Scilab Textbook Companion for
Integrated Circuits
by S. Sharma[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

# Analog Integrated Circuit Design An Overview

**Scilab code Exa 1.1** Constant current

```
// Exa 1.1
clc;
clear;
close;
// Given data
V_EE = 10;// in V
R2 = 2.4;// in k ohm
R1 = 2.4;// in k ohm
R3 = 1;// in k ohm
V_BE3 = 0.7;// in V
I = (V_EE - ((R2*V_EE)/(R1+R2)) - V_BE3)/R3;// in mA
disp(I,"The constant current in mA is");
```

**Scilab code Exa 1.2** Value of RE

```
// Exa 1.2
```

```
clc;
clear;
close;
// Given data
V_CC = 50;// in V
V_BE2 = 0.7;// in V
R = 50;// in k ohm
R = 50 * 10^3;// in ohm
I_C1 = 10;// in  A
I_C1 =I_C1 * 10^-6;// in A
V_T = 26;// in mV
V_T = V_T * 10^-3;// in V
I_C2 = (V_CC - V_BE2)/R;// in A
R_E = (V_T*log(I_C2/I_C1))/I_C1;// in ohm
R_E = R_E * 10^-3;// in k ohm
disp(R_E,"The value of R_E in k  is");
```

**Scilab code Exa 1.3** Collector current

```
// Exa 1.3
clc;
clear;
close;
// Given data
V = 10;// in V
V_BE = 0.715;// in V
V_R = 0-(V_BE - V);// in V
R = 5.6;// in  k ohm
I_R = V_R/R;// in  mA
bita = 100;
I_C = I_R * (bita/(1+bita));// in mA
disp(I_C,"For transistor Q1, the collector current
   in mA is");
I_C2 = I_R;// in mA
disp(I_C2,"For transistor Q2, the collector current
```

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

**Scilab code Exa 1.4** Collector current

```
// Exa 1.4
clc;
clear;
close;
// Given data
V = 10;// in V
V_BE = 0.715;// in V
R = 5.6;// in k ohm
I = (V-V_BE)/(R);// in mA
bita = 100;
I_C1 = (bita/(4+bita))*I;// in mA
disp(I_C1,"For transistor Q1, the collector current in mA is");
I_C2 = I_C1;// in mA
disp(I_C2,"For transistor Q2, the collector current in mA is");
I_C3 = I_C1;// in mA
disp(I_C3,"For transistor Q3, the collector current in mA is");
I_C4 = I_C1;// in mA
disp(I_C4,"For transistor Q4, the collector current in mA is");
```

**Scilab code Exa 1.5** Output resistance

```
// Exa 1.5
clc;
clear;
close;
// Given data
I_D1 = 100;// in  A
k_n = 200;// in  A /V^2
W = 10;// in  m
l = 1;// in  m
V_A = 20;// in V
V_ov = sqrt((I_D1*2)/(k_n*(W/l)));// in V
V_t = 0.7;// in V
V_GS = V_t + V_ov;// in V
V_GS = round(V_GS);// in V
V_DD = 3;// in V
I_REF = 100;// in  A
I_REF = I_REF * 10^-3;// in mA
R = (V_DD - V_GS)/I_REF;// in k ohm
disp(R,"The value of R in k  is");
V_ov_min = V_ov ;// in volt
disp(V_ov_min,"The lowest possible value of V_o in V is");
r_o2 = V_A/I_D1;// in M ohm
disp(r_o2,"The output resistance in M  is");
V_O = V_GS;// in V
del_Io = V_O/r_o2;// in  A
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

```
// Exa 2.2
clc;
clear;
close;
// Given data
I_b1 = 18;// in  A
I_b2 = 22;// in  A
I_b = (I_b1+I_b2)/2;// in  A
disp(I_b,"Input bias current in  A is ");
I_ios = abs(I_b1-I_b2);// in  A
disp(I_ios,"Input offset current in  A is");
```

---

**Scilab code Exa 2.4** Slew rate and maximum possible frequency

```
// Exa 2.4
clc;
clear;
close;
```

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

**Scilab code Exa 2.5** Output voltage

```
// Exa 2.5
clc;
clear;
close;
// Given data
CMRR = 100;
V1 = 300;// in   V
V2 = 240;// in   V
V_id = V1-V2;// in   V
V_cm = (V1+V2)/2;// in   V
A_id = 5000;
A_cm = A_id/CMRR;
V_out = (A_id*V_id) + (A_cm*V_cm);// in   V
V_out = V_out * 10^-3;// in mV
disp("Part (i)")
disp(V_out,"The output Voltage in mV is");
disp("Part (ii)")
CMRR = 10^5;
A_cm = A_id/CMRR;
```

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

**Scilab code Exa 2.6** CMRR

```
// Exa 2.6
clc;
clear;
close;
// Given data
R1 = 1;// in k ohm
R2 = 100;// in k ohm
A_id = R2/R1;// in k ohm
Epsilon = 1 - (90/R2);
A_cm = (R2*Epsilon)/(R1+R2)
CMMR = A_id/A_cm;
CMRR = 20*log10(CMMR);// in dB
disp(CMRR,"The value of CMRR in dB is");
```

**Scilab code Exa 2.6.2** Input offset voltage

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

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

**Scilab code Exa 2.17** Lowest value of RL

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

**Scilab code Exa 2.18** Slew rate and maximum possible frequency

```
// Exa 2.18
clc;
clear;
close;
// Given data
I_CQ = 10;// in  A
I_CQ= I_CQ*10^-6;// in A
I = I_CQ;// in A
C_C = 33;// in pF
C_C=C_C*10^-12;// in F
C = C_C;// in F
S = I/C;// in V/sec
```

```
disp(S*10^-6,"The slew rate in V/  -sec is");
V_m = 12;// in V
f_m = S/(2*%pi*V_m);// in Hz
f_m = f_m * 10^-3;// in kHz
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

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

```
R_of = R_of * 10^3;// in m
disp(R_of,"Output Resistance in m  is");
f_o = 5;// Hz
f_f = f_o*(1+(A*B));// in Hz
f_f = f_f *10^-3;// in kHz
disp(f_f,"Band width with feedback in kHz is");

// 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

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

**Scilab code Exa 3.4** Feedback resistance

```
// Exa 3.4
clc;
clear;
close;
// Given data
A_F = 61;
R1 = 1;// in k ohm
R1 = R1 * 10^3;// in ohm
```

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

**Scilab code Exa 3.5** Closed loop gain and input resistance

```
// Exa 3.5
clc;
clear;
close;
// Given data
A = 2*10^5;
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
B = R1/(R1+R_F);
R_i = 2;// in M ohm
R_i = R_i  * 10^6;// in ohm
R_o = 75;// in ohm
A_F = A/(1+(A*B));
disp(A_F,"The closed loop gain is");
R_if = R_i * (1+(A*B));// in ohm
disp(R_if*10^-9,"Input resistance in G  is");
R_of = R_o/(1+(A*B));// in ohm
R_of = R_of * 10^3;// in m
disp(R_of,"The output resistance in m is");
f_o = 5;// in Hz
f_f = f_o*(1+(A*B));// in Hz
f_f = f_f * 10^-3;// in kHz ... correction....
disp(f_f,"Bandwidth with feedback in kHz is");
```

**Scilab code Exa 3.6** Voltage gain and input resistance

```
// Exa 3.6
clc;
clear;
close;
// Given data
A =2*10^5;
R_i = 2;// in M ohm
R1 = 1;// in ohm
R_o= 75;// in ohm
R_F = 1;// in ohm
B = R1/(R1+R_F);
A_F = -1;
disp(A_F,"The voltage gain is ");
R_if = 330;// in ohm
disp(R_if,"Input resistance in    is");
R_of = R_o/(A/2);// in ohm
disp(R_of,"Output resistance in    is");
f_o = 5;// in Hz
f_F = (A/2)*f_o;// in Hz
f_F = f_F * 10^-6;// in MHz
disp(f_F,"The bandwidth in MHz is");
```

**Scilab code Exa 3.7** Value of Af Rif RoF and fF

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

```
f_o = 5;// in Hz
V_CC = 15;// in V
V_EE = -15;// in V
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
OVS= 13;// output voltage swing in V in
B = R1/(R1+R_F);
A_B = A*B;
A_B1 = 1+(A*B);
A_F = (1+(R_F/R1));
disp("Part (i) For non-inverting amplifier")
disp(A_F,"The value of A_F is");
R_iF = R_i * (A_B1);// in ohm
disp(R_iF*10^-9,"The value of R_iF in  G is");
R_OF = R_o/(A_B1);// in ohm
disp(R_OF,"The value of R_OF in ohm is");
f_F = f_o*A_B1;// in Hz
f_F =f_F * 10^-3;// in kHz
disp(f_F,"The value of f_F in kHz is");
V_ooT= OVS/(1+A*B);// in V
disp("The value of VooT is   "+string(V_ooT)+" V or "+string(V_ooT*10^3)+" mV")

disp("Part (ii) For inverting amplifier")
R_F = 4.7;// in k ohm
R_F = R_F* 10^3;// in ohm
R_1 = 470;// in ohm
A_F = -(R_F)/R_1;
disp(A_F,"The value of A_F is");
R_iF = R_1// in ohm
disp(R_iF,"The value of R_iF in    is");
R_OF = R_o/(A_B1);// in ohm
disp(R_OF,"The value of R_OF in    is");
f_F = f_o*A_B1;// in Hz
f_F =f_F * 10^-3;// in kHz
disp(f_F,"The value of f_F in kHz is");
```

```
V_ooT = OVS/A_B1;// in mV
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

```
// EXA 3.8
clc;
clear;
close;
// Given data
R1 = 5;// in  k ohm
R_F = 500;// in k ohm
V_in = 0.1;// in V
A_F = -(R_F/R1);
disp(A_F,"Voltage gain is");
R_i = R1;// in  k ohm
disp(R_i,"The Input resistance in k  is");
R_o = 0;// in ohm
disp(R_o,"Output resistance in   is");
V_out = A_F*V_in;// in V
disp(V_out,"Output voltage in V is");
I_in = V_in/(R1*10^3);// in A
I_in = I_in * 10^3;// in mA
disp(I_in,"Input current in mA is");
```

**Scilab code Exa 3.9** Input impedance voltage gain and power gain

```
// Exa 3.9
clc;
clear;
close;
// Given data
```

```
R_F = 1;// in M ohm
R_in = 1;// in M ohm
V_in = 1;// in V (assumed)
V_out = -(R_F/R_in)*V_in;
A_v = V_out/V_in;
disp(A_v,"The value of A_v is");
I_in = 1;// in A
I_out = I_in;// in A
A_in = I_out/I_in;
disp(A_in,"The value of A_in is");
A_P = abs(A_v*A_in);
disp(A_P,"The value of A_P is");
```

**Scilab code Exa 3.10** Inverting op amp

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

**Scilab code Exa 3.11** Inverting op amp

```
// Exa 3.11
clc;
clear;
```

```
close;
// Given data
A_v = -8;
V_in= -1;// in V
I1 = 15;// in   A
I1 = I1 * 10^-6;// in A
R1 = -(V_in)/I1;// in ohm
R1 = R1 * 10^-3;// in k ohm
disp(R1,"Minimum value of R1 in k  is");
R_F = -(A_v)*R1;// in  k ohm
disp(R_F,"The minimum value of R_F in k  is");

// 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

```
//Exa 4.1
clc;
clear;
close;
// Given data
R1= 1;// in k
R2= 1;// in k
R3= 1;// in k
RF= 1;// in k
Vin1= 2;// in volt
Vin2= 1;// in volt
Vin3= 4;// in volt
Vout= -(RF/R1*Vin1+RF/R2*Vin2+RF/R3*Vin3)
disp(Vout,"The output voltage in volts is : ")
```

**Scilab code Exa 4.2** Design an adder circuit

```
//Exa 4.2
clc;
clear;
close;
// Given data
RF= 100;// in k
Vout= '−(V1+10∗V2+100∗V3)';// given expression
// Vout= −(RF/R1∗V1+RF/R2∗V2+RF/R3∗V3)
// Comparing the Vout with the given expression
R1= RF;// in k
R2= RF/10;// in k
R3= RF/100;// in k
disp(R1,"The value of R1 in k  is : ");
disp(R2,"The value of R2 in k  is : ");
disp(R3,"The value of R3 in k  is : ");
```

**Scilab code Exa 4.3** Output voltage

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

**Scilab code Exa 4.4** Summing amplifier

```
//Exa 4.4
clc;
clear;
close;
// Given data
RF= 6;// in k
Vout= '-V1+2*V2-3*V3';// given expression or
Vout= '-(V1-2*V2+3*V3)';
// Vout= -(RF/R1*V1+RF/R2*V2+RF/R3*V3)
// Comparing the Vout with the given expression
R1= RF;// in k
R2= RF/2;// in k
R3= RF/3;// in k
disp(R1,"The value of R1 in k  is : ");
disp(R2,"The value of R2 in k  is : ");
disp(R3,"The value of R3 in k  is : ");
```

**Scilab code Exa 4.5** Values of resistances

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

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

**Scilab code Exa 4.6** Output voltage

```
//Exa 4.6
clc;
clear;
close;
// Given data
V1= 2;// in V
V2= -1;// in V
R=10;// assuming value in k
R1=R;// in k
R2= R;// in k
R3= R;// in k
R4= R;// in k
RF= 2*R;// in k
Vin1= V1*(R1*R2/(R1+R2))/(R1+(R2*R3/(R2+R3)));// in
   V
Vout1= Vin1*(1+RF/R1);// in V
Vin2= V2*(R3*R4/(R3+R4))/(R2+(R3*R4/(R3+R4)));// in
   V
Vout2= Vin2*(1+RF/R2);// in V
Vout= Vout1+Vout2;// in V
disp(Vout,"The output voltage in volts is : ")
```

**Scilab code Exa 4.7** Limiting frequency

```
//Exa 4.7
clc;
clear;
```

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

**Scilab code Exa 4.8** Practical integrator circuit

```
//Exa 4.8
clc;
clear;
close;
// Given data
f=10;// in kHz
f=f*10^3;// in Hz
dcGain= 10;
fa= f/10;// in Hz
R1= 10;// in  k
// Formula dcGain= RF/R1
RF= R1*dcGain;// in  k
RF=RF*10^3;// in
R1= R1*10^3;// in
// Formula fa= 1/(2*%pi*RF*CF)
CF= 1/(2*%pi*RF*fa);// in F
CF=CF*10^9;// in nF
Rcomp= R1*RF/(R1+RF);// in
disp(CF,"The value of CF in nF is : ")
disp(Rcomp*10^-3,"The value of Rcomp in k   is : ");

// Note: There is calculation error in evaluating
   the value of CF in the book. So The value of CF
```

```
in the book is wrong.
```

**Scilab code Exa 4.9** Maximum change in output voltage

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

**Scilab code Exa 4.10** Safe frequency and dc gain

```
// Exa 4.10
clc;
clear;
close;
// Given data
R_F = 1.2;// in M ohm
R_F = R_F * 10^6;// in ohm
```

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

---

**Scilab code Exa 4.11** Output voltage

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

```
(4000 *t)-1)) mV")
```

**Scilab code Exa 4.12** Closed loop time constant

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

**Scilab code Exa 4.13** Values of R1 and RF

```
//Exa 4.13
clc;
clear;
close;
// Given data
omega= 10000;// in rad/sec
```

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

**Scilab code Exa 4.14** Sketch of output voltage

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

**Scilab code Exa 4.15** Time duration for saturation

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

**Scilab code Exa 4.16** Values of resistors

```
// Exa 4.16
clc;
clear;
close;
// Given data
C_F = 10;// in  F
C_F = C_F * 10^-6;// in F
R1 = 1/C_F;// in ohm
R1 = R1 * 10^-3;// in k ohm
disp(R1,"The value of R1 in k  is");
R2 = 1/(C_F*2);// in ohm
R2 = R2 * 10^-3;// in k ohm
disp(R2,"The value of R2 in k  is");
R3 = 1/(C_F*5);// in ohm
R3 = R3 * 10^-3;;// in k ohm
disp(R3,"The value of R3 in k  is");
```

**Scilab code Exa 4.17** Practical differentiator circuit

```
// Exa 4.17
clc;
clear;
close;
// Given data
f_max = 150;// in Hz
f_a = f_max;// in Hz
disp(f_a,"The value of f_a in Hz is : ")
C1 = 1;// in   F
C1 = C1 * 10^-6;// in F
R_F = 1/(2*%pi*f_a*C1);// in ohm
disp(R_F*10^-3,"The value of R_F in k   is");
f_b = 10*f_a;// in Hz
R1 = 1/(2*%pi*f_b*C1);// in ohm
C_F = (R1*C1)/R_F;// in F
disp(C_F*10^6,"The value of C_F in   F is");
R_comp = (R1*R_F)/(R1+(R_F));// in ohm
disp(R_comp,"The value of R_comp in    is");
```

**Scilab code Exa 4.18** Output voltage

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

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

**Scilab code Exa 4.19** Values of ROM and Vout

```
// Exa 4.19
clc;
clear;
close;
// Given data
Vp= 1.5;// in V
f= 200;// in Hz
f_a= 1*10^3;// in Hz
C= 0.1*10^-6;// in F
// Formula f_a= 1/(2*%pi*f_a*C)
R= 1/(2*%pi*f_a*C);// in ohm
R= 1.5;// in k   (standard value)
f_b= 20*f_a;// in Hz
// Formula f_b= 1/(2*%pi*R_desh*C)
R_desh= 1/(2*%pi*f_b*C);// in ohm
R_desh= 82;// in ohm (standard value)
R_OM= R;// in kohm
disp(R_OM,"The value of R_OM in k   is : ")
omega= 2*%pi*f;// in radian
// Vin= Vp*sin(omega*t) and Vout= -R*C*dv_in/dt
// Vout= -R*C*Vp*omega*cos(400*%pi*t)
V= -R*10^3*C*Vp*omega;// (assumed)
//Vout= V*cos(400*%pi*t)
disp("Output voltage is "+string(V)+" *cos(400*%pi*t
    ) volts")
disp("Output voltage waveforms shown in figure")
x= -%pi/2:0.1:2*%pi;
plot(x,V*cos(x));
title("Output Voltage waveforms")
xlabel("Time")
```

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

**Scilab code Exa 4.20** Range of gain

```
// Exa 4.20
clc;
clear;
close;
// Given data
R2 = 100;// in ohm
R1 = 200;// in ohm
R_F = 100;// in k ohm
R_F = R_F * 10^3;// in ohm
R_G = 100;// in ohm
Gain_max = ( 1+((2*R_F)/R_G) ) * (R2/R1);
R = 100;// in  k ohm
R_G1 = 0.01+R;// in k ohm
R_G1 = R_G1 * 10^3;// in ohm
Gain_min = ( 1+((2*R_F)/R_G1) ) * (R2/R1);
disp("The gain can be varied from "+string(Gain_min)
   +" to "+string(Gain_max))
```

**Scilab code Exa 4.21** Value of RG

```
// EXa 4.21
clc;
clear;
close;
// Given data
R1 = 100;// in k ohm
R2 = 100;// in k ohm
R_F = 470;// in k ohm
Gain = 100;
```

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

**Scilab code Exa 4.22** Transconductance resistance

```
// Exa 4.22
clc;
clear;
close;
// Given data
R = 100;// in ohm
T = 25;// in degree C
alpha = 0.00392;
R1 = R*(1+(alpha*T));// in ohm
expression= 'R_T= Ro*[1+alpha*T]';
disp(expression,"The expression for the resistance at T C is : ")
disp(R1,"The transducer resistance at 25 C in  is");
T = 100;// in degree C
R2 = R*(1+(alpha*T));// in ohm
disp(R2,"The transducer resistance at 100 C in  is");
```

**Scilab code Exa 4.23** Instrumentation amplifier

```
// Exa 4.23
clc;
clear;
close;
// Given data
R3 = 1;// in k ohm
R4 = 1;// in k ohm
```

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

**Scilab code Exa 4.24** Expression for output voltage

```
// Exa 4.24
clc;
clear;
close;
// Given data
R1= 100;// in  k
R2=200;// in  k
R3= 20;// in  k
R4=40;// in  k
//Vout= [1+R2/R1]*[R4/(R3+R4)]*Vin1-R2/R1*Vin2
A=[1+R2/R1]*[R4/(R3+R4)];// (assumed)
disp("Output voltage is "+string(A)+"*(Vin1-Vin2)")
```

**Scilab code Exa 4.25** Gain of instrumentation amplifier

```
// Exa 4.25
clc;
clear;
close;
// Given data
R_F = 5;// in  k ohm
R_G = 1;// in  k ohm
```

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

**Scilab code Exa 4.27** Output voltage

```
// EXa 4.27
clc;
clear;
close;
// Given data
R_F = 10;// in  k ohm
R_G = 5;// in  k ohm
R1 = 1;// in  k ohm
R2 = 2;// in  k ohm
A = (1+ ((2*R_F)/R_G))*(R2/R1);
V_in2 = 2;// in mV
V_in1 = 1;// in mV
V_out = A*(V_in2-V_in1);// in mV
disp(V_out,"The output voltage in mV is");
```

**Scilab code Exa 4.28** Value of RG

```
// Exa 4.28
clc;
clear;
close;
// Given data
V_out = 3;// in V
V_in2 = 5;// in mV
V_in1 = 2;// in mV
V1 = V_in2-V_in1;// in mV
```

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

**Scilab code Exa 4.31** Three op amp instrumentation amplifier

```
//Exa 4.31
clc;
clear;
close;
// Given data
A=10000;
R1= 100;// in  k
A2= 1/5;// (assumed value)
R2= R1/A2;// in  k
// A= A1*A2 and A1= 1+2*RF/R_GB
RFbyR_GB= (A/A2-1)/2;
// [1+2*RF/RG]*A2= 1 and RG= RGB+100  k
R_G= (1-1/A2)/2*100/[(1/A2-1)/2-RFbyR_GB];// in  k
R_F= RFbyR_GB*R_G;// in  k
disp(R_F,"The value of R_F in  k   is : ")
disp(R_G*10^3,"The value of R_G in    is : ")
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

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

**Scilab code Exa 5.2** First order low pass filter

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

**Scilab code Exa 5.3** Low pass filter

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

**Scilab code Exa 5.4** Second order low pass filter

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

**Scilab code Exa 5.5** Second order low pass filter

```
// Exa 5.5
clc;
clear;
close;
// Given data
R1 = 12;// in k ohm
R_F = 7;// in k ohm
R2 = 33;// in k ohm
R3 = R2;// in k ohm
```

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

**Scilab code Exa 5.6** Second order low pass filter

```
// Exa 5.6
clc;
clear;
close;
// Given data
f_c = 2;// in kHz
f_c = f_c * 10^3;// in Hz
C2 = 0.033;// in  F
C2 = C2 * 10^-6;// in F
C3 = C2;// in F
C = C2;// in F
R2 = 1/(2*%pi*f_c*C);// in ohm
R2 = R2 * 10^-3;// in k ohm
R3=R2;// in kohm
disp(R2,"The value of R2 and R3 in k  is : ");
//R_F= 0.586*R1
R1= 2*R2*(1+0.586)/0.586;// in k ohm
disp(R1,"The value of R1 in k  is : ")
R1= 15;// in k ohm
R_F = 0.586 * R1;// in k ohm
disp(R_F,"The value of R_F in k  is : ");
```

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

**Scilab code Exa 5.7** Second order low pass filter

```
// Exa 5.7
clc;
clear;
close;
// Given data
f_c = 1;// in kHz
f_c = f_c * 10^3;// in Hz
C2 = 0.0047;// in F
C2 = C2 * 10^-6;// in F
C3 = C2;// in F
C = C2;// in F
R2 = 1/(2*%pi*f_c*C);// in ohm
R2 = R2 * 10^-3;// in k ohm
R3= R2;// in kohm
// Let
R1=30;// in kohm
R_F= R1*0.586;// in kohm
disp(floor(R2),"The value of R2 and R3 in k is : ")
disp(R1,"The value of R1 in k is : ")
disp(R_F,"The value of R_F in k is : ")
disp("The standard value of R_F is 20 k ")
```

**Scilab code Exa 5.8** Second order Butterworth filter

```
// Exa 5.8
clc;
clear;
close;
```

```
// Given data
f_c = 1.5;// in kHz
f_c = f_c * 10^3;// in Hz
alpha = sqrt(2);
R_F = (2-alpha);// in ohm
disp(R_F,"The value of R_F in   is : ");
R_i = 1;// in ohm
A_F = 1+(R_F/R_i);
disp(A_F,"The pass band gain is");
Omega_c = 2*%pi*f_c;// in rad/sec
C = 1;// in F
R = 1/Omega_c;// in ohm
R = R * 10^7;// in ohm
R=R*10^-3;// in kohm
R1 = R;// in k ohm
R2=R1;// in kohm
disp(R1,"The value of R1 and R2 in k  is");
C = C/10^7;// in  F
C = C * 10^9;// in nF
C1=C;// in nF
C2= C1;// in nF
disp(C1,"The value of C1 and C2 in nF is");

//Note: The unit of R1 and R2 is wrong in the book
```

**Scilab code Exa 5.9** Second order Butterworth filter

```
// Exa 5.9
clc;
clear;
close;
// Given data
alpha = 1.414;
f_c = 1.5;// in kHz
f_c = f_c * 10^3;// in Hz
```

```
C1 = 2/alpha;// in F
C2 = alpha/2;// in F
R1 = 1;// in ohm
R2 = R1;// in ohm
R_F = 2;// in ohm
Omega_c = 2*%pi*f_c;// in rad/sec
R = 1/Omega_c;// in ohm
R = R * 10^7;// in ohm
R1 = R;// in ohm
R2= R1;// in ohm
R_F = 2*R;// in ohm
C1 = C1/10^7;// in F
C2 = C2/10^7;// in F
disp(R1*10^-3,"The value of R1 and R2 in k ohm");
disp(C1*10^9,"The value of C1 in nF is");
disp(C2*10^9,"The value of C2 in nF is");
disp(R_F*10^-3,"The value of R_F in k ohm");
```

**Scilab code Exa 5.12** Second order low pass filter

```
// Exa 5.12
clc;
clear;
close;
// Given data
f_c = 10;// in kHz
f_c = f_c * 10^3;// in Hz
omega_c= 2*%pi*f_c;// in rad/sec
C = 0.01;// in  F
C= C*10^-6;// in F
Ri= 10*10^3;// in
n=2;
Q= 1/1.414;
R= 1/(2*%pi*f_c*C);// in
Af= 3-1/Q;
```

```
Rf= (Af-1)*Ri;// in
disp(C*10^6,"The value of C in  F is : ")
disp(R*10^-3,"The value of R in k  is : ")
disp(Rf*10^-3,"The value of Rf in k  is : ")
disp("Frequency versus gain magnitude shown in following table:")
disp("      Frequency in Hz      Gain Magnitude in dB |H(s)|")
f= 1000;// in Hz
omega= 2*%pi*f;// in rad/sec
HsdB= 20*log10(Af/sqrt(1+(omega/omega_c)^4))
disp("            "+string(f)+"                              "+string(HsdB))
f= 2000;// in Hz
omega= 2*%pi*f;// in rad/sec
HsdB= 20*log10(Af/sqrt(1+(omega/omega_c)^4))
disp("            "+string(f)+"                              "+string(HsdB))
f= 5000;// in Hz
omega= 2*%pi*f;// in rad/sec
HsdB= 20*log10(Af/sqrt(1+(omega/omega_c)^4))
disp("            "+string(f)+"                              "+string(HsdB))
f= 10000;// in Hz
omega= 2*%pi*f;// in rad/sec
HsdB= 20*log10(Af/sqrt(1+(omega/omega_c)^4))
disp("           "+string(f)+"                              "+string(HsdB))
f= 50000;// in Hz
omega= 2*%pi*f;// in rad/sec
HsdB= 20*log10(Af/sqrt(1+(omega/omega_c)^4))
disp("           "+string(f)+"                             "+string(HsdB))
```

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

**Scilab code Exa 5.13** Fourth order Butterworth filter

```
// Exa 5.13
clc;
clear;
close;
// Given data
f_c = 1;// in kHz
f_c = f_c * 10^3;// in Hz
C = 0.1;// in  F
disp(C,"The value of C in  F is");
C = C * 10^-6;// in F
R = 1/(2*%pi*f_c*C);// in ohm
disp(R*10^-3,"The value of R in k  is");
Q1 = 1/0.765;
alpha1 = 1/Q1;
Q2 = 1/1.848;
alpha2 = 1/Q2;
A_F1 = 3-alpha1;
A_F2 = 3-alpha2;
R_i =10*10^3;// in ohm
R_F = (A_F1-1)*R_i;// in ohm
disp(R_F*10^-3,"For first stage the value of R_F in
   k  is");
R_i = 100*10^3;// ohm
R_F = (A_F2-1)*R_i;// in ohm
disp(R_F*10^-3,"For second stage the value of R_F in
    k  is");
```

**Scilab code Exa 5.14** Value of Resistance

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

**Scilab code Exa 5.15** Passband gain

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

```
// 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

```
// Exa 5.16 printed as 5.13
clc;
clear;
close;
// Given data
R1 = 27;// in k ohm
R1 = R1 * 10^3;// in ohm
R2 = R1;// in ohm
R3 = R2 ;// in ohm
R = R1;// in ohm
R_L = 10;// in k ohm
R_F = 16;// in k ohm
C2 = 0.005;// in   F
C2 = C2 * 10^-6;// in F
C3 = C2;// in F
C = C3;// in F
f_c = 1/(2*%pi*R*C);// in Hz
f_c = f_c * 10^-3;// in kHz
R1= R1*10^-3;// in kohm
disp(f_c,"Cut off frequency in kHz is");
A_F = 1+(R_F/R1);
disp(A_F,"Voltage gain is");
```

**Scilab code Exa 5.17** Second order Bessel Filter

```
// Exa 5.17
```

```
clc;
clear;
close;
// Given data
alpha = 1.732;
k_f = 1.274;
C1 = 1;// in F
C2 = C1;// in F
R1 = alpha/2;// in ohm
R2 = 2/alpha;// in ohm
R_F = R2;// in ohm
f_3dB = 2;// in kHz
f_3dB = f_3dB * 10^3;// in Hz
f_c = f_3dB/k_f;// in Hz
Omega_c = 2*%pi*f_c;// in rad/sec
R1 = R1/Omega_c;// in ohm
R1 = R1 * 10^8;// in ohm
R2 = R2/Omega_c;// in ohm
R2 = R2 * 10^8;// in ohm
R_F = R2;// in ohm
C1 = C1/10^8;// in F
disp(R1*10^-3,"The value of R1 in k  is : ")
disp(R2*10^-3,"The value of R2 and R_F in k  is : "
  )
disp(C1*10^9,"The value of C1 and C2 in nF is : ")
```

**Scilab code Exa 5.18** Wide band pass filter

```
// Exa 5.18 printed as 5.15
clc;
clear;
close;
// Given data
Cdesh = 0.01;// in  F
Cdesh= Cdesh* 10^-6;// in F
```

```
f_H = 1;// in kHz
f_H = f_H * 10^3;// in Hz
Rdesh= 1/(2*%pi*f_H*Cdesh);// in ohm
A_F2 = 2;
R1desh = 10*10^3;// in ohm
Rdesh_F= R1desh;// in ohm
disp("(i) Low-pass Filter Components : ")
disp(R1desh*10^-3,"The value of R1desh in k  is");
disp(Rdesh*10^-3,"The value of Rdesh in k  is : ");
disp(Rdesh_F*10^-3,"The value of Rdesh_F in k  is : ");
disp(Cdesh*10^6,"The value of C in  F is ");
C = 0.05;// in  F
C = C * 10^-6;// in F
f_L = 100;// in Hz
R = 1/(2*%pi*f_L*C);// in ohm
A_F1 = 2;
R1 = 10*10^3;// in ohm
R_F = R1;// in ohm
disp("(ii) High pass Filter Components")
disp(R1*10^-3,"The value of R1 in k  is");
disp(R*10^-3,"The value of R in k  is");
disp(R_F*10^-3,"The value of R_F in k  is");
disp(C*10^6,"The value of C in  F is ");
Q = sqrt(f_H*f_L)/(f_H-f_L);
disp(Q,"The quality factor is");

// 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

```
// Exa 5.19
```

```
clc;
clear;
close;
// Given data
f_c = 2;// in kHz
f_c = f_c * 10^3;// in Hz
A_F = 10;
Q = 4;
C = 0.01;// in   F
C = C * 10^-6;// in F
R1 = Q/(2*%pi*f_c*C*A_F);// in ohm
R1 = R1 * 10^-3;// in k ohm
disp("The value of R1 is "+string(R1)+" k  (standard value 3.3 k )");
R2 = Q/(2*%pi*f_c*C*(2*Q^2-A_F));// in ohm
R2 = R2 * 10^-3;// in k ohm
disp("The value of R2 is "+string(R2)+" k  (standard value 1.5 k )");
R3 = Q/(%pi*f_c*C);// in ohm
R3 = R3 * 10^-3;// in k ohm
disp("The value of R3 is "+string(R3)+" k  (standard value 63 k )");
f_c1 = 1;// in kHz
Rdesh2 = R2*(((f_c*10^-3)/f_c1)^2);// in k ohm
disp("The value of Rdesh_2 is "+string(Rdesh2)+" k (standard value 5.8 k )");
```

**Scilab code Exa 5.20** Wide band reject Filter

```
// Exa 5.20 Printed as 5.17
clc;
clear;
close;
// Given data
f_H = 100;// in Hz
```

```
f_L = 2;// in kHz
f_L = f_L * 10^3;// in Hz
C = 0.01;// in  F
C = C * 10^-6;// in F
R = 1/(2*%pi*f_L*C);// in ohm
R = R * 10^-3;// in k ohm
A_F = 2;
R1 = 10;// in k ohm
// A_F= 1+R_F/R1 or
R_F= (A_F-1)*R1;// in k ohm
disp("(i) High-pass Section Components : ")
disp(C*10^6,"The value of C in  F is : ")
disp(R,"The value of R in k  is");
disp(R_F,"The value of R_F and R1 in k  is");
Cdesh = 0.1;// in  F
Cdesh= Cdesh* 10^-6;// in F
Rdesh = 1/(2*%pi*f_H*Cdesh);// in ohm
Rdesh= Rdesh * 10^-3;// in k ohm
Rdesh1 = 10;// in k ohm
Rdesh_F= Rdesh1;// in k ohm
disp("(ii) Low-pass Section components : ")
disp(Cdesh*10^6,"The value of Cdesh in  F is : ")
disp(Rdesh,"The value of Rdesh in k  is");
disp(Rdesh_F,"The value of Rdesh_F and Rdesh1 in k  is");
R2 = 10;// in k ohm
R3 = R2;// in k ohm
R4 = R2;// in k ohm
R_OM = (R2*R3*R4)/(R2*R3+R3*R4+R4*R2);// in k ohm
disp("(iii) Summing Amplifier component")
disp(R_OM,"The value of R_OM in k  is");
```

**Scilab code Exa 5.21** Active notch filter

```
// Exa 5.21
```

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

**Scilab code Exa 5.22** Phase shift between input and output voltages

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

**Scilab code Exa 5.23** Center frequency and quality factor

```
// Exa 5.23
clc;
clear;
close;
```

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

**Scilab code Exa 5.24** Wide bandpass Filter

```
// Exa 5.24
clc;
clear;
close;
// Given data
f1 = 5;// in kHz
f1 = f1 * 10^3;// in Hz
f2 = 15;// in kHz
f2 = f2 * 10^3;// in Hz
Cdesh = 0.01;// in  F
Cdesh= Cdesh * 10^-6;// in F
Rdesh = 1/(2*%pi*f2*Cdesh);// in ohm
A_F1 = 1.414;
A_F2 = A_F1;
Rdesh1 = 10;// in k ohm
Rdesh_F = (A_F1-1)*Rdesh1;// in k ohm
disp("(i) Low pass Filter components : ")
disp(Rdesh1,"The value of Rdesh1 in k  is : ")
disp(Rdesh*10^-3,"The value of Rdesh in k  is : ")
disp(Rdesh_F,"The value of Rdesh_F in k  is : ")
disp(Cdesh*10^6,"The value of Cdesh in  F is");
C = 0.05;// in  F
C = C * 10^-6;// in F
R = 1/(2*%pi*f1*C);//in ohm
```

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

# Chapter 6

# Sinusoidal Oscillators

**Scilab code Exa 6.3** Frequency of oscillaitor

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

**Scilab code Exa 6.4** Wien Bridge Oscillator

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

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

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

**Scilab code Exa 8.4** CMOS Inverter

```
// Exa 8.4
clc;
clear;
close;
// Given data
unCox= 40;// in   A /V^2
upCox= 20;// in   A /V^2
Ln= 0.5;// in   m
Lp= 0.5;// in   m
Wn= 2.0;// in   m
Wp= unCox*Wn/upCox;// in   m
disp(Wp,"The value of Wp in   m is : ")
```

**Scilab code Exa 8.5** Value of VOH VOL and Vth

```
// Exa 8.5
clc;
clear;
close;
// Given data
VTO= 0.43;// in V
VDD= 2.5;// in V
g=0.4; // value of gamma
W1= 0.375;
```

```
L1=0.25;
W2= 0.75;
L2=0.25;
//VDD-VOUT-VT= VDD-VOUT-(VTO+g*(sqrt(0.6+VOUT)-sqrt(0.6)))=0
//VOUT^2+VOUT*(2*A-g^2)+(A-0.6*g^2)=0, where
A=VTO-VDD-g*sqrt(0.6);// assumed
B= (2*A-g^2);// assumed
C=(A^2-0.6*g^2);//assumed
VOUT= [1 B C];
VOUT= roots(VOUT);// in V
VOUT= VOUT(2);// in V
VOH= VOUT;// in V
disp(VOH,"The value of VOH in volts is : ")
Vout=(W1+3*L2)-(VDD-VTO)*(W2*L1/(W1*L2)-1)+ (VDD)/(VDD-VTO)
VOL= Vout;// in V
disp(VOL,"The value of VOL in volts is : ")
Vth= (VDD+VTO-L1)/(VDD*VTO)*(1-W1*L2/(W2*L1))+(L1*L2/VDD)
disp(Vth,"The value of Vth for circuit A in volts is : ")
W4= 0.365;
L4=0.25;
W3= 0.75;
L3=0.15;
Vth=(L3*L4/VDD)+(VDD/(W3*L4*VDD))-(VDD)/(1-W4*L3/(W3*L4))-2*W4
disp(Vth,"The value of Vth for circuit B in volts is : ")
```

**Scilab code Exa 8.6** Value of Vx

```
// Exa 8.6
clc;
```

```
clear;
close;
// Given data
VTO= 0.43;// in V
VDD= 2.5;// in V
g=0.5; // value of gamma
//VDD-Vx-VT= VDD-Vx-(VTO+g*(sqrt(0.6+Vx)-sqrt(0.6)))
   =0
//Vx^2+Vx*(2*A-g^2)+(A-0.6*g^2)=0, where
A=VTO-VDD-g*sqrt(0.6);// assumed
B= (2*A-g^2);// assumed
C=(A^2-0.6*g^2);//assumed
Vx= [1 B C];
Vx= roots(Vx);// in V
Vx= Vx(2);// in V
disp(Vx,"The value of Vx in volts is : ")
```

# Chapter 10

# Nonlinear Applications of IC Op Amps

**Scilab code Exa 10.1** Threshold voltages

```
// Exa 10.1
clc;
clear;
close;
// Given data
V_CC = 15;// in V
V_sat = V_CC;// in V
R1 = 120;// in ohm
R2 = 51;// in k ohm
R2 = R2 * 10^3;// in ohm
V_in = 1;// in V
V_UT = (V_sat*R1)/(R1+R2);//in V
disp(V_UT*10^3,"When supply voltage is +15V then
   threshold voltage in mV is");
V_ULT = ((-V_sat)*R1)/(R1+R2);// in V
V_ULT = V_ULT;// in V
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

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

**Scilab code Exa 10.3** Time duration

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

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

**Scilab code Exa 10.4** Value of R1 and R2

```
// Exa 10.4
clc;
clear;
close;
// Given data
V_H = 10;// in V
V_L = -10;// in V
I_max = 100;// in  A
I_max = I_max * 10^-6;// in A
V_HV = 0.1;// in V
V_sat = 10;// in V
R2 = 1;// in k ohm
R1 = 199;// in  k ohm
R = (R1*R2)/(R1+R2);// in k ohm
disp(R*10^3,"The resistance in  is");

// Note: The unit of the answer in the book is wrong
```

**Scilab code Exa 10.6** values of VLT VUT and VH

```
// Exa 10.6
clc;
clear;
```

```
close;
// Given data
V_sat = 12;// in V
R1 = 1;// in k ohm
R2 = 3;// in k ohm
V_LT = ((-V_sat)*R1)/R2;// in V
disp(V_LT,"The value of V_LT in V is");
V_UT = (-(-V_sat) * R1)/R2;// in V
disp(V_UT,"The value of V_UT in V is");
V_H = (R1/R2)*(V_sat - (-V_sat));// in V
disp(V_H,"The value of V_H in V is");
```

**Scilab code Exa 10.7** Threshold voltages and hysteresis voltage

```
// Exa 10.7
clc;
clear;
close;
// Given data
R1 = 80;// in k ohm
R2 = 20;// in k ohm
V_sat = 12.5;// in V
V_UT = (R2/(R1+R2))*V_sat;// in V
disp(V_UT,"Upper threshold voltage in V is");
V_LT = (R2/(R1+R2))*(-V_sat);// in V
disp(V_LT,"Lower threshold voltage in V is");
V_HV = (R2/(R1+R2))*(2*V_sat);// in V
disp(V_HV,"The hysteresis voltage in V is");
```

**Scilab code Exa 10.10** Values of VUT VLT and oscillation frequency

```
// Exa 10.10
clc;
```

```
clear;
close;
// Given data
R1 = 86;// in k ohm
V_sat = 15;// in V
R2 = 100;// in k ohm
V_UT = (R1/(R1+R2))*V_sat;// in V
disp(V_UT,"The value of V_UT in V is ");
V_LT = (R1/(R1+R2))*(-V_sat);// in V
disp(V_LT,"The value of V_LT in V is");
R_F = 100;// in k ohm
R_F= R_F*10^3;// in ohm
C = 0.1;// in  F
C = C * 10^-6;// in F
f_o = 1/(2*R_F*C*log( (V_sat-V_LT)/(V_sat-V_UT) ));
    // in Hz
disp(f_o,"Frequency of oscillation in Hz is");
```

**Scilab code Exa 10.12** Change in output voltage

```
// Exa 10.12
clc;
clear;
close;
// Given data
del_Vin = 5;// in V
FRR = 80;// in dB
// Formula FRR= 20*log10(del_Vin/del_Vout)
del_Vout=del_Vin/(10^(FRR/20));// in V
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

```
// Exa 12.1
clc;
clear;
close;
// Given data
n = 8;
Resolution = 2^n;
disp(Resolution,"The resolution is");
disp("That is, the output voltage can have "+string(
    Resolution)+" different values including zero")
V_OFS = 2.55;// in V
Resolution= V_OFS/(2^n - 1)*10^3;
disp("Resolution is : "+string(Resolution)+" mV/1LSB
    ")
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

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

**Scilab code Exa 12.3** VoFS and Vout

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

**Scilab code Exa 12.4** Step size and analog output

```
// Exa 12.4
clc;
clear;
close;
// Given data
n = 4;
V_OFS = 5;// in V
digital_input= '1000';// in binary
D= bin2dec(digital_input);// in decimal
Resolution = V_OFS/((2^n)-1);
V_out = Resolution * D;// in V
disp(V_out,"When input is 1000 then, the output in V
     is");
// When
digital_input= '1111';// in binary
D= bin2dec(digital_input);// in decimal
V_out= Resolution * D;// in V
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

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

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

**Scilab code Exa 12.6** Values of resistors

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

**Scilab code Exa 12.7** Resolution and digital output

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

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

**Scilab code Exa 12.8** Quantizing error

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

**Scilab code Exa 12.9** The value of t2

```
// Exa 12.9
clc;
clear;
close;
// Given data
disp("Part (i)")
V_i = 100;// in mV
V_R = 100;// in mV
t1 = 83.33;// in ms
t2 = (V_i/V_R)*t1;// in ms
disp(t2,"The value of t2 in ms is");
disp("Part (ii)")
Vi = 200;// in mV
t_2 = (Vi/V_R)*t1;// in ms
```

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

**Scilab code Exa 12.10** Digital output

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

**Scilab code Exa 12.11** Conversion time

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

**Scilab code Exa 12.12** Maximum frequency

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

# Chapter 13

# Integrated Circuit Timer

**Scilab code Exa 13.1** Frequency and duty cycle

```
// Exa 13.1
clc;
clear;
close;
// Given data
C = 0.01;// in   F
C = C *10^-6;// in F
R_A = 2;// in  k ohm
R_A = R_A * 10^3;// in ohm
R_B = 100;// in k ohm
R_B = R_B * 10^3;// in ohm
T_HIGH = 0.693*(R_A+R_B)*C;// in s
T_HIGH = T_HIGH;// in sec
T_LOW = 0.693*R_B*C;// in s
T_LOW = T_LOW ;// in sec
T = T_HIGH + T_LOW;// in sec
f = 1/T;// in Hz
disp(f,"Frequency in Hz is");
D = (T_HIGH/T)*100;// in %
disp(D,"Duty cycle in % is");
```

**Scilab code Exa 13.2** Positive and negative pulse width

```
// Exa 13.2
clc;
clear;
close;
// Given data
C = 1;// in  F
C = C * 10^-6;// in F
R_A = 4.7;// in k ohm
R_A = R_A * 10^3;// in ohm
R_B = 1;// in k ohm
R_B = R_B * 10^3;// in ohm
T_on = 0.693*(R_A+R_B)*C;// in s
T_on = T_on;// in sec
disp(T_on * 10^3,"Positive pulse width in ms is");
T_off = 0.693*R_B*C;// in s
T_off = T_off;// in ms
disp(T_off * 10^3,"Negative pulse width in ms is");
f = 1.4/((R_A+2*R_B)*C);// in Hz
disp(f,"Free running frequency in Hz is");
D = ((R_A+R_B)/(R_A+(2*R_B)))*100;// in %
disp(D,"The duty cycle in % is");
```

**Scilab code Exa 13.3** Resistor required

```
// Exa 13.3
clc;
clear;
close;
// Given data
C = 0.01;// in  F
```

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

**Scilab code Exa 13.4** A 555 timer

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

**Scilab code Exa 13.5** Frequency and duty cycle

```
// Exa 13.5
clc;
clear;
```

```
close;
// Given data
C = 0.01;// in   F
C = C *10^-6;// in F
R_A = 2;// in  k ohm
R_A = R_A * 10^3;// in ohm
R_B = 100;// in k ohm
R_B = R_B * 10^3;// in ohm
T_HIGH = 0.693*(R_A+R_B)*C;// in s
T_HIGH = T_HIGH;// in sec
T_LOW = 0.693*R_B*C;// in s
T_LOW = T_LOW ;// in sec
T = T_HIGH + T_LOW;// in sec
f = 1/T;// in Hz
disp(f,"Frequency in Hz is");
D = (T_HIGH/T)*100;// in %
disp(D,"Duty cycle in % is");
```

**Scilab code Exa 13.6** Positive and negative pulse width

```
// Exa 13.6
clc;
clear;
close;
// Given data
C = 1;// in   F
C = C * 10^-6;// in F
R_A = 4.7;// in k ohm
R_A = R_A * 10^3;// in ohm
R_B = 1;// in k ohm
R_B = R_B * 10^3;// in ohm
T_on = 0.693*(R_A+R_B)*C;// in s
T_on = T_on;// in sec
disp(T_on * 10^3,"Positive pulse width in ms is");
T_off = 0.693*R_B*C;// in s
```

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

**Scilab code Exa 13.7** Value of resistor required

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

**Scilab code Exa 13.8** A 555 timer

```
// Exa 13.8
clc;
clear;
close;
// Given data
f = 700;// in Hz
```

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

**Scilab code Exa 13.9** A 555 timer

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

**Scilab code Exa 13.10** Resistor required

```
// Exa 13.10
clc;
clear;
close;
```

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

**Scilab code Exa 13.11** Resistor required

```
// EXa 13.11
clc;
clear;
close;
// Given data
C = 10;// in   F
C = C * 10^-6;// in F
T_off = 1;// in sec
//Formula T_off= 0.693*R2*C
R2 = T_off/(0.693*C);// in ohm
disp(R2,"The value of R2 in     is");
T_on = 3;// in sec
// Formula T_on= 0.693*(R1+R2)*C
R1 =T_on/(C*0.693)-R2;// in ohm
disp(R1,"The value of R1 in     is");
```

**Scilab code Exa 13.12** Value of RLED

```
// Exa 13.12
clc;
clear;
close;
// Given data
C = 0.22;// in   F
```

```
C=C*10^-6;// in F
T_on = 10;// in ms
T_on = T_on * 10^-3;// in s
V_CC = 15;// in V
V_BE = 0.7;// in V
V_EC = 0.2;// in V
V_LED= 1.4;// in V
I_LED= 20*10^-3;// in A
R = T_on/(C*1.1);// in ohm
R = R *10^-3;// in k ohm
disp("Values for first circuit : ")
disp(R,"The value of R in k  is");
V_o = V_CC-(2*V_BE) - V_EC;// in V
disp(V_o,"The output voltage in V is");
R_LED = (V_o - V_LED)/(I_LED);// in ohm
disp(R_LED,"The value of R_LED in   is : ")
// Part (ii)
f= 1*10^3;// in Hz
C=0.01*10^-6;// in F
D= 95/100;// duty cycle
// Formula f= 1.44/((R1+2*R2)*C)
// R1+2*R2= 1.44/(f*C)                    (i)
// D= (R1+R2)/(R1+2*R2) or
// R2= (1-D)/(2*D-1)*R1              (ii)
// From eq (i) and (ii)
R1= 1.44/(f*C*(1+2*((1-D)/(2*D-1))));// in ohm
R2=  (1-D)/(2*D-1)*R1;// in ohm
disp("Values for second circuit : ")
disp(R1*10^-3,"The value of R1 in k  is : ");
disp(R2*10^-3,"The value of R2 in k  is : ");
```

**Scilab code Exa 13.13** Resistor required

```
// Exa 13.13
clc;
```

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

**Scilab code Exa 13.14** A 555 based square wave generator

```
// Exa 13.14
clc;
clear;
close;
// Given data
f = 1;// in kHz
f = f * 10^3;// in Hz
T = 1/f;// in s
T = T * 10^3;// in msec
T_d = T/2;// in msec
T_d = T_d * 10^-3;// in sec
C = 0.1;// in  F
C = C * 10^-6;// in F
R2 = T_d/(0.69*C);// in ohm
R2 = R2 * 10^-3;// in k ohm
disp(C*10^6,"The value of C in  F is : ")
disp(R2,"The value of R2 in k  is");
disp("The value of R1 will be 100  +10 k  pot");
```

**Scilab code Exa 13.15** A 555 timer

```
// Exa 13.15
clc;
clear;
close;
// Given data
f = 800;// in Hz
D = 0.6;
C = 0.1;// in  F
C = C * 10^-6;// in F
// Formula f= 1.44/((R_A+2*R_B)*C)
// R_A+2*R_B= 1.44/(f*C)                    (i)
// D= (R_A+R_B)/(R_A+2*R_B) or
// R_B= (1-D)/(2*D-1)*R_A              (ii)
// From eq (i) and (ii)
R_A= 1.44/(f*C*(1+2*((1-D)/(2*D-1))));// in ohm
R_B=  (1-D)/(2*D-1)*R_A;// in ohm
disp(R_A*10^-3,"The value of R_A in k  is : ");
disp(R_B*10^-3,"The value of R_B in k  is : ");
```

**Scilab code Exa 13.16** A 555 timer

```
// Exa 13.16
clc;
clear;
close;
// Given data
f = 700;// in Hz
D = 0.5;
C = 0.1;// in  F
C = C * 10^-6;// in F
// Formula f= 1.44/((R_A+2*R_B)*C)
// R_A+2*R_B= 1.44/(f*C)                    (i)
// D= (R_A+R_B)/(R_A+2*R_B) or
// R_A+R_B=D*1.44/(f*C)
// From eq (i) and (ii)
```

```
R_B=round(1.44/(f*C))*(1-D);
R_A= round(D*1.44/(f*C))-R_B;
//R_A= 1.44/(f*C*(1+2*((1-D)/(2*D-1))));// in ohm
//R_B= (1-D)/(2*D-1)*R_A;// in ohm
disp(round(R_A),"The value of R_A in    is : ");
disp((R_B*10^-3),"The value of R_B in k   is : ");
```

**Scilab code Exa 13.17** Output pulse width

```
// Exa 13.17
clc;
clear;
close;
// Given data
R_A = 20;// in k ohm
R_A = R_A * 10^3;// in ohm
C = 0.1;// in   F
C = C*10^-6;// in F
pulse_width = 1.1*R_A*C;// in s
disp(pulse_width*10^3,"The output pulse width in ms
   is");
```

**Scilab code Exa 13.18** Relationship between tp and T

```
// Exa 13.18
clc;
clear;
close;
// Given data
n=4;
// t_p= X*T, where
X= [0.2+(n-1)];// (assumed)
disp("The relation between t_p and T is :")
```

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

**Scilab code Exa 13.19** Value of RA

```
// Exa 13.19
clc;
clear;
close;
// Given data
C = 0.02;// in  F
C = C * 10^-6;// in F
f=2*10^3;//frequency in Hz
T = 1/f;// in sec
n = 5;
t_p = (0.2+(n-1))*T;// in sec
R_A = t_p/(1.1*C);// in ohm
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

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

**Scilab code Exa 14.2** Frequency and number of bits

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