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

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Book Description

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

Exa Example (Solved example)

Eqn Equation (Particular equation of the above book)

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

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

Contents

List of Scilab Codes

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Chapter 1

Power System Components

Scilab code Exa 1.1 Base Impedence

Base Impedence

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

Scilab code Exa 1.2 Per unit resistance

Per unit resistance

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

Scilab code Exa 1.3 Leakage Reactance per unit

```
Leakage Reactance per unit
```

```
1  //Exa 1.3
2  clc;
3  clear;
4  close;
5  //Given data :
6  kVA_B=2.5;//kVA
7  kV_B=0.4;//kV
8  reactance=0.96;//in ohm
9  Z_BLV=kV_B^2*1000/kVA_B;//in ohm
10 Zpu=reactance/Z_BLV;//in ohm
11 disp(Zpu,"Leakage reactance Per unit (pu) :");
```

Scilab code Exa 1.4 Per unit impedence

```
Per unit impedence
```

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

Scilab code Exa 1.5 Per unit Reactance

```
Per unit Reactance
```

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

Chapter 2

Supply System

Scilab code Exa 2.1 Saving in feeder

Saving in feeder

```
1  //Exa 2.1
2  clc;
3  clear;
4  close;
5  //Given data :
6  VL1=220;//Volts
7  VL2=400;//Volts
8  disp("We know, W=I^2*2*R=(P/VL)^2*2*rho*l/a");
9  disp("a=(P/VL)^2*2*rho*l/(I^2*2*R)");
10 disp("v=2*(P/VL)^2*2*rho*l/(I1^2*2)*l");
11 saving=(2/(VL1)^2-2/(VL2)^2)/(2/(VL1)^2)*100;//%
12 disp(saving,"% saving in copper : ");
```

Scilab code Exa 2.2 Compare amount of material

Compare amount of material

```
1  //Exa 2.2
2  clc;
3  clear;
4  close;
5
6  disp("Two wire dc system : ");
7  disp("I1=P/V & W=2*I1^2*R1=2*P^2*rho*l/V^2/a1");
8  disp("Therefore, Volume required, v1 is 2*a1*l=4*P
       ^2*rho*l^2/V^2/W");
9  disp("Three phase four wire system : ");
10 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");
11 disp("Therefore, Volume required, v2 is 3.5*a2*l
       =3.5*P^2*rho*l^2/3/V^2/W");
12 v2BYv1=3.5/3/4; //
13 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

```
Percentage additional load
```

```
1  //Exa 2.3
2  clc;
3  clear;
4  close;
5
6  disp("For single phase ac system, P1=V*I1*cosd(fi)
       watts & W1=2*I1^2*R watts");
7  disp("Line losses=W1/P1*100=2*I1^2*R*100/V/I1/cosd(
       fi)");
8  disp("For three phase ac system, P2=sqrt(3)*V*I2*
       cosd(fi) watts & W2=3*I2^2*R watts");
```

```
9  disp("Line losses=W2/P2*100=3*I2^2*R*100/sqrt(3)/V/
        I2/cosd(fi)");
10 //on equating W1/P1*100=W2/P2*100
11 I2BYI1=2*sqrt(3)/3;
12 P1=poly(0,'P1');
13 //P2=sqrt(3)*V*I1*I2BYI1*cosd(fi)=2*P1
14 P2=2*P1;
15 Add_load=P2-P1;
16 Percent_add_load=coeff(numer(Add_load/P1*100));//%
17 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

```
Find extra power
```

```
1  //Exa 2.4
2  clc;
3  clear;
4  close;
5
6  disp("For three wire dc system, line current I1=(VS-
        VL)/R & P1=2*VL*I1=2*VL*(VS-VL)/R");
7  disp("For four wire three phase ac system, line
        current I2=(VS-VL)/R & P2=3*VL*I2*pf=3*VL*(VS-VL)
        /R");
8  //P2=3/2*2*VL*(VS-VL)/R////It implies that P2=3/2*P1
9  P1=poly(0,'P1');
10 P2=3/2*P1;
11 Diff=P2-P1;
12 Percent_Diff=coeff(numer(Diff/P1*100));//%
13 disp(Percent_Diff,"Extra power that can be supplied
        in %");
```

Scilab code Exa 2.5 Percentage additional load

Percentage additional load

```
1  //Exa 2.5
2  clc;
3  clear;
4  close;
5
6  pf=0.9;//power factor
7  disp("Three wire dc system : ");
8  disp("P1=2*I1*V & %P1loss=2*I1^2*R/(2*I1*V)*100=100*
      I1*R/V");
9  disp("Three phase 4-wire ac system : ");
10 disp("P2=3*I1^2*V*pf & %P2loss=3*I2^2*R/(3*I2*V*pf)
      *100=100*I12*R/pf/V");
11 //on equating P1loss=P2loss;
12 I2BYI1=100*pf/100;//ratio
13 //P2=3*I2*V*pf
14 P2BYI1V=3*pf*I2BYI1;
15 P2BYP1=P2BYI1V/2;
16 //LoadIncrease=(P2-P1)*100/P1;
17 LoadIncrease=(P2BYP1-1)*100;//%
18 disp(LoadIncrease,"% Additional load : ");
```

Scilab code Exa 2.6 Weight of copper required

Weight of copper required

```
1  //Exa 2.6
2  clc;
```

```scilab
 3  clear;
 4  close;
 5  format('v',6);
 6  //Given data :
 7  Pin=100;//MW
 8  VL=380;//kV
 9  d=100;//km
10  R=0.045;//ohm/cm^2/km
11  w=0.01;//kg/cm^3
12  Eta=90;//efficiency %
13  cosfi=1;
14  IL=Pin*10^6/sqrt(3)/VL/10^3/cosfi;//Ampere
15  W=Pin*(1-Eta/100);//MW
16  LineLoss=W*10^6/3;//Watts/conductor
17  R1=LineLoss/IL^2;//in ohm
18  R2=R1/d;//resistance per conductor per km
19  a=R/R2;//in cm^2
20  volume=a*d*1000;//cm^3 per km run
21  weight=w*volume;//kg per km run
22  w3=3*d*weight;//kg(weight of copper required for 3
        conductors for 100 km)
23  disp(w3,"Weight of copper required for 3 conductors
        of 100 km length(in kg) : ");
24  //Answer in the book is not accurate.
```

Chapter 3

Transmission Lines

Scilab code Exa 3.1 Weight of material required

Weight of material required

```scilab
1  //Exa 3.1
2  clc;
3  clear;
4  close;
5  //Given data :
6  P=30*10^6;//W
7  pf=0.8;//lagging power factor
8  VL=132*1000;//V
9  l=120*1000;//m
10 Eta=90/100;//Efficiency
11 rho_Cu=1.78*10^-8;//ohm-m
12 D_Cu=8.9*10^3;//kg/m^3
13 rho_Al=2.6*10^-8;//ohm-m
14 D_Al=2*10^3;//kg/m^3
15 IL=P/(sqrt(3)*VL*pf);//A
16 //W=3*IL^2*rho*l/a=(1-Eta)*P
17 a_Cu=(3*IL^2*rho_Cu*l)/(1-Eta)/P;//m^2
18 V_Cu=3*a_Cu*l;//m^3
19 Wt_Cu=V_Cu*D_Cu;//kg
```

```
20  disp(Wt_Cu,"Weight of copper required(kg)");
21  a_Al=(3*IL^2*rho_Al*l)/(1-Eta)/P;//m^2
22  V_Al=3*a_Al*l;//m^3
23  Wt_Al=V_Al*D_Al;//kg
24  disp(Wt_Al,"Weight of Alluminium required(kg)");
25  //Answer in the textbook is not accurate.
```

Scilab code Exa 3.2 Most Economical Cross section Area

Most Economical Cross section Area

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

Scilab code Exa 3.3 Best Current Density

Best Current Density

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

Scilab code Exa 3.4 Economical current density and diameter

Economical current density and diameter

```scilab
1  //Exa 3.4
2  clc;
3  clear;
4  close;
5  //Given data :
6  V=11;//kV
7  P=1500;//kW
8  pf=0.8;//lagging power factor
9  t=300*8;//hours
10 a=poly(0,'a');//cross section area
11 Cc=8000+20000*a//Rs/km
12 R=0.173/a;//ohm/km
13 E_lost_cost=2/100;//Rs/unit
14 i=12;//%(interest and depreciation)
15 Cc_var=20000*a//Rs/km(variable cost)
16 P2a=Cc_var*i/100;//Rs/km
17 P2=P2a/a;
18 I=P/sqrt(3)/V/pf;//A
19 W=3*I^2*R;//W
20 E_loss=W/1000*t;//kWh
21 P3BYa=E_lost_cost*E_loss;//Rs
22 //P2a=P3BYa;//For most economical cross section
23 a=sqrt(coeff((numer(P3BYa))/coeff(numer(P2))));//cm
       ^2
24 d=sqrt(4*a/%pi);//cm
25 del=I/a;//A/cm^2
26 disp(d,"Diameter of conductor in cm : ");
27 disp(del,"Most economical current density in A/cm^2
       : ");
```

19

Scilab code Exa 3.5 Most economical current density

```
Most economical current density
```

```scilab
1  //Exa 3.5
2  clc;
3  clear;
4  close;
5  //Given data :
6  a=poly(0,'a');//cross section area
7  I=poly(0,'I');//Current
8  Cc=500+2000*a//Rs/km
9  i=12;//%(interest and depreciation)
10 E_lost_cost=5/100;//Rs/kWh
11 rho=1.78*10^-8;//ohm-cm
12 load_factor=0.12;
13 Cc_var=2000*a//Rs/km(variable cost)
14 P2a=Cc_var*i/100;//Rs/km
15 P2=P2a/a;
16 R_into_a=rho*1000/(10^-4);//ohm
17 W_into_a=I^2*R_into_a;//W
18 E_loss_into_a=W_into_a*load_factor/1000*8760;//kWh
19 P3BYIsqr=E_lost_cost*E_loss_into_a/I^2;//Rs
20 //P2a=P3BYa;//For most economical cross section
21 IBYa=sqrt(coeff((numer(P2))/coeff(numer(P3BYIsqr))))
       ;//cm^2
22 disp(IBYa,"Most economical current density in A/cm^2
        : ");
```

Scilab code Exa 3.6 Most Economical current density

```
Most Economical current density
```

```scilab
1  //Exa 3.6
2  clc;
3  clear;
4  close;
5  //Given data :
6  A=poly(0,'A');//cross section area
7  I=poly(0,'I');//Current
8  Cc=500+2000*A//Rs/km
9  load_factor=0.12;
10 i=12;//%(depreciation)
11 E_lost_cost=0.05;//Rs/kWh
12 R=0.17/A;//ohm/km
13
14 Cc_var=2000*A//Rs/km(variable cost)
15 P2A=Cc_var*i/100;//Rs/km
16 P2=P2A/A;
17 R_into_A=R*A;//ohm
18 W_into_A_BY_Isqr=R_into_A;//W
19 E_loss_into_A_BY_Isqr=W_into_A_BY_Isqr*load_factor
      /1000*8760;//kWh
20 P3BYIsqr=E_lost_cost*E_loss_into_A_BY_Isqr;//Rs
21 //P2a=P3BYa;//For most economical cross section
22 IBYa=sqrt(coeff((numer(P2))/coeff(numer(P3BYIsqr))))
      ;//cm^2
23 disp(IBYa,"Most economical current density in A/cm^2
       : ");
24 //Answer in the textbook is wrong.
```

Scilab code Exa 3.7 Most economical size

Most economical size

```scilab
1  //Exa 3.7
2  clc;
3  clear;
```

```
 4  close;
 5  //Given data :
 6  P1=1000;//kW
 7  pf1=0.8;//
 8  t1=10;//hours
 9  P2=500;//kW
10  pf2=0.9;//
11  t2=8;//hours
12  P3=100;//kW
13  pf3=1;//
14  t3=6;//hours
15  a=poly(0,'a');//cross section area
16  I=poly(0,'I');//Current
17  L=poly(0,'L');//length in km
18  CcBYL=(8000*a+1500)//Rs/km(variable cost)
19  i=10;//%(depreciation)
20  E_lost_cost=80/100;//Rs/kWh
21  rho=1.72*10^-6;//ohm-cm
22  Cc_varBYL=8000*a*i/100//Rs/km(variable cost)
23  I1=P1*1000/sqrt(3)/10000/pf1;//A
24  I2=P2*1000/sqrt(3)/10000/pf2;//A
25  I3=P3*1000/sqrt(3)/10000/pf3;//A
26  R_into_a_BY_L=rho*1000*100;//ohm
27  W_into_A_BY_Isqr=R_into_a_BY_L;//W
28  E_loss_into_A_BY_L=3*R_into_a_BY_L*[I1^2*t1+I2^2*t2+
       I3^2*t3]*365/1000;//kWh
29  E_loss_cost_into_A_BY_L=E_loss_into_A_BY_L*
       E_lost_cost;//Rs
30  //Cc_var=E_loss_cost;//For most economical cross
       section
31  a=sqrt(coeff((numer(E_loss_cost_into_A_BY_L))/coeff(
       numer(Cc_varBYL/a))));//cm^2
32  disp(a,"Most economical cross sectional area in cm^2
        : ");
```

Chapter 4

Inductance and Capacitance of Transmission Lines

Scilab code Exa 4.1 Loop inductance and reactance

Loop inductance and reactance

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

Scilab code Exa 4.2 Calculate Inductance

Calculate Inductance

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

Scilab code Exa 4.3 Calculate Loop inductance

Calculate Loop inductance

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

```
13  disp(L_steel*10^3,"Loop inductance per km of copper
       conductor line(mH)");
```

Scilab code Exa 4.4 Calculate GMR

```
Calculate GMR
```

```
 1  //Exa 4.4
 2  clc;
 3  clear;
 4  close;
 5  //Given data :
 6  r=3; //mm
 7  d11=r; //mm
 8  d12=2*r; //mm
 9  d34=2*r; //mm
10  d16=2*r; //mm
11  d17=2*r; //mm
12  d14=4*r; //mm
13  d13=sqrt(d14^2-d34^2); //mm
14  d15=d13; //mm
15  Ds1=(0.7788*d11*d12*d13*d14*d15*d16*d17)^(1/7); //mm
16  Ds2=Ds1; //mm
17  Ds3=Ds1; //mm
18  Ds4=Ds1; //mm
19  Ds5=Ds1; //mm
20  Ds6=Ds1; //mm
21  Ds7=(2*r*0.7788*d11*d12*d13*2*r*2*r)^(1/7); //mm
22  Ds=(Ds1*Ds2*Ds3*Ds4*Ds5*Ds6*Ds7)^(1/7); //mm
23  disp(Ds,"Geometric mean radius(mm)");
24  //Answer in the book is wrong
```

Scilab code Exa 4.5 Determine total inductance

Determine total inductance

```
1  //Exa 4.5
2  clc;
3  clear;
4  close;
5  //Given data :
6  r=1.2;//cm
7  rdash=0.7788*r;//cm
8  d12=0.12*100;//cm
9  d11dash=(0.2+1.2)*100;//cm
10 d22dash=(0.2+1.2)*100;//cm
11 d12dash=(0.2+1.2+0.2)*100;//cm
12 d21dash=(1.2)*100;//cm
13 Dm=(d11dash*d12dash*d21dash*d22dash)^(1/4);//cm
14 d11=0.93456;//cm
15 d22=0.93456;//cm
16 d12=20;//cm
17 d21=20;//cm
18 Ds=(d11*d12*d21*d22)^(1/4);//cm
19 L=0.4*log(Dm/Ds);//mH/km
20 disp(L,"Loop inductance of line(mH/km)");
```

Scilab code Exa 4.6 Determine total inductance

Determine total inductance

```
1  //Exa 4.6
2  clc;
3  clear;
4  close;
5  //Given data :
6  r=2/2;//cm
7  rdash=0.7788*r;//cm
```

26

```
8   d12=0.12*100;//cm
9   d11dash=300;//cm
10  d12dash=sqrt(300^2+100^2);//cm
11  d21dash=d12dash;//cm
12  d22dash=d11dash;//cm
13  d11=rdash;//cm
14  d22=rdash;//cm
15  d12=100;//cm
16  d21=100;//cm
17  Dm=(d11dash*d12dash*d21dash*d22dash)^(1/4);//cm
18  Ds=(d11*d12*d21*d22)^(1/4);//cm
19  L=0.4*log(Dm/Ds);//mH/km
20  disp(L,"Loop inductance of line(mH/km)");
```

Scilab code Exa 4.7 Inductance per km

Inductance per km

```
1   //Exa 4.7
2   clc;
3   clear;
4   close;
5   //Given data :
6   r=1.24/2;//cm
7   rdash=0.7788*r;//cm
8   d=2*100;//cm
9   L=0.2*log(d/rdash);//mH
10  disp(L,"Inductance per phase per km(mH)");
```

Scilab code Exa 4.8 Inductance per km

Inductance per km

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

Scilab code Exa 4.9 Inductance per km

```
Inductance per km
```

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

Scilab code Exa 4.10 Spacing between adjacent conductors

Spacing between adjacent conductors

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

Scilab code Exa 4.11 Inductance per phase per km

Inductance per phase per km

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

Scilab code Exa 4.12 Inductance per phase per km

Inductance per phase per km

```scilab
1  //Exa 4.12
2  clc;
3  clear;
4  close;
5  //Given data :
6  r=0.9;//cm
7  rdash=0.7788*r*10^-2;//m
8  daa_dash=sqrt(6^2+6^2);//m
9  dbb_dash=7;//m
10 dcc_dash=daa_dash;//m
11 daa=rdash;//m
12 d_adash_adash=rdash;//m
13 d_adash_a=daa_dash;//m
14 Dsa=(daa*daa_dash*d_adash_adash*d_adash_a)^(1/4);//m
15 Dsb=(daa*7)^(1/2);//m
16 Dsc=(daa*daa_dash)^(1/2);//m
17 Ds=(Dsa*Dsb*Dsc)^(1/3);//m
18 dab=sqrt(3^2+0.5^2);//m
19 dab_dash=sqrt(3^2+6.5^2);//m
20 d_adash_b=sqrt(3^2+6.5^2);//m
21 d_adash_bdash=sqrt(3^2+0.5^2);//m
22 Dab=(dab*dab_dash*d_adash_b*d_adash_bdash)^(1/4);//m
23 Dbc=((dab*dab_dash)^2)^(1/4);//m
24 Dca=((6*6)^2)^(1/4);//m
25 Dm=(Dab*Dbc*Dca)^(1/3);//m
26 L=0.2*log(Dm/Ds);//mH/km
27 disp(L,"Inductance per phase(mH/km)");
```

Scilab code Exa 4.13 GMD GMR and Overall Inductance

GMD GMR and Overall Inductance

```
1  //Exa 4.13
2  clc;
3  clear;
4  close;
5  format('v',5)
6  //Given data :
7  r=5/2; //mm
8  rdash=2.176*r*10^-3; //m
9  daa_dash=sqrt(6^2+16^2); //m
10 dbb_dash=6; //m
11 dcc_dash=daa_dash; //m
12 dab=8; //m
13 dab_dash=sqrt(6^2+8^2); //m
14 dbc=8; //m
15 dbc_dash=sqrt(6^2+8^2); //m
16 dca=16; //m
17 dca_dash=6; //m
18 Dsa=sqrt(rdash*daa_dash); //m
19 Dsb=sqrt(rdash*dbb_dash); //m
20 Dsc=sqrt(rdash*dcc_dash); //m
21 Ds=(Dsa*Dsb*Dsc)^(1/3); //m
22 disp(Ds,"GMD(m) : ");
23 Dab=(dab*dab_dash)^(1/2); //m
24 Dbc=(dbc*dbc_dash)^(1/2); //m
25 Dca=(dca*dca_dash)^(1/2); //m
26 Dm=(Dab*Dbc*Dca)^(1/3); //m
27 disp(Dm,"Deq or Dm(m) : ");
28 L=0.2*log(Dm/Ds); //mH/km
29 L=L*10^-3*100; //H(for 100 km line)
30 disp(L,"Inductance of 100 km line(H)");
31 ///Alternate method is given below
32 d1=dab; //m
33 d2=dca_dash; //m
```

```
34  L=0.2*log(2^(1/6))*sqrt(d1/rdash)*((d1^2+d2^2)/(4*d1
        ^2+d2^2))^(1/6);//mH
35  L=L*10^-3*100;//H(for 100 km line)
36  disp(L,"Using Alternate method, Inductance of 100 km
         line(H)");
```

Scilab code Exa 4.14 Inductance per km

```
Inductance per km
```

```
1  //Exa 4.14
2  clc;
3  clear;
4  close;
5  //Given data :
6  r=5/2;//cm
7  rdash=0.7788*r*10^-2;//m
8  d=6.5;//m
9  s=0.4;//m
10  Ds=sqrt(rdash*s);//m
11  dab=6.5;//m
12  dab_dash=6.9;//m
13  d_adash_b=6.1;//m
14  d_adash_bdash=6.5;//m
15  Dab=(dab*dab_dash*d_adash_b*d_adash_bdash)^(1/4);//m
16  Dbc=Dab;//m
17  dca=13;//m
18  dca_dash=12.6;//m
19  d_cdash_a=13.4;//m
20  d_cdash_adash=13;//m
21  Dca=(dca*dca_dash*d_cdash_a*d_cdash_adash)^(1/4);//m
22  Dm=(Dab*Dbc*Dca)^(1/3);//m
23  L=0.2*log(Dm/Ds);//mH/km
24  disp(L,"Inductance per phase(mH/km)");
```

Scilab code Exa 4.15 Find inductive reactance

Find inductive reactance

```scilab
1  //Exa 4.15
2  clc;
3  clear;
4  close;
5  //Given data :
6  f=50; //Hz
7  r=3.5/2; //cm
8  rdash=0.7788*r*10^-2; //m
9  d=7; //m
10 s=40/100; //m
11 Ds=sqrt(rdash*s); //m
12 dab=7; //m
13 dab_dash=7.4; //m
14 d_adash_b=6.6; //m
15 d_adash_bdash=7; //m
16 Dab=(dab*dab_dash*d_adash_b*d_adash_bdash)^(1/4); //m
17 Dbc=Dab; //m
18 dca=14; //m
19 dca_dash=13.6; //m
20 d_cdash_a=14.4; //m
21 d_cdash_adash=14; //m
22 Dca=(dca*dca_dash*d_cdash_a*d_cdash_adash)^(1/4); //m
23 Dm=(Dab*Dbc*Dca)^(1/3); //m
24 L=0.2*log(Dm/Ds); //mH/km
25 XL=2*%pi*f*L*10^-3; //ohm/km
26 disp(XL,"Inductive reactance of bundled conductor
      line (ohm/km)");
27 //Equivalent single conductor
28 n=2;
29 r1=sqrt(n*%pi*r^2/%pi); //m
```

```
30  r1dash =0.7788* r1 *10^ -2; //m
31  Dm1 =( Dab * Dbc * Dca ) ^(1/3) ; //m
32  L1 =0.2* log ( Dm1 / r1dash ) ; //mH/km
33  XL1 =2* %pi *f* L1 *10^ -3; //ohm/km
34  disp ( XL1 ," Inductive  reactance  with  single  conductor (
        ohm/km)");
```

_____

Scilab code Exa 4.16 Find out Capacitance

Find out Capacitance

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

_____

Scilab code Exa 4.17 Calculate Capacitance

Calculate Capacitance

```
1  //Exa  4.17
2  clc ;
3  clear ;
4  close ;
5  //Given  data  :
```

34

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

Scilab code Exa 4.18 Capacitance per conductor per km

```
Capacitance per conductor per km
```

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

Scilab code Exa 4.19 Capacitance and Charging current

```
Capacitance and Charging current
```

```
1  //Exa 4.19
2  clc;
3  clear;
4  close;
```

```
5  //Given data :
6  f=50; //Hz
7  VL=220; //KV
8  r=20/2/1000; //m
9  d1=3; //m
10 d2=3; //m
11 d3=6; //m
12 epsilon_o=8.854*10^-12; //permitivity
13 CN=2*%pi*epsilon_o/log((d1*d2*d3)^(1/3)/r); //F
14 disp(CN,"Capacitance per phase per meter line(F)");
15 Vph=VL*1000/sqrt(3); //V
16 Ic=2*%pi*f*CN*Vph; //A
17 disp(Ic*1000,"Charging current per phase(mA) : ");
```

Scilab code Exa 4.20 Capacitance to neutral and charging per km

Capacitance to neutral and charging per km

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

Scilab code Exa 4.21 Capacitance to neutral and charging current

Capacitance to neutral and charging current

```
1  //Exa 4.21
2  clc;
3  clear;
4  close;
5  //Given data :
6  r=2.5/2*10^-2;//m
7  VL=132;//KV
8  epsilon_o=8.85*10^-12;//permitivity
9  f=50;//Hz
10 dRRdash=sqrt(7^2+(4+4)^2);//m
11 dBBdash=dRRdash;//m
12 dYYdash=9;//m
13 DSR=sqrt(r*dRRdash);//m
14 DSY=sqrt(r*dYYdash);//m
15 DSB=sqrt(r*dBBdash);//m
16 Ds=(DSR*DSB*DSY)^(1/3);//m
17 dRY=sqrt(4^2+(4.5-3.5)^2);//m
18 dRYdash=sqrt((9-1)^2+4^2);//m
19 dRdashY=sqrt((9-1)^2+4^2);//m
20 dRdashYdash=sqrt(4^2+(4.5-3.5)^2);//m
21 DRY=(dRY*dRYdash*dRdashY*dRdashYdash)^(1/4);//m
22 DYB=((dRY*dRYdash)^2)^(1/4);//m
23 DBR=((8*7)^2)^(1/4);//m
24 Dm=(DRY*DYB*DBR)^(1/3);//m
25 C=2*%pi*epsilon_o/log(Dm/Ds);//F/m
26 C=C/10^-3;//F/km
27 X=1/(2*%pi*f*C);//ohm
28 disp(X/1000,"Capacitive reactance too neutral(kohm)
      : ");
29 Vph=VL*1000/sqrt(3);//Volt
```

```
30  Ic=2*%pi*f*C*Vph;//A
31  disp(Ic,"Charging  current(A/km)");
```

Scilab code Exa 4.22 Capacitance per phase

Capacitance per phase

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

Scilab code Exa 4.23 Capacitance and charging current

Capacitance and charging current

```
1  //Exa  4.23
2  clc;
3  clear;
4  close;
5  //Given  data  :
```

```
 6  VL=132; //kV
 7  f=50; //Hz
 8  r=5/2; //cm
 9  rdash=0.7788*r*10^-2; //m
10  d=6.5; //m
11  s=0.4; //m
12  epsilon_o=8.854*10^-12; // permitivity
13  Ds=sqrt(rdash*s); //m
14  dab=6.5; //m
15  dab_dash=6.9; //m
16  d_adash_b=6.1; //m
17  d_adash_bdash=6.5; //m
18  Dab=(dab*dab_dash*d_adash_b*d_adash_bdash)^(1/4); //m
19  Dbc=Dab; //m
20  dca=13; //m
21  dca_dash=12.6; //m
22  d_cdash_a=13.4; //m
23  d_cdash_adash=13; //m
24  Dca=(dca*dca_dash*d_cdash_a*d_cdash_adash)^(1/4); //m
25  Dm=(Dab*Dbc*Dca)^(1/3); //m
26  L=0.2*log(Dm/Ds); //mH/km
27  C=2*%pi*epsilon_o/log(Dm/Ds); //F/m
28  C=C/10^-3; //F/km
29  disp(C,"Capacitance per km(F/km) : ");
30  Vph=VL*1000/sqrt(3); //Volt
31  Ic=2*%pi*f*C*Vph; //A/km
32  disp(Ic,"Charging current per km(A/km) : ");
```

Scilab code Exa 4.24 Inductive and Capacitive reactances

```
Inductive and Capacitive reactances
```

```
 1  //Exa 4.24
 2  clc;
 3  clear;
```

```
 4  close;
 5  //Given data :
 6  VL=132; //kV
 7  f=50; //Hz
 8  r=31.8/2; //mm
 9  rdash=0.7788*r; //mm
10  d=10*1000; //mm
11  epsilon_o=8.854*10^-12; //permitivity
12  disp("One conductor ACSR moose conductor line : ");
13  LA=0.2*[log(d/rdash)+1/2*log(2)-%i*0.866*log(2)]; //
       mH/km
14  LB=0.2*log(d/rdash); //mH/km
15  LC=0.2*[log(d/rdash)+1/2*log(2)+%i*0.866*log(2)]; //
       mH/km
16  Lav=(LA+LB+LC)/3; //mH/km
17  XL=2*%pi*f*Lav*10^-3; //ohm
18  disp(XL,"Inductive reactance per Km per phase(ohm) :
        ");
19  d1=10; //m
20  d2=10; //m
21  d3=20; //m
22  CN=2*%pi*epsilon_o/log((d1*d2*d3)^(1/3)/(rdash
       *10^-3))/10^3; //F/km
23  XC=1/(2*%pi*f*CN*10^6); //ohm
24  disp(XC/10^6,"Capacitivetive reactance per Km per
       phase(Mohm) : ");
25  disp("Three conductor bundled line : ");
26  S=40/100; //m
27  Ds=(rdash*10^-3*S^2)^(1/3); //m
28  Deq=(d1*d2*d3)^(1/3); //m
29  Ldash=0.2*log(Deq/Ds); //mH/km
30  XLdash=2*%pi*f*Ldash*10^-3; //ohm
31  disp(XLdash,"Inductive reactance per km per phase(
       ohm) : ");
32  Ds=(r*10^-3*S^2)^(1/3); //m
33  Cdash=2*%pi*epsilon_o*10^3/log(Deq/Ds); //microF/km
34  XC=1/(2*%pi*f*Cdash)/10^6; //Mohm
35  disp(XC,"Capacitivetive reactance per km per phase(
```

Mohm) : ");

___

Scilab code Exa 4.25 Capacitance per km

```
Capacitance per km
```

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

___

Scilab code Exa 4.26 Determine the capacitance

```
Determine the capacitance
```

```scilab
1  //Exa 4.26
2  clc;
3  clear;
4  close;
5  //Given data :
6  r=2/100;//m
7  d1=4;//m
8  d2=4;//m
9  d3=8;//m
10 epsilon_o=8.854*10^-12;//permitivity
```

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

Chapter 5

Representation and Performance of short and medium Transmission Lines

Scilab code Exa 5.1 Voltage Regulation and Efficiency

Voltage Regulation and Efficiency

```
1  //Exa 5.1
2  clc;
3  clear;
4  close;
5  //Given data :
6  P=1100;//kW
7  VR=11*1000;//V
8  pf=0.8;//power factor
9  R=2;//ohm
10 X=3;//ohm
11 I=P*1000/VR/pf;//A
12 cos_fi_r=pf;
13 sin_fi_r=sqrt(1-cos_fi_r^2);
14 VS=sqrt((VR*cos_fi_r+I*R)^2+(VR*sin_fi_r+I*X)^2);//V
15 disp(VS,"Voltage at sending end(V)");
```

```
16  Reg=(VS-VR)/VR*100; //%
17  disp(Reg,"% Regulation");
18  LineLoss=I^2*R/1000; //kW
19  Eta_T=P*100/(P+LineLoss); //%
20  disp(Eta_T,"Transmission Efficiency(%)");
```

Scilab code Exa 5.2 Voltage Regulation and Efficiency

```
Voltage Regulation and Efficiency
```

```
1   //Exa 5.2
2   clc;
3   clear;
4   close;
5   //Given data :
6   R=0.4; //ohm
7   X=0.4; //ohm
8   P=2000; //kVA
9   pf=0.8; //power factor
10  VL=3000; //V
11  VR=VL/sqrt(3); //V
12  cos_fi_r=pf;
13  sin_fi_r=sqrt(1-cos_fi_r^2);
14  I=P*1000/3/VR; //A
15  VS=VR+I*(R*cos_fi_r+X*sin_fi_r); //V
16  Reg=(VS-VR)/VR*100; //%
17  disp(Reg,"% Regulation");
18  LineLoss=3*I^2*R/1000; //kW
19  Pout=P*cos_fi_r; //kW
20  Eta_T=Pout*100/(Pout+LineLoss); //%
21  disp(Eta_T,"Transmission Efficiency(%)");
```

Scilab code Exa 5.3 Sending end Voltage and Regulation

Sending end Voltage and Regulation

```
1  //Exa 5.3
2  clc;
3  clear;
4  close;
5  //Given data :
6  l=15;//km
7  P=5;//MW
8  V=11;//kV
9  f=50;//Hz
10 pf=0.8;//power factor
11 cos_fi_r=pf;
12 sin_fi_r=sqrt(1-cos_fi_r^2);
13 L=1.1;//mH/Km
14 VR=V*1000/sqrt(3);//V
15 I=P*1000/sqrt(3)/V/cos_fi_r;//A
16 LineLoss=12/100*P*10^6;//W
17 R=LineLoss/3/I^2;//ohm
18 X=2*%pi*f*L*10^-3*l;//ohm/phase
19 VS=VR+I*(R*cos_fi_r+X*sin_fi_r);//V
20 VSL=sqrt(3)*VS/1000;//KV
21 disp(VSL,"Line voltage at sending end(kV)");
22 Reg=(VSL-V)/V*100;//%
23 disp(Reg,"% Regulation");
```

Scilab code Exa 5.4 Voltage PF Efficiency and Regulation

Voltage PF Efficiency and Regulation

```
1  //Exa 5.4
2  clc;
3  clear;
4  close;
```

```
5  //Given data :
6  l=50;//km
7  S=10000;//kVA
8  pf=0.8;//power factor
9  d=1.2*100;//cm
10 cos_fi_r=pf;
11 sin_fi_r=sqrt(1-cos_fi_r^2);
12 V=33000;//Volts
13 VR=V/sqrt(3);//V
14 f=50;//Hz
15 I=S*1000/sqrt(3)/V;//A
16 LineLoss=10/100*S*10^3*pf;//W
17 R=LineLoss/3/I^2;//ohm
18 rho=1.73*10^-6;//kg/m^3
19 a=rho*l*1000*100/R;//cm^2
20 r=sqrt(a/%pi);//cm
21 L=0.2*log(d/r/0.7788)*l;//mH
22 X=2*%pi*f*L*10^-3;//ohm
23 VS=VR+I*(R*cos_fi_r+X*sin_fi_r);//V
24 VSL=sqrt(3)*VS/1000;//kV
25 disp(VSL,"Line voltage at sending end(kV)");
26 pf_s=(VR*cos_fi_r+I*R)/VS;//lagging(sendinf end pf)
27 disp(pf_s,"Sending end pf(lagging) ");
28 Eta_T=S*pf/(S*pf+LineLoss/1000)*100;
29 disp(Eta_T,"Transmission Efficiency(%)");
30 Reg=(VSL-V/1000)/(V/1000)*100;//%
31 disp(Reg,"% Regulation");
```

Scilab code Exa 5.5 Resistance and Inductance of line

Resistance and Inductance of line

```
1  //Exa 5.5
2  clc;
3  clear;
```

```
 4 close;
 5 //Given data :
 6 VRL=30000;//Volts
 7 VSL=33000;//Volts
 8 f=50;//Hz
 9 P=10*10^6;//W
10 pf=0.8;//power factor
11 cos_fi_r=pf;
12 sin_fi_r=sqrt(1-cos_fi_r^2);
13 VR=VRL/sqrt(3);//V
14 I=P/sqrt(3)/VRL/pf;//A
15 Eta_T=0.96;//Efficiency
16 LineLoss=P*(1/Eta_T-1);//W
17 R=LineLoss/3/I^2;//ohm/phase
18 disp(R,"Resistance per phase(ohm/phase)");
19 VS=VSL/sqrt(3);//V
20 X=(VS-VR-I*R*cos_fi_r)/I/sin_fi_r;//V
21 L=X/2/%pi/f;//H/phase
22 disp(L*1000,"Inductance per phase(mH/phase)");
```

Scilab code Exa 5.6 Voltage and Efficiency of Transmission

Voltage and Efficiency of Transmission

```
 1 //Exa 5.6
 2 clc;
 3 clear;
 4 close;
 5 //Given data :
 6 l=3;//km
 7 P=3000;//KW
 8 VSL=11*10^3;//volt
 9 R=l*0.4;//ohm
10 X=l*0.8;//ohm
11 VS=VSL/sqrt(3);//Volts
```

```
12  pf =0.8; // power  factor
13  cos_fi_r=pf;
14  sin_fi_r=sqrt (1-cos_fi_r^2);
15  //VS=VR+I*(R*cos_fi_r+X*sin_fi_r);//V
16  I_into_VR=P*1000/3/cos_fi_r;//VA
17  //VR^2-VS*VR+I_into_VR*(R*cos_fi_r+X*sin_fi_r);
18  p=[1 -VS I_into_VR*(R*cos_fi_r+X*sin_fi_r)];
19  VR=roots(p);
20  VR=VR(1);// taking  greater  value
21  I=I_into_VR/VR;//A
22  VRL=sqrt(3)*VR;// volt
23  disp(VRL,"Line  voltage  at  load  end(volt)  :  ");
24  Eta_T=P*1000/(P*1000+3*I^2*R)*100;//%
25  disp(Eta_T,"Transmission  Efficiency(%)  :  ");
```

Scilab code Exa 5.7 Power output and Power factor

```
Power output and Power factor
```

```
1  //Exa  5.7
2  clc;
3  clear;
4  close;
5  //Given  data  :
6  R=5;//ohm/phase
7  X=20;//ohm/phase
8  VSL=46.85;//kV
9  VRL=33;//kV
10  VRL=VRL*1000;//v
11  pf=0.8;//power  factor
12  cos_fi_r=pf;
13  sin_fi_r=sqrt(1-cos_fi_r^2);
14  VR=VRL/sqrt(3);//V
15  I=(VSL*1000/sqrt(3)-VR)/(R*cos_fi_r+X*sin_fi_r);//A
16  Pout=sqrt(3)*VRL*I*pf/1000;//kW
```

```
17  disp(Pout,"Power output(kW)");
18  cosfi_s=(VR*pf+I*R)/(VSL*1000/sqrt(3));//power
        factor
19  disp(cosfi_s,"Power factor at sending end(lagging)")
        ;
```

Scilab code Exa 5.8 Current Voltage Regulation Efficiency

Current Voltage Regulation Efficiency

```
1  //Exa 5.8
2  clc;
3  clear;
4  close;
5  //Given data :
6  l=80;//km
7  P=15;//MW
8  VR=66*10^3;//Volt
9  R=l*0.3125;//ohm
10 X=l*1;//ohm
11 Y=l*17.5*10^-6;//S
12 pf=0.8;//power factor
13 cos_fi_r=pf;
14 sin_fi_r=sqrt(1-cos_fi_r^2);
15 IR=P*10^6/(VR*pf);//A
16 IR=IR*(cos_fi_r-%i*sin_fi_r);//A
17 IC=%i*Y*VR;//A
18 IS=IR+IC;//A
19 disp("Sending end current(A), magnitude is "+string(
        abs(IS))+" and angle in degree is "+string(atand(
        imag(IS),real(IS))));
20 VS=VR+IS*(R+%i*X);//volt
21 disp("Sending end voltage(V), magnitude is "+string(
        abs(VS))+" and angle in degree is "+string(atand(
        imag(VS),real(VS))));
```

```
22  fi_s=atand(imag(VS),real(VS))-atand(imag(IS),real(IS
        ));//
23  cos_fis=cosd(fi_s);//sending end pf
24  disp(cos_fis,"Sending end power factor(lag) : ");
25  Reg=(abs(VS)-VR)/VR*100;//%
26  disp(Reg,"Regulation(%) :    ");
27  LineLoss=abs(IS)^2*R/1000;//kW
28  disp(LineLoss,"Line Losses in kW : ");
29  Eta_T=P*1000/(P*1000+LineLoss)*100;//%
30  disp(Eta_T,"Transmission Efficiency(%) : ");
```

Scilab code Exa 5.9 Voltage Efficiency Regulation

Voltage Efficiency Regulation

```
 1  //Exa 5.9
 2  clc;
 3  clear;
 4  close;
 5  //Given data :
 6  l=100;//km
 7  P=20;//MW
 8  VRL=66*10^3;//volt
 9  f=50;//Hz
10  R=10;//ohm
11  L=111.7*10^-3;//H
12  C=0.9954*10^-6;//F
13  pf=0.8;//power factor
14  X=2*%pi*f*L;//ohm
15  Y=2*%pi*f*C;//S
16  cos_fi_r=pf;
17  sin_fi_r=sqrt(1-cos_fi_r^2);
18  VR=VRL/sqrt(3);//volt
19  IR=P*10^6/(sqrt(3)*VRL*pf);//A
20  IR=IR*(cos_fi_r-%i*sin_fi_r);//A
```

```
21  Z=R+%i*X;//ohm
22  Vdash=VR+1/2*IR*Z;//Volt
23  IC=Vdash*%i*Y;//A
24  IS=IR+IC;//A
25  VS=Vdash+1/2*IS*Z;//Volt
26  VSL=abs(VS)*sqrt(3);//Volt
27  disp(VSL,"Sending end line voltage(Volt) :");
28  Reg=(VSL-VRL)/VRL*100;//%
29  disp(Reg,"Regulation(%) :  ");
30  fi_s=atand(imag(VS),real(VS))-atand(imag(IS),real(IS
       ));//
31  cos_fi_s=cosd(fi_s);//sending end pf
32  Eta_T=sqrt(3)*VRL*abs(IR)*cos_fi_r/(sqrt(3)*VSL*abs(
       IS)*cos_fi_s)*100;//%
33  disp(Eta_T,"Transmission Efficiency(%) : ");
34  //Ans is not accurate in the book.
```

Scilab code Exa 5.10 Voltage Regulation Current Efficiency

Voltage Regulation Current Efficiency

```
1  //Exa 5.10
2  clc;
3  clear;
4  close;
5  //Given data :
6  l=200;//km
7  P=50;//MVA
8  VRL=132*10^3;//Volt
9  f=50;//Hz
10 R=l*0.15;//ohm
11 X=l*0.50;//ohm
12 Y=l*2*10^-6;//mho
13 pf=0.85;//power factor
14 cos_fi_r=pf;
```

```
15  sin_fi_r=sqrt(1-cos_fi_r^2);
16  VR=VRL/sqrt(3);//Volt
17  IR=P*10^6/(sqrt(3)*VRL);//A
18  Z=R+%i*X;//ohm
19  IR=IR*(cos_fi_r-%i*sin_fi_r);//A
20  Vdash=VR+1/2*IR*Z;//Volt
21  IC=Vdash*%i*Y;//A
22  IS=IR+IC;//A
23  disp("Sending end current(A), magnitude is "+string(
        abs(IS))+" and angle in degree is "+string(atand(
        imag(IS),real(IS))));
24  VS=Vdash+1/2*IS*Z;//Volt
25  VSL=abs(VS)*sqrt(3);//Volt
26  disp(VSL/1000,"Sending end line voltage(kV) :");
27  Reg=(VSL-VRL)/VRL*100;//%
28  disp(Reg,"Regulation(%) :   ");
29  fi_s=atand(imag(VS),real(VS))-atand(imag(IS),real(IS
        ));//
30  cos_fi_s=cosd(fi_s);//sending end pf
31  Eta_T=sqrt(3)*VRL*abs(IR)*cos_fi_r/(sqrt(3)*VSL*abs(
        IS)*cos_fi_s)*100;//%
32  disp(Eta_T,"Transmission Efficiency(%) : ");
33  //Ans is wrong in the book.Angle of VS is calculated
         wrong leads to wrong answers.
```

Scilab code Exa 5.11 Voltage Current PF

Voltage Current PF

```
1  //Exa 5.11
2  clc;
3  clear;
4  close;
5  //Given data :
6  S=1*10^3;//kVA
```

```
 7  pf =0.71;//power factor
 8  VRL =22*10^3;//Volt
 9  f =50;//Hz
10  R =15;//ohm
11  L =0.2;//H
12  C =0.5*10^-6;//F
13  cos_fi_r=pf;
14  sin_fi_r=sqrt(1-cos_fi_r^2);
15  IR=S*10^3/VRL;//A
16  IR=IR*(cos_fi_r-%i*sin_fi_r);//A
17  X=2*%pi*f*L;//ohm
18  //Z=sqrt(R^2+X^2);//ohm
19  Z=R+%i*X;//ohm
20  Y=2*%pi*f*C;//S
21  ICR=1/2*%i*Y*VRL;//A
22  IL=IR+ICR;//A
23  VS=VRL+IL*Z;//Volt
24  disp("Sending end voltage(Volt), magnitude is "+
        string(abs(VS))+" and angle in degree is "+string
        (atand(imag(VS),real(VS))));
25  ICS=1/2*%i*Y*VS;//A
26  IS=IL+ICS;//A
27  disp("Sending end current(A), magnitude is "+string(
        abs(IS))+" and angle in degree is "+string(atand(
        imag(IS),real(IS))));
28  fi_s=atand(imag(VS),real(VS))-atand(imag(IS),real(IS
        ));//
29  cos_fi_s=cosd(fi_s);//sending end pf
30  disp(cos_fi_s,"Sending end power factor(lag) : ");
```

Scilab code Exa 5.12 Sending End Voltage

Sending End Voltage

```
 1  //Exa 5.12
```

```
2  clc ;
3  clear ;
4  close ;
5  //Given data :
6  P=50*10^6; //W
7  f=50; //Hz
8  l=150; //km
9  pf=0.8; //power factor
10 VRL=110*10^3; //Volt
11 VR=VRL/sqrt(3); //Volt
12 cos_fi_r=pf ;
13 sin_fi_r=sqrt(1-cos_fi_r^2);
14 R=0.1*l; //ohm
15 XL=0.5*l; //ohm
16 Z=R+%i*XL; //ohm
17 IR=P/(sqrt(3)*VRL*pf); //A
18 IR=IR*(cos_fi_r-%i*sin_fi_r); //A
19 Y=3*10^-6*l; //S
20 ICR=1/2*%i*Y*VR; //A
21 IL=IR+ICR; //A
22 VS=VR+IL*Z; //Volt
23 VSL=sqrt(3)*abs(VS); //Volt
24 disp(VSL/1000,"Sending end line to line voltage(kV)
       :");
```

Scilab code Exa 5.13 Voltage Current and PF

Voltage Current and PF

```
1  //Exa 5.13
2  clc ;
3  clear ;
4  close ;
5  //Given data :
6  f=50; //Hz
```

```
 7  l=30; //km
 8  Z=40+%i*125; //ohm
 9  Y=10^-3; //mho
10  P=50*10^6; //W
11  VRL=220*10^3; //Volt
12  VR=VRL/sqrt(3); //Volt
13  pf=0.8; //power factor
14  cos_fi_r=pf;
15  sin_fi_r=sqrt(1-cos_fi_r^2);
16  IR=P/(sqrt(3)*VRL*pf); //A
17  IR=IR*(cos_fi_r-%i*sin_fi_r); //A
18  ICR=1/2*%i*Y*VR; //A
19  IL=IR+ICR; //A
20  VS=VR+IL*Z; //Volt
21  VSL=sqrt(3)*abs(VS); //Volt
22  disp(VSL/1000,"Sending end line to line voltage(kV)
       :");
23  IS=IL+1/2*%i*Y*VS; //A
24  disp("Sending end current(A), magnitude is "+string(
       abs(IS))+" and angle in degree is "+string(atand(
       imag(IS),real(IS))));
25  fi_s=atand(imag(VS),real(VS))-atand(imag(IS),real(IS
       )); //
26  cos_fis=cosd(fi_s); //sending end pf
27  disp(cos_fis,"Sending end power factor(lag) : ");
```

Scilab code Exa 5.14 Sending End Voltage

```
Sending End Voltage
```

```
1  //Exa 5.14
2  clc;
3  clear;
4  close;
5  //Given data :
```

```
 6  f=50; //Hz
 7  l=30; //km
 8  Z=40+%i*125; //ohm
 9  Y=10^-3; //mho
10  P=50*10^6; //W
11  VRL=220*10^3; //Volt
12  VR=VRL/sqrt(3); //Volt
13  pf=0.8; //power factor
14  cos_fi_r=pf;
15  sin_fi_r=sqrt(1-cos_fi_r^2);
16  IR=P/(sqrt(3)*VRL*pf); //A
17  IR=IR*(cos_fi_r-%i*sin_fi_r); //A
18  ICR=1/2*%i*Y*VR; //A
19  IL=IR+ICR; //A
20  VS=VR+IL*Z; //Volt
21  VSL=sqrt(3)*abs(VS); //Volt
22  disp(VSL/1000,"Sending end line to line voltage(kV)
       :");
```

Scilab code Exa 5.15 Voltage Efficiency and PF

```
Voltage Efficiency and PF
```

```
 1  //Exa 5.15
 2  clc;
 3  clear;
 4  close;
 5  //Given data :
 6  f=50; //Hz
 7  l=100; //km
 8  P=50*10^6; //W
 9  pf=0.8; //power factor
10  cos_fi_r=pf;
11  sin_fi_r=sqrt(1-cos_fi_r^2);
12  VRL=132*10^3; //Volt
```

```
13  VR=VRL/sqrt(3);//Volt
14  R=0.1*l;//ohm
15  XL=0.3*l;//ohm
16  Z=R+%i*XL;//ohm
17  Y=3*10^-6*l;//S
18  IR=P/(sqrt(3)*VRL*pf);//A
19  IR=IR*(cos_fi_r-%i*sin_fi_r);//A
20  ICR=1/2*%i*Y*VR;//A
21  IL=IR+ICR;//A
22  VS=VR+IL*Z;//Volt
23  VSL=sqrt(3)*abs(VS);//Volt
24  disp(VSL/1000,"Sending end line voltage(kV) :");
25  ICS=1/2*%i*Y*VS;//A
26  IS=IL+ICS;//A
27  fi_s=atand(imag(VS),real(VS))-atand(imag(IS),real(IS
        ));//
28  cos_fi_s=cosd(fi_s);//sending end pf
29  disp(cos_fi_s,"Sending end power factor(lag) : ");
30  Eta_T=sqrt(3)*VRL*abs(IR)*cos_fi_r/(sqrt(3)*VSL*abs(
        IS)*cos_fi_s)*100;//%
31  disp(Eta_T,"Transmission Efficiency(%) : ");
```

Scilab code Exa 5.16 Voltage at mid point

Voltage at mid point

```
1  //Exa 5.16
2  clc;
3  clear;
4  close;
5  //Given data :
6  f=50;//Hz
7  l=10;//km
8  S1=5000*10^3;//VA
9  S2=10000*10^3;//VA
```

```
10  pf =0.8; //power factor
11  cos_fi_r=pf;
12  sin_fi_r=sqrt(1-cos_fi_r^2);
13  pf2=0.7071; //power factor
14  cos_fi_r2=pf2;
15  sin_fi_r2=sqrt(1-cos_fi_r2^2);
16  R=0.6*l; //ohm
17  XL=1.5*l; //ohm
18  VRL=33*10^3; //Volt
19  VR=VRL/sqrt(3); //Volt
20  I1=S1/(sqrt(3)*VRL); //A
21  I1=I1*(cos_fi_r-%i*sin_fi_r); //A
22  Z1=R+%i*XL; //ohm
23  VB=VR+I1*Z1; //Volt
24  VBL=sqrt(3)*abs(VB); //Volt
25  disp(VBL/1000,"Line voltage at mid point(kV) : ");
26  I2=S2/(sqrt(3)*VBL); //A
27  I2=I2*(cos_fi_r2-%i*sin_fi_r2); //A
28  I=I1+I2; //A
29  disp("Total current(A), magnitude is "+string(abs(I)
        )+" and angle in degree is "+string(atand(imag(I)
        ,real(I))));
30  Z2=R+%i*XL; //ohm
31  VS=VB+I*Z2; //Volt
32  VSL=sqrt(3)*abs(VS); //Volt
33  disp(VSL/1000,"Sending end line voltage(kV) :");
```

Scilab code Exa 5.17 kVA supplied and Power supplied

```
kVA supplied and Power supplied
```

```
1  //Exa 5.17
2  clc;
3  clear;
4  close;
```

```scilab
5  //Given data :
6  P=10;//MWatt
7  pf=0.8;//power factor
8  VRL=30*10^3;//Volt
9  R1=5.5;//ohm
10 XL1=13.5;//ohm
11 R2=6;//ohm
12 XL2=11;//ohm
13 ZA=R1+%i*XL1;//ohm
14 ZB=R2+%i*XL2;//ohm
15 S=P*10^3/pf*expm(%i*%pi/180*(-36.52));//kVA
16 SA=S*ZB/(ZA+ZB);//kVA
17 disp("Load supply by line A(kVA), magnitude is "+
      string(abs(SA))+" at pf "+string(cosd(atand(imag(
      SA),real(SA)))));
18 SB=S*ZA/(ZA+ZB);//kVA
19 disp("Load supply by line B(kVA), magnitude is "+
      string(abs(SB))+" and angle in degree is "+string
      (cosd(atand(imag(SB),real(SB)))));
20 PA=abs(SA)*(cosd(atand(imag(SA),real(SA))));//kW
21 disp(PA,"Power supplied by line A(kW) : ");
22 PB=abs(SB)*(cosd(atand(imag(SB),real(SB))));//kW
23 disp(PB,"Power supplied by line B(kW) : ");
24 //Answer is not accurate in the book.
```

Scilab code Exa 5.18 Rise in Voltage

Rise in Voltage

```scilab
1  //Exa 5.18
2  clc;
3  clear;
4  close;
5  //Given data :
6  L=200;//km
```

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

Scilab code Exa 5.19 Find A B C D parameters

Find A B C D parameters

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

Scilab code Exa 5.20 ABCD constant Voltage and Efficiency

ABCD constant Voltage and Efficiency

```
1  //Exa 5.20
2  clc;
3  clear;
4  close;
5  //Given data :
6  Z=200*expm(%i*%pi/180*80);//ohm
7  Y=0.0013*expm(%i*%pi/180*90);//mho/phase
8  P=80*10^6;//W
9  pf=0.8;//power factor
10 cos_fi_r=pf;
11 sin_fi_r=sqrt(1-cos_fi_r^2);
12 VRL=220*10^3;//Volt
13 VR=VRL/sqrt(3);//Volt
14 f=50;//Hz
15 IR=P/(sqrt(3)*VRL*pf);//A
16 IR=IR*(cos_fi_r-%i*sin_fi_r);//A
17 A=1+1/2*Y*Z;//parameter of 3-phase line
18 D=A;//parameter of 3-phase line
19 B=Z*(1+1/4*Y*Z);//parameter of 3-phase line
20 C=Y;//parameter of 3-phase line
21 disp("Parameter A, magnitude is "+string(abs(A))+"
      and angle in degree is "+string(atand(imag(A),
      real(A))));
22 disp("Parameter B, magnitude is "+string(abs(B))+"
      and angle in degree is "+string(atand(imag(B),
      real(B))));
23 disp("Parameter C, magnitude is "+string(abs(C))+"
      and angle in degree is "+string(atand(imag(C),
      real(C))));
24 disp("Parameter D, magnitude is "+string(abs(D))+"
      and angle in degree is "+string(atand(imag(D),
      real(D))));
25 VS=A*VR+B*IR;//Volt
26 VSL=sqrt(3)*abs(VS);//Volt
27 disp(VSL/1000,"Sending end Line voltage(kV) : ");
28 IS=C*VR+D*IR;//A
29 disp("Sending end current(A), magnitude is "+string(
      abs(IS))+" and angle in degree is "+string(atand(
```

```
     imag(IS),real(IS))));
30  fi_s=atand(imag(VS),real(VS))-atand(imag(IS),real(IS
       )); //
31  cos_fis=cosd(fi_s); //sending end pf
32  disp(cos_fis,"Sending end power factor(lag) : ");
33  Pin=sqrt(3)*VSL*abs(IS)*cos_fis*10^-6; //MW
34  disp(Pin,"Power Input(MW) : ");
35  Eta=P/(Pin*10^6)*100; //%
36  disp(Eta,"Transmission Efficiency(%) : ");
```

Scilab code Exa 5.21 Voltage Current Power and efficiency

```
Voltage Current Power and efficiency
```

```
1  //Exa 5.21
2  clc;
3  clear;
4  close;
5  //Given data :
6  P=50*10^6; //VA
7  pf=0.8; //power factor
8  cos_fi_r=pf;
9  sin_fi_r=sqrt(1-cos_fi_r^2);
10 A=0.98*expm(%i*%pi/180*3); //parameter of 3-phase
      line
11 D=0.98*expm(%i*%pi/180*3); //parameter of 3-phase
      line
12 B=110*expm(%i*%pi/180*75); //parameter of 3-phase
      line
13 C=0.0005*expm(%i*%pi/180*80); //parameter of 3-phase
      line
14 VRL=110*10^3; //Volt
15 VR=VRL/sqrt(3); //Volt
16 IR=P/(sqrt(3)*VRL); //A
17 IR=IR*(cos_fi_r-%i*sin_fi_r); //A
```

```
18  VS=A*VR+B*IR;//Volt
19  VSL=sqrt(3)*abs(VS);//Volt
20  disp(VSL/1000,"Sending end Line voltage(kV) : ");
21  IS=C*VR+D*IR;//A
22  disp("Sending end current(A), magnitude is "+string(
        abs(IS))+" and angle in degree is "+string(atand(
        imag(IS),real(IS))));
23  fi_s=atand(imag(VS),real(VS))-atand(imag(IS),real(IS
        ));//
24  cos_fis=cosd(fi_s);//sending end pf
25  disp(cos_fis,"Sending end power factor(lag) : ");
26  Pin=sqrt(3)*VSL*abs(IS)*cos_fis*10^-6;//MW
27  disp(Pin,"Power Input(MW) : ");
28  Eta=P*pf/(Pin*10^6)*100;//%
29  disp(Eta,"Transmission Efficiency(%) : ");
```

Scilab code Exa 5.22 ABCD constant power and voltage

ABCD constant power and voltage

```
1  //Exa 5.22
2  clc;
3  clear;
4  close;
5  //Given data :
6  f=50;//Hz
7  L=300;//km
8  r=0.15;//ohm/km
9  x=0.5;//ohm/km
10  y=3*10^-6;//mho/km
11  VRL=220*10^3;//Volt
12  VR=VRL/sqrt(3);//Volt
13  P=200*10^6;//W
14  pf=0.85;//power factor
15  cos_fi_r=pf;
```

```scilab
16  sin_fi_r=sqrt(1-cos_fi_r^2);
17  R=r*L;//ohm
18  X=x*L;//ohm
19  Y=y*L;//mho
20  Z=R+%i*X;//ohm
21  //part (i)
22  A=1+1/2*%i*Y*Z;//parameter of 3-phase line
23  D=A;//parameter of 3-phase line
24  B=Z;//parameter of 3-phase line
25  C=%i*Y*(1+1/4*%i*Y*Z);//parameter of 3-phase line
26  disp("Parameter A, magnitude is "+string(abs(A))+"
        and angle in degree is "+string(atand(imag(A),
        real(A))));
27  disp("Parameter B, magnitude is "+string(abs(B))+"
        and angle in degree is "+string(atand(imag(B),
        real(B))));
28  disp("Parameter C, magnitude is "+string(abs(C))+"
        and angle in degree is "+string(atand(imag(C),
        real(C))));
29  disp("Parameter D, magnitude is "+string(abs(D))+"
        and angle in degree is "+string(atand(imag(D),
        real(D))));
30  //part (ii)
31  IR=poly(0,'IR');
32  p=0.024525*IR^2+11.427*IR-2102;//from VS=A*VR+B*IR
        ;//Volt
33  IR=roots(p);
34  IR=IR(2);//taking +ve value
35  P=sqrt(3)*VRL*IR*10^-6;//MW
36  disp(P,"Power received in MW : ");
37  ///part (iii)
38  P=200*10^6;//W
39  IR=P/sqrt(3)/VRL/pf;//A
40  fi=acosd(pf);//degree
41  IR=IR*expm(%i*-fi*%pi/180);
42  VS=A*VR+B*IR;//Volt
43  VSL=sqrt(3)*abs(VS);//Volt
44  disp(VSL/1000,"Sending end Line voltage(kV) : ");
```

Scilab code Exa 5.23 Voltage current power and egulation

Voltage current power and egulation

```
1  //Exa 5.23
2  clc;
3  clear;
4  close;
5  //Given data :
6  A=0.936+%i*0.016;//parameter of 3-phase line
7  D=A;//parameter of 3-phase line
8  B=33.5+%i*138;//parameter of 3-phase line
9  C=(-0.9280+%i*901.223)*10^-6;//parameter of 3-phase
       line
10 VRL=200*10^3;//Volt
11 VR=VRL/sqrt(3);//Volt
12 P=40*10^6;//W
13 pf=0.86;//power factor
14 cos_fi_r=pf;
15 sin_fi_r=sqrt(1-cos_fi_r^2);
16 IR=P/sqrt(3)/VRL/pf;//A
17 fi=acosd(pf);//degree
18 IR=IR*expm(%i*-fi*%pi/180);
19 VS=A*VR+B*IR;//Volt
20 VSL=sqrt(3)*abs(VS);//Volt
21 disp(VSL/1000,"Sending end Line voltage(kV) : ");
22 IS=C*VR+D*IR;//A
23 disp("Sending end current(A), magnitude is "+string(
       abs(IS))+" and angle in degree is "+string(atand(
       imag(IS),real(IS))));
24 fi_s=atand(imag(IS),real(IS))-atand(imag(VS),real(VS
       ));//degree
25 disp(cosd(fi_s),fi_s,"Sending end phase angle(degree
       ) & power factor(leading): ");
```

```
26 Ps=sqrt(3)*abs(VSL)*abs(IS)*cosd(fi_s)*10^-6;//MW
27 disp(Ps,"Sending end power(MW) : ");
28 Vreg=(VSL-VRL)*100/VRL;//%
29 disp(Vreg,"Voltage regulation in % : ");
```

Scilab code Exa 5.24 Sending end voltage and current

```
Sending end voltage and current
```

```
1  //Exa 5.24
2  clc;
3  clear;
4  close;
5  //Given data :
6  A1=0.98*expm(%i*2*%pi/180);//parameter of 3-phase
       line
7  D1=A1;//parameter of 3-phase line
8  B1=28*expm(%i*69*%pi/180);//parameter of 3-phase
       line
9  C1=0.0002*expm(%i*88*%pi/180);//parameter of 3-phase
        line
10 A2=0.95*expm(%i*3*%pi/180);//parameter of 3-phase
       line
11 D2=A2;//parameter of 3-phase line
12 B2=40*expm(%i*85*%pi/180);//parameter of 3-phase
       line
13 C2=0.0004*expm(%i*90*%pi/180);//parameter of 3-phase
        line
14 VRL=110*10^3;//Volt
15 VR=VRL/sqrt(3);//Volt
16 IR=200;//A
17 pf=0.95;//power factor
18 cos_fi_r=pf;
19 sin_fi_r=sqrt(1-cos_fi_r^2);
20 fi=acosd(pf);//degree
```

```
21  A=A1*A2+B1*C2;//generalized  parameter  of  2  line
22  B=A1*B2+B1*D2;//generalized  parameter  of  2  line
23  C=C1*A2+D1*C2;//generalized  parameter  of  2  line
24  D=C1*B2+D1*D2;//generalized  parameter  of  2  line
25  IR=IR*expm(%i*-fi*%pi/180);
26  VS=A*VR+B*IR;//Volt
27  VSL=sqrt(3)*abs(VS);//Volt
28  disp(VSL/1000,"Sending  end  Line  voltage(kV)  :  ");
29  IS=C*VR+D*IR;//A
30  disp("Sending  end  current(A),  magnitude  is  "+string(
       abs(IS))+"  and  angle  in  degree  is  "+string(atand(
       imag(IS),real(IS))));
31  //Answer  for  VSL  is  wrong  in  the  book.
```

Scilab code Exa 5.25 ABCD constant and power factor

ABCD constant and power factor

```
 1  //Exa  5.25
 2  clc;
 3  clear;
 4  close;
 5  //Given  data  :
 6  A1=0.98*expm(%i*1*%pi/180);//parameter  of  3−phase
       line
 7  D1=A1;//parameter  of  3−phase  line
 8  B1=100*expm(%i*75*%pi/180);//parameter  of  3−phase
       line
 9  C1=0.0005*expm(%i*90*%pi/180);//parameter  of  3−phase
        line
10  A2=0.98*expm(%i*1*%pi/180);//parameter  of  3−phase
       line
11  D2=A2;//parameter  of  3−phase  line
12  B2=100*expm(%i*75*%pi/180);//parameter  of  3−phase
       line
```

```
13  C2=0.0005*expm(%i*90*%pi/180);//parameter of 3-phase
        line
14  P=100*10^6;//W
15  VRL=132*10^3;//Volt
16  VR=VRL/sqrt(3);//Volt
17  pf=0.8;//power factor
18  cos_fi_r=pf;
19  sin_fi_r=sqrt(1-cos_fi_r^2);
20  fi=acosd(pf);//degree
21  A=(A1*B2+A2*B1)/(B1+B2);//generalized parameter of 2
        line
22  B=B1*B2/(B1+B2);//generalized parameter of 2 line
23  C=C1+C2-(A1-A2)*(D1-D2)/(B1+B2);//generalized
        parameter of 2 line
24  D=(B1*D2+B2*D1)/(B1+B2);//generalized parameter of 2
        line
25  disp("Generalised constants ot two lines combined
        are : ");
26  disp("Parameter A, magnitude is "+string(abs(A))+"
        and angle in degree is "+string(atand(imag(A),
        real(A))));
27  disp("Parameter B, magnitude is "+string(abs(B))+"
        and angle in degree is "+string(atand(imag(B),
        real(B))));
28  disp("Parameter C, magnitude is "+string(abs(C))+"
        and angle in degree is "+string(atand(imag(C),
        real(C))));
29  disp("Parameter D, magnitude is "+string(abs(D))+"
        and angle in degree is "+string(atand(imag(D),
        real(D))));
30  IR=P/sqrt(3)/VRL/pf;//A
31  IR=IR*expm(%i*-fi*%pi/180);
32  VS=A*VR+B*IR;//Volt
33  VSL=sqrt(3)*abs(VS);//Volt
34  IS=C*VR+D*IR;//A
35  fi_s=atand(imag(VS),real(VS))-atand(imag(IS),real(IS
        ));
36  disp(cosd(fi_s),"Sending end power factor(lagging) :
```

```
");
```

Chapter 6

Representation and Performance of long Transmission Lines

Scilab code Exa 6.1 Determine Auxiliary constant

Determine Auxiliary constant

```
1  //Exa 6.1
2  clc;
3  clear;
4  close;
5  format('v',6);
6  //Given data :
7  r=0.22;//ohm
8  x=0.45;//ohm
9  g=4*10^-9;//S
10 b=2.53*10^-6;//S
11 f=50;//Hz
12 l=1000;//Km
13 //Using Convergent series of complex angles
14 z=r+%i*x;//ohm
15 y=g+%i*b;//ohm
```

```
16  Z=z*l;//ohm
17  Y=y*l;//ohm
18  YZ=Y*Z;//ohm
19  Y2Z2=YZ^2;//ohm
20  Y3Z3=YZ^3;//ohm
21  A=1+YZ/2+Y2Z2/24+Y3Z3/720;//ohm
22  D=A;//oh,m
23  B=Z*(1+YZ/6+Y2Z2/120+Y3Z3/5040);//ohm
24  C=Y*(1+YZ/6+Y2Z2/120+Y3Z3/5040);//ohm
25  disp("Auxiliary Constants by using Convergent series
        of complex angles : ");
26  disp(A,"A = ");
27  disp(B,"B = ");
28  disp(C,"C = ");
29  //Using Convergent series of real angles
30  A=cosh(sqrt(YZ));//ohm
31  D=A;//ohm
32  B=sqrt(Z/Y)*sinh(sqrt(YZ));//ohm
33  C=sqrt(Y/Z)*sinh(sqrt(YZ));//ohm
34  A=cosh(sqrt(YZ));//ohm
35  disp("Auxiliary Constants by using Convergent series
        of real angles : ");
36  disp("A, magnitude is "+string(abs(A))+" and angle
      in degree is "+string(atand(imag(A),real(A))));
37  disp("B, magnitude is "+string(abs(B))+" and angle
      in degree is "+string(atand(imag(B),real(B))));
38  disp("C, magnitude is "+string(abs(C))+" and angle
      in degree is "+string(atand(imag(C),real(C))));
39  disp("We obtain same result by both of the methods."
      )
```

Scilab code Exa 6.2 Sending end voltage and current

```
Sending end voltage and current
```

```
1  //Exa 6.2
2  clc;
3  clear;
4  close;
5  format('v',8);
6  //Given data :
7  Z=200*expm(%i*80*%pi/180);//ohm
8  Y=0.0013*expm(%i*90*%pi/180);//S/phase
9  P=80*10^6;//W
10 pf=0.8;//power factor
11 VRL=220*1000;//V
12 VR=VRL/sqrt(3);//V
13 IR=P/sqrt(3)/VRL/pf;//A
14 fi=acosd(pf);//degree
15 IR=IR*expm(%i*-fi*%pi/180);//A
16 YZ=Y*Z;//ohm
17 Y2Z2=YZ^2;//ohm
18 Y3Z3=YZ^3;//ohm
19 A=1+YZ/2+Y2Z2/24+Y3Z3/720;//ohm
20 D=A;//oh ,m
21 B=Z*(1+YZ/6+Y2Z2/120+Y3Z3/5040);//ohm
22 C=Y*(1+YZ/6+Y2Z2/120+Y3Z3/5040);//mho
23 VS=A*VR+B*IR;//V
24 VSL=sqrt(3)*abs(VS);//V
25 disp(VSL/1000,"Sending end line voltage in kV : ");
26 IS=C*VR+D*IR;//
27 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

```
A0 B0 C0 and D0 constant
```

```
1  //Exa 6.3
```

```
 2  clc;
 3  clear;
 4  close;
 5  format('v',8);
 6  //Given data :
 7  VRL=220;//kV
 8  VR=VRL/sqrt(3);//V
 9  P=10*10^6;//VA
10  Z=1+%i*8;//ohm(in %)
11  Zse=Z/100*VRL^2/100;//ohm/phase
12  A=0.9*expm(%i*0.6*%pi/180);//Auxiliary constant
13  D=A;//Auxiliary constant
14  B=153.2*expm(%i*84.6*%pi/180);//Auxiliary constant
15  C=0.0012*expm(%i*90*%pi/180);//Auxiliary constant
16  A0=A+C*Zse;//constant
17  B0=B+D*Zse;//ohm//constant
18  C0=C;//mho or S//constant
19  D0=A;//constant
20  disp("Constant A0, magnitude is "+string(abs(A0))+"
        and angle in degree is "+string(atand(imag(A0),
        real(A0))));
21  disp("Constant B0(ohm), magnitude is "+string(abs(B0
        ))+" and angle in degree is "+string(atand(imag(
        B0),real(B0))));
22  disp("Constant C0(S), magnitude is "+string(abs(C0))
        +" and angle in degree is "+string(atand(imag(C0)
        ,real(C0))));
23  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

```
A0 B0 C0 and D0 constant
```

```
1  //Exa 6.4
2  clc;
3  clear;
4  close;
5  format('v',8);
6  //Given data :
7  A=0.98*expm(%i*2*%pi/180);//Auxiliary constant
8  D=A;//Auxiliary constant
9  B=28*expm(%i*69*%pi/180);//Auxiliary constant
10 Zse=12*expm(%i*80*%pi/180);//ohm
11 C=(A*D-1)/B;//Auxiliary constant
12 A0=A+C*Zse;//constant
13 B0=B+2*A*Zse+C*Zse^2;//ohm//constant
14 C0=C;//mho or S//constant
15 D0=A0;//constant
16 disp("Constant A0, magnitude is "+string(abs(A0))+"
       and angle in degree is "+string(atand(imag(A0),
       real(A0))));
17 disp("Constant B0(ohm), magnitude is "+string(abs(B0
       ))+" and angle in degree is "+string(atand(imag(
       B0),real(B0))));
18 disp("Constant C0(S), magnitude is "+string(abs(C0))
       +" and angle in degree is "+string(atand(imag(C0)
       ,real(C0))));
19 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

```
A0 B0 C0 and D0 constant
```

```
1  //Exa 6.5
2  clc;
3  clear;
```

```
 4 close ;
 5 format ( 'v' ,8) ;
 6 //Given data :
 7 A=0.92* expm (%i *5.3* %pi /180) ;// Auxiliary constant
 8 D=A ;// Auxiliary constant
 9 B=65.3* expm (%i *81* %pi /180) ;// Auxiliary constant
10 ZT=100* expm (%i *70* %pi /180) ;//ohm
11 YT=0.0002* expm (%i * -75* %pi /180) ;//S
12 C=(A*D -1)/B ;// Auxiliary constant
13 A0=A *(1+2* YT*ZT )+B *( YT )+C*ZT *(1+YT*ZT) ;// constant
14 B0=2*A*ZT+B+C*ZT ^2; //ohm // constant
15 C0=2*A*YT *(1+YT*ZT )+B*YT ^2+C *(1+YT*ZT) ^2; //mho or S
          // constant
16 D0=A0 ;// constant
17 disp (" Constant A0, magnitude is "+string (abs (A0) )+"
          and angle in degree is "+string (atand (imag (A0) ,
          real (A0) ) ) );
18 disp (" Constant B0(ohm) , magnitude is "+string (abs (B0
          ) )+" and angle in degree is "+string (atand (imag (
          B0) ,real (B0) ) ) );
19 disp (" Constant C0(S) , magnitude is "+string (abs (C0) )
          +" and angle in degree is "+string (atand (imag (C0)
          ,real (C0) ) ) );
20 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

```
Equivalent T and Pi network
```

```
 1 //Exa 6.6
 2 clc ;
 3 clear ;
 4 close ;
```

```
 5  format('v',8);
 6  //Given data :
 7  A=0.945*expm(%i*1.02*%pi/180);//Auxiliary constant
 8  D=A;//Auxiliary constant
 9  B=82.3*expm(%i*73.03*%pi/180);//ohm//Auxiliary
        constant
10  C=0.001376*expm(%i*90.4*%pi/180);//S//Auxiliary
        constant
11  //part (i)
12  Y=C;//S
13  Z=2*(A-1)/C;//ohm
14  disp("For equivalent T-network : ");
15  disp("Shunt admittance in S, magnitude is "+string(
        abs(Y))+" and angle in degree is "+string(atand(
        imag(Y),real(Y))));
16  disp("Impedance in ohm, magnitude is "+string(abs(Z)
        )+" and angle in degree is "+string(atand(imag(Z)
        ,real(Z))));
17  disp("For equivalent pi-network : ");
18  Z=B;//ohm
19  disp("Series Impedance in ohm, magnitude is "+string
        (abs(Z))+" and angle in degree is "+string(atand(
        imag(Z),real(Z))));
20  Y=2*(A-1)/B;//S
21  disp("Shunt admittance in S, magnitude is "+string(
        abs(Y))+" and angle in degree is "+string(atand(
        imag(Y),real(Y))));
22  //For T-Network Value of Z is wrog in the book.
```

Chapter 7

Corona

Scilab code Exa 7.1 Line Voltage

```
Line Voltage
```

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

Scilab code Exa 7.2 Disruptive Critical Voltage

```
Disruptive Critical Voltage
```

```
1 //Exa 7.2
2 clc;
3 clear;
4 close;
5 //Given data :
6 Ph=3;//phase
7 V=220;//kV
8 f=50;//Hz
9 r=1.2;//cm
10 d=2;//meter
11 mo=0.96;//Irregularity factor
12 t=20;//degree C
13 T=t+273;//K
14 b=72.2;//cm
15 go=21.1;//kV rms/cm
16 del=3.92*b/T;//Air density factor
17 Vdo=go*del*mo*r*log(d*100/r);//in kV
18 Vdo_line=sqrt(3)*Vdo;//in kV
19 disp(round(Vdo_line),"Disruptive critical voltage
      from line to line(kV rms) : ");
```

Scilab code Exa 7.3 Spacing between Conductors

Spacing between Conductors

```
1 //Exa 7.3
2 clc;
3 clear;
4 close;
5 format('v',5);
6 //Given data :
7 V=132;//kV
8 r=2/2;//cm
9 Vexceed=210;//kV(rms)
10 go=30000/sqrt(2);//Volts/cm
```

```
11  go=go/1000;//kV/cm
12  Vdo=Vexceed/sqrt(3);//Volt
13  mo=1;//assumed
14  del=1;//assumed air density factor
15  //Formula : Vdo=go*del*mo*r*log(d*100/r);//in kV
16  d=exp(Vdo/go/del/mo/r)*r;//cm
17  disp(d*10^-2,"Spacing between conductors in meter :
        ");
```

Scilab code Exa 7.4 Minimum diameter of conductor

```
Minimum diameter of conductor
```

```
1   //Exa 7.4
2   clc;
3   clear;
4   close;
5   format('v',5);
6   //Given data :
7   Ph=3;//phase
8   V=132;//kV
9   f=50;//Hz
10  d=3;//meter
11  d=d*100;//in cm
12  go=21.21;//kV/cm : assumed
13  mo=0.85;//assumed
14  del=0.95;//assumed air density factor
15  Vdo=V/sqrt(3);//kV
16  //Formula : Vdo=go*del*mo*r*log(d*100/r);//in kV
17  //r*log(d/r)=Vdo/go/del/mo: solving
18  //Implementing Hit & Trial method
19  for r=0.1:.1:2
20      if floor(r*log(d/r))==floor(Vdo/go/del/mo) then
21          disp(2*r,"Minimum Diameter of conductor by
                Hit & Trial method(cm) : ");
```

```
22          break;
23       end
24 end
```

Scilab code Exa 7.5 Presence of Corona

Presence of Corona

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

Scilab code Exa 7.6 Critical Disruptive Voltage

Critical Disruptive Voltage

```
1  //Exa 7.6
2  clc;
3  clear;
4  close;
5  format('v',5);
6  //Given data :
7  Ph=3;//phase
8  r=10.4/2;//mm
9  r=r/10;//in cm
10 d=2.5;//meter
11 d=d*100;//in cm
12 t=21;//degree C
13 T=t+273;//K
14 b=73.6;//cm-Hg
15 mo=0.85;
16 mv_l=0.7;
17 mv_g=0.8;
18 go=21.21;//kV/cm : assumed
19 del=3.92*b/T;//Air density factor
20 //Formula : Vdo=go*del*mo*r*log(d*100/r);//kV
21 Vdo=go*del*mo*r*log(d/r);//kV
22 Vdo_line=sqrt(3)*Vdo;//kV
23 Vvo=go*del*mv_l*r*(1+.3/sqrt(del*r))*log(d/r);//kV
24 Vvo_line_local=Vvo*sqrt(3);//kV(rms)
25 disp(Vvo_line_local,"Line to line visual critical
      voltage for local corona(kV-rms) : ")
26 Vvo_line_general=Vvo_line_local*mv_g/mv_l;//kV(rms)
27 disp(Vvo_line_general,"Line to line visual critical
      voltage for general corona(kV-rms) : ")
28 //Note : Answer in the book is not accurate.
```

Scilab code Exa 7.7 Corona Loss

Corona Loss

```
1  //Exa 7.7
2  clc;
3  clear;
4  close;
5  format('v',5);
6  //Given data :
7  Pc1=53;//in kW
8  V1=106;//in kV
9  Pc2=98;//in kW
10 V2=110.9;//in kV
11 Vph1=V1/sqrt(3);//in kV
12 Vph2=V2/sqrt(3);//in kV
13 //Formula : Pc=3*244/del*(f+25)*sqrt(r/d)*(Vph-Vdo)
     ^2*10^-5;//kW/Km
14 disp("Using proportionality : Pc is proportional to
     (Vph-Vdo)^2");
15 disp("We have, Pc1/Pc2 = (Vph1-Vdo)^2/(Vph2-Vdo)^2")
     ;
16 Vdo=(Vph1-sqrt(Pc1/Pc2)*(Vph2))/(1-sqrt(Pc1/Pc2));
17 V3=113;//in kV
18 Vph3=V3/sqrt(3);//in kV
19 Pc3=Pc2*(Vph3-Vdo)^2/(Vph2-Vdo)^2;//in kW
20 disp(Pc3,"Corona Loss at 113 kV in kW : ");
21 VLine=sqrt(3)*Vdo;//in kV
22 disp(VLine,"Disruptive critical voltage between
     lines(kV): ");
```

Scilab code Exa 7.8 Disruptive voltage and corona loss

Disruptive voltage and corona loss

```
1  //Exa 7.8
2  clc;
3  clear;
4  close;
```

```
5  format('v',5);
6  //Given data :
7  f=50;//Hz
8  l=160;//km
9  r=1.036/2;//cm
10 d=2.44*100;//cm
11 g0=21.1;//kV/cm(rms)
12 m0=0.85;//irregularity factor
13 mv=0.72;//roughness factor
14 b=73.15;//cm
15 t=26.6;//degree C
16 del=3.92*b/(273+t);//air density factor
17 Vd0=g0*del*m0*r*log(d/r);//kV(rms)
18 disp(Vd0,"Critical disruptive voltage(rms) in kV : "
      );
19 Vv0=g0*del*mv*r*(1+0.3/sqrt(del*r))*log(d/r);//kV
20 disp(Vv0,"Visual Critical voltage(rms) in kV : ");
21 Vph=110/sqrt(3);//in kV
22 Pc_dash=d/del*(f+25)*sqrt(r/d)*(Vph-0.8*Vd0)
      ^2*10^-5;//kW/km/phase
23 T_Corona_loss=l*3*Pc_dash;//kW
24 disp(T_Corona_loss,"Total corona loss under foul
      weather condition using Peek formula in kW : ");
25 VphBYVd0=Vph/Vd0/0.8;
26 K=0.46;//constant
27 Corona_loss=21*10^-5*f*Vph^2*K/(log10(d/r))^2;//kW/
      km/phase
28 T_corona_loss=Corona_loss*3*l;//kW
29 disp(T_corona_loss,"Total corona loss under foul
      weather condition using Peterson formula in kW :
      ");
```

Scilab code Exa 7.9 Corona Characteristics

Corona Characteristics

```scilab
1  //Example 7.9
2  clc;
3  clear;
4  close;
5  //given data :
6  f=50;//Hz
7  l=175;//km
8  r=1/2;//cm
9  d=3*100;//cm
10 g0=21.1;//kV/cm(rms)
11 m0=0.85;//irregularity factor
12 mv=0.72;//roughness factor
13 mv_dash=0.82;//roughness factor
14 b=74;//cm
15 t=26;//degree C
16 Vph=110/sqrt(3);//kV
17 del=3.92*b/(273+t);//air density factor
18 Vd0=g0*del*m0*r*log(d/r);//kV(rms)
19 Vvo=g0*del*mv*r*(1+0.3/sqrt(del*r))*log(d/r);//kV
      rms
20 Vvo_dash=Vvo*mv_dash/mv;//kV rms
21 Pc=244/del*(f+25)*sqrt(r/d)*(Vph-Vd0)^2*10^-5;//kW/
      Km/phase
22 T_CoronaLoss=Pc*l*3;//kW
23 disp("Power loss due to corona for fair weather
      condition : ");
24 disp(T_CoronaLoss,"Total corona loss using Peek
      formula in kW : ");
25 K=0.0713;//constant for Vph/Vdo=1.142
26 Pc=21*10^-5*f*Vph^2/(log10(d/r))^2*K;//kW/Km/phase
27 T_CoronaLoss=Pc*l*3;//kW
28 disp(T_CoronaLoss,"According Peterson formula, Total
       corona loss for 175 km 3-phase line(kW): ");
29 disp("Power loss due to corona for stormy weather
      condition : ");
30 Vd0=0.8*Vd0;//kV
31 Pc_dash=l*3*244/del*(f+25)*sqrt(r/d)*(Vph-Vd0)
      ^2*10^-5;//kW/Km/phase
```

```
32  disp(Pc_dash,"Total corona loss using Peek formula
       in kW : ");
33  K=0.395;//constant for Vph/Vdo=1.42
34  Pc=21*10^-5*f*Vph^2/(log10(d/r))^2*K;//kW/Km/phase
35  T_CoronaLoss=Pc*l*3;//kW
36  disp(T_CoronaLoss,"According Peterson formula, Total
        corona loss for 175 km 3-phase line(kW): ");
37  //Answer is wrong in the book for corona loss fair
       weather condition using Peek formula.
```

Chapter 8

Electrostatic and Electromagnetic Interference with Communication Lines

Scilab code Exa 8.1 Voltage induced per km

```
Voltage induced per km
```

```
1  //Exa 8.1
2  clc;
3  clear;
4  close;
5  format('v',6);
6  //Given data :
7  f=50;//Hz
8  hor_con=1.2;//horizontal configuration spacing in m
9  x=0.85;//telephone line location below power line in meter
10 I=120;//current in power line in A
11 d=0.4;//spacing between conductors in meter
12 dAD=sqrt(x^2+((hor_con+d)/2)^2);//m
13 dAC=sqrt(x^2+((hor_con-d)/2)^2);//m
14 dBD=dAC;//m
```

```
15  dBC=dAD;//m
16  M=d*log(sqrt(dAD*dBC/dAC/dBD));//mh/km
17  Vm=2*%pi*f*M*10^-3*I;//V
18  disp(Vm,"Voltage induced per Km in the line in Volt
       :");
```

Scilab code Exa 8.2 Induced Voltage at fundamental frequency

```
Induced Voltage at fundamental frequency
```

```
1  //Exa 8.2
2  clc;
3  clear;
4  close;
5  format('v',6);
6  //Given data :
7  f=50;//HzdAP=AO+5;//m
8  l=200;//km
9  V=132*1000;//V
10  Load=28000;//kW
11  pf=0.85;//lagging power factor
12  r=5/1000;//radius of conductor in m
13  //From the figure given in question
14  AO=sqrt(4^2-2^2);//m
15  dAP=AO+5;//m
16  dAQ=dAP+1;//m
17  dBP=sqrt(5^2+2^2);//m
18  dBQ=sqrt(6^2+2^2);//m
19  MA=0.2*log(dAQ/dAP);//mH/km
20  MB=0.2*log(dBQ/dBP);//mH/km
21  MC=MB;//mH/km
22  M=MB-MA;//mH/km(MA,MB and Mc are displaced by 120
       degree)
23  I=Load*1000/sqrt(3)/V/pf;//A
24  Vm=2*%pi*f*M*10^-3*I;//V/km
```

```
25  Vm1=Vm*l;//V(For whole route)
26  disp(Vm1,"Induced Voltage(For whole route) in Volts
        : ");
27  VA=V/sqrt(3);//V
28  VB=V/sqrt(3);//V
29  hA=20+AO;//m
30  VPA=VA*log((2*hA-dAP)/dAP)/log((2*hA-r)/r);//V
31  VPB=VB*log((2*hA-dBP)/dBP)/log((2*hA-r)/r);//V
32  VPC=VPB;//V
33  VP=VPB-VPA;//V
34  disp(VP,"Potential of telephone conductor in Volts :
        ");
35  //Answer in the book is wrong due to little accuracy
        as compared to scilab.
```

Chapter 9

Overhead Line Insulators

Scilab code Exa 9.1 String Efficiency

```
String Efficiency
```

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

```
18  disp("Voltage across the seconf unit is "+string(
        V2byV1*V1byV*100)+" % of V");
19  disp("Voltage across the third unit is "+string(
        V3byV1*V1byV*100)+" % of V");
20  disp("Voltage across the fourth unit is "+string(
        V4byV1*V1byV*100)+" % of V");
21  disp("Voltage across the bottom most unit is "+
        string(V5byV1*V1byV*100)+" % of V");
22  n=5;//no. of unit
23  Strinf_eff=1/n/(V5byV1*V1byV);//%
24  disp(Strinf_eff*100,"String Efficiency(%)");
```

Scilab code Exa 9.2 Voltage Distribution and String efficiency

```
Voltage Distribution and String efficiency
```

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

```
19  disp("Voltage across the seconf unit is "+string(
        V2byV1*V1byV*100)+" % of V");
20  disp("Voltage across the third unit is "+string(
        V3byV1*V1byV*100)+" % of V");
21  disp("Voltage across the fourth unit is "+string(
        V4byV1*V1byV*100)+" % of V");
22  disp("Voltage across the fifth unit is "+string(
        V5byV1*V1byV*100)+" % of V");
23  disp("Voltage across the sixth unit is "+string(
        V6byV1*V1byV*100)+" % of V");
24  n=6;//no. of unit
25  Strinf_eff=1/n/(V6byV1*V1byV);//%
26  disp(Strinf_eff*100,"String Efficiency(%)");
```

Scilab code Exa 9.3 String Efficiency

```
String Efficiency
```

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

```
17  V1=V/(5+20*K+21*K^2+8*K^3+K^4);//kV
18  V5=V1*(1+10*K+15*K^2+7*K^3+K^4);//kV
19  Strinf_eff=V/n/V5;
20  disp(Strinf_eff*100,"Part(ii) Percentage String
      Efficiency(%)");
```

Scilab code Exa 9.4 Voltage Distribution and String Efficiency

```
Voltage Distribution and String Efficiency
```

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

Scilab code Exa 9.5 Maximum Voltage

```
Maximum Voltage
```

```
1  //Exa 9.5
2  clc;
3  clear;
4  close;
5  //Given data :
6  Vs=17.5;//kV
7  n=3;//no. of uniits
8  K=1/8;//shunt to mutual capacitance ratio
9  V3=Vs;//kV
10 V1=V3/(1+3*K+K^2);//kV
11 V2=V1*(1+K);//kV
12 V=V1+V2+V3;//kV
13 //Strinf_eff=V/n/V3;
14 disp(V,"Maximum safe working voltage(kV)");
```

Scilab code Exa 9.6 String Efficiency

```
String Efficiency
```

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

Scilab code Exa 9.7 Maximum line voltage

```
Maximum line voltage
```

```
1  //Exa 9.7
2  clc;
3  clear;
4  close;
5  //Given data :
6  Vs=11; //kV
7  n=5; //no. of uniits
8  K=0.1; //shunt to mutual capacitance ratio
9  V5=Vs; //kV
10 V1=V5/(1+10*K+15*K^2+7*K^3+K^4); //kV
11 V2=V1*(1+K); //kV
12 V3=V1*(1+3*K+K^2); //kV
13 V4=V1*(1+6*K+5*K^2+K^3); //kV
14 V=V1+V2+V3+V4+V5; //kV
15 disp(V,"Maximum safe working voltage(kV)");
```

Scilab code Exa 9.8 Voltage between conductors and string efficiency

```
Voltage between conductors and string efficiency
```

```
1  //Exa 9.8
2  clc;
3  clear;
4  close;
5  //Given data :
6  V2=15; //kV
7  V3=21; //kV
```

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```
8  n=4;//no. of uniits
9  //V3/V2=(1+3*K+K^2)/(1+K)
10 //K^2*V2+K*(V3+3*V2)-V2+V3=0;
11 p=[V2 -V3+3*V2 V2-V3];
12 K=roots(p);
13 K=K(2);//Taking +ve value
14 V1=V2/(1+K);//kV
15 V4=(1+6*K+5*K^2+K^3)*V1;//kV
16 V=V1+V2+V3+V4;//kV
17 VL=sqrt(3)*V;//kV
18 disp(VL,"Voltage between conductors(kV)");
19 Strinf_eff=V/n/V4;
20 disp(Strinf_eff*100,"Percentage String Efficiency(%)
      ");
```

Scilab code Exa 9.9 Capacitance of remaining five units

```
Capacitance of remaining five units
```

```
1  //Exa 9.9
2  clc;
3  clear;
4  close;
5  //Given data :
6  K=0.1;//shunt to mutual capacitance ratio
7  CbyC1=10;
8  C2byC1=(1+K)*CbyC1;
9  C3byC1=(1+3*K)*CbyC1;
10 C4byC1=(1+6*K)*CbyC1;
11 disp("C2 is "+string(C2byC1)+" times of C1");
12 disp("C3 is "+string(C3byC1)+" times of C1");
13 disp("C4 is "+string(C4byC1)+" times of C1");
14 //I5=I4+i4
15 //omega*C5*v=omega*C4*v+omega*C1*4*v
16 C5byC1=(1+10*K)*CbyC1;
```

```
17  disp("C5 is "+string(C5byC1)+" times of C1");
18  //I6=I5+i5
19  //omega*C6*v=omega*C5*v+omega*C1*5*v
20  C6byC1=(1+15*K)*CbyC1;
21  disp("C6 is "+string(C6byC1)+" times of C1");
```

Scilab code Exa 9.10 Line to pin capacitance

```
Line to pin capacitance
```

```
1   //Exa 9.10
2   clc;
3   clear;
4   close;
5   //Given data :
6   n=8;//no. of units
7   p=1:8;
8   //Cp=p*C/(n-p)
9   C1byC=1/(n-p(1));
10  C2byC=2/(n-p(2));
11  C3byC=3/(n-p(3));
12  C4byC=4/(n-p(4));
13  C5byC=5/(n-p(5));
14  C6byC=6/(n-p(6));
15  C7byC=7/(n-p(7));
16  disp("C1 is "+string(C1byC)+" times of C");
17  disp("C2 is "+string(C2byC)+" times of C");
18  disp("C3 is "+string(C3byC)+" times of C");
19  disp("C4 is "+string(C4byC)+" times of C");
20  disp("C5 is "+string(C5byC)+" times of C");
21  disp("C6 is "+string(C6byC)+" times of C");
22  disp("C7 is "+string(C7byC)+" times of C");
```

Scilab code Exa 9.11 String efficiency

```
String efficiency
```

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

Scilab code Exa 9.12 Line voltage and capacitance required

```
Line voltage and capacitance required
```

```
1  //Exa 9.12
2  clc;
3  clear;
4  close;
5  //Given data :
6  V=20;//kV
7  C=poly(0,'C');
8  //Cmutual=C;//F
9  CmutualBYC=1;
10 //Cshunt=C/5;//F
11 CshuntBYC=1/5;
12 //I2=I1+i1 //omega*C*V2=omega*C*V1+omega*Cshunt*V1
```

```
13  V2BYV1 =1+ CshuntBYC ;
14  V3BYV2 =1;//a  V2=V3
15  //V=V1+V2+V3
16  V1=V/( V3BYV2 + V2BYV1 + V2BYV1 );//kV
17  V2= V2BYV1 * V1 ;//kV
18  V3=V2;//kV
19  disp (V3 ,"Voltage  onn  the  line  end  unit  in  kV  :  ");
20  //I3+ix=I2+i2
21  CxBYC =(V2+ CshuntBYC *(V1+V2) -V3 )/V3 ;
22  disp ("Capacitance  required  is  "+string(CxBYC)+"C(in
        F).");
```

Chapter 10

Mechanical Design of Transmission Lines

Scilab code Exa 10.1 Maximum sag

```
Maximum sag
```

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

Scilab code Exa 10.2 Height above ground

```
Height above ground
```

```
1  //Exa 10.2
2  clc;
3  clear;
4  close;
5  //Given data :
6  W=680; //kg/km
7  L=260; //m
8  U_strength=3100; //kg
9  SF=2; //safety factor
10 Clearance=10; //m
11 T=U_strength/SF; //kg
12 w=W/1000; //kg
13 S=w*L^2/(8*T); // ,m
14 h=Clearance+S; //m
15 disp(h,"Height above the ground(m) :");
```

Scilab code Exa 10.3 Horizontal component of tension and maximum sag

```
Horizontal component of tension and maximum sag
```

```
1  //Exa 10.3
2  clc;
3  clear;
4  close;
5  //Given data :
6  w=700/1000; //kg/m
7  L=300; //m
8  Tmax=3500; //kg
9
10 S_T0=w*L^2/8; // ,m
11 //Tmax=T0+w*S
12 //T0^2-T0*Tmax-w*S_T0=0
13 polynomial=[1 -Tmax w*S_T0];
14 T0=roots(polynomial); //kg
15 T0=T0(1); //+ve sign taken
```

```
16  disp(T0,"Horizontal component of tension in kg is :
        ");
17  S=S_T0/T0;//m
18  disp(S,"Maximum sag in m : ");
19  y=S/2;//m
20  x=sqrt(2*y*T0/w);//m
21  disp(x,"Sag will be half at the point where x
        coordinate(in m) will be : ");
```

Scilab code Exa 10.4 Calculate maximum sag

```
Calculate maximum sag
```

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

Scilab code Exa 10.5 Calculate the sag

Calculate the sag

```
 1  //Exa 10.5
 2  clc;
 3  clear;
 4  close;
 5  //Given data :
 6  L=160;//m
 7  d=0.95;//cm
 8  wc=0.65;//kg/m
 9  U_stress=4250;//kg/cm^2
10  Pw=40;//kg/m^2(Wind pressure)
11  SF=5;//factor of safety
12  W_stress=U_stress/SF;//kg/cm^2
13  T=W_stress*%pi/4*d^2;//kg
14  w_w=Pw*d*10^-2;//kg
15  wr=sqrt(wc^2+w_w^2);//kg
16  S=wr*L^2/8/T;//m
17  disp(round(S),"Sag(meter)");
```

Scilab code Exa 10.6 Calculate the maximum sag

Calculate the maximum sag

```
 1  //Exa 10.6
 2  clc;
 3  clear;
 4  close;
 5  //Given data :
 6  L=180;//m
 7  D=1.27;//cm
 8  Pw=33.7;//kg/m^2(Wind pressure)
 9  r=1.25;//cm
10  wc=1.13;//kg/cm^2
```

```
11  U_stress =4220;//kg/cm^2
12  SF =5;//factor  of  safety
13  W_stress = U_stress/SF;//kg/cm^2
14  T = W_stress*%pi/4*D^2;//kg
15  S = wc*L^2/8/T;//msag  in  air
16  disp(S,"Sag  in  still  air(meter)");
17  w1 =2890.3*r*10^-2*(D+r)*10^-2;//kg/m
18  w_w =Pw*(D+2*r)*10^-2;//kg
19  wr=sqrt((wc+w1)^2+w_w^2);//kg
20  Smax =wr*L^2/8/T;//msag  in  air
21  disp(Smax,"Maximum  Sag(meter)");
```

Scilab code Exa 10.7 Calculate the maximum sag

```
Calculate the maximum sag
```

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

Scilab code Exa 10.8 Calculate the maximum sag

Calculate the maximum sag

```
1  //Exa 10.8
2  clc;
3  clear;
4  close;
5  //Given data :
6  wc=1;//kg/m
7  L=280;//m
8  D=20;//mm
9  r=10;//mm
10 Pw=40;//kg/m^2(Wind pressure)
11 rho_i=910;//kg/m^3(density of ice)
12 U_stress=10000;//kg/cm^2
13 SF=2;//factor of safety
14 wi=rho_i*%pi*r*10^-3*(D+r)*10^-3;//kg
15 w_w=Pw*(D+2*r)*10^-3;//kg
16 wr=sqrt((wc+wi)^2+w_w^2);//kg(Resultant force per m
      length of conductor)
17 T=U_stress/SF;//kg
18 Smax=wr*L^2/8/T;//msag in air
19 disp(Smax,"Maximum Sag(meter)");
```

Scilab code Exa 10.9 Sag in inclined and vertical direction

Sag in inclined and vertical direction

```
1  //Exa 10.9
2  clc;
```

```
 3  clear ;
 4  close ;
 5  //Given  data  :
 6  L=250; //m
 7  D=1.42; //cm
 8  wc=1.09; //kg/m
 9  Pw=37.8; //kg/mˆ2(Wind  pressure)
10  r=1.25; //cm
11  Lis=1.43; //m(insulator  string  length)
12  Clearance=7.62; //m
13  rho_i=913.5; //kg/mˆ3(density  of  ice)
14  stress=1050; //kg/cmˆ2
15  T=stress*%pi/4*Dˆ2; //kg
16  wi=rho_i*%pi*r*10^-2*(D+r)*10^-2; //kg
17  w_w=Pw*(D+2*r)*10^-2; //kg
18  wr=sqrt((wc+wi)^2+w_w^2); //kg(Resultant  force  per  m
        length  of  conductor)
19  Smax=wr*L^2/8/T; //max  sag  in  air
20  disp(Smax,"Sag  in  inclined  direction(meter)");
21  Sdash=Smax*(wc+wi)/wr; //max  sag  in  air
22  disp(Sdash,"Sag  in  vertical  direction(meter)");
23  h=Clearance+Sdash+Lis; //m
24  disp(h,"Height  of  lowest  cross  arm(m)");
```

Scilab code Exa 10.10 Lowest point of catenary curve

```
Lowest point of catenary curve
```

```
 1  //Exa  10.10
 2  clc ;
 3  clear ;
 4  close ;
 5  //Given  data  :
 6  wc=0.35; //kg/m
 7  stress=800; //kg/cmˆ2
```

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```
8  L=160;//m
9  SF=2;//safety factor
10 h=70-65;//m
11 T=stress/SF;//kg
12 x=L/2+T*h/(wc*L);//m
13 disp(x,"Distance of lowest point(m)");
14 S1=wc*x^2/SF/T;//max sag in air
15 xmin=70-S1;//m
16 disp(xmin,"minimum point of catenary above the
       ground(m)");
```

Scilab code Exa 10.11 Sag at lower support

Sag at lower support

```
1  //Exa 10.11
2  clc;
3  clear;
4  close;
5  //Given data :
6  L=200;//m
7  h=10;//m
8  D=2;//cm
9  wc=2.3;//kg/m
10 Pw=57.5;//kg/m^2(wind pressure)
11 SF=4;//safety factor
12 stress=4220;//kg/cm^2
13 w_w=Pw*D*10^-2;//kg
14 wr=sqrt(wc^2+w_w^2);//kg
15 f=stress/SF;//kg/cm^2
16 T=f*%pi/4*D^2;//kg
17 x=L/2-T*h/(wr*L);//m
18 S1=wr*x^2/2/T;//max sag in air
19 disp(S1,"Slant sag(m)");
20 Sdash=wc*x^2/2/T;//vertical sag
```

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```
21  disp(Sdash,"Vertical Sag(meter)");
```

Scilab code Exa 10.12 Determine the vertical sag

```
Determine the vertical sag
```

```
1   //Exa 10.12
2   clc;
3   clear;
4   close;
5   //Given data :
6   wc=1.925;//kg/m
7   A=2.2;//cm^2
8   f=8000;//kg/cm^2
9   L=600;//m
10  h=15;//m
11  D=2;//cm
12  SF=5;//safety factor
13  wi=1;//kg(load)
14  w=wi+wc;//kg
15  T=f*A/SF;//kg
16  x=L/2-T*h/(w*L);//m
17  S2=w*(L-x)^2/2/T;//m
18  disp(S2,"Vertical Sag(meter)");
```

Scilab code Exa 10.13 Find the clearance

```
Find the clearance
```

```
1   //Exa 10.13
2   clc;
3   clear;
```

```
 4  close;
 5  //Given data :
 6  h=80-50;//m
 7  L=300;//m
 8  T=2000;//kg
 9  w=0.844;//kg/m
10  x=L/2-T*h/(w*L);//m
11  d_PO=L/2-x;//m
12  d_BO=L-x;//m
13  Smid=w*(L/2-x)^2/2/T;//m
14  S2=w*(L-x)^2/2/T;//m
15  Point_P=S2-Smid;//m
16  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

```
Stringing Tension in the conductor
```

```
 1  //Exa 10.14
 2  clc;
 3  clear;
 4  close;
 5  //Given data :
 6  S1=25;//m
 7  S2=75;//m
 8  Point_P=45;//m
 9  L1=250;//m
10  L2=125;//m(mid point)
11  w=0.7;//kg/m
12  h1=S2-S1;//m(for points A & B)
13  h2=Point_P-S1;//m(for points A & B)
14  //h1=w*L1/2/T*[L1-2*x]
15  //h2=w*L2/2/T*[L2-2*x]
```

```
16  x=(L1-h1/h2/L1*L2*L2)/(-h1/h2/L1*L2*2+2);//m
17  T=(L1-2*x)/(h1/w/L1*2);//kg
18  disp(T,"Stringing Tension(kg)");
```

_____

Scilab code Exa 10.15 Find the clearance

Find the clearance

```
 1  //Exa 10.15
 2  clc;
 3  clear;
 4  close;
 5  //Given data :
 6  L=300;//m
 7  slope=1/20;
 8  w=0.80;//kg/m
 9  hl=30;//m
10  T0=1500;//kg
11  CD=L;//m
12  tan_alfa=slope;
13  ED=CD*tan_alfa;//m
14  AC=hl;//m
15  BE=hl;//m
16  BD=BE+ED;//m
17  //S1=w*x1^2/2/T0;//m
18  //S2=w*(L-x1)^2/2/T0;//m
19  h=15;//m
20  ED=h;//m
21  x1=L/2-T0*h/w/L;//m
22  S1=w*x1^2/2/T0;//m
23  S2=w*(L-x1)^2/2/T0;//m
24  OG=AC-S1-x1*tan_alfa;//m
25  Clearance=OG;//m
26  disp(Clearance,"Clearance of the lowest point from
       ground(m)");
```

```
27  //y=x*tan_alfa −OG;//m
28  //C1=w*x^2/2/T0−(x/20−OG)
29  x=T0/20/w;//m(Byy putting dC1/dx=0)
30  C1=w*x^2/2/T0-(x/20-OG);//m
31  disp(C1,"Minimum clearance(m)");
```
───

Scilab code Exa 10.16 sag and tension

sag and tension

```
 1  //Exa 10.16
 2  clc;
 3  clear;
 4  close;
 5  //Given data :
 6  L=250;//m
 7  D=19.5;//mm
 8  A=2.25*10^-4;//m^2
 9  wc=0.85;//kg/m
10  t1=35;//degree C
11  t2=5;//degree C
12  Pw=38.5;//kg/m^2
13  alfa=18.44*10^-6;//per degree C
14  E=9320;//kg/mm^2
15  E=9320*10^6;//kg/m^2
16  Breaking_Load=8000;//kg
17  SF=2;//Safety factor
18  T1=Breaking_Load/SF;//kg
19  f1=T1/A;//kg/m^2
20  w_w=Pw*D*10^-2;//kg
21  w1=sqrt(wc^2+w_w^2);//kg
22  w2=wc;
23  //f2^2*[(f2−f1)+w1*L^2*E/24/f1^2/A^2+(t2−t1)*E]=w2*L
        ^2*E/24/A^2
24  //f2^3−f2^2*f1−w2*L^2*E/24/A^2=0
```

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```
25  P=[1 -1.0674*10^7 0 -3463.84*10^17];
26  f2=roots(P);
27  f2=f2(1); //kg/m^2
28  S=w2*L^2/8/f2/A; //m
29  disp(S,"Sag at erection(m)");
```

Chapter 11

Insulated Cables

Scilab code Exa 11.1 Insulation Resistance

Insulation Resistance

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

Scilab code Exa 11.2 Insulation Resistance

Insulation Resistance

```
1  //Exa 11.2
2  clc;
3  clear;
4  close;
5  //Given data :
6  rho=5*10^14*10^-2;//ohm-m
7  l=5*1000;//m
8  r1=2.5;//m
9  r2=r1+1;//m
10 R_ins=rho/(2*%pi*l)*log(r2/r1);//ohm
11 disp(R_ins/10^6,"Insulation resistance of cable(Mohm
      ) :");
```

Scilab code Exa 11.3 Calculate the Resistivity

```
Calculate the Resistivity
```

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

Scilab code Exa 11.4 Find Charging current

Find Charging current

```
1  //Exa 11.4
2  clc;
3  clear;
4  close;
5  //Given data :
6  V1=11000;//Volt
7  f=50;//Hz
8  a=0.645;//cm^2
9  d=sqrt(4*a/%pi);//cm
10 d=d/100;//m
11 D=2.18/100;//m
12 epsilon_r=3.5;//relative permitivity
13 V=V1*sqrt(2)/sqrt(3);//V(assuming 3 phase system)
14 gmax=2*V/d/log(D/d);//V/m
15 gmax=gmax/10^5;//KV/cm
16 disp(gmax,"Maximum electrostatic stress(kV/cm)");
17 gmin=2*V/D/log(D/d);//V/m
18 gmin=gmin/10^5;//kV/cm
19 disp(gmin,"Minimum electrostatic stress(kV/cm)");
20 C=0.024*epsilon_r/log10(D/d);//micro F
21 disp(C*10^-6,"Capacitance per km length(F)");//
22 Vp=V1/sqrt(3);//V
23 Ic=2*%pi*f*C*10^-6*Vp;//A
24 disp(Ic,"Charging Current per phase per km length(A)
      ");
```

Scilab code Exa 11.5 Maximum Stress and Charging KVAR

Maximum Stress and Charging KVAR

```
1  //Exa 11.5
2  clc;
```

```
 3  clear;
 4  close;
 5  //Given data :
 6  VL=33*1000;//Volt
 7  f=50;//Hz
 8  l=3.4;//km
 9  d=2.5;//cm
10  radial_thick=0.6;//cm
11  epsilon_r=3.1;//relative permitivity
12  V=VL*sqrt(2)/sqrt(3);//V(assuming 3 phase system)
13  D=d+2*radial_thick;//cm
14  D=D/100;//cm
15  d=d/100;//m
16  gmax=2*V/d/log(D/d);//V/m
17  disp(gmax,"Maximum electrostatic stress(V/m)");
18  C=0.024*epsilon_r*l/log10(D/d);//micro F
19  Vp=VL/sqrt(3);//V
20  Ic=2*%pi*f*C*10^-6*Vp;//A
21  kVA=sqrt(3)*VL*Ic*10^-3;//kVAR
22  disp(kVA,"Total charging kVA(kVAR)");
```

Scilab code Exa 11.6 Determine D and d

Determine D and d

```
 1  //Exa 11.6
 2  clc;
 3  clear;
 4  close;
 5  //Given data :
 6  VL=10*1000;//Volt
 7  Emax=23;//kV/cm
 8  gmax=Emax*10^5;//V/m
 9  d=2*VL/gmax;//m
10  disp(d*10^3,"Diameter of conductor(mm)");
```

```
11  D=%e*d;//m
12  disp(D*10^3,"Internal  diameter  of  sheath(mm)");
```

Scilab code Exa 11.7 Most Economical value of diameter

```
Most Economical value of diameter
```

```
1   //Exa  11.7
2   clc;
3   clear;
4   close;
5   //Given  data  :
6   VL=132*1000;//Volt
7   gmax=60;//kV/cm(peak)
8   gmax=gmax/sqrt(2)*10^5;//V/m(rms)
9   V=VL/sqrt(3);//Volt
10  d=2*V/gmax;//m
11  disp(d*10^3,"Diameter  of  conductor(mm)");
12  D=%e*d;//m
13  disp(D*10^3,"Internal  diameter  of  sheath(mm)");
```

Scilab code Exa 11.8 Maximum safe working voltage

```
Maximum safe working voltage
```

```
1   //Exa  11.8
2   clc;
3   clear;
4   close;
5   //Given  data  :
6   r=0.5;//cm
7   R=3.5;//cm
```

```
8  r1=1;//cm
9  g1max=34;//kV/cm(peak)
10 epsilon_r=5;//relative permitivity
11 g2max=g1max*r/r1/epsilon_r;//kV/cm(peak)
12 Vpeak=r*g1max*log(r1/r)+r1*g2max*log(R/r1);//kV
13 Vrms=Vpeak/sqrt(2);//kV
14 disp(Vrms,"RMS value of max safe working voltage(kV)
      ");
```

Scilab code Exa 11.9 Thickness and working voltage

```
Thickness and working voltage
```

```
1  ////Exa 11.9
2  clc;
3  clear;
4  close;
5  //Given data :
6  g1max=60;//kV/cm
7  g2max=50;//kV/cm
8  epsilon_r1=4;//relative permitivity
9  epsilon_r2=2.5;//relative permitivity
10 D=5;//cm(sheat inside diameter)
11 d=1;//cm
12 //g1max/g2max=epsilon_r2*d1/(epsilon_r1*d)
13 d1=g1max/g2max/epsilon_r2*(epsilon_r1*d);//cm
14 t_inner=(d1-d)/2;//cm
15 disp(t_inner*10,"Radial thickness of inner
      dielectric(mm)");
16 t_outer=(D-d1)/2;//cm
17 disp(t_outer*10,"Radial thickness of outer
      dielectric(mm)");
18 Vpeak=g1max/2*d*log(d1/d)+g2max/2*d1*log(D/d1);//kV
19 Vrms=Vpeak/sqrt(2);//kV
20 disp(Vrms,"Maximum working voltage(rms in kV)");
```

Scilab code Exa 11.10 Working Voltage

Working Voltage

```
1  ////Exa 11.10
2  clc;
3  clear;
4  close;
5  //Given data :
6  r=1;//cm
7  R=2.5;//cm
8  d=2*r;//cm
9  D=2*R;//cm
10 epsilon_r1=5;//relative permitivity
11 epsilon_r2=4;//relative permitivity
12 epsilon_r3=3;//relative permitivity
13 gmax=40;//KV/cm
14 //epsilon_r1*d=epsilon_r2*d1=epsilon_r3*d2
15 d1=(epsilon_r1/epsilon_r2)*d;//cm
16 d2=(epsilon_r1/epsilon_r3)*d;//cm
17 Vpeak=gmax/2*(d*log(d1/d)+d1*log(d2/d1)+d2*log(D/d2)
        );//kV
18 Vrms=Vpeak/sqrt(2);//kV
19 disp(Vrms,"Working voltage(rms) for the cable (kV)")
        ;
```

Scilab code Exa 11.11 Calculate Potential gradient

Calculate Potential gradient

```
1  //Exa 11.11
2  clc;
3  clear;
4  close;
5  //Given data :
6  Vs=66; //kV
7  d=1; //cm
8  d1=1+2*1; //cm
9  D=3+2*1; //cm
10 epsilon_r1=3; //relative permitivity
11 epsilon_r2=2.5; //relative permitivity
12 g2maxBYg1max=d*epsilon_r1/(d1*epsilon_r2);
13 Vmax=Vs*sqrt(2)/sqrt(3); //kV
14 //Vmax=g1max*d/2*log(d1/d)+g2max*d1/2*log(D/d1); //kV
15 g1max=Vmax/(d/2*log(d1/d)+g2maxBYg1max*d1/2*log(D/d1
      )); //kV/cm
16 disp(g1max,"Potential gradient at the surface of
      conductor(kV/cm)");
17 g2max=g1max*g2maxBYg1max; //kV/cm
18 disp(g2max,"Maximum stress in the outer dielectric(
      kV/cm)");
19 Stress=g2max*d1/D; //kV/cm
20 disp(Stress,"Stress at the surface of outer
      dielectric(kV/cm)");
```

Scilab code Exa 11.12 Determine the maximum stress

Determine the maximum stress

```
1  //Exa 11.12
2  clc;
3  clear;
4  close;
5  //Given data :
6  Vs=66; //kV
```

```
7  d=2;//cm
8  d1=2+2*1;//cm
9  D=4+2*1;//cm
10 epsilon_r1=5;//relative permitivity
11 epsilon_r2=3;//relative permitivity
12 g2maxBYg1max=d*epsilon_r1/(d1*epsilon_r2);
13 Vmax=Vs*sqrt(2)/sqrt(3);//kV
14 //Vmax=g1max*d/2*log(d1/d)+g2max*d1/2*log(D/d1);//kV
15 g1max=Vmax/(d/2*log(d1/d)+g2maxBYg1max*d1/2*log(D/d1
      ));//kV/cm
16 disp(g1max,"Potential gradient at the surface of
      conductor(kV/cm)");
17 g2max=g1max*g2maxBYg1max;//kV/cm
18 disp(g2max,"Maximum stress in the outer dielectric(
      kV/cm)");
```

Scilab code Exa 11.13 Minimum Internal Diameter

```
Minimum Internal Diameter
```

```
1  //Exa 11.13
2  clc;
3  clear;
4  close;
5  //Given data :
6  Vs=66;//kV
7  r=0.5;//cm
8  g1max=50;//kV/cm
9  g2max=40;//kV/cm
10 g3max=30;//kV/cm
11 epsilon_r1=4;//relative permitivity
12 epsilon_r2=4;//relative permitivity
13 epsilon_r3=2.5;//relative permitivity
14 //Q=2*%pi*epsilon0*epsilon_r1*r*g1max=2*%pi*epsilon0
      *epsilon_r2*r*g2max=2*%pi*epsilon0*epsilon_r3*r*
      g3max
```

```
15  r1=epsilon_r1*r*g1max/(epsilon_r2*g2max);//cm
16  r2=epsilon_r2*r1*g2max/(epsilon_r3*g3max);//cm
17  Vmax=Vs*sqrt(2);//kV
18  //Vmax=g1max*r*log(r1/r)+g2max*r1*log(r2/r1)+g3max*
        r2*log(R/r2);//kV
19  R=exp((Vmax-g1max*r*log(r1/r)-g2max*r1*log(r2/r1))/
        g3max/r2)*r2;//cm
20  D=2*R;//cm
21  disp(D,"Inner diameter of lead sheath(cm)");
```

Scilab code Exa 11.14 Diameter of intersheath

Diameter of intersheath

```
 1  //Exa 11.14
 2  clc;
 3  clear;
 4  close;
 5  //Given data :
 6  Vrms=66;//kV
 7  Vmax=Vrms*sqrt(2);//kV
 8  gmax=60;//kV/cm
 9  d=2*Vmax/%e/gmax;//cm
10  d1=%e*d;//cm
11  V1=Vrms/%e;//kV
12  dV=Vrms-V1;//kV(Voltage between sheath & intersheath
        )
13  disp(dV,"Voltage between sheath & intersheath(kV)");
```

Scilab code Exa 11.15 Maximum stress and voltage

Maximum stress and voltage

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```
1  //Exa 11.15
2  clc;
3  clear;
4  close;
5  //Given data :
6  Vs=66;//kV
7  Vmax=Vs*sqrt(2)/sqrt(3);//kV
8  D=6;//cm
9  d=2.5;//cm
10 d1=%e*d;//cm
11 gmax=2*Vmax/d/log(D/d);//kV/cm
12 disp(gmax,"Maximum stress without intersheath(kV/cm)
      ");
13 //d1/d=d2/d1=D/d2=alfa(say)
14 alfa=(D/d)^(1/3);
15 d1=alfa*d;//cm
16 d2=alfa*d1;//cm
17 gmax=Vmax/(d/2*log(d1/d)+d1/2*log(d2/d1)+d2/2*log(D/
      d2));//kV/cm
18 V1max=gmax*d/2*log(d1/d);//kV
19 V2max=gmax*d1/2*log(d2/d1);//kV
20 Vpeak1=Vmax-V1max;//kV
21 disp(Vpeak1,"Peak voltage on 1st intersheath(kV)");
22 Vpeak2=Vpeak1-V2max;//kV
23 disp(Vpeak2,"Peak voltage on 2nd intersheath(kV)");
```

Scilab code Exa 11.16 capacitance and charging current

capacitance and charging current

```
1  //Exa 11.16
2  clc;
3  clear;
4  close;
5  //Given data :
```

```
6  Vs =11; //kV
7  f =50; //Hz
8  l =2.5*1000; //m
9  C_all3 =1.8; //micro F
10 Cdash =1.5; //micro F(2*Cc+Cs)
11 Cs = C_all3 /3; //micro F
12 Cc =(Cdash - Cs) /2; //micro F
13 C_N =3* Cc + Cs; //micro F
14 disp (C_N ," Capacitance of core to neutral (micro F)");
15 C_2 = C_N /2; //micro F
16 disp (C_2 ," Capacitance between any two core (micro F)"
     );
17 Vp = Vs *1000/ sqrt (3); //Volt
18 Ic =2*%pi *f* Vp * C_N *10^ -6; //A
19 disp (Ic ," Charging current per phase (A)");
```

Scilab code Exa 11.17 Calculate the KVA taken

```
Calculate the KVA taken
```

```
1  //Exa 11.17
2  clc ;
3  clear ;
4  close ;
5  //Given data :
6  l =10; //km
7  Vs =10; //kV
8  f =50; //Hz
9  C =0.3; //micro F/km(between any two core )
10 C2 = l*C; //micro F(between any two core )
11 C_N =2* C2; //micro F
12 Vp = Vs *1000/ sqrt (3); //Volt
13 Ic =2*%pi *f* Vp * C_N *10^ -6; //A
14 kVA =3* Vp * Ic /1000; //kVAR
15 disp (kVA ," kVA taken by the cable (kVAR)");
```

Scilab code Exa 11.18 Find the capacitance

Find the capacitance

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

Scilab code Exa 11.19 Maximum Stress and total Charging KVAR

Maximum Stress and total Charging KVAR

```
1  //Exa 11.19
2  clc;
3  clear;
4  close;
5  //Given data :
6  Vs=33;//kV
```

```
7  f=50;//Hz
8  l=3.4;//km
9  d=2.5;//cm
10 D=d+2*0.6;//cm
11 epsilon_r=3.1;//relative permitivity
12 C=0.024*epsilon_r/log10(D/d)*l*1000*1000*10^-6;// F/
      phase
13 Vp=Vs*1000/sqrt(3);//Volt
14 Ic=2*%pi*f*C*10^-6*Vp;//A
15 kVAR=3*Vp*Ic*10^-3;//kVAR
16 disp(kVAR,"Total charging kVAR : ");
17 Emax=Vp/(d/2*log(D/d))*10^-3;//kV/cm
18 disp(Emax,"Maximum stress in the cable(kV/cm) ");
```

Scilab code Exa 11.20 Capacitance Charging Current Loss Resistance

Capacitance Charging Current Loss Resistance

```
1  //Exa 11.20
2  clc;
3  clear;
4  close;
5  //Given data :
6  Vs=11;//kV
7  f=50;//Hz
8  D=2;//cm
9  d=0.5;//cm
10 epsilon_r=3.5;//relative permitivity
11 pf=0.05;//power factor
12 C=0.024*epsilon_r/log10(D/d)*10^-6;// F/km
13 disp(C*10^6,"Capacitance of the cable(micro F)");
14 Vp=Vs*1000/sqrt(3);//Volt
15 Ic=2*%pi*f*C*Vp;//A
16 disp(Ic,"Charging current(A)");
17 fi=acosd(pf);//degree
```

```
18  del=90-fi;//degree(Dielectric loss angle)
19  loss_dielectric=2*%pi*f*C*Vp^2*tand(del);//W
20  disp(loss_dielectric,"Dielectric loss(W)");
21  R_INS=Vp^2/loss_dielectric;//ohm
22  disp(R_INS/10^6,"Equivalent insulation resistance(
       Mohm)");
```

Scilab code Exa 11.21 Loss angle and No load current

```
Loss angle and No load current
```

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

Chapter 12

Neutral Grounding

Scilab code Exa 12.1 Reactance of coil

Reactance of coil

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

Scilab code Exa 12.2 Inductance and kVA rating

Inductance and kVA rating

```scilab
1  //Exa 12.2
2  clc;
3  clear;
4  close;
5  format('v',5);
6  //Given data :
7  V=132*1000;//V
8  f=50;//Hz
9  r=10/1000;//m
10 d1=4;//m
11 d2=4;//m
12 d3=d1+d2;//m
13 epsilon_o=8.854*10^-12;//constant
14 l_tl=192*1000;//length of transmission line in m
15 C=2*%pi*epsilon_o/log((d1*d2*d3)^(1/3)/r)*l_tl;//in
       Farad
16 L=1/3/(2*%pi*f)^2/C;//H
17 disp(L,"Necessary Inductance of peterson coil in H :
       ");
18 VP=V/sqrt(3);//V
19 IL=VP/(2*%pi*f)/L;//A
20 Rating=VP*IL/1000;//kVA
21 disp(Rating/1000,"Rating of supressor coil in MVA :"
       );
```