

Scilab Textbook Companion for
Switchgear Protection And Power Systems
by S. S. Rao¹

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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.

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Chapter 3

Fundamentals of Fault Clearing and Switching Phenomena

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

```
1
2 clear ;
3 close ;
4 clc ;
5 R=10;
6 L=0.1;
7 f=50;
8 w=2*%pi*f;
9 k=sqrt((R^2)+((w*L)^2));
10 angle=atan(w*L/R);
11 E=400
12 A=E*sin(angle)/k;
13 i=A*exp((-R)*.02/L);
14 i=round(i*100)/100;
15 mprintf("the transient current =%fA",i)
```

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

```
1
2 clear;
3 close;
4 clc;
5
6 R=10;
7 L=0.1;
8 f=50;
9 w=2*%pi*f;
10 k=sqrt((R^2)+((w*L)^2));
11 angle=atan(w*L/R);
12 E=100;
13 Em=sqrt(2)*E;
14 A=Em*sin(angle)/k;
15 i1=A;
16 Em=round(Em*10)/10;
17 i1=round(i1*10)/10;
18 mprintf("current in amperes for part1=%fA\n",i1);
19 mprintf("current in part 2& part 3= 0\n");
20 mprintf("the DC component vanishes if e=%fV",Em);//
    the error is due to the erroneous values in the
    textbook
21
22 t1=0.5*.02;
23 i2=A*exp((-R)*t1/L);
24 mprintf("\ncurrent at .5 cycles for t1=%fsec \
    ncurrent in the problem = %fA",t1,i2);
25 t2=1.5*.02;
26 i3=A*exp((-R)*t2/L);
27 mprintf("\ncurrent at 1.5 cycles for t2=%fsec \
    ncurrent in the problem = %fA",t2,i3);
28 t3=5.5*.02;
29 i4=A*exp((-R)*t3/L);
30 mprintf("\ncurrent at 5.5 cycles for t3=%fsec \
    ncurrent in the problem = %fA",t3,i4);
31
```

32

```
33 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 t

```
1 clear;  
2 close;  
3 clc;  
4 C=.003e-6  
5 L=1.6e-3  
6 y=sqrt(L*C);  
7 y=round(y*1e7)/1e7;  
8 f=(2*3.14*y)^-1;  
9 f=round(f/100)*100;  
10 i=7500;  
11 E=i*2*3.15*L*50;  
12 Em=1.414*E;  
13 Em=round(Em/10)*10  
14 t=y*pi/2;  
15 t=t*1e6;  
16 t=round(t*100)/100;  
17 e=Em/y;  
18 e=round((e)/1e6)*1e6;  
19 e=fix(e/1e7)*1e7  
20 mprintf("frequency of oscillations=%fc/s",f);  
21 mprintf("\ntime of maximum restriking voltage=  
%fmicrosec",t);  
22 mprintf("\nmaximum restriking voltage=%dV/microsecs"  
,e/1e6);
```

Scilab code Exa 3.4 To find the peak striking voltage and its frequency and the av

```

1
2 clear;
3 close;
4 clc;
5 R=5
6 f=50
7 L=R/(2*%pi*f);
8 V=11e3;
9 Vph=11/sqrt(3);
10 C=0.01d-6;
11 y=sqrt(L*C);
12 Em=sqrt(2)*Vph;
13 ep=2*Em;
14 ep=round(ep*10)/10;
15 y=round(y*1e7)/1e7;
16 t=y*%pi;
17 t=fix(t*1e7)/1e7
18 ea=ep/t;
19 ea=round(ea/1e3)*1e3
20 fn=(2*3.14*y)^-1;
21 Em=round(Em)
22 Emax=Em/y;
23 Emax=round(Emax/1000)*1e3;
24 mprintf("peak restriking voltage=%dkV",ep);
25 printf("\nfrequency of oscillations=%dc/s",fn);
26 printf("\naverage rate of restriking voltage=%fkV/
    microsecs",ea/1e6);
27 printf("\nmax restriking voltage=%dV/microsecs",Emax
    /1e3);

```

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

```

1
2 clear;
3 close;

```

```

4  clc;
5  E=19.1*1e3;
6  L=10*1e-3;
7  C=.02*1e-6;
8  Em=sqrt(2)*E;
9  y=sqrt(L*C);
10 t=%pi*y*1e6;
11 emax=2*Em;
12 eavg=emax/t;
13 eavg=round(eavg/10)*10
14 printf(" average restriking voltage=%dV/microsecs",
        eavg);

```

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

```

1  clear;
2  close;
3  clc;
4  V=78e3;
5  Vph=V/sqrt(3);
6  Em=2*Vph;
7  pf=0.4;
8  angle=acos(pf);
9  k1=sin(angle);
10 k1=round(k1*100)/100;
11 k2=.951;
12 k3=1;
13 k=k1*k2*k3;
14 k=round(k*1000)/1e3;
15 E=k*Em;
16 f=15000;
17 t=1/(2*f);
18 t=round(t*1e6);
19 eavg=2*E/t;
20 eavg=round(eavg/100)*100;

```

```
21 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

```
1 clear;  
2 clc;  
3 Em=100e3  
4 t=70e-6  
5 Ea=Em/t/1e6  
6 f=1/(2*t);  
7 Ea=round(Ea/10)*10;  
8 f=round(f);  
9 printf(" average voltage in volts=%dV/microsecs\n",Ea  
    );  
10 printf(" frequency of oscillation =%dc/s",f);
```

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

```
1  
2 clc;  
3 L=6;  
4 C=0.01e-6;  
5 i=10;  
6 v=i*sqrt(L/C);  
7 R=.5*v/i;  
8 R=round(R/10)*10;  
9 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

```
1 clear ;
2 clc ;
3 Isc= 25e3;
4 i=2.55*Isc;
5 L=1;
6 r=0.24;
7 F=2.046*(i^2)*10^-5/r;
8 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 impedance

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

Scilab code Exa 18.2 to find the value of reactance

```
1 clc;  
2 clear;  
3 w=314;  
4 c=.015e-6;  
5 l=1/(3*w^2*c);//the difference in result is due to  
    erroneous calculation in textbook.  
6 l=round(l*10)/10;  
7 mprintf("inductance =%f Henries",l);
```

```
8 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

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

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

```
1 clc;
2 clear;
3 c=.01e-6*50;
4 w=2*%pi*50;
5 L=1/(3*c*(w^2));
6 L=round(L*100)/100;
7 V=33e3/sqrt(3);
```

```
8 I=V/(w*L);
9 I=round(I*1000)/1000;
10 I=round(I*100)/100;
11 R=V*I/1e3; //the difference in result is due to
    erroneous calculation in textbook.
12 mprintf("the value of L=%fH and rating =%fkVA",L,R);
13 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

```
1  clc;  
2  clear;  
3  i=10;  
4  v=200;  
5  z=v/i;  
6  I1=20/i;  
7  I2=.2/i;  
8  v1=50/v;  
9  r=2/z;  
10 mprintf("the base impedance=%dohm\n",z);  
11 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

```

1  clc;
2  clear;
3  z=2;
4  v=11e3;
5  r=1000e3;
6  zb=v^2/r;
7  y=z/zb;
8  y=round(y*10000)/10000;
9  mprintf("the per unit resistance=%fp.u",y);

```

Scilab code Exa 19.3 to find the new pu reactance

```

1  clc;
2  clear;
3  v=11e3;
4  r=15000e3;
5  zp=.15;
6  vnew=110e3;
7  rnew=30000e3;
8  zb=v^2/r;
9  Z=zp*zb;
10 zbnew=vnew^2/rnew;
11 Zp=Z/zbnew;
12 mprintf("the new per unit reactance=%fp.u",Zp/10);

```

Scilab code Exa 19.4 drawing the reactance diagram of the system

```

1  clc;
2  clear;
3  v1=11e3;
4  v2=22e3;
5  v3=3.3e3;
6  r=10000e3;

```

```

7  zb1=v1^2/r;
8  zb2=v2^2/r;
9  zb3=v3^2/r;
10 zp1=300/zb3;
11 zp2=300*(zb2/zb3)/zb2;
12 zp3=300*(zb1/zb3)/zb1;
13 zp1=round(zp1*10)/10;
14 zp1=round(zp1);
15 zp2=round(zp2*10)/10;
16 zp2=round(zp2);
17 zp3=round(zp3*10)/10;
18 zp3=round(zp3);
19 mprintf("the per unit values =%dp.u. ; %dp.u.; %dp.u
. ",zp1 ,zp2 ,zp3);

```

Scilab code Exa 19.5 to find the fault current

```

1  clc;
2  clear;
3  z=0.2*%i*0.155/(0.2+0.155);
4  v=1;
5  i=v/z;
6  ir=real(i);
7  im=imag(i);
8  im=round(im*100)/100;
9  mprintf("the fault current is =%d+(%fj)A",ir,im);

```

Scilab code Exa 19.6 The reactance calculations

```

1  clc;
2  clear;
3  r=30000e3;
4  v1=11e3;

```

```

5 v2=110e3;
6 zb1=v1^2/r;
7 zb2=v2^2/r;
8 zp1=80/zb2;
9 zp2=.1*i*30000/35000;
10 zp3=.2*i*30000/10000;
11 zp3r=real(zp3);
12 zp2r=real(zp2);
13 zp3i=imag(zp3);
14 zp2i=imag(zp2);
15 zb2=round(zb2*10)/10;
16 zp1=round(zp1*1000)/1000;
17 zp2i=round(zp2i*10000)/10000;
18 zp3i=round(zp3i*10)/10;
19 mprintf("the base impedance of transmission line
    circuiti=%fohm\nper unit reactance of transmission
    line=%fp.u.\n ",zb2,zp1);
20 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

```

1 clc;
2 clear;
3 r1=10e6;
4 r2=7.5e6;
5 r3=5e6;
6 v1=66e3;
7 v2=11e3;
8 v3=3.3e3;
9 zst=.06*r1*i/r2;
10 zps=.07*i;
11 zpt=.09*i;
12 Zp=(zst+zps-zst)/2;

```



```
13 Zs=(zps+zst-zpt)/2;
14 Zt=(zpt+zst-zps)/2;
15 Zpi=imag(Zp);
16 Zsi=imag(Zs);
17 Zti=imag(Zt);
18 Zpi=round(Zpi*100)/100;
19 mprintf("the per unit impedence 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

```
1 clc;
2 clear;
3 old=5000;
4 bank=200;
5 new=old-bank;
6 mprintf("new fault =%dMVA",new);
```

Chapter 20

Symmetric Faults and Current Limiting Reactors

Scilab code Exa 20.1 Calculate Fault MVA and current

```
1 clear;
2 clc;
3 V=6.6e3;
4 r=5e6;
5 X=.12;
6 F=r/X;
7 I=(F/V)/(%i*sqrt(3));
8 Ir=real(I);
9 Ii=imag(I);
10 Imod=sqrt((Ir^2)+(Ii^2));
11 Iangle=atand(Ir/Ii)-90;
12 F=fix(F/1e5)*1e5;
13 Imod=fix(Imod);
14 mprintf("Method 1 \nthe value of fault MVA=%fMVA \n
          the fault current is = %d /-%d A\n", (F/1e6), Imod,
          Iangle);
15 //method 2
16 Vbase=V/sqrt(3);
17 Ifaultpu=1/(X*%i);
```

```

18 Ibase=r/(Vbase*3);
19 Ifault=Ifaultpu*Ibase;
20 P=sqrt(3)*Ifault*V;
21 Ir=real(Ifault);
22 Ii=imag(Ifault);
23 Imod=sqrt((Ir^2)+(Ii^2));
24 Pr=real(P);
25 Pi=imag(P);
26 Pmod=sqrt((Pr^2)+(Pi^2));
27 Pangle=atand(Pr/Pi)-90;
28 Pmod=fix(Pmod/1e5)*1e5;
29 Imod=fix(Imod);
30 mprintf("From method 2\n the value of fault MVA=%f /
    _%d MVA \n the fault current is = %d A", (Pmod/1e6
    ), Pangle, Imod);
31 //method 3
32 v1=6.4e3;
33 I=(v1/V)/X;
34 Ifault=Ibase*I;
35 p=sqrt(3)*Ifault*v1;//the difference in result is
    due to erroneous calculation in textbook.
36 p=round(p/1e5)*1e5;
37 mprintf("\nthe new fault current at 6.4kV is = %fA \
    n the new fault power at service voltage is =%fMVA
    ", Ifault, p/1e6);
38 disp("the difference in result is due to erroneous
    calculation in textbook.");

```

Scilab code Exa 20.2 To find the steady state fault current

```

1 clear;
2 clc;
3 V=3000e3;
4 r1=30;
5 r=5000e3;

```

```

6 vb2=11e3;
7 vb3=33e3;
8 x=.2;
9 Xt=.05*r/V;
10 Xl=r1*r/(vb3^2);
11 xtotal=(x+Xt+Xl)*%i;
12 MVA=r*%i*1e-6/xtotal;
13 Ifault=MVA*1e6/(sqrt(3)*vb3*%i);
14 Ir=real(Ifault);
15 Ii=imag(Ifault);
16 Imod=sqrt((Ir^2)+(Ii^2));
17 Iangle=atand(Ir/Ii)-90;
18 Imod=round(Imod);
19 MVA=round(MVA*10)/10;
20 mprintf("the value of fault current = %d/_%d Amp \n
        fault MVA =%f MVA",Imod,Iangle,MVA);

```

Scilab code Exa 20.03 to find the fault MVA

```

1 clear;
2 clc;
3 rating=25e6;
4 vb=11e3;
5 x=.16/4;
6 faultMVA=rating*1e-6/x;
7 mprintf("the fault MVA from method 1=%dMVA",faultMVA
        );
8 //method 2
9 Ifault=1/(x*%i);
10 Ib=rating/(sqrt(3)*vb);
11 Isc=Ib*25;
12 MVA=sqrt(3)*vb*Isc/1e6;
13 mprintf("\n the fault MVA from method 2=%dMVA",MVA);

```

Scilab code Exa 20.04 calculate the fault current and MVA

```
1 clear;
2 clc;
3 R=3e6;
4 Rb=6000e3;
5 vb1=11e3;
6 vb2=22e3;
7 X=.15;
8 x=.15*Rb/R;
9 xeq=x/2;
10 MVA=Rb/xeq;
11 Ifault=MVA/(sqrt(3)*vb1*%i);
12 Ir=real(Ifault);
13 Ii=imag(Ifault);
14 Imod=sqrt((Ir^2)+(Ii^2));
15 Iangle=atand(Ir/Ii)-90;
16 Imod=round(Imod/10)*10;
17 mprintf("for fault on generator side \n Fault MVA=
    %dMVA \n Fault current=%d/_%dAmp",MVA/1e6,Imod,
    Iangle);
18 x2=.05;
19 Xeq=x2+xeq;
20 MVA=Rb/Xeq;
21 Ifault=MVA/(1.734*vb2*%i);
22 Ir=real(Ifault);
23 Ii=imag(Ifault);
24 Imod=sqrt((Ir^2)+(Ii^2));
25 Iangle=atand(Ir/Ii)-90;
26 mprintf("\nfor fault on transmission side \n Fault
    MVA=%dMVA \n Fault current=%d/_%dAmp(lag)",MVA/1
    e6,Imod,Iangle);
```

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

```
1 clear;
2 clc;
3 R=3e6;
4 Rb=6e6;
5 vb2=11e3;
6 vb3=66e3;
7 x=.2;
8 Xg=x*Rb/R;
9 xt=.05;
10 x1=vb3^2/Rb;
11 x11=20*.1/x1;
12 x12=x11*4;
13
14 X1=Xg+xt+x12;
15 X2=Xg+xt+x11;
16 X=inv(inv(X1)+inv(X2));
17 Ifaultpu=1/(X*%i);
18 Ifault=Ifaultpu*Rb/(sqrt(3)*vb3);
19 MVA=sqrt(3)*vb3*Ifault*%i;
20 Ir=real(Ifault);
21 Ii=imag(Ifault);
22 Imod=sqrt((Ir^2)+(Ii^2));
23 Iangle=atand(Ir/Ii)-90;
24 MVA=fix(MVA/1e5)*1e5;
25 Imod=fix(Imod);
26 mprintf("\n Fault MVA=%fMVA \n Fault current=%d/
    _%dAmp",MVA/1e6,Imod,Iangle);
27 //another method
28 MVA=Rb/X;
29 Ifault=MVA/(sqrt(3)*vb3*%i);
30 Ir=real(Ifault);
31 Ii=imag(Ifault);
```

```

32 Imod=sqrt((Ir^2)+(Ii^2));
33 Iangle=atand(Ir/Ii)-90;
34 MVA=fix(MVA/1e5)*1e5;
35 Imod=fix(Imod);
36 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

```

1 clear;
2 clc;
3 v1=66e3;
4 v2=11e3;
5 x2=.461;
6 x1=.4527;
7 If=229;
8 I1=If*x2/(x1+x2);
9 I2=If*x1/(x1+x2);
10 I=I1+I2;
11 Ig1=I1*v1/v2;
12 Ig1=fix(Ig1);
13 I1=round(I1*10)/10;
14 I2=round(I2*10)/10;
15 mprintf("the fault current supplied by each
      transformer is\n I1=%fA\nI2=%fA\nI3=I1+I2=%dA\n" ,
      I1 ,I2 ,I);
16 I2=fix(I2);
17 Ig2=I2*v1/v2;
18 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

```

1 clear;
2 clc;
3 r=6e6;
4 v1=11e3;
5 v2=66e3;
6 xg=.1;
7 xt=.09;
8 z=4+(1*%i);
9 zb=v2^2/r;
10 zpu=z/zb;
11 E=1;
12 Ifault=E/(zpu+((xg+xt)*%i));
13 Ir=real(Ifault);
14 Ii=imag(Ifault);
15 Imod=sqrt((Ir^2)+(Ii^2));
16 Ib=r/(sqrt(3)*v2);
17 i=Imod*Ib;
18 igb=r/(sqrt(3)*v1);
19 ig=igb*Imod;
20 i=fix(i);
21 ig=fix(ig);
22 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

```

1 clear;
2 clc;
3 r1=20e6;
4 rb=30e6;
5 v1=11e3;
6 v2=110e3;
7 x1g=.2*rb/r1;
8 x1t=.08*rb/r1;
9 x2g=.2;

```



```

10 x2t=.1;
11 x1=.516;
12 x0=x1/2;
13 x1=x1g+x1t;
14 x2=x2g+x2t;
15 x=inv(inv(x2)+inv(x1));
16 z=x+x0;
17 E=1;
18 isc=E/z;
19 ig1=isc*x2/(x1+x2);
20 ig2=isc*x1/(x1+x2);
21 i=ig1+ig2;
22 ib=rb/(1.7355*v1);
23 ig1=fix(ig1*1000)/1000;
24 Ig1=ig1*ib;
25 ib=fix(ib);
26 ig2=fix(ig2*100)/100;
27 Ig2=ig2*ib;
28 Ig2=fix(Ig2);
29 mprintf("the current taken from G1=%dA(lagging)\n
the current taken from G2=%dA(lagging)",Ig1,Ig2);

```

Scilab code Exa 20.08 to calculate the subtransient fault current and breaker current

```

1 clear;
2 clc;
3 r=25e6;
4 rb=5e6;
5 v1=6.6e3;
6 v2=25e3;
7 xs=.2;
8 xt=.3;
9 Xs=xs*r/rb;
10 Xt=xt*r/rb;
11 Z=.125;

```

```

12 v=1;
13 I=v/(Z);
14 ib=r/(1.7355*v1);
15 ib=fix(ib);
16 i=ib*8;
17 ig=I*.25/.5;
18 im=I-ig;
19 it=3*1+im;
20 Ia=ib*it;
21 Imom=1.6*Ia;
22 xt=.15;
23 Zth=.375*.25/(.375+.25);
24 I=v/xt;
25 igen=I*.375/.625;
26 imot=.25*I*.25/.625;
27 itot=igen+(3*imot); //symm breaking current
28 ibr=itot*1.1; //asymm breaking current
29 is=itot*ib;
30 ia=ibr*ib*1.01;
31 ia=fix(ia/100)*100;
32 rbreaking=1.739*v1*ia;
33 rbreaking=fix(rbreaking/1e6)*1e6;
34 Imom=round(Imom/10)*10;
35 ia=round(ia);
36 is=fix(is/100)*100;
37 mprintf("the subtransient fault current If= %d/_-90A
  \nsubtransient 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

```
1 clc;
```

```

2  clear;
3  rb=100e6;
4  rf=1e6;
5  v=3.3e3;
6  x=rf/rb;
7  xpu=.6;
8  xtot=x+xpu;
9  rf2=rf/xtot;
10 rf2=round(rf2/1e4)*1e4;
11 If=rf2/(1.72*v);
12 If=fix(If);
13 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

```

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

```

Scilab code Exa 20.11 to calculate the fault level

```

1  clc;
2  clear;
3  r1=75e6;
4  r2=150e6;
5  rb=r1+r2;
6  rf=rb;

```

```

7 x=.05;
8 xn=x*rb/1e6;
9 xeq=rb/rf;
10 X=xn+xeq;
11 fault=rb/X;
12 f=rb/xn;
13 fault=round(fault/1e4)*1e4
14 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

```

1 clear;
2 clc;
3 rb=100e6;
4 r1=50e6;
5 r2=rb;
6 x1=rb/r1;
7 x2=rb/r2;
8 xeq=inv(inv(x1)+inv(x2));
9 f=rb/xeq;
10 mprintf("the fault level on the line =%fMVA" ,f/1e6);

```

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

```

1 clear;
2 clc;
3 x=.23;
4 r=3750e3;
5 v=6600;
6 res=.866;
7 x1=x*(v^2)/r;

```

```

8 z=sqrt((res^2)+(x1^2));
9 i=1.1*v/(sqrt(3)*z);
10 f=res/x1;
11 x=1.38;
12 i=round(i/100)*100
13 is=sqrt(2)*x*i;
14 is=round(is/10)*10;
15 mprintf("initial short circuit current=%dA \n peak
        short circuit current=%dA",i,is);

```

Scilab code Exa 20.14 to find the subtransient currents

```

1 clear;
2 clc;
3 rb=75000e3;
4 ro=50e6;
5 v1=11e3;
6 v2=66e3;
7 xa=.25*rb/ro;
8 xb=.75;
9 xt=.1;
10 v=1;
11 xeq=inv(inv(xa)+inv(xb))+xt;
12 i=v/xeq;
13 i=round(i*100)/100;
14 ia=i*xb/(xa+xb);
15 ib=i*xa/(xa+xb);
16 ia=round(ia*100)/100;
17 ilt=rb/(sqrt(3)*v1);
18 iht=rb/(sqrt(3)*v2);
19 i=i*iht;
20 i=fix(i)
21 ia=ia*ilt;
22 ilt=rb/(1.73*v1);
23 ib=ib*ilt;

```

```

24 ia=round(ia);
25 ib=round(ib/10)*10;
26 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 c

```

1 clear;
2 clc;
3 x=1;
4 e=1;
5 i=e/x;
6 r=7.5e6;
7 v=6.6e3;
8 i=r/(sqrt(3)*v);
9 i=fix(i);
10 x2=.09;
11 i2=e/x2;
12 I2=i2*i;
13 I2=fix(I2/10)*10;
14 idc=sqrt(2)*I2;
15 mc=idc*2;
16 x3=.15;
17 i3=e/x3;
18 I3=i3*i;
19 ib=I3*1.4;
20 Mva=sqrt(3)*v*ib;
21 idc=round(idc/1e2)*1e2;
22 mc=round(mc/1e2)*1e2;
23 I3=round(I3/10)*10;
24 Mva=fix(Mva/1e4)*1e4;
25 mprintf("sustained short circuit current=%dA\
ninitial symmetric SC current=%fkA\nmaximum dc
component=%fkA\nmaking capacity required=%fkA\
ntransient short circuit current=%fkA\n

```

```
interrupting 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

```
1 clear;  
2 clc;  
3 rb=2e6;  
4 r=1.2e6;  
5 x=7*rb/r;  
6 v=6.6e3;  
7 i=rb/v;  
8 zb=v/i;  
9 r=1200e3;  
10 rb=2000e3;  
11 v=6.6e3;  
12 i=rb/v;  
13 x=.1;  
14 z0=v*x/i;  
15 x1=7*rb/r;  
16 z1=v*x1/(100*i);  
17 z2=2;  
18 z=z0+z1+z2;  
19 ish=v/z;  
20 zb=round(zb*10)/10;  
21 ish=round(ish/10)*10;  
22 mprintf("the shortcircuit current by direct ohmic  
    method=%fA\n", ish);  
23 mprintf("the base impedance=%fohm", zb);
```

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

```
1 clear;
```

```

2  clc;
3  rb=2e6;
4  r=1.2e6;
5  x=7*rb/r;
6  x1=10;
7  x2=11.7;
8  v=6.6e3;
9  i=rb/v;
10 zb=v/i;
11 r=1200e3;
12 rb=2000e3;
13 v=6.6e3;
14 xt=.117;
15 xf=2/zb*100;
16 xtot=xf+x1+x2;
17 ish=i*100/xtot;
18 ish=round(ish/10)*10;
19 mprintf("the short circuit current by percentage
    reactance method=%fA", ish);

```

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

```

1  clear;
2  clc;
3  x1=5;
4  x2=10;
5  x3=11.7;
6  x4=9.1;
7  i=303;
8  xt=x1+x2+x3+x4;
9  ish=303*100/xt;
10 mprintf("the SHORT CIRCUIT CURRENT=%dA", ish)

```

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

```
1 clear;
2 clc;
3 v=3.3e3;
4 rb=3e6;
5 r1=1e6;
6 r2=1.5e6;
7 x1=10;
8 x2=20;
9 X1=x1*rb/r1;
10 X2=x2*rb/r2;
11 x=inv(inv(X1)+inv(X2));
12 kva=rb*100/x;
13 ish=kva/(1.7388*v);
14 ish=round(ish);
15 printf("the value of short circuit current=%dA",ish)
    ;
```

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

```
1 clear;
2 clc;
3 v=3.3e3;
4 rb=3e6;
5 r1=1e6;
6 r2=1.5e6;
7 x1=10;
8 x2=20;
9 X1=x1*rb/r1;
10 X2=x2*rb/r2;
11 x=inv(inv(X1)+inv(X2));
12 kva=rb*100/x;
13 ish=kva/(sqrt(3)*v);
14 rx=10e6;
```

```

15 x2=rb*100/rx;
16 r=inv(inv(X1)-inv(X2))-30;
17 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

```

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

```

Scilab code Exa 20.18.b fault level at generator bus

```

1 clear;
2 clc;
3 z=4000;
4 zb=9;
5 x1=zb/z*100;
6 x2=5;
7 x3=30;
8 x4=30;
9 x=inv(inv(x1+x2)+inv(x3)+inv(x4));
10 x=round(x*100)/100;
11 fault=zb*1e3/x*100;

```

```

12 fault=fix(fault/1e3)*1e3;
13 mprintf("the new fault level of generator bus=%dMVA"
    ,fault/1e3);

```

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

```

1 clear;
2 clc;
3 rb=20e6;
4 r=10e6;
5 v1=11e3;
6 v2=66e3;
7 x1=5;
8 X1=x1*rb/r;
9 xa=20;
10 xb=20;
11 xc=20;
12 xd=20;
13 xbus=25;
14 xtr=X1;
15 xcd=inv(inv(xc)+inv(xd));
16 xab=inv(inv(xa)+inv(xb));
17 xcdbus=xcd+xbus;
18 xn=inv(inv(xab)+inv(xcdbus));
19 xth=xtr+xn;
20 mva=rb/xth*100;
21 i=mva/(1.745*v2);
22 i=round(i);
23 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

```

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

```

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

```

1 clear;
2 clc;
3 xst=20;
4 xtr=28;
5 xs=250;
6 xt=15;
7 v1=25e3;
8 r1=500e6/.8;
9 v2=220e3;
10 rb=600e6;
11 vb=25e3;
12 xf=rb/r1;
13 xst=xst*xf/100;
14 xtr=xtr*xf/100;
15 xs=xs*xf/100;
16 xt=xt/100;
17 xeqs=inv(inv(xst)+inv(xt));
18 xeqt=inv(inv(xtr)+inv(xt));
19 xeg=inv(inv(xs)+inv(xt));
20 e=1;

```

```

21 xeqs=round(xeqs*1000)/1e3;
22 is=e/xeqs;
23 is=round(is);
24 it=e/xeqt;
25 ig=e/xeg;
26 i1=is*xt/(xt+xst);
27 i2=is*xst/(xst+xt);
28 ib=rb/(1.726*22.2*1e3);
29 Is=is*ib;
30 i1=round(i1*10)/10;
31 Is=round(Is/1e3)*1e3;
32 i2=fix(i2*100)/0100;
33 I1=i1*ib;
34 I2=i2*ib;
35 I1=fix(I1/1e2)*1e2;
36 I2=fix(I2/1e2)*1e2;
37 mprintf("total subtransient current T-off=%fkA\
    nsubtransient current on generator side=%fkA\n
    subtransient 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 f

```

1  clc;
2  clear;
3  mvan=6800e6;
4  v=132e3;
5  mvac=200e6;
6  mvae=mvan-mvac;
7  n=mvan/(sqrt(3)*v);
8  e=mvae/(1.681*v);
9  e=fix(e/10)*10;
10 n=fix(n/10)*10;
11 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

```
1 clear;
2 clc;
3 v=400e3;
4 mvn=30000e6;
5 mw=1500e6;
6 mvac=600e6;
7 n=mvn/mw;
8 mvae=mvn-mvac;/////the difference in result is due
   to erroneous calculation in textbook.
9 e=mvae/mw;
10 mprintf("the SC ratio=%d\n effective fault level=%fMVA
   \n effective circuit level of HVDC system(ESCR)=%f
   ",n,mvae/1e6,e);
11 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

```
1 clear;
2 clc;
3 s=1;
4 xt=5;
5 m=s/xt*100;
6 n=2*s/xt*100;
7 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

```
1 clear;
2 clc;
3 va=100*(%e^(%pi*i/2));
4 vb=116*(%e^(%i*0));
5 vc=71*(%e^(%i*(224.8*pi/180)));
6 a=1*%e^(%i*(120*pi/180));
7 b=a^2;
8 va0=1/3*(va+vb+vc);
9 va1=1/3*(va+(a*vb)+(b*vc));
10 va2=1/3*(va+(b*vb)+(a*vc));
11 va0r=real(va0);
12 va0i=imag(va0);
13 va0m=sqrt((va0r^2)+(va0i^2));
14 va0a=atand(va0i/va0r);
15 va1r=real(va1);
16 va1i=imag(va1);
17 va1m=sqrt((va1r^2)+(va1i^2)); //the difference in
    result is due to erroneous calculation in
    textbook.
18 va1a=atand(va1i/va1r);
19 va2r=real(va2);
```

```

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

```

Scilab code Exa 21.02 to calculate the line voltages

```

1 clear;
2 clc;
3 va=22+(16.66*%i);
4 vb=-25.33+(%i*89.34);
5 vc=3.33-(%i*6);
6 a=1*%e^(%i*(120*%pi/180));
7 b=a^2;
8 va0=(va+vb+vc);
9 va1=(va+(b*vb)+(a*vc));
10 va2=(va+(a*vb)+(b*vc));
11 va0r=real(va0);
12 va0i=imag(va0);
13 va0m=sqrt((va0r^2)+(va0i^2));
14 va0a=atand(va0i/va0r);
15 va1r=real(va1);
16 va1i=imag(va1);
17 va1m=round(sqrt((va1r^2)+(va1i^2))*10)/10;
18 va1a=atand(va1i/va1r);
19 va2r=round(real(va2));
20 va2i=round(imag(va2));
21 va2m=round(sqrt((va2r^2)+(va2i^2)));

```



```

22 va2a=atand(va2i/va2r);
23 mprintf("the voltage levels are \n va=%f+j%f V \tor\
    t %f/_%d V",va0r,va0i,va0m,va0a);
24 mprintf("\n vb=%f+j(%f) V \tor\t %f/_%d V",va1r,va1i
    ,va1m,va1a);
25 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

```

1 clear;
2 clc;
3 ib=50;
4 ic=10*e^(%i*%pi/2);
5 ia=10*e^(%i*%pi);
6 a=1*e^(%i*(120*%pi/180));
7 b=a^2;
8 ia0=(ia+ib+ic);
9 ia1=(ia+(b*ib)+(a*ic));
10 ia2=(ia+(a*ib)+(b*ic));
11 ia0r=real(ia0);
12 ia0i=imag(ia0);
13 ia0m=sqrt((ia0r^2)+(ia0i^2));
14 ia0a=atand(ia0i/ia0r);
15 ia1r=real(ia1);
16 ia1i=imag(ia1);
17 ia1m=sqrt((ia1r^2)+(ia1i^2));
18 ia1a=atand(ia1i/ia1r);
19 ia2r=real(ia2);
20 ia2i=imag(ia2);
21 ia2m=sqrt((ia2r^2)+(ia2i^2));
22 ia2a=atand(ia2i/ia2r);
23 mprintf("the current levels are \n ia=%f+j%f A \tor\
    t %f/_%d A",ia0r,ia0i,ia0m,ia0a);
24 mprintf("\n ib=%f+j(%f) A \tor\t %f/_%d A",ia1r,ia1i

```

```

    ,ia1m,ia1a);
25 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

```

1 clear;
2 clc;
3 ia=20;
4 ib=20*(%e^(%i*%pi));
5 ic=0;
6 a=1*%e^(%i*(120*%pi/180));
7 b=a^2;
8 ia0=1/3*(ia+ib+ic);
9 ia1=1/3*(ia+(a*ib)+(b*ic));
10 ia2=1/3*(ia+(b*ib)+(a*ic));
11 ia0r=real(ia0);
12 ia0i=imag(ia0);
13 ia0m=sqrt((ia0r^2)+(ia0i^2));
14 ia0a=0-atan(ia0i/ia0r);
15 ia1r=real(ia1);
16 ia1i=imag(ia1);
17 ia1m=sqrt((ia1r^2)+(ia1i^2));
18 ia1a=atan(ia1i/ia1r);
19 ia2r=real(ia2);
20 ia2i=imag(ia2);
21 ia2m=sqrt((ia2r^2)+(ia2i^2));
22 ia2a=atan(ia2i/ia2r);
23 mprintf("the symmetric components are \n ia0=%f+j%f
    A \tor\t %f/_%d A",ia0r,ia0i,ia0m,ia0a);
24 mprintf("\n ia1=%f+j%f A \tor\t %f/_%d A",ia1r,ia1i,
    ia1m,ia1a);
25 mprintf("\n ia2=%f+j(%f) A \tor\t %f/_%d A",ia2r,
    ia2i,ia2m,ia2a);
26 ib1=b*ia1;

```

```

27 ib2=a*ia2;
28 ic1=a*ia1;
29 ic2=b*ia2;
30 ib0=ia0;
31 ic0=ia0;
32 ib1r=real(ib1);
33 ib1i=imag(ib1);
34 ib1m=sqrt((ib1r^2)+(ib1i^2));
35 ib1a=atand(ib1i/ib1r);
36 ib2r=real(ib2);
37 ib2i=imag(ib2);
38 ib2m=sqrt((ib2r^2)+(ib2i^2));
39 ib2a=atand(ib2i/ib2r);
40 ic1r=real(ic1);
41 ic1i=imag(ic1);
42 ic1m=sqrt((ic1r^2)+(ic1i^2));
43 ic1a=atand(ic1i/ic1r);
44 ic2r=real(ic2);
45 ic2i=imag(ic2);
46 ic2m=sqrt((ic2r^2)+(ic2i^2));
47 ic2a=atand(ic2i/ic2r);
48 mprintf("\n \n ib0=%fA ",ib0);
49 mprintf("\n ib1=%f+j%f A \tor\t %f/_%d A",ib1r,ib1i,
    ib1m,ib1a);
50 mprintf("\n ib2=%f+j(%f) A \tor\t %f/_%d A",ib2r,
    ib2i,ib2m,ib2a);
51 mprintf("\n \n ic0=%f A",ic0);
52 mprintf("\n ic1=%f+j%f A \tor\t %f/_%d A",ic1r,ic1i,
    ic1m,ic1a);
53 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

```
1 clear;
```

```

2  clc;
3  vb=.584+(0*%i);
4  vc=.584+(0*%i);
5  va=0;
6  a=1*e^(%i*(120*%pi/180));
7  b=a^2;
8  vae=(va+vb+vc);
9  vbe=(va+(b*vb)+(a*vc));
10 vce=(va+(a*vb)+(b*vc));
11 va0=vae-vbe;
12 va1=vbe-vce;
13 va2=vce-vae;
14 va0r=real(va0);
15 va0i=imag(va0);
16 va0m=sqrt((va0r^2)+(va0i^2));
17 va0a=atand(va0i/va0r);
18 va1r=real(va1);
19 va1i=imag(va1);
20 va1m=sqrt((va1r^2)+(va1i^2));
21 va1a=0;
22 va2r=real(va2);
23 va2i=imag(va2);
24 va2m=sqrt((va2r^2)+(va2i^2));
25 va2a=atand(va2i/va2r)+180;
26 mprintf("the voltage levels are \n vab=%f+j%f V \tor
   \t %f/_%d V",va0r,va0i,va0m,va0a);
27 mprintf("\n vbc=%f+j(%f) V \tor\t %f/_%d V",va1r,
   va1i,va1m,va1a);
28 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 I_a

```

1  clear;
2  clc;

```

```

3 e=1;
4 x1=.25*%i;
5 x2=.35*%i;
6 x0=.1*%i;
7 ia0=e/(x1+x2+x0);
8 ia1=ia0;
9 ia2=ia0;
10 ia=ia0+ia1+ia2;
11 iar=real(ia);
12 iai=imag(ia);
13 iam=round(sqrt((iar^2)+(iai^2))*100)/100;
14 iaa=0;
15 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

```

1 clear;
2 clc;
3 z1=.25*%i;
4 z2=.35*%i;
5 z0=.1*%i;
6 ea=1;
7 ia1=inv(z1+inv(inv(z2)+inv(z0)))*ea;
8 va1=ea-(ia1*z1);
9 va0=va1;
10 va2=va0;
11 ia0=-va0/z0;
12 ia2=-va2/z2;
13 ia=ia1+ia2+ia0;
14 va=va1+va2+va0;
15 va=fix(va*1000)/1e3;
16 mprintf("the current ia=%dA\tVa=%fV",ia,va);

```

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

```
1 clear;
2 clc;
3 r0=.1;
4 v=1;
5 r1=.05;
6 r2=.05;
7 r3=.2;
8 r4=.2;
9 r34=inv(inv(r3)+inv(r4));
10 r234=r2+r34;
11 r10=r1+r0;
12 r=inv(inv(r234)+inv(r10));
13 ip=v/r;
14 mprintf("the positive sequence current=%fpu",ip);
```

Scilab code Exa 21.09 calculate the symmetric components of the fault

```
1 clear;
2 clc;
3 ia=86.6+(%i*50);
4 ib=25-(43.3*%i);
5 ic=-30;
6 a=1*%e^(%i*(120*%pi/180));
7 b=a^2;
8 ia0=1/3*(ia+ib+ic);
9 ia1=1/3*(ia+(a*ib)+(b*ic));
10 ia2=1/3*(ia+(b*ib)+(a*ic));
11 ia0r=real(ia0);
12 ia0i=imag(ia0);
13 ia0m=sqrt((ia0r^2)+(ia0i^2));
```

```

14 ia0a=atand(ia0r/ia0i);
15 ia1r=real(ia1);
16 ia1i=imag(ia1);
17 ia1m=sqrt((ia1r^2)+(ia1i^2));
18 ia1a=atand(ia1i/ia1r);
19 ia2r=real(ia2);
20 ia2i=imag(ia2);
21 ia2m=sqrt((ia2r^2)+(ia2i^2));
22 ia2a=atand(ia2i/ia2r);
23 in=ia+ib+ic;
24 mprintf("the symmetric components are \n ir0=%f+j%f
      A \tor\t %f/_%d A",ia0r,ia0i,ia0m,ia0a);
25 mprintf("\n ir1=%f+j%f A \tor\t %f/_%d A",ia1r,ia1i,
      ia1m,ia1a);
26 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

```

1 clear;
2 clc;
3 in=9;
4 ia=in/3;
5 ib=ia;
6 ic=ib;
7 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

```
1 clear;
2 clc;
3 v=11e3/sqrt(3);
4 r=25e6;
5 x2=.35*%i;
6 x0=.1*%i;
7 x1=.25*%i;
8 e=1;
9 ia0=e/(x0+x1+x2);
10 ia0=round(ia0*100)/100;
11 ia1=ia0;
12 ia2=ia0;
13 ia=3*ia0;
14 ibase=r/((3)*v);
15 Ifault=3*ia0*ibase;
16 Ifault=round(Ifault/10)*10;
17 va1=e-(ia1*x1);
18 va2=-ia2*x2;
19 va0=-ia0*x0;
```



```

20 a=1*e^(%i*(120*pi/180));
21 b=a^2;
22 va=(va1+va2+va0);
23 vb=(va0+(b*va1)+(a*va2));
24 vc=(va0+(a*va1)+(b*va2));
25 vab=va-vb;
26 vbc=vb-vc;
27 vca=vc-va;
28 vab=vab*v;
29 vbc=vbc*v;
30 vca=vca*v;
31 va0r=real(vab);
32 va0i=imag(vab);
33 va0m=sqrt((va0r^2)+(va0i^2));
34 va0a=atand(va0i/va0r);
35 va1r=real(vbc);
36 va1i=imag(vbc);
37 va1m=sqrt((va1r^2)+(va1i^2));
38 va1a=atand(va1i/va1r);
39 va2r=real(vca);
40 va2i=imag(vca);
41 va2m=sqrt((va2r^2)+(va2i^2));
42 va2a=atand(va2i/va2r);
43 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);
44 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);
45 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);
46
47 Iar=real(Ifault);
48 Iai=imag(Ifault);
49 Iamod=sqrt((Iar^2)+(Iai^2));
50 iaa=atand(Iar/Iai)-90;

```

```
51 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 fault

```
1 clear;
2 clc;
3 v=11e3;
4 r=10e6;
5 x1=.05*%i;
6 x2=.15*%i;
7 x0=.15*%i;
8 e=1;
9 ia1=e/(x0+x1+x2);
10 ia=3*ia1;
11 ic=e/x0;
12 c=ia/ic;
13 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

```
1 clear;
2 clc;
3 v=11e3;
4 r=25e6;
5 e=1;
6 xg0=.05*%i;
7 x1=.15*%i;
8 x2=.15*%i;
9 zbase=v^2/r;
10 res=.3;
11 xd=res/zbase;
```

```

12 x0=xg0+(3*xd*%i);
13 x=x1+x2+x0;
14 ia0=e/x;
15 ia=3*ia0;
16 iabase=r/(1.7398*v);
17 ia=ia*iabase;
18 ia=fix(ia);
19 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 g

```

1 clear;
2 clc;
3 v=11e3/sqrt(3);
4 r=25e6;
5 x1=.25*%i;
6 x2=.35*%i;
7 x0=.1*%i;
8 xn=0;
9 e=1;
10 ia1=e/(x1+(x0*x2/(x0+x2)));
11 va1=e-(ia1*x1);
12 va2=va1;
13 va0=va2;
14 ia2=-va2/x2;
15 ia0=-va0/x0;
16 a=1*%e^(%i*(120*%pi/180));
17 b=a^2;
18 ia=(ia0+ia1+ia2);
19 ib=(ia0+(b*ia1)+(a*ia2));
20 ic=(ia0+(a*ia1)+(b*ia2));
21 in=3*ia0;
22 va=3*va1;
23 vb=0;

```

```

24 vc=vb;
25 vab=va;
26 vbc=vb-vc;
27 vca=-va;
28 vab=v*vab;
29 vca=v*vca;
30 i=r/(3*v);
31 ia0r=real(ia);
32 ia0i=imag(ia);
33 iam=sqrt((ia0r^2)+(ia0i^2));
34 ia1r=real(ib);
35 ia1i=imag(ib);
36 ibm=sqrt((ia1r^2)+(ia1i^2));
37 ia2r=real(ic);
38 ia2i=imag(ic);
39 icm=sqrt((ia2r^2)+(ia2i^2));
40 ic=icm*i;
41 ib=ibm*i;
42 ia=iam*i;
43 ib=round(ib/01e2)*1e2;
44 ic=round(ic/01e2)*1e2;
45 in=in*i*i;
46 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 r

```

1 clear;
2 clc;
3 v=11e3/sqrt(3);
4 r=25e6;
5 x1=.25*i;
6 x2=.35*i;

```

```

7  xg0=.1*%i;
8  xn=0.1*%i;
9  e=1;
10 x0=xg0+(3*xn);
11 ia1=e/(x1+(x0*x2/(x0+x2)));
12 va1=e-(ia1*x1);
13 va2=va1;
14 va0=va2;
15 ia2=-va2/x2;
16 ia0=-va0/x0;
17 a=1*%e^(%i*(120*%pi/180));
18 b=a^2;
19 ia=(ia0+ia1+ia2);
20 ib=(ia0+(b*ia1)+(a*ia2));
21 ic=(ia0+(a*ia1)+(b*ia2));
22 ia0r=real(ia);
23 ia0i=imag(ia);
24 iam=sqrt((ia0r^2)+(ia0i^2));
25 ia1r=real(ib);
26 ia1i=imag(ib);
27 ibm=sqrt((ia1r^2)+(ia1i^2));
28 ia2r=real(ic);
29 ia2i=imag(ic);
30 icm=sqrt((ia2r^2)+(ia2i^2));//the difference in
    result is due to erroneous calculation in
    textbook.
31 iaa=0;
32 iba=atand(ia1i/ia1r);
33 ica=atand(ia2i/ia2r);
34 mprintf("the symmetric components are \n ia0=%f+j%f
    A \tor\t %f/_%d A",ia0r,ia0i,iam,iaa);
35 mprintf("\n ib=%f+j%f A \tor\t %f/_%d A",ia1r,ia1i,
    ibm,iba);
36 mprintf("\n ic=%f+j(%f) A \tor\t %f/_%d A",ia2r,ia2i
    ,icm,ica);
37 in=ib+ic;
38 mprintf("\nneutal current In=%fA",(imag(in)*1310));
39 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 genera

```
1 clear;
2 clc;
3 r=10e6;
4 v=11e3;
5 e=1;
6 x1=.26*%i;
7 x2=.18*%i;
8 x0=.36*%i;
9 ia1=e/(x1+(x0*x2/(x0+x2)));
10 va1=e-(ia1*x1);
11 va2=va1;
12 va0=va2;
13 ia2=-va2/x2;
14 ia0=-va0/x0;
15 a=1*%e^(%i*(120*%pi/180));
16 b=a^2;
17 ia=(ia0+ia1+ia2);
18 ib=(ia0+(b*ia1)+(a*ia2));
19 ic=(ia0+(a*ia1)+(b*ia2));
20 i=r/(sqrt(3)*v);
21 ia=ia*i;
22 ib=ib*i;
23 ic=ic*i;
24 ia0r=real(ia);
25 ia0i=imag(ia);
26 iam=sqrt((ia0r^2)+(ia0i^2));
27 ia1r=real(ib);
28 ia1i=imag(ib);
29 ibm=sqrt((ia1r^2)+(ia1i^2));
30 ia2r=real(ic);
31 ia2i=imag(ic);
```

```

32 icm=sqrt((ia2r^2)+(ia2i^2));
33 icm=round(icm);
34 ibm=round(ibm);
35 iaa=0;
36 iba=180+atand(ia1i/ia1r);
37 ica=atand(ia2i/ia2r);
38 mprintf("the symmetric components are \n ia0=%f+j%f
      A \tor\t %f/_%d A",ia0r,ia0i,iam,iaa);
39 mprintf("\n ib=%f+j%f A \tor\t %f/_%d A",ia1r,ia1i,
      ibm,iba);
40 mprintf("\n ic=%f+j(%f) A \tor\t %f/_%d A",ia2r,ia2i
      ,icm,ica);
41 in=ib+ic;
42 mprintf("\nneutral current In=%fA", (imag(in)*1310));
43 //at generator
44 x1=.16*i;
45 x2=.08*i;
46 x0=.06*i;
47 va1=1-(ia1*x1);
48 va2=-ia2*x2;
49 va0=ia0*x0;
50 va=(va0+va1+va2);
51 vb=(va0+(b*va1)+(a*va2));//the difference in result
      is due to erroneous calculation in textbook.
52
53 vc=(va0+(a*va1)+(b*va2));
54 v=v/sqrt(3);
55 va=v*va/1e3;
56 vb=v*vb/1e3;
57 vc=v*vc/1e3;
58 va0r=real(va);
59 va0i=imag(va);
60 va0m=sqrt((va0r^2)+(va0i^2));
61 va0a=atand(va0i/va0r);
62 va1r=real(vb);
63 va1i=imag(vb);
64 va1m=sqrt((va1r^2)+(va1i^2));
65 va1a=atand(va1i/va1r);

```

```

66 va2r=real(vc);
67 va2i=imag(vc);
68 va2m=sqrt((va2r^2)+(va2i^2));
69 va2a=atand(va2i/va2r);
70 mprintf("\nthe voltage levels are \n va=%f+j%f kV \
tor\t %f/_%d kV",va0r,va0i,va0m,va0a);
71 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.
72 mprintf("\n vc=%f+j(%f) kV \tor\t %f/_%d kV",va2r,
va2i,va2m,va2a);
73 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

```

1 clear;
2 clc;
3 r=1250e3;
4 v=600;
5 z1=.15*%i;
6 z2=.3*%i;
7 z3=.05*%i;
8 z4=.55*%i;
9 x1=inv(inv(z2)+inv(z1));
10 x2=x1;
11 x0=inv(inv(z3)+inv(z4));
12 e=1;
13 ia1=e/(x1+x2+x0);
14 ia2=ia1;
15 ia0=ia2;
16 ia=3*ia1;//the difference in result is due to
erroneous calculation in textbook.
17 base=r/(sqrt(3)*v);
18 ita=ia*base;

```



```

19 mprintf("the fault current=%fA",-imag(ita));
20 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 fault

```

1  clc;
2  clear;
3  e=1;
4  x1=.15*i;
5  x2=.15*i;
6  ia1=e/(x1+x2);
7  a=1*e^(i*(120*pi/180));
8  b=a^2;
9  ia2=-ia1;
10 ia=(b-a)*ia1;
11 iap=e/x1;
12 c=real(ia)/imag(iap);
13 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

```

1  clear;
2  clc;
3  e=1;
4  x1=.6;
5  x2=.25;
6  x0=.15;
7  ia=1;
8  xn=(3*e/3*ia)-((x1+x2+x0)/3);
9  ifault=1;
10 r=sqrt(8/9);

```

```

11 mprintf("the percentage reactance that should be
    added in the generator neutral =%fpercent\n",xn
    *100);
12 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

```

1 clear;
2 clc;
3 x1=.07*%i;
4 x2=.04*%i;
5 x0=.1*%i;
6 e=1;
7 ia=3*e/(x1+x2+x0);
8 ia=-imag(ia);
9 ia0=ia/3;
10 ia1=ia/3;
11 ia2=ia1;
12 ia1=ia1/3;
13 ia2=ia1;
14 ig1=ia0+ia2+ia1;
15 ig2=ia1+ia2;
16 ig3=ig2;
17 c=ig1/ig2;
18 ia=round(ia*10)/10;
19 c=4.05*c;
20 d=4.05;
21 mprintf("for single line to ground fault Ia=-j%fA",
    ia);
22 mprintf("the ratio of contribution of generator I,
    II and III is %d:%d:%d",c,d,d);
23 i3=e/(x1);
24 il=3*e/(x1+x2+x0);
25 y=i3/il;

```

```
26 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

```
1 clear;
2 clc;
3 vf=1;
4 r=1250e3;
5 V=600;
6 x1=.5;
7 x2=.5;
8 x3=.02;
9 ia2=vf/(x1+x2+x3);
10 ia=3*ia2;
11 ia1=ia2;
12 ia0=ia1;
13 iab=r/(sqrt(3)*V);
14 iab=round(iab/10)*10;
15 ia=round(ia*100)/100;
16 If=ia*iab;//the difference in result is due to
    erroneous calculation in textbook.
17 printf("fault current If=%fA",If);
18 disp("the difference in result is due to erroneous
    calculation in textbook.")
```

Scilab code Exa 23.04 To calculate the fault current

```
1 clear;
2 clc;
3 v=1;
4 r=1250e3;
5 V=600;
6 x1=.05*%i;
7 x2=.05*%i;
8 x0=.02*%i;
9 a=1*%e^(%i*(120*%pi/180));
10 b=a^2;
11 ia1=v/(x1+inv(inv(x2)+inv(x0)));
12 ibase=1200;
13 va1=v-(ia1*x1);
14 ia2=-va1/x2;
15 ia0=-va1/x0;
16 ia=(ia0+ia1+ia2);
17 ib=(ia0+(b*ia1)+(a*ia2));
18 ic=(ia0+(a*ia1)+(b*ia2));
19 ia0r=real(ia);
20 ia0i=imag(ia);
21 iam=sqrt((ia0r^2)+(ia0i^2));
22 ia1r=real(ib);
23 ia1i=imag(ib);
24 ibm=sqrt((ia1r^2)+(ia1i^2));//the difference in
    result is due to erroneous calculation in
    textbook.
25 ia2r=real(ic);
26 ia2i=imag(ic);
27 icm=sqrt((ia2r^2)+(ia2i^2));
28 iaa=0;
29 iba=atand(ia1i/ia1r);
30 ica=atand(ia2i/ia2r);
```

```

31 im=ibm*ibase;
32 mprintf("fault current for double line to ground
    fault=%fA",im)
33 disp("the difference in result is due to erroneous
    calculation in textbook.")

```

Scilab code Exa 23.05 To calculate the fault current

```

1 clear;
2 clc;
3 v=1;
4 r=1250e3;
5 V=600;
6 x1=.05*%i;
7 x2=.05*%i;
8 x0=.02*%i;
9 ia1=v/(x1+x2);
10 ia2=-ia1;
11 ia=ia1+ia2;
12 ia0=0;
13 a=1*%e^(%i*(120*%pi/180));
14 b=a^2;
15 ia=(ia0+ia1+ia2);
16 ib=(ia0+(b*ia1)+(a*ia2));
17 ic=(ia0+(a*ia1)+(b*ia2));
18 ia0r=real(ia);
19 ia0i=imag(ia);
20 iam=sqrt((ia0r^2)+(ia0i^2));
21 ia1r=real(ib);
22 ia1i=imag(ib);
23 ibm=sqrt((ia1r^2)+(ia1i^2));
24 ia2r=real(ic);
25 ia2i=imag(ic);
26 icm=sqrt((ia2r^2)+(ia2i^2));
27 iaa=0;

```

```

28 iba=atand(ia1i/ia1r);
29 ica=atand(ia2i/ia2r);
30 ibase=r/(sqrt(3)*V);
31 ibm=ibm*ibase;
32 ibm=round(ibm/100)*100;
33 mprintf("fault current for double line to ground
    fault=%dA",ibm);

```

Scilab code Exa 23.06 to find the subtransient fault currents

```

1 clear;
2 clc;
3 r=1250e3;
4 v=600;
5 z1=.15*i;
6 z2=.3*i;
7 z3=.05*i;
8 z4=.55*i;
9 x1=inv(inv(z2)+inv(z1));
10 x2=x1;
11 x0=inv(inv(z3)+inv(z4));
12 e=1;
13 ia1=e/(x1+x2+x0);
14 ia2=ia1;
15 ia0=ia2;
16 ia=3*ia1;//the difference in result is due to
    erroneous calculation in textbook.
17 base=r/(sqrt(3)*v);
18 ita=ia*base;
19 mprintf("the fault current=%fA",-imag(ita));
20 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

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

Scilab code Exa 23.08 To calculate fault current and phase voltages

```
1 clear;
2 clc;
3 X1=6.6*%i;
4 X2=6.3*%i;
5 X0=12.6*%i;
6 r=37.5e6;
7 v=33e3;
8 e=1;
9 zb=v^2/r;
10 x1=X1/zb;
11 x2=X2/zb;
12 x0=X0/zb;
13 x1g=.18*%i;
14 x2g=.12*%i;
15 x0g=.1*%i;
16 x1=x1+x1g;
```



```

17 x2=x2+x2g;
18 x0=x0+x0g;
19 ia=3*e/(x1+x2+x0);
20 ia1=ia/3;
21 a=1*e^(%i*(120*%pi/180));
22 b=a^2;
23 ibase=r/(sqrt(3)*v);
24 ian=ia*ibase;
25 printf(" fault current=%djAmp", imag(ian));
26 va=e-(ia1*x1g);
27 vb=-ia1*x2g;
28 vc=-ia1*x0g;
29 va0=(va+vb+vc);
30 va1=(va+(b*vb)+(a*vc));
31 va2=(va+(a*vb)+(b*vc));
32 v=v/sqrt(3);
33 va0=va0*v;
34 va1=va1*v;
35 va2=va2*v;
36 va0r=real(va0);
37 va0i=imag(va0);
38 va0m=sqrt((va0r^2)+(va0i^2));
39 va0a=atand(va0i/va0r);
40 va1r=real(va1);
41 va1i=imag(va1);
42 va1m=sqrt((va1r^2)+(va1i^2));
43 va1a=atand(va1i/va1r)-120;
44 va2r=real(va2);
45 va2i=imag(va2);
46 va2m=sqrt((va2r^2)+(va2i^2));
47 va2a=atand(va2i/va2r)+120;
48 mprintf("\nthe voltage levels are \n va=%f+j%f V \
tor\t %d/_%d kV", va0r/1e3, va0i/1e3, va0m/1e3, va0a)
;
49 mprintf("\n vb=%f+j(%f) kV \tor\t %d/_%d kV", va1r/1
e3, va1i/1e3, va1m/1e3, va1a);
50 mprintf("\n vc=%f+j(%f) kV \tor\t %d/_%d kV", va2r/1
e3, va2i/1e3, va2m/1e3, va2a);

```

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

```
1 clear;
2 clc;
3 e=100/75;
4 r=100e6;
5 v=66e3;
6 xg1=.175*%i*e;
7 xg2=.135*%i*e;
8 X1=.1*%i*e;
9 zn=3*58;
10 ibase=r/(sqrt(3)*v);
11 vbase=v/sqrt(3);
12 zb=vbase/ibase;
13 zg0=zn/zb;
14 f=70e3;
15 e=f/v;
16 x1=.367*%i;
17 x2=.313*%i;
18 z0=zg0+(.133*%i);
19 a=1*e^(%i*(120*%pi/180));
20 b=a^2;
21 ia1=e/x1;
22 mprintf("%f",real(vbase));
23 ia=ia1;
24 ib=b*ia;
25 ic=a*ia;
26 ia=ibase*ia;
27 ib=ibase*ib;
28 ic=ibase*ic;
29 ia0r=real(ia);
30 ia0i=imag(ia);
31 iam=sqrt((ia0r^2)+(ia0i^2));
32 ia1r=real(ib);
```

```

33 ia1i=imag(ib);
34 ibm=sqrt((ia1r^2)+(ia1i^2));
35 ia2r=real(ic);
36 ia2i=imag(ic);
37 icm=sqrt((ia2r^2)+(ia2i^2));
38 iaa=-90;
39 iba=180+atand(ia1i/ia1r);
40 ica=atand(ia2i/ia2r);
41 mprintf("the symmetric components for three phase
      fault are \n ia0=%f+j%f A \tor\t %f/_%d A",ia0r,
      ia0i,iam,iaa);
42 mprintf("\n ib=%f+j%f A \tor\t %f/_%d A",ia1r,ia1i,
      ibm,iba);
43 mprintf("\n ic=%f+j(%f) A \tor\t %f/_%d A",ia2r,ia2i
      ,icm,ica);
44 ia1=e/(x1+x2);
45 ia2=-ia1;
46 ia0=0;
47 ia=(ia0+ia1+ia2);
48 ib=(ia0+(b*ia1)+(a*ia2));
49 ic=(ia0+(a*ia1)+(b*ia2));
50 i=r/(sqrt(3)*v);
51 ia=ia*i;
52 ib=ib*i;
53 ic=ic*i;
54 ia0r=real(ia);
55 ia0i=imag(ia);
56 iam=sqrt((ia0r^2)+(ia0i^2));
57 ia1r=real(ib);
58 ia1i=imag(ib);
59 ibm=sqrt((ia1r^2)+(ia1i^2));
60 ia2r=real(ic);
61 ia2i=imag(ic);
62 icm=sqrt((ia2r^2)+(ia2i^2));
63 iaa=0;
64 iba=180+atand(ia1i/ia1r);
65 ica=atand(ia2i/ia2r);
66 icm=round(icm/10)*10;

```

```

67 ibm=round(ibm/10)*10;
68 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);
69 mprintf("\n ib=%f+j%f A \tor\t %f/_%f A",ia1r,ia1i,
      ibm,iba);
70 mprintf("\n ic=%f+j(%f) A \tor\t %f/_%f A",ia2r,ia2i
      ,icm,ica);
71 ia1=e/(x1+x2+z0);
72 ia2=ia1;
73 ia0=ia2;
74 ia=(ia0+ia1+ia2);
75 ib=(ia0+(b*ia1)+(a*ia2));
76 ic=(ia0+(a*ia1)+(b*ia2));
77 i=r/(sqrt(3)*v);
78 ia=ia*874;
79 ia0r=real(ia);
80 ia0i=imag(ia);
81 iam=sqrt((ia0r^2)+(ia0i^2));
82 ia1r=real(ib);
83 ia1i=imag(ib);
84 ibm=sqrt((ia1r^2)+(ia1i^2));
85 ia2r=real(ic);
86 ia2i=imag(ic);
87 icm=sqrt((ia2r^2)+(ia2i^2));
88 iaa=atand(ia0i/ia0r);
89 iba=0;
90 ica=0;
91 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);
92 mprintf("\n ib=%f+j%f A \tor\t %f/_%f A",ia1r,ia1i,
      ibm,iba);
93 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

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

Scilab code Exa 32.02 To find the CT ratio

```
1 clear;
2 clc;
3 r=30e6;
4 v=11.5e3;
```

```

5 v2=69e3;
6 ip=r/(sqrt(3)*v);
7 ip=round(ip);
8 ratio=3000/5;
9 is=ip/ratio;
10 is=sqrt(3)*is;
11 is=round(is*100)/100;
12 printf("at LV side secondary current Is=%fA\t Ip=%f\t
      ",is,ip);
13 ipn=r/(sqrt(3)*v2);
14 Ct=ipn/is;
15 ct=round(Ct/10)*10;
16 is=5;
17 ip=is*ct;
18 printf("\nSecondary current=%dA\tat HV side CT ratio
      =%d:%d\t primary 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 neut

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

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

```
1 clear;
2 clc;
3 v=10e3/sqrt(3);
```

```

4 R=10;
5 i=1;
6 ct=1000/5;
7 ip=i*ct;
8 per=R*ip*100/v;
9 p=10;
10 res=p/100*v/ip;
11 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

```

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

```

Scilab code Exa 33.05 To find the neutral earthing resistance

```

1 clear;
2 clc;
3 i=200;

```



```
4 c=.1;
5 v=11e3/sqrt(3);
6 per=.15;
7 x=per*v/(i);
8 ru=c*x;
9 vi=v*c;
10 y=i\vi;
11 r=sqrt((y^2)-(ru^2));
12 r=round(r*100)/100;
13 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

```
1 clear;
2 clc;
3 i=5;
4 r=.1;
5 va=i^2*r;
6 j=10+2*va;
7 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

```
1 clear;
2 clc;
3 is=5;
4 pr=2;
5 ir=2.5;
6 pe=pr*(is/ir)^2
```

```
7 mprintf("the burden on transformer Pe=%dVA",pe);
```

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

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

Scilab code Exa 35.04 To calculate the ratio error of CT

```
1 clear;  
2 clc;  
3 r1=.1;  
4 r2=.4;  
5 r=r1+r2;  
6 i=1e3/10;  
7 ip=100*5/50;  
8 ie=10;  
9 e=45;  
10 y=i-ie;  
11 per=(ie*y-(10*i))/(i*10);
```

```
12 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

```
1 clear;
2 clc;
3 v=110;
4 x=.1;
5 i=.1;
6 Va=v*i+(i^2*x);
7 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 transmi

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

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

```
1 clear;
2 clc;
3 x=4+(7*%i);
```

```

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

```

Scilab code Exa 44.03 To calculate the steady state limit

```

1 clear;
2 clc;
3 v=1;
4 p=.91;
5 y=acosd(-.91)-180;
6 y=round(y*10)/10;
7 i=v*e^(y*i*pi/180);
8 x=.37*e^(i*pi/2);
9 e=v+(i*x);
10 e=round(e*100)/100;
11 p=abs(e/x)*v;
12 mprintf("the steady state limit=%fp.u.",p);
13 a=atand(imag(i),real(i))

```

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

```

1 clear;
2 clc;
3 j=50e2;
4 r=100e6;
5 f=60;
6 p=2;
7 g=10;
8 n=120*f/p;

```

```

9 w=2*3.14*n/60;
10 ke=.5*j*w^2*100;
11 h=ke/r;
12 m=g*h/(180*f)
13 m=round(m*1000)/1000;
14 mprintf("the value of anglur momentum M=%fMJ/s/ele.
degrees\nthe Inertia Constant H=%dMJ/MVA",m,round
(h));

```

Scilab code Exa 44.04 To calculate the kinetic energy of rotor

```

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

```

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

```

1 clear;
2 clc;
3 r=200;
4 c=8;
5 e=c*r;
6 f=50;
7 mprintf("stored energy=%dMJ",e);
8 ps=160e6;
9 pe=100e6;
10 p=ps-pe;

```



```

11 m=e*1e6/(180*f);
12 a=p/m;
13 mprintf("\nthe angular acceleration=%f elec.degrees/
    sec ^2",a)

```

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

```

1 clear;
2 clc;
3 ke=200e6;
4 r=50e6;
5 ps=25e6;
6 pe=22.5e6;
7 g=50;
8 f=60;
9 p=ps-pe;
10 h=ke/r;
11 m=g*h/(180*f);
12 m=round(m*10000)/10000;
13 n=m*180/(%pi);
14 n=round(n*100)/100;
15 mprintf("the angular momentum is %fMJ.s/elec.degree\
    tor\t%fMJ.s/rad",m,n);
16 a=p/n/1e6;
17 printf("\nthe angular acceleration =%frac/sec ^2",a);

```

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

```

1 clear;
2 clc;
3 pm=500;
4 d=8;
5 pd=pm*sind(d);

```

```

6 pd=round(pd*10)/10;
7 mprintf("the power developed=%fMW",pd);
8 d=d*pi/180;
9 v=asind(cos(3.14-d))+31.9;
10 p=pm*sind(-v);
11 p=round(p);
12 pz=p-pd;
13 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

```

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

```

Chapter 45

Voltage Control and Compensation of Reactive Power

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

```
1 clear;
2 clc;
3 r1=75;
4 c1=.8;
5 p1=r1*c1;
6 rr1=r1*(sin(acos(c1)));
7 r2=150;
8 c2=.8;
9 p2=r2*c2;
10 rr2=r2*(sin(acos(c2)));
11 r3=50;
12 c3=1;
13 p3=r3*c3;
14 rr3=r3*(sin(acos(c3)));
15 rr=-rr1+rr2+rr3;
16 p=p1+p2+p3;
17 r=sqrt(p^2+rr^2);
```

```
18 r=round(r)
19 j=p/r;
20 mprintf("the power factor of the substation=%f",j);
```

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

```
1 clear;
2 clc;
3 c1=.8;
4 p1=120;
5 r1=p1/c1;
6 rr1=r1*(sin(acos(c1)));
7 c2=.9;
8 r2=p1/c2;
9 rr2=r2*(sin(acos(c2)));
10 rr2=round(rr2);
11 rr=rr1-rr2;
12 printf("the kVAR of capacitors = %fkVA",rr);
```

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

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

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

```

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

```

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

```

1 clear;
2 clc;
3 n1=.89;
4 h1=150;
5 c1=.9;
6 h2=200;
7 n2=.9;
8 c2=.8;
9 h3=500;
10 n3=.93;
11 c3=.707;
12 p4=100;
13 p1=h1*.746/n1;
14 p2=h2*.746/n2;
15 p3=h3*.746/n3;
16 rr1=p1*(tan(acos(c1)));
17 rr2=p2*(tan(acos(c2)));
18 rr3=p3*(tan(acos(c3)));
19 rr4=0;
20 rr=rr1+rr2-rr3+rr4;
21 p=p1+p2+p3+p4;
22 c=rr/p;
23 j=cos(atan(c));
24 j=round(j*1000)/1000;
25 printf("the Power Factor of the combined sub-station
    =%f leading",j);

```

Scilab code Exa 45.01 To find the power factor and KVA

```
1 clear;
2 clc;
3 v=460;
4 i=200;
5 r=1.73*v*i/1e3;
6 r=round(r*10)/10;
7 p=120;
8 c=p/r;//the difference in result is due to erroneous
        calculation in textbook.
9 s=sqrt(1-(c^2))
10 rr=r*s;
11 mprintf("the power factor=%f\nthe rating=%fkVA\n the
        kVAr of system=%fkVA",c,r,rr);
12 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

```
1 clear;
2 clc;
3 //for low loads
4 p1(1)=20;
5 p2(1)=30;
6 t1(1)=.1*p1(1)+20;
7 t2(1)=.12*p2(1)+16;
8 //when load is further increased
9 t2(4)=22;
10 p2(4)=(t2(4)-16)/.12;
11 t1(4)=t2(4);
12 //upper limit 125MW
13 p2(5)=125;
14 t1(5)=.12*p2(5)+16;
15 p1(5)=(t1(5)-20)/.1;
16 n=7;
17 t2(1)=19.6;
18 t2(2)=20;
19 t2(3)=21;
```

```

20 t2(4)=22;
21 t2(5)=31;
22 t2(6)=32;
23 t2(7)=32.5;
24 p1(5)=110;
25 p1(6)=120;
26 p1(7)=125;
27 for j=1:4
28     p1(j)=20;
29 end;
30 mprintf("incremental cost(rs./MWhr)\tloading of unit
    1(MW) \t loading of unit 2(MW)\ttotal generating
    power(MW)");
31 for i=1:n
32     p2(i)=(-16+t2(i))/.12;
33     if(t2(i)>=31)
34         p2(i)=125;
35     end;
36     pt(i)=p1(i)+p2(i);
37     mprintf("\n%f\t\t\t%f\t\t\t%f\t\t\t%f",t2(i),p1(i)
    ,p2(i),pt(i));
38
39 end;

```

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

```

1 clear;
2 clc;
3 p=180;
4 p2=(20-16+(180*.1))/(.1+.12);
5 p1=p-p2;
6 t=.1*p1+20;
7 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

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

Chapter 57

Power Flow Calculations

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

```
1 clear;
2 clc;
3 v=100;
4 z=3+(4*%i);
5 i=v/z;
6 y=1/z;
7 ia=atand(imag(i)/real(i));
8 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

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

Scilab code Exa 57.04 To find the Voltage of the circuit

```
1 clear;
2 clc;
3 v1=1;
4 z=.05+.02*i;
5 s=1-.6*i;
6 c=.000005;
7 v(2,1)=1;
8 mprintf("used value in iteration\titeration number\t
    resulting value of V2")
9 for i=2:100
10     v(2,i)=v1-(z*conj(s))/conj(v(2,i-1));
11     j=v(2,i)-v(2,(i-1));
12     mprintf("\n%f+j(%f)V\t\t\t(%d)\t\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)));
13     if(abs(j)<c)
14         break;
15     end;
16 end;
```

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

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

Scilab code Exa 57.06 Reactive and complex power flow

```
1 clear;
2 clc;
3 x=.05;
4 vs=1;
5 vr=1;
6 p=10;
7 d=asin(p*x);
8 qs=(vs^2/x)-(vs*vr*cos(d)/x);
9 qs=round(qs*100)/100;
10 qR=(vs^2/x)-(vs*vr*cos(d)/x);
11 qR=round(qR*100)/100;
12 q=(qs+qR);
13 mprintf(" %f+j%fpu" ,p,q);
```

Scilab code Exa 57.07 To calculate the pu active power flow

```
1 clear;
2 clc;
3 x=.05;
4 d=30;
5 vs=1;
6 vr=1;
7 p=vs*vr*sind(d)/x;
8 mprintf(" active power flow=%fpu" ,p);
```

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

```

1 clear;
2 clc;
3 z=.06*i;
4 i=1+.6*i;
5 vr=1;
6 vs=vr+(i*z);
7 q=.5*((abs(vs))^2-(abs(vr))^2)/abs(z);
8 q=q-.1;
9 a=atand(imag(vs)/real(vs))
10 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

```

1 clear;
2 clc;
3 v=1;
4 i=1.188*e^(-28.6*i*pi/180);
5 s=v*conj(i);
6 p=real(s);
7 q=(imag(s));
8 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 seid

```

1 clear;
2 clc;
3 v=1.1;
4 s(2)=-(.5-.3*i);
5 y(2,1)=1.9*e^(%i*(100)*%pi/180);
6 y(2,2)=1.6*e^(%i*(-80)*%pi/180);
7 v2(1)=1*e^(%i*(-10)*%pi/180);

```

```

8 for i=2:1000
9     j=1/(y(2,2));
10    z(i)=(s(2)/conj(v2(i-1)));
11    f(i)=(y(2,1)*v);
12    v2(i)=j*(z(i)-f(i));
13    c=atand(imag(v2(i))/real(v2(i)));
14    if(abs(v2(i)-v2(i-1))<.01)
15        break;
16    end
17    mprintf("\nfor %dth iteration Voltage = %f/_%fV
            \t\t%f+j%fV",i,abs(v2(i)),c+3,real(v2(i)),
            imag(v2(i)));
18 end

```

Scilab code Exa 57.12 to determine the modified bus voltage

```

1 clear;
2 clc;
3 v2(1)=1;
4 v2(2)=.983664-.032316*i;
5 a=1.6;
6 v2(3)=v2(1)+a*(v2(2)-v2(1));
7 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

```

1 clear;
2 clc;
3 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)
    ];
4 v(1)=1.04;
5 v(2)=1;
6 v(3)=1.04;
7 p2=.5;
8 p3=-1.5;
9 q2=1;
10 s(1)=0;
11 s(2)=0;
12 s(3)=0;
13 for i=2:3
14     for j=1:3
15         s(i)=s(i)+(conj(v(i))*v(j)*y(i,j));
16     end
17 p(i)=real(s(i));
18 q(i)=-imag(s(i));
19 end;
20 k=[(p2-p(2));(p3-p(3));(q2-q(2))];
21 l=[24.27 -12.23 5.64;-12.23 24.95 -3.05;-6.11 3.05
    22.54];
22 z=inv(l)*k;
23 v(2)=v(2)+z(3);
24 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

```

1 clear;
2 clc;
3 ud1=510;
4 ud2=490;
5 ud=(ud1+ud2)/2;
6 id=1;

```

```

7 p=ud*id;
8 b=2*p;
9 r=(ud1-ud2)/id;
10 pl=r;
11 pbl=2*pl;
12 pdr=ud1;
13 pdi=ud2;
14 pz=pdr-pdi;
15 mprintf("power flow per pole=%dMW\nbipolar line flow
    =%dMW\nthe line loss per pole in bipolar 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

```

1 clear;
2 clc;
3 pdi=1000;
4 pdl=60;
5 ud=1;
6 pdr=pdi+pdl;
7 p=(pdr+pdi)/2;
8 id=pdi/ud;
9 pdc=pdr*1e3/id;
10 rec=pdc/2;
11 vdc=(rec+(pdi/2))/2;
12 udr=rec;
13 udi=pdi/2;
14 r=(udr-udi)*1e3/id;
15 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

```
1 clear;
2 clc;
3 pg=6000;
4 pdc=1000;
5 pac=pg-(2*pdc);
6 pac1=1000;
7 pac2=1000;
8 pac3=1000;
9 pac4=pac-pac1-pac2-pac3;
10 mprintf("power flow through 4th AC line=%dMW",pac4);
```

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

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

Chapter 58

Applications of switchgear

Scilab code Exa 58.02 To find the over current factor

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