Scilab Textbook Companion for Linear Integrated Circuits by J. B. Gupta[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

Differential And Cascode Amplifiers

Scilab code Exa 1.1 Operating current and voltage and voltage gain

```
// Exa 1.1
clc;
clear;
close;
// Given data
format('v',7)
V_CC= 10;// in volt
V_EE= V_CC;
V_BE= 0.715;// in volt
R_c1= 2.7;// in k ohm
R_c1= R_c1*10^3;// in ohm
R_c2= R_c1;// in ohm
R_E=3.9;// in k ohm
R_E= R_E*10^3;// in ohm
Bita_ac= 100;
Bita_dc= Bita_ac;
I_E= (V_EE-V_BE)/(2*R_E);// in amp
I_C= I_E;// in amp
V_C= V_CC-I_C*R_c1;// in volt
```

```
V_E= 0-V_BE;// in volt
V_CE= V_C-V_E;// in volt
re_desh= 25*10^-3/I_E;
A_d= R_c1/re_desh;
disp(I_C*10^3,"Operating current in mA");
disp(V_CE,"Operating voltage in volt");
disp(A_d,"Voltage gain")
```

Scilab code Exa 1.2 Quiescent collector current

```
// Exa 1.2
clc;
clear;
close;
// Given data
format('v',7)
V_CC= 10;// in volt
V_EE= 10;// in volt
V_BE=0.7// in volt
I_C=0.5;// in mA
I_C=I_C*10^-3;// in amp
R_C= 10;// in k ohm
R_C= R_C*10^3;// in ohm
R_E= 9.3;// in k ohm
R_E= R_E*10^3;// in ohm
I_E= (V_EE-V_BE)/(2*R_E);// in amp
I_CQ= I_E;// in amp
disp(I_CQ*10^3,"Quiescent collector current in mA");
V_CEQ= V_CC+V_BE-I_C*R_C;// in volt
disp(V_CEQ,"Quiescent collector emitter voltage in
    volt");
```

Scilab code Exa 1.3 Output Voltage base current and base voltage

```
// Exa 1.3
clc;
clear;
close;
// Given data
format('v',9)
V_CC= 12;// in volt
V_EE= 12;// in volt
V_BE= 0.7;// in volt
R_C= 10;// in k ohm
R_C= R_C*10^3;// in ohm
R_E= 10;// in k ohm
R_E= R_E*10^3;// in ohm
R_B= 20;// in k ohm
R_B= R_B*10^3;// in ohm
Bita_dc= 75;
// Part (i)
//Ignoring V_BE
I_T= V_EE/R_E//in amp
I_E= I_T/2;// in amp
I_C=I_E;
V_out= V_CC-I_C*R_C// in volt
disp(V_out,"Output Voltage in volt (Ignoring V_BE)");
//Considering V_BE
I_T= (V_EE-V_BE)/R_E//in amp
I_E= I_T/2;// in amp
I_C=I_E;
V_out= V_CC-I_C*R_C// in volt
disp(V_out,"Output Voltage in volt (Condidering V_BE)");
I_T= (V_EE-V_BE)/(R_E+R_B/(2*Bita_dc));// in amp
I_E= I_T/2;// in amp
I_C=I_E;
V_out= V_CC-I_C*R_C// in volt
disp(V_out,"Output Voltage in volt (With Bita_dc)");

// Part(ii)
```

```
I_C= 0.6;// in mA
I_C=I_C*10^-3;
I_B= I_C/Bita_dc;// in amp
disp(I_B*10^6,"Base current in micro amphere");
V_B= -I_B*R_B;// in volt
disp(V_B,"Base Voltage in volt")

// Part (iii)
Bita_dc= 60;
I_B1= I_C/Bita_dc;// in amp
disp(I_B1*10^6,"Base current for transistor Q1 in
    micro amphere");
V_B1= -I_B1*R_B;// in volt
disp(V_B1,"Base Voltage for transistor Q1 in volt")
Bita_dc= 80;
I_B2= I_C/Bita_dc;// in amp
disp(I_B2*10^6,"Base current for transistor Q2 in
    micro amphere");
V_B2= -I_B2*R_B;// in volt
disp(V_B2,"Base Voltage for transistor Q2 in volt")
```

Scilab code Exa 1.4 Voltage gain

```
// Exa 1.4
clc;
clear;
close;
// Given data
format('v',7)
V_CC= 10;// in volt
V_EE= 10;// in volt
V_BE= 0.7;// in volt
R_C= 2.2;// in k ohm
R_C= R_C*10^3;// in ohm
R_E= 4.7;// in k ohm
```

```
R_E= R_E*10^3;// in ohm
Ri_1= 50;// in ohm
Ri_2= Ri_1;// in ohm
Bita_dc= 100;
Bita_ac = Bita_dc;
// Part (a)
I_CQ = (V_EE-V_BE)/(2*R_E+Ri_1/Bita_dc);// in amp
I_E= I_CQ;// in amp
disp(I_CQ*10^3,"Value of I_CQ in mA");
V_CEQ= V_CC + V_BE - I_CQ*R_C;// in volt
disp(V_CEQ,"Value of V_CEQ in volt");

// Part(b)
re_desh= (26*10^-3)/I_E;// in ohm
// A_d= V_out/V_ind = R_C/re_desh
A_d = R_C/re_desh;
disp(A_d,"Voltage gain ");

// Part(c)
// R_in1= R_in2= 2*Bita_ac*re_desh
R_in1= 2*Bita_ac*re_desh;// in ohm
disp(R_in1*10^-3,"Input resistance in k ohm");

// Part(d)
// R_out1= R_out2= R_C
R_out1= R_C;// in ohm
disp(R_out1*10^-3,"Output resistance in k ohm");
```

Scilab code Exa 1.5 Output voltage

```
// Exa 1.5
clc;
clear;
close;
// Given data
```

```
format('v',7)
V_CC= 15;// in volt
V_EE= 15;// in volt
V_BE= 0.7;// in volt
R_C= 1;// in M ohm
R_C= R_C*10^6;// in ohm
R_E= R_C;// in ohm

Bita_ac= 100;
I_E = (V_EE-V_BE)/(2*R_E);// in amp
re_desh= (26*10^-3)/I_E;// in ohm
A_d = R_C/re_desh;
disp(A_d,"Voltage gain ");
Z_in= 2*Bita_ac*re_desh;// in ohm
disp(Z_in*10^-6,"Input impedence in M ohm");
Z_out= R_C;// in ohm
disp(Z_out*10^-6,"Output impedence in M ohm");
A_cm= R_C/(2*R_E+re_desh);
CMRR= A_d/A_cm;
disp(CMRR,"Common-mode rejection ratio");
disp("When v_in is zero, the ac output voltage is
    zero. So total output voltage at the quiescent
    value in volt")
I_C=I_E;
V_out= V_CC-I_C*R_C;// in volt
disp(V_out);
// when v_in = 1
v_in= 1;// in mV
v_in= v_in*10^-3;// in volt
disp("When v_in = 1 mv, the ac output voltage in
    volt");
v_out= A_d*v_in;
disp(v_out);

// Note : Answer of CMRR in the book is wrong due to
    wrong calculation of A_cm
```

Scilab code Exa 1.6 Magnitude of differential gain

```
// Exa 1.6
clc;
clear;
close;
// Given data
format('v',7)
V_EE= 5;// in volt
R_C= 2;// in k ohm
R_C= R_C*10^3;// in ohm
R_E= 4.3;// in k ohm
R_E= R_E*10^3;// in ohm
V_BE=0.7;// in volt (Assuming)
V_T= 26*10^-3;// in volt
I_E = (V_EE-V_BE)/(2*R_E);// in amp
re_desh= V_T/I_E;// in ohm
A_d = R_C/(2*re_desh);
disp(A_d,"Voltage gain ");
```

Scilab code Exa 1.7 Common mode gain

```
// Exa 1.7
clc;
clear;
close;
// Given data
format('v',7)
V_EE= 5;// in volt
R_C= 2;// in k ohm
R_C= R_C*10^3;// in ohm
R_E= 4.3;// in k ohm
```

```
R_E= R_E*10^3;// in ohm
V_BE=0.7;// in volt (Assuming)
V_T= 26*10^-3;// in volt
I_E = (V_EE-V_BE)/(2*R_E);// in amp
re_desh= V_T/I_E;// in ohm
A_d = R_C/(2*re_desh);
A_cm= R_C/(2*R_E+re_desh);
disp(A_cm,"Common mode gain");
CMRR= A_d/A_cm;
disp(CMRR,"Common mode rejection ratio")
```

Scilab code Exa 1.8 Output voltage

```
// Exa 1.8
clc;
clear;
close;
// Given data
format('v',7)
V_CC= 9;// in volt
V_EE= 9;// in volt
V_BE= 0.7;// in volt (Assuming value)
R_C= 47;// in k ohm
R_C= R_C*10^3;// in ohm
R_E= 43;// in k ohm
R_E= R_E*10^3;// in ohm
Ri_1= 20;// in ohm
Ri_2= Ri_1;// in ohm
v_in1= 2.5;// in mv
v_in1=v_in1*10^-3;// in volt
Bita_1= 75;
Bita_2= Bita_1;
I_CQ = (V_EE-V_BE)/(2*R_E+Ri_1/Bita_1);// in amp
I_E= I_CQ;// in amp
V_CEQ= V_CC + V_BE - I_CQ*R_C;// in volt
```

```
re_desh= (26*10^-3)/I_E;// in ohm
A_d = R_C/re_desh;
v_out= A_d*v_in1;// in volt
disp(v_out,"Output voltage in volt")
```

Scilab code Exa 1.9 Dual input unbalanced input

```
// Exa 1.9
clc;
clear;
close;
// Given data
format('v',7)
V_CC= 10;// in volt
V_EE= 10;// in volt
V_BE= 0.7;// in volt
R_C= 2.2;// in k ohm
R_C= R_C*10^3;// in ohm
R_E= 4.7;// in k ohm
R_E= R_E*10^3;// in ohm
Ri_1= 50;// in ohm
Ri_2= Ri_1;// in ohm
Bita_dc= 100;
Bita_ac = Bita_dc;
I_CQ = (V_EE-V_BE)/(2*R_E+Ri_1/Bita_dc);// in amp
I_E= I_CQ;// in amp
V_CEQ= V_CC + V_BE - I_CQ*R_C;// in volt
re_desh= (26*10^-3)/I_E;// in ohm
A_d = R_C/re_desh;
R_in1= 2*Bita_ac*re_desh;// in ohm
R_out1= R_C;// in ohm
disp(I_CQ*10^3,"Quiescent collector current in mA");
disp(V_CEQ,"Quiescent collector-emitter voltage in
    volt");
disp(R_in1*10^-3,"Input resistance in k ohm");
```

```
disp(R_out1*10^-3,"Output resistance in k ohm");
// However, the voltage gain of dual input , unbalaned output differential amplifier is half the gain of the dual  input, balanced output differential amplifier as
disp(A_d/2,"Voltage gain")

// (ii)
disp("Because of same component values and same biasing arrangement the values of I_CQ,V_CEQ,R_in,R_out and A_d are the same as those for dual input balanced output configuration. Thus");
disp(I_CQ*10^3,"Quiescent collector current in mA");
disp(V_CEQ,"Quiescent collector-emitter voltage in volt");
disp(R_in1*10^-3,"Input resistance in k ohm");
disp(R_out1*10^-3,"Output resistance in k ohm");
disp(A_d,"Voltage gain")
```

Scilab code Exa 1.10 Single input unbalanced input

```
// Exa 1.10
clc;
clear;
close;
// Given data
format('v',7)
V_CC= 9;// in volt
V_EE= 9;// in volt
V_BE= 0.7;// in volt (Assuming value)
R_C= 47;// in k ohm
R_C= R_C*10^3;// in ohm
R_E= 43;// in k ohm
R_E= R_E*10^3;// in ohm
Ri_1= 20;// in ohm
```

```
Ri_2= Ri_1;// in ohm
v_in1= 2.5;// in mv
v_in1=v_in1*10^-3;// in volt
Bita_1= 75;
Bita_2= Bita_1;
I_CQ = (V_EE-V_BE)/(2*R_E+Ri_1/Bita_1);// in amp
I_E= I_CQ;// in amp
V_CEQ= V_CC + V_BE - I_CQ*R_C;// in volt
re_desh= (26*10^-3)/I_E;// in ohm
// However, voltage gain of single-input, unbalanced
   -output differential amplifier is given by so
A_d = R_C/(2*re_desh);
v_out= A_d*v_in1;// in volt
disp(v_out,"Output voltage in volt")
```

Scilab code Exa 1.11 Voltage gain input output resistance

```
// Exa 1.11
clc;
clear;
close;
// Given data
format('v',7)
R_E_desh= 200;// in ohm
V_CC= 10;// in volt
V_EE= 10;// in volt
V_BE= 0.7;// in volt
R_C= 2.2;// in k ohm
R_C= R_C*10^3;// in ohm
R_E= 4.7;// in k ohm
R_E= R_E*10^3;// in ohm
Ri_1= 50;// in ohm
Ri_2= Ri_1;// in ohm
Bita_dc= 100;
Bita_ac = Bita_dc;
```

```
I_CQ = (V_EE-V_BE)/(2*R_E+ R_E_desh+Ri_1/Bita_dc);//
    in amp
I_E= I_CQ;// in amp
disp(I_CQ*10^3,"Value of I_CQ in mA");
V_CEQ= V_CC + V_BE - I_CQ*R_C;// in volt
disp(V_CEQ,"Value of V_CEQ in volt");
re_desh= (26*10^-3)/I_E;// in ohm
A_d = R_C/(re_desh+R_E_desh);
disp(A_d,"Voltage gain");
R_in1= 2*Bita_ac*(re_desh+R_E_desh);// in ohm
disp(R_in1*10^-3,"Input resistance in k ohm");
R_out1= R_C;// in ohm
disp(R_out1*10^-3,"Output resistance in k ohm");
```

Scilab code Exa 1.12 Q point Differential voltage gain

```
// Exa 1.12
clc;
clear;
close;
// Given data
V_D1=0.7;// in volt
V_D2=V_D1;
V_BE= 0.7;// in volt
Bita= 100;
R3=180;// in ohm
V_EE= 15;// in volt
V_CC=15;// in volt
R_C=470;// in ohm
V_B3= -V_EE+V_D1+V_D2;// in volt
V_E3= V_B3-V_BE;// in volt
I_E3= (V_E3-(-V_EE))/R3;// in amp

// Part (i)
I_CQ= I_E3/2;// in amp
```

```
I_CQ= I_CQ*10^3;// in mA
I_CQ= ceil(I_CQ);
I_E=I_CQ;
disp(I_CQ,"Quiescent current in mA")
V_CEQ= V_CC + V_BE - I_CQ*10^-3*R_C;// in volt
disp(V_CEQ,"Value of V_CEQ in volt");
re_desh= 26/I_E;// in ohm
// Part(ii)
A_d = R_C/(re_desh);
disp(A_d,"Differential Voltage gain");
// part(iii)
R_in1= 2*Bita*re_desh;// in ohm
disp(R_in1*10^-3,"Input resistance in k ohm");
```

Scilab code Exa 1.13 voltage gain of differential amplifier

```
// Exa 1.13
clc;
clear;
close;
// Given data
Bita_ac= 100;
Bita_dc= Bita_ac;
V_BE=0.715;// in volt
V_D1= V_BE;
R3=2.7*10^3;// in ohm
R_C=4.7*10^3;// in ohm
V_EE=10;//in volt
V_CC= 10;// in volt
V_Z= 6.2;// in volt
I_ZT= 41;// in mA
I_ZT=I_ZT*10^-3;// in amp
V_B3= -V_EE+V_Z+V_D1;// in volt
V_E3= V_B3-V_BE;// in volt
I_E3= (V_E3-(-V_EE))/R3;// in amp
```

```
// I_CQ1= I_CQ2= I_CQ= I_E3/2
I_CQ= I_E3/2;// in amp
I_CQ1=I_CQ;
I_CQ2=I_CQ1;
I_E=I_CQ;
V_CEQ= V_CC + V_BE - I_CQ*R_C;// in volt

// Part (c)
// Thus Q_point= (I_CQ,V_CEQ)
disp("Operating point values are : "+string(I_CQ
   *10^3)+" mA and "+string(V_CEQ))
re_desh= (26*10^-3)/I_E;// in ohm

// Part(a)
A_d= R_C/re_desh;
disp(A_d,"Voltage gain");

// part(b)
R_in= 2*Bita_ac*re_desh;// in ohm
disp(R_in*10^-3,"Input resistance in k ohm");
```

Scilab code Exa 1.14 Mirrored current

```
// Exa 1.14
clc;
clear;
close;
// Given data
V_CC=12;// in volt
V_BE=0.7;// in volt
R1= 25;// in k ohm
R1=R1*10^3;// in ohm
// I=I_REF= (V_CC-V_BE)/R1
I= (V_CC-V_BE)/R1; // in amp
disp(I*10^3,"Mirrored current in mA")
```

Scilab code Exa 1.15 Reference current and output current

```
// Exa 1.15
clc;
clear;
close;
// Given data
V_CC=10;// in volt
V_BE=0.7;// in volt
R1= 15;// in k ohm
R1=R1*10^3;// in ohm
Bita=100;
I_REF= (V_CC-V_BE)/R1;// in amp
disp(I_REF*10^3,"Reference current in mA")
I_out= I_REF*Bita/(Bita+2);// in amp
disp(I_out*10^3,"Output current in mA")
```

Scilab code Exa 1.16 Finding current

```
// Exa 1.16
clc;
clear;
close;
// Given data
V_CC=15;// in volt
V_BE=0.7;// in volt
R_REF= 2.2;// in k ohm
R_REF= R_REF*10^3;// in ohm
Bita=220;
I_REF= (V_CC-V_BE)/R_REF;// in amp
I= I_REF*Bita/(Bita+2);// in amp
disp(I*10^3,"Current in mA")
```

Scilab code Exa 1.17 Finding current

```
// Exa 1.17
clc;
clear;
close;
// Given data
V_BE=0.7;// in volt
V_Z= 1.8;// in volt
R_E=1;// in k ohm
Bita=180;
//V_Z-V_BE-V_B=0
V_B= V_Z-V_BE;// in volt
I_E= V_B/R_E;// in mA
I= Bita/(Bita+1)*I_E;// in mA
disp(I,"Current in mA")
```

Scilab code Exa 1.18 Current depicted

```
// Exa 1.18
clc;
clear;
close;
// Given data
format('v',7)
V_BE=0.7;// in volt
V_CC=9;// in volt
R1=12;// in k ohm
R1=R1*10^3;// in ohm
Bita=100;
Bita_1= Bita;
```

```
Bita_2=Bita;
Bita_3=Bita;
I_REF= (V_CC-2*V_BE)/R1;// in amp
disp(I_REF*10^3,"Reference current in mA");
I_out= I_REF/(1+2/(Bita*(1+Bita_3)));// in amp
disp(I_out*10^3,"Output current in mA");
I_C2=I_out;// in amp
disp(I_C2*10^3,"Collector current in mA");
I_C1= I_C2;
I_B3= I_REF-I_C1;// in amp
disp(I_B3*10^6,"Base current of transistor in micro
    amphere");
I_E3= I_B3*(1+Bita_3);// in  amp
disp(I_E3*10^6,"Emitter current of transistor in
    micro amphere");
I_B1= I_E3/2;// in amp
disp(I_B1*10^6,"Base current in micro amphere");
```

Scilab code Exa 1.19 Collector current

```
// Exa 1.19
clc;
clear;
close;
// Given data
format('v',7)
V_BE=0.715;// in volt
V_CC=9;// in volt
Bita_dc=100;
Bita_ac= Bita_dc;
V_EE= 10;// in volt
R=5.6;// in k ohm
R= R*10^3;// in ohm
I_REF= (V_EE-V_BE)/R;// in amp
// From 2*I_B + I_C1 -I_REF =0
```

```
I_C1= I_REF*Bita_dc/(2+Bita_dc);// in amp
// By symmetry
I_C2= I_C1;
I_C3= I_C2;
I=3*I_C1;// current through R_C in amp
disp(I*10^3,"Current through R_C in mA");
```

Scilab code Exa 1.20 Differential input resistance

```
// Exa 1.20
clc;
clear;
close;
// Given data
format('v',7)
V_BE=0.7;// in volt
V_CC=5;// in volt
V_EE=-5;// in volt
Bita=100;
R=18.6;// in k ohm
R= R*10^3;// in ohm
I2= (V_CC-V_BE-V_EE)/R;// in amp
I_C3=I2;
I_E= I_C3/2;// in amp
re_desh= (26*10^-3)/I_E;// in ohm
re1_desh=re_desh;
re2_desh=re1_desh;
R_in1= 2*Bita*re_desh;// in ohm
R_in2= R_in1
disp(R_in1*10^-3,"Differential input resistance in k
    ohm")
```

Scilab code Exa 1.21 Voltage gain for the cascode amplifier

```
// Exa 1.21
clc;
clear;
close;
// Given data
format('v',7)
V_BE=0.7;// in volt
V_CC=18;// in volt
R_E=1.1;// in k ohm
R_C=1.8;// in k ohm
R_C=R_C*10^3;// in ohm
R1=4.7;// in k ohm
R2=5.6;// in k ohm
R3=6.8;// in k ohm
I_E1= (V_CC*R1/(R1+R2+R3)-V_BE)/R_E;// in mA
re_desh= 26/I_E1;// in ohm
re2_desh=re_desh
Av= -R_C/re2_desh;
disp(Av,"Voltage gain of the cascode amplifier is :
   ")
```

Chapter 2

Introduction To Operation Amplifiers

Scilab code Exa 2.2 Output voltage

```
// Exa 2.2
clc;
clear;
close;
// Part (i)
// Given data
V_in1= 5;// in micro volt
V_in1=V_in1*10^-6;// in volt
V_in2= -7;// in micro volt
V_in2=V_in2*10^-6;// in volt
Av=2*10^5;
V_out= (V_in1-V_in2)*Av;// in volt
disp(V_out,"(i) Output voltage in first case in volt
    ");

// Part(ii)
V_in1= 10;// in mV
V_in1=V_in1*10^-3;// in volt
V_in2= 20;// in mV
```

```
V_in2=V_in2*10^-3;// in volt
V= Av*(V_in1*sqrt(2)-V_in2*sqrt(2));// V = V_out/sin
    (omega*t) in volts
V=ceil(V);
disp("(ii) Output voltage in second case : "+string(
    V)+"*sin(omega*t) volts")
```

Scilab code Exa 2.4 Input resistance

```
// Exa 2.4
clc;
clear;
close;
// Given data
Rs= 2;// in k ohm
Rs=Rs*10^3;// in ohm
RL= 5;// in k ohm
RL=RL*10^3;// in ohm
Rin= 100;// in k ohm
Rin=Rin*10^3;// in ohm
Rout= 50;// in ohm
A=10^5;
Vout= 10;// in volt
// V1= Vs*Rin/(Rin+Rs) = Vs*100/102          (i)
// V2/(5 kohm)+ V2/(100 kohm) + (V2-10^5*(V1-V2))/50
     = 0
// or 20*V2 + V2 + 2*10^3*V2 = 2*10^8*(V1-V2)
// or V2*(20+1+2*10^3+2*10^8)= 2*10^8*V1
// or V1=V2 (approx)
// For
V_out= 10;// in volt
V1=10;// in volt
V2=V1;
Vs= (Rin+Rs)/Rin*V1;// in volts
V_out_BY_Vs= V_out/Vs;//in volts
```

```
disp(Vs,"Value of Vs in volts");
disp(V_out_BY_Vs,"Value of V_out/Vs ")
disp(Rin*10^-3,"Input resistance of circuit in kohm"
    )
```

Scilab code Exa 2.5 Output voltage

```
// Exa 2.5
clc;
clear;
close;
// Given data
R1= 1;// in k
R2= 2;// in k
R3= 4;// in k
R4= 8;// in k
R5= 1;// in k
R6= 3 ;// in k
Vc= -1;// in V
// V_A= Vout*R5/(R5+R6)      (i)
// Applying Kirchhoff's law at node B and A
// V_B*(1/R3+1/R2) -Vc/R3 = Vout*R5/(R2*(R5+R6))
// V_B/R2 +1= 3*Vout*R5/(R2*(R5+R6))           (ii)
Vout= (R2+R6)/(3*R6/R3+Vc/R2);// in volts
disp(Vout,"The output voltage in volts is 20/7 volts
     or ")
```

Scilab code Exa 2.6 CMMR in db

```
// Exa 2.6
clc;
clear;
close;
```

```
// Given data
Ad= 100;
Acm= 0.01;
CMRR= Ad/Acm;
CMRR_desh= 20*log10(CMRR);// in dB
disp(CMRR_desh,"CMRR in dB")
```

Scilab code Exa 2.7 Common mode gain

```
// Exa 2.7
clc;
clear;
close;
// Given data
Ad= 10^5;
CMRR= 10^5;
Acm= Ad/CMRR;
disp(Acm,"Common mode gain");
```

Scilab code Exa 2.8 Percentage error in the output voltage

```
// Exa 2.8
clc;
clear;
close;
// Given data
format('v',6)
V1=10;// in mV
V2=9;// in mV
Vd= V1-V2;// in mV
Vcm= (V1+V2)/2;// in mV
Ad= 60;// in dB
Ad= 10^(Ad/20);
```

```
CMRR= 80;// in dB
CMRR= 10^(CMRR/20);
V_out= Ad*Vd*10^-3*(1+1/CMRR*Vcm/Vd);// in volt
errorVoltage= V_out-Ad*Vd*10^-3;// in volt
disp(errorVoltage*10^3,"Error Voltage in mV");
PercentError= errorVoltage/V_out*100;// in %
disp(PercentError,"Percentage error is")
```

Scilab code Exa 2.9 Percentage error due to common mode

```
// Exa 2.9
clc;
clear;
close;
// Given data
format('v',7)
V1=745;// in micro volt
V2=740;// in micro volt
Vd= V1-V2;// in micro volt
Vcm= (V1+V2)/2;// in micro volt
Ad= 5*10^5;
CMRR= 80;// in dB
CMRR= 10^(CMRR/20);
V_out= Ad*Vd*10^-6*(1+1/CMRR*Vcm/Vd);// in volt
disp(V_out,"Output voltage in volt")
errorVoltage= V_out-Ad*Vd*10^-6;// in volt
PercentError= errorVoltage/V_out*100;// in %
disp(PercentError,"Percentage error is")
```

Scilab code Exa 2.10 Output voltage

```
// Exa 2.10
clc;
```

```
clear;
close;
// Given data
format('v',9)
Vd=25;// in micro volt
Vd= Vd*10^-6;// in volt
A=200000;
V_out= Vd*A;
disp(V_out,"Output voltage in volt");
```

Scilab code Exa 2.11 Output voltage

```
// Exa 2.11
clc;
clear;
close;
// Given data
format('v',9)
dV_out=20;// in volt
dt= 4;// in micro seconds
SR= dV_out/dt;// in V/micro sec
disp(SR,"Slew rate in V/micro sec");
```

Scilab code Exa 2.12 Input bias current

```
// Exa 2.12
clc;
clear;
close;
// Given data
format('v',9)
IB1= 10;// in mA
IB2= 7.5;// in mA
```

```
I_in_bias= (IB1+IB2)/2;// in mA
disp(I_in_bias,"Input bias current in mA")
I_in_offset= IB1-IB2 ;// in mA
disp(I_in_offset,"Input offset current in mA")

// Note: Units in Answer in the book is wrong
```

Scilab code Exa 2.13 Value of limiting frequency

```
// Exa 2.13
clc;
clear;
close;
// Given data
format('v',9)
SR= 6;// in V/micro S
SR=SR*10^6;// in V/s
// (i)
V_max= 1;// in volt
f_max= SR/(2*%pi*V_max);
disp(f_max*10^-6,"Frequency for V_max=1V in MHz")
// (ii)
V_max= 10;// in volt
f_max= SR/(2*%pi*V_max);
disp(f_max*10^-3,"Frequency for V_max=10V in kHz")
```

Scilab code Exa 2.14 741 op amp

```
// Exa 2.14
clc;
clear;
close;
// Given data
```

```
format('v',9)
V_PP= 3;// in volt
delta_t= 4;// in micro sec
// delta_V= 90% of V_PP - 10% of V_PP = (90%-10%)*
   V_PP
delta_V= 0.8*V_PP;
SR= delta_V/delta_t;// in V/micro sec
disp(SR,"Required slew rate in V/micro second")
```

Chapter 3

Negative Feedback In Op Amps

Scilab code Exa 3.2 Maximum and minimum volgate gain

```
// Exa 3.2
clc;
clear;
close;
//given data
R1=2;// in k ohm
R_f_min=0;
R_f_max=100; // in k ohm
A_f_max = 1+R_f_max/R1;
disp(A_f_max,"Maximum closed loop")
A_f_min = 1+R_f_min/R1;
disp(A_f_min,"Minimum closed loop")
```

Scilab code Exa 3.3 Voltage gain input resistance

```
// Exa 3.3
clc;
clear;
```

```
close;
//given data
R1=100;// in  ohm
R_f=100;// in k ohm
R_f=R_f*10^3;// in ohm
A=2*10^5;
R_in= 2;// in M ohm
R_in=R_in*10^6;// in ohm
R_out= 75;// in ohm
f_o= 5;// in Hz
B= R1/(R1+R_f);
FeedbackFactor= A*B;
A_f = 1+R_f/R1;
disp(A_f,"Voltage gain")
R_inf= R_in*(1+A*B);
disp(R_inf*10^-6,"Input Resistance in M ohm")
R_outf= R_out/(1+A*B);// in ohm
disp(R_outf,"Output Resistance in ohm");
f_f= f_o*(1+A*B);// in Hz
disp(f_f,"Bandwidth in Hz");
```

Scilab code Exa 3.4 Value of Rof and VooT

```
// Exa 3.4
clc;
clear;
close;
//given data
R1=1;// in  k ohm
R1=R1*10^3;// in ohm
R_f=10;// in k ohm
R_f=R_f*10^3;// in ohm
A=200000;
OutputVoltageSwing= 13;// in volt
SupplyVoltage=15;// in volt
```

```
Ri= 2;// in M ohm
Ri=Ri*10^6;// in ohm
Ro= 75;// in ohm
fo= 5;// in Hz
B= R1/(R1+R_f);
AB = A*B;
R_outf= Ro/(1+A*B);// in ohm
disp(R_outf*10^3,"Output Resistance in m ohm");
V_ooT= OutputVoltageSwing/(1+A*B);// in volt
disp(V_ooT*10^3,"Output offset voltage in mV");
```

Scilab code Exa 3.5 Voltage gain input resistance

```
// Exa 3.5
clc;
clear;
close;
//given data
R_in= 2;// in  M ohm
R_in=R_in*10^6;// in ohm
R_out=75;// in  ohm
A=2*10^5;
f_o=5;// in Hz
// For voltage follower
B=1; // since R_f=0
A_f=1;
disp(A_f,"Voltage gain :");
R_inf= A*R_in;// in ohm
R_inf=R_inf*10^-9;// in G ohm
disp(R_inf,"Input resistance in G ohm");
R_outf= R_out/A;// in ohm
disp(R_outf,"Output resistance in ohm");
f_f= A*f_o;// in Hz
disp(f_f*10^-6,"Bandwidth in MHz");
```

Scilab code Exa 3.6 Voltage gain input resistance

```
// Exa 3.6
clc;
clear;
close;
//given data
R1=330;// in  ohm
R_f=3.3;// in k ohm
R_f=R_f*10^3;// in ohm
R_in= 2;// in  M ohm
R_in=R_in*10^6;// in ohm
R_out=75;// in  ohm
A=2*10^5;
f_o=5;// in Hz
B= R1/(R1+R_f);
AB= A*B;
A_f = -R_f/R1;
disp(A_f,"Voltage gain")
R_inf= R1;
disp(R_inf,"Input Resistance in ohm")
R_outf= R_out/(1+A*B);// in ohm
disp(R_outf,"Output Resistance in ohm");
f_f= f_o*(1+A*B);// in Hz
disp(f_f*10^-3,"Bandwidth in kHz");
```

Scilab code Exa 3.7 Voltage gain input resistance

```
// Exa 3.7
clc;
clear;
close;
```

```
//given data
R_in= 2;// in  M ohm
R_in=R_in*10^6;// in ohm
R_out=75;// in  ohm
A=2*10^5;
f_o=5;// in Hz
R1=330;// in ohm (assuming)
R_f=R1;
B= R1/(R1+R_f);
A_f = -1;
disp(A_f,"Voltage gain")
R_inf= R1;
disp(R_inf,"Input Resistance in ohm")
R_outf= R_out/(A/2);// in ohm
disp(R_outf,"Output Resistance in ohm");
f_f= f_o*A/2;// in Hz
disp(f_f*10^-6,"Bandwidth in MHz");
```

Scilab code Exa 3.8 Values of Af R1f and Rof

```
// Exa 3.9
clc;
clear;
close;
//given data
R1=5;// in  k ohm
R1=R1*10^3;// in ohm
R_f=500;// in k ohm
R_f=R_f*10^3;// in ohm
V_in= 0.1;// in volt
A_f = -R_f/R1;
OutPutResOfopamp=0;// in ohm
disp(A_f,"Voltage gain")
R_in= R1;// in ohm
disp(R_in*10^-3,"Input Resistance in k ohm")
```

```
R_out=OutPutResOfopamp;// in ohm
disp(R_out,"Output Resistance in ohm");
V_out= A_f*V_in;// in volt
disp(V_out,"Output voltage in volt");
I_in= V_in/R1;// in amp
disp(I_in*10^3,"Input Current in mA");
```

Scilab code Exa 3.9 Output voltage and input current

```
// Exa 3.9
clc;
clear;
close;
//given data
R1=5;// in  k ohm
R1=R1*10^3;// in ohm
R_f=500;// in k ohm
R_f=R_f*10^3;// in ohm
V_in= 0.1;// in volt
A_f = -R_f/R1;
OutPutResOfopamp=0;// in ohm
disp(A_f,"Voltage gain")
R_in= R1;// in ohm
disp(R_in*10^-3,"Input Resistance in k ohm")
R_out=OutPutResOfopamp;// in ohm
disp(R_out,"Output Resistance in ohm");
V_out= A_f*V_in;// in volt
disp(V_out,"Output voltage in volt");
I_in= V_in/R1;// in amp
disp(I_in*10^3,"Input Current in mA");
```

Scilab code Exa 3.10 Input impedence

```
// Exa 3.10
clc;
clear;
close;
// (i) Given amplifier is an inverting amplifier,
    where
// V_out= -R_f/R_in*V_in = 1Mohm/1Mohm*V_in = -V_in,
    So
// Av= V_out/V_in
Av=-1;
disp(Av,"Input impedence :");
// (ii) Because it is a unity gain inverter, So I_in
    = I_out
// A_in = I_out/I_in
A_in = 1;
disp(A_in,"Voltage gain :");
// (iii) Power gain of op-amp circuit
A_p=abs(Av*A_in);
disp(A_p,"Power gain :");
```

Scilab code Exa 3.11 Inverting Op amp

```
// Exa 3.11
clc;
clear;
close;
// Given data
Av=-30;
disp("Voltage gain,  Vo/Vi= -R_f/R1 = -30");
disp("Or R_f= 30*R1");
disp("Obviously R_f will be larger resistance ,
    being 30 times of R1 and largest resistance value
     is limited to 1 M ohm, So")
R_f=1;// in M ohm
disp(R_f,"Value of R_f in M ohm :");
```

```
R_f= R_f*10^6;// in ohm
R1=R_f/30;// in ohm
disp(R1*10^-3,"Value of R1 in k ohm :");
```

Scilab code Exa 3.12 Inverting Op amp

```
// Exa 3.12
clc;
clear;
close;
// Given data
Av=-8;// voltage gain
I1=15;// in micro A
I1=I1*10^-6;// in amp
Vi=-1;// in volt
R1=abs(Vi)/I1;/// in ohm
disp("Resistace R1 is : "+string(R1*10^-3)+" in k
    ohm (Use 68 k ohm standard value)")
R1=68;// in k ohm (standard value)
R_f= -Av*R1;// in ohm
disp("Resistance R_f is : "+string(R_f)+" k ohm (Use
     560 k ohm standard value)")
```

Scilab code Exa 3.15 Gain of amplifier circuit

```
// Exa 3.15
clc;
clear;
close;
// Given data
R_f=20;// in k ohm
R1=10;// in k ohm

```

```
// Part (i)  When switch S is off
A_off_non_inv= 1+R_f/R1;
A_off_inv= -R_f/R1;
A_off = A_off_non_inv + A_off_inv;
disp(A_off,"Gain of amplifier circuit when switch S
    is off");

// Part (ii)  When switch S is on
A_on= -R_f/R1;
disp(A_on,"Gain of amplifier circuit when switch S
    is on");
```

Scilab code Exa 3.16 VI Characteristic of the impedence

```
// Exa 3.16
clear;
clc;
close;
//Part (a) is a derivation not a numerical problem
//Part (b) is a plot , and can be plotteed with any
    assumed value of R
R=5;//in ohm(assumed)
V=0:12;//in volt
I=-V/R//in Ampere
disp("V-I characteristics is shown in figure.")
plot(V,I);
title("V-I characteristics");
xlabel("V(volt)");
ylabel("I(Ampere)");
```

Scilab code Exa 3.18 Output voltage

```
// Exa 3.18
```

```
clc;
clear;
close;
// Given data
R_f=10;// in k ohm
R1=1;// in k ohm
V_d= 5;// in mV
v_cm= 2;// in mV
A_d= -R_f/R1;
Vout= A_d*V_d;// in mV
disp(abs(Vout),"Output voltage in mV : ")
CMRR_dB= 90;// in dB
CMRR= 10^(CMRR_dB/20);
A_cm= abs(A_d)/CMRR
Mag= A_cm*v_cm;// magnitude of the induced 60 Hz
    noise at the output in mV
disp(Mag*10^3," magnitude of the induced 60 Hz noise
     at the output in micro volt :")
```

Scilab code Exa 3.19 Voltage gain

```
// Exa 3.19
clc;
clear;
close;
// Given data
R1=540;// in ohm
R3=R1;
R_f=5.4;// in k ohm
R_f=R_f*10^3;// in ohm
R2=R_f;// in ohm
v_in1= -2.5;// in volt
v_in2= -3.5;// in volt
R_in=2;// in M ohm
R_in= R_in*10^6;// in ohm
```

```
A=2*10^5;
A_d= (1+R_f/R1);
disp(A_d,"Voltage gain : ");
v_out=A_d*(v_in1-v_in2);// in volt
disp(v_out,"Output voltage in volt");
R_inf1= R_in*(1+A*R1/(R1+R_f));
R_inf2= R_in*(1+A*R2/(R2+R3));
disp("Internal resistance : "+string(R_inf1)+" ohm and "+string(R_inf2)+" ohm  ");
```

Scilab code Exa 3.20 Gain of the circuit

```
// Exa 3.20
clc;
clear;
close;
// Given data
v_in= 100;// in mili volt
v_in=v_in*10^-3;// in volt
v_out= 4.25;// in volt
// Taking
R1=100;// in ohm
// Formula v_out = (1+2*R_f/R1)*v_in
R_f= R1/2*(v_out/v_in-1);// in ohm
R_f=R_f*10^-3;// in k ohm
disp(R_f,"Gain of the circuit in k ohm");
disp("Use 2.2 k ohm standard value");
```

Scilab code Exa 3.21 Voltage gain input resistance

```
// Exa 3.21
clc;
clear;
```

```
close;
// Given data
R1=3.3;// in k ohm
R1=R1*10^3;// in ohm
R2=R1;
R_p= 2.5;// in k ohm
R_p =R_p*10^3;// in ohm
R3=1.2;// in k ohm
R3=R3*10^3;// in ohm
R4=R3;
R_f= 3.9;// in k ohm
R_f =R_f*10^3;// in ohm
R5=R_f;
R_in= 2;// in M ohm
R_in= R_in*10^6;// in ohm
R_out= 75;// in ohm
A=2*10^5;
f_o= 5;// in Hz
A_d= -1*(1+2*R1/R_p)*R_f/R3;
disp(A_d,"Voltage gain ");
A_d=abs(A_d);
R_inf= R_in*(1+(R1+R_p)/(2*R1+R_p)*A);// in ohm
disp(R_inf*10^-9,"Input resistance in G ohm")
R_outf= R_out/(1+A/A_d);// in ohm
disp(R_outf,"Output voltage in ohm")
f_f= A*f_o/A_d;// in Hz
disp(f_f*10^-3,"Bandwidth in kHz");
```

Chapter 4

Frequency Response Of An Op Amp

Scilab code Exa 4.1 Inverting amplifier

```
// Exa 4.1
clc;
clear;
close;
// Given data
Vin= 0.5;// in V
Av= 10;
I_B_max= 1.5;// in micro amp
I_B_max=I_B_max*10^-6;// in A
// Let
I1=100*I_B_max;// in A
R1= Vin/I1;// in ohm
Rf= Av*R1;// in ohm
// R2= R1 || Rf = R1 (approx.)
R2= R1;// in ohm
disp(I1*10^6,"Value of I1 in micro amp");
disp(R1*10^-3,"Value of R1 in kohm");
disp(R2*10^-3,"Value of R2 in kohm");
disp(Rf*10^-3,"Value of Rf in kohm");
```

Scilab code Exa 4.2 Inverting amplifier

```
// Exa 4.2
clc;
clear;
close;
// Given data
Vin= 50;// in mV
Vin = Vin*10^-3;// in V
I_B_max= 200;// in nA
I_B_max=I_B_max*10^-9;// in A
I1=100*I_B_max;// in A(assumed)
Av=100;
R1= Vin/I1;// in
disp(R1*10^-3,"The value of  R1 in  k   is : ")
disp("Standard value of R1 in  k   is ")
disp("2.2")
R1= 2.2;// kohm (standard value)
Rf= Av*R1;// in kohm
disp(Rf,"The value of Rf in  k   is : ")
// R2 = R1 || Rf = R1 (approx)
R2= R1;// in kohm
disp(R2,"The value of R2 in  k   is : ")
Av= 20*log10(Av);// in dB
C1= 100;// in pF
R1= 1.5;// in  k
C2= 3;// in pF
disp(Av,"Voltage gain in dB is : ");
disp(C1,"Value of C1 in pF is : ");
disp(C2,"Value of C2 in pF is : ");
disp(R1,"Value of R1 in  k   is :")
```

Scilab code Exa 4.3 Cut off frequency

```
// Exa 4.3
clc;
clear;
close;
// Given data
A_VD= 200;// in V/mV
A_VD=A_VD*10^3;// in V/V
B1=1;// in MHz
B1=B1*10^6;// in Hz
f1=B1;
f0= f1/A_VD;// in Hz
disp(f0,"Cut-off frequency in Hz")
```

Scilab code Exa 4.4 Full power bandwidth

```
// Exa 4.4
clc;
clear;
close;
// Given data
Vin= 15;// in volt
SR= 0.8;// in V/micro sec
SR=SR*10^6;// in V/sec
omega= SR/Vin;
f= omega/(2*%pi);// in Hz
disp(f*10^-3,"Full power bandwidth in kHz")
disp(f*10^-3,"It means that a 741 op-amp with a
    sinusoidal output of 15 V amplitude will begin to
     show slew limiting distortion if the frequency
    exceeds (in KHz)")
```

Scilab code Exa 4.5 Maximum closed loop voltage gain

```
// Exa 4.5
clc;
clear;
close;
// Given data
SR= 2;// in V/micro sec
del_v_in= 0.5;// in volt
del_t=10;//in micro sec
del_v_inBYdel_t= del_v_in/del_t;// in V/micro sec
// v_out= A_CL*v_in
A_CL= SR/del_v_inBYdel_t;
disp(A_CL,"Closed-loop gain ")
disp(A_CL,"Any closed loop voltage gain of magnitude exceeding 40 would drive the output at a rate greater than the SR allows, so the maximum closed loop gain is")
```

Scilab code Exa 4.6 741 op amp

```
// Exa 4.6
clc;
clear;
close;
// Given data
V_PP= 3;// in volt
del_t= 4;// in micro sec
// del_V= 90% of V_PP - 10% of V_PP = 0.8*V_PP
del_V= 0.8*V_PP;
SR_required= del_V/del_t;// in V/micro sec
disp("The required op-amp must have an SR equal or more than "+string(SR_required)+"  V/micro sec");

// (i)
```

```
disp("The 741 op-amp has an SR of 0.5 V/micro sec. It is too slow and cannot be used");

// (ii)
SR= 50;// in V/micro sec
SR= SR*10^6;// in V/sec
del_t= del_V/SR;// in sec
del_t= del_t*10^9;// in ns
disp(del_t,"The 318 op-amp has an SR of 50 V/micro sec. It is fast enough and can be used. The rese time using a 318 op-amp will be (in ns)")
```

Scilab code Exa 4.7 A 741 or 318 be used

```
// Exa 4.7
clc;
clear;
close;
// Given data
Vout= 6 ;// times Vrms
Vin= 20*10^-3;// times Vrms
f_max= 15;// in kHz
f_max=f_max*10^3;// in Hz
A_CL= Vout/Vin;// at 15 kHz
V_out_peak= 6*1.414;
// Formula f_max= SRmax/(2*%pi*V_out_peak)
SRmax= f_max*2*%pi*V_out_peak*10^-6; // in V/ s
disp("(i) The 741 has an SR of 0.5 V/ s. It is too slow and would distort the sine wave output")
disp("(ii) The 318 has an SR of 50 V/ s. It is fast enough to develop 6 Vrms sine wave output at 15 kHz")
f1percent= f_max;// in Hz
// f1percent= fH/7= GBW/A_CL/7= GBW/(7*A_CL)
GBW= 7*A_CL*f1percent;// in Hz
```

```
GBW= GBW*10^-6;// in MHz
disp(GBW,"Gain bandwidth in MHz ")
disp("The GBW for 318 op-amp is only 15 MHz. So even
     though the 318 op-amp satisfies the SR
    requirement");
disp(" but it does not have a large  enough gain
    bandwidth to provide a gain of 300 ( 1% ) at 15
    kHz")
GBW10= 7*10*f_max;// Gain of 10 in Hz
GBW30= 7*30*f_max;// Gain of 30 in Hz
disp(GBW10*10^-6,"Gain of 10 in MHz");
disp(GBW30*10^-6,"Gain of 30 in MHz");
disp("The 318 op-amp has a large enough gain
    bandwidth to operate both amplifiers.")
```

Chapter 5

General Applications Of Op Amp

Scilab code Exa 5.1 All component used in a circuit

```
// Exa 5.1
clc;
clear;
close;
// Given data
fo= 15;// in kHz
fo= fo*10^3;// in Hz
C=0.01;// in micro F
C=C*10^-6;// in F
L= 1/(4*%pi^2*fo^2*C);// in H
L=ceil(L*10^3);// in mH
// Let L be of 12 mH and internal resistance 30 ohm
R=30;// internal resistance in ohm
XL= 2*%pi*L*10^-3*fo;
Q= XL/R;
R_P= Q^2*R;// in ohm
// If
R1=100;// in ohm
// Formula L= R_f*R_P/(R1*(R_f+R_P));
```

```
R_f= R1*L*R_P/(R_P-R1*L);// in ohm
R_f=R_f*10^3;// in kohm
R_f= 1.2;// in k ohm (Standard value)
disp("The values of component chosen are:-");
disp(L,"Value of L in mH")
disp(C*10^6,"Value of C in micro F")
disp(R_f,"Value of L in k ohm")
disp(R1,"Value of L in ohm")
```

Scilab code Exa 5.2 Output voltage

```
// Exa 5.2
clc;
clear;
close;
// Given data
Rf= 12;// in k ohm
Rs1= 12;// in k ohm
Rs2= 2;// in k ohm
Rs3= 3;// in k ohm
Vi1= 9;// in volt
Vi2= -3;// in volt
Vi3= -1;// in volt
Vout= -Rf*[Vi1/Rs1+Vi2/Rs2+Vi3/Rs3];// in volt
disp(Vout,"Output voltage in volt");
```

Scilab code Exa 5.3 Realize a circuit

```
// Exa 5.3
clc;
clear;
close;
// Given expression Vout= -2*V1+3*V2+4*V3
```

```
// For an operational amplifier
// Vout= -Rf*[V1/R1+V2/R2+V3/R3]
// Compare the above expression with the given
   expression for the output
r_1=2;// value of Rf/R1
r_2=3;// value of Rf/R2
r_3=4;// value of Rf/R3
// Resistance R3 will be minimum value of 10 k ohm
R3=10;// in k ohm
Rf= r_3*R3;// in k ohm
R2= Rf/r_2;// in k ohm
R1= Rf/r_1;// in k ohm
disp(Rf,"Value of Rf in k ohm");
disp(R2,"Value of R2 in k ohm");
disp(R1,"Value of R1 in k ohm");
```

Scilab code Exa 5.4 Output voltage

```
// Exa 5.4
clc;
clear;
close;
// Given data
V1= 2;// in volt
V2= -1;// in volt
// Let R1= (R||R)/(R+(R||R))= (R/2)/(R+R/2) = 1/3
R1=1/3;
Vs1= V1*R1;// in volt
// Let R2= (1+Rf/R)= (1+2*R/R)= 3
R2= 3;
Vo_desh= Vs1*R2;// in volt
Vs2= V2*R1;// in volt
Vo_doubleDesh= Vs2*R2;// in volt
V_out= Vo_desh+Vo_doubleDesh;// in volt
disp(V_out,"Output voltage in volt")
```

Scilab code Exa 5.5 Differential Amplifier

```
// Exa 5.5
clc;
clear;
close;
// Given expression Vout= 10*(V2-V1)
// For a differential amplifier circuit
// Vout= Rf/R*(V2-V1)
// Compare the above expression with the given
   expression for the output , we have
RfbyR= 10;
R=10;// minimum value of resistancce to be used in
   kohm
Rf= RfbyR * R;// in k ohm
disp(Rf,"Value of Rf in k ohm");
```

Scilab code Exa 5.6 Output voltage

```
// Exa 5.6
clc;
clear;
close;
// Given data
R= 10;// in k ohm
Rp= 1;// in k ohm
// Let R1= (1+2*R/Rp)
R1= (1+2*R/Rp);
// output voltage , V5= R1*(V2-V1)
disp("Output voltage in volt is : "+string(R1)+"*(V2
   -V1)");
```

Scilab code Exa 5.7 Instrumentation variable differential gain

```
// Exa 5.7
clc;
clear;
close;
// Given data
R1= 50;// in kohm
// Let us choose
R3= 15;// in k ohm
R4= R3;
// Ad= 1+2*R2/R1                    (i)
// Ad= ((1+2*R2/R1)*(V2-V1))/(V2-V1)= 1+2*R2/R1
// For minimum differential voltage gain
Ad_min=5;
Ad= Ad_min;
R1_max= R1;// since Ad will be minimum only when R1
    will be maximum
// Putting values of Ad and R1 in eq(i)
R2= (Ad-1)*R1/2;// in k ohm
// For maximum differential voltage gain
Ad_max=200;
Ad= Ad_min;
// Putting values of Ad and R2 in eq(i)
R1= 2*R2/(Ad-1);// in k ohm
R1=floor(R1);
// For maximum value of Ad, R1 will have minimum
    value , therefore
R1_min= 1;// in kohm
disp("Value of R1_min is : "+string(R1_min)+" k ohm"
    );
disp("Value of R1 is      : "+string(R1)+"-50 k ohm")
    ;
disp("Value of R2 is      : "+string(R2)+" k ohm");
```

```
disp("Value of R3 is        : "+string(R3)+" k ohm");
disp("Value of R4 is        : "+string(R4)+" k ohm");
```

Scilab code Exa 5.9 Output voltage

```
// Exa 5.9
clc;
clear;
close;
// Given data
R=50;// in k ohm
R=R*10^3;// in ohm
C=2;// in micro F
C=C*10^-6;// in F
f=2;// in kHz
f=f*10^3;// in Hz
Vrms= 10;// in mV
RC= R*C;
// v_out= -1/(RC)*integrate('sqrt(2)*10*sind(4000*
    %pi*t)','t',0,t)= 0.0113*(cosd(4000*t)-1) in mV
disp("Output voltage in mV is : 0.0113*(cosd(4000*t)
    -1)")
```

Scilab code Exa 5.10 Capacitor voltage

```
// Exa 5.10
clc;
clear;
close;
// Given data
Vin= 10;// in volt
R=2.2;// in k ohm
R=R*10^3;//in ohm
```

```
Ad=10^5;// voltage gain
T= 1;// in ms
T=T*10^-3;// in second
C=1;// in micro F
C=C*10^-6;// in F
I= Vin/R;// in volt
V= I*T/C;// in V
disp(V,"The output voltage at the end of the pulse
    in volt");
RC_desh= R*C*Ad;
disp(RC_desh,"The closed-loop time constant in
    second is");
```

Scilab code Exa 5.11 R1 and Rf

```
// Exa 5.11
clc;
clear;
close;
// Given data
C=0.01;// in micro F
C=C*10^-6;// in F
omega= 10000;// in  rad/second
// Vout/V1= (Rf/R1)/(1+s*C*Rf)
// substituting s= j*omega we have
// Vout/V1 = (Rf/R1)/sqrt((omega*C*Rf)^2+1)
// At omega=0
// Vout/V1= Rf/R1
// Formula omega= 1/(C*Rf)
Rf= 1/(C*omega);// in ohm
Rf= Rf*10^-3;// in k ohm
// 20*log10(Rf/R1) = 20
R1= Rf/10;// in k ohm
disp(Rf,"Value of Rf in k ohm");
disp(R1,"Value of R1 in k ohm");
```

Scilab code Exa 5.12 Output voltage

```
// Exa 5.12
clear;
clc;
close;
//Given Data :
R=40*1000;//in ohm(assumed)
C=0.2*10^-6;//IN FARAD
Vout=3;//in Volt
V1=Vout;//in Volt
V2=Vout;//in Volt
t1=0.0001:50;//in msec
t1=t1*10^-3;//in sec
vout=-1/R/C*integrate('2','t',0,t1)+Vout;
t1=0.0001:50;//in msec
plot(t1,vout);
title("Output Voltage");
xlabel("Time in MilliSecond");
ylabel("Output Voltage in Volts");
disp("Assuming Ideal op-amp, sketch for Vout is
   shown in figure.");
```

Scilab code Exa 5.13 Output voltage

```
// Exa 5.13
clc;
clear;
close;
// Given data
R=50;// in k ohm
```

```
R=R*10^3;// in ohm
C=2;// in micro F
C=C*10^-6;// in F
f=2;// in kHz
f=f*10^3;// in Hz
Vmax= 10;// in micro volt
CR= C*R;
v_in= 'Vmax*sind(2*%pi*f*t)'
v_in= '10*sind(4000*%pi*t)';// in micro volt
// v_out= -CR*diff(v_in) = -0.1*10*diff(sind(4000*%pi*t))// in micro volt
disp("Output Voltage")
disp("12.56 cos(4000*pi*t)")
```

Scilab code Exa 5.14 Differentiator to defferentiate an input signal

```
// Exa 5.14
clc;
clear;
close;
// Given data
fa= 1;// in kHz
fa=fa*10^3;// in Hz
Vp=1.5;// in volt
f= 200;// in Hz
C=0.1;// in micro F
C=C*10^-6;// in F
R= 1/(2*%pi*fa*C);// in ohm
R=R*10^-3;// in k ohm
R=floor(R*10)/10;// in k ohm
fb= 20*fa;// in Hz
R_desh= 1/(2*%pi*fb*C);// in ohm
// Let
R_desh= 82;// in ohm
R_OM= R;// in k ohm
```

```
disp(R_OM,"Value of R_OM in k ohm")
CR= C*R;
// Vin= Vp*sin(omega*t)= 1.5*sin(400*t)
// v_out= -CR*diff(v_in) = -0.2827 Cos(400*%pi*t)// in micro volt
disp("Output Voltage")
disp(" -0.2827 Cos(400*%pi*t)");
t=-1/800:0.00001:1/200;//
v_out=-0.2827*cos(400*%pi*t)// in micro volt
plot(t,v_out);
title("Output Voltage Waveform");
xlabel("Time in ms");
ylabel("Vout in Volts");
disp("Output Voltage waveform is shown in figure.")
```

Scilab code Exa 5.15 Differentiator to defferentiate an input signal

```
// Exa 5.15
clc;
clear;
close;
// Given data
fa= 1;// in kHz
fa=fa*10^3;// in Hz
Vp=1.5;// in volt
C=0.1;// in micro F
C=C*10^-6;// in F
// Part (a)
R= 1/(2*%pi*fa*C);// in ohm
R=R*10^-3;// in k ohm
R=floor(R*10)/10;// in k ohm
fb= 20*fa;// in Hz
R_desh= 1/(2*%pi*fb*C);// in ohm
// Let
R_desh= 82;// in ohm
```

```
R_OM= R;// in k ohm
disp(R_OM,"Value of R_OM in k ohm")

// Part(b)
// given data
Vp=1.5;// in volt
f= 200;// in Hz
// v_in= Vp*sin(omega*t) = sin(2*%pi*f*t) = sin(2000*omega*t)
// v_out= -CR*diff(v_in) = -0.942 Cos(2000*%pi*t)// in micro volt
disp("Output Voltage")
disp(" -0.942 Cos(2000*%pi*t)")
```

Chapter 6

Active Filters

Scilab code Exa 6.1 Low pass filter

```
// Exa 6.1
clc;
clear;
close;
// Given Data
f_H= 2;// in kHz
f_H= f_H*10^3;// in Hz
C=0.01;// in micro F
C=C*10^-6;// in F
R= 1/(2*%pi*f_H*C);// in ohm
R=R*10^-3;// in kohm
// R may be taken a pot of 10 k ohm
R=10;// in k ohm
// Since the passbond gain is 2.5, so
// 1+Rf/R1= 2.5 or Rf= 1.5*R1
// Since Rf||R1
R1= R*2.5/1.5;// in k ohm
Rf= R1*1.5;// in k ohm
disp("Value of R1 is : "+string(R1)+" k ohm")
disp("Value of Rf is : "+string(Rf)+" k ohm")
```

Scilab code Exa 6.2 Second order low pass filter

```
// Exa 6.2
clc;
clear;
close;
// Given Data
f_H= 2;// in kHz
f_H= f_H*10^3;// in Hz
C=0.033;// in micor F
C=C*10^-6;// in F
C_desh= C;
R= 1/(2*%pi*f_H*C);// in ohm
R=R*10^-3;// in kohm
R=2.7;// k ohm (Standard value)
R_desh= R;
// So 2*R= Rf*R1/(Rf+R1) = 0.586*R1^2/(1.586*R1)
R1= 2*R*1.586/(0.586);// in k ohm
R1= 15;// k ohm (Standard value)
Rf= 0.586*R1;// in k ohm
Rf= 10;// k ohm (Standard value)
disp("Rf may be taken as a pot of : "+string(Rf)+" k
    ohm")
```

Scilab code Exa 6.3 Second order low pass filter

```
// Exa 6.3
clc;
clear;
close;
// Given Data
f_H= 1;// in kHz
```

```
f_H= f_H*10^3;// in Hz
C=0.0047;// in micro F
C=C*10^-6;// in F
C_desh= C;
R= 1/(2*%pi*f_H*C);// in ohm
R=R*10^-3;// in kohm
R=floor(R);
R_desh= R;
R1=R ;// in k ohm
Rf= 0.586*R1;// in k ohm
Rf= ceil(Rf);// in k ohm
disp(R,"Value of R in k ohm");
disp(C*10^6,"Value of R in micro F");
disp(R1,"Value of R1 in k ohm");
disp(Rf,"Value of Rf in k ohm");
```

Scilab code Exa 6.4 Required value of R1 R2 and C

```
// Exa 6.4
clc;
clear;
close;
// Given Data
f= 1;// in kHz
f= f*10^3;// in Hz
// Vout/Vin= 10
R1= 100;// in k ohm
R1=R1*10^3;// in ohm
R2= 1000;// in k ohm
R2=R2*10^3;// in ohm
omega= 2*%pi*f;
// Vout/Vin at a 3 dB frequency of 1 kHz = 1/sqrt(2)
    = omega*R2*C/sqrt(1+omega^2*R1^2*C2)
C= sqrt(1/(omega^2*(2*R2^2-R1^2)));// in F
disp(R1*10^-3,"Value of R1 in k ohm");
```

```
disp(R2*10^-6,"Value of R2 in k ohm");
disp(C,"Value of C in k ohm");
```

Scilab code Exa 6.5 Cut off frequency

```
// Exa 6.5
clc;
clear;
close;
// Given Data
R= 2.1;// in k ohm
R=R*10^3;// in ohm
R1= 20;// in k ohm
R1=R1*10^3;// in ohm
Rf= 60;// in k ohm
Rf=Rf*10^3;// in ohm
C=0.05;// in micro F
C=C*10^-6;// in F
fL= 1/(2*%pi*R*C);// in Hz
disp(fL*10^-3,"Low cut-off frequency in kHz")
```

Scilab code Exa 6.6 Cut off frequency and a bandwidth

```
// Exa 6.6
clc;
clear;
close;
// Given Data
R= 10;// in k ohm
R=R*10^3;// in ohm
R_desh= R;// in ohm
C=0.1;// in micro F
C=C*10^-6;// in F
```

```
C_desh=0.0025;// in micro F
C_desh=C_desh*10^-6;// in F
fH= 1/(2*%pi*R_desh*C_desh);// in Hz
disp(fH*10^-3,"Higher cut-off frequency in kHz")
fL= 1/(2*%pi*R*C);// in Hz
disp(fL,"Lower cut-off frequency in Hz")
BW= fH-fL;
disp(BW*10^-3,"Bandwidth in kHz")
```

Scilab code Exa 6.7 Narrow bandpass filter

```
// Exa 6.7
clc;
clear;
close;
// Given Data
fc= 1;// in kHz
fc=fc*10^3;// in Hz
Q=5;
Af=8;
// Let C=C1=C2=0.01 // in micro F
C1= 0.01;// in micro F
C1=C1*10^-6;// in F
C2=C1;// in F
C=C2;// in F
R1= Q/(2*%pi*fc*C*Af);// in ohm
R1=R1*10^-3;// in kohm
R1=ceil(R1);
R2= Q/(2*%pi*fc*C*(2*Q^2-Af));// in ohm
R2=R2*10^-3;// in kohm
R2=ceil(R2);
R3= Q/(%pi*fc*C);// in ohm
R3=R3*10^-3;// in kohm
R3=ceil(R3);
// The value of R2_desh required to change the
```

```
    centre frequency from 1 kHz to 2 kHz is
f_desh_c= 2000;// in Hz
R2_desh= R2*(fc/f_desh_c)^2;// in kohm
disp(R1,"Value of R1 in kohm");
disp(R2,"Value of R2 in kohm");
disp(R3,"Value of R3 in kohm");
disp(R2_desh,"Value of R2_desh in kohm");
```

Scilab code Exa 6.8 Centre frequency gain and Q of a filter

```
// Exa 6.8
clc;
clear;
close;
// Given Data
C= 0.1;// in micro F
C=C*10^-6;// in F
R1= 2;// in kohm
R1=R1*10^3;// in ohm
R2= 2/3;// in kohm
R2=R2*10^3;// in ohm
R3= 200;// in kohm
R3=R3*10^3;// in ohm
// R1= Q/(2*%pi*fc*C*Af)            (i)
// R2= Q/(2*%pi*fc*C*(2*Q^2-Af))    (ii)
// R3= Q/(%pi*fc*C)                 (iii)
// From (i) and (iii)
Af= R3/(2*R1);
// From (ii) and (iii)
Q= sqrt(1/2*(R3/(2*R2)+Af));
// From (iii)
fc= Q/(R3*%pi*C);// in Hz
omega_o= 2*%pi*fc;// in radians/second
disp(Af,"Gain");
disp(Q,"Value of Q");
```

```
disp(omega_o,"Centre frequency in radians/second")
```

Scilab code Exa 6.9 Bandpass filter

```
// Exa 6.9
clc;
clear;
close;
// Given Data
fL= 200;// in Hz
fH= 1;// in kHz
fH=fH*10^3;// in Hz
//Let the capacitor C_desh be of 0.01 micro F
C_desh= 0.01*10^-6;// in F
R_desh= 1/(2*%pi*fH*C_desh);// in ohm
R_desh=R_desh*10^-3;// in kohm
R_desh= 18;// in kohm
// Let
C=0.05*10^-6;// in F
R= 1/(2*%pi*fL*C);// in ohm
R=R*10^-3;// in kohm
R= 18;// in k ohm
Rf= 10;// in kohm
disp(Rf,"Value of Rf, Rf_desh , R1 and R1_desh in
   kohm");
disp(R,"Value of R and R_desh in kohm");
disp(C_desh*10^6,"Value of C_desh in micro F")
disp(C*10^6,"Value of C in micro F")
```

Scilab code Exa 6.11 Value of Q for the filter

```
// Exa 6.11
clc;
```

```
clear;
close;
// Given Data
fL= 200;// in Hz
fH= 1;// in kHz
fH=fH*10^3;// in Hz
fc= sqrt(fL*fH);// in Hz
Q= fc/(fH-fL);
disp(Q,"The value of Q for filter")
```

Scilab code Exa 6.12 Wide band filter

```
// Exa 6.12
clc;
clear;
close;
// Given Data
format('v',5)
fH= 200;// in Hz
fL= 2;// in kHz
fL=fL*10^3;// in Hz
C= 0.05;// in micro F
C=C*10^-6;// in F
R_desh= 1/(2*%pi*fH*C);// in ohm
R_desh=R_desh*10^-3;// in kohm
R= 1/(2*%pi*fL*C);// in ohm
R=R*10^-3;// in kohm
disp(R_desh,"Value of R_desh in kohm");
disp("Or 18 kohm (Standard value)")
disp(R,"Value of R in kohm");
disp("Or 1.8 kohm (Standard value)")
```

Scilab code Exa 6.13 Active notch filter

```
// Exa 6.13
clc;
clear;
close;
// Given Data
format('v',7)
fN= 50;// in Hz
C= 0.068;// in micro F
C=C*10^-6;// in F
R= 1/(2*%pi*fN*C);// in ohm
R=R*10^-3;// in kohm
R=ceil(R)
disp(R,"Value of R in kohm");
disp("For R/2, two "+string(R)+" kohm resistors
    connected in parallel may be used and for 2C
    component, two parallel connected 0.068 micro F
    capacitors may be used")
```

Scilab code Exa 6.14 Active notch filter

```
// Exa 6.14
clc;
clear;
close;
// Given Data
format('v',7)
fN= 60;// in Hz
// Let
C= 0.06;// in micro F
C=C*10^-6;// in F
R= 1/(2*%pi*fN*C);// in ohm
R=R*10^-3;// in kohm
disp(R,"Value of R in kohm");
disp("Or 47 kohm (Standard value)")
disp("For R/2, two 47 kohm resistors connected in
```

```
parallel may be used and for 2C component, two
parallel connected 0.06 micro F capacitors may be
used")
```

Scilab code Exa 6.15 Phase shift

```
// Exa 6.15
clc;
clear;
close;
// Given Data
format('v',7)
f= 2;// in kHz
f=f*10^3;// in Hz
C= 0.01;// in micro F
C=C*10^-6;// in F
R= 15;// in kohm
R=R*10^3;// in ohm
fie= -2*atand(2*%pi*f*R*C);
fie= ceil(fie);
disp(fie,"Phase shift in   ");
disp("i.e. "+string(abs(fie))+"   (lagging)")
```

Chapter 7

Oscillators Sinusoidal As Well As Non Sinusoidal

Scilab code Exa 7.1 Phase shift oscillator

```
// Exa 7.1
clc;
clear;
close;
//given data
f=200;// in Hz
// Let us take
C=0.1;// in micro F
C=C*10^-6;// in F
R=1/(2*%pi*f*C*sqrt(6));// in ohm
R=R*10^-3;// in k ohm
// R1>=10*R, Let
R1=10*R;// in kohm
R_f= 29*R1;// in k ohm
R_f=R_f*10^-3; // in M ohm
R_f=ceil(R_f);
disp(R_f,"Resistor of phase-shift oscillator in Mohm
   ")
```

Scilab code Exa 7.2 Phase shift oscillator

```
// Exa 7.2
clc;
clear;
close;
//given data
f=1;// in kHz
f=f*10^3;// in Hz
V_CC= 10;// in volt
I_B_max= 500;// in nA (for 741 IC op-amp)
I_B_max= I_B_max*10^-9;// in A
I1= 100*I_B_max;// in A
V_out= (V_CC-1);// in volt
V_in= V_out/29;
R1= V_in/I1;// in ohm
R1=R1*10^-3;//in k ohm
// 5.6 k ohm resistor may be used for R1, being standard value resistor
R1=5.6;// in k ohm (standard value)
A=29;
R_f= A*R1;
// 180 k ohm resistor may be used to provide A > 29
R_f=180;// in k ohm (standard value)
R_comp= R_f;
R=R1;// in k ohm
R=R*10^3;// in ohm
C=1/(2*%pi*f*R*sqrt(6));// in F
C=C*10^6;// in micro F
disp(R_comp,"Value of R_comp and R_f in kohm");
disp(R*10^-3,"Value of R and R1 in kohm");
disp(C,"Used capacitor in micro F")
```

Scilab code Exa 7.3 Wien bridge oscillator

```
// Exa 7.3
clc;
clear;
close;
//given data
f=10;// in kHz
f=f*10^3;// in Hz
I_Bmax= 500;// in nA
I_Bmax= I_Bmax*10^-9;// in amphere
// Let current through resistor R1 be equal to 100
   times I_Bmax, so
I_1= 100*I_Bmax;// in amp
Vcc= 10;// in volt
Vout= Vcc-1;// in volt
Addition_RfR1= Vout/(500*10^-6);// value of Rf+R1 in
    ohm
Addition_RfR1=Addition_RfR1*10^-3;// in kohm
// Rf= 2*R1, So
R1= Addition_RfR1/3;// (used 5.6 kohm Standard value
    resistor)
R1= 5.6;// in kohm
Rf= 2*R1;// in kohm// (used 12 kohm standard value
   resistor)
Rf=ceil(Rf);
R=R1;// in kohm
C= 1/(2*%pi*f*R);// in F (Used 2700pF standard value
   )
C=2700;// in pF
disp(R1,"Value of R1 in kohm")
disp(Rf,"Value of Rf in kohm")
disp(R,"Value of R in kohm")
disp(C,"Value of C in pF")
```

Scilab code Exa 7.4 Frequency of oscillator

```
// Exa 7.4
clc;
clear;
close;
//given data
R= 1;// in kohm
R=R*10^3;// in ohm
C= 4.7;// in micro F
C=C*10^-6;// in F
omega=1/(R*C);// in radians/second
f=omega/(2*%pi);// in Hz
disp(f,"Frequency of the oscillation of the circuit
   in Hz")
```

Scilab code Exa 7.6 Transfer function

```
// Exa 7.6
clc;
clear;
close;
//given data
R= 10;// in kohm
R=R*10^3;// in ohm
C= 100;// in pF
C=C*10^-12;// in F
f=1/(2*%pi*R*C);// in Hz
disp(f*10^-3,"Frequency of the oscillation of the
   circuit in kHz")
```

Scilab code Exa 7.7 Quadrature oscillator

```
// Exa 7.7
clc;
clear;
close;
//given data
fo= 318;// in Hz
C= 0.015;// in microF
C=C*10^-6;// in F
R=0.159/(fo*C);// in ohm
R=R*10^-3;// in kohm
R=floor(R);
disp(C*10^6,"Value of C1, C2 and C3 in micro F");
disp(R,"Value of R1, R2 and R3 in kohm")
```

Scilab code Exa 7.8 Quadrature oscillator

```
// Exa 7.8
clc;
clear;
close;
//given data
fo= 1.5;// in kHz
fo=fo*10^3;// in Hz

C= 0.01;// in microF
C=C*10^-6;// in F
R=0.159/(fo*C);// in ohm
R=R*10^-3;// in kohm
R=floor(R);
disp(C*10^6,"Value of C1, C2 and C3 in micro F");
```

```
disp(R,"Value of R1, R2 and R3 in kohm")
```

Scilab code Exa 7.9 Signal frequency

```
// Exa 7.9
clc;
clear;
close;
//given data
C= 0.1;// in microF
C=C*10^-6;// in F
R=12;// in kohm
R=R*10^3;// in ohm
R1=120;// in kohm
R1=R1*10^3;// in ohm
Rf=1;// in Mohm
Rf=Rf*10^6;// in ohm
V_sat= 10;// in volt
// Part(i)
f=Rf/(4*R1*R*C);//in Hz
disp(f*10^-3,"Signal Frequency in kHz")

// Part(ii)
Vp_p= 2*R1*V_sat/Rf;// in Vp_p
disp(Vp_p,"Amplitude of the triangular wave in Vp_p"
    )

// Part(iii)
Vp_p= (V_sat)-(-V_sat);
disp(Vp_p,"Amplitude of the square wave in Vp_p")
```

Scilab code Exa 7.11 Peak to peak amplitude of triangular wave

```
// Exa 7.11
clc;
clear;
close;
//given data
C1= 0.01;// in microF
C1=C1*10^-6;// in F
R1=120;// in kohm
R1=R1*10^3;// in ohm
R2=1.2;// in kohm
R2=R2*10^3;// in ohm
R3=6.8;// in kohm
R3=R3*10^3;// in ohm
V_sat= 15;// in volt
// Part(a)
Vp_p= 2*(R2/R3)*V_sat;//in volt
disp(Vp_p,"Peak to peak amplitude of triangular wave
    in volt")

// Part(b)
fo= R3/(4*R1*C1*R2);//in Hz
disp(fo*10^-3,"Frequency of triangular wave in kHz")
    ;
```

Scilab code Exa 7.12 R3 for a 100 micro second output pulse

```
// Exa 7.12
clc;
clear;
close;
//given data
T= 100;// in micro sec
T=T*10^-6;//in se
V_sat= 12;// in volt
V1= 0.7;// in volt
```

```
V= 0.7;// in volt
V_D1= V;
V_D2=V_D1;
C1= 0.1;// in microF
C1=C1*10^-6;// in F
Bita1= 0.1;
// Formula T= R3*C1*log((1+V1/V_sat)/(1-Bita1))
R3= T/(C1*log((1+V1/V_sat)/(1-Bita1)));// in ohm
disp(R3*10^-3,"Value of R3 in kohm")
```

Chapter 8

Comparators And Converters

Scilab code Exa 8.2 Input voltage range

```
// Exa 8.2
clc;
clear;
close;
//given data
A= 92;// in dB
A= 10^(92/20);
V_CC= 15;// in volt
Vout= 30;// in volt
InputOffsetVoltage= 0;// in V
InputVoltage= Vout/A;// in V
disp(InputVoltage*10^3,"Input Voltage in mV")
```

Scilab code Exa 8.3 Two voltage at which comparator will switch

```
// Exa 8.3
clc;
clear;
```

```
close;
//given data
R1= 2;// in kohm
Rf= 390;// in kohm
V_sat= 12;// in V
Bita= R1/(R1+Rf);
UTP= Bita*V_sat;// in volt
LTP= -Bita*V_sat;// in volt
disp(UTP*10^3,"Value of UTP in mv")
disp(LTP*10^3,"Value of LTP in mv")
```

Scilab code Exa 8.5 DC voltage

```
// Exa 8.5
clc;
clear;
close;
//given data
t=0;
Vc=0;
Vo=5;//in volt
// V1= 2*R/(2*R+3*R)= 2/5*Vo
// Vco= 1/5*VR +4/5*Vo = 1/5*(VR+4*Vo)
// Req= R||4*R= 4/5*R
// Vct= Vco*(1-%e^(-t/(Req*C)))= 1/5*(VR+4*Vo)*(1-%e
    ^(-t/(4*R*C/5)))= 1/5*(VR+4*Vo)*(1-%e^(-1.25*t/(R
    *C)))
// T= 2*Rf*C*log(1+2*R3/R2)= 2*R*C*log(7/3)= 1.7*R*C
// t= T/2= .85*R*C, Hence
Vct=2;//in volt
// Vct= 1/5*(VR+4*Vo)*(1-%e^1.0625)
VR= Vct*5/(1-%e^-1.0625)-4*Vo;
disp(VR,"Value of VR in volt")
```

Scilab code Exa 8.6 Output of the scchmitt trigger

```
// Exa 8.6
clc;
clear;
close;
//given data
omega= 200*%pi;// in radians/seconds
f=omega/(2*%pi);// in Hz
T=1/f;// in sec
T=T*10^3;//in ms
Vin= 7;//in volt
t1= 1/omega*asin(6/Vin);// in sec
t1=t1*10^3;// in ms
// The output of the schmitt trigger is at −10 volt
t1= T/2+t1;// in ms
// The output of the schmitt trigger is at +10 volt
t2= 10-t1;// in ms
disp(t1,"The output of the schmitt trigger is at −10
    volt in ms")
disp(t2,"The output of the schmitt trigger is at +10
    volt in ms")
```

Scilab code Exa 8.7 Output voltage

```
// Exa 8.7
clc;
clear;
close;
//given data
R1= 150;// in ohm
R2= 68;// in kohm
```

```
R2=R2*10^3;// in ohm
Vin= 500;// in mv
V_sat= 14;//in volt
V_pos= R1/(R1+R2)*V_sat;// in volt
V_UT= V_pos;//in volt
// In the same way when output is -14 volts and starts increasing in negative direcition
V_sat=-14;//in volt
V_pos= R1*V_sat/(R1+R2);// in volt
V_LT= abs(V_pos);//in volt
disp(V_UT,"Value of V_UT in volts")
disp(V_LT,"Value of V_LT in volts")
```

Scilab code Exa 8.8 Schmitt trigger

```
// Exa 8.8
clc;
clear;
close;
//given data
V_UT= 5;// in V
V_LT= -5;// in V
V_sat= 10;// in V (Assume)
// V_UT= (R1/(R1+R2))*V_sat = 5
// V_LT= (-R1/(R1+R2))*V_sat = -5
// 10*R1/(R+R2)= 5
V_hy= V_UT-V_LT;// in volt
disp(V_hy,"Hysteresis voltage in volt")
```

Scilab code Exa 8.9 Resolution full scale output voltage and weight

```
// Exa 8.9
clc;
```

```
clear;
close;
//given data
V_REF= 10;// in V
MSB2= V_REF/2;// in volt
disp(MSB2,"The second MSB weight in volt")
MSB3= V_REF/4;// in volt
disp(MSB3,"The third MSB weight in volt")
MSB4= V_REF/8;// in volt
disp(MSB4,"The forth MSB (or LSB) weight in volt")
DAC= MSB4;
disp(DAC,"The resolution of the DAC in volt")
FullScaleOutput= V_REF+MSB2+MSB3+MSB4;//in volt
disp(FullScaleOutput,"Full scale output in volt");
disp("If Rf is reduced to one-forth, each input will
    be 4 times smaller than the values above. Thus
    the full scale output will be reduced")
disp(" in the same ratio and becomes "+string(
    FullScaleOutput/4)+" volt")
```

Scilab code Exa 8.10 Analog output

```
// Exa 8.10
clc;
clear;
close;
//given data
V_REF= -5;// in V
V_B= 0;// in volt
V_A= -5;// in volt
V_C=V_A;
V_D=V_C;
Vout= -1*(V_A+V_B/2+V_C/4+V_D/8);// in volt
disp(Vout,"Output voltage in volt")
```

Scilab code Exa 8.11 Output voltage

```
// Exa 8.11
clc;
clear;
close;
//given data
Dn=16;// in volt
MSB1= Dn/2;// in volt
disp(MSB1,"The first MSB output in volt")
MSB2= Dn/4;// in volt
disp(MSB2,"The second MSB output in volt")
MSB3= Dn/8;// in volt
disp(MSB3,"The third MSB output in volt")
MSB4= Dn/16;// in volt
disp(MSB4,"The forth MSB output in volt")
MSB5= Dn/32;// in volt
disp(MSB5,"The fifth MSB output in volt")
MSB6= Dn/64;// in volt
disp(MSB6,"The sixth MSB (LSB) output in volt")
resolution= MSB6;// in volt
disp(resolution,"The resolution in volt")
fullScaleOutput= MSB1+MSB2+MSB3+MSB4+MSB5+MSB6;
disp(fullScaleOutput,"Full scale output occurs for digital input of 111111 in volt");
// For digital input 101011
D0=16;
D1=16;
D2=0;
D3=16;
D4=0;
D5=16;

Vout= (D0*2^0 + D1*2^1 + D2*2^2 + D3*2^3 + D4*2^4 +
```

```
D5*2^5)/2^6;// in volt
disp(Vout,"The voltage output for a digital input of
    101011 in volt")
```

Scilab code Exa 8.12 Output voltage

```
// Exa 8.12
clc;
clear;
close;
//given data
// For the word 100100
N=6;// Number of bits
a5= 1;// Value of bits
a4= 0;// Value of bits
a3= 0;// Value of bits
a2= 1;// Value of bits
a1= 0;// Value of bits
a0= 0;// Value of bits
Vo= 3.6;// in volt
// Formula Vo= (2^(N-1)*a5 + 2^(N-2)*a4 + 2^(N-3)*a3
    + 2^(N-4)*a2 + 2^(N-5)*a1 + 2^(N-6)*a0 ) * K
K= Vo/(2^(N-1)*a5 + 2^(N-2)*a4 + 2^(N-3)*a3 + 2^(N
    -4)*a2 + 2^(N-5)*a1 + 2^(N-6)*a0 );
// For the word 110011
N=6;// Number of bits
a5= 1;// Value of bits
a4= 1;// Value of bits
a3= 0;// Value of bits
a2= 0;// Value of bits
a1= 1;// Value of bits
a0= 1;// Value of bits
Vo= (2^(N-1)*a5 + 2^(N-2)*a4 + 2^(N-3)*a3 + 2^(N-4)*
    a2 + 2^(N-5)*a1 + 2^(N-6)*a0 ) * K;// in volt
disp(Vo,"The value of Vo for the word 110011 in volt
```

```
    ")

// Part(ii)
// For the word 1010
N=4;// Number of bits
a3= 1;// Value of bits
a2= 0;// Value of bits
a1= 1;// Value of bits
a0= 0;// Value of bits
VR= 6;// in volt
Vo= VR/2^N*( 2^(N-1)*a3 + 2^(N-2)*a2 + 2^(N-3)*a1 +
    2^(N-4)*a0  );
disp(Vo,"Value of output voltage in volt")
```

Scilab code Exa 8.13 Unknown voltage

```
// Exa 8.13
clc;
clear;
close;
//given data
R=100;// in kohm
R=R*10^3;// in ohm
C= 1;// in micro F
C=C*10^-6;// in F
V_REF= 5;// in volt
t=0.2;// time taken to read an unknown voltage in
    second
T=R*C;// in second
Vx= T/t*V_REF;// in volt
disp(Vx,"Unknown voltage in volt")
```

Scilab code Exa 8.14 Conversion time

```
// Exa 8.14
clc;
clear;
close;
//given data
f=75;// in MHz
f=f*10^6;// in Hz
// For an 8-bit converter reference voltage
V_REF= 100;// in volt
// For setting D7=1
Vo_7= V_REF*2^7/2^8;//in volt
// For setting D6=1
Vo_6= V_REF*2^6/2^8;//in volt
// For setting D7=1 and D6=1
Vo_76= Vo_7+Vo_6;//in volt
// For setting D5=1 D6=1 and D7=1
Vo_5= V_REF*2^5/2^8+Vo_7+Vo_6;//in volt
disp(Vo_7,"For setting D7=1 output voltage in volt
    is :")
disp(Vo_6,"For setting D6=1 output voltage in volt
    is :")
disp(Vo_76,"For setting D7=1 and D6=1 output voltage
     in volt is :")
disp(Vo_5,"For setting D5=1, D6=1 and D7=1 output
    voltage in volt is :")
disp("All other digits will be set to zero or 1.
    Output will be accordingly indicated as a resul
    of successive approximation. The converted 8-bit
    digital form will be 1110010")
T=1/f;// in sec
disp(T*10^9,"Conversion time in ns")
```

Scilab code Exa 8.15 Time of conversion

```
// Exa 8.15
```

```
clc;
clear;
close;
//given data
f=1;// in MHz
f=f*10^6;// in Hz
T=1/f;// conversion time in sec
N=8;// number of bits
tc= N*T;// in sec
disp(tc*10^6,"Time of Conversion in micro sec : ");
```

Scilab code Exa 8.16 Maximum time upto which the reference voltage can be integrated

```
// Exa 8.16
clc;
clear;
close;
//given data
Vin= 2;//in volt
Vout= 10;//in volt
R=100;// in kohm
R=R*10^3;//in ohm
C=0.1;// in  micro F
C=C*10^-6;//in F
// Formula Vout = -1/(R*C)*integrate('Vin','t',0,t)
    = -Vin*t/(R*C)
t= Vout*R*C/Vin;// in sec
disp(t,"The maximum time upto which the reference
    voltage can be integrated in second")
disp(t*10^3,"Or in mili seconds ")
```

Scilab code Exa 8.17 Maximum permissible leakage current

```
// Exa 8.17
clc;
clear;
close;
//given data
C=0.1;// in  nF
C=C*10^-9;//in F
V=5;//in V
t=1;// in micro S
t=t*10^-6;// in sec
// v= V*(1-%e^(-t/(R*C)))
// Since hold value does not drop by more than 0.5%
   or by 0.005 V, hold value is 0.995 V, Thus
// 0.995*V= V*(1-%e^(-t/(R*C)))
// or %e^(-t/(R*C))= 1-0.995 = 0.005
R= t/(C*log(1/0.005));// in ohm
I= V/R*(1-%e^(-t/(R*C)));// Maximum currnet through
   R in amphere
disp(I*10^3,"Maximum permissible leakage current
   through the hold capacitor in mA")
```

Chapter 9

The 555 IC Timer

Scilab code Exa 9.1 Frequency and duty cycle

```
// Exa 9.1
clc;
clear;
close;
//given data
C=.01;// in micro F
C=C*10^-6;// in  F
R_A= 2;// in kohm
R_A=R_A*10^3;// in ohm
R_B= 100;// in kohm
R_B=R_B*10^3;// in ohm
T_High= 0.693*(R_A+R_B)*C;// in seconds
T_Low= 0.693*R_B*C;// in seconds
T=T_High+T_Low;// in seconds
f=1/T;// in Hz
disp(f,"Frequency of oscillations in Hz");
DutyCycle= T_High/T*100;// in percent
disp(DutyCycle,"Duty cycle in percentage");
```

Scilab code Exa 9.2 Positive and negative Pulse width

```
// Exa 9.2
clc;
clear;
close;
//given data
C=1;// in micro F
C=C*10^-6;// in  F
C1=0.01;// in micro F
C1=C1*10^-6;// in  F
R_A=4.7;// in kohm
R_B=1;// in kohm
R_A=R_A*10^3;// in ohm
R_B=R_B*10^3;// in ohm
T_on= 0.693*(R_A+R_B)*C;// in seconds
T_on=T_on*10^3;// in ms
disp(T_on,"Positive pulse width in mili seconds")
T_off= 0.693*R_B*C;// in seconds
T_off=T_off*10^3;// in ms
disp(T_off,"Negative pulse width in mili seconds")
f=1.4/((R_A+2*R_B)*C);// in Hz
disp(f,"Free running Frequency in Hz");
DutyCycle= (R_A+R_B)/(R_A+2*R_B)*100// in percent
disp(DutyCycle,"Duty cycle in percentage");
```

Scilab code Exa 9.3 Value of resistor required

```
// Exa 9.3
clc;
clear;
close;
//given data
C=0.01;// in micro F
C=C*10^-6;// in  F
```

```
f=1;// in kHz
f=f*10^3;// in Hz
// R_A= R_B
// T_on = T_off = T/2
// Frequency is given by equation f= 1.44/((R_A+R_B)*C)
R_A= 1.44/(2*f*C);// in ohm
R_A=R_A*10^-3;// in k ohm
R_B= R_A;

disp("Resistors required : "+string(R_A)+" k ohm (68 ohm standart value)");
```

Scilab code Exa 9.4 555 timer as an multivibrator

```
// Exa 9.4
clc;
clear;
close;
//given data
f=700;// in Hz
// R_A= R_B
// T_on = T_off = T/2
// Frequency is given by equation f= 1.44/((R_A+R_B)*C)
C=0.01;// in micro F (assumed value)
C=C*10^-6;// in F
R_A= 1.44/(2*f*C);// in ohm
R_A=R_A*10^-3;// in k ohm
R_A=ceil(R_A);
R_B= R_A;
disp("Resistors required : "+string(R_A)+" k ohm (100 ohm standart value)");
```

Scilab code Exa 9.5 555 timer as an multivibrator

```
// Exa 9.5
clc;
clear;
close;
//given data
f=800;// in Hz
D=60;// in percent
// Formula D= (R_A+R_B)/(R_A+2*R_B)*100 = 60
// R_A + R_B = 0.6*R_A + 1.2*R_B
// R_B= 2*R_A
C=0.01;// in micro F  (assumed value)
C=C*10^-6;// in  F
// Frequency is given by equation f= 1.44/((R_A+R_B)
   *C)
R_A= 1.44/(5*C*f);// in ohm
R_A=R_A*10^-3;// in kohm
R_B=2*R_A;// in kohm
disp("Resistors required  : "+string(R_A)+" k ohm
   and "+string(R_B)+" k ohm");
```

Scilab code Exa 9.6 Frequency of free running ramp generator

```
// Exa 9.6
clc;
clear;
close;
//given data
C=.05;// in micro F
C=C*10^-6;// in  F
R= 12;// in kohm
```

```
R=R*10^3;// in ohm
V_CC= 5;// in volt
V_BE= 0.7;// in volt
V_D1= V_BE;// in volt
I_C= (V_CC-V_BE)/R;// in A
f_o= (3*I_C)/(V_CC*C);// in Hz
f_o=f_o*10^-3;// in kHz
disp(f_o,"Frequency of free running ramp generator
    circuit in kHz");
```

Scilab code Exa 9.7 Output pulse width

```
// Exa 9.7
clc;
clear;
close;
//given data
C=.1;// in micro F
C=C*10^-6;// in  F
R_A= 20;// in kohm
R_A=R_A*10^3;// in ohm
PulseWidth= 1.1*R_A*C;// in seconds
disp(PulseWidth*10^3,"The output pulse width in mili
     seconds");
```

Scilab code Exa 9.9 Value of RA

```
// Exa 9.9
clc;
clear;
close;
//given data
C=.02;// in micro F
```

```
C=C*10^-6;// in  F
f=2;// frequency of the outpur trigger in kHz
f=f*10^3;// in Hz
T=1/f;// in seconds
// In a divide-by-5 circuit , n=5, so the pulse width, t_p= [0.2 + (n-1)]*T = [0.2 + (5-1)]*T = 4.2*T
t_p=4.2*T;// in soconds
// Formula t_p = 1.1*R_A*C
R_A= t_p/(1.1*C);// in ohm
R_A=R_A*10^-3;// in kohm
disp(R_A,"The value of R_A in k ohm");
```

Chapter 10

Phase Locked Loop

Scilab code Exa 10.1 Free running frequency

```
// Exa 10.1
clc;
clear;
close;
//given data
V_pos= 12;// in volt
V_Neg= -12;// in volt
V=V_pos-V_Neg;
R1=15;// in k ohm
R1=R1*10^3;// in ohm
C1=0.01;// in micro F
C1=C1*10^-6;// in F
C2=10;// in micro F
C2=C2*10^-6;// in F
// (i)
f_out= 1.2/(4*R1*C1);// in Hz
disp(f_out*10^-3,"Free running frequency in kHz");
// (ii)
f_L= (8*f_out)/V;// in Hz
disp(f_L*10^-3,"Lock range in k Hz");
f_C= sqrt(f_L/(2*%pi*3.6*10^3*C2));// in Hz
```

```
disp(f_C,"Capture range in Hz")
```

Chapter 11

Voltage Regulators

Scilab code Exa 11.1 Minimum input voltage

```
// Exa 11.1
clc;
clear;
close;
//given data
I_dc=300;// in mA
C=200;// in micro F
V_max= 24;// in volt
V_r_rms= 2.4*I_dc/C;// in volt
V_r_peak= sqrt(3)*V_r_rms;// in volt
V_dc= V_max-V_r_peak;// in volt
V_in_low= V_max-V_r_peak;// in volt
disp(V_in_low,"Minimum input voltage in volt")
```

Scilab code Exa 11.2 Current source

```
// Exa 11.2
clc;
```

```
clear;
close;
//given data
I_L= 0.5;// in amp
R_L=25;// in ohm
V_R=12;// in volt (since using 7812 voltage regulator)
V_L= I_L*R_L;
R=V_R/I_L;// in ohm
disp(R,"Resistance required in ohm");
V_out= V_R+V_L;// in volt
disp(V_out,"Output voltage in volt");
V_in= V_out+2;// in volt
disp(V_in,"Input voltage in volt");
```

Scilab code Exa 11.3 Regulated output voltage

```
// Exa 11.3
clc;
clear;
close;
//given data
R1= 240;// in ohm
R2= 1.2;// in kohm
R2=R2*10^3;// in ohm
V_out= 1.25*(1+R2/R1);// in volt
disp(V_out,"Regulated output voltage in volt")
```

Scilab code Exa 11.4 Minimum and maximum output voltage

```
// Exa 11.4
clc;
clear;
```

```
close;
//given data
R1= 40;// in ohm
I_Q= 10;// in mA
I_Q=I_Q*10^-3;// in amp
V_REF= 15;// in volt
// When R2 is set at minimum i.e.
R2= 0;// in ohm
V_out= (1+R2/R1)*V_REF + I_Q*R2;// in volt
disp(V_out,"Minimum output voltage in volt")
// When R2 is set at maximum i.e.
R2= 200;// in ohm
V_out= (1+R2/R1)*V_REF + I_Q*R2;// in volt
disp(V_out,"Minimum output voltage in volt")
```

Scilab code Exa 11.5 Regulated output voltage

```
// Exa 11.5
clc;
clear;
close;
//given data
R1= 2.5;// in kohm
R1= R1*10^3;// in ohm
R2= 1;// in kohm
R2= R2*10^3;// in ohm
V_REF= 1.25;// in volt
I= V_REF/R2;// in amp
// This current also flows through R1. So the output
    voltage
V_out= I*(R1+R2);// in volt
disp(V_out,"Output voltage in volt")
```

Scilab code Exa 11.6 Duty cycle of the pulses

```
// Exa 11.6
clc;
clear;
close;
//given data
R1= 3;// in kohm
R1= R1*10^3;// in ohm
R2= 1;// in kohm
R2= R2*10^3;// in ohm
V_REF= 1.25;// in volt
V_in=20;// in volt
V_out= V_REF*(R1+R2)/R2;// in volt
D=V_out/V_in*100;// in percent
disp(D,"Duty cycle in percent")
```