

Scilab Textbook Companion for
Electronic Instrumentation
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November 8, 2019

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: Electronic Instrumentation

Author: H. S. Kalsi

Publisher: Tata McGraw-Hill, New Delhi

Edition: 2

Year: 2006

ISBN: 0070583706

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 1

Qualities of Measurements

Scilab code Exa 1.1 To calculate 1 Absolute error 2 Percentage of error 3 Relative

```
1 //Exa 1.1 a
2
3 clc;
4 clear all;
5
6 Yn=80; //voltage across a resistor (Volts)
7 Xn=79; //Measured voltage (Volts)
8
9 //solution
10 e=Yn-Xn; //absolute error
11 Pe=(Yn-Xn)/Yn *100; // % error
12 A=1-abs((Yn-Xn)/Yn); //relative accuracy
13 a=100*A;
14 printf('Absolute Error = %d V \n Percentage Error =
        %.2f percent\n Relative accuracy = %.4f \n
        Percentage of accuracy = %0.2f percent \n',e,Pe,A
        ,a);
15 disp("");
```

Scilab code Exa 1.2 To calculate the precision of the 6th measurement

```
1 //Exa 1.2
2
3 clc;
4 clear all;
5
6 //Referring to table 1.1– Set of 10 measurements that
   were recorded in the laboratory.
7
8 X={98;101;102;97;101;100;103;98;106;99}; //From
   table 1.1
9
10 //solution
11 X_n= mean(X); //Average value
12 Prec=1-abs((X(6)-X_n)/X_n); //precision of 6th
   reading
13 printf('The precision of 6th measurement = %0.3f \n'
   ,Prec);
```

Scilab code Exa 1.3 To calculate apparent and actual value of resistances along wi

```
1 // Exa 1.3 a
2
3 clc;
4 clear all;
5
6 Sv=1000; //voltmeter sensitivity(ohm/V)
7 Vt=80; //Voltage across unknown resistance (V)
8 It=10; //Current through unknown resistance (mA)
9 Scale=150; //Volts
10
11 //solution
12
13 //Neglecting milliammeter resistance
```

```

14 Rt=Vt/It; //Total circuit resistance(K ohm)
15 Rv=Sv*Scale/1000; //Voltmeter resistance(K ohm/V)
16 Rx=Rt*Rv/(Rv-Rt); //actual value of unknown
    resistance(K ohm)
17 err=(Rx-Rt)/Rx *100;
18 printf('Apparent value of resistance = %d K ohm \n
    Actual value of resistance = %.2f K ohm \n
    Percentage error = %.1f percent \n',Rt,Rx,err);
19 disp("");
20
21 // Exa 1.3b
22
23 Sv=1000; //voltmeter sensitivity(ohm/V)
24 Vt=30; //Voltage across unknown resistance (V)
25 It=600; //Current through unknown resistance (mA)
26 Scale=150; //Volts
27
28 //solution
29
30 //Neglecting milliammeter resistance
31 Rt=Vt/(It*10^-3); //Total circuit resistance(ohm)
32 Rv=Sv*Scale; //Voltmeter resistance(ohm/V)
33 Rx=Rt*Rv/(Rv-Rt); //actual value of unknown
    resistance(ohm)
34 err=(Rx-Rt)/Rx *100;
35 printf('Apparent value of resistance = %d ohm \n
    Actual value of resistance = %.3f ohm \n
    Percentage error = %.3f \n',Rt,Rx,err);
36 disp("In Example1.3a, a well calibrated voltmeter
    may give a misleading resistance when connected
    across two points in a high resistance circuit.")
37 disp("The same voltmeter, when connected in a low
    resistance circuit(Examole 1.3b) may give a more
    dependable reading. This shows that voltmeters
    have a loading effect in the circuit during
    measurement.");
38 // In the 1.3b example, the answer mentioned in the
    textbook for Rx and percent error is incorrect.

```

Scilab code Exa 1.4 To calculate arithmetic mean along with deviation of each value

```
1 // Exa 1.4
2
3 clc;
4 clear all;
5
6 // Given data
7 x1= 49.7;
8 x2= 50.1;
9 x3= 50.2;
10 x4= 49.6;
11 x5= 49.7;
12
13 // solution
14
15 X_mean= (x1+x2+x3+x4+x5)/5; // Arithmetic mean
16
17 d1= x1-X_mean;
18 d2= x2-X_mean; // deviation from each value
19 d3= x3-X_mean;
20 d4=x4-X_mean;
21 d5=x5-X_mean;
22
23 d_total= d1+d2+d3+d4+d5; //Algebraic sum of
    deviations
24
25 printf('The arithmetic mean is %.2f \n \n',X_mean);
26 printf(' Deviation from x1 is %.2f \n ',d1);
27 printf('Deviation from x2 is %.2f \n ',d2);
28 printf('Deviation from x3 is %.2f \n ',d3);
29 printf('Deviation from x4 is %.2f \n ',d4);
30 printf('Deviation from x5 is %.2f \n \n',d5);
31 printf(' The algebraic sum of deviation is %d \n ',
```

```
d_total);
```

Scilab code Exa 1.5 To find the average deviation for given data

```
1 // Exa 1.5
2 //Data taken from Exa 1.4 as stated
3
4 clc;
5 clear all;
6
7 // Given data
8
9 x1= 49.7;
10 x2= 50.1;
11 x3= 50.2;
12 x4= 49.6;
13 x5= 49.7;
14 n= 5; // number of x values
15
16 // solution
17
18 X_mean= (x1+x2+x3+x4+x5)/5; // Arithmetic Mean
19 d1= x1-X_mean;
20 d2= x2-X_mean; // deviation from each value
21 d3= x3-X_mean;
22 d4=x4-X_mean;
23 d5=x5-X_mean;
24
25 D_av= (abs(d1)+abs(d2)+abs(d3)+abs(d4)+abs(d5))/n;
    //Average deviation
26 printf('The average deviation = %.3f \n',D_av);
```

Scilab code Exa 1.6 To find the standard deviation for the data given

```

1 // Exa 1.6
2 //Data taken from Eg 1.4 as stated
3
4 clc;
5 clear all;
6
7 // Given data
8
9 x1= 49.7;
10 x2= 50.1;
11 x3= 50.2;
12 x4= 49.6;
13 x5= 49.7;
14 n= 5; // number of x values
15
16 // solution
17
18 X_mean= (x1+x2+x3+x4+x5)/5; // Arithmetic Mean
19 d1= x1-X_mean;
20 d2= x2-X_mean; // deviation from each value
21 d3= x3-X_mean;
22 d4=x4-X_mean;
23 d5=x5-X_mean;
24
25 Std_dev= sqrt((d1^2+d2^2+d3^2+d4^2+d5^2)/(n-1)); //
    Standard deviation
26 printf('The standard deviation = %.2f \n',Std_dev);

```

Scilab code Exa 1.7 To calculate the limiting error

```

1 // Exa 1.7
2
3 clc;
4 clear all;
5

```

```

6 // Given data
7
8 Range= 600; //volgmeter range(volts)
9 Accu= 0.02; //Accuracy
10 X= 250; //voltage to be measured(volts)
11
12 // Solution
13
14 Mag= Accu * Range; //magnitude of limiting error
15 X_mag = Mag/X * 100; // limiting error at 250V
    inpercentag
16
17 printf('Limiting error when instrument is used to
    measure at 250V = %.1f percentage \n',X_mag);

```

Scilab code Exa 1.8 To determine the limiting error of the power

```

1 // Exa 1.8
2
3 clc;
4 clear all;
5
6 // Given data
7
8 X= 100; // Range of voltmeter(V)
9 x= 70; // Measured value on voltmeter(V)
10 Y= 150; // Range of milliammeter
11 y= 80; // Measurex d value on milliammeter
12 Accu= 0.015; // Accuracy of instruments
13
14 // Solution
15
16 X_mag= Accu*X; //Magnitude of limiting error for
    voltmeter
17 Y_mag= Accu*Y; // Magnitude of limiting error for

```

```
    milliammeter
18 x_mag= X_mag/x; // limiting error at 70V
19 y_mag= Y_mag/y; // limiting error at 80mA
20
21 disp("Limiting error for the power calculation is
       the sum of the individual limiting errors
       involved");
22 printf(' Therefore , limiting error = %.3f percentage
       \n',(x_mag+y_mag)*100);
23 // The answer vary due to round off error
```

Chapter 2

Indicators and Display Devices

Scilab code Exa 2.1 To calculate the deflecting torque and deflection angle

```
1 // Exa 2.1
2
3 clc;
4 clear all;
5
6 // Given data
7
8 N= 100; // Number of turns
9 W=20; // Width of coil(mm)
10 D= 30; // Depth of coil(mm)
11 B= 0.1; // Flux density (wb/m^2)
12 I= 10; // Current in coil(mA)
13 K= 2*10^-6; // Spring constant(Nm/degree)
14
15 // Solution
16 A= W*10^-3*D*10^-3; // Area of coil(m^2)
17 Td= B*N*A*I*10^-3; // Deflecting torque(Nm)
18 disp("As deflecting torque = restoring torque(K*
      Theta)");
19 Theta= Td/K;
20 printf(' The deflecting torque = %.1f * 10^-6 Nm \n '
```

```
    , Td*10^6);  
21 printf('Therefore, the deflection = %d degrees \n '  
    , Theta);
```

Chapter 3

Ammeters

Scilab code Exa 3.1 To calculate the value of shunt resistance

```
1 // Exa 3.1
2
3 clc;
4 clear all;
5
6 // Given data
7
8 Rm= 100; // Internal resistance in Ohm's
9 Im= 1; // Full scale deflection current in
    milliAmpere
10 I= 100; // Total current in milli Ampere
11
12 // Solution
13
14 Rsh= (Im*Rm)/(I-Im); // Shunt resistance
15 printf('The value of shunt resistance = %.2f Ohm \n
    ', Rsh);
```

Scilab code Exa 3.2 To design an Ayrton shunt

```

1 // Exa 3.2
2
3 clc;
4 clear all;
5
6 // Given data
7
8 //Refer fig. 3.4
9 Rm=100; //Ohms
10 Im=50; ///micro Amp
11
12 // Solution
13
14 //For 0-1mA range
15 // Ish*Rsh=Im*Rm;
16 disp("The four linear equations are as follows:");
17 printf(' R1+R2+R3+R4 = %.2 f \n ',50*100/950); //
    say-equation (3.1)
18
19 //For 0-10 mA range
20 printf(' R1+R2+R3-(50/9950)*R4= % .3 f \n '
    ,100*50/9950); //say-equation (3.2)
21
22 //For 0-50 mA range
23 printf(' R1+R2-(50/49950)*R3-(50/49950)*R4 = %.3 f \n
    ' ,100*50/49950); //say-equation (3.3)
24
25 //For 0-100mA range
26 printf(' R1-(50/99950)*R2-(50/99950)*R3-(50/99950)*
    R4 = %.3 f \n ' ,50*100/99950); //say-equation (3.4)
27
28 //converting it into matrix form
29 A=[1 1 1 1;1 1 1 -(50/9950);1 1 -(50/49950)
    -(50/49950);1 (-50/99950) (-50/99950)
    (-50/99950)];
30
31 B=[-50*100/950 ; -100*50/9950 ; -100*50/49950 ;
    -50*100/99950];

```

```
32
33 [R,y]=linsolve(A,B);A*R+B; //linear equaion solving
    function
34
35 disp("The value of R1,R2 R4 and R4 are given as
    follows-");
36 printf(' R1 = %.5 f Ohms \n R2= %.5 f Ohms \n R3= %.5
    f Ohms \n R4= %.5 f Ohms \n ',R(1),R(2),R(3),R(4)
    );
37
38 // The value of R3 vary due to round off errors
```

Chapter 4

Voltmeters and Multimeters

Scilab code Exa 4.1 To calculate the sensitivity

```
1 // Exa 4.1
2
3 clc;
4 clear all;
5
6 // Given data
7
8 Iful = 200; // Fullscale deflection current in micro
             // Amperes
9 Sen= 1/(Iful*10^-3) ; // Sensitivity of Voltmeter(K
                       // Ohms/V)
10
11 // Solution
12
13 printf(' The sensitivity of the voltmeter = %d k
         // Ohms/V \n',Sen);
```

Scilab code Exa 4.2 Determine the value of multiplier resistance

```

1 // Exa 4.2
2
3 clc;
4 clear all;
5
6 // Given data
7
8 Iful= 50; // Fullscale deflection current in micro
           Amperes
9 Rm= 500; // Internal resistance in Ohms
10 V= 10; // Full range voltage of instrument(Volts)
11
12 // Solution
13
14 Rs= V/(Iful *10^-6)-Rm; // Multiplier resistance
15
16 printf('The value of multiplier resistance = %.1f k
           Ohms\n',Rs/1000);

```

Scilab code Exa 4.3 To convert a basic D Arsonval movement into a multirange dc vo

```

1 // Exa 4.3
2
3 clc;
4 clear all;
5
6 // Given data
7 // Refer Fig. 4.3 on page no. 77
8
9 Rm=50; // Internal resistance of Voltmeter(ohms)
10 Ifsd=2; // full sclae deflection current(mA)
11
12 //Solution
13
14 // For 10V range(V4 position of switch)

```

```

15 V1=10; //Volts
16 Rt1=V1/(Ifsd*10^-3); //total resistance in k Ohms
17 R4=Rt1-Rm;
18 printf('The value of R4 = %d Ohms \n',R4);
19 // For a 50V range(V3 position of switch)
20 V2=50; //Volts
21 Rt2=V2/(Ifsd*10^-3);
22 R3=Rt2-(R4+Rm);
23 printf(' The value of R3 = %d k Ohms \n',R3/1000);
24
25 // For 100V range(V2 position of switch)
26 V3=100; //Volts
27 Rt3=V3/(Ifsd*10^-3); //total resistance in k Ohms
28 R2=Rt3-(R3+R4+Rm);
29 printf(' The value of R2 = %d k Ohms \n',R2/1000);
30 // For a 250V range(V3 position of switch)
31 V4=250; //Volts
32 Rt4=V4/(Ifsd*10^-3);
33 R1=Rt4-(R2+R3+R4+Rm);
34 printf(' The value of R1 = %d k Ohms \n',R1/1000);

```

Scilab code Exa 4.4 To calculate the value of multiplier resistance

```

1 // Exa 4.4
2
3 clc;
4 clear all;
5
6 // Given data
7
8 Iful= 200; // Full scale deflection current in micro
           Amperes
9 Rm= 100; // Internal resistance of the movement in
           Ohms
10 Range= 50; // Voltage range

```

```

11
12 // Solution
13
14 S= 1/(Iful * 10^-6); // Sensitivity of voltmeter is
    ohms/volt
15 // Rs=S*Range-Rm ;
16 Rs=S*Range-Rm; // Multiplier resistance
17
18 printf(' The value of multiplier resistance = %.1f K
    Ohms \n', Rs/1000);

```

Scilab code Exa 4.5 To calculate the value of multiplier resistance for multiple r

```

1 // Exa 4.5
2
3 clc;
4 clear all;
5 // Refer circuit diagram in Fig. 4.5 page no.79
6
7 // Given data
8
9 Ifsd=50; // Full scale deflection current (micro Amp
    )
10 Rm= 1000; // Internal resistance in Ohms
11 V1= 5; // Range of voltmeter 1 (V)
12 V2=10; //Range of voltmeter 2 (V)
13 V3=50; // Range of voltmeter 3 (V)
14
15 // Solution
16
17 S= 1/(Ifsd*10^-6); // Sensitivity of voltmeter in
    Ohms/V
18 // The value of multiplier resistance for different
    ranges
19

```

```

20 // For 5V range
21 Rs1= S*V1-Rm;
22
23 // For 10V range
24 Rs2= S*V2-Rm;
25 // For 50V range
26 Rs3=S*V3-Rm;
27
28 printf(' The value of multiplier resistance for 0-5V
, 0-10V and 0-50V range are \n %d k Ohms, %d k
Ohms, %d k Ohms respectively \n ',Rs1/1000, Rs2
/1000, Rs3/1000);

```

Scilab code Exa 4.6 To determine which voltmeter can give accurate value of voltage

```

1 // Exa 4.6
2
3 clc;
4 clear all;
5 // Referring Fig. 4.6- Example on loading effect
from page no.81
6
7 // Given data
8 R1=10000; // Ohms
9 R2=10000; // Ohms
10 V=100; // Applied Voltage
11
12 // Solution
13
14 VR2= R2/(R1+R2)* V; // True Voltage across R2
resistance
15 printf('True voltage across R2 = %d V \n ',VR2);
16
17 // Case-1 : Using a voltmeter 1 having sensitivity
of 1000 Ohms/V

```

```

18
19 S1=1000; // Sensitivity in Ohms/volt
20 R21=S1*VR2; //R2 resistance on its 50 V range(Ohms)
21 Req1=R21*R2/(R21+R2);// Equivalent resistance across
    R2(ohms)
22 printf('Connecting the meter 1 across R2 causes an
    equivalent parallel resistance given by %.2f k
    Ohms \n ',Req1/1000);
23 V21=Req1/(Req1+R2) * V;
24 printf('Now the voltage across the total combination
    is given by %.2f V \n ',V21);
25
26 // Case-2 : Using a voltmeter having sensitivity of
    20,000 Ohms/V
27
28 S22=20000; // Sensitivity in Ohms/volt
29 R22=S22*VR2; // R2 resistance on its 50V range(Ohms)
30 Req2=R22*R2/(R22+R2);// Equivalent resistance across
    R2(ohms)
31 printf('Connecting the meter 2 across R2 causes an
    equivalent parallel resistance given by %.2f k
    Ohms \n ',Req2/1000);
32 V22=Req2/(Req2+R2) * V;
33 printf('Now the voltage across the total combination
    is given by %.2f V \n ',V22);
34
35 disp(" This example shows that a high sensitivity
    voltmeter(i.e voltmeter 2 in this case) should
    be used to get accurate readings");
36 // The answers vary due to riund off error.

```

Scilab code Exa 4.7 To determine voltage across Rb with both meters along with the

```

1 // Exa 4.7
2

```

```

3  clc;
4  clear all;
5  // Referring circuit given in fig. 4.7 on page no.81
6
7  S1=1000; // Sensitivity of meter 1 (Ohms/volt)
8  S2=20000; // Sensitivity of meter 2(Ohms/volt)
9  Rm1=200; // Meter resistance(Ohms)
10 Rm2=1500; // Meter resistance(Ohms)
11 V1=10; // Range of voltmeter 1(Volts)
12 V2=10;
13 Ra=25000; // in Ohms
14 Rb=5000; // in Ohms
15 V=30; // Applied Voltage(V)
16
17 //Solution
18
19 VRb= Rb/(Ra+Rb) * V; // Voltage across Rb
20 printf('The voltage across the resistance Rb,
    without either meter connected = %d V\n ',VRb);
21
22 // For meter 1
23 Rt1=S1* V1; // Total resistance of meter1
24
25 Req1= Rb*Rt1/(Rb+Rt1); // Total resistance across Rb
26 VRb1= Req1/(Req1+Ra) * V; // Voltage reading across
    Rb with meter1
27 printf('The voltage across Rb when meter 1 is used
    is = %.2f V \n ',VRb1);
28 Err1=(VRb-VRb1)/VRb *100; // Voltmeter 1 error
29 printf(' Voltmeter 1 error in percentage = %.1f \n
    ',Err1);
30
31 // For meter 2
32
33 Rt2=S2* V2; // Total resistance of meter 2
34
35 Req2= Rb*Rt2/(Rb+Rt2); // Total resistance across Rb
36 VRb2= Req2/(Req2+Ra) * V; // Voltage reading across

```

```

    Rb with meter2
37 printf('The voltage across Rb when meter 2 is used
    is = %.1f V \n',VRb2);
38
39 Err2=(VRb-VRb2)/VRb *100; // Voltmeter 2 error
40 printf(' Voltmeter 2 error in percentage = %d \n ',
    Err2);

```

Scilab code Exa 4.8 To calculate voltage reading and percentage error on different

```

1 // Exa 4.8
2
3 clc;
4 clear all;
5
6 // Given data
7
8 Ra= 45; // in k Ohms
9 Rb=5; // in k Ohms
10 V=50; // Supplied Voltage(V)
11 S=20; // sensitivity in k Ohms/V
12
13 // Solution
14
15 VRb=Rb/(Ra+Rb) * V;
16 printf('The voltage drop across Rb without the
    voltmeter connected is = %d V\n',VRb);
17
18 // On the 5V range
19 Range1 = 5; // Volts
20
21 Rm1=S*Range1; // k Ohms
22 Req1=Rm1*Rb/(Rm1+Rb); // k Ohms
23 VRb1=Req1/(Req1+Ra) *V; // Voltage across Rb on 5V
    range

```

```

24 printf(' The voltmeter reading on 5V range is = %.3f
      V\n',VRb1);
25 Err1=(VRb-VRb1)/VRb * 100;
26 printf(' Percentage error on 5V range in percentage
      = %.2f \n',Err1);
27
28 // On 10V range
29
30 Range2 = 10; // Volts
31
32 Rm2=S*Range2;// k Ohms
33 Req2=Rm2*Rb/(Rm2+Rb); // k Ohms
34 VRb2=Req2/(Req2+Ra) *V; // Voltage across Rb on 10V
      range
35 printf(' The voltmeter reading on 10V range is = %.3
      f V\n',VRb2);
36 Err2=(VRb-VRb2)/VRb * 100;
37 printf(' Percentage error on 10V range in percentage
      = %.3f \n',Err2);
38
39 // On 30V range
40
41 Range3 = 30; // Volts
42
43 Rm3=S*Range3;// k Ohms
44 Req3=Rm3*Rb/(Rm3+Rb); // k Ohms
45 VRb3=Req3/(Req3+Ra) *V; // Voltage across Rb on 30V
      range
46 printf(' The voltmeter reading on 30V range is = %.3
      f V \n',VRb3);
47 Err3=(VRb-VRb3)/VRb * 100;
48 printf(' Percentage error on 30V range in percentage
      = %.1f \n',round(Err3));
49
50 disp(" In this example, the 30V range introduces the
      least error due to loading. However, the voltage
      being measured causes only a 10% full scale
      deflection , whereas on the 10V range the applied

```

```

    voltage causes approximately a one third of the
    fullscale deflection with less than 3% error.”);
51 //The answers vary due to round off error

```

Scilab code Exa 4.9 To calculate the value of multiplier resistance

```

1 // Exa 4.9
2
3 clc;
4 clear all;
5
6 // Given data
7 // As per values given in Fig.4.19(page no.94)
8
9 ein=10; // Input RMS voltage(V)
10 Ifsd=1; // Full scale deflection current(mA)
11 Rm=200; // Internal resistance of voltmeter(Ohms)
12
13 // Solution
14
15 Range=0.45*ein; // Range of Voltmeter
16 Sdc=1/(Ifsd*10^-3); // DC Sensitivity of meter
    movem(k Ohm/V)
17 Rs=Sdc* Range-Rm; // Multiplier resistance(Ohm)
18 printf(' The value of the multiplier resistor = %.1f
    k Ohms\n',Rs/1000);

```

Scilab code Exa 4.10 To calculate the value of multiplier resistance

```

1 // Exa 4.10
2
3 clc;
4 clear all;

```

```

5
6 // Given data
7
8 Vin=10; // Input RMS voltage(V)
9 Ifsd=1; // Full scale deflection current(mA)
10 Rm=250; // Internal resistance of voltmeter(ohms)
11
12 // Solution
13
14 Sdc=1/(Ifsd*10^-3); // DC sensitivity(K ohm/V)
15 Sac=0.9*Sdc; //AC sensitivity(k Ohm/V)
16 Rs=Sac*Vin-Rm; // Multiplier resistor(Ohm)
17 printf(' The value of multiplier resistor = %.2f k
        Ohms \n',Rs/1000);

```

Scilab code Exa 4.11 To find the value of R1 and R2 along with max value of R2 to

```

1 // Exa 4.11
2
3 clc;
4 clear all;
5
6 // Given data
7 Rm=100; // Meter resistance(Ohms)
8 Ifsd=1; // Full scale deflection current(mA)
9 Rh=2000; // Half of full scale deflection resistance
        (Ohms)
10 V=3; // Internal battery voltage(V)
11
12 // Solution
13 // Using equations 4.1 and 4.2 given on page no. 104
14
15 R1=Rh-Ifsd*10^-3*Rh/V ; // Current limiting
        resistance(Ohms)
16 R2= Ifsd*10^-3*Rm*Rh/(V-Ifsd*10^-3*Rh); // Zero

```

```
    adjust resistance(Ohms)
17  V1= V-0.05*V; // Voltage after 5 percent drop in
    battery voltage
18  R3=Ifsd*10-3*Rh*Rm/(V1-Ifsd*10-3*Rh); // Maximum
    value of R2 to compensate drop in battery
19
20  printf(' The values of R1 and R2 are %.1f Ohms and
    %d Ohms respectively \n ',R1,R2);
21  printf('The maximum value of R2 to compensate for a
    5 percentage drop \n in battery voltage is =%.2f
    Ohms \n',R3);
```

Chapter 5

Digital Voltmeters

Scilab code Exa 5.1 To determine the voltage at output of integrator after 1 sec

```
1 // Exa 5.1
2
3 clc;
4 clear all;
5
6 // Given data
7
8 R=100; // in k Ohms
9 C=1; //in micro farads
10 ei=1; // Applied voltage to integrator (V)
11 t1=1; // time in Sec
12
13 // Solution
14
15 // Using equation 5.1 from page no. 118
16 eo=ei*t1/(R*103*C*10-6); // Output voltage from
    integrator
17 printf(' The voltage at output of integrator after 1
    sec is = %d Volts \n',eo);
```

Scilab code Exa 5.2 To find the time interval of t2

```
1 // Exa 5.2
2
3 clc;
4 clear all;
5
6 // Given data
7 // With reference to data given in Exa 5.1
8
9 ei=1; // Applied input voltage to integrator(V)
10 t1=1; // sec
11
12 // Given data
13
14 er=5; // Reference voltage applied at time t1 to
    integrator(V)
15
16 // Solution
17 // Using equation 5.3 from page no. 118
18
19 t2=ei/er * t1; // Time interval t2(sec)
20 printf(' The time interval of t2 is = %.1f sec \n',
    t2);
```

Scilab code Exa 5.3 To find resolution of a three and half digit display on 1V and

```
1 // Exa 5.3
2
3 clc;
4 clear all;
5
```

```

6 // Given data
7 // 3 1/2 digit display
8
9 V1=1; // Volts
10 V2=10; //Volts
11
12 // Solution
13 disp("Number of full digits is 3.");
14 n=3; //Full digits
15 Reso=1/10^n;
16 printf(' Resolution = %.3f . Hence, meter cannot
        distinguish two values if their difference is
        less than %.3f \n ',Reso,Reso);
17 printf('For full scale reading of 1V, the resolution
        is %.3f V \n ',V1*Reso);
18 printf('For full scale reading of 10V, the
        resolution is %.2f V \n ',V2*Reso);

```

Scilab code Exa 5.4 To find the resolution and how output will be displayed on 1V

```

1 // Exa 5.4
2
3 clc;
4 clear all;
5
6 // Given data
7
8 n=4; // Number of full digits
9 V1=12.98; //Reading 1 to be measured(V)
10 V2=0.6973; //Reading 2 to be measured(V)
11
12 // Solution
13
14 Reso=1/10^n; //Resolution
15 printf(' Resolution is %.4f \n ',Reso);

```

```
16 disp("There are 5 digit places in 4 and 1/2 digits
    display , therefore 12.98      would be displayed
    as 12.980");
17 disp("");
18 printf(' Resolution on 1V range = %.4f. Any reading
    upto the 4th decimal can be displayed \n ',1*Reso
    );
19 disp("Therefore. 12.98 would be displayed as 12.980
    and 0.6973 will be displayed as 0.6973");
20 disp("");
21 printf(' Resolution on 10V range = %.3f. Therefore.
    12.98 would be displayed as 12.98 \n ',10*Reso);
22 disp("Therefore on a 10V range ,the reading of 0.6973
    would be displayed as 0.697 instead of 0.6973");
```

Chapter 7

Oscilloscope

Scilab code Exa 7.1 To determine the peak to peak amplitude of the signal

```
1 // Exa 7.1
2
3 clc;
4 clear all;
5
6 // Given data
7 // Referring to waveform shown in fig 7.50 on page
   211
8
9 V_attn= 0.5; // Vertical attenuator(V/div)
10 div=3; // No of vertical divisions
11
12 // Solution
13
14 // Using equation :  $V_{p-p}=(\text{volts/div}) * (\text{no. Of div} / 1)$ ;
15
16 Vp_p=V_attn * div/1 ;
17
18 printf(' The peak to peak amplitude of the signal =
   %.1f Volts \n',Vp_p);
```

Scilab code Exa 7.2 To determine the frequency of the signal

```
1 // Exa 7.2
2
3 clc;
4 clear all;
5
6 //Given data
7 // Referring waveform shown in fig 7.50 on page no.
   211
8
9 div=4; // No of horizontal divisions for One cycle
10 // Given data
11 time_div= 2; // Time per div control in micro sec/
   div
12
13 // Solution
14
15 // The period of signal is given as  $T=(\text{time}/\text{div}) *(\text{No of div/ cycle})$ ;
16 T=time_div *10-6 * div/1 ; // Time period is
   calculated over 1 cycle
17 F= 1/T; // Frequency is inverse of time period
18
19 printf(' The frequency of signal = %d kHz \n',F
   /1000);
```

Chapter 10

Measuring Instruments

Scilab code Exa 10.1 To find the value of distributed capacitance and value of inductance

```
1 // Exa 10.1
2
3 clc;
4 clear all;
5
6 // Given data
7
8 // 1st measurement
9 f1=1; // in MHZ
10 C1=500; // in pf
11 // 2nd measurement
12 f2=2; //in MHZ
13 C2=110; // in pf
14
15 // Solution
16 // Using equation 10.2(page no. 278) to calculate
    distributed Capacitance
17
18 Cs=(C1-4*C2)/3; // Distributed capacitance in pf
19 printf('The value of distributed capacitance = %d pf
    \n',Cs);
```

```

20 // using equation of resonant frequency given as f1
    =1/(2*%pi*sqrt(L*(C1+Cs)));
21 // Therefore
22 L=1/(4*(%pi)^2*f1^2*(C1+Cs)); // Inductor value
23
24 printf(' The value of L(inductor) is =%.3f micro H \
    n',L*10^6);

```

Scilab code Exa 10.2 To determine the value of self capacitance

```

1 // Exa 10.2
2
3 clc;
4 clear all;
5
6 // Given data
7
8 f1=2; // in MHz
9 f2=6; // in MHz
10 C1=500; // in pf
11 C2=50; // in pf
12
13 // Solution
14
15 disp(" Given that f2=3*f1");
16 disp(" Therefore by using equation 10.1");
17 disp(" 1/(2*%pi*sqrt(L*(C2+Cs)) = 3/(2*%pi*sqrt(L*(
    C1+Cs)))");
18 disp(" Therefore");
19 disp(" C1+Cs=9(C2+Cs)");
20 //Therefore Cs is given as
21 Cs=(C1-9*C2)/8;// Self capacitance in pf
22 printf(' \nThe value of the self capacitance is = %
    .2f pf \n', Cs);

```

Chapter 11

Bridges

Scilab code Exa 11.1 To find the unknown resistance Rx

```
1 // Exa 11.1
2
3 clc;
4 clear all;
5
6 // Given data
7
8 // Wheatstone's bridge circuit
9 R1=10; // k Ohms
10 R2=15; // k Ohms
11 R3=40; // k Ohms
12
13 // Solution
14 // From the equation (11.4) of balanced bridge we
    have
15
16 Rx=R2*R3/R1; // Unknown resistance Rx
17 printf(' The unknown resistance Rx is = %d k Ohms \n
    ',Rx);
```

Scilab code Exa 11.2 To calculate the current through galvanometer

```
1 // Exa 11.2
2
3 clc;
4 clear all;
5
6 // Given data
7 //Referring fig. 11.5 – Unbalanced Wheatstone bridge
8
9 R1=1; // in k Ohms
10 R2= 2.5; // in k Ohms
11 R3=3.5; // in k Ohms
12 R4=10; // in k Ohms
13 V= 6; // Applied Voltage(V)
14 Rg=0.3; // Galvanometer resistance in k Ohms
15
16 // Solution
17
18 // Eth=Ea-Eb ; \\ Thevenin's equivalent voltage
19 Eth=V*(R4/(R2+R4) - R3/(R1+R3));
20 Rth=(R1*R3/(R1+R3)) + (R2*R4/(R2+R4)) ;
21 // Referring the equivalent circuit connected along
    with the galvanometer as shown in fig. 11.6
22 Ig=Eth/(Rth+Rg) ; // Current through galvanometer
23 printf(' The current through galvanometer is = %.2f
    micro Amp \n', round(Ig*10^3));
24 //The answer vary due to round off error
```

Scilab code Exa 11.3 To calculate the current through galvanometer by approximation

```
1 // Exa 11.3
```

```

2
3 clc;
4 clear all;
5
6 // Given data
7
8 // Referring Fig. 11.9(page no.311) – slightly
   unbalanced Wheatstone bridge
9 R= 700; // in Ohms
10 Dell_R= 35; // in Ohms
11 E=10; // Supplied voltage(V)
12 Rg=125; //Internal resistance of galvanometer(Ohms)
13
14 // Solution
15
16 Eth= E*Dell_R/(4*R) ; // Thevenin's equivalent
   voltage(V)
17 Rth=R; // Thevenin's equivalent resistance(Ohms)
18 Ig= Eth/(Rth+Rg); // Current through galvanometer(
   Amp)
19 printf(' The current through galvanometer by the
   approximation method is %.1f micro Amp \n',Ig
   *10^6);

```

Scilab code Exa 11.4 To find value of Rx

```

1 // Exa 11.4
2
3 clc;
4 clear all;
5
6 // Given data
7 // Referring Fig. 11.12(page no.315)– Kelvin's bridge
8
9 Ra_b=1000; // The ratio of Ra to Rb

```

```

10 R1= 5; // in Ohms
11
12 // Solution
13
14 // We have  $R1=0.5*R2$ 
15  $R2=R1/0.5$ ;
16
17 //From the eqation for Kelvin 'd bridge–  $Rx*Ra=Rb*R2$ 
18  $Rx=R2*(1/1000)$ ; // Unknown resistance
19 printf(' The value of Rx = %.2 f Ohm \n ',Rx);

```

Scilab code Exa 11.5 To determine temperature at which bridge is balanced and ampl

```

1 // Exa 11.5
2
3 clc;
4 clear all;
5
6 // Given data
7 // Refering circuit in Fig. 11.15(a) and graph in
   11.15(b) on page no.317
8
9 R1=5; // k Ohms
10 R2=5; //k Ohms
11 R3= 5; // k Ohms
12 E=6; // Applied voltage (V)
13
14 // Solution
15
16 // The value of Rv when bridge is balanced is
   calculated as
17  $Rv=R2*R3/R1$ ;
18 printf(' The value of Rv = %d K Ohms \n' , Rv);
19 disp(" From the graph, the temperature at which
   bridge is balanced is = 80          degree celsius");

```

```

20 disp(" From the graph , the resistance Rv for
      balancing bridge at 60 degree celcius comes out
      to be 4.5 k Ohms ");
21 // Therefore
22 Rv1=4.5; // Resistance Rv at 60 degree celcius(K
      ohms)
23 es=E*(R3/(R1+R3) - Rv1/(R2+Rv1) ); // Error signal
24 printf(' The amplitude of error signal at 60 degree
      celsius is = %.3f V \n',es);

```

Scilab code Exa 11.6 To find the equivalent series circuit of the unknown impedance

```

1 // Exa 11.6
2
3 clc;
4 clear all;
5
6 // Given data
7 f=2; // kHz
8 C3=100; // micro farads
9 R1=10; // k Ohms
10 R2=50; // k Ohms
11 R3=100; // k Ohms
12
13 // Solution
14
15 // Using equations 11.12(a) and 11.12(b) (page no.
      321)to find values of Rx and Cx
16
17 Rx=R2*R3/R1;
18 Cx=R1/R2 *C3;
19
20 printf(' The equivalent circuit consist of
      resistance Rx of %d K ohms \n in series with a
      capacitor Cx of %d micro farads \n',Rx,Cx);

```

Scilab code Exa 11.7 To find the equivalent series circuit of the unknown impedance

```
1 // Exa 11.7
2
3 clc;
4 clear all;
5
6 // Given data
7
8 C1=0.01; // micro farads
9 R1=470; // k Ohms
10 R2=5.1; // k Ohms
11 R3=100; // k Ohms
12
13 // Solution
14 // Using equation 11.15 given on page no. 324 to
    find Rx and Lx
15
16 Rx=R2*R3/R1;
17 Lx=R2*R3*C1;
18
19 printf(' The series equivalent of the unknown
    impedance consist of series combination\n of Rx
    = %.2f k Ohms and Lx= %.1f H \n' , Rx, Lx);
```

Scilab code Exa 11.8 To find the series equivalent inductance and resistance of the

```
1 // Exa 11.8
2
3 clc;
4 clear all;
```

```

5
6 // Given data
7
8 w=3000; // Angular frequency in rad/s
9 R2=10*10^3; // Ohms
10 R1= 2*10^3; // Ohms
11 C1=1*10^-6; // farads
12 R3=1*10^3; // Ohms
13
14 // Solution
15
16 // Using equations 11.19 and 11.18 (page no.326) to
    find values of Rx and Lx
17
18 Rx=w^2*R1*R2*R3*C1^2/(1+w^2*R1^2*C1^2);
19 Lx=R2*R3*C1/(1+w^2*R1^2*C1^2);
20
21 printf(' The series equivalent inductance and
    resistance of the network consist of\n Rx of %.2
    f k Ohms and Lx of %d mH \n',Rx/1000,Lx*10^3);

```

Scilab code Exa 11.9 To determine the unknown capacitance and dissipation factor

```

1 // Exa 11.9
2
3 clc;
4 clear all;
5
6 // Given data
7
8 // Referring Fig. 11.26(page no.328) – an AC bridge(
    SCHERING'S BRIDGE)
9
10 R1= 1; // k Ohms
11 C1=0.5; // micro farads

```

```

12 R2=2; // k Ohms
13 C3=0.5; // micro farads
14 f= 1000; // Hz
15
16 // Solution
17 // Using Equations 11.20(a) and 11.20(b) given on
    page no. 328 we get value Rx and Cx
18
19 Rx=C1/C3*R2; // in k Ohms
20 Cx=R1/R2 * C3; // in micro farads
21
22 D=2*%pi*f*Cx*10^-6/Rx*10^3; // Dissipation factor
23
24 printf(' The unknown capacitance Cx is equal to %.2f
    micro farads\n ',Cx);
25 printf(' The dissipation factor = %.4f \n ',D);

```

Scilab code Exa 11.10 To find the equivalent parallel resistance and capacitance of

```

1 // Exa 11.10
2
3 clc;
4 clear all;
5
6 // Given data
7
8 // Wien's bridge
9 R1=3.1; // k Ohms
10 C1=5.2; // micro farads
11 R2=25; // k Ohms
12 f=2.5; // kHz
13 R4=100; // k Ohms
14
15 // Solution
16

```

```
17 w=2*pi*f; // Angular frequency
18 // Substituting the value of C3 from Eq. 11.22(page
    no. 330) in Eq.11.21(pagr no. 330) to get value
    of R3 as follows
19 R3=R4/R2 *(R1+1/(w^2*R1*C1^2));
20 // Also we can get C3 from Eq. 11.22(page no. 330)
21 C3=1/(w^2*C1*R1*R3);
22 printf(' The parallel resistance of %.1f K ohms and
    capacitance of %.1f pf\n      causes a Wien bridge
    to null with values of given component values. \
n',R3,C3*10^6);
```

Chapter 12

Recorders

Scilab code Exa 12.1 To determine the frequency of the signal

```
1 // Exa 12.1
2
3 clc;
4 clear all;
5
6 // Given data
7
8 Chart_speed=40; // in mm/sec
9 Time_base=5; // in mm
10
11 // Solution
12
13 Period= Time_base/Chart_speed;
14 frequ=1/Period;
15 printf(' The frequency of the signal = %d cycles/sec
        \n',frequ);
```

Scilab code Exa 12.2 To find chart speed to record on 5mm of recording paper

```
1 // Exa 12.2
2
3 clc;
4 clear all;
5
6 // Given data
7
8 fre=20; // in Hz
9 Time_base=5*10^-3; // in
10
11 // Solution
12
13 Period=1/fre; // in sec
14 // Since period= timebase/ chart speed;
15 Chart_speed=Time_base/Period; // in mm/sec
16
17 printf(' The chart speed used to record one complete
        cycle on 5mm of recording paper =%.1f mm/sec \n
        ',Chart_speed*10^3);
```

Chapter 13

Transducers

Scilab code Exa 13.1 To find the value of output voltage

```
1 // Exa 13.1
2
3 clc;
4 clear all;
5
6 // Given data
7 // Refer circuit given in Fig no.13.2(b) given on
   page no.381
8
9 Shaft=3; // Shaft stroke in inches
10 Wiper=0.9; // in inches
11 R=5; // Total resistance(R1+R2) in K ohms
12 Vt=5; // Applied voltage in volts
13
14 // Solution
15
16 R2=Wiper/Shaft * R ; // in k Ohms
17 // Since  $V_o/V_t=R_2/(R_1+R_2)$ ;
18 // Therefore
19  $V_o=R_2/(R) * V_t$ ; // Output Voltage(R1+R2)
20 printf(' The output voltage = %.1f V \n',Vo);
```

Scilab code Exa 13.2 To find the new value of V_c

```
1 // Exa 13.2
2
3 clc;
4 clear;
5
6 // Given data
7 Ra=5; // (R1+R2) in k Ohms
8 Rb=5; // (R3+R4) in k Ohms
9 Vt=5; // Applied voltage (V)
10 Shaft=5; // Shaft distance in inches
11
12 // Solution
13
14 disp(" As given , wiper moves 0.5 inch towards A from
      the centre , it will have moved 3 inches from B")
      ;
15 Wiper=3; // Wiper movement from B in inches
16 Wiper1=2.5; //Wiper movement from A in inches
17 R2=Wiper/Shaft * R; // in k Ohms
18 R4=Wiper1/Shaft * R; // in k Ohms
19 //Ve=VR2-VR4
20 Vc=(R2/(Ra)) *Vt - (R4/(Rb)) * Vt;
21
22 printf(' The new value of Vc= %.1f V \n',Vc);
```

Scilab code Exa 13.3 To calculate the change in resistance

```
1 // Exa 13.3
2
```

```

3  clc;
4  clear all;
5
6  // Given data
7
8  K=2; // Gauge factor
9  strain=1*10^-6; // Ratio of change in length to
    original length
10 R=130; // Resistance in Ohms
11
12 // Solution
13
14 // As K = ratio of dell R/R to dell L/L
15 Dell_R =K*R*strain ; // Change in resistance
16 printf(' The change in resistance = %d micro Ohms \n
    ',Dell_R*10^6);

```

Scilab code Exa 13.4 To find the meter reading at 77 degree fahrenheit and at 150

```

1  // Exa 13.4
2
3  clc;
4  clear all;
5
6  // Given data
7
8  R= 4; // Resistance of thermistor in k Ohms
9  R1=0.003; // Meter resistance in k Ohms
10 Rc=0.017; // in k Ohms
11 Vt=15; // in Volts
12
13 // Solution
14
15 // From fig. 13.2(b)– graph of Temp vs Resistance we
    find that ,thermistor resistance at 25 degree

```

```

        Celsius is 4 K ohms and at 65.5556 degree
        Celsius it is 950 ohms.
16 R_25= 4; // in k Ohms
17 R_65=0.95; // in k Ohms
18
19 I1=Vt/(R_25+R1+Rc); // current at 25 degree Celsius(
    A)
20 I2=Vt/(R_65+R1+Rc); // current at 65.556 degree
    Celsius(A)
21
22 printf(' The current meter reading at 25 degree
    Celsius = %.2f mA and at 150 degree fahrenheit =
    %.1f mA \n ', I1,I2);

```

Scilab code Exa 13.5 To calculate the output voltage vs core position for various

```

1 // Exa 13.5
2
3 clc;
4 clear all;
5
6 // Given data
7
8 Input=6.3; // V
9 Output=5.2; // V
10 Range= 9.5; // inches
11
12 // Solution
13
14 // 0.5 inches core displacement produces 5.2 V
15 // Therefore, a 0.45 inch movement produces voltage
    as
16 V1=0.45*5.2/0.5;
17 // Similarly – 0.30 inches core movement produces
    voltage as

```

```

18 V2=-0.30*-5.2/(-0.5); // V
19 // Also -0.25 inch core movement produces voltage as
20 V3=-0.25*-5.2/(-0.5); // V
21
22 printf('The core movement of 0.45 inch produces
        voltage of %.2f V and\n movement of -0.30 inch
        produces voltage of %.2f V \n' ,V1,V2);
23 printf(' The core movement of -0.25 inch from the
        centre produces voltage of %.1f V \n',V3);

```

Scilab code Exa 13.6 To calculate the amount of electrical energy to be applied

```

1 // Exa 13.6
2
3 clc;
4 clear all;
5
6 // Given data
7
8 K=0.32; // Coupling co efficient
9 Op=1; // Output in oz.in.
10
11 // Solution
12
13 // 1 oz.in.= 1 oz.in. * (1 ft/12 in.) * (1 lb/16 oz)
        * (1.3561/1 ft lb) = 7.06*10-3 J ;
14
15 Elec_mech= 7.06*10-3; // Electrical energy
        converted to mechanical energy(J)
16 Ee=Elec_mech/K; // Applied Electrical energy
17 printf(' The electrical energy of %.2f mJ must be
        applied \n',Ee*103);
18 // The answer mentioned in the book is incorrect

```

Scilab code Exa 13.7 To calculate the required series resistance along with the da

```
1 // Exa 13.7
2
3 clc;
4 clear all;
5
6 // Given data
7 // Referring circuit in fig. 13.7(a) and graph in fig
   .13.7(b) on page no.422
8
9 I=10; // mA
10 V=30; // Volts
11 Illumination=400; // in l/m^2
12
13 // Solution
14
15 disp(" From graph(13.7(b) , cell resistance at 400 l
   /m^2 is 1 K ohms");
16 Rcell=1; // K ohms
17
18 R1=V/I - Rcell; //Required series resistance
19
20 Rdark=100; //Cells dark resistance in K ohms
21 Idark=V/(R1+Rdark); // Dark current
22 printf(' The required series resistance and dark
   current level are %d K ohms amd %.1f mA
   respectively \n',R1,Idark);
```

Chapter 14

Signal Conditioning

Scilab code Exa 14.1 To design a differentiator and draw its output waveform

```
1 // Exa 14.1
2
3 clc;
4 clear all;
5
6
7 // Given data
8
9 fa=800; // The highest frequency(Hz)
10 Vp=2; //Volts
11
12
13 // Solution
14 disp("Let C1=0.1 micro farads")
15 C1=0.1; // micro farads
16 // Then Rf is given as
17 Rf=1/(2*%pi*C1*10^-6*fa); // Ohms
18 printf(' Calculated value of Rf = %.3f k Ohms.
        selecting nearest higher value of 2.2 k Ohms \n '
        ,Rf/1000);
19
```

```

20 fb=20*fa;
21 R1=1/(2*%pi*C1*10^-6*fb); // Ohms
22 printf('The calculated value of R1 = %.1f Ohms. Let
      R1=100 Ohms \n',R1);
23
24 // Since R1*C1=Rf*Cf
25 Cf=R1*C1*10^-6/2200; //Rf is taken as 2.2 k Ohms as
      stated above
26 printf(' The value of Cf = %.5f micro farads. Let Cf
      =0.0047 micro farads \n',Cf*10^6);
27
28 Rom=(1/100+1/2200)^-1;
29 printf(' Rom = %.1f Ohms \n',Rom);
30
31 t=0:0.1*10^-3:1.5*2.50*10^-3;
32
33 Vin=Vp*sin(2*%pi*fa*t); //Input Voltage equation
34 xlabel("Time(sec)");
35 ylabel("Voltage(V)");
36 title("Input Voltage");
37 plot2d(t,Vin);
38 figure(1);
39
40 Vo=-2200*0.1*10^-6*Vp*2*%pi*fa*cos(2*%pi*800*t); //
      Output voltage equation
41 xlabel("Time(sec)");
42 ylabel("Voltage(V)");
43 title("Output Voltage");
44 plot2d(t,Vo);
45 // The answers vary due to round off error

```

Scilab code Exa 14.2 To determine the output voltage of opamp

```

1 // Exa 14.2
2

```

```

3  clc;
4  clear;
5
6  // Given data
7
8  Va=2; // Volts
9  Vb=1; // Volts
10 Vc=3; // Volts
11 Ra=3; // k Ohms
12 Rb=3; // k Ohms
13 Rc=3; // k Ohms
14 Rf=1; // k Ohms
15 Rom=270; // Ohms
16 Supply=15; // Volts
17
18 // Solution
19
20 disp(" Assuming that the opamp is initially nulled")
    ;
21 // Using equation 14.8 to determine the output
    voltage
22 Vo=- (Rf/Ra *Va+Rf/Rb *Vb+Rf/Rc *Vc);
23 printf(' The output voltage = %d Volts \n',Vo);

```

Scilab code Exa 14.3 To determine the output voltage at 0 degree celsius and 100 d

```

1  // Exa 14.3
2
3  clc;
4  clear all;
5
6  // Given data
7
8  R1=2.2; // k Ohms
9  Rf=10; // k Ohms

```

```

10 R=120; // (Ra=Rb=Rc) k Ohms
11 E=5; // Volts
12 Vcc=15; // Volts
13 Rt=120; // k Ohms at reference temperature of 25
    degree celsius
14 Tco=- 1; // Temperature co-efficient in K/degree
    celsius

15
16 // Given data
17
18 disp(" At 25 degree celsius , Ra=Rb=Rc=120 K.
    Therefore , the bridge is balanced and Va=Vb.
    Therefore , Vo=0.");
19 Delta_R=Tco*(0-25);
20 // For 0 degree celsius
21 printf(' At 0 degree celsius the change delta_R in
    the resistance of the thermistor is %d k Ohms \n
    ',Delta_R);

22
23 Vo=-(Delta_R)*E*Rf/(2*(2*R+Delta_R)*R1);
24 printf(' The output voltage at 0 degree celsius = %
    .2f Volts \n ',Vo);
25 // For 100 degree celsius
26 Delta_R1=Tco*(100-25);
27 Vo1=-(Delta_R1)*E*Rf/(2*(2*R+Delta_R1)*R1);
28
29 printf(' The output voltage at 100 degree celsius =
    %.2f Volts \n ',Vo1);

```

Scilab code Exa 14.4 To determine the change in resistance of each gauge element

```

1 // Exa 14.4
2 // Refer circuit 14.25 given on page no. 484
3
4 clc;

```

```

5 clear all;
6
7 // Given data
8
9 E=10; // Volts
10 R=50; // Unstrained gauge resistance (Ohms)
11 Gain=100; // Amplifier gain
12 Vo=1.5; // Output Voltage
13
14 // Solution
15
16 // Using the formula: Vo=E*(Delta_R/R)*gain
17
18 Delta_R=Vo*R/(E*Gain); // Change in resistance
19
20 printf('The change in resistance =%.2f Ohms\n This
        means that Rt1 and Rt3 decrease by 0.07 ohms \n
        and Rt2 and Rt4 increase by 0.07 ohms when a
        certain weight is placed on the scale platform\n',
        Delta_R);
21 // The answer mentioned in the textbook is incorrect
    as R=50 Ohms and not 100 Ohms.

```

Chapter 15

Filters

Scilab code Exa 15.1 To design a low pass filter

```
1 //Exa 15.1
2
3 clc;
4 clear all;
5
6
7 // Given data
8 Fh=2; // kHz
9 Af=2; // Pass band gain
10
11 // Solution
12
13 disp(" Let C1= 0.01 micro farads ");
14 C=0.01; //micro farads
15 R=1/(2*%pi*Fh*C); // k Ohms
16 printf(' The calculated value of R is %.3f K ohms.
        Nearest practical value for R1 is 8.2 k Ohms\n',R
        );
17 // Af=1+Rf/R1;
18 // As Af=2. So, Rf=R1
19 disp(" In this case , Rf=R1= 10 k Ohms is selected ")
```

);

Scilab code Exa 15.2 To calculate the value of resistance

```
1 // Exa 15.2
2
3 clc;
4 clear all;
5
6 // Given data
7
8 Wc=20*10^3; // Angular cutoff frequency in rad/s
9 C=0.01*10^-6; //in farads
10
11 // Solution
12
13 // As Wc=1/(R*C);
14 R=1/(Wc*C);
15
16 printf(' The value of resistance required = %d k
        Ohms \n',R/1000);
```

Scilab code Exa 15.3 To design a second order low pass filter

```
1 // Exa 15.3
2
3 clc;
4 clear all;
5
6 // Given data
7
8 Fh= 2*10^3; // Cutoff frequency in Hz
9
```

```

10 // Solution
11
12 disp(" Let C2=C3=0.0033 micro farads ");
13
14 // Fh=1/(2*%pi*R*C); where R=R2=R3 and C2=C3=C;
15 C=0.0033*10^-6; // farads
16 // Therefore
17 R=1/(2*%pi*Fh*C);
18 printf(' Calculated value of R = %.1f K ohms. Let ,
        R=R2=R3=22 k Ohms is selected\n',R/1000);
19 // Since Rf/R1=0.586, therefore Rf=0.586*R1;
20 // Let fix value of R1 as
21 R1=10*10^3; // Ohms
22 Rf=0.586*R1;
23 printf(' The remaining components after calculation
        comes out to be as Rf= %.2f k Ohms and R1= %d k
        Ohms \n',Rf/1000,R1/1000);

```

Scilab code Exa 15.4 To determine the low cuoff frequency of second order high pass

```

1 // Exa 15.4
2
3 clc;
4 clear all;
5
6 // Given data
7 // Second order filter
8
9 R=47*10^3; // Ohms(R2=R3=R)
10 C=0.0022*10^-6; // farads(C2=C3=C)
11
12 // Solution
13
14 F1=1/(2*%pi*R*C); //low cutoff frequency(Hz)
15 printf(' The low cutoff frequency for a high pass

```

```
filter =%.2f kHz\n',F1/1000);
```

Scilab code Exa 15.5 Design a wide band pass filter and to calculate the value of

```
1 // Exa 15.5
2
3 clc;
4 clear all;
5
6 // Given data
7
8 F1=100; // lower cutoff frequency in Hz
9 Fh=1000; // higher cutoff frequency in Hz
10 Af=4; // pass band gain
11
12 // Solution
13
14 // Wide bandpass filter design
15 // 1. For a low pass filter  $F_h=1 \text{ KHz} = 1/(2*\%pi*R*C)$ ;
16
17 disp(" For a low pass filter section");
18 disp(" Let C1=0.01 micro farads ");
19 C1=0.01; // micro farads
20 R1=1/(2*%pi*Fh*C1*10^-6);
21 printf('The value of resistor = %.1f K ohms \n',R1
        /1000);
22
23 // 2. For a high pass filter  $F_l=100 \text{ Hz}=1/(2*\%pi*R*C)$ 
        ;
24 disp(" For a high pass filter section");
25 disp(" Let C2=0.01 micro farads ");
26 C2=0.01; // micro farads
27 R2=1/(2*%pi*F1*C2*10^-6);
28 printf(' The value of resistor = %d K ohms \n',R2
        /1000);
```

```

29
30 disp(" Since the pass band gain is 4, the gain of
    the high pass and low pass filter sections are
    set each equal to 2. Therefore , R1=Rf=10 K ohms
    for both sections.");
31
32 // Q for filter
33 Fc=sqrt(F1*Fh);
34
35 Q=Fc/(Fh-F1);
36 printf(' The value of Q =%.2f which is less than 10,
    as expected for a wide band pass filter\n',Q);

```

Scilab code Exa 15.6 Design a narrow band pass filter

```

1 // Exa 15.6
2
3 clc;
4 clear all;
5
6 //Given data
7 // Referring fig. 15.17– Narrow band pass filter
8
9 Fc=1; // kHz
10 Q=5; //Quality factor
11 Avo=8; //Voltage gain
12 Fc1=1.5;//New centre frequency(kHz)
13
14 // Solution
15
16 disp(" Let C1=C2=C3=C(say)=0.01 micro farads");
17 C=0.01;//micro farads
18 // But
19 R1=Q/(2*%pi*Fc*10^3*C*10^-6*Avo); // From eqn. 15.45
    on page no.530

```

```

20 R2=Q/(2*%pi*Fc*10^3*C*10^-6*(2*Q^2-Avo)); // From eqn
    . 15.47 on page no. 530
21 R3=Q/(%pi*Fc*10^3*C*10^-6); // From eqn. 15.46 on
    agr no. 530
22 printf(' The Values of R1, R2 and R3 are %.3f k Ohms
    (approx 10 k Ohms), %.3f k Ohms(approx 2 k Ohms
    and %.3f k Ohms(aprox 159 k Ohms) respectively\n'
    ,R1/1000,R2/1000,R3/1000);
23 // To change Fc to Fc1 we simply have to change R2
    to R21 given as
24 R21=2000*(Fc/Fc1)^2; // since R2=2 k Ohms(approx)
25 printf(' The calculated value of new R2 to change
    Fc from 1 kHz to 1.5 kHz keeping Avo(Voltage gain
    ) and BW constant is = %.2f ohms (approx 820 Ohms
    ) \n',R21);

```

Scilab code Exa 15.7 Design a wide band reject filter

```

1 // Exa 15.7
2
3 clc;
4 clear all;
5
6 // Given data
7 // Refering fig. 15.20– Wide band reject filter
8
9 F1=100; // Hz
10 Fh=1000; // Hz
11
12 // Solution
13 // 1. For a high pass filter Fh=1 KHz =1/(2*%pi*R*C)
    ;
14 disp(" For a high pass filter section");
15 disp(" Let C1=0.01 micro farads ");
16 C1=0.01; // micro farads

```

```

17 R1=1/(2*pi*Fh*C1*10^-6);
18 printf(' The value of resistor = %.1f k Ohms \n',R1
    /1000);
19
20 // 2. For a low pass filter Fl=100 Hz=1/(2*pi*R*C);
21 disp(" For a low pass filter section");
22 disp(" Let C2=0.01 micro farads ");
23 C2=0.01; // micro farads
24 R2=1/(2*pi*Fl*C2*10^-6);
25 printf(' The value of resistor = %.1f k Ohms \n',R2
    /1000);
26
27 disp(" Since the pass band gain is 4, the gain of
    the high pass and low pass filter sections are
    set each equal to 2. Therefore , R1=Rf=10 k Ohmss
    for both section");
28 disp(" Further , the gain of the summing amplifier is
    set to 1, therefore R2=R3=R4=10 k Ohms"); // K
    ohms
29 R=10000; //Ohms(R=R2=R3=R4)
30 Rom=(1/R+1/R+1/R)^-1;
31 printf(' The value of Rom = %.1f k Ohms\n',Rom
    /1000);
32 // There is a printing mistake as c=0.1 micro fard
    is printed instead of 0.01 micro farad.

```

Scilab code Exa 15.8 Design a 50 Hz active notch filter

```

1 // Exa 15.8
2
3 clc;
4 clear all;
5
6 // Given data
7 // Active notch filter

```

```

8
9 Fn=50; //Notch out frequency(Hz)
10
11 // Solution
12
13 disp(" Let C=0.047 micro farads");
14 C=0.047; // micro farads
15 R=1/(2*%pi*Fn*C*10^-6);
16
17 printf(' The value of R is calculated as %d k Ohms
        \n',round(R/1000));
18 disp("For R/2, two 68 k Ohms resistors connected in
        parallel are used and for the 2C components, two
        0.047 micro farad capacitors connected in
        parallel are used.");

```

Scilab code Exa 15.9 To determine the phase angle for the all pass filter

```

1 // Exa 15.9
2
3 clc;
4 clear all;
5
6 // Given data
7 // Referring Fig. 15.2(a)- All pass filter
8 f=2.5; // Input frequency in kHz
9
10 // Solution
11
12 disp(" Let C=0.01 micro farads and R= 15 k Ohms");
13 C=0.01; // micro farads
14 R=15; // k Ohms
15 Phi=2*atan(2*%pi*f*C*R); // phase angle in radians
16
17 printf(' This means that the output voltage Vo has

```

the same frequency and amplitude as the input voltage but lags it by $-\phi$ degrees\n',Phi*180/%pi);

Scilab code Exa 15.10 To determine the values of the external components

```
1 // Exa 15.10
2
3 clc;
4 clear all;
5
6 // Given data
7 // Second order inverting Butterworth low pass
  filter
8 // Referring Table 15.1 and 15.3 in page no 517 and
  538 respectively
9
10 Af=6; // DC gain
11 Fc=1.5; // KHz
12 Q=10;
13
14 // Solution
15
16 disp(" According to Table 15.1, the inverting
  configurations would normally be used to give an
  inverting low pass output. However, to obtain a
  gain of 6, an inverting uncommitted opamp has to
  be used, hence the non-inverting filter
  configuration must be used.");
17
18 // From table 15.4 given on page no 538
19 R2=316/Q;
20 R3=100/(3.16*Q-1);
21 // R1 treated as open circuit
22 printf(' \n The R1 is open while R2 and R3 are %.1f
```

```

    ,k Ohms %.1f k Ohms respectively \n',R2,R3);
23 // From equations 15.54 given on page no 538 we get
    R4 and R5
24 R4=(5.03)*10^7/(Fc*10^3); //Ohms
25 R5=R4;
26 printf(' \n The calculated value of R4=R5=%.2f k
    Ohms \n',R4/1000);
27 disp(" use R4=R5=33 k Ohms");
28
29 disp(" Let R6=1.8 K ohms");
30 R6=1.8; // K ohms
31 R7=R6*Af;
32 R8=(1/R6 + 1/R7)^-1;
33
34 printf(' The values of R6 and R7 are %.1f k Ohms, %
    .3f K ohms respectively \n',R6,R7);
35 printf(' The value of R8 = %.3f k Ohms \n ',R8);

```

Scilab code Exa 15.11 Using FLT U2 design a notch filter

```

1 // Exa 15.11
2
3 clc;
4 clear all;
5
6 // Given data
7
8 Fc=4; // kHz
9 Q=8;
10
11 // Solution
12
13 disp(" The FLT-U2 can be used as a notch filter by
    summing the inverted output of the bandpass
    filter designed with the input signal by means of

```

```

    the uncommitted opamp.");
14
15 // From table 15.3 given on page no 538
16 R2=100;// k Ohms
17 R3=100/((3.40*Q)-1);
18 // R1 treated as open circuit
19 printf(' The R1 is open while R2 and R3 are %.1f , %
    .2f K ohms respectively \n',R2,R3);
20
21 // From equations 15.54 given on page no 538 we get
    R4 and R5
22 R4=(5.03)*10^7/(Fc*10^3);
23 R5=R4;
24 printf(' The calculated value of R4=R5=%.2f k Ohms
    (12 k Ohms) \n',R4/1000);
25 disp(" Let R6=R7=R8=10 K ohms ");
26 R=10000;//R=R6=R7=R8=10 k Ohms
27 R9=(1/R+1/R+1/R)^-1;
28 printf(' The value of R9 =%.2f K ohms \n',R9/1000);
29 disp(" The complete circuit diagram is shown in fig.
    15.26 on page no. 541.");
30 // The value of R3 vary due to round off error.

```

Chapter 16

Measurement Setup

Scilab code Exa 16.1 To calculate modulation index

```
1 // Exa 16.1
2
3 clc;
4 clear all;
5
6 // Given data
7
8 fd=75; // Frequency deviation in KHz
9 fm=5; // Frequency of modulating signal in kHz
10
11 // Solution
12
13 // From equation 16.5 (page no. 590) we calculate Mi
14     as
15 Mi=fd/fm; // Modulation index
16 printf(' The modulation index =%d \n',Mi);
```

Chapter 17

Data acquisition and conversion

Scilab code Exa 17.1 To determine the weights assigned to 1st 2nd and 3rd LSB and

```
1 // Exa 17.1
2
3 clc;
4 clear all;
5
6 // Given data
7 // A 5 bit resistive divider
8
9 n=5; // since 5 bit resistive divider
10 Ip1=[1 1 0 1 1]; // Digital input 1(1st element of
    array is MSB)
11 Ip2=[1 0 1 1 0]; // Digital input 2(1st element of
    array is MSB)
12 V1=10; // Voltage corresponding to binary 1
13 V0=0; // Voltage corresponding to binary 0
14
15 // Solution
16
17 LSB_weight=1/(2^n - 1);
18 printf('The LSB weight = %.4f \n ',LSB_weight);
19 LSB2_weight=2^(2-1)/(2^n-1);
```

```

20 printf('The 2nd LSB weight = %.4f \n ',LSB2_weight')
    ;
21 LSB3_weight=2^(3-1)/(2^n-1);
22 printf('The 3rd LSB weight = %.4f \n ',LSB3_weight')
    ;
23 LSB_op=V1*LSB_weight;// Change in output voltage due
    to change in LSB
24 printf('The change in output voltage due to change
    in LSB = %.4f V \n ',LSB_op);
25 LSB2_op=V1*LSB2_weight;
26 printf('The 2nd LSB causes a change in output
    voltage of %.4f V \n ',LSB2_op);
27 LSB3_op=V1*LSB3_weight;
28 printf('The 3rd LSB causes a change in output
    voltage of %.4f V \n ',LSB3_op);
29 Va=(V1*2^4+V1*2^3+V0*2^2+V1*2^1+V1*2^0)/(2^n-1);//
    output voltage for digital Ipl
30 Vb=(V1*2^4+V0*2^3+V1*2^2+V1*2^1+V0*2^0)/(2^n-1);
31 printf('The output voltage for a digital input 1 and
    2 are %.2f V and %.3f V respectively \n ',Va,Vb)
    ;

```

Scilab code Exa 17.2 To determine the output voltages for each bit

```

1
2 // Exa17.2
3
4 clc;
5 clear all;
6
7 // Given data
8
9 n=5;// 5 bit ladder
10 V=10;// For binary 1
11

```

```

12 // Solution
13 // referring table 17.4(page no. 615)–Various Output
    voltage for corresponding MSB
14
15 disp("The output voltage for each bit is as follows:
    ");
16 disp("");
17 for i=1:n
18 MSB(i)=V/2^i; //voltage corresponding to MSB i
19 printf(' %d MSB          Va = V/2^%d = %.4f V \n ',
    i,i, MSB(i));
20 end

```

Scilab code Exa 17.3 To calculate the output voltage

```

1 // Exa 17.3
2
3 clc;
4 clear all;
5
6 // Given data
7
8 Vin=5; // Input voltage(Volts)
9 Rin=2.5; // k Ohms
10 Rf=1; //k Ohms
11
12 // Solution
13
14 Iin=Vin/Rin; //Input current (mA)
15 If=Iin;
16 Vout=-If*Rf;
17
18 printf('The output voltage = %d Volts \n',Vout);

```

Scilab code Exa 17.4 To determine the output current for various 4 bit combination

```
1 // Exa 17.4
2
3 clc;
4 clear all;
5
6 // Given data
7 Vref=5; //Reference voltage (V)
8 R=5; // k Ohms
9
10 // Solution
11
12 disp("From fig. 17.18(c) , for a 4-bit D/A converter
      I=Vref/R* (D3+D2*2^-1+D1*2^-2+D0*^-3)");
13 //16-input combinations are as follows
14 Ip={ [0 0 0 0]; [0 0 0 1]; [0 0 1 0]; [0 0 1 1]; [0 1 0
      0]; [0 1 0 1]; [0 1 1 0]; [0 1 1 1]; [1 0 0 0]; [1 0 0
      1];
15 [1 0 1 0]; [1 0 1 1]; [1 1 0 0]; [1 1 0 1]; [1 1 1 0]; [1
      1 1 1]}; // [D3 D2 D1 D0 bits]
16
17 disp(" Input Bits          Output Current (mA)
      percent Fraction of maximum ");
18 for i=1:16
19 Iout(i)=Vref/R * (Ip(i,1)+Ip(i,2)*2^-1+Ip(i,3)*2^-2+
      Ip(i,4)*2^-3);
20
21 printf(' %d %d %d %d          %.3 f
      %.3 f      \n', Ip(i,1), Ip(i,2), Ip(i,3),
      Ip(i,4), Iout(i), (Iout(i)/1.875)*100); // 1.875(mA)
      is the highest output current
22 end
```

Chapter 20

Measurement of power

Scilab code Exa 20.1 To calculate the Rf test power

```
1 // Exa 20.1
2
3 clc;
4 clear all;
5
6 // Given data
7
8 V1=20; // superimposed small AF voltage(V)
9 V2=30; // Bridge balance voltage(V)
10 R1=100; // Bridge arm resistor(ohms)
11
12 // Solution
13
14 RF_pwr=(V2^2-V1^2)/(4*R1);
15 printf('RF test power = %.2f W \n',RF_pwr);
```

Scilab code Exa 20.2 To calculate the power radiated by a transmission line

```

1 // Exa 20.2
2
3 clc;
4 clear all;
5
6 // Given data
7
8 M=200; // mass in grams
9 Heat =1; //Sp. Heat of water(cal/gm degree)
10 T1=30; //Initial temperature (degree Celsius)
11 T2=40; //Final temperature (degree Celsius)
12
13 // Solution
14
15 Pwr_rad=4.18*M*Heat*(T2-T1); // in Watt
16 printf(' The power radiated = %.2f kW \n',Pwr_rad
        /1000);
17
18 // The answer in the textbook is mentioned as 8.3 kW
        but by calculation it comes out to be 8.36 kW.

```

Scilab code Exa 20.3 To determine the standing wave ratio

```

1 // Exa 20.3
2
3 clc;
4 clear all;
5
6 // Given data
7
8 Vmax=8; //Maximum value of voltage
9 Vmin=2; //minimum value of voltage
10
11 //Solution
12 SWR=(Vmax+Vmin)/(Vmax-Vmin); //Standing wave ratio

```

```
13 printf('Standing Wave Ratio = %.2f \n ',SWR);
```

Chapter 21

Control systems

Scilab code Exa 21.1 To find the percentage error in measurement

```
1 // Exa 21.1
2
3 clc;
4 clear all;
5
6 // Given data
7 Emax=20; //Max value of variable(mA)
8 Emin=4; //Min value of variable(mA)
9 Em=13; //Measured value of variable
10 Eref=10; //Set(ref) point of variable(mA)
11
12 // Solution
13 //Ep=(Em-Eref)/(Emax-Emin)*100; // Percentage error
    from page no.(703)
14 //Therefore
15 Ep=(Em-Eref)/(Emax-Emin)*100;
16 printf('The value of Ep = %.2f percent. Since Ep is
    positive, the measurement is above the set point
    \n ',Ep);
```
