

Scilab Textbook Companion for
Power System Analysis And Design
by B. R. Gupta¹

Created by
Ankur Gupta
B.E.
Electrical Engineering
Thapar University
College Teacher
Dr Sunil K. Singla
Cross-Checked by
Lavitha Pereira

July 31, 2019

¹Funded by a grant from the National Mission on Education through ICT, <http://spoken-tutorial.org/NMEICT-Intro>. This Textbook Companion and Scilab codes written in it can be downloaded from the "Textbook Companion Project" section at the website <http://scilab.in>

Book Description

Title: Power System Analysis And Design

Author: B. R. Gupta

Publisher: S. Chand & Co. Ltd., New Delhi

Edition: 6

Year: 2011

ISBN: 81-219-2238-0

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 2

Line Parameters

Scilab code Exa 2.1 find loop resistance and inductance per km of line

```
1 clear
2 clc;
3 dia=1.213;
4 dist=1.25*100;
5 f=50;
6 rad=dia/2;
7 effrad=.7788*rad;
8 L=4d-7 * log (dist/effrad)*1d3;
9 X=2*%pi*f*L;
10 mprintf("L=%0.2 f *1e-4 H/km, X=%0.1 f ohm/km",L*1e4, X)
    ;
```

Scilab code Exa 2.3 inductance per km of a 3 phase line in equilateral triangle

```
1 clear
2 clc;
3 Dia=1.63;
4 Dist=3*100;
```

```

5 Reff=.7788*.5*Dia;
6 Reff=round(Reff*1e3)*1e-3
7 L = .4605 * log10(Dist/Reff);
8
9 mprintf("L= %.4 f mH/km" ,L)

```

Scilab code Exa 2.4 inductance per km of a 3 phase line in parallel formation

```

1 clear
2 clc;
3 rad=1.81;
4 Dist1=6*100;
5 Dist2=Dist1;
6 Dist3=12*100;
7 Reff=.7788*rad;
8 Dist=(Dist1*Dist2*Dist3)^(1/3);
9 L = .4605 * log10(Dist/Reff);
10 mprintf("L=%.4 f mH/km" ,L);

```

Scilab code Exa 2.5 find GMR of 4 bundled conductors

```

1 clear
2 clc;
3 d=25;
4 rad=1.573;
5 Ds=.7788*rad;
6 Dsb=((Ds*d*d*sqrt(2)*d)^4)^(1/16);
7 mprintf("GMR= %.3 f cm" ,fix(Dsb*1000)/1000);

```

Scilab code Exa 2.6 find inductance of bundled conductors

```

1 clear
2 clc;
3 d=45;
4 D=12e2;
5 rad=1.6;
6
7 //(a)
8 reff=.7788*rad;
9 GMR=(reff*d*reff*d)^(1/4);
10 Dab=(D*(D+d)*D*(D-d))^(1/4);
11 Dbc=Dab;
12 Dca=((D*2)*((2*D)+d)*(D*2)*((2*D)-d))^(1/4);
13 Deq=(Dab*Dbc*Dca)^(1/3);
14 L=.4605 *log10 (Deq/GMR);
15 mprintf("\n(a)\tL=%0.2 f mH/km",L);
16
17 //(b)
18 R=sqrt(2)*rad;
19 reff=R*.7788;
20 Deq=(D*D*(2*D))^(1/3);
21 L=.4605 *log10 (Deq/reff);
22
23 mprintf("\n(b)\tL=%0.3 f mH/km",L);

```

Scilab code Exa 2.7 find inductance of conductors in vertical configuration

```

1 clear
2 clc;
3 D=3e2;
4 h=5e2;
5 rad=1.1;
6
7 m=(h^2 + D^2)^(1/2);
8 n=(h^2 + (D*2)^2)^(1/2);
9 reff=.7788* rad;

```

```

10 L=2e-7 * log ((2)^(1/6)* (D/reff)^(1/2) * (m/n)
    ^ (1/3)) *1e3;
11 mprintf("L=%0.2f * 1e-4 H/phase/km",L*1e4);

```

Scilab code Exa 2.8 find inductance of conductors in given configuration

```

1 clear;
2 clc;
3 D=3e2;
4 d1=6e2;
5 d2=7e2;
6 rad=.9;
7
8 reff=.7788* rad;
9 Daa=(d1^2 + d1^2)^(1/2);
10 Dcc=Daa;
11 Dbb=d2;
12 GMRa=sqrt(reff*Daa);
13 GMRb=sqrt(reff*Dbb);
14 GMRc=sqrt(reff*Dcc);
15 Ds=(GMRa*GMRb*GMRc)^(1/3);
16 Ds=round(Ds*10)/10
17
18 Dab=(D^2 + ((d2-d1)/2)^2)^(1/2);
19 Dcb=Dab;
20 Dc1b1=Dab;
21 Da1b1=Dab;
22
23 Dab1=(D^2 + (((d2-d1)/2)+d1)^2)^(1/2);
24 Da1b=Dab1;
25 Dc1b=Dab1;
26 Dcb1=Dab1;
27
28 Dac=2*D;
29 Da1c1=Dac;

```

```

30 Da1c=(d1);
31 Dac1=Da1c;
32
33 GMRab=(Dab*Da1b1*Da1b*Dab1)^(1/4);
34 GMRbc=(Dcb*Dc1b1*Dc1b*Dcb1)^(1/4);
35 GMRac=(Dac*Da1c1*Da1c*Dac1)^(1/4);
36
37 Deq=(GMRab*GMRbc*GMRac)^(1/3);
38 Deq=round(Deq*10)/10
39
40 L=2e-7 * log (Deq/Ds) * 1e3;
41 mprintf("L=%0.3 f *1e-4 H/phase/km",L*1e4);

```

Scilab code Exa 2.9 capacitance between single phase conductors

```

1 clear;
2 clc;
3
4 l=10;
5 D=1.25;
6 dia=1.213e-2;
7
8 Cab=.01206/log10(D/(dia/2))
9 C=1*Cab;
10 Cn=2*C;
11
12 mprintf("Capacitance between 2 conductors= %0.4 f e-6F
/km\n", C);
13 mprintf("Capacitance between conductor and neutral=
%0.4 f e-6F/km\n", Cn);

```

Scilab code Exa 2.10 capacitance between three phase conductors

```

1  clearglobal;
2  clc;
3
4  V=220e3;
5  f=50;
6  l=200;
7  d1=6;
8  d2=12;
9  rad=1.81e-2;
10
11 Deq=(d1*d1*d2)^(1/3);
12 Cn=.02412/log10(Deq/rad);
13 mprintf(" Capacitance per phase per km = %.1f *1e-3 e
        -6F/phase/km \n", Cn *1000);
14 C=l*Cn;
15 C=round(C*100)/100
16 mprintf(" Capacitance per phase = %.2f e-6F/phase\n",
        C);
17 Xc=1/(2 * %pi * f * C *1e-6);
18 mprintf(" Capacitive reactance per phase = %.0f ohms/
        phase\n", Xc);
19 I=2 * %pi * f * C *1e-6 * V / sqrt(3);
20 I=round(I*100)/100
21 mprintf(" Charging current = %.2f A/phase\n", I);
22 MVA=sqrt(3)*V *I *1e-6;
23 mprintf(" Charging MVA = %.2f MVA\n", fix(MVA*100)
        /100);

```

Scilab code Exa 2.11 capacitance of bundled conductors

```

1  clear;
2  clc;
3
4  r= 1.6e-2;
5  d= 45e-2;

```

```

6 D=12;
7 Dscb=sqrt(r*d);
8 Deq=(D*D*(2*D))^(1/3);
9 Cn= .02412/(log10 (Deq/Dscb));
10 mprintf(" Capacitance per phase per km= %.4 f e-6 F/km
    \n", Cn);

```

Scilab code Exa 2.12 capacitance of double circuit three phase lines in hexagon

```

1 clear
2 clc;
3
4 D=350;
5 r=1.09;
6 f=50;
7 V=132e3;
8 d=100;
9
10 //(b)
11 Cn=.04824 / log10((sqrt(3)*D)/(2*r));
12 Cn=round(Cn*10000)/1e4
13 C=Cn/2;
14 mprintf(" Capacitance per conductor per km = %.5 f e-6
    F/conductor/km\n", C);
15
16 //(c)
17 w=2 * %pi * f;
18 Vn=V/sqrt(3);
19 Ic= w * Cn * Vn * 1e-6;
20 Ic=round(Ic *1e3)/1e3
21 I=Ic * d;
22 MVA= sqrt(3)*V * I / 1e6;
23 mprintf(" Charging MVA = %.2 f MVA\n", MVA);

```

Scilab code Exa 2.13 capacitance of double circuit three phase lines

```
1 clear
2
3 clc;
4
5 r=.9e-2;
6 d=6;
7 D1=6;
8 D2=7;
9
10 Daa=sqrt ((d*d)+(D1*D1));
11 Daa=round(Daa*1e3)/1e3
12 Dbb=D2;
13 Dcc=Daa;
14 Deq=5.074;
15
16 Dsc_a = round(sqrt(r*Daa)*1e4)/1e4;
17 Dsc_b = round(sqrt(r*Dbb)*1e4)/1e4;
18 Dsc_c = round(sqrt(r*Dcc)*1e4)/1e4;
19
20 Dsc=(Dsc_a*Dsc_b*Dsc_c)^(1/3);
21 Cn=.02412/log10(Deq/Dsc);
22
23 mprintf(" Capacitance per conductor per km = %f e-6 F
    /conductor/km\n", Cn);
```

Scilab code Exa 2.14 capacitance of conductor taking neutral into account

```
1 clear;
2 clc;
3
```



```

4 h=5.5;
5 Dia=1.213e-2;
6 d=1.25;
7 l=10;
8
9 r=Dia/2;
10 Cn=(2*.01206)/(log10 (d/(Dia* 0.5 * sqrt(1 + (d*d
    *.25/h^2))))));
11 C=Cn * l;
12
13 mprintf(" Capacitance per conductor= %.5f e-6 F/
    conductor\n",C);

```

Scilab code Exa 2.15 resistance at 20 and 50 deg C

```

1 clear
2 clc;
3
4 dia=4.22e-3;
5 n=6;
6 T1=20;
7 T2=50;
8 rho1 = 2.826e-8;
9 a=.004;
10 dL=1.5e-2;
11 L=1000;
12
13 A=%pi * n *dia *dia / 4;
14 R1= rho1 * L * (1+dL) / A;
15 R2= R1 * (1+ (a * (T2-T1)));
16
17 mprintf(" Temperature at %d = %.4f ohm/km\n", T1, R1)
    ;
18 mprintf(" Temperature at %d = %.4f ohm/km", T2, R2);

```

Scilab code Exa 2.16 finding line parameters charging current and charging MVA

```
1 clear;
2 clc;
3
4 A= 1.5e-4;
5 Deff=39.8e-3;
6 D= 8;
7 rho1=1.73e-6 / 100;
8 l=1e3;
9 f=50;
10 V=132e3;
11
12 //(a)
13 R= rho1 * l / A;
14 r=.5 * Deff;
15 L= .4605 * log10 (D/(.7788 *r));
16 mprintf("L = %.2 f mH/km\n",L);
17
18 C= .02412/(log10 (D/r));
19 mprintf("C = %.5 f e-6 F/km\n",C);
20
21 //(b)
22 Ic = 2 * %pi * f * C *1e-6 * V / sqrt(3);
23 mprintf("Charging current = %.4 f A/km/phase\n",Ic);
24 MVA=sqrt(3)*V *Ic *1e-6;
25 mprintf("Charging MVA = %.4 f MVA/km\n",MVA);
```

Scilab code Exa 2.17 inductance of conductors in horizontal plane

```
1 clear;
2 clc;
```

```

3
4 r=.9e-2;
5 d=3.5;
6
7
8 //(b)
9
10 L= .4605 * log10(1.375 * sqrt(d/r));
11 mprintf(" (b) L= %.2 f mH/km", L);

```

Scilab code Exa 2.18 inductance of conductors in horizontal plane

```

1 clear;
2 clc;
3 clear;
4
5
6 dia=26.88;
7 d=450
8 d1=15.25*1e3;
9
10 R=dia/2;
11 R1= .7788 * R;
12 R1=round(R1*100)/100
13 GMR= 1.09 * (R1 * d*d*d)^(.25);
14 GMR=round(GMR*10)/10
15 GMD=(d1* d1 * (2*d1))^(1/3);
16 GMD=round(GMD/10)*10
17 L=.4605 * log10 (GMD/GMR);
18
19 mprintf(" L= %.4 f mH/km", L);

```

Scilab code Exa 2.19 inductance of 3 wire 3 phase line in horizontal configuration

```

1  clear
2  clc
3
4  dia=2.5e-2
5  d=3
6
7  r=dia/2
8  r1=.7788*r
9
10 c=exp(%i *2*%pi/3)
11 b=exp(%i *-2*%pi/3)
12 k=2
13
14 Dab=d
15 Dac=2*d
16 Dbc=d
17 Dca=2*d
18
19 La=round(k*(log(1/r1) + log(1/Dab)*b + log(1/Dac)*c)
      *1e3)/1e4
20 Lb=round(k*(log(1/Dab) + log(1/r1)*b + log(1/Dbc)*c)
      /b*1e3)/(1e4)
21 Lc=round(k*(log(1/Dac) + log(1/Dbc)*b + log(1/r1)*c)
      /c*1e3)/(1e4)
22
23 disp(La, "La= (mH/km)")
24 disp(Lb, "Lb= (mH/km)")
25 disp(Lc, "Lc= (mH/km)")

```

Scilab code Exa 2.20 capacitance of conductors in horizontal plane

```

1  clear;
2  clc;
3
4  dia=26.88e-3;

```

```

5 d=45e-2;
6 d1=15.25;
7
8 r=dia/2;
9
10 GMR= 1.09 * (r * d*d*d)^(.25);
11 GMD=(d1* d1 * (2*d1))^(1/3);
12
13 C= 0.02412 / log10 (GMD/GMR);
14 mprintf("C= %.4f e-6 F/km", C);

```

Scilab code Exa 2.21 inductance per km per phase of bundled conductor

```

1 clear;
2 clc;
3 f=50;
4 dia=25e-3;
5 sp=.3;
6 D=6;
7
8 rad=dia/2;
9 r=.7788*rad;
10 GMR= ((r*r*sp*sp)^.25);
11 Dab= (D* (D+sp)* D *(D-sp))^.25;
12 Dbc=Dab;
13 Dac= ((2*D)* ((2*D) +sp)* (2*D) *((2*D)-sp))^.25;
14 Deq=(Dab * Dbc *Dac)^(1/3);
15 L=.4605 * log10 (Deq/GMR);
16 mprintf("\nL= %.3f mH/phase/km", L);
17 XL=2 * %pi * f * L *1e-3;
18 mprintf("\nXL= %.2f ohm/phase/km", XL);

```

Chapter 3

Performance of Transmission lines

Scilab code Exa 3.1 convert to per unit system at common base

```
1 clear;
2 clc;
3
4
5 sg1=10e6;
6 vg1=13.2e3;
7 sg2=15e6;
8 vg2=13.2e3;
9 sm1=8e6;
10 vm1=12.5e3;
11 sm2=12e6;
12 vm2=12.5e3;
13 Xg=15;
14 Xm=20;
15
16 sb=50e6;
17 vb=13.8e3;
18
19 xg1=Xg * (vg1/vb)^2 * (sb/sg1);
```

```

20 xg2=Xg * (vg2/vb)^2 * (sb/sg2);
21 xm1=Xm * (vm1/vb)^2 * (sb/sm1);
22 xm2=Xm * (vm2/vb)^2 * (sb/sm2);
23 mprintf ("\nReactance of Generator 1= %.2f percent"
    ,xg1);
24 mprintf ("\nReactance of Generator 2= %.2f percent"
    ,xg2);
25 mprintf ("\nReactance of Motor 1= %.2f percent",xm1
    );
26 mprintf ("\nReactance of Motor 2= %.2f percent",xm2
    );

```

Scilab code Exa 3.2 convert to per unit system at common base with neutral resistance

```

1 clear;
2 clc;
3
4 vg=11e3;
5 sg=90e6;
6 xg=.25;
7
8 st1=100e6;
9 vt1a=10e3;
10 vt1b=132e3;
11 nt1=vt1a/vt1b;
12 xt1=.06;
13
14 st2=30e6 *3;
15 vt2a=66e3 * sqrt(3);
16 vt2b=10e3;
17 nt2=vt2a/vt2b;
18 xt2=.05;
19
20 sm1=50e6;
21 vm1=10e3;

```

```

22 xm1=.2;
23
24 sm2=40e6;
25 vm2=10e3;
26 xm2=.2;
27
28 x1=100;
29
30 Sb=sg;
31 Vbg=v;
32
33 Xg=xg * (vg/Vbg)^2 * (Sb/sg);
34 Xt1=xt1 * (vt1a/Vbg)^2 * (Sb/st1);
35
36 Vb1=Vbg/nt1;
37 Xl=x1 * (Sb) / (Vb1)^2 ;
38
39 Vbm=Vb1/nt2;
40
41 Xt2=xt2 * (vt2b/Vbm)^2 * (Sb/st2);
42 Xm1=xm1 * (vm1/Vbm)^2 * (Sb/sm1);
43 Xm2=xm2 * (vm2/Vbm)^2 * (Sb/sm2);
44
45 mprintf ("\nReactance of Generator = %.2 f ",Xg);
46 mprintf ("\nReactance of Transformer 1= %.4 f ",Xt1)
    ;
47 mprintf ("\nReactance of Line = %.3 f ",Xl);
48 mprintf ("\nReactance of Transformer 2= %.3 f ",Xt2)
    ;
49 mprintf ("\nReactance of Motor 1= %.3 f ",Xm1);
50 mprintf ("\nReactance of Motor 2= %.3 f ",Xm2);

```

Scilab code Exa 3.3 find X of windings of 3 winding transformer

```
1 clear;
```



```

2  clc;
3
4  s1=30e6;
5  v1=132e3;
6  s2=20e6;
7  v2=11e3;
8  v3=6.6e3;
9  s3=10e3;
10
11 xa=.07;
12 xb=.09;
13 xc=.04;
14 va=v1;
15 vb=v1;
16 vc=v2;
17 sa=s1;
18 sb=s1;
19 sc=s2;
20
21 Sb=s1;
22 Vb1=v1;
23 Vb2=v2;
24 Vb3=v3;
25
26 Xa=xa * (va/Vb1)^2 * (Sb/sa);
27 Xb=xb * (vb/Vb1)^2 * (Sb/sb);
28 Xc=xc * (vc/Vb2)^2 * (Sb/sc);
29
30 X = [1 1 0; 1 0 1; 0 1 1]^(-1) * [ Xa; Xb; Xc];
31
32 mprintf("\nX1= %.2 f pu",X(1,1));
33 mprintf("\nX2= %.2 f pu",X(2,1));
34 mprintf("\nX3= %.2 f pu",X(3,1));

```

Scilab code Exa 3.4 find voltage regulation and capacitor required to make voltage

```

1  clear;
2  clc;
3
4  d=15;
5  Vr=11e3/sqrt(3);
6  pfr=.8;
7  Pd=5e6;
8  Pl=.12*Pd;
9  l=1.1e-3;
10 L=l*d;
11
12 I= Pd/(3*pfr*Vr);
13 R=Pl/(3*I*I);
14 X=2 * %pi* 50 *L;
15 pfa=acos(pfr);
16 Vs=Vr + (I * R * pfr) + (I * X * sin(pfa));
17 vs=sqrt(3)*Vs;
18
19 VR=(Vs-Vr)/Vr;
20
21 mprintf("\n(a) Voltage Regulation = %.2f percent ",
          VR*100);
22
23 pfa0=atan(R/X);
24 pf0=cos(pfa0);
25
26 mprintf("\n(b) pf at VR=0 = %.3f ", pf0);
27
28 I0= (I* pfr)/pf0;
29 Ic= (I * sin(pfa))+(I0*sin(pfa0));
30 Xc=Vr/Ic
31 C=1/(100*%pi*Xc);
32
33 mprintf("\n(c) C = %.1f e-6 F", C*1e6);

```

Scilab code Exa 3.5 receiving end voltage and current

```
1 clear;
2 clc;
3
4 Vs=11e3/sqrt(3);
5 Pd=1200e3;
6 R=5.31;
7 X=5.54;
8 pfr=.8;
9
10
11 VIr= Pd/(3*pfr);
12 a=1;
13 b=-1*Vs;
14 pfa=acos(pfr)
15 c=(VIr * R * pfr) + (VIr * X * sin(pfa))
16
17 Vr=(-b+sqrt(b^2 - (4*a*c)))/(2*a);
18
19 I=VIr/Vr;
20 vr=sqrt(3)*Vr;
21
22 mprintf("Receiving end Voltage = %.3f KV and Current
          = %.2f A ",vr/1000,I);
```

Scilab code Exa 3.6 receiving end voltage and current

```
1 clear;
2 clc;
3
4 Pd=1e6;
5 pf=.8;
6 v1=30e3;
7 v2=10e3;
```

```

8 Rl=25;
9 Xl=12;
10 rt=.8;
11 xt=2.5;
12 n=v1/v2;
13
14 Rt=rt*(n^2);
15 Xt=xt*(n^2);
16
17 R=Rt+Rl;
18 X=Xt+Xl;
19
20 Vr=v1/sqrt(3);
21 I=Pd/(3*Vr*.8);
22
23 pfa=acos(pf)
24 Vs=Vr + (I * R * pf) + (I * X * sin(pfa));
25 vs=sqrt(3)*Vs*1e-3;
26
27 VR=(Vs-Vr)/Vr;
28
29 mprintf("\nSending End Voltage = %.2f KV",vs);
30 mprintf("\nVoltage Regulation= %.2f",VR*100);

```

Scilab code Exa 3.7 determine per phase R and X for given efficiency

```

1 clear;
2 clc;
3
4 Vs=33e3/sqrt(3);
5 Vr=30e3/sqrt(3);
6 Pr=10e6;
7 pf=.8;
8 eff=.96;
9

```

```

10 I=Pr/(3*Vr*pf);
11
12 Ps=Pr/eff;
13 Pl=Ps-Pr;
14
15 R=Pl/(3*I*I);
16 pfa=acos(pf);
17 X=((Vs-Vr)-(I*R*pf))/(I*sin(pfa));
18
19 mprintf("R= %.1f ohm per phase , X= %.1f ohm per
           phase" ,R,X);

```

Scilab code Exa 3.8 receiving end voltage and current power factor and Voltage reg

```

1 clear;
2 clc;
3
4 R=48.7;
5 X=80.2;
6 Z=complex(R,X);
7 c=8.42e-9;
8 l=200;
9 C=c*l;
10 Y=complex(0,(C* 100*%pi));
11
12 Vr=88e3/sqrt(3);
13 Pr=13.5e6;
14 pf=.9;
15 pfa=-1* acos(pf);
16 Irm=Pr/(3*Vr*pf);
17 Ir=complex(Irm *pf , Irm * sin(pfa));
18
19 Vs=(Vr*(1+((Z*Y)/2)))+(Ir*Z*(1+(Z*Y/4)));
20 V=abs(Vs);
21 vs=sqrt(3)*V*1e-3;

```

```

22 phi=atan(imag(Vs)/real(Vs))*(180/%pi);
23 mprintf("\nSending End Voltage = %.2f kV",vs);
24 mprintf("\nSending End Power Angle = %.1f deg ",phi)
    ;
25
26 Is=(Vr*Y)+(Ir*(1+(Y*Z/2)));
27 I=abs(Is);
28 mprintf("\nSending End Current = %.2f A",I);
29
30 Vr0=V/(1+(Y*Z/2));
31 V0=abs(Vr0);
32 VR=(V0-Vr)/Vr;
33 mprintf("\nVoltage Regulation = %.1f ",VR*100);

```

Scilab code Exa 3.9 receiving end voltage and current power factor and Voltage reg

```

1 clear;
2 clc;
3
4 R=48.7;
5 X=80.2;
6 Z=complex(R,X);
7 c=8.42e-9;
8 l=200;
9 C=c*l;
10 Y=complex(0,(C* 100*%pi));
11
12 Vr=88e3/sqrt(3);
13 Pr=13.5e6;
14 pf=.9;
15 pfa=-1* acos(pf);
16 Irm=Pr/(3*Vr*pf);
17 Ir=complex(Irm *pf, Irm * sin(pfa));
18
19 Vs=(Vr*(1+((Z*Y)/2)))+(Ir*Z);

```

```

20 V=abs(Vs);
21 vs=sqrt(3)*V*1e-3;
22 phi=atan(imag(Vs)/real(Vs))*(180/%pi);
23 mprintf("\nSending End Voltage = %.2f kV",vs);
24 mprintf("\nSending End Power Angle = %.2f deg ",phi)
    ;
25
26 Is=(Vr*Y*(1+(Z*Y/4)))+(Ir*(1+(Y*Z/2)));
27 I=abs(Is);
28 mprintf("\nSending End Current = %.2f A",I);
29
30 Vr0=V/(1+(Y*Z/2));
31 V0=abs(Vr0);
32 VR=(V0-Vr)/Vr;
33 mprintf("\nVoltage Regulation = %.2f ",VR*100);

```

Scilab code Exa 3.10 receiving end voltage and current power factor and Voltage re

```

1 clear;
2 clc;
3
4 d=100;
5 f=50;
6 r=.153;
7 l=1.21e-3;
8 c=.00958e-6;
9 xl=2*%pi*f*l;
10 xc=1/(2*%pi*f*c);
11 Vr=110e3/sqrt(3);
12 Pr=20e6;
13 pf=.9;
14 pfa=-1*acos(pf);
15 Irm=Pr/(3*Vr*pf);
16 Ir=complex(Irm *pf, Irm * sin(pfa));
17

```

```

18 Z=complex(r,xl) * d;
19 Y=complex(0,1/xc) *d;
20
21 //disp(abs(Z),Y,abs(Ir));
22
23 Vs=(Vr*(1+((Z*Y)/2)))+(Ir*Z);
24 V=abs(Vs);
25 vs=sqrt(3)*V*1e-3;
26 mprintf("\nSending End Voltage = %.2f kV",vs);
27
28 Is=(Vr*Y*(1+(Z*Y/4)))+(Ir*(1+(Y*Z/2)));
29 I=abs(Is);
30 mprintf("\nSending End Current = %.2f A",I);
31
32 phi1=atan(imag(Vs)/real(Vs))*(180/%pi);
33 phi2=atan(imag(Is)/real(Is))*(180/%pi);
34 phi=phi1-phi2;
35 pfs=cosd(phi);
36 mprintf("\nSending End Power factor = %.3f ",pfs);
37
38
39 Vr0=V/(1+(Y*Z/2));
40 V0=abs(Vr0);
41 VR=(V0-Vr)/Vr;
42 mprintf("\nVoltage Regulation = %.2f ",VR*100);
43
44 eff=Pr*100/(3*pfs*V*I)
45 mprintf("\nEfficiency = %.0f percent ",eff);

```

Scilab code Exa 3.11 find receiving end parameters

```

1 clear;
2 clc;
3
4 d=500;

```



```

5 z=complex(.105, .3768);
6 y=complex(0, 2.822e-6);
7 Z=z*d;
8 Y=y*d;
9 YZ=Y*Z;
10
11 A=1+(YZ/2)+((YZ)^2/24);
12 B=Z * (1+(YZ/6)+((YZ)^2/120));
13 C=Y * (1+(YZ/6)+((YZ)^2/120));
14 D=A;
15
16 A=round(abs(A)*10000)/10000 * exp(%i * round(atan(
    imag(A)/real(A))*100)/100)
17 B=round(abs(B)*1000)/1000 * exp(%i * round(atan(
    imag(B)/real(B))*100)/100)
18
19 //see(B)
20
21
22 Vr=220e3/sqrt(3); //incorrectly taken as 127021 in
    textbook.
23 Vr=round(Vr)
24 Pr=40e6;
25 pf=.9;
26 pfa=-1*acos(pf);
27 Irm=Pr/(3*Vr);
28 Ir=complex(Irm *pf, Irm * round(sin(pfa)*100)/100);
29
30 Vs=(A*Vr)+(B*Ir);
31 V=abs(Vs);
32 vs=sqrt(3)*V*1e-3;
33 phi1=atand(imag(Vs)/real(Vs));
34 mprintf("\nSending End Voltage = %.2f kV",vs);
35
36 Is=(C*Vr)+(D*Ir);
37 I=abs(Is);
38 phi2=atand(imag(Is)/real(Is))
39 mprintf("\nSending End Current = %.2f A",I);

```

```

40
41 phi=phi2-phi1;
42 pfs=cosd(phi);
43 mprintf("\nSending End Power factor = %.3f ",pfs);
44 mprintf("\nSending End Power Angle = %.3f ",phi1);
45
46 MVA=sqrt(3) * vs* I /1000;
47 mprintf("\nSending End Power = %.3f ",MVA);
48
49 disp("difference in results is due to taking Vr=
      127021V instead of 127017V")

```

Scilab code Exa 3.12 find OC receiving end parameters

```

1 clear;
2 clc;
3
4 d=500;
5 z=complex(.105, .3768);
6 y=complex(0, 2.822e-6);
7 Z=z*d;
8 Y=y*d;
9 YZ=Y*Z;
10
11 A=1+(YZ/2)+((YZ)^2/24);
12 B=Z * (1+(YZ/6)+((YZ)^2/120));
13 C=Y * (1+(YZ/6)+((YZ)^2/120));
14 D=A;
15
16 Vr=220e3/sqrt(3);
17 Pr=40e6;
18 pf=.9;
19 pfa=-1*acos(pf);
20 Ir=0;
21

```

```

22 Vs=(A*Vr)+(B*Ir);
23 V=abs(Vs);
24 vs=sqrt(3)*V*1e-3;
25 phi1=atan(imag(Vs)/real(Vs))*(180/%pi);
26 mprintf("\nSending End Voltage = %.2f kV",vs);
27
28 Is=(C*Vr)+(D*Ir);
29 I=abs(Is);
30 phi2=atan(imag(Is)/real(Is))*(180/%pi);
31 mprintf("\nSending End Current = %.1f A",I);
32
33 phi2=phi2+180;
34 phi=phi1-phi2;
35 pfs=cosd(phi);
36 mprintf("\nSending End Power factor = %.4f ",pfs);

```

Scilab code Exa 3.13 find characteristic impedance propagation constant and ABCD f

```

1 clear;
2 clc;
3
4 Z=complex(14.1, 51.48);
5 Y=complex(0, 1.194e-3);
6 Zc=sqrt(Z/Y);
7 g=sqrt(Z*Y);
8 A=cosh(g);
9 B=Zc* sinh(g);
10 C=sinh(g)/Zc;
11 D=A;
12
13 mprintf("\nZc= %s", string(round(abs(Zc)*1000)/1000)
        + '/_'+ string(round(atan(imag(Zc)/real(Zc))
        *100)/100) )
14 mprintf("\npropagation const= %s", string(round(abs(g)
        *1000)/1000) + '/_'+ string(round(atan(imag(g)/

```

```

    real(g))*100)/100) )
15 mprintf("\nA= %s", string(round(abs(A)*1000)/1000) +
    '/_'+ string(round(atan(imag(A)/real(A))*100)
    /100) )
16 mprintf("\nB= %s", string(round(abs(B)*1000)/1000) +
    '/_'+ string(round(atan(imag(B)/real(B))*100)
    /100) )
17 mprintf("\nC= %s", string(round(abs(C)*1000)/1000) +
    '/_'+ string(round(atan(imag(C)/real(C))*100)
    /100 +180) )
18 mprintf("\nD= %s", string(round(abs(D)*1000)/1000) +
    '/_'+ string(round(atan(imag(D)/real(D))*100)
    /100) )

```

Scilab code Exa 3.14 find receiving end voltage and current

```

1 clear;
2 clc;
3
4 Z=complex(200*cosd(80), 200*sind(80));
5 Y=complex(.0013*cosd(90), .0013*sind(90));
6 YZ=Y*Z;
7
8 A=1+(YZ/2)+((YZ)^2/24);
9 B=Z * (1+(YZ/6)+((YZ)^2/120));
10 phiA=atan(imag(A)/real(A))*(180/%pi);
11 phiB=atan(imag(B)/real(B))*(180/%pi);
12
13 P=60e6
14 pf=.8;
15 Vs=round(220/sqrt(3))*1e3;
16 Virm=P/(3*pf)
17 pfa=acos(pf);
18 VIr=complex(Virm *pf, Virm * sin(pfa));
19

```

```

20 pfa=pfa*(180/%pi);
21 a=(round(abs(A)*1000)/1000)^2;
22 b=round(((2*(abs(A)*(Virm)*cosd(phiA)*abs(B)*cosd(
    phiB-pfa)))+(2*(abs(A)*(Virm)*sind(phiA)*abs(B)
    )*sind(phiB-pfa)))-(Vs^2))/1e7)*1e7;
23 c=abs(B)^2*(Virm)^2;
24 Vr=sqrt((-b+sqrt((b*b)-(4*a*c)))/(2*a));
25
26 vr=sqrt(3)*Vr/1000;
27 Ir=Vlr/(Vr*pf);
28 mprintf("Receiveing End Line voltage= %.0f kV", fix(
    vr));
29 mprintf("\n Receiveing End Line Current= %.0f A", Ir
    );

```

Scilab code Exa 3.15 finding and comparing pi and T network parameters

```

1 clear;
2 clc;
3
4 Z=complex(180*cosd(75), 180*sind(75));
5 Y=complex(1e-3*cosd(90), 1e-3*sind(90));
6
7 g=sqrt(Y*Z);
8 Zc=sqrt(Z/Y);
9
10 Z1=Zc * sinh(g);
11 Y1=(1/Zc) *1e3*((cosh(g)-1)/sinh(g));
12
13
14 mprintf("\nZpi= %s", string(round(abs(Z1)*100)/100
    + '/' + string(round(atan(imag(Z1)/real(Z1))*100)
    /100) );
15 mprintf("\nYpi/2= %s *1E-3", string(round(abs(Y1)
    *10000)/10000) + '/' + string(round(atan(imag(Y1)

```

```
/real(Y1))*10)/10) )
```

Scilab code Exa 3.16 sending end parameters using nominal pi circuit and long line

```
1 clear;
2 clc;
3
4 Vr=132e3/sqrt(3);
5 P=40e6;
6 pf=.8;
7 Irm=P/(3*Vr)
8 pfa=-1* acos(pf);
9 Ir=complex(Irm *pf, Irm * sin(pfa));
10
11 Z=complex(52, 200)
12 Y=complex(0, 1.5e-3)
13 YZ=Y*Z;
14
15 A=1+ (YZ/2);
16 D=A;
17 B=Z;
18 C=Y*(1+(YZ/4));
19
20 Vs=(A*Vr)+(B*Ir);
21 V=abs(Vs)
22 vs=V*sqrt(3)*1e-3;
23 mprintf("(a)\nSending End Voltage= %.0f kV", vs)
24
25 Is=(C*Vr)+(D*Ir);
26 I=abs(Is)
27 mprintf("\nSending End Current= %.1f A", I)
28
29 phi1=atan(imag(Vs)/real(Vs))*(180/%pi);
30 phi2=atan(imag(Is)/real(Is))*(180/%pi);
31 phi=phi1-phi2;
```

```

32 pfs=cosd(phi);
33 fprintf("\nSending End pf= %.3f ",pfs)
34
35 Ps=sqrt(3)* vs * I * pfs /1000;
36 fprintf("\nSending End Power= %.1f ",Ps)
37
38
39 //(b)
40 Zc=sqrt(Z/Y);
41 g=sqrt(Z*Y);
42 A=cosh(g);
43 B=Zc* sinh(g);
44 C=sinh(g)/Zc;
45 D=A;
46
47 Vs=(A*Vr)+(B*Ir);
48 V=abs(Vs)
49 vs=V*sqrt(3)*1e-3;
50 fprintf("\n\n\n(b)\nSending End Voltage= %.1f kV",
        vs)
51
52 Is=(C*Vr)+(D*Ir);
53 I=abs(Is)
54 fprintf("\nSending End Current= %.1f A", fix(I*10)
        /10)
55
56 phi1=atan(imag(Vs)/real(Vs))*(180/%pi);
57 phi2=atan(imag(Is)/real(Is))*(180/%pi);
58 phi=phi1-phi2;
59 pfs=cosd(phi);
60 fprintf("\nSending End pf= %.3f ",pfs)
61
62 Ps=sqrt(3)* vs * I * pfs /1000;
63 fprintf("\nSending End Power= %.1f ",Ps)

```

Scilab code Exa 3.17 ABCD parameters of pi network

```
1 clear;
2 clc;
3
4 Y1=500^-1;
5 Y2=1000^-1;
6 Z=100;
7
8 A= 1+Y2 * Z;
9 B=Z;
10 C=Y1+Y2+(Y1*Y2*Z);
11 D=1+Y1 * Z
12
13 mprintf("A= %.1f ; B= %.1f ohm ; C=%.1f *1e-3seimens
          ; D= %.1f", A, B, C*1e3, D);
```

Scilab code Exa 3.18 ABCD parameters of composite system

```
1 clear;
2 clc;
3
4 A1=complex(.98 * cosd(2), .98* sind(2));
5 B1=complex(28 * cosd(69), 28* sind(69));
6 C1=complex(.0002 * cosd(80), .0002* sind(80));
7 D1=A1;
8
9 A2=complex(.95 * cosd(3), .95* sind(3));
10 B2=complex(40 * cosd(85), 40* sind(85));
11 C2=complex(.0004 * cosd(90), .0004* sind(90));
12 D2=A2;
13
14 //(a)
15
16 A= (A1* A2) + (B1* C2);
```



```

17 B= (A1* B2) + (B1* D2);
18 C= (C1* A2) + (D1* C2);
19 D= (C1* B2) + (D1* D2);
20
21
22 mprintf("(a)");
23 mprintf("\nA= %s", string(round(abs(A)*1000)/1000) +
    ' / _ ' + string(round(atan(imag(A)/real(A))*10)/10)
    )
24 mprintf("\nB= %s", string(round(abs(B)*100)/100) + ' /
    _ ' + string(round(atan(imag(B)/real(B))*100)/100)
    )
25 mprintf("\nC= %s *1e-4", string(round(abs(C)*100000)
    /10) + ' / _ ' + string(round(atan(imag(C)/real(C))
    *10)/10 ) )
26 mprintf("\nD= %s", string(round(abs(D)*1000)/1000) +
    ' / _ ' + string(round(atan(imag(D)/real(D))*10)/10)
    )
27
28
29 //(b)
30
31 Vr=110e3/sqrt(3);
32 pf=.95;
33 Irm=200
34 pfa=-1* acos(pf);
35 Ir=complex(Irm *pf, Irm * sin(pfa));
36
37 Vs=(A*Vr)+(B*Ir);
38 V=abs(Vs)
39 vs=V*sqrt(3)*1e-3;
40 mprintf("\n\n\n(b)\nSending End Voltage= %.2 f kV",
    vs)
41
42 Is=(C*Vr)+(D*Ir);
43 I=abs(Is)
44 mprintf("\nSending End Current= %.1 f A", I)
45

```

```

46 phi1=atan(imag(Vs)/real(Vs))*(180/%pi);
47 phi2=atan(imag(Is)/real(Is))*(180/%pi);
48 phi=phi1-phi2;
49 pfs=cosd(phi);
50 mprintf("\nSending End pf= %.2 f ",pfs)

```

Scilab code Exa 3.19 ferrenti effect

```

1 clear;
2 clc;
3
4 Vr=220e3/sqrt(3);
5 d=300;
6 f=50;
7
8 V=-1*((Vr*(2*%pi*f)^2 * d*d *1e-10)/18);
9 Vs=Vr+V;
10 vs=sqrt(3) * Vs /1000;
11 mprintf("Sending end voltage=%.2 f kV, and voltage
    rise =%.0 f V/phase", vs, -1*V)

```

Scilab code Exa 3.20 P and Q consumed by generator and motor in circuit and line 1

```

1 clear;
2 clc;
3
4 E=11e3/sqrt(3);
5 E1=complex(E*cosd(0), E*sind(0));
6 E2=complex(E*cosd(40), E*sind(40));
7 Z=complex(0,15);
8 I=(E1-E2)/Z;
9
10 if (real(I)<0)      then

```

```

11     mprintf("E1=generator , E2=motor");
12     else
13         mprintf("E2=generator , E1=motor");
14 end
15
16 S1=3 * E1 *1e-6* conj(I);
17 S2=3 * E2 *1e-6* conj(I);
18
19 mprintf("\n\n(a) Real Power consumed by E2= %.3 f MW,\
    nPower delivered by E1= %.3 f MW", -1*real(S2),
    -1*real(S1) );
20 mprintf("\n\n(b) Reactive Power supplied by E1= %.3 f
    MVar,\nPower supplied by E2= %.3 f MVar", imag(S1
    ), imag(S2)*-1 );
21 mprintf("\n\n(C) Reactive Power absorbed by line= %
    .3 f MVar", 2* imag(S1) );

```

Scilab code Exa 3.21 compensation parameters

```

1 clear;
2 clc;
3
4 Vr=132e3/sqrt(3);
5 P=50e6;
6 pf=.8;
7 Irm=P/(3*Vr)
8 pfa=-1* acos(pf);
9 Ir=complex(Irm *pf, Irm * sin(pfa));
10
11 A=complex(.98*cosd(3), .98*sind(3));
12 B=complex(110*cosd(75), 110*sind(75));
13
14 Vs=(A*Vr)+(B*Ir);
15 V=abs(Vs)
16 vs=V*sqrt(3)*1e-3;

```

```

17 mprintf("\n\n\n(a)\nSending End Voltage= %.1 f kV" ,
    vs)
18
19 phi1=atan(imag(Vs)/real(Vs))*(180/%pi);
20 mprintf("\nPower Angle= %.2 f " ,phi1)
21
22
23 Ss=((vs)^2 * conj(A/B))-((sqrt(3)*Vr/1000)*(sqrt(3)
    *Vs/1000)/conj(B));
24 Ps=real(Ss);
25 Qs=imag(Ss);
26
27 mprintf("\n\n\n(b)\nSending End Active Power= %.1 f
    MW" , Ps)
28 mprintf("\nSending End Reactive Power= %.1 f MVar
    lagging" , Qs)
29
30 Pl=Ps-(P * cos(pfa)*1e-6);
31 Ql=Qs-(P* -1*sin(pfa)*1e-6);
32 mprintf("\n\n\n(c)\nLine Loss= %.1 f MW" , Pl)
33 mprintf("\nMVar absorbed by line= %.1 f MVar" , Ql)
34
35 Pr=(P * cos(pfa)*1e-6);
36 Qr=(P * sin(pfa)*1e-6);
37 Vs1=140;
38 Vr1=132;
39
40 bd=acos(( Pr+real(((Vr1)^2 * conj(A/B))) ) * (abs(B)
    /(Vs1 *Vr1)));
41 Qr1= (((Vs1 *Vr1)/abs(B))*sin(bd))- imag(((Vr1)^2 *
    conj(A/B)));
42 Q=-Qr-Qr1;
43 mprintf("\n\n\n(d)\nCapacity of static capacitor= %
    .1 f MVar" , Q)
44
45 Vs2=132;
46 Vr2=132;
47 bd2=asin(( imag(((Vr2)^2 * conj(A/B))) ) * (abs(B)/(

```

```

    Vs2 *Vr2)));
48 P2= (((Vs2 *Vr2)/abs(B))*cos(bd2))- real(((Vr2)^2 *
    conj(A/B)));
49 mprintf("\n\n\n(e)\nPower supplied= %.2 f MW",P2)

```

Scilab code Exa 3.22 find tapsetting of transformer

```

1 clear;
2 clc;
3
4 Pr=90e6
5 pf=.9;
6 S=Pr/(3*pf);
7
8 P=Pr/3
9 Q=sqrt(S^2 - P^2);
10
11 V1=220e3/sqrt(3);
12 V2=220e3/sqrt(3);
13
14 R=15
15 X=50;
16
17 tr=sqrt(1-(((R*P)+(X*Q))/(V1^2)));
18 mprintf("tap setting tr= %.4f, ts=%.3 f",fix(1e4/tr)
    /1e4,tr)

```

Scilab code Exa 3.23 find tap setting under given conditions

```

1 clear;
2 clc;
3
4 Vb=132

```

```

5 Sb=100
6 X=.15
7
8 v1=125
9 V1=v1/Vb;
10 Q1=50;
11 Qpu1=Q1/Sb;
12
13 Vn1=(V1 + sqrt(V1^2 - (4*Qpu1*X)))/(2*1);
14 vn1=Vn1 * Vb;
15 Vo1=33;
16 t1=vn1/Vo1;
17
18 v2=140
19 V2=v2/Vb;
20 Q2=20;
21 Qpu2=Q2/Sb;
22
23 Vn2=(V2 + sqrt(V2^2 - (4*Qpu2*X)))/(2*1);
24 vn2=Vn2 * Vb;
25 Vo2=33;
26 t2=vn2/Vo2;
27
28 tm=(t1+t2)/2;
29 dt=tm-t1;
30 ts=dt*100/tm
31
32 mprintf("tap setting = +- %.0f percent", ts);

```

Scilab code Exa 3.26 find capacity of phase modifier at different loads

```

1 clear;
2 clc;
3
4 Vr1=132

```

```

5 Vs1=140
6 VA=40;
7 pf=.8;
8 Pr=VA*pf;
9 pfa=-1* acos(pf);
10 Qr=(VA * sin(pfa));
11
12 A=complex(.98*cosd(3), .98*sind(3));
13 B=complex(110*cosd(75), 110*sind(75));
14
15 bd1=acos(( Pr+real(((Vr1)^2 * conj(A/B))) ) * (abs(B
    )/(Vs1 *Vr1)));
16 Qr1= (((Vs1 *Vr1)/abs(B))*sin(bd1))-imag(((Vr1)^2 *
    conj(A/B)));
17
18 Q1=-Qr-Qr1;
19 mprintf("\n\n\n(a)\nCapacity of static capacitor= %
    .2f MVar leading", fix(Q1*100)/100)
20
21 Prn=0;
22 Qrn=0;
23
24 bd2=acos((Prn+real(((Vr1)^2 * conj(A/B))) ) * (abs(B
    )/(Vs1 *Vr1)));
25 Qr2= (((Vs1 *Vr1)/abs(B))*sin(bd2))-imag(((Vr1)^2 *
    conj(A/B)));
26
27 Q2=-Qrn-Qr2;
28 mprintf("\n\n\n(b)\nCapacity of static capacitor= %
    .1f MVar lagging", -Q2)

```

Scilab code Exa 3.28 power transfer and SPM rating to improve pf

```

1 clear;
2 clc;

```

```

3
4 Vr=220
5 Vs=240
6
7 A=complex(.9*cosd(1), .9*sind(1));
8 B=complex(140*cosd(84), 140*sind(84));
9
10 b=atan(imag(B)/real(B));
11 d=b
12 vs=complex (Vs *cos(d), Vs *sin(d));
13 P= (((Vs *Vr)/abs(B))*cos(b-d))- real(((Vr)^2 * conj
      (A/B)));
14 mprintf("(a) Max Power Transmitted = %.2f MW", P);
15
16 Pr=80;
17 Sr=100;
18 Qr=sqrt(Sr^2 - Pr^2);
19 bd1=round(acos(( Pr+real(((Vr)^2 * conj(A/B)))) ) * (
      abs(B)/(Vs *Vr)))*1000)/1000;
20 Qr1= (((Vs *Vr)/abs(B))*sin(bd1))-imag(((Vr)^2 *
      conj(A/B)));
21
22 Q=+Qr-Qr1;
23 mprintf("\n\n(b)\nCapacity of static capacitor= %
      .2f MVar leading", Q)
24 disp("There is a calculation error in the textbook.
      40-49.37=10.63")
25
26 d1=b-bd1;
27 d1=d1*180/%pi
28 mprintf("\n\n(c)\nLoad Angle factor= %.2f deg", d1
      )

```

Scilab code Exa 3.29 overall ABCD parameters


```

1  clear;
2  clc;
3
4  A=complex(.93*cosd(3), .93*sind(3));
5  B=complex(150*cosd(70), 150*sind(70));
6  D=A;
7
8  C=((A*D)-1)/B
9
10 Z=complex(100*cosd(70), 100*sind(70));
11 Y=complex(.00025*cosd(-75), .00025*sind(-75));
12
13 m1=[A B; C D]
14 m2=[1 0 ; Y 1 ]
15 m3=[1 Z ; 0 1 ]
16
17 A0=m1*m2*m3;
18 A1=A0(1,1)
19 B1=A0(1,2)
20 C1=A0(2,1)
21 D1=A0(2,2)
22
23 mprintf("\nA0= %s", string(round(abs(A1)*1000)/1000)
    + '/_'+ string(round(atan2(imag(A1)/real(A1))*10)
    /10) )
24 mprintf("\nB0= %s", string(round(abs(B1)*1000)/1000)
    + '/_'+ string(round(atan2(imag(B1)/real(B1))
    *100)/100) )
25 mprintf("\nC0= %s", string(round(abs(C1)*100000)
    /100000) + '/_'+ string(round(atan2(imag(C1)/real(
    C1))*1)/1) ) )
26 mprintf("\nD0= %s", string(round(abs(D1)*1000)/1000)
    + '/_'+ string(round(atan2(imag(D1)/real(D1))*10)
    /10) )

```

Scilab code Exa 3.30 find wavelength and velocity of propagation

```
1 clear;
2 clc;
3
4 f=50;
5 l=200;
6 Z=complex(14.1, 51.48);
7 Y=complex(0, 1.194e-3);
8 g=sqrt(Z*Y);
9
10 b=imag(g)/l;
11 wl=2*pi/b;
12 v=f*wl
13 mprintf("\nwavelength = %.4f*1e3 km",wl*1e-3);
14 mprintf("\nVelocity of Propagation = %.2f*1e5 km/sec
    ",v*1e-5);
```

Scilab code Exa 3.31 sending end parameters using pu

```
1 clear;
2 clc;
3
4 clear;
5 clc;
6
7
8 vr=220e3/sqrt(3);
9 Vb=vr
10 Vr=vr/Vb
11 Sr=40e6;
12 Sb=40e6;
13 Ib=Sb/(3*Vb)
14 Zb=Vb/Ib;
15
```

```

16 pf=.9;
17 pfa=-1*acos(pf);
18 Irm=(Sr/(3*vr))/Ib;
19 Ir=complex(Irm *pf, Irm * sin(pfa));
20
21
22 d=500;
23 z=complex(.105, .3768);
24 y=complex(0, 2.822e-6);
25 Z1=z*d;
26 Y1=y*d;
27 Z=Z1/Zb;
28 Y=Y1*Zb;
29 YZ=Y*Z;
30
31 A=1+(YZ/2)+((YZ)^2/24);
32 B=Z * (1+(YZ/6)+((YZ)^2/120));
33 C=Y * (1+(YZ/6)+((YZ)^2/120));
34 D=A;
35
36
37 Vs=(A*Vr)+(B*Ir);
38 V=abs(Vs);
39 vs=sqrt(3)*V*1e-3*Vb;
40 phi1=atan(imag(Vs)/real(Vs))*(180/%pi);
41 mprintf("\nSending End Voltage = %.2f kV",vs);
42
43 Is=(C*Vr)+(D*Ir);
44 I=abs(Is)*Ib;
45 phi2=atan(imag(Is)/real(Is))*(180/%pi);
46 mprintf("\nSending End Current = %.1f A",I);
47
48 phi=phi2-phi1;
49 pfs=cosd(phi);
50 mprintf("\nSending End Power factor = %.3f ",pfs);
51
52 MVA=sqrt(3) * vs* I /1000;
53 mprintf("\nSending End Power = %.2f ",MVA);

```

Scilab code Exa 3.32 find voltage at sending end

```
1 clear;
2 clc;
3
4 VAt1=10
5 VAt2=10
6 Xt1=.1;
7 Xt2=.08
8 Vt1a=13.8
9 Vt1b=138
10 Vt2a=138
11 Vt2b=69
12 n1=Vt1b/Vt1a
13 n2=Vt2b/Vt2a
14
15
16 Sb=10
17 Vbb=138;
18 Vba=Vbb / n1;
19 Vbc=Vbb*n2;
20
21 Zbc=Vbc^2/Sb;
22
23 R=300;
24 Rpu=R/Zbc;
25
26 v=66
27 V=v/Vbc;
28 I=V/Rpu;
29 Va=V+(I*complex(0,Xt1+Xt2));
30 va=abs(Va)*Vba;
31
32 mprintf(" Voltage in ckt A = %.3f kV" , va);
```

Scilab code Exa 3.33 find pu values of system

```
1 clear;
2 clc;
3
4 xg1=.2
5 xg2=.3
6 xt1=.2;
7 xt2=.06
8 z1=complex(40,150);
9
10 Vg1=250
11 Vg2=250;
12 Vt1a=250
13 Vt1b=800;
14 Vt2a=1000;
15 Vt2b=500
16 nt1=Vt1b/Vt1a;
17 nt2=Vt2b/Vt2a;
18
19 sg1=2000;
20 sg2=2000;
21 st1=4000;
22 st2=8000;
23
24 Vb1=250;
25 Vb2=Vb1*nt1;
26 Vb3=Vb2*nt2;
27
28 Sb=5000;
29 Zb1=Vb2^2/Sb;
30
31 Z1=z1/Zb1;
32 Xt1=xt1 /((Vb1/Vt1a)^2 * (st1/Sb));
```

```

33 Xt2=xt2 / ((Vb2/Vt2a)^2 * (st2/Sb));
34 Xg1=xg1 / (sg1/Sb);
35 Xg2=xg2 / (sg2/Sb);
36
37 mprintf ("\nReactance of Generator 1= %.1 f ",Xg1);
38 mprintf ("\nReactance of Generator 2= %.2 f ",Xg2);
39 mprintf ("\nReactance of Transformer 1= %.2 f ",Xt1)
    ;
40 disp (round(Z1*1e4)/1e4,"Impedance of Line = ");
41 mprintf ("\nReactance of Transformer 2= %.4 f ",Xt2)
    ;

```

Scilab code Exa 3.34 find pu values of system

```

1 clear;
2 clc;
3
4 sg1=10
5 sg2=20
6 st1=10
7 st2=10*3;
8
9 vg1=6.6;
10 vg2=11.5;
11 vt1a=6.6
12 vt1b=115
13 vt2a=75*sqrt(3);
14 vt2b=7.5*sqrt(3);
15 nt1=vt1b/vt1a;
16 nt2=vt2b/vt2a;
17 xg1=.1
18 xg2=.1
19 xt1=.15
20 xt2=.1
21

```

```

22
23 Sb=20;
24 Vb1=6.6;
25 Vb2=Vb1*nt1;
26 Vb3=Vb2*nt2;
27
28 Xg1=xg1*Sb/sg1;
29 Xg2=xg2*Sb/sg2;
30 Xt1=xt1 * Sb/st1;
31 Xt2= xt2 * Sb/st2 * (vt2a/Vb2)^2
32
33 mprintf ("\nReactance of Generator 1= %.1 f",Xg1);
34 mprintf ("\nReactance of Generator 2= %.1 f",Xg2);
35 mprintf ("\nReactance of Transformer 1= %.1 f ",Xt1)
    ;
36 mprintf ("\nReactance of Transformer 2= %.5 f ",fix(
    Xt2*1e5)/1e5);
37
38
39 Zb1=Vb2^2/Sb;
40
41 xab=100;
42 xad=100
43 xbc=150;
44 xbd=200;
45 xdc=50;
46
47 Xab=xab/Zb1;
48 Xad=xad/Zb1;
49 Xbc=xbc/Zb1;
50 Xbd=xbd/Zb1;
51 Xdc=xdc/Zb1;
52
53 printf("\nXab=%.4 f\t", Xab);
54 printf("Xad=%.4 f\t", Xad);
55 printf("Xbc=%.4 f\t", Xbc);
56 printf("Xbd=%.4 f\t", Xbd);
57 printf("Xdc=%.4 f\t", Xdc);

```

Scilab code Exa 3.35 find pu values of system

```
1 clear;
2 clc;
3
4 sg1=25
5 sg2=15
6 sg3=30
7 st1=30
8 st2=15
9 st3=10*3;
10
11 vg1=6.6;
12 vg2=6.6;
13 vg3=13.2;
14 vt1a=6.6
15 vt1b=115
16 vt2a=6.6
17 vt2b=115
18 vt3a=69*sqrt(3);
19 vt3b=6.9*sqrt(3);
20 nt1=vt1b/vt1a;
21 nt2=vt2b/vt2a;
22 nt3=vt3b/vt3a;
23
24 xg1=.2
25 xg2=.15
26 xg3=.15
27 xt1=.1
28 xt2=.1
29 xt3=.1
30
31 Sb=30;
32 Vb1=6.6;
```



```

33 Vb2=Vb1*nt1;
34 Vb3=Vb2*nt2;
35 Vb4=Vb2*nt3;
36
37 Xg1=xg1*Sb/sg1;
38 Xg2=xg2*Sb/sg2;
39 Xg3=xg3*Sb/sg3* (vg3/Vb4)^2;
40 Xt1=xt1 * Sb/st1;
41 Xt2=xt2 * Sb/st2;
42 Xt3= xt2 * Sb/st3 * (vt3b/Vb4)^2
43
44 mprintf ("\nReactance of Generator 1= %.2 f pu",Xg1)
    ;
45 mprintf ("\nReactance of Generator 2= %.1 f pu",Xg2)
    ;
46 mprintf ("\nReactance of Generator 3= %.4 f pu",Xg3)
    ;
47 mprintf ("\nReactance of Transformer 1= %.1 f pu",
    Xt1);
48 mprintf ("\nReactance of Transformer 2= %.1 f pu",
    Xt2);
49 mprintf ("\nReactance of Transformer 3= %.3 f pu",
    Xt3);
50
51
52 Zb1=Vb2^2/Sb;
53
54 x11=120;
55 x12=90
56
57 X11=x11/Zb1;
58 X12=x12/Zb1;
59
60 mprintf ("\nReactance of Line 1 = %.4 f pu",X11);
61 mprintf ("\nReactance of line 2 = %.3 f pu",X12);

```

Scilab code Exa 3.36 calculate actual values of generator current line current loa

```
1 clear;
2 clc;
3
4 vg=11e3;
5 sg=80e6;
6 xg=.25;
7
8 st1=100e6;
9 vt1a=11e3;
10 vt1b=220e3;
11 nt1=vt1a/vt1b;
12 xt1=.05;
13
14 st2=150e6;
15 vt2a=230e3 ;
16 vt2b=33e3;
17 nt2=vt2a/vt2b;
18 xt2=.04;
19
20 r=250;
21
22 z1=complex(5,100);
23
24 Sb=100e6;
25 Vbg=11e3;
26
27 Xg=xg * (vg/Vbg)^2 * (Sb/sg);
28 Xt1=xt1 * (vt1a/Vbg)^2 * (Sb/st1);
29
30 Vb1=Vbg/nt1;
31 Z1=z1 * (Sb) / (Vb1)^2 ;
32
```

```

33 Vbm=Vb1/nt2;
34 Xt2=xt2 * (vt2a/Vb1)^2 * (Sb/st2);
35 R=r * (Sb) / (Vbm)^2 ;
36
37
38 Vg=vg/Vbg;
39 i=Vg/(Z1+complex(R,Xt1+Xt2+Xg))
40 I=round(abs(i)*1e4)/1e4;
41
42 Ic=I*Sb/(sqrt(3)*Vbg);
43 Il=I*Sb/(sqrt(3)*Vb1);
44 Ir=I*Sb/(sqrt(3)*Vbm);
45 Vload=Ir*r/1000;
46 Vloadll=sqrt(3) * Vload;
47 Pr=3*Ir*Ir*r/1e6;
48 mprintf("\n Generator Current = %.1f A",Ic);
49 mprintf("\n Line Current = %.3f A",Il);
50 mprintf("\n Load Current = %.1f A",Ir);
51 mprintf("\n Load Voltage = %.2f kV",Vloadll);
52 mprintf("\n Load Power = %.3f MW",Pr);

```

Scilab code Exa 3.38 sending and receiving end voltage and current in parallel OH

```

1 clear;
2 clc;
3
4 z1=complex(4,6)
5 z2=complex(3,2)
6
7 Vs=3.3e3/sqrt(3)
8 Is=250
9 pf=.8
10 pfa=acos(pf)
11 I=Is *(exp(%i * -pfa))
12

```

```

13 I1=I * z2/(z1+z2)
14 pfa1=atan(imag(I1)/real(I1))
15 pf1=cos(pfa1)
16 mprintf("\n(a) Current in OH line = %.1f A pf= %.3f"
    , abs(I1), pf1)
17
18 I2=I * z1/(z1+z2)
19 pfa2=atan(imag(I2)/real(I2))
20 pf2=cos(pfa2)
21 mprintf("\n(b) Current in cable = %.2f A pf= %.2f",
    abs(I2), pf2)
22
23 vr=sqrt((Vs)^2-imag(I1*z1)^2)-real(I1*z1)
24 Vr=vr*sqrt(3)/1000;
25 mprintf("\n(c) Receiving end voltage = %.3f KV", Vr)
26
27 d=atan(imag(I1*z1)/(Vr+real(I1*z1)))
28 phi=pfa-d;
29 pfr=cos(phi)
30 mprintf("\n(d) Receiving end pf = %.1f lagging", pfr
    )

```

Scilab code Exa 3.39 find receiving end voltage and efficiency of transmission

```

1 clear;
2 clc;
3
4 l=300
5 R=.4 *3
6 X=.8*3
7 Vs=11e3/sqrt(3);
8 P=3000;
9 pf=.8
10 pfa=acos(pf)
11 VIr=P/(3*pf)

```

```
12
13 a=1;
14 b=-Vs
15 c=Vlr * 1e3 * ((R*cos(pfa))+(X*sin(pfa)))
16 vr=(-b+sqrt((b*b )- (4*a*c)))/(2*a)
17 Ir=Vlr*1e3/vr;
18 Vr=vr*sqrt(3)/1000;
19 fprintf("\nReceiving End Voltage = %.2f kV",Vr)
20
21 P1=3* (Ir)^2 * R/ 1000;
22 eff=P*100/(P+P1)
23 fprintf("\nefficiency = %.2f percent",eff)
```

Chapter 4

Overhead Line Insulators

Scilab code Exa 4.1 find voltage across string and string efficiency

```
1 clear;
2 clc;
3
4 C=1;
5 C1=0.1;
6 V=66;
7 n=4;
8
9 v1= 1;
10 v2= (C+C1) * v1;
11 v3= (C * v2) + (C1*(v1+v2));
12 v4= (C * v3) + (C1*(v1+v2+v3));
13
14 V1= V/(sqrt(3)*(v1+v2+v3+v4));
15 V2= v2* V1;
16 V3= v3* V1;
17 V4= v4* V1;
18 mprintf("\n V1= %.2 f kV",V1);
19 mprintf("\n V2= %.2 f kV",V2);
20 mprintf("\n V3= %.2 f kV",V3);
21 mprintf("\n V4= %.2 f kV",V4);
```

```

22
23 eff= (V1+V2+V3+V4)/(n*V4) *100;
24 mprintf("\n string efficiency= %.1f percent",eff);

```

Scilab code Exa 4.2 calculate string efficiency with presesnce of guard ring

```

1 clear
2 clc
3
4 c1=.15
5 c2=.05
6 V=100
7
8 A=[
9 1+c1 -(1+c2) -c2
10 c1 1+c1 -(1+c2)
11 1 0 0
12 ]
13
14 B=[0 0 1]'
15 Vm=inv(A) * B
16 Vm = round(Vm*1e4)/1e4
17 V1=V/(Vm(1)+Vm(2)+Vm(3))
18 V2=Vm(2) * V1
19 V3=Vm(3) * V1
20
21 ef=V/(3*V3)
22
23 mprintf(" Voltage distribution in percentage of total
    voltage:\nV1=%.2f\tV2=%.2f\tV3=%.2f\nstring
    efficiency=%.1f percent",V1, V2, V3,ef*100)

```

Scilab code Exa 4.3 find voltage across string and string efficiency

```

1 clear;
2 clc;
3
4 n=3
5 V=11;
6 C1=1;
7 C2=.2 * C1;
8
9 v1=1;
10 v2=(C1+C2)*v1/C1;
11 v3=((C1*v2)+(C2*(v1+v2)))/C1;
12
13 V3=V
14 V1=fix((V3/v3)*100)/100;
15 V2=round((V1*v2)*100)/100;
16
17 Vln=V1+V2+V3;
18 Vll=sqrt(3)*Vln;
19 eff=Vln*100/(n*V);
20
21 mprintf("\n(a) Maximum line to neutral voltage = %.2
    f kV", Vln);
22 mprintf("\n(b) String Efficiency = %.0f percent",
    eff);

```

Scilab code Exa 4.4 find capacitance ratio system voltage and string efficiency

```

1 clear;
2 clc;
3 v3=20;
4 v2=15;
5 //putting v1=15/(1+k)
6 s=poly([-1 5 3], "x", "coeff");
7 K=roots(s);
8 k=K(2)

```



```

 9 v1=15/(1+k);
10 //disp(v1)
11 x=v1(1);
12 //disp(x);
13 vnew=x+v3+v2;
14 x1=sqrt(3)*vnew;
15 n=vnew/(3*v3);
16 mprintf("capacitance ratio= %.2f \nthe line to
    neutral voltage= %.1fkV \n string efficiency=%.1
    fpercent",k,x1,n*100);

```

Scilab code Exa 4.5 guard ring find string efficiency

```

1 clear;
2 clc;
3 a=.26;
4 b=.15;
5 c=.35;
6 y=[(1+b) b;-(1+a) (1+c)];
7 z=[1+a;a];
8 v=round(inv(y)*z*1e3)*1e-3;
9 t=v(1,1);
10 u=v(2,1);
11 n=(t+u+1)/(3*u);
12 mprintf("the string efficiency is =%.2f",n);

```

Scilab code Exa 4.6 voltage across various discs in insulator

```

1 clear;
2 clc;
3 k=.1;
4 n=4;
5 for i=1:4

```

```

6      z(i)=2*cosh((i-.5)*sqrt(k))*sinh(.5*sqrt(k))/
          sinh(n*sqrt(k));
7  end
8  mprintf("v1= %.3fV, v2= %.3fV, v3= %.3fV, v4= %.3fV"
          , z(1), z(2), z(3), z(4))

```

Scilab code Exa 4.7 line to oin capacitances so that voltage distribution is unifo

```

1  clear;
2  clc;
3  c=1;
4  w=1;
5  v=1;
6  c1=c*w*v/(4*w*v);
7  c2=2*w*v/(3*w*v);
8  c3=3*w*v/(2*w*v);
9  c4=4*w*v/(1*w*v);
10 mprintf("the capacitance are \nc1=%0.2fC\nc2=%0.2fC\
          nc3=%0.1fC\nc4=%0.0fC" , c1 , c2 , c3 , c4);

```

Scilab code Exa 4.8 find mutual capacitances of insulator discs

```

1  clear;
2  clc;
3  w=1;
4  c=1;
5  v=1;
6  y=5;
7  c2=w*c*v+(w*y*v);
8  c3=2*w*c+6*w*c;
9  c4=3*w*c+8*w*c;
10 mprintf("the capacitance is \nc2=%dC\nc3=%dC\nc3=%dC"
          , c2 , c3 , c4);

```

Scilab code Exa 4.9 find ratio of capacitances of insulator to earth capacitance o

```
1 clear;
2 clc;
3 v=1;
4 v1=.4*v;
5 v2=.6*v;
6 k=(v2-v1)/v1;
7 mprintf("the ratio of capacitance to insulator to
  the capacitance to earth=%d",1/k);
```

Chapter 5

Mechanical Design of Overhead Lines

Scilab code Exa 5.1 finding sag in different weather conditions

```
1 clear;
2 clc;
3
4 m=.847;
5 g=9.81;
6 dia=1.95e-2;
7 l=244;
8 T=3.56e4;
9 Th_ice=.96e-2;
10 F_wind= 382;
11 W_ice=8920;
12 h=7.62;
13 L=1.43;
14
15 //(a)
16 w=m*g;
17 S= (w*l*1)/(8*T);
18 mprintf("\n (a)Sag= %.2 f m" , S);
19
```

```

20 // (b)
21 D=dia+Th_ice+Th_ice;
22 Fw=F_wind * D;
23 Wice = W_ice * (%pi/4) * ((D*D)-(dia*dia));
24 F=((w+Wice)^2 + Fw^2)^.5;
25 s=(F*l*l)/(8*T);
26 a=atan(Fw/(w+Wice));
27 S2=s * cos (a);
28 mprintf("\n (b) Vertical Sag= %.2f m", S2);
29
30 // (c)
31 H=h+L+S2;
32 mprintf("\n (c) Height of lowest cross arm= %.2f m",
H);

```

Scilab code Exa 5.2 clearance of line

```

1 clear;
2 clc;
3
4 l=336;
5 h1=33.6;
6 h2=29;
7 w=8.33;
8 T=3.34e4;
9
10 // (a)
11 lc=l+ (2*T * (h1-h2)/(w*l));
12 S=w*lc*lc/(8*T);
13 cl= h1-S;
14 mprintf("\n (a) Clearance= %.3f m", cl);
15
16 // (b)
17 d1=lc/2;
18 d2=l-d1;

```

```
19 mprintf("\\n (b) Distance of point O from lower
    support = %.2f m", d2);
```

Scilab code Exa 5.3 height of mid point from ground

```
1 clear;
2 clc;
3 l=300;
4 h1=80;
5 h2=50;
6 w=8.28;
7 T=19620;
8
9 //(a)
10 lc=1+ (2*T * (h1-h2)/(w*l));
11 dOC=(lc/2)-1;
12 hOC=w*dOC*dOC/(2*T);
13 dOP=dOC + (l/2);
14 hOP=w*dOP*dOP/(2*T);
15 hPC=hOP-hOC;
16 hP=hPC+ h2;
17 mprintf("\\nHeight of mid point P above C =%.3f m",
    hPC);
18 mprintf("\\nHeight of mid point P above water level =
    %.3f m",hP);
```

Scilab code Exa 5.4 finding sag

```
1 clear;
2 clc;
3
4 m=2.292;
5 g=9.81;
```

```

6 l=152;
7 Pw=39.063;
8 dia=2.068e-2;
9 ar=3.065;
10 stress=1054.63;
11
12 //(a)
13 w=m*g;
14 T=stress * ar *g;
15 Fw=Pw* g * dia;
16 Ft= sqrt(w^2 + Fw^2);
17 S=Ft * l *l /(8* T);
18 mprintf("\n Sag= %.2 f m", S);
19 Sy= S * w/Ft;
20 mprintf("\n Vertical Component of Sag= %.3 f m", fix(
    Sy*1000)/1000);

```

Scilab code Exa 5.5 finding minimum clearance and position of clearance point

```

1 clear;
2 clc;
3
4 h1=55;
5 h2=50;
6 l=300;
7 g=9.81;
8 T=2000*g;
9 m=.85;
10 w=m*g;
11
12 //(a)
13 lc=l+ (2*T * (h1-h2)/(w*l));
14 S= w * lc *lc /(8*T);
15 cl=h1-S;
16 mprintf("\n (a)Minimum Clearance between conductor

```

```

    and water= %.2f m", c1);
17
18 //(b)
19 d0B=lc/2;
20 d0A=1-d0B;
21 mprintf("\n (b) Distance of point O from lower
    support= %.1f m", d0A);

```

Scilab code Exa 5.6 find sag and tension under erection conditions

```

1 clear
2 clc
3
4 safety=2
5 d=1.95e-2
6 A=2.25e-4
7 E=91.4 *1e9
8 alpha=18.44 *1e-6
9 Temp21=10
10 Temp22=40
11 Tmax=77900
12 w=8.31
13 span=250
14
15
16 Fw=378 * d
17 Fw=round(Fw*100)/100
18 Ft1=sqrt(w^2 + Fw^2)
19 T1=Tmax/safety
20 Ft2=w
21
22
23 c_1=1
24 c_2=T1 -(alpha * A * E * (Temp22-Temp21)) - A*E*Ft1
    ^2 * span^2 /(24*T1^2)

```



```

25 c_3=0
26 c_4=A*E*Ft2^2 * span^2 /24
27 pol=poly([-c_4 -c_3 -c_2 c_1], "xx", "c")
28 T2s=roots(pol)
29
30 T2=T2s(1)
31 T2=round(T2)
32 Sag1= w * span *span / (8 * T2)
33
34 //difference in results is seen as the author has
    used hit and trial aproach to solve T2, while the
    program uses iterative method to solve equations
    . The equations have the same coefficients
35 mprintf("sag at erection= %.2f m", Sag1)
36
37 disp("difference in results is seen as the author
    has used hit and trial aproach to solve T2, while
    the program usesiterative method to solve
    equations. The equations have the same
    coefficients")

```

Scilab code Exa 5.7 representing line as parabola and catenary

```

1 clear;
2 clc;
3
4 l=600;
5 wc=12;
6 wi=14;
7 T=50000;
8
9 //(a)
10 F=wc+wi;
11 S= F * l * l/ (8*T);
12 mprintf("\n (a)Sag when representing line as a

```

```

        parabola= %.1 f m" , S);
13
14 //(b)
15 S=(F * l * l / (8*T)) * (1+ ((1*1/48)*(F *F/(T*T))));
16 mprintf("\n (b)Sag when representing line as a
        catenary= %.3 f m" , S);

```

Scilab code Exa 5.8 galloping and dancing conductors find clearance under ice and

```

1 clear;
2 clc;
3
4 h1=75;
5 h2=45;
6 l=300;
7 g=9.81;
8 T=2500*g;
9 m=.9;
10 w=m*g;
11
12 //(a)
13 lc=1+ (2*T * (h1-h2)/(w*l));
14 dOC=(lc/2)-1;
15 hCO=w * dOC *dOC / (2*T);
16 dOP=dOC+(1/2);
17 hPO=w * dOP *dOP / (2*T);
18
19 hPC=hPO-hCO;
20 mprintf("\nHeight of mid point P above C =%.2 f m" ,
        hPC);
21 hP=hPC+h2;
22 mprintf("\nHeight of mid point P above water level =
        %.2 f m" ,hP);

```

Scilab code Exa 5.9 galloping and dancing conductors find clearance under no ice a

```
1 clear;
2 clc;
3
4 l=244;
5 m=.847;
6 g=9.81;
7 w=m*g;
8 T=3.56e4;
9
10 L=l*(1+ ((w*w * l*l)/(24* T *T)));
11 mprintf("length of conductor between 2 towers = %.3f
           m", L);
```

Scilab code Exa 5.10 find maximum sag under given condition

```
1 clear;
2 clc;
3
4 ar=.484;
5 d=.889e-2;
6 m=428e-3;
7 g=9.81;
8 T=1973 *g;
9 sfac=2;
10 w=m*g;
11 l=200;
12 T=T/sfac;
13
14 //(a)
15 S=w* l*l/(8*T);
```

```
16 mprintf("\\n (a)maximum sag due to copper weight = %
    .3 f m",S);
17
18 //(b)
19 t=1e-2;
20 D=d+(2*t);
21 wi=8920 * (D^2 - d^2) * %pi /4;
22
23 F=w+wi;
24 S=F* l*l/(8*T);
25 mprintf("\\n (b)maximum sag due to addition weight of
    ice = %.1 f m",S);
```

Chapter 6

Corona

Scilab code Exa 6.1 Finding local and general visual and disruptive corona voltage

```
1 clear;
2 clc;
3
4 dia=22.26e-3;
5 r=dia/2;
6 V=220e3;
7 d=6;
8 mvg=.82;
9 mvl=.72;
10 temp=25;
11 P=73;
12 m0=.84;
13
14
15 del=3.86*P/(273+temp);
16 Vd=(3e6/sqrt(2))*r*del*m0* log(d/r) *1e-3;
17 mprintf("\nDisruptive critical voltage = %.0f KV/
    phase", Vd)
18
19 Vv1=(3e6/sqrt(2))*r*del*mvl* log(d/r)* (1+(.03/sqrt(
    del*r))) *1e-3;
```

```

20 mprintf("\nVisual local voltage = %.1f KV/phase",
    Vv1)
21
22 Vvg=(3e6/sqrt(2))*r*del*mvg* log(d/r)* (1+(.03/sqrt(
    del*r))) *1e-3;
23 mprintf("\nVisual general voltage = %.1f KV/phase",
    Vvg)

```

Scilab code Exa 6.2 Finding total loss in fair weather and bad weather using peeks

```

1 clear;
2 clc;
3
4 dia=22.26e-3;
5 r=dia/2;
6 V=220;
7 d=6;
8 temp=25;
9 P=73;
10 m0=.84;
11 f=50;
12 l=250;
13
14 V=round(V/sqrt(3));
15 del=round((3.86*P/(273+temp))*10000)/10000;
16 Vd=round((3e6/sqrt(2))*r*del*m0* log(d/r) *1e-3);
17
18 //(a) Good Weather
19 Pc=243.5 * ((f+25)/del) * sqrt(r/d)* (V-Vd)^2 * 1e
    -5;
20 PC= Pc * l;
21 Ptot= 3 *PC;
22 mprintf("\ntotal loss in good weather = %.2f kW",
    Ptot);
23

```

```

24 // (b) Bad Weather
25 Vd1=.8*Vd;
26 Pc1=243.5 * ((f+25)/del) * sqrt(r/d)* (V-Vd1)^2 * 1e
    -5;
27 PC1= Pc1 * 1;
28 Ptot1= 3 *PC1;
29 mprintf("\ntotal loss in bad weather = %.0f kW",
    Ptot1);

```

Scilab code Exa 6.3 finding visual corona voltage

```

1 clear;
2 clc;
3
4 dia=1.04e-2;
5 r=dia/2;
6 m=.85;
7 d=2.44;
8 P=74;
9 temp=21;
10
11 del=round((3.86*P/(273+temp))*1000)/1000;
12
13 Vv=(3e6/sqrt(2))*r*del*m* log(d/r)* (1+(.03/sqrt(del
    *r))) *1e-3;
14 mprintf("\nVisual local voltage = %.2f KV/phase", Vv
    )

```

Scilab code Exa 6.4 finding minimum distance between conductors to limit disruptive

```

1 clear;
2 clc;
3

```

```
4 dia=30e-3;
5 r=dia/2;
6 del=.95;
7 m0=.95;
8 Vd=230e3;
9 Vd=Vd/sqrt(3);
10
11 x=round(Vd*100/((3e6/sqrt(2))* r * del * m0))/100;
12 d= exp(x) * r;
13 mprintf("\n minimum spacing between conductors = %.2
    f m", d);
```

Chapter 7

Interference Between Power and Communication Lines

Scilab code Exa 7.1 finding magnitude of voltage induced in telephone line due to

```
1 clear;
2 clc;
3
4 D1=1.2
5 D2=.6;
6 h=1;
7 H=10
8
9 DaP=sqrt((D1-(D2/2))^2+1)
10 DcQ=DaP
11 DbP=sqrt(((D2/2))^2+1)
12 DbQ=DbP
13 DcP=sqrt((D1+(D2/2))^2+1)
14 DaQ=DcP
15
16 Ia=300*exp(%i * 0);
17 Ib=300*exp(%i *-2* %pi/3);
18 Ic=300*exp(%i *2* %pi/3);
19
```

```

20 si=2e-7* ((Ia * log(DaQ/DaP))+(Ib * log(DbQ/DbP))+(
    Ic * log(DcQ/DcP)))
21
22 V=2*%pi * 50* abs(si);
23
24 mprintf("voltage induced in telephone line = %.2f e
    -3V/m", V*1e3)

```

Scilab code Exa 7.2 finding magnitude of voltage induced in telephone line due to

```

1 clear;
2 clc;
3
4 D1=1.2
5 D2=.6;
6 h=1;
7 H=10
8
9 DaP=sqrt((D1-(D2/2))^2+h^2)
10 DaQ=sqrt((D1+(D2/2))^2+h^2)
11
12 Ia=2000*exp(%i * 0);
13 si=2e-6* ((Ia * log(DaQ/DaP)))
14
15 V=2*%pi * 50* abs(si);
16
17 mprintf("voltage induced in telephone line = %.3f V/
    m", V)

```

Scilab code Exa 7.3 potential of conductor due electrostatic effect

```

1 clear;
2 clc;

```

```

3
4 D1=1.2
5 D2=.6;
6 h=1;
7 H=10
8
9 DaP=sqrt((D1-(D2/2))^2+1)
10 DcQ=DaP
11 DbP=sqrt(((D2/2))^2+1)
12 DbQ=DbP
13 DcP=sqrt((D1+(D2/2))^2+1)
14 DaQ=DcP
15
16 dia=14.15e-3;
17 r=dia/2;
18
19 Va=11e3*exp(%i * 0)/sqrt(3);
20 Vb=11e3*exp(%i *-2* %pi/3)/sqrt(3);
21 Vc=11e3*exp(%i *2* %pi/3)/sqrt(3);
22
23 Vpa=Va * (log(((2*H) - DaP)/DaP)/log(((2*H) - r)/r))
24 Vpb=Vb * (log(((2*H) - DbP)/DbP)/log(((2*H) - r)/r))
25 Vpc=Vc * (log(((2*H) - DcP)/DcP)/log(((2*H) - r)/r))
26
27 Vp=Vpa+Vpb+Vpc;
28 mprintf(" Potential of P= %.0f V", abs(Vp))

```

Scilab code Exa 7.4 Voltage induced in telephone conductor due electrostatic effect

```

1 clear;
2 clc;
3
4 f=50;
5 d=9e-3;
6 l=3.5;

```

```

7 h=16;
8 dc=.5;
9 hp=4
10
11 ha= round((sqrt(3)*1/2)*100)/100;
12 DaP=ha+hp;
13 DaQ=DaP+dc;
14
15 DbP=round(sqrt((1/2)^2+hp^2) *100)/100
16 DcP=DbP
17 DbQ=round(sqrt((1/2)^2+(hp+dc)^2) *100)/100
18 DcQ=DbQ
19
20 Ia=200*exp(%i * 0);
21 Ib=200*exp(%i *-2* %pi/3);
22 Ic=200*exp(%i *2* %pi/3);
23
24 si=2e-7* ((Ia * log(DaQ/DaP))+(Ib * log(DbQ/DbP))+(
      Ic * log(DcQ/DcP)))
25
26 V=2*%pi * 50* abs(si);
27
28 mprintf(" voltage induced in telephone line = %.3f e
      -3V/m", V*1e3)

```

Scilab code Exa 7.5 Voltage induced in conductor due electrostatic effect

```

1 clear;
2 clc;
3
4 f=50;
5 dia=9e-3;
6 l=3.5;
7 h=16;
8 dc=.5;

```

```

9 hp=4
10
11 ha= round((sqrt(3)*1/2)*100)/100;
12 DaP=ha+hp;
13 DaQ=DaP+dc;
14 H=ha+h;
15
16 DbP=round((sqrt((1/2)^2+hp^2))*100)/100;
17 DcP=DbP
18 DbQ=round((sqrt((1/2)^2+(hp+dc)^2))*100)/100;
19 DcQ=DbQ
20
21 r=dia/2;
22
23 Va=132e3*exp(%i * 0)/sqrt(3);
24 Vb=132e3*exp(%i *-2* %pi/3)/sqrt(3);
25 Vc=132e3*exp(%i *2* %pi/3)/sqrt(3);
26
27 Vpa=Va * (log(((2*H) - DaP)/DaP)/log(((2*H) - r)/r))
28 Vpb=Vb * (log(((2*h) - DbP)/DbP)/log(((2*h) - r)/r))
29 Vpc=Vc * (log(((2*h) - DcP)/DcP)/log(((2*h) - r)/r))
30
31 Vp=Vpa+Vpb+Vpc;
32 mprintf(" Potential of P= %.0f V", fix(abs(Vp)))

```

Chapter 8

Underground Cables

Scilab code Exa 8.1 inductance of a 3 core belted cable

```
1 clear;
2 clc;
3
4 n=37;
5 r=.238
6 t=.5;
7
8 r1=r*3.5;
9 GMR=.7788*r1;
10 D= 2*(r1+t);
11 L=.4605 * log10(D/GMR);
12 mprintf("\n L= %.4f mH/km/conductor", fix(L*1e4)*1e
    -4);
```

Scilab code Exa 8.2 find most economical diameter of cable so that it not exceed m

```
1 clear;
2 clc;
```

```

3
4 V=33;
5 V=V/sqrt(3);
6 T=35;
7
8 x=1;
9 r=V/(T * x);
10 R= %e * r;
11 t=R-r;
12
13 mprintf("\nMost economical conductor radius = %.3f
         cm", fix(R*1000)/1000);
14 mprintf("\nInsulation Thickness = %.3f cm", t);

```

Scilab code Exa 8.3 find most economical diameter of cable so that it not exceed m

```

1 clear;
2 clc;
3
4 V=132;
5 V=V/sqrt(3);
6 T=60;
7
8 V=V*sqrt(2);
9 x=1;
10 r=V/(T * x);
11 R= %e * r;
12 t=R-r;
13
14 mprintf("\nMost economical conductor diameter = %.2f
         cm", fix(2*R*100)/100);
15 mprintf("\nOverall diameter of insulation = %.3f cm"
         , fix(2*r*1000)/1000);

```

Scilab code Exa 8.4 find positions of intersheaths max min stress and voltage on

```
1 clear;
2 clc;
3
4 V=66;
5 V=V/sqrt(3);
6 T=60;
7 d=2;
8 r=d/2;
9 D=5.3;
10 R=D/2;
11
12 V=fix(V*sqrt(2) *10)/10;
13
14 a=(R/r)^(1/3);
15 a=round(a*1e3)/1e3;
16 r1=a*r;
17 r2=round(a*r1*1000)/1000;
18 V1= V *((1/r)-(1/r2)) *r ;
19 V2= (V-( V1* ((1/r)-(1/r1)))) *r1;
20 //An error exists in the text book while calculating
    V1 and V2 and hence Emax and Emin
21
22 Emax= (V-V1)/(r * log (a));
23 Emin= (V-V1)/(r1 * log (a));
24 mprintf("\n When intersheaths are used:\n Emax= %.2 f
    kV/cm \t Emin= %2f kV/cm",Emax,Emin);
25 mprintf("\n Peak voltages at intersheaths:\n V1= %.2
    f kV \t V2= %.2 f kV\n",V1,V2);
26 disp("An error exists in the text book while
    calculating V1 and V2 and hence Emax and Emin")
27
28 Emax= (V)/(r * 3*log (a));
```



```

29 Emin= (V)/(R * 3*log (a));
30 mprintf("\n When intersheaths are not used:\n Emax=
    %.1f kV/cm \t Emin= %.2f kV/cm",Emax,Emin);

```

Scilab code Exa 8.5 radius voltage of intersheath and ratio of maximum stress with

```

1 clear;
2 clc;
3
4 //solving for prt (c) only
5
6 R=3;
7 r=1;
8 V=60;
9
10
11 a=sqrt(R/r);
12 r1=a*r;
13
14 mprintf("\n (c) r1= %.3f cm", r1);
15
16 V1=V*((a)/(1+a));
17 mprintf("\n      V1 voltage at intersheath= %.2f cm",
    V1);
18
19 b=2/(1+a);
20 mprintf("\n      ratio of max electric stress with
    and without intersheath= %.3f cm", b);

```

Scilab code Exa 8.6 find maximum voltage in a cable having 2 insulation materials

```

1 clear;
2 clc;

```

```

3
4 r=0.5;
5 R=2.5;
6 Vga=60;
7 ea=4;
8 eb=2.5;
9 Vgb=50;
10
11 v=Vga*ea*r;
12
13 r1=v/(eb*Vgb);
14
15 V=v *((log(r1/r)/ea)+(log(R/r1)/eb));
16
17 mprintf("Maximum working voltage = %.2 f kV", V);

```

Scilab code Exa 8.7 parameters of underground feeder

```

1 clear;
2 clc;
3
4 V=33e3;
5 V=V/sqrt(3);
6 f=50;
7 l=3.4e3;
8 d=2.5
9 r=d/2;
10 t=.6;
11 R=r+t;
12 e=3.1;
13
14 //disp(R);
15
16 c=2* %pi * 8.85 * e/ log(R/r);
17 C=c*l;

```

```

18 C=C*1e-6;
19 mprintf("\n(a)C= %.3f e-6 F/phase", C);
20
21 I=V * 2 * %pi * f * C*1e-6 ;
22 mprintf("\n(b) Charging Current I= %.2f A/phase", I);
23
24 KVAR=3*V*I *1e-3;
25 mprintf("\n(c) Charging KVAR= %.1f ", KVAR);
26
27 pf=.03;
28 phi=acos(pf);
29 lossang=(%pi/2)-phi;
30 Loss=2*%pi*f*C*1e-6*V*V*sin(lossang);
31 mprintf("\n(d) Dielectric Loss per phase= %.1f W",
        Loss);
32
33 Emax=V*1e-3/(r*log(R/r));
34 mprintf("\n(e)Emax= %.2f KV/cm (rms)",Emax)

```

Scilab code Exa 8.8 effective capacitance in cables

```

1 clear;
2 clc;
3
4 V=11e3;
5 V=V/sqrt(3);
6 f=50;
7 C1=.65;
8 C2=.75;
9
10 Cs=C2/3;
11 Cc=(C1/2)-(C2/6);
12 C=Cs+(3*Cc);
13 mprintf("\n(a) effective capacitance of each of the
        core to neutral = %.2f e-6 F",C);

```

```

14
15 I=V * 2 * %pi * f * C*1e-6 ;
16 mprintf("\n(b) Charging Current I= %.3f A/phase", I);
17
18 Cap=(1.5*Cc) + (.5 * Cs);
19 mprintf("\n(c) Capacitance between any 2 conductors =
    %.3f e-6 F", Cap);

```

Scilab code Exa 8.9 find current rating of cable

```

1 clear;
2 clc;
3
4 T2=65;
5 T1=20;
6 n=3;
7 restivity=.02826;
8 A=400;
9
10
11 R=restivity/A;
12
13 Eff_SnL=2/100;
14 Rdc20= (1+Eff_SnL)*(1+Eff_SnL)*R;
15
16 a=0.004
17 Rdc65=Rdc20 * (1+(a*(T2-T1)));
18
19 Eff_Skin_Prox=3.5/100;
20 Rac= (1+Eff_Skin_Prox)*(1+Eff_Skin_Prox)*Rdc65;
21
22 ti_core=2.7;
23 ti_belt=1.2;
24 tins=ti_belt+ti_core;
25

```

```

26 r=13;
27 ratio_tins_dia=tins/(2*r);
28
29 Gi3=.65;
30
31 Gi=Gi3/3;
32
33 R1=35.2e-3;
34 R2=40e-3;
35 h=.75
36 g1=5;
37 g2=1.5;
38 Gp=g1*log(R2/R1)/(2*pi);
39 Gs=g2*log((2*h)/R2)/(2*pi);
40
41 sheathlosses=.1;
42
43 I=((T2-T1)/(n* Rac * (Gi + ((1+sheathlosses)*(Gp+Gs)
    ))))^0.5
44 mprintf("Current Rating =%d Amperes",I);

```

Chapter 9

Load Flow Studies

Scilab code Exa 9.1 form Y bus

```
1 clear;
2 clc
3
4 y=[0 1 (-.4*%i)
5 0 2 (-.3*%i)
6 1 2 (-.5*%i)]
7 n=2
8 e=3
9
10 Y=zeros(n,n)
11
12 for i=1:e
13     n1=real(y(i,1))
14     n2=real(y(i,2))
15     ynew=y(i,3)
16     if(n1==0)
17         Y(n2,n2)=Y(n2,n2)+ynew
18     else
19         Y(n1,n1)= Y(n1,n1)+ynew
20         Y(n1,n2)= Y(n1,n2)-ynew
21         Y(n2,n1)= Y(n2,n1)-ynew
```

```

22         Y(n2,n2)= Y(n2,n2)+ynew
23     end
24 end
25 disp(Y)

```

Scilab code Exa 9.3 form Y bus and effect of adding a line

```

1  clear
2  clc
3
4  data=[ 1 2 .025 .1
5        2 3 .02 .08
6        3 4 .05 .2
7        1 4 .04 .16
8  ]
9
10 n=4
11 e=4
12 Y=zeros(n,n)
13
14 for i=1:e
15     ynew = 1/(data(i,3)+(%i *real(data(i,4))))
16     n1=real(data(i,1))
17     n2=real(data(i,2))
18     if(n1==0)
19         Y(n2,n2)=Y(n2,n2)+ynew
20     else
21         Y(n1,n1)= Y(n1,n1)+ynew
22         Y(n1,n2)= Y(n1,n2)-ynew
23         Y(n2,n1)= Y(n2,n1)-ynew
24         Y(n2,n2)= Y(n2,n2)+ynew
25     end
26 end
27
28 disp(round(Y*1e2)/100,"(a)")

```

```

29
30 data(e+1,:)= [1 3 .1 .4]
31 i=e+1
32 ynew = 1/(data(i,3)+(%i *real(data(i,4))))
33
34 n1=real(data(i,1))
35 n2=real(data(i,2))
36 if(n1==0)
37     Y(n2,n2)=Y(n2,n2)+ynew
38 else
39     Y(n1,n1)= Y(n1,n1)+ynew
40     Y(n1,n2)= Y(n1,n2)-ynew
41     Y(n2,n1)= Y(n2,n1)-ynew
42     Y(n2,n2)= Y(n2,n2)+ynew
43 end
44
45
46 disp(round(Y*1e2)/100,"(b)")

```

Scilab code Exa 9.4 find y bus

```

1 clear
2 clc
3
4 data=[ 1 2 .2+%i*.8 %i*.02
5 2 3 .3+%i*.9 %i*.03
6 2 4 .25+%i*1 %i*.04
7 3 4 .2+%i*.8 %i*.02
8 1 3 .1+%i*.4 %i*.01
9 ]
10
11 n=4
12 e=5
13 Y=zeros(n,n)
14

```



```

15 for i=1:e
16     ynew = 1/(data(i,3))
17     y0=data(i,4)
18     n1=real(data(i,1))
19     n2=real(data(i,2))
20     if(n1==0)
21         Y(n2,n2)=Y(n2,n2)+ynew+y0
22     else
23         Y(n1,n1)= Y(n1,n1)+ynew+y0
24         Y(n1,n2)= Y(n1,n2)-ynew
25         Y(n2,n1)= Y(n2,n1)-ynew
26         Y(n2,n2)= Y(n2,n2)+ynew+y0
27     end
28 end
29
30 disp(fix(Y*1e3)/1e3)

```

Scilab code Exa 9.5 find missing elements of y bus

```

1 clear
2 clc
3
4 Y=[
5 .7-%i*3      -.2+%i      -.5+2*%i      %inf
6 %inf         %inf        -.3+2*%i      -.5+3*%i
7 %inf         %inf        %inf         -1+4*%i
8 %inf         %inf        %inf
9     %inf
10 ]
11 disp("inf shows that this value is to be found ")
12 disp(Y," given")
13
14 Y(1,4)=round(Y(1,1)+Y(1,3)+Y(1,2))
15 Y(4,4)=0-Y(1,4)-Y(2,4)-Y(3,4)
16 Y(4,1)=Y(1,4)

```

```

16 Y(2,1)=Y(1,2)
17 Y(3,2)=Y(2,3)
18 Y(3,1)=Y(1,3)
19 Y(4,2)=Y(2,4)
20 Y(4,3)=Y(3,4)
21 Y(2,2)=0-Y(2,1)-Y(2,4)-Y(2,3)
22 Y(3,3)=0-Y(3,1)-Y(3,4)-Y(3,2)
23
24
25
26 disp(Y,"completed")

```

Scilab code Exa 9.7 find y bus with mutual coupling of lines present

```

1 clear
2 clc
3
4 z=[
5 %i*1      0      0      0      0
6 0          %i*.4  %i*.2  0  0
7 0          %i*.2  %i*.5  0  0
8 0      0      0 %i*.2      0
9 0      0      0      0 %i*.25
10 ]
11
12 y=inv(z)
13
14 A=[
15 1 0 0 0
16 -1 1 0 0
17 -1 0 1 0
18 0 0 1 -1
19 0 -1 0 -1
20 ]
21

```

```
22 Y=A'*y*A
23
24 disp(Y)
```

Scilab code Exa 9.8 find reactive power generations losses and powers transferred

```
1 clear
2 clc
3
4 G=[
5 %inf %inf 1.5 1
6 0 %inf 2.0 .5
7 3.5 %inf 0 0
8 0 %inf 2 .8
9 ]
10
11
12 ld=[
13 1 2 %i*.2
14 2 3 %i*.1
15 3 4 %i*.1
16 1 4 %i*.2
17 1 3 %i*.2
18 ]
19
20 n=4
21 e=5
22 Y=zeros(n,n)
23
24 for i=1:e
25     ynew = 1/(ld(i,3))
26     y0=0
27     n1=real(ld(i,1))
28     n2=real(ld(i,2))
29     if(n1==0)
```

```

30         Y(n2,n2)=Y(n2,n2)+ynew+y0
31     else
32         Y(n1,n1)= Y(n1,n1)+ynew+y0
33         Y(n1,n2)= Y(n1,n2)-ynew
34         Y(n2,n1)= Y(n2,n1)-ynew
35         Y(n2,n2)= Y(n2,n2)+ynew+y0
36     end
37 end
38
39 G(1,1)= G(1,3)+G(2,3)+G(3,3)+G(4,3)-(G(2,1)+G(3,1)+G
    (4,1))
40
41 G(1,5)=G(1,1)-G(1,3)
42 G(2,5)=G(2,1)-G(2,3)
43 G(3,5)=G(3,1)-G(3,3)
44 G(4,5)=G(4,1)-G(4,3)
45
46 //d1=0
47 A=%i * [
48 Y(2,2) Y(2,3) Y(2,4)
49 Y(3,2) Y(3,3) Y(3,4)
50 Y(4,2) Y(4,3) Y(4,4)
51 ]
52 d(1)=0
53 d(2:4)=inv(A) * [G(2,5) G(3,5) G(4,5)]'
54 d=round((d)*1000)/1000
55 G(1,6)= %i *((Y(1,1) * cos(d(1)-d(1)))+(Y(1,2) *
    cos(d(1)-d(2)))+(Y(1,3) * cos(d(1)-d(3)))+(Y
    (1,4) * cos(d(1)-d(4)))));
56 G(2,6)= %i *((Y(2,1) * cos(d(2)-d(1)))+(Y(2,2) *
    cos(d(2)-d(2)))+(Y(2,3) * cos(d(2)-d(3)))+(Y
    (2,4) * cos(d(2)-d(4)))));
57 G(3,6)= %i *((Y(3,1) * cos(d(3)-d(1)))+(Y(3,2) *
    cos(d(3)-d(2)))+(Y(3,3) * cos(d(3)-d(3)))+(Y
    (3,4) * cos(d(3)-d(4)))));
58 G(4,6)= %i *((Y(4,1) * cos(d(4)-d(1)))+(Y(4,2) *
    cos(d(4)-d(2)))+(Y(4,3) * cos(d(4)-d(3)))+(Y
    (4,4) * cos(d(4)-d(4)))));

```

```

59
60 G(:,6)=round(G(:,6) *10000)/10000
61 G(:,2)=G(:,6) + G(:,4)
62 G(:,2)=round(G(:,2)*1e4)/1e4
63 mprintf("\n(a) Q1= %.4f, Q2= %.4f, Q3= %.3f, Q4= %.4
    f, ", G(1,2),G(2,2),G(3,2),G(4,2))
64
65 Q1=G(1,6)+G(2,6)+G(3,6)+G(4,6)
66 mprintf("\n(b) reactive line losses=%.4fpu",Q1)
67
68 X=ld(:,3)/%i
69
70 P(1)=round((sin(d(1)-d(2))/X(1))*1000)/1000
71 P(2)=round((sin(d(2)-d(3))/X(2))*1000)/1000
72 P(3)=round((sin(d(3)-d(4))/X(3))*1000)/1000
73 P(4)=round((sin(d(1)-d(4))/X(4))*1000)/1000
74 P(5)=round((sin(d(1)-d(3))/X(5))*1000)/1000
75
76 Q(1)=round(((1-cos(d(1)-d(2)))/X(1))*10000)/10000
77 Q(2)=round(((1-cos(d(2)-d(3)))/X(2))*10000)/10000
78 Q(3)=round(((1-cos(d(3)-d(4)))/X(3))*10000)/10000
79 Q(4)=round(((1-cos(d(1)-d(4)))/X(4))*10000)/10000
80 Q(5)=round(((1-cos(d(1)-d(3)))/X(5))*10000)/10000
81
82 mprintf("\n(c)")
83 mprintf("\nP12 = -P21 = %.3f, Q12=Q21=%.4f",P(1),Q
    (1))
84 mprintf("\nP23 = -P32 = %.3f, Q23=Q32=%.3f",P(2),Q
    (2))
85 mprintf("\nP34 = -P43 = %.3f, Q34=Q43=%.3f",P(3),Q
    (3))
86 mprintf("\nP14 = -P41 = %.3f, Q14=Q41=%.4f",P(4),Q
    (4))
87 mprintf("\nP13 = -P31 = %.3f, Q13=Q31=%.4f",P(5),Q
    (5))

```

Scilab code Exa 9.9 solve using gauss seidel for 1 variable

```
1 clear
2 clc
3
4 e=1e-5
5 x=1
6 E=100
7 while (E>e)
8     x1=.5*(7+log10(x))
9     E=abs(x-x1)
10    x=x1
11 end
12
13 mprintf("x = %f",x)
```

Scilab code Exa 9.10 solve using gauss seidel for 2 variables

```
1 clear
2 clc
3
4 x=.5
5 y=.5
6 for i=1:4
7     x=(.7*sin(x))+(.2*cos(y))
8     y=(.7*cos(x))- (.2*sin(y))
9
10 end
11
12 mprintf("x= %f, y=%f",x,y)
```

Scilab code Exa 9.11 find bus voltage and load angle using GS

```
1 clear
2 clc
3
4 ey=1/(.05 + %i*.15)
5 y=[
6 1 2 ey
7 1 5 ey
8 2 5 ey
9 2 3 ey
10 3 4 ey
11 4 5 ey
12 ]
13 n=5
14 e=6
15
16 Y=zeros(n,n)
17
18 for i=1:e
19     n1=real(y(i,1))
20     n2=real(y(i,2))
21     ynew=y(i,3)
22     if(n1==0)
23         Y(n2,n2)=Y(n2,n2)+ynew
24     else
25         Y(n1,n1)= Y(n1,n1)+ynew
26         Y(n1,n2)= Y(n1,n2)-ynew
27         Y(n2,n1)= Y(n2,n1)-ynew
28         Y(n2,n2)= Y(n2,n2)+ynew
29     end
30 end
31 // bus no | PL | QL | PG | QG | V | th | btype |
    Qmin | Qmax
```

```

32
33 data = [
34 1 1 .5 %inf %inf 1.02 0 1 %inf %inf
35 2 0 0 2 %inf 1.02 0 2 .2 .6
36 3 .5 .2 0 0 1 0 3 %inf %inf
37 4 .5 .2 0 0 1 0 3 %inf %inf
38 5 .5 .2 0 0 1 0 3 %inf %inf
39
40 ]
41 disp(Y, "(a)")
42 j = data(:,1); // Bus number.
43 PL = data(:,2);
44 QL = data(:,3);
45 PG = data(:,4);
46 QG = data(:,5);
47 V = data(:,6);
48 th = data(:,7);
49 btype = data(:,8); // Type of Bus 1-Slack, 2-PV,
50 // 3-PQ.
51 Qmin = data(:,9);
52 Qmax = data(:,10);
53 n = max(j);
54 P = PG - PL;
55 Q = QG - QL
56
57 for i=1:n
58     V(i,1)=V(i,1) * exp (%i * th(i,1)* %pi / 180)
59 end
60
61 Vprev = V;
62 toler = 1000;
63 iteration = 1;
64 while (iteration==1)
65     for i = 2:n
66         summ = 0;
67         for k = 1:n
68             if i ~= k
69                 summ = summ + Y(i,k)* V(k);

```



```

69         end
70     end
71     if btype(i) == 2
72         Q(i) = -imag(conj(V(i))*(summ + Y(i,i)*V
73             (i)));
74         if (Q(i) > Qmax(i)) | (Q(i) < Qmin(i))
75             if Q(i) < Qmin(i)
76                 Q(i) = Qmin(i);
77             else
78                 Q(i) = Qmax(i);
79             end
80             btype(i) = 3;
81         end
82     end
83     V(i) = (1/Y(i,i))*(((P(i)- %i*Q(i))/conj(V(i)
84         ))) - summ);
85     if btype(i) == 2
86         V(i) = abs(Vprev(i))*exp(%i * atan(imag(
87             V(i))/real(V(i))));
88     end
89     end
90     iteration = iteration + 1;
91     toler = max(abs(abs(V) - abs(Vprev)));
92     Vprev = V;
93 end
94 disp(" (b) ")
95 mprintf("\nV3 = %.2 f ang(%.2 f) deg", abs(V(3)),atand
96     (imag(V(3))/real(V(3))))
97 mprintf("\nV4 = %.3 f ang(%.2 f) deg", abs(V(4)),atand
98     (imag(V(4))/real(V(4))))
99 mprintf("\nV5 = %.4 f ang(%.2 f) deg", abs(V(5)),atand
100     (imag(V(5))/real(V(5))))
101 mprintf("\ndelta 2 = %.2 f deg",atand(imag(V(2,1))/
102     real(V(2,1))))
103 mprintf("\nQ2 = %.4 f ",Q(2,1))

```

Scilab code Exa 9.12 find bus voltage and load angle using GS minimum value of Q2

```
1 clear
2 clc
3
4 ey=1/(.05 + %i*.15)
5 y=[
6 1 2 ey
7 1 5 ey
8 2 5 ey
9 2 3 ey
10 3 4 ey
11 4 5 ey
12 ]
13 n=5
14 e=6
15
16 Y=zeros(n,n)
17
18 for i=1:e
19     n1=real(y(i,1))
20     n2=real(y(i,2))
21     ynew=y(i,3)
22     if(n1==0)
23         Y(n2,n2)=Y(n2,n2)+ynew
24     else
25         Y(n1,n1)= Y(n1,n1)+ynew
26         Y(n1,n2)= Y(n1,n2)-ynew
27         Y(n2,n1)= Y(n2,n1)-ynew
28         Y(n2,n2)= Y(n2,n2)+ynew
29     end
30 end
31 // bus no | PL | QL | PG | QG | V | th | btype |
    Qmin | Qmax
```

```

32
33 data = [
34 1 1 .5 %inf %inf 1.02 0 1 %inf %inf
35 2 0 0 2 %inf 1.02 0 2 .3 %inf
36 3 .5 .2 0 0 1 0 3 %inf %inf
37 4 .5 .2 0 0 1 0 3 %inf %inf
38 5 .5 .2 0 0 1 0 3 %inf %inf
39
40 ]
41
42 j = data(:,1); // Bus number.
43 PL = data(:,2);
44 QL = data(:,3);
45 PG = data(:,4);
46 QG = data(:,5);
47 V = data(:,6);
48 th = data(:,7);
49 btype = data(:,8); // Type of Bus 1-Slack, 2-PV,
50 // 3-PQ.
51 Qmin = data(:,9);
52 Qmax = data(:,10);
53 n = max(j);
54 P = PG - PL;
55 Q = QG - QL
56
57 for i=1:n
58     V(i,1)=V(i,1) * exp (%i * th(i,1)* %pi / 180)
59 end
60
61 Vprev = V;
62 toler = 1000;
63 iteration = 1;
64 while (iteration==1)
65     for i = 2:n
66         summ = 0;
67         for k = 1:n
68             if i ~= k
69                 summ = summ + Y(i,k)* V(k);

```

```

69         end
70     end
71     if btype(i) == 2
72         Q(i) = -imag(conj(V(i))*(summ + Y(i,i)*V
73             (i)));
74         if (Q(i) > Qmax(i)) | (Q(i) < Qmin(i))
75             if Q(i) < Qmin(i)
76                 Q(i) = Qmin(i);
77             else
78                 Q(i) = Qmax(i);
79             end
80             btype(i) = 3;
81         end
82     end
83     V(i) = (1/Y(i,i))*(((P(i)- %i*Q(i))/conj(V(i)
84         ))) - summ);
85     if btype(i) == 2
86         V(i) = abs(Vprev(i))*exp(%i * atan(imag(
87             V(i))/real(V(i))));
88     end
89     end
90     iteration = iteration + 1;
91     toler = max(abs(abs(V) - abs(Vprev)));
92     Vprev = V;
93 end
94 V=round(V*1e3)/1e3
95 ansmat(:,1)=[1;2;3;4;5]
96 ansmat(:,2)=round(abs(V(:,1))*1000)/1000
97 for i=1:5
98     ansmat(i,3)=round(atan(imag(V(i))/real(V(i)))*1
99         e3)/1e3
100 end
101 disp(ansmat," bus no   |V|       delta")

```

Scilab code Exa 9.13 solve using newton raphson 1 variable

```

1 clear
2 clc
3 E=10
4 x=1
5 e=1e-5
6
7 while (E>e)
8     f=(2*x) - (.43429 * log(x)) -7
9     df=2-(.43429 /x)
10    x1=x-(f/df)
11    E=abs(x1-x)
12    x=x1
13 end
14 mprintf(" x=%f" ,x)

```

Scilab code Exa 9.14 solve using newton raphson 2 variables

```

1 clear
2 clc
3
4 E=10
5 x=3.4
6 y=2.2
7 e=1e-5
8
9 while (E>e)
10    X=[x;y]
11    f=(x) + (3* .43429 * log(x)) -y^2
12    dfx=1 + (3* .43429 /x)
13    dfy=-2*y
14    g=(2*x*x) - (x*y) - (5*x) +1
15    dgx=(4*x) - (y) - (5)
16    dgy=-x
17    J=[dfx dfy; dgx dgy]
18    F=[f;g]

```

```

19     X1=X-(inv(J)* F)
20     E=max(abs(X1-X))
21     x=X1(1,1)
22     y=X1(2,1)
23 end
24 mprintf("x= %.4f , y=%.4f" , x,y)

```

Scilab code Exa 9.15 solve using newton raphson 1 variable

```

1 clear
2 clc
3 E=10
4 x=0
5 e=1e-4
6
7 while (E>e)
8     f=(3*x) - (cos(x))-1
9     df=3+sin(x)
10    x1=x-(f/df)
11    E=abs(x1-x)
12    x=x1
13 end
14 mprintf("x=%.4f" ,x)

```

Scilab code Exa 9.17 solve system using newton raphson method

```

1 clear
2 clc
3
4 y=[
5 1 2 .026+%i*.11 %i*.04
6 2 3 .026+%i*.11 %i*.04
7 1 3 .026+%i*.11 %i*.04

```

```

8 ]
9
10
11 n=3
12 e=3
13 Y=zeros(n,n)
14
15 for i=1:e
16     ynew = 1/(y(i,3))
17     y0=y(i,4)/2
18     n1=real(y(i,1))
19     n2=real(y(i,2))
20     if(n1==0)
21         Y(n2,n2)=Y(n2,n2)+ynew+y0
22     else
23         Y(n1,n1)= Y(n1,n1)+ynew+y0
24         Y(n1,n2)= Y(n1,n2)-ynew
25         Y(n2,n1)= Y(n2,n1)-ynew
26         Y(n2,n2)= Y(n2,n2)+ynew+y0
27     end
28 end
29 for i=1:n
30     for j=1:n
31         if i==j then
32             Yb(i,j)= string(round(abs(Y(i,j))*1000)
33                 /1000) + '/' + string(round(atan(imag
34                 (Y(i,j))/real(Y(i,j)))*100)/100)
35         else
36             Yb(i,j)= string(round(abs(Y(i,j))*1000)
37                 /1000) + '/' + string(round((atan(
38                 imag(Y(i,j))/real(Y(i,j)))+180)*100)
39                 /100)
40         end
41     end
42 end
43 Y=round(Y*1e3)/1e3
44 disp(Yb," (a) Ybus")
45 // bus no | PL | QL | PG | QG | V | th | btype

```

```

41
42 data = [
43 1 %inf %inf 1 .5 1.03 0 1
44 2 1.5 %inf 0 0 1.03 0 2
45 3 0 0 1.2 .5 1 0 3
46 ]
47
48 j = data(:,1); // Bus number.
49 PG = data(:,2);
50 QG = data(:,3);
51 PL = data(:,4);
52 QL = data(:,5);
53 V = data(:,6);
54 th = data(:,7)* %pi / 180;
55 btype = data(:,8); // Type of Bus 1-Slack, 2-PV,
    3-PQ.
56 nbus = max(j);
57 P = PG - PL;
58 Q = QG - QL
59 Psp = P;
60 Qsp = Q;
61 G = real(Y);
62 B = imag(Y);
63 for i=1:nbus
64     V(i,1)=V(i,1) * exp (%i * th(i,1))
65 end
66
67 pv = [2] // which bus is PV
68 pq = [3] // which bus is PQ
69 npv = length(pv);
70 npq = length(pq);
71
72 Tol = 1;
73 Iter = 1;
74 while (Iter == 1)
75
76     P = zeros(nbus,1);
77     Q = zeros(nbus,1);

```



```

78
79     for i = 1:nbus
80         for k = 1:nbus
81             P(i) = P(i) + V(i)* V(k)*(G(i,k)*cos(th(
                i)-th(k)) + B(i,k)*sin(th(i)-th(k)));
82             Q(i) = Q(i) + V(i)* V(k)*(G(i,k)*sin(th(
                i)-th(k)) - B(i,k)*cos(th(i)-th(k)));
83         end
84     end
85
86     dPa = Psp-P;
87     dQa = Qsp-Q;
88     k = 1;
89     dQ = zeros(npq,1);
90     for i = 1:nbus
91         if btype(i) == 3
92             dQ(k,1) = dQa(i);
93             k = k+1;
94         end
95     end
96     dP = dPa(2:nbus);
97     M = [dP; dQ];
98
99     H = zeros(nbus-1,nbus-1);
100    for i = 1:(nbus-1)
101        m = i+1;
102        for k = 1:(nbus-1)
103            n = k+1;
104            if n == m
105                for n = 1:nbus
106                    H(i,k) = H(i,k) + V(m)* V(n)*(-G
                        (m,n)*sin(th(m)-th(n)) + B(m,
                        n)*cos(th(m)-th(n)));
107                end
108                H(i,k) = H(i,k) - V(m)^2*B(m,m);
109            else
110                H(i,k) = V(m)* V(n)*(G(m,n)*sin(th(m)
                    )-th(n)) - B(m,n)*cos(th(m)-th(n))

```

```

    ));
111     end
112   end
113 end
114
115 N = zeros(nbus-1,npq);
116 for i = 1:(nbus-1)
117   m = i+1;
118   for k = 1:npq
119     n = pq(k);
120     if n == m
121       for n = 1:nbus
122         N(i,k) = N(i,k) + V(n)*(G(m,n)*
           cos(th(m)-th(n)) + B(m,n)*sin
           (th(m)-th(n)));
123       end
124       N(i,k) = N(i,k) + V(m)*G(m,m);
125     else
126       N(i,k) = V(m)*(G(m,n)*cos(th(m)-th(n)
           )) + B(m,n)*sin(th(m)-th(n)));
127     end
128   end
129 end
130
131 J3 = zeros(npq,nbus-1);
132 for i = 1:npq
133   m = pq(i);
134   for k = 1:(nbus-1)
135     n = k+1;
136     if n == m
137       for n = 1:nbus
138         J3(i,k) = J3(i,k) + V(m)* V(n)*(
           G(m,n)*cos(th(m)-th(n)) + B(m
           ,n)*sin(th(m)-th(n)));
139       end
140       J3(i,k) = J3(i,k) - V(m)^2*G(m,m);
141     else
142       J3(i,k) = V(m)* V(n)*(-G(m,n)*cos(th

```

```

(m)-th(n)) - B(m,n)*sin(th(m)-th(
n)));
143     end
144     end
145 end
146
147 L = zeros(npq,npq);
148 for i = 1:npq
149     m = pq(i);
150     for k = 1:npq
151         n = pq(k);
152         if n == m
153             for n = 1:nbus
154                 L(i,k) = L(i,k) + V(n)*(G(m,n)*
                    sin(th(m)-th(n)) - B(m,n)*cos
                    (th(m)-th(n)));
155                 end
156                 L(i,k) = L(i,k) - V(m)*B(m,m);
157             else
158                 L(i,k) = V(m)*(G(m,n)*sin(th(m)-th(n)
                    )) - B(m,n)*cos(th(m)-th(n)));
159             end
160         end
161     end
162
163 J = [H N; J3 L];
164
165 X = inv(J)*M;
166 dTh = X(1:npq+npv);
167 dV = X(nbus:nbus+npq-1);
168
169
170 th(2:nbus) = dTh + th(2:nbus);
171 k = 1;
172 for i = 2:nbus
173     if btype(i) == 3
174         V(i) = dV(k) + V(i);
175         k = k+1;

```

```

176         end
177     end
178
179     Iter = Iter + 1;
180     Tol = max(abs(M));
181
182 end
183 mprintf("\n\n(b)P2= %.3f , P2= %.3f , P3= %.3f , Q3= %
        .3f" , P(2),Q(2) ,P(3), Q(3))
184 J=fix(J*1e3)/1e3
185 disp(J, "(c)J")
186
187 mprintf("\n(d)\n")
188 mprintf("%.3f = %.3f dd2 + %.3f dd3 +%.3f dV3/|V3|\n
        ", dP(1), J(1,1), J(1,2), J(1,3) )
189 mprintf("%.3f = %.3f dd2 + %.3f dd3 +%.3f dV3/|V3|\n
        ", dP(2), J(2,1), J(2,2), J(2,3) )
190 mprintf("%.3f = %.3f dd2 + %.3f dd3 +%.3f dV3/|V3|\n
        ", dQ(1), J(3,1), J(3,2), J(3,3) )

```

Scilab code Exa 9.18 solve system using fast decoupled method

```

1 clear
2 clc
3
4 y=[
5 1 2 %i*.11
6 2 3 %i*.11
7 1 3 %i*.11
8 ]
9
10
11 n=3
12 e=3
13 Y=zeros(n,n)

```

```

14
15 for i=1:e
16     ynew = 1/(y(i,3))
17     n1=real(y(i,1))
18     n2=real(y(i,2))
19     if(n1==0)
20         Y(n2,n2)=Y(n2,n2)+ynew
21     else
22         Y(n1,n1)= Y(n1,n1)+ynew
23         Y(n1,n2)= Y(n1,n2)-ynew
24         Y(n2,n1)= Y(n2,n1)-ynew
25         Y(n2,n2)= Y(n2,n2)+ynew
26     end
27 end
28 Y=round(Y*1e3)/1e3
29 disp(Y,"(a)Ybus")
30 // bus no | PL | QL | PG | QG | V | th | btype
31
32 data = [
33 1 %inf %inf 1 .5 1.03 0 1
34 2 1.5 %inf 0 0 1.03 0 2
35 3 0 0 1.2 .5 1 0 3
36 ]
37
38 j = data(:,1); // Bus number.
39 PG = data(:,2);
40 QG = data(:,3);
41 PL = data(:,4);
42 QL = data(:,5);
43 V = data(:,6);
44 th = data(:,7)* %pi / 180;
45 btype = data(:,8); // Type of Bus 1-Slack, 2-PV,
46 // 3-PQ.
47 nbus = max(j);
48 P = PG - PL;
49 Q = QG - QL
49 Psp = P;
50 Qsp = Q;

```

```

51 G = real(Y);
52 B = imag(Y);
53 for i=1:nbus
54     V(i,1)=V(i,1) * exp (%i * th(i,1))
55 end
56
57 pv = [2]           // which bus is PV
58 pq = [3]           // which bus is PQ
59 npv = length(pv);
60 npq = length(pq);
61
62 Tol = 1;
63 Iter = 1;
64 while (Iter == 1)
65
66     P = zeros(nbus,1);
67     Q = zeros(nbus,1);
68
69     for i = 1:nbus
70         for k = 1:nbus
71             P(i) = P(i) + V(i)* V(k)*(G(i,k)*cos(th(
72                 i)-th(k)) + B(i,k)*sin(th(i)-th(k)));
73             Q(i) = Q(i) + V(i)* V(k)*(G(i,k)*sin(th(
74                 i)-th(k)) - B(i,k)*cos(th(i)-th(k)));
75
76         end
77     end
78
79     dPa = Psp-P;
80     dQa = Qsp-Q;
81     k = 1;
82     dQ = zeros(npq,1);
83     for i = 1:nbus
84         if btype(i) == 3
85             dQ(k,1) = dQa(i);
86             k = k+1;
87         end
88     end
89     dP = dPa(2:nbus);

```

```

87     M = [dP; dQ];
88
89     H = zeros(nbus-1,nbus-1);
90     for i = 1:(nbus-1)
91         m = i+1;
92         for k = 1:(nbus-1)
93             n = k+1;
94             if n == m
95                 for n = 1:nbus
96                     H(i,k) = H(i,k) + V(m)* V(n)*(-G
                        (m,n)*sin(th(m)-th(n)) + B(m,
                        n)*cos(th(m)-th(n)));
97                 end
98                 H(i,k) = H(i,k) - V(m)^2*B(m,m);
99             else
100                H(i,k) = V(m)* V(n)*(G(m,n)*sin(th(m)
                    )-th(n)) - B(m,n)*cos(th(m)-th(n)
                    ));
101            end
102        end
103    end
104
105    N = zeros(nbus-1,npq);
106    for i = 1:(nbus-1)
107        m = i+1;
108        for k = 1:npq
109            n = pq(k);
110            if n == m
111                for n = 1:nbus
112                    N(i,k) = N(i,k) + V(n)*(G(m,n)*
                        cos(th(m)-th(n)) + B(m,n)*sin
                        (th(m)-th(n)));
113                end
114                N(i,k) = N(i,k) + V(m)*G(m,m);
115            else
116                N(i,k) = V(m)*(G(m,n)*cos(th(m)-th(n)
                    )) + B(m,n)*sin(th(m)-th(n));
117            end

```

```

118         end
119     end
120
121     J3 = zeros(npq,nbus-1);
122     for i = 1:npq
123         m = pq(i);
124         for k = 1:(nbus-1)
125             n = k+1;
126             if n == m
127                 for n = 1:nbus
128                     J3(i,k) = J3(i,k) + V(m)* V(n)*(
                            G(m,n)*cos(th(m)-th(n)) + B(m
                            ,n)*sin(th(m)-th(n)));
129                 end
130                 J3(i,k) = J3(i,k) - V(m)^2*G(m,m);
131             else
132                 J3(i,k) = V(m)* V(n)*(-G(m,n)*cos(th
                            (m)-th(n)) - B(m,n)*sin(th(m)-th(
                            n)));
133             end
134         end
135     end
136
137     L = zeros(npq,npq);
138     for i = 1:npq
139         m = pq(i);
140         for k = 1:npq
141             n = pq(k);
142             if n == m
143                 for n = 1:nbus
144                     L(i,k) = L(i,k) + V(n)*(G(m,n)*
                            sin(th(m)-th(n)) - B(m,n)*cos
                            (th(m)-th(n)));
145                 end
146                 L(i,k) = L(i,k) - V(m)*B(m,m);
147             else
148                 L(i,k) = V(m)*(G(m,n)*sin(th(m)-th(n)
                            )) - B(m,n)*cos(th(m)-th(n)));

```



```

149         end
150     end
151 end
152
153     J = [H N; J3 L];
154
155     X = inv(J)*M;
156     dTh = X(1:npq+npv);
157     dV = X(nbus:nbus+npq-1);
158
159
160     th(2:nbus) = dTh + th(2:nbus);
161     k = 1;
162     for i = 2:nbus
163         if btype(i) == 3
164             V(i) = -dV(k) + V(i);
165             k = k+1;
166         end
167     end
168
169     Iter = Iter + 1;
170     Tol = max(abs(M));
171
172 end
173
174 V=round(V*10000)/10000
175 th=round(th*1e5)/1e5
176
177 mprintf("\n(b)P2=%0.0f P3=%0.0f Q3=%0.3f \n", P(2), P
(3), Q(3))
178 disp(-imag(Y(2:3,2:3)), "(c)B''")
179 disp(-imag(Y(3,3)), "B''''")
180
181 P = zeros(nbus,1);
182 Q = zeros(nbus,1);
183
184 for i = 1:nbus
185     for k = 1:nbus

```

```

186         P(i) = P(i) + real(V(i)* V(k)*Y(i,k)* exp(%i
           * (th(k)-th(i))))
187         Q(i) = Q(i) - imag(V(i)* V(k)*Y(i,k)* exp(%i
           * (th(k)-th(i))))
188     end
189 end
190 /" please note: there is an error in the book in
      calculation of Q3=-.0497 (part(e)) during value
      substitution in formula vi. The variation in
      results is due to the same error, verified
      seperately on calculator"
191 mprintf("\n\n(e)P2= %.3f, P3= %.3f, Q3= %.3f", P(2),
           P(3), Q(3))
192
193 Q(3)=-.49
194 P1=P(1)+P(2)+P(3)
195 Q1=Q(1)+Q(2)+Q(3)
196
197
198 mprintf("\n\n(f)real line losses= %.1f, reactive
           line losses= %.1f", P1, Q1)
199
200
201 data(1,2)=PL(1)+P(1);
202 data(1,3)=QL(1)+Q(1);
203 data(2,3)=QL(2)+Q(2);
204
205
206 mprintf("\n\n(g)PG1= %.1f, QG1= %.2f, PG2= %.1f, QG2=
           %.2f\n\n", data(1,2), data(1,3), data(2,2), data
           (2,3))
207
208 disp(" please note: there is an error in the book in
      calculation of Q3=-.0497 (part(e)) during value
      substitution in formula vi. The variation in
      results is due to the same error, verified
      seperately on calculator")

```

Scilab code Exa 9.19 solve system using gauss seidel method with acceleration cons

```
1 clear
2 clc
3
4 y=[
5 1 2 2-%i*8
6 1 3 1-%i*4
7 2 3 .666-%i*2.664
8 2 4 1-%i*4
9 3 4 2-%i*8
10 ]
11 n=max(real(y(:,1:2)))
12 e=5
13
14 Y=zeros(n,n)
15
16 for i=1:e
17     n1=real(y(i,1))
18     n2=real(y(i,2))
19     ynew=y(i,3)
20     if(n1==0)
21         Y(n2,n2)=Y(n2,n2)+ynew
22     else
23         Y(n1,n1)= Y(n1,n1)+ynew
24         Y(n1,n2)= Y(n1,n2)-ynew
25         Y(n2,n1)= Y(n2,n1)-ynew
26         Y(n2,n2)= Y(n2,n2)+ynew
27     end
28 end
29
30 disp(Y," Ybus")
31 // bus no | P | Q | V | th | btype
32
```

```

33 data = [
34 1 %inf %inf 1.06 0 1
35 2 .5 .2 1 0 3
36 3 .4 .3 1 0 3
37 4 .3 .1 1 0 3
38 ]
39
40 j = data(:,1); // Bus number.
41 P = data(:,2);
42 Q = data(:,3);
43 V = data(:,4);
44 th = data(:,5);
45 btype = data(:,6); // Type of Bus 1-Slack, 2-PV,
    3-PQ.
46 n = max(j);
47
48 a=1.6
49
50 for i=1:n
51     V(i,1)=V(i,1) * exp (%i * th(i,1)* %pi / 180)
52 end
53
54 Vprev = V;
55 toler = 1000;
56 iteration = 1;
57 disp("(b)")
58 while (iteration==1)
59     for i = 2:n
60         summ = 0;
61         for k = 1:n
62             if i ~= k
63                 summ = summ + Y(i,k)* V(k);
64             end
65         end
66         V(i) = (1/Y(i,i))*(((P(i)- %i*Q(i))/conj(V(i)
        ))) - summ);
67         dv=V(i)-Vprev(i)
68         mprintf("\nV%d = %.3f ang(%.2f) deg", i,abs(

```

```
        V(i)),atand(imag(V(i))/real(V(i))))
69     V(i)=Vprev(i)+(a*dv)
70     if btype(i) == 2
71         V(i) = abs(Vprev(i))*exp(%i * atan(imag(
            V(i))/real(V(i))));
72     end
73 end
74 iteration = iteration + 1;
75 toler = max(abs(abs(V) - abs(Vprev)));
76 Vprev = V;
77 end
```

Chapter 10

Balanced and Unbalanced Faults

Scilab code Exa 10.1 find fault current and fault level

```
1 clear
2 clc
3
4 Sg1=100
5 Vg1=11
6 xg1=.15 *%i
7
8 Sg2=50
9 Vg2=11
10 xg2=.1 *%i
11
12 St1=100
13 Vt1a=11
14 Vt1b=132
15 xt1=.1 *%i
16 nt1=Vt1b/Vt1a
17
18 St2=50
19 Vt2a=11
```

```

20 Vt2b=132
21 xt2=.08 *%i
22 nt2=Vt2b/Vt2a
23
24 Sb=100
25 Vb1=11
26 Vb2=nt1*Vb1
27
28 x1=.2 * 200 *%i
29 X1=x1/(Vb2*Vb2/Sb)
30
31 Xg2=xg2*Sb/Sg2
32 Xt2=xt2 * Sb/St2
33
34 X=( ((xg1 +xt1) * (Xg2 +Xt2) )/ ((xg1 +xt1) + (Xg2 +
      Xt2) )) +X1/2
35
36 I=1/X
37
38 Ib1=Sb*1e3/(Vb1*sqrt(3))
39 Ib2=Sb*1e3/(Vb2*sqrt(3))
40 If=abs(I*Ib2)
41 Ifg=abs(I*Ib1)
42 Ifg1=Ifg * (Xg2 +Xt2)/(xg1+xt1+Xt2+Xg2)
43 Ifg2=Ifg * (xg1 +xt1)/(xg1+xt1+Xt2+Xg2)
44 MVAf=abs(I*1*Sb)
45
46 mprintf("Total fault current = %.2f A, Fault Level=
      %f MVA,\n Fault current supplied by generator 1=
      %f A, generator 2=%f A",If, MVAf, Ifg1, Ifg2)

```

Scilab code Exa 10.2 find fault level and X to limit current during 3 phase fault

```

1 clear
2 clc

```

```

3
4 s=50
5 v=11
6 x=.15
7 S=50
8 V=11
9
10 Xe=.15/4
11 FMVA= round(10000/Xe)/10000
12 Fault=FMVA * S
13 mprintf("\n(a) fault level = %.3f pu", Fault)
14
15 sga=.5*Fault
16 sgb=800-sga
17
18 xb=.15/2
19 X=(S/sgb)-xb
20 x=X*(V*V/S)
21 mprintf("\n(b)X = %.3f ohms", x)

```

Scilab code Exa 10.3 find fault current and fault level during 3 phase fault

```

1 clear
2 clc
3
4 G=[100 11 .2]
5 T=[100 11 132 .05]
6 L=[
7 1.2e-3 100
8 1e-3 50
9 1e-3 50
10 ]
11 B=[100 11]
12 T(5)= T(3)/T(2)
13 B(3)=B(2)* T(5)

```



```

14 B(4)=B(3)^2/B(1)
15 for(i=1:3)
16     L(i,3)= 2*%pi*50* L(i,1)* L(i,2);
17     L(i,4)= L(i,3)/B(4)
18 end
19 l=L(:,4)
20 X1=l(1)*l(2)/(l(1)+l(2)+l(3))
21 X2=l(3)*l(2)/(l(1)+l(2)+l(3))
22 X3=l(1)*l(3)/(l(1)+l(2)+l(3))
23 X=((G(3)+T(4)+(X1))^-1) + ((G(3)+T(4)+(X3))^-1)
    ^-1 +X2
24 SF=round(10/X)/10
25 S=SF* B(1)
26 IF=round(10/X)/10
27 I=IF*B(1)*1e6/(sqrt(3)*B(3)*1e3)
28 mprintf("Fault level = %.0f MVA, Fault current %.1f
    A", S,I)

```

Scilab code Exa 10.4 find subtransient currents in system

```

1 clear
2 clc
3
4 T=[10 132 6.6 .15]
5 M=[5 6.6 .3 .2 ]
6 B=[10 6.6]
7 T(5)= T(3)/T(2)
8 B(3)=B(2)* T(5)
9 B(4)= B(1)*1e6/(sqrt(3)*B(2)*1e3)
10 M(5)=M(4) *B(1)/M(1)
11 M(6)=M(3) *B(1)/M(1)
12
13 X1=1/((1/M(5))+(1/M(5))+(1/T(4)))
14 IF1=round(100/X1)/100
15 I1=IF1*B(4)

```

```

16 mprintf("\n(a) sub transient fault current=%0.0f A",
    I1)
17
18 It=round(100/T(4))/100
19 Im=1/M(5)
20 ID=It+Im
21 iD=ID*B(4)
22 mprintf("\n(b) current through D=%0.0f A", iD)
23
24 RD=iD*1.6
25 mprintf("\n(c) current rating of D=%0.0f A", RD)
26
27 X2=1/((1/M(6))+(1/T(4)))
28 IF2=round(100/X2)/100
29 I2=IF2*round(B(4)*10)/10
30 iCB=1.1 *I2
31 mprintf("\n(d) current to be interrupted by D=%0.1f
    A", fix(iCB*10)/10)

```

Scilab code Exa 10.5 calculate total generator and motor current in 3phase fault

```

1 clear
2 clc
3
4 G=[100 11 .25]
5 M=[50 11 .2 40 .8]
6 x1=.05
7 vt=10.95
8
9 B=[100 11]
10 B(3)= B(1)*1e6/(sqrt(3)*B(2)*1e3)
11
12 IL=M(4)*1e6 / (sqrt(3)*vt*1e3*M(5))
13 I1=round(((IL/B(3) * exp(%i * acos(M(5)))))*1000)
    /1000

```

```

14
15 Vt=round(1e3*vt/B(2))/1e3
16
17 V=fix((Vt + I1*x1*%i)*1e4)*1e-4
18
19 M(6)=M(3) *B(1)/M(1)
20
21 xth= round( G(3) * (M(6) +x1)/(G(3) + (M(6) +x1))
          *10000)/10000
22
23 If=fix(V*1e3/(%i *xth))/1e3
24 temp= fix(imag(If)*100)/100
25 If=complex(real(If), temp)
26 Ifg=fix((If * (M(6) +x1)/(G(3) + (M(6) +x1)))*100)
          /100
27 Ifm=round((If * (G(3)      )/(G(3) + (M(6) +x1)))
          *1000)/1000
28
29 Ig=(Ifg + I1) * B(3)
30 Im=(Ifm - I1) *B(3)
31
32 mprintf("\ntotal generator current during fault= %s
          A", string(round(abs(Ig)*10)/10) + '/' + string(
          round(atan(imag(Ig)/real(Ig))*10)/10))
33 mprintf("\ntotal motor current during fault= %s A",
          string(fix(abs(Im)*1)/1) + '/' + string(fix(atan(
          imag(Im)/real(Im))*10)/10 +180))

```

Scilab code Exa 10.6 find symmetrical components

```

1 clear
2 clc
3
4 I=[
5 5*exp(%i * %pi * 60 / 180)

```

```

6 5*exp(%i * %pi * -60 / 180)
7 0
8 ]
9 a=exp(%i * 2 * %pi/3)
10 A=[1 1 1
11 1 a^2 a
12 1 a a^2
13 ]
14
15 Is=inv(A)*I
16
17 mprintf("\nIa0= %s", string(round(abs(Is(1))*1000)
      /1000) + '/_'+ string(round(atan(imag(Is(1))/real
      (Is(1)))*100)/100) )
18 mprintf("\nIa1= %s", string(round(abs(Is(2))*1000)
      /1000) + '/_'+ string(round(atan(imag(Is(2))/real
      (Is(2)))*100)/100) )
19 mprintf("\nIa2= %s", string(round(abs(Is(3))*1000)
      /1000) + '/_'+ string(round(atan(imag(Is(3))/real
      (Is(3)))*100)/100 +180) )

```

Scilab code Exa 10.8 find zero sequence components

```

1 clear
2 clc
3
4 G=[50 11 0 .08
5 30 11 0 .07]
6 T=[50 11 220 .1
7 30 220 11 .09]
8
9 B=[50 11]
10
11 T(1,5)= T(1,3)/T(1,2)
12 T(2,5)= T(2,3)/T(2,2)

```

```

13 B(3)=B(2)* T(1,5)
14 B(4)=B(3)* T(2,5)
15
16 B(5)= B(3)^2/B(1)
17
18 Z=555.6
19 z=Z/B(5)
20
21 zt2=T(2,4) * B(1)/T(2,1)
22 zg2=G(2,4) * B(1)/G(2,1)
23
24 Zn=3
25 zn=Zn *3 / ( B(4)^2/B(1))
26
27 mprintf("zero seq netwk: xt1= %.1f, xt2=%.2f, Xg1=%
    .2f Xg2=%.3f, xl=%.3f, Zn=%.2fi",T(1,4), zt2, G
    (1,4), zg2, z,zn)

```

Scilab code Exa 10.10 find fault MVA and current and line to line voltages during

```

1 clear
2 clc
3
4 Z=[.2 .2 .05]' * %i
5 S=30
6 V=11
7 I=S*1e6/(sqrt(3)*V*1e3)
8 E=1
9
10 Ia1=E/(Z(1)+Z(2)+Z(3))
11 If= 3*abs(Ia1) * S*1e6/(sqrt(3)* V*1e3)
12 Ia2=Ia1
13 Ia0=Ia1
14
15 a=exp(%i * 2 * %pi/3)

```

```

16 A=[1 1 1
17 1 a^2 a
18 1 a a^2
19 ]
20
21 Va1=E-Ia1*Z(1)
22 Va2=0-Ia2*Z(2)
23 Va0=0-Ia0*Z(3)
24
25 Vp=[ Va0 Va1 Va2]’
26 v=A*Vp
27
28 vab=v(1)-v(2)
29 vbc=v(2)-v(3)
30 vca=v(3)-v(1)
31
32 Vb11=V/sqrt(3)
33
34 Vab=vab * Vb11
35 Vbc=vbc * Vb11
36 Vca=vca * Vb11
37 V11=[Vab Vbc Vca]
38 mprintf(“\n(a)\n line currents: If= %f A, Line
    voltages in KV ”, If)
39 mprintf(“\nVab= %s”, string(round(abs(V11(1))*10)
    /10) + ‘/_’+ string(round(atan2(imag(V11(1))/real(
    V11(1)))*10)/10) )
40 mprintf(“\nVbc= %s”, string(round(abs(V11(2))*10)
    /10) + ‘/_’+ string(round(atan2(imag(V11(2))/real(
    V11(2)))*10)/10 +180) )
41 mprintf(“\nVca= %s”, string(round(abs(V11(3))*10)
    /10) + ‘/_’+ string(round(atan2(imag(V11(3))/real(
    V11(3)))*10)/10 +180))
42
43
44
45 If3=E/Z(1)
46 if3=abs(If3)* S*1e6/(sqrt(3)* V*1e3)

```

```

47
48 mprintf("\\n(b)3 phase fault current is  $-\%.0$  fi A",
        if3)

```

Scilab code Exa 10.11 thevinin equivalent impedances of sequence networks as seen

```

1 clear
2 clc
3
4 X=[
5   .25 .25 .05
6   .2 .2 .05
7   .06 .06 .06
8   .07 .07 .07
9   .1 .1 .3
10  .1 .1 .3
11 ]
12
13 B=[
14     100 11
15     100 11
16     100 11
17     100 11
18     100 220
19     100 220
20  ]
21 V1=11
22 V2=220
23 S=100
24 Xe=3*.03
25 //end 9
26 X1=(((X(1,1)*B(1,1) *V1/(S*B(1,2))) +(X(3,1)*B(3,1)
        *V1/(S*B(3,2))) )^-1+((X(2,1)*B(2,1) *V1/(S*B
        (2,2)))+(X(4,1)*B(4,1) *V1/(S*B(4,2))) +(X(5,1)*
        B(5,1) *V2/(S*B(5,2)))^-1 +(X(6,1)*B(6,1) *V2/(S*

```

```

    B(6,2)))^-1)^-1)^-1)^-1
27
28 X2=(((X(1,2)*B(1,1) *V1/(S*B(1,2))) + (X(3,2)*B(3,1)
    *V1/(S*B(3,2))) )^-1+((X(2,2)*B(2,1) *V1/(S*B
    (2,2)))+(X(4,2)*B(4,1) *V1/(S*B(4,2))) +((X(5,2)*
    B(5,1) *V2/(S*B(5,2)))^-1 + (X(6,2)*B(6,1) *V2/(S*
    B(6,2)))^-1)^-1)^-1)^-1
29
30 X0=(((X(3,3)*B(3,1) *V1/(S*B(3,2)))^-1 + ((Xe *B
    (4,1) *V1/(S*B(4,2))) + (X(2,3)*B(2,1) *V1/(S*B
    (2,2))) + (X(4,3)*B(4,1) *V1/(S*B(4,2))) +((X
    (5,3)*B(5,1) *V2/(S*B(5,2))))^-1 + (X(6,3)*B(6,1)
    *V2/(S*B(6,2)))^-1)^-1 )^-1 )^-1 )^-1
31
32 Z1=%i * round(X1*1e3)/1e3
33 Z2=%i * round(X2*1e3)/1e3
34 Z0=%i * round(X0*1e3)/1e3
35
36 Z=[Z1 Z2 Z0] '
37
38 mprintf("\nZ1= %.3 fj\n", imag(Z(1)))
39 mprintf("Z2= %.3 fj\n", imag(Z(2)))
40 mprintf("Z0= %.3 fj\n", imag(Z(3)))

```

Scilab code Exa 10.12 find fault current voltage at fault point and current and vo

```

1 clear
2 clc
3
4 X=[
5 .25 .25 .05
6 .2 .2 .05
7 .06 .06 .06
8 .07 .07 .07
9 .1 .1 .3

```



```

10  .1  .1  .3
11  ]
12
13  B=[
14      100  11
15      100  11
16      100  11
17      100  11
18      100  220
19      100  220
20  ]
21  V1=11
22  V2=220
23  S=100
24  Xe=3*.03
25  //end 9
26  X1=((X(1,1)*B(1,1) *V1/(S*B(1,2))) + (X(3,1)*B(3,1)
      *V1/(S*B(3,2))) )^-1+((X(2,1)*B(2,1) *V1/(S*B
      (2,2)))+(X(4,1)*B(4,1) *V1/(S*B(4,2))) +((X(5,1)*
      B(5,1) *V2/(S*B(5,2)))^-1 + (X(6,1)*B(6,1) *V2/(S*
      B(6,2)))^-1)^-1)^-1)^-1
27
28  X2=((X(1,2)*B(1,1) *V1/(S*B(1,2))) + (X(3,2)*B(3,1)
      *V1/(S*B(3,2))) )^-1+((X(2,2)*B(2,1) *V1/(S*B
      (2,2)))+(X(4,2)*B(4,1) *V1/(S*B(4,2))) +((X(5,2)*
      B(5,1) *V2/(S*B(5,2)))^-1 + (X(6,2)*B(6,1) *V2/(S*
      B(6,2)))^-1)^-1)^-1)^-1
29
30  X0=((X(3,3)*B(3,1) *V1/(S*B(3,2)))^-1 + ((Xe *B
      (4,1) *V1/(S*B(4,2))) + (X(2,3)*B(2,1) *V1/(S*B
      (2,2))) + (X(4,3)*B(4,1) *V1/(S*B(4,2))) +((X
      (5,3)*B(5,1) *V2/(S*B(5,2))))^-1 + (X(6,3)*B(6,1)
      *V2/(S*B(6,2)))^-1)^-1 )^-1 )^-1 )^-1
31
32  Z1=%i * round(X1*1e3)/1e3
33  Z2=%i * round(X2*1e3)/1e3
34  Z0=%i * round(X0*1e3)/1e3
35  Z=[Z1 Z2 Z0]'

```

```

36 //end ques 11
37
38 a=exp(%i * 2 * %pi /3)
39 A= [1 1 1 ; 1 a^2 a; 1 a a^2]
40
41 //12(a)
42 Ia1a=1/(Z1+Z2+Z0)
43 Ia1a=round(Ia1a *1e2)/1e2
44 mIa1a=[ Ia1a Ia1a Ia1a]'
45 mIa=A*mIa1a
46 Ia=round(mIa(1)*100)/100
47 Iaa = round(abs(mIa(1))*100)/100
48 Iba=round(S*1e7/(sqrt(3) * V2 * 1e3))/10
49 IFa=round(Iba * Iaa *100)/100
50
51 mprintf("\n(a) Fault current = %.2f A",IFa)
52
53 //12(b)
54
55 Va1=round((1- (Z1 * Ia1a))*100)/100
56 Va2=round((0- (Z2 * Ia1a))*100)/100
57 Va0=round((0- (Z0 * Ia1a))*100)/100
58 mVa1=[ Va0 Va1 Va2]'
59 mVa=A*mVa1
60 v=mVa * V2 / sqrt(3)
61 v=round(v *10000)/10000
62
63 mprintf("\n\n(b)line to neutral voltages in KV ")
64 mprintf("\nVa= %s", string(fix(abs(v(1))*100)/100)
65 )
66 mprintf("\nVb= %s", string(fix(abs(v(2))*100)/100) +
67 ' /_ ' + string(round(atan(imag(v(2))/real(v(2)))
68 *100)/100 +180 ) )
69 mprintf("\nVc= %s", string(fix(abs(v(3))*100)/100) +
70 ' /_ ' + string(round(atan(imag(v(3))/real(v(3)))
71 *100)/100 +180))
72
73 //12(c) --- g2

```

```

69
70 Ia1g2= Ia1a * (((X(1,1)*B(1,1) *V1/(S*B(1,2))) +(X
    (3,1)*B(3,1) *V1/(S*B(3,2))) ))/((((X(1,1)*B(1,1)
    *V1/(S*B(1,2))) +(X(3,1)*B(3,1) *V1/(S*B(3,2)))
    )+(X(2,1)*B(2,1) *V1/(S*B(2,2)))+(X(4,1)*B(4,1)
    *V1/(S*B(4,2))) +(X(5,1)*B(5,1) *V2/(S*B(5,2)))
    ^-1 +(X(6,1)*B(6,1) *V2/(S*B(6,2)))^-1)^-1))
71 Ia1g2=round(Ia1g2 *1e2)/1e2
72
73 Ia2g2= Ia1a * (((X(1,2)*B(1,1) *V1/(S*B(1,2))) +(X
    (3,2)*B(3,1) *V1/(S*B(3,2))) ))/((((X(1,2)*B(1,1)
    *V1/(S*B(1,2))) +(X(3,2)*B(3,1) *V1/(S*B(3,2)))
    )+(X(2,2)*B(2,1) *V1/(S*B(2,2)))+(X(4,2)*B(4,1)
    *V1/(S*B(4,2))) +(X(5,2)*B(5,1) *V2/(S*B(5,2)))
    ^-1 +(X(6,2)*B(6,1) *V2/(S*B(6,2)))^-1)^-1))
74 Ia2g2=round(Ia2g2 *1e2)/1e2
75
76 Ia0g2= Ia1a * (((X(3,3)*B(3,1) *V1/(S*B(3,2))) ))
    /((((Xe *B(4,1) *V1/(S*B(1,2))) +(X(3,3)*B(3,1) *
    V1/(S*B(3,2))) )+(X(2,3)*B(2,1) *V1/(S*B(2,2)))+(
    X(4,3)*B(4,1) *V1/(S*B(4,2))) +(X(5,3)*B(5,1) *
    V2/(S*B(5,2)))^-1 +(X(6,3)*B(6,1) *V2/(S*B(6,2)))
    ^-1)^-1))
77 Ia0g2=round(Ia0g2 *1e2)/1e2
78
79 mIa1g2=[ Ia0g2 Ia1g2 Ia2g2]'
80 mIag2=A*mIa1g2
81 Ibc=round(S*1e7/(sqrt(3) * V1 * 1e3))/10
82 Iag2=abs(mIag2) * Ibc
83
84
85 mprintf("\n\n(c)line currents in A at generator 2 ")
86 mprintf("\nIa= %s", string(round(abs(Iag2(1))*10
    /10) )
87 mprintf("\nIb= %s", string(round(abs(Iag2(2))*10
    /10) )
88 mprintf("\nIc= %s", string(round(abs(Iag2(3))*10
    /10) )

```

```

89
90
91 Va1g2=round((1- (X(2,1) *%i * Ia1g2))*100)/100
92 Va2g2=round((0- (X(2,2) *%i * Ia2g2))*100)/100
93 Va0g2=round((0- ((X(2,3) +Xe) *%i * Ia0g2))*10000)
    /10000
94 mVa1g2=[ Va0g2  Va1g2  Va2g2]’
95 mVag2=A*mVa1g2
96 vg2=mVag2 * V1 / sqrt(3)
97
98 mprintf("\n\nline to neutral voltages in KV at
    generator 2 ")
99 mprintf("\nVa= %s", string(fix(abs(vg2(1))*100)/100)
    )
100 mprintf("\nVb= %s", string(fix(abs(vg2(2))*100)/100)
    )
101 mprintf("\nVc= %s", string(fix(abs(vg2(3))*100)/100)
    )
102
103 //12(c) --- g1
104
105 Ia1g1= (Ia1a-Ia1g2) * exp(%i * 1*%pi /6) *-1
106 Ia1g1=round(Ia1g1 *1e2)/1e2
107
108 Ia2g1= (Ia1a-Ia2g2)* exp(%i *-1*%pi /6) *-1
109 Ia2g1=round(Ia2g1 *1e2)/1e2
110
111 Ia0g1= 0
112
113 mIa1g1=[ Ia0g1  Ia1g1  Ia2g1]’
114 mIag1=A*mIa1g1
115 mIag1=round(mIag1*1e1)/1e1
116 Ibc=round(S*1e7/(sqrt(3) * V1 * 1e3))/10
117 Iag1=abs(mIag1) * Ibc
118
119
120 mprintf("\n\nline currents in A at generator 1”)
121 mprintf("\nIa= %s", string(round(abs(Iag1(1))*1)/1)

```

```

    )
122 mprintf("\nIb= %s", string(round(abs(Iag1(2))*1)/1)
    )
123 mprintf("\nIc= %s", string(round(abs(Iag1(3))*1)/1)
    )
124
125
126 Va1g1=round((1- (X(1,1) *%i * (Ia1a-Ia1g2)))*10000)
    /10000
127 Va1g1=Va1g1 * exp(%i * 1*%pi /6)
128 Va2g1=round((0- (X(1,2) *%i * (Ia1a-Ia2g2)))*10000)
    /10000
129 Va2g1=Va2g1 * exp(%i *- 1*%pi /6)
130 Va0g1=0
131 mVa1g1=[ Va0g1 Va1g1 Va2g1]'
132 mVag1=A*mVa1g1
133 vg1=mVag1 * V1 / sqrt(3)
134
135 mprintf("\n\nline to neutral voltages in KV at
    generator 1 ")
136 mprintf("\nVa= %s", string(fix(abs(vg1(1))*100)/100)
    )
137 mprintf("\nVb= %s", string(fix(abs(vg1(2))*100)/100)
    )
138 mprintf("\nVc= %s", string(fix(abs(vg1(3))*100)/100)
    )

```

Scilab code Exa 10.13 calculate fault current during LG fault

```

1 clear
2 clc
3
4 Sb=37.5
5 Vb=33
6 Zb=Vb*Vb/Sb

```

```

7 Ib= Sb *1e6 / (sqrt(3) *Vb *1e3)
8 x1=[.18 .12 .1]
9 x2=[6.3 6.3 12.6]
10 X2=x2/Zb
11
12 X=x1+X2
13
14 x=X(1)+X(2)+X(3)
15
16 If=3*1/x
17 IF=If*Ib
18 mprintf(" Fault current is %.1f A", IF)

```

Scilab code Exa 10.14 find line currents and voltages under LL fault conditions

```

1 clear
2 clc
3
4 Z=[.2 .2 .05]' * %i
5 S=30
6 V=11
7 I=S*1e6/(sqrt(3)*V*1e3)
8 E=1
9
10 Ia1=E/(Z(1)+Z(2))
11 Ia2=-Ia1
12 Ia0=0
13 Ibase=S*1e6/(sqrt(3)* V*1e3)
14
15 Ia=0
16 Ib=sqrt(3)*Ia1*Ibase
17 Ic=-Ib
18
19 mprintf("\nLine currents: (Ia Ib Ic) in Ampere")
20 mprintf("\nIa= %d", Ia)

```

```

21 mprintf("\nIb= -%d", abs(Ib))
22 mprintf("\nIc= %d", abs(Ic))
23
24 a=exp(%i * 2 * %pi/3)
25 A=[1 1 1
26 1 a^2 a
27 1 a a^2
28 ]
29
30 Va1=E-Ia1*Z(1)
31 Va2=0-Ia2*Z(2)
32 Va0=0-Ia0*Z(3)
33
34 Vb11=V/sqrt(3)
35 Vp=[ Va0 Va1 Va2]'
36 v=A*Vp*Vb11
37
38 mprintf("\nline to neutral voltages in KV ")
39 mprintf("\nVa= %s", string(round(abs(v(1))*1000)
      /1000) + '/' + string(round(atan2(imag(v(1))/real(
      v(1)))*10)/10) )
40 mprintf("\nVb= %s", string(round(abs(v(2))*1000)
      /1000) + '/' + string(round(atan2(imag(v(2))/real(
      v(2)))*10)/10 +180) )
41 mprintf("\nVc= %s", string(round(abs(v(3))*1000)
      /1000) + '/' + string(round(atan2(imag(v(3))/real(
      v(3)))*10)/10 +180))

```

Scilab code Exa 10.15 find line currents and voltages under LLG fault conditions

```

1 clear
2 clc
3
4 clear
5 clc

```

```

6
7 Z=[.2 .2 .05]' * %i
8 S=30
9 V=11
10 I=round(S*1e8/(sqrt(3)*V*1e3) )/1e2
11 E=1
12
13 Ia1=E/(Z(1)+(Z(2)*Z(3)/(Z(2)+Z(3))))
14 Ia1=round(Ia1*1000)/1000
15 Ia2=-Ia1 * Z(3)/(Z(2)+Z(3))
16 Ia0=-Ia1 * Z(2)/(Z(2)+Z(3))
17
18 a=exp(%i * 2 * %pi/3)
19 A=[1 1 1
20 1 a^2 a
21 1 a a^2
22 ]
23
24 Ia=A*[ Ia0 Ia1 Ia2]' * I
25
26 mprintf("Line currents: ")
27 mprintf("\nIa= %.2f ang(0) A",abs(Ia(1)))
28 mprintf("\nIb= %.2f ang(%.2f) A",abs(Ia(2)),atand(
    imag(Ia(2))/real(Ia(2))+180)
29 mprintf("\nIc= %.2f ang(%.2f) A",abs(Ia(3)),atand(
    imag(Ia(3))/real(Ia(3))))
30
31
32 If=Ia(2)+Ia(3)
33 mprintf("\nFault current= %.0f ang(%.2f) A",abs(If),
    atand(imag(If)/real(If)))
34
35 Va1=1-(Ia1*Z(1))
36 Va2=Va1
37 Va0=Va1
38
39 Va=A*[Va0 Va1 Va2]' * V/sqrt(3)
40 mprintf("\nLine to neutral voltages: ")

```



```

41 mprintf("\nVa= %.3 f ang(%.2 f) kV",abs(Va(1)),atand(
    imag(Va(1))/real(Va(1)))
42 mprintf("\nVb= %.3 f KV",abs(Va(2)))
43 mprintf("\nVc= %.3 f KV",abs(Va(3)))

```

Scilab code Exa 10.16 find line currents under LG fault conditions

```

1 clear
2 clc
3
4 X=[
5   .25 .25 .05
6   .2 .2 .05
7   .06 .06 .06
8   .07 .07 .07
9   .1 .1 .3
10  .1 .1 .3
11 ]
12
13 B=[
14     100 11
15     100 11
16     100 11
17     100 11
18     100 220
19     100 220
20     ]
21 V1=11
22 V2=220
23 S=100
24 Xe=3*.03
25 //end 9
26 X1=((X(1,1)*B(1,1) *V1/(S*B(1,2))) +(X(3,1)*B(3,1)
    *V1/(S*B(3,2))) )^-1+((X(2,1)*B(2,1) *V1/(S*B
    (2,2)))+(X(4,1)*B(4,1) *V1/(S*B(4,2))) +(X(5,1)*

```

```

    B(5,1) *V2/(S*B(5,2)))^-1 +(X(6,1)*B(6,1) *V2/(S*
    B(6,2)))^-1)^-1)^-1)^-1
27
28 X2=(((X(1,2)*B(1,1) *V1/(S*B(1,2))) +(X(3,2)*B(3,1)
    *V1/(S*B(3,2))) )^-1+((X(2,2)*B(2,1) *V1/(S*B
    (2,2)))+(X(4,2)*B(4,1) *V1/(S*B(4,2))) +(X(5,2)*
    B(5,1) *V2/(S*B(5,2)))^-1 +(X(6,2)*B(6,1) *V2/(S*
    B(6,2)))^-1)^-1)^-1)^-1
29
30 X0=(((X(3,3)*B(3,1) *V1/(S*B(3,2)))^-1 + ((Xe      *B
    (4,1) *V1/(S*B(4,2))) + (X(2,3)*B(2,1) *V1/(S*B
    (2,2))) + (X(4,3)*B(4,1) *V1/(S*B(4,2))) +(((X
    (5,3)*B(5,1) *V2/(S*B(5,2))))^-1 +(X(6,3)*B(6,1)
    *V2/(S*B(6,2)))^-1)^-1 )^-1 )^-1
31
32 Z1=%i * round(X1*1e3)/1e3
33 Z2=%i * round(X2*1e3)/1e3
34 Z0=%i * round(X0*1e3)/1e3
35
36 //end q11
37
38 a=exp(%i * 2 * %pi /3)
39 A= [1 1 1 ; 1 a^2 a; 1 a a^2]
40
41
42 Ia1=1/(Z1 + (Z2*Z0/(Z2+Z0)))
43 Ia1=round(Ia1 *1e3)/1e3
44 Ia2=(Z0/(Z2+Z0)) * Ia1 *-1
45 Ia2=round(Ia2 *1e3)/1e3
46 Ia0=(Z2/(Z2+Z0)) * Ia1 *-1
47 Ia0=round(Ia0 *1e3)/1e3
48
49 mIa1=[ Ia0 Ia1 Ia2]’
50 mIa=A*mIa1
51 Ib=round(S*1e7/(sqrt(3) * V2 * 1e3))/10
52 Ia=round(abs(mIa)) * Ib
53
54

```

```

55 mprintf("\nline currents are: in Amperes ")
56 mprintf("\nIa= %s", string(round(abs(Ia(1))*10)/10)
    )
57 mprintf("\nIb= %s", string(round(abs(Ia(2))*10)/10)
    + '/_'+ string(round(atan(imag(mIa(2)*Ib)/real(
    mIa(2)*Ib))*100)/100 +180 ))
58 mprintf("\nIc= %s", string(round(abs(Ia(3))*10)/10)
    + '/_'+ string(round(atan(imag(mIa(3)*Ib)/real(
    mIa(3)*Ib))*100)/100 ))

```

Scilab code Exa 10.17 find pu values of sequence networks

```

1 clear
2 clc
3
4 S=50
5 V=11
6 Z=V*V/S
7
8 If1=1870
9 If2=2590
10 If3=4130
11
12 X1=V*1e3 /(sqrt(3)*If1)
13 x1=X1/Z
14 X2=((V*1e3*sqrt(3)/(sqrt(3)))/(If2))- X1
15 x2=X2/Z
16 X0=((sqrt(3)* V *1e3)/If3) - X1-X2
17 x0=X0/Z
18
19 mprintf("x1= %.2 f pu \n x2= %.2 f pu \n x0= %.2 f pu",
    x1, x2,x0)

```

Scilab code Exa 10.18 calculate current in generator and motor during fault

```
1 clear
2 clc
3
4 Vt=10.95
5 V=11
6 S=100
7 I=round(S*1e7/(sqrt(3)*V*1e3))/10 //Error in
   evaluation of base current in textbook
8
9 vt=Vt/V
10 pf=.8
11 P=40
12
13 I1=round(P*1e7/(sqrt(3)*Vt*pf*1e3))/10
14 I1=I1 * exp (%i * acos(pf))/I
15
16 x1g=.2
17 x2g=.2
18 x0g=.05
19
20 Sm=50
21 x1m=.2 * S/Sm
22 x2m=.2 * S/Sm
23 x0m=.05
24
25 xt1=.05
26 xt2=.05
27 xt0=.15
28
29
30 V=vt+ (I1 * %i * x0m)
31 x0m=.05* S/Sm
32 Ia1=V/(%i*((x1g*(x1m+xt1)/(x1g+x1m+xt1))+(x2g*(x2m+
   xt2)/(x2g+x2m+xt2))+(x0g*(x0m+xt0)/(x0g+x0m+xt0))
   ))
33 Ia1=round(Ia1 * 1000)/1000
```

```

34 Ig1=round((Ia1 * (x1m + xt1)/(x1m+x1g+xt1) + I1)
      *1000)/1000
35 Im1=round((Ia1 * (x1g)/(x1m+x1g+xt1) - I1)*1000)
      /1000
36 Ig2=round((Ia1 * (x2m + xt2)/(x2m+x2g+xt2))*1000)
      /1000
37 Im2=round((Ia1 * (x2g)/(x2m+x2g+xt2))*1000)/1000
38 Ig0=round((Ia1 * (x0m + xt0)/(x0m+x0g+xt0))*100)/100
39 Im0=round((Ia1 * (x0g)/(x0m+x0g+xt0))*100)/100
40
41 Im=round((Im1+Im2+Im0)*1000) *1e-3
42 Ig=round((Ig1+Ig2+Ig0)*1000) *1e-3
43
44 mprintf("\nCurrent Through motor = %.2f, ang (%.1f)
      deg", abs(Im)*I, atand(imag(Im)/real(Im))+180)
45 mprintf("\nCurrent Through generator = %.2f, ang (%
      .1f) deg", abs(Ig)*I, atand(imag(Ig)/real(Ig)))
46 disp("Error in evaluation of base current in
      textbook")

```

Scilab code Exa 10.19 find short circuit MVA of parallel connection of 2 stations

```

1 clear
2 clc
3
4 S=100
5 V=11
6 Z=V*V/S
7
8 SCA=1000
9 SCB=650
10
11 xa=S/SCA
12 xb=S/SCB
13 Xc=.5

```

```

14 xc=Xc/Z
15
16 X=round(((xa *(xb+xc))/(xa+xb+xc))*1000)/1000
17 FS=S/X
18 mprintf(" Fault MVA= %.2 f MVA" ,FS)

```

Scilab code Exa 10.20 find X to prevent overloading of circuit breakers

```

1 clear
2 clc
3
4 V=33
5 S=75
6 Z=V*V/S
7
8 sg=15
9 xg=.15
10 Xg=xg *S/sg
11 xt=.08
12 x=Xg/3
13
14 CB=750
15 XF=S/CB
16 xi=((x*xt)-(XF*(x+xt)))/(XF-x)
17 xi=round(xi*10000)/10000
18 X=xi*Z
19 mprintf(" reactance of reactor X= %.3 f ohm" ,X)

```

Scilab code Exa 10.21 determine fault current and voltages during LG fault when di

```

1 clear
2 clc
3

```

```

4 V=6.6
5 S=10
6 Z=V*V/S
7 I=S*1e6/(sqrt(3)*V*1e3)
8
9 X1=.15
10 X2=.75*X1
11 X0=.3*X1
12
13 x1=X1/3
14 x2=X2/3
15 x0=X0/3
16
17 E=1
18
19 x1=X1/3
20 x2=X2/3
21 x0=X0/3
22 IFa=abs(3*E/(%i * (x1+x2+x0)))
23 IFa=round(IFa*1000)/1000
24 ifa=IFa * I
25 mprintf("\n(a) fault current when all gen neutrals
          grounded= %.2f A", ifa)
26
27 x1=X1/3
28 x2=X2/3
29 x0=X0
30 IFb=abs(3*E/(%i * (x1+x2+x0)))
31 IFb=round(IFb*1000)/1000
32 ifb=IFb * I
33 mprintf("\n(b) fault current when one gen neutral
          grounded= %.2f A", ifb)
34
35 x1=X1/3
36 x2=X2/3
37 x0=X0
38 R0=.3
39 r0=round(3*R0/Z*1000)/1000

```

```

40 IFc=abs(3*E/(complex(r0,(x1+x2+x0))))
41 IFc=round(IFc*1000)/1000
42 ifc=IFc * I
43 mprintf("\n(c) fault current when one neutral grounded
        thru resistance= %.2f A",ifc)

```

Scilab code Exa 10.22 determine fault current and voltages during LG fault when al

```

1 clear
2 clc
3
4 x1g=.1
5 x2g=.1
6 x0g=.05
7
8 x1t=.05
9 x2t=.05
10 x0t=.05
11
12 x1l=.4
13 x2l=.4
14 x0l=.8
15
16 x1lm=x1l/2
17 x2lm=x2l/2
18 x0lm=x0l/2
19
20 X1=x1g+x1lm
21 X2=x2g+x2lm
22 X0=(x0g+x0lm)*(x0lm+x0t)/(x0g+x0lm+x0lm+x0t)
23
24 X=X1+X2+X0
25 Ia1=round((1/(%i*X))*1000)/1000
26 Ia2=round((Ia1)*1000)/1000
27 Ia0=round((Ia1)*1000)/1000

```



```

28 Ia=Ia1+Ia2+Ia0
29 IFa=abs(Ia)
30
31 Va1=1-(Ia1 * X1 *%i)
32 Va2=0-(Ia2 * X2 *%i)
33 Va0=0-(Ia0 * X0 *%i)
34
35 a=exp(%i * 2 * %pi/3)
36 A=[1 1 1
37 1 a^2 a
38 1 a a^2
39 ]
40
41 va1=[Va0 Va1 Va2]’
42 Va=A*va1
43 mprintf("\n(a)")
44 mprintf("\If= %.3 f ang(%.2 f)",abs(Ia),270)
45 mprintf("\nVa= %.3 f ang(%.2 f)",abs(Va(1)),atand(imag
(Va(1))/real(Va(1))))
46 mprintf("\nVb= %.3 f ang(%.2 f)",abs(Va(2)),atand(imag
(Va(2))/real(Va(2)))+180)
47 mprintf("\nVc= %.3 f ang(%.2 f)",abs(Va(3)),atand(imag
(Va(3))/real(Va(3)))+180)
48
49
50 X1=x1g+x1lm
51 X2=x2g+x2lm
52 X0=(x0g+x0lm)
53
54 X=X1+X2+X0
55 Ia1=round((1/(%i*X))*1000)/1000
56 Ia2=round((Ia1)*1000)/1000
57 Ia0=round((Ia1)*1000)/1000
58 Ia=Ia1+Ia2+Ia0
59 IFa=abs(Ia)
60
61 Va1=1-(Ia1 * X1 *%i)
62 Va2=0-(Ia2 * X2 *%i)

```

```

63 Va0=0-(Ia0 * X0 *%i)
64
65 a=exp(%i * 2 * %pi/3)
66 A=[1 1 1
67 1 a^2 a
68 1 a a^2
69 ]
70
71 va1=[Va0 Va1 Va2]'
72 Va=A*va1
73 mprintf("\n(b)")
74 mprintf("\nIf= %.3 f ang(%.2 f)",abs(Ia),270)
75 mprintf("\nVa= %.3 f ang(%.2 f)",abs(Va(1)),atand(imag
    (Va(1))/real(Va(1))))
76 mprintf("\nVb= %.3 f ang(%.2 f)",abs(Va(2)),atand(imag
    (Va(2))/real(Va(2)))+180)
77 mprintf("\nVc= %.3 f ang(%.2 f)",abs(Va(3)),atand(imag
    (Va(3))/real(Va(3)))+180)

```

Scilab code Exa 10.24 find reactance added to limit fault current in LG fault

```

1 clear
2 clc
3
4 X1=.4
5 X2=.3
6 X0=.05
7
8 S=15
9 V=13.2
10 Z=V*V/S
11 E=1
12 If=1
13
14 Xn=((3*E/(If))-(X1+X2+X0))/3

```

```

15 xn=Xn*Z
16 mprintf("\n(a)Xn= %.3 f ohm ",xn)
17
18 Rn=((3*E/(If))-((X1+X2+X0)*%i))/3
19 rn=Rn*Z
20 mprintf("\n(b)Rn= %.2 f ohm ",rn)
21 //the differnece in result is due to error in
    calculation in textbook
22 disp("the differnece in result is due to error in
    calculation in textbook")

```

Scilab code Exa 10.27 find SC MVA for 3 phase fault

```

1 clear
2 clc
3
4 S=50
5 data=[.05 20
6 .08 50
7 .06 30
8 .08 50
9 .04 30
10 .05 40
11 .05 50
12 .05 40
13 ]
14 for(i=1:8)
15     X(i)=round(data(i,1) * S/data(i,2)*10000)/10000
16 end
17
18 X1=round((((X(2)*X(8))+(X(2)*X(7))+(X(7)*X(8)))/X(2)
19         )*1000)/1000
19 X2=round((((X(2)*X(8))+(X(2)*X(7))+(X(7)*X(8)))/X(7)
20         )*1000)/1000
20 X3=round((((X(2)*X(8))+(X(2)*X(7))+(X(7)*X(8)))/X(8)

```

```

    )*1000)/1000
21 X4=round((((1/X(1)) + (1/X2))^-1)*1000)/1000
22 X5=round((((1/X(4)) + (1/X3))^-1)*1000)/1000
23 X6=round((X4*X5/(X4+X5+X1))*1000)/1000
24 X7=round((X4*X1/(X4+X5+X1))*1000)/1000
25 X8=round((X1*X5/(X4+X5+X1))*1000)/1000
26 X9=round((X7+X(5))*1000)/1000
27 X10=round((X8+X(6))*1000)/1000
28 X11=round((((1/X10) + (1/X9))^-1)*1000)/1000
29 X12=round((X11+X6)*1000)/1000
30 X13=((1/X12) + (1/X(3)))^-1
31 MVA=S/X13
32 //Mismatch is due to error in calculation in the
    textbook
33 mprintf("Fault MVA=%.2 f MVA",MVA)
34 disp("Mismatch is due to error in calculation in the
    textbook")

```

Scilab code Exa 10.28 find fault current and fault level LG 3 phase LL and LLG fault

```

1 clear
2 clc
3
4 S=30
5 SF=1000
6 V1=33
7 V2=132
8 Z1=V1*V1/S
9 I2=S*1e6/(sqrt(3)*V2*1e3)
10
11
12 x1g=%i*S/SF
13 x2g=x1g*2/3
14 x0g=x1g/3
15 r0g=60/Z1

```

```

16 z0g=r0g+x0g
17 xt=%i *.1
18
19 X1=xt+x1g
20 X2=xt+x2g
21 X0=xt
22
23 FMVAa=round(abs(S/X1)*100)/100
24 IFa=abs(1/X1)* I2
25 mprintf("\n(a)3 phase fault Fault MVA=%0.2f MVA,
        Fault Current=%0.2f A",FMVAa,IFa)
26
27 IFb=abs(3/(X1+X2+X0))* I2
28 FMVAb=IFb * sqrt(3) * V2 * 1e-3
29 mprintf("\n(b)single line to ground fault Fault MVA=
        %0.2f MVA, Fault Current=%0.2f A",FMVAb,IFb)
30
31 IFc=abs(sqrt(3)/(X1+X2))* I2
32 FMVAc=IFc * sqrt(3) * V2 * 1e-3
33 mprintf("\n(c)L-L Fault MVA=%0.2f MVA, Fault Current
        =%0.1f A",FMVAc,IFc)
34
35 IFd=abs(1/(X1+(X2*X0/(X2+X0))))* I2
36 FMVAd=IFd * sqrt(3) * V2 * 1e-3
37 mprintf("\n(d)L-L-G fault Fault MVA=%0.2f MVA, Fault
        Current=%0.2f A",FMVAd,IFd)

```

Scilab code Exa 10.29 find fault current and fault level LG fault in middle of line

```

1 clear
2 clc
3
4 a=exp(%i * 2*%pi/3)
5
6 V=33

```

```

7 S=45
8 SF=2000
9 V2=132
10 Z=V2*V2/S
11 I=S*1e6 /(sqrt(3) * V2 * 1e3)
12
13 X1=.4* 60
14 X2=.4* 60
15 X0=1 * 60
16
17 x1=X1/Z
18 x2=X2/Z
19 x0=X0/Z
20
21 xg=.0225
22 xt=.1
23
24 xf1=x1/2 + xg + xt
25 xf2=x2/2 + xg + xt
26 xf0=(x0/2 + xt)/2
27 xf=xf1+xf2+xf0
28 ia1=round(1000/xf)/1000
29 iF1=3*ia1
30 IF1=iF1*I
31 mprintf("\\n(a) Fault Current = %.2fA",IF1)
32
33 IA1=ia1*-1*%i
34 IA2=ia1*-1*%i
35 IA0= ia1 * .5*-1*%i
36
37 IA=round((IA1 +IA2 +IA0)*10000)/10000
38 IB=round((IA1*a*a) + (a*IA2) +IA0)*10000)/10000
39 IC=round((IA1*a) + (a*a*IA2) +IA0)*10000)/10000
40 mprintf("\\n(b)From T1 to P: (in order - IA,IB, IC in
    pu)")
41 disp(IC, IB, IA)
42
43 IA1b=0

```

```

44 IA2b=0
45 IA0b=ia1 * .5*-1*i
46 IAb=round((IA1b +IA2b +IA0b)*10000)/10000
47 IBb=round(((IA1b*a*a) + (a*IA2b) +IA0b)*10000)/10000
48 ICb=round(((IA1b*a) + (a*a*IA2b) +IA0b)*10000)/10000
49 mprintf("\nFrom P to T2: (in order – IA,IB, IC in pu
    )")
50 disp(ICb, IBb, IAb)
51
52
53
54 //(c)
55
56
57 Ia0=0
58 Ia1=IA1 * exp(%i * -1*pi/6)
59 Ia2=IA2 * exp(%i * 1*pi/6)
60
61 Ia=round((Ia1 +Ia2 +Ia0)*1000)/1000
62 Ib=round(((Ia1*a*a) + (a*Ia2) +Ia0)*1000)/1000
63 Ic=round(((Ia1*a) + (a*a*Ia2) +Ia0)*1000)/1000
64 mprintf("\n(c) Currents in lines connecting source
    to T1 (in order – Ia,Ib, Ic in pu)")
65 disp(Ic, Ib, Ia)
66
67
68 mprintf("\n(d) Currents in star wdg of T1")
69 mprintf("\nIa= %.4 fj , Ib= %.4 fj , Ic= %.4 fj", imag(IA
    ), imag(IB), imag(IC))
70 mprintf("\nIa1= %.4 fj , Ia2= %.4 fj , Ia0= %.4 fj", imag
    (IA1), imag(IA2), imag(IA0))
71 mprintf("\nIb1= %.4 f /_%.3 f , Ib2=%.4 f/_%.3 f , Ib0= %
    .4 fj", abs(IA1 *a*a),atand(imag(IA1*a*a)/real(IA1
    *a*a))+180,abs(IA1 *a),atand(imag(IA2*a)/real(IA2
    *a)),imag(IA0))
72 mprintf("\nIc1= %.4 f /_%.3 f , Ic2=%.4 f/_%.3 f , Ic0= %
    .4 fj", abs(IA1 *a),atand(imag(IA1*a)/real(IA1*a))
    ,abs(IA1 *a*a),atand(imag(IA2*a*a)/real(IA2*a*a))

```

```

+180, imag(IA0))
73
74
75 Iab1 = round(IA1*1e3 /sqrt(3))/1e3
76 Iab2 = round(IA2*1e3 /sqrt(3))/1e3
77 Iab0 = round(IA0*1e3 /sqrt(3))/1e3
78
79 Ibc1=Iab1 * a*a
80 Ibc2=Iab2 * a
81 Ibc0=Iab0
82
83 Ica1=Iab1 * a
84 Ica2=Iab2 * a *a
85 Ica0=Iab0
86
87 Iab= Iab1 +Iab2 +Iab0
88 Ibc= Ibc1 +Ibc2 +Ibc0
89 Ica= Ica1 +Ica2 +Ica0
90
91 mprintf("\n\nCurrents in delta wdg of T1")
92 mprintf("\nIab= %.4 fj , Ibc= %.4 fj , Ica= %.4 fj", imag
    (Iab), imag(Ibc), imag(Ica))
93 mprintf("\nIab1= %.4 fj , Iab2= %.4 fj , Iab0= %.4 fj",
    imag(Iab1), imag(Iab2), imag(Iab0))
94 mprintf("\nIbc1= %.4 f /_%.3 f , Ibc2=%.4 f/_%.3 f , Ibc0=
    %.4 fj", abs(Ibc1), atand(imag(Ibc1)/real(Ibc1))
    +180, abs(Ibc2), atand(imag(Ibc2)/real(Ibc2)), imag(
    Ibc0))
95 mprintf("\nIca1= %.4 f /_%.3 f , Ica2=%.4 f/_%.3 f , Ica0=
    %.4 fj", abs(Ica1), atand(imag(Ica1)/real(Ica1)),
    abs(Ica2), atand(imag(Ica2)/real(Ica2))+180, imag(
    Ica0))
96
97 mprintf("\n\n Currents in star wdg of T2")
98 mprintf("\nIa= %.4 fj , Ib= %.4 fj , Ic= %.4 fj", imag(
    IAb), imag(IBb), imag(ICb))
99 mprintf("\nIa1= %.4 f , Ia2= %.4 f , Ia0= %.4 fj", imag(
    IA1b), imag(IA2b), imag(IA0b))

```



```

100 mprintf("\nIb1= %.4f , Ib2= %.4f , Ib0= %.4fj" , imag(
      IA1b *a*a) , imag(IA1b *a) , imag(IA0b))
101 mprintf("\nIc1= %.4f , Ic2= %.4f , Ic0= %.4fj" , imag(
      IA1b *a) , imag(IA1b*a *a) , imag(IA0b))
102
103
104 Iab1b = round(IA1b*1e3 /sqrt(3))/1e3
105 Iab2b = round(IA2b*1e3 /sqrt(3))/1e3
106 Iab0b = round(IA0b*1e3 /sqrt(3))/1e3
107
108 Ibc1b=Iab1b * a*a
109 Ibc2b=Iab2b * a
110 Ibc0b=Iab0b
111
112 Ica1b=Iab1b * a
113 Ica2b=Iab2b * a *a
114 Ica0b=Iab0b
115
116 Iabb= Iab1b +Iab2b +Iab0b
117 Ibcb= Ibc1b +Ibc2b +Ibc0b
118 Icab= Ica1b +Ica2b +Ica0b
119
120 mprintf("\n\nCurrents in delta wdg of T2")
121 mprintf("\nIab= %.3fj , Ibc= %.3fj , Ica= %.3fj" , imag
      (Iabb) , imag(Ibcb) , imag(Icab))
122 mprintf("\nIab1= %.3f , Iab2=%.3f , Iab0= %.3fj" , imag
      (Iab1b) , imag(Iab2b) , imag(Iab0b))
123 mprintf("\nIbc1= %.3f , Ibc2=%.3f , Ibc0= %.3fj" , imag
      (Ibc1b) , imag(Ibc2b) , imag(Ibc0b))
124 mprintf("\nIca1= %.3f , Ica2=%.3f , Ica0= %.3fj" , imag
      (Ica1b) , imag(Ica2b) , imag(Ica0b))

```

Scilab code Exa 10.30 find fault current and fault level LG fault

```
1 clear
```

```
2  clc
3
4  R1=4
5  R2=2
6
7  S=50
8  V1=11
9  V2=132
10 V3=33
11 Z1=V1*V1/S
12 Z2=V2*V2/S
13 Z3=V3*V3/S
14
15 r1=3*R1/Z1
16 r2=3*R2/Z3
17
18
19 x1g=.4*%i
20 x2g=.3*%i
21 x0g=.1*%i
22
23 x1t1=.08*%i
24 x2t1=.08*%i
25 x0t1=.08*%i
26
27 x1t2=.05*%i
28 x2t2=.05*%i
29 x0t2=.05*%i
30
31 x1t3=.04*%i
32 x2t3=.04*%i
33 x0t3=.04*%i
34
35 x1t4=.06*%i
36 x2t4=.06*%i
37 x0t4=.06*%i
38
39
```

```

40 X11=20*%i
41 X21=20*%i
42 X01=50*%i
43
44 x11=X11/Z2
45 x21=X21/Z2
46 x01=X01/Z2
47
48 X1=x1g+x1t2+x11+x1t1+x1t3
49 X2=x2g+x2t2+x21+x2t1+x2t3
50 X0=r2+(((x0t2+x01+x0t1)*x0t4/(x0t2+x01+x0t1+x0t4))+
        x0t3)
51
52 IF=abs(3*1/(X1+X2+X0))
53 IB=S*1e6/(sqrt(3)*V3*1e3)
54 If=IF*IB
55 SF=IF*S
56 mprintf(" fault current= %.0fA, fault level=%0.2f MVA"
        ,If,SF)

```

Scilab code Exa 10.31 find line voltages and currents for OC fault

```

1 clear
2 clc
3
4 a=exp(%i *2*%pi/3)
5
6 Z1=complex(2.8,1)
7 Z2=complex(.1,.6)
8
9 V=400
10 E=V/sqrt(3)
11
12 Ia1=E/(Z1+Z2)
13 Ia2=-Ia1

```

```

14
15 Ia=Ia1+Ia2
16 Ib= (a^2-a)*Ia1
17 Ic=-Ib
18
19 disp( "Line Currents Ia , Ib , Ic , in amperes")
20 mprintf("\nIa= %s", string(round(abs(Ia)*10)/10) + '/'
    _'+ string(0) )
21 mprintf("\nIb= %s", string(round(abs(Ib)*10)/10) + '/'
    _'+ string(round(atan(imag(Ib)/real(Ib))*100)
    /100 -180) )
22 mprintf("\nIc= %s", string(round(abs(Ic)*10)/10) + '/'
    _'+ string(round(atan(imag(Ic)/real(Ic))*100)
    /100) )
23
24 Va2=-Z2 * Ia2
25 Vaa=3*Va2
26 Van=(Z1*Ia1)+(Z2*Ia2)
27 Vcn=(a*Z1*Ia1)+(a*a*Z2*Ia2)
28 Vbn=(a*a*Z1*Ia1)+(a*Z2*Ia2)
29 VNn=Va2
30
31
32 mprintf("\n\n\nVaa= %s", string(round(abs(Vaa)*100)
    /100) + '/'_'+ string(round(atan(imag(Vaa)/real(
    Vaa))*10)/10))
33 mprintf("\nVan= %s", string(round(abs(Van)*100)/100)
    + '/'_'+ string(round(atan(imag(Van)/real(Van))
    *10)/10))//error in value substitution in
    textbook
34 mprintf("\nVbn= %s", string(round(abs(Vbn)*10)/10) +
    '/'_'+ string(round(atan(imag(Vbn)/real(Vbn))*10)
    /10 -180))
35 mprintf("\nVcn= %s", string(round(abs(Vcn)*10)/10) +
    '/'_'+ string(round(atan(imag(Vcn)/real(Vcn))*10)
    /10 +180)) //error in value substitution in
    textbook
36 mprintf("\nVNn= %s", string(round(abs(VNn)*100)/100)

```

```
    + '/'_'+ string(round(atan(imag(VNn)/real(VNn))
    *10)/10))
37 disp("error is due to mistake in value substitution
    in textbook")
```

Scilab code Exa 10.32 fault MVA with and without reactors

```
1 clear
2 clc
3
4 S=10
5 xg=.1
6 xe=.08
7
8 X1= 1/((1/.1) + 1/(xe + ((xg+xe)/2)))
9 FMVA1=S* (1/X1)
10 mprintf("When reactors are used , fault level=%0.2 f
    MVA" , FMVA1)
11
12 X2= xg/3
13 FMVA2=S* (1/X2)
14 mprintf("\nWhen reactors are not used , fault level=%0
    .0 f MVA" ,FMVA2)
```

Scilab code Exa 10.33 find subtransient current in system

```
1 clear
2 clc
3
4 S=25
5 pf=.8
6 P=15
7 Vt=10.6
```

```

8 V1=11
9 V2=11 * 66/11
10 I1=S*1e6/(sqrt(3)*V1*1e3)
11 I2=S*1e6/(sqrt(3)*V2*1e3)
12 I1=(P*1e6/(sqrt(3)*Vt*1e3*pf)) * exp (%i * acos(pf))
13 vt=Vt/V1
14 Z=V2*V2/S
15 XL=10
16 x1=XL/Z
17 xt=.1
18 xg=.15
19 xm=.15
20
21 Xth=xm * (xg+xt+xt+x1)/(xm + xg+xt+xt+x1)
22 IF=vt/Xth
23 If=IF*I2
24
25 Ifg=IF*I1 *%i*-1* xm /(xm + xg+xt+xt+x1)
26 ifg=abs(Ifg + I1)
27 Ifm=IF*I1 *%i *-1* (xg+xt+xt+x1)/(xg+xt+xt+x1+xm)
28 ifm=abs(Ifm - I1)
29
30 mprintf("total fault current = %.0f A, current
    through generator=%.0f A, current through motor=%
    .0f A\n",If, ifg, ifm)
31 //error in calculation of Ifm-I =-.623 - 6.891j
    instead of -.623-j5.96
32 disp("error in calculation of Ifm-I =-.623 - 6.891j
    ->(correct) instead of -.623-j5.96 -> incorrect")

```

Scilab code Exa 10.34 reactance needed to restrict 6 times fault current

```

1 clear
2 clc
3

```

```

4 S=25
5 V=11
6 Z=V*V/S
7 I=S*1e6/(sqrt(3)*V*1e3)
8 Isc=6*I
9 Xt=V*1e3/(sqrt(3)*Isc)
10 Xi=.15*Z
11 Xo=Xt-Xi
12 x=Xo*100/Z
13 mprintf(" External reactance required is %.3f pu",x)

```

Scilab code Exa 10.35 symmetrical components of line and delta currents

```

1 clear
2 clc
3
4 Ia=10*exp(%i *30 *%pi/180)
5 Ib=15*exp(%i *-60*%pi/180)
6 Ic=0-(Ia+Ib)
7
8 Iac=(Ia +Ia +Ib)/3
9 Icb=Ic +Iac
10 Iba=Iac-Ia
11 Ia0=(Ia +Ib +Ic)/3
12
13 a=exp(%i * 2 * %pi/3)
14
15 Ia1=(Ia + a*Ib + a*a*Ic)/3
16 Ia2=(Ia + a*Ic + a*a*Ib)/3
17
18 disp(round(Ia1*100)/100, " Ia1", "(a) Symmetrical Line
    Components")
19 disp(round(Ia2*100)/100, " Ia2")
20 disp(round(Ia0*100)/100, " Ia0")
21

```

```
22 Iac0=(Iac+Icb+Iba)/3
23 Iac1=(Iac+ a*Icb+ a*a*Iba)/3
24 Iac2=(Iac+a*a*Icb+a*Iba)/3
25
26 disp(round(Iac1*100)/100, " Iac1", "(b) Symmetrical
    Delta Components")
27 disp(round(Iac2*100)/100, " Iac2")
28 disp(round(Iac0*100)/100, " Iac0")
```

Chapter 11

Digital Techniques in Fault Calculations

Scilab code Exa 11.1 z bus formulation

```
1 clear;
2 clc;
3
4 n=5; //no of elements
5 Z=0;
6 z=[ 4 1 1 1; 4 2 1 1; 4 3 1 1; 1 2 1 4; 1 3 1 4];
7
8 // z = [ from node | to node| z between nodes | type
          modification] type modification should be in
          ascending order
9
10 for(i=1:n)
11     mcase=z(i,4)
12     znew=z(i,3)
13     n1=z(i,1)
14     n2=z(i,2)
15     dim=max(size(Z))
16     select mcase
17     case 1 then
```

```

18         if Z(1,1)==0 then
19             dim=dim-1
20         end
21         Z(dim+1, dim+1)=znew
22     case 2 then
23         Z(1:dim,dim+1)=Z(1:dim, n1)
24         Z(dim+1,1:dim)=Z(n1,1:dim)
25         Z(dim+1, dim+1)=znew+Z(n1,n1)
26     case 3 then
27         Z=Z-((Z(1:dim, n2)*Z(n2,1:dim))/(znew+Z(
                n2,n2)))
28     case 4 then
29         Z=Z-(((Z(1:dim, n1)-Z(1:dim, n2))*(Z(n1
                ,1:dim)-Z(n2,1:dim)))/(znew+Z(n2,n2)+
                Z(n1,n1)-(2*Z(n1,n2))))
30     else
31         break
32     end
33 end
34 disp(Z)

```

Scilab code Exa 11.2 formulate positive and negative sequence impedance matrices f

```

1 clear;
2 clc;
3
4 n=5;
5 Z=0;
6 z=[ 0 1 .25*%i 1; 1 2 .06*%i 2; 2 3 .05*%i 2;3 4
      .07*%i 2; 0 4 .2*%i 3];
7
8 for(i=1:n)
9     mcase=z(i,4)
10    znew=z(i,3)
11    n1=real(z(i,1))

```

```

12     n2=real(z(i,2))
13     dim=max(size(Z))
14     select mcase
15         case 1 then
16             if Z(1,1)==0 then
17                 dim=dim-1
18             end
19             Z(dim+1, dim+1)=znew
20         case 2 then
21             Z(dim+1, dim+1)=znew+Z(n1, n1)
22             Z(1:dim, dim+1)=Z(1:dim, n1)
23             Z(dim+1, 1:dim)=Z(n1, 1:dim)
24         case 3 then
25
26             Z=Z-((Z(1:dim, n2)*Z(n2, 1:dim))/(znew+Z(
                n2, n2)))
27         case 4 then
28             Z=Z-(((Z(1:dim, n1)-Z(1:dim, n2))*(Z(n1
                , 1:dim)-Z(n2, 1:dim)))/(znew+Z(n2, n2)+
                Z(n1, n1)-(2*Z(n1, n2))))
29         else
30             break
31     end
32 end
33 mprintf(" Z1bus=Z2bus=");
34 disp(Z)

```

Scilab code Exa 11.3 formulate zero sequence impedance matrices for the network

```

1 clear;
2 clc;
3
4 n=5;
5 Z=0;
6 z=[ 0 1 .05*%i 1; 0 2 .06*%i 1; 2 3 .15*%i 2; 3 4

```

```

        .07*%i 2; 0 4 .14*%i 3];
7
8 for(i=1:n)
9     mcase=z(i,4)
10    znew=z(i,3)
11    n1=real(z(i,1))
12    n2=real(z(i,2))
13    dim=max(size(Z))
14    select mcase
15        case 1 then
16            if Z(1,1)==0 then
17                dim=dim-1
18            end
19            Z(dim+1, dim+1)=znew
20        case 2 then
21            Z(dim+1,dim+1)=znew+Z(n1,n1)
22            Z(1:dim,dim+1)=Z(1:dim, n1)
23            Z(dim+1,1:dim)=Z(n1,1:dim)
24        case 3 then
25
26            Z=Z-(((Z(1:dim, n2)*Z(n2,1:dim))/(znew+Z(
                n2,n2))))
27        case 4 then
28            Z=Z-(((Z(1:dim, n1)-Z(1:dim, n2))*(Z(n1
                ,1:dim)-Z(n2,1:dim)))/(znew+Z(n2,n2)+
                Z(n1,n1)-(2*Z(n1,n2))))
29        else
30            break
31    end
32 end
33 mprintf(" Z0bus=");
34 disp(Z)

```

Scilab code Exa 11.4 finding fault current and fault voltage at bus

```

1  clear;
2  clc;
3
4  n=5;
5  Z=0;
6  z=[ 0 1 .25*%i 1; 1 2 .06*%i 2; 2 3 .05*%i 2;3 4
      .07*%i 2; 0 4 .2*%i 3];
7
8  for(i=1:n)
9      mcase=z(i,4)
10     znew=z(i,3)
11     n1=real(z(i,1))
12     n2=real(z(i,2))
13     dim=max(size(Z))
14     select mcase
15         case 1 then
16             if Z(1,1)==0 then
17                 dim=dim-1
18             end
19             Z(dim+1, dim+1)=znew
20         case 2 then
21             Z(dim+1,dim+1)=znew+Z(n1,n1)
22             Z(1:dim,dim+1)=Z(1:dim, n1)
23             Z(dim+1,1:dim)=Z(n1,1:dim)
24         case 3 then
25
26             Z=Z-((Z(1:dim, n2)*Z(n2,1:dim))/(znew+Z(
                n2,n2)))
27         case 4 then
28             Z=Z-(((Z(1:dim, n1)-Z(1:dim, n2))*(Z(n1
                ,1:dim)-Z(n2,1:dim)))/(znew+Z(n2,n2)+
                Z(n1,n1)-(2*+Z(n1,n2))))
29         else
30             break
31     end
32 end
33
34 E=1

```

```

35 V=ones(1,4);
36 Ib=262.4;
37 i2=V(1,2) / Z(2,2);
38 I2=Ib*i2;
39
40 Ia=I2 * exp(%i * 0);
41 Ib=I2 * exp(%i *-2* %pi /3);
42 Ic=I2 * exp(%i *2 * %pi /3);
43 mprintf("(a)\nLine currents at bus 2\nIa = %.2f ang
    ( %.0f ) deg A,\nIb = %.2f ang ( %.0f ) deg A,\n
    Ic = %.2f ang ( %.0f ) deg A",abs(Ia),acotd(real
    (Ia)/imag(Ia))-180,abs(Ib),acotd(real(Ib)/imag(Ib)
    )),abs(Ic),acotd(real(Ic)/imag(Ic)))
44
45
46 Vb=220;
47 v3=E* (1-(Z(3,2)/Z(2,2)))
48 V3=v3*Vb/sqrt(3);
49 Va=V3 * exp(%i * 0);
50 Vb=V3 * exp(%i *-2* %pi /3);
51 Vc=V3 * exp(%i *2 * %pi /3);
52 mprintf("\n(b)\nLine voltages at bus 2\nVa = %.3f
    ang ( %.2f ) degkV,\nVb = %.3f ang ( %.2f ) degkV
    ,\nVc = %.3f ang ( %.2f ) degkV",abs(Va),atand(
    imag(Va)/real(Va)),abs(Vb),atand(imag(Vb)/real(Vb)
    ))+180,abs(Vc),atand(imag(Vc)/real(Vc))+180)

```

Scilab code Exa 11.5 finding fault current and fault voltage at bus

```

1 clear;
2 clc;
3
4 n=5;
5 Z=0;
6 z=[ 0 1 .25*%i 1; 1 2 .06*%i 2; 2 3 .05*%i 2; 3 4

```

```

        .07*%i 2; 0 4 .2*%i 3];
7
8 for(i=1:n)
9     mcase=z(i,4)
10    znew=z(i,3)
11    n1=real(z(i,1))
12    n2=real(z(i,2))
13    dim=max(size(Z))
14    select mcase
15        case 1 then
16            if Z(1,1)==0 then
17                dim=dim-1
18            end
19            Z(dim+1, dim+1)=znew
20        case 2 then
21            Z(dim+1,dim+1)=znew+Z(n1,n1)
22            Z(1:dim,dim+1)=Z(1:dim, n1)
23            Z(dim+1,1:dim)=Z(n1,1:dim)
24        case 3 then
25
26            Z=Z-(((Z(1:dim, n2)*Z(n2,1:dim))/(znew+Z(
                n2,n2))))
27        case 4 then
28            Z=Z-(((Z(1:dim, n1)-Z(1:dim, n2))*(Z(n1
                ,1:dim)-Z(n2,1:dim)))/(znew+Z(n2,n2)+
                Z(n1,n1)-(2*+Z(n1,n2))))
29        else
30            break
31    end
32 end
33 Z1=Z;
34 Z2=Z;
35
36 n=5;
37 Z=0;
38 z=[ 0 1 .05*%i 1; 0 2 .06*%i 1; 2 3 .15*%i 2;3 4
        .07*%i 2; 0 4 .14*%i 3];
39

```

```

40 for(i=1:n)
41     mcase=z(i,4)
42     znew=z(i,3)
43     n1=real(z(i,1))
44     n2=real(z(i,2))
45     dim=max(size(Z))
46     select mcase
47         case 1 then
48             if Z(1,1)==0 then
49                 dim=dim-1
50             end
51             Z(dim+1, dim+1)=znew
52         case 2 then
53             Z(dim+1, dim+1)=znew+Z(n1,n1)
54             Z(1:dim, dim+1)=Z(1:dim, n1)
55             Z(dim+1, 1:dim)=Z(n1, 1:dim)
56         case 3 then
57
58             Z=Z-(((Z(1:dim, n2)*Z(n2, 1:dim))/(znew+Z(
                    n2,n2))))
59         case 4 then
60             Z=Z-(((Z(1:dim, n1)-Z(1:dim, n2))*(Z(n1
                    , 1:dim)-Z(n2, 1:dim)))/(znew+Z(n2,n2)+
                    Z(n1, n1)-(2*+Z(n1, n2))))
61         else
62             break
63     end
64 end
65 Z0=Z;
66
67 Ib=262.4;
68 Vb=220;
69 E=1
70 V=ones(1,4);
71
72 I3(3,1)=E/(Z1(3,3)+Z2(3,3)+Z0(3,3));
73 I3(1,1)=I3(3,1)
74 I3(2,1)=I3(3,1)

```



```

75 i3=I3*Ib
76 a=exp(%i * 2*%pi/3)
77 A=[1 1 1; 1 a^2 a; 1 a a^2]
78 I=A*i3;
79 //I=round(I*100)/100;
80 mprintf("(a)\nLine currents at bus 3\nIa = %.2f ang
( %.0f ) deg A,\nIb = %.2f ang ( %.0f ) deg A,\n
Ic = %.2f ang ( %.0f ) deg A",abs(I(1)),acotd(
real(I(1))/imag(I(1)))-180,abs(I(2)),acotd(real(I
(2))/imag(I(2)))-180,abs(I(3)),acotd(real(I(3))/
imag(I(3)))-180)

81
82
83 V2(1,1)=-1* Z0(2,3)*I3(3,1);
84 V2(2,1)=E-( Z1(2,3)*I3(1,1));
85 V2(3,1)=-1* Z2(2,3)*I3(2,1);
86 v=A*V2;
87 V=Vb*v/sqrt(3);
88 mprintf("\n(b)\nLine voltages at bus 2\nVa = %.2f
ang ( %.2f ) degkV,\nVb = %.2f ang ( %.2f ) degkV
,\nVc = %.2f ang ( %.2f ) degkV",abs(V(1)),atand(
imag(V(1))/real(V(1))),abs(V(2)),atand(imag(V(2))
/real(V(2)))+180,abs(V(3)),atand(imag(V(3))/real(
V(3)))+180)

```

Scilab code Exa 11.6 find z bus

```

1 clear;
2 clc;
3
4 n=4;
5 Z=0;
6 z=[ 4 1 .5*%i 1; 4 2 .4*%i 1; 1 3 .2*%i 2; 2 3 .1*%i
4];
7

```

```

8  for(i=1:n)
9      mcase=z(i,4)
10     znew=z(i,3)
11     n1=real(z(i,1))
12     n2=real(z(i,2))
13     dim=max(size(Z))
14     select mcase
15         case 1 then
16             if Z(1,1)==0 then
17                 dim=dim-1
18             end
19             Z(dim+1, dim+1)=znew
20         case 2 then
21             Z(dim+1, dim+1)=znew+Z(n1,n1)
22             Z(1:dim, dim+1)=Z(1:dim, n1)
23             Z(dim+1, 1:dim)=Z(n1, 1:dim)
24         case 3 then
25
26             Z=Z-(((Z(1:dim, n2)*Z(n2, 1:dim))/(znew+Z(
                n2,n2))))
27         case 4 then
28             Z=Z-(((Z(1:dim, n1)-Z(1:dim, n2))*(Z(n1
                , 1:dim)-Z(n2, 1:dim)))/(znew+Z(n2,n2)+
                Z(n1, n1)-(2*+Z(n1, n2))))
29         else
30             break
31     end
32 end
33 mprintf(" Zbus=");
34 Z=round(Z*1e5)/1e5
35 disp(Z)

```

Scilab code Exa 11.7 find z bus of an augmented network

```
1 clear;
```

```

2  clc;
3
4  no=4;
5  Z=0;
6  z=[ 4 1 .5*%i 1; 4 2 .4*%i 1; 1 3 .2*%i 2; 2 3 .1*%i
      4];
7
8  for(i=1:no)
9      mcase=z(i,4)
10     znew=z(i,3)
11     n1=real(z(i,1))
12     n2=real(z(i,2))
13     dim=max(size(Z))
14     select mcase
15         case 1 then
16             if Z(1,1)==0 then
17                 dim=dim-1
18             end
19             Z(dim+1, dim+1)=znew
20         case 2 then
21             Z(dim+1,dim+1)=znew+Z(n1,n1)
22             Z(1:dim,dim+1)=Z(1:dim, n1)
23             Z(dim+1,1:dim)=Z(n1,1:dim)
24         case 3 then
25
26             Z=Z-(((Z(1:dim, n2)*Z(n2,1:dim))/(znew+Z(
                n2,n2))))
27         case 4 then
28             Z=Z-(((Z(1:dim, n1)-Z(1:dim, n2))*(Z(n1
                ,1:dim)-Z(n2,1:dim)))/(znew+Z(n2,n2)+
                Z(n1,n1)-(2*+Z(n1,n2))))
29         else
30             break
31     end
32 end
33
34
35 m=1

```

```
36 n=3
37 p=1
38 q=4
39 no2=4
40 znew=.5*%i
41 zm=.1*%i
42 za=.2*%i
43
44 for j=1:no2
45     if j==q then
46         Z(q,q)=Z(p,q)-((zm/za)*(Z(m,q)-Z(n,q)))-((zm
            *zm/za)-znew);
47     else
48         Z(q,j)=Z(p,j)-((zm/za)*(Z(m,j)-Z(n,j)))
49         Z(j,q)=Z(q,j)
50     end
51 end
52 Z=round(Z*1e5)/1e5
53 disp(Z)
```

Chapter 12

Power System Transients

Scilab code Exa 12.1 find L C surge impedance and velocity of propagation

```
1 clear;
2 clc;
3
4 rc=.5e-2;
5 rs=1.5e-2;
6 u=4
7
8 L=2e-7 * log(rs/rc);
9 mprintf("\nL= %.1 f e-7H/m", L*1e7)
10 C=u*1e-9/(18 * log(rs/rc))
11 mprintf("\nC= %.3 f e-9F/m", C*1e9)
12 v=1/sqrt(L*C);
13 mprintf("\nv= %.1 f e8m/s", v*1e-8)
14 Zc=sqrt(L/C)
15 mprintf("\nZc= %.0 f ohm", Zc)
```

Scilab code Exa 12.2 find surge transmitted

```

1 clear;
2 clc;
3
4 ef=100;
5 Zc=400;
6 Z=50;
7 et=2*ef*Z/(Z+Zc)
8 mprintf("Surge transmitted= %.2f kV",et)

```

Scilab code Exa 12.3 find surge Vand I transmitted

```

1 clear;
2 clc;
3
4 ef=200;
5 Zc=400;
6 Z1=500;
7 Z2=300;
8 et=2*ef*(Z1*Z2/(Z1+Z2))/((Z1*Z2/(Z1+Z2))+Zc)
9 mprintf("\nSurge Voltage transmitted= %.2f kV",et)
10 it1=et/Z1;
11 mprintf("\nSurge Current transmitted= %.3f kA",it1)
12 it2=et/Z2;
13 mprintf("\nSurge Current transmitted= %.3f kA",fix(
    it2*100)/100)
14 er=et-ef;
15 mprintf("\nSurge Voltage Reflected= %.2f kV",er)
16 ir=it1+it2-(ef/Zc)
17 mprintf("\nSurge Current Reflected= %.2f kA",ir)

```

Scilab code Exa 12.4 find voltage across the inductance and the reflected voltage

```

1 clear

```

```

2  clc
3
4  E=100
5  Zc=400
6  L=4000
7
8  mprintf("et= %d exp( - %.1f t) KV\n", 2*E, Zc/L)
9  mprintf("er= %d (2*exp( - %.1f t) -1) KV\n", E, Zc/L
)

```

Scilab code Exa 12.7 find surge arrester voltage and current

```

1  clear
2  clc
3
4  V=300e3
5  R=400
6  k=1.5e-27
7
8  E=10
9  x=1
10 e=1e-5
11 while (E>e)
12     f=(k*R*x^6) +x -(2*V)
13     df=(6* k*R*x^5) +1
14     x1=x-(f/df)
15     E=abs(x1-x)
16     x=x1
17 end
18 eA=round(x)
19 IA=k*eA^6
20
21 mprintf("eA=%d, Ia=%d ",eA, IA)

```

Scilab code Exa 12.8 find surge arrester voltage and current

```
1 clear
2 clc
3
4 V=300e3
5 R1=400
6 R2=50
7 R=1+(400/50)
8 k=1.5e-27
9
10 E=10
11 x=1
12 e=1e-5
13 while (E>e)
14     f=(k*R1*x^6) +(R*x) -(2*V)
15     df=(6* k*R1*x^5) +R
16     x1=x-(f/df)
17     E=abs(x1-x)
18     x=x1
19 end
20 eA=round(x)
21 IA=k*eA^6
22
23 mprintf("eA=%d, Ia=%0.1 f ",eA, IA)
```

Scilab code Exa 12.9 find reflection and refraction coefficients

```
1 clear;
2 clc;
3
4 ef=3000;
```



```

5 Zc=300;
6 ea=1700;
7 iF=ef/Zc
8 mprintf("\nCurrent in line= %d kA",iF)
9 Ia=((2*ef)-ea)/Zc
10 mprintf("\nCurrent through Arrester= %.3f kA",Ia)
11 Ia=round(Ia *1000)/1000
12 R=ea/Ia
13 mprintf("\nresistance of arrester= %.2f ohm",R)
14 er=ea-ef;
15 mprintf("\nSurge Voltage Reflected= %.0f kV",er)
16 Cr=er/ef;
17 CR=ea/ef;
18 mprintf("\nCoeff of Reflection = %.3f, Coeff of
    Refraction=%.3f",Cr,CR)
19 Cr=(R-Zc)/(R+Zc);
20 CR=(R*2)/(R+Zc);
21 mprintf("\nVerification: Coeff of Reflection = %.3f,
    Coeff of Refraction=%.3f",Cr,CR)

```

Scilab code Exa 12.10 reflection and transmission of voltage and current wave

```

1 clear;
2 clc;
3
4 ef=10000;
5 Zc=400;
6 iF=ef/Zc
7 mprintf("\n(a)\nIncident Wave magnitude= %d A",iF)
8
9 R=1000
10 et=ef*(R*2)/(R+Zc);
11 it=et/R;
12 er=et-ef;
13 mprintf("\n(b)\nSurge Voltage Reflected= %.3f KV",er)

```

```

    /1000)
14  ir=-1*er/Zc
15  mprintf("\nSurge Current Reflected= %.3 f A",ir)
16  edr=et*it;
17  mprintf("\nRate of dissipation of energy= %.2 f KW",
    edr/1000)
18  err=er*-ir;
19  mprintf("\nRate of reflection of energy= %.3 f KW",
    err/1000)
20
21  mprintf("\n(c)\nfor complete dissipation , R=Zc= %.0 f
    ohm",Zc);
22
23  R=50
24  et=ef*(R*2)/(R+Zc);
25  mprintf("\n(d)\nSurge Voltage Transmitted= %.3 f KV",
    et/1000)
26  it=et/R;
27  mprintf("\nSurge Current Transmitted= %.2 f A",it)
28  er=et-ef;
29  mprintf("\nSurge Voltage Reflected= %.3 f kV",er
    /1000)
30  ir=-1*er/Zc
31  mprintf("\nSurge Current Reflected= %.3 f A",ir)
32  edr=et*it;
33  mprintf("\nRate of dissipation of energy= %.2 f KW",
    edr/1000)
34  err=er*-ir;
35  mprintf("\nRate of reflection of energy= %.2 f KW",
    err/1000)

```

Scilab code Exa 12.11 find V and I transmitted

```

1  clear;
2  clc;

```

```

3
4 Zc=400
5 ef=20
6 z1=150;
7 z2=200
8 z=round((z1*z2/(z1+z2))*100)/100
9
10 et=2*ef*z/(Zc+z)
11 mprintf("\nSurge Voltage Transmitted= %.4 f kV",et)
12
13 it1=et*1000/z1;
14 mprintf("\nSurge Current Transmitted in line 1= %.3 f
      A",it1)
15
16 it2=et*1000/z2;
17 mprintf("\nSurge Current Transmitted in line 2= %.2 f
      A",it2)
18
19 er=et-ef
20 mprintf("\nSurge Voltage Reflected= %.4 f kV",er)
21 ir=-1*er*1000/Zc
22 mprintf("\nSurge Current Reflected= %.2 f A",ir)

```

Scilab code Exa 12.12 reflection transmission and absorption of wave

```

1 clear;
2 clc;
3
4 ef=100
5 Zc=400
6 z=50
7
8 R=z+Zc;
9 E=(2*ef/(Zc+z+R))^2 *R
10 E=round(E*100)/100

```

```

11 mprintf("\n(a) Energy transfer max when R= %.0 f ohm,
    energy= %.2 f KW", R,E);
12
13 etB=2*ef*z/(z+Zc+R);
14 etB=round(etB*100)/100
15 mprintf("\n(b) Surge Voltage Transmitted= %.3 f kV",
    etB)
16
17 it=etB*1000/z;
18 it=round(it*100)/100
19 mprintf("\nSurge Current Transmitted = %.2 f A",it)
20
21 etA=2*ef*(z+R)/(z+Zc+R);
22 etA=round(etA*100)/100
23
24 erA=etA-ef
25 mprintf("\n(c) Surge Voltage Reflected= %.2 f kV",erA)
26 irA=-1*erA*1000/Zc
27 mprintf("\nSurge Current Reflected= %.3 f A",irA)
28
29
30 iF=ef*1000/Zc
31 Pi=ef*iF
32 mprintf("\n(d) Power Incident= %.0 f kW",Pi)
33 Pr=erA*-irA
34 mprintf("\nPower Reflected= %.2 f kW",Pr)
35 Pt=erA*it
36 mprintf("\nPower Transmitted= %.0 f kW",Pt)

```

Scilab code Exa 12.14 find voltage and current surges

```

1 clear;
2 clc
3
4 I=5;

```

```

5 z1=400
6 z2=50
7 V=I * z1* z2/(z2+z1)
8 mprintf("\nSurge Voltage Transmitted= %f kV",V)
9 ic=V/z2
10 mprintf("\nSurge Current Transmitted in cable= %f kA
    ",ic)
11
12 io=-V/z1;
13 mprintf("\nSurge Current Transmitted in OH line= %f
    kA",io)

```

Scilab code Exa 12.16 find restriking voltage due to current chopping

```

1 clear;
2 clc
3
4 i=100
5 L=4e-3
6 C=300e-12
7 E=i* sqrt(L/C)
8 T=1/ sqrt(L*C)
9 mprintf("e= %.0f *1e3 sin( %.3f *1e6 t) kV",E/1e3,T
    /1e6)

```

Chapter 13

Power System Stability

Scilab code Exa 13.1 find P Q E and load angle for changes to P and E

```
1 clear;
2 clc
3
4 Xd=.7
5 pf=.8
6 pfa=acos(pf)
7 V=1
8 I0=1* exp( %i * pfa *-1)
9 E0=V+ (%i * Xd * I0)
10 E=round(abs(E0)*100)/100
11 d0=atand(imag(E0)/real(E0))
12 E0=E * exp(%i * d0 * %pi/180)
13 Pe0=E*V*sind(d0)/Xd
14 Qe0=(E*V*cosd(d0)/Xd)-(V*V/Xd)
15
16 mprintf("\n(a)\nPe= %.1f Qe=%.1f E= %.2f load angle=
    %.1f",Pe0, Qe0, E, d0);
17
18 e1=E0
19 E1=abs(e1)
20 Pe1=1.2* Pe0;
```

```

21 d1=asind(Pe1* Xd/ (V*E1))
22 Qe1=(E1*V*cosd(d1)/Xd)-(V*V/Xd)
23
24 mprintf("\n(b)\nPe= %.2f Qe=%.2f E= %.2f load angle=
    %.1f",Pe1, Qe1, E1, d1);
25
26 e2=1.2 * E0
27 E2=abs(e2)
28 Pe2=Pe0;
29 d2=asind(Pe2* Xd/ (V*E2))
30 Qe2=(E2*V*cosd(d2)/Xd)-(V*V/Xd)
31
32 mprintf("\n(c)\nPe= %.1f Qe=%.2f E= %.2f load angle=
    %.1f",Pe2, Qe2, E2, d2);

```

Scilab code Exa 13.2 find inertia constants retardation

```

1 clear;
2 clc
3
4 P=4
5 f=50
6 G=200
7 H=6
8 J=G*H
9 mprintf("\n(a) stored energy = %.0f MJ",J)
10
11 P1=120
12 P11=160
13 Pa=P1-P11
14 M=J/(180*f)
15 a=Pa/M
16 mprintf("\n(b) acceleration = %.0f elec deg/ sec sq",
    a)
17

```

```

18 c=5
19 t=c/f
20 dd=.5*a*t*t
21 N=120*f/P
22 a=a*60/(180*P)
23 Nn=N+(a*t)
24 mprintf("\\n(c) change in power angle = %.1f elec deg,
           change in speed = %.1f rpm",dd,Nn)
25
26 G2=150
27 H2=4
28 Gb=100
29 Heq=((G*H)+(H2*G2))/Gb
30 mprintf("\\n(d) Equivalent inertia constant = %.0f MJ/
           MVA",Heq)

```

Scilab code Exa 13.3 find steady state stability parameters

```

1 clear;
2 clc
3
4 f=50;
5 H=9;
6 x=.6
7 P=.7
8 pf=.8
9 pfa=acos(pf)
10 V=1
11 D=.14
12 dd=10 * %pi/180
13
14 S=P/pf * exp(%i * pfa)
15 I=conj(S/V)
16 E=V+ (%i * x *I)
17 d0=atand(imag(E)/real(E))

```



```

18 Pr=abs(E) * V * cosd(d0)/x
19 mprintf("\nSynchronising Power Coefficient = %.3f pu
    ",Pr)
20
21 w1=sqrt(Pr * f *%pi/H)
22 mprintf("\nUndamped Speed Of oscillations = %.2f rad
    /sec",w1)
23 w1=round(w1*100)/100
24
25 z=(D/2) * sqrt(%pi * f/(H*Pr))
26 mprintf("\nDamping Ratio = %.4f ",z)
27
28 wd=w1 *sqrt(1-(z*z))
29 Wd=wd / (2*%pi)
30 mprintf("\ndamped angular frequency Of oscillations
    = %.3f rad/sec = %.3f Hz",wd, Wd)
31
32 z=round(z*1e4)/1e4
33 c_1=10/sqrt(1-z^2)
34 c_2=z*w1
35
36 mprintf("\n\nd = %.2f + %.3f exp(-%.3f t) sin(% .3f t
    + %.1f deg)", d0, c_1, c_2,wd, acosd(z))
37
38 c_3=w1 * 10 / (360 * sqrt(1-z^2))
39 mprintf("\n\nf = %.0f - %.4f exp(-%.3f t) sin(% .3f t
    )", f, c_3, c_2,wd)

```

Scilab code Exa 13.4 derive expressions for oscillations of delta and freq as func

```

1 clear;
2 clc
3 dP=.1
4 f=50;
5 H=9;

```

```

6 x=.6
7 P=.7
8 pf=.8
9 pfa=acos(pf)
10 V=1
11 D=.14
12 dd=10 * %pi/180
13
14 S=P/pf * exp(%i * pfa)
15 I=conj(S/V)
16 E=V+ (%i * x * I)
17 d0=atand(imag(E)/real(E))
18 Pr=abs(E) * V * cosd(d0)/x
19
20 w1=sqrt(Pr * f * %pi/H)
21 w1=round(w1*100)/100
22
23 z=(D/2) * sqrt(%pi * f/(H*Pr))
24
25 wd=w1 *sqrt(1-(z*z))
26 Wd=wd / (2*%pi)
27
28 z=round(z*1e4)/1e4
29 c_1=1/sqrt(1-z^2)
30 c_2=z*w1
31 c_3=180 * f * dP/(9 * w1^2)
32
33 mprintf("\n\nd = %.2f + %.3f(1- (%.3f exp(-%.3f t)
      sin(%.3f t + %.1f deg)))", d0, c_3,c_1, c_2,wd,
      acosd(z))
34
35 c_4= dP * f /(w1* 9 * sqrt(1-z^2))
36 mprintf("\n\nf = %.0f + %.4f exp(-%.3f t) sin(%.3f t
      )", f, c_4, c_2,wd)

```

Scilab code Exa 13.5 finding steady state reactance and transfer limit for difference

```
1 clear;
2 clc
3
4 E=1.1
5 V=1
6 xg=.7
7 xt=.1
8 x1=.2
9 X1=x1+xg+xt
10 X2=.2
11 xL=.5
12 xC=-.5
13
14
15 X=X1+X2
16 P1=E*V/X
17 mprintf("\n(a) Steady State limit = %.4f", P1)
18
19 X3=xL
20 X=((X1*X2) + (X2*X3) + (X1*X3))/X3
21 P2=E*V/X
22 mprintf("\n(b) Steady State limit = %.4f", P2)
23
24 X3=xC
25 X=((X1*X2) + (X2*X3) + (X1*X3))/X3
26 P3=E*V/X
27 mprintf("\n(c) Steady State limit = %.3f", P3)
28
29 X=X1+xC+X2
30 P4=E*V/X
31 mprintf("\n(d) Steady State limit = %.2f", P4)
```

Scilab code Exa 13.6 frequency of oscillation of generator due to loading

```

1 clear;
2 clc
3
4 f=50
5 xg=1
6 x1=.5
7 E=1.1
8 V=1
9 H=5
10 p=.5
11
12 X=x1+xg
13 d0=asin(p)
14 Pr=E*V*cos(d0)/X
15 M=H/(%pi*f)
16 wn=sqrt(Pr/M)/(2*%pi)
17
18 mprintf("Freq of oscillation = %.2f Hz", wn)

```

Scilab code Exa 13.7 system stability and finding critical load angle

```

1 clear
2 clc
3
4 xd=.2
5 x1=.4
6 x2=.4
7 Pi=1.5
8 E=1.2
9 V=1
10
11
12 X=xd +((x1*x2)/(x1+x2))
13 pe=E*V/X
14 d0 = asin(Pi/pe)

```

```

15
16 X2=xd+x1
17 pe2=E*V/X2
18 d1 = asin(Pi/pe2)
19 dm=%pi - d1
20
21 A1=((Pi * d1)+ ( pe2 * cos(d1)))- ((Pi * d0)+ ( pe2
    * cos(d0)))
22 A2=((Pi * dm)+ ( pe2 * cos(dm)))- ((Pi * d1)+ ( pe2
    * cos(d1)))
23
24 if abs(A1)<abs(A2) then
25     mprintf("STABLE\n\n")
26 else
27     mprintf("UNSTABLE\n\n")
28 end
29
30 E=10
31 x=2
32 e=1e-3
33 a=Pi
34 b=pe2
35 c=-A1 +(Pi * d1 ) + (cos (d1) * pe2)
36
37 while (E>e)
38     f=(a*x) + (b * cos(x)) - c
39     df=1.5 - (2*sin(x))
40     x1=x-(f/df)
41     E=abs(x1-x)
42     x=x1
43 end
44 d2=x1 * 180/%pi
45 mprintf("\ndelta 2 = %.2 f deg",d2)

```

Scilab code Exa 13.8 system stability and finding critical load angle in 3 phase f

```

1  clear
2  clc
3
4  xd=.2
5  x1=.4
6  x2=.4
7  Pi=1.5
8  E=1.2
9  V=1
10
11 Xs1=xd +((x1*x2)/(x1+x2))
12 pe=E*V/Xs1
13 d0 = asin(Pi/pe)
14 dc= (%pi/2)-d0
15 dc=round(dc*1e3)/1e3
16
17 X1=x1;
18 X2=x2/2
19 X3=x2/2
20 Xs2=((X1*X2) + (X2*X3) + (X1*X3))/X3
21 pe2=E*V/Xs2
22
23
24
25 Xs3=xd+ x1
26 pe3=E*V/Xs3
27 d2 = asin(Pi/pe3)
28 dm=%pi- d2
29
30
31 if pe2<Pi then
32     mprintf("UNSTABLE for sustained fault\n\n")
33 else
34     mprintf("STABLE for sustained fault\n\n")
35 end
36
37
38 A1=((Pi * dc)+ ( pe2 * cos(dc)))- ((Pi * d0)+ ( pe2

```

```

    * cos(d0)))
39 A2=((Pi * dm)+ ( pe3 * cos(dm)))- ((Pi * dc)+ ( pe3
    * cos(dc)))
40
41 if abs(A1)<abs(A2) then
42     mprintf("STABLE system\n\n")
43 else
44     mprintf("UNSTABLE  system\n\n")
45 end
46
47
48 E=10
49 x=2
50 e=1e-3
51 a=Pi
52 b=pe3
53 c=-A1 +(Pi * dc ) + (cos (dc) * pe3)
54
55 while (E>e)
56     f=(a*x) + (b * cos(x)) - c
57     df=1.5 - (2*sin(x))
58     x1=x-(f/df)
59     E=abs(x1-x)
60     x=x1
61 end
62 d2=x1 * 180/%pi
63 mprintf("\ndelta 2 = %.2 f deg", d2)
64
65 Pmb=pe2
66 Pmc=pe3
67 d0=round(d0*1000)/1000
68 dcc=acosd(((Pi*(dm-d0))- (Pmb*cos(d0))+ (Pmc*cos(dm)
    ))/(Pmc-Pmb))
69 mprintf("\nCritical Clearing angle = %.1 f deg", dcc)

```

Scilab code Exa 13.9 system stability and finding critical load angle in 3 phase f

```
1 clear
2 clc
3
4 xd=.2
5 x1=.4
6 x2=.4
7 Pi=1.5
8 E=1.2
9 V=1
10
11 Xs1=xd +((x1*x2)/(x1+x2))
12 pe=E*V/Xs1
13 d0 = asin(Pi/pe)
14
15 Xs3=xd+ x1
16 pe3=E*V/Xs3
17 d2 = asin(Pi/pe3)
18 dm=%pi - d2
19
20 Pmb=0
21 Pmc=pe3
22 dcc=acosd(((Pi*(dm-d0))- (Pmb*cos(d0))+ (Pmc*cos(dm)
    ))/(Pmc-Pmb))
23 mprintf(" Critical Clearing angle = %.2f deg", dcc)
```

Scilab code Exa 13.10 system stability and finding critical load angle due to sudd

```
1 clear
2 clc
3
4 Pm=1
5 Pe1=.25
6 d1=round(asin(Pe1)*1000)/1000
```



```

7
8 Pe2=.5
9 d2=round(asin(Pe2)*1000)/1000
10
11 d3=0;
12
13 A1=((Pe2 * d2)+ ( 1 * cos(d2)))- ((Pe2 * d1)+ ( 1 *
      cos(d1)))
14
15 E=10
16 x=.811
17 e=1e-3
18 a=Pe2
19 b=1
20 c=A1 -((Pe2 * d2)+ ( 1 * cos(d2)))
21
22 while (E>e)
23 //for (i=1:4)
24     f=(a*x) + (b * cos(x)) + c
25     df=a - (b*sin(x))
26     x1=x-(f/df)
27     disp(x1,f,df)
28     E=abs(x1-x)
29     x=x1
30 end
31 d3=x1 * 180/%pi
32
33 mprintf("\ndelta 3 = %.1f deg",d3)

```

Scilab code Exa 13.11 inertia constant of 2 generators in parallel

```

1 clear
2 clc
3
4 G1=50

```

```

5 H1=8
6
7 G2=100
8 H2=4
9 Gb=100
10
11 Ha=(H1*G1/Gb) + (H2*G2/Gb)
12 mprintf("\n(a)Ha= %d MJ/MVA", Ha)
13
14 Hb=Ha*2
15 mprintf("\n(b)Hb= %d MJ/MVA", Hb)
16
17 He= (Ha*Hb)/(Ha+Hb)
18 mprintf("\n(c)He= %.3 f MJ/MVA", He)

```

Scilab code Exa 13.12 find frequency deviation in case of delay in opening steam v

```

1 clear
2 clc
3
4 G=100
5 f=50
6 H=5
7 dL=50
8 t=.6
9
10
11 J = G*H*1e3;
12 dJ=dL*1e3*t
13 f2=sqrt((J-dJ)/J)*f
14 fd=(f-f2)/f;
15 mprintf("Freq deviation = %.3 f percent", fd*1e2)

```

Scilab code Exa 13.13 find critical clearing angle during prefault fault and post

```
1 clear
2 clc
3
4 Pi=1
5 Pma=1.75
6 Pmb=.4
7 Pmc=1.25
8
9 d0=asin(Pi/Pma)
10 dm=%pi - asin(Pi/Pmc)
11
12 dcc=acosd(((Pi*(dm-d0))- (Pmb*cos(d0))+ (Pmc*cos(dm)
    ))/(Pmc-Pmb))
13 mprintf(" Critical Clearing angle = %.1f deg", dcc)
```

Scilab code Exa 13.14 point by point solution of swing equation

```
1 clear
2 clc
3 clf
4
5 Sb = 50;
6 S=50;
7 V =1;
8 Xd = 0.2;
9 X1 =0.4;
10 X2 = 0.4;
11 H = 2.7;
12 E=1.05 ;
13 G=1;
14
```

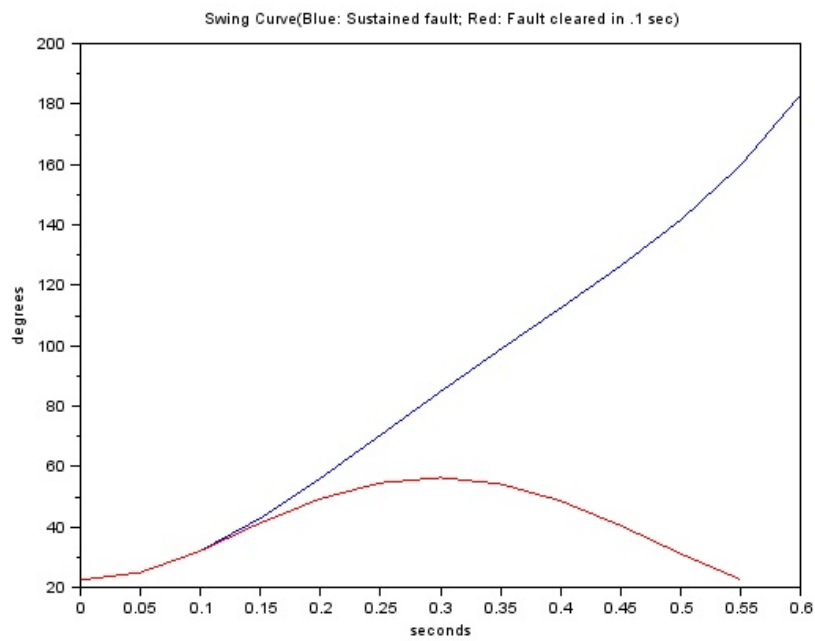


Figure 13.1: point by point solution of swing equation

```

15 M = G*H/(180*50);
16
17 pe0 = (E*V/X1);
18 d0=asind(S/(Sb*pe0 ));
19 Pe0=pe0 * sind(d0);
20
21 pe1 = (E*V/(X1+X2+Xd));
22
23 pe2 = (E*V/(X1+Xd));
24
25 dt=.05
26 c_1=dt*dt/M
27
28 for i=1:14
29     if i==1 then
30         m_t(i)=0;
31         m_Pm(i)=Pe0
32         m_sind(i)=sind(d0)
33         m_Pe(i)=S/Sb
34         m_Pa(i)=0
35         m_cPe(i)=c_1 * m_Pa(i)
36         m_dd(i)=0
37         m_d(i)=d0
38     else if i==2 then
39         m_t(i)=0;
40         m_Pm(i)=pe1
41         m_d(i)=d0
42         m_sind(i)=sind(m_d(i))
43         m_Pe(i)=m_sind(i)*m_Pm(i)
44         m_Pa(i)=(1 - m_Pe(i) + m_Pa(i-1))/2
45         m_cPe(i)=c_1 * m_Pa(i)
46         m_dd(i)=0
47     else
48         m_t(i)=m_t(i-1) +dt;
49         m_Pm(i)=pe1
50         m_dd(i)=m_dd(i-1) + m_cPe(i-1)
51         m_d(i)=m_d(i-1)+m_dd(i)
52         m_sind(i)=sind(m_d(i))

```

```

53         m_Pe(i)=m_Pm(i) * m_sind(i)
54         m_Pa(i)=(1 - m_Pe(i))
55         m_cPe(i)=c_1 * m_Pa(i)
56     end
57 end
58
59 end
60 res1(:,1)=m_t(:)
61 res1(:,2)=m_Pm(:)
62 res1(:,3)=m_sind(:)
63 res1(:,4)=m_Pe(:)
64 res1(:,5)=m_Pa(:)
65 res1(:,6)=m_cPe(:)
66 res1(:,7)=m_dd(:)
67 res1(:,8)=m_d(:)
68 res1=round(res1*1000)/1000
69 i=1
70 head=[' ' 't' ' ' 'Pm' ' ' 'sin d' ' ' ' '
        'Pe' ' ' 'Pa' ' ' '8.33Pa' ' ' 'd delta' '
        delta']
71 disp(res1, head, "(a)")
72 plot(m_t, m_d)
73 title('Swing Curve(Blue: Sustained fault; Red: Fault
        cleared in .1 sec)');
74 xlabel('seconds');
75 ylabel('degrees');
76
77
78 //(b)
79 while i<15
80     if i==1 then
81         m_t2(i)=0;
82         m_Pm2(i)=Pe0
83         m_sind2(i)=sind(d0)
84         m_Pe2(i)=S/Sb
85         m_Pa2(i)=0
86         m_cPe2(i)=c_1 * m_Pa2(i)
87         m_dd2(i)=0

```

```

88         m_d2(i)=d0
89     else if i==2 then
90         m_t2(i)=0;
91         m_Pm2(i)=pe1
92         m_d2(i)=d0
93         m_sind2(i)=sind(m_d2(i))
94         m_Pe2(i)=m_sind2(i)*m_Pm2(i)
95         m_Pa2(i)=(1 - m_Pe2(i) + m_Pa2(i-1))/2
96         m_cPe2(i)=c_1 * m_Pa2(i)
97         m_dd2(i)=0
98     else
99         m_t2(i)=m_t2(i-1) +dt;
100        if m_t2(i) == .1 then
101            m_Pm2(i)=pe1
102            m_dd2(i)=m_dd2(i-1) + m_cPe2(i-1)
103            m_d2(i)=m_d2(i-1)+m_dd2(i)
104            m_sind2(i)=sind(m_d2(i))
105            m_Pe2(i)=m_Pm2(i) * m_sind2(i)
106            m_Pa2(i)=(1 - m_Pe2(i))
107            m_cPe2(i)=c_1 * m_Pa2(i)
108
109            i=i+1
110            m_t2(i)=m_t2(i-1)
111            m_Pm2(i)=pe2
112            m_dd2(i)=m_dd2(i-1)
113            m_d2(i)=m_d2(i-1)
114            m_sind2(i)=sind(m_d2(i))
115            m_Pe2(i)=m_Pm2(i) * m_sind2(i)
116            m_Pa2(i)=(1 - m_Pe2(i) + m_Pa2(i-1))
                /2
117            m_cPe2(i)=c_1 * m_Pa2(i)
118        else
119            m_Pm2(i)=m_Pm2(i-1)
120            m_dd2(i)=m_dd2(i-1) + m_cPe2(i-1)
121            m_d2(i)=m_d2(i-1)+m_dd2(i)
122            m_sind2(i)=sind(m_d2(i))
123            m_Pe2(i)=m_Pm2(i) * m_sind2(i)
124            m_Pa2(i)=(1 - m_Pe2(i))

```

```

125             m_cPe2(i)=c_1 * m_Pa2(i)
126             end
127         end
128     end
129     i=i+1
130 end
131 res2(:,1)=m_t2(:)
132 res2(:,2)=m_Pm2(:)
133 res2(:,3)=m_sind2(:)
134 res2(:,4)=m_Pe2(:)
135 res2(:,5)=m_Pa2(:)
136 res2(:,6)=m_cPe2(:)
137 res2(:,7)=m_dd2(:)
138 res2(:,8)=m_d2(:)
139 res2=round(res2*1000)/1000
140 disp(res2,head, "(b)")
141
142 plot(m_t2, m_d2, 'r')
143 //(c)
144 D0=d0 * %pi/180
145 Pi=1
146 Dm=%pi - asin(Pi/pe2)
147
148 dcc=acosd(((Pi * (Dm-D0))-(pe1*cos(D0))+(pe2*cos(Dm)
149         ))/(pe2 -pe1))
149 tcc=.395
150 mprintf("\n\n(c) dcc= %.1f deg; clearing time=%.3f
151         sec", dcc,tcc)

```

Scilab code Exa 13.15 find maximum load that can be supplied by generator

```

1 clear
2 clc
3
4 P=50

```



```

5 pe=100
6
7
8 E=10
9 x=1
10 e=1e-3
11
12 d0=30/180 * %pi
13 while (E>e)
14     f=cos(d0)+cos(x) - ((%pi - d0-x)*sin(x))
15     df= (-%pi+d0+x)*cos(x)
16     x1=x-(f/df)
17
18     E=abs(x1-x)
19     x=x1
20 end
21 d1=x1 * 180/%pi
22
23 P1=sind(d1) *pe
24 Pr=P1-P
25 mprintf("\nPower Required = %.2f MW",Pr)

```

Scilab code Exa 13.16 finding steady state reactance and transfer limit for differ

```

1 clear;
2 clc
3
4 E=1.5
5 V=1
6 xg=1
7 xm=1
8
9 xt1=.1
10 xt2=.1
11 x1=.4

```

```

12 x2=.4
13 x1=(x1*x2)/(x1+x2)
14 X1=x1+xg+xt1
15 X2=xt2+xm
16 xL=.8
17 xC=-.8
18
19
20 X3=xC
21 X=((X1*X2) + (X2*X3) + (X1*X3))/X3
22 P1=E*V/X
23 mprintf("\n(a) Steady State limit = %.3f", P1)
24
25 X3=xL
26 X=((X1*X2) + (X2*X3) + (X1*X3))/X3
27 P2=E*V/X
28 mprintf("\n(b) Steady State limit = %.3f", P2)

```

Scilab code Exa 13.17 find inertia constant and momentum of generator

```

1 clear
2 clc
3
4 f=50
5 w=2*%pi*f
6 I=8800
7 pf=.85
8 J=.5*I*w*w*1e-6
9 P=60
10 MVA=P/pf
11 H=J/MVA
12 M=J/(180*f)
13
14 mprintf("Inertia const= %.3f MJ/MVA, Momentum= %.5 f
    MJ-s/elec deg",H,M)

```

Scilab code Exa 13.18 find inertia constant of each machine and parallel ombinatio

```
1 clear
2 clc
3
4 f=50
5 w=2*%pi*f
6 I1=25000
7 pf1=.8
8 J1=.5*I1*w*w*1e-6
9 P1=45
10 G1=P1/pf1
11 H1=J1/G1
12 M1=J1/(180*f)
13
14 mprintf("machine 1 \nInertia const= %.2 f MJ/MVA,
           Momentum= %.3 f MJ-s/elec deg",H1,M1)
15
16 I2=9000
17 pf2=.75
18 J2=.5*I2*w*w*1e-6
19 P2=60
20 G2=P2/pf2
21 H2=J2/G2
22 M2=J2/(180*f)
23
24 mprintf("\n\nmachine 2 \nInertia const= %.2 f MJ/MVA,
           Momentum= %.5 f MJ-s/elec deg",H2,M2)
25
26 M=(M1*M2)/(M1+M2)
27 Gb=100
28 H=M*180 * f /Gb
29 mprintf("\n\n Equivalent constant at 100MVA base \
           nInertia const= %.4 f MJ/MVA, Momentum= %.5 f MJ-s/
```

```
elec deg",H,fix(M*100000)/100000)
```

Scilab code Exa 13.19 find critical clearing angle and critical clearing time in 3

```
1 clear
2 clc
3
4 Pm=2
5 Pi=1
6 H=6
7 G=1
8 f=50
9 p=Pi/Pm
10 M=G*H/(%pi*f)
11 d0=asin(p)
12
13 dcc=acos(((p*(%pi - (2*d0)))- (Pi*cos(d0)))/(Pm-Pi))
14 mprintf(" Critical Clearing angle = %.4f rad\n\n",
          dcc)
15
16 tcc=sqrt(2*M*(dcc-d0)/Pi)
17 mprintf(" Critical Clearing time = %.3f sec = %.2f
          cycles", tcc , tcc*50)
```

Scilab code Exa 19.20 finding acceleration torque and change in torque angle due t

```
1 clear
2 clc
3
4 f=50
5 G=20
6 V=13.2
7 H=9
```

```

8  nP=4
9
10 J=G*H
11 fprintf("\n(a) Stored Energy = %.0f MJ", J)
12 disp("The unit is incorrectly mentioned as 'mJ' in
      the textbook.");
13
14 Pi= 25*.735
15 P=15
16 Pa=Pi-P
17 M=G*H/(180*f)
18 a=Pa/M
19 fprintf("\n(b) Acceleration = %.2f elec deg/sec sq",a
      )
20
21
22 c=15
23 t=c/f
24 dd=.5*a*t*t
25 fprintf("\n(c) change in angle = %.2f deg",dd )
26
27 A=a * 60 / (180*nP)
28 Ns=120*f/nP
29 N=Ns+(A*t)
30 fprintf("\n(d) New speed = %.3f rpm", fix(N*1000)/1000
      )

```

Chapter 16

Distribution

Scilab code Exa 16.1 find voltage at load points in single feeded dc feeder

```
1 clear
2 clc
3
4 I1=100
5 I2=150
6 I3=200
7
8 l1=150
9 l2=100
10 l3=100
11
12 r=.1/1000
13
14 Va=200
15
16 rac=l1*r;
17 rcd=l2*r
18 rbd=l3*r
19
20 dvc=(I1+I2+I3)*rac;
21 dvd=(I1+I2+I3)*rac + (I2+I3)*rcd ;
```

```

22 dvb=(I1+I2+I3)*rac + (I2+I3)*rcd + (I3*rbd);
23
24 Vc=Va-dvc
25 Vd=Va-dvd
26 Vb=Va-dvb
27
28 mprintf(" voltage at B= %.2f V  C= %.2f V  D= %.2f V
        ", Vb, Vc, Vd)

```

Scilab code Exa 16.2 find voltage at load points in addition to distributed load i

```

1  clear
2  clc
3
4  I1=100
5  I2=150
6  I3=200
7
8  l1=150
9  l2=100
10 l3=100
11
12 r=.1/1000
13 U=1
14
15 Va=200
16
17 rac=l1*r;
18 rcd=l2*r
19 rbd=l3*r
20
21 Iac= I1+I2+I3 + U*(l1+l2+l3)
22 dvc=(Iac - (.5* U * l1))*rac;
23 Vc=Va-dvc
24

```

```

25 Icd= I2+I3 + U*(l2+l3)
26 dvd=(Icd - (.5* U * l2))*rcd ;
27 Vd=Vc-dvd
28
29 Idb= I3 + U*(l3)
30 dvb=(Idb - (.5* U * l3))*rbd ;
31 Vb=Vd-dvb
32
33 mprintf(" voltage at B= %.3 f V  C= %.3 f V  D= %.3 f V
      ", Vb, Vc, Vd)

```

Scilab code Exa 16.3 find voltage at load points in doubly feeded dc feeder

```

1 clear;
2 clc
3
4 r1=.02
5 r2=.05
6 r3=.03
7
8 Ic1=100
9 Id1=180
10
11 Va=255;
12 Vb=250
13
14 dV=abs(Va-Vb)
15 Ia=(dV+(r1*0)+(r2*Ic1)+(r3*(Id1+Ic1)))/(r1+r2+r3)
16
17 Ib=- (Ia-(Ic1+Id1))
18
19 Vc=Va-Ia*r1
20 Vd=Vc-((Ia-Ic1)*r2)
21
22 mprintf(" IA= %.0 f A, IB=%.0 fA , Vc=%.2 f V, Vd=%.2 f V"

```


, Ia, Ib, Vc, Vd)

Scilab code Exa 16.4 find voltage at load points in addition to distributed load i

```
1 clear
2 clc
3
4 l=300
5 l1=120
6 l3=120
7 l2=l-l1-l3
8 U=.25
9 Ic1=40
10 Id1=60
11
12 r=.1/100
13 r1=l1*r;
14 r2=l2*r
15 r3=l3*r
16
17 Va=300
18 Vb=300
19
20 dV=abs(Va-Vb)
21 Ia=(dV+(r1*.5*U*l1)+(r2*.5*U*l2)+(r3*.5*U*l3)+(r2*(
      Ic1+U*l1)))+(r3*(Ic1+U*l1 +Id1+U*l2)))/(r1+r2+r3)
22 I=Ic1+Id1+(U*l)
23 Ib=I-Ia
24
25 Vc=Va-(Ia-.5*U*l1)*r1
26 Vd=Vb-((Ib-.5*U*l3)*r3)
27
28 mprintf("IA= %.1 f A, IB=%.1 fA, Vc=%.2 f V, Vd=%.2 f V"
      , Ia, Ib, Vc, Vd)
```

Scilab code Exa 16.5 voltage drop in singly feeded ac feeder with concentrated load

```
1 clear
2 clc
3
4 l=400
5 l1=100
6 l2=250
7 l3=400
8 r=.25/1000
9
10 I1=100
11 I2=120
12 I3=80
13
14 V=240
15
16 dv=r*((l1*I1)+(l2*I2)+(l3*I3))
17 Ve=V-dv
18
19 mprintf("\nVoltage at end is %.0f V, drop = %.0f V",
          Ve, dv)
```

Scilab code Exa 16.6 voltage drop in singly feeded ac feeder with distributed and

```
1 clear
2 clc
3
4 l1=100
5 l2=250
6 l3=400
7 r=.25/1000
```

```

8 l=.125/1000
9
10 I1=100
11 I2=120
12 I3=80
13
14 pf1=.7
15 pf2=1
16 pf3=.8
17
18 phi1=acos(pf1)
19 phi2=acos(pf2)
20 phi3=acos(pf3)
21
22 Z1=11 * ((r*cos(phi1))+(l*sin(phi1)))
23 Z2=12 * ((r*cos(phi2))+(l*sin(phi2)))
24 Z3=13 * ((r*cos(phi3))+(l*sin(phi3)))
25
26 V=240
27
28 dv=(Z1*I1)+(Z2*I2)+(Z3*I3)
29 Ve=V-dv
30
31 mprintf("\nVoltage at end is %.2f V, drop = %.2f V",
          Ve, dv)

```

Scilab code Exa 16.7 currents in a 3 phase ac circuit

```

1 clear
2 clc
3
4 V=240
5
6 P1=50e3
7 P2=50e3

```

```

8 P3=200e3
9 Pm=500e3
10 pfm=.8
11
12
13 I1=P1/V
14 I2=P2/V
15 I3=P3/V
16 Im=Pm/(3*V*pfm)
17
18 i1=fix(I1*exp(%i *0*%pi/3)*100)/100
19 i2=fix((fix(I2*100)/100)*exp(%i *-2*%pi/3)*1000)
    /1000
20 i3=fix(I3*exp(%i *2*%pi/3)*100)/100
21 in=abs(round((i1+i2+i3)*100)/100)
22
23 iR=sqrt((I1)^2+(Im)^2+(2*I1*Im*pfm))
24 iY=sqrt((I2)^2+(Im)^2+(2*I2*Im*pfm))
25 iB=sqrt((I3)^2+(Im)^2+(2*I3*Im*pfm))
26
27 mprintf("\nIR= %.0 f A", iR)
28 mprintf("\nIY= %.0 f A", iY)
29 mprintf("\nIB= %.0 f A", iB)
30 mprintf("\nIn= %.2 f A", in)

```

Scilab code Exa 16.8 voltage drop at the end of one phase in unbalanced 3 phase ne

```

1 clear
2 clc
3
4 V=230
5
6 I1=80
7 I2=70
8 I3=50

```

```

9
10 pf1=.8
11 pf2=.9
12 pf3=1
13
14 phi1=acos(pf1)
15 phi2=acos(pf2)
16 phi3=acos(pf3)
17
18 i1=I1*exp(%i *0*%pi/3) * exp(%i * -phi1)
19 i2=I2*exp(%i*-2*%pi/3) * exp(%i * -phi2)
20 i3=I3*exp(%i *2*%pi/3) * exp(%i * -phi3)
21
22 r=.2
23
24 in=i1+i2+i3
25
26 dvR=r*i1
27 dvN=r*in
28
29 VR=V+dvR+dvN
30
31 mprintf("VR= %.1f V ang (%.1f)deg V", abs(VR), atand
    (imag(VR)/real(VR)))

```

Scilab code Exa 16.9 find supply voltage and phase angle between sending end and r

```

1 clear
2 clc
3
4 Vb=240
5
6 Ib=100* exp(%i *-1* acos (.8))
7 Ia=100* exp(%i *-1* acos (.6))
8

```

```

9 z=complex(.2, .3)
10
11 Va=round((Vb + (Ib * z/2)))
12 Isa = (Ia * exp(%i * 1 * atan(imag(Va)/real(Va)))) +
      Ib
13 //Isa=Isa*%i
14
15 Vs=Va + (Isa * z/2)
16 Vs=round(Vs*100)/100
17 vs=abs(Vs)
18 phi=atand(imag(Vs)/real(Vs))
19
20 mprintf(" |Vs| = %.2f A, phase angle between Vs & Vb
      = %.2f deg", fix(vs*100)/100, phi)

```

Scilab code Exa 16.10 find currents in a hexagon shaped concentrated loads

```

1 clear
2 clc
3
4 I=200
5
6 r1=.05
7 r2=.06
8 r3=.02
9 r4=.04
10 r5=.03
11 r6=.01
12 ra=.02
13 rb=.03
14
15 I1=100
16 I3=30
17 I4=50
18 I5=20

```

```

19 // (a)
20 dv=0
21 A=[
22 (ra) (-rb) (r6+r5 +r4+r3)
23 1 1 0
24 (ra+r1+r2) (-rb) -(r1+r2)
25 ]
26
27 B=[
28 dv+ (r5*(I5) +r4*(I5+I4)+r3*(I5+I4+I3))
29 I
30 dv+(r2*I1)
31 ]
32 i=inv(A)*B
33
34 mprintf("\n(a) Ia = %.0f A, Ib= %.0f A", i(1), i(2))
35
36 // (b)
37 dv=-5
38 A=[
39 (ra) (-rb) (r6+r5 +r4+r3)
40 1 1 0
41 (ra+r1+r2) (-rb) -(r1+r2)
42 ]
43
44 B=[
45 dv+(r5*(I5) +r4*(I5+I4)+r3*(I5+I4+I3))
46 I
47 dv+(r2*I1)
48 ]
49 i=inv(A)*B
50
51 mprintf("\n(b) Ia = %d A, Ib= %d A", i(1), i(2))

```

Scilab code Exa 16.11 find point of minimum in a line

```

1 clear
2 clc
3
4 L=1200
5 L1=900
6 L2=600
7
8 r=1.5
9
10 x=(L1*L + L*L*r/2)/(L1 + L2 + (r*2*L/2))
11 y=L-x
12 mprintf("\nCurrent in CB= %.0f a A", x)
13 mprintf("\nCurrent in CA= %.0f a A", y)

```

Scilab code Exa 16.12 voltage at far end in a double ac conductor with concentrated

```

1 clear
2 clc
3
4 V=250
5
6 L=[
7 150 200 280 320 390 450 500
8 20 40 35 25 10 20 30
9 ]
10
11 r=.1/(2*500)
12
13 D=L(1,:)
14 I=L(2,:)
15
16 dv=2*r*D*I
17
18 Ve=V-dv
19

```



```
20 mprintf(" Voltage at far end is %.2f V", Ve)
```

Scilab code Exa 16.13 voltage at far end in a double ac conductor doubly fed with

```
1 clear
2 clc
3
4 V=250
5
6 L=[
7 150 50 80 40 70 60 50 150
8 0 20 60 95 120 130 150 180
9 ]
10
11 r=.1/(2*500)
12
13 D=L(1,:)
14 I1=L(2,:)
15 I2=ones(8,1)
16
17 dv1=2*r*D*I1
18 dv2=2*r*D*I2
19
20 Ia=dv1/dv2
21 Ib=L(length(L))-Ia
22
23 Vc=V-(2*r*((Ia*D(1))+((Ia-I1(2))*D(2))+((Ia-I1(3))*D
24 mprintf(" Ia= %.2f A, Ib= %.2f A, Vmin at C = %.3f V"
    ,Ia, Ib, Vc)
```

Scilab code Exa 16.14 find currents in a pentagon shaped concentrated loads with a

```

1 clear
2 clc
3
4
5 r1=.03
6 r2=.02
7 r3=.03
8 r4=.04
9 r5=.04
10 r6=.01
11 r7=.02
12
13 I1=20
14 I2=30
15 I3=25
16 I4=30
17 I5=125
18 I6=20
19
20 dv=0
21 A=[
22 (r5+r1+r4+r3+r2) (r3+r2)
23 (r3+r2) (r3+r2+r6+r7)
24 ]
25
26
27 B=[
28 ((r4*I5)+(r3*(I5-I4))+ (r2*(I5-I4-I3)) + (r1*I1))
29 ((r3*(I5-I4))+ (r2*(I5-I4-I3))+(r7*I6))
30 ]
31 i=inv(A)*B
32 x=i(1)
33 y=i(2)
34
35 mprintf("\nEA = %.2 f A, AB= %.2 f A, ED= %.2 f A, DF=
%.2 f A, DC= %.2 f A, BC= %.2 f A, FB= %.2 f A", x,x-
I1, I5-x,y, I5-I4-x-y, I5-I4-I3-x-y, y-I6)

```

Scilab code Exa 16.15 find currents in a triangle shaped loads

```
1 clear
2 clc
3
4 z1=complex(2,1)
5 z2=complex(2,3)
6 z3=complex(1,2)
7
8 ib= 40 * exp (%i * -1 * acos (.8))
9 ic= 60 * exp (%i * -1 * acos (.6))
10
11 i1=((ib*z2)+((ib+ic)*z3))/(z1+z2+z3)
12 i2=i1-ib
13 i3=i2-ic
14
15 mprintf("\n Current A to B in Ampere")
16 disp(round(i1*100)/100)
17 mprintf("\n Current B to C in Ampere")
18 disp(round(i2*100)/100)
19 mprintf("\n Current A to C in Ampere")
20 disp(round(-i3*100)/100)
```

Scilab code Exa 16.16 find optimum cross section of cables for consumers at differ

```
1 clear
2 clc
3
4 //(a)
5 V=230
6 df=5/100
7
```

```

8 I1=20
9 I2=10
10 L1=300
11 L2=200
12 L=500
13 I=I1+I2
14
15 rho=.0286
16 T=20
17 dT=30
18 a=.004
19 rho1=rho*(1+(dT*a))
20 rho1=round(rho1*1000)/1000
21
22 A=1
23 A1=I1/I
24 A2=I2/I
25
26 A=rho1*2*((L*round(I/A))+(L1*round(I1/A1)))/(df * V)
27 A=round(A*100)/100
28
29 A1=A*A1
30 A2=A*A2
31
32 mprintf("\n(a) CROSSECTIONS: SC= %.2 f mm sq , CA= %.2 f
      mm sq , CB= %.2 f mm sq", A, A1, A2 )
33
34 R=2*rho1 * (L/A)
35 R1=2*rho1 * (L1/A1)
36 R2=2*rho1 * (L2/A2)
37
38 P=(I*I*R)+(I1*I1*R1)+(I2*I2*R2)
39
40 PL=P*100/((V*I1)+(V*I2))
41 mprintf("\n(b) Percentage power loss = %.1 f percent",
      PL )

```

Scilab code Exa 16.17 voltage at far end in a double ac conductor singly fed with

```
1 clear
2 clc
3
4 I1=100
5 I2=50
6 I3=50
7 I4=100
8 I5=0
9
10 L=500
11 l1=50
12 l2=100
13 l3=100
14 l4=150
15 l5=L-l1-l2-l3-l4
16
17 R=.075
18 r=R/L
19 U=1
20
21 Va=230
22
23 r1=l1*r;
24 r2=l2*r
25 r3=l3*r
26 r4=l4*r
27 r5=l5*r
28
29 Ia= I1+I2+I3+I4+I5 + U*(l1+l2+l3+l4+l5)
30 dvab=(Ia - (.5* U * l1))*r1;
31 Vb=Va-dvab
32
```

```

33 Ib= Ia- (U*(11)) - I1
34 dvbc=(Ib - (.5* U * 12))*r2;
35 Vc=Vb-dvbc
36
37 Ic= Ib- (U*(12)) - I2
38 dvcd=(Ic - (.5* U * 13))*r3;
39 Vd=Vc-dvcd
40
41 Id= Ic- (U*(+13)) - I3
42 dvde=(Id - (.5* U * 14))*r4;
43 Ve=Vd-dvde
44
45 Ie= Id- (U*(14)) - I4
46 dvef=(Ie - (.5* U * 15))*r5;
47 Vf=Ve-dvef
48
49 mprintf(" voltage at B= %.4f V  C= %.4f V  D= %.4f V
      E= %.2f V  F= %.1f V ", Vb, Vc, Vd, Ve, Vf)

```

Scilab code Exa 16.18 voltage at far end in a double ac conductor with concentrate

```

1 clear
2 clc
3
4 Vc=220
5
6 Z=2*complex(.15, .2)
7 Z1=.5*Z
8 Z2=.5*Z
9
10 Ib= 60 * exp (%i * -acos (.9))
11 Ic= 100 * exp (%i * -acos (.8))
12
13 Vb=Vc + (Ic * Z2)
14 Iab=Ib + Ic

```

```

15
16 Va=Vb + (Iab * Z1)
17 Vs=abs(Va)
18
19 Is= abs(Iab)
20 pf=cosd(abs(atan(imag(Va)/real(Va))+abs(atan(imag(
    Iab)/real(Iab))))))
21
22 mprintf("\nsending end voltage = %.1f V", Vs)
23 mprintf("\nsending end current = %.2f A", Is)
24 mprintf("\nsending end pf = %.3f", pf)

```

Scilab code Exa 16.19 find most economical center of distribution

```

1 clear
2 clc
3
4 ab=1000
5 bc=900
6 ac=600
7
8 A=500
9 B=750
10 C=450
11
12 theta=acos((ab^2 + ac^2 - bc^2)/(2*ac*ab))
13 am=ac * cos(theta)
14 cm=ac * sin(theta)
15
16 x= ((B*ab)+(C*am))/(A+B+C)
17 y= ((C*cm))/(A+B+C)
18
19 mprintf("Coordinates wrt A are (%.2f, %.0f)", x,y)

```

Scilab code Exa 16.20 find optimum cross section for double dc line doubly fed com

```
1 clear
2 clc
3
4 rho=1/58
5
6 l1=90
7 l2=90
8 l3=100
9 l4=80
10 l5=90
11 l6=90
12 l7=90
13
14 I1=50
15 I2=40
16 I3=20
17 I4=30
18 I5=45
19 I6=50
20
21 I=I1+I2+I3+I4+I5+I6
22 L=l1+l2+l3+l4+l5+l6+l7
23 Ia=((I1*l2)+((I1+I2)*l3)+((I1+I2+I3)*l4)+((I1+I2+I3+
      I4)*l5)+((I1+I2+I3+I4+I5)*l6)+((I1+I2+I3+I4+I5+I6
      )*l7))/L
24
25 Ib=I-Ia
26 V=230*2
27 V1=440
28
29 dv=V-V1
30
```



```

31 r=dv/((Ia*(l1+l2+l3+l4))-((I1*I2)+((I1+I2)*l3)+((I1+
    I2+I3)*l4)))
32
33 a=rho*2/r
34
35 mprintf(" crossection area (in mm sq)= %.2f", a)

```

Scilab code Exa 16.21 find currents in a hexagon shaped concentrated loads in 2 li

```

1 clear
2 clc
3
4 r1=.08
5 r2=.1
6 r3=.12
7 r4=.14
8 r5=.09
9 r6=.16
10
11 I1=20
12 I2=50
13 I3=25
14 I4=40
15 I5=30
16
17 x=((r2*I1)+(r3*(I1+I2))+(r4*(I1+I2+I3))+(r5*(I1+I2+
    I3+I4))+(r6*(I1+I2+I3+I4+I5)))/(r1+r2+r3+r4+r5+r6
    )
18
19 iab=x
20 ibc=iab-I1
21 icd=ibc-I2
22 ide=icd-I3
23 ief=ide-I4
24 ifa=ief-I5

```

```

25
26 iab=round(iab*10)/10
27 ibc=round(ibc*10)/10
28 icd=round(icd*10)/10
29 ide=round(ide*10)/10
30 ief=round(ief*10)/10
31 ifa=round(ifa*10)/10
32
33
34 mprintf("\n(a) Current A to B in Ampere = %.1f", iab
    )
35 mprintf("\n Current B to C in Ampere = %.1f", ibc)
36 mprintf("\n Current C to D in Ampere = %.1f", icd)
37 mprintf("\n Current D to E in Ampere = %.1f", ide)
38 mprintf("\n Current E to F in Ampere = %.1f", ief)
39 mprintf("\n Current F to A in Ampere = %.1f", ifa)
40
41
42
43 Vb=230+((r6*ifa)+(r5*ief)+(r4*ide))
44 mprintf("\n Minimum voltage at B, in Volts = %.3f\n\
    n", Vb)
45
46 //(b)
47 r7=.1
48
49
50 B=[
51 (r4+r5+r6) -r7
52 (r1+r2+r3) (r7+r1+r3+r2)
53 ]
54
55 C=[
56 ((r5*I5)+(r4*(I5+I4)))
57 ((r2*(I5+I2+I3+I4))+(r1*(I1+I2+I3+I4+I5))+(r3*(I1+I2
    +I3)))
58 ]
59

```

```

60 A= inv(B)*C
61 x=A(1)
62 y=A(2)
63 iab=I1+I2+I3+I4+I5 - x-y
64 ibc=iab-I1
65 icd=ibc-I2
66 iaf=x
67 ife=iaf-I5
68 ied=ife-I4
69 iad=y
70
71 mprintf("\n(b) Current A to B in Ampere = %.1f", iab
    )
72 mprintf("\n Current B to C in Ampere = %.1f", ibc)
73 mprintf("\n Current C to D in Ampere = %.1f", icd)
74 mprintf("\n Current E to D in Ampere = %.1f", ied)
75 mprintf("\n Current F to E in Ampere = %.1f", ife)
76 mprintf("\n Current A to F in Ampere = %.1f", iaf)
77 mprintf("\n Current A to D in Ampere = %.1f", iad)
78
79 Ve=230-((r6*iaf)+(r5*ife))
80 mprintf("\n Minimum voltage at E, in Volts = %.3f",
    Ve)

```

Scilab code Exa 16.22 kelvins law

```

1 clear
2 clc
3
4 V=33e3
5 L=10
6 Ce=.8
7 data=[
8 4e6 .8 10
9 2e6 .8 6

```

```

10 1e6 .8 8
11 ]
12 rho=.0286*1e3
13 P=2000
14 q=0
15 for i=1:3
16     I(i,1)=data (i,1)/(sqrt(3) * V * data(i,2))
17     E(i,1)= I(i)^2 * rho*3* data (i,3) * 1e-3
18     q=q+E(i)
19 end
20 Q=q*365*Ce
21
22 a=sqrt(Q/P)
23
24 mprintf("a=%.2f sq mm", fix(a*100)/100)

```

Scilab code Exa 16.23 find cross section of cable for given losses in a singly fed

```

1 clear
2 clc
3
4 V=220
5
6 rho1=.0286
7 T=20
8 dT=30
9 a=.004
10 rho=rho1*(1+(dT*a))
11 rho=round(rho*1000)/1000
12
13 P1=5
14 ef1=.81
15 pf1=.77
16 I1= P1*735.5/(V*pf1*ef1)
17 I1=I1 * exp(%i *-1 * acos (pf1))

```

```

18 I1=round(I1 *1000)/1000
19 Ic=I1
20
21
22 P2=26
23 ef2=.87
24 pf2=.85
25 I2= P2*735.5/(V*pf2*ef2)
26 I2=round(I2*100)/100
27 I2=I2 * exp(%i *-1 * acos (pf2))
28 Ib=fix((I1+I2)*100)/100
29
30 P3=10
31 ef3=.83
32 pf3=.82
33 I3= P3*735.5/(V*pf3*ef3)
34 I3=I3 * exp(%i *-1 * acos (pf3))
35 Ia=I1+I2+I3
36
37 P=real (Ia * V )
38 PLa=round(.05*P)
39
40 l1=40
41 l2=35
42 l3=30
43
44 PL1=2 * (round(abs(Ia)*100)/100)^2 * rho * l1
45 PL2=2 * (fix(abs(Ib)*100)/100)^2 * rho * l2
46 PL3=2 * (round(abs(Ic)*100)/100)^2 * rho * l3
47
48 PL1=fix(PL1/100)*100
49 PL2=round(PL2/100)*100
50 PL3=round(PL3/10)*10
51
52
53 a=(PLa/(PL1+PL2+PL3))^-1
54
55 mprintf("a=%.2 f sq mm", a)

```

```
56 disp("the difference in the result is due to error
      in calculation of abs(I2)=141.12 instead of
      144.12")
```

Scilab code Exa 16.24 find loss factor load factor annual load loss and annual cos

```
1 clear
2 clc
3
4 Pp=3e3;
5 Et=1e7
6 Plp=220
7 C=2.1
8
9 lf=(Et/8760)/Pp
10 lf=round(lf*100)/100
11 mprintf("\nLoad Factor = %.2f ", lf)
12
13 L=(.3*lf) + (.7*lf*lf)
14 L=round(L*1000)/1000
15 mprintf("\nLoss Factor = %.3f ", L)
16
17 Loss=L*Plp
18 mprintf("\nLoss = %.1f kW", Loss)
19
20 CLY=Loss*8760*C
21 mprintf("\nCost of Energy Loss = Rs %.1f ",CLY)
```

Scilab code Exa 16.25 effect of starting of induction motor on domestic load

```
1 clear
2 clc
3
```

```

4  x1=.1
5
6  st1=10
7  vt1a=66
8  vt1b=11
9  xt1=.1
10 n1=vt1b/vt1a
11
12 st2=5
13 vt2a=11
14 vt2b=3.3
15 xt2=.08
16 n2=vt2b/vt2a
17
18 st3=05
19 vt3a=11
20 vt3b=.415
21 xt3=.06
22 n3=vt3b/vt3a
23
24 Sm=5
25 pfm=.8
26
27 S1=1
28 pfl=.8
29
30 Sb=10
31 Vb1=66
32 Vb2=Vb1*n1
33 Vb3=Vb2*n2
34 Vb4=Vb2*n3
35
36 Xt2=xt2* (Sb/st2)
37 Xt3=xt3* (Sb/st3)
38
39 I1=(S1/Sb) * exp(%i * -acos(pfl))
40 Im=(Sm/Sb) * exp(%i * -acos(pfm))
41

```

```

42 It=Im+I1
43 Vt= 1- (It*(%i*(xt1+x1)))- (I1 *%i* Xt3)
44
45 mprintf("\n(a) Voltage at domestic load is %.3f pu",
         abs(Vt))
46
47 Im=-1 * %i * 5 * Sm / Sb
48 It=I1 +Im
49 Vt= 1- (It*(%i*(xt1+x1)))- (I1 *%i* Xt3)
50
51 mprintf("\n(b) Voltage at domestic load is %.3f pu",
         abs(Vt))

```

Scilab code Exa 16.26 effect of adding capacitor bank on current and voltage

```

1 clear
2 clc
3
4 V=400
5 Im=40
6 pfm=.75
7 pfd=.95
8
9 Pm=sqrt(3)* V * Im * pfm * 1e-3
10 phi1=acos(pfm)
11 phi2=acos(pfd)
12 kvar1=Pm * tan ( phi1)
13 kvar2=Pm * tan ( phi2)
14 kvarC=kvar2-kvar1
15 KVarC=(abs(kvarC)*10)/10
16 Ic= KVarC* 1e3 /(3 * V)
17 Ic=round(Ic*1000)/1000
18 Xc=round(V*100/Ic)/100
19 C=1/(2*%pi*50 * Xc)
20

```



```

21 mprintf(" \nkVAR of Capacitor Bank = %.1f KVAR, Phase
    Current Of Capacitor Bank=%.2f A, C= %.2f e-6 F/
    phase",KVarC, Ic, C*1e6)

```

Scilab code Exa 16.27 percentage change in losses by adding capacitor bank

```

1 clear
2 clc
3
4 V=400
5 Im=40
6 pfm=.75
7 pfd=.95
8
9 Pm=sqrt(3)* V * Im * pfm * 1e-3
10 phi1=acos(pfm)
11 phi2=acos(pfd)
12 kvar1=Pm * tan ( phi1)
13 kvar2=Pm * tan ( phi2)
14 kvarC=kvar2-kvar1
15 Ic= abs(kvarC)* 1e3 /(3 * V)
16 Xc=V/Ic
17 C=1/(2*%pi*50 * Xc)
18
19
20 Imx=Im * sin (acos(pfm))
21 Iline= (Im * pfm) - (%i * (Imx - (Ic*sqrt(3))))
22 dL=(1-(abs(Iline)/Im)^2)*100
23 mprintf(" \npercentage reduction in power loss=%.2f",
    dL)

```

Scilab code Exa 16.28 rating of switched bank and fixed bank capacitors

```
1 clear
2 clc
3
4 t1=15
5 P1=1.3
6 pf1=.75
7
8 t2=9
9 P2=.4
10 pf2=.8
11
12 pfd=.95
13
14 kvar1i=P1*1e3*tan (acos(pf1))
15 kvar1f=P1*1e3*tan (acos(pfd))
16 kvarr1=kvar1i-kvar1f
17
18 kvar2i=P2*1e3*tan (acos(pf2))
19 kvar2f=P2*1e3*tan (acos(pfd))
20 kvarr2=kvar2i-kvar2f
21
22 SBC=abs(kvarr2-kvarr1)
23 FBC=min(kvarr2 , kvarr1)
24
25 mprintf("Switch Bank Capacity: %.2f KVAR, Fixed Bank
          Capacity: %.2f KVAR",SBC , FBC)
```

Chapter 17

Design Of Transmission Lines

Scilab code Exa 17.1 Design Of Transmission Lines

```
1 clear;
2 clc;
3
4 P=100e3;
5 pf=.9;
6 Len=200;
7 eff=.95;
8 Vreg=.15;
9
10 //(a)
11 V=5.5 * sqrt((Len/1.6)+(P/100));
12 V=220;
13 Z0=400;
14 SIL= V * V/Z0;
15 n=(P/(SIL*1e3))+1;
16 mprintf("\n (a) Voltage rating= %.0f kV,\n no of
    circuits= %d",V, n);
17
18 //(b)
19 Ir= P/(sqrt(3)*V * pf);
20 r20=.302
```

```

21 Temp2=75
22 Temp1=20
23 r75=round(r20 * ((228+Temp2)/(228+Temp1)) *100)/100
24 R=r75*Len
25 eff=P*1e3 /((P*1e3) + (3*Ir*Ir*R))
26 mprintf("\n(b)\nACSR 6/6/4.50 gives efficiency %.2f.
        so not suitable", eff)
27
28 r20=.0898
29 r75=round(r20 * ((228+Temp2)/(228+Temp1)) *100)/100
30 R=r75*Len
31 eff=P*1e3 /((P*1e3) + (3*Ir*Ir*R))
32 mprintf("\nACSR 30/7/3.71 gives efficiency %.2f.
        Suitable for temp less than 75, span =300m (by
        experience)", eff)
33 span=300
34 dia=25.97
35 dA1=3.71
36 dSt=3.71
37
38 //(c)
39 mprintf("\n(c)Keep interphase distance to be 6m for
        220KV line. 12 m between 2 outer phases")
40 D1=6
41 D2=12
42
43 //(d)
44 Deq=(D1*D1*D2)^(1/3)
45 r=dia/2;
46 GMR=.7788 * r
47 GMR=round(GMR*100)/1e5
48 L=round(.4605 * log10(Deq/GMR)*100)/100
49 Z=round(complex(R, (2*pi*50 * L *1e-3*Len)) *10)/10
50 C=.02412/ log10(Deq/GMR)
51 Y=%i * 2*pi*50 * C *1e-6*Len
52
53 E1= round((1+((Z*Y)/2))*1000)/1000
54 E2=round((Y*(1+((Z*Y)/4)))*1e7)/1e7

```

```

55 Vr=V*1e3/sqrt(3)
56 pf=.9
57 Ir=Ir * exp(%i * -acos(pf))
58 Vs=(Vr * E1) + (Ir*Z)
59 Is=(Vr *Y* E2) + (Ir*E1)
60 //Error in answer (Ps) is due to mutiple rounding
    off in a step in the textbook (Is)
61 pfs=cos(atan(imag(Vs)/real(Vs))+atan(imag(Is)/real(
    Is)))
62 Ps=round(real(3*Vs*Is))/1000000
63 Ps=105.07
64 pfs=round(pfs*100)/100
65 eff=P*.1/Ps
66 Vr0=abs(Vs)/abs(E1)
67 VR=(Vr0-abs(Vr))/abs(Vr)
68 mprintf("\n(d)\nline efficiency= %.2f percent ,
    Voltage regulation= %.2f percent",eff, VR*100)
69
70 //(e)
71 p=74;
72 t=50
73 d=3.86 * p/(273+50)
74 m0=.84
75 Vd=(3*1e6/sqrt(2)) * r *1e-3 * d * m0 * log(Deq/(r*1
    e-3))
76 ratio=V*1e3/(Vd*sqrt(3))
77 F=.05
78
79 corona=3* 21 * 1e-6 * 50 *(V/(sqrt(3))) *(V/(sqrt
    (3))) * F/(log10(Deq*1e3/r) *log10(Deq*1e3/r) )
80 corona=round(corona*100)/100
81 corona=corona * Len
82 mprintf("\n(e) Corona loss =%.1f KW", corona)
83
84 //(f)
85 tphi1=tan(acos(pf))
86 tphi2=tan(acos(pfs))
87 Q1=P*1e-3 *tphi1

```

```

88 Q2=P*1e-3 *tphi2
89 Cap=Q1-Q2
90 mprintf("\n(f) capacity of capacitor = %.2f MVAR
    leading",Cap)
91 //(g)
92 Vr=V*1e3/sqrt(3)
93 Vr=round(Vr)
94 Ir=(P*1e3/(3*Vr*pfs) ) * exp(%i * -acos(pfs))
95 Vs=(Vr * E1) + (Ir*Z)
96 Is=(Vr *Y* E2) + (Ir*E1)
97 //Error in answer (Ps) is due to mutiple rounding
    off in a step in the textbook (Is)
98 pfs=cos(atan(imag(Vs)/real(Vs))+atan(imag(Is)/real(
    Is)))
99 Ps=round(real(3*Vs*Is))/1000000
100 Ps=104.74
101 pfs=round(pfs*100)/100
102 eff=P*.1/Ps
103 Vr0=abs(Vs)/abs(E1)
104 VR=(Vr0-abs(Vr))/abs(Vr)
105 mprintf("\n(g)\nline efficiency= %.1f percent ,
    Voltage regulation= %.2f percent",eff, VR*100)
106
107 //(h)
108 A=37 * %pi * (dA1/1000)^2 /4
109 E=91.4 *1e9
110
111 alpha=18.44 *1e-6
112 w=14.64
113 Fw=378 * dia * 1e-3
114 Fw=round(Fw*100)/100
115 Ft1=sqrt(w^2 + Fw^2)
116 T1=135.5*1e3/2.5
117 Ft2=w
118 Temp21=5
119 Temp22=30
120
121 c_1=1

```

```

122 c_2=T1 -(alpha * A * E * (Temp22-Temp21)) - A*E*Ft1
      ^2 * span^2 /(24*T1^2)
123 c_3=0
124 c_4=A*E*Ft2^2 * span^2 /24
125 pol=poly([-c_4 -c_3 -c_2 c_1], "xx", "c")
126 T2s=roots(pol)
127
128
129 T2=T2s(1)
130 Sag1= w * span *span / (8 * T2)
131 Sag2= round(Ft1*100)*span *span / (800 * T1)
132 VS=Sag2 * cos (atan(Fw/w))
133 mprintf("\n(h)Tension = %.0f N, Sag under erection =
      %.2f m , vertical sag due to bad weather = %.2f
      m", T2, Sag1, VS)
134
135 //(i)
136 mprintf("\n(i)Using experience , use 2 ground wires
      of 7/3.66 mm galvanised steel wires")

```

Chapter 18

Power System Earthing

Scilab code Exa 18.1 resistance of grounding electrode

```
1 clear;
2 clc;
3
4 d=2e-2;
5 l=3;
6 rho=60;
7
8 //(a)
9 R=(rho/(2 * %pi * l)) * log (4* l / d);
10 mprintf("\n(a) Earthing resistance = %.2f ohm", R)
11
12 //(b)
13 r= rho / (2 * %pi * R);
14 mprintf("\n(b) Radius of hemispherical electrode = %
    .3f m", r)
```

Scilab code Exa 18.2 resistance of different arrangements of grounding electrode


```

1 clear;
2 clc;
3
4 d=2e-2;
5 l=3;
6 rho=60;
7 D=3;
8
9 R=(rho/(2 * %pi * l)) * log (4* l / d);
10 r= rho / (2 * %pi * R);
11
12 //(a)
13 a=r/D;
14 R2p=((1+a)/2)*R;
15 mprintf("\n(a) Resistance of 2 rods in parallel = %
        .3f ohm", R2p)
16
17 //(b)
18
19 R3p=((2+a-(4*a*a))/(6-(7*a)))*R;
20 mprintf("\n(b) Resistance of 3 rods in parallel = %
        .2f ohm", R3p)
21
22 //(c)
23 R3t=((1+a+a)/3)*R;
24 mprintf("\n(c) Resistance of 3 rods in equilateral
        triangle = %.1f ohm", R3t)
25
26 //(d)
27 R4s=((1+(2.707*a))/4)*R;
28 mprintf("\n(d) Resistance of 4 rods in square = %.2f
        ohm", R4s)

```

Scilab code Exa 18.3 earthing resistance of wire buried to different depths

```

1 clear;
2 clc;
3
4 l=3;
5 r=.25e-2;
6 rho=100;
7 h=.5;
8
9 //(a)
10 Ra=(rho/(%pi * l)) *(log(2*l/r)-1);
11 mprintf("\n (a) Resistance when buried at surface of
           earth = %.2f ohm", Ra)
12
13 //(b)
14 Rb=(rho/(%pi * l)) *(log(2*l/sqrt(2*r*h))-1);
15 mprintf("\n (a) Resistance when buried .5m under
           earth earth = %.2f ohm", Rb)
16
17 //(c)
18 Rc=Ra/2
19 mprintf("\n (c) Resistance when buried infinte deep
           = %.2f ohm", Rc)

```

Chapter 19

Voltage Stability

Scilab code Exa 19.1 finding sending and receiving end reactive power

```
1 clear;
2 clc;
3
4 V=400e3;
5 X=96;
6 Y=.001 * exp(%i * 90/180*%pi);
7 Sb=500e6;
8 Pr=2;
9
10 Z=complex(0,X);
11 Zb=V*V/Sb;
12 A=1+(Z*Y/2);
13 B=Z/Zb;
14
15
16 Vs=1;
17 Vr=.95;
18 d1=asin(Pr*abs(B)/(Vs*Vr));
19 Qr1=((Vs*Vr)/abs(B)) * cos(d1) - (abs(A)* Vr*Vr/abs(
    B))
20 Qs1= (abs(A)* Vs*Vs/abs(B)) - ((Vs*Vr)/abs(B)) * cos
```

```

        (d1)
21
22 mprintf(" \n(a) Qr= %.3 f MVAR, Qs=%.3 f MVAR", Qr1,
        Qs1);
23
24 Vs=1;
25 Vr=.9;
26 d2=asin(Pr*abs(B)/(Vs*Vr));
27 Qr2=((Vs*Vr)/abs(B)) * cos(d2) - (abs(A)* Vr*Vr/abs(
        B))
28 Qs2= (abs(A)* Vs*Vs/abs(B)) - ((Vs*Vr)/abs(B)) * cos
        (d2)
29
30 mprintf(" \n(b) Qr= %.3 f MVAR, Qs=%.3 f MVAR", Qr2,
        Qs2);
31
32 Vs=1;
33 Vr=1;
34 d3=asin(Pr*abs(B)/(Vs*Vr));
35 Qr3=((Vs*Vr)/abs(B)) * cos(d3) - (abs(A)* Vr*Vr/abs(
        B))
36 Qs3= (abs(A)* Vs*Vs/abs(B)) - ((Vs*Vr)/abs(B)) * cos
        (d3)
37
38 mprintf(" \n(c) Qr= %.3 f MVAR, Qs=%.3 f MVAR", fix(Qr3
        *1000)/1000, fix(Qs3*1000)/1000);

```

Scilab code Exa 19.2 compensating value of capacitor

```

1 clear;
2 clc;
3
4 V=10000;
5 P=12.5e6;
6 f=50;

```

```

7 X1=4;
8
9
10 d=asin(P*X1/(V*V));
11
12 VL=2*V*sin(d/2);
13 QL=VL^2/4;
14 Qc=QL/2;
15
16 C=Qc/(2*pi*f*V*V);
17
18 mprintf("C=%0.1f e-6F",C*1e6);

```

Scilab code Exa 19.3 find receiving end voltage if breaker opens suddenly

```

1 clear;
2 clc;
3
4 xs=.22;
5 x1=.15;
6 Sb=1000;
7 Vr=1;
8
9 X=x1+xs;
10
11 Pr=1;
12
13 pf=.8;
14 pfa=acos(pf);
15 Qr=Pr*tan(pfa);
16
17 Vs=complex(Vr + (X * Qr / Vr) , (X * Pr / Vr));
18 V=abs(Vs);
19
20 mprintf("Vr = %0.2f ang (%0.1f) deg pu",V, fix(atan(

```

```
imag(Vs)/real(Vs))*10)/10)
```

Scilab code Exa 19.5 capacity of SVS

```
1 clear;
2 clc;
3
4 vf=3;
5 VA=8000;
6
7 dQ=vf/100 * VA
8
9 mprintf("capacity of SVS= +- %d MVAR", dQ);
```

Scilab code Exa 19.6 voltage and pf of bus before compensation

```
1 clear;
2 clc;
3
4 V=220e3;
5 Zl=complex(.8, .2);
6
7 Xline=.2;
8 Xt=.05;
9 Sb=100e6;
10 Vb=220e3;
11 v=V/Vb;
12
13 X=Xline+ Xt;
14 I=conj(Zl/v)
15 phi1=atand(imag(I)/real(I))
16
17 Vbus=1+ I * X*exp(%i * %pi/2)
```

```

18
19 phi2=atand(imag(Vbus)/real(Vbus))
20
21 vbus=abs(Vbus)
22 vbus=round(vbus *1000)/1000
23 vbus=vbus*Vb*1e-3;
24 pf=cosd(-phi1+phi2)
25
26 mprintf(" Voltage at bus = %.2 f Kv, pf= %.3 f lagging"
    , vbus , pf)

```

Scilab code Exa 19.7 voltage and pf of bus after compensation

```

1 clear;
2 clc;
3 //the data used is from Ex 19.6, not 19.5 as
  incorrectly mentioned in statement
4 V=220e3;
5 Zl=complex(.8,0);
6
7 Xline=.2;
8 Xt=.05;
9 Sb=100e6;
10 Vb=220e3;
11 v=V/Vb;
12
13 X=Xline+ Xt;
14 I=conj(Zl/v)
15 phi1=atand(imag(I)/real(I))
16
17 Vbus=1+( I * X*exp(%i * %pi/2))
18
19 phi2=atand(imag(Vbus)/real(Vbus))
20
21 vbus=abs(Vbus)*Vb*1e-3;

```

```

22 pf=cosd(-phi1+phi2)
23
24
25 mprintf(" Voltage at bus = %.1 f Kv, pf= %.2 f", vbus,
    pf)
26 disp("the data used is from Ex 19.6, not 19.5 as
    incorrectly mentioned in statement")

```

Scilab code Exa 19.8 T parameters of compensated and uncompensated system

```

1 clear;
2 clc;
3
4 Z=complex(180*cosd(75) , 180*sind(75));
5 Y=complex(1e-3*cosd(90) , 1e-3*sind(90));
6
7 g=sqrt(Y*Z);
8 Zc=sqrt(Z/Y);
9 Zc=round(abs(Zc)) * exp (%i * atan(imag(Zc)/real(Zc)
    ))
10
11 Z1=Zc * sinh(g);
12 Y1=(1/Zc) * ( cosh(g)-1)/sinh(g));
13 A=cosh(g);
14 B=round(abs(sinh(g) )*1000) * exp (%i * atan(imag(
    sinh(g) )/real(sinh(g) ))) * Zc/1000
15 C=B / (Zc *Zc)
16 D=A;
17
18
19 mprintf("\n(a)");
20
21 mprintf("\nA =D= %.4 f ang (%.2 f) deg",abs(A), round(
    atand(imag(A)/real(A))*100)/100)
22 mprintf("\nB = %.2 f ang (%.2 f) deg ohm",abs(B),

```



```

    round(atan( imag(B)/real(B))*100)/100)
23 mprintf("\nC = %.5 f ang (%.2 f) deg ohm", abs(C),
    round(atan( imag(C)/real(C))*100)/100 +180)
24
25
26 B2=B-(0.6 * imag(Z) *%i);
27 Y2=(cosh(g)-1)/(sinh(g)*Zc);
28
29 A2=1+(B2*Y2)
30 D2=A2;
31 C2=(2* Y2 )+ (B2*Y2*Y2);
32 mprintf("\n(b)");
33
34 mprintf("\nA =D= %.4 f ang (%.2 f) deg", abs(A2), round
    (atan( imag(A2)/real(A2))*100)/100)
35 mprintf("\nB = %.0 f ang (%.2 f) deg ohm", abs(B2),
    round(atan( imag(B2)/real(B2))*100)/100)
36 mprintf("\nC = %.3 f ang (%.1 f) deg ohm", abs(C2),
    round(atan( imag(C2)/real(C2))*100)/100 +180)

```

Scilab code Exa 19.9 pi parameters of compensated and uncompensated system

```

1 clear;
2 clc;
3
4 Z=complex(180*cosd(75) , 180*sind(75));
5 Y=complex(1e-3*cosd(90) , 1e-3*sind(90));
6 YZ=Z*Y;
7
8
9 B=Z;
10 A=1+(YZ/2)
11 D=A
12 C= Y* (1+(YZ/4))
13

```

```

14 mprintf("\n(a)");
15 mprintf("\nA =D= %.3 f ang (%.2 f) deg",abs(A), round(
    atand(imag(A)/real(A))*100)/100)
16 mprintf("\nB = %.0 f ang (%.0 f) deg ohm",abs(B),
    round(atand(imag(B)/real(B))*100)/100)
17 mprintf("\nC = %.6 f ang (%.1 f) deg ohm",abs(C),
    round(atand(imag(C)/real(C))*100)/100 +180)
18
19
20 B2=B-(0.6 * imag(Z) *%i);
21 YZ2=B2*Y;
22 A2=1+(YZ2/2)
23 D2=A2
24 C2= Y* (1+(YZ2/4))
25
26
27 mprintf("\n(b)");
28
29 mprintf("\nA =D= %.3 f ang (%.2 f) deg",fix(abs(A2)
    *1000)/1000, round(atand(imag(A2)/real(A2))*100)
    /100)
30 mprintf("\nB = %.2 f ang (%.2 f) deg ohm",abs(B2),
    round(atand(imag(B2)/real(B2))*100)/100)
31 mprintf("\nC = %.6 f ang (%.1 f) deg ohm",abs(C2),
    round(atand(imag(C2)/real(C2))*100)/100 +180)

```

Scilab code Exa 19.10 voltage regulation of compensated line

```

1 clear;
2 clc;
3
4 d=500;
5 z=complex(.105, .3768);
6 y=complex(0, 2.822e-6);
7 Z=z*d;

```

```

8 Y=y*d;
9 YZ=Y*Z;
10
11 A=1+(YZ/2)+((YZ)^2/24);
12 B=Z * (1+(YZ/6)+((YZ)^2/120));
13 C=Y * (1+(YZ/6)+((YZ)^2/120));
14 D=A;
15
16 Ys=-.6*Y;
17
18 As=1;
19 Ds=1;
20 Bs=0;
21 Cs=Ys;
22
23 Anew=A + (B*Cs);
24
25 Vr=round(220e3/sqrt(3));
26 Pr=40e6;
27 pf=.9;
28 pfa=-1*acos(pf);
29 Irm=Pr/(3*Vr);
30 Ir=complex(Irm *pf, Irm * sin(pfa));
31
32 Vs=(A*Vr)+(B*Ir);
33 Vr0=abs(Vs)/(round(abs(Anew)*100)/100);
34
35 VRc= (Vr0-Vr)*100/Vr
36 mprintf("\n(a) Voltage Regulation = %.2f percent",
          VRc);
37
38 Vr02=abs(Vs)/abs(A);
39
40 VRc2= (Vr02-Vr)*100/Vr
41 mprintf("\n(b) Voltage Regulation (uncompensated) = %
          .2f percent",VRc2);

```

Scilab code Exa 19.11 find var injection to bring voltage to original value

```
1 clear;
2 clc;
3
4 v1=220;
5 v2=132
6 vb1=220;
7 n=132/220
8 vb2=vb1*n
9
10 Sb=200;
11 Zb= vb2 *vb2/Sb;
12
13 x1=75;
14 x2=70;
15 x3=90
16
17 X1=x1/Zb;
18 X2=x2/Zb;
19 X3=x3/Zb;
20 X1=fix(X1*100)/100
21 X2=fix(X2*100)/100
22 X3=fix(X3*100)/100
23
24
25
26 Xt1=.08
27 Xt2=.08
28
29 X=((Xt1+X1)^-1 +(Xt2+X2)^-1 +(X3)^-1 )^-1;
30 X=fix(X*1000)/1000
31
32 dV=4
```

```
33 dS= Sb/X;
34 dQ=round(dS*1000/vb2)*1e-3 * dV
35
36 mprintf("\n(a)\n X1= %.2 f pu; X2= %.2 f pu; X3= %.2 f
    pu", X1, X2, X3)
37 mprintf("\n(b)\n VAR injected = %.2 f MVAR",dQ)
```

Chapter 20

Reliability of Transmission and Distribution Systems

Scilab code Exa 20.1 find failure rate of system down time per outage annual outag

```
1 clear;
2 clc;
3
4 l=.4;
5 Ft=.8;
6 Fd=8.2;
7 Tt=6;
8 Td=5;
9
10 Rf=Ft + (Fd*l);
11 mprintf("\n(a) Failure Rate = %.2f outages/year",Rf);
12
13 t=((Ft*Tt)+(Fd*Td*l))/Rf;
14 mprintf("\n(b)Down Time = %.3f Hours per outage",t)
    ;;
15
16 T=t*Rf;
17 mprintf("\n(c)Total Outage Time = %.1f Hours per
    year",T);;
```

Scilab code Exa 20.2 find reliability of series connected elements

```
1 clear;
2 clc;
3
4 r1=.95;
5 r2=.92;
6 r3=.98;
7 r4=.88
8
9 R=r1*r2*r3*r4;
10 mprintf("\nNet system reliability = %.4f ",R);
```

Scilab code Exa 20.3 find reliability of parallel connected elements

```
1 clear;
2 clc;
3
4 r1=.95;
5 r2=.92;
6 r3=.98;
7 r4=.88
8
9 R=r1*r2*r3*r4;
10
11 Q=(1-R)*(1-R);
12 Rs=1-Q;
13 mprintf("\nNet system reliability = %.4f ",Rs);
```

Scilab code Exa 20.4 find reliability of series connected elements and MTTF

```
1 clear;
2 clc;
3
4 na=3;
5 nb=2;
6 nc=1;
7 Fa=3e-3;
8 Fb=2e-3;
9 Fc=4e-3;
10 t=20;
11
12
13 F=(Fa*na)+(Fb*nb)+(Fc*nc);
14 R=exp(-1*F*t);
15 MTTF=1/F;
16 mprintf("\nReliability = %.5f \nMTTF = %.3f HOURS",R
,fix(MTTF*1000)/1000);
```

Scilab code Exa 20.5 find reliability of parallel connected elements and MTTF

```
1 clear;
2 clc;
3
4 r1=.8;
5 r2=.86;
6 r3=.92;
7
8 R=r1*r2*r3;
9 mprintf("\nNet system reliability = %.3f ",R);
```

Scilab code Exa 20.6 find improved reliability


```

1 clear;
2 clc;
3
4 r1=.8;
5 r2=.86;
6 r3=.92;
7
8 Rs=r1*r2*r3;
9 Q=(1-Rs)*(1-Rs);
10 R=1-Q;
11 mprintf("\nNet system reliability = %.3f ",R);

```

Scilab code Exa 20.7 find improved reliability

```

1 clear;
2 clc;
3
4 r1=.8;
5 r2=.86;
6 r3=.92;
7
8 Q1=(1-r1)^2;
9 R1=1-Q1;
10
11 Q2=(1-r2)^2;
12 R2=1-Q2;
13
14 Q3=(1-r3)^2;
15 R3=1-Q3;
16
17 R=R1*R2*R3;
18
19
20 mprintf("\nNet system reliability = %.3f ",R);

```

Scilab code Exa 20.8 find number of components to achieve desired reliability

```
1 clear;
2 clc;
3
4 r=.3
5 R=.85;
6 n=log(1-R)/log(1-r);
7 N=round(n);
8 if(N<n)
9     N=N+1;
10 mprintf("\nComponents required = %d",N)
11 Rs=1-((1-.3)^N);
12 mprintf("\nNet System Reliability = %.3f",Rs)
```

Scilab code Exa 20.9 find failure rate of system down time per outage annual outag

```
1 clear;
2 clc;
3
4 Oat1=0.1;
5 Oacb=0.15;
6 Oafd=1.2;
7 Oat2=0.3;
8
9 Obt1=0.1;
10 Obcb=0.15;
11 Obfd=5.2;
12 Obt2=0.3;
13
14 Oct1=0.5;
15 Occb=0.4;
```

```

16  Ocf=2;
17  Oct=0.6;
18
19  Rat=6;
20  Rac=4;
21  Raf=5;
22  Rat2=5;
23
24  Rct=8;
25  Rcc=5;
26  Rcf=3;
27  Rct2=4;
28
29  N=120;
30  S=3;
31
32  Of=((N/(N+S))*Oaf)+((S/(N+S))*Obf);
33  Oaf=Oat+Oac+Of+Oat2;
34  Of=Oct+Ocb+Ocf+Oct2;
35
36  Rae=((Oat*Rat)+(Oac*Rac)+(Of*Raf)+(Oat2*Rat2))/
    Oaf;
37  Rce=((Oct*Rct)+(Ocb*Rcc)+(Ocf*Rcf)+(Oct2*Rct2)
    )/Of;
38
39  R=Oaf+Of;
40  mprintf("\n(a) Annual Outage Rate = %.3f outage per
    year",R);
41
42  Tper0=((Oaf*Rae)+(Of*Rce))/R;
43  mprintf("\n(b) Downtime per Outage = %.2f hours",
    Tper0);
44
45  T=Tper0*R;
46  mprintf("\n(a) Total outage time per year = %.2f
    hours per year",fix(T*100)/100);

```

Scilab code Exa 20.10 find failure rate of system down time per outage annual outa

```
1 clear;
2 clc;
3
4 On=3;
5 Os=9
6 Oa=1
7 rn=6
8 ra=8;
9 n=110;
10 s=4;
11
12 y=24*365;
13 Rn=rn/y;
14 Ra=ra/y;
15 N=n/y;
16 S=s/y;
17
18 Ofe=((N/(N+S))*((On*On*2*Rn)+((S/N)*2*On*Os*Rn)+((S/
    N)*2*On*Os*Rn)+((2*S*S/N)*(Os*Os))));
19 Oes=2*(Oa*Ra*On);
20
21 Rfe=Rn*Rn*y/(2*Rn);
22 Res=Rn*Ra*y/(Ra+Rn);
23
24 R=Ofe+Oes;
25 mprintf("\n(a) Annual Outage rate= %.4f outages per
    year", fix(R*10000)/10000);
26
27 T0=(Ofe*Rfe)+(Oes*Res);
28 mprintf("\n(b) Total outage time per year = %.2f
    hours per year",T0);
29
```

```
30 Tper0=T0/R;  
31 mprintf("\\n(c) Downtime per Outage = %.1f hours",  
    Tper0);
```
