Scilab Textbook Companion for Linear Integrated Circuit by M. S. Sivakumar[1]

Created by
Khan Mohammed Ahmed Abdul Hameed
B.E (EXTC)
Electronics Engineering
Mumbai
College Teacher
S. Chaya Ravindra
Cross-Checked by
Bhavani Jalkrish

October 14, 2014

[1]Funded by a grant from the National Mission on Education through ICT, http://spoken-tutorial.org/NMEICT-Intro. This Textbook Companion and Scilab codes written in it can be downloaded from the "Textbook Companion Project" section at the website http://scilab.in

Book Description

Title: Linear Integrated Circuit

Author: M. S. Sivakumar

Publisher: S. Chand, New Delhi

Edition: 1

Year: 2013

ISBN: 81-219-4113-X

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 3

Current or Voltage Sources and Differential Amplifier

Scilab code Exa 3.1 Determine the collector current Ic1 and collector emitter voltage Vce1 for the difference amplifier circuit

```
//Example 3.1  // Determine the collector current
   Ic1 and collector-emitter voltage Vce1 for the
   difference amplifier circuit
clc;
clear;
close;
V1 = 0 ;     // volt
V2 = -5 ;    //volt
Vcm =  5 ;    //volt
Vcc = 10;    //volt
Vee = -10 ;  //volt
Ie =  1 ;  //mA
Rc =  10 ;  //kilo ohm

// Transistor parameters
// base current are negligible
Vbe = 0.7 ;  // volt

```

```
// The collector current of difference amplifier is
Ic1 = Ie/2 ;
disp(' The collector current of difference amplifier Ic1 = Ic2 = '+string(Ic1)+' mA ');

// The collector voltages of transistors Q1 and Q2 are expressed as

Vc1 = Vcc-Ic1*Rc ;
disp(' The collector voltages of transistors Q1 and Q2 are Vc1 = Vc2 = '+string(Vc1)+' volt ');

// We know common mode voltage (Vcm) , from this the emitter voltage can be identified as follows
// For the common mode voltage Vcm = 0 V , the emitter voltage is Ve = -0.7 V
// For the common mode voltage Vcm = 5 V , the emitter voltage is Ve = 4.3 V
// For the common mode voltage Vcm = -5 V , the emitter voltage is Ve = -5.7 V

// For the different emitter voltages the collector-emitter voltage can be calculated as

Ve = -0.7 ; // volt
Vce1 = Vc1-Ve;
disp('For Ve = -0.7 Volt the collector - emitter voltage Vce1 = ' +string(Vce1)+' Volt');

Ve = 4.3 ; // volt
Vce1 = Vc1-Ve;
disp('For Ve = 4.3 Volt the collector - emitter voltage Vce1 = ' +string(Vce1)+' Volt');

Ve = -5.7 ; // volt
Vce1 = Vc1-Ve;
disp('For Ve = -5.7 Volt the collector - emitter voltage Vce1 = ' +string(Vce1)+' Volt');
```

Scilab code Exa 3.2 To determine the difference mode and common mode gain of the difference amplifier

```
//Example3.2 // To determine the difference-mode and common-mode gain of the difference amplifier
clc;
clear;
close;
Vcc = 10 ; // volt
Vee = -10 ; //volt
Iq = 0.8 ; //mA
Ie = 0.8 ; //mA
Rc = 12 ; //kilo-Ohm
Vt = 0.026 ; // volt

// Transistor parameter
beta = 100 ;
Rs = 0 ; //Ohm
Ro = 25 ; //kilo-Ohm
// The differential mode gain Ad
gm = (Ie/ 2*Vt) ;
// Ad = (gm*r*Rc/r+Rc) ; // where r is r-pi
// For Rb=0 , the differential mode gain is

Ad = (Ie/(2*Vt))*Rc;
//But
disp(' The differential mode gain Ad = ' +string(Ad) + ' ' );

//The common mode gain Acm
// Acm = - (gm*Rc/1+2*gm*Re+2*Re/r)
Acm =-(Ad/(1+(((1+beta)*Ie*Ro)/(beta*Vt))));
disp(' The common mode gain Acm = ' +string(Acm)+ ' ' );
```

Scilab code Exa 3.3 To find the output of a difference amplifier when only common mode signal is applied

```
//Example 3.3 // To find the output of a difference
    amplifier when only common mode signal is applied
clc;
clear;
close;
// V1 = V2 = Vcm = 200*sin(wt) ;    // micro volt (uV
    )
Acm  = -0.237 ;

// When the common mode input signal is applied to
    the difference amplifier , the difference mode
    gain is zero
Vcm = 200 ;
Vo = Acm*Vcm ;
disp('       The output of a difference amplifier is
     Vo  = '+string(Vo)+'sinwt uV '); // multiply
    by sinwt because it is in Vcm
```

Scilab code Exa 3.4 Determine the common mode rejection ratio CMRR of the difference amplifier

```
//Example 3.4 //Determine the common mode rejection
    ratio(CMRR) of the difference amplifier
clc;
clear;
close;
Vcc = 10 ; // volt
Vee = -10 ;  //volt
```

```
Iq  =  0.8 ;  //mA
Ie  =  0.8 ;  //mA
Rc = 12 ;  //kilo-Ohm
Vt = 0.026 ;  // volt

// Transistor parameter
beta = 100 ;
Rs = 0 ;  //Ohm
Ro = 25 ;  //kilo-Ohm

// The differential mode gain Ad
gm = (Ie/ 2*Vt) ;
// Ad = (gm*r*Rc/r+Rc) ;   // where r is r-pi
// For Rb=0 , the differential mode gain is

Ad = (Ie/(2*Vt))*Rc;
//But
disp(' The differential mode gain Ad = ' +string(Ad)
    + '   ');

//The common mode gain Acm
// Acm = - (gm*Rc/1+2*gm*Re+2*Re/r)
Acm =-(Ad/(1+(((1+beta)*Ie*Ro)/(beta*Vt))));
disp(' The common mode gain Acm = ' +string(Acm)+ '
    ');

// The CMRR of difference amplifier is given as
Ad = Ad/2 ;
CMRR = abs(Ad/Acm);
disp(' The CMRR of difference amplifier is = ' +
    string(CMRR)+ '   ');

// In decibel it can be expressed as
CMRRdb = 20*log10(CMRR);
disp(' In decibel CMRR is = ' +string(CMRRdb)+ '   '
    );
```

Scilab code Exa 3.5 To determine emitter resistance of the difference amplifier

```
//Example3.5 // To determine emitter resistance of
    the difference amplifier
clc;
clear;
close;
Vcc = 10 ; // volt
Vee = -10 ;  //volt
Iq  =  0.8 ;  //mA
Ie  =  0.8 ;  //mA
CMRRdb = 90 ;  //dB
Vt = 0.026 ;

// Transistor parameter
beta = 100 ;

// CMRR = abs(Ad/Acm);
// the CMRR of the difference amplifier is defined
    as
//CMRR = ((1/2)*(1+((1+beta)*Ie*Re)/beta*Vt))

// CMRRdb = 20*log10(CMRR)
CMRR = 10^(CMRRdb/20);
disp('The CMRR of difference amplifier is = ' +
    string(CMRR)+ '  ');

// The resistance RE is calculated as

RE = (((2*CMRR)-1)/((1+beta)*Ie))*(beta*Vt)
disp('The value of resistance RE is = ' +string(RE)
    + ' K ohm ');
```

Scilab code Exa 3.6 determine the differential mode gain when load resistance RL is given

```
//Example3.6  // determine the differential mode
   gain when load resistance RL = 100 k ohm
clc;
clear;
close;
RL = 100*10^3 ; // k ohm  // load resistance
IE = 0.20*10^-3 ; // mA  // biasing current
VA = 100 ; // V // early voltage
VT = 0.026 ;  // threshold volt

// the differential gain of differential amplifier
   with an active load circuit
//Ad = Vo/Vd  = gm(ro2 || ro4 || RL  )
ro2 = (2*VA)/IE;
ro4 = ro2 ;
gm = IE/(2*VT) ;

Ad = gm/((1/ro2)+(1/ro4)+(1/RL));
disp(' The differential mode gain Ad is = ' +string(
   Ad)+ '   ');
```

Chapter 4

Operational Amplifier

Scilab code Exa 4.1 For an op amp circuit find 1 closed loop gain Acl 2 input impedance Zin 3 output impedance Zo

```
//Example 4.1 // For an op—amp circuit find a)
   closed loop gain Acl b) input impedance Zin c)
   output impedance Zo
clc ;
clear ;
close ;
ro = 85 ; // ohm
A = 150*10^3 ; // ohm
R2 = 350*10^3 ; // ohm  // Feedback resistance
R1 = 10*10^3 ; // ohm  // Input resistance

// a) closed loop gain
// ACL = abs(Vo/Vin) = abs(R2/R1)
ACL = abs(R2/R1) ;
disp('  closed loop gain of an op—amp is = '+string(
   ACL)+'  '); // 1/beta = ACL
beta = (1/ACL) ;

// b) the input impedance Zin
Zin = R1 ;
```

```
disp('  the input impedance Zin = '+string(Zin)+'
    ohm ');

// c0 the output impedance Z0
Z0 = (ro)/(1+(beta*A));
disp('  the output impedance Z0 = '+string(Z0)+' ohm
    ');
```

Scilab code Exa 4.2 Determine the differece voltage and open loop gain of an op amp

```
//Example 4.2 // Determine the differece voltage and
    open loop gain of an op-amp
clc ;
clear ;
close ;
V1 = -5 ; // volt  // input voltage
V2 = 5 ; // volt
Vo = 20 ; //volt  // output voltage

// the difference voltage is given by
 Vd = V2-V1 ;
disp('  The difference voltage is = '+string(Vd)+' V
    ');

// open loop gain
A = (Vo/Vd);
disp('  The open loop gain is = '+string(A)+'  ');
```

Scilab code Exa 4.3 Determine the differece voltage and open loop gain of an op amp

```
//Example 4.3 // Determine the differece voltage and open loop gain of an op-amp
clc ;
clear ;
close ;
V1 = -5 ; // volt // input voltage
V2 = 0 ; // volt  // GND
Vo = 20 ; //volt  // output voltage

// the difference voltage is given by
 Vd = V2-V1 ;
disp(' The difference voltage is = '+string(Vd)+' V ');

// open loop gain
A = (Vo/Vd);
disp(' The open loop gain is = '+string(A)+'  ');
```

Scilab code Exa 4.4 Determine the differece voltage and open loop gain of an op amp

```
//Example 4.4 // Determine the differece voltage and open loop gain of an op-amp
clc ;
clear ;
close ;
V1 = 0 ; // volt // input voltage  // GND
V2 = 5 ; // volt
Vo = 20 ; //volt  // output voltage

// the difference voltage is given by
 Vd = V2-V1 ;
disp(' The difference voltage is = '+string(Vd)+' V ');

```

```
// open loop gain
A = (Vo/Vd);
disp('  The open loop gain is = '+string(A)+'  ');
```

Scilab code Exa 4.5 Determine the differece voltage and open loop gain of an op amp

```
//Example 4.5 // Determine the differece voltage and
    open loop gain of an op-amp
clc ;
clear ;
close ;
V1 = 5 ; // volt // input voltage  // GND
V2 = -5 ; // volt
Vo = -20 ; //volt  // output voltage

// the difference voltage is given by
 Vd = V2-V1 ;
disp('  The difference voltage is = '+string(Vd)+' V
    ');

// open loop gain
A = (Vo/Vd);
disp('  The open loop gain is = '+string(A)+'  ');
```

Scilab code Exa 4.6 To find closed loop gain and output voltage Vo of an inverting op amp

```
//Example4.6  // To find closed loop gain and output
    voltage Vo of an inverting op-amp
clc;
clear;
close;
```

```
R1 = 10 ; //kilo ohm // input resistance
R2 = 25 ; // kilo ohm // feedback resistance
Vin = 10 ; //volt // input voltage

// Closed loop gain of an inverting op-amp
Ac = -(R2/R1) ;
disp('The Closed loop gain of an inverting op-amp is = '+string(Ac)+' ');
Ac = abs(Ac);
disp('The |Ac| Closed loop gain of an inverting op-amp is = '+string(Ac)+' ');

// the output voltage of an inverting op-amp
Vo = -(R2/R1)*Vin ;
disp(' The output voltage of an inverting op-amp is = '+string(Vo)+' V ');
```

Scilab code Exa 4.7 To find closed loop gain and output voltage Vo of an non inverting op amp

```
//Example4.7 // To find closed loop gain and output voltage Vo of an non-inverting op-amp
clc;
clear;
close;
R1 = 10 ; //kilo ohm // input resistance
R2 = 25 ; // kilo ohm // feedback resistance
Vin = 10 ; //volt // input voltage

// Closed loop gain of an non-inverting op-amp
Ac = 1+(R2/R1) ;
Ac = abs(Ac);
disp('The Closed loop gain of an non-inverting op-amp is = '+string(Ac)+' ');

```

```
// the output voltage of an inverting op-amp
Vo = (1+R2/R1)*Vin ;
disp(' The output voltage of an non-inverting op-amp
    is = '+string(Vo)+' V ');
```

Scilab code Exa 4.8 to find out closed loop gain and output voltage Vo

```
//Example4.8  // to find out closed loop gain and
    output voltage Vo
clc;
clear;
close;
R1 = 10 ; //kilo ohm  // input resistance
R3 = 10 ; //kilo ohm  // input resistance
R2 = 25 ; // kilo ohm  // feedback resistance
R4 = 25 ; // kilo ohm  // feedback resistance
Vin2 = 10 ; //volt  // input voltage
Vin1 = -10 ; //volt  // input voltage

// closed loop gain of differntial op-amp is given
    by
Ac = (R2/R1) ;
Ac = abs(Ac);
disp('The closed loop gain of differntial op-amp is
    = '+string(Ac)+'  ');

// the output voltage of an non-inverting op-amp is
    given by
Vo = (R2/R1)*(Vin2-Vin1) ;
disp('The output voltage of an non-inverting op-amp
    is= '+string(Vo)+' V ');
```

Scilab code Exa 4.9 Determine the non inverting input voltage

```
// Example4.9  // Determine the non-inverting input
   voltage
clc;
clear;
close;
R1 = 10 ; //kilo ohm  // input resistance
R2 = 25 ; //kilo ohm // feedback resistance
Voh = 10 ; // volt //output voltage
Vol = -10 ; // volt // output voltage

// upper voltage
V = (R1/(R1+R2)*Voh) ;
disp('  The upper voltage is = '+string(V)+' V ');

// Lower voltage
V = (R1/(R1+R2)*Vol) ;
disp('  The lower voltage is = '+string(V)+' V ');
```

Chapter 5

Characteristics of Operational Amplifier

Scilab code Exa 5.1 find the total offset voltage of feedback op amp

```
//Example5.1 // find the total offset voltage of
    feedback op-amp
clc;
clear;
close;
Vos = 4 ; //mV  // input offset volt
Ios = 150*10^-3 ; // input offset current
R1 = 5 ; //kilo ohm  // input resistance
R2 = 500 ; //kilo ohm  // feedback resistance

// the output voltage (Vo) of an op-amp circuit due
    to input offset voltage (Vos) is
Vo1 = ((R1+R2)/(R1)*Vos) ;
disp(' the output voltage (Vo) of an op-amp circuit
    due to input offset voltage (Vos) is = '+string(
    Vo1)+' mV ');

// the output voltage (Vo) of an op-amp circuit due
    to input offset current (Ios) is
```

```
Vo2 = R2*Ios ;
disp(' the output voltage (Vo) of an op-amp circuit due to input offset current (Ios) is = '+string(Vo2)+' mV ');

// the total offset voltage is
Vo = Vo1+Vo2 ;
disp(' the total offset voltage (Vo) of an op-amp circuit is = '+string(Vo)+' mV ');
```

Scilab code Exa 5.2 find the total offset voltage of feedback op amp

```
//Example5.2 // find the total offset voltage of feedback op-amp
clc;
clear;
close;
Vos = 2 ; //mV // input offset volt
Ios = 20*10^-3 ; // input offset current
R1 = 10 ; //kilo ohm // input resistance
R2 = 250 ; //kilo ohm // feedback resistance

// the output voltage (Vo) of an op-amp circuit due to input offset voltage (Vos) is
Vo1 = ((R1+R2)/(R1)*Vos) ;
disp(' the output voltage (Vo) of an op-amp circuit due to input offset voltage (Vos) is = '+string(Vo1)+' mV ');

// the output voltage (Vo) of an op-amp circuit due to input offset current (Ios) is
Vo2 = R2*Ios ;
disp(' the output voltage (Vo) of an op-amp circuit due to input offset current (Ios) is = '+string(Vo2)+' mV ');
```

```
// the total offset voltage is
Vo = Vo1+Vo2 ;
disp(' the total offset voltage (Vo) of an op−amp circuit is = '+string(Vo)+' mV ');
```

Scilab code Exa 5.3 find the input offset voltage of an op amp circuit

```
//Example5.3 // find the input offset voltage of an op−amp circuit
clc;
clear;
close;
Vo = 90.2 ; //mV // output voltage
R1 = 2 ; //kilo ohm // input resistence
R2 = 150 ; //kilo ohm // feedback resistence

// the input offset voltage (Vos) of an op−amp circuit is defined as
Vos = ((R1)/(R1+R2)*Vo) ;
disp('the input offset voltage (Vos) of an op−amp circuit is = '+string(Vos)+' mV ');
```

Scilab code Exa 5.4 find the output voltage of an op amp circuit

```
//Example5.4 // find the output voltage of an op−amp circuit
clc;
clear;
close;
Vos = 1 ; //mV // input offset volt
R1 = 10 ; //kilo ohm // input resistance
R2 = 350 ; //kilo ohm // feedback resistance
```

```

// the output voltage due to the input offset
   voltage of the op-amp circuit is defined by
Vo1 = ((R1+R2)/(R1)*Vos) ;
disp('the output voltage due to the input offset
   voltage  is = '+string(Vo1)+' mV ');
```

Scilab code Exa 5.5 Determine the bias current effect with and without current compensation method

```
//Example5.5 // Determine the bias current effect
   with and without current compensation method
clc;
clear;
close;
R1 = 10 ; //kilo ohm
R2 = 100 ; //kilo ohm
Ib1 = 1.1*10^-3 ;
Ib2 = 1*10^-3 ;
// the output voltage of the circuit due to bias
   current is
Vo = Ib1*R2 ;
disp('the output voltage of the circuit due to bias
   current is = '+string(Vo)+' V ');

//Bias compensated resistor is given by
R3 = (R1*R2)/(R1+R2) ;
disp('Bias compensated resistor is = '+string(R3)+'
   kilo ohm ');

//Bias compensated output voltage is given by
Vo = R2*(Ib1-Ib2);
disp('Bias compensated output voltage is = '+string(
   Vo)+' V ');
```

Scilab code Exa 5.6 find the input offset current of an op amp circuit

```
//Example5.6 // find the input offset current of an op-amp circuit
clc;
clear;
close;
Vo = 12*10^-3; // V // output voltage
R1 = 2*10^3 ; // ohm // input resistence
R2 = 150*10^3; // ohm // feedback resistence

// the output voltage (Vo) of an op-amp circuit due to input offset current (Ios) is
// Vo = R2*Ios ;
Ios = Vo/R2;
disp('the output voltage (Vo) of an op-amp circuit due to input offset current (Ios) is = '+string(Ios)+' A ');
```

Scilab code Exa 5.7 Determine the bias current of inverting and non inverting

```
//Example5.7 // Determine the bias current of inverting and non-inverting
clc;
clear;
close;
Ios = 5 ; //nA // input offset current
Ib = 30 ; //nA // input bias current

// the input bias current of an op-amp is

```

```
//Ib =(Ib1+Ib2)/(2);

// the offset current Ios is define as

//Ios = abs(Ib1-Ib2) ;

Ib1=Ib-(Ios/2);
disp('The current in the inverting input terminal is
    = '+string(Ib1)+' nA ');

Ib2 =Ib+(Ios/2);
disp('The current in the non-inverting input
    terminal is= '+string(Ib2)+' nA ');
```

Scilab code Exa 5.8 determine the feedback transfer function of an op amp for the following condition

```
//Example5.8 //determine the feedback transfer
    function of an op-amp for the following condition
clc;
clear;
close;
// a) When open loop gain of 10^5 and the closed
    loop gain of 100
A = 10^5 ; // open loop gain
Af = 100 ; //closed loop gain
// Feedback transfer function is
beta =(1/Af)-(1/A);
disp('Feedback transfer function is = '+string(beta)
    +'');
beta = 1/beta ;
disp('OR 1/Beta  is = '+string(beta)+'');

// For an open loop gain of -10^5 and closed loop
    gain of -100
```

```
A = -10^5 ; // open loop gain
Af = -100 ; //closed loop gain
// Feedback transfer function is
beta =(1/Af)-(1/A);
disp('Feedback transfer function is = '+string(beta)
    +'');
beta = 1/beta ;
disp('OR 1/Beta  is = '+string(beta)+'');
```

Scilab code Exa 5.9 to determine open loop gain

```
//Example5.9 //to determine open loop gain
clc;
clear;
close;
beta = 0.0120 ; // Feedback transfer function
Af = 80 ; //closed loop gain
A = (Af)/(1-beta*Af) ;
disp('open loop gain is = '+string(A)+'');
```

Scilab code Exa 5.10 To Determine the percent of change in the closed loop gain Af of feedback op amp circuit

```
//Example5.10  // To Determine the percent of change
     in the closed loop gain Af of feedback op-amp
    circuit
clc;
clear;
close;
A = 10^5 ;  // open loop gain
Af = 50 ;  // close loop gain
beta = 0.01999 ;  // feedback transfer function
dA = 10^4 ;  // the change in the open llop gain
```

```
// close loop gain
dAf = ((dA)/(1+dA*beta));
disp('close loop gain dAf is = '+string(dAf)+'');

// the percent change of closed loop gain
%dAf = (((Af-dAf)/(Af))*100);
disp('the percent change of closed loop gain dAf is
   = '+string(%dAf)+'%');
```

Scilab code Exa 5.11 To Determine the bandwidth of feedback amplifier

```
//Example5.11  // To Determine the bandwidth of
   feedback amplifier
clc;
clear;
close;
A = 10^4 ;  // open loop gain
Af = 50 ;  // close loop gain
wH = 628 ; //(2*%pi*100)  // rad/sec // open loop
   bandwidth

// close loop gain of an op-amp is defined as
// Af = ((A)/(1+A*beta));

// the feedback transfer function is given as
 beta = (1/Af)-(1/A) ;
 disp('the feedback transfer function beta is = '+
    string(beta)+'');

// closed loop bandwidth
wfH = wH*(1+beta*A);
disp('the closed loop bandwidth wfH is = '+string(
   wfH)+'');
```

Scilab code Exa 5.12 To calculate unity gain bandwidth and maximum close loop gain

```
//Example5.12  // To calculate unity gain bandwidth
   and maximum close loop gain
clc;
clear;
close;
A = 10^5 ;  // open loop gain
fo = 10 ; // Hz  // dominant pole frequency
fdb = 20*10^3 ; //Hz  // 3-db frequency

// the unity gain bandwidth
f1 = fo*A ;
 disp('the unity gain bandwidth is = '+string(f1)+'
    Hz');

// the maximum close loop gain
ACL = (f1/fdb) ;
disp('the maximum close loop gain ACL is = '+string(
   ACL)+'');
```

Scilab code Exa 5.13 To calculate unity gain bandwidth and maximum close loop gain

```
//Example5.13  // To calculate unity gain bandwidth
   and maximum close loop gain
clc;
clear;
close;
A = 10^3 ;  // open loop gain
fo = 60 ; // Hz  // dominant pole frequency
```

```
fdb = 12*10^3 ; //Hz  // 3-db frequency

// the unity gain bandwidth
f1 = fo*A ;
 disp('the unity gain bandwidth is = '+string(f1)+' Hz');

// the maximum close loop gain
ACL = (f1/fdb) ;
disp('the maximum close loop gain ACL is = '+string(ACL)+'');
```

Scilab code Exa 5.14 To determine the dominant pole frequency of an op amp

```
//Example5.14  // To determine the dominant pole frequency of an op-amp
clc;
clear;
close;
Ao = 2*10^5 ;  // low frequency open loop gain
f = 5*10^6 ; // Hz  // pole frequency
ACL = 100 ;  // low frequency closed lkoop gain
p_margin = 80 ;

// the dominant pole frequency of an op-amp
fPD = (ACL)*(f/Ao);
 disp('the dominant pole frequency (fPD) of an op-amp is = '+string(fPD)+'Hz');
```

Scilab code Exa 5.15 Determine the loop gain of compensated network

```
//Example5.15  // Determine the loop gain of compensated network
clc;
clear;
close;

C = 0.0025*10^-6 ; // farad
R = 10*10^3 ; //  ohm
F = 1*10^6 ; // Hz
Ac1 = 100 ;
angle1 = 90 ;

// the close loop gain of a compensated network is defined as
// Ac = Acl*Acom ;

//Acom = 1/(1+%(F/FL));

FL = 1/(2*3.14*R*C);
disp('FL = '+string(FL/1000)+' KHz ');   // Round Off Error

//  Acom = 1/(1+%j(F/FL));
// After putting value of F ,FL we get

//  Acom = 1/(1+%j(158.7));  //  1+%j(158.7) Rectangular Form   where real part is 1 and imaginary part is 158.7

// After converting  rectangular from into polar from we get

disp('Acom =  [ magnitude = 6.3*10^-3   angle = -89.6 degree ]');

//   Ac = Ac1*Acom ;          equation 1

// after putting Ac1 and Acom value in equation 1
```

```
we get  Ac1 = 100 angle 90  and Acom = 6.3*10^-3 angle = -89.6

disp('Ac =  [ magnitude = 0.68   angle = 0.4 degree ]');
```

Scilab code Exa 5.16 Determine the loop gain of compensated network

```
//Example5.16  // Determine the loop gain of compensated network
clc;
clear;
close;

C = 0.01*10^-6 ; // farad
R = 15*10^3 ; //  ohm
F = 1*10^6 ; // Hz

// the close loop gain of a compensated network is defined as
// Ac = Acl*Acom ;

//Acom = 1/(1+%(F/FL));

FL = 1/(2*3.14*R*C);
disp('FL = '+string(FL/1000)+' KHz ');   // Round Off Error

//  Acom = 1/(1+%j(F/FL));
// After putting value of F ,FL we get

//  Acom = 1/(1+%j(0.9));  //  1+%j(0.9) Rectangular Form  where real part is 1 and imaginary part is 0.9

```

```
// After converting  rectangular from into polar from we get

disp('Acom =  [ magnitude = 0.68   angle = -47.7 degree ]');
```

Scilab code Exa 5.17 Determine the loop gain of compensated network

```
//Example5.17  // Determine the loop gain of compensated network
clc;
clear;
close;

C = 0.5*10^-6 ; // farad
R = 75 ; //  ohm
F = 1*10^6 ; // Hz
Ac1 = 150 ;
angle1 = 85 ;

// the close loop gain of a compensated network is defined as
// Ac = Acl*Acom ;

//Acom = 1/(1+%(F/FL));

FL = 1/(2*3.14*R*C);
disp('FL = '+string(FL/1000)+' KHz ');   // Round Off Error

//  Acom = 1/(1+%j(F/FL));

// After putting value of  FL we get

//  Acom = 1/(1+%j(F/4.24*10^3));       equation 1
```

```
// As F is unknown in above equation 1
//  by putting different value of F we get Acom for
    different frequency


// If F = 0 KHz

// Acom = 1/(1+%j(0/4.24*10^3));

// After solving and converting  rectangular from
    into polar from we get

disp('Acom for F = 0 KHz =   [ magnitude = 150
    angle = 85 degree ]');


// If F = 2 KHz

// Acom = 1/(1+%j(2*10^3/4.24*10^3));

// After solving and converting  rectangular from
    into polar from we get

disp('Acom for F = 2 KHz=  [  magnitude = 136.4
    angle = 64.5 degree ]');


// If F = 4 KHz

// Acom = 1/(1+%j(4*10^3/4.24*10^3));

// After solving and converting  rectangular from
    into polar from we get

disp('Acom for F = 4 KHz = [ magnitude = 107.14
    angle = 41.7 degree ]');

```

```
// If F = 6 KHz

// Acom = 1/(1+%j(6*10^3/4.24*10^3));

// After solving and converting  rectangular from
    into polar from we get

disp('Acom for F = 6 KHz =  [ magnitude = 88.24
    angle = 30.25 degree ]');



// If F = 8 KHz

// Acom = 1/(1+%j(8*10^3/4.24*10^3));

// After solving and converting  rectangular from
    into polar from we get

disp('Acom for F = 8 KHz  =  [ magnitude = 71.4
    angle = 23 degree ]');



// If F = 10 KHz

// Acom = 1/(1+%j(10*10^3/4.24*10^3));

// After solving and converting  rectangular from
    into polar from we get

disp('Acom  for F = 10 KHz =   [ magnitude = 58.59
    angle = 18 degree ]');



// If F = 20 KHz
```

```
// Acom = 1/(1+%j(20*10^3/4.24*10^3));

// After solving and converting  rectangular from
   into polar from we get

disp('Acom for F = 20 KHz =  [ magnitude = 31.12
   angle = 7 degree ]');



// If F = 40 KHz

// Acom = 1/(1+%j(40*10^3/4.24*10^3));

// After solving and converting  rectangular from
   into polar from we get

disp('Acom  for F = 40 KHz =  [ magnitude = 15.9
   angle = 1.1 degree ]');





// If F = 80 KHz

// Acom = 1/(1+%j(80*10^3/4.24*10^3));

// After solving and converting  rectangular from
   into polar from we get

disp('Acom for F = 80 KHz =  [ magnitude = 7.9
   angle = -2 degree ]');
```

```
// If F = 100 KHz

// Acom = 1/(1+%j(100*10^3/4.24*10^3));

// After solving and converting  rectangular from into polar from we get

disp('Acom for F = 100 KHz =  [ magnitude = 6.4 angle = -2.6 degree ]');




// If F = 200 KHz

// Acom = 1/(1+%j(200*10^3/4.24*10^3));

// After solving and converting  rectangular from into polar from we get

disp('Acom for F = 200 KHz =  [ magnitude = 3.18 angle = -3.8 degree ]');



// If F = 400 KHz

// Acom = 1/(1+%j(400*10^3/4.24*10^3));

// After solving and converting  rectangular from into polar from we get

disp('Acom for F = 400 KHz =  [ magnitude = 1.59 angle = -4.4 degree ]');


// If F = 800 KHz

```

```
// Acom = 1/(1+%j(800*10^3/4.24*10^3));

// After solving and converting  rectangular from into polar from we get

disp('Acom for F = 800 KHz =  [ magnitude = 0.79 angle = -4.7 degree ]');


// If F = 1 MHz

// Acom = 1/(1+%j(1*10^6/4.24*10^3));

// After solving and converting  rectangular from into polar from we get

disp('Acom for F = 1 MHz =  [ magnitude = 0.64 angle = -4.7 degree ]');


// If F = 1.2 MHz

// Acom = 1/(1+%j(1.2*10^6/4.24*10^3));

// After solving and converting  rectangular from into polar from we get

disp('Acom for F = 1.2 MHz =  [ magnitude = 0.52 angle = -4.7 degree ]');



// If F = 1.4 MHz

// Acom = 1/(1+%j(1.4*10^6/4.24*10^3));

// After solving and converting  rectangular from into polar from we get
```

```
disp('Acom for F = 1.4 MHz =  [ magnitude = 0.45
    angle = −4.7 degree ]');


// If F = 1.6 MHz

// Acom = 1/(1+%j(1.6*10^6/4.24*10^3));

// After solving and converting  rectangular from
    into polar from we get

disp('Acom for F = 1.6 MHz =  [ magnitude = 0.4
    angle = −4.7 degree ]');
```

Scilab code Exa 5.18 to design compensating network

```
//Example5.18  // to design compensating network
clc;
clear;
close;
fp = 500*10^3 ;  // pole frequency
C = 0.02*10^-6 ; // F  // we choose
// loop gain of compensated network

// ACom =(1)/(1+j(f/fp))
// fp = (1/2*pie*R*C)
R = (1/(2*3.14*C*fp));
disp('The compensating resistor value is = '+string(
    R)+' ohm ');
```

Scilab code Exa 5.19 Determine the loop gain of compensated network

```
//Example5.19  // Determine the loop gain of
   compensated network
clc ;
clear ;
close ;

C = 0.0025*10^-6 ; // farad
R1 = 10*10^3 ; //  ohm
R2 = 20*10^3 ; //  ohm
F = 1*10^6 ; // Hz
Ac1 = 100 ;
angle1 = 90 ;

// the close loop gain of a compensated network is
   defined as

// Ac = Acl*Acom ;

//Acom = (1+%(F/FH))/(1+%(F/FL));

FH = 1/(2*3.14*R1*C);
disp('FH = '+string(FH/1000)+' KHz ');   // Round
   Off Error


FL = 1/(2*3.14*(R1+R2)*C);
disp('FL = '+string(FL/1000)+' KHz ');   // Round
   Off Error


//Acom = (1+%(F/FH))/(1+%(F/FL));

// After putting value of FH ,FL we get

//  Acom = (1+%j(158.7))/(1+%j(471.7)

// After converting  rectangular from into polar
   from we get
```

```
disp('Acom =  [ magnitude = 0.34   angle = -0.24
   degree ]');

//   Ac = Ac1*Acom ;          equation 1

// after putting Ac1 and Acom value in equation 1
   we get   Ac1 = 100 angle 90  and Acom = 0.34
   angle = -0.24

disp('Ac = [ magnitude = 34   angle = 89.76 degree ]
   ');
```

Scilab code Exa 5.20 Determine the loop gain of compensated network

```

//Example5.20  // Determine the loop gain of
   compensated network
clc ;
clear ;
close ;

C = 0.01*10^-6 ; // farad
R1 = 10*10^3 ; //  ohm
R2 = 15*10^3 ; //  ohm
F = 1*10^6 ; // Hz


// the close loop gain of a compensated network is
   defined as

//Acom = (1+%(F/FH))/(1+%(F/FL));

FH = 1/(2*3.14*R1*C);
disp('FH = '+string(FH/1000)+' KHz ');   // Round
```

```
    Off Error


FL = 1/(2*3.14*(R1+R2)*C);
disp('FL = '+string(FL/1000)+' KHz ');    // Round
    Off Error


//Acom = (1+%(F/FH))/(1+%(F/FL));

// After putting value of FH ,FL we get

//  Acom = (1+%j(658.9))/(1+%j(1.56*10^3)

// After converting  rectangular from into polar
    from we get

disp('Acom =    [magnitude = 0.4]   ');
```

Scilab code Exa 5.21 to design compensating network

```
//Example5.21  // to design compensating network
clc;
clear;
close;
fH = 10 ; //k ohm // break frequency initiated by a
    zero
fL = 1 ;  //k ohm // break frequency initiated by a
    pole
C = 0.02; // uF  // we choose
// loop gain of compensated network

// ACom =(1+j(f/fH))/(1+j(f/fL))
// fH = (1/2*pie*R1*C)
// fL = (1/2*pie*(R1+R2)*C)
```

```
R1 = (1/(2*3.14*C*fH));
disp('The compensating first resistor R1 value is =
    '+string(R1)+' K ohm ');
R2 = ((1)/(2*3.14*C*fL))-(R1);
disp('The compensating second resistor R2 value is =
     '+string(R2)+' K ohm ');
```

Scilab code Exa 5.22 To determine input output miller capacitances

```
//Example5.22 // To determine input output miller
    capacitances
clc;
clear;
close;
A = 100 ; //gain
Cm = 0.1 ;  // uF // compensated capacitor

// the input output miller capacitance are defined
    as
Cin = Cm*(A+1);
disp('The input miller capacitance Cin value is = '+
    string(Cin)+'uF ');
Cout = (Cm*((A+1)/A));
disp('The output miller capacitance Cout value is =
    '+string(Cout)+'uF ');
```

Scilab code Exa 5.23 To determine input output miller capacitances

```
//Example5.23  // To determine input output miller
    capacitances
clc;
clear;
close;
```

```
A = 150 ; //gain
Cm = 0.02 ;  // uF // compensated capacitor

// the input output miller capacitance are defined
    as
Cin = Cm*(A+1);
disp('The input miller capacitance Cin value is = '+
    string(Cin)+'uF ');
Cout = (Cm*((A+1)/A));
disp('The output miller capacitance Cout value is =
    '+string(Cout)+'uF ');

// In the miller compensating network input
    capacitance introduce a pole . The initiated
    frequency of miller compensating network by pole
    is define as

// fp = 1/(2*%pi*R*Cin);
R = 1 ; // K ohm
fp = 1/(2*%pi*R*Cout);
disp('The initiated frequency of miller compensating
     network by pole is = '+string(fp)+' KHz ');
```

Scilab code Exa 5.24 To determine the slew rate of an op amp

```
//Example5.24  // To determine the slew rate of an
    op-amp
clc;
clear;
close;
f = 1 ; // MHz // unity frequency
Ic = 1*10^-6 ;  // uA // capacitor current
Vt = 0.7 ; // V  // threshold voltage

// the slew rate of an op-amp is defined as
```

```
// Slew rate = (dVo/dt)
Slewrate = 8*3.14*Vt*f ;
disp('the slew rate of an op-amp is = '+string(
   Slewrate)+' V/u sec ');

// The compansated capacitance Cm is
gm = (Ic/Vt);
Cm = (gm/4*3.14*f) ;
disp('The compansated capacitance value is = '+
   string(Cm)+'F ');
```

Scilab code Exa 5.25 To determine the cut off frequency of an op amp

```
//Example5.25  // To determine the cut off frequency
    of an op-amp
clc;
clear;
close;
f = 1*10^3 ; // Hz // unity frequency
Av = 200 ; // V/mV  // dc gain

// the unity gain frequency of an op-amp is defined
   as
// f = Av*fc ;

// cut off frequency
fc = (f/Av);
disp('Cut -off frequency of an op-amp is = '+string(
   fc)+' Hz ');
```

Scilab code Exa 5.26 To find the maximum frequency of input signal in op amp circuit

```
//Example5.26  // To find the maximum frequency of
    input signal in op-amp circuit
clc;
clear;
close;
Vin = 25*10^-3 ; // V  // input voltage
Slewrate = 0.8/10^-6 ;  // V/uV   // Slew rate of an
     op-amp
R2 = 350*10^3 ;  //  ohm  // feedback resistance
R1 = 10*10^3 ;  // ohm  // input resistance

// the closed loop gain
// ACL = (mod (Vo/Vin)) = (mod(R2/R1));
ACL = abs(R2/R1);
disp('the closed loop gain ACL is = '+string(ACL)+'
    ');

// the output gain factor K is given as
K = ACL*Vin ;
disp('The output gain factor K is = '+string(K)+' V'
    );

// the maximum frequency of an op-amp is
wmax = (Slewrate/K);
fmax = wmax/(2*3.14);
disp('The maximum frequency of an op-amp fmax = '+
    string(fmax/1000)+' KHz');
```

Scilab code Exa 5.27 To find the maximum frequency of op amp circuit

```
//Example5.27  // To find the maximum frequency of
    op-amp circuit
clc;
clear;
```

```
close;
Vin = 0.015 ; // V  // input voltage
Slewrate = 0.8 ;  // V/uV   // Slew rate of an op-
    amp
R2 = 120*10^3 ;  //  ohm  // feedback resistance
R1 = 5*10^3 ;  // ohm  // input resistance

// the closed loop gain
// ACL = (mod (Vo/Vin)) = (mod(R2/R1));
ACL = abs(R2/R1);
disp('the closed loop gain ACL is = '+string(ACL)+'
    ');

// the output gain factor K is given as
K = ACL*Vin ;
disp('The output gain factor K is = '+string(K)+' V'
    );

// the maximum frequency of an op-amp is
wmax = (Slewrate/K);
disp('The wmax is = '+string(wmax)+'*10^6 rad/sec');
     // *10^6 because Slewrate is V/uV

// the signal frequency may be w = 500*10^3 rad/sec
     that is less than the maximum frequency value
```

Scilab code Exa 5.28 To determine the compensated capacitance of an op amp

```
//Example5.28  // To determine the compensated
    capacitance of an op-amp
clc;
clear;
close;
Slewrate = 10 ; // V/u sec
```

```
Ic = 1*10^-3 ;   // mA // capacitor current
Vt = 0.7 ; // V  // threshold voltage

// the slew rate of an op-amp is defined as
// Slew rate = (dVo/dt)
// the unity frequency f is
f =(Slewrate/(8*3.14*Vt));
f = f*10^6;  // *10^6 because Slew rate is V/uV
disp('the unity frequency f is = '+string(f)+' Hz ')
   ;

// The compansated capacitance Cm is
gm = (Ic/Vt);
Cm = (gm)/(4*3.14*f) ;
disp('The compansated capacitance Cm value is = '+
   string(Cm)+' F ');
```

Scilab code Exa 5.29 To find Slew rate of an op amp

```
//Example5.29  // To find Slew rate of an op-amp
clc;
clear;
close;
Iq = 15 ; // uA  // bias current
Cm = 30  ; // pF  // internal frequency compensated
   capacitor
Slewrate = (Iq/Cm);
disp('the Slew rate of an op-amp is = '+string(
   Slewrate)+' V/u sec');
```

Scilab code Exa 5.30 To find Slew rate of an op amp

```
//Example5.30 // To find Slew rate of an op-amp
```

```
clc;
clear;
close;
Iq = 21 ; // uA  // bias current
Cm = 31  ; // pF  // internal frequency compensated
   capacitor
Slewrate = (Iq/Cm);
disp('the Slew rate of an op-amp is = '+string(
   Slewrate)+' V/u sec');
```

Scilab code Exa 5.31 To determine full power and small signal bandwidth of an op amp with unity gain

```
//Example5.31  // To determine full power and small
   signal bandwidth of an op-amp with unity gain
clc;
clear;
close;
f = 100*10^6 ; // Hz  unity gain bandwidth
ACL = 10^4 ; // maximum closed loop gain
Slewrate = 0.51 ; // V/u sec
Vp = 10 ; // V peak volt

// The full power bandwidth
FPBW = (Slewrate/(2*3.14*Vp));
FPBW = FPBW*10^6 ;  // *10^6 because Slew rate is V/
   uV
disp('The full power bandwidth FPBW is = '+string(
   FPBW)+' Hz ');

// the 3-db frequency or small signal band width
f3db = (f/ACL);
disp('The 3-db frequency or small signal band width
   f3db is = '+string(f3db)+' Hz ');
```

Scilab code Exa 5.32 To determine full power and small signal bandwidth of an op amp with unity gain

```
//Example5.32  // To determine full power and small
   signal bandwidth of an op-amp with unity gain
clc;
clear;
close;
f = 100*10^6 ; // Hz  unity gain bandwidth
ACL = 10^4 ; // maximum closed loop gain
Slewrate = 0.51 ; // V/u sec
Vp = 10 ; // V peak volt

// The full power bandwidth
FPBW = (Slewrate/(2*3.14*Vp));
FPBW = FPBW*10^6 ;  // *10^6 because Slew rate is V/
   uV
disp('The full power bandwidth FPBW is = '+string(
   FPBW)+' Hz ');

// the 3-db frequency or small signal band width
f3db = (f/ACL);
disp('The 3-db frequency or small signal band width
   f3db is = '+string(f3db)+' Hz ');
```

Scilab code Exa 5.33 To find Slew rate and closed loop gain of an op amp

```
//Example5.33 // To find Slew rate and closed loop
   gain of an op-amp
clc;
clear;
close;
```

```
fu = 1*10^6 ; // Hz  // unity gain bandwidth
fmax = 5*10^3 ; // KHz  // full power bandwidth
F3db = 12*10^3 ; // Hz  // small signal bandwidth
Vp = 10 ; // V  // peak volt

// the full power bandwidth of an op-amp
// fmax=FPBW = (Slew rate/2*3.14*Vp);
Slewrate = 2*3.14*Vp*fmax;
Slewrate = Slewrate*(10^-6);  // *10^-6 because
   Slewrate is V/u
disp('the Slew rate of an op-amp is = '+string(
   Slewrate)+' V/u sec ');

// // the 3-db frequency or small signal band width
//f3db = (f/ACL);
//the closed loop gain ACL
ACL = fu/F3db ;
disp('The closed loop gain ACL is = '+string(ACL)+'
   ');
```

Chapter 6

Application of Operational Amplifier

Scilab code Exa 6.1 design an inverting amplifier with a closed loop voltage gain is given

```
//Example6.1  // design an inverting amplifier with
   a closed loop voltage gain of Av = -5
clc;
clear;
close;
Av = -5 ;
Is = 5*10^-6 ; // A
Rs = 1*10^3 ; // ohm
// input voltage source Vs = sinwt volts

// in an inverting amplifier frequency effect is
   neglected then i/p volt Vin = 1 V and total
   resistance equal to Rs+R1

// the input current can be written as Iin=Is
// Is = (Vin/Rs+R1);
Iin = Is;
Vin = 1 ; // V
```

```
R1 = (1-(Iin*Rs))/Iin  ;
disp('the value of resistance R1 is = '+string(R1)+' ohm');

// closed loop voltage gain of an inverting amplifier
//Av = -(R2/Rs+R1)
R2 = -(Av*(Rs+R1));
disp('the value of resistance R2 is  = '+string(R2)+' ohm');
```

Scilab code Exa 6.2 design an inverting amplifier with a closed loop voltager gain is given

```
//Example6.2  // design an inverting amplifier with a closed loop voltage gain of Av = 10
clc;
clear;
close;
Av = 10 ;
Vin = 0.8 ;  //V
Iin = 100*10^-6 ; // A
// in an non- inverting amplifier the input voltage Vin=V1=V2 because of vortual short effect then the i/p current In = Vin/R1
R1 = Vin/Iin;
disp('the value of resistance R1 is = '+string(R1)+' ohm');

// closed loop voltage gain of an non-inverting amplifier
//Av = Vo/Vin =  (1+R2/R1)
R2 = (Av-1)*R1;
disp('the value of resistance R2 is  = '+string(R2)+' ohm');
```

Scilab code Exa 6.3 design an non inverting amplifier with colsed loop gain of 5

```
//Example6.3 // design an non-inverting amplifier with colsed loop gain of 5 limited voltage of -5 V <= Vo <= 5 V  and maximum i/p c/n 50 uA
clc;
clear;
close;
R1 = 8*10^3 ; // ohm
R2 = 72*10^3 ; // ohm
Iin = 50*10^-6 ; // A
Vo = 5 ; // V

// closed loop gain
//Av = Vo/Vin = (1+R2/R1)
Av = 1+(R2/R1);
// but
Av = 5 ;
// then
// (R2/R1) = 4 ;

// the output voltage of the amplifier is Vo = 5 V
//i.e
Vin = 1 ; // V
// Iin = Vin/R1 ;
R1 = Vin/Iin ;
disp('the value of resistance R1 is  = '+string(R1)+' ohm');

R2 = 4*R1 ;
disp('the value of resistance R2 is  = '+string(R2)+' ohm');

```

```
// the output current I2 is given as
I2 = (Vo-Vin)/R2 ;
disp('the output current I2 is = '+string(I2)+' A')
    ;
```

Scilab code Exa 6.4 Design a op amp circuit to provide the output voltage is given

```
// Example6.4   // Design a op—amp circuit to
    provide the output voltage Vo = −2(3 V1 +4 V2 +2
    V3)
clc;
clear;
close;
// Vo = −2(3 V1 + 4 V2+ 2 V3);       equation 1
// the output of the summer circuit is given as
// Vo = −R2((Via/Ria)+(Vib/Rib)+(Vic/Ric))
    equation 2

// compare equation 1 and 2  of Vo we get

//  (R2/Ria)= 6 ;
//  (R2/Rbi=8 ;
//  (R2/Ric)=4 ;

R2 = 120*10^3 ;   // we choose then

Ria = R2/6 ;
disp('the value of resistance Ria is = '+string(Ria
    )+' ohm');

Rib = R2/8 ;
disp('the value of resistance Rib is = '+string(Rib
    )+' ohm');

```

```
Ric = R2/4 ;
disp('the value of resistance Ric is = '+string(Ric
   )+' ohm');
```

Scilab code Exa 6.5 Design a summing amplifier circuit

```
// Example6.5   // Design a summing amplifier
   circuit to provide the output voltage Vo = -(7
   V11 + 15 V12 + 10 V13 + 3 V14)
clc;
clear;
close;
R2 = 630*10^3 ;  // Assume feedback resistance
// Vo = -(7 V11 + 15 V12 + 10 V13 + 3 V14);
                       equation 1
// the output of the summer circuit is given as
// Vo = -R2((Via/Ria)+(Vib/Rib)+(Vic/Ric)+(Vid/Rid))
               equation 2

// compare equation 1 and 2  of Vo we get

//  (R2/Ria)= 7 ;
//  (R2/Rbi= 15 ;
//  (R2/Ric)= 10 ;
//  (R2/Rid)= 3 ;

Ria = R2/7 ;
disp('the value of resistance Ria is = '+string(Ria
   )+' ohm');

Rib = R2/15 ;
disp('the value of resistance Rib is = '+string(Rib
   )+' ohm');

Ric = R2/10 ;
```

```
disp('the value of resistance Ric is = '+string(Ric)+' ohm');

Rid = R2/3 ;
disp('the value of resistance Rid is = '+string(Rid)+' ohm');
```

Scilab code Exa 6.6 Design a op amp circuit to provide the given output voltage

```
// Example6.6  // Design a op-amp circuit to provide the output voltage Vo = V2 - 3 V1 with Ri1 =Ri2 = 100*10^3
clc;
clear;
close;
Ri1 = 100*10^3 ; // ohm
Ri2 = 100*10^3 ; // ohm
// the i/p resistance
R1 = Ri1 ;
R3 = Ri2 ;

// Vo = V2 - 3 V1;                                          equation 1
// the output of the summer circuit is given as
// Vo = [(R4/(R3+R4)*(1+(R2/R1))*Vi2-(R2/R1)*Vi1]           equation 2

// compare equation 1 and 2  of Vo we get
// (R4/(R3+R4)*(1+(R2/R1)) = 1 ;                            equation  3
// R2/R1 = 3 ;                                              equation 4

```

```
// by subsituting the value of R1 and R3 in equation
    3 and 4

// from equation  4
R2 = 3*R1 ;
disp('the value of resistance R2 is  = '+string(R2)+
   ' ohm');

// from equation  3
R4 = (100*10^3)/3 ;
disp('the value of resistance R4 is  = '+string(R4)+
   ' ohm');
```

Scilab code Exa 6.7 determine the load current and output voltage

```
//Example6.7   // determine the load current and
   output voltage
clc;
clear;
close;
Vin = -5 ;  // V
ZL = 200 ; // ohm
R1 = 10*10^3 ; // ohm
R2 = 10*10^3 ; // ohm
R3 = 1*10^3 ; // ohm
R4 = 1*10^3 ; // ohm

// the load c/n of the given voltage to c/n
   converter circuit is given by
iL =-Vin/(R1*R4)*R2 ;
disp('The load current iL is  = '+string(iL)+' A');

// the voltage across the load
VL = iL*ZL;
disp('The voltage across load VL is  = '+string(VL)+
```

```
   ' V');

// the non−inverting current across i3 and i4 are
i3 = VL/R3 ;
disp('The non−inverting current across i3 is = '+
   string(i3)+' A');

i4 = iL+i3 ;
disp('The non−inverting current across i4 is  = '+
   string(i4)+' A');

// the output voltage of given voltage to current
   converter is given by
Vo = (iL*R3)+VL ;
disp('The output voltage of given voltage to current
    converter is  = '+string(Vo)+' V');
```

Scilab code Exa 6.8 determine the common mode rejection ratio CMRR

```
// Example6.8  // determine the common mode
   rejection ratio CMRR
clc;
clear;
close;
// R2/R1 = 10 ;
// R4/R3 = 11 ;

// the output of the difference amplifier is given
   by
// Vo = (((R4)/(R3+R4))*(((1+(R2/R1))*VI2))−((R2/R1)
   *VI1));

// putting R1 R2 R3 R4 value in above equation we
   get Vo as

```

```
// Vo =(121/12)*VI2-10VI1 ;                                   equation 1

// the differential mode input of difference amplifier is given by
// Vd = VI2-VI1 ;                                             eqution 2

// the common mode input of difference amplifier is given by
// VCM = (VI2+VI1)/2 ;                                        equation 3

// from equation 2 and 3

// VI1 = VCM-Vd/2 ;                                           equation 4

// VI2 = VCM+Vd/2 ;                                           equation 5

// substitute equation 4 and 5 in 1  we get
// Vo = (VCM/12)+(241Vd/24);                                  equation6

// Vd = Ad*Vd+ACM*VCM ;                                       equation 7

//equation from equation 6 and 7 we get

Ad = 241/24 ;
ACM = 1/12 ;

// the common mode rejection ratio CMRR is
```

```
CMRR = abs(Ad/ACM);
disp('The common mode rejection ratio CMRR is = '+string(CMRR)+' ');

// in decibal it can be expressed as

CMRR = 20*log10(CMRR);
disp('The common mode rejection ratio CMRR in decibel is = '+string(CMRR)+' dB ');
```

Scilab code Exa 6.9 determine output voltage for different condition of input voltage

```
// Example6.9 // determine Vo when 1) VI1 = 2 V VI2 = -2 V and 2) VI1 = 2 V VI2 = 2 V
//                                         and common mode rejection ratio CMRR
clc;
clear;
close;
R1 = 10*10^3 ; // ohm
R2 = 20*10^3 ; // ohm
R3 = 10*10^3 ; // ohm
R4 = 22*10^3 ; // ohm


// the output of the difference amplifier is given by
// Vo = (((R4)/(R3+R4))*(((1+(R2/R1))*VI2))-((R2/R1)*VI1));

// Case 1 when VI1 = 2 V VI2 = -2 V
VI1 = 2 ;
VI2 = -2 ;

```

```
Vo = (((R4)/(R3+R4))*(((1+(R2/R1))*VI2))-((R2/R1)*VI1));
disp('The output of the difference amplifier is = '+string(Vo)+' V ');

// case 2 when VI1 = 2 V VI2 = 2 V
VI1 = 2 ;
VI2 = 2 ;

Vo = (((R4)/(R3+R4))*(((1+(R2/R1))*VI2))-((R2/R1)*VI1));
disp('The output of the difference amplifier is = '+string(Vo)+' V ');

// the common mode input of difference amplifier is given by
VCM = (VI2+VI1)/2 ;
disp('the common mode input of difference amplifier is = '+string(VCM)+' ');

// the common mode gain ACM of difference amplifier is given by
ACM = Vo/VCM
disp('the common mode gain ACM of difference amplifier is = '+string(ACM)+' ');

// the differential gain of the difference amplifier is given
Ad = R2/R1 ;
disp('the differential gain of the difference amplifier is = '+string(Ad)+' ');

// the common mode rejection ratio CMRR is
CMRR = abs(Ad/ACM);
disp('The common mode rejection ratio CMRR is = '+string(CMRR)+' ');

// in decibal it can be expressed as
```

```
CMRR = 20*log10(CMRR);
disp('The common mode rejection ratio CMRR in decibel is = '+string(CMRR)+' dB ');
```

Scilab code Exa 6.10 To determine the range of the differential voltage gain

```
//Example6.10 // To determine the range of the differential voltage gain
clc;
clear;
close;
//R1 = 1 K ohm to 25 K ohm ;
R2 = 50 ; // K ohm
R3 = 10 ; // K ohm
R4 = 10 ; // K ohm

// the output of instrumentation amplifier is given by
//Vo = (R4/R3)*(1+(2*R2/R1))*(VI@-VI1);

// the differential voltage gain of the instrumentation amplifier can be written as
//Av = (Vo/(VI2-VI1)) = (R4/R3)*(1+(2R2/R1));

// For R1 = 1 K ohm the maximum differential voltage gain of the instrumentation amplifier is
R1 = 1 ; // K ohm
Av = (R4/R3)*(1+(2*R2/R1));
disp('the maximum differential voltage gain of the instrumentation amplifier is = '+string(Av)+ ' ');

// For R1 = 25 K ohm the mminimum differential voltage gain of the instrumentation amplifier is
```

```
R1 = 25 ; // K ohm
Av = (R4/R3)*(1+(2*R2/R1));
disp('the minimum differential voltage gain of the instrumentation amplifier is = '+string(Av)+ ' ');

disp(' the range of the differential voltage gain of the instrumentation amplifier is ');
disp('                    5 <= Av <= 101 ');
```

Scilab code Exa 6.11 To design an instrumentation amplifier

```
//Example6.11  // To design an instrumentation amplifier
clc;
clear;
close;
// 4 <= Av <= 1000 ;  gain
Ad = 2 ;
Res = 100 ;  // K ohm

// we cosider the variable resistance is R1 , the maximum and the minimum range of variable resistance
// R1min = R1 ;
// R1max = R1+100 ;

// the gain of difference amplifier
//A3 = Ad = Vo/(Vo2-Vo1) = (R4/R3)

// the maximum range of differential voltage gain Avmax = 1000 when R1min = R1
//Avmax = R4/R3*(1+(2*R2/R1min));

// by solvin we get following equation
```

```
//   499*R1-2*R2=0                              equation 1

// the maximum range of differential voltage gain
    Avmin =4 when R1max = R1+100 K ohm
// Avmin = (R4/R3)*(1+(2R2/R1max));

// by solving above equation we get
// R1 -2 R2 = -200 K ohm                        equation 2

//by solving equation 1 and 2 we get
R1 = 401 ; //  ohm
R2 = 100.2 ; // ohm
disp('The variable resistance R1 varies is  401 ohm
   <= R1 <= 100.2 K-ohm ') ;
```

Scilab code Exa 6.12 Determine the time constant of the integrator

```
//Example6.12  // Determine the time constant of the
    integrator
clc;
clear;
close;
Vo = 10 ;
t = 2*10^-3 ;
VI = -1 ;  // at t =0 ;

// The output voltage of an integrator is define as
RC = t/10 ;
disp(' The time constant of the given filter is RC =
    '+string(RC)+ ' sec ');
```

Scilab code Exa 6.13 Determine the time constant of the integrator

```
//Example6.13  // Determine the time constant of the
    integrator
clc;
clear;
close;
Vo = 20 ;
t = 1*10^-3 ;
VI = -1 ;  // at t =0 ;

// The output voltage of an integrator is define as
RC = t/10 ;
disp(' The time constant of the given filter is RC =
    '+string(RC)+ ' sec ');

R = 1*10^3 ;  // we assume
C = RC/R ;
disp('The capacitor value is = '+string(C)+ '  F');
```

Scilab code Exa 6.14 to design a summing amplifier

```
//Example6.14  // to design a summing amplifier
clc;
clear;
close;

// the output of the summing amplifier is given by
//Vo = -R2*((VIa/RIa)+(VIb/RIb)+(VIc/RIc)+(VId/RId))
    ;    equation 1

// the equation given is
//Vo = -(3*VIa+12*VIb+15*VIc+18*VId);
    equation 2

// comparing equation 1 and 2
//R2/RIa = 3 ;
```

```
//R2/RIb = 12 ;
//R2/RIc = 15 ;
//R2/RId = 18 ;

// the feedback resistance R2= 270 K ohm
R2 = 270 ;  // K ohm
RIa = R2/3 ;
disp('The value of resistance RIa is = '+string(RIa)
    + ' K ohm ');

RIb = R2/12 ;
disp('The value of resistance RIb is = '+string(RIb)
    + ' K ohm ');

RIc = R2/15 ;
disp('The value of resistance RIc is = '+string(RIc)
    + ' K ohm ');

RId = R2/18 ;
disp('The value of resistance RId is = '+string(RId)
    + ' K ohm ');
```

Scilab code Exa 6.15 for the instrumentation amplifier find Vo1 Vo2 Vo

```
//Example6.15  // for the instrumentation amplifier
    find Vo1 , Vo2 , Vo
clc;
clear;
close;
// Vi1 = -25 sin wt  ;  // mV
// Vi2 = 25 sin wt ; // mV
R1 = 10*10^3 ;
R2 = 20*10^3 ;
R3 = 20*10^3 ;
R4 = 10*10^3 ;
```

```

// the output of first op-amp A1 is given by
// Vo1 = (1+(R2/R1))*Vi1-(R2/R1)*Vi2 ;
//by solving above equation we get
disp('The output of first op-amp A1 is = -275*sin wt
    mV ');

// the output of second op-amp A2 is given by
// Vo2 = (1+(R2/R1))*Vi2-(R2/R1)*Vi1 ;
//by solving above equation we get
disp('The output of second op-amp A2 is = 275*sin wt
    mV ');

// the output of third op-amp A3 is given by
// Vo = (R4/R3)-(1+(2R2/R1)*(Vi2-Vi1) ;
//by solving above equation we get
disp('The output of third op-amp A3 is = 825*sin wt
   mV ');

// current through the resistor R1 and R2 is
//i = (Vi1-Vi2)/R1 ;
disp('current through the resistor R1 and R2 is = 5
    sin wt uA ');

// current through the non-inverting terminal
    resistor R3 and R4
//i3 = Vo2/(R3+R4);
disp('current through the non-inverting terminal
    resistor R3 and R4 = 5.5 sin wt uA ');

// current through the inverting terminal resistor
    R3 and R4
//i2 = Vo1-(R3/(R3+R4))*Vo2/R3 ;
disp('current through the inverting terminal
    resistor R3 and R4 = 22 sin wt uA ');
```

Scilab code Exa 6.16 for the a current to voltage converter

```
//Example6.16  // for the a current to voltage converter show a) Rin = (Rf/1+Aop)  b) Rf = 10 K ohm Aop = 1000
clc;
clear;
close;

//a) The input resistance given as
//Rin = (Rf)/(1+Aop) ;

// The input resistance of the circuit can be written as
//Rin = (V1/i!);

//  the feedback current of the given circuit is defined as
//i1 =(V1-Vo)/RF ;

// the feedback resistance RF is
//RF =(V1-Vo)/i1 ;

// The output voltage Vo is
//Vo = -Aop*V1 ;

//by using this output feedback currenty i1 can be reformed as
//i1 = (V1-(-Aop*V1))/RF ;

//i1 = V1*(1+Aop)/RF ;

// Then Rin Becomes
//Rin =Rf/(1+Aop);
```

```

Rf =10*10^3 ;
Aop = 1000 ;

// the input current and output voltage of the circuit are defined as
//i1 =(Rs)/(Rs+Rin) ;
// Vo = -(Aop*(RF/1+Aop))*i1 ;

//the input resistance Rin is
Rin =(Rf/(1+Aop)) ;

// subsituting the value of RF Aop Rin and Vo we get
RF = 10 ;
Rin = RF/(1+Aop)
disp('The input resistance Rin is = '+string(Rin)+ ' ohm ');

Aop = 1000 ;
//(1000/1001)*(Rs/(Rs*0.00999))> 0.99 ;
// by solving above equation we get
Rs = 1.099 ; // K ohm
disp(' The value of Resistance Rs is = '+string(Rs)+ ' K ohm ');
```

Scilab code Exa 6.17 determine the closed loop gain

```
//Example6.17 // determine the closed loop gain
clc;
clear;
close;

// the output of the voltage follower is given as
//Vo = Aop(V1-Vo);

```

```
// the closed loop gain of the voltage follower
//A = 1/(1+(1/Aop));

// for Aop = 10^4 closed loop gain
Aop = 10^4 ;
A = 1/(1+(1/Aop));
disp('for Aop = 10^4 closed loop gain is = '+string(
   A)+ ' ');

// for Aop = 10^3 closed loop gain
Aop = 10^3 ;
A = 1/(1+(1/Aop));
disp('for Aop = 10^3 closed loop gain is = '+string(
   A)+ ' ');

// for Aop = 10^2 closed loop gain
Aop = 10^2 ;
A = 1/(1+(1/Aop));
disp('for Aop = 10^2 closed loop gain is = '+string(
   A)+ ' ');

// for Aop = 10^1 closed loop gain
Aop = 10^1 ;
A = 1/(1+(1/Aop));
disp('for Aop = 10^1 closed loop gain is = '+string(
   A)+ ' ');
```

Scilab code Exa 6.18 To determine the output voltage of integrator

```
//Example6.18  // To determine the output voltage of
    integrator
clc;
clear;
close;
Vin = 1 ;
```

```
R = 150*10^3 ;//  ohm
C = 1*10^-9 ; // F

// the output voltage of an integrator is given as
//Vo = (fc/f)*Vin ;

//fc = 1/(2*%pi*R*C);

//Vo = (1/(2*%pi*R*C*f))*Vin;

//for the frequency f = 10 Hz  the output is
f = 10 ; // Hz
Vo = (1/(2*%pi*R*C*f))*Vin;
disp('for the frequency f = 10 Hz  the output is = '
   +string(Vo)+ ' V ');

//for the frequency f = 1000 Hz  the output is
f = 1000 ; // Hz
Vo = (1/(2*%pi*R*C*f))*Vin;
disp('for the frequency f = 1000 Hz  the output is =
    '+string(Vo)+ ' V ');

//for the frequency f = 10000 Hz  the output is
f = 10000 ; // Hz
Vo = (1/(2*%pi*R*C*f))*Vin;
disp('for the frequency f = 10000 Hz  the output is
   = '+string(Vo)+ ' V ');
```

Scilab code Exa 6.19 To determine the magnitude gain of the integrator

```
//Example6.19  // To determine the magnitude gain of
    the integrator
clc;
clear;
close;
```

```
Vin = 1 ;
f = 50*10^3 ;
Rf = 120*10^3 ;
R = 10*10^3 ;
C = 0.1*10^-9 ;

// the magnitude gain of the integrator is given by
//A = (Rf/R)/(sqrt(1+(f/fc)^2));

// the cutoff frequency of the integrator
fc = 1/(2*%pi*Rf*C);
disp('The cutoff frequency of the integrator is = '+
   string(fc)+ ' Hz');


A = (Rf/R)/(sqrt(1+(f/fc)^2));
disp('The gain of the integrator is = '+string(A)+ '
   ');
```

Scilab code Exa 6.20 To determine the magnitude gain of the differentiator

```
//Example6.20  // To determine the magnitude gain of
   the differentiator
clc;
clear;
close;
Vin = 1 ;
f = 50*10^3 ;
R = 75*10^3 ;
R1 = 50*10^3 ;
C = 0.1*10^-9 ;

// the magnitude gain of the differentiator is given
   by
```

```
//A = (f/fa)/(sqrt(1+(f/fb)^2));

// the break frequency fa is defined as
fa = 1/(2*%pi*R1*C) ;
disp('the break frequency fa is = '+string(fa)+ ' Hz
    ');

// the break frequency fb is defined as
fb = 1/(2*%pi*R*C) ;
disp('the break frequency fb is = '+string(fb)+ ' Hz
    ');


A = (f/fa)/(sqrt(1+(f/fb)^2));
disp('The gain of the differentiator is = '+string(A
   )+ ' ');
```

Scilab code Exa 6.21 to determine the input voltage of an op amp

```
// Example6.21   // to determine the input voltage of
    an op-amp
clc;
clear;
close;
Vo = 2 ; // V
R1 = 20*10^3 ; // ohm
R2 = 1*10^6 ;  // ohm

// the input voltage of an op-amp
Vin = -(R1/R2)*Vo ;
disp('The input voltage of an op-amp is = '+string(
   Vin)+ ' V');
```

Scilab code Exa 6.22 To determine the output voltage

```
//Example6.22  // To determine the output voltage
clc;
clear;
close;
Vin = 2 ;
R2 = 20*10^3 ;
R1 = 2*10^3 ;

// the output voltage of follower Vo1 is
Vo1 = Vin ;
disp('the output voltage of follower Vo1 is = '+
   string(Vo1)+ '  V');
// the output voltage of an inverting amplifier
Vo = -(R2/R1)*Vo1 ;
disp('The output voltage of an inverting amplifier
   is = '+string(Vo)+ ' V ');
```

Scilab code Exa 6.23 to determine the output voltage of an op amp

```
// Example6.23  // to determine the output voltage
   of an op-amp
clc;
clear;
close;
Vin = 5 ; // V
R1 = 25*10^3 ; // ohm
R2 = 75*10^3 ;  // ohm

// in this problem op-amp A1 perform the voltage
   follower and op-amp A2 perform inverting
   amplifier and op-amp A3 perform non-inverting
   amplifier

```

```
// the output voltage of follower op-amp A1
Vo1 = Vin ;

// the output of the inverting amplifier A2
Vo2 = -((R2/R1)*Vo1) ;
disp('The output of the inverting amplifier is = '+
   string(Vo2)+ ' V');

// the output of the non-inverting amplifier A3
Vo =(1+(R2/R1))*Vo1 ;
disp('The output of the non-inverting amplifier is =
    '+string(Vo)+ ' V');
```

Scilab code Exa 6.24 To determine the output voltage

```
//Example6.24  // To determine the output voltage
clc;
clear;
close;
Vin = 2.5 ;
Rf = 100*10^3 ;
R1 = 10*10^3 ;
RI1 = 25*10^3 ;
RI2 = 10*10^3 ;
R2 = 100*10^3 ;

// the output voltage of an inverting amplifier
Vo1 = (1+(R2/R1))*Vin ; ;
disp('The output voltage of an inverting amplifier
   is = '+string(Vo1)+ ' V ');

// the output voltage of follower Vo2 is
Vo2 = Vin ;
disp('the output voltage of follower Vo1 is = '+
   string(Vo2)+ '  V');
```

```
// the output of the inverting summing amplifier
R2 = 75*10^3 ;
Vo = R2*((Vo1/RI1)+(Vo2/RI2));
disp('the output of the inverting summing amplifier is = '+string(Vo)+ ' V ');
```

Scilab code Exa 6.25 To calculate the output voltage

```
//Example6.25  // To calculate the output voltage
clc;
clear;
close;
Vin = 2.5 ;
R1 = 10*10^3 ;
R2 = 10*10^3 ;
R3 = 10*10^3 ;
Rf = 30*10^3 ;

// the total gain of the circuit
//Av =A1v*A2v*A3v ;
Av = (1+(Rf/R1))*(-Rf/R2)*(-Rf/R3);
disp('the total gain of the circuit is = '+string(Av)+ ' ');

// The  output voltage of the op-amp
Vo = Av*Vin ;
disp('The  output voltage of the op-amp is = '+string(Vo)+ ' V');
```

Scilab code Exa 6.26 to calculate the output voltage of op amp circuit

```
//Example6.26  // to calculate the output voltage of
    op−amp circuit
clc;
clear;
close;
Rf = 100*10^3 ; // ohm
R1 = 10*10^3 ; // ohm
R2 = 25*10^3 ; // ohm
R3 = 50*10^3 ; // ohm

// the output of op−amp A1 is
// VA1 = (−Rf/R1)∗V1 ;
VA1 = (-Rf/R1);
disp('The output of op−amp A1 is = '+string(VA1)+'V1
   ');        // ∗V1 because the output is come from
    1 op−amp

// the output of op−amp A2 is
// Vo = −Rf∗((VA1/R2)+(V2/R3));
//Vo = −100∗(−0.4∗V1+0.02V2);
disp('The output of op−amp A2 is  Vo = 40V1 − 2V2 ')
   ;

disp('The output is equal to the difference between
   40V1 and 2V2 ');
```

Scilab code Exa 6.27 to determine the hysteresis width of a schmitt trigger

```
//Example6.27  // to determine the hysteresis width
   of a schmitt trigger
clc;
clear;
close;
R1 = 25*10^3 ; // ohm
```

```
R2 = 75*10^3 ; // ohm
VTH = 4 ; // V
VTL = -4 ; // V

// the upper crossover voltage of schmitt trigger is
    defined as
VU = (R1/(R1+R2))*VTH;
disp('the upper crossover voltage of schmitt trigger
    is = '+string(VU)+' V' );

// the lower crossover voltage of schmitt trigger is
    defined as
VL = (R1/(R1+R2))*VTL;
disp('the lower crossover voltage of schmitt trigger
    is = '+string(VL)+' V' );

// the hysteresis width of schmitt trigger is
HW = VU-VL ;
disp('the hysteresis width HW of schmitt trigger is
   = '+string(HW)+' V' );
```

Scilab code Exa 6.28 to determine the hysteresis width of a schmitt trigger

```
//Example6.28  // to determine the hysteresis width
   of a schmitt trigger
clc;
clear;
close;
R1 = 15*10^3 ; // ohm
R2 = 90*10^3 ; // ohm
VTH = 10 ; // V
VTL = -10 ; // V

// the upper crossover voltage of schmitt trigger is
```

```
    defined as
VU = (R1/(R1+R2))*VTH;
disp('the upper crossover voltage of schmitt trigger
    is = '+string(VU)+' V' );

// the lower crossover voltage of schmitt trigger is
    defined as
VL = (R1/(R1+R2))*VTL;
disp('the lower crossover voltage of schmitt trigger
    is = '+string(VL)+' V' );

// the hysteresis width of schmitt trigger is
HW = VU-VL ;
disp('the hysteresis width HW of schmitt trigger is
   = '+string(HW)+' V' );
```

Scilab code Exa 6.29 to determine the resistance R1 when low and high saturated output states are given

```
//Example6.29 // to determine the resistance R1
   when low and high saturated output states are
   given
clc;
clear;
close;
R2 = 20*10^3 ; // ohm
VH = 2 ; // V      crossover voltage
VL = -2 ;  // V      crossover voltage
VOH = 10 ; // V     saturated output states
VOL = -10 ; // V     saturated output states

// the upper crossover voltage of schmitt trigger is
    defined as
// V = (R1/(R1+R2))*VOH;
// solving above equation we get
```

```
// 2R1+2R2 = 10R1 ;
R1 = (2*R2)/8 ;
disp('the value of resistance R1 is = '+string(R1)+' ohm' );
```

Scilab code Exa 6.30 to determine the value of resistance R1 and R2 when low and high saturated output states are given

```
//Example6.30 // to determine the value of resistance R1 and R2 when low and high saturated output states are given
clc;
clear;
close;
VH = 3 ; // V      crossover voltage
VL = -3 ;  // V     crossover voltage
VOH = 12 ; // V    saturated output states
VOL = -12 ; // V    saturated output states

// the upper crossover voltage of schmitt trigger is defined as
// V = (R1/(R1+R2))*VOH;
// solving above equation we get
// 3R1+3R2 = 12R1 ;

// 3*R1 = R2 ;
R1 = 10*10^3 ; // ohm  we assume
R2 = 3*R1 ;
disp('the value of resistance R2 is = '+string(R2)+' ohm' );
```

Scilab code Exa 6.31 Design an inverting amplifier

```
//Example6_31   // Design an inverting amplifier
clc;
clear;
close;
Av = -5 ;
//V1 = 0.1 sin wt ;
V1 = 0.1   ; // *sin wt ;
i = 5*10^-6 ;

// the input resistance
R1 = V1/i ;
disp('the input resistance is = '+string(R1)+ ' ohm'
   );

// The resistance R2
//Av = -(R2/R1);
R2 = -(Av*R1);
disp('The resistance R2 is = '+string(R2)+ ' ohm');
```

Scilab code Exa 6.32 Design an non inverting amplifier

```
//Example 6_32  // Design an non inverting amplifier
clc;
clear;
close;
Av = 5 ;
//V1 = 0.1 sin wt ;
V1 = 0.1 ;
i = -5*10^-6 ;

// the input resistance
R1 = -V1/i ;
disp('the input resistance is = '+string(R1)+ ' ohm'
   );

```

```
// The resistance R2
//Av = 1+(R2/R1);
R2 = (Av-1)*R1;
disp('The resistance R2 is = '+string(R2)+ ' ohm');
```

Scilab code Exa 6.33 To calculate phase shift between two extremes

```
//Example6_33  // To calculate phase shift between
   two extremes
clc;
clear;
close;
C = 0.22*10^-6 ;
R = 1*10^3 ;
f = 1*10^3 ;

// the cut off frequency of phase shifter
fc = 1/(2*%pi*R*C) ;
disp('the cut off frequency of phase shifter is = '
   +string(fc)+ 'Hz');

// the phase shift
f = 1 ; // KHz
fc = 7.23 ;  // KHz
PS = -2*atand(f/fc);
disp('The phase shift is = '+string(PS)+ ' ');
```

Scilab code Exa 6.34 To design a phase shifter

```
//Example6_34  // To design a phase shifter
clc;
clear;
close;
```

```
f = 2*10^3 ;
PS = -135 ;
// the phase shift
// PS = -2*atand(2*%pi*R*C);
//RC = 192.1*10^-6 ;
C = 0.1*10^-6 ;
R = (192.1*10^-6)/C
disp('The value of resistance is = '+string(R)+ ' ohm');
```

Scilab code Exa 6.35 Design a difference amplifier

```
//Example6_35  // Design a difference amplifier
clc;
clear;
close;
Ri = 50*10^3 ;
Ad = 30

R1 = Ri/2 ;
disp('The value of resistance R1 is = '+string(R1)+' ohm');
R3 = R1 ;
disp('The value of resistance R3 is = '+string(R3)+' ohm');

// the differential gain
//Ad = R2/R1 ;
R2 = 30*R1 ;
disp('The value of resistance R2 is = '+string(R2)+' ohm');

R4 = R2 ;
disp('The value of resistance R4 is = '+string(R4)+' ohm');
```

Scilab code Exa 6.36 Calculate CMRR ratio

```
//Example6_36  // Calculate CMRR ratio
clc;
clear;
close;
Ad = 10.24 ;
Acm = 0.48 ;

// the common mode rejection ratio CMRR is defined
    as
CMRRdB = 20*log10(Ad/Acm);
disp('THe common mode rejection ratio is = '+string(
    CMRRdB)+ ' dB' );
```

Scilab code Exa 6.37 Design current to voltage converter

```
//Example6_37  // Design current to voltage
    converter
clc;
clear;
close;
Vo =-10 ;
is = 100*10^-6 ;

// the output voltage of current to voltage
    converter is defined as
//Vo =-1s*R2
R2 = -Vo/is ;
disp(' The feedback resistance is = '+string(R2)+ '
    ohm');
```

```
R1 = R2 ;
disp(' The value of resistance R1 is = '+string(R1)+
    ' ohm');
```

Scilab code Exa 6.38 Design high sensitivity current to voltage converter

```
//Example6_38   // Design high sensitivity current to
    voltage converter
clc;
clear;
close;
R1 = 5*10^3 ;
is = 1 ;
KR = 0.01/10^9 ;  //    V / nA

// the output voltage of high sensitivity current to
    voltage converter
Vo =-KR*is ;
KR = 10*10^6 ;
R = 1*10^6 ;   //we assume   then
K = 10 ;
//1 + (R2/R1)+(R2/R) = 10 ;
// solving above equation we get

R2 = 9*((5*10^6)/(10^3+5)) ;
disp ('The value of resistance R2 is = '+string(R2)+
    ' ohm');
```

Scilab code Exa 6.39 Determine a load current in a V to I converter

```
//Example6_39   // Determine a load current in a V to
    I converter
```

```
clc;
clear;
close;
R1 = 10*10^3 ;
R2 = 10*10^3 ;
R3 = 1*10^3 ;
R4 = 1*10^3 ;
VI = -5 ;

// The Load Current
iL = -VI/R3 ;
disp('The load current iL is = '+string(iL)+ ' A');

VL = 0.5 ;
// The  Current i3 and iA
i3 = VL/R3 ;
disp('The current i3 is = '+string(i3)+ ' A');

iA = i3+iL ;
disp('The current iA is = '+string(iA)+ ' A');

// the output voltage
Vo = (iA*R3)+VL ;
disp('The output voltage is = '+string(Vo)+ ' V');

ZL =100 ;
// The current i1 and i2
//i1 = (VI-iL*ZL)/R1 ;
i1 = (iL*ZL-Vo)/R2 ;
disp('The current i1 is = '+string(i1)+ ' A');

i2 = i1 ;
disp('The current i2 is = '+string(i2)+ ' A');
```

Scilab code Exa 6.40 Design an instrumentation amplifier

```
//Example6_40  // Design an instrumentation amplifier
clc;
clear;
close;
//A = 5 to 500 ;  adjustable gain
VR = 100*10^3 ;

// the maximum differential gain of instrumentation amplifier is 500
//Amax = (R4/R3)*(1+(2R2/R1));
//by solving above equation we get following equation
// 2R2 -249R1f = 0                                equation 1

// the minimum differential gain of instrumentation amplifier is 5
// Amin = (R4/R3)*(1+(2R2/R1)) ;
//by solving above equation we get following equation
// 2R2 -1.5R1f = 150*10^3                          equation 2

//by solving equation 1 and 2 we get
disp('The value of resistance R1f is = 0.0606 K ohm ');

disp('The value of resistance R2 is = 75.5 K ohm ');
```

Scilab code Exa 6.41 To find the value of resistance R1 for instrumentation amplifier

```
//Example6_41  // To find the value of resistance R1
    for instrumentation amplifier
clc;
clear;
close;
A =100 ;
R2 = 450*10^3 ;
R3 = 1*10^3 ;
R4 = 1*10^3 ;

// The gain of differential amplifier
// A = (R4/R3)*(1+(2R2/R1)) ;
//but  R3 = R4  then
// A = 1+(2R2/R1) ;
R1 = 2*R2/(A-1);
disp('The value of resistane R1 is = '+string(R1)+ '
    ohm');
```

Scilab code Exa 6.42 determine the time constant of an integrator

```
//Example6_42  // determine the time constant of an
   integrator
clc;
clear;
close;
Vo = 10 ;  // at t= 1 m sec
t = 1 ; // m sec

// the output of integrator
//Vo = t/RC ; when t is from 0 to 1
RC = t/Vo ;
disp(' At t = 1 msec the time constant RC is = '+
   string(RC)+ ' m sec');

disp (' if C = 0.01 uF then R of RC time constant is
```

```
    = 10 K ohm ');

disp (' if C = 0.001 uF then R of RC time constant
    is = 100 K ohm ');
```

Scilab code Exa 6.43 Design an integrator circuit

```
//Example6_43   // Design an integrator circuit
clc;
clear;
close;
A = 10 ;
f =20*10^3 ;
R = 10*10^3 ;  // we assume
Rf =10*R ;

disp(' THe feedback resistance Rf is = '+string(Rf)+
    ' ohm');

// for proper integration f>= 10fa
fa = f/10 ;
disp('The frequency fa is = '+string(fa)+ ' Hz');

// in practical integrator
//fa = 1/(2*%pi*Rf*C);

C = 1/(2*%pi*Rf*fa);
disp(' The value of capacitor C is = '+string(C)+ '
    F ');
```

Chapter 7

Filters and Rectifiers

Scilab code Exa 7.1 Design active low filter with cut off frequency 10 KHz

```
//Example7.1  // Design active low filter with cut-
   off frequency 10 KHz
clc;
clear;
close;
fc = 10 ; // KHz
C = 0.01 ; //uF // we assume

// the cut-off frequency of active low pass filter
   is defined as
// fc = (1/2*%pi*R3*C);

// R3 can be calculated as
R3 = (1/(2*%pi*fc*C));
disp('The resistor value is = '+string(R3)+' k ohm '
   );
```

Scilab code Exa 7.2 Design active low filter with cut off frequency 15 KHz

```
//Example7.2   // Design active low filter with cut-off frequency 15 KHz
clc;
clear;
close;
fc = 15*10^3 ; // Hz
C = 0.1*10^-6 ; //F // we assume

// the cut-off frequency of active low pass filter is defined as
// fc = (1/2*%pi*R3*C);

// R3 can be calculated as
R3 = (1/(2*%pi*fc*C));
disp('The resistor value is = '+string(R3)+' ohm ');

// the pass band gain of filter is given by
// Af = 1+(R2/R1);
// assume that the inverting terminal resistor R2 =0.5*R1;
// in Af equation if we put R2=0.5R1 in R1 R1 cancellout each other
Af = 1+(0.5)
disp('The pass band gain is = '+string(Af)+' ');
```

Scilab code Exa 7.3 Design active low filter with cut off frequency 20 KHz

```
//Example7.3   // Design active low filter with cut-off frequency 20 KHz
clc;
clear;
close;
fc = 20 ; // KHz
f = 100 ; // frequency of filter
Af = 10 ;  // desired pass band gain
```

```
C = 0.05 ; //nF // we assume

// the cut-off frequency of active low pass filter
    is defined as
// fc = (1/2*%pi*R3*C);

// R3 can be calculated as
R3 = (1/(2*%pi*fc*C));
disp('The resistor value is = '+string(R3)+' ohm ');

// the pass band gain of filter is given by
// Af = 1+(R2/R1);
// assume that the inverting terminal resistor R1=
    100 k ohm;
R1 = 100 ; // k ohm
R2 = (Af*R1)-R1;
disp('The resistor R2 value is = '+string(R2)+' k
    ohm ');

// the magnitude of an active low pass filter is
    given as
A = Af/(sqrt(1+(f/fc)^2));
disp('The magnitude of an active low pass filter is
    = '+string(A)+' ');

//the phase angle of the filter
Angle = -atand(f/fc);
disp('The phase angle of the filter is = '+string(
    Angle)+' ');
```

Scilab code Exa 7.4 to determine the cut off frequency and pass band gain Af

```
//Example7.4  // to determine the cut-off frequency
    and pass band gain Af
```

```
clc;
clear;
close;
R1 = 1 ; // k ohm
R2 = 12 ; // k ohm
R3 = 1.2 ;  // k ohm
C = 0.05 ; //uF // we assume

// the frequency of the first order low pass filter
   is defined as
fc = (1/(2*%pi*R3*C));
disp('The frequency of the first order low pass
   filter is = '+string(fc)+' KHz ');

// the pass band gain of filter is given by
Af =(1+R2/R1);
disp('The pass band gain of filter is = '+string(Af)
   +'');
```

Scilab code Exa 7.5 to design a first order high pass filter with cut off frequency 2KHz

```
//Example7.5  // to design a first order high pass
   filter with cut-off frequency 2KHz
clc;
clear;
close;
Af = 10 ;
fc = 2 ; // KHz
R3 = 2 ; //K ohm // we assume
R1 = 10 ; // k ohm
// the capacitor of high pass filter is given by
C = 2*%pi*R3*fc;
disp('The capacitor of high pass filter is = '+
   string(C)+' uF ');
```

```

// the voltage gain of the high pass filter is
// Af = 1+(R2/R1);
R2 = R1*(Af-1);
disp('The second resistor value is = '+string(R2)+'
   K ohm ');
```

Scilab code Exa 7.6 to design an active high pass filter with cut off frequency 10KHz

```
//Example7.6  // to design an active high pass
   filter with cut-off frequency 10KHz
clc;
clear;
close;
fc = 10 ; // KHz
C = 0.01 ; //uF // we assume
// the cut-off frequency of active high pass filter
   is given by
// fc = 2*%pi*R3*C;
// R3 can be calculated as
R3 = (1/(2*%pi*fc*C));
disp('The resistance R3 is = '+string(R3)+' K ohm ')
   ;
```

Scilab code Exa 7.7 to design an active high pass filter with cut off frequency 25KHz

```
//Example7.7  // to design an active high pass
   filter with cut-off frequency 25KHz
clc;
clear;
close;
```

```
fc = 25 ; // KHz
C = 0.1 ; //nF // we assume
// the cut-off frequency of active high pass filter is given by
// fc = 2*%pi*R3*C;
// R3 can be calculated as
R3 = (1/(2*%pi*fc*C));
disp('The resistance R3 is = '+string(R3)+' ohm ');

// the desire pass band gain of filter is given by
//Af = 1+(R2/R1);
// assume that the inverting terminal resistor R2 =0.2*R1;
// in Af equation if we put R2=0.2R1 in R1 R1 cancellout each other
Af = 1+(0.2)
disp('The pass band gain is = '+string(Af)+' ');
```

Scilab code Exa 7.8 to design an active high pass filter with cut off frequency 20KHz

```

//Example7.8 // to design an active high pass filter with cut-off frequency 20KHz
clc;
clear;
close;
Af = 15 ;
fc = 20 ; //KHz
f = 80 ; // KHz the frequency of filter
C = 0.05 ; //nF // we assume
// the cut-off frequency of active high pass filter is given by
// fc = 2*%pi*R3*C;
// R3 can be calculated as
```

```
R3 = (1/(2*%pi*fc*C));
disp('The resistance R3 is = '+string(R3*1000)+' K ohm ');   // Round Off Error

// the desire pass band gain of filter is given by
//Af = 1+(R2/R1);
// assume that the inverting terminal resistor R1=50 K ohm;
R1 = 50 ; // K ohm
R2 = (R1*Af)-(R1)
disp('The resistance R2 is = '+string(R2)+' K ohm ');

// the magnitude of an active high pass filter is given as
A = Af*(f/fc)/(sqrt(1+(f/fc)^2));
disp('The magnitude of an active high pass filter is = '+string(A)+' ');

//the phase angle of the filter
Angle = -atand(f/fc)+atand(%inf);
disp('The phase angle of the filter is = '+string(Angle)+' degree');   // Round Off Error
```

Scilab code Exa 7.9 to calculate upper and lower cut off frequency of the band pass filter

```
//Example7.9   // to calculate upper and lower cut-off frequency of the band pass filter
clc;
clear;
close;
R1 = 10*10^3 ; //K ohm
R2 = 10 ; //K ohm
C1 = 0.1*10^-6 ; // uF
```

```
C2 = 0.001 ;   //uF

// the lower cut-off frequency of band pass filter
   is
fLC = 1/(2*%pi*R1*C1);
disp('The lower cut-off frequency FLC of band pass
   filter is = '+string(fLC)+' Hz ');

// The upper cut-off frequency of band pass filter
   is
fUC = 1/(2*%pi*R2*C2);
disp('The upper cut-off frequency FUC of band pass
   filter is = '+string(fUC)+' KHz ');
```

Scilab code Exa 7.10 to design an active band pass filter with lower cut off frequency 10 KHz an upper 50 KHZ

```
//Example7.10  // to design an active band pass
   filter with lower cut-off frequency 10 KHz an
   upper 50 KHZ
clc;
clear;
close;
fL = 10 ; // KHz
fH = 50 ; // KHz
C1 = 0.002 ; // nF
C2 = 0.002 ;  // nF

// the lower cut-off frequency of band pass filter
   is
// fL = 1/(2*%pi*R3*C1);
R3 = 1/(2*%pi*fL*C1);
disp('The resistance R3 Value is = '+string(R3)+' M
   ohm ');

```

```
// The upper cut-off frequency of band pass filter is
// fH = 1/(2*%pi*R6*C2);
R6 = 1/(2*%pi*fH*C2);
disp('The resistance R6 value is = '+string(R6)+' M ohm ');
```

Scilab code Exa 7.11 to design an active band pass filter with lower cut off frequency 20 KHz an upper 40 KHZ

```
//Example7.11  // to design an active band pass filter with lower cut-off frequency 20 KHz an upper 40 KHZ
clc;
clear;
close;
fL = 20 ; // KHz
fH = 40 ; // KHz
// the inverting terminal resistance 2R1=R2 and 4R4=R5
C1 = 0.001 ; // nF
C2 = 0.001 ;  // nF

// the lower cut-off frequency of band pass filter is
// fL = 1/(2*%pi*R3*C1);
R3 = 1/(2*%pi*fL*C1);
disp('The resistance R3 Value is = '+string(R3)+' M ohm ');

// The upper cut-off frequency of band pass filter is
// fH = 1/(2*%pi*R6*C2);
R6 = 1/(2*%pi*fH*C2);
disp('The resistance R6 value is = '+string(R6)+' M
```

```
   ohm ');

// the desire pass band gain of filter is defined as
R1 = 1 ; // M ohm we assume
//we define inverting terminal resistance 2R1=R2
R2 = 2 ; // M ohm
// then
R4 = 1 ; //M ohm
R5 = 4 ; // M ohm
Af = (1+(R2/R1))*(1+(R5/R4));
disp('The desire pass band gain of filter is = '+
    string(Af)+' ');
```

Scilab code Exa 7.12 to design an active band pass filter with lower cut off frequency 20 KHz an upper 80 KHz

```

//Example7.12 // to design an active band pass
    filter with lower cut-off frequency 20 KHz an
    upper 80 KHZ
clc;
clear;
close;
f = 100 ; // KHz  the frequency of band pass filter
fL = 20 ; // KHz
fH = 80 ; // KHz
// the inverting terminal resistance R1=0.5*R2 and
   R4=0.25*R5
C1 = 0.001 ; // nF
C2 = 0.001 ;  // nF

// the lower cut-off frequency of band pass filter
    is
// fL = 1/(2*%pi*R3*C1);
R3 = 1/(2*%pi*fL*C1);
```

```
disp('The resistance R3 Value is = '+string(R3)+' M ohm ');

// The upper cut-off frequency of band pass filter is
// fH = 1/(2*%pi*R6*C2);
R6 = 1/(2*%pi*fH*C2);
disp('The resistance R6 value is = '+string(R6)+' M ohm '); // Round Off Error

// the desire pass band gain of filter is defined as
R1 = 1 ; // M ohm we assume
//we define inverting terminal resistance R1=0.5*R2
R2 = 2 ; // M ohm
// then
R4 = 1 ; //M ohm
R5 = 4 ; // M ohm
Af = (1+(R2/R1))*(1+(R5/R4));
disp('The desire pass band gain of filter is = '+string(Af)+' ');

// the magnitude of gain of band pass filter is given as
A = Af*(f^2/(fL*fH))/((sqrt(1+(f/fL)^2))*(sqrt(1+(f/fH)^2)));
disp('The magnitude of gain of band pass filter  is = '+string(A)+' '); // Round Off Error

//the phase angle of the filter
Angle = 2*atand(%inf)-atand(f/fL)-atand(f/fH);
disp('The phase angle of gain of band pass filter is = '+string(Angle)+' degree'); // Round Off Error
```

Scilab code Exa 7.13 to determine the output voltage of the precision rectifier circuit

```
//Example7.13  // to determine the output voltage of
    the precision rectifier circuit
clc;
clear;
close;
Vi = 10 ; //V i/p volt
R1 = 20 ; // K ohm
R2 = 40 ; // K ohm
Vd = 0.7 ; // V  the diode voltage drop

// the output of the half wave precision rectifier
   is defined as
// Vo = -(R2/R1)*Vi ; for Vi < 0
//     = 0 otherwise
// i.e for Vi > 0
//              Vo = 0
// for Vi < 0
Vo = -(R2/R1)*Vi
disp('The output of the half wave precision
   rectifier Vo is = '+string(Vo)+' V ');
```

Scilab code Exa 7.14 to determine the output voltage of the precision rectifier circuit for different input voltages

```
//Example7.14  // to determine the output voltage of
    the precision rectifier circuit for i/p voltage
   a) Vi = 5 b) Vi = -5
clc;
clear;
close;
Vi = 5 ; //V i/p volt
R1 = 5 ; // K ohm
```

```
R2 = 15 ; // K ohm
Vd = 0.7 ; // V   the diode voltage drop

// the output of the half wave precision rectifier
   is defined as
// Vo = -(R2/R1)*Vi ; for Vi < 0
//    = 0 otherwise

// for Vi = 5 V
// i.e for Vi > 0
//                   Vo = 0
// for Vi < 0
Vo = -(R2/R1)*Vi;
disp('The output of the half wave precision
   rectifier Vo is = '+string(Vo)+' V ');

// for Vi = -5 V
// i.e for Vi > 0
//                   Vo = 0
// for Vi < 0
Vi =-5 ; // V
Vo = -(R2/R1)*Vi;
disp('The output of the half wave precision
   rectifier Vo is = '+string(Vo)+' V ');
```

Scilab code Exa 7.15 to determine the output voltage of the precision rectifier circuit for different input voltages

```
//Example7.15  // to determine the output voltage of
    the precision rectifier circuit for i/p voltage
   a) Vi = 7 b) Vi = -7
clc;
clear;
close;
Vi = 7 ; //V i/p volt
```

```
R1 = 5 ; // K ohm
R3 = 5 ; // K ohm
R4 = 5 ; // K ohm
R2 = 15 ; // K ohm
R5 = 15 ; // K ohm
Vd = 0.7 ; // V  the diode voltage drop

// the output of the full wave precision rectifier is defined as
// Vo = -A*Vi ;       for Vi < 0       equation 1
//    = A*Vi  ;       otherwise        equation 2

// or  Vo = abs(A*Vi) ;

// The gain of precision full wave rectifier
A = (((R2*R5)/(R1*R3))-(R5/R4)) ;
disp('The gain of precision full wave rectifier A is = '+string(A)+' ');


// for Vi = 7 V            the output voltage is
Vi = 7 ;
      Vo = -A*Vi ;      // from equation 1
      Vo =  A*Vi ;      // from equation 2
Vo = abs(A*Vi) ;
disp('The output voltage Vo is = '+string(Vo)+' V ');

// for Vi = -7 V            the output voltage is
Vi = -7 ;
      Vo = -A*Vi ;      // from equation 1
      Vo =  A*Vi ;      // from equation 2
Vo = abs(A*Vi) ;
disp('The output voltage Vo is = '+string(Vo)+' V ');
```

Chapter 8

Analog Multiplier

Scilab code Exa 8.1 to determine the output voltage of inverting amplifier

```
//Example8.1  // to determine the output voltage of
   inverting amplifier (V2)
clc;
clear;
close;
Vin = 18 ; // V
V1 = -6 ;  // V

// in the op—amp due to the infinite i/p resiostance
    the input current is = 0
// i1+i2 = 0
// it gives relation
Vo = -Vin ;

// the output of multiplier is defined as
//Vo = K*V1*V2

K = 1 ; // we assume

V2 = (Vo/(K*V1));
disp('the output voltage of inverting amplifier (V2)
```

```
is = '+string(V2)+' V ');
```

Scilab code Exa 8.2 to determine the output voltage of multiplier

```
//Example8.2 // to determine the output voltage of multiplier
clc;
clear;
close;
Vin = 15 ; // V

// the output of multiplier is defined as
//Vo = K*V1*V2
// because of i/p terminal the circuit performs mathematical operation squaring
// i.e V1 = V2 = Vin
K = 1 ; // we assume
Vo = K*(Vin)^2;
disp('the output voltage of multiplier is = '+string(Vo)+' V ');
```

Scilab code Exa 8.3 to determine the output voltage of multiplier and inverting amplifier

```
// Example8.3 // to determine the output voltage of multiplier and inverting amplifier
clc;
clear;
close;
Vin = 16 ;
// the output of the inverting amplifier
K =1 ; // we assume
Vos = sqrt(abs(Vin)/K) ;
```

```
disp('the output voltage of inverting amplifier is =
    '+string(Vos)+' V ');

// the output of the multiplier
Vo = K*Vos^2 ;
disp('the output voltage of multiplier is = '+string
   (Vo)+' V ');
```

Scilab code Exa 8.4 determine the output of balanced demodulator

```
//Example8.4  //determine the output of balanced
   demodulator
clc;
clear;
close;
// Vc1 = 10*cos*wc*t ;
// Vm2 = 20*cos*wm*t*cos*wc*t

// the amplitude of carrier and modulated signal
Ac1 = 10 ;  // V
// K*Am2*Ac2 = 20 ; // V

// the output of multiplier
// Vo1 = K*Vc1*Vm2 ;
disp('           The output voltage of multiplier is
    =        (K^2*Ac1*Ac2*Am2)/2*(cos*wm*t+cos*wm*t*
   cos*2*w*t)');


//the output of low pass filter
// Vo = ((K^2*Ac1*Ac2*Acm)/2)*cos*wm*t ;
disp('           The output voltage of low pass
   filter is  =   100coswmt');
```

Scilab code Exa 8.5 Output voltage of of RMS detector

```
//Example8.5  // output voltage of of RMS detector
clc;
clear;
close;
Vin = 10 ;
T = 1 ;  // we assume that the charging and
    discharging period of capacitor

// the output voltage of RMS detector
// Vo =sqrt(1/T*)integrate(Vin^2*(t),t,0,1 [,atol [,
    rtol]])  ;
Vo = 10 ;
disp('output voltage of RMS detector is = '+string(
    Vo)+' V ');
```

Chapter 9

Phase Locked Loop

Scilab code Exa 9.1 to find output voltage for a constant input signal frequency of 200 KHz

```
//Example9.1  // to find output voltage for a
   constant input signal frequency of 200 KHz
clc;
clear;
close;
fo = 2*%pi*1*10^3 ; // KHz/V  // VCO sensitivity
   range 4.1
fc = 500  ; // Hz a free running frequency
f1 = 200 ; // Hz  input frequency
f2 = 2*10^3 ; // Hz  input frequency

// the output voltage of PLL is defined as
//Vo = (wo-wc)/ko
ko = fo ;
// when i/p locked with o/p wo=wi
// Vo = (wi-wc)/ko ;

//for the i/p frequency fi = 200 Hz
fi = 200 ;  // Hz
Vo = (((2*%pi*fi)-(2*%pi*fc))/ko);
```

```
disp('The output voltage of switching regulator
    circuit is = '+string(Vo)+' V ');

//for the i/p frequency fi = 200 Hz
fi = 2*10^3 ;  // Hz
Vo = (((2*%pi*fi)-(2*%pi*fc))/ko);
disp('The output voltage of switching regulator
    circuit is = '+string(Vo)+' V ');
```

Scilab code Exa 9.2 to find VCO output frequency

```
//Example9.2  // to find VCO output frequency
clc;
clear;
close;
fc = 400  ; // KHz a free running frequency
f = 10 ;  // KHz  low pass filter bandwidth
fi = 500 ; // KHz  input frequency

// In PLL a phase detector produces the sum and
    difference frequencies are defined as

sum = fi+fc ;
disp('The sum frequency produce by phase detector is
     = '+string(sum)+' KHz ');

difference = fi-fc ;
disp('The difference frequency produce by phase
    detector is = '+string(difference)+' KHz ');

disp('The phase detector frequencies are outside of
    the low pass filter');

disp('The VCO will be in its free running frequency
    ');
```

Scilab code Exa 9.3 to determine the lock range of PLL

```
//Example9.3    // to determine the lock range of PLL
clc;
clear;
close;
Ko = 25 ; // KHz
fo = 50 ; // KHz
A = 2 ;
Vd = 0.7 ;
AL = 1 ;

// the amximum output swing of phase detector
// Vd = Kd*(%pi/2) ;

// the sensitivity of phase detector Kd is
Kd = Vd*(2/%pi) ;
disp('The sensitivity of phase detector Kd is = '+
    string(Kd)+'');

// The maximum control voltage of VCO Vfmax
Vfmax = (%pi/2)*Kd*A ;
disp('The maximum control voltage of VCO Vfmax = '+
    string(Vfmax)+' V');

// the maximum frequency swing of VCO
fL = (Ko*Vfmax);
disp('The maximum frequency swing of VCO = '+string(
    fL)+' KHz');

// The maximum range of frequency which lock a PLL
    are
fi = fo-fL ;
disp('The maximum range of frequency which lock a
```

```
    PLL is = '+string(fi)+ ' KHz ');

fi = fo+fL ;
disp('The maximum range of frequency which lock a
    PLL is = '+string(fi)+ ' KHz ');

disp('The maximum and minimum rage between 15 KHz to
     85 KHZ ')


// the lock range is
fLock = 2*fL ;
disp('The lock range is = '+string(fLock)+ ' KHz ');
```

Scilab code Exa 9.4 to determine the output frequency capacitor charging time of VCO

```
//Example9.4   // to determine the output frequency
    capacitor charging time of VCO
clc;
clear;
close;
Vcc = 12 ;
Vcs = 6
R = 10 ; // K ohm
C = 1 ; // uF

// the current through the control resistor R
i =(Vcc-Vcs)/R ;
disp('The current through the control resistor R is
    = '+string(i)+ ' mA ');

// The charging time of capacitor
t = (0.25*Vcc*C)/i ;
disp('The charging time of capacitor is = '+string(t
```

```
    )+ ' msec ');

// In VCO the capacitor charging and discharging
    time period are equal ,so the total time period
    of tringular and square wave forms can be written
     as 2*t ;
t = ((0.5*Vcc*C)/i);
disp('The total time period of tringular and square
    wave is = '+string(t)+ ' msec ');

// the output frequency of VCO is
fo = 1/t ;
disp('The output frequency of VCO is = '+string(fo)+
     ' KHz ');
```

Scilab code Exa 9.5 to design VCO with output square wave pulse time of 50 msec

```
//Example9.5  // to design VCO with output square
    wave pulse time of 50 msec
clc;
clear;
close;
Vcc =6 ;
Vcs = 5 ;
R = 22 ; //K ohm
C = 0.02 ; // uF
t = 50*10^-3 ; // sec   output square wave pluse

// In VCO the capacitor charging and discharging
    time period are equal ,so the total time period
    of tringular and square wave forms can be written
     as 2*t ;


```

```
// the charging or discharging time of capacitor
tcap = t/2 ;
disp('The charging or discharging time of capacitor is = '+string(tcap)+ ' msec ');

// the output frequency of VCO is
fo = 1/t ;
disp('The output frequency of VCO is is = '+string(fo)+ ' Hz ');

// the output frequency of VCO
 // fo = (1/4*R*C);
 R = 1/(4*fo*C) ;
disp('The output frequency of VCO is = '+string(R)+ ' ohm');

// the current through the control resistor R
i =(Vcc-Vcs)/R ;
disp('The current through the control resistor R is = '+string(i)+ ' uA ');

// the capacitor charging current
// (V/t)=(i/C) ;
V = (i/C)*tcap ;
disp('The capacitor charging current is = '+string(V)+ ' V = 0.33Vcc ');
```

Scilab code Exa 9.6 to determine the center frequency of VCO lock and capture range of PLL

```
//Example9.6  // to determine the center frequency of VCO lock and capture range of PLL
clc;
clear;
close;
```

```
R = 15 ; // K ohm
C = 0.12 ; // uF
Vcc = 12 ;

// the center frequency of VCO fo
fo = (1.2/4*R*C);
disp('The center frequency of VCO is is = '+string(fo)+ ' Hz ');

fo = 4 ; // KHz
// the lock range of PLL
fL = (8*fo/Vcc) ;
disp('The lock range of PLL is = '+string(fL)+ ' KHz/V ');

// the capture range of PLL
fc = ((fo-fL)/(2*%pi*3.6*10^3*C)^(1/2)) ;
disp('The lock range of PLL is = '+string(fc)+ ' Hz/V ');
```

Scilab code Exa 9.7 determine the lock range of the FSK demodulator

```
//Example9.7  // determine the lock range of the FSK demodulator
clc;
clear;
close;
Vcc = 12 ;
Fvco = 0.25*Vcc ;
f = 200*10^3 ; // KHz


// the total time period of VCO
t = 1/f ;
disp('The total time period of VCO is = '+string(t)+
```

```
    ' sec ');

// In VCO the capacitor charging and discharging
   time period are equal ,so the total time period
   of tringular and square wave forms can be written
    as 2*t ;


// the charging or discharging time of capacitor
tcap = t/2 ;
disp('The charging or discharging time of capacitor
   is = '+string(tcap)+ ' sec ');

// the voltage swing of VCO for 12 V supply
Fvco = 0.25*Vcc ;
disp('The voltage swing of VCO for 12 V supply is =
   '+string(Fvco)+ ' V ');

// The lock range of PLL
//FL = (1/2*%pi*f)*(Fvco/tcap);
FL = (3/(2*%pi*f*tcap));
disp('The lock range of PLL FL is = '+string(FL)+ '
   Hz ');

// the capture range
fcap = sqrt(f*FL);
disp('The capture range is = '+string(fcap)+ ' Hz ')
   ;
```

Chapter 11

Digital to Analog converter

Scilab code Exa 11.1 to determine the full scale voltage of Digital to analog converter

```
//Example11.1   // to determine the full scale
    voltage of D/A
clc;
clear;
close;
Vref = 12 ;
Rf = 10 ; // K ohm
R = 5 ; // K ohm

// the full scale voltage of D/A converter
VFS = Vref*(Rf/R) ;
disp('the full scale voltage of D/A converter VFS is
     = '+string(VFS)+ ' V ');
```

Scilab code Exa 11.2 determine the output voltage of digital to analog converter for the different binary inputs

```
//Example11.2  // determine the output voltage of D/A converter for the binary inputs a) 10101010  b) 11001100  c) 11101110 d) 00010001
clc;
clear;
close;
del = 12*10^-3 ;  // mA

// the input voltage of D/A converter
 //Vo = del*binary input (BI)

// For BI 10101010 the output
BI = '10101010' ;
BI = bin2dec(BI);
Vo = del*BI ;
disp('For BI 10101010 the output of D/A converter is = ' +string(Vo)+ ' V ');

// For BI 11001100 the output
BI = '11001100' ;
BI = bin2dec(BI);
Vo = del*BI ;
disp('For BI 11001100 the output of D/A converter is = ' +string(Vo)+ ' V ');

// For BI 11101110 the output
BI = '11101110' ;
BI = bin2dec(BI);
Vo = del*BI ;
disp('For BI 11101110 the output of D/A converter is = ' +string(Vo)+ ' V ');

// For BI 00010001 the output
BI = '00010001' ;
BI = bin2dec(BI);
Vo = del*BI ;
disp('For BI 00010001 the output of D/A converter is = ' +string(Vo)+ ' V ');
```

Scilab code Exa 11.3 determine the resolution of 4 bit digital to analog converter

```
//Example11.3    // determine the resolution of 4-bit
    D/A converter
clc;
clear;
close;
VFS = 12 ;
N = 4 ;

// the resolution of 4-bit D/A converter is defined
   as
Resolution = VFS/(2^N-1) ;
disp('the resolution of 4-bit D/A converter is = '+
   string(Resolution)+ ' V ');
```

Scilab code Exa 11.4 determine the number of bit required to design a 4 bit Digital to Analog converter

```
//Example11.4    // determine the number of bit
   required to design a 4-bit D/A converter
clc;
clear;
close;
VFS = 5 ;
Resolution = 10*10^-3 ; // A

// the resolution of 4-bit D/A converter is defined
   as
// Resolution = VFS/(2^N-1) ;
```

```
N = (VFS/Resolution)+1 ;
N = log10(N)/log10(2);
disp('the number of bit required to design a 4-bit D/A converter is = '+string(N)+ '   = 9 ');
```

Scilab code Exa 11.5 determine the analog output voltage

```
//Example11.5   // determine the analog output voltage
clc;
clear;
close;
Vref = 12  ;
BI = 101 ;   BI = 111 ;   BI = 011 ; BI = 001 ;  BI = 100 ;
Rf = 40*10^3 ;
R = 0.25*Rf ;

// The output voltage of given binary weighted resistor D/A converter is defined as

// Vo = -(Rf*Vref/R)*(2^0*b0+2^-1*b1+2^-2*b2) ;

// Vo = -(Rf*Vref/R)*(b0+2^-1*b1+2^-2*b2) ;

// for the given value Rf,R and Vref the output voltage

// Vo = -48*(b0+2^-1*b1+2^-2*b2) ;

// for the binary input 101 analog output is
b2 = 1 ;
b1 = 0 ;
b0 = 1 ;
Vo = -48*(b0+2^-1*b1+2^-2*b2) ;
```

```
disp('for the binary input 101 analog output is = '+
   string(Vo)+ ' V ');


// for the binary input 111 analog output is
b2 = 1 ;
b1 = 1 ;
b0 = 1 ;
Vo = -48*(b0+2^-1*b1+2^-2*b2) ;
disp('for the binary input 111 analog output is = '+
   string(Vo)+ ' V ');


// for the binary input 011 analog output is
b2 = 0 ;
b1 = 1 ;
b0 = 1 ;
Vo = -48*(b0+2^-1*b1+2^-2*b2) ;
disp('for the binary input 011 analog output is = '+
   string(Vo)+ ' V ');


// for the binary input 001 analog output is
b2 = 0 ;
b1 = 0 ;
b0 = 1 ;
Vo = -48*(b0+2^-1*b1+2^-2*b2) ;
disp('for the binary input 001 analog output is = '+
   string(Vo)+ ' V ');


// for the binary input 100 analog output is
b2 = 1 ;
b1 = 0 ;
b0 = 0 ;
Vo = -48*(b0+2^-1*b1+2^-2*b2) ;
disp('for the binary input 100 analog output is = '+
   string(Vo)+ ' V');
```

Scilab code Exa 11.6 determine the analog output voltage and feed back current If

```
//Example11.6    // determine the analog output
   voltage and feed back current If
clc;
clear;
close;
Vref = 12  ;
BI = 1001 ;   BI = 1101 ;   BI = 1010 ; BI = 0011 ;
Rf = 25 ;  // K ohm
R = 0.25*Rf ;

// The output voltage of given binary weighted
   resistor D/A converter is defined as

// Vo = -(Rf*Vref/R)*(2^0*b0+2^-1*b1+2^-2*b2+2^-3*b3
   ) ;

// Vo = -(Rf*Vref/R)*(b0+2^-1*b1+2^-2*b2+2^-3*b3) ;

// for the given value Rf,R and Vref the output
   voltage

// Vo = -60*(b0+2^-1*b1+2^-2*b2+2^-3*b3) ;

// for the binary input 1001 analog output is
b3 = 1 ;
b2 = 0 ;
b1 = 0 ;
b0 = 1 ;
Vo = -60*(b0+2^-1*b1+2^-2*b2+2^-3*b3) ;
disp('for the binary input 1001 analog output is = '
   +string(Vo)+ ' V ');
```

```

// the feedback current If is given by
If = -(Vo/Rf) ;
disp('the feedback current If is = '+string(If)+ '
   mA ');


// for the binary input 1101 analog output is
b3 = 1 ;
b2 = 1 ;
b1 = 0 ;
b0 = 1 ;
Vo = -60*(b0+2^-1*b1+2^-2*b2+2^-3*b3) ;
disp('for the binary input 1101 analog output is = '
   +string(Vo)+ ' V ');

// the feedback current If is given by
If = -(Vo/Rf) ;
disp('the feedback current If is = '+string(If)+ '
   mA ');


// for the binary input 1010 analog output is
b3 = 1 ;
b2 = 0 ;
b1 = 1 ;
b0 = 0 ;
Vo = -60*(b0+2^-1*b1+2^-2*b2+2^-3*b3) ;
disp('for the binary input 1010 analog output is = '
   +string(Vo)+ ' V ');

// the feedback current If is given by
If = -(Vo/Rf) ;
disp('the feedback current If is = '+string(If)+ '
   mA ');


// for the binary input 0011 analog output is
```

```
b3 = 0 ;
b2 = 0 ;
b1 = 1 ;
b0 = 1 ;
Vo = -60*(b0+2^-1*b1+2^-2*b2+2^-3*b3) ;
disp('for the binary input 0011 analog output is = '+string(Vo)+ ' V ');

// the feedback current If is given by
If = -(Vo/Rf) ;
disp('the feedback current If is = '+string(If)+ ' mA ');
```

Scilab code Exa 11.7 determine the feed back current If and analog output voltage

```

//Example11.7 // determine the feed back current If and analog output voltage
clc;
clear;
close;
Vref = 8  ;    // V
BI = 001 ;    BI = 010 ;    BI = 110 ;
Rf = 25*10^3 ; // Hz
R = 0.2*Rf ;

// The output current of given binary weighted resistor D/A converter is defined as

// If = -(Vref/R)*(2^0*b0+2^-1*b1+2^-2*b2) ;

// If = -(Vref/R)*(b0+2^-1*b1+2^-2*b2) ;

// for the given value Rf,R and Vref the output
```

```
current

// If = -(1.6*10^-3)*(b0+2^-1*b1+2^-2*b2) ;

// for the binary input 001 the feedback current If is given by
b2 = 0 ;
b1 = 0 ;
b0 = 1 ;
If = (1.6*10^-3)*(b0+2^-1*b1+2^-2*b2) ;
disp('for the binary input 001 analog output is = '+string(If*1000)+ ' mA ');

// An analog output voltage Vo is
Vo = -If*Rf ;
disp('An analog output voltage Vo is = '+string(Vo)+' V ');


// for the binary input 010 the feedback current If is given by
b2 = 0 ;
b1 = 1 ;
b0 = 0 ;
If = (1.6*10^-3)*(b0+2^-1*b1+2^-2*b2) ;
disp('for the binary input 010 analog output is = '+string(If*1000)+ ' mA');

// the An analog output voltage Vo is
Vo = -If*Rf ;
disp('An analog output voltage Vo is = '+string(Vo)+' V ');


// for the binary input 110 the feedback current If is given by
b2 = 1 ;
b1 = 1 ;
```

```
b0 = 0 ;
If = (1.6*10^-3)*(b0+2^-1*b1+2^-2*b2) ;
disp('for the binary input 110 analog output is = '+
    string(If*1000)+ ' mA ');

// the An analog output voltage Vo is
Vo = -If*Rf ;
disp('An analog output voltage Vo is = '+string(Vo)+
    ' V ');
```

Scilab code Exa 11.8 determine the feed back current If and analog output voltage

```
//Example11.8 // determine the feed back current If
    and analog output voltage
clc;
clear;
close;
Vref = 5  ;
BI = 101 ;   BI = 011 ;   BI = 100 ;  BI = 001 ;
Rf = 25*10^3 ;
R = 0.2*Rf ;

// The output current of given R-2R ladder D/A
    converter is defined as

// If = -(Vref/2*R)*(2^0*b0+2^-1*b1+2^-2*b2)  ;

// If = -(Vref/2*R)*(b0+2^-1*b1+2^-2*b2) ;

// for the given value Rf,R and Vref the output
    current

// If = (0.5*10^ -3)*(b0+2^-1*b1+2^-2*b2) ;

```

```
// for the binary input 101 the feedback current If
   is given by
b2 = 1 ;
b1 = 0 ;
b0 = 1 ;
If = (0.5*10^-3)*(b0+2^-1*b1+2^-2*b2) ;
disp('for the binary input 101 analog output is = '+
   string(If)+ ' A ');

// An analog output voltage Vo is
Vo = -If*Rf ;
disp('An analog output voltage Vo is = '+string(Vo)+
    ' V ');


// for the binary input 011 the feedback current If
   is given by
b2 = 0 ;
b1 = 1 ;
b0 = 1 ;
If = (0.5*10^-3)*(b0+2^-1*b1+2^-2*b2) ;
disp('for the binary input 011 analog output is = '+
   string(If)+ ' A');

// the An analog output voltage Vo is
Vo = -If*Rf ;
disp('An analog output voltage Vo is = '+string(Vo)+
    ' V ');


// for the binary input 100 the feedback current If
   is given by
b2 = 1 ;
b1 = 0 ;
b0 = 0 ;
If = (0.5*10^-3)*(b0+2^-1*b1+2^-2*b2) ;
disp('for the binary input 100 analog output is = '+
   string(If)+ ' A ');
```

```

// the An analog output voltage Vo is
Vo = -If*Rf ;
disp('An analog output voltage Vo is = '+string(Vo)+
    ' V ');

// for the binary input 001 the feedback current If
    is given by
b2 = 0 ;
b1 = 0 ;
b0 = 1 ;
If = (0.5*10^-3)*(b0+2^-1*b1+2^-2*b2) ;
disp('for the binary input 001 analog output is = '+
    string(If)+ ' A ');

// the An analog output voltage Vo is
Vo = -If*Rf ;
disp('An analog output voltage Vo is = '+string(Vo)+
    ' V ');
```

Scilab code Exa 11.9 determine the analog output voltage and feed back current If

```
//Example11.9  // determine the analog output
    voltage and feed back current If
clc;
clear;
close;
Vref = 10  ;
BI = 1001 ;   BI = 1100 ;   BI = 1010 ; BI = 0011 ;
Rf = 50 ;  // K ohm
R = 0.4*Rf ;

// The output voltage of given R-2R ladder D/A
    converter is defined as
```

```

// Vo = -(Rf*Vref/2R)*(2^0*b0+2^-1*b1+2^-2*b2+2^-3*b3) ;

// Vo = -(Rf*Vref/2R)*(b0+2^-1*b1+2^-2*b2+2^-3*b3) ;

// for the given value Rf,R and Vref the output voltage

// Vo = -12.5*(b0+2^-1*b1+2^-2*b2+2^-3*b3) ;

// for the binary input 1001 analog output is
b3 = 1 ;
b2 = 0 ;
b1 = 0 ;
b0 = 1 ;
Vo = -12.5*(b0+2^-1*b1+2^-2*b2+2^-3*b3) ;
disp('for the binary input 1001 analog output is = '+string(Vo)+ ' V ');

// the feedback current If is given by
If = -(Vo/Rf) ;
disp('the feedback current If is = '+string(If)+ ' mA ');


// for the binary input 1100 analog output is
b3 = 1 ;
b2 = 1 ;
b1 = 0 ;
b0 = 0 ;
Vo = -12.5*(b0+2^-1*b1+2^-2*b2+2^-3*b3) ;
disp('for the binary input 1100 analog output is = '+string(Vo)+ ' V ');

// the feedback current If is given by
If = -(Vo/Rf) ;
disp('the feedback current If is = '+string(If)+ '
```

```
   mA ');


// for the binary input 1010 analog output is
b3 = 1 ;
b2 = 0 ;
b1 = 1 ;
b0 = 0 ;
Vo = -12.5*(b0+2^-1*b1+2^-2*b2+2^-3*b3) ;
disp('for the binary input 1010 analog output is = '
    +string(Vo)+ ' V ');

// the feedback current If is given by
If = -(Vo/Rf) ;
disp('the feedback current If is = '+string(If)+ '
   mA ');


// for the binary input 0011 analog output is
b3 = 0 ;
b2 = 0 ;
b1 = 1 ;
b0 = 1 ;
Vo = -12.5*(b0+2^-1*b1+2^-2*b2+2^-3*b3) ;
disp('for the binary input 0011 analog output is = '
    +string(Vo)+ ' V ');

// the feedback current If is given by
If = -(Vo/Rf) ;
disp('the feedback current If is = '+string(If)+ '
   mA ');
```

Scilab code Exa 11.10 determine the analog output voltage and feed back current If

```
//Example11.10  // determine the analog output
   voltage and feed back current If
clc;
clear;
close;
Vref = 15  ;
BI = 1000 ;
Rf = 40 ;  // K ohm
R = 0.4*Rf ;

// by using voltage divider rule Vin can be
   calculated as
 Vin = -(Vref*2*R)/(2*R+2*R) ;

// The output voltage of given R−2R ladder D/A
   converter is defined as

// Vo = −(Rf*Vin/R)

Vo = (Vref*Rf)/(2*R)
disp('for the binary input 1000 output voltage is =
   '+string(Vo)+ ' V ');

// the feedback current If is given by
If = -(Vo/Rf) ;
disp('the feedback current If is = '+string(If)+ '
   mA ');
```

Scilab code Exa 11.11 to find the resolution and analog output voltage of 8 bit Digital to Analog converter

```
//Example11.11 // to find the resolution and analog
   output voltage of 8−bit D/A converter
clc;
clear;
```

```
close;
VFS = 10 ;
N = 8 ;
BI = 10101111 ;  BI = 11100011 ;  BI = 00101001 ; BI = 01000110

// the resolution of 8-bit D/A converter is defined as
Resolution = VFS/(2^N-1) ;

// An analog output voltage of D/A converter is given by
// Vo = Resolution*(2^-0*b0+2^-1*b1+....+2^-N*bn-1)
// Vo = Resolution*(2^-0*b0+2^-1*b1+2^-2*b2+2^-3*b3+2^-4*b4+2^-5*b5+2^-6*b6+2^-7*b7);

// For the BI 10101111 output analog voltage is
BI = '10101111';
BI = bin2dec(BI);
Vo = Resolution*BI ;
disp('For the BI 10101111 output analog voltage is = '+string(Vo)+ ' V ');

// For the BI 11100010 output analog voltage is
BI = '11100010';
BI = bin2dec(BI);
Vo = Resolution*BI ;
disp('For the BI 11100010 output analog voltage is = '+string(Vo)+ ' V ');

// For the BI 00101001 output analog voltage is
BI = '00101001';
BI = bin2dec(BI);
Vo = Resolution*BI ;
disp('For the BI 00101001 output analog voltage is = '+string(Vo)+ ' V ');

// For the BI 01000110 output analog voltage is
```

```
BI = '01000110';
BI = bin2dec(BI);
Vo = Resolution*BI ;
disp('For the BI 01000110 output analog voltage is =
    '+string(Vo)+ ' V ');
```

Chapter 12

Analog to Digital converter

Scilab code Exa 12.2 Determine the different parameter of 8 bit Analog to Digital converter

```
//Examle12.2  // Determine the following parameter
   of 8-bit A/D converter a) Normalized step size b)
    Actual step size  c) Normalized maximum
   quantization level  d) Actual maximum
   quantization  e) Normalized peak quantization
   error  f) Actual peak quantization error  g)
   Percentage of quantization error
clc;
clear;
close;
N = 8 ;
Vin = 12 ;

//a) Normalized step size of A/D converter
Ns = 2^-N ;
disp('Normalized step size of A/D converter is = '+
   string(Ns)+ ' ');

// b) Actual step size of A/D converter
As = Vin*Ns ;
```

```
disp('Actual step size of A/D converter is = '+
    string(As)+ ' ');

// c) Normalized maximum quantization level of A/D
    converter
Qmax = 1-2^-N ;
disp('Normalized maximum quantization level of A/D
    converter is = '+string(Qmax)+ ' ');

// d) Actual maximum quantization level of A/D
    converter
QAmax = Qmax*Vin ;
disp('Actual maximum quantization level of A/D
    converter is = '+string(QAmax)+ ' ');

// e) Normalized peak quantization error of A/D
    converter
Qp = 2^-(N+1);
disp('Normalized peak quantization error of A/D
    converter is = '+string(Qp)+ ' ' );

// f) Actual peak quantization error of A/D
    converter
Qe = Qp*Vin ;
disp('Actual peak quantization error of A/D
    converter is = '+string(Qe)+ ' V ');

// g) Percentage of quantization error of A/D
    converter
%Qp = 2^-(N+1)*100 ;
disp('Percentage of quantization error of A/D
    converter is = '+string(%Qp)+ ' ') ;
```

Scilab code Exa 12.3 to determine the binary output of the 8 bit dual slope Analog to Digital converter

```
//Example12.3    // to determine the binary output of the 8-bit dual slope A/D converter
clc;
clear;
close;
Vin = 8.5 ;
VR = 10 ;
f = 2 ;  //MHz
N = 8 ;
C = 0.1*10^-6 ;
R = 2*10^3 ;

// the output of integrator is defined as
// Viao(T1) = -(Vin/R*C)*T1 ;

// charging time of capacitor
T1 = 2^N/f ;
disp('charging time of capacitor  is = '+string(T1)+' u sec');

// the integrator output
T1 = T1*10^-6 ;
Viao =-(Vin/(R*C))*T1;
disp('the integrator output is = '+string(Viao)+' V');

// the binary output of a dual slope A/D converter
Bn = (2^N*Vin)/VR;
disp('the decimal output of a dual slope A/D converter is = '+string(Bn)+'   = 218' );

Bn=218;
Bn = dec2bin(Bn) ;
disp('  The binary output of a dual slope A/D converter is = '+string(Bn)+' ' );
```

Scilab code Exa 12.4 to determine the resolution of 12 bit Analog to Digital converter

```
//Example12.4   // to determine the resolution of 12-
   bit A/D converter
clc;
clear;
close;
N =12 ;
Vin = 15 ;

// Resolution of an A/D converter
Resolution = Vin/(2^N-1);
disp('Resolution of an A/D converter is = '+string(
   Resolution)+ ' V ');
;
```

Scilab code Exa 12.5 to determine the output time and duty cycle of V to T converter

```
// Example12.5   // to determine the output time and
   duty cycle of V/T converter
clc;
clear;
close;
Vin = 5 ;
C = 0.1*10^-6 ;
R = 10*10^3 ;
C1 = 100*10^-6 ;

// The output time of a V/T converter is given as
T = (7.5*C1)/(Vin) ;
```

```
disp('The output time of a V/T converter is =' + string(T)+ ' sec');

TH = 0.075 ;
TL=TH ; // we consider
// The duty cycle of V?T converter
D = (TL+TH)/(TH) ;
disp('The duty cycle of V?T converter is = '+string(D)+ ' ');

// The output voltage of an integrator is define as
Vio = -(Vin)/(R*C)*T ;
disp('The output voltage of an integrator is is = '+string(Vio)+ ' V');
```

Chapter 13

Wave Form Generators

Scilab code Exa 13.1 to design RC phase shift oscillator for the oscillation frequency f is 1 KHz

```
//Example13.1   // to design RC phase shift oscillator for the oscillation frequency f = 1 KHz
clc;
clear;
close;
f =1 ; // KHz
C = 0.01 ; // uF

// The oscillation frequency of practical RC phase shift oscillator is defined as
//w = 1/(sqrt(6)*R*C);

// gain of practical RC phase shift oscillator is
//A = R1/R = 29                                   equation 1
// the frequency selective element resistor
//R = 1/(sqrt(6)*w*C);
R = 1/(sqrt(6)*2*%pi*f*C);
```

```
disp('the frequency selective element resistor is =
    '+string(R)+ ' K ohm ');

// The feedback resistance
R1 = 29*R ;                                            //
    from equation 1
disp('The feedback resistance is = '+string(R1)+ ' K
    ohm');
```

Scilab code Exa 13.2 to determine the oscillaton frequency of the phase shift oscillator

```
//Example13.2  // to determine the oscillaton
    frequency of the phase shift oscillator
clc;
clear;
close;
C = 0.05 ;  // uF
R = 2.5 ;  // K ohm

// the oscillator frequency of practical RC phase
    shift oscillator f
f = 1/(2*%pi*(sqrt(6)*(R*C)));
disp('the oscillator frequency of practical RC phase
    shift oscillator f is = '+string(f)+ ' KHz ');
```

Scilab code Exa 13.3 to calculate the frequency of a wein bridge oscillator

```
//Example13.3  // to calculate the frequency of a
    wein bridge oscillator
clc;
clear;
```

```
close;
C = 2400*10^-12 ;  // F
R = 10*10^3 ;  // ohm

// the oscillator frequency of practical RC phase
   shift oscillator f
f = 1/(2*%pi*R*C);
disp('the oscillator frequency of practical RC phase
    shift oscillator f is = '+string(f)+ ' Hz ');
```

Scilab code Exa 13.4 to design the wien bridge oscillator for the oscillation frequency f is 1 KHz

```
//Example13.4  // to design the wien bridge
   oscillator for the oscillation frequency f = 1
   KHz
clc;
clear;
close;
f = 1 ; // K ohm
C = 0.01 ;  // uF


// the frequency f is define as
// f = 1/(2*%pi*R*C);

// the resistor R is
R = 1/(2*%pi*f*C);
disp('the resistor R is = '+string(R)+ ' K ohm ');

// the loop gain of the wien bridge oscillator is
   unity which is defined as
// A = (1+(R2/R1))*(1/3) = 1 ;
//  R2/R1 = 2 ;
R1 = 10 ;  // K ohm we assume
```

```
R2 = 2*R1 ;
disp('The resistor R2 value is = '+string(R2)+ ' K
    ohm ');
```

Scilab code Exa 13.5 to calculate the frequency of a wein bridge oscillator

```
//Example13.5  // to calculate the frequency of a
    wein bridge oscillator
clc;
clear;
close;
C = 0.05*10^-6 ;  // F
R = 20*10^3 ;  // ohm
R1 = 10*10^3 ;  // ohm
R2 = 20*10^3 ;  //ohm

// the frequency of wien bridge oscillator f
f = 1/(2*%pi*R*C);
disp('the frequency of wien bridge oscillator f is =
     '+string(f)+ ' Hz ');
```

Scilab code Exa 13.6 Determine the frequency response of the astable multivibrator circuit

```
//Example13.6  // Determine the frequency response
    of the astable multivibrator circuit
clc;
clear;
close;
Vsat = 2.5 ;
VT = 0.7 ;

// The frequency of the astable multivibrator is
```

```
//f = (1/(2*R*C*log((Vsat+VT)/(Vsat-VT))));

disp('The frequency of the astable multivibrator is=
    0.87/RC ');
```

Scilab code Exa 13.7 Design astable multivibrator for the frequency f is 10 KHz

```
//Example13.7  // Design astable multivibrator for
   the frequency f = 10 KHz
clc;
clear;
close
f = 10 ; // K ohm
Vsat = 3 ;
VT = 0.7 ;

// The saturation voltage of an astable
   multivibrator is defined as
//  Vsat = (R1+R2/R1)+VT ;
R1 = 10 ;  // K ohm  we choose
R2 = ((Vsat/VT)-1)*R1 ;
disp('The value of resistance R2 is = '+string(R2)+
    ' K ohm ');

// The frequency of an astable multivibrator is
   defined as
C = 0.01 ;  // uF
// f = (1/(2*R*C*log(1+(2*R1/R2))));

R = 1/(2*f*C*log(1+2*R1/R2));
disp('The value of resistor R is = '+string(R)+ ' K
   ohm');
```

Scilab code Exa 13.8 to design astable multivibrator

```
//Example13.8  // to design astable multivibrator
clc;
clear;
close;
f = 25*10^3 ;

// The output frequency of practical astable
   multivibrator is defined as
//  f = 1/(2*R*C);
C = 0.1*10^-6 ; // uF  we choose
R = 1/(2*f*C);
disp('The value of resistor R is = '+string(R)+ '
   ohm ' );
```

Scilab code Exa 13.9 Design a monostable circuit with frequency 25KHz

```

//Example13.9   // Design a monostable circuit with
   frequency f = 25 KHz
clc;
clear;
close;
f =25*10^3 ; // Hz

// The output frequency of monostable multivibrator
   is defined as
//  f = 1/(0.69*R*C);
C = 0.1*10^-6 ;
R = 1/(0.69*f*C);
```

```
disp('The value of resistance R is = '+string(R)+ ' ohm ');

// In the practical monostable multivibrator
//  ln(1+(R2/R1))= 0.69 ;
R1 = 10*10^3 ;  // we choose
R2 = R1*(1.99372-1);
disp('The value of resistance R2 is = '+string(R2/1000)+  ' K ohm ');  // Round Off Error
```

Scilab code Exa 13.10 Determine the frequency of the monostable multivibrator

```
//Example13.10  // Determine the frequency of the monostable multivibrator
clc;
clear;
close;
R1 = 5*10^3 ;
R2 =15*10^3 ;
C = 0.01*10^-6 ;
R = 12*10^3 ;

// the output of monostable multivibrator is defined as
f = 1/(R*C*(log(1+(R2/R1))));
disp('the output of monostable multivibrator is = '+string(f)+ ' Hz');
```

Scilab code Exa 13.11 Determine the frequency of the monostable multivibrator

```
//Example13.11  // Determine the frequency of the
   monostable multivibrator
clc;
clear;
close;
R1 = 5*10^3 ;
R2 =15*10^3 ;
C = 0.01 ;
R = 25 ;

// the output of monostable multivibrator is defined
    as
f = 1/(R*C);
disp('the output of monostable multivibrator is = '
   +string(f)+ ' KHz');
```

Chapter 14

Special Function ICs

Scilab code Exa 14.1 to determine the regulated voltage

```
//Example14.1 // to determine the regulated voltage
clc;
clear;
close;
R1 = 250 ; //ohm
R2 = 2500 ; // ohm
Vref = 2 ; //V //reference voltage
Iadj = 100*10^-6; // A  // adjacent current

//the output voltage of the adjustable voltage
   regulator is defined by
Vo = (Vref*((R2/R1)+1)+(Iadj*R2)) ;
disp('the output voltage of the adjustable voltage
   regulator is = '+string(Vo)+' V ');
```

Scilab code Exa 14.2 to determine the current drawn from the dual power supply

```
//Example14.2 // to determine the current drawn from
    the dual power supply
clc;
clear;
close;
V = 10 ;  // V
P = 500 ; // mW

// we assume that  each power supply provides half
   power supply to IC
P1 = (P/2);

// the total power dissipation of the IC
// P1 = V*I  ;
I = P1/V ;
disp('the total power dissipation of the IC is = '+
   string(I)+' mA ');
```

Scilab code Exa 14.3 to determine the output voltage

```
//Example14.3 // to determine the output voltage
clc;
clear;
close;
R1 = 100*10^3 ; //ohm
R2 = 500*10^3 ; // ohm
Vref = 1.25 ; //V //reference voltage

//the output voltage of the adjustable voltage
   regulator is defined by
Vo = Vref*(R1+R2)/R1;
disp('the output voltage of the adjustable voltage
   regulator is = '+string(Vo)+' V ');
```

Scilab code Exa 14.4 determine the output voltage of the switching regulator circuit

```
//Example14.4 // determine the output voltage of the
    switching regulator circuit
clc;
clear;
close;
d = 0.7 ;  // duty cycle
Vin = 5 ; // V // input voltage

// The output voltage of switching regulator circuit
    is given by
Vo = d*Vin ;
disp('The output voltage of switching regulator
   circuit is = '+string(Vo)+' V ');
```

Scilab code Exa 14.5 determine the duty cycle of the switching regulator circuit

```
//Example14.5 // determine the duty cycle of the
   switching regulator circuit
clc;
clear;
close;
Vo = 4.8 ; // V // output voltage
Vin = 5 ; // V // input voltage

// The output voltage of switching regulator circuit
    is given by
// Vo = d*Vin ;

```

```
// Duty cycle is given as
d =Vo/Vin ;
disp('The output voltage of switching regulator
    circuit is = '+string(d)+'  ');
```

Scilab code Exa 14.6 determine the duty cycle of the switching regulator circuit

```
//Example14.6 // determine the duty cycle of the
    switching regulator circuit
clc;
clear;
close;
T =120 ; //msec // total pulse time
// T = ton + toff ;
ton = T/2 ;

// The duty cycle of switching regulator circuit is
    given by
d = ton/T;
disp('The output voltage of switching regulator
    circuit is = '+string(d)+'  ');
```

Scilab code Exa 14.7 determine the duty cycle of the switching regulator circuit

```
//Example14.7 // determine the duty cycle of the
    switching regulator circuit
clc;
clear;
close;
ton = 12 ; //msec // on time of pulse
// ton = 2*toff ;  given
```

```
// T = ton + toff ;
toff = ton/2 ;
T = ton+toff ;  // total time

// The duty cycle of switching regulator circuit is
   given by
d = ton/T;
disp('The output voltage of switching regulator
   circuit is = '+string(d)+'  ');
```

Scilab code Exa 14.8 determine the output voltage of the audio power amplifier IC LM380

```
// Example14.8  // determine the output voltage of
   the audio power amplifier IC LM380
clc;
clear;
close;
Vcc = 12 ; // V
Ic3 = 12*10^-6 ;  // A  // collector current of the
   transistor Q3
Ic4 = 12*10^-6 ;  // A  // collector current of the
   transistor Q4
R11 = 25*10^3 ; // ohm
R12 = 25*10^3 ;  // ohm

// the collector current of Q3 is defined as
 // Ic3 = (Vcc-3*Veb)/(R11+R12);
Veb = (Vcc-(R11+R12)*Ic3)/3 ;
disp('The emitter bias voltage is = '+string(Veb)+'
  V ');

// the output voltage of the IC LM380
Vo = (1/2)*Vcc+(1/2)*Veb;
disp('The output voltage of the IC LM380 is = '+
```

```
string(Vo)+' V ');
```

Scilab code Exa 14.9 determine the output voltage of the audio power amplifier IC LM380

```
// Example14.9   // determine the output voltage of
   the audio power amplifier IC LM380
clc;
clear;
close;
Vcc = 10 ; // V
Ic3 = 0.01*10^-6 ;  // A  // collector current of
   the transistor Q3
Ic4 = 0.01*10^-6 ;  // A  // collector current of
   the transistor Q4
R11 = 25*10^3 ; // ohm
R12 = 25*10^3 ;  // ohm

// the collector current of Q3 is defined as
 // Ic3 = (Vcc-3*Veb)/(R11+R12);
Veb = (Vcc-(R11+R12)*Ic3)/3 ;
disp('The emitter bias voltage is = '+string(Veb)+'
   V ');

// the output voltage of the IC LM380
Vo = (1/2)*Vcc+(1/2)*Veb;
disp('The output voltage of the IC LM380 is = '+
   string(Vo)+' V ');
```

Scilab code Exa 14.10 Design a video amplifier of IC 1550 circuit

```

```

```
// Example14.10   // Design a video amplifier of IC
   1550 circuit
clc;
clear;
close;
Vcc = 12 ; // V
Av = -10 ;
Vagc = 0 ; // at bandwidth of 20 MHz
hfe = 50 ; // forward emitter parameter
rbb = 25 ;  // ohm  // base resistor
Cs = 1*10^-12 ;  // F  // source capacitor
Cl = 1*10^-12 ;  // F  // load capacitor
Ie1 = 1*10^-3 ; // A // emitter current of Q1
f = 1000*10^6 ; // Hz
Vt = 52*10^-3 ;
Vt1 = 0.026 ;

// When Vagc =0 the transistor Q2 is cut-off and the
    collector current of transistor Q2 flow through
   the transistor Q3
// i.e Ic1=Ie1=Ie3
Ie3 = 1*10^-3 ; // A // emitter current of Q3
Ic1 = 1*10^-3 ;  // A  // collector current of the
   transistor Q1

// it indicates that the emitter current of Q2 is
   zero Ie2 = 0 then the emitter resistor of Q2 is
   infinite
re2 = %inf ;

// emitter resistor of Q3
re3 = (Vt/Ie1);
disp('The emitter resistor of Q3 is = '+string(re3)+
   ' ohm ( at temperature 25 degree celsius) ');

// the trans conductance of transistor is
gm = (Ie1/Vt1);
disp('The trans conductance of transistor is = '+
```

```
    string(gm*1000)+' mA/V '); // Round Off Error

// the base emitter resistor rbe
rbe = (hfe/gm);
disp('The base emitter resistor rbe is = '+string(
    rbe/1000)+' K ohm '); // Round Off Error

// the emitter capacitor Ce
Ce = (gm/(2*%pi*f));
disp('The emitter capacitor Ce = '+string(Ce)+' F ')
    ; // Round Off Error

// the voltage gain of video amplifier is
// Av = (Vo/Vin) ;
// Av = -((alpha3*gm)/(rbb*re3)*((1/rbb)+(1/rbe)+sCe
    )*((1/re2)+(1/re3)+sC3)*((1/Rl)+(s(Cs+Cl))))
 // At Avgc = 0 i.e s=0 in the above Av equation
alpha3 = 1 ;
s = 0 ;
// Rl = -((alpha3*gm)/(rbb*re3)*(((1/rbb)+(1/rbe))
    *((1/re2)+(1/re3))*(Av)));

// After solving above equation for Rl We get Rl
    Equation as
Rl = 10/(37.8*10^-3);
disp('The value of resistance RL is = '+string(Rl)+'
     ohm ');

// there are three poles present in the transfer
    function of video amplifier each pole generate
    one 3-db frequency
Rl = 675 ;
// fa = 1/(2*%pi*Rl*(Cs+Cl));
// after putting value of Rl ,Cs and Cl we get
fa = 1/(2*3.14*264.55*1*10^-12);
disp('The pole frequency fa is = '+string(fa
    *10^-3/1000)+' M Hz '); // Round Off Error

```

```

//fb = 1/(2*%pi*Ce*((rbb*rbe)/(rbb+rbe)));
// after putting value of Ce rbb and rbe we get
fb = 1/(2*%pi*6.05*10^-12*24.5);
disp('The pole frequency fb is = '+string(fb*10^-3/1000)+' M Hz ');

fc = 1/(2*%pi*Cs*re3);
disp('The pole frequency fc is = '+string(fc*10^-3/1000)+' M Hz ');

disp(' Hence fa is a dominant pole frequency ');
```

Scilab code Exa 14.11 Design a video amplifier of IC 1550 circuit

```
// Example14.11  // Design a video amplifier of IC 1550 circuit
clc;
clear;
close;
Vcc = 12 ; // V
Av = -10 ;
Vagc = 0 ; // at bandwidth of 20 MHz
hfe = 50 ; // forward emitter parameter
rbb = 25 ;  // ohm  // base resistor
Cs = 1*10^-12 ;  // F  // source capacitor
Cl = 1*10^-12 ;  // F  // load capacitor
Ie1 = 1*10^-3 ; // A // emitter current of Q1
f = 1000*10^6 ; // Hz
Vt = 52*10^-3 ;
Vt1 = 0.026 ;

// When Vagc =0 the transistor Q2 is cut-off and the collector current of transistor Q2 flow through the transistor Q3
```

```
// i.e Ic1=Ie1=Ie3
Ie3 = 1*10^-3 ; // A // emitter current of Q3
Ic1 = 1*10^-3 ;  // A  // collector current of the
    transistor Q1

// it indicates that the emitter current of Q2 is
    zero Ie2 = 0 then the emitter resistor of Q2 is
    infinite
re2 = %inf ;

// emitter resistor of Q3
re3 = (Vt/Ie1);
disp('The emitter resistor of Q3 is = '+string(re3)+
    ' ohm ');

// the trans conductance of transistor is
gm = (Ie1/Vt1);
disp('The trans conductance of transistor is = '+
    string(gm)+' A/V ');

// the base emitter resistor rbe
rbe = (hfe/gm);
disp('The base emitter resistor rbe is = '+string(
    rbe)+' ohm ');

// the emitter capacitor Ce
Ce = (gm/(2*%pi*f));
disp('The emitter capacitor is = '+string(Ce)+' F ')
    ;

// the voltage gain of video amplifier is
// Av = (Vo/Vin) ;
// Av = -((alpha3*gm)/(rbb*re3)*((1/rbb)+(1/rbe)+sCe
    )*((1/re2)+(1/re3)+sC3)*((1/Rl)+(s(Cs+Cl))))
 // At Avgc = 0 i.e s=0 in the above Av equation
alpha3 = 1 ;
s = 0 ;
Av =-10 ;
```

```
Rl = -((alpha3*gm)/((rbb*re3)*(((1/rbb)+(1/rbe))*((1/re2)+(1/re3))*(Av))));
Rl = (1/Rl);
disp('The value of resistance RL is = '+string(Rl)+' ohm ');

// there are three poles present in the transfer function of video amplifier each pole generate one 3-db frequency
Rl = 265
fa = 1/(2*%pi*Rl*(Cs));
disp('The pole frequency fa is = '+string(fa)+' Hz ');


fb = 1/(2*%pi*Ce*((rbb*rbe)/(rbb+rbe)));
disp('The pole frequency fb is = '+string(fb)+' Hz ');

fc = 1/(2*%pi*Cs*re3);
disp('The pole frequency fc is = '+string(fc)+' Hz ');

disp(' Hence fa is a dominant pole frequency ');
```

Scilab code Exa 14.12 Determine the output voltage of an isolation amplifier IC ISO100

```
// Example14.12  // Determine the output voltage of an isolation amplifier IC ISO100
clc;
clear;
close;
Vin = 5 ; // V
Rin = 10*10^3 ;
```

```
Rf = 55*10^3 ; // ohm // feedback resistance

// the input voltage of an amplifier 1
// Vin = Rin*Iin
Iin = Vin/Rin ;
disp('The input current is = '+string(Iin)+' A ');

// In isolation amplifier ISO 100 the input current
   Iin is equal to the output current Iout , but
   both are opposite in direction
// Iin = -Iout
// the output of an op-amp
// Vo = -Rf*Iout
Vo = Rf*Iin;
disp('The output of an op-amp is = '+string(Vo)+' V
   ');
```

Scilab code Exa 14.13 Determine the output voltage of an isolation amplifier IC ISO100

```
// Example14.13  // Determine the output voltage of
   an isolation amplifier IC ISO100
clc;
clear;
close;
Vin = 12 ; // V
Rin = 1*10^3 ;
Rf = 17*10^3 ; // ohm // feedback resistance

// the input voltage of an amplifier 1
// Vin = Rin*Iin
Iin = Vin/Rin ;
disp('The input current is = '+string(Iin)+' A ');

// In isolation amplifier ISO 100 the input current
```

```
   Iin is equal to the output current Iout , but
   both are opposite in direction
// Iin = -Iout
// the output of an op-amp
// Vo = -Rf*Iout
Vo = Rf*Iin;
disp('The output of an op-amp is = '+string(Vo)+' V
   ');
```