Scilab Textbook Companion for Electronic Instrumentation by H. S. Kalsi[1]

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Book Description

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

Exa Example (Solved example)

Eqn Equation (Particular equation of the above book)

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

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

Contents

List of Scilab Codes

Chapter 1

Qualities of Measurements

Scilab code Exa 1.1 To calculate 1 Absolute error 2 Percentage of error 3 Relative accuracy 4 percentage of accuracy

```
//Exa 1.1a

clc;
clear all;

Yn=80;//voltage across a resistor(Volts)
Xn=79;//Measured voltage (Volts)

//solution
e=Yn-Xn; //absolute error
Pe=(Yn-Xn)/Yn *100;//% error
A=1-abs((Yn-Xn)/Yn); //relative accuracy
a=100*A;
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);
disp("");
```

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

```
//Exa 1.2

clc;
clear all;

//Refering to table 1.1- Set of 10 measurements that
    were recorded in the laboratory.

X={98;101;102;97;101;100;103;98;106;99}; //From
   table 1.1

//solution
X_n= mean(X); //Average value
Prec=1-abs((X(6)-X_n)/X_n);//precision of 6th
   reading
printf('The precision of 6th measurement = %0.3f \n'
   ,Prec);
```

Scilab code Exa 1.3 To calculate apparent and actual value of resistances along with error due to loading effect of the voltmeter

```
// Exa 1.3a

clc;
clear all;

Sv=1000; //voltmeter sensitivity(ohm/V)
Vt=80; //Voltage across unknown resistance (V)
It=10; //Current through unknown resistance (mA)
Scale=150; //Volts
```

```
//solution

//Neglecting milliammeter resistance
Rt=Vt/It; //Total circuit resistance(K  ohm)
Rv=Sv*Scale/1000; //Voltmeter resistance(K ohm/V)
Rx=Rt*Rv/(Rv-Rt); //actual value of unknown
    resistance(K ohm)
err=(Rx-Rt)/Rx *100;
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);
disp("");

// Exa 1.3b

Sv=1000; //voltmeter sensitivity(ohm/V)
Vt=30; //Voltage across unknown resistance (V)
It=600; //Current through unknown resistance (mA)
Scale=150; //Volts

//solution

//Neglecting milliammeter resistance
Rt=Vt/(It*10^-3); //Total circuit resistance(ohm)
Rv=Sv*Scale; //Voltmeter resistance(ohm/V)
Rx=Rt*Rv/(Rv-Rt); //actual value of unknown
    resistance(ohm)
err=(Rx-Rt)/Rx *100;
printf('Apparent value of resistance = %d ohm \n
    Actual value of resistance = %.3f ohm \n
    Percentage error = %.3f \n',Rt,Rx,err);
disp("In Example1.3a, a well calibrated voltmeter
    may give a misleading resistance when connected
    across two points in a high resistance circuit.")
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.");
// In the 1.3b example, the answer mentioned in the
    textbook for Rx and percent error is isncorrect.
```

Scilab code Exa 1.4 To calculate arithmatic mean along with deviation of each value and algebraic sum of deviations

```
// Exa 1.4

clc;
clear all;

// Given data
x1= 49.7;
x2= 50.1;
x3= 50.2;
x4= 49.6;
x5= 49.7;

// solution

X_mean= (x1+x2+x3+x4+x5)/5; // Arithmatic mean

d1= x1-X_mean;
d2= x2-X_mean; // deviation from each value
d3= x3-X_mean;
d4=x4-X_mean;
d5=x5-X_mean;

d_total= d1+d2+d3+d4+d5; //Algebraic sum of
    deviations

printf('The arithmatic mean is %.2f \n \n',X_mean);
printf(' Deviation from x1 is %.2f \n ',d1);
```

```
printf('Deviation from x2 is %.2f \n ',d2);
printf('Deviation from x3 is %.2f \n ',d3);
printf('Deviation from x4 is %.2f \n ',d4);
printf('Deviation from x5 is %.2f \n \n',d5);
printf(' The algebraic sum of deviation is %d \n',
    d_total);
```

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

```
// Exa 1.5
//Data taken from Exa 1.4 as stated

clc;
clear all;

// Given data

x1= 49.7;
x2= 50.1;
x3= 50.2;
x4= 49.6;
x5= 49.7;
n= 5; // number of x values

// solution

X_mean= (x1+x2+x3+x4+x5)/5; // Arithmatic Mean
d1= x1-X_mean;
d2= x2-X_mean; // deviation from each value
d3= x3-X_mean;
d4=x4-X_mean;
d5=x5-X_mean;

D_av= (abs(d1)+abs(d2)+abs(d3)+abs(d4)+abs(d5))/n;
    //Average deviation
```

```
printf('The average deviation = %.3f \n',D_av);
```

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

```
// Exa 1.6
//Data taken from Eg 1.4 as stated

clc;
clear all;

// Given data

x1= 49.7;
x2= 50.1;
x3= 50.2;
x4= 49.6;
x5= 49.7;
n= 5; // number of x values

// solution

X_mean= (x1+x2+x3+x4+x5)/5; // Arithmatic Mean
d1= x1-X_mean;
d2= x2-X_mean; // deviation from each value
d3= x3-X_mean;
d4=x4-X_mean;
d5=x5-X_mean;

Std_dev= sqrt((d1^2+d2^2+d3^2+d4^2+d5^2)/(n-1));  //
    Standard deviation
printf('The standard deviation = %.2f \n',Std_dev);
```

Scilab code Exa 1.7 To calculate the limiting error

```
// Exa 1.7

clc;
clear all;

// Given data

Range= 600; //volgmeter range(volts)
Accu= 0.02; //Accuracy
X= 250; //voltage to be measured(volts)

// Solution

Mag= Accu * Range; //magnitude of limiting error
X_mag = Mag/X * 100; // limiting error at 250V
    inpercentag

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

```
// Exa 1.8

clc;
clear all;

// Given data

X= 100; // Range of voltmeter(V)
x= 70; // Measured value on voltmeter(V)
Y= 150; // Range of milliammeter
y= 80; // Measurex d value on milliammeter
Accu= 0.015; // Accuracy of instruments

```

```
// Solution

X_mag= Accu*X; //Magnitude of limiting error for
   voltmeter
Y_mag= Accu*Y; // Magnitude of limiting error for
   milliammeter
x_mag= X_mag/x; // limiting error at 70V
y_mag= Y_mag/y; // limiting error at 80mA

disp("Limiting error for the power calculation is
   the sum of the individual limiting errors
   involved");
printf(' Therefore, limiting error = %.3f percentage
    \n',(x_mag+y_mag)*100);
// 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

```
// Exa 2.1

clc;
clear all;

// Given data

N= 100; //  Number of turns
W=20; // Width of coil(mm)
D= 30; // Depth of coil(mm)
B= 0.1; // Flux density (wb/m^2)
I= 10; // Current in coil(mA)
K= 2*10^-6; // Spring constant(Nm/degree)

// Solution
A= W*10^-3*D*10^-3; // Area of coil(m^2)
Td= B*N*A*I*10^-3; // Deflecting torque(Nm)
disp("As deflecting torque = restoring torque(K*
   Theta)");
Theta= Td/K;
```

```
printf(' The defecting torque = %.1f * 10^-6 Nm \n '
    , Td*10^6);
printf('Therefore, the deflection = %d degrees \n '
    , Theta);
```

Chapter 3

Ammeters

Scilab code Exa 3.1 To calculate the value of shunt resistance

```
//  Exa 3.1

clc;
clear all;

// Given data

Rm= 100; // Internal resistance in Ohm's
Im= 1; // Full scale deflecfion current in
    milliAmpere
I= 100; // Total current in milli Ampere

// Solution

Rsh= (Im*Rm)/(I-Im); // Shunt resistance
printf('The value of shunt resistance = %.2f  Ohm \n
    ', Rsh);
```

Scilab code Exa 3.2 To design an Aryton shunt

```
// Exa 3.2

clc;
clear all;

// Given data

//Refer fig. 3.4
Rm=100;//Ohms
Im=50; ///micro Amp

// Solution

//For 0-1mA range
 // Ish*Rsh=Im*Rm;
 disp("The four linear equations are as follows:");
 printf(' R1+R2+R3+R4 = %.2f \n ',50*100/950);  //say-equaion (3.1)

 //For 0-10 mA range
 printf('R1+R2+R3-(50/9950)*R4= % .3f \n ',100*50/9950); //say-equation(3.2)

 //For 0-50 mA range
 printf('R1+R2-(50/49950)*R3-(50/49950)*R4 = %.3f \n ',100*50/49950); //say-equation(3.3)

 //For 0-100mA range
 printf('R1-(50/99950)*R2-(50/99950)*R3-(50/99950)*R4 = %.3f \n ',50*100/99950);//say-equation(3.4)

 //converting it into matrix form
 A=[1 1 1 1;1 1 1 -(50/9950);1 1 -(50/49950) -(50/49950);1 (-50/99950)  (-50/99950) (-50/99950)];

 B=[-50*100/950 ; -100*50/9950  ; -100*50/49950 ; -50*100/99950];
```

```

[R,y]=linsolve(A,B);A*R+B;//linear equaion solving function

disp("The value of R1,R2 R4 and R4 are given as follows-");
printf(' R1 = %.5f Ohms \n R2= %.5f Ohms \n R3= %.5f Ohms \n R4= %.5f Ohms \n ',R(1),R(2),R(3),R(4));

// The value of R3 vary due to round off errors
```

Chapter 4

Voltmeters and Multimeters

Scilab code Exa 4.1 To calculate the sensitivity

```
// Exa 4.1

clc;
clear all;

// Given data

Iful = 200; // Fullscale deflection current in micro
    Amperes
Sen= 1/(Iful*10^-3) ; // Sensitivity of Voltmeter(K
    Ohms/V)

// Solution

printf(' The sensitivity of the voltmeter = %d k
    Ohms/V \n',Sen);
```

Scilab code Exa 4.2 Determine the value of multiplier resistance

```
// Exa 4.2

clc;
clear all;

// Given data

Iful= 50; // Fullscale deflection current in micro
    Amperes
Rm= 500; // Internal resistance in Ohms
V= 10; // Full range voltage of instrument(Volts)

// Solution

Rs= V/(Iful *10^-6)-Rm; // Multiplier resistance

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 voltmeter

```
// Exa 4.3

clc;
clear all;

// Given data
// Refer Fig. 4.3 on page no. 77

Rm=50; // Internal resistance of Voltmeter(ohms)
Ifsd=2; // full sclae deflection current(mA)

//Solution

```

```
// For 10V range(V4 position of switch)
V1=10;//Volts
Rt1=V1/(Ifsd*10^-3); //total resistance in  k Ohms
R4=Rt1-Rm;
printf('The value of R4 = %d Ohms \n',R4);
// For a 50V range(V3 position of switch)
V2=50;//Volts
Rt2=V2/(Ifsd*10^-3);
R3=Rt2-(R4+Rm);
printf(' The value of R3 = %d k Ohms \n',R3/1000);

// For 100V range(V2 position of switch)
V3=100;//Volts
Rt3=V3/(Ifsd*10^-3); //total resistance in  k Ohms
R2=Rt3-(R3+R4+Rm);
printf(' The value of R2 = %d k Ohms \n',R2/1000);
// For a 250V range(V3 position of switch)
V4=250;//Volts
Rt4=V4/(Ifsd*10^-3);
R1=Rt4-(R2+R3+R4+Rm);
printf(' The value of R1 = %d k Ohms \n',R1/1000);
```

Scilab code Exa 4.4 To calculate the value of multiplier resistance

```
// Exa 4.4

clc;
clear all;

// Given data

Iful= 200; // Full scale deflection current in micro
    Amperes
Rm= 100;// Internal resistance of the movement in
    Ohms
```

```
Range= 50; // Voltage range

// Solution

S= 1/(Iful * 10^-6); // Sensitivity of voltmeter is ohms/volt
// Rs=S*Range-Rm ;
Rs=S*Range-Rm; // Multiplier resistance

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 range dc voltmeter

```
// Exa 4.5

clc;
clear all;
// Refer circuit diagram in  Fig. 4.5  page no.79

// Given data

Ifsd=50; // Full scale deflection current (micro Amp)
Rm= 1000; // Internal resistance in Ohms
V1= 5; // Range of voltmeter 1 (V)
V2=10; //Range of voltmeter 2 (V)
V3=50;// Range of voltmeter 3 (V)

// Solution

S= 1/(Ifsd*10^-6);  // Sensitivity of voltmeter in Ohms/V
 // The value of multiplier resistance for different
```

```
ranges

// For 5V range
Rs1= S*V1-Rm;

// For 10V range
Rs2= S*V2-Rm;
// For 50V range
Rs3=S*V3-Rm;

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 measured

```
// Exa 4.6

clc;
clear all;
// Referring Fig. 4.6- Example on loading effect from page no.81

// Given data
R1=10000; // Ohms
R2=10000;// Ohms
V=100; // Applied Voltage

// Solution

VR2= R2/(R1+R2)* V;// True Voltage across R2 resistance
printf('True voltage across R2 = %d V \n ',VR2);
```

```
// Case-1 : Using a voltmeter 1 having sensitivity
    of 1000 Ohms/V

S1=1000;  // Sensitivity in Ohms/volt
R21=S1*VR2; //R2 resistance on its 50 V range(Ohms)
Req1=R21*R2/(R21+R2);// Equivalent resistance across
     R2(ohms)
printf('Connecting the meter 1 across R2 causes an
    equivalent parallel resistance given by %.2f k
    Ohms \n ',Req1/1000);
V21=Req1/(Req1+R2) * V;
printf('Now the voltage across the total combination
     is given by %.2f V \n ',V21);

// Case-2 : Using a voltmeter having sensitivity of
    20,000 Ohms/V

S22=20000; // Sensitivity in Ohms/volt
R22=S22*VR2;// R2 resistance on its 50V range(Ohms)
Req2=R22*R2/(R22+R2);// Equivalent resistance across
     R2(ohms)
printf('Connecting the meter 2 across R2 causes an
    equivalent parallel resistance given by %.2f k
    Ohms \n ',Req2/1000);
V22=Req2/(Req2+R2) * V;
printf('Now the voltage across the total combination
     is given by %.2f V \n ',V22);

disp(" This example shows that a high sensitivity
    voltmeter(i.e voltmeter 2 in  this case) should
    be used to get accurate readings");
// The answers vary due to riund off error.
```

Scilab code Exa 4.7 To determine voltage across Rb with both meters along with their repective errors

```
// Exa 4.7

clc;
clear all;
// Referring circuit given in fig. 4.7 on page no.81

S1=1000; // Sensitivity of meter 1 (Ohms/volt)
S2=20000;// Sensitivity of meter 2(Ohms/volt)
Rm1=200;// Meter resistance(Ohms)
Rm2=1500;// Meter resistance(Ohms)
V1=10; // Range of voltmeter 1(Volts)
V2=10;
Ra=25000; // in Ohms
Rb=5000;// in Ohms
V=30; // Applied Voltage(V)

//Solution

VRb= Rb/(Ra+Rb) * V; // Voltage across Rb
printf('The voltage across the resistance Rb,
    without either meter connected = %d V\n ',VRb);

// For meter 1
Rt1=S1* V1; // Total resistance of meter1

Req1= Rb*Rt1/(Rb+Rt1); // Total resistance across Rb
VRb1= Req1/(Req1+Ra) * V; // Voltage reading across
    Rb with meter1
printf('The voltage across Rb when meter 1 is used
    is = %.2f V \n',VRb1);
Err1=(VRb-VRb1)/VRb *100; // Voltmeter 1 error
printf(' Voltmeter 1  error in percentage = %.1f  \n
     ',Err1);

// For meter 2
```

```

Rt2=S2* V2; // Total resistance of meter 2

Req2= Rb*Rt2/(Rb+Rt2); // Total resistance across Rb
VRb2= Req2/(Req2+Ra) * V; // Voltage reading across
    Rb with meter2
printf('The voltage across Rb when meter 2 is used
    is = %.1f V \n',VRb2);

Err2=(VRb-VRb2)/VRb *100; // Voltmeter 2 error
printf(' Voltmeter 2  error in percentage = %d \n ',
    Err2);
```

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

```
// Exa 4.8

clc;
clear all;

// Given data

Ra= 45; // in k Ohms
Rb=5; // in k Ohms
V=50; // Supplied Voltage(V)
S=20; // sensitivity in k Ohms/V

// Solution

VRb=Rb/(Ra+Rb) * V;
printf('The voltage drop across Rb without the
    voltmeter connected is = %d V\n',VRb);

// On the 5V range
```

```
Range1 = 5; // Volts

Rm1=S*Range1;// k Ohms
Req1=Rm1*Rb/(Rm1+Rb);  // k Ohms
VRb1=Req1/(Req1+Ra) *V; // Voltage across Rb on 5V range
printf(' The voltmeter reading on 5V range is = %.3f V\n',VRb1);
Err1=(VRb-VRb1)/VRb * 100;
printf(' Percentage error on 5V range in percentage = %.2f \n',Err1);

// On 10V range

Range2 = 10; // Volts

Rm2=S*Range2;// k Ohms
Req2=Rm2*Rb/(Rm2+Rb);  // k Ohms
VRb2=Req2/(Req2+Ra) *V; // Voltage across Rb on 10V range
printf(' The voltmeter reading on 10V range is = %.3f V\n',VRb2);
Err2=(VRb-VRb2)/VRb * 100;
printf(' Percentage error on 10V range in percentage = %.3f \n',Err2);

// On 30V range

Range3 = 30; // Volts

Rm3=S*Range3;// k Ohms
Req3=Rm3*Rb/(Rm3+Rb);  // k Ohms
VRb3=Req3/(Req3+Ra) *V; // Voltage across Rb on 30V range
printf(' The voltmeter reading on 30V range is = %.3f V \n',VRb3);
Err3=(VRb-VRb3)/VRb * 100;
printf(' Percentage error on 30V range in percentage
```

```
= %.1f \n',round(Err3));

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.");
//The answers vary due to round off error
```

Scilab code Exa 4.9 To calculate the value of multiplier resistance

```
// Exa 4.9

clc;
clear all;

// Given data
// As per values given in Fig.4.19(page no.94)

ein=10; // Input RMS voltage(V)
Ifsd=1; // Full scale deflection current(mA)
Rm=200;// Internal resistance of voltmeter(Ohms)

// Solution

Range=0.45*ein; // Range of Voltmeter
Sdc=1/(Ifsd*10^-3); // DC Sensitivity of meter movement(k Ohm/V)
Rs=Sdc* Range-Rm;// Multiplier resistance(Ohm)
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

```
// Exa 4.10

clc;
clear all;

// Given data

Vin=10; // Input RMS voltage(V)
Ifsd=1; // Full scale deflection current(mA)
Rm=250;// Internal resistance of voltmeter(ohms)

// Solution

Sdc=1/(Ifsd*10^-3); // DC sensitivity(K ohm/V)
Sac=0.9*Sdc; //AC sensitivity(k Ohm/V)
Rs=Sac*Vin-Rm;// Multiplier resistor(Ohm)
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 compensate a drop

```
// Exa 4.11

clc;
clear all;

// Given data
Rm=100; // Meter resistance(Ohms)
Ifsd=1; // Full scale deflection current(mA)
Rh=2000; // Half of full scale deflection resistance (Ohms)
V=3; // Internal battery voltage(V)
```

```
// Solution
// Using equations 4.1 and 4.2 given on page no. 104

R1=Rh-Ifsd*10^-3*Rh/V ;// Current limiting resistance(Ohms)
R2= Ifsd*10^-3*Rm*Rh/(V-Ifsd*10^-3*Rh); // Zero adjust resistance(Ohms)
 V1= V-0.05*V; // Voltage after 5 percent drop in battery voltage
R3=Ifsd*10^-3*Rh*Rm/(V1-Ifsd*10^-3*Rh);// Maximum value of R2 to compensate drop in battery

printf(' The values of R1 and R2 are %.1f Ohms and %d Ohms respectively \n ',R1,R2);
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 ouptut of integrator after 1 sec

```
// Exa 5.1

clc;
clear all;

// Given data

R=100; //  in k Ohms
C=1;  //in micro farads
ei=1;// Applied voltage to integrator(V)
t1=1; // time in Sec

// Solution

// Using equation 5.1 from page no. 118
eo=ei*t1/(R*10^3*C*10^-6); // Output voltage from
   integrator
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

```
// Exa 5.2

clc;
clear all;

// Given data
// With reference to data given in Exa 5.1

ei=1; // Applied input voltage to integrator(V)
t1=1; // sec

// Given data

er=5;// Reference voltage applied at time t1 to
    integrator(V)

// Solution
// Using equation 5.3 from page no. 118

t2=ei/er * t1;// Time interval t2(sec)
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 10V ranges

```
// Exa 5.3

clc;
clear all;
```

```

// Given data
// 3 1/2 digit display

V1=1; // Volts
V2=10;//Volts

// Solution
disp("Number of full digits is 3.");
n=3;//Full digits
Reso=1/10^n;
printf(' Resolution = %.3f . Hence, meter cannot distinguish two values if their difference is less than %.3f \n ',Reso,Reso);
printf('For full scale reading of 1V, the resolution is %.3f V \n ',V1*Reso);
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 and 10V ranges

```
// Exa 5.4

clc;
clear all;

// Given data

n=4; // Number of full digits
V1=12.98;//Reading 1 to be measured(V)
V2=0.6973;//Reading 2 to be measured(V)

// Solution

```

```
Reso=1/10^n; //Resolution
printf(' Resolution is %.4f \n ',Reso);
disp("There are 5 digit places in 4 and 1/2 digits
   display, therefore 12.98      would be displayed
   as 12.980");
disp("");
printf(' Resolution on 1V range = %.4f. Any reading
   upto the 4th decimal can be displayed \n ',1*Reso
   );
disp("Therefore. 12.98 would be displayed as 12.980
   and 0.6973 will be displayed as 0.6973");
disp("");
printf(' Resolution on 10V range = %.3f. Therefore.
   12.98 would be dislayed as 12.98 \n ',10*Reso);
disp("Therefore on a 10V range,the reading of 0.6973
    would be displayed as o.697 instead of 0.6973");
```

Chapter 7

Oscilloscope

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

```
// Exa 7.1

clc;
clear all;

// Given data
// Referring to waveform shown in fig 7.50 on page
   211

V_attn= 0.5; // Vertical attenuator(V/div)
div=3; // No of vertical divisions

// Solution

// Using equation : Vp-p=(volts/div) * (no. Of div
   /1);

Vp_p=V_attn * div/1 ;

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

```
// Exa 7.2

clc;
clear all;

//Given data
// Refering waveform shown in fig 7.50 on page no.
   211

div=4; // No of horizontal divisions for One cycle
// Given data
time_div= 2; // Time per div control in micro sec/
   div

// Solution

// The period of signal is given as T=(time/div) *(
   No of div/ cycle);
T=time_div *10^-6 * div/1 ; // Time period is
   calculated over 1 cycle
F= 1/T; // Frequency is inverse of time period

printf(' The frequency of signal = %d kHz \n',F
   /1000);
```

Chapter 10

Measuring Instruments

Scilab code Exa 10.1 To finf the value of distributed capacitance and value of inductor

```
// Exa 10.1

clc;
clear all;

// Given data

// 1st measurement
f1=1; //  in MHZ
C1=500; // in pf
// 2nd measurement
f2=2; //in MHz
C2=110; // in pf

// Solution
// Using equation 10.2(page no. 278) to calculate
   distributed Capacitance

Cs=(C1-4*C2)/3; // Distributed capacitance in pf
printf('The value of distributed capacitance = %d pf
```

```
\n',Cs);
// using equation of resonant frequency given as f1 =1/(2*%pi*sqrt(L*(C1+Cs));
// Therefore
L=1/(4*(%pi)^2*f1^2*(C1+Cs)); // Inductor value

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

```
// Exa 10.2

clc;
clear all;

// Given data

f1=2; // in MHz
f2=6; // in MHz
C1=500; // in pf
C2=50; // in pf

// Solution

disp("Given that f2=3*f1");
disp("Therefore by using equation 10.1");
disp(" 1/(2*%pi*sqrt(L*(C2+Cs)) = 3/(2*%pi*sqrt(L*(C1+Cs))");
disp("Therefore");
disp("C1+Cs=9(C2+Cs)");
//Therefore Cs is given as
Cs=(C1-9*C2)/8;// Self capacitance in pf
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

```
// Exa 11.1

clc;
clear all;

// Given data

// Wheatstone's bridge  circuit
R1=10; // k Ohms
R2=15; // k Ohms
R3=40; // k Ohms

// Solution
// From the equation (11.4) of balanced bridge we have

Rx=R2*R3/R1; // Unknown resistance Rx
printf(' The unknown resistance Rx is = %d k Ohms \n',Rx);
```

Scilab code Exa 11.2 To calculate the current through galvanometer

```
// Exa 11.2

clc;
clear all;

// Given data
//Refering fig. 11.5 - Unbalanced Wheatstone bridge

R1=1; // in k Ohms
R2= 2.5; // in k Ohms
R3=3.5; // in k Ohms
R4=10; // in k Ohms
V= 6; // Applied Voltage(V)
Rg=0.3; // Galvanometer resistance in k Ohms

// Solution

// Eth=Ea-Eb ; \\ Thevenin's equivalent voltage
Eth=V*(R4/(R2+R4) - R3/(R1+R3));
Rth=(R1*R3/(R1+R3)) + (R2*R4/(R2+R4)) ;
// Refering the equivalent circuit connected along
   with the galvanometer as shown in fig. 11.6
Ig=Eth/(Rth+Rg) ; // Current through galvanometer
printf(' The current through galvanometer is = %.2f
   micro Amp \n',round(Ig*10^3));
//The answer vary due to round off error
```

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

```
// Exa 11.3

clc;
clear all;

// Given data

// Refering Fig. 11.9(page no.311) - slightly
    unbalanced Wheatstone bridge
R= 700; // in Ohms
Dell_R= 35; // in Ohms
E=10; // Supplied voltage(V)
Rg=125;//Internal resistance of galvanometer(Ohms)

// Solution

Eth= E*Dell_R/(4*R) ; // Thevenin's equivalent
    voltage(V)
Rth=R; // Thevenin's equivalent resistance(Ohms)
Ig= Eth/(Rth+Rg); // Current through galvanometer(
    Amp)
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

```
// Exa 11.4

clc;
clear all;

// Given data
// Refering Fig. 11.12(page no.315)- Kelvin's bridge

```

```
Ra_b=1000;// The ratio of Ra to Rb
R1= 5; // in Ohms

// Solution

// We have R1=0.5*R2
R2=R1/0.5;

//From the eqation for Kelvin'd bridge- Rx*Ra=Rb*R2
Rx=R2*(1/1000); // Unknown resistance
printf(' The value of Rx = %.2f Ohm \n ',Rx);
```

Scilab code Exa 11.5 To determine temperature at which bridge is balanced and amplitude of error signal at 60 degree celsius

```
// Exa 11.5

clc;
clear all;

// Given data
// Refering circuit in Fig. 11.15(a) and graph in
   11.15(b) on page no.317

R1=5; // k Ohms
R2=5; //k Ohms
R3= 5; // k Ohms
E=6; // Applied voltage(V)

// Solution

// The value of Rv when bridge is balanced is
   calculated as
Rv=R2*R3/R1;
printf(' The value of Rv = %d K Ohms \n' , Rv);
```

```
disp(" From the graph, the temperature at which
    bridge is balanced is = 80      degree celsius");
disp(" From the graph, the resistance Rv for
    balancing bridge at 60 degree celcius comes out
    to be 4.5 k Ohms ");
// Therefore
Rv1=4.5; // Resistance Rv at 60 degree celcius(K
   ohms)
es=E*(R3/(R1+R3) - Rv1/(R2+Rv1) ); // Error signal
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

```
// Exa 11.6

clc;
clear all;

// Given data
f=2; // kHz
C3=100; // micro farads
R1=10; // k Ohms
R2=50; // k Ohms
R3=100; // k Ohms

// Solution

// Using equations 11.12(a) and 11.12(b) (page no.
    321)to find values of Rx and Cx

Rx=R2*R3/R1;
Cx=R1/R2 *C3;

```

```
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

```
// Exa 11.7

clc;
clear all;

// Given data

C1=0.01; // micro farads
R1=470; // k Ohms
R2=5.1; // k Ohms
R3=100; // k Ohms

// Solution
// Using equation 11.15 given on page no. 324 to
   find Rx and Lx

Rx=R2*R3/R1;
Lx=R2*R3*C1;

printf(' The series equivalent of the unknown
   impedence 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 nework

```
// Exa 11.8

 clc;
clear all;

// Given data

w=3000; // Angular frequency in rad/s
R2=10*10^3; // Ohms
R1= 2*10^3; // Ohms
C1=1*10^-6; // farads
R3=1*10^3; // Ohms

// Solution

// Using equations 11.19 and 11.18 (page no.326)to
    find values of Rx and Lx

Rx=w^2*R1*R2*R3*C1^2/(1+w^2*R1^2*C1^2);
Lx=R2*R3*C1/(1+w^2*R1^2*C1^2);

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

```
// Exa 11.9

clc;
clear all;

// Given data

```

```
// Refering Fig. 11.26(page no.328) - an AC bridge(
    SCHERING'S BRIDGE)

R1= 1; // k Ohms
C1=0.5; // micro farads
R2=2; // k Ohms
C3=0.5; // micro farads
f= 1000; // Hz

// Solution
// Using Equations 11.20(a) and 11.20(b) given on
    page no. 328 we get value Rx and Cx

Rx=C1/C3*R2;// in k Ohms
Cx=R1/R2 * C3; // in micro farads

D=2*%pi*f*Cx*10^-6*Rx*10^3; // Dissipation factor

printf(' The unknown capacitance Cx is equal to %.2f
     micro farads\n ',Cx);
printf(' The dissipation factor = %.4f \n ',D);
```

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

```
// Exa 11.10

clc;
clear all;

// Given data

// Wien's bridge
R1=3.1; // k Ohms
C1=5.2; // micro farads
```

```
R2=25; // k Ohms
f=2.5; // kHz
R4=100;// k Ohms

// Solution

w=2*%pi*f; // Angular frequency
// 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
R3=R4/R2 *(R1+1/(w^2*R1*C1^2));
// Also we can get C3 from Eq. 11.22(page no. 330)
C3=1/(w^2*C1*R1*R3);
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

```
// Exa 12.1

clc;
clear all;

// Given data

Chart_speed=40; // in mm/sec
Time_base=5; // in mm

// Solution

Period= Time_base/Chart_speed;
frequ=1/Period;
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

```
// Exa 12.2

clc;
clear all;

// Given data

fre=20; // in Hz
Time_base=5*10^-3; // in

// Solution

Period=1/fre;  // in sec
// Since period= timebase/ chart speed;
Chart_speed=Time_base/Period; // in mm/sec

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

```
// Exa 13.1

clc;
clear all;

// Given data
// Refer circuit given in Fig no.13.2(b) given on page no.381

Shaft=3; // Shaft stroke in inches
Wiper=0.9;// in inches
R=5; // Total resistance(R1+R2) in K ohms
Vt=5; // Applied voltage in volts

// Solution

R2=Wiper/Shaft * R ;// in k Ohms
// Since Vo/Vt=R2/(R1+R2);
// Therefore
Vo=R2/(R) *Vt; // Output Voltage(R1+R2)
printf(' The output voltage = %.1f V \n',Vo);
```

Scilab code Exa 13.2 To find the new value of Vc

```
// Exa 13.2

clc;
clear all;

// Given data
Ra=5; // (R1+R2) in k Ohms
Rb=5;// (R3+R4) in k Ohms
Vt=5; // Applied voltage (V)
Shaft=5; // Shaft distance in inches

// Solution

disp(" As given, wiper moves 0.5 inch towards A from
    the centre, it will have moved 3 inches from B")
    ;
Wiper=3; // Wiper movement from B in inches
Wiper1=2.5;//Wiper movement from A in inches
R2=Wiper/Shaft * R; // in k Ohms
R4=Wiper1/Shaft * R; // in k Ohms
//Ve=VR2-VR4
Vc=(R2/(Ra)) *Vt - (R4/(Rb)) * Vt;

printf(' The new value of Vc= %.1f V \n',Vc);
```

Scilab code Exa 13.3 To calculate the change in resistance

```
// Exa 13.3

```

```
clc;
clear all;

// Given data

K=2; // Gauge factor
strain=1*10^-6; // Ratio of change in length to
    original length
R=130; // Resistance in Ohms

// Solution

// As K = ratio of dell R/R to dell L/L
Dell_R =K*R*strain ; // Change in resistance
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 degree fahrenheit

```
// Exa 13.4

clc;
clear all;

// Given data

R= 4;// Resistance of thermistor in k Ohms
R1=0.003;// Meter resistance in k Ohms
Rc=0.017; // in k Ohms
Vt=15;// in Volts

// Solution

// 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.
R_25= 4;// in k Ohms
R_65=0.95; // in k Ohms

I1=Vt/(R_25+R1+Rc); // current at 25 degree Celsius(A)
I2=Vt/(R_65+R1+Rc); // current at 65.556 degree Celsius(A)

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 core movements

```
// Exa 13.5

clc;
clear all;

// Given data

Input=6.3; // V
Output=5.2; // V
Range= 9.5; // inches

// Solution

// 0.5 inches core displacement produces 5.2 V
// Therefore, a 0.45 inch movement produces voltage as
V1=0.45*5.2/0.5;
```

```
// Similarly - 0.30 inches core movement produces voltage as
V2=-0.30*-5.2/(-0.5); // V
// Also -0.25 inch core movement produces voltage as
V3=-0.25*-5.2/(-0.5); // V

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);
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

```
// Exa 13.6

clc;
clear all;

// Given data

K=0.32; // Coupling co efficient
Op=1;// Output in oz.in.

// Solution

// 1 oz.in.= 1 oz.in. * (1 ft/12 in.) * (1 lb/16 oz) * (1.3561/1 ft lb) = 7.06*10^-3 J ;

Elec_mech= 7.06*10^-3; // Electrical energy converted to mechanical energy(J)
Ee=Elec_mech/K; // Applied Electrical energy
printf(' The electrical energy of %.2f mJ must be applied \n',Ee*10^3);
```

```
// The answer mentioned in the book is incorrect
```

Scilab code Exa 13.7 To calculate the required series resistance along with the dark current level

```
// Exa 13.7

clc;
clear all;

// Given data
// Refering circuit in fig. 13.7(a) and graph in fig
   .13.7(b) on page no.422

I=10; // mA
V=30;// Volts
Illumination=400;// in l/m^2

// Solution

disp(" From graph(13.7(b) , cell resistance at 400 l
   /m^2 is 1 K ohms");
Rcell=1; // K ohms

R1=V/I - Rcell; //Required series resistance

Rdark=100;//Cells dark resistance in K ohms
Idark=V/(R1+Rdark); // Dark current
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

```
// Exa 14.1

 clc;
clear all;


// Given data

fa=800; // The highest frequency(Hz)
Vp=2; //Volts


// Solution
disp("Let C1=0.1 micro farads")
C1=0.1; // micro farads
// Then Rf is given as
Rf=1/(2*%pi*C1*10^-6*fa);// Ohms
printf(' Calculated value of Rf = %.3f k Ohms.
   selecting nearest higher value of 2.2 k Ohms \n '
   ,Rf/1000);
```

```

fb=20*fa;
R1=1/(2*%pi*C1*10^-6*fb);// Ohms
printf('The calculated value of R1 = %.1f Ohms. Let
    R1=100 Ohms \n',R1);

// Since R1*C1=Rf*Cf
Cf=R1*C1*10^-6/2200;//Rf is taken as 2.2 k Ohms as
    stated above
printf(' The value of Cf = %.5f micro farads. Let Cf
    =0.0047 micro farads \n',Cf*10^6);

Rom=(1/100+1/2200)^-1;
printf(' Rom = %.1f Ohms \n',Rom);

t=0:0.1*10^-3:1.5*2.50*10^-3;

Vin=Vp*sin(2*%pi*fa*t);//Input Voltage equation
xlabel("Time(sec)");
ylabel("Voltage(V)");
title("Input Voltage");
plot2d(t,Vin);
figure(1);

Vo=-2200*0.1*10^-6*Vp*2*%pi*fa*cos(2*%pi*800*t);//
    Output voltage equation
xlabel("Time(sec)");
ylabel("Voltage(V)");
title("Output Voltage");
plot2d(t,Vo);
// The answers vary due to round off error
```

Scilab code Exa 14.2 To determine the output voltage of opamp

```
// Exa 14.2
```

```

clc;
clear all;

// Given data

Va=2;// Volts
Vb=1;// Volts
Vc=3; // Volts
Ra=3;// k Ohms
Rb=3;// k Ohms
Rc=3;// k Ohms
Rf=1;// k Ohms
Rom=270;// Ohms
Supply=15;// Volts

// Solution

disp(" Assuming that the opamp is initially nulled")
    ;
// Using equation 14.8 to determine the output
    voltage
Vo=-(Rf/Ra *Va+Rf/Rb *Vb+Rf/Rc *Vc);
printf('  The output voltage = %d Volts \n',Vo);
```

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

```
// Exa 14.3

clc;
clear all;

// Given data

```

```
R1=2.2;// k Ohms
Rf=10;// k Ohms
R=120;// (Ra=Rb=Rc) k Ohms
E=5; // Volts
Vcc=15; // Volts
Rt=120; //  k Ohms at reference temperature of 25
    degree celsius
Tco=- 1; // Temperature co-efficient in  K/degree
    celsius

// Given data

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

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

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

```
// Exa 14.4
```

```
// Refer circuit 14.25 given on page no. 484

clc;
clear all;

// Given data

E=10;// Volts
R=50;// Unstrained gauge resistance(Ohms)
Gain=100;// Amplifier gain
Vo=1.5;// Output Voltage

// Solution

// Using the formula: Vo=E*(Delta_R/R)*gain

Delta_R=Vo*R/(E*Gain);// Change in resistance

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);
// 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

```
//Exa 15.1

clc;
clear all;


// Given data
Fh=2;// kHz
Af=2;// Pass band gain

// Solution

disp(" Let C1= 0.01 micro farads ");
C=0.01;//micro farads
R=1/(2*%pi*Fh*C);// k Ohms
printf(' The calculated value of R is %.3f K ohms.
    Nearest practical value for R1 is 8.2 k Ohms\n',R
    );
//Af=1+Rf/R1;
// As Af=2. So, Rf=R1
disp(" In this case , Rf=R1= 10 k Ohms is selected "
```

```
);
```

Scilab code Exa 15.2 To calculate the value of resistance

```
// Exa 15.2

clc;
clear all;

// Given data

Wc=20*10^3; // Angular cutoff frequency in rad/s
C=0.01*10^-6; //in  farads

// Solution

// As Wc=1/(R*C);
R=1/(Wc*C);

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

```
// Exa 15.3

clc;
clear all;

// Given data

Fh= 2*10^3;// Cutoff frequency in Hz

```

```
// Solution

disp(" Let C2=C3=0.0033 micro farads ");

// Fh=1/(2*%pi*R*C); where R=R2=R3 and C2=C3=C;
C=0.0033*10^-6; // farads
// Therefore
R=1/(2*%pi*Fh*C);
printf('  Calculated value of R = %.1f K ohms. Let,
   R=R2=R3=22 k Ohms is selected\n',R/1000);
// Since Rf/R1=0.586, therefore Rf=0.586*R1;
// Let fix value of R1 as
R1=10*10^3; // Ohms
Rf=0.586*R1;
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 Butterworth filter

```
// Exa 15.4

clc;
clear all;

// Given data
// Second order filter

R=47*10^3; // Ohms(R2=R3=R)
C=0.0022*10^-6; // farads(C2=C3=C)

// Solution

Fl=1/(2*%pi*R*C); //low cutoff frequency(Hz)
```

```
printf(' The low cutoff frequency for a high pass
    filter =%.2f kHz\n',Fl/1000);
```

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

```
// Exa 15.5

clc;
clear all;

// Given data

Fl=100;// lower cutoff frequency in Hz
Fh=1000;// higher cutoff frequency in Hz
Af=4;// pass band gain

// Solution

// Wide bandpass filter design
// 1. For a low pass filter Fh=1 KHz =1/(2*%pi*R*C);

disp(" For a low pass filter section");
disp(" Let C1=0.01 micro farads ");
C1=0.01;// micro farads
R1=1/(2*%pi*Fh*C1*10^-6);
printf('The value of resistor = %.1f K ohms \n',R1
    /1000);

// 2. For a high pass filter Fl=100 Hz=1/(2*%pi*R*C)
    ;
disp(" For a high pass filter section");
disp(" Let C2=0.01 micro farads ");
C2=0.01;// micro farads
R2=1/(2*%pi*Fl*C2*10^-6);
```

```
printf(' The value of resistor = %d K ohms \n',R2/1000);

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.");

// Q for filter
Fc=sqrt(Fl*Fh);

Q=Fc/(Fh-Fl);
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

```
// Exa 15.6

clc;
clear all;

//Given data
// Refering fig. 15.17- Narrow band pass filter

Fc=1; // kHz
Q=5; //Quality factor
Avo=8; //Voltage gain
Fc1=1.5; //New centre frequency(kHz)

// Solution

disp(" Let C1=C2=C3=C(say)=0.01 micro farads");
C=0.01; //micro farads
// But
```

```
R1=Q/(2*%pi*Fc*10^3*C*10^-6*Avo); // From eqn. 15.45
     on page no.530
R2=Q/(2*%pi*Fc*10^3*C*10^-6*(2*Q^2-Avo));// From eqn
    . 15.47 on page no. 530
R3=Q/(%pi*Fc*10^3*C*10^-6); // From eqn. 15.46 on
    agr no. 530
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);
// To change Fc to Fc1 we simply have to change R2
    to R21 given as
R21=2000*(Fc/Fc1)^2;// since R2=2 k Ohms(approx)
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

```
// Exa 15.7

clc;
clear all;

// Given data
// Refering fig. 15.20- Wide band reject filter

Fl=100;// Hz
Fh=1000;// Hz

// Solution
// 1. For a high pass filter Fh=1 KHz =1/(2*%pi*R*C)
    ;
disp(" For a high pass filter section");
```

```
disp(" Let C1=0.01 micro farads ");
C1=0.01;// micro farads
R1=1/(2*%pi*Fh*C1*10^-6);
printf('  The value of resistor = %.1f k Ohms \n',R1/1000);

// 2. For a low pass filter Fl=100 Hz=1/(2*%pi*R*C);
disp(" For a low pass filter section");
disp(" Let C2=0.01 micro farads ");
C2=0.01;// micro farads
R2=1/(2*%pi*Fl*C2*10^-6);
printf('  The value of resistor = %.1f k Ohms \n',R2/1000);

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");
disp(" Further, the gain of the summing amplifier is set to 1, therefore R2=R3=R4=10 k Ohms"); // K ohms
R=10000;//Ohms(R=R2=R3=R4)
Rom=(1/R+1/R+1/R)^-1;
printf('  The value of Rom = %.1f k Ohms\n',Rom/1000);
// 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

```
// Exa 15.8

clc;
clear all;

```

```
// Given data
// Active notch filter

Fn=50; //Notch out frequency(Hz)

// Solution

disp(" Let C=0.047 micro farads");
C=0.047; // micro farads
R=1/(2*%pi*Fn*C*10^-6);

printf('  The value of R is calculated as %d k Ohms
   \n',round(R/1000));
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

```
// Exa 15.9

clc;
clear all;

// Given data
// Refering Fig. 15.2(a)- All pass filter
f=2.5;// Input frequency in kHz

// Solution

disp(" Let C=0.01 micro farads and R= 15 k Ohms");
C=0.01;// micro farads
R=15;// k Ohms
Phi=2*atan(2*%pi*f*C*R); // phase angle in radians
```

```
printf(' This means that the output voltage Vo has the same frequency and amplitude as the input voltage but lags it by - %d degrees\n',Phi*180/%pi);
```

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

```
// Exa 15.10

clc;
clear all;

// Given data
// Second order inverting Butterworth low pass filter
// Refering Table 15.1 and 15.3 in page no 517 and 538 respectively

Af=6;// DC gain
Fc=1.5;// KHz
Q=10;

// Solution

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 br used, hence the non-inverting filter configuration must be used.");

// From table 15.4 given on page no 538
R2=316/Q;
```

```
R3=100/(3.16*Q-1);
// R1 treated as open circuit
printf(' \n The R1 is open while R2 and R3 are %.1f
    ,k Ohms %.1f k Ohms respectively \n',R2,R3);
// From equations 15.54 given on page no 538 we get
    R4 and R5
R4=(5.03)*10^7/(Fc*10^3);//Ohms
R5=R4;
printf(' \n The calculated value of R4=R5=%.2f k
    Ohms \n',R4/1000);
disp("  use R4=R5=33 k Ohms");

disp(" Let R6=1.8 K ohms");
R6=1.8; // K ohms
R7=R6*Af;
R8=(1/R6 + 1/R7)^-1;

printf(' The values of R6 and R7 are %.1f k Ohms, %
    .3f K ohms respectively \n',R6,R7);
printf(' The value of R8 = %.3f k Ohms \n ',R8);
```

Scilab code Exa 15.11 Using FLT U2 design a notch filter

```
// Exa 15.11

clc;
clear all;

// Given data

Fc=4;// kHz
Q=8;

// Solution

```

```
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.");

// From table 15.3 given on page no 538
R2=100;// k Ohms
R3=100/((3.40*Q)-1);
// R1 treated as open circuit
printf(' The R1 is open while R2 and R3 are %.1f , %
   .2f K ohms respectively \n',R2,R3);

// From equations 15.54 given on page no 538 we get
   R4 and R5
R4=(5.03)*10^7/(Fc*10^3);
R5=R4;
printf(' The calculated value of R4=R5=%.2f k Ohms
   (12 k Ohms) \n',R4/1000);
disp(" Let R6=R7=R8=10 K ohms ");
R=10000;//R=R6=R7=R8=10 k Ohms
R9=(1/R+1/R+1/R)^-1;
printf(' The value of R9 =%.2f K ohms \n',R9/1000);
disp(" The complete circuit diagram is shown in fig.
    15.26 on page no. 541.");
// The value of R3 vary due to round off error.
```

Chapter 16

Measurement Setup

Scilab code Exa 16.1 To calculate modulation index

```
// Exa 16.1

clc;
clear all;

// Given data

fd=75; // Frequency deviation in KHz
fm=5;// Frequency of modulating signal in kHz

// Solution

// From equation 16.5 (page no. 590) we calculate Mi as
Mi=fd/fm; // Modulation index

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 change in output voltage due to change in the bits

```
// Exa 17.1

clc;
clear all;

// Given data
// A 5 bit resistive divider

n=5;// since 5 bit resistive divider
Ip1=[1 1 0 1 1];// Digital input 1(1st element of array is MSB)
Ip2=[1 0 1 1 0];//Digital input 2(1st element of array is MSB)
V1=10;// Voltage corresponding to binary 1
V0=0;// Voltage corresponding to binary 0

// Solution

LSB_weight=1/(2^n - 1);
printf('The LSB weight = %.4f \n ',LSB_weight);
```

```
LSB2_weight=2^(2-1)/(2^n-1);
printf('The 2nd LSB weight = %.4f \n ',LSB2_weight');
LSB3_weight=2^(3-1)/(2^n-1);
printf('The 3rd LSB weight = %.4f \n ',LSB3_weight');
LSB_op=V1*LSB_weight;// Change in output voltage due to change in LSB
printf('The change in output voltage due to change in LSB = %.4f V \n ',LSB_op);
LSB2_op=V1*LSB2_weight;
printf('THe 2nd LSB causes a change in output voltage of %.4f V \n ',LSB2_op);
LSB3_op=V1*LSB3_weight;
printf('THe 3rd LSB causes a change in output voltage of %.4f V \n ',LSB3_op);
Va=(V1*2^4+V1*2^3+V0*2^2+V1*2^1+V1*2^0)/(2^n-1);// output voltage for digital Ip1
Vb=(V1*2^4+V0*2^3+V1*2^2+V1*2^1+V0*2^0)/(2^n-1);
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

```

// Exa17.2

clc;
clear all;

// Given data

n=5;// 5 bit ladder
V=10;// For binary 1
```

```

// Solution
// refering table 17.4(page no. 615)-Various Output
   voltage for corresponding MSB

disp("The output voltage for each bit is as follows:
   ");
disp("");
for i=1:n
MSB(i)=V/2^i; //voltage corresponding to MSB i
printf('  %d MSB              Va = V/2^%d = %.4f V \n ',
   i,i, MSB(i));
end
```

Scilab code Exa 17.3 To calculate the output voltage

```
// Exa 17.3

clc;
clear all;

// Given data

Vin=5;// Input voltage(Volts)
Rin=2.5;// k Ohms
Rf=1;//k Ohms

// Solution

Iin=Vin/Rin;//Input current(mA)
If=Iin;
Vout=-If*Rf;

printf('The output voltage = %d Volts \n',Vout);
```

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

```
// Exa 17.4

clc;
clear all;

// Given data
Vref=5;//Reference voltage(V)
R=5;// k Ohms

// Solution

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)");
//16-input combinations are as follows
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];
[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]

disp("  Input Bits        Output Current(mA)  percent Fraction of maximum ");
for i=1:16
Iout(i)=Vref/R * (Ip(i,1)+Ip(i,2)*2^-1+Ip(i,3)*2^-2+Ip(i,4)*2^-3);

printf('   %d  %d  %d  %d                 %.3f                %.3f       \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
end
```

Chapter 20

Measurement of power

Scilab code Exa 20.1 To calculate the Rf test power

```
// Exa 20.1

clc;
clear all;

// Given data

V1=20;// superimposed small AF voltage(V)
V2=30;//Bridge balance voltage(V)
R1=100;// Bridge arm resistor(ohms)

// Solution

RF_pwr=(V2^2-V1^2)/(4*R1);
printf('RF test power = %.2f W \n',RF_pwr);
```

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

```
// Exa 20.2

clc;
clear all;

// Given data

M=200;// mass in grams
Heat =1;//Sp. Heat of water(cal/gm degree)
T1=30;//Initial temperature (degree Celsius)
T2=40;//Final temperature (degree Celsius)

// Solution

Pwr_rad=4.18*M*Heat*(T2-T1); // in Watt
printf(' The power radiated = %.2f kW \n',Pwr_rad
   /1000);

// 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

```
// Exa 20.3

clc;
clear all;

// Given data

Vmax=8;//Maximum value of voltage
Vmin=2;//minimum value of voltage

//Solution
SWR=(Vmax+Vmin)/(Vmax-Vmin);//Standing wave ratio
```

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

Chapter 21

Control systems

Scilab code Exa 21.1 To find the percentage error in measurement

```
// Exa 21.1

clc;
clear all;

// Given data
Emax=20; //Max value of variable(mA)
Emin=4;//Min value of variable(mA)
Em=13;//Measured value of variable
Eref=10;//Set(ref) point of variable(mA)

// Solution
//Ep=(Em-Eref)/(Emax-Emin)*100; // Percentage error from page no.(703)
//Therefore
Ep=(Em-Eref)/(Emax-Emin)*100;
printf('The value of Ep = %.2f percent. Since Ep is positive, the measurement is above the set point \n ',Ep);
```