# Scilab Textbook Companion for Analog Integrated Circuits by J. B. Gupta[1]

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# Book Description

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

**Exa** Example (Solved example)

**Eqn** Equation (Particular equation of the above book)

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

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

# Contents

# List of Scilab Codes

# Chapter 1

# Differential Amplifiers

**Scilab code Exa 1.1** DC voltages and currents

```
// Example 1.1
clc;
clear;
close;
// Given data
format('v',6);
VCC= 9;//in V
VEE= -9;// in V
RC= 3.9;//in  k
RE= 3.3;// in  k
VBE= 0.7;// in V
IE= (abs(VEE)-VBE)/(2*RE);// emitter current in mA
IC= IE;// collector current in mA
// Collector voltage,
VC= VCC-IC*RC;// in V
disp(VC,"The collector voltage in volts is : ");
// Emitter voltage,
VE= 0-VBE;// in V
disp(VE,"The emitter voltage in volts is : ");
// Colleccctor-emitter voltage,
VCE= VC-VE;// in V
```

```
disp(VCE,"The collector-emitter voltage in volts is : ");

// Note : There is some difference between coding output and the answer of the book because in the book the value of IE is used as 1.25mA while the calculated value of IE is 1.258
```

**Scilab code Exa 1.2** Quiescent collector current and collector emitter voltage

```
// Example 1.2
clc;
clear;
close;
// Given data
format('v',6);
VCC= 10;//in V
VEE= -10;// in V
RC= 10;//in k
RE= 9.3;// in k
VBE= 0.7;// in V
IE= (abs(VEE)-VBE)/(2*RE);// emitter current in mA
ICQ= IE;//quiescent collector current in mA
disp(ICQ,"The quiescent collector current in mA");
// Quiescent Collector-emitter voltage,
VCEQ= VCC+VBE-ICQ*RC;// in V
disp(VCEQ,"The quiescent collector-emitter voltage in volts is : ");
```

**Scilab code Exa 1.3** Output voltage

```
// Example 1.3
```

```
clc;
clear;
close;
// Given data
format('v',6);
VCC= 12;//in V
VEE= -12;// in V
RC= 10;//in  k
RE= 10;// in  k
RB= 20;// in  k
VBE= 0.7;// in V
// Part (a)
beta_dc= 75;
// Tail current , IT= 2*IE= VEE/RE (ignoring VBE), hence
IT= abs(VEE)/RE;// in mA
IC= IT/2;//collector current in mA
// output voltage ,
Vout1= VCC-IC*RC;// in V
IT= (abs(VEE)-VBE)/RE;// tail current in mA (on considering VBE)
IC= IT/2;//collector current in mA
Vout2= VCC-IC*RC;// in V
// Tail current ,
IT= (abs(VEE)-VBE)/(RE+RB/(2*beta_dc));// in mA
IC= IT/2;//collector current in mA
// output voltage ,
Vout3= VCC-IC*RC;// in V
disp("Part (a) : There are three different  values of output voltage in volts");
disp(Vout1);
disp(Vout2);
disp(Vout3);

// Part (b)
IT= abs(VEE)/RE;// in mA
IC= IT/2;//collector current in mA
IB= IC/(beta_dc);// base current in mA
```

```
IB= IB*10^3;// in  A
VB= -IB*RB;//base voltage  in mV
VB= VB*10^-3;// in V
disp("Part (b) : ");
disp(IB,"The value of base current in  A is : ");
disp(VB,"The value of base voltage in volts is : ");

// Part (c)
beta_dc1= 60;
beta_dc2= 80;
IB1= IC/beta_dc1;//base current for transistor Q1, in mA
IB1= IB1*10^3;// in  A
disp("Part (c)")
disp(IB1,"The value of base current for transistor Q1 in  A is : ");
VB1= -IB1*RB;// in mV
VB1= VB1*10^-3;// in V
disp(VB1,"The value of base voltage for transistor Q1 in volts is : ");
IB2= IC/beta_dc2;//base current for transistor Q2, in mA
IB2= IB2*10^3;// in  A
disp(IB2,"The value of base current for transistor Q2 in  A is : ");
VB2= -IB2*RB;// in mV
VB2= VB2*10^-3;// in V
disp(VB2,"The value of base voltage for transistor Q2 in volts is : ");

// Note : In the part (c), the unit of base current for transistor Q2 in the book is wrong it will be  A
```

**Scilab code Exa 1.4** ICQ and VCEQ

```
// Example 1.4
clc;
clear;
close;
// Given data
format('v',7);
RC= 2.2;//in  k
RE= 4.7;// in  k
RE= RE*10^3;// in
Ri1= 50;// in
Ri2= 50;// in
VCC= 10;//in V
VEE= 10;// in V
VBE= 0.7;// in V
beta_dc= 100;
beta_ac= 100;

// Part (a)
// Formula Used : ICQ= IE= (VEE-VBE)/(2*RE+Ri/beta_dc)
ICQ= (VEE-VBE)/(2*RE+Ri1/beta_dc);//quiescent collector current in A
ICQ= ICQ*10^3;// in mA
IE= ICQ;// in mA
disp("Part (a)")
disp(ICQ,"The value of ICQ in mA is : ");
// Quiescent collector-emitter voltage,
VCEQ= VCC+VBE-ICQ*RC;// in V
disp(VCEQ,"The value of VCEQ in volts is : ");

// Part (b)
re_desh= 26/IE;// AC emitter resistance in
// Formula Used : Ad= Vout/Vind= RC/re_desh
Ad= RC*10^3/re_desh;// voltage gain
disp("Part (b)")
disp(Ad,"The voltage gain is : ");

// Part (c)
```

```
Rin1= 2*beta_ac*re_desh;// input resistance in
Rin1= Rin1*10^-3;//in k
Rin2= Rin1;// in k
disp("Part (c)");
disp(Rin1,"The input resistance in k is : ");

// Part (d)
Rout1= RC;// in k
disp("Part (d)");
disp(Rout1,"The output resistance in k is : ");
```

**Scilab code Exa 1.5** Voltage gain input resistance output resistance and CMRR

```
// Example 1.5
clc;
clear;
close;
// Given data
format('v',7);
VCC= 15;//in V
VEE= 15;// in V
RC= 1;//in M
RE= RC;// in M
beta_ac= 100;
VBE= 0.7;// in V
IE= (VEE-VBE)/(2*RE);//emitter current in A
IC= IE;// in collector current in A
re_desh= 26/IE;// ac resistance of each emitter diode in k
Ad= RC*10^3/re_desh;// Voltage gain
disp(Ad,"The voltage gain is : ");
Zin= 2*beta_ac*re_desh;// input impedance in k
Zin= Zin*10^-3;// in M
disp(Zin,"The input impedance in M is : ");
```

```
Zout= RC;//output impedance in M
disp(Zout,"The output impedance in M  is : ");
Acm= (RC*10^3)/(2*RE*10^3+re_desh);// common−mode gain
CMRR= Ad/Acm;// common−mode rejection ratio
disp(CMRR,"The common−mode rejection ratio is : ");
// When v_in is zero
Vout= VCC- IC*RC;// in V
disp(Vout,"When v_in is zero then the total output voltage at the quiescent value in volts is :  ");
// When v_in= 1mV,
v_in= 1*10^-3;// in V
Vout= Ad*v_in;// in V
disp(Vout,"When v_in is −1mV then the ac output voltage in volts is : ");

// Note : The value of CMRR in the book is wrong because the correct value of Acm is "0.4991" and in the book it is taken as "0.4225"
```

**Scilab code Exa 1.6** Magnitude of differential gain

```
// Example 1.6
clc;
clear;
close;
// Given data
format('v',6);
VEE= 5;// supply voltage in V
RC= 2*10^3;// collector resistance in
RE= 4.3;// emitter resistance in k
VBE= 0.7;// in V
VT= 26;// in mV
IE= (VEE-VBE)/(2*RE);//emitter current in mA
re_desh= VT/IE;//dynamic emitter resistance in
```

```
Ad= RC/(2*re_desh);// differential mode gain
disp(Ad,"The differential mode gain is : ");
```

**Scilab code Exa 1.7** Common mode gain and CMRR

```
// Example 1.7
clc;
clear;
close;
// Given data
format('v',6);
VEE= 5;// supply voltage in V
RC= 2*10^3;// collector resistance in
RE= 4.3;// emitter resistance in k
VBE= 0.7;// in V
VT= 26;// in mV
IE= (VEE-VBE)/(2*RE);//emitter current in mA
re_desh= VT/IE;//dynamic emitter resistance in
Ad= RC/(2*re_desh);// differential mode gain
Acm= RC/(2*RE*10^3+re_desh);// common mode gain
disp(Acm,"The common mode gain is : ");
CMRR= Ad/Acm;// common mode rejection ratio
disp(CMRR,"The CMRR is : ");
```

**Scilab code Exa 1.8** Output voltage

```
// Example 1.8
clc;
clear;
close;
// Given data
format('v',6);
VEE= 9;//in V
```

```
VCC= 9;//in V
RC= 47*10^3;// collector resistance in
RE= 43*10^3;// emitter resistance in
vin1= 2.5*10^-3;// in V
Ri1= 20*10^3;// in
Ri2= Ri1;// in
VBE= 0.7;// in V
VT= 26*10^-3;// in V
beta1= 75;
beta2= 75;
IE= (VEE-VBE)/(2*RE+Ri1/beta1);//emitter current in A
ICQ= IE;// quiescent current in A
VCEQ= VCC+VBE-ICQ*RC;// quiescent collector voltage in V
re_desh= VT/IE;//AC emitter resistance in
Ad= RC/re_desh;// voltage gain
vout= Ad*vin1;// output voltage in V
disp(vout,"The output voltage in volts is : ");
```

**Scilab code Exa 1.9** Dual input unbalanced output

```
// Example 1.9
clc;
clear;
close;
// Given data
format('v',7);
RC= 2.2;//in k
RE= 4.7;// in k
Ri1= 50*10^-3;// in k
Ri2= 50*10^-3;// in k
VCC= 10;//in V
VEE= 10;// in V
VBE= 0.7;// in V
```

```
beta_dc= 100;
beta_ac= 100;

// Part (i)
// Formula Used : ICQ= IE= (VEE-VBE)/(2*RE+Ri/beta_dc)
ICQ= (VEE-VBE)/(2*RE+Ri1/beta_dc);//quiescent collector current in mA
IE= ICQ;// in mA
disp("Part (i) : Dual-input, unbalanced output")
disp(ICQ,"The value of ICQ in mA is : ");
// Quiescent collector-emitter voltage,
VCEQ= VCC+VBE-ICQ*RC;// in V
disp(VCEQ,"The value of VCEQ in volts is : ");
re_desh= 26/IE;// AC emitter resistance in
Rin1= 2*beta_ac*re_desh;// input resistance in
Rin1= Rin1*10^-3;//in  k
Rin2= Rin1;// in  k
disp(Rin1,"The value of Rin1 in  k   is : ");
Rout= RC;// in  k
disp(Rout,"The value of Rout in  k   is : ");
disp(RC,"The value of RC in  k   is : ")
// Formula Used : Ad= Vout/Vind= RC/re_desh
Ad= RC*10^3/(re_desh*2);// voltage gain of dual input, unbalanced output
disp(Ad,"The value of Ad is : ");

// Part (ii)
disp("Part (ii) : Single-output, balanced output");
disp(ICQ,"The value of ICQ in mA is : ");
disp(VCEQ,"The value of VCEQ in volts is : ");
disp(Rin1,"The value of Rin1 in  k   is : ");
disp(Rout,"The value of Rout in  k   is : ");
disp(RC,"The value of RC in  k   is : ")
// Formula Used : Ad= Vout/Vind= RC/re_desh
Ad= RC*10^3/(re_desh);// voltage gain of dual input, unbalanced output
disp(Ad,"The value of Ad is : ");
```

**Scilab code Exa 1.10** Single input unbalanced output

```
// Example 1.10
clc;
clear;
close;
// Given data
format('v',7);
VEE= 9;//in V
VCC= 9;//in V
RC= 47*10^3;// collector resistance in
RE= 43*10^3;// emitter resistance in
vin1= 2.5*10^-3;// in V
Ri1= 20*10^3;// in
Ri2= Ri1;// in
VBE= 0.7;// in V
VT= 26*10^-3;// in V
beta1= 75;
beta2= 75;
IE= (VEE-VBE)/(2*RE+Ri1/beta1);//emitter current in A
ICQ= IE;// quiescent current in A
VCEQ= VCC+VBE-ICQ*RC;// quiescent collector voltage in V
re_desh= VT/IE;//AC emitter resistance in
Ad= RC/(2*re_desh);// voltage gain
vout= Ad*vin1;// output voltage in V
disp(vout,"The output voltage in volts is : ");
```

**Scilab code Exa 1.11** Q point differential voltage gain and output resistance

```
// Example 1.11
clc;
clear;
close;
// Given data
format('v',6);
VEE= 15;//in V
VD1= 0.7;// in V
VD2= 0.7;// in V
VBE= 0.7;// in V
Beta= 100;
VT= 26;// in mV
R3= 180;//in
RC= 470;// in
VB3= -VEE+VD1+VD2;//in V
VE3= VB3-VBE;//voltage at emitter terminal of transistor Q3 in V
IE3= (VE3-(-VEE))/R3;//emitter current through transistor Q3 in A

//Part (i)
ICQ= IE3/2;//quiescent current in A
ICQ= round(ICQ*10^3);//in mA
IE= ICQ;//emitter current in mA
disp(ICQ,"(i) : Quiescent current in mA is : ")
VCEQ= VEE+VBE-ICQ*10^-3*RC;//quiescent collector-emitter voltage in V
disp(VCEQ,"The quiescent collector-emitter voltage in volts is : ")
re_desh= VT/IE;//AC emitter resistance in

// Part (ii)
Ad= RC/re_desh;// differential voltage gain
disp(Ad,"(ii) : Differential voltage gain is : ")

// Part (iii)
Rin1= 2*Beta*re_desh;// in
Rin1= Rin1*10^-3;// in k
```

```
disp(Rin1,"(iii) : The input resistance in k  is : ")
```

**Scilab code Exa 1.12** Voltage gain input resistance and operation point

```
// Example 1.12
clc;
clear;
close;
// Given data
format('v',6);
VEE= 10;//in V
VCC=10;// in V
VD1= 0.715;// in V
Vz= 6.2// in V
VBE= VD1;// in V
Izt= 41;// in mA
R3= 2.7;// in  k
RC= 4.7;// in  k
VT= 26;// in mV
beta_ac= 100;
beta_dc= 100;
VB3= -VEE+Vz+VD1;//voltage at the base of transistor Q3 in V
VE3= VB3-VBE;// voltage at the emitter of transistor Q3 in V
IE3= (VE3-(-VEE))/R3;//emitter current through transistor Q3 in mA
ICQ= IE3/2;//quiescent current in mA
VCEQ= VCC+VBE-ICQ*RC;// in V
disp("Part (a) : The Q-point values : ");
disp(ICQ,"The value of ICQ in mA is : ");
disp(VCEQ,"The value of VCEQ in volts is : ")
re_desh= VT/ICQ;//dynamic emitter resistance in
Ad= RC*10^3/re_desh;// voltage gain
```

```
disp(Ad,"Part (b) : The voltage gain is : ")
Rin= 2*beta_ac*re_desh;// differential input resistance in
Rin=Rin*10^-3;// in k
disp(Rin,"Part (c) : The differential input resistance in k is : ")
```

**Scilab code Exa 1.13** Mirrored current

```
// Example 1.13
clc;
clear;
close;
// Given data
format('v',6);
VCC= 12;// in V
VBE= 0.7;// in V
R1= 25;// in k
// I= I_REF= (VCC-VBE)/R1
I= (VCC-VBE)/R1;// mirrored current in mA
disp(I,"The mirrored current in mA is : ");
```

**Scilab code Exa 1.14** Reference current and output current

```
// Example 1.14
clc;
clear;
close;
// Given data
format('v',6);
VCC= 10;// in V
VBE= 0.7;// in V
R1= 15;// in k
```

```
Beta= 100;
I_REF= (VCC-VBE)/R1;//reference current in mA
disp(I_REF,"The reference current in mA is : ")
Iout= I_REF*Beta/(Beta+2);// output current in mA
disp(Iout,"The output current in mA is : ")
```

**Scilab code Exa 1.15** Value of Current

```
// Example 1.15
clc;
clear;
close;
// Given data
format('v',5);
VCC= 15;// in V
VBE= 0.7;// in V
R1= 2.2;// in  k
Beta= 220;
I_REF= (VCC-VBE)/R1;//reference current in mA
// Formula : I= IC= I_REF*(Beta/(Beta+2))
IC= I_REF*Beta/(Beta+2);// in mA
disp(IC,"The value of current in mA is : ")
```

**Scilab code Exa 1.16** Value of Current

```
// Example 1.16
clc;
clear;
close;
// Given data
format('v',6);
Vz= 1.8;// in V
VBE= 0.7;// in V
```

```
RE= 1;// in  k
Beta= 180;
VB= Vz-VBE;// in V
IE= VB/RE;//emitter current in mA
// Formula : I= IC= IE*(Beta/(Beta+1))
IC= IE*Beta/(Beta+1);// in mA
disp(IC,"The value of current in mA is : ")
```

**Scilab code Exa 1.17** Value of each current

```
// Example 1.17
clc;
clear;
close;
// Given data
format('v',7);
VCC= 9;// in V
R1= 12;// in  k
VBE= 0.7;// in V
Beta= 100;
I_REF= (VCC-2*VBE)/R1;//reference current in mA
disp(I_REF,"The reference current in mA is : ")
Iout= I_REF/(1+2/(Beta*(1+Beta)));//output current in mA
disp(Iout,"The output current in mA is : ")
IC2= Iout;//collector current in mA
disp(IC2,"The collector current in mA is : ")
// IB3= I_REF-IC1= I_REF-IC2  (since IC1= IC2)
IB3= I_REF-IC2;//base current of transistor Q3 in mA
IB3= IB3*10^3;// in   A
disp(IB3,"The base current of transistor Q3 in   A is : ")
IB3= 0.1;// in   A
IE3= (1+Beta)*IB3;// emitter current of transistor Q3 in   A
```

```
disp(IE3,"The emitter current of transistor Q3 in  A is : ")
IB1= IE3/2;//base current in  A
IB2= IB1;// in  A
disp(IB1,"The base current in  A is : ")
```

**Scilab code Exa 1.18** Collector current of each transistor

```
// Example 1.18
clc;
clear;
close;
// Given data
format('v',5);
VEE= 10;// in V
VBE= 0.715;// in V
beta_ac= 100;
beta_dc= 100;
R= 5.6;// in k
I_REF= (VEE-VBE)/R;// in mA
IC1= I_REF*beta_ac/(2+beta_ac);// in mA
// IC1= IC2= IC3  (by symmetry)
IC2= IC1;// in mA
IC3= IC2;// in mA
I_RC= IC1+IC2+IC3;// current through RC in mA
disp(I_RC,"The current through RC in mA is : ");
```

**Scilab code Exa 1.19** Differential input resistance

```
// Example 1.19
clc;
clear;
close;
```

```
// Given data
format('v',8);
VCC= 5;// in V
VBE= 0.7;// in V
VEE= -5;// in V
VT= 26;// in mV
R= 18.6;// in  k
Beta= 100;
I2= (VCC-VBE-VEE)/R;// in mA
IC3= I2;// in mA (due to current mirror action)
IE= IC3/2;// emitter current of transistor Q1 and Q2
re_desh= VT/IE;//AC emitter resistance of transistor in
Rin1= 2*Beta*re_desh;// in
Rin1= Rin1*10^-3;// in  k
disp(Rin1,"The differential input resistance in  k is : ")
```

**Scilab code Exa 1.20** Voltage gain

```
// Example 1.20
clc;
clear;
close;
// Given data
format('v',6);
VCC= 18;// in V
R1= 4.7;// in  k
R2= 5.6;// in  k
R3= 6.8;// in  k
RE= 1.1;// in  k
VBE= 0.7;// in V
VT= 26;// in mV
RC= 1.8*10^3;// in
IE1= (VCC*R1/(R1+R2+R3)-VBE)/RE;// in mA
```

```
re_desh= VT/IE1;//dynamic resistance of each transistor in
Av= -RC/re_desh;// voltage gain of the cascode amplifier
disp(Av,"The voltage gain of the cascode amplifier is : ")
```

# Chapter 2

# Operational Amplifiers and Their Parameters

**Scilab code Exa 2.2** Output voltage

```
// Example 2.2
clc;
clear;
close;
// Given data
format('v',6);
// Part (i)
Vin1= 5;// in  V
Vin1= Vin1*10^-6;// in V
Vin2= -7;//in  V
Vin2= Vin2*10^-6;// in V
Av= 2*10^5;// unit less
Rin= 2;// in M
Vout= (Vin1-Vin2)*Av;// in V
disp(Vout,"The output voltage in volts is : ")
```

**Scilab code Exa 2.4** Input resistance

```
// Example 2.4
clc;
clear;
close;
// Given data
format('v',5);
Rs= 2;// in k
RL= 5;// in k
A= 10^5;// unit less
Rin= 100;//in k
Rout= 50;// in
Vout= 10;// in V
// For Vout = 10 V, V1= V2 = Vout
V1= Vout;// in V
V2= V1;// in V
// From equation V1= Vs*Rin/(Rin+Rs)
Vs= V1*(Rin+Rs)/Rin;// in V
Vout_by_Vs= Vout/Vs;// value of Vout/Vs
disp(Vs,"The value of Vs in volts is : ");
disp(Vout_by_Vs,"The value of Vout/Vs is : ");
disp(Rin,"The input resistance of the circuit in k
    is : ");
```

**Scilab code Exa 2.6** CMRR in dB

```
// Example 2.6
clc;
clear;
close;
// Given data
format('v',5);
Ad= 100;// differential mode gain
Acm= 0.01;// common mode gain
```

```
CMRR= Ad/Acm;
CMRR_desh= 20*log10(CMRR);// CMRR in dB
disp(CMRR_desh,"CMRR in dB is : ");
```

**Scilab code Exa 2.7** Common mode gain

```
// Example 2.7
clc;
clear;
close;
// Given data
format('v',5);
Ad= 10^5;// differential mode gain
CMRR= 10^5;
// Common−mode gain ,
Acm= Ad/CMRR;
disp(Acm,"The common−mode gain is : ");
```

**Scilab code Exa 2.8** Percentage error in the output voltage

```
// Example 2.8
clc;
clear;
close;
// Given data
format('v',6);
V1= 10;// in mV
V2= 9;// in mV
Ad= 60;// differential voltage gain in dB
Ad= 10^(Ad/20);
CMRR= 80;// in dB
CMRR= 10^(CMRR/20);
Vd= V1-V2;// difference signal in mV
```

```
Vcm= (V1+V2)/2;// common−mode signal in mV
// Output voltage ,
Vout= Ad*Vd*(1+1/CMRR*Vcm/Vd);// in mV
AdVd= Ad*Vd;// in mV
// Error voltage
Verror= Vout-AdVd;// in mV
Per_error= Verror/Vout*100;// percentage error
disp(Verror,"The error voltage in mV is : ")
disp(Per_error,"The percentage error in the output
    voltage is : ")
```

**Scilab code Exa 2.9** Output voltage and percentage error

```
// Example 2.9
clc;
clear;
close;
// Given data
format('v',9);
V1= 745;// in  V
V2= 740;// in  V
Ad= 5*10^5;// differential voltage gain
CMRR= 80;// in dB
CMRR= 10^(CMRR/20);
Vd= V1-V2;// difference signal in  V
Vcm= (V1+V2)/2;// common−mode signal in  V
// Output voltage ,
Vout= Ad*Vd*(1+1/CMRR*Vcm/Vd);// in  V
AdVd= Ad*Vd;// in  V
// Error voltage
Verror= Vout-AdVd;// in  V
Vout= Vout*10^-6;// in V
Verror= Verror*10^-6;// in V
Per_error= Verror/Vout*100;// percentage error
disp(Vout,"The output voltage in volts is : ")
```

```
disp(Per_error,"The percentage error in the output
   voltage is : ")
```

**Scilab code Exa 2.10** Output voltage

```
// Example 2.10
clc;
clear;
close;
// Given data
format('v',9);
Vd= 25;//differential input voltage in  V
Vd= Vd*10^-6;// in V
A= 200000;// open loop gain
// Output voltage,
Vout= A*Vd;// in V
disp("The output voltage is :   "+string(Vout)+ "V"
   )
```

**Scilab code Exa 2.11** Slew rate

```
// Example 2.11
clc;
clear;
close;
// Given data
format('v',9);
dVout= 20;// change in output voltage in V
dt= 4;// change in time in  s
SR= dVout/dt;// slew rate in V/ s
disp(SR,"The slew rate in V/ s is : ")
```

**Scilab code Exa 2.12** Input bias current and input offset current

```
// Example 2.12
clc;
clear;
close;
// Given data
format('v',9);
IB1= 10;// in  A
IB2= 7.5;// in  A
// Input bias current,
I_in_bias= (IB1+IB2)/2;// in  A
// Input offset current,
I_in_offset= IB1-IB2;// in  A
disp(I_in_bias,"The input bias current in  A is : ")
disp(I_in_offset,"The input offset current in  A is : ")
```

---

**Scilab code Exa 2.13** Limiting frequency

```
// Example 2.13
clc;
clear;
close;
// Given data
format('v',6);
SR= 6;// slew rate in V/ s
SR= 6*10^6;// in V/s

// Part (i) For Vmax= 1V
Vmax= 1;// in V
```

```
fmax= SR/(2*%pi*Vmax);// limiting frequency in Hz
fmax= fmax*10^-6;// in MHz
disp(fmax,"Part (i) : The limiting frequency for maximum voltage of 1V in MHz is : ");

// Part (ii) For Vmax= 10V
Vmax= 10;// in V
fmax= SR/(2*%pi*Vmax);// limiting frequency in Hz
fmax= fmax*10^-3;// in kHz
disp(fmax,"Part (ii) : The limiting frequency for maximum voltage of 10V in kHz is : ");
```

**Scilab code Exa 2.14** Required slew rate

```
// Example 2.14
clc;
clear;
close;
// Given data
format('v',6);
Vpp= 3;// output voltage in V
del_t= 4;// in  s
del_V= 90*Vpp/100-10*Vpp/100;// in V
// Required slew rate,
SR= del_V/del_t;// in V/ s
disp(SR,"The required slew rate in V/ s is : ");
```

# Chapter 3

# Op Amps With Negative Feedback

**Scilab code Exa 3.1** Non inverting amplifier

```
// Example 3.1
clc;
clear;
close;
// Given data
format('v',6);
Af= 10;// voltage gain
R1= 3;// in
Rf= (Af-1)*R1;// From Af= 1+Rf/R1
disp(R1,"The value of R1 in     is : ");
disp(Rf,"The value of Rf in     is : ");
```

---

**Scilab code Exa 3.2** Minimum and maximum closed loop voltage gains

```
// Example 3.2
clc;
```

```
clear;
close;
// Given data
format('v',6);
R1= 2;// in  k
Rf_min= 0;
Rf_max= 100;// in  k
// Formula Used : Af= 1+Rf/R1
Af_max= 1+Rf_max/R1;// maximum closed loop voltage gain
Af_min= 1+Rf_min/R1;// minimum closed loop voltage gain
disp(Af_max,"The maximum closed loop voltage gain is : ");
disp(Af_min,"The minimum closed loop voltage gain is : ");
```

**Scilab code Exa 3.3** Voltage gain input resistance output resistance and bandwidth

```
// Example 3.3
clc;
clear;
close;
// Given data
format('v',6);
R1= 100;// in
Rf= 100*10^3;// in
A= 2*10^5;//unit less
Rin= 2*10^6;// in
Rout= 75;// in
f0= 5;// in Hz
B= R1/(R1+Rf);// feedback fraction
AB= A*B;// feedback factor
Af= 1+Rf/R1;// voltage gain
```

```
Rin_f= Rin*(1+AB);// input resistance in
Rout_f= Rout/(1+AB);// output resistance in
f_f= f0*(1+AB);// bandwidth in Hz
Rin_f= Rin_f*10^-6;// in M
disp(Af,"The voltage gain is : ");
disp(Rin_f,"The input resistance in M  is : ");
disp(Rout_f,"The output resistance in   is : ")
disp(f_f,"The bandwidth in Hz is : ");
```

**Scilab code Exa 3.4** Voltage gain input resistance output resistance and bandwidth

```
// Example 3.4
clc;
clear;
close;
// Given data
format('v',9);
Rin= 2*10^6;// in
Rout= 75;// in
f0= 5;// in Hz
A= 2*10^5;//unit less
B=1;// for voltage follower
Rf= 0;
Af= 1;// voltage gain (since Rf=0)
Rin_f= A*Rin;// input resistance in
Rin_f= Rin_f*10^-9;// in G
Rout_f= Rout/A;//output resistance in
f_f= f0*A;// bandwidth in Hz
f_f= f_f*10^-6;// in MHz
disp(Af,"The voltage gain is : ");
disp(Rin_f,"The input resistance in G  is : ");
disp(Rout_f,"The output resistance in   is : ")
disp(f_f,"The bandwidth in MHz is : ");
```

**Scilab code Exa 3.5** Voltage gain input resistance output resistance and bandwidth

```
// Example 3.5
clc;
clear;
close;
// Given data
format('v',8);
Rin= 2*10^6;// in
Rout= 75;// in
f0= 5;// in Hz
R1= 330;//in
Rf= 3.3*10^3;// in
A= 2*10^5;//unit less
B= R1/(R1+Rf);// feedback fraction
AB= A*B;// feedback factor
Af= -Rf/R1;// colsed-loop voltage gain
Rin_f= R1;// input resistance with feedback in
Rout_f=Rout/(1+AB);// output resistance with feedback in
f_f= f0*(1+AB);// closed-loop bandwidth in Hz
f_f= f_f*10^-3;// in kHz
disp(Af,"The closed-loop voltage gain is : ");
disp(Rin_f,"The input resistance in    is : ");
disp(Rout_f,"The output resistance in    is : ");
disp(f_f,"The bandwidth in kHz is : ");
```

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

```
// Example 3.6
```

```
clc;
clear;
close;
// Given data
format('v',8);
Rin= 2*10^6;// in
Rout= 75;// in
f0= 5;// in Hz
A= 2*10^5;//unit less
B= 1/2;// feedback fraction (since R1=Rf)
Af= -1;// voltage gain
R1= 330;//in    (assume)
Rin_f= R1;// input resistance with feedback in
Rout_f= Rout/(A/2);// output resistance in
f_f= A/2*f0;// in Hz
f_f= f_f*10^-6;// in MHz
disp(Af,"The closed-loop voltage gain is : ");
disp(Rin_f,"The input resistance in    is : ");
disp(Rout_f,"The output resistance in    is : ");
disp(f_f,"The bandwidth in kHz is : ");
```

**Scilab code Exa 3.7** Value of Af RIF Rof ff and VooT

```
// Example 3.7
clc;
clear;
close;
// Given data
format('v',8);
Rin= 2*10^6;// in
Rout= 75;// in
f0= 5;// in Hz
A= 200000;//unit less
VCC= 15;// in V
VEE= -15;// in V
```

```
Vout_swing= 13;// in V
// Part (i) : Non-inverting Amplifier
R1= 1*10^3;// in
Rf= 10*10^3;//in
B= R1/(R1+Rf);// feedback fraction
AB= A*B;// feedback factor
Af= 1+Rf/R1;// voltage gain
Rin_f= Rin*(1+AB);// input resistance in
Rin_f=Rin_f*10^-9;// in G
Rout_f= Rout/(1+AB);// output resistance in
f_f= f0*(1+AB);// bandwidth in Hz
f_f=f_f*10^-3;// in kHz
VooT= Vout_swing/(1+AB);//in V
VooT= VooT*10^3;// in mV
disp("Part (i) : Non-inverting Amplifier :- ");
disp(Af,"The closed-loop voltage gain is : ");
disp(Rin_f,"The input resistance in G  is : ");
disp(Rout_f,"The output resistance in   is : ");
disp(f_f,"The bandwidth in kHz is : ");
disp("The output offset voltage with feedback is :
    "+string(VooT)+" mV")

// Part (ii) : Inverting Amplifier
R1= 470;// in
Rf= 4.7*10^3;//in
B= R1/(R1+Rf);// feedback fraction
AB= A*B;// feedback factor
Af= -Rf/R1;// voltage gain
Rin_f= R1;// input resistance in
Rout_f= Rout/(1+AB);// output resistance in
f_f= f0*(1+AB);// bandwidth in Hz
f_f=f_f*10^-3;// in kHz
VooT= Vout_swing/(1+AB);//in V
VooT= VooT*10^3;// in mV
disp("Part (ii) : Inverting Amplifier :- ");
disp(Af,"The closed-loop voltage gain is : ");
disp(Rin_f,"The input resistance in G  is : ");
disp(Rout_f,"The output resistance in   is : ");
```

```
disp(f_f,"The bandwidth in kHz is : ");
disp("The output offset voltage with feedback is : "+string(VooT)+" mV")
```

**Scilab code Exa 3.8** Voltage gain input resistance and output resistance

```
// Example 3.8
clc;
clear;
close;
// Given data
format('v',8);
Rf= 500*10^3;// in
R1= 5*10^3;//in
Vin= 0.1;// input voltage in V
Af= -Rf/R1;// voltage gain
Rin= R1;// input resistance in
Rin= Rin*10^-3;// in k
Rout= 0;// in
Vout= Af*Vin;// output voltage in V
I_in= Vin/R1;// input current in A
I_in= I_in*10^3;// in mA
disp(Af,"The amplifier circuit voltage gain is : ");
disp(Rin,"The amplifier circuit input resistance in k is : ");
disp(Rout,"The amplifier circuit output resistance in is : ");
disp(Vout,"The output voltage in volts is : ");
disp(I_in,"The input current in mA is : ");
```

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

```
// Example 3.9
```

```
clc;
clear;
close;
// Given data
format('v',8);
Rf= 1*10^6;// in
Rin= 1*10^6;// in
Vout_by_Vin= -Rf/Rin;// (since Vout= -Rf/Rin*Vin)
Av= Vout_by_Vin;// voltage gain
disp(Av,"The voltage gain is : ");
// I_in= Iout (As it is a unity gain inverter)
Ain= 1;//input impedance (since I_in= Iout)
disp(Ain,"The input impedance is : ");
Ap= abs(Av*Ain);// power gain
disp(Ap,"The power gain is : ");
```

**Scilab code Exa 3.10** Designing of an Inverting op amp circuit

```
// Example 3.10
clc;
clear;
close;
// Given data
format('v',4);
Av= -30;// voltage gain
Rf= 1*10^6;// in
//Since, Av= Vo/Vi=-Rf/R1, so
R1= -Rf/Av;// in
R1= R1*10^-3;// in k
Rf= Rf*10^-6;// in M
disp(Rf,"The value of Rf in M  is : ")
disp(R1,"The value of R1 in k  is : ");
```

**Scilab code Exa 3.11** Designing of an Inverting op amp circuit

```
// Example 3.11
clc;
clear;
close;
// Given data
format('v',6);
Av= -8;// voltage gain
Vi= 1;// input voltage in V
I1= 15;//maximum current in  A
I1= I1*10^-6;// in A
R1= Vi/I1;// in
R1= R1*10^-3;// in k
disp(R1,"The value of R1 in k  is : ");
disp("The standard value of R1 is 68 k ");
R1= 68;// in k
Rf= -Av*R1;// in k
disp(Rf,"The value of Rf in k  is : ");

// Note : The calculated value of Rf in the book is wrong [-(-8)*68 is not equal to 384], it will be 544 k
```

---

**Scilab code Exa 3.14** Gain of the amplifier circuit

```
// Example 3.14
clc;
clear;
close;
// Given data
format('v',6);
Rf= 20*10^3;// in
R1= 10*10^3;// in

```

```
//Part (i) When switch S is off,
Aoff_non_inv= 1+Rf/R1;// non-inverting amplifier
   circuit gain
 Aoff_inv= -Rf/R1;// inverting amplifier gain
 Aoff= Aoff_non_inv+Aoff_inv;// amplifier circuit
    gain
 disp(Aoff,"Part (i) : When switch S is off, the
    gain of the amplifier circuit is : ");

// Part (ii) When switch S is on,
Aon= -Rf/R1;// amplifier circuit gain
disp(Aon,"Part (ii) : When switch S is on, the gain
   of the amplifer circuit is : ");
```

**Scilab code Exa 3.17** Output voltage

```
// Example 3.17
clc;
clear;
close;
// Given data
format('v',6);
R1= 1*10^3;// in
R2= 1*10^3;// in
Rf= 10*10^3;// in
R3= 10*10^3;// in
Vd= 5;// in mV
Vcm= 2;// in mV
CMRR_dB= 90;// in dB
CMRR= 10^(CMRR_dB/20);
Ad= Rf/R1;// differential voltage gain
// Part (i)
Vout= Ad*Vd;// output voltage in mV
disp(Vout,"Part (i) : The output voltage in mV is :
   ");
```

```
// Part (ii)
Acm= Ad/CMRR;// common mode gain
AcmVcm= Acm*Vcm;// magnitude of the induced 60Hz noise at the output in mV
AcmVcm= AcmVcm*10^3;// in  V
disp(AcmVcm,"The magnitude of the induced 60Hz noise at the output in  V is : ")
```

**Scilab code Exa 3.18** Voltage gain output voltage and internal resistance

```
// Example 3.18
clc;
clear;
close;
// Given data
format('v',6);
R1= 540;// in
R3= 540;// in
R2= 5.4*10^3;// in
Rf= 5.4*10^3;// in
Vin1= -2.5;// in V
Vin2= -3.5;//in V
Rin= 2*10^6;//input impedance in
A= 2*10^5;// open loop voltage gain
Ad= (1+Rf/R1);// voltage gain
disp(Ad,"The voltage gain is : ");
Vout=Ad*(Vin1-Vin2);// output voltage in V
disp(Vout,"The output voltage in volts is : ");
Rin_f1= Rin*(1+A*R1/(R1+Rf));// in
Rin_f2= Rin*(1+A*R2/(R1+Rf));// in
format('e',10);
disp(Rin_f1,"The value of Rin_f1 in    is : ")
disp(Rin_f2,"The value of Rin_f2 in    is : ")
```

**Scilab code Exa 3.19** Gain of the circuit

```
// Example 3.19
clc;
clear;
close;
// Given data
format('v',4);
Vin= 100*10^-3;// in V
Vout= 4.25;// in V
R1= 100;// in
// Formula Used : Vout= (1+2*Rf/Rf)*Vin
Rf= (Vout/Vin-1)*R1/2;// in
Rf= Rf*10^-3;// in k
disp(R1,"The value of R1 in    is : ")
disp(Rf,"The value of Rf in k   is : ")
disp("(Standard value of Rf is 2.2 k  )")
```

---

**Scilab code Exa 3.20** Voltage gain input resistance output resistance and bandwidth

```
// Example 3.20
clc;
clear;
close;
// Given data
format('v',9);
R1= 3.3;// in k
R2= 3.3;// in k
R3= 1.2;// in k
R4= 1.2;// in k
Rf= 3.9;// in k
```

```
R5= 3.9;// in  k
Rp= 2.5;// in  k
A= 2*10^5;// unit less
f0= 5;// in Hz
Rin= 2*10^6;// in
Rout= 75;// in
Ad= -(1+2*R1/Rp)*Rf/R3;// voltage gain
disp(Ad,"The voltage gain is : ");
Rinf= Rin*(1+A*(R1+Rp)/(2*R1+Rp));//input resistance in
Rinf= Rinf*10^-9;// in  G
disp(Rinf,"The input resistance in  G   is : ");
Routf= Rout/(1+A/Ad);// output resistance in
disp(Routf,"The output resistance in     is : ");
f_f= A*f0/abs(Ad);// bandwidth in Hz
f_f= f_f*10^-3;// in kHz
disp(f_f,"The bandwidth in kHz is : ");
```

# Chapter 4

# Linear Applications of Op Amps

**Scilab code Exa 4.1** Designing of an adder circuit

```
// Example 4.1
clc;
clear;
close;
// Given data
format('v',6);
Vout= '-(V1+10*V2+100*V3)';//given expression
Rf= 100;// in k
// Vout= -Rf*(V1/R1+V2/R2+V3/R3)= -(Rf/R1*V1+Rf/R2*
   V2+Rf/R3*V3)      (i)
// Compare equation(i) with given expression
R1= Rf/1;//in k
R2= Rf/10;// in k
R3= Rf/100;// in k
disp(Rf,"The value of Rf in k  is : ");
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 4.2** Output voltage

```
// Example 4.2
clc;
clear;
close;
// Given data
format('v',6);
Rf= 12;// in k
R1= 12;// in k
R2= 2;// in k
R3= 3;// in k
V1= 9;// in V
V2= -3;// in V
V3= -1;// in V
Vout= -Rf*(V1/R1+V2/R2+V3/R3);// output voltage in V
disp(Vout,"The output voltage in volts is : ");
```

---

**Scilab code Exa 4.3** Summing amplifier

```
// Example 4.3
clc;
clear;
close;
// Given data
format('v',6);
Vout= '(-V1+2*V2-3*V3)';//given expression
Rf= 6;// in k
// Vout= -(Rf/R1*V1+Rf/R2*V2+Rf/R3*V3)     (i)
// Compare equation(i) with given expression
R1= Rf/1;//in k
R2= Rf/2;// in k
```

```
R3= Rf/3;// in k
disp(Rf,"The value of Rf in k is : ");
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 4.4** Value of R1 R2 and Rf

```
// Example 4.4
clc;
clear;
close;
// Given data
format('v',6);
Vout= '(-2*V1+3*V2+4*V3)';//given expression
R3= 10;// in k
// Vout= -(Rf/R1*V1+Rf/R2*V2+Rf/R3*V3)        (i)
// Compare equation(i) with given expression
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 4.5** Output voltage

```
// Example 4.5
clc;
clear;
close;
format('v',6);
// Given data
```

```
V1= 2;// in V
V2= -1;// in V
R=100;// in     (assumed)
Vs1= V1*(R/2)/(R+R/2);// in V
Rf= 2*R;// in
Vo_1= Vs1*(1+Rf/R);// in V
Vs2= V2*(R/2)/(R+R/2);// in V
Vo_2= Vs2*(1+Rf/R);// in V
Vout= Vo_1+Vo_2;//output voltage in V
disp(Vout,"The output voltage in volts is : ");
```

**Scilab code Exa 4.7** Capacitor voltage at the end of pulse

```
// Example 4.7
clc;
clear;
close;
format('v',6);
// Given data
Vin= 10;// in V
R= 2.2;// in k
R= R*10^3;// in k
Ad= 10^5;// differential voltage gain
C=1;// in  F
C= C*10^-6;// in F
T= 1;// in ms
T= T*10^-3;// in s
I= Vin/R;// in mA
V= I*T/C;// output voltage at the end of pulse in mV
V= V*10^-3;// in V
disp(V,"The output voltage at the end of the pulse
   in volts is : ")
RC_desh= R*C*Ad;// closed-loop time constant in sec.
disp(RC_desh,"The closed-loop time constant in
   seconds : ")
```

**Scilab code Exa 4.8** Value of R1 and Rf

```
// Example 4.8
clc;
clear;
close;
format('v',6);
// Given data
A_dB= 20;// peak gain in dB
A= 10^(A_dB/20);// peak gain
omega= 10000;// in rad/second
C= 0.01;// in  F
C= C*10^-6;// in F
Rf= 10;// in k
// Vout/V1= Rf/R1= A
R1= Rf/A;// in k
disp(Rf,"The value of Rf in k  is : ");
disp(R1,"The value of R1 in k  is : ");
```

**Scilab code Exa 4.9** Output voltage

```
// Example 4.9
clc;
clear;
close;
format('v',6);
// Given data
R= 40;// in k
R= R*10^3;// in
C= 0.2;// in  F
C= C*10^-6;// in F
```

```
Vin= 5;// in V
V1= 3;// in V
t= 50;// in ms
Vout= 3;// in V
t=[0:0.1:50];
vout= -1/(R*C)*integrate('(Vin-V1)','t',0,t)*10^-3+ Vout;//in V
plot(t,vout);
title("Sketch of output voltage");
xlabel("Time in milliseconds");
ylabel("Output voltage in volts")
disp("Plot for output voltage shown in figure");
```

---

**Scilab code Exa 4.10** Time duration required for saturation

```
// Example 4.10
clc;
clear;
close;
format('v',6);
// Given data
R= 500;// in k
R= R*10^3;// in
C= 10;// in  F
C= C*10^-6;// in F
vout= 12;// in V
v= -0.5;// in V
vout_by_t= -1/(R*C)*integrate('-t','t',0,1);//in V/sec
// Time required for saturation of output voltage
t= vout/vout_by_t;// in sec
disp(t,"The time duration required for saturation of output voltage in seconds is : ")
```

---

**Scilab code Exa 4.12** Output voltage

```
// Example 4.12
clc;
clear;
close;
format('v',7);
// Given data
fa= 1;// in kHz
fa= fa*10^3;// in Hz
Vp= 1.5;// in V
f= 200;// in Hz
C= 0.1*10^-6;// in F
t= poly(0,'t');
R= 1/(2*%pi*fa*C);// in
R= 1.5;// in k  (standard value)
fb= 20*fa;// in Hz
R_desh= 1/(2*%pi*fb*C);// in
R_desh= 82;// in    (standard value), so
R_OM= R;// in k
// Vin= Vp*sin(omega*t)= Vp*sin(2*%pi*f)*t
disp("The input votage : Vin = "+string(Vp)+ " sin(400*%pi*t)")
RC= R*10^3*C;// in  F
V= -RC*Vp*400*%pi;
//Vout= -RC*dVin/dt= -RC*Vp*400*%pi*cos(400*%pi*t)
disp("The output voltage : Vout = "+string(V)+" cos(400*%pi*t)")
x=[0:0.1:5*%pi/2];
plot(V*cos(x))
title("output Waveform");
xlabel("---- Time ---->");
ylabel("---- output voltage ---->");
disp("output Waveform is shown in figure.")
```

**Scilab code Exa 4.13** Differentiator to differentiate an input signal

```
// Example 4.13
clc;
clear;
close;
format('v',6);
// Given data
Vp= 1;// in V
f= 1000;// in Hz
R= 1.5*10^3;// in
C= 0.1*10^-6;// in F
// Vin= Vp*sin(omega*t)= Vp*sin(2*%pi*f)*t
disp("The input votage : Vin = sin(2000*%pi*t)")
RC= R*C;// in  F
V= -RC*2000*%pi;
//Vout= –RC*dVin/dt= –RC*Vp*2000*%pi*cos(2000*%pi*t)
disp("The output voltage : Vout = "+string(V)+" cos(2000*%pi*t)")
x=[0:0.1:4*%pi];
plot(-1.88*cos(x))
title("Output Waveform");
xlabel("——— Time ———>");
ylabel("——— output voltage ———>");
disp("Waveform is shown in figure.")
```

**Scilab code Exa 4.15** Instrumentation amplifier

```
// Example 4.15
clc;
clear;
close;
```

```
format('v',6);
// Given data
R1= 50;// in k
R3=15;// in k
R4=R3;// in k
// For minimum differential voltage gain,
Ad_min= 5;// and
Ad= Ad_min;
// From Ad= 1+2*R2/R1
R2= (Ad-1)*R1/2;// in k
// For maximum differential voltage gain,
Ad_max= 200;// and
Ad= Ad_max;
// From Ad= 1+2*R2/R1
R1_min= round(2*R2/(Ad-1));// in k
disp("The value of R1 : "+string(R1_min)+" k - "+
   string(R1)+" k ")
disp(R2,"The value of R2 in k is : ")
disp(R3,"The value of R3 and R4 in k is : ")
```

# Chapter 5

# Waveform Generators

**Scilab code Exa 5.1** Frequency and duty cycle

```
// Example 5.1
clc;
clear;
close;
// Given data
format('v',6);
C= 0.01;// in   F
C=C*10^-6;// in F
R_A= 2;// in  k
R_A=R_A*10^3;// in
R_B= 100;// in  k
R_B=R_B*10^3;// in
T_HIGH= 0.693*(R_A+R_B)*C;//charging period in second
T_LOW= 0.693*R_B*C;// discharging period in second
T= T_HIGH+T_LOW;// overall period of oscillations in second
f= 1/T;// frequency of oscillations in Hz
D= T_HIGH/T*100;// duty cycle in %
disp(f,"The frequency of oscillations in Hz is : ")
disp(D,"Duty cycle in % is : ")
```

**Scilab code Exa 5.2** Positive and negative pulse width and free running frequency

```
// Example 5.2
clc;
clear;
close;
// Given data
format('v',6);
C= 1;// in  F
C=C*10^-6;// in F
R_A= 4.7;// in k
R_A=R_A*10^3;// in
R_B= 1;// in k
R_B=R_B*10^3;// in
T_on= 0.693*(R_A+R_B)*C;//positive pulse width in second
T_on= T_on*10^3;// in ms
T_off= 0.693*R_B*C;// pulse width in second
T_off= T_off*10^3;// in ms
f= 1.4/((R_A+2*R_B)*C);// free running frequency in Hz
D= round((R_A+R_B)/(R_A+2*R_B)*100);// in %
disp(T_on,"The positive pulse width in ms")
disp(T_off,"The negative pulse width in ms")
disp(f,"The frequency of oscillations in Hz is : ")
disp(D,"Duty cycle in % is : ")
```

**Scilab code Exa 5.3** Required resistor

```
// Example 5.3
```

```
clc;
clear;
close;
// Given data
format('v',6);
C= 0.01;// in   F
C= C*10^-6;// in F
f= 1;// in kHz
f= f*10^3;// in Hz
// For 50% duty cycle, Ton= Toff = T/2 and R_A= R_B
// From equation, f= 1.44/((R_A+R_B)*C)= 1.44/(2*R_A*C)
R_A= 1.44/(2*f*C);// in
R_A= R_A*10^-3;// in  k
R_B= R_A;// in  k
disp(R_A,"The value of R_A and R_B in  k   : ")
disp("(Standard value 68  k  )")
```

**Scilab code Exa 5.4** Designing of a 555 timer

```
// Example 5.4
clc;
clear;
close;
// Given data
format('v',5);
f= 700;// in Hz
C= 0.01;// in   F  (assumed)
C= C*10^-6;// in F
// For 50% duty cycle, Ton= Toff = T/2 and R_A= R_B
// From equation, f= 1.44/((R_A+R_B)*C)= 1.44/(2*R_A*C)
R_A= 1.44/(2*f*C);// in
R_A= R_A*10^-3;// in  k
R_B= R_A;// in  k
```

```
C= C*10^6;// in  F
disp(R_A,"The value of R_A and R_B in k  : ")
disp("(Standard value 100 k )")
disp(C,"The value of C in  F is : ")
```

**Scilab code Exa 5.5** Designing of a 555 timer

```
// Example 5.5
clc;
clear;
close;
// Given data
format('v',5);
f= 800;// in Hz
C= 0.01;// in  F (assumed)
C= C*10^-6;// in F
D= 60;// in duty cycle in %
// D= (R_A+R_B)/(R_A+2*R_B)*100= 60 or
// R_B= 2*R_A
R_A= 1.44/(f*5*C);// in    (From f=1.44/((R_A+2*R_B)*C))
R_A= R_A*10^-3;//in k
R_B= 2*R_A;// in k
C= C*10^6;//in F
disp(R_A,"The value of R_A in k  is : ");
disp(R_B,"The value of R_B in k  is : ");
disp(C,"The value of C in  F is : ")
```

**Scilab code Exa 5.6** Resonance frequencies

```
// Example 5.6
clc;
clear;
```

```
close;
// Given data
format('v',5);
Rs= 5*10^3;//series resistance in
Ls= 0.8;// seried inductance in H
Cs= 0.08*10^-12;//series capacitance in F
Cp= 1.0*10^-12;// parallel capacitance in F
fs= 1/(2*%pi*sqrt(Ls*Cs));// series resonant frequency in Hz
fs= fs*10^-3;// in kHz
fp= 1/(2*%pi)*sqrt((1+Cs/Cp)/(Ls*Cs));// parallel resonant frequency in Hz
fp= fp*10^-3;// in kHz
disp(fs,"The series resonant frequency in kHz is : ")
disp(fp,"The parallel resonant frequency in kHz is : ")
```

**Scilab code Exa 5.7** Power dissipated in the crystal

```
// Example 5.7
clc;
clear;
close;
// Given data
format('v',6);
C1= 1000*10^-12;// in F
C2= 100*10^-12;// in F
f= 1*10^6;// in Hz
R1= 1*10^6;// in    (assume)
R2= 10*10^3;// in    (assume)
Rs= 800;// in
VDD= 5;// in V
C_T= C1*C2/(C1+C2);//total capacitance in F
// At resonance, X_L= X_CT or 2*%pi*f*L= 1/(2*%pi*f*
```

```
C_T), So
L= 1/((2*%pi*f)^2*C_T);// in H
L= L*10^3;// in mH
disp(L,"The value of inductance in mH is : ")
i_p= VDD/(R1+R2+Rs);//current through crystal in A
// Power dissipated in the crystal,
P_D= (0.707*i_p)^2*Rs;// in W
P_D= P_D*10^9;//in nW
disp(P_D,"The power dissipated in the crystal in nW is : ")
```

**Scilab code Exa 5.8** Signal frequency and amplitude of triangular and square wave

```
// Example 5.8
clc;
clear;
close;
// Given data
format('v',6);
R= 12*10^3;// in
R1= 120*10^3;// in
Rf= 1*10^6;// in
C= 0.1*10^-6;// in F
Vsupply= 12;// in V
Vsat= 10;//in V
//Part (i) : Signal frequency,
f= Rf/(4*R1*R*C);// in Hz
f= f*10^-3;// in kHz
disp("Part (i) : The signal frequency : "+string(f)+" kHz")
// Part (ii) : Amplitude of triangular wave,
Vpp= 2*R1/Rf*Vsat;// Vp-p
disp("Part (ii) : Amplitude of the triangular wave is : "+string(Vpp)+" Vp-p")
```

```
// Amplitude of square wave,
Vpp= Vsat-(-Vsat);//Vp-p
disp("Amplitude of the square wave is : "+string(Vpp
    )+" Vp-p")
```

**Scilab code Exa 5.10** A Wien bridge oscillator

```
// Example 5.10
clc;
clear;
close;
// Given data
format('v',6);
I_Bmax= 500;// in nA
I_Bmax= I_Bmax*10^-9;// in A
VCC= 10;// in V
f= 10*10^3;// in Hz
I1= 500*10^-6;// current through R1 in A (assume)
Vout= (VCC-1);//output voltage in V
// Rf+R1= Vout/I1 and Rf= 2*R1, so
R1= Vout/(3*I1);// in
R1= R1*10^-3;// in k
disp("The value of R1 is : "+string(R1)+" k (
    standard value 5.6 k )");
R1= 5.6;// in k (standard value)
Rf= 2*R1;// in k
disp("The value of Rf is : "+string(Rf)+" k (
    standard value 12 k )");
R= R1;// in k
R= R*10^3;// in
C= 1/(2*%pi*f*R);// in F
C= C*10^12;// in pF
disp("The value of C is : "+string(C)+" pF");
```

**Scilab code Exa 5.11** Frequency of oscillation

```
// Example 5.11
clc;
clear;
close;
// Given data
format('v',6);
R= 1*10^3;// in
C= 4.7*10^-6;// in F
omega= 1/(R*C);// radians/second
f= omega/(2*%pi);// in Hz
disp(f,"The frequency of oscillation in Hz is : ")
```

# Chapter 6

# Digitally Controlled Frequency Synthesizers

**Scilab code Exa 6.1** Free runnting frequency

```
// Example 6.1
clc;
clear;
close;
// Given data
format('v',6);
R1= 15*10^3;// in
C1= 0.01*10^-6;// in F
C2= 10*10^-6;// in F
R2= 3.6*10^3;// in
Vpos= 12;// in V
Vneg= -12;// in V
f_out= 1.2/(4*R1*C1);// free running frequency in Hz
f_out= f_out*10^-3;// in kHz
disp("The free running frequency is : "+string(f_out)+" kHz");
f_L= 8*f_out/(Vpos-(Vneg));//Lock-range in kHz
disp("Lock-range of the circuit is :    "+string(f_L)+" kHz");
```

```
f_L= f_L*10^3;// in Hz
f_C= sqrt(f_L/(2*%pi*R2*C2));// Hz
disp("Capture-range of the circuit is :    "+string(
   f_C)+" Hz");
```

**Scilab code Exa 6.2** Frequency of reference oscillator

```
// Example 6.2
clc;
clear;
close;
// Given data
format('v',12);
f_out_max= 200;// in kHz
f_lowest= 1;// in Hz
// Frequency of reference oscillator ,
f_ref_os= 2.2*f_out_max;// in kHz
disp("The frequency of reference oscillator is : "+
   string(f_ref_os)+" kHz")
// Formula used : f_lowest= f_ref_os/2^n
n= round(log(f_ref_os*10^3/f_lowest)/log(2));//
   number of bits required
disp("The number of bits required is : "+string(n))
```

# Chapter 7

# Active Filters

**Scilab code Exa 7.1** Low pass filter

```
// Example 7.1
clc;
clear;
close;
// Given data
format('v',6);
f_H= 2*10^3;//cut-off frequency in Hz
C= 0.01*10^-6;// in F
passband_gain= 2.5;
R= 1/(2*%pi*f_H*C);// in
R= 8.2;// in k  (standard value)
// 1+Rf/R1= passband_gain or Rf should be equal to
   1.5*R1 since Rf||R1= R
R1= passband_gain/1.5*R;// in k
disp("The value of R1 is : "+string(R1)+" k ");
disp("(Standard value 15 k )");
Rf= floor(1.5*R1);// in k
disp("The value of Rf is : "+string(Rf)+" k ");
```

**Scilab code Exa 7.2** Second order low pass filter

```
// Example 7.2
clc;
clear;
close;
// Given data
format('v',6);
f_H= 2*10^3;//cut-off frequency in Hz
C= 0.033*10^-6;// in F
R= 1/(2*%pi*f_H*C);// in
// 2*R= Rf*R1/(Rf+R1)= 0.586*R1^2/(1.586*R1) since
   Rf= 0.586*R1
R1= 2*R*1.586/0.586;// in
R1= round(R1*10^-3);// in k
disp("The value of R1 is : "+string(R1)+" k ");
disp("(The value of R1 may be taken of 15 k )");
R1= 15;// in k
Rf= R1*0.586;// in k
//Rf= floor(1.5*R1);// in k
disp("The value of Rf is : "+string(Rf)+" k ");
disp("(The value of Rf may be taken as a pot of 10
    k )");
```

**Scilab code Exa 7.3** Second order low pass filter

```
// Example 7.3
clc;
clear;
close;
// Given data
format('v',7);
f_H= 1*10^3;//cut-off frequency in Hz
C= 0.0047*10^-6;// in F
R= 1/(2*%pi*f_H*C);// in
```

```
R= (R*10^-3);// in  k
R1= 30;// in  k  (assume)
Rf= 0.586*R1;// in  k
C= C*10^6;// in  F
disp("The value of R''= R= "+string(R)+"  k  (standard value 33  k )");
disp("The value of C''= C= "+string(C)+"   F  ");
disp("The value of R1=  "+string(R1)+"  k  ");
disp("The value of Rf=  "+string(Rf)+"  k  (standard value 20  k  pot) ");
```

**Scilab code Exa 7.4** Flattest band second order active filter

```
// Example 7.4
clc;
clear;
close;
// Given data
format('v',5);
fc= 1*10^3;// in Hz
alpha= 1.414;
C= 0.1*10^-6;// in F (assume)
C_desh= C*alpha^2/4;// in F
C_desh= C_desh*10^6;// in  F
disp("The value of C'' is : "+string(C_desh)+"   F");
C_desh= C_desh*10^-6;// in F
R_desh= 1/(2*%pi*fc*sqrt(C*C_desh));// in
R_desh= R_desh*10^-3;// in  k
disp("The value of R'' is : "+string(R_desh)+"  k  (standard value 2.2  k )")
```

**Scilab code Exa 7.5** Flattest passband second order active filter

```
// Example 7.5
clc;
clear;
close;
// Given data
format('v',5);
alpha= 1.414;// passband
C= 0.01*10^-6;// in F (assume)
fc= 1*10^3;// in Hz
dc_gain= 6;
R= 1/(2*%pi*C*fc);// in
R= R*10^-3;// in k
disp("The value of R is : "+string(R)+" k (
    standard value 15 k )");
R= 15;// in k
Af= 3-alpha;// and Af= 1+Rf/R1 or
// Rf= (Af-1)*R1    (i)
// 2*R= Rf || R1, hence from (i)
R1= 2*R*Af/(Af-1);// in k
disp("The value of R1 is : "+string(R1)+" k (
    standard value 82 k )");
R1= 82;// in k
Rf= (Af-1)*R1;// in k
disp("The value of Rf is : "+string(Rf)+" k (
    standard value 47 k )");
Aamp= dc_gain/Af;
disp("The value of Aamp is : "+string(Aamp));
```

**Scilab code Exa 7.7** Cut off frequency

```
// Example 7.7
clc;
clear;
close;
// Given data
```

```
format('v',6);
R= 2.1*10^3;// in k
C= 0.05*10^-6;// in F
R1= 20*10^3;// in
Rf= 60*10^3;// in
// Low cut-off frequency,
f_L= 1/(2*%pi*R*C);// in Hz
f_L= f_L*10^-3;// in kHz
disp(f_L,"The cut-off frequency in kHz is : ")
```

**Scilab code Exa 7.8** Centre frequency and gain

```
// Example 7.8
clc;
clear;
close;
// Given data
format('v',6);
R1= 2*10^3;// in
R2= 2/3*10^3;// in
R3= 200*10^3;// in
C= 0.1*10^-6;// in F
Af= R3/(2*R1);// gain
disp(Af,"The value of Af is : ")
// R1= Q/(2*%pi*f_C*C*Af)                    (i)
// R2= Q/(2*%pi*f_C*C*(2*Q^2-Af))    (ii)
// R3= Q/(%pi*f_C*C)                              (iii)
Q= sqrt((R3/(2*R2)+Af)/2);// from (ii) and (iii)
disp(Q,"The value of Q is : ");
f_C= Q/(R3*%pi*C);// in Hz (from (iii))
disp(f_C,"The value of f_C in Hz is : ");
omega_0= 2*%pi*f_C;// in radians/second
disp(omega_0,"The value of omega_0 in radians/seconds is : ")
```

**Scilab code Exa 7.10** Bandpass active filter

```
// Example 7.10
clc;
clear;
close;
// Given data
format('v',6);
f_L= 2*10^3;// in Hz
f_H= 2.5*10^3;// in Hz
Af= -5;
f_C= sqrt(f_L*f_H);// centre frequency in Hz
del_f= f_H-f_L;//bandwidth in Hz
Q= f_C/del_f;// selectivity
// Assume C1= C2= C= 0.01 F
C= 0.01*10^-6;// in F
R3= 1/(%pi*del_f*C);// in
R3= R3*10^-3;// in k
disp("The value of R3 is : "+string(R3)+" k ( standard value 64 k )");
R3= 64;// in k
R3= R3*10^3;// in
R1= -R3/(2*Af);//in
R2= R1/(4*%pi^2*f_C^2*R1*R3*C^2-.1)
R1= R1*10^-3;// in k
C=C*10^6;// in F
disp("The value of R1 is : "+string(R1)+" k ");
disp("The value of R2 is : "+string(R2)+" k ( standard value 800 )");
disp("The value of C is : "+string(C)+" F ");
```

**Scilab code Exa 7.11** Narror bandpass filter

```
// Example 7.11
clc;
clear;
close;
// Given data
format('v',6);
f_C= 1*10^3;//centre frequency in Hz
f_C_desh= 2*10^3;//new centre frequency in Hz
Q= 5;// selectivity
Af= -8;
C= 0.01*10^-6;// in F (assume)
R3= Q/(%pi*f_C*C);//in
R3= R3*10^-3;// in k
disp("The value of R3 is : "+string(R3)+" k  (160 k  (approx))");
R1= round(-R3/(2*Af));// in k
disp("The value of R1 is : "+string(R1)+" k ");
R2= R1*10^3/(4*%pi^2*f_C^2*R1*10^3*R3*10^3*C^2-1);// in
R2= R2*10^-3;// in k
disp("The value of R2 is : "+string(R2)+" k  (2 k (approx))");
R2= 2;// in k  (approx)
R2_desh= R2*(f_C/f_C_desh)^2;// in k
R2_desh= R2_desh*10^3;// in
disp("The value of R2'' is : "+string(R2_desh)+"  ")
```

---

**Scilab code Exa 7.12** Cut off frequencies

```
// Example 7.12
clc;
clear;
close;
// Given data
```

```
format('v',6);
R= 10*10^3;// in
C1= 0.1*10^-6;// in F
C2= 0.0025*10^-6;// in F
f_H= 1/(2*%pi*R*C2);//higher cut-off frequency in Hz
f_H= f_H*10^-3;// in kHz
f_L= 1/(2*%pi*R*C1);//lower cut-off frequency in Hz
BW= f_H-f_L*10^-3;// bandwidth in kHz
disp(f_H,"The higher cut-off frequency in kHz is : "
    )
disp(f_L,"The lower cut-off frequency in Hz is : ")
disp(BW,"The bandwidth in kHz is : ")
```

**Scilab code Exa 7.13** Designing of a bandpass filter

```
// Example 7.13
clc;
clear;
close;
// Given data
format('v',5);
f_L= 200;// in Hz
f_H= 1*10^3;// in Hz
alpha=4;// passband gain
C_desh= 0.01*10^-6;// in F (assume)
R_desh= 1/(2*%pi*f_H*C_desh);// in
R_desh= R_desh*10^-3;// in k
disp("The value of R'' is : "+string(R_desh)+" k  (
    Approx. 20 k )")
R_desh= 20;// in k  (standard value)
// First Order High-Pass Filter
C= 0.05*10^-6;// in F (assume)
R= 1/(2*%pi*f_L*C);// in
R= R*10^-3;// in k
R1= 10;// in k
```

```
Rf= R1;// in k
C_desh= C_desh*10^6;// in  F
C= C*10^6;// in  F
disp("The value of R is : "+string(R)+" k  (Approx. 20 k )")
R= 20;// in k  (standard value)
disp("The value of R1 and Rf is : "+string(R1)+" k ")
disp("The value of C'' is : "+string(C_desh)+"  F")
disp("The value of C is : "+string(C)+"  F")
```

**Scilab code Exa 7.14** A wide band stop filter

```
// Example 7.14
clc;
clear;
close;
// Given data
format('v',5);
f_H= 200;// in Hz
f_L= 2*10^3;// in Hz
C= 0.05*10^-6;// in F
// For low-pass filter ,
R_desh= 1/(2*%pi*f_H*C);// in
R_desh= R_desh*10^-3;// in k
disp("The value of R'' is : "+string(R_desh)+" k  ( Approx. 20 k )")
// For high-pass filter ,
R= 1/(2*%pi*f_L*C);// in
R= R*10^-3;// in k
disp("The value of R is : "+string(R)+" k  ( Approx. 2 k )")
```

**Scilab code Exa 7.15** A 50 Hz active notch filter

```
// Example 7.15
clc;
clear;
close;
// Given data
format('v',5);
C= 0.068*10^-6;// in F
f_N= 50;// in Hz
R= 1/(2*%pi*f_N*C);// in
R= R*10^-3;// in k
disp("The value of R is : "+string(R)+" k ( Approx . 50 k )")
```

---

**Scilab code Exa 7.16** Phase shift

```
// Example 7.16
clc;
clear;
close;
// Given data
format('v',5);
R= 15*10^3;// in
C= 0.01*10^-6;// in F
f= 2*10^3;// in Hz
PhaseShift= -2*atand(2*%pi*f*R*C);// in
disp("The phase shift is : "+string(PhaseShift)+" i.e. "+string(abs(PhaseShift))+" (lagging)")
```

---

**Scilab code Exa 7.18** Bandpass centre frequency

```
// Example 7.18
```

```
clc;
clear;
close;
// Given data
format('v',6);
R_A= 2.2*10^3;// in
R_B= 1.2*10^3;// in
Rf= 4.7*10^3;// in
C= 0.01*10^-6;// in F
k_lp= 1.238;
k_hp= 1/k_lp;
// Part (i)
alpha= 3*R_B/(R_A+R_B);
disp(alpha,"Part (i) : The value of alpha is : ");
disp("Given filter is 1db peak Chebyshev");

// Part (ii)
f_0= 1/(2*%pi*Rf*C);//critical frequency in Hz
f_0= f_0*10^-3;// in kHz
f_low_pass= f_0*k_lp;// in kHz
disp(f_low_pass,"Part (ii) : The low-pass frequency
    in kHz is : ")
f_high_pass= f_0*k_hp;// in kHz
disp(f_high_pass,"The high-pass frequency in kHz is
    : ")

// Part (iii)
fc= f_0;// bandpass centre frequency in kHz
disp(fc,"Part (iii) : The bandpass centre frequency
    in kHz is : ")

// Part (iv)
// Formula used : delta_f= fc/Q= fc/(1/alpha)
delta_f= fc/(1/alpha);// in kHz
disp(delta_f,"Part (iv) : The bandpass width in kHz
    is : ")

// Part (v)
```

```
A0= 1/alpha;// bandpass gain at centre frequency
disp(A0,"Part (v) : The bandpass gain at centre
   frequency is : ")
```

# Chapter 8

# Non Linear circuits

**Scilab code Exa 8.2** Peak value and average value of voltage

```
// Example 8.2
clc;
clear;
close;
// Given data
format('v',5);
R1= 5;// in k
R2= 10;// in k
V_peak= R1*R2/(R1+R2);// in V
Vav= V_peak/%pi;// in V
disp("Peak value of V1 is : "+string(V_peak)+" V")
disp("Average value of Vo is : "+string(Vav)+" V")
```

**Scilab code Exa 8.7** DC voltage with proper sign

```
// Example 8.7
clc;
clear;
```

```
close;
// Given data
format('v',6);
t= 0;
Vc= 0;// in volts
Vo= 5;// in volts
R= 10;// in 2    (assume)
RC= 1;// (assume)
R3= 2*R;// in
R2= 3*R;// in
// From equation : T= 2*Rf*C*log[1+2*R3/R2]
T= 2*RC*log(1+2*R3/R2);
Vc_t= 2;// in volts
t= T/2;
//Voltage across capacitor ,
// Vc_t= Vco*[1-%e^(-t/ReqC)]= 1/5*(VR+4*Vo)*[1-%e^(-t/4*RC/5)]
VR= Vc_t*5/[1-%e^(-t/(4*RC/5))]-4*Vo;
disp("The value of VR is : "+string(VR)+" volts")
```

**Scilab code Exa 8.9** Output voltage

```
// Example 8.9
clc;
clear;
close;
// Given data
format('v',7);
// Part (c)
R1= 150;// in
R2= 68*10^3;// in
Vin= 50*10^-3;// in V
Vsat= 14;// in V
Vpositive= Vsat*(R1/(R1+R2));// in V
V_UT= Vpositive;// in V
```

```
V_LT= Vpositive;// in V
disp(V_UT,"The value of V_UT in volts is : ")
disp(V_LT,"The value of V_LT in volts is : ")
```

**Scilab code Exa 8.10** Schmitt trigger

```
// Example 8.10
clc;
clear;
close;
// Given data
format('v',9);
V_UT= 5;// in V
V_LT= -5;// in V
// Hysteresis voltage ,
Vhy= V_UT-V_LT;// in V
disp(Vhy,"The hysteresis voltage in volts is : ")
```

# Chapter 10

# Voltage Regulators

**Scilab code Exa 10.1** Minimum input voltage

```
// Example 10.1
clc;
clear;
close;
// Given data
format('v',6);
Idc= 300;// in mA
C= 200;// in   F
Vmax= 24;// in V
Vrms= 2.4*Idc/C;//in V
Vr_peak= sqrt(3)*Vrms;// in V
Vdc= Vmax-Vr_peak;// in V
disp(Vdc,"The minimum input voltage in volts is : ")
```

**Scilab code Exa 10.2** Input voltage

```
// Example 10.2
clc;
```

```
clear;
close;
// Given data
format('v',6);
VR= 12;// in V
IL= 0.5;// in A
RL= 25;// in
// Resistanc required,
R= VR/IL;// in
VL= IL*RL;// in V
Vout= VR+VL;//output voltage in V
Vin= Vout+2;// input voltage in V
disp(Vin,"The input voltage in volts is : ")
```

**Scilab code Exa 10.3** Regulated output voltage

```
// Example 10.3
clc;
clear;
close;
// Given data
format('v',6);
R1= 240;// in
R2= 1.2*10^3;// in
// Regulated output voltage in the circuit,
Vout= 1.25*(1+R2/R1);// in V
disp(Vout,"The regulated output voltage in volts is
    : ");
```

**Scilab code Exa 10.4** Minimum and maximum output voltage

```
// Example 10.4
clc;
```

```
clear;
close;
// Given data
format('v',6);
V_REG= 15;// in V
I_Q= 10*10^-3;// in A
R1= 40;// in
// When potentiometer R2=0    (minimum)
R2= 0;// in
Vout= (1+R2/R1)*V_REG+I_Q*R2;
disp(Vout,"The minimum output voltage in volts is : ");
// When potentiometer R2=200    (maximum)
R2= 200;// in
Vout= (1+R2/R1)*V_REG+I_Q*R2;
disp(Vout,"The minimum output voltage in volts is : ");
```

**Scilab code Exa 10.5** Regulated output voltage

```
// Example 10.5
clc;
clear;
close;
// Given data
format('v',6);
V_REF= 1.25;// in V
R1= 2.5*10^3;// in
R2= 1*10^3;// in
I= V_REF/R2;// in A
// The output voltage ,
Vout= I*(R1+R2);// in V
disp(Vout,"The regulated output voltage in volts is : ")
```

**Scilab code Exa 10.6** Duty cycle of the pulses

```
// Example 10.6
clc;
clear;
close;
// Given data
format('v',6);
V_REF= 1.25;// in V
R1= 3*10^3;// in
R2= 1*10^3;// in
Vin= 20;// in V
Vout= V_REF*(R1+R2)/R2;// output voltage in volts
// Duty cycle ,
D= Vout/Vin*100;// in %
disp("The duty cycle is "+string(D)+" %")
```