Scilab Textbook Companion for Principles of Power Systems by V. K. Mehta And R. Mehta[1]

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Book Description

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

Exa Example (Solved example)

Eqn Equation (Particular equation of the above book)

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

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

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Chapter 1

Introduction

Scilab code Exa 1.1 efficiency and energy

```
1  // Chapter 1
2  // Example 1.1
3  // Page 6
4
5  clear;
6  clc;
7  Pi = 4200;
8  E = 120;
9  I = 32.2;
10
11 printf(" (i) Input Power,     Pi = %.4f J/s = 4200 W\n
      ", Pi)
12
13 Po = E*I;
14 printf("     Output Power,   Po = %.4f W\n", Po)
15
16 // Calculation of efficiency
17 n = Po/Pi*100;
18 printf("     Efficiency, n = %.2f %%\n", n)
19
20 Pl = Pi-Po;
```

```
21  printf("(ii)      Power lost, Pl = %.4f W\n", Pl)
22
23  //Calculation of energy lost per minute of operation
24  El = Pl*60;
25  printf("      Energy lost per minute(=60s) of
        operation= Pl*t = %.4f J\n",El)
```

Chapter 2

Generating Stations

Scilab code Exa 2.1 `calorific value fuel`

```
1  //Chapter 1
2  //Example 2.1
3  //Page 16
4
5  clear;
6  clc;
7
8  n_overall = 20;
9  W = 0.6;
10
11  printf("Let x kcal/kg be the calorific value of fuel
       .\n")
12  printf("Heat produced by 0.6 kg of coal = 0.6 x kcal
       \n")
13  printf("Heat equivalent of 1 kWh = 860 k cal\n")
14
15  //Calculation of calorific value of coal
16  printf("Now, n_overall = Electrical output in heat
       units/ Heat of combustion\n")
17
18  x=860/(0.6*0.2);
```

```
19  printf("x = %.4f  kcal/kg\n",  x)
```

Scilab code Exa 2.2 `annual coal bill`

```
1  //Chapter  2
2  //Example  2.2
3  //Page  17
4
5  clear;
6  clc;
7
8  max_demand = 20000;
9  n_boiler = 0.85;
10  coal_consumption = 0.9;
11  load_factor = 40;
12  n_turbine = 0.90;
13  cost_per_ton = 300;
14
15  //Calculation of  thermal  efficiency
16
17  printf("(i)   Thermal  efficiency = %.2f %%\n\n",
       n_boiler*n_turbine*100);
18  printf("(ii)   Units  generated  per  annum = %.3f kWh\n
       ", max_demand*load_factor*8760);
19  printf("\t Coal  consumption/annum = %.3f tons\n",
       coal_consumption*7008*1e4/1000);
20  printf("\t Annual  coal  bill = Rs %.4f\n",
       cost_per_ton*coal_consumption*7008*1e4/1000);
```

Scilab code Exa 2.3 `average load`

```
1  //Chapter 2
2  //Example 2.3
3  //Page 17
4
5  clear;
6  clc;
7
8  cost_per_annum = 300000;
9  cal_value = 5000;
10 cost_per_kg = 0.03;
11 n_thermal = 0.33;
12 n_electrical = 0.90;
13
14 n_overall = n_thermal*n_electrical;
15 printf("Overall efficiency = %.2f %% \n\n",
       n_overall*100);
16 coal_per_annum = cost_per_annum/cost_per_kg;
17 printf("Coal used/annum = %.2f kg\n\n",
       coal_per_annum);
18 hoc = coal_per_annum*cal_value;
19 //hoc-heat of combustion
20 printf("Heat of combustion = %.2f kcal \n\n", hoc);
21 heat_op = n_overall*hoc;
22 printf("Heat output = %.2f kcal \n\n", heat_op);
23 upa = heat_op/860;
24 //upa- units generated per annum
25 printf("Units generated per annum = %.0f kWh \n\n",
       upa);
26 avgl = upa/8760;
27 //avgl- average load on station
28 printf("Average load on station = %.1f kW \n\n",
       avgl);
```

Scilab code Exa 2.4 `limiting value`

```
1  //Chapter 2
2  //Example 2.4
3  //Page 17
4
5  clear;
6  clc;
7
8  w=13500;
9  kWh1=7.5;
10 c=5000;
11 kWh2=2.9;
12 hours=8;
13
14 //limiting value
15 printf("Limiting value =%.2f kg \n\n", (w+kWh1)/(c+
      kWh2));
16
17 //coal consumption per hour
18
19 printf("Coal consumption per hour = %.1f kg \n\n", c
      /hours);
```

Scilab code Exa 2.5 `coal consumption per hour`

```
1  //Chapter 2
2  //Example 2_5
```

```
3  //PAge 18
4
5  clear;clc;
6
7  power=100;
8  cv=6400;
9  n_thermal =0.3;
10 n_electrical =0.92;
11
12 //coal consumption
13 n_overall = n_thermal*n_electrical;
14 ugpa=power*1000;
15 h=ugpa*860/n_overall;
16 printf("Coal consumption per hour = %.1f kg \n\n", h
       /cv);
```

Scilab code Exa 2.6 total energy available

```
1  //chatper 2
2  //example 2_6
3  //page 23
4
5  clear;
6  clc;
7
8  capacity = 5*10^6;
9  h = 200;
10 n_overall = 75;
11 density=1000;
12
13 w = capacity*density*9.81;
14 printf("Weight of water available is W = %.2f N \n",
       w);
```

```
15  e = w*h*n_overall/3600/1000;
16  //e − electrical energy
17  printf("Electrical energy available = W*H*n_overall
        = %.2f kWh \n", e);
```

Scilab code Exa 2.7 yearly gross output

```
1   //Chapter 2
2   //Example 2_7
3   //Page 23
4
5   clear;clc;
6
7   w=94;
8   h=39;
9   n_plant=0.8;
10
11  work=w*h*9.81;
12  printf("Work done/sec = %.1f kW \n\n", work);
13
14  printf("This is gross plant capacity\n");
15
16  fc=n_plant*work;
17  printf("(i)\t Firm capacity = %.1f kW \n\n", fc);
18
19  printf("(ii)\t Yearly gross output = %.1f kW \n\n",
        fc*8760);
```

Scilab code Exa 2.8 energy per hour

```
1  //Chapter 2
2  //Example 2_8
3  //Page 23
4
5  clear;clc;
6
7  h=100;
8  n_hydraulic=0.86;
9  n_electrical=0.92;
10
11 n_overall=n_hydraulic*n_electrical;
12 w=9.81*1e3;
13 printf("Weight of water available = %.1f N \n\n", w)
     ;
14 power=w*h*n_overall;
15 printf("Power produced = %.1f kW \n\n", power/1000);
16 printf("Energy produced per hour = %.1f kWh \n\n",
     power/1000);
```

Scilab code Exa 2.9 maximum demand

```
1  //Chapter 2
2  //Example 2_9
3  //PAge 23
4
5  clear;clc;
6
7  area=5e9;
8  h=30;
9  rainfall=1.25;
10 k=0.8;
11 n_overall=0.7;
12 lf=0.4;
```

```
13
14  //generator rating
15  vol=area*rainfall*k;
16  printf("Volume of water which can be utilised per
        annum =%1.0f m^3 \n\n", vol);
17  w=area*9.81*1e3;
18  printf("Weight of water available =%2.2f N \n\n", w)
        ;
19  e=w*h*n_overall/1e3/3600;
20  printf("Electrical energy available pr annum = %1.2f
        kWh\n\n", e);
21  ap=e/8760;
22  printf("Average power = %.1f kW \n\n", ap);
23  printf("MAximum demand = %.0f kW \n\n", ap/lf);
```

Scilab code Exa 2.10 `level of reservoir`

```
1  //Chapter 2
2  //Example 2_10
3  //Page 24
4
5  clear;clc;
6
7  area=2.4;
8  capacity=5e6;
9  head=100
10 n_penstock=0.95;
11 n_turbine=0.9;
12 n_generation=0.85;
13 load_kWh=15000;
14
15
16 //calculation of total electrical energy that can be
```

```
              generated
17  w=capacity*1e3*9.81;
18  printf(" Wt. of water available= %.2f N \n\n", w);
19  n_overall=n_penstock*n_turbine*n_generation;
20  printf(" Overall efficiency= %.2f \n\n", n_overall);
21  energy=w*head*n_overall/1000/3600;
22  printf(" Electrical energy that can be generated= %.1
        f kWh \n\n", energy);
23
24  //calculation of fall in reservoir level
25  printf(" Level of reservoir= %.3f m \n\n", capacity/
        area/1e6);
26  printf("kWh generated in 3 hours=%.2f kWh \n\n",
        load_kWh*3);
27  fall= capacity/area/1e6*load_kWh*3/energy*100;
28  printf(" Fall in reservoir level= %.2f cm \n\n",fall)
        ;
```

Scilab code Exa 2.11 excess power

```
1  //Chapter 2
2  //Example 2_11
3  //PAge 25
4
5  clear;clc;
6
7  h=25;
8  power=400;
9  vol=[10 6 1.5];
10  months=[4 2 6];
11  n_overall=0.8;
12
13  //standby capacity
```

```
14  pd1=vol(1)*1e3*9.81*n_overall*h/1000
15  pd2=pd1*vol(2)/vol(1)
16  pd3=pd1*vol(3)/vol(1)
17  cap=power-pd3
18  printf("(i)\t Capacity of standby unit = %.1f kW \n\
        n", cap);
19
20  //excess power
21  discharge = vol.*months
22  avg_dis=sum(discharge)/12
23  pd=avg_dis*pd1/vol(1)
24  ep=pd-power
25  printf("(ii)\t Excess power available = %.1f kW \n\n
        ", ep);
```

Scilab code Exa 2.12 `load factor`

```
1  //Chapter 2
2  //Example 2_12
3  //Page 25
4
5  clear;clc;
6
7  md=10;
8  h=20;
9  n_overall=0.8;
10 lf=0.4;
11
12
13 //river discharge
14 ugpw=md*lf*24*7*1e3;
15 printf("(i) Units generated per week =%.1f kWh \n\n"
        , ugpw);
```

```
16  app=1e3*9.81*h*n_overall/1000;
17  upw=app*24*7;
18  q=ugpw/upw;
19  printf("\t River dishcharge required = %.2f m^3/sec"
        , q);
20
21  //load factor
22  flow=20;
23  pd=app*flow;
24  ug=pd*24;
25  lf=ug/1e4/24;
26  printf("(ii) Load factor =%.2f %% \n\n", lf*100);
```

Scilab code Exa 2.13 installed capacity 1

```
1   //Chapter 2
2   //Example 2_13
3   //Page 26
4
5   clear;clc;
6
7   d=[500 520 850 800 875 900 546];
8   days=7;
9   h=15;
10  n_overall=0.85;
11  lf=0.4;
12
13  scf(0)
14  bar(d, 1, 'red');
15  xlabel('Days');
16  ylabel('Discharge')
```
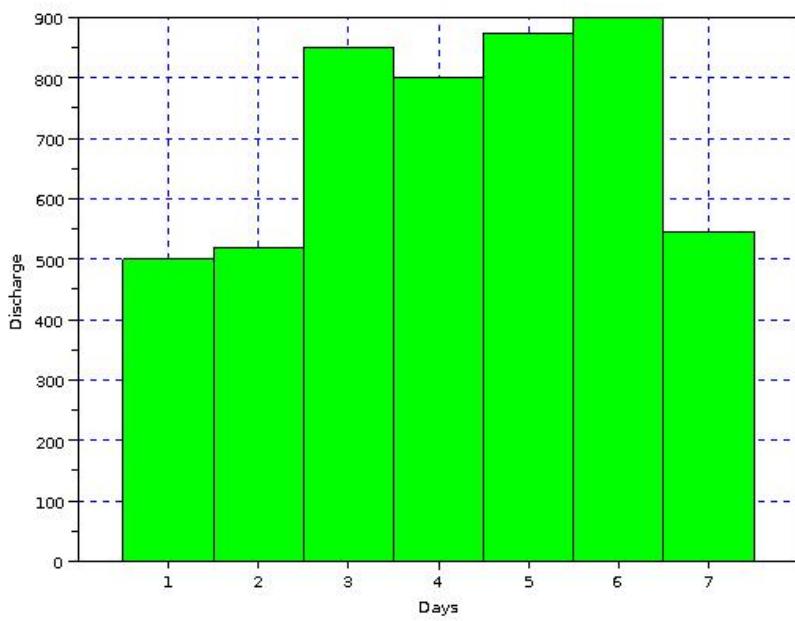
Figure 2.1: installed capacity 1

```
17  xgrid(0);
18
19  //Average daily discharge
20  avg=sum(d)/days;
21  printf(")(i) Average daily discharge = %.0f m^3/sec \
        n\n", avg);
22
23  //Pondage required
24  vol=0;
25  j=0;
26  for i=1:7
27    if d(i)<avg
28      vol= vol+d(i);
29      j=j+1;
30    end;
31  end;
32
33  v=vol*24*3600;
34  v_req=j*avg*24*3600;
35  p=v_req-v;
36  printf(")(ii) Pondage required = %.0f m^3 \n\n", p);
37
38  //Installed capacity
39  w=avg*1000*9.81;
40  app=w*h*n_overall;
41  ic=app/lf;
42  printf(")(iii) Installed capacity of the plant = %.0f
        MW \n\n", ic/1e6);
```

Scilab code Exa 2.14 engine efficiency

```
1  //Chapter 2
2  //Example 2_14
```

```
3 //Page 28
4
5 clear;clc;
6
7 fc=0.28;
8 cv=1e4;
9 n_alternator=0.95;
10
11 heat=cv*fc;
12 printf("Heat equivalent of ikWh =860 kcal\n");
13 n_overall = 860/heat;
14 printf("(i)\t Overall efficiency = %.2f %% \n\n",
       n_overall*100);
15 printf("(ii)\t Engine efficiency =%.2f %% \n\n",
       n_overall/n_alternator*100);
```

Scilab code Exa 2.15 thermal efficiency

```
1 //Chapter 2
2 //Example 2_15
3 //PAge 30
4
5 clear;clc;
6
7 fc=1e3;
8 ugpd=4e3;
9 cv=1e4;
10 n_alternator=0.96;
11 n_mech=0.95;
12
13 //specific fuel consumption
14 printf("(i)\t Specific fuel consumption = %.2f kg/
       kWh \n\n", fc/ugpd);
```

```
15
16  //overall efficiency
17  heat_per_day = fc*cv;
18  e=ugpd*860;
19  printf("\t\t Electrical output in heat units per day
        =%3.0f kcal \n\n", e);
20  n_overall = e/1e7*100;
21  printf("(ii)\t Overall efficiency = %.2f %% \n\n",
      n_overall);
22
23  //thermal efficiency
24  n_engine = n_overall/n_alternator;
25  printf("\t\t Engine efficiency = %.2f %% \n\n",
      n_engine);
26  printf("(iii)\t Thermal efficiency = %.2f %% \n\n",
      n_engine/n_mech);
```

Scilab code Exa 2.16 overall efficiency

```
1  //Chapter 2
2  //Example 2_16
3  //PAge 30
4
5  clear;clc;
6
7  p1=700;
8  p2=500;
9  n1=1;
10 n2=2;
11 fc=0.28;
12 cv=10200;
13 days=30;
14 pcf=0.4;
```

```
15
16  max_energy=(p1*n1+p2*n2)*24*days;
17  printf("(i)\tMaximum energy that can be produced in
        a month = %.1f kWh \n\n", max_energy);
18  act_energy=pcf*max_energy;
19  printf("\t\t Actual energy produced = %.1f kWh \n\n"
        , act_energy);
20  f_c=act_energy*fc;
21  printf("\t\t Fuel consumption in a month =%.0f kg \n
        \n", f_c);
22
23  op=act_energy*860;
24  ip=f_c*cv;
25  printf("(ii)\t Overall efficiency =%.2f %% \n\n", op
        /ip*100);
```

Scilab code Exa 2.17 nuclear power 1

```
1  //Chapter 2
2  //Example 2_17
3  //Page 34
4
5  clear;clc;
6
7  p=300*1e6;
8  e=200*1e6;
9
10  eph=p*3600;
11  printf("Energy recieved per hour = %.0f*10^10 J \n\n
        ", eph*1e-10);
12  epf=e*1.6*1e-19;
13  printf("Energy released per fission = %.2f*10^-11 J
        \n\n", epf*1e11);
```

```
14  n=eph/epf;
15  printf("Number of atoms fissioned per hour = %.2f
        *10^21 \n\n", n*1e-21);
16  m=235/6.023/10^23*n;
17  printf("Mass of Uranium fissioned per hour = %.2f g
        \n\n", m);
```

Scilab code Exa 2.18 `energy per second`

```
1  //Chapter 2
2  //Example 2_18
3  //Page 35
4
5  clear;clc;
6
7  d=30;
8  m=2;
9  e=200*1e6;
10
11  n=m/235*6.023*10^26;
12  fr=n/d/8760;
13  epf=e*1.6*10^-19;
14  p=epf*fr;
15
16  printf("Number of atoms = %.2f*10^24 \n\n", n*1e-24)
        ;
17  printf("Fission rate = %.3f*10^18 \n\n", fr*10^-19);
18  printf("Energy per fission = %.2f*10^-11 J \n\n",
        epf*10^11);
19  printf("Energy released per second = %.3f MW \n\n",
        p*10^-7);
```

Chapter 3

Variable Load on Power Stations

Scilab code Exa 3.1 energy per year

```
1  //Chapter 3
2  //Example 3_1
3  //Page 50
4
5
6  clear;clc;
7
8  max_dem=100;
9  lf=0.4;
10
11 //energy generated
12 printf("Energy generated per annum = %.1f kWh\n\n",
      max_dem*lf*8760*1000);
```

34

Scilab code Exa 3.2 `load factor`

```
1  //Chapter 3
2  //Example 3_2
3  //Page 50
4
5  clear;
6  clc;
7
8  cl = 43;
9  max_dem = 20;
10 ugpa = 61.5e6;
11
12 //Demand factor and load factor
13
14 printf("Demand factor = %.3f \n\n", max_dem/cl);
15
16 avg_dem = ugpa/8760;
17 printf("Load facor = %.3f \n\n", avg_dem/max_dem
       /1000);
```

Scilab code Exa 3.3 `annual load factor`

```
1  //Chapter3
2  //Example 3_3
3  //PAge 50
4
5  clear;clc;
6
7  max_dem =100;
8  p1=100;
9  t1=2;
10 p2=50;
```

```
11  t2=6;
12  no_operation =45;
13
14
15  //Annual load factor
16  e_per_day=(p1*t1)+(p2*t2);
17  printf(" Energy per day = %.2f MWh \n\n", e_per_day)
18  operation_days=365-no_operation;
19  e_per_year = e_per_day*operation_days;
20  printf(" energy per year = %.2f MWh\n\n", e_per_year)
21  alf= e_per_year/max_dem/(operation_days*24);
22  printf(" Annual load factor = %.2f %% \n\n", alf*100)
       ;
```

Scilab code Exa 3.4 `maximum energy`

```
1  //Chapter 3
2  //Example 3_4
3  //PAge 50
4
5  clear;
6  clc;
7
8  max_dem=25;
9  lf=0.6;
10  pcf=0.5;
11  puf=0.72;
12
13  //reserve capacity
14  avg_dem=lf*max_dem;
15  pc=avg_dem/pcf;
16  printf(" (i)\t Reserve capacity of plant = %.1f MW \n
       \n", pc-max_dem);
```

```
17  printf(" (ii)\t Daily energy produced = %.1f MWh \n\n
       ", avg_dem*24);
18  printf(" (iii)\t Maximum energy produced = %.1f MWh/
       day \n\n", avg_dem*24/puf);
```

Scilab code Exa 3.5 `diesel station`

```
1  //Chapter 3
2  //Example 3_5
3  //PAge 51
4
5  clear;clc;
6
7  ic=1500;
8  ce=750;
9  dp=100;
10 dl=450;
11 max_dem=2500;
12 e_per_year =45e5;
13
14 //diversity factor and annual load factor
15 printf(" Diversity factor = %.2f \n\n", (ic+ce+dp+dl)
       /max_dem);
16 avg_dem = e_per_year/8760;
17 printf("Average demand = %.2f kW \n\n", avg_dem);
18 printf("Load factor = %.1f %% \n\n", avg_dem/max_dem
       *100);
```

Scilab code Exa 3.6 `reserve capacity`

```
1  // Chapter 3
2  // Example 6
3  // PAge 51
4
5  clear ; clc ;
6
7  max_dem =15000;
8  lf =0.5;
9  pcf =0.4;
10
11 // reserve capacity
12 e_per_annum = max_dem * lf *8760;
13 printf ( " Energy  generated  per  annum  =  %.0 f  kWh  \n\n " ,
       e_per_annum )
14 pc = e_per_annum / pcf /8760;
15 printf ( " Plant  capacity  =%.0 f  kW  \n\n " , pc )
16 printf ( " Reserve  capacity  =%.1 f  kW  \n\n " , pc - max_dem )
     ;
```

Scilab code Exa 3.7 `connected load`

```
1  // Chapter 3
2  // Example 3_7
3  // Page 51
4
5  clear ;
6  clc ;
7
8  md1 =1500;
9  d1 =1.2;
10 df1 =0.8;
11 md2 =2000;
12 d2 =1.1;
```

```
13  df2=0.9;
14  md3=10000;
15  d3=1.25;
16  df3=1;
17  odf=1.35;
18
19  //Maximum demand and connected load
20  sum_md=md1+md2+md3;
21  printf("Maximum demand on supply system = %.1f kW \n
        \n", sum_md/odf);
22  sum_domestic = md1*d1;
23  printf("Connected domestic load = %.1f kW \n\n",
        sum_domestic/df1);
24  sum_commercial = md2*d2;
25  printf("Connected commercial load = %.1f kW \n\n",
        sum_commercial/df2);
26  sum_industrial =md3*d3;
27  printf("Connected industrial load = %.1f kW \n\n",
        sum_industrial/df3);
```

Scilab code Exa 3.8 `feeder max demand`

```
1  //Chapter 3
2  //Example 3_8
3  //Page 52
4
5  tl=[10 12 15];
6  tdf=[0.65 0.6 0.7];
7  tdg=[1.5 3.5 1.5];
8  df=1.3;
9  total=0;
10
11 //maximum load
```

```
12  n=3;
13  for i=1:n;
14    sum_md(i)=tl(i)*tdf(i);
15    printf("Sum of maximum demands on transformer %i =
          %.2f kW \n\n", i,   sum_md(i));
16    md(i)=sum_md(i)/tdg(i);
17    printf("Maximum demand on transformer %i = %.3f kW
          \n\n", i, md(i));
18    total=total+md(i);
19  end;
20
21  mdf=total/df;
22  printf("Maximum demand on feeder = %.2f kW \n\n",
      mdf)
```

Scilab code Exa 3.9 `max capacity`

```
1  //Chapter 3
2  //Example 3_9
3  //PAge 52
4
5  clear;
6  clc;
7
8  houses=1e3;
9  cl=1.5;
10 dem_fac=0.4;
11 div_fac=2.5;
12 factories=10;
13 md_f=90;
14 tubewells=7;
15 mdt=7;
16 df=1.2;
```
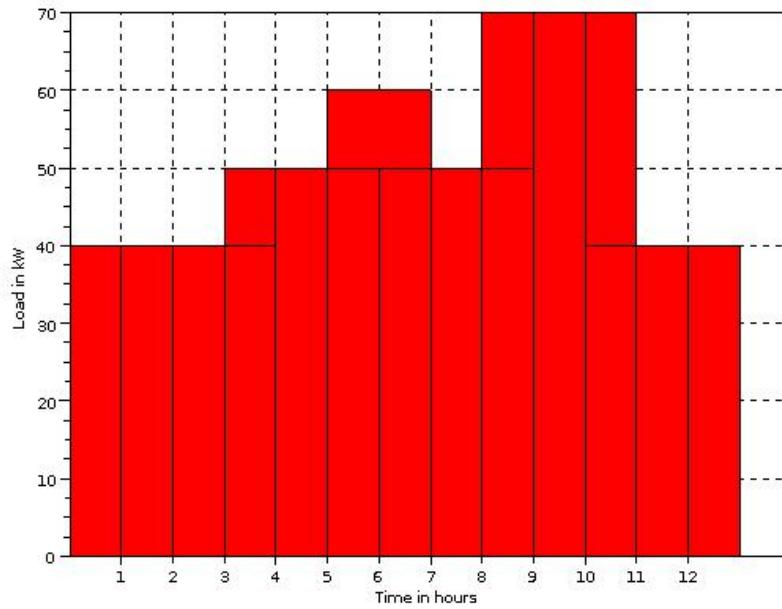
Figure 3.1: load curve

```
17
18  //Minimum capacity of power station
19
20  sum_md=cl*dem_fac*houses;
21  md_dl=sum_md/div_fac;
22  md_t=mdt*tubewells;
23  total_md=md_dl+md_t+md_f;
24  md_station=total_md/df;
25  printf("Minimum capacity of station required=%.2f kW
         \n\n", md_station);
```

Scilab code Exa 3.10 `load curve`

```
1  //Chapter 3
2  //Example 3_10
3  //Page 53
4
5  clear;clc;
6
7  time=[6 4 2 4 4 4];
8  load_mw=[40 50 60 50 70 40];
9
10 scf(0);
11 y=[40 40 40 50 50 60 50 50 70 70 40 40];
12 bar(y, 2, 'red');
13 xlabel('Time in hours');
14 ylabel('Load in kW');
15 xgrid(0)
16
17
18 md=max(y);
19 printf("\t (i)Maximum demand = %.0f MW \n\n", md);
20
21 area=0;
22 n=6;
23 for i=1:n;
24    area=area+time(i)*load_mw(i);
25 end;
26
27 printf("\t (ii)Units generated per day = %.0f kWh \n
     \n", area*1000);
28 al=area*1000/24;
29 printf("\t (iii)Average load = %.0f kW \n\n", al);
30 lf=al/md/1000;
31 printf("\t (iv)Load factor = %.2f %% \n\n", lf*100);
```
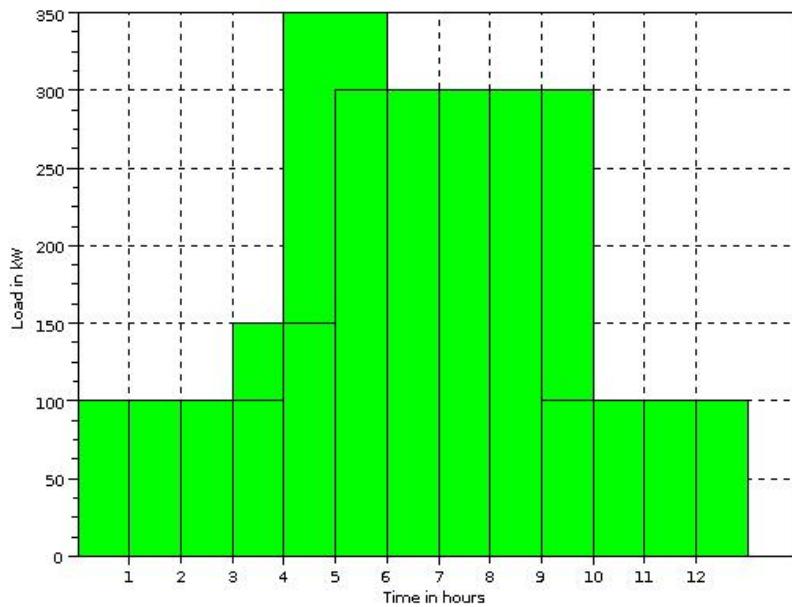
Figure 3.2: diversity and load factor

Scilab code Exa 3.11 `diversity and load factor`

```
1  //Chapter 3
2  //Example 3_11
3  //Page 54
4
5  clear;
6  clc;
```

```
 7
 8  l=[200 100 50 100]
 9  p=[100 150 350 300 100];
10  t=[6 2 2 8 6];
11
12  scf(2);
13  y=[100 100 100 150 350 300 300 300 300 100 100 100];
14  bar(y, 2, 'green');
15  xgrid(0)
16  xlabel('Time in hours');
17  ylabel('Load in kW');
18
19  md=max(p);
20  printf("Maximum demand = %.0f kW \n\n", md);
21  sum_l=sum(l);
22
23  printf("(i) Diversity factor = %.3f \n\n", sum_l/md)
        ;
24
25  ugpd=0;
26  for i=1:5
27     ugpd=ugpd+p(i)*t(i);
28  end;
29  printf("(ii) Units generated per day = %.0f kWh \n\n
        ", ugpd);
30
31  al=ugpd/24;
32  printf("(iii) Average load = %.1f kW \n\n", al);
33
34  printf("\t Load factor = %.1f %% \n\n", al/md*100);
```

Scilab code Exa 3.12 `station load factor`

```scilab
1  //Chapter 3
2  //Example 3_12
3  //Page 54
4
5  clear;clc;
6
7  c=[0 600 200 800 0; 200 0 1000 0 200; 0 200 1200 0
       200];
8  t=[8 6 2 6 2];
9
10 for i=1:3
11    energy(i)=0;
12    sum_md=0;
13    md(i)=max(c(i,:));
14    printf("Max demand of customer %i = %.0f W \n\n",i
         , md(i));
15
16    for j=1:5
17       energy(i)=energy(i)+c(i,j)*t(j);
18
19    end;
20    sum_md=sum_md+md(i);
21    lf(i)=energy(i)/md(i)/24*100;
22
23    printf("Load factor of customer %i = %.2f %% \n\n"
         , i,lf(i));
24
25 end;
26
27 for j=1:5
28    sum_c(j)=0;
29    for i=1:3
30
31       sum_c(j)=sum_c(j)+(c(i,j));
32
33    end;
34 end;
35 sim=max(sum_c);
```

```
36  df = sum (md) / sim ;
37  printf (" Diversity  factor  = %.2 f \n\n", df );
38
39  slf = sum ( energy ) / sim /24;
40  printf (" Station  load  factor  = %.2 f %% \n\n", slf
        *100) ;
```

Scilab code Exa 3.13 `15 min peak`

```
1  // Chapter  3
2  // Example  3_13
3  // Page  55
4
5  clear ; clc ;
6
7  peak =3000;
8  area =12;
9  area_per_cm =1000;
10 peak_time =15;
11
12 ad = area_per_cm *2* area /24;
13 printf (" Average  demand  = %.0 f  kW \n\n", ad );
14 lf = area_per_cm / peak *100;
15 printf (" Load  factor  = %.2 f %% \n\n", lf );
```

Scilab code Exa 3.14 `heat rate`

```
1  // Chapter  3
2  // Example  3_14
```

46

```scilab
3  //Page 56
4
5  clear;clc;
6
7  p=[260 200 160 100];
8  t=[6 8 4 6];
9  sets=4;
10 p_set=75;
11 cv=10000;
12 heat=2860;
13
14 //load factor
15 n=4;
16 upd=0;
17 for i=1:n
18  upd=(upd+(p(i)*t(i)));
19 end;
20
21 dlf=upd/max(p)/24;
22 printf("(i)\t Daily load factor=%.2f %% \n\n", dlf
     *100);
23
24 //average demand per day
25 adpd=upd/24;
26 printf("(ii)\t Average demand per day=%.0f kW \n\n",
      adpd*1000);
27 sc=p_set*1000*sets;
28 pcf=adpd/sc*1000;
29 printf("\t Plant capacity factor =%.2f %% \n\n", pcf
     *100);
30
31 //fuel per day
32 hpd=heat*upd;
33 fpd=hpd/cv;
34 printf("(iii)\tFuel required per day = %.1f tons \n\
     n", fpd);
```
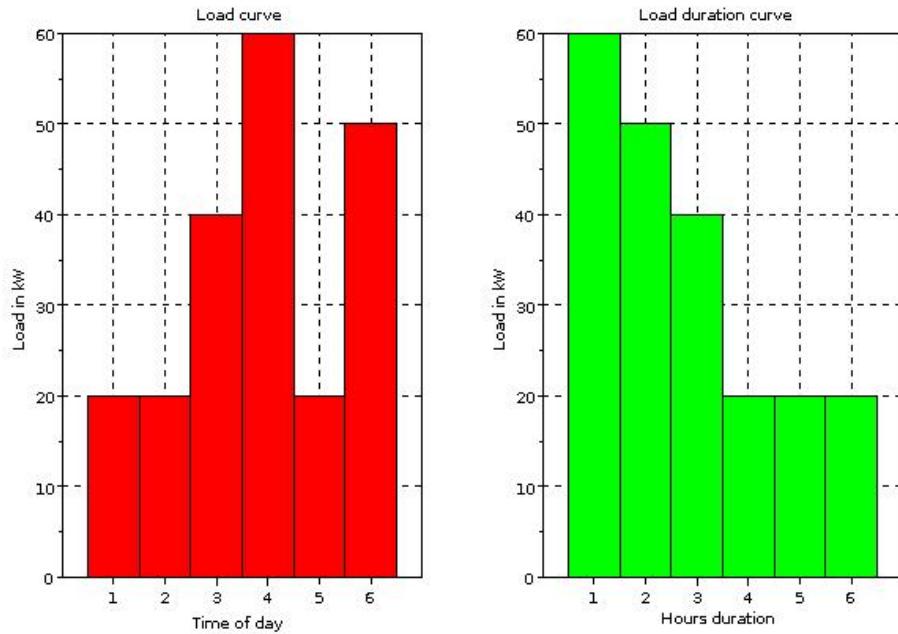
Figure 3.3: load duration curve

Scilab code Exa 3.15 `load duration curve`

```
1  //Chapter 3
2  //Example 3_15
3  //Page 56
4
5  clear;clc;
6
```

```
 7  l=[20 40 60 20 50 20];
 8  t=[2 4 4 4 4 6];
 9
10  scf(0);
11  subplot(1,2,1)
12  y=[20 20 40 60 20 50];
13  bar(y, 1, 'red');
14  xgrid(0);
15  xlabel('Time of day');
16  ylabel('Load in kW');
17  title('Load curve');
18
19  subplot(1,2,2)
20  r=[60 50 40 20 20 20];
21  bar(r, 1, 'green');
22  xgrid(0);
23
24  xlabel('Hours duration');
25  ylabel('Load in kW');
26  title('Load duration curve');
27
28  area=0;
29  for i=1:6
30     area=area+l(i)*t(i);
31  end;
32  printf("Units generated per day = %.0f MWh \n\n",
          area);
```

Scilab code Exa 3.16 `utilisation factor`

```
1  //Chapter 3
2  //Example 3_16
3  //Page 57
```

```
4
5  clear;clc;
6
7  const=4;
8  maxl=20;
9  tg1=10;
10 tg2=10;
11 tg3=5;
12
13 ic=tg1+tg2+tg3;
14 ad=0.5*(maxl+const);
15 pf=ad/ic;
16 ugpa=ad*1000*8760;
17 lf=ad/maxl*100;
18 uf=maxl/ic;
19
20 printf("Installed capacity = %.0f MW \n\n", ic);
21 printf("Average demand = %.0f MW \n\n", ad);
22 printf("Plant factor = %.2f %% \n\n", pf*100);
23 printf("Units generated per annum = %.2f*10^6 kWh \n
       \n", ugpa*1e-6);
24 printf("Load factor = %.2f %% \n\n", lf);
25 printf("Utilisation factor = %.2f %% \n\n", uf*100);
```

Scilab code Exa 3.17 maximum load on feeder

```
1  //Chapter 3
2  //Example 3_17
3  //Page 57
4
5  clear;clc;
6
7  //Transformer 1- general power service and lighting
```

```
 8  ahp =10;  akw =5;
 9  bhp =7.5;  bkw =4;
10  chp =15;
11  dhp =5;  dkw =2;
12
13  // Transformer  2  −  residence  lighting
14  ekw =5;
15  fkw =4;
16  gkw =8;
17  hkw =15;
18  ikw =20;
19
20  // Transformer  3  −  Store  lighting  and  power
21  jkw =10;  jhp =5;
22  kkw =8;  khp =25;
23  lkw =4;
24
25  n =0.72;
26
27  // Referring  to  Article  3.8  for  demand  factor  values
        for  various  load  types
28  // The  factor  used  to  convert  HP  to  kW  is  0.746
29  a= ahp *0.746/ n *0.65+ akw *0.6;
30  b= bhp *0.746/ n *0.75+ bkw *0.6;
31  c= chp *0.746/ n *0.65;
32  d= dhp *0.746/ n *0.75+ dkw *0.6;
33
34  t1 = a+b+c+d;
35  // diversity  factor  for  consumers  of  this  type  is  1.5
        as  per  Article  3.8
36  md1 = t1 /1.5;
37
38  e= ekw *0.5;
39  f= fkw *0.5;
40  g= gkw *0.5;
41  h= hkw *0.5;
42  i= ikw *0.5;
43
```

```
44  t2=e+f+g+h+i;
45  //diversity factor is given to be between 3 and 4,
        taking average of these two values
46  md2=t2/3.5;
47
48  j=jhp*0.746/n*0.75+jkw*0.5;
49  k=khp*0.746/n*0.55+kkw*0.5;
50  l=lkw*0.5;
51
52  t3=j+k+l;
53  //diversity factor is 1.5
54  md3=t3/1.5;
55
56  //diversity factor between transformers is 1.3
57  max_load=(md1+md2+md3)/1.3;
58
59  printf("Individual maximum demand of the group of
        consumers connected to transformer 1 as obtaiined
        from Article 3.8 are as follows: \n");
60  printf("\t a: %.2f kW \n", a);
61  printf("\t b: %.2f kW \n", b);
62  printf("\t c: %.2f kW \n", c);
63  printf("\t d: %.2f kW \n\n", d);
64  printf("Total = %.2f kW \n", t1);
65  printf("Maximum demand on transformer 1 = %.2f kW \n
        \n\n", md1);
66
67  printf("Individual maximum demand of the group of
        consumers connected to transformer 2 are as
        follows: \n");
68  printf("\t e: %.2f kW \n", e);
69  printf("\t f: %.2f kW \n", f);
70  printf("\t g: %.2f kW \n", g);
71  printf("\t h: %.2f kW \n", h);
72  printf("\t i: %.2f kW \n\n", i);
73  printf("Total = %.2f kW \n", t2);
74  printf("Maximum demand on transformer 2 = %.2f kW \n
        \n\n", md2);
```

```
75
76  printf("Individual maximum demand of the group of
        consumers connected to transformer 3 are as
        follows: \n");
77  printf("\t j: %.2f kW \n", j);
78  printf("\t k: %.2f kW \n", k);
79  printf("\t l: %.2f kW \n\n", l);
80  printf("Total = %.2f kW \n", t3);
81  printf("Maximum demand on transformer 3 = %.2f kW \n
        \n\n", md3);
82
83  printf("Diversity factor between transformers is 1.3
        \n");
84  printf("Maximum load on feeder = %.2f kW \n\n",
        max_load);
```

Scilab code Exa 3.18 daily load cycle

```
1  //Chapter 3
2  //Example 3_18
3  //Page 61
4
5  clear;clc;
6
7  l=[20 40 50 35 70 40];
8  t=[8 3 5 3 3 2];
9
10 scf(0);
11 y=[20 20 20 20 20 20 20 20 40 40 40 50 50 50 50 50
       35 35 35 70 70 70 40 40];
12 bar(y, 1, 'red');
```
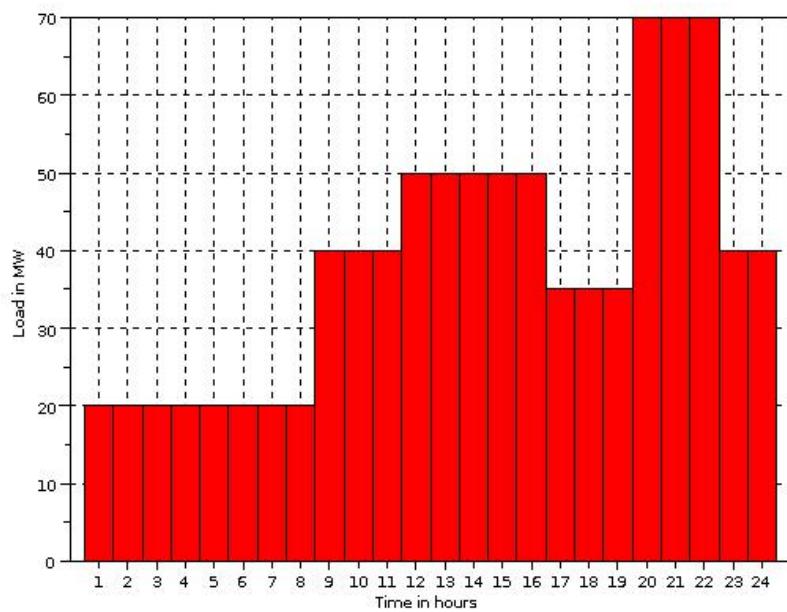
Figure 3.4: daily load cycle

```
13  xlabel ( ' Time  in  hours ' ) ;
14  ylabel ( ' Load  in  MW' ) ;
15  xgrid (0) ;
16
17  ugpa =0;
18  for  i =1:6;
19     ugpa=ugpa+l(i)*t(i);
20  end ;
21
22  printf ( " Units  generated  per  day  =  %.0 f  MWh  \n\n",
        ugpa ) ;
23
24  al=ugpa*1000/24;
25  lf=al/max(l)/1000;
26  printf ( " Average  load  =  %.1 f  kW  \n\n" ,  al ) ;
27  printf ( " Load  factor  =  %.2 f  %% \n\n" ,  lf *100) ;
```

Scilab code Exa 3.19 `installed capacity`

```
1  //Chapter  3
2  //Example  3_19
3  //Page  61
4
5  clear ; clc ;
6
7  pl =[10  5  8  7];
8  df =1.5;
9  lf =0.6;
10 sets =4;
11
12 //maximum  demand
13 md=sum(pl)/df;
14 printf ( " ( i ) \t  Max .  demand  on  station  =  %.0 f  MW  \n\n"
```

```
        , md ) ;
15
16  // units generated per annum
17  printf ( ” ( ii ) \t Units generated /day = %.0 f kWh \n\n” ,
        md* lf *8760*1000) ;
18
19  // installed capacity
20  printf ( ” ( iii ) \t Installed capacity = %.1 f MW \n\n” ,
        1.2* md ) ;
21  printf ( ” \t \t Suitable unit sizes are %.1 f MW \n\n” ,
        1.2* md/ sets ) ;
```

Scilab code Exa 3.20 `capacity factor`

```
 1  // Chapter 3
 2  // Example 3_20
 3  // Page 64
 4
 5  clear ; clc ;
 6
 7  bl =18;
 8  sc =20;
 9  asso =7.35*1 e6 ;
10  ablso =101.35*1 e6 ;
11  pl =12;
12  hours =2190;
13
14  printf ( ” Standby station \n\n” ) ;
15  alf = asso / pl /1000/ hours ;
16  printf ( ” \t Annual loadfactor = %.2 f %% \n\n” , alf
        *100) ;
17  apcf = asso / sc /1000/8760;
18  printf ( ” \t Annual plan capacity factor = %.2 f %% \n\
```

```
      n", apcf*100);
19
20  printf("Base load station\n\n");
21  alf_base=ablso/bl/1000/8760;
22  printf("Annual load factor = %.2f %% \n\n", alf_base
        *100);
```

Scilab code Exa 3.21 steam plant capacity

```
1  //Chapter 3
2  //Example 3_31
3  //Page 64
4
5  clear;clc;
6
7  max_l=60000;
8  min_l=20000;
9  peak_l=50000;
10 lf=1;
11 n_steam=0.6;
12
13 s=poly(0,"s");
14 p=333*s^2+24000*s-338000;
15 r=roots(p);
16 x=r(1);
17 y=40000*round(x)/24;
18 steam_capacity=max_l-y;
19
20 printf("x=%d \n", x);
21 printf("y=%d kW \n", y);
22 printf("Capacity of steam plant = %d kW \n",
```

```
            steam_capacity);
```

Scilab code Exa 3.22 generated units

```
1  //Chapter 3
2  //Example 3_22
3  //Page 65
4
5  clear;clc;
6
7  ratio = [7, 4, 1];
8  lf=1;
9
10  //Referring to the graph in page 66
11
12  ugpa=1000*(1/2*(320+160)*8760);
13  steam=ugpa*ratio(1)/sum(ratio);
14  ror=ugpa*ratio(2)/sum(ratio);
15  reservoir=ugpa*ratio(3)/sum(ratio);
16
17  md_ror=ror/8760;
18  y=sqrt(reservoir*32/876000);
19  md_res=y;
20  md_steam=320-y-md_ror/1000;
21  lf_res=reservoir/md_res/1000/8760;
22  lf_steam=steam/md_steam/1000/8760;
23
24  printf("Units generated per annum = %.2f*10^6 kW \n\
       n", ugpa/10^6);
25  printf("Units generated by steam plant = %.2f*10^6
       kWh \n", steam/10^6);
26  printf("Units generated by run of river plant = %.2f
       *10^6 kWh \n", ror/10^6);
27  printf("Units generated by reservoir plant = %.2f
       *10^6 kWh \n\n", reservoir/10^6);
```

```
28
29  printf(" (i) Maximum demand of run of river plant =
        %d kW \n", md_ror);
30  printf("     Maximum demand of reservoir plant = %d
        MW \n", md_res);
31  printf("      Maximum demand of steam plant = %d MW \n
        \n", md_steam);
32
33  printf(" (ii) Load factor of run of river plant = %d
        %% \n", lf*100);
34  printf("      Load factor of reservoir plant = %d %%
        \n", lf_res*100);
35  printf("      Load factor of steam plant = %.2f %% \n
        ", lf_steam*100);
```

Chapter 4

Economics of Power Generation

Scilab code Exa 4.1 annual depreciation charge

```
1  //Chapter 4
2  //Example 4_1
3  //Page 74
4
5  clear;clc;
6
7  p=90000;
8  n=20;
9  s=10000;
10
11 adc=(p-s)/n;
12 printf("Annual depreciation charge = Rs. %.0f \n\n "
       , adc);
```

Scilab code Exa 4.2 payment for sinking fund

```
1  //Chapter 4
2  //Example 4_2
3  //Page 74
4
5  clear;clc;
6
7  p=200000;
8  s=10000;
9  n=20;
10 r=0.08;
11
12 q=(p-s)*r/((1+r)^n-1);
13 printf("Annual payment for sinking fund = Rs. %.0f \
      n\n", q);
```

Scilab code Exa 4.3 value after 20years

```
1  //Chapter 4
2  //Example 4_3
3  //Page 75
4
5  clear;clc;
6
7  p=1560000;
8  s=60000;
9  n=25;
10 y=20;
11 r=0.05;
12
13 printf("(i)Straight line method\n");
14 ad=(p-s)/n;
15 val1=p-ad*y;
16 printf("\t Value of equipment after %.0f years = Rs.
```

```
        %.0 f \n\n", y, val1);
17
18  printf(" (ii)Diminishing value method\n");
19  x=1-(s/p)^(1/n);
20  val2=p*(1-x)^y;
21  printf("\t Value of equipment after %.0 f years = Rs.
        %.0 f \n\n", y, val2);
22
23  printf(" (iii)Sinking fund method\n");
24  q=(p-s)*r/((1+r)^n-1);
25  sf=q*((1+r)^y-1)/r;
26  val3=p-sf;
27  printf("\t Value of equipment after %.0 f years = Rs.
        %.0 f \n\n", y, val3);
```

Scilab code Exa 4.4 fixed and running charges

```
1  //Chapter 4
2  //Example 4_4
3  //Page 76
4
5  clear;clc;
6
7  md=50000;
8  p=95*1e6;
9  lf=0.4;
10 fuel_oil=9*1e6;
11 tax=7.5*1e6;
12 rate=0.12;
13
14 ugpa=md*lf*8760;
15 printf("Units generated per annum = %.0 f kWh \n\n",
        ugpa);
```

```
16
17  afc=rate*p;
18  printf("Annual fixed charges = Rs. %.0f \n\n", afc);
19
20  arc=fuel_oil+tax;
21  tac=afc+arc;
22  cpu=tac/ugpa;
23  printf("Cost per unit= Rs. %.2f \n\n", cpu);
```

Scilab code Exa 4.5 cost per unit

```
1  //Chapter 4
2  //Example 4_5
3  //Page 76
4
5  clear;clc;
6
7  ic=50000;
8  units=220*1e6;
9  afc_per_kW=160;
10 rc_per_kWh=0.04;
11
12 afc=afc_per_kW*ic;
13 arc=rc_per_kWh*units;
14 tac=afc+arc;
15 cpu=tac/units;
16
17 printf("Annual fixed charges = Rs. %.0f \n\n", afc);
18 printf("Annual running charges = Rs. %.0f \n\n", arc
      );
19
20 printf("Total annual charges = Rs. %.0f \n\n", tac);
21 printf("Cost per unit = Rs. %.5f \n\n", cpu);
```

Scilab code Exa 4.6 load factor values

```
1  // Chapter4
2  // Example 4_6
3  // Page 76
4
5  clear;clc;
6
7  md=100;
8  cost=160000;
9  afc_rate=0.12;
10 interest=0.05;
11 dep=0.05;
12 tax=0.02;
13 lf1=1;
14 lf2=0.5;
15
16 afc=afc_rate*cost;
17 printf("Annual fixed charges = Rs. %.0f \n\n", afc);
18
19 printf("When laod factor is 100%% \n");
20 ugpa1=md*lf1*8760;
21 fc1=afc/ugpa1;
22 printf("Units generated per annum = %.0f kWh \n",
       ugpa1);
23 printf("Fixed charges per kWh = Rs. %.5f \n\n", fc1)
       ;
24
25 printf("When laod factor is 50%% \n");
26 ugpa2=md*lf2*8760;
27 fc2=afc/ugpa2;
28 printf("Units generated per annum = %.0f kWh \n",
```

```
      ugpa2 ) ;
29 printf ( " Fixed  charges  per  kWh  =  Rs .  %.5 f  \n\n" ,  fc2 )
      ;
```

Scilab code Exa 4.7 cost per kWh

```
1  // Chapter  4
2  // Example  4_7
3  // Page  77
4
5  clear ; clc ;
6
7  pc =50;
8  lf =0.4;
9  p =12*1 e6 ;
10 tax =400000;
11 other_cost =0.01;
12 interest =0.05;
13 dep =0.06;
14
15 md = pc ;
16 printf ( " Annual  fixed  charges \n" ) ;
17 i_and_d = p *( interest + dep ) ;
18 afc = i_and_d + tax ;
19 printf ( " Interest  and  depreciation  =  Rs .  %.0 f  \n" ,
      i_and_d ) ;
20 printf ( " Wages  and  taxation  =  Rs .  %.0 f  \n" ,  tax ) ;
21 printf ( " Total  annual  fixed  charges  =  Rs .  %.0 f  \n\n" ,
      afc ) ;
22
23 printf ( " Annual  running  charges \n" ) ;
24 ugpa = md * lf *8760*1000;
25 cost = other_cost * ugpa ;
```

```
26  tac=cost+afc;
27  cpkWh=tac/ugpa;
28  printf("Units  generated  per  annum  =  %.0f  kWh  \n",
        ugpa);
29  printf("Cost  of  fuel  and  lubrication  =  Rs.  %.0f  \n",
        cost);
30  printf("Total  annual  charges  =  Rs.  %.0f  \n",  tac);
31  printf("Cost  per  kWh  =  Rs.  %.4f  \n\n",  cpkWh);
```

Scilab code Exa 4.8 reserve capacity and kWh

```
1  //Chapter  4
2  //Example  4_8
3  //PAge  77;
4
5  clear;clc;
6
7  ic=300;
8  cf=0.5;
9  lf=0.6;
10  cost=9*1e7;
11  p=1e9;
12  i_d=0.1;
13
14  md=ic*cf/lf;
15  rc=ic-md;
16  printf("Reserve  capacity  =  %.0f  MW  \n\n",  rc);
17
18  ugpa=md*lf*8760*1000;
19  afc=i_d*p;
20  arc=cost;
21  tac=afc+arc;
22  cost=tac/ugpa;
```

```
23  printf("Units generated per annum = %.0f kWh \n",
       ugpa);
24  printf("Annaul fixed charges = Rs. %.0f \n", afc);
25  printf("Annual running charges = Rs. %.0f \n", arc);
26  printf("Total annual charges = Rs. %.0f \n", tac);
27  printf("Cost per kWh = Rs. %.3f \n", cost);
```

Scilab code Exa 4.9 `two part form`

```
1  //Chapter 4
2  //Example 4_9
3  //Page 78
4
5  clear;clc;
6
7  md=40;
8  lf=0.6;
9  cost=7*1e5;
10  fc_rate = 0.2;
11
12  ic=50;
13  p=1000;
14  dep=0.1;
15  r_per_kW=1;
16  r_per_kWh=0.1;
17
18  ugpa=md*lf*1000*8760;
19  cc=ic*1e6;
20
21  printf("Annual fixed charges\n");
22  d=dep*cc;
23  sm=fc_rate*cost;
24  afc=d+sm;
```

```
25  c_per_kW=afc/md/1000+r_per_kW;
26
27  printf("\t  Depreciation = Rs. %.0f \n", d);
28  printf("\t  Sales, maintainence = Rs. %.0f \n", sm);
29  printf("\t  Total annual fixed charges = Rs. %.0f \n"
        , afc);
30  printf("\t  Cost per kW = Rs. %.2f \n\n", c_per_kW);
31
32  printf("Annual running charges\n");
33  s_m=(1-fc_rate)*cost;
34  c_per_kWh=s_m/ugpa+r_per_kWh;
35  printf("\t  Salaries, maintainence = Rs. %.0f \n",
        s_m);
36  printf("\t  Cost per kWh = Rs. %.4f \n\n", c_per_kWh)
        ;
37
38  printf("Total generation cost in two part form is
        given by: \n \t\t\t\t\t\t Rs. (%.2f *kW + %.4f
        *kWh) \n\n", c_per_kW, c_per_kWh);
```

Scilab code Exa 4.10 a b c form

```
1  //Chapter 4
2  //Example 4_10
3  //Page 78
4
5  clear;clc;
6
7  md=60;
8  lf=0.5;
9  b_and_e=5*1e6;
10 fotw=900000;
11 int_dep=0.1;
```

```
12  org =500000;
13
14  ugpa=md*lf*8760*1000;
15  a=org;
16  asfc=int_dep*b_and_e;
17  b=asfc/md/1000;
18  c=fotw/ugpa;
19
20  printf("Units generated per annum = %.0f kWh \n\n",
        ugpa);
21
22  printf("Annual fixed cost = Rs. %.0f \n\n", a);
23
24  printf("Annual semi fixed cost = Rs. %.2f \n\n", b);
25
26  printf("Annual running cost = Rs. %.5f \n\n", c);
```

Scilab code Exa 4.11 overall generation cost

```
1  //Chapter 4
2  //Example 4_11
3  //Page 79
4
5  clear;clc;
6
7  cost=3000;
8  i=0.05;
9  dep=0.02;
10  om=0.02;
11  i_r=0.015;
12  l=0.125;
13  d=1.25;
14  m_d=0.8
```

```
15  lf=0.4;
16
17  //assume ic=100kW
18  ic=100;
19
20  md=m_d*ic;
21  ad=md*lf;
22  cc=cost*100;
23
24  fc=cc*(i+dep);
25  agg_md=md*d;
26  afc=fc/agg_md;
27
28  rc=cc*(om+i_r);
29  ugpa=ad*8760;
30  u=ugpa*(1-l);
31  arc=rc/u;
32
33  printf("Annual fixed charges\n");
34  printf("    Annual fixed charges = Rs. %.0f \n", fc);
35  printf("    Aggregate of maximum demamd = %.0f kW \n",
          agg_md);
36  printf("    Annual fixed charges = Rs. %.0f per kW of
         max demand\n\n", afc);
37
38  printf("Annual running charges\n");
39  printf("    Annual running charges = Rs. %.0f \n", rc)
         ;
40  printf("    Units generated per annum = %.0f kWh \n",
         ugpa);
41  printf("    Units reaching customer  = %.0f kWh \n", u
         );
42  printf("    Annual running charges = Rs. %.5f \n\n",
         arc);
43
44  printf("Generation cost in two part form is: \n \t\t
         \t\t\t Rs(%.0f * kW + %.5f * kWh)\n\n", afc, arc)
         ;
```

```
45
46  t=fc+rc;
47  printf("Total  annual  charges  =  Rs.  %.0f  \n\n",  t);
48  printf("Cost  per  kWh  =  Rs.  %.4f  \n\n",  t/u);
```

Scilab code Exa 4.12 `private and public supply`

```
1  //Chapter  4
2  //Example  4_12
3  //Page  80
4
5  clear;clc;
6
7  md=1;
8  lf=0.5;
9  cc=12*1e5;
10  rm=0.005;
11  fc=1600;
12  id=0.1;
13  fcon=0.3;
14  w=50000;
15  c=150;
16  rc=0.15;
17
18  ugpa=md*1000*lf*8760;
19
20  printf("(i)  Private  oil  engine  generating  plant\n");
21  afc=fcon*ugpa;
22  a_f_c=afc*fc/1000;
23  arm=rm*ugpa;
24  aw=w;
25  aid=id*cc;
26
```

```
27  printf(" Annual fuel consumption = %.0f kg \n", afc)
      ;
28  printf(" Annual cost of fuel = Rs. %.0f \n", a_f_c);
29  printf(" Annual cost of maintainence and repair = Rs
      . %.0f \n", arm);
30  printf(" Annual wages = Rs. %.0f \n", aw);
31  printf(" Annual interest and depreciation = Rs. %.0f
      \n\n", aid);
32  printf(" Total annual charges = Rs. %.0f \n\n",
      a_f_c+arm+aw+aid);
33
34
35  afc2=c*1000;
36  arc=rc*ugpa;
37  t=afc2+arc;
38  printf("(ii) Public supply\n");
39  printf(" Annual fixed charges = Rs. %.0f \n", afc2);
40  printf("Annual running charges = Rs. %.0f \n", arc);
41  printf("Total annual charges = Rs. %.0f \n\n",t);
```

Scilab code Exa 4.13 `steam and hydro`

```
1  //Chapter 4
2  //Example 4_13
3  //Page 80
4
5  clear;clc;
6
7  md=100;
8  lf=0.3;
9  hp=1e8;
10 max0(2)=40;
11
```

```
12  cc=[1250 2500];
13  id=[0.12 .1];
14  oc=[0.05 0.015];
15  tc=[0 0.002];
16
17  ugpa=md*lf*8760*1000;
18  printf("Units generated per annum = %.0f kWh \n\n",
        ugpa);
19
20  printf("STEAM IN CONJUNCTION WITH HYDRO STATION\n");
21  u(2)=hp;
22  u(1)=ugpa-u(2);
23  printf("Units supplied by hydro station = %.0f kWh \
        n\n", u(2));
24  printf("Units supplied by steam station = %.0f kWh \
        n\n", u(1));
25
26
27  max0(1)=md-max0(2);
28  printf("Maximum output of steam station = %.0f MW \n
        \n", max0(2));
29
30  for i=1:2
31    if i==1
32      printf("\n(a) Steam station\n");
33    end;
34
35    if i==2
36      printf("\n(b) Hydro station\n");
37    end;
38
39    capc(i)=max0(i)*1000*cc(i);
40    aid(i)=id(i)*capc(i);
41    opc(i)=oc(i)*u(i);
42    trc(i)=tc(i)*u(i);
43    tac(i)=opc(i)+trc(i)+aid(i);
44
45    printf("Capital cost = Rs. %.0f \n", capc(i));
```

73

```
46    printf("Annual interest and depreciation = Rs. %.0
         f \n", aid(i));
47    printf("Operating cost = Rs. %.0f \n", opc(i));
48    printf("Transmission cost = Rs. %.0f \n", trc(i));
49    printf("Total annual cost = Rs. %.0f \n\n", tac(i)
         );

50
51 end;

52
53 t=sum(tac);
54 printf("Total annual charges for both steam and
       hydro stations = Rs. %.0f \n", t);
55 o_c=t/ugpa;
56 printf("Overall cost per kWh = Rs. %.5f \n\n", o_c);

57
58 for j=1:2

59
60    if j==1
61       printf("\nSTEAM STATION\n");
62    end;

63
64    if j==2
65       printf("\nHYDRO STATION\n");
66    end;

67
68    cct(j)=cc(j)*md*1000;
69    a_id(j)=id(j)*cct(j);
70    fc(j)=a_id(j)/ugpa;
71    opct(j)=oc(j);
72    trct(j)=tc(j);
73    ovct(j)=fc(j)+opct(j)+trct(j);

74
75    printf("Capital cost = Rs. %.0f \n", cct(j));
76    printf("Annual interest and depreciation = Rs. %.0
         f \n", a_id(j));
77    printf("Fixed charges/kWh = Rs. %.5f \n", fc(j));
78    printf("Operating cost/kWh = Rs. %.4f \n", opct(j)
         );
```

```
79    printf(" Transmission cost/kWh = Rs. %.4 f \n", trct
          (j));
80    printf(" Overall/kWh cost = Rs. %.5 f \n\n", ovct(j)
          );
81 end;
```

Scilab code Exa 4.14 `unit cost`

```
1  //Chapter 4
2  //Example 4_14
3  //Page 81
4
5  clear;clc;
6
7  mw=150;
8  cc_steam=1600;
9  cc_hydro=3000;
10 oc_steam=0.06;
11 oc_hydro=0.03;
12 interest=0.07;
13
14 md=mw*10^3;
15 printf("MAximum demand = %d MW \n", mw);
16 printf("STEAM PLANT: \n");
17 cc_s=cc_steam*md;
18 ai_s=interest*cc_s;
19 fc_s=ai_s;
20 rc_s=oc_steam;
21
22 printf("Capital cost = Rs. %d*10^6 \n", cc_s/10^6);
23 printf("Annual interest = Rs. %.2 f *10^6 \n", ai_s
         /10^6);
24 printf("Fixed cost/unit = Rs. %.2 f *10^6/x \n", fc_s
```

```
      /10^6);
25  printf(" Running cost/unit = Rs. %.2f \n", rc_s);
26  printf(" Total cost/unit = Rs. %.2f*10^6/x+%.2f \n\n"
      , ai_s/10^6, rc_s);
27
28  printf("HYDRO PLANT: \n");
29  cc_h=cc_hydro*md;
30  ai_h=interest*cc_h;
31  fc_h=ai_h;
32  rc_h=oc_hydro;
33
34  printf(" Capital cost = Rs. %d*10^6 \n", cc_h/10^6);
35  printf(" Annual interest = Rs. %.2f*10^6 \n", ai_h
      /10^6);
36  printf(" Fixed cost/unit = Rs. %.2f*10^6/x \n", fc_h
      /10^6);
37  printf(" Running cost/unit = Rs. %.2f \n", rc_h);
38  printf(" Total cost/unit = Rs. %.2f*10^6/x+%.2f \n\n"
      , ai_h/10^6, rc_h);
39
40  x=490*10^6;
41  printf("By equating the overall cost, we get x = %.2
      f kWh \n", x);
42
43  lf=x/md/8760;
44  printf("Load factor = %.2f %%", lf*100);
```

Scilab code Exa 4.15 generation cost

```
1  //Chapter 4
2  //Example 4_15
3  //Page 82
4
```

```scilab
 5  clear;clc;
 6
 7  cc_h=2100;
 8  cc_s=1200;
 9  rc_h=0.032;
10  rc_s=0.05;
11  id_s=0.09;
12  id_h=0.075;
13  resc_h=0.33;
14  resc_s=0.25;
15  units=40*10^6;
16
17  u=8760;
18  printf(" x kW - maximum demand \ny -annual load
        factor at which cost for both stations are same \
        nUnits generated per annum = %dxy kWh \n\n", u);
19
20  ic_s=1+resc_s;
21  ic_h=1+resc_h;
22  printf("Installed capacity of steam plant = %.2fx kW
        \n", ic_s);
23  printf("Installed capacity of hydro plant = %.2fx kW
        \n\n", ic_h);
24  printf("STEAM STATION: \n");
25  ccs=cc_s*ic_s;
26  ids=id_s*ccs;
27  rcs=rc_s*8760;
28  printf("Capital cost = Rs. %dx \n", ccs);
29  printf("Interest and depreciation = Rs. %dx \n", ids
        );
30  printf("Running cost/annum = Rs %dxy \n", rcs);
31  printf("Overall cost/kWh = Rs (%dx+%dxy)/(%dxy) \n\n
        ", ids, rcs, u);
32
33  printf("HYDRO STATION: \n");
34  cch=cc_h*ic_h;
35  idh=id_h*cch;
36  rch=rc_h*8760;
```

```
37  printf(" Capital  cost  =  Rs.  %dx  \n", cch);
38  printf(" Interest  and  depreciation  =  Rs.  %dx  \n", idh
        );
39  printf(" Running  cost/annum  =  Rs  %dxy  \n", rch);
40  printf(" Overall  cost/kWh  =  Rs  (%dx+%dxy)/(%dxy)  \n\n
        ", idh, rch, u);
41
42  y=47.46;
43  printf(" Equating  operating  cost,  Load  factor  y  =  %.2
        f %%  \n", y);
44  md=units/8760/y*100;
45  printf("Max  demand  =  x  =  %.2f*10^3  kW  \n", md/1000);
46  cost=(ids*md+rcs*md*y/100);
47  printf(" Cost  of  generation  =  Rs.  %.2f*10^3  \n\n",
        cost/1000);
```

Scilab code Exa 4.16 hours of operation

```
1  //Chapter  4
2  //Example  4_16
3  //Page  83
4
5  clear;clc;
6
7  cap_b=17241;
8  cap_a=50000-cap_b;
9  y=8760*cap_b/50000;
10
11  printf(" Capacity  of  station  B  =  %d kW  \n", cap_b);
12  printf(" Capacity  of  station  A  =  %d kW  \n", cap_a);
13  printf("Number  of  hours  if  station  B  operation  =  %d
        hours  \n\n", y);
```

Chapter 5

Tariff

Scilab code Exa 5.1 `simple tariff 1`

```
1  // Chapter 5
2  // Exxample 5_1
3  // PAge 91
4
5  clear; clc;
6
7  md =200;
8  lf =0.4;
9  mdc =100;
10 ec =0.1;
11
12 ugpa = md * lf *8760;
13 ac = mdc * md + ec * ugpa;
14 oc = ac / ugpa;
15
16 printf(" Units  generated  per  annum  = %.0 f  kWh  \n\n",
       ugpa);
17 printf(" Annual  charges  = %.0 f  kWh  \n\n", ac);
18 printf(" Overall  cost  per  kWh = Rs.  %.5 f  \n\n", oc);
```

Scilab code Exa 5.2 `flat rate 1`

```
1  //Chapter 5
2  //Example 5_2
3  //Page 91
4
5  clear;clc;
6
7  i=20;
8  v=220;
9  e=8760;
10 t=500;
11 et=0.2;
12 et_plus=0.1;
13
14 lf=1;
15 md=i*v*lf/1000;
16 printf("Assuming load factor to be unity\n");
17 printf("Maximum demand = %.1f kW \n\n", md);
18
19 u=md*t;
20 c=et*u;
21 ru=e-u;
22 c_extra=et_plus*ru;
23 total=c+c_extra;
24 eqfr=total/e;
25
26 printf("(i) Units consumed = %.0f kWh \n\n", u);
27 printf("    Charges = Rs. %.0f \n\n", c);
28 printf("    Remaining units = %.0f kWh \n\n", ru);
29 printf("    Extra charges = Rs. %.0f \n\n", c_extra)
      ;
```

```
30 printf("      Total annual bill = Rs. %.0 f \n\n\n",
      total);
31 printf("(ii)Equivalent flat rate = Rs. %.5 f \n\n",
      eqfr);
```

Scilab code Exa 5.3 `economical tariff`

```
1  //Chapter 5
2  //Example 5_3
3  //Page 92
4
5  clear;clc;
6
7  rs=100;
8  exceed=0.15;
9  fr=0.3;
10
11 x=rs/(fr-exceed);
12
13 printf("Number of units at which charges due to both
       tariffs become equal = %.2 f units \n\n", x);
14 printf("Tariff (a) is economical if consumption is
       more than %.2 f units \n\n", x);
```

Scilab code Exa 5.4 `number of units`

```
1  //Chapter 5
2  //Example 5_4
3  //Page 92
```

```
4
5 clear;clc;
6
7 fc=30;
8 rc=0.03;
9 fu=400;
10 rfu=0.06;
11 add_u=0.05;
12
13 rate=fu*rfu-fu*add_u;
14 x=(fc-rate)/(add_u-rc);
15
16 printf("x is the number of units taken per annum for
        which the annual charges due to both tariffs
      become equal. \n\n");
17 printf("Annual charges due to first tariff = Rs. (%d
    +%.2f*x) \n\n", fc, rc);
18 printf("Annual charges due to second tariff = Rs. (
    %d+%.2f*x) \n\n", rate, add_u);
19 printf("Equating the two equations, x = %.2f kWh \n\
    n", x);
```

Scilab code Exa 5.5 two part 1

```
1 //Chapter 5
2 //Example 5_5
3 //PAge 92
4
5 clear;clc;
6
7 md=50;
8 u=18*1e7;
9 ad=75;
```

```
10  fc=9000000;
11  fcg=2800000;
12  fctnd=3200000;
13  l=0.15;
14  rc=0.9;
15
16  printf("Annual fixed charges\n");
17  fuel=(1-rc)*fc;
18  tac=fcg+fctnd+fuel;
19  printf("Total annual charges = Rs. %.0f \n", tac);
20  cmd=tac/ad/1000;
21  printf("Cost per kW of maximum demand = Rs. %.0f \n\
        n", cmd);
22
23  printf("Annual running charges\n");
24  cf=rc*fc;
25  udc=(1-l)*u;
26  c=cf/udc;
27
28  printf("Cost of fuel = Rs. %.0f \n", cf);
29  printf("Units deliivered to consumers = %.0f kWh \n"
        , udc);
30  printf("Cost per kWh = Rs. %.3f \n\n", c);
31
32  printf("Tariff is Rs. %.0f of maximum demand plus %
        .3f rupess per kWh \n\n", cmd, c);
```

Scilab code Exa 5.6 substation and consumer

```
1  //Chapter 5
2  //Exampl 5_6
3  //PAge 93
4
```

```
5  clear;clc;
6
7  md=75;
8  lf=0.4;
9  gcc=60;
10 goc=0.04;
11 tcc=2000000;
12 dcc=1500000;
13 tdf=1.2;
14 ddf=1.25;
15 n_tr=0.9;
16 n_dr=0.85;
17
18 printf("Cost at Substation\n\n");
19 printf("\t (i) Annual fixed charges\n");
20 gc=gcc*md*1000;
21 tafc=gc+tcc;
22 agg=md*1000*tdf;
23 ac=tafc/agg;
24
25 printf("\t\t Generation cost = Rs. %.0f \n", gc);
26 printf("\t\t Transmission cost = Rs. %.0f \n",tcc);
27 printf("\t\t Total annual fixed charges at the
       substation=Rs. %.0f \n", tafc);
28 printf("\t\t Aggregate of all max demands by various
        substations = %.0f kW \n", agg);
29 printf("\t\t Annual cost per kW of maximum demand =
       Rs. %.2f \n\n", ac);
30
31 printf("\t (ii) Running charges\n");
32 c=goc/n_tr;
33 printf("\t\t Cost per kWh at substation = Rs. %.4f \
       n\n", c);
34
35 printf("Cost at Consumers premises\n");
36 cp=tafc+dcc;
37 aggm=agg*ddf;
38 ckW=cp/aggm;
```

```
39  ckWh=c/n_dr;
40
41  printf("\t\t Total annual fixed charges at consumers
           premises = Rs. %.0f \n\n", cp);
42  printf("\t\t Aggregate of max demands of all
          consumers = %.0f kW \n\n", aggm);
43  printf("\t\t Annual cost per kW of max demand = Rs.
          %.0f \n\n", ckW);
44  printf("\t\t Cost per kWh at consumers premises = Rs
          . %.4f \n\n", ckWh);
```

Scilab code Exa 5.7 solving for L

```
1  //Chapter 5
2  //Example 5_7
3  //Page 94
4
5  clear;clc;
6
7  fcd=300;
8  fcs=1200;
9  rcd=0.25;
10  rcs=0.0625;
11
12  printf("Let L be the load factor\n");
13
14  printf("DIESEL STATION: \n");
15  apd=100/8760;
16  fc_d=fcd*apd;
17  rc_d=100*rcd;
18  printf("Average power = %.4f kW \n", apd);
19  printf("Maximum demand = %.4f/L kW \n", apd);
20  printf("Fixed charges = Rs. %.2f/L \n", fc_d);
```

```
21  printf("Running charges = Rs. %.2f \n", rc_d);
22  printf("Fixed and running charges = Rs. (%.2f/L + %
        .2f) \n\n", fc_d, rc_d);
23
24  printf("STEAM STATION: \n");
25  aps=100/8760;
26  fc_s=fcs*aps;
27  rc_s=100*rcs;
28  printf("Fixed charges = Rs. %.2f/L \n", fc_s);
29  printf("Running charges = Rs. %.2f \n", rc_s);
30  printf("Fixed and running charges = Rs. (%.2f/L + %
        .2f) \n\n", fc_s, rc_s);
31
32  l=54.72;
33  printf("Equating the two charges and solving, we get
        L = %.2f %% \n\n", l);
```

Scilab code Exa 5.8 annual bill 1

```
1  //Chapter 5
2  //Example 5_8
3  //PAge 95
4
5  clear;clc;
6
7  md=100;
8  pf=0.8;
9  lf=0.6;
10  fc=75;
11  rc=0.15;
12
13  ucpy=md*lf*8760;
14  mdkva=md/pf;
```

```
15  bill=fc*mdkva+rc*ucpy;
16
17  printf("Units consumed per year = %.0f kWh \n\n",
         ucpy);
18  printf("Max demand in kVA = %.0f kWh \n\n", mdkva);
19  printf("Annual bill = %.0f kWh \n\n", bill);
```

Scilab code Exa 5.9 annual saving 1

```
1  //Chapter 5
2  //Example 5_9
3  //PAge 95
4
5  clear;clc;
6
7  ml=240;
8  pf=0.8;
9  ac=50000;
10  fc=50;
11  rc=0.1;
12
13  md1=ml/pf;
14  ab1=fc*md1+rc*ac;
15  flat1=ab1/ac;
16
17  md2=ml/1;
18  ab2=fc*md2+rc*ac;
19  as=ab1-ab2;
20
21  printf("With power factor = %.1f \n", pf);
22  printf("Maximum demand = %.0f kVA \n", md1);
23  printf("Annual bill = Rs. %.0f \n", ab1);
24  printf("Flat rate per unit = Rs. %.3f \n\n", flat1);
```

```
25
26 printf("With power factor unity \n");
27 printf("Maximum demand = %.0f kVA \n", md2);
28 printf("Annual bill = Rs. %.0f \n", ab2);
29
30
31 printf("Annual saving = Rs. %.0f\n", as);
```

Scilab code Exa 5.10 monthly bill 1

```
1 //Chapter 5
2 //Example 5_10
3 //Page 96
4
5 clear;clc;
6
7 md=50;
8 ec=36000;
9 re=23400;
10 fc=80;
11 rc=0.08;
12 plus=0.5;
13 pfl=86;
14
15 al=ec/24/30;
16 arp=re/24/30;
17 phi=atan(arp/al);
18 pf=cos(phi);
19 pfsc=ec*plus*(pfl-pf*100)/100;
20 mb=fc*md+rc*ec+pfsc;
21
22 printf("Average laod = %.0f kW \n\n", al);
23 printf("Average reactive power = %.1f kVAR \n\n",
```

```
      arp);
24 printf("Power factor angle = %.2f radians \n\n", phi
      );
25 printf("Power factor = %.4f \n\n", pf);
26 printf("Power factor surcharge = Rs. %.1f \n\n",
      pfsc);
27 printf("Monthly bill = Rs. %.2f \n\n", mb);
```

Scilab code Exa 5.11 `cost at varying pf`

```
1 //Chapter 5
2 //Example 5_11
3 //Page 96
4
5 clear;clc;
6
7 fc=150;
8 rc=0.08;
9 lf=0.3;
10 pf1=1;
11 pf2=0.7;
12
13 md1=fc*100/8760/lf/pf1;
14 oc1=md1+rc*100;
15 printf("(i) When power factor is unity\n ");
16 printf("    MAx demand charge per unit = %.2f paise
      \n", md1);
17 printf("    Energy charge per unit = %.0f paise \n",
      rc*100);
18 printf("    Overall cost per unit = %.2f paise \n\n"
      , oc1);
19
20 md2=fc*100/8760/lf/pf2;
```

```
21  oc2=md2+rc*100;
22  printf(" (i) When power factor is unity\n ");
23  printf("     MAx demand charge per unit = %.2f paise
        \n", md2);
24  printf("     Energy charge per unit = %.0f paise \n",
        rc*100);
25  printf("     Overall cost per unit = %.2f paise \n\n"
        , oc2);
```

Scilab code Exa 5.12 difference in cost annually

```
1  //Chapter 5
2  //Example 5_12
3  //Page 97
4
5  clear;clc;
6
7  h=8;
8  d=300;
9  kwh1=0.05;
10 kva1=4.5;
11 kwh2=5.5;
12 kva2=5;
13 al=200;
14 pf1=0.8;
15 md=250;
16 hvc=50;
17 lhv=0.04;
18 id=0.12;
19
20 md1=md/pf1;
21 cap=md1/(1-lhv);
22 ci=hvc*cap;
```

```
23  aid=ci*id;
24  ac1=cap*kva1*12;
25  uc1=al*h*d/(1-lhv);
26  ackwh1=kwh1*uc1;
27  tac1=aid+ac1+ackwh1;
28
29  printf(")(i) High voltage supply\n");
30  printf(")     Max demand in kVA = %.2f \n", md1);
31  printf(")     Considering losses in hv equipment, the
        capacity is = %.2f kVA \n", cap);
32  printf(")     Annual interest and depreciation = Rs. %
        .0f \n", aid);
33  printf(")     Annual charge due to max kVA demand = Rs
        . %.0f \n", ac1);
34  printf(")     Units consumed/year = %.0f kWh \n", uc1)
        ;
35  printf(")     Annual charge due to kWh consumption =
        Rs. %.0f \n", ackwh1);
36  printf(")     Total annual cost = Rs. %.0f \n\n", tac1
        );
37
38  md2=md/pf1;
39  ac2=md2*kva2*12;
40  uc2=al*h*d;
41  ackwh2=kwh2*uc2/100;
42  tac2=ac2+ackwh2;
43
44  printf(")(ii)Low voltage supply\n");
45  printf(")     Max demand in kVA = %.2f \n", md2);
46  printf(")     Annual charge due to max kVA demand = Rs
        . %.0f \n", ac2);
47  printf(")     Units consumed/year = %.0f kWh \n", uc2)
        ;
48  printf(")     Annual charge due to kWh consumption =
        Rs. %.0f \n", ackwh2);
49  printf(")     Total annual cost = Rs. %.0f \n\n", tac2
        );
50
```

```
51  printf("Difference in annual costs of two systems =
        Rs. %.0f \n", tac2 - tac1);
```

Scilab code Exa 5.13 cheaper alternative

```
1  //Chapter 5
2  //Example 5_13
3  //Page 97
4
5  clear;clc;
6
7  p=1000;
8  md=2500;
9  inc=5.5*1e6;
10
11  ds=1000;
12  rs=400;
13  id=0.1;
14  fc=75;
15  rc=0.05;
16
17  gcc=120;
18  grc=0.03;
19
20  cc=rs*ds;
21  aid=id*cc;
22  ep=md-2*ds;
23  kw1=fc*ep;
24  kwh1=rc*inc;
25  tac1=aid+kw1+kwh1;
26
27  printf("(i) Purchasing diesel set: \n");
28  printf("Capital cost = Rs. %.0f \n", cc);
```

```
29  printf("Annual interest and depreciation = Rs. %.0f
        \n", aid);
30  printf("Extra power to be generated = %.0f kW \n",
        ep);
31  printf("Annual charge due to extra kW max demand =
        Rs. %.0f \n", kw1);
32  printf("Annual charge due to extra kWh consumption =
         Rs. %.0f \n", kwh1);
33  printf("Total Annual cost = Rs. %.0f \n\n", tac1);
34
35  kw2=ep*gcc;
36  kwh2=grc*inc;
37  tac2=kw2+kwh2;
38  printf("(ii) Purchasing from grid supply: \n");
39  printf("Annual charge due to extra kW max demand =
        Rs. %.0f \n", kw2);
40  printf("Annual charge due to extra kWh consumption =
         Rs. %.0f \n", kwh2);
41  printf("Total Annual cost = Rs. %.0f \n\n", tac2);
42
43  cheap=abs(tac1-tac2);
44
45  if tac1<tac2
46
47    printf("Alternative (i) is cheaper by Rs. %.0f\n",
          cheap);
48  else
49   printf("Alternative (ii) is cheaper by Rs. %.0f\n",
          cheap);
```

Chapter 6

Power factor improvement

Scilab code Exa 6.1 extra power supplied

```
1  //Chapter 6
2  //Example 6_1
3  //Page 109
4
5  clear;clc;
6
7  kw=300;
8  pf=0.6;
9
10 kva=kw/pf;
11 p=kva-kw;
12
13 printf("kVA = %0.f kW \n\n", kva);
14 printf("Increased power supplied by the alternator =
        %0.f kW \n\n", p);
```

Scilab code Exa 6.2 capacitance in parallel

```
1  //Chapter 6
2  //Example 6_2
3  //Page 109
4
5  clear;clc;
6
7  v=400;
8  f=50;
9  im=31.7;
10 pf1=0.7;
11 pf2=0.9;
12
13 acim=im*pf1;
14 i=acim/pf2;
15 rcim=im*sin(acos(pf1));
16 rci=i*sin(acos(pf2));
17 ic=rcim-rci;
18 c=ic/v/(2*%pi*f);
19
20 printf("Active component of Im = %.2f A \n\n", acim)
      ;
21 printf("Active component of I = %.1f*I A \n\n", pf2)
      ;
22 printf("Reactive component of Im = %.2f A \n\n",
      rcim);
23 printf("Reactive component of I = %.2f A \n\n", rci)
      ;
24 printf("Current through capacitor = %.2f A \n\n", ic
      );
25 printf("C = %.2f uF \n\n", c*1e6);
```

Scilab code Exa 6.3 `kw kva and pf`

```
1  //Chapter 6
2  //Example 6_3
3  //Page 110
4
5  clear;clc;
6
7  kw=[20 100 50];
8  pf=[1 -0.707 0.9];
9
10 tkvar=0;
11 for i=1:3
12   kva(i)=abs(kw(i)/pf(i));
13   printf("kVA %i = %.2f kVA \n", i,kva(i));
14   kvar(i)=kva(i)*sin(acos(pf(i)));
15   printf("kVAR %i = %.2f kVAR \n", i,kvar(i));
16 end;
17 tkvar=kvar(1)+kvar(2)+kvar(3);
18 tkva=sqrt(sum(kw)^2+(tkvar)^2);
19 printf("Total kW = %.2f kW \n", sum(kw));
20 printf("Total kVAR = %.2f kVAR \n", tkvar);
21 printf("Total kVA = %.2f kVA \n", tkva);
22 printf("Power factor = %.2f lagging\n", sum(kw)/tkva
      );
```

Scilab code Exa 6.4 rating of capacitors

```
1  //Chapter 6
2  //Example 6_4
3  //Page 111
4
5  clear;clc;
6
7  p=5;
```

```
 8  pf1=0.75;
 9  pf2=0.9;

11  phi1=acos(pf1);
12  phi2=acos(pf2);

14  lead_kvar=p*(tan(phi1)-tan(phi2));
15  c=lead_kvar/3;

17  printf("Leading kVAR taken by condensor bank = %.2f
        kVAR \n\n", lead_kvar);
18  printf("Rating of capacitors connected in phase = %
        .3f kVAR \n\n",c);
```

Scilab code Exa 6.5 capacitance of each capacitor

```
 1  //Chapter 6
 2  //Example 6_5
 3  //Page 111
 4
 5  clear;clc;
 6
 7  f=50;
 8  v=400;
 9  op=74.6;
10  pf1=0.75;
11  n=0.93;
12  pf2=0.95;
13  nc=4;
14  vc=100;
15
16  p=op/n;
17  phi1=acos(pf1);
```

```
18  phi2=acos(pf2);
19  lead=p*(tan(phi1)-tan(phi2));
20  lead_each=lead/3;
21  icp=2*%pi*f*v;
22  kvar=v*icp/1000;
23  c=lead_each/kvar;
24  c_each=c*nc;
25
26  printf("Leading kVAR taken by the condensor bank = %
        .2f kVAR \n\n", lead);
27  printf("Leading kVAR taken by the each of the three
        sets = %.2f kVAR \n\n", lead_each);
28  printf("Phase current of each capacitor is = %.2f*C
        A \n\n", icp);
29  printf("kVAR/phase = %.2f*C \n\n", kvar);
30  printf("C = %.2f uF \n\n", c*1e6);
31  printf("Capacitance of each capacitor is = %.2f uF \
        n\n", c_each*1e6);
```

Scilab code Exa 6.6 annual saving 2

```
1  //Chapter 6
2  //Example 6_6
3  //Page 112
4
5  clear;clc;
6
7  p=800;
8  pf1=0.8;
9  pf2=0.9;
10  h=3000;
11  fc=100;
12  rc=0.2;
```

```
13  cap=60;
14  id=0.1;
15
16  phi1=acos(pf1);
17  phi2=acos(pf2);
18
19  lead=p*(tan(phi1)-tan(phi2));
20
21  printf("Leading kVAR taken by the capacitors = %.2f
        \n\n", lead);
22  printf("Annual cost before pf correction\n");
23
24  md1=p/pf1;
25  kva1=fc*md1;
26  uc1=p*h;
27  ec1=rc*uc1;
28  tac1=kva1+ec1;
29
30  printf("Max kVA demand = %.2f \n", md1);
31  printf("kVA demand charges = Rs. %.0f \n", kva1);
32  printf("Units consumed per year = %.0f kWh \n", uc1)
        ;
33  printf("Energy charges per year = Rs. %.0f \n", ec1)
        ;
34  printf("Total annual cost = Rs. %.0f \n\n", tac1);
35
36  printf("Annual cost after pf correction\n");
37
38  md2=p/pf2;
39  kva2=fc*md2;
40  ec2=rc*uc1;
41  cc=cap*lead;
42  aid=id*cc;
43  tac2=kva2+ec2+aid;
44
45  printf("Max kVA demand = %.2f \n", md2);
46  printf("kVA demand charges = Rs. %.0f \n", kva2);
47  printf("Energy charges per year = Rs. %.0f \n", ec2)
```

```
     ;
48  printf("Capital cost of capacitors = Rs. %.0f \n",
        cc);
49  printf("Annual interest and depreciation = Rs. %.0f
        \n", aid);
50  printf("Total annual cost = Rs. %.0f \n\n", tac2);
51
52  as=tac1-tac2;
53  printf("Annual saving = Rs. %.0f \n", as);
```

Scilab code Exa 6.7 annual saving 3

```
1   //Chapter 6
2   //Example 6_7
3   //PAge 112
4
5   clear;clc;
6
7   p1=200;
8   pf1=0.85;
9   pf2=0.9;
10  h=2500;
11  fc=150;
12  rc=0.05;
13  cap=420;
14  loss=100;
15  id=0.1;
16
17  phi1=acos(pf1);
18  phi2=acos(pf2);
19
20  ini=p1*tan(phi1);
21  x=(ini-p1*tan(phi2))/(1+0.1*tan(phi2));
```

```
22  printf("Lead kVAR taken by tha capacitor is = %.2f
        kVAR \n\n", x);
23
24  printf("Annual cost before pf correction \n");
25
26  md1=p1/pf1;
27  kva1=fc*md1;
28  uc1=p1*h;
29  ec1=rc*uc1;
30  tac1=kva1+ec1;
31
32  printf("Max kVA demand = %.2f \n", md1);
33  printf("kVA demand charges = Rs. %.0f \n", kva1);
34  printf("Units consumed per year = %.0f kWh \n", uc1)
        ;
35  printf("Energy charges per year = Rs. %.0f \n", ec1)
        ;
36  printf("Total annual cost = Rs. %.0f \n\n", tac1);
37
38  printf("Annual cost after pf correction \n");
39
40  md2=p1/pf2;
41  kva2=fc*md2;
42  ec2=rc*uc1;
43
44  aid=x*cap*id;
45  cap_loss=0.1*x*h;
46  al=cap_loss*rc;
47  tac2=kva2+ec2+aid+al;
48
49  printf("Max kVA demand = %.2f \n", md2);
50  printf("kVA demand charges = Rs. %.0f \n", kva2);
51  printf("Energy charges per year = Rs. %.0f \n", ec2)
        ;
52  printf("Annual interest and depreciation = Rs. %.0f
        \n", aid);
53  printf("Annual energy loss in capacitors = %.0f kWh
        \n", cap_loss);
```

```
54  printf("Annual cost of losses occuring in capacitors
         = Rs. %.0f \n", al);
55  printf("Total annual cost = Rs. %.0f \n\n", tac2);
56
57  as=tac1-tac2;
58  printf("Annual saving = Rs. %.0f \n", as);
```

Scilab code Exa 6.8 net annual saving

```
1  //Chapter 6
2  //Example 6_8
3  //PAge 113
4
5  clear;clc;
6
7  md=750;
8  pf=0.8;
9  nc=250;
10 pr=8.5;
11 ic=20000;
12 fc=0.1;
13
14 phi=acos(pf);
15 ac=md*pf;
16 rc=md*sin(phi);
17 lead=rc-nc;
18 kva=sqrt(ac^2+lead^2);
19 red=md-kva;
20 m_saving=pr*red;
21 y_saving=m_saving*12;
22 fc_year=fc*ic;
23 net=y_saving-fc_year;
24
```

```
25  printf("Monthly demand = %.0f kVA \n", md);
26  printf("kW component of demand = %.0f \n", ac);
27  printf("kVA component of demand = %.0f \n", rc);
28  printf("Lead kVA = %.0f kVA \n", lead);
29  printf("kVA after improvement = %.2f kVA \n", kva);
30  printf("Reduction in kVA = %.2f kVA \n", red);
31  printf("Monthly saving on kVA charges = Rs. %.2f \n"
        , m_saving);
32  printf("Yearly saving on kVA charges = Rs. %.2f \n",
         y_saving);
33  printf("Fixed charges per year = Rs. %.0f \n",
        fc_year);
34  printf("Net annual saving = Rs. %.0f \n\n", net);
```

Scilab code Exa 6.9 `motor power factor`

```
1  //Chapter 6
2  //Example 6_9
3  //Page 113
4
5  clear;clc;
6
7  p1=200;
8  p2=80;
9  pf1=0.8;
10 pf2=0.9;
11
12 p=p1+p2;
13 phi1=acos(pf1);
14 phi2=acos(pf2);
15
16 //From the figure given,
17
```

```
18  lead=p1*tan(phi1)-p*tan(phi2);
19  kva_rating=sqrt(p2^2+lead^2);
20  pf=p2/kva_rating;
21
22  printf("Combined load = %.0f kW \n\n", p);
23  printf("(i) Leading kVAR taken by the motor = %.2f
        kVAR \n\n", lead);
24  printf("(ii) kVA rating of the motor = %.2f kVA \n\n
        ", kva_rating);
25  printf("(iii) pf of the motor = %.2f \n\n", pf);
```

Scilab code Exa 6.10 `total annual bill`

```
1  //Chapter 6
2  //Example 6_10
3  //Page 114
4
5  clear;clc;
6
7  im=37.3;
8  pf1=0.8;
9  n_im=0.85;
10  sm=18.65;
11  pf2=0.9;
12  n_sm=0.9;
13  ll=10;
14  pf3=1;
15  fc=60;
16  rc=0.05;
17  h=2000;
18
19  ip_im=im/n_im;
20  lag_im=ip_im*tan(acos(pf1));
```

```
21  printf("Input power to induction motor = %.2f kW \n"
        , ip_im);
22  printf("Lagging kVAR taken by induction motor = %.2f
        kW \n\n", lag_im);
23
24  ip_sm=sm/n_sm;
25  lead_sm=ip_sm*tan(acos(pf2));
26  printf("Input power to synchronous motor = %.2f kW \
        n", ip_sm);
27  printf("Leading kVAR taken by synchronous motor = %
        .2f kW \n\n", lead_sm);
28  net=lag_im-abs(lead_sm);
29  tap=ip_im+ip_sm+ll;
30  tkva=abs(sqrt(net^2+tap^2));
31  dc=fc*tkva;
32  ec=tap*h;
33  aec=abs(rc*ec);
34  t=dc+aec;
35
36  printf("Net lagging kVAR = %.2f \n", net);
37  printf("Total active power = %.2f \n", tap);
38  printf("Total kVA = %.2f \n", tkva);
39  printf("Annual demand charges = Rs. %.2f \n", dc);
40  printf("Energy consumed per year = %.2f kWh \n", ec)
        ;
41  printf("Annual energy charges = Rs. %.2f \n", aec);
42  printf("Total annual bill = Rs. %.2f \n", t);
```

Scilab code Exa 6.11 synchronous motor power factor

```
1  //Chapter 6
2  //Example 6_11
3  //Page 114
```

```
 4
 5  clear;clc;
 6
 7  ll=500;
 8  l1=400;
 9  pf1=0.707;
10  l2=800;
11  pf2=0.8;
12  l3=500;
13  pf3=0.6;
14  dcg=540;
15  n=0.9;
16
17  tlag=l1*tan(acos(pf1))+l3*tan(acos(pf3));
18  lead=l2*tan(acos(pf2));
19  tlead=tlag-lead;
20  ip=dcg/n;
21  tan_phi=tlead/lead;
22  phi=atan(tan_phi);
23  pf=cos(phi);
24
25  printf("Total lagging kVAR taken = %.2f \n", tlag);
26  printf("Leading kVAR taken = %.2f \n", lead);
27  printf("Total leading kVAR taken = %.2f \n", tlead);
28  printf("Motor input = %.2f kW \n", ip);
29  printf("phi = %.2f radians\n", phi);
30  printf("Power factor of synchronous motor = %.2f
        lead\n", pf);
```

Scilab code Exa 6.12 annual saving 5

```
1  //Chapter 6
2  //Example 6_12
```

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```scilab
3  //Page 115
4
5  clear;clc;
6
7  sm=100;
8  im=200;
9  pf2=0.707;
10  n2=0.82;
11  ll=30;
12  fc=100;
13  rc=0.06;
14  pf1=0.8;
15  n1=0.93;
16
17  printf("(i) When synchronous motor runs at %.1f pf
        lag:\n\n", pf1);
18  ip_sm=sm*735.5/n1/1000;
19  lag1=ip_sm*tan(acos(pf1));
20  printf("\t Input to synchronous motor = %.2f kW \n",
        ip_sm);
21  printf("\t Lagging kVAR taken by synchronous motor =
        %.2f kVAR \n\n", lag1);
22
23  ip_im=im*735.5/n2/1000;
24  lag2=ip_im*tan(acos(pf2));
25  printf("\t Input to induction motor = %.2f kW \n",
        ip_im);
26  printf("\t Lagging kVAR taken by induction motor = %
        .2f kVAR \n\n", lag2);
27
28  tlag1=lag1+lag2;
29  tap1=ip_im+ip_sm+ll;
30  tkva1=sqrt(tlag1^2+tap1^2);
31  dc1=tkva1*fc;
32  ec1=tap1*8760;
33  aec1=ec1*rc;
34  tab1=aec1+dc1;
35  printf("\t Total lagging kVAR = %.2f kVAR \n", tlag1
```

```
      );
36  printf("\t Total active power = %.2f kW \n", tap1);
37  printf("\t Total kVA = %.2f kVA \n", tkva1);
38  printf("\t Annual kVA demand charges = Rs. %.2f \n",
        dc1);
39  printf("\t Energy consumed per year = %.2f kWh \n",
        ec1);
40  printf("\t Annual energy charges = Rs. %.2f \n",
        aec1);
41  printf("\t Total annual bill = Rs. %.2f \n\n", tab1)
        ;
42
43  printf("(ii) When synchronous motor runs at %.1f pf
         lead :\n\n", pf1);
44  net=-lag1+lag2;
45  tap2=ip_im+ip_sm+ll;
46  tkva2=sqrt(net^2+tap2^2);
47  dc2=tkva2*fc;
48  ec2=tap2*8760;
49  aec2=ec2*rc;
50  tab2=aec2+dc2;
51  printf("\t Net lagging kVAR = %.2f kVAR \n", net);
52  printf("\t Total active power = %.2f kW \n", tap2);
53  printf("\t Total kVA = %.2f kVA \n", tkva2);
54  printf("\t Annual kVA demand charges = Rs. %.2f \n",
        dc2);
55  printf("\t Energy consumed per year = %.2f kWh \n",
        ec2);
56  printf("\t Annual energy charges = Rs. %.2f \n",
        aec2);
57  printf("\t Total annual bill = Rs. %.2f \n\n", tab2)
        ;
58
59  as=tab1-tab2;
60  printf("Annual saving = Rs. %.0f \n\n", as);
```

Scilab code Exa 6.13 `economical pf operation`

```
1  //Chapter 6
2  //Example 6_13
3  //Page 118
4
5  clear;clc;
6
7  md=175;
8  pf=0.75;
9  fc=72;
10 pae=120;
11 id=0.1;
12
13 x=fc;
14 y=pae*id;
15 ec_pf=sqrt(1-(y/x)^2);
16
17 printf("MAx demand charges = Rs. %.0f per kVA per
        annum\n", fc);
18 printf("Expenditure on phase advancing equipment =
        Rs. %.0f /kVAR/annum \n", y);
19 printf("Most economical power factor at which
        factory should operate = %.3f lag \n", ec_pf);
```

Scilab code Exa 6.14 `annual saving 6`

```
1  //Chapter 6
```

```
2  //Example 6_14
3  //PAge 119
4
5  clear;clc;
6
7  ad=400;
8  pf1=0.8;
9  lf=0.5;
10 fc=50;
11 rc=0.05;
12 pf2=0.95;
13 pae=100;
14 id=0.1;
15
16 p=ad/lf;
17 printf("Max kW demand = %.0f kW \n\n", p);
18
19 phi1=acos(pf1);
20 phi2=acos(pf2);
21
22 lead=p*(tan(phi1)-tan(phi2));
23 printf("(i) Leading kVAR taken by the phase
       advancing equipment = %.2f kVAR \n", lead);
24 printf("    Capacity of phase advancing equipment =
       %.2f kVAR \n\n", lead);
25 x=fc;
26 y=pae*id;
27 max1=p/pf1;
28 max2=p/pf2;
29 as=fc*(max1-max2);
30 aexp=y*lead;
31 net=as-aexp;
32
33 printf("(ii) Max demand charges = %.0f kW \n", x);
34 printf("    Expenditure on phase advnacing
       equipement = Rs. %.2f /kVAR/annnum \n", y);
35 printf("    Max demand at %.1f pf = %.2f kVA \n",
       pf1,max1);
```

```
36  printf ("      Max demand at %.1 f pf = %.2 f kVA \n",
        pf2 , max2 );
37  printf ("       Annual saving in max demand charges =
        Rs. %.2 f \n", as );
38  printf ("       Annual expenditure in max demand
        charges = Rs. %.2 f \n", aexp );
39  printf ("       Net Annual saving = Rs. %.2 f \n", net );
```

Scilab code Exa 6.15 annual saving 9

```
1  // Chapter 6
2  // Example 6_15
3  // Page 119
4
5  clear ; clc ;
6
7  md =50;
8  lf =0.5;
9  pf =0.75;
10  fc =100;
11  rc =0.05;
12  lfc =600;
13  id =0.1;
14
15  x = fc ;
16  y = id * lfc ;
17  z = y / x ;
18  ec_pf = sqrt (1 -z ^2);
19  kwd = md / lf ;
20  m1 = kwd / pf ;
21  m2 = kwd / ec_pf ;
22  as = fc *( m1 - m2 );
23
```

```
24  printf("Max demand charge = Rs. %.0f/kVA/annum \n",
        x);
25  printf("Expendiutre on capacitors = Rs. %.0f/kVA/
        annum \n", y);
26  printf("Most economical pf = %.2f \n", ec_pf);
27  printf("Max kW demand = %.0f kW \n", kwd);
28  printf("Max kVA demand at %.2f pf = %.2f kVA \n", pf
        , m1);
29  printf("Max kVA demand at %.2f pf = %.2f kVA \n",
        ec_pf, m2);
30  printf("Annual saving = Rs. %.0f \n", as);
```

Scilab code Exa 6.16 annual bill 3

```
1  //Chapter 6
2  //Example 6_16
3  //Page 120
4
5  clear;clc;
6
7  p=200;
8  pf=0.8;
9  fc=100;
10 rc=0.05;
11 pae=500;
12 id=0.1;
13 h=5000;
14
15 x=fc;
16 y=pae*id;
17 ec_pf=sqrt(1-(y/x)^2);
18 cap=p*(tan(acos(pf))-tan(acos(ec_pf)));
19 uc=h*p;
```

```
20  ec=uc*rc;
21  cpae=y*cap;
22  dc=x*p/ec_pf;
23  ab=ec+cpae+dc;
24
25  printf("Max demand charges = %.0f kW \n", x);
26  printf("Expenditure on phase advnacing equipement =
        Rs. %.2f /kVAR/annnum \n\n", y);
27  printf("(i) Most economical power factor at which
        factory should operate = %.3f lag \n\n", ec_pf);
28  printf("(ii)Capacity of phase advancing equipment =
        %.2f kVAR \n\n", cap);
29  printf("(iii) Units consumed per year = %.0f kWh \n"
        , uc);
30  printf("Annual energy charges = Rs. %.0f \n", ec);
31  printf("Annual cost of phase advancing equipment =
        Rs. %.0f \n", cpae);
32  printf("Max demand charges = Rs. %.0f \n", dc);
33  printf("Annual bill for energy = Rs. %.0f \n", ab);
```

Scilab code Exa 6.17 annual saving 8

```
1  //Chapter 6
2  //Example 6_17
3  //Page 120
4
5  clear;clc;
6
7  u=80000;
8  md=500;
9  pf1=0.707;
10 fc=120;
11 rc=0.025;
```

```
12 pae=50;
13 pf2=0.9;
14 id=0.1;
15
16 printf("Energy consumed per year = %.0f kWh\n", u);
17 printf("Max kVA demand = %.0f \n", md);
18
19 ac=md*fc+rc*u;
20 printf("Annual cost of supply = Rs. %.0f \n",ac);
21 m1=md*pf1;
22 p=m1;
23 printf("Max kW demand at %.3f pf = %.2f \n", pf1, m1
       );
24 lead=p*(tan(acos(pf1))-tan(acos(pf2)));
25 printf("Leading kVAR taken by phase advancing
       equipment = %.1f kVAR \n", lead);
26 cpae=pae*id*lead;
27 printf("Annual cost of phase advancing equipment =
       Rs. %.0f \n", cpae);
28 m2=p/pf2;
29 printf("Max kW demand at %.3f pf = %.2f \n", pf2, m2
       );
30 red=md-m2;
31 printf("Reduction in kVA demand = %.1f \n", red);
32 as=fc*red;
33 printf("Annual saving in kVA charges = Rs. %.0f \n",
       as);
34 printf("Annual saving = Rs. %.0f \n", as-cpae);
```

Scilab code Exa 6.18 `pfc equipment`

```
1 //Chapter 6
2 //Example 6_18
```

```scilab
3  //Page 123
4
5  clear;clc;
6
7  pf1=0.7;
8  pf2=0.85;
9  add_cost=800;
10
11  //Referring to figure 6.15,
12  //The initial capacity of the plant is OB kVA at pf
       = pf1
13  a1=pf2/pf1;
14  BD=a1-1;
15  tc=BD*add_cost;
16  phi1=(acosd(pf1));
17  phi2=(acosd(pf2));
18  lead=a1*sind(phi1)-sind(phi2);
19  cost=tc/lead;
20
21  disp("COST OF INCREASING PLANT CAPACITY: ");
22  printf("The initial capacity of the plant is OB kVA
       at pf = pf1 \n\n");
23  printf("The increase in kVA capacity of the plant =
       %.4f*OB \n\n", BD);
24  printf("Total cost of increasing the plant capacity
       = Rs. %.2f*OB \n\n", tc);
25
26  disp("COST OF POWER FACTOR CORRECTION EQUIPMENT: ");
27  printf("Leading kVAR taken by p.f correction
       equipment = %.2f*OB \n\n", lead);
28  printf("Let the cost per kVAR of the equipment be Rs
       . y \n\n");
29  printf("Total cost of p.f correction equipment = Rs.
       %.2f*y*OB \n\n", lead);
30  printf("Equating the total cost, y = Rs. %.1f \n\n",
       cost);
```

Scilab code Exa 6.19 phase advancers

```
1  // Chapter 6
2  // Example 6_19
3  // Page 124
4
5  clear ; clc ;
6
7  pf1 =0.7;
8  pf2 =0.866;
9  tc =100;
10 id =0.1;
11
12 // Referring to phasor diagram of figure 6.16 ,
13 a1 = pf2 / pf1 ;
14 BD = a1 -1;
15 ac = BD *10;
16 phi1 =( acosd ( pf1 ));
17 phi2 =( acosd ( pf2 ));
18 lead = a1 * sind ( phi1 ) - sind ( phi2 );
19 pae_cost = lead * id ;
20 cost = ac / pae_cost ;
21
22 disp ( " COST OF INCREASING PLANT CAPACITY : " );
23 printf ( " The increase in kVA capacity of the plant =
      %.4 f *OB \n\n" , BD );
24 printf ( " Total cost of increasing the plant capacity
      = Rs . %.2 f *OB \n\n" , ac );
25
26 disp ( " COST OF PHASE ADVANCING EQUIPMENT : " );
27 printf ( " Leading kVAR taken by p . f correction
      equipment = %.3 f *OB \n\n" , lead );
```

```
28  printf("Let the cost per kVAR of the equipment be Rs
        . y \n\n");
29  printf("Annual cost of phase advancing equipment =
        Rs. %.3f*y*OB \n\n", pae_cost);
30  printf("Equating the total costs for economy, y = Rs
        . %.2f \n\n", cost);
```

Chapter 7

Supply Systems

Scilab code Exa 7.1 saving in feeder copper

```
1  //Chapter 7
2  //Example 7_1
3  //Page 145
4
5  clear;clc;
6
7  v1=200;
8  v2=400;
9
10 //ratio of two voltages r is
11 r=v1/v2;
12 v2_by_v1=1/(2/r);
13 //In the above relation 'v' is volume
14 saving=(1-v2_by_v1)*100;
15
16 printf("%% saving in feeder copper = %d %% \n\n",
       saving);
```

Scilab code Exa 7.4 `additional load`

```
1  //Chapter 7
2  //Example 7_4
3  //Page 149
4
5  clear;clc;
6
7  p1=200;
8
9  //The inference from the derivation is that power
       supplied by 3-phase , 3-wire a.c. system is twice
        the power supplied by single phase 2 wire system
10
11 p2=2*p1;
12
13 printf("Power supplied by 3-phase, 3-wire a.c.
       system is = %d kW \n\n", p2);
14 per=(p2-p1)/p1*100;
15 printf("Thus three phase three wire system can
       supply %d %% additional load \n\n", per);
```

Scilab code Exa 7.5 `conductor volume comparision`

```
1  //Chapter 7
2  //Example 7_5
3  //Page 149
4
```

```scilab
5  clear;clc;
6
7  l=50;
8  mva=5;
9  pf=0.8;
10 kv=33;
11 n=0.9;
12 sr=2.85*1e-8;
13
14 p=mva*1e6*pf;
15 w=0.1*p;
16
17 //Single phase 2-wire system
18 i1=mva*1e6/kv/1000;
19 area1=2*sr*i1^2*l*1000/w;
20 vol1=2*area1*l*1000;
21
22 //3-phase 3-wire system
23 i2=mva*1e6/sqrt(3)/kv/1000;
24 area2=3*i2^2*sr*l*1000/w;
25 vol2=3*area2*l*1000;
26
27 printf("(I) SINGLE PHASE, 2-WIRE SYSTEM: \n");
28 printf("Line current = %.1f A \n", i1);
29 printf("Area of cross section = %.3f*10^-4 m^2 \n",
       area1*1e4);
30 printf("Volume of conductor required = %.2f m^3 \n\n
       ", vol1);
31
32 printf("(II) 3-PHASE, 3-WIRE SYSTEM: \n");
33 printf("Line current = %.1f A \n", i2);
34 printf("Area of cross section = %.3f*10^-4 m^2 \n",
       area2*1e4);
35 printf("Volume of conductor required = %.2f m^3 \n\n
       ", vol2);
```

Scilab code Exa 7.6 voltages in DC 2wire system

```
1  //Chapter 7
2  //Example 7_6
3  //Page 149
4
5  clear;clc;
6
7  kv=11;
8  pf=0.8;
9  r=0.15;
10 vd=0.15;
11 tr=0.05;
12 avd=0.25;
13
14 //single phase system
15 volt_drop=vd*kv*1000;
16 i1=volt_drop/r;
17 p1=i1*kv*1000*pf/1000;
18
19 //DC two wire system
20 v=sqrt((p1*1000*tr)/avd);
21
22 printf("SINGLE PHASE SYSTEM: \n");
23 printf("Voltage drop = %.2f*I1 V \n", vd);
24 printf("Also voltage drop = %d V \n", volt_drop);
25 printf("Load current = I1 = %d A \n", i1);
26 printf("Power recieved by consumer = %.2f*10^4 kW \n
       \n", p1*1e-4);
27
28 printf("DC TWO WIRE SYSTEM: \n");
29 printf("Load current = I2 = %d/V A \n", p1*1000);
```

```
30  printf ("Voltage  drop  = %.2 f *%.3 f /V  \n", p1 *1000, tr)
       ;
31  printf ("Allowable  voltage  drop  = %.2 f  V  \n", avd);
32  printf ("V = %d V  \n\n", v);
```

Scilab code Exa 7.7 area of conductor 1

```
1  // Chapter  7
2  // Example  7_7
3  // Page  153
4
5  clear ; clc ;
6
7  l =1;
8  i =200;
9  // cost  = (20*a  + 20)
10  cost =5;
11  id =0.1;
12  p =1.73*1e -6;
13
14  ra =p*l *1 e5 ;
15  e =2* i ^2* ra *8760/1000;
16  ac = cost *e /100;
17  cc =20*1000;
18  vac = id * cc ;
19  a= sqrt ( ac / vac );
20
21  printf ("Resistance  of  one  conductor  = %.3 f /a  ohm  \n\
       n", ra);
22  printf ("Energy  lost  per  annum  = %.1 f /a  kWh  \n\n", e)
       ;
23  printf ("Annual  cost  of  energy  lost  = Rs.  %d/a  \n\n",
       ac);
```

```
24  printf ("Capital cost is given to be Rs.20*a per
       metre. Threfore for 1km cable = Rs. %d*a \n\n",
       cc);
25  printf ("Variable annual charge = Rs. %d*a \n\n", vac
       );
26  printf ("Area of cross section = %.2f cm^2 \n\n", a);
```

Scilab code Exa 7.8 `area of conductor 2`

```
1  //Chapter 7
2  //Example 7_8
3  //Page 153
4
5  clear; clc;
6
7  mw=5;
8  kv=33;
9  pf=0.8;
10 cost=4;
11 id=0.1;
12 p=1e-6;
13
14 //cost = Rs (25000*a + 2500)
15
16 ra=p*1e5;
17 i=mw*1e6/sqrt(3)/kv/1000/pf;
18 e=3*i^2*ra*8760/1000;
19 ac=cost*e/100;
20 cc=25000;
21 vac=id*cc;
22 a=sqrt(ac/vac);
23
24 printf ("Resistance of one conductor = %.3f/a ohm \n\
```

```
      n ) , ra ) ;
25  printf(" Line current = %.2 f A \n\n", i );
26  printf(" Energy lost per annum = %.1 f /a kWh \n\n", e)
      ;
27  printf(" Annual cost of energy lost = Rs. %d/a \n\n",
      ac ) ;
28  printf(" Capital cost is given to be Rs.20*a per
      metre. Threfore for 1km cable = Rs. %d*a \n\n",
      cc ) ;
29  printf(" Variable annual charge = Rs. %d*a \n\n", vac
      ) ;
30  printf(" Area of cross section = %.2 f cm^2 \n\n", a );
```

Scilab code Exa 7.9 area of conductor 3

```
1  // Chapter 7
2  // Example 7_9
3  // Page 154
4
5  clear ; clc ;
6
7  i =250;
8  cc =5;
9  id =0.1;
10 cost =5;
11 d=8.93;
12 p=1.73*1e-8;
13 l=1;
14
15 ra=p*l;
16 e=2*i^2*ra*8760/1000;
17 ac=cost*e/100;
18 mass=2*d*l*1000;
```

```
19  cc=cc*mass;
20  vac=id*cc;
21  a=sqrt(ac/vac);
22
23  printf("Resistance of one conductor = %.3f*10^-8/a
        ohm \n\n", ra*1e8);
24  printf("Line current = %.2f A \n\n", i);
25  printf("Energy lost per annum = %d*10^-8/a kWh \n\n"
        , e*1e8);
26  printf("Annual cost of energy lost = Rs. %d*10^-8/a
        \n\n", ac*1e8);
27  printf("Mass of 1m feeder = %.2f*10^3*a \n\n", mass
        *1e-3);
28  printf("Capital cost is given to be Rs.20*a per
        metre. Threfore for 1km cable = Rs. %d*a \n\n",
        cc);
29  printf("Variable annual charge = Rs. %d*a \n\n", vac
        );
30  printf("Area of cross section = %.2f*10^-4 m^2 \n\n"
        , a*1e4);
```

Scilab code Exa 7.10 `area of conductor 4`

```
1  //Chapter 7
2  //Example 7_10
3  //Page 154
4
5  clear;clc;
6
7  h=[6 12 6];
8  mw=[20 5 6];
9  pf=[0.8 0.8 0.8];
10 days=365;
```

```
11  kv=110;
12  cc=6000;
13  id=0.1;
14  cost=6;
15  ra=0.176;
16
17  v=kv*1000;
18  printf("Resistance of one conductor = %.3f/a ohm \n\
       n", ra);
19  printf("Line voltage = %d V \n\n", v);
20  sum_i=0;
21  for i=1:3
22    I(i)=mw(i)*1e6/sqrt(3)/v/pf(i);
23    printf("Current at %d MW = %.2f A \n\n", mw(i), I(
         i));
24    sum_i=sum_i+I(i)^2*h(i);
25  end
26  e=3*ra*sum_i/1000;
27  loss=e*days;
28  ac=cost*loss/100;
29  vac=id*cc;
30  a=sqrt(ac/vac);
31
32  printf("Energy lost per day in  three phase line = %
        .2f/a kWh \n\n", e);
33  printf("Energy lost per annum = %.2f/a kWh \n\n",
       loss);
34  printf("Annual cost of energy lost = Rs. %.2f/a \n\n
       ", ac);
35  printf("Variable annual charge = Rs. %d*a \n\n", vac
       );
36  printf("Area of cross section = %.2f cm^2 \n\n", a);
```

Chapter 8

Mechanical Design of Overhead Lines

Scilab code Exa 8.1 string efficiency 1

```
1  //Chapter 8
2  //Example 8_1
3  //page 171
4
5  clear;clc;
6
7  v=33*1e3;
8  k=0.11;
9  ins=3;
10
11 v_string=v/sqrt(3);
12 v1=v_string/(3+4*k+k^2);
13 v2=v1*(1+k);
14 v3=v1*(1+3*k+k^2);
15 n=v_string*100/ins/v3;
16
17 printf(" (i)Voltage across top unit = %.2f kV \n\n",
       v1/1000);
18 printf("    Voltage across middle unit = %.2f kV \n\n
```

```
      ", v2/1000);
19 printf("    Voltage across bottom unit = %.2f kV \n\n
      ", v3/1000);
20 printf("(ii) String efficiency = %.2f %% \n\n", n);
```

Scilab code Exa 8.2 string efficiency 2

```
 1 //Chapter 8
 2 //Example 8_2
 3 //Page 172
 4
 5 clear;clc;
 6
 7 v1=8;
 8 v2=11;
 9
10 k=(v2-v1)/v1;
11 v3=v2+(v2+v1)*k;
12 v=v1+v2+v3;
13 lv=sqrt(3)*v;
14 n=v*100/3/v3;
15
16 printf("k = %.2f kV \n\n", k);
17 printf("Voltage across third unit = %.2f kV \n\n",
      v3);
18 printf("Voltage between line and earth = %.2f kV \n\
      n", v);
19 printf("Line voltage = %.2f kV \n\n", lv)
20 printf("String efficiency = %.2f %% \n\n", n);
```

Scilab code Exa 8.3 `string efficiency 3`

```
1  //Chapter 8
2  //Example 8_3
3  //Page 172
4
5  clear;clc;
6
7  ins=3;
8  v3=17.5;
9  k=1/8;
10 v1=v3/(1+3*k+k^2);
11 v2=(1+k)*v1;
12 v=v1+v2+v3;
13
14 n=v*100/3/v3;
15
16 printf("Voltage across first unit = %.2f kV \n\n",
      v1);
17 printf("Voltage across second unit = %.2f kV \n\n",
      v2);
18 printf("Voltage between line and earth = %.2f kV \n\
      n", v);
19 printf("String efficiency = %.2f %% \n\n", n);
```

Scilab code Exa 8.4 `voltage between busbars`

```
1  //Chapter 8
```

```
2  //Example 8_4
3  //Page 173
4
5  clear;clc;
6
7  v2=11;
8  v3=13.1;
9
10 p1=poly([1 3 1], 'k', 'c');
11 p2=poly([1 1],'k', 'c');
12 p=v3*p2-v2*p1;
13 r=roots(p, 'e');
14 k=r(2);
15
16 v1=v2/(1+k);
17 printf("V1 = %.2f kV \n\n", v1);
18
19 v=v1+v2+v3;
20 printf("Voltage between line and earth = %.2f kV \n\
      n", v);
21 printf("Voltage between bus bars = %.2f kV \n\n", v*
      sqrt(3));
```

Scilab code Exa 8.5 string efficiency 4

```
1  //Chapter 8
2  //Example 8_5
3  //Page 173
4
5  clear;clc;
6
7  ins=3;
8  v3=15;
```

```
 9  k =1/8;
10  v1 = v3 /(1+3* k + k ^2) ;
11  v2 =(1+ k )* v1 ;
12  v = v1 + v2 + v3 ;
13
14  n = v *100/3/ v3 ;
15
16  printf (" Voltage  across  first  unit  = %.2 f  kV  \n\n",
        v1 ) ;
17  printf (" Voltage  across  second  unit  = %.2 f  kV  \n\n",
        v2 ) ;
18  printf (" Voltage  between  line  and  earth  = %.2 f  kV  \n\
        n",  v ) ;
19  printf (" String  efficiency  = %.2 f %% \n\n",  n ) ;
```

Scilab code Exa 8.6 string efficiency 5

```
 1  // Chapter  8
 2  // Example  8 _6
 3  // Page  174
 4
 5  clear ; clc ;
 6
 7  ins =4;
 8  k =0.1;
 9  x =1;
10
11  v1 = x *1;
12  v2 = x *(1+ k ) ;
13  v3 = x *(1+3* k + k ^2) ;
14  v4 = x *(1+6* k +5* k ^2) ;
15  v = v1 + v2 + v3 + v4 ;
16
```

```
17  pv1=v1/v*100;
18  pv2=v2/v*100;
19  pv3=v3/v*100;
20  pv4=v4/v*100;
21
22  n=v/ins/v4*100;
23
24  printf("\n(i) Voltage across top unit = %.2f V \n",
        v1);
25  printf("Voltage across second unit = %.2f V \n", v2)
        ;
26  printf("Voltage across third unit = %.2f V \n", v3);
27  printf("Voltage across fourth unit = %.2f V \n\n",
        v4);
28  printf("Voltage across the string = %.2f V \n", v);
29
30  printf("The voltage across each unit expressed as a
        percentage becomes: \n");
31  printf("\t Top unit = %.2f %% \n", pv1);
32  printf("\t Second from top = %.2f %% \n", pv2);
33  printf("\t Third from top = %.2f %% \n", pv3);
34  printf("\t Fourth from top = %.2f %% \n\n", pv4);
35
36  printf("(ii) String efficiency = %.2f %% \n", n);
```

Scilab code Exa 8.7 string efficiency 6

```
1  //Chapter 8
2  //Example 8_7
3  //Page 175
4
5  clear;clc;
6
```

```
 7  ins=5;
 8  vl=100;
 9  k=0.1;
10
11  v1=1;
12  v2=(1+k);
13  v3=(1+3*k+k^2);
14  v4=(1+6*k+5*k^2);
15  v5=(2+1*k+6*k^2);
16
17  v=v1+v2+v3+v4+v5;
18
19  pv1=v1/v*100;
20  pv2=v2/v*100;
21  pv3=v3/v*100;
22  pv4=v4/v*100;
23  pv5=v5/v*100;
24
25  v_string=vl/sqrt(3);
26  v_1=pv1/100*v_string;
27  v_2=pv2/100*v_string;
28  v_3=pv3/100*v_string;
29  v_4=pv4/100*v_string;
30  v_5=pv5/100*v_string;
31
32  n=v_string/ins/v_5;
33
34  printf("Voltage across string = %.2f kV \n\n",
        v_string);
35  printf("(i) Voltage across top insulator = %.2f kV \
        n", v_1);
36  printf("     Voltage across second unit = %.2f V \n",
        v_2);
37  printf("     Voltage across third unit = %.2f V \n",
        v_3);
38  printf("     Voltage across fourth unit = %.2f V \n",
        v_4);
39  printf("     Voltage across fifth unit = %.2f V \n\n"
```

```
      , v_5 ) ;
40
41 printf (" ( i i )  String  efficiency  = %.2 f %% \n\n" , n
      *100) ;
```

Scilab code Exa 8.8 `voltage between conductors`

```
1 // Chapter 8
2 // Example 8_8
3 // Page 176
4
5 clear ; clc ;
6
7 v2 =13.2 ;
8 v3 =18 ;
9
10 p1=poly ( [1 3 1 ] ,  'k ' ,  'c ') ;
11 p2=poly ( [1 1 ] , 'k ' ,  'c ') ;
12 p=v3*p2-v2*p1 ;
13 r=roots (p ,  'e ') ;
14 k=r (2) ;
15
16 v1=v2/(1+k) ;
17 printf ( "Voltage  across  first  unit  = V1 = %.2 f kV \n\
      n" , v1) ;
18 v4=v1*(1+k^3+5*k^2+6*k) ;
19 printf ( "Voltage  across  fourth  unit  = V4 = %.2 f kV \n
      \n" , v4) ;
20
21 v=v1+v2+v3+v4 ;
22 printf ( "Voltage  between  line  and  earth  = %.2 f kV \n\
      n" , v) ;
23 printf ( "Voltage  between  bus  bars  = %.2 f kV \n\n" , v*
```

```scilab
        sqrt (3) );
```

Scilab code Exa 8.9 string efficiency 7

```scilab
1  // Chapter 8
2  // Example 8_9
3  // Page 177
4
5  clear ; clc ;
6
7  ins =4;
8  k =1/5;
9
10  v1 =1;
11  v2 = v1 *(1+ k );
12  v3 = v1 *(1+3* k + k ^2) ;
13  v4 = v1 *(1+6* k +5* k ^2+ k ^3) ;
14  v = v1 + v2 + v3 + v4 ;
15
16  pv1 = v1 / v *100;
17  pv2 = v2 / v *100;
18  pv3 = v3 / v *100;
19  pv4 = v4 / v *100;
20
21  n = v / ins / v4 *100;
22
23  printf ( " \ n ( i )  V1 = %.2 f  V  \ n " , v1 ) ;
24  printf ( " V2 = %.2 f  V  \ n " , v2 ) ;
25  printf ( " V3 = %.2 f  V  \ n " , v3 ) ;
26  printf ( " V4 = %.2 f  V  \ n \ n " , v4 ) ;
27  printf ( " Voltage  across  the  string  = %.2 f  V  \ n " , v ) ;
28
29  printf ( " The  voltage  across  each  unit  expressed  as  a
```

```
        percentage becomes : \n");
30 printf("\t Top unit = %.2f %% \n", pv1);
31 printf("\t Second from top = %.2f %% \n", pv2);
32 printf("\t Third from top = %.2f %% \n", pv3);
33 printf("\t Fourth from top = %.2f %% \n\n", pv4);
34
35 printf("(ii) String efficiency = %.2f %% \n", n);
```

Scilab code Exa 8.10 string efficiency

```
1  //Chapter 8
2  //Example 8_10
3  //Page 177
4
5  clear;clc;
6
7  shunt_cap=0.15;
8  line_cap=0.1;
9  n=3;
10
11 v1=13.25/40.55;
12 v2=12.5*v1/13.25;
13 v3=14.8*v1/13.25;
14
15 pv1=v1*100;
16 pv2=v2*100;
17 pv3=v3*100;
18 eff=1/n/v3*100;
19
20 printf("V1 = %.3f V \n", v1);
21 printf("V2 = %.3f V \n", v2);
22 printf("V3 = %.3f V \n\n", v3);
23
```

```
24  printf (" (i) Voltage expressed as a percentage of V :
        \n");
25  printf ("     Top unit = %.2 f %% \n", pv1);
26  printf ("     Middle unit = %.2 f %% \n", pv2);
27  printf ("     Third unit = %.2 f %% \n\n", pv3);
28
29  printf (" (ii) String efficiency = %.2 f %% \n\n", eff)
        ;
```

Scilab code Exa 8.11 string eff 1

```
1  // Chapter 8
2  // Example 8_11
3  // Page 179
4
5  clear ; clc ;
6
7  n=3;
8  shunt =0.2;
9  line =0.1;
10 lower =0.3;
11
12 v2 =15.4/15.5;
13 v3 =12 -11*0.993;
14 v=1+ v2+v3 ;
15 eff =v/n/v3 ;
16
17 printf (" V2 = %.3 f *V1 \n", v2);
18 printf (" V3 = %.3 f *V1 \n", v3);
19 printf (" Voltage between conductor and earth = %.2 f *
        V1 \n", v);
20 printf (" String efficiency = %d %% \n\n", eff *100);
```

Scilab code Exa 8.12 `v across each insulator`

```
1  //Chapter 8
2  //Example 8_11
3  //Page 179
4
5  clear;clc;
6
7  c1=1/6;
8  c2=2/5;
9  c3=3/4;
10 c4=4/3;
11 c5=5/2;
12 c6=6/1;
13
14 printf("At Junction A : C1 = %.3f C \n", c1);
15 printf("At Junction B : C2 = %.3f C \n", c2);
16 printf("At Junction C : C3 = %.3f C \n", c3);
17 printf("At Junction D : C4 = %.3f C \n", c4);
18 printf("At Junction E : C5 = %.3f C \n", c5);
19 printf("At Junction F : C6 = %.3f C \n", c6);
```

Scilab code Exa 8.13 `rms line voltage`

```
1  //Chapter 8
2  //Example 8_13
3  //Page 184
4
```

```
5  clear ; clc ;
6
7  r =1;
8  d =100;
9  go =30/ sqrt (2);
10 mo =0.9;
11 delta =0.952;
12
13 vc = mo * go * delta * r * log ( d / r );
14 lv = vc * sqrt (3);
15
16 printf (" Disruptive  critical  voltage  = %.2 f  kV / phase
        \n\n", vc );
17 printf (" Line  voltage  = %.2 f  kV  \n\n", lv );
```

Scilab code Exa 8.14 conductor spacing

```
1  // Chapter  8
2  // Example  8_14
3  // Page  184
4
5  clear ; clc ;
6
7  v =132;
8  r =1.956/2;
9  vd =210;
10 go =30/ sqrt (2);
11 mo =1;
12 delta =1;
13
14 vc = vd / sqrt (3);
15 dr = exp ( vc / mo / go / delta / r );
16 d = dr * r ;
```

```
17
18 printf(" Conductor spacing = %.2 f cm \n\n", d);
```

Scilab code Exa 8.15 `total corona loss`

```
1  //Chapter 8
2  //Example 8_15
3  //Page 185
4
5  clear;clc;
6
7  v=220;
8  r=1.5;
9  d=200;
10 t=40;
11 b=76;
12 mo=0.85;
13 f=50;
14
15 delta=3.92*b/(273+t);
16 go=30/sqrt(2);
17
18 vc=mo*go*delta*r*log(d/r);
19 v_phase=v/sqrt(3);
20
21 pc=242.2/delta*(f+25)*sqrt(r/d)*(v_phase-vc)^2*1e-5;
22
23 printf(" Delta = %.3 f \n\n", delta);
24 printf(" Disruptive critical voltage per phase = %.2 f
       kV \n\n", vc);
25 printf(" Supply voltage per phase = %.2 f kV \n\n",
       v_phase);
26 printf(" Corona loss = %.5 f kW/km/phase \n\n", pc);
```

```
27  printf("Total corona loss = %.5f kW \n\n", pc*3);
```

Scilab code Exa 8.16 power loss

```
1  //Chapter 8
2  //Example 8_16
3  //Page 185
4
5  clear;clc;
6
7  pc=53;
8  v=106;
9  loss=98;
10 pl=110.9;
11 cv=113;
12
13 sq=sqrt(loss/pc);
14 vc=(sq*v/sqrt(3)-pl/sqrt(3))/(sq-1);
15 w=(cv/sqrt(3)-vc)^2/(v/sqrt(3)-vc)^2*pc;
16
17 printf("Critical disruptive voltage = %.2f kV \n\n",
       vc);
18 printf("Power loss at %.0f kV = %.0f kW \n\n", cv, w
       );
```

Scilab code Exa 8.17 ground clearing 1

```
1  //Chapter 8
2  //Example 8_17
```

```
3 //Page 190
4
5 clear;clc;
6
7 w=680;
8 sf=2;
9 strength=3100;
10 l=260;
11 gc=10;
12
13 t=strength/sf;
14 sag=w/1000*l^2/8/t;
15
16 printf("Working tension = %.0f kg \n\n", t);
17 printf("Sag = %.1f m \n\n", sag);
18 printf("Conductor should be supported at a height of
      %.1f m \n\n", sag+gc);
```

Scilab code Exa 8.18 sag and vertical sag

```
1 //Chapter 8
2 //Example 8_18
3 //Page 190
4
5 clear;clc;
6
7 l=150;
8 t=2000;
9 ww=1.5;
10 sg=9.9;
11 area=2;
12
13 w=sg*area*100/1000;
```

```
14  wt=sqrt(w^2+ww^2);
15  sag=wt*l^2/8/t;
16  theta=atan(ww/w);
17  vsag=sag*cos(theta);
18
19  printf("Weight of conductor per length = %.2f kg \n\
        n", w);
20  printf("Total weight of 1m conductor = %.2f kg \n\n"
        , wt);
21  printf("Sag = %.2f m \n\n", sag);
22  printf("theta = %.2f degrees \n\n", theta/%pi*180);
23  printf("Vertical sag = %.2f m \n\n", vsag);
```

Scilab code Exa 8.19 vertical sag 2

```
1  //Chapter 8
2  //Example 8_19
3  //Page 191
4
5  clear;clc;
6
7  l=200;
8  w=1170/1000;
9  bs=4218;
10  area=1.29;
11  pr=122;
12  sf=5;
13
14  t=bs*area/sf;
15  d=sqrt(4*area/%pi);
16  ww=pr*d*1e-2;
17  wt=sqrt(w^2+ww^2);
18  sag=wt*l^2/8/t;
```

```
19  theta=atan(ww/w);
20  vsag=sag*cos(theta);
21
22  printf("Working tension = %.0f kg \n\n", t);
23  printf("Diameter of the conductor = %.2f \n\n", d);
24  printf("Total weight of the conductor per metre
        length = %.2f kg \n\n", wt);
25  printf("Slant sag = %.2f m \n\n", sag);
26  printf("theta = %.2f degrees \n\n", theta*180/%pi);
27  printf("Vertical sag = %.2f m \n\n", vsag);
```

Scilab code Exa 8.20 `sag in tr lines`

```
1  //Chapter 8
2  //Example 8_20
3  //Page 191
4
5  clear;clc;
6
7  l=275;
8  d=1.96;
9  us=8060;
10  sf=2;
11  ice_t=1.27;
12  w=0.865;
13  pr=2;
14  wcc=0.91;
15  wp=3.9;
16
17  t=us/sf;
18  vol=%pi*ice_t*(d+ice_t)*100;
19  wi=wcc*vol/1000;
20  ww=wp*(d+2*ice_t)*100/1000;
```

```
21  wt=sqrt((w+wi)^2+ww^2);
22  sag=wt*l^2/8/t;
23
24  printf("Working tension = %.0f kg \n\n", t);
25  printf("Volume of ice per metre length of the
        conductor = %.0f cm^3 \n\n", vol);
26  printf("Weight of ice per metre length of conductor
        is %.2f kg \n\n", wi);
27  printf("Wind force/m length of conductor is %.3f kg
        \n\n", ww);
28  printf("Total weight of conductor per metre length
        of conductor is %.3f kg \n\n", wt);
29  printf("Sag = %.2f m \n\n", sag);
```

Scilab code Exa 8.21 `safety factor`

```
1   //Chapter 8
2   //Example 8_21
3   //Page 192
4
5   clear;clc;
6
7   l=214;
8   vsag=2.35;
9   w=1.125;
10  ww=1.5;
11  area=3.225;
12  bs=2540;
13
14  wt=sqrt(w^2+ww^2);
15  t=bs*area;
16  s=vsag*wt/w;
17  f=t*8*s/(wt*l^2);
```

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```
18
19  printf("Total weight of 1m length of conductor = %.3
        f kg \n\n", wt);
20  printf("Working tension = %.0f/f kg \n\n",t);
21  printf("Slant sag = %.2f m \n\n", s);
22  printf("Safety factor = %.0f \n\n", f);
```

Scilab code Exa 8.22 ground clearance 2

```
1  //Chapter 8
2  //Example 8_22
3  //Page 192;
4
5  clear;clc;
6
7  l=150;
8  area=2;
9  us=5000;
10 sf=5;
11 sg=8.9;
12 ww=1.5;
13 mc=7;
14
15 w=area*sg*100/1000;
16 t=us*area/sf;
17 wt=sqrt(w^2+ww^2);
18 s=wt*l^2/8/t;
19 vsag=s*w/wt;
20
21 printf("Wt of conductor = %.2f kg \n\n", w);
22 printf("Working tension = %.0f kg \n\n", t);
23 printf("Total weight = %.2f kg \n\n", wt);
24 printf("Slant sag = %.2f m \n\n", s);
```

```
25 printf(" Vertcal  sag  = %.2 f  m  \n\n",  vsag);
26 printf(" Ground  clearance  = %.2 f  m  \n\n",  vsag+mc);
```

Scilab code Exa 8.23 `clearence from water level`

```
1 //Chapter 8
2 //Example 8_23
3 //Page 193
4
5 clear;clc;
6
7 l=500;
8 w=1.5;
9 t=1600;
10 h2=90;
11 h1=30;
12 h=h2-h1;
13
14 printf("x1+x2=500 \n");
15 d=h*2*t/w/l;
16 printf("x2-x1=%.0 f \n\n", d);
17
18 A=[1 1; -1 1];
19 b=[l; d];
20 X=A\b;
21 x1=X(1);
22 x2=X(2);
23
24 s1=w*x1^2/2/t;
25 cl=h1-s1;
26 x=l/2-x1;
27 smid=w*x^2/2/t;
28 clmp=cl+smid;
```

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```
29
30  printf("x1 = %.0f m \n", x1);
31  printf("x2 = %.0f m \n\n", x2);
32  printf("S1 = %.0f m \n", s1);
33  printf("Clearance of the lowest point O from water
        level = %.0f m \n", cl);
34  printf("The distance from the lowest point to the
        midpoint = %.0f m \n", x);
35  printf("Sag at midpoint = %.2f m \n", smid);
36  printf("Clearance of mid point from water level = %
        .2f m \n\n", clmp);
```

Scilab code Exa 8.24 sag

```
1  //Chapter 8
2  //Example 8_24
3  //Page 194
4
5  clear;clc;
6
7  l=600;
8  wi=1;
9  h=15;
10 w=1.925;
11 t=8000*2.2/5;
12
13 wt=w+wi;
14 d=2*h*t/(1+w)/l;
15
16 A=[1 1; -1 1];
17 b=[l; d];
18 X=A\b;
19 x1=X(1);
```

```
20  x2=X(2);
21
22  s2=wt*x2^2/2/t;
23
24  printf("x1 = %.0f m \n", x1);
25  printf("x2 = %.0f m \n\n", x2);
26  printf("S2 = %.2f m \n", s2);
```

Scilab code Exa 8.25 clearence from water level 2

```
1   //Chapter 8
2   //Example 8_25
3   //Page 195
4
5   clear;clc;
6
7   h2=90;
8   h1=40;
9   h=h2-h1;
10  l=400;
11  t=2000;
12  w=1;
13
14  d=h*2*t/l;
15
16  A=[1 1; -1 1];
17  b=[l; d];
18  X=A\b;
19  x1=X(1);
20  x2=X(2);
21
22  printf("x1 = %.0f m \n", x1);
23  printf("x2 = %.0f m \n\n", x2);
```

```
24
25  x=abs(x1)+l/2;
26  s2=w*x2^2/2/t;
27  smid=w*x^2/2/t;
28  hb=s2-smid;
29  cl=h2-hb;
30
31  printf("The distance from the lowest point to the
         midpoint = %.0f m \n", x);
32  printf("Sag at midpoint = %.2f m \n", smid);
33  printf("S2 = %.2f m \n", s2);
34  printf("Height of point B from mid point = %.0f m \n
         ", hb);
35  printf("Clearance of mid point from water level = %
         .2f m \n\n", cl);
```

Scilab code Exa 8.26 `clearence from ground`

```
 1  //Chapter 8
 2  //Example 8_26
 3  //Page 195
 4
 5  clear;clc;
 6
 7  grad=20;
 8  h1=22;
 9  h2=22;
10  l=300;
11  lc=2;
12  w=1;
13  t=1500;
14
15  eh=h1-lc;
```

```
16  h=l*(1/grad);
17  dc=sqrt(l^2-h^2);
18  d=2*t*h/w/dc;
19
20  a=[1 1; -1 1];
21  b=[dc; d];
22  x=a\b;
23  s2=w*x(2)^2/2/t;
24  bc=eh+h;
25  og=bc-s2-x(1)*tand(asind(1/grad));
26
27  printf("Effective height of each tower = %d m \n\n",
          eh);
28  printf("Vertical distance between towers is = %d m \
          n\n", h);
29  printf("Horizontal distance between two towers = %d
          m \n\n", dc);
30  printf("x1+x2=%d \n\n", dc);
31  printf("x2-x2=%d m \n\n", d);
32  printf("Solving the two, x1 = %d m , x2 = %d m \n\n"
          , x(1), x(2));
33  printf("Sag S2 = %.2f m \n\n", s2);
34  printf("BC = %.2f m \n\n", bc);
35  printf("Clearance from the lowest point O from the
          ground = %.2f m \n\n", og);
```

Scilab code Exa 8.27 `min clearance`

```
1  //Chapter 8
2  //Example 8_27
3  //Page 196
4
5  clear;clc;
```

```
 6
 7  c=8;
 8  l=300;
 9  s=10;
10  slope=15;
11
12  printf("On level ground: \n")
13  wbyt=8*s/l^2;
14  h=s+c;
15  printf("Height of tower = %d m \n\n", h);
16
17  printf("On sloping ground: \n");
18  hs=l/slope;
19  printf("Vertical distance between two towers = %d m
         \n", hs);
20  x1=75;
21  x2=225;
22  printf("From the graph: \nx1 = 75m, x2 = 225m \n");
23  s1=wbyt*x1^2/2;
24  s2=wbyt*x2^2/2;
25  printf("S1 = %.2f m \n", s1);
26  printf("S2 = %.2f m \n", s2);
27  cl=38-s2-5;
28  printf("Clearance = %.2f m \n", cl);
29  x=75;
30  //minimum clearance
31  minc=8;
32  printf("x = %d m \n", x);
33  printf("Minimum clearance = %d m \n", minc);
```

Chapter 9

Electrical Design of Overhead Lines

Scilab code Exa 9.1 `loop inductance per km 1`

```
1  //Chapter 9
2  //Example 9_1
3  //Page 214
4
5  clear;clc;
6
7  d=200;
8  r=1.2/2;
9
10 loop_l=(1e-7)*(1+4*log(d/r));
11
12 printf("Loop indictance per length of the line = %.2
       f*10^-7 H \n\n", loop_l*1e7 );
13 printf("Loop indictance per km of the line = %.3f mH
       \n\n", loop_l*1e6 );
```

Scilab code Exa 9.2 `loop inductance per km 2`

```
1  //Chapter  9
2  //Example  9_2
3  //PAge  214
4
5  clear;clc;
6
7  d=300;
8  r=1;
9  mr1=1;
10  mr2=100;
11
12  loop_l=(1e-7)*(mr1+4*log(d/r));
13  loop_ls=(1e-7)*(mr2+4*log(d/r));
14
15
16  printf(")(i) With  copper  conductors  mr=1  \n Loop
       indictance  per  meter  = %.2 f*10^-7 H \n\n", loop_l
       *1e7 );
17  printf("Loop  indictance  per  km  = %.3 f mH \n\n",
       loop_l*1e6 );
18
19  printf(")(ii) With  steel  conductors  mr=100 \n Loop
       indictance  per  meter  = %.2 f*10^-7 H \n\n",
       loop_ls*1e7 );
20  printf("Loop  indictance  per  km  = %.3 f mH \n\n",
       loop_ls*1e6 );
```

Scilab code Exa 9.3 `inductance per phase per km 3`

```
1  //Chapter 9
2  //Example 9_3
3  //PAge 215
4
5  clear;clc;
6
7  d=200;
8  r=1.24/2;
9
10 loop_l=(1e-7)*(0.5+2*log(d/r));
11 loop_ls=loop_l*1000;
12
13
14 printf("Loop inductance/phase/m = %d*10^-7 H \n\n",
       loop_l*1e7 );
15
16 printf("Loop indictance per km = %.1f mH \n\n",
       loop_ls*1e3 );
```

Scilab code Exa 9.4 `inductance per phase per km 4`

```
1  //Chapter 9
2
3  //Example 9_4
4  //Page 215
5
```

```
6  clear;clc;
7
8  r=1.24/2;
9  d12=2;
10 d23=2.5;
11 d31=4.5;
12
13 deq=(d12*d23*d31)^(1/3)*100;
14 printf("Equivalent equilateral spacing = %.2f cm \n\
      n", deq);
15
16 loop_l=(1e-7)*(0.5+2*log(deq/r));
17
18 printf("Inductance/phase/m = %.2f*10^-7 H \n\n",
      loop_l*1e7 );
19 printf(" Inductance/phase/km = %.3f mH \n\n", loop_l
      *1e6 );
```

Scilab code Exa 9.5 inductance per phase per km 5

```
1  //Chapter 9
2  //Example 9_5
3  //PAge 215
4
5  clear;clc;
6
7  r=2.54/2;
8  d12=2;
9  d23=2;
10 d31=4;
11
12 deq=(d12*d23*d31)^(1/3);
13 printf("Equivalent equilateral spacing = %.3f cm \n\
```

```
      n" , deq ) ;
14
15  loop_l =(1e -7) *(0.5+2* log ( deq *100/ r ) ) ;
16
17  printf (" Inductance / phase /m = %.2 f *10^ -7 H \n\n" ,
          loop_l *1e7 ) ;
18  printf ("  Inductance / phase /km = %.3 f mH \n\n" , loop_l
          *1e6 ) ;
```

Scilab code Exa 9.6 `loop inductance per km 3`

```
1  // Chapter 9
2  // Example 9_6
3  // Page 215
4
5  clear ; clc ;
6
7  r =1/2;
8  dab =25;
9  daa =100;
10  dabdash = sqrt ( dab ^2+ daa ^2) ;
11
12  gmr =0.7788* r ;
13
14  ds =(( gmr * daa ) ^2) ^(1/4) ;
15  dm =( dab ^2* dabdash ^2) ^(1/4) ;
16  l =2*1 e -7* log ( dm / ds ) ;
17
18  printf (" GMR of conductor = %.3 f cm \n\n" , gmr ) ;
19  printf (" Self GMD = %.2 f cm \n\n" , ds ) ;
20  printf (" Mutual GMD = %.2 f cm \n\n" , dm ) ;
21  printf (" Inductance / conductor /m = %.2 f *10^ -7 H \n\n" ,
          l *1e7 ) ;
```

```
22 printf(" Inductance/conductor/km = %.3f mH \n\n", 2*
      l*1e6 );
```

Scilab code Exa 9.7 inductance per phase per km 4

```
1  //Chapter 9
2  //Example 9_7
3  //Page 216
4
5  clear;clc;
6
7  r=1.3;
8  d_acd=6;
9  d_bbd=d_acd;
10 d_ab=3;
11 d_bc=3;
12 d_adbd=d_bc;
13 d_aa=1.01*1e-2;
14 d_bb=d_aa;
15 d_adad=d_aa;
16 d_bdbd=d_aa;
17 d_bdb=d_aa;
18 d_ca=6;
19 d_cad=6;
20 d_cda=6;
21 d_cdad=6;
22
23 gmr=r*0.7788;
24 d_abd=sqrt(d_acd^2+d_ab^2);
25 d_adb=d_abd;
26 d_aad=sqrt(d_acd^2+(d_ab+d_bc)^2);
27 ds1=(d_aa*d_aad*d_adad*d_aad)^(1/4);
28 ds2=(d_bb*d_bbd*d_bdbd*d_bbd)^(1/4);
```

```
29  ds=(ds1*ds2*ds1)^(1/3);
30  dab=(d_ab*d_abd*d_adb*d_adbd)^(1/4);
31  dbc=dab;
32  dca=(d_ca*d_cad*d_cda*d_cdad)^(1/4);
33  dm=(dab*dbc*dca)^(1/3);
34  l=(1e-7)*2*log(dm/ds);
35
36  printf("GMR of conductor = %.2f cm \n\n", gmr);
37  printf("Distance a to b_dash = %.2f m \n", d_abd);
38  printf("Distance a to a_dash = %.2f m \n\n", d_aad);
39  printf("Ds1 = %.2f m \n", ds1);
40  printf("Ds2 = %.2f m \n", ds2);
41  printf("Ds = %.2f m \n\n", ds);
42  printf("Dab = %.2f m \n", dab);
43  printf("Dbc = %.2f m \n", dbc);
44  printf("Dca = %.2f m \n", dca);
45  printf("Dm = %.2f m \n\n", dm);
46  printf("Inductance per phase per metre length = %.2f
        mH \n\n",l*1e6);
```

Scilab code Exa 9.8 inductance per phase per km 6

```
1  //Chapter 9
2  //Example 9_8
3  //Page 217
4
5  clear;clc;
6
7  r=0.75;
8
9  //According to the figure in the text book
10  dab=3;
11  dbc=3;
```

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```
12  dacd =4;
13  dbbd =5.5;
14  dcad =4;
15
16  dca = dab + dbc ;
17
18  gmr = r *0.7788;
19  Daa = gmr ;
20  Dadad = gmr ;
21  Dab = sqrt ( dab ^2+ r ^2) ;
22  Dabd = sqrt ( dab ^2+( dacd + r ) ^2) ;
23  Daad = sqrt (( dab + dbc ) ^2+ dacd ^2) ;
24  Dada = Daad ;
25
26  Ds1 =( Daa * Daad * Dada * Dadad ) ^(1/4) /10;
27  Ds2 =( Daa * dbbd * Daa * dbbd ) ^(1/4) /10;
28  Ds3 = Ds1 ;
29
30  Ds =( Ds1 * Ds2 * Ds3 ) ^(1/3) ;
31
32  DAB =( Dab * Dabd * Dabd * Dab ) ^(1/4) ;
33  DBC = DAB ;
34  DCA =( dca * dacd * dacd * dca ) ^(1/4) ;
35
36  Dm =( DAB * DBC * DCA ) ^(1/3) ;
37
38  l_ph_m =1 e -7*2* log ( Dm / Ds ) ;
39
40  printf (" GMR of conductor = %.3 f cm \n\n", gmr );
41  printf (" Distance a to b = %.2 f m \n", Dab );
42  printf (" Distance a to b-dash = %.2 f m \n", Dabd );
43  printf (" Distance a to a-dash = %.2 f m \n\n", Daad );
44
45  printf (" Ds1 = %.3 f m \n", Ds1 );
46  printf (" Ds2 = %.3 f m \n", Ds2 );
47  printf (" Ds3 = %.3 f m \n", Ds3 );
48  printf (" Equivalent self GMD of one phase = %.3 f m \n
        \n", Ds );
```

```
49
50  printf("DAB = %.3 f  m  \n", DAB);
51  printf("DBC = %.3 f  m  \n", DBC);
52  printf("DCA = %.3 f  m  \n", DCA);
53  printf("Equivalent  mutual GMD = %.3 f  m  \n\n", Dm);
54
55  printf("Inductance/phase/m = %.3 f*10^-3  mH  \n\n",
         l_ph_m/10*1e7);
56  printf("Inductance/phase/km = %.3 f  mH  \n\n", l_ph_m
         /10*1e7);
```

Scilab code Exa 9.9 inductance per phase per km 7

```
1   //Chapter  9
2   //Example  9_9
3   //Page  218
4
5   clear;clc;
6
7   r=5.3;
8   dab=8;
9   dbc=dab;
10  dcad=dab;
11  dadbd=dab;
12  dbdcd=dab;
13
14  gmr=r*0.7788/100;
15
16  Ds1=(gmr*3*dab*3*dab*gmr)^(1/4);
17  Ds2=Ds1;
18  Ds3=Ds1;
19
20  Ds=(Ds1*Ds2*Ds3)^(1/3);
```

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```
21
22  DAB=(dab*4*dab*2*dab*dab)^(1/4);
23  DCA=(2*dab*1*dab*5*dab*2*dab)^(1/4);
24  DBC=DAB;
25
26  Dm=(DAB*DBC*DCA)^(1/3);
27
28  l_ph_m=1e-7*2*log(Dm/Ds);
29
30  printf("GMR of conductor = %.4f cm \n\n", gmr);
31
32  printf("Ds1 = %.3f m \n", Ds1);
33  printf("Ds2 = %.3f m \n", Ds2);
34  printf("Ds3 = %.3f m \n", Ds3);
35  printf("Equivalent self GMD of one phase = %.3f m \n
        \n", Ds);
36
37  printf("DAB = %.3f m \n", DAB);
38  printf("DBC = %.3f m \n", DBC);
39  printf("DCA = %.3f m \n", DCA);
40  printf("Equivalent mutual GMD = %.3f m \n\n", Dm);
41
42  printf("Inductance/phase/m = %.3f*10^-7 mH \n\n",
        l_ph_m*1e7);
```

Scilab code Exa 9.10 `loop inductance per km 4`

```
1  //Chapter 9
2  //Example 9_10
3  //Page 219
4
5  clear;clc;
6
```

```
7   //From the figure
8   Daad =20;
9   Dadb =100;
10  Dbbd =20;
11
12  Dab= Daad + Dadb ;
13  Dabd = Daad + Dadb + Dbbd ;
14  Dadbd = Dadb + Dbbd ;
15
16  gmr =0.7788;
17  Daa = gmr ;
18  Dadad = gmr ;
19
20  Dm=( Dab * Dabd * Dadb * Dadbd ) ^(1/4) ;
21
22  Ds=( Daa * Daad * Dadad * Daad ) ^(1/4) ;
23
24  l=4*1e -4* log(Dm/Ds);
25
26  printf (" GMR of conductor = %.4 f cm \n\n", gmr );
27  printf (" Equivalent self GMD of one phase = %.3 f m \n
        \n", Ds );
28  printf (" Equivalent mutual GMD = %.3 f m \n\n", Dm );
29  printf (" Loop Inductance /km = %.3 f mH/km \n\n", l*1e3
        );
```

Scilab code Exa 9.11 capacitance per km

```
1   //Chapter 9
2   //Example 9_11
3   //Page 224
4
5   clear;clc;
```

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```
6
7  r=1;
8  d=300;
9  e0=8.854*1e-12;
10 c=%pi*e0/log(d/r);
11 printf("Capacitance of the line = %.4f*10^-2 uF/km",
        c*1000*1e8);
```

Scilab code Exa 9.12 capacitance of each line conductor

```
1  //Chapter 9
2  //Example 9_12
3  //Page 225
4
5  clear;clc;
6
7  r=1.25/2;
8  d=200;
9  e0=8.854*1e-12;
10 c=2*%pi*e0/log(d/r);
11 printf("Capacitance of the line = %.4f uF/km \n", c
        *1e9);
```

Scilab code Exa 9.13 charging current per phase

```
1  //Chapter 9
2  //Example 9_13
3  //Page 225
4
```

```
5 clear;clc;
6
7 v=66*1e3;
8 f=50;
9 d1=2;
10 d2=2.5;
11 d3=4.5;
12 d=282;
13 r=1.25/2;
14
15 e0=8.854*1e-12;
16 c=2*%pi*e0/log(d/r);
17 printf(" (i) Line to nuetral Capacitance for 100km
       line = %.4 f uF \n\n", c*1000*1e8);
18
19 ic=v/sqrt(3)*(2*%pi*f*c*100);
20 printf(" (ii) Charging current per phase = %.2 f A \n\
       n", ic*1000);
```

Scilab code Exa 9.14 `capacitance of line`

```
1 //Chapter 9
2 //Example 9_14
3 //Page 225
4
5 clear;clc;
6
7 l=100;
8 f=50;
9 d=250;
10 r=2/2;
11 e0=8.854*1e-12;
12 c=2*%pi*e0/log(d/r);
```

```
13  printf("Capacitance of the line = %.4f*10^-9 F/km \n
        \n", c*1e9*1000);
14  printf("Capacitance of 100km line = %.4f uF/phase \n
        \n", c*1000*1e8);
```

Scilab code Exa 9.15 charging current per phase 2

```
1  //Chapter 9
2  //Example 9_15
3  //Page 226
4
5  clear;clc;
6
7  f=50;
8  v=132*1e3;
9  d1=4;
10 d2=4;
11 d3=8;
12 r=1e-2;
13
14 deq=(d1*d2*d3)^(1/3);
15 printf("Deq = %.2f m \n\n", deq);
16 e0=8.854*1e-12;
17 c=2*%pi*e0/log(deq/r);
18 printf("Capacitance of each conductor to nuetral = %
        .4f uF/km \n\n", c*1e9);
19 cn=c*1e9*100;
20 printf("Capacitance/phase for 100km line = %.4f uF/
        km \n\n", cn);
21 ic=v/sqrt(3)*(2*%pi*f)*cn/1e6;
22 printf("Charging current per phase= %.2f A \n\n", ic
        );
```

Chapter 10

Performance of Transmission Lines

Scilab code Exa 10.1 transmission efficiency 1

```
1  //Chapter 10
2  //Example 10_1
3  //Page 133
4
5  clear;clc;
6
7  load_kw=1100;
8  vr=33;
9  pf=0.8;
10 r=10;
11 xl=15;
12
13 phir=acos(0.8);
14 i=load_kw/vr/pf;
15 z=r+%i*xl;
16 i_vector=i*(cos(phir)- %i*(sin(phir)));
17 vs=vr*1000+z*i_vector;
18 alpha=imag(vs)/real(vs);
19 phis=phir+alpha;
```

```
20  loss=i^2*r;
21  op=load_kw;
22  ps=op+loss/1000;
23  n=op/ps*100;
24
25  printf("Line current = %.2f A \n", i);
26  printf("              = %.2f+j(%.2f) \n\n", real(
      i_vector), imag(i_vector));
27
28  printf("(i) Sending end voltage = %.2f+j(%.2f) \n",
      real(vs), imag(vs));
29  printf("    Magnitude of Vs = %.0f V \n\n", abs(vs))
      ;
30  printf("(ii) Angle betwen Vs and Vr = %.2f degrees \
      n", alpha*180/%pi);
31  printf("      Sending end power factor angle = %.2f
      degrees \n", phis*180/%pi);
32  printf("      Sending end power factor = %.2f \n\n",
      cos(phir));
33  printf("(iii) Line loss = %.2f kW \n", loss/1000);
34  printf("      Output delivered = %.0f kW \n", op);
35  printf("      Power sent = %.3f kW \n", ps);
36  printf("      Transmission efficiency = %.2f %% \n",
      n);
```

Scilab code Exa 10.2 `length of conductor`

```
1  //Chapter 10
2  //Example 10_2
3  //Page 235
4
5  clear;clc;
6
```

```
7  area=0.775;
8  pr=200;
9  pf=1;
10 v=3300;
11 n=0.9;
12 sr=1.725*1e-6;
13
14 ps=pr*1000/n;
15 loss=ps-pr*1000;
16 i=pr*1000/v;
17 r=loss/2/i^2;
18 l=r*area/sr;
19
20 printf("Sending end power = %.0f W \n\n", ps);
21 printf("Line losses = %.0f W \n\n", loss);
22 printf("Line current = %.1f A \n\n", i);
23 printf("Resistance of the line = %.3f ohms \n\n", r)
      ;
24 printf("Length of the conductor = %.2f km \n\n", l
      /1000/100);
```

Scilab code Exa 10.3 transmission efficiency 2

```
1  //Chapter 10
2  //Example 10_3
3  //Page 235
4
5  clear;clc;
6
7  load_kw=5000;
8  v_r=22;
9  pfr=0.8;
10 r=4;
```

```
11  xl=6;
12
13  vr=22*1000/sqrt(3);
14  z=r+%i*xl;
15  i=load_kw*1000/3/vr/pfr;
16  vr_phasor=vr+%i*0;
17  i_phasor=i*(pfr-%i*sin(acos(pfr)));
18  vs_phasor=vr_phasor+i_phasor*z;
19  vs=abs(vs_phasor);
20  lv=vs*sqrt(3);
21  reg=(vs-vr)/vr*100;
22  loss=3*i^2*r;
23  n=load_kw/(load_kw+loss/1000);
24
25  printf("Impedance per phase = %.0f+j(%.0f) \n\n",
        real(z), imag(z));
26  printf("Line current = %.2f A \n\n", i);
27  printf("                = %.2f+j(%.2f) \n\n", real(
        i_phasor), imag(i_phasor));
28  printf("(i) Sending end voltage phasor =%.2f+j(%.2f)
         \n\n", real(vs_phasor), imag(vs_phasor));
29  printf("    Magnitude of Vs = %.2f V \n\n", vs);
30  printf("    Line value of Vs = %.2f kV \n\n", lv
        /1000);
31  printf("(ii) Percentage regulation = %.3f %% \n\n",
        reg);
32  printf("(iii) Line losses = %.3f kW \n\n", loss
        /1000);
33  printf("        Transmission efficiency = %.2f %% \n\n
        ", n*100);
```

Scilab code Exa 10.4 length of line

```
1  //Chapter 10
2  //Example 10_4
3  //Page 236
4
5  clear;clc;
6
7  load_kw=15000;
8  pf=0.8;
9  r=1;
10 vr=132;
11 loss=0.05;
12
13 i=load_kw*1000/sqrt(3)/vr/1000/pf;
14 l_loss=loss*load_kw;
15 r=l_loss*1000/3/i^2;
16 l=r;
17
18 printf("Line current = %.0f A \n\n", i);
19 printf("Line losses = %.0f kW \n\n", l_loss);
20 printf("R = %.2f ohm \n\n", r);
21 printf("Length of the line = %.2f km \n\n", l);
```

Scilab code Exa 10.5 transmission eff

```
1  //Chapter 10
2  //Example 10_5
3  //Page 236
4
5  clear;clc;
6
7  kw=3600;
8  pf=0.8;
9  vs=33;
```

```
10  r=5.31;
11  x=5.54;
12
13  //Sending end voltage per phase
14  vsp=vs*1000/sqrt(3);
15  printf("Sending end voltage per- phase = %d V \n",
        vsp);
16  //line current
17  il=kw/3*1000/pf;
18  printf("Line current = %d*10^5/Vr \n", il/10^5);
19  //using approximate expression,
20  vr=18435;
21  printf("(i) Vr = %d V \n", vr);
22  lv=sqrt(3)*vr/1000;
23  printf("    Line voltage at recieving end = %.2f kV
        \n\n", lv);
24  //line current
25  lc=il/vr;
26  printf("(ii) Line current = %.2f A \n\n", lc);
27  loss=3*lc^2*r;
28  eff=kw/(kw+loss/1000);
29  printf("(iii) Line losses = %.3f kW \n", loss/1000);
30  printf("        Transmission efficiency = %.2f %% \n\n
        ", eff*100)
```

Scilab code Exa 10.6 sending end pf

```
1  //Chapter 10
2  //Example 10_6
3  //Page 237
4
5  clear;clc;
6
```

```
 7  r=6;
 8  xl=8;
 9  pfr=0.9;
10  vr=110*1000/sqrt(3);
11  vs=120*1000/sqrt(3);
12
13  i=(vs-vr)/(r*pfr+xl*sin(acos(pfr)));
14  op=3*vr*i*pfr/1000;
15  pfs=(vr*pfr+i*r)/vs;
16
17  printf("Recieving end voltage = %.0f V \n\n", vr);
18  printf("Sending end voltage = %.0f V \n\n", vs);
19  printf("Load current = %.2f A \n\n", i);
20  printf("(i) Power output = %.0f kW \n\n", op);
21  printf("(ii) Sending end power factor = %.2f lag \n\
        n", pfs);
```

Scilab code Exa 10.7 transmission efficiency 3

```
 1  //Chapter 10
 2  //Example 10_7
 3  //Page 237
 4
 5  clear;clc;
 6
 7  vr=11*1000/sqrt(3);
 8  r=1.5;
 9  xl=4;
10  pfr=0.8;
11  pd=5000;
12
13  i=pd*1000/3/vr;
14  vs=vr+i*r*pfr+i*xl*sin(acos(pfr));
```

```
15  reg=(vs-vr)/vr*100;
16  loss=3*i^2*r;
17  op=pd*pfr;
18  ip=op+loss/1000;
19  n=op/ip*100;
20
21  printf("Recieving end voltage = %.0f V \n\n", vr);
22  printf("Load current = %.2f A \n\n", i);
23  printf("Sending ebd voltage = %.2f V \n\n", vs);
24  printf("%% Regulation = %.2f %% \n\n", reg);
25  printf("Lone losses = %.0f kW \n\n", loss/1000);
26  printf("Output power = %.0f kW \n\n", op);
27  printf("Input power = %.0f kW \n\n", ip);
28  printf("Transmission efficiency = %.2f %% \n\n", n);
```

Scilab code Exa 10.8 transmission efficiency 4

```
1  //Chapter 10
2  //Example 10_8
3  //Page 238
4
5  clear;clc;
6
7  f=50;
8  ll=16;
9  pd=1000;
10  v_r=11;
11  pfr=0.8;
12  r=0.03;
13  l=0.7;
14
15  r_ohm=r*ll;
16  xl=l*2*%pi*f*ll/1000;
```

```
17  vr=v_r*1000/sqrt(3);
18  i=pd*1000/3/vr/pfr;
19  vs=vr+i*r_ohm*pfr+i*xl*sin(acos(pfr));
20  reg=(vs-vr)/vr*100;
21  loss=3*i^2*r_ohm;
22  op=pd;
23  ip=op+loss/1000;
24  n=op/ip*100;
25
26  printf("Resistance of each conductor = %.2f ohm \n\n
        ", r_ohm);
27  printf("Reactance of each conductor = %.2f ohm \n\n"
        , xl);
28  printf("Recieving end voltage = %.0f V \n\n", vr);
29  printf("Load current = %.2f A \n\n", i);
30  printf("Sending end voltage = %.2f V \n\n", vs);
31  printf("%% Regulation = %.2f %% \n\n", reg);
32  printf("Line losses = %.3f kW \n\n", loss/1000);
33  printf("Output power = %.0f kW \n\n", op);
34  printf("Input power = %.1f kW \n\n", ip);
35  printf("Transmission efficiency = %.2f %% \n\n", n);
```

Scilab code Exa 10.9 transmission efficiency 5

```
1  // Chapter 10
2  // Example 10_9
3  // Page 238
4
5  clear;clc;
6
7  pd=2000;
8  pfr=0.8;
9  vrd=6.6;
```

```
10  ll=20;
11  f=50;
12  vr=33;
13  r=0.4;
14  xl=0.5;
15  rp=7.5;
16  xlp=13.2;
17  rs=0.35;
18  xls=0.65;
19
20  rc=ll*r;
21  xlc=ll*xl;
22
23  eqr=rp+rs*(vr/vrd)^2;
24  eqxl=xlp+xls*(vr/vrd)^2;
25
26  tr=rc+eqr;
27  txl=xlc+eqxl;
28
29  vr_phase=vr*1000/sqrt(3);
30  i=pd*1000/sqrt(3)/vr/1000;
31  vs=vr_phase+i*tr*pfr+i*txl*sin(acos(pfr));
32  pfs=(vr_phase*pfr+i*tr)/vs;
33  loss=3*i^2*tr/1000;
34  op=pd*pfr;
35  ip=op+loss;
36  n=op/ip*100;
37
38  printf("Resistance of each conductor = %.2f ohm \n\n
        ", rc);
39  printf("Reactance of each conductor = %.2f ohm \n\n"
        , xlc);
40
41  printf("Equivalent resistance of transformer
        referred to primary = %.2f ohm \n\n", eqr);
42  printf("Equivalent reactance of transformer referred
         to primary = %.2f ohm \n\n", eqxl);
43
```

```
44  printf("Total resistance of line and transformer = %
        .2f ohm \n\n", tr);
45  printf("Total Reactance of line and transformer = %
        .2f ohm \n\n", txl);
46  printf("Recieving end voltage per phase = %.0f V \n\
        n", vr_phase);
47  printf("Load current = %.2f A \n\n", i);
48  printf("Sending end voltage = %.2f kV \n\n", vs*sqrt
        (3)/1000);
49  printf("Sending end power factor = %.2f \n\n", pfs);
50  printf("Line losses = %.3f kW \n\n", loss);
51  printf("Output power = %.0f kW \n\n", op);
52  printf("Input power = %.1f kW \n\n", ip);
53  printf("Transmission efficiency = %.2f %% \n\n", n);
```

Scilab code Exa 10.10 `supply pf for medium tr lines`

```
1   //Chapter 10
2   //Example 10_10
3   //Page 241
4
5   clear;clc;
6
7   r=0.25;
8   xl=0.8;
9   y=14*1e-6;
10  vr=66000;
11  pd=15000;
12  pfr=0.8;
13  ll=100;
14
15  tr=ll*r;
16  txl=ll*xl;
```

```
17  ty=y*ll ;
18
19  z=tr+%i*txl ;
20  l=pd/vr/pfr ;
21  i=pd*1000/vr/pfr ;
22  vr_phasor=vr+%i*0 ;
23  ir_phasor=i*(pfr-%i*sin(acos(pfr))) ;
24  ic=%i*ty*vr ;
25
26  is_phasor=ir_phasor+ic ;
27  mag_is=abs(is_phasor) ;
28  vd=is_phasor*z ;
29  vs_phasor=vr_phasor+is_phasor*z ;
30  mag_vs=abs(vs_phasor) ;
31  reg=(mag_vs-vr)/vr*100 ;
32  theta1=atan(-imag(is_phasor)/real(is_phasor)) ;
33  theta2=atan(imag(vs_phasor)/real(vs_phasor)) ;
34  thetas=abs(theta1)+theta2 ;
35  pfs=cos(thetas) ;
36
37  printf("Total resistance = %.0f ohm \n\n", tr);
38  printf("Total reactance = %.0f ohm \n\n", txl);
39  printf("Total susceptance = %.0f ohm \n\n", ty);
40  printf("Recieving end voltage = %.0f V \n\n", vr);
41  printf("Load current = %.0f A \n\n", i);
42  printf("Vr phasor = %.2f+j%.2f \n\n", real(vr_phasor
        ), imag(vr_phasor));
43  printf("Load current phasor = %.2f+j%.2f \n\n", real
        (ir_phasor), imag(ir_phasor));
44  printf("Capacitive current = j%.2f \n\n", imag(ic));
45  printf("(i) Sending end current = %.2f+j%.2f \n",
        real(is_phasor), imag(is_phasor));
46  printf("     Magnitude = %.0f V \n\n", mag_is);
47  printf("(ii) Voltage drop = %.2f+j%.2f \n", real(vd)
        , imag(vd))
48  printf("     Sending end voltage = %.2f+j%.2f \n",
        real(vs_phasor), imag(vs_phasor));
49  printf("     Magnitude of Vs = %.0f V \n\n", mag_vs)
```

```
   ;
50 printf(" (iii) %% Regulation = %.2f %% \n\n", reg);
51 printf(" (iv) Phase angle between Vr and Ir = %.2f
       degrees \n\n", theta1*180/%pi);
52 printf("      Phase angle between Vr and Vs = %.2f
       degrees \n\n", theta2*180/%pi);
53 printf("      Supply power factor angle = %.2f
       degrees \n\n", thetas*180/%pi);
54 printf("      Supply power factor = %.2f lag \n\n",
       pfs);
```

Scilab code Exa 10.11 nominal t method 1

```
1  //Chapter 10
2  //Example 10_11
3  //Page 244
4
5  clear;clc;
6
7  r=0.1;
8  xl=0.2;
9  y=0.04*1e-4;
10 ll=100;
11 f=50;
12 pd=10000;
13 v_r=66000;
14 pfr=0.8;
15
16 tr=r*ll;
17 txl=ll*xl;
18 ty=ll*y;
19
20 vr=v_r/sqrt(3);
```

```
21  ir=pd*1000/sqrt(3)/v_r/pfr;
22  z=tr+%i*txl;
23  ir_p=ir*(pfr-%i*sin(acos(pfr)));
24  v1=vr+ir_p*z/2;
25  ic=%i*ty*v1;
26  is=ir_p+ic;
27  vs=v1+is*z/2;
28  theta1=atan(imag(vs)/real(vs));
29  theta2=atan(imag(is)/real(is));
30  thetas=theta1+abs(theta2);
31  pfs=cos(thetas);
32  ps=3*abs(vs)*abs(is)*pfs/1000;
33  n=pd/ps;
34
35  printf("Total resistance per phase = %.2f ohm \n\n",
         tr);
36  printf("Total reactance per phase = %.2f ohm \n\n",
       txl);
37  printf("Total susceptance per phase = %.5f ohm \n\n"
       , ty);
38
39  printf("Recieving end voltage = %.0f V \n\n", vr);
40  printf("Load current = %.2f A \n\n", ir);
41  printf("Impedance per phase = %.2f+j%.2f \n\n", real
       (z), imag(z));
42
43  printf("Receiving end voltage is the reference
         phasor = %.2f+j0 \n\n", vr);
44  printf("Load current = %.2f+j%.2f \n\n", real(ir_p),
         imag(ir_p));
45  printf("Voltage across C = %.2f+j%.2f \n\n", real(v1
       ), imag(v1));
46  printf("Charging current = %.2f+j%.2f \n\n", real(ic
       ), imag(ic));
47  printf("Sending end current = %.2f+j%.2f \n\n", real
       (is), imag(is));
48  printf("Sending end current magnitude = %.2f A \n\n"
       , abs(is));
```

```
49  printf("Sending end voltage = %.2f+j%.2f \n\n", real
        (vs), imag(vs));
50  printf("Sending end voltage magnitude = %.2f V \n\n"
        , abs(vs)*sqrt(3)/1000);
51  printf("Phase angle between Vr and Vs = %.2f degrees
         \n\n", theta1*180/%pi);
52  printf("Phase angle between Vr and Is = %.2f degrees
         \n\n", abs(theta2*180/%pi));
53  printf("Sending end power factor angle = %.2f
        degrees \n\n", thetas*180/%pi);
54  printf("Sending end power factor = %.2f \n\n", pfs);
55  printf("Sending end power = %.3f kW \n\n", ps);
56  printf("Power delivered = %.0f kW \n\n", pd);
57  printf("Transmission efficiency = %.2f %% \n\n", n
        *100);
```

Scilab code Exa 10.12 `nominal t method 2`

```
1  //Chapter 10
2  //Example 10_12
3  //Page 245
4
5  clear;clc;
6
7  f=50;
8  ll=100;
9  pd=20*1e6;
10 pfr=0.9;
11 v_r=110*1e3;
12 r=0.2;
13 xl=0.4;
14 y=2.5*1e-6;
15
```

```scilab
16  tr=r*ll;
17  txl=ll*xl;
18  ty=ll*y;
19
20  vr=v_r/sqrt(3);
21  ir=pd/sqrt(3)/v_r/pfr;
22  z=tr+%i*txl;
23  ir_p=ir*(pfr-%i*sin(acos(pfr)));
24  v1=vr+ir_p*z/2;
25  ic=%i*ty*v1;
26  is=ir_p+ic;
27  vs=v1+is*z/2;
28  lv=abs(vs)*sqrt(3);
29  loss=3*is^2*tr/2+3*ir^2*tr/2;
30  n=(pd)/(pd+loss);
31
32  printf("Total resistance per phase = %.2f ohm \n\n",
        tr);
33  printf("Total reactance per phase = %.2f ohm \n\n",
      txl);
34  printf("Total susceptance per phase = %.5f ohm \n\n"
      , ty);
35  printf("Phase impedance = %.2f+j(%.2f) \n\n", real(z
      ), imag(z));
36  printf("Recieving end voltage = %.0f V \n\n", vr);
37  printf("Load current = %.2f A \n\n", ir);
38  printf("Impedance per phase = %.2f+j(%.2f) \n\n",
      real(z), imag(z));
39
40  printf("Receiving end voltage is the reference
      phasor = %.2f+j0 \n\n", vr);
41  printf("Load current = %.2f+j(%.2f) \n\n", real(ir_p
      ), imag(ir_p));
42  printf("Voltage across C = %.2f+j(%.2f) \n\n", real(
      v1), imag(v1));
43  printf("Charging current = %.2f+j(%.2f) \n\n", real(
      ic), imag(ic));
44  printf("Sending end current = %.2f+j(%.2f) \n\n",
```

```
        real ( is ) , imag ( is ) ) ;
45 printf ( " Sending end current magnitude = %.2 f A \n\n"
        , abs ( is ) ) ;
46 printf ( " Sending end voltage = %.2 f+j (%.2 f) \n\n" ,
        real ( vs ) , imag ( vs ) ) ;
47 printf ( " Sending end voltage magnitude = %.2 f V \n\n"
        , abs ( vs ) ) ;
48 printf ( " Line value of sending end voltage = %.2 f V \
        n\n" , lv /1000) ;
49 printf ( " Total line losses for three phases = %.3 f MW
        \n\n" , loss /1 e6 ) ;
50 printf ( " Transmission efficiency = %.2 f %% \n\n" , n
        *100) ;
```

Scilab code Exa 10.13 `nominal pi method 1`

```
1  // Chapter 10
2  // Example 10_13
3  // Page 247
4
5  clear ; clc ;
6
7  f =50;
8  ll =150;
9  r =0.1;
10 xl =0.5;
11 y =3*1 e -6;
12 pd =50*1 e6 ;
13 v_r =110*1 e3 ;
14 pfr =0.8;
15
16 tr = r * ll ;
17 ty = y * ll ;
```

```
18  txl=xl*ll;
19
20  z=tr+%i*txl;
21  vr=v_r/sqrt(3);
22  ir=pd/sqrt(3)/v_r/pfr;
23  ir_p=ir*(pfr-%i*sin(acos(pfr)));
24  ic1=vr*%i*ty/2;
25  il=ir_p+ic1;
26  vs=vr+il*z;
27  ic2=vs*%i*ty/2;
28  is=il+ic2;
29
30  printf("Total resistance / phase = %.2f ohm \n\n",tr
        );
31  printf("Total reactance / phase = %.2f ohm \n\n",txl
        );
32  printf("Total susceptance / phase = %.6f S \n\n",ty)
        ;
33
34  printf("Recieving end voltage = %.0f V \n\n", vr);
35  printf("                         = %.0f+j0 \n\n", vr);
36  printf("Load current = %.2f+j(%.2f) \n\n", real(ir_p
        ), imag(ir_p));
37  printf("Charging current at load end = j(%.2f) \n\n"
        , imag(ic1));
38  printf("Line current = %.2f+j(%.2f) \n\n", real(il),
         imag(il));
39  printf("Sending end voltage = %.2f+j(%.2f) \n\n",
        real(vs), imag(vs));
40  printf("Line to line sending end voltage = %.2f kV \
        n\n", abs(vs)*sqrt(3)/1000);
41  printf("Charging current at sending end = j(%.2f) \n
        \n", imag(ic2));
42  printf("Sending end current = %.2f+j(%.2f) A \n\n",
        real(is), imag(is));
43  printf("Sending end current = %.2f A \n\n", abs(is))
        ;
```

Scilab code Exa 10.14 `nominal pi method 2`

```scilab
1  //Chapter  10
2  //Example  10_14
3  //Page  248
4
5  clear;clc;
6
7  ll=100;
8  r=0.1;
9  xl=0.5;
10 y=10*1e-6;
11 pd=20*1e6;
12 pfr=0.9;
13 v_r=66*1e3;
14
15 tr=r*ll;
16 ty=y*ll;
17 txl=xl*ll;
18
19 z=tr+%i*txl;
20 vr=v_r/sqrt(3);
21 ir=pd/sqrt(3)/v_r/pfr;
22 ir_p=ir*(pfr-%i*sin(acos(pfr)));
23 ic1=vr*%i*ty/2;
24 il=ir_p+ic1;
25 vs=vr+il*z;
26 ic2=vs*%i*ty/2;
27 is=il+ic2;
28 theta1=atan(imag(vs)/real(vs));
29 theta2=atan(imag(is)/real(is));
30 thetas=theta1+abs(theta2);
```

```
31  pfs=cos(thetas);
32  reg=(abs(vs)-vr)/vr*100;
33  ps=3*abs(vs)*abs(is)*pfs;
34  n=pd/ps*100;
35
36  printf("Total resistance / phase = %.2f ohm \n\n",tr
       );
37  printf("Total reactance / phase = %.2f ohm \n\n",txl
       );
38  printf("Total susceptance / phase = %.6f S \n\n",ty)
       ;
39
40  printf("Recieving end voltage = %.0f V \n\n", vr);
41  printf("Load current = %.2f A \n\n", ir);
42  printf("Recieving end voltage phasor = %.0f+j0 \n\n"
       , vr);
43  printf("Load current = %.2f+j(%.2f) \n\n", real(ir_p
       ), imag(ir_p));
44  printf("Charging current at load end = j(%.2f) \n\n"
       , imag(ic1));
45  printf("Line current = %.2f+j(%.2f) \n\n", real(il),
        imag(il));
46  printf("Sending end voltage = %.2f+j(%.2f) \n\n",
       real(vs), imag(vs));
47  printf("Line to line sending end voltage = %.2f kV \
       n\n", abs(vs)*sqrt(3)/1000);
48  printf("Charging current at sending end = %.2f+j(%.2
       f) \n\n", real(ic2),imag(ic2));
49  printf("Sending end current = %.2f+j(%.2f) A \n\n",
       real(is), imag(is));
50  printf("Sending end current = %.2f A \n\n", abs(is))
       ;
51
52  printf("(i) Angle between Vr and Vs = %.2f degrees \
       n\n", theta1*180/%pi);
53  printf("    Angle between Vr and Is = %.2f degrees \
       n\n", theta2*180/%pi);
54  printf("    Angle between Is and Vs = %.2f degrees \
```

```
      n\n", thetas*180/%pi);
55 printf("      Sending end power factor = %.2f \n\n",
      pfs);
56 printf("(ii) %% Voltage regulation = %.2f %% \n\n",
      reg);
57 printf("(iii) Sending end power = %.2f MW \n\n", ps
      /1e6);
58 printf("        Transmission efficiency = %.2f %% \n\n
      ", n);
```

Scilab code Exa 10.15 `long tr line`

```
1  //Chapter 10
2  //Example 10_15
3  //Page 254
4
5  clear;clc;
6
7  ll=200;
8  r=0.16;
9  xl=0.25;
10 y=1.5*1e-6;
11 pd=20*1e6;
12 pfr=0.8;
13 v_r=110*1e3;
14
15 tr=r*ll;
16 ty=y*ll;
17 txl=xl*ll;
18
19 z=tr+%i*txl;
20 vr=v_r/sqrt(3);
21 ir=pd/sqrt(3)/v_r/pfr;
```

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```
22
23  vs=vr*cosh(ty*z)+ir*sqrt(z/ty)*sinh(z*ty);
24  is=vr*sqrt(ty/z)*sinh(ty*z)+ir*cosh(ty*z);
25
26  printf("Recieving end voltage per phase = %.0f V \n\
        n", vr);
27  printf("Recieving end current = %.0f A \n\n", ir);
28  printf("Sending end voltage = %.2f+j%.2f = %.2f kV \
        n\n", real(vs), imag(vs), abs(vs)*sqrt(3)/1000);
29  printf("Sending end current = %.2f+j%.2f = %.2f A \n
        \n", real(is), imag(is), abs(is));
```

Scilab code Exa 10.16 generalised contants 1

```
1  //Chapter 10
2  //Example 10_16
3  //Page 258
4
5  clear;clc;
6
7  pd=30*1e6;
8  v_r=132*1e3;
9  pfr=0.85;
10 z=20+%i*52;
11 y=%i*315*1e-6;
12
13 a=1+z*y/2;
14 d=a;
15 b=z*(1+z*y/4);
16 c=y;
17
18 vr=v_r/sqrt(3)/1000;
19 ir=pd/sqrt(3)/v_r/pfr;
```

```
20  ir_p=ir*(pfr-%i*sin(acos(pfr)));
21  vs=a*vr*1000+b*ir_p;
22  mag_vs=abs(vs)/1000;
23  ll=mag_vs*sqrt(3);
24
25  reg=(mag_vs/abs(a)-vr)/vr*100;
26
27  printf("(i) GENERALISED CONSTANTS OF LINE: \n");
28  printf("    A = %.3f+j(%.6f) \n", real(a), imag(a));
29  printf("    B = %.2f+j(%.2f) \n", real(b), imag(b));
30  printf("    C = %.6f+j(%.4f) \n", real(c), imag(c));
31  printf("    D = %.3f+j(%.6f) \n\n", real(d), imag(d)
    );
32
33  printf("(ii) SENDING END VOLTAGE: \n");
34  printf("    Recieving end voltage per phase = %.0f
    kV \n\n", vr);
35  printf("    Recieving end current = %.0f A \n\n",
    ir);
36  printf("    Recieving end current phasor = %.2f+j(%
    .2f) \n\n", real(ir_p), imag(ir_p));
37  printf("    Sending end voltage per phase = %.2f+j(
    %.2f) V \n\n", real(vs), imag(vs));
38  printf("    Magnitude of Sending end voltage = %.2f
    kV \n\n", mag_vs);
39  printf("    Line value = %.2f kV \n\n", ll);
40
41  printf("(iii) REGULATION: \n");
42  printf("    %% regulation = %.2f %% \n\n", reg);
```

Scilab code Exa 10.17 generalised contants 2

```
1  //Chapter 10
```

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```scilab
2  //Example 10_17
3  //Page 259
4
5  clear;clc;
6
7  v_r=132*1e3;
8  pd=50*1e6;
9  pfr=0.8;
10 a=0.9497+%i*0.02321;
11 d=a;
12 b=19.9595+%i*93.90216;
13 c=%i*0.0015;
14
15 vr=v_r/sqrt(3);
16 ir=pd/sqrt(3)/v_r/pfr;
17 printf("Recieving end voltage per phase = %.0f V \n\
       n", vr);
18 printf("Recieving end current = %.0f A \n\n", ir);
19 printf("Recieving end voltage phasor = %.0f+j0 V \n\
       n", vr);
20 ir_p=ir*(pfr-%i*sin(acos(pfr)));
21 printf("Load current phasor = %.2f+j(%.2f) \n\n",
       real(ir_p), imag(ir_p));
22
23 vs=a*vr+b*ir_p;
24 mag_vs=abs(vs);
25 printf("Sending end voltage per phase = %.2f+j(%.2f)
        V \n\n", real(vs), imag(vs));
26
27 is=c*vr+d*ir_p;
28 mag_is=abs(is);
29 printf("Sending end current = %.2f+j(%.2f) = %.2f A
       \n\n", real(is), imag(is), abs(is));
30
31 ic=is-ir_p;
32 printf("Charging current = %.2f+j(%.2f) \n\n", real(
       ic), imag(ic));
33
```

```
34  reg=(abs(vs)/a-vr)/vr*100;
35  printf("%% regulation = %.2f %% \n\n", reg);
```

Scilab code Exa 10.18 generalised contants 3

```
1  //Chapter 10
2  //Example 10_18
3  //Page 260
4
5  clear;clc;
6
7  v_r=110*1e3;
8  pd=50*1e6;
9  pfr=0.8;
10 a=0.97865+%i*0.051289;
11 d=a;
12 b=28.47009+%i*106.25184;
13 c=0.00008682+%i*0.0004924;
14
15 vr=v_r/sqrt(3);
16 ir=pd/sqrt(3)/v_r;
17 printf("Recieving end voltage per phase = %.0f V \n\
      n", vr);
18 printf("Recieving end current = %.0f A \n\n", ir);
19 printf("Recieving end voltage phasor = %.0f+j0 V \n\
      n", vr);
20 ir_p=ir*(pfr-%i*sin(acos(pfr)));
21 printf("Load current phasor = %.2f+j(%.2f) \n\n",
      real(ir_p), imag(ir_p));
22
23 vs=a*vr+b*ir_p;
24 mag_vs=abs(vs);
25 printf("(i) Sending end voltage per phase = %.2f+j(%
```

```
                  .2 f ) V \n", real(vs), imag(vs));
26 printf("       Magnitude of Sending end voltage = %.2 f
       kV \n\n", mag_vs);
27
28 is=c*vr+d*ir_p;
29 mag_is=abs(is);
30 printf("(ii) Sending end current = %.2 f+j(%.2 f) = %
       .2 f A \n", real(is), imag(is), abs(is));
31 printf("       Magnitude of Sending end current = %.2 f
       kV \n\n", mag_is);
32
33 t1=atan(imag(is)/real(is))*180/%pi;
34 t2=atan(imag(vs)/real(vs))*180/%pi;
35 pfs=cos((abs(t1)+t2)*%pi/180);
36 ps=3*mag_vs*mag_is*pfs/1e6;
37 printf("(iii) Sending end power = %.2 f MW \n\n", ps)
       ;
38
39 pr=pd*pfr/1e6;
40 printf("(iv) Recieving end power = %.2 f MW \n\n", pr
       );
41 printf("       Transmission efficiency = %.2 f %% \n\n"
       , pr/ps*100);
```

Chapter 11

Underground Cables

Scilab code Exa 11.1 insulaiton resistance

```
1  // Chapter 11
2  // Example 11_1
3  // Page 273
4
5  clear ; clc ;
6
7  r1 =1/2;
8  l =2000;
9  p =5*1 e12 ;
10 r2 =0.5+0.4;
11
12 r=p* log ( r2 / r1 ) /(2* %pi * l ) ;
13
14 printf ( " Internal  resistance  of  the  cable  is  =  %.2 f
       MW  \n\n" ,  r /1 e6 ) ;
```

Scilab code Exa 11.2 insulation thickness

```
1  //Chapter 11
2  //Example 11_2
3  //Page 274
4
5  clear;clc;
6
7  l=1000;
8  r=495*1e6;
9  r1=2.5/2;
10 p=4.5*1e12;
11
12
13 r2=r1*exp(2*%pi*r*l/p);
14
15 printf("Insulation thickness = %.2f cm \n\n", r2-r1)
      ;
```

Scilab code Exa 11.3 insulaiton resistance 2

```
1  //Chapter 11
2  //Example 11_3
3  //Page 274
4
5  clear;clc;
6
7  l=5000;
8  r=0.4*1e6;
9  r1=20/2;
10 r2=50/2;
11
12 p=2*%pi*r*l/log(r2/r1);
13
14 printf("Resistance of the insulating material = %.2f
```

```
  *10^9 ohm-m \n\n", p*1e-9);
```

Scilab code Exa 11.4 `cable capacitance`

```
1  //Chapter 11
2  //Example 11_4
3  //Page 275
4
5  clear;clc;
6
7  er=4;
8  l=1000;
9  d_out=1.8;
10 d_in=1;
11
12 c=er*l*1e-9/41.4/log10(d_out/d_in)/10;
13
14 printf("Capacitance of the cable = %.3f uF \n\n", c
      *10e6);
```

Scilab code Exa 11.5 `total charging kvar`

```
1  //Chapter 11
2  //Example 11_5
3  //Page 276
4
5  clear;clc;
6
7  er=4;
```

```
 8  l =1000;
 9  d_in =10;
10  d_out =10+2*7;
11  v =66*1 e3 ;
12  f =50;
13
14  c = er *l *1 e -9/(41.4* log ( d_out / d_in ))* log (10) ;
15
16  printf (" Capacitance  of  the  cable  = %.3 f  uF  \n\n" ,  c
        *10 e5 );
17
18  v_ph = v / sqrt (3) ;
19  xc =1/(2*% pi *f *c );
20  ic = v_ph / xc ;
21
22  printf (" Voltage  between  core  and  sheath  = %.0 f  V  \n\
        nCharging  current  = %.2 f  A  \n\n" ,  v_ph ,  ic );
```

Scilab code Exa 11.6 total charging kvar 1

```
 1  // Chapter  11
 2  // Example  11_6
 3  // Page  276
 4
 5  clear ; clc ;
 6
 7  er =3;
 8  l =4000;
 9  d_in =2.5;
10  d_out = d_in +2*0.5;
11  v =33*1 e3 ;
12  f =50;
13
```

```
14  c=er*l*1e-9/(41.4*log(d_out/d_in))*log(10);

15
16  printf(")(i) Capacitance of the cable = %.3f uF \n\n"
        , c*10e5);

17
18  v_ph=v/sqrt(3);
19  xc=1/(2*%pi*f*c);
20  ic=v_ph/xc;

21
22  printf(")(ii) Voltage between core and sheath = %.0f
        V \n\n    Charging current/phase = %.2f A \n\n",
        v_ph, ic);

23
24  kvar=3*ic*v_ph;
25  printf(")(iii) Total charging kVAR = %.2f*10^3 kVAR \
        n\n", kvar*1e-3);
```

Scilab code Exa 11.7 minimum dielectric stress

```
1  //Chapter 11
2  //Example 11_7
3  //Page 278
4
5  clear;clc;
6
7  v=33;
8  d_in=1;
9  d_out=4;
10
11  g_max=2*v/d_in/log(d_out/d_in);
12  g_min=2*v/d_out/log(d_out/d_in);
13
14  printf("Maximum stress in the insulation = %.2f kV/
```

```
       cm \n\n", g_max);
15 printf("Minimum stress in the insulation = %.2f kV/
       cm \n\n", g_min);
```

Scilab code Exa 11.8 operating voltage

```
1 //Chapter 11
2 //Example 11_8
3 //Page 278
4
5 clear;clc;
6
7 g_max=40;
8 g_min=10;
9 d_in=2;
10
11 d_out=d_in*g_max/g_min;
12 v=g_max*d_in*log(d_out/d_in)/2;
13
14 printf("(i) Insulation thickness = %.0f cm \n\n", (
       d_out-d_in)/2);
15 printf("(ii) Operating voltage = %.2f kV rms \n\n",
       v);
```

Scilab code Exa 11.9 charging current

```
1 //Chapter 11
2 //Example 11_9
3 //Page 279
```

```
 4
 5  clear;clc;
 6
 7  v=11;
 8  area=0.645;
 9  d_out=2.18;
10  er=3.5;
11  l=1000;
12  f=50;
13
14  d_in=sqrt(4*area/%pi);
15  g_max=2*v/d_in/log(d_out/d_in);
16  g_min=2*v/d_out/log(d_out/d_in);
17
18  printf("(i) Maximum stress in the insulation = %.2f
        kV/cm \n\n", g_max);
19  printf("(ii) Minimum stress in the insulation = %.2f
        kV/cm \n\n", g_min);
20
21  c=er*l*1e-9/(41.4*log(d_out/d_in))*log(10);
22
23  printf("(iii) Capacitance of the cable = %.3f uF \n\
        n", c*10e5);
24
25  xc=1/(2*%pi*f*c);
26  ic=v*1e3/xc;
27
28  printf("(iv) Charging current = %.2f A \n\n", ic);
```

Scilab code Exa 11.10 economical conductor diameter

```
1  //Chapter 11
2  //Example 11_10
```

```
3  //Page 280
4
5  clear;clc;
6
7  v=50;
8  g_max=40;
9
10 v_rms=v*sqrt(2);
11 d=2*v_rms/g_max;
12
13 printf("Peak value of cable voltage = %.2f kV \n\n",
       v_rms);
14 printf("Most economical conductor diameter = %.2f cm
       \n\n", d);
```

Scilab code Exa 11.11 internal sheath diameter

```
1  //Chapter 11
2  //Example 11_11
3  //Page 280
4
5  clear;clc;
6
7  v=132;
8  g_max=60;
9
10 vp=v/sqrt(3);
11 pv_ph=vp*sqrt(2);
12
13 d=2*pv_ph/g_max;
14 d_out=2.718*d;
15
16 printf("Phase value of cable voltage = %.2f kV \n\n"
```

```
    , vp ) ;
17 printf (" Peak  value  of  phase  voltage  = %.2 f  kV  \n\n" ,
      pv_ph ) ;
18
19 printf (" Most  economical  conductor  diameter  = %.2 f  cm
      \n\n" , d ) ;
20 printf (" Internal  diameter  of  sheath  = %.2 f  cm  \n\n" ,
      d_out ) ;
```

Scilab code Exa 11.12 rms safe working voltage

```
1 // Chapter  11
2 // Example  11 _12
3 // Page  282
4
5 clear ; clc ;
6
7 d_in =2;
8 d_out =8;
9 e1 =5;
10 e2 =4;
11 e3 =3;
12 g_max =40;
13
14 d1 = e1 * d_in / e2 ;
15 d2 = e1 * d_in / e3 ;
16
17 printf (" GRADED  CABLE:  \n" ) ;
18 printf (" d1  =  %.2 f  cm  \n" , d1 ) ;
19 printf (" d2  =  %.2 f  cm  \n" , d2 ) ;
20
21 v = g_max /2*( d_in * log ( d1 / d_in )+ d1 * log ( d2 / d1 )+ d2 * log (
      d_out / d2 ) ) ;
```

```
22  sv=v/sqrt(2);
23
24  printf("Permissible peak voltage for the cable = %.3
       f kV \n", v);
25  printf("Safe working rms voltage for the cable = %.3
       f kV \n\n", sv);
26
27  pv=g_max/2*d_in*log(d_out/d_in);
28  printf("UNGRADED CABLE: \n");
29  printf("Permissible peak voltage for the cable = %.3
       f kV \n", pv);
30  printf("Safe working rms voltage for the cable = %.3
       f kV \n\n", pv/sqrt(2));
```

Scilab code Exa 11.13 rms safe working voltage 2

```
1  //Chapter 11
2  //Example 11_13
3  //Page 283
4
5  clear;clc;
6
7  d_in=3;
8  d_out=9;
9  e1=5;
10 e2=4;
11 g1_max=30;
12 g2_max=20;
13
14 d1=g1_max*e1*d_in/g2_max/e2;
15 ri=(d1-d_in)/2;
16 ro=(d_out-d1)/2;
17 v=g1_max/2*d_in*log(d1/d_in)+g2_max/2*d1*log(d_out/
```

```
      d1);
18
19  printf("d1 = %.3f cm \n\n", d1);
20  printf("Radial thickness of inner dielectric = %.3f
       cm \n\n", ri);
21  printf("Radial thickness of outer dielectric = %.3f
       cm \n\n", ro);
22  printf("Permissible peak voltage for the cable = %.3
       f kV \n", v);
23  printf("Safe working rms voltage for the cable = %.3
       f kV \n\n", v/sqrt(2));
```

Scilab code Exa 11.14 max dielectric stress

```
1  //Chapter 11
2  //Example 11_14
3  //Page 284
4
5  clear;clc;
6
7  d_in=2;
8  d1=4;
9  d_out=6;
10  v=66;
11  e1=5;
12  e2=3;
13
14  vp=v*sqrt(2/3);
15
16  g1max=2*vp/d_in/(log(d1/d_in)+e1*log(d_out/d1)/e2);
17  g2max=2*vp/d1/(e2*log(d1/d_in)/e1+log(d_out/d1));
18
19  printf("g1max = %.2f kV/cm \n\n", g1max);
```

```
20  printf("g2max = %.2 f  kV/cm  \n\n", g2max);
```

Scilab code Exa 11.15 intersheath grading 1

```
1  //Chapter 11
2  //Example 11_15
3  //Page 285
4
5  clear;clc;
6
7  d_in=2;
8  d1=3.1;
9  d2=4.2;
10  d_out=5.3;
11  v=66;
12
13  vp=v*sqrt(2/3);
14
15  g1_max=1/(d_in/2)/log(d1/d_in);
16  g2_max=1/(d1/2)/log(d2/d1);
17  g3_max=1/(d2/2)/log(d_out/d2);
18
19  v2=g1_max/g2_max;
20  v3=g1_max/g3_max;
21
22  vd=1+v2+v3;
23  va1=vp/vd;
24  va2=v2*va1;
25
26  vf=vp-va1;
27  vs=vp-va1-va2;
28
29  printf("g1_max = %.2 fV1  \n", g1_max);
```

```
30  printf(" g2_max = %.2fV1 \n", g2_max);
31  printf(" g3_max = %.2fV1 \n\n", g3_max);
32
33  printf("V2 = %.3fV1 \n", v2);
34  printf("V3 = %.3fV1 \n\n", v3);
35
36  printf("V1 = %.2f kV \n\n", va1);
37
38  printf(" Voltage on the first intersheath = %.2f kV \
        n", vf);
39  printf(" Voltage on the second intersheath = %.2f kV
        \n\n", vs);
```

Scilab code Exa 11.16 intersheath grading 2

```
1  // Chapter 11
2  // Example 11_16
3  // Page 286
4
5  clear; clc;
6
7  v=66;
8  d_in=2;
9  d_out=5.3;
10  d1=(2*d_out*d_in)^(1/3);
11  d2=d1^2/2;
12
13  vp=v*sqrt(2/3);
14
15  v1=vp/(1+d1/d_in+d2/d_in);
16  v2=d1/d_in*v1;
17  vf=vp-v1;
18  vs=vp-v1-v2;
```

```
19
20  maxs=v1/(d_in*log(d1/d_in)/2);
21  mins=v1/(d1*log(d1/d_in)/2);
22
23  printf(")(i) POSITIONS OF INTERSHEATHS: \n");
24  printf(")d1 = %.2f cm \n", d1);
25  printf(")d2 = %.2f cm \n\n", d2);
26
27  printf(")(ii) VOLTAGE ON INTERSHEATH: \n");
28  printf(")V1 = %.2f kV \n", v1);
29  printf(")V2 = %.2f kV \n", v2);
30  printf(")Voltage on first intersheath = %.2f kV \n",
        vf);
31  printf(")Voltage on second intersheath = %.2f kV \n\n
        ", vs);
32
33  printf(")(iii) STRESSES ON DIELECTRIC: \n");
34  printf(")Maximum stress = %.2f kV/cm \n", maxs);
35  printf(")Minimum stress = %.2f kV/cm \n\n", mins);
```

Scilab code Exa 11.17 three core cable Ic

```
1  //Chapter 11
2  //Example 11_17
3  //Page 289
4
5  clear;clc;
6
7  c=0.3;
8  v=11;
9  f=50;
10 l=5;
11
```

```
12  c3=l*c;
13  vph=v*1000/sqrt(3);
14  cn=2*c3;
15  ic=2*%pi*f*cn*vph/1e6;
16
17  printf("The capacitance between a pair of cores with
        third core earthed for a length of %d km is: \n
      C3 = %.2f uF \n\n", l, c3);
18  printf("Phase voltage = %.0f V \n\n", vph);
19  printf("Core to nuetral capacitance = %.2f uF \n\n",
        cn);
20  printf("Charging current = %.2f A \n\n", ic);
```

Scilab code Exa 11.18 `three core cable Ic2`

```
1  //Chapter 11
2  //Example 11_18
3  //Page 290
4
5  clear;clc;
6
7  v=66;
8  v_ph=66*1000/sqrt(3);
9  f=50;
10  c1=12.6;
11  c2=7.4;
12
13  ce=c1/3;
14  cc=(c2-ce)/2;
15  cn=ce+3*cc;
16  ic=2*%pi*f*v_ph*cn/1e6;
17
18  printf("Core-core capacitance of the cable = %.2f uF
```

```
       \n\n", cc);
19 printf("Core−earth capacitance of the cable = %.2f
      uF \n\n", ce);
20 printf("Core to nuetral capacitance of the cable = %
      .2f uF \n\n", cn);
21 printf("Charging current = %.2f A \n\n", ic);
```

Scilab code Exa 11.19 `kva taken by cable`

```
1 //Chapter 11
2 //Example 11_19
3 //Page 290
4
5 clear;clc;
6
7 c=0.18;
8 l=20;
9 v=3300;
10 f=50;
11
12 c3=c*l;
13 v_ph=v/sqrt(3);
14
15 cn=2*c3;
16 ic=2*%pi*f*v_ph*cn/1e6;
17 kva=3*v_ph*ic;
18
19 printf("Capacitance between pair of cores with third
         core = %.2f uF \n\n", c3);
20 printf("Core to nuetral capacitance of the cable = %
      .2f uF \n\n", cn);
21 printf("Charging current = %.2f A \n\n", ic);
22 printf("kVA taken by the cable = %.2f kVA \n\n", kva
```

```
    /1000) ;
```

Scilab code Exa 11.20 permissible current loading

```
1  //Chapter 11
2  //Example 11_20
3  //Page 292
4
5  clear;clc;
6
7  k=5;
8  r=30/2;
9  r1=r+40;
10 er=110*1e-6;
11
12 s1=k/2/%pi*log(r1/r);
13 s2=0.45;
14 s=s1+s2;
15 n=1;
16 t=55;
17 i=sqrt(t/n/er/s);
18
19 printf("Thermal resistance of the dielectric of the
       cable = %.2f thermal ohms per metre length \n\n",
       s1);
20 printf("Total thermal resistance = %.2f thermal ohms
       per metre legth \n\n", s);
21 printf("Maximum permissible current loading = %.0f A
       \n\n", i);
```

Scilab code Exa 11.21 `loop testing fault location 1`

```
1  //Chapter  11
2  //Example  11_21
3  //Page  296
4
5  clear;clc;
6
7  q=15;
8  p=45;
9  ll=2*300;
10
11  d=q/(p+q)*ll;
12
13  printf("Distance  of  the  fault  point  from  test  end =
        %.0f  m  \n\n", d);
```

Scilab code Exa 11.22 `loop testing fault location 2`

```
1  //Chapter  11
2  //Example  11_22
3  //Page  297
4
5  clear;clc;
6
7  q=1;
8  p=3*q;
9  ll=2*500;
```

```
10  d=q/(p+q)*ll;
11
12  printf("Distance of the fault point from test end =
        %.0f m \n\n", d);
```

Scilab code Exa 11.23 loop testing fault location 3

```
1  //Chapter 11
2  //Example 11_23
3  //Page 297
4
5  clear;clc;
6
7  q=1;
8  p=2.75*q;
9  r1=1;
10 m1=1000;
11 r2=2.25;
12 m2=1000;
13 l=500;
14
15 r=r1/m1*l+r2/m2*l;
16 x=q/(p+q)*r;
17 d=x*1000;
18
19 printf("Resistance of the loop = %.3f ohm \n\n", r);
20 printf("Resistance of faulty cable from test end
        upto fault point = %.3f ohm \n\n", x);
21 printf("Distance of fault point from the testing end
        = %.0f m \n\n", d);
```

Scilab code Exa 11.24 distance from fault end

```
1  //Chapter 11
2  //Example 11_24
3  //Page 297
4
5  clear;clc;
6
7  s=200;
8  r=20;
9  l=20;
10 //R+X is represented by the variable rx
11 rx=r*(l+l);
12 x=(rx-s)/2;
13 d=x/r;
14
15 printf("Resistance of cable from test end to fault
       point = %d ohm \n\n", x);
16 printf("Distance of fault from test end = %d km \n\n
       ", d);
```

Chapter 13

D C Distribution

Scilab code Exa 13.1 PD at each point

```
1  //Chapter 13
2  //Example 13_1
3  //Page 313
4
5  clear;clc;
6
7  Va=300;
8  Ic=100;
9  Id=150;
10 Ie=200;
11 Ib=50;
12 Lac=500;
13 Lcd=400;
14 Lde=600;
15 Leb=400;
16 r=0.01;
17
18 R=r*2;
19 Rac=R*Lac/1000;
20 Rcd=R*Lcd/1000;
21 Rde=R*Lde/1000;
```

```
22  Reb=R*Leb/1000;
23
24  Ieb=Ib;
25  Ide=Ieb+Ie;
26  Icd=Ide+Id;
27  Iac=Icd+Ic;
28
29  Vc=Va-Iac*Rac;
30  Vd=Vc-Icd*Rcd;
31  Ve=Vd-Ide*Rde;
32  Vb=Ve-Ieb*Reb;
33
34  printf("Resistance per 1000m of distributor = %.2f
        ohm \n\n", R);
35  printf("Resistance of section AC = %.3f ohm \n", Rac
        );
36  printf("Resistance of section CD = %.3f ohm \n", Rcd
        );
37  printf("Resistance of section DE = %.3f ohm \n", Rde
        );
38  printf("Resistance of section EB = %.3f ohm \n\n",
        Reb);
39
40  printf("I_EB = %.0f A \n", Ieb);
41  printf("I_DE = %.0f A \n", Ide);
42  printf("I_CD = %.0f A \n", Icd);
43  printf("I_AC = %.0f A \n\n", Iac);
44
45  printf("Potential difference at load point C = Vc =
        %.1f V \n", Vc);
46  printf("Potential difference at load point D = Vd =
        %.1f V \n", Vd);
47  printf("Potential difference at load point E = Ve =
        %.1f V \n", Ve);
48  printf("Potential difference at load point B = Vb =
        %.1f V \n", Vb);
```

Scilab code Exa 13.2 cross sectional area of conductor

```
1  //Chapter 13
2  //Example 13_2
3  //Page 314
4
5  clear;clc;
6
7  ll=300;
8  max_drop=10;
9  p=1.78*1e-8;
10 Lac=40;
11 Lcd=60;
12 Lde=50;
13 Lef=100;
14 Lfb=50;
15 Ic=30;
16 Id=40;
17 Ie=100;
18 If=50;
19
20 Ief=If;
21 Ide=Ief+Ie;
22 Icd=Ide+Id;
23 Iac=Icd+Ic;
24
25 Rac=Lac/100;
26 Rcd=Lcd/100;
27 Rde=Lde/100;
28 Ref=Lef/100;
29
30 vd=Iac*Rac+Icd*Rcd+Ide*Rde+Ief*Ref;
```

```
31  r=max_drop/vd;
32  //for 100 m length of the conductor area is given by
       ,
33  area=p*100*2/r;
34
35  printf("Resistance of 100 m length of distributor =
       %.5f ohm \n\n", r);
36  printf("Area = %.3f cm^2 \n", area*1e4);
```

Scilab code Exa 13.3 voltages across trams

```
1  //Chapter 13
2  //Example 13_3
3  //Page 315
4
5  clear;clc;
6
7  l1=2;
8  l2=6-2;
9  i1=40;
10  i2=20;
11  v=600;
12  rw=0.25;
13  rt=0.03;
14
15  r=rw+rt;
16  i_sa=i1+i2;
17  i_ab=i2;
18  v_sa=i_sa*r*l1;
19  v_ab=i_ab*r*l2;
20  va=v-v_sa;
21  vb=va-v_ab;
22
```

```
23  printf("Reisistance of trolley wire and track/km = %
        .2f ohm \n\n", r);
24  printf("Current in section SA = %d A \n\n", i_sa);
25  printf("Current in section AB = %d A \n\n", i_ab);
26  printf("Voltage drop in section SA = %.2f V \n\n",
        v_sa);
27  printf("Voltage drop in section AB = %.2f V \n\n",
        v_ab);
28  printf("Voltage across tram A = %.2f V \n\n", va);
29  printf("Voltage across tram B = %.2f V \n\n", vb);
```

Scilab code Exa 13.4 `voltage at tapping points`

```
1  //Chapter 13
2  //Example 13_4
3  //Page 315
4
5  clear;clc;
6
7  Va=250;
8  Ic=15;
9  Id=20;
10  Ib=12;
11  Lab=75;
12  Lcd=50;
13  Lbc=100;
14  area=0.27;
15  p=1.78*1e-6;
16
17  //single core resistance of the section of 100m
        length
18  R=p*100*100/area;
19  Rab=R*Lab/100*2;
```

```
20  Rbc=R*Lbc/100*2;
21  Rcd=R*Lcd/100*2;
22
23  Icd=Id;
24  Ibc=Icd+Ic;
25  Iab=Ibc+Ib;
26
27  Vb=Va-Iab*Rab;
28  Vc=Vb-Ibc*Rbc;
29  Vd=Vc-Icd*Rcd;
30
31  printf("(i) CURRENTS IN VARIOUS SECTIONS: \n");
32  printf("I_AB = %.0f A \n", Iab);
33  printf("I_BC = %.0f A \n", Ibc);
34  printf("I_CD = %.0f A \n\n", Icd);
35
36  printf("(ii) Single core resistance of the section
        of 100m length = %.3f ohm \n", R);
37  printf("Resistance of section AB = %.3f ohm \n", Rab
        );
38  printf("Resistance of section BC = %.3f ohm \n", Rbc
        );
39  printf("Resistance of section CD = %.3f ohm \n\n",
        Rcd);
40
41
42  printf("(iii) Voltage at tapping point B = Vb = %.2f
         V \n", Vb);
43  printf("Voltage at tapping point C = Vc = %.2f V \n"
        , Vc);
44  printf("Voltage at tapping point D = Vd = %.2f V \n"
        , Vd);
```

Scilab code Exa 13.5 `max voltage drop`

```scilab
1  //Chapter 13
2  //Example 13_5
3  //Page 317
4
5  clear;clc;
6
7  l=200;
8  i=2;
9  r_km=0.3;
10 x=150;
11
12 r=2*r_km/1000;
13 vd=i*r*(l*x-x^2/2);
14 I=i*l;
15 R=r*l;
16 tvd=1/2*I*R;
17
18 printf("Resistance of distributor per metre run = %
       .4f ohm \n\n", r);
19 printf("(i) Voltage drop upto %d m from feeding
       point = %.1f V \n\n", x, vd);
20 printf("(ii) Total current entering distributor = %d
        A \n\n", I);
21 printf("     Total resistance of distributor = %.2f
      ohm \n\n", R);
22 printf("     Maximum voltage drop = %d V \n\n", tvd)
       ;
```

Scilab code Exa 13.6 `x section of distributor`

```scilab
1  //Chapter 13
```

```
 2  //Example 13_6
 3  //Page 317
 4
 5  clear;clc;
 6
 7  l=500;
 8  i=0.4;
 9  vd=10;
10  p=1.7*1e-6;
11
12  I=i*l;
13  r=vd/0.5/I/l;
14  area=p*100*2/r;
15
16  printf(" Resistance per metre length of the
          distributor = %.2 f*10^-3 ohm \n\n", r*1e3);
17  printf(" Area of cross section of the distributor = %
          .1 f cm^2 \n\n", area);
```

Scilab code Exa 13.7 voltage at feeding points

```
 1  //Chapter 13
 2  //Example 13_7
 3  //Page 318
 4
 5  clear;clc;
 6
 7  l=250;
 8  i=1.6;
 9  r=0.0002;
10  v=250;
11
12  I=i*l;
```

```
13  R=2*r*l;
14  vd=0.5*I*R;
15  vfp=v+vd;
16  x=l/2;
17  v_d=i*r*2*(l*x-x^2/2);
18  v_fp=v_d+v;
19  printf("Current entering the distributor = %d A \n\n
        ", I);
20  printf("Total Resistance of the distributor = %.4f
        ohm \n\n", R);
21  printf("(i) Voltage drop over the entire distibutor
        = %d V \n\n", vd);
22  printf("    Voltage at feeding point = %d V \n\n",
        vfp);
23  printf("(ii) Voltage drop upto distance %d m from
        feeding point = %d V \n\n", x, v_d);
24  printf("    Voltage at feeding point = %d V \n\n",
        v_fp);
```

Scilab code Exa 13.9 `power loss in distributor`

```
1  //Chapter 13
2  //Example 13_9
3  //Page 319
4
5  clear;clc;
6
7  x=200;
8  l=300;
9  i=0.75;
10  r=0.00018;
11  v=250;
12
```

```
13  vd=i*r*(l*x-x^2/2);
14  printf("Voltage drop = %.1f V \n\n", vd);
15  printf("Voltage at a distance %d m from supply end =
          %.1f V \n\n", x, v-vd);
16
17  p=i^2*r*l^3/3;
18  printf("Power loss in distributor = %.2f W \n\n", p)
       ;
```

Scilab code Exa 13.10 `minimum consumer voltage`

```
1  //Chapter 13
2  //Example 13_10
3  //Page 321
4
5  clear;clc;
6
7  Va=220;
8  Ic=20;
9  Id=40;
10  Ie=50;
11  If=30;
12  Vb=220;
13  Lac=100;
14  Lcd=150;
15  Lde=150;
16  Lef=100;
17  Lfb=100;
18  area=1;
19  p=1.7*1e-6;
20
21  //resistance for 100 m length of conductor
22  R=2*p*100/area;
```

```
23
24  Rac=R*Lac;
25  Rcd=R*Lcd;
26  Rde=R*Lde;
27  Ref=R*Lef;
28  Rfb=R*Lfb;
29
30  //considering drop across various sections of the
        distributor and adding them to calculate Ia
31  Ia=(Va-Vb+(Ic*Rcd)+(Ic+Id)*Rde+(Ic+Id+Ie)*Ref+(Ic+Id
        +Ie+If)*Rfb)/(Rac+Rcd+Rde+Ref+Rfb);
32
33  Ve=Va-(Ia*Rac+(Ia-Ic)*Rcd+(Ia-Ic-Id)*Rde);
34
35  printf("Resistance per 100 m of distributor = %.2f
        *10^-4 ohm \n\n", R*1e4);
36  printf("Resistance of section AC = %.3f ohm \n", Rac
        );
37  printf("Resistance of section CD = %.3f ohm \n", Rcd
        );
38  printf("Resistance of section DE = %.3f ohm \n", Rde
        );
39  printf("Resistance of section EF = %.3f ohm \n", Ref
        );
40  printf("Resistance of section FB = %.3f ohm \n\n",
        Rfb);
41
42  printf("Ia = %.1f A \n", Ia);
43
44  printf("Minimum consumer voltage = Ve = %.2f V \n",
        Ve);
```

Scilab code Exa 13.11 currents and voltages

```scilab
1  //Chapter 13
2  //Example 13_11
3  //Page 322
4
5  clear;clc;
6
7  Va=230;
8  Ic=25;
9  Id=50;
10 Ie=30;
11 If=40;
12 Vb=235;
13 Lac=50;
14 Lcd=25;
15 Lde=25;
16 Lef=50;
17 Lfb=50;
18 r=0.3;
19 l=200;
20
21 //resistance for 1000 m length of conductor
22 R=2*r;
23
24 Rac=R*Lac/1000;
25 Rcd=R*Lcd/1000;
26 Rde=R*Lde/1000;
27 Ref=R*Lef/1000;
28 Rfb=R*Lfb/1000;
29
30 //considering drop across various sections of the
      distributor and adding them to calculate Ia
31 Ia=(Va-Vb+(Ic*Rcd)+(Ic+Id)*Rde+(Ic+Id+Ie)*Ref+(Ic+Id
      +Ie+If)*Rfb)/(Rac+Rcd+Rde+Ref+Rfb);
32
33 Iac=Ia;
34 Icd=Ia-Ic;
35 Ide=Ia-Ic-Id;
36 Ief=Ia-Ic-Id-Ie;
```

```
37  Ifb=Ia-Ic-Id-Ie-If;
38
39  Vd=Va-(Iac*Rac+Icd*Rcd);
40
41  printf("Resistance per 1000 m of distributor = %.2f
        ohm \n\n", R);
42  printf("Resistance of section AC = %.3f ohm \n", Rac
        );
43  printf("Resistance of section CD = %.3f ohm \n", Rcd
        );
44  printf("Resistance of section DE = %.3f ohm \n", Rde
        );
45  printf("Resistance of section EF = %.3f ohm \n", Ref
        );
46  printf("Resistance of section FB = %.3f ohm \n\n",
        Rfb);
47
48  printf("Ia = %.1f A \n\n", Ia);
49
50  printf("(i) Current in section AC = Iac = %.2f A \n"
        , Iac);
51  printf("    Current in section CD = Icd = %.2f A \n"
        , Icd);
52  printf("    Current in section DE = Ide = %.2f A \n"
        , Ide);
53  printf("    Current in section EF = Ief = %.2f A \n"
        , Ief);
54  printf("    Current in section FB = Ifb = %.2f A \n\
        n", Ifb);
55
56  printf("(ii) Voltage at D = Vd = %.2f V \n", Vd  );
```

Scilab code Exa 13.12 power loss in distributor2

```scilab
1  //Chapter 13
2  //Example 13_12
3  //Page 323
4
5  clear;clc;
6
7  Va=440;
8  Ic=100;
9  Id=200;
10 Ie=250;
11 If=300;
12 Vb=430;
13 Lac=150;
14 Lcd=150;
15 Lde=50;
16 Lef=100;
17 Lfb=150;
18 r=0.01;
19 l=600;
20
21 //resistance for 100 m length of conductor
22 R=2*r;
23
24 Rac=R*Lac/100;
25 Rcd=R*Lcd/100;
26 Rde=R*Lde/100;
27 Ref=R*Lef/100;
28 Rfb=R*Lfb/100;
29
30 //considering drop across various sections of the
       distributor and adding them to calculate Ia
31 Ia=(Va-Vb+(Ic*Rcd)+(Ic+Id)*Rde+(Ic+Id+Ie)*Ref+(Ic+Id
       +Ie+If)*Rfb)/(Rac+Rcd+Rde+Ref+Rfb);
32
33 Iac=Ia;
34 Icd=Ia-Ic;
35 Ide=Ia-Ic-Id;
36 Ief=Ia-Ic-Id-Ie;
```

```
37  Ifb=Ia-Ic-Id-Ie-If;
38
39  Ib=abs(Ifb);
40
41  P=Iac^2*Rac+Icd^2*Rcd+Ide^2*Rde+Ief^2*Ref+Ifb^2*Rfb;
42
43  printf("Resistance per 100 m of distributor = %.2f
        ohm \n\n", R);
44  printf("Resistance of section AC = %.3f ohm \n", Rac
        );
45  printf("Resistance of section CD = %.3f ohm \n", Rcd
        );
46  printf("Resistance of section DE = %.3f ohm \n", Rde
        );
47  printf("Resistance of section EF = %.3f ohm \n", Ref
        );
48  printf("Resistance of section FB = %.3f ohm \n\n",
        Rfb);
49
50  printf("Ia = %.1f A \n\n", Ia);
51
52  printf("(i) Current supplied from end A = Ia = %.2f
        A \n", Ia);
53  printf("    Current supplied from end B = Ib = %.2f
        A \n\n", Ib);
54
55  printf("(ii) Power loss in the distributor = %.3f kW
        \n\n", P/1000);
```

Scilab code Exa 13.13 current supplied by stations

```
1  //Chapter 13
2  //Example 13_13
```

```
3  //Page 324
4
5  clear;clc;
6
7  l=6;
8  va=600;
9  vb=590;
10 i=300;
11 r=0.04;
12
13 x=3.425;
14 ia=341.7-50*x;
15 ib=i-ia;
16
17 printf(" (i)  x = %.3f km \n", x);
18 printf(" (ii) Current suplied by A = %.2f A \n", ia);
19 printf("      Current suplied by B = %.2f A \n", ib);
```

Scilab code Exa 13.14 `maximum voltage drop`

```
1  //Chapter 13
2  //Example 13_14
3  //Page 327
4
5  clear;clc;
6
7  l=1000;
8  i=0.5;
9  r_km=0.05;
10 v=220;
11
12 r=2*r_km/1000;
13 I=i*l;
```

```
14  R=r*l;
15  vd=I*R/8;
16  maxv=v-vd;
17
18  printf("Resistance of distributor per metre = %.1f
        *10^-3 ohm \n\n", r*1e3);
19  printf("Total current supplied by distributor = %d A
        \n\n", I);
20  printf("Total resistance of the distributor = %.1f
        ohm \n\n", R);
21  printf("Maximum voltage drop = %.2f V \n\n", vd);
22  printf("Maximm voltage drop will occur at the
        midpoint of the distributor = %.2f V \n\n", maxv)
        ;
```

Scilab code Exa 13.15 currents supplied from two ends

```
1  //Chapter 13
2  //Example 13_15
3  //Page 327
4
5  clear;clc;
6
7  l=500;
8  i=1;
9  Va=255;
10 Vb=250;
11 r_km=0.1;
12
13 r=2*r_km/1000;
14 x=(Va-Vb)/(i*r*l)+(l/2);
15 Vc=Va-i*r*x^2/2;
16 ia=i*x;
```

```
17  ib=i*(l-x);
18
19  printf("Resistance  of  distributor  per  metre = %.4f
        ohm \n\n", r);
20  printf("(i) Minimum  potential  occurs  at %d m from A
        \n\n", x);
21  printf("      Minimum  voltage  Vc = %d V \n\n", Vc);
22  printf("(ii) Current  supplied  from A = %d A \n\n",
        ia);
23  printf("        Current  supplied  from B = %d A \n\n",
        ib);
```

Scilab code Exa 13.16 voltage calculations

```
1   //Chapter 13
2   //Example 13_16
3   //Page 328
4
5   clear;clc;
6
7   i=1.25;
8   //minimum voltage occurs at point C
9   Vc=220;
10  x=450;
11  r_km=0.05;
12  l=800;
13
14  r=2*r_km/1000;
15  Vac=i*r*x^2/2;
16  Va=Vc+Vac;
17  Vbc=i*r*(l-x)^2/2;
18  Vb=Vc+Vbc;
19
```

```
20  printf (" Voltage  drop  in  section  AC  =  %.2 f  V  \n\n",
        Vac ) ;
21  printf (" Voltage  at  feeding  point  A  =  %.2 f  V  \n\n",
        Va ) ;
22  printf (" Voltage  drop  in  section  BC  =  %.2 f  V  \n\n",
        Vbc ) ;
23  printf (" Voltage  at  feeding  point  B  =  %.2 f  V  \n\n",
        Vb ) ;
```

Scilab code Exa 13.17 `max voltage drop 2`

```
1  // Chapter  13
2  // Example  13_17
3  // Page  329
4
5  clear ; clc ;
6
7  l =1000;
8  i =1.25;
9  r_km =0.05;
10
11  r =2* r_km /1000;
12  I = i * l ;
13  R = r * l ;
14  vd = I * R /8;
15
16  // Part  1  is  derivation  of  maximum  voltage  drop  and
        is  not  included  in  the  code .  Only  Part  2  is
        solved .
17
18  printf (" ( i )  Total  current  supplied  by  distributor  =
        %d  A  \n\n", I ) ;
19  printf (" Total  resistance  of  the  distributor  =  %.1 f
```

233

```
      ohm \n\n", R);
20 printf("Maximum voltage drop = %.2f V \n\n", vd);
```

Scilab code Exa 13.19 concentrated and uniform loads

```
 1 //Chapter 13
 2 //Example 13_19
 3 //Page 330
 4
 5 clear;clc;
 6
 7 l=900;
 8 Va=400;
 9 Ic=50;
10 Id=100;
11 Ie=150;
12 Lac=200;
13 Lcd=300;
14 Lde=300;
15 Leb=100;
16 r=0.0001;
17 x=500;
18 i=0.5;
19
20 Rac=Lac*r;
21 Rcd=Lcd*r;
22 Rde=Lde*r;
23
24 Ide=Ie;
25 Icd=Ie+Id;
26 Iac=Ic+Icd;
27
28 Vac=Iac*Rac;
```

```
29  Vcd=Rcd*Icd;
30  Vde=Ide*Rde;
31
32  tdrop=Vac+Vcd+Vde;
33
34  Vab=i*r*l^2/2;
35  Vad=i*r*(l*x-x^2/2);
36
37  Vb=Va-(tdrop+Vab);
38  Vd=Va-(Vac+Vcd+Vad);
39
40  disp("DROPS DUE TO CONCENTRATED LOADS: ");
41  printf("Iac = %d A \n", Iac);
42  printf("Icd = %d A \n", Icd);
43  printf("Ide = %d A \n\n", Ide);
44
45  printf("Drop in section AC = %.2f V \n", Vac);
46  printf("Drop in section CD = %.2f V \n", Vcd);
47  printf("Drop in section DE = %.2f V \n", Vde);
48  printf("Total drop over AB = %.2f V \n\n\n", tdrop);
49
50  disp("DROPS DUE TO UNIFORM LOADING: ");
51  printf("Drop over AB = %.2f V \n", Vab);
52  printf("Drop over Ad = %.2f V \n\n", Vad);
53
54  printf("(i) Voltage at point B = %.2f V \n\n", Vb);
55  printf("(ii) Voltage at point D = %.2f V \n\n", Vd);
```

Scilab code Exa 13.20 loading

```
1  //Chapter 13
2  //Example 13_20
3  //Page 331
```

```
 4
 5 clear;clc;
 6
 7 l=1000;
 8 r=0.1;
 9 va=240;
10 vb=240;
11 i_load=0.5;
12 ic=120;
13 id=60;
14 ie=100;
15 i_f=40;
16 //solving for current
17 I=166;
18 printf(" (i) I = %d A \n\n", I);
19 Ia=I+i_load*400;
20 Ib=154+i_load*(l-400);
21 printf(" (ii) Current supplied by A = %d A \n", Ia);
22 printf("       Current supplied by B = %d A \n", Ib);
23 //drop due to concentrated loading
24 cld=I*200/10000+46*200/10000;
25 //drop due to distributed loading
26 dld=i_load*400^2/2/10000;
27 vd=va-cld-dld;
28 printf("Drop due to concentrated loading = %.2f V \n
      ", cld);
29 printf("Drop due to distributed loading = %.2f V \n"
      , dld);
30 printf("Vd = %.2f V \n", vd);
```

Scilab code Exa 13.21 point of min potential

```
 1 //Chapter 13
```

```
2  //Example 13_21
3  //Page 332
4
5  clear;clc;
6
7  l=500;
8  v=240;
9  r=0.001;
10
11  x=50;
12  printf(")(i) Point of minimum potential = %d A \n\n",
        x);
13  tc=160+200;
14  Ia=100+x;
15  Ib=360-150;
16  vd=v-150*(100*r)-x*(150*r);
17  printf("(ii)Total current = %d A \n", tc);
18  printf("Current supplied by A = %d A \n", Ia);
19  printf("Current supplied by B = %d A \n", Ib);
20  printf("Minimum potential = %.2f V \n", vd);
```

Scilab code Exa 13.22 `ring distributor`

```
1   //Chapter 13
2   //Example 13_22
3   //Page 334
4
5   clear;clc;
6
7   l=300;
8   va=240;
9   lab=150;
10  ib=120;
```

```
11  lbc =50;
12  ic =80;
13  lca =100;
14  r =0.03;
15
16  rd =2* r;
17  rab =rd* lab /100;
18  rbc =rd* lbc /100;
19  rca =rd* lca /100;
20
21  Ia =86.67;
22  Iab =Ia ;
23  Ibc =Ia -ib ;
24  Ica =Ia -(ib+ic );
25
26  Vb=va -Iab*rab ;
27  Vc=Vb+Ibc*rbc ;
28
29  printf ("Resistance per 100m = %.2f ohms \n", rd);
30  printf ("Rab = %.2f ohms \n", rab);
31  printf ("Rbc = %.2f ohms \n", rbc);
32  printf ("Rca = %.2f ohms \n\n", rca);
33
34  printf ("(i) Ia = %.2f A \n", Ia);
35  printf ("Iab = %.2f \n", Iab);
36  printf ("Ibc = %.2f \n", Ibc);
37  printf ("Ica = %.2f \n\n", Ica);
38
39  printf ("(ii) Vb = %.2f V \n", Vb);
40  printf ("      Vc = %.2f V \n", Vc)
```

Scilab code Exa 13.23 `current tapping`

```
1  //Chapter 13
2  //Example 13_23
3  //Page 335
4
5  clear;clc;
6
7  v=220;
8  ib=10;
9  ic=20;
10 id=30;
11 ie=10;
12 rab=0.1;
13 rbc=0.05;
14 rcd=0.01;
15 rde=0.025;
16 rea=0.075;
17
18 //by solving for current through the loop,
19 I=29.04;
20 printf("(i) I = %.2f A \n\n", I);
21
22 iab=I;
23 ibc=I-ib;
24 icd=I-(ib+ic);
25 ide=I-(ib+ic+id);
26 iea=I-(ib+ic+id+ie);
27 printf("Iab = %.2f A \n", iab);
28 printf("Ibc = %.2f A \n", ibc);
29 printf("Icd = %.2f A \n", icd);
30 printf("Ide = %.2f A \n", ide);
31 printf("Iea = %.2f A \n", iea);
```

Scilab code Exa 13.24 currents and voltages

```scilab
1  //Chapter 13
2  //Example 13_24
3  //Page 336
4
5  clear;clc;
6
7  va=250;
8  rab=0.02;
9  rbc=0.018;
10 rcd=0.025;
11 rda=0.02;
12 ib=150;
13 ic=300;
14 id=250;
15 //interconnector resistance
16 icr=0.02;
17
18 I=(rbc*ib+rcd*(ib+ic)+rda*(ib+ic+id))/(rab+rbc+rcd+
      rda);
19 printf("I = %.2f A \n", I);
20
21 //from fig(ii)
22 vab=I*rab;
23 vbc=186.75*rbc;
24 vcd=113.25*rcd;
25 vda=363.25*rda;
26
27 vb=va-vab;
28 vc=vb-vbc;
29 vd=vc+vcd;
30
31 printf("Vab = %.3f V \n", vab);
32 printf("Vbc = %.3f V \n", vbc);
33 printf("Vcd = %.3f V \n", vcd);
34 printf("Vda = %.3f V \n\n", vda);
35
36 printf("Vb = %.3f V \n", vb);
37 printf("Vc = %.3f V \n", vc);
```

```
38  printf("Vd = %.3 f  V  \n\n" , vd );
39
40  printf("WITH INTERCONNECTOR:  \n") ;
41  eo=va -vc ;
42  ro =( rab+rbc )*( rab+rcd )/( rab+rbc+rab+rcd );
43  ith=eo /( ro+rab );
44  I1 =( rbc*ib+rda*ith )/( rab+rbc );
45
46  dab=I1 * rab ;
47  dbc =53.15* rbc ;
48  dad =244.45* rda ;
49
50  pb=va -dab ;
51  pc=pb -dbc ;
52  pd=va -dad ;
53
54  printf("Thevenin  voltage  = %.3 f  V  \n" , eo );
55  printf("Rac = %.2 f  ohms  \n" , ro );
56  printf("Current  in  interconnecter  = %.2 f  A  \n\n" ,
         ith );
57
58  printf("I1  = %.2 f  A  \n" , I1 );
59  printf("Drop  in  AB = %.3 f  V  \n" , dab );
60  printf("Drop  in  BC = %.3 f  V  \n" , dbc );
61  printf("Drop  in  AD = %.3 f  V  \n\n" , dad );
62
63  printf("Potential  of  B = %.3 f  V  \n" , pb );
64  printf("Potential  of  C = %.3 f  V  \n" , pc );
65  printf("Potential  of  D = %.3 f  V  \n\n" , pd );
```

Scilab code Exa 13.25 interconnector paramenters

```
1  // Chapter  13
```

```
2  //Example 13_25
3  //Page 338
4
5  clear;clc;
6
7  I=10.65/0.26;
8  vbd=30.96*.025+.96*.01;
9  e0=.7836;
10 r0=(.075+.1+.05)*(.025+.01)/(.075+.1+.05+.025+.01);
11 ibd=e0/(r0+0.05);
12 vdrop=9.8*0.05;
13
14 printf("I = %.2f A \n", I);
15 printf("Voltage drop along BCD = %.4f V \n", vbd);
16 printf("Thevenin voltage E0 = %.4f V \n", e0);
17 printf("Ro = %.3f ohms \n", r0);
18 printf("(i) Current in interconnector = %.2f A \n",
       ibd);
19 printf("(ii) Voltage drop along interconnector = %.2
       f V \n", vdrop);
```

Scilab code Exa 13.26 voltage at loads

```
1  //Chapter 13
2  //Example 13_26
3  //Page 341
4
5  clear;clc;
6
7  I1=50;
8  I2=40;
9  r=0.1;
10 v=250;
```

```
11  Rae =0.1;
12  Rnl =0.2;
13  Rbg =0.1;
14
15  Vel=v-I1*Rae -(I1-I2)*Rnl;
16  Vlg=v+(I1-I2)*Rnl-I2*Rbg;
17
18  printf ("Voltage at the load end on the +ve side = %d
        V \n\n", Vel);
19  printf ("Voltage at the load end on the -ve side = %d
        V \n\n", Vlg);
```

Scilab code Exa 13.27 `voltage at load end`

```
1  //Chapter 13
2  //Example 13_27
3  //Page 342
4
5  clear;clc;
6
7  v1=240;
8  v2=240;
9  r1=5;
10  r2=6;
11  Rae=0.1;
12  Rnl=0.1;
13  Rbc=0.1;
14
15  I1=v1/r1;
16  I2=v2/r2;
17  In=I1-I2;
18
19  V1=v1+I1*Rae+In*Rnl;
```

```
20  V2=v2-In*Rnl+I2*Rbc;
21
22  printf("Current on +ve outer = %d A \n\n", I1);
23  printf("Current on -ve outer = %d A \n\n", I2);
24  printf("Current in nuetral = %d A \n\n", In);
25
26  printf("Voltage at the load end on the +ve side = %
        .2f V \n\n", V1);
27  printf("Voltage at the load end on the -ve side = %
        .2f V \n\n", V2);
```

Scilab code Exa 13.28 voltage calculations 2

```
1  //Chapter 13
2  //Example 13_28
3  //Page 343
4
5  clear;clc;
6
7  v1=250;
8  v2=250;
9  l1=35;
10  l2=20;
11
12  r1=v1^2/l1/1000;
13  r2=v2^2/l2/1000;
14
15  I=(v1+v2)/(r1+r2);
16  V1=I*r1;
17  V2=I*r2;
18
19  printf("Resistance of load on the +ve side = %.3f
        ohm \n\n", r1);
```

```
20  printf(" Resistance of load on the -ve side = %.3 f
        ohm \n\n", r2);
21  printf(" Circuit current = %.2 f A \n\n", I);
22  printf(" Voltage across +ve outer and middle wire = %
        .1 f V \n\n", V1);
23  printf(" Voltage across -ve outer and middle wire = %
        .1 f V \n\n", V2);
```

Scilab code Exa 13.29 voltage across various loads

```
1  //Chapter 13
2  //Example 13_29
3  //Page 344
4
5  clear;clc;
6
7  v1=250;
8  v2=250;
9
10  r=[0.015 0.01 0.006 0.014 0.02 0.02 0.024 0.02];
11  i=[50 30 30 6 14 10 36 60];
12
13  v=r.*i;
14
15  vck=v1-v(1)-v(5)+v(6);
16  vdm=vck-v(2)-v(3)+v(4);
17  vjg=v2-v(6)-v(8);
18  vlh=vjg+v(5)-v(4)-v(7);
19
20  printf(" Voltage acorss load CK = %.2 f V \n\n", vck);
21  printf(" Voltage acorss load DM = %.2 f V \n\n", vdm);
22  printf(" Voltage acorss load JG = %.2 f V \n\n", vjg);
23  printf(" Voltage acorss load LH = %.2 f V \n\n", vlh);
```

Scilab code Exa 13.30 voltage across various loads 3

```
1  //Chapter 13
2  //Example 13_30
3  //Page 344
4
5  clear;clc;
6
7  l=[200 160 240 100 60 100 100 340 160 100];
8  r=0.02;
9  R=r.*l/100;
10 i=[100 40 15 25 35 25 5 15 75 95];
11 v=R.*i;
12 v1=250;
13 v2=250;
14
15 vck=v1-v(1)-v(5)-v(7);
16 vdm=vck-v(2)-v(4)+v(5);
17 vjg=v2+v(7)-v(10);
18 vlh=vjg+v(6)-v(5)-v(9);
19 vpf=vlh+v(4)-v(3)-v(8);
20
21 printf("Voltage acorss load CK = %.2f V \n\n", vck);
22 printf("Voltage acorss load DM = %.2f V \n\n", vdm);
23 printf("Voltage acorss load JG = %.2f V \n\n", vjg);
24 printf("Voltage acorss load LH = %.2f V \n\n", vlh);
25 printf("Voltage acorss load PF = %.2f V \n\n", vpf);
```

Scilab code Exa 13.31 `break in lines`

```
1  //Chapter  13
2  //Example  13_31
3  //Page  345
4
5  clear;clc;
6
7  v1=240;
8  v2=240;
9  r1=4;
10 r2=6;
11 Rae=0.15;
12 Rnl=0.15;
13 Rbc=0.15;
14
15 i1=v1/r1;
16 i2=v2/r2;
17 in=i1-i2;
18
19 V1=v1+i1*Rae+in*Rnl;
20 V2=v2-in*Rnl+i2*Rbc;
21
22 printf("Current on +ve outer = %d A \n", i1);
23 printf("Current on -ve outer = %d A \n", i2);
24 printf("Current in nuetral = %d A \n\n", in);
25
26 printf("Voltage at the load end on the +ve side = %
       .2f V \n", V1);
27 printf("Voltage at the load end on the -ve side = %
       .2f V \n\n\n", V2);
28
29 disp("(i) WHEN NUETRAL BREAKS: ");
30 tr=r1+r2+Rae+Rbc;
31 i=(V1+V2)/tr;
32 vn1=i*r1;
33 vn2=i*r2;
34 printf("Total circuit resistance = %.1f ohm \n", tr)
```

```
   ;
35  printf("Load current = %.2f A \n", i);
36  printf("Voltage across %d ohm resistance = %.2f V \n
       ", r1, vn1);
37  printf("Voltage across %d ohm resistance = %.2f V \n
       \n", r2, vn2);
38
39  disp("( ii ) WHEN +VE OUTER BREAKS: ");
40  trd=r2+Rbc+Rnl;
41  id=V2/trd;
42  vd=id*r2;
43
44  printf("Total circuit resistance = %.1f ohm \n", trd
       );
45  printf("Load current = %.2f A \n", id);
46  printf("Voltage across %d ohm resistance = %.2f V \n
       \n", r2, vd);
47
48  disp("( iii ) WHEN −VE OUTER BREAKS: ");
49  trdd=r1+Rae+Rnl;
50  idd=V1/trdd;
51  vdd=idd*r1;
52
53  printf("Total circuit resistance = %.1f ohm \n",
       trdd);
54  printf("Load current = %.2f A \n", idd);
55  printf("Voltage across %d ohm resistance = %.2f V \n
       \n", r1, vdd);
```

Scilab code Exa 13.32 current in two machines

```
1  //Chapter 13
2  //Example 13_32
```

```scilab
3  //Page 348
4
5  clear;clc;
6
7  v1=250;
8  v2=250;
9  w1=1500;
10 w2=2000;
11
12 i1=w1*1000/v1;
13 i2=w2*1000/v2;
14 in=i1-i2;
15 w=w1+w2;
16 ig=w*1000/(v1+v2);
17 ia=ig-i1;
18 ib=i2-ig;
19
20 printf("Load current on +ve outer = %d A \n\n", i1);
21 printf("Load current on -ve outer = %d A \n\n", i2);
22 printf("Current in nuetral = %d A \n\n", in);
23 printf("Total load on main generator = %d W \n\n", w
       );
24 printf("Current supplied by main generator = %d A \n
       \n", ig);
25 printf("Current in machine A = %d A \n\n", ia);
26 printf("Current in machine B = %d A \n\n", ib);
```

Scilab code Exa 13.33 current and load calculations

```scilab
1  //Chapter 13
2  //Example 13_33
3  //Page 349
4
```

```
 5  clear;clc;
 6
 7  v1=250;
 8  v2=250;
 9  w1=150;
10  w2=100;
11  loss=3;
12
13  tl=w1+w2+loss*2;
14  i1=w1*1000/v1;
15  i2=w2*1000/v2;
16  in=i1-i2;
17  w=w1+w2;
18  ig=tl*1000/(v1+v2);
19  ia=i1-ig;
20  ib=ig-i2;
21  la=ia*v1/1000;
22  lb=ib*v2/1000;
23
24  printf(")(i) Total load on main generator = %d kW \n\
        n", tl);
25
26  printf(")(ii) Current supplied by main generator = %d
         A \n\n", ig);
27  printf(")\t Load current on +ve outer = %d A \n\n",
        i1);
28  printf(")\t Load current on -ve outer = %d A \n\n",
        i2);
29  printf(")\t Current in nuetral = %d A \n\n", in);
30  printf(")\t Current in machine A = %d A \n\n", ia);
31  printf(")\t Current in machine B = %d A \n\n", ib);
32  printf(")\t Load on machine A = %d kW \n\n", la);
33  printf(")\t Load on machine B = %d kW \n\n", lb);
```

Scilab code Exa 13.34 current and load calculations 2

```scilab
1  //Chapter  13
2  //Example  13_34
3  //Page  350
4
5  clear;clc;
6
7  v1=250;
8  v2=250;
9  i1=1200;
10 i2=1000;
11 l=200;
12 loss1=5;
13 loss2=5;
14
15 p1=v1*i1/1000;
16 p2=v2*i2/1000;
17 p3=l;
18
19 tl=p1+p2+p3+loss1+loss2;
20 ig=tl*1000/(v1+v2);
21 in=i1-i2;
22 i3=p3/(v1+v2)*1000;
23 ia=i1+i3-ig;
24 ib=ig-i2-i3;
25 la=ia*v1/1000;
26 lb=ib*v2/1000;
27
28 printf("Load  on  positive  side  = %d kW \n\n", p1);
29 printf("Load  on  negative  side  = %d kW \n\n", p2);
30 printf("Load  on  outers  = %d kW \n\n", p3);
31
32 printf("(i) Total  load  on  main  generator  = %d W \n\n
      ", tl);
33 printf("    Current  supplied  by  main  generator  = %d
       A \n\n", ig);
34
```

```
35  printf("(ii) Current in nuetral = %d A \n\n", in);
36  printf("\t Current in machine A = %d A \n\n", ia);
37  printf("\t Current in machine B = %d A \n\n", ib);
38  printf("\t Load on machine A = %d W \n\n", la);
39  printf("\t Load on machine B = %d W \n\n", lb);
```

Scilab code Exa 13.35 `load on main generator`

```
 1  //Chapter 13
 2  //Example 13_35
 3  //Page 350
 4
 5  clear;clc;
 6
 7  v=500;
 8  ip=800;
 9  in=550;
10  io=1500;
11  ra=0.2;
12  //no load current
13  inl=5;
14
15  tip=io+ip;
16  tin=io+in;
17  cn=ip-in;
18  printf("Total current on positive side = %d A \n",
        tip);
19  printf("Total current on negative side = %d A \n",
        tin);
20  printf("Current in nuetral wire = %d A \n\n", cn);
21
22  e=v/2-ra*5;
23  printf("(i)BAck emf = %d V \n", e);
```

```
24  ib=130;
25  ia=120;
26  printf(" Ib = %d A \n", ib);
27  printf(" Ia = %d A \n\n", ia);
28
29  va=199+ra*ib;
30  vb=249+ra*ib;
31  printf(" (ii) Voltage across machine A = %d V \n", va
        );
32  printf("       Voltage across machine B = %d V \n\n",
        vb);
33  l=tip-ia;
34  printf(" (iii) Load on main generator = %d A \n", l);
```

Scilab code Exa 13.36 output of booster

```
1  //Chapter 13
2  //Example 13_36
3  //Page 352
4
5  clear;clc;
6
7  v=500;
8  l=3;
9  i=120;
10  r=0.5;
11
12  tr=r*l;
13  vd=tr*i;
14  tv=vd;
15  op=i*tv/1000;
16
17  printf(" Total resistance of line = %.1f ohm \n\n",
```

```
     tr);
18  printf(" Full load voltage drop in the line = %d V \n
     \n", vd);
19  printf(" Terminal voltage of booster = %d V \n\n", tv
     );
20  printf(" Output of booster = %.2f kW \n\n", op);
```

Chapter 14

A C distribution

Scilab code Exa 14.1 voltage drop in distributor

```
1  //Chapter 14
2  //Example 14_1
3  //Page 359
4
5  clear;clc;
6
7  l=300;
8  i1=100;
9  i2=200;
10 l1=200;
11 pf1=0.707;
12 pf2=0.8;
13 r=0.2;
14 x=0.1;
15
16 l2=l-l1;
17 z=r+%i*x;
18 Zac=z*l1/1000;
19 Zcb=z*l2/1000;
20 I2=i2*(pf2-%i*sin(acos(pf2)));
21 I1=i1*(pf1-%i*sin(acos(pf1)));
```

```
22  Icb=I2;
23  Iac=I1+I2;
24  Vcb=Icb*Zcb;
25  Vac=Iac*Zac;
26  vd=Vac+Vcb;
27
28  printf("Impedance of distributor/km = %.2f+j(%.2f)
        ohm \n\n", real(z), imag(z));
29
30  printf("Impedance of section AC = Zac = %.2f+j(%.2f)
        ohm \n", real(Zac), imag(Zac));
31  printf("Impedance of section CB = Zcb = %.2f+j(%.2f)
        ohm \n\n", real(Zcb), imag(Zcb));
32
33  printf("Load current at point B = %.2f+j(%.2f) A \n"
        , real(I2), imag(I2));
34  printf("Load current at point C = %.2f+j(%.2f) A \n\
        n", real(I1), imag(I1));
35  printf("Current in section CB = %.2f+j(%.2f) A \n",
        real(Icb), imag(Icb));
36  printf("Current in section AC = %.2f+j(%.2f) A \n\n"
        , real(Iac), imag(Iac));
37  printf("Voltage drop in section CB = %.2f+j(%.2f) A
        \n", real(Vcb), imag(Vcb));
38  printf("Voltage drop in section AC = %.2f+j(%.2f) A
        \n\n", real(Vac), imag(Vac));
39  printf("Voltage drop in the distributor = %.2f+j(%.2
        f) A \n\n", real(vd), imag(vd));
40  printf("Magnitude of drop = %.2f V \n\n", abs(vd));
```

Scilab code Exa 14.2 phase difference and Vs

```
1  //Chapter 14
```

```scilab
2  //Example 14_2
3  //Page 359
4
5  clear;clc;
6
7  l=2000;
8  i1=80;
9  pf1=0.9;
10  i2=120;
11  pf2=0.8;
12  r=0.05;
13  x=0.1;
14  Vb=230+%i*0;
15  l1=1000;
16  l2=l-l1;
17
18  z=r+%i*x;
19  Zac=z*l1/1000;
20  Zcb=z*l2/1000;
21
22  printf("Impedance of distributor/km = %.2f+j(%.2f)
       ohm \n\n", real(z), imag(z));
23
24  printf("Impedance of section AC = Zac = %.2f+j(%.2f)
        ohm \n", real(Zac), imag(Zac));
25  printf("Impedance of section CB = Zcb = %.2f+j(%.2f)
       ohm \n\n\n", real(Zcb), imag(Zcb));
26
27  I2=i2*(pf2-%i*sin(acos(pf2)));
28  I1=i1*(pf1-%i*sin(acos(pf1)));
29
30  printf("(i)Load current at point B = %.2f+j(%.2f) A
      \n", real(I2), imag(I2));
31  printf("Load current at point C = %.2f+j(%.2f) A \n\
      n", real(I1), imag(I1));
32
33  Icb=I2;
34  Iac=I1+I2;
```

```
35
36  Vcb=Icb*Zcb;
37  Vac=Iac*Zac;
38
39  printf("Current in section CB = %.2f+j(%.2f) A \n",
        real(Icb), imag(Icb));
40  printf("Current in section AC = %.2f+j(%.2f) A \n\n"
        , real(Iac), imag(Iac));
41
42  printf("Voltage drop in section CB = %.2f+j(%.2f) A
        \n", real(Vcb), imag(Vcb));
43  printf("Voltage drop in section AC = %.2f+j(%.2f) A
        \n\n", real(Vac), imag(Vac));
44
45  Va=Vb+Vcb+Vac;
46  printf("Sending end voltage = %.2f+j(%.2f) \n", real
        (Va), imag(Va));
47  printf("Magnitude of sending end voltage = %.2f V \n
        \n\n", abs(Va));
48
49  pd=atan(imag(Va)/abs(Va));
50  printf("(ii)The phase difference between Va and Vb =
        %.2f degrees \n\n", pd*180/%pi);
```

Scilab code Exa 14.3 `phase difference`

```
1  //Chapter 14
2  //Example 14_3
3  //Page 360
4
5  clear;clc;
6
7  r=0.1;
```

```
 8  x=0.15;
 9  Vb=200+%i*0;
10  i1=100;
11  pf2=0.8;
12  i2=100;
13  pf1=0.6;
14
15  z=r*2+%i*x*2;
16  Zam=z/2;
17  Zmb=z/2;
18
19  printf("Impedance of distributor/km = %.2f+j(%.2f)
         ohm \n\n", real(z), imag(z));
20
21  printf("Impedance of section AC = Zac = %.2f+j(%.2f)
          ohm \n", real(Zam), imag(Zam));
22  printf("Impedance of section CB = Zcb = %.2f+j(%.2f)
          ohm \n\n\n", real(Zmb), imag(Zmb));
23
24  //part 1
25  I2=i2*(pf2-%i*sin(acos(pf2)));
26  printf("(i)Load current at point B = %.2f+j(%.2f) A
         \n", real(I2), imag(I2));
27  Imb=I2;
28  printf("Current in section MB = %.2f+j(%.2f) A \n",
         real(Imb), imag(Imb));
29  Vmb=Imb*Zmb;
30  printf("Voltage drop in section MB = %.2f+j(%.2f) A
         \n", real(Vmb), imag(Vmb));
31  Vm=Vb+Vmb;
32  printf("Voltage at point M = %.2f+j(%.2f) \n", real(
         Vm), imag(Vm));
33  printf("Magnitude of Vm = %.2f V \n", abs(Vm));
34  alpha=atan(imag(Vm)/abs(Vm));
35  printf("Phase angle between Vm and Vb = %.2f degrees
          \n\n\n", alpha*180/%pi);
36
37  //part 2
```

```
38  phi1=acos(pf1)-alpha;
39  printf("Phase angle between I1 and Vb = %.2f degrees
        \n", phi1*180/%pi);
40  I1=i1*(cos(phi1)-%i*sin(phi1));
41  printf("(ii)Load current at point M = %.2f+j(%.2f) A
        \n", real(I1), imag(I1));
42  Iam=I1+I2;
43  printf("Current in section AM = %.2f+j(%.2f) A \n",
        real(Iam), imag(Iam));
44  Vam=Iam*Zam;
45  printf("Voltage drop in section AM = %.2f+j(%.2f) A
        \n", real(Vam), imag(Vam));
46
47
48  Va=Vm+Vam;
49  printf("Sending end voltage = %.2f+j(%.2f) \n", real
        (Va), imag(Va));
50  printf("Magnitude of sending end voltage = %.2f V \n
        \n\n", abs(Va));
51
52  pd=atan(imag(Va)/abs(Va));
53  printf("(iii)The phase difference between Va and Vb
        = %.2f degrees \n\n", pd*180/%pi);
```

Scilab code Exa 14.4 thevenins theorem

```
1  //Chapter 14
2  //Example 14_4
3  //Page 362
4
5  clear;clc;
6
7  Ib=20;
```

```
 8  Ic=15;
 9  pfb=0.8;
10  pfc=0.6;
11  zab=1+%i*1;
12  zac=1+%i*3;
13  zbc=1+%i*2;
14
15  Iab=Ib*(pfb-%i*sin(acos(pfb)));
16  Iac=Ic*(pfc-%i*sin(acos(pfc)));
17  Vab=Iab*zab;
18  Vac=Iac*zac;
19
20  Eo=Vac-Vab;
21  Zo=zab+zac;
22  Ibc=Eo/(Zo+zbc);
23  Iabs=Iab-Ibc;
24  Iacs=Iac-Ibc;
25  Ia=Iab+Iac;
26
27  printf("Current in section AB = %.2f+j(%.2f) \n",
         real(Iab), imag(Iab));
28  printf("Current in section AC = %.2f+j(%.2f) \n",
         real(Iac), imag(Iac));
29  printf("Voltage drop in section AB = %.2f+j(%.2f) \n
         ", real(Vab), imag(Vab));
30  printf("Voltage drop in section AC = %.2f+j(%.2f) \n
         ", real(Vac), imag(Vac));
31  printf("Thevenins equivalent circuit emf Eo = %.2f+(
         %.2f) \n", real(Eo), imag(Eo));
32  printf("Thevenins equivalent impedance Zo = %.2f+(%
         .2f) \n", real(Zo), imag(Zo));
33  printf("Current in BC = %.2f+j(%.2f) \n", real(Ibc),
         imag(Ibc));
34  printf("Current in AB = %.2f+j(%.2f) \n", real(Iabs)
         , imag(Iabs));
35  printf("Current in AC = %.2f+j(%.2f) \n", real(Iacs)
         , imag(Iacs));
36  printf("Current fed at A = %.2f+j(%.2f) \n", real(Ia
```

```
       ) , imag ( Ia ) ) ;
```

Scilab code Exa 14.5 `line voltage at sending end`

```
1  // Chapter  14
2  // Example  14_5
3  // Page  363
4
5  clear ; clc ;
6
7  i1 =5;
8  i2 =14.08;
9  pf1 =0.8;
10 pf2 =0.85;
11 l1 =600;
12 l2 =400;
13 hp =10;
14 n =0.90;
15 vb =400;
16 r =1;
17 x =0.5;
18
19 z = r +% i * x ;
20 Zac = z * l1 /1000;
21 Zcb = z * l2 /1000;
22
23 printf ( " Impedance  of  distributor /km  = %.2 f + j (%.2 f )
         ohm  \n\n " , real ( z ) , imag ( z ) ) ;
24
25 printf ( " Impedance  of  section  AC  =  Zac  = %.2 f + j (%.2 f )
         ohm  \n " , real ( Zac ) , imag ( Zac ) ) ;
26 printf ( " Impedance  of  section  CB  =  Zcb  = %.2 f + j (%.2 f )
         ohm  \n\n\n " , real ( Zcb ) , imag ( Zcb ) ) ;
```

```
27
28  Vb=vb/sqrt(3)+%i*0;
29  printf("Voltage at point B taken as the reference
        vector = %.0f+j%.0f \n", real(Vb), imag(Vb));
30  Ib=hp*746/sqrt(3)/vb/n/pf2;
31  I2=i2*(pf2-%i*sin(acos(pf2)));
32  I1=i1*(pf1-%i*sin(acos(pf1)));
33  Iac=I2+I1;
34  Icb=I2;
35  Vcb=Icb*Zcb;
36  Vac=Iac*Zac;
37  Va=Vb+Vcb+Vac;
38
39  printf("Line current at B = %.2f A \n\n", Ib);
40
41  printf("Load current at point B = %.2f+j(%.2f) A \n"
        , real(I2), imag(I2));
42  printf("Load current at point C = %.2f+j(%.2f) A \n\
        n", real(I1), imag(I1));
43
44  printf("Current in section CB = %.2f+j(%.2f) A \n",
        real(Icb), imag(Icb));
45  printf("Current in section AC = %.2f+j(%.2f) A \n\n"
        , real(Iac), imag(Iac));
46
47  printf("Voltage drop in section CB = %.2f+j(%.2f) A
        \n", real(Vcb), imag(Vcb));
48  printf("Voltage drop in section AC = %.2f+j(%.2f) A
        \n\n", real(Vac), imag(Vac));
49
50  printf("Voltage at A/phase = %.2f+j(%.2f) A \n\n",
        real(Va), imag(Va));
51  printf("Magnitude of Va/phase = %.2f V \n\n", abs(Va
        ));
52  printf("Line voltage at A = %.2f V \n\n", abs(Va)*
        sqrt(3));
```

Scilab code Exa 14.6 `station voltages`

```
1  //Chapter  14
2  //Example  14_6
3  //Page  365
4
5  x=139.7;
6  y=-42.8;
7
8  iab=x+%i*(y);
9  ibc=(x-40)+%i*(y+30);
10 icd=(x-160)+%i*(y+30);
11 ida=(x-220.6)+%i*(y+65);
12 va=11000/sqrt(3);
13 vb=va-(iab)*(1+%i*0.6);
14 vc=vb-(ibc)*(1.2+%i*0.9);
15 vd=vc-(icd)*(0.8+%i*0.5);
16
17 printf("Current  in  section  AB = %.2 f+j(%.2 f)  A  \n",
      real(iab), imag(iab));
18
19 printf("Current  in  section  BC = %.2 f+j(%.2 f)  A  \n",
      real(ibc), imag(ibc));
20
21 printf("Current  in  section  CD = %.2 f+j(%.2 f)  A  \n",
      real(icd), imag(icd));
22
23 printf("Current  in  section  DA = %.2 f+j(%.2 f)  A  \n\n"
      , real(ida), imag(ida));
24
25 printf("Voltage  at  supply  end = %d V/phase  \n", va);
26
```

```
27  printf("Voltage at station B = %.2f+j(%.2f) V \n",
        real(vb), imag(vb));

28
29  printf("Voltage at station C = %.2f+j(%.2f) V \n",
        real(vc), imag(vc));

30
31  printf("Voltage at station D = %.2f+j(%.2f) V \n",
        real(vd), imag(vd));
```

Scilab code Exa 14.7 `current in nuetral`

```
1  //Chapter 14
2  //Example 14_7
3  //Page 368
4
5  clear;clc;
6
7  lr=10*1e3;
8  ly=8*1e3;
9  lb=5*1e3;
10  v=400;
11
12  ph_v=v/sqrt(3);
13  ir=lr/ph_v;
14  iy=ly/ph_v;
15  ib=lb/ph_v;
16
17  hc=iy*cos(30*%pi/180)-ib*cos(30*%pi/180);
18  vc=ir-iy*cos(60*%pi/180)-ib*cos(60*%pi/180);
19  in=sqrt(hc^2+vc^2);
20
21  printf("(i) Phase voltage = %.2f V \n", ph_v);
22  printf("\t Ir = %.1f A \n", ir);
```

```
23  printf("\t Iy = %.1f A \n", iy);
24  printf("\t Ib = %.1f A \n", ib);
25
26  printf("(ii) The three line currents are different
        in magnitude and displaced by 120 degrees from
        one another. Resolving currents on x and y axis:\
        n");
27  printf("\t Resultant horizontal component = %.1f A \
        n", hc);
28  printf("\t Resultant vertical component = %.1f A \n"
        , vc);
29  printf("\t Current in nuetral wire = %.1f A \n", in)
        ;
```

Scilab code Exa 14.8 `lamp and motor load`

```
1  //Chapter 14
2  //Example 14_8
3  //Page 369
4
5  clear;clc;
6
7  v=400;
8  vl=230;
9  ia=70;
10 ib=84;
11 ic=33;
12 im=200;
13 pf=0.2;
14
15 //part 1
16 printf("LAMP LOAD ALONE: \n");
17
```

```scilab
18  //Refering to the phasor diagram in the book
19  hc=ib*cos(30*%pi/180)-ic*cos(30*%pi/180);
20  vc=ia-ib*cos(60*%pi/180)-ic*cos(60*%pi/180);
21  in=sqrt(hc^2+vc^2);
22
23  printf("Resultant horizontal component = %.2f A \n",
         hc);
24  printf("Resultant vertical component = %.2f A \n",
        vc);
25  printf("Neutral component = %.2f A \n\n", in);
26
27  //part 2
28  printf("BOTH LAMP AND MOTOR LOAD: \n");
29
30  ac=im*pf;
31  rc=im*sin(acos(pf));
32  Ir=sqrt((ac+ia)^2+rc^2);
33  Iy=sqrt((ac+ib)^2+rc^2);
34  Ib=sqrt((ac+ic)^2+rc^2);
35
36  printf("Nuetral current remains the same, ie In = %
        .2f A \n", in);
37  printf("Active component of motor current = %.0f A \
        n", ac);
38  printf("Reactive component of motor current = %.0f A
         \n", rc);
39  printf("\t Ir = %.2f A \n", Ir);
40  printf("\t Iy = %.2f A \n", Iy);
41  printf("\t Ib = %.2f A \n\n", Ib);
42
43  //part 3
44  printf("POWER SUPPLIED: \n");
45
46  pl=vl*(ia+ib+ic);
47  pm=sqrt(3)*v*im*pf;
48
49  printf("Power supplied to lamps = %.0f W \n", pl);
50  printf("Power supplied to motor = %.0f W \n", pm);
```

Scilab code Exa 14.9 component currents

```
1  //Chapter 14
2  //Example 14_9
3  //Page 370
4
5  clear;clc;
6
7  v=400;
8  ph_v=230;
9  lr=20*1e3;
10 ly=28.75*1e3;
11 lb=28.75*1e3;
12
13 ir=lr/ph_v;
14 iy=ly/ph_v;
15 ib=lb/ph_v;
16
17 //referring to the phasor diagram in the text book
18 xc=ir-iy*cos(30*%pi/180)-ib*cos(30*%pi/180);
19 yc=iy*cos(60*%pi/180)-ib*cos(60*%pi/180);
20 in=sqrt(xc^2+yc^2);
21
22 printf("\t Ir = %.1f A \n", ir);
23 printf("\t Iy = %.1f A \n", iy);
24 printf("\t Ib = %.1f A \n\n", ib);
25
26 printf("\t Resultant X-component = %.1f A \n", xc);
27 printf("\t Resultant Y-component = %.1f A \n", yc);
28 printf("\t Current in nuetral wire = %.1f A \n\n",
      in);
29
```

```
30  printf("WHEN LOAD FROM B TO N IS REMOVED: \n");
31  printf("\t Ir = %.2f A in phase with Vrn \n", ir);
32  printf("\t Iy = %.2f A lagging Vyn by 30 degrees \n"
        , iy);
33  printf("\t Ib = 0 A \n\n");
34
35  ac=ir-iy*cos(30*%pi/180);
36  rc=0-iy*sin(30*%pi/180);
37  nc=sqrt(ac^2+rc^2)
38
39  printf("Resultant X-component = %.2f A \n", ac);
40  printf("Resultant Y-component = %.2f A \n", rc);
41  printf("Nuetral current = %.2f A \n\n", nc);
```

Scilab code Exa 14.10 phase voltage calculation

```
1   //Chapter 14
2   //Example 14_10
3   //Page 371
4
5   clear;clc;
6
7   v=400;
8   ph_v=230;
9   r=0.2;
10  i=30;
11  pfr=-0.866;
12  pfy=0.866;
13  pfb=1;
14  ar=0;
15  ay=-120;
16  ab=120;
17
```

```
18  // referring to the phasor diagram given in the text
        book
19  air = -30;
20  aiy = -90;
21  aib =120;
22  vr=ph_v*(cos(0)-%i*sin(0));
23  vy=ph_v*(cos(-120*%pi/180)-%i*sin(-120*%pi/180));
24  vb=ph_v*(cos(120*%pi/180)-%i*sin(120*%pi/180));
25
26  ir=i*(cos(-30*%pi/180)+%i*sin(-30*%pi/180));
27  iy=i*(cos(-90*%pi/180)+%i*sin(-90*%pi/180));
28  ib=i*(cos(120*%pi/180)+%i*sin(120*%pi/180));
29
30
31  in=ir+iy+ib;
32
33  er=vr+r*ir+2*r*in;
34
35  printf("Vr = %.0f/_%.0f \n", ph_v, ar);
36  printf("Vy = %.0f/_%.0f \n", ph_v, ay);
37  printf("Vb = %.0f/_%.0f \n\n", ph_v, ab);
38
39  printf("Ir = %.0f/_%.0f \n", i, air);
40  printf("Iy = %.0f/_%.0f \n", i, aiy);
41  printf("Ib = %.0f/_%.0f \n\n", i, aib);
42
43  printf("Nuetral current = %.2f+j(%.2f) \n\n", real(
        in), imag(in));
44  printf("The supply voltage of phase R to nuetral =
        Er = %.2f/_%.2f volts \n\n", abs(er), atan(imag(
        er)/real(er))*180/%pi);
```

Scilab code Exa 14.11 voltages across lamps

```
1  //Chapter 14
2  //Example 14_11
3  //Page 372
4
5  clear;clc;
6
7  v=400;
8  ph_v=230;
9  w1=100;
10 w2=150;
11
12 r1=ph_v^2/w1;
13 r2=ph_v^2/w2;
14
15 i=v/(r1+r2);
16 v1=i*r1;
17 v2=i*r2;
18
19 printf("Resistance of lamp L1 = R1 = %.2f ohm \n\n",
       r1);
20 printf("Resistance of lamp L2 = R2 = %.2f ohm \n\n",
       r2);
21 printf("Curretn through lamps = %.3f A \n\n", i);
22 printf("Voltage across lamp L1 = V1 = %.0f V \n\n",
       v1);
23 printf("Voltage across lamp L2 = V2 = %.0f V \n\n",
       v2);
```

Chapter 15

Voltage Control

Scilab code Exa 15.1 Vs per phase

```
1  //Chapter 15
2  //Example 15_1
3  //Page 384
4
5  clear;clc;
6
7  kw=10000;
8  pf=0.8;
9  v=33;
10 r=5;
11 x=10;
12
13 i2=kw*1000/sqrt(3)/v/1000/pf;
14 ip=i2*pf;
15 iq=i2*sind(acosd(pf));
16 v1=v*1000/sqrt(3);
17 im=231;
18 capacity=3*v1*im/1000;
19
20 printf("Load current = %d A \n", i2);
21 printf("Ip = %.2f A \n", ip);
```

```
22  printf (" Iq = %.2 f A \n", iq);
23  printf (" Sending end voltage per phase = %d V \n", v1
        );
24  printf (" Im = %d A \n", im );
25  printf (" Capacity of synchrounous condenser = %d kVAR
          \n", capacity );
```

Scilab code Exa 15.2 sunchronous condensor capacity

```
1  // Chapter 15
2  // Example 15 _2
3  // Page 385
4
5  clear ; clc ;
6
7  kw =25000;
8  pf =0.8;
9  v =33;
10  r =5;
11  x =20;
12
13  i2 = kw *1000/ sqrt (3)/ v /1000/ pf ;
14  ip = i2 * pf ;
15  iq = i2 * sind ( acosd ( pf ));
16  v1 = v *1000/ sqrt (3);
17  im =579.5;
18  capacity =3* v1 * im /10^6;
19
20  printf (" Load current = %d A \n", i2 );
21  printf (" Ip = %.2 f A \n", ip );
22  printf (" Iq = %.2 f A \n", iq );
23  printf (" Sending end voltage per phase = %d V \n", v1
        );
```

```
24 printf("Im = %d A \n", im);
25 printf("Capacity of synchrounous condenser = %.2f
      MVAR \n", capacity);
```

Chapter 17

Symmetrical Fault Calculations

Scilab code Exa 17.1 short circuit current

```
1  //Chapter  17
2  //Page  402
3  //Example  17_1
4
5  clear;clc;
6
7  kva=[15000  20000];
8  x=[30  50];
9  vl=12000;
10
11 base=input(" Enter  base kVA:     ");
12
13 for  i=1:2;
14    per_x(i)=base*x(i)/kva(i);
15    printf("%% Reactance  of  alternator  %i  is  = %.2f %%
         \n\n", i,      per_x(i));
16 end;
17
18 i=base*1000/sqrt(3)/vl;
19 printf("Line  current  = %.0f A  \n\n", i);
20
```

```
21  tx=per_x(1)*per_x(2)/(per_x(1)+per_x(2));
22  printf("Total percentage reactance from generator
        nuetral upto fault point = %.2f %% \n\n", tx);
23
24  isc=i*100/tx;
25  printf("Short circuit current = %.0f A \n\n", isc);
```

Scilab code Exa 17.2 percentage reactance

```
1  //Chapter 17
2  //Example 17_2
3  //Page 404
4
5  clear;clc;
6
7  mva=20*1e6;
8  kv=10*1e3;
9  x=5;
10 sc=8;
11
12 i=mva/sqrt(3)/kv;
13 vph=kv/sqrt(3);
14 tperx=(1/sc)*100;
15 ext=tperx-x;
16 perx=ext*vph/100/i;
17
18 printf("Full load current = %.2f A \n\n", i);
19 printf("Voltage per phase = %.2f V \n\n", vph);
20 printf("Total percentage reactance required = %.2f
        %% \n\n", tperx);
21 printf("External percentage reactance required = %.2
        f %% \n\n", ext);
22 printf("Percentage reactance = %.2f ohm \n\n", perx)
```

Scilab code Exa 17.3 short circuit kva 1

```
1  //Chapter 17
2  //Example 17_3
3  //Page 404
4
5  clear;clc;
6
7  kv=10;
8  r=1;
9  x=4;
10 mvaa=10;
11 mvat=5;
12 xt=5;
13 mvabb=10;
14 xa=10;
15
16 base=input("Enter base kVA: ");
17
18 per_xa=base*xa/(mvaa*1000);
19 per_xt=base*xt/(mvat*1000);
20
21 per_xl=x*mvabb*1000/10/kv^2;
22 per_rl=r*mvabb*1000/10/kv^2;
23
24 tx=per_xa+per_xt+per_xl;
25 tr=per_rl;
26 per_z=sqrt(tr^2+tx^2);
27 sckva1=mvabb*1000*100/per_z;
28
29 txgf=per_xa+per_xt;
```

```
30  sckva2=mvaa*1000*100/txgf;
31
32  printf("%% reactance of alternator = %.2f %% \n\n",
        per_xa);
33  printf("%% reactance of transformer = %.2f %% \n\n",
         per_xt);
34  printf("%% reactance of transmission line = %.2f %%
        \n\n", per_xl);
35  printf("%% resistance of transmission line = %.2f %%
        \n\n", per_rl);
36
37  printf("(i) Total %% reactance = %.2f %% \n\n", tx);
38  printf("    Total %% resistance = %.2f %% \n\n", tr)
        ;
39  printf("    %% impedance from generator nuetral upto
         fault point = %.2f %% \n\n", per_z);
40  printf("    Short circuit kva = %.0f kVA \n\n",
        sckva1);
41
42  printf("(ii) %% impedance from generator nuetral
        upto fault point = %.2f %% \n\n", txgf);
43  printf("    Short circuit kva = %.0f kVA \n\n",
        sckva2);
```

Scilab code Exa 17.4 fault mva calculations

```
1  //Chapter 17
2  //Example 17_4
3  //Page 405
4
5  clear;clc;
6
7  kva=[10000 10000 5000];
```

```
8  x=[12 12 18];
9  kva_tr=5000;
10 x_tr=5;
11
12 base=input("Enter base kva:   ");
13
14 for i=1:3;
15   per_x(i)= x(i)*base/kva(i);
16   printf("%% x(%i) = %.0f \n\n", i, per_x(i));
17 end
18 per_xt=x_tr*base/kva_tr;
19 printf("%% Xt = %.0f \n\n", per_xt);
20
21 tx1=1/(1/per_x(1)+1/per_x(2)+1/per_x(3));
22 fmva1=base*100/tx1*1/1000;
23 tx2=tx1+per_xt;
24 fmva2=base*100/tx2*1/1000;
25
26 printf("(i) Total percentage reactance from
       generator to fault F1 = %.2f %% \n\n", tx1);
27 printf("   Fault MVA = %.2f \n\n", fmva1);
28
29 printf("(ii) Total percentage reactance from
       generator to fault to F2 = %.2f %% \n\n", tx2);
30 printf("    Fault MVA = %.2f \n\n", fmva2);
```

Scilab code Exa 17.5 fault mva calculations 2

```
1 //Chapter 17
2 //Example 17_5
3 //Page 407
4
5 clear;clc;
```

```
 6
 7  kva=[10000 10000 8000 8000];
 8  x=[10 10 12 12];
 9  kva_bb=5000;
10  x_bb=10;
11
12  base=input("Enter base kva:   ");
13
14  for i=1:4;
15    per_x(i)= x(i)*base/kva(i);
16    printf("%% reactance of generator %i = %.0f \n\n",
          i, per_x(i));
17  end
18  per_bb=x_bb*base/kva_bb;
19  printf("%% reactance of bus bar = %.0f \n\n", per_bb
      );
20
21  xa=per_x(1)*per_x(2)/(per_x(1)+per_x(2));
22  xb=per_x(3)*per_x(4)/(per_x(3)+per_x(4));
23
24  xf=xa+per_bb;
25  tx=xf*xb/(xf+xb);
26
27  printf("Total %% reactance from generator nuetral to
        fult point is = %.2f %% \n\n", tx);
28
29  fmva=base*100/tx/1000;
30  printf("Fault MVA = %.2f \n\n", fmva);
```

Scilab code Exa 17.6 reactance

```
1  //Chapter 17
2  //Example 17_6
```

```
 3  // Page 408
 4
 5  clear ; clc ;
 6
 7  kva1 =3000;
 8  kva2 =4500;
 9  x1 =7;
10  x2 =8;
11  rc =150*1e6/1000;
12  kvatr =7500;
13  xt =7.5;
14  bv =3300;
15
16  base =7500;
17  printf (" Let base kVA be 7500 kVA \n");
18  per_x1 = x1 * base / kva1 ;
19  per_x2 = x2 * base / kva2 ;
20  per_xt = xt * base / kvatr ;
21
22  r_ab = per_x1 * per_x2 /( per_x1 + per_x2 );
23  c = base *100/ r_ab / rc ;
24  per_x = abs (( c *( r_ab + per_xt ) - per_xt )/( c -1));
25  x = per_x *10*( bv /1000)^2/ base ;
26
27  printf ("%% reactance of generator A = %.2 f %% \n\n",
            per_x1 );
28  printf ("%% reactance of generator B = %.2 f %% \n\n",
            per_x2 );
29  printf ("%% reactance of transformer = %.2 f %% \n\n",
            per_xt );
30  printf ("%% reactance of the bus bar = %.2 f %% \n\n",
            per_x );
31  printf ("%% reactance in ohms = %.3 f ohms \n\n", x);
```

Scilab code Exa 17.7 short circuit mva

```
1  //Chapter 17
2  //Example 17_7
3  //Page 409
4
5  clear;clc;
6
7  mva1=1500;
8  mva2=1200;
9  v=33;
10 x=1;
11
12 base=input("Base MVA:  ");
13 per_x1=base*100/mva1;
14 per_x2=base*100/mva2;
15 printf("%% reactance of station A = %.2f %% \n\n",
       per_x1);
16 printf("%% reactance of station B = %.2f %% \n\n",
       per_x2);
17
18 per_xt=base*1000*x/10/v^2;
19 printf("%% reactance of interconnector = %.2f %% \n\
       n", per_xt);
20
21 x1=per_x1+per_xt;
22 tx1=x1*per_x2/(x1+per_x2);
23 scmva1=base*100/tx1;
24
25 x2=per_x2+per_xt;
26 tx2=x2*per_x1/(x2+per_x1);
27 scmva2=base*100/tx2;
28
29 printf("FAULT ON STATION A: \n\n");
30 printf("Total %% reactance upto fault point F2 = %.2
       f %% \n\n", tx2);
31 printf("Short circuit MVA = %.2f \n\n", scmva2);
32
```

```
33  printf("FAULT ON STATION B: \n\n");
34  printf("Total %% reactance upto fault point F1 = %.2
        f %% \n\n", tx1);
35  printf("Short circuit MVA = %.2f \n\n", scmva1);
```

Scilab code Exa 17.8 steady state input

```
1  //Chapter 17
2  //Example 17_8
3  //Page 410
4
5  clear;clc;
6
7  kva=5000;
8  x=12;
9  r=6;
10
11  base=input("Input base kva:   ");
12
13  perx=base*x/kva;
14  printf("With reactors: \n");
15  x1=(perx+r)/2+r;
16  tx1=x1*x/(x1+x);
17  sci1=base*100/tx1;
18  printf("Total %% reactance from generator to fault =
        %.2f %% \n", tx1);
19  printf("Short circuit input = %.3f MVA \n\n", sci1
        /1000);
20
21  printf("Without reactors: \n");
22  tx2=x/3;
23  sci2=base*100/tx2;
24  printf("Total %% reactance from generator to fault =
```

```
       %.2 f %% \n" , tx2 ) ;
25  printf ( " Short  circuit  input  = %.3 f MVA \n\n" , sci2
       /1000 ) ;
```

Scilab code Exa 17.9 short circuit mva 2

```
 1  // Chapter  17
 2  // Example  17_9
 3  // Page  411
 4
 5  clear ; clc ;
 6
 7  gmva =10;
 8  gx =30;
 9  rmva =10;
10  rx =10;
11  tmva =5;
12  tx =5;
13
14  base = input ( " Enter  base MVA:  " ) ;
15
16  pergx = base * gx / gmva ;
17  printf ( "%% reactance  of  each  generator  = %.0 f %% \n\
       n" , pergx ) ;
18
19  perrx = base * rx / rmva ;
20  printf ( "%% reactance  of  each  generator  = %.0 f %% \n\
       n" , perrx ) ;
21
22  pertx = base * tx / tmva ;
23  printf ( "%% reactance  of  each  generator  = %.0 f %% \n\
       n" , pertx ) ;
24
```

```
25  xbc =( pergx + perrx ) /2+ pertx ;
26  tx = xbc * pergx /( xbc + pergx ) + pertx ;
27  sc = base *100/ tx ;
28  printf (" Total %% reactance = %.2 f %% \n\n", tx );
29  printf ("S.C MVA = %.2 f \n\n", sc );
```

Scilab code Exa 17.10 `sc kVA`

```
1  //Chapter 17
2  //Example 17_10
3  //Page 412
4
5  clear ; clc ;
6
7  q =50000;
8  x =20;
9  b =10;
10  n1 =3;
11  n2 =9;
12
13  //from the derivation
14  sckva1 =( q/x+q *( n1 -1) /( b* n1+x ) ) *100;
15  sckva2 =( q/x+q *( n2 -1) /( b* n2+x ) ) *100;
16  //When n is very large
17  sckva3 =( q/x+q/b ) *100;
18
19  printf (" (i) Short circuit kVA with %d sections = %d
        kVA \n\n", n1 , sckva1 );
20  printf (" (ii) Short circuit kVA with %d sections = %d
         kVA \n\n", n2 , sckva2 );
21  printf (" (iii) Short circuit kVA when n is very large
         = %d kVA \n\n", sckva3 );
```

Scilab code Exa 17.11 `reactor reactance`

```
1  //Chapter 17
2  //Example 17_11
3  //Page 414
4
5  clear;clc;
6
7  v=33;
8  pmva=10;
9  qmva=50;
10 xp=20;
11 xq=10;
12 rc=500;
13 base=50;
14
15 per_xg=base/pmva*xp;
16 per_xt=base/qmva*xq;
17 printf("%% reactance of each generator = %d %% \n",
       per_xg);
18 printf("%% reactance of transformer = %d %% \n",
       per_xt);
19
20 per_x=base*100/rc;
21 printf("Required %% reactance = %d %% \n", per_x);
22 x=100/15;
23 rr=x*10*v^2/base/1000;
24 printf("Reactance of reactor = %.3f ohms \n\n", rr);
```

Scilab code Exa 17.12 reactance of reactor

```
1  //Chapter  17
2  //Example  17_12
3  //Page  415
4
5  clear;clc;
6
7  ml=5000;
8  v=6600;
9  x=6;
10 m=5;
11
12 base=input("Base  kVA:  ");
13 x=base*100/m/ml-6;
14 xohm=x*10*(v/1000)^2/ml;
15
16 printf("%% reactance  of  the  reactor  = %.2f %% \n\n",
        x);
17 printf("Reactance  in  ohms  = %.2f \n\n", xohm);
```

Scilab code Exa 17.13 fault mva calculations 3

```
1  //Chapter  17
2  //Example  17_13
3  //Page  416
4
5  clear;clc;
```

```
 6
 7  mva =[15 15 8];
 8  x=[12 12 10];
 9  mvat =5;
10  xt =4;
11  mvar =10;
12  xr =15;
13
14  base=input("Enter base mva: ");
15  for i=1:3
16  perx(i)=base*x(i)/mva(i);
17  printf("%% X(%i) = %.2f %% \n\n", i, perx(i));
18  end;
19  perxt=base*xt/mvat;
20  perxr=base*xr/mvar;
21  printf("%% Xt = %.2f %% \n\n", perxt);
22  printf("%% Xr = %.2f %% \n\n", perxr);
23
24  xabt=perx(1)/2+perxt;
25  xcr=perx(3)+perxr;
26  tx=xabt*xcr/(xabt+xcr);
27  f=base*100/tx;
28
29  printf("Total %% reactance = %.2f %% \n\n", tx);
30  printf("Fault MVA = %.2f MVA \n\n", f);
```

Scilab code Exa 17.14 fault current fed by alternator

```
1  //Chapter 17
2  //Example 17_14
3  //Page 417
4
5  clear;clc;
```

```
 6
 7  mva=10;
 8  kv=6.6;
 9  xa=20;
10  mvat=5;
11  kvpt=6.6;
12  kvst=33;
13  xt=10;
14  r=0.2;
15  x=1;
16  ll=50;
17
18  base=input("Enter base MVA: ");
19
20  per_xa=base*xa/mva;
21  per_xt=base*xt/mvat;
22  per_xl=mva*1000*ll*x/10/kvst^2;
23  per_rl=mva*1000*ll*r/10/kvst^2;
24
25  tx=per_xl+per_xa+per_xt;
26  tr=per_rl;
27
28  per_z=sqrt(tx^2+tr^2);
29  scmva=base*100/per_z;
30
31  isc=scmva*1e6/sqrt(3)/kv/1000;
32
33  printf("%% reactance of the alternator = %.2f %% \n\
        n", per_xa);
34  printf("%% reactance of the transformer = %.2f %% \n
        \n", per_xt);
35  printf("%% reactance of the transmission line = %.2f
        %% \n\n", per_xl);
36  printf("%% resistance of the transmission line = %.2
        f %% \n\n", per_rl);
37  printf("Total %% reactance upto fault point = %.2f
        %% \n\n", tx);
38  printf("Total %% resistance upto fault point = %.2f
```

```
       %% \n\n", tr);
39  printf("Total %% impedance upto fault point = %.2 f
       %% \n\n", per_z);
40  printf("Short circuit MVA = %.2 f MVA \n\n", scmva);
41  printf("Short circuit current fed by the alternator
       to the fault = %.2 f A \n\n", isc);
```

Scilab code Exa 17.15 `short circuit current calculations`

```
 1  //Chapter 17
 2  //Example 17_15
 3  //Page 418
 4
 5  clear;clc;
 6
 7  kv=11;
 8  mva=10;
 9  xa=12;
10  mvar=10;
11  xr=24;
12  mvat=6;
13  xt=3;
14  ts=66;
15
16  base=input("Enter base MVA: ");
17  per_xa=base*xa/mva;
18  per_xr=base*xr/mvar;
19  per_xt=base*xt/mvat;
20
21  //From the figure, the total reactance from
       generator to fault point is
22
23  l1=per_xa/2+per_xr;
```

```
24  l2=per_xa/2;
25  tx=l1*l2/(l1+l2)+per_xt;
26
27  fmva=base*100/tx;
28  isc=fmva*1e6/sqrt(3)/ts/1000;
29
30  printf("%% reactance of the alternator = %.2f %% \n\
        n", per_xa);
31  printf("%% reactance of the transformer = %.2f %% \n
        \n", per_xt);
32  printf("%% reactance of the reactor = %.2f %% \n\n",
        per_xr);
33
34  printf("Total %% reactance upto fault point = %.2f
        %% \n\n", tx);
35  printf("Fault MVA = %.2f MVA \n\n", fmva);
36  printf("Short circuit current fed by the alternator
        to the fault = %.2f A \n\n", isc);
```

Chapter 18

Unsymmetrical Fault Calculations

Scilab code Exa 18.3 sequence currents

```
1  //Chapter 18
2  //Example 18_3
3  //Page 429
4
5  clear;clc;
6
7  a=1*(cosd(120)+%i*sind(120));
8
9  Ir=12+%i*6;
10 Iy=12+%i*-12;
11 Ib=-15+%i*10;
12
13    Ir0=1/3*(Ir+Iy+Ib);
14    Ir1=1/3*(Ir+a*Iy+a^2*Ib);
15    Ir2=1/3*(Ir+a^2*Iy+a*Ib);
16
17 disp("RED PHASE:");
18 printf("Ir0 = %.2f+j(%.2f) A \n", real(Ir0), imag(
     Ir0));
```

```
19  printf(" Ir1 = %.2 f+j (%.2 f) A \n", real(Ir1), imag(
        Ir1));
20  printf(" Ir2 = %.2 f+j (%.2 f) A \n\n", real(Ir2), imag(
        Ir2));
21
22  Iy0=Ir0;
23  Iy1=a^2*Ir1;
24  Iy2=a*Ir2;
25  disp("YELLOW PHASE:");
26  printf(" Iy0 = %.2 f+j (%.2 f) A \n", real(Iy0), imag(
        Iy0));
27  printf(" Iy1 = %.2 f+j (%.2 f) A \n", real(Iy1), imag(
        Iy1));
28  printf(" Iy2 = %.2 f+j (%.2 f) A \n\n", real(Iy2), imag(
        Iy2));
29
30  Ib0=Ir0;
31  Ib1=a*Ir1;
32  Ib2=a^2*Ir2;
33  disp("BLUE PHASE:");
34  printf(" Ib0 = %.2 f+j (%.2 f) A \n", real(Ib0), imag(
        Ib0));
35  printf(" Ib1 = %.2 f+j (%.2 f) A \n", real(Ib1), imag(
        Ib1));
36  printf(" Ib2 = %.2 f+j (%.2 f) A \n\n", real(Ib2), imag(
        Ib2));
```

Scilab code Exa 18.4 sequence components for voltage

```
1  // Chapter  18
2  // Example  18_4
3  // Page  430
4
```

```
5  clear ; clc ;

6
7  a=1*( cosd (120) +%i * sind (120) );

8
9  Er0 =100;
10 Er1 =200 -%i *100;
11 Er2 = -100;

12
13 Er= Er0 + Er1 + Er2 ;
14 Ey= Er0 +a^2* Er1 +a* Er2 ;
15 Eb= Er0 +a* Er1 +a^2* Er2 ;

16
17 printf (" Er = %.2 f /_%.2 f volts \n\n", abs (Er), atand
       ( imag (Er)/ real (Er)));
18 printf (" Ey = %.2 f /_%.2 f volts \n\n", abs (Ey), atand
       ( imag (Ey)/ real (Ey)) -180) ;
19 printf (" Eb = %.2 f /_%.2 f volts \n\n", abs (Eb), atand
       ( imag (Eb)/ real (Eb)));
```

Scilab code Exa 18.5 sequence components calculations

```
1  // Chapter 18
2  // Example 18_5
3  // Page 431

4
5  clear ; clc ;

6
7  a=1*( cosd (120) +%i * sind (120) );

8
9  Er0 =0.5 -%i *0.866;
10 Er1 =2*( cosd (0) +%i * sind (0) );
11 Er =3*( cosd (0) +%i * sind (0) );

12
```

```
13  Er2=Er-Er0-Er1;
14  Ey=Er0+a^2*Er1+a*Er2;
15  Eb=Er0+a*Er1+a^2*Er2;
16
17  printf("Er2 = %.2f /_%.2f volts \n\n", abs(Er2),
        atand(imag(Er2)/real(Er2)));
18  printf("Ey = %.2f /_%.2f volts \n\n", abs(Ey), atand
        (imag(Ey)/real(Ey))-180);
19  printf("Eb = %.2f volts \n\n", abs(Eb));
```

Scilab code Exa 18.6 `zero sequence currents`

```
1  //Chapter 18
2  //Example 18_6
3  //Page 431
4
5  clear;clc;
6
7  i=12;
8
9  printf("Zero sequence current is equal to 1/3rd the
        current in nuetral wire.\n");
10 printf("Zero sequence current in each phase = %d A \
        n\n", i/3);
```

Scilab code Exa 18.7 `with and without fuse`

```
1  //Chapter 18
2  //Example 18_7
```

```scilab
3  //Page 432
4
5  clear;clc;
6
7  i=90;
8
9  disp("(i) BEFORE REMOVAL OF FUSES: ");
10
11  a=1*(cosd(120)+%i*sind(120));
12
13  Ir=90*(cosd(0)+%i*sind(0));
14  Iy=90*(cosd(240)+%i*sind(240));
15  Ib=90*(cosd(120)+%i*sind(120));
16
17  Ir0=1/3*(Ir+Iy+Ib);
18  Ir2=1/3*(Ir+a^2*Iy+a*Ib);
19
20  Iy2=a*Ir2;
21  Ib2=a^2*Ir2;
22
23  Ir1=Ir;
24  Iy1=Iy;
25  Ib1=Ib;
26
27  printf("Ir = %.2f /_%.2f A \n", abs(Ir), atand(imag(
      Ir)/real(Ir)));
28  printf("Iy = %.2f /_%.2f A \n", abs(Iy), atand(imag(
      Iy)/real(Iy))+180);
29  printf("Ib = %.2f /_%.2f A \n\n", abs(Ib), atand(
      imag(Ib)/real(Ib))+180);
30
31  printf("Zero sequence components of three line
      currents are: \n");
32  printf("Ir0 = Iy0 = Ib0 = %d A \n\n", real(Ir0));
33
34  printf("Ir2 = %d A \n", abs(Ir2));
35  printf("Iy2 = %d A \n", abs(Iy2));
36  printf("Ib2 = %d A \n\n", abs(Ib2));
```

```
37
38  printf("Ir1 = %.2f /_%.2f A \n", abs(Ir), atand(imag
        (Ir)/real(Ir)));
39  printf("Iy1 = %.2f /_%.2f A \n", abs(Iy), atand(imag
        (Iy)/real(Iy))+180);
40  printf("Ib1 = %.2f /_%.2f A \n\n\n", abs(Ib), atand(
        imag(Ib)/real(Ib))+180);
41
42  disp("AFTER REMOVAL OF FUSES: ");
43
44  Ird=90*(cosd(0)+%i*sind(0));
45  Iyd=0;
46  Ibd=0;
47
48  printf("Ir = %.2f /_%.2f A \n", abs(Ird), atand(imag
        (Ird)/real(Ird)));
49  printf("Iy = %d A \n", Iyd);
50  printf("Ib = %d A \n\n", Ibd);
51
52  Ir0d=1/3*(Ird+Iyd+Ibd);
53  Ir1d=1/3*(Ird+a*Iyd+a^2*Ibd);
54  Ir2d=1/3*(Ird+a^2*Iyd+a*Ibd);
55
56  printf("Zero sequence components of three line
        currents are: \n");
57  printf("Ir0 = Iy0 = Ib0 = %d /_0 A \n\n", real(Ir0d)
        );
58
59  Iy0d=Ir0d;
60  Ib0d=Ir0d;
61
62  Iy1d=a^2*Ir1d;
63  Iy2d=a*Ir2d;
64
65  Ib1d=a*Ir1d;
66  Ib2d=a^2*Ir2d;
67
68  printf("Ir1 = %.2f /_%.2f A \n", abs(Ir1d), atand(
```

```
      imag(Ir1d)/real(Ir1d)));
69 printf("Ir2 = %.2f /_%.2f A \n\n", abs(Ir2d), atand(
      imag(Ir2d)/real(Ir2d))+180);
70
71 printf("Iy1 = %.2f /_%.2f A \n", abs(Iy1d), atand(
      imag(Iy1d)/real(Iy1d))+180);
72 printf("Iy2 = %.2f /_%.2f A \n\n", abs(Iy2d), atand(
      imag(Iy2d)/real(Iy2d))+180);
73
74 printf("Ib1 = %.2f /_%.2f A \n", abs(Ib1d), atand(
      imag(Ib1d)/real(Ib1d))+180);
75 printf("Ib2 = %.2f /_%.2f A \n\n", abs(Ib2d), atand(
      imag(Ib2d)/real(Ib2d))+180);
76
77 Iyd=Iy0d+Iy1d+Iy2d;
78 printf("Curretn in yellow line = %d A \n\n", real(
      Iyd));
```

Scilab code Exa 18.8 `line current values`

```
1 //Chapter 18
2 //Example 18_8
3 //Page 433
4
5 clear;clc;
6
7 a=1*(cosd(120)+%i*sind(120));
8
9 In=300*(cosd(300)+%i*sind(300));
10 Ir1=200*(cosd(0)+%i*sind(0));
11 Ir2=100*(cosd(60)+%i*sind(60));
12
13 Ir0=1/3*In;
```

```
14
15  Ir=Ir0+Ir1+Ir2;
16  Iy=Ir0+a^2*Ir1+a*Ir2;
17  Ib=Ir0+a*Ir1+a^2*Ir2;
18
19  printf("Ir = %.2f /_%.2f volts \n\n", abs(Ir), atand
        (imag(Ir)/real(Ir)));
20  printf("Iy = %.2f /_%.2f volts \n\n", abs(Iy), atand
        (imag(Iy)/real(Iy))-180);
21  printf("Ib = %.2f /_%.2f volts \n\n", abs(Ib), atand
        (imag(Ib)/real(Ib)));
```

Scilab code Exa 18.9 `currents in three phases`

```
1  //Chapter 18
2  //Example 18_9
3  //Page 434
4
5  clear;clc;
6
7  a=1*(cosd(120)+%i*sind(120));
8
9  Ir=10*(cosd(0)+%i*sind(0));
10  Iy=10*(cosd(180)+%i*sind(180));
11  Ib=0;
12
13  Ir0=1/3*(Ir+Iy+Ib);
14  Ir1=1/3*(Ir+a*Iy+a^2*Ib);
15  Ir2=1/3*(Ir+a^2*Iy+a*Ib);
16
17  Iy0=Ir0;
18  Iy1=a^2*Ir1;
19  Iy2=a*Ir2;
```

```
20
21  Ib0=Ir0;
22  Ib1=a*Ir1;
23  Ib2=a^2*Ir2;
24
25  printf("Ir = %.2f /_%.2f A \n", abs(Ir), atand(imag(
        Ir)/real(Ir)));
26  printf("Iy = %.2f /_%.2f A \n", abs(Iy), atand(imag(
        Iy)/real(Iy))+180);
27  printf("Ib = %.d A \n\n", Ib);
28
29  disp("RED PHASE: ");
30  printf("Ir0 = %d A \n", real(Ir0));
31  printf("Ir1 = %.2f /_%.2f A \n", abs(Ir1), atand(
        imag(Ir1)/real(Ir1)));
32  printf("Ir2 = %.2f /_%.2f A \n\n", abs(Ir2), atand(
        imag(Ir2)/real(Ir2)));
33
34  disp("YELLOW PHASE: ");
35  printf("Iy0 = %d A \n", real(Iy0));
36  printf("Iy1 = %.2f /_%.2f A \n", abs(Iy1), atand(
        imag(Iy1)/real(Iy1))-180);
37  printf("Iy2 = %.2f /_%.2f A \n\n", abs(Iy2), atand(
        imag(Iy2)/real(Iy2))+180);
38
39  disp("BLUE PHASE: ");
40  printf("Ib0 = %d  A \n", real(Ib0));
41  printf("Ib1 = %.2f /_%.2f A \n", abs(Ib1), atand(
        imag(Ib1)/real(Ib1)));
42  printf("Ib2 = %.2f /_%.2f A \n\n", abs(Ib2), atand(
        imag(Ib2)/real(Ib2))-180);
```

Scilab code Exa 18.10 resistor and line currents

```
1   //Chapter 18
2   //Example 18_10
3   //Page 435
4
5   clear;clc;
6
7   a=1*(cosd(120)+%i*sind(120));
8
9   rr=5;
10  ry=10;
11  rb=20;
12
13  Er=-100*(cosd(0)+%i*sind(0));
14  Ey=100*(cosd(60)+%i*sind(60));
15  Eb=100*(cosd(-60)+%i*sind(-60));
16
17  Ir=Er/rr;
18  Iy=Ey/ry;
19  Ib=Eb/rb;
20
21  printf("Er = %.2f /_%.2f V \n", Er, atand(imag(Er)/
        real(Er)));
22  printf("Ey = %.2f /_%.2f V \n", abs(Ey), atand(imag(
        Ey)/real(Ey)));
23  printf("Eb = %.2f /_%.2f V \n\n", abs(Eb), atand(
        imag(Eb)/real(Eb)));
24
25  printf("Ir = %.2f /_%.2f A \n", Ir, atand(imag(Ir)/
        real(Ir)));
26  printf("Iy = %.2f /_%.2f A \n", abs(Iy), atand(imag(
        Iy)/real(Iy)));
27  printf("Ib = %.2f /_%.2f A \n\n", abs(Ib), atand(
        imag(Ib)/real(Ib)));
28
29  disp("SEQUENCE CURRENTS IN RESISTORS: ");
30
31  Ir0=1/3*(Ir+Iy+Ib);
32  Ir1=1/3*(Ir+a*Iy+a^2*Ib);
```

```
33  Ir2 =1/3*( Ir+a^2*Iy+a*Ib );
34
35  Iy0 = Ir0 ;
36  Iy1 = a^2*Ir1 ;
37  Iy2 = a*Ir2 ;
38
39  Ib0 = Ir0 ;
40  Ib1 = a*Ir1 ;
41  Ib2 = a^2*Ir2 ;
42
43  printf ("Ir0 = %.2 f /_%.2 f A \n", abs (Ir0), atand (
       imag (Ir0)/real (Ir0))+180);
44  printf ("Ir1 = %.2 f /_%.2 f A \n", abs (Ir1), atand (
       imag (Ir1)/real (Ir1))+180);
45  printf ("Ir2 = %.2 f /_%.2 f A \n\n", abs (Ir2), atand (
       imag (Ir2)/real (Ir2))-180);
46
47  printf ("Iy0 = %.2 f /_%.2 f A \n", abs (Iy0), atand (
       imag (Iy0)/real (Iy0))+180);
48  printf ("Iy1 = %.2 f /_%.2 f A \n", abs (Iy1), atand (
       imag (Iy1)/real (Iy1)));
49  printf ("Iy2 = %.2 f /_%.2 f A \n\n", abs (Iy2), atand (
       imag (Iy2)/real (Iy2)));
50
51  printf ("Ib0 = %.2 f /_%.2 f A \n", abs (Ib0), atand (
       imag (Ib0)/real (Ib0))+180);
52  printf ("Ib1 = %.2 f /_%.2 f A \n", abs (Ib1), atand (
       imag (Ib1)/real (Ib1)));
53  printf ("Ib2 = %.2 f /_%.2 f A \n\n", abs (Ib2), atand (
       imag (Ib2)/real (Ib2)));
54
55  disp ("SEQUENCE CURRENTS IN SUPPLY LINES: ");
56  ir=Ib - Iy ;
57  iy=Ir - Ib ;
58  ib=Iy - Ir ;
59
60  ir0 =1/3*( ir+iy+ib );
61  ir1 =1/3*( ir+a*iy+a^2*ib );
```

```
62  ir2 =1/3*( ir+a^2* iy+a*ib );

63

64

65  printf (" Line  current  in  R-line  =  Ir  =  %.2f  /_%.2f  A
        \n", abs (ir), atand (imag (ir)/real (ir)) -180);
66  printf (" Line  current  in  Y-line  =  Iy  =  %.2f  /_%.2f  A
        \n", abs (iy), atand (imag (iy)/real (iy)) +180);
67  printf (" Line  current  in  B-line  =  Ib  =  %.2f  /_%.2f  A
        \n\n", abs (ib), atand (imag (ib)/real (ib)));

68

69  printf (" Ir0  =  %d  A  \n", abs (ir0));
70  printf (" Ir1  =  %.2f  /_%.2f  A  \n", abs (ir1), atand (
        imag (ir1)/real (ir1)) -180);
71  printf (" Ir2  =  %.2f  /_%.2f  A  \n\n", abs (ir2), atand (
        imag (ir2)/real (ir2)) +180);
```

Scilab code Exa 18.11 current calculations

```
1   // Chapter  18
2   // Example  18_11
3   // Page  437

4

5   clear ; clc ;

6

7   a=1*( cosd (120) +%i*sind (120));

8

9   Ir =20*( cosd (0) +%i*sind (0));
10  Iy =20*( cosd (180) +%i*sind (180));
11  Ib =0;

12

13  Ir0 =1/3*( Ir+Iy+Ib );
14  Ir1 =1/3*( Ir+a*Iy+a^2*Ib );
15  Ir2 =1/3*( Ir+a^2*Iy+a*Ib );
```

```
16
17  Iy0=Ir0;
18  Iy1=a^2*Ir1;
19  Iy2=a*Ir2;
20
21  Ib0=Ir0;
22  Ib1=a*Ir1;
23  Ib2=a^2*Ir2;
24
25  printf(" Ir = %.2 f /_%.2 f A \n", abs(Ir), atand(imag(
        Ir)/real(Ir)));
26  printf(" Iy = %.2 f /_%.2 f A \n", abs(Iy), atand(imag(
        Iy)/real(Iy))+180);
27  printf(" Ib = %d A \n\n", abs(Ib));
28
29  disp("RED LINE: ");
30  printf(" Ir0 = %d A \n", real(Ir0));
31  printf(" Ir1 = %.2 f /_%.2 f A \n", abs(Ir1), atand(
        imag(Ir1)/real(Ir1)));
32  printf(" Ir2 = %.2 f /_%.2 f A \n\n", abs(Ir2), atand(
        imag(Ir2)/real(Ir2)));
33
34  disp("YELLOW LINE: ");
35  printf(" Iy0 = %d A \n", real(Iy0));
36  printf(" Iy1 = %.2 f /_%.2 f A \n", abs(Iy1), atand(
        imag(Iy1)/real(Iy1))+180);
37  printf(" Iy2 = %.2 f /_%.2 f A \n\n", abs(Iy2), atand(
        imag(Iy2)/real(Iy2))+180);
38
39  disp("BLUE LINE: ");
40  printf(" Ib0 = %d  A \n", real(Ib0));
41  printf(" Ib1 = %.2 f /_%.2 f A \n", abs(Ib1), atand(
        imag(Ib1)/real(Ib1)));
42  printf(" Ib2 = %.2 f /_%.2 f A \n\n", abs(Ib2), atand(
        imag(Ib2)/real(Ib2))+180);
```

Scilab code Exa 18.12 current calculations 2

```
1  //Chapter 18
2  //Example 18_12
3  //Page 438
4
5  clear;clc;
6
7  a=1*(cosd(120)+%i*sind(120));
8
9  z1=5-%i*10;
10 z2=6+%i*5;
11 z3=3+%i*15;
12
13 Vry=3300*(cosd(0)+%i*sind(0));
14 Vyb=a^2*Vry;
15
16 Vr_minus_Vy=3300;
17 Vy_minus_Vb=3300*(cosd(120)-%i*sind(120));
18
19 printf("Since Ir+Iy+Ib=0, Ir0=Iy0=Ib0=0 A \n");
20
21 v=[Vr_minus_Vy; Vy_minus_Vb];
22
23 za=z1-a^2*z2;
24 zb=z1-a*z2;
25 zc=a^2*z2-a*z3;
26 zd=a*z2-a^2*z3;
27 z=[za zb; zc zd];
28
29 I=z\v;
30
```

```
31  printf (" Ir1  = %.2 f+j (%.2 f)  \n", real (I(1)), imag (I
        (1)));
32  printf (" Ir2  = %.2 f+j (%.2 f)  \n\n", real (I(2)), imag (I
        (2)));
33
34  ir=I(1)+I(2);
35  printf (" Ir  = %.2 f  /_%.2 f  \n\n", abs (ir), atand (imag (
        ir)/real (ir)));
```

Scilab code Exa 18.13 current calculations 3

```
1   // Chapter  18
2   // Example  18_13
3   // Page  440
4
5   clear ; clc ;
6
7   a=1*( cosd (120) +%i* sind (120));
8
9   r=1;
10  vry =200;
11  vyb =346;
12  vbr =400;
13
14  // referring  to  the  phasor  diagram
15  // vbr  is  twice  vry , ie , factor  =2
16  // vyb =1.75  times  vry
17  alpha = acosd ((1+1.75* cosd (90))/2);
18
19  Vry = vry *( cosd (180) +%i* sind (180));
20  Vyb = vyb *( cosd (90) +%i* sind (90));
21  Vbr = vbr *( cosd (-alpha) +%i* sind (-alpha));
22
```

```
23 printf("Vry = %.2f+j(%.2f) V \n", real(Vry), imag(
      Vry));
24 printf("Vyb = %.2f+j(%.2f) V \n", real(Vyb), imag(
      Vyb));
25 printf("Vbr = %.2f+j(%.2f) V \n\n", real(Vbr), imag(
      Vbr));
26
27 Ir=Vry/sqrt(3);
28 Iy=Vyb/sqrt(3);
29 Ib=Vbr/sqrt(3);
30
31 disp("Line current : ");
32 printf("Ir = %.2f /_%.2f A \n", abs(Ir), atand(imag(
      Ir)/real(Ir))+180);
33 printf("Iy = %.2f /_90 A \n", abs(Iy));
34 printf("Ib = %.2f /_%.2f A \n\n", abs(Ib), atand(
      imag(Ib)/real(Ib)));
35
36 Ir0=1/3*(Ir+Iy+Ib);
37 Ir1=1/3*(Ir+a*Iy+a^2*Ib);
38 Ir2=1/3*(Ir+a^2*Iy+a*Ib);
39
40 printf("Ir0 = %d A \n", abs(Ir0));
41 printf("Ir1 = %.2f /_%.2f A \n", abs(Ir1), atand(
      imag(Ir1)/real(Ir1))-180);
42 printf("Ir2 = %.2f /_%.2f A \n", abs(Ir2), atand(
      imag(Ir2)/real(Ir2)));
```

Scilab code Exa 18.14 impedance and voltage calculations

```
1 //Chapter 18
2 //Example 18_14
3 //Page 449
```

```scilab
 4
 5  clear;clc;
 6
 7  mva=10;
 8  kv=11;
 9  g=[%i*1.2 %i*0.9 %i*0.4];
10  f=[%i*1 %i*1 %i*3];
11
12  Er=kv*1000/sqrt(3);
13  printf("Phase enf of R phase = %d V \n", Er);
14
15  printf("(i) Total impedance to any sequence current
       is sum of generator and feeder impedances of that
        sequence currents \n");
16
17  for i=1:3
18    tz(i)=g(i)+f(i);
19    printf("\tTotal Z(%i) = j(%.1f) ohm \n", i,imag(tz
        (i)));
20  end
21
22  z=sum(tz);
23  I1=Er/z;
24  I2=I1;
25  I0=I1;
26
27  Ir=3*I0;
28
29  Vr=Er-I0*sum(g);
30  printf("I1 = I2 = I0 = j(%d) A \n\n", imag(I0));
31  printf("Fault current = j(%d) A \n\n\n", imag(Ir));
32
33  printf("(ii) Line to nuetral voltage of R-phase = %
       .2f V \n\n", Vr);
```

Scilab code Exa 18.15 ratio of fault currents

```
1  //Chapter 18
2  //Example 18_15
3  //Page 450
4
5  clear;clc;
6
7  kv=11;
8  mva=10;
9  X0=%i*0.05;
10 X1=%i*0.15;
11 X2=%i*0.15;
12
13 Er=1;
14 I0=Er/(X0+X1+X2);
15 I1=I0;
16 I2=I0;
17 Ir=3*I0;
18 Ish=Er/X1;
19 ratio=Ir/Ish;
20
21 disp("Line to ground fault: ");
22 printf("I1=I2=I0=j(%.2f) A \n", imag(I0));
23 printf("Fault current = j(%.2f) A \n\n", imag(Ir));
24
25 disp("Three phase fault: ");
26 printf("Fault current = j(%.2f) A \n\n", imag(Ish));
27 printf("Ratio of two fault currents = %.3f A \n\n",
      ratio);
28 printf("Thus single line to ground fault is %.3f
      times that due to dead short circuit on the 3
```

phases \n\n", ratio);

Scilab code Exa 18.16 `fault current`

```
1  //Chapter 18
2  //Example 18_16
3  //Page 450
4
5  clear;clc;
6
7  kv=11;
8  mva=25;
9  X0=%i*0.05;
10 X1=%i*0.2;
11 X2=%i*0.2;
12
13 Xn=%i*0.3;
14 Er=1;
15 pu_xn=Xn*mva*1000/kv^2/1000;
16 I0=Er/(X0+X1+X2+3*pu_xn);
17 I1=I0;
18 I2=I0;
19 Ir=3*I0;
20 fc=mva*1e6/sqrt(3)/kv/1000*abs(Ir);
21
22 printf("Per unit value of Xn = %.4f p.u \n\n", imag(
      pu_xn));
23 printf("I1=I2=I0=j(%.3f) A \n\n", imag(I0));
24 printf("Fault current = j(%.3f) A \n\n", imag(Ir));
25 printf("Fault current in amperes = Rated current *
      Per unit value\n");
26 printf("                              %d A \n\n", fc);
```

Scilab code Exa 18.17 `fault current 2`

```
1  //Chapter  18
2  //Example  18_17
3  //Page  451
4
5  clear;clc;
6
7  Er=10.4*1e3/sqrt(3);
8  X1=0.6;
9  X2=0.5;
10 X0=0.2;
11
12 If=sqrt(3)*Er/(X1+X2);
13
14 printf("Phase  emf  of  R-phase  =  %d  V  \n\n", Er);
15 printf("Fault  current  for  line  to  line  fault  =  %.1f
       A  \n\n", If);
```

Scilab code Exa 18.18 `fault current 3`

```
1  //Chapter  18
2  //Example  18_18
3  //Page  451
4
5  clear;clc;
6
7  X1=%i*0.08;
```

```
8   X2=%i*0.07;
9   X0=%i*0.05;
10
11  //pu value
12  Er=1;
13
14  If=-3*X2*Er/(X1*X2+X1*X0+X2*X0);
15  printf("Fault current = j%d p.u \n\n", imag(If));
```

Scilab code Exa 18.19 fault current 4

```
1   //Chapter 18
2   //Example 18_19
3   //Page 452
4
5   clear;clc;
6
7   mva=20;
8   kv=11;
9   xn=5;
10  x1=20;
11  x2=10;
12
13  Er=kv*1000/sqrt(3);
14  printf("Phase emf of red phase = %d V \n\n", Er);
15
16  //from the reactance diagram given in the text;
17  r_x1=x1/2;
18  r_x2=x2/2;
19  r_xn=30;
20
21  X1=r_x1*kv^2*10/mva/1000;
22  X2=r_x2*kv^2*10/mva/1000;
```

```
23  X0=r_xn*kv^2*10/mva/1000;
24
25  Ir=3*Er/(X1+X2+X0)/%i;
26
27  printf("X1 = %.3f ohm \n\n", X1);
28  printf("X2 = %.3f ohm \n\n", X2);
29  printf("X0 = %.3f ohm \n\n", X0);
30
31  printf("Fault current = j(%d) A \n\n", imag(Ir));
```

Scilab code Exa 18.20 reactance calculations

```
1  //Chapter 18
2  //Example 18_20
3  //Page 453
4
5  clear;clc;
6
7  mva=50;
8  kv=11;
9
10  //three phase fault
11  I1=2000;
12  //line to line fault
13  I2=2600;
14  //line to ground fault
15  I3=4200;
16
17  Eph=kv*1000/sqrt(3);
18
19  X1=Eph/I1;
20  X2=sqrt(3)*Eph/I2-X1;
21  X3=3*Eph/I3-X1-X2;
```

```
22
23  printf("X1 = %.3f ohm \n\n", X1);
24  printf("X2 = %.3f ohm \n\n", X2);
25  printf("X3 = %.3f ohm \n\n", X3);
```

Chapter 19

Circuit Breakers

Scilab code Exa 19.1 circuit breaker rating

```
1  //Chapter 19
2  //Example 19_1
3  //Page 483
4
5  clear;clc;
6
7  i=1500;
8  mva=1000;
9  v=33*1e3;
10 t=3;
11
12 printf(" (i) Rated normal current = %.0f A \n\n", i);
13 printf(" (ii) Breaking capacity = %.0f MVA \n\n", mva
       );
14 rsbc=mva*1e6/sqrt(3)/v;
15 printf(" (iii) Rated symmetrical breaking capacity =
       %.0f A \n\n", rsbc);
16 rmc=2.55*rsbc;
17 printf(" (iv) Rated making current = %.0f A \n\n",
       rmc);
18 printf(" (v) Rated short time rating = %.0f A for %.0
```

```
        f  sec  \n\n", rsbc , t ) ;
19  printf (" ( vi )  Rated  service  voltage  = %.0 f  kV  \n\n" ,
        v /1000) ;
```

Scilab code Exa 19.2 average rrrv

```
1  // Chapter  19
2  // Example  19_2
3  // Page  484
4
5  clear ; clc ;
6
7  f =50;
8  v =11*1 e3 ;
9  x =5;
10  c =0.01*1 e -6;
11
12  l=x /2/%pi/ f ;
13  emax = sqrt (2) * v /1000/ sqrt (3) ;
14  fn =1/2/%pi/ sqrt ( l*c ) ;
15  t =1/2/ fn ;
16  avg =2* emax / t ;
17
18  printf (" Inductance  per  phase  = %.5 f  H  \n\n" , l ) ;
19  printf (" ( i )  Maximum  value  of  recovery  voltage  = %.2 f
        kV  \n\n" , emax ) ;
20  printf ("      Peak  restriking  voltage  = %.2 f  kV  \n\n" ,
        2* emax ) ;
21  printf (" ( ii )  Frequency  of  oscillation  = %.0 f  Hz  \n\n
        " , fn ) ;
22  printf (" ( iii )  Time  t  at  which  peak  restriking
        voltage  occurs  = %.2 f  us  \n\n" , t *1 e6 ) ;
23  printf ("        Average  rate  of  rise  of  recovery
```

```
     voltage = %.0f kV/sec \n\n", avg);
```

Scilab code Exa 19.3 natural frequency of oscillations

```
1  //Chapter 19
2  //Example 19_3
3  //Page 484
4
5  clear;clc;
6
7  tp=50*1e-6;
8  rvp=100*1e3;
9
10 rrrv=rvp/tp;
11 fn=1/2/tp;
12
13 printf("Average RRRV = %.0f kV/sec \n\n", rrrv/1000)
      ;
14 printf("Natural frequency of oscillatins = %.0f Hz \
      n\n", fn);
```

Scilab code Exa 19.4 voltage during chopping

```
1  //Chapter 19
2  //Example 19_4
3  //PAge 485
4
5  clear;clc;
6
```

```
 7  i =7;
 8  l =35.2;
 9  c =0.0023*1e -6;
10
11  e=i*sqrt(l/c);
12  printf(" Voltage  across  breaker  = %.0f  kV  \n\n", e
        /1000) ;
```

Chapter 20

Fuses

Scilab code Exa 20.1 radius of wire

```
1  //Chapter 20
2  //Example 20_1
3  //Page 495
4
5  clear;clc;
6
7  r1=0.8;
8  i1=8;
9  i2=1;
10
11 r2=r1*(i2/i1)^(2/3);
12
13 printf("Radius = %.1f mm \n\n", r2);
```

Chapter 21

Protective relays

Scilab code Exa 21.1 `relay operating time`

```
1  //Chapter  21
2  //Example  21.1
3  //Page  507
4
5  i =5;
6  cs =1.25;
7  ts =0.6;
8  tv1 =400;
9  tv2 =5;
10 fc =4000;
11
12 pup=i*cs;
13 frc=fc*tv2/tv1;
14 psm=frc/pup;
15 ot =3.5*0.6;
16
17 printf(" Pick  up  current  = %.2 f  A  \n\n", pup);
18 printf(" Fault  current  in  relay  coil  = %.0 f  A  \n\n",
       frc);
19 printf(" Plug  multiplier  setting  = %.0 f   \n\n", psm);
20 printf(" Corresponding  to  the  plug  multiplier  setting
```

```
of %.0 f , the  time  of  operation  is  3.5  seconds.\n
\t  Therefore  actual  relay  operating  time  = %.2 f
s \n\n", psm, ot);
```

Chapter 22

Protection of Alternators and Transformers

Scilab code Exa 22.1 `Merz Price principle`

```
1  //Chapter 22
2  //Example 22_1
3  //Page 529
4
5  clear;clc;
6
7  mva=10*1e6;
8  v=6.6*1e3;
9  ph_z=0.1;
10 i=175;
11 awp=0.1;
12
13 vph=v/sqrt(3);
14 flc=mva/sqrt(3)/v;
15 x=v*mva/1e6/flc/sqrt(3)/100;
16 zw=x*ph_z;
17 emfw=vph*ph_z;
18
19 r=sqrt((emfw/i)^2-zw^2);
```

```
20
21  printf(" Voltage  per  phase  = %.0 f  V  \n\n", vph);
22  printf(" Full  load  current  = %.0 f  V  \n\n", flc);
23  printf(" Reactance  per  phase  = %.3 f  ohm  \n\n", x);
24  printf(" Reactance  of  10  percent  winding  = %.4 f  ohm  \
        n\n", zw);
25  printf("EMF  induced  in  10  percent  winding  = %.0 f  V  \
        n\n", emfw);
26  printf(" Impedance  offered  by  fault  by  10  percent
        winding  is  Zf=sqrt(%.4 f^2+r^2)  \n\n", zw);
27  printf(" Earthing  resistance  to  be  provided  = %.3 f
        ohm  \n\n", r);
```

Scilab code Exa 22.2 `unprotected winding calculations`

```
1  // Chapter  22
2  // Example  22_2
3  // Page  530
4
5  clear; clc;
6
7  r=7.5;
8  mva=10;
9  i1=1000;
10  i2=5;
11  kv=6.6;
12  oc=0.5;
13
14  v_ph=kv*1000/sqrt(3);
15  min_fc=i1/i2*oc;
16  emf=v_ph/100;
17  efc=emf/r;
18  uw=min_fc/efc;
```

```
19
20  printf(" Voltage  per  phase  =  %d  V  \n\n", v_ph);
21  printf(" Minimum  fault  current  which  will  operate  the
            relay  =  %d  A  \n\n", min_fc);
22  printf(" EMF  induced  in  %%x  winding  =  %.2 f*x  V  \n\n",
            emf)
23  printf(" Earth  fault  current  which  %%x  winding  will
            cause  =  %.2 f*x  A  \n\n", efc);
24  printf(" This  current  must  be  equal  to  %dA  \n\n",
        min_fc);
25  printf(" Unprotected  winding ,  x= %.2 f  %%  \n\n", uw);
```

Scilab code Exa 22.3 `unprotected winding and r`

```
 1  //Chapter  22
 2  //Example  22_3
 3  //Page  530
 4
 5  clear;clc;
 6
 7  mva=10;
 8  kv=6.6;
 9  i1=1000;
10  i2=5;
11  oc=0.75;
12  r=6;
13  x=10;
14
15  v_ph=kv*1000/sqrt(3);
16  min_fc=i1/i2*oc;
17  emf=v_ph/100;
18  efc=emf/r;
19  uw=min_fc/efc;
```

```
20
21  printf(" ( i )  x%% of  the  winding  is  unprotected ,  \n\n"
        )
22  printf(" Voltage  per  phase  =  %d  V  \n\n", v_ph);
23  printf(" Minimum  fault  current  which  will  operate  the
          relay  =  %d  A  \n\n", min_fc);
24  printf(" EMF  induced  in  %%x  winding  =  %.2 f*x  V  \n\n",
        emf)
25  printf(" Earth  fault  current  which  %%x  winding  will
        cause  =  %.2 f*x  A  \n\n", efc);
26  printf(" This  current  must  be  equal  to  %d  A  \n\n",
        min_fc);
27  printf(" Unprotected  winding ,  x=  %.2 f  %%  \n\n", uw);
28
29  min_r=emf*x/min_fc;
30  printf(" ( ii )  The  minimum  earthing  resistance
        required  to  provide  protection  for  %d  %%  of
        stator  winding  =  %.2 f  ohm  \n\n", (100-x), min_r);
```

Scilab code Exa 22.4 `earthing resistance r`

```
 1  // Chapter  22
 2  // Example  22 _4
 3  // Page  531
 4
 5  clear ; clc ;
 6
 7  mva =10;
 8  kv =6.6;
 9  x =(100 -85) ;
10
11  v_ph=kv *1000/ sqrt (3) ;
12  i=mva *1e6/ sqrt (3) /kv /1000;
```

```
13  min_fc =0.2* i ;
14  emf =0.15* v_ph ;
15  r=emf / min_fc ;
16
17  printf (" Full  load  current  = %.2 f A \n\n", i);
18  printf (" Minimum  fault  current  which  will  operate  the
          relay  = %.2 f A \n\n", min_fc );
19  printf (" Voltage  induced  in %d %% winding  is %.2 f V \
          n\n", x, emf );
20  printf (" Earth  fault  current  which %d %% winding  will
          cause  = %.2 f/r \n\n", x, emf );
21  printf (" This  current  must  be equal  to minimum  fusing
          current  %.2 f A \n\n", min_fc );
22  printf (" Earthing  resistance  required  = %.2 f ohm \n\n
          ", r);
```

Scilab code Exa 22.5 turn ratio 1

```
 1  // Chapter  22
 2  // Example  22 _5
 3  // Page  538
 4
 5  clear ; clc ;
 6
 7  v1 =220;
 8  v2 =11000;
 9  v=220;
10  i1 =600;
11  i2 =5;
12
13  lc= sqrt (3) * i2 ;
14  pap= sqrt (3) *v* i1 ;
15  i=pap / sqrt (3) / v2 ;
```

```
16
17  ratio=i/lc;
18
19  printf("Line current of delta connected CTs on %d V
        side = %.2f A \n\n", v1, lc);
20  printf("Phase current of star connected CTs on %d V
        side = %.2f A \n\n", v2, lc);
21  printf("The line current on the %d V side = %.2f A \
        n\n",v2, i);
22  printf("Turn ratio of CTs on %d V side = %.3f:1 \n\n
        ", v2, ratio);
```

Scilab code Exa 22.6 turn ratio 2

```
1  //Chapter 22
2  //Example 22_6
3  //Page 538
4
5  clear;clc;
6
7  v1=0.4;
8  v2=11;
9  v=400;
10 i1=500;
11 i2=5;
12
13 lc=sqrt(3)*i2;
14 pap=sqrt(3)*v*i1;
15 i=pap/sqrt(3)/v2/1000;
16
17 ratio=i/lc;
18
19 printf("Line current of delta connected CTs on %d V
```

```
       side = %.2 f A \n\n", v1 , lc ) ;
20 printf (" Phase current of star connected CTs on %d V
       side = %.2 f A \n\n", v2 , lc ) ;
21 printf (" The line current on the %d V side = %.2 f A \
       n\n",v2 , i ) ;
22 printf (" Turn ratio of CTs on %d V side = %.1 f :1 \n\n
       ", v2 , ratio ) ;
```

Chapter 26

Neutral Grounding

Scilab code Exa 26.1 peterson coil reactance

```
1  // Chapter 26
2  // Example 26_1
3  // Page 599
4
5  clear ; clc ;
6
7  f =50;
8  v =33*1 e3 ;
9  c =4.5*1 e -6;
10
11  xl =1/(3*2*%pi*f*c);
12  printf ("Reactance of Peterson Coil = %.2 f ohm \n\n",
          xl );
```

Scilab code Exa 26.2 peterson coil rating

```
1  //Chapter 26
2  //Example 26_2
3  //Page 599
4
5  clear;clc;
6
7  v=230*1e3;
8  lt=200;
9  c=0.02*1e-6;
10 f=50;
11
12 cle=c*lt;
13 l=1/(3*(2*%pi*f)^2*cle);
14 xl=2*%pi*f*l;
15 vph=v/sqrt(3);
16 fi=vph/xl;
17 rating=vph*fi;
18
19 printf("Capacitance of line to earth = %.6f F \n\n",
       cle);
20 printf("Required inductance of Peterson coil = %.2f
     F \n\n", l);
21 printf("Current through Peterson coil = %.0f A \n\n"
     , fi);
22 printf("Rating of Peterson coil = %.0f kVA \n\n",
     rating/1000);
```

Scilab code Exa 26.3 reactance to nuetralize capacitance

```
1  //Chapter 26
2  //Example 26_3
3  //Page 600
4
```

```
 5 clear;clc;
 6
 7 f=50;
 8 c=1.2*1e-6;
 9 c1=c;
10 c2=0.9*c;
11 c3=0.8*c;
12
13 xl1=1/(3*2*%pi*f*c1);
14 xl2=1/(3*2*%pi*f*c2);
15 xl3=1/(3*2*%pi*f*c3);
16
17 printf("Inductive reactance of coil to nuetralize
       capacitance of 100%% of the length of the line is
       %.2f ohm \n\n", xl1);
18 printf("Inductive reactance of coil to nuetralize
       capacitance of 90%% of the length of the line is
       %.2f ohm \n\n", xl2);
19 printf("Inductive reactance of coil to nuetralize
       capacitance of 80%% of the length of the line is
       %.2f ohm \n\n", xl3);
```

Scilab code Exa 26.4 `coil rating`

```
 1 //Chapter 26
 2 //Example 26_4
 3 //PAge 600
 4
 5 clear;clc;
 6
 7 v=132*1e3;
 8 f=50;
 9 lt=200;
```

```
10  d=20;
11  s=4;
12  eo=8.854*1e-12;
13
14  r=d/2/1000;
15  c=2*%pi*eo/log(s/r);
16  w=2*%pi*f;
17  l=1/(3*w^2*c*lt)/1000;
18  xl=2*%pi*f*l;
19  fi=v/sqrt(3)/xl;
20  rating=v/sqrt(3)*fi;
21
22  printf("Capacitance between phase and nuetral = %.2f
        *10^-9 F/km \n\n", c*1e12);
23  printf("Capacitance between phase and earth = %.2f
        *10^-7 F \n\n", c*lt*1e7*1000);
24  printf("Required Inductance of the arc supression
        coil = %.2f H \n\n", l);
25  printf("Current through the coil = %.0f A \n\n", fi)
        ;
26  printf("Rating of the coil = %.0f kVA \n\n", rating
        /1000);
```