvino , David Bates
// Seventh Edition
// The McGraw-Hill Companies
// Example 8-1, page 263

clear;clc; close;

// Given data

Vcc=10;// collector supply voltage in volts
R1=10*10^3;// in ohms
R2=2.2*10^3;// in ohms
Rc=3.6*10^3;// collector resistance
Re=1*10^3;// emitter resistance

// Calculations

Vbb=R2*Vcc/(R1+R2);// base voltage in ohms
Ve=Vbb-0.7;// emitter voltage
```

```
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-emitter voltage in volts
disp("Volts",Vce,"Collector-Emitter Voltage")

// Result
// collector-emitter voltage is 4.92 volts.
```

Scilab code Exa 8.3 example3

```
// find emitter current
// Electronic Principles
// By Albert Malvino , David Bates
// Seventh Edition
// The McGraw-Hill Companies
// Example 8-3, page 266

clear;clc; close;

// Given data
R1=10*10^3;// in ohms
R2=2.2*10^3;// in ohms
Rc=3.6*10^3;// in ohms
Re=1*10^3;// in ohms
Bdc=200;// current gain
Vbb=1.8;// base supply voltage in volts
Vbe=0.7;// voltage across emitter in volts

// Calculations
Rth=(R1*R2)/(R1+R2);// thevenin voltage in volts(R1
```

```
    ||R2)
Rin=Bdc*Re;// input resistance of base
// as Rth<0.01*Rin, voltage divider is stiff
Ie=(Vbb-Vbe)/(Re+(Rth/Bdc));// emitter current in
    amperes
disp("Amperes",Ie,"Emitter Current")

// Result
// voltage divider is stiff, emitter current is 1.09
    milliamperes
```

Scilab code Exa 8.4 example4

```
// find resistances to fit in the given VDB design
// Electronic Principles
// By Albert Malvino , David Bates
// Seventh Edition
// The McGraw-Hill Companies
// Example 8-4, page 269

clear;clc; close;

// Given data
// 2N3904
Bdc=100;// current gain
Vcc=10 ;// supply voltage in volts
Ic=10*10^-3;// collector current in amperes

// Calculations
Ve=0.1*Vcc;// emitter voltage in volts
Ie=Ic;// collector current is equal to emitter
    current
Re=Ve/Ie;// emitter resistance in ohms
```

```
Rc=4*Re;// collector resistance in ohms
R2max=0.01*Bdc*Re;// in ohms
V2=Ve+0.7;// in volts
V1=Vcc-V2;// in volts
R1=(V1*R2max)/V2;// in ohms
disp("Ohms",R1,"R1=")
disp("Ohms",R2max,"R2=")
disp("Ohms",Rc," Collector Resistance=")
disp("Ohms",Re,"Emitter Resistance=")

// Result
// R1=488 ohms, R2=100 ohms, Rc=400 ohms, Re=100
    ohms
```

Scilab code Exa 8.5 example5

```
// find collector voltage
// Electronic Principles
// By Albert Malvino , David Bates
// Seventh Edition
// The McGraw-Hill Companies
// Example 8-5, page 271

clear;clc; close;

// Given data
Re=1.8*10^3;// emitter current in ohms
Rc=3.6*10^3;// collector resistance in ohms
Rb=2.7*10^3;// in ohms
Vre=1.3;// voltage across the emitter resistor in
    volts
Vcc=10;// collector supply voltage in volts

```

```
// Calculations
Ie=Vre/Re;// emitter current in amperes
Ic=Ie;// collector current is equal to emitter current
Vc=Vcc-Ic*Rc;// collector voltage in volts
disp("Volts",Vc,"Collector Voltage")

// Result
// collector voltage is 7.4 volts
```

Scilab code Exa 8.6 example6

```
// find collector to ground voltage
// Electronic Principles
// By Albert Malvino , David Bates
// Seventh Edition
// The McGraw-Hill Companies
// Example 8-6, page 271

clear;clc; close;

// Given data
Vee=15;// in volts
Vcc=15;// in volts
Rc=10*10^3;// in ohms
Re=20*10^3;// in ohms

// Calculations
Ie=(Vee-0.7)/Re;// emitter current in amperes
Ic=Ie;// collector current is equal to emitter current
Vc=Vcc-Ic*Rc;// collector voltage in volts
disp("Volts",Vc,"Collector Voltage")
```

```
// Result
// collector to ground voltage is 7.85 volts
```

Scilab code Exa 8.7 example7

```
// calculate the 3 transistor voltages for pnp
   circuit
// Electronic Principles
// By Albert Malvino , David Bates
// Seventh Edition
// The McGraw-Hill Companies
// Example 8-7, page 278

clear;clc; close;

// Given data
Vee=10;// in volts
Vcc=10;// in volts
Rc=3.6*10^3;// in ohms
Re=1*10^3;// in ohms
R1=10*10^3;// in ohms
R2=2.2*10^3;// in ohms

// Calculations
V2=(R2/(R2+R1))*Vee;//voltage across R2
Ve=V2-0.7;// voltage across emitter resistor in
   volts
Ie=Ve/Re;// emitter current in amperes
Ic=Ie;// collector current is equal to emitter
   current
Vc=Ic*Rc;// collector-ground voltage in volts
Vb=Vcc-V2;// base -ground voltage in volts
```

```
Vee=Vcc-Ve;// emitter-ground voltage in volts
disp("Volts",Vc,"Collector Voltage")
disp("Volts",Vb,"Base Voltage")
disp("Volts",Vee,"Emitter Voltage")

// Result
// collector-ground voltage is 3.96 volts
// base-ground voltage is 8.2 volts
// emitter-ground voltage is 8.9 volts
```

Chapter 9

AC Models

Scilab code Exa 9.1 example1

```
// find the value of capacitance
// Electronic Principles
// By Albert Malvino , David Bates
// Seventh Edition
// The McGraw-Hill Companies
// Example 9-1, page 289

clear;clc; close;

// Given data
R=2*10^3;// resistance in ohms
fmin=20;// lower frequency range
fmax=20*10^3;// higher frequency range

// Calculations
Xc=200;// Xc<0.1*R at 20 Hertz
C=1/(2*%pi*fmin*Xc);// in faraday
disp("Faraday",C,"Capacitance=")

// Result
// Capacitance required is 39.8 micro Faraday
```

Scilab code Exa 9.2 example2

```
// find the value of capacitance
// Electronic Principles
// By Albert Malvino , David Bates
// Seventh Edition
// The McGraw-Hill Companies
// Example 9-2, page 293

clear;clc; close;

// Given data
R1=600;// resistance in ohms
R2=1*10^3;// resistance in ohms
R=(R1*R2)/(R1+R2);// R=R1||R2
f=1*10^3;// frequency in hertz

// Calculations
Xc=37.5;// Xc<0.1*R at 1000 Hertz
C=1/(2*%pi*f*Xc);// in faraday
disp("Faraday",C,"Capacitance=")

// Result
// Capacitance required is 4.2 micro Faraday
```

Scilab code Exa 9.3 example3

```
// find maximum small signal emitter current
// Electronic Principles
// By Albert Malvino , David Bates
// Seventh Edition
// The McGraw−Hill Companies
// Example 9−3, page 297

clear;clc; close;

// Given data
Vee=2;// in volts
Vbe=0.7;// in volts
Re=1*10^3;// in ohms

// Calculations
Ieq=(Vee-Vbe)/Re;// Q point emitter current in
    amperes
ieppmax=0.1*Ieq;// maximum small signal emitter
    current in amperes
disp(ieppmax,"maximum small signal emitter current")

// Result
// Maximum small signal emitter current is 130
    microApp.
```

Scilab code Exa 9.4 example4

```
// find re(ac)
// Electronic Principles
// By Albert Malvino , David Bates
// Seventh Edition
// The McGraw−Hill Companies
// Example 9−4, page 301
```

```
clear;clc; close;

// Given data
Ie=3*10^-3;// emitter current in amperes

// Calculations
re=25*10^-3/Ie;// ac emitter resistance in ohms
disp("Ohms",re,"re(ac)=")

// Result
// re(ac) of the base-biased amplifier is 8.33 ohms
```

Scilab code Exa 9.5 example5

```
// find re(ac)
// Electronic Principles
// By Albert Malvino , David Bates
// Seventh Edition
// The McGraw-Hill Companies
// Example 9-5, page 301

clear;clc; close;

// Given data
Ie=1.1*10^-3;// emitter current in amperes

// Calculations
re=25*10^-3/Ie;// ac emitter resistance in ohms
disp("Ohms",re,"re(ac)=")

// Result
// re(ac) of the base-biased amplifier is 22.7 ohms
```

Scilab code Exa 9.6 example6

```
// find re(ac)
// Electronic Principles
// By Albert Malvino , David Bates
// Seventh Edition
// The McGraw-Hill Companies
// Example 9-6, page 301

clear;clc; close;

// Given data
Ie=1.3*10^-3;// emitter current in amperes

// Calculations
re=25*10^-3/Ie;// ac emitter resistance in ohms
disp("Ohms",re,"re(ac)=")

// Result
// re(ac) of the base-biased amplifier is 19.2 ohms
```

Chapter 10

Voltage Amplifiers

Scilab code Exa 10.1 example1

```
// find voltage gain  and voltage across load resistor
// Electronic Principles
// By Albert Malvino , David Bates
// Seventh Edition
// The McGraw-Hill Companies
// Example 10-1, page 322

clear;clc; close;

// Given data
R1=10*10^3;// in ohms
R2=2.2*10^3;// in ohms
Re=1*10^3;// in ohms
Rl=10*10^3;// in ohms
Rc=3.6*10^3;// in ohms
Vin=2.2*10^-3;// in volts
Vcc=10;// in volts

// Calculations
rc=(Rc*Rl)/(Rc+Rl);// ac collector resistance in
```

```
ohms,Rc||Rl
re_=22.7;// ac resistance in ohms
Av=rc/re_;// voltage gain
vout=Av*Vin;// output voltage in volts
disp("Volts",vout,"Output voltage")

// Results
// output voltage is 256 mVolts
```

Scilab code Exa 10.2 example2

```
// find voltage gain  and output voltage across load
    resistor
// Electronic Principles
// By Albert Malvino , David Bates
// Seventh Edition
// The McGraw-Hill Companies
// Example 10-2, page 323

clear;clc; close;

// Given data
R1=10*10^3;// in ohms
R2=2.2*10^3;// in ohms
Re=10*10^3;// in ohms
Vin=5*10^-3;// in volts
Vcc=9;// in volts
Rc=3.6*10^3;// in ohms
Rl=2.2*10^3;// in ohms

// Calculations
rc=(Rc*Rl)/(Rc+Rl);// ac collector resistance in
   ohms,Rc||Rl
```

```
Ie=(Vcc-0.7)/Re;// dc emitter current in amperes
re_=(25*10^-3)/Ie;// ac resistance of the emitter diode
Av=rc/re_;// voltage gain
vout=Av*Vin;// output voltage in volts
disp("Volts",vout,"Output voltage")

// Results
// Output voltage is 228 mVolts.
```

Scilab code Exa 10.3 example3

```
// find output voltage
// Electronic Principles
// By Albert Malvino , David Bates
// Seventh Edition
// The McGraw-Hill Companies
// Example 10-3, page 325

clear;clc; close;

// Given data
B=300;
R1=10*10^3;// in ohms
R2=2.2*10^3;// in ohms
Re=1*10^3;// in ohms
Rl=10*10^3;// in ohms
Rc=3.6*10^3;// in ohms
Rg=600;// internal resistance of ac generator in ohms
vg=2*10^-3;// in volts
Vcc=10;// in volts

```

```
// Calculations
rc=(Rc*Rl)/(Rc+Rl);// ac collector resistance in
   ohms,Rc||Rl
re_=22.7;// ac resistance in ohms
Av=rc/re_;// voltage gain
zinbase=B*re_;// input impedance of base in ohms
zinstage_=(1/R1)+(1/R2)+(1/zinbase);// input
   impedance of base in ohms
zinstage=zinstage_^-1
vin=(zinstage/(Rg+zinstage))*vg;// input voltage in
   volts
vout=Av*vin;// output voltage in volts
disp("Volts",vout,"Output voltage")

// Results
// Output voltage is 165 mVolts.
```

Scilab code Exa 10.4 example4

```
// find output voltage
// Electronic Principles
// By Albert Malvino , David Bates
// Seventh Edition
// The McGraw-Hill Companies
// Example 10-4, page 325

clear;clc; close;

// Given data
B=50;
R1=10*10^3;// in ohms
R2=2.2*10^3;// in ohms
Re=1*10^3;// in ohms
```

```
Rl=10*10^3;// in ohms
Rc=3.6*10^3;// in ohms
Rg=600;// internal resistance of ac generator in
    ohms
vg=2*10^-3;// in volts
Vcc=10;// in volts

// Calculations
rc=(Rc*Rl)/(Rc+Rl);// ac collector resistance in
    ohms,Rc||Rl
re_=22.7;// ac resistance in ohms
Av=rc/re_;// voltage gain
zinbase=B*re_;// input impedance of base in ohms
zinstage_=(1/R1)+(1/R2)+(1/zinbase);// input
    impedance of base in ohms
zinstage=zinstage_^-1
vin=(zinstage/(Rg+zinstage))*vg;// input voltage in
    volts
vout=Av*vin;// output voltage in volts
disp("Volts",vout,"Output voltage")

// Results
// Output voltage is 126 mVolts.
```

Scilab code Exa 10.5 example5

```
// calculate ac collector voltage,ac output voltage
    across load resistor
// Electronic Principles
// By Albert Malvino , David Bates
// Seventh Edition
// The McGraw-Hill Companies
// Example 10-5, page 327
```

```
clear;clc; close;

// Given data
B=100;
R1=10*10^3;// in ohms
R2=2.2*10^3;// in ohms
Re=1*10^3;// in ohms
Rl=10*10^3;// in ohms
Rc=3.6*10^3;// in ohms
Rg=600;// internal resistance of ac generator in
    ohms
Vg=1*10^-3;// in volts
Vcc=10;// in volts

// Calculations
re_=22.7;// ac resistance in ohms
zinbase=B*re_;// input impedance of first base in
    ohms
zinstage_=(1/R1)+(1/R2)+(1/zinbase);// input
    impedance of base in ohms
zinstage=zinstage_^-1
vin=(zinstage/(Rg+zinstage))*Vg;// input voltage in
    volts
rc1=Rc*zinstage/(Rc+zinstage);// rc=Rc||zinstage in
    ohms in first stage
Av1=rc1/zinbase;// voltage gain
vc1=Av1*vin;// collector voltage in volts in first
    stage
rc2=Rc*Rl/(Rc+Rl);// rc2=Rc||Rl in ohms in second
    stage
Av2=rc2/zinbase;// voltage gain
vc2=Av2*vc1;// output voltage across load resistot
    in volts
disp("Volts",vc1,"ac collector voltage in first
    stage=")
disp("Volts",vc2,"ac output voltage across the load
    resistor")
```

```

// Results
// ac collector voltage in first stage is 216 *10^-6
    Volts
// ac output voltage across the load resistor is 252
    *10^-6 Volts
```

Scilab code Exa 10.6 example6

```
// calculate output across load resistor
// Electronic Principles
// By Albert Malvino , David Bates
// Seventh Edition
// The McGraw-Hill Companies
// Example 10-6, page 331

clear;clc; close;

// Given data
B=200;
re=180;// in ohms
R1=10*10^3;// in ohms
R2=2.2*10^3;// in ohms
Rc=3.6*10^3;// in ohms
Vg=50*10^-3;// in volts
Vcc=10;// in volts
Rg=600;// internal resistance in ohms

// Calculations
rc=2.65*10^3;// in ohms
zinbase=B*re;// input impedance of base in ohms
zinstage_=(1/R1)+(1/R2)+(1/zinbase);// input
    impedance of base in ohms
```

```
zinstage=zinstage_^-1
vin=(zinstage/(Rg+zinstage))*Vg;// input voltage in volts
Av=rc/re;// voltage gain
vout=Av*vin;// output voltage across load resistor in volts
disp("Volts",vout,"Output voltage")

// Results
// output voltage across load resistor is 544 mVolts
```

Scilab code Exa 10.7 example7

```
// calculate output across load resistor
// Electronic Principles
// By Albert Malvino , David Bates
// Seventh Edition
// The McGraw-Hill Companies
// Example 10-7, page 332

clear;clc; close;

// Given data
B=200;
re_=22.7;// in ohms
re=180;// in ohms
R1=10*10^3;// in ohms
R2=2.2*10^3;// in ohms
Rc=3.6*10^3;// in ohms
Vg=50*10^-3;// in volts
Vcc=10;// in volts
Rg=600;// internal resistance in ohms

```

```
// Calculations
rc=2.65*10^3;// in ohms
zinbase=B*(re+re_);// input impedance of base in
   ohms
zinstage_=(1/R1)+(1/R2)+(1/zinbase);// input
   impedance of base in ohms
zinstage=zinstage_^-1
vin=(zinstage/(Rg+zinstage))*Vg;// input voltage in
   volts
Av=rc/(re+re_);// voltage gain
vout=Av*vin;// output voltage across load resistor
   in volts
disp("Volts",vout,"Output voltage")

// Results
// output voltage across load resistor is 485 mVolts
```

Scilab code Exa 10.8 example8

```
// calculate output across load resistor
// Electronic Principles
// By Albert Malvino , David Bates
// Seventh Edition
// The McGraw-Hill Companies
// Example 10-8, page 333

clear;clc; close;

// Given data
B=200;
re=180;// in ohms
R1=10*10^3;// in ohms
R2=2.2*10^3;// in ohms
```

```
Rc=3.6*10^3;// in ohms
Vg=1*10^-3;// in volts
Vcc=10;// in volts
Rg=600;// internal resistance in ohms

// Calculations
zinbase=B*re;// input impedance of base in ohms
zinstage_=(1/R1)+(1/R2)+(1/zinbase);// input impedance of base in ohms
zinstage=zinstage_^-1;
vin=(zinstage/(Rg+zinstage))*Vg;// input voltage in volts
rc1=Rc*zinstage/(Rc+zinstage);//in ohms
Av1=rc1/re;// voltage gain
vc=Av1*vin;// output voltage across load resistor in volts
rc2=2.65*10^3;// in ohms
Av2=rc2/re;// voltage gain
vout=Av2*vc;// outout voltage in volts
disp("Volts",vout,"Output voltage")

// Results
// output voltage across load resistor is 70 mVolts
```

Scilab code Exa 10.9 example9

```
// calculate minimum and maximum voltage gai of 2 stage amplifier
// Electronic Principles
// By Albert Malvino , David Bates
// Seventh Edition
// The McGraw-Hill Companies
// Example 10-9, page 335
```

```
clear;clc; close;

// Given data
rmin=0;// minimum adjustable resistance in ohms
rmax=10*10^3;// maximum adjustable resistance in ohms
re=100;// in ohms

// Calculations
rfmin=rmin+1*10^3;// minimum feedback resistance in ohms
rfmax=rmax+1*10^3;// maximum feedback resistance in ohms
Avmin=rfmin/re;// minimum voltage gain
Avmax=rfmax/re;// maximum voltage gain
disp(Avmin,"Minimum Voltage gain=")
disp(Avmax,"Maximum Voltage gain=")

// Results
// minimum voltage gain is 10
// maximum voltage gain is 110
```

Chapter 12

Power Amplifiers

Scilab code Exa 12.1 example1

```
// calculate dc collector current,dc collector-
    emitter voltage,ac resistance seen by collector
// Electronic Principles
// By Albert Malvino , David Bates
// Seventh Edition
// The McGraw-Hill Companies
// Example 12-1, page 384

clear;clc; close;

// Given data
R1=490;// in ohms
R2=68;// in ohms
Rc=120;// in ohms
Re=20;// in ohms
Vcc=30;// in volts
Rl=180;// in ohms
Vc=12;// in volts

// Calculations
Vb=R2*Vcc/(R2+R1);// in volts
```

```
Ve=Vb-0.7;
Ie=Ve/Re;// in amperes
Icq=Ie;// dc collector current in amperes
Vceq=Vc-Ve;// dc collector-emitter voltage in volts
rc=Rc*Rl/(Rc+Rl);// rc=Rc||Rl
disp("Amperes",Icq,"dc collector current=")
disp("Volts",Vceq,"dc collector-emitter voltage=")
disp("ohms",rc,"ac resistance =")

// Results
// dc collector current is 147 mAmperes
// dc collector-emitter voltage is 9 volts
// ac resistance seen by collector is 72 ohms
```

Scilab code Exa 12.2 example2

```
// calculate ac load line saturation, cutoff points,
    maximum peak-to-peak output voltage
// Electronic Principles
// By Albert Malvino , David Bates
// Seventh Edition
// The McGraw-Hill Companies
// Example 12-2, page 384

clear;clc; close;

// Given data
R1=490;// in ohms
R2=68;// in ohms
Rc=120;// in ohms
Re=20;// in ohms
Vcc=30;// in volts
Rl=180;// in ohms
```

```
Vc=12;// in volts

// Calculations
Vb=R2*Vcc/(R2+R1);// in volts
Ve=Vb-0.7;
Ie=Ve/Re;// in amperes
Icq=Ie;// dc collector current in amperes
Vceq=Vc-Ve; // dc collector-emitter voltage in volts
rc=Rc*Rl/(Rc+Rl);// rc=Rc||Rl
Icsat=Icq+Vceq/rc;// ac saturation current in amperes
Vcecutoff=Vceq+(Icq*rc);// in volts
// as supply voltage is 30 volts MPP<30
MPP=2*Vceq ; // as (Icq*rc)>Vceq
disp("Amperes",Icsat,"ac load line saturation")
disp("Volts",Vcecutoff,"ac cutoff voltage")
disp("Volts",MPP,"maximum peak-to-peak output voltage=")

// Results
// ac load line saturation is 273 mAmperes
// ac voltage at cutoff point is 19.7 volts
// maximum peak-to-peak output voltage is 18 volts
```

Scilab code Exa 12.3 example3

```
// calculate power output gain
// Electronic Principles
// By Albert Malvino , David Bates
// Seventh Edition
// The McGraw-Hill Companies
// Example 12-3, page 387

```

```
clear;clc; close;

// Given data
R1=490;// in ohms
R2=68;// in ohms
Rc=120;// in ohms
Re=20;// in ohms
Vcc=30;// in volts
Rl=180;// in ohms
Ri=100;// input independence in ohms
PP=18;// peak-to-peak voltage in volts
Vin=200*10^-3;// in volts

// Calculations
zinstage=490*68*100/((490*68)+(490*100)+(68*100));// in ohms
Pin=(Vin)^2/(8*zinstage);// ac input power in watts
Pout=(PP)^2/(8*Rl);// ac output power in watts
Ap=Pout/Pin;// power gain
disp(Ap,"Power gain=")

// Result
// power gain is 1682
```

Scilab code Exa 12.4 example4

```
// calculate transistor power dissipation and efficiency
// Electronic Principles
// By Albert Malvino , David Bates
// Seventh Edition
// The McGraw-Hill Companies
// Example 12-4, page 387
```

```

clear;clc; close;
// Given data
R1=490;// in ohms
R2=68;// in ohms
Rc=120;// in ohms
Re=20;// in ohms
Vcc=30;// in volts
Rl=180;// in ohms
Ri=100;// input independence in ohms
PP=18;// peak-to-peak voltage in volts
Vin=200*10^-3;// in volts
Vc=12;// in volts

// Calculations
Vb=R2*Vcc/(R2+R1);// in volts
Ve=Vb-0.7;
Ie=Ve/Re;// in amperes
Icq=Ie;// dc collector current in amperes
Vceq=Vc-Ve;// dc collector-emitter voltage in volts
Pdq=Vceq*Icq;// transistor power dissipation
// to find stage efficiency
Ibias=Vcc/(R1+R2);// in amperes
Idc=Ibias+Icq;// in amperes
Pdc=Idc*Vcc;// dc input power in watts
Pout=(PP)^2/(8*Rl);// ac output power in watts
n=(Pout/Pdc)*100;// efficiency
disp("Watts",Pdq,"transistor power dissipation=")
disp("%",n,"efficiency=")

// Results
// transistor power dissipation is 1.34 watts
// efficiency of stage is 3.72%
```

Scilab code Exa 12.6 example6

```
// calculate dc collector current,dc collector-
    emitter voltage,ac resistance seen by collector
// Electronic Principles
// By Albert Malvino , David Bates
// Seventh Edition
// The McGraw-Hill Companies
// Example 12-6, page 391

clear;clc; close;
// Given data
R1=50;// in ohms
R2=100;// in ohms
Re=16;// in ohms
Vcc=12;// in volts
Rl=16;// in ohms

// Calculations
Vb=R2*Vcc/(R2+R1);// in volts
Ve=Vb-0.7;
Ie=Ve/Re;// in amperes
Icq=Ie;// dc collector current in amperes
Vceq=Vcc-Ve;// dc collector-emitter voltage in volts
re=Re/2;// in ohms,re=Re||Rl
disp("Amperes",Icq,"dc collector current=")
disp("Volts",Vceq,"dc collector-emitter voltage=")
disp("ohms",re,"ac resistance =")

// Results
// Icq=456 mAmperes,Vceq=4.7 ohms,re=8 ohms
```

Scilab code Exa 12.7 example7

```
// calculate ac load line saturation , cutoff points ,
    maximum peak−to−peak output voltage
// Electronic Principles
// By Albert Malvino , David Bates
// Seventh Edition
// The McGraw−Hill Companies
// Example 12−7, page 392

clear;clc; close;
// Given data
R1=50;// in ohms
R2=100;// in ohms
Re=16;// in ohms
Vcc=12;// in volts
Rl=16;// in ohms

// Calculations
Vb=R2*Vcc/(R2+R1);// in volts
Ve=Vb-0.7;
Ie=Ve/Re;// in amperes
Icq=Ie;// dc collector current in amperes
Vceq=Vcc-Ve;// dc collector−emitter voltage in volts
re=Re/2;// in ohms, re=Re||Rl
icsat=Icq+(Vceq/re);// ac load line saturation in
   amperes
Vcecutoff=Vceq+(Icq*re);// cutoff point in volts
MPP=2*Icq*re;// MPP output voltage in Vpp
disp("Amperes",icsat,"ac load line saturation")
disp("Volts",Vcecutoff,"ac cutoff voltage")
disp("Volts",MPP,"maximum peak−to−peak output
   voltage=")

// Result
// ac load line saturation is 1.04 amperes
// cutoff voltage is 8.35 volts
// MPP output voltage is 7.3 Vpp.
```

Scilab code Exa 12.8 example8

```
// calculate transistor power dissipation and
   maximum output power
// Electronic Principles
// By Albert Malvino , David Bates
// Seventh Edition
// The McGraw-Hill Companies
// Example 12-8, page 397

clear;clc; close;
// Given data
R1=100;// in ohms
R2=100;// in ohms
Vcc=20;// in volts
Rl=8;// in ohms

// Calculations
MPP=Vcc;// in volts
Pdmax=(MPP^2)/(40*Rl);// maximum transistor power
   dissipation in watts
Poutmax=(MPP^2)/(8*Rl);// maximum output power in
   watts
disp("Watts",Pdmax,"maximum power dissipation=")
disp("Watts",Poutmax,"maximum output power=")


// Result
// maximum power dissipation is 1.25 watts
// maximum output power is 6.25 watts
```

Scilab code Exa 12.9 example9

```
// calculate efficiency
// Electronic Principles
// By Albert Malvino , David Bates
// Seventh Edition
// The McGraw-Hill Companies
// Example 12-9, page 398

clear;clc; close;
// Given data
R=15;// adjustable resistance in ohms
R1=100;// in ohms
R2=100;// in ohms
Vcc=20;// in volts
Rl=8;// in ohms
Vceq=10;// in volts

// Calculations
Ibias=Vcc/(R1+R2+R);// dc current through biasing
    resistors
Icsat=Vceq/Rl;// saturation current in amperes
Iav=Icsat/%pi;// collector current in the conducting
     transistor
Idc=Ibias+Iav;// total current drain in amperes
Pdc=Vcc*Idc;// dc input power in watts
MPP=Vcc;// in volts
Poutmax=(MPP^2)/(8*Rl);// maximum output power in
    watts
E=(Poutmax/Pdc)*100;// efficiency in percentage
disp("%",E,"efficiency=")
```

```
// Result
// efficiency is 63.6%
```

Scilab code Exa 12.10 example10

```
// calculate efficiency
// Electronic Principles
// By Albert Malvino , David Bates
// Seventh Edition
// The McGraw−Hill Companies
// Example 12−10, page 400

clear;clc; close;
// Given data
R=3.9*10^3;// resistance in ohms
R1=3.9*10^3;// in ohms
Vcc=20;// in volts
Rl=10;// in ohms
Vceq=10;// in volts
Vbe=0.7;// in volts

// Calculations
Ibias=(Vcc-(2*Vbe))/(2*R);// dc current through biasing resistors
Iq=Ibias;// quiescent collector current assuming compensating diodes match the emitter diodes
Icsat=Vceq/Rl;// saturation current in amperes
Iav=Icsat/%pi;// collector current in the conducting transistor
Idc=Ibias+Iav;// total current drain in amperes
Pdc=Vcc*Idc;// dc input power in watts
MPP=Vcc;// in volts
Poutmax=(MPP^2)/(8*Rl);// maximum output power in
```

```
   watts
E=(Poutmax/Pdc)*100;// efficiency in percentage
disp("%",E,"efficiency=")
disp("Amperes",Iq,"quiescent collector current=")

// Result
// efficiency is 78%
// quiescent collector current is 2.38 mAmperes
```

Scilab code Exa 12.12 example12

```
// calculate bandwidth of amplifier
// Electronic Principles
// By Albert Malvino , David Bates
// Seventh Edition
// The McGraw-Hill Companies
// Example 12-12, page 410

clear;clc; close;
// Given data
c=470*10^-12;// capacitance in faraday
l=2*10^-6;// inductance in henry
Rl=1*10^3;// load resistance in ohms
Ql=100;

// Calculations
fr=1/(2*%pi*sqrt(l*c));// resonant frequency in
   hertz
Xl=2*%pi*fr*l;// in ohms
Rp=Ql*Xl;// equivalent parallel resistance of coil
   in ohms
rc=(Rp*Rl)/(Rp+Rl);// ac collector resistance in
   ohms
```

```
Q=rc/Xl;// Q of the overall circuit
BW=fr/Q;// band width in hertz
disp("Hertz",BW,"bandwidth=")

// Result
// bandwidth is 390 KHertz
```

Scilab code Exa 12.13 example13

```
// calculate worst-case power dissipation
// Electronic Principles
// By Albert Malvino , David Bates
// Seventh Edition
// The McGraw-Hill Companies
// Example 12-13, page 411

clear;clc; close;
// Given data
c=470*10^-12;// capacitance in faraday
l=2*10^-6;// inductance in henry
Rl=1*10^3;// load resistance in ohms
Ql=100;
Vcc=15;// in volts

// Calculations
MPP=2*Vcc;// maximum peak-to-peak output in volts
fr=1/(2*%pi*sqrt(l*c));// resonant frequency in
    hertz
Xl=2*%pi*fr*l;// in ohms
Rp=Ql*Xl;// equivalent parallel resistance of coil
    in ohms
rc=(Rp*Rl)/(Rp+Rl);// ac collector resistance in
    ohms
```

```
Pd=MPP^2/(40*rc);// worst-case power dissipation of
    the transistor in watts
disp("Watts",Pd,"worst-case power dissipation=")

// Result
// worst-case power dissipation is 26 mWatts
```

Scilab code Exa 12.14 example14

```
// calculate maximum power rating
// Electronic Principles
// By Albert Malvino , David Bates
// Seventh Edition
// The McGraw-Hill Companies
// Example 12-14, page 414

clear;clc; close;
// Given data
// 2N3904
Pd=625*10^-3;// power rating at 25 degree celcius
    ambient
D=5*10^-3;// derating factor in watts per degree
    celcius
T2=50;// highest range in celcius
T1=25;// ambient temperature in degree celcius

// Calculations
dT=T2-T1;// in degree celcius
dP=D*dT;// change in power
Pdmax=Pd-dP;// in watts
disp("Watts",Pdmax,"maximum power rating=")

// Result
```

```
// maximum power rating is 500 mWatts.
```

Chapter 13

JFETs

Scilab code Exa 13.1 example1

```
// calculate input resistance of JFET
// Electronic Principles
// By Albert Malvino , David Bates
// Seventh Edition
// The McGraw-Hill Companies
// Example 13-1, page 428

clear;clc; close;

// Given data
// 2N5486 JFET
Vgs=20;// reverse gate voltage in volts
Ig=1*10^-9 ;// gate current in amperes

// Calculations
Rin=Vgs/Ig;// in ohms
disp("ohms",Rin,"input resistance=")

// Result
// input resistance is 20,000 Mohms
```

Scilab code Exa 13.2 example2

```
// calculate ohmic resistance , gate-source cutoff
   voltage
// Electronic Principles
// By Albert Malvino , David Bates
// Seventh Edition
// The McGraw-Hill Companies
// Example 13-2, page 430

clear; clc; close;

// Given data
// MPF4857
Vp=6;// pinchoff voltage in volts
Idss=100*10^-3 ;// maximum drain current in amperes

// Calculations
Rds=Vp/Idss;// ohmic resistance in ohms
Vgsoff=-Vp;// gate source cutoff voltge is negative
   of pinchoff voltage
disp("ohms",Rds,"input resistance=")
disp("Volts",Vgsoff,"gate-source cutoff voltage=")

// Result
// input resistance is 60 ohms
// gate-source cutoff voltage is -6 Volts
```

Scilab code Exa 13.3 example3

```
// calculate gate voltage and drain current at half
    cutoff point
// Electronic Principles
// By Albert Malvino , David Bates
// Seventh Edition
// The McGraw-Hill Companies
// Example 13-3, page 431

clear; clc; close;

// Given data
// 2N5668
Vgsoff=-4;// gate-source cutoff voltage in volts
Idss=5*10^-3 ;// maximum drain current in amperes

// Calculations
Vgs=-Vgsoff/2 ;// gate voltage at half cutoff point
    in volts
Id=Idss/4 ;// drain current at half cutoff point in
    amperes
disp("Amperes",Id,"Drain current=")
disp("Volts",Vgs,"gate Voltage=")


// Result
// Gate voltage at half cutoff point is -2 Volts
// Drain current is 1.25 mAmperes
```

Scilab code Exa 13.4 example4

```
// calculate drain current at half cutoff point
```

```
// Electronic Principles
// By Albert Malvino , David Bates
// Seventh Edition
// The McGraw-Hill Companies
// Example 13-4, page 432

clear; clc; close;

// Given data
// 2N5459
Vgsoff=-8;// gate-source cutoff voltage in volts
Idss=16*10^-3 ;// maximum drain current in amperes

// Calculations
Id=Idss/4 ;// drain current at half cutoff point in
    amperes
disp("Amperes",Id,"Drain current=")

// Result
// Drain current is 4 mAmperes
```

Scilab code Exa 13.6 example6

```
// calculate medium source resistance , drain voltage
// Electronic Principles
// By Albert Malvino , David Bates
// Seventh Edition
// The McGraw-Hill Companies
// Example 13-6, page 436

clear; clc; close;

// Given data
```

```
Vp=4 ;// pinchoff voltage in volts
Idss=10*10^-3 ;// maximum drain current in amperes
Vdd=30;// in volts
Rd=2*10^3;// drain resistance in ohms

// Calculations
Rds=Vp/Idss;// medium source resistance in ohms
Id=Idss/4 ;// drain current in amperes
Vd=Vdd-(Id*Rd);// drain voltage in volts
disp("ohms",Rds,"medium source resistance=")
disp("Volts",Vd,"Drain Voltage=")


// Result
// medium source resistance is 400 ohms
// drain voltage is 25 volts
```

Scilab code Exa 13.8 example8

```
// find Q point
// Electronic Principles
// By Albert Malvino , David Bates
// Seventh Edition
// The McGraw-Hill Companies
// Example 13-8, page 440

clear; clc; close;

// Given data
Vdd=30;// in volts
Rd=1*10^3;// drain resistance in ohms
Rs=2*10^3;// source resistance in ohms

```

```
// Calculations
// 3:1 voltage divider produces a gate voltage of 10
   Volts
Vs=10;// voltage across source resistor in volts
Id=Vs/Rs;// drain current in amperes
Vd=Vdd-(Id*Rd);// drain voltage in volts
Vds=Vd-Vs;// drain-source voltage in volts
disp("Amperes",Id,"Drain current=")
disp("Volts",Vds,"Drain-source Voltage=")


// Result
// Q point is (15,5*10^-3)
```

Scilab code Exa 13.10 example10

```
// find drain current,voltage between drain and
   ground
// Electronic Principles
// By Albert Malvino , David Bates
// Seventh Edition
// The McGraw-Hill Companies
// Example 13-10, page 443

clear; clc; close;

// Given data
Vdd=15;// in volts
Rd=1*10^3;// drain resistance in ohms
Rs=3*10^3;// source resistance in ohms

// Calculations
// 15 Volts occur across source resistor
```

```
Vs=15;// voltage across source resistor in volts
Id=Vs/Rs;// drain current in amperes
Vd=Vdd-(Id*Rd);// drain voltage in volts
disp("Amperes",Id,"Drain current=")
disp("Volts",Vd,"Drain Voltage=")


// Result
// Drain current is 5 mAmperes
// Voltage between drain and ground is 10 Volts
```

Scilab code Exa 13.11 example11

```
// find drain current,drain voltage
// Electronic Principles
// By Albert Malvino , David Bates
// Seventh Edition
// The McGraw-Hill Companies
// Example 13-11, page 444

clear; clc; close;

// Given data
Vdd=10;// in volts
Vee=5;// in volts
Rd=1*10^3;// drain resistance in ohms
Re=2*10^3;// source resistance in ohms

// Calculations
Id=(Vee-0.7)/Re;// drain current set up by bipolar
    junction transistor in amperes
Vd=Vdd-(Id*Rd);// drain voltage in volts
disp("Amperes",Id,"Drain current=")
```

```
disp("Volts",Vd,"Drain Voltage=")

// Result
// Drain current is 2.15 mAmperes
// Drain voltage is 7.85 Volts
```

Scilab code Exa 13.12 example12

```
// find gate-source cutoff voltage and
   transconductance
// Electronic Principles
// By Albert Malvino , David Bates
// Seventh Edition
// The McGraw-Hill Companies
// Example 13-12, page 447

clear; clc; close;

// Given data
Idss=5*10^-3;// maximum drain current in amperes
gmo=5000*10^-6;// maximum transconductance in Seimen
Vgs=-1;// Gate-source voltage in volts

// Calculations
Vgsoff=-2*Idss/gmo;// gate-source cutoff voltage in
   volts
gm=gmo*(1-(Vgs/Vgsoff));// Transconductance at given
   Vgs
disp("Volts",Vgsoff,"Gate source cutoff voltage=")
disp("Seimen",gm,"transconductance=")

// Result
// Gate source cutoff voltage is -2 Volts
```

```
// Transconductance is 2500 MicroSeimens
```

Scilab code Exa 13.13 example13

```
// calculate output voltage
// Electronic Principles
// By Albert Malvino , David Bates
// Seventh Edition
// The McGraw-Hill Companies
// Example 13-13, page 449

clear; clc; close;

// Given data
Rd=3.6*10^3;// in ohms
Rl=10*10^3;// in ohms
gm=5000*10^-6;// transconductance in Seimen
Vin=10^-3;// input voltage in Vpp

// Calculations
rd=Rd*Rl/(Rd+Rl);// ac drain resistance in ohms
Av=gm*rd;// voltage gain
Vout=Vin*Av;// output voltage in volts
disp("Volts",Vout,"Output voltage=")

// Result
// Output voltage is 13.3 mVpp
```

Scilab code Exa 13.14 example14

```
// calculate output voltage
// Electronic Principles
// By Albert Malvino , David Bates
// Seventh Edition
// The McGraw-Hill Companies
// Example 13-14, page 450

clear; clc; close;

// Given data
Rs=10^3;// in ohms
Rl=10^3;// in ohms
gm=2500*10^-6;// transconductance in Seimen
Vin=10^-3;// input voltage in Vpp

// Calculations
rs=Rs*Rl/(Rs+Rl);// ac drain resistance in ohms
Av=gm*rs/(1+(gm*rs));// voltage gain
Vout=Vin*Av;// output voltage in volts
disp("Volts",Vout,"Output voltage=")

// Result
// Output voltage is 0.556 mVpp
```

Scilab code Exa 13.15 example15

```
// calculate voltage gain
// Electronic Principles
// By Albert Malvino , David Bates
// Seventh Edition
// The McGraw-Hill Companies
// Example 13-15, page 450

```

```
clear; clc; close;

// Given data
Rs1=220;// in ohms
Rs2=780;// in ohms
Rl=3*10^3;// in ohms
gm=2000*10^-6;// transconductance in Seimen


// Calculations
Rs=Rs1+Rs2;// total dc source resistance in ohms
rs=Rs*Rl/(Rs+Rl);// ac drain resistance in ohms
Av=gm*rs/(1+(gm*rs));// voltage gain
disp(Av,"Votage gain=")

// Result
// voltage gain is 0.6
```

Scilab code Exa 13.16 example16

```
// calculate drain current,voltage gain
// Electronic Principles
// By Albert Malvino , David Bates
// Seventh Edition
// The McGraw-Hill Companies
// Example 13-16, page 451

clear; clc; close;

// Given data
Vdd=30;// in voltage
Rs=2.2*10^3;// in ohms
Rl=3.3*10^3;// in ohms
```

```
gm=3500*10^-6;// transconductance in Seimen

// Calculations
// 3:1 voltage divider produces a gate voltage of 10
    Volts
Vs=10;// voltage across source resistor in volts
Id=Vs/Rs;// drain current in amperes
rs=Rs*Rl/(Rs+Rl);// ac drain resistance in ohms
Av=gm*rs/(1+(gm*rs));// voltage gain
disp("Amperes",Id,"Drain Current=")
disp(Av,"Votage gain=")

// Results
// Drain current is 4.55 mAmperes
// Voltage gain is 0.822
```

Chapter 14

MOSFETs

Scilab code Exa 14.1 example1

```
// calculate drain current at given gate-source
   voltages
// Electronic Principles
// By Albert Malvino , David Bates
// Seventh Edition
// The McGraw-Hill Companies
// Example 14-1, page 482

clear; clc; close;

// Given data
// D-MOSFET
Vgsoff=-3;// gate-source cutoff voltage in volts
Idss=6*10^-3 ;// maximum drain current in amperes
Vgs1=-1 ;// gate source voltage in volts
Vgs2=-2 ;// gate source voltage in volts
Vgs3=0  ;// gate source voltage in volts
Vgs4=1  ;// gate source voltage in volts
Vgs5=2  ;// gate source voltage in volts

// Calculations
```

```
Id1=Idss*(1-(Vgs1/Vgsoff))^2 ;// drain current in
   amperes
Id2=Idss*(1-(Vgs2/Vgsoff))^2 ;// drain current in
   amperes
Id3=Idss*(1-(Vgs3/Vgsoff))^2 ;// drain current in
   amperes
Id4=Idss*(1-(Vgs4/Vgsoff))^2 ;// drain current in
   amperes
Id5=Idss*(1-(Vgs5/Vgsoff))^2 ;// drain current in
   amperes
disp("amperes",Id1,"drain current 1=")
disp("amperes",Id2,"drain current 2=")
disp("amperes",Id3,"drain current 3=")
disp("amperes",Id4,"drain current 4=")
disp("amperes",Id5,"drain current 5=")

// Result
// Values of Drain current is 2.67, 0.667, 6, 10.7,
   16.7 mAmperes respectively.
```

Scilab code Exa 14.2 example2

```
// calculate the circuit's output voltage
// Electronic Principles
// By Albert Malvino , David Bates
// Seventh Edition
// The McGraw-Hill Companies
// Example 14-2, page 482

clear; clc; close;

// Given data
// D-MOSFET amplifier
```

```
Vgsoff=-2 ;// gate−source cutoff voltage in volts
Idss=4*10^-3 ;// maximum drain current in amperes
gmo=2000*10^-6 ;// in seimens
Vdd=15; // in volts from the figure
Rd=2*10^3;// in ohms from the figure
Rl=10*10^3;// in ohms from the figure
Vin=20*10^-3 ;// input voltage in volts

// Calculations
Vds=Vdd-(Idss*Rd) ;// drain source voltage in volts
rd=(Rd*Rl)/(Rd+Rl) ;// ac drain resistance in ohms
gm=gmo ; // as Vgs=0
Av=gm*rd ;// amplifier's voltage gain
Vout=Av*Vin; // in volts
disp("Volts ",Vout,"output voltage=")

// Result
// Output voltage is 66.8 mVolts
```

Scilab code Exa 14.6 example6

```
// calculate output voltage
// Electronic Principles
// By Albert Malvino , David Bates
// Seventh Edition
// The McGraw−Hill Companies
// Example 14−6, page 496

clear; clc; close;

// Given data
Vdd=20;// supply voltage in volts
Rd=10*10^3;// resistance in ohms
```

```
Rdson=50;// static drain-source on-resistance in ohms

// Calculations
Voutlow=Vdd; // when input voltage is low, the lower MOSFET is open and the output voltage= supply voltage
Vouthigh=Vdd*(Rdson/(Rdson+Rd)) ;// when input voltage is high, the lower MOSFET has a resistance of Rd and the output voltage= ground voltage
disp("Volts ",Vouthigh,"output voltage at high input voltage=")
disp("Volts ",Voutlow,"output voltage at low input voltage=")

// Result
// Output voltage is 20 Volts when input voltage is low
// Output voltage is 100 mVolts when input voltage is high
```

Scilab code Exa 14.7 example7

```
// calculate output voltage
// Electronic Principles
// By Albert Malvino , David Bates
// Seventh Edition
// The McGraw-Hill Companies
// Example 14-7, page 496

clear; clc; close;

```

```
// Given data
Vdd=10;// supply voltage in volts
Rd=2*10^3;// resistance in ohms
Rdson=500;// static drain-source on-resistance in ohms

// Calculations
Voutlow=Vdd; // when input voltage is low, the lower MOSFET is open and the output voltage= supply voltage
Vouthigh=Vdd*(Rdson/(Rdson+Rd)) ;// when input voltage is high, the lower MOSFET has a resistance of Rd and the output voltage= ground voltage
disp("Volts ",Vouthigh,"output voltage at high input voltage=")
disp("Volts ",Voutlow,"output voltage at low input voltage=")

// Result
// Output voltage is 10 Volts when input voltage is low
// Output voltage is 2 Volts when input voltage is high
```

Scilab code Exa 14.9 example9

```
// calculate current through the motor winding
// Electronic Principles
// By Albert Malvino , David Bates
// Seventh Edition
// The McGraw-Hill Companies
// Example 14-9, page 502
```

```
clear; clc; close;

// Given data
// MTP4N80E
Vgson=10 ;// gate-source on-voltage in volts
Idon=2; // on-state drain current in amperes
Rdson=1.95; // static drain-source on resistance in
    ohms
Vdd=30;// drain cutoff voltage in volts
Rd=30;// drain cutoff voltage in ohms

// Calculations
Idsat=Vdd/Rd;// drain saturation current in amperes
// as Idsat<Idon the power FET is equivalent to a
    resistance of Rdson so Rdson will have to be
    included to find the actual current
Id=Vdd/(Rd+Rdson) ;// current in amperes
disp("Amperes",Id,"Current through the motor
    windings=")

// Result
// Current through the motor windings is 0.939
    Amperes
```

Scilab code Exa 14.12 example12

```
// calculate the RC time constant and lamp power at
    full brightness
// Electronic Principles
// By Albert Malvino , David Bates
// Seventh Edition
// The McGraw-Hill Companies
```

```
// Example 14-12, page 504

clear; clc; close;

// Given data
R1=2*10^6;// resistance in ohms
R2=1*10^6;// resistance in ohms
R=10;// resistance of the lamp in ohms
Rdson=1.07;// static drain-source on-resistance in
   ohms
Vdd=30;// drain cutoff voltage in volts
C=10*10^-6;// capacitance in faraday

// Calculations
Rth=R1*R2/(R1+R2);// thevenin resistance in ohms
RC=Rth*C;// time constant in seconds
Id=Vdd/(R+Rdson) ;// lamp current in amperes
P=Id*Id*R;// lamp power in watts at full brightness
disp("seconds",RC,"time constant=")
disp("watts",P,"lamp power =")

// Result
// RC time constant is 6.67 seconds
// Lamp power is 73.4 Watts
```

Scilab code Exa 14.13 example13

```
// find the constant k value and drain current of E-
   MOSFET
// Electronic Principles
// By Albert Malvino , David Bates
// Seventh Edition
// The McGraw-Hill Companies
```

```
// Example 14-13, page 506

clear; clc; close;

// Given data
// 2N7000
Idon=600*10^-3 ;// in amperes
Vgson=4.5;// from data sheet in volts
Vgsth=2.1;// from data sheet in volts
Vgs1=3 ;// gate source voltage in volts
Vgs2=4.5 ;// gate source voltage in volts

// Calculations
k=Idon/([Vgson-Vgsth]^2)
Id1=k*([Vgs1-Vgsth]^2)
Id2=k*([Vgs2-Vgsth]^2)
disp(k,"constant=")
disp("amperes",Id1,"drain current 1=")
disp("amperes",Id2,"drain current 2=")

// Result
// Constant k is 104 mAmperes/Volts^2
// Drain current when Vgs is 3 Volts is 84.4
   mAmperes
// Drain current when Vgs is 4.5 Volts is 600
   mAmperes
```

Scilab code Exa 14.14 example14

```
// find value of Rd for the MOSFET
// Electronic Principles
// By Albert Malvino , David Bates
// Seventh Edition
```

```
// The McGraw-Hill Companies
// Example 14-14, page 507

clear; clc; close;

// Given data
Idon=3*10^-3;// from the data sheet of the E-MOSFET
   in amperes
Vdson=10;// from data sheet of the E-MOSFET in volts
Vdd=25 ;// drain cutoff voltage in volts

// Calculations
Rd=(Vdd-Vdson)/Idon ;// Rd in ohms
disp("ohms",Rd,"resistance=")

// Result
// A resistance of 5kohms will allow the MOSFET to
   operate at a specified Q point.
```

Scilab code Exa 14.15 example15

```
// find Vgs,Id,gm,Vout
// Electronic Principles
// By Albert Malvino , David Bates
// Seventh Edition
// The McGraw-Hill Companies
// Example 14-15, page 508

clear; clc; close;

// Given data
k=104*10^-3 ;// constant k of the E-MOSFET
Idon=600*10^-3 ;// in amperes
```

```
Vgsth=2.1;// in volts
R1=10^6;// in ohms from the given figure
R2=350*10^3;// in ohms from the given figure
Vin=100*10^-3;// in volts from the given figure
Rd=68;// in ohms from the given figure
Rl=10^3;// in ohms from the given figure
Vdd=12;// drain cutoff voltage in volts from the given figure

// Calculations
Vg=(R2/(R1+R2))*Vdd ;// ground voltage in volts
Vgs=Vg;// Vgs = ground voltage
Id=k*([Vgs-Vgsth]^2)
gm=2*k*(Vgs-Vgsth);//transconductance in Seimens
rd=Rd*Rl/(Rd+Rl) ;// rd=Rd||Rl in ohms
Av=gm*rd;// voltage gain
Vout=Av*Vin;// output voltage in volts
disp("Volts",Vgs,"gate-source voltage=")
disp("Amperes",Id,"drain current=")
disp("Seimen",gm,"transconductane=")
disp("Volts",Vout,"output voltage=")

// Result
// Vgs is 3.11 Volts
// Drain current is 106 mAmperes
// Transconductance is 210 mSeimens
// Output voltage is 1.34 mVolts
```

Chapter 15

Thyristors

Scilab code Exa 15.1 example1

```
// find diode current
// Electronic Principles
// By Albert Malvino , David Bates
// Seventh Edition
// The McGraw-Hill Companies
// Example 15-1, page 524

clear; clc; close;

// Given data
Vb=10;// breakover voltage of the diode
V=15;// input voltage in volts
Ih=4*10^-3;// holding current in amperes
Vd=0.7 ;// voltage across diode in volts
R=100;// resistance in ohms

// Calculations
// as V>Vb ,the diode breaks over .Taking into
   consideration the voltage across the diode
I=(V-Vd)/R;// diode current in amperes
disp("Amperes",I,"diode current=")
```

```

// Result
// Diode current is 143 mAmperes
```

Scilab code Exa 15.4 example4

```
// find input and supply voltage for the SCR
// Electronic Principles
// By Albert Malvino , David Bates
// Seventh Edition
// The McGraw-Hill Companies
// Example 15-4, page 531

clear; clc; close;

// Given data
Vgt=0.75 ;// gate trigger voltage in volts
Igt=7*10^-3;// gate trigger current in amperes
Rg=10^3;// in ohms
Rl=100;// in ohms
Ih=6*10^-3;// holding current in amperes

// Calculations
Vin=Vgt + (Igt*Rg);// input voltage in volts
Vcc=0.7 + (Ih*Rl);// supply voltage in volts
disp("Volts",Vin,"Input voltage=")
disp("Volts",Vcc,"Supply voltage=")

// Result
// Minimum input voltage needed to trigger the SCR
    is 7.75 Volts
// Supply voltage that turns off the SCR is 1.3
    Volts
```

Scilab code Exa 15.5 example5

```
// find peak output voltage and frequency
// Electronic Principles
// By Albert Malvino , David Bates
// Seventh Edition
// The McGraw-Hill Companies
// Example 15-5, page 532

clear; clc; close;

// Given data
R1=900;// from the figure in ohms
R2=100;// from the figure in ohms
Vgt=1 ;// gate trigger voltage in volts
Igt=200*10^-6;// gate trigger current in amperes
C=0.2*10^-6;// capacitance in faraday
R=50;// thevenin resistance facing the capacitance
    when the SCR is off

// Calculations
Rth=R1*R2/(R1+R2);// thevenin resistance
Rg=Rth;// in ohms
Vin=Vgt + (Igt*Rg);// input voltage in volts
Vpeak=10*Vin;// because of 10:1 voltage divider , the
     output voltage is 10(Vin)
T=0.2*R*C ;// period of sawtooth is 20% of time
    constant in seconds
f=1/T;// frequency in Hertz
disp("Volts",Vpeak,"Peak output voltage=")
disp("hertz",f,"frequency=")

```

```
// Results
// Peak output voltage is 10.1 Volts
// Frequency is 50 KHertz
```

Scilab code Exa 15.6 example6

```
// find supply voltage
// Electronic Principles
// By Albert Malvino , David Bates
// Seventh Edition
// The McGraw-Hill Companies
// Example 15-6, page 536

clear; clc; close;

// Given dataVz=5.6;// breakdown voltage in volts
Vgt=0.75;// gate trigger voltage in volts
Vz=5.6;// breakdown voltage in volts

// Calculations
Vcc=Vz+Vgt;// overvoltage firing the SCR in volts
disp("Volts",Vcc,"Supply voltage=")

// Results
// Supply voltage that turns the crowbar is 6.35
   volts
```

Scilab code Exa 15.8 example8

```
// find current through the resistor
// Electronic Principles
// By Albert Malvino , David Bates
// Seventh Edition
// The McGraw-Hill Companies
// Example 15-8, page 546

clear; clc; close;

// Given data
R1=82;// givenin ohms
R2=22;// given in ohms
Vgt=75;//  in volts

// Calculations
// Ideally the triac has 0 voltas across it when
    conducting
I=Vgt/R2;// current through 22 ohm resistor in
    amperes
disp("Amperes",I,"current through 22 ohm resistor=")

// Results
// Current through the 22 ohm resistor is 3.41
    Amperes
```

Chapter 16

Frequency Effects

Scilab code Exa 16.1 example1

```
// calculate voltage gain of ac amplifier
// Electronic Principles
// By Albert Malvino , David Bates
// Seventh Edition
// The McGraw-Hill Companies
// Example 16-1, page 567

clear; clc; close;

// Given data
f1=20;// cutoff frequency in hertz
f2=20*10^3;// cutoff frequency in hertz
fin1=5;// input frequency in hertz
fin2=200*10^3;// input frequency in hertz
Avmid=200;// midband voltage gain

// Calculations
Av1=Avmid/((1+((f1/fin1)^2))^0.5)// Voltage gain for
    input frequency below midband
Av2=Avmid*1/((1+((fin2/f2)^2))^0.5); // Voltage gain
    for input frequency above midband
```

```
disp(Av1,"Voltage  gain for input frequency below
   midband")
disp(Av2,"Voltage gain or input frequency above
   midband")

// Result
// Voltage gain for an input frequency of 5 Hertz is
    48.5
// Voltage gain for an input frequency of 20 KHertz
   is 19.9
```

Scilab code Exa 16.3 example3

```
// calculate voltage gain
// Electronic Principles
// By Albert Malvino , David Bates
// Seventh Edition
// The McGraw-Hill Companies
// Example 16-3, page 569

clear; clc; close;

// Given data
f=10;// cutoff frequency in hertz
Avmid=100000;// midband voltage gain
f1=100;// input frequency in hertz
f2=10^3;// input frequency in hertz
f3=10^4;// input frequency in hertz
f4=10^5;// input frequency in hertz
f5=10^6;// input frequency in hertz

// Calculations
Av1=Avmid/((1+(f1/f)^2)^0.5)// Voltage gain for
```

```
input frequency below midband
Av2=Avmid/((1+(f2/f)^2)^0.5)// Voltage gain for input frequency below midband
Av3=Avmid/((1+(f3/f)^2)^0.5)// Voltage gain for input frequency below midband
Av4=Avmid/((1+(f4/f)^2)^0.5)// Voltage gain for input frequency below midband
Av5=Avmid/((1+(f5/f)^2)^0.5)// Voltage gain for input frequency below midband
disp(Av1,"Voltage gain 1=")
disp(Av2,"Voltage gain 2=")
disp(Av3,"Voltage gain 3=")
disp(Av4,"Voltage gain 4=")
disp(Av5,"Voltage gain 5=")

// Result
// Voltage gain for an input frequency of 100 Hertz is approximately 10000
// Voltage gain for an input frequency of 1000 Hertz is approximately 1000
// Voltage gain for an input frequency of 1000 Hertz is approximately 100
// Voltage gain for an input frequency of 10000 Hertz is approximately 10
// Voltage gain for an input frequency of 100000 Hertz is approximately 1
```

Scilab code Exa 16.4 example4

```
// calculate decibel power gain
// Electronic Principles
// By Albert Malvino , David Bates
// Seventh Edition
```

```
// The McGraw-Hill Companies
// Example 16-4, page 571

clear; clc; close;

// Given data
Ap1=1;// power gain
Ap2=2;// power gain
Ap3=4;// power gain
Ap4=8;// power gain

// Calculations
Apdb1=10*log10(Ap1)// decibel power gain
Apdb2=10*log10(Ap2)// decibel power gain
Apdb3=10*log10(Ap3)// decibel power gain
Apdb4=10*log10(Ap4)// decibel power gain
disp("dB",Apdb1,"decibel power gain 1=")
disp("dB",Apdb2,"decibel power gain 2=")
disp("dB",Apdb3,"decibel power gain 3=")
disp("dB",Apdb4,"decibel power gain 4=")

// Result
// decibal power gain for a voltage gain of 1 is 0 dB
// decibal power gain for a voltage gain of 2 is 3 dB
// decibal power gain for a voltage gain of 4 is 6 dB
// decibal power gain for a voltage gain of 8 is 9 dB
```

Scilab code Exa 16.5 example5

```
// calculate decibel power gain
// Electronic Principles
// By Albert Malvino , David Bates
// Seventh Edition
// The McGraw-Hill Companies
// Example 16-5, page 571

clear; clc; close;

// Given data
Ap1=1;// power gain
Ap2=0.5;// power gain
Ap3=0.25;// power gain
Ap4=0.125;// power gain

// Calculations
Apdb1=10*log10(Ap1)// decibel power gain
Apdb2=10*log10(Ap2)// decibel power gain
Apdb3=10*log10(Ap3)// decibel power gain
Apdb4=10*log10(Ap4)// decibel power gain
disp("dB",Apdb1,"decibel power gain 1=")
disp("dB",Apdb2,"decibel power gain 2=")
disp("dB",Apdb3,"decibel power gain 3=")
disp("dB",Apdb4,"decibel power gain 4=")


// Result
// decibal power gain for a voltage gain of 1 is 0 dB
// decibal power gain for a voltage gain of 0.5 is -3 dB
// decibal power gain for a voltage gain of 0.25 is -6 dB
// decibal power gain for a voltage gain of 0.125 is -9 dB
```

Scilab code Exa 16.6 example6

```
// calculate decibel power gain
// Electronic Principles
// By Albert Malvino , David Bates
// Seventh Edition
// The McGraw-Hill Companies
// Example 16-6, page 572

clear; clc; close;

// Given data
Ap1=1;// power gain
Ap2=10;// power gain
Ap3=100;// power gain
Ap4=1000;// power gain

// Calculations
Apdb1=10*log10(Ap1)// decibel power gain
Apdb2=10*log10(Ap2)// decibel power gain
Apdb3=10*log10(Ap3)// decibel power gain
Apdb4=10*log10(Ap4)// decibel power gain
disp("dB",Apdb1,"decibel power gain 1=")
disp("dB",Apdb2,"decibel power gain 2=")
disp("dB",Apdb3,"decibel power gain 3=")
disp("dB",Apdb4,"decibel power gain 4=")


// Result
// decibal power gain for a voltage gain of 1 is 0
   dB
// decibal power gain for a voltage gain of 10 is 10
```

```
dB
// decibal power gain for a voltage gain of 100 is
20 dB
// decibal power gain for a voltage gain of 1000 is
30 dB
```

Scilab code Exa 16.7 example7

```
// calculate decibel power gain
// Electronic Principles
// By Albert Malvino , David Bates
// Seventh Edition
// The McGraw-Hill Companies
// Example 16-7, page 572

clear; clc; close;

// Given data
Ap1=1;// power gain
Ap2=0.1;// power gain
Ap3=0.01;// power gain
Ap4=0.001;// power gain

// Calculations
Apdb1=10*log10(Ap1)// decibel power gain
Apdb2=10*log10(Ap2)// decibel power gain
Apdb3=10*log10(Ap3)// decibel power gain
Apdb4=10*log10(Ap4)// decibel power gain
disp("dB",Apdb1,"decibal power gain 1=")
disp("dB",Apdb2,"decibal power gain 2=")
disp("dB",Apdb3,"decibal power gain 3=")
disp("dB",Apdb4,"decibal power gain 4=")

```

```
// Result
// decibal power gain for a voltage gain of 1 is 0
    dB
// decibal power gain for a voltage gain of 0.1 is
    −10 dB
// decibal power gain for a voltage gain of 0.01 is
    −20 dB
// decibal power gain for a voltage gain of 0.001 is
     −30 dB
```

Chapter 17

Differential Amplifiers

Scilab code Exa 17.1 example1

```
// find ideal currents and voltages
// Electronic Principles
// By Albert Malvino , David Bates
// Seventh Edition
// The McGraw-Hill Companies
// Example 17-1, page 625

clear; clc; close;

// Given data
Vee=15;// in volts from the figure
Vcc=15;// in volts from the figure
Re=7.5*10^3;// emitter resistance in ohms
Rc=5*10^3;// collector resistance in ohms

// Calculations
It=Vee/Re;// tail current in amperes
Ie=It/2;// emitter current in amperes
Ic=Ie;// collector current is equal to emitter
    current
Vc=Vcc-(Ic*Rc);// quiescent voltage in volts
```

```
disp("Amperes",It,"tail current=")
disp("Amperes",Ie,"emitter current=")
disp("Volts",Vc,"quiescent collector voltage=")

// Result
// Tail current is 2 mAmperes
// Emitter current is 1 mAmperes
// Collector has a quiescent voltage of 10 Volts
```

Scilab code Exa 17.2 example2

```
// calculate currents and voltages using second
   approximation
// Electronic Principles
// By Albert Malvino , David Bates
// Seventh Edition
// The McGraw-Hill Companies
// Example 17-2, page 626

clear; clc; close;

// Given data
Vee=15;// in volts from the figure
Vcc=15;// in volts from the figure
Re=7.5*10^3;// emitter resistance in ohms
Rc=5*10^3;// collector resistance in ohms
Vin=10^-3;// in volts
B=300;// given

// Calculations
It=(Vee-0.7)/Re;// tail current in amperes using
   second approximation
Ie=It/2;// emitter current in amperes
```

```
Ic=Ie;// collector current is equal to emitter
   current
Vc=Vcc-(Ic*Rc);// quiescent voltage in volts
disp("Amperes",It,"tail current=")
disp("Amperes",Ie,"emitter current=")
disp("Volts",Vc,"quiescent collector voltage=")

// Result
// Tail current is 1.91 mAmperes
// Emitter current is 0.955 mAmperes
// Collector has a quiescent voltage of 10.2 Volts
```

Scilab code Exa 17.3 example3

```
// find currents and voltages
// Electronic Principles
// By Albert Malvino , David Bates
// Seventh Edition
// The McGraw-Hill Companies
// Example 17-3, page 626

clear; clc; close;

// Given data
Vee=12;// in volts from the figure
Vcc=12;// in volts from the figure
Re=5*10^3;// emitter resistance in ohms
Rcright=3*10^3;// collector resistance in ohms
Rcleft=0;// collector resistance in ohms

// Calculations
It=Vee/Re;// tail current in amperes
Ie=It/2;// emitter current in amperes
```

```
Ic=Ie;// collector current is equal to emitter
    current
Vcright=Vcc-(Ic*Rcright);// quiescent voltage of
    right collector in volts
Vcleft=Vcc-(Ic*Rcleft);// quiescent voltage of left
    collector in volts
disp("Amperes",It,"tail current=")
disp("Amperes",Ie,"emitter current=")
disp("Volts",Vcright,"right quiescent collector
    voltage=")
disp("Volts",Vcleft,"left quiescent collector
    voltage=")

// Result
// Tail current is 2.4 mAmperes
// Emitter current is 1.2 mAmperes
// Right hand side collector has a quiescent voltage
     of 8.4 Volts
// Left hand side collector has a quiescent voltage
    of 12 Volts
```

Scilab code Exa 17.4 example4

```
// calculate ac output voltage and input impedance
    of the diff amp
// Electronic Principles
// By Albert Malvino , David Bates
// Seventh Edition
// The McGraw-Hill Companies
// Example 17-4, page 631

clear; clc; close;

```

```
// Given data
Vee=15;// in volts from the figure
Vcc=15;// in volts from the figure
Re=7.5*10^3;// emitter resistance in ohms
Rc=5*10^3;// collector resistance in ohms
Vin=10^-3;// in volts
B=300;// given

// Calculations
It=Vee/Re;// tail current in amperes
Ie=It/2;// emitter current in amperes
re=25*10^-3/Ie;// ac emitter resistance in ohms
Av=Rc/re;// voltage gain
Vout=Av*Vin;// ac output voltage in volts
zin=2*B*re;// input impedance of either base in ohms
disp("Volts",Vout,"output voltage=")
disp("ohms",zin,"input impedance=")

// Result
// ac output voltage is 200 mVolts
// Input impedance of the differential amplifier is 15 Kohms
```

Scilab code Exa 17.5 example5

```
// calculate ac output voltage and input impedance of the diff amp using second approximation
// Electronic Principles
// By Albert Malvino , David Bates
// Seventh Edition
// The McGraw-Hill Companies
// Example 17-5, page 632

```

```
clear; clc; close;

// Given data
Vee=15;// in volts from the figure
Vcc=15;// in volts from the figure
Re=7.5*10^3;// emitter resistance in ohms
Rc=5*10^3;// collector resistance in ohms
Vin=10^-3;// in volts
B=300;// given

// Calculations
It=(Vee-0.7)/Re;// tail current in amperes using
    second approximation
Ie=It/2;// emitter current in amperes
re=25*10^-3/Ie;// ac emitter resistance in ohms
Av=Rc/re;// voltage gain
Vout=Av*Vin;// ac output voltage in volts
zin=2*B*re;// input impedance of either base in ohms
disp("Volts",Vout,"output voltage=")
disp("ohms",zin,"input impedance=")

// Result
// ac output voltage is 191 mVolts
// Input impedance of the differential amplifier is
    15.7 Kohms
```

Scilab code Exa 17.8 example8

```
// calculate error output voltage
// Electronic Principles
// By Albert Malvino , David Bates
// Seventh Edition
// The McGraw-Hill Companies
```

```
// Example 17-8, page 639

clear; clc; close;

// Given data
Av=200;// voltage gain
Inbias=3*10^-6;// input bias current in amperes
Inoff=0.5*10^-6;// input offset current in amperes
Vinoff=10^-3;// input offset voltage in volts
Rb1=10^3;// in ohms
Rb2=0;// in ohms

// Calculations
V1err=(Rb1-Rb2)*Inbias;// unwanted dc error input in volts
V2err=(Rb1+Rb2)*Inoff/2;// unwanted dc error input in volts
V3err=Vinoff;// unwanted dc error input in volts
Verror=Av*(V1err+V2err+V3err);// output error voltage in volts
disp("Volts",Verror,"output error voltage=")

// Result
// Output error voltage is 850 mVolts
```

Scilab code Exa 17.9 example9

```
// calculate error output voltage
// Electronic Principles
// By Albert Malvino , David Bates
// Seventh Edition
// The McGraw-Hill Companies
// Example 17-9, page 640
```

```

clear; clc; close;

// Given data
Av=300;// voltage gain
Inbias=80*10^-9;// input bias current in amperes
Inoff=20*10^-9;// input offset current in amperes
Vinoff=5*10^-3;// input offset voltage in volts
Rb1=10^4;// in ohms
Rb2=10^4;// in ohms

// Calculations
V1err=(Rb1-Rb2)*Inbias;// unwanted dc error input in volts
V2err=(Rb1+Rb2)*Inoff/2;// unwanted dc error input in volts
V3err=Vinoff;// unwanted dc error input in volts
Verror=Av*(V1err+V2err+V3err);// output error voltage in volts
disp("Volts",Verror,"output error voltage=")

// Result
// Output error voltage is 1.56 Volts
```

Scilab code Exa 17.10 example10

```
// calculate common mode voltage gain and output voltage
// Electronic Principles
// By Albert Malvino , David Bates
// Seventh Edition
// The McGraw-Hill Companies
// Example 17-10, page 642
```

```

clear; clc; close;

// Given data
Rc=10^6;// collector resistance in ohms
Re=10^6;// emitter resistance in ohms
Vin=10^-3;// input voltage in volts

// Calculations
Avcm=Rc/(2*Re);// swamped voltage gain
Vout=Vin*Avcm;// output voltage in volts
disp("Volts",Vout,"output voltage=")

// Result
// Output voltage is 0.5 mVolts
```

Scilab code Exa 17.12 example12

```
// calculate output voltage
// Electronic Principles
// By Albert Malvino , David Bates
// Seventh Edition
// The McGraw-Hill Companies
// Example 17-12, page 644

clear; clc; close;

// Given data
Av=200000;// voltage gain
CMRRdb=90;// common mode rejection ratio in decibals
Vin=10^-6;// input voltage in volts
```

```

// Calculations
CMRR=10^(CMRRdb/20);// common mode rejection ratio
Avcm=Av/CMRR;// swamped voltage gain
Vout1=Vin*Av;// desired output voltage in volts
Vout2=Vin*Avcm;// common mode output voltage in
    volts
Vout=Vout1+Vout2;// total output voltage in volts
disp("Volts",Vout,"output voltage=")

// Result
// Output voltage is 6.32 microVolts
```

Scilab code Exa 17.13 example13

```
// calculate load voltage
// Electronic Principles
// By Albert Malvino , David Bates
// Seventh Edition
// The McGraw-Hill Companies
// Example 17-13, page 651

clear; clc; close;

// Given data
Vee=15;// in volts from the figure
Vcc=15;// in volts from the figure
Re=7.5*10^3;// emitter resistance in ohms
Rc=7.5*10^3;// collector resistance in ohms
Rl=15*10^3;// load resistance in ohms
Vin=10*10^-3;// input voltage in volts

// Calculations
```

```
It=Vee/Re;// tail current in amperes
Ie=It/2;// emitter current in amperes
re=(25*10^-3)/Ie;// ac emitter resistance in ohms
Av=Rc/re;// unloaded voltage gain
Vout=Av*Vin;// unloaded output voltage in volts
Rth=2*Rc;// thevenin resistance in ohms
Vl=Vout/2;// load voltage in volts as Rl=Rth
disp("Volts",Vl,"load voltage=")

// Result
// Load voltage is 1.5 Volts
```

Chapter 18

Operational Amplifiers

Scilab code Exa 18.4 example4

```
// find slew rate of op-amp
// Electronic Principles
// By Albert Malvino , David Bates
// Seventh Edition
// The McGraw-Hill Companies
// Example 18-4, page 673

clear; clc; close;

// Given data
dV=0.25;// voltage change in volts
dT=0.1*10^-6;// time duration in which the voltage
    change took place in seconds

// Calculations
Sr=dV/dT;// slew rate in volts/second
disp(Sr,"Slew rate=")

// Result
// slew rate of the op-amp is 2.5 Megavolts/second
```

Scilab code Exa 18.5 example5

```
// find power band width
// Electronic Principles
// By Albert Malvino , David Bates
// Seventh Edition
// The McGraw-Hill Companies
// Example 18-5, page 673

clear; clc; close;

// Given data
Sr=15*10^6;// slew rate in volts/second
Vp=10;// peak voltage in volts

// Calculations
fmax=Sr/(2*%pi*Vp);// power band width in hertz
disp("Hertz ",fmax,"power band width=")

// Result
// Power bandwidth is 239 kHertz
```

Scilab code Exa 18.6 example6

```
// find power band width
// Electronic Principles
// By Albert Malvino , David Bates
// Seventh Edition
```

```
// The McGraw-Hill Companies
// Example 18-6, page 673

clear; clc; close;

// Given data
Vp=8;// peak voltage in volts
Sr1=0.5*10^6;// slew rate in volts/second
Sr2=5*10^6;// slew rate in volts/second
Sr3=50*10^6;// slew rate in volts/second

// Calculations
fmax1=Sr1/(2*%pi*Vp);// power band width in hertz
fmax2=Sr2/(2*%pi*Vp);// power band width in hertz
fmax3=Sr3/(2*%pi*Vp);// power band width in hertz
disp("Hertz ",fmax1,"power band width 1=")
disp("Hertz ",fmax2,"power band width 2=")
disp("Hertz ",fmax3,"power band width 3=")

// Result
// Power bandwidth when slew rate is 0.5 Volts/micro seconds is 10 kHertz
// Power bandwidth when slew rate is 5 Volts/micro seconds is 100 kHertz
// Power bandwidth when slew rate is 50 Volts/micro seconds is 1 MHertz
```

Scilab code Exa 18.7 example7

```
// find closed-loop voltage gain, bandwidth and output voltage
// Electronic Principles
// By Albert Malvino , David Bates
```

```
// Seventh Edition
// The McGraw-Hill Companies
// Example 18-7, page 678

clear; clc; close;

// Given data
R1=1.5*10^3;// in ohms from the given figure
Rf=75*10^3;// in ohms from the given figure
Vin=10^-2;// input voltage in mVpp
f1=10^3;// frequency in hertz
f2=10^6;// frequency in hertz
funity=10^6;// unity gain frequency in hertz

// Calculations
Avcl=-Rf/R1;// closed loop voltage gain
f2cl=funity/-Avcl;// closed-loop bandwidth
Vout1=Avcl*Vin;// output voltage at 10^3 Hertz
Vout2=-Vin;// output voltage at 10^6 Hertz as it is unity gain frequency in hertz
disp(Avcl,"closed loop voltage gain=")
disp("Hertz",f2cl,"closed loop bandwidth=")
disp("Volts",Vout1,"output voltage 1=")
disp("Volts",Vout2,"output voltage 2=")

// Result
// Closed loop voltage gain is -50
// Closed loop bandwidth is 20 Khertz
// Output voltage is -500 mVpp at 1 KHertz
// Output voltage is -10 mVpp at 1000 KHertz
```

Scilab code Exa 18.8 example8

```
// find output voltage
// Electronic Principles
// By Albert Malvino , David Bates
// Seventh Edition
// The McGraw-Hill Companies
// Example 18-8, page 679

clear; clc; close;

// Given data
R1=1.5*10^3;// in ohms from the given figure
Rf=75*10^3;// in ohms from the given figure
Vin=0;// input voltage in mVpp
Inbias=80*10^-9;// input bias current in amperes
Inoff=20*10^-9;// input offset current in amperes
Vinoff=2*10^-3;// input offset voltage in volts
Rb1=0;// in ohms

// Calculations
Rb2=R1*Rf/(R1+Rf);// in ohms
V1err=(Rb1-Rb2)*Inbias;// unwanted dc error input in volts
V2err=(Rb1+Rb2)*Inoff/2;// unwanted dc error input in volts
V3err=Vinoff;// unwanted dc error input in volts
Avcl=-Rf/R1;// cloased loop voltage gain
Verror=Avcl*(V1err+V2err+V3err);// output error voltage in volts;
Vout=Verror;// output voltage in volts
disp("Volts",Verror,"output error voltage=")

// Result
// Output voltage will be (+ or -) 94.9 mVolts
```

Scilab code Exa 18.9 example9

```
// find output voltage
// Electronic Principles
// By Albert Malvino , David Bates
// Seventh Edition
// The McGraw-Hill Companies
// Example 18-9, page 679

clear; clc; close;

// Given data
R1=1.5*10^3;// in ohms from the given figure
Rf=75*10^3;// in ohms from the given figure
Vin=0;// input voltage in mVpp
Inbias=500*10^-9;// input bias current in amperes
Inoff=200*10^-9;// input offset current in amperes
Vinoff=6*10^-3;// input offset voltage in volts
Rb1=0;// in ohms

// Calculations
Rb2=R1*Rf/(R1+Rf);// in ohms
V1err=(Rb1-Rb2)*Inbias;// unwanted dc error input in volts
V2err=(Rb1+Rb2)*Inoff/2;// unwanted dc error input in volts
V3err=Vinoff;// unwanted dc error input in volts
Avcl=-Rf/R1;// cloased loop voltage gain
Verror=Avcl*(V1err+V2err+V3err);// output error voltage in volts;
Vout=Verror;// output voltage in volts
disp("Volts",Verror,"output error voltage=")

// Result
// Output voltage will be (+ or -) 270.5 mVolts
```

Scilab code Exa 18.10 example10

```
// find closed-loop voltage gain, bandwidth and
    output voltage
// Electronic Principles
// By Albert Malvino , David Bates
// Seventh Edition
// The McGraw-Hill Companies
// Example 18-10, page 683

clear; clc; close;

// Given data
R1=10^2;// in ohms from the given figure
Rf=3.9*10^3;// in ohms from the given figure
Vin=50*10^-3;// input voltage in mVpp
f=250*10^3;// frequency in hertz
funity=10^6;// unity gain frequency in hertz

// Calculations
Avcl=(Rf/R1)+1;// cloased loop voltage gain
f2cl=funity/Avcl;// closed-loop bandwidth
// Avcl at 250 Khertz is equilaent to a voltage gain
    of 4
Vout=4*Vin;// output voltage at 250*10^3 Hertz
disp(Avcl,"closed loop voltage gain=")
disp("Hertz",f2cl,"closed loop bandwidth=")
disp("Volts",Vout,"output voltage=")

// Result
// Closed loop voltage gain is 40
// Closed loop bandwidth is 25 Khertz
```

```
// Output voltage is 200 mVpp at 250 KHertz
```

Scilab code Exa 18.11 example11

```
// find output error voltage
// Electronic Principles
// By Albert Malvino , David Bates
// Seventh Edition
// The McGraw-Hill Companies
// Example 18-11, page 684

clear; clc; close;

// Given data
R1=10^2;// in ohms from the given figure
Rf=3.9*10^3;// in ohms from the given figure
Inbias=500*10^-9;// input bias current in amperes
Inoff=200*10^-9;// input offset current in amperes
Vinoff=6*10^-3;// input offset voltage in volts
Rb1=0;// in ohms

// Calculations
Avcl=(Rf/R1)+1;// cloased loop voltage gain
Rb2=R1*Rf/(R1+Rf);// in ohms
V1err=(Rb1-Rb2)*Inbias;// unwanted dc error input in volts
V2err=(Rb1+Rb2)*Inoff/2;// unwanted dc error input in volts
V3err=Vinoff;// unwanted dc error input in volts
Verror=Avcl*(V1err+V2err+V3err);// output error voltage in volts;
disp("Volts",Verror,"output error voltage=")

```

```
// Result
// Output error voltage is 238 mVolts
```

Scilab code Exa 18.12 example12

```
// find ac output voltage
// Electronic Principles
// By Albert Malvino , David Bates
// Seventh Edition
// The McGraw-Hill Companies
// Example 18-12, page 687

clear; clc; close;

// Given data
Rf=100*10^3;// in ohms from the given figure
R1=20*10^3;// in ohms from the given figure
R2=10*10^3;// in ohms from the given figure
R3=50*10^3;// in ohms from the given figure
V1=100*10^-3;// voltage in Vpp from the given figure
V2=200*10^-3;// voltage in Vpp from the given figure
V3=300*10^-3;// voltage in Vpp from the given figure

// Calculations
Av1cl=-Rf/R1;// cloased loop voltage gain
Av2cl=-Rf/R2;// cloased loop voltage gain
Av3cl=-Rf/R3;// cloased loop voltage gain
Vout=(Av1cl*V1)+(Av2cl*V2)+(Av3cl*V3);// output voltage in Vpp
disp("Vpp",Vout,"output voltage=")

// Result
// Output voltage is -3.1 Vpp
```

Scilab code Exa 18.13 example13

```
// find output voltage and bandwidth
// Electronic Principles
// By Albert Malvino , David Bates
// Seventh Edition
// The McGraw-Hill Companies
// Example 18-13, page 688

clear; clc; close;

// Given data
Vin=10*10^-3;// ac input source in Vpp
R=100*10^3;// internal resistance in ohms
Rl=1;// load resistance in ohms
funity=10^6;// unity gain frequency in hertz

// Calculations
Avcl=1;// closed loop voltage gain of a voltage
    follower
Vout=Avcl*Vin;// output voltage in volts
f2cl=funity/Avcl;// closed-loop bandwidth
disp("Hertz",f2cl,"closed loop bandwidth=")
disp(Vout,"output voltage=")

// Result
// Output voltage is 10 mVpp
// bandwidth is 1 MHertz
```

Chapter 19

Negative Feedback

Scilab code Exa 19.1 example1

```
// find feedback fraction ,ideal and exact closed-
   loop voltage gain ,percent error
// Electronic Principles
// By Albert Malvino , David Bates
// Seventh Edition
// The McGraw-Hill Companies
// Example 19-1, page 709

clear; clc; close;

// Given data
R1=10^2;// in ohms from the given figure
Rf=3.9*10^3;// in ohms from the given figure
Avol=10^5;// Avol of 741C

// Calculations
B=R1/(R1+Rf);// feedback fraction
Avideal=1/B;// ideal closed loop voltage gain
%error=100/(1+(Avol*B));// percentage % in closed-
   loop voltage gain
Avexact=Avol/(1+(Avol*B));// exact closed loop
```

```
   voltage gain
disp("hertz",B,"bandwidth=")
disp(Avideal,"Ideal closed-loop voltage gain=")
disp(Avexact,"exact closed-loop voltage gain=")
disp("%",%error,"percentage eroor=")

// Result
// Bandwidth is 0.025
// Ideal closed-loop voltage gain is 40
// Exact closed-loop voltage gain is 39.984
// Percentage error is 0.04%
```

Scilab code Exa 19.2 example2

```
// find closed-loop input impedance
// Electronic Principles
// By Albert Malvino , David Bates
// Seventh Edition
// The McGraw-Hill Companies
// Example 19-2, page 713

clear; clc; close;

// Given data
R1=10^2;// in ohms from the given figure
Rf=3.9*10^3;// in ohms from the given figure
Avol=10^5;// Avol of 741C
Rin=2*10^6;// in ohms
Rcm=200*10^6;// in ohms

// Calculations
B=R1/(R1+Rf);// feedback fraction
zincl=(1+(Avol*B))*Rin;// closed-loop input
```

```
    impedance in ohms
// as zincl >100 Mega ohms
zincl=Rcm*zincl/(zincl+Rcm)
disp("ohms",zincl,"closed-loop input impedance=")

// Result
// closed-loop input impedance is 192 Mohms
```

Scilab code Exa 19.3 example3

```
// find closed-loop output impedance
// Electronic Principles
// By Albert Malvino , David Bates
// Seventh Edition
// The McGraw-Hill Companies
// Example 19-3, page 714

clear; clc; close;

// Given data
R1=10^2;// in ohms from the given figure
Rf=3.9*10^3;// in ohms from the given figure
Avol=10^5;// Avol of 741C
Rout=75;// in ohms
Rcm=200*10^6;// in ohms

// Calculations
B=R1/(R1+Rf);// feedback fraction
zoutcl=Rout/(1+(Avol*B));// closed-loop output
    impedance in ohms
disp("ohms",zoutcl,"closed-loop output impedance=")

// Result
```

```
// closed-loop output impedance is 0.03 ohms
```

Scilab code Exa 19.4 example4

```
// find closed-loop total harmonic distortion
// Electronic Principles
// By Albert Malvino , David Bates
// Seventh Edition
// The McGraw-Hill Companies
// Example 19-4, page 714

clear; clc; close;

// Given data
R1=10^2;// in ohms from the given figure
Rf=3.9*10^3;// in ohms from the given figure
Avol=10^5;// Avol of 741C
THDol=7.5;// open loop total harmonic distortion in
    %

// Calculations
B=R1/(R1+Rf);// feedback fraction
THDcl=THDol/(1+(Avol*B));// closed loop total
    harmonic distortion in %
disp("%",THDcl,"closed-loop total harmonic
    distortion=")

// Result
// closed-loop total harmonic distortion is 0.003%
```

Scilab code Exa 19.6 example6

```
// find closed-loop input and output impedance
// Electronic Principles
// By Albert Malvino , David Bates
// Seventh Edition
// The McGraw-Hill Companies
// Example 19-6, page 717

clear; clc; close;

// Given data
Rf=5*10^3;// in ohms from the given figure
Avol=10^5;// Avol of 741C
Rout=75;// in ohms

// Calculations
zincl=Rf/(1+Avol);// closed-loop input impedance in
    ohms
zoutcl=Rout/(1+Avol);// closed-loop output impedance
     in ohms
disp("ohms",zincl,"closed-loop input impedance=")
disp("ohms",zoutcl,"closed-loop output impedance=")

// Result
// closed-loop input impedance is 0.05 ohms
// closed-loop output impedance is 0.00075 ohms
```

Scilab code Exa 19.9 example9

```
// find closed-loop bandwidth
// Electronic Principles
// By Albert Malvino , David Bates
// Seventh Edition
// The McGraw-Hill Companies
// Example 19-9, page 723

clear; clc; close;

// Given data
// LF411A
AvolB=1000-1;// given
f2ol=160;// open-loop bandwidth in hertz

// Calculations
f2cl=(1+AvolB)*f2ol;// closed-loop bandwidth in
    hertz
disp("hertz",f2cl,"closed-loop bandwidth")

// Result
// closed-loop bandwidth is 160 KHertz
```

Scilab code Exa 19.10 example10

```
// find closed-loop bandwidth
// Electronic Principles
// By Albert Malvino , David Bates
// Seventh Edition
// The McGraw-Hill Companies
// Example 19-10, page 723

```

```
clear; clc; close;

// Given data
// LM308
Avol=250000;// given
f2ol=1.2;// open-loop bandwidth in hertz
Avcl=50;// closed loop voltage gain

// Calculations
f2cl=(Avol/Avcl)*f2ol;// closed-loop bandwidth in
    hertz
disp("hertz",f2cl,"closed-loop bandwidth")

// Result
// closed-loop bandwidth is 6 KHertz
```

Scilab code Exa 19.11 example11

```
// find closed-loop bandwidth
// Electronic Principles
// By Albert Malvino , David Bates
// Seventh Edition
// The McGraw-Hill Companies
// Example 19-11, page 724

clear; clc; close;

// Given data
// LM12
Avol=50000;// given
f2ol=14;// open-loop bandwidth in hertz

// Calculations
```

```
f2cl=(1+Avol)*f2ol;// closed-loop bandwidth in hertz
disp("hertz",f2cl,"closed-loop bandwidth")

// Result
// closed-loop bandwidth is 700 KHertz
```

Scilab code Exa 19.12 example12

```
// find closed-loop bandwidth
// Electronic Principles
// By Albert Malvino , David Bates
// Seventh Edition
// The McGraw-Hill Companies
// Example 19-12, page 724

clear; clc; close;

// Given data
// OP-07A
AvolB=2500-1;// given
f2ol=20;// open-loop bandwidth in hertz

// Calculations
f2cl=(1+AvolB)*f2ol;// closed-loop bandwidth in
    hertz
disp("hertz",f2cl,"closed-loop bandwidth")

// Result
// closed-loop bandwidth is 50 KHertz
```

Scilab code Exa 19.13 example13

```
// find closed-loop bandwidth,peak voltage
// Electronic Principles
// By Albert Malvino , David Bates
// Seventh Edition
// The McGraw-Hill Companies
// Example 19-13, page 724

clear; clc; close;

// Given data
// LM741C
funity=10^6;// in hertz
Sr=0.5*10^6;// slew rate in Volts/second
Avcl=10;// closed-loop voltage gain

// Calculations
f2cl=funity/Avcl;// closed-loop bandwidth in hertz
Vpeak=Sr/(2*%pi*f2cl);// peak voltage in volts
disp("hertz",f2cl,"closed-loop bandwidth")
disp("Volts",Vpeak,"peak voltage=")

// Result
// closed-loop bandwidth is 100 KHertz
// Peak voltage is 0.795 Volts
```

Chapter 20

Linear Op Amp Circuits

Scilab code Exa 20.2 example2

```
// find maximum,minimum voltage gain
// Electronic Principles
// By Albert Malvino , David Bates
// Seventh Edition
// The McGraw-Hill Companies
// Example 20-2, page 747

clear; clc; close;

// Given data
R1=1.2*10^3;// in ohms
R2=91*10^3;// in ohms

// Calculations
Avmin=-R2/R1;// minimum voltage gain
Avmax=0;// maximum voltage gain is 0
disp(Avmin,"minimum voltage gain=")
disp(Avmax,"maximum voltage gain=")

// Result
// Minimum voltage gain is -75.8
```

```
// Maximum voltage gain is 0
```

Scilab code Exa 20.3 example3

```
// find maximum positive voltage gain and value of other fixed resistance
// Electronic Principles
// By Albert Malvino , David Bates
// Seventh Edition
// The McGraw-Hill Companies
// Example 20-3, page 747

clear; clc; close;

// Given data
nR=7.5*10^3;// in ohms
R=1.5*10^3;// in ohms

// Calculations
n=nR/R;// obvious
Av=n;// maximum positive voltage gain
R2=nR/(n-1);// other fixed resistance in hms
disp(Av,"maximum voltage gain=")
disp("ohms",R2,"resistance=")

// Result
// Maximum voltage gain is 5
// Other resistance is 1.875 Kohms
```

Scilab code Exa 20.5 example5

```
// find voltage gain of each channel
// Electronic Principles
// By Albert Malvino , David Bates
// Seventh Edition
// The McGraw-Hill Companies
// Example 20-5, page 759

clear; clc; close;

// Given data
R1=1*10^3;// in ohms
R2=2*10^3;// in ohms
R3=3*10^3;// in ohms
R4=4*10^3;// in ohms
R5=5*10^3;// in ohms
Rf=6*10^3;// in ohms

// Calculations
R12=R1*R2/(R1+R2);// R1||R2
R45=R4*R5/(R4+R5);// R4||R5
R35=R3*R5/(R3+R5);// R3||R5
Av1=-Rf/R1;// voltage gain of channel
Av2=-Rf/R2;// voltage gain of channel
Av3=((Rf/R12)+1)*(R45/(R3+R45));// voltage gain of
    channel
Av4=((Rf/R12)+1)*(R35/(R4+R35));// voltage gain of
    channel
disp(Av1,"voltage gain 1=")
disp(Av2,"voltage gain 2=")
disp(Av3,"voltage gain 3=")
disp(Av4,"voltage gain 4=")

// Results
// Voltage gain of channel 1 is -6
// Voltage gain of channel 2 is -3
// Voltage gain of channel 3 is 4.26
```

```
// Voltage gain of channel 4 is 3.19
```

Scilab code Exa 20.6 example6

```
// find decimal equivalent of binary input and
    output voltage of the converter
// Electronic Principles
// By Albert Malvino , David Bates
// Seventh Edition
// The McGraw−Hill Companies
// Example 20−6, page 762

clear; clc; close;

// Given data
D0=1;// binary input
D1=0;// binary input
D2=0;// binary input
D3=1;// binary input
Vref=5;// in volts

// Calculations
BIN=(D0*2^0)+(D1*2^1)+(D2*2^2)+(D3*2^3);// decimal
    equivalent of binary input
Vout=-(BIN*2*Vref/(2^4));// output voltage in volts
disp(BIN,"decimal equivalent of binary input=")
disp("Volts",Vout,"output voltage=")

// Result
// decimal equivalent of binary input 1001 is 9
// Output voltage of the convertor is −5.625 Volts
```

Scilab code Exa 20.7 example7

```
// find  closed loop output impedance,short loaded
    current and voltage gain of the circuit
// Electronic Principles
// By Albert Malvino , David Bates
// Seventh Edition
// The McGraw-Hill Companies
// Example 20-7, page 764

clear; clc; close;

// Given data
R1=10^3;// in ohms
R2=51*10^3;// in ohms
Avol=100000;// Avol of 741C
zoutol=75;// open-loop output impedance in ohms
Bdc=125;// current gain
Isc=25*10^-3;// short-load current in amperes

// Calculations
Av=-R2/R1;// voltage gain
B=R1/(R1+R2);//feedback fraction
zoutcl=zoutol/(1+(Avol*B));// closed-loop output
    impedance in ohms
Imax=Bdc*Isc;// boosted value of short loaded
    current in amperes
disp("ohms",zoutcl,"Closed loop output impedance=")
disp(Av,"Voltage gain=")
disp("amperes",Imax,"Short-load current=")

// Result
```

```
// Closed loop output impedance is 0.039 ohms
// Voltage gain is -51
// Short-load current is 3.13 Amperes
```

Scilab code Exa 20.8 example8

```
// find output current and maximum load resistance
// Electronic Principles
// By Albert Malvino , David Bates
// Seventh Edition
// The McGraw-Hill Companies
// Example 20-8, page 768

clear; clc; close;

// Given data
R=10*10^3;// in ohms
Vin=10;// input voltage in volts
Vcc=15;// in volts

// Calculations
iout=Vin/R;// output current in amperes
Rlmax=R*((Vcc/Vin)-1);// maximum load resistance in
    ohms
disp("Amperes",iout,"output current=")
disp("ohms",Rlmax,"Maximum load resistance=")

// Result
// Output current is 1 mAmperes
// Maximum load resistance is 5 Kohms
```

Scilab code Exa 20.9 example9

```
// find output current and maximum load resistance
// Electronic Principles
// By Albert Malvino , David Bates
// Seventh Edition
// The McGraw-Hill Companies
// Example 20-9, page 768

clear; clc; close;

// Given data
R=15*10^3;// in ohms
Vin=3;// input voltage in volts
Vcc=15;// in volts

// Calculations
iout=-Vin/R;// output current in amperes
Rlmax=(R/2)*((Vcc/Vin)-1);// maximum load resistance in ohms
disp("Amperes",iout,"output current=")
disp("ohms",Rlmax,"Maximum load resistance=")

// Result
// Output current is -0.2 mAmperes
// Maximum load resistance is 30 Kohms
```

Scilab code Exa 20.10 example10

```
// find maximum,minimum voltage gain
// Electronic Principles
// By Albert Malvino , David Bates
// Seventh Edition
// The McGraw-Hill Companies
// Example 20-10, page 771

clear; clc; close;

// Given data
Rdsmin=50;// in ohms
Rdsmax=120*10^3;// in ohms
R1=1*10^3;// in ohms
R2=47*10^3;// in ohms
R3=100*10^3;// in ohms

// Calculations
Avmax=((R2/R1)+1)*(Rdsmax/(Rdsmax+R3));// maximum
    voltage gain
Avmin=((R2/R1)+1)*(Rdsmin/(Rdsmin+R3));// minimum
    voltage gain
disp(Avmin,"minimum voltage gain=")
disp(Avmax,"maximum voltage gain=")

// Result
// Minimum voltage gain is 0.024
// Maximum voltage gain is 26.2
```

Chapter 21

Active Filters

Scilab code Exa 21.1 example1

```
// find voltage gain ,cutoff frequency
// Electronic Principles
// By Albert Malvino , David Bates
// Seventh Edition
// The McGraw-Hill Companies
// Example 21-1, page 806

clear;clc; close;

// Given data
R1=10^3;// in ohms
R2=39*10^3;// in ohms
R3=12*10^3;// in ohms
C1=680*10^-12;// capacitance in faraday

// Calculations
Av=(R2/R1)+1;// voltage gain
fc=1/(2*%pi*R3*C1);// cutoff frequency in hertz
disp(Av,"Voltage gain=")
disp("Hertz",fc,"cutoff frequency=")

```

```
// Result
// voltage gain is 40
// cutoff frequency is 19.5 KHertz
```

Scilab code Exa 21.2 example2

```
// find voltage gain ,cutoff frequency
// Electronic Principles
// By Albert Malvino , David Bates
// Seventh Edition
// The McGraw-Hill Companies
// Example 21-2, page 807

clear;clc; close;

// Given data
R1=220;// in ohms
R2=43*10^3;// in ohms
C1=100*10^-12;// capacitance in faraday

// Calculations
Av=-R2/R1;// voltage gain
fc=1/(2*%pi*R2*C1);// cutoff frequency in hertz
disp(Av,"Voltage gain=")
disp("Hertz",fc,"cutoff frequency=")

// Result
// Voltage gain is -195
// Cutoff frequency is 37 KHertz
```

Scilab code Exa 21.3 example3

```
// find pole frequency ,Q, cutoff frequency
// Electronic Principles
// By Albert Malvino , David Bates
// Seventh Edition
// The McGraw-Hill Companies
// Example 21-3, page 811

clear;clc; close;

// Given data
C1=820*10^-12;// capacitance in faraday
C2=1.64*10^-9;// capacitance in faraday
R=30*10^3;// resistance in ohms

// Calculations
Q=((C2/C1)^0.5)/2;// q of the filter
fp=1/(2*%pi*R*((C1*C2)^0.5));// peak frequency in
    hertz
fc=fp;// for Butterworth response cutoff frequency
    is equal to peak frequency
disp(Q,"Q of the filter=")
disp("hertz",fc,"cutoff frequency=")
disp("hertz",fp,"peak frequency=")

// Result
// Q of the filter is 0.707(Butterworth response)
// peak frequency is 4.58 kHertz
// cutoff frequency is 4.58 kHertz
```

Scilab code Exa 21.4 example4

```
// find pole frequency ,Q, cutoff frequency
// Electronic Principles
// By Albert Malvino , David Bates
// Seventh Edition
// The McGraw-Hill Companies
// Example 21-4, page 811

clear;clc; close;

// Given data
C1=330*10^-12;// capacitance in faraday
C2=440*10^-12;// capacitance in faraday
R=51*10^3;// resistance in ohms
Kc=0.786;// constant for Bessel response

// Calculations
Q=((C2/C1)^0.5)/2;// q of the filter
fp=1/(2*%pi*R*((C1*C2)^0.5));// peak frequency in
    hertz
fc=Kc*fp;// for Bessel's response cutoff frequency
    is Kc*peak frequency
disp(Q,"Q of the filter=")
disp("hertz",fc,"cutoff frequency=")
disp("hertz",fp,"peak frequency=")

// Result
// Q of the filter is 0.577(Bessel response)
// peak frequency is 8.19 kHertz
// cutoff frequency is 6.44 kHertz
```

Scilab code Exa 21.5 example5

```
// find pole frequency ,Q, cutoff frequency , 3-db
   frequencies
// Electronic Principles
// By Albert Malvino , David Bates
// Seventh Edition
// The McGraw-Hill Companies
// Example 21-5, page 812

clear;clc; close;

// Given data
C1=390*10^-12;// capacitance in faraday
C2=27*10^-9;// capacitance in faraday
R=22*10^3;// resistance in ohms
Ap=12.5;// in decibel
K0=0.99;// constant
Kc=1.38;// constant
K3=1.54;// constant

// Calculations
Q=((C2/C1)^0.5)/2;// q of the filter
fp=1/(2*%pi*R*((C1*C2)^0.5));// peak frequency in
   hertz
fc=Kc*fp;// cutoff frequency in hertz
f3db=K3*fp;// 3-db frequency in hertz
disp(Q,"Q of the filter=")
disp("hertz",fc,"cutoff frequency=")
disp("hertz",fp,"peak frequency=")
disp("hertz",f3db,"3db frequency=")

```

```
// Result
// Q of the filter is 4.16
// peak frequency is 2.23 kHertz
// cutoff frequency is 3.08 kHertz
// 3-db frequency is 3.43 kHertz
```

Scilab code Exa 21.6 example6

```
// find pole frequency ,Q, cutoff frequency
// Electronic Principles
// By Albert Malvino , David Bates
// Seventh Edition
// The McGraw-Hill Companies
// Example 21-6, page 817

clear;clc; close;

// Given data
C=330*10^-12;// capacitance in faraday
R1=51*10^3;// resistance in ohms
R2=30*10^3;// resistance in ohms
R=47*10^3;// resistance in ohms

// Calculations
Av=(R2/R1)+1;// midband voltage gain
Q=1/(3-Av);// q of the filter
fp=1/(2*%pi*R*C);// peak frequency in hertz
fc=fp;// for Butterworth response cutoff frequency
    is equal to peak frequency
disp(Q,"Q of the filter=")
disp("hertz",fc,"cutoff frequency=")
disp("hertz",fp,"peak frequency=")

```

```
// Result
// Q of the filter is 0.709
// peak frequency is 10.3 kHertz
// cutoff frequency is 10.3 kHertz
```

Scilab code Exa 21.7 example7

```
// find pole frequency ,Q, cutoff frequency
// Electronic Principles
// By Albert Malvino , David Bates
// Seventh Edition
// The McGraw-Hill Companies
// Example 21-7, page 817

clear;clc; close;

// Given data
C=100*10^-12;// capacitance in faraday
R1=56*10^3;// resistance in ohms
R2=15*10^3;// resistance in ohms
R=82*10^3;// resistance in ohms
Kc=0.786;// constant for Bessel response

// Calculations
Av=(R2/R1)+1;// midband voltage gain
Q=1/(3-Av);// q of the filter
fp=1/(2*%pi*R*C);// peak frequency in hertz
fc=Kc*fp;// for Bessel's response cutoff frequency
    is Kc*peak frequency
disp(Q,"Q of the filter=")
disp("hertz",fc,"cutoff frequency=")
disp("hertz",fp,"peak frequency=")

```

```
// Result
// Q of the filter is 0.578
// peak frequency is 19.4 kHertz
// cutoff frequency is 15.2 kHertz
```

Scilab code Exa 21.9 example9

```
// find pole frequency ,Q, cutoff frequency
// Electronic Principles
// By Albert Malvino , David Bates
// Seventh Edition
// The McGraw-Hill Companies
// Example 21-9, page 820

clear;clc; close;

// Given data
C=4.7*10^-9;// capacitance in faraday
R1=24*10^3;// resistance in ohms
R2=12*10^3;// resistance in ohms

// Calculations
Q=((R1/R2)^0.5)/2;// q of the filter
fp=1/(2*%pi*C*((R1*R2)^0.5));// peak frequency in
    hertz
fc=fp;// for Butterworth response cutoff frequency
    is equal to peak frequency
disp(Q,"Q of the filter=")
disp("hertz",fc,"cutoff frequency=")
disp("hertz",fp,"peak frequency=")

// Results
// Q of the filter is 0.707(Butterworth response)
```

```
// peak frequency is 2 kHertz
// cutoff frequency is 2 kHertz
```

Scilab code Exa 21.10 example10

```
// find pole frequency ,Q, resonant , cutoff ,3-db frequency
// Electronic Principles
// By Albert Malvino , David Bates
// Seventh Edition
// The McGraw-Hill Companies
// Example 21-10, page 821

clear;clc; close;

// Given data
C=10^-9;// capacitance in faraday
R1=10*10^3;// resistance in ohms
R2=15*10^3;// resistance in ohms
R=30*10^3;// resistance in ohms
K0=0.94;// constant
Kc=1.32;// constant
K3=1.48;// constant

// Calculations
Av=(R2/R1)+1;// midband voltage gain
Q=1/(3-Av);// q of the filter
fp=1/(2*%pi*R*C);// peak frequency in hertz
fc=fp/Kc;// cutoff frequency in hertz
f0=fp/K0;// resonant frequency in hertz
f3db=fp/K3;// 3-db frequency in hertz
disp(Q,"Q of the filter=")
disp("hertz",fc,"cutoff frequency=")
```

```
disp("hertz",fp,"peak frequency=")
disp("hertz",f0,"resonant frequency=")
disp("hertz",f3db,"3db frequency=")

// Result
// Q is 2
// peak frequency is 5.31 kHertz
// cutoff frequency is 4.02 kHertz
// resonant frequency is 5.65 kHertz
// 3-db frequency is 3.59 kHertz
```

Scilab code Exa 21.12 example12

```
// find voltage gain ,center frequency ,Q
// Electronic Principles
// By Albert Malvino , David Bates
// Seventh Edition
// The McGraw-Hill Companies
// Example 21-12, page 827

clear;clc; close;

// Given data
C=120*10^-9;// capacitance in faraday
R1=13*10^3;// resistance in ohms
R2=10*10^3;// resistance in ohms
R=22*10^3;// resistance in ohms

// Calculations
Av=(R2/R1)+1;// voltage gain
Q=0.5/(2-Av);// q of the filter
f0=1/(2*%pi*R*C);// center frequency in hertz
disp(Q,"Q of the filter=")
```

```
disp(Av,"Voltage gain=")
disp("hertz",f0,"resonant frequency=")

// Result
// Q is 2.17
// resonant frequency is 60.3 Hertz
// Voltage gain is 1.77
```

Scilab code Exa 21.13 example13

```
// find phase shift of output voltage
// Electronic Principles
// By Albert Malvino , David Bates
// Seventh Edition
// The McGraw-Hill Companies
// Example 21-13, page 833

clear;clc; close;

// Given data
C=100*10^-9;// capacitance in faraday
R=10^3;// resistance in ohms
f=10^3;// frequency in hertz

// Calculations
fo=1/(2*%pi*R*C);// cutoff frequency in hertz
angle=2*atan(fo/f)*180/%pi;// phase shift in degree
disp("degrees",angle,"phase shift=")

// Result
// Phase shift is 116 degrees
```

Chapter 22

Non Linear Op Amp Circuits

Scilab code Exa 22.4 example4

```
// find trip point,cutoff frequency
// Electronic Principles
// By Albert Malvino , David Bates
// Seventh Edition
// The McGraw-Hill Companies
// Example 22-4, page 854

clear;clc; close;

// Given data
Vcc=15;// in volts from the figure
C=10*10^-6;// capacitance in faraday
R1=200*10^3;// resistance in ohms
R2=100*10^3;// resistance in ohms

// Calculations
Vref=(R2/(R1+R2))*Vcc;// reference voltage in volts
R=R1*R2/(R1+R2);// equivalent resistance in ohms
fc=1/(2*%pi*R*C);// cutoff frequency in hertz
disp("hertz",fc,"cutoff frequency=")
disp("Volts",Vref,"Trip point=")
```

```

// Result
// Trip point is 5 Volts
// cutoff frequency is 0.239 Hertz
```

Scilab code Exa 22.5 example5

```
// find duty cycle of output waveform
// Electronic Principles
// By Albert Malvino , David Bates
// Seventh Edition
// The McGraw-Hill Companies
// Example 22-5, page 855

clear;clc; close;

// Given data
Vp=10;// peak voltage in volts
Vcc=15;// in volts from the figure
C=10*10^-6;// capacitance in faraday
R1=200*10^3;// resistance in ohms
R2=100*10^3;// resistance in ohms

// Calculations
// input is a sine wave it is 10sin(angle)
Vref=(R2/(R1+R2))*Vcc;// reference voltage in volts
// output is a rectangular waveform whose trip point is 5 Volts
angle1=asin(Vref/Vp)*180/%pi;// angle where switching occurs
angle2=180-angle1;// other angle where switching occurs
angle=angle2-angle1;// conduction angle in degrees
```

```
D=angle*100/360;// duty cycle in %
disp("%",D,"duty cycle=")

// Result
// duty cycle is 33.3 %
```

Scilab code Exa 22.6 example6

```
// find trip points and hysteresis
// Electronic Principles
// By Albert Malvino , David Bates
// Seventh Edition
// The McGraw-Hill Companies
// Example 22-6, page 860

clear;clc; close;

// Given data
Vsat=13.5;// in volts
R1=1*10^3;// resistance in ohms
R2=47*10^3;// resistance in ohms

// Calculations
B=R1/(R1+R2);// feedback fraction
UTP=(R1/R2)*Vsat;// upper trip point in volts
LTP=-(R1/R2)*Vsat;// lower trip point in volts
H=UTP-LTP;// hysteresis in volts
disp("Volts",UTP,"upper trip point=")
disp("Volts",LTP,"lower trip point=")
disp("Volts",H,"hysteresis=")

// Result
// Trip points are -0.287 and +0.287 Volts
```

```
// Hysteresis is 0.574 Volts
```

Scilab code Exa 22.7 example7

```
// find output voltage, closed loop time constant
// Electronic Principles
// By Albert Malvino , David Bates
// Seventh Edition
// The McGraw-Hill Companies
// Example 22-7, page 865

clear;clc; close;

// Given data
Avol=100000;// open loop voltage gain
Vin=8;// input voltage in volts
C=1*10^-6;// capacitance in faraday
R=2*10^3;// resistance in ohms
T=10^-3;// in seconds

// Calculations
t=R*C*(1+Avol);// closed loop time constant in
    seconds
V=(T*Vin)/(R*C);// magnitude of negative output
    voltage at end of pulse in volts
disp("seconds",t,"time constant=")
disp("Volts",V,"output voltage=")

// Result
// Closed loop time constant is 200 seconds
// Output voltage at end of pulse is -4 volts
```

Scilab code Exa 22.8 example8

```
// find output voltage
// Electronic Principles
// By Albert Malvino , David Bates
// Seventh Edition
// The McGraw-Hill Companies
// Example 22-8, page 868

clear;clc; close;

// Given data
fin=10^3;// frequency in hertz'
Vp=5;// peak voltage in volts
C=10*10^-6;// capacitance in faraday
R=10^3;// resistance in ohms

// Calculations
Vout=Vp/(2*fin*R*C);// output voltage in Vpp
disp("Volts",Vout,"output voltage=")

// Result
// Output voltage is 0.25 Vpp
```

Scilab code Exa 22.10 example10

```
// find frequency of output signal
// Electronic Principles
```

```
// By Albert Malvino , David Bates
// Seventh Edition
// The McGraw-Hill Companies
// Example 22-10, page 871

clear;clc; close;

// Given data
R1=18*10^3;// resistance in ohms
R2=2*10^3;// resistance in ohms
R=10^3;// resistance in ohms
C=0.1*10^-6;// capacitance in faraday

// Calculations
B=R1/(R1+R2);// feedback fraction
T=2*R*C*log((1+B)/(1-B));// time period of output
    signal
f=1/T;// frequency of output signal
disp("hertz",f,"Frequency=")

// Result
// Frequency of output signal is 1.7 KHertz
```

Scilab code Exa 22.12 example12

```
// find frequency and peak-to-peak voltage
// Electronic Principles
// By Albert Malvino , David Bates
// Seventh Edition
// The McGraw-Hill Companies
// Example 22-12, page 873

clear;clc; close;
```

```

// Given data
Vsat=13;// in volts
R1=1*10^3;// resistance in ohms
R2=100*10^3;// resistance in ohms
R3=10*10^3;// resistance in ohms
R4=100*10^3;// resistance in ohms
C=10*10^-6;// capacitance in faraday

// Calculations
UTP=(R1/R2)*Vsat;// upper trip point in volts
H=2*UTP;// hysteresis in volts
Vout=H;// peak to peak voltage in volts
f=R2/(4*R1*R3*C);// frequency in hertz
disp("hertz",f,"Frequency=")
disp("Volts",Vout,"output voltage=")

// Result
// Peak-to-peak output is 0.26 Volts
// frequency is 250 Hertz
```

Chapter 23

Oscillators

Scilab code Exa 23.1 example1

```
// find minimum and maximum frequency
// Electronic Principles
// By Albert Malvino , David Bates
// Seventh Edition
// The McGraw-Hill Companies
// Example 23-1, page 897

clear;clc; close;

// Given data
C=0.01*10^-6;// capacitance in faraday
Rmin=1*10^3;// resistance in ohms
Rmax=101*10^3;// resistance in ohms

// Calculations
fcmin=1/(2*%pi*Rmax*C);// cutoff frequency in hertz
fcmax=1/(2*%pi*Rmin*C);// cutoff frequency in hertz
disp("hertz",fcmax,"Maximum frequency of
    osscillation=")
disp("hertz",fcmin,"Minimum frequency of
    osscillation=")
```

```
// Result
// Minimum frequency of osscillation is 158 Hertz
// Maximum frequency of osscillation is 15.9 KHertz
```

Scilab code Exa 23.2 example2

```
// find output voltage of oscillator
// Electronic Principles
// By Albert Malvino , David Bates
// Seventh Edition
// The McGraw-Hill Companies
// Example 23-2 , page 897

clear;clc; close;

// Given data
R=10^3;// lamp resistance in ohms
V=2;// lamp voltage in volts
Rb=2*10^3;// feedback resistance in ohms

// Calculations
I=V/R;// lamp current in amperes
Vout=I*(R+Rb);// output voltage in volts
disp("Volts",Vout,"output voltage=")

// Result
// Output voltage of the oscillator is 6vrms
```

Scilab code Exa 23.4 example4

```
// find frequency of oscillation
// Electronic Principles
// By Albert Malvino , David Bates
// Seventh Edition
// The McGraw-Hill Companies
// Example 23-4, page 908

clear;clc; close;

// Given data
C1=0.001*10^-6;// capacitance in faraday
C2=0.01*10^-6;// capacitance in faraday
C3=50*10^-12;// capacitance in faraday
L=15*10^-6;// inductance in henry

// Calculations
C=1/((1/C1)+(1/C2)+(1/C3));// equivalent capacitance in faraday
fr=1/(2*%pi*(L*C)^0.5);// frequency of oscillation in hertz
disp("hertz",fr,"frequency of osscillation=")

// Result
// frequency of oscillation is 5.81 MHertz
```

Scilab code Exa 23.5 example5

```
// find series and parallel resonant frequencies of crystal
// Electronic Principles
// By Albert Malvino , David Bates
```

```
// Seventh Edition
// The McGraw−Hill Companies
// Example 23−5, page 912

clear;clc; close;

// Given data
L=3;// inductance in henry
Cm=10*10^-12;// capacitance in faraday
Cs=0.05*10^-12;// capacitance in faraday
R=2*10^3;// resistance in ohms

// Calculations
fs=1/(2*%pi*(L*Cs)^0.5);// series resonant frequency
    in hertz
Cp=Cm*Cs/(Cm+Cs);// equivalent parallel capacitance
fp=1/(2*%pi*(L*Cp)^0.5);// parallel resonant
   frequency in hertz
disp("hertz",fs,"Series resonant frequency=")
disp("hertz",fp,"parallel resonant frequency=")

// Result
// Series resonant frequency of the crystal is 411
   Khertz
// Parallel resonant frequency of the crystal is 412
    Khertz
```

Scilab code Exa 23.6 example6

```
// find minimum trigger voltage ,maximum capacitor
   voltage ,width of output pulse
// Electronic Principles
// By Albert Malvino , David Bates
```

```
// Seventh Edition
// The McGraw−Hill Companies
// Example 23−6, page 918

clear;clc; close;

// Given data
C=0.47*10^-6;// capacitance in faraday
R=33*10^3;// resistance in ohms
Vcc=12;// in volts

// Calculations
UTP=2*Vcc/3;// upper trip point in volts
LTP=Vcc/3;// lower trip point in volts
W=1.1*R*C;// pulse width
disp("Volts",UTP,"Maximum trigger voltage=")
disp("Volts",LTP,"Minimum trigger voltage=")
disp("seconds",W,"pulse width=")

// Result
// Minimum trigger voltage is 4 Volts
// Maximum capacitor voltage is 8 Volts
// Pulse width is 17.1 mSeconds
```

Scilab code Exa 23.7 example7

```
// find width of output pulse
// Electronic Principles
// By Albert Malvino , David Bates
// Seventh Edition
// The McGraw−Hill Companies
// Example 23−7, page 919

```

```
clear;clc; close;

// Given data
C=470*10^-6;// capacitance in faraday
R=10*10^6;// resistance in ohms

// Calculations
W=1.1*R*C;// pulse width
disp("seconds",W,"pulse width=")

// Result
// Pulse width is 1.44 hrs
```

Scilab code Exa 23.8 example8

```
// find frequency of output and duty cycle
// Electronic Principles
// By Albert Malvino , David Bates
// Seventh Edition
// The McGraw-Hill Companies
// Example 23-8, page 922

clear;clc; close;

// Given data
C=47*10^-9;// capacitance in faraday
R1=75*10^3;// resistance in ohms
R2=30*10^3;// resistance in ohms

// Calculations
f=1.44/((R1+2*R2)*C);// frequency in hertz
D=(R1+R2)/(R1+(2*R2));// duty cycle
disp("hertz",f,"frequency in hertz=")
```

```
disp("%",D,"duty cycle")

// Result
// Frequency of output signal is 227 hertz
// duty cycle is 0.778
```

Scilab code Exa 23.10 example10

```
// find period of output pulses ,minimum and maximum
     pulse width, quiescent pulse width
// Electronic Principles
// By Albert Malvino , David Bates
// Seventh Edition
// The McGraw-Hill Companies
// Example 23-10, page 927

clear;clc; close;

// Given data
C=0.01*10^-6;// capacitance in faraday
R=9.1*10^3;// resistance in ohms
Vcc=12;// in volts
f=2.5*10^3;// frequency in hertz
Vmod=2;// peak voltage

// Calculations
T=1/f;// period of output pulses
UTP=2*Vcc/3;// upper trip point in volts
UTPmin=UTP-Vmod;// minimum upper trip point in volts
UTPmax=UTP+Vmod;// maximum upper trip point in volts
W=1.1*R*C;// quiescent pulse width
Wmin=-R*C*log(1-(UTPmin/Vcc));// minimum pulse width
Wmax=-R*C*log(1-(UTPmax/Vcc));// maximum pulse width
```

```
disp("seconds",T,"period of output cycle=")
disp("Volts",UTPmin,"Minium UTP=")
disp("Volts",UTPmax,"Maxium UTP=")
disp("seconds",W,"Quiescent pulse width=")
disp("seconds",Wmin,"minimum pulse width=")
disp("seconds",Wmax,"maximum pulse width=")

// Result
// Period of output pulses is 400 Microseconds
// Quiescent pulse width is 100 Micro seconds
// Minimum UTP is 6 Volts
// Maximum UTP is 10 Volts
// Minimum pulse width is 63.1 Microseconds
// Maximum pulse width is 163 Microseconds
```

Scilab code Exa 23.12 example12

```
// find slope of output ramp,its peak value,duration
// Electronic Principles
// By Albert Malvino , David Bates
// Seventh Edition
// The McGraw-Hill Companies
// Example 23-12, page 929

clear;clc; close;

// Given data
C=100*10^-9;// capacitance in faraday
Ic=10^-3;// collector cuurent in amperes
Vcc=15;// in volts
f=2.5*10^3;// frequency in hertz

// Calculations
```

```
S=Ic/C;// slope in Volts/second
V=2*Vcc/3;// peak value of ramp
T=2*Vcc/(3*S);// duration of ramp in seconds
disp(S,"slope of output ramp=")
disp("Volts",V,"peak value=")
disp("seconds",T,"duration of the ramp=")

// Result
// slope of output ramp is 10^4 Volts/Second
// Peak value is 10 Volts
// duration of the ramp is 10^-2 second
```

Chapter 24

Regulated Power Supplies

Scilab code Exa 24.1 example1

```
// find output ,load ,collector current
// Electronic Principles
// By Albert Malvino , David Bates
// Seventh Edition
// The McGraw-Hill Companies
// Example 24-1, page 954

clear; clc; close;

// Given data
Vin=15;// input voltage
Rs=10;// in ohms
Vz=9.1;// in volts
Vbe=0.8;// in volts
Rl=40;// in ohms

// Calculations
Vout=Vz+Vbe;// output voltage in volts
Is=(Vin-Vout)/Rs;// current through series resistor
   in amperes
Il=Vout/Rl;// load current in amperes
```

```
Ic=Is-Il;// collector current in ampers
disp("Volts",Vout,"output voltage=")
disp("amperes",Il,"load current=")
disp("amperes",Ic,"collector current=")

// Results
// Output voltage is 9.9
// Load current is 248 mAmperes
// Collector current is 262 mAmperes
```

Scilab code Exa 24.2 example2

```
// find output voltage,load,collector current
// Electronic Principles
// By Albert Malvino , David Bates
// Seventh Edition
// The McGraw-Hill Companies
// Example 24-2, page 954

clear; clc; close;

// Given data
Vin=15;// input voltage
Rs=10;// in ohms
Vz=6.2;// in volts
Vbe=0.81;// in volts
Rl=40;// in ohms
R1=750;// in ohms
R2=250 ;// in ohms

// Calculations
Vout=((R1+R2)/R1)*(Vz+Vbe);// output voltage in
   volts
```

```
Is=(Vin-Vout)/Rs;// current through series resistor
    in amperes
Il=Vout/Rl;// load current in amperes
Ic=Is-Il;// collector current in ampers
disp("Volts",Vout,"output voltage=")
disp("amperes",Il,"load current=")
disp("amperes",Ic,"collector current=")

// Results
// Output voltage is 9.35
// Load current is 234 mAmperes
// Collector current is 331 mAmperes
```

Scilab code Exa 24.3 example3

```
// find efficiency and power dissipated
// Electronic Principles
// By Albert Malvino , David Bates
// Seventh Edition
// The McGraw-Hill Companies
// Example 24-3, page 955

clear; clc; close;

// Given data
Vin=15;// input voltage
Rs=10;// in ohms
Vz=6.2;// in volts
Vbe=0.81;// in volts
Rl=40;// in ohms
R1=750;// in ohms
R2=250 ;// in ohms

```

```
// Calculations
Vout=((R1+R2)/R1)*(Vz+Vbe);// output voltage in volts
Is=(Vin-Vout)/Rs;// current through series resistor in amperes
Il=Vout/Rl;// load current in amperes
Ic=Is-Il;// collector current in ampers
Pout=Vout*Il;// load power in watts
Iin=Is;// as I3 is very low input current in amperes
Pin=Vin*Iin;// input power in watts
E=(Pout/Pin)*100;// efficiency in %
Preg=Pin-Pout;// power dissipated by regulator in watts
disp("%",E,"efficiency=")
disp("watts",Preg,"power dissipated=")

// Results
// Efficiency is 25.8 %
// Power dissipated by regulator is 6.29 watts
```

Scilab code Exa 24.4 example4

```
// find output voltage,input,load,collector current
// Electronic Principles
// By Albert Malvino , David Bates
// Seventh Edition
// The McGraw-Hill Companies
// Example 24-4, page 955

clear; clc; close;

// Given data
Vin=15;// input voltage
```

```
Rs=10;// in ohms
Vz=6.8;// in volts
Rl=40;// in ohms
R1=7.5*10^3;// in ohms
R2=2.5*10^3 ;// in ohms

// Calculations
Vout=((R1+R2)/R1)*Vz;// output voltage in volts
Is=(Vin-Vout)/Rs;// current through series resistor in amperes
Iin=Is;// as I3 is very low input current in amperes
Il=Vout/Rl;// load current in amperes
Ic=Is-Il;// collector current in ampers
disp("Volts",Vout,"output voltage=")
disp("amperes",Iin,"input current=")
disp("amperes",Il,"load current=")
disp("amperes",Ic,"collector current=")

// Results
// Output voltage is 9.07 Volts
// Input current is 593 mAmperes
// Load current is 227 mAmperes
// Collector current is 366 mAmperes
```

Scilab code Exa 24.6 example6

```
// find load regulation and line regulation
// Electronic Principles
// By Albert Malvino , David Bates
// Seventh Edition
// The McGraw-Hill Companies
// Example 24-6, page 956

```

```
clear; clc; close;

// Given data
Vnl=9.91;// in volts
Vfl=9.81;// in volts
Vhl=9.94;// in volts
Vll=9.79 ;// in volts

// Calculations
ld=((Vnl-Vfl)/Vfl)*100 ;// load regulation in %
ln=((Vhl-Vll)/Vll)*100;// loan regulation in %
disp("%",ld,"load regulation=")
disp("%",ln,"line regulation=")

// Results
// load regulation is 1.02%
// line regulation is 1.53%
```

Scilab code Exa 24.7 example7

```
// find output voltage,power dissipation
// Electronic Principles
// By Albert Malvino , David Bates
// Seventh Edition
// The McGraw-Hill Companies
// Example 24-7, page 962

clear; clc; close;

// Given data
Vin=15;// input voltage
Vz=6.2;// in volts
Vbe=0.7;// in volts
```

```
Rl=40;// in ohms
R1=3*10^3;// in ohms
R2=1*10^3 ;// in ohms

// Calculations
Vout=((R1+R2)/R1)*(Vz+Vbe);// output voltage in
    volts
Ic=Vout/Rl;// transistor current is equal to load
    current
Pd=(Vin-Vout)*Ic;// power dissipation in watts
disp("Volts",Vout,"output voltage=")
disp("Watts",Pd,"power dissipation=")

// Results
// Output voltage is 9.2 Volts
// power dissipation is 1.33 Watts
```

Scilab code Exa 24.8 example8

```
// find efficiency
// Electronic Principles
// By Albert Malvino , David Bates
// Seventh Edition
// The McGraw-Hill Companies
// Example 24-8, page 963

clear; clc; close;

// Given data
Vin=15;// input voltage
Vz=6.2;// in volts
Vbe=0.7;// in volts
Rl=40;// in ohms
```

```
R1=3*10^3;// in ohms
R2=1*10^3 ;// in ohms

// Calculations
Vout=((R1+R2)/R1)*(Vz+Vbe);// output voltage in volts
Il=Vout/Rl;// load current in amperes
Ic=Il;// transistor current is equal to load current
Pout=Vout*Il;// load power in watts
Pin=Vin*Ic;// input power in watts
E=(Pout/Pin)*100;// efficiency in %
disp("%",E,"efficiency=")

// Results
// Efficiency is 61.3 %
```

Scilab code Exa 24.10 example10

```
// find load regulation and line regulation
// Electronic Principles
// By Albert Malvino , David Bates
// Seventh Edition
// The McGraw-Hill Companies
// Example 24-10, page 964

clear; clc; close;

// Given data
Vnl=10.16;// in volts
Vfl=10.15;// in volts
Vhl=10.16;// in volts
Vll=10.07;// in volts

```

```
// Calculations
ld=((Vnl-Vfl)/Vfl)*100 ;// load regulation in %
ln=((Vhl-Vll)/Vll)*100;// loan regulation in %
disp("%",ld,"load regulation=")
disp("%",ln,"line regulation=")

// Results
// load regulation is 0.0985%
// line regulation is 0.894%
```

Scilab code Exa 24.13 example13

```
// find output voltage
// Electronic Principles
// By Albert Malvino , David Bates
// Seventh Edition
// The McGraw-Hill Companies
// Example 24-13, page 972

clear; clc; close;

// Given data
R1=2*10^3;// in ohms
R2=22*10^3 ;// in ohms

// Calculations
Vout=((R1+R2)/R1)*1.25;// output voltage in volts
disp("Volts",Vout,"output voltage=")

// Results
// Output voltage is 15 Volts
```

Scilab code Exa 24.15 example15

```
// find output voltage
// Electronic Principles
// By Albert Malvino , David Bates
// Seventh Edition
// The McGraw-Hill Companies
// Example 24-15, page 984

clear; clc; close;

// Given data
R1=2.21*10^3;// in ohms
R2=2.8*10^3 ;// in ohms
Vref=2.21;// in volts

// Calculations
Vout=((R1+R2)/R1)*Vref;// output voltage in volts
disp("Volts",Vout,"output voltage=")

// Results
// Output voltage is 5.01 Volts
```

Scilab code Exa 24.16 example16

```
// find output voltage
// Electronic Principles
// By Albert Malvino , David Bates
```

```
// Seventh Edition
// The McGraw-Hill Companies
// Example 24-16, page 984

clear; clc; close;

// Given data
R1=1*10^3;// in ohms
R2=5.79*10^3 ;// in ohms
Vref=2.21;// in volts

// Calculations
Vout=((R1+R2)/R1)*Vref;// output voltage in volts
disp("Volts",Vout,"output voltage=")

// Results
// Output voltage is 15 Volts
```