

Scilab Textbook Companion for  
Power System Operation and Control  
by B. R. Gupta<sup>1</sup>

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# Book Description

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

**Exa** Example (Solved example)

**Eqn** Equation (Particular equation of the above book)

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

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

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# Chapter 1

## Introduction

Scilab code Exa 1.1 Load Demand and energy

```
1 //exa 1.1
2 clc;clear;close;
3 format('v',6);
4 B=100; //W(8 Bulb)
5 F=60; //W(2 Fan)
6 L=100; //W(2 Light)
7 LoadConnected=8*B+2*F+2*L; //W
8 disp(LoadConnected,"(a) Connected Load (W)")
9 //12 midnight to 5am
10 demand1=1*F; //W
11 //5am to 7am
12 demand2=2*F+1*L; //W
13 //7am to 9am
14 demand3=0; //W
15 //9am to 6pm
16 demand4=2*F; //W
17 //6pm to midnight
18 demand5=2*F+4*B; //W
19 DEMAND=[demand1 demand2 demand3 demand4 demand5]
20 max_demand=max(DEMAND);
21 disp(max_demand,"(b) Maximum demand (W)");
```



```

22 df=max_demand/LoadConnected;//demand factor
23 disp(df,"(c) Demand factor");
24 E=demand1*5+demand2*2+demand3*2+demand4*9+demand5*6;
    //Wh
25 E=E/1000;//kWh
26 disp(E,"(d) Energy consumed during 24 hours(kWh)")
27 Edash=LoadConnected*24/1000;//kWh
28 disp(Edash,"(e) Energy consumed during 24 hours if
    all devices are used(kWh)")

```

---

### Scilab code Exa 1.2 Demand and Diversity Factor

```

1 //exa 1.2
2 clc;clear;close;
3 format('v',6);
4 LoadA=2.5*1000;//W
5 //12 midnight to 5am
6 d1A=100;//W
7 //5am to 6am
8 d2A=1.1*1000;//W
9 //6am to 8am
10 d3A=200;//W
11 //8am to 5pm
12 d4A=0;//W
13 //5pm to 12 midnight
14 d5A=500;//W
15 LoadB=3*1000;//W
16 //11 pm to 7am
17 d1B=0;//W
18 //7 am to 8 am
19 d2B=300;//W
20 //8 am to 10 am
21 d3B=1*1000;//W
22 //10 am to 6 pm
23 d4B=200;//W

```

```

24 //6 pm to 11 pm
25 d5B=600; //W
26 DEMAND_A=[d1A d2A d3A d4A d5A]; //W
27 DEMAND_B=[d1B d2B d3B d4B d5B]; //W
28 max_demand_A=max(DEMAND_A); //W
29 max_demand_B=max(DEMAND_B); //W
30 df_A=max_demand_A/LoadA; //demand factor
31 df_B=max_demand_B/LoadB; //demand factor
32 disp(df_B,df_A,"Demand factor of consumer A & B are"
);
33 gd_factor=(max_demand_A+max_demand_B)/max_demand_A;
34 disp(gd_factor,"Group diversity factor")
35 E_A=d1A*5+d2A*1+d3A*2+d4A*9+d5A*7; //Wh
36 E_B=d1B*8+d2B*1+d3B*2+d4B*8+d5B*5; //Wh
37 E_A=E_A/1000; //kWh
38 E_B=E_B/1000; //kWh
39 disp(E_B,E_A,"Energy consumed by A & B during 24
hours(kWh)")
40 Emax_A=max_demand_A*24/1000; //kWh
41 Emax_B=max_demand_B*24/1000; //kWh
42 disp(Emax_B,Emax_A,"Maximum energy consumer A & B
can consume during 24 hours(kWh)")
43 ratio_A=E_A/Emax_A;
44 format('v',7);
45 ratio_B=E_B/Emax_B;
46 disp(ratio_B,ratio_A,"Ratio of actual energy to
maximum energy of consumer A & B")

```

---

### Scilab code Exa 1.3 Increase in peak demand

```

1 //exa 1.3
2 clc;clear;close;
3 format('v',6);
4 n1=600; //No. of apartments
5 L1=5; //kW//Each Apartment Load

```

```

6 n2=20; //No. of general purpose shops
7 L2=2; //kW//Each Shop Load
8 df=0.8; //demand factor
9 //1 Floor mill
10 L3=10; //kW//Load
11 df3=0.7; //demand factor
12 //1 Saw mill
13 L4=5; //kW//Load
14 df4=0.8; //demand factor
15 //1 Laundry
16 L5=20; //kW//Load
17 df5=0.65; //demand factor
18 //1 Cinema
19 L6=80; //kW//Load
20 df6=0.5; //demand factor
21 //Street lights
22 n7=200; //no. of tube lights
23 L7=40; //W//Load of each light
24 //Residential Load
25 df8=0.5; //demand factor
26 gdf_r=3; //group diversity factor
27 pdf_r=1.25; //peak diversity factor
28 //Commercial Load
29 gdf_c=2; //group diversity factor
30 pdf_c=1.6; //peak diversity factor
31 //Solution :
32 //Maximum demand of each apartment
33 dmax_1a=L1*df8; //kW
34 //Maximum demand of 600 apartment
35 dmax_a=n1*dmax_1a/gdf_r; //kW
36 //demand of apartments at system peak time
37 d_a_sp=dmax_a/pdf_r; //kW
38 //Maximum Commercial demand
39 dmax_c=(n2*L2*df+L3*df3+L4*df4+L5*df5+L6*df6)/gdf_c;
//kW
40 //Commercial demand at system peak time
41 d_c_sp=dmax_c/pdf_c; //kW
42 //demand of street light at system peak time

```

```

43 d_sl_sp=n7*L7/1000; //kW
44 //Increase in system peak demand
45 DI=d_a_sp+d_c_sp+d_sl_sp; //kW
46 disp(DI,"Increase in system peak demand(kW)");

```

---

#### Scilab code Exa 1.4 Load Factor and Energy Supplied

```

1 //exa 1.4
2 clc;clear;close;
3 format('v',6);
4 //12 to 5 am
5 L1=20; //MW
6 t1=5; //hours
7 //5 to 9 am
8 L2=40; //MW
9 t2=4; //hours
10 //9 to 6 pm
11 L3=80; //MW
12 t3=9; //hours
13 //6 to 10 pm
14 L4=100; //MW
15 t4=4; //hours
16 //10 to 12 am
17 L5=20; //MW
18 t5=2; //hours
19 //Energy Produced in 24 hours
20 E=L1*t1+L2*t2+L3*t3+L4*t4+L5*t5; //MWh
21 disp(E,"Energy Supplied by the plant in 24 hours(MWh
    ) :");
22 LF=E/24; //%%//Load Factor
23 disp(LF,"Load Factor(%)");

```

---

#### Scilab code Exa 1.5 Capacity and utilisation factor

```

1 //exa 1.5
2 clc;clear;close;
3 format('v',6);
4 C=125; //MW//Installed Capacity
5 //12 to 5 am
6 L1=20; //MW
7 t1=5; //hours
8 //5 to 9 am
9 L2=40; //MW
10 t2=4; //hours
11 //9 to 6 pm
12 L3=80; //MW
13 t3=9; //hours
14 //6 to 10 pm
15 L4=100; //MW
16 t4=4; //hours
17 //10 to 12 am
18 L5=20; //MW
19 t5=2; //hours
20 //Energy Poduced in 24 hours
21 E=L1*t1+L2*t2+L3*t3+L4*t4+L5*t5; //MWh
22 LF=E/24; //%%//Load Factor
23 CF=LF/C; //%%//Capacity Factor
24 disp(CF,"Capacity Factor(%) : ");
25 UF=100/C; //%%//Utilisation Factor
26 disp(UF,"Utilisation Factor(%) : ");

```

---

### Scilab code Exa 1.6 Energy Load curve and Mass Curve

```

1 //exa 1.6
2 clc;clear;close;
3 format('v',6);
4 //12 to 5 am & 10 to 12 am
5 L1=20; //MW
6 E1=L1*24; //MWh

```

```

7 //5 to 9 am
8 L2=40; //MW
9 E2=E1+(L2-L1)*17; //MWh
10 //9 to 6 pm
11 L3=80; //MW
12 E3=E2+(L3-L2)*13; //MWh
13 //6 to 10 pm
14 L4=100; //MW
15 E4=E3+(L4-L3)*4; //MWh
16 //Plotting Energy load curve
17 L=[0,L1,L2,L3,L4]; //MW
18 E=[0,E1,E2,E3,E4]; //Mwh
19 subplot(2,1,1)
20 plot(E,L)
21 xlabel('Energy(MWh)');
22 ylabel('Load(MW)');
23 title('Energy Load Curve');
24 //Energy Supplied
25 //Upto 5am
26 t1=5; //hours
27 E1=L1*t1; //MWh
28 //Upto 9am
29 t2=4; //hours
30 E2=E1+L2*t2; //MWh
31 //Upto 6pm
32 t3=9; //hours
33 E3=E2+L3*t3; //MWh
34 //Upto 10pm
35 t4=4; //hours
36 E4=E3+L4*t4; //MWh
37 //Upto 12pm
38 t4=2; //hours
39 E4=E3+L4*t4; //MWh
40 //Plotting Mass curve
41 T=[0,1,2,3,4]; //MW
42 E=[0,E1,E2,E3,E4]; //Mwh
43 subplot(2,1,2)
44 plot(T,E)

```

```

45 ylabel('Energy(MWh)');
46 xlabel('0-1: 12-5am 1-2: 5-9am 2-3: 9-6pm 3-4: 6-10
    pm above4: 10-12pm');
47 title('Mass Curve');

```

---

#### Scilab code Exa 1.7 Load Factor Plant capacity reserve capacity

```

1 //exa 1.7
2 clc;clear;close;
3 format('v',9);
4 dmax=40;//MW//Maximum demand
5 CF=0.5;//Capacity Factor
6 UF=0.8;//Utilisation Factor
7 LF=CF/UF;//Load Factor
8 disp(LF,"(a) Load Factor : ");
9 C=dmax/UF;//MW//Plant Capacity
10 disp(C,"(b) Plant Capacity(MW) : ");
11 RC=C-dmax;//MW//Reserve Capacity
12 disp(RC,"(c) Reserve Capacity(MW) : ");
13 p=dmax*LF*24*365;//MWh//Annual Energy Production
14 disp(p,"(d) Annual Energy Production(MWh) : ");

```

---

#### Scilab code Exa 1.8 Load Curve and energy required

```

1 //exa 1.8
2 clc;clear;close;
3 format('v',6);
4 L1=50;//MW//Initial
5 t1=5;//hours
6 L2=50;//MW//5am
7 t2=4;//hours
8 L3=100;//MW//9am
9 t3=9;//hours

```

```

10 L4=100; //MW//6pm
11 t4=2; //hours
12 L5=150; //MW//8pm
13 t5=2; //hours
14 L6=80; //MW//10pm
15 t6=2; //hours
16 L7=50; //MW
17 //Energy Required in 24 hours
18 E=L1*t1+(L2+L3)/2*t2+(L3+L4)/2*t3+(L4+L5)/2*t4+(L5+
    L6)/2*t5+(L6+L1)/2*t6; //MWh
19 disp(E,"Energy required in one day(MWh)");
20 DLF=E/L5/24*100; //%%//Daily Load Factor
21 disp(DLF,"Daily Load Factor(%)");
22 //Plotting load curve
23 T=[0,1,2,3,4,5,6]; //Slots
24 L=[L1,L2,L3,L4,L5,L6,L7]; //MW
25 plot(T,L)
26 ylabel('Load(MW)');
27 xlabel('0-1: 12-5am 1-2: 5-9am 2-3: 9-6pm 3-4: 6-8pm
    4-5:8-10pm 5-6 :10-12pm');
28 title('Chronological Load Curve');

```

---

### Scilab code Exa 1.9 Load duration curve and Mass curve

```

1 //exa 1.9
2 clc;clear;close;
3 format('v',6);
4 L1=50; //MW//Initial
5 t1=5; //hours
6 L2=50; //MW//5am
7 t2=4; //hours
8 L3=100; //MW//9am
9 t3=9; //hours
10 L4=100; //MW//6pm
11 t4=2; //hours

```



```

12 L5=150; //MW//8pm
13 t5=2; //hours
14 L6=80; //MW//10pm
15 t6=2; //hours
16 L7=50; //MW
17 //Load Duration Curve
18 l1=L5; //Mw
19 l2=L4; //MW
20 l3=L1; //MW
21 L=[l1,l2,l2,l3,l3]
22 T=0:6:24; //Duration in hours
23 subplot(2,1,1)
24 plot(T,L)
25 ylabel('Load (MW)');
26 xlabel('Hours');
27 title('Load Duration Curve');
28 //Energy Consumed
29 //Upto 5am
30 t1=5; //hours
31 E1=L1*t1; //MWh
32 //Upto 9am
33 t2=4; //hours
34 E2=E1+L2*t2; //MWh
35 //Upto 6pm
36 t3=9; //hours
37 E3=E2+L3*t3; //MWh
38 //Upto 10pm
39 t4=4; //hours
40 E4=E3+L4*t4; //MWh
41 //Upto 12pm
42 t4=2; //hours
43 E4=E3+L4*t4; //MWh
44 //Plotting Mass curve
45 T=[0,1,2,3,4]; //MW
46 E=[0,E1,E2,E3,E4]; //Mwh
47 subplot(2,1,2)
48 plot(T,E)
49 ylabel('Energy (MWh)');

```

```

50 xlabel('0-1: 12-5am 1-2: 5-9am 2-3: 9-6pm 3-4: 6-10
    pm above4: 10-12pm');
51 title('Mass Curve');

```

---

### Scilab code Exa 1.10 Station Capacity and Reserve capacity

```

1 //exa 1.10
2 clc;clear;close;
3 format('v',6);
4 E=438*10^4; //kWh
5 LF=20; //% annual
6 CF=15; //%/Capacity Factor
7 Lmax=E/(LF/100)/24/365; //kW
8 Lmax=Lmax/1000; //MW
9 C=Lmax/CF*LF; //MW/Plant Capacity
10 disp(C,"Plant Capacity(MW): ");
11 RC=C-Lmax; //MW/Reserve Capacity
12 disp(RC,"Reserve Capacity(MW) : ");

```

---

### Scilab code Exa 1.11 Maximum demand and annual energy supplied

```

1 //exa 1.11
2 clc;clear;close;
3 format('v',7);
4 L1=10000; //kW
5 L2=6000; //kW
6 L3=8000; //kW
7 L4=7000; //kW
8 df=1.5; //diversity factor
9 LF=65; //%/Load Factor
10 Dinc=60; //%/Increase in maximum demand
11 L=L1+L2+L3+L4; //kW/Sum
12 L=L/1000; //MW

```

```

13 Dmax=L/df; //MW
14 disp(Dmax,"Maximum demand on station(MWh)");
15 E=Dmax*365*24*LF/100; //MWh// Annual Energy
16 format('v',9);
17 disp(E,"Annual Energy Supplied(MWh)");
18 Din_max=Dinc/100*Dmax; //MW
19 format('v',7);
20 C=Dmax+Din_max; //MW
21 disp(C,"Installed Capacity(MW)")

```

---

#### Scilab code Exa 1.12 Weekly Load Factor

```

1 //exa 1.12
2 clc;clear;close;
3 format('v',5);
4 //Arranging data for Load Duration Curve
5 //week days 5-9pm load
6 L1=350; //MW
7 t1=4*5; //hours
8 //week days 8-12am & 1-5pm load
9 L2=250; //MW
10 t2=t1+8*5; //hours
11 //saturday & sunday 5-9pm load
12 L3=200; //MW
13 t3=t2+4*2; //hours
14 //All days 150MW load
15 L4=150; //MW
16 t4=t3+6*5+15*2; //hours
17 //All days 100MW load
18 L5=100; //MW
19 t5=t4+6*5+5*2; //hours
20 A=31600; //Total Load Curve Area
21 LF=A/L1/24/7*100; //%%//Weekly load factor
22 disp(LF,"Weekly Load factor(%)");
23 disp("Load Duration Curve is shown in figure.");

```

```

24 //Load Duration Curve
25 L=[L1 L2 L3 L4 L5]; //MW
26 T=[t1 t2 t3 t4 t5]; //hours
27 plot2d2(T,L);
28 xtitle('Load Duration Curve', 'Time(Hours)', 'Load(MW)
      ');

```

---

#### Scilab code Exa 1.13 Annual Load factor

```

1 //exa 1.13
2 clc;clear;close;
3 format('v',7);
4 LF=0.825; //Daily Load Factor
5 ratio1=0.87; //daily peak load to monthly peak load
6 ratio2=0.78; //monthly peak load to annually peak
  load
7 LF_annual=LF*ratio1*ratio2; //Annual Load Factor
8 disp(LF_annual,"Annual Load Factor : ");

```

---

#### Scilab code Exa 1.14 Peak Load on transformer and feeder

```

1 //exa 1.14
2 clc;clear;close;
3 format('v',5);
4 //Transformer1
5 Lm=300; //kW
6 df_m=0.6; //demand factor
7 Lc=100; //kW//Commercial Load
8 df_c=0.5; //demand factor
9 //Transformer2
10 Lr2=500; //kW//Residential Load
11 df_Lr2=0.4; //demand factor
12 //Transformer3

```

```

13 Lr3=400; //kW
14 df_Lr3=0.5; //demand factor
15 //Diversity factors
16 df1=2.3;
17 df2=2.5;
18 df3=2;
19 DF=1.4; //Diversity factor between transformers
20 //Solution :
21 disp(" Part (a)");
22 Lp1=(Lm*df_m+Lc*df_c)/df1; //kW//Peak load on
    Transformer1
23 disp(Lp1," Peak load on Transformer1 (kW)");
24 Lp2=Lr2*df_Lr2/df2; //kW//Peak load on Transformer2
25 disp(Lp2," Peak load on Transformer2 (kW)");
26 Lp3=Lr3*df_Lr3/df3; //kW//Peak load on Transformer3
27 disp(Lp3," Peak load on Transformer3 (kW)");
28 disp(" Part (b)");
29 LpF=(Lp1+Lp2+Lp3)/DF; //Peak load on feeder
30 disp(LpF," Peak load on feeder (kW)");

```

---

#### Scilab code Exa 1.16 Max Load and Load factor

```

1 //exa 1.16
2 clc;clear;close;
3 format('v',8);
4 L=[20 25 30 25 35 20]; //MW
5 T=[6 4 2 4 4 4]; //Hours
6 Lmax=max(L); //MW
7 disp(Lmax," (a) Maximum demand (MW)");
8 E=L(1)*sum(T)+(L(2)-L(1))*T(2)+(L(3)-L(1))*T(3)+(L
    (4)-L(1))*T(4)+(L(5)-L(1))*T(5)+(L(6)-L(1))*T(6);
    //MWh
9 E=E*1000; //kWh
10 disp(E," (b) Units generated per day (kWh)");
11 Lavg=E/sum(T); //kWh

```

```

12 Lavg=Lavg/1000; //MW
13 disp(Lavg,"(c) Average Load(MW)");
14 format('v',6);
15 LF=Lavg/Lmax*100; //%
16 disp(LF,"(d) Load Factor(%)");

```

---

#### Scilab code Exa 1.17 Real Power

```

1 //exa 1.17
2 clc;clear;close;
3 format('v',8);
4 pf=0.8; //power factor
5 delf=1; //%%//drop in frequency(delf/f)
6 //delP=-2*(sind(theta))^2*delf
7 theta=acosd(pf); //degree
8 delP_BY_delf=-2*sind(theta)^2; //increase in load wrt
   frequency
9 disp(-delP_BY_delf,"1% drop in frequency, Increased
   in Load(%)");

```

---

#### Scilab code Exa 1.18 Total Energy generated

```

1 //exa 1.18
2 clc;clear;close;
3 format('v',8);
4 Lmax=100; //MW
5 LF=40; //%%//Load Factor
6 Lavg=Lmax*LF/100; //MW
7 E=Lavg*24*365; //MWh
8 disp(E,"Energy generated in a year(MWh)");

```

---

### Scilab code Exa 1.19 Motor Load Change

```
1 //exa 1.19 page 25
2 clc;clear;close;
3 format('v',5);
4 V=400;//V
5 s1=0.03;//initial slip
6 delV=1;//%/// Voltage Drop
7 R1=0.290;//ohm/phase
8 R2=0.15;//ohm/phase
9 X=0.7;//ohm/phase(X1+X2)
10 //V1^2*s1=V2^2*s2 for speed independent torque
11 //taking for calculating s2
12 V1=1;//V
13 V2=V1-V1*delV/100;//V
14 s2=V1^2/V2^2*s1;//slip
15 I2ByI1=sqrt([R1+R2/s1]^2+X^2)/sqrt([R1+R2/s2]^2+X^2)
    *(V2/V1)
16 delI=(I2ByI1-1)*100;//%// Current Increase
17 disp(delI,"1% drop in Voltage increases current by(%
    )");
18 //P=(R1+R2/s)*I^2
19 P2ByP1=(R1+R2/s2)/(R1+R2/s1)*I2ByI1^2;//ratio
20 delP=(1-P2ByP1)*100;//%//Power Decrease
21 format('v',4);
22 disp(delP,"1% drop in Voltage decreases power input
    by(%)");
23 //Answer in the textbook is not accurate.
```

---

## Chapter 2

# Economic Operation of Power System and Unit Commitment

Scilab code Exa 2.2 Saving per year

```
1 //exa 2.2
2 clc;clear;close;
3 format('v',8);
4 //For equal incremental cost
5 L1=125;//MW
6 L2=100;//MW
7 //For equal sharing
8 L=(L1+L2)/2;//MW
9 //Change in cost Unit 1
10 dC1=integrate('0.2*P1+30','P1',L1,L);//Rs./hour
11 //Change in cost Unit 2
12 dC2=integrate('0.15*P2+40','P2',L2,L);//Rs./hour
13 dCyearly=(dC1+dC2)*24*365;//Rs./year
14 disp(dCyearly,"Saving per year in economic load
15 allocation(Rs./year)");
16 //Answer in the textbook is not accurate.
```

---



### Scilab code Exa 2.3 Increase in generation

```
1 //exa 2.3
2 clc;clear;close;
3 format('v',6);
4 L=400;//MW///total load
5 delPD=50;//MW//increase in demand
6 //dC1/dP1=0.2*P1+30
7 //dC2/dP2=0.15*P2+40
8 twoC1=0.2;//from above equation
9 twoC2=0.15;//from above equation
10 delP1_by_delPD=(1/twoC1)/(1/twoC1+1/twoC2);
11 delP2_by_delPD=(1/twoC2)/(1/twoC1+1/twoC2);
12 delP1=delP1_by_delPD*delPD;//MW
13 disp(delP1,"Increase in generation of unit1(MW) : ")
    ;
14 delP2=delP2_by_delPD*delPD;//MW
15 disp(delP2,"Increase in generation of unit2(MW) : ")
    ;
16 format('v',7);
17 P1=L/2+delP1;//load on unit 1
18 disp(P1,"Total load on unit1(MW) : ");
19 P2=L/2+delP2;//load on unit 2
20 disp(P2,"Total load on unit2(MW) : ");
21 format('v',6);
22 disp("Checking incremental cost :");
23 dC1_by_dP1=0.2*P1+30;//Rs./MWh
24 disp(dC1_by_dP1,"Incremental cost of unit 1(Rs./MWh)
    : ");
25 dC2_by_dP2=0.2*P2+30;//Rs./MWh
26 disp(dC2_by_dP2,"Incremental cost of unit 2(Rs./MWh)
    : ");
27 disp("Conclusion : Cost are same(Approximately).");
28 //Note : Values calculated in the book are slightly
    wrong because of accuracy in calculation as
    compared to scilab accuracy.
```

---

## Scilab code Exa 2.5 Loss Coefficient and Transmission Loss

```
1 //exa 2.5
2 clc;clear;close;
3 format('v',8);
4 I1=0.8;//p.u.
5 I2=1;//p.u.
6 Za=0.04+%i*0.12;//p.u.
7 Zb=0.03+%i*0.1;//p.u.
8 Zc=0.03+%i*0.12;//p.u.
9 V=1;//p.u.
10 //Solution :
11 V1=V+(I1+I2)*Za+I1*(Zb);//p.u.
12 V2=V+(I1+I2)*Za+I2*(Zc);//p.u.
13 P1=real(I1*V1);//p.u.
14 P2=real(I2*V2);//p.u.
15 fi1=atan(imag(V1),real(V1));
16 fi2=atan(imag(V2),real(V2));
17 disp("Loss Coefficients are : ")
18 B11=[real(Za)+real(Zb)]/[abs(V1)^2*cos(fi1)^2];//p.u
19 .
19 disp(B11,"B11(p.u.) : ");
20 B22=[real(Za)+real(Zc)]/[abs(V2)^2*cos(fi2)^2];//p.u
21 .
21 disp(B22,"B22(p.u.) : ");
22 B12=[real(Za)]/[abs(V1)*abs(V2)*cos(fi1)*cos(fi2)];
23 //p.u.
23 disp(B12,"B12(p.u.) : ");
24 PL=P1^2*B11+P2^2*B22+2*P1*P2*B12;//p.u.
25 format('v',10);
26 disp(PL,"Transmission Loss(p.u.) : ");
27 //Note : Values calculated in the book are slightly
      wrong because of accuracy in calculation as
      compared to scilab accuracy.
```

---

## Scilab code Exa 2.7 Loss Formula Coefficients

```
1 //exa 2.7
2 clc;clear;close;
3 format('v',8);
4 Za=0.03+%i*0.09;//p.u.
5 Ia=1.5-%i*0.4;//p.u.
6 Zb=0.10+%i*0.30;//p.u.
7 Ib=0.5-%i*0.2;//p.u.
8 Zc=0.03+%i*0.09;//p.u.
9 Ic=1-%i*0.1;//p.u.
10 Zd=0.04+%i*0.12;//p.u.
11 Id=1-%i*0.2;//p.u.
12 Ze=0.04+%i*0.12;//p.u.
13 Ie=1.5-%i*0.3;//p.u.
14 V=1;//p.u.
15 base=100;//MVA
16 //Solution
17 //Currents of load
18 IL1=0.4;//p.u.
19 IL2=0.6;//p.u.
20 //Current distribution factors :
21 Na1=1;Na2=0;
22 Nb1=0.6;Nb2=-0.4;
23 Nc1=0;Nc2=1;
24 Nd1=0.4;Nd2=0.4;
25 Ne1=0.6;Ne2=0.6;
26 //Bus Voltages
27 V1=V+Ia*Za;//p.u.
28 V2=V-Ib*Zb+Ic*Zc;//p.u.
29 //Phase Angles
30 theta1=atand(imag(Ia),real(Ia));//degree
31 theta2=atand(imag(Ic),real(Ic));//degree
32 //Power Factors :
```

```

33 cos_fi1=cosd(atan2(imag(V1),real(V1))-theta1);//
    source 1 power factor
34 cos_fi2=cosd(atan2(imag(V2),real(V2))-theta2);//
    source 2 power factor
35 disp("Loss formula Coefficients in p.u. :")
36 B11=[Na1^2*real(Za)+Nb1^2*real(Zb)+Nc1^2*real(Zc)+
    Nd1^2*real(Zd)+Ne1^2*real(Ze)]/[abs(V1)^2*cos_fi1
    ];//p.u.
37 disp(B11,"B11(p.u) : ");
38 format('v',7);
39 B22=[Na2^2*real(Za)+Nb2^2*real(Zb)+Nc2^2*real(Zc)+
    Nd2^2*real(Zd)+Ne2^2*real(Ze)]/[abs(V2)^2*cos_fi2
    ];//p.u.
40 disp(B22,"B22(p.u) : ");
41 B12=[Na1*Na2*real(Za)+Nb1*Nb2*real(Zb)+Nc1*Nc2*real(
    Zc)+Nd1*Nd2*real(Zd)+Ne1*Ne2*real(Ze)]/[abs(V1)*
    abs(V2)*cos_fi1*cos_fi2*cosd(theta1-theta2)];//
    p.u.
42 disp(B12,"B12(p.u) : ");
43 //Converting p.u. to actual value
44 format('v',10);
45 disp("Loss formula Coefficients in MW-1 :")
46 B11=B11/base;//MW-1
47 disp(B11,"B11(MW-1) : ");
48 format('v',9);
49 B22=B22/base;//MW-1
50 disp(B22,"B22(MW-1) : ");
51 B12=B12/base;//MW-1
52 disp(B12,"B12(MW-1) : ");
53 //Note : Values calculated in the book are slightly
    wrong because of accuracy in calculation as
    compared to scilab accuracy.

```

---

Scilab code Exa 2.8 Required generationa at each plant

```

1 //exa 2.8
2 clc;clear;close;
3 format('v',8);
4 //dC1/dP1=0.2*P1+22;//Rs./MWh
5 //dC2/dP2=0.15*P2+30;//Rs./MWh
6 B22=0;B12=0;//Because Loss is independent wrt P2
7 P1=100;//MW
8 PL=15;//MW
9 B11=PL/P1^2;//MW^-1
10 L1=1/[1-0.003*P1];//Penalty Factor plant 1
11 L2=1;//Penalty Factor of plant 2
12 lambda=60;
13 //lambda=dC1/dP1*L1=dC2/dP2*L2
14 //dC1/dP1*L1=dC2/dP2*L2
15 P2=((0.2*P1+22)*L1-30)/0.15;//MW
16 P=P1+P2-B11*P1^2;//MW//Total Load
17 disp(P1,"Required generation at plant1(MW)");
18 disp(P2,"Required generation at plant2(MW)");
19 disp(P,"Total Load(MW)");

```

---

### Scilab code Exa 2.9 Saving in Rs per hour

```

1 //exa 2.9
2 clc;clear;close;
3 format('v',6);
4 //dC1/dP1=0.2*P1+22;//Rs./MWh
5 //dC2/dP2=0.15*P2+30;//Rs./MWh
6 B22=0;B12=0;//Because Loss is independent wrt P2
7 P1=100;//MW
8 PL=15;//MW
9 B11=PL/P1^2;//MW^-1
10 L1=1/[1-0.003*P1];//Penalty Factor plant 1
11 L2=1;//Penalty Factor of plant 2
12 lambda=60;
13 //lambda=dC1/dP1*L1=dC2/dP2*L2

```

```

14 //dC1/dP1*L1=dC2/dP2*L2
15 P2=((0.2*P1+22)*L1-30)/0.15; //MW
16 P=P1+P2-B11*P1^2; //MW//Total Load
17 //dC1/dP1=dC2/dP2; neglecting transmission loss
18 clear('P2'); //for recalculation
19 //0.2*P1-0.15*P2-8=0; //eqn (1)
20 //P1=0.75*P2+40; //P1+P2-B11*P1^2-P=0; //eqn (2)
21 //1.75*P2-B11*P1^2=P-40
22 Eqn=[-B11 1.75 40-P];
23 P2=roots(Eqn);
24 P2=P2(2); //MW//neglecting higher value
25 P1=0.75*P2+40; //MW
26 dC1=integrate('0.2*P+22','P',100,P1); //Rs.//
    Additional Cost plant1
27 dC2=integrate('0.15*P+30','P',200,P2); //Rs.//
    Decreased Cost plant2
28 dC=dC1+dC2; //Rs./hour//Net change in cost
29 disp(dC,"Taking transmission loss in account, Net
    saving per hour in fuel cost(Rs,/hour)");
30 //Note : Values calculated in the book are slightly
    wrong because of accuracy in calculation as
    compared to scilab accuracy.

```

---

### Scilab code Exa 2.10 Transmission Loss and Received Power

```

1 //exa 2.10
2 clc;clear;close;
3 format('v',5);
4 B11=0.001; //MW^-1
5 B22=0.0024; //MW^-1
6 B12=-0.0005; //MW^-1
7 //dC1/dP1=0.8*P1+16; //Rs./MWh
8 //dC2/dP2=0.08*P2+12; //Rs./MWh
9 lambda=20;
10 //Iterations for calculating value

```

```

11 P1(1)=0;
12 P2=0;
13 for i=2:1:10
14     P1(i)=(0.2+0.001*P2(i-1))/0.006;
15     P2(i)=(0.4+0.001*P1(i))/0.0088;
16     if P1(i)==P1(i-1) then
17 break;
18     end
19 end
20 P1=P1(i); //MW
21 disp(P1," Generation P1(MW) : ");
22 P2=P2(i); //MW
23 disp(P2," Generation P2(MW) : ");
24 format('v',4);
25 PL=B11*P1^2+2*B12*P1*P2+B22*P2^2; //MW
26 disp(PL," Transmission Loss(MW) : ");
27 format('v',5);
28 Pr=P1+P2-PL; //MW
29 disp(Pr," Received Power(MW) : ");

```

---

### Scilab code Exa 2.11 Cost Characteristics

```

1 //exa 2.11
2 clc;clear;close;
3 format('v',7);
4 //C1=561+7.92*P1+0.001562*P1^2;//Rs./hour
5 //C2=310+7.85*P2+0.00194*P2^2;//Rs./hour
6 a1=561;a2=310;
7 b1=7.92;b2=7.85;
8 c1=0.001562;c2=0.00194;
9 ce=c1*c2/(c1+c2);
10 be=ce*(b1/c1+b2/c2);
11 ae=a1-b1^2/4/c1+a2-b2^2/4/c2+be^2/4/ce;
12 disp(" Coefficients are : ");
13 disp(" ae = "+string(ae)+" & be = "+string(be));

```

```

14 format('v',10);
15 disp(ce,"ce = ")
16 PT=poly(0,'PT');
17 disp("Cost Characteristics : ")
18 disp("CT=870.753+7.8888*PT+0.0008653*PT^2");

```

---

### Scilab code Exa 2.12 Daily Operating Schedule

```

1 //exa 2.12
2 clc;clear;close;
3 format('v',7);
4 //C1=7700+52.8*P1+5.5*10^-3*P1^2;//Rs./hour
5 //C2=2500+15*P2+0.05*P2^2;//Rs./hour
6 a1=7700;a2=2500;
7 b1=52.8;b2=15;
8 c1=5.5*10^-3;c2=0.05;
9 P1=poly(0,'P1');
10 P2=poly(0,'P2');
11 dC1bydP1=52.8+2*5.5*10^-3*P1;
12 dC2bydP2=15+2*0.05*P2;
13 disp("For 1200 MW Load :");
14 P=1200;//MW
15 //Let loads of unit are P1 & 1200-P1
16 //Economical Loading dC1/dP1=dC2/dP2
17 eqn=52.8+2*5.5*10^-3*P1-15-2*0.05*(1200-P1);
18 P1=roots(eqn);//MW
19 P2=1200-P1;//MW
20 disp(P1,"P1(MW) : ");
21 disp(P2,"P2(MW) : ");
22 disp("For 900 MW Load :");
23 P=900;//MW
24 clear('P1','P2');
25 P1=poly(0,'P1');
26 P2=poly(0,'P2');
27 //Let loads of unit are P1 & 900-P1

```



```

28 //Economical Loading  $dC1/dP1=dC2/dP2$ 
29 eqn=52.8+2*5.5*10-3*P1-15-2*0.05*(900-P1);
30 P1=roots(eqn); //MW
31 P2=900-P1; //MW
32 disp(P1,"P1(MW) : ");
33 disp(P2,"P2(MW) : ");
34 disp("For 500 MW Load :");
35 P=500; //MW
36 clear('P1','P2');
37 P1=poly(0,'P1');
38 P2=poly(0,'P2');
39 //Let loads of unit are P1 & 500-P1
40 //Economical Loading  $dC1/dP1=dC2/dP2$ 
41 eqn=52.8+2*5.5*10-3*P1-15-2*0.05*(500-P1);
42 P1=roots(eqn); //MW
43 P2=500-P1; //MW
44 //Minimum load is 200MW
45 if P1<200 then
46     P2=P1+P2
47     P1=0;
48 end
49 disp(P1,"P1(MW) : ");
50 disp(P2,"P2(MW) : ");
51 format('v',10);
52 C=(2500+15*P2+0.05*P22)*10; //Rs.// Operating cost
    for 10 hour
53 disp(C,"Operating cost for 10 hour(Rs.)");
54 disp("Other option : ");
55 P1=200; //MW
56 P2=300; //MW
57 disp(P1,"P1(MW) : ");
58 disp(P2,"P2(MW) : ");
59 C1=7700+52.8*P1+5.5*10-3*P12; //Rs./hour
60 C2=2500+15*P2+0.05*P22; //Rs./hour
61 C=10*(C1+C2); //Rs.// Operating cost for 10 hour
62 disp(C,"Operating cost for 10 hour(Rs.)");

```

---

### Scilab code Exa 2.13 Cost of generation

```
1 //exa 2.13
2 clc;clear;close;
3 format('v',10);
4 //C1=2000+20*P1+0.05*P1^2;//Rs./hour
5 //C2=2750+26*P2+0.03091*P2^2;//Rs./hour
6 P1=350;//MW
7 P2=550;//MW
8 C1=2000+20*P1+0.05*P1^2;//Rs./hour
9 C2=2750+26*P2+0.03091*P2^2;//Rs./hour
10 C=C1+C2;//Rs./hour
11 disp(C,"(a) Total Cost(Rs./hour)");
12 P=P1+P2;//MW//Total Load
13 P1=poly(0,'P1');
14 P2=poly(0,'P2');
15 dC1bydP1=20+2*0.05*P1;
16 dC2bydP2=26+2*0.03091*P2;
17 disp("(b) For Economic Scheduling")
18 format('v',7);
19 //dC1/dP1=dC2/dP2 for economic shedding
20 //Let loads of unit are P1 & P-P1
21 eqn=20+2*0.05*P1-26-2*0.03091*(P-P1);
22 P1=roots(eqn);//MW
23 P2=P-P1;//MW
24 disp(P2,P1,"Loads P1 & P2 in MW are : ");
25 C1=2000+20*P1+0.05*P1^2;//Rs./hour
26 C2=2750+26*P2+0.03091*P2^2;//Rs./hour
27 Cnew=C1+C2;//Rs./hour
28 disp(Cnew,"Total Cost(Rs./hour)");
29 saving=C-Cnew;//Rs./hour
30 disp(saving,"Total saving(Rs./hour)");
31 format('v',5);
32 Lt=P1-350;//MW//Tie line load
```

```
33 disp(Lt,"Tie line load from Plant1 to Plant2(MW) : ")
    );
```

---

### Scilab code Exa 2.14 Extra Operating Cost

```
1 //exa 2.14
2 clc;clear;close;
3 format('v',7);
4 //C=5000+450*P+0.5*P^2;//Rs./hour
5 e1=+2;//%//error
6 e2=-2;//%//error
7 P=200;//MW//Total Load
8 //Considering error
9 P1=poly(0,'P1');
10 P2=poly(0,'P2');
11 C1=(5000+450*P+0.5*P1^2)*0.98;//Rs./hour
12 C2=(5000+450*P+0.5*P2^2)*1.02;//Rs./hour
13 //Let loads of unit are P1 & P-P1
14 //dC1/dP1=dC2/dP2 for economic shedding
15 eqn=450*0.98+2*0.5*P1*0.98-450*1.02-2*0.5*(P-P1)
    *1.02;
16 P1=roots(eqn);//MW
17 P2=P-P1;//MW
18 //if no instrumentation error
19 C1=(5000+450*P1+0.5*P1^2)*0.98;//Rs./hour
20 C2=(5000+450*P2+0.5*P2^2)*1.02;//Rs./hour
21 C=C1+C2;//Rs./hour
22 //Due to instrumentation error
23 P1=P/2;//MW
24 P2=P/2;//MW
25 C1=(5000+450*P1+0.5*P1^2)*0.98;//Rs./hour
26 C2=(5000+450*P2+0.5*P2^2)*1.02;//Rs./hour
27 Cerr=C1+C2;//Rs./hour
28 Cextra=Cerr-C;//Rs./hour
29 disp(Cextra,"Extra operating cost(Rs./hour)");
```

---

Scilab code Exa 2.15 Find Optimum Scheduling

```
1 //exa 2.15
2 clc;clear;close;
3 format('v',7);
4 P1=poly(0,'P1');
5 P2=poly(0,'P2');
6 P3=poly(0,'P3');
7 Q1=0.002*P1^2+0.86*P1+20; // tons/hour
8 Q2=0.004*P2^2+1.08*P2+20; // tons/hour
9 Q3=0.0028*P3^2+0.64*P3+36; // tons/hour
10 Pmax=120; //MW
11 Pmin=36; //MW
12 P=200; //MW
13 C=500; //Rs./ ton
14 //C1=C*Q1;C2=C*Q2;C3=C*Q3; // Rs./ ton
15 dC1bydP1=2*P1+430; //Rs./ hour
16 dC2bydP2=4*P2+540; //Rs./ hour
17 dC3bydP3=2.8*P3+320; //Rs./ hour
18 //P1+P2+P3=P
19 A1=[1 1 1]; // Coefficient Matrix
20 B1=[P]; // Coefficient Matrix
21 //For minimal cost above 3 equation should be equal
22 //eqn1=2*P1-4*P2+430-540;
23 //eqn2=4*P2-2.8*P3-320+540;
24 A2=[0 4 -2.8]; // Coefficient Matrix
25 B2=[-540+320]; // Coefficient Matrix
26 //eqn3=-2*P1+2.8*P3+320-430;
27 A3=[-2 0 2.8]; // Coefficient Matrix
28 B3=[430-320]; // Coefficient Matrix
29 //solving by matrix method
30 A=[A1;A2;A3]; // Coefficient Matrix
31 B=[B1;B2;B3]; // Coefficient Matrix
32 X=A^-1*B; //Solution Matrix
```

```

33 P1=X(1); //MW
34 P2=X(2); //MW
35 P3=X(3); //MW
36 Pmax=120; //MW
37 Pmin=36; //MW
38 if P2<Pmin then
39     P2=Pmin; //MW
40 end;
41 //P1+P3=P-P2//eqn(4)
42 A1=[1 1]; // Coefficient Matrix
43 B1=[P-P2]; // Coefficient Matrix
44 //eqn3=-2*P1+2.8*P3+320-430;
45 A2=[-2 2.8]; // Coefficient Matrix
46 B2=[430-320]; // Coefficient Matrix
47 //solving by matrix method
48 A=[A1;A2]; // Coefficient Matrix
49 B=[B1;B2]; // Coefficient Matrix
50 X=A^-1*B; //Solution Matrix
51 P1=X(1); //MW
52 P3=X(2); //MW
53 disp("According to optimum scheduling , Load
    distribution is :");
54 disp(P1,"P1(MW) : ");
55 disp(P2,"P2(MW) : ");
56 disp(P3,"P3(MW) : ");

```

---

### Scilab code Exa 2.16 Heat inputs and savings

```

1 //exa 2.16
2 clc;clear;close;
3 format('v',11);
4 L=30; //MW
5 //I=(32+32*L+1.68*L^2)*10^5;
6 t1=18; ///hours
7 t2=6; ///hours

```

```

8 //Full load 18 hours
9 I1=(32+32*L+1.68*L^2)*10^5*t1;//kJ
10 //Half load 6 hours
11 I2=(32+32*L/2+1.68*(L/2)^2)*10^5*t2
12 I=I1+I2;//kJ
13 disp(I,"(a) Heat input per day(kJ)");
14 E=L*t1+L/2*t2;//MWh//Energy produced in 24 hours
15 Lu=E/(t1+t2);//MW
16 Inew=(32+32*Lu+1.68*Lu^2)*10^5*(t1+t2);//kJ
17 saving=I-Inew;//kJ
18 saving=saving/(E*1000);//kJ/kWh
19 disp(saving,"(b) Saving in heat per kWh of energy(kJ
    /kWh) : ");

```

---

#### Scilab code Exa 2.17 Find Optimum Scheduling

```

1 //exa 2.17
2 clc;clear;close;
3 format('v',7);
4 P=800;//MW(Total Load)
5 //Using Variable for Cost Curve Equation
6 P1=poly(0,'P1');P2=poly(0,'P2');P3=poly(0,'P3');
7 //Cost Curve Equation
8 C1=450+6.5*P1+0.0013*P1^2;//Rs./hour
9 C2=300+7.8*P2+0.0019*P2^2;//Rs./hour
10 C3=80+8.1*P3+0.005*P3^2;//Rs./hour
11 //Part(a) is not computational
12 //Part (b)
13 dC1BydP1=6.5+2*0.0013*P1;//Rs./MWh//eqn(1)
14 dC2BydP2=7.8+2*0.0019*P2;//Rs./MWh//eqn(2)
15 dC3BydP3=8.1+2*0.005*P3;//Rs./MWh//eqn(3)
16 //P1+P2+P3=P;//MW//eqn(4)
17 A1=[1 1 1];//Coefficient Matrix
18 B1=[800];//Coefficient Matrix
19 //Equating eqn(1) & (2)

```

```

20 A2=[2*0.0013 -2*0.0019 0]; // Coefficient Matrix
21 B2=[7.8-6.5]; // Coefficient Matrix
22 //Equating eqn(2) & (3)
23 A3=[0 2*0.0019 -2*0.005]; // Coefficient Matrix
24 B3=[8.1-7.8]; // Coefficient Matrix
25 //Solution By Matrix method
26 A=[A1;A2;A3]; // Coefficient Matrix
27 B=[B1;B2;B3]; // Coefficient Matrix
28 X=A^-1*B; // Solution Matrix
29 P1=X(1); //MW
30 P2=X(2); //MW
31 P3=X(3); //MW
32 disp("(b) According to optimum scheduling , Load
    distribution is :");
33 disp(P1,"P1(MW) : ");
34 disp(P2,"P2(MW) : ");
35 disp(P3,"P3(MW) : ");
36 //Part(c)
37 disp("(c) Optimum scheduling : ");
38 P1max=600; //MW
39 P1min=100; //MW
40 P2max=400; //MW
41 P2min=50; //MW
42 P3max=200; //MW
43 P3min=50; //MW
44 if P2<P2max&P2>P2min then
45     disp("P2 is within maximum and minimum limits.")
46     ;
47     P1=P1max; //MW
48     P3=P3min; //MW
49     P2=P-P1-P3; //MW
49 end;
50 //Lambda=dC2/dP2 as P2 is niether maximum limit nor
    minimum limit .
51 dC2BydP2=7.8+2*0.0019*P2; //Rs./MWh
52 lambda=dC2BydP2; //Rs./MWh
53 dC1BydP1=6.5+2*0.0013*P1; //Rs./MWh
54 dC3BydP3=8.1+2*0.005*P3; //Rs./MWh

```

```

55 if dC1BydP1<lambda then
56     disp("Condition for P1 satisfied.");
57 end;
58 if dC3BydP3>lambda then
59     disp("Condition for P3 satisfied.");
60 end;
61 disp("Load distribution is : ");
62 disp(P1,"P1(MW) : ");
63 disp(P2,"P2(MW) : ");
64 disp(P3,"P3(MW) : ");

```

---

#### Scilab code Exa 2.18 Transmission Loss

```

1 //exa 2.18
2 clc;clear;close;
3 format('v',6);
4 Bmn=[0.0676 0.00953 -0.00507
5 0.00953 0.0521 0.00901
6 -0.00507 0.00901 0.0294];//Loss Coefficient
7 Bno=[-0.0766;0.00342;0.0189];//Loss Coefficient
8 Boo=0.04357;//Loss Coefficient
9 P1=107.9;//MW
10 P2=50;//MW
11 P3=60;//MW
12 //solution :
13 PL=[P1 P2 P3]*Bmn+[P1 P2 P3]*Bno+Boo;//MW
14 PL=sum(-PL);//MW
15 disp(PL,"Transmission Loss(MW)");
16 //Note : Values calculated in the book are slightly
    wrong because of accuracy in calculation as
    compared to scilab accuracy.

```

---

#### Scilab code Exa 2.19 Find Load Distribution



```

1 //exa 2.19
2 clc;clear;close;
3 format('v',6);
4 //lambda1=0.1*P1+20;//Rs./MWh
5 //lambda2=0.12*P2+16;//Rs./MWh
6 P=180;//MW
7 //Let loads are P1 & P-P1
8 //Economical loading lambda1=lambda2
9 P1=poly(0,'P1');P2=poly(0,'P2');
10 eqn=0.1*P1+20-0.12*(P-P1)-16;
11 P1=roots(eqn);//MW
12 P2=P-P1;//MW
13 disp(P1,"Load P1(MW) : ");
14 disp(P2,"Load P2(MW) : ");

```

---

**Scilab code Exa 2.20** Find the load division

```

1 //exa 2.20
2 clc;clear;close;
3 format('v',6);
4 //F1=0.004*P1^2+2*P1+80;//Rs./hr
5 //F2=0.006*P2^2+1.5*P2+100;//Rs./hr
6 P=250;//MW
7 P1=poly(0,'P1');P2=poly(0,'P2');
8 dF1bydP1=2*0.004*P1+2;
9 dF2bydP2=2*0.006*P2+1.5;
10 //Let loads are P1 & P-P1
11 //Economical loading lambda1=lambda2
12 eqn=2*0.004*P1+2-2*0.006*(P-P1)-1.5;
13 P1=roots(eqn);//MW
14 P2=P-P1;//MW
15 disp(P1,"Load P1(MW) : ");
16 disp(P2,"Load P2(MW) : ");

```

---

## Scilab code Exa 2.21 Minimum cost of generation

```
1 //exa 2.21
2 clc;clear;close;
3 format('v',8);
4 //F1=(8*P1+0.024*P1^2+80)*10^6;//Btu./hr
5 //F2=(6*P2+0.04*P2^2+120)*10^6;//Btu./hr
6 Pmax=100;//MW
7 Pmin=10;//MW
8 C=2.5;//Rs./million Btu
9 //C1=2.5*F1/10^6
10 //C2=2.5*F2/10^6
11 //For Maximum Load of 100 MW
12 P1=poly(0,'P1');P2=poly(0,'P2');
13 dC1bydP1=8*2.5+2.5*2*0.024*P1;
14 dC2bydP2=6*2.5+2.5*2*0.04*P2;
15 //Let loads are P1 & Pmax-P1
16 //Economical loading lambda1=lambda2
17 eqn=8*2.5+2.5*2*0.024*P1-6*2.5-2.5*2*0.04*(Pmax-P1);
18 P1=roots(eqn);//MW
19 P2=Pmax-P1;//MW
20 C1=2.5*((8*P1+0.024*P1^2+80)*10^6)/10^6;//Rs./hour
21 C2=2.5*((6*P2+0.04*P2^2+120)*10^6)/10^6;//Rs./hour
22 C100=(C1+C2)*12;//Rs.(Total cost of 12 hours on 100
    MW load)
23 //For Maximum load of 50 MW
24 //Let loads are P1 & Pmax-P1
25 //Economical loading : lambda1=lambda2
26 Pmax1=50;//MW
27 clear('P1','P2');
28 P1=poly(0,'P1');P2=poly(0,'P2');
29 eqn=8*2.5+2.5*2*0.024*P1-6*2.5-2.5*2*0.04*(Pmax1-P1)
    ;
30 P1=roots(eqn);//MW
```

```

31 P2=Pmax1-P1; //MW
32 C1=2.5*((8*P1+0.024*P1^2+80)*10^6)/10^6; //Rs./hour
33 C2=2.5*((6*P2+0.04*P2^2+120)*10^6)/10^6; //Rs./hour
34 C50=(C1+C2)*12; //Rs.(Total cost of 12 hours on 50MW
    load)
35 C=C100+C50; //Rs.(Total cost for 24 hours)
36 disp(C,"Minimum total cost for 24 hours(Rs.) : ");
37 E=(Pmax*12+Pmax1*12)*10^3; //kWh
38 //Operating cost per unit energy
39 Co=C/E; //Rs./kWh
40 disp(Co,"Operating cost per unit energy(Rs./kWh) : "
    );
41 //Answer is wrong in the textbook. Calculation
    mistake in energy generation calculation & Cost
    calculation.

```

---

### Scilab code Exa 2.22 Find Optimum Scheduling

```

1 //exa 2.22
2 clc;clear;close;
3 format('v',10);
4 //F1=0.05*P1^2+21.5*P1+800; //Rs./hr
5 //F2=0.1*P2^2+27*P2+500; //Rs./hr
6 //F3=0.07*P3^2+16*P3+900; //Rs./hr
7 PT=200; //MW
8 Pmax=120; //MW
9 Pmin=39; //MW
10 //coefficients :
11 c1=0.05; c2=0.1; c3=0.07;
12 b1=21.5; b2=27; b3=16;
13 a1=800; a2=500; a3=900;
14 lambda=(1/2*[b1/c1+b2/c2+b3/c3]+PT)/[1/2*[1/c1+1/c2
    +1/c3]];
15 //Economical loading dF1/dP1=dF2/dP2=dF3/dP3
16 P1=poly(0,'P1'); P2=poly(0,'P2'); P3=poly(0,'P3');

```

```

17 dF1bydP1=2*0.05*P1+21.5;
18 dF2bydP2=2*0.1*P2+27;
19 dF2bydP3=2*0.07*P3+16;
20 //Solving equation :
21 A=[2*0.05 0 0;0 2*0.1 0;0 0 2*0.07];
22 B=[lambda-21.5;lambda-27;lambda-16];
23 X=A^-1*B;
24 P1=X(1); //MW
25 P2=X(2); //MW
26 P3=X(3); //MW
27 if P2<Pmin then
28     P2=Pmin;
29 end
30 P1plusP3=PT-P2; //MW
31 //dF1/dP1=dF3/dP3
32 //Let loads are P1 & P1plusP3-P1
33 clear('P1','P3');
34 P1=poly(0,'P1');P3=poly(0,'P3');
35 eqn=2*0.05*P1+21.5-2*0.07*(P1plusP3-P1)-16;
36 P1=roots(eqn); //MW
37 P3=P1plusP3-P1; //MW
38 disp("Optimum scheduling :");
39 disp(P3,P2,P1,"Loads P1, P2 & P3 in MW are :");
40 F1=0.05*P1^2+21.5*P1+800; //Rs./hr
41 F2=0.1*P2^2+27*P2+500; //Rs./hr
42 F3=0.07*P3^2+16*P3+900; //Rs./hr
43 C=F1+F2+F3; //Rs/hour
44 disp(C,"For this schedule, total cost per hour(Rs./
    hour)");

```

---

### Scilab code Exa 2.23 Generation schedule and load demand

```

1 //exa 2.23
2 clc;clear;close;
3 format('v',7);

```

```

4 //dF1/dP1=0.025*P1+15;//
5 //dF2/dP2=0.05*P2+20;//
6 PL=15.625; //MW
7 P1=125; //MW
8 lambda=24; //Rs. per MWh
9 B11=PL/P1^2; // Coefficient Loss
10 //dF2/dP2*L2=lambda
11 P2=poly(0, 'P2');
12 L2=1; //penalty factor
13 eqn=(0.05*P2+20)*L2-lambda;
14 P2=roots(eqn); //MW
15 //PL=B11*P1^2
16 P1=poly(0, 'P1');
17 dPLbydP1=2*B11*P1;
18 L1=1/(1-dPLbydP1); //penalty factor
19 eqn=(0.025*P1+15)-lambda/L1
20 P1=roots(numer(eqn)); //MW
21 disp(P2,P1," Generation P1 & P2 in MW are ");
22 PL=B11*P1^2; //MW
23 LD=P1-PL+P2; //MW
24 disp(LD," Load Demand(MW) :");

```

---

Scilab code Exa 2.24 Optimum Schedule and total generation

```

1 //exa 2.24
2 clc;clear;close;
3 format('v',7);
4 //dC1/dP1=0.02*P1+16;//
5 //dC2/dP2=0.04*P2+20;//
6 PL=10; //MW
7 P1=100; //MW
8 lambda=25; //Rs. per MWh
9 B11=PL/P1^2; B22=0; B12=0; // Coefficient Loss
10 //dF2/dP2*L2=lambda
11 P2=poly(0, 'P2');

```

```

12 L2=1; //penalty factor
13 eqn=(0.04*P2+20)*L2-lambda;
14 P2=roots(eqn); //MW
15 //PL=B11*P1^2
16 P1=poly(0, 'P1');
17 dPLbydP1=2*B11*P1;
18 L1=1/(1-dPLbydP1); //penalty factor
19 eqn=(0.02*P1+16)-lambda/L1
20 P1=roots(numer(eqn)); //MW
21 disp(P2,P1," Generation P1 & P2 in MW are ")
22 PL=B11*P1^2; //MW
23 LD=P1-PL+P2; //MW
24 disp(LD," Load Demand(MW) :");

```

---

## Chapter 3

# Hydrothermal Coordination

Scilab code Exa 3.1 MW rating

```
1 //Exa 3.1
2 clc;clear;close;
3 format('v',6);
4 head=205;//m(Mean Head)
5 A=1000;//km^2(Catchment area)
6 rf=125;//cm(Annual Rainfall)
7 a=80;//%(Available rainfall for power generation)
8 LF=75;//%(Load factor)
9 head_loss=5;//m(Head Loss)
10 Eta_turbine=0.9;//Efficiency of turbine
11 Eta_generator=0.95;//Efficiency of generator
12 //Calculation
13 WaterUsed=A*10^6*rf/100*a/100;//m^3/year(Discharge)
14 WaterUsed=WaterUsed/(365*24*60*60);//m^3/sec
15 Eff_Head=head-head_loss;//m(Effective Head)
16 P=735.5/75*WaterUsed*Eff_Head*Eta_turbine*
    Eta_generator/1000;//MW(Load of station)
17 Ppeak=P/(LF/100);//MW(Peak Load )
18 disp(Ppeak,"MW rating of station(MW)");
19 //type ot turbine
20 if head>200 then
```

```

21     disp("Pelton turbine is more suitable because
        head>200 meter.");
22 end;

```

---

### Scilab code Exa 3.2 Capacity of hydro plant and steel plant

```

1 //Exa 3.2
2 clc;clear;close;
3 format('v',6);
4 WF=50; //m^3/sec (Water flow)
5 head=90; //m
6 LF=75; //%(Load factor)
7 Eta=90; //%(Efficiency of hydro plant)
8 L=5; //%(Transmission losses)
9 TC=350; //MW
10 hp=140; //MW//Hydro power
11 //Calculation
12 P=735.5/75*WF*head*Eta/100/1000; //MW(Power available
    )
13 Pnet=P*(100-L)/100; //MW///Net Available hydro power
14 E=Pnet*24; //MW-hours////Hydro Energy
15 disp(E," Available hydro energy(MW-hours) : ");
16 format('v',5);
17 C1=hp/((100-L)/100); //MW//Capacity of hydro plant
18 disp(C1," Capacity of hydro plant(MW) : ");
19 C2=TC-hp; //MW//Capacity of thermal plant
20 disp(C2," Capacity of thermal plant(MW) : ");

```

---

### Scilab code Exa 3.3 Water Used and operating cost

```

1 //Exa 3.3
2 clc;clear;close;
3 format('v',9);

```



```

4 P1=700; //MW(Load for 14 hours)
5 P2=500; //MW(Load for 10 hours)
6 B22=0.0005; //Loss Coefficient
7 t1=14; //hour
8 t2=10; //hour
9 r2=2.5; //Rs/hour/(m^3/sec)
10 // Characteristics of units :
11 //C1=(24+0.02*P1)*P1; //Rs./hour
12 //W2=(6+0.0025*P2)*P2; //m^3/sec
13 lambda=37.944; //Rs./MWh(For peak load conditions)
14 P1=348.6; //MW(For peak load conditions)
15 P2=454.84; //MW(For peak load conditions)
16 PL=103.44; //MW(For peak load conditions)
17 lambda_dash=31.73; //Rs./MWh(For peak load conditions
)
18 P1_dash=193.25; //MW(For peak off conditions)
19 P2_dash=378.25; //MW(For peak off conditions)
20 PL_dash=71.50; //MW(For peak off conditions)
21 W=[(6+0.0025*P2)*P2*t1+(6+0.0025*P2_dash)*P2_dash*t2
]*3600/10^3; //m^3//D3ily water used
22 disp(W,"Daily water used by plant(m^3) : ");
23 C=(24+0.02*P1)*P1*t1+(24+0.02*P1_dash)*P1_dash*t2; //
Rs.
24 disp(C,"Daily operating cost of plant(Rs.) : ");

```

---

#### Scilab code Exa 3.4 Load on plant and cost of water

```

1 //Exa 3.4
2 clc;clear;close;
3 format('v',7);
4 t1=14; //hour(working hour of hydro station)
5 t2=24; //hour(Working hour of steam station)
6 // Characteristics of units :
7 //C=(5+8*Ps+0.05*Ps^2); //Rs./hour
8 //dW/dPh=30+0.05*Ph; //m^3/MW-sec

```

```

9 W=500*106; //m3(Water Quantity used)
10 Ps=250; //MW(Load on steam station)
11 lambda=8+0.1*Ps; //Rs./MW-hour
12 //W=Ph*(30+0.05*Ph)*t1*3600; //
13 //0.05*Ph2*t1*3600+Ph*30*t1*3600-W=0
14 Ph=poly(0, 'Ph');
15 Ph=roots(0.05*Ph2*t1*3600+Ph*30*t1*3600-W); //MW
16 Ph=Ph(2); //MW//Leaving negative root
17 disp(Ph,"Load on hydro plant(MW)");
18 r=lambda/(30+0.05*Ph); //Rs./hour/(m3/sec)
19 disp(r,"Cost of water use(Rs./hour/(m3/sec)) : ");
20 //Answer is slightly differ due to accuracy in
    calculations.

```

---

## Chapter 4

# Modelling of turbine generators and automatic controllers

Scilab code Exa 4.1 Shared load and power factor

```
1 //Exa 4.1
2 clc;clear;close;
3 format('v',8);
4 kVA=4000;//kVA//rating
5 f1_n1=50;//Hz(No load frequency of machine1)
6 f1_f1=47.5;//Hz(No load frequency of machine1)
7 f2_n1=50;//Hz(No load frequency of machine2)
8 f2_f1=48;//Hz(No load frequency of machine2)
9 L=6000;//kW(Load)
10 L1=poly(0,'L1');//Load of machine1
11 //f1_n1-(f1_n1-f1_f1)*L1/kVA=f1_n1-(f2_n1-f2_f1)*L2/
    kVA where L2=L-L1
12 L1=(f2_n1-f2_f1)*L/[(f1_n1-f1_f1)+(f2_n1-f2_f1)];//
    kW
13 L2=L-L1;//kW
14 disp("Part (a)");
15 disp(L1,"Load supplied by first machine(kW)");
16 disp(L2,"Load supplied by second machine(kW)");
17 disp("Part (b)");
```

```

18 L2=4000; //kW//Machine2 is supplying 4000kW
19 fdrop1=f1_n1-f1_f1; //Hz(frequency drop of machine 1)
20 fdrop2=f2_n1-f2_f1; //Hz(frequency drop of machine 2)
21 L1=L2*fdrop2/fdrop1; //kW//Load supplied by machine 1
22 L=L1+L2; //kW//Total Load
23 disp(L,"Total load supplied without getting over
        loaded (kW)")

```

---

#### Scilab code Exa 4.2 Current Power factor and emf

```

1 //Exa 4.2
2 clc;clear;close;
3 format('v',6);
4 Lt=3000; //kW//Total Load
5 pf=0.8; //Power factor Lagging
6 I=150; //A
7 ZA=0.4+%i*12; //ohm//synchronous impedance
8 ZB=0.5+%i*10; //ohm//synchronous impedance
9 Vt=6.6; //kV//Terminal Voltage
10 L=Lt/2; //kW//Load supplied by each machine
11 LA=L; //kW
12 LB=L; //kW
13 //LB=sqrt(3)*Vt*IB*cosd(theta_B);
14 theta_B=acosd(LB/sqrt(3)/Vt/I); //degree
15 IB=I*(cosd(theta_B)-%i*sind(theta_B)); //A
16 I_total=Lt/sqrt(3)/Vt/pf; //A//Total Current
17 IA_plus_IB=I_total*(0.8-%i*0.6); //A
18 IA=IA_plus_IB-IB; //A
19 cos_thetaA=real(IA)/abs(IA); //lagging power factor
20 EA=Vt/sqrt(3)+IA*ZA/1000; //kV per phase
21 del_A=atand(imag(EA)/real(EA)); //degree//Load Angle
22 emf_A=abs(EA); //kV per phase//Induced emf of machine
    A
23 EB=Vt/sqrt(3)+IB*ZB/1000; //kV per phase
24 del_B=atand(imag(EB)/real(EB)); //degree//Load Angle

```

```

25 emf_B=abs(EB); //kV per phase//Induced emf of machine
    A
26 IA=abs(IA); //A
27 disp(IA,"Current on machine A(A) : ");
28 pfA=cos_thetaA; //power factor
29 disp(pfA,"Lagging power factor of machine A");
30 format('v',5);
31 disp(emf_A,"Induced emf of machine A(kV per phase)")
    ;
32 disp(del_A,"Load angle of machine A(degree)");
33 disp(del_B,"Load angle of machine B(degree)");
34 disp(emf_B,"Induced emf of machine B(kV per phase)")
    ;
35 //Answer in the textbook is not accurate.

```

---

### Scilab code Exa 4.3 Synchronising power

```

1 //Exa 4.3
2 clc;clear;close;
3 format('v',5);
4 P=5; //MVA
5 V=1000; //V
6 speed=1500; //rpm//speed
7 ns=speed/60; //rps
8 f=50; //Hz
9 pf=0.8; //Power factor Lagging
10 Xs=20; //%/synchronous reluctance
11 Xs=Xs/100; //p.u.
12 disp("Part (a)");
13 V=1; //p.u.//on no load
14 E=1; //p.u.//on no load
15 Ps=V*E/Xs; //p.u.
16 Ps=Ps*P; //MW per elect. radian
17 Ps=Ps*1000; //kW per elect. radian
18 //1 mech. radian=%pi/90 elect. radian

```

```

19 Ps=Ps*%pi/90;//kW per mech. degree
20 disp(Ps,"Synchronising power per mech. degree(kW)");
21 d=0.5;//degree////displacement
22 Ts=Ps*1000*d/2/%pi/ns;//N-m
23 format('v',6);
24 disp(Ts,"Synchronising torque(N-m)");
25 disp("Part(b)");
26 theta=acosd(pf);//degree
27 E=V+(cosd(theta)-%i*sind(theta))*%i*Xs;//p.u.
28 Ps=V*E/Xs;//p.u.
29 Ps=Ps*P;//MW per elect. radian
30 Ps=Ps*1000;//kW per elect. radian
31 //1 mech. radian=%pi/90 elect. radian
32 Ps=Ps*%pi/90;//kW per mech. degree
33 Ps=abs(Ps);//kW per mech. degree
34 disp(Ps,"Synchronising power per mech. degree(kW)");
35 d=0.5;//degree////displacement
36 Ts=abs(Ps)*1000*d/2/%pi/ns;//N-m
37 disp(Ts,"Synchronising torque(N-m)");
38 //Answer in the textbook is not accurate.

```

---

#### Scilab code Exa 4.4 Synchronising power and torque

```

1 //Exa 4.4
2 clc;clear;close;
3 format('v',6);
4 P=2;//MVA
5 V=6000;//V
6 speed=750;//rpm//speed
7 ns=speed/60;//rps
8 Zs=6;//ohm/phase
9 f=50;//Hz
10 pf=0.8;//Power factor Lagging
11 //Calculation
12 I=P*10^6/sqrt(3)/V;//A//Current

```

```

13 theta=acosd(pf); // degree
14 E=V/sqrt(3)+I*(cosd(theta)-%i*sind(theta))*%i*Zs; //V
15 Ps=V*sqrt(3)*E/Zs/1000; //kW per elect. radian
16 Ps=Ps*4*%pi/180; //kW per mech. degree
17 Ps=abs(Ps); //kW per mech. degree
18 disp(Ps,"Synchronising power per mech. degree(kW)");
19 Ts=abs(Ps)*1000/2/%pi/ns; //N-m
20 disp(Ts,"Synchronising torque(N-m)");
21 //Answer in the textbook is not accurate.

```

---

#### Scilab code Exa 4.5 Load current and power factor

```

1 //Exa 4.5
2 clc;clear;close;
3 format('v',6);
4 I=100; //A/// Current
5 V=11; //kV
6 Xs=4; //ohm/phase
7 f=50; //Hz
8 pf=0.8; //Power factor Lagging
9 // Calculation
10 theta=acosd(pf); // degree
11 disp("Part (a)");
12 E=V*1000/sqrt(3)+I*(cosd(theta)-%i*sind(theta))*%i*
    Xs; //V
13 del=atand(imag(E)/real(E)); // degree
14 E=abs(E); //V/phase
15 disp(E,"Open circuit phase emf(V/phase)");
16 disp(del,"Angle delta (degree)");
17 disp("Part (b)");
18 del_dash=10+del; // degree
19 P_by_V=E*sind(del_dash)/Xs; //per phase
20 //P=V*I*cos_fi
21 I_cos_fi=P_by_V;
22 //V*1000/sqrt(3)+I*(cos_fi-%i*sin_fi)*%i*Xs=E

```

```

23 I_sin_fi={sqrt(E^2-(4*I_cos_fi^2))-V*1000/sqrt(3)
    }/4;
24 tan_fi=I_sin_fi/I_cos_fi;
25 fi=atand(tan_fi);//degree
26 I=I_cos_fi/cosd(fi);//A
27 disp(I,"New load current(A)");
28 pf=cosd(fi);//lagging power factor
29 disp(pf,"Its power factor(lagging)");
30 disp("Part(c)");
31 pf1=0.8;//original power factor
32 Idash=I*pf/pf1;//Current
33 disp(Idash,"New value of load current(A)");
34 //Answer is slightly differ because of accuracy in
    calculations.

```

---

#### Scilab code Exa 4.6 Inertia Constant

```

1 //Exa 4.6
2 clc;clear;close;
3 format('v',7);
4 G=200;//MVA
5 H=6;//MJ/MVA///Inertia Constant
6 V=11;//kV
7 f=50;//Hz
8 L1=120;//MW
9 L2=160;//MW
10
11 //Calculation
12 disp("Part(a)");
13 Es=G*H;//MJ////Stored Energy
14 disp(Es,"Stored energy(MJ)");
15 disp("Part(b)");
16 Pa=L1-L2;//MW
17 M=G*H/180/f;//MJ-sec/elect.deg.
18 alfa=-Pa/M;//elect.deg./sec^2///Retardation

```



```

19 disp(alfa,"Motor retardation (elect.deg.sec^2)");
20 disp("Part(c)");
21 n=5;//cycles
22 t=n/f;//sec
23 del_change=1/2*-alfa*t^2;//elect.deg.
24 disp(del_change,"Change in power angle(elect.deg.)")
    ;
25 alfa=alfa*60/(180*4);//rpm/sec
26 ns=1500;//rpm
27 nr=ns+(-alfa)*t;//rpm;//rotor speed
28 disp(nr,"Rotor speed at the end of 5 cycle(rpm)");
29 disp("Part(d)")
30 H2=4;//MJ/MVA
31 G2=150;//MVA
32 Gb=100;//MVA
33 Heb=H*G/Gb+H2*G2/Gb;//MJ/MVA
34 disp(Heb,"Inertia constant for the equivalent
    generator (MJ/MVA)");

```

---

# Chapter 5

## Frequency Control

Scilab code Exa 5.1 Change in power output

```
1 //Example 5.1
2 clc;clear;close;
3 P=100; //MW
4 drop=4; //%(No load to full load drop)
5 f=50; //Hz
6 disp("Part (i)");
7 p=1; //MW(For calculating per unit MW)
8 R=(drop/100)*f/p; //Hz/p.u.MW
9 disp(R,"Speed regulation in Hz/p.u.MW");
10 R=(drop/100)*f/P; //Hz/MW
11 disp(R,"Speed regulation in Hz/MW");
12 disp("Part (ii)");
13 del_f=-0.1; //Hz(Frequency drop)
14 delP=-1/R*del_f; //MW(Change in power output)
15 disp(delP,"Change in power output(MW)");
```

---

Scilab code Exa 5.2 Frequency Deviation

```

1 //Example 5.2
2 clc;clear;close;
3 format('v',6);
4 P=100;//MVA
5 f=50;//Hz
6 H=5;//kW-sec/kVA(Constant)
7 delP=50;//MW(Increased Load)
8 td=0.5;//s(Time delay)
9 P=P/1000;//kVA
10 KE=P*H;//kW-sec
11 delP=delP/1000;//kW(Increased Load)
12 KE_loss=delP*td;//kW-s
13 f_new=sqrt((KE-KE_loss)/KE)*f;//Hz
14 f_dev=(f-f_new)/f*100;//%(Frequency deviation)
15 disp(f_dev,"Frequency deviation(%)");

```

---

### Scilab code Exa 5.3 Value of R

```

1 //Example 5.3
2 clc;clear;close;
3 format('v',7);
4 P1=500;//MW
5 P2=200;//MW
6 f=50;//Hz
7 delP=140;//MW(System load increase)
8 f_new=49.5;//Hz(Frequency after drop)
9 delP1=delP*P1/(P1+P2);//MW
10 delP2=delP*P2/(P1+P2);//MW
11 f_dev=f_new-f;//Hz
12 //For delPd=0, R1 &R2 can be calculated as :
13 R1=-1/delP1*f_dev;//Hz/MW
14 R2=-1/delP2*f_dev;//Hz/MW
15 disp(R2,R1,"Value of R for unit 1 & 2(Hz/MW)");

```

---

### Scilab code Exa 5.4 Static Frequency Drop

```
1 //Example 5.4
2 clc;clear;close;
3 format('v',8);
4 f=50; //Hz
5 R=2; //Hz/pu MW
6 Pr=10000; //MW(Rated Capacity)
7 P=Pr/2; //MW(Operating Power)
8 delP=2; //%(Load Increase)
9 del_f=f*1/100; //Hz(1% change in frequency)
10 del_PL=P*1/100; //MW(1% change in load)
11 //Rate of change of load with frequency :
12 D=del_PL/del_f; //MW/Hz
13 D=D/Pr; //p.u. MW/Hz
14 //Frequency response characteristic :
15 Beta=D+1/R; //p.u. MW/Hz
16 M=delP/100*P; //MW
17 M=M/Pr; //p.u. MW
18 del_fo=-M/Beta; //Hz
19 disp(del_fo,"Static frequency drop(Hz)")
20 R=%inf;
21 Beta=D+1/R; //p.u. MW/Hz
22 del_fo=-M/Beta; //Hz
23 disp(del_fo,"If speed governer loop is open ,
    frequency drop(Hz)")
```

---

### Scilab code Exa 5.5 Primary ALFC loop parameter

```
1 //Example 5.5
2 clc;clear;close;
3 format('v',7);
```

```

4 C=10000; //MW( Control area capacity)
5 P=5000; //MW
6 H=5; //s
7 R=3; //Hz/pu MW
8 f=50; //Hz
9 del_f=f*1/100; //Hz
10 del_PL=P*1/100; //MW
11 D=del_PL/del_f; //MW/Hz
12 D=D/C; //p.u. MW/Hz
13 //Primary ALFC loop parameters :
14 Kp=1/D; //Hz/p.u. MW
15 Tp=2*H/f/D; //s
16 disp("Primary ALFC loop parameters :")
17 disp(Kp,"Kp(Hz/p.u. MW)");
18 disp(Tp,"Tp(seconds)");

```

---

#### Scilab code Exa 5.6 Increased Generation

```

1 //Example 5.6
2 clc;clear;close;
3 format('v',6);
4 f=50; //Hz
5 R=2; //Hz/pu MW
6 Pr=10000; //MW(Rated Capacity)
7 P=Pr/2; //MW(Operating Power)
8 delP=2; //%(Load Increase)
9 del_f=f*1/100; //Hz(1% change in frequency)
10 del_PL=P*1/100; //MW(1% change in load)
11 //Rate of change of load with frequency :
12 D=del_PL/del_f; //MW/Hz
13 D=D/Pr; //p.u. MW/Hz
14 //Frequency response characteristic :
15 Beta=D+1/R; //p.u. MW/Hz
16 M=delP/100*P; //MW
17 M=M/Pr; //p.u. MW

```

```

18 del_fo=-M/Beta; //Hz
19 disp("Frequency drop contribution to increase in
    load(MW) : ");
20 delP_fo=-del_fo*(D*Pr); //MW
21 disp(delP_fo);
22 disp("Increase in generation to meet the increase
    load(MW) ");
23 delP_gen=-del_fo/R*Pr; //MW
24 disp(delP_gen);

```

---

#### Scilab code Exa 5.7 Frequency Deviation

```

1 //Example 5.7
2 clc;clear;close;
3 format('v',5);
4 G=100; //MVA
5 f=50; //Hz
6 n=3000; //rpm
7 L=25; //MW//Load
8 td=0.5; //sec
9 H=4.5; //MW-sec/MVA
10 // Calculation
11 KE=H*G; //MW-sec////at no load
12 KE_Loss=L*td; //MW-sec////due to increase in load
13 f_new=sqrt((KE-KE_Loss)/KE)*f; //Hz
14 delF=(f-f_new)/f*100; //%////frequency deviation
15 disp(delF,"Frequency deviation (%)");

```

---

#### Scilab code Exa 5.8 Change in step and frequency

```

1 //Example 5.8
2 clc;clear;close;
3 format('v',6);

```

```

4 C=4000; //MW
5 f=50; //Hz
6 L=2500; //MW//Load
7 R=2; //Hz/p.u.MW////Speed regulation constant
8 H=5; //sec////Inertia constant
9 delPL=2; //%/////change in load
10 delf=1; //%/////change in frequency
11 disp("Part(a)");
12 D=delPL/delf*L/f; //MW/Hz
13 D=D/C; //p.u.MW/Hz
14 Beta=D+1/R; //p.u.MW/Hz
15 delf0=-0.2; //Hz
16 M=-(delf0)*Beta; //p.u.MW
17 M=M*C; //MW
18 disp(M,"Largest change in step load(MW)");
19 disp("Part(b)");
20 Kp=1/D; //Hz/p.u.MW
21 Tp=2*H/f/D; //sec
22 Tdash=(R+Kp)/R/Tp; //sec
23 disp(Tdash,"(R+Kp)/(R*Tp) in seconds = ");
24 printf('Change in frequency as a funtion of time, \
      ndelf(t) = -0.2*(1-epsilon^(-%f*t))',Tdash);

```

---

### Scilab code Exa 5.9 Frequency response and value of Ki

```

1 //Example 5.9
2 clc;clear;close;
3 format('v',7);
4 C=4000; //MW
5 f=50; //Hz
6 L=C; //MW//Load
7 R=2.5; //%/////Speed regulation constant
8 H=5; //sec////Inertia constant
9 delPL=1; //%/////change in load
10 delf=1; //%/////change in frequency

```

```

11 disp(" Part (a)");
12 Ls=80; //MW; //increase in step to load
13 R=R/100*f; //z/p.u.MW
14 D=delPL/delf*L/f; //MW/Hz
15 D=D/C; //p.u.MW/Hz
16 M=Ls/L; //unitless //for given step load
17 Kp=1/D; //Hz/p.u.MW
18 Tp=2*H/f/D; //sec
19 Tdash1=(R+Kp)/R/Tp; //sec
20 disp(Tdash1, "(R+Kp)/(R*Tp) in seconds = ");
21 Tdash2=(R*Kp*M)/(R+Kp); //sec
22 disp(Tdash2, "(R*Kp*M)/(R+Kp) in seconds = ");
23 delf0=-Tdash2; //Hz//// Static frequency error
24 disp(delf0, "Static frequency error (Hz)");
25 disp(" Part (b)");
26 Ki=(1+Kp/R)^2/4/Tp/Kp; //p.u.MW/Hz
27 disp(Ki, "Critical value of Ki(p.u.MW/Hz)");

```

---

#### Scilab code Exa 5.10 Change in step and frequency error

```

1 //Example 5.10
2 clc;clear;close;
3 format('v',7);
4 s=poly(0,'s'); //for transfer function
5 Tg=0.2; //sec////time constant of governing system
6 Tt=2; //sec////time constant of turbine
7 Gr=1/(1+Tg*s); //Transfer function of governer
8 Gt=1/(1+Tt*s); //Transfer function of turbine
9 C=1500; //MW
10 f=50; //Hz
11 R=4; //%/////Speed regulation constant
12 H=5; //sec////Inertia constant
13 delPL=1; //%/////change in load
14 delf=1; //%/////change in frequency
15 disp(" Part (a)");

```



```

16 R=R/100*f; //z/p.u.MW
17 D=delpL/delf*C/f; //MW/Hz
18 D=D/C; //p.u.MW/Hz
19 Kp=1/D; //Hz/p.u.MW
20 Tp=2*H/f/D; //sec
21 Gp=Kp/(1+Tp*s); //Transfer function of power system
22 delFs=-Gp/(1+Gr*Gt*Gp/R);
23 disp(delFs,"delFs = M/s*");
24 disp("Part(b)");
25 delf0_by_M=-Kp/(1+Kp/R); //Hz
26 delf0=delf/100*f; //Hz
27 M=delf0/delf0_by_M; //p.u.MW
28 M=M*C; //MW
29 disp(M,"Largest step change(MW)");
30 //Transfer functions multiplication Gr*Gt*Gp is
    calculated & it is not possible to show together
    without calculated as in the book.

```

---

### Scilab code Exa 5.11 Static Frequency Drop

```

1 //Example 5.11
2 clc;clear;close;
3 format('v',8);
4 GA=5000; //MW
5 GB=10000; //MW
6 R=2; //Hz/p.u.MW////Speed regulation constant
7 D=0.01; //p.u.MW/Hz
8 Ls=100; //MW//Load increase
9 RA=R*GB/GA; //Hz/p.u.MW
10 DA=D*GA/GB; //p.u.MW/Hz
11 RB=R; //Hz/p.u.MW
12 DB=D; //p.u.MW/Hz
13 Beta_A=DA+1/RA; //p.u.MW/Hz
14 Beta_B=DB+1/RB; //p.u.MW/Hz
15 MA=0; //Load increase

```

```

16 MB=Ls/GB; //p.u.MW
17 delf0=-MB/(Beta_A+Beta_B); //Hz
18 disp(delf0," Static frequency drop(Hz)");
19 format('v',6);
20 delPAB=Beta_A*MB/(Beta_A+Beta_B); //p.u.MW
21 delPAB=delPAB*GB; //MW
22 disp(delPAB," Change in tie line power(MW)");

```

---

Scilab code Exa 5.12 Change in frequency and tie line power

```

1 //Example 5.12
2 clc;clear;close;
3 format('v',8);
4 GA=500; //MW
5 GB=2000; //MW
6 RA=2.5; //Hz/p.u.MW//// Speed regulation constant
7 RB=2; //Hz/p.u.MW//// Speed regulation constant
8 Ls=20; //MW//Load increase
9 f=50; //Hz
10 delL=1; //%///// change in load
11 delf=1; //%///// change in frequency
12 DA=delL/delf*GA/f; //MW/Hz
13 DA=DA/GB; //p.u.MW/Hz
14 DB=delL/delf*GB/f; //MW/Hz
15 DB=DB/GB; //p.u.MW/Hz
16 RA=RA*GB/GA; //Hz/p.u.MW
17 Beta_A=DA+1/RA; //p.u.MW/Hz
18 Beta_B=DB+1/RB; //p.u.MW/Hz
19 disp(" Part (a)");
20 MA=Ls/GB; // unitless
21 MB=0; // unitless
22 delf0=-MA/(Beta_A+Beta_B); //Hz
23 disp(delf0," Change in frequency(Hz)");
24 delPAB=-Beta_B*MA/(Beta_B+Beta_A); //p.u.MW
25 delPAB=delPAB*GB; //MW

```

```

26 disp(delPAB,"Change in tie line power(MW)");
27 disp("Part(b)");
28 MB=Ls/GB; // unitless
29 MA=0; // unitless
30 delf0=-MB/(Beta_A+Beta_B); //Hz
31 disp(delf0,"Change in frequency(Hz)");
32 delPAB=Beta_A*MB/(Beta_B+Beta_A); //p.u.MW
33 delPAB=delPAB*GB; //MW
34 disp(delPAB,"Change in tie line power(MW)");

```

---

### Scilab code Exa 5.13 Frequency of collision

```

1 //Example 5.13
2 clc;clear;close;
3 format('v',5);
4 G=4000; //MW
5 R=2; //Hz/p.u.MW////Speed regulation constant
6 H=5; //sec
7 C=600; //MW//Capacity
8 theta=40; //degree///Power angle
9 f=50; //Hz
10 disp("Part(a)");
11 T=C/G*cosd(theta); //sec
12 omega0=sqrt([2*%pi*f*T/H-(f/4/R/H)^2]); //radian/sec
13 disp(omega0,"Frequency of oscillation(radian/sec)");
14 disp("Part(b)");
15 delLB=100; //MW//change in load in area B
16 delPAB=delLB/2; //MW//because Beta_A=Beta_B
17 disp(delPAB,"Change in tie line power(MW)");
18 disp("Part(c)");
19 format('v',6);
20 omega0=sqrt([2*%pi*f*T/H]); //radian/sec
21 disp(omega0,"Frequency of oscillation(radian/sec)");

```

---

### Scilab code Exa 5.14 Frequency at shared load

```
1 //Example 5.14
2 clc;clear;close;
3 format('v',6);
4 C1=300; //MW
5 C2=400; //MW
6 G1=4; //%%droop characteristics of governer
7 G2=5; //%%droop characteristics of governer
8 L=600; //MW
9 f=50; //Hz
10 //Load on first generator =L1
11 //Load on second generator =L-L1
12 //f-G1*f/100*(L1/C1)=f-G2*f/100*(L2/C2)
13 L1=G2*L/C2/(G1/C1+G2/C2); //MW
14 L2=L-L1; //MW
15 disp(L1,"Load on first generator(MW)");
16 disp(L2,"Load on second generator(MW)");
17 fLoad=f*(1-L1/C1*G1/100); //Hz
18 disp(fLoad,"Frequency at load(Hz)");
```

---

### Scilab code Exa 5.15 Change in frequency

```
1 //Example 5.15
2 clc;clear;close;
3 format('v',6);
4 G=100; //MVA
5 f=50; //Hz
6 delL=50; //MW
7 Tc=0.4; //sec
8 H=5; //kWs/kVA
9 KE=G*1000*H; //kWs
```

```

10 delKE=delL*1000*Tc;////kWs///due to decrease in load
11 fnew=sqrt((KE+delKE)/KE) *f; //Hz
12 fdev=(fnew-f)/f*100; // %
13 disp(fnew,"New frequency (Hz)");
14 disp(fdev,"Frequency deviation (%)");

```

---

#### Scilab code Exa 5.16 Percentage frequency deviation

```

1 //Example 5.16
2 clc;clear;close;
3 format('v',7);
4 G=100; //MVA
5 f=50; //Hz
6 delL=60; //MW
7 Tc=0.35; //sec
8 H=5; //kWs/kVA
9 KE=G*1000*H; //kWs
10 delKE=(G-delL)*1000*Tc;////kWs///due to decrease in
    load
11 fnew=sqrt((KE+delKE)/KE) *f; //Hz
12 fdev=(fnew-f)/f*100; // %
13 disp(fnew,"New frequency (Hz)");
14 format('v',6);
15 disp(fdev,"Frequency deviation (%)");

```

---

#### Scilab code Exa 5.17 Rate of frequency increase

```

1 //Example 5.17
2 clc;clear;close;
3 format('v',6);
4 KE=1500; //MJ
5 Pin=5; //MW
6 f=50; //Hz

```

```

7 t=1; //sec
8 delKE=Pin*t; //MJ//due to power inputs
9 fnew=sqrt((KE+delKE)/KE) *f; //Hz
10 delf=fnew-f; //Hz/second
11 disp(delf,"Frequency increase rate(Hz/sec)");

```

---

#### Scilab code Exa 5.18 Primary ALFC loop parameter

```

1 //Example 5.18
2 clc;clear;close;
3 format('v',6);
4 C=2000; //MW// Capacity
5 L=1000; //MW// Load
6 H=5; //kWs/KVA
7 R=2.4; //Hz/puMW// Regulation
8 f=50; //Hz
9 delL=1; //%////change in load
10 delf=1; //%////change in frequency
11 D=delL/delf*L/f; //MW/Hz
12 D=D/C; //p.u.MW/Hz
13 Kp=1/D; //Hz/p.u.MW
14 Tp=2*H/f/D; //sec
15 disp("Primary ALFC loop parameters are : ");
16 disp(D,"D(p.u.MW/Hz)");
17 disp(Kp,"Kp(Hz/p.u.MW)");
18 disp(Tp,"Tp(sec)");

```

---

#### Scilab code Exa 5.19 Compute the time error

```

1 //Example 5.19
2 clc;clear;close;
3 format('v',6);
4 Tp=10; //sec

```

```

5 Tg=0; //sec
6 Tt=0; //sec
7 Kp=100; //Hz/p.u.MW
8 R=3; //Hz/CuMW
9 delPD=0.1; //p.u.
10 Ki=0.1; //constant
11 f=50; //Hz
12 s=poly(0, 's');
13 delFs=-Kp/Tp*[delPD/(s^2+s*{(1+Kp/R)/Tp})+Ki*Kp/Tp];
14 n=1; //cycle
15 time_error=n/f; //sec
16 disp(time_error, "Total time error(sec)");

```

---

#### Scilab code Exa 5.20 Generated output Power and frequency

```

1 //Example 5.20
2 clc;clear;close;
3 format('v',6);
4 L=14; //MW//Total Load
5 C1=15; //MW
6 R1=3; //%/speed regulation
7 C2=4; //MW
8 R2=4; //%/speed regulation
9 LB=4; //MW//Load on bus bar
10 LA=10; //MW//Load on bus bar
11 f=50; //Hz
12 //Load on station A= L1 MW
13 //Load on station B= L-L1 MW
14 //f-C1*f/100*(L1/C1)=f-C2*f/100*(L2/C2)
15 L1=R2*L/C2/(R1/C1+R2/C2); //MW
16 L2=L-L1; //MW
17 disp(L1, "Load generation at station A(MW)");
18 disp(L2, "Load generation at station B(MW)");
19 Pt=L1-LA; //MW//Power transmitted A to B
20 f_oper=f-R1/100/C1*(L1)*f; //Hz

```

```
21 disp(f_oper," Operating Frequency(Hz)");
```

---

### Scilab code Exa 5.21 No Load Frequencies

```
1 //Example 5.21
2 clc;clear;close;
3 format('v',6);
4 C1=300; //MW
5 C2=400; //MW
6 G1=4; //%%/droop characteristics of governer
7 G2=6; //%%/droop characteristics of governer
8 L=400; //MW
9 f=50; //Hz
10 L1=C1*L/(C1+C2); //MW//Load on 300 MW generator
11 L2=L*C2/(C1+C2); //MW//Load on 400 MW generator
12 f01=f*(C1)/(C1-G1/100*L1); //Hz///No load frequency
13 disp(f01,"No load frequency of 300 MW generator(Hz)"
    );
14 f02=f*(C2)/(C2-G2/100*L2); //Hz///No load frequency
15 disp(f02,"No load frequency of 400 MW generator(Hz)"
    );
```

---

### Scilab code Exa 5.22 Generation and transfer of power

```
1 //Example 5.22
2 clc;clear;close;
3 format('v',6);
4 C1=200; //MW
5 C2=100; //MW
6 R1=1.5; //%%/speed regulation
7 R2=3; //%%/speed regulation
8 L=100; //MW///Load on each bus
9 f=50; //Hz
```



```

10 RA=R1/100*f/C1; //Hz/MW
11 RB=R2/100*f/C2; //Hz/MW
12 //Let PA= generation at plant A
13 //PB=2*L-PA will be generation at plant B
14 //RA*PA=RB*PB
15 PA=RB*2*L/(RA+RB); //MW
16 PB=2*L-PA; //MW
17 disp(PA,"Load generation at plant A(MW)");
18 disp(PB,"Load generation at plant B(MW)");
19 Pt=PA-L; //MW//Power transfer
20 disp(Pt,"Power transfer from A to B(MW)");

```

---

#### Scilab code Exa 5.23 Voltage Boost Needed

```

1 //Example 5.23
2 clc;clear;close;
3 format('v',7);
4 Z=1.5+%i*2.5; //ohm
5 V=11; //kV
6 P=20; //MW
7 pf=0.8; //power factor
8 theta=acosd(pf);
9 I=P*1000/sqrt(3)/V/pf; //
10 I=I*expm(%i*-theta*%pi/180); //A
11 Vdrop=I*Z; //V
12 Vboost=Vdrop; //V
13 disp(Vboost,"Voltage boost needed at station A(V)");

```

---

#### Scilab code Exa 5.24 Phase angle and pu real and active

```

1 //Example 5.24
2 clc;clear;close;
3 format('v',6);

```

```

4 Z=3+%i*9; %%//impedence
5 Z=Z/100; //p.u.// Impedence
6 I=1; //p.u.
7 IZ=Z; //p.u.
8 disp("Part (a)");
9 //2*I^2-2*cos(del)=[abs(IZ)]^2
10 cos_del=acosd((2*I^2-[abs(IZ)]^2)/2); //degree
11 disp(cos_del,"Phase angle between two station(degree
    )");
12 angle_abc=87.277; //degree
13 theta=180-angle_abc-atan(imag(IZ)/real(IZ)); //
    degree
14 Preal=I^2*cosd(theta); //p.u.
15 disp(Preal,"Real power transfer(p.u.)");
16 Preactive=I^2*sind(theta); //p.u.
17 disp(Preactive,"Reactive power transfer(p.u.)");
18 disp("Part (b)");
19 //1.05^2+1^2-2*1.05*cos(del)=[abs(IZ)]^2
20 cos_del=acosd((1.05^2+1^2-[abs(IZ)]^2)/2/1.05); //
    degree
21 disp(cos_del,"Phase angle between two station(degree
    )");
22 angle_dbc=60.53; //degree
23 theta=atan(imag(IZ)/real(IZ))-angle_dbc //degree
24 Preal=I^2*cosd(theta); //p.u.
25 disp(Preal,"Real power transfer(p.u.)");
26 Preactive=I^2*sind(theta); //p.u.
27 disp(Preactive,"Reactive power transfer(p.u.)");
28 //Answer in the textbook is not accurate.

```

---

# Chapter 6

## Reactive power control

Scilab code Exa 6.1 Voltage and power factor

```
1 //exa 6.1
2 clc;clear;close;
3 format('v',6);
4 kV=220;//kV
5 Z=0.8+%i*0.2;//pu
6 V=1;//V(Voltage at load terminal)
7 X=0.2+0.05i;//pu(line and transformer reactance)
8 P=real(Z);//pu
9 Q=imag(Z);//pu
10 BaseMVA=100;//MVA
11 BasekV=220;//kV
12 I=sqrt((P^2+Q^2)/V^2)*expm(%i*atan(-imag(Z),real(Z)))
    );//pu
13 Vb=V+I*(X*expm(%i*pi/2));//pu(Voltage at 200 kV bus
    )
14 fi_p=atand(imag(Vb),real(Vb));//degree(power angle)
15 Vb=abs(Vb)*kV;//kV(Voltage at 200 kV bus)
16 pf=cosd(fi_p+atand(imag(Z),real(Z)));//power factor
    at 220 kV bus
17 disp(Vb,"Voltage at 220 kV bus (kV)");
18 disp(pf,"Power factor at 220 kV bus (lagging)");
```

---

### Scilab code Exa 6.2 Voltage and power factor

```
1 //exa 6.2
2 clc;clear;close;
3 format('v',6);
4 kV=220;//kV
5 Z=0.8+%i*0.2;//pu
6 V=1;//V(Voltage at load terminal)
7 X=0.2+0.05i;//pu(line and transformer reactance)
8 P=real(Z);//pu
9 Q=imag(Z);//pu
10 BaseMVA=100;//MVA
11 BasekV=220;//kV
12 I=sqrt((P^2+Q^2)/V^2);//pu
13 Vb=V+I*(X*expm(%i*%pi/2));//pu(Voltage at 200 kV bus
   )
14 fi_p=atand(imag(Vb),real(Vb));//degree(power angle)
15 Vb=abs(Vb)*kV;//kV(Voltage at 200 kV bus)
16 pf=cosd(fi_p);//power factor at 220 kV bus
17 disp(Vb,"Voltage at 220 kV bus (kV)");
18 format('v',5);
19 disp(pf,"Power factor at 220 kV bus (lagging)");
```

---

### Scilab code Exa 6.3 Find ABCD Parameters

```
1 //exa 6.3
2 clc;clear;close;
3 format('v',7);
4 l=350;//km(length of line)
5 Z=180*expm(%i*75*%pi/180);//ohm/phase(Total)
6 Y=1*10^-3*expm(%i*90*%pi/180);//Siemens/phase(Total)
```

```

7 z=Z/l; //ohm/km
8 y=Y/l; //Siemens/km
9 re=1*sqrt(z*y); //
10 Zc=sqrt(z/y); //ohm
11 disp("Part (a) A,B,C,D parameters are : ");
12 A=cosh(re); // unitless
13 D=A; // unitless
14 B=Zc*sinh(re); //ohm
15 C=sinh(re)/Zc; // unitless
16 A_mag=abs(A); // unitless
17 A_angle=atand(imag(A)/real(A)); // degree
18 B_mag=abs(B); //ohm
19 B_angle=atand(imag(B)/real(B)); // degree
20 C_mag=abs(C); // unitless
21 C_angle=atand(imag(C)/real(C)); // degree
22 C_angle=C_angle+180; // degree (Converting -ve to +ve
    angle)
23 D_mag=abs(D); // unitless
24 D_angle=atand(imag(D)/real(D)); // degree
25 disp(A_mag,"Magnitude of A : ");
26 format('v',5);
27 disp(A_angle,"Angle of A(degree) : ");
28 format('v',7);
29 disp(B_mag,"Magnitude of B(ohm) : ");
30 format('v',6);
31 disp(B_angle,"Angle of B(degree) : ");
32 format('v',8);
33 disp(C_mag,"Magnitude of C : ");
34 format('v',6);
35 disp(C_angle,"Angle of C(degree) : ");
36 format('v',7);
37 disp(D_mag,"Magnitude of D : ");
38 format('v',5);
39 disp(D_angle,"Angle of D(degree) : ");
40 //60% series compensation
41 B=B-%i*60/100*abs(Z)*sind(atand(imag(Z),real(Z))); //
    ohm(considering series compensation=60%)
42 //For Equivalent pi-circuit

```

```

43 disp("Part (b) A,B,C,D parameters of compensated line
      are : ");
44 Ydash=2/Zc*[(cosh(re)-1)/sinh(re)]; //S
45 A=1+B*Ydash/2; // unitless
46 D=A; // unitless
47 C=2*Ydash/2+B*(Ydash/2)^2; // unitless
48 A_mag=abs(A); // unitless
49 A_angle=atand(imag(A)/real(A)); // degree
50 B_mag=abs(B); // ohm
51 B_angle=atand(imag(B)/real(B)); // degree
52 C_mag=abs(C); // unitless
53 C_angle=atand(imag(C)/real(C)); // degree
54 C_angle=C_angle+180; // degree (Converting -ve to +ve
      angle)
55 D_mag=abs(D); // unitless
56 D_angle=atand(imag(D)/real(D)); // degree
57 format('v',4);
58 disp(B_mag,"Magnitude of B(ohm) : ");
59 format('v',6);
60 disp(B_angle,"Angle of B(degree) : ");
61 format('v',7);
62 disp(A_mag,"Magnitude of A : ");
63 format('v',5);
64 disp(A_angle,"Angle of A(degree) : ");
65 format('v',6);
66 disp(C_mag,"Magnitude of C : ");
67 format('v',5);
68 disp(C_angle,"Angle of C(degree) : ");
69 format('v',7);
70 disp(D_mag,"Magnitude of D : ");
71 format('v',5);
72 disp(D_angle,"Angle of D(degree) : ");
73 //Answer for some parts are not accurate in the
      textbook.

```

---

#### Scilab code Exa 6.4 Constant of nominal pi circuit

```
1 //exa 6.4
2 clc;clear;close;
3 format('v',6);
4 l=350;//km(length of line)
5 Z=180*expm(%i*75*%pi/180);//ohm/phase(Total)
6 Y=1*10^-3*expm(%i*90*%pi/180);//Siemens/phase(Total)
7 z=Z/l;//ohm/km
8 y=Y/l;//Siemens/km
9 re=1*sqrt(z*y);//
10 Zc=sqrt(z/y);//ohm
11 disp("For Uncompensated Line, Constants are :");
12 B=Z;//ohm//B Parameter
13 A=1+Z*Y/2;//unitless//A Parameter
14 D=A;//unitless//D Parameter
15 C=Y*(1+Z*Y/4);//S//C Parameter
16 A_mag=abs(A);
17 A_angle=atand(imag(A)/real(A));//degree
18 B_mag=abs(B);
19 B_angle=atand(imag(B)/real(B));//degree
20 C_mag=abs(C);
21 C_angle=atand(imag(C)/real(C))+180;//degree
22 D_mag=abs(D);
23 D_angle=atand(imag(D)/real(D));//degree
24 disp(B_angle,B_mag,"Magnitude and Angle(degree) of B
    (ohm) is ");
25 disp(A_angle,A_mag,"Magnitude and Angle(degree) of A
    is ");
26 disp(D_angle,D_mag,"Magnitude and Angle(degree) of D
    is ");
27 format('v',9);
28 disp(C_mag,"Magnitude of C(S) is ");
29 format('v',6);
30 disp(C_angle,"Angle(degree) of C is ");
31 disp("For Compensated Line, Constants are :");
32 B=Z-0.6*%i*406;//ohm//B Parameter
33 A=1+conj(B)*Y/2;//unitless//A Parameter
```

```

34 D=A; // unitless //D Parameter
35 C=Y*(1+Z*Y/4); //S//C Parameter
36 A_mag=abs(A);
37 A_angle=atand(imag(A)/real(A)); //degree
38 B_mag=abs(B);
39 B_angle=-atand(imag(B)/real(B)); //degree
40 C_mag=abs(C);
41 C_angle=atand(imag(C)/real(C))+180; //degree
42 D_mag=abs(D);
43 D_angle=atand(imag(D)/real(D)); //degree
44 disp(B_angle,B_mag,"Magnitude and Angle(degree) of B
    (ohm) is ");
45 disp(A_angle,A_mag,"Magnitude and Angle(degree) of A
    is ");
46 disp(D_angle,D_mag,"Magnitude and Angle(degree) of D
    is ");
47 format('v',9);
48 disp(C_mag,"Magnitude of C(S) is ");
49 format('v',6);
50 disp(C_angle,"Angle(degree) of C is ");

```

---

### Scilab code Exa 6.5 VAR injection ay bus

```

1 //exa 6.5
2 clc;clear;close;
3 format('v',6);
4 kv1=220; //kv
5 kv2=132; //kv
6 baseMVA=200; //MVA
7 //Base impedance in 132 kv circuit
8 baseZ2=kv2^2/baseMVA; //ohm
9 z1=%i*75; //ohm
10 z2=%i*70; //ohm
11 z3=%i*90; //ohm
12 z1=z1/baseZ2; //pu

```



```

13 z2=z2/baseZ2;//pu
14 z3=z3/baseZ2;//pu
15 X_AD=%i*0.08+z1;//pu//Reactance from A to D
16 X_BD=%i*0.08+z2;//pu//Reactance from A to D
17 Zp=z3*X_AD*X_BD/(z3*X_AD+z3*X_BD+X_BD+X_AD);//
    parallel combination
18 sc_D=baseMVA/abs(Zp);//MVA//Short Circuit MVA at D
19 delQBYdelV=sc_D/kv2;//MVA/kv
20 delQ=delQBYdelV*4;//MVar
21 disp(delQ,"Var injection at Bus D(MVar) : ");
22 //Answer in the textbook is not accurate.

```

---

#### Scilab code Exa 6.6 Capacity of shunt compensation

```

1 //exa 6.6
2 clc;clear;close;
3 format('v',6);
4 A=0.98*expm(%i*3*%pi/180);//Constant
5 B=110*expm(%i*75*%pi/180);//ohm/phase
6 P=50;//MVA
7 pf=0.8;//lagging
8 V=132;//kV
9 //Formula : Pr=|Vs|*|Vr|/|B|*cosd(Beta-delta)-|A|*|
    Vr|^2/|B|*cosd(Beta-alfa) :
10 betaSUBdelta=acosd((P*pf+abs(A)*V^2/abs(B)*cosd(
    atand(imag(B),real(B))-atand(imag(A),real(A))))/V
    ^2*abs(B));
11 Qr=V^2/abs(B)*sind(betaSUBdelta)-abs(A)*V^2/abs(B)*
    sind(atand(imag(B),real(B))-atand(imag(A),real(A)
    ));//MVar
12 Qr=P*0.6-Qr;//MVar//Since load require lagging
    component
13 disp(Qr,"(a) Capacity of shunt compensation
    equipment(MVar) : ");
14 //part(b)

```

```

15 //Formula : Pr=|Vs|*|Vr|/|B|*cosd(Beta-delta)-|A|*|
    Vr|^2/|B|*cosd(Beta-alfa) :
16 format('v',5);
17 P=0; //MW
18 betaSUBdelta=acosd((P*pf+abs(A)*V^2/abs(B)*cosd(
    atand(imag(B),real(B))-atand(imag(A),real(A))))/V
    ^2*abs(B));
19 Qr=V^2/abs(B)*sind(betaSUBdelta)-abs(A)*V^2/abs(B)*
    sind(atand(imag(B),real(B))-atand(imag(A),real(A)
    )); //MVar
20 Qr=P*0.6-Qr; //MVar// Since load require lagging
    component
21 disp(-Qr,"(b) Capacity of shunt compensation
    equipment(MVar) : ");

```

---

### Scilab code Exa 6.7 Find tap settings

```

1 //exa 6.7
2 clc;clear;close;
3 format('v',6);
4 V=220; //kV
5 Z=20+%i*60; //ohm
6 Pr=100; //MVA
7 pf=0.8; //lagging pf
8 P=Pr*10^6*pf/3; //W
9 theta=acosd(pf); //degree
10 Q=Pr*10^6*sind(theta)/3; //Vars
11 V1=V/sqrt(3)*1000; //V
12 V2=V1; //V
13 //ts^2*[1-(R*P+X*Q)/V1/V2]=V2/V1
14 ts=sqrt(V2/V1/[1-(real(Z)*P+imag(Z)*Q)/V1/V2]);
15 tr=1/ts;
16 disp(ts,"Tap settings : ts is ");
17 format('v',5);
18 disp(tr,"tr is ");

```

---

Scilab code Exa 6.8 Find tap settings

```
1 //exa 6.8
2 clc;clear;close;
3 format('v',6);
4 kV1=132;//kV
5 kV2=33;//kV
6 kV3=11;//kV
7 MVA1=75;//MVA
8 MVA2=50;//MVA
9 MVA3=25;//MVA
10 X=0.12;//p.u.
11 //part(a)
12 P=60;//MW
13 V1=125;//kV
14 V1=V1/kV1;//p.u.
15 Q=MVA2/MVA1;//p.u.
16 //V1=Vn+X*Q/Vn
17 Vn=poly(0,'Vn');
18 eqn=Vn^2-V1*Vn+X*Q
19 Vn=roots(eqn);//p.u.
20 Vn=Vn(1);//p.u.
21 Vn=Vn*kV1;//kV
22 k=Vn/kV2;//Transformer ratio
23 disp(k,"Under Load condition , transformer ratio is ")
24 );
25 //part(b)
26 V1=140;//kV
27 V1=V1/kV1;//p.u.
28 Q=MVA3/MVA1;//p.u.
29 //V1=Vn+X*Q/Vn
30 Vn=poly(0,'Vn');
31 eqn=Vn^2-V1*Vn+X*Q
32 Vn=roots(eqn);//p.u.
```

```

32 Vn=Vn(1); //p.u.
33 Vn=Vn*kV1; //kV
34 k=Vn/kV2; //Transformer ratio
35 disp(k,"Under No Load condition , transformer ratio
    is ");

```

---

### Scilab code Exa 6.9 Settings of tap changes

```

1 //exa 6.9
2 clc;clear;close;
3 format('v',7);
4 V=132; //kV
5 Z=25+%i*66; //ohm
6 Pr=100; //MW
7 pf=0.9; //lagging pf
8 P=Pr*10^6/3; //W
9 theta=acosd(pf); // degree
10 Q=Pr*10^6*tand(theta)/3; // vars
11 V1=V/sqrt(3)*1000; //V
12 V2=V1; //V
13 // ts ^2*[1-(R*P+X*Q)/V1/V2]=V2/V1
14 ts=sqrt(V2/V1/[1-(real(Z)*P+imag(Z)*Q)/V1/V2]);
15 tr=1/ts;
16 disp(ts,"Tap settings : ts is ");
17 format('v',5);
18 disp(tr,"tr is ");

```

---