Scilab Textbook Companion for Elements of Power System by J. B. Gupta[1]

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Book Description

Title: Elements of Power System

Author: J. B. Gupta

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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

Power System Components

Chapter 2

Power System Components

Scilab code Exa 1.1 \begin{code}
Base Impedence

\lstinputlisting{../2078/CH1/EX1.1/Example1_1.sce}
Base Impedence
\end{code}

```
//Exa 1.1
clc;
clear;
close;
//Given data :
BaseVoltage=1100;//in Volts
BasekVA=10^6;//kVA
BasekV=BaseVoltage/1000;//kV
IB=BasekVA/BasekV;//in Ampere
ZB=BasekV*1000/IB;//in ohm
disp(ZB,"Base Impedence (in ohm) :");
```

Scilab code Exa 1.2 \begin{code}
Per unit resistance
\tcaption{Per unit resistance}

\lstinputlisting{../2078/CH1/EX1.2/Example1_2.sce}
Per unit resistance
\end{code}

```
//Exa 1.2
clc;
clear;
close;
//Given data :
R=5;//in ohm
kVA_B=10;//kVA
kV_B=11;//kV
RB=kV_B^2*1000/kVA_B;//in ohm
Rpu=R/RB;//in ohm
disp(Rpu,"Per unit resistance (pu) :");
```

Scilab code Exa 1.3 Scilab code Exa 1.3 Leakage Reactance per unit
\tcaption{Leakage Reactance per unit}

Leakage Reactance per unit
\lstinputlisting{../2078/CH1/EX1.3/Example1_3.sce}

```
//Exa 1.3
clc;
clear;
close;
//Given data :
kVA_B=2.5;//kVA
kV_B=0.4;//kV
reactance=0.96;//in ohm
Z_BLV=kV_B^2*1000/kVA_B;//in ohm
Zpu=reactance/Z_BLV;//in ohm
disp(Zpu,"Leakage reactance Per unit (pu) :");
```

Scilab code Exa 1.4 \begin{code}
Per unit impedence
\tcaption{Per unit impedence}

\lstinputlisting{../2078/CH1/EX1.4/Example1_4.sce}
Per unit impedence
\end{code}

```
//Exa 1.4
clc;
clear;
close;
format('v',6);
//Given data :
Z=30+%i*110;//in ohm
kVA_B=100*1000;//kVA
kV_B=132;//kV
Z_BLV=kV_B^2*1000/kVA_B;//in ohm
Zpu=Z*kVA_B/kV_B^2/1000;//pu
disp(Zpu,"Leakage reactance Per unit (pu) :");
```

Scilab code Exa 1.5 Scilab code Exa 1.5 \tcaption{Per unit Reactance}
Per unit Reactance
\begin{verbatim}
Per unit Reactance

```
//Exa 1.5
clc;
clear;
close;
format('v',6);
//Given data :
oldkVA_B=30000;//kVA
oldkV_B=11;//kV
oldZpu=0.2;//pu
newkVA_B=50000;//kVA
newkV_B=33;//kV
newZpu=oldZpu*newkVA_B/oldkVA_B*(oldkV_B/newkV_B)^2;//pu
disp(newZpu,"New Per unit impedence(pu) :");
```


```
//Exa 1.5
clc;
clear;
close;
format('v',6);
//Given data :
oldkVA_B=30000;//kVA
oldkV_B=11;//kV
oldZpu=0.2;//pu
newkVA_B=50000;//kVA
newkV_B=33;//kV
```

```
newZpu=oldZpu*newkVA_B/oldkVA_B*(oldkV_B/newkV_B)^2;
    //pu
disp(newZpu,"New Per unit impedence(pu) :");
```

Chapter 3

Supply System

Chapter 4

Supply System

Scilab code Exa 2.1 \begin{code}
Saving in feeder
\tcaption{Saving in feeder}

\lstinputlisting{../2078/CH2/EX2.1/Example2_1.sce}
Saving in feeder
\end{code}

```
//Exa 2.1
clc;
clear;
close;
//Given data :
VL1=220;//Volts
VL2=400;//Volts
disp("We know, W=I^2*2*R=(P/VL)^2*2*rho*l/a");
disp("a=(P/VL)^2*2*rho*l/(I^2*2*R)");
disp("v=2*(P/VL)^2*2*rho*l/(I1^2*2)*l");
saving=(2/(VL1)^2-2/(VL2)^2)/(2/(VL1)^2)*100;//%
disp(saving,"% saving in copper : ");
```

Scilab code Exa 2.2 \begin{code}
Compare amount of material
\tcaption{Compare amount of material}

\lstinputlisting{../2078/CH2/EX2.2/Example2_2.sce}
Compare amount of material
\end{code}

```
//Exa 2.2
clc;
clear;
close;

disp("Two wire dc system : ");
disp("I1=P/V & W=2*I1^2*R1=2*P^2*rho*l/V^2/a1");
disp("Therefore, Volume required, v1 is 2*a1*l=4*P
   ^2*rho*l^2/V^2/W");
disp("Three phase four wire system : ");
disp("I2=P/3/Vas Power by each phase is P/3 & W=3*I1
   ^2*R2=P^2*rho*l/3/V^2/a2");
disp("Therefore, Volume required, v2 is 3.5*a2*l
   =3.5*P^2*rho*l^2/3/V^2/W");
v2BYv1=3.5/3/4;//
disp("For 3-phase four wire system material required
    is "+string(v2BYv1)+" times the material
   required in two wire system.");
```

Scilab code Exa 2.3 \begin{code}
Percentage additional load
\tcaption{Percentage additional load}

\lstinputlisting{../2078/CH2/EX2.3/Example2_3.sce}
Percentage additional load
\end{code}

```
//Exa 2.3
clc;
clear;
close;

disp("For single phase ac system, P1=V*I1*cosd(fi)
   watts & W1=2*I1^2*R watts");
disp("Line losses=W1/P1*100=2*I1^2*R*100/V/I1/cosd(
   fi)");
disp("For three phase ac system, P2=sqrt(3)*V*I2*
   cosd(fi) watts & W2=3*I2^2*R watts");
disp("Line losses=W2/P2*100=3*I2^2*R*100/sqrt(3)/V/
   I2/cosd(fi)");
//on equating W1/P1*100=W2/P2*100
I2BYI1=2*sqrt(3)/3;
P1=poly(0,'P1');
//P2=sqrt(3)*V*I1*I2BYI1*cosd(fi)=2*P1
P2=2*P1;
Add_load=P2-P1;
Percent_add_load=coeff(numer(Add_load/P1*100));//%
disp(Percent_add_load,"Additional load that can be
   tranmitted by converting sigle to 3-phase line in
    %");
```

Scilab code Exa 2.4 \begin{code}
Find extra power
\tcaption{Find extra power}

\lstinputlisting{../2078/CH2/EX2.4/Example2_4.sce}
Find extra power
\end{code}

```
//Exa 2.4
clc;
clear;
close;

disp("For three wire dc system, line current I1=(VS-VL)/R & P1=2*VL*I1=2*VL*(VS-VL)/R");
disp("For four wire three phase ac system, line current I2=(VS-VL)/R & P2=3*VL*I2*pf=3*VL*(VS-VL)/R");
//P2=3/2*2*VL*(VS-VL)/R////It implies that P2=3/2*P1
P1=poly(0,'P1');
P2=3/2*P1;
Diff=P2-P1;
Percent_Diff=coeff(numer(Diff/P1*100));//%
disp(Percent_Diff,"Extra power that can be supplied in %");
```

Scilab code Exa 2.5 \begin{code}
Percentage additional load
\tcaption{Percentage additional load}

\lstinputlisting{../2078/CH2/EX2.5/Example2_5.sce}
Percentage additional load
\end{code}

```
//Exa 2.5
clc;
clear;
close;

pf=0.9;//power factor
disp("Three wire dc system : ");
disp("P1=2*I1*V & %P1loss=2*I1^2*R/(2*I1*V)*100=100*
    I1*R/V");
disp("Three phase 4-wire ac system : ");
disp("P2=3*I1^2*V*pf & %P2loss=3*I2^2*R/(3*I2*V*pf)
    *100=100*I12*R/pf/V");
//on equating P1loss=P2loss;
I2BYI1=100*pf/100;//ratio
//P2=3*I2*V*pf
P2BYI1V=3*pf*I2BYI1;
P2BYP1=P2BYI1V/2;
//LoadIncrease=(P2-P1)*100/P1;
LoadIncrease=(P2BYP1-1)*100;//%
disp(LoadIncrease,"% Additional load : ");
```

Scilab code Exa 2.6 \begin{code}
Weight of copper reqiured
\tcaption{Weight of copper reqiured}

\lstinputlisting{../2078/CH2/EX2.6/Example2_6.sce}
Weight of copper reqiured
\end{code}

```
//Exa 2.6
clc;
clear;
close;
```

```
format('v',6);
//Given data :
Pin=100;//MW
VL=380;//kV
d=100;//km
R=0.045;//ohm/cm^2/km
w=0.01;//kg/cm^3
Eta=90;//efficiency %
cosfi=1;
IL=Pin*10^6/sqrt(3)/VL/10^3/cosfi;//Ampere
W=Pin*(1-Eta/100);//MW
LineLoss=W*10^6/3;//Watts/conductor
R1=LineLoss/IL^2;//in ohm
R2=R1/d;//resistance per conductor per km
a=R/R2;//in cm^2
volume=a*d*1000;//cm^3 per km run
weight=w*volume;//kg per km run
w3=3*d*weight;//kg(weight of copper required for 3
   conductors for 100 km)
disp(w3,"Weight of copper required for 3 conductors
   of 100 km length(in kg) : ");
//Answer in the book is not accurate.
```

Chapter 5

Transmission Lines

Chapter 6

Transmission Lines

Scilab code Exa 3.1 \begin{code}
Weight of material required
\tcaption{Weight of material required}

\lstinputlisting{../2078/CH3/EX3.1/Example3_1.sce}
Weight of material required
\end{code}

```
//Exa 3.1
clc;
clear;
close;
//Given data :
P=30*10^6;//W
pf=0.8;//lagging power factor
VL=132*1000;//V
l=120*1000;//m
Eta=90/100;//Efficiency
rho_Cu=1.78*10^-8;//ohm-m
D_Cu=8.9*10^3;//kg/m^3
rho_Al=2.6*10^-8;//ohm-m
```

```
D_Al=2*10^3;//kg/m^3
IL=P/(sqrt(3)*VL*pf);//A
//W=3*IL^2*rho*l/a=(1-Eta)*P
a_Cu=(3*IL^2*rho_Cu*l)/(1-Eta)/P;//m^2
V_Cu=3*a_Cu*l;//m^3
Wt_Cu=V_Cu*D_Cu;//kg
disp(Wt_Cu,"Weight of copper required(kg)");
a_Al=(3*IL^2*rho_Al*l)/(1-Eta)/P;//m^2
V_Al=3*a_Al*l;//m^3
Wt_Al=V_Al*D_Al;//kg
disp(Wt_Al,"Weight of Alluminium required(kg)");
//Answer in the textbook is not accurate.
```

Scilab code Exa 3.2 \begin{code}
Most Economical Cross section Area
\tcaption{Most Economical Cross section Area}

\lstinputlisting{../2078/CH3/EX3.2/Example3_2.sce}
Most Economical Cross section Area
\end{code}

```
//Exa 3.2
clc;
clear;
close;
//Given data :
a=poly(0,'a');
cost=90*a+20;//Rs./m
i=10;//%(interest and depreciation)
l=2;//km
cost_E=4;//paise/unit
Im=250;//A
a=1;//cm^2
```

```
rho_c=0.173;//ohm/km/cm^2
l2=1*1000;//km
R=rho_c*l/a;//ohm
W=2*Im^2*R;//W
Eloss=W/1000*365*24/2;//per annum(kWh)
P3BYa=cost_E/100*Eloss;//Rs
Cc=90*a*l*1000;//Rs(capital cost of feeder cable)
P2a=Cc*i/100;//Rs
//P2a=P3BYa;//For most economical cross section
a=sqrt(P3BYa*a/(P2a/a));//cm^2
disp(a,"Most economical cross sectional area in cm^2
    : ");
```

Scilab code Exa 3.3 \begin{code}
Best Current Density
\tcaption{Best Current Density}

\lstinputlisting{../2078/CH3/EX3.3/Example3_3.sce}
Best Current Density
\end{code}

```
//Exa 3.3
clc;
clear;
close;
//Given data :
t=2600;//hour
Con_Cost=3;//Rs/kg(conductor cost)
R=1.78*10^-8;//ohm-m
D=6200;//kg/m^3
E_Cost=10/100;//Rs/unit(energy cost)
i=12;//%(interest and depreciation)
a=poly(0,'a');//mm^2    ////cross sectional area
```

```
W=a*1000*D/1000/1000;//kg/km(Weight of conductor of
    1km length)
cost=Con_Cost*W;//Rs./km(cost of conductor of 1km
    length)
In_Dep=cost*i/100;//Rs(Annual interest and
    depreciation per conductor per km)
In_DepBYa=In_Dep/a;
I=poly(0,'I');//A
E_lost_aBY_Isqr=R*1000/10^-6*t/1000;//Energy lost/
    annum/km/conductor
E_lost_cost_aBY_Isqr=E_Cost*E_lost_aBY_Isqr;//Rs/
    annum
//In_Dep=E_lost_cost;//For most economical cross
    section
IBYa=sqrt(coeff(numer(In_DepBYa)/numer(
    E_lost_cost_aBY_Isqr)));//cm^2
disp(IBYa,"Best current density in A/mm^2 : ");
//Answer in the textbook is not accurate.
```

Scilab code Exa 3.4 \begin{code}
Economical current density and diameter
\tcaption{Economical current density and diameter}

\lstinputlisting{../2078/CH3/EX3.4/Example3_4.sce}
Economical current density and diameter
\end{code}

```
//Exa 3.4
clc;
clear;
close;
//Given data :
V=11;//kV
```

```
P=1500;//kW
pf=0.8;//lagging power factor
t=300*8;//hours
a=poly(0,'a');//cross section area
Cc=8000+20000*a//Rs/km
R=0.173/a;//ohm/km
E_lost_cost=2/100;//Rs/unit
i=12;//%(interest and depreciation)
Cc_var=20000*a//Rs/km(variable cost)
P2a=Cc_var*i/100;//Rs/km
P2=P2a/a;
I=P/sqrt(3)/V/pf;//A
W=3*I^2*R;//W
E_loss=W/1000*t;//kWh
P3BYa=E_lost_cost*E_loss;//Rs
//P2a=P3BYa;//For most economical cross section
a=sqrt(coeff((numer(P3BYa))/coeff(numer(P2))));//cm^2
d=sqrt(4*a/%pi);//cm
del=I/a;//A/cm^2
disp(d,"Diameter of conductor in cm : ");
disp(del,"Most economical current density in A/cm^2 : ");
```

Scilab code Exa 3.5 \begin{code}
Most economical current density
\tcaption{Most economical current density}

\lstinputlisting{../2078/CH3/EX3.5/Example3_5.sce}
Most economical current density
\end{code}

```
//Exa 3.5
```

```
clc;
clear;
close;
//Given data :
a=poly(0,'a');//cross section area
I=poly(0,'I');//Current
Cc=500+2000*a//Rs/km
i=12;//%(interest and depreciation)
E_lost_cost=5/100;//Rs/kWh
rho=1.78*10^-8;//ohm-cm
load_factor=0.12;
Cc_var=2000*a//Rs/km(variable cost)
P2a=Cc_var*i/100;//Rs/km
P2=P2a/a;
R_into_a=rho*1000/(10^-4);//ohm
W_into_a=I^2*R_into_a;//W
E_loss_into_a=W_into_a*load_factor/1000*8760;//kWh
P3BYIsqr=E_lost_cost*E_loss_into_a/I^2;//Rs
//P2a=P3BYa;//For most economical cross section
IBYa=sqrt(coeff((numer(P2))/coeff(numer(P3BYIsqr))));//cm^2
disp(IBYa,"Most economical current density in A/cm^2 : ");
```

Scilab code Exa 3.6 \begin{code}
Most Economical current density
\tcaption{Most Economical current density}

\lstinputlisting{../2078/CH3/EX3.6/Example3_6.sce}
Most Economical current density
\end{code}

```
//Exa 3.6
```

```
clc;
clear;
close;
//Given data :
A=poly(0,'A');//cross section area
I=poly(0,'I');//Current
Cc=500+2000*A//Rs/km
load_factor=0.12;
i=12;//%(depreciation)
E_lost_cost=0.05;//Rs/kWh
R=0.17/A;//ohm/km

Cc_var=2000*A//Rs/km(variable cost)
P2A=Cc_var*i/100;//Rs/km
P2=P2A/A;
R_into_A=R*A;//ohm
W_into_A_BY_Isqr=R_into_A;//W
E_loss_into_A_BY_Isqr=W_into_A_BY_Isqr*load_factor/1000*8760;//kWh
P3BYIsqr=E_lost_cost*E_loss_into_A_BY_Isqr;//Rs
//P2a=P3BYa;//For most economical cross section
IBYa=sqrt(coeff((numer(P2))/coeff(numer(P3BYIsqr))));//cm^2
disp(IBYa,"Most economical current density in A/cm^2 : ");
//Answer in the textbook is wrong.
```

Scilab code Exa 3.7 Scilab code Exa 3.7 \begin{verbatim}
Most economical size
Most economical size

```
//Exa 3.7
clc;
```

```
clear;
close;
//Given data :
P1=1000;//kW
pf1=0.8;//
t1=10;//hours
P2=500;//kW
pf2=0.9;//
t2=8;//hours
P3=100;//kW
pf3=1;//
t3=6;//hours
a=poly(0,'a');//cross section area
I=poly(0,'I');//Current
L=poly(0,'L');//length in km
CcBYL=(8000*a+1500)//Rs/km(variable cost)
i=10;//%(depreciation)
E_lost_cost=80/100;//Rs/kWh
rho=1.72*10^-6;//ohm-cm
Cc_varBYL=8000*a*i/100//Rs/km(variable cost)
I1=P1*1000/sqrt(3)/10000/pf1;//A
I2=P2*1000/sqrt(3)/10000/pf2;//A
I3=P3*1000/sqrt(3)/10000/pf3;//A
R_into_a_BY_L=rho*1000*100;//ohm
W_into_A_BY_Isqr=R_into_a_BY_L;//W
E_loss_into_A_BY_L=3*R_into_a_BY_L*[I1^2*t1+I2^2*t2+
    I3^2*t3]*365/1000;//kWh
E_loss_cost_into_A_BY_L=E_loss_into_A_BY_L*
    E_lost_cost;//Rs
//Cc_var=E_loss_cost;//For most economical cross
    section
a=sqrt(coeff((numer(E_loss_cost_into_A_BY_L))/coeff(
    numer(Cc_varBYL/a))));//cm^2
disp(a,"Most economical cross sectional area in cm^2
     : ");
```

```
//Exa 3.7
```

```
clc;
clear;
close;
//Given data :
P1=1000;//kW
pf1=0.8;//
t1=10;//hours
P2=500;//kW
pf2=0.9;//
t2=8;//hours
P3=100;//kW
pf3=1;//
t3=6;//hours
a=poly(0,'a');//cross section area
I=poly(0,'I');//Current
L=poly(0,'L');//length in km
CcBYL=(8000*a+1500)//Rs/km(variable cost)
i=10;//%(depreciation)
E_lost_cost=80/100;//Rs/kWh
rho=1.72*10^-6;//ohm-cm
Cc_varBYL=8000*a*i/100//Rs/km(variable cost)
I1=P1*1000/sqrt(3)/10000/pf1;//A
I2=P2*1000/sqrt(3)/10000/pf2;//A
I3=P3*1000/sqrt(3)/10000/pf3;//A
R_into_a_BY_L=rho*1000*100;//ohm
W_into_A_BY_Isqr=R_into_a_BY_L;//W
E_loss_into_A_BY_L=3*R_into_a_BY_L*[I1^2*t1+I2^2*t2+
    I3^2*t3]*365/1000;//kWh
E_loss_cost_into_A_BY_L=E_loss_into_A_BY_L*
    E_lost_cost;//Rs
//Cc_var=E_loss_cost;//For most economical cross
    section
a=sqrt(coeff((numer(E_loss_cost_into_A_BY_L))/coeff(
    numer(Cc_varBYL/a))));//cm^2
disp(a,"Most economical cross sectional area in cm^2
     : ");
```

Chapter 7

Inductance and Capacitance of Transmission Lines

Chapter 8

Inductance and Capacitance of Transmission Lines

Scilab code Exa 4.1 Scilab code Exa 4.1 \tcaption{Loop inductance and reactance}
Loop inductance and reactance
\begin{verbatim}
Loop inductance and reactance

```
//Exa 4.1
clc;
clear;
close;
//Given data :
f=50;//Hz
d=1*100;//cm
r=1.25/2;//cm
r_dash=r*0.7788;//cm
L=0.4*log(d/r_dash);//mH
disp(L,"Loop inductance per km(mH)");
XL=2*%pi*f*L*10^-3;//ohm/Km
disp(XL,"Reactance of transmission line(ohm/km)");
```

```
//Exa 4.1
clc;
clear;
close;
//Given data :
f=50;//Hz
d=1*100;//cm
r=1.25/2;//cm
r_dash=r*0.7788;//cm
L=0.4*log(d/r_dash);//mH
disp(L,"Loop inductance per km(mH)");
XL=2*%pi*f*L*10^-3;//ohm/Km
disp(XL,"Reactance of transmission line(ohm/km)");
```

Scilab code Exa 4.2 \begin{code}
Calculate Inductance

```
//Exa 4.2
clc;
clear;
close;
//Given data :
f=50;//Hz
a=10;//cm^2
l=500/1000;//km
r=sqrt(a/%pi);//cm
d=5*100;//cm
r_dash=r*0.7788;//cm
L=0.4*log(d/r_dash)*l;//mH
disp(L,"Loop inductance per km(mH)");
```

\end{code}
Calculate Inductance

```
//Exa 4.2
clc;
clear;
close;
//Given data :
f=50;//Hz
a=10;//cm^2
l=500/1000;//km
r=sqrt(a/%pi);//cm
d=5*100;//cm
r_dash=r*0.7788;//cm
L=0.4*log(d/r_dash)*l;//mH
disp(L,"Loop inductance per km(mH)");
```

Scilab code Exa 4.3 \begin{code}
Calculate Loop inductance

\lstinputlisting{../2078/CH4/EX4.3/Example4_3.sce}
\end{code}
Calculate Loop inductance

```
//Exa 4.3
clc;
clear;
close;
//Given data :
r=1/2;//cm
d=1*100;//cm
mu=50;//relative permeability
```

```
r_dash=r*0.7788;//cm
L_cu=.1+0.4*log(d/r);//mH
disp(L_cu,"Loop inductance per km of copper
    conductor line(mH)");
L_steel=(mu+4*log(d/r))*10^-7*10^3;//mH
disp(L_steel*10^3,"Loop inductance per km of copper
    conductor line(mH)");
```

Scilab code Exa 4.4 \begin{code}
Calculate GMR
\tcaption{Calculate GMR}

\lstinputlisting{../2078/CH4/EX4.4/Example4_4.sce}
Calculate GMR
\end{code}

```
//Exa 4.4
clc;
clear;
close;
//Given data :
r=3;//mm
d11=r;//mm
d12=2*r;//mm
d34=2*r;//mm
d16=2*r;//mm
d17=2*r;//mm
d14=4*r;//mm
d13=sqrt(d14^2-d34^2);//mm
d15=d13;//mm
Ds1=(0.7788*d11*d12*d13*d14*d15*d16*d17)^(1/7);//mm
Ds2=Ds1;//mm
Ds3=Ds1;//mm
```

```
Ds4=Ds1; //mm
Ds5=Ds1; //mm
Ds6=Ds1; //mm
Ds7=(2*r*0.7788*d11*d12*d13*2*r*2*r)^(1/7); //mm
Ds=(Ds1*Ds2*Ds3*Ds4*Ds5*Ds6*Ds7)^(1/7); //mm
disp(Ds,"Geometric mean radius(mm)");
//Answer in the book is wrong
```

Scilab code Exa 4.5 \begin{code}
Determine total inductance
\tcaption{Determine total inductance}

\lstinputlisting{../2078/CH4/EX4.5/Example4_5.sce}
Determine total inductance
\end{code}

```
//Exa 4.5
clc;
clear;
close;
//Given data :
r=1.2; //cm
rdash=0.7788*r; //cm
d12=0.12*100; //cm
d11dash=(0.2+1.2)*100; //cm
d22dash=(0.2+1.2)*100; //cm
d12dash=(0.2+1.2+0.2)*100; //cm
d21dash=(1.2)*100; //cm
Dm=(d11dash*d12dash*d21dash*d22dash)^(1/4); //cm
d11=0.93456; //cm
d22=0.93456; //cm
d12=20; //cm
d21=20; //cm
```

```
Ds=(d11*d12*d21*d22)^(1/4);//cm
L=0.4*log(Dm/Ds);//mH/km
disp(L,"Loop inductance of line(mH/km)");
```

Scilab code Exa 4.6 \begin{code}
Determine total inductance
\tcaption{Determine total inductance}

\lstinputlisting{../2078/CH4/EX4.6/Example4_6.sce}
Determine total inductance
\end{code}

```
//Exa 4.6
clc;
clear;
close;
//Given data :
r=2/2;//cm
rdash=0.7788*r;//cm
d12=0.12*100;//cm
d11dash=300;//cm
d12dash=sqrt(300^2+100^2);//cm
d21dash=d12dash;//cm
d22dash=d11dash;//cm
d11=rdash;//cm
d22=rdash;//cm
d12=100;//cm
d21=100;//cm
Dm=(d11dash*d12dash*d21dash*d22dash)^(1/4);//cm
Ds=(d11*d12*d21*d22)^(1/4);//cm
L=0.4*log(Dm/Ds);//mH/km
disp(L,"Loop inductance of line(mH/km)");
```

Scilab code Exa 4.7 \begin{code}
Inductance per km
\tcaption{Inductance per km}

\lstinputlisting{../2078/CH4/EX4.7/Example4_7.sce}
Inductance per km
\end{code}

```
//Exa 4.7
clc;
clear;
close;
//Given data :
r=1.24/2;//cm
rdash=0.7788*r;//cm
d=2*100;//cm
L=0.2*log(d/rdash);//mH
disp(L,"Inductance per phase per km(mH)");
```

Scilab code Exa 4.8 \begin{code}
Inductance per km
\tcaption{Inductance per km}

\lstinputlisting{../2078/CH4/EX4.8/Example4_8.sce}
Inductance per km
\end{code}

```
//Exa 4.8
clc;
clear;
close;
//Given data :
r=(20/2)/10;//cm
d1=4*100;//cm
d2=5*100;//cm
d3=6*100;//cm
rdash=0.7788*r;//cm
L=0.2*log((d1*d2*d3)^(1/3)/rdash);//mH
disp(L,"Inductance per phase(mH)");
```

Scilab code Exa 4.9 \begin{code}
Inductance per km
\tcaption{Inductance per km}

\lstinputlisting{../2078/CH4/EX4.9/Example4_9.sce}
Inductance per km
\end{code}

```
//Exa 4.9
clc;
clear;
close;
//Given data :
r=4/2;//cm
rdash=0.7788*r;//cm
d=300;//cm
d3=6*100;//cm
LA=0.2*[log(d/rdash)+1/2*log(2)-%i*0.866*log(2)];//mH
disp(LA,"Inductance per km of phase1(mH)");
```

```
LB=0.2*log(d/rdash);//mH
disp(LB,"Inductance per km of phase2(mH)");
LC=0.2*[log(d/rdash)+1/2*log(2)+%i*0.866*log(2)];//
    mH
disp(LC,"Inductance per km of phase3(mH)");
```

Scilab code Exa 4.10 \begin{code}
Spacing between adjacent conductors
\tcaption{Spacing between adjacent conductors}

\lstinputlisting{../2078/CH4/EX4.10/Example4_10.sce}
Spacing between adjacent conductors
\end{code}

```
//Exa 4.10
clc;
clear;
close;
//Given data :
r=1.2/2*10;//mm
rdash=0.7788*r;//mm
d=3.5*1000;//mm
L=2*10^-7*log(d/rdash);//H/m
Lav=1/3*(L+L+L);//H/m
d=rdash*exp(Lav/(2*10^-7)-1/3*log(2));//mm
disp(d/1000,"Spacing between adjacent conductors(m)"
    );
```

Scilab code Exa 4.11 \begin{code}
Inductance per phase per km
\tcaption{Inductance per phase per km}

\lstinputlisting{../2078/CH4/EX4.11/Example4_11.sce}
Inductance per phase per km
\end{code}

```
//Exa 4.11
clc;
clear;
close;
//Given data :
r=20;//mm
rdash=0.7788*r;//mm
d=7*1000;//mm
L=10^-7*log(sqrt(3)/2*d/rdash);//H/m
disp(L*10^3/10^-3,"Spacing between adjacent
    conductors(mH)");
```

Scilab code Exa 4.12 \begin{code}
Inductance per phase per km
\tcaption{Inductance per phase per km}

\lstinputlisting{../2078/CH4/EX4.12/Example4_12.sce}
Inductance per phase per km
\end{code}

```
//Exa 4.12
clc;
clear;
close;
```

```
//Given data :
r=0.9; //cm
rdash=0.7788*r*10^-2; //m
daa_dash=sqrt(6^2+6^2); //m
dbb_dash=7; //m
dcc_dash=daa_dash; //m
daa=rdash; //m
d_adash_adash=rdash; //m
d_adash_a=daa_dash; //m
Dsa=(daa*daa_dash*d_adash_adash*d_adash_a)^(1/4); //m
Dsb=(daa*7)^(1/2); //m
Dsc=(daa*daa_dash)^(1/2); //m
Ds=(Dsa*Dsb*Dsc)^(1/3); //m
dab=sqrt(3^2+0.5^2); //m
dab_dash=sqrt(3^2+6.5^2); //m
d_adash_b=sqrt(3^2+6.5^2); //m
d_adash_bdash=sqrt(3^2+0.5^2); //m
Dab=(dab*dab_dash*d_adash_b*d_adash_bdash)^(1/4); //m
Dbc=((dab*dab_dash)^2)^(1/4); //m
Dca=((6*6)^2)^(1/4); //m
Dm=(Dab*Dbc*Dca)^(1/3); //m
L=0.2*log(Dm/Ds); //mH/km
disp(L,"Inductance per phase(mH/km)");
```

Scilab code Exa 4.13 \begin{code}
GMD GMR and Overall Inductance
\tcaption{GMD GMR and Overall Inductance}

\lstinputlisting{../2078/CH4/EX4.13/Example4_13.sce}
GMD GMR and Overall Inductance
\end{code}

```
//Exa 4.13
```

```
clc;
clear;
close;
format('v',5)
//Given data :
r=5/2;//mm
rdash=2.176*r*10^-3;//m
daa_dash=sqrt(6^2+16^2);//m
dbb_dash=6;//m
dcc_dash=daa_dash;//m
dab=8;//m
dab_dash=sqrt(6^2+8^2);//m
dbc=8;//m
dbc_dash=sqrt(6^2+8^2);//m
dca=16;//m
dca_dash=6;//m
Dsa=sqrt(rdash*daa_dash);//m
Dsb=sqrt(rdash*dbb_dash);//m
Dsc=sqrt(rdash*dcc_dash);//m
Ds=(Dsa*Dsb*Dsc)^(1/3);//m
disp(Ds,"GMD(m) : ");
Dab=(dab*dab_dash)^(1/2);//m
Dbc=(dbc*dbc_dash)^(1/2);//m
Dca=(dca*dca_dash)^(1/2);//m
Dm=(Dab*Dbc*Dca)^(1/3);//m
disp(Dm,"Deq or Dm(m) : ");
L=0.2*log(Dm/Ds);//mH/km
L=L*10^-3*100;//H(for 100 km line)
disp(L,"Inductance of 100 km line(H)");
///Alternate method is given below
d1=dab;//m
d2=dca_dash;//m
L=0.2*log(2^(1/6))*sqrt(d1/rdash)*((d1^2+d2^2)/(4*d1
   ^2+d2^2))^(1/6);//mH
L=L*10^-3*100;//H(for 100 km line)
disp(L,"Using Alternate method, Inductance of 100 km
    line(H)");
```

Scilab code Exa 4.14 \begin{code}
Inductance per km
\tcaption{Inductance per km}

\lstinputlisting{../2078/CH4/EX4.14/Example4_14.sce}
Inductance per km
\end{code}

```
//Exa 4.14
clc;
clear;
close;
//Given data :
r=5/2;//cm
rdash=0.7788*r*10^-2;//m
d=6.5;//m
s=0.4;//m
Ds=sqrt(rdash*s);//m
dab=6.5;//m
dab_dash=6.9;//m
d_adash_b=6.1;//m
d_adash_bdash=6.5;//m
Dab=(dab*dab_dash*d_adash_b*d_adash_bdash)^(1/4);//m
Dbc=Dab;//m
dca=13;//m
dca_dash=12.6;//m
d_cdash_a=13.4;//m
d_cdash_adash=13;//m
Dca=(dca*dca_dash*d_cdash_a*d_cdash_adash)^(1/4);//m
Dm=(Dab*Dbc*Dca)^(1/3);//m
L=0.2*log(Dm/Ds);//mH/km
disp(L,"Inductance per phase(mH/km)");
```

Scilab code Exa 4.15 \begin{code}
Find inductive reactance
\tcaption{Find inductive reactance}

\lstinputlisting{../2078/CH4/EX4.15/Example4_15.sce}
Find inductive reactance
\end{code}

```
//Exa 4.15
clc;
clear;
close;
//Given data :
f=50;//Hz
r=3.5/2;//cm
rdash=0.7788*r*10^-2;//m
d=7;//m
s=40/100;//m
Ds=sqrt(rdash*s);//m
dab=7;//m
dab_dash=7.4;//m
d_adash_b=6.6;//m
d_adash_bdash=7;//m
Dab=(dab*dab_dash*d_adash_b*d_adash_bdash)^(1/4);//m
Dbc=Dab;//m
dca=14;//m
dca_dash=13.6;//m
d_cdash_a=14.4;//m
d_cdash_adash=14;//m
Dca=(dca*dca_dash*d_cdash_a*d_cdash_adash)^(1/4);//m
Dm=(Dab*Dbc*Dca)^(1/3);//m
```

```
L=0.2*log(Dm/Ds);//mH/km
XL=2*%pi*f*L*10^-3;//ohm/km
disp(XL,"Inductive reactance of bundled conductor
    line(ohm/km)");
//Equivalent single conductor
n=2;
r1=sqrt(n*%pi*r^2/%pi);//m
r1dash=0.7788*r1*10^-2;//m
Dm1=(Dab*Dbc*Dca)^(1/3);//m
L1=0.2*log(Dm1/r1dash);//mH/km
XL1=2*%pi*f*L1*10^-3;//ohm/km
disp(XL1,"Inductive reactance with single conductor(
    ohm/km)");
```

Scilab code Exa 4.16 \begin{code}
Find out Capacitance
\tcaption{Find out Capacitance}

\lstinputlisting{../2078/CH4/EX4.16/Example4_16.sce}
Find out Capacitance
\end{code}

```
//Exa 4.16
clc;
clear;
close;
//Given data :
r=15/2;//mm
d=1.5*1000;//mm
l=30;//km
epsilon_o=8.854*10^-12;//permitivity
C=%pi*epsilon_o/log(d/r)*l*1000;//F
disp(C*10^6,"Capacitance of line(micro F)");
```

Scilab code Exa 4.17 \begin{code}
Calculate Capacitance
\tcaption{Calculate Capacitance}

\lstinputlisting{../2078/CH4/EX4.17/Example4_17.sce}
Calculate Capacitance
\end{code}

```
//Exa 4.17
clc;
clear;
close;
//Given data :
r=2/2;//cm
d=2.5*100;//cm
l=100;//km
epsilon_o=8.854*10^-12;//permitivity
C=2*%pi*epsilon_o/log(d/r)*l*1000;//F
disp(C*10^6,"Capacitance of line(micro F)");
```

Scilab code Exa 4.18 \begin{code}
Capacitance per conductor per km
\tcaption{Capacitance per conductor per km}

\lstinputlisting{../2078/CH4/EX4.18/Example4_18.sce}
Capacitance per conductor per km
\end{code}

```
//Exa 4.18
clc;
clear;
close;
//Given data :
r=2/2/100;//m
d1=3.5;//m
d2=5;//m
d3=8;//m
epsilon_o=8.854*10^-12;//permitivity
CN=2*%pi*epsilon_o*1000/log((d1*d2*d3)^(1/3)/r);//F
disp(CN*10^6,"Capacitance of line(micro F)");
```

Scilab code Exa 4.19 \begin{code}
Capacitance and Charging current
\tcaption{Capacitance and Charging current}

\lstinputlisting{../2078/CH4/EX4.19/Example4_19.sce}
Capacitance and Charging current
\end{code}

```
//Exa 4.19
clc;
clear;
close;
//Given data :
f=50;//Hz
VL=220;//KV
r=20/2/1000;//m
d1=3;//m
d2=3;//m
d3=6;//m
epsilon_o=8.854*10^-12;//permitivity
```

```
CN=2*%pi*epsilon_o/log((d1*d2*d3)^(1/3)/r);//F
disp(CN,"Capacitance per phase per meter  line(F)");
Vph=VL*1000/sqrt(3);//V
Ic=2*%pi*f*CN*Vph;//A
disp(Ic*1000,"Charging current per phase(mA) : ");
```

Scilab code Exa 4.20 \begin{code}
Capacitance to neutral and charging per km
\tcaption{Capacitance to neutral and charging per km}

\lstinputlisting{../2078/CH4/EX4.20/Example4_20.sce}
Capacitance to neutral and charging per km
\end{code}

```
//Exa 4.20
clc;
clear;
close;
//Given data :
f=50;//Hz
VL=110;//kV
r=1.05/2;//cm
d1=3.5;//m
d2=3.5;//m
d3=7;//m
epsilon_o=8.854*10^-12;//permitivity
CN=2*%pi*epsilon_o/log((d1*d2*d3)^(1/3)*100/r);//F
disp(CN,"Capacitance per phase per meter  line(F)");
Vph=VL*1000/sqrt(3);//V
Ic=2*%pi*f*CN*Vph;//A/m
disp(Ic/10^-3,"Charging current per phase(A/km) : ")
    ;
```

Scilab code Exa 4.21 \begin{code}
Capacitance to neutral and charging current
\tcaption{Capacitance to neutral and charging current}

\lstinputlisting{../2078/CH4/EX4.21/Example4_21.sce}
Capacitance to neutral and charging current
\end{code}

```
//Exa 4.21
clc;
clear;
close;
//Given data :
r=2.5/2*10^-2;//m
VL=132;//KV
epsilon_o=8.85*10^-12;//permitivity
f=50;//Hz
dRRdash=sqrt(7^2+(4+4)^2);//m
dBBdash=dRRdash;//m
dYYdash=9;//m
DSR=sqrt(r*dRRdash);//m
DSY=sqrt(r*dYYdash);//m
DSB=sqrt(r*dBBdash);//m
Ds=(DSR*DSB*DSY)^(1/3);//m
dRY=sqrt(4^2+(4.5-3.5)^2);//m
dRYdash=sqrt((9-1)^2+4^2);//m
dRdashY=sqrt((9-1)^2+4^2);//m
dRdashYdash=sqrt(4^2+(4.5-3.5)^2);//m
DRY=(dRY*dRYdash*dRdashY*dRdashYdash)^(1/4);//m
DYB=((dRY*dRYdash)^2)^(1/4);//m
DBR=((8*7)^2)^(1/4);//m
Dm=(DRY*DYB*DBR)^(1/3);//m
```

```
C=2*%pi*epsilon_o/log(Dm/Ds);//F/m
C=C/10^-3;//F/km
X=1/(2*%pi*f*C);//ohm
disp(X/1000,"Capacitive reactance too neutral(kohm) : ");
Vph=VL*1000/sqrt(3);//Volt
Ic=2*%pi*f*C*Vph;//A
disp(Ic,"Charging current(A/km)");
```

Scilab code Exa 4.22 \begin{code}
Capacitance per phase
\tcaption{Capacitance per phase}

\lstinputlisting{../2078/CH4/EX4.22/Example4_22.sce}
Capacitance per phase
\end{code}

```
//Exa 4.22
clc;
clear;
close;
//Given data :
d1=8;//m
d2=6;//m
epsilon_o=8.854*10^-12;//permitivity
r=3*5/2*10^-3;//m
C=4*%pi*epsilon_o/log(2^(1/3)*d1/r*((d1^2+d2^2)/(4*d1^2+d2^2)^(1/3)));//F/m
C100=C*100*1000*10^6;//microF
disp(C100,"Capacitance of 100 km line(micro Farad) : ");
//answer in the textbook is wrong.
```

Scilab code Exa 4.23 \begin{code}
Capacitance and charging current
\tcaption{Capacitance and charging current}

\lstinputlisting{../2078/CH4/EX4.23/Example4_23.sce}
Capacitance and charging current
\end{code}

```
//Exa 4.23
clc;
clear;
close;
//Given data :
VL=132;//kV
f=50;//Hz
r=5/2;//cm
rdash=0.7788*r*10^-2;//m
d=6.5;//m
s=0.4;//m
epsilon_o=8.854*10^-12;//permitivity
Ds=sqrt(rdash*s);//m
dab=6.5;//m
dab_dash=6.9;//m
d_adash_b=6.1;//m
d_adash_bdash=6.5;//m
Dab=(dab*dab_dash*d_adash_b*d_adash_bdash)^(1/4);//m
Dbc=Dab;//m
dca=13;//m
dca_dash=12.6;//m
d_cdash_a=13.4;//m
d_cdash_adash=13;//m
Dca=(dca*dca_dash*d_cdash_a*d_cdash_adash)^(1/4);//m
```

```
Dm=(Dab*Dbc*Dca)^(1/3);//m
L=0.2*log(Dm/Ds);//mH/km
C=2*%pi*epsilon_o/log(Dm/Ds);//F/m
C=C/10^-3;//F/km
disp(C,"Capacitance per km(F/km) : ");
Vph=VL*1000/sqrt(3);//Volt
Ic=2*%pi*f*C*Vph;//A/km
disp(Ic,"Charging current per km(A/km) : ");
```

Scilab code Exa 4.24 \begin{code}
Inductive and Capacitive reactances
\tcaption{Inductive and Capacitive reactances}

\lstinputlisting{../2078/CH4/EX4.24/Example4_24.sce}
Inductive and Capacitive reactances
\end{code}

```
//Exa 4.24
clc;
clear;
close;
//Given data :
VL=132;//kV
f=50;//Hz
r=31.8/2;//mm
rdash=0.7788*r;//mm
d=10*1000;//mm
epsilon_o=8.854*10^-12;//permitivity
disp("One conductor ACSR moose conductor line : ");
LA=0.2*[log(d/rdash)+1/2*log(2)-%i*0.866*log(2)];//
   mH/km
LB=0.2*log(d/rdash);//mH/km
```

```
LC=0.2*[log(d/rdash)+1/2*log(2)+%i*0.866*log(2)];//
    mH/km
Lav=(LA+LB+LC)/3;//mH/km
XL=2*%pi*f*Lav*10^-3;//ohm
disp(XL,"Inductive reactance per Km per phase(ohm) :
     ");
d1=10;//m
d2=10;//m
d3=20;//m
CN=2*%pi*epsilon_o/log((d1*d2*d3)^(1/3)/(rdash
    *10^-3))/10^3;//F/km
XC=1/(2*%pi*f*CN*10^6);//ohm
disp(XC/10^6,"Capacitivetive reactance per Km per
    phase(Mohm) : ");
disp("Three conductor bundled line : ");
S=40/100;//m
Ds=(rdash*10^-3*S^2)^(1/3);//m
Deq=(d1*d2*d3)^(1/3);//m
Ldash=0.2*log(Deq/Ds);//mH/km
XLdash=2*%pi*f*Ldash*10^-3;//ohm
disp(XLdash,"Inductive reactance per km per phase(
    ohm) : ");
Ds=(r*10^-3*S^2)^(1/3);//m
Cdash=2*%pi*epsilon_o*10^3/log(Deq/Ds);//microF/km
XC=1/(2*%pi*f*Cdash)/10^6;//Mohm
disp(XC,"Capacitivetive reactance per km per phase(
    Mohm) : ");
```

Scilab code Exa 4.25 \begin{code}
Capacitance per km
\tcaption{Capacitance per km}

\lstinputlisting{../2078/CH4/EX4.25/Example4_25.sce}

Capacitance per km
\end{code}

```
//Exa 4.25
clc;
clear;
close;
//Given data :
r=1.5/2;//cm
d=3*100;//cm
h=6*100;//cm
epsilon_o=8.854*10^-12;//permitivity
C=%pi*epsilon_o/log(d/(1+d^2/4/h^2)^r)*10^3;//F
disp(C,"Capacitance per km of line(F) : ");
```

Scilab code Exa 4.26 \begin{code}
Determine the capacitance
\tcaption{Determine the capacitance}

\lstinputlisting{../2078/CH4/EX4.26/Example4_26.sce}
Determine the capacitance
\end{code}

```
//Exa 4.26
clc;
clear;
close;
//Given data :
r=2/100;//m
d1=4;//m
d2=4;//m
d3=8;//m
```

```
epsilon_o=8.854*10^-12;//permitivity
CN=2*%pi*epsilon_o/log((d1*d2*d3)^(1/3)/r);//F
disp(CN,"Part(i) Capacitance per phase per meter
    length(F) : ");
h1=20;//m
h2=20;//m
h3=20;//m
h12=sqrt(20^2+4^2);//m
h23=sqrt(20^2+4^2);//m
h31=sqrt(20^2+8^2);//m
Deq=(d1*d2*d3)^(1/3);//m
CN=2*%pi*epsilon_o/(log(Deq/r)-log((h12*h23*h31/h1/
    h2/h3)^(1/3)) );//F
disp(CN,"Part(ii) Capacitance per phase per meter
    length(F) : ");
```

Chapter 9

Representation and Performance of short and medium Transmission Lines

Chapter 10

Representation and Performance of short and medium Transmission Lines

Scilab code Exa 5.1 `\begin{code}`
`Voltage Regulation and Efficiency`
`\tcaption{Voltage Regulation and Efficiency}`

`\lstinputlisting{../2078/CH5/EX5.1/Example5_1.sce}`
`Voltage Regulation and Efficiency`
`\end{code}`

```
//Exa 5.1
clc;
clear;
close;
//Given data :
P=1100;//kW
VR=11*1000;//V
pf=0.8;//power factor
```

```
R=2;//ohm
X=3;//ohm
I=P*1000/VR/pf;//A
cos_fi_r=pf;
sin_fi_r=sqrt(1-cos_fi_r^2);
VS=sqrt((VR*cos_fi_r+I*R)^2+(VR*sin_fi_r+I*X)^2);//V
disp(VS,"Voltage at sending end(V)");
Reg=(VS-VR)/VR*100;//%
disp(Reg,"% Regulation");
LineLoss=I^2*R/1000;//kW
Eta_T=P*100/(P+LineLoss);//%
disp(Eta_T,"Transmission Efficiency(%)");
```

Scilab code Exa 5.2 \begin{code}
Voltage Regulation and Efficiency
\tcaption{Voltage Regulation and Efficiency}

\lstinputlisting{../2078/CH5/EX5.2/Example5_2.sce}
Voltage Regulation and Efficiency
\end{code}

```
//Exa 5.2
clc;
clear;
close;
//Given data :
R=0.4;//ohm
X=0.4;//ohm
P=2000;//kVA
pf=0.8;//power factor
VL=3000;//V
VR=VL/sqrt(3);//V
cos_fi_r=pf;
```

```
sin_fi_r=sqrt(1-cos_fi_r^2);
I=P*1000/3/VR;//A
VS=VR+I*(R*cos_fi_r+X*sin_fi_r);//V
Reg=(VS-VR)/VR*100;//%
disp(Reg,"% Regulation");
LineLoss=3*I^2*R/1000;//kW
Pout=P*cos_fi_r;//kW
Eta_T=Pout*100/(Pout+LineLoss);//%
disp(Eta_T,"Transmission Efficiency(%)");
```

Scilab code Exa 5.3 \begin{code}
Sending end Voltage and Regulation
\tcaption{Sending end Voltage and Regulation}

\lstinputlisting{../2078/CH5/EX5.3/Example5_3.sce}
Sending end Voltage and Regulation
\end{code}

```
//Exa 5.3
clc;
clear;
close;
//Given data :
l=15;//km
P=5;//MW
V=11;//kV
f=50;//Hz
pf=0.8;//power factor
cos_fi_r=pf;
sin_fi_r=sqrt(1-cos_fi_r^2);
L=1.1;//mH/Km
VR=V*1000/sqrt(3);//V
I=P*1000/sqrt(3)/V/cos_fi_r;//A
```

```
LineLoss=12/100*P*10^6;//W
R=LineLoss/3/I^2;//ohm
X=2*%pi*f*L*10^-3*l;//ohm/phase
VS=VR+I*(R*cos_fi_r+X*sin_fi_r);//V
VSL=sqrt(3)*VS/1000;//KV
disp(VSL,"Line voltage at sending end(kV)");
Reg=(VSL-V)/V*100;//%
disp(Reg,"% Regulation");
```

Scilab code Exa 5.4 \begin{code}
Voltage PF Efficiency and Regulation
\tcaption{Voltage PF Efficiency and Regulation}

\lstinputlisting{../2078/CH5/EX5.4/Example5_4.sce}
Voltage PF Efficiency and Regulation
\end{code}

```
//Exa 5.4
clc;
clear;
close;
//Given data :
l=50;//km
S=10000;//kVA
pf=0.8;//power factor
d=1.2*100;//cm
cos_fi_r=pf;
sin_fi_r=sqrt(1-cos_fi_r^2);
V=33000;//Volts
VR=V/sqrt(3);//V
f=50;//Hz
I=S*1000/sqrt(3)/V;//A
```

```
LineLoss=10/100*S*10^3*pf;//W
R=LineLoss/3/I^2;//ohm
rho=1.73*10^-6;//kg/m^3
a=rho*l*1000*100/R;//cm^2
r=sqrt(a/%pi);//cm
L=0.2*log(d/r/0.7788)*l;//mH
X=2*%pi*f*L*10^-3;//ohm
VS=VR+I*(R*cos_fi_r+X*sin_fi_r);//V
VSL=sqrt(3)*VS/1000;//kV
disp(VSL,"Line voltage at sending end(kV)");
pf_s=(VR*cos_fi_r+I*R)/VS;//lagging(sendinf end pf)
disp(pf_s,"Sending end pf(lagging) ");
Eta_T=S*pf/(S*pf+LineLoss/1000)*100;
disp(Eta_T,"Transmission Efficiency(%)");
Reg=(VSL-V/1000)/(V/1000)*100;//%
disp(Reg,"% Regulation");
```

Scilab code Exa 5.5 \begin{code}
Resistance and Inductance of line
\tcaption{Resistance and Inductance of line}

\lstinputlisting{../2078/CH5/EX5.5/Example5_5.sce}
Resistance and Inductance of line
\end{code}

```
//Exa 5.5
clc;
clear;
close;
//Given data :
VRL=30000;//Volts
VSL=33000;//Volts
f=50;//Hz
```

```
P=10*10^6;//W
pf=0.8;//power factor
cos_fi_r=pf;
sin_fi_r=sqrt(1-cos_fi_r^2);
VR=VRL/sqrt(3);//V
I=P/sqrt(3)/VRL/pf;//A
Eta_T=0.96;//Efficiency
LineLoss=P*(1/Eta_T-1);//W
R=LineLoss/3/I^2;//ohm/phase
disp(R,"Resistance per phase(ohm/phase)");
VS=VSL/sqrt(3);//V
X=(VS-VR-I*R*cos_fi_r)/I/sin_fi_r;//V
L=X/2/%pi/f;//H/phase
disp(L*1000,"Inductance per phase(mH/phase)");
```

Scilab code Exa 5.6 `\begin{code}`
`Voltage and Efficiency of Transmission`
`\tcaption{Voltage and Efficiency of Transmission}`

`\lstinputlisting{../2078/CH5/EX5.6/Example5_6.sce}`
`Voltage and Efficiency of Transmission`
`\end{code}`

```
//Exa 5.6
clc;
clear;
close;
//Given data :
l=3;//km
P=3000;//KW
VSL=11*10^3;//volt
R=l*0.4;//ohm
X=l*0.8;//ohm
```

```
VS=VSL/sqrt(3);//Volts
pf=0.8;//power factor
cos_fi_r=pf;
sin_fi_r=sqrt(1-cos_fi_r^2);
//VS=VR+I*(R*cos_fi_r+X*sin_fi_r);//V
I_into_VR=P*1000/3/cos_fi_r;//VA
//VR^2-VS*VR+I_into_VR*(R*cos_fi_r+X*sin_fi_r);
p=[1 -VS I_into_VR*(R*cos_fi_r+X*sin_fi_r)];
VR=roots(p);
VR=VR(1);//taking greater value
I=I_into_VR/VR;//A
VRL=sqrt(3)*VR;//volt
disp(VRL,"Line voltage at load end(volt) : ");
Eta_T=P*1000/(P*1000+3*I^2*R)*100;//%
disp(Eta_T,"Transmission Efficiency(%) : ");
```

Scilab code Exa 5.7 `\begin{code}`
`Power output and Power factor`

```
\lstinputlisting{../2078/CH5/EX5.7/Example5_7.sce}
\end{code}
```

`Power output and Power factor`

```
//Exa 5.7
clc;
clear;
close;
//Given data :
R=5;//ohm/phase
X=20;//ohm/phase
VSL=46.85;//kV
VRL=33;//kV
```

```
VRL=VRL*1000;//v
pf=0.8;//power factor
cos_fi_r=pf;
sin_fi_r=sqrt(1-cos_fi_r^2);
VR=VRL/sqrt(3);//V
I=(VSL*1000/sqrt(3)-VR)/(R*cos_fi_r+X*sin_fi_r);//A
Pout=sqrt(3)*VRL*I*pf/1000;//kW
disp(Pout,"Power output(kW)");
cosfi_s=(VR*pf+I*R)/(VSL*1000/sqrt(3));//power
    factor
disp(cosfi_s,"Power factor at sending end(lagging)")
    ;
```

Scilab code Exa 5.8 \begin{code}
Current Voltage Regulation Efficiency

```
//Exa 5.8
clc;
clear;
close;
//Given data :
l=80;//km
P=15;//MW
VR=66*10^3;//Volt
R=l*0.3125;//ohm
X=l*1;//ohm
Y=l*17.5*10^-6;//S
pf=0.8;//power factor
cos_fi_r=pf;
sin_fi_r=sqrt(1-cos_fi_r^2);
IR=P*10^6/(VR*pf);//A
IR=IR*(cos_fi_r-%i*sin_fi_r);//A
IC=%i*Y*VR;//A
```

```
IS=IR+IC;//A
disp("Sending end current(A), magnitude is "+string(
    abs(IS))+" and angle in degree is "+string(atand(
    imag(IS),real(IS))));
VS=VR+IS*(R+%i*X);//volt
disp("Sending end voltage(V), magnitude is "+string(
    abs(VS))+" and angle in degree is "+string(atand(
    imag(VS),real(VS))));
fi_s=atand(imag(VS),real(VS))-atand(imag(IS),real(IS
    ));//
cos_fis=cosd(fi_s);//sending end pf
disp(cos_fis,"Sending end power factor(lag) : ");
Reg=(abs(VS)-VR)/VR*100;//%
disp(Reg,"Regulation(%) :  ");
LineLoss=abs(IS)^2*R/1000;//kW
disp(LineLoss,"Line Losses in kW : ");
Eta_T=P*1000/(P*1000+LineLoss)*100;//%
disp(Eta_T,"Transmission Efficiency(%) : ");
```

\end{code}

Current Voltage Regulation Efficiency

```
//Exa 5.8
clc;
clear;
close;
//Given data :
l=80;//km
P=15;//MW
VR=66*10^3;//Volt
R=l*0.3125;//ohm
X=l*1;//ohm
Y=l*17.5*10^-6;//S
pf=0.8;//power factor
cos_fi_r=pf;
sin_fi_r=sqrt(1-cos_fi_r^2);
```

```
IR=P*10^6/(VR*pf);//A
IR=IR*(cos_fi_r-%i*sin_fi_r);//A
IC=%i*Y*VR;//A
IS=IR+IC;//A
disp("Sending end current(A), magnitude is "+string(
    abs(IS))+" and angle in degree is "+string(atand(
    imag(IS),real(IS))));
VS=VR+IS*(R+%i*X);//volt
disp("Sending end voltage(V), magnitude is "+string(
    abs(VS))+" and angle in degree is "+string(atand(
    imag(VS),real(VS))));
fi_s=atand(imag(VS),real(VS))-atand(imag(IS),real(IS
    ));//
cos_fis=cosd(fi_s);//sending end pf
disp(cos_fis,"Sending end power factor(lag) : ");
Reg=(abs(VS)-VR)/VR*100;//%
disp(Reg,"Regulation(%) :  ");
LineLoss=abs(IS)^2*R/1000;//kW
disp(LineLoss,"Line Losses in kW : ");
Eta_T=P*1000/(P*1000+LineLoss)*100;//%
disp(Eta_T,"Transmission Efficiency(%) : ");
```

Scilab code Exa 5.9 \begin{code}
Voltage Efficiency Regulation
\tcaption{Voltage Efficiency Regulation}

\lstinputlisting{../2078/CH5/EX5.9/Example5_9.sce}
Voltage Efficiency Regulation
\end{code}

```
//Exa 5.9
clc;
clear;
```

```
close;
//Given data :
l=100;//km
P=20;//MW
VRL=66*10^3;//volt
f=50;//Hz
R=10;//ohm
L=111.7*10^-3;//H
C=0.9954*10^-6;//F
pf=0.8;//power factor
X=2*%pi*f*L;//ohm
Y=2*%pi*f*C;//S
cos_fi_r=pf;
sin_fi_r=sqrt(1-cos_fi_r^2);
VR=VRL/sqrt(3);//volt
IR=P*10^6/(sqrt(3)*VRL*pf);//A
IR=IR*(cos_fi_r-%i*sin_fi_r);//A
Z=R+%i*X;//ohm
Vdash=VR+1/2*IR*Z;//Volt
IC=Vdash*%i*Y;//A
IS=IR+IC;//A
VS=Vdash+1/2*IS*Z;//Volt
VSL=abs(VS)*sqrt(3);//Volt
disp(VSL,"Sending end line voltage(Volt) :");
Reg=(VSL-VRL)/VRL*100;//%
disp(Reg,"Regulation(%) :  ");
fi_s=atand(imag(VS),real(VS))-atand(imag(IS),real(IS
    ));//
cos_fi_s=cosd(fi_s);//sending end pf
Eta_T=sqrt(3)*VRL*abs(IR)*cos_fi_r/(sqrt(3)*VSL*abs(
    IS)*cos_fi_s)*100;//%
disp(Eta_T,"Transmission Efficiency(%) : ");
//Ans is not accurate in the book.
```

Chapter 11

Power System Components

Scilab code Exa 1.1 Base Impedence

```
//Exa 1.1
clc;
clear;
close;
//Given data :
BaseVoltage=1100;//in Volts
BasekVA=10^6;//kVA
BasekV=BaseVoltage/1000;//kV
IB=BasekVA/BasekV;//in Ampere
ZB=BasekV*1000/IB;//in ohm
disp(ZB,"Base Impedence (in ohm) :");
```

Scilab code Exa 1.2 Per unit resistance

```
//Exa 1.2
clc;
clear;
close;
```

```
//Given data :
R=5;//in ohm
kVA_B=10;//kVA
kV_B=11;//kV
RB=kV_B^2*1000/kVA_B;//in ohm
Rpu=R/RB;//in ohm
disp(Rpu,"Per unit resistance (pu) :");
```

Scilab code Exa 1.3 Leakage Reactance per unit

```
//Exa 1.3
clc;
clear;
close;
//Given data :
kVA_B=2.5;//kVA
kV_B=0.4;//kV
reactance=0.96;//in ohm
Z_BLV=kV_B^2*1000/kVA_B;//in ohm
Zpu=reactance/Z_BLV;//in ohm
disp(Zpu,"Leakage reactance Per unit (pu) :");
```

Scilab code Exa 1.4 Per unit impedence

```
//Exa 1.4
clc;
clear;
close;
format('v',6);
//Given data :
Z=30+%i*110;//in ohm
kVA_B=100*1000;//kVA
kV_B=132;//kV
```

```
Z_BLV=kV_B^2*1000/kVA_B;//in ohm
Zpu=Z*kVA_B/kV_B^2/1000;//pu
disp(Zpu,"Leakage reactance Per unit (pu) :");
```

Scilab code Exa 1.5 Per unit Reactance

```
//Exa 1.5
clc;
clear;
close;
format('v',6);
//Given data :
oldkVA_B=30000;//kVA
oldkV_B=11;//kV
oldZpu=0.2;//pu
newkVA_B=50000;//kVA
newkV_B=33;//kV
newZpu=oldZpu*newkVA_B/oldkVA_B*(oldkV_B/newkV_B)^2;
    //pu
disp(newZpu,"New Per unit impedence(pu) :");
```

Chapter 12

Supply System

Scilab code Exa 2.1 `Saving in feeder`

```
//Exa 2.1
clc;
clear;
close;
//Given data :
VL1=220;//Volts
VL2=400;//Volts
disp("We know, W=I^2*2*R=(P/VL)^2*2*rho*l/a");
disp("a=(P/VL)^2*2*rho*l/(I^2*2*R)");
disp("v=2*(P/VL)^2*2*rho*l/(I1^2*2)*l");
saving=(2/(VL1)^2-2/(VL2)^2)/(2/(VL1)^2)*100;//%
disp(saving,"% saving in copper : ");
```

Scilab code Exa 2.2 `Compare amount of material`

```
//Exa 2.2
clc;
clear;
```

```
close;

disp("Two wire dc system : ");
disp("I1=P/V & W=2*I1^2*R1=2*P^2*rho*l/V^2/a1");
disp("Therefore, Volume required, v1 is 2*a1*l=4*P
   ^2*rho*l^2/V^2/W");
disp("Three phase four wire system : ");
disp("I2=P/3/Vas Power by each phase is P/3 & W=3*I1
   ^2*R2=P^2*rho*l/3/V^2/a2");
disp("Therefore, Volume required, v2 is 3.5*a2*l
   =3.5*P^2*rho*l^2/3/V^2/W");
v2BYv1=3.5/3/4;//
disp("For 3-phase four wire system material required
    is "+string(v2BYv1)+" times the material
   required in two wire system.");
```

Scilab code Exa 2.3 `Percentage additional load`

```
//Exa 2.3
clc;
clear;
close;

disp("For single phase ac system, P1=V*I1*cosd(fi)
   watts & W1=2*I1^2*R watts");
disp("Line losses=W1/P1*100=2*I1^2*R*100/V/I1/cosd(
   fi)");
disp("For three phase ac system, P2=sqrt(3)*V*I2*
   cosd(fi) watts & W2=3*I2^2*R watts");
disp("Line losses=W2/P2*100=3*I2^2*R*100/sqrt(3)/V/
   I2/cosd(fi)");
//on equating W1/P1*100=W2/P2*100
I2BYI1=2*sqrt(3)/3;
P1=poly(0,'P1');
//P2=sqrt(3)*V*I1*I2BYI1*cosd(fi)=2*P1
```

```
P2=2*P1;
Add_load=P2-P1;
Percent_add_load=coeff(numer(Add_load/P1*100));//%
disp(Percent_add_load,"Additional load that can be
    tranmitted by converting sigle to 3-phase line in
    %");
```

Scilab code Exa 2.4 Find extra power

```
//Exa 2.4
clc;
clear;
close;

disp("For three wire dc system, line current I1=(VS-
    VL)/R & P1=2*VL*I1=2*VL*(VS-VL)/R");
disp("For four wire three phase ac system, line
    current I2=(VS-VL)/R & P2=3*VL*I2*pf=3*VL*(VS-VL)
    /R");
//P2=3/2*2*VL*(VS-VL)/R////It implies that P2=3/2*P1
P1=poly(0,'P1');
P2=3/2*P1;
Diff=P2-P1;
Percent_Diff=coeff(numer(Diff/P1*100));//%
disp(Percent_Diff,"Extra power that can be supplied
    in %");
```

Scilab code Exa 2.5 Percentage additional load

```
//Exa 2.5
clc;
clear;
close;
```

```
pf=0.9;//power factor
disp("Three wire dc system : ");
disp("P1=2*I1*V & %P1loss=2*I1^2*R/(2*I1*V)*100=100*I1*R/V");
disp("Three phase 4-wire ac system : ");
disp("P2=3*I1^2*V*pf & %P2loss=3*I2^2*R/(3*I2*V*pf)*100=100*I12*R/pf/V");
//on equating P1loss=P2loss;
I2BYI1=100*pf/100;//ratio
//P2=3*I2*V*pf
P2BYI1V=3*pf*I2BYI1;
P2BYP1=P2BYI1V/2;
//LoadIncrease=(P2-P1)*100/P1;
LoadIncrease=(P2BYP1-1)*100;//%
disp(LoadIncrease,"% Additional load : ");
```

Scilab code Exa 2.6 Weight of copper reqiured

```
//Exa 2.6
clc;
clear;
close;
format('v',6);
//Given data :
Pin=100;//MW
VL=380;//kV
d=100;//km
R=0.045;//ohm/cm^2/km
w=0.01;//kg/cm^3
Eta=90;//efficiency %
cosfi=1;
IL=Pin*10^6/sqrt(3)/VL/10^3/cosfi;//Ampere
W=Pin*(1-Eta/100);//MW
LineLoss=W*10^6/3;//Watts/conductor
```

```
R1=LineLoss/IL^2;//in ohm
R2=R1/d;//resistance per conductor per km
a=R/R2;//in cm^2
volume=a*d*1000;//cm^3 per km run
weight=w*volume;//kg per km run
w3=3*d*weight;//kg(weight of copper required for 3
    conductors for 100 km)
disp(w3,"Weight of copper required for 3 conductors
    of 100 km length(in kg) : ");
//Answer in the book is not accurate.
```

Chapter 13

Transmission Lines

Scilab code Exa 3.1 Weight of material required

```
//Exa 3.1
clc;
clear;
close;
//Given data :
P=30*10^6;//W
pf=0.8;//lagging power factor
VL=132*1000;//V
l=120*1000;//m
Eta=90/100;//Efficiency
rho_Cu=1.78*10^-8;//ohm-m
D_Cu=8.9*10^3;//kg/m^3
rho_Al=2.6*10^-8;//ohm-m
D_Al=2*10^3;//kg/m^3
IL=P/(sqrt(3)*VL*pf);//A
//W=3*IL^2*rho*l/a=(1-Eta)*P
a_Cu=(3*IL^2*rho_Cu*l)/(1-Eta)/P;//m^2
V_Cu=3*a_Cu*l;//m^3
Wt_Cu=V_Cu*D_Cu;//kg
disp(Wt_Cu,"Weight of copper required(kg)");
a_Al=(3*IL^2*rho_Al*l)/(1-Eta)/P;//m^2
```

```
V_Al=3*a_Al*l;//m^3
Wt_Al=V_Al*D_Al;//kg
disp(Wt_Al,"Weight of Alluminium required(kg)");
//Answer in the textbook is not accurate.
```

Scilab code Exa 3.2 Most Economical Cross section Area

```
//Exa 3.2
clc;
clear;
close;
//Given data :
a=poly(0,'a');
cost=90*a+20;//Rs./m
i=10;//%(interest and depreciation)
l=2;//km
cost_E=4;//paise/unit
Im=250;//A
a=1;//cm^2
rho_c=0.173;//ohm/km/cm^2
l2=1*1000;//km
R=rho_c*l/a;//ohm
W=2*Im^2*R;//W
Eloss=W/1000*365*24/2;//per annum(kWh)
P3BYa=cost_E/100*Eloss;//Rs
Cc=90*a*l*1000;//Rs(capital cost of feeder cable)
P2a=Cc*i/100;//Rs
//P2a=P3BYa;//For most economical cross section
a=sqrt(P3BYa*a/(P2a/a));//cm^2
disp(a,"Most economical cross sectional area in cm^2
    : ");
```

Scilab code Exa 3.3 Best Current Density

```
//Exa 3.3
clc;
clear;
close;
//Given data :
t=2600;//hour
Con_Cost=3;//Rs/kg(conductor cost)
R=1.78*10^-8;//ohm-m
D=6200;//kg/m^3
E_Cost=10/100;//Rs/unit(energy cost)
i=12;//%(interest and depreciation)
a=poly(0,'a');//mm^2    ////cross sectional area
W=a*1000*D/1000/1000;//kg/km(Weight of conductor of
   1km length)
cost=Con_Cost*W;//Rs./km(cost of conductor of 1km
   length)
In_Dep=cost*i/100;//Rs(Annual interest and
   depreciation per conductor per km)
In_DepBYa=In_Dep/a;
I=poly(0,'I');//A
E_lost_aBY_Isqr=R*1000/10^-6*t/1000;//Energy lost/
   annum/km/conductor
E_lost_cost_aBY_Isqr=E_Cost*E_lost_aBY_Isqr;//Rs/
   annum
//In_Dep=E_lost_cost;//For most economical cross
   section
IBYa=sqrt(coeff(numer(In_DepBYa)/numer(
   E_lost_cost_aBY_Isqr)));//cm^2
disp(IBYa,"Best current density in A/mm^2 : ");
//Answer in the textbook is not accurate.
```

Scilab code Exa 3.4 Economical current density and diameter

```
//Exa 3.4
clc;
```

```
clear;
close;
//Given data :
V=11;//kV
P=1500;//kW
pf=0.8;//lagging power factor
t=300*8;//hours
a=poly(0,'a');//cross section area
Cc=8000+20000*a//Rs/km
R=0.173/a;//ohm/km
E_lost_cost=2/100;//Rs/unit
i=12;//%(interest and depreciation)
Cc_var=20000*a//Rs/km(variable cost)
P2a=Cc_var*i/100;//Rs/km
P2=P2a/a;
I=P/sqrt(3)/V/pf;//A
W=3*I^2*R;//W
E_loss=W/1000*t;//kWh
P3BYa=E_lost_cost*E_loss;//Rs
//P2a=P3BYa;//For most economical cross section
a=sqrt(coeff((numer(P3BYa))/coeff(numer(P2))));//cm
   ^2
d=sqrt(4*a/%pi);//cm
del=I/a;//A/cm^2
disp(d,"Diameter of conductor in cm : ");
disp(del,"Most economical current density in A/cm^2
   : ");
```

Scilab code Exa 3.5 Most economical current density

```
//Exa 3.5
clc;
clear;
close;
//Given data :
```

```
a=poly(0,'a');//cross section area
I=poly(0,'I');//Current
Cc=500+2000*a//Rs/km
i=12;//%(interest and depreciation)
E_lost_cost=5/100;//Rs/kWh
rho=1.78*10^-8;//ohm-cm
load_factor=0.12;
Cc_var=2000*a//Rs/km(variable cost)
P2a=Cc_var*i/100;//Rs/km
P2=P2a/a;
R_into_a=rho*1000/(10^-4);//ohm
W_into_a=I^2*R_into_a;//W
E_loss_into_a=W_into_a*load_factor/1000*8760;//kWh
P3BYIsqr=E_lost_cost*E_loss_into_a/I^2;//Rs
//P2a=P3BYa;//For most economical cross section
IBYa=sqrt(coeff((numer(P2))/coeff(numer(P3BYIsqr))));//cm^2
disp(IBYa,"Most economical current density in A/cm^2 : ");
```

Scilab code Exa 3.6 Most Economical current density

```
//Exa 3.6
clc;
clear;
close;
//Given data :
A=poly(0,'A');//cross section area
I=poly(0,'I');//Current
Cc=500+2000*A//Rs/km
load_factor=0.12;
i=12;//%(depreciation)
E_lost_cost=0.05;//Rs/kWh
R=0.17/A;//ohm/km

```

```
Cc_var=2000*A//Rs/km(variable cost)
P2A=Cc_var*i/100;//Rs/km
P2=P2A/A;
R_into_A=R*A;//ohm
W_into_A_BY_Isqr=R_into_A;//W
E_loss_into_A_BY_Isqr=W_into_A_BY_Isqr*load_factor
   /1000*8760;//kWh
P3BYIsqr=E_lost_cost*E_loss_into_A_BY_Isqr;//Rs
//P2a=P3BYa;//For most economical cross section
IBYa=sqrt(coeff((numer(P2))/coeff(numer(P3BYIsqr))))
   ;//cm^2
disp(IBYa,"Most economical current density in A/cm^2
    : ");
//Answer in the textbook is wrong.
```

Scilab code Exa 3.7 Most economical size

```
//Exa 3.7
clc;
clear;
close;
//Given data :
P1=1000;//kW
pf1=0.8;//
t1=10;//hours
P2=500;//kW
pf2=0.9;//
t2=8;//hours
P3=100;//kW
pf3=1;//
t3=6;//hours
a=poly(0,'a');//cross section area
I=poly(0,'I');//Current
L=poly(0,'L');//length in km
CcBYL=(8000*a+1500)//Rs/km(variable cost)
```

```
i=10;//%(depreciation)
E_lost_cost=80/100;//Rs/kWh
rho=1.72*10^-6;//ohm-cm
Cc_varBYL=8000*a*i/100//Rs/km(variable cost)
I1=P1*1000/sqrt(3)/10000/pf1;//A
I2=P2*1000/sqrt(3)/10000/pf2;//A
I3=P3*1000/sqrt(3)/10000/pf3;//A
R_into_a_BY_L=rho*1000*100;//ohm
W_into_A_BY_Isqr=R_into_a_BY_L;//W
E_loss_into_A_BY_L=3*R_into_a_BY_L*[I1^2*t1+I2^2*t2+I3^2*t3]*365/1000;//kWh
E_loss_cost_into_A_BY_L=E_loss_into_A_BY_L*E_lost_cost;//Rs
//Cc_var=E_loss_cost;//For most economical cross section
a=sqrt(coeff((numer(E_loss_cost_into_A_BY_L))/coeff(numer(Cc_varBYL/a))));//cm^2
disp(a,"Most economical cross sectional area in cm^2 : ");
```

Chapter 14

Inductance and Capacitance of Transmission Lines

Scilab code Exa 4.1 Loop inductance and reactance

```
//Exa 4.1
clc;
clear;
close;
//Given data :
f=50;//Hz
d=1*100;//cm
r=1.25/2;//cm
r_dash=r*0.7788;//cm
L=0.4*log(d/r_dash);//mH
disp(L,"Loop inductance per km(mH)");
XL=2*%pi*f*L*10^-3;//ohm/Km
disp(XL,"Reactance of transmission line(ohm/km)");
```

Scilab code Exa 4.2 Calculate Inductance

```
//Exa 4.2
clc;
clear;
close;
//Given data :
f=50;//Hz
a=10;//cm^2
l=500/1000;//km
r=sqrt(a/%pi);//cm
d=5*100;//cm
r_dash=r*0.7788;//cm
L=0.4*log(d/r_dash)*l;//mH
disp(L,"Loop inductance per km(mH)");
```

Scilab code Exa 4.3 Calculate Loop inductance

```
//Exa 4.3
clc;
clear;
close;
//Given data :
r=1/2;//cm
d=1*100;//cm
mu=50;//relative permeability
r_dash=r*0.7788;//cm
L_cu=.1+0.4*log(d/r);//mH
disp(L_cu,"Loop inductance per km of copper
   conductor line(mH)");
L_steel=(mu+4*log(d/r))*10^-7*10^3;//mH
disp(L_steel*10^3,"Loop inductance per km of copper
   conductor line(mH)");
```

Scilab code Exa 4.4 Calculate GMR

```
//Exa 4.4
clc;
clear;
close;
//Given data :
r=3;//mm
d11=r;//mm
d12=2*r;//mm
d34=2*r;//mm
d16=2*r;//mm
d17=2*r;//mm
d14=4*r;//mm
d13=sqrt(d14^2-d34^2);//mm
d15=d13;//mm
Ds1=(0.7788*d11*d12*d13*d14*d15*d16*d17)^(1/7);//mm
Ds2=Ds1;//mm
Ds3=Ds1;//mm
Ds4=Ds1;//mm
Ds5=Ds1;//mm
Ds6=Ds1;//mm
Ds7=(2*r*0.7788*d11*d12*d13*2*r*2*r)^(1/7);//mm
Ds=(Ds1*Ds2*Ds3*Ds4*Ds5*Ds6*Ds7)^(1/7);//mm
disp(Ds,"Geometric mean radius(mm)");
//Answer in the book is wrong
```

Scilab code Exa 4.5 Determine total inductance

```
//Exa 4.5
clc;
clear;
close;
//Given data :
r=1.2;//cm
rdash=0.7788*r;//cm
d12=0.12*100;//cm
```

```
d11dash=(0.2+1.2)*100; //cm
d22dash=(0.2+1.2)*100; //cm
d12dash=(0.2+1.2+0.2)*100; //cm
d21dash=(1.2)*100; //cm
Dm=(d11dash*d12dash*d21dash*d22dash)^(1/4); //cm
d11=0.93456; //cm
d22=0.93456; //cm
d12=20; //cm
d21=20; //cm
Ds=(d11*d12*d21*d22)^(1/4); //cm
L=0.4*log(Dm/Ds); //mH/km
disp(L,"Loop inductance of line(mH/km)");
```

Scilab code Exa 4.6 Determine total inductance

```
//Exa 4.6
clc;
clear;
close;
//Given data :
r=2/2; //cm
rdash=0.7788*r; //cm
d12=0.12*100; //cm
d11dash=300; //cm
d12dash=sqrt(300^2+100^2); //cm
d21dash=d12dash; //cm
d22dash=d11dash; //cm
d11=rdash; //cm
d22=rdash; //cm
d12=100; //cm
d21=100; //cm
Dm=(d11dash*d12dash*d21dash*d22dash)^(1/4); //cm
Ds=(d11*d12*d21*d22)^(1/4); //cm
L=0.4*log(Dm/Ds); //mH/km
disp(L,"Loop inductance of line(mH/km)");
```

Scilab code Exa 4.7 Inductance per km

```
//Exa 4.7
clc;
clear;
close;
//Given data :
r=1.24/2;//cm
rdash=0.7788*r;//cm
d=2*100;//cm
L=0.2*log(d/rdash);//mH
disp(L,"Inductance per phase per km(mH)");
```

Scilab code Exa 4.8 Inductance per km

```
//Exa 4.8
clc;
clear;
close;
//Given data :
r=(20/2)/10;//cm
d1=4*100;//cm
d2=5*100;//cm
d3=6*100;//cm
rdash=0.7788*r;//cm
L=0.2*log((d1*d2*d3)^(1/3)/rdash);//mH
disp(L,"Inductance per phase(mH)");
```

Scilab code Exa 4.9 Inductance per km

```
//Exa 4.9
clc;
clear;
close;
//Given data :
r=4/2;//cm
rdash=0.7788*r;//cm
d=300;//cm
d3=6*100;//cm
LA=0.2*[log(d/rdash)+1/2*log(2)-%i*0.866*log(2)];//mH
disp(LA,"Inductance per km of phase1(mH)");
LB=0.2*log(d/rdash);//mH
disp(LB,"Inductance per km of phase2(mH)");
LC=0.2*[log(d/rdash)+1/2*log(2)+%i*0.866*log(2)];//mH
disp(LC,"Inductance per km of phase3(mH)");
```

Scilab code Exa 4.10 Spacing between adjacent conductors

```
//Exa 4.10
clc;
clear;
close;
//Given data :
r=1.2/2*10;//mm
rdash=0.7788*r;//mm
d=3.5*1000;//mm
L=2*10^-7*log(d/rdash);//H/m
Lav=1/3*(L+L+L);//H/m
d=rdash*exp(Lav/(2*10^-7)-1/3*log(2));//mm
disp(d/1000,"Spacing between adjacent conductors(m)");
```

Scilab code Exa 4.11 Inductance per phase per km

```
//Exa 4.11
clc;
clear;
close;
//Given data :
r=20;//mm
rdash=0.7788*r;//mm
d=7*1000;//mm
L=10^-7*log(sqrt(3)/2*d/rdash);//H/m
disp(L*10^3/10^-3,"Spacing between adjacent
    conductors(mH)");
```

Scilab code Exa 4.12 Inductance per phase per km

```
//Exa 4.12
clc;
clear;
close;
//Given data :
r=0.9;//cm
rdash=0.7788*r*10^-2;//m
daa_dash=sqrt(6^2+6^2);//m
dbb_dash=7;//m
dcc_dash=daa_dash;//m
daa=rdash;//m
d_adash_adash=rdash;//m
d_adash_a=daa_dash;//m
Dsa=(daa*daa_dash*d_adash_adash*d_adash_a)^(1/4);//m
Dsb=(daa*7)^(1/2);//m
Dsc=(daa*daa_dash)^(1/2);//m
```

```
Ds=(Dsa*Dsb*Dsc)^(1/3);//m
dab=sqrt(3^2+0.5^2);//m
dab_dash=sqrt(3^2+6.5^2);//m
d_adash_b=sqrt(3^2+6.5^2);//m
d_adash_bdash=sqrt(3^2+0.5^2);//m
Dab=(dab*dab_dash*d_adash_b*d_adash_bdash)^(1/4);//m
Dbc=((dab*dab_dash)^2)^(1/4);//m
Dca=((6*6)^2)^(1/4);//m
Dm=(Dab*Dbc*Dca)^(1/3);//m
L=0.2*log(Dm/Ds);//mH/km
disp(L,"Inductance per phase(mH/km)");
```

Scilab code Exa 4.13 GMD GMR and Overall Inductance

```
//Exa 4.13
clc;
clear;
close;
format('v',5)
//Given data :
r=5/2;//mm
rdash=2.176*r*10^-3;//m
daa_dash=sqrt(6^2+16^2);//m
dbb_dash=6;//m
dcc_dash=daa_dash;//m
dab=8;//m
dab_dash=sqrt(6^2+8^2);//m
dbc=8;//m
dbc_dash=sqrt(6^2+8^2);//m
dca=16;//m
dca_dash=6;//m
Dsa=sqrt(rdash*daa_dash);//m
Dsb=sqrt(rdash*dbb_dash);//m
Dsc=sqrt(rdash*dcc_dash);//m
Ds=(Dsa*Dsb*Dsc)^(1/3);//m
```

```
disp(Ds,"GMD(m) : ");
Dab=(dab*dab_dash)^(1/2);//m
Dbc=(dbc*dbc_dash)^(1/2);//m
Dca=(dca*dca_dash)^(1/2);//m
Dm=(Dab*Dbc*Dca)^(1/3);//m
disp(Dm,"Deq or Dm(m) : ");
L=0.2*log(Dm/Ds);//mH/km
L=L*10^-3*100;//H(for 100 km line)
disp(L,"Inductance of 100 km line(H)");
///Alternate method is given below
d1=dab;//m
d2=dca_dash;//m
L=0.2*log(2^(1/6))*sqrt(d1/rdash)*((d1^2+d2^2)/(4*d1^2+d2^2))^(1/6);//mH
L=L*10^-3*100;//H(for 100 km line)
disp(L,"Using Alternate method, Inductance of 100 km line(H)");
```

Scilab code Exa 4.14 Inductance per km

```
//Exa 4.14
clc;
clear;
close;
//Given data :
r=5/2;//cm
rdash=0.7788*r*10^-2;//m
d=6.5;//m
s=0.4;//m
Ds=sqrt(rdash*s);//m
dab=6.5;//m
dab_dash=6.9;//m
d_adash_b=6.1;//m
d_adash_bdash=6.5;//m
Dab=(dab*dab_dash*d_adash_b*d_adash_bdash)^(1/4);//m
```

```
Dbc=Dab;//m
dca=13;//m
dca_dash=12.6;//m
d_cdash_a=13.4;//m
d_cdash_adash=13;//m
Dca=(dca*dca_dash*d_cdash_a*d_cdash_adash)^(1/4);//m
Dm=(Dab*Dbc*Dca)^(1/3);//m
L=0.2*log(Dm/Ds);//mH/km
disp(L,"Inductance per phase(mH/km)");
```

Scilab code Exa 4.15 Find inductive reactance

```
//Exa 4.15
clc;
clear;
close;
//Given data :
f=50;//Hz
r=3.5/2;//cm
rdash=0.7788*r*10^-2;//m
d=7;//m
s=40/100;//m
Ds=sqrt(rdash*s);//m
dab=7;//m
dab_dash=7.4;//m
d_adash_b=6.6;//m
d_adash_bdash=7;//m
Dab=(dab*dab_dash*d_adash_b*d_adash_bdash)^(1/4);//m
Dbc=Dab;//m
dca=14;//m
dca_dash=13.6;//m
d_cdash_a=14.4;//m
d_cdash_adash=14;//m
Dca=(dca*dca_dash*d_cdash_a*d_cdash_adash)^(1/4);//m
Dm=(Dab*Dbc*Dca)^(1/3);//m
```

```
L=0.2*log(Dm/Ds);//mH/km
XL=2*%pi*f*L*10^-3;//ohm/km
disp(XL,"Inductive reactance of bundled conductor
   line(ohm/km)");
//Equivalent single conductor
n=2;
r1=sqrt(n*%pi*r^2/%pi);//m
r1dash=0.7788*r1*10^-2;//m
Dm1=(Dab*Dbc*Dca)^(1/3);//m
L1=0.2*log(Dm1/r1dash);//mH/km
XL1=2*%pi*f*L1*10^-3;//ohm/km
disp(XL1,"Inductive reactance with single conductor(
   ohm/km)");
```

Scilab code Exa 4.16 Find out Capacitance

```
//Exa 4.16
clc;
clear;
close;
//Given data :
r=15/2;//mm
d=1.5*1000;//mm
l=30;//km
epsilon_o=8.854*10^-12;//permitivity
C=%pi*epsilon_o/log(d/r)*l*1000;//F
disp(C*10^6,"Capacitance of line(micro F)");
```

Scilab code Exa 4.17 Calculate Capacitance

```
//Exa 4.17
clc;
clear;
```

```
close;
//Given data :
r=2/2; //cm
d=2.5*100; //cm
l=100; //km
epsilon_o=8.854*10^-12; //permitivity
C=2*%pi*epsilon_o/log(d/r)*l*1000; //F
disp(C*10^6,"Capacitance of line(micro F)");
```

Scilab code Exa 4.18 Capacitance per conductor per km

```
//Exa 4.18
clc;
clear;
close;
//Given data :
r=2/2/100; //m
d1=3.5; //m
d2=5; //m
d3=8; //m
epsilon_o=8.854*10^-12; //permitivity
CN=2*%pi*epsilon_o*1000/log((d1*d2*d3)^(1/3)/r); //F
disp(CN*10^6,"Capacitance of line(micro F)");
```

Scilab code Exa 4.19 Capacitance and Charging current

```
//Exa 4.19
clc;
clear;
close;
//Given data :
f=50; //Hz
VL=220; //KV
```

```
r=20/2/1000; //m
d1=3; //m
d2=3; //m
d3=6; //m
epsilon_o=8.854*10^-12; //permitivity
CN=2*%pi*epsilon_o/log((d1*d2*d3)^(1/3)/r); //F
disp(CN,"Capacitance per phase per meter  line(F)");
Vph=VL*1000/sqrt(3); //V
Ic=2*%pi*f*CN*Vph; //A
disp(Ic*1000,"Charging current per phase(mA) : ");
```

Scilab code Exa 4.20 Capacitance to neutral and charging per km

```
//Exa 4.20
clc;
clear;
close;
//Given data :
f=50; //Hz
VL=110; //kV
r=1.05/2; //cm
d1=3.5; //m
d2=3.5; //m
d3=7; //m
epsilon_o=8.854*10^-12; //permitivity
CN=2*%pi*epsilon_o/log((d1*d2*d3)^(1/3)*100/r); //F
disp(CN,"Capacitance per phase per meter  line(F)");
Vph=VL*1000/sqrt(3); //V
Ic=2*%pi*f*CN*Vph; //A/m
disp(Ic/10^-3,"Charging current per phase(A/km) : ")
   ;
```

Scilab code Exa 4.21 Capacitance to neutral and charging current

```
//Exa 4.21
clc;
clear;
close;
//Given data :
r=2.5/2*10^-2;//m
VL=132;//KV
epsilon_o=8.85*10^-12;//permitivity
f=50;//Hz
dRRdash=sqrt(7^2+(4+4)^2);//m
dBBdash=dRRdash;//m
dYYdash=9;//m
DSR=sqrt(r*dRRdash);//m
DSY=sqrt(r*dYYdash);//m
DSB=sqrt(r*dBBdash);//m
Ds=(DSR*DSB*DSY)^(1/3);//m
dRY=sqrt(4^2+(4.5-3.5)^2);//m
dRYdash=sqrt((9-1)^2+4^2);//m
dRdashY=sqrt((9-1)^2+4^2);//m
dRdashYdash=sqrt(4^2+(4.5-3.5)^2);//m
DRY=(dRY*dRYdash*dRdashY*dRdashYdash)^(1/4);//m
DYB=((dRY*dRYdash)^2)^(1/4);//m
DBR=((8*7)^2)^(1/4);//m
Dm=(DRY*DYB*DBR)^(1/3);//m
C=2*%pi*epsilon_o/log(Dm/Ds);//F/m
C=C/10^-3;//F/km
X=1/(2*%pi*f*C);//ohm
disp(X/1000,"Capacitive reactance too neutral(kohm)
    : ");
Vph=VL*1000/sqrt(3);//Volt
Ic=2*%pi*f*C*Vph;//A
disp(Ic,"Charging current(A/km)");
```

Scilab code Exa 4.22 Capacitance per phase

```
//Exa 4.22
clc;
clear;
close;
//Given data :
d1=8;//m
d2=6;//m
epsilon_o=8.854*10^-12;//permitivity
r=3*5/2*10^-3;//m
C=4*%pi*epsilon_o/log(2^(1/3)*d1/r*((d1^2+d2^2)/(4*
   d1^2+d2^2)^(1/3)));//F/m
C100=C*100*1000*10^6;//microF
disp(C100,"Capacitance of 100 km line(micro Farad) :
    ");
//answer in the textbook is wrong.
```

Scilab code Exa 4.23 Capacitance and charging current

```
//Exa 4.23
clc;
clear;
close;
//Given data :
VL=132;//kV
f=50;//Hz
r=5/2;//cm
rdash=0.7788*r*10^-2;//m
d=6.5;//m
s=0.4;//m
epsilon_o=8.854*10^-12;//permitivity
Ds=sqrt(rdash*s);//m
dab=6.5;//m
dab_dash=6.9;//m
d_adash_b=6.1;//m
d_adash_bdash=6.5;//m
```

```
Dab=(dab*dab_dash*d_adash_b*d_adash_bdash)^(1/4);//m
Dbc=Dab;//m
dca=13;//m
dca_dash=12.6;//m
d_cdash_a=13.4;//m
d_cdash_adash=13;//m
Dca=(dca*dca_dash*d_cdash_a*d_cdash_adash)^(1/4);//m
Dm=(Dab*Dbc*Dca)^(1/3);//m
L=0.2*log(Dm/Ds);//mH/km
C=2*%pi*epsilon_o/log(Dm/Ds);//F/m
C=C/10^-3;//F/km
disp(C,"Capacitance per km(F/km) : ");
Vph=VL*1000/sqrt(3);//Volt
Ic=2*%pi*f*C*Vph;//A/km
disp(Ic,"Charging current per km(A/km) : ");
```

Scilab code Exa 4.24 Inductive and Capacitive reactances

```
//Exa 4.24
clc;
clear;
close;
//Given data :
VL=132;//kV
f=50;//Hz
r=31.8/2;//mm
rdash=0.7788*r;//mm
d=10*1000;//mm
epsilon_o=8.854*10^-12;//permitivity
disp("One conductor ACSR moose conductor line : ");
LA=0.2*[log(d/rdash)+1/2*log(2)-%i*0.866*log(2)];//
   mH/km
LB=0.2*log(d/rdash);//mH/km
LC=0.2*[log(d/rdash)+1/2*log(2)+%i*0.866*log(2)];//
   mH/km
```

```
Lav=(LA+LB+LC)/3;//mH/km
XL=2*%pi*f*Lav*10^-3;//ohm
disp(XL,"Inductive reactance per Km per phase(ohm) : ");
d1=10;//m
d2=10;//m
d3=20;//m
CN=2*%pi*epsilon_o/log((d1*d2*d3)^(1/3)/(rdash*10^-3))/10^3;//F/km
XC=1/(2*%pi*f*CN*10^6);//ohm
disp(XC/10^6,"Capacitivetive reactance per Km per phase(Mohm) : ");
disp("Three conductor bundled line : ");
S=40/100;//m
Ds=(rdash*10^-3*S^2)^(1/3);//m
Deq=(d1*d2*d3)^(1/3);//m
Ldash=0.2*log(Deq/Ds);//mH/km
XLdash=2*%pi*f*Ldash*10^-3;//ohm
disp(XLdash,"Inductive reactance per km per phase(ohm) : ");
Ds=(r*10^-3*S^2)^(1/3);//m
Cdash=2*%pi*epsilon_o*10^3/log(Deq/Ds);//microF/km
XC=1/(2*%pi*f*Cdash)/10^6;//Mohm
disp(XC,"Capacitivetive reactance per km per phase(Mohm) : ");
```

Scilab code Exa 4.25 Capacitance per km

```
//Exa 4.25
clc;
clear;
close;
//Given data :
r=1.5/2;//cm
d=3*100;//cm
```

```
h=6*100;//cm
epsilon_o=8.854*10^-12;//permitivity
C=%pi*epsilon_o/log(d/(1+d^2/4/h^2)^r)*10^3;//F
disp(C,"Capacitance per km of line(F) : ");
```

Scilab code Exa 4.26 Determine the capacitance

```
//Exa 4.26
clc;
clear;
close;
//Given data :
r=2/100;//m
d1=4;//m
d2=4;//m
d3=8;//m
epsilon_o=8.854*10^-12;//permitivity
CN=2*%pi*epsilon_o/log((d1*d2*d3)^(1/3)/r);//F
disp(CN,"Part(i) Capacitance per phase per meter length(F) : ");
h1=20;//m
h2=20;//m
h3=20;//m
h12=sqrt(20^2+4^2);//m
h23=sqrt(20^2+4^2);//m
h31=sqrt(20^2+8^2);//m
Deq=(d1*d2*d3)^(1/3);//m
CN=2*%pi*epsilon_o/(log(Deq/r)-log((h12*h23*h31/h1/h2/h3)^(1/3)) );//F
disp(CN,"Part(ii) Capacitance per phase per meter length(F) : ");
```

Chapter 15

Representation and Performance of short and medium Transmission Lines

Scilab code Exa 5.1 Voltage Regulation and Efficiency

```
//Exa 5.1
clc;
clear;
close;
//Given data :
P=1100;//kW
VR=11*1000;//V
pf=0.8;//power factor
R=2;//ohm
X=3;//ohm
I=P*1000/VR/pf;//A
cos_fi_r=pf;
sin_fi_r=sqrt(1-cos_fi_r^2);
VS=sqrt((VR*cos_fi_r+I*R)^2+(VR*sin_fi_r+I*X)^2);//V
disp(VS,"Voltage at sending end(V)");
Reg=(VS-VR)/VR*100;//%
disp(Reg,"% Regulation");
```

```
LineLoss=I^2*R/1000;//kW
Eta_T=P*100/(P+LineLoss);//%
disp(Eta_T,"Transmission Efficiency(%)");
```

Scilab code Exa 5.2 Voltage Regulation and Efficiency

```
//Exa 5.2
clc;
clear;
close;
//Given data :
R=0.4;//ohm
X=0.4;//ohm
P=2000;//kVA
pf=0.8;//power factor
VL=3000;//V
VR=VL/sqrt(3);//V
cos_fi_r=pf;
sin_fi_r=sqrt(1-cos_fi_r^2);
I=P*1000/3/VR;//A
VS=VR+I*(R*cos_fi_r+X*sin_fi_r);//V
Reg=(VS-VR)/VR*100;//%
disp(Reg,"% Regulation");
LineLoss=3*I^2*R/1000;//kW
Pout=P*cos_fi_r;//kW
Eta_T=Pout*100/(Pout+LineLoss);//%
disp(Eta_T,"Transmission Efficiency(%)");
```

Scilab code Exa 5.3 Sending end Voltage and Regulation

```
//Exa 5.3
clc;
clear;
```

```
close;
//Given data :
l=15;//km
P=5;//MW
V=11;//kV
f=50;//Hz
pf=0.8;//power factor
cos_fi_r=pf;
sin_fi_r=sqrt(1-cos_fi_r^2);
L=1.1;//mH/Km
VR=V*1000/sqrt(3);//V
I=P*1000/sqrt(3)/V/cos_fi_r;//A
LineLoss=12/100*P*10^6;//W
R=LineLoss/3/I^2;//ohm
X=2*%pi*f*L*10^-3*l;//ohm/phase
VS=VR+I*(R*cos_fi_r+X*sin_fi_r);//V
VSL=sqrt(3)*VS/1000;//KV
disp(VSL,"Line voltage at sending end(kV)");
Reg=(VSL-V)/V*100;//%
disp(Reg,"% Regulation");
```

Scilab code Exa 5.4 Voltage PF Efficiency and Regulation

```
//Exa 5.4
clc;
clear;
close;
//Given data :
l=50;//km
S=10000;//kVA
pf=0.8;//power factor
d=1.2*100;//cm
cos_fi_r=pf;
sin_fi_r=sqrt(1-cos_fi_r^2);
V=33000;//Volts
```

```
VR=V/sqrt(3);//V
f=50;//Hz
I=S*1000/sqrt(3)/V;//A
LineLoss=10/100*S*10^3*pf;//W
R=LineLoss/3/I^2;//ohm
rho=1.73*10^-6;//kg/m^3
a=rho*l*1000*100/R;//cm^2
r=sqrt(a/%pi);//cm
L=0.2*log(d/r/0.7788)*l;//mH
X=2*%pi*f*L*10^-3;//ohm
VS=VR+I*(R*cos_fi_r+X*sin_fi_r);//V
VSL=sqrt(3)*VS/1000;//kV
disp(VSL,"Line voltage at sending end(kV)");
pf_s=(VR*cos_fi_r+I*R)/VS;//lagging(sendinf end pf)
disp(pf_s,"Sending end pf(lagging) ");
Eta_T=S*pf/(S*pf+LineLoss/1000)*100;
disp(Eta_T,"Transmission Efficiency(%)");
Reg=(VSL-V/1000)/(V/1000)*100;//%
disp(Reg,"% Regulation");
```

Scilab code Exa 5.5 Resistance and Inductance of line

```
//Exa 5.5
clc;
clear;
close;
//Given data :
VRL=30000;//Volts
VSL=33000;//Volts
f=50;//Hz
P=10*10^6;//W
pf=0.8;//power factor
cos_fi_r=pf;
sin_fi_r=sqrt(1-cos_fi_r^2);
VR=VRL/sqrt(3);//V
```

```
I=P/sqrt(3)/VRL/pf;//A
Eta_T=0.96;//Efficiency
LineLoss=P*(1/Eta_T-1);//W
R=LineLoss/3/I^2;//ohm/phase
disp(R,"Resistance per phase(ohm/phase)");
VS=VSL/sqrt(3);//V
X=(VS-VR-I*R*cos_fi_r)/I/sin_fi_r;//V
L=X/2/%pi/f;//H/phase
disp(L*1000,"Inductance per phase(mH/phase)");
```

Scilab code Exa 5.6 `Voltage and Efficiency of Transmission`

```
//Exa 5.6
clc;
clear;
close;
//Given data :
l=3;//km
P=3000;//KW
VSL=11*10^3;//volt
R=l*0.4;//ohm
X=l*0.8;//ohm
VS=VSL/sqrt(3);//Volts
pf=0.8;//power factor
cos_fi_r=pf;
sin_fi_r=sqrt(1-cos_fi_r^2);
//VS=VR+I*(R*cos_fi_r+X*sin_fi_r);//V
I_into_VR=P*1000/3/cos_fi_r;//VA
//VR^2-VS*VR+I_into_VR*(R*cos_fi_r+X*sin_fi_r);
p=[1 -VS I_into_VR*(R*cos_fi_r+X*sin_fi_r)];
VR=roots(p);
VR=VR(1);//taking greater value
I=I_into_VR/VR;//A
VRL=sqrt(3)*VR;//volt
disp(VRL,"Line voltage at load end(volt) : ");
```

```
Eta_T=P*1000/(P*1000+3*I^2*R)*100;//%
disp(Eta_T,"Transmission Efficiency(%) : ");
```

Scilab code Exa 5.7 `Power output and Power factor`

```
//Exa 5.7
clc;
clear;
close;
//Given data :
R=5;//ohm/phase
X=20;//ohm/phase
VSL=46.85;//kV
VRL=33;//kV
VRL=VRL*1000;//v
pf=0.8;//power factor
cos_fi_r=pf;
sin_fi_r=sqrt(1-cos_fi_r^2);
VR=VRL/sqrt(3);//V
I=(VSL*1000/sqrt(3)-VR)/(R*cos_fi_r+X*sin_fi_r);//A
Pout=sqrt(3)*VRL*I*pf/1000;//kW
disp(Pout,"Power output(kW)");
cosfi_s=(VR*pf+I*R)/(VSL*1000/sqrt(3));//power
    factor
disp(cosfi_s,"Power factor at sending end(lagging)")
    ;
```

Scilab code Exa 5.8 `Current Voltage Regulation Efficiency`

```
//Exa 5.8
clc;
clear;
close;
```

```
//Given data :
l=80;//km
P=15;//MW
VR=66*10^3;//Volt
R=l*0.3125;//ohm
X=l*1;//ohm
Y=l*17.5*10^-6;//S
pf=0.8;//power factor
cos_fi_r=pf;
sin_fi_r=sqrt(1-cos_fi_r^2);
IR=P*10^6/(VR*pf);//A
IR=IR*(cos_fi_r-%i*sin_fi_r);//A
IC=%i*Y*VR;//A
IS=IR+IC;//A
disp("Sending end current(A), magnitude is "+string(abs(IS))+" and angle in degree is "+string(atand(imag(IS),real(IS))));
VS=VR+IS*(R+%i*X);//volt
disp("Sending end voltage(V), magnitude is "+string(abs(VS))+" and angle in degree is "+string(atand(imag(VS),real(VS))));
fi_s=atand(imag(VS),real(VS))-atand(imag(IS),real(IS));//
cos_fis=cosd(fi_s);//sending end pf
disp(cos_fis,"Sending end power factor(lag) : ");
Reg=(abs(VS)-VR)/VR*100;//%
disp(Reg,"Regulation(%) :  ");
LineLoss=abs(IS)^2*R/1000;//kW
disp(LineLoss,"Line Losses in kW : ");
Eta_T=P*1000/(P*1000+LineLoss)*100;//%
disp(Eta_T,"Transmission Efficiency(%) : ");
```

Scilab code Exa 5.9 Voltage Efficiency Regulation

```
//Exa 5.9
```

```
clc;
clear;
close;
//Given data :
l=100;//km
P=20;//MW
VRL=66*10^3;//volt
f=50;//Hz
R=10;//ohm
L=111.7*10^-3;//H
C=0.9954*10^-6;//F
pf=0.8;//power factor
X=2*%pi*f*L;//ohm
Y=2*%pi*f*C;//S
cos_fi_r=pf;
sin_fi_r=sqrt(1-cos_fi_r^2);
VR=VRL/sqrt(3);//volt
IR=P*10^6/(sqrt(3)*VRL*pf);//A
IR=IR*(cos_fi_r-%i*sin_fi_r);//A
Z=R+%i*X;//ohm
Vdash=VR+1/2*IR*Z;//Volt
IC=Vdash*%i*Y;//A
IS=IR+IC;//A
VS=Vdash+1/2*IS*Z;//Volt
VSL=abs(VS)*sqrt(3);//Volt
disp(VSL,"Sending end line voltage(Volt) :");
Reg=(VSL-VRL)/VRL*100;//%
disp(Reg,"Regulation(%) :  ");
fi_s=atand(imag(VS),real(VS))-atand(imag(IS),real(IS
   ));//
cos_fi_s=cosd(fi_s);//sending end pf
Eta_T=sqrt(3)*VRL*abs(IR)*cos_fi_r/(sqrt(3)*VSL*abs(
   IS)*cos_fi_s)*100;//%
disp(Eta_T,"Transmission Efficiency(%) : ");
//Ans is not accurate in the book.
```

Scilab code Exa 5.10 Voltage Regulation Current Efficiency

```
//Exa 5.10
clc;
clear;
close;
//Given data :
l=200;//km
P=50;//MVA
VRL=132*10^3;//Volt
f=50;//Hz
R=l*0.15;//ohm
X=l*0.50;//ohm
Y=l*2*10^-6;//mho
pf=0.85;//power factor
cos_fi_r=pf;
sin_fi_r=sqrt(1-cos_fi_r^2);
VR=VRL/sqrt(3);//Volt
IR=P*10^6/(sqrt(3)*VRL);//A
Z=R+%i*X;//ohm
IR=IR*(cos_fi_r-%i*sin_fi_r);//A
Vdash=VR+1/2*IR*Z;//Volt
IC=Vdash*%i*Y;//A
IS=IR+IC;//A
disp("Sending end current(A), magnitude is "+string(
    abs(IS))+" and angle in degree is "+string(atand(
    imag(IS),real(IS))));
VS=Vdash+1/2*IS*Z;//Volt
VSL=abs(VS)*sqrt(3);//Volt
disp(VSL/1000,"Sending end line voltage(kV) :");
Reg=(VSL-VRL)/VRL*100;//%
disp(Reg,"Regulation(%) : ");
fi_s=atand(imag(VS),real(VS))-atand(imag(IS),real(IS
    ));//
```

```
cos_fi_s=cosd(fi_s);//sending end pf
Eta_T=sqrt(3)*VRL*abs(IR)*cos_fi_r/(sqrt(3)*VSL*abs(
   IS)*cos_fi_s)*100;//%
disp(Eta_T,"Transmission Efficiency(%) : ");
//Ans is wrong in the book.Angle of VS is calculated
    wrong leads to wrong answers.
```

Scilab code Exa 5.11 `Voltage Current PF`

```
//Exa 5.11
clc;
clear;
close;
//Given data :
S=1*10^3;//kVA
pf=0.71;//power factor
VRL=22*10^3;//Volt
f=50;//Hz
R=15;//ohm
L=0.2;//H
C=0.5*10^-6;//F
cos_fi_r=pf;
sin_fi_r=sqrt(1-cos_fi_r^2);
IR=S*10^3/VRL;//A
IR=IR*(cos_fi_r-%i*sin_fi_r);//A
X=2*%pi*f*L;//ohm
//Z=sqrt(R^2+X^2);//ohm
Z=R+%i*X;//ohm
Y=2*%pi*f*C;//S
ICR=1/2*%i*Y*VRL;//A
IL=IR+ICR;//A
VS=VRL+IL*Z;//Volt
disp("Sending end voltage(Volt), magnitude is "+
   string(abs(VS))+" and angle in degree is "+string
   (atand(imag(VS),real(VS))));
```

```
ICS=1/2*%i*Y*VS;//A
IS=IL+ICS;//A
disp("Sending end current(A), magnitude is "+string(
   abs(IS))+" and angle in degree is "+string(atand(
   imag(IS),real(IS))));
fi_s=atand(imag(VS),real(VS))-atand(imag(IS),real(IS
   ));//
cos_fi_s=cosd(fi_s);//sending end pf
disp(cos_fi_s,"Sending end power factor(lag) : ");
```

Scilab code Exa 5.12 Sending End Voltage

```
//Exa 5.12
clc;
clear;
close;
//Given data :
P=50*10^6;//W
f=50;//Hz
l=150;//km
pf=0.8;//power factor
VRL=110*10^3;//Volt
VR=VRL/sqrt(3);//Volt
cos_fi_r=pf;
sin_fi_r=sqrt(1-cos_fi_r^2);
R=0.1*l;//ohm
XL=0.5*l;//ohm
Z=R+%i*XL;//ohm
IR=P/(sqrt(3)*VRL*pf);//A
IR=IR*(cos_fi_r-%i*sin_fi_r);//A
Y=3*10^-6*l;//S
ICR=1/2*%i*Y*VR;//A
IL=IR+ICR;//A
VS=VR+IL*Z;//Volt
VSL=sqrt(3)*abs(VS);//Volt
```

```
disp(VSL/1000,"Sending end line to line voltage(kV)
  :");
```

Scilab code Exa 5.13 Voltage Current and PF

```
//Exa 5.13
clc;
clear;
close;
//Given data :
f=50;//Hz
l=30;//km
Z=40+%i*125;//ohm
Y=10^-3;//mho
P=50*10^6;//W
VRL=220*10^3;//Volt
VR=VRL/sqrt(3);//Volt
pf=0.8;//power factor
cos_fi_r=pf;
sin_fi_r=sqrt(1-cos_fi_r^2);
IR=P/(sqrt(3)*VRL*pf);//A
IR=IR*(cos_fi_r-%i*sin_fi_r);//A
ICR=1/2*%i*Y*VR;//A
IL=IR+ICR;//A
VS=VR+IL*Z;//Volt
VSL=sqrt(3)*abs(VS);//Volt
disp(VSL/1000,"Sending end line to line voltage(kV)
  :");
IS=IL+1/2*%i*Y*VS;//A
disp("Sending end current(A), magnitude is "+string(
  abs(IS))+" and angle in degree is "+string(atand(
  imag(IS),real(IS))));
fi_s=atand(imag(VS),real(VS))-atand(imag(IS),real(IS
  ));//
cos_fis=cosd(fi_s);//sending end pf
```

```
disp(cos_fis,"Sending end power factor(lag) : ");
```

Scilab code Exa 5.14 Sending End Voltage

```
//Exa 5.14
clc;
clear;
close;
//Given data :
f=50;//Hz
l=30;//km
Z=40+%i*125;//ohm
Y=10^-3;//mho
P=50*10^6;//W
VRL=220*10^3;//Volt
VR=VRL/sqrt(3);//Volt
pf=0.8;//power factor
cos_fi_r=pf;
sin_fi_r=sqrt(1-cos_fi_r^2);
IR=P/(sqrt(3)*VRL*pf);//A
IR=IR*(cos_fi_r-%i*sin_fi_r);//A
ICR=1/2*%i*Y*VR;//A
IL=IR+ICR;//A
VS=VR+IL*Z;//Volt
VSL=sqrt(3)*abs(VS);//Volt
disp(VSL/1000,"Sending end line to line voltage(kV)
    :");
```

Scilab code Exa 5.15 Voltage Efficiency and PF

```
//Exa 5.15
clc;
clear;
```

```
close;
//Given data :
f=50;//Hz
l=100;//km
P=50*10^6;//W
pf=0.8;//power factor
cos_fi_r=pf;
sin_fi_r=sqrt(1-cos_fi_r^2);
VRL=132*10^3;//Volt
VR=VRL/sqrt(3);//Volt
R=0.1*l;//ohm
XL=0.3*l;//ohm
Z=R+%i*XL;//ohm
Y=3*10^-6*l;//S
IR=P/(sqrt(3)*VRL*pf);//A
IR=IR*(cos_fi_r-%i*sin_fi_r);//A
ICR=1/2*%i*Y*VR;//A
IL=IR+ICR;//A
VS=VR+IL*Z;//Volt
VSL=sqrt(3)*abs(VS);//Volt
disp(VSL/1000,"Sending end line voltage(kV) :");
ICS=1/2*%i*Y*VS;//A
IS=IL+ICS;//A
fi_s=atand(imag(VS),real(VS))-atand(imag(IS),real(IS
    ));//
cos_fi_s=cosd(fi_s);//sending end pf
disp(cos_fi_s,"Sending end power factor(lag) : ");
Eta_T=sqrt(3)*VRL*abs(IR)*cos_fi_r/(sqrt(3)*VSL*abs(
    IS)*cos_fi_s)*100;//%
disp(Eta_T,"Transmission Efficiency(%) : ");
```

Scilab code Exa 5.16 Voltage at mid point

```
//Exa 5.16
clc;
```

```
clear;
close;
//Given data :
f=50;//Hz
l=10;//km
S1=5000*10^3;//VA
S2=10000*10^3;//VA
pf=0.8;//power factor
cos_fi_r=pf;
sin_fi_r=sqrt(1-cos_fi_r^2);
pf2=0.7071;//power factor
cos_fi_r2=pf2;
sin_fi_r2=sqrt(1-cos_fi_r2^2);
R=0.6*l;//ohm
XL=1.5*l;//ohm
VRL=33*10^3;//Volt
VR=VRL/sqrt(3);//Volt
I1=S1/(sqrt(3)*VRL);//A
I1=I1*(cos_fi_r-%i*sin_fi_r);//A
Z1=R+%i*XL;//ohm
VB=VR+I1*Z1;//Volt
VBL=sqrt(3)*abs(VB);//Volt
disp(VBL/1000,"Line voltage at mid point(kV) : ");
I2=S2/(sqrt(3)*VBL);//A
I2=I2*(cos_fi_r2-%i*sin_fi_r2);//A
I=I1+I2;//A
disp("Total current(A), magnitude is "+string(abs(I))+" and angle in degree is "+string(atand(imag(I),real(I))));
Z2=R+%i*XL;//ohm
VS=VB+I*Z2;//Volt
VSL=sqrt(3)*abs(VS);//Volt
disp(VSL/1000,"Sending end line voltage(kV) :");
```

Scilab code Exa 5.17 kVA supplied and Power supplied

```
//Exa 5.17
clc;
clear;
close;
//Given data :
P=10;//MWatt
pf=0.8;//power factor
VRL=30*10^3;//Volt
R1=5.5;//ohm
XL1=13.5;//ohm
R2=6;//ohm
XL2=11;//ohm
ZA=R1+%i*XL1;//ohm
ZB=R2+%i*XL2;//ohm
S=P*10^3/pf*expm(%i*%pi/180*(-36.52));//kVA
SA=S*ZB/(ZA+ZB);//kVA
disp("Load supply by line A(kVA), magnitude is "+
    string(abs(SA))+" at pf "+string(cosd(atand(imag(
    SA),real(SA)))));
SB=S*ZA/(ZA+ZB);//kVA
disp("Load supply by line B(kVA), magnitude is "+
    string(abs(SB))+" and angle in degree is "+string
    (cosd(atand(imag(SB),real(SB)))));
PA=abs(SA)*(cosd(atand(imag(SA),real(SA))));//kW
disp(PA,"Power supplied by line A(kW) : ");
PB=abs(SB)*(cosd(atand(imag(SB),real(SB))));//kW
disp(PB,"Power supplied by line B(kW) : ");
//Answer is not accurate in the book.
```

Scilab code Exa 5.18 Rise in Voltage

```
//Exa 5.18
clc;
clear;
close;
```

```
//Given data :
L=200;//km
f=50;//Hz
omega=2*%pi*f;//rad/s
Rise=omega^2*L^2*10^-8/18;//%
disp(Rise,"Percentage rise in voltage : ");
```

Scilab code Exa 5.19 Find A B C D parameters

```
//Exa 5.19
clc;
clear;
close;
//Given data :
L=80;//km
f=50;//Hz
Z=(0.15+%i*0.78)*L;//ohm
Y=(%i*5*10^-6)*L;//mho
A=1+1/2*Y*Z;//parameter of 3-phase line
D=A;//parameter of 3-phase line
B=Z*(1+1/4*Y*Z);//parameter of 3-phase line
C=Y;//parameter of 3-phase line
disp(A,"Parameter A : ");
disp(B,"Parameter B : ");
disp(C,"Parameter C : ");
disp(D,"Parameter D : ");
//Answer of B is wrong in the book.
```

Scilab code Exa 5.20 ABCD constant Voltage and Efficiency

```
//Exa 5.20
clc;
clear;
```

```
close;
//Given data :
Z=200*expm(%i*%pi/180*80);//ohm
Y=0.0013*expm(%i*%pi/180*90);//mho/phase
P=80*10^6;//W
pf=0.8;//power factor
cos_fi_r=pf;
sin_fi_r=sqrt(1-cos_fi_r^2);
VRL=220*10^3;//Volt
VR=VRL/sqrt(3);//Volt
f=50;//Hz
IR=P/(sqrt(3)*VRL*pf);//A
IR=IR*(cos_fi_r-%i*sin_fi_r);//A
A=1+1/2*Y*Z;//parameter of 3-phase line
D=A;//parameter of 3-phase line
B=Z*(1+1/4*Y*Z);//parameter of 3-phase line
C=Y;//parameter of 3-phase line
disp("Parameter A, magnitude is "+string(abs(A))+" and angle in degree is "+string(atand(imag(A),real(A))));
disp("Parameter B, magnitude is "+string(abs(B))+" and angle in degree is "+string(atand(imag(B),real(B))));
disp("Parameter C, magnitude is "+string(abs(C))+" and angle in degree is "+string(atand(imag(C),real(C))));
disp("Parameter D, magnitude is "+string(abs(D))+" and angle in degree is "+string(atand(imag(D),real(D))));
VS=A*VR+B*IR;//Volt
VSL=sqrt(3)*abs(VS);//Volt
disp(VSL/1000,"Sending end Line voltage(kV) : ");
IS=C*VR+D*IR;//A
disp("Sending end current(A), magnitude is "+string(abs(IS))+" and angle in degree is "+string(atand(imag(IS),real(IS))));
fi_s=atand(imag(VS),real(VS))-atand(imag(IS),real(IS));//
```

```
cos_fis=cosd(fi_s);//sending end pf
disp(cos_fis,"Sending end power factor(lag) : ");
Pin=sqrt(3)*VSL*abs(IS)*cos_fis*10^-6;//MW
disp(Pin,"Power Input(MW) : ");
Eta=P/(Pin*10^6)*100;//%
disp(Eta,"Transmission Efficiency(%) : ");
```

Scilab code Exa 5.21 Voltage Current Power and efficiency

```
//Exa 5.21
clc;
clear;
close;
//Given data :
P=50*10^6;//VA
pf=0.8;//power factor
cos_fi_r=pf;
sin_fi_r=sqrt(1-cos_fi_r^2);
A=0.98*expm(%i*%pi/180*3);//parameter of 3-phase
    line
D=0.98*expm(%i*%pi/180*3);//parameter of 3-phase
    line
B=110*expm(%i*%pi/180*75);//parameter of 3-phase
    line
C=0.0005*expm(%i*%pi/180*80);//parameter of 3-phase
    line
VRL=110*10^3;//Volt
VR=VRL/sqrt(3);//Volt
IR=P/(sqrt(3)*VRL);//A
IR=IR*(cos_fi_r-%i*sin_fi_r);//A
VS=A*VR+B*IR;//Volt
VSL=sqrt(3)*abs(VS);//Volt
disp(VSL/1000,"Sending end Line voltage(kV) : ");
IS=C*VR+D*IR;//A
disp("Sending end current(A), magnitude is "+string(
```

```
    abs(IS))+" and angle in degree is "+string(atand(
    imag(IS),real(IS))));
fi_s=atand(imag(VS),real(VS))-atand(imag(IS),real(IS
    ));//
cos_fis=cosd(fi_s);//sending end pf
disp(cos_fis,"Sending end power factor(lag) : ");
Pin=sqrt(3)*VSL*abs(IS)*cos_fis*10^-6;//MW
disp(Pin,"Power Input(MW) : ");
Eta=P*pf/(Pin*10^6)*100;//%
disp(Eta,"Transmission Efficiency(%) : ");
```

Scilab code Exa 5.22 ABCD constant power and voltage

```
//Exa 5.22
clc;
clear;
close;
//Given data :
f=50;//Hz
L=300;//km
r=0.15;//ohm/km
x=0.5;//ohm/km
y=3*10^-6;//mho/km
VRL=220*10^3;//Volt
VR=VRL/sqrt(3);//Volt
P=200*10^6;//W
pf=0.85;//power factor
cos_fi_r=pf;
sin_fi_r=sqrt(1-cos_fi_r^2);
R=r*L;//ohm
X=x*L;//ohm
Y=y*L;//mho
Z=R+%i*X;//ohm
//part (i)
A=1+1/2*%i*Y*Z;//parameter of 3-phase line
```

```
D=A;//parameter of 3-phase line
B=Z;//parameter of 3-phase line
C=%i*Y*(1+1/4*%i*Y*Z);//parameter of 3-phase line
disp("Parameter A, magnitude is "+string(abs(A))+" and angle in degree is "+string(atand(imag(A),real(A))));
disp("Parameter B, magnitude is "+string(abs(B))+" and angle in degree is "+string(atand(imag(B),real(B))));
disp("Parameter C, magnitude is "+string(abs(C))+" and angle in degree is "+string(atand(imag(C),real(C))));
disp("Parameter D, magnitude is "+string(abs(D))+" and angle in degree is "+string(atand(imag(D),real(D))));
//part (ii)
IR=poly(0,'IR');
p=0.024525*IR^2+11.427*IR-2102;//from VS=A*VR+B*IR;//Volt
IR=roots(p);
IR=IR(2);//taking +ve value
P=sqrt(3)*VRL*IR*10^-6;//MW
disp(P,"Power received in MW : ");
///part (iii)
P=200*10^6;//W
IR=P/sqrt(3)/VRL/pf;//A
fi=acosd(pf);//degree
IR=IR*expm(%i*-fi*%pi/180);
VS=A*VR+B*IR;//Volt
VSL=sqrt(3)*abs(VS);//Volt
disp(VSL/1000,"Sending end Line voltage(kV) : ");
```

Scilab code Exa 5.23 Voltage current power and egulation

```
//Exa 5.23
```

```
clc;
clear;
close;
//Given data :
A=0.936+%i*0.016;//parameter of 3−phase line
D=A;//parameter of 3−phase line
B=33.5+%i*138;//parameter of 3−phase line
C=(-0.9280+%i*901.223)*10^-6;//parameter of 3−phase
    line
VRL=200*10^3;//Volt
VR=VRL/sqrt(3);//Volt
P=40*10^6;//W
pf=0.86;//power factor
cos_fi_r=pf;
sin_fi_r=sqrt(1-cos_fi_r^2);
IR=P/sqrt(3)/VRL/pf;//A
fi=acosd(pf);//degree
IR=IR*expm(%i*-fi*%pi/180);
VS=A*VR+B*IR;//Volt
VSL=sqrt(3)*abs(VS);//Volt
disp(VSL/1000,"Sending end Line voltage(kV) : ");
IS=C*VR+D*IR;//A
disp("Sending end current(A), magnitude is "+string(
    abs(IS))+" and angle in degree is "+string(atand(
    imag(IS),real(IS))));
fi_s=atand(imag(IS),real(IS))-atand(imag(VS),real(VS
    ));//degree
disp(cosd(fi_s),fi_s,"Sending end phase angle(degree
    ) & power factor(leading): ");
Ps=sqrt(3)*abs(VSL)*abs(IS)*cosd(fi_s)*10^-6;//MW
disp(Ps,"Sending end power(MW) : ");
Vreg=(VSL-VRL)*100/VRL;//%
disp(Vreg,"Voltage regulation in % : ");
```

Scilab code Exa 5.24 Sending end voltage and current

```
//Exa 5.24
clc;
clear;
close;
//Given data :
A1=0.98*expm(%i*2*%pi/180);//parameter of 3-phase
    line
D1=A1;//parameter of 3-phase line
B1=28*expm(%i*69*%pi/180);//parameter of 3-phase
    line
C1=0.0002*expm(%i*88*%pi/180);//parameter of 3-phase
     line
A2=0.95*expm(%i*3*%pi/180);//parameter of 3-phase
    line
D2=A2;//parameter of 3-phase line
B2=40*expm(%i*85*%pi/180);//parameter of 3-phase
    line
C2=0.0004*expm(%i*90*%pi/180);//parameter of 3-phase
     line
VRL=110*10^3;//Volt
VR=VRL/sqrt(3);//Volt
IR=200;//A
pf=0.95;//power factor
cos_fi_r=pf;
sin_fi_r=sqrt(1-cos_fi_r^2);
fi=acosd(pf);//degree
A=A1*A2+B1*C2;//generalized parameter of 2 line
B=A1*B2+B1*D2;//generalized parameter of 2 line
C=C1*A2+D1*C2;//generalized parameter of 2 line
D=C1*B2+D1*D2;//generalized parameter of 2 line
IR=IR*expm(%i*-fi*%pi/180);
VS=A*VR+B*IR;//Volt
VSL=sqrt(3)*abs(VS);//Volt
disp(VSL/1000,"Sending end Line voltage(kV) : ");
IS=C*VR+D*IR;//A
disp("Sending end current(A), magnitude is "+string(
    abs(IS))+" and angle in degree is "+string(atand(
    imag(IS),real(IS))));
```

```
//Answer for VSL is wrong in the book.
```

Scilab code Exa 5.25 `ABCD constant and power factor`

```
//Exa 5.25
clc;
clear;
close;
//Given data :
A1=0.98*expm(%i*1*%pi/180);//parameter of 3-phase line
D1=A1;//parameter of 3-phase line
B1=100*expm(%i*75*%pi/180);//parameter of 3-phase line
C1=0.0005*expm(%i*90*%pi/180);//parameter of 3-phase line
A2=0.98*expm(%i*1*%pi/180);//parameter of 3-phase line
D2=A2;//parameter of 3-phase line
B2=100*expm(%i*75*%pi/180);//parameter of 3-phase line
C2=0.0005*expm(%i*90*%pi/180);//parameter of 3-phase line
P=100*10^6;//W
VRL=132*10^3;//Volt
VR=VRL/sqrt(3);//Volt
pf=0.8;//power factor
cos_fi_r=pf;
sin_fi_r=sqrt(1-cos_fi_r^2);
fi=acosd(pf);//degree
A=(A1*B2+A2*B1)/(B1+B2);//generalized parameter of 2 line
B=B1*B2/(B1+B2);//generalized parameter of 2 line
C=C1+C2-(A1-A2)*(D1-D2)/(B1+B2);//generalized parameter of 2 line
```

```
D=(B1*D2+B2*D1)/(B1+B2);//generalized parameter of 2 line
disp("Generalised constants ot two lines combined are : ");
disp("Parameter A, magnitude is "+string(abs(A))+" and angle in degree is "+string(atand(imag(A),real(A))));
disp("Parameter B, magnitude is "+string(abs(B))+" and angle in degree is "+string(atand(imag(B),real(B))));
disp("Parameter C, magnitude is "+string(abs(C))+" and angle in degree is "+string(atand(imag(C),real(C))));
disp("Parameter D, magnitude is "+string(abs(D))+" and angle in degree is "+string(atand(imag(D),real(D))));
IR=P/sqrt(3)/VRL/pf;//A
IR=IR*expm(%i*-fi*%pi/180);
VS=A*VR+B*IR;//Volt
VSL=sqrt(3)*abs(VS);//Volt
IS=C*VR+D*IR;//A
fi_s=atand(imag(VS),real(VS))-atand(imag(IS),real(IS));
disp(cosd(fi_s),"Sending end power factor(lagging) :");
```

Chapter 16

Representation and Performance of long Transmission Lines

Scilab code Exa 6.1 Determine Auxiliary constant

```
//Exa 6.1
clc;
clear;
close;
format('v',6);
//Given data :
r=0.22;//ohm
x=0.45;//ohm
g=4*10^-9;//S
b=2.53*10^-6;//S
f=50;//Hz
l=1000;//Km
//Using Convergent series of complex angles
z=r+%i*x;//ohm
y=g+%i*b;//ohm
Z=z*l;//ohm
Y=y*l;//ohm
```

```
YZ=Y*Z;//ohm
Y2Z2=YZ^2;//ohm
Y3Z3=YZ^3;//ohm
A=1+YZ/2+Y2Z2/24+Y3Z3/720;//ohm
D=A;//oh,m
B=Z*(1+YZ/6+Y2Z2/120+Y3Z3/5040);//ohm
C=Y*(1+YZ/6+Y2Z2/120+Y3Z3/5040);//ohm
disp("Auxiliary Constants by using Convergent series
    of complex angles : ");
disp(A,"A = ");
disp(B,"B = ");
disp(C,"C = ");
//Using Convergent series of real angles
A=cosh(sqrt(YZ));//ohm
D=A;//ohm
B=sqrt(Z/Y)*sinh(sqrt(YZ));//ohm
C=sqrt(Y/Z)*sinh(sqrt(YZ));//ohm
A=cosh(sqrt(YZ));//ohm
disp("Auxiliary Constants by using Convergent series
    of real angles : ");
disp("A, magnitude is "+string(abs(A))+" and angle
   in degree is "+string(atand(imag(A),real(A))));
disp("B, magnitude is "+string(abs(B))+" and angle
   in degree is "+string(atand(imag(B),real(B))));
disp("C, magnitude is "+string(abs(C))+" and angle
   in degree is "+string(atand(imag(C),real(C))));
disp("We obtain same result by both of the methods."
   )
```

Scilab code Exa 6.2 Sending end voltage and current

```
//Exa 6.2
clc;
clear;
close;
```

```
format('v',8);
//Given data :
Z=200*expm(%i*80*%pi/180);//ohm
Y=0.0013*expm(%i*90*%pi/180);//S/phase
P=80*10^6;//W
pf=0.8;//power factor
VRL=220*1000;//V
VR=VRL/sqrt(3);//V
IR=P/sqrt(3)/VRL/pf;//A
fi=acosd(pf);//degree
IR=IR*expm(%i*-fi*%pi/180);//A
YZ=Y*Z;//ohm
Y2Z2=YZ^2;//ohm
Y3Z3=YZ^3;//ohm
A=1+YZ/2+Y2Z2/24+Y3Z3/720;//ohm
D=A;//oh,m
B=Z*(1+YZ/6+Y2Z2/120+Y3Z3/5040);//ohm
C=Y*(1+YZ/6+Y2Z2/120+Y3Z3/5040);//mho
VS=A*VR+B*IR;//V
VSL=sqrt(3)*abs(VS);//V
disp(VSL/1000,"Sending end line voltage in kV : ");
IS=C*VR+D*IR;//
disp("Sending end current in A, magnitude is "+
   string(abs(IS))+" and angle in degree is "+string
   (atand(imag(IS),real(IS))));
```

Scilab code Exa 6.3 `A0 B0 C0 and D0 constant`

```
//Exa 6.3
clc;
clear;
close;
format('v',8);
//Given data :
VRL=220;//kV
```

```
VR=VRL/sqrt(3);//V
P=10*10^6;//VA
Z=1+%i*8;//ohm(in %)
Zse=Z/100*VRL^2/100;//ohm/phase
A=0.9*expm(%i*0.6*%pi/180);//Auxiliary constant
D=A;//Auxiliary constant
B=153.2*expm(%i*84.6*%pi/180);//Auxiliary constant
C=0.0012*expm(%i*90*%pi/180);//Auxiliary constant
A0=A+C*Zse;//constant
B0=B+D*Zse;//ohm//constant
C0=C;//mho or S//constant
D0=A;//constant
disp("Constant A0, magnitude is "+string(abs(A0))+"
   and angle in degree is "+string(atand(imag(A0),
   real(A0))));
disp("Constant B0(ohm), magnitude is "+string(abs(B0
   ))+" and angle in degree is "+string(atand(imag(
   B0),real(B0))));
disp("Constant C0(S), magnitude is "+string(abs(C0))
   +" and angle in degree is "+string(atand(imag(C0)
   ,real(C0))));
disp("Constant D0, magnitude is "+string(abs(D0))+"
   and angle in degree is "+string(atand(imag(D0),
   real(D0))));
```

Scilab code Exa 6.4 `A0 B0 C0 and D0 constant`

```
//Exa 6.4
clc;
clear;
close;
format('v',8);
//Given data :
A=0.98*expm(%i*2*%pi/180);//Auxiliary constant
D=A;//Auxiliary constant
```

```
B=28*expm(%i*69*%pi/180);//Auxiliary constant
Zse=12*expm(%i*80*%pi/180);//ohm
C=(A*D-1)/B;//Auxiliary constant
A0=A+C*Zse;//constant
B0=B+2*A*Zse+C*Zse^2;//ohm//constant
C0=C;//mho or S//constant
D0=A0;//constant
disp("Constant A0, magnitude is "+string(abs(A0))+" and angle in degree is "+string(atand(imag(A0),real(A0))));
disp("Constant B0(ohm), magnitude is "+string(abs(B0))+" and angle in degree is "+string(atand(imag(B0),real(B0))));
disp("Constant C0(S), magnitude is "+string(abs(C0))+" and angle in degree is "+string(atand(imag(C0),real(C0))));
disp("Constant D0, magnitude is "+string(abs(D0))+" and angle in degree is "+string(atand(imag(D0),real(D0))));
```

Scilab code Exa 6.5 `A0 B0 C0 and D0 constant`

```
//Exa 6.5
clc;
clear;
close;
format('v',8);
//Given data :
A=0.92*expm(%i*5.3*%pi/180);//Auxiliary constant
D=A;//Auxiliary constant
B=65.3*expm(%i*81*%pi/180);//Auxiliary constant
ZT=100*expm(%i*70*%pi/180);//ohm
YT=0.0002*expm(%i*-75*%pi/180);//S
C=(A*D-1)/B;//Auxiliary constant
A0=A*(1+2*YT*ZT)+B*(YT)+C*ZT*(1+YT*ZT);//constant
```

```
B0=2*A*ZT+B+C*ZT^2;//ohm//constant
C0=2*A*YT*(1+YT*ZT)+B*YT^2+C*(1+YT*ZT)^2;//mho or S //constant
D0=A0;//constant
disp("Constant A0, magnitude is "+string(abs(A0))+" and angle in degree is "+string(atand(imag(A0),real(A0))));
disp("Constant B0(ohm), magnitude is "+string(abs(B0))+" and angle in degree is "+string(atand(imag(B0),real(B0))));
disp("Constant C0(S), magnitude is "+string(abs(C0))+" and angle in degree is "+string(atand(imag(C0),real(C0))));
disp("Constant D0, magnitude is "+string(abs(D0))+" and angle in degree is "+string(atand(imag(D0),real(D0))));
```

Scilab code Exa 6.6 Equivalent T and Pi network

```
//Exa 6.6
clc;
clear;
close;
format('v',8);
//Given data :
A=0.945*expm(%i*1.02*%pi/180);//Auxiliary constant
D=A;//Auxiliary constant
B=82.3*expm(%i*73.03*%pi/180);//ohm//Auxiliary constant
C=0.001376*expm(%i*90.4*%pi/180);//S//Auxiliary constant
//part (i)
Y=C;//S
Z=2*(A-1)/C;//ohm
disp("For equivalent T-network : ");
```

```
disp("Shunt admittance in S, magnitude is "+string(
    abs(Y))+" and angle in degree is "+string(atand(
    imag(Y),real(Y))));
disp("Impedance in ohm, magnitude is "+string(abs(Z)
    )+" and angle in degree is "+string(atand(imag(Z)
    ,real(Z))));
disp("For equivalent pi-network : ");
Z=B;//ohm
disp("Series Impedance in ohm, magnitude is "+string
    (abs(Z))+" and angle in degree is "+string(atand(
    imag(Z),real(Z))));
Y=2*(A-1)/B;//S
disp("Shunt admittance in S, magnitude is "+string(
    abs(Y))+" and angle in degree is "+string(atand(
    imag(Y),real(Y))));
//For T-Network Value of Z is wrog in the book.
```

Chapter 17

Corona

Scilab code Exa 7.1 Line Voltage

```
//Exa 7.1
clc;
clear;
close;
//Given data :
r=1;//cm
d=4;//meter
g0=30/sqrt(2);//kV/cm
LineVoltage=sqrt(3)*g0*r*log(d*100/r);//kV
disp(round(LineVoltage),"Line Voltage for comencing
    of corena(in kV) :");
```

Scilab code Exa 7.2 Disruptive Critical Voltage

```
//Exa 7.2
clc;
clear;
close;
```

```
//Given data :
Ph=3;//phase
V=220;//kV
f=50;//Hz
r=1.2;//cm
d=2;//meter
mo=0.96;//Irregularity factor
t=20;//degree C
T=t+273;//K
b=72.2;//cm
go=21.1;//kV rms/cm
del=3.92*b/T;//Air density factor
Vdo=go*del*mo*r*log(d*100/r);//in kV
Vdo_line=sqrt(3)*Vdo;//in kV
disp(round(Vdo_line),"Disruptive critical voltage
    from line to line(kV rms) : ");
```

Scilab code Exa 7.3 Spacing between Conductors

```
//Exa 7.3
clc;
clear;
close;
format('v',5);
//Given data :
V=132;//kV
r=2/2;//cm
Vexceed=210;//kV(rms)
go=30000/sqrt(2);//Volts/cm
go=go/1000;//kV/cm
Vdo=Vexceed/sqrt(3);//Volt
mo=1;//assumed
del=1;//assumed air density factor
//Formula : Vdo=go*del*mo*r*log(d*100/r);//in kV
d=exp(Vdo/go/del/mo/r)*r;//cm
```

```
disp(d*10^-2,"Spacing between conductors in meter :
   ");
```

Scilab code Exa 7.4 Minimum diameter of conductor

```
//Exa 7.4
clc;
clear;
close;
format('v',5);
//Given data :
Ph=3;//phase
V=132;//kV
f=50;//Hz
d=3;//meter
d=d*100;//in cm
go=21.21;//kV/cm : assumed
mo=0.85;//assumed
del=0.95;//assumed air density factor
Vdo=V/sqrt(3);//kV
//Formula : Vdo=go*del*mo*r*log(d*100/r);//in kV
//r*log(d/r)=Vdo/go/del/mo: solving
//Implementing Hit & Trial method
for r=0.1:.1:2
    if floor(r*log(d/r))==floor(Vdo/go/del/mo) then
        disp(2*r,"Minimum Diameter of conductor by
           Hit & Trial method(cm) : ");
        break;
    end
end
```

Scilab code Exa 7.5 Presence of Corona

```
//Exa 7.5
clc;
clear;
close;
format('v',7);
//Given data :
r=2.5/2;//cm
epsilon_r=4;//constant
r1=3/2;//cm
r2=9/2;//cm
V=20;//kV(rms)
//Formula : gmax=q/(2*epsilon*r)
g2maxBYg1max=r/epsilon_r/r1;//unitless
//Formula : V=g1max*r*log(r1/r)+g2max*r1*log(r2/r1)
g1max=V/(r*log(r1/r)+g2maxBYg1max*r1*log(r2/r1));//
    in kV/cm
disp(g1max,"g1max(kV/cm) = ");
disp("g1max > go, Corona will be present.");
```

Scilab code Exa 7.6 `Critical Disruptive Voltage`

```
//Exa 7.6
clc;
clear;
close;
format('v',5);
//Given data :
Ph=3;//phase
r=10.4/2;//mm
r=r/10;//in cm
d=2.5;//meter
d=d*100;//in cm
t=21;//degree C
T=t+273;//K
b=73.6;//cm-Hg
```

```
mo=0.85;
mv_l=0.7;
mv_g=0.8;
go=21.21;//kV/cm : assumed
del=3.92*b/T;//Air density factor
//Formula : Vdo=go*del*mo*r*log(d*100/r);//kV
Vdo=go*del*mo*r*log(d/r);//kV
Vdo_line=sqrt(3)*Vdo;//kV
Vvo=go*del*mv_l*r*(1+.3/sqrt(del*r))*log(d/r);//kV
Vvo_line_local=Vvo*sqrt(3);//kV(rms)
disp(Vvo_line_local,"Line to line visual critical
    voltage for local corona(kV-rms) : ")
Vvo_line_general=Vvo_line_local*mv_g/mv_l;//kV(rms)
disp(Vvo_line_general,"Line to line visual critical
    voltage for general corona(kV-rms) : ")
//Note : Answer in the book is not accurate.
```

Scilab code Exa 7.7 Corona Loss

```
//Exa 7.7
clc;
clear;
close;
format('v',5);
//Given data :
Pc1=53;//in kW
V1=106;//in kV
Pc2=98;//in kW
V2=110.9;//in kV
Vph1=V1/sqrt(3);//in kV
Vph2=V2/sqrt(3);//in kV
//Formula : Pc=3*244/del*(f+25)*sqrt(r/d)*(Vph-Vdo)
    ^2*10^-5;//kW/Km
disp("Using proportionality : Pc is proportional to
    (Vph-Vdo)^2");
```

```
disp("We have, Pc1/Pc2 = (Vph1−Vdo)^2/(Vph2−Vdo)^2")
    ;
Vdo=(Vph1-sqrt(Pc1/Pc2)*(Vph2))/(1-sqrt(Pc1/Pc2));
V3=113;//in kV
Vph3=V3/sqrt(3);//in kV
Pc3=Pc2*(Vph3-Vdo)^2/(Vph2-Vdo)^2;//in kW
disp(Pc3,"Corona Loss at 113 kV in kW : ");
VLine=sqrt(3)*Vdo;//in kV
disp(VLine,"Disruptive critical voltage between
    lines(kV):  ");
```

Scilab code Exa 7.8 Disruptive voltage and corona loss

```
//Exa 7.8
clc;
clear;
close;
format('v',5);
//Given data :
f=50;//Hz
l=160;//km
r=1.036/2;//cm
d=2.44*100;//cm
g0=21.1;//kV/cm(rms)
m0=0.85;//irregularity factor
mv=0.72;//roughness factor
b=73.15;//cm
t=26.6;//degree C
del=3.92*b/(273+t);//air density factor
Vd0=g0*del*m0*r*log(d/r);//kV(rms)
disp(Vd0,"Critical disruptive voltage(rms) in kV : "
    );
Vv0=g0*del*mv*r*(1+0.3/sqrt(del*r))*log(d/r);//kV
disp(Vv0,"Visual Critical voltage(rms) in kV : ");
Vph=110/sqrt(3);//in kV
```

```
Pc_dash=d/del*(f+25)*sqrt(r/d)*(Vph-0.8*Vd0)^2*10^-5;//kW/km/phase
T_Corona_loss=l*3*Pc_dash;//kW
disp(T_Corona_loss,"Total corona loss under foul weather condition using Peek formula in kW : ");
VphBYVd0=Vph/Vd0/0.8;
K=0.46;//constant
Corona_loss=21*10^-5*f*Vph^2*K/(log10(d/r))^2;//kW/km/phase
T_corona_loss=Corona_loss*3*l;//kW
disp(T_corona_loss,"Total corona loss under foul weather condition using Peterson formula in kW : ");
```

Scilab code Exa 7.9 Corona Characteristics

```
//Example 7.9
clc;
clear;
close;
//given data :
f=50;//Hz
l=175;//km
r=1/2;//cm
d=3*100;//cm
g0=21.1;//kV/cm(rms)
m0=0.85;//irregularity factor
mv=0.72;//roughness factor
mv_dash=0.82;//roughness factor
b=74;//cm
t=26;//degree C
Vph=110/sqrt(3);//kV
del=3.92*b/(273+t);//air density factor
Vd0=g0*del*m0*r*log(d/r);//kV(rms)
Vvo=g0*del*mv*r*(1+0.3/sqrt(del*r))*log(d/r);//kV
```

```
rms
Vvo_dash=Vvo*mv_dash/mv;//kV rms
Pc=244/del*(f+25)*sqrt(r/d)*(Vph-Vd0)^2*10^-5;//kW/Km/phase
T_CoronaLoss=Pc*l*3;//kW
disp("Power loss due to corona for fair weather condition : ");
disp(T_CoronaLoss,"Total corona loss using Peek formula in kW : ");
K=0.0713;//constant for Vph/Vdo=1.142
Pc=21*10^-5*f*Vph^2/(log10(d/r))^2*K;//kW/Km/phase
T_CoronaLoss=Pc*l*3;//kW
disp(T_CoronaLoss,"According Peterson formula, Total corona loss for 175 km 3-phase line(kW): ");
disp("Power loss due to corona for stormy weather condition : ");
Vd0=0.8*Vd0;//kV
Pc_dash=l*3*244/del*(f+25)*sqrt(r/d)*(Vph-Vd0)^2*10^-5;//kW/Km/phase
disp(Pc_dash,"Total corona loss using Peek formula in kW : ");
K=0.395;//constant for Vph/Vdo=1.42
Pc=21*10^-5*f*Vph^2/(log10(d/r))^2*K;//kW/Km/phase
T_CoronaLoss=Pc*l*3;//kW
disp(T_CoronaLoss,"According Peterson formula, Total corona loss for 175 km 3-phase line(kW): ");
//Answer is wrong in the book for corona loss fair weather condition using Peek formula.
```

Chapter 18

Electrostatic and Electromagnetic Interference with Communication Lines

Scilab code Exa 8.1 Voltage induced per km

```
//Exa 8.1
clc;
clear;
close;
format('v',6);
//Given data :
f=50;//Hz
hor_con=1.2;//horizontal configuration spacing in m
x=0.85;//telephone line location below power line in
    meter
I=120;//current in power line in A
d=0.4;//spacing between conductors in meter
dAD=sqrt(x^2+((hor_con+d)/2)^2);//m
dAC=sqrt(x^2+((hor_con-d)/2)^2);//m
dBD=dAC;//m
dBC=dAD;//m
M=d*log(sqrt(dAD*dBC/dAC/dBD));//mh/km
```

```
Vm=2*%pi*f*M*10^-3*I;//V
disp(Vm,"Voltage induced per Km in the line in Volt
    :");
```

Scilab code Exa 8.2 Induced Voltage at fundamental frequency

```
//Exa 8.2
clc;
clear;
close;
format('v',6);
//Given data :
f=50;//HzdAP=AO+5;//m
l=200;//km
V=132*1000;//V
Load=28000;//kW
pf=0.85;//lagging power factor
r=5/1000;//radius of conductor in m
//From the figure given in question
AO=sqrt(4^2-2^2);//m
dAP=AO+5;//m
dAQ=dAP+1;//m
dBP=sqrt(5^2+2^2);//m
dBQ=sqrt(6^2+2^2);//m
MA=0.2*log(dAQ/dAP);//mH/km
MB=0.2*log(dBQ/dBP);//mH/km
MC=MB;//mH/km
M=MB-MA;//mH/km(MA,MB and Mc are displaced by 120
    degree)
I=Load*1000/sqrt(3)/V/pf;//A
Vm=2*%pi*f*M*10^-3*I;//V/km
Vm1=Vm*l;//V(For whole route)
disp(Vm1,"Induced Voltage(For whole route) in Volts
    : ");
VA=V/sqrt(3);//V
```

```
VB=V/sqrt(3);//V
hA=20+A0;//m
VPA=VA*log((2*hA-dAP)/dAP)/log((2*hA-r)/r);//V
VPB=VB*log((2*hA-dBP)/dBP)/log((2*hA-r)/r);//V
VPC=VPB;//V
VP=VPB-VPA;//V
disp(VP,"Potential of telephone conductor in Volts :
   ");
//Answer in the book is wrong due to little accuracy
    as compared to scilab.
```

Chapter 19

Overhead Line Insulators

Scilab code Exa 9.1 String Efficiency

```
//Exa 9.1
clc;
clear;
close;
//Given data :
C1=1;//
C=6;
K=C1/C;
V2byV1=(1+K);
V3byV1=(1+3*K+K^2);
V4byV1=(1+6*K+5*K^2+K^3);
//I5=I4+i4;
//omega*C*V5=omega*C*V4+omega*C1*(V1+V2+V3+V4)
V5byV1=1+10*K+15*K^2+7*K^3+K^4
VbyV1=1+V2byV1+V3byV1+V4byV1+V5byV1;
V1byV=1/VbyV1;
disp("Voltage across the first unit is "+string(
   V1byV*100)+" % of V");
disp("Voltage across the seconf unit is "+string(
   V2byV1*V1byV*100)+" % of V");
disp("Voltage across the third unit is "+string(
```

```
V3byV1*V1byV*100)+" % of V");
disp("Voltage across the fourth unit is "+string(V4byV1*V1byV*100)+" % of V");
disp("Voltage across the bottom most unit is "+string(V5byV1*V1byV*100)+" % of V");
n=5;//no. of unit
Strinf_eff=1/n/(V5byV1*V1byV);//%
disp(Strinf_eff*100,"String Efficiency(%)");
```

Scilab code Exa 9.2 Voltage Distribution and String efficiency

```
//Exa 9.2
clc;
clear;
close;
//Given data :
C1=1;//
C=10;
K=C1/C;
V2byV1=(1+K);
V3byV1=(1+3*K+K^2);
V4byV1=(1+6*K+5*K^2+K^3);
V5byV1=1+10*K+15*K^2+7*K^3+K^4
//I6=I5+i5;
//omega*C*V6=omega*C*V5+omega*C1*(V1+V2+V3+V4+V5)
V6byV1=V5byV1+K*(1+V2byV1+V3byV1+V4byV1+V5byV1);
VbyV1=1+V2byV1+V3byV1+V4byV1+V5byV1+V6byV1;
V1byV=1/VbyV1;
disp("Voltage across the first unit is "+string(V1byV*100)+" % of V");
disp("Voltage across the seconf unit is "+string(V2byV1*V1byV*100)+" % of V");
disp("Voltage across the third unit is "+string(V3byV1*V1byV*100)+" % of V");
disp("Voltage across the fourth unit is "+string(
```

```
V4byV1*V1byV*100)+" % of V");
disp("Voltage across the fifth unit is "+string(
   V5byV1*V1byV*100)+" % of V");
disp("Voltage across the sixth unit is "+string(
   V6byV1*V1byV*100)+" % of V");
n=6;//no. of unit
Strinf_eff=1/n/(V6byV1*V1byV);//%
disp(Strinf_eff*100,"String Efficiency(%)");
```

Scilab code Exa 9.3 String Efficiency

```
//Exa 9.3
clc;
clear;
close;
//Given data :
V=66;//kV
//Part(i)
n=5;//no. of uniits
K=1/5;//shunt to mutual capacitance ratio
V1=V/(5+20*K+21*K^2+8*K^3+K^4);//kV
V5=V1*(1+10*K+15*K^2+7*K^3+K^4);//kV
Strinf_eff=V/n/V5;
disp(Strinf_eff*100,"Part(i) Percentage String
   Efficiency(%)");
//Part(ii)
n=5;//no. of uniits
K=1/6;//shunt to mutual capacitance ratio
V1=V/(5+20*K+21*K^2+8*K^3+K^4);//kV
V5=V1*(1+10*K+15*K^2+7*K^3+K^4);//kV
Strinf_eff=V/n/V5;
disp(Strinf_eff*100,"Part(ii) Percentage String
   Efficiency(%)");
```

Scilab code Exa 9.4 Voltage Distribution and String Efficiency

```
//Exa 9.4
clc;
clear;
close;
//Given data :
Vs=20;//kV
n=3;//no. of uniits
K=0.1;//shunt to mutual capacitance ratio
V3=Vs;//kV
V1=V3/(1+3*K+K^2);//kV
disp(V1,"Voltage across top most unit(kV)");
V2=V1*(1+K);//kV
disp(V2,"Voltage across middle unit(kV)");
V=V1+V2+V3;//kV
Strinf_eff=V/n/V3;
disp(Strinf_eff*100,"Percentage String Efficiency(%)
    ");
```

Scilab code Exa 9.5 Maximum Voltage

```
//Exa 9.5
clc;
clear;
close;
//Given data :
Vs=17.5;//kV
n=3;//no. of uniits
K=1/8;//shunt to mutual capacitance ratio
V3=Vs;//kV
V1=V3/(1+3*K+K^2);//kV
```

```
V2=V1*(1+K);//kV
V=V1+V2+V3;//kV
//Strinf_eff=V/n/V3;
disp(V,"Maximum safe working voltage(kV)");
```

Scilab code Exa 9.6 String Efficiency

```
//Exa 9.6
clc;
clear;
close;
//Given data :
Vs=12;//kV
n=4;//no. of uniits
K=0.1;//shunt to mutual capacitance ratio
V4=Vs;//kV
V1=V4/(1+6*K+5*K^2+K^3);//kV
V2=V1*(1+K);//kV
V3=V1*(1+3*K+K^2);//kV
V=V1+V2+V3+V4;//kV
disp(V,"Maximum safe working voltage(kV)");
Strinf_eff=V/n/V4;
disp(Strinf_eff*100,"Percentage String Efficiency(%)
   ");
```

Scilab code Exa 9.7 Maximum line voltage

```
//Exa 9.7
clc;
clear;
close;
//Given data :
Vs=11;//kV
```

```
n=5;//no. of uniits
K=0.1;//shunt to mutual capacitance ratio
V5=Vs;//kV
V1=V5/(1+10*K+15*K^2+7*K^3+K^4);//kV
V2=V1*(1+K);//kV
V3=V1*(1+3*K+K^2);//kV
V4=V1*(1+6*K+5*K^2+K^3);//kV
V=V1+V2+V3+V4+V5;//kV
disp(V,"Maximum safe working voltage(kV)");
```

Scilab code Exa 9.8 Voltage between conductors and string efficiency

```
//Exa 9.8
clc;
clear;
close;
//Given data :
V2=15;//kV
V3=21;//kV
n=4;//no. of uniits
//V3/V2=(1+3*K+K^2)/(1+K)
//K^2*V2+K*(V3+3*V2)-V2+V3=0;
p=[V2 -V3+3*V2 V2-V3];
K=roots(p);
K=K(2);//Taking +ve value
V1=V2/(1+K);//kV
V4=(1+6*K+5*K^2+K^3)*V1;//kV
V=V1+V2+V3+V4;//kV
VL=sqrt(3)*V;//kV
disp(VL,"Voltage between conductors(kV)");
Strinf_eff=V/n/V4;
disp(Strinf_eff*100,"Percentage String Efficiency(%)
    ");
```

Scilab code Exa 9.9 Capacitance of remaining five units

```
//Exa 9.9
clc;
clear;
close;
//Given data :
K=0.1;//shunt to mutual capacitance ratio
CbyC1=10;
C2byC1=(1+K)*CbyC1;
C3byC1=(1+3*K)*CbyC1;
C4byC1=(1+6*K)*CbyC1;
disp("C2 is "+string(C2byC1)+" times of C1");
disp("C3 is "+string(C3byC1)+" times of C1");
disp("C4 is "+string(C4byC1)+" times of C1");
//I5=I4+i4
//omega*C5*v=omega*C4*v+omega*C1*4*v
C5byC1=(1+10*K)*CbyC1;
disp("C5 is "+string(C5byC1)+" times of C1");
//I6=I5+i5
//omega*C6*v=omega*C5*v+omega*C1*5*v
C6byC1=(1+15*K)*CbyC1;
disp("C6 is "+string(C6byC1)+" times of C1");
```

Scilab code Exa 9.10 Line to pin capacitance

```
//Exa 9.10
clc;
clear;
close;
//Given data :
n=8;//no. of units
```

```
p=1:8;
//Cp=p*C/(n-p)
C1byC=1/(n-p(1));
C2byC=2/(n-p(2));
C3byC=3/(n-p(3));
C4byC=4/(n-p(4));
C5byC=5/(n-p(5));
C6byC=6/(n-p(6));
C7byC=7/(n-p(7));
disp("C1 is "+string(C1byC)+" times of C");
disp("C2 is "+string(C2byC)+" times of C");
disp("C3 is "+string(C3byC)+" times of C");
disp("C4 is "+string(C4byC)+" times of C");
disp("C5 is "+string(C5byC)+" times of C");
disp("C6 is "+string(C6byC)+" times of C");
disp("C7 is "+string(C7byC)+" times of C");
```

Scilab code Exa 9.11 `String efficiency`

```
//Exa 9.11
clc;
clear;
close;
//Given data :
v2byv1=25/23.25;//ratio(By Kirchoff law)
v3byv1=1.65/1.1625;//ratio(By Kirchoff law)
Vbyv1=1+v2byv1+v3byv1;//ratio(Final voltage between
    line conductor & earth)
v1byV=1/Vbyv1;//ratio
v2byV=v2byv1*v1byV;//ratio
v3byV=v3byv1*v1byV;//ratio
eff=1/3/v3byV*100;//string efficiency in %(V/3/v3)
disp(eff,"String efficiency in % is ");
```

Scilab code Exa 9.12 `Line voltage and capacitance required`

```
//Exa 9.12
clc;
clear;
close;
//Given data :
V=20;//kV
C=poly(0,'C');
//Cmutual=C;//F
CmutualBYC=1;
//Cshunt=C/5;//F
CshuntBYC=1/5;
//I2=I1+i1//omega*C*V2=omega*C*V1+omega*Cshunt*V1
V2BYV1=1+CshuntBYC;
V3BYV2=1;//a V2=V3
//V=V1+V2+V3
V1=V/(V3BYV2+V2BYV1+V2BYV1);//kV
V2=V2BYV1*V1;//kV
V3=V2;//kV
disp(V3,"Voltage onn the line end unit in kV : ");
//I3+ix=I2+i2
CxBYC=(V2+CshuntBYC*(V1+V2)-V3)/V3;
disp("Capacitance required is "+string(CxBYC)+"C(in
   F).");
```

Chapter 20

Mechanical Design of Transmission Lines

Scilab code Exa 10.1 Maximum sag

```
//Exa 10.1
clc;
clear;
close;
//Given data :
L=200;//m
w=0.7;//kg
T=1400;//kg
S=w*L^2/(8*T);// ,m
disp(S,"maximum sag(m) :");
```

Scilab code Exa 10.2 Height above ground

```
//Exa 10.2
clc;
clear;
```

```
close;
//Given data :
W=680;//kg/km
L=260;//m
U_strength=3100;//kg
SF=2;//safety factor
Clearance=10;//m
T=U_strength/SF;//kg
w=W/1000;//kg
S=w*L^2/(8*T);// ,m
h=Clearance+S;//m
disp(h,"Height above the ground(m) :");
```

Scilab code Exa 10.3 Horizontal component of tension and maximum sag

```
//Exa 10.3
clc;
clear;
close;
//Given data :
w=700/1000;//kg/m
L=300;//m
Tmax=3500;//kg

S_T0=w*L^2/8;// ,m
//Tmax=T0+w*S
//T0^2-T0*Tmax-w*S_T0=0
polynomial=[1 -Tmax w*S_T0];
T0=roots(polynomial);//kg
T0=T0(1);//+ve sign taken
disp(T0,"Horizontal component of tension in kg is :
   ");
S=S_T0/T0;//m
disp(S,"Maximum sag in m : ");
y=S/2;//m
```

```
x=sqrt(2*y*T0/w);//m
disp(x,"Sag will be half at the point where x
   coordinate(in m) will be : ");
```

Scilab code Exa 10.4 Calculate maximum sag

```
//Exa 10.4
clc;
clear;
close;
//Given data :
L=150;//m
wc=1;//kg
A=1.25;//cm^2
U_stress=4200;//kg/cm^2
Pw=100;//kg/m^2(Wind pressure)
SF=4;//factor of safety
W_stress=U_stress/SF;//kg/cm^2
T=W_stress*A;//kg
d=sqrt(A/(%pi/4));//cm
w_w=Pw*d*10^-2;//kg
wr=sqrt(wc^2+w_w^2);//kg
S=wr*L^2/8/T;//m
disp(S,"Maximum sag(m)");
```

Scilab code Exa 10.5 Calculate the sag

```
//Exa 10.5
clc;
clear;
close;
//Given data :
L=160;//m
```

```
d=0.95;//cm
wc=0.65;//kg/m
U_stress=4250;//kg/cm^2
Pw=40;//kg/m^2(Wind pressure)
SF=5;//factor of safety
W_stress=U_stress/SF;//kg/cm^2
T=W_stress*%pi/4*d^2;//kg
w_w=Pw*d*10^-2;//kg
wr=sqrt(wc^2+w_w^2);//kg
S=wr*L^2/8/T;//m
disp(round(S),"Sag(meter)");
```

Scilab code Exa 10.6 Calculate the maximum sag

```
//Exa 10.6
clc;
clear;
close;
//Given data :
L=180;//m
D=1.27;//cm
Pw=33.7;//kg/m^2(Wind pressure)
r=1.25;//cm
wc=1.13;//kg/cm^2
U_stress=4220;//kg/cm^2
SF=5;//factor of safety
W_stress=U_stress/SF;//kg/cm^2
T=W_stress*%pi/4*D^2;//kg
S=wc*L^2/8/T;//msag in air
disp(S,"Sag in still air(meter)");
w1=2890.3*r*10^-2*(D+r)*10^-2;//kg/m
w_w=Pw*(D+2*r)*10^-2;//kg
wr=sqrt((wc+w1)^2+w_w^2);//kg
Smax=wr*L^2/8/T;//msag in air
disp(Smax,"Maximum Sag(meter)");
```

Scilab code Exa 10.7 Calculate the maximum sag

```
//Exa 10.7
clc;
clear;
close;
//Given data :
D=19.5;//mm
wc=0.85;//kg/m
L=275;//m
Pw=39;//kg/m^2(Wind pressure)
r=13;//mm
U_stress=8000;//kg/cm^2
SF=2;//factor of safety
rho_i=910;//kg/m^3(density of ice)
T=U_stress/SF;//kg
wi=rho_i*%pi*r*10^-3*(D+r)*10^-3;//kg
w_w=Pw*(D+2*r)*10^-3;//kg
wr=sqrt((wc+wi)^2+w_w^2);//kg
Smax=wr*L^2/8/T;//msag in air
disp(Smax,"Maximum Sag(meter)");
```

Scilab code Exa 10.8 Calculate the maximum sag

```
//Exa 10.8
clc;
clear;
close;
//Given data :
wc=1;//kg/m
L=280;//m
```

```
D=20; //mm
r=10; //mm
Pw=40; //kg/m^2(Wind pressure)
rho_i=910; //kg/m^3(density of ice)
U_stress=10000; //kg/cm^2
SF=2; //factor of safety
wi=rho_i*%pi*r*10^-3*(D+r)*10^-3; //kg
w_w=Pw*(D+2*r)*10^-3; //kg
wr=sqrt((wc+wi)^2+w_w^2); //kg(Resultant force per m length of conductor)
T=U_stress/SF; //kg
Smax=wr*L^2/8/T; //msag in air
disp(Smax,"Maximum Sag(meter)");
```

Scilab code Exa 10.9 Sag in inclined and vertical direction

```
//Exa 10.9
clc;
clear;
close;
//Given data :
L=250; //m
D=1.42; //cm
wc=1.09; //kg/m
Pw=37.8; //kg/m^2(Wind pressure)
r=1.25; //cm
Lis=1.43; //m(insulator string length)
Clearance=7.62; //m
rho_i=913.5; //kg/m^3(density of ice)
stress=1050; //kg/cm^2
T=stress*%pi/4*D^2; //kg
wi=rho_i*%pi*r*10^-2*(D+r)*10^-2; //kg
w_w=Pw*(D+2*r)*10^-2; //kg
wr=sqrt((wc+wi)^2+w_w^2); //kg(Resultant force per m length of conductor)
```

```
Smax=wr*L^2/8/T;//max sag in air
disp(Smax,"Sag in inclined direction(meter)");
Sdash=Smax*(wc+wi)/wr;//max sag in air
disp(Sdash,"Sag in vertical direction(meter)");
h=Clearance+Sdash+Lis;//m
disp(h,"Height of lowest cross arm(m)");
```

Scilab code Exa 10.10 Lowest point of catenary curve

```
//Exa 10.10
clc;
clear;
close;
//Given data :
wc=0.35;//kg/m
stress=800;//kg/cm^2
L=160;//m
SF=2;//safety factor
h=70-65;//m
T=stress/SF;//kg
x=L/2+T*h/(wc*L);//m
disp(x,"Distance of lowest point(m)");
S1=wc*x^2/SF/T;//max sag in air
xmin=70-S1;//m
disp(xmin,"minimum point of catenary above the
   ground(m)");
```

Scilab code Exa 10.11 Sag at lower support

```
//Exa 10.11
clc;
clear;
close;
```

```
//Given data :
L=200;//m
h=10;//m
D=2;//cm
wc=2.3;//kg/m
Pw=57.5;//kg/m^2(wind pressure)
SF=4;//safety factor
stress=4220;//kg/cm^2
w_w=Pw*D*10^-2;//kg
wr=sqrt(wc^2+w_w^2);//kg
f=stress/SF;//kg/cm^2
T=f*%pi/4*D^2;//kg
x=L/2-T*h/(wr*L);//m
S1=wr*x^2/2/T;//max sag in air
disp(S1,"Slant sag(m)");
Sdash=wc*x^2/2/T;// vertical sag
disp(Sdash,"Vertical Sag(meter)");
```

Scilab code Exa 10.12 Determine the vertical sag

```
//Exa 10.12
clc;
clear;
close;
//Given data :
wc=1.925;//kg/m
A=2.2;//cm^2
f=8000;//kg/cm^2
L=600;//m
h=15;//m
D=2;//cm
SF=5;//safety factor
wi=1;//kg(load)
w=wi+wc;//kg
T=f*A/SF;//kg
```

```
x=L/2-T*h/(w*L);//m
S2=w*(L-x)^2/2/T;//m
disp(S2,"Vertical Sag(meter)");
```

Scilab code Exa 10.13 Find the clearance

```
//Exa 10.13
clc;
clear;
close;
//Given data :
h=80-50;//m
L=300;//m
T=2000;//kg
w=0.844;//kg/m
x=L/2-T*h/(w*L);//m
d_PO=L/2-x;//m
d_BO=L-x;//m
Smid=w*(L/2-x)^2/2/T;//m
S2=w*(L-x)^2/2/T;//m
Point_P=S2-Smid;//m
disp("Mid point P is "+string(Point_P)+" meter below
    point B or "+string(80-Point_P)+" meter above
   the water level.");
```

Scilab code Exa 10.14 Stringing Tension in the conductor

```
//Exa 10.14
clc;
clear;
close;
//Given data :
S1=25;//m
```

```
S2=75;//m
Point_P=45;//m
L1=250;//m
L2=125;//m(mid point)
w=0.7;//kg/m
h1=S2-S1;//m(for points A & B)
h2=Point_P-S1;//m(for points A & B)
//h1=w*L1/2/T*[L1-2*x]
//h2=w*L2/2/T*[L2-2*x]
x=(L1-h1/h2/L1*L2*L2)/(-h1/h2/L1*L2*2+2);//m
T=(L1-2*x)/(h1/w/L1*2);//kg
disp(T,"Stringing Tension(kg)");
```

Scilab code Exa 10.15 Find the clearance

```
//Exa 10.15
clc;
clear;
close;
//Given data :
L=300;//m
slope=1/20;
w=0.80;//kg/m
hl=30;//m
T0=1500;//kg
CD=L;//m
tan_alfa=slope;
ED=CD*tan_alfa;//m
AC=hl;//m
BE=hl;//m
BD=BE+ED;//m
//S1=w*x1^2/2/T0;//m
//S2=w*(L-x1)^2/2/T0;//m
h=15;//m
ED=h;//m
```

```
x1=L/2-T0*h/w/L;//m
S1=w*x1^2/2/T0;//m
S2=w*(L-x1)^2/2/T0;//m
OG=AC-S1-x1*tan_alfa;//m
Clearance=OG;//m
disp(Clearance,"Clearance of the lowest point from
    ground(m)");
//y=x*tan_alfa-OG;//m
//C1=w*x^2/2/T0-(x/20-OG)
x=T0/20/w;//m(Byy putting dC1/dx=0)
C1=w*x^2/2/T0-(x/20-OG);//m
disp(C1,"Minimum clearance(m)");
```

Scilab code Exa 10.16 sag and tension

```
//Exa 10.16
clc;
clear;
close;
//Given data :
L=250;//m
D=19.5;//mm
A=2.25*10^-4;//m^2
wc=0.85;//kg/m
t1=35;//degree C
t2=5;//degree C
Pw=38.5;//kg/m^2
alfa=18.44*10^-6;//per degree C
E=9320;//kg/mm^2
E=9320*10^6;//kg/m^2
Breaking_Load=8000;//kg
SF=2;//Safety factor
T1=Breaking_Load/SF;//kg
f1=T1/A;//kg/m^2
w_w=Pw*D*10^-2;//kg
```

```
w1=sqrt(wc^2+w_w^2);//kg
w2=wc;
//f2^2*[(f2-f1)+w1*L^2*E/24/f1^2/A^2+(t2-t1)*E]=w2*L
    ^2*E/24/A^2
//f2^3-f2^2*f1-w2*L^2*E/24/A^2=0
P=[1 -1.0674*10^7 0 -3463.84*10^17];
f2=roots(P);
f2=f2(1);//kg/m^2
S=w2*L^2/8/f2/A;//m
disp(S,"Sag at erection(m)");
```

Chapter 21

Insulated Cables

Scilab code Exa 11.1 Insulation Resistance

```
//Exa 11.1
clc;
clear;
close;
//Given data :
rho=5*10^14*10^-2;//ohm-m
l=5*1000;//m
r1=1.25;//m
r2=r1+1;//m
R_ins=rho/(2*%pi*l)*log(r2/r1);//ohm
disp(R_ins/10^6,"Insulation resistance of cable(Mohm
   ) :");
```

Scilab code Exa 11.2 Insulation Resistance

```
//Exa 11.2
clc;
clear;
```

```
close;
//Given data :
rho=5*10^14*10^-2;//ohm-m
l=5*1000;//m
r1=2.5;//m
r2=r1+1;//m
R_ins=rho/(2*%pi*l)*log(r2/r1);//ohm
disp(R_ins/10^6,"Insulation resistance of cable(Mohm
    ) :");
```

Scilab code Exa 11.3 Calculate the Resistivity

```
//Exa 11.3
clc;
clear;
close;
//Given data :
l=3000;//cm
d1=1.5;//cm
r1=d1/2;//cm
d2=5;//cm
r2=d2/2;//cm
R_INS=1800;//Mohm
rho=R_INS*10^6*(2*%pi*l)/log(r2/r1);//ohm-m
disp(rho,"Resistivity (ohm-m) :");
```

Scilab code Exa 11.4 Find Charging current

```
//Exa 11.4
clc;
clear;
close;
//Given data :
```

```
V1=11000;//Volt
f=50;//Hz
a=0.645;//cm^2
d=sqrt(4*a/%pi);//cm
d=d/100;//m
D=2.18/100;//m
epsilon_r=3.5;//relative permitivity
V=V1*sqrt(2)/sqrt(3);//V(assuming 3 phase system)
gmax=2*V/d/log(D/d);//V/m
gmax=gmax/10^5;//KV/cm
disp(gmax,"Maximum electrostatic stress(kV/cm)");
gmin=2*V/D/log(D/d);//V/m
gmin=gmin/10^5;//kV/cm
disp(gmin,"Minimum electrostatic stress(kV/cm)");
C=0.024*epsilon_r/log10(D/d);//micro F
disp(C*10^-6,"Capacitance per km length(F)");//
Vp=V1/sqrt(3);//V
Ic=2*%pi*f*C*10^-6*Vp;//A
disp(Ic,"Charging Current per phase per km length(A)
   ");
```

Scilab code Exa 11.5 Maximum Stress and Charging KVAR

```
//Exa 11.5
clc;
clear;
close;
//Given data :
VL=33*1000;//Volt
f=50;//Hz
l=3.4;//km
d=2.5;//cm
radial_thick=0.6;//cm
epsilon_r=3.1;//relative permitivity
V=VL*sqrt(2)/sqrt(3);//V(assuming 3 phase system)
```

```
D=d+2*radial_thick;//cm
D=D/100;//cm
d=d/100;//m
gmax=2*V/d/log(D/d);//V/m
disp(gmax,"Maximum electrostatic stress(V/m)");
C=0.024*epsilon_r*l/log10(D/d);//micro F
Vp=VL/sqrt(3);//V
Ic=2*%pi*f*C*10^-6*Vp;//A
kVA=sqrt(3)*VL*Ic*10^-3;//kVAR
disp(kVA,"Total charging kVA(kVAR)");
```

Scilab code Exa 11.6 Determine D and d

```
//Exa 11.6
clc;
clear;
close;
//Given data :
VL=10*1000;//Volt
Emax=23;//kV/cm
gmax=Emax*10^5;//V/m
d=2*VL/gmax;//m
disp(d*10^3,"Diameter of conductor(mm)");
D=%e*d;//m
disp(D*10^3,"Internal diameter of sheath(mm)");
```

Scilab code Exa 11.7 Most Economical value of diameter

```
//Exa 11.7
clc;
clear;
close;
//Given data :
```

```
VL=132*1000;//Volt
gmax=60;//kV/cm(peak)
gmax=gmax/sqrt(2)*10^5;//V/m(rms)
V=VL/sqrt(3);//Volt
d=2*V/gmax;//m
disp(d*10^3,"Diameter of conductor(mm)");
D=%e*d;//m
disp(D*10^3,"Internal diameter of sheath(mm)");
```

Scilab code Exa 11.8 Maximum safe working voltage

```
//Exa 11.8
clc;
clear;
close;
//Given data :
r=0.5;//cm
R=3.5;//cm
r1=1;//cm
g1max=34;//kV/cm(peak)
epsilon_r=5;//relative permitivity
g2max=g1max*r/r1/epsilon_r;//kV/cm(peak)
Vpeak=r*g1max*log(r1/r)+r1*g2max*log(R/r1);//kV
Vrms=Vpeak/sqrt(2);//kV
disp(Vrms,"RMS value of max safe working voltage(kV)
   ");
```

Scilab code Exa 11.9 Thickness and working voltage

```
////Exa 11.9
clc;
clear;
close;
```

```
//Given data :
g1max=60;//kV/cm
g2max=50;//kV/cm
epsilon_r1=4;//relative permitivity
epsilon_r2=2.5;//relative permitivity
D=5;//cm(sheat inside diameter)
d=1;//cm
//g1max/g2max=epsilon_r2*d1/(epsilon_r1*d)
d1=g1max/g2max/epsilon_r2*(epsilon_r1*d);//cm
t_inner=(d1-d)/2;//cm
disp(t_inner*10,"Radial thickness of inner
    dielectric(mm)");
t_outer=(D-d1)/2;//cm
disp(t_outer*10,"Radial thickness of outer
    dielectric(mm)");
Vpeak=g1max/2*d*log(d1/d)+g2max/2*d1*log(D/d1);//kV
Vrms=Vpeak/sqrt(2);//kV
disp(Vrms,"Maximum working voltage(rms in kV)");
```

Scilab code Exa 11.10 Working Voltage

```
////Exa 11.10
clc;
clear;
close;
//Given data :
r=1;//cm
R=2.5;//cm
d=2*r;//cm
D=2*R;//cm
epsilon_r1=5;//relative permitivity
epsilon_r2=4;//relative permitivity
epsilon_r3=3;//relative permitivity
gmax=40;//KV/cm
//epsilon_r1*d=epsilon_r2*d1=epsilon_r3*d2
```

```
d1=(epsilon_r1/epsilon_r2)*d;//cm
d2=(epsilon_r1/epsilon_r3)*d;//cm
Vpeak=gmax/2*(d*log(d1/d)+d1*log(d2/d1)+d2*log(D/d2)
   );//kV
Vrms=Vpeak/sqrt(2);//kV
disp(Vrms,"Working voltage(rms) for the cable (kV)")
   ;
```

Scilab code Exa 11.11 `Calculate Potential gradient`

```
//Exa 11.11
clc;
clear;
close;
//Given data :
Vs=66;//kV
d=1;//cm
d1=1+2*1;//cm
D=3+2*1;//cm
epsilon_r1=3;//relative permitivity
epsilon_r2=2.5;//relative permitivity
g2maxBYg1max=d*epsilon_r1/(d1*epsilon_r2);
Vmax=Vs*sqrt(2)/sqrt(3);//kV
//Vmax=g1max*d/2*log(d1/d)+g2max*d1/2*log(D/d1);//kV
g1max=Vmax/(d/2*log(d1/d)+g2maxBYg1max*d1/2*log(D/d1
   ));//kV/cm
disp(g1max,"Potential gradient at the surface of
   conductor(kV/cm)");
g2max=g1max*g2maxBYg1max;//kV/cm
disp(g2max,"Maximum stress in the outer dielectric(
   kV/cm)");
Stress=g2max*d1/D;//kV/cm
disp(Stress,"Stress at the surface of outer
   dielectric(kV/cm)");
```

Scilab code Exa 11.12 Determine the maximum stress

```
//Exa 11.12
clc;
clear;
close;
//Given data :
Vs=66;//kV
d=2;//cm
d1=2+2*1;//cm
D=4+2*1;//cm
epsilon_r1=5;//relative permitivity
epsilon_r2=3;//relative permitivity
g2maxBYg1max=d*epsilon_r1/(d1*epsilon_r2);
Vmax=Vs*sqrt(2)/sqrt(3);//kV
//Vmax=g1max*d/2*log(d1/d)+g2max*d1/2*log(D/d1);//kV
g1max=Vmax/(d/2*log(d1/d)+g2maxBYg1max*d1/2*log(D/d1
    ));//kV/cm
disp(g1max,"Potential gradient at the surface of
    conductor(kV/cm)");
g2max=g1max*g2maxBYg1max;//kV/cm
disp(g2max,"Maximum stress in the outer dielectric(
    kV/cm)");
```

Scilab code Exa 11.13 Minimum Internal Diameter

```
//Exa 11.13
clc;
clear;
close;
//Given data :
Vs=66;//kV
```

```
r=0.5;//cm
g1max=50;//kV/cm
g2max=40;//kV/cm
g3max=30;//kV/cm
epsilon_r1=4;//relative permitivity
epsilon_r2=4;//relative permitivity
epsilon_r3=2.5;//relative permitivity
//Q=2*%pi*epsilon0*epsilon_r1*r*g1max=2*%pi*epsilon0
    *epsilon_r2*r*g2max=2*%pi*epsilon0*epsilon_r3*r*
    g3max
r1=epsilon_r1*r*g1max/(epsilon_r2*g2max);//cm
r2=epsilon_r2*r1*g2max/(epsilon_r3*g3max);//cm
Vmax=Vs*sqrt(2);//kV
//Vmax=g1max*r*log(r1/r)+g2max*r1*log(r2/r1)+g3max*
    r2*log(R/r2);//kV
R=exp((Vmax-g1max*r*log(r1/r)-g2max*r1*log(r2/r1))/
    g3max/r2)*r2;//cm
D=2*R;//cm
disp(D,"Inner diameter of lead sheath(cm)");
```

Scilab code Exa 11.14 Diameter of intersheath

```
//Exa 11.14
clc;
clear;
close;
//Given data :
Vrms=66;//kV
Vmax=Vrms*sqrt(2);//kV
gmax=60;//kV/cm
d=2*Vmax/%e/gmax;//cm
d1=%e*d;//cm
V1=Vrms/%e;//kV
dV=Vrms-V1;//kV(Voltage between sheath & intersheath
    )
```

```
disp(dV,"Voltage between sheath & intersheath(kV)");
```

Scilab code Exa 11.15 Maximum stress and voltage

```
//Exa 11.15
clc;
clear;
close;
//Given data :
Vs=66;//kV
Vmax=Vs*sqrt(2)/sqrt(3);//kV
D=6;//cm
d=2.5;//cm
d1=%e*d;//cm
gmax=2*Vmax/d/log(D/d);//kV/cm
disp(gmax,"Maximum stress without intersheath(kV/cm)
   ");
//d1/d=d2/d1=D/d2=alfa(say)
alfa=(D/d)^(1/3);
d1=alfa*d;//cm
d2=alfa*d1;//cm
gmax=Vmax/(d/2*log(d1/d)+d1/2*log(d2/d1)+d2/2*log(D/
   d2));//kV/cm
V1max=gmax*d/2*log(d1/d);//kV
V2max=gmax*d1/2*log(d2/d1);//kV
Vpeak1=Vmax-V1max;//kV
disp(Vpeak1,"Peak voltage on 1st intersheath(kV)");
Vpeak2=Vpeak1-V2max;//kV
disp(Vpeak2,"Peak voltage on 2nd intersheath(kV)");
```

Scilab code Exa 11.16 capacitance and charging current

```
//Exa 11.16
```

```
clc;
clear;
close;
//Given data :
Vs=11;//kV
f=50;//Hz
l=2.5*1000;//m
C_all3=1.8;//micro F
Cdash=1.5;//micro F(2*Cc+Cs)
Cs=C_all3/3;//micro F
Cc=(Cdash-Cs)/2;//micro F
C_N=3*Cc+Cs;//micro F
disp(C_N,"Capacitance of core to neutral(micro F)");
C_2=C_N/2;//micro F
disp(C_2,"Capacitance between any two core(micro F)"
   );
Vp=Vs*1000/sqrt(3);//Volt
Ic=2*%pi*f*Vp*C_N*10^-6;//A
disp(Ic,"Charging current per phase(A)");
```

Scilab code Exa 11.17 `Calculate the KVA taken`

```
//Exa 11.17
clc;
clear;
close;
//Given data :
l=10;//km
Vs=10;//kV
f=50;//Hz
C=0.3;//micro F/km(between any two core)
C2=l*C;//micro F(between any two core)
C_N=2*C2;//micro F
Vp=Vs*1000/sqrt(3);//Volt
Ic=2*%pi*f*Vp*C_N*10^-6;//A
```

```
kVA=3*Vp*Ic/1000;//kVAR
disp(kVA,"kVA taken by the cable(kVAR)");
```

Scilab code Exa 11.18 Find the capacitance

```
//Exa 11.18
clc;
clear;
close;
//Given data :
Cs3=1;//micro F/km(between shorted conductor)
Cs=Cs3/3;//micro F
Cdash=0.6;//micro F(Cdash=2*Cc+Cs : between two
    shorted conductor)
Cc=(Cdash-Cs)/2;//micro F
C2=1/2*[3*Cc+Cs];//micro F
disp(C2,"Capacitance between any two cores(micro F)"
    );
C2dash=2*Cc+2/3*Cs;//micro F
disp(C2dash,"Capacitance between any two shorted
    conductors and third conductor(micro F)");
```

Scilab code Exa 11.19 Maximum Stress and total Charging KVAR

```
//Exa 11.19
clc;
clear;
close;
//Given data :
Vs=33;//kV
f=50;//Hz
l=3.4;//km
d=2.5;//cm
```

```
D=d+2*0.6;//cm
epsilon_r=3.1;//relative permitivity
C=0.024*epsilon_r/log10(D/d)*l*1000*1000*10^-6;// F/
    phase
Vp=Vs*1000/sqrt(3);//Volt
Ic=2*%pi*f*C*10^-6*Vp;//A
kVAR=3*Vp*Ic*10^-3;//kVAR
disp(kVAR,"Total charging kVAR : ");
Emax=Vp/(d/2*log(D/d))*10^-3;//kV/cm
disp(Emax,"Maximum stress in the cable(kV/cm) ");
```

Scilab code Exa 11.20 Capacitance Charging Current Loss Resistance

```
//Exa 11.20
clc;
clear;
close;
//Given data :
Vs=11;//kV
f=50;//Hz
D=2;//cm
d=0.5;//cm
epsilon_r=3.5;//relative permitivity
pf=0.05;//power factor
C=0.024*epsilon_r/log10(D/d)*10^-6;// F/km
disp(C*10^6,"Capacitance of the cable(micro F)");
Vp=Vs*1000/sqrt(3);//Volt
Ic=2*%pi*f*C*Vp;//A
disp(Ic,"Charging current(A)");
fi=acosd(pf);//degree
del=90-fi;//degree(Dielectric loss angle)
loss_dielectric=2*%pi*f*C*Vp^2*tand(del);//W
disp(loss_dielectric,"Dielectric loss(W)");
R_INS=Vp^2/loss_dielectric;//ohm
disp(R_INS/10^6,"Equivalent insulation resistance(
```

Mohm)");

Scilab code Exa 11.21 Loss angle and No load current

```
//Exa 11.21
clc;
clear;
close;
//Given data :
Vs=11;//kV
f=50;//Hz
C_N_by_2=2.5;//micro F(between 2 core 1 core shorted
    )
C_N=C_N_by_2*2;//micro F
Vp=Vs*1000/sqrt(3);//Volt
Ic=2*%pi*f*Vp*C_N*10^-6;//A
R_INS2=810;//kohm
R_INS=R_INS2/2;//kohm
del=atand(1/(R_INS*10^3*2*%pi*f*C_N*10^-6));//degree
disp(del,"Loss angle(degree)");
Ie=Vp/R_INS/1000;//A
I=sqrt(Ic^2+Ie^2);//A
disp(I,"No load current drawn by cable(A)");
```

Chapter 22

Neutral Grounding

Scilab code Exa 12.1 Reactance of coil

```
//Exa 12.1
clc;
clear;
close;
format('v',6);
//Given data :
f=50;//Supply frequency in Hz
C=4.5*10^-6;//in Farad
Omega_L=1/3/2/%pi/f/C;//in ohm
disp(Omega_L,"Reactance of coil (ohm) :");
```

Scilab code Exa 12.2 Inductance and kVA rating

```
//Exa 12.2
clc;
clear;
close;
format('v',5);
```

```
//Given data :
V=132*1000;//V
f=50;//Hz
r=10/1000;//m
d1=4;//m
d2=4;//m
d3=d1+d2;//m
epsilon_o=8.854*10^-12;//constant
l_tl=192*1000;//length of transmission line in m
C=2*%pi*epsilon_o/log((d1*d2*d3)^(1/3)/r)*l_tl;//in
    Farad
L=1/3/(2*%pi*f)^2/C;//H
disp(L,"Necessary Inductance of peterson coil in H :
    ");
VP=V/sqrt(3);//V
IL=VP/(2*%pi*f)/L;//A
Rating=VP*IL/1000;//kVA
disp(Rating/1000,"Rating of supressor coil in MVA :"
    );
```