Scilab Textbook Companion for Electrical Power Systems by C. L. Wadhwa[1]

Created by
Anuj Bansal
B.E
Electrical Engineering
Thapar University, Patiala(Punjab)
College Teacher
Dr. Sunil Kumar Singla
Cross-Checked by
Lavitha Pereira

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Book Description

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

Exa Example (Solved example)

Eqn Equation (Particular equation of the above book)

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

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

Contents

List of Scilab Codes

Chapter 1

FUNDAMENTALS OF POWER SYSTEMS

Scilab code Exa 1.1 To determine the Base values and pu values

```
// To determine the Base values and p.u values
clear
clc;
Sb=100;// base value of power(MVA)
Vb=33;// base value of voltage (Kv)
Vbl=Vb*110/32;
Vbm=Vbl*32/110;
Zp.ut=0.08*100*32*32/(110*33*33);
Zp.u.l=50*100/(Vbl^2);
Zp.um1=.2*100*30*30/(30*33*33);
Zp.um2=.2*100*30*30/(20*33*33);
Zp.um3=.2*100*30*30/(50*33*33);
mprintf("Base value of voltage in line = %.2f kV\n",
   Vbl);
mprintf("Base value of voltage in motor circuit=%.0f
    kV\n",Vbm);
mprintf("p.u value of reactance transformer =%.5f p.
   u\n",Zp.ut);
mprintf("p.u value of impedence of line=%.4f p.u\n",
```

```
    Zp.u.l);
mprintf("p.u value of reactance of motor 1 =%.4f p.u
    \n",Zp.um1);
mprintf("p.u value of reactance of motor 2 =%.3f p.u
    \n",Zp.um2);
mprintf("p.u value of reactance of motor 3 =%.4f p.u
    \n",Zp.um3);
```

Chapter 2

LINE CONSTANT CALCULATIONS

Scilab code Exa 2.2 To dtermine inductance of a 3 phase line

```
//To dtermine inductance of a 3 phase line
clear
clc;
GMD=0.7788*0.8/(2*100);
Mgmd=((1.6*3.2*1.6)^(1/3));
Z=2*(10^-4)*1000*log(2.015/.003115);
mprintf("The self GMD of the conductor =%.6f metres\n",GMD);
mprintf("The mutual GMD of the conductor =%.3f metres\n ",Mgmd);
mprintf("Inductance =%.3f mH/km\n",Z);
```

Scilab code Exa 2.3 Determine the equivalent radius of bundle conductor having its part conductors r on the periphery of circle of dia d

```
//What will be the equivalent radius of bundle conductor having its part conductors 'r' on the
```

```
   periphery of circle  of dia'd' if the number of
   conductors is 2,3,4 ,6 ?

clear
clc;
r=poly(0,"r");
D11=r^1;
D12=2*r;
D14=4*r
D13=sqrt(16-4)*r;
Ds1=((1*2*2*sqrt(3)*4*2*sqrt(3)*2*2)^(1/7))*r;
Ds7=((2*1*2*2**2*2*2)^(1/7))*r;//we get this after
   Taking r outside the 1/7th root
Ds=((((1*2*2*sqrt(3)*4*2*sqrt(3)*2*2)^(1/7))^6)
   *((2*1*2*2**2*2*2)^(1/7)))^(1/7)*r;
Dseq=((.7788)^(1/7))*Ds;
disp(Dseq,"Dseq.= ");
```

Scilab code Exa 2.4 To determine the inductance of single phase Transmission line

```
// To determine the inductance of single phase
   Transmission line
clear
clc;
GMDa=0.001947;// GMD of conductor in group A
DSA=((.001947*6*12*.001947*6*6*0.001947*6*12)^(1/9))
   ;
DSB=sqrt(5*(10^-3)*.7788*6);
Dae=sqrt((9^2)+6^2);
Dcd=sqrt((12^2)+9^2);
DMA=((9*10.81*10.81*9*15*10.81)^(1/6));
LA=2*(10^-7)*(10^6)*log(DMA/DSA);
LB=2*(10^-7)*(10^6)*log(DMA/DSB);
Tot=LA+LB;
```

```
mprintf("inductance of line A,LA=%.3f mH/km\n",LA);//Answers don't match due to difference in rounding off of digits
mprintf("inductance of line B,LB=%.1f mH/km\n",LB);//Answers don't match due to difference in rounding off of digits
mprintf("total inductance of line =%.2f mH/km\n",Tot);//Answers don't match due to difference in rounding off of digits
```

Scilab code Exa 2.5 To determine the inductance per Km of 3 phase line

```
// To determine the inductance per Km of 3-phase line
clear
clc;
GMDc=1.266*0.7788*(10^-2);// self GMD of each conductor
Dbc=sqrt((4^2)+(.75^2));
Dab=Dbc;
Dab`=sqrt((4^2)+(8.25^2));
Daa=sqrt((8^2)+(7.5^2));
Dm1=(Dbc*8*7.5*9.1685)^(1/4);
Dm2=(Dbc*Dbc*9.1685*9.1685)^(1/4);
Dm3=Dm1;
Dm=((Dm1*Dm2*Dm3)^(1/3));
Ds1=sqrt(GMDc*Daa);// self GMD of each phase
Ds3=Ds1;
Ds2=sqrt(GMDc*9);
Ds=((Ds1*Ds2*Ds3)^(1/3));
Z=2*(10^-4)*(1000)*log(Dm/Ds);
mprintf("inductance=%.3f mH/km/phase\n",Z);
```

Scilab code Exa 2.6 To determine the inductance of double circuit line

```
// To determine the inductance of double circuit
   line
clear
clc;
GMDs=.0069;//self GMD of the conductor
Dab=sqrt((3^2)+.5^2);
Dbc=Dab;
Dac=6;
Dab‘=sqrt((3^2)+6^2);
Daa=sqrt((6^2)+5.5^2);
Dm1=((3.04*6*5.5*6.708)^.25);
Dm2=((3.04*3.04*6.708*6.708)^.25);
Dm=4.89;
Ds1=sqrt(GMDs*Daa);
Ds2=0.2217;
Ds=.228;
Z=2*(10^-7)*(10^6)*log(Dm/Ds);
mprintf("inductance =%.3f mH/km",Z);
```

Scilab code Exa 2.7 To determine the inductance per Km per phase of single circuit

```
// // To determine the inductance per Km per phase
   of single circuit
clear
clc;
Ds=sqrt(0.025*.4*.7788);
Dm=((6.5*13.0*6.5)^(1/3));
Z=2*(10^-4)*1000*log(Dm/Ds);
mprintf("inductance =%.3f mH/km/phase",Z);
```

Chapter 3

CAPACITANCE OF TRANSMISSION LINES

Scilab code Exa 3.1 To determine the capacitance and charging current

```
//To determine the capacitance and charging current
clear
clc;
Dm=2.015;// mutual GMD of conductors(m)
r=.4;// radius of conductor(cm)
C=10^-9*1000/(18*log(201.5/.4));
Ic=132*1000*8.928*314*(10^-9)/sqrt(3);
mprintf("capacitance =%.13f F/km\n",C);//Answers don
    't match due to different reprentation
mprintf("charging current=%.4f amp/km",Ic);
```

Scilab code Exa 3.2 To determine the capacitance and charging current

```
//To determine the capacitance and charging current
clear
clc;
```

```
GMDm=6.61;//mutual GMD(m)
Ds1=sqrt(1.25*(10^-2)*10.965);
Ds3=Ds1;
Ds2=sqrt(1.25*(10^-2)*9);
Ds=((Ds1*Ds2*Ds3)^.333333);
C=1/(18*log(GMDm/Ds));
Ic=220*1000*314*.01905*(10^-6)/sqrt(3);
mprintf("capacitance =%.6f micro-Farad/km\n",C);
mprintf("charging current =%.2f amp/km",Ic);
```

Scilab code Exa 3.3 To determine the capacitance and charging current

```
//To determine the capacitance and charging current
clear
clc;
GMD=8.19;
Ds=sqrt(2.25*(10^-2)*.4);
C=1/(18*log(GMD/Ds));
Ic=220*1000*314*C*(10^-6)/sqrt(3);
mprintf("capacitance per km =%.5f micro-Farad\n",C);
mprintf("charging current =%.3f amp",Ic);
```

Chapter 4

PERFORMANCE OF LINES

Scilab code Exa 4.1 To determine the sending end voltage and current power and power factor Evaluate A B C D parameters

```
//To detremine the the voltage at the generating
   station and efficiency of transmission
clear
clc;
R=0.496;// resistance
X=1.536;
Vr=2000;
Z=(10*2*2/(11*11)) + %i*30*2*2/(11*11);
Zt=(.04+(1.3*2*2/(11*11))) + %i*(.125 +
   (4.5*2*2/(11*11)));//Transformer impedence
Il=250*1000/2000;// line current(amps.)
Pl=Il*Il*R;//line loss(kW)
Po=250*0.8;// output(kW)
cosr=0.8;// power factor
sinr=.6;
%n=200*100/(200+7.7);
Vs=(Vr*cosr+Il*R)+%i*(Vr*sinr+Il*X);
V=sqrt((1662^2)+ (1392^2));
mprintf("efficiency= %.1f percent \n",%n);
mprintf("Sending end voltage,|Vs|=%.0f volts",V);
```

Scilab code Exa 4.2 To determine power input and output i star connected ii delta connected

```
//To determine power input and output (i) star connected (ii)delta connected
clear
clc;
mprintf("when load is star connected\n");
Vln=400/sqrt(3);// Line to neutral voltage(V)
Z=7+ %i*11;//Impedence per phase
Il=231/Z;// line current(amp.)
I=abs(231/Z);
Pi=3*I*I*7;
Po=3*I*I*6;
mprintf("power input =%.0f watts\n",Pi);//Answers don't match due to difference in rounding off of digits
mprintf("power output=%.0f watts\n",Po);//Answers don't match due to difference in rounding off of digits
mprintf("when load is delta connected\n");
Ze=2+ %i*3;// equivalent impedence(ohm)
Zp=3+%i*5;// impedence per phase
il=231/Zp;//Line current(amps.)
IL=abs(il);
pi=3*IL*IL*3;
po=3*IL*IL*2;
mprintf("power input=%.1f watts\n",pi);//Answers don't match due to difference in rounding off of digits
mprintf("power output = %.0f watts \n",po);//Answers don't match due to difference in rounding off of digits
```

Scilab code Exa 4.3 To determine efficiency and regulation of line

```
// To determine efficiency and regulation of line
clear
clc;
a=100/.5
Xl=2*(10^-7)*log(100/.5);//inductance(H/meter)
XL=20*(1000)*Xl;// inductance of 20 km length
R=6.65;// resistance(ohm)
Rc=20*1000/(58*90);// resistance of copper(ohm)
I=10*1000/(33*.8*sqrt(3));// the current(amps.)
Pl=3*I*I*Rc/(10^6);//loss (MW)
n=10/(10+Pl);
mprintf("efficiency=%.4f percent \n",n);
Vr=19052;
cosr=.8;//power factor
sinr=.6;
Vs=abs(((Vr*cosr+I*Rc) +%i*(Vr*sinr+ I*R)));
mprintf("Vs =%.0f volts\n",Vs);//Answer don't match
   due to difference in rounding off of digits
Reg=(Vs-Vr)*100/Vr;
mprintf(" regulation =%.2f percent",Reg)
```

Scilab code Exa 4.4 To calculate the voltage across each load impedence and current in the nuetral

```
//To calculate the voltage across each load
   impedence and current in the nuetral
clear
clc;
IR=(400)/((sqrt(3)*(6.3+%i*9)));
IY=231*(cosd(-120) + %i*sind(-120))/8.3;
```

```
IB=231*(cosd(120) + %i*sind(120))/(6.3-%i*8);
In=abs((IR +IY +IB));//Neutral current
mprintf("Neutral current =%.2f amps\n",In);
VR=abs(IR*(6+ %i*9));
VY=abs(IY*(8));
VB=abs(IB*(6-%i*8));
mprintf("Voltage across Phase R =%.1f volts \n",VR);
mprintf("Voltage across Phase Y =%.2f volts \n",VY);
mprintf("Voltage across Phase B =%.0f volts \n",VB);
```

Scilab code Exa 4.5 To determine efficiency and regulation of 3 phase line

```
// To determine efficiency and regulation of 3 phase
    line
clear
clc;
R=100*.1;//Resistance of line (ohm)
X1=2*(10^-7)*100*1000*log(200/.75);//inductance of
    line
X2=X1*314;//inductive reactance
C=2*(%pi*100)*8.854*(10^-12)*100*1000*(10^6)/(log
    (200/.75));// capacitance per phase (micro farad)
mprintf("Using Nominal-T method\n");
Ir=20*1000/(sqrt(3)*66*.8);
Vr=66*1000/sqrt(3);
Vc=(38104*.8+ Ir*5) +%i*(38104*.6+ Ir*17.55);//
    voltage across condenser
Ic=%i*314*(Vc)*.9954*(10^-6);
is=Ir+Ic;
Is=abs(Ir+Ic);
Vs=abs(Vc + (is*(5 + %i*17.53)));
VR=abs(Vs*(-%i*3199)/(5-%i*3181));// no load
    recieving end voltage
Reg=(VR-Vr)*100/Vr;
Pl=3*(Ir*Ir*5 + Is*Is*5)/1000000;
```

```
%n=20*100/(20+Pl);
mprintf("percent regulation=%.1f \n",Reg);
mprintf("percent efficiency=%.1f \n\n",%n);
mprintf("Using Nominal-pi method\n");
Ir1=218.68*(.8-%i*.6);
Ic1=%i*314*.4977*(10^-6)*Vr;
Il=Ir1+Ic1;
vs1=Vr+Il*(10+%i*35.1);
Vs1=abs(vs1);
Vr1=Vs1*(-%i*6398)/(10-%i*6363);
VR1=abs(Vr1);// no load recieving end voltage
Reg2=(VR1-Vr)*100/Vr;
IL=abs(Ir1+Ic1);
Loss=3*IL*IL*10;
%n=20*100/21.388;
mprintf("percent regulation=%.2f \n",Reg2);
mprintf("percent efficiency=%.1f \n",%n);
```

Scilab code Exa 4.6 To find the rms value and phase values i The incident voltage to neutral at the recieving end ii The reflected voltage to neutral at the recieving end iii The incident and reflected voltage to neutral at 120 km from the recieving end

```
//To find the rms value and phase values (i)The
    incident voltage to neutral at the recieving end
    (ii)The reflected voltage to neutral at the
    recieving end (iii)The incident and reflected
    voltage to neutral at 120 km from the recieving
    end.
clear
clc;
R=0.2;
L=1.3;
C=0.01*(10^-6);
z=R+%i*L*314*(10^-3);// serie impedence
```

```
y=%i*314*C;// shunt admittance
Zc=sqrt(z/y);// characterstic impedence
Y=sqrt(y*z);
Vr=132*1000/sqrt(3);
Ir=0;
Vin=(Vr + Ir*Zc)/2;// incident voltage to neutral at
    the recieving end
mprintf("Vr =%.3f volts \n",Vr);//Answer don't match
    due to difference in rounding off of digits
mprintf("(i)The incident voltage to neutral at the
  recieving end =%.3f volts \n",Vin);//Answer don't
    match due to difference in rounding off of
  digits
Vin2=(Vr - Ir*Zc)/2;// The reflected voltage to
  neutral at the recieving end
mprintf("(ii)The reflected voltage to neutral at the
   recieving end=%.3f volts \n",Vin2);//Answer don'
  t match due to difference inrounding off of
  digits
Vrp=Vr*exp(.2714*120*(10^-3))*exp(%i
  *1.169*120*(10^-3))/1000;//Taking Vrp=Vr+
Vrm=Vr*exp(-0.0325)*exp(-%i*.140)/1000;//Taking Vrm=
  Vr-
v1=Vrm/2;// reflected voltage to neutral at 120 km
  from the recieving end
phase_v1=atand(imag(v1)/real(v1));//Phase angle of
  v1
v2=Vrp/2;//incident voltage to neutral at 120 km
  from the recieving end
phase_v2=atand(imag(v2)/real(v2));//Phase angle of
  v2
mprintf("(iii) reflected voltage to neutral at 120
  km from the recieving end =%.2f at angle of %.2f
  \n",abs(v1),phase_v1);
mprintf("incident voltage to neutral at 120 km from
  the recieving end = %.2f at angle of %.2f\n",abs(
  v2),phase_v2);
```

Scilab code Exa 4.7 To determine of efficiency of line

```
//To determine of efficiency of line
clear
clc;
Ir=40*1000/(sqrt(3)*132*.8);
Vr=132*1000/sqrt(3);
Zc=380*(cosd(-13.06)+ %i*sind(-13.06));
IR=Ir*(cosd(-36.8)+ %i*sind(-36.8));
Vsp=(Vr+IR*Zc)*(1.033*(cosd(8.02)+ %i*sind(8.02)))
    /2;
Vsm=(Vr-IR*Zc)*(.968*(cosd(-8.02)+ %i*sind(-8.02)))
    /2;
vs=Vsp+ Vsm;
Vs=abs(vs);
is=(Vsp-Vsm)/Zc;
Is=abs(is)
P=3*Vs*Is*cosd(33.72)/10^6;
n=40*100/P;
mprintf("efficiency=%.1f",n);//Answer don't match
    due to difference in rounding off of digits
```

Scilab code Exa 4.8 To determine the ABCD parameters of Line

```
//To determine the ABCD parameters of Line
clear
clc;
yl=(0.2714+ %i*1.169)*120*(10^-3);
Ir=40*1000/(sqrt(3)*132*.8)
A=cosh(yl);
phase_A=atand(imag(A)/real(A));//Phase angle of A
IR=Ir*(cosd(-36.8)+ %i*sind(-36.8))
```

```
Vr=132*1000/sqrt(3);
Zc=380*(cosd(-13.06)+ %i*sind(-13.06));
B=Zc*sinh(yl);
phase_B=atand(imag(B)/real(B));//Phase angle of B
Vs=(A*Vr+B*IR);
f=abs(B);
d=abs(Vs);
C=sinh(yl)/Zc;
phase_C=atand(imag(C)/real(C));//Phase angle of C
D=cosh(yl);
phase_D=atand(imag(D)/real(D));//Phase angle of D
mprintf("A=%.2f at an angle of %.2f \n",abs(A),
    phase_A)
mprintf("B=%.1f at an angle of %.0f \n",abs(B),
    phase_B)
mprintf("C=%.2f at an angle of %.2f \n",abs(C),
    phase_C)
mprintf("D=%.2f at an angle of %.2f \n",abs(D),
    phase_D)
```

Scilab code Exa 4.9 To determine the sending end voltage and efficiency using Nominal pi and Nominal T method

```
//To determine the sending end voltage and
    efficiency using Nominal_pi and Nominal-T method
clear
clc;
Ir=218.7*(.8-%i*.6);
Ic1=%i*314*.6*(10^-6)*76200;
Il=Ic1+Ir;
Vs=76200 + Il*(24+ %i*48.38);
phase_Vs=atand(imag(Vs)/real(Vs));//phase angle of
    VS
Pl=3*24*abs(Il)*abs(Il)/1000000;//The Loss(MW)
n=40*100/(40+Pl);
```

```
mprintf("Using Nominal- pi method\n ");
mprintf("Vs=%.0f volts at an angle of %.2f \n",abs(Vs),phase_Vs)
mprintf("efficiency=%.2f percent\n",n);
mprintf("\nUsing Nominal-T method\n");
Vc=76200*(.8+%i*.6) + 218.7*(12+ %i*24.49);
Ic=%i*314*1.2*(10^-6)*(63584+ %i*51076);
Is=199.46+ %i*23.95;
Vs=(Vc + Is*(12+ %i*24.49))/1000;
phase_Vs=atand(imag(Vs)/real(Vs));//Phase angle of Vs
Pl1=3*12*((200.89^2)+ 218.7^2)/1000000;//The loss(MW)
n1=40*100/(40+Pl1);
mprintf("Vs=%.2f  at an angle of %.2f \n",abs(Vs),phase_Vs)
mprintf("efficiency=%.2f percent\n",n1);
```

Scilab code Exa 4.10 To determine the sending end voltage and current power and power factor Evaluate A B C D parameters

```
// To determine the sending end voltage and current, power and power factor. Evaluate A, B , C, D parameters.
clear
clc;
R=.1557*160
GMD=(3.7*6.475*7.4)^(1/3);
Z1=2*(10^-7)*log(560/.978)*160*1000;
XL=63.8;
C=(10^-9)*2*(10^6)*%pi*160*1000/(36*%pi*log(560/.978));
Z=sqrt((.1557^2) + .39875^2)*(cosd(68.67)+ %i*sind(68.67));
jwC=%i*314*1.399*(10^-6)/160;
```

```
Zc=sqrt(Z/jwC);
y=sqrt(Z*jwC);
yl=y*160;
A=cosh(yl);
B=Zc*sinh(yl)
C=sinh(yl)/Zc;
Ir=50000/(sqrt(3)*132);
Vs=(A*76.208) +(B*(10^-3)*Ir*(cosd(-36.87)+%i*sind
    (-36.87)));
VS=152.34;
Is=C*76.208*(10^3) +(A*Ir*(cosd(-36.87)+%i*sind
    (-36.87)));
Ps=3*abs(Vs)*abs(Is)*cosd(33.96);
pf=cosd(33.96);
Vnl=abs(Vs)/abs(A);
reg=(Vnl-76.208)*100/76.208;
n=50000*.8*100/abs(Ps);
mprintf(" Vs line to line =%.2f kV\n",VS);
disp(Is,"sending end current Is(A)=");//Answer don't
     match due to difference in rounding off of
    digits
mprintf("sending end power=%.0f kW\n",Ps);
mprintf("sending end p.f =%.3f\n",pf);
mprintf("percent regulation=%.1f \n",reg);
mprintf("percent efficency=%.1f ",n);
```

Chapter 5

HIGH VOLTAGE DC TRANSMISSION

Scilab code Exa 5.1 To determine the dc output voltage when delay anglw a0 b30 c45

```
//To determine the d.c. output voltage when delay
   anglw (a)0 (b)30 (c)45
clear
clc;
Vo=3*sqrt(2)*110/%pi;
Vd=Vo*(cosd(0) + cosd(15))/2;
Vd1=Vo*(cosd(30) + cosd(45))/2;
Vd2=Vo*(cosd(45) + cosd(60))/2;
mprintf("(a)For a=0, Vd=%.2f kV\n",Vd);
mprintf("(b)For a=30,Vd=%.2f kV\n",Vd1);
mprintf("(c)For a=45,Vd=%.2f kV\n",Vd2);
```

Scilab code Exa 5.2 To determine the necessary line secondary voltage and tap ratio required

```
// To determine the necessary line secondary voltage
    and tap ratio required.
clear
clc;
VL=100*2*%pi/(3*sqrt(2)*(cosd(30) + cosd(45)));
mprintf("VL=%.2f kV\n",VL);//Answers don't match due
    to difference in rounding off of digits
Tr=VL/110;
mprintf("tap ratio=%.2f \n",Tr);
```

Scilab code Exa 5.3 To determine the effective reactance per phase

```
// To determine the effective reactance per phase
clear
clc;
Vd=100000;
Id=800;// current
X=((3*sqrt(2)*94.115*.866*1000/%pi)-Vd)*%pi/(3*Id);
mprintf("effective reactance per phase , X=%.2f ohm\
  n",X);//Answer don't match due to difference in
  rounding off of digits
```

Scilab code Exa 5.4 Calculate the direct current delivered

```
//Calculate the direct current delivered
clear
clc;
a=15;
d0=10;
y=15;
X=15;
R=10;
```

```
Id=(3*sqrt(2)*120*(cosd(a)-cosd(d0+y))*1000)/((R +
   (3*2*X)/%pi)*%pi);
mprintf("Id=%.2f amp.\n",Id);
```

Chapter 6

CORONA

Scilab code Exa 6.1 To determine the critical disruptive voltage and critical voltage for local and general corona

```
//To determine the critical disruptive voltage and
    critical voltage for local and general corona.
clear
clc;
t=21;// air temperature
b=73.6;// air pressure
do=3.92*73.6/(273+t);
m=.85;
r=.52;
d=250;
Vd=21.1*m *do*r*log(250/.52);
vd=sqrt(3)*Vd;
m=.7;
vv=21.1*m*do*r*(1+ (.3/sqrt(r*do)))*log(250/.52);
Vv=vv*sqrt(3);
Vvg=Vv*.8/.7;
mprintf("critical disruptive line to line voltage=%
    .2f kV \n",vd);
mprintf("visual critical voltage for local corona=%
    .2f kV \n",vv);
```

```
mprintf("visual critical voltage for general corona=%.2f kV \n",Vvg);
```

Scilab code Exa 6.2 To determine whether corona will be present in the air space round the conductor

```
// To determine whether corona will be present in the air space round the conductor
clear
clc;
d=2.5;
di=3;// internal diameter
do=9;// external diameter
ri=di/2;// internal radius
ro=do/2;// external diameter
g1max=20/(1.25*log(ri/(d/2))+ .208*1.5*log(ro/ri));
mprintf("g1max=%.0f kV/cm \n",g1max);
mprintf("Since the gradient exceeds 21.1/kV/cm , corona will be present.")
```

Scilab code Exa 6.3 To determine the critical disruptive voltage and corona loss

```
// To determine the critical disruptive voltage and corona loss
clear
clc;
m=1.07;
r=.625
V=21*m *r*log(305/.625);
Vl=V*sqrt(3);
mprintf("critical disruptive voltage=%.0f kV\n",V);
```

```
mprintf("since operating voltage is 110 kV , corona
   loss= 0 ");
```

Scilab code Exa 6.4 To determine the voltage for which corona will commence on the line

```
//To determine the voltage for which corona will
   commence on the line
clear
clc;
r=.5;
V=21*r*log(100/.5);
mprintf("critical disruptive voltage=%.1f kV",V);
```

Scilab code Exa 6.5 To determine the corona characterstics

```
//To determine the corona characterstics
clear
clc;
D=1.036;// conductor diameter(cm)
d=2.44;//delta spacing(m)
r=D/2;//radius(cm)
Ratio=d*100/r;
j=r/(d*100);
Rat2=sqrt(j);
t=26.67;//temperature
b=73.15;// barometric pressure
mv=.72;
V=63.5;
f=50;//frequency
do=3.92*b/(273+t);//do=dell
vd=21.1*.85*do*r*log(Ratio);
mprintf("critical disruptive voltage=%.2f kV\n",vd);
```

```
Vv=21.1*mv*do*r*(1+ (.3/sqrt(r*do)))*log(Ratio);
Pl=241*(10^-5)*(f+25)*Rat2*((V-vd)^2)/do;//power
    loss
Vd=.8*vd;
Pl2=241*(10^-5)*(f+25)*Rat2*((V-Vd)^2)*160/do;//loss
     per phase /km
Total= 3*Pl2;
mprintf("visual critical voltage=%.0f kV\n",Vv);
mprintf("Power loss=%.3f kW/phase/km\n",Pl);
mprintf("under foul weather condition ,\n");
mprintf("critical disruptive voltage=%.2f kV\n",Vd);
mprintf("Total loss=%.0f kW\n",Total);
```

Chapter 7

MECHANICAL DESIGN OF TRANSMISSION LINES

Scilab code Exa 7.1 Calculate the sag

```
//Calculate the sag
clear
clc;
sf=5;//Factor of safety
d=.95;// conductor dia(cm)
Ws=4250/sf;// working stress(kg/cm_2)
A=%pi*(d^2)/4;// area (cm_2)
Wp=40*d*(10^-2);//wind pressure (kg/cm)
W=sqrt((.65^2) +(.38^2));// Total effective weight(
    kg/m)
T=850*A;// working tension (kg)
c=T/W;
l=160;
d=l^2/(8*800);
mprintf("sag,d=%.0f metres\n",d);
```

Scilab code Exa 7.2 To calculate the maximum Sag

```
// To calculate the maximum Sag
clear
clc;
D=1.95 + 2.6;// overall diameter(cm)
A=4.55*(10^-2);// area(m_2)
d=19.5;//diameter of conductor(mm)
r=d/2;//radius of conductor(mm)
Wp=A*39;//wind pressure(kg/m_2)
t=13;//ice coating(mm)
US=8000;// ultimate strength(kg)
Aice=%pi*(10^-6)*((r+t)^2 - r^2);//area section of
    ice (m_2)
Wice=Aice*910;
W=(sqrt((.85+Wice)^2 + Wp^2));// total weight of ice
    (kg/m)
T=US/2;// working teansion (kg)
c=T/W;
l=275;//length of span(m)
Smax=l*l/(8*c);
mprintf("Maximum sag=%.1f metres\n",Smax);
```

Scilab code Exa 7.3 To determine the Sag

```
//To determine the Sag
clear
clc;
A=13.2;// cross section of conductor (mm_2)
Ar=4.1*(10^-3);// projected area
Wp=Ar*48.82;// wind loadind /m(kg/m)
w=.115;
W=sqrt((.1157^2) + (Wp^2));// effective loading per
    metre(kg)
q1=W/.115;
```

```
b=w/A;
f1=21;//working stress
T1=f1*A;
c=T1/W;
l=45.7;
S=l*l/(8*c);
dT=32.2-4.5;// difference in temperature
E=1.26*(10000);
a=16.6*(10^-6);
d=8.765*(10^-3);
K=f1-((l*d*q1)^2)*E/(24*f1*f1);
p=poly([-84.23 0 -14.44 1], 'f2', 'c');
r=roots(p);
f2= 14.823332;// accepted value of f2
T=f2*A;
c=T/w;
d1=l*l/(8*c);
mprintf("sag at 32.2 Celsius , d=%.4f metres",d1);
```

Scilab code Exa 7.4 To determine the clearence between the conductor and water level

```
// To determine the clearence between the conductor
   and water level
clear
clc;
T=2000;// working tension (kg)
w=1;
c=T/w;
h=90-30;
l=300;//span(m)
a=(l/2)-(c*h/l);
b=550;
d1=a*a/(2*c);
d2=(400^2)/(2*c);// sag at 400 metres(m)
```

```
Hm=d2-d1;//height of mid point with respect to A
Cl=30+Hm;
mprintf("the clearence between the conductor and
   water level midway between the towers= %.3f
   metres \n",Cl);
```

Chapter 8

OVERHEAD LINE INSULATORS

Scilab code Exa 8.1 To determine the maximum voltage that the string of the suspension insulators can withstand

```
// To determine the maximum voltage that the string
   of the suspension insulators can withstand.
clear
clc;
E3=17.5;
E1=64*E3/89;
E2=9*E1/8;
E=E1+E2+E3;
mprintf("the maximum voltage that the string of the
   suspension insulators can withstand=%.2f kV\n",E)
   ;
```

Chapter 9

INSULATED CABLES

Scilab code Exa 9.1 To determine the economic overall diameter of a 1core cable metal sheathead

```
// To determine the economic overall diameter of a
   1- core cable metal sheathead.
clear
clc;
V=85;// working voltage (kV)
gmax=65;// dielectric strength of insulating
   material (kV/cm)
r=V/gmax;
d=2*r;
D=2.6*%e;
mprintf("Diameter of the sheath =%.2f cm\n",D);
```

Scilab code Exa 9.2 To determine the minimum internal diameter of the lead sheath

```
// To determine the minimum internal diameter of the
    lead sheath
```

```
clear
clc;
e1=4;
e2=4;
e3=2.5;
g1max=50;
g2max=40;
g3max=30;
r=.5;// radius (cm)
r1=r*e1*g1max/(e2*g2max);
r2=r1*e2*g2max/(e3*g3max);
V=66;
lnc=(V-((r*g1max*log(r1/r))+(r1*g2max*log(r2/r1))));
m=lnc/(r2*g3max);
R=r2*(%e^m);
D=2*R;
mprintf("minimum internal diameter of the lead
    sheath ,D=%.2f cms\n",D);
```

Scilab code Exa 9.3 To determine the maximum safe working voltage

```
// To determine the maximum safe working voltage
clear
clc;
r=.5;//radius of conductor(cm)
g1max=34;
er=5;
r1=1;
R=7/2;//external dia(cm)
g2max=(r*g1max)/(er*r1);
V=((r*g1max*log(r1/r))+(r1*g2max*log(R/r1)));
V=V/(sqrt(2));
mprintf("Maximum safe working volltage ,V =%.2f kV r
    .m.s\n",V);
```

Scilab code Exa 9.4 To determine the maximum stresses in each of the three layers

```
//To determine the maximum stresses in each of the
   three layers .
clear
clc;
r=.9;
r1=1.25
r2=r1+.35;
r3=r2+.35;// radius of outermost layer
Vd=20;// voltage difference (kV)
g1max=Vd/(r*log(r1/r));
g2max=Vd/(r1*log(r2/r1));
g3max=(66-40)/(r2*log(r3/r2));
mprintf("g1max =%.1f kV/cm\n",g1max);
mprintf("g2max =%.2f kV/cm\n",g2max);
mprintf("g3max =%.0f kV/cm\n",g3max);
```

Scilab code Exa 9.5 o dtermine the equivalent star connected capacity and the kVA required

```
//To dtermine the equivalent star connected capacity
    and the kVA required.
clear
clc;
V=20;//voltage (kV)
w=314;
C=2*3.04*10^-6;//capacitance per phase(micro-farad)
KVA=V*V*w*C*1000;
mprintf("3-phase kVA required =%.0f kVA",KVA); //
   Answer don't match due to difference in rounding
```

```
off of digits
```

Scilab code Exa 9.6 Determine the capacitance a between any two conductors b between any two bunched conductors and the third conductor c Also calculate the charging current per phase per km

```
// Determine the capacitance (a)between any two
   conductors (b)between any two bunched conductors
   and the third conductor (c)Also calculate the
   charging current per phase per km
clear
clc;
C1=.208;
C2=.096;
Cx=3*C1;
w=314;
V=10;
Cy=(C1+ 2*C2);
Co=((1.5*Cy)-(Cx/6));
C=Co/2;
mprintf("(i)Capacitance between any two conductors=%
   .3f micro-Farad/km\n",C);
c=((2*C2 + ((2/3)*C1)));
mprintf("(ii)Capacitance between any two bunched
   conductors and the third conductor=%.2f micro-
   Farad/km\n",c);
I=V*w*Co*1000*(10^-6)/sqrt(3);
mprintf("(iii)the charging current per phase per km
   =%.3f A\n",I);
```

Scilab code Exa 9.7 To calculate the induced emf in each sheath

```
// To calculate the induced emf in each sheath .
```

```
clear
clc;
rm=(2.28/2)-(.152/2);// mean radius of sheath (cm)
d=5.08;
a=d/rm;
w=314;
Xm=2*(10^-7)*log(a);// mutual inductance (H/m)
Xm2=2000*Xm;
V=w*Xm2*400;
mprintf("Voltage induced =%.2f volts \n",V);//Answer don't match exactly due to difference in rounding off of digits i between calculations
```

Scilab code Exa 9.8 To determine the ratio of sheath loss to core loss of the cable

```
//To determine the ratio of sheath loss to core loss of the cable
clear
clc;
R=2*.1625;
Rs=2*2.14;
M=314;
w=6.268*10^-4;
r=Rs*M*M*w*w/(R*((Rs^2)+(M*M*w*w)));
mprintf("ratio=%.4f \n",r);
```

Chapter 10

VOLTAGE CONTROL

Scilab code Exa 10.1 To determine the total power active and reactive supplied by the generator and the pf at which the generator must operate

```
// To determine the total power , active and reactive , supplied by the generator and the p.f at which the generator must operate .
clear
clc;
V=1;//voltage (p.u)
Pa=.5;//active power at A (p.u)
Pr=.375;// reactive power at A(p.u)
Xca=0.075+0.04;// reactance between C and A
Pl=((Pa^2)+(Pr^2))*Xca/(V^2);
pac=1.5;
prc=2;
Pta=.5+1.5;// total active power between E and C
Ptr=Pr+Pl+2;// reactive power between E and C
Xt=.05+.025;//total reactance beteween E an C
Pl2=((2*2) + (2.4199^2));// loss (p.u)
Pat=200;
Prt=315.9;
pf=.5349;
mprintf("Total active power supplied by generator =%
```

```
    .0f MW\n",Pat);
mprintf("Total reactive power supplied by generator
    =%.1f MW \n",Prt);
mprintf("p.f of the generator =%.4f \n",pf);
```

Scilab code Exa 10.2 Determine the settings of the tap changers required to maintain the voltage of load bus bar

```
// Determine the settings of the tap changers
    required to maintain the voltage of load bus bar
clear
clc;
l1=150;
tstr=1;
load2=72.65;
R=30;
P=(l1*(10^6))/3;
X=80;
Q=(load2*(10^6))/3;
Vs=(230*(10^3))/sqrt(3);
Vr=Vs;
ts2=1/(1-(((R*P)+(X*Q))/(Vs*Vr)));
ts=sqrt(ts2);
mprintf("ts=%.2f p.u\n",ts);
```

Scilab code Exa 10.3 i Find the sending end Voltage and the regulation of line ii Determine the reactance power supplied by the line and by synchronous capacotor and pf of line iii Determine the maximum power transmitted

```
// (i) Find the sending end Voltage and the
    regulation of line (ii) Determine the reactance
    power supplied by the line and by synchronous
```

```
   capacotor and p.f of line (iii)Determine the
   maximum power transmitted
clear
clc;
A=.895;
Vr=215;
B=182.5;
x=A*(Vr^2)/B;
y=78.6-1.4;//b-a
p=acosd(.9);
X1=x/50;
Vs=265*182.5/215;
Vr1=Vs/A;
Reg=100*(Vr1-Vr)/Vr;
mprintf("(i) sending end voltage (kV)=%.1f kV\n",Vs)
   ;
mprintf("recieving end voltage =%.0f kV\n",Vr1);
mprintf("Regulation = %.2f percent\n",Reg);
Vs1=236;
Q=Vs1*Vr/B;
QP=.25*50;
PR=.50*50;
cosQ=.958;
mprintf("\n(ii)QP(MVAr)=%.1f MV Ar\n",QP);
mprintf(" PR(MVAr)=%.0f MV Ar\n",PR);
mprintf("CosQ=%.3f \n",cosQ);
MN=4.55;
Sbmax=MN*50;
mprintf("maximum power transmitted =%.1f MW\n",Sbmax
   );
```

Scilab code Exa 10.4 Determine the KV Ar of the Modifier and the maximum load that can be transmitted

```
// Determine the KV Ar of the Modifier and the
```

```
   maximum load that can be transmitted
clear
clc;
a=0;
b=73.3
A=1;
B=20.88;
Vs=66;
Vr=66;
Load=75;
p=poly([14624 400 1],'Qr','c');
r=roots(p);
Qr=- 40.701538;
C=-Qr + (75*.6/.8);
Smax=(Vr^2)*(1-cosd(b))/B;
mprintf("The phase modifier capacity =%.2f MVAr\n",
   C);
mprintf("Maximum power transmitted ,Pmax =%.2f MW",
   Smax);
```

Chapter 11

NEUTRAL GROUNDING

Scilab code Exa 11.1 To find the inductance and KVA rating of the arc suppressor coil in the system

```
// To find the inductance and KVA rating of the arc
   suppressor coil in the system
clear
clc;
C1=2*%pi*(10^-9)/(36*%pi*log((4*4*8)^(1/3)
   /(10*(10^-3))));
C=C1*192*(10^9);// capacitance per phase (micro
   farad)
L=(10)^6/(3*314*314*C);
V=132;//voltage (kV)
MVA=V*V/(3*314*L);
mprintf("inductance ,L=%.2f H\n",L);
mprintf("MVA rating of suppressor  coil =%.3f MVA
   per coil",MVA);
```

Scilab code Exa 11.2 Determine the reactance to neutralize the capacitance of i 100 percent of the length of line ii 90 percent of the length of line iii 80 percent of the length of line

```
// Determine the reactance to neutralize the
   capacitance of (i)100% of the length of line (ii)
   90% of the length of line (iii)80% of the length
   of line
clear
clc;
wL=1/(3*314*(10)^-6);
mprintf("(i)inductive reactance for 100 percent of
   the length of line=%.1f ohms\n",wL);
wL=10^6/(3*314*.9);
mprintf("(ii)inductive reactance for 90percent of
   the length of line=%.1f ohms\n",wL);
wL=1/(3*314*(10)^-6)/.8;
mprintf("(iii)inductive reactance for 80 percent of
   the length of line=%.1f ohms\n",wL);
```

Chapter 12

TRANSIENTS IN POWER SYSTEMS

Scilab code Exa 12.1 To determine the i the neutral impedence of line ii line current iii rate of energy absorption rate of reflection and state form of reflection iv terminating resistance v amount of reflected and transmitted power

```
// To determine the (i)the neutral impedence of line
   (ii)line current (iii)rate of energy absorption
   , rate of reflection and state form of reflection
   (iv) terminating resistance (v)amount of
   reflected and transmitted power
clear
clc;
L=2*(10^-7)*log(100/.75);//inductance per unit
   length
C=2*%pi*(10^-9)/(36*%pi*log(100/.75));//Capacitance
   per phase per unit length (F/m)
Z1=sqrt(L/C);
E=11000;
mprintf("(i)the natural impedence of line=%.0f ohms\
   n",Z1);
Il=E/(sqrt(3)*Z1);//line current(amps)
```

```
mprintf("(ii)line current =%.1f amps\n",Il);
R=1000;
Z2=R;
E1=2*Z2*E/((Z1+Z2)*sqrt(3));
Pr=3*E1*E1/(R*1000);//Rate of power consumption
Vr=(Z2-Z1)*E/(sqrt(3)*(Z2+Z1)*1000);//Reflected
    voltage
Er=3*Vr*Vr*1000/Z1//rate of reflected voltage
mprintf("(iii)rate of energy absorption =%.1f kW\n",
    Pr);
mprintf("rate of reflected energy =%.1f kW\n",Er);
mprintf("(iv)Terminating resistance should be equal
    to surge impedence of line  =%.0f ohms\n",Z1);
L=.5*(10^-8);
C=10^-12;
Z=sqrt(L/C);// surge impedence
VR=2*Z*11/((Z1+Z)*sqrt(3));
Vrl=(Z-Z1)*11/((Z1+Z)*sqrt(3));
PR1=3*VR*VR*1000/(Z);
d=abs(Vrl);
Prl=3*d*d*1000/Z1;
mprintf("(v)Refracted power =%.1f kW\n",PR1);
mprintf("Reflected power =%.1f kW\n",Prl);
////Answer don't match exactly due to difference in
    rounding off of digits i between calculations
```

Scilab code Exa 12.2 Find the voltage rise at the junction due to surge

```
//Find the voltage rise at the junction due to surge
clear
clc;
Xlc=.3*(10^-3);// inductance of cable(H)
Xcc=.4*(10^-6);// capacitance of cable (F)
Xlo=1.5*(10^-3);//inductance of overhead line(H)
Xco=.012*(10^-6);// capacitance of overhead line (F)
```

```
Znc=sqrt((Xlc/Xcc));
Znl=sqrt((Xlo/Xco));
mprintf("Natural impedence of cable=%.2f ohms \n",
    Znc);
mprintf("Natural impedence of overhead line=%.1f
    ohms \n",Znl);
E=2*Znl*15/(353+27);
mprintf("voltage rise at the junction due to surge =
    %.2f kV \n",E);
```

Scilab code Exa 12.3 To find the surge voltages and currents transmitted into branch line

```
// To find the surge voltages and currents
    transmitted into branch line
clear
clc;
Z1=600;
Z2=800;
Z3=200;
E=100;
E1=2*E/(Z1*((1/Z1)+(1/Z2)+(1/Z3)));
Iz2=E1*1000/Z2;
Iz3=E1*1000/Z3;
mprintf("Transmitted voltage =%.2f kV \n",E1);
mprintf("The transmitted current in line Z2=%.2f
    amps \n",Iz2);
mprintf("The transmitted current in line Z3=%.1f
    amps \n",Iz3);
////Answer don't match exactly due to difference in
    rounding off of digits i between calculations
```

Scilab code Exa 12.4 Determine the maximum value of transmitted wave

```
//Determine the maximum value of transmitted wave
clear
clc;
Z=350;//surge impedencr (ohms)
C=3000*(10^-12);// earth capacitance(F)
t=2*(10^-6);
E=500;
E1=2*E*(1-exp((-1*t/(Z*C))));
mprintf("the maximum value of transmitted voltage=%
    .0f kV \n",E1);
```

Scilab code Exa 12.5 Determine the maximum value of transmitted surge

```
//Determine the maximum value of transmitted surge
clear
clc;
Z=350;//surge impedencr (ohms)
L=800*(10^-6);
t=2*(10^-6);
E=500;
E1=E*(1-exp((-1*t*2*Z/L)));
mprintf("The maximum value of transmitted voltage=%
    .1f kV \n",E1);
```

Scilab code Exa 12.6 Determine i the value of the Voltage wave when it has travelled through a distance 50 Km ii Power loss and Heat loss

```
// Determine (i)the value of the Voltage wave when
    it has travelled through a distance 50 Km. (ii)
    Power loss and Heat loss.

clear
clc;
```

```
eo=50;
x=50;
R=6;
Z=400;
G=0;
v=3*(10^5);
e=2.68;
e1=(eo*(e^((-1/2)*R*x/Z)));
// answess does not match due to the difference in
   rounding off of digits.
mprintf("(i)the value of the Voltage wave when it
   has travelled through a distance 50 Km=%.1f kV \n
   ",e1);
Pl=e1*e1*1000/400;
io=eo*1000/Z;
t=x/v;
H=-(50*125*400*((e^-.75)-1))/(6*3*10^5)
mprintf("(ii)Power loss=%.3fkW  \n heat loss=%.3f kJ
   ",Pl,H);
```

Chapter 13

SYMMETRICAL COMPONENTS AND FAULT CALCULATIONS

Scilab code Exa 13.1 Determine the symmetrical components of voltages

```
// Determine the symmetrical components of voltages.
clear
clc;
Va=100*(cosd(0) + %i*sind(0));
Vb=33*(cosd(-100) + %i*sind(-100));
Vc=38*(cosd(176.5) + %i*sind(176.5));
L=1*(cosd(120) + %i*sind(120));
Va1=((Va + L*Vb + (L^2)*Vc))/3;
Va2=((Va + L*Vc + (L^2)*Vb))/3;
Vco=((Va + Vb + Vc))/3;
disp(Va1,"Va1=");
disp(Va2,"Va2=");
disp(Vco,"Vco=");
```

Scilab code Exa 13.2 Find the symmetrical component of currents

```
// Find the symmetrical component of currents
clear
clc;
Ia=500+ %i*150;// Line current in phase a
Ib=100- %i*600;// Line current in phase b
Ic=-300+ %i*600;// Line current in phase c
L=(cosd(120)+ %i*sind(120));
Iao=(Ia+Ib+Ic)/3;
Ia1=(Ia+Ib*L+(L^2)*Ic)/3;
Ia2=(Ia + (L^2)*Ib +(L*Ic))/3;
disp(Iao,"Iao(amps)=");
disp(Ia1,"Ia1(amps)=");
disp(Ia2,"Ia2(amps)=");// Answer in the book is not
    correct.wrong calculation in the book
```

Scilab code Exa 13.3 Determine the fault current and line to line voltages

```
// Determine the fault current and line to line
    voltages
clear
clc;
Ea=1;
Z1=.25*%i;
Z2=.35*%i;
Zo=.1*%i;
Ia1=Ea/(Z1+Z2+Zo);
L=-.5+%i*.866;
Ia2=Ia1;
Iao=Ia2;
Ia=Ia1+Ia2+Iao;
Ib=25*1000/((sqrt(3)*13.2));
If=Ib*abs(Ia);
Va1=Ea-(Ia1*Z1);
```

```
Va2=-Ia2*Z2;
Va0=-Iao*Zo;
Va=Va1+Va2+Va0;
Vb1=(L^2)*Va1;
Vb2=L*Va2;
Vbo=Va0;
Vco=Va0;
Vc1=L*Va1;
Vc2=(L^2)*Va2;
Vb=Vb1 + Vb2+Vbo;
Vc=Vco+Vc1+Vc2;
Vab=Va-Vb;
Vac=Va-Vc;
Vbc=Vb-Vc;
vab=(13.2*abs(Vab))/sqrt(3);
vac=(13.2*abs(Vac))/sqrt(3);
vbc=(13.2*abs(Vbc))/sqrt(3);
disp(If,"fault current (amps)=");//Answer don't
    match due to difference in rounding off of digits
disp(Vab,"Vab(kV)=");//Answer don't match due to
    difference in rounding off of digits
disp(Vac,"Vac(kV)=");//Answer don't match due to
    difference in rounding off of digits
disp(Vbc,"Vbc(kV)=");//Answer don't match due to
    difference in rounding off of digits
```

Scilab code Exa 13.4 determine the fault current and line to line voltages at the fault

```
//Determine the fault current and line to line
    voltage at the fault .
clear
clc;
Ea=1;
L=(cosd(120)+ %i*sind(120));
```

```
Z1=%i*.25;
Z2=%i*.35;
Ia1=Ea/(Z1+Z2);
Ia2=-Ia1;
Iao=0;
Ib1=(L^2)*Ia1;
Ib2=L*Ia2;
Ibo=0;
Ib=Ib1+Ib2 +Ibo;
Iba=1093;
If=Iba*abs(Ib);
Va1=Ea-(Ia1*Z1);
Va2=-Ia2*Z2;
Vao=0;
Va=Va1+Va2+Vao;
Vb=(L^2)*Va1 + L*Va2;
Vc=Vb;
Vab=Va-Vb;
Vac=Va-Vc;
Vbc=Vb-Vc;
mprintf("Fault current =%.2f amps\n",If);//Answer
    don't match due to difference in rounding off of
    digits
vab=(abs(Vab)*13.2)/sqrt(3);
vbc=(abs(Vbc)*13.2)/sqrt(3);
vac=(abs(Vac)*13.2)/sqrt(3);
mprintf("Vab=%.2f kV\n",vab);
mprintf("Vac=%.2f kV\n",vac);
mprintf("Vbc=%.2f kV\n",vbc);
```

Scilab code Exa 13.5 determine the fault current and line to line voltages at the fault

```
// determine the fault current and line to line
    voltages at the fault
```

```
clear
clc;
Ea=1+ 0*%i;
Zo=%i*.1;
Z1=%i*.25;
Z2=%i*.35;
Ia1=Ea/(Z1+(Zo*Z2/(Zo+Z2)));
Va1=Ea-Ia1*Z1;
Va2=Va1;
Vao=Va2;
Ia2=-Va2/Z2;
Iao=-Vao/Zo;
I=Ia2+Iao;
If=3*Iao;// fault current
Ib=1093;// base current
Ifl=abs(If*Ib);
disp(Ifl,"Fault current(amps) =");//Answer don't
    match due to difference in rounding off of digits
Va=3*Va1
Vb=0;
Vc=0;
Vab=abs(Va)*13.2/sqrt(3);
Vac=abs(Va)*13.2/sqrt(3);
Vbc=abs(Vb)*13.2/sqrt(3);
mprintf("Vab=%.3f kV\n",Vab);
mprintf("Vac=%.3f kV\n",Vac);
mprintf("Vbc=%.3f kV\n",Vbc);
```

Scilab code Exa 13.6 Determine the fault current when i LG ii LL iii LLG fault takes place at P

```
//Determine the fault current when (i)L-G (ii)L-L (
    iii)L-L-G fault takes place at P.
clear
clc;
```

```
Vbl=13.8*115/13.2;// base voltage on the line side
    of transformer(kV)
Vbm=120*13.2/115;// base voltage on the motor side
    of transformer(kV)
Xt=10*((13.2/13.8)^2)*30/35;// percent reactance of
    transformer
Xm=20*((12.5/13.8)^2)*30/20;// percent reactance of
    motor
Xl=80*30*100/(120*120);//percent reactance of line
Xn=2*3*30*100/(13.8*13.8);// neutral reactance
Xz=200*30*100/(120*120);
Zn=%i*.146;// negative sequence impedence
Zo=.06767;// zero sequence impedence
Z=%i*.3596;//total impedence
Ia1=1/Z;
Ia2=Ia1;
Iao=Ia2;
If1=3*Ia1;
Ib=30*1000/(sqrt(3)*13.8);
Ibl=30*1000/(sqrt(3)*120);
Ifc=Ibl*abs(If1);
Z1=%i*.146;
Z2=Z1;
IA1=1/(Z1+Z2)
IA2=-IA1
L=(cosd(120)+ %i*sind(120));
IAo=0;
IB=(L^2)*IA1 + L*IA2;
IC=-IB;
IF=abs(IB)*Ibl;
Zo=%i*.06767;
ia1=1/(Z1+(Zo*Z2/(Zo+Z2)));
ia2=ia1*Zo/(Z2+Zo);
iao=%i*3.553;
If2=3*iao;
IF2=abs(If2*Ibl);
mprintf("Fault Current (i)L-G fault , If=%.0f amps\n
    ",Ifc);
```

```
mprintf("(ii)L-L fault ,If=%.1f amps\n",IF);
mprintf("(iii)L-L-G, If =%.0f amps\n",IF2);
```

Scilab code Exa 13.8 Determine the percent increase of busbar voltage

```
//Determine the percent increase of busbar voltage
clear
clc;
vx=3;// percent reactance of the series element
sinr=.6;
V=vx*sinr;
mprintf("Percent drop of volts=%.1f percent\n",V);
```

Scilab code Exa 13.9 Determine the short circuit capacity of the breaker

```
//Determine the short circuit capacity of the
   breaker
clear
clc;
Sb=8;// Base MVA
Zeq=(%i*.15)*(%i*.315)/(%i*.465);
Scc=abs(Sb/Zeq);
mprintf("short circuit capacity=%.2f MVA\n",Scc);
```

Scilab code Exa 13.10 To determine the short circuit capacity of each station

```
// To determine the short circuit capacity of each
   station
clear
```

```
clc;
X=1200*100/800;// percent reactance of other
    generating station
Xc=.5*1200/(11*11);
Sc=1200*100/86.59;// short circuit MVA of the bus
Xf=119.84;// equivalent fault impedence between F
    and neutral bus
MVA=1200*100/Xf;
mprintf("short circuit capacity of each station=%.0f
    MVA\n",MVA);
```

Scilab code Exa 13.11 Determine the Fault MVA

```
// Determine the Fault MVA
clear
clc;
Sb=100;// base power (MVA)
SC=Sb/.14;
mprintf("S.C. MVA =%.2f MVA\n ",SC);
```

Scilab code Exa 13.12 To Determine the subtransient current in the alternator motor and the fault

```
// To Determine the subtransient current in the
    alternator , motor and the fault
clear
clc;
Ib=50*1000/(sqrt(3)*13.2);// base current (amps.)
Vf=12.5/13.5;// the Prefault Voltage (p.u)
Xf=(%i*.3)*(%i*.2)/(%i*.5);// Fault impedence(p.u)
If=.9469/(Xf);//Fault current (p.u)
Ifl=30*1000/((sqrt(3)*12.5*.8));//full load current
    (amps)
```

```
Il=1732*(cosd(36.8)+%i*sind(36.8))/2186;//load current(p.u)
Ifm=3*(If)/5;// fault current supplied by motor (p.u)
Ifg=2*(If)/5;// fault current supplied by generator (p.u)
Ig=abs(Ifg +Il);//Net current supplied by generator during fault(p.u)
Im=abs(Ifm-Il);//Net current supplied by motor during fault(p.u)
Igf=Ig*2186;
Imf=Im*2186;
Ifc=2186*If;
mprintf("Fault current from the generator =%.3f amps\n",Igf);
mprintf("Fault current from the motor =%.3f amps\n",Imf);
disp(Ifc,"Fault current (amps)=");
```

Scilab code Exa 13.13 To Determine the reactance of the reactor to prevent the brakers being overloaded

```
//To Determine the reactance of the reactor to prevent the brakers being overloaded
clear
clc;
Sb=75;// Base MVA
Xpu=.15*Sb/15;// p.u reactance of the generator
Xt=-%i*.08;//p.u reactanceof the transformer
X=9.75/112;
Xa=X*33*33/75;
mprintf("the reactance of the reactor =%.3f ohms\n",Xa);
```

Scilab code Exa 13.14 Determine the subtransient currents in all phases of machine1 the fault current and the voltages of machine 1 and voltage at the fault point

```
// Determine the subtransient currents in all phases
    of machine-1 , the fault current and the
   voltages of machine 1 and voltage at the fault
   point.
clear
clc;
Z1eq= %i*(((8+5)*(8+5+12))/(100*(13+25)));
Z2eq=Z1eq;
Zoeq=%i*(5*45)*(10^-2)/(5+45);
Ea=1;
Ia1=Ea/(Z1eq+ ((Zoeq*Z2eq)/(Zoeq+Z2eq)));
Ia2=(-Ia1*Zoeq)/(Zoeq+Z2eq);
Iao=(-Ia1*Z2eq)/(Zoeq+Z2eq);
Va1=Ea-(Ia1*Z1eq);
Va2=-Ia2*Z2eq;
Vao=Va2;
Ia=0;
Ib=(-.5 - %i*.866)*Ia1 + ((-.5 + %i*.866)*Ia2) + Iao
   ;
Ic=(-.5 + %i*.866)*Ia1 + (-.5 - %i*.866)*Ia2 + Iao;
ia1=Ia1*25/38;
IA1=%i*ia1;
ia2=Ia2*25/38;
IA2=-%i*ia2;
IA=IA1 + IA2;
IB=IA1*(-.5 - %i*.866) + IA2*(-.5 + %i*.866);
IC=IA1*(-.5 + %i*.866) + IA2*(-.5 - %i*.866);
Va=Va1+Va2+Vao;
Vb=0;
Vc=0;
```

```
Vab=.2564-Vb;
Vbc=Vb-Vc;
Vca=Vc-.2564;
VA1=Ea-IA1*(%i*.05);
VA2=-IA2*(%i*.05);
VA=VA1+VA2;
VB=(((-.5 - %i*.866)*VA1) +((-.5 + %i*.866)*VA2));
VC=VA1*(-.5 + %i*.866) + VA2*(-.5 - %i*.866);
VAB=VA-VB;
VBC=VB-VC;
VCA=VC-VA;
//Answers don't match due to difference in rounding
    off of digits
disp(Ia,"fault currents ,Ia=");
disp(Ib,"Ib=");
disp(Ic,"Ic=");//Calculation in book is wrong.
disp(IA,"IA=");
disp(IB,"IB");
disp(IC,"IC");
disp("Voltages at fault point");
disp(Vab,"Vab(p.u)=");
disp(Vbc,"Vbc(p.u)=");
disp(Vca,"Vca(p.u)=");
disp(VAB,"VAB=");
disp(VBC,"VBC=");
disp(VCA,"VCA=");
```

Scilab code Exa 13.15 To determine the i pre fault current in line a ii the subtransient current in pu iii the subtransient current in each phase of generator in pu

```
// To determine the (i) pre- fault current in line a
    (ii) the subtransient current in p.u (iii) the
    subtransient current in each phase of generator
    in p.u
```

```
clear
clc;
Ia1=-.8 -%i*2.6 + .8 -%i*.4;
Ia2=-%i*3;
Iao=-%i*3;
A=-.8 -%i*2.6 + .8 +%i*2;
a=.8;
b=.6;
Ipf=a + %i*b;
Isfc=3*Ia1;
iA1=.8- %i*.4;
iA2=-%i*1;
iAo=0;
IA1=%i*iA1;
IA2=-%i*iA2;
IA=IA1 + IA2;
L=cosd(120)+ %i*sind(120);
IB=(L^2)*IA1 + IA2*L;
IC=(L^2)*IA2 + IA1*L;
disp(Ipf,"(i) pre- fault current in line a=");
disp(Isfc,"(ii) the subtransient fault current in p.
   u=");
disp(IA,"IA=");
disp(IB,"IB=");
disp(IC,"IC=");
```

Scilab code Exa 13.16 Determine the shorrt circuit MVA of the transformer

```
// Determine the shorrt circuit MVA of the
   transformer
clear
clc;
S.C.MVA=.5/.05;
mprintf("S.C.MVA=%.0f MVA",S.C.MVA);
```

Scilab code Exa 13.17 To determine the line voltages and currents in per unit on delta side of the transformer

```
//To determine the line voltages and currents in per
    unit on delta side of the transformer
clear
clc;
vab=2000;
vbc=2800;
vca=2500;
vb=2500;// base voltage (V)
Vab=vab/vb;// per unit voltages
Vbc=vbc/vb;
Vca=vca/vb;
a=acosd(((1.12^2)-((.8^2)+1))/(2*.8));
b=acosd(((.8^2)-((1.12^2)+1))/(2*1.12));
Vlab=Vab*(cosd(76.06)+%i*sind(76.06));// line
    voltage
Vlca=Vca*(cosd(180)+%i*sind(180));// line voltage
Vlbc=Vbc*(cosd(-43.9)+%i*sind(-43.9));// line
    voltage
L=1*(cosd(120) + %i*sind(120));
Vab1=(Vlab +(L*Vlbc) + ((L^2)*Vlca))/3;//
    symmetrical component of line voltage
Vab2=(Vlab +(L*Vlca) + ((L^2)*Vlbc))/3;//
    symmetrical component of line voltage
Vabo=0;// symmetrical component of line voltage
Van1=Vab1*(cosd(-30)+ %i*sind(-30));
Van2=Vab2*(cosd(30)+ %i*sind(30));
Ia1=Van1/(1*(cosd(0) + %i*sind(0)));
Ia2=Van2/(1*(cosd(0) + %i*sind(0)));
VA1=-%i*Van1;
VA2=%i*Van2;
VA=VA1+ VA2;
```

```
VB1=(L^2)*VA1;
VB2=(L)*VA2;
VB=VB1 + VB2;
VC2=(L^2)*VA2;
VC1=(L)*VA1;
VC=VC1 + VC2;
VAB=VA-VB;
VBC=VB-VC;
VCA=VC-VA;
IA=VA;
IB=VB;
IC=VC;
phase_IA=atand(imag(IA)/real(IA));
phase_IB=atand(imag(IB)/real(IB));
phase_IC=atand(imag(IC)/real(IC));
disp(VAB,"VAB(p.u)=");
disp(VBC,"VBC(p.u)=");
disp(VCA,"VCA(p.u)=");
mprintf("IA(p.u)=%.2f at an agle of %.1f\n",abs(IA),
    phase_IA);
mprintf("IB(p.u)=%.2f at an agle of %.1f\n",abs(IB),
    phase_IB);
mprintf("IC(p.u)=%.2f at an agle of %.1f",abs(IC),
    phase_IC);
```

Chapter 14

PROTECTIVE RELAYS

Scilab code Exa 14.1 To determine the time of operation of relay

```
// To determine the time of operation of relay .
clear
clc;
If=4000;// fault current
I=5*1.25;// operating current of relay
CT=400/5;// CT ratio
PSM=If/(I*CT);// plug setting multiplier
mprintf("PSM=%.3f\n",PSM);
mprintf("operating time for PSM=8 is 3.2sec.\n");
mprintf("actual operating time = 1.92 sec.");
```

Scilab code Exa 14.2 To determine the phase shifting network to be used

```
// To determine the phase shifting network to be
   used.
clear
clc;
Z=1000*(cosd(60) + %i*sind(60));//impedence
```

```
X=tand(50)*1000*cosd(60);
Xl=1000*sind(60);
Xc=Xl-X;
C=1000000/(314*Xc);
//Answers don't match due to difference in rounding
    off of digits
disp(X,"X=");
disp(Xc,"Xc=");
disp(C,"C(micro farads)=");
```

Scilab code Exa 14.3 To provide time current grading

```
//To provide time current grading .
clear
clc;
Isec1=4000/40;// secondary current(amps)
PSM=100/5;// PSM if 100% setting is used
Isec2=4000/40;
PSM2=100/6.25;//PSM if setting used is 125%
TMSb=.72/2.5;
PSM1=5000/(6.25*40);
to=2.2;
tb=to*TMSb;
PSMa=5000/(6.25*80);
TMS=1.138/3;
PSMa1=6000/(6.25*80);
ta=(2.6*.379);
mprintf("Actual operating time of realy at b=%.3f
    sec. \n",tb);
mprintf("Actual operating time of realy at a=%.3f
    sec. \n",ta);
```

Scilab code Exa 14.4 To determine the proportion of the winding which remains unprotected against earth fault

```
// To determine the proportion of the winding which
   remains unprotected against earth fault.
clear
clc;
Vph=6600/(sqrt(3));
Ifull=5000/(sqrt(3)*6.6);
Ib=Ifull*.25;
x=Ib*800/Vph;
mprintf("percent of the winding remains unprotected=
   %.2f  \n",x);
```

Scilab code Exa 14.5 To determine i percent winding which remains unprotected ii min value of earthing resistance required to protect 80 percent of winding

```
// To determine (i) % winding which remains
   unprotected (ii)min. value of earthing resistance
    required to protect 80% of winding
clear
clc;
Iph=10000/sqrt(3);// phase voltage of alternator(V)
x=1.8*100*10*1000/(5*Iph);
mprintf("(i) percent winding which remains
   unprotected=%.2f  \n",x);
Ip=Iph*.2;
R=1.8*1000/(5*Ip);
mprintf("(ii)minimum  value of earthing resistance
   required to protect 80 percent of winding =%.4f
   ohms \n",R)
```

Scilab code Exa 14.6 To determine whether relay will operate or not

```
//To determine whether relay will operate or not.
clear
clc;
Ic=360-320;// the difference current (amp)
Io=40*5/400;
Avg=(360+320)/2;// average sum of two currents
Iavg=340*5/400;
Ioc=.1*Iavg + .2;
mprintf("operating current=%.3f amp. \n",Ioc);
mprintf("since current through  operating coil is %
   .3f amp. \n ",Io);
mprintf("therefore Relay will not operate ");
```

Scilab code Exa 14.7 To determine the ratio of CT on HV side

```
// To determine the ratio of CT on HV side
clear
clc;
Il=400*6.6/33;// line current on star side of PT(
   amps)
Ic=5/sqrt(3);// current in CT secondary
mprintf(" the CT ratio on HT will be %d : %.3f",Il,
   Ic);
```

Scilab code Exa 14.8 To determine the number of turns each current transformer should have

```
// To determine the number of turns each current
   transformer should have .
clear
clc;
```

```
Il=10000/((sqrt(3))*132);
ILV=10000/((sqrt(3))*6.6);
a=5/sqrt(3);
mprintf("ratio of CT on LV side is %.3f : %.3f\n",
   ILV,a);
mprintf("ratio of CT on HT side is %.3f : %d",Il,5);
```

Scilab code Exa 14.9 To determine the R1 R2 and C also The potential across relays

```
//To determine the R1, R2 and C. also The potential
   across relays
clear
clc;
Vs=110;
I=1;
R2=Vs/((3-%i*sqrt(3))*I);
c=abs(R2);
mprintf("R2=%.2f ohms\n",c);
R1=2*c;
d=abs(R1);
C=(10^6)/(.866*d*314);
mprintf("R1=%.2f ohms\n",R1);
mprintf("C=%.1f micro farads\n",C);
Vt=d*(-.5 - %i*.866) + (c - %i*55 );
disp(Vt," Voltage across the terminals of the relay
   will be (V)=");
```

Scilab code Exa 14.10 To determine the kneepoint voltage and cross section of core

```
// To determine the kneepoint voltage and cross
   section of core
```

```
clear
clc;
Ic=5*.25;// operating current(amp)
Vsec=5/1.25;// secondary voltage(V)
Bm=1.4;
f=50;
N=50;
V=15*Vsec;
A=60/(4.44*Bm*f*N);
mprintf(" the knee point must be slightly higher than =%.3f V\n",V);
mprintf("area of cross section=%.6f m_2\n",A);
```

Scilab code Exa 14.11 To determine the VA output of CT

```
// To determine the VA output of CT .
clear
clc;
o.p=5*5*(.1+.1) +5;
mprintf(" VA output of CT =%.0f VA\n ",o.p);
```

Chapter 15

CIRCUIT BREAKERS

Scilab code Exa 15.1 To determine the voltage appearing across the pole of CB also determine the value of resistance to be used across contacts

```
// To determine the voltage appearing across the pole of C.B. also determine the value of resistance to be used across contacts
clear
clc;
i=5;
L=5*(10^6);
C=.01;
e=i*sqrt(L/C);
mprintf("the voltage appearing across the pole of C.B.=%.0f V\n",e);
R=.5*sqrt(L/C);
mprintf("the value of resistance to be used across contacts, R=%.0f ohms\n",R);
```

Scilab code Exa 15.2 To determine the rate of rise of restriking voltage

```
// To determine the rate of rise of restriking
   voltage
clear
clc;
Vnl=132*sqrt(2)/sqrt(3);//peak value of peak to
   neutral voltage(kV)
Vr1=Vnl*.95;//recovery voltage (kV)
Vr=102.4*.916;// active recovery voltage(kV)
Vrmax=2*Vr;
fn=16*(10^3);
t=1/(2*fn);
RRRV=Vrmax*(10^-6)/t;
mprintf("rate of rise of restriking voltage, RRRV=%
   .0f kV/micro-sec",RRRV);
```

Scilab code Exa 15.3 To Determine the average rate of rise of restriking voltage

```
// To Determine the average rate of rise of
   restriking voltage
clear
clc;
Vm=132*sqrt(2)/sqrt(3);
K1=.9;
K2=1.5
K=K1*K2;
sinq=.92;
Vr=K*Vm*sinq;
fn=16*(10^3);
RRRV=2*Vr*(10^-6)*fn*2;
mprintf("average rate of rise of restriking voltage,
   RRRV=%.3f kV/micro-sec\n",RRRV);
```

Scilab code Exa 15.4 To determine the rated normal current breaking current making current and short time rating current

```
// To determine the rated normal current , breaking
   current , making current and short time rating (
   current)
clear
clc;
In=1500;
mprintf("rated normal current=%.0f amps\n",In);
Ib=2000/(sqrt(3)*33);
mprintf("breaking current=%.2f KA\n",Ib);
Im=2.55*Ib;
mprintf("making current =%.2f kA\n",Im);
Is=Ib;
mprintf("short time rating  for 3 sec=%.2f kA\n",Is)
   ;
```

Scilab code Exa 15.5 TO Determine i sustained short circuit current in the breaker ii initial symmetrical rms current in the breaker iii maximum possible dc component of the short circuit current in the breaker iv momentary current rating of the breaker v the current

```
//TO Determine (i)sustained short circuit current in
    the breaker (ii)initial symmetrical r.m.s
   current in the breaker (iii)maximum possible d.c
   component of the short circuit current in the
   breaker (iv)momentary current rating of the
   breaker (v)the current to be interrupted by the
   breaker (vi)the interupting kVA.
clear
clc;
MVA=10;
Is=MVA*1000/(sqrt(3)*13.8);
mprintf("(i)sustained short circuit current in the
```

```
breaker =%.0f amps\n",Is);
MVA1=100;
Isc=MVA1*1000/(sqrt(3)*13.8);
mprintf("(ii)initial symmetrical r.m.s current in the breaker r.m.s=%.0f amps\n",Isc);
Im=sqrt(2)*Isc;
mprintf("(iii)maximum possible d.c component of the short circuit current in the breaker =%.0f amps\n",Im);
Im2=1.6*Isc;
mprintf("(iv)momentary current rating of the breaker =%.0f amps\n",Im2);
Ib=1.2*Isc;
mprintf("(v)the current to be interrupted by the breaker =%.0f amps\n",Ib);
KVA=sqrt(3)*13.8*5016;
mprintf("(vi)the interupting =%.0f KVA\n",KVA);
//Answers don't match due to difference in rounding off of digits
```

Chapter 17

POWER SYSTEM SYNCHRONOUS STABILITY

Scilab code Exa 17.1 To determine the acceleration Also determine the change in torque angle and rpmat the end of 15 cycles

```
// To determine the acceleration . Also determine
   the change in torque angle and r.p.mat the end of
    15 cycles
clear
clc;
H=9;
G=20;// machine Rating(MVA)
KE=H*G;
mprintf("(a)K.E stored in the rotor =%.0f MJ\n",KE);
Pi=25000*.735;
PG=15000;
Pa=(Pi-PG)/(1000);
f=50;
M=G*H/(%pi*f);
a=Pa/M;
mprintf("(b) The accelerating power =%.3f MW\n",Pa);
mprintf("Acceleration =%.3f rad/sec_2\n",a);
t=15/50;
```

```
del=sqrt(5.89)*t/2;
Del=del^2;
k=2.425*sqrt(Del)*60/4*%pi;
speed=1504.2;
mprintf("(c)Rotor speed at the end of 15 cycles =%.1
   f r.p.m",speed);
```

Scilab code Exa 17.2 To determine the frequency of natural oscillations if the genrator is loaded to i 60 Percent and ii 75 percent of its maximum power transfer capacity

```
// To determine the frequency of natural
   oscillations if the genrator is loaded to (i)60%
   and (ii)75% of its maximum power transfer
   capacity
clear
clc;
V1=1.1;
V2=1;
X=.5;
cosdo=.8;
G=1;
H=3;
f=50;
M=G*H/(%pi*f);
dPe=V1*V2*cosdo/X;
fn=(((dPe)/M)^.5)/6.28;
sind0=.75;
d0=asind(sind0);
dPe2=V1*V2*cosd(d0)/X;
fn2=(((dPe2)/M)^.5)/6.28;
mprintf("(i)fn=%.2f Hz\n",fn);
mprintf("(i)fn(Hz)=%.2f Hz",fn2);
```

Scilab code Exa 17.3 To calculate the maximum value of d during the swinging of the rotor around its new equilibrium position

```
//To calculate the maximum value of d during the
   swinging of the rotor around its new equilibrium
   position
clc
clear
a=.25;//sindo=.25
do=asind(a);//
b=.5//sindc=.5
dc=asind(b);
c=cosd(do)+.5*do*%pi/180;
dm=dc;
e=1;
while(e>.0001)
    dm=dm+.1;
    e=abs(c-(((.5*dm*%pi)/180)+cosd(dm)));
end
printf("dm approximately found to be %d degree",dm);
```

Scilab code Exa 17.4 To calculate the critical clearing angle for the condition described

```
// To calculate the critical clearing angle for the
   condition described.
clear
clc;
sindo=.5;
d0=asind(sindo)*%pi/180;
r1=.2;
r2=.75;
```

```
sindm=.5/.75;
d=asind(sindm);
cosdm=cosd(d);
dm=%pi*(180-(asind(sindm)))/180;
Dc=((.5*(dm-d0))-(r2*cosdm)-(r1*cosd(d0)))/(r2-r1);
dc=acosd(Dc);// critical angle
mprintf("The critical clearing angle  is given by=%
   .2f degrees",dc);//Answers don't match due to
   difference in rounding off of digits
```

Scilab code Exa 17.5 To calculate the critical clearing angle for the generator for a 3phase fault

```
// To calculate the critical clearing angle for the
   generator for a 3-phase fault
clear
clc;
ZA=.375;
ZB=.35;
ZC=.0545;
ZAB=((ZA*ZB)+(ZB*ZC)+(ZC*ZA))/ZC;//Reactance between
    the generator and infinite bus during the fault(
   p.u)
Zgbf=%i*.3+ %i*(.55/2) +%i*.15;//Reactance between
   the generator and infinite bus before the fault(p
   .u)
Zgb=%i*.3+ %i*(.55) +%i*.15;//Reactance between the
   generator and infinite bus after the fault is
   cleared (p.u)
Pmaxo=1.2*1/abs(Zgbf);// Maximum power output Before
    the fault(p.u)
Pmax1=1.2*1/abs(ZAB);// Maximum power output during
   the fault(p.u)
Pmax2=1.2*1/abs(Zgb);// Maximum power output after
   the fault(p.u)
```

```
r1=Pmax1/Pmaxo;
r2=Pmax2/Pmaxo;
Ps=1;
sindo=Ps/Pmaxo;
do=asind(sindo);
d0=asind(sindo)*%pi/180;
sindm=1/Pmax2;
cosdm=cosd(asind(sindm));
Dm=%pi*(180-(asind(sindm)))/180;
Dc=(((sindo*(Dm-d0))-(r2*cosdm))-(r1*cosd(do)))/(r2-
    r1);
dc=acosd(Dc);// critical angle
mprintf("The critical clearing angle is given by= %
    .1f ",dc);
```

Scilab code Exa 17.6 determine the critical clearing angle

```
//(A) determine the critical clearing angle
clear
clc;
Pm=%i*.12 + %i*.035 + ((%i*.25*%i*.3)/%i*.55);
Pm1=0;
Pm2=1.1*1/.405;
r1=0;
r2=2.716/3.775;
d0=(asind(1/3.775));
dM=(180-asind(1/2.716));
do=d0*%pi/180;
dm=dM*%pi/180;
dc=acosd((((dm-do)*sind(d0))-(r1*cosd(d0))+(r2*cosd(
    dM)))/(r2-r1));
mprintf("dc=%.2f",dc);
```

Scilab code Exa 17.7 To determine the centre and radius for the pull out curve ans also minimum output vars when the output powers are i 0 ii 25pu iii 5pu

```
// To determine the centre and radius for the pull
   out curve ans also minimum output vars when the
   output powers are (i)0 (ii).25p.u (iii) .5p.u
clear
clc;
Pc=0;
V=.98;
Qc=V^2*((1/.4)-(1/1.1))/2;
R=V^2*((1/.4)+(1/1.1))/2;
Q=-(.98^2*((1.1-.4)/.44)/2) + (.98^2)*1.5/(2*.44);
mprintf("(i)Q=%.2f MVAr\n",abs(Q)*100);
P=.25;
Q2=-((1.637^2)-(.25^2))^.5 + .7639;
mprintf("(ii)Q=%.4f p.u\n",Q2);
Q3=-((1.637^2)-(.5^2))^.5 + .7639;
mprintf("(iii)Q=%.4f p.u",Q3);
```

Scilab code Exa 17.8 Compute the prefault faulted and post fault reduced Y matrices

```
// Compute the prefault, faulted and post fault
   reduced Y matrices
clear
clc;
y=[-%i*5 0 %i*5 ; 0 -%i*5 %i*5;%i*5 %i*5 -%i*10 ];
YAA=[-%i*5 0;0 -%i*5];
YAB=[%i*5;%i*5];
YBA=[%i*5 %i*5];
YBB=[%i*10];
Y=YAA-YAB*(inv(YBB))*YBA;
Yfull=[-%i*5 0 %i*5;0 -%i*7.5 %i*2.5;%i*5 %i*2.5 -%i
```

```
*12.5];
disp(Yfull,"(i)faulted case, full matrix(admittance)=");
Y=[-%i*3 %i*1;%i*1 -%i*7];
disp(Y,"(ii)Pre-fault case, reduced admittance matrix=");
Y=[-%i*5 0 %i*5;0 -%i*2.5 %i*2.5;%i*5 %i*2.5 -%i*7.5];
disp(Y,"(iii)Post-fault case, full matrix(admittance)=");
Y=[-%i*1.667 %i*1.667;%i*1.667 -%i*1.667];
disp(Y," reduced admittance matrix=");
```

Scilab code Exa 17.9 Determine the reduced admittance matrices for pre-fault fault and post fault conditions and determine the power angle characterstics for three conditions

```
//Determine the reduced admittance matrices for prefault, fault and post fault conditions and determine the power angle characterstics for three conditions.
clear
clc;
Y=[-%i*8.33 0 %i*8.33 0;0 -%i*28.57 0 %i*28.75;%i*8.33 0 -%i*15.67 %i*7.33;0 %i*28.57 %i*7.33 -%i*35.9];
YBB=[-%i*15.67 %i*7.33;%i*7.33 -%i*35.9];
YAA=[-%i*8.33 0;0 -%i*28.57];
YAB=[%i*8.33 0;0 %i*28.57];
YBA=YAB;
Y=YAA-(YAB*(inv(YBB))*YBA);
Y1=([-%i*8.33 0;0 -%i*28.57])-(([0;(%i*28.57/-%i*35.9)]*[0 %i*28.57]));
disp(Y1,"Reduced admittance matrix during fault=");
Yfull=[-%i*8.33 0 %i*8.33 0;0 -%i*28.57 0 %i*28.75;
```

```
    %i*8.33 0 -%i*12.33 %i*4;0 %i*28.57 %i*4 -%i
    *32.57];
YBB=[-%i*12.33 %i*4;%i*4 -%i*32.57];
Y=YAA-(YAB*(inv(YBB))*YBA);
disp(Y,"(i) Post fault condition ,reduced matrix=");
Y12=Y(1,2);
E1=1.1;
E2=1;
printf("\n Power angle characterstics , Pe= %fsind",
    abs(Y12)*E1*E2);
```

Scilab code Exa 17.10 To Determine the rotor angle and angular frequency using runga kutta and eulers modified method

```
// To Determine the rotor angle and angular
    frequency using runga kutta and euler's modified
     method

clc
clear
Pm=3;
r1Pm=1.2;
r2Pm=2;
H=3;
f=60;
Dt=.02;
Pe=1.5;
Do=asind(1.5/3);
do=Do/57.33;
wo=0;
d=0;
K10=0;
l10=62.83*(1.5-1.2*sin(do))*.02;
K20=(377.5574-376.992)*.02;
l20=62.83*(1.5-1.2*sin(do))*.02;
```

```
K30=(377.5574-376.992)*.02;
l30=62.83*(1.5-1.2*sin(.5296547))*.02;
K40=l30*0.02;
l40=62.83*(1.5-1.2*sin(.5353094))*.02;
d1=.53528;
Dwo=(3*1.13094+2*1.123045+1.115699)/6;
w1=wo+Dwo;
d1=.53528;
mprintf("Runga-Kutta method-\n")
mprintf("w1=%.6f \nd1=%.5f\n",w1,d1);
d7=1.026;
w7=6.501;
wp=376.992+6.501;
K17=(wp-376.992)*0.02;
l17=62.83*(1.5-1.2*sin(1.026))*.02;
K27=(6.501+.297638)*0.02;
l27=62.83*(1.5-1.2*sin(1.09101))*.02;
K37=(6.501+.2736169)*0.02;
l37=62.83*(1.5-1.2*sin(1.0939863))*.02;
K47=(6.501+.545168)*0.02;
l47=62.83*(1.5-1.2*sin(1.16149))*.02;
Dd7=(K17+2*K27+2*K37+K47)/6;
d8=d7+Dd7;
Dw7=(l17+2*l27+2*l37+l47)/6;
w8=w7+Dw7;
mprintf("d8=%.5f rad.\nw8=%.4frad/sec\n\n",d8,w8)
mprintf("using Euler's Modified Method-\n");
d0=0;
d10=.524;
w=62.83*(1.5-1.2*sin(.524));
d11=d10+0;
w11=w*.02;
d=1.13094;
dav=(0+d)/2;
wav=(56.547+56.547)/2;
d01=.524+.56547*.02;
w11=0+56.547*0.02;
mprintf("d01=%.4f\nw11=%.5f",d01,w11);
```

Chapter 18

LOAD FLOWS

Scilab code Exa 18.1 Determine the voltages at the end of first iteration using gauss seidal method

```
//Determine the voltages at the end of first
   iteration using gauss seidal method
clear
clc;
Y=[3-%i*12 -2+%i*8 -1+%i*4 0;-2+%i*8 3.666-%i*14.664
    -.666+%i*2.6664 -1+%i*4;-1+%i*4 -.666+%i*2.6664
   3.666-%i*14.664 -2+%i*8;0 -1+%i*4 -2+%i*8 3-%i
   *12];
P2=-.5;
P3=-.4;
P4=-.3;
Q4=-.1;
Q3=-.3;
Q2=-.2;
V2=1;
V3=1;
V4=1;
V10=1.06;
V30=1;
V40=1;
```

```
V21=(((P2-%i*Q2)/V2)-Y(2,1)*V10-Y(2,3)*V30-Y(2,4)*V40)/(Y(2,2));
V21acc=1+1.6*(V21-1);
disp(V21acc,"V21acc=");
V31=(((P3-%i*Q3)/V3)-Y(3,1)*V10-Y(3,2)*V21acc-Y(3,4)*V40)/(Y(3,3));
V31acc=1+1.6*(V31-1);
disp(V31acc,"V31acc=");
V41=(((P4-%i*Q4)/V4)-Y(4,2)*V21acc-Y(4,3)*V31acc)/(Y(4,4));
V41acc=1+1.6*(V41-1);
disp(V41acc,"V41acc=");
```

Scilab code Exa 18.2 Determine the voltages starting with a flat voltage profile

```
//Determine the voltages starting with a flat voltage profile.
clear
clc;

Y=[3-%i*12 -2+%i*8 -1+%i*4 0;-2+%i*8 3.666-%i*14.664 -.666+%i*2.6664 -1+%i*4;-1+%i*4 -.666+%i*2.6664 3.666-%i*14.664 -2+%i*8;0 -1+%i*4 -2+%i*8 3-%i*12];
P2=.5;
P3=-.4;
P4=-.3;
Q4=-.1;
Q3=-.3;
V3=1;
V4=1;
V1=1.06;
V2=1.04;
V30=1;
```

```
V40=1;
Q2=-imag([V2*[Y(2,1)*V1+Y(2,2)*V2+Y(2,3)*V3+Y(2,4)*V4]]);
V21=(((P2-%i*Q2)/V2)-Y(2,1)*V1-Y(2,3)*V30-Y(2,4)*V40)/(Y(2,2));
d=atand(0.0291473/1.0472868);
V21=1.04*(cosd(d)+%i*sind(d));
disp(V21,"V21=");
V31=(((P3-%i*Q3)/V3)-Y(3,1)*V1-Y(3,2)*V21-Y(3,4)*V40)/(Y(3,3));
disp(V31,"V31=");
V41=(((P4-%i*Q4)/V4)-Y(4,2)*V21-Y(4,3)*V31)/(Y(4,4));
disp(V41,"V41=");
```

Scilab code Exa 18.3 Solve the prevous problem for for voltages at the end of first iteration

```
//Solve the prevous problem for for voltages at the end of first iteration. for .2<=Q2<=1
clear
clc;

Y=[3-%i*12 -2+%i*8 -1+%i*4 0;-2+%i*8 3.666-%i*14.664 -.666+%i*2.664 -1+%i*4;-1+%i*4 -.666+%i*2.664 3.666-%i*14.664 -2+%i*8;0 -1+%i*4 -2+%i*8 3-%i*12];
P2=.5;
P3=-.4;
P4=-.3;
Q4=-.1;
Q3=-.3;
V3=1;
V4=1;
V1=1.06;
```

```
V2=1;
V30=1;
V40=1;
Q2=.2;
V3=1;
V21=(((P2-%i*Q2)/V2)-Y(2,1)*V1-Y(2,3)*V30-Y(2,4)*V40)/(Y(2,2));
V31=(((P3-%i*Q3)/V3)-Y(3,1)*V1-Y(3,2)*V21-Y(3,4)*V40)/(Y(3,3));
V41=(((P4-%i*Q4)/V4)-Y(4,2)*V21-Y(4,3)*V31)/(Y(4,4));
disp(V21,"V21=");
disp(V31,"V31=");
disp(V41,"V41=");
```

Scilab code Exa 18.4 Determine the set of load flow equations at the end of first iteration by using Newton Raphson method

```
//Determine the set of load flow equations at the end of first iteration by using Newton Raphson method.
clear
clc;
Y=[6.25-%i*18.75 -1.25+%i*3.75 -5+%i*15;-1.25+%i*3.75 2.916-%i*8.75 -1.666+%i*5;-5+%i*15 -1.666+%i*5 6.666-%i*20];
V1=1.06;
G11=6.25;
G12=-1.25;
G21=G12;
G13=-5;
G31=G13;
G22=2.916;
G23=-1.666;
G32=G23;
```

```
G33=6.666;
B11=18.75;
B12=-3.75;
B21=B12;
B13=-15;
B31=B13;
B22=8.75;
B23=-5;
B32=B23;
B33=20;
e1=1.06;
e2=1;
e3=1;
f1=0;
f2=0;
f3=0;
P2=e2*(e1*G21+f1*B21) +f2*(f1*G21-e1*B21) +e2*(e2*
    G22+f2*B22)+f2*(f2*G22-e2*B22)+e2*(e3*G23+f3*B23)
    +f2*(f3*G23-e3*B23);
P3=-.3
Q2=-.225;
Q3=-.9;
dP2=.2-(-.225);
dP3=-.6-(-.3);
dQ2=0-(-.225);
dQ3=-.25-(-.9);
a1=2*e2*G22+e1*G21+f1*B21+e3*G23+f3*B23;//a1=dP2/de2
a2=2*e3*G33+e1*G31+f1*B31+e3*G32+f2*B32;//a2=dP3/de3
b1=2*f2*G22 +f1*G21-e1*B21+f3*G23-e3*B23;//b1=dP2/
    df2
b2=20.9;//dP3/df3
a3=e2*G23-f2*B23;//dP2/de3
a4=-1.666;//dP3/de2
b3=-5;//dP2/df3
b4=-5;//dP3/df2
c1=2*e2*B22-f1*G21+e1*B21-f3*G23+e3*B23;//dQ2/de2
c2=19.1;//dQ3/de3
c3=-2.991;//dQ2/df2
```

```
c4=-6.966; //dQ3/df3
mprintf("set of linear equations at the end of first
    iteration are\n");
mprintf("%.3fde2 %.3fde3+ %.3fdf2 %.3fdf3 = %.3f\n"
    ,2.846,-1.666,8.975,-5,2.75);
mprintf("%.3fde2 +%.3fde3 %.3fdf2 +%.3fdf3 = %.3f\n"
    ,-1.666,6.366,-5,20.90,-.3);
mprintf("%.3fde2  %.3fde3 %.3fdf2 +%.3fdf3 = %.3f\n"
    ,8.525,-5,-2.991,1.666,.225);
mprintf("%.3fde2 +%.3fde3+ %.3fdf2 %.3fdf3 = %.3f\n"
    ,-5,19.1,1.666,-6.966,.65);
```

Scilab code Exa 18.5 Determine the equations at the end of first iteration after applying given constraints

```
//Determine the equations at the end of first
    iteration after applying given constraints.
clear
clc;
Q2=-.225;
dP2=.2-(-.075);
dP3=-.6-(-.3);
dQ3=-.25-(-.9);
dV2=1.04^2 - 1^2; //dV2=|dV2|^2
mprintf("set of linear equations at the end of first
    iteration are\n");
mprintf("%.3fde2 %.3fde3+ %.3fdf2 %.3fdf3 = %.3f\n"
    ,2.846,-1.666,8.975,-5,2.75);
mprintf("%.3fde2 +%.3fde3 %.3fdf2 +%.3fdf3 = %.3f\n"
    ,-1.666,6.366,-5,20.90,-.3);
mprintf("%.3fde2  %.3fde3 %.3fdf2 +%.3fdf3 = %.3f\n"
    ,8.525,-5,-2.991,1.666,.225);
mprintf("%.3fde2 +%.3fde3+ %.3fdf2 +%.3fdf3 = %.5f\n
    ",2,0,0,0,dV2);
```

Chapter 19

ECONOMIC LOAD DISPATCH

Scilab code Exa 19.1 To Determine the economic operating schedule and the corresponding cost of generation b Determine the savings obtained by loading the units

```
// To Determine the economic operating schedule and
   the corresponding cost of generation.(b)Determine
    the savings obtained by loading the units.
clear
clc;
//dF1/dP1=.4*P1+40 per MWhr
//dF2/dP2=.5*P1+30 per MWhr
mprintf("two equations are :\n");
mprintf("%.1f P1 %.1f P2 = %.1f\n",.4,-.5,-10);
mprintf("%.1f P1+ %.1fP2 = %.1f\n",1,1,180);
A=[.4 -.5;1 1];
B=[-10;180];
P=(inv(A))*B;
P1=P(1,1);
P2=P(2,1);
F1=.2*(P1)^2 +40*P1+120;
F2=.25*(P2)^2+30*P2+150;
```

```
Total=F1+F2;//Total cost
mprintf("(a)Cost of Generation=Rs %.2f /hr\n",Total)
    ;
P1=90;
P2=90;
F1=.2*(P1)^2 +40*P1+120;
F2=.25*(P2)^2+30*P2+150;
Total2=F1+F2;//Total cost
savings=Total2-Total
mprintf("(b)Savings=Rs %.2f /hr\n",savings)
```

Scilab code Exa 19.2 Determine the incremental cost of recieved power and penalty factor of the plant

```
//Determine the incremental cost of recieved power
    and penalty factor of the plant
clear
clc;
pf=10/8;//penalty factor
cost=(.1*10+3)*pf;//Cost of recieved power=dF1/dP1
mprintf("Penalty Factor=%.1f\n",pf);
mprintf("Cost of recieved Power=Rs %.1f /MWhr",cost)
    ;
```

Scilab code Exa 19.4 Determine the minimum cost of generation

```
//Determine the minimum cost of generation .
clear
clc;
//dF1/dP1=.048*P1+8
//dF2/dP2=.08*P1+6
mprintf("two equations are :\n");
mprintf("%.3f P1 %.2f P2 = %.1f\n",.048,-.08,-2);
```

```
mprintf("%.1f P1+ %.1fP2 = %.1f\n",1,1,50);
A=[.048 -.08;1 1];
B=[-2;50];
P=(inv(A))*B;
P1=P(1,1);
P2=P(2,1);
F1=(.024*(P1)^2 +8*P1+80)*(10^6);
F2=(.04*(P2)^2+6*P2+120)*(10^6);
mprintf("when load is 150MW , equations are: :\n");
mprintf("%.3f P1 %.2f P2 = %.1f\n",.048,-.08,-2);
mprintf("%.1f P1+ %.1fP2 = %.1f\n",1,1,150);
A=[.048 -.08;1 1];
B=[-2;150];
P=(inv(A))*B;
P1=P(1,1);
P2=P(2,1);
f1=(.024*(P1)^2 +8*P1+80)*(10^6);
f2=(.04*(P2)^2+6*P2+120)*(10^6);
Total=(F1+F2+f1+f2)*12*2/(10^6);
mprintf("Total cost=Rs. %.2f",Total)
```

Chapter 20

LOAD FREQUENCY CONTROL

Scilab code Exa 20.1 Determine the load taken by the set C and indicate the direction in which the energy is flowing

```
//Determine the load taken by the set C and indicate
    the direction in which the energy is flowing
clear
clc;
//let x MW flows from A to B
//Load on station A=75+x
//%drop in speed =5*(75+x)/200
//load on station B =(30-x)
//%drp in speed=(30-x)*4/75
x=(1.6-1.875)/(.025+.12+.0533);//by manipulating
   equation : 5*(75+x)/200 + 3*x/25 =(30-x)*4/75
mprintf("x=%.2f MW\n",x);
mprintf("which means power of magnitude %.2f MW will
    be from B to A",abs(x));
```

Scilab code Exa 20.2 Determine the load shared by each machine

```
// Determine the load shared by each machine .
clear
clc;
//Let x be the power supplied by 110 MW unit
// the percent drop in speed = 5x/110
x=(250*11)/(21+11);// by manipulating equation : 5x
    /110=5x(250-x)/210
P=250-x;//Power shared by 210 MW unit
mprintf("Power supplied by 210 MW unit = %.2f MW \n"
    ,P);
```

Scilab code Exa 20.3 Determine the frequency to which the generated voltage drops before the steam flow commences to increase to meet the new load

```
// Determine the frequency to which the generated
    voltage drops before the steam flow commences to
    increase to meet the new load
clear
clc;
E=4.5*100;//Energy stored at no load(MJ)
E1=25*.6;//Energy lost by rotor(MJ)
fnew=sqrt((E-E1)/E)*50;
mprintf("new frequency will be %.2f Hz",fnew);
```

Chapter 21

COMPENSATION IN POWER SYSTEMS

Scilab code Exa 21.1 Determine the load bus voltage

```
//Determine the load bus voltage
clear
clc;
load1=10+%i*15;//load per phase(MVA)
SCC=250/3;
V=11/sqrt(3);
P=30;
Q=45;
Z=(11/sqrt(3))^2/(250/3);//Equivalent short circuit
    impedence
dsc=atand(5);
R=.0949;
X=.4746;
//Using equation: V^2= (Vcosd+PR/V)^2 + (Vsind+QX/V)
    ^2, we get
y=poly([51.7 0 -27.5 0 1],'V','c');
disp(y,"we get equation :");
X=roots(y);
disp(X,"Roots of above equation are ");
```

```
V=5.046;
mprintf("V=%.3f\n",V);
dV=6.35-V;
Ssc=250;
//using expression ,a=dV/v=1(Pcos(dsc)+Qsin(dsc))/Ssc +j(Psin(dsc)-Qcos(dsc))/Ssc
a=(P*cosd(dsc)+Q*sind(dsc))/Ssc +%i*(P*sind(dsc)-Q*cosd(dsc))/Ssc;
disp(abs(a),"dV/V= ");
```

Chapter 22

POWER SYSTEM VOLTAGE STABILITY

Scilab code Exa 22.2 To Determine the source voltage when the load is disconnected to load pf i unity ii 8 lag

```
// To Determine the source voltage when the load is
   disconnectedto load p.f (i) unity (ii).8 lag.
clear
clc;
Vb=500;
Sb=1000;
Zb=Vb^2/Sb;
Xpu=.35*100/Zb;
Zth=1000/5000;
X=Xpu+Zth;
V=1;
Q=0;
P=1;
Eth=V+(Q*X/V)+%i*(P*X/V);
Q=.75;
Eth1=V+(Q*X/V)+%i*(P*X/V);
printf("(i) For p.f unity , Eth=%.2f V",Eth);
disp(Eth1,"(i) For p.f .8 , Eth=");
```

Scilab code Exa 22.3 To determine thee Ac system voltage when the dc system is disconnected or shutdown

```
// To determine thee Ac system voltage when the dc
   system is disconnected or shutdown
clear
clc;

X=.625;
P=1;
Q=.6;
V=1;
Eth=V+(Q*X/V)+%i*(P*X/V);
Phase_Eth=atand(imag(Eth)/real(Eth));
mprintf("Eth=%.2f at an angle %.0f degrees",abs(Eth)
   ,Phase_Eth);
```

Scilab code Exa 22.4 To Calculate the new on and off times for constant energy

```
// To Calculate the new on and off times for
   constant energy.
clear
clc;

P=.5;
toff=4;
ton=(P*toff-0*toff)/(.8-P);
mprintf("toff= 4min.\n")
mprintf("ton(min.)=%.3f min.\n",ton);
```

Scilab code Exa 22.6 To discuss the effect of tap changing

```
// To discuss the effect of tap changing
clear
clc;
V=1;
Qload=1*V
Qcap=-.75*V^2;
Qnet=Qload+Qcap;
VS=1-.75*2*V;// voltage sensitivity
mprintf("Voltage sensitivity=%.3f\n",VS);
mprintf("since the voltage sensitivity is negative
    ,\n voltage regulation by tap changing will
    reduce net reactive load and improive voltage
    stability ");
```

Scilab code Exa 22.7 To determine the effect of tapping to raise the secondary voltage by 10percent

```
//To determine the effect of tapping to raise the
    secondary voltage by 10%
clear
clc;

Y=-%i*10;
n=1+.1;
Y1=n*(n-1)*Y;
Y2=(1-n)*Y;
disp(Y1,"Y1=");
disp(Y2,"Y2=");
disp("The shunt elements equal to a reactor of 1.1V1
    ^2 size oin the primary side and a capacitive of
```

```
sixe 1V2^2 on the secondary side");
```

Scilab code Exa 22.8 Calculate the additional reactive power capability at full load

```
//Calculate the additional reactive power capability
    at full load
clear;
clc;
P=1;//assuming
S1=P/.95;//For pf .95
S2=P/.8;//For pf .8
dMVA=(S2-S1)*100/P;//Increase in MVA rating
Q1=P*tand(acosd(.95));//Q for pf .95
Q2=P*tand(acosd(.8));//Q for pf .8
dPc=(Q2-Q1)*100/Q1//Percent additional Reactive
   Power Capability
mprintf("Percent additional Reactive Power
   Capability is %.0f",dPc)
```

Chapter 23

STATE ESTIMATION IN POWER SYSTEMS

Scilab code Exa 23.1 To determine the state vector at the end of first iteration

```
// To determine the state vector at the end of first
    iteration
clear
clc;
C1=.02*100;
C2=.05;
Fs=100;
S1=.41 -%i*.11;
S2=-.4 +%i*.10;
S3=-.105 +%i*.11;
S4=-.105 +%i*.11;
S5=.14 -%i*.14;
S6=-.7 +%i*.35;
Z12=.08+%i*.24;
Z23=.06+%i*.18;
Z31=.02+%i*.06;
Z21=Z12;
Z32=Z23;
```

```
Z13=Z31;
W1=(50*10^(-6))/((C1*abs(S1)+(C2*(Fs)))^2);
W2=(50*10^(-6))/((C1*abs(S2)+C2*(Fs))^2);
W3=(50*10^(-6))/((C1*abs(S3)+C2*(Fs))^2);
W4=(50*10^(-6))/((C1*abs(S4)+C2*(Fs))^2);
W5=(50*10^(-6))/((C1*abs(S5)+C2*(Fs))^2);
W6=(50*10^(-6))/((C1*abs(S6)+C2*(Fs))^2);
disp(W1,"W1=");//Answers for W1,W2,W3,W4,W5,W6 in
    the book is wrongly Calculated
disp(W2,"W2=");
disp(W3,"W3=");
disp(W4,"W4=");
disp(W5,"W5=");
disp(W6,"W6=");
a1=W1/(abs(13)^2)
[D]=diag([W1/(abs(Z13)^2);W2/(abs(Z31)^2);W3/(abs(
    Z12)^2);W4/(abs(Z21)^2);W5/(abs(Z23)^2);W6/(abs(
    Z32)^2)]);
A=[-1 0 1;1 0 -1;1 -1 0;-1 1 0;0 1 -1;0 -1 1];
B=[-1 0;1 0;1 -1;-1 1;0 1;0 -1];
b=[1;-1;0;0;-1;1];
C=(B')*D;//Assuming Transpose(B)D=C
F=(B')*D*B;//Assuming Transpose(B)*D*B=F
G=(inv(F))*C;//Assuming(BTDB)-1*(BT)*D=F
E1=1.05;
E2=E1;
E3=E1;
invH=diag([Z31/E3;Z13/E1;Z12/E1;Z21/E2;Z23/E2;Z32/E2
    ]);
Sm=[.41+%i*.11;-.4-%i*.1;-.105-%i*.11;.14+%i
    *.14;.72+%i*.37;-.7+%i*.35];
EMo=invH*Sm;
a=EMo-b*E1;
E=G*a;
disp(E,"E=");  //Answers differs due to wrong
    calculation of W1,W2,W3,W4,W5,W6
```

Scilab code Exa 23.2 Determine The States of the systems at the end of first iteration

```
// Determine The States of the systems at the end of
    first iteration.
clear
clc
Qm1=-.24;
Qm2=-.24;
Qm3=.5;
do=0;
Pm1=.12;
Pm2=.21;
Pm3=-.30;
W1=3;
r1=W1;//assuming r1=Inverse(R1)
W2=5;
r2=W2;//assuming r2=Inverse(R1)
W3=2;
r3=W3;//assuming r3=Inverse(R1)
X12=%i*.03;
X13=%i*.01;
X23=%i*.02;
X21=X12;
X31=X13;
X32=X23;
Vo=[1.05;1.05];
H=[-1/.03 -1/.01;((1/.03)+(1/.02)) -1/.02;-1/.02
    ((1/.01)+1/.02)];//assuming dh/dl=H
A1=[3327+34700+5000 9990-20825-15000;-25835
    30000+12500+45000];
V=Vo+inv(A1)*(H')*(diag([W1;W2;W3]))*[Qm1;Qm2;Qm3];
d=do+inv(A1)*(H')*(diag([W1;W2;W3]))*[Pm1;Pm2;Pm3];
    //assuming d=dell matrix and do=intial matrix=0
```

```
disp(V,"V=");
disp(d,"d=");
```

Scilab code Exa 23.3 Problem on State Estimator Linear Model

```
//Problem on State Estimator Linear Model

clear
clc;
A=[-3.33 0;0 10;5 -5];
R=[10^-4 0 0;0 10^-4 0;0 0 10^-4];
O=inv(((A')*(inv(R))*(A)))*((A')*(inv(R))
    *[.12;.21;-.30]);//assuming theat matrix=0
f12=-3.33*(O(1,1));
f31=10*(O(2,1));
f23=5*(O(1,1)-O(2,1));
J=(((.12-f12)^2)+((.21-f31)^2)+((-.3-f23)^2))
    /(10^-4);
disp(O,"O=");//Answer does not match due to
    difference in rounding off of digits
disp(J,"J=");//Answer does not match due to
    difference in rounding off of digits
```

Scilab code Exa 23.4 Determine theta1 Theta2

```
//Determine theta1 Theta2
clear
clc;
A=[5 -5;2.5 0;4 -4];
R=[10^-4 0 0;0 10^-4 0;0 0 10^-4];
O=inv(((A')*(inv(R))*(A)))*((A')*(inv(R))
    *[.60;.05;.35]);//assuming theat matrix=0
f12=5*(O(1,1)-O(2,1));
```

```
f13=2.5*(O(1,1));
f32=-4*(O(2,1));
J=(((.6-f12)^2)+((.05-f13)^2)+((.35-f32)^2))/(10^-4);
//Answer does not match due to difference in rounding off of digits
disp(O(1,1),"Theta1=");
disp(O(2,1),"Theta2=");
```

Chapter 24

UNIT COMMITMENT

Scilab code Exa 24.3 Priority List Method

```
// Priority List Method
clear
clc;
Fc1=1.1;//Fuel cost(1)=Rs 1.1/MBtu
Fc2=1;//Fuel cost(2)=1/MBtu
Fc3=1.2;//Fuel cost(3)=1.2/MBtu
P1max=600;
P1=P1max;
F1=600+7.1*P1+0.00141*(P1^2);//For P1= Pm1ax
Favg1=F1*Fc1/600;//Full load average production cost
P2max=450;
P2=P2max;
F2=350+7.8*P2+0.00195*(P2^2);//For P2= P2max
Favg2=F2*Fc2/450;//Full load average production cost
P3max=250;
P3=P3max;
F3=80+8*P3+0.0049*(P3^2);//For P3= P3max
Favg3=F3*Fc3/250;//Full load average production cost
mprintf("Priority List is as follows\n");
mprintf("Unit          Rs/MWhr       MinMW          Max MW\
    n")
```

```
mprintf(" 2              %.3f          100               %.0f
    \n",Favg2,P2max)
mprintf(" 1              %.4f          60                %.0f
    \n",Favg1,P1max)
mprintf(" 3              %.2f           50               %.0f
    \n\n",Favg3,P3max)
Fmax1=P1max+P2max+P3max;
Fmax2=P2max+P1max
Fmax3=P2max
mprintf("Unit Commitment Scheme is follows\n")
mprintf("Combination            Min.MW from Combination
            Max.MW from Combination\n");
mprintf("2+1+3                       310
                                  %.0f    \n",Fmax1);
mprintf("2+1                         260
                                  %.0f    \n",Fmax2);
mprintf("2                           100
                                  %.0f    ",Fmax3);
```

Scilab code Exa 24.4 illustrate the dynamic programming for preparing an optimal unit commitment

```
// illustrate the dynamic programming for preparing
    an optimal unit commitment.

clear
clc;
function[F1]=F1(P1)
    F1=7.1*P1+.00141*(P1^2)
    mprintf("F1(%.0f)=%.1f\n",P1,F1);
endfunction
function[f2]=f2(P2)
    f2=7.8*P2+.00195*(P2^2)
    mprintf("f2(%.0f)=%.0f\n",P2,f2);
endfunction
```

```
function[F]=F(P1,P2)
    F1=7.1*P1+.00141*(P1^2)
    F2=7.8*P2+.00195*(P2^2)
    F=F1+F2
    mprintf("F1(%.0f)+f2(%.0f)=%.0f\n",P1,P2,F);
    endfunction
P1max=600;
P2max=450;
mprintf("Unit Commitment using Load 500MW\n")
F1(500);
mprintf("Since min. Power of second unit is 100MW ,
   we find\n");
F(400,100);
F(380,120);
F(360,140);
mprintf("Therefore for load 500 MW , the load
   commitment on unit 1 is 400 MW and that on 2 is
   100 MW which gives min. cost\n");
mprintf("Next we increase the load by 50 MW and
   loading unit 1 we get, \n");
F1(550);
mprintf("Also if we distribute a part of load to
   unit 2 we get ,\n")
F(450,100);
F(400,150);
F(350,200);
mprintf("Therefore for load 550 MW , the load
   commitment on unit 1 is 400 MW and that on 2 is
   150 MW which gives min. cost\n");
```

Chapter 25

ECONOMIC SCHEDULING OF HYDROTHERMAL PLANTS AND OPTIMAL POWER FLOWS

Scilab code Exa 25.1 illustrating the procedure for economic scheduling clear all

```
// illustrating the procedure for economic
   scheduling
clear
clc;
q2=25;
q3=25
q1=70-(q2+q3);
Wo=120;
W3=50;
Wi1=0;
Wi2=0;
W1=Wo+Wi1-q1;
W2=W1+Wi2-q2
PH1=9.81*(10^-3)*20*[1+(.5*.006*(120+100))]*(20-2);
```

```
PH2=9.81*(10^-3)*20*[1+(.5*.006*(100+75))]*(23);//Answer in the book is not Correct due to wrong calculation
PH3=9.81*(10^-3)*20*[1+(.5*.006*(75+50))]*(23);
PT1=8-PH1;
PT2=12-PH2;
PT3=7-PH3;
L11=20+PT1;//dFT/dPT=PT+20
L12=20+PT2;//dF/dp=PT+20
L13=20+PT3;//dF/dp=PT+20
//dPL/dPH=0
L31=L11;
L32=L12;
L33=L13;
e=.006;
ho=.1962
Rho=2;
L21=L31*ho*[1+(.5*e*(2*Wo+Wi1-2*q1+Rho))]
L22=L21-L31*[.5*ho*e*(q1-Rho)]-L32*[.5*ho*e*(q2-Rho)]//for m=1
L23=L22-L32*[.5*ho*e*(q2-Rho)]-L33*[.5*ho*e*(q3-Rho)]//for m=2
G1=L22-L32*ho*[1+.5*.006*(2*100-2*25+2)]//G1=dF/dq2 Answer doent match due to wrong calculation of PH2 in a book;
G2=L23-L33*ho*[1+.5*.006*(2*W2+0-2*q3+Rho)]//G1=dF/dq3;
a=0.4;
qnew2=q2-a*G1;// Answer differs due to wrong calculation of PH2 in the book
qnew3=q3-a*G2;
q1=120-50-(qnew2+qnew3);
mprintf("Let q2=%.0f    q3=%.0f     q1=%.0f\n",q2,q3,q1);
mprintf("W1=%.0f     W2=%.0f\n",W1,W2);
mprintf("PH1=%.2f      PH2=%.3f     PH3=%.1f\n",PH1,PH2,PH3);
mprintf("Thermal generation during Three Intervals \
```

```
    n PT1=%.2f        PT2=%.2f       PT3=%.1f\n",PT1,PT2,
    PT3);
mprintf("Value of L1 for the three intervals , \n L11
    =%.2f      L12=%.2f      L13=%.1f\n",L11,L12,L13);
mprintf("Neglecting transmission losses we get\n L11
    =L31    L12=L32    L13=L33\n");
mprintf("L21=%.3f\n",L21)
mprintf("For m=1 and 2 we get \n L22=%.1f \n L23=%.1
    f\n",L22,L23);
mprintf("Gradient Vectors \n dF/dq2=%.2f\n dF/dq3=%
    .1f\n",G1,G2)
mprintf("q2new=%.3f \n q3new=%.1f\n q1=%.0f",qnew2,
    qnew3,q1)
```