Scilab Textbook Companion for Generation Of Electrical Energy by B. R. Gupta[1]

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Book Description

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

Exa Example (Solved example)

Eqn Equation (Particular equation of the above book)

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

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

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Chapter 2

LOADS AND LOAD CURVES

Scilab code Exa 2.1 connected load demand factor and other load factors connected to the system

```
clc
disp("example =2.1")
printf("\n")
disp("solution for (a)")
nb=8;nf=2;nl=2 //given number of equipments is 8
   bulbs 2 fans 2plugs
lb=100;lf=60;ll=100 //corresponding wattages
cl=nb*lb+nf*lf+nl*ll; //total connected load
printf("connected load = 8X100W+2X60W+2X100W=%dW\n",
   cl);
disp("solution for (b)")
disp("total wattage at different times is")
t1=5;t2=2;t3=2;t4=9;t5=6;
fr=[0 1 0] //12 to 5am period of duration 5h
s=[0 2 1] //5am to 7am period of duration 2h
t=[0 0 0] //7am to 9am period of duration 2h
fo=[0 2 0] //9am to 6pm period of duration 9h
fi=[4 2 0] //6pm to 12pm period of duration 6h
w=[fr;s;t;fo;fi]
wt=[100*w(:,1),60*w(:,2),100*w(:,3)]
```

```
wtt=[sum(wt(1,:));sum(wt(2,:));sum(wt(3,:));sum(wt(4,:));sum(wt(5,:))]
printf("\t%dW\n\t%dW\n\t%dW\n\t%dW\n\t%dW",wtt(1),wtt(2),wtt(3),wtt(4),wtt(5))
printf("\nthe maximum demand is %dW\n",max(wtt))
m=max(wtt)
disp("solution for (c)")
printf("\ndemand factor =%3f\n",m/cl)
disp("solution for (d)")//energy consumed is power multiply by corresponding time
energy=[wtt(1,1)*t1;wtt(2,1)*t2;wtt(3,1)*t3;wtt(4,1)*t4;wtt(5,1)*t5]
printf("\t%dWh\n\t%dWh\n\t%dWh\n\t%dWh\n\t%dWh",energy(1),energy(2),energy(3),energy(4),energy(5))
e=sum(energy)
printf("\ntotal energy consumed during 24 hours = %dWh+%dWh+%dWh+%dWh+%dWh=%dWh\n",energy(1),energy(2),energy(3),energy(4),energy(5),e)
disp("solution for (e)");
ec=cl*24;
printf("\nif all devices are used throughout the day the energy consumed in Wh is %dWh \n\t\t%.2fkWh",ec,ec/1000)
//for 24 hours of max. load
```

Scilab code Exa 2.2 diversity factor conserning different loads

```
clc
disp("example 2.2")
disp("(a)");
```

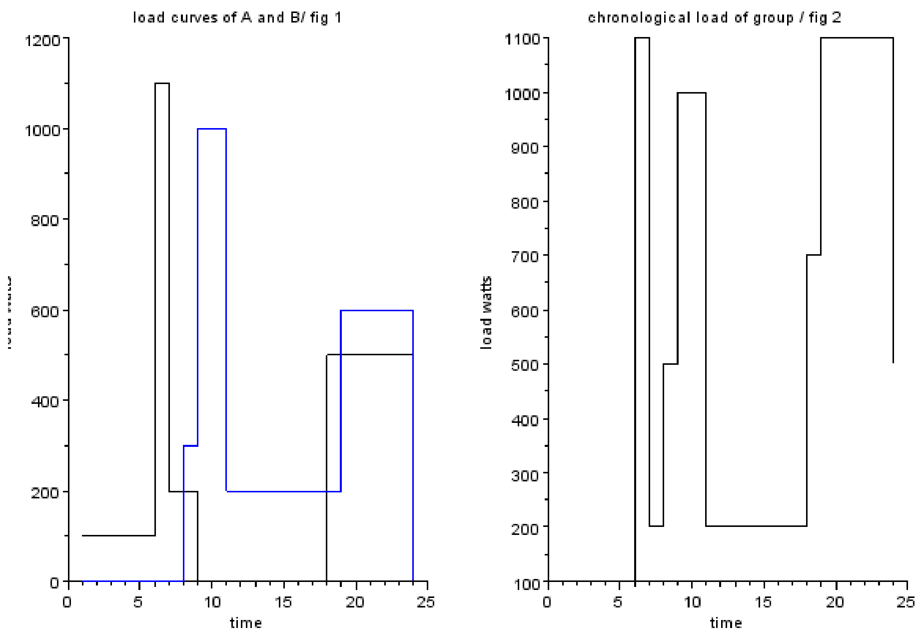

Figure 2.1: diversity factor conserning different loads

```
mca=1.1;cla=2.5;mcb=1;clb=3;        //mca=maximum demand of consumera;cla=connected load of a;mcb=maximum load of consumer b;clb=connected load of consumer b
printf("maximum demand of consumer A =%1fkW \n \ndemand factor of consumer A =%2f \n \nmaximum demand of consumer B =%dkW\n \ndemand factor of consumer B = %2f",mca,mca/cla,mcb,mcb/clb)
disp("(b)")
printf("The variation in demand versus time curves are plotted and shown in Fig This is known as chonological load curve.")
A=[100*ones(1,5),1100*ones(1,1),200*ones(1,2),0*ones(1,9),500*ones(1,7)]
B=[0*ones(1,7),300*ones(1,1),1000*ones(1,2),200*ones(1,8),600*ones(1,5),0*ones(1,1)]; //time line of different periods by a and b consumers
t=1:1:24         ;//for 24 hours ploting
ma=max(A);mb=max(B);
subplot(121);        //matrix plotting
plot2d2(t,A,1);
plot2d2(t,B,2);
xtitle("load curves of A and B/ fig 1","time","load watts")
C=A+B;
subplot(122);
plot2d2(t,C,1);
xtitle("chronological load of group / fig 2","time","load watts")
mg=max(C); //maximum demand of group
disp("(c)")
printf("maximum demand of the group is %dW",mg);
gd=(ma+mb)/mg;
printf("group diversity factor = %3f",gd) ; //group diversity factor is sum of individual maximum consumaer load to the group max load
disp("(d)")
sa=sum(A)
```

```
printf("energy consumed by A during 24 hours is = %dWh",sa)
printf("\nit is seen that energy consumed by A is equal to the area under the chronological load curve of A \n energy consumed by B during 24 hours is")
sb=sum(B);
printf("300x1+100x2+200x8+600x5=%dWh",sb);
disp("(e)");
printf("maximum energy which A could consume in 24 hours = %.2fkWh \nmaximum energy which B consume in 24 hours is =%.2fkWh",mca*24,mcb*24 );
disp("(f)");
printf("actual energy/maximum energy");
mca=mca*10^3;mcb=mcb*10^3
aemea=sa/(mca*24)
aemeb=sb/(mcb*24)
printf("\nfor A = %d/%d =%f \nfor b =%d/%d =%f",sa,mca*24,sa/(mca*24),sb,mcb*24,aemeb);
```

Scilab code Exa 2.3 load demand power from load

```
clc
disp("example 2.3")
printf("\n")
cola=5;na=600;ns=20;
cls=2;clfm=10;clsm=5;cll=20;clci=80;
dffl=0.7;dfsm=0.8;dfl=0.65;dfci=0.5;
nsl=200;clsl=0.04;dfa=0.5;gdfa=3.0;
pdfa=1.25;gdfc=2;pdfc=1.6;dfs=0.8; //given col||cl=connected load,n=number,df=demand factor,gdf=group diversity factor,pdf=peak diversity factor,a=appartement,c=commertials,s=shop,sl=streetlight
```

```
,fm=flourmill ,sm=saw mill ,l=laundry ,ci=cinema complex.
mdea=cola*dfa
printf("maximum demand of each appartment =%.2fkWh \n",mdea)
mda=(na*mdea)/gdfa
printf("maximum demand of 600 apatments =%.2fkW \n",mda);
datsp=mda/pdfa
printf("demand of 600 apartments at time of the system peak =%dkW \n",datsp);
mdtcc=((cls*ns*dfs)+(clfm*dffl)+(clsm*dfsm)+(cll*dfl)+(clci*dfci))/gdfc
printf("maximum demand of total commertial complex=%dkW \n",mdtcc)
dcsp=mdtcc/pdfc
printf("demand of the commertial load at the time of the peak = %dkW\n",dcsp);
dsltsp=nsl*clsl
printf("demand of the street lighting at the time of the system peak =%dkW",dsltsp);
ispd=datsp+dcsp+dsltsp
printf("\nincrease in system peak deamand =%dkW ",ispd)
```

Scilab code Exa 2.4 load deviation curve and load factor

```
clc
disp("example 2.4")
printf("\n")
printf("the chronological load curve is plotted in
```

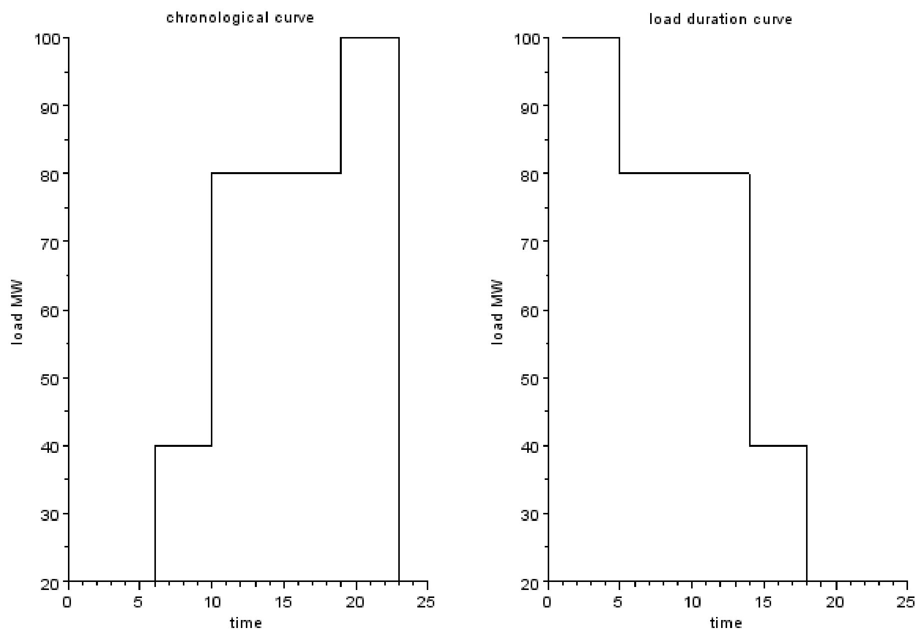

Figure 2.2: load deviation curve and load factor

```
    fig 1 the durition of loads is as under :")
lc=[20*ones(1,5),40*ones(1,4),80*ones(1,9),100*ones
    (1,4),20*ones(1,2)]
ldc=gsort(lc);
[mm,nn]=size(ldc)
printf("\n")
for i=1:nn
printf("\t%dW",ldc(i));//arranging accending order
end
e=sum(ldc)
printf("\nthe load duration curve is ploted in 2 the
     energy produced by plant in 24 hours \n =100x4
    +80x(13-4)+40(17-13)+20(24-17)=%dMWh \n",e);
lff=e/(24*max(ldc));
printf("load factor =1420/2400=%f=%f in persent",lff
    ,lff*100)
t=1:1:24
subplot(121);
plot2d2(t,lc);
xtitle("chronological curve","time","load MW");
subplot(122);
plot2d2(t,ldc);
xtitle("load duration curve","time","load MW");
```

Scilab code Exa 2.5 capacity factor and utilisation factor

```
clc
disp("example 2.5")
lf=0.5917;ml=100;ic=125; //lf=load factor,ic=
    installed capacity,ml=maximum load,cf=capacity
    factor,uf=utillization factor
```

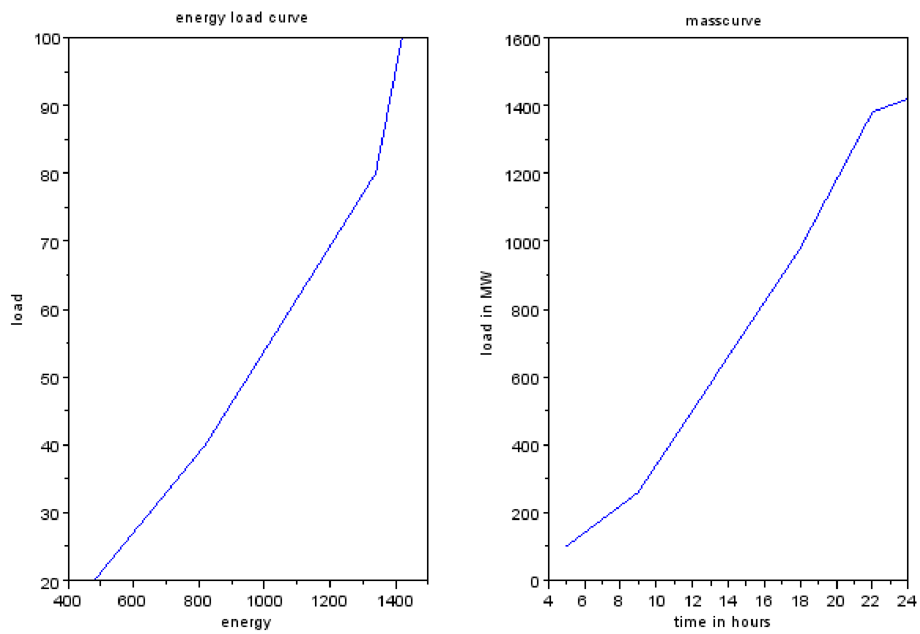

Figure 2.3: mass curve of 24 example

```
cf=(ml*lf)/ic;uf=ml/lf
printf("capacity factor =%f",cf)
printf("\nutilisation factor =%f",uf)
```

Scilab code Exa 2.6 mass curve of 24 example

```
clc
disp("Example 2.6")
time=[5 9 18 22 24]
loadt=[20 40 80 100 20]                    //given
    time and load
```

```
k=size(time)
k=k(1,2)
timed(1,1)=time(1,1)
for x=2:k                                          //finding time duration of each load
    timed(1,x)=time(1,x)-time(1,x-1)
end
[m n]=gsort(loadt)                    //sorting decresing order
for x=1:k                                         //sorting the load and timeduration correspondingly
    timed1(1,x)=timed(1,n(x))
end
tim(1,1)=timed1(1,1)
for x=2:k
    tim(1,x)=timed1(1,x)+tim(1,x-1)
end
lo(1,1)=24*min(m)
m(k+1)=[]
printf("the energy at different load levels is as under :")
printf("\nload=%dMW, energy=%dMWh",m(k),lo(1,1))
y=2
for x=k-2:-1:1
   lo(1,y)=lo(1,y-1)+(tim(1,x))*(m(x)-m(x+1))
   t=m(x);l=lo(1,y)
    printf("\nload=%dMW, energy=%dMWh",t,l)
    y=y+1
end
for x=1:k
    for y=x+1:k
        if m(1,x)==m(1,y) then
            m(1,y)=[]
        end
    end
end
pop=gsort(m,'g','i')
subplot(121)
```

```
plot(lo,pop)
xtitle("energy load curve","energy","load")
//time=[5 9 18 22 24]
//loadt=[20 40 80 100 20]
printf("\nthe energy load curve is plotted in fig 1
   \nthe energy supplied up to different times of
   the day is as under :")
et(1,1)=time(1,1)*loadt(1,1)
for x=2:k
    printf("\nenergy supplied upto %d is %dMWh",time
       (1,x-1),et(1,x-1))
    et(1,x)=et(1,x-1)+loadt(1,x)*(time(1,x)-time(1,x
       -1))

end
subplot(122)
plot(time,et)
xtitle("masscurve","time in hours","load in MW")
```

Scilab code Exa 2.7 annual production of plant with factors

```
clc
disp("example 2.7")
md=40;cf=0.5;uf=0.8;//maximum demand in MW;capacity
   factor;utility factor
disp("(a)")
lf=cf/uf;  //load factor is ratio of capacity factor
    to the utility  factor
printf("load factor = capacity factor/utilisation
   factor =%f",lf)
disp("(b)")
pc=md/uf;  //plant capacity is ratio of maximum
   demand to utility factor
```

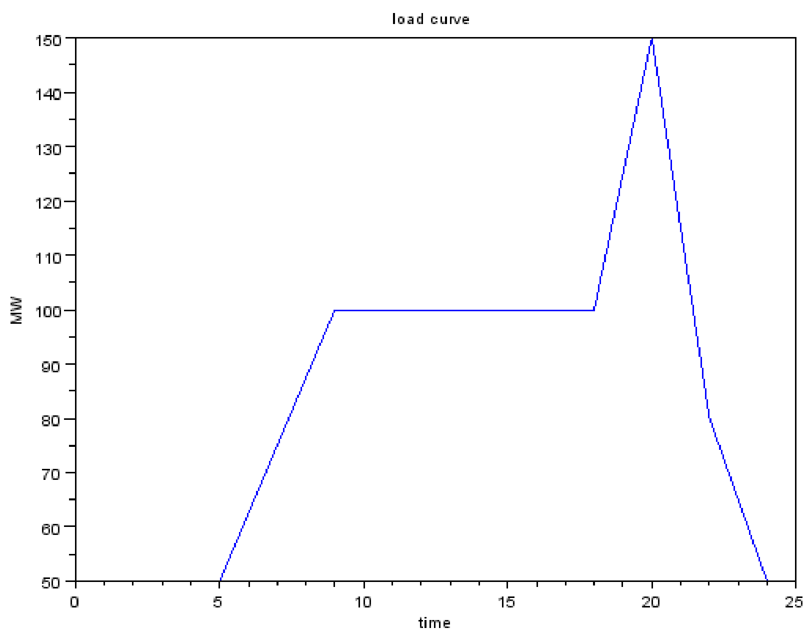

Figure 2.4: daily load factor

```
printf("plant capacity = maximum demand/utilisation
    factor =%dMW",pc)
disp("(c)")
rc=pc-md;  //reserve capacity is plant capacity
    minus maximum demand
printf("reserve capacity =%dMW",rc)
disp("d")
printf("annual energy production =%dMWh",md*lf*8760)
```

Scilab code Exa 2.8 daily load factor

```
clc
disp("example 2.8")
disp("the chronological load curve is plotted in fig 1")
a=[0 5 9 18 20 22 24] //time in matrix format
b=[50 50 100 100 150 80 50]//load in matrix format
for x=1:6
   z(1,x)=((b(1,x)+b(1,x+1))/2)*(a(1,(x+1))-a(1,x))
end
e=sum(z);
printf("energy required required by the system in 24 hrs \n =50x5MWh+((100+50)/2)x4MWh +(100x9)MWh +(100+150)MWh+(150+80)MWh+(80+50)MWh \n =%dMWh",sum(z))
dlf=e/(max(b)*24)
printf("\ndaily load factor =2060/(150x24) =%f",dlf)
plot(a,b)
xtitle("load curve","time","MW")
```

Scilab code Exa 2.9 load duration curve and mass curve

```
clc
clear
disp("example 2.9")
disp("load duration curve in fig1")
disp("the energy consumed upto different times is as")
a=[0 5 9 18 20 22 24]  //time in matrix format
b=[50 50 100 100 150 80 50] //load in matrix format
```

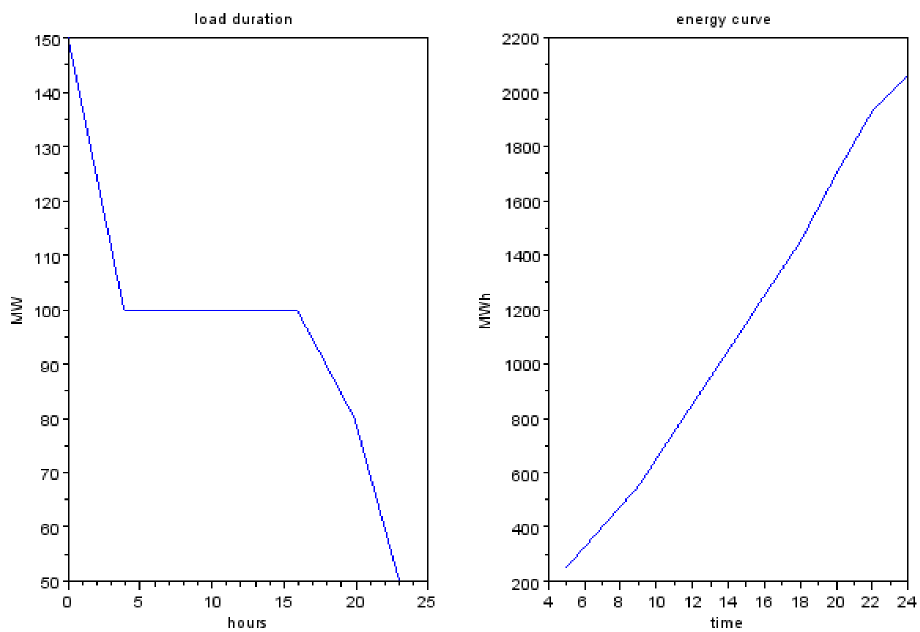

Figure 2.5: load duration curve and mass curve

```
for x=1:6
   z(1,x)=((b(1,x)+b(1,x+1))/2)*(a(1,(x+1))-a(1,x))
end
et=0
for x=1:6
    et=et+z(1,x);
    A=a(1,(x+1))
    ett(1,x)=et;
    q(1,x)=a(1,x+1)
    printf("\nfrom mid night upto %d,energy=%dMWh",A
       ,et)
end
q(1,x+1)=[]
[m n]=gsort(b)
m(1,7)=[];m(1,6)=[]; //rearranging for mass  curve
disp("energy curve in fig 2")
t=[0 3.88 15.88 19.88 23]
for j=1:6
    k(1,j)=a(1,(j+1))
end
subplot(121);
plot(t,m);
xtitle("load duration","hours","MW")
subplot(122);
plot(q,ett,-9);
xtitle("energy curve","time","MWh")
```

Scilab code Exa 2.10 reserve capacity of plant with different factors

```
clc
disp("example 2.10")
egd1=438*10^4;plp=0.2;pcf=0.15;//annual load
   duration ;annual  load factor;plant capacity
```

```
factor
pml=egd1/(plp*8760)
pc=(pml*plp)/pcf
printf("annual load factor =energy generated during 1 year/(max. load)x8760=%.1f \n maximum load = %dkW",plp,pml)
printf("\ncapacity factor =(max.load/plant capacity)x(load factor)\n plant capacity =max.load/0.75 = %fMW \n reserve capacity =3.333-2.5=%fMW",pc,pc-pml)
```

Scilab code Exa 2.11 suggested installed capacity for a plant

```
clc
disp("example 2.11")
p1=10;p2=6;p3=8;p4=7 //peak demands of 4 areas
df=1.5;lf=0.65;imdp=0.6;//diversity factor ;annual load factor ;ratio of maximum demand
p=p1+p2+p3+p4
md=p/df
ae=md*lf*8760
imd=imdp*md
ic=md+imd
printf(" sum of maximum=%dMW",p)
printf("\n maximum demand = sum of max.demands/diversity factor =%d/%f = %fMW",p,df,md)
printf("\n annual energy =%fMWh \n increase in maximum demand =%fMW \n installed capacity =%fMW",ae,imd,ic)
```

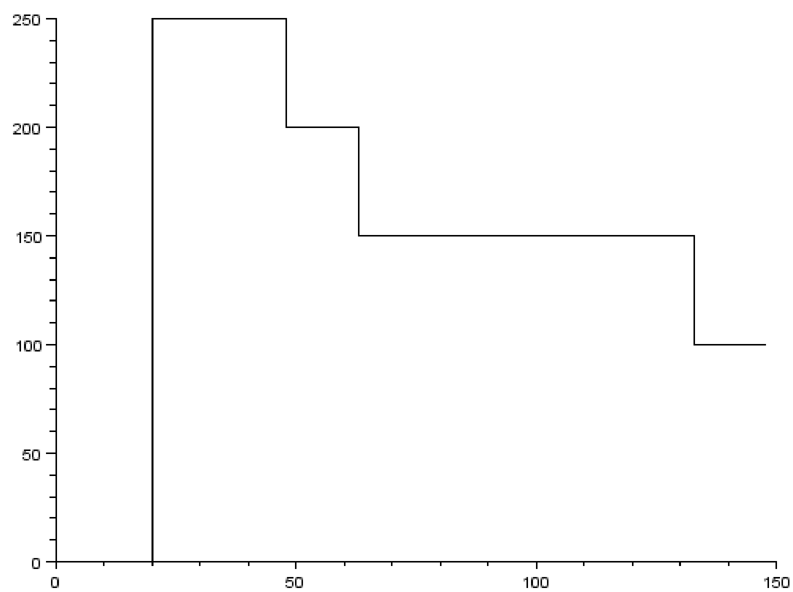

Figure 2.6: load duration curve

Scilab code Exa 2.12 load duration curve

```
clc
disp("example 2.12")
disp("from the above data,the durations of different
    loads during one week are")
aw=[0 5 8 12 13 17 21 24]  //given week timings and
   corresponding loads
```

```
lw=[100 150 250 100 250 350 150]
aen=[0 5 17 21 24]    //given weakends timing and corresponding
len=[100 150 200 150]
saw=size(aw);saen=size(aen)
sae=saw(1,2)-1;saen=saen(1,2)-1
for x=1:sae                        //getting duration of load
    tdw(1,x)=aw(1,x+1)-aw(1,x)
end
for x=1:saen
    tden(1,x)=aen(1,x+1)-aen(1,x)
end
taw=5*tdw                          //duration of entair week
taen=2*tden
alw=[taw taen;lw len]
lwen=[lw len]      //arranging load in accending order
[m n]=gsort(lwen)
kn=size(lwen)
kld=kn(1,2)

for x=2:kld

    ldcq(:,x)=alw(:,n(x))
    if x>1 then
    ldcq(1,x)=ldcq(1,x)+ldcq(1,x-1)
    end
end

plot2d2(ldcq(1,:),ldcq(2,:))
printf(" load              duration \n 350MW  4x5=20hours \n 250MW  20+8x5=60hours \n 200MW  60+4x2 =68hours \n 150MW  68+6x5+15x2 =128hours \n 100MW  128+6x5+5x2 =168hours")
disp("the load duration curve is plotted in fig")
disp("the total area under the load duration curve
```

```
    is 31600MWh which represents the energy
    conumption in one week.")
eclw=ldcq(2,1)*ldcq(1,1)
for x=2:1:kld
    eclw=eclw+(ldcq(2,x)*(ldcq(1,x)-ldcq(1,x-1)))
end
lf=eclw/(max(lwen)*24*7)
printf("total energy consumed is %dWh",eclw)
printf("\ntotal maximum energy could consume %dWh",
    eclw/lf)
printf("\nload factor =%f",lf)
```

Scilab code Exa 2.13 annual load factor daily load factor and different ratioes

```
clc
disp("example 2.13")
dlf=0.825;    //daily load factor
lptmlp=0.87;   //average daily peak load to monthly
    load peak
mlptalp=0.78;   //average monthly peak load to annual
     load peak
printf("annual load factor =%fx%fx%f=%f.",dlf,lptmlp
    ,mlptalp,dlf*lptmlp*mlptalp)
```

Scilab code Exa 2.14 peak load on different transformers and peak load on feeder

```
clc
```

```
disp("example 2.14")
disp("(a)")
//given
transformer1.motorload=300;transformer1.demandfactorm=0.6;tarnsformer1.commercialload=100;transformer1.demandfactorc=0.5;transformer1.diversityfactor=2.3;transformer2.residentalload=500;transformer2.demandfactor=0.4;transformer2.diversitryfactor=2.5;transformer3.residentalload=400;transformer3.demandfactor=0.5;transformer3.diversityfactor=2.0;diversitybtwxmer=1.4
peakloadoftransformer1=((transformer1.motorload*transformer1.demandfactorm)+(tarnsformer1.commercialload*transformer1.demandfactorc))/transformer1.diversityfactor
peakloadonxmer=(transformer2.residentalload*transformer2.demandfactor)/transformer2.diversitryfactor
peakloadonxmer3=(transformer3.residentalload*transformer3.demandfactor)/(transformer3.diversityfactor)
printf("peak load on transformer 1 =(300x0.6+100x0.5)/2.3 =%dkW \npeak load on transformer 2 =%dkW \n peak load on transformer 3 =%dkW",peakloadoftransformer1,peakloadonxmer,peakloadonxmer3)
disp("(b)")
peakloadonfeeder=(peakloadoftransformer1+peakloadonxmer+peakloadonxmer3)/diversitybtwxmer
printf("peak load on feeder =(100+80+100)/1.4 =%dkW",peakloadonfeeder)
```

Chapter 3

power plant economics

Scilab code Exa 3.1 annual plant cost and generation cost of two different units

```
clc
disp("example 3.1")
totpow=110*10^3 //(kW)
uc1=18000;fcr1=0.1;cf1=0.55;fuelcons1=0.7;fuelcost1=1500/1000;om1=0.2;utilizationf1=1;
uc2=30000;fcr2=0.1;cf2=0.60;fuelcons2=0.65;fuelcost2=1500/1000;om2=0.2;utilizationf2=1;
//given uck=unit capital cost k;fcrk= fixed charge rate of kth unit;cfk=capacity factor at k th unit; omk=annual cost of operating labour ;totpow=total power rating of units
afc1=fcr1*uc1*totpow;afc2=fcr2*uc2*totpow;
e1=8760*cf1*totpow;e2=8760*cf2*totpow;
annualfuel1=e1*fuelcons1;annualfuel2=e2*fuelcons2;
fc1=annualfuel1*fuelcost1;fc2=annualfuel2*fuelcost2;
om11=om1*fc1;om22=om2*fc2;
aoc1=fc1+om1;aoc2=fc2+om2;
apc1=aoc1+afc1;apc2=aoc2+afc2;
gc1=apc1/fc1;gc2=apc2/fc2
disp("solution for (a)")
```

```
printf("\nafc1=Rs.%d\n e1=%dkWh\n annualfual1=%fkg \n fc1=Rs.%d \n om1=Rs.%d \n aoc1=Rs.%f \n apc1=Rs.%f \n gc1=%fkWh\n",afc1,e1,annualfuel1,fc1,om11,aoc1,apc1,gc1)
  disp("solution for (b)")
printf("\nafc2=Rs.%d\n e2=%dkWh\n annualfual2=%fkg \n fc2=Rs.%d \n om22=Rs.%d \n aoc2=Rs.%f \n apc2=Rs.%f \n gc2=%fkWh\n",afc2,e2,annualfuel2,fc2,om22,aoc2,apc2,gc1)
ogc=(apc1+apc2)/(e1+e2)

printf("\n\nsolution of (c)\nogc=Rs.%f/kWh",ogc)
```

Scilab code Exa 3.2 annual depreciation reserve

```
clear
clc
disp("example 3.2")
c=2*10^8;//cost
s=0.15;//salvage value
ul=25; ///useful value
i=0.08;//life of plant
disp("solution for (a)")
printf("\nannual straight line depreciation reserve =Rs.%.1eperyear\n",c*(1-s)/ul)
disp("solution for (b)")
it=(i+1)^25-1
iit=i/it
asdr=c*(1-s)*iit*100
printf("\n annual sinking fund depreciation reserve is =Rs%.3eperyear",asdr)
```

Scilab code Exa 3.3 solving accumulated depreciation

```
clear
clc
disp("example 3.3")
cost=2*10^8
sal=0.15
use=25
t=(1-(sal^(1/use)))
printf("rate of depretion by fixed percentage method =%fpersent",t*100)
rd=cost*(1-t)^10
printf("\nremaining depreciation at the end of 10th year =Rs.%f=Rs.%fx10^8",rd,rd/(10^8))
printf("\naccumulated depreciation at the end of 10 year is Rs.%f =Rs.%fx10^8",cost-rd,(cost-rd)/10^8)
```

Scilab code Exa 3.4 load factor verses generation cost

```
clc
clear
disp("example 3 4")
p=100  //ratring of steam station
fc=3000 //fixed cost of plant per year
rg=0.9 //90 paise per kv generation
```

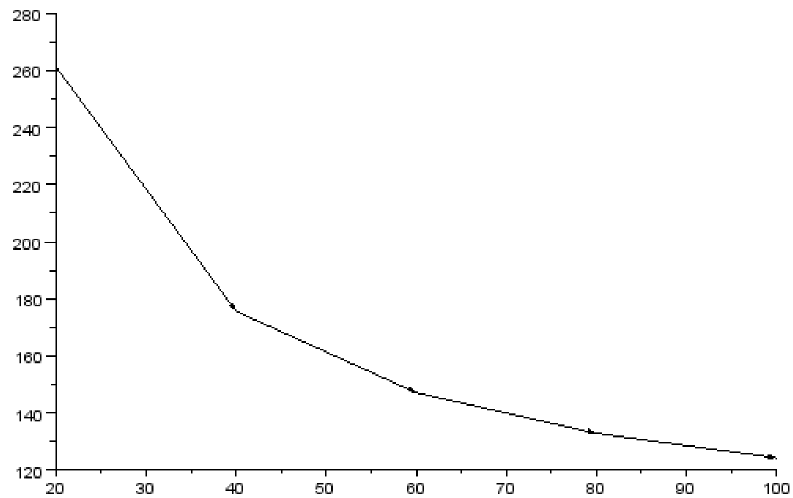

Figure 3.1: load factor verses generation cost

```
uf=1  //utilization factor 1
lf=20:20:100 //let load factor be 5 discreate units
lm=uf*lf  //lwt load MW is as same as lf as
   utilisation factor is 1
n=size(lm)
fc=fc*ones(1,n(2))
op=rg*100*ones(1,n(2))
for i=1:n(2)
    negp(1,i)=lm(i)*8760
    fcgp(1,i)=fc(i)*10000/negp(i)
    tgc(1,i)=fcgp(i)+op(i)
end
plot2d4(lf,tgc)
printf("load factor")
disp(lf)
printf("load MW\n")
fcgp=fcgp/100;op=op/100;tgc=tgc/100
printf("%dMW\t%dMW\t%dMW\t%dMW\t%dMW",lm(1),lm(2),lm
   (3),lm(4),lm(5))
```

```
disp("fixed cost")
printf("Rs%d\tRS%d\tRs%d\tRs%d\tRs%d",fc(1),fc(2),fc(3),fc(4),fc(5))
disp("number of KW hrs of energy generated in paise per unit of energy")
printf("%dkWh\t%dkWh\t%dkWh\t%dkWh\t%dkWh",negp(1),negp(2),negp(3),negp(4),negp(5))
disp("fixed cost in paise per unit of energy")
printf("Rs%.3f\tRS%.3f\tRs%.3f\tRs%.3f\tRs%.3f",fcgp(1),fcgp(2),fcgp(3),fcgp(4),fcgp(5))
disp("operating cost in paise per unit of energy")
printf("Rs%.3f\tRS%.3f\tRs%.3f\tRs%.3f\tRs%.3f",op(1),op(2),op(3),op(4),op(5))
disp("totla generation cost in paise per unit of energy")
printf("Rs%.3f\tRS%.3f\tRs%.3f\tRs%.3f\tRs%.3f",tgc(1),tgc(2),tgc(3),tgc(4),tgc(5))
```

Scilab code Exa 3.5 generation cost of per unit of energy

```
clear
clc
disp("example 3.5")
ic=120 //installed capacity
ccppkw=40000 ///capital cost of plant
iand=0.15 //interest and depreciation
fco=0.64 //fuel consumption
fc=1.5//fuel cost
oc=50*10^6 //operating cost
pl=100//peak load
lf=0.6 //load factor
al=lf*pl//avarrage load
printf(" average load %dMW",al)
```

```
eg=al*8760*10^3//energy generated
printf("\n energy generated =%ekWhr",eg)
ti=ic*ccppkw //total investiment
printf("\n total investement Rs.%e",ti)
ind=ti*iand*10^3//interest and depreciation
printf("\n investement amd depression is Rs.%e",ind)
fcons=eg*fco //fual consumption
printf("\n fuel consumtion is %ekgper year",fcons)
fcost=fcons*fc//fuel cost
aco=ti+fcost+ind+oc//annual cost
printf("\n fuel cost Rs.%eper year \n annual plant
    cost Rs%eper  year \n generation cost Rs%fper
    year",fcost,aco,aco/eg)
```

Scilab code Exa 3.6 comparision between costs of different alternators

```
clear
clc
disp("example 3.6")
md=50*10^3;//maximum demand in kW
ecy=0
pst=600*md+2.5*ecy//public supply tariff equation
lfr=0.5; //load factor
rc=20*10^3;//reserve capacity
cik=30000; //capital investiment
inad=0.15;///interest and depreciation
fuc=0.6;fuco=1.4;oct=0.8//fuel consumption//fuel
    cost//other cost
avl=md*lfr;//average load
ecy=avl*8760  //energy cosumption per year
disp("solution of (a)")
printf(" average load = %dkW \n energy consumton =
    %dkWh\n annual expenditure is Rs%dperyear\n",avl,
```

```
ecy,pst)
disp("(b) private steam plant")
ict=md+rc; //installed capacity
caint=cik*ict; //capital investiment
iande=inad*caint; //interest and depreciation
fuelcon=ecy*fuc; //fuel consumption
fucost=fuelcon*fuco; //fuel cost
opwe=oct*ecy //other expenditure
totex=iande+fucost+opwe//total expenditure
printf("\n installed capacity is Rs%d \n capital
   investiment is Rs%d \n interest and depreciation
   is Rs.%d \n fuel consumption is Rs.%f \n fuel
   cost is Rs.%f per year \n wage,repair and other
   expenses are Rs%f per year \n total expenditure
   is Rs%e per year",ict,caint,iande,fuelcon,fucost,
   opwe,totex)
```

Scilab code Exa 3.7 overall generation cost per kWh for thermal and hydro plant

```
clc
clear
disp("example 3 7")
md=500 //given maximum demand
lf=0.5 //load factor
hp=7200;he=0.36//operating cost of hydro plant
tp=3600;te=1.56 //operating cost of thermal plant
teg=md*1000*lf*8760 //total energy generated
printf("total energy generated per year %2.2eW",teg)
t=(hp-tp)/(te-he) //time of operating useing (de/dp)
ph=md*(1-t/8760) //from triangle adf
pt=md-ph
et=pt*t*1000/2
```

```
eh=teg-et
co=hp*ph*1000+he*eh+tp*pt*1000+te*et
ogc=co/teg
printf("\n capacity of hydro plant is %dMW \n
   capacity of thermal plant %dMW\n energy
   generatede by hydro plant %dkWh\n energy
   generated by thermal plant %dkWh\n over all
   generation cost is %.3f/kWh",ph,pt,eh,et,ogc)
```

Scilab code Exa 3.16 generation cost of a plant

```
clear
clc
disp("data 3.16")
pu=500*10^3  ;pc=2*pu //plant unit,plant capacity
land=11.865*10^9
cicost=30.135*10^9
ccost=land+cicost;   //capital cost =land cost+civil
    cost
plife=25;    //plant life
ir=0.16;    //interest rate
ond=1.5*10^-2;// o and mof capital cost
gr=0.5*10^-2  //grneral reserve of capital cost
calv=4158  //calorific value kj per kg
coalcost=990  //caol cost per ton
heat=2500//heat rate kcal/kWh
retur=0.08 //return
salvage=0
plf=0.69 ;auxcons=0.075 //auxiliary consumption
disp("cost calculation ")
disp("using sinking fund depreciation")
ande=(ir/((ir+1)^(plife)-1))*100
afixcost=ccost*(ir+ond+retur+gr+(ande/100))
```

```
afcppc=afixcost/pc
printf("annual depretion reserve is %fpersent \n
   annual fixed cost Rs%f \n annual fixed cost per
   Rs%dkWh",ande,afixcost,afcppc)
fclco=(heat*coalcost)/(calv*1000)
engepc=24*365*plf
enavil=engepc*(1-auxcons)
gencost=(afcppc/enavil)+fclco
printf("\nfuel cost Rs.%f/kWh \nenergy generated per
    kW of plant capacity Rs.%fkWh \nenergy available
    bus bar %fkWh \n generation cost Rs%f perkWh",
   fclco,engepc,enavil,gencost)
```

Scilab code Exa 3.17 to find the generation cost and total annual cost

```
clear
clc
disp("dat 3.17")
pco=120*10^3 //3 units of 40MW
caco=68*10^8 //6 year of consumption
inr=0.16 //intrest rate
de=2.5*10^-2 //depreciation
oanm=1.5*10^-2//OandM
ger=0.5*10^-2//general reserve
pllf=0.6 //plant load facot
aucon=0.5*10^-2 //auxiliary consumption
tac=caco*(inr+de+oanm+aucon) ///total cost
engpy=pco*pllf*24*365 //energy generatedper year
eabb=engpy*(1-ger) //energy available at bus bar
geco=tac/eabb //generation cost
printf(" total annual costs is Rs%e per year \n
   energy generated per year =%ekWh/year \n energy
   available at bus bar %ekWh/year \n generation
```

```
cost is Rs.%fper kWh",tac,engpy,eabb,geco)
```

Chapter 4

TARIFFS AND POWER FACTOR IMPROVEMENT

Scilab code Exa 4.1 monthly electricity consumption

```
clc
clear
disp('example 4 1')
day=30 //days
pll=40;nll=5;tll=3 //light load
pfl=100;nfl=3;tfl=5 //fan load
prl=1*1000 //refrigerator
pml=1*1000;nml=1 //misc. load
t1=2.74;t11=15//tariff
t2=2.70;t22=25  //tariff on 25 units
tr=2.32; //reamaining units
tc=7.00;//constant charge
dis=0.05//discount for prompt payment
te=(pll*nll*tll+pfl*nfl*tfl)*day+prl*day+pml*day
tee=te/1000
mb=tc+tr*(tee-t11-t22)+t1*t11+t2*t22
nmb=mb*(1-dis)
```

```
printf("total energy consumption in %d day %dunits \nthe monthly bill Rs%.2f \nnet monthly bill Rs%.2f",day,tee,mb,nmb)
```

Scilab code Exa 4.2 total electricity bill per year

```
clc
clear
disp('example 4 2')
l=100;//connected load
md=80;//maximum demand
wt=0.6; //working time
c=6000; //constant cost
t=700; //cost on per kW
re=1.8;//rate
ec=l*wt*8760//electricity consumption per year
teb=c+md*t+re*ec //total electricity bill per year
printf(" energy consumption %dkWh \n total electricity bill per year Rs%d",ec,teb)
```

Scilab code Exa 4.3 annual cost operating cost tariff

```
clc
clear
disp('example 4 3')
md=160;lff=0.7;dfc=1.7//maximum demand //load factor //diversity factor bt consumers
ic=200;//installed capacity
ccp=30000//capital cost of plant per kW
ctds=1800*10^6 //capital cost of transmission and distribution
```

```
idi=0.11 //interest ,depreciation insurance and taxes on capital investiment
fmc=30*10^6  //fixed managerial and general maintanance cost
ol=236*10^6 //operating labour ,maintanance and suppies
cm=90*10^6 //cost of metering ,billing and collection
eca=0.05  //energy consumed by auxillary
el=0.15//energy loss and maintanance
p=0.25
lf=0.8//load factor
ap=0.5 //addition energy for profit
disp('a')
printf(" capital cost of plant Rs%e \n total capital cost Rs%e\n interest ,depereiation system Rs%e ",ccp*ic*10^3,ccp*ic*10^3+ctds,(ccp*ic*10^3+ctds)*idi)
printf("\n sum of maximum demand of consumers energy prodused %dMW \n energy produced %ekWh \n energy consumed by auxilliries %ekWh\n energy output %ekWH \n energy sold to consumer %ekWh\n",md*dfc,md*8760*lff*10^3,md*8760*lff*eca*10^3,md*8760*lff*10^3*(1-eca),md*8760*lff*10^3*(1-eca)*(1-el))
disp('(b)fixed cost')
idetc=(ccp*ic*10^3+ctds)*idi
tot=idetc+fmc;
printf(" interest , deprecition etc Rs%e per year\n managerial and maintence Rs%.eper year \n total \t Rs%e ",idetc,fmc,tot)
pro=p*tot
gtot=tot+pro
printf("\n profit@%d \tRs%eper year \n grand total Rs%e per year",p*100,pro,gtot)
disp('Operating cost')
tot2=ol+cm
pro2=tot2*p
gtot2=tot2+pro2
printf(" Operating labour ,supplies maintenance etc
```

```
   Rs.%eper year \n metering,billing etc Rs%eper
   year\n total\t\tRs%e per year\n profit \t Rs%eper
    year \n grand total \t Rs%e per year",ol,cm,tot2
   ,pro2,gtot2)
disp('tariff')
co=gtot/(md*dfc*1000)
es=md*8760*lff*10^3*(1-eca)*(1-el)
cs=gtot2/es
printf(" cost per kW \tRs%e \n cost per kWh \tRs%e",
   co,cs)
disp('(b)')
ep=md*1000*8760*lf
printf(" energy produced %ekWh \n energy consumed by
    auxiliaries %ekWh/year \n energy output of plant
    %ekWh \n energy sold to consumer %ekWh",ep,ep*
   eca,ep*(1-eca),ep*(1-eca)*(1-el))
estc=ep*(1-eca)*(1-el)
```

Scilab code Exa 4.4 monthly bill and average tariff per kWH

```
clc
clear
disp('example 4 4')
v=230;ec=2020;//voltage //energy consumption
i=40;pf=1;t=2;c=3.5;rc=1.8;mon=30;//current/power
   factor/time/cost/reamining cost/month
ecd=v*i*pf*t*mon/1000 //energy corresponding to
   maximum demand
cost=ecd*c
ren=ec-ecd
rcost=ren*rc
```

```
tmb=cost+rcost
at=tmb/ec
printf(" energy corresponding to maximum demand
   %dkWh \n cost of above energy Rs%d \n remaining
   energy %dkWh \n cost of reamaining energy Rs%.1f
   \n total monthly bill Rs.%.1f\n avarage tariff
   Rs%.3fper kWh",ecd,cost,ren,rcost,tmb,at)
```

Scilab code Exa 4.5 better consumption per year

```
clc
clear
disp('example 4 5')
t1=3000;t11=0.9 //cost equation
t2=3; //rate
x=t1/(t2-t11)
printf("if energy consumption per month is more than
    %.1fkWh,\ntariff is more suitable",x)
```

Scilab code Exa 4.6 avarage energy cost in different case

```
clc
clear
disp("example 4 6")
aec=201500 //annual energy consumption
lf=0.35//load factor constnt
t=4000//tariff
tmd=1200//tariff for maximum demand
t3=2.2
lfb=0.55 //load factor improved
ecd=0.25//energy consumption reduced
```

```
md=aec/(8760*lf)
yb=t+md*tmd+t3*aec
mdb=aec/(8760*lfb)
ybb=t+mdb*tmd+t3*aec
ne=aec*(1-ecd)
md3=ne/(8760*lf)
ybc=t+md3*tmd+t3*ne
aeca=yb/aec
aecb=ybb/aec
aecc=ybc/ne
disp('a')
printf("maximum demand %.2fkW \n yearly bill Rs.%d
   per year \n(b)\n maximum demand %.2fkW \n yearly
   bill Rs.%dper year",md,yb,mdb,ybb)
disp("c")
printf(" new energy %dkWh \n maximum demand %.2fkW \
   n yearly bill Rs.%dper year \n average energy
   cost in case a Rs%.4fper kWh \n average energy
   cost in case b Rs%.3fper kWh\n average energy
   cost in case c Rs%.3fper kWh ",ne,md3,ybc,aeca,
   aecb,aecc)
```

Scilab code Exa 4.7 selection of cheeper transformer

```
clc
clear
disp('example 4 7')
pl1=20;pf1=0.8;t1=2000//load in MVA //power factor
   //duration
pl2=10;pf2=0.8;t2=1000//load in MVA //power factor
   //duration
pl3=2;pf3=0.8;t3=500//load in MVA //power factor //
   duration
```

```
pt=20 ///transformar power rating
fte=0.985;ste=0.99 ///full load efficiency for first
    and second transformer
ftl=120;stl=90 //core  loss inKW for first and
   second transformer
cst=200000;//cost of second transformer with
   compared with first transformer
aid=0.15;//annual  interest and depreciation
ce=0.8 //cost of energy
tfl=pt*(1-fte)*1000//total full load
fle=tfl-ftl //full load copper loss
elc=fle*t1+(fle*t2/(pt/pl2)^2)+(fle*t3/(pt/pl3)^2)
   //energy loss due to copper loss
eli=ftl*(t1+t2+t3)//energy loss due to iron loss
celo=(elc+eli)*ce //cost of energy loss
disp("   first transformer")
printf(" total full load losses %dkW \n full load
   copper losses %dkW \n energy loss due to copper
   losses %dkWh/year\n energy loss due to iron
   losses %dkWh/year \n cost of energy losses
   Rs%dper year",tfl,fle,elc,eli,celo)
stfl=pt*(1-ste)*1000//total full load
sle=stfl-stl//full load copper loss
selc=sle*t1+(sle*t2/(pt/pl2)^2)+(sle*t3/(pt/pl3)^2)
   //energy loss due to copper loss
seli=stl*(t1+t2+t3)//energy loss due to iron loss
scelo=(selc+seli)*ce//cost of energy loss
disp("   second transformer")
printf(" total full load losses %dkW \n full load
   copper losses %dkW \n energy loss due to copper
   losses %dkWh/year\n energy loss due to iron
   losses %dkWh/year \n cost of energy losses
   Rs%dper year",stfl,sle,selc,seli,scelo)
aidc=stfl*aid*1000
tybc=aidc+scelo
printf("additional interest and depreciation due to
   higher cost of second transformer Rs%d \n total
   yearly charges for second transformer Rs%d per
```

```
year",aidc,tybc)
```

Scilab code Exa 4.8 most economical power factor and rating of capacitor bank

```
clc
clear
disp('example 4 8')
p=500 //load
pf=0.8//power factor
t=400 //tariff
md=100 //maximum demand tariff
ccb=600 //cost of capacitor bank
id=0.11//interest and depreciation
sd=ccb*id/t//sin(ph2)
d2=asind(sd)
pf2=cosd(d2)
kva=p*(tand(acosd(pf))-tand(d2))
printf(" the most economic power factor %.3f lagging
    \n kvar requirement %.2fkVAR",pf2,kva)
```

Scilab code Exa 4.9 maximum load at unity power factor which can be supplied by this substation

```
clc
clear
disp("example 4 9")
l1=300;//load and power factor for three different
    loads
```

```
pf1=1;
l2=1000;
pf2=0.9;
l3=1500;
pf3=0.8
printf(" for %dkW unit power factor load \n power factor angle %.f\n reactive power %.fkvr",l1,acosd(pf1),l1*(tand(acosd(pf1))))
printf(" \nfor %dkW unit power factor load \n power factor angle %.2f\n reactive power %.2fkvr",l2,acosd(pf2),l2*(tand(acosd(pf2))))
printf(" \nfor %dkW unit power factor load \n power factor angle %.2f\n reactive power %.2fkvr",l3,acosd(pf3),l3*(tand(acosd(pf3))))
tl=l1+l2+l3
tt=l3*(tand(acosd(pf3)))+l2*(tand(acosd(pf2)))+l1*(tand(acosd(pf1)))
printf("\n total kW \t%dkW\n total kVAR %.1fkVAR \n total kVA %.2fkVA \n overall power factor %.3flagging",tl,tt,(tl^2+tt^2)^0.5,tl/(tl^2+tt^2)^0.5)
printf("\n the maximum unity power factor load which yhe station can supply is equal to the kVA i.e.%.2fkVR",(tl^2+tt^2)^0.5)
```

Scilab code Exa 4.10 kvar rating of star connected capacitor and capacitance for power factor

```
clc
clear
disp("example 4 10")
v=400//voltage
i=25///current
```

```
pf=0.8//at power factor
pf2=0.9//over all power factor
kw=v*i*pf*sqrt(3)/1000
printf("kw rating of induction motor %.2fkW",kw)
dm=acosd(pf)
rp=kw*tand(dm)
printf("\n power factor angle %.2f \n reactive power
    %.2fkVR",dm,rp)
fdm=acosd(pf2)
rp2=kw*tand(fdm)
printf("\n final power factor %.2f \n final
   reactance power %.2fkVR",fdm,rp2)
ckvb=rp-rp2
cc=ckvb*1000/(sqrt(3)*v)
vc=v/sqrt(3)
xc=vc/cc
f=50
cec=1*10^(6)/(xc*2*%pi*f)
printf("\n kvar rating of capacitor bank %.4f \n
   current through each capacitor %.2fA\n voltage
   across each capacitor %.2f \n reactance of each
   capacitor %.2fohm \n capacitance of each
   capacitance %.2fuf",ckvb,cc,vc,xc,cec)
```

Scilab code Exa 4.11 kva and power factor of synchronous motor

```
clc
clear
disp("example 4 11")
v=400//line voltage
i=50 //line current
pf=0.8 //at power factor
pf2=0.95 // overall power factor
```

```
sm=25 //hp of synchronous motor
e=0.9//efficiency
kwri=v*i*pf*sqrt(3)/1000
kvari=v*i*sqrt(3)/1000
karri=(-kwri^2+kvari^2)^0.5
kwsm=sm*735.5/(e*1000)
tkw=kwri+kwsm
printf(" kw rating of installation %.1fkW \n kVA
   rating of installation %.2fkva \n kVAR rating %.2
   fkvar \n kw input to synchrounous motor %.2fkw \n
    total kw=%.2f\n",kwri,kvari,karri,kwsm,tkw)
pd=acosd(pf2)
tkr=tkw*tand(pd)
krsm=tkr-karri
kasm=(kwsm^2+krsm^2)^0.5
pfsm=kwsm/kasm
if krsm<0 then
    ch=char('capacitor')
    ich=char('leading')
else
    ch=char('inductive')
    ich=char('lagging')
end
printf(" overall power factor angle %.2fkw \n total
   kvar %.2fkvar \n kvar of synchrounous motor %.2
   fkvar %c \n kva of synchrounous motor %.2fkva \n
   power factor of synchrounous motor %.2f %c",pd,
   tkr,krsm,ch,kasm,pfsm,ich)
```

Scilab code Exa 4.12 parallel operation of synchronous and induction motor under different

```
clc
clear
disp("example 4 12")
psm=100 //power of synchrounous motors
pim=200 //power of inducion motor
v=400 //voltage
pff=0.71;pp=-1//power factor
rsm=0.1 //resistance of synchrounous motor
rt=0.03 //resistance of cable
pf(1)=1;p(1)=1 //power factor in a
pf(2)=0.8;p(2)=1 //power factor in b
pf(3)=0.6;p(3)=1 //power factor in c
i1=pim*1000/(v*pff*sqrt(3))
i11=i1*(complex(pff,pp*sind(acosd(pff))))
i2f=psm*1000/(v*sqrt(3))
ch=['a' 'b' 'c']
for i=1:3
    printf("\n (%c)",ch(i))
    d=acosd(pf(i))
    it(i)=i11(1)+complex(i2f,(p(i)*i2f*tand(d)))
    opf(i)=cosd(atand(imag(it(i))/real(it(i))))
    clsm=3*((i2f)^2)*rsm
    clt=3*(abs(it(i))^2)*rt/1000
    printf("\n total current %.2f %.fjA \n overall
       power factor %.3f lagging \n copper losses in
        synchrounous motor %.fW \n copper losses in
       cable %.2fKW",it(i),imag(it(i)),opf(i),clsm,
       clt)
end
disp("(d)")
printf("copper loss of synchronous motor this is
   evidently minimum when tand=%d cosd=%d",0,1)
```

Scilab code Exa 4.13 finding power factor and load on different generator

```
clc
clear
disp('example 4 13')
p=2//constant output in MW
pf=0.9//power factor
pa=10//load
pb=5
pfb=0.8//power factor at load of 5MW
td=tand(acosd(pf))
go=p*(1-td*%i)
op=0.8
tp=tand(acosd(pfb))
printf("power factor of indection generator is leading therefor induction generator output %d%.2fiMVA /n (a) \n",real(go),imag(go))
tl=pa*(1+tp*%i)
sg=tl-go
da=atand(imag(sg)/real(sg))
printf(" total load %d+%.1fiMW \n synchronous generator load %d+%.3fiMW \n\t\t=%.2fMW at angle %.2f \n power factor of synchronous generator is %.2flagging",real(tl),imag(tl),real(sg),imag(sg),abs(sg),da,cosd(da))
tl1=pb*(1+tp*%i)
sg1=tl1-go
da1=atand(imag(sg1)/real(sg1))
disp("(b)")
printf(" total load %d+%.1fiMW \n synchronous generator load %d+%.3fiMW \n\t\t=%.2fMW at angle %.2f \n power factor of synchronous generator is %.2flagging",real(tl1),imag(tl1),real(sg1),imag(sg1),abs(sg1),da1,cosd(da1))
```

Scilab code Exa 4.14 loss if capacitor is connected in star and delta

```
clc
clear
disp("example 4 14")
c=40*10^(-6) //bank of capacitors in farads
v=400 //line voltage
i=40///line current
pf=0.8//power factor
f=50//line frequency
xc=1/(2*%pi*f*c)
ic=v/(sqrt(3)*xc)
il=i*(pf-sind(acosd(pf))*%i)
til=il+%i*ic
od=atand(imag(til)/real(til))
opf=cosd(od)
nlol=(abs(od)/i)^2
disp("(a)")
printf(" line current of capacitor bank %.1fA \n
    load current %d%diA \n total line current %d%.1
    fjA \n overall p.f %.3f \n new line loss to old
    line loss  %.3f",ic,real(il),imag(il),real(til),
    imag(til),opf,nlol)
pcb=(v/xc)
printf("\n phase current of capacitor bank %.3fA",
    pcb)
lcb=pcb*sqrt(3)
printf("\n line current of capacitor bank %.1fA",lcb
    )
tcu=il+lcb*%i
printf("\n total current %d%.1fjA =%.2fA at an angle
     %.2f",tcu,imag(tcu),abs(tcu),atand(imag(tcu)/
    real(tcu)))
pf2=cosd(atand(imag(tcu)/real(tcu)))
printf("\n power factor %.1f \n ratio of new line
    loss to original loss %.3f",pf2,(abs(tcu)/i)^2)
```

Scilab code Exa 4.15 persentage reduction in line loss with the connection of capacitors

```
clc
clear all
disp("example 4 15")
p=30 //b.h.p of induction motor
f=50//line frequency
v=400//line voltage
e=0.85//effiency
pf=0.8 //power factor
i=p*746/(v*e*pf*sqrt(3))
i=i*complex(pf,-sind(acosd(pf)))
ccb=imag(i)/sqrt(3)
xc=v/ccb
c=10^6/(2*f*%pi*xc)
prl=((abs(i)^2-real(i)^2)/abs(i)^2)*100
printf(" current drawn by motor is %.1fA \n the line
    loss will be minimum when i is munimum.the
    minimum value of i is %dA and occurs when the
    capacitor bank draws a line current of %djA \n
    capacitor C %.2fuf \n percentage loss reduction
    %d",abs(i),i,imag(i),abs(c),prl)
```

Scilab code Exa 4.16 kva of capacitor bank and transformerand etc

```
clc
clear
```

```
disp("example 4 16")
po=666.66 //power
f=50 //frequency
v=400 //voltage
pf=0.8 ;p=-1//power factor
pf2=0.95;p2=-1//improved power factor
vc=2200 //capacitor voltage
rc=vc
il=po*1000/(v*pf*sqrt(3))
il1=il*(complex(pf,p*sind(acosd(pf))))
i2c=il*pf
tad=tand(acosd(pf2))
i2=complex(i2c,i2c*tad*p2)
printf(" load current i1 %.2f%.2fA \n load current
   current on improved power factor %.2f%.2fjA",il1,
   imag(il1),i2,imag(i2))
disp("(a)")
ic=abs(il1-i2)
ilc=ic*v/vc
pic=ilc/sqrt(3)
xc=vc/pic
ca=10^6/(2*%pi*f*xc)
printf(" line current of %dV capacitor bank %.2fA\n
   line current of %d capacitor bank %.2fA \n phase
   current of capacitor bank %.2fA \n reactance %.2f
    \n capacitance %.2fF*10^(-6)",v,ic,vc,ilc,pic,xc
   ,ca)
disp("(b)")
kr=3*vc*pic/1000
printf(" kVA rating %.1fkVA \n kVA rating of
   transformer to convert %dV to %dV will be the
   same as the kVA rating of capacitor bank",kr,v,vc
   )
pl=100*(abs(il1)^2-abs(i2)^2)/abs(il1)^2
printf("percentage reduction in losses %d percent",
   pl)
disp("(d)")
pi=ic/sqrt(3)
```

```
xcc=v/pi
cc=1*10^6/(2*%pi*f*xcc)
roc=ca/cc
printf(" phase current %.1fA \n reactance %.2fohm \n
    capasitance %.2f*10^-6F \n ratio of capacitance
   %.3f",pi,xcc,cc,roc)
```

Scilab code Exa 4.17 MVA rating of three winding of transformer

```
clc
clear
disp("example 4 17")
v1=132//line voltage at primary
v2=11//line voltage at secondary
p=10 //power
pf=0.8 //power factor
mva=p*(complex(pf,sind(acosd(pf))))
printf(" MVA rating of secondary = %dMVA =%d+%djMVA
   \n ",p,mva,imag(mva))
printf("\n since the power factor at primary
   terminals is unity,rating of primary need be
   %dMVA only \n the tertiary will supply capacitor
   curren.since p.f is to be raised to 1 ,the mav
   compensation needed is 6MVA so rating of
   teritiary is %dMVA",mva,imag(mva))
```

Scilab code Exa 4.18 load power and power factor of 3 ph alternator

```
clc
```

```
clear
disp("example 4 18")
v=11 //line voltage
f=50//line frequency
l=400 //load of alternator
pf=0.8 //power factor
e=0.85//efficiency
p=l/pf
lo=l+p*sind(acosd(pf))*%i
disp("a")
printf("when pf is rased to 1 the alternator can
    supply %dkW for the same value of armture current
     hence it can supply %dKW to synchronous motor",p
    ,p-l)
disp("b")
printf("b.h.p =%.2fHP",100*e/0.746)
kvam=p-lo
td=atand(imag(kvam)/real(kvam))
pff=cosd(td)
printf("\ncosd=%.3fleading",pff)
```

Scilab code Exa 4.19 maintaining of poer factor using capacitor

```
clc
clear
kw=100  //let kw=100kw
pf=0.6 //power foctor
pf2=0.8 //power factor
kvar=kw*tand(acosd(pf))
kvar2=kw*tand(acosd(pf2))
ckar=((kvar-kvar2))/10
ck=round(ckar)*10
disp("example 4 19")
```

```
printf("capacitor kVAR required for %dkW\n load for
   same power factor improvement %dKVAR",round(ckar)
   ,ck)
pff=0.95:-0.05:0.4
pff=200*pff
n=size(pff)
z=zeros(1,n(2))
```

Scilab code Exa 4.20 maintaining of poer factor using capacitor

```
clc
clear
disp("example 4 20")
p=160 //kva for transformer
pf=0.6 //power factor
el=96 //effective load
eli=120 //effective load increase
rc=eli*(tand(acosd(pf))-tand(acosd(eli/p)))
opf=eli/p
printf(" required capacitor kVAR %dKVAR \n overall
   power factor %.2f \n it is seen that point d is
   on %.2f line",rc,opf,opf)
```

Scilab code Exa 4.21 difference in annual fixed charges of consumer for change in pf

```
clc
```

```
clear all
disp("example 4 21")
md=800 //maximum demand
pf=0.707 //power factor
c=80 //cost
p=200 //power
e=0.99//efficiency
pff=0.8 //fulload pf
ikva=md/pf
iafc=(round(ikva*100)*(c)/100)
rsm=ikva*pf
act=p*(0.7355)/e
at=-act*sind(acosd(pff))
tkw=rsm+act
tkvr=rsm+at
tkva=(tkw^2+tkvr^2)^0.5
ikvad=tkva-ikva
infc=ikvad*c
printf(" initial kVA %.2fkVA \n initial annual fixed
    charges Rs%.1f \n after installation of
   synchronous motor reactive power of induction
   motor %dkVars\n active power input of
   synchrounous motor %.2fkW\n reactive power input
   to synchrounous motor %.2fKVAR \n total kW %.2fKW
    \n total kVars %.2fkVARS \n total kVA %.2fkVA \n
    increase in KVA demand %.2fkVA\n increase in
   annual fixed charges Rs%.1f ",ikva,iafc,rsm,act,
   at,tkw,tkvr,tkva,ikvad,infc)
```

Scilab code Exa 4.22 finding annual cost and difference in annual cost in two units

```
clc
clear
disp("example 4 22")
```

```
t=16//working  time
d=300 //working days
hv=1;hvmd=50 //tariff on high voltage
lv=1.1;lvmd=60 //tariff on low voltage
al=250//avarage load
pf=0.8//power factor
md=300 //maximum demand
hvec=500//cost of hv equipment
l=0.05 //loss of hv equipment
id=0.12  //interest and depreciistion
ter=al*md*t
mdv=md/pf
printf(" total energy requirement %2.2ekWH \n
   maximum demand %dKVA",ter,mdv)
disp("(a)HV supply")
chv=mdv*hvec
idc=chv*id
ere=ter/(1-l)
dch=mdv*hvmd
ech=round(ere*hv/1000)*1000
tanc=ech+dch+idc
printf(" cost of HV equipment Rs%e\n interest and
   depreciation charges Rs%d \n energy received
   %ekWh\n demand charges Rs%d \n energy charges
   Rs%2e \n total annual cost Rs%d",chv,idc,ere,dch,
   ech,tanc)
disp("(b) LV supply")
lvdc=mdv*lvmd
lvec=ter*lv
lvtac=lvec+lvdc
lvdac=lvtac-tanc
printf(" demand charges Rs%d \n energy charges Rs%2.
   e \n total annual cost Rs%d \n difference in
   annual cost Rs%d",lvdc,lvec,lvtac,lvdac)
```

Chapter 5

SELECTION OF PLANT

Scilab code Exa 5.1 slection of plant on criteria of investment other

```
clear
clc
disp("solution of exp 5.1")
aerpe=100*10^6
md=25*10^3
function [u]=ucc(dd,e)
    u=600*dd+0.3*e //rs per kW
    endfunction
sc=30*10^3

a.cci=9000//per kW
a.shr=4000
b.cci=10500
b.shr=3500
c.cci=12000
c.shr=3000
salc=3000
sal=2280
sh=10
```

```
tax=0.04
ins=0.5*10^-2
cir=0.07
hv=5000//l cal per kg
fuc=225//rs per ton
acsnm=150000//for each plan
pl=20
dr=cir/((cir+1)^pl-1)
tfcr=cir+dr+tax+ins
printf("depreciation rate %f \n total fixed rate =%f
    ",dr,tfcr)
a.ci=a.cci*sc;b.ci=b.cci*sc;c.ci=c.cci*sc
a.afca=a.ci*tfcr;b.afca=b.ci*tfcr;c.afca=c.ci*tfcr
a.afuc=a.shr*fuc*10^8/(hv*10^3)
b.afuc=b.shr*fuc*10^8/(hv*10^3)
c.afuc=c.shr*fuc*10^8/(hv*10^3)
ass=12*(salc+sh*sal)
tota=a.afca+ass+a.afuc+acsnm
totb=b.afca+ass+b.afuc+acsnm
totc=c.afca+ass+c.afuc+acsnm
    printf("\nannual fixed cost of a is Rs%d   fuel
       cost of plan a is Rs%d and total cost of a is
        Rs%d",a.afca,a.afuc,tota)
printf("\nannual fixed cost of b is Rs%d   fuel cost
     of plan b is Rs%d and total cost of b is Rs%d",b
    .afca,b.afuc,totb)
printf("\nannual fixed cost of c is Rs%d   fuel cost
     of plan c is Rs%d and total cost of c is Rs%d",c
    .afca,c.afuc,totc)

ppt=ucc(md,aerpe)
printf("\nannual cost of purchasing electricty from
    utility is Rs600x%d+0.3x%.1e is Rs%d",md,aerpe,
    ppt)
```

Scilab code Exa 5.2 slection of plant on criteria of investment with out interest and depreciation

```
clear
clc
disp("example 5.2")
aer=100*10^6
md=25*10^3
function [u]=ucc(dd,e)
   u=600*dd+0.3*e //rs per kW
   endfunction
p=30*10^3
ap=9000//per kW
ahr=4000
bp=10500
bhr=3500
cp=12000
chr=3000
salc=3000
sal=2280
sh=10
t=0.04
i=0.5*10^-2
r=0.07
hv=5000//l cal per kg
fuc=225//rs per ton
mc=150000//for each plan
n=20
dr=r/((r+1)^n-1)
pwf=r/(1-(r+1)^(-n))
printf("persent of worth factor is %f",pwf)
afc=ahr*fuc*10^8/(hv*10^3)
```

```
bfc=bhr*fuc*10^8/(hv*10^3)
cfc=chr*fuc*10^8/(hv*10^3)
ass=12*(salc+sh*sal)
aaoc=ass+mc+afc
baoc=ass+mc+bfc
caoc=ass+mc+cfc
ai=ap*p;bi=bp*p;ci=cp*p
atac=(t+i)*ap*p+aaoc
btac=(i+t)*bp*p+baoc
ctac=(i+t)*cp*p+caoc
uts=ucc(md,aer)
apw=atac/pwf;bpw=btac/pwf;cpw=ctac/pwf;utss=uts/pwf
ta=apw+ai;tb=bpw+bi;tc=cpw+ci
printf("\nannual cost excludinding interest and \ndepreciation of a \t\tRs%d \npersent worth factor \t\t %f \npresent worth annual cost of a is Rs%d \n investement of a is \tRs%d \n total persent worth of a is \t%d",atac,pwf,apw,ai,ta)
printf("\n\n annual cost excludinding interest and \ndepreciation of b \t\tRs%d \npersent wort factor \t\t%f \npresent worth annual cost of b is Rs%d \n investement of b is \tRs%d \n total persent worth of b is \t%d",btac,pwf,bpw,bi,tb)
printf("\n \nannual cost excludinding interest and \ndepreciation of c \t\tRs%d \npersent wort factor \t\t%f \npresent worth annual cost of c is Rs%d \n investement of c is \tRs%d \n total persent worth of c is \t%d",ctac,pwf,cpw,ci,tc)
printf("\n \nannual cost excludinding interest and \ndepreciation of utility service \tRs%d \npersent wort factor \t\t\t%f \npresent worth annual cost of utility service is Rs%d \n investement of utility service is \t\t nill \n total persent worth of utility service is %d",uts,pwf,utss,utss)
printf("\n\n\tsince the present worth of the utility service is the minimum,it is the obvious choice \nout of the other plans,plan A is the best since
```

```
it has the lowest present worth")
```

Scilab code Exa 5.3 calculate the capital cost

```
clear
clc
disp("example 5.3")
aer=100*10^6   //from example 5.1
md=25*10^3
function [u]=ucc(dd,e)
   u=600*dd+0.3*e //rs per kW
   endfunction
p=30*10^3
ap=9000//per kW
ahr=4000
bp=10500
bhr=3500
cp=12000
chr=3000
salc=3000
sal=2280
sh=10
t=0.04
i=0.5*10^-2
r=0.07
hv=5000//l cal per kg
fuc=225//rs per ton
mc=150000//for each plan
n=20
dr=r/((r+1)^n-1)
pwf=r/(1-(r+1)^(-n))
uts=ucc(md,aer)
afc=ahr*fuc*10^8/(hv*10^3)
```

```
bfc=bhr*fuc*10^8/(hv*10^3)
cfc=chr*fuc*10^8/(hv*10^3)
ass=12*(salc+sh*sal)
aaoc=ass+mc+afc
baoc=ass+mc+bfc
caoc=ass+mc+cfc
aw=([[dr+t+i]*ap*p+aaoc]/r)+ap*p
bw=([[dr+t+i]*bp*p+baoc]/r)+bp*p
cw=([[dr+t+i]*cp*p+caoc]/r)+cp*p
utt=uts/r+p
printf("\n plan A is \t\tRs.%d \n plan B is \t\tRs.%d \n planC is \t\tRs.%d \nutility services is \tRs%d",aw,bw,cw,utt)
disp("the utility service has the lowest capitalized cost and is the obvious choice. Out of the other plans,plan A is the best")
```

Scilab code Exa 5.4 rate of return method for best plan

```
clear
clc
disp("example 5.4")
aer=100*10^6
md=25*10^3
utse=6600*10^4
p=30*10^3
ap=9000//per kW
ahr=4000
bp=10500
bhr=3500
cp=12000
chr=3000
salc=3000
```

```
sal=2280
sh=10
t=0.04
i=0.5*10^-2
r=0.07
hv=5000//l cal per kg
fuc=225//rs per ton
mc=150000//for each plan
n=20
dr=r/((r+1)^n-1)
pwf=r/(1-(r+1)^(-n))
afc=ahr*fuc*10^8/(hv*10^3)
bfc=bhr*fuc*10^8/(hv*10^3)
cfc=chr*fuc*10^8/(hv*10^3)
ass=12*(salc+sh*sal)
aaoc=ass+mc+afc
baoc=ass+mc+bfc
caoc=ass+mc+cfc

sol.a.totalannualcost=(t+i)*ap*p+aaoc
sol.b.totalannualcost=(i+t)*bp*p+baoc
sol.c.totalannualcost=(i+t)*cp*p+caoc

sol.a.pinvestement=ap*p;sol.b.pinvestement=bp*p;sol.
    c.pinvestement=cp*p

sol.a.annuity=utse-sol.a.totalannualcost;
sol.b.annuity=utse-sol.b.totalannualcost;
sol.c.annuity=utse-sol.c.totalannualcost;

sol.a.ratioaandp=sol.a.annuity/sol.a.pinvestement;
sol.b.ratioaandp=sol.b.annuity/sol.b.pinvestement;
sol.c.ratioaandp=sol.c.annuity/sol.c.pinvestement;
function [R]=alt(r)
    R=abs(r/(1-wr))
endfunction
ra=round((sol.a.ratioaandp)*100)
    rb=round((sol.b.ratioaandp)*100)
```

```
    rc=round((sol.c.ratioaandp)*100)
for x=-0.12:0.001:-0.07 //for itration
    wr=(1+x)^n
    re=alt(x)
    re=(round(re*100))
        if  re==ra then
     sol.a.return=(abs(x)*100)
        end
        if re==rb then
     sol.b.return=(abs(x)*100)
        end
         if re==rc then
     sol.c.return=(abs(x)*100)
         end
 end
 disp("for (a)")
printf("total annual cost Rs.%d\ninvestement Rs.%d\
   nannuity Rs%d \nratio of a and b %f \nrate of
   return %.1fpercent",sol.a.totalannualcost,sol.a.
   pinvestement,sol.a.annuity,sol.a.ratioaandp,sol.a
   .return)
disp("for (b)")
printf("total annual cost Rs.%d\ninvestement Rs.%d\
   nannuity Rs%d \nratio of a and b %f \nrate of
   return %.1fpercent",sol.b.totalannualcost,sol.b.
   pinvestement,sol.b.annuity,sol.b.ratioaandp,sol.b
   .return)
disp("for (c)")
printf("total annual cost Rs.%d\ninvestement Rs.%d\
   nannuity Rs%d \nratio of a and b %f \nrate of
   return %.1fpercent",sol.c.totalannualcost,sol.c.
   pinvestement,sol.c.annuity,sol.c.ratioaandp,sol.c
   .return)
sb=sol.b.annuity-sol.a.annuity
sc=sol.c.annuity-sol.b.annuity
ib=sol.b.pinvestement-sol.a.pinvestement
ic=sol.b.pinvestement-sol.a.pinvestement
rcb=sb/ib;rcc=sc/ic;
```

```
printf("\nsaving in annual cost excluding interest
   and depreciation B over A \t %d C over A \t %d",
   sb,sc)
printf("\nadditional investement P is \t\t\t\tB over
    A \t %d C over A \t %d",ib,ic)
printf("\nrate of saving to investement \t\t\t\
   tAoverB \t\t %f BoverC  \t%f",rcb,rcc)
printf("\nrate of return on capital investement\n
   evidently plan A is the best \t\t\t\tA over B \
   tNegative B over C \tNegative")
```

Chapter 7

THERMAL POWER PLANTS

Scilab code Exa 7.1 calculation of energy input to the thermal plant and output from thermal plant

```
clear
clc
disp("exanple7.1")
pow=100*10^6
calv=6400
threff=0.3
elceff=0.92
kcal=0.239*10^-3
eo=pow*3600
ei=eo/(threff*elceff)
eikc=ei*kcal
colreq=eikc/6400
printf("energy output in 1 hour is %eWatt.sec ",eo);
printf("\nenergy input in one hour is %ejoules Watt.
    sec\n",ei)
printf(" energy input in 1 hour is %ekcal.",eikc);
printf("\n coal required is %.3fkg per hour",colreq)
    ;
```

Chapter 8

hydro electric plants

Scilab code Exa 8.1 hydro plant power with parameters of reservoir

```
clear
clc
disp("example 8.1")
h=100 //given height
q=200 //discharge
e=0.9 //efficiency
p=(735.5/75)*q*h*e
printf("\npower developed by hydro plant is %ekW",p)
```

Scilab code Exa 8.2 STORAGE CAPACITY AND HYDRO GRAPH

```
clear
clc
disp("example 8.2")
```

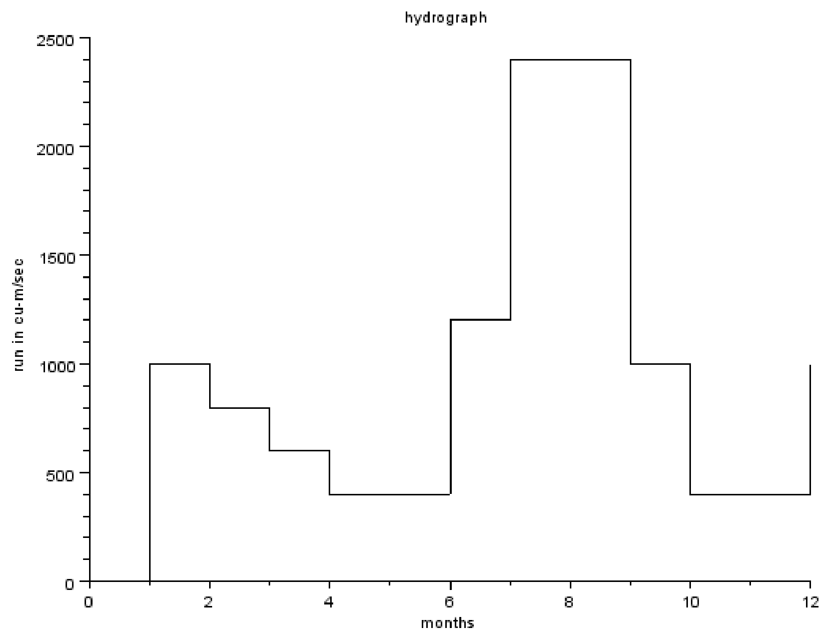

Figure 8.1: STORAGE CAPACITY AND HYDRO GRAPH

```
flow=[0 1000 800 600 400 400 1200 2400 2400 1000 400 400 1000] //flow in matrix from in the order of months
y=0:12
h=150
e=0.85
avg=sum(flow)/12
printf("\naverage rate of inflow is %dcu-m/sec",avg)
p=(735.5/75)*avg*h*e
printf("\npower developed is %fkW",p)
plot2d2(y,flow)

xtitle('hydrograph','months','run in cu-m/sec')
disp("hydrograph is ploted in figure")
for x=1:12
       t=flow(1,x)
    a=avg
        if t<a|t==avg then
        t=0
    else
        t=t-1000
       end
     flow1(1,x)=t;
    end
sto=sum(flow1)
printf("\nstorage capacity of given plant is %dsec-m-month",sto)
```

Scilab code Exa 8.3 STORAGE CAPACITY AND HYDRO GRAPH

```
clear
```

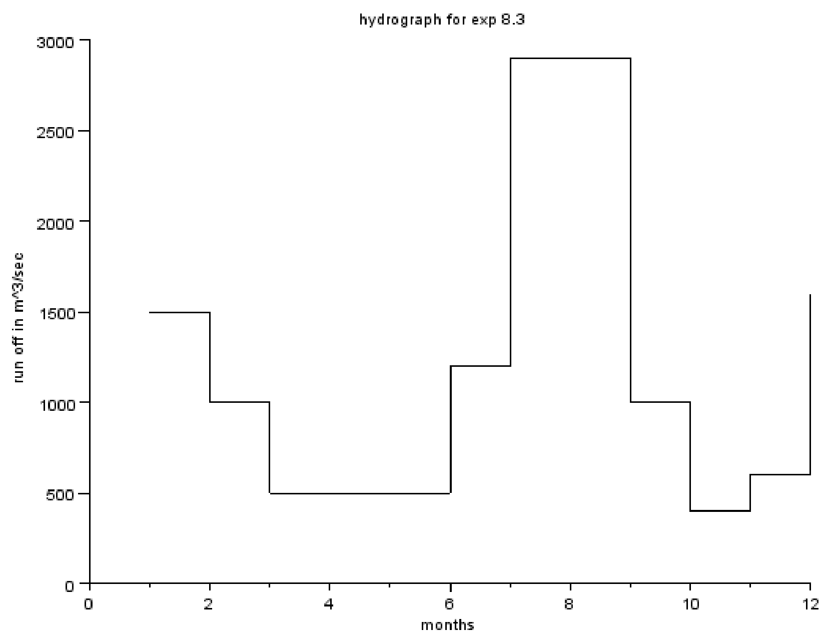

Figure 8.2: STORAGE CAPACITY AND HYDRO GRAPH

```
clc
disp("example 8.3")
flow=[1500 1000 500 500 500 1200 2900 2900 1000 400
    600 1600]
cod=1000//constant demand
plot2d2(flow)
xtitle('hydrograph for exp 8.3','months','run off in
     m^3/sec')
avg=sum(flow)/12
if cod<avg then
    for x=1:6
       t=flow(1,x)
        if t>cod|t==avg then

        t=0
    else
        t=cod-t
       end
     flow1(1,x)=t;
 end

 else
     for x=1:12
       t=flow(1,x)
    a=cod
        if t>a|t==avg then
        t=0
    else
        t=t-cod
       end
     flow1(1,x)=t;
    end
end

sto=sum(flow1)
printf("storage capacity of plant is %dsec-m-month",
    sto)
```

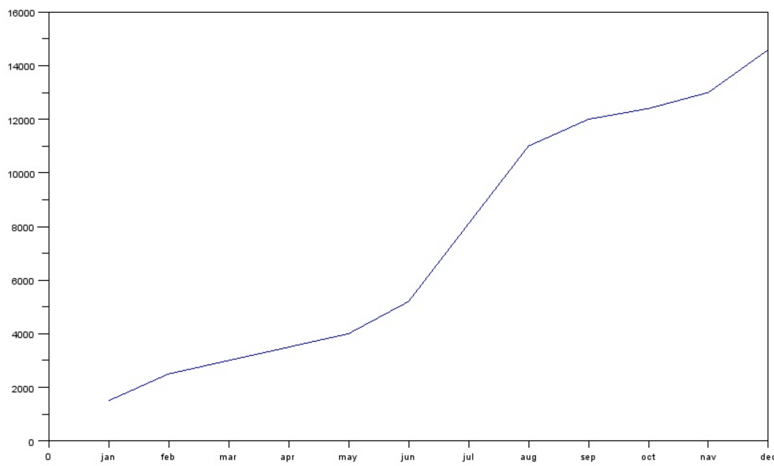

Figure 8.3: derevation of mass curve

Scilab code Exa 8.4 derevation of mass curve

```
clear
clc
disp("example 8.4")
flow=[1500 1000 500 500 500 1200 2900 2900 1000 400
   600 1600]
cod=1000//constant demand
[m n]=size(flow)
mf(1)=1500
for i=2:n
    mf(i)=mf(i-1)+flow(i)
```

```
end
plot(mf)
dd=1:cod:mf(n)
avg=sum(flow)/12
if cod<avg then
    for x=1:6
       t=flow(1,x)
        if t>cod|t==avg then

        t=0
    else
        t=cod-t
       end
     flow1(1,x)=t;
 end

 else
     for x=1:12
       t=flow(1,x)
    a=cod
        if t>a|t==avg then
        t=0
    else
        t=t-cod
       end
     flow1(1,x)=t;
    end
end

sto=sum(flow1)
printf("storage capacity of plant is %dsec—m—month",
   sto)
```

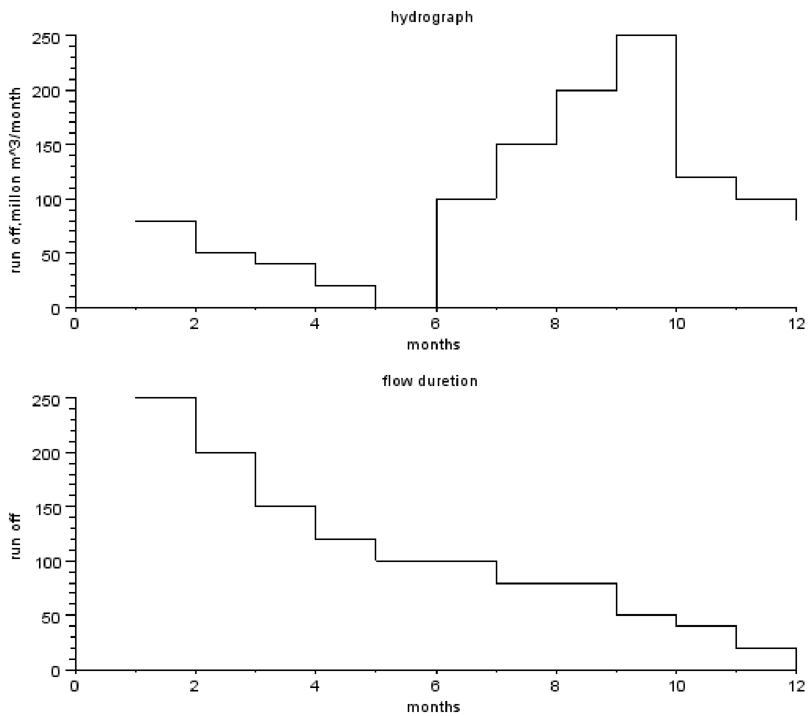

Figure 8.4: HYDRO GRAPH

Scilab code Exa 8.5 HYDRO GRAPH

```
clear
clc
disp("solution of 8.5")
flow=[80 50 40 20 0 100 150 200 250 120 100 80]
h=100;e=80
subplot(211)
plot2d2(flow)
xtitle('hydrograph','months','run off,millon m^3/
    month' )
fd=gsort(flow)
subplot(212)
plot2d2(fd)
xtitle('flow duretion','months','run off')

t=1:12
for x=2:10
    d=fd(1,x)
    ad=fd(1,(x-1))
    if d==ad then
        t(1,x)=[]
        t(1,x-1)=t(1,x-1)+1
        fd(1,x)=[]
    end
end
ffw=[fd;t]
disp("load duration data is as under")
disp(ffw)
mf=sum(flow)*10^6/(30*24*3600)
disp("(a)")
printf("meanflow is %fm^3-sec",mf)
disp("(b)")
p=(735.5/75)*mf*h*e
```

```
printf("power delevered in %dkW=%.3fMW",p,p/1000)
```

Scilab code Exa 8.6 WATER USED AND LOAD FACTOR OF HYDRO STATION

```
clear
clc
disp("example 8.6")
mh=205//mean height
a=1000*10^6//in miters
r=1.25//annual rain fall
er=0.8//efficiency
lf=0.75//load factor
hl=5//head loss
et=0.9//efficiency of turbine
eg=0.95//efficiency of generator
wu=a*r*er/(365*24*3600)
printf("\nwater used is \t\t%fm^3/sec",wu)
eh=mh-hl
printf("\neffective head is \t%dm",eh)
p=(735.5/75)*(wu*eh*et*eg)
printf("\npower generated is \t%fkW =\t%fMW",p,p
   /1000)
pl=p/lf
printf("\npeak load is \t\t%fMw \ntherefore the MW
   rating of station is \t%fMW",pl/1000,pl/1000)
if eh<=200 then
printf("\nfor a head above 200m pelton turbine is
   suitable,\nfrancis turbine is suitable in the
   range of 30m-200m.,\nhowever pelton is most
   suitable")
else
    printf("only pelton turbine is most suitable")
```

```
end
```

Chapter 9

Nuclear Power stations

Scilab code Exa 9.1 energy equivalent of matter 1 gram

```
clear
clc
disp("example 9.1")
m=1*10^-3//mass of 1 grm in kgs
c=3*10^8
e=m*c^2;
E=e/(1000*3600)
printf("energy equivalent of 1 gram is %dkWh",E)
```

Scilab code Exa 9.2 mass defect of 1 amu

```
clear
clc
disp("example 9.2")
amu=1.66*10^-27//mass equvalent in kgs
```

```
c=3*10^8
j=6.242*10^12
e=amu*c^2
E=e*j;
printf("energy evalent in joules is %ejoules \n energy equvalent in Mev is %dMeV \n hense shown",e,E)
```

Scilab code Exa 9.3 binding energy of 1h2 28ni59 92u235

```
clear
clc
disp("example 9.3")
hm=2.0141
hp=1.007825
hn=1.008665
nm=58.9342
np=28
nn=59
um=235.0439
up=92
un=235
hmd=hp+hn-hm;nmd=np*hp+(nn-np)*hn-nm;umd=up*hp+(un-up)*hn-um;
hbe=931*hmd;nbe=931*nmd;ube=931*umd;
ahbe=hbe/2;anbe=nbe/nn;aube=ube/un;
printf("\t(a)\n mass defect is for hydrogen %famu \n total binding energy for hydrogens %fMev \n average binding energy for hydrogen is %fMeV",hmd,hbe,ahbe)
printf("\n\t(b)\n mass defect is for nickel %famu \n total binding energy for nickel is %fMev \n average binding energy for nickelis %fMeV",nmd,
```

```
    nbe,anbe)
printf("\n\t(c)\n mass defect of uranium is %famu \n
    total binding energy uranium is %fMev \n average
    binding energy uranium is %fMeV",umd,ube,aube)
```

Scilab code Exa 9.4 half life of uranium

```
clear
clc
disp("example 9.4")
no=1.7*10^24
hl=7.1*10^8
t=10*10^8
lm=0.693/(hl)
lmda=lm/(8760*3600)
ia=lmda*no
n=no*(exp(-lm*t))
printf("(lamda) disintegrations per sec is %ebq \n
   initial activity is lamda*na is %ebq \n final
   number of atoms is %eatoms",lmda,ia,n)
```

Scilab code Exa 9.5 power produced by fissioning 5 grams of uranium

```
clear
clc
disp("example 9.5")
um=5
owp=2.6784*10^15
an=6.023*10^23
```

```
na1g=an/235
na5g=an*5/235
p=na5g/owp
printf("1 watt power requvires %efussions per day \n
    number of atoms in 5 gram is %eatoms \n power is
    %eMW ",owp,na5g,p)
```

Scilab code Exa 9.6 fuel requirement for given energy

```
clear
clc
disp("example 9.6")
pp=235
pe=0.33
lf=1
teo=pp*8760*3600*10^6
ei=teo/pe
nfr=3.1*10^10//fessions required
tnfr=nfr*ei
t1gu=2.563*10^21 //total uranium atoms in 1 grm
fure=tnfr/t1gu
printf("total energy input %eWatt sec \n energy
   input is %eWatt-sec\n total number of fissions
   required is %efissions \n fuel required is %e
   grams %dkg",teo,ei,tnfr,fure,fure/1000)
```

Scilab code Exa 9.7 number of collisions for energy change

```
clear
```

```
clc
disp("example 9.7")
en=3*10^6
a=12
fen=0.1
Es=2/(12+2/3)
re=exp(Es)
printf("(a)\nratio of energies per collision is %f",re)
rietf=en/fen
ldie=log(rietf)
nc=ldie/Es
printf("(b)\npatio of iniial to final energies is %e \n logarithemic decrement in energy is %f \n number of collisions is %d",rietf,ldie,nc)
```

Chapter 10

ECONOMIC OPERATION OF STEAM PLANTS

Scilab code Exa 10.1 SHARING OF LOAD BETWEEN STATIONS

```
clear
clc
disp("example 10.1")
mp=250 //maximum power
function [ic]=unit1(p1) //ic equation of unit 1
    ic=0.2*p1+30
endfunction
function [ic]=unit2(p2)//ic equation of unit 2
    ic=0.15*p2+40
endfunction
mil=20//minimum load
disp("minimum load ic is")
ic=[unit1(mil),unit2(mil)]
[m,n]=max(ic)
if m==unit2(mil) then
    for x=20:100
      if m==unit1(x) then
        break
        end
```

```
    end
    printf("ic of unit1 =ic of unit2 when unit2=%dMW and unit1=%dMW",mil,x)
end
function [p1,p2]=un(ic)
    p1=(ic-30)/0.2
    p2=(ic-40)/0.15
endfunction
printf("load division \n")
me=ceil(unit2(mil)/10)
for x=me*10:5:100
   ii=0
    [m,n]=un(x)
    if m>=mp|n>=mp then
        if n>mp then
            p=2
        end
        if m>mp then
            p=1
        end
        for y=x-5:0.5:x
            [c,v]=un(y)
            m1=[c,v]
            if mp==m1(p) then
                ii=1
                break
            end
        end
        [pp qq]=un(y)
    printf("\n for plant ic %3.1fMW \tthen p1=%dMW\t p2 =%dMW",unit1(pp),pp,qq)
    ii=1
    break
    end
   if ii==0 then
       l=m+n
       printf("\n for plant ic %dMW \tthen p1 is %dMW\t plant2 is %dMW and total is %dMW ",
```

```
            x,m,n,l)
    end
end
a=unit1(mp);b=unit2(mp)
printf("\n for plant ic %dMW \tthen p1 is %dMW\t
   plant2 is %dMW and total is %dMW ",a,mp,mp,2*mp)
```

Scilab code Exa 10.2 COST ON DIFFERENT STATIONS ON INCREMENTAL COST METHOD

```
clear
clc
disp("example 10.2")
mp=250      //from example 10.1
function [ic]=unit1(p1)
    ic=0.2*p1+30
endfunction
function [ic]=unit2(p2)
    ic=0.15*p2+40
endfunction
mil=20
ttt=225
function [p1,p2]=un(ic)
    p1=(ic-30)/0.2
    p2=(ic-40)/0.15
endfunction
for x=40:5:60
    [e,r]=un(x)
    if ttt==e+r then
        printf("for the same incremental costs unit1
            should supply %dMW and unit 2 shold
           supply %dMW, for equal sharing each unit
           should supply %3.1fMW",e,r,ttt/2)
```

```
        break
    end
end
opo=ttt/2
u1=integrate('unit1','p1',opo,e)
u2=integrate('unit2','p2',r,opo)
uuu=(u1+u2)*8760
printf("\nyearly extra cost is (%3.2f-%3.2f)8760 =
   %dper year",u1,u2,uuu)
printf("\nthis if the load is equally shared by the
   two units an extra cost of Rs.%d will be incurred
   .in other words economic loading would result in
   saving of Rs.%dper year",uuu,uuu)
```

Scilab code Exa 10.3 SHARING OF LOAD BETWEEN STATIONS WITH PARTICIPATION FACTOR

```
clear
clc
disp("example 10.3")
function [ic]=unit1(p1)
    ic=0.2*p1+30
endfunction
function [ic]=unit2(p2)
    ic=0.15*p2+40
endfunction
tol=400
pd=50
u1c=5
u2c=1/0.15//from example10_1
p1pd=u1c/(u1c+u2c)
p2pd=u2c/(u1c+u2c)
pi=p1pd*pd
```

```
pt=p2pd*pd
printf("p1=%1.5fMW\n p2=%1.5fMW",pi,pt)
p11=pi+tol/2
p22=pt+tol/2
up1=unit1(p11)
up2=unit2(p22)
 printf("\nthe total load on 2 units would be %3.2
   fMW and %3.2fMW respectevily. it is easy to
   check that incremental cost will be same for two
    units at these loading.\n incremental cost of
   unit1 is %3.2fRs.MW,\n incremantal cost of unit
   2 is %3.2fRs./MW",p11,p22,up1,up2)
```

Scilab code Exa 10.5 LOSS COEFFICIENTS AND TRANSMISSION LOSS

```
clear
clc
disp("example10.5")
i1=0.8
i2=1.0
l1=complex(0.04,0.12)
l2=complex(0.03,0.1)
l3=complex(0.03,0.12)
vl=1

i3=i1+i2
v1=vl+i3*(l1)+i1*(l2)
v2=vl+i3*(l1)+i2*(l3)
p1=real(i1*v1)
p2=real(i2*v2)
cos1=real(v1)/abs(v1)
cos2=real(v2)/abs(v2)
b11=abs((real(l1)+real(l2))/(v1^2*cos1^2))
```

```
b22=abs((real(l1)+real(l3))/(v2^2*cos2^2))
b12=abs((real(l1))/(v1*v2*cos1*cos2))
pl=(p1^2)*b11+(p2^2)*b22+2*p1*p2*b12
printf("i1+i3=%dpu\nv1=%1.3f+%1.3fp.u\nv2=%1.3f+%1.3fp.u\np1=%1.3fp.u\np2=%1.3fp.u\ncos(ph1)=%1.3f\ncos(ph2)=%1.3f\nb11=%1.5fp.u\nb22=%1.5fp.u\nb12=%1.5fp.u\npl=%1.6fp.u",i3,v1,imag(v1),v2,imag(v2),p1,p2,cos1,cos2,b11,b22,b12,pl)
```

Scilab code Exa 10.7 LOSS COEFFICIENTS AND TRANSMISSION LOSS

```
clear
clc
disp("example10.7")
za=complex(0.03,0.09)
zb=complex(0.1,0.3)
zc=complex(0.03,0.09)
zd=complex(0.04,0.12)
ze=complex(0.04,0.12)
ia=complex(1.5,-0.4)
ib=complex(0.5,-0.2)
ic=complex(1,-0.1)
id=complex(1,-0.2)
ie=complex(1.5,-0.3)
il1=.4
il2=.6
na1=1;nb1=0.6;nc1=0;nd1=.4;ne1=.6
na2=0;nb2=-0.4;nc2=1;nd2=.4;ne2=.6
vl=1
//some thing is messed
v1=vl+za*ia
v2=vl-zb*ib+zc*ic
a1=atan(imag(ia)/real(ia))
```

```
a2=atan(imag(ic)/real(ic))
cosa=cos(a1-a2)
cosph1=cos(atan(imag(v1)/real(v1))-a1)
cosph2=cos(atan(imag(v2)/real(v2))-a2)
b11=(na1^2*real(za)+nb1^2*real(zb)+nc1^2*real(zc)+
   nd1^2*real(zd)+ne1^2*real(ze))/(abs(v1)^2*cosph1)
b22=(na2^2*real(za)+nb2^2*real(zb)+nc2^2*real(zc)+
   nd2^2*real(zd)+ne2^2*real(ze))/((abs(v2)^2)*
   cosph2)
bb12=(abs(v1)*abs(v2)*cosph1*cosph2)
ab12=(na2*na1*real(za)+nb2*nb1*real(zb)+nc1*nc2*real
   (zc)+nd2*nd1*real(zd)+ne2*ne1*0.03)
b12=cosa*ab12/bb12
printf("bus voltages at 2 buses are \nv1=%1.3f+i%1.3
   f,\nv2=%1.3f+i%1.3f",real(v1),imag(v1),real(v2),
   imag(v2))
printf("\nloss coffecients are \nb11=%1.5fp.u\nb22=
   %1.5fp.u\nb12=%1.5fp.u \n",b11,b22,b12)
printf("loss coffecients in actual values is \nb11=
   %eM(W)-1\nb22=%eM(W)-1\nb12=%eM(W)-1\n",b11/100,
   b22/100,b12/100)
```

Scilab code Exa 10.8 SHARING OF LOAD BETWEEN STATIONS WITH PARTICIPATION FACTOR

```
clear
clc
disp("example 10.8")
r1=22;r2=30;q1=0.2;q2=0.15
b22=0;b12=0;p1=100;pl=15//transmission losses are 0
b11=pl/(p1)^2
function [p1,p2]=power(x) //mathematical computation
    p1=(x-r1)/(q1+2*b11*x)
```

```
     p2=(x-r2)/q2
endfunction
[a,b]=power(60)
printf("l1=1/(1-%.3f*p1)\nl2=[1/(1-0)]=1\ngiven
   lamda=60\nsince ic1*l1=lamda ;ic2*l2=lamda\ntotal
    load=%dMW",b11*2,a+b-(b11*a^2))
```

Scilab code Exa 10.9 COST CONDITIONS WITH CHANGE IN LOAD ON PLANT

```
clear
clc
disp("example 10.9")
r1=22;r2=30;q1=0.2;q2=0.15
b22=0;b12=0;p1=100;pl=15//transmission losses are 0
b11=pl/(p1)^2
function [p1,p2]=power(x) //mathematical computation
    p1=(x-r1)/(q1+2*b11*x)
     p2=(x-r2)/q2
endfunction
[a,b]=power(60)
pt=a+b-(b11*a^2)




z=integrate('q1*u+r1','u',a,161.80)
y=integrate('q2*v+r2','v',b,162.5)
m=z+y
printf("net change in cost =Rs.%dper hour",m)
printf("\nthus scheduling the generation by taking
   transmission losses into account would mean a
   saving of Rs.%dper hour in fuel cost",m)
```

Scilab code Exa 10.10 SHARING OF LOAD BETWEEN STATIONS WITH ITRATION METHOD

```
clear
clc
disp("example 10.10")
b11=0.001
b12=-0.0005
b22=0.0024
q1=0.08
r1=16
q2=0.08
r2=12
lamda=20

p2=0
for x=1:4
    p1=(1-(r1/lamda)-(2*p2*b12))/((q1/lamda)+2*b11)

p2=(1-(r2/lamda)-(2*p1*b12))/((q2/lamda)+2*b22)

end
pl=b11*p1^2+2*b12*p1*p2+b22*p2^2
pr=p1+p2-pl
printf("thus \t p1=%2.1fMW, p2=%2.1fMW\n pl=%1.1fMW\
   npower resevied %2.1fMW",p1,p2,pl,pr)
```

Scilab code Exa 10.11 COST CHARACTERISTIC UNDER COMBAINED STATIONS CONDITION

```
clear
clc
disp("example 10.11")
a1=561;b1=7.92;c1=0.001562
a2=310;b2=7.85;c2=0.00194
ce=c1*c2/(c1+c2)
printf("\nce=%e",ce)
be=((b1/c1)+(b2/c2))*ce
printf("\nbe=%1.4f",be)
ae=a1-((b1^2)/4*c1)+a2-((b2^2)/4*c2)+((be^2)/4*ce)
printf("ae=%3.3f \n cost characteristics of
    composite unit for demand pt is \n ct=%3.3f+%1.4f
    *p1+%ep1^2",ae,ae,be,ce)
```

Scilab code Exa 10.12 SHARING OF LOAD BETWEEN STATIONS

```
clear
clc
disp("example 10.12")
a1=7700;b1=52.8;c1=5.5*10^-3
a2=2500;b2=15;c2=0.05//given eqution
plo=200;pup=800
ct=1000
l=[500,900,1200,500];t=[6 16 20 24]//from given
    graph
function [p1,p2]=cost(y)
    p1=(2*c2*y-(b1-b2))/(2*(c1+c2))
    p2=y-p1
endfunction
ma=max(l)
```

```
mi=min(l)
for x=1:3
    [e g]=cost(l(x))
    if e<plo|g<plo|e>pup|g>pup then
        if e<plo|g<plo then
    [v,u]=min(e,g)
    if u==1 then
        e=plo
        g=l(x)-e
    else
        g=plo
        e=l(x)-g
    end
    end

end
printf("\np1=%3.2fMW\tp2=%3.2fMW",e,g)
end
```

Scilab code Exa 10.13 ECONOMIC SCHEDULING BETWEEN POWER STATION

```
clc
clear all
disp("example 10 13")
a1=2000;b1=20;c1=0.05;p1=350;p2=550
a2=2750;b2=26;c2=0.03091
function [co]=cost(a,b,c,p)
    co=a+b*p+c*p^2
endfunction
disp("(a)")
toco=cost(a1,b1,c1,p1)+cost(a2,b2,c2,p2)
printf("total cost when each system supplies its own
```

```
    load Rs%.3f per hour",toco)
l=p1+p2
p11=(b2-b1+2*c2*l)/(2*(c1+c2))
p22=l-p11
totco=cost(a1,b1,c1,p11)+cost(a2,b2,c2,p22)
sav=toco-totco
tilo=p11-p1
disp("(b)")
printf("\n total cost when load is supplied in
   economic load dispatch method Rs%d per hour \n
   saving %.3f \n tie line load %.3f MW",totco,sav,
   tilo)
```

Scilab code Exa 10.14 ECONOMIC SCHEDULING BETWEEN POWER STATION

```
clear
clc
disp("example10.14")
a1=5000;b1=450;c1=0.5;//for system 1
e1=0.02;e2=-0.02//error
a1c=a1*(1-e1);b1c=b1*(1-e1);c1c=c1*(1-e1)
a2c=a1*(1-e2);b2c=b1*(1-e2);c2c=c1*(1-e2)
tl=200
function [co]=cost(a,b,c,p)
    co=a+b*p+c*p^2
endfunction
p11=(b2c-b1c+2*c2c*tl)/(2*(c1c+c2c))
p22=tl-p11
totco=cost(a1c,b1c,c1c,p11)+cost(a2c,b2c,c2c,p22)
printf("\npower at station 1 is %dMW \t power at
   station 2 is %dMW \n total cost on economic
   critieria method Rs%d per hour",p11,p22,totco)
```

```
tocoe=cost(a1c,b1c,c1c,tl/2)+cost(a2c,b2c,c2c,tl/2)
eop=tocoe-totco
printf("\nextra operating cost due to erroneous
    scheduling Rs.%d per hour",eop)
```

Scilab code Exa 10.15 ECONOMIC SCHEDULING BETWEEN POWER STATION

```
clc
clear all
disp("example 10_15")
c1=0.002;b1=0.86;a1=20
c2=0.004;b2=1.08;a2=20
c3=0.0028;b3=0.64;a3=36
fc=500
maxl=120
minl=36
tl=200
d=[1 1 1;2*fc*c1 -fc*2*c2 0;0 -fc*2*c2 fc*2*c3]
p=[tl;fc*(b2-b1);fc*(b2-b3)]
pp=inv(d)*p //matrix inversion method
printf("\nloads on generaating station by economic
    creatirian method is %dMW,%dMW,%dMW",pp(1),pp(2),
    pp(3))
for i=1:3
    if pp(i)<minl then
        pp(i)=minl
        printf("\nload on generating station %d is
            less then minimum value %dMW \n so it is
            made equal to minimum value %dMW",i,minl,
            minl)
        e=[1 1;d(2,1) -d(3,3)]
        q=[(tl-pp(i));-p(i)]
```

```
        qq=inv(e)*q //matrix inversion method
printf("\nloads on generaating station by economic creatirian method is %.3fMW,%.3fMW",qq(1),qq(2))
    end
    if pp(i)>maxl then
        pp(i)=maxl
        printf("\nload on generating station %d is greater than maximum value %dMW \n so it is made equal to mmaximum value %dMW",i,maxl,maxl)
        e=[1 1;d(2,1) -d(3,3)]
        q=[(tl-pp(i));-p(i)]
        qq=inv(e)*q //matrix inversion method
printf("\nloads on generaating station by economic creatirian method is %.2fMW,%.2fMW",qq(1),qq(2))
    end
end
```

Scilab code Exa 10.16 COMPARITION BETWEEN UNIFORM LOAD AND DISTRUBTED LOAD

```
clc
clear all
disp("example 10.16")
//given
ia=32;ib=32;ic=1.68;f=10^5
wt=18;rt=24-wt
p=30
function [in]=inpu(a,b,c,f,t,p)
    in=(a+b*p+c*p^2)*f*t
endfunction
hi1=inpu(ia,ib,ic,f,wt,p);hi2=inpu(ia,ib,ic,f,rt,p/2)
```

```
disp("(a)")
printf("for full load condition for %d hours is %ekj
    \n for half load condition for%d s %ekj \n total
    load %ekj",wt,hi1,rt,hi2,hi1+hi2)
disp("(b)")
te=p*wt+(p/2)*rt
ul=te/24
hin=inpu(ia,ib,ic,f,24,ul)
sav=hi1+hi2-hin
savp=sav/(te*1000)
printf("\n total energy produced\t%dMW \n unifor
   load\t%dMW \n heat input under uniform load
   condition %ekj \n saving in heat energy %ekj \n
   saving in heat energy per kWh %dkj/kWh",te,ul,hin
   ,sav,savp)
```

Scilab code Exa 10.17 ECONOMIC SCHEDULING BETWEEN POWER STATION

```
clc
clear all
disp("example 10.17")
//given
a1=450;b1=6.5;c1=0.0013
a2=300;b2=7.8;c2=0.0019
a3=80;b3=8.1;c3=0.005
tl=800//total load
ma(1)=600
mi(1)=100
ma(2)=400
mi(2)=50
ma(3)=200
mi(3)=50
```

```
d=[1 1 1;2*c1 -2*c2 0;0 -2*c2 2*c3]
p=[tl;(b2-b1);(b2-b3)]
pp=inv(d)*p //matrix inversion method
printf("\nloads on generaating station by economic
    creatirian method isp1=%fMW, p2=%fMW, p3=%fMW",pp
    (1),pp(2),pp(3))
for i=1:3
    if pp(i)<mi(i) then
        pp(i)=mi(i)
    end
    if pp(i)>ma(i) then
        pp(i)=ma(i)
    end
end
pp(2)=tl-pp(1)-pp(3)
printf("\nloads on generating station under critical
     conditions p1=%dMW p2=%dMW p3=%dMW",pp(1),pp(2),
    pp(3))
```

Chapter 11

HYDRO THERMAL CO ORDINATION

Scilab code Exa 11.1 SCHEDULING OF POWER PLANT

```
clc
clear
disp("example 11 1")
wd=[0 5 8 12 13 17 21 24] //given week days
w1ld=[100 150 250 100 250 350 150] //given load in
   week days
wld=[w1ld 0]
we=[0 5 17 21 24]//given week ends
wed=[100 150 200 150]//given load in week ends
wed=[wed 0]
h=90//head
f=50 //flow
et=0.97//is available for 97 persent
eff=0.9 //efficiency
tl=0.05 //transmission loss
pa=735.5*f*h*eff/75 //power available
nap=pa*(1-tl) //net available power
```

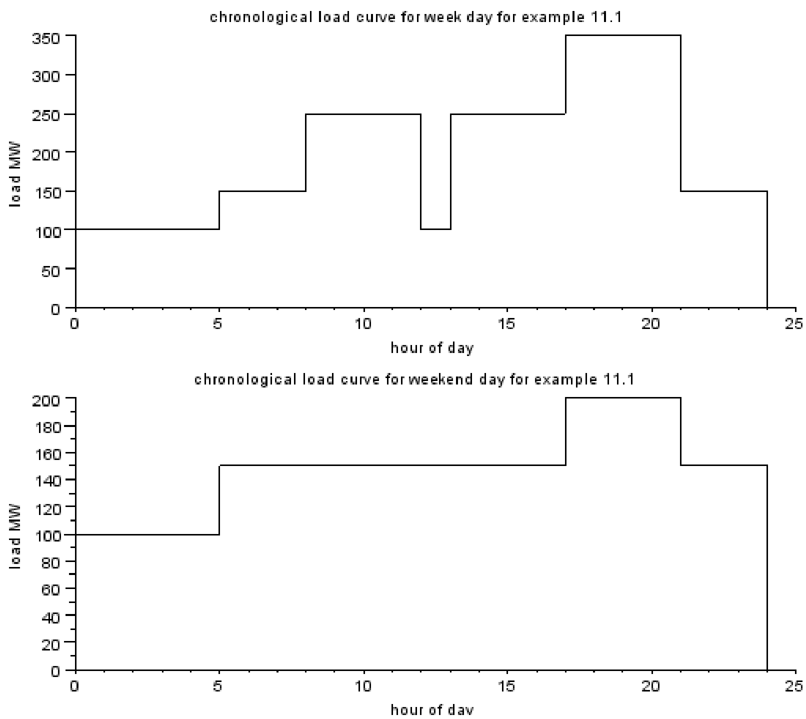

Figure 11.1: SCHEDULING OF POWER PLANT

```
he=nap*24/1000 //hydro energy for 24 in MW
he1=round(he/100)*100
[m,n]=size(wd)
[x,y]=min(w1ld)
[q,r]=max(w1ld)
for i=1:n-1
    fl(i)=wd(i+1)-wd(i)
end
[o,p]=size(we)
for i=1:p-1
    fl1(i)=we(i+1)-we(i)
end
for j=x:10:q
    pp=w1ld-j
    for l=1:n-1
    if pp(l)<0 then
        pp(l)=0
    end
    end
    heq=pp*fl
    heq=round(heq/100)*100
    if heq==he1 then
        break
    end
end//rearrangeing for plot
subplot(211)
plot2d2(wd,wld)
xtitle("chronological load curve for week day for
   example 11.1","hour of day","load MW")
subplot(212)
plot2d2(we,wed)
xtitle("chronological load curve for weekend day for
    example 11.1","hour of day","load MW")

printf("power available from the hydro plant for
   %dMW of the time is %.2fMW",et*100,pa/1000)
printf("\nnet available hydra power after taking
   transmission loss into account %.2fMW",nap/100)
```

```
printf("\nhydro energy available during 24 hours %.2fMW",he)
printf("\nthe magnitude of hydro power is %dMW \ntotal capacity of hydro plant required on week days %dMW ",q-j,(q-j)/(1-tl))
printf("capacity of thermal plant on week days %dMW",q)
printf("\nthe schedule for hydro plant is on week days")
for i=1:n
    if wd(i)>12 then
        wd(i)=wd(i)-12
    end
end
disp(wd)
disp(round(pp/(1-tl)))
disp("the schedule for thermal plant is on week days ")
disp(wd)
disp(wlld-pp)
[m,n]=size(we)
[x,y]=min(wed)
[q,r]=max(wed)
for j=x:10:q
    pp=wed-j
    for l=1:n-1
    if pp(l)<0 then
        pp(l)=0
    end
end
pp(n)=[]
    heq=pp*fll
    heq=floor(heq/100)*100
    if heq==he1 then
        break
    end
end
printf("\nthe magnitude of hydro power is %dMW \
```

```
ntotal capacity of hydro plant required on week ends %dMW ",q-j,(q-j)/(1-tl))
printf("capacity of thermal plant on week ends %dMW",q)
printf("\nthe schedule for hydro plant is on week ends")
for i=1:n
    if we(i)>12 then
        we(i)=we(i)-12
    end
end
disp(we)
disp(round(pp/(1-tl)))
disp("the schedule for thermal plant is on week days")
disp(we)
pp(n)=0
disp(wed-pp)
```

Scilab code Exa 11.2 generation schedule and daily water usage of power plant

```
clc
clear all
disp("example 11.2")
//given
l1=700;t1=14;l2=500;t2=10
ac=24;bc=0.02//variables of cost equation
aw=6;bw=0.0025 //variables of watere quantity equation
b22=0.0005 //loss coefficient
r2=2.5
lam=1:0.001:40
```

```
gg=1;q=1
for lam=25:0.001:40
    a=[2*bc 0;0 r2*bw*2+2*b22*lam]
    b=[lam-ac;lam-aw*r2]
    p=inv(a)*b
    g=round(p(1)+p(2))
    l=round(l1+b22*p(2)^2)
    lq=round(l2+b22*p(2)^2)
    if g>=l then
        printf("\nfor load condition %dMW \n then , \n \t lamda %f \t p1=%fMW \n \t p2=%fMW \t pl=%fMW",l1,lam,p(1),p(2),2*b22*p(2))
        break
    end
end
for lam=25:0.001:40
    a=[2*bc 0;0 r2*bw*2+2*b22*lam]
    b=[lam-ac;lam-aw*r2]
    pq=inv(a)*b
    g=round(pq(1)+pq(2))
    lq=round(l2+b22*pq(2)^2)

    if g>=lq then
        printf("\nfor load condition %dMW \n then , \n \t lamda %f \t p1=%fMW \n \t p2=%fMW \t pl=%fMW",l2,lam,pq(1),pq(2),2*b22*pq(2))
        break
    end
end
dwu=[(aw+bw*p(2))*p(2)*t1+t2*(aw+bw*pq(2))*pq(2)]*3600
doc=[(ac+bc*p(1))*p(1)*t1+(ac+bc*pq(1))*pq(1)*t2]
printf("\ndaily water used %fm^3 \ndaily operating cost of thermal plant Rs%f",dwu,doc)
```

Scilab code Exa 11.3 water usage and cost of water by hydro power plant

```
clc
clear all
disp("example 11.3")
//given
p=250//load
rt=14 //run time
t=24//total time
ac=5;bc=8;cc=0.05 //variables of cost equation
bw=30;cw=0.05 //variables of water per power
qw=500//quantity of water
lam=bc+cc*2*p //lambda
a=-qw*(10^6)/(3600*rt)
inn=sqrt(bw^2-4*cw*a)
phh1=(-bw+inn)/(2*cw)//solution of quadratic
    equation
phh2=(-bw-inn)/(2*cw)
if phh1>0 then
     r=lam/(bw+cw*phh1)
    printf(" hydro plant power is %fMW \n the cost
        of water is %fRs.per hour/m^3/sec",phh1,r)
end
if phh2>0 then
     r=lam/(bw+cw*phh2)
    printf(" hydro plant power is %fMW \n the cost
        of water is %fRs.per hour/m^3/sec",phh2,r)
end
```

Chapter 12

parallel operation of alternators

Scilab code Exa 12.1 load sharing between alternators

```
clc
clear
disp('example 12 1')
p=4000  //given kva of alternator
fnl1=50  //frequency on no load
fl1=47.5 //frequency on load
fnl2=50 //frequency on no load on second alternator
fl2=48  //frequency on load on second alternator
l=6000 //load given two to alternator
df1=fnl1-fl1  //change in 1 alternator frequency
df2=fnl2-fl2  //change in 2 alternator frequency
l1=df2*(l)/(df2+df1)  //load on 1 alternator
disp('a')
l2=l-l1
printf(" load on 1 alternator %.2fkW \n load on 2
   alternator %.2fkW",l1,l2)
ml1=df2*p/df1   //load on 1 machine when machine 2
   on full load
ll=ml1+p
```

```
disp('b')
printf(" load supplied by machine 1 with full load on machine2 %dkW \n total load is %dkW",ml1,l1)
```

Scilab code Exa 12.2 different parameters between parallel operation of generator

```
clc
clear
disp('example12_2')
l1=3000 //load on 1 machine
pf1=0.8  //pf on 1 machine
i2=150  //current on  2 machine
z1=0.4+12*%i  //synchronour impedence
z2=0.5+10*%i
vt=6.6  //terminal voltage
al=l1/2  //active load on each machine
cosdb=al/(vt*i2*sqrt(3)) //cos db
db=acosd(cosdb)  //angle in digree
ib=i2*complex(cosdb,-sind(db))  //current in complex number
it=l1/(vt*pf1*sqrt(3))  //total current
itc=complex(it*pf1,-it*sind(acosd(pf1)))  //total current in complex
ia=itc-ib
pfa=atan(imag(ia)/real(ia))  //pf of current a
ea=(vt/sqrt(3))+ia*(z1)/1000  //voltage a
pha=atand(imag(ea)/real(ea))  //phase angle of unit a
printf("induced emf of a machine a %.2f+%.2fi =%fkV per phase",real(ea),imag(ea),abs(ea))
eb=(vt/sqrt(3))+ib*(z2)/1000  //voltage b
phb=atand(imag(eb)/real(eb))  //phase angle of unit
```

```
   b
printf("\ninduced emf of a machine b %.2f+%.2fi =
   %fkV per phase",real(eb),imag(eb),abs(eb))
```

Scilab code Exa 12.3 circulating current between parallel generators

```
clc
clear
disp('example12_3')
e1=3000;ph1=20;e2=2900;ph2=0;//given induced emf of
   two machines
z1=2+20*%i;z2=2.5+30*%i //impedence of two
   synchronous machine
zl=10+4*%i //load impedence
e11=e1*(cosd(ph1)+sind(ph1)*%i)
e22=e2*(cosd(ph2)+sind(ph2)*%i)
is=(e11-e22)*zl/(z1*z2+(z1+z2)*zl)
printf("current is %.2f%.2fiA =%.2fA",real(is),imag(
   is),abs(is))
```

Scilab code Exa 12.4 different parameters between parallel operation of generator

```
clc
clear
disp('example 12 4')
z=10+5*%i //load
e1=250;e2=250 //emf of generator
z1=2*%i;z2=2*%i //synchronous impedence
```

```
v=(e1*z2+z1*e2)/((z1*z2/z)+z1+z2);vph=atand(imag(v)/real(v)) //substitution the value in equation 12.10
i1=(z2*e1+(e1-e2)*z)/(z1*z2+(z1+z2)*z);iph=atand(imag(i1)/real(i1)) //substitution the value in equation 12.7
pf1=cosd(vph-iph)
pd=v*i1*pf1
printf("terminal voltage %.2fV \ncurrent supplied by each %.2fA \npower factor of each %.3f lagging \npower delivered by each %.4fKW",abs(v),abs(i1),abs(pf1),abs(pd))
```

Scilab code Exa 12.5 synchronising power per mechanical degree of angular displacement

```
clc
clear
disp('example 12 5')
po=5 //mva rating
v=10 //voltage in kv
n=1500;ns=n/60 //speed
f=50 //freaquency
pfb=0.8//power factor in b
x=0.2*%i //reactance of machine
md=0.5 //machanical displacement
//no load
v=1;e=1;
p=4
spu=v*e/abs(x);sp=spu*po*1000;mt=(%pi*p)/(180*2)
spm=sp*mt //synchronous power in per mech.deree
st=spm*md*1000/(2*ns*%pi)
disp('(a)')
```

```
printf(" synchronous power %dkW \n synchronous
   torque for %.1f displacement %dN-M",spm,md,st)
disp('(b) full load')
ee=e+x*(pfb-sind(acosd(pfb))*%i)
spb=v*abs(ee)*cosd(atand(imag(ee)/real(ee)))/abs(x)
    //synchronous power
sppm=spb*po*1000*mt //synchronous power per mech.
   degree
stp=sppm*md*1000/(2*%pi*ns)//synchrounous torque
   under load
printf(" synchronous power %dkW \n synchronous
   torque for %.1f displacement %dN-M",sppm,md,stp)
```

Scilab code Exa 12.6 synchronising power per mechanical degree of angular displacement

```
clc
clear
disp('example 12 6')
po=2*10^6;p=8;n=750;v=6000;x=6*%i;pf=0.8; //given
i=po/(v*sqrt(3))
e=(v/sqrt(3))+i*x*(pf-sind(acosd(pf))*%i)
mt=p*%pi/(2*180)
cs=cosd(atand(imag(e)/real(e)))
ps=abs(e)*v*sqrt(3)*cs*mt/(1000*abs(x))
ns=n/60
ts=ps*1000/(2*%pi*ns)
printf(" synchronous power %.1fkW per mech.degree \n
    synchrounous torque %dN-m",ps,ts)
```

Scilab code Exa 12.7 load parameters between alternators

```
clc
clear
disp('example 12 7')
i=100;pf=-0.8;v=11*1000;x=4*%i;ds=10;pfc=-0.8 //
   given,currents,power factor,voltage,reactance,
   delta w.r.t steem supply,pf of alternator
e=(v/sqrt(3))+(i*x*(pf-sind(acosd(pf))*%i))
disp('a')
ph=atand(imag(e)/real(e))
printf(" open circuit emf %dvolts per phase and %.2f
    degree",abs(e),ph)
d=ds-ph
eee=round(abs(e)/100)*100
ic=round(abs(eee)*sind(d)/abs(x))
iis=(eee^2-(abs(x)*ic)^2)^(0.5)
is=(iis-v/sqrt(3))/abs(x)
tad=is/ic
d=atand(tad)
ii=ic/cosd(d)
pff=cosd(d)
disp('b.')
printf(" current %.1fA \n power factor %.3f",ii,pff)
disp('c.')
ia=ii*pff/abs(pfc)
printf("current %.2fA",ia)
```

Chapter 13

MAJOR ELECTRICAL EQUIPMENT IN POWER PLANTS

Scilab code Exa 13.1 fault current with different generators

```
clc
clear
disp('example 13.1')
pg=3000  //kva rating of generators single phase
xg=0.1  //10%reactanse of generator
vg=11   //voltage at the terminals of generator
xbf=5    //reactanse of feeder fron bus to fault
pb=pg;vb=vg;ib=pg/vg  //let power and voltage of as respective base then current base
zb=(vb*10^3)/ib   //base impedence
xpu=xbf/zb  //per unit reactance of feeder
tx=(xg/2)+(xpu) //total reactance
sckva=pg/tx  //short circuit kva is ratio ofpower to total reactance
sci=sckva/vg   //short circuit current
disp('a')
printf(" p.u.feeder reactor %.3fp.u \n total
```

```
   reactance is %.3fp.u \n short circuit kVA %dkVA \
   n short circuit current %.1fA",xpu,tx,sckva,sci)
gz=zb*xg  //generator impedence
tz=(gz/2)+xbf  //total impedence
scc=(vg*10^3)/tz  //short circuit current in ampears
disp('b')
printf(" generator impedence %.3fohm \n total
   impedence %.3f ohm \n short circuit current %.1fA
   ",gz,tz,scc)
```

Scilab code Exa 13.2 short circuit current parallel generator

```
clc
clear
disp('example 13.2')
pa1=20000 ;pa2=30000  //kva in in 3 ph power
va1=11    ;va2=11  //voltage in kilo volts
pt1=20000 ;pt2=30000//kva of 3 ph transformer
vpt1=11   ;vpt2=11//voltage of primery of
   transformer
vst1=132  ;vst2=132//voltage of secondary of
   transformer
xg1=0.5  ;xg2=0.65   //reactance of generator
xt1=0.05 ;xt2=0.05 //reactance of transformer with
   their own kva
pb=pa2;vbg=va2;vbt=vpt2;//assumeing base quantoties
xtn1=xt1*pb/pa1 ;xtn2=xt2*pb/pa2 //transformer
   reactance with new base
xgn1=xg1*pb/pa1;xgn2=xg2*pb/pa2
xn1=xtn1+xgn1;xn2=xtn2+xgn2  //reactancee up to
   fault from each generator
xn=(xn1*xn2)/(xn1+xn2)  //equalent reactance between
    generator and fault
```

```
sckva=pb/xn ; //short circuit KVA
disp('(a)')
printf(" equivalent reactance is %.4f p.u \n short
    circuit KVA %dKVA",xn,sckva)
disp('(b)')
sccb=sckva/(vst1*sqrt(3))
sccg1=sccb*(xn2/(xn1+xn2))*vst1/vpt1
sccg2=sccb*(xn1/(xn1+xn2))*vst2/vpt2
printf(" short circuit current on bus bar side %.1fA
     \n short circuit current of generator 1 is %.1fA
     \n short circuit current of generator 2 is %.1fA
     \n",sccb,sccg1,sccg2)
```

Scilab code Exa 13.3 short circuit MVA

```
clc
clear
disp('example 13.3')
pa1=20000 ;pa2=30000  //kva in in 3 ph power
va1=11    ;va2=11  //voltage in kilo volts
pt1=20000 ;pt2=30000//kva of 3 ph transformer
vpt1=11   ;vpt2=11//voltage of primery of
    transformer
vst1=132  ;vst2=132//voltage of secondary of
    transformer
xg1=0.5  ;xg2=0.65   //reactance of generator
xt1=0.05 ;xt2=0.05 //reactance of transformer with
    their own kva
pb=pa2;vbg=va2;vbt=vpt2;//assumeing base quantoties
xtn1=xt1*pb/pa1 ;xtn2=xt2*pb/pa2 //transformer
    reactance with new base
xgn1=xg1*pb/pa1;xgn2=xg2*pb/pa2
xn1=xtn1+xgn1;xn2=xtn2+xgn2  //reactancee up to
```

```
fault from each generator
xn=(xn1*xn2)/(xn1+xn2)  //equalent reactance between generator and fault
sckva=pb/xn ; //short circuit KVA
pf=50000  //fault kva rating
xf=pb/pf  //reactance from fault
xx=xf*xn1/(xn1-xf)
x=xx-xn2 //reactance to be added
bi=(vst1^2)*1000/(pb)
xo=x*bi
printf(" reactance to be added in circuit of generator 2 have %.1f p.u. \n reactance in ohms %.1f",x,xo)
```

Scilab code Exa 13.4 fault MVA in parallel generators

```
clc
clear
disp('example 13.4')
pa=50;xgb=0.5;xb=0.1;//given power,reactance of generator
x1=xgb+xb;
x=x1*x1*xgb/(x1*x1+x1*xgb+x1*xgb)
f=pa/x
printf(" total reactance %.4f.p.u \n fault MVA %.1fMVA",x,f)
```

Scilab code Exa 13.5 REATING OF CIRCUIT BREAKER

```
clc
clear
disp('example13_5')
vb=33
pb=20;zb=vb^2/pb   //base voltage and base power
pa1=10;pa2=10;xa1=0.08;xa2=0.08;  //given power and
   reactance for different branches
pbb=20;xb=0.06;pc=15;xc=0.12;pd=20;xd=0.08;
xab=2.17;xbc=3.26;xcd=1.63;xda=4.35;
xap1=xa1*pb/pa1;
xap2=xa2*pb/pa2;xap=xap1*xap2/(xap1+xap2)
xbp=xb*pb/pbb;
xcp=xc*pb/pc;
xdp=xd*pb/pd;    //generators reactance in per unit
xabp=round(xab*100/zb)/100;
xbcp=round(xbc*100/zb)/100;
xcdp=round(xcd*100/zb)/100;
xdap=round(xda*100/zb)/100  //reactance in per unit
   between bus
function [s1,s2,s3]=del2star(d12,d23,d31)
    dsum=d12+d23+d31
    s1=d12*d31/(dsum)
    s2=d12*d23/(dsum)
    s3=d31*d23/dsum
endfunction
function [d12,d31,d23]=star2del(s1,s2,s3)
    d12=s1+s2+(s1*s2)/s3
    d23=s2+s3+(s2*s3)/s1
    d31=s3+s1+(s3*s1)/s2
endfunction
[xac,xrc,xra]=star2del(xcdp,xdap,xdp)
rc=xrc*xcp/(xrc+xcp)
ra=xra*xap/(xra+xap)
[xpr,xpc,xpa]=del2star(xac,rc,ra)
xf1=xbcp+xpc
xf2=xpr+xabp
xf=xf1*xf2/(xf1+xf2)
xfr=xf+xpa
```

```
xx=xfr*xbp/(xfr+xbp)
netr=xx //net reactance
fkva=pb*1000/xx
printf("the rating of circuit breaker should be %d
   KVA, or %d MVA",fkva,fkva/1000)
```

Scilab code Exa 13.6 ratio of mech stresses on short circuit to mech stresses on full load

```
clc
clear
disp('example 13_6')
p=150 //given ,power
v=11 //given voltage
xg=0.12 //reactance of generator
xb=0.08 //reactance of line
scca=1/xg
ms=scca^2
sccb=1/(xg+xb)
ms1=sccb^2
disp('a')
printf("short circuit current is %.3fp.u \n ratio of
    mechanical stress on short circuit to aech.
   stresses on full load %.2f",scca,ms)
disp('b')
printf("short circuit current is with reactor %.3fp.
   u \n ratio of mechanical stress on short circuit
   to aech. stresses on full load with reactor %.f",
   sccb,ms1)
```

Scilab code Exa 13.7 percentage drop in bus bar voltage

```
clc
clear
disp('example13_7')
xf=complex(0,0.04)
pf=0.8;ph=acosd(pf)
v=1;i=1;//let v and i
vb=v+i*xf*(complex(cosd(ph),-sind(ph)))
iv=vb-abs(v);
printf("bus bar voltage %.4f.p.u at angle %.1f\n
   increase in voltage %.4f =%.4fpersent",abs(vb),
   atand(imag(vb)/real(vb)),iv,iv*100)
```

Scilab code Exa 13.8 short circuit MVA on hv and lv side

```
clc
clear
disp('example 13 8');
p1=30;x1=0.3 //power and reactance of different sets
p2=30;x2=0.3
p3=20;x3=0.3
l=10 ;xl=0.04
pb=p1;xp3=x3*pb/p3
tr=(xp3*x1*x2)/(xp3*x1+xp3*x2+x1*x2)
sc=pb/tr
disp('a')
```

```
printf("total reactance %.4f p.u \n short circuit
   MVA on l.v.bus %.2fMVA",tr,sc)
disp('b')
xlp=xl*pb/l
trr=tr+xlp
scc=pb/trr
printf("total reactance seen from h.v.side of
   transformer %.2fp.u \n short circuit MVA %.2fMVA"
   ,trr,scc)
```

Scilab code Exa 13.9 limiting the MVA with reactance

```
clc
clear
disp("example 13 9")
p1=30;x1=0.15;p2=10;x2=0.125;
pt=10;vs=3.3;pm=100
pb=p1 //let base as power of unit 1
x22=x2*pb/p2;x11=x1*pb/p1
xx=1/((1/x22)+(1/x11)+(1/x11))
xl=(pb/pm)-xx
xt2=xl*pt/pb
bi=vs^2/pt
xtt=xt2*bi
disp('a')
printf("reactance of transformer is %.4f.p.u \n
   reactance of transformer on %dMVA base is %.5fp.u
   . \n reactance of transformer %.4fohm",xl,pt,xl,
   xtt)
```

Scilab code Exa 13.10 fault current with different circuit

```
clc
clear
disp('example 13 10') //given //p=power/v=voltage/f=
   frequency/x=reactance/iff=feeder reactance take
   off
pa=20;va=11;f=50;xa=0.2;pb=30;xb=0.2;pf=10;xf=0.06;
   iff=0.5
pba=20;vba=11
xap=xa*pba/pb
xfp=xf*pba/pf
nx=xfp+(xa/2)*(xa/2+xap)/(xa+xap)
fcp=nx^(-1)
bc=pba*1000/(va*sqrt(3))
fc=fcp*bc
disp('a')
printf("fault current %.2fohm",fc)
ic=iff*fcp
xtx=ic^(-1)
xn=xtx-nx
zb=va^2/pba
xnn=xn*zb
disp('b')
printf("reactance required %.4fohm",xnn)
```

Scilab code Exa 13.11 fault level and fault MVA

```
clc
clear
disp('example 13 11')
n1=5;x=0.4;d=0.1;g=20  //given
mva=(g/x)+(g*(n1-1)/(x+n1*d))
n2=10  //given
mva2=(g/x)+(g*(n2-1)/(x+n2*d))
disp('a')
printf("fault MVA =(g/x)+(g*(n-1)/(x+nd)) \n fault
   level is to equal to fault MVA if n=infinity")
disp('b')
printf(" MVA=%.2fMVA if n=%d \n MVA=%.2fMVA if n=%d"
   ,mva,n1,mva2,n2)
fl=g*((1/x)+(1/d))
disp('c')
printf("\nfault level %dMVA",fl)
```

Chapter 14

SYSTEM INTERCONNECTIONS

Scilab code Exa 14.1 speed regulation and frequency drop in alternator

```
clc
clear
disp('example 14.1')
p=100  //rating of alternater
sd=0.04 //speed of alrternator drops
df=-0.1  //change in frequency and drops so -ve
f=50    //frequency is 50hz
r=sd*f/p  //r in hz/MW
dp=-(df)/r
printf("speed regulation of alternator is %.2fHz/MW
   \n change in power output %dMW",r,dp)
```

Scilab code Exa 14.2 frequency deviation in alternator

```
clc
clear
disp('example14.2')
p=100 //power of alternator
f=50  //frequency
h=5   //h constant of machine kW-sec kVA
inl=50 //load suddenly increase by
de=0.5 //time delay
ke=h*p*10^3 //kinetic energy
lke=inl*10^3*de //loss in kinetic energy
nf=((1-(lke/ke))^(de))*f //now frequency
fd=(1-nf/f)*100  //frequency deviation
printf("kinetic energy stored at rated speed %.1e kW
   -sec \nloss in kinetic energy due to increase in
   load %.1e kW-sec \n new frequency %.3fHz \
   nfrequency deviation %.3f",ke,lke,nf,fd)
```

Scilab code Exa 14.3 speed regulation in sharing alternator

```
clc
clear
disp('example 14_3')
ar1=500 //alternator rating1
pl=0.5  //each alternator is operating at half load
ar2=200 //alternator rating2
f=50   //frequency
il=140  //load increase by 140 MW
fd=49.5  //frequency drops
fdd=-f+fd //frequency deviation
dp1=(ar1*pl)-il  //change in load alternator 1
dp2=-(ar2*pl)+il //change in load of alternator 2
r1=-fdd/dp1
r2=-fdd/dp2
```

```
printf(" R1=%.3fohm \n R2=%.4fohm",r1,r2)
```

Scilab code Exa 14.4 static frequency drop for change in load

```
clc
clear
disp('example14.4')
rc=10000 //rated capacity
r=2   //regulation in all units
li=0.02 //load increase
f=50  //frequency
d=rc/(2*f) //d=partial derevative with respect to
   frequency
d=d/rc
b=d+1/r
m=li*rc/2
mpu=m/rc
df=-mpu/b
dff=-mpu/d
printf("static frequency drop %fHz \nfrequency drop
   %dHz",df,dff)
```

Scilab code Exa 14.5 primary ALFC loop paramers

```
clc
clear
disp('example 14.5')
cac=10000  //control area capacity
nol=5000  //normal operating
```

```
h=5          //inertial constent
r=3          //regulation
cf=1         //1%change in corresponds to 1% change in
   load
f=50         //frequency
d=cac/(2*f)
dpu=d/(cac)
kp=1/dpu
tp=2*h/(f*dpu)
printf("d=%.2fp.u.MW/hz, \nkp=%dhz/p.u.MW \n tp=
   %dsecond",dpu,kp,tp)
```

Scilab code Exa 14.6 frequency drop and increased generation to meet the increase in load

```
clc
clear
disp('example 14.6')
rc=10000 //rated capacity
r=2    //regulation in all units
li=0.02 //load increase
f=50   //frequency
d=rc/(2*f) //d=partial derevative with respect to
   frequency
dd=d/rc
b=dd+1/r
m=li*rc/2
mpu=m/rc
df=-mpu/b
dff=-mpu/dd
cf=abs(df*d)
inc=-(df/r)*10^4
printf("the contribution of frequency drop to meet
```

```
    increase in load %.3fMW \nincrease in generation
    cost Rs%.2f",cf,inc)
```

Scilab code Exa 14.7 frequency deviation before the value opens to meet the load demand

```
clc
clear
disp('example 14.7')
p=100  //MVA of generated
f=50   //frequency
rpm=3000 //no load rpm
lad=25  //load applied to the machiene
t=0.5  //time delay
h=4.5  //inertia constent
ke=h*p  //kinetic energy is product of h*p
lke=lad*t  //loss of ke
nf=(((ke-lke)/ke)^t)*f  //new frequency ((1-lke/ke)^
    t)*f
fd=(1-(nf/f))*100    //frequency deviation
printf("ke at no load %dMW-sec \n loss in k.e due to
     load %.1fMW-sec \nnew frequency %.1fHz \
    nfrequency deviation %.1fpercent",ke,lke,nf,fd)
```

Scilab code Exa 14.8 largest change in step load for constant duration of frequency

```
clc
clear
```

```
disp('example 14.8')
c=4000//capacity
f=50  //frequency
ol=2500 //operating load
r=2   //speed regulation
h=5  //inertial constant
dl=0.02 //change in load
df=0.01  //change in frequency
dff=-0.2 //change in steady state frequency
d=(dl*ol)/(df*f) //
dpu=d/c  //din pu
b=dpu+(1/r)
m=-dff*b
printf("largest chang in load is %.3fp.u.MW=%dMW",m,
   m*c)
kp=(1/dpu)
tp=(kp)*2*h/f
tt=(r+kp)/(r*tp) //time constant
printf("\ndf=(dff)(1-e^%f*t)",tt)
```

Scilab code Exa 14.9 frequency responce and static frequency error in the absence of secondary loop

```
clc
clear
disp('example14.9')
c=4000 //capacity of system
f=50  //frequency //operatingload=rated area
   capacity
h=5  //time constent
r=0.025  //
dl=0.01 //change in load
df=0.01 //change in frequency
```

```
rr=r*f //
d=(dl*c)/(df*f)
dpu=d/c
kp=1/dpu
tp=(kp)*(2*h/f)
tt=(rr+kp)/(rr*tp)
sfe=(kp*rr*dpu)/(rr+kp)
ki=(1+(kp/r))^2/(4*tp*kp)
printf("df=-%.5f(1-e^(-%.1f)) \n ki=%.4fp.u.MW/Hz",
    sfe,tt,ki)
```

Scilab code Exa 14.10 change in frequency in transfer function

```
clc
clear
disp('example14.10')
tg=0.2 //time constent of steam turbine
t=2 //time constant of turbine
h=5 //inertia constent
r=0.04  //given
dl=0.01  //change in load
df=0.01  //change in frequency
c=1500  //capacity
f=50  //frequency
adl=0.01 //max allowable change in load
printf("\ntransfer function of governor gr= 1/(1+%.1
    f*s) \n transfer function of turbine gt=1/(1+%d*s
    )",tg,t)
rr=r*f
d=(dl*c)/(df*f)
dpu=(d/c)
kp=(1/dpu)
tp=(kp*(2*h)/(f))
```

```
printf("\ntransfer function of power system \n Gp=(%d/(1+%d*s)\n Df=-gp/(1+(0.5*(gr*gt*gp)))",kp,tp)
ddf=-(kp)/(1+kp/r)
dff=df*f
m=dff/(ddf)
mm=m*c
disp('(b)')
printf("\nthe largest step in the load if the frequency change by more than %.2f in steady state %dMW",adl,mm)
if mm<0
    printf("\nthe minu sign is becose of the that if frequency is to increase by %f \nthe change in load be negative.",adl)
else
    printf("\nthe largest step in load if the frequency is to decrease by %f /n the change in load be positive",adl)
end
disp('(c)')

disp('when integral controller is used,static frequency error is zero')
```

Scilab code Exa 14.11 stactic frequency drop and change in power line with perameters

```
clc
clear
disp('example 14_11')
pa=5000    //power of unit a
pb=10000    //power of unit b
r=2        //given speed regulation in p.uMW
```

```
d=0.01    //d in p.u.MW/Hz
dpa=0     //change in power  in unit a
dpb=-100 //change in power in unit b
pbas=10000  //assume base as 10000
ra=r*pbas/pa  //speed regulation of the unit a
da=d*pa/pbas  //da of unit b
rb=r*pbas/pb //speed regulation of unit b
db=d*pb/pbas  //db of unit b
ba=da+(1/ra)  //area frequency response of a
bb=db+(1/rb)  //area frequency response of b
ma=dpa/pbas   //change in power a in per unit in
   unit a
mb=dpb/pbas   //change in power a in per unit in
   unit b
df=(ma+mb)/(ba+bb) //change in frequency
dpab=(ba*mb-bb*ma)/(ba+bb)  //change in power
   between ab
printf("change in frequency is %.5fHz \nchange in
   power %.6f p.u.MW",df,dpab)
```

Scilab code Exa 14.12 change in frequency and change power in different area

```
clc
clear
disp('example 14.12')
pa=500    //power of unit a
pb=2000   //power of unit b
ra=2.5    //speed regulation of a
rb=2      //speed regulation of b
dl=0.01   //change in load
df=0.01   // change in frequency
pt=20      //change in tie line power
```

```
ptl=0      //let other power station has zero
pbas=2000  //assume base as 2000MW
f=50        //assume frequency
da=(dl*pa)/(df*f)  //change in power w.r.t frequency
dapu=da/(pbas)  // change in power w.r.t frequency in per unit
db=(dl*pb)/(df*f) //change in power in unit b
dbpu=db/pbas      //change in power w.r.t frequency in per unit
raa=ra*pbas/pa  //speed regulation with pbase
rbb=rb*pbas/pb  //speed regulation with pbase
ba=dapu+(1/raa)  //area frequency response a
bb=dbpu+(1/rbb)  //area frequency response b
ma=pt/pbas       //assume change in power in unit a alone due to tie power
mb=ptl/pbas       //change in power in unit b
df=-(ma+mb)/(ba+bb) //change in frequency
dpp=(ba*mb-bb*ma)/(ba+bb)  //change in power
disp('(a)')
printf("change in frequency is %.3fHz  \n change in power between ab %.5fp.u.MW \n \t\t%.2fMW",df,dpp,dpp*pbas)
ma2=ptl/pbas       //assume change in power in unit a alone due to tie power
mb2=pt/pbas       //change in power in unit b
df2=-(ma2+mb2)/(ba+bb) //change in frequency
dpp2=(ba*mb2-bb*ma2)/(ba+bb)  //change in power
disp('(b)')
dpba=dpp2*pbas
printf("change in frequency is %.3fHz  \n change in power between ab %.5fp.u.MW \n",df2,dpp2)
printf(" change in power %fMW",dpba)
```

Scilab code Exa 14.13 steady state change in tie line power if step change in power

```
clc
clear
disp('example 14.13')
p=4000 //power area
n=2    //number of units
r=2    //speed regulation
h=5
pt=600    //given tie power
pan=40   //power angle
stp=100
f=50
t=(pt/p)*cosd(pan)
wo=((2*%pi*f*t/h)^2-(f/(4*r*h))^2)^(0.5)
printf("the damped angular frequency is %.2fradians/
   sec if speed govenor loop is closed",wo)
disp('(b)')
printf("since the two area are imilier ,each area
   will supply half of increase in load .this also
   evident besause ba=bb  \n change in power %dMW \n
    speed regulation is infininy",stp/2)
wo1=(2*%pi*f*t/h)^(0.5) //if govenor loop is open
   alpha is zero
printf("damped angular frequency if speed governor
   loop is open %.3frad/sec ",wo1)
```

Scilab code Exa 14.14 capacitance of shunt load capacitor to maintain voltage constant

```
clc
clear
```

```
disp('example14.14')
Aa=0.98;Ap=3 //magnitude and angle of constant A
Ba=110;Bp=75 //magnitude and angle of constant B
p=50       //given power 50
pf=0.8    //given power factor is 0.8
vr=132    //voltage at reseving station
vs=132  //voltage at source station to be maintained
vsr1=p*pf+(Aa*(vr^2)/Ba)*cosd(Bp-Ap)
ph=vsr1*Ba/(vs*vr)
phh=acosd(ph)
del=Bp-phh
qrr=((vs*vr/Ba)*sind(phh))-((Aa*(vr)^(2)/Ba)*sind(Bp
    -Ap))  //reactive power to maintain voltage equal
qrre=p*sind(acosd(pf)) //reactive power for the load
qrc=qrre-qrr
printf("the reactive power supply and reseving power
     is %dkV \nreactive power %.2fMvar",vs,qrr)
printf("\nthe required compensator network neeeded %
    .2fMvar",qrc)
disp('(b)')
cosb=(Aa*cosd(Bp-Ap)*(vr)^(2)/Ba)*(Ba/(vs*vr)) //
    under no oad condition
phb=acosd(cosb)
qrb=(vs*vr*sind(phb)/Ba)-(Aa*vr*vr*sind(Bp-Ap)/Ba)
if qrb>0 then
    printf("thus under no load condition the line
        delivers %.2fMvar at receiving end.the
        reactive power must be absorbed by shunt
        reactor at receving end. thus the capacity of
         shunt reactor, for no load condition is %.2
        fMvar. ",qrb,qrb)
else
    printf("thus under no load condition the line
        absorbs %.2fMvar at receiving end.the
        reactive power must be delivered by shunt
        reactor at receving end. or reactive must
        suppiled by the source thus the capacity of
        shunt reactor, for no load condition is %.2
```

```
fMvar. ",qrb,qrb)
end
```

Scilab code Exa 14.15 maintaining voltage costant by tapping transformer

```
clc
clear
disp('example 14.15')
v=220  //line voltage
ps=11 ;ss=220;pr=220;sr=11  //primer and secondary end terminal voltages of tapping transformer
zr=20;zi=60  //impedence of line in real ndimagenary parts
p=100  //power at recieving end is 100MVA
pf=0.8  //power factor at recievin end
t=1   //prodect of 2 off terminal tap setting is  1
vt=11  //tap setting for 11 kv voltage bus
P=(p*pf*10^6)/3 //real power
Q=(p*sind(acosd(pf))*10^6)/3  //reactance power
v1=v*(10^3)/sqrt(3)
ts=(1/(1-(zr*P+zi*Q)/(v1^2)))^(0.5)
printf(" tapping ratio at the source %.3f  \n tapping ratio at the receving end %.2f",ts,1/ts)
```

Scilab code Exa 14.16 output voltage with reactive power

```
clc
clear
disp('example 14.16')
```

```
vp=132;vs=33;vt=11  //voltage at primary ,secondary ,teritiory
pp=75;ps=50;pt=25  //MVA rating at prinary , secondary,teritiory
rpr=0.12;rv=132;rp=75  //reactance power of primary under rv and rp as voltage and power base
poa=60;rea=50  //load real and reactive power a
pva=125;svaa=33 //primary and secondary voltage a
svsb=25;pvb=140;svbb=33  //primary and secondary voltage at no load
disp('(a)')
vbas=132 ;mvabas=75  //assume voltage and MVA base
v1pu=pva/vbas   //voltage in per unit
v1apu=round(v1pu*1000)/1000  //rounding off
qre=rea/mvabas  //reactive power in per unit
vn1a=(v1apu+sqrt(v1apu^2-4*rpr*qre))/2  //voltage using quadratic equation formulae
vn2a=(v1apu-sqrt(v1apu^2-4*rpr*qre))/2
vnaa=vn1a*vbas
v12=pvb/vbas
q=svsb/mvabas
vn1b=(v12+sqrt(v12^2-4*rpr*q))/2  //voltage using quadratic equation formulae
vn1b=round(vn1b*1000)/1000
vnbb=vn1b*vbas    //vn in no load condition
printf("vn=%.3f.p.u \n vn=%.3fkV",vn1a,vnaa)
disp('(b)')
printf("vn=%.3f.p.u \n vn=%.3fkV",vn1b,vnbb)
z=vnaa/svaa;x=vnbb/svbb;
printf("\n transformation ratio under load condition %.3f \n transformation ratio under no load condition %.3f \n the actual ratio can be taken as mean of the above value i.e.%.3fpercent\n varying by (+/-)%.3fpercent",z,x,(z+x)/2,x-(z+x)/2)
```

Scilab code Exa 14.17 generation at each station and transfer of power of different plants

```
clc
clear
disp('example 14.7')
ca=200  //capacity of unit a
cb=100   //capacity of unit b
ra=1.5    //speed regulation of unit a
rb=3      //speed regulation of unit b
f=50       //frequency
pla=100    //load on each bus
plb=100
raa=ra*f/(pla*ca)
rbb=rb*f/(plb*cb)
pa=rbb*(pla+plb)/(raa+rbb)
pb=pla+plb-pa
tp=pa-pla
printf(" generation at the plant a is %dMW and \n
   generation at the plant b is %dMW \n transfer
   power from plant a to b is %dMW",pa,pb,tp)
```

Scilab code Exa 14.18 current transfer between two station

```
clc
clear
disp('example 14.18')
za=1.5;zb=2.5;//impedence between two lines
```

```
v=11  //plant operatio\ng voltage
l=20 ; pf=0.8 ;//load at 20 MW at 0.8 pf
i=l*10^3/(v*pf*sqrt(3));ph=-acosd(pf) //current and phase angle of transfrming current
vd=complex(za,zb)*complex(i*cosd(ph),i*sind(ph))  //voltage drop due to loss
printf("the current transfer is %.1fA at an angle %.2f",i,ph)
printf("\nvoltage drop in the interconnector is %.2f+j%.2fV \n so voltage boost needed is %.2f+j%.2fV",real(vd),imag(vd),real(vd),imag(vd))
```

Scilab code Exa 14.19 current in interconnector with different power factor

```
clc
clear
disp('example 14.19')
zaa=3;zbb=9  //impedence given between line
 pas=1   //power at two units are equal to 1p.u
par=1
pbs=1.05  //power at sending end is 1.05 and power at receiving end is 1p.u
pbr=1
i=1 //assume current is 1p.u
los=i*complex(zaa/100,zbb/100)
csd=((abs(los)^2)-pas^2-par^2)/(2*pas*par)  //load angle between two stations
csa=(pas^2+abs(los)^2-par^2)/(2*pas*abs(los))  //angle between source and loss
ta=180-atand(zbb/zaa)-acosd(csa)  //transfering power factor angle
printf("load angle is %.2f\n",cosd(csd))
```

```
if sind(ta)<0 then
    printf("real power is %.3fp.u \nreactive power %.3fp.u lagging",cosd(ta),abs(sind(ta)))
  else
          printf("real power is %.3fp.u \nreactive power %.3fp.u leading",cosd(ta),sind(ta))

end
csd2=(abs(los)^2-pbs^2-pbr^2)/(2*pbs*pbr)  //load angle between two stations
csa2=(pbr^2-pbs^2+abs(los)^2)/(2*pbr*abs(los))  // angle between source and loss
    f=180-atand(zbb/zaa)-acosd(csa2)  //transfering power factor angle
disp('(b)')

printf("load angle is %.2f\n",cosd(csd2))
if sind(f)<0 then
    printf("real power is %.3fp.u \nreactive power %.3fp.u lagging",cosd(f),abs(sind(f)))
  else
          printf("real power is %.3fp.u \nreactive power %.3fp.u leading",cosd(f),sind(f))

end
```

Chapter 15

NEW ENERGY SOURCES

Scilab code Exa 15.1 open circuit voltage internal resistance maximumpower in MHD engine

```
clc
clear
disp('example 15.1')
a=0.1  //plate area
b=3    //flux density
d=0.5  //distence between plates
v=1000  //average gas velosity
c=10    //condectivity
e=b*v*d
ir=d/(c*a)  //internal resistence
mapo=e^2/(4*ir) //maximum power output
printf("E=%dV \ninternal resistence %.1fohm \
   nmaximum power output %dW =%.3fMW",e,ir,mapo,mapo
   /10^6)
```

Scilab code Exa 15.2 open circuit voltage gradiant in duct due to load in MHD engine

```
clc
clear
disp('example 15.2')
b=4.2 //flux density
v=600  //gas velocity
d=0.6  //dimension of plate
k=0.65  //constent
e=b*v*d //open circuit voltage
vg=e/d  //voltage gradient
v=k*e   //voltage across load
vgg=v/d  //voltage gradient due to load voltage
printf("voltage E=%dV \n voltage gradient %dV/m \n
   voltage across load %.1fV \n voltage gradient due
    to load voltage %dv",e,vg,v,vgg)
```

Scilab code Exa 15.3 losses in duct power delivered to load efficiency current density in duct in MHD generator

```
clc
clear
disp("example 15.3")
b=4.2 //flux density
v=600  //gas velocity
d=0.6  //dimension of plate
k=0.65  //constent
sl=0.6  //length given
sb=0.35  //breath given
sh=1.7   //height given
c=60     //given condectivity
e=b*v*d //open circuit voltage
```

```
vg=e/d  //voltage gradient
v=k*e   //voltage across load
vgg=v/d  //voltage gradient due to load voltage
rg=d/(c*sb*sh)
vd=e-v //voltage drop in duct
i=vd/rg  //current due to voltage drop in duct
j=i/(sb*sh) //current density
si=e/(rg)  //short circuit current
sj=si/(sb*sh)  //short circuit current density
pd=j*vg     //power density
p=pd*sl*sh*sb //power
pp=e*i  //also power
pde=v*i  //power delevered is V*i
los=p-pde  //loss
eff=pde/p  //efficiency
maxp=e^2/(4*rg)
printf("resistence of duct %fohms \n voltage drop in
    duct %.1fV \n current %.1fA \ncurrent density
   %fA/m^2 \nshort circuit current %.1fA \nshort
   current density %fA/m^2 \n power %fMW \npower
   delivered to load %fW \n loss in duct %fW \
   nefficiency is %f \nmaximum power delivered to
   load %dMW",rg,vd,i,j,si,sj,p/10^6,pde/10^6,los
   /10^6,eff,maxp/10^6)
```

Scilab code Exa 15.4 output voltage maximum power output in MHD generator

```
clc
clear
disp("example 15.4")
c=50 //conduntance
a=0.2 //area
```

```
d=0.24 //distence between electrodes
v=1800 //gas velosity
b=1 //flux density
k=0.7
ov=k*b*v*d
tp=c*d*a*b^2*v^2*(1-k)
eff=k
op=eff*tp
e=b*v*d
rg=d/(c*a)
si=e/rg
maxp=e^2/(4*rg)
printf("output voltage %.1fV \ntotal power %.4fMW \n efficiency %.1f \n output power %fMW \n open circuit voltage %dV \n internal resistence %.3fohm \n short circuit current %dA \n maximum power output is %.3fMW",ov,tp/10^6,eff,op/10^6,e,rg,si,maxp/10^6)
```

Scilab code Exa 15.5 power collected by surface of collector and temperature rise in photo generators

```
clc
clear
disp('example 15.5')
a=100 //area
spd=0.7 //sun light power density
m=1000 //weight of water collector
tp=30 //temperature of water
th2=60 //angle of incidence
cp=4186 //specific heat of water
sp=spd*cosd(th2)*a //solar power collected by collector
```

```
ei=sp*3600*10^3  //energy input in 1 hour
temp=ei/(cp*10^3)
tw=tp+temp
printf("solar power collected by collector %dkW \
   nenergy input in one hour %e J \n rise in
   temperature is %.1f'C \n temperature of water %.1
   f'c",sp,ei,temp,tw)
```

Scilab code Exa 15.6 peak watt capacity of PV panel and number of modules of photo voltaic cell

```
clc
clear
disp('example 15.6')
vo=100 //motor rated voltage
efm=0.4 //efficiency of motor pump
efi=0.85 //efficiency of inverter
h=50 //head of water
v=25 //volume of water per day
ov=18 //pv pannel output module
pr=40 //power rating
ao=2000 //annual output of array
dw=1000 //density of water
en=v*dw*h*9.81 //energy needed to pump water every
   day
enkw=en/(3.6*10^6)  //energy in kilo watt hour
oe=efm*efi  //overall efficiency
epv=round(enkw/oe)  //energy out of pv system
de=ao/365  //daily energy output
pw=epv*10^3/de  //peak wattage of pv array
rv=vo*(%pi)/sqrt(2)  //rms voltage
nm=rv/ov  //number of modules in series
nm=ceil(nm)
```

```
rpp=nm*pr //rated peak power output
np=pw/rpp //number of strings in parallel
np=round(np)
printf(" energy needed o pump water every day %fkWh/
   day \n overall efficiency %.2f \n energy output
   of pv system %dkWh/day ",enkw,oe,epv)
printf("\n annual energy out of array %dWh/Wp \
   ndaily energy output of array %.3fWh/Wp \n peak
   wattage of pv array %.2fWp \n rms output voltage
   %.2fV\nnumber of modules in series %d \n rated
   peak power output of each string %.2fW \n number
   of strings in parallel %d",epv,de,pw,rv,nm,rpp,np
   )
```

Scilab code Exa 15.7 power available power density torque at maximum power of wind mills

```
clc
clear
disp("example 15.7")
ws=20 //wind speed
rd=10 //rotor diameter
ros=30 //rotor speed
ad=1.293 //air density
mc=0.593 //maximum value of power coefficient
p1=0.5*ad*(%pi)*(rd^2)*(ws^3)/4 //power
p=p1/10^3
pd=p/((%pi)*(rd/2)^2)  //power density
pm=p*(mc)  //maximum power
mt=(pm*10^3)/((%pi)*rd*(ros/60))
printf("power %.fkW \n power density %.3fkW/m^3 \
   nmaximum power %fkW \n maximum torque %.1fN-m",p,
   pd,pm,mt)
```

Scilab code Exa 15.8 difference pressure in pascals and other unit of wind mill

```
clc
clear
disp("example 15.8")
cp=0.593
d=1.293
s=15
a=2/3
dp=2*d*(s^2)*a*(1-a)
dlp=760*dp/(101.3*10^3) //760 mmhg=101.3*10^3 pascal
    then pressure in mm of hg
dpa=dlp/760 //pressure in atmosphere
printf("pressure in pascal %.1fpascal \npressure in
    height of mercury %.2fmm-hg \npressure in
    atmosphere %.5fatm",dp,dlp,dpa)
```

Scilab code Exa 15.9 output surface area of reservoir in tidal power plant

```
clc
clear
disp("example 15.9")
ng=50 //number of generator
r=30  //rated power
mah=10 //maximum head
mih=1  //minimum head
```

```
tg=12  //duration of generation
efg=0.9  //efficiency of generated
g=9.81   //gravity
le=5   //lenght of embankment
ro=1025 //density
ti=r/(0.9)^2
q=ti*10^(6)/(ro*g*mah) //maximum input
q=floor(q*10^2)/10^2
qw=q*ng  //total quantity of water
tcr=qw*tg*3600/2  //total capacity of resevoir
sa=tcr/mah   //surface area
wbe=sa/(le*10^6)  //wash behind embankment
avg=r/2
te=avg*tg*365*ng  //total energy output
printf("quantity of water for maximum output %fm^3-
    sec ",q)
printf("\nsurface area of reservoir %fkm^3 ",sa
    /10^6)
printf("\nwash behind embankment %fkm \ntotal energy
     output %eMWh",wbe,te)
```

Scilab code Exa 15.10 comparison between tidel and coal plant

```
clc
clear
disp('example 15.10')
tc=2100  //total capacity of plant
n=60     //number of generaed
p=35     //power of generated by each generator
h=10     //head of water
d=12     //duration of generation
cee=2.1  //cost of electrical energy per kWh
efft=0.85 //efficiency of turbine
```

```
effg=0.9  //efficiency of generator
g=9.81   //gravity
ro=1025   //density
acc=0.7   //assuming coal conumotion
pi=p/(efft*effg) //power input
q=pi*10^6/(h*g*ro) //quantity of water
tqr=q*n*d*3600/2  //total quantity of water in
    reservoir
avp=tc/2 //average output during 12h
toe=avp*d  //total energy in 12 hours
eg=toe*365 //energy generated for totel year
coe=eg*cee*10^3 //cost of electrical energy
    generated
sc=eg*10^3*acc //saving cost
printf("total quantity of water in reservoir %em^3 \
    nenergy generated per year %eMW \ncost of
    electrical energy Rs%e \nsaving in cost Rs.%e ",
    tqr,eg,coe,sc)
```

Chapter 17

GENERATING CAPACITY RELIABILITY EVALUATION

Scilab code Exa 17.1 CAPACITY OUTAGE PROBABILITY TABLE

```
clc
clear all
disp("example 17.1")
//given
n=2 //number of generating station
f=0.03 //F.O.R
a=1-f
p=40 //generation station power
function [y]=comb(m,r)
y=factorial(m)/(factorial(m-r)*factorial(r))
endfunction
for i=0:n
    pg(i+1)=comb(n,i)*((f)^i)*((a)^(n-i))
    printf("\nnumber of units out %d ,capacity out %dMW ,capacity available %dMW ,probability %4f ",i,p*i,p*(n-i),pg(i+1))
end
```

Scilab code Exa 17.2 CAPACITY OUTAGE PROBABILITY TABLE AND CUMMULATIVE PROBABILITY

```
clc
clear
disp("example 17 2")
//given
n1=2 //number of generating station
f1=0.03 //F.O.R
a1=1-f1
p1=40 //genetaion station power
n2=1  //number of genreting station
f2=0.03 //F.O.R for second set
a2=1-f2
p2=30 //generating station power in second set
function [y]=comb(m,r)
y=factorial(m)/(factorial(m-r)*factorial(r))
endfunction
for i=0:n2
    pg2(i+1)=comb(n2,i)*((f2)^i)*((a2)^(n2-i))
   co2(i+1)=p2*i;ca2(i+1)=p2*(n2-i)
    printf("\nnumber of units out %d ,capacity out
       %dMW ,capacity available  %dMW ,probability
       %4f ",i,co2(i+1),ca2(i+1),pg2(i+1))
end
printf("\nfor exp 17 1 ")
for i=0:n1
    pg1(i+1)=comb(n1,i)*((f1)^i)*((a1)^(n1-i))
    co1(i+1)=p1*i;ca1(i+1)=p1*(n1-i)
    printf("\nnumber of units out %d ,capacity out
       %dMW ,capacity available %dMW ,probability
       %4f ",i,co1(i+1),ca1(i+1),pg1(i+1))
```

```
end
printf("\ncombination of 2 set of stations")
tp=1
pocg=0
for i=0:n1
    for j=0:n2
        og=co1(i+1)+co2(j+1) //now total system capacity out
        cg=ca1(i+1)+ca2(j+1)  //now total system capacity available
        tp=tp-pocg
        pocg=pg1(i+1)*pg2(j+1) //individual stste probability
        printf("\ncapacity out %dMW ,capacity available %dMW ,individual state probability %.6f ,cumulative probability %.6f",og,cg,pocg,tp)
    end
end
```

Scilab code Exa 17.3 CAPACITY OUTAGE PROBABILITY TABLE AND CUMMULATIVE PROBABILITY

```
clc
clear all
disp("example 17 3")
//given
n=4 //number of generating station
f=0.05 //F.O.R
a=1-f
p=50 //generation station power
```

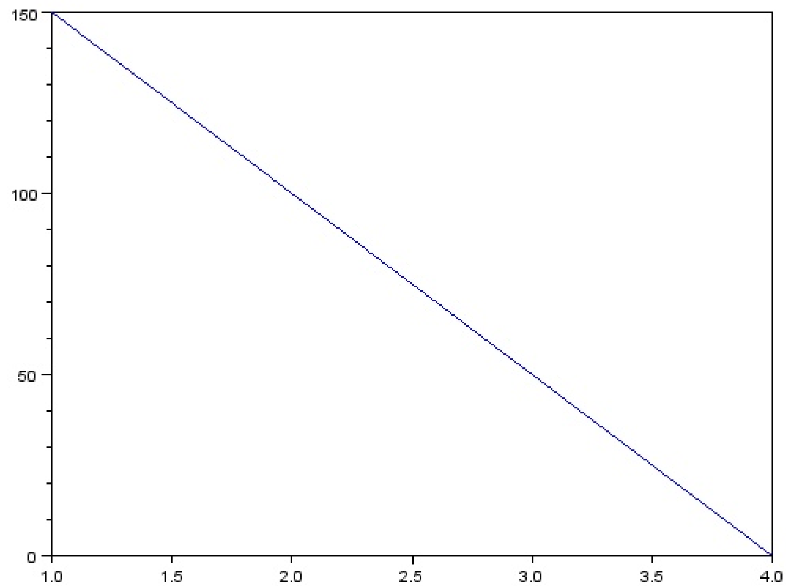

Figure 17.1: CAPACITY OUTAGE PROBABILITY TABLE AND CUMMULATIVE PROBABILITY

```
mp=150 //maximum alowable  power
lf=50 //load factor in persentage
function [y]=comb(m,r)
y=factorial(m)/(factorial(m-r)*factorial(r))
endfunction
for i=0:n
    pg(i+1)=comb(n,i)*((f)^i)*((a)^(n-i))
    co(i+1)=p*i;ca(i+1)=p*(n-i)
    printf("\nnumber of units out %d ,capacity out
       %dMW ,capacity available %dMW ,probability
       %4f ",i,co(i+1),ca(i+1),pg(i+1))
end
ld=mp:-lf:0
[m n]=size(ld)
plot(ld)
tg(n-1)=round(10000/(n-1))/100
tg(n)=tg(n-1)*2
tg(n+1)=100
tg(2)=0;tg(1)=0 //maximum load limit
for i=0:n
    el(i+1)=pg(i+1)*tg(i+1)
    printf("\nnumber of units out %d ,capacity out
       %dMW ,capacity available %dMW ,probability
       %4f ,tg in persentage %.2f ,expected load %.6
       fMW",i,co(i+1),ca(i+1),pg(i+1),tg(i+1),el(i
       +1))
end
lt=sum(el)
printf("\n\nexpected loss of load is %.6fMW percent
   of time. assuming 365 days in a year, then
   expected loss of load is %.3fMW days per year",lt
   ,lt*365/100)
```

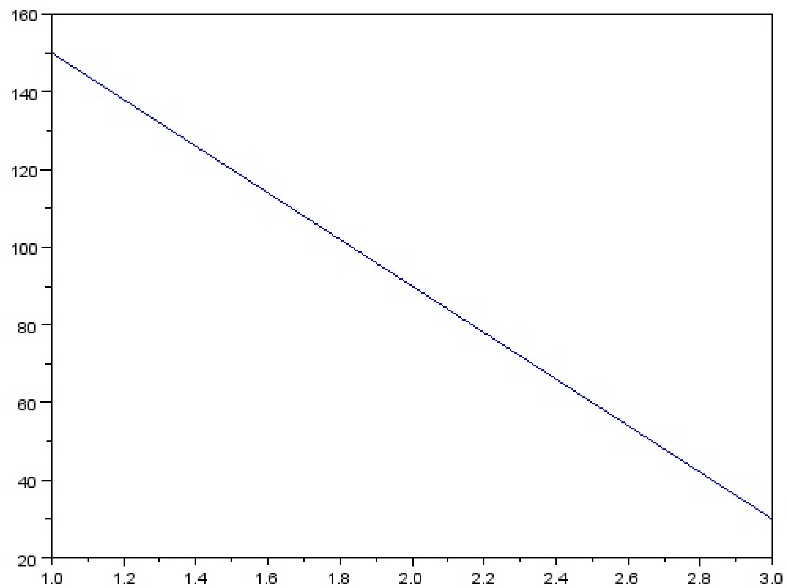

Figure 17.2: CAPACITY OUTAGE PROBABILITY TABLEAND EXPECTED LOAD

Scilab code Exa 17.4 CAPACITY OUTAGE PROBABILITY TABLEAND EXPECTED LOAD

```
clc
clear all
disp("example 17 4")
//given
n=4 //number of generating station
f=0.02 //F.O.R
a=1-f
p=50 //generation station power
mp=150 //maximum alowable  power
minp=30 //minimum power
lf=60 //load factor in persentage
function [y]=comb(m,r)
y=factorial(m)/(factorial(m-r)*factorial(r))
endfunction
for i=0:n
    pg(i+1)=comb(n,i)*((f)^i)*((a)^(n-i))
    co(i+1)=p*i;ca(i+1)=p*(n-i)
    printf("\nnumber of units out %d ,capacity out
       %dMW ,capacity available %dMW ,probability %
       .7f ",i,co(i+1),ca(i+1),pg(i+1))
end
ld=mp:-lf:minp
[m n1]=size(ld)
[mm m]=max(co)
plot(ld)
tg(1)=0
for i=2:n+1
    tg(i)=(mp-ca(i))*100/(2*lf) //percentage time
end
disp("")
for i=1:n+1
```

```
    el(i)=pg(i)*tg(i)
    printf("\nnumber of units out %d ,capacity out
       %dMW ,capacity available %dMW ,probability
       %4f ,tg in persentage %.2f ,expected load %.6
       fMW",i-1,co(i),ca(i),pg(i),tg(i),el(i))
end
lt=sum(el)
printf("\n\nexpected loss of load is %.6fMW percent
   of time. assuming 365 days in a year, then
   expected loss of load is %.3fMW days per year ,
   some times the loss of load is also expressed as
   reciprocal of this figure and then the units are
   years per day this result is %.4fMW years per day
   .",lt,lt*365/100,100/(lt*365))
```

Chapter 20

ENERGY AUDIT

Scilab code Exa 20.1 economic power factor electricity bill

```
clc
clear
disp('example 20.1')
lod=1 //industrial installation load
pf=0.78  //power factor
tf=200   //tariff
md=3.5   //extra maximum demand
ic=500   //installation of capacitor
id=0.15  //interest and depreciation
lf=0.8  //load factor
sinp=ic*id/tf
ph2=asind(sinp)
epf2=cosd(ph2)
ph1=acosd(pf)
ph1=round(ph1*10^2)/10^2
ph2=round(ph2*10^2)/10^2
q=lod*(tand(ph1)-tand(ph2))
q=round(q*10^4)/10^4
ikva=lod/pf
```

```
ikv=round(ikva*(10^5))/10^2
aeu=lod*lf*8760*10^6
eb=ikv*tf+aeu*md
printf("(a)\neconomic power factor %.3flagging \n(b)
    \ncapacitor kVAr to improve the power factor %.4
   f \n(c) \ninitial kVA %.2fKVA \nannual energy
   used %0.3ekWh \nelectrical bill Rs%e per year",
   epf2,q,ikv,aeu,eb)
kvc=round((lod*10^3/(round(epf2*1000)/10^3))*10^2)
   /10^2
ebc=kvc*tf+aeu*md
aidc=q*10^3*ic*id
te=ebc+aidc
asc=eb-te
printf("\n(d)\nKVA after installation of capacitors
   %.2fKVA \n",kvc)
printf("energy bill after installation of capacitor
   Rs%e per year \n",ebc)
printf("annual interest and depreciation of
   capacitor bank Rs%.1fper year \ntotal expendition
    after installation of capacitors Rs%e per year \
   n annual savings due to installation of
   capacitors Rs%d per year",aidc,te,asc)
```

Scilab code Exa 20.2 annual cost method present worth method

```
clc
clear
disp('example 20.2')
ee=5*10^16  //electrical energy requirement
eer=0.1   //energy requirement
i=5*10^6  //investement
n=20      //life time
```

```
ec=4.1     //energy cost
r=0.13    //interest rate
dr=r/((1+r)^(n)-1) //depreciation rate
dr=round(dr*10^5)/10^5
tfc=r+dr    //total fixed cost
ace=i*tfc   //annual cost
ace=round(ace/10^2)*10^2
eb=i*ec    //electrical bill with present motor
teb=eb*(1-eer) //electrical bill with efficiency motor
tac=teb+ace    //total annual cost with efficiency cost
as=eb-tac  //annual saving
printf(" depreciation rate %.5f \n total fixed charge rate %f\n annual cost of efficiency motor Rs%eper year \n total electrical bill with present motors Rs%eper year \n total electrical bill with efficiency motor Rs.%e \n total annual cost if motors are replaced by high efficiency motors Rs%e per year \n annual saving Rs%d per year",dr,tfc,ace,eb,teb,tac,as)
disp('b')
pwf=r/(1-((1+r)^-n)) //present worth factor
pwf=round(pwf*10^5)/10^5
pwm=teb/pwf    //present worth annual cost with existing motors
pwm=round(pwm/10^4)*10^4 //present worth with existing motors
pwem=eb/pwf //present worth with efficiency motor
pwem=round(pwem/10^4)*10^4
pwam=teb/pwf
pwam=round(pwam/10^4)*10^4
tpw=pwam+i  //total persent worth
printf("present worth factor %.5f \n present worth of annual cost with existing motors Rs%e \n present worth of annual cost with new motor Rs%e \n total present worth %e per year",pwf,pwem,pwam,tpw)
```

Chapter 23

CAPTIVE POWER GENERATION

Scilab code Exa 23.1 COST OF DIESEL ENGINE CAPITIVE POWER PLANT

```
clc
clear
disp('example:23.1')
sp=11*10^3;pc=300*10^6;ir=0.15;lp=15;fc=7;eff=0.35;
   cv=10100;mc=0.02;lf=0.8;er=860  //let the given
   variable be --sp=size of plant ,pc=project cost,
   ir=interest rate,lp=life of the plant,fc=fuel
   cost,eff=efficiency,cv=calorific value,er=860,mc=
   maintenance cost,lf=load factor,
cac=pc/sp //let the variable cac be captel cost
printf("\ncapitel cost is %.1f/kW",cac)
crfd1=(1+ir)^(-lp)
crfd=1-crfd1
crf=ir/crfd //crf=capitel cost recovery factor
printf("\nCRF=%.3f",crf)
anfc=cac*crf //anual fixed cost is prodect of
```

```
capitel cost and capitel recovery factor
printf("\nannual fixed cost is Rs%.2f/kW",anfc)
hr=er/eff //heat rate is energy ratedivided by efficiency
printf("\nheat rate is %fcal/kWh",hr)
gpf=cv/hr;//kW generated per liter is division of calorific value to hr
printf("\nnumber of kWh generated per liter of fuel is %.2fkWh/litre",gpf)
fcp=fc/gpf //fuel cost per unit is fuel cost divided by generated per liter
printf("\nfuel cost per unit Rs%fper kWh",fcp)
aomc=cac*mc //annual operation and maintenence cost
printf("\nannual operation cost Rs.%.4f/kW",aomc)
afom=anfc+aomc
printf("\nannual fixed, operation and maintence cost Rs.%.2f/kW",afom)
egpy=8760*lf //energy generated is 24*12*60
printf("\nenergygenerated per year is %dkWh",egpy)
afomc=afom/egpy
printf("\nannual fixed operation and maintenence cost per kWh of energy %.4f/kWh",afomc)
gco=fcp+afomc //generated cost is sum of fuel cost and maintenence cost
printf("\ngenerated cost is Rs%.4f/kWh",gco)
```

Scilab code Exa 23.2 GENERATION COST OF CAPITIVE POWER PLANT in suger mill

```
clc
clear
disp('example 23.2')
sp=25*10^3 //size of the plant
```

```
cc=800*10^6  //capital cost
ir=0.1    //interest rate
lp=20    //life of the plant
mc=0.05  //maintence cost
lf=0.6   //load factor
sub=0.3  //subsidy
nc=cc*(1-sub)
nck=nc/sp
crf=ir/(1-(1+ir)^(-lp))
afc=nck*crf
aomc=nck*mc
tac=afc+aomc
aeg=8760*lf
gc=tac/aeg
printf("net capital cost Rs%d*10^6 \nnet capital
   cost per KW Rs%f/kW \ncrf %f \nannual fixed cost
   Rs%d per kW \nannual operation and maintenance
   cost Rs%dper kW \nTotal annual cost Rs%dper kW \
   nAnnual energy generated per kW of plant capacity
    %.1fkWh \ngeneration cost Rs%.3fkWh",nc/(10^6),
   nck,crf,afc,aomc,tac,aeg,gc)
```

Scilab code Exa 23.11.2 calculation of wheeling charges

```
clc
clear
disp("sample problem in 23.11.2")
pp=11 //power capacity
cost=35 //cost of the system
in=0.14 //interest
lis=30 //life of system
sv=0.15 //salvage value
es=13.5*10^6 //energy sent
los=0.05 //losses
omc=0.02 //O&M charges
```

```
gr=0.006 //general revenue
rd=(1-sv)*100/lis
rdd=rd/100
tac=cost*(in+omc+rdd+gr)
ery=es*(1-los)
wc=(tac/ery)*10^5
printf("rate of depreciation is %.3fpercent \ntotal
    annual cost is Rs.%.5f lakhs/year \nenergy
    received per year %ekWh/year \nwheeling charges
    Rs%f",rd,tac,ery,wc)
```