

Scilab Textbook Companion for
Linear Integrated Circuit
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October 14, 2014

¹Funded 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.

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Chapter 3

Current or Voltage Sources and Differential Amplifier

Scilab code Exa 3.1 Determine the collector current I_{c1} and collector emitter voltage V_{ce1} for the difference amplifier circuit

```
1 //Example 3.1 // Determine the collector current
   Ic1 and collector-emitter voltage Vce1 for the
   difference amplifier circuit
2 clc;
3 clear;
4 close;
5 V1 = 0 ; // volt
6 V2 = -5 ; //volt
7 Vcm = 5 ; //volt
8 Vcc = 10; //volt
9 Vee = -10 ; //volt
10 Ie = 1 ; //mA
11 Rc = 10 ; //kilo ohm
12
13 // Transistor parameters
14 // base current are negligible
15 Vbe = 0.7 ; // volt
16
```

```

17 // The collector current of difference amplifier is
18 Ic1 = Ie/2 ;
19 disp(' The collector current of difference
    amplifier Ic1 = Ic2 = '+string(Ic1)+' mA ');
20
21 // The collector voltages of transistors Q1 and Q2
    are expressed as
22
23 Vc1 = Vcc-Ic1*Rc ;
24 disp(' The collector voltages of transistors Q1 and
    Q2 are Vc1 = Vc2 = '+string(Vc1)+' volt ');
25
26 // We know common mode voltage (Vcm) , from this the
    emitter voltage can be identified as follows
27 // For the common mode voltage Vcm = 0 V , the
    emitter voltage is Ve = -0.7 V
28 // For the common mode voltage Vcm = 5 V , the
    emitter voltage is Ve = 4.3 V
29 // For the common mode voltage Vcm = -5 V , the
    emitter voltage is Ve = -5.7 V
30
31 // For the different emitter voltages the collector-
    emitter voltage can be calculated as
32
33 Ve = -0.7 ; // volt
34 Vce1 = Vc1-Ve;
35 disp('For Ve = -0.7 Volt the collector - emitter
    voltage Vce1 = ' +string(Vce1)+' Volt ');
36
37 Ve = 4.3 ; // volt
38 Vce1 = Vc1-Ve;
39 disp('For Ve = 4.3 Volt the collector - emitter
    voltage Vce1 = ' +string(Vce1)+' Volt ');
40
41 Ve = -5.7 ; // volt
42 Vce1 = Vc1-Ve;
43 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

```
1 //Example3.2 // To determine the difference-mode and
   common-mode gain of the difference amplifier
2 clc;
3 clear;
4 close;
5 Vcc = 10 ; // volt
6 Vee = -10 ; //voltage
7 Iq = 0.8 ; //mA
8 Ie = 0.8 ; //mA
9 Rc = 12 ; //kilo-Ohm
10 Vt = 0.026 ; // volt
11
12 // Transistor parameter
13 beta = 100 ;
14 Rs = 0 ; //Ohm
15 Ro = 25 ; //kilo-Ohm
16 // The differential mode gain Ad
17 gm = (Ie/ 2*Vt) ;
18 // Ad = (gm*r*Rc/r+Rc) ; // where r is r-pi
19 // For Rb=0 , the differential mode gain is
20
21 Ad = (Ie/(2*Vt))*Rc;
22 //But
23 disp(' The differential mode gain Ad = ' +string(Ad)
   + ' ');
24
25 //The common mode gain Acm
26 // Acm = - (gm*Rc/1+2*gm*Re+2*Re/r)
27 Acm = -(Ad/(1+(((1+beta)*Ie*Ro)/(beta*Vt))));
28 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

```
1 //Example 3.3 // To find the output of a difference
    amplifier when only common mode signal is applied
2 clc;
3 clear;
4 close;
5 // V1 = V2 = Vcm = 200*sin(wt) ; // micro volt (uV
    )
6 Acm = -0.237 ;
7
8 // When the common mode input signal is applied to
    the difference amplifier , the difference mode
    gain is zero
9 Vcm = 200 ;
10 Vo = Acm*Vcm ;
11 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

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

```

7 Iq = 0.8 ; //mA
8 Ie = 0.8 ; //mA
9 Rc = 12 ; //kilo-Ohm
10 Vt = 0.026 ; // volt
11
12 // Transistor parameter
13 beta = 100 ;
14 Rs = 0 ; //Ohm
15 Ro = 25 ; //kilo-Ohm
16
17 // The differential mode gain Ad
18 gm = (Ie/ 2*Vt) ;
19 // Ad = (gm*r*Rc/r+Rc) ; // where r is r-pi
20 // For Rb=0 , the differential mode gain is
21
22 Ad = (Ie/(2*Vt))*Rc;
23 //But
24 disp(' The differential mode gain Ad = ' +string(Ad)
      + ' ');
25
26 //The common mode gain Acm
27 // Acm = - (gm*Rc/1+2*gm*Re+2*Re/r)
28 Acm = -(Ad/(1+(((1+beta)*Ie*Ro)/(beta*Vt)))));
29 disp(' The common mode gain Acm = ' +string(Acm)+ '
      ' );
30
31 // The CMRR of difference amplifier is given as
32 Ad = Ad/2 ;
33 CMRR = abs(Ad/Acm);
34 disp(' The CMRR of difference amplifier is = ' +
      string(CMRR)+ ' ');
35
36 // In decibel it can be expressed as
37 CMRRdb = 20*log10(CMRR);
38 disp(' In decibel CMRR is = ' +string(CMRRdb)+ '
      ');

```

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

```
1 //Example3.5 // To determine emitter resistance of
  the difference amplifier
2 clc;
3 clear;
4 close;
5 Vcc = 10 ; // volt
6 Vee = -10 ; //volt
7 Iq = 0.8 ; //mA
8 Ie = 0.8 ; //mA
9 CMRRdb = 90 ; //dB
10 Vt = 0.026 ;
11
12 // Transistor parameter
13 beta = 100 ;
14
15 // CMRR = abs(Ad/Acm);
16 // the CMRR of the difference amplifier is defined
  as
17 //CMRR = ((1/2)*(1+((1+beta)*Ie*Re)/beta*Vt))
18
19 // CMRRdb = 20*log10(CMRR)
20 CMRR = 10^(CMRRdb/20);
21 disp(' The CMRR of difference amplifier is = ' +
  string(CMRR)+ ' ');
22
23 // The resistance RE is calculated as
24
25 RE = (((2*CMRR)-1)/((1+beta)*Ie))*(beta*Vt)
26 disp(' The value of resistance RE is = ' +string(RE)
  + ' K ohm ');
```

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

```
1 //Example3.6 // determine the differential mode
   gain when load resistance  $R_L = 100$  k ohm
2 clc;
3 clear;
4 close;
5  $R_L = 100 \times 10^3$  ; // k ohm // load resistance
6  $I_E = 0.20 \times 10^{-3}$  ; // mA // biasing current
7  $V_A = 100$  ; // V // early voltage
8  $V_T = 0.026$  ; // threshold volt
9
10 // the differential gain of differential amplifier
   with an active load circuit
11 //  $A_d = V_o/V_d = g_m(ro_2 || ro_4 || R_L)$ 
12  $ro_2 = (2 \times V_A)/I_E$ ;
13  $ro_4 = ro_2$  ;
14  $g_m = I_E/(2 \times V_T)$  ;
15
16  $A_d = g_m/((1/ro_2)+(1/ro_4)+(1/R_L))$ ;
17 disp(' The differential mode gain  $A_d$  is = ' +string(
    $A_d$ ) + ' ');
```

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

```
1 //Example 4.1 // For an op-amp circuit find a)
   closed loop gain Acl b) input impedance Zin c)
   output impedance Zo
2 clc ;
3 clear ;
4 close ;
5 ro = 85 ; // ohm
6 A = 150*10^3 ; // ohm
7 R2 = 350*10^3 ; // ohm // Feedback resistance
8 R1 = 10*10^3 ; // ohm // Input resistance
9
10 // a) closed loop gain
11 // ACL = abs(Vo/Vin) = abs(R2/R1)
12 ACL = abs(R2/R1) ;
13 disp(' closed loop gain of an op-amp is = '+string(
   ACL)+' '); // 1/beta = ACL
14 beta = (1/ACL) ;
15
16 // b) the input impedance Zin
17 Zin = R1 ;
```

```

18 disp(' the input impedance Zin = '+string(Zin)+'
    ohm ');
19
20 // c0 the output impedance Z0
21 Z0 = (ro)/(1+(beta*A));
22 disp(' the output impedance Z0 = '+string(Z0)+' ohm
    ');

```

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

```

1 //Example 4.2 // Determine the difference voltage and
    open loop gain of an op-amp
2 clc ;
3 clear ;
4 close ;
5 V1 = -5 ; // volt // input voltage
6 V2 = 5 ; // volt
7 Vo = 20 ; //volt // output voltage
8
9 // the difference voltage is given by
10 Vd = V2-V1 ;
11 disp(' The difference voltage is = '+string(Vd)+' V
    ');
12
13 // open loop gain
14 A = (Vo/Vd);
15 disp(' The open loop gain is = '+string(A)+' ');

```

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

```

1 //Example 4.3 // Determine the difference voltage and
   open loop gain of an op-amp
2 clc ;
3 clear ;
4 close ;
5 V1 = -5 ; // volt // input voltage
6 V2 = 0 ; // volt // GND
7 Vo = 20 ; //volt // output voltage
8
9 // the difference voltage is given by
10 Vd = V2-V1 ;
11 disp(' The difference voltage is = '+string(Vd)+' V
   ');
12
13 // open loop gain
14 A = (Vo/Vd);
15 disp(' The open loop gain is = '+string(A)+' ');

```

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

```

1 //Example 4.4 // Determine the difference voltage and
   open loop gain of an op-amp
2 clc ;
3 clear ;
4 close ;
5 V1 = 0 ; // volt // input voltage // GND
6 V2 = 5 ; // volt
7 Vo = 20 ; //volt // output voltage
8
9 // the difference voltage is given by
10 Vd = V2-V1 ;
11 disp(' The difference voltage is = '+string(Vd)+' V
   ');
12

```

```

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

```

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

```

1 //Example 4.5 // Determine the difference voltage and
  open loop gain of an op-amp
2 clc ;
3 clear ;
4 close ;
5 V1 = 5 ; // volt // input voltage // GND
6 V2 = -5 ; // volt
7 Vo = -20 ; //volt // output voltage
8
9 // the difference voltage is given by
10 Vd = V2-V1 ;
11 disp(' The difference voltage is = '+string(Vd)+' V
  ');
12
13 // open loop gain
14 A = (Vo/Vd);
15 disp(' The open loop gain is = '+string(A)+' ');

```

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

```

1 //Example4.6 // To find closed loop gain and output
  voltage  $V_o$  of an inverting op-amp
2 clc;
3 clear;
4 close;

```

```

5 R1 = 10 ; //kilo ohm // input resistance
6 R2 = 25 ; // kilo ohm // feedback resistance
7 Vin = 10 ; //volt // input voltage
8
9 // Closed loop gain of an inverting op-amp
10 Ac = -(R2/R1) ;
11 disp('The Closed loop gain of an inverting op-amp is
      = '+string(Ac)+' ');
12 Ac = abs(Ac);
13 disp('The |Ac| Closed loop gain of an inverting op-
      amp is = '+string(Ac)+' ');
14
15 // the output voltage of an inverting op-amp
16 Vo = -(R2/R1)*Vin ;
17 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 V_o of an non inverting op amp

```

1 //Example4.7 // To find closed loop gain and output
  voltage  $V_o$  of an non-inverting op-amp
2 clc;
3 clear;
4 close;
5 R1 = 10 ; //kilo ohm // input resistance
6 R2 = 25 ; // kilo ohm // feedback resistance
7 Vin = 10 ; //volt // input voltage
8
9 // Closed loop gain of an non-inverting op-amp
10 Ac = 1+(R2/R1) ;
11 Ac = abs(Ac);
12 disp('The Closed loop gain of an non-inverting op-
      amp is = '+string(Ac)+' ');
13

```

```

14 // the output voltage of an inverting op-amp
15 Vo = (1+R2/R1)*Vin ;
16 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

```

1 //Example4.8 // to find out closed loop gain and
  output voltage Vo
2 clc;
3 clear;
4 close;
5 R1 = 10 ; //kilo ohm // input resistance
6 R3 = 10 ; //kilo ohm // input resistance
7 R2 = 25 ; // kilo ohm // feedback resistance
8 R4 = 25 ; // kilo ohm // feedback resistance
9 Vin2 = 10 ; //volt // input voltage
10 Vin1 = -10 ; //volt // input voltage
11
12 // closed loop gain of differntial op-amp is given
  by
13 Ac = (R2/R1) ;
14 Ac = abs(Ac);
15 disp('The closed loop gain of differntial op-amp is
      = '+string(Ac)+' ');
16
17 // the output voltage of an non-inverting op-amp is
  given by
18 Vo = (R2/R1)*(Vin2-Vin1) ;
19 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


```
1 // Example4.9 // Determine the non-inverting input
  voltage
2 clc;
3 clear;
4 close;
5 R1 = 10 ; //kilo ohm // input resistance
6 R2 = 25 ; //kilo ohm // feedback resistance
7 Voh = 10 ; // volt //output voltage
8 Vol = -10 ; // volt // output voltage
9
10 // upper voltage
11 V = (R1/(R1+R2)*Voh) ;
12 disp(' The upper voltage is = '+string(V)+' V ');
13
14 // Lower voltage
15 V = (R1/(R1+R2)*Vol) ;
16 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

```
1 //Example5.1 // find the total offset voltage of
  feedback op-amp
2 clc;
3 clear;
4 close;
5 Vos = 4 ; //mV // input offset volt
6 Ios = 150*10^-3 ; // input offset current
7 R1 = 5 ; //kilo ohm // input resistance
8 R2 = 500 ; //kilo ohm // feedback resistance
9
10 // the output voltage (Vo) of an op-amp circuit due
  to input offset voltage (Vos) is
11 Vo1 = ((R1+R2)/(R1)*Vos) ;
12 disp(' the output voltage (Vo) of an op-amp circuit
  due to input offset voltage (Vos) is = '+string(
  Vo1)+' mV ');
13
14 // the output voltage (Vo) of an op-amp circuit due
  to input offset current (Ios) is
```

```

15 Vo2 = R2*Ios ;
16 disp(' the output voltage (Vo) of an op-amp circuit
    due to input offset current (Ios) is = '+string(
    Vo2)+' mV ');
17
18 // the total offset voltage is
19 Vo = Vo1+Vo2 ;
20 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

```

1 //Example5.2 // find the total offset voltage of
    feedback op-amp
2 clc;
3 clear;
4 close;
5 Vos = 2 ; //mV // input offset volt
6 Ios = 20*10^-3 ; // input offset current
7 R1 = 10 ; //kilo ohm // input resistance
8 R2 = 250 ; //kilo ohm // feedback resistance
9
10 // the output voltage (Vo) of an op-amp circuit due
    to input offset voltage (Vos) is
11 Vo1 = ((R1+R2)/(R1)*Vos) ;
12 disp(' the output voltage (Vo) of an op-amp circuit
    due to input offset voltage (Vos) is = '+string(
    Vo1)+' mV ');
13
14 // the output voltage (Vo) of an op-amp circuit due
    to input offset current (Ios) is
15 Vo2 = R2*Ios ;
16 disp(' the output voltage (Vo) of an op-amp circuit
    due to input offset current (Ios) is = '+string(
    Vo2)+' mV ');

```

```

17
18 // the total offset voltage is
19 Vo = Vo1+Vo2 ;
20 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

```

1 //Example5.3 // find the input offset voltage of an
  op-amp circuit
2 clc;
3 clear;
4 close;
5 Vo = 90.2 ; //mV // output voltage
6 R1 = 2 ; //kilo ohm // input resistance
7 R2 = 150 ; //kilo ohm // feedback resistance
8
9 // the input offset voltage (Vos) of an op-amp
  circuit is defined as
10 Vos = ((R1)/(R1+R2)*Vo) ;
11 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

```

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

```

```

8
9 // the output voltage due to the input offset
  voltage of the op-amp circuit is defined by
10 Vo1 = ((R1+R2)/(R1)*Vos) ;
11 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

```

1 //Example5.5 // Determine the bias current effect
  with and without current compensation method
2 clc;
3 clear;
4 close;
5 R1 = 10 ; //kilo ohm
6 R2 = 100 ; //kilo ohm
7 Ib1 = 1.1*10^-3 ;
8 Ib2 = 1*10^-3 ;
9 // the output voltage of the circuit due to bias
  current is
10 Vo = Ib1*R2 ;
11 disp('the output voltage of the circuit due to bias
  current is = '+string(Vo)+' V ');
12
13 //Bias compensated resistor is given by
14 R3 = (R1*R2)/(R1+R2) ;
15 disp('Bias compensated resistor is = '+string(R3)+'
  kilo ohm ');
16
17 //Bias compensated output voltage is given by
18 Vo = R2*(Ib1-Ib2);
19 disp('Bias compensated output voltage is = '+string(
  Vo)+' V ');

```

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

```
1 //Example5.6 // find the input offset current of an
  op-amp circuit
2 clc;
3 clear;
4 close;
5 Vo = 12*10^-3; // V // output voltage
6 R1 = 2*10^3 ; // ohm // input resistance
7 R2 = 150*10^3; // ohm // feedback resistance
8
9 // the output voltage (Vo) of an op-amp circuit due
  to input offset current (Ios) is
10 // Vo = R2*Ios ;
11 Ios = Vo/R2;
12 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

```
1 //Example5.7 // Determine the bias current of
  inverting and non-inverting
2 clc;
3 clear;
4 close;
5 Ios = 5 ; //nA // input offset current
6 Ib = 30 ; //nA // input bias current
7
8 // the input bias current of an op-amp is
9
```

```

10 //Ib =(Ib1+Ib2)/(2);
11
12 // the offset current Ios is define as
13
14 //Ios = abs(Ib1-Ib2) ;
15
16 Ib1=Ib-(Ios/2);
17 disp('The current in the inverting input terminal is
      = '+string(Ib1)+' nA ');
18
19 Ib2 =Ib+(Ios/2);
20 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

```

1 //Example5.8 //determine the feedback transfer
  function of an op-amp for the following condition
2 clc;
3 clear;
4 close;
5 // a) When open loop gain of 10^5 and the closed
  loop gain of 100
6 A = 10^5 ; // open loop gain
7 Af = 100 ; //closed loop gain
8 // Feedback transfer function is
9 beta =(1/Af)-(1/A);
10 disp('Feedback transfer function is = '+string(beta)
      +''');
11 beta = 1/beta ;
12 disp('OR 1/Beta is = '+string(beta)+'');
13
14 // For an open loop gain of -10^5 and closed loop
  gain of -100

```

```

15 A = -10^5 ; // open loop gain
16 Af = -100 ; //closed loop gain
17 // Feedback transfer function is
18 beta =(1/Af)-(1/A);
19 disp('Feedback transfer function is = '+string(beta)
      +'');
20 beta = 1/beta ;
21 disp('OR 1/Beta is = '+string(beta)+'');

```

Scilab code Exa 5.9 to determine open loop gain

```

1 //Example5.9 //to determine open loop gain
2 clc;
3 clear;
4 close;
5 beta = 0.0120 ; // Feedback transfer function
6 Af = 80 ; //closed loop gain
7 A = (Af)/(1-beta*Af) ;
8 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

```

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

```



```

9
10 // close loop gain
11 dAf = ((dA)/(1+dA*beta));
12 disp('close loop gain dAf is = '+string(dAf)+'');
13
14 // the percent change of closed loop gain
15 %dAf = (((Af-dAf)/(Af))*100);
16 disp('the percent change of closed loop gain dAf is
      = '+string(%dAf)+'%');

```

Scilab code Exa 5.11 To Determine the bandwidth of feedback amplifier

```

1 //Example5.11 // To Determine the bandwidth of
  feedback amplifier
2 clc;
3 clear;
4 close;
5 A = 10^4 ; // open loop gain
6 Af = 50 ; // close loop gain
7 wH = 628 ; //(2*%pi*100) // rad/sec // open loop
  bandwidth
8
9 // close loop gain of an op-amp is defined as
10 // Af = ((A)/(1+A*beta));
11
12 // the feedback transfer function is given as
13 beta = (1/Af)-(1/A) ;
14 disp('the feedback transfer function beta is = '+
      string(beta)+'');
15
16 // closed loop bandwidth
17 wfH = wH*(1+beta*A);
18 disp('the closed loop bandwidth wfH is = '+string(
      wfH)+'');

```

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

```
1 //Example5.12 // To calculate unity gain bandwidth
   and maximum close loop gain
2 clc;
3 clear;
4 close;
5 A = 10^5 ; // open loop gain
6 fo = 10 ; // Hz // dominant pole frequency
7 fdb = 20*10^3 ; //Hz // 3-db frequency
8
9 // the unity gain bandwidth
10 f1 = fo*A ;
11 disp('the unity gain bandwidth is = '+string(f1)+'
   Hz');
12
13 // the maximum close loop gain
14 ACL = (f1/fdb) ;
15 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

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

```

7 fdb = 12*10^3 ; //Hz // 3-db frequency
8
9 // the unity gain bandwidth
10 f1 = fo*A ;
11 disp('the unity gain bandwidth is = '+string(f1)+'
      Hz');
12
13 // the maximum close loop gain
14 ACL = (f1/fdb) ;
15 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

```

1 //Example5.14 // To determine the dominant pole
  frequency of an op-amp
2 clc;
3 clear;
4 close;
5 Ao = 2*10^5 ; // low frequency open loop gain
6 f = 5*10^6 ; // Hz // pole frequency
7 ACL = 100 ; // low frequency closed lkoop gain
8 p_margin = 80 ;
9
10 // the dominant pole frequency of an op-amp
11 fPD = (ACL)*(f/Ao);
12 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

```

1 //Example5.15 // Determine the loop gain of
   compensated network
2 clc;
3 clear;
4 close;
5
6 C = 0.0025*10^-6 ; // farad
7 R = 10*10^3 ; // ohm
8 F = 1*10^6 ; // Hz
9 Ac1 = 100 ;
10 angle1 = 90 ;
11
12 // the close loop gain of a compensated network is
   defined as
13 // Ac = Ac1*Acom ;
14
15 //Acom = 1/(1+%(F/FL));
16
17 FL = 1/(2*3.14*R*C);
18 disp('FL = '+string(FL/1000)+' KHz '); // Round
   Off Error
19
20 // Acom = 1/(1+%j(F/FL));
21 // After putting value of F ,FL we get
22
23 // Acom = 1/(1+%j(158.7)); // 1+%j(158.7)
   Rectangular Form where real part is 1 and
   imaginary part is 158.7
24
25 // After converting rectangular form into polar
   from we get
26
27 disp('Acom = [ magnitude = 6.3*10^-3 angle =
   -89.6 degree ]');
28
29 // Ac = Ac1*Acom ; equation 1
30
31 // after putting Ac1 and Acom value in equation 1

```

```

    we get   Acl = 100  angle 90   and Acom = 6.3*10^-3
            angle = -89.6
32
33 disp('Ac = [ magnitude = 0.68   angle = 0.4 degree
            ] ');

```

Scilab code Exa 5.16 Determine the loop gain of compensated network

```

1 //Example5.16 // Determine the loop gain of
  compensated network
2 clc;
3 clear;
4 close;
5
6 C = 0.01*10^-6 ; // farad
7 R = 15*10^3 ; // ohm
8 F = 1*10^6 ; // Hz
9
10 // the close loop gain of a compensated network is
   defined as
11 // Ac = Acl*Acom ;
12
13 //Acom = 1/(1+%(F/FL));
14
15 FL = 1/(2*3.14*R*C);
16 disp('FL = '+string(FL/1000)+' KHz '); // Round
   Off Error
17
18 // Acom = 1/(1+%j(F/FL));
19 // After putting value of F ,FL we get
20
21 // Acom = 1/(1+%j(0.9)); // 1+%j(0.9)
   Rectangular Form where real part is 1 and
   imaginary part is 0.9
22

```

```

23 // After converting rectangular from into polar
    from we get
24
25 disp('Acom = [ magnitude = 0.68    angle = -47.7
    degree ]');

```

Scilab code Exa 5.17 Determine the loop gain of compensated network

```

1 //Example5.17 // Determine the loop gain of
    compensated network
2 clc;
3 clear;
4 close;
5
6 C = 0.5*10^-6 ; // farad
7 R = 75 ; // ohm
8 F = 1*10^6 ; // Hz
9 Ac1 = 150 ;
10 angle1 = 85 ;
11
12 // the close loop gain of a compensated network is
    defined as
13 // Ac = Acl*Acom ;
14
15 //Acom = 1/(1+%(F/FL));
16
17 FL = 1/(2*3.14*R*C);
18 disp('FL = '+string(FL/1000)+' KHz '); // Round
    Off Error
19
20 // Acom = 1/(1+%j(F/FL));
21
22 // After putting value of FL we get
23
24 // Acom = 1/(1+%j(F/4.24*10^3)); equation 1

```

```

25
26 // As F is unknown in above equation 1
27 // by putting different value of F we get Acom for
    different frequency
28
29
30 // If F = 0 KHz
31
32 // Acom = 1/(1+%j(0/4.24*10^3));
33
34 // After solving and converting rectangular from
    into polar from we get
35
36 disp('Acom for F = 0 KHz = [ magnitude = 150
    angle = 85 degree ]');
37
38
39 // If F = 2 KHz
40
41 // Acom = 1/(1+%j(2*10^3/4.24*10^3));
42
43 // After solving and converting rectangular from
    into polar from we get
44
45 disp('Acom for F = 2 KHz= [ magnitude = 136.4
    angle = 64.5 degree ]');
46
47
48 // If F = 4 KHz
49
50 // Acom = 1/(1+%j(4*10^3/4.24*10^3));
51
52 // After solving and converting rectangular from
    into polar from we get
53
54 disp('Acom for F = 4 KHz = [ magnitude = 107.14
    angle = 41.7 degree ]');
55

```

```

56
57 // If F = 6 KHz
58
59 // Acom = 1/(1+%j(6*10^3/4.24*10^3));
60
61 // After solving and converting rectangular from
    into polar from we get
62
63 disp('Acom for F = 6 KHz = [ magnitude = 88.24
    angle = 30.25 degree ]');
64
65
66
67 // If F = 8 KHz
68
69 // Acom = 1/(1+%j(8*10^3/4.24*10^3));
70
71 // After solving and converting rectangular from
    into polar from we get
72
73 disp('Acom for F = 8 KHz = [ magnitude = 71.4
    angle = 23 degree ]');
74
75
76
77 // If F = 10 KHz
78
79 // Acom = 1/(1+%j(10*10^3/4.24*10^3));
80
81 // After solving and converting rectangular from
    into polar from we get
82
83 disp('Acom for F = 10 KHz = [ magnitude = 58.59
    angle = 18 degree ]');
84
85
86
87 // If F = 20 KHz

```



```

88
89 // Acom = 1/(1+%j(20*10^3/4.24*10^3));
90
91 // After solving and converting rectangular from
    into polar from we get
92
93 disp('Acom for F = 20 KHz = [ magnitude = 31.12
    angle = 7 degree ]');
94
95
96
97 // If F = 40 KHz
98
99 // Acom = 1/(1+%j(40*10^3/4.24*10^3));
100
101 // After solving and converting rectangular from
    into polar from we get
102
103 disp('Acom for F = 40 KHz = [ magnitude = 15.9
    angle = 1.1 degree ]');
104
105
106
107
108
109 // If F = 80 KHz
110
111 // Acom = 1/(1+%j(80*10^3/4.24*10^3));
112
113 // After solving and converting rectangular from
    into polar from we get
114
115 disp('Acom for F = 80 KHz = [ magnitude = 7.9
    angle = -2 degree ]');
116
117
118
119

```

```

120 // If F = 100 KHz
121
122 // Acom = 1/(1+%j(100*10^3/4.24*10^3));
123
124 // After solving and converting rectangular from
    into polar from we get
125
126 disp('Acom for F = 100 KHz = [ magnitude = 6.4
    angle = -2.6 degree ]');
127
128
129
130
131 // If F = 200 KHz
132
133 // Acom = 1/(1+%j(200*10^3/4.24*10^3));
134
135 // After solving and converting rectangular from
    into polar from we get
136
137 disp('Acom for F = 200 KHz = [ magnitude = 3.18
    angle = -3.8 degree ]');
138
139
140
141 // If F = 400 KHz
142
143 // Acom = 1/(1+%j(400*10^3/4.24*10^3));
144
145 // After solving and converting rectangular from
    into polar from we get
146
147 disp('Acom for F = 400 KHz = [ magnitude = 1.59
    angle = -4.4 degree ]');
148
149
150 // If F = 800 KHz
151

```

```

152 // Acom = 1/(1+%j(800*10^3/4.24*10^3));
153
154 // After solving and converting rectangular from
    into polar from we get
155
156 disp('Acom for F = 800 KHz = [ magnitude = 0.79
    angle = -4.7 degree ]');
157
158
159 // If F = 1 MHz
160
161 // Acom = 1/(1+%j(1*10^6/4.24*10^3));
162
163 // After solving and converting rectangular from
    into polar from we get
164
165 disp('Acom for F = 1 MHz = [ magnitude = 0.64
    angle = -4.7 degree ]');
166
167
168 // If F = 1.2 MHz
169
170 // Acom = 1/(1+%j(1.2*10^6/4.24*10^3));
171
172 // After solving and converting rectangular from
    into polar from we get
173
174 disp('Acom for F = 1.2 MHz = [ magnitude = 0.52
    angle = -4.7 degree ]');
175
176
177
178 // If F = 1.4 MHz
179
180 // Acom = 1/(1+%j(1.4*10^6/4.24*10^3));
181
182 // After solving and converting rectangular from
    into polar from we get

```

```

183
184 disp('Acom for F = 1.4 MHz = [ magnitude = 0.45
      angle = -4.7 degree ]');
185
186
187 // If F = 1.6 MHz
188
189 // Acom = 1/(1+%j(1.6*10^6/4.24*10^3));
190
191 // After solving and converting rectangular from
      into polar from we get
192
193 disp('Acom for F = 1.6 MHz = [ magnitude = 0.4
      angle = -4.7 degree ]');

```

Scilab code Exa 5.18 to design compensating network

```

1 //Example5.18 // to design compensating network
2 clc;
3 clear;
4 close;
5 fp = 500*10^3 ; // pole frequency
6 C = 0.02*10^-6 ; // F // we choose
7 // loop gain of compensated network
8
9 // ACom =(1)/(1+j(f/fp))
10 // fp = (1/2*pie*R*C)
11 R = (1/(2*3.14*C*fp));
12 disp('The compensating resistor value is = '+string(
      R)+' ohm ');

```

Scilab code Exa 5.19 Determine the loop gain of compensated network

```

1 //Example5.19 // Determine the loop gain of
   compensated network
2 clc ;
3 clear ;
4 close ;
5
6 C = 0.0025*10^-6 ; // farad
7 R1 = 10*10^3 ; // ohm
8 R2 = 20*10^3 ; // ohm
9 F = 1*10^6 ; // Hz
10 Ac1 = 100 ;
11 angle1 = 90 ;
12
13 // the close loop gain of a compensated network is
   defined as
14
15 // Ac = Ac1*Acom ;
16
17 //Acom = (1+% (F/FH))/(1+% (F/FL));
18
19 FH = 1/(2*3.14*R1*C);
20 disp('FH = '+string(FH/1000)+' KHz '); // Round
   Off Error
21
22
23 FL = 1/(2*3.14*(R1+R2)*C);
24 disp('FL = '+string(FL/1000)+' KHz '); // Round
   Off Error
25
26
27 //Acom = (1+% (F/FH))/(1+% (F/FL));
28
29 // After putting value of FH ,FL we get
30
31 // Acom = (1+%j(158.7))/(1+%j(471.7))
32
33 // After converting rectangular from into polar
   from we get

```

```

34
35 disp('Acom = [ magnitude = 0.34    angle = -0.24
           degree ]');
36
37 //   Ac = Ac1*Acom ;           equation 1
38
39 // after putting Ac1 and Acom value in equation 1
   we get   Ac1 = 100 angle 90   and Acom = 0.34
           angle = -0.24
40
41 disp('Ac = [ magnitude = 34    angle = 89.76 degree ]
           ');

```

Scilab code Exa 5.20 Determine the loop gain of compensated network

```

1
2 //Example5.20 // Determine the loop gain of
   compensated network
3 clc ;
4 clear ;
5 close ;
6
7 C = 0.01*10^-6 ; // farad
8 R1 = 10*10^3 ; // ohm
9 R2 = 15*10^3 ; // ohm
10 F = 1*10^6 ; // Hz
11
12
13 // the close loop gain of a compensated network is
   defined as
14
15 //Acom = (1+%(F/FH))/(1+%(F/FL));
16
17 FH = 1/(2*3.14*R1*C);
18 disp('FH = '+string(FH/1000)+' KHz '); // Round

```

```

    Off Error
19
20
21 FL = 1/(2*3.14*(R1+R2)*C);
22 disp('FL = '+string(FL/1000)+' KHz '); // Round
    Off Error
23
24
25 //Acom = (1+%(F/FH))/(1+%(F/FL));
26
27 // After putting value of FH ,FL we get
28
29 // Acom = (1+%j(658.9))/(1+%j(1.56*10^3))
30
31 // After converting rectangular from into polar
    from we get
32
33 disp('Acom = [magnitude = 0.4] ');

```

Scilab code Exa 5.21 to design compensating network

```

1 //Example5.21 // to design compensating network
2 clc;
3 clear;
4 close;
5 fH = 10 ; //k ohm // break frequency initiated by a
    zero
6 fL = 1 ; //k ohm // break frequency initiated by a
    pole
7 C = 0.02; // uF // we choose
8 // loop gain of compensated network
9
10 // ACom =(1+j ( f/fH ))/(1+j ( f/fL ))
11 // fH = (1/2*pie*R1*C)
12 // fL = (1/2*pie*(R1+R2)*C)

```

```

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

```

Scilab code Exa 5.22 To determine input output miller capacitances

```

1 //Example5.22 // To determine input output miller
  capacitances
2 clc;
3 clear;
4 close;
5 A = 100 ; //gain
6 Cm = 0.1 ; // uF // compensated capacitor
7
8 // the input output miller capacitance are defined
  as
9 Cin = Cm*(A+1);
10 disp('The input miller capacitance Cin value is = '+
      string(Cin)+'uF ');
11 Cout = (Cm*((A+1)/A));
12 disp('The output miller capacitance Cout value is =
      '+string(Cout)+'uF ');

```

Scilab code Exa 5.23 To determine input output miller capacitances

```

1 //Example5.23 // To determine input output miller
  capacitances
2 clc;
3 clear;
4 close;

```



```

5 A = 150 ; //gain
6 Cm = 0.02 ; // uF // compensated capacitor
7
8 // the input output miller capacitance are defined
  as
9 Cin = Cm*(A+1);
10 disp('The input miller capacitance Cin value is = '+
      string(Cin)+'uF ');
11 Cout = (Cm*((A+1)/A));
12 disp('The output miller capacitance Cout value is =
      '+string(Cout)+'uF ');
13
14 // In the miller compensating network input
    capacitance introduce a pole . The initiated
    frequency of miller compensating network by pole
    is define as
15
16 // fp = 1/(2*%pi*R*Cin);
17 R = 1 ; // K ohm
18 fp = 1/(2*%pi*R*Cout);
19 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

```

1 //Example5.24 // To determine the slew rate of an
  op-amp
2 clc;
3 clear;
4 close;
5 f = 1 ; // MHz // unity frequency
6 Ic = 1*10^-6 ; // uA // capacitor current
7 Vt = 0.7 ; // V // threshold voltage
8
9 // the slew rate of an op-amp is defined as

```

```

10 // Slew rate = (dVo/dt)
11 Slewrate = 8*3.14*Vt*f ;
12 disp('the slew rate of an op-amp is = '+string(
    Slewrate)+' V/u sec ');
13
14 // The compensated capacitance Cm is
15 gm = (Ic/Vt);
16 Cm = (gm/4*3.14*f) ;
17 disp('The compensated capacitance value is = '+
    string(Cm)+'F ');

```

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

```

1 //Example5.25 // To determine the cut off frequency
    of an op-amp
2 clc;
3 clear;
4 close;
5 f = 1*10^3 ; // Hz // unity frequency
6 Av = 200 ; // V/mV // dc gain
7
8 // the unity gain frequency of an op-amp is defined
    as
9 // f = Av*fc ;
10
11 // cut off frequency
12 fc = (f/Av);
13 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

```

1
2 //Example5.26 // To find the maximum frequency of
   input signal in op-amp circuit
3 clc;
4 clear;
5 close;
6 Vin = 25*10^-3 ; // V // input voltage
7 Slewrate = 0.8/10^-6 ; // V/uV // Slew rate of an
   op-amp
8 R2 = 350*10^3 ; // ohm // feedback resistance
9 R1 = 10*10^3 ; // ohm // input resistance
10
11 // the closed loop gain
12 // ACL = (mod (Vo/Vin)) = (mod(R2/R1));
13 ACL = abs(R2/R1);
14 disp('the closed loop gain ACL is = '+string(ACL)+'
   ');
15
16 // the output gain factor K is given as
17 K = ACL*Vin ;
18 disp('The output gain factor K is = '+string(K)+' V'
   ');
19
20 // the maximum frequency of an op-amp is
21 wmax = (Slewrate/K);
22 fmax = wmax/(2*3.14);
23 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

```

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

```

```

4 close;
5 Vin = 0.015 ; // V // input voltage
6 Slewrate = 0.8 ; // V/uV // Slew rate of an op-
  amp
7 R2 = 120*10^3 ; // ohm // feedback resistance
8 R1 = 5*10^3 ; // ohm // input resistance
9
10 // the closed loop gain
11 // ACL = (mod (Vo/Vin)) = (mod(R2/R1));
12 ACL = abs(R2/R1);
13 disp('the closed loop gain ACL is = '+string(ACL)+'
  ');
14
15 // the output gain factor K is given as
16 K = ACL*Vin ;
17 disp('The output gain factor K is = '+string(K)+' V'
  ');
18
19 // the maximum frequency of an op-amp is
20 wmax = (Slewrate/K);
21 disp('The wmax is = '+string(wmax)+'*10^6 rad/sec');
  // *10^6 because Slewrate is V/uV
22
23 // 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

```

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

```

```

6 Ic = 1*10^-3 ; // mA // capacitor current
7 Vt = 0.7 ; // V // threshold voltage
8
9 // the slew rate of an op-amp is defined as
10 // Slew rate = (dVo/dt)
11 // the unity frequency f is
12 f =(Slewrates/(8*3.14*Vt));
13 f = f*10^6; // *10^6 because Slew rate is V/uV
14 disp('the unity frequency f is = '+string(f)+' Hz ')
    ;
15
16 // The compensated capacitance Cm is
17 gm = (Ic/Vt);
18 Cm = (gm)/(4*3.14*f) ;
19 disp('The compensated capacitance Cm value is = '+
    string(Cm)+' F ');

```

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

```

1 //Example5.29 // To find Slew rate of an op-amp
2 clc;
3 clear;
4 close;
5 Iq = 15 ; // uA // bias current
6 Cm = 30 ; // pF // internal frequency compensated
    capacitor
7 Slewrates = (Iq/Cm);
8 disp('the Slew rate of an op-amp is = '+string(
    Slewrates)+' V/u sec ');

```

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

```

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

```

```

2  clc;
3  clear;
4  close;
5  Iq = 21 ; // uA // bias current
6  Cm = 31 ; // pF // internal frequency compensated
   capacitor
7  Slewrate = (Iq/Cm);
8  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

```

1  //Example5.31 // To determine full power and small
   signal bandwidth of an op-amp with unity gain
2  clc;
3  clear;
4  close;
5  f = 100*10^6 ; // Hz unity gain bandwidth
6  ACL = 10^4 ; // maximum closed loop gain
7  Slewrate = 0.51 ; // V/u sec
8  Vp = 10 ; // V peak volt
9
10 // The full power bandwidth
11 FPBW = (Slewrate/(2*3.14*Vp));
12 FPBW = FPBW*10^6 ; // *10^6 because Slew rate is V/
   uV
13 disp('The full power bandwidth FPBW is = '+string(
   FPBW)+' Hz ');
14
15 // the 3-db frequency or small signal band width
16 f3db = (f/ACL);
17 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

```
1 //Example5.32 // To determine full power and small
    signal bandwidth of an op-amp with unity gain
2 clc;
3 clear;
4 close;
5 f = 100*10^6 ; // Hz unity gain bandwidth
6 ACL = 10^4 ; // maximum closed loop gain
7 Slewrate = 0.51 ; // V/u sec
8 Vp = 10 ; // V peak volt
9
10 // The full power bandwidth
11 FPBW = (Slewrate/(2*3.14*Vp));
12 FPBW = FPBW*10^6 ; // *10^6 because Slew rate is V/
    uV
13 disp('The full power bandwidth FPBW is = '+string(
    FPBW)+' Hz ');
14
15 // the 3-dB frequency or small signal band width
16 f3db = (f/ACL);
17 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

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

```

5 fu = 1*10^6 ; // Hz // unity gain bandwidth
6 fmax = 5*10^3 ; // KHz // full power bandwidth
7 F3db = 12*10^3 ; // Hz // small signal bandwidth
8 Vp = 10 ; // V // peak volt
9
10 // the full power bandwidth of an op-amp
11 // fmax=FPBW = (Slew rate/2*3.14*Vp);
12 Slewrate = 2*3.14*Vp*fmax;
13 Slewrate = Slewrate*(10^-6); // *10^-6 because
    Slewrate is V/u
14 disp('the Slew rate of an op-amp is = '+string(
    Slewrate)+' V/u sec ');
15
16 // // the 3-db frequency or small signal band width
17 //f3db = (f/ACL);
18 //the closed loop gain ACL
19 ACL = fu/F3db ;
20 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

```
1 //Example6.1 // design an inverting amplifier with
   a closed loop voltage gain of  $A_v = -5$ 
2 clc;
3 clear;
4 close;
5  $A_v = -5$  ;
6  $I_s = 5 \times 10^{-6}$  ; // A
7  $R_s = 1 \times 10^3$  ; // ohm
8 // input voltage source  $V_s = \sin \omega t$  volts
9
10 // in an inverting amplifier frequency effect is
   neglected then i/p volt  $V_{in} = 1$  V and total
   resistance equal to  $R_s + R_1$ 
11
12 // the input current can be written as  $I_{in} = I_s$ 
13 //  $I_s = (V_{in} / (R_s + R_1))$ ;
14  $I_{in} = I_s$ ;
15  $V_{in} = 1$  ; // V
```

```

16 R1 = (1-(Iin*Rs))/Iin ;
17 disp('the value of resistance R1 is = '+string(R1)+'
      ohm');
18
19 // closed loop voltage gain of an inverting
      amplifier
20 //Av = -(R2/Rs+R1)
21 R2 = -(Av*(Rs+R1));
22 disp('the value of resistance R2 is = '+string(R2)+'
      ohm');

```

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

```

1 //Example6.2 // design an inverting amplifier with
      a closed loop voltage gain of Av = 10
2 clc;
3 clear;
4 close;
5 Av = 10 ;
6 Vin = 0.8 ; //V
7 Iin = 100*10^-6 ; // A
8 // in an non- inverting amplifier the input voltage
      Vin=V1=V2 because of vortual short effect then
      the i/p current In = Vin/R1
9 R1 = Vin/Iin;
10 disp('the value of resistance R1 is = '+string(R1)+'
      ohm');
11
12 // closed loop voltage gain of an non-inverting
      amplifier
13 //Av = Vo/Vin = (1+R2/R1)
14 R2 = (Av-1)*R1;
15 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

```
1 //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
2 clc;
3 clear;
4 close;
5 R1 = 8*10^3 ; // ohm
6 R2 = 72*10^3 ; // ohm
7 Iin = 50*10^-6 ; // A
8 Vo = 5 ; // V
9
10 // closed loop gain
11 //Av = Vo/Vin = (1+R2/R1)
12 Av = 1+(R2/R1);
13 // but
14 Av = 5 ;
15 // then
16 // (R2/R1) = 4 ;
17
18 // the output voltage of the amplifier is Vo = 5 V
19 //i.e
20 Vin = 1 ; // V
21 // Iin = Vin/R1 ;
22 R1 = Vin/Iin ;
23 disp('the value of resistance R1 is = '+string(R1)+
   ' ohm');
24
25 R2 = 4*R1 ;
26 disp('the value of resistance R2 is = '+string(R2)+
   ' ohm');
27
```

```

28 // the output current I2 is given as
29 I2 = (Vo-Vin)/R2 ;
30 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

```

1 // Example6.4 // Design a op-amp circuit to
  // provide the output voltage  $V_o = -2(3 V_1 + 4 V_2 + 2 V_3)$ 
2 clc;
3 clear;
4 close;
5 //  $V_o = -2(3 V_1 + 4 V_2 + 2 V_3)$ ; equation 1
6 // the output of the summer circuit is given as
7 //  $V_o = -R_2((V_{ia}/R_{ia})+(V_{ib}/R_{ib})+(V_{ic}/R_{ic}))$ 
  // equation 2
8
9 // compare equation 1 and 2 of  $V_o$  we get
10
11 //  $(R_2/R_{ia})= 6$  ;
12 //  $(R_2/R_{ib})=8$  ;
13 //  $(R_2/R_{ic})=4$  ;
14
15 R2 = 120*10^3 ; // we choose then
16
17 Ria = R2/6 ;
18 disp('the value of resistance Ria is = '+string(Ria
    )+' ohm');
19
20 Rib = R2/8 ;
21 disp('the value of resistance Rib is = '+string(Rib
    )+' ohm');
22

```

```

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

```

Scilab code Exa 6.5 Design a summing amplifier circuit

```

1 // Example6.5 // Design a summing amplifier
  circuit to provide the output voltage  $V_o = -(7$ 
     $V_{11} + 15 V_{12} + 10 V_{13} + 3 V_{14})$ 
2 clc;
3 clear;
4 close;
5 R2 = 630*10^3 ; // Assume feedback resistance
6 //  $V_o = -(7 V_{11} + 15 V_{12} + 10 V_{13} + 3 V_{14})$ ;
    equation 1
7 // the output of the summer circuit is given as
8 //  $V_o = -R_2((V_{1a}/R_{1a})+(V_{1b}/R_{1b})+(V_{1c}/R_{1c})+(V_{1d}/R_{1d}))$ 
    equation 2
9
10 // compare equation 1 and 2 of  $V_o$  we get
11
12 //  $(R_2/R_{1a})= 7$  ;
13 //  $(R_2/R_{1b})= 15$  ;
14 //  $(R_2/R_{1c})= 10$  ;
15 //  $(R_2/R_{1d})= 3$  ;
16
17 R1a = R2/7 ;
18 disp('the value of resistance R1a is = '+string(R1a
    )+' ohm');
19
20 R1b = R2/15 ;
21 disp('the value of resistance R1b is = '+string(R1b
    )+' ohm');
22
23 Ric = R2/10 ;

```

```

24 disp('the value of resistance Ric is = '+string(Ric
      )+' ohm');
25
26 Rid = R2/3 ;
27 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

```

1 // Example6.6 // Design a op-amp circuit to
  // provide the output voltage  $V_o = V_2 - 3 V_1$  with
  //  $R_{i1} = R_{i2} = 100 \times 10^3$ 
2 clc;
3 clear;
4 close;
5 Ri1 = 100*10^3 ; // ohm
6 Ri2 = 100*10^3 ; // ohm
7 // the i/p resistance
8 R1 = Ri1 ;
9 R3 = Ri2 ;
10
11 //  $V_o = V_2 - 3 V_1$ ;
                                     equation 1
12 // the output of the summer circuit is given as
13 //  $V_o = [(R_4/(R_3+R_4))*(1+(R_2/R_1))*V_{i2} - (R_2/R_1)*V_{i1}]$ 
                                     equation 2
14
15 // compare equation 1 and 2 of  $V_o$  we get
16 //  $(R_4/(R_3+R_4))*(1+(R_2/R_1)) = 1$  ;
                                     equation 3
17 //  $R_2/R_1 = 3$  ;
                                     equation 4
18

```

```

19 // by substituting the value of R1 and R3 in equation
    3 and 4
20
21 // from equation 4
22 R2 = 3*R1 ;
23 disp('the value of resistance R2 is = '+string(R2)+
    ' ohm');
24
25 // from equation 3
26 R4 = (100*10^3)/3 ;
27 disp('the value of resistance R4 is = '+string(R4)+
    ' ohm');

```

Scilab code Exa 6.7 determine the load current and output voltage

```

1 //Example6.7 // determine the load current and
    output voltage
2 clc;
3 clear;
4 close;
5 Vin = -5 ; // V
6 ZL = 200 ; // ohm
7 R1 = 10*10^3 ; // ohm
8 R2 = 10*10^3 ; // ohm
9 R3 = 1*10^3 ; // ohm
10 R4 = 1*10^3 ; // ohm
11
12 // the load c/n of the given voltage to c/n
    converter circuit is given by
13 iL = -Vin/(R1*R4)*R2 ;
14 disp('The load current iL is = '+string(iL)+' A');
15
16 // the voltage across the load
17 VL = iL*ZL;
18 disp('The voltage across load VL is = '+string(VL)+

```

```

    ' V');
19
20 // the non-inverting current across i3 and i4 are
21 i3 = VL/R3 ;
22 disp('The non-inverting current across i3 is = '+
    string(i3)+' A');
23
24 i4 = iL+i3 ;
25 disp('The non-inverting current across i4 is = '+
    string(i4)+' A');
26
27 // the output voltage of given voltage to current
    converter is given by
28 Vo = (iL*R3)+VL ;
29 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

```

1 // Example6.8 // determine the common mode
    rejection ratio CMRR
2 clc;
3 clear;
4 close;
5 // R2/R1 = 10 ;
6 // R4/R3 = 11 ;
7
8 // the output of the difference amplifier is given
    by
9 //  $V_o = (((R4)/(R3+R4))*(((1+(R2/R1))*V_{I2})) - ((R2/R1)
    *V_{I1}))$ ;
10
11 // putting R1 R2 R3 R4 value in above equation we
    get Vo as
12

```



```

13 //  $V_o = (121/12)*V_{I2} - 10V_{I1}$  ;
                                                    equation 1
14
15 // the differential mode input of difference
    amplifier is given by
16 //  $V_d = V_{I2} - V_{I1}$  ;
    equation 2
17
18 // the common mode input of difference amplifier is
    given by
19 //  $V_{CM} = (V_{I2} + V_{I1})/2$  ;
                                                    equation
    3
20
21 // from equation 2 and 3
22
23 //  $V_{I1} = V_{CM} - V_d/2$  ;
                                                    equation
    4
24
25 //  $V_{I2} = V_{CM} + V_d/2$  ;
                                                    equation
    5
26
27 // substitute equation 4 and 5 in 1 we get
28 //  $V_o = (V_{CM}/12) + (241V_d/24)$  ;
                                                    equation6
29
30 //  $V_d = A_d * V_d + A_{CM} * V_{CM}$  ;
                                                    equation 7
31
32 //equation from equation 6 and 7 we get
33
34  $A_d = 241/24$  ;
35  $A_{CM} = 1/12$  ;
36
37 // the common mode rejection ratio CMRR is

```

```

38 CMRR = abs(Ad/ACM);
39 disp('The common mode rejection ratio CMRR is = '+
      string(CMRR)+' ');
40
41 // in decibal it can be expressed as
42
43 CMRR = 20*log10(CMRR);
44 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

```

1 // Example6.9 // determine Vo when 1) VI1 = 2 V VI2
  = -2 V and 2) VI1 = 2 V VI2 = 2 V
2 // and common
  mode rejection ratio CMRR
3 clc;
4 clear;
5 close;
6 R1 = 10*10^3 ; // ohm
7 R2 = 20*10^3 ; // ohm
8 R3 = 10*10^3 ; // ohm
9 R4 = 22*10^3 ; // ohm
10
11
12 // the output of the difference amplifier is given
  by
13 // 
$$V_o = \left( \frac{R_4}{R_3+R_4} \right) * \left( \left( 1 + \frac{R_2}{R_1} \right) * V_{I2} \right) - \left( \frac{R_2}{R_1} \right) * V_{I1}$$
;
14
15 // Case 1 when VI1 = 2 V VI2 = -2 V
16 VI1 = 2 ;
17 VI2 = -2 ;
18

```

```

19 Vo = (((R4)/(R3+R4))*(((1+(R2/R1))*VI2))-((R2/R1)*
    VI1));
20 disp('The output of the difference amplifier is = '
    +string(Vo)+' V ');
21
22 // case 2 when VI1 = 2 V VI2 = 2 V
23 VI1 = 2 ;
24 VI2 = 2 ;
25
26 Vo = (((R4)/(R3+R4))*(((1+(R2/R1))*VI2))-((R2/R1)*
    VI1));
27 disp('The output of the difference amplifier is = '
    +string(Vo)+' V ');
28
29 // the common mode input of difference amplifier is
    given by
30 VCM = (VI2+VI1)/2 ;
31 disp('the common mode input of difference amplifier
    is = '+string(VCM)+' ');
32
33 // the common mode gain ACM of difference amplifier
    is given by
34 ACM = Vo/VCM
35 disp('the common mode gain ACM of difference
    amplifier is = '+string(ACM)+' ');
36
37 // the differential gain of the difference amplifier
    is given
38 Ad = R2/R1 ;
39 disp('the differential gain of the difference
    amplifier is = '+string(Ad)+' ');
40
41 // the common mode rejection ratio CMRR is
42 CMRR = abs(Ad/ACM);
43 disp('The common mode rejection ratio CMRR is = '+
    string(CMRR)+' ');
44
45 // in decibal it can be expressed as

```

```

46 CMRR = 20*log10(CMRR);
47 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

```

1 //Example6.10 // To determine the range of the
  differential voltage gain
2 clc;
3 clear;
4 close;
5 //R1 = 1 K ohm to 25 K ohm ;
6 R2 = 50 ; // K ohm
7 R3 = 10 ; // K ohm
8 R4 = 10 ; // K ohm
9
10 // the output of instrumentation amplifier is given
  by
11 //Vo = (R4/R3)*(1+(2*R2/R1))*(VI@-VI1);
12
13 // the differential voltage gain of the
  instrumentation amplifier can be written as
14 //Av = (Vo/(VI2-VI1)) = (R4/R3)*(1+(2R2/R1));
15
16 // For R1 = 1 K ohm the maximum differential
  voltage gain of the instrumentation amplifier is
17 R1 = 1 ; // K ohm
18 Av = (R4/R3)*(1+(2*R2/R1));
19 disp('the maximum differential voltage gain of the
  instrumentation amplifier is = '+string(Av)+' ')
  ;
20
21 // For R1 = 25 K ohm the mminimum differential
  voltage gain of the instrumentation amplifier is

```

```

22 R1 = 25 ; // K ohm
23 Av = (R4/R3)*(1+(2*R2/R1));
24 disp('the minimum differential voltage gain of the
        instrumentation amplifier is = '+string(Av)+ ' ')
        ;
25
26 disp(' the range of the differential voltage gain of
        the instrumentation amplifier is ');
27 disp('                    5 <= Av <= 101 ');

```

Scilab code Exa 6.11 To design an instrumentation amplifier

```

1 //Example6.11 // To design an instrumentation
  amplifier
2 clc;
3 clear;
4 close;
5 // 4 <= Av <= 1000 ; gain
6 Ad = 2 ;
7 Res = 100 ; // K ohm
8
9 // we consider the variable resistance is R1 , the
  maximum and the minimum range of variable
  resistance
10 // R1min = R1 ;
11 // R1max = R1+100 ;
12
13 // the gain of difference amplifier
14 //A3 = Ad = Vo/(Vo2-Vo1) = (R4/R3)
15
16 // the maximum range of differential voltage gain
  Avmax = 1000 when R1min = R1
17 //Avmax = R4/R3*(1+(2*R2/R1min));
18
19 // by solvin we get following equation

```

```

20 // 499*R1-2*R2=0                                equation 1
21
22 // the maximum range of differential voltage gain
    Avmin =4 when R1max = R1+100 K ohm
23 // Avmin = (R4/R3)*(1+(2R2/R1max));
24
25 // by solving above equation we get
26 // R1 -2 R2 = -200 K ohm                        equation 2
27
28 //by solving equation 1 and 2 we get
29 R1 = 401 ; // ohm
30 R2 = 100.2 ; // ohm
31 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

```

1 //Example6.12 // Determine the time constant of the
    integrator
2 clc;
3 clear;
4 close;
5 Vo = 10 ;
6 t = 2*10^-3 ;
7 VI = -1 ; // at t =0 ;
8
9 // The output voltage of an integrator is define as
10 RC = t/10 ;
11 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

```

1 //Example6.13 // Determine the time constant of the
   integrator
2 clc;
3 clear;
4 close;
5 Vo = 20 ;
6 t = 1*10^-3 ;
7 VI = -1 ; // at t =0 ;
8
9 // The output voltage of an integrator is define as
10 RC = t/10 ;
11 disp(' The time constant of the given filter is RC =
      '+string(RC)+ ' sec ');
12
13 R = 1*10^3 ; // we assume
14 C = RC/R ;
15 disp('The capacitor value is = '+string(C)+ ' F');

```

Scilab code Exa 6.14 to design a summing amplifier

```

1 //Example6.14 // to design a summing amplifier
2 clc;
3 clear;
4 close;
5
6 // the output of the summing amplifier is given by
7 //Vo = -R2*(( VIa/RIa)+(VIb/RIb)+(VIc/RIc)+(VID/RIId))
   ;    equation 1
8
9 // the equation given is
10 //Vo = -(3*VIa+12*VIb+15*VIc+18*VID);
   equation 2
11
12 // comparing equation 1 and 2
13 //R2/RIa = 3 ;

```

```

14 //R2/RIb = 12 ;
15 //R2/RIc = 15 ;
16 //R2/RIId = 18 ;
17
18 // the feedback resistance R2= 270 K ohm
19 R2 = 270 ; // K ohm
20 RIa = R2/3 ;
21 disp('The value of resistance RIa is = '+string(RIa)
      + ' K ohm ');
22
23 RIb = R2/12 ;
24 disp('The value of resistance RIb is = '+string(RIb)
      + ' K ohm ');
25
26 RIc = R2/15 ;
27 disp('The value of resistance RIc is = '+string(RIc)
      + ' K ohm ');
28
29 RIId = R2/18 ;
30 disp('The value of resistance RIId is = '+string(RIId)
      + ' K ohm ');

```

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

```

1 //Example6.15 // for the instrumentation amplifier
  find Vo1 , Vo2 , Vo
2 clc;
3 clear;
4 close;
5 // Vi1 = -25 sin wt ; // mV
6 // Vi2 = 25 sin wt ; // mV
7 R1 = 10*10^3 ;
8 R2 = 20*10^3 ;
9 R3 = 20*10^3 ;
10 R4 = 10*10^3 ;

```



```

11
12 // the output of first op-amp A1 is given by
13 //  $V_{o1} = (1+(R_2/R_1))*V_{i1}-(R_2/R_1)*V_{i2}$  ;
14 //by solving above equation we get
15 disp('The output of first op-amp A1 is = -275*sin wt
      mV ');
16
17 // the output of second op-amp A2 is given by
18 //  $V_{o2} = (1+(R_2/R_1))*V_{i2}-(R_2/R_1)*V_{i1}$  ;
19 //by solving above equation we get
20 disp('The output of second op-amp A2 is = 275*sin wt
      mV ');
21
22 // the output of third op-amp A3 is given by
23 //  $V_o = (R_4/R_3)-(1+(2R_2/R_1))*(V_{i2}-V_{i1})$  ;
24 //by solving above equation we get
25 disp('The output of third op-amp A3 is = 825*sin wt
      mV ');
26
27 // current through the resistor R1 and R2 is
28 //  $i = (V_{i1}-V_{i2})/R_1$  ;
29 disp('current through the resistor R1 and R2 is = 5
      sin wt uA ');
30
31 // current through the non-inverting terminal
      resistor R3 and R4
32 //  $i_3 = V_{o2}/(R_3+R_4)$ ;
33 disp('current through the non-inverting terminal
      resistor R3 and R4 = 5.5 sin wt uA ');
34
35 // current through the inverting terminal resistor
      R3 and R4
36 //  $i_2 = V_{o1}-(R_3/(R_3+R_4))*V_{o2}/R_3$  ;
37 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

```
1 //Example6.16 // for the a current to voltage
   converter show a)  $R_{in} = (R_f/1+A_{op})$  b)  $R_f = 10\text{ K}$ 
   ohm  $A_{op} = 1000$ 
2 clc;
3 clear;
4 close;
5
6 //a) The input resistance given as
7 // $R_{in} = (R_f)/(1+A_{op})$  ;
8
9 // The input resistance of the circuit can be
   written as
10 // $R_{in} = (V_1/i_1)$  ;
11
12 // the feedback current of the given circuit is
   defined as
13 // $i_1 = (V_1 - V_o)/R_f$  ;
14
15 // the feedback resistance  $R_f$  is
16 // $R_f = (V_1 - V_o)/i_1$  ;
17
18 // The output voltage  $V_o$  is
19 // $V_o = -A_{op} * V_1$  ;
20
21 //by using this output feedback currenty  $i_1$  can be
   reformed as
22 // $i_1 = (V_1 - (-A_{op} * V_1))/R_f$  ;
23
24 // $i_1 = V_1 * (1 + A_{op})/R_f$  ;
25
26 // Then  $R_{in}$  Becomes
27 // $R_{in} = R_f / (1 + A_{op})$  ;
```

```

28
29 Rf =10*103 ;
30 Aop = 1000 ;
31
32 // the input current and output voltage of the
   circuit are defined as
33 //i1 =(Rs)/(Rs+Rin) ;
34 // Vo = -(Aop*(RF/1+Aop))*i1 ;
35
36 //the input resistance Rin is
37 Rin =(Rf/(1+Aop)) ;
38
39 // subsituting the value of RF Aop Rin and Vo we get
40 RF = 10 ;
41 Rin = RF/(1+Aop)
42 disp('The input resistance Rin is = '+string(Rin)+ '
   ohm ');
43
44 Aop = 1000 ;
45 //(1000/1001)*(Rs/(Rs*0.00999))> 0.99 ;
46 // by solving above equation we get
47 Rs = 1.099 ; // K ohm
48 disp(' The value of Resistance Rs is = '+string(Rs)+
   ' K ohm ');

```

Scilab code Exa 6.17 determine the closed loop gain

```

1 //Example6.17 // determine the closed loop gain
2 clc;
3 clear;
4 close;
5
6 // the output of the voltage follower is given as
7 //Vo = Aop(V1-Vo);
8

```

```

 9 // the closed loop gain of the voltage follower
10 //A = 1/(1+(1/Aop));
11
12 // for Aop = 10^4 closed loop gain
13 Aop = 10^4 ;
14 A = 1/(1+(1/Aop));
15 disp('for Aop = 10^4 closed loop gain is = '+string(
    A)+ ' ');
16
17 // for Aop = 10^3 closed loop gain
18 Aop = 10^3 ;
19 A = 1/(1+(1/Aop));
20 disp('for Aop = 10^3 closed loop gain is = '+string(
    A)+ ' ');
21
22 // for Aop = 10^2 closed loop gain
23 Aop = 10^2 ;
24 A = 1/(1+(1/Aop));
25 disp('for Aop = 10^2 closed loop gain is = '+string(
    A)+ ' ');
26
27 // for Aop = 10^1 closed loop gain
28 Aop = 10^1 ;
29 A = 1/(1+(1/Aop));
30 disp('for Aop = 10^1 closed loop gain is = '+string(
    A)+ ' ');

```

Scilab code Exa 6.18 To determine the output voltage of integrator

```

1 //Example6.18 // To determine the output voltage of
  integrator
2 clc;
3 clear;
4 close;
5 Vin = 1 ;

```

```

6 R = 150*10^3 ;// ohm
7 C = 1*10^-9 ; // F
8
9 // the output voltage of an integrator is given as
10 //Vo = (fc/f)*Vin ;
11
12 //fc = 1/(2*%pi*R*C);
13
14 //Vo = (1/(2*%pi*R*C*f))*Vin;
15
16 //for the frequency f = 10 Hz the output is
17 f = 10 ; // Hz
18 Vo = (1/(2*%pi*R*C*f))*Vin;
19 disp('for the frequency f = 10 Hz the output is = '
      +string(Vo)+ ' V ');
20
21 //for the frequency f = 1000 Hz the output is
22 f = 1000 ; // Hz
23 Vo = (1/(2*%pi*R*C*f))*Vin;
24 disp('for the frequency f = 1000 Hz the output is =
      '+string(Vo)+ ' V ');
25
26 //for the frequency f = 10000 Hz the output is
27 f = 10000 ; // Hz
28 Vo = (1/(2*%pi*R*C*f))*Vin;
29 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

```

1 //Example6.19 // To determine the magnitude gain of
  the integrator
2 clc;
3 clear;
4 close;

```

```

5 Vin = 1 ;
6 f = 50*10^3 ;
7 Rf = 120*10^3 ;
8 R = 10*10^3 ;
9 C = 0.1*10^-9 ;
10
11 // the magnitude gain of the integrator is given by
12 //A = (Rf/R)/(sqrt(1+(f/fc)^2));
13
14 // the cutoff frequency of the integrator
15 fc = 1/(2*pi*Rf*C);
16 disp('The cutoff frequency of the integrator is = '+
      string(fc)+ ' Hz');
17
18
19 A = (Rf/R)/(sqrt(1+(f/fc)^2));
20 disp('The gain of the integrator is = '+string(A)+
      ');

```

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

```

1 //Example6.20 // To determine the magnitude gain of
  the differentiator
2 clc;
3 clear;
4 close;
5 Vin = 1 ;
6 f = 50*10^3 ;
7 R = 75*10^3 ;
8 R1 = 50*10^3 ;
9 C = 0.1*10^-9 ;
10
11 // the magnitude gain of the differentiator is given
  by

```

```

12 //A = (f/fa)/(sqrt(1+(f/fb)^2));
13
14 // the break frequency fa is defined as
15 fa = 1/(2*%pi*R1*C) ;
16 disp('the break frequency fa is = '+string(fa)+ ' Hz
      ');
17
18 // the break frequency fb is defined as
19 fb = 1/(2*%pi*R*C) ;
20 disp('the break frequency fb is = '+string(fb)+ ' Hz
      ');
21
22
23 A = (f/fa)/(sqrt(1+(f/fb)^2));
24 disp('The gain of the differentiator is = '+string(A
      )+ ' ');

```

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

```

1 // Example6.21 // to determine the input voltage of
  an op-amp
2 clc;
3 clear;
4 close;
5 Vo = 2 ; // V
6 R1 = 20*10^3 ; // ohm
7 R2 = 1*10^6 ; // ohm
8
9 // the input voltage of an op-amp
10 Vin = -(R1/R2)*Vo ;
11 disp('The input voltage of an op-amp is = '+string(
      Vin)+ ' V');

```

Scilab code Exa 6.22 To determine the output voltage

```
1 //Example6.22 // To determine the output voltage
2 clc;
3 clear;
4 close;
5 Vin = 2 ;
6 R2 = 20*10^3 ;
7 R1 = 2*10^3 ;
8
9 // the output voltage of follower Vo1 is
10 Vo1 = Vin ;
11 disp('the output voltage of follower Vo1 is = '+
      string(Vo1)+ ' V');
12 // the output voltage of an inverting amplifier
13 Vo = -(R2/R1)*Vo1 ;
14 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

```
1 // Example6.23 // to determine the output voltage
  of an op-amp
2 clc;
3 clear;
4 close;
5 Vin = 5 ; // V
6 R1 = 25*10^3 ; // ohm
7 R2 = 75*10^3 ; // ohm
8
9 // 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
10
```



```

11 // the output voltage of follower op-amp A1
12 Vo1 = Vin ;
13
14 // the output of the inverting amplifier A2
15 Vo2 = -((R2/R1)*Vo1) ;
16 disp('The output of the inverting amplifier is = '+
      string(Vo2)+ ' V');
17
18 // the output of the non-inverting amplifier A3
19 Vo = (1+(R2/R1))*Vo1 ;
20 disp('The output of the non-inverting amplifier is =
      '+string(Vo)+ ' V');

```

Scilab code Exa 6.24 To determine the output voltage

```

1 //Example6.24 // To determine the output voltage
2 clc;
3 clear;
4 close;
5 Vin = 2.5 ;
6 Rf = 100*10^3 ;
7 R1 = 10*10^3 ;
8 RI1 = 25*10^3 ;
9 RI2 = 10*10^3 ;
10 R2 = 100*10^3 ;
11
12 // the output voltage of an inverting amplifier
13 Vo1 = (1+(R2/R1))*Vin ; ;
14 disp('The output voltage of an inverting amplifier
      is = '+string(Vo1)+ ' V ');
15
16 // the output voltage of follower Vo2 is
17 Vo2 = Vin ;
18 disp('the output voltage of follower Vo1 is = '+
      string(Vo2)+ ' V');

```

```

19
20 // the output of the inverting summing amplifier
21 R2 = 75*10^3 ;
22 Vo = R2*((Vo1/RI1)+(Vo2/RI2));
23 disp('the output of the inverting summing amplifier
      is = '+string(Vo)+ ' V ');

```

Scilab code Exa 6.25 To calculate the output voltage

```

1 //Example6.25 // To calculate the output voltage
2 clc;
3 clear;
4 close;
5 Vin = 2.5 ;
6 R1 = 10*10^3 ;
7 R2 = 10*10^3 ;
8 R3 = 10*10^3 ;
9 Rf = 30*10^3 ;
10
11 // the total gain of the circuit
12 //Av =A1v*A2v*A3v ;
13 Av = (1+(Rf/R1))*(-Rf/R2)*(-Rf/R3);
14 disp('the total gain of the circuit is = '+string(Av
      )+ ' ');
15
16 // The output voltage of the op-amp
17 Vo = Av*Vin ;
18 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

1

```

2 //Example6.26 // to calculate the output voltage of
   op-amp circuit
3 clc;
4 clear;
5 close;
6 Rf = 100*10^3 ; // ohm
7 R1 = 10*10^3 ; // ohm
8 R2 = 25*10^3 ; // ohm
9 R3 = 50*10^3 ; // ohm
10
11 // the output of op-amp A1 is
12 //  $VA1 = (-Rf/R1)*V1$  ;
13 VA1 = (-Rf/R1);
14 disp('The output of op-amp A1 is = '+string(VA1)+'V1
   '); // *V1 because the output is come from
   1 op-amp
15
16 // the output of op-amp A2 is
17 //  $Vo = -Rf*((VA1/R2)+(V2/R3))$ ;
18 // $Vo = -100*(-0.4*V1+0.02V2)$ ;
19 disp('The output of op-amp A2 is Vo = 40V1 - 2V2 ');
   ;
20
21 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

```

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

```

```

6 R2 = 75*10^3 ; // ohm
7 VTH = 4 ; // V
8 VTL = -4 ; // V
9
10 // the upper crossover voltage of schmitt trigger is
    defined as
11 VU = (R1/(R1+R2))*VTH;
12 disp('the upper crossover voltage of schmitt trigger
    is = '+string(VU)+' V' );
13
14 // the lower crossover voltage of schmitt trigger is
    defined as
15 VL = (R1/(R1+R2))*VTL;
16 disp('the lower crossover voltage of schmitt trigger
    is = '+string(VL)+' V' );
17
18 // the hysteresis width of schmitt trigger is
19 HW = VU-VL ;
20 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

```

1 //Example6.28 // to determine the hysteresis width
    of a schmitt trigger
2 clc;
3 clear;
4 close;
5 R1 = 15*10^3 ; // ohm
6 R2 = 90*10^3 ; // ohm
7 VTH = 10 ; // V
8 VTL = -10 ; // V
9
10 // the upper crossover voltage of schmitt trigger is

```

```

        defined as
11 VU = (R1/(R1+R2))*VTH;
12 disp('the upper crossover voltage of schmitt trigger
        is = '+string(VU)+' V' );
13
14 // the lower crossover voltage of schmitt trigger is
        defined as
15 VL = (R1/(R1+R2))*VTL;
16 disp('the lower crossover voltage of schmitt trigger
        is = '+string(VL)+' V' );
17
18 // the hysteresis width of schmitt trigger is
19 HW = VU-VL ;
20 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

```

1 //Example6.29 // to determine the resistance R1
  when low and high saturated output states are
  given
2 clc;
3 clear;
4 close;
5 R2 = 20*10^3 ; // ohm
6 VH = 2 ; // V    crossover voltage
7 VL = -2 ; // V    crossover voltage
8 VOH = 10 ; // V   saturated output states
9 VOL = -10 ; // V   saturated output states
10
11 // the upper crossover voltage of schmitt trigger is
  defined as
12 //  $V = (R1/(R1+R2))*VOH$ ;
13 // solving above equation we get

```

```

14 // 2R1+2R2 = 10R1 ;
15 R1 = (2*R2)/8 ;
16 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

```

1 //Example6.30 // to determine the value of
  resistance R1 and R2 when low and high saturated
  output states are given
2 clc;
3 clear;
4 close;
5 VH = 3 ; // V      crossover voltage
6 VL = -3 ; // V      crossover voltage
7 VOH = 12 ; // V      saturated output states
8 VOL = -12 ; // V      saturated output states
9
10 // the upper crossover voltage of schmitt trigger is
   defined as
11 //  $V = (R1/(R1+R2))*VOH$ ;
12 // solving above equation we get
13 //  $3R1+3R2 = 12R1$  ;
14
15 //  $3*R1 = R2$  ;
16 R1 = 10*10^3 ; // ohm we assume
17 R2 = 3*R1 ;
18 disp('the value of resistance R2 is = '+string(R2)+'
      ohm' );

```

Scilab code Exa 6.31 Design an inverting amplifier

```

1 //Example6_31 // Design an inverting amplifier
2 clc;
3 clear;
4 close;
5 Av = -5 ;
6 //V1 = 0.1 sin wt ;
7 V1 = 0.1 ; // *sin wt ;
8 i = 5*10^-6 ;
9
10 // the input resistance
11 R1 = V1/i ;
12 disp('the input resistance is = '+string(R1)+ ' ohm'
      );
13
14 // The resistance R2
15 //Av = -(R2/R1);
16 R2 = -(Av*R1);
17 disp('The resistance R2 is = '+string(R2)+ ' ohm');

```

Scilab code Exa 6.32 Design an non inverting amplifier

```

1 //Example 6_32 // Design an non inverting amplifier
2 clc;
3 clear;
4 close;
5 Av = 5 ;
6 //V1 = 0.1 sin wt ;
7 V1 = 0.1 ;
8 i = -5*10^-6 ;
9
10 // the input resistance
11 R1 = -V1/i ;
12 disp('the input resistance is = '+string(R1)+ ' ohm'
      );
13

```

```

14 // The resistance R2
15 //Av = 1+(R2/R1);
16 R2 = (Av-1)*R1;
17 disp('The resistance R2 is = '+string(R2)+ ' ohm');

```

Scilab code Exa 6.33 To calculate phase shift between two extremes

```

1 //Example6_33 // To calculate phase shift between
  two extremes
2 clc;
3 clear;
4 close;
5 C = 0.22*10^-6 ;
6 R = 1*10^3 ;
7 f = 1*10^3 ;
8
9 // the cut off frequency of phase shifter
10 fc = 1/(2*pi*R*C) ;
11 disp('the cut off frequency of phase shifter is = '
      +string(fc)+ 'Hz');
12
13 // the phase shift
14 f = 1 ; // KHz
15 fc = 7.23 ; // KHz
16 PS = -2*atand(f/fc);
17 disp('The phase shift is = '+string(PS)+ ' ');

```

Scilab code Exa 6.34 To design a phase shifter

```

1 //Example6_34 // To design a phase shifter
2 clc;
3 clear;
4 close;

```



```

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

```

Scilab code Exa 6.35 Design a difference amplifier

```

1 //Example6_35 // Design a difference amplifier
2 clc;
3 clear;
4 close;
5 Ri = 50*10^3 ;
6 Ad = 30
7
8 R1 = Ri/2 ;
9 disp('The value of resistance R1 is = '+string(R1)+
      ' ohm');
10 R3 = R1 ;
11 disp('The value of resistance R3 is = '+string(R3)+
      ' ohm');
12
13 // the differential gain
14 //Ad = R2/R1 ;
15 R2 = 30*R1 ;
16 disp('The value of resistance R2 is = '+string(R2)+
      ' ohm');
17
18 R4 = R2 ;
19 disp('The value of resistance R4 is = '+string(R4)+
      ' ohm');

```

Scilab code Exa 6.36 Calculate CMRR ratio

```
1 //Example6_36 // Calculate CMRR ratio
2 clc;
3 clear;
4 close;
5 Ad = 10.24 ;
6 Acn = 0.48 ;
7
8 // the common mode rejection ratio CMRR is defined
   as
9 CMRRdB = 20*log10(Ad/Acn);
10 disp('The common mode rejection ratio is = '+string(
    CMRRdB)+ ' dB' );
```

Scilab code Exa 6.37 Design current to voltage converter

```
1 //Example6_37 // Design current to voltage
   converter
2 clc;
3 clear;
4 close;
5 Vo = -10 ;
6 is = 100*10^-6 ;
7
8 // the output voltage of current to voltage
   converter is defined as
9 //Vo = -Is*R2
10 R2 = -Vo/is ;
11 disp(' The feedback resistance is = '+string(R2)+ '
    ohm');
```

```

12
13 R1 = R2 ;
14 disp(' The value of resistance R1 is = '+string(R1)+
      ' ohm');

```

Scilab code Exa 6.38 Design high sensitivity current to voltage converter

```

1 //Example6_38 // Design high sensitivity current to
  voltage converter
2 clc;
3 clear;
4 close;
5 R1 = 5*10^3 ;
6 is = 1 ;
7 KR = 0.01/10^9 ; // V / nA
8
9 // the output voltage of high sensitivity current to
  voltage converter
10 Vo =-KR*is ;
11 KR = 10*10^6 ;
12 R = 1*10^6 ; //we assume then
13 K = 10 ;
14 //1 + (R2/R1)+(R2/R) = 10 ;
15 // solving above equation we get
16
17 R2 = 9*((5*10^6)/(10^3+5)) ;
18 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

```

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

```

```

2  clc;
3  clear;
4  close;
5  R1 = 10*10^3 ;
6  R2 = 10*10^3 ;
7  R3 = 1*10^3 ;
8  R4 = 1*10^3 ;
9  VI = -5 ;
10
11 // The Load Current
12 iL = -VI/R3 ;
13 disp('The load current iL is = '+string(iL)+ ' A');
14
15 VL = 0.5 ;
16 // The Current i3 and iA
17 i3 = VL/R3 ;
18 disp('The current i3 is = '+string(i3)+ ' A');
19
20 iA = i3+iL ;
21 disp('The current iA is = '+string(iA)+ ' A');
22
23 // the output voltage
24 Vo = (iA*R3)+VL ;
25 disp('The output voltage is = '+string(Vo)+ ' V');
26
27 ZL =100 ;
28 // The current i1 and i2
29 //i1 = (VI-iL*ZL)/R1 ;
30 i1 = (iL*ZL-Vo)/R2 ;
31 disp('The current i1 is = '+string(i1)+ ' A');
32
33 i2 = i1 ;
34 disp('The current i2 is = '+string(i2)+ ' A');

```

Scilab code Exa 6.40 Design an instrumentation amplifier

```

1 //Example6_40 // Design an instrumentation
  amplifier
2 clc;
3 clear;
4 close;
5 //A = 5 to 500 ; adjustable gain
6 VR = 100*103 ;
7
8 // the maximum differential gain of instrumentation
  amplifier is 500
9 //Amax = (R4/R3)*(1+(2R2/R1));
10 //by solving above equation we get following
  equation
11 // 2R2 -249R1f = 0

    equation 1
12
13 // the minimum differential gain of instrumentation
  amplifier is 5
14 // Amin = (R4/R3)*(1+(2R2/R1)) ;
15 //by solving above equation we get following
  equation
16 // 2R2 -1.5R1f = 150*103

    equation 2
17
18 //by solving equation 1 and 2 we get
19 disp('The value of resistance R1f is = 0.0606 K ohm
    ');
20
21 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

```

1 //Example6_41 // To find the value of resistance R1
   for instrumentation amplifier
2 clc;
3 clear;
4 close;
5 A =100 ;
6 R2 = 450*103 ;
7 R3 = 1*103 ;
8 R4 = 1*103 ;
9
10 // The gain of differential amplifier
11 // A = (R4/R3)*(1+(2R2/R1)) ;
12 //but R3 = R4 then
13 // A = 1+(2R2/R1) ;
14 R1 = 2*R2/(A-1);
15 disp('The value of resistane R1 is = '+string(R1)+ '
   ohm');

```

Scilab code Exa 6.42 determine the time constant of an integrator

```

1 //Example6_42 // determine the time constant of an
   integrator
2 clc;
3 clear;
4 close;
5 Vo = 10 ; // at t= 1 m sec
6 t = 1 ; // m sec
7
8 // the output of integrator
9 //Vo = t/RC ; when t is from 0 to 1
10 RC = t/Vo ;
11 disp(' At t = 1 msec the time constant RC is = '+
   string(RC)+ ' m sec');
12
13 disp (' if C = 0.01 uF then R of RC time constant is

```

```

    = 10 K ohm ');
14
15 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

```

1 //Example6_43 // Design an integrator circuit
2 clc;
3 clear;
4 close;
5 A = 10 ;
6 f =20*10^3 ;
7 R = 10*10^3 ; // we assume
8 Rf =10*R ;
9
10 disp(' The feedback resistance Rf is = '+string(Rf)+
    ' ohm');
11
12 // for proper integration f>= 10fa
13 fa = f/10 ;
14 disp('The frequency fa is = '+string(fa)+ ' Hz');
15
16 // in practical integrator
17 //fa = 1/(2*pi*Rf*C);
18
19 C = 1/(2*pi*Rf*fa);
20 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

```
1 //Example7.1 // Design active low filter with cut-
  off frequency 10 KHz
2 clc;
3 clear;
4 close;
5 fc = 10 ; // KHz
6 C = 0.01 ; //uF // we assume
7
8 // the cut-off frequency of active low pass filter
  is defined as
9 //  $fc = (1/2 * \pi * R3 * C)$ ;
10
11 // R3 can be calculated as
12 R3 = (1/(2 * pi * fc * C));
13 disp('The resistor value is = ' + string(R3) + ' k ohm '
  );
```

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


```

1 //Example7.2 // Design active low filter with cut-
  off frequency 15 KHz
2 clc;
3 clear;
4 close;
5 fc = 15*10^3 ; // Hz
6 C = 0.1*10^-6 ; //F // we assume
7
8 // the cut-off frequency of active low pass filter
  is defined as
9 //  $fc = (1/2*\%pi*R3*C)$ ;
10
11 // R3 can be calculated as
12 R3 = (1/(2*%pi*fc*C));
13 disp('The resistor value is = '+string(R3)+' ohm ');
14
15 // the pass band gain of filter is given by
16 //  $Af = 1+(R2/R1)$ ;
17 // assume that the inverting terminal resistor R2
  =0.5*R1;
18 // in Af equation if we put R2=0.5R1 in R1 R1
  cancellout each other
19 Af = 1+(0.5)
20 disp('The pass band gain is = '+string(Af)+' ');

```

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

```

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

```

```

8 C = 0.05 ; //nF // we assume
9
10 // the cut-off frequency of active low pass filter
    is defined as
11 //  $f_c = (1/2 * \pi * R3 * C)$ ;
12
13 // R3 can be calculated as
14 R3 = (1/(2 *  $\pi$  *  $f_c$  * C));
15 disp('The resistor value is = '+string(R3)+' ohm ');
16
17 // the pass band gain of filter is given by
18 //  $A_f = 1 + (R2/R1)$ ;
19 // assume that the inverting terminal resistor R1=
    100 k ohm;
20 R1 = 100 ; // k ohm
21 R2 = (Af*R1)-R1;
22 disp('The resistor R2 value is = '+string(R2)+' k
    ohm ');
23
24 // the magnitude of an active low pass filter is
    given as
25 A = Af/(sqrt(1+(f/fc)^2));
26 disp('The magnitude of an active low pass filter is
    = '+string(A)+' ');
27
28 //the phase angle of the filter
29 Angle = -atand(f/fc);
30 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

```

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

```

```

2  clc;
3  clear;
4  close;
5  R1 = 1 ; // k ohm
6  R2 = 12 ; // k ohm
7  R3 = 1.2 ; // k ohm
8  C = 0.05 ; //uF // we assume
9
10 // the frequency of the first order low pass filter
    is defined as
11 fc = (1/(2*%pi*R3*C));
12 disp('The frequency of the first order low pass
    filter is = '+string(fc)+' KHz ');
13
14 // the pass band gain of filter is given by
15 Af =(1+R2/R1);
16 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

```

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

```

```

12
13 // the voltage gain of the high pass filter is
14 //  $A_f = 1 + (R_2/R_1)$ ;
15 R2 = R1*(Af-1);
16 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

```

1 //Example7.6 // to design an active high pass
  filter with cut-off frequency 10KHz
2 clc;
3 clear;
4 close;
5 fc = 10 ; // KHz
6 C = 0.01 ; //uF // we assume
7 // the cut-off frequency of active high pass filter
  is given by
8 //  $f_c = 2 * \pi * R_3 * C$ ;
9 // R3 can be calculated as
10 R3 = (1/(2*%pi*fc*C));
11 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

```

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

```

```

5 fc = 25 ; // KHz
6 C = 0.1 ; //nF // we assume
7 // the cut-off frequency of active high pass filter
  is given by
8 //  $fc = 2 * \pi * R3 * C$ ;
9 // R3 can be calculated as
10 R3 = (1/(2*%pi*fc*C));
11 disp('The resistance R3 is = '+string(R3)+' ohm ');
12
13 // the desire pass band gain of filter is given by
14 //  $Af = 1 + (R2/R1)$ ;
15 // assume that the inverting terminal resistor R2
  =0.2*R1;
16 // in Af equation if we put R2=0.2R1 in R1 R1
  cancellout each other
17 Af = 1+(0.2)
18 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

```

1
2 //Example7.8 // to design an active high pass
  filter with cut-off frequency 20KHz
3 clc;
4 clear;
5 close;
6 Af = 15 ;
7 fc = 20 ; //KHz
8 f = 80 ; // KHz the frequency of filter
9 C = 0.05 ; //nF // we assume
10 // the cut-off frequency of active high pass filter
  is given by
11 //  $fc = 2 * \pi * R3 * C$ ;
12 // R3 can be calculated as

```

```

13 R3 = (1/(2*%pi*fc*C));
14 disp('The resistance R3 is = '+string(R3*1000)+' K
      ohm '); // Round Off Error
15
16 // the desire pass band gain of filter is given by
17 //Af = 1+(R2/R1);
18 // assume that the inverting terminal resistor R1=50
      K ohm;
19 R1 = 50 ; // K ohm
20 R2 = (R1*Af)-(R1)
21 disp('The resistance R2 is = '+string(R2)+' K ohm ')
      ;
22
23 // the magnitude of an active high pass filter is
      given as
24 A = Af*(f/fc)/(sqrt(1+(f/fc)^2));
25 disp('The magnitude of an active high pass filter is
      = '+string(A)+' ');
26
27 //the phase angle of the filter
28 Angle = -atand(f/fc)+atand(%inf);
29 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

```

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

```

```

8 C2 = 0.001 ; //uF
9
10 // the lower cut-off frequency of band pass filter
    is
11 fLC = 1/(2*%pi*R1*C1);
12 disp('The lower cut-off frequency FLC of band pass
    filter is = '+string(fLC)+' Hz ');
13
14 // The upper cut-off frequency of band pass filter
    is
15 fUC = 1/(2*%pi*R2*C2);
16 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

```

1 //Example7.10 // to design an active band pass
    filter with lower cut-off frequency 10 KHz an
    upper 50 KHZ
2 clc;
3 clear;
4 close;
5 fL = 10 ; // KHz
6 fH = 50 ; // KHz
7 C1 = 0.002 ; // nF
8 C2 = 0.002 ; // nF
9
10 // the lower cut-off frequency of band pass filter
    is
11 // fL = 1/(2*%pi*R3*C1);
12 R3 = 1/(2*%pi*fL*C1);
13 disp('The resistance R3 Value is = '+string(R3)+' M
    ohm ');
14

```

```

15 // The upper cut-off frequency of band pass filter
    is
16 //  $f_H = 1/(2*\%pi*R6*C2)$ ;
17 R6 = 1/(2*\%pi*fH*C2);
18 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

```

1 //Example7.11 // to design an active band pass
    filter with lower cut-off frequency 20 KHz an
    upper 40 KHZ
2 clc;
3 clear;
4 close;
5 fL = 20 ; // KHz
6 fH = 40 ; // KHz
7 // the inverting terminal resistance 2R1=R2 and 4R4=
    R5
8 C1 = 0.001 ; // nF
9 C2 = 0.001 ; // nF
10
11 // the lower cut-off frequency of band pass filter
    is
12 //  $f_L = 1/(2*\%pi*R3*C1)$ ;
13 R3 = 1/(2*\%pi*fL*C1);
14 disp('The resistance R3 Value is = '+string(R3)+' M
    ohm ');
15
16 // The upper cut-off frequency of band pass filter
    is
17 //  $f_H = 1/(2*\%pi*R6*C2)$ ;
18 R6 = 1/(2*\%pi*fH*C2);
19 disp('The resistance R6 value is = '+string(R6)+' M

```



```

    ohm ');
20
21 // the desire pass band gain of filter is defined as
22 R1 = 1 ; // M ohm we assume
23 //we define inverting terminal resistance 2R1=R2
24 R2 = 2 ; // M ohm
25 // then
26 R4 = 1 ; //M ohm
27 R5 = 4 ; // M ohm
28 Af = (1+(R2/R1))*(1+(R5/R4));
29 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

```

1
2 //Example7.12 // to design an active band pass
   filter with lower cut-off frequency 20 KHz an
   upper 80 KHZ
3 clc;
4 clear;
5 close;
6 f = 100 ; // KHz the frequency of band pass filter
7 fL = 20 ; // KHz
8 fH = 80 ; // KHz
9 // the inverting terminal resistance R1=0.5*R2 and
   R4=0.25*R5
10 C1 = 0.001 ; // nF
11 C2 = 0.001 ; // nF
12
13 // the lower cut-off frequency of band pass filter
   is
14 //  $fL = 1/(2*\%pi*R3*C1)$ ;
15 R3 =  $1/(2*\%pi*fL*C1)$ ;

```

```

16 disp('The resistance R3 Value is = '+string(R3)+' M
    ohm ');
17
18 // The upper cut-off frequency of band pass filter
    is
19 //  $f_H = 1/(2*\%pi*R6*C2)$ ;
20 R6 = 1/(2*\%pi*fH*C2);
21 disp('The resistance R6 value is = '+string(R6)+' M
    ohm '); // Round Off Error
22
23 // the desire pass band gain of filter is defined as
24 R1 = 1 ; // M ohm we assume
25 //we define inverting terminal resistance R1=0.5*R2
26 R2 = 2 ; // M ohm
27 // then
28 R4 = 1 ; //M ohm
29 R5 = 4 ; // M ohm
30 Af = (1+(R2/R1))*(1+(R5/R4));
31 disp('The desire pass band gain of filter is = '+
    string(Af)+' ');
32
33 // the magnitude of gain of band pass filter is
    given as
34 A = Af*(f^2/(fL*fH))/((sqrt(1+(f/fL)^2))*(sqrt(1+(f/
    fH)^2)));
35 disp('The magnitude of gain of band pass filter is
    = '+string(A)+' '); // Round Off Error
36
37 //the phase angle of the filter
38 Angle = 2*atand(%inf)-atand(f/fL)-atand(f/fH);
39 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

```
1 //Example7.13 // to determine the output voltage of
   the precision rectifier circuit
2 clc;
3 clear;
4 close;
5 Vi = 10 ; //V i/p volt
6 R1 = 20 ; // K ohm
7 R2 = 40 ; // K ohm
8 Vd = 0.7 ; // V the diode voltage drop
9
10 // the output of the half wave precision rectifier
   is defined as
11 //  $V_o = -(R2/R1)*V_i$  ; for  $V_i < 0$ 
12 // = 0 otherwise
13 // i.e for  $V_i > 0$ 
14 //  $V_o = 0$ 
15 // for  $V_i < 0$ 
16  $V_o = -(R2/R1)*V_i$ 
17 disp('The output of the half wave precision
   rectifier  $V_o$  is = '+string(Vo)+' V ');
```

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

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

```

7 R2 = 15 ; // K ohm
8 Vd = 0.7 ; // V the diode voltage drop
9
10 // the output of the half wave precision rectifier
    is defined as
11 //  $V_o = -(R_2/R_1)*V_i$  ; for  $V_i < 0$ 
12 //      = 0 otherwise
13
14 // for  $V_i = 5$  V
15 // i.e for  $V_i > 0$ 
16 //       $V_o = 0$ 
17 // for  $V_i < 0$ 
18  $V_o = -(R_2/R_1)*V_i$ ;
19 disp('The output of the half wave precision
    rectifier  $V_o$  is = '+string( $V_o$ )+' V ');
20
21 // for  $V_i = -5$  V
22 // i.e for  $V_i > 0$ 
23 //       $V_o = 0$ 
24 // for  $V_i < 0$ 
25  $V_i = -5$  ; // V
26  $V_o = -(R_2/R_1)*V_i$ ;
27 disp('The output of the half wave precision
    rectifier  $V_o$  is = '+string( $V_o$ )+' V ');

```

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

```

1 //Example7.15 // to determine the output voltage of
    the precision rectifier circuit for i/p voltage
    a)  $V_i = 7$  b)  $V_i = -7$ 
2 clc;
3 clear;
4 close;
5  $V_i = 7$  ; //V i/p volt

```

```

6 R1 = 5 ; // K ohm
7 R3 = 5 ; // K ohm
8 R4 = 5 ; // K ohm
9 R2 = 15 ; // K ohm
10 R5 = 15 ; // K ohm
11 Vd = 0.7 ; // V the diode voltage drop
12
13 // the output of the full wave precision rectifier
    is defined as
14 //  $V_o = -A*V_i$  ; for  $V_i < 0$ 
                                equation 1
15 //  $V_o = A*V_i$  ; otherwise
                                equation 2
16
17 // or  $V_o = \text{abs}(A*V_i)$  ;
18
19 // The gain of precision full wave rectifier
20 A = (((R2*R5)/(R1*R3))-(R5/R4)) ;
21 disp('The gain of precision full wave rectifier A is
    = '+string(A)+' ');
22
23
24 // for  $V_i = 7$  V the output voltage is
25 Vi = 7 ;
26     Vo = -A*Vi ; // from equation 1
27     Vo = A*Vi ; // from equation 2
28 Vo = abs(A*Vi) ;
29 disp('The output voltage Vo is = '+string(Vo)+' V ')
    ;
30
31 // for  $V_i = -7$  V the output voltage is
32 Vi = -7 ;
33     Vo = -A*Vi ; // from equation 1
34     Vo = A*Vi ; // from equation 2
35 Vo = abs(A*Vi) ;
36 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

```
1 //Example8.1 // to determine the output voltage of
   inverting amplifier (V2)
2 clc;
3 clear;
4 close;
5 Vin = 18 ; // V
6 V1 = -6 ; // V
7
8 // in the op-amp due to the infinite i/p resistance
   the input current is = 0
9 //  $i_1 + i_2 = 0$ 
10 // it gives relation
11 Vo = -Vin ;
12
13 // the output of multiplier is defined as
14 //  $V_o = K * V_1 * V_2$ 
15
16 K = 1 ; // we assume
17
18 V2 = (Vo/(K*V1));
19 disp('the output voltage of inverting amplifier (V2)')
```

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

Scilab code Exa 8.2 to determine the output voltage of multiplier

```
1 //Example8.2 // to determine the output voltage of
  multiplier
2 clc;
3 clear;
4 close;
5 Vin = 15 ; // V
6
7 // the output of multiplier is defined as
8 //Vo = K*V1*V2
9 // because of i/p terminal the circuit performs
  mathematical operation squaring
10 // i.e V1 = V2 = Vin
11 K = 1 ; // we assume
12 Vo = K*(Vin)^2;
13 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

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

```

9 disp('the output voltage of inverting amplifier is =
      '+string(Vos)+' V ');
10
11 // the output of the multiplier
12 Vo = K*Vos^2 ;
13 disp('the output voltage of multiplier is = '+string
      (Vo)+' V ');

```

Scilab code Exa 8.4 determine the output of balanced demodulator

```

1 //Example8.4 //determine the output of balanced
  demodulator
2 clc;
3 clear;
4 close;
5 // Vc1 = 10*cos*wc*t ;
6 // Vm2 = 20*cos*wm*t*cos*wc*t
7
8 // the amplitude of carrier and modulated signal
9 Ac1 = 10 ; // V
10 // K*Am2*Ac2 = 20 ; // V
11
12 // the output of multiplier
13 // Vol = K*Vc1*Vm2 ;
14 disp('          The output voltage of multiplier is
      =          (K^2*Ac1*Ac2*Am2)/2*(cos*wm*t+cos*wm*t*
      cos*2*w*t) ');
15
16
17 //the output of low pass filter
18 // Vo = ((K^2*Ac1*Ac2*Am2)/2)*cos*wm*t ;
19 disp('          The output voltage of low pass
      filter is = 100coswmt ');

```

Scilab code Exa 8.5 Output voltage of of RMS detector

```
1 //Example8.5 // output voltage of of RMS detector
2 clc;
3 clear;
4 close;
5 Vin = 10 ;
6 T = 1 ; // we assume that the charging and
           discharging period of capacitor
7
8 // the output voltage of RMS detector
9 // Vo =sqrt(1/T*)integrate(Vin^2*(t),t,0,1 [,atol [,
           rtol]]) ;
10 Vo = 10 ;
11 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

```
1 //Example9.1 // to find output voltage for a
   constant input signal frequency of 200 KHz
2 clc;
3 clear;
4 close;
5 fo = 2*%pi*1*10^3 ; // KHz/V // VCO sensitivity
   range 4.1
6 fc = 500 ; // Hz a free running frequency
7 f1 = 200 ; // Hz input frequency
8 f2 = 2*10^3 ; // Hz input frequency
9
10 // the output voltage of PLL is defined as
11 //Vo = (wo-wc)/ko
12 ko = fo ;
13 // when i/p locked with o/p wo=wi
14 // Vo = (wi-wc)/ko ;
15
16 //for the i/p frequency fi = 200 Hz
17 fi = 200 ; // Hz
18 Vo = (((2*%pi*fi)-(2*%pi*fc))/ko);
```

```

19 disp('The output voltage of switching regulator
      circuit is = '+string(Vo)+' V ');
20
21 //for the i/p frequency fi = 200 Hz
22 fi = 2*10^3 ; // Hz
23 Vo = (((2*pi*fi)-(2*pi*fc))/ko);
24 disp('The output voltage of switching regulator
      circuit is = '+string(Vo)+' V ');

```

Scilab code Exa 9.2 to find VCO output frequency

```

1 //Example9.2 // to find VCO output frequency
2 clc;
3 clear;
4 close;
5 fc = 400 ; // KHz a free running frequency
6 f = 10 ; // KHz low pass filter bandwidth
7 fi = 500 ; // KHz input frequency
8
9 // In PLL a phase detector produces the sum and
  difference frequencies are defined as
10
11 sum = fi+fc ;
12 disp('The sum frequency produce by phase detector is
      = '+string(sum)+' KHz ');
13
14 difference = fi-fc ;
15 disp('The difference frequency produce by phase
      detector is = '+string(difference)+' KHz ');
16
17 disp('The phase detector frequencies are outside of
      the low pass filter ');
18
19 disp('The VCO will be in its free running frequency
      ');

```

Scilab code Exa 9.3 to determine the lock range of PLL

```
1 //Example9.3 // to determine the lock range of PLL
2 clc;
3 clear;
4 close;
5 Ko = 25 ; // KHz
6 fo = 50 ; // KHz
7 A = 2 ;
8 Vd = 0.7 ;
9 AL = 1 ;
10
11 // the amximum output swing of phase detector
12 // Vd = Kd*(%pi/2) ;
13
14 // the sensitivity of phase detector Kd is
15 Kd = Vd*(2/%pi) ;
16 disp('The sensitivity of phase detector Kd is = '+
      string(Kd)+' ');
17
18 // The maximum control voltage of VCO Vfmax
19 Vfmax = (%pi/2)*Kd*A ;
20 disp('The maximum control voltage of VCO Vfmax = '+
      string(Vfmax)+' V');
21
22 // the maximum frequency swing of VCO
23 fL = (Ko*Vfmax);
24 disp('The maximum frequency swing of VCO = '+string(
      fL)+' KHz');
25
26 // The maximum range of frequency which lock a PLL
      are
27 fi = fo-fL ;
28 disp('The maximum range of frequency which lock a
```

```

    PLL is = '+string(fi)+ ' KHz ');
29
30 fi = fo+fL ;
31 disp('The maximum range of frequency which lock a
    PLL is = '+string(fi)+ ' KHz ');
32
33 disp('The maximum and minimum rage between 15 KHz to
    85 KHZ ')
34
35
36 // the lock range is
37 fLock = 2*fL ;
38 disp('The lock range is = '+string(fLock)+ ' KHz ');

```

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

```

1 //Example9.4 // to determine the output frequency
    capacitor charging time of VCO
2 clc;
3 clear;
4 close;
5 Vcc = 12 ;
6 Vcs = 6
7 R = 10 ; // K ohm
8 C = 1 ; // uF
9
10 // the current through the control resistor R
11 i =(Vcc-Vcs)/R ;
12 disp('The current through the control resistor R is
    = '+string(i)+ ' mA ');
13
14 // The charging time of capacitor
15 t = (0.25*Vcc*C)/i ;
16 disp('The charging time of capacitor is = '+string(t

```

```

    )+ ' msec ');
17
18 // 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 ;
19 t = ((0.5*Vcc*C)/i);
20 disp('The total time period of tringular and square
    wave is = '+string(t)+' msec ');
21
22 // the output frequency of VCO is
23 fo = 1/t ;
24 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

```

1 //Example9.5 // to design VCO with output square
    wave pulse time of 50 msec
2 clc;
3 clear;
4 close;
5 Vcc =6 ;
6 Vcs = 5 ;
7 R = 22 ; //K ohm
8 C = 0.02 ; // uF
9 t = 50*10-3 ; // sec output square wave pluse
10
11 // 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 ;
12
13

```

```

14 // the charging or discharging time of capacitor
15 tcap = t/2 ;
16 disp('The charging or discharging time of capacitor
      is = '+string(tcap)+ ' msec ');
17
18 // the output frequency of VCO is
19 fo = 1/t ;
20 disp('The output frequency of VCO is is = '+string(
      fo)+ ' Hz ');
21
22 // the output frequency of VCO
23 // fo = (1/4*R*C);
24 R = 1/(4*fo*C) ;
25 disp('The output frequency of VCO is = '+string(R)+
      ' ohm');
26
27 // the current through the control resistor R
28 i =(Vcc-Vcs)/R ;
29 disp('The current through the control resistor R is
      = '+string(i)+ ' uA ');
30
31 // the capacitor charging current
32 // (V/t)=(i/C) ;
33 V = (i/C)*tcap ;
34 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

```

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

```

```

5 R = 15 ; // K ohm
6 C = 0.12 ; // uF
7 Vcc = 12 ;
8
9 // the center frequency of VCO fo
10 fo = (1.2/4*R*C);
11 disp('The center frequency of VCO is is = '+string(
    fo)+ ' Hz ');
12
13 fo = 4 ; // KHz
14 // the lock range of PLL
15 fL = (8*fo/Vcc) ;
16 disp('The lock range of PLL is = '+string(fL)+ ' KHz
    /V ');
17
18 // the capture range of PLL
19 fc = ((fo-fL)/(2*pi*3.6*10^3*C)^(1/2)) ;
20 disp('The lock range of PLL is = '+string(fc)+ ' Hz/
    V ');

```

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

```

1 //Example9.7 // determine the lock range of the FSK
    demodulator
2 clc;
3 clear;
4 close;
5 Vcc = 12 ;
6 Fvco = 0.25*Vcc ;
7 f = 200*10^3 ; // KHz
8
9
10 // the total time period of VCO
11 t = 1/f ;
12 disp('The total time period of VCO is = '+string(t)+

```



```

        ' sec ');
13
14 // 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 ;
15
16
17 // the charging or discharging time of capacitor
18 tcap = t/2 ;
19 disp('The charging or discharging time of capacitor
    is = '+string(tcap)+ ' sec ');
20
21 // the voltage swing of VCO for 12 V supply
22 Fvco = 0.25*Vcc ;
23 disp('The voltage swing of VCO for 12 V supply is =
    '+string(Fvco)+ ' V ');
24
25 // The lock range of PLL
26 //FL = (1/2*%pi*f)*(Fvco/tcap);
27 FL = (3/(2*%pi*f*tcap));
28 disp('The lock range of PLL FL is = '+string(FL)+ '
    Hz ');
29
30 // the capture range
31 fcap = sqrt(f*FL);
32 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

```
1 //Example11.1 // to determine the full scale
   voltage of D/A
2 clc;
3 clear;
4 close;
5 Vref = 12 ;
6 Rf = 10 ; // K ohm
7 R = 5 ; // K ohm
8
9 // the full scale voltage of D/A converter
10 VFS = Vref*(Rf/R) ;
11 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

```

1 //Example11.2 // determine the output voltage of D/
  A converter for the binary inputs a) 10101010 b)
  11001100 c) 11101110 d) 00010001
2 clc;
3 clear;
4 close;
5 del = 12*10^-3 ; // mA
6
7 // the input voltage of D/A converter
8 //Vo = del*binary input (BI)
9
10 // For BI 10101010 the output
11 BI = '10101010' ;
12 BI = bin2dec(BI);
13 Vo = del*BI ;
14 disp('For BI 10101010 the output of D/A converter is
  = ' +string(Vo)+ ' V ');
15
16 // For BI 11001100 the output
17 BI = '11001100' ;
18 BI = bin2dec(BI);
19 Vo = del*BI ;
20 disp('For BI 11001100 the output of D/A converter is
  = ' +string(Vo)+ ' V ');
21
22 // For BI 11101110 the output
23 BI = '11101110' ;
24 BI = bin2dec(BI);
25 Vo = del*BI ;
26 disp('For BI 11101110 the output of D/A converter is
  = ' +string(Vo)+ ' V ');
27
28 // For BI 00010001 the output
29 BI = '00010001' ;
30 BI = bin2dec(BI);
31 Vo = del*BI ;
32 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

```
1 //Example11.3 // determine the resolution of 4-bit
   D/A converter
2 clc;
3 clear;
4 close;
5 VFS = 12 ;
6 N = 4 ;
7
8 // the resolution of 4-bit D/A converter is defined
   as
9 Resolution = VFS/(2^N-1) ;
10 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

```
1 //Example11.4 // determine the number of bit
   required to design a 4-bit D/A converter
2 clc;
3 clear;
4 close;
5 VFS = 5 ;
6 Resolution = 10*10^-3 ; // A
7
8 // the resolution of 4-bit D/A converter is defined
   as
9 // Resolution = VFS/(2^N-1) ;
```

```

10 N = (VFS/Resolution)+1 ;
11 N = log10(N)/log10(2);
12 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

```

1 //Example11.5 // determine the analog output
    voltage
2 clc;
3 clear;
4 close;
5 Vref = 12 ;
6 BI = 101 ; BI = 111 ; BI = 011 ; BI = 001 ; BI
    = 100 ;
7 Rf = 40*10^3 ;
8 R = 0.25*Rf ;
9
10 // The output voltage of given binary weighted
    resistor D/A converter is defined as
11
12 //  $V_o = -(R_f * V_{ref} / R) * (2^0 * b_0 + 2^{-1} * b_1 + 2^{-2} * b_2)$  ;
13
14 //  $V_o = -(R_f * V_{ref} / R) * (b_0 + 2^{-1} * b_1 + 2^{-2} * b_2)$  ;
15
16 // for the given value Rf,R and Vref the output
    voltage
17
18 //  $V_o = -48 * (b_0 + 2^{-1} * b_1 + 2^{-2} * b_2)$  ;
19
20 // for the binary input 101 analog output is
21 b2 = 1 ;
22 b1 = 0 ;
23 b0 = 1 ;
24  $V_o = -48 * (b_0 + 2^{-1} * b_1 + 2^{-2} * b_2)$  ;

```

```

25 disp('for the binary input 101 analog output is = '+
      string(Vo)+ ' V ');
26
27
28 // for the binary input 111 analog output is
29 b2 = 1 ;
30 b1 = 1 ;
31 b0 = 1 ;
32 Vo = -48*(b0+2-1*b1+2-2*b2) ;
33 disp('for the binary input 111 analog output is = '+
      string(Vo)+ ' V ');
34
35
36 // for the binary input 011 analog output is
37 b2 = 0 ;
38 b1 = 1 ;
39 b0 = 1 ;
40 Vo = -48*(b0+2-1*b1+2-2*b2) ;
41 disp('for the binary input 011 analog output is = '+
      string(Vo)+ ' V ');
42
43
44 // for the binary input 001 analog output is
45 b2 = 0 ;
46 b1 = 0 ;
47 b0 = 1 ;
48 Vo = -48*(b0+2-1*b1+2-2*b2) ;
49 disp('for the binary input 001 analog output is = '+
      string(Vo)+ ' V ');
50
51
52 // for the binary input 100 analog output is
53 b2 = 1 ;
54 b1 = 0 ;
55 b0 = 0 ;
56 Vo = -48*(b0+2-1*b1+2-2*b2) ;
57 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 I_f

```
1 //Example11.6 // determine the analog output
   voltage and feed back current  $I_f$ 
2 clc;
3 clear;
4 close;
5 Vref = 12 ;
6 BI = 1001 ; BI = 1101 ; BI = 1010 ; BI = 0011 ;
7 Rf = 25 ; // K ohm
8 R = 0.25*Rf ;
9
10 // The output voltage of given binary weighted
   resistor D/A converter is defined as
11
12 //  $V_o = -(R_f \cdot V_{ref} / R) \cdot (2^0 \cdot b_0 + 2^{-1} \cdot b_1 + 2^{-2} \cdot b_2 + 2^{-3} \cdot b_3)$ 
   ) ;
13
14 //  $V_o = -(R_f \cdot V_{ref} / R) \cdot (b_0 + 2^{-1} \cdot b_1 + 2^{-2} \cdot b_2 + 2^{-3} \cdot b_3)$  ;
15
16 // for the given value  $R_f, R$  and  $V_{ref}$  the output
   voltage
17
18 //  $V_o = -60 \cdot (b_0 + 2^{-1} \cdot b_1 + 2^{-2} \cdot b_2 + 2^{-3} \cdot b_3)$  ;
19
20 // for the binary input 1001 analog output is
21 b3 = 1 ;
22 b2 = 0 ;
23 b1 = 0 ;
24 b0 = 1 ;
25  $V_o = -60 \cdot (b_0 + 2^{-1} \cdot b_1 + 2^{-2} \cdot b_2 + 2^{-3} \cdot b_3)$  ;
26 disp('for the binary input 1001 analog output is = '
   +string( $V_o$ ) + ' V ');
```

```

27
28 // the feedback current If is given by
29 If = -(Vo/Rf) ;
30 disp('the feedback current If is = '+string(If)+ '
      mA ');
31
32
33 // for the binary input 1101 analog output is
34 b3 = 1 ;
35 b2 = 1 ;
36 b1 = 0 ;
37 b0 = 1 ;
38 Vo = -60*(b0+2-1*b1+2-2*b2+2-3*b3) ;
39 disp('for the binary input 1101 analog output is = '
      +string(Vo)+ ' V ');
40
41 // the feedback current If is given by
42 If = -(Vo/Rf) ;
43 disp('the feedback current If is = '+string(If)+ '
      mA ');
44
45
46 // for the binary input 1010 analog output is
47 b3 = 1 ;
48 b2 = 0 ;
49 b1 = 1 ;
50 b0 = 0 ;
51 Vo = -60*(b0+2-1*b1+2-2*b2+2-3*b3) ;
52 disp('for the binary input 1010 analog output is = '
      +string(Vo)+ ' V ');
53
54 // the feedback current If is given by
55 If = -(Vo/Rf) ;
56 disp('the feedback current If is = '+string(If)+ '
      mA ');
57
58
59 // for the binary input 0011 analog output is

```



```

60 b3 = 0 ;
61 b2 = 0 ;
62 b1 = 1 ;
63 b0 = 1 ;
64 Vo = -60*(b0+2-1*b1+2-2*b2+2-3*b3) ;
65 disp('for the binary input 0011 analog output is = '
      +string(Vo)+ ' V ');
66
67 // the feedback current If is given by
68 If = -(Vo/Rf) ;
69 disp('the feedback current If is = '+string(If)+ '
      mA ');

```

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

```

1
2 //Example11.7 // determine the feed back current If
  and analog output voltage
3 clc;
4 clear;
5 close;
6 Vref = 8 ; // V
7 BI = 001 ; BI = 010 ; BI = 110 ;
8 Rf = 25*103 ; // Hz
9 R = 0.2*Rf ;
10
11 // The output current of given binary weighted
  resistor D/A converter is defined as
12
13 // If = -(Vref/R)*(20*b0+2-1*b1+2-2*b2) ;
14
15 // If = -(Vref/R)*(b0+2-1*b1+2-2*b2) ;
16
17 // for the given value Rf,R and Vref the output

```

```

        current
18
19 // If =  $-(1.6 \times 10^{-3}) \cdot (b_0 + 2^{-1} \cdot b_1 + 2^{-2} \cdot b_2)$  ;
20
21 // for the binary input 001 the feedback current If
    is given by
22 b2 = 0 ;
23 b1 = 0 ;
24 b0 = 1 ;
25 If =  $(1.6 \times 10^{-3}) \cdot (b_0 + 2^{-1} \cdot b_1 + 2^{-2} \cdot b_2)$  ;
26 disp('for the binary input 001 analog output is = '+
    string(If*1000)+ ' mA ');
27
28 // An analog output voltage Vo is
29 Vo = -If*Rf ;
30 disp('An analog output voltage Vo is = '+string(Vo)+
    ' V ');
31
32
33 // for the binary input 010 the feedback current If
    is given by
34 b2 = 0 ;
35 b1 = 1 ;
36 b0 = 0 ;
37 If =  $(1.6 \times 10^{-3}) \cdot (b_0 + 2^{-1} \cdot b_1 + 2^{-2} \cdot b_2)$  ;
38 disp('for the binary input 010 analog output is = '+
    string(If*1000)+ ' mA');
39
40 // the An analog output voltage Vo is
41 Vo = -If*Rf ;
42 disp('An analog output voltage Vo is = '+string(Vo)+
    ' V ');
43
44
45 // for the binary input 110 the feedback current If
    is given by
46 b2 = 1 ;
47 b1 = 1 ;

```

```

48 b0 = 0 ;
49 If = (1.6*10^-3)*(b0+2^-1*b1+2^-2*b2) ;
50 disp('for the binary input 110 analog output is = '+
      string(If*1000)+ ' mA ');
51
52 // the An analog output voltage Vo is
53 Vo = -If*Rf ;
54 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

```

1 //Example11.8 // determine the feed back current If
  and analog output voltage
2 clc;
3 clear;
4 close;
5 Vref = 5 ;
6 BI = 101 ; BI = 011 ; BI = 100 ; BI = 001 ;
7 Rf = 25*10^3 ;
8 R = 0.2*Rf ;
9
10 // The output current of given R-2R ladder D/A
   converter is defined as
11
12 // If = -(Vref/2*R)*(2^0*b0+2^-1*b1+2^-2*b2) ;
13
14 // If = -(Vref/2*R)*(b0+2^-1*b1+2^-2*b2) ;
15
16 // for the given value Rf,R and Vref the output
   current
17
18 // If = (0.5*10^-3)*(b0+2^-1*b1+2^-2*b2) ;
19

```

```

20 // for the binary input 101 the feedback current If
    is given by
21 b2 = 1 ;
22 b1 = 0 ;
23 b0 = 1 ;
24 If = (0.5*10^-3)*(b0+2^-1*b1+2^-2*b2) ;
25 disp('for the binary input 101 analog output is = '+
    string(If)+ ' A ');
26
27 // An analog output voltage Vo is
28 Vo = -If*Rf ;
29 disp('An analog output voltage Vo is = '+string(Vo)+
    ' V ');
30
31
32 // for the binary input 011 the feedback current If
    is given by
33 b2 = 0 ;
34 b1 = 1 ;
35 b0 = 1 ;
36 If = (0.5*10^-3)*(b0+2^-1*b1+2^-2*b2) ;
37 disp('for the binary input 011 analog output is = '+
    string(If)+ ' A');
38
39 // the An analog output voltage Vo is
40 Vo = -If*Rf ;
41 disp('An analog output voltage Vo is = '+string(Vo)+
    ' V ');
42
43
44 // for the binary input 100 the feedback current If
    is given by
45 b2 = 1 ;
46 b1 = 0 ;
47 b0 = 0 ;
48 If = (0.5*10^-3)*(b0+2^-1*b1+2^-2*b2) ;
49 disp('for the binary input 100 analog output is = '+
    string(If)+ ' A ');

```

```

50
51 // the An analog output voltage Vo is
52 Vo = -If*Rf ;
53 disp('An analog output voltage Vo is = '+string(Vo)+
      ' V ');
54
55 // for the binary input 001 the feedback current If
      is given by
56 b2 = 0 ;
57 b1 = 0 ;
58 b0 = 1 ;
59 If = (0.5*10^-3)*(b0+2^-1*b1+2^-2*b2) ;
60 disp('for the binary input 001 analog output is = '+
      string(If)+ ' A ');
61
62 // the An analog output voltage Vo is
63 Vo = -If*Rf ;
64 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

```

1 //Example11.9 // determine the analog output
      voltage and feed back current If
2 clc;
3 clear;
4 close;
5 Vref = 10 ;
6 BI = 1001 ; BI = 1100 ; BI = 1010 ; BI = 0011 ;
7 Rf = 50 ; // K ohm
8 R = 0.4*Rf ;
9
10 // The output voltage of given R-2R ladder D/A
      converter is defined as

```

```

11
12 //  $V_o = -(R_f \cdot V_{ref} / 2R) \cdot (2^0 \cdot b_0 + 2^{-1} \cdot b_1 + 2^{-2} \cdot b_2 + 2^{-3} \cdot b_3)$  ;
13
14 //  $V_o = -(R_f \cdot V_{ref} / 2R) \cdot (b_0 + 2^{-1} \cdot b_1 + 2^{-2} \cdot b_2 + 2^{-3} \cdot b_3)$  ;
15
16 // for the given value  $R_f, R$  and  $V_{ref}$  the output
    voltage
17
18 //  $V_o = -12.5 \cdot (b_0 + 2^{-1} \cdot b_1 + 2^{-2} \cdot b_2 + 2^{-3} \cdot b_3)$  ;
19
20 // for the binary input 1001 analog output is
21 b3 = 1 ;
22 b2 = 0 ;
23 b1 = 0 ;
24 b0 = 1 ;
25  $V_o = -12.5 \cdot (b_0 + 2^{-1} \cdot b_1 + 2^{-2} \cdot b_2 + 2^{-3} \cdot b_3)$  ;
26 disp('for the binary input 1001 analog output is = '
    +string(Vo)+ ' V ');
27
28 // the feedback current  $I_f$  is given by
29  $I_f = -(V_o / R_f)$  ;
30 disp('the feedback current  $I_f$  is = '+string(I_f)+ '
    mA ');
31
32
33 // for the binary input 1100 analog output is
34 b3 = 1 ;
35 b2 = 1 ;
36 b1 = 0 ;
37 b0 = 0 ;
38  $V_o = -12.5 \cdot (b_0 + 2^{-1} \cdot b_1 + 2^{-2} \cdot b_2 + 2^{-3} \cdot b_3)$  ;
39 disp('for the binary input 1100 analog output is = '
    +string(Vo)+ ' V ');
40
41 // the feedback current  $I_f$  is given by
42  $I_f = -(V_o / R_f)$  ;
43 disp('the feedback current  $I_f$  is = '+string(I_f)+ '

```

```

        mA ');
44
45
46 // for the binary input 1010 analog output is
47 b3 = 1 ;
48 b2 = 0 ;
49 b1 = 1 ;
50 b0 = 0 ;
51 Vo = -12.5*(b0+2-1*b1+2-2*b2+2-3*b3) ;
52 disp('for the binary input 1010 analog output is = '
        +string(Vo)+ ' V ');
53
54 // the feedback current If is given by
55 If = -(Vo/Rf) ;
56 disp('the feedback current If is = '+string(If)+ '
        mA ');
57
58
59 // for the binary input 0011 analog output is
60 b3 = 0 ;
61 b2 = 0 ;
62 b1 = 1 ;
63 b0 = 1 ;
64 Vo = -12.5*(b0+2-1*b1+2-2*b2+2-3*b3) ;
65 disp('for the binary input 0011 analog output is = '
        +string(Vo)+ ' V ');
66
67 // the feedback current If is given by
68 If = -(Vo/Rf) ;
69 disp('the feedback current If is = '+string(If)+ '
        mA ');

```

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

```

1 //Example11.10 // determine the analog output
   voltage and feed back current If
2 clc;
3 clear;
4 close;
5 Vref = 15 ;
6 BI = 1000 ;
7 Rf = 40 ; // K ohm
8 R = 0.4*Rf ;
9
10 // by using voltage divider rule Vin can be
   calculated as
11 Vin = -(Vref*2*R)/(2*R+2*R) ;
12
13 // The output voltage of given R-2R ladder D/A
   converter is defined as
14
15 // Vo = -(Rf*Vin/R)
16
17 Vo = (Vref*Rf)/(2*R)
18 disp('for the binary input 1000 output voltage is =
   '+string(Vo)+ ' V ');
19
20 // the feedback current If is given by
21 If = -(Vo/Rf) ;
22 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

```

1 //Example11.11 // to find the resolution and analog
   output voltage of 8-bit D/A converter
2 clc;
3 clear;

```



```

4  close;
5  VFS = 10 ;
6  N = 8 ;
7  BI = 10101111 ; BI = 11100011 ; BI = 00101001 ; BI
    = 01000110
8
9  // the resolution of 8-bit D/A converter is defined
    as
10 Resolution = VFS/(2^N-1) ;
11
12 // An analog output voltage of D/A converter is
    given by
13 //  $V_o = \text{Resolution} \cdot (2^{-0} \cdot b_0 + 2^{-1} \cdot b_1 + \dots + 2^{-N} \cdot b_{N-1})$ 
14 //  $V_o = \text{Resolution} \cdot (2^{-0} \cdot b_0 + 2^{-1} \cdot b_1 + 2^{-2} \cdot b_2 + 2^{-3} \cdot b_3$ 
     $+ 2^{-4} \cdot b_4 + 2^{-5} \cdot b_5 + 2^{-6} \cdot b_6 + 2^{-7} \cdot b_7)$ ;
15
16 // For the BI 10101111 output analog voltage is
17 BI = '10101111';
18 BI = bin2dec(BI);
19 Vo = Resolution*BI ;
20 disp('For the BI 10101111 output analog voltage is =
    '+string(Vo)+ ' V ');
21
22 // For the BI 11100010 output analog voltage is
23 BI = '11100010';
24 BI = bin2dec(BI);
25 Vo = Resolution*BI ;
26 disp('For the BI 11100010 output analog voltage is =
    '+string(Vo)+ ' V ');
27
28 // For the BI 00101001 output analog voltage is
29 BI = '00101001';
30 BI = bin2dec(BI);
31 Vo = Resolution*BI ;
32 disp('For the BI 00101001 output analog voltage is =
    '+string(Vo)+ ' V ');
33
34 // For the BI 01000110 output analog voltage is

```

```
35 BI = '01000110';
36 BI = bin2dec(BI);
37 Vo = Resolution*BI ;
38 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

```
1 //Examble12.2 // 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
2 clc;
3 clear;
4 close;
5 N = 8 ;
6 Vin = 12 ;
7
8 //a) Normalized step size of A/D converter
9 Ns = 2^-N ;
10 disp('Normalized step size of A/D converter is = '+
      string(Ns)+ ' ');
11
12 // b) Actual step size of A/D converter
13 As = Vin*Ns ;
```

```

14 disp('Actual step size of A/D converter is = '+
      string(As)+ ' ');
15
16 // c) Normalized maximum quantization level of A/D
      converter
17 Qmax = 1-2^-N ;
18 disp('Normalized maximum quantization level of A/D
      converter is = '+string(Qmax)+ ' ');
19
20 // d) Actual maximum quantization level of A/D
      converter
21 QAmax = Qmax*Vin ;
22 disp('Actual maximum quantization level of A/D
      converter is = '+string(QAmax)+ ' ');
23
24 // e) Normalized peak quantization error of A/D
      converter
25 Qp = 2^-(N+1);
26 disp('Normalized peak quantization error of A/D
      converter is = '+string(Qp)+ ' ');
27
28 // f) Actual peak quantization error of A/D
      converter
29 Qe = Qp*Vin ;
30 disp('Actual peak quantization error of A/D
      converter is = '+string(Qe)+ ' V ');
31
32 // g) Percentage of quantization error of A/D
      converter
33 %Qp = 2^-(N+1)*100 ;
34 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

```

1 //Example12.3 // to determine the binary output of
   the 8-bit dual slope A/D converter
2 clc;
3 clear;
4 close;
5 Vin = 8.5 ;
6 VR = 10 ;
7 f = 2 ; //MHz
8 N = 8 ;
9 C = 0.1*10^-6 ;
10 R = 2*10^3 ;
11
12 // the output of integrator is defined as
13 //  $V_{iAO}(T1) = -(V_{in}/R*C)*T1$  ;
14
15 // charging time of capacitor
16 T1 = 2^N/f ;
17 disp('charging time of capacitor is = '+string(T1)+
   ' u sec');
18
19 // the integrator output
20 T1 = T1*10^-6 ;
21 Viao = -(Vin/(R*C))*T1;
22 disp('the integrator output is = '+string(Viao)+ ' V
   ');
23
24 // the binary output of a dual slope A/D converter
25 Bn = (2^N*Vin)/VR;
26 disp('the decimal output of a dual slope A/D
   converter is = '+string(Bn)+ ' = 218' );
27
28 Bn=218;
29 Bn = dec2bin(Bn) ;
30 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

```
1 //Example12.4 // to determine the resolution of 12-  
    bit A/D converter  
2 clc;  
3 clear;  
4 close;  
5 N =12 ;  
6 Vin = 15 ;  
7  
8 // Resolution of an A/D converter  
9 Resolution = Vin/(2^N-1);  
10 disp('Resolution of an A/D converter is = '+string(  
    Resolution)+ ' V ');  
11 ;
```

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

```
1 // Example12.5 // to determine the output time and  
    duty cycle of V/T converter  
2 clc;  
3 clear;  
4 close;  
5 Vin = 5 ;  
6 C = 0.1*10^-6 ;  
7 R = 10*10^3 ;  
8 C1 = 100*10^-6 ;  
9  
10 // The output time of a V/T converter is given as  
11 T = (7.5*C1)/(Vin) ;
```

```

12 disp('The output time of a V/T converter is =' +
        string(T)+ ' sec');
13
14 TH = 0.075 ;
15 TL=TH ; // we consider
16 // The duty cycle of V?T converter
17 D = (TL+TH)/(TH) ;
18 disp('The duty cycle of V?T converter is = '+string(
        D)+ ' ');
19
20 // The output voltage of an integrator is define as
21 Vio = -(Vin)/(R*C)*T ;
22 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

```
1 //Example13.1 // to design RC phase shift
   oscillator for the oscillation frequency f = 1
   KHz
2 clc;
3 clear;
4 close;
5 f =1 ; // KHz
6 C = 0.01 ; // uF
7
8 // The oscillation frequency of practical RC phase
   shift oscillator is defined as
9 //w = 1/(sqrt(6)*R*C);
10
11 // gain of practical RC phase shift oscillator is
12 //A = R1/R = 29

   equation 1
13 // the frequency selective element resistor
14 //R = 1/(sqrt(6)*w*C);
15 R = 1/(sqrt(6)*2*%pi*f*C);
```



```

16 disp('the frequency selective element resistor is =
      '+string(R)+ ' K ohm ');
17
18 // The feedback resistance
19 R1 = 29*R ;
                                     //
      from equation 1
20 disp('The feedback resistance is = '+string(R1)+ ' K
      ohm');

```

Scilab code Exa 13.2 to determine the oscillaton frequency of the phase shift oscillator

```

1 //Example13.2 // to determine the oscillaton
      frequency of the phase shift oscillator
2 clc;
3 clear;
4 close;
5 C = 0.05 ; // uF
6 R = 2.5 ; // K ohm
7
8 // the oscillator frequency of practical RC phase
      shift oscillator f
9 f = 1/(2*pi*(sqrt(6)*(R*C)));
10 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

```

1 //Example13.3 // to calculate the frequency of a
      wein bridge oscillator
2 clc;
3 clear;

```

```

4 close;
5 C = 2400*10^-12 ; // F
6 R = 10*10^3 ; // ohm
7
8 // the oscillator frequency of practical RC phase
  shift oscillator f
9 f = 1/(2*pi*R*C);
10 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

```

1 //Example13.4 // to design the wien bridge
  oscillator for the oscillation frequency  $f = 1$ 
  KHz
2 clc;
3 clear;
4 close;
5 f = 1 ; // K ohm
6 C = 0.01 ; // uF
7
8
9 // the frequency  $f$  is define as
10 //  $f = 1/(2*pi*R*C)$ ;
11
12 // the resistor  $R$  is
13  $R = 1/(2*pi*f*C)$ ;
14 disp('the resistor  $R$  is = '+string(R)+ ' K ohm ');
15
16 // the loop gain of the wien bridge oscillator is
  unity which is defined as
17 //  $A = (1+(R2/R1))*(1/3) = 1$  ;
18 //  $R2/R1 = 2$  ;
19  $R1 = 10$  ; // K ohm we assume

```

```

20 R2 = 2*R1 ;
21 disp('The resistor R2 value is = '+string(R2)+ ' K
      ohm ');

```

Scilab code Exa 13.5 to calculate the frequency of a wein bridge oscillator

```

1 //Example13.5 // to calculate the frequency of a
  wein bridge oscillator
2 clc;
3 clear;
4 close;
5 C = 0.05*10^-6 ; // F
6 R = 20*10^3 ; // ohm
7 R1 = 10*10^3 ; // ohm
8 R2 = 20*10^3 ; //ohm
9
10 // the frequency of wien bridge oscillator f
11 f = 1/(2*%pi*R*C);
12 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

```

1 //Example13.6 // Determine the frequency response
  of the astable multivibrator circuit
2 clc;
3 clear;
4 close;
5 Vsat = 2.5 ;
6 VT = 0.7 ;
7
8 // The frequency of the astable multivibrator is

```

```

9 //f = (1/(2*R*C*log((Vsat+VT)/(Vsat-VT))));
10
11 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

```

1 //Example13.7 // Design astable multivibrator for
  the frequency f = 10 KHz
2 clc;
3 clear;
4 close
5 f = 10 ; // K ohm
6 Vsat = 3 ;
7 VT = 0.7 ;
8
9 // The saturation voltage of an astable
  multivibrator is defined as
10 // Vsat = (R1+R2/R1)+VT ;
11 R1 = 10 ; // K ohm we choose
12 R2 = ((Vsat/VT)-1)*R1 ;
13 disp('The value of resistance R2 is = '+string(R2)+
      ' K ohm ');
14
15 // The frequency of an astable multivibrator is
  defined as
16 C = 0.01 ; // uF
17 // f = (1/(2*R*C*log(1+(2*R1/R2))));
18
19 R = 1/(2*f*C*log(1+2*R1/R2));
20 disp('The value of resistor R is = '+string(R)+ ' K
      ohm');

```

Scilab code Exa 13.8 to design astable multivibrator

```
1 //Example13.8 // to design astable multivibrator
2 clc;
3 clear;
4 close;
5 f = 25*103 ;
6
7 // The output frequency of practical astable
  multivibrator is defined as
8 // f = 1/(2*R*C);
9 C = 0.1*10-6 ; // uF we choose
10 R = 1/(2*f*C);
11 disp('The value of resistor R is = '+string(R)+'
  ohm ');
```

Scilab code Exa 13.9 Design a monostable circuit with frequency 25KHz

```
1
2 //Example13.9 // Design a monostable circuit with
  frequency f = 25 KHz
3 clc;
4 clear;
5 close;
6 f =25*103 ; // Hz
7
8 // The output frequency of monostable multivibrator
  is defined as
9 // f = 1/(0.69*R*C);
10 C = 0.1*10-6 ;
11 R = 1/(0.69*f*C);
```

```

12 disp('The value of resistance R is = '+string(R)+ '
      ohm ');
13
14 // In the practical monostable multivibrator
15 // ln(1+(R2/R1))= 0.69 ;
16 R1 = 10*10^3 ; // we choose
17 R2 = R1*(1.99372-1);
18 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

```

1 //Example13.10 // Determine the frequency of the
  monostable multivibrator
2 clc;
3 clear;
4 close;
5 R1 = 5*10^3 ;
6 R2 =15*10^3 ;
7 C = 0.01*10^-6 ;
8 R = 12*10^3 ;
9
10 // the output of monostable multivibrator is defined
    as
11 f = 1/(R*C*(log(1+(R2/R1))));
12 disp('the output of monostable multivibrator is = '
      +string(f)+ ' Hz');

```

Scilab code Exa 13.11 Determine the frequency of the monostable multivibrator

```
1 //Example13.11 // Determine the frequency of the
   monostable multivibrator
2 clc;
3 clear;
4 close;
5 R1 = 5*103 ;
6 R2 =15*103 ;
7 C = 0.01 ;
8 R = 25 ;
9
10 // the output of monostable multivibrator is defined
   as
11 f = 1/(R*C);
12 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

```
1 //Example14.1 // to determine the regulated voltage
2 clc;
3 clear;
4 close;
5 R1 = 250 ; //ohm
6 R2 = 2500 ; // ohm
7 Vref = 2 ; //V //reference voltage
8 Iadj = 100*10^-6; // A // adjacent current
9
10 //the output voltage of the adjustable voltage
    regulator is defined by
11 Vo = (Vref*((R2/R1)+1)+(Iadj*R2)) ;
12 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


```

1 //Example14.2 // to determine the current drawn from
   the dual power supply
2 clc;
3 clear;
4 close;
5 V = 10 ; // V
6 P = 500 ; // mW
7
8 // we assume that each power supply provides half
   power supply to IC
9 P1 = (P/2);
10
11 // the total power dissipation of the IC
12 // P1 = V*I ;
13 I = P1/V ;
14 disp('the total power dissipation of the IC is = '+
   string(I)+' mA ');

```

Scilab code Exa 14.3 to determine the output voltage

```

1 //Example14.3 // to determine the output voltage
2 clc;
3 clear;
4 close;
5 R1 = 100*103 ; //ohm
6 R2 = 500*103 ; // ohm
7 Vref = 1.25 ; //V //reference voltage
8
9 //the output voltage of the adjustable voltage
   regulator is defined by
10 Vo = Vref*(R1+R2)/R1;
11 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

```
1 //Example14.4 // determine the output voltage of the
   switching regulator circuit
2 clc;
3 clear;
4 close;
5 d = 0.7 ; // duty cycle
6 Vin = 5 ; // V // input voltage
7
8 // The output voltage of switching regulator circuit
   is given by
9 Vo = d*Vin ;
10 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

```
1 //Example14.5 // determine the duty cycle of the
   switching regulator circuit
2 clc;
3 clear;
4 close;
5 Vo = 4.8 ; // V // output voltage
6 Vin = 5 ; // V // input voltage
7
8 // The output voltage of switching regulator circuit
   is given by
9 // Vo = d*Vin ;
10
```

```

11 // Duty cycle is given as
12 d =Vo/Vin ;
13 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

```

1 //Example14.6 // determine the duty cycle of the
  switching regulator circuit
2 clc;
3 clear;
4 close;
5 T =120 ; //msec // total pulse time
6 // T = ton + toff ;
7 ton = T/2 ;
8
9 // The duty cycle of switching regulator circuit is
  given by
10 d = ton/T;
11 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

```

1 //Example14.7 // determine the duty cycle of the
  switching regulator circuit
2 clc;
3 clear;
4 close;
5 ton = 12 ; //msec // on time of pulse
6 // ton = 2*toff ; given

```

```

7 // T = ton + toff ;
8 toff = ton/2 ;
9 T = ton+toff ; // total time
10
11 // The duty cycle of switching regulator circuit is
    given by
12 d = ton/T;
13 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

```

1 // Example14.8 // determine the output voltage of
    the audio power amplifier IC LM380
2 clc;
3 clear;
4 close;
5 Vcc = 12 ; // V
6 Ic3 = 12*10^-6 ; // A // collector current of the
    transistor Q3
7 Ic4 = 12*10^-6 ; // A // collector current of the
    transistor Q4
8 R11 = 25*10^3 ; // ohm
9 R12 = 25*10^3 ; // ohm
10
11 // the collector current of Q3 is defined as
12 //  $I_{c3} = (V_{cc} - 3*V_{eb}) / (R_{11} + R_{12})$ ;
13  $V_{eb} = (V_{cc} - (R_{11} + R_{12}) * I_{c3}) / 3$  ;
14 disp('The emitter bias voltage is = '+string(Veb)+'
    V ');
15
16 // the output voltage of the IC LM380
17  $V_o = (1/2) * V_{cc} + (1/2) * V_{eb}$ ;
18 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

```
1 // Example14.9 // determine the output voltage of
  the audio power amplifier IC LM380
2 clc;
3 clear;
4 close;
5 Vcc = 10 ; // V
6 Ic3 = 0.01*10^-6 ; // A // collector current of
  the transistor Q3
7 Ic4 = 0.01*10^-6 ; // A // collector current of
  the transistor Q4
8 R11 = 25*10^3 ; // ohm
9 R12 = 25*10^3 ; // ohm
10
11 // the collector current of Q3 is defined as
12 // Ic3 = (Vcc-3*Veb)/(R11+R12);
13 Veb = (Vcc-(R11+R12)*Ic3)/3 ;
14 disp('The emitter bias voltage is = '+string(Veb)+'
  V ');
15
16 // the output voltage of the IC LM380
17 Vo = (1/2)*Vcc+(1/2)*Veb;
18 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

1

```

2 // Example14.10 // Design a video amplifier of IC
   1550 circuit
3 clc;
4 clear;
5 close;
6 Vcc = 12 ; // V
7 Av = -10 ;
8 Vagc = 0 ; // at bandwidth of 20 MHz
9 hfe = 50 ; // forward emitter parameter
10 rbb = 25 ; // ohm // base resistor
11 Cs = 1*10^-12 ; // F // source capacitor
12 Cl = 1*10^-12 ; // F // load capacitor
13 Ie1 = 1*10^-3 ; // A // emitter current of Q1
14 f = 1000*10^6 ; // Hz
15 Vt = 52*10^-3 ;
16 Vt1 = 0.026 ;
17
18 // When Vagc =0 the transistor Q2 is cut-off and the
   collector current of transistor Q2 flow through
   the transistor Q3
19 // i.e Ic1=Ie1=Ie3
20 Ie3 = 1*10^-3 ; // A // emitter current of Q3
21 Ic1 = 1*10^-3 ; // A // collector current of the
   transistor Q1
22
23 // it indicates that the emitter current of Q2 is
   zero Ie2 = 0 then the emitter resistor of Q2 is
   infinite
24 re2 = %inf ;
25
26 // emitter resistor of Q3
27 re3 = (Vt/Ie1);
28 disp('The emitter resistor of Q3 is = '+string(re3)+
   ' ohm ( at temperature 25 degree celsius) ');
29
30 // the trans conductance of transistor is
31 gm = (Ie1/Vt1);
32 disp('The trans conductance of transistor is = '+

```

```

    string(gm*1000)+' mA/V '); // Round Off Error
33
34 // the base emitter resistor rbe
35 rbe = (hfe/gm);
36 disp('The base emitter resistor rbe is = '+string(
    rbe/1000)+' K ohm '); // Round Off Error
37
38 // the emitter capacitor Ce
39 Ce = (gm/(2*pi*f));
40 disp('The emitter capacitor Ce = '+string(Ce)+' F ');
    ; // Round Off Error
41
42 // the voltage gain of video amplifier is
43 // Av = (Vo/Vin) ;
44 // Av = -((alpha3*gm)/(rbb*re3)*((1/rbb)+(1/rbe)+sCe
    )*((1/re2)+(1/re3)+sC3)*((1/Rl)+(s(Cs+Cl))))
45 // At Avgc = 0 i.e s=0 in the above Av equation
46 alpha3 = 1 ;
47 s = 0 ;
48 // Rl = -((alpha3*gm)/(rbb*re3)*(((1/rbb)+(1/rbe))
    *((1/re2)+(1/re3))*(Av)));
49
50 // After solving above equation for Rl We get Rl
    Equation as
51 Rl = 10/(37.8*10^-3);
52 disp('The value of resistance RL is = '+string(Rl)+'
    ohm ');
53
54 // there are three poles present in the transfer
    function of video amplifier each pole generate
    one 3-db frequency
55 Rl = 675 ;
56 // fa = 1/(2*pi*Rl*(Cs+Cl));
57 // after putting value of Rl ,Cs and Cl we get
58 fa = 1/(2*3.14*264.55*1*10^-12);
59 disp('The pole frequency fa is = '+string(fa
    *10^-3/1000)+' M Hz '); // Round Off Error
60

```

```

61
62 //fb = 1/(2*%pi*Ce*((rbb*rbe)/(rbb+rbe)));
63 // after putting value of Ce rbb and rbe we get
64 fb = 1/(2*%pi*6.05*10^-12*24.5);
65 disp('The pole frequency fb is = '+string(fb
        *10^-3/1000)+' M Hz ');
66
67 fc = 1/(2*%pi*Cs*re3);
68 disp('The pole frequency fc is = '+string(fc
        *10^-3/1000)+' M Hz ');
69
70 disp(' Hence fa is a dominant pole frequency ');

```

Scilab code Exa 14.11 Design a video amplifier of IC 1550 circuit

```

1 // Example14.11 // Design a video amplifier of IC
  1550 circuit
2 clc;
3 clear;
4 close;
5 Vcc = 12 ; // V
6 Av = -10 ;
7 Vagc = 0 ; // at bandwidth of 20 MHz
8 hfe = 50 ; // forward emitter parameter
9 rbb = 25 ; // ohm // base resistor
10 Cs = 1*10^-12 ; // F // source capacitor
11 Cl = 1*10^-12 ; // F // load capacitor
12 Ie1 = 1*10^-3 ; // A // emitter current of Q1
13 f = 1000*10^6 ; // Hz
14 Vt = 52*10^-3 ;
15 Vt1 = 0.026 ;
16
17 // When Vagc =0 the transistor Q2 is cut-off and the
  collector current of transistor Q2 flow through
  the transistor Q3

```



```

18 // i.e Ic1=Ie1=Ie3
19 Ie3 = 1*10-3 ; // A // emitter current of Q3
20 Ic1 = 1*10-3 ; // A // collector current of the
    transistor Q1
21
22 // it indicates that the emitter current of Q2 is
    zero Ie2 = 0 then the emitter resistor of Q2 is
    infinite
23 re2 = %inf ;
24
25 // emitter resistor of Q3
26 re3 = (Vt/Ie1);
27 disp('The emitter resistor of Q3 is = '+string(re3)+
    ' ohm ');
28
29 // the trans conductance of transistor is
30 gm = (Ie1/Vt1);
31 disp('The trans conductance of transistor is = '+
    string(gm)+ ' A/V ');
32
33 // the base emitter resistor rbe
34 rbe = (hfe/gm);
35 disp('The base emitter resistor rbe is = '+string(
    rbe)+ ' ohm ');
36
37 // the emitter capacitor Ce
38 Ce = (gm/(2*%pi*f));
39 disp('The emitter capacitor is = '+string(Ce)+ ' F ')
    ;
40
41 // the voltage gain of video amplifier is
42 // Av = (Vo/Vin) ;
43 // Av = -((alpha3*gm)/(rbb*re3)*((1/rbb)+(1/rbe)+sCe
    )*((1/re2)+(1/re3)+sC3)*((1/Rl)+(s(Cs+Cl))))
44 // At Avgc = 0 i.e s=0 in the above Av equation
45 alpha3 = 1 ;
46 s = 0 ;
47 Av = -10 ;

```

```

48 Rl = -((alpha3*gm)/((rbb*re3)*((1/rbb)+(1/rbe))
        *((1/re2)+(1/re3))*(Av))));
49 Rl = (1/Rl);
50 disp('The value of resistance RL is = '+string(Rl)+'
        ohm ');
51
52 // there are three poles present in the transfer
        function of video amplifier each pole generate
        one 3-db frequency
53 Rl = 265
54 fa = 1/(2*pi*Rl*(Cs));
55 disp('The pole frequency fa is = '+string(fa)+' Hz ');
56
57
58 fb = 1/(2*pi*Ce*((rbb*rbe)/(rbb+rbe)));
59 disp('The pole frequency fb is = '+string(fb)+' Hz ');
60
61 fc = 1/(2*pi*Cs*re3);
62 disp('The pole frequency fc is = '+string(fc)+' Hz ');
63
64 disp(' Hence fa is a dominant pole frequency ');

```

Scilab code Exa 14.12 Determine the output voltage of an isolation amplifier IC ISO100

```

1 // Example14.12 // Determine the output voltage of
        an isolation amplifier IC ISO100
2 clc;
3 clear;
4 close;
5 Vin = 5 ; // V
6 Rin = 10*10^3 ;

```

```

7 Rf = 55*10^3 ; // ohm // feedback resistance
8
9 // the input voltage of an amplifier 1
10 // Vin = Rin*Iin
11 Iin = Vin/Rin ;
12 disp('The input current is = '+string(Iin)+' A ');
13
14 // In isolation amplifier ISO 100 the input current
    Iin is equal to the output current Iout , but
    both are opposite in direction
15 // Iin = -Iout
16 // the output of an op-amp
17 // Vo = -Rf*Iout
18 Vo = Rf*Iin;
19 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

```

1 // Example14.13 // Determine the output voltage of
    an isolation amplifier IC ISO100
2 clc;
3 clear;
4 close;
5 Vin = 12 ; // V
6 Rin = 1*10^3 ;
7 Rf = 17*10^3 ; // ohm // feedback resistance
8
9 // the input voltage of an amplifier 1
10 // Vin = Rin*Iin
11 Iin = Vin/Rin ;
12 disp('The input current is = '+string(Iin)+' A ');
13
14 // In isolation amplifier ISO 100 the input current

```

```
    Iin is equal to the output current Iout , but
    both are opposite in direction
15 // Iin = -Iout
16 // the output of an op-amp
17 // Vo = -Rf*Iout
18 Vo = Rf*Iin;
19 disp('The output of an op-amp is = '+string(Vo)+' V
    ');
```
