Scilab Textbook Companion for Electronic Instrumentation And Measurements by D. A. Bell[1]

Created by
Dhiraj N.v
B.E (pursuing)
Electronics Engineering
The National Institute Of Engineering
College Teacher
M.S Vijaykumar
Cross-Checked by
TechPassion

May 20, 2016

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

Book Description

Title: Electronic Instrumentation And Measurements

Author: D. A. Bell

Publisher: Oxford Publications, New Delhi

Edition: 2

Year: 2010

ISBN: 9780198065555

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

units Dimensions and Standards

Scilab code Exa 1.1 Flux density

```

// Example 1-1 in page 8
// Given data
clc;
phi=500*10^-8;// one maxwell=10^-8 Wb, phi=total flux
Area=(2.54*10^-2)^2;// area in m^2, cross section is one inch and 1inch=2.54cm
// Calculation
B=phi/Area; //flux density(B) in tesla
printf("total flux density=%.2f mT",B*1000);
// Result
// the toatal flux density is 7.75 mT
```

Scilab code Exa 1.2 temparature conversion

```

//example 1-2 in page 8
clc;
//given data
body_temp=98.6;//human body temperature is 98.6
   degree fahrenheit
//calculations
cel_temp=(body_temp-32)/1.8;//temperature in celsius
kel_temp=cel_temp+273.15;// temperature in kelvin
printf("celsius temperature=%.0f degree celsius \n",
   cel_temp);
printf("kelvin temperature=%.2f K",kel_temp);
//result
//the celsius temperature=37 degree celsius
//the kelvin temperature=310.15 K
```

Chapter 2

Measurement Errors

Scilab code Exa 2.1 resistance at a given temparature

```

//example 2-1 in page 16
clc;
//given data
Rmin=1.14;// minimum resistance 1.14 k-ohm
Rmax=1.26// maximum resistance 1.26 k-ohm
R=1.2;//stated value
dT=75-25;//change in temperature from 25 to 75 degree celsius
// calculation
ab=Rmax-R;//Absolute maximum error
abmin=Rmin-R;// Absolute minmum error
T=(ab/1.2)*100;// Tolerance
Rlarge=R+ab;//largest resistance  possible at 25 degree celsius
dR_per_C=(1.26/10^6)*500;// resistance change per degree celsius dR_per_C
dR=dR_per_C*dT;// total resistance increase
R_75=Rlarge+dR;//maximum resistance at 75 degree celsius
printf("Percentage Tolerance to be stated=+/- %d
```

```
percent \n",T);
printf("Maximum resistance at 75 degree celsius=%.4f K-ohm",R_75);
//result
//Tolerance=5%
//maximum resistance at 75 degree celsius=1.2915 kohm
```

Scilab code Exa 2.2 error in sum voltage

```
//example 2-2 in page 20
clc;
//given data
V1=100;//stated voltage one
V2=80;//stated voltage two
e1=(1/100)*V1;//absolute error of v1
e2=(5/100)*V2;//absolute error of v2
//calculation
e=e1+e2;//absolute error for the sum of the voltages
E=V1+V2;// sum voltage
emax=(e/E)*100;//maximum percentage error
printf("E=%d V +/- %.1f percent",E,emax);
//result
//E=180 V +/- 2.8 percent
```

Scilab code Exa 2.3 error in difference voltage

```

//example 2-2 in page 20
```

```
clc;
//given data
V1=100;//stated voltage one
V2=80;//stated voltage two
e1=(1/100)*V1;//absolute error of v1
e2=(5/100)*V2;//absolute error of v2
//calculation
e=e1+e2;//absolute error for the sum of the voltages
E=V1-V2;// difference voltage
emax=(e/E)*100;//maximum percentage error
printf("E=%d V +/- %d percent",E,emax);
//result
//E=20 V +/- 25 percent
```

Scilab code Exa 2.4 power dissipated and accuracy

```

//Theory problem
```

Scilab code Exa 2.5 average voltage and deviation

```

// example 2-5 in page 25
clc;
//given data
V=[1.001 1.002 0.999 0.998 1.000];// 5 digital
    voltmeters reading in volts
//calculation
Vav=sum(V)/5;// average of 5 readings in volts
```

```
D=abs(V-Vav);//deviation of each reading from the
    average voltage
Dav=sum(D)/5;//average of deviation in volts
printf("Average measured voltage=%d V\n",Vav);
printf("Average deviation=%.4f V",Dav);
//result
//the Average measured voltage=1 V
//The Average deviation=0.0012 V
```

Scilab code Exa 2.6 standard deviation and probable error

```
//To determine the standard deviation and probable
    measurement
//example 2-6 in page 26
clc;
//given data
V=[1.001 1.002 0.999 0.998 1.000];// 5 digital
    voltmeters readings in matrix V in volts
//calculation
Vavg=sum(V)/5;// average of 5 readings in volts
D=abs(V-Vavg);//deviation of each reading from the
    average in volts
D1=D.*D;// get the square of each deviation
x=sum(D1);// sum of the squares of the deviation
sigma=sqrt(x/5);// standard deviation in volts
printf("standard deviation=%.4f V\n",sigma);
eP=0.6745*0.0014;//probable error in volts and sigma
    =0.0014 V
printf("probable error=%.2f mV",eP*1000);
//result
//standard deviation=0.0014 V
//propable error=0.94 V
```

Chapter 3

Electromechanical Instruments

Scilab code Exa 3.1 torque on the coil

```
// To find the Torque on the coil
// example3-1 in page 37
clc;
//Given data
N=100;//Number of turns
B=0.2;//Magnetic flux density of 0.2 tesla
D=0.01; l=0.015; //diameter and length of the coil
    in meters
I=.001;// current=1 mA
//calculation
T=B*l*I*N*D;// torque in N-m
printf("Torque=%f N-m",T);
//result
//Torque=0.000003 N-m
```

Scilab code Exa 3.2 voltage and megohm sensitivity

```
//To find the voltage sensitivity and Megohm sensitivity
// Example3-2 in page 39
clc;
//Given data
Is=(1*10^-6)/(10^-3);// current sensitivity in A/m
R=1000;// critical damping resistance of 1 kohm
//calculation
Vs=R*Is;//voltage sensitivity in mV/mm
Rs=Vs/Is;// megohm sensitivity i M-ohm
printf("Voltage sensitivity=%d mV/mm\n",Vs);
printf("megohm sensitivity=%d M-ohm",Rs/1000);
//result
//Voltage sensitivity=1 mV/mm
//Megohm sensitivity=1 Kohm
```

Scilab code Exa 3.3 total current through the ammeter

```

//example 3-3 in page 41
clc;
//Given Data
A=['a' 'b' 'c'];
m=0;
Rm=99;//coil resistance in ohm
IM=0.1e-3;//FSD(IM)=0.1 mA
Rs=1;//shunt resistance in ohm
//calculation
n=2;//initialisation
while n&gt;0.25,
    n=n/2;
    Im=IM*n;
    Vm=Im*Rm;// Meter voltage in volts
```

```
    Is=Vm/Rs;//current throught the shunt resistance in ampere
    I=Im+Is;//toatal current through the ammeter I=Im+Is in ampere
    m=m+1;
    printf("(%c) current through the ammeter at %.2f FSD=%.1f mA\n",A(m),n,I*1000);
end
```

Scilab code Exa 3.4 shunt resistance

```
// To find the Shut resistance of the ammeter
// example 3-4 in paage 43
clc;
//Given data
A=['b' 'a'];
Im=100*10^-6;// FSD(Im) in ampere
Rm=1000;// Coil resistance is 1 K-ohm
// calculation
I=10;// FSD initialisation
m=0;
while I&gt;0.1,
    I=I/10;
    Vm=Im*Rm;//voltage across the meter in volts
    Is=I-Im;//current through shunt resistance in ampere
    Rs=Vm/Is;//shunt resistance in ohm
    m=m+1;
    printf("(%c) shunt resistance value for %.1f A FSD is %f ohm\n ",A(m),I,Rs);
end
```

Scilab code Exa 3.5 ammeter range

```
//Theory problem
```

Scilab code Exa 3.6 multiplier resistance and applied voltage

```

//Theory
```

Scilab code Exa 3.7 multiplier resistances

```
// To find the required multiplier resistance for
   the two given circuits
//Example3-7 in page 49
clc;
//Given data
V=[10 50 100];// voltage ranges in volt
Im=50e-6;// FSD=50 micro-A
Rm=1700;// coil resistance in ohm
//calculation
printf("for circuit as in figure 3-16(a)\n");
for n=1:3
    R=(V(n)/Im)-Rm;
```

```
    printf("R%d=%.4f M ohm\n",n,R/10^6);
end
printf("for circuit as in figure 3-16(b)\n");
R=zeros(1,3);
for n=1:3
    R(n)=(V(n)/Im)-Rm-R(1)-R(2);
    printf("R%d=%.4f M ohm \n",n,R(n)/10^6);
end
//result
// for circuit as in figure 3-16(a)
//R1=198300 ohm
//R2=998300 ohm
//R3=1998300 ohm
//for circuit as in figure 3-16(b)
//R1=198300 ohm
//R2=800000 ohm
//R3=1000000 ohm
```

This code can be downloaded from the website wwww.scilab.in

Scilab code Exa 3.8 multiplier resistance

```
// To find the required multiplier resistance for
   the two given circuits
//Example3-7 in page 49
clc;
//Given data
V=[10 50 100];// voltage ranges in volt
Im=50e-6;// FSD=50 micro-A
Rm=1700;// coil resistance in ohm
//calculation
printf("for circuit as in figure 3-16(a)\n");
```

```
for n=1:3
    R=(V(n)/Im)-Rm;
    printf("R%d=%.4f M ohm\n",n,R/10^6);
end
printf("for circuit as in figure 3-16(b)\n");
R=zeros(1,3);
for n=1:3
    R(n)=(V(n)/Im)-Rm-R(1)-R(2);
    printf("R%d=%.4f M ohm \n",n,R(n)/10^6);
end
```

This code can be downloaded from the website wwww.scilab.in

Scilab code Exa 3.9 pointer indication for the voltmeter

```

// example 3-9 in page 53
clc;
//given data
A=['a' 'b'];
Rm=1e+3;// coil resistance of 1 k ohm
Rs=890.7e+3;//multiplier resistance in ohm
Vf=0.7;//voltage drop across the diode in volt
//calculation
m=0;// reference to indicate a and b respectively
for n=75:-25:50 //voltages 50 and 75 volts
    Iav=(0.637)*(((1.414*n)-2*Vf)/(Rs+Rm));//
       average current through pmcc instrument in
       ampere
    m=m+1;
    printf("(%c),\nIav for %d V is %.2f micro-A\n",A
       (m),n,Iav*10^6);
```

```
    printf("pointer indication for %d V is %.2f FSD\n",n,10000*Iav);
end
```

Scilab code Exa 3.10 sensitivity of the voltmeter

```
//To find the sensitivity
//example 3-10 in page 54
clc;
//given data
Im=157e-6;// peak current=157 micro ampere
Vrms=100;// FSD rms voltage in volt
//calculation
Irms=0.707*Im;//FSD rms current
R=Vrms/Irms;// total circuit resistance
S=R/Vrms;//sensitivity
printf("sensitivity=%d K-ohm/volt\n",S/1000);
//result
//sensitivity=9 k-ohm/Volt
```

Scilab code Exa 3.11 value of given resistances

```
//To find  resistance Rs and Rsh in the given ciruit
// example 3-10 in page 55
clc;
//data given
Iav=50e-6;//average current through PMCC instrument =50 micro ampere
Rm=1700;// coil resistance in ohm
```

```
Vf=0.7;// diode forward drop in volts
If=100e-6;// forward current = 100 micro-ampere
Vrms=50;// ac rms voltage in volts
// calculation
Im=Iav/(0.5*0.637);//peak current in ampere
Ifp=(100/20)*If;//at 20% of FSD, diode peak current(
    If) must be at least 100 micro ampere; therefore,
     at 100% of FSD,
Ishp=Ifp-Im;// peak current through Rsh in ampere
Vm=Im*Rm;// peak voltage in volts
Rsh=Vm/Ishp;
Rs=(1.414*Vrms-Vm-Vf)/Ifp;
printf("Rsh=%d ohm\n",Rsh);
printf("Rs=%.1f K-ohm\n",Rs/1000);
//result
//Rsh=778 ohm
//Rs=139.5 K-ohm
```

Scilab code Exa 3.12 calculate the value of Rl

```
//To find the the resistance Rl
// example 3-12 in page 58
clc;
// Given data
Iav=1e-3;// Average current through the PMCC = 1 mA
Ip=250e-3;// primary current= 250 mA
Rm=1700;// coil resistance in ohm
Ns=500;// number of secondary turns
Np=4;//number of primary turns
Vf=0.7;//diode forward drop in volts
Rs=20e+3;// Rs=20 k ohm
//calculation
Im=Iav/0.637;//peak current
```

```
Em=(Im*(Rs+Rm))+(2*Vf);//secondary peak voltage
Es=Em*0.707;//secondary rms voltage
Irms=1.11*Iav;// RMS meter current
Is=Ip*(Np/Ns);//transformer rms secondary current
Il=Is-Irms;//current through Rl
Rl=Es/Il;
printf("Rl=%.1f K-ohm\n",Rl/1000);
//result
//Rl=28.2 K-ohm
```

Scilab code Exa 3.13 percentage error

```

//Given Data
clc;
Im=100e-6;// FSD=100 micro amps
e=1;// specified accuracy
//calculation
for n=1:2
    I=Im/n;//indicated current
    Ie=(e/100)*Im;//error current
    Imax=I+Ie;//actual measured maximum current
    Imin=I-Ie;//actual measured minimum current
    eI=(Ie/I)*100;//Percentage error in the measured
        currrent
    printf("At %.1f FSD\n",1/n);
printf("Actual measured current=%d to %d micro-A\n",
   Imin*(1e+6),Imax*(1e+6));
printf("error=(+/-)%d persent of measured current\n"
   ,eI);
printf("\n");
end
//result
```

```
// At 1.000000 FSD
//Actual measured current=99 to 101 micro-A
//error=(+/-)1 persent of measured current

//At 0.500000 FSD
//Actual measured current=49 to 51 micro-A
//error=(+/-)2 persent of measured current
```

Scilab code Exa 3.14 instrument indication and resistance scale

```

// example 3-14 in page 61
clc;
//Given Data
Eb=1.5;//battery rating in volts
Im=100e-6;// FSD=100 micro ampere
R=15e+3;// R1+Rx=15 K-ohm
//calculation
printf("meter indication when Rx=0 is %d micro-A (
   FSD)\n",(Eb/R+0)*10^6);// here Rx=0
for n=0.25:0.25:0.75//FSD's in ampere at which
   resistance Rx should be calculated
    Rx=(Eb/(n*Im))-R;// resistance in ohm
    printf("Rx for %.2f FSD=%.0f K-ohm \n",n,Rx
       /1000);
end
//result
// meter indication when Rx=0 is 100 micro A (FSD)
//Rx for 0.25 FSD=45 K-ohm
//Rx for 0.5 FSD=15 K-ohm
//Rx for 0.75 FSD=5 K-ohm
```

Scilab code Exa 3.15 to find the resistance

```

//example3-15 in page 63
clc;
//Given data
R1=15e+3; // resistance R1=15 K-ohm
Rm=50;// coil resistance in ohm
R2=50;// resistance R2 in ohm
Im=50e-6;// FSD=50 micro-ampere
//calculations
printf("at Rx=0 &amp; Eb=1.3 V,\n");
 Rx=0; Eb=1.3;
 Ib=Eb/(Rx+R1);
 I2=Ib-Im;
 Vm=Im*Rm;
 R21=Vm/I2;// the resistance R2 in ohm
 printf("R2=%.2f ohm\n",R21);
 for Eb=1.5:-0.2:1.3,// To find Rx
     Vm=0.5*Im*Rm;
     if Eb==1.3
         R2=R21;
     end
     I2=Vm/R2;
     Ib=I2+Im*0.5;
     Rx=(Eb/Ib)-R1;
     printf("At 0.5 FSD with Eb=%.1f V,\n",Eb);
     printf("Rx=%d K-ohm \n",Rx/1000);
 end
 //result
//at Rx=0 &amp; Eb=1.3 V
//R2=68.181818 ohm
```

```
//At 0.5 FSD with Eb=1.5V,
//Rx=15 K-ohm
//At 0.5 FSD with Eb=1.3 V,
//Rx=15 K-ohm
```

Scilab code Exa 3.16 ohmeter indication and the resistance

```

// example 3-16 in page65
clc;
//Given data
//the equivalent circuit is derived as shown in the
    fig3-24 from the R X 1 range ohmmeter circuit
E=1.5;// battery rating in volts
//calculation
for Rx=0:24:24,//Rx in ohm
    Ib=E/(Rx+14+((10*(9990+2875+3820))
        /(9990+2875+3820)));

    Im=Ib*(10/(10+9990+2875+3820));// meter current
    printf("meter current when Rx=%d ohm is %.2f
        micro-A\n",Rx,Im*1e+6);
end
```

Chapter 4

analog electronic volt ohm milliammeter

Scilab code Exa 4.1 meter current and voltage input resistance

```
// To find the meter current and the voltmeter resistance
//example 4-1 in page 88
clc;

//given data
Vcc=20;//Vcc in volts
R=9.3e+3;// R=Rs+Rm=9.3 K-ohm
Im=1e-3'// Im=1 mA
hfe=100;
E=10;// E in volts
Vb=0.7;//voltage drop across base in volts

// calculation
Ve=E-Vb;// emitter voltage in volts
printf("meter current=%d mA\n",Ve*1000/R);
Ib=Im/hfe;// base current
printf("input resistance with transistor = %d M-ohm\n",E/(Ib*1000000));
```

```
printf("input resistance with out transistor = %.1f K-ohm\n",R/1000);
//result
//meter current = 1 mA
//input resistance with transistor = 1 M-ohm
//input resistance with out transistor = 9300 ohm
```

Scilab code Exa 4.2 meter circuit voltage and currents

```
// To find currents I2 and I3 and calculate the meter circuit voltage in the given circuit
//example 4-2 in page 89
clc;
//Given data
R2=3.9e+3;//resistance R2=R3=3.9 K-ohm
R3=R2;
Vcc=12;//Vcc in volt
Vee=-12;// Vee in volt
Vbe=0.7;// voltage drop across the base_emitter
Vp=0;// base voltage of transistor 2
//calculation
VR2=0-Vbe-Vee;
VR3=VR2;
I2=VR2/R2;
I3=I2;
printf("I2=I3=%.1f mA\n",I2*1000);
for E=1:-0.5:0.5// voltage applied to the base of transistor 1 in volts
    Ve1=E-Vbe;// emitter voltage of transistor 1
    Ve2=Vp-Vbe;// emitter voltage of transistor 2
    V=Ve1-Ve2;// voltage difference b/w the two emitters
    printf("when E=%.1f V,\n",E);
```

```
    printf("circuit voltage (V)=%.1f V\n",V);
end
//result
//I2=I3=2.9 mA
//when E=1.0 V,
//circuit voltage (V)=1.0 V
//when E=0.5 V,
//circuit voltage (V)=0.5 V
```

Scilab code Exa 4.3 meter reading and gate source voltage

```

// example 4-3 in page 93
clc;
//Given data
Range=10;//range in volts
Ra=800e+3; Rb=100e+3; Rc=60e+3; Rd=40e+3; // given
   resistance values in ohm
E=7.5; //battery voltage in volts
Vgs=-5;// gate source voltage in volts
Vp=5;// base voltage of transistor 2 in volts
R=1e+3;// R=Rs+Rm=1 K-ohm
Im=1e-3;//FSD=1 mA
Vbe=0.7//base emitter voltage in volt
//calculation
Eg=E*((Rc+Rd)/(Ra+Rb+Rc+Rd));//gate voltage
Vs=Eg-Vgs;//souce voltage
Ve1=Vs-Vbe;// emitter voltage of transistor 1
Ve2=Vp-Vbe;//emitter voltage of transistor 2
V=Ve1-Ve2;// voltage difference b/w the two emitters
I=V/R;
P=I/Im;//P% of full scale
printf("THE METER READING=%.1f V\n",P*Range);
```

```
//result
//THE METER READING=7.500000 V
```

Scilab code Exa 4.4 suitable resistance values

```
// to determine the resistance values for the
   circuit in the figure4-7
//example 4-4 in page 97
clc;
//Given data
E=20e-3;//maximum input voltage = 20 mV
Ib=0.2e-6;//op-amp input current 0.2 micro amps
Im=100e-6;//FSD=100 micro amps
Rm=10e+3;// coil resistance in 10 k-ohm
//As I4>>Ib select
I4=1000*Ib;// current in ampere
// at full scale Im=100 micro-A
Vout=Im*Rm;
printf("R3=%d ohm\n",E/I4);
printf("R4=%.1f K-ohm\n",(Vout-E)/(1000*I4));
//result
//R3=100 ohm
//R4=4900 ohm
```

Scilab code Exa 4.5 value of resistance and voltage at output

```

//example 4-5 in page 98
clc;
```

```
//data given
E=1;// E=1 V
Im=1e-3;//FSD=1 mA
Rm=100;// Rm in ohm
//calculation
R3=E/Im;
printf("R3=%d K-ohm\n",R3/1000);
printf("Vout=%.1f V\n",Im*(R3+Rm));
//result
//R3=1 K-ohm
//Vout=1.1 V
```

Scilab code Exa 4.6 resistance scale marking

```

// example 4-6 in page 100
clc;
// data give
Eb=1.5;// Full scale voltage in volts
R1=1e+3;//R1=1 K-ohm
//calculation
for n=1:2
    E=Eb*(n/3);// 1/3rd and 2/3rd value of full
       scale
    Rx=R1/((Eb/E)-1);
    printf("at %d/3 FSD, Rx=%d ohm\n",n,Rx)
end
```

Scilab code Exa 4.7 value of R3 and deflection

```

// example 4-7 in page 107
clc;
// Given data
Iav=1e-3;//for, FSD the average meter current is 1 mA
Rm=1.2e+3;// coil resistance 1.2 K-ohm
E=100e-3;// ac input rms voltage=100 mV
//calculations
Ip=(2/0.637)*Iav;// peak current for half wave rectifier
Ep=E/0.707;// input peak voltage
R3=Ep/Ip;
printf("R3=%d ohm\n\n",R3);
printf("When E=50 mV,\n");
Ep=(50e-3)/0.707;
Ip=Ep/R3;
printf("meter deflection=Iav=%.1f mA\n",(0.637/2)*Ip*1000);//half scale
```

Chapter 5

Digital instrument Basics

Scilab code Exa 5.1 high and low output voltages

```
// to find the high and low output voltage values
// example 5-1 in page 120
clc;
//Given data
Vcc=5;// DC source in volts
Io=1e-3;// output current= 1mA
R1=1e+3;//R1=1K-ohm
Vi=0;//lowest input voltage
Vd=0.7;// silicon-diode drop in volts
//calculation
printf("High output voltage=%d V\n",Vcc-(Io*R1));
printf("low output voltage=%.1f V\n",Vi+Vd);
//result
//High output voltage=4 V
//low output voltage=0.7 V
```

Scilab code Exa 5.2 collector and base voltage

```
// To find the collector and base voltages
// example 5-2 in page 121
clc;
// Given data
R1=15e+3; R2=27e+3; Rc1=2.7e+3; R11=R1; R21=R2; //
    resistance values in Ohm where R11=R1' and R21=R2
    '
Vc2=0.2;// collector voltage of on transistor in
    volt
Vce=Vc2;//collector-emitter saturation voltage in
    volt
Vbb=-5;//dc power supply in volt
Vcc=5;//dc power supply in volt
//calculations
Vr1r2=Vc2-Vbb;//voltage across Ri and R2 in volt
Vr1=(R1/(R1+R2))*Vr1r2;// voltage across R1 resistor
     in volt
Vb1=Vc2-Vr1;// base voltage
printf("Vb1=%.1f V\n",Vb1);
//with Q1 off
Vrc1=(Rc1/(Rc1+R11+R21))*(Vcc-Vbb);
Vc1=Vcc-Vrc1;// collector voltage in volt
printf("Vc1=%.1f V",Vc1);
//result
//Vb1=-1.657143 V
//Vc1=4.395973 V
```

Scilab code Exa 5.3 supply current required

```

//example 5-3 in page 124
clc;
// Given data
// 3(1/2) digit display
If1=20e-3;//forward current per segment of led=20 mA
If2=300e-6;//forward current per segment of lcd
//calculations
for n=1:2
    if n==1
       I=If1;
       else I=If2;
    end
    It=3*7*I+2*I;// each digit has 7 segments and
       there are three digits with a half digit that
        has 2 segments
    printf("case %d,\n Total current=%.0f mA\n",n,It
       *1000);
end
//result
// case 1,
//Total current=0.460000 A
//case 2,
//Total current=0.006900 A
```

Scilab code Exa 5.4 out put frequency

```
// to find the out put frequency in fig 5-10
// example 5-4 in page 130
clc;
//Given data
To=1e-6;//oscillator time period=1 micro-second
N=16;// modulus number of the counter = 16
n=3;// number of counters
//calculations
T=To*(N^n);//out put time period
printf("output frequency=%d hertz",1/T);//output
    frequency
//result
//output frequency=244 hertz
```

Scilab code Exa 5.5 number of clock pulses counted

```
//To find the number of pulses counted
//example5-5 in page 131
clc;
//data given
Vr=1.25;//peak voltage of ramp in volts
tr=125e-3;//time period of the ramp=1.25 ms
T=1/(1e+6);// frequency =1 Mhz and time period of
    the clock pulses is 1/f
for Vi=0.75:(0.9-0.75):0.9,// analog input voltages
    for which clock pulses has to b found
    t1=(tr/Vr)*Vi;//time period of the comparator
        high out put
    N=t1/T;// pulses counted
    printf("number of pulses counted for Vi=%.2f V
        are %d\n",Vi,N/100);
end
//result
```

```
//number of pulses counted for Vi=0.750000 V are 750
//number of pulses counted for Vi=0.900000 V are 900
```

Scilab code Exa 5.6 number of output bits required

```

// example 5-6 in page 133
clc;
//Given data
//error should be less thsn 1%
// for less than 1% error count&gt;=100
n=6;
N=0;
while(N&lt;100)
N=(2^n)-1;//count value
if(N&lt;100)
n=n+1;//increment n and check weather N has exceeded 100
end
end
printf("for less 1percent error,use n=%d\n",n);
//end
// for less 1percent error,use n=7
```

Scilab code Exa 5.7 output voltage of DAC

```

// example 5-7 in page 135
clc;
```

```
//Given data
D=8; C=0; B=2; A=0; //corresponding analog input
    voltages for the digital input 1-0-1-0
Vi=10;//input voltage in volts
//calculation
Vo=(D+C+B+A)*Vi/16;// output voltage
printf("out put voltage=%.2f V",Vo);
//result
//out put voltage=6.25 V
```

Chapter 6

Digital voltmeters and frequency meters

Scilab code Exa 6.1 maximum time and suitable frequency

```
//Theory Problem
```

Scilab code Exa 6.2 measurement accuracy

```

//Theory Problem
```

Scilab code Exa 6.3 determine the measured frequency

```
//Theory Problem
```

Scilab code Exa 6.4 percentage measurement error

```
//THEORY PROBLEM
```

Chapter 7

Low High and Precise Resistance Measurements

Scilab code Exa 7.1 Caption find the resistance

```
// To find the value of measured Resistance R
// example 7-1 in page 165
clc;
// Given data
I=0.5;//measured current in amps
V=500;// voltmeter indication in volts
Ra=10;//ammeter resistance in ohms
//calculation
R=(V/I)-Ra;// measured resistance
printf("The value of R=%d ohm",R);
//result
// The value of R=990 ohm
```

Scilab code Exa 7.2 ammeter and ohmeter indications

```
// To find the ammeter and ohmeter indication for
   the circuit 7-1(a)
// example 7-2 in page 166
clc;
//Data given
V=1000; S=10e+3; // voltmeter range and sensitivity
   in volt and ohm/volt
R=990;// the resistance measured
E=500;// supply voltage in volts
Ra=10;// ammeter resistance in ohm
//calculaTION
Rv=V*S;// voltmeter resistance
R1=(R*Rv)/(R+Rv);// as voltmeter is connected in
   parallel with the measured resistance , the
   equivalent resistance is the parallel combination
    of both resistancs
Ev=(E*R1)/(R1+Ra);// voltmeter reading using voltage
    divider formula
I=Ev/R1;// ammeter reading
printf("voltmeter reading=%.0f V\nAmmeter reading=%
   .1f A\n",Ev,I);
//result
//voltmeter reading=495 V
//Ammeter reading=0.5 A
```

Scilab code Exa 7.3 accuracy

```
// To determine which of the circuits 7-1(a) or 7-2(
   b) has greater accuracy
// example 7-3 in page 166
clc;
```

```
//Data given
V1=495; I1=0.5; // voltmeter and ammeter reading in volt and ampere respectively of circuit 7-1(a)
V2=500; I2=0.5;// voltmeter and ammeter reading in volt and ampere respectively of circuit 7-1(b)
//calculation
printf("R from circuit 7-1(a)=%d ohm\nR from circuit 7-1(b)=%d ohm\n",V1/I1,V2/I2);
printf("thus circuit 7-1(a) gives the more accurate result");
//result
//R from circuit 7-1(a)=990 ohm
//R from circuit 7-1(b)=1000 ohm
//thus circuit 7-1(a) gives the more accurate result
```

Scilab code Exa 7.4 find the resistance

```
// to calculate the value of Resistance R
// example 7-4 in page 169
clc;
// data given
P=3.5e+3; Q=7e+3; S=5.51e+3; // resistance values of the wheatstone bridge arms in ohm
//calculation
R=S*P/Q;// equation for balancng condition
printf("R=%f K-ohm\n",R/1000);
S=[1e+3 8e+3];// adjusting s from 1 t0 8 K-ohm
for n=1:2
    R=S(n)*P/Q;
    printf("when S=%d K-ohm,\n",S(n)/1000);
    printf("R=%d ohm\n",R);
end
//result
```

```
//Measurement range is from 500 ohm to 4000 ohm
```

Scilab code Exa 7.5 accracy upper and lower values

```
// To calculate the accuracy of the measured value of resistance and to find the upper and lower values
// example 7-5 in page 169
clc;
//Data given
R=2.755e+3;//measured value of R in ohm
E=[0.05 0.05 0.1]// percentage errors of the resistances P Q and S respectivly
//calculation
Re=sum(E);// percentage error in R
Rmax=R+((Re/100)*R);//upper limit of resistance R in ohm
Rmin=R-((Re/100)*R);// lower limit of resistance R in ohm
printf("the upper and lower limits of R are %.4f K-ohm and %.4f K-ohm respectively",Rmax/1000,Rmin/1000);
//result
// the upper and lower limits of R are 2.760510 K-ohm and 2.749490 K-ohm respectively
```

Scilab code Exa 7.6 minimum change

```
// to calculate the minimum change detectable by the
    bridge
// example 7-6 in page 172
clc;
//Given data
P=3.5e+3; Q=7e+3; S=4e+3; R=2e+3; // bridge arm
   resistances in ohm
Eb=10;// supply voltage in volt
Ig=1e-6;//galvano meter reading in ampere
rg=2.5e+3;//galvanometer resistance=2.5 K-ohm
//calculations
r=((P*R)/(P+R))+((Q*S)/(Q+S));// internal resistance
    of the bridge in ohm
dVR=Ig*(r+rg);// open-circuit galvano meter voltage
   i,e VR-VS in volt
VR=Eb*R/(R+P);// voltage across resistance R in volt
VP=Eb-(VR+dVR);//voltage across resistance P in volt
IR=VP/P;// current through P which is equal to
   current through R in ampere
dR=((VR+dVR)/IR)-R;//Change in R value that the
   device can detect in ohm
printf("the minimum change in R which is detected by
    the bridge is %f ohm\n",dR);
//result
// the minimum change in R which is detected by the
   bridge is 5.466141 ohm
```

Scilab code Exa 7.7 ratio of resistances

```
// to determinr the required ratio of R/P
// example 7-7 in page 176
clc;
// Given data
```

```
S=0.1; Q=0.15; // resistances in ohm
//calculation
r=S/Q;// here R/P=S/Q
printf("the required ratio is %d/%d",(S*100),(Q*100));
//result
// the required ratio is 10/15
```

Scilab code Exa 7.8 volume and surface lekage resistance

```
// to find the volume resistance and the surface leakage resistance
// example 7-8 in page 180
clc;
//Data given
Is=5e-6;// surface current in ampere
Iv=1.5e-6;// volume current in ampere
E=10000;// supply voltage in volt
// calculation
printf("volume resistance=%0.1e ohm\n",E/Iv);
printf("surface leakage resistance=%0.1e ohm",E/(Is-Iv));
//result
//volume resistance=6.7e+009 ohm
//surface leakage resistance=2.9e+009 ohm
```

Chapter 8

Inductance and capacitance Measurements

Scilab code Exa 8.1 components and connections

```
// To find the components and connections
// example 8-1 in page 194
clc;
// Given data
C=0.005e-6; Rs=8e+3; f=1e+3; // the circuits
    capacitance,resistance and measurement frequency
    in farad, ohm and hertz respectively
ohm_meter_reading=134e+3;// in ohm
//calculation
Xs=1/(2*%pi*f*C);//series inductive reactance in ohm
Rp=(Rs*Rs+Xs*Xs)/Rs;// parallel resistance ih ohm
Xp=(Rs*Rs+Xs*Xs)/Xs;// parallel inductive reactance
    in ohm
Cp=1/(2*%pi*f*Xp);// parallel capacitance in farad
printf("Rp=%d K-ohm\nXp=%.1f K-ohm\nCp=%.3f micro-F"
    ,Rp/1000,Xp/1000,Cp*1000000);
//result
```

```
// since the measured terminal resistance is 134 k-
   ohm, the circuit must consist of a 0.005 micro-
   farad capacitor connected in parallel with a 134
   kilo-ohm resistor.For a series connected circuit.
    the terminal resistance would be much higher
   than 134 K-ohm
```

Scilab code Exa 8.2 range of capacitance

```
// to find the range of Cx in fig 8-5
// example 8-2 in page 199
clc;
// data given
C1=0.1e-6; //standard capacitance in micro farad
r=[100/1 1/100];// range of the ratio R3/R4
Cx=C1*r;// range of Cx
printf("The range of Cx is from %.3f micro-F to %d
   micro-F",Cx(2)*10^6,Cx(1)*10^6);
//result
//The range of Cx is from 0.001 micro-F to 10 micro-
   F
```

Scilab code Exa 8.3 resistance capacitance and dissipation factor

```
// to find the capacitance, resistance and the
   dissipation factor
// example 8-3 in page 202
clc;
//Given data
```

```
f=100;// frequency in Hz
C1=0.1e-6;// satndard capacitance in farad
R=[125 0 10e+3 14.7e+3];// resistances R1,R3 and R4
    values in ohms as R2 is not used it is take as 0
    for convinence
//calculation
Cs=C1*(R(3)/R(4));//series capacitance
Rs=R(1)*R(4)/R(3);// series resistance
D=2*%pi*f*Cs*Rs;// dissipation factor
printf("Cs=%.3f micro-F\nRs=%.1f ohm\nD=%.3f",Cs
    *10^6,Rs,D);
//result
//Cs=0.068 micro-F
//Rs=183.8 ohm
//D=0.008
```

Scilab code Exa 8.4 resistance capacitance and dissipation factor

```
// To find the resistance,capacitance and
    dissipation factors
// example 8-4 in page 204
clc;
//Given Data
f=100;// frequency in Hz
C1=0.1e-6;// satndard capacitance in farad
R=[375e+3 0 10e+3 14.7e+3];// resistances R1,R3 and
    R4 values in ohms as R2 is not used it is take as
     0 for convinence
//calculation
Cp=C1*(R(3)/R(4));//parallel capacitance in farad
Rp=R(1)*R(4)/R(3);// parallel resistance in ohm
D=1/(2*%pi*f*Cp*Rp);// dissipation factor
printf("Cp=%.3f micro-F\nRp=%.1f K-ohm\nD=%2.1e\n",
```

```
    Cp*10^6,Rp/1000,D);
//result
// Cp=0.068027 micro-F
//Rp=551.250000 K-ohm
//D=0.042441
```

Scilab code Exa 8.5 parallel resistance and capacitance

```
// to calculate the equivalent parallel capacitance
    and resistance
// example 8-5 in page 204
clc;
//Given dATA
R3=10e+3;// resistance R3 in ohm
f=100;//frequency in hertz
Cs=0.068e-6; Rs=183.8; // series capacitance in
    farad and resistance in ohm
//Calculation
Xs=1/(2*%pi*f*Cs);// series capacitive reactance in
    ohm
Rp=(Rs*Rs+Xs*Xs)/Rs;//equivalent parallel resistance
     in ohm
Xp=(Rs*Rs+Xs*Xs)/Xs;//equivalent parallel capacitive
     reactance in ohm
Cp=1/(2*%pi*f*Xp);// equivalent capacitance in farad
R4=C1*R3/Cp;// parallel resistance in ohm
R1=R3*Rp/R4;// parallel resistance in ohm
printf("Rp=%.2f M-ohm\nCp=%.3f Micro-F\nR1=%.2f M-
    ohm\nR4=%.1f K-ohm",Rp/10^6,Cp*10^6,R1/10^6,R4
    /1000);
//result
//Rp=2.98 M-ohm
//Cp=0.068 Micro-F
```

```
//R1=2.03 M-ohm
//R4=14.7 K-ohm
```

Scilab code Exa 8.6 find the resistance

```
// To find the resistance R1 and R3 in fig 8-8
// example 8-6 in page 207
clc;
// Given data
R4=5e+3; L1=100e-3; Ls=500e-3; Rs=270; R3=1e+3; //
    resistances in ohm and inductances in henry
//calculation
printf("R3=%d K-ohm\n",R4*L1/(Ls*1000));
printf("R1=%d ohm",Rs*R3/R4);
//result
//R3=1 K-ohm
//R1=54 ohm
```

Scilab code Exa 8.7 inductance resistance and Q factor

```
// to find the resistance inductance and the Q
    factor of the inductor
// example 8-7 in page 209
clc;
// given data
// it is a maxwell's induction bridge
C3=0.1e-6; R1=1.26e+3; R4=500; R3=470; //
    capacitance and resistor values in farad and ohm
f=100;// frequency =100 Hz
```

```
//calculation
printf("Ls=%d mH\n",C3*R1*R4*1000);// here Ls=C3*R1*
    R4
printf("Rs=%.2f K-ohm\n",R1*R4/(R3*1000));//here Rs=
    R1*R4/R3
printf("Q=%.2f",(2*%pi*f*C3*R1*R4)/(R1*R4/R3));// Q=
    w*Ls/Rs
//result
//Ls=63 mH
//Rs=1.34 K-ohm
//Q=0.03
```

Scilab code Exa 8.8 induactance resistance and Q factor

```
//to find the resistance inductance and the Q factor
    of the inductor
// example 8-8 in page 210
clc;
// given data
// it is a maxwell's induction bridge
C3=0.1e-6; R1=1.26e+3; R4=500; R3=75; // capacitance
    and resistor values in farad and ohm
f=100;// frequency =100 Hz
//calculation
printf("Lp=%d mH\n",C3*R1*R4*1000);// here Lp=C3*R1*
    R4
printf("Rp=%.1f K-ohm\n",R1*R4/(R3*1000));//here Rp=
    R1*R4/R3
printf("Q=%d",(R1*R4/R3)/(2*%pi*f*C3*R1*R4));// Q=Rs
    /(w*Lp)
//result
//Lp=63 mH
//Rp=8.4 K-ohm
```

```
//Q=212
```

Scilab code Exa 8.9 find the inductance and resistance

```
// to find series equivalent inductance and resistance and find R1 and R3 for maxwell circuit
// example 8-9 in page 211
clc;
printf("part a,\n");
//Data Given
Lp=63e-3; Rp=8.4e+3; f=100;// the parallel inductance in henry and resistace in ohm with 100 hertz frequency
//calculation
Xp=2*%pi*f*Lp;//parallel inductive reactance in ohm
Rs=(Rp*Xp*Xp)/(Xp*Xp+Rp*Rp);// series resistance in ohm
printf("Rs=%.3f ohm\n",Rs);// equivalent series resistance in ohm
Xs=(Rp*Rp*Xp)/(Xp*Xp+Rp*Rp);// series inductive reactance in ohm
Ls=Xs/(2*%pi*f);// equivalent series inductance in henry
printf("Ls=%.0f mH\n",Ls*1000);
printf("part b,\n");
//Data given
C3=0.1e-6; R4=500; // capacitance in farad and resistance in ohm of maxwell bridge
//calculation
R1=Ls/(C3*R4);//resistance in ohm
printf("R3=%.2f M-ohm",(R1*R4)/(Rs*10^6));
printf("\nR1=%.2f K-ohm",R1/1000);
//result
```

```
//part a,
//Rs=0.187 ohm
//Ls=63 mH
//part b,
//R3=3.38 M-ohm
//R1=1.26 K-ohm
```

Scilab code Exa 8.10 find the capacitance and resistance

```
// to find Cx and Rx of figure 8-7 for new balance
// example 8-10 in page 214
clc;
//Data given
C1=0.1e-6; R3=10e+3; R4=14.66e+3; R1=369.3e+3; //
   bridge capacitance and resistance in farad and
   ohm respectively
Rp=553.1e+3; Cp=0.068e-6;// parallel resistance in
   ohm and capacitance in farad
//calculations
Cx=(C1*R3/R4)-Cp;// here Cx+Cp = C1*R3/R4 in farad
printf("Cx=%d pF\n",Cx*10^12);
R=R1*R4/R3;// let R=Rx parallel with Rp in ohm
Rx=1/((1/R)-(1/Rp));// Rx in ohm
printf("Rx=%.0f M-ohm\n",Rx/10^6);
//result
//Cx=212 pF
//Rx=26 M-ohm
```

Scilab code Exa 8.11 determine the q factor

```
// to determine the Q factor
// example 8-11 in page 221
clc;
//Data given
E=100D-3; R=[5 10]; XC=100; XL=XC; // supply resistance , capacitive reactance and inductive reactance respectively for the fig 8-17, all in ohm
//calculation
for n=1:2
    I=E/R(n);// current in ampere
    V=I*XC;// VL=VC=V and XC=XL, voltage in volts
    Q=V/E;// Q factor
    printf("for %d st coil ,\n",n);
    printf("voltmeter indication=%d V\n",V);
    printf("Q=%d\n",Q);
end
//result
//for 1 st coil ,
//voltmeter indication=2 V
//Q=20
//for 2 st coil ,
//voltmeter indication=1 V
//Q=10
```

Scilab code Exa 8.12 coil inductane and resistance

```
// To Determine the coil inductance and the resistance
// example 8-12 in page 225
clc;
// Data given
f=1.25e+6; C=147D-12; Q=98; // frequency in hertz ,
```

```
   Capacitance in farad and Q factor of the Q metre
//calculation
L=1/((2*%pi*f)^2*C);// inductance in henry
printf("inductance=%.0f micro-henry\n",L*10^6);
printf("R=%.1f ohm",(2*%pi*f*L)/Q);
//result
//inductance=110 micro-henry
//R=8.8 ohm
```

Chapter 9

Cathode Ray Oscilloscopes

Scilab code Exa 9.2 peak to peak voltage and time period

```
// to find the peak to peak voltage and the time
   period for the sweep generator circuit in fig 9-7
// example 9-2 in page 243
clc;
// Given Data
R3=4.2e+3; C1=0.25D-6; Vb1=4.9; Vbe=0.7;//resistance
    in ohm, capacitance in farad and voltages in
   volt respectively
UL=2;// UTP,LTP=(+/-)2 V
//Calculation
dV=2*UL;//peak-peak voltage in volt
Ic1=(Vb1-Vbe)/R3;//current in ampere
T=dV*C1/Ic1;// time period in seconds
printf("peak-peak voltage=%d V p-to-p\n",dV);
printf("time period=%d ms",T*1000);
//result
//peak-peak voltage=4 V p-to-p
//time period=1 ms
x=linspace(0,1,100);
```

```
y=4*x-2;
plot(x,y);
xlabel('Time period in ms');
ylabel('voltage in V');
set(gca(),"grid",[1 1]);
```

Scilab code Exa 9.3 amplitude freuency and phase difference

```
// to find the amplitude,frequency and the phase difference b/w two waveforms in the figure 9-20
// example 9-3 in page 256
clc;
//Data Given
x=['A' 'B'];
V=200D-3;// volatge/division=200mV
T=0.1D-3;//time/division=0.1ms
one_cycle=360;// one cycle=360 degree
Vd=[6 2.4];// vertical divisions of A and B respectively
Hd=[6 7];// horizontal divisions of A and B respectively
//calculation
for n=1:2
    Vp=Vd(n)*V;// V peak-to-peak
    Tp=T*Hd(n);// time period
    f=1/Tp;//frequency
    printf("V peak-peak of wave from %c=%.2f V\n",x(n),Vp);
    printf("frequency of wave form %c=%.0f Hz\n",x(n),f);
end
phase_diff=Hd(2)-Hd(1);
phase_diff=one_cycle*phase_diff/6;// here one cycle
```

```
    makes 6 horizontal divisions
printf("phase difference=%d degree",phase_diff);
//result
//V peak-peak of wave from A=1.20 V
//frequency of wave form A=1667 Hz
//V peak-peak of wave from B=0.48 V
//frequency of wave form B=1429 Hz
//phase difference=60 degree
```

Scilab code Exa 9.4 pulse amplitude frequency raise and fall time

```
// to find the pulse amplitude,frequency,rise time
    and fall time of fig9-22
// example 9-3 in page 259
clc;
// Data given
Vpd=2; // voltage/division=2 V
Hpd=5D-6;// time/division=5 micro seconds per
    division
Vd=4;// number of vertical divisions
Hd=5.6// number of horizontal divisions
// calculation
printf("Pulse amplitude=%d V\n",Vd*Vpd);
printf("frequency=%.1f kHz\n",(1/(Hd*Hpd))/10^3);
printf("raise time=%.1f micro-s\nfall time=%d micro-
    s",0.5*Hpd*10^6,10^6*0.6*Hpd);
//result
//Pulse amplitude=8 V
//frequency=35.7 kHz
//raise time=2.5 micro-s
//fall time=3.0 micro-s
```

Scilab code Exa 9.5 longest pulse width

```
// to find the longest pulse width
// example 9-5 in page 261
clc;
//Given data
Ri=10e+6;// input resistance in ohm
Cc=0.1e-6;// coaxial cable capacitance in farad
//calculation
printf("pulse width=%.1f s",Ri*Cc/10);// here pulse
    width=tou/10 seconds
//result
//pulse width=0.1 s
```

Scilab code Exa 9.6 shortest pulse width

```
// to find the shortest pulse width that can be
    displayed
// example 9-6 in page 262
clc;
//DATA GIVEN
Rs=3.3e+3; Ci=15D-12;// source resistance in ohm and
     input capacitance in farad
//calculation
printf("shortest pulse width=%.3f micro-second",10*
    Rs*Ci*2.2*10^6);//here shortest pulse width =10*
    tuo in seconds where tuo is the rise time imposed
     by the oscilloscope
```

```
//result
//shortest pulse width=1.089 micro-second
```

Scilab code Exa 9.7 raise time

```
//to find the raise time of the displayed waveform
// example 9-7 in page 262
clc;
//Data given
Rs=3.3e+3; Ci=15D-12;//source resistance in ohm and
   input capacitance in farad
tri=[109e-9 327e-9];//input raise times in seconds
   for which trd is to be determined
//calculations
tuo=2.2*Rs*Ci;//tuo is the rise time in seconds
   imposed by the ossciloscope
for n=1:2
    trd=sqrt(tri(n)^2+tuo^2); // displayed raise
       time in seconds
    printf("the displayed raise time for input pulse
        raise time %d ns=%d ns\n",tri(n)*10^9,trd
       *10^9);
end
//result
//the displayed raise time for input pulse raise
   time 109 ns=154 ns
//the displayed raise time for input pulse raise
   time 327 ns=344 ns
```

Scilab code Exa 9.8 terminal oscilloscope voltage and frequency

```
//to find the terminal oscilloscope voltage and its
    frequency
// exmaple 9-8 in page 264
clc;
//Data given
Vs=1; //supply voltage in volt
Rs=600;//source resistance in ohm
Ri=1e+6;//input resistance in ohm
Ci=30D-12;//input parallel capacitance in farad
Ccc=100D-12;//coaxial cable capacitance in farad
f=100;// signal frequency in hertz
//calculation
Vi=Vs*Ri/(Rs+Ri);// input voltage in volts
Xc=1/(2*%pi*f*(Ci+Ccc));//capacitive reactance in
    ohm for total capacitance
printf("the input terminal voltage at 100 Hz =%.4f V
    \n",Vi);
printf("when Vi=(Vs-3 dB),\n");
f=1/(2*%pi*(Ci+Ccc)*Rs);// frequency in hertz
printf("frequency=%.2f MHz",f/10^6);
//result
//the input terminal voltage at 100 Hz =0.9994 V
//when Vi=(Vs-3 dB),
//frequency=2.04 MHz
```

Scilab code Exa 9.9 find the capacitance

```
// to find the capacitance to compensate a probe and
    input capacitance
//example 9-9 in page 267
clc;
```

```
//data given
Ci=30D-12;// input capacitance in farad
Ccc=100D-12;// coaxial cable capacitance in farad
R1=9e+6; Ri=1e+6;// resistances in ohm
//calculation
C2=Ccc+Ci;// capacitance in farad
C1=C2*Ri/R1;// capacitance in farad
printf("C1=%.1f pF\n",C1*10^12);
printf("The probe input capacitance as seen from the source=%d pF",(C1*C2)*10^12/(C1+C2))
//result
//C1=14.4 pF
//The probe input capacitance as seen from the source=13 pF
```

Scilab code Exa 9.10 find the frequency

```
// to find the frequency
// example 9-10 in page 268
clc;
// data given
C=13D-12; Rs=600; // input capacitance in farad and source resistance in ohm
//calculation
printf("frequency=%.1f MHz",1/(2*%pi*C*Rs*10^6));
//result
//frequency=20.4 MHz
```

Scilab code Exa 9.11 find the frequency

```
// to determine the frequency
// example 9-11 in page 269
clc;
// Data Given
C=3.5D-12; Rs=600; // capacitance in farad and source resistance in ohm
//calculation
printf("frequency=%.1f MHz",1/(2*%pi*C*Rs*10^6));
//result
//frequency=75.8 MHz
```

Scilab code Exa 9.12 minimum time per sensitivity

```
// to find the minimum time/division sensitivity
// example 9-12 in page 278
clc;
//Data Given
f=50e+6;// frequency of the waveform in hertz
//calculation
T=1/f;//time period in seconds
printf("using the five times magnifier,\n");
printf("minimum time/div setting=%d ns/div",5*(T/4)*10^9);// here one cycle occupies 4 horizontal divisions
//result
//using the five times magnifier,
//minimum time/div setting=25 ns/div
```

Scilab code Exa 9.13 raise time

```
// to determine the raise time  displayed waveform
// example9-13 in page 279
clc;
// Data given
fH=[20e+6 50e+6];// upper cut-off frequency in hertz
tri=21D-9;// input raise time in seconds
// calculation
for n=1:2
    tro=0.35/fH(n);// tro is the raise time in seconds
    trd=sqrt(tri^2+tro^2);// trd is the fall time in seconds
    printf("for fH=%d MHz,\ntrd=%d ns\n",fH(n)/10^6,trd*10^9);
end
//result
//for fH=20 MHz,
//trd=27 ns
//for fH=50 MHz,
//trd=22 ns
```

Chapter 11

signal generators

Scilab code Exa 11.1 maximum and minimum output frequencies

```
// to calculate the maximum and minimmum output
   frequencies of oscillator in fig 11-1
// example 11-1 in page 317
clc;
// Data Given
R=[5e+3 500];// resistance R2 and R1 all in ohm
C1=300D-9; C2=C1;// Capacitance=300 nF
// calculation
f=['f(min)' 'f(max)'];
for n=1:2
    printf("%s=%d Hz\n",f(n),1/(2*%pi*C1*R(n)));//
       frequency in hertz
end
//result
//f(min)=106 Hz
//f(max)=1061 Hz
```

Scilab code Exa 11.2 find the resistor values

```
//to find the resistor values in fig 11-3
// example 11-2 in page 319
clc;
//data given
Vi=5; //input sine wave voltage in volt
VR3=[0.1 1];// range of voltage across resistor R3
    in volt
IB=500D-9;// input current to the op-amp in ampere
//calculation
V=Vi-VR3(1);// with R1 and R2 in the circuit , V=VR1+
    VR2 in volt
I3=100D-6;// as I3>>IB, select I3=100 micro ampere
R3=VR3(1)/I3;// resistance in ohm
R=V/I3;//R=R1+R2 in ohm
//with R2 switched off the circuit
I3=VR3(2)/R3;// current in ampere
VR1=Vi-VR3(2);// voltage in volt
R1=VR1/I3;// here I3=I1, resistance in ohm
R2=R-R1;// resistance in ohm
printf("R1=%d K-ohm\nR2=%d K-ohm\nR3=%d K-ohm",R1
    /1000,R2/1000,R3/1000);
//result
//R1=4 K-ohm
//R2=45 K-ohm
//R3=1 K-ohm
```

Scilab code Exa 11.3 find the output frequency

```
// to find the output frequency of the circuit 11-8
// example 11-3 in page 326
clc;
// Data given
Vcc=15;// supply voltage=15 V
C1=0.1D-6;// capacitance in farad
R1=1e+3; R2=10e+3;// resistances in ohm
utp=3; ltp=-3;// upper and lower trigger points in
    volt
//calculation
a=['For contact at top of R1' 'For R1 contact at 10%
    from bottom'];
V3=Vcc-1;// voltage in volt
dV=utp-ltp;//change in voltage in volt
V1=[V3 10*V3/100];// V1 when R1 is at the top and 10
    % from the bottom of R1 in volt
for n=1:2
    I2=V1(n)/R2;// current in ampere
    t=C1*dV/I2;// time in seconds
    f=1/(2*t);// frequency in hertz
    printf("%s,\nfrequency=%.2f Hz\n\n",a(n),f);
end
//result
//For contact at top of R1,
//frequency=1166.67 Hz
//For R1 contact at 10% from bottom,
//frequency=116.67 Hz
```

Scilab code Exa 11.4 output square wave frequency

```
// to find the out put square wave frequency in
```

```
11-14
// example 11-4 in page 332
clc;
//Data given
Vcc=12;//supply voltage (+/-)12 V
R=10^3*[20 6.2 5.6];//resistance R1, R2 and R3 all
    in ohm
C1=0.2D-6;// capacitance=0.2 micro farad
// calculation
Vo=Vcc-1;// out put voltage = (+/-)(Vcc-1) in volt
utp=Vo*R(3)/(R(2)+R(3));// upper trigger point in
    volt
ltp=-utp;// lower trigger point in volt
t=C1*R(1)*log((Vo-ltp)/(Vo-utp));// time in seconds
printf("out put frequency=%d Hz",1/(2*t));
//result
//out put frequency=121 Hz
```

Scilab code Exa 11.5 output pulse width and the capacitance

```
// to find the output pulse width and capacitance
    for the given pulse width in figure 11-15
// example 11-5 in page 334
clc;
//data given
Vcc=10;//supply voltage in Volt
Vee=10;// supply voltage in volt
VB=1;// base voltage in volt
R=1e+3*[22 10];//resistances R1 in ohm and R2 in ohm
C=[100D-12 0.01D-6];//capacitance C1 in farad and C2
    in farad
//calculation
Vop=Vcc-1;// positive output voltage in volt
```

```
Von=-(Vee-1);// negative output voltage in volt
PW=C(2)*R(2)*log((Vop-Von)/VB);//pulse width in seconds
printf("PULSE WIDTH=%d micro-sec\n",PW*10^6);
PW=6e-3;//to calculate C2 for PW=6 ms
C2=PW/(R(2)*log((Vop-Von)/VB));// capacitance in farad
printf("For pulse width of 6 ms,\nC2=%.1f micro-F",C2*10^6);
//result
//PULSE WIDTH=289 micro-sec
//For pulse width of 6 ms,
//C2=0.2 micro-F
```

Chapter 12

instrument calibration

Scilab code Exa 12.1 accuracy

```
//to find the accuracy as a percentage of reading
    and percentage of full scale
// example 12-1 in page 355
clc;
// Data given
r=[10 50];//scale readings
c=[-0.5 1.7];// respective correction
f=100;//full scale reading
//calculation
for n=1:2
    pr=c(n)*100/r(n);// accuracy as a percentage of
        reading
    pf=c(n)*100/f;//accuracy as a percentage of full
        scale
    printf("accuracy as a percentage of reading for
        scale reading %d= %.1f percent\n",r(n),pr);
    printf("accuracy as a percentage of full scale=
        %.1f percent\n",pf);
end
```

```
//result
//accuracy as a percentage of reading for scale reading 10= -5.0
//accuracy as a percentage of full scale= -0.5
//accuracy as a percentage of reading for scale reading 50= 3.4
//accuracy as a percentage of full scale= 1.7
```

Scilab code Exa 12.2 error and correction figure

```
// to find the wattmeter error and the correction figure
// example 12-2 in page 357
clc;
//Data given
V=114;// measured voltage in volt
P=120;// indicated power in watt
I=1;// current in ampere
//calculation
cf=V*I-P;// here power = v*i, capacitance in farad
e=cf*100/P;//percentage error
printf("correction figure=%d W\n",cf);
printf("wattmeter error=%d percent",e);
//result
//correction figure=-6 W
//wattmeter error=-5 percent
```

Scilab code Exa 12.4 resistance voltage and current

```
// to find the resistance.,voltage and current in
   fig 12-8
//examole 12-4 in page364
clc;
// Data given
V=1.0190;// the standard cell voltage in volt, VBC=
   VB2=V
VB1=3;// terminal voltage of battery B1 in volt
RAB=100; l=100D-2;  //resistance in ohm and length
   in meter of the wire AB
lBC=50.95D-2;//length of BC in meter
//calculation
printf("At calibration,\n");
VAB=l*V/lBC;// voltage accross AB in volt where V/
   lBC is the volatge per unit length
I=VAB/RAB;// current in ampere
printf("current through AB=%d mA\n",I*1000);
R1=(VB1-VAB)/I;// resistance in ohm
printf("Resistance R1=%d ohm\n\n",R1);// R=V/I ohm
printf("Vx=%.2f V\n",94D-2*V/lBC);//volatge Vx in
   volt when null is obtained at 94.3cm
printf("\nR2=%d K-ohm",(VB1+V)/(20D-6*1000));// R2
   in ohm to limit the standard cell current to a
   maximum of 20 micro-A
//result
//At calibration,
//current through AB=20 mA
//Resistance R1=50

//Vx=1.88 V

//R2=200 K-ohm
```

Scilab code Exa 12.5 maximum voltage and instrument resolution

```
// to find the maximum measurable voltage and the
   instrument resolution
// example 12-5 in page 367
clc;
// Data given
V=1.0190;// Standard cell voltage V=VR3=VB2 in volt
R13=100; R3=509.5; R4=290.5;// R13 is the slider
   resistance and resistance R3 and R4 all in ohm
R=100;// resistances R6 through R12 in ohm
l=100D-2;// length of the sliding wire in meter
// claculaion
VAE=(V/R3)*(R3+R4);// maximum measurable voltage in
   volt where I1=V/R3
printf("Maximum measurable voltage=%.1f V\n",VAE);
I2=VAE/(8*R);//current I2 in ampere
VAB=I2*R13;//voltage across R13 in volt
Vpl=VAB/l;// slide wire voltage per unit length in
   volt/meter
printf("instrument resolution=(+/-)%.1f mV",Vpl)
//result
//Maximum measurable voltage=1.6 V
//instrument resolution=(+/-)0.2 mV
```

Chapter 16

Laboratory power supplies

Scilab code Exa 16.1 load effects and line regulation

```
//to find the source & load effects and load & line
   regulation
// example 16-1 in page 423
clc;
//Data Given
Es=[12 11.95]; // change in Dc power supply when ac
   drops by 10%
Eo=[12 11.9];// change in output voltage when load
   current goes from zero to  maximum
//calculation
printf("source effect=%d mV\n",(Es(1)-Es(2))*1000);
printf("line regulation=%.2f percent\n",(Es(1)-Es(2)
   )*100/Es(1));
printf("load effect=%d mV\n",(Eo(1)-Eo(2))*1000);
printf("line regulation=%.2f percent\n",(Eo(1)-Eo(2)
   )*100/Eo(1));
//result
//source effect=50 mV
//line regulation=0.42 percent
```

```
//load effect=99 mV
//line regulation=0.83 percent
```

Scilab code Exa 16.2 maximum and minimum output voltage

```
// to find the maximum and minimum output voltages in the fig 16-8(b)
// example 16-2 in page 428
clc;
//Data given
Vz=6; R=1000*[0 5.6 5.6 3];// zener voltage and the resistance values
A=['when the moving contact is at the bottom of R4' '0' '0' 'when the moving contact is at the top of R4'];
//calculation
for n=1:3:4
    I3=Vz/(R(3)+R(n));
    Eo=I3*sum(R);
    printf("%s,Eo=%.1f V\n",A(n),Eo);
end
//result
//when the moving contact is at the bottom of R4,Eo=15.2 V
//when the moving contact is at the top of R4,Eo=9.9 V
```

This code can be downloaded from the website wwww.scilab.in