Scilab Textbook Companion for High Voltage Engineering by M. S. Naidu And V. Kamaraju[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 2

Conduction and Breakdown in Gases

Scilab code Exa 2.1 calculation of breakdown strength of air

```
//developed in windows XP operating system
//platform Scilab 5.4.1
clc;clear;
//example 2.1
//calculation of breakdown strength of air

//given data
d1=0.1//length(in cm) of the gap
d2=20//length(in cm) of the gap

//calculation
//from equation of breakdown strength
E1=24.22+(6.08/(d1^(1/2)))//for gap d1
E2=24.22+(6.08/(d2^(1/2)))//for gap d2

printf('the breakdown strength of air for 0.1mm air
   gap is %3.2f kV/cm.',E1)
printf('\nthe breakdown strength of air for 20 cm
   air gap is %3.2f kV/cm.',E2)
```

Scilab code Exa 2.2 calculation of Townsend primary ionization coefficient

```
//developed in windows XP operating system
//platform Scilab 5.4.1
clc;clear;
//example 2.2
//calculation of Townsend primary ionization
    coefficient

//given data
d1=0.4//gap distance(in cm)
d2=0.1//gap distance(in cm)
I1=5.5*10^-8//value of current(in A)
I2=5.5*10^-9//value of current(in A)

//calculation
//from equation of current at anode I=I0*exp(alpha*d
    )
alpha=(log(I1/I2))*(1/(d1-d2))

printf('Townsend primary ioniztion coefficient is %3
    .3f /cm torr',alpha)
```

Scilab code Exa 2.3 calculation of Townsend secondary ionization coefficient

```
//developed in windows XP operating system
//platform Scilab 5.4.1
clc;clear;
//example 2.3
//calculation of Townsend secondary ionization
    coefficient
```

```
//given data
d=0.9//gap distance(in cm)
alpha=7.676//value of alpha

//calculation
//from condition of breakdown.....gama*exp(alpha*d)
   =1
gama=1/(exp(d*alpha))

printf('the value of Townsend secondary ioniztion
    coefficient is %3.3e',gama)
```

Scilab code Exa 2.4 calculation of breakdown voltage of a spark gap

```
//developed in windows XP operating system
//platform Scilab 5.4.1
clc;clear;
//example 2.4
//calculation of breakdown voltage of a spark gap

//given data
A=15//value of A(in per cm)
B=360//value of B(in per cm)
d=0.1//spark gap(in cm)
gama=1.5*10^-4//value of gama
p=760//value of pressure of gas(in torr)

//calculation
//from equation of breakdown voltage
V=(B*p*d)/(log((A*p*d)/(log(1+(1/gama)))))

printf('the value of breakdown voltage of the spark
    gap is %d V',V)
//correct answer is 5625 V
```

Scilab code Exa 2.5 `calculation of minimum spark over voltage`

```
//developed in windows XP operating system
//platform Scilab 5.4.1
clc;clear;
//example 2.5
//calculation of minimum spark over voltage

//given data
A=15//value of A(in per cm)
B=360//value of B(in per cm)
gama=10^-4//value of gama
e=2.178//value of constant

//calculation
Vbmin=(B*e/A)*(log(1+(1/gama)))

printf('the value of minimum spark over voltage is %d V.',Vbmin)
//correct answer is 481 V
```

Chapter 3

Conduction and Breakdown in Liquid Dielectrics

Scilab code Exa 3.1 determination of power law dependence between the gap spacing

```
//developed in windows XP operating system
//platform Scilab 5.4.1
clc;clear;
//example 3.1
//determination of power law dependence between the
   gap spacing  and the applied voltage of the oil

//given data
d1=4//gap spacing(in mm)
d2=6//gap spacing(in mm)
d3=10//gap spacing(in mm)
d4=12//gap spacing(in mm)
V1=90//voltage(in kV) at breakdown
V2=140//voltage(in kV) at breakdown
V3=210//voltage(in kV) at breakdown
V4=255//voltage(in kV) at breakdown

//calculation
//from the relationship between breakdown voltage
```

```
    and the gap spacing.....V = K*d^n
//we get n = (log(V)-log(K))/log(d) = slope of line
    from given data
n=(log(V4)-log(V1))/(log(d4)-log(d1))
K=exp(log(V1)-n*log(d1))//Y intercept on the power
    law dependence graph
//plotting of graph
dn=[1:20]
Vn=K*dn^n
plot(dn,Vn)
xlabel("Gas spacing (mm)")
ylabel("Breakdown voltage (kV)")

printf('The power law dependence between the gap
    spacing  and the applied voltage of the oil is %3
    .2f*d^%3.3f',K,n)
```

Chapter 4

Breakdown in Solid Dielectrics

Scilab code Exa 4.1 calculation of heat generated in specimen due to dielectric lo

```
//developed in windows XP operating system
//platform Scilab 5.4.1
clc;clear;
//example 4.1
//calculation of heat generated in specimen due to
   dielectric loss

//given data
epsilonr=4.2//value of the dielectric constant
tandelta=0.001//value of tandelta
f=50//value of frequency(in Hz)
E=50*10^3//value of electric field(in V/cm)

//calculation
//from equation of dielectric heat loss......H=(E*E*
   f*epsilonr*tandelta)/(1.8*10^12)
H=(E*E*f*epsilonr*tandelta)/(1.8*10^12)

printf('The heat generated in specimen due to
   dielectric loss is %3.3f mW/cm^3.',H*10^3)
```

Scilab code Exa 4.2 calculation of voltage at which an internal discharge can occu

```
//developed in windows XP operating system
//platform Scilab 5.4.1
clc;clear;
//example 4.2
//calculation of voltage at which an internal discharge can occur

//given data
d1=1//thickness(in mm) of the internal void
dt=10//thickness(in mm) of the specimen
epsilon0=8.89*10^-12//electrical permittivity(in F/m) of free space
epsilonr=4//relative permittivity of the dielectric
Vb=3//breakdown strength(in kV/mm) of air

//calculation
d2=dt-d1
epsilon1=epsilon0*epsilonr//electrical permittivity(in F/m) of the dielectric
V1=Vb*d1//voltage at which air void of d1 thickness breaks
V=(V1*(d1+(epsilon0*d2/epsilon1))/d1)

printf('the voltage at which an internal discharge can occur is %3.2f kV.',V)
//correction : we have to find applied voltage V
```

Scilab code Exa 4.3 calculation of the dimensions of electrodes in coaxial cylindr

```
//developed in windows XP operating system
```

```
//platform Scilab 5.4.1
clc;clear;
//example 4.3
//calculation of the dimensions of electrodes in coaxial cylindrical capacitor

//given data
epsilon0=(36*%pi*10^9)^-1//electrical permittivity(in F/m) of free space
//consider high density polyethylene as the dielectric material
epsilonr=2.3//relative permittivity of high density polyethylene
l=0.2//effective length(in m)
C=1000*10^-12//capacitance(in F) of the capacitor
V=15//operating voltage(in kV)
Emax=50//maximum stress(in kV/cm) for breakdown stress 200 kV/cm and factor of safety of 4

//calculation
//from equation of capacitance of coaxial cylindrical capacitor
//C=(2*%pi*epsilon0*epsilonr*l)/(lod(d2/d1))..............(1)
//from equation of Emax occuring near electrodes
//Emax=V/(r1*(log(r2/r1)))................................(2)
//from equation (1) and equation (2),we get
logr2byr1=(2*%pi*epsilon0*epsilonr*l)/C//logd2/d1 = logr2/r1
r1=V/(Emax*logr2byr1)//from equation (1)
r2=r1*exp(logr2byr1)

printf('the value of inner diameter of electrodes in coaxial cylindrical capacitor is %3.2f cm',r1)
printf('\nthe value of outer diameter of electrodes in coaxial cylindrical capacitor is %3.2f cm',r2)
printf('\nthe thickness of the insulation is %3.2f
```

cm',(r2-r1))

Chapter 6

Generation of High Voltages and Currents

Scilab code Exa 6.1 calculation of percentage ripple the regulation and the optimu

```
//developed in windows XP operating system
//platform Scilab 5.4.1
clc;clear;
//example 6.1
//calculation of percentage ripple ,the regulation and the optimum number of stages for minimum regulation in Cockcroft−Walton type voltage multiplier

//given data
C=0.05*10^-6//value of capacitance(in F)
Vmax=125*10^3//value of supply transformer secondary voltage(in V)
f=150//frequency(in Hz)
I=5*10^-3//load current(in A)
nst=8//number of stages

//calculation
n=nst*2//number of capacitors
```

```
//from equation of ripple voltage
deltaV=(I/(f*C))*(n*(n+1)/2)
perripple=(deltaV*100)/(16*Vmax)
deltaVn=(I/(f*C))*(((2*nst^3)/3)+(nst*nst/2)-(nst/6))//voltage drop...here n = nst = number of stages
reg=deltaVn/(2*nst*Vmax)//regulation
nopt=round(sqrt(Vmax*f*C/I))//optimum number of stages

printf('the value of percentage ripple is %3.2f percentage.',perripple)
printf('\nthe value of the regulation is %3.1f percentage.',reg*100)
printf('\nthe optimum number of stages for minimum regulation is %d.',nopt)
```

Scilab code Exa 6.2 calculation of series inductance and input voltage to transfor

```
//developed in windows XP operating system
//platform Scilab 5.4.1
clc;clear;
//example 6.2
//calculation of series inductance and input voltage to transformer

//given data
kva=100*10^3//value of volt-ampere of transformer(in VA)
V=250*10^3//value of transformer secondary voltage(in V)
Vi=400//value of transformer primary voltage(in V)
Vc=500*10^3//voltage(in V)
Ic=0.4//charging current(in A)
perX=8//percentage leakage reactance
f=50//value of frequency(in Hz)
```

```
perR1=2//percentage resistance
perR2=2//percentage resistance of inductor


//calculation
I=kva/V//maximum value of current that can be supplied
Xc=Vc/Ic//reactance of cable
Xl=(perX*V)/(100*I)//leakage reactance
adrec=Xc-Xl//additional reactance
Xadrec=adrec/(2*%pi*f)
perR=perR1+perR2//total resistance
R=(perR*V)/(100*I)
VE2=I*R//excitation at secondary
VE1=VE2*Vi/V//primary voltage
IkW=(VE1/Vi)*100//input kW

printf('The value of series inductance is %d H.',round(Xadrec))
printf('\nThe value of input voltage to the transformer is %d V.',VE1)
```

Scilab code Exa 6.3 calculation of series resistance damping resistance and maximu

```
//developed in windows XP operating system
//platform Scilab 5.4.1
clc;clear;
//example 6.3
//calculation of series resistance ,damping resistance and maximum output voltage of the generator

//given data
n=8//number of stages
C=0.16*10^-6//value of condenser(in farad)
```

```
Cl=1000*10^-12//value of load capacitor (in farad)
t1=1.2*10^-6//time to front(in second)
t2=50*10^-6//time to tail(in second)
Vc=120*10^3//charging voltage(in V)

//calculation
C1=C/n//generator capacitance
C2=Cl//load capacitance
R1=(t1*(C1+C2))/(3*C1*C2)
R2=(t2/(0.7*(C1+C2)))-R1
V=n*Vc//dc charging voltage for n stages
alpha=1/(R1*C2)
betaa=1/(R2*C1)
Vmax=(V*(exp(-alpha*t1)-exp(-betaa*t1)))/(R1*C2*(
    alpha-betaa))

printf('The value of series resistance is %d ohm',
    round(R1))
printf('\nThe value of damping resistance is %d ohm'
    ,round(R2))
printf('\nThe value of maximum output voltage of the
     generator is %3.2f kV',-Vmax*10^-3)

//Vmax value from the equation is 892.02 kV
```

Scilab code Exa 6.4 calculation of circuit inductance and dynamic resistance

```
//developed in windows XP operating system
//platform Scilab 5.4.1
clc;clear;
//example 6.4
//calculation of circuit inductance and dynamic
    resistance

//given data
```

```
alpha=0.0535*10^6//from table
LC=65//value of product
C=8//value of capacitor (in microfarad)
Ip=10//output peak current(in kA)
t1=8//time to front(in microsecond)

//calculation
L=LC/C//inductance(in microhenry)
Rd=2*(LC*10^-6)*alpha/t1//dynamic resistance
V=Ip*14/C//charging voltage

printf('The value of circuit inductance is %3.3f
    microhenry',L)
printf('\nThe value of dynamic resistance is %3.4f
    ohm',Rd)
printf('\nThe value of charging voltage is %3.1f kV'
    ,V)
//the correct value of charging voltage is 17.5 kV
```

Scilab code Exa 6.5 calculation circuit inductance and dynamic resistance

```
//developed in windows XP operating system
//platform Scilab 5.4.1
clc;clear all;
//example 6.5
//calculation circuit inductance and dynamic
    resistance

//given data
C=8*10^-6//value of capacitor (in farad)
Ip=10//output peak current(in kA)
t1=8*10^-6//time to front(in second)
t2=20*10^-6//time to first half cycle(in second)
V=25*10^3//charging voltage
im=10*10^3//output currennt(in A)
```

```
//calculation
omega=%pi/t2
omegat1=omega*t1
alpha=omega*(1/atan(omegat1))
LC=1/((t1^2)+(alpha^2))
L=LC/C
R=2*L*alpha
V=omega*L*10*exp(-alpha*t1)

printf('The value of circuit inductance is %3.2f microhenry',L*10^6)
printf('\nThe value of dynamic resistance is %3.4f ohm',R)
printf('\nThe value of charging voltage is %3.2f kV',V)

//correct answers is
//The value of charging voltage is 1.59 kV
```

Scilab code Exa 6.6 calculation of front and tail time

```
//developed in windows XP operating system
//platform Scilab 5.4.1
clc;clear;
//example 6.6
//calculation of front and tail time

//given data
n=12//number of stages
C=0.126*10^-6//capacitance(in Farad)
R1=800//wavefront resistance(in ohm)
R2=5000//xavetail resistance(in ohm)
C2=1000*10^-12//load capacitance(in Farad)

```

```

//calculation
C1=C/n
t1=3*R1*(C1*C2)/(C1+C2)
t2=0.7*(R1+R2)*(C1+C2)

printf('The time to front is %3.2f microsecond',t1*10^6)
printf('\nThe time to tail is %3.1f microsecond',t2*10^6)
```

Scilab code Exa 6.7 calculation of peak value of output voltage and highest resona

```
//developed in windows XP operating system
//platform Scilab 5.4.1
clc;clear all;
//example 6.7
//calculation of peak value of output voltage and highest resonant frequency produced

//given data
V=10*10^3//voltage(in V) at primary winding
L1=10*10^-3//inductance(in H)
L2=200*10^-3//inductance(in H)
K=0.6//coefficient of coupling
C1=2*10^-6//capacitance(in Farad) on primary side
C2=1*10^-9//capacitance(in Farad) on secondary side

//calculation
M=K*sqrt(L1*L2)
omega1=1/sqrt(L1*C1)
sigma=sqrt(1-(K^2))
omega2=1/sqrt(L2*C2)
gama2=sqrt(((omega1^2+omega2^2)/2)+sqrt(((omega1^2+omega2^2)/2)-(sigma^2*omega1^2*omega2^2)))
```

```
gama1=sqrt(((omega1^2+omega2^2)/2)-sqrt(((omega1^2+omega2^2)/2)-(sigma^2*omega1^2*omega2^2)))
fh=gama2/(2*%pi)//highest frequency
V2p=(V*M)/(sigma*L1*L2*C2*(gama2^2-gama1^2))

printf('The value of highest resonant frequency produced is %3.2f kHz',fh*10^-3)
printf('\nThe peak value of output voltage is %3.2f kV',V2p*10^-3)

//gama1 and gama2 are imaginary numbers....Moreover their magnitudes will also be same....so peak value of output voltage from equation is zero
```

Scilab code Exa 6.8 calculation of output voltage

```
//developed in windows XP operating system
//platform Scilab 5.4.1
clc;clear all;
//example 6.8
//calculation of output voltage

//given data
V1=10//voltage(in kV) at primary winding
C1=2*10^-6//capacitance(in Farad) on primary side
C2=1*10^-9//capacitance(in Farad) on secondary side
pern=5//energy efficiency(in percentage)

//calculation
n=pern/100
V2=V1*sqrt(n*C1/C2)

printf('The value of output voltage is %3.1f kV',V2)
//correct answer is 100 kV
```

Scilab code Exa 6.9 calculation of self capacitance and leakage reactance

```
//developed in windows XP operating system
//platform Scilab 5.4.1
clc;clear all;
//example 6.9
//calculation of self capacitance and leakage reactance

//given data
Vi=350*10^3//rating(in VA)
V=350*10^3//secondary voltage(in V)
V1=6.6*10^3//primary voltage(in V)
perV=8//percentage ratedd voltage
perR=1//percentage rise
f=50//frequency(in Hz)

//calculation
I=Vi/V
Xl=(perV*V)/(100*I)
I0=perR*V/(100*Xl)
Xc=((1+(perR/100))*V)/I0
C=1/(Xc*2*%pi*f)

printf('The value of self capacitance is %3.3f nF',C*10^9)
printf('\nThe value of leakage reactance is %d kohm',Xl*10^-3)
```

Scilab code Exa 6.10 calculation of resistance and inductance

```
//developed in windows XP operating system
```

```
//platform Scilab 5.4.1
clc;clear all;
//example 6.10
//calculation of resistance and inductance

//given data
CR=70.6//value from table
LC=11.6//value from table
C=1//capacitance(in microfarad)
pern=98.8//percentage voltage efficiency
V=10//rating(in kV)
LC2=65//value from table
alpha=0.0535//value from table

//calculation
R=CR/C
L=LC/C
Vo=pern*V/100
L2=LC2/C
R2=2*L2*alpha
Ip=V*C/14

printf('The value of resistance for 1/50 microsecond
    voltage is %3.1f ohm',R)
printf('\nThe value of inductance for 1/50
   microsecond voltage is %3.1f microhenry',L)
printf('\nThe value of output voltage is %3.2f kV',
   Vo)
printf('\nThe value of inductance for 8/20
   microsecond voltage is %d microhenry',L2)
printf('\nThe value of resistance for 8/20
   microsecond voltage is %3.3f ohm',R2)
printf('\nThe peak value of current is %d A',Ip
   *10^3)
```

Chapter 7

Measurement of High Voltages and Currents

Scilab code Exa 7.1 calculation of capacitance of generating voltmeter

```
//developed in windows XP operating system
//platform Scilab 5.4.1
clc;clear all;
//example 7.1
//calculation of capacitance of generating voltmeter

//given data
Irms=2*10^-6//current(in A)
V1=20*10^3//applied voltage(in V)
V2=200*10^3//applied voltage(in V)
rpm=1500//assume synchronous speed(in rpm) of motor

//calculation
Cm=Irms*sqrt(2)/(V1*(rpm/60)*2*%pi)
Irmsn=V2*Cm*2*%pi*(rpm/60)/sqrt(2)

printf('The capacitance of the generating voltmeter
    is %3.1f pF',Cm*10^12)
```

Scilab code Exa 7.2 Design of a peak reading voltmeter

```
//developed in windows XP operating system
//platform Scilab 5.4.1
clc;clear all;
//example 7.2
//Design of a peak reading voltmeter

//given data
r=1000//ratio is 1000:1
V=100*10^3//read voltage(in V)
R=10^7//value of resistance(in ohm)

//calculation
//take range as 0-10 microampere
Vc2=V/r//voltage  at C2 arm
//Cs * R = 1 to 10 s
Cs=10/R

printf('The value of Cs is %d microfarad',Cs*10^6)
printf('\nThe value of R is %3.1e ohm',R)
```

Scilab code Exa 7.3 calculation of correction factors for atmospheric conditions

```
//developed in windows XP operating system
//platform Scilab 5.4.1
clc;clear all;
//example 7.3
//calculation of correction factors for atmospheric
   conditions

//given data
```

```
t=37//temperature(in degree celsius)
p=750//atmospheric pressure(in mmHg)

//calculation
d=p*293/(760*(273+t))

printf('The air density factor is %3.4f',d)
```

Scilab code Exa 7.4 calculation of divider ratio

```
//developed in windows XP operating system
//platform Scilab 5.4.1
clc;clear all;
//example 7.4
//calculation of divider ratio

//given data
R1=16*10^3//high voltage arm resistance(in ohm)
n=16//number of members
R=250//resistance(in ohm) of each member in low
   voltage arm
R2dash=75//terminating resistance(in ohm)

//calculation
R2=R/n
a=1+(R1/R2)+(R1/R2dash)

printf('The divider ratio is %3.1f',a)
```

Scilab code Exa 7.5 calculation of capacitance needed for correct compensation

```
//developed in windows XP operating system
//platform Scilab 5.4.1
```

```
clc;clear all;
//example 7.5
//calculation of capacitance needed for correct compensation

//given data
Cgdash=20*10^-12//ground capacitance(in farad)
n=15//number of capacitors
r=120//resistance(in ohm)
R2=5//resistance(in ohm) of LV arm

//calculation
Ce=(2/3)*n*Cgdash
R1=n*r/2
T=R1*Ce/2
C2=T/R2

printf('The value of capacitance needed for correct compensation is %3.1e F or %d nf',C2,round(C2*10^9))
```

Scilab code Exa 7.6 calculation of ohmic value of shunt an its dimensions

```
//developed in windows XP operating system
//platform Scilab 5.4.1
clc;clear all;
//example 7.6
//calculation of ohmic value of shunt an its dimensions

//given data
I=50*10^3//impulse current (in A)
Vm=50//voltage(in V) drop across shunt
B=10*10^6//bandwidth(in Hz) of the shunt
mu0=4*%pi*10^-7//magnetic permeability(in H/m) of
```

```
    free space

//calculation
R=Vm/I//resistance of shunt
L0=1.46*R/B
mu=mu0//in this case ...mu = mu0 * mur ~mu0
rho=30*10^-8//resistivity(in ohm m) of the tube
    material
d=sqrt((1.46*rho)/(mu*B))//thickness of the tube(in
    m)
l=10^-1//length(in m) (assume)
r=(rho*l)/(2*%pi*R*d)

printf('The value of resistance is %d milliohm',
    round(R*10^3))
printf('\nThe length of shunt is %d cm',l*100)
printf('\nThe radius of shunt is %3.1f mm',r*10^3)
printf('\nThe thickness of shunt is %3.3f mm',d
    *10^3)
```

Scilab code Exa 7.7 Estimation of values of mutual inductance resistance and capac

```
//developed in windows XP operating system
//platform Scilab 5.4.1
clc;clear all;
//example 7.7
//Estimation of values of mutual inductance,
    resistance and capacitance

//given data
It=10*10^3//impulse current(in A)
Vmt=10//meter reading(in V) for full scale
    deflection
dibydt=10^11//rate of change of current(in A/s)

```

```
//calculation
MbyCR=Vmt/It
t=It/dibydt
f=1/(4*t)
omega=2*%pi*f
CR=10*%pi/omega
M=10^-3*CR
R=2*10^3//assume resistance(in ohm)
C=CR/R

printf('The value of mutual inductance is %d nH',M
   *10^9)
printf('\nThe value of resistance is %3.0e ohm',R)
printf('\nThe value of capacitance is %d pF',round(C
   *10^12))
```

Scilab code Exa 7.8 calculation of resistance and capacitance

```
//developed in windows XP operating system
//platform Scilab 5.4.1
clc;clear all;
//example 7.8
//calculation of resistance and capacitance

//given data
t1=8*10^-6//fronttime(in s)
t2=20*10^-6//tailtime(in s)


//calculation
f2=1/t2//frequency corresponding to tail time
fl=f2/5
omega=2*%pi*fl
CR=10*%pi/omega
M=10^-3*(1/CR)
```

```
R=2*10^3//assume resistance(in ohm)
C=CR/R

printf('The value of resistance is %3.0e ohm',R)
printf('\nThe value of capacitance is %3.2f
    microfarad',C*10^6)
```

Chapter 8

Overvoltage Phenomenon and Insulation Coordination in Electric Power Systems

Scilab code Exa 8.1 calculation of surge impedance velocity and time taken by the

```
//developed in windows XP operating system
//platform Scilab 5.4.1
clc;clear all;
//example 8.1
//calculation of surge impedance,velocity and time
   taken by the surge to travel to the other end

//given data
L=1.26*10^-3//inductance(in H/km)
C=0.009*10^-6//capacitance(in F/km)
l=400//length(in km) of the transmission line

//calculation
v=1/sqrt(L*C)
Xs=sqrt(L/C)
t=l/v

```

```
printf('The value of surge impedance is %3.1f ohm',Xs)
printf('\nThe value of velocity is %3.0e km/s',v)
printf('\nThe time taken by the surge to travel to the other end is %3.2f ms',t*10^3)
```

Scilab code Exa 8.2 calculation of the voltage build up at the junction

```
//developed in windows XP operating system
//platform Scilab 5.4.1
clc;clear all;
//example 8.2
//calculation of the voltage build up at the junction

//given data
Z1=500//surge impedance(in ohm) of transmission line
Z2=60//surge impedance(in ohm) of cable
e=500//value of surge(in kV)

//calculation
tau=(Z1-Z2)/(Z2+Z1)//coefficient of reflection
Vj=(1+tau)*e

printf('The value of the voltage build up at the junction is %d kV',round(Vj))
```

Scilab code Exa 8.5 calculation of the transmitted reflected voltage and current w

```
//developed in windows XP operating system
//platform Scilab 5.4.1
clc;clear all;
//example 8.5
```

```
//calculation of the transmitted,reflected voltage and current waves

//given data
L1=0.189*10^-3//inductance(in H/km) of the cable
C1=0.3*10^-6//capacitance(in Farad/km) of the cable
L2=1.26*10^-3//inductance(in H/km) of the overhead line
C2=0.009*10^-6//capacitance(in Farad/km) of the overhead line
e=200*10^3//surge volatge(in kV)

//calculation
Z1=sqrt(L1/C1)//surge impedance of the cable
Z2=sqrt(L2/C2)//surge impedance of the line
tau=(Z2-Z1)/(Z2+Z1)//when wave travels along the cable
edash=tau*e//reflected wave
edashdash=(1+tau)*e//transmitted wave
Idash=edash/Z1//reflected current wave
Idashdash=edashdash/Z2//transmitted current wave
Z2n=Z1
Z1n=Z2
taun=(Z2n-Z1n)/(Z2n+Z1n)//when wave travels along the line
edashn=taun*e//reflected wave
edashdashn=(1+taun)*e//transmitted wave
Idashdashn=edashdashn/Z2n//transmitted current wave
Idashn=edashn/Z1n//reflected current wave

printf('When wave travels along the cable,the transmitted voltage is %3.2f kV',edashdash*10^-3)
printf('\nWhen wave travels along the cable,the reflected voltage is %3.2f kV',edash*10^-3)
printf('\nWhen wave travels along the cable,the transmitted current is %3.3f kA',Idashdash*10^-3)
printf('\nWhen wave travels along the cable,the reflected current is %3.2f kA',Idash*10^-3)
```

```
printf('\nWhen wave travels along the line,the transmitted voltage is %3.2f kV',edashdashn*10^-3)
printf('\nWhen wave travels along the line,the reflected voltage is %3.2f kV',edashn*10^-3)
printf('\nWhen wave travels along the line,the transmitted current is %3.3f kA',Idashdashn*10^-3)
printf('\nWhen wave travels along the line,the reflected current is %3.3f kA or %d A',abs(Idashn*10^-3),abs(Idashn))
```

Scilab code Exa 8.6 calculation of value of voltage at the receiving end in Bewley

```
//developed in windows XP operating system
//platform Scilab 5.4.1
clc;clear all;
//example 8.6
//calculation of value of voltage at the receiving end in Bewley lattice diagram

//given data
alpha=0.8

//calculation
Vut=2*alpha/(1+alpha^2)

printf('The value of voltage at the receiving end in Bewley lattice diagram is %3.4fu(t) V',Vut)
```

Scilab code Exa 8.7 calculation of sparkover voltage and the arrester current

```
//developed in windows XP operating system
```

```
//platform Scilab 5.4.1
clc;clear all;
//example 8.7
//calculation of sparkover voltage and the arrester current

//given data
Xs=400//surge impedance(in ohm)
Xv=1000//surge voltage(in kV)

//calculation
//for line terminated
Iam=2*Xv/Xs//maximum arrester current
//as Iam = 5 kA   from graph Vd = 330 kV
Vd=330//sparkover voltage(in kV)
Vso=Vd+(Vd*5/100)
//for continuous line
Iamn=Xv/Xs//maximum arrester current
//as Iamn = 2.5 kA   from graph   Vdn = 280 kV
Vdn=280//sparkover voltage(in kV)
Vson=Vdn+(Vdn*5/100)

printf('The sparkover voltage for terminated line is %d kV',Vso)
printf('\nThe arrester current for terminated line is %d kA',Iam)
printf('\nThe sparkover voltage for continuous line is %d kV',Vson)
printf('\nThe arrester current for continuous line is %3.1f kA',Iamn)
//values of sparover voltages are
//for terminated line = 346 kV
//for continuous line = 294 kV
```

Scilab code Exa 8.8 calculation of rise in voltage at the other end

```
//developed in windows XP operating system
//platform Scilab 5.4.1
clc;clear all;
//example 8.8
//calculation of rise in voltage at the other end

//given data
R=0.1//resistance(in ohm/km)
L=1.26*10^-3//inductance(in H/km)
C=0.009*10^-6//capacitance(in F/km)
l=400//length(in km) of the line
V1=230//line voltage(in kV)
f=50//frequency(in Hz)
G=0

//calculation
//Neglecting resistance of line
V1p=V1/sqrt(3)
omega=2*%pi*f
Xl=complex(0,omega*L*l)
Xc=complex(0,-1/(omega*C*l))
V2=V1p*((1-(Xl/(2*Xc)))-1)

//Considering all the parameters
omegaL=complex(0,omega*L)
omegaC=complex(0,omega*C)
i=l*sqrt((R+omegaL)*(G+omegaC))
betal=imag(i)*l
V2n=V1p/cos(betal)

printf('Neglecting resistance of line,the rise in
    voltage at the other end is %3.1f kV',V2)
printf('\nConsidering all the parameters,the rise in
    voltage at the other end is %3.2f kV',V2n-V1p)

//By considering all the parameters the rise in
    voltage at the other end is 94.50 kV
```

Scilab code Exa 8.9 working out of insulation coordination

```
//developed in windows XP operating system
//platform Scilab 5.4.1
clc;clear all;
//example 8.9
//working out of insulation coordination

//given data
V=220//voltage(in kV) of substation
BIL=1050//value of BIL(in kV)
BtoS=1.24//ratio of BIL to SIL

//calculation
Vh=245//highest voltage(in kV)
Vg=Vh*sqrt(2)/sqrt(3)//highest system voltage
Vs=3*Vg//expected switching voltage(in kV)
Vfw=760//impulse sparkover voltage(in kV)
Vd1=690//discharge voltage(in kV) for 5 kA
Vd2=615//discharge voltage(in kV) for 2 kA
//SIL = BIL/BtoS = 846 ~ 850 kV
SIL=850//value of SIL(in kV)
Pmlig=(BIL-Vd1)/BIL//protective margin for lightning
    impulses
Pmswi=(SIL-Vd2)/SIL//protective margin for switching
    gears
Pmspr=(BIL-Vfw)/BIL//margin when lightning arrester
   just sparks

printf('The protective margin for lightning impulses
    is %3.1f percentage',Pmlig*100)
printf('\nThe protective margin for switching gears
   is %3.1f percentage',Pmswi*100)
printf('\nThe margin when lightning arrester just
```

```
sparks is %3.1f percentage',Pmspr*100)
```

Chapter 9

Non Destructive Testing of Materials and Electrical Apparatus

Scilab code Exa 9.1 calculation of the volume resistivity

```
//developed in windows XP operating system
//platform Scilab 5.4.1
clc;clear all;
//example 9.1
//calculation of the volume resistivity

//given data
V=1000//applied voltage(in V)
Rs=10^7//standard resistance(in ohm)
n=3000//universal shunt ratio
Ds=33.3//deflection(in cm) for Rs
D=3.2//deflection(in cm)
d=10//diameter(in cm) of the electrodes
t=2*10^-1//thickness(in cm) of the specimen

//calculation
G=V/(Rs*n*Ds)//galvanometer sensitivity
```

```
R=V/(D*G)//resistance of the specimen
r=d/2//radius of the electrodes
rho=(%pi*r^2*R)/t//volume resistivity

printf('The volume resistivity is %3.3e ohmcm',rho)
```

Scilab code Exa 9.2 calculation of resistivity of the specimen

```
//developed in windows XP operating system
//platform Scilab 5.4.1
clc;clear all;
//example 9.2
//calculation of resistivity of the specimen

//given data
tm=30//time (in minute)
ts=20//time(in second)
Vn=1000//voltage(in V) to which the condenser was charged
V=500//voltage(in V) fall to
C=0.1*10^-6//capacitance(in Farad)
d=10//diameter(in cm) of the electrodes
th=2*10^-1//thickness(in cm) of the specimen

//calculation
t=(tm*60)+ts
R=t/(C*log(Vn/V))//resistance
r=d/2//radius of the electrodes
rho=(%pi*r^2*R)/th//volume resistivity

printf('The resistivity of the specimen is %3.3e ohmcm',rho)
```

Scilab code Exa 9.3 calculation of dielectric constant and complex permittivity of

```
//developed in windows XP operating system
//platform Scilab 5.4.1
clc;clear all;
//example 9.3
//calculation of dielectric constant and complex permittivity of bakelite

//given data
C=147*10^-12//capacitance(in Farad)
Ca=35*10^-12//air capacitance(in Farad)
tandelta=0.0012
epsilon0=(36*%pi*10^9)^-1//electrical permittivity(in F/m) of free space


//calculation
epsilonr=C/Ca//dielectric constant
Kdash=epsilonr
Kdashdash=tandelta*Kdash
Kim=complex(Kdash,-Kdashdash)
epsilonast=epsilon0*Kim

printf('The dielectric constant is %3.1f ',epsilonr)
disp(epsilonast,'The complex permittivity(in F/m)is ')
```

Scilab code Exa 9.4 calculation of capacitance and tandelta of bushing

```
//developed in windows XP operating system
//platform Scilab 5.4.1
clc;clear all;
//example 9.4
//calculation of capacitance and tandelta of bushing
```

```

//given data
R3=3180//resistance(in ohm)
R4=636//resistance(in ohm)
Cs=100//standard condenser(in pF)
f=50//frequency(in Hz)
C3=0.00125*10^-6//capacitance(in farad)

//calculation
omega=2*%pi*f
Cx=R3*Cs/R4//unknown capacitance
tandelta=omega*C3*R3

printf('The capacitance is %d pF',Cx)
printf('\nThe value of tandelta of bushing is %3.5f',tandelta)
```

Scilab code Exa 9.5 calculation of dielectric constant and tandelta of the transfo

```
//developed in windows XP operating system
//platform Scilab 5.4.1
clc;clear all;
//example 9.5
//calculation of dielectric constant and tandelta of the transformer oil

//given data
f=1*10^3//frequency(in Hz)
C1=504//capacitance(in pF) for standard condenser and leads
D1=0.0003//dissipation factor for standard condenser and leads
C2=525//capacitance(in pF) for standard condenser in parallel with the empty test cell
D2=0.00031//dissipation factor for standard
```

```
condenser in parallel with the empty test cell
C3=550//capacitance(in pF) for standard condenser in parallel with the test cell and oil
D3=0.00075//dissipation factor for standard condenser in parallel with the test cell and oil

//calculation
Ctc=C2-C1//capacitance of the test cell
Ctcoil=C3-C1//capacitance of the test cell + oil
epsilonr=Ctcoil/Ctc//dielectric constant of oil
deltaDoil=D3-D2//deltaD of oil

printf('The dielectric constant is %3.2f',epsilonr)
printf('\nThe value of tandelta of the transformer oil is %3.5f',deltaDoil)
```

Scilab code Exa 9.6 calculation of magnitude of the charge transferred from the ca

```
//developed in windows XP operating system
//platform Scilab 5.4.1
clc;clear all;
//example 9.6
//calculation of magnitude of the charge transferred from the cavity

//given data
Vd=0.2//discharge voltage(in V)
s=1//sensitivity(in pC/V)
epsilonr=2.5//relative permittivity
epsilon0=(36*%pi*10^9)^-1//electrical permittivity(in F/m) of free space
d1=1*10^-2//diameter(in m) of the cylindrical disc
t1=1*10^-2//thickness(in m) of the cylindrical disc
d2=1*10^-3//diameter(in m) of the cylindrical cavity
t2=1*10^-3//thickness(in m) of the cylindrical
```

```
   cavity


//calculation
Dm=Vd*s//discharge magnitude
Ca=epsilon0*(%pi*(d2/2)^2)/t2//capacitance of the
   cavity
Cb=epsilon0*epsilonr*(%pi*(d2/2)^2)/(t1-t2)//
   capacitance
qc=((Ca+Cb)/Cb)*Dm

printf('The charge transferred from the cavity is %3
   .2f pC',qc)
```

Scilab code Exa 9.7 calculation of dielectric constant and loss factor tandelta

```
//developed in windows XP operating system
//platform Scilab 5.4.1
clc;clear all;
//example 9.7
//calculation of dielectric constant and loss factor
    tandelta

//given data
R3=1000/%pi//resistance(in ohm) in CD branch
R4=62//variable resistance(in ohm)
Cs=100*10^-12//standard capacitance(in F)
epsilon0=8.854*10^-12//electrical permittivity(in F/
   m) of free space
f=50//frequency(in Hz)
C3=50*10^-9//variable capacitor(in F)
d=1*10^-3//thickness(in m) of sheet
a=100*10^-4//electrode effective area(in m^2)

//calculation
```

```
Cx=R3*Cs/R4
epsilonr=Cx*d/(epsilon0*a)
omega=2*%pi*f
tandelta=omega*C3*R3*d

printf('The dielectric constant is %3.2f',epsilonr)
printf('\nThe loss factor tandelta is %3.7f',
    tandelta)
//In equation of tandelta d is multiplied
```

Scilab code Exa 9.8 calculation of voltage at balance

```
//developed in windows XP operating system
//platform Scilab 5.4.1
clc;clear all;
//example 9.8
//calculation of voltage at balance

//given data
V=10000//applied voltage(in V)
R3=1000/%pi//resistance(in ohm) in CD branch
R4=62//variable resistance(in ohm)
Cs=100*10^-12//standard capacitance(in F)
f=50//frequency(in Hz)
C3=50*10^-9//variable capacitor(in F)

//calculation
Rx=C3*R4/Cs
Cx=R3*Cs/R4
omega=2*%pi*f
zx=complex(Rx,-1/(omega*Cx))
VR4=R4*V/(R4+zx)
MVR4=sqrt((real(VR4))^2+(imag(VR4))^2)//magnitude

printf('The voltage across AD branch at balance is
```

```
%3.1f V',MVR4)
```

Scilab code Exa 9.9 calculation of maximum and minimum value of capacitance and ta

```
//developed in windows XP operating system
//platform Scilab 5.4.1
clc;clear all;
//example 9.9
//calculation of maximum and minimum value of
    capacitance and tandelta

//given data
R3min=100//minimum value of R3 resistance(in ohm)
R3max=11100//maximum value of R3 resistance(in ohm)
R4min=100//minimum value of R4 resistance(in ohm)
R4max=1000//maximum value of R4 resistance(in ohm)
Cs=100*10^-12//standard capacitance(in farad)
C3min=1*10^-9//minimum value of C3 capacitance(in
    farad)
C3max=1.11*10^-6//maximum value of C3 capacitance(in
     farad)
f=50//frequency(in Hz)

//calculation
Cxmax=R3max*Cs/R4min
Cxmin=R3min*Cs/R4max
omega=2*%pi*f
tandeltamax=omega*R3max*C3max
tandeltamin=omega*R3min*C3min

printf('The maximum value of capacitance is %3.1f nF
    ',Cxmax*10^9)
printf('\nThe minimum value of capacitance is %d pF'
    ,Cxmin*10^12)
printf('\nThe maximum value of tandelta is %3.2f',
```

```
    tandeltamax)
printf('\nThe minimum value of tandelta is %3.2e',
    tandeltamin)
```