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

Created by
Apoorva M N
B.E
Electrical Engineering
Sri Jayachamarajendra College of Engineering
College Teacher
Prof. R S Ananda Murthy
Cross-Checked by
TechPassion

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Book Description

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

Exa Example (Solved example)

Eqn Equation (Particular equation of the above book)

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

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

Contents

List of Scilab Codes

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Chapter 1

Introduction

Scilab code Exa 1.1 efficiency and energy

```
//Chapter 1
//Example 1.1
//Page 6

clear;
clc;
Pi = 4200;
E = 120;
I = 32.2;

printf("(i) Input Power,     Pi = %.4f J/s = 4200 W\n
    ", Pi)

Po = E*I;
printf("     Output Power,    Po = %.4f W\n", Po)

//Calculation of efficiency
n = Po/Pi*100;
printf("     Efficiency, n = %.2f %%\n", n)

Pl = Pi-Po;
```

```
printf("(ii)      Power lost , Pl = %.4f W\n", Pl)

//Calculation of energy lost per minute of operation
El = Pl*60;
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

```
//Chapter 1
//Example 2.1
//Page 16

clear;
clc;

n_overall = 20;
W = 0.6;

printf("Let x kcal/kg be the calorific value of fuel
    .\n")
printf("Heat produced by 0.6 kg of coal = 0.6 x kcal
    \n")
printf("Heat equivalent of 1 kWh = 860 k cal\n")

//Calculation of calorific value of coal
printf("Now, n_overall = Electrical output in heat
    units/ Heat of combustion\n")

x=860/(0.6*0.2);
```

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

Scilab code Exa 2.2 annual coal bill

```
//Chapter 2
//Example 2.2
//Page 17

clear;
clc;

max_demand = 20000;
n_boiler = 0.85;
coal_consumption = 0.9;
load_factor = 40;
n_turbine = 0.90;
cost_per_ton = 300;

//Calculation of thermal efficiency

printf("(i) Thermal efficiency = %.2f %%\n\n",
    n_boiler*n_turbine*100);
printf("(ii) Units generated per annum = %.3f kWh\n
    ", max_demand*load_factor*8760);
printf("\t Coal consumption/annum = %.3f tons\n",
    coal_consumption*7008*1e4/1000);
printf("\t Annual coal bill = Rs %.4f\n",
    cost_per_ton*coal_consumption*7008*1e4/1000);
```

Scilab code Exa 2.3 average load

```
//Chapter 2
//Example 2.3
//Page 17

clear;
clc;

cost_per_annum = 300000;
cal_value = 5000;
cost_per_kg = 0.03;
n_thermal = 0.33;
n_electrical = 0.90;

n_overall = n_thermal*n_electrical;
printf("Overall efficiency = %.2f %% \n\n",
    n_overall*100);
coal_per_annum = cost_per_annum/cost_per_kg;
printf("Coal used/annum = %.2f kg\n\n",
    coal_per_annum);
hoc = coal_per_annum*cal_value;
//hoc-heat of combustion
printf("Heat of combustion = %.2f kcal \n\n", hoc);
heat_op = n_overall*hoc;
printf("Heat output = %.2f kcal \n\n", heat_op);
upa = heat_op/860;
//upa- units generated per annum
printf("Units generated per annum = %.0f kWh \n\n",
    upa);
avgl = upa/8760;
//avgl- average load on station
printf("Average load on station = %.1f kW \n\n",
    avgl);
```

Scilab code Exa 2.4 limiting value

```
//Chapter 2
//Example 2.4
//Page 17

clear;
clc;

w=13500;
kWh1=7.5;
c=5000;
kWh2=2.9;
hours=8;

//limiting value
printf("Limiting value =%.2f kg \n\n", (w+kWh1)/(c+
    kWh2));

//coal consumption per hour

printf("Coal consumption per hour = %.1f kg \n\n", c
    /hours);
```

Scilab code Exa 2.5 coal consumption per hour

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

```
//PAge 18

clear;clc;

power=100;
cv=6400;
n_thermal =0.3;
n_electrical =0.92;

//coal consumption
n_overall = n_thermal*n_electrical;
ugpa=power*1000;
h=ugpa*860/n_overall;
printf("Coal consumption per hour = %.1f kg \n\n", h
   /cv);
```

Scilab code Exa 2.6 total energy available

```
//chatper 2
//example 2_6
//page 23

clear;
clc;

capacity = 5*10^6;
h = 200;
n_overall = 75;
density=1000;

w = capacity*density*9.81;
printf("Weight of water available is W = %.2f N \n",
    w);
```

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

Scilab code Exa 2.7 yearly gross output

```
//Chapter 2
//Example 2_7
//Page 23

clear;clc;

w=94;
h=39;
n_plant=0.8;

work=w*h*9.81;
printf("Work done/sec = %.1f kW \n\n", work);

printf("This is gross plant capacity\n");

fc=n_plant*work;
printf("(i)\t Firm capacity = %.1f kW \n\n", fc);

printf("(ii)\t Yearly gross output = %.1f kW \n\n",
    fc*8760);
```

Scilab code Exa 2.8 energy per hour

```
//Chapter 2
//Example 2_8
//Page 23

clear;clc;

h=100;
n_hydraulic=0.86;
n_electrical=0.92;

n_overall=n_hydraulic*n_electrical;
w=9.81*1e3;
printf("Weight of water available = %.1f N \n\n", w)
    ;
power=w*h*n_overall;
printf("Power produced = %.1f kW \n\n", power/1000);
printf("Energy produced per hour = %.1f kWh \n\n",
    power/1000);
```

Scilab code Exa 2.9 maximum demand

```
//Chapter 2
//Example 2_9
//PAge 23

clear;clc;

area=5e9;
h=30;
rainfall=1.25;
k=0.8;
n_overall=0.7;
lf=0.4;
```

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

Scilab code Exa 2.10 level of reservoir

```
//Chapter 2
//Example 2_10
//Page 24

clear;clc;

area=2.4;
capacity=5e6;
head=100
n_penstock=0.95;
n_turbine=0.9;
n_generation=0.85;
load_kWh=15000;


//calculation of total electrical energy that can be
```

```
    generated
w=capacity*1e3*9.81;
printf("Wt. of water available= %.2f N \n\n", w);
n_overall=n_penstock*n_turbine*n_generation;
printf("Overall efficiency= %.2f \n\n", n_overall);
energy=w*head*n_overall/1000/3600;
printf("Electrical energy that can be generated= %.1
    f kWh \n\n",energy);

//calculation of fall in reservoir level
printf("Level of reservoir= %.3f m \n\n", capacity/
    area/1e6);
printf("kWh generated in 3 hours=%.2f kWh \n\n",
    load_kWh*3);
fall= capacity/area/1e6*load_kWh*3/energy*100;
printf("Fall in reservoir level= %.2f cm \n\n",fall)
    ;
```

Scilab code Exa 2.11 excess power

```
//Chapter 2
//Example 2_11
//PAge 25

clear;clc;

h=25;
power=400;
vol=[10 6 1.5];
months=[4 2 6];
n_overall=0.8;

//standby capacity
```

```
pd1=vol(1)*1e3*9.81*n_overall*h/1000
pd2=pd1*vol(2)/vol(1)
pd3=pd1*vol(3)/vol(1)
cap=power-pd3
printf("(i)\t Capacity of standby unit = %.1f kW \n\n", cap);

//excess power
discharge = vol.*months
avg_dis=sum(discharge)/12
pd=avg_dis*pd1/vol(1)
ep=pd-power
printf("(ii)\t Excess power available = %.1f kW \n\n", ep);
```

Scilab code Exa 2.12 load factor

```
//Chapter 2
//Example 2_12
//Page 25

clear;clc;

md=10;
h=20;
n_overall=0.8;
lf=0.4;


//river discharge
ugpw=md*lf*24*7*1e3;
printf("(i) Units generated per week =%.1f kWh \n\n", ugpw);
```

```
app=1e3*9.81*h*n_overall/1000;
upw=app*24*7;
q=ugpw/upw;
printf("\t River dishcharge required = %.2f m^3/sec"
   , q);

//load factor
flow=20;
pd=app*flow;
ug=pd*24;
lf=ug/1e4/24;
printf("(ii) Load factor =%.2f %% \n\n", lf*100);
```

Scilab code Exa 2.13 installed capacity 1

```
//Chapter 2
//Example 2_13
//Page 26

clear;clc;

d=[500 520 850 800 875 900 546];
days=7;
h=15;
n_overall=0.85;
lf=0.4;

scf(0)
bar(d, 1, 'red');
xlabel('Days');
ylabel('Discharge')
```

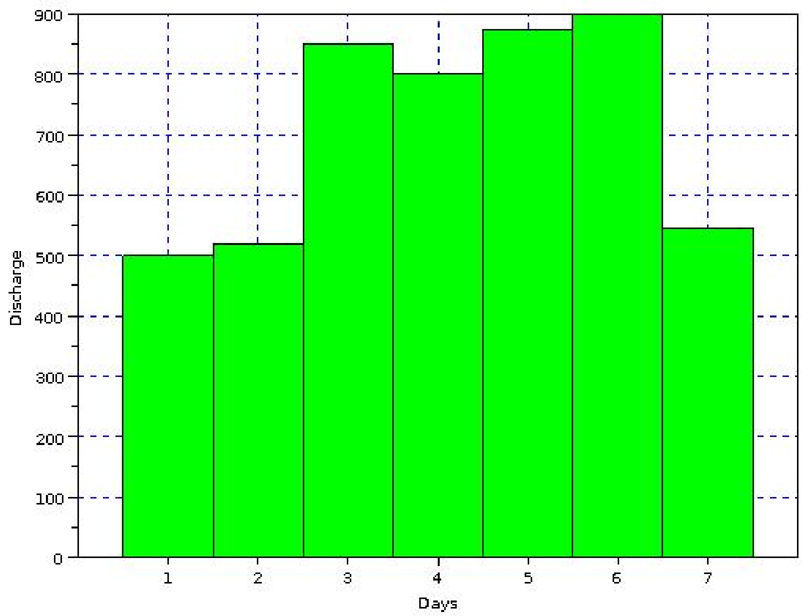

Figure 2.1: installed capacity 1

```
xgrid(0);

//Average daily discharge
avg=sum(d)/days;
printf("(i) Average daily discharge = %.0f m^3/sec \
   n\n", avg);

//Pondage required
vol=0;
j=0;
for i=1:7
  if d(i)<avg
    vol= vol+d(i);
    j=j+1;
  end;
end;

v=vol*24*3600;
v_req=j*avg*24*3600;
p=v_req-v;
printf("(ii) Pondage required = %.0f m^3 \n\n", p);

//Installed capacity
w=avg*1000*9.81;
app=w*h*n_overall;
ic=app/lf;
printf("(iii) Installed capacity of the plant = %.0f
    MW \n\n", ic/1e6);
```

Scilab code Exa 2.14 engine efficiency

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

```
//Page 28

clear;clc;

fc=0.28;
cv=1e4;
n_alternator=0.95;

heat=cv*fc;
printf("Heat equivalent of ikWh =860 kcal\n");
n_overall = 860/heat;
printf("(i)\t Overall efficiency = %.2f %% \n\n",
    n_overall*100);
printf("(ii)\t Engine efficiency =%.2f %% \n\n",
    n_overall/n_alternator*100);
```

Scilab code Exa 2.15 thermal efficiency

```
//Chapter 2
//Example 2_15
//PAge 30

clear;clc;

fc=1e3;
ugpd=4e3;
cv=1e4;
n_alternator=0.96;
n_mech=0.95;

//specific fuel consumption
printf("(i)\t Specific fuel consumption = %.2f kg/
    kWh \n\n", fc/ugpd);
```

```

//overall efficiency
heat_per_day = fc*cv;
e=ugpd*860;
printf("\t\t Electrical output in heat units per day
    =%3.0f kcal \n\n", e);
n_overall = e/1e7*100;
printf("(ii)\t Overall efficiency = %.2f %% \n\n",
    n_overall);

//thermal efficiency
n_engine = n_overall/n_alternator;
printf("\t\t Engine efficiency = %.2f %% \n\n",
    n_engine);
printf("(iii)\t Thermal efficiency = %.2f %% \n\n",
    n_engine/n_mech);
```

Scilab code Exa 2.16 overall efficiency

```
//Chapter 2
//Example 2_16
//PAge 30

clear;clc;

p1=700;
p2=500;
n1=1;
n2=2;
fc=0.28;
cv=10200;
days=30;
pcf=0.4;
```

```

max_energy=(p1*n1+p2*n2)*24*days;
printf("(i)\tMaximum energy that can be produced in
    a month = %.1f kWh \n\n", max_energy);
act_energy=pcf*max_energy;
printf("\t\t Actual energy produced = %.1f kWh \n\n"
    , act_energy);
f_c=act_energy*fc;
printf("\t\t Fuel consumption in a month =%.0f kg \n
    \n", f_c);

op=act_energy*860;
ip=f_c*cv;
printf("(ii)\t Overall efficiency =%.2f %% \n\n", op
    /ip*100);
```

Scilab code Exa 2.17 nuclear power 1

```
//Chapter 2
//Example 2_17
//Page 34

clear;clc;

p=300*1e6;
e=200*1e6;

eph=p*3600;
printf("Energy recieved per hour = %.0f*10^10 J \n\n
    ", eph*1e-10);
epf=e*1.6*1e-19;
printf("Energy released per fission = %.2f*10^-11 J
    \n\n", epf*1e11);
```

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

Scilab code Exa 2.18 energy per second

```
//Chapter 2
//Example 2_18
//Page 35

clear;clc;

d=30;
m=2;
e=200*1e6;

n=m/235*6.023*10^26;
fr=n/d/8760;
epf=e*1.6*10^-19;
p=epf*fr;

printf("Number of atoms = %.2f*10^24 \n\n", n*1e-24);
printf("Fission rate = %.3f*10^18 \n\n", fr*10^-19);
printf("Energy per fission = %.2f*10^-11 J \n\n", epf*10^11);
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

```
//Chapter 3
//Example 3_1
//Page 50


clear;clc;

max_dem=100;
lf=0.4;

//energy generated
printf("Energy generated per annum = %.1f kWh\n\n",
   max_dem*lf*8760*1000);
```

Scilab code Exa 3.2 load factor

```
//Chapter 3
//Example 3_2
//Page 50

clear;
clc;

cl = 43;
max_dem = 20;
ugpa = 61.5e6;

//Demand factor and load factor

printf("Demand factor = %.3f \n\n", max_dem/cl);

avg_dem = ugpa/8760;
printf("Load facor = %.3f \n\n", avg_dem/max_dem
    /1000);
```

Scilab code Exa 3.3 annual load factor

```
//Chapter3
//Example 3_3
//PAge 50

clear;clc;

max_dem =100;
p1=100;
t1=2;
p2=50;
```

```
t2=6;
no_operation =45;


//Annual load factor
e_per_day=(p1*t1)+(p2*t2);
printf("Energy per day = %.2f MWh \n\n", e_per_day)
operation_days=365-no_operation;
e_per_year = e_per_day*operation_days;
printf("energy per year = %.2f MWh\n\n", e_per_year)
alf= e_per_year/max_dem/(operation_days*24);
printf("Annual load factor = %.2f %% \n\n", alf*100)
    ;
```

Scilab code Exa 3.4 maximum energy

```
//Chapter 3
//Example 3_4
//PAge 50

clear;
clc;

max_dem=25;
lf=0.6;
pcf=0.5;
puf=0.72;

//reserve capacity
avg_dem=lf*max_dem;
pc=avg_dem/pcf;
printf("(i)\t Reserve capacity of plant = %.1f MW \n
    \n", pc-max_dem);
```

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

Scilab code Exa 3.5 diesel station

```
//Chapter 3
//Example 3_5
//PAge 51

clear;clc;

ic=1500;
ce=750;
dp=100;
dl=450;
max_dem=2500;
e_per_year =45e5;

//diversity factor and annual load factor
printf("Diversity factor = %.2f \n\n", (ic+ce+dp+dl)
   /max_dem);
avg_dem = e_per_year/8760;
printf("Average demand = %.2f kW \n\n", avg_dem);
printf("Load factor = %.1f %% \n\n", avg_dem/max_dem
   *100);
```

Scilab code Exa 3.6 reserve capacity

```
//Chapter 3
//Example 6
//PAge 51

clear;clc;

max_dem=15000;
lf=0.5;
pcf=0.4;

//reserve capacity
e_per_annum=max_dem*lf*8760;
printf("Energy generated per annum = %.0f kWh \n\n",
    e_per_annum)
pc=e_per_annum/pcf/8760;
printf("Plant capacity =%.0f kW \n\n", pc)
printf("Reserve capacity =%.1f kW \n\n", pc-max_dem)
   ;
```

Scilab code Exa 3.7 connected load

```
//Chapter 3
//Example 3_7
//Page 51

clear;
clc;

md1=1500;
d1=1.2;
df1=0.8;
md2=2000;
d2=1.1;
```

```
df2=0.9;
md3=10000;
d3=1.25;
df3=1;
odf=1.35;

//Maximum demand and connected load
sum_md=md1+md2+md3;
printf("Maximum demand on supply system = %.1f kW \n
   \n", sum_md/odf);
sum_domestic = md1*d1;
printf("Connected domestic load = %.1f kW \n\n",
   sum_domestic/df1);
sum_commercial = md2*d2;
printf("Connected commercial load = %.1f kW \n\n",
   sum_commercial/df2);
sum_industrial =md3*d3;
printf("Connected industrial load = %.1f kW \n\n",
   sum_industrial/df3);
```

Scilab code Exa 3.8 feeder max demand

```
//Chapter 3
//Example 3_8
//Page 52

tl=[10 12 15];
tdf=[0.65 0.6 0.7];
tdg=[1.5 3.5 1.5];
df=1.3;
total=0;

//maximum load
```

```
n=3;
for i=1:n;
  sum_md(i)=tl(i)*tdf(i);
  printf("Sum of maximum demands on transformer %i =
      %.2f kW \n\n", i,   sum_md(i));
  md(i)=sum_md(i)/tdg(i);
  printf("Maximum demand on transformer %i = %.3f kW
      \n\n", i, md(i));
  total=total+md(i);
end;

mdf=total/df;
printf("Maximum demand on feeder = %.2f kW \n\n",
    mdf)
```

Scilab code Exa 3.9 max capacity

```
//Chapter 3
//Example 3_9
//PAge 52

clear;
clc;

houses=1e3;
cl=1.5;
dem_fac=0.4;
div_fac=2.5;
factories=10;
md_f=90;
tubewells=7;
mdt=7;
df=1.2;
```

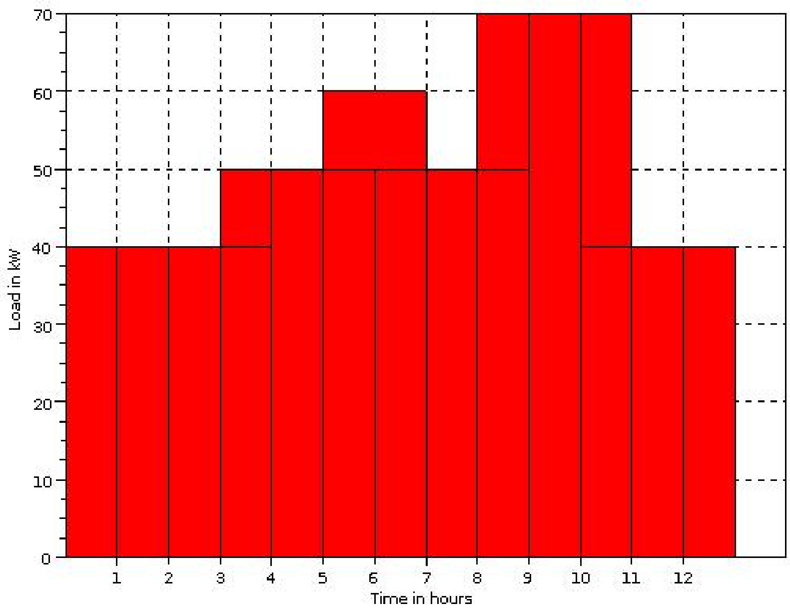

Figure 3.1: load curve

```

//Minimum capacity of power station

sum_md=cl*dem_fac*houses;
md_dl=sum_md/div_fac;
md_t=mdt*tubewells;
total_md=md_dl+md_t+md_f;
md_station=total_md/df;
printf("Minimum capacity of station required=%.2f kW
    \n\n", md_station);
```

Scilab code Exa 3.10 load curve

```
//Chapter 3
//Example 3_10
//Page 53

clear;clc;

time=[6 4 2 4 4 4];
load_mw=[40 50 60 50 70 40];

scf(0);
y=[40 40 40 50 50 60 50 50 70 70 40 40];
bar(y, 2, 'red');
xlabel('Time in hours');
ylabel('Load in kW');
xgrid(0)


md=max(y);
printf("\t (i)Maximum demand = %.0f MW \n\n", md);

area=0;
n=6;
for i=1:n;
  area=area+time(i)*load_mw(i);
end;

printf("\t (ii)Units generated per day = %.0f kWh \n
   \n", area*1000);
al=area*1000/24;
printf("\t (iii)Average load = %.0f kW \n\n", al);
lf=al/md/1000;
printf("\t (iv)Load factor = %.2f %% \n\n", lf*100);
```

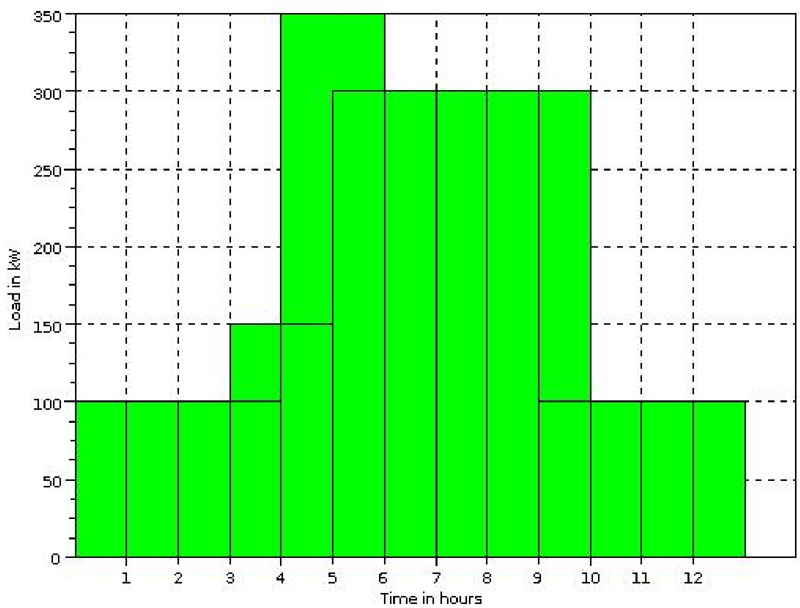

Figure 3.2: diversity and load factor

Scilab code Exa 3.11 diversity and load factor

```
//Chapter 3
//Example 3_11
//Page 54

clear;
clc;
```

```
l=[200 100 50 100]
p=[100 150 350 300 100];
t=[6 2 2 8 6];

scf(2);
y=[100 100 100 150 350 300 300 300 300 100 100 100];
bar(y, 2, 'green');
xgrid(0)
xlabel('Time in hours');
ylabel('Load in kW');

md=max(p);
printf("Maximum demand = %.0f kW \n\n", md);
sum_l=sum(l);

printf("(i) Diversity factor = %.3f \n\n", sum_l/md)
    ;

ugpd=0;
for i=1:5
  ugpd=ugpd+p(i)*t(i);
end;
printf("(ii) Units generated per day = %.0f kWh \n\n
    ", ugpd);

al=ugpd/24;
printf("(iii) Average load = %.1f kW \n\n", al);

printf("\t Load factor = %.1f %% \n\n", al/md*100);
```

Scilab code Exa 3.12 station load factor

```
//Chapter 3
//Example 3_12
//Page 54

clear;clc;

c=[0 600 200 800 0; 200 0 1000 0 200; 0 200 1200 0
    200];
t=[8 6 2 6 2];

for i=1:3
  energy(i)=0;
  sum_md=0;
  md(i)=max(c(i,:));
  printf("Max demand of customer %i = %.0f W \n\n",i
     , md(i));

  for j=1:5
    energy(i)=energy(i)+c(i,j)*t(j);

  end;
  sum_md=sum_md+md(i);
  lf(i)=energy(i)/md(i)/24*100;

  printf("Load factor of customer %i = %.2f %% \n\n"
     , i,lf(i));

end;

for j=1:5
  sum_c(j)=0;
  for i=1:3

    sum_c(j)=sum_c(j)+(c(i,j));

  end;
end;
sim=max(sum_c);
```

```
df=sum(md)/sim;
printf("Diversity factor = %.2f \n\n", df);

slf=sum(energy)/sim/24;
printf("Station load factor = %.2f %% \n\n", slf
    *100);
```

Scilab code Exa 3.13 15 min peak

```
//Chapter 3
//Example 3_13
//Page 55

clear;clc;

peak=3000;
area=12;
area_per_cm=1000;
peak_time=15;

ad=area_per_cm*2*area/24;
printf("Average demand = %.0f kW \n\n", ad);
lf=area_per_cm/peak*100;
printf("Load factor = %.2f %% \n\n", lf);
```

Scilab code Exa 3.14 heat rate

```
//Chapter 3
//Example 3_14
```

```
//Page 56

clear;clc;

p=[260 200 160 100];
t=[6 8 4 6];
sets=4;
p_set=75;
cv=10000;
heat=2860;

//load factor
n=4;
upd=0;
for i=1:n
 upd=(upd+(p(i)*t(i)));
end;

dlf=upd/max(p)/24;
printf("(i)\t Daily load factor=%.2f %% \n\n", dlf
   *100);

//average demand per day
adpd=upd/24;
printf("(ii)\t Average demand per day=%.0f kW \n\n",
    adpd*1000);
sc=p_set*1000*sets;
pcf=adpd/sc*1000;
printf("\t Plant capacity factor =%.2f %% \n\n", pcf
   *100);

//fuel per day
hpd=heat*upd;
fpd=hpd/cv;
printf("(iii)\tFuel required per day = %.1f tons \n\
   n", fpd);
```

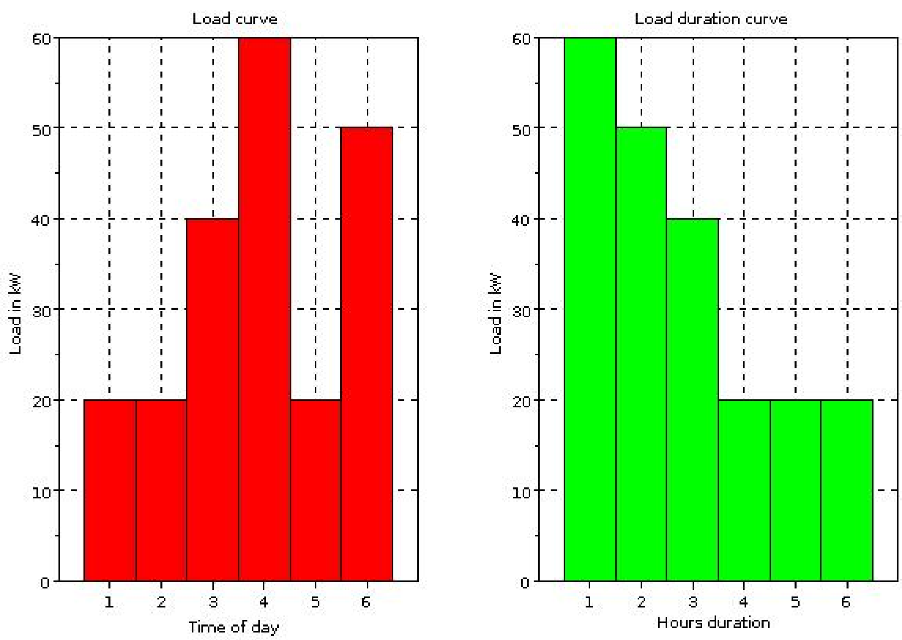

Figure 3.3: load duration curve

Scilab code Exa 3.15 load duration curve

```
//Chapter 3
//Example 3_15
//Page 56

clear;clc;

```

```
l=[20 40 60 20 50 20];
t=[2 4 4 4 4 6];

scf(0);
subplot(1,2,1)
y=[20 20 40 60 20 50];
bar(y, 1, 'red');
xgrid(0);
xlabel('Time of day');
ylabel('Load in kW');
title('Load curve');

subplot(1,2,2)
r=[60 50 40 20 20 20];
bar(r, 1, 'green');
xgrid(0);

xlabel('Hours duration');
ylabel('Load in kW');
title('Load duration curve');

area=0;
for i=1:6
  area=area+l(i)*t(i);
end;
printf("Units generated per day = %.0f MWh \n\n",
    area);
```

Scilab code Exa 3.16 utilisation factor

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

```
clear;clc;

const=4;
maxl=20;
tg1=10;
tg2=10;
tg3=5;

ic=tg1+tg2+tg3;
ad=0.5*(maxl+const);
pf=ad/ic;
ugpa=ad*1000*8760;
lf=ad/maxl*100;
uf=maxl/ic;

printf("Installed capacity = %.0f MW \n\n", ic);
printf("Average demand = %.0f MW \n\n", ad);
printf("Plant factor = %.2f %% \n\n", pf*100);
printf("Units generated per annum = %.2f*10^6 kWh \n\n", ugpa*1e-6);
printf("Load factor = %.2f %% \n\n", lf);
printf("Utilisation factor = %.2f %% \n\n", uf*100);
```

Scilab code Exa 3.17 maximum load on feeder

```
//Chapter 3
//Example 3_17
//Page 57

clear;clc;

//Transformer 1- general power service and lighting
```

```
ahp=10; akw=5;
bhp=7.5; bkw=4;
chp=15;
dhp=5; dkw=2;

//Transformer 2 - residence lighting
ekw=5;
fkw=4;
gkw=8;
hkw=15;
ikw=20;

//Transformer 3 - Store lighting and power
jkw=10; jhp=5;
kkw=8; khp=25;
lkw=4;

n=0.72;

//Referring to Article 3.8 for demand factor values
   for various load types
//The factor used to convert HP to kW is 0.746
a=ahp*0.746/n*0.65+akw*0.6;
b=bhp*0.746/n*0.75+bkw*0.6;
c=chp*0.746/n*0.65;
d=dhp*0.746/n*0.75+dkw*0.6;

t1=a+b+c+d;
//diversity factor for consumers of this type is 1.5
    as per Article 3.8
md1=t1/1.5;

e=ekw*0.5;
f=fkw*0.5;
g=gkw*0.5;
h=hkw*0.5;
i=ikw*0.5;

```

```
t2=e+f+g+h+i;
//diversity factor is given to be between 3 and 4, taking average of these two values
md2=t2/3.5;

j=jhp*0.746/n*0.75+jkw*0.5;
k=khp*0.746/n*0.55+kkw*0.5;
l=lkw*0.5;

t3=j+k+l;
//diversity factor is 1.5
md3=t3/1.5;

//diversity factor between transformers is 1.3
max_load=(md1+md2+md3)/1.3;

printf("Individual maximum demand of the group of consumers connected to transformer 1 as obtaiined from Article 3.8 are as follows: \n");
printf("\t a: %.2f kW \n", a);
printf("\t b: %.2f kW \n", b);
printf("\t c: %.2f kW \n", c);
printf("\t d: %.2f kW \n\n", d);
printf("Total = %.2f kW \n", t1);
printf("Maximum demand on transformer 1 = %.2f kW \n\n\n", md1);

printf("Individual maximum demand of the group of consumers connected to transformer 2 are as follows: \n");
printf("\t e: %.2f kW \n", e);
printf("\t f: %.2f kW \n", f);
printf("\t g: %.2f kW \n", g);
printf("\t h: %.2f kW \n", h);
printf("\t i: %.2f kW \n\n", i);
printf("Total = %.2f kW \n", t2);
printf("Maximum demand on transformer 2 = %.2f kW \n\n\n", md2);
```

```
printf("Individual maximum demand of the group of consumers connected to transformer 3 are as follows: \n");
printf("\t j: %.2f kW \n", j);
printf("\t k: %.2f kW \n", k);
printf("\t l: %.2f kW \n\n", l);
printf("Total = %.2f kW \n", t3);
printf("Maximum demand on transformer 3 = %.2f kW \n\n\n", md3);

printf("Diversity factor between transformers is 1.3 \n");
printf("Maximum load on feeder = %.2f kW \n\n", max_load);
```

Scilab code Exa 3.18 daily load cycle

```
//Chapter 3
//Example 3_18
//Page 61

clear;clc;

l=[20 40 50 35 70 40];
t=[8 3 5 3 3 2];

scf(0);
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];
bar(y, 1, 'red');
```

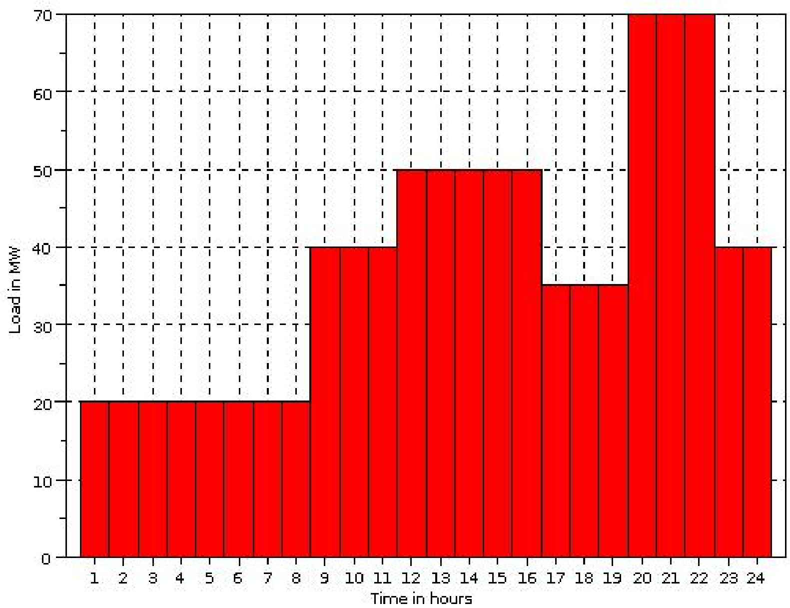

Figure 3.4: daily load cycle

```
xlabel('Time in hours');
ylabel('Load in MW');
xgrid(0);

ugpa=0;
for i=1:6;
  ugpa=ugpa+l(i)*t(i);
end;

printf("Units generated per day = %.0f MWh \n\n", ugpa);

al=ugpa*1000/24;
lf=al/max(l)/1000;
printf("Average load = %.1f kW \n\n", al);
printf("Load factor = %.2f %% \n\n", lf*100);
```

Scilab code Exa 3.19 installed capacity

```
//Chapter 3
//Example 3_19
//Page 61

clear;clc;

pl=[10 5 8 7];
df=1.5;
lf=0.6;
sets=4;

//maximum demand
md=sum(pl)/df;
printf("(i)\t Max. demand on station = %.0f MW \n\n"
```

```
, md);

//units generated per annum
printf("(ii)\t Units generated/day = %.0f kWh \n\n", md*lf*8760*1000);

//installed capacity
printf("(iii)\t Installed capacity = %.1f MW \n\n", 1.2*md);
printf("\t\t Suitable unit sizes are %.1f MW \n\n", 1.2*md/sets);
```

Scilab code Exa 3.20 capacity factor

```
//Chapter 3
//Example 3_20
//Page 64

clear;clc;

bl=18;
sc=20;
asso=7.35*1e6;
ablso=101.35*1e6;
pl=12;
hours=2190;

printf("Standby station\n\n");
alf=asso/pl/1000/hours;
printf("\t Annual loadfactor = %.2f %% \n\n", alf*100);
apcf=asso/sc/1000/8760;
printf("\t Annual plan capacity factor = %.2f %% \n\
```

```
    n", apcf*100);

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

Scilab code Exa 3.21 steam plant capacity

```
//Chapter 3
//Example 3_31
//Page 64

clear;clc;

max_l=60000;
min_l=20000;
peak_l=50000;
lf=1;
n_steam=0.6;

s=poly(0,"s");
p=333*s^2+24000*s-338000;
r=roots(p);
x=r(1);
y=40000*round(x)/24;
steam_capacity=max_l-y;

printf("x=%d \n", x);
printf("y=%d kW \n", y);
printf("Capacity of steam plant = %d kW \n",
```

```
steam_capacity);
```

Scilab code Exa 3.22 generated units

```
//Chapter 3
//Example 3_22
//Page 65

clear;clc;

ratio = [7, 4, 1];
lf=1;

//Referring to the graph in page 66

ugpa=1000*(1/2*(320+160)*8760);
steam=ugpa*ratio(1)/sum(ratio);
ror=ugpa*ratio(2)/sum(ratio);
reservoir=ugpa*ratio(3)/sum(ratio);

md_ror=ror/8760;
y=sqrt(reservoir*32/876000);
md_res=y;
md_steam=320-y-md_ror/1000;
lf_res=reservoir/md_res/1000/8760;
lf_steam=steam/md_steam/1000/8760;

printf("Units generated per annum = %.2f*10^6 kW \n\
   n", ugpa/10^6);
printf("Units generated by steam plant = %.2f*10^6
   kWh \n", steam/10^6);
printf("Units generated by run of river plant = %.2f
   *10^6 kWh \n", ror/10^6);
printf("Units generated by reservoir plant = %.2f
   *10^6 kWh \n\n", reservoir/10^6);
```

```
printf("(i) Maximum demand of run of river plant = %d kW \n", md_ror);
printf("    Maximum demand of reservoir plant = %d MW \n", md_res);
printf("    Maximum demand of steam plant = %d MW \n\n", md_steam);

printf("(ii) Load factor of run of river plant = %d %% \n", lf*100);
printf("     Load factor of reservoir plant = %d %% \n", lf_res*100);
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

```
//Chapter 4
//Example 4_1
//Page 74

clear;clc;

p=90000;
n=20;
s=10000;

adc=(p-s)/n;
printf("Annual depreciation charge = Rs. %.0f \n\n"
    , adc);
```

Scilab code Exa 4.2 payment for sinking fund

```
//Chapter 4
//Example 4_2
//Page 74

clear;clc;

p=200000;
s=10000;
n=20;
r=0.08;

q=(p-s)*r/((1+r)^n-1);
printf("Annual payment for sinking fund = Rs. %.0f \
   n\n", q);
```

Scilab code Exa 4.3 value after 20years

```
//Chapter 4
//Example 4_3
//Page 75

clear;clc;

p=1560000;
s=60000;
n=25;
y=20;
r=0.05;

printf("(i)Straight line method\n");
ad=(p-s)/n;
val1=p-ad*y;
printf("\t Value of equipment after %.0f years = Rs.
```

```
%.0f \n\n", y, val1);

printf("(ii)Diminishing value method\n");
x=1-(s/p)^(1/n);
val2=p*(1-x)^y;
printf("\t Value of equipment after %.0f years = Rs. %.0f \n\n", y, val2);

printf("(iii)Sinking fund method\n");
q=(p-s)*r/((1+r)^n-1);
sf=q*((1+r)^y-1)/r;
val3=p-sf;
printf("\t Value of equipment after %.0f years = Rs. %.0f \n\n", y, val3);
```

Scilab code Exa 4.4 fixed and running charges

```
//Chapter 4
//Example 4_4
//Page 76

clear;clc;

md=50000;
p=95*1e6;
lf=0.4;
fuel_oil=9*1e6;
tax=7.5*1e6;
rate=0.12;

ugpa=md*lf*8760;
printf("Units generated per annum = %.0f kWh \n\n", ugpa);
```

```
afc=rate*p;
printf("Annual fixed charges = Rs. %.0f \n\n", afc);

arc=fuel_oil+tax;
tac=afc+arc;
cpu=tac/ugpa;
printf("Cost per unit= Rs. %.2f \n\n", cpu);
```

Scilab code Exa 4.5 cost per unit

```
//Chapter 4
//Example 4_5
//Page 76

clear;clc;

ic=50000;
units=220*1e6;
afc_per_kW=160;
rc_per_kWh=0.04;

afc=afc_per_kW*ic;
arc=rc_per_kWh*units;
tac=afc+arc;
cpu=tac/units;

printf("Annual fixed charges = Rs. %.0f \n\n", afc);
printf("Annual running charges = Rs. %.0f \n\n", arc
    );

printf("Total annual charges = Rs. %.0f \n\n", tac);
printf("Cost per unit = Rs. %.5f \n\n", cpu);
```

Scilab code Exa 4.6 load factor values

```
//Chapter4
//Example 4_6
//Page 76

clear;clc;

md=100;
cost=160000;
afc_rate=0.12;
interest=0.05;
dep=0.05;
tax=0.02;
lf1=1;
lf2=0.5;

afc=afc_rate*cost;
printf("Annual fixed charges = Rs. %.0f \n\n", afc);

printf("When laod factor is 100%% \n");
ugpa1=md*lf1*8760;
fc1=afc/ugpa1;
printf("Units generated per annum = %.0f kWh \n",
   ugpa1);
printf("Fixed charges per kWh = Rs. %.5f \n\n", fc1)
   ;

printf("When laod factor is 50%% \n");
ugpa2=md*lf2*8760;
fc2=afc/ugpa2;
printf("Units generated per annum = %.0f kWh \n",
```

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

Scilab code Exa 4.7 cost per kWh

```
//Chapter 4
//Example 4_7
//Page 77

clear;clc;

pc=50;
lf=0.4;
p=12*1e6;
tax=400000;
other_cost=0.01;
interest=0.05;
dep=0.06;

md=pc;
printf("Annual fixed charges\n");
i_and_d=p*(interest+dep);
afc=i_and_d+tax;
printf("Interest and depreciation = Rs. %.0f \n", i_and_d);
printf("Wages and taxation = Rs. %.0f \n", tax);
printf("Total annual fixed charges = Rs. %.0f \n\n", afc);

printf("Annual running charges\n");
ugpa=md*lf*8760*1000;
cost=other_cost*ugpa;
```

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

Scilab code Exa 4.8 reserve capacity and kWh

```
//Chapter 4
//Example 4_8
//PAge 77;

clear;clc;

ic=300;
cf=0.5;
lf=0.6;
cost=9*1e7;
p=1e9;
i_d=0.1;

md=ic*cf/lf;
rc=ic-md;
printf("Reserve capacity = %.0f MW \n\n", rc);

ugpa=md*lf*8760*1000;
afc=i_d*p;
arc=cost;
tac=afc+arc;
cost=tac/ugpa;
```

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

Scilab code Exa 4.9 two part form

```
//Chapter 4
//Example 4_9
//Page 78

clear;clc;

md=40;
lf=0.6;
cost=7*1e5;
fc_rate = 0.2;

ic=50;
p=1000;
dep=0.1;
r_per_kW=1;
r_per_kWh=0.1;

ugpa=md*lf*1000*8760;
cc=ic*1e6;

printf("Annual fixed charges\n");
d=dep*cc;
sm=fc_rate*cost;
afc=d+sm;
```

```
c_per_kW=afc/md/1000+r_per_kW;

printf("\t Depreciation = Rs. %.0f \n", d);
printf("\t Sales , maintainence = Rs. %.0f \n", sm);
printf("\t Total annual fixed charges = Rs. %.0f \n"
    , afc);
printf("\t Cost per kW = Rs. %.2f \n\n", c_per_kW);

printf("Annual running charges\n");
s_m=(1-fc_rate)*cost;
c_per_kWh=s_m/ugpa+r_per_kWh;
printf("\t Salaries , maintainence = Rs. %.0f \n",
    s_m);
printf("\t Cost per kWh = Rs. %.4f \n\n", c_per_kWh)
    ;

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

```
//Chapter 4
//Example 4_10
//Page 78

clear;clc;

md=60;
lf=0.5;
b_and_e=5*1e6;
fotw=900000;
int_dep=0.1;
```

```
org=500000;

ugpa=md*lf*8760*1000;
a=org;
asfc=int_dep*b_and_e;
b=asfc/md/1000;
c=fotw/ugpa;

printf("Units generated per annum = %.0f kWh \n\n",
   ugpa);

printf("Annual fixed cost = Rs. %.0f \n\n", a);

printf("Annual semi fixed cost = Rs. %.2f \n\n", b);

printf("Annual running cost = Rs. %.5f \n\n", c);
```

Scilab code Exa 4.11 overall generation cost

```
//Chapter 4
//Example 4_11
//Page 79

clear;clc;

cost=3000;
i=0.05;
dep=0.02;
om=0.02;
i_r=0.015;
l=0.125;
d=1.25;
m_d=0.8
```

```
lf=0.4;

//assume ic=100kW
ic=100;

md=m_d*ic;
ad=md*lf;
cc=cost*100;

fc=cc*(i+dep);
agg_md=md*d;
afc=fc/agg_md;

rc=cc*(om+i_r);
ugpa=ad*8760;
u=ugpa*(1-l);
arc=rc/u;

printf("Annual fixed charges\n");
printf("  Annual fixed charges = Rs. %.0f \n", fc);
printf("  Aggregate of maximum demamd = %.0f kW \n", agg_md);
printf("  Annual fixed charges = Rs. %.0f per kW of max demand\n\n", afc);

printf("Annual running charges\n");
printf("  Annual running charges = Rs. %.0f \n", rc);
printf("  Units generated per annum = %.0f kWh \n", ugpa);
printf("  Units reaching customer  = %.0f kWh \n", u);
printf("  Annual running charges = Rs. %.5f \n\n", arc);

printf("Generation cost in two part form is: \n \t\t\t\t\t Rs(%.0f * kW + %.5f * kWh)\n\n", afc, arc);
```

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

Scilab code Exa 4.12 private and public supply

```
//Chapter 4
//Example 4_12
//Page 80

clear;clc;

md=1;
lf=0.5;
cc=12*1e5;
rm=0.005;
fc=1600;
id=0.1;
fcon=0.3;
w=50000;
c=150;
rc=0.15;

ugpa=md*1000*lf*8760;

printf("(i) Private oil engine generating plant\n");
afc=fcon*ugpa;
a_f_c=afc*fc/1000;
arm=rm*ugpa;
aw=w;
aid=id*cc;

```

```
printf(" Annual fuel consumption = %.0f kg \n", afc);
printf(" Annual cost of fuel = Rs. %.0f \n", a_f_c);
printf(" Annual cost of maintainence and repair = Rs. %.0f \n", arm);
printf(" Annual wages = Rs. %.0f \n", aw);
printf(" Annual interest and depreciation = Rs. %.0f \n\n", aid);
printf(" Total annual charges = Rs. %.0f \n\n", a_f_c+arm+aw+aid);


afc2=c*1000;
arc=rc*ugpa;
t=afc2+arc;
printf("(ii) Public supply\n");
printf(" Annual fixed charges = Rs. %.0f \n", afc2);
printf("Annual running charges = Rs. %.0f \n", arc);
printf("Total annual charges = Rs. %.0f \n\n",t);
```

Scilab code Exa 4.13 steam and hydro

```
//Chapter 4
//Example 4_13
//Page 80

clear;clc;

md=100;
lf=0.3;
hp=1e8;
max0(2)=40;

```

```
cc=[1250 2500];
id=[0.12 .1];
oc=[0.05 0.015];
tc=[0 0.002];

ugpa=md*lf*8760*1000;
printf("Units generated per annum = %.0f kWh \n\n",
   ugpa);

printf("STEAM IN CONJUNCTION WITH HYDRO STATION\n");
u(2)=hp;
u(1)=ugpa-u(2);
printf("Units supplied by hydro station = %.0f kWh \
   n\n", u(2));
printf("Units supplied by steam station = %.0f kWh \
   n\n", u(1));


max0(1)=md-max0(2);
printf("Maximum output of steam station = %.0f MW \n
   \n", max0(2));

for i=1:2
  if i==1
    printf("\n(a) Steam station\n");
  end;

  if i==2
    printf("\n(b) Hydro station\n");
  end;

  capc(i)=max0(i)*1000*cc(i);
  aid(i)=id(i)*capc(i);
  opc(i)=oc(i)*u(i);
  trc(i)=tc(i)*u(i);
  tac(i)=opc(i)+trc(i)+aid(i);

  printf("Capital cost = Rs. %.0f \n", capc(i));
```

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

end;

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

for j=1:2

  if j==1
    printf("\nSTEAM STATION\n");
  end;

  if j==2
    printf("\nHYDRO STATION\n");
  end;

  cct(j)=cc(j)*md*1000;
  a_id(j)=id(j)*cct(j);
  fc(j)=a_id(j)/ugpa;
  opct(j)=oc(j);
  trct(j)=tc(j);
  ovct(j)=fc(j)+opct(j)+trct(j);

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

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

Scilab code Exa 4.14 unit cost

```
//Chapter 4
//Example 4_14
//Page 81

clear;clc;

mw=150;
cc_steam=1600;
cc_hydro=3000;
oc_steam=0.06;
oc_hydro=0.03;
interest=0.07;

md=mw*10^3;
printf("MAximum demand = %d MW \n", mw);
printf("STEAM PLANT: \n");
cc_s=cc_steam*md;
ai_s=interest*cc_s;
fc_s=ai_s;
rc_s=oc_steam;

printf("Capital cost = Rs. %d*10^6 \n", cc_s/10^6);
printf("Annual interest = Rs. %.2f*10^6 \n", ai_s
   /10^6);
printf("Fixed cost/unit = Rs. %.2f*10^6/x \n", fc_s
```

```
/10^6);
printf("Running cost/unit = Rs. %.2f \n", rc_s);
printf("Total cost/unit = Rs. %.2f*10^6/x+%.2f \n\n", ai_s/10^6, rc_s);

printf("HYDRO PLANT: \n");
cc_h=cc_hydro*md;
ai_h=interest*cc_h;
fc_h=ai_h;
rc_h=oc_hydro;

printf("Capital cost = Rs. %d*10^6 \n", cc_h/10^6);
printf("Annual interest = Rs. %.2f*10^6 \n", ai_h/10^6);
printf("Fixed cost/unit = Rs. %.2f*10^6/x \n", fc_h/10^6);
printf("Running cost/unit = Rs. %.2f \n", rc_h);
printf("Total cost/unit = Rs. %.2f*10^6/x+%.2f \n\n", ai_h/10^6, rc_h);

x=490*10^6;
printf("By equating the overall cost, we get x = %.2f kWh \n", x);

lf=x/md/8760;
printf("Load factor = %.2f %%", lf*100);
```

Scilab code Exa 4.15 generation cost

```
//Chapter 4
//Example 4_15
//Page 82

```

```
clear;clc;

cc_h=2100;
cc_s=1200;
rc_h=0.032;
rc_s=0.05;
id_s=0.09;
id_h=0.075;
resc_h=0.33;
resc_s=0.25;
units=40*10^6;

u=8760;
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);

ic_s=1+resc_s;
ic_h=1+resc_h;
printf("Installed capacity of steam plant = %.2fx kW
     \n", ic_s);
printf("Installed capacity of hydro plant = %.2fx kW
     \n\n", ic_h);
printf("STEAM STATION: \n");
ccs=cc_s*ic_s;
ids=id_s*ccs;
rcs=rc_s*8760;
printf("Capital cost = Rs. %dx \n", ccs);
printf("Interest and depreciation = Rs. %dx \n", ids
    );
printf("Running cost/annum = Rs %dxy \n", rcs);
printf("Overall cost/kWh = Rs (%dx+%dxy)/(%dxy) \n\n
    ", ids, rcs, u);

printf("HYDRO STATION: \n");
cch=cc_h*ic_h;
idh=id_h*cch;
rch=rc_h*8760;
```

```
printf("Capital cost = Rs. %dx \n", cch);
printf("Interest and depreciation = Rs. %dx \n", idh);
printf("Running cost/annum = Rs %dxy \n", rch);
printf("Overall cost/kWh = Rs (%dx+%dxy)/(%dxy) \n\n", idh, rch, u);

y=47.46;
printf("Equating operating cost, Load factor y = %.2f %% \n", y);
md=units/8760/y*100;
printf("Max demand = x = %.2f*10^3 kW \n", md/1000);
cost=(ids*md+rcs*md*y/100);
printf("Cost of generation = Rs. %.2f*10^3 \n\n", cost/1000);
```

Scilab code Exa 4.16 hours of operation

```
//Chapter 4
//Example 4_16
//Page 83

clear;clc;

cap_b=17241;
cap_a=50000-cap_b;
y=8760*cap_b/50000;

printf("Capacity of station B = %d kW \n", cap_b);
printf("Capacity of station A = %d kW \n", cap_a);
printf("Number of hours if station B operation = %d hours \n\n", y);
```

Chapter 5

Tariff

Scilab code Exa 5.1 simple tariff 1

```
//Chapter 5
//Exxample 5_1
//PAge 91

clear;clc;

md=200;
lf=0.4;
mdc=100;
ec=0.1;

ugpa=md*lf*8760;
ac=mdc*md+ec*ugpa;
oc=ac/ugpa;

printf("Units generated per annum = %.0f kWh \n\n",
   ugpa);
printf("Annual charges = %.0f kWh \n\n", ac);
printf("Overall cost per kWh = Rs. %.5f \n\n", oc);
```

Scilab code Exa 5.2 flat rate 1

```
//Chapter 5
//Example 5_2
//Page 91

clear;clc;

i=20;
v=220;
e=8760;
t=500;
et=0.2;
et_plus=0.1;

lf=1;
md=i*v*lf/1000;
printf("Assuming load factor to be unity\n");
printf("Maximum demand = %.1f kW \n\n", md);

u=md*t;
c=et*u;
ru=e-u;
c_extra=et_plus*ru;
total=c+c_extra;
eqfr=total/e;

printf("(i) Units consumed = %.0f kWh \n\n", u);
printf("    Charges = Rs. %.0f \n\n", c);
printf("    Remaining units = %.0f kWh \n\n", ru);
printf("    Extra charges = Rs. %.0f \n\n", c_extra)
    ;
```

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

Scilab code Exa 5.3 economical tariff

```
//Chapter 5
//Example 5_3
//Page 92

clear;clc;

rs=100;
exceed=0.15;
fr=0.3;

x=rs/(fr-exceed);

printf("Number of units at which charges due to both
    tariffs become equal = %.2f units \n\n", x);
printf("Tariff (a) is economical if consumption is
   more than %.2f units \n\n", x);
```

Scilab code Exa 5.4 number of units

```
//Chapter 5
//Example 5_4
//Page 92
```

```
clear;clc;

fc=30;
rc=0.03;
fu=400;
rfu=0.06;
add_u=0.05;

rate=fu*rfu-fu*add_u;
x=(fc-rate)/(add_u-rc);

printf("x is the number of units taken per annum for
    which the annual charges due to both tariffs
   become equal. \n\n");
printf("Annual charges due to first tariff = Rs. (%d
   +%.2f*x) \n\n", fc, rc);
printf("Annual charges due to second tariff = Rs. (
   %d+%.2f*x) \n\n", rate, add_u);
printf("Equating the two equations, x = %.2f kWh \n\
   n", x);
```

Scilab code Exa 5.5 two part 1

```
//Chapter 5
//Example 5_5
//PAge 92

clear;clc;

md=50;
u=18*1e7;
ad=75;
```

```
fc=9000000;
fcg=2800000;
fctnd=3200000;
l=0.15;
rc=0.9;

printf("Annual fixed charges\n");
fuel=(1-rc)*fc;
tac=fcg+fctnd+fuel;
printf("Total annual charges = Rs. %.0f \n", tac);
cmd=tac/ad/1000;
printf("Cost per kW of maximum demand = Rs. %.0f \n\n", cmd);

printf("Annual running charges\n");
cf=rc*fc;
udc=(1-l)*u;
c=cf/udc;

printf("Cost of fuel = Rs. %.0f \n", cf);
printf("Units deliivered to consumers = %.0f kWh \n", udc);
printf("Cost per kWh = Rs. %.3f \n\n", c);

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

```
//Chapter 5
//Exampl 5_6
//PAge 93

```

```
clear;clc;

md=75;
lf=0.4;
gcc=60;
goc=0.04;
tcc=2000000;
dcc=1500000;
tdf=1.2;
ddf=1.25;
n_tr=0.9;
n_dr=0.85;

printf("Cost at Substation\n\n");
printf("\t (i) Annual fixed charges\n");
gc=gcc*md*1000;
tafc=gc+tcc;
agg=md*1000*tdf;
ac=tafc/agg;

printf("\t\t Generation cost = Rs. %.0f \n", gc);
printf("\t\t Transmission cost = Rs. %.0f \n",tcc);
printf("\t\t Total annual fixed charges at the substation=Rs. %.0f \n", tafc);
printf("\t\t Aggregate of all max demands by various substations = %.0f kW \n", agg);
printf("\t\t Annual cost per kW of maximum demand = Rs. %.2f \n\n", ac);

printf("\t (ii) Running charges\n");
c=goc/n_tr;
printf("\t\t Cost per kWh at substation = Rs. %.4f \n\n", c);

printf("Cost at Consumers premises\n");
cp=tafc+dcc;
aggm=agg*ddf;
ckW=cp/aggm;
```

```
ckWh=c/n_dr;

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

Scilab code Exa 5.7 solving for L

```
//Chapter 5
//Example 5_7
//Page 94

clear;clc;

fcd=300;
fcs=1200;
rcd=0.25;
rcs=0.0625;

printf("Let L be the load factor\n");

printf("DIESEL STATION: \n");
apd=100/8760;
fc_d=fcd*apd;
rc_d=100*rcd;
printf("Average power = %.4f kW \n", apd);
printf("Maximum demand = %.4f/L kW \n", apd);
printf("Fixed charges = Rs. %.2f/L \n", fc_d);
```

```
printf("Running charges = Rs. %.2f \n", rc_d);
printf("Fixed and running charges = Rs. (%.2f/L + %.2f) \n\n", fc_d, rc_d);

printf("STEAM STATION: \n");
aps=100/8760;
fc_s=fcs*aps;
rc_s=100*rcs;
printf("Fixed charges = Rs. %.2f/L \n", fc_s);
printf("Running charges = Rs. %.2f \n", rc_s);
printf("Fixed and running charges = Rs. (%.2f/L + %.2f) \n\n", fc_s, rc_s);

l=54.72;
printf("Equating the two charges and solving, we get L = %.2f %% \n\n", l);
```

Scilab code Exa 5.8 annual bill 1

```
//Chapter 5
//Example 5_8
//PAge 95

clear;clc;

md=100;
pf=0.8;
lf=0.6;
fc=75;
rc=0.15;

ucpy=md*lf*8760;
mdkva=md/pf;
```

```
bill=fc*mdkva+rc*ucpy;

printf("Units consumed per year = %.0f kWh \n\n",
   ucpy);
printf("Max demand in kVA = %.0f kWh \n\n", mdkva);
printf("Annual bill = %.0f kWh \n\n", bill);
```

Scilab code Exa 5.9 annual saving 1

```
//Chapter 5
//Example 5_9
//PAge 95

clear;clc;

ml=240;
pf=0.8;
ac=50000;
fc=50;
rc=0.1;

md1=ml/pf;
ab1=fc*md1+rc*ac;
flat1=ab1/ac;

md2=ml/1;
ab2=fc*md2+rc*ac;
as=ab1-ab2;

printf("With power factor = %.1f \n", pf);
printf("Maximum demand = %.0f kVA \n", md1);
printf("Annual bill = Rs. %.0f \n", ab1);
printf("Flat rate per unit = Rs. %.3f \n\n", flat1);
```

```

printf("With power factor unity \n");
printf("Maximum demand = %.0f kVA \n", md2);
printf("Annual bill = Rs. %.0f \n", ab2);


printf("Annual saving = Rs. %.0f\n", as);
```

Scilab code Exa 5.10 monthly bill 1

```
//Chapter 5
//Example 5_10
//Page 96

clear;clc;

md=50;
ec=36000;
re=23400;
fc=80;
rc=0.08;
plus=0.5;
pfl=86;

al=ec/24/30;
arp=re/24/30;
phi=atan(arp/al);
pf=cos(phi);
pfsc=ec*plus*(pfl-pf*100)/100;
mb=fc*md+rc*ec+pfsc;

printf("Average laod = %.0f kW \n\n", al);
printf("Average reactive power = %.1f kVAR \n\n",
```

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

Scilab code Exa 5.11 cost at varying pf

```
//Chapter 5
//Example 5_11
//Page 96

clear;clc;

fc=150;
rc=0.08;
lf=0.3;
pf1=1;
pf2=0.7;

md1=fc*100/8760/lf/pf1;
oc1=md1+rc*100;
printf("(i) When power factor is unity\n ");
printf("    MAx demand charge per unit = %.2f paise \n", md1);
printf("    Energy charge per unit = %.0f paise \n", rc*100);
printf("    Overall cost per unit = %.2f paise \n\n", oc1);

md2=fc*100/8760/lf/pf2;
```

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

Scilab code Exa 5.12 difference in cost annually

```
//Chapter 5
//Example 5_12
//Page 97

clear;clc;

h=8;
d=300;
kwh1=0.05;
kva1=4.5;
kwh2=5.5;
kva2=5;
al=200;
pf1=0.8;
md=250;
hvc=50;
lhv=0.04;
id=0.12;

md1=md/pf1;
cap=md1/(1-lhv);
ci=hvc*cap;
```

```
aid=ci*id;
ac1=cap*kva1*12;
uc1=al*h*d/(1-lhv);
ackwh1=kwh1*uc1;
tac1=aid+ac1+ackwh1;

printf("(i) High voltage supply\n");
printf("    Max demand in kVA = %.2f \n", md1);
printf("    Considering losses in hv equipment, the
    capacity is = %.2f kVA \n", cap);
printf("    Annual interest and depreciation = Rs. %
    .0f \n", aid);
printf("    Annual charge due to max kVA demand = Rs
    . %.0f \n", ac1);
printf("    Units consumed/year = %.0f kWh \n", uc1)
    ;
printf("    Annual charge due to kWh consumption =
    Rs. %.0f \n", ackwh1);
printf("    Total annual cost = Rs. %.0f \n\n", tac1
    );

md2=md/pf1;
ac2=md2*kva2*12;
uc2=al*h*d;
ackwh2=kwh2*uc2/100;
tac2=ac2+ackwh2;

printf("(ii)Low voltage supply\n");
printf("    Max demand in kVA = %.2f \n", md2);
printf("    Annual charge due to max kVA demand = Rs
    . %.0f \n", ac2);
printf("    Units consumed/year = %.0f kWh \n", uc2)
    ;
printf("    Annual charge due to kWh consumption =
    Rs. %.0f \n", ackwh2);
printf("    Total annual cost = Rs. %.0f \n\n", tac2
    );

```

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

Scilab code Exa 5.13 cheaper alternative

```
//Chapter 5
//Example 5_13
//Page 97

clear;clc;

p=1000;
md=2500;
inc=5.5*1e6;

ds=1000;
rs=400;
id=0.1;
fc=75;
rc=0.05;

gcc=120;
grc=0.03;

cc=rs*ds;
aid=id*cc;
ep=md-2*ds;
kw1=fc*ep;
kwh1=rc*inc;
tac1=aid+kw1+kwh1;

printf("(i) Purchasing diesel set: \n");
printf("Capital cost = Rs. %.0f \n", cc);
```

```
printf("Annual interest and depreciation = Rs. %.0f \n", aid);
printf("Extra power to be generated = %.0f kW \n", ep);
printf("Annual charge due to extra kW max demand = Rs. %.0f \n", kw1);
printf("Annual charge due to extra kWh consumption = Rs. %.0f \n", kwh1);
printf("Total Annual cost = Rs. %.0f \n\n", tac1);

kw2=ep*gcc;
kwh2=grc*inc;
tac2=kw2+kwh2;
printf("(ii) Purchasing from grid supply: \n");
printf("Annual charge due to extra kW max demand = Rs. %.0f \n", kw2);
printf("Annual charge due to extra kWh consumption = Rs. %.0f \n", kwh2);
printf("Total Annual cost = Rs. %.0f \n\n", tac2);

cheap=abs(tac1-tac2);

if tac1<tac2

  printf("Alternative (i) is cheaper by Rs. %.0f\n", cheap);
else
 printf("Alternative (ii) is cheaper by Rs. %.0f\n", cheap);
```

Chapter 6

Power factor improvement

Scilab code Exa 6.1 extra power supplied

```
//Chapter 6
//Example 6_1
//Page 109

clear;clc;

kw=300;
pf=0.6;

kva=kw/pf;
p=kva-kw;

printf("kVA = %0.f kW \n\n", kva);
printf("Increased power supplied by the alternator =
    %0.f kW \n\n", p);
```

Scilab code Exa 6.2 capacitance in parallel

```
//Chapter 6
//Example 6_2
//Page 109

clear;clc;

v=400;
f=50;
im=31.7;
pf1=0.7;
pf2=0.9;

acim=im*pf1;
i=acim/pf2;
rcim=im*sin(acos(pf1));
rci=i*sin(acos(pf2));
ic=rcim-rci;
c=ic/v/(2*%pi*f);

printf("Active component of Im = %.2f A \n\n", acim)
    ;
printf("Active component of I = %.1f*I A \n\n", pf2)
    ;
printf("Reactive component of Im = %.2f A \n\n",
    rcim);
printf("Reactive component of I = %.2f A \n\n", rci)
    ;
printf("Current through capacitor = %.2f A \n\n", ic
    );
printf("C = %.2f uF \n\n", c*1e6);
```

Scilab code Exa 6.3 kw kva and pf

```
//Chapter 6
//Example 6_3
//Page 110

clear;clc;

kw=[20 100 50];
pf=[1 -0.707 0.9];

tkvar=0;
for i=1:3
  kva(i)=abs(kw(i)/pf(i));
  printf("kVA %i = %.2f kVA \n", i,kva(i));
  kvar(i)=kva(i)*sin(acos(pf(i)));
  printf("kVAR %i = %.2f kVAR \n", i,kvar(i));
end;
tkvar=kvar(1)+kvar(2)+kvar(3);
tkva=sqrt(sum(kw)^2+(tkvar)^2);
printf("Total kW = %.2f kW \n", sum(kw));
printf("Total kVAR = %.2f kVAR \n", tkvar);
printf("Total kVA = %.2f kVA \n", tkva);
printf("Power factor = %.2f lagging\n", sum(kw)/tkva
   );
```

Scilab code Exa 6.4 rating of capacitors

```
//Chapter 6
//Example 6_4
//Page 111

clear;clc;

p=5;
```

```
pf1=0.75;
pf2=0.9;

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

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

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

Scilab code Exa 6.5 capacitance of each capacitor

```
//Chapter 6
//Example 6_5
//Page 111

clear;clc;

f=50;
v=400;
op=74.6;
pf1=0.75;
n=0.93;
pf2=0.95;
nc=4;
vc=100;

p=op/n;
phi1=acos(pf1);
```

```
phi2=acos(pf2);
lead=p*(tan(phi1)-tan(phi2));
lead_each=lead/3;
icp=2*%pi*f*v;
kvar=v*icp/1000;
c=lead_each/kvar;
c_each=c*nc;

printf("Leading kVAR taken by the condensor bank = %
    .2f kVAR \n\n", lead);
printf("Leading kVAR taken by the each of the three
    sets = %.2f kVAR \n\n", lead_each);
printf("Phase current of each capacitor is = %.2f*C
    A \n\n", icp);
printf("kVAR/phase = %.2f*C \n\n", kvar);
printf("C = %.2f uF \n\n", c*1e6);
printf("Capacitance of each capacitor is = %.2f uF \
    n\n", c_each*1e6);
```

Scilab code Exa 6.6 annual saving 2

```
//Chapter 6
//Example 6_6
//Page 112

clear;clc;

p=800;
pf1=0.8;
pf2=0.9;
h=3000;
fc=100;
rc=0.2;
```

```
cap=60;
id=0.1;

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

lead=p*(tan(phi1)-tan(phi2));

printf("Leading kVAR taken by the capacitors = %.2f\n\n", lead);
printf("Annual cost before pf correction\n");

md1=p/pf1;
kva1=fc*md1;
uc1=p*h;
ec1=rc*uc1;
tac1=kva1+ec1;

printf("Max kVA demand = %.2f \n", md1);
printf("kVA demand charges = Rs. %.0f \n", kva1);
printf("Units consumed per year = %.0f kWh \n", uc1);
printf("Energy charges per year = Rs. %.0f \n", ec1);
printf("Total annual cost = Rs. %.0f \n\n", tac1);

printf("Annual cost after pf correction\n");

md2=p/pf2;
kva2=fc*md2;
ec2=rc*uc1;
cc=cap*lead;
aid=id*cc;
tac2=kva2+ec2+aid;

printf("Max kVA demand = %.2f \n", md2);
printf("kVA demand charges = Rs. %.0f \n", kva2);
printf("Energy charges per year = Rs. %.0f \n", ec2)
```

```
;
printf("Capital cost of capacitors = Rs. %.0f \n", cc);
printf("Annual interest and depreciation = Rs. %.0f \n", aid);
printf("Total annual cost = Rs. %.0f \n\n", tac2);

as=tac1-tac2;
printf("Annual saving = Rs. %.0f \n", as);
```

Scilab code Exa 6.7 annual saving 3

```
//Chapter 6
//Example 6_7
//PAge 112

clear;clc;

p1=200;
pf1=0.85;
pf2=0.9;
h=2500;
fc=150;
rc=0.05;
cap=420;
loss=100;
id=0.1;

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

ini=p1*tan(phi1);
x=(ini-p1*tan(phi2))/(1+0.1*tan(phi2));
```

```
printf("Lead kVAR taken by tha capacitor is = %.2f kVAR \n\n", x);

printf("Annual cost before pf correction\n");

md1=p1/pf1;
kva1=fc*md1;
uc1=p1*h;
ec1=rc*uc1;
tac1=kva1+ec1;

printf("Max kVA demand = %.2f \n", md1);
printf("kVA demand charges = Rs. %.0f \n", kva1);
printf("Units consumed per year = %.0f kWh \n", uc1);
printf("Energy charges per year = Rs. %.0f \n", ec1);
printf("Total annual cost = Rs. %.0f \n\n", tac1);

printf("Annual cost after pf correction\n");

md2=p1/pf2;
kva2=fc*md2;
ec2=rc*uc1;

aid=x*cap*id;
cap_loss=0.1*x*h;
al=cap_loss*rc;
tac2=kva2+ec2+aid+al;

printf("Max kVA demand = %.2f \n", md2);
printf("kVA demand charges = Rs. %.0f \n", kva2);
printf("Energy charges per year = Rs. %.0f \n", ec2);
printf("Annual interest and depreciation = Rs. %.0f \n", aid);
printf("Annual energy loss in capacitors = %.0f kWh \n", cap_loss);
```

```
printf("Annual cost of losses occuring in capacitors
    = Rs. %.0f \n", al);
printf("Total annual cost = Rs. %.0f \n\n", tac2);

as=tac1-tac2;
printf("Annual saving = Rs. %.0f \n", as);
```

Scilab code Exa 6.8 net annual saving

```
//Chapter 6
//Example 6_8
//PAge 113

clear;clc;

md=750;
pf=0.8;
nc=250;
pr=8.5;
ic=20000;
fc=0.1;

phi=acos(pf);
ac=md*pf;
rc=md*sin(phi);
lead=rc-nc;
kva=sqrt(ac^2+lead^2);
red=md-kva;
m_saving=pr*red;
y_saving=m_saving*12;
fc_year=fc*ic;
net=y_saving-fc_year;

```

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

Scilab code Exa 6.9 motor power factor

```
//Chapter 6
//Example 6_9
//Page 113

clear;clc;

p1=200;
p2=80;
pf1=0.8;
pf2=0.9;

p=p1+p2;
phi1=acos(pf1);
phi2=acos(pf2);

//From the figure given,

```

```
lead=p1*tan(phi1)-p*tan(phi2);
kva_rating=sqrt(p2^2+lead^2);
pf=p2/kva_rating;

printf("Combined load = %.0f kW \n\n", p);
printf("(i) Leading kVAR taken by the motor = %.2f
    kVAR \n\n", lead);
printf("(ii) kVA rating of the motor = %.2f kVA \n\n
    ", kva_rating);
printf("(iii) pf of the motor = %.2f \n\n", pf);
```

Scilab code Exa 6.10 total annual bill

```
//Chapter 6
//Example 6_10
//Page 114

clear;clc;

im=37.3;
pf1=0.8;
n_im=0.85;
sm=18.65;
pf2=0.9;
n_sm=0.9;
ll=10;
pf3=1;
fc=60;
rc=0.05;
h=2000;

ip_im=im/n_im;
lag_im=ip_im*tan(acos(pf1));
```

```
printf("Input power to induction motor = %.2f kW \n", ip_im);
printf("Lagging kVAR taken by induction motor = %.2f kW \n\n", lag_im);

ip_sm=sm/n_sm;
lead_sm=ip_sm*tan(acos(pf2));
printf("Input power to synchronous motor = %.2f kW \n", ip_sm);
printf("Leading kVAR taken by synchronous motor = %.2f kW \n\n", lead_sm);
net=lag_im-abs(lead_sm);
tap=ip_im+ip_sm+ll;
tkva=abs(sqrt(net^2+tap^2));
dc=fc*tkva;
ec=tap*h;
aec=abs(rc*ec);
t=dc+aec;

printf("Net lagging kVAR = %.2f \n", net);
printf("Total active power = %.2f \n", tap);
printf("Total kVA = %.2f \n", tkva);
printf("Annual demand charges = Rs. %.2f \n", dc);
printf("Energy consumed per year = %.2f kWh \n", ec);
printf("Annual energy charges = Rs. %.2f \n", aec);
printf("Total annual bill = Rs. %.2f \n", t);
```

Scilab code Exa 6.11 synchronous motor power factor

```
//Chapter 6
//Example 6_11
//Page 114
```

```

clear;clc;

ll=500;
l1=400;
pf1=0.707;
l2=800;
pf2=0.8;
l3=500;
pf3=0.6;
dcg=540;
n=0.9;

tlag=l1*tan(acos(pf1))+l3*tan(acos(pf3));
lead=l2*tan(acos(pf2));
tlead=tlag-lead;
ip=dcg/n;
tan_phi=tlead/lead;
phi=atan(tan_phi);
pf=cos(phi);

printf("Total lagging kVAR taken = %.2f \n", tlag);
printf("Leading kVAR taken = %.2f \n", lead);
printf("Total leading kVAR taken = %.2f \n", tlead);
printf("Motor input = %.2f kW \n", ip);
printf("phi = %.2f radians\n", phi);
printf("Power factor of synchronous motor = %.2f
    lead\n", pf);
```

Scilab code Exa 6.12 annual saving 5

```
//Chapter 6
//Example 6_12
```

```
//Page 115

clear;clc;

sm=100;
im=200;
pf2=0.707;
n2=0.82;
ll=30;
fc=100;
rc=0.06;
pf1=0.8;
n1=0.93;

printf("(i) When synchronous motor runs at %.1f pf lag:\n\n", pf1);
ip_sm=sm*735.5/n1/1000;
lag1=ip_sm*tan(acos(pf1));
printf("\t Input to synchronous motor = %.2f kW \n", ip_sm);
printf("\t Lagging kVAR taken by synchronous motor = %.2f kVAR \n\n", lag1);

ip_im=im*735.5/n2/1000;
lag2=ip_im*tan(acos(pf2));
printf("\t Input to induction motor = %.2f kW \n", ip_im);
printf("\t Lagging kVAR taken by induction motor = %.2f kVAR \n\n", lag2);

tlag1=lag1+lag2;
tap1=ip_im+ip_sm+ll;
tkva1=sqrt(tlag1^2+tap1^2);
dc1=tkva1*fc;
ec1=tap1*8760;
aec1=ec1*rc;
tab1=aec1+dc1;
printf("\t Total lagging kVAR = %.2f kVAR \n", tlag1
```

```
);
printf("\t Total active power = %.2f kW \n", tap1);
printf("\t Total kVA = %.2f kVA \n", tkva1);
printf("\t Annual kVA demand charges = Rs. %.2f \n", dc1);
printf("\t Energy consumed per year = %.2f kWh \n", ec1);
printf("\t Annual energy charges = Rs. %.2f \n", aec1);
printf("\t Total annual bill = Rs. %.2f \n\n", tab1);

printf("(ii) When synchronous motor runs at %.1f pf lead:\n\n", pf1);
net=-lag1+lag2;
tap2=ip_im+ip_sm+ll;
tkva2=sqrt(net^2+tap2^2);
dc2=tkva2*fc;
ec2=tap2*8760;
aec2=ec2*rc;
tab2=aec2+dc2;
printf("\t Net lagging kVAR = %.2f kVAR \n", net);
printf("\t Total active power = %.2f kW \n", tap2);
printf("\t Total kVA = %.2f kVA \n", tkva2);
printf("\t Annual kVA demand charges = Rs. %.2f \n", dc2);
printf("\t Energy consumed per year = %.2f kWh \n", ec2);
printf("\t Annual energy charges = Rs. %.2f \n", aec2);
printf("\t Total annual bill = Rs. %.2f \n\n", tab2);

as=tab1-tab2;
printf("Annual saving = Rs. %.0f \n\n", as);
```

Scilab code Exa 6.13 economical pf operation

```
//Chapter 6
//Example 6_13
//Page 118

clear;clc;

md=175;
pf=0.75;
fc=72;
pae=120;
id=0.1;

x=fc;
y=pae*id;
ec_pf=sqrt(1-(y/x)^2);

printf("MAx demand charges = Rs. %.0f per kVA per
    annum\n", fc);
printf("Expenditure on phase advancing equipment =
    Rs. %.0f /kVAR/annum \n", y);
printf("Most economical power factor at which
    factory should operate = %.3f lag \n", ec_pf);
```

Scilab code Exa 6.14 annual saving 6

```
//Chapter 6
```

```
//Example 6_14
//PAge 119

clear;clc;

ad=400;
pf1=0.8;
lf=0.5;
fc=50;
rc=0.05;
pf2=0.95;
pae=100;
id=0.1;

p=ad/lf;
printf("Max kW demand = %.0f kW \n\n", p);

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

lead=p*(tan(phi1)-tan(phi2));
printf("(i) Leading kVAR taken by the phase
    advancing equipment = %.2f kVAR \n", lead);
printf("    Capacity of phase advancing equipment =
    %.2f kVAR \n\n", lead);
x=fc;
y=pae*id;
max1=p/pf1;
max2=p/pf2;
as=fc*(max1-max2);
aexp=y*lead;
net=as-aexp;

printf("(ii) Max demand charges = %.0f kW \n", x);
printf("     Expenditure on phase advnacing
    equipement = Rs. %.2f /kVAR/annnum \n", y);
printf("     Max demand at %.1f pf = %.2f kVA \n",
    pf1,max1);
```

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

Scilab code Exa 6.15 annual saving 9

```
//Chapter 6
//Example 6_15
//Page 119

clear;clc;

md=50;
lf=0.5;
pf=0.75;
fc=100;
rc=0.05;
lfc=600;
id=0.1;

x=fc;
y=id*lfc;
z=y/x;
ec_pf=sqrt(1-z^2);
kwd=md/lf;
m1=kwd/pf;
m2=kwd/ec_pf;
as=fc*(m1-m2);

```

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

Scilab code Exa 6.16 annual bill 3

```
//Chapter 6
//Example 6_16
//Page 120

clear;clc;

p=200;
pf=0.8;
fc=100;
rc=0.05;
pae=500;
id=0.1;
h=5000;

x=fc;
y=pae*id;
ec_pf=sqrt(1-(y/x)^2);
cap=p*(tan(acos(pf))-tan(acos(ec_pf)));
uc=h*p;
```

```
ec=uc*rc;
cpae=y*cap;
dc=x*p/ec_pf;
ab=ec+cpae+dc;

printf("Max demand charges = %.0f kW \n", x);
printf("Expenditure on phase advnacing equipement = Rs. %.2f /kVAR/annnum \n\n", y);
printf("(i) Most economical power factor at which factory should operate = %.3f lag \n\n", ec_pf);
printf("(ii)Capacity of phase advancing equipment = %.2f kVAR \n\n", cap);
printf("(iii) Units consumed per year = %.0f kWh \n", uc);
printf("Annual energy charges = Rs. %.0f \n", ec);
printf("Annual cost of phase advancing equipment = Rs. %.0f \n", cpae);
printf("Max demand charges = Rs. %.0f \n", dc);
printf("Annual bill for energy = Rs. %.0f \n", ab);
```

Scilab code Exa 6.17 annual saving 8

```
//Chapter 6
//Example 6_17
//Page 120

clear;clc;

u=80000;
md=500;
pf1=0.707;
fc=120;
rc=0.025;
```

```
pae=50;
pf2=0.9;
id=0.1;

printf("Energy consumed per year = %.0f kWh\n", u);
printf("Max kVA demand = %.0f \n", md);

ac=md*fc+rc*u;
printf("Annual cost of supply = Rs. %.0f \n",ac);
m1=md*pf1;
p=m1;
printf("Max kW demand at %.3f pf = %.2f \n", pf1, m1
    );
lead=p*(tan(acos(pf1))-tan(acos(pf2)));
printf("Leading kVAR taken by phase advancing
    equipment = %.1f kVAR \n", lead);
cpae=pae*id*lead;
printf("Annual cost of phase advancing equipment =
    Rs. %.0f \n", cpae);
m2=p/pf2;
printf("Max kW demand at %.3f pf = %.2f \n", pf2, m2
    );
red=md-m2;
printf("Reduction in kVA demand = %.1f \n", red);
as=fc*red;
printf("Annual saving in kVA charges = Rs. %.0f \n",
     as);
printf("Annual saving = Rs. %.0f \n", as-cpae);
```

Scilab code Exa 6.18 pfc equipment

```
//Chapter 6
//Example 6_18
```

```
//Page 123

clear;clc;

pf1=0.7;
pf2=0.85;
add_cost=800;

//Referring to figure 6.15,
//The initial capacity of the plant is OB kVA at pf = pf1
a1=pf2/pf1;
BD=a1-1;
tc=BD*add_cost;
phi1=(acosd(pf1));
phi2=(acosd(pf2));
lead=a1*sind(phi1)-sind(phi2);
cost=tc/lead;

disp("COST OF INCREASING PLANT CAPACITY: ");
printf("The initial capacity of the plant is OB kVA at pf = pf1 \n\n");
printf("The increase in kVA capacity of the plant = %.4f*OB \n\n", BD);
printf("Total cost of increasing the plant capacity = Rs. %.2f*OB \n\n", tc);

disp("COST OF POWER FACTOR CORRECTION EQUIPMENT: ");
printf("Leading kVAR taken by p.f correction equipment = %.2f*OB \n\n", lead);
printf("Let the cost per kVAR of the equipment be Rs. y \n\n");
printf("Total cost of p.f correction equipment = Rs. %.2f*y*OB \n\n", lead);
printf("Equating the total cost, y = Rs. %.1f \n\n", cost);
```

Scilab code Exa 6.19 phase advancers

```
//Chapter 6
//Example 6_19
//Page 124

clear;clc;

pf1=0.7;
pf2=0.866;
tc=100;
id=0.1;

//Referring to phasor diagram of figure 6.16,
a1=pf2/pf1;
BD=a1-1;
ac=BD*10;
phi1=(acosd(pf1));
phi2=(acosd(pf2));
lead=a1*sind(phi1)-sind(phi2);
pae_cost=lead*id;
cost=ac/pae_cost;

disp("COST OF INCREASING PLANT CAPACITY: ");
printf("The increase in kVA capacity of the plant = %.4f*OB \n\n", BD);
printf("Total cost of increasing the plant capacity = Rs. %.2f*OB \n\n", ac);

disp("COST OF PHASE ADVANCING EQUIPMENT: ");
printf("Leading kVAR taken by p.f correction equipment = %.3f*OB \n\n", lead);
```

```
printf("Let the cost per kVAR of the equipment be Rs. y \n\n");
printf("Annual cost of phase advancing equipment = Rs. %.3f*y*OB \n\n", pae_cost);
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

```
//Chapter 7
//Example 7_1
//Page 145

clear;clc;

v1=200;
v2=400;

//ratio of two voltages r is
r=v1/v2;
v2_by_v1=1/(2/r);
//In the above relation 'v' is volume
saving=(1-v2_by_v1)*100;

printf("%% saving in feeder copper = %d %% \n\n",
   saving);
```

Scilab code Exa 7.4 additional load

```
//Chapter 7
//Example 7_4
//Page 149

clear;clc;

p1=200;

//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

p2=2*p1;

printf("Power supplied by 3-phase, 3-wire a.c.
   system is = %d kW \n\n", p2);
per=(p2-p1)/p1*100;
printf("Thus three phase three wire system can
   supply %d %% additional load \n\n", per);
```

Scilab code Exa 7.5 conductor volume comparision

```
//Chapter 7
//Example 7_5
//Page 149

```

```
clear;clc;

l=50;
mva=5;
pf=0.8;
kv=33;
n=0.9;
sr=2.85*1e-8;

p=mva*1e6*pf;
w=0.1*p;

//Single phase 2-wire system
i1=mva*1e6/kv/1000;
area1=2*sr*i1^2*l*1000/w;
vol1=2*area1*l*1000;

//3-phase 3-wire system
i2=mva*1e6/sqrt(3)/kv/1000;
area2=3*i2^2*sr*l*1000/w;
vol2=3*area2*l*1000;

printf("(I) SINGLE PHASE, 2-WIRE SYSTEM: \n");
printf("Line current = %.1f A \n", i1);
printf("Area of cross section = %.3f*10^-4 m^2 \n",
    area1*1e4);
printf("Volume of conductor required = %.2f m^3 \n\n
    ", vol1);

printf("(II) 3-PHASE, 3-WIRE SYSTEM: \n");
printf("Line current = %.1f A \n", i2);
printf("Area of cross section = %.3f*10^-4 m^2 \n",
    area2*1e4);
printf("Volume of conductor required = %.2f m^3 \n\n
    ", vol2);
```

Scilab code Exa 7.6 voltages in DC 2wire system

```
//Chapter 7
//Example 7_6
//Page 149

clear;clc;

kv=11;
pf=0.8;
r=0.15;
vd=0.15;
tr=0.05;
avd=0.25;

//single phase system
volt_drop=vd*kv*1000;
i1=volt_drop/r;
p1=i1*kv*1000*pf/1000;

//DC two wire system
v=sqrt((p1*1000*tr)/avd);

printf("SINGLE PHASE SYSTEM: \n");
printf("Voltage drop = %.2f*I1 V \n", vd);
printf("Also voltage drop = %d V \n", volt_drop);
printf("Load current = I1 = %d A \n", i1);
printf("Power recieved by consumer = %.2f*10^4 kW \n
   \n", p1*1e-4);

printf("DC TWO WIRE SYSTEM: \n");
printf("Load current = I2 = %d/V A \n", p1*1000);
```

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

Scilab code Exa 7.7 area of conductor 1

```
//Chapter 7
//Example 7_7
//Page 153

clear;clc;

l=1;
i=200;
//cost = (20*a + 20)
cost=5;
id=0.1;
p=1.73*1e-6;

ra=p*l*1e5;
e=2*i^2*ra*8760/1000;
ac=cost*e/100;
cc=20*1000;
vac=id*cc;
a=sqrt(ac/vac);

printf("Resistance of one conductor = %.3f/a ohm \n\
    n", ra);
printf("Energy lost per annum = %.1f/a kWh \n\n", e)
    ;
printf("Annual cost of energy lost = Rs. %d/a \n\n",
     ac);
```

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

Scilab code Exa 7.8 area of conductor 2

```
//Chapter 7
//Example 7_8
//Page 153

clear;clc;

mw=5;
kv=33;
pf=0.8;
cost=4;
id=0.1;
p=1e-6;

//cost = Rs (25000*a + 2500)

ra=p*1e5;
i=mw*1e6/sqrt(3)/kv/1000/pf;
e=3*i^2*ra*8760/1000;
ac=cost*e/100;
cc=25000;
vac=id*cc;
a=sqrt(ac/vac);

printf("Resistance of one conductor = %.3f/a ohm \n\
```

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

Scilab code Exa 7.9 area of conductor 3

```
//Chapter 7
//Example 7_9
//Page 154

clear;clc;

i=250;
cc=5;
id=0.1;
cost=5;
d=8.93;
p=1.73*1e-8;
l=1;

ra=p*l;
e=2*i^2*ra*8760/1000;
ac=cost*e/100;
mass=2*d*l*1000;
```

```
cc=cc*mass;
vac=id*cc;
a=sqrt(ac/vac);

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

Scilab code Exa 7.10 area of conductor 4

```
//Chapter 7
//Example 7_10
//Page 154

clear;clc;

h=[6 12 6];
mw=[20 5 6];
pf=[0.8 0.8 0.8];
days=365;
```

```
kv=110;
cc=6000;
id=0.1;
cost=6;
ra=0.176;

v=kv*1000;
printf("Resistance of one conductor = %.3f/a ohm \n\n", ra);
printf("Line voltage = %d V \n\n", v);
sum_i=0;
for i=1:3
  I(i)=mw(i)*1e6/sqrt(3)/v/pf(i);
  printf("Current at %d MW = %.2f A \n\n", mw(i), I(i));
  sum_i=sum_i+I(i)^2*h(i);
end
e=3*ra*sum_i/1000;
loss=e*days;
ac=cost*loss/100;
vac=id*cc;
a=sqrt(ac/vac);

printf("Energy lost per day in  three phase line = %.2f/a kWh \n\n", e);
printf("Energy lost per annum = %.2f/a kWh \n\n", loss);
printf("Annual cost of energy lost = Rs. %.2f/a \n\n", ac);
printf("Variable annual charge = Rs. %d*a \n\n", vac);
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

```
//Chapter 8
//Example 8_1
//page 171

clear;clc;

v=33*1e3;
k=0.11;
ins=3;

v_string=v/sqrt(3);
v1=v_string/(3+4*k+k^2);
v2=v1*(1+k);
v3=v1*(1+3*k+k^2);
n=v_string*100/ins/v3;

printf("(i)Voltage across top unit = %.2f kV \n\n",
   v1/1000);
printf("    Voltage across middle unit = %.2f kV \n\n
```

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

Scilab code Exa 8.2 string efficiency 2

```
//Chapter 8
//Example 8_2
//Page 172

clear;clc;

v1=8;
v2=11;

k=(v2-v1)/v1;
v3=v2+(v2+v1)*k;
v=v1+v2+v3;
lv=sqrt(3)*v;
n=v*100/3/v3;

printf("k = %.2f kV \n\n", k);
printf("Voltage across third unit = %.2f kV \n\n",
   v3);
printf("Voltage between line and earth = %.2f kV \n\
   n", v);
printf("Line voltage = %.2f kV \n\n", lv)
printf("String efficiency = %.2f %% \n\n", n);
```

Scilab code Exa 8.3 string efficiency 3

```
//Chapter 8
//Example 8_3
//Page 172

clear;clc;

ins=3;
v3=17.5;
k=1/8;
v1=v3/(1+3*k+k^2);
v2=(1+k)*v1;
v=v1+v2+v3;

n=v*100/3/v3;

printf("Voltage across first unit = %.2f kV \n\n",
    v1);
printf("Voltage across second unit = %.2f kV \n\n",
    v2);
printf("Voltage between line and earth = %.2f kV \n\
    n", v);
printf("String efficiency = %.2f %% \n\n", n);
```

Scilab code Exa 8.4 voltage between busbars

```
//Chapter 8
```

```
//Example 8_4
//Page 173

clear;clc;

v2=11;
v3=13.1;

p1=poly([1 3 1], 'k', 'c');
p2=poly([1 1],'k', 'c');
p=v3*p2-v2*p1;
r=roots(p, 'e');
k=r(2);

v1=v2/(1+k);
printf("V1 = %.2f kV \n\n", v1);

v=v1+v2+v3;
printf("Voltage between line and earth = %.2f kV \n\n", v);
printf("Voltage between bus bars = %.2f kV \n\n", v*sqrt(3));
```

Scilab code Exa 8.5 string efficiency 4

```
//Chapter 8
//Example 8_5
//Page 173

clear;clc;

ins=3;
v3=15;
```

```
k=1/8;
v1=v3/(1+3*k+k^2);
v2=(1+k)*v1;
v=v1+v2+v3;

n=v*100/3/v3;

printf("Voltage across first unit = %.2f kV \n\n",
    v1);
printf("Voltage across second unit = %.2f kV \n\n",
    v2);
printf("Voltage between line and earth = %.2f kV \n\
    n", v);
printf("String efficiency = %.2f %% \n\n", n);
```

Scilab code Exa 8.6 string efficiency 5

```
//Chapter 8
//Example 8_6
//Page 174

clear;clc;

ins=4;
k=0.1;
x=1;

v1=x*1;
v2=x*(1+k);
v3=x*(1+3*k+k^2);
v4=x*(1+6*k+5*k^2);
v=v1+v2+v3+v4;

```

```
pv1=v1/v*100;
pv2=v2/v*100;
pv3=v3/v*100;
pv4=v4/v*100;

n=v/ins/v4*100;

printf("\n(i) Voltage across top unit = %.2f V \n",
    v1);
printf("Voltage across second unit = %.2f V \n", v2)
    ;
printf("Voltage across third unit = %.2f V \n", v3);
printf("Voltage across fourth unit = %.2f V \n\n",
    v4);
printf("Voltage across the string = %.2f V \n", v);

printf("The voltage across each unit expressed as a
    percentage becomes: \n");
printf("\t Top unit = %.2f %% \n", pv1);
printf("\t Second from top = %.2f %% \n", pv2);
printf("\t Third from top = %.2f %% \n", pv3);
printf("\t Fourth from top = %.2f %% \n\n", pv4);

printf("(ii) String efficiency = %.2f %% \n", n);
```

Scilab code Exa 8.7 string efficiency 6

```
//Chapter 8
//Example 8_7
//Page 175

clear;clc;

```

```
ins=5;
vl=100;
k=0.1;

v1=1;
v2=(1+k);
v3=(1+3*k+k^2);
v4=(1+6*k+5*k^2);
v5=(2+1*k+6*k^2);

v=v1+v2+v3+v4+v5;

pv1=v1/v*100;
pv2=v2/v*100;
pv3=v3/v*100;
pv4=v4/v*100;
pv5=v5/v*100;

v_string=vl/sqrt(3);
v_1=pv1/100*v_string;
v_2=pv2/100*v_string;
v_3=pv3/100*v_string;
v_4=pv4/100*v_string;
v_5=pv5/100*v_string;

n=v_string/ins/v_5;

printf("Voltage across string = %.2f kV \n\n", v_string);
printf("(i) Voltage across top insulator = %.2f kV \n", v_1);
printf("    Voltage across second unit = %.2f V \n", v_2);
printf("    Voltage across third unit = %.2f V \n", v_3);
printf("    Voltage across fourth unit = %.2f V \n", v_4);
printf("    Voltage across fifth unit = %.2f V \n\n"
```

```
    , v_5);

printf("(ii) String efficiency = %.2f %% \n\n", n
    *100);
```

Scilab code Exa 8.8 voltage between conductors

```
//Chapter 8
//Example 8_8
//Page 176

clear;clc;

v2=13.2;
v3=18;

p1=poly([1 3 1], 'k', 'c');
p2=poly([1 1],'k', 'c');
p=v3*p2-v2*p1;
r=roots(p, 'e');
k=r(2);

v1=v2/(1+k);
printf("Voltage across first unit = V1 = %.2f kV \n\
    n", v1);
v4=v1*(1+k^3+5*k^2+6*k);
printf("Voltage across fourth unit = V4 = %.2f kV \n
    \n", v4);

v=v1+v2+v3+v4;
printf("Voltage between line and earth = %.2f kV \n\
    n", v);
printf("Voltage between bus bars = %.2f kV \n\n", v*
```

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

Scilab code Exa 8.9 string efficiency 7

```
//Chapter 8
//Example 8_9
//Page 177

clear;clc;

ins=4;
k=1/5;

v1=1;
v2=v1*(1+k);
v3=v1*(1+3*k+k^2);
v4=v1*(1+6*k+5*k^2+k^3);
v=v1+v2+v3+v4;

pv1=v1/v*100;
pv2=v2/v*100;
pv3=v3/v*100;
pv4=v4/v*100;

n=v/ins/v4*100;

printf("\n(i) V1 = %.2f V \n", v1);
printf("V2 = %.2f V \n", v2);
printf("V3 = %.2f V \n", v3);
printf("V4 = %.2f V \n\n", v4);
printf("Voltage across the string = %.2f V \n", v);

printf("The voltage across each unit expressed as a
```

```
    percentage becomes: \n");
printf("\t Top unit = %.2f %% \n", pv1);
printf("\t Second from top = %.2f %% \n", pv2);
printf("\t Third from top = %.2f %% \n", pv3);
printf("\t Fourth from top = %.2f %% \n\n", pv4);

printf("(ii) String efficiency = %.2f %% \n", n);
```

Scilab code Exa 8.10 string efficiency

```
//Chapter 8
//Example 8_10
//Page 177

clear;clc;

shunt_cap=0.15;
line_cap=0.1;
n=3;

v1=13.25/40.55;
v2=12.5*v1/13.25;
v3=14.8*v1/13.25;

pv1=v1*100;
pv2=v2*100;
pv3=v3*100;
eff=1/n/v3*100;

printf("V1 = %.3f V \n", v1);
printf("V2 = %.3f V \n", v2);
printf("V3 = %.3f V \n\n", v3);

```

```
printf("(i) Voltage expressed as a percentage of V :
    \n");
printf("     Top unit = %.2f %% \n", pv1);
printf("     Middle unit = %.2f %% \n", pv2);
printf("     Third unit = %.2f %% \n\n", pv3);

printf("(ii) String efficiency = %.2f %% \n\n", eff)
    ;
```

Scilab code Exa 8.11 string eff 1

```
//Chapter 8
//Example 8_11
//Page 179

clear;clc;

n=3;
shunt=0.2;
line=0.1;
lower=0.3;

v2=15.4/15.5;
v3=12-11*0.993;
v=1+v2+v3;
eff=v/n/v3;

printf("V2 = %.3f*V1 \n", v2);
printf("V3 = %.3f*V1 \n", v3);
printf("Voltage between conductor and earth = %.2f*
    V1 \n", v);
printf("String efficiency = %d %% \n\n", eff*100);
```

Scilab code Exa 8.12 v across each insulator

```
//Chapter 8
//Example 8_11
//Page 179

clear;clc;

c1=1/6;
c2=2/5;
c3=3/4;
c4=4/3;
c5=5/2;
c6=6/1;

printf("At Junction A : C1 = %.3f C \n", c1);
printf("At Junction B : C2 = %.3f C \n", c2);
printf("At Junction C : C3 = %.3f C \n", c3);
printf("At Junction D : C4 = %.3f C \n", c4);
printf("At Junction E : C5 = %.3f C \n", c5);
printf("At Junction F : C6 = %.3f C \n", c6);
```

Scilab code Exa 8.13 rms line voltage

```
//Chapter 8
//Example 8_13
//Page 184

```

```
clear;clc;

r=1;
d=100;
go=30/sqrt(2);
mo=0.9;
delta=0.952;

vc=mo*go*delta*r*log(d/r);
lv=vc*sqrt(3);

printf("Disruptive critical voltage = %.2f kV/phase
    \n\n", vc);
printf("Line voltage = %.2f kV \n\n", lv);
```

Scilab code Exa 8.14 conductor spacing

```
//Chapter 8
//Example 8_14
//Page 184

clear;clc;

v=132;
r=1.956/2;
vd=210;
go=30/sqrt(2);
mo=1;
delta=1;

vc=vd/sqrt(3);
dr=exp(vc/mo/go/delta/r);
d=dr*r;
```

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

Scilab code Exa 8.15 total corona loss

```
//Chapter 8
//Example 8_15
//Page 185

clear;clc;

v=220;
r=1.5;
d=200;
t=40;
b=76;
mo=0.85;
f=50;

delta=3.92*b/(273+t);
go=30/sqrt(2);

vc=mo*go*delta*r*log(d/r);
v_phase=v/sqrt(3);

pc=242.2/delta*(f+25)*sqrt(r/d)*(v_phase-vc)^2*1e-5;

printf("Delta = %.3f \n\n", delta);
printf("Disruptive critical voltage per phase = %.2f
    kV \n\n", vc);
printf("Supply voltage per phase = %.2f kV \n\n",
    v_phase);
printf("Corona loss = %.5f kW/km/phase \n\n", pc);
```

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

Scilab code Exa 8.16 power loss

```
//Chapter 8
//Example 8_16
//Page 185

clear;clc;

pc=53;
v=106;
loss=98;
pl=110.9;
cv=113;

sq=sqrt(loss/pc);
vc=(sq*v/sqrt(3)-pl/sqrt(3))/(sq-1);
w=(cv/sqrt(3)-vc)^2/(v/sqrt(3)-vc)^2*pc;

printf("Critical disruptive voltage = %.2f kV \n\n",
    vc);
printf("Power loss at %.0f kV = %.0f kW \n\n", cv, w
    );
```

Scilab code Exa 8.17 ground clearing 1

```
//Chapter 8
//Example 8_17
```

```
//Page 190

clear;clc;

w=680;
sf=2;
strength=3100;
l=260;
gc=10;

t=strength/sf;
sag=w/1000*l^2/8/t;

printf("Working tension = %.0f kg \n\n", t);
printf("Sag = %.1f m \n\n", sag);
printf("Conductor should be supported at a height of
    %.1f m \n\n", sag+gc);
```

Scilab code Exa 8.18 sag and vertical sag

```
//Chapter 8
//Example 8_18
//Page 190

clear;clc;

l=150;
t=2000;
ww=1.5;
sg=9.9;
area=2;

w=sg*area*100/1000;
```

```
wt=sqrt(w^2+ww^2);
sag=wt*l^2/8/t;
theta=atan(ww/w);
vsag=sag*cos(theta);

printf("Weight of conductor per length = %.2f kg \n\n", w);
printf("Total weight of 1m conductor = %.2f kg \n\n", wt);
printf("Sag = %.2f m \n\n", sag);
printf("theta = %.2f degrees \n\n", theta/%pi*180);
printf("Vertical sag = %.2f m \n\n", vsag);
```

Scilab code Exa 8.19 vertical sag 2

```
//Chapter 8
//Example 8_19
//Page 191

clear;clc;

l=200;
w=1170/1000;
bs=4218;
area=1.29;
pr=122;
sf=5;

t=bs*area/sf;
d=sqrt(4*area/%pi);
ww=pr*d*1e-2;
wt=sqrt(w^2+ww^2);
sag=wt*l^2/8/t;
```

```
theta=atan(ww/w);
vsag=sag*cos(theta);

printf("Working tension = %.0f kg \n\n", t);
printf("Diameter of the conductor = %.2f \n\n", d);
printf("Total weight of the conductor per metre
    length = %.2f kg \n\n", wt);
printf("Slant sag = %.2f m \n\n", sag);
printf("theta = %.2f degrees \n\n", theta*180/%pi);
printf("Vertical sag = %.2f m \n\n", vsag);
```

Scilab code Exa 8.20 sag in tr lines

```
//Chapter 8
//Example 8_20
//Page 191

clear;clc;

l=275;
d=1.96;
us=8060;
sf=2;
ice_t=1.27;
w=0.865;
pr=2;
wcc=0.91;
wp=3.9;

t=us/sf;
vol=%pi*ice_t*(d+ice_t)*100;
wi=wcc*vol/1000;
ww=wp*(d+2*ice_t)*100/1000;
```

```
wt=sqrt((w+wi)^2+ww^2);
sag=wt*l^2/8/t;

printf("Working tension = %.0f kg \n\n", t);
printf("Volume of ice per metre length of the
   conductor = %.0f cm^3 \n\n", vol);
printf("Weight of ice per metre length of conductor
   is %.2f kg \n\n", wi);
printf("Wind force/m length of conductor is %.3f kg
   \n\n", ww);
printf("Total weight of conductor per metre length
   of conductor is %.3f kg \n\n", wt);
printf("Sag = %.2f m \n\n", sag);
```

Scilab code Exa 8.21 safety factor

```
//Chapter 8
//Example 8_21
//Page 192

clear;clc;

l=214;
vsag=2.35;
w=1.125;
ww=1.5;
area=3.225;
bs=2540;

wt=sqrt(w^2+ww^2);
t=bs*area;
s=vsag*wt/w;
f=t*8*s/(wt*l^2);
```

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

Scilab code Exa 8.22 ground clearance 2

```
//Chapter 8
//Example 8_22
//Page 192;

clear;clc;

l=150;
area=2;
us=5000;
sf=5;
sg=8.9;
ww=1.5;
mc=7;

w=area*sg*100/1000;
t=us*area/sf;
wt=sqrt(w^2+ww^2);
s=wt*l^2/8/t;
vsag=s*w/wt;

printf("Wt of conductor = %.2f kg \n\n", w);
printf("Working tension = %.0f kg \n\n", t);
printf("Total weight = %.2f kg \n\n", wt);
printf("Slant sag = %.2f m \n\n", s);
```

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

Scilab code Exa 8.23 clearence from water level

```
//Chapter 8
//Example 8_23
//Page 193

clear;clc;

l=500;
w=1.5;
t=1600;
h2=90;
h1=30;
h=h2-h1;

printf("x1+x2=500 \n");
d=h*2*t/w/l;
printf("x2-x1=%.0f \n\n", d);

A=[1 1; -1 1];
b=[l; d];
X=A\b;
x1=X(1);
x2=X(2);

s1=w*x1^2/2/t;
cl=h1-s1;
x=l/2-x1;
smid=w*x^2/2/t;
clmp=cl+smid;
```

```

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

Scilab code Exa 8.24 sag

```
//Chapter 8
//Example 8_24
//Page 194

clear;clc;

l=600;
wi=1;
h=15;
w=1.925;
t=8000*2.2/5;

wt=w+wi;
d=2*h*t/(1+w)/l;

A=[1 1; -1 1];
b=[l; d];
X=A\b;
x1=X(1);
```

```
x2=X(2);

s2=wt*x2^2/2/t;

printf("x1 = %.0f m \n", x1);
printf("x2 = %.0f m \n\n", x2);
printf("S2 = %.2f m \n", s2);
```

Scilab code Exa 8.25 clearence from water level 2

```
//Chapter 8
//Example 8_25
//Page 195

clear;clc;

h2=90;
h1=40;
h=h2-h1;
l=400;
t=2000;
w=1;

d=h*2*t/l;

A=[1 1; -1 1];
b=[l; d];
X=A\b;
x1=X(1);
x2=X(2);

printf("x1 = %.0f m \n", x1);
printf("x2 = %.0f m \n\n", x2);
```

```
x=abs(x1)+l/2;
s2=w*x2^2/2/t;
smid=w*x^2/2/t;
hb=s2-smid;
cl=h2-hb;

printf("The distance from the lowest point to the
    midpoint = %.0f m \n", x);
printf("Sag at midpoint = %.2f m \n", smid);
printf("S2 = %.2f m \n", s2);
printf("Height of point B from mid point = %.0f m \n
    ", hb);
printf("Clearance of mid point from water level = %
    .2f m \n\n", cl);
```

Scilab code Exa 8.26 clearence from ground

```
//Chapter 8
//Example 8_26
//Page 195

clear;clc;

grad=20;
h1=22;
h2=22;
l=300;
lc=2;
w=1;
t=1500;

eh=h1-lc;
```

```
h=l*(1/grad);
dc=sqrt(l^2-h^2);
d=2*t*h/w/dc;

a=[1 1; -1 1];
b=[dc; d];
x=a\b;
s2=w*x(2)^2/2/t;
bc=eh+h;
og=bc-s2-x(1)*tand(asind(1/grad));

printf("Effective height of each tower = %d m \n\n",
    eh);
printf("Vertical distance between towers is = %d m \
    n\n", h);
printf("Horizontal distance between two towers = %d
    m \n\n", dc);
printf("x1+x2=%d \n\n", dc);
printf("x2-x2=%d m \n\n", d);
printf("Solving the two, x1 = %d m , x2 = %d m \n\n"
    , x(1), x(2));
printf("Sag S2 = %.2f m \n\n", s2);
printf("BC = %.2f m \n\n", bc);
printf("Clearance from the lowest point O from the
    ground = %.2f m \n\n", og);
```

Scilab code Exa 8.27 min clearance

```
//Chapter 8
//Example 8_27
//Page 196

clear;clc;
```

```

c=8;
l=300;
s=10;
slope=15;

printf("On level ground: \n")
wbyt=8*s/l^2;
h=s+c;
printf("Height of tower = %d m \n\n", h);

printf("On sloping ground: \n");
hs=l/slope;
printf("Vertical distance between two towers = %d m
   \n", hs);
x1=75;
x2=225;
printf("From the graph: \nx1 = 75m, x2 = 225m \n");
s1=wbyt*x1^2/2;
s2=wbyt*x2^2/2;
printf("S1 = %.2f m \n", s1);
printf("S2 = %.2f m \n", s2);
cl=38-s2-5;
printf("Clearance = %.2f m \n", cl);
x=75;
//minimum clearance
minc=8;
printf("x = %d m \n", x);
printf("Minimum clearance = %d m \n", minc);
```

Chapter 9

Electrical Design of Overhead Lines

Scilab code Exa 9.1 loop inductance per km 1

```
//Chapter 9
//Example 9_1
//Page 214

clear;clc;

d=200;
r=1.2/2;

loop_l=(1e-7)*(1+4*log(d/r));

printf("Loop indictance per length of the line = %.2
   f*10^-7 H \n\n", loop_l*1e7 );
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

```
//Chapter 9
//Example 9_2
//PAge 214

clear;clc;

d=300;
r=1;
mr1=1;
mr2=100;

loop_l=(1e-7)*(mr1+4*log(d/r));
loop_ls=(1e-7)*(mr2+4*log(d/r));


printf("(i) With copper conductors mr=1 \n Loop
   indictance per meter = %.2f*10^-7 H \n\n", loop_l
   *1e7 );
printf("Loop indictance per km = %.3f mH \n\n",
   loop_l*1e6 );

printf("(ii) With steel conductors mr=100 \n Loop
   indictance per meter = %.2f*10^-7 H \n\n",
   loop_ls*1e7 );
printf("Loop indictance per km = %.3f mH \n\n",
   loop_ls*1e6 );
```

Scilab code Exa 9.3 inductance per phase per km 3

```
//Chapter 9
//Example 9_3
//PAge 215

clear;clc;

d=200;
r=1.24/2;

loop_l=(1e-7)*(0.5+2*log(d/r));
loop_ls=loop_l*1000;


printf("Loop inductance/phase/m = %d*10^-7 H \n\n",
   loop_l*1e7 );

printf("Loop indictance per km = %.1f mH \n\n",
   loop_ls*1e3 );
```

Scilab code Exa 9.4 inductance per phase per km 4

```
//Chapter 9

//Example 9_4
//Page 215

```

```
clear;clc;

r=1.24/2;
d12=2;
d23=2.5;
d31=4.5;

deq=(d12*d23*d31)^(1/3)*100;
printf("Equivalent equilateral spacing = %.2f cm \n\n", deq);

loop_l=(1e-7)*(0.5+2*log(deq/r));

printf("Inductance/phase/m = %.2f*10^-7 H \n\n",
    loop_l*1e7 );
printf(" Inductance/phase/km = %.3f mH \n\n", loop_l
    *1e6 );
```

Scilab code Exa 9.5 inductance per phase per km 5

```
//Chapter 9
//Example 9_5
//PAge 215

clear;clc;

r=2.54/2;
d12=2;
d23=2;
d31=4;

deq=(d12*d23*d31)^(1/3);
printf("Equivalent equilateral spacing = %.3f cm \n\
```

```
    n", deq);

loop_l=(1e-7)*(0.5+2*log(deq*100/r));

printf("Inductance/phase/m = %.2f*10^-7 H \n\n",
    loop_l*1e7 );
printf(" Inductance/phase/km = %.3f mH \n\n", loop_l
    *1e6 );
```

Scilab code Exa 9.6 loop inductance per km 3

```
//Chapter 9
//Example 9_6
//Page 215

clear;clc;

r=1/2;
dab=25;
daa=100;
dabdash=sqrt(dab^2+daa^2);

gmr=0.7788*r;

ds=((gmr*daa)^2)^(1/4);
dm=(dab^2*dabdash^2)^(1/4);
l=2*1e-7*log(dm/ds);

printf("GMR of conductor = %.3f cm \n\n", gmr);
printf("Self GMD = %.2f cm \n\n", ds);
printf("Mutual GMD = %.2f cm \n\n", dm);
printf("Inductance/conductor/m = %.2f*10^-7 H \n\n",
     l*1e7 );
```

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

Scilab code Exa 9.7 inductance per phase per km 4

```
//Chapter 9
//Example 9_7
//Page 216

clear;clc;

r=1.3;
d_acd=6;
d_bbd=d_acd;
d_ab=3;
d_bc=3;
d_adbd=d_bc;
d_aa=1.01*1e-2;
d_bb=d_aa;
d_adad=d_aa;
d_bdbd=d_aa;
d_bdb=d_aa;
d_ca=6;
d_cad=6;
d_cda=6;
d_cdad=6;

gmr=r*0.7788;
d_abd=sqrt(d_acd^2+d_ab^2);
d_adb=d_abd;
d_aad=sqrt(d_acd^2+(d_ab+d_bc)^2);
ds1=(d_aa*d_aad*d_adad*d_aad)^(1/4);
ds2=(d_bb*d_bbd*d_bdbd*d_bbd)^(1/4);
```

```
ds=(ds1*ds2*ds1)^(1/3);
dab=(d_ab*d_abd*d_adb*d_adbd)^(1/4);
dbc=dab;
dca=(d_ca*d_cad*d_cda*d_cdad)^(1/4);
dm=(dab*dbc*dca)^(1/3);
l=(1e-7)*2*log(dm/ds);

printf("GMR of conductor = %.2f cm \n\n", gmr);
printf("Distance a to b_dash = %.2f m \n", d_abd);
printf("Distance a to a_dash = %.2f m \n\n", d_aad);
printf("Ds1 = %.2f m \n", ds1);
printf("Ds2 = %.2f m \n", ds2);
printf("Ds = %.2f m \n\n", ds);
printf("Dab = %.2f m \n", dab);
printf("Dbc = %.2f m \n", dbc);
printf("Dca = %.2f m \n", dca);
printf("Dm = %.2f m \n\n", dm);
printf("Inductance per phase per metre length = %.2f
    mH \n\n",l*1e6);
```

Scilab code Exa 9.8 inductance per phase per km 6

```
//Chapter 9
//Example 9_8
//Page 217

clear;clc;

r=0.75;

//According to the figure in the text book
dab=3;
dbc=3;
```

```
dacd=4;
dbbd=5.5;
dcad=4;

dca=dab+dbc;

gmr=r*0.7788;
Daa=gmr;
Dadad=gmr;
Dab=sqrt(dab^2+r^2);
Dabd=sqrt(dab^2+(dacd+r)^2);
Daad=sqrt((dab+dbc)^2+dacd^2);
Dada=Daad;

Ds1=(Daa*Daad*Dada*Dadad)^(1/4)/10;
Ds2=(Daa*dbbd*Daa*dbbd)^(1/4)/10;
Ds3=Ds1;

Ds=(Ds1*Ds2*Ds3)^(1/3);

DAB=(Dab*Dabd*Dabd*Dab)^(1/4);
DBC=DAB;
DCA=(dca*dacd*dacd*dca)^(1/4);

Dm=(DAB*DBC*DCA)^(1/3);

l_ph_m=1e-7*2*log(Dm/Ds);

printf("GMR of conductor = %.3f cm \n\n", gmr);
printf("Distance a to b = %.2f m \n", Dab);
printf("Distance a to b-dash = %.2f m \n", Dabd);
printf("Distance a to a-dash = %.2f m \n\n", Daad);

printf("Ds1 = %.3f m \n", Ds1);
printf("Ds2 = %.3f m \n", Ds2);
printf("Ds3 = %.3f m \n", Ds3);
printf("Equivalent self GMD of one phase = %.3f m \n
   \n", Ds);
```

```
printf("DAB = %.3f m \n", DAB);
printf("DBC = %.3f m \n", DBC);
printf("DCA = %.3f m \n", DCA);
printf("Equivalent mutual GMD = %.3f m \n\n", Dm);

printf("Inductance/phase/m = %.3f*10^-3 mH \n\n",
    l_ph_m/10*1e7);
printf("Inductance/phase/km = %.3f mH \n\n", l_ph_m
    /10*1e7);
```

Scilab code Exa 9.9 inductance per phase per km 7

```
//Chapter 9
//Example 9_9
//Page 218

clear;clc;

r=5.3;
dab=8;
dbc=dab;
dcad=dab;
dadbd=dab;
dbdcd=dab;

gmr=r*0.7788/100;

Ds1=(gmr*3*dab*3*dab*gmr)^(1/4);
Ds2=Ds1;
Ds3=Ds1;

Ds=(Ds1*Ds2*Ds3)^(1/3);
```

```
DAB=(dab*4*dab*2*dab*dab)^(1/4);
DCA=(2*dab*1*dab*5*dab*2*dab)^(1/4);
DBC=DAB;

Dm=(DAB*DBC*DCA)^(1/3);

l_ph_m=1e-7*2*log(Dm/Ds);

printf("GMR of conductor = %.4f cm \n\n", gmr);

printf("Ds1 = %.3f m \n", Ds1);
printf("Ds2 = %.3f m \n", Ds2);
printf("Ds3 = %.3f m \n", Ds3);
printf("Equivalent self GMD of one phase = %.3f m \n
   \n", Ds);

printf("DAB = %.3f m \n", DAB);
printf("DBC = %.3f m \n", DBC);
printf("DCA = %.3f m \n", DCA);
printf("Equivalent mutual GMD = %.3f m \n\n", Dm);

printf("Inductance/phase/m = %.3f*10^-7 mH \n\n",
   l_ph_m*1e7);
```

Scilab code Exa 9.10 loop inductance per km 4

```
//Chapter 9
//Example 9_10
//Page 219

clear;clc;

```

```
//From the figure
Daad=20;
Dadb=100;
Dbbd=20;

Dab=Daad+Dadb;
Dabd=Daad+Dadb+Dbbd;
Dadbd=Dadb+Dbbd;

gmr=0.7788;
Daa=gmr;
Dadad=gmr;

Dm=(Dab*Dabd*Dadb*Dadbd)^(1/4);

Ds=(Daa*Daad*Dadad*Daad)^(1/4);

l=4*1e-4*log(Dm/Ds);

printf("GMR of conductor = %.4f cm \n\n", gmr);
printf("Equivalent self GMD of one phase = %.3f m \n
    \n", Ds);
printf("Equivalent mutual GMD = %.3f m \n\n", Dm);
printf("Loop Inductance/km = %.3f mH/km \n\n", l*1e3
    );
```

Scilab code Exa 9.11 capacitance per km

```
//Chapter 9
//Example 9_11
//Page 224

clear;clc;
```

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

Scilab code Exa 9.12 capacitance of each line conductor

```
//Chapter 9
//Example 9_12
//Page 225

clear;clc;

r=1.25/2;
d=200;
e0=8.854*1e-12;
c=2*%pi*e0/log(d/r);
printf("Capacitance of the line = %.4f uF/km \n", c
    *1e9);
```

Scilab code Exa 9.13 charging current per phase

```
//Chapter 9
//Example 9_13
//Page 225

```

```
clear;clc;

v=66*1e3;
f=50;
d1=2;
d2=2.5;
d3=4.5;
d=282;
r=1.25/2;

e0=8.854*1e-12;
c=2*%pi*e0/log(d/r);
printf("(i) Line to nuetral Capacitance for 100km
   line = %.4f uF \n\n", c*1000*1e8);

ic=v/sqrt(3)*(2*%pi*f*c*100);
printf("(ii) Charging current per phase = %.2f A \n\
   n", ic*1000);
```

Scilab code Exa 9.14 capacitance of line

```
//Chapter 9
//Example 9_14
//Page 225

clear;clc;

l=100;
f=50;
d=250;
r=2/2;
e0=8.854*1e-12;
c=2*%pi*e0/log(d/r);
```

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

Scilab code Exa 9.15 charging current per phase 2

```
//Chapter 9
//Example 9_15
//Page 226

clear;clc;

f=50;
v=132*1e3;
d1=4;
d2=4;
d3=8;
r=1e-2;

deq=(d1*d2*d3)^(1/3);
printf("Deq = %.2f m \n\n", deq);
e0=8.854*1e-12;
c=2*%pi*e0/log(deq/r);
printf("Capacitance of each conductor to nuetral = %
   .4f uF/km \n\n", c*1e9);
cn=c*1e9*100;
printf("Capacitance/phase for 100km line = %.4f uF/
   km \n\n", cn);
ic=v/sqrt(3)*(2*%pi*f)*cn/1e6;
printf("Charging current per phase= %.2f A \n\n", ic
   );
```

Chapter 10

Performance of Transmission Lines

Scilab code Exa 10.1 transmission efficiency 1

```
//Chapter 10
//Example 10_1
//Page 133

clear;clc;

load_kw=1100;
vr=33;
pf=0.8;
r=10;
xl=15;

phir=acos(0.8);
i=load_kw/vr/pf;
z=r+%i*xl;
i_vector=i*(cos(phir)- %i*(sin(phir)));
vs=vr*1000+z*i_vector;
alpha=imag(vs)/real(vs);
phis=phir+alpha;
```

```
loss=i^2*r;
op=load_kw;
ps=op+loss/1000;
n=op/ps*100;

printf("Line current = %.2f A \n", i);
printf("             = %.2f+j(%.2f) \n\n", real(
   i_vector), imag(i_vector));

printf("(i) Sending end voltage = %.2f+j(%.2f) \n",
   real(vs), imag(vs));
printf("    Magnitude of Vs = %.0f V \n\n", abs(vs))
   ;
printf("(ii) Angle betwen Vs and Vr = %.2f degrees \
   n", alpha*180/%pi);
printf("     Sending end power factor angle = %.2f
   degrees \n", phis*180/%pi);
printf("     Sending end power factor = %.2f \n\n",
   cos(phir));
printf("(iii) Line loss = %.2f kW \n", loss/1000);
printf("      Output delivered = %.0f kW \n", op);
printf("      Power sent = %.3f kW \n", ps);
printf("      Transmission efficiency = %.2f %% \n",
    n);
```

Scilab code Exa 10.2 length of conductor

```
//Chapter 10
//Example 10_2
//Page 235

clear;clc;

```

```
area=0.775;
pr=200;
pf=1;
v=3300;
n=0.9;
sr=1.725*1e-6;

ps=pr*1000/n;
loss=ps-pr*1000;
i=pr*1000/v;
r=loss/2/i^2;
l=r*area/sr;

printf("Sending end power = %.0f W \n\n", ps);
printf("Line losses = %.0f W \n\n", loss);
printf("Line current = %.1f A \n\n", i);
printf("Resistance of the line = %.3f ohms \n\n", r)
    ;
printf("Length of the conductor = %.2f km \n\n", l
    /1000/100);
```

Scilab code Exa 10.3 transmission efficiency 2

```
//Chapter 10
//Example 10_3
//Page 235

clear;clc;

load_kw=5000;
v_r=22;
pfr=0.8;
r=4;
```

```
xl=6;

vr=22*1000/sqrt(3);
z=r+%i*xl;
i=load_kw*1000/3/vr/pfr;
vr_phasor=vr+%i*0;
i_phasor=i*(pfr-%i*sin(acos(pfr)));
vs_phasor=vr_phasor+i_phasor*z;
vs=abs(vs_phasor);
lv=vs*sqrt(3);
reg=(vs-vr)/vr*100;
loss=3*i^2*r;
n=load_kw/(load_kw+loss/1000);

printf("Impedance per phase = %.0f+j(%.0f) \n\n", real(z), imag(z));
printf("Line current = %.2f A \n\n", i);
printf("                = %.2f+j(%.2f) \n\n", real(i_phasor), imag(i_phasor));
printf("(i) Sending end voltage phasor =%.2f+j(%.2f) \n\n", real(vs_phasor), imag(vs_phasor));
printf("    Magnitude of Vs = %.2f V \n\n", vs);
printf("    Line value of Vs = %.2f kV \n\n", lv/1000);
printf("(ii) Percentage regulation = %.3f %% \n\n", reg);
printf("(iii) Line losses = %.3f kW \n\n", loss/1000);
printf("      Transmission efficiency = %.2f %% \n\n", n*100);
```

Scilab code Exa 10.4 length of line

```
//Chapter 10
//Example 10_4
//Page 236

clear;clc;

load_kw=15000;
pf=0.8;
r=1;
vr=132;
loss=0.05;

i=load_kw*1000/sqrt(3)/vr/1000/pf;
l_loss=loss*load_kw;
r=l_loss*1000/3/i^2;
l=r;

printf("Line current = %.0f A \n\n", i);
printf("Line losses = %.0f kW \n\n", l_loss);
printf("R = %.2f ohm \n\n", r);
printf("Length of the line = %.2f km \n\n", l);
```

Scilab code Exa 10.5 transmission eff

```
//Chapter 10
//Example 10_5
//Page 236

clear;clc;

kw=3600;
pf=0.8;
vs=33;
```

```
r=5.31;
x=5.54;

//Sending end voltage per phase
vsp=vs*1000/sqrt(3);
printf("Sending end voltage per- phase = %d V \n",
    vsp);
//line current
il=kw/3*1000/pf;
printf("Line current = %d*10^5/Vr \n", il/10^5);
//using approximate expression ,
vr=18435;
printf("(i) Vr = %d V \n", vr);
lv=sqrt(3)*vr/1000;
printf("    Line voltage at recieving end = %.2f kV
    \n\n", lv);
//line current
lc=il/vr;
printf("(ii) Line current = %.2f A \n\n", lc);
loss=3*lc^2*r;
eff=kw/(kw+loss/1000);
printf("(iii) Line losses = %.3f kW \n", loss/1000);
printf("      Transmission efficiency = %.2f %% \n\n
    ", eff*100)
```

Scilab code Exa 10.6 sending end pf

```
//Chapter 10
//Example 10_6
//Page 237

clear;clc;

```

```
r=6;
xl=8;
pfr=0.9;
vr=110*1000/sqrt(3);
vs=120*1000/sqrt(3);

i=(vs-vr)/(r*pfr+xl*sin(acos(pfr)));
op=3*vr*i*pfr/1000;
pfs=(vr*pfr+i*r)/vs;

printf("Recieving end voltage = %.0f V \n\n", vr);
printf("Sending end voltage = %.0f V \n\n", vs);
printf("Load current = %.2f A \n\n", i);
printf("(i) Power output = %.0f kW \n\n", op);
printf("(ii) Sending end power factor = %.2f lag \n\
   n", pfs);
```

Scilab code Exa 10.7 transmission efficiency 3

```
//Chapter 10
//Example 10_7
//Page 237

clear;clc;

vr=11*1000/sqrt(3);
r=1.5;
xl=4;
pfr=0.8;
pd=5000;

i=pd*1000/3/vr;
vs=vr+i*r*pfr+i*xl*sin(acos(pfr));
```

```
reg=(vs-vr)/vr*100;
loss=3*i^2*r;
op=pd*pfr;
ip=op+loss/1000;
n=op/ip*100;

printf("Recieving end voltage = %.0f V \n\n", vr);
printf("Load current = %.2f A \n\n", i);
printf("Sending ebd voltage = %.2f V \n\n", vs);
printf("%% Regulation = %.2f %% \n\n", reg);
printf("Lone losses = %.0f kW \n\n", loss/1000);
printf("Output power = %.0f kW \n\n", op);
printf("Input power = %.0f kW \n\n", ip);
printf("Transmission efficiency = %.2f %% \n\n", n);
```

Scilab code Exa 10.8 transmission efficiency 4

```
//Chapter 10
//Example 10_8
//Page 238

clear;clc;

f=50;
ll=16;
pd=1000;
v_r=11;
pfr=0.8;
r=0.03;
l=0.7;

r_ohm=r*ll;
xl=l*2*%pi*f*ll/1000;
```

```
vr=v_r*1000/sqrt(3);
i=pd*1000/3/vr/pfr;
vs=vr+i*r_ohm*pfr+i*xl*sin(acos(pfr));
reg=(vs-vr)/vr*100;
loss=3*i^2*r_ohm;
op=pd;
ip=op+loss/1000;
n=op/ip*100;

printf("Resistance of each conductor = %.2f ohm \n\n
    ", r_ohm);
printf("Reactance of each conductor = %.2f ohm \n\n"
    , xl);
printf("Recieving end voltage = %.0f V \n\n", vr);
printf("Load current = %.2f A \n\n", i);
printf("Sending end voltage = %.2f V \n\n", vs);
printf("%% Regulation = %.2f %% \n\n", reg);
printf("Line losses = %.3f kW \n\n", loss/1000);
printf("Output power = %.0f kW \n\n", op);
printf("Input power = %.1f kW \n\n", ip);
printf("Transmission efficiency = %.2f %% \n\n", n);
```

Scilab code Exa 10.9 transmission efficiency 5

```
//Chapter 10
//Example 10_9
//Page 238

clear;clc;

pd=2000;
pfr=0.8;
vrd=6.6;
```

```
ll=20;
f=50;
vr=33;
r=0.4;
xl=0.5;
rp=7.5;
xlp=13.2;
rs=0.35;
xls=0.65;

rc=ll*r;
xlc=ll*xl;

eqr=rp+rs*(vr/vrd)^2;
eqxl=xlp+xls*(vr/vrd)^2;

tr=rc+eqr;
txl=xlc+eqxl;

vr_phase=vr*1000/sqrt(3);
i=pd*1000/sqrt(3)/vr/1000;
vs=vr_phase+i*tr*pfr+i*txl*sin(acos(pfr));
pfs=(vr_phase*pfr+i*tr)/vs;
loss=3*i^2*tr/1000;
op=pd*pfr;
ip=op+loss;
n=op/ip*100;

printf("Resistance of each conductor = %.2f ohm \n\n
    ", rc);
printf("Reactance of each conductor = %.2f ohm \n\n"
    , xlc);

printf("Equivalent resistance of transformer
    referred to primary = %.2f ohm \n\n", eqr);
printf("Equivalent reactance of transformer referred
     to primary = %.2f ohm \n\n", eqxl);

```

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

Scilab code Exa 10.10 supply pf for medium tr lines

```
//Chapter 10
//Example 10_10
//Page 241

clear;clc;

r=0.25;
xl=0.8;
y=14*1e-6;
vr=66000;
pd=15000;
pfr=0.8;
ll=100;

tr=ll*r;
txl=ll*xl;
```

```
ty=y*ll;

z=tr+%i*txl;
l=pd/vr/pfr;
i=pd*1000/vr/pfr;
vr_phasor=vr+%i*0;
ir_phasor=i*(pfr-%i*sin(acos(pfr)));
ic=%i*ty*vr;

is_phasor=ir_phasor+ic;
mag_is=abs(is_phasor);
vd=is_phasor*z;
vs_phasor=vr_phasor+is_phasor*z;
mag_vs=abs(vs_phasor);
reg=(mag_vs-vr)/vr*100;
theta1=atan(-imag(is_phasor)/real(is_phasor));
theta2=atan(imag(vs_phasor)/real(vs_phasor));
thetas=abs(theta1)+theta2;
pfs=cos(thetas);

printf("Total resistance = %.0f ohm \n\n", tr);
printf("Total reactance = %.0f ohm \n\n", txl);
printf("Total susceptance = %.0f ohm \n\n", ty);
printf("Recieving end voltage = %.0f V \n\n", vr);
printf("Load current = %.0f A \n\n", i);
printf("Vr phasor = %.2f+j%.2f \n\n", real(vr_phasor), imag(vr_phasor));
printf("Load current phasor = %.2f+j%.2f \n\n", real(ir_phasor), imag(ir_phasor));
printf("Capacitive current = j%.2f \n\n", imag(ic));
printf("(i) Sending end current = %.2f+j%.2f \n", real(is_phasor), imag(is_phasor));
printf("     Magnitude = %.0f V \n\n", mag_is);
printf("(ii) Voltage drop = %.2f+j%.2f \n", real(vd), imag(vd))
printf("      Sending end voltage = %.2f+j%.2f \n", real(vs_phasor), imag(vs_phasor));
printf("      Magnitude of Vs = %.0f V \n\n", mag_vs)
```

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

Scilab code Exa 10.11 nominal t method 1

```
//Chapter 10
//Example 10_11
//Page 244

clear;clc;

r=0.1;
xl=0.2;
y=0.04*1e-4;
ll=100;
f=50;
pd=10000;
v_r=66000;
pfr=0.8;

tr=r*ll;
txl=ll*xl;
ty=ll*y;

vr=v_r/sqrt(3);
```

```
ir=pd*1000/sqrt(3)/v_r/pfr;
z=tr+%i*txl;
ir_p=ir*(pfr-%i*sin(acos(pfr)));
v1=vr+ir_p*z/2;
ic=%i*ty*v1;
is=ir_p+ic;
vs=v1+is*z/2;
theta1=atan(imag(vs)/real(vs));
theta2=atan(imag(is)/real(is));
thetas=theta1+abs(theta2);
pfs=cos(thetas);
ps=3*abs(vs)*abs(is)*pfs/1000;
n=pd/ps;

printf("Total resistance per phase = %.2f ohm \n\n", tr);
printf("Total reactance per phase = %.2f ohm \n\n", txl);
printf("Total susceptance per phase = %.5f ohm \n\n", ty);

printf("Recieving end voltage = %.0f V \n\n", vr);
printf("Load current = %.2f A \n\n", ir);
printf("Impedance per phase = %.2f+j%.2f \n\n", real(z), imag(z));

printf("Receiving end voltage is the reference phasor = %.2f+j0 \n\n", vr);
printf("Load current = %.2f+j%.2f \n\n", real(ir_p), imag(ir_p));
printf("Voltage across C = %.2f+j%.2f \n\n", real(v1), imag(v1));
printf("Charging current = %.2f+j%.2f \n\n", real(ic), imag(ic));
printf("Sending end current = %.2f+j%.2f \n\n", real(is), imag(is));
printf("Sending end current magnitude = %.2f A \n\n", abs(is));
```

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

Scilab code Exa 10.12 nominal t method 2

```
//Chapter 10
//Example 10_12
//Page 245

clear;clc;

f=50;
ll=100;
pd=20*1e6;
pfr=0.9;
v_r=110*1e3;
r=0.2;
xl=0.4;
y=2.5*1e-6;

```

```
tr=r*ll;
txl=ll*xl;
ty=ll*y;

vr=v_r/sqrt(3);
ir=pd/sqrt(3)/v_r/pfr;
z=tr+%i*txl;
ir_p=ir*(pfr-%i*sin(acos(pfr)));
v1=vr+ir_p*z/2;
ic=%i*ty*v1;
is=ir_p+ic;
vs=v1+is*z/2;
lv=abs(vs)*sqrt(3);
loss=3*is^2*tr/2+3*ir^2*tr/2;
n=(pd)/(pd+loss);

printf("Total resistance per phase = %.2f ohm \n\n", tr);
printf("Total reactance per phase = %.2f ohm \n\n", txl);
printf("Total susceptance per phase = %.5f ohm \n\n", ty);
printf("Phase impedance = %.2f+j(%.2f) \n\n", real(z), imag(z));
printf("Recieving end voltage = %.0f V \n\n", vr);
printf("Load current = %.2f A \n\n", ir);
printf("Impedance per phase = %.2f+j(%.2f) \n\n", real(z), imag(z));

printf("Receiving end voltage is the reference phasor = %.2f+j0 \n\n", vr);
printf("Load current = %.2f+j(%.2f) \n\n", real(ir_p), imag(ir_p));
printf("Voltage across C = %.2f+j(%.2f) \n\n", real(v1), imag(v1));
printf("Charging current = %.2f+j(%.2f) \n\n", real(ic), imag(ic));
printf("Sending end current = %.2f+j(%.2f) \n\n",
```

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

Scilab code Exa 10.13 nominal pi method 1

```
//Chapter 10
//Example 10_13
//Page 247

clear;clc;

f=50;
ll=150;
r=0.1;
xl=0.5;
y=3*1e-6;
pd=50*1e6;
v_r=110*1e3;
pfr=0.8;

tr=r*ll;
ty=y*ll;
```

```
txl=xl*ll;

z=tr+%i*txl;
vr=v_r/sqrt(3);
ir=pd/sqrt(3)/v_r/pfr;
ir_p=ir*(pfr-%i*sin(acos(pfr)));
ic1=vr*%i*ty/2;
il=ir_p+ic1;
vs=vr+il*z;
ic2=vs*%i*ty/2;
is=il+ic2;

printf("Total resistance / phase = %.2f ohm \n\n",tr);
printf("Total reactance / phase = %.2f ohm \n\n",txl);
printf("Total susceptance / phase = %.6f S \n\n",ty);

printf("Recieving end voltage = %.0f V \n\n", vr);
printf("                         = %.0f+j0 \n\n", vr);
printf("Load current = %.2f+j(%.2f) \n\n", real(ir_p), imag(ir_p));
printf("Charging current at load end = j(%.2f) \n\n", imag(ic1));
printf("Line current = %.2f+j(%.2f) \n\n", real(il), imag(il));
printf("Sending end voltage = %.2f+j(%.2f) \n\n", real(vs), imag(vs));
printf("Line to line sending end voltage = %.2f kV \n\n", abs(vs)*sqrt(3)/1000);
printf("Charging current at sending end = j(%.2f) \n\n", imag(ic2));
printf("Sending end current = %.2f+j(%.2f) A \n\n", real(is), imag(is));
printf("Sending end current = %.2f A \n\n", abs(is));
```

Scilab code Exa 10.14 nominal pi method 2

```
//Chapter 10
//Example 10_14
//Page 248

clear;clc;

ll=100;
r=0.1;
xl=0.5;
y=10*1e-6;
pd=20*1e6;
pfr=0.9;
v_r=66*1e3;

tr=r*ll;
ty=y*ll;
txl=xl*ll;

z=tr+%i*txl;
vr=v_r/sqrt(3);
ir=pd/sqrt(3)/v_r/pfr;
ir_p=ir*(pfr-%i*sin(acos(pfr)));
ic1=vr*%i*ty/2;
il=ir_p+ic1;
vs=vr+il*z;
ic2=vs*%i*ty/2;
is=il+ic2;
theta1=atan(imag(vs)/real(vs));
theta2=atan(imag(is)/real(is));
thetas=theta1+abs(theta2);
```

```
pfs=cos(thetas);
reg=(abs(vs)-vr)/vr*100;
ps=3*abs(vs)*abs(is)*pfs;
n=pd/ps*100;

printf("Total resistance / phase = %.2f ohm \n\n",tr);
printf("Total reactance / phase = %.2f ohm \n\n",txl);
printf("Total susceptance / phase = %.6f S \n\n",ty);

printf("Recieving end voltage = %.0f V \n\n", vr);
printf("Load current = %.2f A \n\n", ir);
printf("Recieving end voltage phasor = %.0f+j0 \n\n", vr);
printf("Load current = %.2f+j(%.2f) \n\n", real(ir_p), imag(ir_p));
printf("Charging current at load end = j(%.2f) \n\n", imag(ic1));
printf("Line current = %.2f+j(%.2f) \n\n", real(il), imag(il));
printf("Sending end voltage = %.2f+j(%.2f) \n\n", real(vs), imag(vs));
printf("Line to line sending end voltage = %.2f kV \n\n", abs(vs)*sqrt(3)/1000);
printf("Charging current at sending end = %.2f+j(%.2f) \n\n", real(ic2),imag(ic2));
printf("Sending end current = %.2f+j(%.2f) A \n\n", real(is), imag(is));
printf("Sending end current = %.2f A \n\n", abs(is));

printf("(i) Angle between Vr and Vs = %.2f degrees \n\n", theta1*180/%pi);
printf("    Angle between Vr and Is = %.2f degrees \n\n", theta2*180/%pi);
printf("    Angle between Is and Vs = %.2f degrees \
```

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

Scilab code Exa 10.15 long tr line

```
//Chapter 10
//Example 10_15
//Page 254

clear;clc;

ll=200;
r=0.16;
xl=0.25;
y=1.5*1e-6;
pd=20*1e6;
pfr=0.8;
v_r=110*1e3;

tr=r*ll;
ty=y*ll;
txl=xl*ll;

z=tr+%i*txl;
vr=v_r/sqrt(3);
ir=pd/sqrt(3)/v_r/pfr;
```

```
vs=vr*cosh(ty*z)+ir*sqrt(z/ty)*sinh(z*ty);
is=vr*sqrt(ty/z)*sinh(ty*z)+ir*cosh(ty*z);

printf("Recieving end voltage per phase = %.0f V \n\n", vr);
printf("Recieving end current = %.0f A \n\n", ir);
printf("Sending end voltage = %.2f+j%.2f = %.2f kV \n\n", real(vs), imag(vs), abs(vs)*sqrt(3)/1000);
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

```
//Chapter 10
//Example 10_16
//Page 258

clear;clc;

pd=30*1e6;
v_r=132*1e3;
pfr=0.85;
z=20+%i*52;
y=%i*315*1e-6;

a=1+z*y/2;
d=a;
b=z*(1+z*y/4);
c=y;

vr=v_r/sqrt(3)/1000;
ir=pd/sqrt(3)/v_r/pfr;
```

```
ir_p=ir*(pfr-%i*sin(acos(pfr)));
vs=a*vr*1000+b*ir_p;
mag_vs=abs(vs)/1000;
ll=mag_vs*sqrt(3);

reg=(mag_vs/abs(a)-vr)/vr*100;

printf("(i) GENERALISED CONSTANTS OF LINE: \n");
printf("     A = %.3f+j(%.6f) \n", real(a), imag(a));
printf("     B = %.2f+j(%.2f) \n", real(b), imag(b));
printf("     C = %.6f+j(%.4f) \n", real(c), imag(c));
printf("     D = %.3f+j(%.6f) \n\n", real(d), imag(d));

printf("(ii) SENDING END VOLTAGE: \n");
printf("     Recieving end voltage per phase = %.0f kV \n\n", vr);
printf("     Recieving end current = %.0f A \n\n", ir);
printf("     Recieving end current phasor = %.2f+j(%.2f) \n\n", real(ir_p), imag(ir_p));
printf("     Sending end voltage per phase = %.2f+j(%.2f) V \n\n", real(vs), imag(vs));
printf("     Magnitude of Sending end voltage = %.2f kV \n\n", mag_vs);
printf("     Line value = %.2f kV \n\n", ll);

printf("(iii) REGULATION: \n");
printf("     %% regulation = %.2f %% \n\n", reg);
```

Scilab code Exa 10.17 generalised contants 2

```
//Chapter 10
```

```
//Example 10_17
//Page 259

clear;clc;

v_r=132*1e3;
pd=50*1e6;
pfr=0.8;
a=0.9497+%i*0.02321;
d=a;
b=19.9595+%i*93.90216;
c=%i*0.0015;

vr=v_r/sqrt(3);
ir=pd/sqrt(3)/v_r/pfr;
printf("Recieving end voltage per phase = %.0f V \n\n", vr);
printf("Recieving end current = %.0f A \n\n", ir);
printf("Recieving end voltage phasor = %.0f+j0 V \n\n", vr);
ir_p=ir*(pfr-%i*sin(acos(pfr)));
printf("Load current phasor = %.2f+j(%.2f) \n\n", real(ir_p), imag(ir_p));

vs=a*vr+b*ir_p;
mag_vs=abs(vs);
printf("Sending end voltage per phase = %.2f+j(%.2f) V \n\n", real(vs), imag(vs));

is=c*vr+d*ir_p;
mag_is=abs(is);
printf("Sending end current = %.2f+j(%.2f) = %.2f A \n\n", real(is), imag(is), abs(is));

ic=is-ir_p;
printf("Charging current = %.2f+j(%.2f) \n\n", real(ic), imag(ic));

```

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

Scilab code Exa 10.18 generalised contants 3

```
//Chapter 10
//Example 10_18
//Page 260

clear;clc;

v_r=110*1e3;
pd=50*1e6;
pfr=0.8;
a=0.97865+%i*0.051289;
d=a;
b=28.47009+%i*106.25184;
c=0.00008682+%i*0.0004924;

vr=v_r/sqrt(3);
ir=pd/sqrt(3)/v_r;
printf("Recieving end voltage per phase = %.0f V \n\n", vr);
printf("Recieving end current = %.0f A \n\n", ir);
printf("Recieving end voltage phasor = %.0f+j0 V \n\n", vr);
ir_p=ir*(pfr-%i*sin(acos(pfr)));
printf("Load current phasor = %.2f+j(%.2f) \n\n", real(ir_p), imag(ir_p));

vs=a*vr+b*ir_p;
mag_vs=abs(vs);
printf("(i) Sending end voltage per phase = %.2f+j(%
```

```
.2f) V \n", real(vs), imag(vs));
printf("     Magnitude of Sending end voltage = %.2f kV \n\n", mag_vs);

is=c*vr+d*ir_p;
mag_is=abs(is);
printf("(ii) Sending end current = %.2f+j(%.2f) = %.2f A \n", real(is), imag(is), abs(is));
printf("      Magnitude of Sending end current = %.2f kV \n\n", mag_is);

t1=atan(imag(is)/real(is))*180/%pi;
t2=atan(imag(vs)/real(vs))*180/%pi;
pfs=cos((abs(t1)+t2)*%pi/180);
ps=3*mag_vs*mag_is*pfs/1e6;
printf("(iii) Sending end power = %.2f MW \n\n", ps);

pr=pd*pfr/1e6;
printf("(iv) Recieving end power = %.2f MW \n\n", pr);
printf("      Transmission efficiency = %.2f %% \n\n", pr/ps*100);
```

Chapter 11

Underground Cables

Scilab code Exa 11.1 insulaiton resistance

```
//Chapter 11
//Example 11_1
//Page 273

clear;clc;

r1=1/2;
l=2000;
p=5*1e12;
r2=0.5+0.4;

r=p*log(r2/r1)/(2*%pi*l);

printf("Internal resistance of the cable is = %.2f
   MW \n\n", r/1e6);
```

Scilab code Exa 11.2 insulation thickness

```
//Chapter 11
//Example 11_2
//Page 274

clear;clc;

l=1000;
r=495*1e6;
r1=2.5/2;
p=4.5*1e12;


r2=r1*exp(2*%pi*r*l/p);

printf("Insulation thickness = %.2f cm \n\n", r2-r1)
    ;
```

Scilab code Exa 11.3 insulaiton resistance 2

```
//Chapter 11
//Example 11_3
//Page 274

clear;clc;

l=5000;
r=0.4*1e6;
r1=20/2;
r2=50/2;

p=2*%pi*r*l/log(r2/r1);

printf("Resistance of the insulating material = %.2f
```

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

Scilab code Exa 11.4 cable capacitance

```
//Chapter 11
//Example 11_4
//Page 275

clear;clc;

er=4;
l=1000;
d_out=1.8;
d_in=1;

c=er*l*1e-9/41.4/log10(d_out/d_in)/10;

printf("Capacitance of the cable = %.3f uF \n\n", c
    *10e6);
```

Scilab code Exa 11.5 total charging kvar

```
//Chapter 11
//Example 11_5
//Page 276

clear;clc;

er=4;
```

```
l=1000;
d_in=10;
d_out=10+2*7;
v=66*1e3;
f=50;

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

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

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

printf("Voltage between core and sheath = %.0f V \n\
    nCharging current = %.2f A \n\n", v_ph, ic);
```

Scilab code Exa 11.6 total charging kvar 1

```
//Chapter 11
//Example 11_6
//Page 276

clear;clc;

er=3;
l=4000;
d_in=2.5;
d_out=d_in+2*0.5;
v=33*1e3;
f=50;

```

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

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

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

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

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

Scilab code Exa 11.7 minimum dielectric stress

```
//Chapter 11
//Example 11_7
//Page 278

clear;clc;

v=33;
d_in=1;
d_out=4;

g_max=2*v/d_in/log(d_out/d_in);
g_min=2*v/d_out/log(d_out/d_in);

printf("Maximum stress in the insulation = %.2f kV/
```

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

Scilab code Exa 11.8 operating voltage

```
//Chapter 11
//Example 11_8
//Page 278

clear;clc;

g_max=40;
g_min=10;
d_in=2;

d_out=d_in*g_max/g_min;
v=g_max*d_in*log(d_out/d_in)/2;

printf("(i) Insulation thickness = %.0f cm \n\n", (
    d_out-d_in)/2);
printf("(ii) Operating voltage = %.2f kV rms \n\n",
    v);
```

Scilab code Exa 11.9 charging current

```
//Chapter 11
//Example 11_9
//Page 279
```

```
clear;clc;

v=11;
area=0.645;
d_out=2.18;
er=3.5;
l=1000;
f=50;

d_in=sqrt(4*area/%pi);
g_max=2*v/d_in/log(d_out/d_in);
g_min=2*v/d_out/log(d_out/d_in);

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

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

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

xc=1/(2*%pi*f*c);
ic=v*1e3/xc;

printf("(iv) Charging current = %.2f A \n\n", ic);
```

Scilab code Exa 11.10 economical conductor diameter

```
//Chapter 11
//Example 11_10
```

```
//Page 280

clear;clc;

v=50;
g_max=40;

v_rms=v*sqrt(2);
d=2*v_rms/g_max;

printf("Peak value of cable voltage = %.2f kV \n\n",
    v_rms);
printf("Most economical conductor diameter = %.2f cm
    \n\n", d);
```

Scilab code Exa 11.11 internal sheath diameter

```
//Chapter 11
//Example 11_11
//Page 280

clear;clc;

v=132;
g_max=60;

vp=v/sqrt(3);
pv_ph=vp*sqrt(2);

d=2*pv_ph/g_max;
d_out=2.718*d;

printf("Phase value of cable voltage = %.2f kV \n\n"
```

```
, vp);
printf("Peak value of phase voltage = %.2f kV \n\n", pv_ph);

printf("Most economical conductor diameter = %.2f cm \n\n", d);
printf("Internal diameter of sheath = %.2f cm \n\n", d_out);
```

Scilab code Exa 11.12 rms safe working voltage

```
//Chapter 11
//Example 11_12
//Page 282

clear;clc;

d_in=2;
d_out=8;
e1=5;
e2=4;
e3=3;
g_max=40;

d1=e1*d_in/e2;
d2=e1*d_in/e3;

printf("GRADED CABLE: \n");
printf("d1 = %.2f cm \n", d1);
printf("d2 = %.2f cm \n", d2);

v=g_max/2*(d_in*log(d1/d_in)+d1*log(d2/d1)+d2*log(d_out/d2));
```

```
sv=v/sqrt(2);

printf("Permissible peak voltage for the cable = %.3
    f kV \n", v);
printf("Safe working rms voltage for the cable = %.3
    f kV \n\n", sv);

pv=g_max/2*d_in*log(d_out/d_in);
printf("UNGRADED CABLE: \n");
printf("Permissible peak voltage for the cable = %.3
    f kV \n", pv);
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

```
//Chapter 11
//Example 11_13
//Page 283

clear;clc;

d_in=3;
d_out=9;
e1=5;
e2=4;
g1_max=30;
g2_max=20;

d1=g1_max*e1*d_in/g2_max/e2;
ri=(d1-d_in)/2;
ro=(d_out-d1)/2;
v=g1_max/2*d_in*log(d1/d_in)+g2_max/2*d1*log(d_out/
```

```
d1);

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

Scilab code Exa 11.14 max dielectric stress

```
//Chapter 11
//Example 11_14
//Page 284

clear;clc;

d_in=2;
d1=4;
d_out=6;
v=66;
e1=5;
e2=3;

vp=v*sqrt(2/3);

g1max=2*vp/d_in/(log(d1/d_in)+e1*log(d_out/d1)/e2);
g2max=2*vp/d1/(e2*log(d1/d_in)/e1+log(d_out/d1));

printf("g1max = %.2f kV/cm \n\n", g1max);
```

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

Scilab code Exa 11.15 intersheath grading 1

```
//Chapter 11
//Example 11_15
//Page 285

clear;clc;

d_in=2;
d1=3.1;
d2=4.2;
d_out=5.3;
v=66;

vp=v*sqrt(2/3);

g1_max=1/(d_in/2)/log(d1/d_in);
g2_max=1/(d1/2)/log(d2/d1);
g3_max=1/(d2/2)/log(d_out/d2);

v2=g1_max/g2_max;
v3=g1_max/g3_max;

vd=1+v2+v3;
va1=vp/vd;
va2=v2*va1;

vf=vp-va1;
vs=vp-va1-va2;

printf("g1_max = %.2fV1 \n", g1_max);
```

```
printf("g2_max = %.2fV1 \n", g2_max);
printf("g3_max = %.2fV1 \n\n", g3_max);

printf("V2 = %.3fV1 \n", v2);
printf("V3 = %.3fV1 \n\n", v3);

printf("V1 = %.2f kV \n\n", va1);

printf("Voltage on the first intersheath = %.2f kV \n", vf);
printf("Voltage on the second intersheath = %.2f kV \n\n", vs);
```

Scilab code Exa 11.16 intersheath grading 2

```
//Chapter 11
//Example 11_16
//Page 286

clear;clc;

v=66;
d_in=2;
d_out=5.3;
d1=(2*d_out*d_in)^(1/3);
d2=d1^2/2;

vp=v*sqrt(2/3);

v1=vp/(1+d1/d_in+d2/d_in);
v2=d1/d_in*v1;
vf=vp-v1;
vs=vp-v1-v2;
```

```
maxs=v1/(d_in*log(d1/d_in)/2);
mins=v1/(d1*log(d1/d_in)/2);

printf("(i) POSITIONS OF INTERSHEATHS: \n");
printf("d1 = %.2f cm \n", d1);
printf("d2 = %.2f cm \n\n", d2);

printf("(ii) VOLTAGE ON INTERSHEATH: \n");
printf("V1 = %.2f kV \n", v1);
printf("V2 = %.2f kV \n", v2);
printf("Voltage on first intersheath = %.2f kV \n",
    vf);
printf("Voltage on second intersheath = %.2f kV \n\n
    ", vs);

printf("(iii) STRESSES ON DIELECTRIC: \n");
printf("Maximum stress = %.2f kV/cm \n", maxs);
printf("Minimum stress = %.2f kV/cm \n\n", mins);
```

Scilab code Exa 11.17 three core cable Ic

```
//Chapter 11
//Example 11_17
//Page 289

clear;clc;

c=0.3;
v=11;
f=50;
l=5;

```

```
c3=l*c;
vph=v*1000/sqrt(3);
cn=2*c3;
ic=2*%pi*f*cn*vph/1e6;

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);
printf("Phase voltage = %.0f V \n\n", vph);
printf("Core to nuetral capacitance = %.2f uF \n\n",
    cn);
printf("Charging current = %.2f A \n\n", ic);
```

Scilab code Exa 11.18 three core cable Ic2

```
//Chapter 11
//Example 11_18
//Page 290

clear;clc;

v=66;
v_ph=66*1000/sqrt(3);
f=50;
c1=12.6;
c2=7.4;

ce=c1/3;
cc=(c2-ce)/2;
cn=ce+3*cc;
ic=2*%pi*f*v_ph*cn/1e6;

printf("Core-core capacitance of the cable = %.2f uF
```

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

Scilab code Exa 11.19 kva taken by cable

```
//Chapter 11
//Example 11_19
//Page 290

clear;clc;

c=0.18;
l=20;
v=3300;
f=50;

c3=c*l;
v_ph=v/sqrt(3);

cn=2*c3;
ic=2*%pi*f*v_ph*cn/1e6;
kva=3*v_ph*ic;

printf("Capacitance between pair of cores with third
    core = %.2f uF \n\n", c3);
printf("Core to nuetral capacitance of the cable = %
   .2f uF \n\n", cn);
printf("Charging current = %.2f A \n\n", ic);
printf("kVA taken by the cable = %.2f kVA \n\n", kva
```

```
/1000);
```

Scilab code Exa 11.20 permissible current loading

```
//Chapter 11
//Example 11_20
//Page 292

clear;clc;

k=5;
r=30/2;
r1=r+40;
er=110*1e-6;

s1=k/2/%pi*log(r1/r);
s2=0.45;
s=s1+s2;
n=1;
t=55;
i=sqrt(t/n/er/s);

printf("Thermal resistance of the dielectric of the
    cable = %.2f thermal ohms per metre length \n\n",
    s1);
printf("Total thermal resistance = %.2f thermal ohms
    per metre legth \n\n", s);
printf("Maximum permissible current loading = %.0f A
    \n\n", i);
```

Scilab code Exa 11.21 loop testing fault location 1

```
//Chapter 11
//Example 11_21
//Page 296

clear;clc;

q=15;
p=45;
ll=2*300;

d=q/(p+q)*ll;

printf("Distance of the fault point from test end =
    %.0f m \n\n", d);
```

Scilab code Exa 11.22 loop testing fault location 2

```
//Chapter 11
//Example 11_22
//Page 297

clear;clc;

q=1;
p=3*q;
ll=2*500;
```

```
d=q/(p+q)*ll;

printf("Distance of the fault point from test end =
   %.0f m \n\n", d);
```

Scilab code Exa 11.23 loop testing fault location 3

```
//Chapter 11
//Example 11_23
//Page 297

clear;clc;

q=1;
p=2.75*q;
r1=1;
m1=1000;
r2=2.25;
m2=1000;
l=500;

r=r1/m1*l+r2/m2*l;
x=q/(p+q)*r;
d=x*1000;

printf("Resistance of the loop = %.3f ohm \n\n", r);
printf("Resistance of faulty cable from test end
   upto fault point = %.3f ohm \n\n", x);
printf("Distance of fault point from the testing end
    = %.0f m \n\n", d);
```

Scilab code Exa 11.24 distance from fault end

```
//Chapter 11
//Example 11_24
//Page 297

clear;clc;

s=200;
r=20;
l=20;
//R+X is represented by the variable rx
rx=r*(l+l);
x=(rx-s)/2;
d=x/r;

printf("Resistance of cable from test end to fault
    point = %d ohm \n\n", x);
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

```
//Chapter 13
//Example 13_1
//Page 313

clear;clc;

Va=300;
Ic=100;
Id=150;
Ie=200;
Ib=50;
Lac=500;
Lcd=400;
Lde=600;
Leb=400;
r=0.01;

R=r*2;
Rac=R*Lac/1000;
Rcd=R*Lcd/1000;
Rde=R*Lde/1000;
```

```
Reb=R*Leb/1000;

Ieb=Ib;
Ide=Ieb+Ie;
Icd=Ide+Id;
Iac=Icd+Ic;

Vc=Va-Iac*Rac;
Vd=Vc-Icd*Rcd;
Ve=Vd-Ide*Rde;
Vb=Ve-Ieb*Reb;

printf("Resistance per 1000m of distributor = %.2f
   ohm \n\n", R);
printf("Resistance of section AC = %.3f ohm \n", Rac
   );
printf("Resistance of section CD = %.3f ohm \n", Rcd
   );
printf("Resistance of section DE = %.3f ohm \n", Rde
   );
printf("Resistance of section EB = %.3f ohm \n\n",
   Reb);

printf("I_EB = %.0f A \n", Ieb);
printf("I_DE = %.0f A \n", Ide);
printf("I_CD = %.0f A \n", Icd);
printf("I_AC = %.0f A \n\n", Iac);

printf("Potential difference at load point C = Vc =
   %.1f V \n", Vc);
printf("Potential difference at load point D = Vd =
   %.1f V \n", Vd);
printf("Potential difference at load point E = Ve =
   %.1f V \n", Ve);
printf("Potential difference at load point B = Vb =
   %.1f V \n", Vb);
```

Scilab code Exa 13.2 cross sectional area of conductor

```
//Chapter 13
//Example 13_2
//Page 314

clear;clc;

ll=300;
max_drop=10;
p=1.78*1e-8;
Lac=40;
Lcd=60;
Lde=50;
Lef=100;
Lfb=50;
Ic=30;
Id=40;
Ie=100;
If=50;

Ief=If;
Ide=Ief+Ie;
Icd=Ide+Id;
Iac=Icd+Ic;

Rac=Lac/100;
Rcd=Lcd/100;
Rde=Lde/100;
Ref=Lef/100;

vd=Iac*Rac+Icd*Rcd+Ide*Rde+Ief*Ref;
```

```
r=max_drop/vd;
//for 100 m length of the conductor area is given by
    ,
area=p*100*2/r;

printf("Resistance of 100 m length of distributor =
    %.5f ohm \n\n", r);
printf("Area = %.3f cm^2 \n", area*1e4);
```

Scilab code Exa 13.3 voltages across trams

```
//Chapter 13
//Example 13_3
//Page 315

clear;clc;

l1=2;
l2=6-2;
i1=40;
i2=20;
v=600;
rw=0.25;
rt=0.03;

r=rw+rt;
i_sa=i1+i2;
i_ab=i2;
v_sa=i_sa*r*l1;
v_ab=i_ab*r*l2;
va=v-v_sa;
vb=va-v_ab;

```

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

Scilab code Exa 13.4 voltage at tapping points

```
//Chapter 13
//Example 13_4
//Page 315

clear;clc;

Va=250;
Ic=15;
Id=20;
Ib=12;
Lab=75;
Lcd=50;
Lbc=100;
area=0.27;
p=1.78*1e-6;

//single core resistance of the section of 100m
    length
R=p*100*100/area;
Rab=R*Lab/100*2;
```

```
Rbc=R*Lbc/100*2;
Rcd=R*Lcd/100*2;

Icd=Id;
Ibc=Icd+Ic;
Iab=Ibc+Ib;

Vb=Va-Iab*Rab;
Vc=Vb-Ibc*Rbc;
Vd=Vc-Icd*Rcd;

printf("(i) CURRENTS IN VARIOUS SECTIONS: \n");
printf("I_AB = %.0f A \n", Iab);
printf("I_BC = %.0f A \n", Ibc);
printf("I_CD = %.0f A \n\n", Icd);

printf("(ii) Single core resistance of the section
    of 100m length = %.3f ohm \n", R);
printf("Resistance of section AB = %.3f ohm \n", Rab
    );
printf("Resistance of section BC = %.3f ohm \n", Rbc
    );
printf("Resistance of section CD = %.3f ohm \n\n",
    Rcd);


printf("(iii) Voltage at tapping point B = Vb = %.2f
    V \n", Vb);
printf("Voltage at tapping point C = Vc = %.2f V \n"
    , Vc);
printf("Voltage at tapping point D = Vd = %.2f V \n"
    , Vd);
```

Scilab code Exa 13.5 max voltage drop

```
//Chapter 13
//Example 13_5
//Page 317

clear;clc;

l=200;
i=2;
r_km=0.3;
x=150;

r=2*r_km/1000;
vd=i*r*(l*x-x^2/2);
I=i*l;
R=r*l;
tvd=1/2*I*R;

printf("Resistance of distributor per metre run = %.4f ohm \n\n", r);
printf("(i) Voltage drop upto %d m from feeding point = %.1f V \n\n", x, vd);
printf("(ii) Total current entering distributor = %d A \n\n", I);
printf("     Total resistance of distributor = %.2f ohm \n\n", R);
printf("     Maximum voltage drop = %d V \n\n", tvd);
```

Scilab code Exa 13.6 x section of distributor

```
//Chapter 13
```

```
//Example 13_6
//Page 317

clear;clc;

l=500;
i=0.4;
vd=10;
p=1.7*1e-6;

I=i*l;
r=vd/0.5/I/l;
area=p*100*2/r;

printf("Resistance per metre length of the
    distributor = %.2f*10^-3 ohm \n\n", r*1e3);
printf("Area of cross section of the distributor = %
    .1f cm^2 \n\n", area);
```

Scilab code Exa 13.7 voltage at feeding points

```
//Chapter 13
//Example 13_7
//Page 318

clear;clc;

l=250;
i=1.6;
r=0.0002;
v=250;

I=i*l;
```

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

Scilab code Exa 13.9 power loss in distributor

```
//Chapter 13
//Example 13_9
//Page 319

clear;clc;

x=200;
l=300;
i=0.75;
r=0.00018;
v=250;

```

```
vd=i*r*(l*x-x^2/2);
printf("Voltage drop = %.1f V \n\n", vd);
printf("Voltage at a distance %d m from supply end = %.1f V \n\n", x, v-vd);

p=i^2*r*l^3/3;
printf("Power loss in distributor = %.2f W \n\n", p);
```

Scilab code Exa 13.10 minimum consumer voltage

```
//Chapter 13
//Example 13_10
//Page 321

clear;clc;

Va=220;
Ic=20;
Id=40;
Ie=50;
If=30;
Vb=220;
Lac=100;
Lcd=150;
Lde=150;
Lef=100;
Lfb=100;
area=1;
p=1.7*1e-6;

//resistance for 100 m length of conductor
R=2*p*100/area;
```

```
Rac=R*Lac;
Rcd=R*Lcd;
Rde=R*Lde;
Ref=R*Lef;
Rfb=R*Lfb;

//considering drop across various sections of the
    distributor and adding them to calculate Ia
Ia=(Va-Vb+(Ic*Rcd)+(Ic+Id)*Rde+(Ic+Id+Ie)*Ref+(Ic+Id
    +Ie+If)*Rfb)/(Rac+Rcd+Rde+Ref+Rfb);

Ve=Va-(Ia*Rac+(Ia-Ic)*Rcd+(Ia-Ic-Id)*Rde);

printf("Resistance per 100 m of distributor = %.2f
    *10^-4 ohm \n\n", R*1e4);
printf("Resistance of section AC = %.3f ohm \n", Rac
    );
printf("Resistance of section CD = %.3f ohm \n", Rcd
    );
printf("Resistance of section DE = %.3f ohm \n", Rde
    );
printf("Resistance of section EF = %.3f ohm \n", Ref
    );
printf("Resistance of section FB = %.3f ohm \n\n",
    Rfb);

printf("Ia = %.1f A \n", Ia);

printf("Minimum consumer voltage = Ve = %.2f V \n",
    Ve);
```

Scilab code Exa 13.11 currents and voltages

```
//Chapter 13
//Example 13_11
//Page 322

clear;clc;

Va=230;
Ic=25;
Id=50;
Ie=30;
If=40;
Vb=235;
Lac=50;
Lcd=25;
Lde=25;
Lef=50;
Lfb=50;
r=0.3;
l=200;

//resistance for 1000 m length of conductor
R=2*r;

Rac=R*Lac/1000;
Rcd=R*Lcd/1000;
Rde=R*Lde/1000;
Ref=R*Lef/1000;
Rfb=R*Lfb/1000;

//considering drop across various sections of the
   distributor and adding them to calculate Ia
Ia=(Va-Vb+(Ic*Rcd)+(Ic+Id)*Rde+(Ic+Id+Ie)*Ref+(Ic+Id
   +Ie+If)*Rfb)/(Rac+Rcd+Rde+Ref+Rfb);

Iac=Ia;
Icd=Ia-Ic;
Ide=Ia-Ic-Id;
Ief=Ia-Ic-Id-Ie;
```

```
Ifb=Ia-Ic-Id-Ie-If;

Vd=Va-(Iac*Rac+Icd*Rcd);

printf("Resistance per 1000 m of distributor = %.2f
    ohm \n\n", R);
printf("Resistance of section AC = %.3f ohm \n", Rac
    );
printf("Resistance of section CD = %.3f ohm \n", Rcd
    );
printf("Resistance of section DE = %.3f ohm \n", Rde
    );
printf("Resistance of section EF = %.3f ohm \n", Ref
    );
printf("Resistance of section FB = %.3f ohm \n\n",
    Rfb);

printf("Ia = %.1f A \n\n", Ia);

printf("(i) Current in section AC = Iac = %.2f A \n"
    , Iac);
printf("    Current in section CD = Icd = %.2f A \n"
    , Icd);
printf("    Current in section DE = Ide = %.2f A \n"
    , Ide);
printf("    Current in section EF = Ief = %.2f A \n"
    , Ief);
printf("    Current in section FB = Ifb = %.2f A \n\
    n", Ifb);

printf("(ii) Voltage at D = Vd = %.2f V \n", Vd  );
```

Scilab code Exa 13.12 power loss in distributor2

```
//Chapter 13
//Example 13_12
//Page 323

clear;clc;

Va=440;
Ic=100;
Id=200;
Ie=250;
If=300;
Vb=430;
Lac=150;
Lcd=150;
Lde=50;
Lef=100;
Lfb=150;
r=0.01;
l=600;

//resistance for 100 m length of conductor
R=2*r;

Rac=R*Lac/100;
Rcd=R*Lcd/100;
Rde=R*Lde/100;
Ref=R*Lef/100;
Rfb=R*Lfb/100;

//considering drop across various sections of the
   distributor and adding them to calculate Ia
Ia=(Va-Vb+(Ic*Rcd)+(Ic+Id)*Rde+(Ic+Id+Ie)*Ref+(Ic+Id
   +Ie+If)*Rfb)/(Rac+Rcd+Rde+Ref+Rfb);

Iac=Ia;
Icd=Ia-Ic;
Ide=Ia-Ic-Id;
Ief=Ia-Ic-Id-Ie;
```

```
Ifb=Ia-Ic-Id-Ie-If;

Ib=abs(Ifb);

P=Iac^2*Rac+Icd^2*Rcd+Ide^2*Rde+Ief^2*Ref+Ifb^2*Rfb;

printf("Resistance per 100 m of distributor = %.2f
    ohm \n\n", R);
printf("Resistance of section AC = %.3f ohm \n", Rac
    );
printf("Resistance of section CD = %.3f ohm \n", Rcd
    );
printf("Resistance of section DE = %.3f ohm \n", Rde
    );
printf("Resistance of section EF = %.3f ohm \n", Ref
    );
printf("Resistance of section FB = %.3f ohm \n\n",
    Rfb);

printf("Ia = %.1f A \n\n", Ia);

printf("(i) Current supplied from end A = Ia = %.2f
    A \n", Ia);
printf("    Current supplied from end B = Ib = %.2f
    A \n\n", Ib);

printf("(ii) Power loss in the distributor = %.3f kW
     \n\n", P/1000);
```

Scilab code Exa 13.13 current supplied by stations

```
//Chapter 13
//Example 13_13
```

```
//Page 324

clear;clc;

l=6;
va=600;
vb=590;
i=300;
r=0.04;

x=3.425;
ia=341.7-50*x;
ib=i-ia;

printf("(i) x = %.3f km \n", x);
printf("(ii) Current suplied by A = %.2f A \n", ia);
printf("     Current suplied by B = %.2f A \n", ib);
```

Scilab code Exa 13.14 maximum voltage drop

```
//Chapter 13
//Example 13_14
//Page 327

clear;clc;

l=1000;
i=0.5;
r_km=0.05;
v=220;

r=2*r_km/1000;
I=i*l;
```

```
R=r*l;
vd=I*R/8;
maxv=v-vd;

printf("Resistance of distributor per metre = %.1f
    *10^-3 ohm \n\n", r*1e3);
printf("Total current supplied by distributor = %d A
    \n\n", I);
printf("Total resistance of the distributor = %.1f
    ohm \n\n", R);
printf("Maximum voltage drop = %.2f V \n\n", vd);
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

```
//Chapter 13
//Example 13_15
//Page 327

clear;clc;

l=500;
i=1;
Va=255;
Vb=250;
r_km=0.1;

r=2*r_km/1000;
x=(Va-Vb)/(i*r*l)+(l/2);
Vc=Va-i*r*x^2/2;
ia=i*x;
```

```
ib=i*(l-x);

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

Scilab code Exa 13.16 voltage calculations

```
//Chapter 13
//Example 13_16
//Page 328

clear;clc;

i=1.25;
//minimum voltage occurs at point C
Vc=220;
x=450;
r_km=0.05;
l=800;

r=2*r_km/1000;
Vac=i*r*x^2/2;
Va=Vc+Vac;
Vbc=i*r*(l-x)^2/2;
Vb=Vc+Vbc;

```

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

Scilab code Exa 13.17 max voltage drop 2

```
//Chapter 13
//Example 13_17
//Page 329

clear;clc;

l=1000;
i=1.25;
r_km=0.05;

r=2*r_km/1000;
I=i*l;
R=r*l;
vd=I*R/8;

//Part 1 is derivation of maximum voltage drop and
   is not included in the code. Only Part 2 is
   solved.

printf("(i) Total current supplied by distributor =
   %d A \n\n", I);
printf("Total resistance of the distributor = %.1f
```

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

Scilab code Exa 13.19 concentrated and uniform loads

```
//Chapter 13
//Example 13_19
//Page 330

clear;clc;

l=900;
Va=400;
Ic=50;
Id=100;
Ie=150;
Lac=200;
Lcd=300;
Lde=300;
Leb=100;
r=0.0001;
x=500;
i=0.5;

Rac=Lac*r;
Rcd=Lcd*r;
Rde=Lde*r;

Ide=Ie;
Icd=Ie+Id;
Iac=Ic+Icd;

Vac=Iac*Rac;
```

```
Vcd=Rcd*Icd;
Vde=Ide*Rde;

tdrop=Vac+Vcd+Vde;

Vab=i*r*l^2/2;
Vad=i*r*(l*x-x^2/2);

Vb=Va-(tdrop+Vab);
Vd=Va-(Vac+Vcd+Vad);

disp("DROPS DUE TO CONCENTRATED LOADS: ");
printf("Iac = %d A \n", Iac);
printf("Icd = %d A \n", Icd);
printf("Ide = %d A \n\n", Ide);

printf("Drop in section AC = %.2f V \n", Vac);
printf("Drop in section CD = %.2f V \n", Vcd);
printf("Drop in section DE = %.2f V \n", Vde);
printf("Total drop over AB = %.2f V \n\n\n", tdrop);

disp("DROPS DUE TO UNIFORM LOADING: ");
printf("Drop over AB = %.2f V \n", Vab);
printf("Drop over Ad = %.2f V \n\n", Vad);

printf("(i) Voltage at point B = %.2f V \n\n", Vb);
printf("(ii) Voltage at point D = %.2f V \n\n", Vd);
```

Scilab code Exa 13.20 loading

```
//Chapter 13
//Example 13_20
//Page 331
```

```
clear;clc;

l=1000;
r=0.1;
va=240;
vb=240;
i_load=0.5;
ic=120;
id=60;
ie=100;
i_f=40;
//solving for current
I=166;
printf("(i) I = %d A \n\n", I);
Ia=I+i_load*400;
Ib=154+i_load*(l-400);
printf("(ii) Current supplied by A = %d A \n", Ia);
printf("     Current supplied by B = %d A \n", Ib);
//drop due to concentrated loading
cld=I*200/10000+46*200/10000;
//drop due to distributed loading
dld=i_load*400^2/2/10000;
vd=va-cld-dld;
printf("Drop due to concentrated loading = %.2f V \n
   ", cld);
printf("Drop due to distributed loading = %.2f V \n"
   , dld);
printf("Vd = %.2f V \n", vd);
```

Scilab code Exa 13.21 point of min potential

```
//Chapter 13
```

```
//Example 13_21
//Page 332

clear;clc;

l=500;
v=240;
r=0.001;

x=50;
printf("(i) Point of minimum potential = %d A \n\n",
    x);
tc=160+200;
Ia=100+x;
Ib=360-150;
vd=v-150*(100*r)-x*(150*r);
printf("(ii)Total current = %d A \n", tc);
printf("Current supplied by A = %d A \n", Ia);
printf("Current supplied by B = %d A \n", Ib);
printf("Minimum potential = %.2f V \n", vd);
```

Scilab code Exa 13.22 ring distributor

```
//Chapter 13
//Example 13_22
//Page 334

clear;clc;

l=300;
va=240;
lab=150;
ib=120;
```

```
lbc=50;
ic=80;
lca=100;
r=0.03;

rd=2*r;
rab=rd*lab/100;
rbc=rd*lbc/100;
rca=rd*lca/100;

Ia=86.67;
Iab=Ia;
Ibc=Ia-ib;
Ica=Ia-(ib+ic);

Vb=va-Iab*rab;
Vc=Vb+Ibc*rbc;

printf("Resistance per 100m = %.2f ohms \n", rd);
printf("Rab = %.2f ohms \n", rab);
printf("Rbc = %.2f ohms \n", rbc);
printf("Rca = %.2f ohms \n\n", rca);

printf("(i) Ia = %.2f A \n", Ia);
printf("Iab = %.2f \n", Iab);
printf("Ibc = %.2f \n", Ibc);
printf("Ica = %.2f \n\n", Ica);

printf("(ii) Vb = %.2f V \n", Vb);
printf("     Vc = %.2f V \n", Vc)
```

Scilab code Exa 13.23 current tapping

```
//Chapter 13
//Example 13_23
//Page 335

clear;clc;

v=220;
ib=10;
ic=20;
id=30;
ie=10;
rab=0.1;
rbc=0.05;
rcd=0.01;
rde=0.025;
rea=0.075;

//by solving for current through the loop,
I=29.04;
printf("(i) I = %.2f A \n\n", I);

iab=I;
ibc=I-ib;
icd=I-(ib+ic);
ide=I-(ib+ic+id);
iea=I-(ib+ic+id+ie);
printf("Iab = %.2f A \n", iab);
printf("Ibc = %.2f A \n", ibc);
printf("Icd = %.2f A \n", icd);
printf("Ide = %.2f A \n", ide);
printf("Iea = %.2f A \n", iea);
```

Scilab code Exa 13.24 currents and voltages

```
//Chapter 13
//Example 13_24
//Page 336

clear;clc;

va=250;
rab=0.02;
rbc=0.018;
rcd=0.025;
rda=0.02;
ib=150;
ic=300;
id=250;
//interconnector resistance
icr=0.02;

I=(rbc*ib+rcd*(ib+ic)+rda*(ib+ic+id))/(rab+rbc+rcd+
   rda);
printf("I = %.2f A \n", I);

//from fig(ii)
vab=I*rab;
vbc=186.75*rbc;
vcd=113.25*rcd;
vda=363.25*rda;

vb=va-vab;
vc=vb-vbc;
vd=vc+vcd;

printf("Vab = %.3f V \n", vab);
printf("Vbc = %.3f V \n", vbc);
printf("Vcd = %.3f V \n", vcd);
printf("Vda = %.3f V \n\n", vda);

printf("Vb = %.3f V \n", vb);
printf("Vc = %.3f V \n", vc);
```

```
printf("Vd = %.3f V \n\n", vd);

printf("WITH INTERCONNECTOR: \n");
eo=va-vc;
ro=(rab+rbc)*(rab+rcd)/(rab+rbc+rab+rcd);
ith=eo/(ro+rab);
I1=(rbc*ib+rda*ith)/(rab+rbc);

dab=I1*rab;
dbc=53.15*rbc;
dad=244.45*rda;

pb=va-dab;
pc=pb-dbc;
pd=va-dad;

printf("Thevenin voltage = %.3f V \n", eo);
printf("Rac = %.2f ohms \n", ro);
printf("Current in interconnecter = %.2f A \n\n",
    ith);

printf("I1 = %.2f A \n", I1);
printf("Drop in AB = %.3f V \n", dab);
printf("Drop in BC = %.3f V \n", dbc);
printf("Drop in AD = %.3f V \n\n", dad);

printf("Potential of B = %.3f V \n", pb);
printf("Potential of C = %.3f V \n", pc);
printf("Potential of D = %.3f V \n\n", pd);
```

Scilab code Exa 13.25 interconnector paramenters

```
//Chapter 13
```

```
//Example 13_25
//Page 338

clear;clc;

I=10.65/0.26;
vbd=30.96*.025+.96*.01;
e0=.7836;
r0=(.075+.1+.05)*(.025+.01)/(.075+.1+.05+.025+.01);
ibd=e0/(r0+0.05);
vdrop=9.8*0.05;

printf("I = %.2f A \n", I);
printf("Voltage drop along BCD = %.4f V \n", vbd);
printf("Thevenin voltage E0 = %.4f V \n", e0);
printf("Ro = %.3f ohms \n", r0);
printf("(i) Current in interconnector = %.2f A \n",
    ibd);
printf("(ii) Voltage drop along interconnector = %.2
    f V \n", vdrop);
```

Scilab code Exa 13.26 voltage at loads

```
//Chapter 13
//Example 13_26
//Page 341

clear;clc;

I1=50;
I2=40;
r=0.1;
v=250;
```

```
Rae=0.1;
Rnl=0.2;
Rbg=0.1;

Vel=v-I1*Rae-(I1-I2)*Rnl;
Vlg=v+(I1-I2)*Rnl-I2*Rbg;

printf("Voltage at the load end on the +ve side = %d
    V \n\n", Vel);
printf("Voltage at the load end on the -ve side = %d
    V \n\n", Vlg);
```

Scilab code Exa 13.27 voltage at load end

```
//Chapter 13
//Example 13_27
//Page 342

clear;clc;

v1=240;
v2=240;
r1=5;
r2=6;
Rae=0.1;
Rnl=0.1;
Rbc=0.1;

I1=v1/r1;
I2=v2/r2;
In=I1-I2;

V1=v1+I1*Rae+In*Rnl;
```

```
V2=v2-In*Rnl+I2*Rbc;

printf("Current on +ve outer = %d A \n\n", I1);
printf("Current on -ve outer = %d A \n\n", I2);
printf("Current in nuetral = %d A \n\n", In);

printf("Voltage at the load end on the +ve side = %
    .2f V \n\n", V1);
printf("Voltage at the load end on the -ve side = %
    .2f V \n\n", V2);
```

Scilab code Exa 13.28 voltage calculations 2

```
//Chapter 13
//Example 13_28
//Page 343

clear;clc;

v1=250;
v2=250;
l1=35;
l2=20;

r1=v1^2/l1/1000;
r2=v2^2/l2/1000;

I=(v1+v2)/(r1+r2);
V1=I*r1;
V2=I*r2;

printf("Resistance of load on the +ve side = %.3f
    ohm \n\n", r1);
```

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

Scilab code Exa 13.29 voltage across various loads

```
//Chapter 13
//Example 13_29
//Page 344

clear;clc;

v1=250;
v2=250;

r=[0.015 0.01 0.006 0.014 0.02 0.02 0.024 0.02];
i=[50 30 30 6 14 10 36 60];

v=r.*i;

vck=v1-v(1)-v(5)+v(6);
vdm=vck-v(2)-v(3)+v(4);
vjg=v2-v(6)-v(8);
vlh=vjg+v(5)-v(4)-v(7);

printf("Voltage acorss load CK = %.2f V \n\n", vck);
printf("Voltage acorss load DM = %.2f V \n\n", vdm);
printf("Voltage acorss load JG = %.2f V \n\n", vjg);
printf("Voltage acorss load LH = %.2f V \n\n", vlh);
```

Scilab code Exa 13.30 voltage across various loads 3

```
//Chapter 13
//Example 13_30
//Page 344

clear;clc;

l=[200 160 240 100 60 100 100 340 160 100];
r=0.02;
R=r.*l/100;
i=[100 40 15 25 35 25 5 15 75 95];
v=R.*i;
v1=250;
v2=250;

vck=v1-v(1)-v(5)-v(7);
vdm=vck-v(2)-v(4)+v(5);
vjg=v2+v(7)-v(10);
vlh=vjg+v(6)-v(5)-v(9);
vpf=vlh+v(4)-v(3)-v(8);

printf("Voltage acorss load CK = %.2f V \n\n", vck);
printf("Voltage acorss load DM = %.2f V \n\n", vdm);
printf("Voltage acorss load JG = %.2f V \n\n", vjg);
printf("Voltage acorss load LH = %.2f V \n\n", vlh);
printf("Voltage acorss load PF = %.2f V \n\n", vpf);
```

Scilab code Exa 13.31 break in lines

```
//Chapter 13
//Example 13_31
//Page 345

clear;clc;

v1=240;
v2=240;
r1=4;
r2=6;
Rae=0.15;
Rnl=0.15;
Rbc=0.15;

i1=v1/r1;
i2=v2/r2;
in=i1-i2;

V1=v1+i1*Rae+in*Rnl;
V2=v2-in*Rnl+i2*Rbc;

printf("Current on +ve outer = %d A \n", i1);
printf("Current on -ve outer = %d A \n", i2);
printf("Current in nuetral = %d A \n\n", in);

printf("Voltage at the load end on the +ve side = %
    .2f V \n", V1);
printf("Voltage at the load end on the -ve side = %
    .2f V \n\n\n", V2);

disp("(i) WHEN NUETRAL BREAKS: ");
tr=r1+r2+Rae+Rbc;
i=(V1+V2)/tr;
vn1=i*r1;
vn2=i*r2;
printf("Total circuit resistance = %.1f ohm \n", tr)
```

```
;
printf("Load current = %.2f A \n", i);
printf("Voltage across %d ohm resistance = %.2f V \n", r1, vn1);
printf("Voltage across %d ohm resistance = %.2f V \n\n", r2, vn2);

disp("(ii) WHEN +VE OUTER BREAKS: ");
trd=r2+Rbc+Rnl;
id=V2/trd;
vd=id*r2;

printf("Total circuit resistance = %.1f ohm \n", trd);
printf("Load current = %.2f A \n", id);
printf("Voltage across %d ohm resistance = %.2f V \n\n", r2, vd);

disp("(iii) WHEN -VE OUTER BREAKS: ");
trdd=r1+Rae+Rnl;
idd=V1/trdd;
vdd=idd*r1;

printf("Total circuit resistance = %.1f ohm \n", trdd);
printf("Load current = %.2f A \n", idd);
printf("Voltage across %d ohm resistance = %.2f V \n\n", r1, vdd);
```

Scilab code Exa 13.32 current in two machines

```
//Chapter 13
//Example 13_32
```

```
//Page 348

clear;clc;

v1=250;
v2=250;
w1=1500;
w2=2000;

i1=w1*1000/v1;
i2=w2*1000/v2;
in=i1-i2;
w=w1+w2;
ig=w*1000/(v1+v2);
ia=ig-i1;
ib=i2-ig;

printf("Load current on +ve outer = %d A \n\n", i1);
printf("Load current on -ve outer = %d A \n\n", i2);
printf("Current in nuetral = %d A \n\n", in);
printf("Total load on main generator = %d W \n\n", w
   );
printf("Current supplied by main generator = %d A \n
   \n", ig);
printf("Current in machine A = %d A \n\n", ia);
printf("Current in machine B = %d A \n\n", ib);
```

Scilab code Exa 13.33 current and load calculations

```
//Chapter 13
//Example 13_33
//Page 349

```

```
clear;clc;

v1=250;
v2=250;
w1=150;
w2=100;
loss=3;

tl=w1+w2+loss*2;
i1=w1*1000/v1;
i2=w2*1000/v2;
in=i1-i2;
w=w1+w2;
ig=tl*1000/(v1+v2);
ia=i1-ig;
ib=ig-i2;
la=ia*v1/1000;
lb=ib*v2/1000;

printf("(i) Total load on main generator = %d kW \n\n", tl);

printf("(ii) Current supplied by main generator = %d A \n\n", ig);
printf("\t Load current on +ve outer = %d A \n\n", i1);
printf("\t Load current on -ve outer = %d A \n\n", i2);
printf("\t Current in nuetral = %d A \n\n", in);
printf("\t Current in machine A = %d A \n\n", ia);
printf("\t Current in machine B = %d A \n\n", ib);
printf("\t Load on machine A = %d kW \n\n", la);
printf("\t Load on machine B = %d kW \n\n", lb);
```

Scilab code Exa 13.34 current and load calculations 2

```
//Chapter 13
//Example 13_34
//Page 350

clear;clc;

v1=250;
v2=250;
i1=1200;
i2=1000;
l=200;
loss1=5;
loss2=5;

p1=v1*i1/1000;
p2=v2*i2/1000;
p3=l;

tl=p1+p2+p3+loss1+loss2;
ig=tl*1000/(v1+v2);
in=i1-i2;
i3=p3/(v1+v2)*1000;
ia=i1+i3-ig;
ib=ig-i2-i3;
la=ia*v1/1000;
lb=ib*v2/1000;

printf("Load on positive side = %d kW \n\n", p1);
printf("Load on negative side = %d kW \n\n", p2);
printf("Load on outers = %d kW \n\n", p3);

printf("(i) Total load on main generator = %d W \n\n
    ", tl);
printf("    Current supplied by main generator = %d
    A \n\n", ig);

```

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

Scilab code Exa 13.35 load on main generator

```
//Chapter 13
//Example 13_35
//Page 350

clear;clc;

v=500;
ip=800;
in=550;
io=1500;
ra=0.2;
//no load current
inl=5;

tip=io+ip;
tin=io+in;
cn=ip-in;
printf("Total current on positive side = %d A \n", tip);
printf("Total current on negative side = %d A \n", tin);
printf("Current in nuetral wire = %d A \n\n", cn);

e=v/2-ra*5;
printf("(i)BAck emf = %d V \n", e);
```

```
ib=130;
ia=120;
printf("Ib = %d A \n", ib);
printf("Ia = %d A \n\n", ia);

va=199+ra*ib;
vb=249+ra*ib;
printf("(ii) Voltage across machine A = %d V \n", va);
printf("      Voltage across machine B = %d V \n\n", vb);
l=tip-ia;
printf("(iii) Load on main generator = %d A \n", l);
```

Scilab code Exa 13.36 output of booster

```
//Chapter 13
//Example 13_36
//Page 352

clear;clc;

v=500;
l=3;
i=120;
r=0.5;

tr=r*l;
vd=tr*i;
tv=vd;
op=i*tv/1000;

printf("Total resistance of line = %.1f ohm \n\n",
```

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

Chapter 14

A C distribution

Scilab code Exa 14.1 voltage drop in distributor

```
//Chapter 14
//Example 14_1
//Page 359

clear;clc;

l=300;
i1=100;
i2=200;
l1=200;
pf1=0.707;
pf2=0.8;
r=0.2;
x=0.1;

l2=l-l1;
z=r+%i*x;
Zac=z*l1/1000;
Zcb=z*l2/1000;
I2=i2*(pf2-%i*sin(acos(pf2)));
I1=i1*(pf1-%i*sin(acos(pf1)));
```

```
Icb=I2;
Iac=I1+I2;
Vcb=Icb*Zcb;
Vac=Iac*Zac;
vd=Vac+Vcb;

printf("Impedance of distributor/km = %.2f+j(%.2f)
   ohm \n\n", real(z), imag(z));

printf("Impedance of section AC = Zac = %.2f+j(%.2f)
    ohm \n", real(Zac), imag(Zac));
printf("Impedance of section CB = Zcb = %.2f+j(%.2f)
    ohm \n\n", real(Zcb), imag(Zcb));

printf("Load current at point B = %.2f+j(%.2f) A \n"
   , real(I2), imag(I2));
printf("Load current at point C = %.2f+j(%.2f) A \n\
   n", real(I1), imag(I1));
printf("Current in section CB = %.2f+j(%.2f) A \n",
   real(Icb), imag(Icb));
printf("Current in section AC = %.2f+j(%.2f) A \n\n"
   , real(Iac), imag(Iac));
printf("Voltage drop in section CB = %.2f+j(%.2f) A
   \n", real(Vcb), imag(Vcb));
printf("Voltage drop in section AC = %.2f+j(%.2f) A
   \n\n", real(Vac), imag(Vac));
printf("Voltage drop in the distributor = %.2f+j(%.2
   f) A \n\n", real(vd), imag(vd));
printf("Magnitude of drop = %.2f V \n\n", abs(vd));
```

Scilab code Exa 14.2 phase difference and Vs

```
//Chapter 14
```

```
//Example 14_2
//Page 359

clear;clc;

l=2000;
i1=80;
pf1=0.9;
i2=120;
pf2=0.8;
r=0.05;
x=0.1;
Vb=230+%i*0;
l1=1000;
l2=l-l1;

z=r+%i*x;
Zac=z*l1/1000;
Zcb=z*l2/1000;

printf("Impedance of distributor/km = %.2f+j(%.2f)
    ohm \n\n", real(z), imag(z));

printf("Impedance of section AC = Zac = %.2f+j(%.2f)
     ohm \n", real(Zac), imag(Zac));
printf("Impedance of section CB = Zcb = %.2f+j(%.2f)
     ohm \n\n\n", real(Zcb), imag(Zcb));

I2=i2*(pf2-%i*sin(acos(pf2)));
I1=i1*(pf1-%i*sin(acos(pf1)));

printf("(i)Load current at point B = %.2f+j(%.2f) A
    \n", real(I2), imag(I2));
printf("Load current at point C = %.2f+j(%.2f) A \n\
    n", real(I1), imag(I1));

Icb=I2;
Iac=I1+I2;
```

```
Vcb=Icb*Zcb;
Vac=Iac*Zac;

printf("Current in section CB = %.2f+j(%.2f) A \n",
   real(Icb), imag(Icb));
printf("Current in section AC = %.2f+j(%.2f) A \n\n"
   , real(Iac), imag(Iac));

printf("Voltage drop in section CB = %.2f+j(%.2f) A
   \n", real(Vcb), imag(Vcb));
printf("Voltage drop in section AC = %.2f+j(%.2f) A
   \n\n", real(Vac), imag(Vac));

Va=Vb+Vcb+Vac;
printf("Sending end voltage = %.2f+j(%.2f) \n", real
   (Va), imag(Va));
printf("Magnitude of sending end voltage = %.2f V \n
   \n\n", abs(Va));

pd=atan(imag(Va)/abs(Va));
printf("(ii)The phase difference between Va and Vb =
    %.2f degrees \n\n", pd*180/%pi);
```

Scilab code Exa 14.3 phase difference

```
//Chapter 14
//Example 14_3
//Page 360

clear;clc;

r=0.1;
```

```
x=0.15;
Vb=200+%i*0;
i1=100;
pf2=0.8;
i2=100;
pf1=0.6;

z=r*2+%i*x*2;
Zam=z/2;
Zmb=z/2;

printf("Impedance of distributor/km = %.2f+j(%.2f)
  ohm \n\n", real(z), imag(z));

printf("Impedance of section AC = Zac = %.2f+j(%.2f)
   ohm \n", real(Zam), imag(Zam));
printf("Impedance of section CB = Zcb = %.2f+j(%.2f)
   ohm \n\n\n", real(Zmb), imag(Zmb));

//part 1
I2=i2*(pf2-%i*sin(acos(pf2)));
printf("(i)Load current at point B = %.2f+j(%.2f) A
  \n", real(I2), imag(I2));
Imb=I2;
printf("Current in section MB = %.2f+j(%.2f) A \n",
  real(Imb), imag(Imb));
Vmb=Imb*Zmb;
printf("Voltage drop in section MB = %.2f+j(%.2f) A
  \n", real(Vmb), imag(Vmb));
Vm=Vb+Vmb;
printf("Voltage at point M = %.2f+j(%.2f) \n", real(
  Vm), imag(Vm));
printf("Magnitude of Vm = %.2f V \n", abs(Vm));
alpha=atan(imag(Vm)/abs(Vm));
printf("Phase angle between Vm and Vb = %.2f degrees
   \n\n\n", alpha*180/%pi);

//part 2
```

```
phi1=acos(pf1)-alpha;
printf("Phase angle between I1 and Vb = %.2f degrees \n", phi1*180/%pi);
I1=i1*(cos(phi1)-%i*sin(phi1));
printf("(ii)Load current at point M = %.2f+j(%.2f) A \n", real(I1), imag(I1));
Iam=I1+I2;
printf("Current in section AM = %.2f+j(%.2f) A \n", real(Iam), imag(Iam));
Vam=Iam*Zam;
printf("Voltage drop in section AM = %.2f+j(%.2f) A \n", real(Vam), imag(Vam));


Va=Vm+Vam;
printf("Sending end voltage = %.2f+j(%.2f) \n", real(Va), imag(Va));
printf("Magnitude of sending end voltage = %.2f V \n\n\n", abs(Va));

pd=atan(imag(Va)/abs(Va));
printf("(iii)The phase difference between Va and Vb = %.2f degrees \n\n", pd*180/%pi);
```

Scilab code Exa 14.4 thevenins theorem

```
//Chapter 14
//Example 14_4
//Page 362

clear;clc;

Ib=20;
```

```
Ic=15;
pfb=0.8;
pfc=0.6;
zab=1+%i*1;
zac=1+%i*3;
zbc=1+%i*2;

Iab=Ib*(pfb-%i*sin(acos(pfb)));
Iac=Ic*(pfc-%i*sin(acos(pfc)));
Vab=Iab*zab;
Vac=Iac*zac;

Eo=Vac-Vab;
Zo=zab+zac;
Ibc=Eo/(Zo+zbc);
Iabs=Iab-Ibc;
Iacs=Iac-Ibc;
Ia=Iab+Iac;

printf("Current in section AB = %.2f+j(%.2f) \n",
   real(Iab), imag(Iab));
printf("Current in section AC = %.2f+j(%.2f) \n",
   real(Iac), imag(Iac));
printf("Voltage drop in section AB = %.2f+j(%.2f) \n
   ", real(Vab), imag(Vab));
printf("Voltage drop in section AC = %.2f+j(%.2f) \n
   ", real(Vac), imag(Vac));
printf("Thevenins equivalent circuit emf Eo = %.2f+(
   %.2f) \n", real(Eo), imag(Eo));
printf("Thevenins equivalent impedance Zo = %.2f+(%
   .2f) \n", real(Zo), imag(Zo));
printf("Current in BC = %.2f+j(%.2f) \n", real(Ibc),
    imag(Ibc));
printf("Current in AB = %.2f+j(%.2f) \n", real(Iabs)
   , imag(Iabs));
printf("Current in AC = %.2f+j(%.2f) \n", real(Iacs)
   , imag(Iacs));
printf("Current fed at A = %.2f+j(%.2f) \n", real(Ia
```

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

Scilab code Exa 14.5 line voltage at sending end

```
//Chapter 14
//Example 14_5
//Page 363

clear;clc;

i1=5;
i2=14.08;
pf1=0.8;
pf2=0.85;
l1=600;
l2=400;
hp=10;
n=0.90;
vb=400;
r=1;
x=0.5;

z=r+%i*x;
Zac=z*l1/1000;
Zcb=z*l2/1000;

printf("Impedance of distributor/km = %.2f+j(%.2f)
   ohm \n\n", real(z), imag(z));

printf("Impedance of section AC = Zac = %.2f+j(%.2f)
    ohm \n", real(Zac), imag(Zac));
printf("Impedance of section CB = Zcb = %.2f+j(%.2f)
    ohm \n\n\n", real(Zcb), imag(Zcb));
```

```

Vb=vb/sqrt(3)+%i*0;
printf("Voltage at point B taken as the reference vector = %.0f+j%.0f \n", real(Vb), imag(Vb));
Ib=hp*746/sqrt(3)/vb/n/pf2;
I2=i2*(pf2-%i*sin(acos(pf2)));
I1=i1*(pf1-%i*sin(acos(pf1)));
Iac=I2+I1;
Icb=I2;
Vcb=Icb*Zcb;
Vac=Iac*Zac;
Va=Vb+Vcb+Vac;

printf("Line current at B = %.2f A \n\n", Ib);

printf("Load current at point B = %.2f+j(%.2f) A \n", real(I2), imag(I2));
printf("Load current at point C = %.2f+j(%.2f) A \n\n", real(I1), imag(I1));

printf("Current in section CB = %.2f+j(%.2f) A \n", real(Icb), imag(Icb));
printf("Current in section AC = %.2f+j(%.2f) A \n\n", real(Iac), imag(Iac));

printf("Voltage drop in section CB = %.2f+j(%.2f) A \n", real(Vcb), imag(Vcb));
printf("Voltage drop in section AC = %.2f+j(%.2f) A \n\n", real(Vac), imag(Vac));

printf("Voltage at A/phase = %.2f+j(%.2f) A \n\n", real(Va), imag(Va));
printf("Magnitude of Va/phase = %.2f V \n\n", abs(Va));
printf("Line voltage at A = %.2f V \n\n", abs(Va)*sqrt(3));
```

Scilab code Exa 14.6 station voltages

```
//Chapter 14
//Example 14_6
//Page 365

x=139.7;
y=-42.8;

iab=x+%i*(y);
ibc=(x-40)+%i*(y+30);
icd=(x-160)+%i*(y+30);
ida=(x-220.6)+%i*(y+65);
va=11000/sqrt(3);
vb=va-(iab)*(1+%i*0.6);
vc=vb-(ibc)*(1.2+%i*0.9);
vd=vc-(icd)*(0.8+%i*0.5);

printf("Current in section AB = %.2f+j(%.2f) A \n",
    real(iab), imag(iab));

printf("Current in section BC = %.2f+j(%.2f) A \n",
    real(ibc), imag(ibc));

printf("Current in section CD = %.2f+j(%.2f) A \n",
    real(icd), imag(icd));

printf("Current in section DA = %.2f+j(%.2f) A \n\n"
    , real(ida), imag(ida));

printf("Voltage at supply end = %d V/phase \n", va);

```

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

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

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

Scilab code Exa 14.7 current in nuetral

```
//Chapter 14
//Example 14_7
//Page 368

clear;clc;

lr=10*1e3;
ly=8*1e3;
lb=5*1e3;
v=400;

ph_v=v/sqrt(3);
ir=lr/ph_v;
iy=ly/ph_v;
ib=lb/ph_v;

hc=iy*cos(30*%pi/180)-ib*cos(30*%pi/180);
vc=ir-iy*cos(60*%pi/180)-ib*cos(60*%pi/180);
in=sqrt(hc^2+vc^2);

printf("(i) Phase voltage = %.2f V \n", ph_v);
printf("\t Ir = %.1f A \n", ir);
```

```
printf("\t Iy = %.1f A \n", iy);
printf("\t Ib = %.1f A \n", ib);

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");
printf("\t Resultant horizontal component = %.1f A \
    n", hc);
printf("\t Resultant vertical component = %.1f A \n"
    , vc);
printf("\t Current in nuetral wire = %.1f A \n", in)
    ;
```

Scilab code Exa 14.8 lamp and motor load

```
//Chapter 14
//Example 14_8
//Page 369

clear;clc;

v=400;
vl=230;
ia=70;
ib=84;
ic=33;
im=200;
pf=0.2;

//part 1
printf("LAMP LOAD ALONE: \n");

```

```
//Refering to the phasor diagram in the book
hc=ib*cos(30*%pi/180)-ic*cos(30*%pi/180);
vc=ia-ib*cos(60*%pi/180)-ic*cos(60*%pi/180);
in=sqrt(hc^2+vc^2);

printf("Resultant horizontal component = %.2f A \n", hc);
printf("Resultant vertical component = %.2f A \n", vc);
printf("Neutral component = %.2f A \n\n", in);

//part 2
printf("BOTH LAMP AND MOTOR LOAD: \n");

ac=im*pf;
rc=im*sin(acos(pf));
Ir=sqrt((ac+ia)^2+rc^2);
Iy=sqrt((ac+ib)^2+rc^2);
Ib=sqrt((ac+ic)^2+rc^2);

printf("Nuetral current remains the same, ie In = %.2f A \n", in);
printf("Active component of motor current = %.0f A \n", ac);
printf("Reactive component of motor current = %.0f A \n", rc);
printf("\t Ir = %.2f A \n", Ir);
printf("\t Iy = %.2f A \n", Iy);
printf("\t Ib = %.2f A \n\n", Ib);

//part 3
printf("POWER SUPPLIED: \n");

pl=vl*(ia+ib+ic);
pm=sqrt(3)*v*im*pf;

printf("Power supplied to lamps = %.0f W \n", pl);
printf("Power supplied to motor = %.0f W \n", pm);
```

Scilab code Exa 14.9 component currents

```
//Chapter 14
//Example 14_9
//Page 370

clear;clc;

v=400;
ph_v=230;
lr=20*1e3;
ly=28.75*1e3;
lb=28.75*1e3;

ir=lr/ph_v;
iy=ly/ph_v;
ib=lb/ph_v;

//referring to the phasor diagram in the text book
xc=ir-iy*cos(30*%pi/180)-ib*cos(30*%pi/180);
yc=iy*cos(60*%pi/180)-ib*cos(60*%pi/180);
in=sqrt(xc^2+yc^2);

printf("\t Ir = %.1f A \n", ir);
printf("\t Iy = %.1f A \n", iy);
printf("\t Ib = %.1f A \n\n", ib);

printf("\t Resultant X-component = %.1f A \n", xc);
printf("\t Resultant Y-component = %.1f A \n", yc);
printf("\t Current in nuetral wire = %.1f A \n\n",
    in);

```

```
printf("WHEN LOAD FROM B TO N IS REMOVED: \n");
printf("\t Ir = %.2f A in phase with Vrn \n", ir);
printf("\t Iy = %.2f A lagging Vyn by 30 degrees \n"
    , iy);
printf("\t Ib = 0 A \n\n");

ac=ir-iy*cos(30*%pi/180);
rc=0-iy*sin(30*%pi/180);
nc=sqrt(ac^2+rc^2)

printf("Resultant X-component = %.2f A \n", ac);
printf("Resultant Y-component = %.2f A \n", rc);
printf("Nuetral current = %.2f A \n\n", nc);
```

Scilab code Exa 14.10 phase voltage calculation

```
//Chapter 14
//Example 14_10
//Page 371

clear;clc;

v=400;
ph_v=230;
r=0.2;
i=30;
pfr=-0.866;
pfy=0.866;
pfb=1;
ar=0;
ay=-120;
ab=120;

```

```
//referring to the phasor diagram given in the text book
air=-30;
aiy=-90;
aib=120;
vr=ph_v*(cos(0)-%i*sin(0));
vy=ph_v*(cos(-120*%pi/180)-%i*sin(-120*%pi/180));
vb=ph_v*(cos(120*%pi/180)-%i*sin(120*%pi/180));

ir=i*(cos(-30*%pi/180)+%i*sin(-30*%pi/180));
iy=i*(cos(-90*%pi/180)+%i*sin(-90*%pi/180));
ib=i*(cos(120*%pi/180)+%i*sin(120*%pi/180));


in=ir+iy+ib;

er=vr+r*ir+2*r*in;

printf("Vr = %.0f/_%.0f \n", ph_v, ar);
printf("Vy = %.0f/_%.0f \n", ph_v, ay);
printf("Vb = %.0f/_%.0f \n\n", ph_v, ab);

printf("Ir = %.0f/_%.0f \n", i, air);
printf("Iy = %.0f/_%.0f \n", i, aiy);
printf("Ib = %.0f/_%.0f \n\n", i, aib);

printf("Nuetral current = %.2f+j(%.2f) \n\n", real(in), imag(in));
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

```
//Chapter 14
//Example 14_11
//Page 372

clear;clc;

v=400;
ph_v=230;
w1=100;
w2=150;

r1=ph_v^2/w1;
r2=ph_v^2/w2;

i=v/(r1+r2);
v1=i*r1;
v2=i*r2;

printf("Resistance of lamp L1 = R1 = %.2f ohm \n\n",
    r1);
printf("Resistance of lamp L2 = R2 = %.2f ohm \n\n",
    r2);
printf("Curretn through lamps = %.3f A \n\n", i);
printf("Voltage across lamp L1 = V1 = %.0f V \n\n",
   v1);
printf("Voltage across lamp L2 = V2 = %.0f V \n\n",
   v2);
```

Chapter 15

Voltage Control

Scilab code Exa 15.1 Vs per phase

```
//Chapter 15
//Example 15_1
//Page 384

clear;clc;

kw=10000;
pf=0.8;
v=33;
r=5;
x=10;

i2=kw*1000/sqrt(3)/v/1000/pf;
ip=i2*pf;
iq=i2*sind(acosd(pf));
v1=v*1000/sqrt(3);
im=231;
capacity=3*v1*im/1000;

printf("Load current = %d A \n", i2);
printf("Ip = %.2f A \n", ip);
```

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

Scilab code Exa 15.2 sunchronous condensor capacity

```
//Chapter 15
//Example 15_2
//Page 385

clear;clc;

kw=25000;
pf=0.8;
v=33;
r=5;
x=20;

i2=kw*1000/sqrt(3)/v/1000/pf;
ip=i2*pf;
iq=i2*sind(acosd(pf));
v1=v*1000/sqrt(3);
im=579.5;
capacity=3*v1*im/10^6;

printf("Load current = %d A \n", i2);
printf("Ip = %.2f A \n", ip);
printf("Iq = %.2f A \n", iq);
printf("Sending end voltage per phase = %d V \n", v1
    );
```

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

Chapter 17

Symmetrical Fault Calculations

Scilab code Exa 17.1 short circuit current

```
//Chapter 17
//Page 402
//Example 17_1

clear;clc;

kva=[15000 20000];
x=[30 50];
vl=12000;

base=input("Enter base kVA:     ");

for i=1:2;
  per_x(i)=base*x(i)/kva(i);
  printf("%% Reactance of alternator %i is = %.2f %%
      \n\n", i,     per_x(i));
end;

i=base*1000/sqrt(3)/vl;
printf("Line current = %.0f A \n\n", i);

```

```
tx=per_x(1)*per_x(2)/(per_x(1)+per_x(2));
printf("Total percentage reactance from generator
    nuetral upto fault point = %.2f %% \n\n", tx);

isc=i*100/tx;
printf("Short circuit current = %.0f A \n\n", isc);
```

Scilab code Exa 17.2 percentage reactance

```
//Chapter 17
//Example 17_2
//Page 404

clear;clc;

mva=20*1e6;
kv=10*1e3;
x=5;
sc=8;

i=mva/sqrt(3)/kv;
vph=kv/sqrt(3);
tperx=(1/sc)*100;
ext=tperx-x;
perx=ext*vph/100/i;

printf("Full load current = %.2f A \n\n", i);
printf("Voltage per phase = %.2f V \n\n", vph);
printf("Total percentage reactance required = %.2f
    %% \n\n", tperx);
printf("External percentage reactance required = %.2
    f %% \n\n", ext);
printf("Percentage reactance = %.2f ohm \n\n", perx)
```

;

Scilab code Exa 17.3 short circuit kva 1

```
//Chapter 17
//Example 17_3
//Page 404

clear;clc;

kv=10;
r=1;
x=4;
mvaa=10;
mvat=5;
xt=5;
mvabb=10;
xa=10;

base=input("Enter base kVA:  ");

per_xa=base*xa/(mvaa*1000);
per_xt=base*xt/(mvat*1000);

per_xl=x*mvabb*1000/10/kv^2;
per_rl=r*mvabb*1000/10/kv^2;

tx=per_xa+per_xt+per_xl;
tr=per_rl;
per_z=sqrt(tr^2+tx^2);
sckva1=mvabb*1000*100/per_z;

txgf=per_xa+per_xt;
```

```
sckva2=mvaa*1000*100/txgf;

printf("%% reactance of alternator = %.2f %% \n\n",
   per_xa);
printf("%% reactance of transformer = %.2f %% \n\n",
    per_xt);
printf("%% reactance of transmission line = %.2f %%
   \n\n", per_xl);
printf("%% resistance of transmission line = %.2f %%
    \n\n", per_rl);

printf("(i) Total %% reactance = %.2f %% \n\n", tx);
printf("    Total %% resistance = %.2f %% \n\n", tr)
   ;
printf("    %% impedance from generator nuetral upto
    fault point = %.2f %% \n\n", per_z);
printf("    Short circuit kva = %.0f kVA \n\n",
   sckva1);

printf("(ii) %% impedance from generator nuetral
   upto fault point = %.2f %% \n\n", txgf);
printf("     Short circuit kva = %.0f kVA \n\n",
   sckva2);
```

Scilab code Exa 17.4 fault mva calculations

```
//Chapter 17
//Example 17_4
//Page 405

clear;clc;

kva=[10000 10000 5000];
```

```
x=[12 12 18];
kva_tr=5000;
x_tr=5;

base=input("Enter base kva:   ");

for i=1:3;
  per_x(i)= x(i)*base/kva(i);
  printf("%% x(%i) = %.0f \n\n", i, per_x(i));
end
per_xt=x_tr*base/kva_tr;
printf("%% Xt = %.0f \n\n", per_xt);

tx1=1/(1/per_x(1)+1/per_x(2)+1/per_x(3));
fmva1=base*100/tx1*1/1000;
tx2=tx1+per_xt;
fmva2=base*100/tx2*1/1000;

printf("(i) Total percentage reactance from
    generator to fault F1 = %.2f %% \n\n", tx1);
printf("    Fault MVA = %.2f \n\n", fmva1);

printf("(ii) Total percentage reactance from
    generator to fault to F2 = %.2f %% \n\n", tx2);
printf("     Fault MVA = %.2f \n\n", fmva2);
```

Scilab code Exa 17.5 fault mva calculations 2

```
//Chapter 17
//Example 17_5
//Page 407

clear;clc;
```

```

kva=[10000 10000 8000 8000];
x=[10 10 12 12];
kva_bb=5000;
x_bb=10;

base=input("Enter base kva:   ");

for i=1:4;
  per_x(i)= x(i)*base/kva(i);
  printf("%% reactance of generator %i = %.0f \n\n", i, per_x(i));
end
per_bb=x_bb*base/kva_bb;
printf("%% reactance of bus bar = %.0f \n\n", per_bb);

xa=per_x(1)*per_x(2)/(per_x(1)+per_x(2));
xb=per_x(3)*per_x(4)/(per_x(3)+per_x(4));

xf=xa+per_bb;
tx=xf*xb/(xf+xb);

printf("Total %% reactance from generator nuetral to fult point is = %.2f %% \n\n", tx);

fmva=base*100/tx/1000;
printf("Fault MVA = %.2f \n\n", fmva);
```

Scilab code Exa 17.6 reactance

```
//Chapter 17
//Example 17_6
```

```
//Page 408

clear;clc;

kva1=3000;
kva2=4500;
x1=7;
x2=8;
rc=150*1e6/1000;
kvatr=7500;
xt=7.5;
bv=3300;

base=7500;
printf("Let base kVA be 7500 kVA \n");
per_x1=x1*base/kva1;
per_x2=x2*base/kva2;
per_xt=xt*base/kvatr;

r_ab=per_x1*per_x2/(per_x1+per_x2);
c=base*100/r_ab/rc;
per_x=abs((c*(r_ab+per_xt)-per_xt)/(c-1));
x=per_x*10*(bv/1000)^2/base;

printf("%% reactance of generator A = %.2f %% \n\n",
    per_x1);
printf("%% reactance of generator B = %.2f %% \n\n",
    per_x2);
printf("%% reactance of transformer = %.2f %% \n\n",
    per_xt);
printf("%% reactance of the bus bar = %.2f %% \n\n",
    per_x);
printf("%% reactance in ohms = %.3f ohms \n\n", x);
```

Scilab code Exa 17.7 short circuit mva

```
//Chapter 17
//Example 17_7
//Page 409

clear;clc;

mva1=1500;
mva2=1200;
v=33;
x=1;

base=input("Base MVA:  ");
per_x1=base*100/mva1;
per_x2=base*100/mva2;
printf("%% reactance of station A = %.2f %% \n\n",
    per_x1);
printf("%% reactance of station B = %.2f %% \n\n",
    per_x2);

per_xt=base*1000*x/10/v^2;
printf("%% reactance of interconnector = %.2f %% \n\
    n", per_xt);

x1=per_x1+per_xt;
tx1=x1*per_x2/(x1+per_x2);
scmva1=base*100/tx1;

x2=per_x2+per_xt;
tx2=x2*per_x1/(x2+per_x1);
scmva2=base*100/tx2;

printf("FAULT ON STATION A: \n\n");
printf("Total %% reactance upto fault point F2 = %.2
    f %% \n\n", tx2);
printf("Short circuit MVA = %.2f \n\n", scmva2);

```

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

Scilab code Exa 17.8 steady state input

```
//Chapter 17
//Example 17_8
//Page 410

clear;clc;

kva=5000;
x=12;
r=6;

base=input("Input base kva:   ");

perx=base*x/kva;
printf("With reactors: \n");
x1=(perx+r)/2+r;
tx1=x1*x/(x1+x);
sci1=base*100/tx1;
printf("Total %% reactance from generator to fault =
     %.2f %% \n", tx1);
printf("Short circuit input = %.3f MVA \n\n", sci1
    /1000);

printf("Without reactors: \n");
tx2=x/3;
sci2=base*100/tx2;
printf("Total %% reactance from generator to fault =
```

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

Scilab code Exa 17.9 short circuit mva 2

```
//Chapter 17
//Example 17_9
//Page 411

clear;clc;

gmva=10;
gx=30;
rmva=10;
rx=10;
tmva=5;
tx=5;

base=input("Enter base MVA: ");

pergx=base*gx/gmva;
printf("%% reactance of each generator = %.0f %% \n\
    n", pergx);

perrx=base*rx/rmva;
printf("%% reactance of each generator = %.0f %% \n\
    n", perrx);

pertx=base*tx/tmva;
printf("%% reactance of each generator = %.0f %% \n\
    n", pertx);

```

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

Scilab code Exa 17.10 sc kVA

```
//Chapter 17
//Example 17_10
//Page 412

clear;clc;

q=50000;
x=20;
b=10;
n1=3;
n2=9;

//from the derivation
sckva1=(q/x+q*(n1-1)/(b*n1+x))*100;
sckva2=(q/x+q*(n2-1)/(b*n2+x))*100;
//When n is very large
sckva3=(q/x+q/b)*100;

printf("(i) Short circuit kVA with %d sections = %d
    kVA \n\n", n1, sckva1);
printf("(ii) Short circuit kVA with %d sections = %d
    kVA \n\n", n2, sckva2);
printf("(iii) Short circuit kVA when n is very large
    = %d kVA \n\n", sckva3);
```

Scilab code Exa 17.11 reactor reactance

```
//Chapter 17
//Example 17_11
//Page 414

clear;clc;

v=33;
pmva=10;
qmva=50;
xp=20;
xq=10;
rc=500;
base=50;

per_xg=base/pmva*xp;
per_xt=base/qmva*xq;
printf("%% reactance of each generator = %d %% \n", per_xg);
printf("%% reactance of transformer = %d %% \n", per_xt);

per_x=base*100/rc;
printf("Required %% reactance = %d %% \n", per_x);
x=100/15;
rr=x*10*v^2/base/1000;
printf("Reactance of reactor = %.3f ohms \n\n", rr);
```

Scilab code Exa 17.12 reactance of reactor

```
//Chapter 17
//Example 17_12
//Page 415

clear;clc;

ml=5000;
v=6600;
x=6;
m=5;

base=input("Base kVA: ");
x=base*100/m/ml-6;
xohm=x*10*(v/1000)^2/ml;

printf("%% reactance of the reactor = %.2f %% \n\n",
    x);
printf("Reactance in ohms = %.2f \n\n", xohm);
```

Scilab code Exa 17.13 fault mva calculations 3

```
//Chapter 17
//Example 17_13
//Page 416

clear;clc;
```

```
mva=[15 15 8];
x=[12 12 10];
mvat=5;
xt=4;
mvar=10;
xr=15;

base=input("Enter base mva: ");
for i=1:3
perx(i)=base*x(i)/mva(i);
printf("%% X(%i) = %.2f %% \n\n", i, perx(i));
end;
perxt=base*xt/mvat;
perxr=base*xr/mvar;
printf("%% Xt = %.2f %% \n\n", perxt);
printf("%% Xr = %.2f %% \n\n", perxr);

xabt=perx(1)/2+perxt;
xcr=perx(3)+perxr;
tx=xabt*xcr/(xabt+xcr);
f=base*100/tx;

printf("Total %% reactance = %.2f %% \n\n", tx);
printf("Fault MVA = %.2f MVA \n\n", f);
```

Scilab code Exa 17.14 fault current fed by alternator

```
//Chapter 17
//Example 17_14
//Page 417

clear;clc;
```

```

mva=10;
kv=6.6;
xa=20;
mvat=5;
kvpt=6.6;
kvst=33;
xt=10;
r=0.2;
x=1;
ll=50;

base=input("Enter base MVA: ");

per_xa=base*xa/mva;
per_xt=base*xt/mvat;
per_xl=mva*1000*ll*x/10/kvst^2;
per_rl=mva*1000*ll*r/10/kvst^2;

tx=per_xl+per_xa+per_xt;
tr=per_rl;

per_z=sqrt(tx^2+tr^2);
scmva=base*100/per_z;

isc=scmva*1e6/sqrt(3)/kv/1000;

printf("%% reactance of the alternator = %.2f %% \n\n", per_xa);
printf("%% reactance of the transformer = %.2f %% \n\n", per_xt);
printf("%% reactance of the transmission line = %.2f %% \n\n", per_xl);
printf("%% resistance of the transmission line = %.2f %% \n\n", per_rl);
printf("Total %% reactance upto fault point = %.2f %% \n\n", tx);
printf("Total %% resistance upto fault point = %.2f
```

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

Scilab code Exa 17.15 short circuit current calculations

```
//Chapter 17
//Example 17_15
//Page 418

clear;clc;

kv=11;
mva=10;
xa=12;
mvar=10;
xr=24;
mvat=6;
xt=3;
ts=66;

base=input("Enter base MVA: ");
per_xa=base*xa/mva;
per_xr=base*xr/mvar;
per_xt=base*xt/mvat;

//From the figure , the total reactance from generator to fault point is

l1=per_xa/2+per_xr;
```

```
l2=per_xa/2;
tx=l1*l2/(l1+l2)+per_xt;

fmva=base*100/tx;
isc=fmva*1e6/sqrt(3)/ts/1000;

printf("%% reactance of the alternator = %.2f %% \n\n", per_xa);
printf("%% reactance of the transformer = %.2f %% \n\n", per_xt);
printf("%% reactance of the reactor = %.2f %% \n\n", per_xr);

printf("Total %% reactance upto fault point = %.2f %% \n\n", tx);
printf("Fault MVA = %.2f MVA \n\n", fmva);
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

```
//Chapter 18
//Example 18_3
//Page 429

clear;clc;

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

Ir=12+%i*6;
Iy=12+%i*-12;
Ib=-15+%i*10;

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

disp("RED PHASE:");
printf("Ir0 = %.2f+j(%.2f) A \n", real(Ir0), imag(
   Ir0));
```

```
printf("Ir1 = %.2f+j(%.2f) A \n", real(Ir1), imag(
    Ir1));
printf("Ir2 = %.2f+j(%.2f) A \n\n", real(Ir2), imag(
    Ir2));

Iy0=Ir0;
Iy1=a^2*Ir1;
Iy2=a*Ir2;
disp("YELLOW PHASE:");
printf("Iy0 = %.2f+j(%.2f) A \n", real(Iy0), imag(
    Iy0));
printf("Iy1 = %.2f+j(%.2f) A \n", real(Iy1), imag(
    Iy1));
printf("Iy2 = %.2f+j(%.2f) A \n\n", real(Iy2), imag(
    Iy2));

Ib0=Ir0;
Ib1=a*Ir1;
Ib2=a^2*Ir2;
disp("BLUE PHASE:");
printf("Ib0 = %.2f+j(%.2f) A \n", real(Ib0), imag(
    Ib0));
printf("Ib1 = %.2f+j(%.2f) A \n", real(Ib1), imag(
    Ib1));
printf("Ib2 = %.2f+j(%.2f) A \n\n", real(Ib2), imag(
    Ib2));
```

Scilab code Exa 18.4 sequence components for voltage

```
//Chapter 18
//Example 18_4
//Page 430

```

```
clear;clc;

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

Er0=100;
Er1=200-%i*100;
Er2=-100;

Er=Er0+Er1+Er2;
Ey=Er0+a^2*Er1+a*Er2;
Eb=Er0+a*Er1+a^2*Er2;

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

Scilab code Exa 18.5 sequence components calculations

```
//Chapter 18
//Example 18_5
//Page 431

clear;clc;

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

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

```

```
Er2=Er-Er0-Er1;
Ey=Er0+a^2*Er1+a*Er2;
Eb=Er0+a*Er1+a^2*Er2;

printf("Er2 = %.2f /_%.2f volts \n\n", abs(Er2),
   atand(imag(Er2)/real(Er2)));
printf("Ey = %.2f /_%.2f volts \n\n", abs(Ey), atand
   (imag(Ey)/real(Ey))-180);
printf("Eb = %.2f volts \n\n", abs(Eb));
```

Scilab code Exa 18.6 zero sequence currents

```
//Chapter 18
//Example 18_6
//Page 431

clear;clc;

i=12;

printf("Zero sequence current is equal to 1/3rd the
   current in nuetral wire.\n");
printf("Zero sequence current in each phase = %d A \
   n\n", i/3);
```

Scilab code Exa 18.7 with and without fuse

```
//Chapter 18
//Example 18_7
```

```
//Page 432

clear;clc;

i=90;

disp("(i) BEFORE REMOVAL OF FUSES: ");

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

Ir=90*(cosd(0)+%i*sind(0));
Iy=90*(cosd(240)+%i*sind(240));
Ib=90*(cosd(120)+%i*sind(120));

Ir0=1/3*(Ir+Iy+Ib);
Ir2=1/3*(Ir+a^2*Iy+a*Ib);

Iy2=a*Ir2;
Ib2=a^2*Ir2;

Ir1=Ir;
Iy1=Iy;
Ib1=Ib;

printf("Ir = %.2f /_%.2f A \n", abs(Ir), atand(imag(Ir)/real(Ir)));
printf("Iy = %.2f /_%.2f A \n", abs(Iy), atand(imag(Iy)/real(Iy))+180);
printf("Ib = %.2f /_%.2f A \n\n", abs(Ib), atand(imag(Ib)/real(Ib))+180);

printf("Zero sequence components of three line currents are: \n");
printf("Ir0 = Iy0 = Ib0 = %d A \n\n", real(Ir0));

printf("Ir2 = %d A \n", abs(Ir2));
printf("Iy2 = %d A \n", abs(Iy2));
printf("Ib2 = %d A \n\n", abs(Ib2));
```

```
printf("Ir1 = %.2f /_%.2f A \n", abs(Ir), atand(imag(Ir)/real(Ir)));
printf("Iy1 = %.2f /_%.2f A \n", abs(Iy), atand(imag(Iy)/real(Iy))+180);
printf("Ib1 = %.2f /_%.2f A \n\n\n", abs(Ib), atand(imag(Ib)/real(Ib))+180);

disp("AFTER REMOVAL OF FUSES: ");

Ird=90*(cosd(0)+%i*sind(0));
Iyd=0;
Ibd=0;

printf("Ir = %.2f /_%.2f A \n", abs(Ird), atand(imag(Ird)/real(Ird)));
printf("Iy = %d A \n", Iyd);
printf("Ib = %d A \n\n", Ibd);

Ir0d=1/3*(Ird+Iyd+Ibd);
Ir1d=1/3*(Ird+a*Iyd+a^2*Ibd);
Ir2d=1/3*(Ird+a^2*Iyd+a*Ibd);

printf("Zero sequence components of three line currents are: \n");
printf("Ir0 = Iy0 = Ib0 = %d /_0 A \n\n", real(Ir0d));

Iy0d=Ir0d;
Ib0d=Ir0d;

Iy1d=a^2*Ir1d;
Iy2d=a*Ir2d;

Ib1d=a*Ir1d;
Ib2d=a^2*Ir2d;

printf("Ir1 = %.2f /_%.2f A \n", abs(Ir1d), atand(
```

```
    imag(Ir1d)/real(Ir1d)));
printf("Ir2 = %.2f /_%.2f A \n\n", abs(Ir2d), atand(imag(Ir2d)/real(Ir2d))+180);

printf("Iy1 = %.2f /_%.2f A \n", abs(Iy1d), atand(imag(Iy1d)/real(Iy1d))+180);
printf("Iy2 = %.2f /_%.2f A \n\n", abs(Iy2d), atand(imag(Iy2d)/real(Iy2d))+180);

printf("Ib1 = %.2f /_%.2f A \n", abs(Ib1d), atand(imag(Ib1d)/real(Ib1d))+180);
printf("Ib2 = %.2f /_%.2f A \n\n", abs(Ib2d), atand(imag(Ib2d)/real(Ib2d))+180);

Iyd=Iy0d+Iy1d+Iy2d;
printf("Curretn in yellow line = %d A \n\n", real(Iyd));
```

Scilab code Exa 18.8 line current values

```
//Chapter 18
//Example 18_8
//Page 433

clear;clc;

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

In=300*(cosd(300)+%i*sind(300));
Ir1=200*(cosd(0)+%i*sind(0));
Ir2=100*(cosd(60)+%i*sind(60));

Ir0=1/3*In;
```

```
Ir=Ir0+Ir1+Ir2;
Iy=Ir0+a^2*Ir1+a*Ir2;
Ib=Ir0+a*Ir1+a^2*Ir2;

printf("Ir = %.2f /_%.2f volts \n\n", abs(Ir), atand(imag(Ir)/real(Ir)));
printf("Iy = %.2f /_%.2f volts \n\n", abs(Iy), atand(imag(Iy)/real(Iy))-180);
printf("Ib = %.2f /_%.2f volts \n\n", abs(Ib), atand(imag(Ib)/real(Ib)));
```

Scilab code Exa 18.9 currents in three phases

```
//Chapter 18
//Example 18_9
//Page 434

clear;clc;

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

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

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

Iy0=Ir0;
Iy1=a^2*Ir1;
Iy2=a*Ir2;
```

```

Ib0=Ir0;
Ib1=a*Ir1;
Ib2=a^2*Ir2;

printf("Ir = %.2f /_%.2f A \n", abs(Ir), atand(imag(
   Ir)/real(Ir)));
printf("Iy = %.2f /_%.2f A \n", abs(Iy), atand(imag(
   Iy)/real(Iy))+180);
printf("Ib = %.d A \n\n", Ib);

disp("RED PHASE: ");
printf("Ir0 = %d A \n", real(Ir0));
printf("Ir1 = %.2f /_%.2f A \n", abs(Ir1), atand(
   imag(Ir1)/real(Ir1)));
printf("Ir2 = %.2f /_%.2f A \n\n", abs(Ir2), atand(
   imag(Ir2)/real(Ir2)));

disp("YELLOW PHASE: ");
printf("Iy0 = %d A \n", real(Iy0));
printf("Iy1 = %.2f /_%.2f A \n", abs(Iy1), atand(
   imag(Iy1)/real(Iy1))-180);
printf("Iy2 = %.2f /_%.2f A \n\n", abs(Iy2), atand(
   imag(Iy2)/real(Iy2))+180);

disp("BLUE PHASE: ");
printf("Ib0 = %d  A \n", real(Ib0));
printf("Ib1 = %.2f /_%.2f A \n", abs(Ib1), atand(
   imag(Ib1)/real(Ib1)));
printf("Ib2 = %.2f /_%.2f A \n\n", abs(Ib2), atand(
   imag(Ib2)/real(Ib2))-180);
```

Scilab code Exa 18.10 resistor and line currents

```
//Chapter 18
//Example 18_10
//Page 435

clear;clc;

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

rr=5;
ry=10;
rb=20;

Er=-100*(cosd(0)+%i*sind(0));
Ey=100*(cosd(60)+%i*sind(60));
Eb=100*(cosd(-60)+%i*sind(-60));

Ir=Er/rr;
Iy=Ey/ry;
Ib=Eb/rb;

printf("Er = %.2f /_%.2f V \n", Er, atand(imag(Er)/real(Er)));
printf("Ey = %.2f /_%.2f V \n", abs(Ey), atand(imag(Ey)/real(Ey)));
printf("Eb = %.2f /_%.2f V \n\n", abs(Eb), atand(imag(Eb)/real(Eb)));

printf("Ir = %.2f /_%.2f A \n", Ir, atand(imag(Ir)/real(Ir)));
printf("Iy = %.2f /_%.2f A \n", abs(Iy), atand(imag(Iy)/real(Iy)));
printf("Ib = %.2f /_%.2f A \n\n", abs(Ib), atand(imag(Ib)/real(Ib)));

disp("SEQUENCE CURRENTS IN RESISTORS: ");

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

```
Ir2=1/3*(Ir+a^2*Iy+a*Ib);

Iy0=Ir0;
Iy1=a^2*Ir1;
Iy2=a*Ir2;

Ib0=Ir0;
Ib1=a*Ir1;
Ib2=a^2*Ir2;

printf("Ir0 = %.2f /_%.2f A \n", abs(Ir0), atand(imag(Ir0)/real(Ir0))+180);
printf("Ir1 = %.2f /_%.2f A \n", abs(Ir1), atand(imag(Ir1)/real(Ir1))+180);
printf("Ir2 = %.2f /_%.2f A \n\n", abs(Ir2), atand(imag(Ir2)/real(Ir2))-180);

printf("Iy0 = %.2f /_%.2f A \n", abs(Iy0), atand(imag(Iy0)/real(Iy0))+180);
printf("Iy1 = %.2f /_%.2f A \n", abs(Iy1), atand(imag(Iy1)/real(Iy1)));
printf("Iy2 = %.2f /_%.2f A \n\n", abs(Iy2), atand(imag(Iy2)/real(Iy2)));

printf("Ib0 = %.2f /_%.2f A \n", abs(Ib0), atand(imag(Ib0)/real(Ib0))+180);
printf("Ib1 = %.2f /_%.2f A \n", abs(Ib1), atand(imag(Ib1)/real(Ib1)));
printf("Ib2 = %.2f /_%.2f A \n\n", abs(Ib2), atand(imag(Ib2)/real(Ib2)));

disp("SEQUENCE CURRENTS IN SUPPLY LINES: ");
ir=Ib-Iy;
iy=Ir-Ib;
ib=Iy-Ir;

ir0=1/3*(ir+iy+ib);
ir1=1/3*(ir+a*iy+a^2*ib);
```

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


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

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

Scilab code Exa 18.11 current calculations

```
//Chapter 18
//Example 18_11
//Page 437

clear;clc;

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

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

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

```

Iy0=Ir0;
Iy1=a^2*Ir1;
Iy2=a*Ir2;

Ib0=Ir0;
Ib1=a*Ir1;
Ib2=a^2*Ir2;

printf("Ir = %.2f /_%.2f A \n", abs(Ir), atand(imag(Ir)/real(Ir)));
printf("Iy = %.2f /_%.2f A \n", abs(Iy), atand(imag(Iy)/real(Iy))+180);
printf("Ib = %d A \n\n", abs(Ib));

disp("RED LINE: ");
printf("Ir0 = %d A \n", real(Ir0));
printf("Ir1 = %.2f /_%.2f A \n", abs(Ir1), atand(imag(Ir1)/real(Ir1)));
printf("Ir2 = %.2f /_%.2f A \n\n", abs(Ir2), atand(imag(Ir2)/real(Ir2)));

disp("YELLOW LINE: ");
printf("Iy0 = %d A \n", real(Iy0));
printf("Iy1 = %.2f /_%.2f A \n", abs(Iy1), atand(imag(Iy1)/real(Iy1))+180);
printf("Iy2 = %.2f /_%.2f A \n\n", abs(Iy2), atand(imag(Iy2)/real(Iy2))+180);

disp("BLUE LINE: ");
printf("Ib0 = %d  A \n", real(Ib0));
printf("Ib1 = %.2f /_%.2f A \n", abs(Ib1), atand(imag(Ib1)/real(Ib1)));
printf("Ib2 = %.2f /_%.2f A \n\n", abs(Ib2), atand(imag(Ib2)/real(Ib2))+180);
```

Scilab code Exa 18.12 current calculations 2

```
//Chapter 18
//Example 18_12
//Page 438

clear;clc;

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

z1=5-%i*10;
z2=6+%i*5;
z3=3+%i*15;

Vry=3300*(cosd(0)+%i*sind(0));
Vyb=a^2*Vry;

Vr_minus_Vy=3300;
Vy_minus_Vb=3300*(cosd(120)-%i*sind(120));

printf("Since Ir+Iy+Ib=0, Ir0=Iy0=Ib0=0 A \n");

v=[Vr_minus_Vy; Vy_minus_Vb];

za=z1-a^2*z2;
zb=z1-a*z2;
zc=a^2*z2-a*z3;
zd=a*z2-a^2*z3;
z=[za zb; zc zd];

I=z\v;

```

```
printf("Ir1 = %.2f+j(%.2f) \n", real(I(1)), imag(I
   (1)));
printf("Ir2 = %.2f+j(%.2f) \n\n", real(I(2)), imag(I
   (2)));

ir=I(1)+I(2);
printf("Ir = %.2f /_%.2f \n\n", abs(ir), atand(imag(
   ir)/real(ir)));
```

Scilab code Exa 18.13 current calculations 3

```
//Chapter 18
//Example 18_13
//Page 440

clear;clc;

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

r=1;
vry=200;
vyb=346;
vbr=400;

//referring to the phasor diagram
//vbr is twice vry, ie, factor =2
//vyb=1.75 times vry
alpha=acosd((1+1.75*cosd(90))/2);

Vry=vry*(cosd(180)+%i*sind(180));
Vyb=vyb*(cosd(90)+%i*sind(90));
Vbr=vbr*(cosd(-alpha)+%i*sind(-alpha));

```

```
printf("Vry = %.2f+j(%.2f) V \n", real(Vry), imag(Vry));
printf("Vyb = %.2f+j(%.2f) V \n", real(Vyb), imag(Vyb));
printf("Vbr = %.2f+j(%.2f) V \n\n", real(Vbr), imag(Vbr));

Ir=Vry/sqrt(3);
Iy=Vyb/sqrt(3);
Ib=Vbr/sqrt(3);

disp("Line current : ");
printf("Ir = %.2f /_%.2f A \n", abs(Ir), atand(imag(Ir)/real(Ir))+180);
printf("Iy = %.2f /_90 A \n", abs(Iy));
printf("Ib = %.2f /_%.2f A \n\n", abs(Ib), atand(imag(Ib)/real(Ib)));

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

printf("Ir0 = %d A \n", abs(Ir0));
printf("Ir1 = %.2f /_%.2f A \n", abs(Ir1), atand(imag(Ir1)/real(Ir1))-180);
printf("Ir2 = %.2f /_%.2f A \n", abs(Ir2), atand(imag(Ir2)/real(Ir2)));
```

Scilab code Exa 18.14 impedance and voltage calculations

```
//Chapter 18
//Example 18_14
//Page 449
```

```
clear;clc;

mva=10;
kv=11;
g=[%i*1.2 %i*0.9 %i*0.4];
f=[%i*1 %i*1 %i*3];

Er=kv*1000/sqrt(3);
printf("Phase enf of R phase = %d V \n", Er);

printf("(i) Total impedance to any sequence current
    is sum of generator and feeder impedances of that
     sequence currents \n");

for i=1:3
  tz(i)=g(i)+f(i);
  printf("\tTotal Z(%i) = j(%.1f) ohm \n", i,imag(tz
     (i)));
end

z=sum(tz);
I1=Er/z;
I2=I1;
I0=I1;

Ir=3*I0;

Vr=Er-I0*sum(g);
printf("I1 = I2 = I0 = j(%d) A \n\n", imag(I0));
printf("Fault current = j(%d) A \n\n\n", imag(Ir));

printf("(ii) Line to nuetral voltage of R-phase = %
    .2f V \n\n", Vr);
```

Scilab code Exa 18.15 ratio of fault currents

```
//Chapter 18
//Example 18_15
//Page 450

clear;clc;

kv=11;
mva=10;
X0=%i*0.05;
X1=%i*0.15;
X2=%i*0.15;

Er=1;
I0=Er/(X0+X1+X2);
I1=I0;
I2=I0;
Ir=3*I0;
Ish=Er/X1;
ratio=Ir/Ish;

disp("Line to ground fault: ");
printf("I1=I2=I0=j(%.2f) A \n", imag(I0));
printf("Fault current = j(%.2f) A \n\n", imag(Ir));

disp("Three phase fault: ");
printf("Fault current = j(%.2f) A \n\n", imag(Ish));
printf("Ratio of two fault currents = %.3f A \n\n",
    ratio);
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

```
//Chapter 18
//Example 18_16
//Page 450

clear;clc;

kv=11;
mva=25;
X0=%i*0.05;
X1=%i*0.2;
X2=%i*0.2;

Xn=%i*0.3;
Er=1;
pu_xn=Xn*mva*1000/kv^2/1000;
I0=Er/(X0+X1+X2+3*pu_xn);
I1=I0;
I2=I0;
Ir=3*I0;
fc=mva*1e6/sqrt(3)/kv/1000*abs(Ir);

printf("Per unit value of Xn = %.4f p.u \n\n", imag(
    pu_xn));
printf("I1=I2=I0=j(%.3f) A \n\n", imag(I0));
printf("Fault current = j(%.3f) A \n\n", imag(Ir));
printf("Fault current in amperes = Rated current *
    Per unit value\n");
printf("                              %d A \n\n", fc);
```

Scilab code Exa 18.17 fault current 2

```
//Chapter 18
//Example 18_17
//Page 451

clear;clc;

Er=10.4*1e3/sqrt(3);
X1=0.6;
X2=0.5;
X0=0.2;

If=sqrt(3)*Er/(X1+X2);

printf("Phase emf of R-phase = %d V \n\n", Er);
printf("Fault current for line to line fault = %.1f
    A \n\n", If);
```

Scilab code Exa 18.18 fault current 3

```
//Chapter 18
//Example 18_18
//Page 451

clear;clc;

X1=%i*0.08;
```

```
X2=%i*0.07;
X0=%i*0.05;

//pu value
Er=1;

If=-3*X2*Er/(X1*X2+X1*X0+X2*X0);
printf("Fault current = j%d p.u \n\n", imag(If));
```

Scilab code Exa 18.19 fault current 4

```
//Chapter 18
//Example 18_19
//Page 452

clear;clc;

mva=20;
kv=11;
xn=5;
x1=20;
x2=10;

Er=kv*1000/sqrt(3);
printf("Phase emf of red phase = %d V \n\n", Er);

//from the reactance diagram given in the text;
r_x1=x1/2;
r_x2=x2/2;
r_xn=30;

X1=r_x1*kv^2*10/mva/1000;
X2=r_x2*kv^2*10/mva/1000;
```

```
X0=r_xn*kv^2*10/mva/1000;

Ir=3*Er/(X1+X2+X0)/%i;

printf("X1 = %.3f ohm \n\n", X1);
printf("X2 = %.3f ohm \n\n", X2);
printf("X0 = %.3f ohm \n\n", X0);

printf("Fault current = j(%d) A \n\n", imag(Ir));
```

Scilab code Exa 18.20 reactance calculations

```
//Chapter 18
//Example 18_20
//Page 453

clear;clc;

mva=50;
kv=11;

//three phase fault
I1=2000;
//line to line fault
I2=2600;
//line to ground fault
I3=4200;

Eph=kv*1000/sqrt(3);

X1=Eph/I1;
X2=sqrt(3)*Eph/I2-X1;
X3=3*Eph/I3-X1-X2;
```

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

Chapter 19

Circuit Breakers

Scilab code Exa 19.1 circuit breaker rating

```
//Chapter 19
//Example 19_1
//Page 483

clear;clc;

i=1500;
mva=1000;
v=33*1e3;
t=3;

printf("(i) Rated normal current = %.0f A \n\n", i);
printf("(ii) Breaking capacity = %.0f MVA \n\n", mva
    );
rsbc=mva*1e6/sqrt(3)/v;
printf("(iii) Rated symmetrical breaking capacity =
    %.0f A \n\n", rsbc);
rmc=2.55*rsbc;
printf("(iv) Rated making current = %.0f A \n\n",
    rmc);
printf("(v) Rated short time rating = %.0f A for %.0
```

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

Scilab code Exa 19.2 average rrrv

```
//Chapter 19
//Example 19_2
//Page 484

clear;clc;

f=50;
v=11*1e3;
x=5;
c=0.01*1e-6;

l=x/2/%pi/f;
emax=sqrt(2)*v/1000/sqrt(3);
fn=1/2/%pi/sqrt(l*c);
t=1/2/fn;
avg=2*emax/t;

printf("Inductance per phase = %.5f H \n\n", l);
printf("(i) Maximum value of recovery voltage = %.2f
     kV \n\n", emax);
printf("     Peak restriking voltage = %.2f kV \n\n",
     2*emax);
printf("(ii) Frequency of oscillation = %.0f Hz \n\n
    ", fn);
printf("(iii) Time t at which peak restriking
    voltage occurs = %.2f us \n\n", t*1e6);
printf("       Average rate of rise of recovery
```

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

Scilab code Exa 19.3 natural frequency of oscillations

```
//Chapter 19
//Example 19_3
//Page 484

clear;clc;

tp=50*1e-6;
rvp=100*1e3;

rrrv=rvp/tp;
fn=1/2/tp;

printf("Average RRRV = %.0f kV/sec \n\n", rrrv/1000)
    ;
printf("Natural frequency of oscillatins = %.0f Hz \
    n\n", fn);
```

Scilab code Exa 19.4 voltage during chopping

```
//Chapter 19
//Example 19_4
//PAge 485

clear;clc;

```

```
i=7;
l=35.2;
c=0.0023*1e-6;

e=i*sqrt(l/c);
printf("Voltage across breaker = %.0f kV \n\n", e
   /1000);
```

Chapter 20

Fuses

Scilab code Exa 20.1 radius of wire

```
//Chapter 20
//Example 20_1
//Page 495

clear;clc;

r1=0.8;
i1=8;
i2=1;

r2=r1*(i2/i1)^(2/3);

printf("Radius = %.1f mm \n\n", r2);
```

Chapter 21

Protective relays

Scilab code Exa 21.1 relay operating time

```
//Chapter 21
//Example 21.1
//Page 507

i=5;
cs=1.25;
ts=0.6;
tv1=400;
tv2=5;
fc=4000;

pup=i*cs;
frc=fc*tv2/tv1;
psm=frc/pup;
ot=3.5*0.6;

printf("Pick up current = %.2f A \n\n", pup);
printf("Fault current in relay coil = %.0f A \n\n",
   frc);
printf("Plug multiplier setting = %.0f  \n\n", psm);
printf("Corresponding to the plug multiplier setting
```

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

Chapter 22

Protection of Alternators and Transformers

Scilab code Exa 22.1 Merz Price principle

```
//Chapter 22
//Example 22_1
//Page 529

clear;clc;

mva=10*1e6;
v=6.6*1e3;
ph_z=0.1;
i=175;
awp=0.1;

vph=v/sqrt(3);
flc=mva/sqrt(3)/v;
x=v*mva/1e6/flc/sqrt(3)/100;
zw=x*ph_z;
emfw=vph*ph_z;

r=sqrt((emfw/i)^2-zw^2);
```

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

Scilab code Exa 22.2 unprotected winding calculations

```
//Chapter 22
//Example 22_2
//Page 530

clear;clc;

r=7.5;
mva=10;
i1=1000;
i2=5;
kv=6.6;
oc=0.5;

v_ph=kv*1000/sqrt(3);
min_fc=i1/i2*oc;
emf=v_ph/100;
efc=emf/r;
uw=min_fc/efc;
```

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

Scilab code Exa 22.3 unprotected winding and r

```
//Chapter 22
//Example 22_3
//Page 530

clear;clc;

mva=10;
kv=6.6;
i1=1000;
i2=5;
oc=0.75;
r=6;
x=10;

v_ph=kv*1000/sqrt(3);
min_fc=i1/i2*oc;
emf=v_ph/100;
efc=emf/r;
uw=min_fc/efc;
```

```
printf("(i) x%% of the winding is unprotected, \n\n")
printf("Voltage per phase = %d V \n\n", v_ph);
printf("Minimum fault current which will operate the relay = %d A \n\n", min_fc);
printf("EMF induced in %%x winding = %.2f*x V \n\n", emf)
printf("Earth fault current which %%x winding will cause = %.2f*x A \n\n", efc);
printf("This current must be equal to %d A \n\n", min_fc);
printf("Unprotected winding, x= %.2f %% \n\n", uw);

min_r=emf*x/min_fc;
printf("(ii) The minimum earthing resistance required to provide protection for %d %% of stator winding = %.2f ohm \n\n", (100-x), min_r);
```

Scilab code Exa 22.4 earthing resistance r

```
//Chapter 22
//Example 22_4
//Page 531

clear;clc;

mva=10;
kv=6.6;
x=(100-85);

v_ph=kv*1000/sqrt(3);
i=mva*1e6/sqrt(3)/kv/1000;
```

```
min_fc=0.2*i;
emf=0.15*v_ph;
r=emf/min_fc;

printf("Full load current = %.2f A \n\n", i);
printf("Minimum fault current which will operate the
    relay = %.2f A \n\n", min_fc);
printf("Voltage induced in %d %% winding is %.2f V \
   n\n", x, emf);
printf("Earth fault current which %d %% winding will
    cause = %.2f/r \n\n", x, emf);
printf("This current must be equal to minimum fusing
    current %.2f A \n\n", min_fc);
printf("Earthing resistance required = %.2f ohm \n\n
   ", r);
```

Scilab code Exa 22.5 turn ratio 1

```
//Chapter 22
//Example 22_5
//Page 538

clear;clc;

v1=220;
v2=11000;
v=220;
i1=600;
i2=5;

lc=sqrt(3)*i2;
pap=sqrt(3)*v*i1;
i=pap/sqrt(3)/v2;
```

```
ratio=i/lc;

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

Scilab code Exa 22.6 turn ratio 2

```
//Chapter 22
//Example 22_6
//Page 538

clear;clc;

v1=0.4;
v2=11;
v=400;
i1=500;
i2=5;

lc=sqrt(3)*i2;
pap=sqrt(3)*v*i1;
i=pap/sqrt(3)/v2/1000;

ratio=i/lc;

printf("Line current of delta connected CTs on %d V
```

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

Chapter 26

Neutral Grounding

Scilab code Exa 26.1 peterson coil reactance

```
//Chapter 26
//Example 26_1
//Page 599

clear;clc;

f=50;
v=33*1e3;
c=4.5*1e-6;

xl=1/(3*2*%pi*f*c);
printf("Reactance of Peterson Coil = %.2f ohm \n\n",
    xl);
```

Scilab code Exa 26.2 peterson coil rating

```
//Chapter 26
//Example 26_2
//Page 599

clear;clc;

v=230*1e3;
lt=200;
c=0.02*1e-6;
f=50;

cle=c*lt;
l=1/(3*(2*%pi*f)^2*cle);
xl=2*%pi*f*l;
vph=v/sqrt(3);
fi=vph/xl;
rating=vph*fi;

printf("Capacitance of line to earth = %.6f F \n\n",
    cle);
printf("Required inductance of Peterson coil = %.2f
    F \n\n", l);
printf("Current through Peterson coil = %.0f A \n\n"
    , fi);
printf("Rating of Peterson coil = %.0f kVA \n\n",
    rating/1000);
```

Scilab code Exa 26.3 reactance to nuetralize capacitance

```
//Chapter 26
//Example 26_3
//Page 600

```

```
clear;clc;

f=50;
c=1.2*1e-6;
c1=c;
c2=0.9*c;
c3=0.8*c;

xl1=1/(3*2*%pi*f*c1);
xl1=1/(3*2*%pi*f*c2);
xl1=1/(3*2*%pi*f*c3);

printf("Inductive reactance of coil to nuetralize
    capacitance of 100%% of the length of the line is
     %.2f ohm \n\n", xl1);
printf("Inductive reactance of coil to nuetralize
    capacitance of 90%% of the length of the line is
    %.2f ohm \n\n", xl2);
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

```
//Chapter 26
//Example 26_4
//PAge 600

clear;clc;

v=132*1e3;
f=50;
lt=200;
```

```
d=20;
s=4;
eo=8.854*1e-12;

r=d/2/1000;
c=2*%pi*eo/log(s/r);
w=2*%pi*f;
l=1/(3*w^2*c*lt)/1000;
xl=2*%pi*f*l;
fi=v/sqrt(3)/xl;
rating=v/sqrt(3)*fi;

printf("Capacitance between phase and nuetral = %.2f *10^-9 F/km \n\n", c*1e12);
printf("Capacitance between phase and earth = %.2f *10^-7 F \n\n", c*lt*1e7*1000);
printf("Required Inductance of the arc supression coil = %.2f H \n\n", l);
printf("Current through the coil = %.0f A \n\n", fi);
printf("Rating of the coil = %.0f kVA \n\n", rating/1000);
```