Scilab Textbook Companion for
Integrated Circuits
by S. Sharma[1]

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

Exa Example (Solved example)

Eqn Equation (Particular equation of the above book)

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

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

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List of Scilab Codes

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Chapter 1

Analog Integrated Circuit Design An Overview

Scilab code Exa 1.1 Constant current

```
1  // Exa 1.1
2  clc;
3  clear;
4  close;
5  // Given data
6  V_EE = 10;// in V
7  R2 = 2.4;// in k ohm
8  R1 = 2.4;// in k ohm
9  R3 = 1;// in k ohm
10 V_BE3 = 0.7;// in V
11 I = (V_EE - ((R2*V_EE)/(R1+R2)) - V_BE3)/R3;// in mA
12 disp(I,"The constant current in mA is");
```

Scilab code Exa 1.2 Value of RE

```
1  // Exa 1.2
```

```
 2  clc ;
 3  clear ;
 4  close ;
 5  // Given data
 6  V_CC = 50;// in V
 7  V_BE2 = 0.7;// in V
 8  R = 50;// in k ohm
 9  R = 50 * 10^3;// in ohm
10  I_C1 = 10;// in  A
11  I_C1 =I_C1 * 10^-6;// in A
12  V_T = 26;// in mV
13  V_T = V_T * 10^-3;// in V
14  I_C2 = (V_CC - V_BE2)/R;// in A
15  R_E = (V_T*log(I_C2/I_C1))/I_C1;// in ohm
16  R_E = R_E * 10^-3;// in k ohm
17  disp(R_E,"The value of R_E in k   is");
```

Scilab code Exa 1.3 Collector current

```
 1  // Exa 1.3
 2  clc ;
 3  clear ;
 4  close ;
 5  // Given data
 6  V = 10;// in V
 7  V_BE = 0.715;// in V
 8  V_R = 0-(V_BE - V);// in V
 9  R = 5.6;// in  k ohm
10  I_R = V_R/R;// in  mA
11  bita = 100;
12  I_C = I_R * (bita/(1+bita));// in mA
13  disp(I_C,"For transistor Q1, the collector current
       in mA is");
14  I_C2 = I_R;// in mA
15  disp(I_C2,"For transistor Q2, the collector current
```

```
      in mA is");
16  I_C3 = I_R; // in mA
17  disp(I_C3,"For transistor Q3, the collector current
      in mA is");
18  I_C4 = I_R; // in mA
19  disp(I_C4,"For transistor Q4, the collector current
      in mA is");
```

Scilab code Exa 1.4 `Collector current`

```
 1  // Exa 1.4
 2  clc;
 3  clear;
 4  close;
 5  // Given data
 6  V = 10; // in V
 7  V_BE = 0.715; // in V
 8  R = 5.6; // in k ohm
 9  I = (V-V_BE)/(R); // in mA
10  bita = 100;
11  I_C1 = (bita/(4+bita))*I; // in mA
12  disp(I_C1,"For transistor Q1, the collector current
      in mA is");
13  I_C2 = I_C1; // in mA
14  disp(I_C2,"For transistor Q2, the collector current
      in mA is");
15  I_C3 = I_C1; // in mA
16  disp(I_C3,"For transistor Q3, the collector current
      in mA is");
17  I_C4 = I_C1; // in mA
18  disp(I_C4,"For transistor Q4, the collector current
      in mA is");
```

Scilab code Exa 1.5 `Output resistance`

```
1  // Exa 1.5
2  clc;
3  clear;
4  close;
5  // Given data
6  I_D1 = 100;// in  A
7  k_n = 200;// in  A /V^2
8  W = 10;// in  m
9  l = 1;// in  m
10 V_A = 20;// in V
11 V_ov = sqrt((I_D1*2)/(k_n*(W/l)));// in V
12 V_t = 0.7;// in V
13 V_GS = V_t + V_ov;// in V
14 V_GS = round(V_GS);// in V
15 V_DD = 3;// in V
16 I_REF = 100;// in  A
17 I_REF = I_REF * 10^-3;// in mA
18 R = (V_DD - V_GS)/I_REF;// in k ohm
19 disp(R,"The value of R in k   is");
20 V_ov_min = V_ov ;// in volt
21 disp(V_ov_min,"The lowest possible value of V_o in V
       is");
22 r_o2 = V_A/I_D1;// in M ohm
23 disp(r_o2,"The output resistance in M   is");
24 V_O = V_GS;// in V
25 del_Io = V_O/r_o2;// in  A
26 disp(del_Io,"The change in output current in  A   is"
       );
```

Chapter 2

The 741 IC Op Amp

Scilab code Exa 2.2 Input bias current

```
1  // Exa 2.2
2  clc;
3  clear;
4  close;
5  // Given data
6  I_b1 = 18;// in  A
7  I_b2 = 22;// in  A
8  I_b = (I_b1+I_b2)/2;// in  A
9  disp(I_b,"Input bias current in  A  is ");
10 I_ios = abs(I_b1-I_b2);// in  A
11 disp(I_ios,"Input offset current in  A  is");
```

Scilab code Exa 2.4 Slew rate and maximum possible frequency

```
1  // Exa 2.4
2  clc;
3  clear;
4  close;
```

```
5  // Given data
6  I_CQ = 10;// in A
7  I_CQ= I_CQ*10^-6;// in A
8  I = I_CQ;// in A
9  C_C = 33;// in pF
10 C_C=C_C*10^-12;// in F
11 C = C_C;// in F
12 S = I/C;// in V/sec
13 disp(S*10^-6,"The slew rate in V/ -sec is");
14 V_m = 12;// in V
15 f_m = S/(2*%pi*V_m);// in Hz
16 f_m = f_m * 10^-3;// in kHz
17 disp(f_m,"Maximum possible frequency in kHz is");
```

Scilab code Exa 2.5 `Output voltage`

```
1  // Exa 2.5
2  clc;
3  clear;
4  close;
5  // Given data
6  CMRR = 100;
7  V1 = 300;// in V
8  V2 = 240;// in V
9  V_id = V1-V2;// in V
10 V_cm = (V1+V2)/2;// in V
11 A_id = 5000;
12 A_cm = A_id/CMRR;
13 V_out = (A_id*V_id) + (A_cm*V_cm);// in V
14 V_out = V_out * 10^-3;// in mV
15 disp("Part (i)")
16 disp(V_out,"The output Voltage in mV is");
17 disp("Part (ii)")
18 CMRR = 10^5;
19 A_cm = A_id/CMRR;
```

```
20 V_out = (A_id*V_id) + (A_cm*V_cm);// in  V
21 V_out = V_out* 10^-3;// in mV
22 disp(V_out,"The output voltage in mV is");
```

Scilab code Exa 2.6 `CMRR`

```
1 // Exa 2.6
2 clc;
3 clear;
4 close;
5 // Given data
6 R1 = 1;// in k ohm
7 R2 = 100;// in k ohm
8 A_id = R2/R1;// in k ohm
9 Epsilon = 1 - (90/R2);
10 A_cm = (R2*Epsilon)/(R1+R2)
11 CMMR = A_id/A_cm;
12 CMRR = 20*log10(CMMR);// in dB
13 disp(CMRR,"The value of CMRR in dB is");
```

Scilab code Exa 2.6.2 `Input offset voltage`

```
1 // Exa 2.6 Again
2 clc;
3 clear;
4 close;
5 // Given data
6 gm1= 1/5.26;// in mA/V
7 gm1= gm1*10^-3;// in A/v
8 I= 9.5;// in  A
9 I=I*10^-6;// in A
10 del_I= 5.5*10^-3*I;// in A
11 V_OS= del_I/gm1;// in V
```

14

```
12  disp ( V_OS *10^3 ,"The  offset  voltage  in  mV  is  :  ")
```

Scilab code Exa 2.17 Lowest value of RL

```
1  // Exa  2.17
2  clc ;
3  clear ;
4  close ;
5  // Given  data
6  V = 10; // in V
7  R1 = 1; // in k ohm
8  R1=R1*10^3; // in ohm
9  R2 = 9; // in  k ohm
10 R2= R2*10^3; // in ohm
11 I_out = 20; // in mA
12 I_out=I_out*10^-3; // in A
13 R_L = V/( I_out -(V/(R1+R2)) ); // in ohm
14 disp ( R_L ,"The  lowest  value  of  R_L  in  ohm  is");
```

Scilab code Exa 2.18 Slew rate and maximum possible frequency

```
1  // Exa  2.18
2  clc ;
3  clear ;
4  close ;
5  // Given  data
6  I_CQ = 10; // in  A
7  I_CQ= I_CQ *10^-6; // in A
8  I = I_CQ; // in A
9  C_C = 33; // in pF
10 C_C=C_C*10^-12; // in F
11 C = C_C; // in F
12 S = I/C; // in V/sec
```

15

```
13  disp (S *10^ -6 ,"The  slew  rate  in  V/  −sec  is ");
14  V_m  =  12;// in  V
15  f_m  =  S/(2*%pi* V_m);// in  Hz
16  f_m  =  f_m  *  10^ -3;// in  kHz
17  disp (f_m ,"Maximum  possible  frequency  in  kHz  is ");
```

Chapter 3

Op Amp With Negative Feedback

Scilab code Exa 3.1 Closed loop voltage gain

```
1  // Exa 3.1
2  clc;
3  clear;
4  close;
5  // Given data
6  A = 2*10^5;
7  R_F = 4.7*10^3;// in ohm
8  R1 = 470;// in ohm
9  K = R_F/(R1+R_F);
10 B = R1/(R1+R_F);
11 A_F = -(A*R_F)/(R1+R_F+(R1*A));
12 disp(A_F,"The closed loop voltage gain is");
13 R_in = 2;// in M ohm
14 R_in = R_in * 10^6;// in ohm
15 R_inf = R1 + ( (R_F*R_in)/(R_F+R_in + (A*R_in)) );//
       in ohm
16 disp(R_inf,"Input resistance in     is");
17 R_o = 75;// in ohm
18 R_of = R_o/(1+(A*B));// in ohm
```

```
19 R_of = R_of * 10^3;// in  m
20 disp(R_of,"Output Resistance in m   is");
21 f_o = 5;// Hz
22 f_f = f_o*(1+(A*B));// in Hz
23 f_f = f_f *10^-3;// in kHz
24 disp(f_f,"Band width with feedback in kHz is");
25
26 // Note: In the book, the unit of output resistant
      is wrong it will be m   (not M )
```

Scilab code Exa 3.2 `Inverting op amp`

```
1 // EXa 3.2
2 clc;
3 clear;
4 close;
5 // Given data
6 A_F = -30;
7 R_F = 1;// in M ohm
8 R1 = -(R_F/A_F);// in Mohm
9 R_i = R1;// in Mohm
10 disp(R_i*10^3,"Input resistance in k   is");
```

Scilab code Exa 3.4 `Feedback resistance`

```
1 // Exa 3.4
2 clc;
3 clear;
4 close;
5 // Given data
6 A_F = 61;
7 R1 = 1;// in k ohm
8 R1 = R1 * 10^3;// in ohm
```

```
9   R_F = (A_F-1)*R1; // in ohm
10  R_F = R_F * 10^-3; // k ohm
11  disp(R_F,"The value of feedback resistance in k    is
        ");
```

Scilab code Exa 3.5 Closed loop gain and input resistance

```
1   // Exa 3.5
2   clc;
3   clear;
4   close;
5   // Given data
6   A = 2*10^5;
7   R1 = 1; // in k ohm
8   R1 = R1  *10^3; // in ohm
9   R_F = 10; // in k ohm
10  R_F = R_F * 10^3; // in ohm
11  B = R1/(R1+R_F);
12  R_i = 2; // in M ohm
13  R_i = R_i  * 10^6; // in ohm
14  R_o = 75; // in ohm
15  A_F = A/(1+(A*B));
16  disp(A_F,"The closed loop gain is");
17  R_if = R_i * (1+(A*B)); // in ohm
18  disp(R_if*10^-9,"Input resistance in G   is");
19  R_of = R_o/(1+(A*B)); // in ohm
20  R_of = R_of * 10^3; // in m
21  disp(R_of,"The output resistance in m is");
22  f_o = 5; // in Hz
23  f_f = f_o*(1+(A*B)); // in Hz
24  f_f = f_f * 10^-3; // in kHz ... correction ....
25  disp(f_f,"Bandwidth with feedback in kHz is");
```

Scilab code Exa 3.6 Voltage gain and input resistance

```
1  // Exa 3.6
2  clc;
3  clear;
4  close;
5  // Given data
6  A =2*10^5;
7  R_i = 2;// in M ohm
8  R1 = 1;// in ohm
9  R_o= 75;// in ohm
10 R_F = 1;// in ohm
11 B = R1/(R1+R_F);
12 A_F = -1;
13 disp(A_F,"The voltage gain is ");
14 R_if = 330;// in ohm
15 disp(R_if,"Input resistance in    is");
16 R_of = R_o/(A/2);// in ohm
17 disp(R_of,"Output resistance in    is");
18 f_o = 5;// in Hz
19 f_F = (A/2)*f_o;// in Hz
20 f_F = f_F * 10^-6;// in MHz
21 disp(f_F,"The bandwidth in MHz is");
```

Scilab code Exa 3.7 Value of Af Rif RoF and fF

```
1  // Exa 3.7
2  clc;
3  clear;
4  close;
5  // Given data
6  A = 2*10^5;
7  R_i = 2;//in   M ohm
8  R_i = 2*10^6;// in ohm
9  R_o = 75;//in ohm
```

```
10  f_o = 5;// in Hz
11  V_CC = 15;// in V
12  V_EE = -15;// in V
13  R1 = 1;// in k ohm
14  R1 = R1 * 10^3;// in ohm
15  R_F = 10;// in k ohm
16  R_F = R_F * 10^3;// in ohm
17  OVS= 13;// output voltage swing in V in
18  B = R1/(R1+R_F);
19  A_B = A*B;
20  A_B1 = 1+(A*B);
21  A_F = (1+(R_F/R1));
22  disp("Part (i) For non-inverting amplifier")
23  disp(A_F,"The value of A_F is");
24  R_iF = R_i * (A_B1);// in ohm
25  disp(R_iF*10^-9,"The value of R_iF in G is");
26  R_OF = R_o/(A_B1);// in ohm
27  disp(R_OF,"The value of R_OF in ohm is");
28  f_F = f_o*A_B1;// in Hz
29  f_F =f_F * 10^-3;// in kHz
30  disp(f_F,"The value of f_F in kHz is");
31  V_ooT= OVS/(1+A*B);// in V
32  disp("The value of VooT is    "+string(V_ooT)+" V or
        "+string(V_ooT*10^3)+" mV")
33
34  disp("Part (ii) For inverting amplifier")
35  R_F = 4.7;// in k ohm
36  R_F = R_F* 10^3;// in ohm
37  R_1 = 470;// in ohm
38  A_F = -(R_F)/R_1;
39  disp(A_F,"The value of A_F is");
40  R_iF = R_1// in ohm
41  disp(R_iF,"The value of R_iF in    is");
42  R_OF = R_o/(A_B1);// in ohm
43  disp(R_OF,"The value of R_OF in    is");
44  f_F = f_o*A_B1;// in Hz
45  f_F =f_F * 10^-3;// in kHz
46  disp(f_F,"The value of f_F in kHz is");
```

```
47  V_ooT = OVS/A_B1;// in mV
48  disp("The value of VooT is    "+string(V_ooT)+" V or
         "+string(V_ooT*10^3)+" mV")
```

Scilab code Exa 3.8 Voltage gain and input output resistance

```
1  // EXA 3.8
2  clc;
3  clear;
4  close;
5  // Given data
6  R1 = 5;// in   k ohm
7  R_F = 500;// in k ohm
8  V_in = 0.1;// in V
9  A_F = -(R_F/R1);
10  disp(A_F,"Voltage gain is");
11  R_i = R1;// in   k ohm
12  disp(R_i,"The Input resistance in k   is");
13  R_o = 0;// in ohm
14  disp(R_o,"Output resistance in    is");
15  V_out = A_F*V_in;// in V
16  disp(V_out,"Output voltage in V is");
17  I_in = V_in/(R1*10^3);// in A
18  I_in = I_in * 10^3;// in mA
19  disp(I_in,"Input current in mA is");
```

Scilab code Exa 3.9 Input impedance voltage gain and power gain

```
1  // Exa 3.9
2  clc;
3  clear;
4  close;
5  // Given data
```

```
6  R_F = 1;// in M ohm
7  R_in = 1;// in M ohm
8  V_in = 1;// in V (assumed)
9  V_out = -(R_F/R_in)*V_in;
10 A_v = V_out/V_in;
11 disp(A_v,"The value of A_v is");
12 I_in = 1;// in A
13 I_out = I_in;// in A
14 A_in = I_out/I_in;
15 disp(A_in,"The value of A_in is");
16 A_P = abs(A_v*A_in);
17 disp(A_P,"The value of A_P is");
```

Scilab code Exa 3.10 Inverting op amp

```
1  // Exa 3.10
2  clc;
3  clear;
4  close;
5  // Given data
6  R_F = 1;// in M ohm
7  R_F = R_F * 10^6;// in ohm
8  Av= -30;
9  R1 = R_F/abs(Av);// in ohm
10 R1 = R1 * 10^-3;// in k ohm
11 disp(R_F*10^-6,"The value of R_F in M  is : ")
12 disp(R1,"The value of R1 in k   is");
```

Scilab code Exa 3.11 Inverting op amp

```
1  // Exa 3.11
2  clc;
3  clear;
```

```
 4  close ;
 5  // Given data
 6  A_v = -8;
 7  V_in= -1;// in V
 8  I1 = 15;// in  A
 9  I1 = I1 * 10^-6;// in A
10  R1 = -(V_in)/I1;// in ohm
11  R1 = R1 * 10^-3;// in k ohm
12  disp(R1,"Minimum value of R1 in k   is");
13  R_F = -(A_v)*R1;// in   k ohm
14  disp(R_F,"The minimum value of R_F in k   is");
15
16  // Note: There is calculation error in the book to
        find the value of R_F so the answer in the book
        is wrong.
```

Chapter 4

Linear Applications of IC Op Amps

Scilab code Exa 4.1 Output voltage

```
1  //Exa 4.1
2  clc ;
3  clear ;
4  close ;
5  // Given data
6  R1= 1;// in k
7  R2= 1;// in k
8  R3= 1;// in k
9  RF= 1;// in k
10 Vin1= 2;// in volt
11 Vin2= 1;// in volt
12 Vin3= 4;// in volt
13 Vout= -(RF/R1*Vin1+RF/R2*Vin2+RF/R3*Vin3)
14 disp(Vout,"The output voltage in volts is : ")
```

Scilab code Exa 4.2 Design an adder circuit

25

```
1  //Exa 4.2
2  clc;
3  clear;
4  close;
5  // Given data
6  RF= 100;// in k
7  Vout= '-(V1+10*V2+100*V3)';// given expression
8  // Vout= -(RF/R1*V1+RF/R2*V2+RF/R3*V3)
9  // Comparing the Vout with the given expression
10 R1= RF;// in k
11 R2= RF/10;// in k
12 R3= RF/100;// in k
13 disp(R1,"The value of R1 in k   is : ");
14 disp(R2,"The value of R2 in k   is : ");
15 disp(R3,"The value of R3 in k   is : ");
```

Scilab code Exa 4.3 `Output voltage`

```
1  //Exa 4.3
2  clc;
3  clear;
4  close;
5  // Given data
6  R1= 12;// in k
7  R2= 2;// in k
8  R3= 3;// in k
9  RF= 12;// in k
10 V1= 9;// in volt
11 V2= -3;// in volt
12 V3= -1;// in volt
13 Vout= -(RF/R1*V1+RF/R2*V2+RF/R3*V3)
14 disp(Vout,"The output voltage in volts is : ")
```

Scilab code Exa 4.4 Summing amplifier

```
1  //Exa 4.4
2  clc;
3  clear;
4  close;
5  // Given data
6  RF= 6;// in k
7  Vout= '-V1+2*V2-3*V3';// given expression or
8  Vout= '-(V1-2*V2+3*V3)';
9  // Vout= -(RF/R1*V1+RF/R2*V2+RF/R3*V3)
10 // Comparing the Vout with the given expression
11 R1= RF;// in k
12 R2= RF/2;// in k
13 R3= RF/3;// in k
14 disp(R1,"The value of R1 in k  is : ");
15 disp(R2,"The value of R2 in k  is : ");
16 disp(R3,"The value of R3 in k  is : ");
```

Scilab code Exa 4.5 Values of resistances

```
1  //Exa 4.5
2  clc;
3  clear;
4  close;
5  // Given data
6  R3= 10;// in k
7  Vout= '-2*V1+3*V2+4*V3';// given expression or
8  Vout= '-(2*V1-3*V2-4*V3)';
9  // Vout= -(RF/R1*V1+RF/R2*V2+RF/R3*V3)
10 // Comparing the Vout with the given expression , we
      get
11 RF= 4*R3;// in k
12 R2= RF/3;// in k
13 R1= RF/2;// in k
```

```
14 disp(RF,"The value of RF in k  is : ");
15 disp(R2,"The value of R2 in k  is : ");
16 disp(R1,"The value of R1 in k  is : ");
```

Scilab code Exa 4.6 `Output voltage`

```
1 //Exa 4.6
2 clc;
3 clear;
4 close;
5 // Given data
6 V1= 2;// in V
7 V2= -1;// in V
8 R=10;// assuming value in k
9 R1=R;// in k
10 R2= R;// in k
11 R3= R;// in k
12 R4= R;// in k
13 RF= 2*R;// in k
14 Vin1= V1*(R1*R2/(R1+R2))/(R1+(R2*R3/(R2+R3)));// in
      V
15 Vout1= Vin1*(1+RF/R1);// in V
16 Vin2= V2*(R3*R4/(R3+R4))/(R2+(R3*R4/(R3+R4)));// in
      V
17 Vout2= Vin2*(1+RF/R2);// in V
18 Vout= Vout1+Vout2;// in V
19 disp(Vout,"The output voltage in volts is : ")
```

Scilab code Exa 4.7 `Limiting frequency`

```
1 //Exa 4.7
2 clc;
3 clear;
```

```
4 close;
5 // Given data
6 R1= 10;// in k
7 CF= 0.1;// in micro F
8 CF= CF*10^-6;// in F
9 RF= 10*R1;// in k
10 RF= RF*10^3;// in
11 fa= 1/(2*%pi*RF*CF);// in Hz
12 disp(fa,"Limiting frequency in Hz is : ")
```

Scilab code Exa 4.8 Practical integrator circuit

```
1 //Exa 4.8
2 clc;
3 clear;
4 close;
5 // Given data
6 f=10;// in kHz
7 f=f*10^3;// in Hz
8 dcGain= 10;
9 fa= f/10;// in Hz
10 R1= 10;// in k
11 // Formula dcGain= RF/R1
12 RF= R1*dcGain;// in k
13 RF=RF*10^3;// in
14 R1= R1*10^3;// in
15 // Formula fa= 1/(2*%pi*RF*CF)
16 CF= 1/(2*%pi*RF*fa);// in F
17 CF=CF*10^9;// in nF
18 Rcomp= R1*RF/(R1+RF);// in
19 disp(CF,"The value of CF in nF is : ")
20 disp(Rcomp*10^-3,"The value of Rcomp in k  is : ");
21
22 // Note: There is calculation error in evaluating
      the value of CF in the book. So The value of CF
```

Scilab code Exa 4.9 Maximum change in output voltage

```
1  //Exa 4.9
2  clc;
3  clear;
4  close;
5  // Given data
6  Vin=5;// in V
7  R1= 1;// in k
8  R1= R1*10^3;// in
9  CF= 0.1;// in  F
10 CF= CF*10^-6;// in F
11 f= 1;// in kHz
12 f= f *10^3;// in Hz
13 T= 1/f;// in sec
14 delta_Vout= Vin*T/(2*R1*CF);// in V
15 disp(delta_Vout,"The maximum change in output
      voltage in volts is : ")
16 S= 2*%pi*f*Vin;// in V/sec
17 disp(S*10^-6,"The minimum slew rate required in V/
      micro-sec is : ")
```

Scilab code Exa 4.10 Safe frequency and dc gain

```
1  // Exa 4.10
2  clc;
3  clear;
4  close;
5  // Given data
6  R_F = 1.2;// in M ohm
7  R_F = R_F * 10^6;// in ohm
```

30

```
 8  C_F = 10;// in nF
 9  C_F = C_F * 10^-9;// in F
10  f_a = 1/(2*%pi*R_F*C_F);// in Hz
11  disp(f_a,"The safe frequency in Hz is");
12  R1 = 120;// in k ohm
13  R1 = R1 * 10^3;// in ohm
14  A = R_F/R1;
15  AindB= 20*log10(A);// in dB
16  disp(AindB,"The d.c gain in dB is");
17  f = 10;// in kHz
18  f = f * 10^3;// in Hz
19  A = (R_F/R1)/(sqrt( 1+ ((f/f_a)^2) ));
20  V_in_peak = 5;// in V
21  V_out_peak = V_in_peak*A;// in V
22  disp(V_out_peak*10^3,"The peak of output voltage in
       mV is");
```

Scilab code Exa 4.11 `Output voltage`

```
 1  // Exa 4.11
 2  clc;
 3  clear;
 4  close;
 5  // Given data
 6  Vrms= 10;// in mV
 7  f= 2*10^3;// in kHz
 8  C= 2*10^-6;// in F
 9  R= 50*10^3;// in ohm
10  SF= -1/(C*R);// scale factor
11  //Vout= -1/(R*C)*sqrt(2)*Vrms*integrate('sind(2*%pi*
       f*t)','t',0,t);// in mV
12  //Vout= 1/(R*C)*sqrt(2)*Vrms/(2*%pi*f)*(cos(4000*t)
       -1);// in mV
13  V= 1/(R*C)*sqrt(2)*Vrms/(2*%pi*f);// (assumed)
14  disp("Output voltage in mV is : "+string(V)+"*(cos
```

$(4000 *t)-1)) \text{ mV"})$

Scilab code Exa 4.12 `Closed loop time constant`

```
1  //Exa 4.12
2  clc;
3  clear;
4  close;
5  // Given data
6  Vin =10;// in V
7  R= 2.2;// in  k
8  R= R*10^3;// in
9  T= 1;// in ms
10 T= T*10^-3;// in sec
11 C= 1;// in   F
12 C= C*10^-6;// in F
13 gain= 10^5;// differential voltage gain
14 I= Vin/R;// in A
15 V= I*T/C;// in V
16 disp(V,"The capacitor voltage at the end of the
     pulse in volts is : ")
17 RC_desh= R*C*gain;// in sec
18 disp(RC_desh,"The closed loop time constant in sec
     is : ")
```

Scilab code Exa 4.13 `Values of R1 and RF`

```
1  //Exa 4.13
2  clc;
3  clear;
4  close;
5  // Given data
6  omega= 10000;// in rad/sec
```

```
7  GaindB= 20;// peak gain in dB
8  Gain= 10^(GaindB/20);
9  C= 0.01;// in  F
10 C= C*10^-6;// in F
11 // Formula omega= 1/(C*RF)
12 RF= 1/(C*omega);// in
13 R1= RF/Gain;// in
14 disp(RF*10^-3,"The value of RF in k   is : ")
15 disp(R1*10^-3,"The value of R1 in k   is : ")
```

Scilab code Exa 4.14 Sketch of output voltage

```
1  //Exa 4.14
2  clc;
3  clear;
4  close;
5  // Given data
6  R= 40*10^3;// in
7  C= 0.2*10^-6;// in F
8  Vin= 5;// in V
9  V1=3;// in V
10 V2= V1;// in V
11 Vout= V2;// in V
12 t= 0:0.1:50;// in ms
13 Vout= -1/(R*C)*integrate('Vin-V1','t',0,t)/10^3+Vout
       ;// in volts
14 plot(t,Vout);
15 xlabel("Time in milliseconds")
16 ylabel("Output voltage in volts")
17 title("Vout Graph")
18 disp("The Vout graph shown in figure")
```

Scilab code Exa 4.15 Time duration for saturation

```
1  // Exa 4.15
2  clc;
3  clear;
4  close;
5  // Given data
6  R = 500;// in k ohm
7  R = R * 10^3;// in ohm
8  C = 10;// in F
9  C = C * 10^-6;// in F
10 V= -0.5;// in V
11 Vout= 12;// in V
12 // Vout= -1/RC*integrate('V*t','t',0,t)= -1/(R*C)*V*
       t
13 t= Vout/(-1/(R*C)*V);// in sec
14 disp(t,"Time duration required for saturation of
       output voltage in second is : ")
```

Scilab code Exa 4.16 Values of resistors

```
1  // Exa 4.16
2  clc;
3  clear;
4  close;
5  // Given data
6  C_F = 10;// in F
7  C_F = C_F * 10^-6;// in F
8  R1 = 1/C_F;// in ohm
9  R1 = R1 * 10^-3;// in k ohm
10 disp(R1,"The value of R1 in k is");
11 R2 = 1/(C_F*2);// in ohm
12 R2 = R2 * 10^-3;// in k ohm
13 disp(R2,"The value of R2 in k is");
14 R3 = 1/(C_F*5);// in ohm
15 R3 = R3 * 10^-3;;// in k ohm
16 disp(R3,"The value of R3 in k is");
```

Scilab code Exa 4.17 `Practical differentiator circuit`

```
1  // Exa 4.17
2  clc;
3  clear;
4  close;
5  // Given data
6  f_max = 150;// in Hz
7  f_a = f_max;// in Hz
8  disp(f_a,"The value of f_a in Hz is : ")
9  C1 = 1;// in   F
10 C1 = C1 * 10^-6;// in F
11 R_F = 1/(2*%pi*f_a*C1);// in ohm
12 disp(R_F*10^-3,"The value of R_F in k   is");
13 f_b = 10*f_a;// in Hz
14 R1 = 1/(2*%pi*f_b*C1);// in ohm
15 C_F = (R1*C1)/R_F;// in F
16 disp(C_F*10^6,"The value of C_F in   F   is");
17 R_comp = (R1*R_F)/(R1+(R_F));// in ohm
18 disp(R_comp,"The value of R_comp in      is");
```

Scilab code Exa 4.18 `Output voltage`

```
1  // Exa 4.18
2  clc;
3  clear;
4  close;
5  // Given data
6  Vmax= 10;// in   V
7  f= 2*10^3;// in kHz
8  //Vin= Vmax*sin(2*%pi*f*t);// in   V
```

```
9  disp("The input voltage is "+string(Vmax)+"*sin ("+
       string(2*f)+"%pi*t)   V ")
```

Scilab code Exa 4.19 Values of ROM and Vout

```
1  // Exa 4.19
2  clc;
3  clear;
4  close;
5  // Given data
6  Vp= 1.5;// in V
7  f= 200;// in Hz
8  f_a= 1*10^3;// in Hz
9  C= 0.1*10^-6;// in F
10 // Formula f_a= 1/(2*%pi*f_a*C)
11 R= 1/(2*%pi*f_a*C);// in ohm
12 R= 1.5;// in k   (standard value)
13 f_b= 20*f_a;// in Hz
14 // Formula f_b= 1/(2*%pi*R_desh*C)
15 R_desh= 1/(2*%pi*f_b*C);// in ohm
16 R_desh= 82;// in ohm (standard value)
17 R_OM= R;// in kohm
18 disp(R_OM,"The value of R_OM in k   is : ")
19 omega= 2*%pi*f;// in radian
20 // Vin= Vp*sin(omega*t) and Vout= -R*C*dv_in/dt
21 // Vout= -R*C*Vp*omega*cos(400*%pi*t)
22 V= -R*10^3*C*Vp*omega;// (assumed)
23 //Vout= V*cos(400*%pi*t)
24 disp("Output voltage is "+string(V)+" *cos(400*%pi*t
       ) volts")
25 disp("Output voltage waveforms shown in figure")
26 x= -%pi/2:0.1:2*%pi;
27 plot(x,V*cos(x));
28 title("Output Voltage waveforms")
29 xlabel("Time")
```

```
30 ylabel("Vout")
```

Scilab code Exa 4.20 Range of gain

```
1  // Exa 4.20
2  clc;
3  clear;
4  close;
5  // Given data
6  R2 = 100;// in ohm
7  R1 = 200;// in ohm
8  R_F = 100;// in k ohm
9  R_F = R_F * 10^3;// in ohm
10 R_G = 100;// in ohm
11 Gain_max = ( 1+((2*R_F)/R_G) ) * (R2/R1);
12 R = 100;// in  k ohm
13 R_G1 = 0.01+R;// in k ohm
14 R_G1 = R_G1 * 10^3;// in ohm
15 Gain_min = ( 1+((2*R_F)/R_G1) ) * (R2/R1);
16 disp("The gain can be varied from "+string(Gain_min)
       +" to "+string(Gain_max))
```

Scilab code Exa 4.21 Value of RG

```
1  // EXa 4.21
2  clc;
3  clear;
4  close;
5  // Given data
6  R1 = 100;// in k ohm
7  R2 = 100;// in k ohm
8  R_F = 470;// in k ohm
9  Gain = 100;
```

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```
10  R_G = (2*R_F)/(Gain -1);// in ohm
11  disp(R_G,"The value of R_G in ohm is");
```

Scilab code Exa 4.22 Transconductance resistance

```
1  // Exa 4.22
2  clc;
3  clear;
4  close;
5  // Given data
6  R = 100;// in ohm
7  T = 25;// in degree C
8  alpha = 0.00392;
9  R1 = R*(1+(alpha*T));// in ohm
10  expression= 'R_T= Ro*[1+alpha*T]';
11  disp(expression,"The expression for the resistance
      at T C is : ")
12  disp(R1,"The transducer resistance at 25 C  in     is
      ");
13  T = 100;// in degree C
14  R2 = R*(1+(alpha*T));// in ohm
15  disp(R2,"The transducer resistance at 100 C  in
      is");
```

Scilab code Exa 4.23 Instrumentation amplifier

```
1  // Exa 4.23
2  clc;
3  clear;
4  close;
5  // Given data
6  R3 = 1;// in k ohm
7  R4 = 1;// in k ohm
```

```
8  R_min = R4/R3;
9  R_4 = 50;// in k ohm
10 R_max = (R_4+R4)/R3;
11 R2 = 10;// in k ohm
12 A_F = 5;
13 R1 = (((A_F/R_min)-1)*R2)/2;// in k ohm
14 disp(R1,"The value of R1 in k   is");
15 disp(R2,"The value of R2 in k   is : ")
```

Scilab code Exa 4.24 Expression for output voltage

```
1  // Exa 4.24
2  clc;
3  clear;
4  close;
5  // Given data
6  R1= 100;// in k
7  R2=200;// in k
8  R3= 20;// in k
9  R4=40;// in k
10 //Vout= [1+R2/R1]*[R4/(R3+R4)]*Vin1-R2/R1*Vin2
11 A=[1+R2/R1]*[R4/(R3+R4)];// (assumed)
12 disp("Output voltage is "+string(A)+"*(Vin1-Vin2)")
```

Scilab code Exa 4.25 Gain of instrumentation amplifier

```
1  // Exa 4.25
2  clc;
3  clear;
4  close;
5  // Given data
6  R_F = 5;// in  k ohm
7  R_G = 1;// in  k ohm
```

```
 8  R1 = 10;// in  k ohm
 9  R2 = 20;// in  k ohm
10  A = (1 + ((2*R_F)/R_G))*(R2/R1);
11  disp(A,"The gain of instrumentaion amplifier is");
```

Scilab code Exa 4.27 `Output voltage`

```
 1  // EXa 4.27
 2  clc;
 3  clear;
 4  close;
 5  // Given data
 6  R_F = 10;// in  k ohm
 7  R_G = 5;// in  k ohm
 8  R1 = 1;// in  k ohm
 9  R2 = 2;// in  k ohm
10  A = (1+ ((2*R_F)/R_G))*(R2/R1);
11  V_in2 = 2;// in mV
12  V_in1 = 1;// in mV
13  V_out = A*(V_in2-V_in1);// in mV
14  disp(V_out,"The output voltage in mV is");
```

Scilab code Exa 4.28 `Value of RG`

```
 1  // Exa 4.28
 2  clc;
 3  clear;
 4  close;
 5  // Given data
 6  V_out = 3;// in V
 7  V_in2 = 5;// in mV
 8  V_in1 = 2;// in mV
 9  V1 = V_in2-V_in1;// in mV
```

```
10  V1 = V1 * 10^-3;// in V
11  A = V_out/V1;
12  R_F = 15;// in   k ohm
13  R1 = 1;// in   k ohm
14  R2 = 2;// in   k ohm
15  R = R2/R1;// in k   ohm
16  R_G = (2*R_F)/((A/R)-1);//in   k ohm
17  R_G = R_G * 10^3;// in ohm
18  disp(R_G,"The value of R_G in     is");
```

Scilab code Exa 4.31 Three op amp instrumentation amplifier

```
 1  //Exa 4.31
 2  clc;
 3  clear;
 4  close;
 5  // Given data
 6  A=10000;
 7  R1= 100;// in k
 8  A2= 1/5;// (assumed value)
 9  R2= R1/A2;// in k
10  // A= A1*A2 and A1= 1+2*RF/R_GB
11  RFbyR_GB= (A/A2-1)/2;
12  // [1+2*RF/RG]*A2= 1 and RG= RGB+100  k
13  R_G= (1-1/A2)/2*100/[(1/A2-1)/2-RFbyR_GB];// in  k
14  R_F= RFbyR_GB*R_G;// in  k
15  disp(R_F,"The value of R_F in k   is : ")
16  disp(R_G*10^3,"The value of R_G in     is : ")
17  disp("This is the base resistance required in series
        with the pot of 100  k ")
```

Chapter 5

Filters

Scilab code Exa 5.1 Cut off frequency and passband voltage gain

```
1  // Exa 5.1
2  clc;
3  clear;
4  close;
5  // Given data
6  R = 10;// in k ohm
7  R = R * 10^3;// in ohm
8  C = 0.001;// in  F
9  C = C * 10^-6;// in F
10 f_c = 1/(2*%pi*R*C);// Hz
11 f_c = f_c * 10^-3;// in kHz
12 disp(f_c,"Cutoff frequency in kHz is");
13 R_F = 100;// in k ohm
14 R1 = 10;// in k ohm
15 A_F = 1+(R_F/R1);
16 disp(A_F,"The passband voltage gain is");
```

Scilab code Exa 5.2 First order low pass filter

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```
1  // Exa  5.2
2  clc;
3  clear;
4  close;
5  // Given  data
6  R1 = 10;// in  k ohm
7  R_F = R1;// in  k ohm
8  disp(R_F,"The  value  of  R_F in  k    is");
9  C = 0.001;// in    F
10 C = C   *10^-6;// in  F
11 f_c = 10;// in  kHz
12 f_c = f_c * 10^3;// in  Hz
13 R = 1/(2*%pi*f_c*C);// in  ohm
14 R  = R * 10^-3;// in  k ohm
15 disp(R,"The  value  of  R in  k    is");
```

Scilab code Exa 5.3 Low pass filter

```
1  // Exa  5.3
2  clc;
3  clear;
4  close;
5  // Given  data
6  f_c = 2;// in  kHz
7  f_c = f_c * 10^3;// in  Hz
8  C = 0.01;// in    F
9  C = C * 10^-6;// in  F
10 R = 1/(2*%pi*f_c*C);// in  ohm
11 R = R * 10^-3;// in  k ohm
12 R = 8.2;// in  k ohm(Practical  value)
13 A_F = 2.5;
14 R1 = (A_F*R)/1.5;// in  k ohm
15 R_F = 1.5*R1;// in  k ohm
16 disp(R1,"The  value  of  R1 in  k    is  :  ")
17 disp(R_F,"The  value  of  R_F in  k    is  :  ")
```

Scilab code Exa 5.4 Second order low pass filter

```
1  // Exa 5.4
2  clc;
3  clear;
4  close;
5  // Given data
6  f_c = 1;// in kHz
7  f_c = f_c * 10^3;// in Hz
8  C = 0.005*10^-6;// in F
9  R3 = 1/(2*%pi*f_c*C);// in ohm
10  R3 = R3 * 10^-3;// in k ohm
11  R2 = R3;// in k ohm
12  R1 = 33;// in k ohm (standard value)
13  R_F = 0.586*R1;// in k ohm
14  disp(R1,"The value of R1 in k   is : ")
15  disp(R3,"The value of R2 and R3 in k   is");
16  disp(R_F,"The value of R_F in k   is : ")
17  disp(C*10^6,"The value of C2 and C3 in  F   is :")
```

Scilab code Exa 5.5 Second order low pass filter

```
1  // Exa 5.5
2  clc;
3  clear;
4  close;
5  // Given data
6  R1 = 12;// in k ohm
7  R_F = 7;// in k ohm
8  R2 = 33;// in k ohm
9  R3 = R2;// in k ohm
```

```
10  R = R2;// in k ohm
11  R = R * 10^3;// in ohm
12  C1 = 0.002;// in  F
13  C1 = C1 * 10^-6;// in F
14  C2 = C1;// in F
15  C = C1;// in F
16  f_c = 1/(2*%pi*R*C);// in Hz
17  f_c = f_c * 10^-3;// in kHz
18  disp(f_c,"Cut off frequency in kHz is");
19  A_F = 1+(R_F/R1);
20  disp(A_F,"Pass band voltage gain is");
```

Scilab code Exa 5.6 `Second order low pass filter`

```
 1  // Exa 5.6
 2  clc;
 3  clear;
 4  close;
 5  // Given data
 6  f_c = 2;// in kHz
 7  f_c = f_c * 10^3;// in Hz
 8  C2 = 0.033;// in  F
 9  C2 = C2 * 10^-6;// in F
10  C3 = C2;// in F
11  C = C2;// in F
12  R2 = 1/(2*%pi*f_c*C);// in ohm
13  R2 = R2 * 10^-3;// in k ohm
14  R3=R2;// in kohm
15  disp(R2,"The value of R2 and R3 in k   is : ");
16  //R_F= 0.586*R1
17  R1= 2*R2*(1+0.586)/0.586;// in k ohm
18  disp(R1,"The value of R1 in k   is : ")
19  R1= 15;// in k ohm
20  R_F = 0.586 * R1;// in k ohm
21  disp(R_F,"The value of R_F in k   is : ");
```

```
22 disp("R_F may be taken as a pot of 10 k ")
```

Scilab code Exa 5.7 Second order low pass filter

```
1  // Exa 5.7
2  clc;
3  clear;
4  close;
5  // Given data
6  f_c = 1;// in kHz
7  f_c = f_c * 10^3;// in Hz
8  C2 = 0.0047;// in  F
9  C2 = C2 * 10^-6;// in F
10 C3 = C2;// in F
11 C = C2;// in F
12 R2 = 1/(2*%pi*f_c*C);// in ohm
13 R2 = R2 * 10^-3;// in k ohm
14 R3= R2;// in kohm
15 // Let
16 R1=30;// in kohm
17 R_F= R1*0.586;// in kohm
18 disp(floor(R2),"The value of R2 and R3 in k   is : "
      )
19 disp(R1,"The value of R1 in k   is : ")
20 disp(R_F,"The value of R_F in k   is : ")
21 disp("The standard value of R_F is 20 k ")
```

Scilab code Exa 5.8 Second order Butterworth filter

```
1  // Exa 5.8
2  clc;
3  clear;
4  close;
```

```
5  // Given data
6  f_c = 1.5;// in kHz
7  f_c = f_c * 10^3;// in Hz
8  alpha = sqrt(2);
9  R_F = (2-alpha);// in ohm
10 disp(R_F,"The value of R_F in   is : ");
11 R_i = 1;// in ohm
12 A_F = 1+(R_F/R_i);
13 disp(A_F,"The pass band gain is");
14 Omega_c = 2*%pi*f_c;// in rad/sec
15 C = 1;// in F
16 R = 1/Omega_c;// in ohm
17 R = R * 10^7;// in ohm
18 R=R*10^-3;// in kohm
19 R1 = R;// in k ohm
20 R2=R1;// in kohm
21 disp(R1,"The value of R1 and R2 in k  is");
22 C = C/10^7;// in  F
23 C = C * 10^9;// in nF
24 C1=C;// in nF
25 C2= C1;// in nF
26 disp(C1,"The value of C1 and C2 in nF is");
27
28 //Note: The unit of R1 and R2 is wrong in the book
```

Scilab code Exa 5.9 Second order Butterworth filter

```
1  // Exa 5.9
2  clc;
3  clear;
4  close;
5  // Given data
6  alpha = 1.414;
7  f_c = 1.5;// in kHz
8  f_c = f_c * 10^3;// in Hz
```

```
 9  C1 = 2/alpha;// in F
10  C2 = alpha/2;// in F
11  R1 = 1;// in ohm
12  R2 = R1;// in ohm
13  R_F = 2;// in ohm
14  Omega_c = 2*%pi*f_c;// in rad/sec
15  R = 1/Omega_c;// in ohm
16  R = R * 10^7;// in ohm
17  R1 = R;// in ohm
18  R2= R1;// in ohm
19  R_F = 2*R;// in ohm
20  C1 = C1/10^7;// in F
21  C2 = C2/10^7;// in F
22  disp(R1*10^-3,"The value of R1 and R2 in k ohm");
23  disp(C1*10^9,"The value of C1 in nF is");
24  disp(C2*10^9,"The value of C2 in nF is");
25  disp(R_F*10^-3,"The value of R_F in k ohm");
```

Scilab code Exa 5.12 Second order low pass filter

```
 1  // Exa 5.12
 2  clc;
 3  clear;
 4  close;
 5  // Given data
 6  f_c = 10;// in kHz
 7  f_c = f_c * 10^3;// in Hz
 8  omega_c= 2*%pi*f_c;// in rad/sec
 9  C = 0.01;// in  F
10  C= C*10^-6;// in F
11  Ri= 10*10^3;// in
12  n=2;
13  Q= 1/1.414;
14  R= 1/(2*%pi*f_c*C);// in
15  Af= 3-1/Q;
```

```scilab
16  Rf= (Af-1)*Ri;// in
17  disp(C*10^6,"The value of C in  F  is : ")
18  disp(R*10^-3,"The value of R in k   is : ")
19  disp(Rf*10^-3,"The value of Rf in k   is : ")
20  disp("Frequency versus gain magnitude shown in
        following table:")
21  disp("        Frequency in Hz
        Gain Magnitude in dB |H(s)|")
22  f= 1000;// in Hz
23  omega= 2*%pi*f;// in rad/sec
24  HsdB= 20*log10(Af/sqrt(1+(omega/omega_c)^4))
25  disp("            "+string(f)+"
                                                    "+
        string(HsdB))
26  f= 2000;// in Hz
27  omega= 2*%pi*f;// in rad/sec
28  HsdB= 20*log10(Af/sqrt(1+(omega/omega_c)^4))
29  disp("            "+string(f)+"
                                                    "+
        string(HsdB))
30  f= 5000;// in Hz
31  omega= 2*%pi*f;// in rad/sec
32  HsdB= 20*log10(Af/sqrt(1+(omega/omega_c)^4))
33  disp("            "+string(f)+"
                                                    "+
        string(HsdB))
34  f= 10000;// in Hz
35  omega= 2*%pi*f;// in rad/sec
36  HsdB= 20*log10(Af/sqrt(1+(omega/omega_c)^4))
37  disp("            "+string(f)+"
                                                    "+
        string(HsdB))
38  f= 50000;// in Hz
39  omega= 2*%pi*f;// in rad/sec
40  HsdB= 20*log10(Af/sqrt(1+(omega/omega_c)^4))
41  disp("            "+string(f)+"
                                                    "+
        string(HsdB))
```

```
42  f= 100000;// in Hz
43  omega= 2*%pi*f;// in rad/sec
44  HsdB= 20*log10(Af/sqrt(1+(omega/omega_c)^4))
45  disp("            "+string(f)+"
                                              "+
      string(HsdB))
```

Scilab code Exa 5.13 Fourth order Butterworth filter

```
1   // Exa 5.13
2   clc;
3   clear;
4   close;
5   // Given data
6   f_c = 1;// in kHz
7   f_c = f_c * 10^3;// in Hz
8   C = 0.1;// in  F
9   disp(C,"The value of C in  F  is");
10  C = C * 10^-6;// in F
11  R = 1/(2*%pi*f_c*C);// in ohm
12  disp(R*10^-3,"The value of R in k   is");
13  Q1 = 1/0.765;
14  alpha1 = 1/Q1;
15  Q2 = 1/1.848;
16  alpha2 = 1/Q2;
17  A_F1 = 3-alpha1;
18  A_F2 = 3-alpha2;
19  R_i =10*10^3;// in ohm
20  R_F = (A_F1-1)*R_i;// in ohm
21  disp(R_F*10^-3,"For first stage the value of R_F in
        k    is");
22  R_i = 100*10^3;// ohm
23  R_F = (A_F2-1)*R_i;// in ohm
24  disp(R_F*10^-3,"For second stage the value of R_F in
         k    is");
```

Scilab code Exa 5.14 Value of Resistance

```
1  // Exa 5.14
2  clc;
3  clear;
4  close;
5  // Given data
6  f_c = 10;// in kHz
7  f_c = f_c *10^3;// in Hz
8  C = 0.0047;// in  F
9  C = C * 10^-6;// in F
10 R = 1/(2*%pi*f_c*C);// in ohm
11 R = R * 10^-3;// in k ohm
12 disp(R,"The value of R in k  is");
```

Scilab code Exa 5.15 Passband gain

```
1  // Exa 5.15
2  clc;
3  clear;
4  close;
5  // Given data
6  R = 15;// in k ohm
7  R = R *10^3;// in ohm
8  C = 0.01;// in  F
9  C = C * 10^-6;// in F
10 f_c = 1/(2*%pi*R*C);// in Hz
11 f_c= round(f_c);
12 disp(f_c,"Cut off frequency in Hz is");
13 Omega_c = 2*%pi*f_c;// in rad/sec
14 disp(Omega_c*10^-3,"The value of omega_c in k rad/
      sec is");
```

```
15
16  // Note: There is calculation error to find the
       value of omega_c. So the answer in the book is
       wrong
```

Scilab code Exa 5.16 Cut off frequency and passband voltage gain

```
1   // Exa 5.16 printed as 5.13
2   clc;
3   clear;
4   close;
5   // Given data
6   R1 = 27;// in k ohm
7   R1 = R1 * 10^3;// in ohm
8   R2 = R1;// in ohm
9   R3 = R2 ;// in ohm
10  R = R1;// in ohm
11  R_L = 10;// in k ohm
12  R_F = 16;// in k ohm
13  C2 = 0.005;// in  F
14  C2 = C2 * 10^-6;// in F
15  C3 = C2;// in F
16  C = C3;// in F
17  f_c = 1/(2*%pi*R*C);// in Hz
18  f_c = f_c * 10^-3;// in kHz
19  R1= R1*10^-3;// in kohm
20  disp(f_c,"Cut off frequency in kHz is");
21  A_F = 1+(R_F/R1);
22  disp(A_F,"Voltage gain is");
```

Scilab code Exa 5.17 Second order Bessel Filter

```
1   // Exa 5.17
```

```
2  clc;
3  clear;
4  close;
5  // Given data
6  alpha = 1.732;
7  k_f = 1.274;
8  C1 = 1;// in F
9  C2 = C1;// in F
10  R1 = alpha/2;// in ohm
11  R2 = 2/alpha;// in ohm
12  R_F = R2;// in ohm
13  f_3dB = 2;// in kHz
14  f_3dB = f_3dB * 10^3;// in Hz
15  f_c = f_3dB/k_f;// in Hz
16  Omega_c = 2*%pi*f_c;// in rad/sec
17  R1 = R1/Omega_c;// in ohm
18  R1 = R1 * 10^8;// in ohm
19  R2 = R2/Omega_c;// in ohm
20  R2 = R2 * 10^8;// in ohm
21  R_F = R2;// in ohm
22  C1 = C1/10^8;// in F
23  disp(R1*10^-3,"The value of R1 in k   is : ")
24  disp(R2*10^-3,"The value of R2 and R_F in k   is : "
     )
25  disp(C1*10^9,"The value of C1 and C2 in nF is : ")
```

Scilab code Exa 5.18 Wide band pass filter

```
1  // Exa 5.18 printed as 5.15
2  clc;
3  clear;
4  close;
5  // Given data
6  Cdesh = 0.01;// in  F
7  Cdesh= Cdesh* 10^-6;// in F
```

```
8   f_H = 1;// in kHz
9   f_H = f_H * 10^3;// in Hz
10  Rdesh= 1/(2*%pi*f_H*Cdesh);// in ohm
11  A_F2 = 2;
12  R1desh = 10*10^3;// in ohm
13  Rdesh_F= R1desh;// in ohm
14  disp(" (i) Low-pass Filter Components : ")
15  disp(R1desh*10^-3,"The value of R1desh in k   is");
16  disp(Rdesh*10^-3,"The value of Rdesh in k   is : ");
17  disp(Rdesh_F*10^-3,"The value of Rdesh_F in k   is :
        ");
18  disp(Cdesh*10^6,"The value of C in  F  is ");
19  C = 0.05;// in  F
20  C = C * 10^-6;// in F
21  f_L = 100;// in Hz
22  R = 1/(2*%pi*f_L*C);// in ohm
23  A_F1 = 2;
24  R1 = 10*10^3;// in ohm
25  R_F = R1;// in ohm
26  disp(" (ii) High pass Filter Components")
27  disp(R1*10^-3,"The value of R1 in k   is");
28  disp(R*10^-3,"The value of R in k   is");
29  disp(R_F*10^-3,"The value of R_F in k   is");
30  disp(C*10^6,"The value of C in  F  is ");
31  Q = sqrt(f_H*f_L)/(f_H-f_L);
32  disp(Q,"The quality factor is");
33
34  // Note : In High pass filter components, the value
        of R is calculated 31.83 k   but at last it is
        writter as 3.183 k   so the answer of R in High
        pass filter components is wrong.
```

Scilab code Exa 5.19 Narror band pass filter

```
1   // Exa 5.19
```

```
2  clc;
3  clear;
4  close;
5  // Given data
6  f_c = 2;// in kHz
7  f_c = f_c * 10^3;// in Hz
8  A_F = 10;
9  Q = 4;
10 C = 0.01;// in  F
11 C = C * 10^-6;// in F
12 R1 = Q/(2*%pi*f_c*C*A_F);// in ohm
13 R1 = R1 * 10^-3;// in k ohm
14 disp("The value of R1 is "+string(R1)+" k   (
      standard value 3.3 k )");
15 R2 = Q/(2*%pi*f_c*C*(2*Q^2-A_F));// in ohm
16 R2 = R2 * 10^-3;// in k ohm
17 disp("The value of R2 is "+string(R2)+" k   (
      standard value 1.5 k )");
18 R3 = Q/(%pi*f_c*C);// in ohm
19 R3 = R3 * 10^-3;// in k ohm
20 disp("The value of R3 is "+string(R3)+" k   (
      standard value 63 k )");
21 f_c1 = 1;// in kHz
22 Rdesh2 = R2*(((f_c*10^-3)/f_c1)^2);// in k ohm
23 disp("The value of Rdesh_2 is "+string(Rdesh2)+" k
       (standard value 5.8 k )");
```

Scilab code Exa 5.20 `Wide band reject Filter`

```
1  // Exa 5.20 Printed as 5.17
2  clc;
3  clear;
4  close;
5  // Given data
6  f_H = 100;// in Hz
```

```
7  f_L = 2;// in kHz
8  f_L = f_L * 10^3;// in Hz
9  C = 0.01;// in   F
10 C = C * 10^-6;// in F
11 R = 1/(2*%pi*f_L*C);// in ohm
12 R = R * 10^-3;// in k ohm
13 A_F = 2;
14 R1 = 10;// in k ohm
15 // A_F= 1+R_F/R1 or
16 R_F= (A_F-1)*R1;// in k ohm
17 disp(" (i) High-pass Section Components : ")
18 disp(C*10^6,"The value of C in   F  is : ")
19 disp(R,"The value of R in k   is");
20 disp(R_F,"The value of R_F and R1 in k   is");
21 Cdesh = 0.1;// in   F
22 Cdesh= Cdesh* 10^-6;// in F
23 Rdesh = 1/(2*%pi*f_H*Cdesh);// in ohm
24 Rdesh= Rdesh * 10^-3;// in k ohm
25 Rdesh1 = 10;// in k ohm
26 Rdesh_F= Rdesh1;// in k ohm
27 disp(" (ii) Low-pass Section components : ")
28 disp(Cdesh*10^6,"The value of Cdesh in   F  is : ")
29 disp(Rdesh,"The value of Rdesh in k   is");
30 disp(Rdesh_F,"The value of Rdesh_F and Rdesh1 in k
       is");
31 R2 = 10;// in k ohm
32 R3 = R2;// in k ohm
33 R4 = R2;// in k ohm
34 R_OM = (R2*R3*R4)/(R2*R3+R3*R4+R4*R2);// in k ohm
35 disp(" (iii) Summing Amplifier component")
36 disp(R_OM,"The value of R_OM in k   is");
```

Scilab code Exa 5.21 `Active notch filter`

```
1 // Exa 5.21
```

```
2 clc;
3 clear;
4 close;
5 // Given data
6 f_N = 50;// in Hz
7 C = 0.47;// in  F
8 C = C * 10^-6;// in F
9 R = 1/(2*%pi*f_N*C);// in ohm
10 R = R * 10^-3;// in k ohm
11 disp(R,"Resistance in k ohm is");
```

Scilab code Exa 5.22 Phase shift between input and output voltages

```
1 // EXa 5.22
2 clc;
3 clear;
4 close;
5 // Given data
6 R = 10;// in k ohm
7 R = R * 10^3;// in ohm
8 C = 0.01;// in  F
9 C = C * 10^-6;// in F
10 f = 2;// in kHz
11 f = f * 10^3;// in Hz
12 Phi = -2*atand(2*%pi*R*C*f);// in degree
13 disp(Phi,"The phase shift in degree is");
```

Scilab code Exa 5.23 Center frequency and quality factor

```
1 // Exa 5.23
2 clc;
3 clear;
4 close;
```

```
5  // Given data
6  f_L = 200; // in Hz
7  f_H = 1; // in kHz
8  f_H = f_H * 10^3; // in Hz
9  f_c = sqrt(f_H*f_L); // in Hz
10 disp(f_c,"The center frequency in Hz is");
11 Q = f_c/(f_H-f_L);
12 disp(Q,"Quality factor is");
```

Scilab code Exa 5.24 Wide bandpass Filter

```
1  // Exa 5.24
2  clc;
3  clear;
4  close;
5  // Given data
6  f1 = 5; // in kHz
7  f1 = f1 * 10^3; // in Hz
8  f2 = 15; // in kHz
9  f2 = f2 * 10^3; // in Hz
10 Cdesh = 0.01; // in  F
11 Cdesh= Cdesh * 10^-6; // in F
12 Rdesh = 1/(2*%pi*f2*Cdesh); // in ohm
13 A_F1 = 1.414;
14 A_F2 = A_F1;
15 Rdesh1 = 10; // in k ohm
16 Rdesh_F = (A_F1-1)*Rdesh1; // in k ohm
17 disp("(i) Low pass Filter components : ")
18 disp(Rdesh1,"The value of Rdesh1 in k   is : ")
19 disp(Rdesh*10^-3,"The value of Rdesh in k   is : ")
20 disp(Rdesh_F,"The value of Rdesh_F in k   is : ")
21 disp(Cdesh*10^6,"The value of Cdesh in  F  is");
22 C = 0.05; // in  F
23 C = C * 10^-6; // in F
24 R = 1/(2*%pi*f1*C); //in ohm
```

```scilab
25  R1 = 10;// in k ohm
26  R_F = (A_F1-1)*R1;// in k ohm
27  disp("(ii) High pass Filter components : ")
28  disp(R1,"The value of R1 in  k   is : ");
29  disp(R,"The value of R in     is : ");
30  disp(R_F,"The value of R_F in  k   is : ");
31  disp(C*10^6,"The value of C in  F   is : ");
```

Chapter 6

Sinusoidal Oscillators

Scilab code Exa 6.3 Frequency of oscillaitor

```
1  // Exa 6.3
2  clc;
3  clear;
4  close;
5  // Given data
6  R3 = 6;// in k ohm
7  R4 = 2;// in k ohm
8  A = 1+(R3/R4);
9  if A>3 then
10     disp("The circuit will work as the oscillator")
11 end
12 R = 5.1;// in k ohm
13 R = R * 10^3;// in ohm
14 C = 0.001;// in F
15 C = C * 10^-6;// in F
16 f = 1/(2*%pi*R*C);// in Hz
17 f = f * 10^-3;// in kHz
18 disp(f,"The frequency of oscillations in kHz is");
```

Scilab code Exa 6.4 Wien Bridge Oscillator

```
1  // Exa 6.4
2  clc;
3  clear;
4  close;
5  // Given data
6  C = 0.05;// in  F
7  C = C * 10^-6;// in F
8  f = 1;// in kHz
9  f = f * 10^3;// in Hz
10 R = 1/(2*%pi*f*C);// in ohm
11 R = R * 10^-3;// in k ohm
12 disp(R,"The value of R1 and R2 in  k   is");
13 R4 = 10;// in k ohm
14 disp(R4,"The value of R3 in  k   is");
15 R3 = 2*R4;// in k ohm
16 disp(R3,"The value of R4 in  k   is");
```

Chapter 8

CMOS Realization Of Inverters

Scilab code Exa 8.2 Value of RL ans WbyL

```scilab
1  // Exa 8.2
2  clc;
3  clear;
4  close;
5  // Given data
6  NMH= 1;// in V
7  VIH= 2;// in V
8  VTon= 0.5;// in V
9  VOL= 0.2;// in V
10 VDD= 3;// in V
11 KP= 30*10^-6;// in A/V^2
12 PD= 100*10^-6;// power dissipation in W
13 // Formula VIH= VTon +2*sqrt(2*VDD/(3*kn*RL))-1/(kn*
      RL) (i)
14 // Let x= 1/(kn*RL), putting the values in (i), we
      get
15 // x^2-5*x+2.25=0
16 x= [1 -5 2.25];
17 x= roots(x);
18 x=x(2);
19 // Formula PD= VDD*(VDD-VOL)/(2*RL)
```

```
20 RL= VDD*(VDD-VOL)/(2*PD);// in
21 disp(RL,"The value of RL in    is : ")
22 kn= 1/(x*RL);// in A/V^2
23 // Formula kn= KP*(W/L)
24 WbyL= kn/KP;
25 disp(WbyL,"The value of (W/L)n is : ")
```

Scilab code Exa 8.4 CMOS Inverter

```
1 // Exa 8.4
2 clc;
3 clear;
4 close;
5 // Given data
6 unCox= 40;// in   A /V^2
7 upCox= 20;// in   A /V^2
8 Ln= 0.5;// in   m
9 Lp= 0.5;// in   m
10 Wn= 2.0;// in   m
11 Wp= unCox*Wn/upCox;// in   m
12 disp(Wp,"The value of Wp in   m   is : ")
```

Scilab code Exa 8.5 Value of VOH VOL and Vth

```
1 // Exa 8.5
2 clc;
3 clear;
4 close;
5 // Given data
6 VTO= 0.43;// in V
7 VDD= 2.5;// in V
8 g=0.4;  // value of gamma
9 W1= 0.375;
```

```
10  L1 =0.25;
11  W2=  0.75;
12  L2 =0.25;
13  //VDD–VOUT–VT= VDD–VOUT–(VTO+g∗( s q r t ( 0.6+VOUT)−s q r t
        ( 0.6 ) ) )=0
14  //VOUTˆ2+VOUT∗(2∗A−gˆ2)+(A−0.6∗gˆ2)=0, where
15  A=VTO -VDD -g* sqrt (0.6) ;// assumed
16  B=  (2*A -g^2) ;// assumed
17  C=(A^2 -0.6* g^2) ;//assumed
18  VOUT=  [1 B C];
19  VOUT=  roots (VOUT) ;// in V
20  VOUT=  VOUT (2) ;// in V
21  VOH=  VOUT ;// in V
22  disp (VOH ,"The value of VOH in volts is : ")
23  Vout =(W1 +3*L2) -(VDD -VTO) *(W2*L1 /(W1*L2) -1) +  (VDD) /(
        VDD -VTO)
24  VOL=  Vout ;// in V
25  disp (VOL ,"The value of VOL in volts is : ")
26  Vth=  (VDD+VTO -L1) /(VDD*VTO) *(1-W1*L2 /(W2*L1) )+(L1*L2
        /VDD)
27  disp (Vth ,"The value of Vth for circuit A in volts is
          : ")
28  W4=  0.365;
29  L4 =0.25;
30  W3=  0.75;
31  L3 =0.15;
32  Vth =(L3*L4 /VDD) +(VDD /(W3*L4*VDD) ) -(VDD) /(1-W4*L3 /(W3
        *L4) ) -2*W4
33  disp (Vth ,"The value of Vth for circuit B in volts is
          : ")
```

Scilab code Exa 8.6 Value of Vx

```
1  // Exa 8.6
2  clc ;
```

```
3  clear;
4  close;
5  // Given data
6  VTO= 0.43;// in V
7  VDD= 2.5;// in V
8  g=0.5; // value of gamma
9  //VDD–Vx–VT= VDD–Vx–(VTO+g*(sqrt(0.6+Vx)−sqrt(0.6)))
       =0
10 //Vx^2+Vx*(2*A−g^2)+(A−0.6*g^2)=0, where
11 A=VTO-VDD-g*sqrt(0.6);// assumed
12 B= (2*A-g^2);// assumed
13 C=(A^2-0.6*g^2);//assumed
14 Vx= [1 B C];
15 Vx= roots(Vx);// in V
16 Vx= Vx(2);// in V
17 disp(Vx,"The value of Vx in volts is : ")
```

Chapter 10

Nonlinear Applications of IC Op Amps

Scilab code Exa 10.1 Threshold voltages

```
1  // Exa 10.1
2  clc;
3  clear;
4  close;
5  // Given data
6  V_CC = 15;// in V
7  V_sat = V_CC;// in V
8  R1 = 120;// in ohm
9  R2 = 51;// in k ohm
10 R2 = R2 * 10^3;// in ohm
11 V_in = 1;// in V
12 V_UT = (V_sat*R1)/(R1+R2);//in V
13 disp(V_UT*10^3,"When supply voltage is +15V then
       threshold voltage in mV is");
14 V_ULT = ((-V_sat)*R1)/(R1+R2);// in V
15 V_ULT = V_ULT;// in V
16 disp(V_ULT*10^3,"When supply voltage is -15V then
       threshold voltage in mV is");
```

Scilab code Exa 10.2 `Value of R1 and R2`

```
1  // EXa 10.2
2  clc;
3  clear;
4  close;
5  // Given data
6  V_sat = 12;// in V
7  V_H = 6;// in V
8  R1 = 10;// in k ohm
9  R1 = R1 * 10^3;// in ohm
10 // Formula V_H= R1/(R1+R2)*(V_sat-(-V_sat)) and Let
11 V = V_H/(V_sat-(-V_sat));// in V (assumed)
12 R2= (R1-V*R1)/V
13 disp(R1*10^-3,"The value of R1 in  k   is");
14 disp(R2*10^-3,"The value of R2 in  k   is");
```

Scilab code Exa 10.3 `Time duration`

```
1  // Exa 10.3
2  clc;
3  clear;
4  close;
5  // Given data
6  V_P = 5;// in V
7  V_LT = -1.5;// in V
8  V_H = 2;// in V
9  f = 1;// in kHz
10 f = f * 10^3;// in Hz
11 V_UT = V_H-V_LT;// in V
12 V_m = V_P/2;// in V
13 // Formula V_LT= V_m*sind(theta)
```

```
14  theta= asind(-V_LT/V_m);
15  T = 1/f;// in sec
16  theta1 = theta+180;// in degree
17  T1 = (T*theta1)/360;// in sec
18  T2 = T-T1;// in sec
19  disp(T1*10^3,"The value of T1 in ms is : ")
20  disp(T2*10^3,"The value of T2 in ms is : ")
```

Scilab code Exa 10.4 Value of R1 and R2

```
1  // Exa 10.4
2  clc;
3  clear;
4  close;
5  // Given data
6  V_H = 10;// in V
7  V_L = -10;// in V
8  I_max = 100;// in  A
9  I_max = I_max * 10^-6;// in A
10  V_HV = 0.1;// in V
11  V_sat = 10;// in V
12  R2 = 1;// in k ohm
13  R1 = 199;// in  k ohm
14  R = (R1*R2)/(R1+R2);// in k ohm
15  disp(R*10^3,"The resistance in    is");
16
17  // Note: The unit of the answer in the book is wrong
```

Scilab code Exa 10.6 values of VLT VUT and VH

```
1  // Exa 10.6
2  clc;
3  clear;
```

```
4 close;
5 // Given data
6 V_sat = 12;// in V
7 R1 = 1;// in k ohm
8 R2 = 3;// in k ohm
9 V_LT = ((-V_sat)*R1)/R2;// in V
10 disp(V_LT,"The value of V_LT in V is");
11 V_UT = (-(-V_sat) * R1)/R2;// in V
12 disp(V_UT,"The value of V_UT in V is");
13 V_H = (R1/R2)*(V_sat - (-V_sat));// in V
14 disp(V_H,"The value of V_H in V is");
```

Scilab code Exa 10.7 Threshold voltages and hysteresis voltage

```
1 // Exa 10.7
2 clc;
3 clear;
4 close;
5 // Given data
6 R1 = 80;// in k ohm
7 R2 = 20;// in k ohm
8 V_sat = 12.5;// in V
9 V_UT = (R2/(R1+R2))*V_sat;// in V
10 disp(V_UT,"Upper threshold voltage in V is");
11 V_LT = (R2/(R1+R2))*(-V_sat);// in V
12 disp(V_LT,"Lower threshold voltage in V is");
13 V_HV = (R2/(R1+R2))*(2*V_sat);// in V
14 disp(V_HV,"The hysteresis voltage in V is");
```

Scilab code Exa 10.10 Values of VUT VLT and oscillation frequency

```
1 // Exa 10.10
2 clc;
```

```
3  clear;
4  close;
5  // Given data
6  R1 = 86;// in k ohm
7  V_sat = 15;// in V
8  R2 = 100;// in k ohm
9  V_UT = (R1/(R1+R2))*V_sat;// in V
10 disp(V_UT,"The value of V_UT in V is ");
11 V_LT = (R1/(R1+R2))*(-V_sat);// in V
12 disp(V_LT,"The value of V_LT in V is");
13 R_F = 100;// in k ohm
14 R_F= R_F*10^3;// in ohm
15 C = 0.1;// in  F
16 C = C * 10^-6;// in F
17 f_o = 1/(2*R_F*C*log( (V_sat-V_LT)/(V_sat-V_UT) ));
      // in Hz
18 disp(f_o,"Frequency of oscillation in Hz is");
```

Scilab code Exa 10.12 Change in output voltage

```
1  // Exa 10.12
2  clc;
3  clear;
4  close;
5  // Given data
6  del_Vin = 5;// in V
7  FRR = 80;// in dB
8  // Formula FRR= 20*log10(del_Vin/del_Vout)
9  del_Vout=del_Vin/(10^(FRR/20));// in V
10 disp(del_Vout*10^3,"Change in output voltage in mV
      is : ")
```

Chapter 12

Digital to Analog and Analog to Digital Converters

Scilab code Exa 12.1 `Resolution`

```
1 // Exa 12.1
2 clc;
3 clear;
4 close;
5 // Given data
6 n = 8;
7 Resolution = 2^n;
8 disp(Resolution,"The resolution is");
9 disp("That is , the output voltage can have "+string(
     Resolution)+" different values including zero")
10 V_OFS = 2.55;// in V
11 Resolution= V_OFS/(2^n - 1)*10^3;
12 disp("Resolution is : "+string(Resolution)+" mV/1LSB
     ")
13 disp("That is , an input change of 1 LSB causes the
     output to change by "+string(Resolution)+" mV")
```

Scilab code Exa 12.2 `Final output voltage`

```
1  // Exa 12.2
2  clc;
3  clear;
4  close;
5  // Given data
6  n = 4;
7  V_OFS = 15;// in V
8  digital_input = '0110';// in binary
9  D= bin2dec(digital_input);
10 Resolution = V_OFS/((2^n)-1);// in V/LSB
11 V_out = Resolution*D;// in V
12 disp(V_out,"Final output voltage in V is");
```

Scilab code Exa 12.3 `VoFS and Vout`

```
1  // Exa 12.3
2  clc;
3  clear;
4  close;
5  // Given data
6  n = 8;
7  Resolution = 20;// in mV/LSB
8  digital_input= '10000000';// in binary
9  D= bin2dec(digital_input);// in decimal
10 Resolution=Resolution*10^-3;// in V/LSB
11 V_OFS = Resolution * ((2^n)-1);// in V
12 disp(V_OFS,"The value of V_OFS in V is");
13 V_out = Resolution*D;// in V
14 disp(V_out,"The value of V_out in V is");
```

Scilab code Exa 12.4 `Step size and analog output`

```
1  // Exa 12.4
2  clc ;
3  clear ;
4  close ;
5  // Given data
6  n = 4;
7  V_OFS = 5;// in V
8  digital_input= '1000';// in binary
9  D= bin2dec(digital_input);// in decimal
10 Resolution = V_OFS/((2^n)-1);
11 V_out = Resolution * D;// in V
12 disp(V_out,"When input is 1000 then, the output in V
       is");
13 // When
14 digital_input= '1111';// in binary
15 D= bin2dec(digital_input);// in decimal
16 V_out= Resolution * D;// in V
17 disp(V_out,"When input is 1111 then , the output in
      V is");
```

Scilab code Exa 12.5 Full scale output voltage and percentage resolution

```
1  // Exa 12.5
2  clc ;
3  clear ;
4  close ;
5  // Given data
6  n=12;
7  digital_input= '010101101101';// in binary
8  D= bin2dec(digital_input);// in decimal
9  step_size= 8;// in mV
10 step_size=step_size*10^-3;// in V
11 VoFS= step_size*(2^n-1);// in V
12 disp(VoFS,"The full scale output voltage in V is : "
      )
```

```
13 Per_resolution= step_size/VoFS*100;// in %
14 disp(Per_resolution,"Percentage resolution is :")
15 Vout= step_size*D;// in V
16 disp(Vout,"The output voltage in V is : ")
```

Scilab code Exa 12.6 Values of resistors

```
1 // EXa 12.6
2 clc;
3 clear;
4 close;
5 // Given data
6 V_R = 10;// in V
7 n = 4;
8 Resolution = 0.5;// in V
9 R_F = 10;// in k ohm
10 R = (1/2^n)*(V_R/Resolution)*R_F;// in k ohm
11 disp(R,"The value of resistor in k   is");
```

Scilab code Exa 12.7 Resolution and digital output

```
1 // Exa 12.7
2 clc;
3 clear;
4 close;
5 // Given data
6 V_i = 5.1;// in V
7 n = 8;
8 Re = 2^n;
9 Resolution = V_i/(2^n-1);// in V/LSB
10 disp(Resolution*10^3,"The Resolution in mV/LSB is");
11 // When
12 V_i = 1.28;// in V
```

```
13  D = round(V_i/Resolution);
14  D_in_binary= dec2bin(D);// in binary
15  disp(D_in_binary,"The digital output is :")
```

Scilab code Exa 12.8 Quantizing error

```
1  // Exa 12.8
2  clc;
3  clear;
4  close;
5  // Given data
6  V_i = 4.095;//input voltage in V
7  n = 12;
8  Q_E = V_i/( ((2^n)-1)*2 );// in V
9  Q_E = Q_E * 10^3;// in mV
10  disp(Q_E,"The quantizing error in mV is");
```

Scilab code Exa 12.9 The value of t2

```
1  // Exa 12.9
2  clc;
3  clear;
4  close;
5  // Given data
6  disp("Part (i)")
7  V_i = 100;// in mV
8  V_R = 100;// in mV
9  t1 = 83.33;// in ms
10  t2 = (V_i/V_R)*t1;// in ms
11  disp(t2,"The value of t2 in ms is");
12  disp("Part (ii)")
13  Vi = 200;// in mV
14  t_2 = (Vi/V_R)*t1;// in ms
```

```
15  disp ( t_2 ,"The value of t_2 in ms is");
```

Scilab code Exa 12.10 `Digital output`

```
1  // Exa 12.10
2  clc;
3  clear;
4  close;
5  // Given data
6  C_F = 12;//clock frequency in kHz
7  C_F = C_F * 10^3;// in Hz
8  V_i = 100;// in mV
9  V_R = 100;// in mV
10 t1 = 83.33*10^-3;// in sec
11 D = C_F * t1*(V_i/V_R);// in counts
12 disp("The Digital output is : "+string(round(D))+"
       counts");
```

Scilab code Exa 12.11 `Conversion time`

```
1  // Exa 12.12
2  clc;
3  clear;
4  close;
5  // Given data
6  n = 8;
7  T_C = 9;//in   sec
8  T_C = T_C * 10^-6;// in sec
9  f_max = 1/(2*%pi*T_C*(2^n));// in Hz
10 disp(f_max ,"Maximum frequency in Hz is");
```

Scilab code Exa 12.12 Maximum frequency

```
1  // Exa 12.12
2  clc;
3  clear;
4  close;
5  // Given data
6  n = 8;
7  T_C = 9; //in    sec
8  T_C = T_C * 10^-6; // in sec
9  f_max = 1/(2*%pi*T_C*(2^n)); // in Hz
10 disp(f_max,"Maximum frequency in Hz is");
```

Chapter 13

Integrated Circuit Timer

Scilab code Exa 13.1 Frequency and duty cycle

```
1  // Exa 13.1
2  clc ;
3  clear ;
4  close ;
5  // Given data
6  C = 0.01; // in  F
7  C = C *10^-6; // in F
8  R_A = 2; // in  k ohm
9  R_A = R_A * 10^3; // in ohm
10 R_B = 100; // in k ohm
11 R_B = R_B * 10^3; // in ohm
12 T_HIGH = 0.693*(R_A+R_B)*C; // in s
13 T_HIGH = T_HIGH; // in sec
14 T_LOW = 0.693*R_B*C; // in s
15 T_LOW = T_LOW ; // in sec
16 T = T_HIGH + T_LOW; // in sec
17 f = 1/T; // in Hz
18 disp(f,"Frequency in Hz is");
19 D = (T_HIGH/T)*100; // in %
20 disp(D,"Duty cycle in % is");
```

Scilab code Exa 13.2 `Positive and negative pulse width`

```scilab
1  // Exa 13.2
2  clc;
3  clear;
4  close;
5  // Given data
6  C = 1;// in  F
7  C = C * 10^-6;// in F
8  R_A = 4.7;// in k ohm
9  R_A = R_A * 10^3;// in ohm
10 R_B = 1;// in k ohm
11 R_B = R_B * 10^3;// in ohm
12 T_on = 0.693*(R_A+R_B)*C;// in s
13 T_on = T_on;// in sec
14 disp(T_on * 10^3,"Positive pulse width in ms is");
15 T_off = 0.693*R_B*C;// in s
16 T_off = T_off;// in ms
17 disp(T_off * 10^3,"Negative pulse width in ms is");
18 f = 1.4/((R_A+2*R_B)*C);// in Hz
19 disp(f,"Free running frequency in Hz is");
20 D = ((R_A+R_B)/(R_A+(2*R_B)))*100;// in %
21 disp(D,"The duty cycle in % is");
```

Scilab code Exa 13.3 `Resistor required`

```scilab
1  // Exa 13.3
2  clc;
3  clear;
4  close;
5  // Given data
6  C = 0.01;// in  F
```

```
7  C = C * 10^-6;// in F
8  f = 1;// in kHz
9  f = f * 10^3;// in Hz
10 R_A = 1.44/(2*f*C);// in ohm
11 R_A = R_A * 10^-3;// in k ohm
12 R_B= R_A;// in kohm
13 disp(R_A,"The value of both the resistors required
      in k   is");
```

Scilab code Exa 13.4 `A 555 timer`

```
1  // Exa 13.4
2  clc;
3  clear;
4  close;
5  // Given data
6  f = 700;// in Hz
7  C = 0.01;// in  F
8  C = C * 10^-6;// in F
9  a = 1.44;
10 R_A = a/(2*f*C);// in ohm
11 R_A = R_A * 10^-3;// in k ohm
12 R_B =R_A;// in k ohm
13 disp(C*10^6,"The the value of C in  F  is : ")
14 disp(R_A,"The value of both the resistors in k   is"
      );
15 disp("(Standard value of resistor is 100 k  )")
```

Scilab code Exa 13.5 `Frequency and duty cycle`

```
1  // Exa 13.5
2  clc;
3  clear;
```

```
 4  close;
 5  // Given data
 6  C = 0.01;// in  F
 7  C = C *10^-6;// in F
 8  R_A = 2;// in  k ohm
 9  R_A = R_A * 10^3;// in ohm
10  R_B = 100;// in k ohm
11  R_B = R_B * 10^3;// in ohm
12  T_HIGH = 0.693*(R_A+R_B)*C;// in s
13  T_HIGH = T_HIGH;// in sec
14  T_LOW = 0.693*R_B*C;// in s
15  T_LOW = T_LOW ;// in sec
16  T = T_HIGH + T_LOW;// in sec
17  f = 1/T;// in Hz
18  disp(f,"Frequency in Hz is");
19  D = (T_HIGH/T)*100;// in %
20  disp(D,"Duty cycle in % is");
```

Scilab code Exa 13.6 Positive and negative pulse width

```
 1  // Exa 13.6
 2  clc;
 3  clear;
 4  close;
 5  // Given data
 6  C = 1;// in  F
 7  C = C * 10^-6;// in F
 8  R_A = 4.7;// in k ohm
 9  R_A = R_A * 10^3;// in ohm
10  R_B = 1;// in k ohm
11  R_B = R_B * 10^3;// in ohm
12  T_on = 0.693*(R_A+R_B)*C;// in s
13  T_on = T_on;// in sec
14  disp(T_on * 10^3,"Positive pulse width in ms is");
15  T_off = 0.693*R_B*C;// in s
```

```
16  T_off = T_off ;// in ms
17  disp ( T_off * 10^3 ," Negative pulse width in ms is ") ;
18  f = 1.4/(( R_A +2* R_B )*C) ;// in Hz
19  disp (f ," Free running frequency in Hz is ") ;
20  D = (( R_A + R_B )/( R_A +(2* R_B )))*100 ;// in %
21  disp (D ," The duty cycle in % is ") ;
```

Scilab code Exa 13.7 Value of resistor required

```
1  // Exa 13.7
2  clc ;
3  clear ;
4  close ;
5  // Given data
6  C = 0.01;// in  F
7  C = C * 10^-6;// in F
8  f = 1;// in kHz
9  f = f* 10^3;// in Hz
10  a = 1.44;
11  R_A = a/(2*f*C) ;// in ohm
12  R_A = R_A * 10^-3;// in k ohm
13  R_B = R_A ;// in k ohm
14  disp ( R_A ," The value of both the resistors required
        in  k   is ") ;
```

Scilab code Exa 13.8 A 555 timer

```
1  // Exa 13.8
2  clc ;
3  clear ;
4  close ;
5  // Given data
6  f = 700 ;// in Hz
```

```
 7  C = 0.01;// in  F
 8  C = C * 10^-6;// in F
 9  a = 1.44;
10  R_A = a/(2*f*C);// in ohm
11  R_A = R_A * 10^-3;// in k ohm
12  R_B =R_A;// in k ohm
13  disp(C*10^6,"The the value of C in  F  is : ")
14  disp(R_A,"The value of both the resistors in k   is"
       );
15  disp("(Standard value of resistor is 100 k  )")
```

Scilab code Exa 13.9 `A 555 timer`

```
 1  // Exa  13.9
 2  clc;
 3  clear;
 4  close;
 5  // Given data
 6  f = 800;// in Hz
 7  C = 0.01;// in  F
 8  C =C * 10^-6;// in F
 9  R_A = 1.44/(5*f*C);// in ohm
10  R_A = R_A * 10^-3;// in k ohm
11  disp(R_A,"The value of R_A in k   is");
12  R_B = 2*R_A;// in k ohm
13  disp(R_B,"The value of R_B in k   is ");
```

Scilab code Exa 13.10 `Resistor required`

```
 1  // Exa  13.10
 2  clc;
 3  clear;
 4  close;
```

```
5 // Given data
6 C = 10; // in F
7 C = C*10^-6; // in F
8 T_ON = 5; // in sec
9 R = T_ON/(1.1*C); // in ohm
10 disp(R,"The resistor value in ohm is");
```

Scilab code Exa 13.11 `Resistor required`

```
1 // EXa 13.11
2 clc;
3 clear;
4 close;
5 // Given data
6 C = 10; // in F
7 C = C * 10^-6; // in F
8 T_off = 1; // in sec
9 //Formula T_off= 0.693*R2*C
10 R2 = T_off/(0.693*C); // in ohm
11 disp(R2,"The value of R2 in is");
12 T_on = 3; // in sec
13 // Formula T_on= 0.693*(R1+R2)*C
14 R1 =T_on/(C*0.693)-R2; // in ohm
15 disp(R1,"The value of R1 in is");
```

Scilab code Exa 13.12 `Value of RLED`

```
1 // Exa 13.12
2 clc;
3 clear;
4 close;
5 // Given data
6 C = 0.22; // in F
```

```
7  C=C*10^-6;// in F
8  T_on = 10;// in ms
9  T_on = T_on * 10^-3;// in s
10  V_CC = 15;// in V
11  V_BE = 0.7;// in V
12  V_EC = 0.2;// in V
13  V_LED= 1.4;// in V
14  I_LED= 20*10^-3;// in A
15  R = T_on/(C*1.1);// in ohm
16  R = R *10^-3;// in k ohm
17  disp("Values for first circuit : ")
18  disp(R,"The value of R in k  is");
19  V_o = V_CC-(2*V_BE) - V_EC;// in V
20  disp(V_o,"The output voltage in V is");
21  R_LED = (V_o - V_LED)/(I_LED);// in ohm
22  disp(R_LED,"The value of R_LED in   is : ")
23  // Part (ii)
24  f= 1*10^3;// in Hz
25  C=0.01*10^-6;// in F
26  D= 95/100;// duty cycle
27  // Formula f= 1.44/((R1+2*R2)*C)
28  // R1+2*R2= 1.44/(f*C)                    (i)
29  // D= (R1+R2)/(R1+2*R2)  or
30  // R2= (1-D)/(2*D-1)*R1             (ii)
31  // From eq (i) and (ii)
32  R1= 1.44/(f*C*(1+2*((1-D)/(2*D-1))));// in ohm
33  R2=  (1-D)/(2*D-1)*R1;// in ohm
34  disp("Values for second circuit : ")
35  disp(R1*10^-3,"The value of R1 in k  is : ");
36  disp(R2*10^-3,"The value of R2 in k  is : ");
```

Scilab code Exa 13.13 Resistor required

```
1  // Exa 13.13
2  clc;
```

```
3  clear;
4  close;
5  // Given data
6  T = 5;// in msec
7  T = T * 10^-3;// in sec
8  C = 0.1;// in  F
9  C = C * 10^-6;// in F
10  R = T/(C*1.1);// in ohm
11  R = R * 10^-3;// in k ohm
12  disp(R,"The resistor in k   is");
```

Scilab code Exa 13.14 A 555 based square wave generator

```
1  // Exa 13.14
2  clc;
3  clear;
4  close;
5  // Given data
6  f = 1;// in kHz
7  f = f * 10^3;// in Hz
8  T = 1/f;// in s
9  T = T * 10^3;// in msec
10  T_d = T/2;// in msec
11  T_d = T_d * 10^-3;// in sec
12  C = 0.1;// in  F
13  C = C * 10^-6;// in F
14  R2 = T_d/(0.69*C);// in ohm
15  R2 = R2 * 10^-3;// in k ohm
16  disp(C*10^6,"The value of C in  F  is : ")
17  disp(R2,"The value of R2 in k   is");
18  disp("The value of R1 will be 100    +10 k   pot");
```

Scilab code Exa 13.15 A 555 timer

```
1  // Exa 13.15
2  clc;
3  clear;
4  close;
5  // Given data
6  f = 800; // in Hz
7  D = 0.6;
8  C = 0.1; // in  F
9  C = C * 10^-6; // in F
10 // Formula f= 1.44/((R_A+2*R_B)*C)
11 // R_A+2*R_B= 1.44/(f*C)                    (i)
12 // D= (R_A+R_B)/(R_A+2*R_B) or
13 // R_B= (1-D)/(2*D-1)*R_A              (ii)
14 // From eq (i) and (ii)
15 R_A= 1.44/(f*C*(1+2*((1-D)/(2*D-1)))); // in ohm
16 R_B=  (1-D)/(2*D-1)*R_A; // in ohm
17 disp(R_A*10^-3,"The value of R_A in k  is : ");
18 disp(R_B*10^-3,"The value of R_B in k  is : ");
```

Scilab code Exa 13.16 `A 555 timer`

```
1  // Exa 13.16
2  clc;
3  clear;
4  close;
5  // Given data
6  f = 700; // in Hz
7  D = 0.5;
8  C = 0.1; // in  F
9  C = C * 10^-6; // in F
10 // Formula f= 1.44/((R_A+2*R_B)*C)
11 // R_A+2*R_B= 1.44/(f*C)                    (i)
12 // D= (R_A+R_B)/(R_A+2*R_B) or
13 // R_A+R_B=D*1.44/(f*C)
14 // From eq (i) and (ii)
```

```
15  R_B=round (1.44/( f∗C ))∗(1-D);
16  R_A= round (D∗1.44/( f∗C ))-R_B;
17  //R_A= 1.44/( f∗C∗(1+2∗((1−D)/(2∗D−1)))) ;// in ohm
18  //R_B= (1−D)/(2∗D−1)∗R_A ;// in ohm
19  disp ( round (R_A) ,"The value of R_A in    is : ");
20  disp ((R_B∗10^-3) ,"The value of R_B in k   is : ");
```

Scilab code Exa 13.17 `Output pulse width`

```
1  // Exa 13.17
2  clc ;
3  clear ;
4  close ;
5  // Given data
6  R_A = 20;// in k ohm
7  R_A = R_A ∗ 10^3;// in ohm
8  C = 0.1;// in   F
9  C = C∗10^-6;// in F
10 pulse_width = 1.1∗R_A∗C;// in s
11 disp ( pulse_width ∗10^3,"The output pulse width in ms
       is");
```

Scilab code Exa 13.18 `Relationship between tp and T`

```
1  // Exa 13.18
2  clc ;
3  clear ;
4  close ;
5  // Given data
6  n=4;
7  // t_p= X∗T, where
8  X= [0.2+(n-1)];// (assumed)
9  disp ("The relation between t_p and T is :")
```

```
10  disp (" t_p  =  " + string (X)+ " *T") ;
```

Scilab code Exa 13.19 Value of RA

```
1  // Exa  13.19
2  clc ;
3  clear ;
4  close ;
5  // Given  data
6  C  =  0.02; // in   F
7  C  =  C  *  10^-6; // in  F
8  f =2*10^3; // frequency  in  Hz
9  T  =  1/f ; // in  sec
10  n  =  5;
11  t_p  =  (0.2+(n-1))*T ; // in  sec
12  R_A  =  t_p/(1.1*C) ; // in  ohm
13  disp ( R_A *10^-3 ," The  value  of  R_A  in  k    is ") ;
```

Chapter 14

Phase Locked Loops

Scilab code Exa 14.1 Free running frequency and Lock range

```
1  // Exa 14.1
2  clc;
3  clear;
4  close;
5  // Given data
6  R_T = 10; // in k ohm
7  R_T = R_T * 10^3; // in ohm
8  C_T = 0.005; // in  F
9  C_T = C_T * 10^-6; // in F
10 C=10*10^-6; // in F
11 f_out = 0.25/(R_T*C_T); // in Hz
12 disp("Free Running frequency is : "+string(f_out
       *10^-3)+" kHz");
13 // Part (ii)
14 V=20; // in V
15 f_L= 8*f_out/V; // in Hz
16 disp("Lock range in kHz is :   "+string(f_L*10^-3)+"
       kHz")
17 // Part (iii)
18 f_C= sqrt(f_L/(2*%pi*3.6*10^3*C)); // in Hz
19 disp("Capture range is :   "+string(f_C)+" Hz")
```

Scilab code Exa 14.2 Frequency and number of bits

```
1  // Exa 14.2
2  clc;
3  clear;
4  close;
5  // Given data
6  f_out_max = 200;// in kHz
7  f_out_min = 4;// in Hz
8  f_CLK = 2.2*f_out_max;// in kHz
9  disp(f_CLK,"Frequency of reference oscillation in
      kHz is");
10 f_CLK= f_CLK*10^3;// in Hz
11 // Formula f_out_min= f_CLK/2^n
12 n=log(f_CLK/f_out_min)/log(2);
13 disp(round(n),"The number of bits required in the
      phase accumulator is : ")
```