Scilab Textbook Companion for Switchgear Protection And Power Systems by S. S. Rao[1]

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Book Description

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

Exa Example (Solved example)

Eqn Equation (Particular equation of the above book)

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

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

Contents

List of Scilab Codes

Chapter 3

Fundamentals of Fault Clearing and Switching Phenomena

Scilab code Exa 3.1 To find the transient current of RL circuit

```
To find the transient current of RL circuit
```

```

clear ;
close ;
clc ;
R=10;
L=0.1;
f=50;
w=2*%pi*f;
k=sqrt((R^2)+((w*L)^2));
angle=atan(w*L/R);
E=400
A=E*sin(angle)/k;
i=A*exp((-R)*.02/L);
i=round(i*100)/100;
mprintf("the transient current =%fA",i)
```

Scilab code Exa 3.2 to find the DC component and instantaneous value of currents and voltages

```
to find the DC component and instantaneous value of currents and voltages
```

```

clear;
close;
clc;

R=10;
L=0.1;
f=50;
w=2*%pi*f;
k=sqrt((R^2)+((w*L)^2));
angle=atan(w*L/R);
E=100;
Em=sqrt(2)*E;
A=Em*sin(angle)/k;
i1=A;
Em=round(Em*10)/10;
i1=round(i1*10)/10;
mprintf("current in amperes for part1=%fA\n",i1);
mprintf("current in part 2& part 3= 0\n");
mprintf("the DC component vanishes if e=%fV",Em);//the error is due to the erroneous values in the textbook

t1=0.5*.02;
i2=A*exp((-R)*t1/L);
mprintf("\ncurrent at .5 cycles for t1=%fsec \ncurrent in the problem = %fA",t1,i2);
t2=1.5*.02;
i3=A*exp((-R)*t2/L);
```

```
mprintf("\ncurrent at 1.5 cycles for t2=%fsec \ncurrent in the problem = %fA",t2,i3);
t3=5.5*.02;
i4=A*exp((-R)*t3/L);
mprintf("\ncurrent at 5.5 cycles for t3=%fsec \ncurrent in the problem = %fA",t3,i4);


disp("the difference in result is due to erroneous value in textbook.")
```

Scilab code Exa 3.3 To find Max Rate of restriking voltage and time for RRRV and the frequency

`To find Max Rate of restriking voltage and time for RRRV and the frequency`

```
clear;
close;
clc;
C=.003e-6
L=1.6e-3
y=sqrt(L*C);
y=round(y*1e7)/1e7;
f=(2*3.14*y)^-1;
f=round(f/100)*100;
i=7500;
E=i*2*3.15*L*50;
Em=1.414*E;
Em=round(Em/10)*10
t=y*%pi/2;
t=t*1e6;
t=round(t*100)/100;
e=Em/y;
e=round((e)/1e6)*1e6;
e=fix(e/1e7)*1e7
```

```
mprintf("frequency of oscillations=%fc/s",f);
mprintf("\ntime of maximum restriking voltage=
    %fmicrosec",t);
mprintf("\nmaximum restriking voltage=%dV/microsecs"
    ,e/1e6);
```

Scilab code Exa 3.4 To find the peak striking voltage and its frequency and the avg of RRRV and its max rate

`To find the peak striking voltage and its frequency and the avg of RRRV and its ma`

```

clear;
close;
clc;
R=5
f=50
L=R/(2*%pi*f);
V=11e3;
Vph=11/sqrt(3);
C=0.01d-6;
y=sqrt(L*C);
Em=sqrt(2)*Vph;
ep=2*Em;
ep=round(ep*10)/10;
y=round(y*1e7)/1e7;
t=y*%pi;
t=fix(t*1e7)/1e7
ea=ep/t;
ea=round(ea/1e3)*1e3
fn=(2*3.14*y)^-1;
Em=round(Em)
Emax=Em/y;
Emax=round(Emax/1000)*1e3;
mprintf("peak restriking voltage=%dkV",ep);
```

```
printf("\nfrequency of oscillations=%dc/s",fn);
printf("\naverage rate of restriking voltage=%fkV/
    microsecs",ea/1e6);
printf("\nmax restriking voltage=%dV/microsecs",Emax
    /1e3);
```

Scilab code Exa 3.5 The average rate of rise of restriking voltage

The average rate of rise of restriking voltage

```

clear;
close;
clc;
E=19.1*1e3;
L=10*1e-3;
C=.02*1e-6;
Em=sqrt(2)*E;
y=sqrt(L*C);
t=%pi*y*1e6;
emax=2*Em;
eavg=emax/t;
eavg=round(eavg/10)*10
printf("average restriking voltage=%dV/microsecs",
    eavg);
```

Scilab code Exa 3.6 To estimate the average rate of restriking voltage

To estimate the average rate of restriking voltage

```
clear;
close;
```

```
clc;
V=78e3;
Vph=V/sqrt(3);
Em=2*Vph;
pf=0.4;
angle=acos(pf);
k1=sin(angle);
k1=round(k1*100)/100;
k2=.951;
k3=1;
k=k1*k2*k3;
k=round(k*1000)/1e3;
E=k*Em;
f=15000;
t=1/(2*f);
t=round(t*1e6);
eavg=2*E/t;
eavg=round(eavg/100)*100;
printf("average restriking voltage=%fkV/microsecs",
   eavg/1e3);
```

Scilab code Exa 3.7 to find the peak striking voltage and the time to reach it

to find the peak striking voltage and the time to reach it

```
clear;
clc;
Em=100e3
t=70e-6
Ea=Em/t/1e6
f=1/(2*t);
Ea=round(Ea/10)*10;
f=round(f);
```

```
printf("average voltage in volts=%dV/microsecs\n",Ea
    );
printf("frequency of oscillation =%dc/s",f);
```

Scilab code Exa 3.8 To find the value of resistance to be used across the contact space

To find the value of resistance to be used across the contact space

```

clc;
L=6;
C=0.01e-6;
i=10;
v=i*sqrt(L/C);
R=.5*v/i;
R=round(R/10)*10;
printf("damping resistance in ohms=%fkohms",R/1e3);
```

Chapter 17

Electrical Substations and Equipments and Busbar Layouts

Scilab code Exa 17.1 to find the min force on the conductors

```
to find the min force on the conductors
```

```
clear ;
clc ;
Isc= 25e3;
i=2.55*Isc;
L=1;
r=0.24;
F=2.046*(i^2)*10^-5/r;
mprintf("the force on busbar per meter length =%d
   kgfper meter",F/1e3);
```

Chapter 18

Neutral Grounding or Earthing

Scilab code Exa 18.1 To calculate the ohmic value of impedence

To calculate the ohmic value of impedence

```
clc;
clear;
P=2000e3;
V=400;
r=.4;
z=V^2/(r*P);
mprintf("the value of z=%f ohm",z);
```

Scilab code Exa 18.2 to find the value of reactance

to find the value of reactance

```
clc;
clear;
w=314;
c=.015e-6;
```

```
l=1/(3*w^2*c);//the difference in result is due to
    erroneous calculation in textbook.
l=round(l*10)/10;
mprintf("inductance =%f Henries",l);
disp("the difference in result is due to erroneous
    calculation in textbook.")
```

Scilab code Exa 18.3 calculate the reactance to neutralize different value of line capacitance

`calculate the reactance to neutralize different value of line capacitance`

```
clc;
clear;
c1=1.5e-6;
w=2*%pi*50;
L1=1/(3*c1*(w^2));
c2=.9*c1;
L2=1/(3*c2*(w^2));
c3=.95*c1;
L3=1/(3*c3*(w^2));
L1=round(L1*100)/100;
L2=round(L2*10)/10;
L3=round(L3*100)/100;
mprintf("the inductance for 100 percent line
    capacitance=%f henries \n",L1);
mprintf("for 90percent line capacitance,the
    inductance=%f henries\n",L2);
mprintf("for 95percent line capacitane inductance=%f
     henries",L3);
```

Scilab code Exa 18.4 To find the inductance and the KVA rating

To find the inductance and the KVA rating

```
clc;
clear;
c=.01e-6*50;
w=2*%pi*50;
L=1/(3*c*(w^2));
L=round(L*100)/100;
V=33e3/sqrt(3);
I=V/(w*L);
I=round(I*1000)/1000;
I=round(I*100)/100;
R=V*I/1e3; //the difference in result is due to
    erroneous calculation in textbook.
mprintf("the value of L=%fH and rating =%fkVA",L,R);
disp("the difference in result is due to erroneous
    calculation in textbook.");
```

Chapter 19

Introduction to Fault Calculations

Scilab code Exa 19.1 expressing the quantities in per unit form

expressing the quantities in per unit form

```
clc;
clear;
i=10;
v=200;
z=v/i;
I1=20/i;
I2=.2/i;
v1=50/v;
r=2/z;
mprintf("the base impedence=%dohm\n",z);
mprintf("the base values for 20A=%dp.u.\n.the base
   values for 2A=%fp.u.\nthe base values for 50V=%fp
   .u.\n the base values for 2ohm=%fp.u",I1,I2,v1,r)
   ;
```

Scilab code Exa 19.2 conversion in per unit

conversion in per unit

```
clc;
clear;
z=2;
v=11e3;
r=1000e3;
zb=v^2/r;
y=z/zb;
y=round(y*10000)/10000;
mprintf("the per unit resistance=%fp.u",y);
```

Scilab code Exa 19.3 to find the new pu reactance

to find the new pu reactance

```
clc;
clear;
v=11e3;
r=15000e3;
zp=.15;
vnew=110e3;
rnew=30000e3;
zb=v^2/r;
Z=zp*zb;
zbnew=vnew^2/rnew;
Zp=Z/zbnew;
mprintf("the new per unit reactance=%fp.u",Zp/10);
```

Scilab code Exa 19.4 drawing the reactance diagram of the system drawing the reactance diagram of the system

```
clc;
clear;
v1=11e3;
v2=22e3;
v3=3.3e3;
r=10000e3;
zb1=v1^2/r;
zb2=v2^2/r;
zb3=v3^2/r;
zp1=300/zb3;
zp2=300*(zb2/zb3)/zb2;
zp3=300*(zb1/zb3)/zb1;
zp1=round(zp1*10)/10;
zp1=round(zp1);
zp2=round(zp2*10)/10;
zp2=round(zp2);
zp3=round(zp3*10)/10;
zp3=round(zp3);
mprintf("the per unit values =%dp.u. ; %dp.u.; %dp.u
    . ",zp1,zp2,zp3);
```

Scilab code Exa 19.5 to find the fault current

to find the fault current

```
clc;
clear;
z=0.2*%i*0.155/(0.2+0.155);
v=1;
i=v/z;
ir=real(i);
im=imag(i);
```

```
im=round(im*100)/100;
mprintf("the fault current is =%d+(%fj)A",ir,im);
```

Scilab code Exa 19.6 The reactance calculations

The reactance calculations

```
clc;
clear;
r=30000e3;
v1=11e3;
v2=110e3;
zb1=v1^2/r;
zb2=v2^2/r;
zp1=80/zb2;
zp2=.1*%i*30000/35000;
zp3=.2*%i*30000/10000;
zp3r=real(zp3);
zp2r=real(zp2);
zp3i=imag(zp3);
zp2i=imag(zp2);
zb2=round(zb2*10)/10;
zp1=round(zp1*1000)/1000;
zp2i=round(zp2i*10000)/10000;
zp3i=round(zp3i*10)/10;
mprintf("the base impedence of transmission line
    circuti=%fohm\nper unit reactance of transmission
    line=%fp.u.\n ",zb2,zp1);
mprintf("per unit reactance of transformer to new
    base=%f+(%fj)p.u.\nPer unit reactance of motor to
    new base=%f+(%fj)p.u.",zp2r,zp2i,zp3r,zp3i);
```

Scilab code Exa 19.7 to find the pu impedences to find the pu impedences

```
clc;
clear;
r1=10e6;
r2=7.5e6;
r3=5e6;
v1=66e3;
v2=11e3;
v3=3.3e3;
zst=.06*r1*%i/r2;
zps=.07*%i;
zpt=.09*%i;
Zp=(zst+zps-zst)/2;
Zs=(zps+zst-zpt)/2;
Zt=(zpt+zst-zps)/2;
Zpi=imag(Zp);
Zsi=imag(Zs);
Zti=imag(Zt);
Zpi=round(Zpi*100)/100;
mprintf("the per unit impedencce of circuit \nZp=
    %fjp.u ;\n Zs=%fjp.u;\n Zt=%fjp.u",Zpi,Zsi,Zti);
```

Scilab code Exa 19.9 To calculate the new fault level

To calculate the new fault level

```
clc;
clear;
old=5000;
bank=200;
new=old-bank;
mprintf("new fault =%dMVA",new);
```

Chapter 20

Symmetric Faults and Current Limiting Reactors

Scilab code Exa 20.1 Calculate Fault MVA and current

Calculate Fault MVA and current

```
clear;
clc;
V=6.6e3;
r=5e6;
X=.12;
F=r/X;
I=(F/V)/(%i*sqrt(3));
Ir=real(I);
Ii=imag(I);
Imod=sqrt((Ir^2)+(Ii^2));
Iangle=atand(Ir/Ii)-90;
F=fix(F/1e5)*1e5;
Imod=fix(Imod);
mprintf("Method 1 \nthe value of fault MVA=%fMVA \n
   the fault current is = %d /_%d A\n",(F/1e6),Imod,
   Iangle);
//method 2
```

```
Vbase=V/sqrt(3);
Ifaultpu=1/(X*%i);
Ibase=r/(Vbase*3);
Ifault=Ifaultpu*Ibase;
P=sqrt(3)*Ifault*V;
Ir=real(Ifault);
Ii=imag(Ifault);
Imod=sqrt((Ir^2)+(Ii^2));
Pr=real(P);
Pi=imag(P);
Pmod=sqrt((Pr^2)+(Pi^2));
Pangle=atand(Pr/Pi)-90;
Pmod=fix(Pmod/1e5)*1e5;
Imod=fix(Imod);
mprintf("From method 2\n the value of fault MVA=%f /_%d MVA \n the fault current is = %d A",(Pmod/1e6),Pangle,Imod);
//method 3
v1=6.4e3;
I=(v1/V)/X;
Ifault=Ibase*I;
p=sqrt(3)*Ifault*v1;//the difference in result is due to erroneous calculation in textbook.
p=round(p/1e5)*1e5;
mprintf("\nthe new fault current at 6.4kV is = %fA \n the newfault power at service voltage is =%fMVA",Ifault,p/1e6);
disp("the difference in result is due to erroneous calculation in textbook.");
```

Scilab code Exa 20.2 To find the steady state fault current

To find the steady state fault current

```
clear;
```

```
clc;
V=3000e3;
r1=30;
r=5000e3;
vb2=11e3;
vb3=33e3;
x=.2;
Xt=.05*r/V;
Xl=r1*r/(vb3^2);
xtotal=(x+Xt+Xl)*%i;
MVA=r*%i*1e-6/xtotal;
Ifault=MVA*1e6/(sqrt(3)*vb3*%i);
Ir=real(Ifault);
Ii=imag(Ifault);
Imod=sqrt((Ir^2)+(Ii^2));
Iangle=atand(Ir/Ii)-90;
Imod=round(Imod);
MVA=round(MVA*10)/10;
mprintf("the value of falut current = %d/_%d Amp \n
    fault MVA =%f MVA",Imod,Iangle,MVA);
```

Scilab code Exa 20.03 to find the fault MVA

to find the fault MVA

```
clear;
clc;
rating=25e6;
vb=11e3;
x=.16/4;
faultMVA=rating*1e-6/x;
mprintf("the fault MVA from method 1=%dMVA",faultMVA
    );
//method 2
Ifault=1/(x*%i);
```

```
Ib=rating/(sqrt(3)*vb);
Isc=Ib*25;
MVA=sqrt(3)*vb*Isc/1e6;
mprintf("\n the fault MVA from method 2=%dMVA",MVA);
```

Scilab code Exa 20.04 calculate the fault current and MVA

```
calculate the fault current and MVA
```

```
clear;
clc;
R=3e6;
Rb=6000e3;
vb1=11e3;
vb2=22e3;
X=.15;
x=.15*Rb/R;
xeq=x/2;
MVA=Rb/xeq;
Ifault=MVA/(sqrt(3)*vb1*%i);
Ir=real(Ifault);
Ii=imag(Ifault);
Imod=sqrt((Ir^2)+(Ii^2));
Iangle=atand(Ir/Ii)-90;
Imod=round(Imod/10)*10;
mprintf("for fault on generator side \n Fault MVA=
    %dMVA \n Fault current=%d/_%dAmp",MVA/1e6,Imod,
    Iangle);
x2=.05;
Xeq=x2+xeq;
MVA=Rb/Xeq;
Ifault=MVA/(1.734*vb2*%i);
Ir=real(Ifault);
Ii=imag(Ifault);
Imod=sqrt((Ir^2)+(Ii^2));
```

```
Iangle=atand(Ir/Ii)-90;
mprintf("\nfor fault on transmission side \n Fault MVA=%dMVA \n Fault current=%d/_%dAmp(lag)",MVA/1e6,Imod,Iangle);
```

Scilab code Exa 20.05.a Calculate the Fault MVA and current

```
Calculate the Fault MVA and current
```

```
clear;
clc;
R=3e6;
Rb=6e6;
vb2=11e3;
vb3=66e3;
x=.2;
Xg=x*Rb/R;
xt=.05;
xl=vb3^2/Rb;
xl1=20*.1/xl;
xl2=xl1*4;

X1=Xg+xt+xl2;
X2=Xg+xt+xl1;
X=inv(inv(X1)+inv(X2));
Ifaultpu=1/(X*%i);
Ifault=Ifaultpu*Rb/(sqrt(3)*vb3);
MVA=sqrt(3)*vb3*Ifault*%i;
Ir=real(Ifault);
Ii=imag(Ifault);
Imod=sqrt((Ir^2)+(Ii^2));
Iangle=atand(Ir/Ii)-90;
MVA=fix(MVA/1e5)*1e5;
Imod=fix(Imod);
```

```
mprintf("\n Fault MVA=%fMVA \n Fault current=%d/
   _%dAmp",MVA/1e6,Imod,Iangle);
//another method
MVA=Rb/X;
Ifault=MVA/(sqrt(3)*vb3*%i);
Ir=real(Ifault);
Ii=imag(Ifault);
Imod=sqrt((Ir^2)+(Ii^2));
Iangle=atand(Ir/Ii)-90;
MVA=fix(MVA/1e5)*1e5;
Imod=fix(Imod);
mprintf("\n \n from second method\nFault MVA=%fMVA \
   n Fault current=%d/_%dAmp",MVA/1e6,Imod,Iangle);
```

Scilab code Exa 20.05.b calculating the fault current

`calculating the fault current`

```
clear;
clc;
v1=66e3;
v2=11e3;
x2=.461;
x1=.4527;
If=229;
I1=If*x2/(x1+x2);
I2=If*x1/(x1+x2);
I=I1+I2;
Ig1=I1*v1/v2;
Ig1=fix(Ig1);
I1=round(I1*10)/10;
I2=round(I2*10)/10;
mprintf("the fault current supplied by each
   transformer is\n I1=%fA\nI2=%fA\nI3=I1+I2=%dA\n",
   I1,I2,I);
```

```
I2=fix(I2);
Ig2=I2*v1/v2;
mprintf("the fault current supplied by each
    generator \n Ig1=%dA\n Ig2=%dA\n",Ig1,Ig2);
```

Scilab code Exa 20.06 To calculate the current supplied by alternator

`To calculate the current supplied by alternator`

```
clear;
clc;
r=6e6;
v1=11e3;
v2=66e3;
xg=.1;
xt=.09;
z=4+(1*%i);
zb=v2^2/r;
zpu=z/zb;
E=1;
Ifault=E/(zpu+((xg+xt)*%i));
Ir=real(Ifault);
Ii=imag(Ifault);
Imod=sqrt((Ir^2)+(Ii^2));
Ib=r/(sqrt(3)*v2);
i=Imod*Ib;
igb=r/(sqrt(3)*v1);
ig=igb*Imod;
i=fix(i);
ig=fix(ig);
mprintf("the base current on HT side = %dA\n the
    current from generator = %dA",i,ig);
```

Scilab code Exa 20.07 finding the current supplied by generator

```
finding the current supplied by generator
```

```
clear;
clc;
r1=20e6;
rb=30e6;
v1=11e3;
v2=110e3;
x1g=.2*rb/r1;
x1t=.08*rb/r1;
x2g=.2;
x2t=.1;
xl=.516;
x0=xl/2;
x1=x1g+x1t;
x2=x2g+x2t;
x=inv(inv(x2)+inv(x1));
z=x+x0;
E=1;
isc=E/z;
ig1=isc*x2/(x1+x2);
ig2=isc*x1/(x1+x2);
i=ig1+ig2;
ib=rb/(1.7355*v1);
ig1=fix(ig1*1000)/1000;
Ig1=ig1*ib;
ib=fix(ib);
ig2=fix(ig2*100)/100;
Ig2=ig2*ib;
Ig2=fix(Ig2);
mprintf("the current taken from G1=%dA(lagging)\n
    the current taken from G2=%dA(lagging)",Ig1,Ig2);
```

Scilab code Exa 20.08 to calulate the subtransient fault current and breaker current rating

```
to calulate the subtransient fault current and breaker current rating
```

```
clear;
clc;
r=25e6;
rb=5e6;
v1=6.6e3;
v2=25e3;
xs=.2;
xt=.3;
Xs=xs*r/rb;
Xt=xt*r/rb;
Z=.125;
v=1;
I=v/(Z);
ib=r/(1.7355*v1);
ib=fix(ib);
i=ib*8;
ig=I*.25/.5;
im=I-ig;
it=3*1+im;
Ia=ib*it;
Imom=1.6*Ia;
xt=.15;
Zth=.375*.25/(.375+.25);
I=v/xt;
igen=I*.375/.625;
imot=.25*I*.25/.625;
itot=igen+(3*imot);//symm breaking current
ibr=itot*1.1;//asymm breaking current
is=itot*ib;
ia=ibr*ib*1.01;
ia=fix(ia/100)*100;
rbreaking=1.739*v1*ia;
rbreaking=fix(rbreaking/1e6)*1e6;
```

```
Imom=round(Imom/10)*10;
ia=round(ia);
is=fix(is/100)*100;
mprintf("the subtransient fault current If= %d/_-90A
    \nsubtansient current in breaker A=%dA\n the
    momentary current = %dA\n,the current to be
    interrupted asymmetric=%dA \n symmetric
    interrupting current=%dA\n the rating of the CB
    in kva=%dkVA",i,Ia,Imom,ia,is,rbreaking/1e3);
```

Scilab code Exa 20.09 to calculate the fault level

to calculate the fault level

```
clc;
clear;
rb=100e6;
rf=1e6;
v=3.3e3;
x=rf/rb;
xpu=.6;
xtot=x+xpu;
rf2=rf/xtot;
rf2=round(rf2/1e4)*1e4;
If=rf2/(1.72*v);
If=fix(If);
mprintf("the fault level is=%fMVA\n the fault
    current=%dA",rf2/1e6,If);;
```

Scilab code Exa 20.10 to calculate the max possible fault level

to calculate the max possible fault level

```
clear;
clc;
r=500e3;
x=4.75/100;
fault=r/x;
fault=fix(fault/1e5)*1e5;
mprintf("the fault level on LT side=%dkVA",fault/1e3
    );
```

Scilab code Exa 20.11 to calculate the fault level

to calculate the fault level

```
clc;
clear;
r1=75e6;
r2=150e6;
rb=r1+r2;
rf=rb;
x=.05;
xn=x*rb/1e6;
xeq=rb/rf;
X=xn+xeq;
fault=rb/X;
f=rb/xn;
fault=round(fault/1e4)*1e4
mprintf("fault level on LT sid eof transformer=%fMVA
    \n fault level when source of reactance is
    neglected=%fMVA",fault/1e6,f/1e6);
```

Scilab code Exa 20.12 To calculate the fault level at any point of line

To calculate the fault level at any point of line

```
clear;
clc;
rb=100e6;
r1=50e6;
r2=rb;
x1=rb/r1;
x2=rb/r2;
xeq=inv(inv(x1)+inv(x2));
f=rb/xeq;
mprintf("the fault level on the line =%dMVA",f/1e6);
```

Scilab code Exa 20.13 to find initial short circuit current and peak SC current

to find initial short circuit current and peak SC current

```
clear;
clc;
x=.23;
r=3750e3;
v=6600;
res=.866;
x1=x*(v^2)/r;
z=sqrt((res^2)+(x1^2));
i=1.1*v/(sqrt(3)*z);
f=res/x1;
x=1.38;
i=round(i/100)*100
is=sqrt(2)*x*i;
is=round(is/10)*10;
mprintf("initial short circuit current=%dA \n peak
    short circuit current=%dA",i,is);
```

Scilab code Exa 20.14 to find the subtransient currents

`to find the subtransient currents`

```
clear;
clc;
rb=75000e3;
ro=50e6;
v1=11e3;
v2=66e3;
xa=.25*rb/ro;
xb=.75;
xt=.1;
v=1;
xeq=inv(inv(xa)+inv(xb))+xt;
i=v/xeq;
i=round(i*100)/100;
ia=i*xb/(xa+xb);
ib=i*xa/(xa+xb);
ia=round(ia*100)/100;
ilt=rb/(sqrt(3)*v1);
iht=rb/(sqrt(3)*v2);
i=i*iht;
i=fix(i)
ia=ia*ilt;
ilt=rb/(1.73*v1);
ib=ib*ilt;
ia=round(ia);
ib=round(ib/10)*10;
mprintf("sub transient current generator A=%dA \n
   generator B=%dA \n HT side=%dA",ia,ib,i);
```

Scilab code Exa 20.15 to find SC current and rms current and making and breaking capacity required

`to find SC current and rms current and making and breaking capacity required`

```
clear;
clc;
x=1;
e=1;
i=e/x;
r=7.5e6;
v=6.6e3;
i=r/(sqrt(3)*v);
i=fix(i);
x2=.09;
i2=e/x2;
I2=i2*i;
I2=fix(I2/10)*10
idc=sqrt(2)*I2;
mc=idc*2;
x3=.15;
i3=e/x3;
I3=i3*i;
ib=I3*1.4;
Mva=sqrt(3)*v*ib;
idc=round(idc/1e2)*1e2;
mc=round(mc/1e2)*1e2;
I3=round(I3/10)*10;
Mva=fix(Mva/1e4)*1e4
mprintf("sustained short circuit current=%dA\ninitial symmetric SC current=%fkA\nmaximum dc component=%fkA\nmaking capacity required=%fkA\ntransient short circuit current=%fkA\ninterrupting capacity required=%fMVA, Asymmetric",i,I2/1e3,idc/1e3,mc/1e3,I3/1e3,Mva/1e6);
```

Scilab code Exa 20.16.a to find the short circuit current

```
to find the short circuit current
```

```
clear;
clc;
rb=2e6;
r=1.2e6;
x=7*rb/r;
v=6.6e3;
i=rb/v;
zb=v/i;
r=1200e3;
rb=2000e3;
v=6.6e3;
i=rb/v;
x=.1;
z0=v*x/i;
x1=7*rb/r;
z1=v*x1/(100*i);
z2=2;
z=z0+z1+z2;
ish=v/z;
zb=round(zb*10)/10;
ish=round(ish/10)*10;
mprintf("the shortcircuit current by direct ohmic
    method=%fA\n",ish);
mprintf("the base impedence=%fohm",zb);
```

Scilab code Exa 20.16.b to find SC current by ohmic method

`to find SC current by ohmic method`

```
clear;
clc;
rb=2e6;
r=1.2e6;
x=7*rb/r;
x1=10;
```

```
x2=11.7;
v=6.6e3;
i=rb/v;
zb=v/i;
r=1200e3;
rb=2000e3;
v=6.6e3;
xt=.117;
xf=2/zb*100;
xtot=xf+x1+x2;
ish=i*100/xtot;
ish=round(ish/10)*10;
mprintf("the short circuit current by percentage
   reactance method=%fA",ish);
```

Scilab code Exa 20.16.c To find the new SC current

`To find the new SC current`

```
clear;
clc;
x1=5;
x2=10;
x3=11.7;
x4=9.1;
i=303;
xt=x1+x2+x3+x4;
ish=303*100/xt;
mprintf("the SHORT CIRCUIT CURRENT=%dA",ish)
```

Scilab code Exa 20.17.a To find the SC current of the circuit

`To find the SC current of the circuit`

```
clear;
clc;
v=3.3e3;
rb=3e6;
r1=1e6;
r2=1.5e6;
x1=10;
x2=20;
X1=x1*rb/r1;
X2=x2*rb/r2;
x=inv(inv(X1)+inv(X2));
kva=rb*100/x;
ish=kva/(1.7388*v);
ish=round(ish);
printf("the value of short circuit current=%dA",ish)
    ;
```

Scilab code Exa 20.17.b to find the reactance of the reactor

```
to find the reactance of the reactor
```

```
clear;
clc;
v=3.3e3;
rb=3e6;
r1=1e6;
r2=1.5e6;
x1=10;
x2=20;
X1=x1*rb/r1;
X2=x2*rb/r2;
x=inv(inv(X1)+inv(X2));
kva=rb*100/x;
ish=kva/(sqrt(3)*v);
rx=10e6;
```

```
x2=rb*100/rx;
r=inv(inv(X1)-inv(X2))-30;
printf("the reactance of generator to be converted=
    %dpercent",r);
```

Scilab code Exa 20.18.a To calculate the reactance of the reactor to limit SC MVA

To calculate the reactance of the reactor to limit SC MVA

```
clear;
clc;
r1=3e6;
x=10;
r=150e6;
rb=9e6;
x1=x*rb/r1;
xc=inv(2*inv(x1));
xt=rb*100/r;
x=(inv(inv(xt)-inv(xc)))-5;
printf("the reactance that should be added= %d
    percent",x);
```

Scilab code Exa 20.18.b fault level at generator bus

fault level at generator bus

```
clear;
clc;
z=4000;
zb=9;
x1=zb/z*100;
```

```
x2=5;
x3=30;
x4=30;
x=inv(inv(x1+x2)+inv(x3)+inv(x4));
x=round(x*100)/100;
fault=zb*1e3/x*100;
fault=fix(fault/1e3)*1e3;
mprintf("the new fault level of generator bus=%dMVA"
    ,fault/1e3);
```

Scilab code Exa 20.19 to calculate the current fed to the faults

to calculate the current fed to the faults

```
clear;
clc;
rb=20e6;
r=10e6;
v1=11e3;
v2=66e3;
x1=5;
X1=x1*rb/r;
xa=20;
xb=20;
xc=20;
xd=20;
xbus=25;
xtr=X1;
xcd=inv(inv(xc)+inv(xd));
xab=inv(inv(xa)+inv(xb));
xcdbus=xcd+xbus;
xn=inv(inv(xab)+inv(xcdbus));
xth=xtr+xn;
mva=rb/xth*100;
i=mva/(1.745*v2);
```

```
i=round(i);
printf("the SC MVA=%fMVA \n the SC current=%dA",mva
    /1e6,i);
```

Scilab code Exa 20.20.b to calculate the percentage change of reactors R

to calculate the percentage change of reactors R

```
clear;
clc;
g=20;
v=11e3;
r=20e6;
n=4;
x=.4;
x1=g/(n-1);
z=((x1/x)-(x1))/1.33;
R=(z/100)*(v^2)/r;
R=round(R*1000)/1000;
printf("the value of reactance=%fohms",R);
```

Scilab code Exa 20.21 calculate the MVA and current by both generator and transformer side

calculate the MVA and current by both generator and transformer side

```
clear;
clc;
xst=20;
xtr=28;
xs=250;
xt=15;
```

```
v1=25e3;
r1=500e6/.8;
v2=220e3;
rb=600e6;
vb=25e3;
xf=rb/r1;
xst=xst*xf/100;
xtr=xtr*xf/100;
xs=xs*xf/100;
xt=xt/100;
xeqs=inv(inv(xst)+inv(xt));
xeqt=inv(inv(xtr)+inv(xt));
xeg=inv(inv(xs)+inv(xt));
e=1;
xeqs=round(xeqs*1000)/1e3;
is=e/xeqs;
is=round(is);
it=e/xeqt;
ig=e/xeg;
i1=is*xt/(xt+xst);
i2=is*xst/(xst+xt);
ib=rb/(1.726*22.2*1e3);
Is=is*ib;
i1=round(i1*10)/10;
Is=round(Is/1e3)*1e3;
i2=fix(i2*100)/0100;
I1=i1*ib;
I2=i2*ib;
I1=fix(I1/1e2)*1e2;
I2=fix(I2/1e2)*1e2;
mprintf("total subtransient current T-off=%fkA\nsubtransient current on generator side=%fkA\nsubtransient current on transformer side=%fkA",Is/1e3,I1/1e3,I2/1e3);
```

Scilab code Exa 20.22 calculate the short circuit level and normal and effective fault current

```
calculate the short circuit level and normal and effective fault current
```

```
clc;
clear;
mvan=6800e6;
v=132e3;
mvac=200e6;
mvae=mvan-mvac;
n=mvan/(sqrt(3)*v);
e=mvae/(1.681*v);
e=fix(e/10)*10;
n=fix(n/10)*10;
printf("normal fault current=%f/_-90 kA\nEffective fault current=%f/_-90 kA",n/1e3,e/1e3);
```

Scilab code Exa 20.23 calculate the SC ratio and effective SC ratio of HVDC current

```
calculate the SC ratio and effective SC ratio of HVDC current
```

```
clear;
clc;
v=400e3;
mvan=30000e6;
mw=1500e6;
mvac=600e6;
n=mvan/mw;
mvae=mvan-mvac;////the difference in result is due to erroneous calculation in textbook.
e=mvae/mw;
mprintf("the SC raio=%d\neffective fault level=%fMVA\neffective circuit level of HVDC system(ESCR)=%f",n,mvae/1e6,e);
```

```
disp('the difference in result is due to erroneous
    calculation in textbook.');
```

Scilab code Exa 20.24 to calculate the fault levels on secondary sides of transformer

```
to calculate the fault levels on secondary sides of transformer
```

```
clear;
clc;
s=1;
xt=5;
m=s/xt*100;
n=2*s/xt*100;
mprintf("fault level on lt side=%dMVA\n fault level
    on HT side=%dMVA",m,n);
```

Chapter 21

Symmetric Components

Scilab code Exa 21.01 Calculate the symmetric components of unbalanced lines

```
Calculate the symmetric components of unbalanced lines
```

```
clear;
clc;
va=100*(%e^(%pi*%i/2));
vb=116*(%e^(%i*0));
vc=71*(%e^(%i*(224.8*%pi/180)));
a=1*%e^(%i*(120*%pi/180));
b=a^2;
va0=1/3*(va+vb+vc);
va1=1/3*(va+(a*vb)+(b*vc));
va2=1/3*(va+(b*vb)+(a*vc));
va0r=real(va0);
va0i=imag(va0);
va0m=sqrt((va0r^2)+(va0i^2));
va0a=atand(va0i/va0r);
va1r=real(va1);
va1i=imag(va1);
va1m=sqrt((va1r^2)+(va1i^2));//the difference in
   result is due to erroneous calculation in
```

```
    textbook.
va1a=atand(va1i/va1r);
va2r=real(va2);
va2i=imag(va2);
va2m=sqrt((va2r^2)+(va2i^2));
va2a=atand(va2i/va2r);
mprintf("the symmetric components are \n va0=%f+j%f V \tor\t %f/_%d V",va0r,va0i,va0m,va0a);
mprintf("\n va1=%f+j%f V \tor\t %f/_%d V",va1r,va1i,va1m,va1a);
mprintf("\n va2=%f+j(%f) V \tor\t %f/_%d V",va2r,va2i,va2m,va2a);
disp('the difference in result is due to erroneous calculation in textbook.')
```

Scilab code Exa 21.02 to calculate the line voltages

```
to calculate the line voltages
```

```
clear;
clc;
va=22+(16.66*%i);
vb=-25.33+(%i*89.34);
vc=3.33-(%i*6);
a=1*%e^(%i*(120*%pi/180));
b=a^2;
va0=(va+vb+vc);
va1=(va+(b*vb)+(a*vc));
va2=(va+(a*vb)+(b*vc));
va0r=real(va0);
va0i=imag(va0);
va0m=sqrt((va0r^2)+(va0i^2));
va0a=atand(va0i/va0r);
va1r=real(va1);
va1i=imag(va1);
```

```
va1m=round(sqrt((va1r^2)+(va1i^2))*10)/10;
va1a=atand(va1i/va1r);
va2r=round(real(va2));
va2i=round(imag(va2));
va2m=round(sqrt((va2r^2)+(va2i^2)));
va2a=atand(va2i/va2r);
mprintf("the voltage levels are \n va=%f+j%f V \tor\t %f/_%d V",va0r,va0i,va0m,va0a);
mprintf("\n vb=%f+j(%f) V \tor\t %f/_%d V",va1r,va1i,va1m,va1a);
mprintf("\n vc=%f+j(%f) V \tor\t %f/_%d V",va2r,va2i,va2m,va2a);
```

Scilab code Exa 21.03 To determine the line currents

```
To determine the line currents
```

```
clear;
clc;
ib=50;
ic=10*%e^(%i*%pi/2);
ia=10*%e^(%i*%pi);
a=1*%e^(%i*(120*%pi/180));
b=a^2;
ia0=(ia+ib+ic);
ia1=(ia+(b*ib)+(a*ic));
ia2=(ia+(a*ib)+(b*ic));
ia0r=real(ia0);
ia0i=imag(ia0);
ia0m=sqrt((ia0r^2)+(ia0i^2));
ia0a=atand(ia0i/ia0r);
ia1r=real(ia1);
ia1i=imag(ia1);
ia1m=sqrt((ia1r^2)+(ia1i^2));
ia1a=atand(ia1i/ia1r);
```

```
ia2r=real(ia2);
ia2i=imag(ia2);
ia2m=sqrt((ia2r^2)+(ia2i^2));
ia2a=atand(ia2i/ia2r);
mprintf("the current levels are \n ia=%f+j%f A \tor\t %f/_%d A",ia0r,ia0i,ia0m,ia0a);
mprintf("\n ib=%f+j(%f) A \tor\t %f/_%d A",ia1r,ia1i,ia1m,ia1a);
mprintf("\n ic=%f+j(%f) A \tor\t %f/_%d A",ia2r,ia2i,ia2m,ia2a);
```

Scilab code Exa 21.04 to find the symmetric components of line currents

to find the symmetric components of line currents

```
clear;
clc;
ia=20;
ib=20*(%e^(%i*%pi));
ic=0;
a=1*%e^(%i*(120*%pi/180));
b=a^2;
ia0=1/3*(ia+ib+ic);
ia1=1/3*(ia+(a*ib)+(b*ic));
ia2=1/3*(ia+(b*ib)+(a*ic));
ia0r=real(ia0);
ia0i=imag(ia0);
ia0m=sqrt((ia0r^2)+(ia0i^2));
ia0a=0-atand(ia0r/ia0i);
ia1r=real(ia1);
ia1i=imag(ia1);
ia1m=sqrt((ia1r^2)+(ia1i^2));
ia1a=atand(ia1i/ia1r);
ia2r=real(ia2);
ia2i=imag(ia2);
```

```
ia2m=sqrt((ia2r^2)+(ia2i^2));
ia2a=atand(ia2i/ia2r);
mprintf("the symmetric components  are \n ia0=%f+j%f
    A \tor\t %f/_%d A",ia0r,ia0i,ia0m,ia0a);
mprintf("\n ia1=%f+j%f A \tor\t %f/_%d A",ia1r,ia1i,
   ia1m,ia1a);
mprintf("\n ia2=%f+j(%f) A \tor\t %f/_%d A",ia2r,
   ia2i,ia2m,ia2a);
ib1=b*ia1;
ib2=a*ia2;
ic1=a*ia1;
ic2=b*ia2;
ib0=ia0;
ic0=ia0;
ib1r=real(ib1);
ib1i=imag(ib1);
ib1m=sqrt((ib1r^2)+(ib1i^2));
ib1a=atand(ib1i/ib1r);
ib2r=real(ib2);
ib2i=imag(ib2);
ib2m=sqrt((ib2r^2)+(ib2i^2));
ib2a=atand(ib2i/ib2r);
ic1r=real(ic1);
ic1i=imag(ic1);
ic1m=sqrt((ic1r^2)+(ic1i^2));
ic1a=atand(ic1i/ic1r);
ic2r=real(ic2);
ic2i=imag(ic2);
ic2m=sqrt((ic2r^2)+(ic2i^2));
ic2a=atand(ic2i/ic2r);
mprintf("\n \n ib0=%fA ",ib0);
mprintf("\n ib1=%f+j%f A \tor\t %f/_%d A",ib1r,ib1i,
   ib1m,ib1a);
mprintf("\n ib2=%f+j(%f) A \tor\t %f/_%d A",ib2r,
   ib2i,ib2m,ib2a);
mprintf("\n \n ic0=%f A",ic0);
mprintf("\n ic1=%f+j%f A \tor\t %f/_%d A",ic1r,ic1i,
   ic1m,ic1a);
```

```
mprintf("\n ic2=%f+j(%f) A \tor\t %f/_%d A",ic2r,
    ic2i,ic2m,ic2a);
```

Scilab code Exa 21.05 to calculate the voltages of phase and line voltages

to calculate the voltages of phase and line voltages

```
clear;
clc;
vb=.584+(0*%i);
vc=.584+(0*%i);
va=0;
a=1*%e^(%i*(120*%pi/180));
b=a^2;
vae=(va+vb+vc);
vbe=(va+(b*vb)+(a*vc));
vce=(va+(a*vb)+(b*vc));
va0=vae-vbe;
va1=vbe-vce;
va2=vce-vae;
va0r=real(va0);
va0i=imag(va0);
va0m=sqrt((va0r^2)+(va0i^2));
va0a=atand(va0i/va0r);
va1r=real(va1);
va1i=imag(va1);
va1m=sqrt((va1r^2)+(va1i^2));
va1a=0;
va2r=real(va2);
va2i=imag(va2);
va2m=sqrt((va2r^2)+(va2i^2));
va2a=atand(va2i/va2r)+180;
mprintf("the voltage levels are \n vab=%f+j%f V \tor
    \t %f/_%d V",va0r,va0i,va0m,va0a);
```

```
mprintf("\n vbc=%f+j(%f) V \tor\t %f/_%d V",va1r,va1i,va1m,va1a);
mprintf("\n vca=%f+j(%f) V \tor\t %f/_%d V",va2r,va2i,va2m,va2a);
```

Scilab code Exa 21.06 to calculate the value of Ia

```
to calculate the value of Ia
```

```
clear;
clc;
e=1;
x1=.25*%i;
x2=.35*%i;
x0=.1*%i;
ia0=e/(x1+x2+x0);
ia1=ia0;
ia2=ia0;
ia=ia0+ia1+ia2;
iar=real(ia);
iai=imag(ia);
iam=round(sqrt((iar^2)+(iai^2))*100)/100;
iaa=0;
mprintf("the current levels are \n ia=%f+j(%f) A \tor\t %f/_%d A",iar,iai,iam,iaa);
```

Scilab code Exa 21.07 to find the line and phase voltage of phase a

```
to find the line and phase voltage of phase a
```

```
clear;
clc;
```

```
z1=.25*%i;
z2=.35*%i;
z0=.1*%i;
ea=1;
ia1=inv(z1+inv(inv(z2)+inv(z0)))*ea;
va1=ea-(ia1*z1);
va0=va1;
va2=va0;
ia0=-va0/z0;
ia2=-va2/z2;
ia=ia1+ia2+ia0;
va=va1+va2+va0;
va=fix(va*1000)/1e3;
mprintf("the current ia=%dA\tVa=%fV",ia,va);
```

Scilab code Exa 21.08 to find positive sequence component of fault current

to find positive sequence component of fault current

```
clear;
clc;
r0=.1;
v=1;
r1=.05;
r2=.05;
r3=.2;
r4=.2;
r34=inv(inv(r3)+inv(r4));
r234=r2+r34;
r10=r1+r0;
r=inv(inv(r234)+inv(r10));
ip=v/r;
mprintf("the positive sequence current=%fpu",ip);
```

Scilab code Exa 21.09 calculate the symmetric components of the fault

`calculate the symmetric components of the fault`

```
clear;
clc;
ia=86.6+(%i*50);
ib=25-(43.3*%i);
ic=-30;
a=1*%e^(%i*(120*%pi/180));
b=a^2;
ia0=1/3*(ia+ib+ic);
ia1=1/3*(ia+(a*ib)+(b*ic));
ia2=1/3*(ia+(b*ib)+(a*ic));
ia0r=real(ia0);
ia0i=imag(ia0);
ia0m=sqrt((ia0r^2)+(ia0i^2));
ia0a=atand(ia0r/ia0i);
ia1r=real(ia1);
ia1i=imag(ia1);
ia1m=sqrt((ia1r^2)+(ia1i^2));
ia1a=atand(ia1i/ia1r);
ia2r=real(ia2);
ia2i=imag(ia2);
ia2m=sqrt((ia2r^2)+(ia2i^2));
ia2a=atand(ia2i/ia2r);
in=ia+ib+ic;
mprintf("the symmetric components  are \n ir0=%f+j%f
    A \tor\t %f/_%d A",ia0r,ia0i,ia0m,ia0a);
mprintf("\n ir1=%f+j%f A \tor\t %f/_%d A",ia1r,ia1i,
    ia1m,ia1a);
mprintf("\n ir2=%f+j(%f) A \tor\t %f/_%d A\n neutral
    current in = %fA",ia2r,ia2i,ia2m,ia2a,in);
```

Scilab code Exa 21.10 to calculate the zero components of currents

```
to calculate the zero components of currents
```

```
clear;
clc;
in=9;
ia=in/3;
ib=ia;
ic=ib;
mprintf("the zero sequence components are ia0=%dA \t
    ib0=%dA \t ic0=%d",ia,ib,ic);
```

Chapter 22

Unsymmetrical Faults on Unloaded Generator

Scilab code Exa 22.01 to calculate the sub transient currents for different types of fault

```
to calculate the sub transient currents for different types of fault
```

```
clear;
clc;
v=11e3/sqrt(3);
r=25e6;
x2=.35*%i;
x0=.1*%i;
x1=.25*%i;
e=1;
ia0=e/(x0+x1+x2);
ia0=round(ia0*100)/100;
ia1=ia0;
ia2=ia0;
ia=3*ia0;
ibase=r/((3)*v);
Ifault=3*ia0*ibase;
Ifault=round(Ifault/10)*10;
```

```
va1=e-(ia1*x1);
va2=-ia2*x2;
va0=-ia0*x0;
a=1*%e^(%i*(120*%pi/180));
b=a^2;
va=(va1+va2+va0);
vb=(va0+(b*va1)+(a*va2));
vc=(va0+(a*va1)+(b*va2));
vab=va-vb;
vbc=vb-vc;
vca=vc-va;
vab=vab*v;
vbc=vbc*v;
vca=vca*v;
va0r=real(vab);
va0i=imag(vab);
va0m=sqrt((va0r^2)+(va0i^2));
va0a=atand(va0i/va0r);
va1r=real(vbc);
va1i=imag(vbc);
va1m=sqrt((va1r^2)+(va1i^2));
va1a=atand(va1i/va1r);
va2r=real(vca);
va2i=imag(vca);
va2m=sqrt((va2r^2)+(va2i^2));
va2a=atand(va2i/va2r);
mprintf("the subtransient voltage levels are \n vab=
   %f+j%f V \tor\t %f/_%d kV",round(va0r*100/1e3)
   /100,round(va0i*100/1e3)/100,round(va0m*100/1e3)
   /100,va0a);
mprintf("\n vbc=%f+j(%f) kV \tor\t %f/_%d V",round(
   va1r*100/1e3)/100,round(va1i*100/1e3)/100,round(
   va1m*100/1e3)/100,round(va1a)+180);
mprintf("\n vca=%f+j(%f) kV \tor\t %f/_%d V",round(
   va2r*100/1e3)/100,round(va2i*100/1e3)/100,round(
   va2m*100/1e3)/100,180+va2a);

Iar=real(Ifault);
```

```
Iai=imag(Ifault);
Iamod=sqrt((Iar^2)+(Iai^2));
iaa=atand(Iar/Iai)-90;
mprintf("\n the subtransient line current \n Ia=%f+j
    (%f) A \tor\t %f/_%d A",Iar,Iai,Iamod,iaa);
```

Scilab code Exa 22.02 To find ratio of line currents to single line to ground faults

To find ratio of line currents to single line to ground faults

```
clear;
clc;
v=11e3;
r=10e6;
x1=.05*%i;
x2=.15*%i;
x0=.15*%i;
e=1;
ia1=e/(x0+x1+x2);
ia=3*ia1;
ic=e/x0;
c=ia/ic;
mprintf("the ratio of line to ground fault to 3phase
    fault=%f",c);
```

Scilab code Exa 22.03 to calculate line current for single line to ground fault

to calculate line current for single line to ground fault

```
clear;
clc;
v=11e3;
r=25e6;
e=1;
xg0=.05*%i;
x1=.15*%i;
x2=.15*%i;
zbase=v^2/r;
res=.3;
xd=res/zbase;
x0=xg0+(3*xd*%i);
x=x1+x2+x0;
ia0=e/x;
ia=3*ia0;
iabase=r/(1.7398*v);
ia=ia*iabase;
ia=fix(ia);
printf("the line current for a line to ground fault=
    %dA",-imag(ia));
```

Scilab code Exa 22.04.a To calculate subtransient voltage between double line to ground fault

`To calculate subtransient voltage between double line to ground fault`

```
clear;
clc;
v=11e3/sqrt(3);
r=25e6;
x1=.25*%i;
x2=.35*%i;
x0=.1*%i;
xn=0;
e=1;
```

```
ia1=e/(x1+(x0*x2/(x0+x2)));
va1=e-(ia1*x1);
va2=va1;
va0=va2;
ia2=-va2/x2;
ia0=-va0/x0;
a=1*%e^(%i*(120*%pi/180));
b=a^2;
ia=(ia0+ia1+ia2);
ib=(ia0+(b*ia1)+(a*ia2));
ic=(ia0+(a*ia1)+(b*ia2));
in=3*ia0;
va=3*va1;
vb=0;
vc=vb;
vab=va;
vbc=vb-vc;
vca=-va;
vab=v*vab;
vca=v*vca;
i=r/(3*v);
ia0r=real(ia);
ia0i=imag(ia);
iam=sqrt((ia0r^2)+(ia0i^2));
ia1r=real(ib);
ia1i=imag(ib);
ibm=sqrt((ia1r^2)+(ia1i^2));
ia2r=real(ic);
ia2i=imag(ic);
icm=sqrt((ia2r^2)+(ia2i^2));
ic=icm*i;
ib=ibm*i;
ia=iam*i;
ib=round(ib/01e2)*1e2;
ic=round(ic/01e2)*1e2;
in=in*i*%i;
mprintf("the line voltages are\nvab=%fV \t vbc=%fkV
   \t vca=%f/_180kV\nthe line currents are\nia=%fA \
```

```
t ib=%dA \t ic=%dA \t in=%dA",vab/1e3,vbc/1e3,-
vca/1e3,ia,-ib,ic,-real(in));
```

Scilab code Exa 22.04.b To calculate fault current following through the neutral reactor

```
To calculate fault current following through the neutral reactor
```

```
clear;
clc;
v=11e3/sqrt(3);
r=25e6;
x1=.25*%i;
x2=.35*%i;
xg0=.1*%i;
xn=0.1*%i;
e=1;
x0=xg0+(3*xn);
ia1=e/(x1+(x0*x2/(x0+x2)));
va1=e-(ia1*x1);
va2=va1;
va0=va2;
ia2=-va2/x2;
ia0=-va0/x0;
a=1*%e^(%i*(120*%pi/180));
b=a^2;
ia=(ia0+ia1+ia2);
ib=(ia0+(b*ia1)+(a*ia2));
ic=(ia0+(a*ia1)+(b*ia2));
ia0r=real(ia);
ia0i=imag(ia);
iam=sqrt((ia0r^2)+(ia0i^2));
ia1r=real(ib);
ia1i=imag(ib);
ibm=sqrt((ia1r^2)+(ia1i^2));
```

```
ia2r=real(ic);
ia2i=imag(ic);
icm=sqrt((ia2r^2)+(ia2i^2));//the difference in
    result is due to erroneous calculation in
    textbook.
iaa=0;
iba=atand(ia1i/ia1r);
ica=atand(ia2i/ia2r);
mprintf("the symmetric components  are \n ia0=%f+j%f
     A \tor\t %f/_%d A",ia0r,ia0i,iam,iaa);
mprintf("\n ib=%f+j%f A \tor\t %f/_%d A",ia1r,ia1i,
    ibm,iba);
mprintf("\n ic=%f+j(%f) A \tor\t %f/_%d A",ia2r,ia2i
    ,icm,ica);
in=ib+ic;
mprintf("\nneutal current In=%fA",(imag(in)*1310));
disp("//the difference in result is due to erroneous
     calculation in textbook.")
```

Scilab code Exa 22.05 TO find fault current and line to neutral voltages at generator terminals

TO find fault current and line to neutral voltages at generator terminals

```
clear;
clc;
r=10e6;
v=11e3;
e=1;
x1=.26*%i;
x2=.18*%i;
x0=.36*%i;
ia1=e/(x1+(x0*x2/(x0+x2)));
va1=e-(ia1*x1);
va2=va1;
```

```
va0=va2;
ia2=-va2/x2;
ia0=-va0/x0;
a=1*%e^(%i*(120*%pi/180));
b=a^2;
ia=(ia0+ia1+ia2);
ib=(ia0+(b*ia1)+(a*ia2));
ic=(ia0+(a*ia1)+(b*ia2));
i=r/(sqrt(3)*v);
ia=ia*i;
ib=ib*i;
ic=ic*i;
ia0r=real(ia);
ia0i=imag(ia);
iam=sqrt((ia0r^2)+(ia0i^2));
ia1r=real(ib);
ia1i=imag(ib);
ibm=sqrt((ia1r^2)+(ia1i^2));
ia2r=real(ic);
ia2i=imag(ic);
icm=sqrt((ia2r^2)+(ia2i^2));
icm=round(icm);
ibm=round(ibm);
iaa=0;
iba=180+atand(ia1i/ia1r);
ica=atand(ia2i/ia2r);
mprintf("the symmetric components  are \n ia0=%f+j%f
    A \tor\t %f/_%d A",ia0r,ia0i,iam,iaa);
mprintf("\n ib=%f+j%f A \tor\t %f/_%d A",ia1r,ia1i,
   ibm,iba);
mprintf("\n ic=%f+j(%f) A \tor\t %f/_%d A",ia2r,ia2i
   ,icm,ica);
in=ib+ic;
mprintf("\nneutal current In=%fA",(imag(in)*1310));
//at generator
x1=.16*%i;
x2=.08*%i;
x0=.06*%i;
```

```
va1=1-(ia1*x1);
va2=-ia2*x2;
va0=ia0*x0;
va=(va0+va1+va2);
vb=(va0+(b*va1)+(a*va2));//the difference in result is due to erroneous calculation in textbook.

vc=(va0+(a*va1)+(b*va2));
v=v/sqrt(3);
va=v*va/1e3;
vb=v*vb/1e3;
vc=v*vc/1e3;
va0r=real(va);
va0i=imag(va);
va0m=sqrt((va0r^2)+(va0i^2));
va0a=atand(va0i/va0r);
va1r=real(vb);
va1i=imag(vb);
va1m=sqrt((va1r^2)+(va1i^2));
va1a=atand(va1i/va1r);
va2r=real(vc);
va2i=imag(vc);
va2m=sqrt((va2r^2)+(va2i^2));
va2a=atand(va2i/va2r);
mprintf("\nthe voltage levels are \n va=%f+j%f kV \tor\t %f/_%d kV",va0r,va0i,va0m,va0a);
mprintf("\n vb=%f+j(%f) kV \tor\t %f/_%d kV",va1r,va1i,va1m,va1a);//the difference in result is due to erroneous calculation in textbook.
mprintf("\n vc=%f+j(%f) kV \tor\t %f/_%d kV",va2r,va2i,va2m,va2a);
disp("the difference in result is due to erroneous calculation in textbook.");
```

Scilab code Exa 22.06 To calculate subtransient voltage between line to line fault

`To calculate subtransient voltage between line to line fault`

```
clear;
clc;
r=1250e3;
v=600;
z1=.15*%i;
z2=.3*%i;
z3=.05*%i;
z4=.55*%i;
x1=inv(inv(z2)+inv(z1));
x2=x1;
x0=inv(inv(z3)+inv(z4));
e=1;
ia1=e/(x1+x2+x0);
ia2=ia1;
ia0=ia2;
ia=3*ia1;//the difference in result is due to
    erroneous calculation in textbook.
base=r/(sqrt(3)*v);
ita=ia*base;
mprintf("the fault current=%fA",-imag(ita));
disp("the difference in result is due to erroneous
    calculation in textbook.");
```

Scilab code Exa 22.07 ratio of line currents for line to line to three phase faults

`ratio of line currents for line to line to three phase faults`

```
clc;
clear;
```

```
e=1;
x1=.15*%i;
x2=.15*%i;
ia1=e/(x1+x2);
a=1*%e^(%i*(120*%pi/180));
b=a^2;
ia2=-ia1;
ia=(b-a)*ia1;
iap=e/x1;
c=real(ia)/imag(iap);
mprintf("the ratio to line to line fault to three
    phase fault=%f",c);
```

Scilab code Exa 22.08 To calculate the percentage reactance and resistance

To calculate the percentage reactance and resistance

```
clear;
clc;
e=1;
x1=.6;
x2=.25;
x0=.15;
ia=1;
xn=(3*e/3*ia)-((x1+x2+x0)/3);
ifault=1;
r=sqrt(8/9);
mprintf("the percentage reactance that should be
    added in the generator neutral =%fpercent\n",xn
    *100);
mprintf("resistance to be added in neutral to ground
     circuit to achieve the same purpose is %f",r);
```

Scilab code Exa 22.09 To find the SC current and ratio of generator contribution

`To find the SC current and ratio of generator contribution`

```
clear;
clc;
x1=.07*%i;
x2=.04*%i;
x0=.1*%i;
e=1;
ia=3*e/(x1+x2+x0);
ia=-imag(ia);
ia0=ia/3;
ia1=ia/3;
ia2=ia1;
ia1=ia1/3;
ia2=ia1;
ig1=ia0+ia2+ia1;
ig2=ia1+ia2;
ig3=ig2;
c=ig1/ig2;
ia=round(ia*10)/10;
c=4.05*c;
d=4.05;
mprintf("for single line to ground fault Ia=-j%fA",
    ia);
mprintf("\nthe ratio of contribution of generator I,
     II and III is %d:%d:%d",c,d,d);
i3=e/(x1);
il=3*e/(x1+x2+x0);
y=i3/il;
mprintf("\nthe ratio of 3-phase to line to ground
    fault=%f",y);
```

Chapter 23

Faults On Power Systems

Scilab code Exa 23.03 To calculate the fault current

To calculate the fault current

```
clear;
clc;
vf=1;
r=1250e3;
V=600;
x1=.5;
x2=.5;
x3=.02;
ia2=vf/(x1+x2+x3);
ia=3*ia2;
ia1=ia2;
ia0=ia1;
iab=r/(sqrt(3)*V);
iab=round(iab/10)*10;
ia=round(ia*100)/100;
If=ia*iab;//the difference in result is due to
    erroneous calculation in textbook.
printf("fault current If=%fA",If);
```

```
disp("the difference in result is due to erroneous
    calculation in textbook.")
```

Scilab code Exa 23.04 To calculate the fault current

```
To calculate the fault current
```

```
clear;
clc;
v=1;
r=1250e3;
V=600;
x1=.05*%i;
x2=.05*%i;
x0=.02*%i;
a=1*%e^(%i*(120*%pi/180));
b=a^2;
ia1=v/(x1+inv(inv(x2)+inv(x0)));
ibase=1200;
va1=v-(ia1*x1);
ia2=-va1/x2;
ia0=-va1/x0;
ia=(ia0+ia1+ia2);
ib=(ia0+(b*ia1)+(a*ia2));
ic=(ia0+(a*ia1)+(b*ia2));
ia0r=real(ia);
ia0i=imag(ia);
iam=sqrt((ia0r^2)+(ia0i^2));
ia1r=real(ib);
ia1i=imag(ib);
ibm=sqrt((ia1r^2)+(ia1i^2));//the difference in
    result is due to erroneous calculation in
    textbook.
ia2r=real(ic);
ia2i=imag(ic);
```

```
icm=sqrt((ia2r^2)+(ia2i^2));
iaa=0;
iba=atand(ia1i/ia1r);
ica=atand(ia2i/ia2r);
im=ibm*ibase;
mprintf("fault current for double line to ground
    fault=%fA",im)
disp("the difference in result is due to erroneous
    calculation in textbook.")
```

Scilab code Exa 23.05 To calculate the fault current

To calculate the fault current

```
clear;
clc;
v=1;
r=1250e3;
V=600;
x1=.05*%i;
x2=.05*%i;
x0=.02*%i;
ia1=v/(x1+x2);
ia2=-ia1;
ia=ia1+ia2;
ia0=0;
a=1*%e^(%i*(120*%pi/180));
b=a^2;
ia=(ia0+ia1+ia2);
ib=(ia0+(b*ia1)+(a*ia2));
ic=(ia0+(a*ia1)+(b*ia2));
ia0r=real(ia);
ia0i=imag(ia);
iam=sqrt((ia0r^2)+(ia0i^2));
ia1r=real(ib);
```

```
ia1i=imag(ib);
ibm=sqrt((ia1r^2)+(ia1i^2));
ia2r=real(ic);
ia2i=imag(ic);
icm=sqrt((ia2r^2)+(ia2i^2));
iaa=0;
iba=atand(ia1i/ia1r);
ica=atand(ia2i/ia2r);
ibase=r/(sqrt(3)*V);
ibm=ibm*ibase;
ibm=round(ibm/100)*100;
mprintf("fault current for double line to ground
    fault=%dA",ibm);
```

Scilab code Exa 23.06 to find the subtransient fault currents

to find the subtransient fault currents

```
clear;
clc;
r=1250e3;
v=600;
z1=.15*%i;
z2=.3*%i;
z3=.05*%i;
z4=.55*%i;
x1=inv(inv(z2)+inv(z1));
x2=x1;
x0=inv(inv(z3)+inv(z4));
e=1;
ia1=e/(x1+x2+x0);
ia2=ia1;
ia0=ia2;
ia=3*ia1;//the difference in result is due to
    erroneous calculation in textbook.
```

```
base=r/(sqrt(3)*v);
ita=ia*base;
mprintf("the fault current=%fA",-imag(ita));
disp("the difference in result is due to erroneous
    calculation in textbook.");
```

Scilab code Exa 23.07 To calculate the fault current for different cases

To calculate the fault current for different cases

```
clear;
clc;
e=1;
r=1500e3;
v=11e3;
x1=.1;
ia=3*e/(x1*3);
ibase=r/(sqrt(3)*v);
i=ia*ibase;
mprintf("the single line to ground fault = %dA",i);
ia1=e/(2*x1);
ib=sqrt(3)*ia1;
ib=ibase*ib;
mprintf("\nline to line fault current=%dA",ib);
```

Scilab code Exa 23.08 To calculate fault current and phase voltages

To calculate fault current and phase voltages

```
clear;
clc;
X1=6.6*%i;
```

```
X2=6.3*%i;
X0=12.6*%i;
r=37.5e6;
v=33e3;
e=1;
zb=v^2/r;
x1=X1/zb;
x2=X2/zb;
x0=X0/zb;
x1g=.18*%i;
x2g=.12*%i;
x0g=.1*%i;
x1=x1+x1g;
x2=x2+x2g;
x0=x0+x0g;
ia=3*e/(x1+x2+x0);
ia1=ia/3;
a=1*%e^(%i*(120*%pi/180));
b=a^2;
ibase=r/(sqrt(3)*v);
ian=ia*ibase;
printf("fault  current=%djAmp",imag(ian));
va=e-(ia1*x1g);
vb=-ia1*x2g;
vc=-ia1*x0g;
va0=(va+vb+vc);
va1=(va+(b*vb)+(a*vc));
va2=(va+(a*vb)+(b*vc));
v=v/sqrt(3);
va0=va0*v;
va1=va1*v;
va2=va2*v;
va0r=real(va0);
va0i=imag(va0);
va0m=sqrt((va0r^2)+(va0i^2));
va0a=atand(va0i/va0r);
va1r=real(va1);
va1i=imag(va1);
```

```
va1m=sqrt((va1r^2)+(va1i^2));
va1a=atand(va1i/va1r)-120;
va2r=real(va2);
va2i=imag(va2);
va2m=sqrt((va2r^2)+(va2i^2));
va2a=atand(va2i/va2r)+120;
mprintf("\nthe voltage levels are \n va=%f+j%f V \tor\t %d/_%d kV",va0r/1e3,va0i/1e3,va0m/1e3,va0a);
mprintf("\n vb=%f+j(%f) kV \tor\t %d/_%d kV",va1r/1e3,va1i/1e3,va1m/1e3,va1a);
mprintf("\n vc=%f+j(%f) kV \tor\t %d/_%d kV",va2r/1e3,va2i/1e3,va2m/1e3,va2a);
```

Scilab code Exa 23.09 To calculate fault currents for different types of faults

```
To calculate fault currents for different types of faults
```

```
clear;
clc;
e=100/75;
r=100e6;
v=66e3;
xg1=.175*%i*e;
xg2=.135*%i*e;
X1=.1*%i*e;
zn=3*58;
ibase=r/(sqrt(3)*v);
vbase=v/sqrt(3);
zb=vbase/ibase;
zg0=zn/zb;
f=70e3;
e=f/v;
x1=.367*%i;
```

```
x2=.313*%i;
z0=zg0+(.133*%i);
a=1*%e^(%i*(120*%pi/180));
b=a^2;
ia1=e/x1;
mprintf("%f",real(vbase));
ia=ia1;
ib=b*ia;
ic=a*ia;
ia=ibase*ia;
ib=ibase*ib;
ic=ibase*ic;
ia0r=real(ia);
ia0i=imag(ia);
iam=sqrt((ia0r^2)+(ia0i^2));
ia1r=real(ib);
ia1i=imag(ib);
ibm=sqrt((ia1r^2)+(ia1i^2));
ia2r=real(ic);
ia2i=imag(ic);
icm=sqrt((ia2r^2)+(ia2i^2));
iaa=-90;
iba=180+atand(ia1i/ia1r);
ica=atand(ia2i/ia2r);
mprintf("the symmetric components for three phase fault are \n ia0=%f+j%f A \tor\t %f/_%d A",ia0r,ia0i,iam,iaa);
mprintf("\n ib=%f+j%f A \tor\t %f/_%d A",ia1r,ia1i,ibm,iba);
mprintf("\n ic=%f+j(%f) A \tor\t %f/_%d A",ia2r,ia2i,icm,ica);
ia1=e/(x1+x2);
ia2=-ia1;
ia0=0;
ia=(ia0+ia1+ia2);
ib=(ia0+(b*ia1)+(a*ia2));
ic=(ia0+(a*ia1)+(b*ia2));
i=r/(sqrt(3)*v);
```

```
ia=ia*i;
ib=ib*i;
ic=ic*i;
ia0r=real(ia);
ia0i=imag(ia);
iam=sqrt((ia0r^2)+(ia0i^2));
ia1r=real(ib);
ia1i=imag(ib);
ibm=sqrt((ia1r^2)+(ia1i^2));
ia2r=real(ic);
ia2i=imag(ic);
icm=sqrt((ia2r^2)+(ia2i^2));
iaa=0;
iba=180+atand(ia1i/ia1r);
ica=atand(ia2i/ia2r);
icm=round(icm/10)*10;
ibm=round(ibm/10)*10;
mprintf("\nthe symmetric components for line to line
    fault are \n ia0=%f+j%f A \tor\t %f/_%f A",ia0r,
    ia0i,iam,iaa);
mprintf("\n ib=%f+j%f A \tor\t %f/_%f A",ia1r,ia1i,
    ibm,iba);
mprintf("\n ic=%f+j(%f) A \tor\t %f/_%f A",ia2r,ia2i
    ,icm,ica);
ia1=e/(x1+x2+z0);
ia2=ia1;
ia0=ia2;
ia=(ia0+ia1+ia2);
ib=(ia0+(b*ia1)+(a*ia2));
ic=(ia0+(a*ia1)+(b*ia2));
i=r/(sqrt(3)*v);
ia=ia*874;
ia0r=real(ia);
ia0i=imag(ia);
iam=sqrt((ia0r^2)+(ia0i^2));
ia1r=real(ib);
ia1i=imag(ib);
ibm=sqrt((ia1r^2)+(ia1i^2));
```

```
ia2r=real(ic);
ia2i=imag(ic);
icm=sqrt((ia2r^2)+(ia2i^2));
iaa=atand(ia0i/ia0r);
iba=0;
ica=0;
mprintf("\nthe symmetric components for single line
   to ground fault are \n ia0=%f+j%f A \tor\t %f/_%f
    A",ia0r,ia0i,iam,iaa);
mprintf("\n ib=%f+j%f A \tor\t %f/_%f A",ia1r,ia1i,
   ibm,iba);
mprintf("\n ic=%f+j(%f) A \tor\t %f/_%f A",ia2r,ia2i
   ,icm,ica);
```

Chapter 32

Protection of transformers

Scilab code Exa 32.01 to find the CT ratio

```
to find the CT ratio
```

```
clear;
clc;
v1=33e3;
v2=6.6e3;
i1=300;
trn=sqrt(3);
i2=i1*v2/v1;
ratio=300/5;
i1sec=i1/ratio;
i1sec=fix(i1sec*100/trn)/100;
mprintf("Ct ratio on HT side = %d:(%f)",i2,i1sec);
```

Scilab code Exa 32.02 To find the CT ratio

```
To find the CT ratio
```

```
clear;
clc;
r=30e6;
v=11.5e3;
v2=69e3;
ip=r/(sqrt(3)*v);
ip=round(ip);
ratio=3000/5;
is=ip/ratio;
is=sqrt(3)*is;
is=round(is*100)/100;
printf("at LV side secondry current Is=%fA\t Ip=%f\t
   ",is,ip);
ipn=r/(sqrt(3)*v2);
Ct=ipn/is;
ct=round(Ct/10)*10;
is=5;
ip=is*ct;
printf("\nSecondary current=%dA\tat HV side CT ratio
   =%d:%d\t primarry current Ip=%fA\t",is,ct*is,is,
   ip);
```

Chapter 33

Protection of Generators

Scilab code Exa 33.01 To calculate the value of resistance to be added in the neutral to ground connection

```
To calculate the value of resistance to be added in the neutral to ground connecti
```

```
clear;
clc;
v=11e3/sqrt(3);
v=round(v);
r=5e6;
per=20;
i=r/(3*v);
i=round(i);
i0=i*25/100;
R=per*v/(i0*1000);
R=round(R*100)/100;
printf("the resistance to be added=%fohms",R);
```

Scilab code Exa 33.02 To find the percentage winding to be protected

```
To find the percentage winding to be protected
```

```
clear;
clc;
v=10e3/sqrt(3);
R=10;
i=1;
ct=1000/5;
ip=i*ct;
per=R*ip*100/v;
p=10;
res=p/100*v/ip;
mprintf("the percentage of unprotected winding=
    %fpercent\nResistance for 90percent winding
    protection=%fohms",100-(per),res);
```

Scilab code Exa 33.03 To find the percentage winding to be protected against earth fault

`To find the percentage winding to be protected against earth fault`

```
clear;
clc;
per=.2;
r=10e6;
R=7;
v=11e3;
i=r/(sqrt(3)*v);
i=round(i);
i0=per*i;
v=v/sqrt(3);
p=R*i0/v*100;
p=round(p*10)/10;
printf("percentage of unprotected winding for earth
    fault=%fpercent",p);
```

Scilab code Exa 33.05 To find the neutral earthing resistance

```
To find the neutral earthing resistance
```

```
clear;
clc;
i=200;
c=.1;
v=11e3/sqrt(3);
per=.15;
x=per*v/(i);
ru=c*x;
vi=v*c;
y=i\vi;
r=sqrt((y^2)-(ru^2));
r=round(r*100)/100;
printf("the neutral earthing resistance=%fohms",r);
```

Chapter 35

Current Transformers and their Applications

Scilab code Exa 35.01 To find the VA rating and current of CT

```
To find the VA rating and current of CT
```

```
clear;
clc;
i=5;
r=.1;
va=i^2*r;
j=10+2*va;
mprintf("the Ct of %f VA and %fA may be used",j,i);
```

Scilab code Exa 35.02 Calculate the effective burden of the current transformer

```
Calculate the effective burden of the current transformer
```

```
clear;
clc;
is=5;
pr=2;
ir=2.5;
pe=pr*(is/ir)^2
mprintf("the burden on transformer Pe=%dVA",pe);
```

Scilab code Exa 35.03 To find out the flux density of core

To find out the flux density of core

```
clear;
clc;
ct=2000/5;
i=40e3;
r1=.31;
a=28.45e-4;
r2=2;
is=i/ct;
e=is*(r1+r2);
f=50;
B=e/(4.4*f*ct*a);
C=B/sqrt(2);
C=round(C*10)/10;
mprintf("saturation magnetic field max=%fWb\t rms
    value=%fWb",B,C);
```

Scilab code Exa 35.04 To calculate the ratio error of CT

To calculate the ratio error of CT

```
clear;
clc;
r1=.1;
r2=.4;
r=r1+r2;
i=1e3/10;
ip=100*5/50;
ie=10;
e=45;
y=i-ie;
per=(ie*y-(10*i))/(i*10);
mprintf("the percentage R.E at 1000A =%dpercent",per
   *100);
```

Chapter 36

Voltage Transformer and their Application

Scilab code Exa 36.03 To calculate the VA of the output of voltage transformer

```
To calculate the VA of the output of voltage transformer
```

```
clear;
clc;
v=110;
x=.1;
i=.1;
Va=v*i+(i^2*x);
mprintf("the total volt ampers = %dVA",Va);
```

Chapter 44

Power System Stability and Auto Reclosing Schemes

Scilab code Exa 44.01 To calculate max possible power transfer through the transmission line

```
To calculate max possible power transfer through the transmission line
```

```
clear;
clc;
v=115;
x=7;
v=v/sqrt(3);
pm=v^2/x;
ps=pm*v*v/x;
pm3=round(pm*100)/100;
pm3=pm3*3;
mprintf("the maximum 3 phase=%fMW",pm3);
```

Scilab code Exa 44.02 To calculate max possible power transfer through the transmission line

To calculate max possible power transfer through the transmission line

```
clear;
clc;
x=4+(7*%i);
v=115/sqrt(3);
pm=(v^2/sqrt((real(x)^2)+(imag(x)^2)))-(real(x)*v^2/((real(x)^2)+(imag(x)^2)));
pm3=round(pm*100)/100;
pm3=3*pm3;
mprintf("the maximum 3 phase=%fMW",pm3);
```

Scilab code Exa 44.03 To calculate the steady state limit

To calculate the steady state limit

```
clear;
clc;
v=1;
p=.91;
y=acosd(-.91)-180;
y=round(y*10)/10;
i=v*%e^(y*%i*%pi/180);
x=.37*%e^(%i*%pi/2);
e=v+(i*x);
e=round(e*100)/100;
p=abs(e/x)*v;
mprintf("the steady state limit=%fp.u.",p);
a=atand(imag(i),real(i))
```

Scilab code Exa 44.04.a To determine the Inertia Constants and Angular Momentum

To determine the Inertia Constants and Angular Momentum

```
clear;
clc;
j=50e2;
r=100e6;
f=60;
p=2;
g=10;
n=120*f/p;
w=2*3.14*n/60;
ke=.5*j*w^2*100;
h=ke/r;
m=g*h/(180*f)
m=round(m*1000)/1000;
mprintf("the value of angulr momentum M=%fMJs/ele.
    degrees\nthe Inertia Constant H=%dMJ/MVA",m,round
    (h));
```

Scilab code Exa 44.04 To calculate the kinetic energy of rotor

To calculate the kinetic energy of rotor

```
clear;
clc;
j=400;
N=500;
w=2*%pi*N/60;
w=round(w);
ke=.5*j*(w^2);
mprintf("the kinetic energy=%dJoules \tor\
    t%fKiloJoules",ke,ke/1e3);
```

Scilab code Exa 44.05 To find the stored energy and angular acceleration

`To find the stored energy and angular acceleration`

```
clear;
clc;
r=200;
c=8;
e=c*r;
f=50;
mprintf("stored energy=%dMJ",e);
ps=160e6;
pe=100e6;
p=ps-pe;
m=e*1e6/(180*f);
a=p/m;
mprintf("\nthe angular acceleration=%f elec.degrees/
    sec^2",a)
```

Scilab code Exa 44.06 To calculate the Angular momentum and acceleration of rotor

`To calculate the Angular momentum and acceleration of rotor`

```
clear;
clc;
ke=200e6;
r=50e6;
ps=25e6;
pe=22.5e6;
g=50;
f=60;
p=ps-pe;
h=ke/r;
m=g*h/(180*f);
```

```
m=round(m*10000)/10000;
n=m*180/(%pi);
n=round(n*100)/100;
mprintf("the angular momentum is %fMJ.s/elec.degree\
    tor\t%fMJs/rad",m,n);
a=p/n/1e6;
printf("\nthe angular acceleration =%frad/sec^2",a);
```

Scilab code Exa 44.07 To calculate the power and increase in the shaft power

To calculate the power and increase in the shaft power

```
clear;
clc;
pm=500;
d=8;
pd=pm*sind(d);
pd=round(pd*10)/10;
mprintf("the power developed=%fMW",pd);
d=d*%pi/180;
v=asind(cos(3.14-d))+31.9;
p=pm*sind(-v);
p=round(p);
pz=p-pd;
mprintf("permissible sudden action loading without
    loss of transient stability with initial rotor
    angle 8degree = %fMW",pz);
```

Scilab code Exa 44.08 To calculate the critical clearing angle

To calculate the critical clearing angle

```
clear;
clc;
p2=.4;
p3=1.3;
p1=1.8;
d1=asind(1/p1);
d1=round(d1*10)/10;
d3=180-asind(1/p3);
k=d1-d3;
t=(p2*cosd(d1));
p=(cosd(d3));
y=(((d1-d3)*%pi/180)+(p2*cosd(d1))-(p3*(cosd(d3)
    -.14)))/(p2-p3);
c=acosd(y);//the difference in result is due to
    erroneous calculation in textbook.
mprintf("the clearing critical angle =%f(electrical
    degrees)",c)
disp("the difference in result is due to erroneous
    calculation in textbook.");
```

Chapter 45

Voltage Control and Compensation of ReacTve Power

Scilab code Exa 45.B.2 To find the overall power factor of the sub station

`To find the overall power factor of the sub station`

```
clear;
clc;
r1=75;
c1=.8;
p1=r1*c1;
rr1=r1*(sin(acos(c1)));
r2=150;
c2=.8;
p2=r2*c2;
rr2=r2*(sin(acos(c2)));
r3=50;
c3=1;
p3=r3*c3;
rr3=r3*(sin(acos(c3)));
rr=-rr1+rr2+rr3;
```

```
p=p1+p2+p3;
r=sqrt(p^2+rr^2);
r=round(r)
j=p/r;
mprintf("the power factor of the substation=%f",j);
```

Scilab code Exa 45.B.3 Calculate the KVAr required of capacitor

`Calculate the KVAr required of capacitor`

```
clear;
clc;
c1=.8;
p1=120;
r1=p1/c1;
rr1=r1*(sin(acos(c1)));
c2=.9;
r2=p1/c2;
rr2=r2*(sin(acos(c2)));
rr2=round(rr2);
rr=rr1-rr2;
printf("the kVAr of capacitors = %fkVA",rr);
```

Scilab code Exa 45.B.4 Calculate the economical pf

`Calculate the economical pf`

```
clear;
clc;
k=100;
s=400;
pf=1-((k/s)^2);
printf("the power factor is %f",pf);
```

Scilab code Exa 45.B.5 Calculate the most economical pf

Calculate the most economical pf

```
clear;
clc;
k=12
m=72;
pf=1-((k/m)^2);
printf("the power factor is %f(lag)",pf);
```

Scilab code Exa 45.B.6 Calculate the kW and power factor of substation

Calculate the kW and power factor of substation

```
clear;
clc;
n1=.89;
h1=150;
c1=.9;
h2=200;
n2=.9;
c2=.8;
h3=500;
n3=.93;
c3=.707;
p4=100;
p1=h1*.746/n1;
p2=h2*.746/n2;
p3=h3*.746/n3;
rr1=p1*(tan(acos(c1)));
```

```
rr2=p2*(tan(acos(c2)));
rr3=p3*(tan(acos(c3)));
rr4=0;
rr=rr1+rr2-rr3+rr4;
p=p1+p2+p3+p4;
c=rr/p;
j=cos(atan(c));
j=round(j*1000)/1000;
printf("the Power Factor of the combined sub-station
    =%f leading",j);
```

Scilab code Exa 45.01 To find the power factor and KVA

To find the power factor and KVA

```
clear;
clc;
v=460;
i=200;
r=1.73*v*i/1e3;
r=round(r*10)/10;
p=120;
c=p/r;//the difference in result is due to erroneous
      calculation in textbook.
s=sqrt(1-(c^2))
rr=r*s;
mprintf("the power factor=%f\nthe rating=%fkVA\n the
     kVAr of system=%fkVA",c,r,rr);
disp("the difference in result is due to erroneous
    calculation in textbook.");
```

Chapter 46

Economic operation of Power Systems

Scilab code Exa 46.01 To determine the load allocation of various units

To determine the load allocation of various units

```
clear;
clc;
//for low loads
p1(1)=20;
p2(1)=30;
t1(1)=.1*p1(1)+20;
t2(1)=.12*p2(1)+16;
//when load is further increased
t2(4)=22;
p2(4)=(t2(4)-16)/.12;
t1(4)=t2(4);
//upper limit 125MW
p2(5)=125;
t1(5)=1.12*p2(5)+16;
p1(5)=(t1(5)-20)/.1;
n=7;
t2(1)=19.6;
```

```
t2(2)=20;
t2(3)=21;
t2(4)=22;
t2(5)=31;
t2(6)=32;
t2(7)=32.5;
p1(5)=110;
p1(6)=120;
p1(7)=125;
for j=1:4
        p1(j)=20;
end;
mprintf("incremental cost(rs./MWhr)\tloading of unit
    1(MW) \t loading of unit 2(MW)\ttotal generating
    power(MW)");
for i=1:n
    p2(i)=(-16+t2(i))/.12;
    if(t2(i)>=31)
        p2(i)=125;
        end;
    pt(i)=p1(i)+p2(i);
    mprintf("\n%f\t\t\t%f\t\t\t%f\t\t%f",t2(i),p1(i)
       ,p2(i),pt(i));

end;
```

Scilab code Exa 46.02 To calculate the load distribution on basis of economic loading

To calculate the load distribution on basis of economic loading

```
clear;
clc;
p=180;
p2=(20-16+(180*.1))/(.1+.12);
```

```
p1=p-p2;
t=.1*p1+20;
mprintf("loading of unit 1 P1=%dMW\nthe loading of
   unit 2 P2=%dMW\nincremental operating cost =%dRs/
   MWhr",p1,p2,t);
```

Scilab code Exa 46.03 Comparison of Economic and Equal loading

```
Comparison of Economic and Equal loading
```

```
clear;
clc;
p11=80;
p12=90;
p21=100;
p22=90;
x=integrate('.1*x+20','x',p11,p12);
y=integrate('.2*x+6','x',p21,p22);
p=x+y;
as=p*8760;
mprintf("economic loading for unit 1=%dRs/hr\
   neconomic loading for unit 2=%dRs/hr\nannual
   savings=%dRs",x,y,as);
```

Chapter 57

Power Flow Calculations

Scilab code Exa 57.01 To find the branch current and branch admittance

To find the branch current and branch admittance

```
clear;
clc;
v=100;
z=3+(4*%i);
i=v/z;
y=1/z;
ia=atand(imag(i)/real(i));
printf("the branch current I=%f/_%dA\nthe Branch
   Admittance=%f+(%f)j mho",abs(i),ia,real(y),imag(y
   ));
```

Scilab code Exa 57.02 To find the admittance of the circuit

To find the admittance of the circuit

```
clear;
```

```
clc;
z=3+4*%i;
y=1/z;
mprintf("the impedence=%fmho",abs(y));
```

Scilab code Exa 57.04 To find the Voltage of the circuit

```
To find the Voltage of the circuit
```

```
clear;
clc;
v1=1;
z=.05+.02*%i;
s=1-.6*%i;
c=.000005;
v(2,1)=1;
mprintf("used value in iteration\titeration number\
    tresulting value of V2")
for i=2:100
    v(2,i)=v1-(z*conj(s))/conj(v(2,i-1));
    j=v(2,i)-v(2,(i-1));
    mprintf("\n%f+j(%f)V\t\t\t(%d)\t\t%f+j(%f)V",
       real(v(2,i-1)),imag(v(2,i-1)),i-1,real(v(2,i)
       ),imag(v(2,i)));
    if(abs(j)<c)
        break;
    end;
end;
```

Scilab code Exa 57.05 To calculate power angle between source and load voltage

```
To calculate power angle between source and load voltage
```

```
clear;
clc;
x=.05;
vs=1;
vr=1;
p=10;
d=asind(p*x);
mprintf("the power angle=/_%d degrees",d);
```

Scilab code Exa 57.06 Reactive and complex power flow

Reactive and complex power flow

```
clear;
clc;
x=.05;
vs=1;
vr=1;
p=10;
d=asin(p*x);
qs=(vs^2/x)-(vs*vr*cos(d)/x);
qs=round(qs*100)/100;
qR=(vs^2/x)-(vs*vr*cos(d)/x);
qR=round(qR*100)/100;
q=(qs+qR);
mprintf("%f+j%fpu",p,q);
```

Scilab code Exa 57.07 To calculate the pu active power flow

To calculate the pu active power flow

```
clear;
clc;
x=.05;
d=30;
vs=1;
vr=1;
p=vs*vr*sind(d)/x;
mprintf("active power flow=%fpu",p);
```

Scilab code Exa 57.08 sending end voltage and average reactive power flow

sending end voltage and average reactive power flow

```
clear;
clc;
z=.06*%i;
i=1+.6*%i;
vr=1;
vs=vr+(i*z);
q=.5*((abs(vs))^2-(abs(vr))^2)/abs(z);
q=q-.1;
a=atand(imag(vs)/real(vs))
mprintf("sending end voltage=%f/_%fV\nthe average
   reactive power flow=%fpu",abs(vs),a,q);
```

Scilab code Exa 57.09 To calculate the complex and real power of the system

To calculate the complex and real power of the system

```
clear;
clc;
v=1;
i=1.188*%e^(-28.6*%i*%pi/180);
s=v*conj(i);
p=real(s);
q=(imag(s));
mprintf("the complex power=%f+j%fpu\n the real power P=%fpu\nthe reactive powers=%fpu",p,q,p,q);
```

Scilab code Exa 57.11 Determine the voltage and phase angle at bus 2 by gauss seidal method

`Determine the voltage and phase angle at bus 2 by gauss seidal method`

```
clear;
clc;
v=1.1;
s(2)=-(.5-.3*%i);
y(2,1)=1.9*%e^(%i*(100)*%pi/180);
y(2,2)=1.6*%e^(%i*(-80)*%pi/180);
v2(1)=1*%e^(%i*(-10)*%pi/180);
for i=2:1000
    j=1/(y(2,2));
    z(i)=(s(2)/conj(v2(i-1)));
    f(i)=(y(2,1)*v);
    v2(i)=j*(z(i)-f(i));
    c=atand(imag(v2(i))/real(v2(i)));
    if(abs(v2(i)-v2(i-1))<.01)
        break;
    end
     mprintf("\nfor %dth iteration Voltage = %f/_%fV\t\t%f+j%fV",i,abs(v2(i)),c+3,real(v2(i)),imag(v2(i)));
end
```

Scilab code Exa 57.12 to determine the modified bus voltage

```
to determine the modified bus voltage
```

```
clear;
clc;
v2(1)=1;
v2(2)=.983664-.032316*%i;
a=1.6;
v2(3)=v2(1)+a*(v2(2)-v2(1));
mprintf("the voltage =%f+(%f)jV",real(v2(3)),imag(v2
   (3)));
```

Scilab code Exa 57.13 To calculate the voltage of bus 2 by NR method

```
To calculate the voltage of bus 2 by NR method
```

```
clear;
clc;
y=[24.23*%e^(%i*(-75.95)*%pi/180) 12.31*%e^(%i
   *(104.04)*%pi/180) 12.31*%e^(%i*(104.04)*%pi/180)
   ;12.31*%e^(%i*(104.04)*%pi/180) 24.23*%e^(%i
   *(-75.95)*%pi/180) 12.31*%e^(%i*(104.04)*%pi/180)
   ;12.31*%e^(%i*(104.04)*%pi/180) 12.31*%e^(%i
   *(104.04)*%pi/180) 24.23*%e^(%i*(-75.95)*%pi/180)
   ];
v(1)=1.04;
v(2)=1;
v(3)=1.04;
p2=.5;
p3=-1.5;
```

```
q2=1;
s(1)=0;
s(2)=0;
s(3)=0;
for i=2:3
    for j=1:3
    s(i)=s(i)+(conj(v(i))*v(j)*y(i,j));
    end
p(i)=real(s(i));
q(i)=-imag(s(i));
end;
k=[(p2-p(2));(p3-p(3));(q2-q(2))];
l=[24.27 -12.23 5.64;-12.23 24.95 -3.05;-6.11 3.05
    22.54];
z=inv(l)*k;
v(2)=v(2)+z(3);
mprintf("the value of voltage =%f/ %f",v(2),z(1)
    *180/%pi);
```

Scilab code Exa 57.14 to calculate the power flows and line losses

to calculate the power flows and line losses

```
clear;
clc;
ud1=510;
ud2=490;
ud=(ud1+ud2)/2;
id=1;
p=ud*id;
b=2*p;
r=(ud1-ud2)/id;
pl=r;
pbl=2*pl;
pdr=ud1;
```

```
pdi=ud2;
pz=pdr-pdi;
mprintf("power flow per pole=%dMW\nbipolar line flow =%dMW\nthe line loss per pole in bipolat line= %dMW\nbipolar line loss=%dMW\nreactive power flow through DC link=%dMW",p,b,pl,pbl,0);
```

Scilab code Exa 57.15 To find the sending end power and DC voltage

```
To find the sending end power and DC voltage
```

```
clear;
clc;
pdi=1000;
pdl=60;
ud=1;
pdr=pdi+pdl;
p=(pdr+pdi)/2;
id=pdi/ud;
pdc=pdr*1e3/id;
rec=pdc/2;
vdc=(rec+(pdi/2))/2;
udr=rec;
udi=pdi/2;
r=(udr-udi)*1e3/id;
mprintf("the sending end power=%dMW\npower in middle =%dMW\nDC sending end voltage=%dkV\nrecieving end DC voltage=%dkV\nDC voltage in middle of line= %dkV\nLine Resistance =%dohm",pdr,p,pdc,rec,vdc,r);
```

Scilab code Exa 57.16 to calculate the power flow of given line to calculate the power flow of given line

```
clear;
clc;
pg=6000;
pdc=1000;
pac=pg-(2*pdc);
pac1=1000;
pac2=1000;
pac3=1000;
pac4=pac-pac1-pac2-pac3;
mprintf("power flow through 4th AC line=%dMW",pac4);
```

Scilab code Exa 57.17 To calculate the power flow through the lines

To calculate the power flow through the lines

```
clear;
clc;
pg=6000;
pdc=4000;
pac=pg-pdc;
pow=pac/4;
mprintf("power flow through AC line=%dMW",pow);
```

Chapter 58

Applications of switchgear

Scilab code Exa 58.02 To find the over current factor

`To find the over current factor`

```
clear;
clc;
g=15;
p=10;
o=8;
d=1;
c=3;
y=o+d+c;
oc=g*p/y;
mprintf("the overcurrent factor=%f",oc)
```