Scilab Textbook Companion for Fundamentals of Electric Drives and Control by B. R. Gupta and V. Singhal[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.

Contents

List of Scilab Codes

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Chapter 1

Fundamentals of Electric Drive

Scilab code Exa 1.1 Electrical Energy and Rating

```
1  //Example  No.  1.1
2  clc ;
3  clear ;
4  close ;
5  format ( 'v' ,9) ;
6
7  //Given  Data  :
8  J=12; // journey  per  hour
9  Load =5500; //Kg
10 t_up =1.5; // min
11 W_cage =500; //Kg
12 t_down =1.25; // min
13 h=50; //m
14 Wb =3000; //Kg( Balance  weight )
15 Eff_hoist =0.8;
16 Eff_motor =0.85;
17 g=9.81; // gravity  constant
18 E_upward =( Load + W_cage - Wb )*g*h; //J
19 E_downward =(Wb - W_cage )*g*h; //J
20 Edj=E_upward + E_downward ; //J( Energy  used  in  double
        journey )
```

```
21 disp(Edj,"Electrical energy used per journey in J :
     ");
22 Ein=Edj/Eff_hoist/Eff_motor;//J or W-s
23 Ein=Ein/1000/3600;//KWh
24 Ein_hour=Ein*J;//KWh
25 disp(Ein_hour,"Electrical energy consumption in one
     hour in KWh : ");
26 Rating=E_upward/Eff_hoist/t_up/60;//W
27 disp(Rating/1000,"Rating of motor in KW : ");
```

Chapter 3

Dynamics of Electric Drives

Scilab code Exa 3.1 Moment of Inertia and Load Torque

```
1  //Example No. 3.1
2  clc;
3  clear;
4  close;
5
6  //Given Data :
7  MoI=0.3;//Kg-m^2
8  T=20;//N-m
9  MoIshaft=10;//in Kg-m^2
10 LostT=10;//%
11
12 //Solution :
13 MoItotal=MoI+MoIshaft;//in Kg-m^2
14 LoadTorque=T-T*LostT/100;//in N-m
15 disp(MoItotal,"Total Moment of Inertia in Kg-m^2 : "
      );
16 disp(LoadTorque,"Load Torque in N-m : ");
```

Scilab code Exa 3.2 equivalent inertia and load of motor

```
1  //Example No. 3.2
2  clc;
3  clear;
4  close;
5  format('v',8);
6
7  //Given Data :
8  n=0.1;//teeth ratio
9  ETAg=90/100;//efficiency
10 J0=0.4;//Kg-m^2
11 J1=10;//Kg-m^2
12 TL=50;//N-m
13 N=1400;//speed in rpm
14
15 //Solution :
16 J=J0+n^2*J1;//Kg-m^2
17 T=n*TL/ETAg;//N-m
18 MotorSpeed=2*%pi*N/60;//rad/sec
19 Pdev=MotorSpeed*T;//Watt
20 disp(J,"Equivalent Inertia in Kg-m^2 : ");
21 disp(T,"Load Torque refered to motor side in N-m : "
      );
22 disp(Pdev,"Power developed by motor in watt : ");
```

Scilab code Exa 3.3 kw rating and distance

```
1  //Example No. 3.3
2  clc;
3  clear;
4  close;
5  format('v',8);
6
7  //Given Data :
8  v=60;//Km/hr
9  w=400;//KN
```

```
10  friction=5; //N/KN weight
11  tan_theta=1/100; //inclination
12  g=9.81; // gravity constant
13
14  //Solution :
15  sin_theta=tan_theta;
16  W_sin_theta=w*1000*sin_theta; //N
17  R=friction*W_sin_theta/10; //frictional resistance in
        N
18  P=W_sin_theta+R; //N
19  v=60*1000/60/60; //m/s
20  Power=P*v; //Watt
21  disp(Power/1000,"Final KW rating of the motor of
        train : ");
22  Force=P; //down the inclined force in N
23  u=v; //initial velocity in m/s
24  v=0; //final velocity in m/s
25  m=w*1000/g; //in Kg
26  KE=1/2*m*u^2; //in Joule
27  d=KE/P; //distance in meter
28  disp(d,"Distance covered in meter : ");
```

Scilab code Exa 3.4 acceleration

```
 1  //Example No. 3.4
 2  clc;
 3  clear;
 4  close;
 5  format('v',6);
 6
 7  //Given Data :
 8  MotorOutput=200; //KW
 9  v=60; //Km/hr
10  w=400; //KN
11  friction=5; //N/KN weight
```

```
12  tan_theta =1/100; // inclination
13  g=9.81; // gravity constant
14
15  // Solution :
16  sin_theta=tan_theta;
17  W_sin_theta=w*1000*sin_theta; //N
18  R=friction*W_sin_theta/10; // frictional resistance in
        N
19  P=W_sin_theta+R; //N
20  v=60*1000/60/60; //m/s
21  Power=P*v; //Watt
22  Pdash=MotorOutput*1000-Power; // Power causes
        acceleration in watt or N–m/s
23  m=w*1000/g; // in Kg
24  a=Pdash/m; // in m/sˆ2
25  disp(a,"Acceleration in m/sˆ2 : ");
```

Scilab code Exa 3.5 `diameter`

```
1  // Example No. 3.5
2  clc ;
3  clear ;
4  close ;
5  format ( 'v ' ,6) ;
6
7  // Given Data :
8  MotorSpeed =200; // rpm
9  d1=50; // diameter of motor pulley in cm
10  MachineSpeed =100; // rpm
11
12  // Solution :
13  d2=MotorSpeed/MachineSpeed*d1; // diameter of machine
        pulley in cm
14  disp(d2 ," Diameter of machine pulley in cm : ");
```

Scilab code Exa 3.6 inertia and torque

```
1  //Example No.  3.6
2  clc;
3  clear;
4  close;
5  format('v',6);
6
7  //Given Data :
8  v=1.2;//belt conveyer speed in m/s
9  TransRate=100;//rate of transportation of material
       in tons/hour
10 l=200;//length of belt in meter
11 MotorSpeed=1200;//rpm
12 MoI=0.1;//Moment of Inertia in Kg-m^2
13
14
15 //Solution :
16 //Part A
17 TransRate=TransRate*1000/60/60;//rate of
       transportation of material in Kg/sec
18 TransTime=l/v;//in sec
19 omega=MotorSpeed*2*%pi/60;//rad/sec
20 M=TransRate*TransTime;//Kg
21 J=M*(v/omega)^2;//Kg-m^2
22 disp(J,"Load Inertia in Kg-m^2 : ");
23
24 //Part B
25 t=8;//sec
26 a=v/t;//m/s^2
27 TorqueInertai=MoI*omega/t;//N-m
28 F=M*a;//N
29 Tload=F*v/omega;//N-m
30 TotalTorque=Tload+TorqueInertai;//N-m
```

13

```
31 disp(TotalTorque,"Total Torque in N-m : ");
```

Scilab code Exa 3.7 `torque and moment`

```
1  //Example No.  3.7
2  clc;
3  clear;
4  close;
5  format('v',7);
6
7  //Given Data :
8  w=400;//Kg
9  v=1;//m/s
10 MotorSpeed=1000;//rpm
11 MoI=0.5;//Moment of Inertia in Kg-m^2
12 winch=0.3;//Kg-m^2
13 Tnl=80;//N-m
14 Speed_nl=1000;//rpm
15 g=9.81;//gravity constant
16
17 //Solution :
18 mass=w*g;//N
19 omega=MotorSpeed*2*%pi/60;//rad/sec
20 TotTorque=Tnl+mass*v/omega;//N-m
21 disp(TotTorque,"Total Motor Torque in N-m :  ");
22 J=MoI+winch+w*(v/omega)^2;//Kg-m^2
23 disp(J,"Moment of Inertia refered to motor shaft in
      Kg-m^2 : ");
```

Scilab code Exa 3.9 `torque and power`

```
1  //Example No.  3.9
2  clc;
```

```scilab
3  clear;
4  close;
5  format('v',7);
6
7  //Given Data :
8  Jmotor=0.3;//Kg−m^2
9  Jgd_load=15;//Kg−m^2(Inertia gear driven load)
10 GSRratio=0.1;//gear speed reduction ratio
11 Jbd_load=0.6;//Kg−m^2(Inertia belt driven load)
12 d1=10;//cm(diameter of driver pulley)
13 d2=30;//cm(diameter of driven pulley)
14 MotorSpeed=1440;//rpm
15 Tload1=100;//N−m
16 Tload2=35;//N−m
17
18 //Solution :
19 MotorSpeed=MotorSpeed*2*%pi/60;//rad/sec
20 Speed_gd=GSRratio*MotorSpeed;//rad/sec
21 Speed_bd=MotorSpeed*d1/d2;//rad/sec
22 //Equating Kinetic Energies
23 //1/2*J*MotorSpeed^2=1/2*Jmotor*MotorSpeed^2+1/2*
       Jgd_load*speed_gd^2+1/2*Jbd_load*speed_bd^2
24 J=(1/2*Jmotor*MotorSpeed^2+1/2*Jgd_load*Speed_gd
       ^2+1/2*Jbd_load*Speed_bd^2)*2/MotorSpeed^2
25 disp(J,"Moment of Inertia refered to motor shaft in
       Kg−m^2 : ");
26 //Equating power of motor
27 //T*(MotorSpeed)=Tload1*Speed_gd+Tload2*Speed_bd
28 T=(Tload1*Speed_gd+Tload2*Speed_bd)/MotorSpeed;//N−m
29 disp(T,"Torque in N−m : ");
30 Pdev=T*MotorSpeed;//watt
31 disp(Pdev,"Power developed by the motor in watts : "
       );
```

Scilab code Exa 3.10 equivalent moment and torque

15

```
1  //Example No. 3.10
2  clc;
3  clear;
4  close;
5  format('v',6);
6
7  //Given Data :
8  MotorSpeed=1440;//rpm
9  Jmotor=0.4;//Kg-m^2
10 Jdc_load=0.6;//Kg-m^2(Inertia directly coupled load)
11 w_tl=100;//kg(weight of transratioonal load)
12 F_res=1.2;//N/Kg(Friction resistance for
       translational load)
13 v=10;//m/s
14 T_RotLoad=1.5;//N-m
15 g=9.81;//gravity constant
16
17 //Solution :
18 MotorSpeed=MotorSpeed*2*%pi/60;//rad/sec
19 F_horz=w_tl*F_res;//N(horizontal force of
       translational load)
20 mass=w_tl*g;//N
21 J=Jmotor+Jdc_load+mass*(v/MotorSpeed)^2;//Kg-m^2
22 disp(J,"Moment of Inertia at motor shaft in Kg-m^2 :
        ");
23 T=T_RotLoad+F_horz*v/MotorSpeed;//N-m
24 disp(T,"Torque at motor shaft in N-m : ");
```

Scilab code Exa 3.11 operating speed

```
1  //Example No. 3.11
2  clc;
3  clear;
4  close;
5  format('v',6);
```

```
 6
 7 //Given Data :
 8 //T=0.6+1.9*omega_m
 9 //TL=2.8*sqrt(omega_m)
10
11 //Solution :
12 P=[3.61 -5.56 0.36];//Polynomial for omega_m
      calculated by equating T=TL
13 omega_m=roots(P);//rad/sec
14 disp(omega_m(2),"Operating speed in rad/sec at which
       system has steady state stability : ");
```

Scilab code Exa 3.12 `operating speed`

```
 1 //Example No.  3.12
 2 clc ;
 3 clear ;
 4 close ;
 5 format('v',6);
 6
 7 //Given Data :
 8 //T=15-0.5*omega_m
 9 //TL=0.5*omega_m^2
10
11 //Solution :
12 P=[1 1 -30];//Polynomial for omega_m calculated by
      equating T=TL
13 omega_m=roots(P);//rad/sec
14 disp(omega_m(2),"Operating speed in rad/sec at which
       system has steady state stability : ");
```

Chapter 4

Selection of Motor Power Rating

Scilab code Exa 4.1 `time constant and temperature`

```
1  //Example No. 4.1
2  clc;
3  clear;
4  close;
5  format('v',6);
6
7  //Given Data :
8  P=30;//KW
9  theta1=30;//degree C
10 t1=40;//min
11 theta2=45;//degree C
12 t2=80;//min(t2=2*t1)
13 disp("theta=theta_f*(1-exp(-t/T))");
14 //Let exp(-t1/T)=a then exp(-t2/T)=a^2
15 //theta1/theta2=(1-a)/(1-a^2)
16 //a^2*theta1-a*theta2+theta2-theta1=0
17 P=[theta1 -theta2 theta2-theta1];//Polynomial for a
18 a=roots(P);
19 a=a(2);//discarding value 1 as it cant give value of
```

```
        T
20  T=-t1/log(a);//min
21  disp(T,"Thermal time constant in min : ");
22  theta_f=theta1/(1-exp(-t1/T));//degreeC
23  disp(theta_f,"Final temperature rise in degree C : "
        );
```

Scilab code Exa 4.2 `temperature and time constant`

```
 1  //Example No. 4.2
 2  clc;
 3  clear;
 4  close;
 5  format('v',6);
 6
 7  //Given Data :
 8  P=30;//KW
 9  theta1=20;//degree C
10  t1=30;//min
11  theta2=30;//degree C
12  t2=60;//min(t2=2*t1)
13  disp("theta=theta_f*(1-exp(-t/T))");
14  //Let exp(-t1/T)=x then exp(-t2/T)=x^2
15  //theta1/theta2=(1-x)/(1-x^2)
16  //x^2*theta1-x*theta2+theta2-theta1=0
17  P=[theta1 -theta2 theta2-theta1];//Polynomial for a
18  x=roots(P);
19  x=x(2);//discarding value 1 as it cant give value of
        T
20  T=-t1/log(x);//min
21  disp(T,"Thermal time constant in min : ");
22  theta_f=theta1/(1-exp(-t1/T));//degreeC
23  disp(theta_f,"Final temperature rise in degree C : "
        );
```

Scilab code Exa 4.3 `temperature heating and cooling time constant`

```scilab
1  //Example No. 4.3
2  clc;
3  clear;
4  close;
5  format('v',6);
6
7  //Given Data :
8  P=30; //KW
9  theta1=54-30; //degree C
10 t1=1; //hour
11 theta2=67-30; //degree C
12 t2=2; //hour(t2=2*t1)
13 disp("theta=theta_f*(1-exp(-t/T))");
14 //Let exp(-t1/T)=a then exp(-t2/T)=a^2
15 //theta1/theta2=(1-a)/(1-a^2)
16 //a^2*theta1-a*theta2+theta2-theta1=0
17 P=[theta1 -theta2 theta2-theta1]; //Polynomial for a
18 a=roots(P);
19 a=a(2); //discarding value 1 as it cant give value of
       T
20 T=-t1/log(a); //hour
21 theta_f=theta1/(1-exp(-t1/T)); //degreeC
22 theta_steady=theta_f+30; //degreeC
23 disp(theta_steady,"Final steady state temperature in
       degree C : ");
24 disp(T,"Heating time constant in hour : ");
25 theta2=theta_f; //degree C
26 t=2.7; //hour
27 theta=40-30; //degree C
28 Tdash=-t/log(theta/theta2); //hour
29 disp(Tdash,"Cooling time constant in hour : ");
```

Scilab code Exa 4.4 `temperature rise`

```
1  //Example No. 4.4
2  clc;
3  clear;
4  close;
5  format('v',6);
6
7  //Given Data :
8  T=110; //min
9  Tdash=150; //min
10 t=30; //min
11 tdash=45; //min
12 theta_f=50; //degree C
13 //theta=theta_f-(theta_f-theta1)*exp(-t/T)
14 //theta1=theta*exp(-tdash/Tdash);
15 theta=(theta_f-theta_f*exp(-t/T))/(1-exp(-tdash/
      Tdash)*exp(-t/T)); //degreeC
16 disp(theta,"Maximum temperature rise of the motor in
       degree C : ");
```

Scilab code Exa 4.5 `temperature rise and heating time constant`

```
1  //Example No. 4.5
2  clc;
3  clear;
4  close;
5  format('v',6);
6
7  //Given Data :
8  theta1=20; //degreeC
9  theta2=28; //degreeC
```

```
10  dthetaBYdt1 =0.08; //degreeC/min
11  dthetaBYdt2 =0.06; //degreeC/min
12  //theta=theta_f -(theta_f-theta1)*exp(-t/T)
13  //dtheta/dt=(theta_f-theta)/T
14  //dthetaBYdt1/dthetaBYdt2=(theta_f-theta1)/(theta_f-
       theta2)
15  theta_f =( theta2 * dthetaBYdt1 - theta1 * dthetaBYdt2 )/(
       dthetaBYdt1 - dthetaBYdt2 )
16  disp ( theta_f ,"Final  temperature  rise  in  degree  C  :  "
       );
17  T =( theta_f - theta1 )/ dthetaBYdt1 ; //min
18  disp (T ,"Heating  time  constant  in  min  :  ");
```

Scilab code Exa 4.6 `proper size of motor`

```
1  //Example No. 4.6
2  clc ;
3  clear ;
4  close ;
5  format ('v',6) ;
6
7  //Given  Data  :
8  cycle1 =50; //hp
9  t1 =20; //sec
10  cycle2 =100; //hp
11  t2 =20; //sec
12  cycle3 =150; //hp
13  t3 =10; //sec
14  cycle4 =120; //hp
15  t4 =20; //sec
16  cycle5 =0; //hp
17  t5 =15; //sec
18  hp_rms = sqrt (( cycle1^2*t1 + cycle2^2*t2 + cycle3^2*t3 +
       cycle4^2*t4 + cycle5^2*t5 )/( t1 + t2 + t3 + t4 + t5 )); //hp
19  disp ( hp_rms ,"hp(rms)  for  the  motor  :  ");
```

```
20  disp("We should  choose  100hp  motor.")
```

Scilab code Exa 4.7 `maximum temperature rise`

```
1  //Example No.  4.7
2  clc;
3  clear;
4  close;
5  format('v',6);
6
7  //Given  Data :
8  t_on=15;//min
9  t_off=25;//min
10 T=100;//min
11 Tdash=140;//min
12 theta_f=55;//degree C
13
14 //theta=theta_f-(theta_f-theta1)*exp(-t/T)
15 //theta1=theta*exp(-tdash/Tdash);
16 theta_max=theta_f*[1-exp(-t_on/T)]/(1-exp(-(t_off/
      Tdash+t_on/T)));//degreeC
17 disp(theta_max,"Maximum temperature rise in degree C
        : ");
```

Scilab code Exa 4.8 `ratio`

```
1  //Example No.  4.8
2  clc;
3  clear;
4  close;
5  format('v',6);
6
7  //Given  Data :
```

```
8  Rating=100;//KW
9  alfa=0.9;//unitless
10 ts=20;//min
11 T=100;//min
12 S=sqrt((1+alfa)/(1-exp(-ts/T)));
13 ShortTimeRating=S*Rating;//KW
14 disp(ShortTimeRating,"Short time rating in KW : ");
15 //Answer is wrong in the textbook.
```

Scilab code Exa 4.9 time and intermittent periodic duty rating

```
1  //Example No.  4.9
2  clc;
3  clear;
4  close;
5  format('v',7);
6
7  //Given Data :
8  T=80;//min
9  Tdash=110;//min
10 Rating=50;//KW
11 ts=15;//min
12 S=sqrt(1/(1-exp(-ts/T)));
13 ShortTimeRating=S*Rating;//KW
14 disp(ShortTimeRating,"Short time rating of motor in
      KW : ");
15 t_off=20;//min
16 S=sqrt((1-exp(-(ts/T+t_off/Tdash)))/(1-exp(-(ts/T)))
      )
17 DutyRating=S*Rating;//KW
18 disp(DutyRating,"Intermittent periodic duty rating
      in KW : ");
```

Scilab code Exa 4.10 `continuous rating`

```
1  //Example No. 4.10
2  clc;
3  clear;
4  close;
5  format('v',5);
6
7  //Given Data :
8  T=90;//min
9  t=25;//min
10 ShortTimeRating=50;//KW
11 Eff=80/100;//Efficiency
12 //Let full load rating is P KW and Losses=Pc
13 //CuLoss=(P/(P*Eff))^2 & alfa=Pc/CuLoss
14 alfa=(Eff)^2;//unitless
15 S=sqrt(((1+alfa)/(1-exp(-t/T))-alfa));
16 ContinuousRating_fl=ShortTimeRating/S;//KW
17 disp(ContinuousRating_fl,"Continuous rating of motor
       in KW : ");
```

Scilab code Exa 4.11 `half hour rating`

```
1  //Example No. 4.11
2  clc;
3  clear;
4  close;
5  format('v',7);
6
7  //Given Data :
8  Rating=25;//KW
9  T=90;//min
10 ts=30;//min
11 S=sqrt(1/(1-exp(-ts/T)));
12 HalfHourRating=S*Rating;//KW
```

```
13 disp(HalfHourRating,"Half hour rating of motor in KW
       : ");
14 //Answer wrong in textbook.
```

Scilab code Exa 4.12 continuous rating

```
1  //Example No. 4.12
2  clc;
3  clear;
4  close;
5  format('v',8);
6
7  //Given Data :
8  T=60;//min
9  t=20;//min
10 ShortTimeRating=300;//W
11 Eff=80/100;//Efficiency
12 //Let full load rating is P KW and Losses=Pc
13 //CuLoss=(P/(P*Eff))^2 & alfa=Pc/CuLoss
14 alfa=(Eff)^2;//unitless
15 S=sqrt(((1+alfa)/(1-exp(-t/T))-alfa));
16 ContinuousRating_fl=ShortTimeRating/S;//KW
17 disp(ContinuousRating_fl,"Continuous rating of motor
       in W : ");
```

Scilab code Exa 4.13 moment of inertia

```
1  //Example No. 4.13
2  clc;
3  clear;
4  close;
5  format('v',7);
6
```

```
7  //Given Data :
8  P=6;//poles
9  f=50;//Hz
10 MoI=9.5;//Kg-m^2
11 Tr=550;//N-m
12 S=5/100;//Slip
13 Tmax=720;//N-m
14 T_LH=1020;//N-m
15 th=12;//sec
16 Tmin=220;//N-m
17 Snl=3/100;//No load slip
18 Ns=120*f/P;//rpm
19 Nnl=Ns-Ns*Snl;//rpm
20 Nrated=Ns-Ns*S;//rpm
21 omega_mo=Nnl*2*%pi/60;//rad/s
22 omega_mr=Nrated*2*%pi/60;//rad/s
23 J=[Tr/(omega_mo-omega_mr)]*[th/log((T_LH-Tmin)/(T_LH
     -Tmax))];//Kg-m^2
24 MoI_flywheel=J-MoI;//Kg-m^2
25 disp(MoI_flywheel,"Moment of inertia of flywheel in
     Kg-m^2 : ");
26 //Answer in the book is wrong.
```

Chapter 5

DC Motor Drives

Scilab code Exa 5.1 armature resistance and torque

```scilab
1  //Example No. 5.1
2  clc;
3  clear;
4  close;
5  format('v',7);
6
7  //Given Data :
8  T=10;//turns
9  Coil=144;//no. of coils
10 R=0.011;//ohm
11 fi=0.05;//Wb(flux per pole)
12 N=200;//rpm
13 par_paths=2;//for wave winding
14 T_path=Coil*T/par_paths;//no. of turns in each
      parallel path
15 R_path=R*T_path;//ohm
16 Ra=R_path/par_paths;//ohm(armature resistance)
17 disp(Ra,"Armature resistance in ohm : ");
18 p=12;//poles
19 emf=par_paths*Coil*T*p*fi*N/60/2;//V
20 R1=1000;//ohm
```

```
21  IL=emf/R1;//A
22  Ia=IL;//A
23  T=par_paths*Coil*T*p*fi*Ia/2/%pi/par_paths;//N-m
24  disp(T,"Torque in N-m : ");
```

Scilab code Exa 5.2 speed and torque

```
1  //Example No.  5.2
2  clc;
3  clear;
4  close;
5  format('v',7);
6
7  //Given  Data :
8  Ia=110;//A
9  V=480;//volt
10  Ra=0.2;//ohm
11  p=6;//poles
12  C=864;//conductors
13  fi=0.05;//Wb(flux  per  pole)
14  back_emf=V-(Ia*Ra);//Volt
15  N=back_emf*60*p/C/p/fi;//rpm
16  disp(N,"Speed  in  rpm : ");
17  T=C*p*fi*Ia/2/%pi/p;//N-m
18  disp(T,"Torque  in  N-m : ");
```

Scilab code Exa 5.3 voltage

```
1  //Example No.  5.3
2  clc;
3  clear;
4  close;
5  format('v',7);
```

29

```
6
7  //Given Data :
8  Ia=100; //A
9  V=200; // volt
10 N=600; //rpm
11 Ra=0.05; //ohm
12 Eff=85/100; //
13 Ia1=Ia*Eff; //armature current in separately excited
       dc motor
14 emf=V-Ia*Ra; //V(motoring mode induced emf)
15 N1=500; //rpm(generating mode speed)
16 Gen_emf=emf*N1/N; //V
17 Vo=Gen_emf-Ia1*Ra; //V
18 disp(Vo,"Voltage of source in Volt : ");
```

Scilab code Exa 5.4 speed and resistance

```
1  //Example No. 5.4
2  clc;
3  clear;
4  close;
5  format('v',7);
6
7  //Given Data :
8  Ia1=10; //A
9  V1=200; // volt
10 N1=1800; //rpm
11 Ra=0.6; //ohm
12 Rfield=360; //ohm
13 V2=180; // volt
14 I_line=20; //A
15 // fi2=V2/V1*fi1
16 fi2BYfi1=V2/V1;
17 //Ia1*fi1=Ia2*fi2
18 Ia2=Ia1/fi2BYfi1; //A
```

```
19  Eb1=V1-Ia1*Ra;//V
20  Eb2=V2-Ia2*Ra;//V
21  //Eb1/Eb2=fi1*N1/fi2/N2
22  N2=N1/(Eb1/Eb2*fi2BYfi1);//rpm
23  disp(N2,"Motor speed after supply voltage decreases
        in rpm : ");
24  Ifield=V2/Rfield;//A
25  Ia=I_line-Ifield
26  //V2=Ia*(R+Ra)
27  R=V2/Ia-Ra;//ohm
28  disp(R,"Additional resistance in ohm : ");
```

Scilab code Exa 5.5 braking resistance

```
1   //Example No. 5.5
2   clc;
3   clear;
4   close;
5   format('v',7);
6
7   //Given Data :
8   Ia1=10;//A
9   V1=200;//volt
10  N1=1800;//rpm
11  Ra=0.6;//ohm
12  Rfield=360;//ohm
13  V2=180;//volt
14  I_line=20;//A
15
16  Ia=Ia1-V1/Rfield;//A(At changeover time)
17  emf=V1-Ia*Ra;//volt
18  Ifield=emf/Rfield;//A(At changeover time)
19  Iout=Ia1-Ifield;//A
20  Rbraking=emf/Iout;//ohm(Braking Resistance)
21  disp(Rbraking,"Braking resistance in ohm : ");
```

Scilab code Exa 5.6 Energy Dissipated

```
1  //Example No. 5.6
2  clc;
3  clear;
4  close;
5  format('v',7);
6
7  //Given Data :
8  Ia1=10;//A
9  V1=200;//volt
10 N1=1800;//rpm
11 Ra=0.6;//ohm
12 Rfield=360;//ohm
13 V2=180;//volt
14 I_line=20;//A
15 //Part (a)
16 Ia=Ia1-V1/Rfield;//A(At changeover time)
17 emf=V1-Ia*Ra;//volt
18 Ifield=emf/Rfield;//A(At changeover time)
19 Iout=Ia1-Ifield;//A
20 Rbraking=emf/Iout;//ohm(Braking Resistance)
21
22 I_initial=Iout;//A(Inotial current)
23 t=30;//sec(time taken to stop)
24 I_change_rate=I_initial/t;//A/s
25 //i=I_initial-I_change_rate*t , for 0<t<30(during
       braking time)
26 E_dissipated=integrate('(I_initial^2+(I_initial/30)
       ^2/3*t^2-2*I_initial*I_initial/30*t)*Rbraking','t
       ',0,t);//W-s
27 disp(E_dissipated,"Part(a) Energy dissipated in
       watts-sec : ");
28 //Part (b)
```

```
29  //Rbraking=Rbraking−Rbraking/30∗t;//ohm
30  E=integrate('I_initial^2∗(Rbraking−Rbraking/30∗t)','
       t',0,30);//Watt−sec
31  disp(E,"Part(b) Energy dissipated in watts−sec : ");
32  //calculation of first part is not accurate in the
       book.
```

Scilab code Exa 5.7 Resistance and Breaking Torque

```
1  //Example No. 5.7
2  clc;
3  clear;
4  close;
5  format('v',7);
6
7  //Given Data :
8  I=50;//A
9  V=200;//volt
10  N=1000;//rpm
11  Ra=0.2;//ohm
12  Eb=V-I*Ra;//V
13  Rt=(V+Eb)/2/I;//ohm(Total resistance required)
14  disp(Rt-0.5,"Additional resistance required to limit
        the current in ohm : ");
15  omega_m=N/60*2*%pi;//rad/s
16  T=Eb*2*I/omega_m;//N−m
17  disp(T,"Braking torque in N−m : ");
18  Eb=0;//for speed=0
19  I=V/Rt;//A
20  //T proportional to I(for separately excited motor)
21  T=T*(I/100);//N−m
22  disp(T,"Torque when speed decreased to zero in N−m :
        ");
```

Scilab code Exa 5.8 Speed of Motor

```
1  //Example No. 5.8
2  clc;
3  clear;
4  close;
5  format('v',6);
6
7  //Given Data :
8  Ra=0.2;//ohm
9  Rf=100;//ohm
10 N=500;//rpm
11 Rb=2;//ohm
12 E1=100;//V
13 If1=2;//A
14 If2=2.5;//A
15 If3=3;//A
16 E2=125;//V
17 E3=150;//V
18 //Ib=Rf*If1/2
19 //Ia=If+Ib;//A
20 omega_m=N/60*2*%pi;//rad/s
21 Kefi1=E1/omega_m;
22 Kefi2=E2/omega_m;
23 Kefi3=E3/omega_m;
24 T1=E1/omega_m*51*If1;//N-m
25 T2=E2/omega_m*51*If2;//N-m
26 T3=E3/omega_m*51*If3;//N-m
27 Tload=300;//N-m
28 Kefi=2.36;
29 If=2.482;//A
30 Ia=51*If;//A
31 E=If*Rf/2+Ia*Ra;//V
32 N=E/Kefi;//rad/s
```

34

```
33  N=N*60/2/%pi;//rpm
34  disp(N,"Speed of motor in rpm : ");
```

Scilab code Exa 5.9 Find Resistance to be added

```
 1  //Example No. 5.9
 2  clc;
 3  clear;
 4  close;
 5  format('v',6);
 6
 7  //Given Data :
 8  E1=200;//V
 9  E2=300;//V
10  E3=400;//V
11  E4=500;//V
12  E5=600;//V
13  E6=700;//V
14  Ia1=20;//A
15  Ia2=30;//A
16  Ia3=40;//A
17  Ia4=50;//A
18  Ia5=60;//A
19  Ia6=70;//A
20  Rt=0.6;//ohm
21  Tload=600;//N-m
22  omega_m=Tload*2*%pi/60;//rad/s
23  Kefi1=E1/omega_m;
24  Kefi2=E2/omega_m;
25  Kefi3=E3/omega_m;
26  Kefi4=E4/omega_m;
27  Kefi5=E5/omega_m;
28  Kefi6=E6/omega_m;
29  T1=E1/omega_m*Ia1;//N-m
30  T2=E2/omega_m*Ia2;//N-m
```

```scilab
31  T3=E3/omega_m*Ia3;//N-m
32  T4=E4/omega_m*Ia4;//N-m
33  T5=E5/omega_m*Ia5;//N-m
34  T6=E6/omega_m*Ia6;//N-m
35  subplot(1,2,1);
36  plot([Ia1 Ia2 Ia3 Ia4 Ia5 Ia6],[Kefi1 Kefi2 Kefi3
         Kefi4 Kefi5 Kefi6])
37  title('Ia Vs Kefi');
38  xlabel("Ia(A)");
39  ylabel("Kefi");
40  subplot(1,2,2);
41  plot([Ia1 Ia2 Ia3 Ia4 Ia5 Ia6],[T1 T2 T3 T4 T5 T6])
42  title('Ia Vs T');
43  xlabel("Ia(A)");
44  ylabel("T(N-m)");
45  //From the graph :
46  T=600;//N-m
47  Ia=63;//A
48  Kefi=9.8;
49  E=Kefi*omega_m;//V
50  R=E/Ia;//ohm
51  Rdb=R-Rt
52  disp(Rdb,"Resistance for dynamic braking in ohm : ")
         ;
```

Scilab code Exa 5.10 Speed at Full load and Torque

```scilab
1  //Example No. 5.10
2  clc;
3  clear;
4  close;
5  format('v',7);
6
7  //Given Data :
8  V=240;//V
```

```
9   Ra =0.4; //ohm
10  N1 =600; //rpm
11  Ifl =25; //A
12  Radd =1; //ohm
13  // If1=If2
14  //T1=T2 leads to If1*Ia1=If2*Ia2: Ia1=Ia2
15  Ia1 =25; //A
16  Ia2 =25; //A
17  Eb1=V-Ia1*Ra; //V
18  Eb2=V-Ia2*(Ra+Radd); //V
19  N2=N1*Eb2/Eb1; //rpm
20  disp(N2,"Speed at full load torque in rpm : ");
21  //T3=2*T1
22  // If3=If1
23  Ia3 =2*Ia1; //A
24  Eb3=V-Ia3*(Ra+Radd); //V
25  N3=N1*Eb3/Eb1; //rpm
26  disp(N3,"Speed at twice the full load torque in rpm
        : ");
27  Eb4 =0; //V(at speed zero Eb=0)
28  Ia4=V/(Ra+Radd); //V
29  T4ByT1=Ia4/Ia1; //(field constant)
30  disp("Stalling torque is "+string(T4ByT1)+" times of
        full load torque.");
```

Scilab code Exa 5.11 New Value of Field Current

```
1  //Example No. 5.11
2  clc;
3  clear;
4  close;
5  format('v',5);
6
7  //Given Data :
8  V =250; //V
```

37

```
 9  Ra =1;//ohm
10  Ia1 =25;//A
11  N1 =900;//rpm
12  If =2;//A
13  N2 =1100;//rpm
14  Eb1 =V - Ia1 * Ra;//V
15  // If1 * Ia1=If2 * Ia2
16  // Eb2=V-Ia2 * Ra;//V
17  //-Ia2^2 * Ra+Ia2 * V-Eb1 * Ia1 * N2/N1=0;
18  polynomial =[-Ra V -Eb1 * Ia1 * N2/N1];
19  Ia2 =roots ( polynomial );//A
20  Ia2 =Ia2 (2);//A( wide range not allowed )
21  If2 =Ia1 / Ia2 * If;//A
22  disp (If2 ,"New value of field current in A : ");
```

Scilab code Exa 5.12 Field Current Firing Angle

```
 1  //Example No. 5.12
 2  clc;
 3  clear;
 4  close;
 5  format ('v',6);
 6
 7  //Given Data :
 8  V =230;//V
 9  f =50;//Hz
10  Rf =200;//ohm
11  Ra =0.3;//ohm
12  T =50;//N-m
13  N =900;//rpm
14  Kv =0.8;//V/A-rad/s
15  Kt =0.8;//N-m/A^2
16  Vm =V * sqrt (2);//V
17  Vf =2 * Vm/%pi;//V
18  If =Vf / Rf;//A
```

```
19  disp(If,"Field current in A :");
20  //T=Kt*If*Ia
21  Ia=T/Kt/If;//A
22  omega=N*2*%pi/60;//rad/s
23  Eb=Kv*omega*If;//V
24  Va=Eb+Ia*Ra;//V
25  //Va=Vm/%pi*(1+cosd(alfa_a))
26  alfa_a=acosd(Va/Vm*%pi-1);//degree
27  disp(alfa_a,"Fringe angle of converter in degree : "
       );
28  Pout=Ia*Va;//W
29  Iin=sqrt(2/2/180*Ia^2*integrate('1','omega',alfa_a
       ,180));
30  VAin=V*Iin;//VA
31  pf_in=Pout/VAin;//lagging
32  disp(pf_in,"Power factor of convertyer(lagging) : ")
```

Scilab code Exa 5.13 Torque Developed and Motor Speed

```
1  //Example No. 5.13
2  clc;
3  clear;
4  close;
5  format('v',7);
6
7  //Given Data :
8  V=230;//V
9  f=50;//Hz
10 Rf=200;//ohm
11 Ra=0.25//ohm
12 Kv=1.1;//V/A-rad/s
13 Kt=1.1;//N-m/A^2
14 alfa_a=45;//degree
15 Ia=50;//A
16 alfa_f=0;
```

```
17  Vf=2*V*sqrt(2)/%pi*cosd(alfa_f);//V
18  Va=2*V*sqrt(2)/%pi*cosd(alfa_a);//V
19  If=Vf/Rf;//A
20  T=Kt*Ia*If;//N-m
21  disp(T,"Torque developed in N-m : ");
22  Eb=Va-Ia*Ra-2;//V
23  omega=Eb/Kv/If;//rad/s
24  N=omega*60/2/%pi;//rpm
25  disp(N,"Motor speed in rpm : ");
```

Scilab code Exa 5.14 Firing Angle of Converter

```
1   //Example No. 5.14
2   clc;
3   clear;
4   close;
5   format('v',7);
6
7   //Given Data :
8   V=400;//V
9   Ra=0.3//ohm
10  Rf=250;//ohm
11  Ia=50;//A
12  Kv=1.3;//V/A-rad/s
13  N=1200;//rpm
14  alfa_f=0;
15  Vf=3*sqrt(3)*V*sqrt(2)/sqrt(3)/%pi*cosd(alfa_f);//V
16  If=Vf/Rf;//A
17  Eb=Kv*If*2*%pi*N/60;//V
18  Va=Eb+Ia*Ra;//V
19  alfa_a=acosd(Va/3/sqrt(3)/V/sqrt(2)*sqrt(3)*%pi);//
        degree
20  disp(alfa_a,"Fringe angle of converter in degree : "
        );
```

Scilab code Exa 5.15 Input Power Speed and Torque

```
1  //Example No. 5.15
2  clc;
3  clear;
4  close;
5  format('v',7);
6
7  //Given Data :
8  V=500;//V
9  Ia=200;//A
10 Ra=0.1//ohm
11 Kv=1.4;//V/A-rad/s
12 Kt=1.4;//N-m/A^2
13 If=2;//A
14 cycle=0.5;//sec
15 Pin=cycle*V*Ia/1000;//KW
16 disp(Pin,"Input power in KW : ");
17 Va=cycle*V;//V
18 Eb=Va-Ia*Ra;//V
19 omega=Eb/Kv/2;//rad/s
20 N=omega*60/2/%pi;//rpm
21 disp(N,"Speed in rpm : ");
22 T=Kt*2*Ia;//N-m
23 disp(T,"Torque in N-m : ");
```

Scilab code Exa 5.16 Average Voltage Power and Speed

```
1  //Example No. 5.16
2  clc;
3  clear;
4  close;
```

```
5  format('v',7);
6
7  //Given Data :
8  Ra=0.1//ohm
9  Rb=7.5//ohm
10 Kv=1.4;//V/A-rad/s
11 Ia=120;//A
12 If=1.6;//A
13 cycle=0.35;//sec
14
15 Vavg=Rb*Ia*(1-cycle);//V
16 disp(Vavg,"Average voltage across chopper in volt :
       ");
17 Pb=Ia^2*Rb*(1-cycle)^2;//W
18 disp(Pb,"Power dissipated in watts : ");
19 emf=Vavg+Ra*Ia;//V
20 omega=emf/Kv/If;//rad/s
21 N=omega*60/2/%pi;//rpm
22 disp(N,"Speed in rpm : ");
23 //Answer of Pb & speed is wrong in the book.
```

Scilab code Exa 5.17 Speed Torque Characteristics

```
1  //Example No. 5.17
2  clc;
3  clear;
4  close;
5  format('v',7);
6
7  //Given Data :
8  V=220;//V
9  f=50;//Hz
10 L=0.012;//H
11 Ra=0.72;//ohm
12 K=2;//V/rad/s
```

```
13  T=60; //N−m
14  alfa=90; //degree
15  Va=3*sqrt(3)*V*sqrt(2)/2/%pi*(1+cosd(alfa)); //V
16  Ia=5; //A
17  disp(Ia,"Armature Current in A : ");
18  T1=Ia*K; //N−m
19  disp(T1,"Torque in N−m : ");
20  Eb=Va-Ia*Ra; //V
21  omega=Eb/K; //rad/s
22  N1=omega*60/2/%pi; //rpm
23  disp(N1,"Speed in rpm : ");
24  disp("");
25  Ia=10; //A
26  disp(Ia,"Armature Current in A : ");
27  T2=Ia*K; //N−m
28  disp(T2,"Torque in N−m : ");
29  Eb=Va-Ia*Ra; //V
30  omega=Eb/K; //rad/s
31  N2=omega*60/2/%pi; //rpm
32  disp(N2,"Speed in rpm : ");
33  Ia=20; //A
34  disp(Ia,"Armature Current in A : ");
35  T3=Ia*K; //N−m
36  disp(T3,"Torque in N−m : ");
37  Eb=Va-Ia*Ra; //V
38  omega=Eb/K; //rad/s
39  N3=omega*60/2/%pi; //rpm
40  disp(N3,"Speed in rpm : ");
41  Ia=30; //A
42  disp(Ia,"Armature Current in A : ");
43  T4=Ia*K; //N−m
44  disp(T4,"Torque in N−m : ");
45  Eb=Va-Ia*Ra; //V
46  omega=Eb/K; //rad/s
47  N4=omega*60/2/%pi; //rpm
48  disp(N4,"Speed in rpm : ");
49  plot([T1 T2 T3 T4],[N1 N2 N3 N4]);
50  title('Speed Torque Characteristics');
```

```
51  xlabel('Torque(N-m)');
52  ylabel('speed(RPM)');
```

Scilab code Exa 5.18 No Load Speed and Firing Angle

```
1  //Example No. 5.18
2  clc;
3  clear;
4  close;
5  format('v',6);
6
7  //Given Data :
8  V=400;//V
9  f=50;//Hz
10 I=50;//A
11 Ra=0.1;//ohm
12 K=0.3;//V/rpm
13 Ia=5;//A
14 alfa=30;//degree
15 Vavg=3*sqrt(3)*V*sqrt(2)/sqrt(3)/2/%pi*(1+cosd(alfa)
    );//V
16 Eb=Vavg-Ia*Ra;//V
17 N=Eb/K;//rpm
18 disp(N,"No load speed in rpm : ");
19 Speed=1600;//rpm
20 Eb=Speed*K;//V
21 Vin=Eb+I*Ra;//V
22 alfa=acosd(Vin/3/sqrt(3)/V/sqrt(2)*sqrt(3)*2*%pi-1);
    //degree
23 disp(alfa,"Fringe angle in degree : ");
```

Scilab code Exa 5.19 Power fed back

44

```
1  //Example No. 5.19
2  clc ;
3  clear ;
4  close ;
5  format ('v',7);
6
7  //Given Data :
8  V=230; //V
9  f=50; //Hz
10 Rf=200; //ohm
11 Ra=0.25 //ohm
12 Kv=1.1; //V/A-rad/s
13 Kt=1.1; //N-m/A^2
14 alfa_a=45; //degree
15 Ia=50; //A
16 alfa_f=0;
17 Vf=2*V*sqrt(2)/%pi*cosd(alfa_f); //V
18 Va=2*V*sqrt(2)/%pi*cosd(alfa_a); //V
19 If=Vf/Rf; //A
20 T=Kt*Ia*If; //N-m
21 Eb=Va-Ia*Ra-2; //V
22 omega=Eb/Kv/If; //rad/s
23 Eg=-Eb; //V
24 Va=Eg+Ia*Ra+2; //V
25 alfa=acosd(Va/2/V/sqrt(2)*%pi); //degree
26 disp(alfa,"Fringe angle to converter in degree : ");
27 P=abs(Va)*Ia; //W(power fed back to source)
28 disp(P,"Power fed back to source in Watts : ");
29 //Answer wrong in the book.
```

Scilab code Exa 5.20 Find back emf

```
1  //Example No. 5.20
2  clc ;
3  clear ;
```

```
4 close;
5 format('v',7);
6
7 //Given Data :
8 V=240;//V
9 alfa=100;//degree
10 Ra=6//ohm
11 Ia=1.8;//A
12 Vm=V*sqrt(2);//V
13 Vdc=Vm/%pi*(1+cosd(alfa));//Volt
14 Eb=Vdc-Ia*Ra;//V
15 disp(Eb,"Back emf in volt : ");
```

Scilab code Exa 5.21 Compute Speed and Torque

```
1 0//Example No. 5.21
2 clc;
3 clear;
4 close;
5 format('v',5);
6
7 //Given Data :
8 V1=230;//V
9 N1=1500;//rpm
10 Ra=1;//ohm
11 Ia=10;//A
12 T=5;//N-m
13 //V=K*omega+Ia*Ra
14 K=V1/(N1*2*%pi/60+Ia*Ra);//V-s/rad or N-m/A
15 Ia=T/K;//A
16 alfa1=30;//degree
17 V=2*V1*sqrt(2)/%pi*cosd(alfa1);//Volt
18 omega=(V-Ia*Ra)/K;//rad/s
19 N=omega*60/2/%pi;//rpm
20 disp(N,"Parrt(a) Speed in rpm : ");
```

```
21  alfa =45; // degree
22  N =950; // rpm
23  V =2* V1 * sqrt (2) /%pi * cosd ( alfa ) ; // Volt
24  Ia =(V-K*2*%pi /60* N)/Ra ; // A
25  T=K* Ia ; // N–m
26  disp (T," Part (b) Torque in N–m : ");
27  // Answer is wrong in the book .
```

Scilab code Exa 5.22 RMS current and Power factor

```
1   // Example No . 5.22
2   clc ;
3   clear ;
4   close ;
5   format ('v ' ,6);
6
7   // Given Data :
8   V1 =500; // V
9   N1 =1500; // rpm
10  Ia =100; // A
11  V2 =350; // V
12  Ra =1.1; // ohm
13  alfa =45; // degree
14  N2 =1200; // rpm
15  // V=K*omega+Ia*Ra
16  K =(V1 - Ia * Ra )/( N1 *2*%pi /60) ; // V–s/ rad or N–m/A
17  V =3* sqrt (3) * V2 * sqrt (2) /2/%pi/ sqrt (3) *(1+ cosd ( alfa )) ;
        // Volt
18  Ia =(V-K* N2 *2*%pi /60)/ Ra ; // A
19  disp (Ia ," RMS soirce current in A : ");
20  Vin_rms = Ia * sqrt (120/180) ; // V
21  Iavg = Ia /3; // A
22  disp ( Iavg ," Average thyristor current in A : ");
23  Irms = Ia / sqrt (3); // A
24  disp ( Irms ," RMS thyristor current in A : ");
```

```
25  pf_in=V*Ia/sqrt(3)/V2/Vin_rms;//lagging
26  disp(pf_in,"Input  power  factor)lagging  :  ");
```

Scilab code Exa 5.23 Time taken by the motor

```
1  //Example No.  5.23
2  clc;
3  clear;
4  close;
5  format('v',9);
6
7  //Given  Data :
8  T1=40; //N-m
9  N1=500; //rpm
10  J=0.01; //N-m_sec^2/rad
11  T2=100; //N-m
12  N2=1000; //rpm
13  disp("Te=J*d(omega)/dt+D*omega+TL");
14  d_omegaBYdt=(T2-T1)/J;//
15  //t=omega/d_omegaBYdt+A;
16  omega1=N1*2*%pi/60;//rad/s
17  t=0; //s(initial  time)
18  A=t-omega1/d_omegaBYdt;//
19  omega2=N2*2*%pi/60;//rad/s
20  t=omega2/d_omegaBYdt+A;//s
21  disp(t,"Time  taken  by  the  motor  in  sec  :  ");
```

Scilab code Exa 5.24 Max and Min Armature Current and Excursion

```
1  //Example No.  5.24
2  clc;
3  clear;
4  close;
```

```
5  format ('v',9);
6
7  //Given Data :
8  f=400; //Hz
9  V=200; //V
10 T=30; //N-m
11 N=1000; //rpm
12 R=0.2; //ohm
13 L=2; //mH
14 Kv=1.5; //V-sec/rad
15 Kt=1.5; //N-m/A
16 Ia=T/Kt; //A
17 omega=N*2*%pi/60; //rad/s
18 Eb=Kv*omega; //V
19 alfa=(Eb+Ia*R)/V;
20 T=1/f*1000; //ms
21 Ton=alfa*T; //ms
22 Toff=T-Ton; //ms
23 Imax=V/R*[(1-exp(-alfa*T*10^-3*R/(L*10^-3)))/(1-exp
      (-T*10^-3*R/(L*10^-3)))]-Eb/R; //A
24 disp(Imax,"(a) Maximum motor armature current in A :
      ");
25 Imin=V/R*[(exp(alfa*T*R/L)-1)/(exp(T*R/L)-1)]-Eb/R;
      //A
26 disp(round(Imin),"(a) Minimum motor armature current
      in A : ");
27 Iexc=Imax; //A
28 disp(Iexc,"(b) Excursion of  armature current in A :
      ");
```

Scilab code Exa 5.25 Avg Motor Current and Speed

```
1  //Example No. 5.25
2  clc;
3  clear;
```

```
4 close;
5 format('v',9);
6
7 //Given Data :
8 V=230;//V
9 f=50;//Hz
10 Rf=1.5;//ohm
11 Kt=0.25;//N−m/A
12 T=25;//N−m
13 Kv=0.25;//V−sec/rad
14 Vdc=2*sqrt(2)*V/%pi;//V
15 Em=Vdc;//V
16 Ia=sqrt(T/Kt);//A
17 disp(Ia,"Average motor current in A : ")
18 omega_m=(Em-Ia*Rf)/Kv/Ia;//rad/s
19 N=omega_m*60/2/%pi;//RPM
20 disp(N,"Motor speed in RPM : ");
```

Scilab code Exa 5.26 `Armature current and firing angle`

```
1 //Example No. 5.26
2 clc;
3 clear;
4 close;
5 format('v',9);
6
7 //Given Data :
8 V1=675;//V
9 alfa1=90.5;//degree
10 N1=350;//rpm
11 Ia1=30;//A
12 N2=500;//rpm
13 Rf=0.22;//ohm
14 Ra=0.22;//ohm
15 Ia2=Ia1*N2/N1;//A
```

```
16  disp ( Ia2 ,"Armature  current  of  converter  in  A  :  " ) ;
17  Va1 = V1 * sqrt (2) /% pi *(1+ cosd ( alfa1 ) ) ; //V
18  Eb1 = Va1 - Ia1 *( Ra + Rf ) ; //V
19  // Eb1 / Eb2 = Ia1 * N1 /( Ia2 * N2 )
20  // Eb2 = Va2 - Ia2 *( Ra + Rf )
21  Va2 = Eb1 * Ia2 * N2 /( Ia1 * N1 ) + Ia2 *( Ra + Rf ) ; //V
22  alfa2 = acosd ( Va2 / V1 / sqrt (2) *% pi -1) ; // degree
23  disp ( alfa2 ,"Fringe  angle  of  converter  in  degree  :  " )
        ;
```

Scilab code Exa 5.27 Torque and Armature Current

```
 1  // Example  No.  5.27
 2  clc ;
 3  clear ;
 4  close ;
 5  format ('v' ,9) ;
 6
 7  // Given  Data  :
 8  V1 =230; //V
 9  P =15; // hp
10  N =1500; // rpm
11  V2 =220; //V
12  Ke =0.03; //V/A-s
13  Kt =0.03; //N-m/A^2
14  alfa =45; // degree
15  Vm = V1 * sqrt (2) ; //V
16  omega = N *2*% pi /60; // rad / s
17  T =4* Kt * Vm ^2* cosd ( alfa ) ^2/(% pi ^2*( Ke * omega ) ^2) ; //N-m
18  Ia = sqrt ( T / Kt ) ; //A
19  disp ("part  (a)  :  " ) ;
20  disp (T ,"Torque  in  N-m  :  " ) ;
21  disp ( Ia ,"Armature  current  in  A  :  " ) ;
22  disp ("part  (b)  :  " ) ;
23  Ia = Vm *(1+ cosd ( alfa )) /(% pi *( Ke * omega )) ; //A
```

```
24  T=Kt*Ia^2;//N-m
25  disp(Ia,"Armature current in A : ");
26  disp(T,"Torque in N-m : ");
```

Scilab code Exa 5.28 Motor Current and Torque

```
1  //Example No. 5.28
2  clc;
3  clear;
4  close;
5  format('v',9);
6
7  //Given Data :
8  V1=230;//V
9  N=1000;//rpm
10 P=15;//hp
11 Rt=0.2;//ohm
12 Ke=0.03;//V/A-s
13 Kt=0.03;//N-m/A^2
14 alfa=30;//degree
15 Vm=V1*sqrt(2);//V
16 omega=N*2*%pi/60;//rad/s
17 V=Vm/%pi*(1+cosd(alfa));//V
18 //V=Ke*Ia*omega+Ia*Rt
19 Ia=V/(Ke*omega+Rt);//A
20 disp(Ia,"Motor current in A : ");
21 T=Kt*Ia^2;//N-m
22 disp(T,"Torque in N-m : ");
```

Scilab code Exa 5.29 Firing Angle of Converter

```
1  //Example No. 5.29
2  clc;
```

```
 3  clear;
 4  close;
 5  format('v',9);
 6
 7  //Given Data :
 8  V=220;//V
 9  Vin=230;//V
10  N1=1500;//rpm
11  Ia1=10;//A
12  Ra=3;//ohm
13  N2=600;//rpm
14  E1=V-Ia1*Ra;//V
15  E2=E1*N2/N1;//V
16  Ia2=Ia1/2;//A(because of Tnew=T/2)
17  Vapp=E2+Ia2*Ra;//V
18  alfa=acosd(Vapp*%pi/2/sqrt(2)/Vin);//degree
19  disp(alfa,"Firing angle of converter in degree : ");
```

Scilab code Exa 5.30 `Speed of Motor`

```
 1  //Example No. 5.30
 2  clc;
 3  clear;
 4  close;
 5  format('v',9);
 6
 7  //Given Data :
 8  V=230;//V
 9  N=870;//rpm
10  Ia=100;//A
11  Ra=0.05;//ohm
12  T=400;//N-m
13  E=V-Ia*Ra;//V
14  Vgen=V+Ia*Ra;//V
15  N2=N*Vgen/E;//rpm
```

```
16 disp(N2,"Motor speed in rpm : ");
```

Scilab code Exa 5.31 On time of chopper

```
1  //Example No. 5.31
2  clc;
3  clear;
4  close;
5  format('v',9);
6
7  //Given Data :
8  V=220; //V
9  P=2.2; //KW
10 N1=1000; //rpm
11 Ra=2; //ohm
12 f=250; //Hz
13 alfa=0.9; //cycle
14 N2=1200; //rpm
15 N3=800; //rpm
16 Ia1=P*1000/V; //A
17 Ia2=Ia1*N2/N1; //A
18 Eb2=alfa*V-Ia2*Ra; //V
19 Eb3=Eb2*N3/N2; //V
20 Ia3=Ia1*N3/N1; //A
21 alfa3=(Eb3+Ia3*Ra)/V; //cycle
22 ton=alfa3/f; //sec
23 disp(ton,'On time of chopper in sec : ');
```

Scilab code Exa 5.32 Braking Current and Resistance

```
1  //Example No. 5.32
2  clc;
3  clear;
```

```
 4  close ;
 5  format ( ' v ' , 9 ) ;
 6
 7  // Given Data :
 8  V =230; // V
 9  N1 =1000; // rpm
10  Ia1 =100; // A
11  Ra =0.1; // ohm
12  Rf =0.1; // ohm
13  N2 =800; // rpm
14  Ia2=sqrt (2) * Ia1 ; // A( As T2=2*T1 & T proportional to
        Ia ^2)
15  Eb1=V - Ia1 *( Ra+Rf ) ; // V
16  Eb2=N2 * Ia2 /( N1 * Ia1 ) * Eb1 ; // V
17  // Eb2=Ia2 *( Ra+Rf+Rbraking )
18  Rbraking=Eb2 / Ia2 - Ra - Rf ; // ohm
19  disp ( Rbraking , ' Braking resistance in ohm : ' );
20  Ibraking=Eb2 / Rbraking ; // A
21  disp ( Ibraking , ' Braking current in A : ' );
22  // Braking current is not calculated in the textbook
        but asked in the example .
```

Scilab code Exa 5.33 Torque Speed and PF

```
 1  // Example No . 5.33
 2  clc ;
 3  clear ;
 4  close ;
 5  format ( ' v ' , 9 ) ;
 6
 7  // Given Data :
 8  P =6; // poles
 9  V =220; // V
10  f =50; // Hz
11  Ra =0.2; // ohm
```

```
12  Rf =150; //ohm
13  Z=150; //no. of conductors
14  fi =0.02027; //Wb( flux )
15  alfa=0; //degree
16  alfa_a=45; //degree
17  Ia=25; //A
18  A=2; //
19  T=Z*P*fi*Ia/(2*%pi*A); //N−m
20  disp(T,"Totque in N−m : ");
21  Vm=V*sqrt(2); //V
22  Vdc=2*Vm/%pi*cosd(alfa_a); //V
23  Eb=Vdc - Ia*Ra; //V
24  N=Eb*60*A/(Z*P*fi); //rpm
25  disp(N,"Speed in rpm : ");
26  Pout=Vdc*Ia; //W
27  pf=Pout/V/Ia; //lagging
28  disp(pf,'Lagging power factor : ' );
```

Scilab code Exa 5.34 Find Motor Speed

```
1  //Example No. 5.35
2  clc;
3  clear;
4  close;
5  format('v',9);
6
7  //Given Data :
8  V1=200; //V
9  N1=940; //rpm
10  Ra=0.02; //ohm
11  Ia=100; //A
12  N2=500; //rpm
13  Eb1=V1-Ia*Ra; //V
14  //Eb1/Eb2=N1/N2
15  //Eb2=V2−Ia*Ra; //V
```

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```
16  V2=Eb1*N2/N1+Ia*Ra;//V
17  cycle=V2/V1;
18  disp(cycle,"Duty cycle : ");
```

Scilab code Exa 5.35 Duty Cycle of Chopper

```
1  //Example No. 5.35
2  clc;
3  clear;
4  close;
5  format('v',9);
6
7  //Given Data :
8  V1=200;//V
9  N1=940;//rpm
10 Ra=0.02;//ohm
11 Ia=100;//A
12 N2=500;//rpm
13 Eb1=V1-Ia*Ra;//V
14 //Eb1/Eb2=N1/N2
15 //Eb2=V2-Ia*Ra;//V
16 V2=Eb1*N2/N1+Ia*Ra;//V
17 cycle=V2/V1;
18 disp(cycle,"Duty cycle : ");
```

Scilab code Exa 5.36 Resistance and Braking Torque

```
1  //Example No. 5.36
2  clc;
3  clear;
4  close;
5  format('v',9);
6
```

```
7  //Given Data :
8  V1=220;//V
9  Ra=0.05;//ohm
10  N1=1000;//rpm
11  Ia=100;//A
12  N2=500;//rpm
13  Eb=V1-Ia*Ra;//V
14  Ib=2*Ia;//A
15  Rb=(V1+Eb)/Ib-Ra;//ohm
16  disp(Rb,"Resistance to be added in ohm : ");
17  Tb=Eb/(N1*2*%pi/60)*Ib;//N-m
18  disp(Tb,"Initial braking torque in N-m : ");
19  Eb2=Eb*N2/N1;//V
20  Ib2=(V1+Eb2)/(Ra+Rb);//A
21  Tb2=Eb2/(N2*2*%pi/60)*Ib2;//N-m
22  disp(Tb2,"Initial braking torque in N-m : ");
```

Scilab code Exa 5.37 Find Motor Speed

```
1  //Example No. 5.37
2  clc;
3  clear;
4  close;
5  format('v',9);
6
7  //Given Data :
8  V1=230;//V
9  N1=870;//rpm
10  Ia=100;//A
11  Ra=0.05;//ohm
12  T=400;//N-m
13  Eb=V1-Ia*Ra;//V
14  Vgen=V1+Ia*Ra;//V
15  N2=N1*Vgen/Eb;//rpm
16  disp(N2,"Speed in rpm : ");
```

Scilab code Exa 5.38 Torque Speed and PF

```
1  //Example No. 5.38
2  clc;
3  clear;
4  close;
5  format('v',9);
6
7  //Given Data :
8  P=10;//KW
9  V1=230;//V
10 N1=1200;//rpm
11 Ra=0.5;//ohm
12 Ke=0.182;//V/rpm
13 V2=260;//V
14 alfa=30;//degree
15 Ia=30;//A
16 Vm=V2*sqrt(2);//V
17 Vdc=2*Vm/%pi*cosd(alfa);//V
18 Eb=Vdc-Ia*Ra;//V
19 Kt=Ke*60/2/%pi;//N-m/A
20 T=Kt*Ia;//N-m
21 disp(T,"Torque in N-m : ");
22 N2=Eb/Ke;//rpm
23 disp(N2,"Speed in rpm : ");
24 Pout=Vdc*Ia;//W
25 pf=Pout/V2/Ia;//lagging power factor
26 disp(pf,"Lagging power factor : ");
```

Scilab code Exa 5.39 On Time of chopper

```
1  //Example No. 5.39
2  clc;
3  clear;
4  close;
5  format('v',9);
6
7  //Given Data :
8  P=2.2;//KW
9  V=220;//V
10 N1=1000;//rpm
11 Ra=2;//ohm
12 f=250;//Hz
13 alfa=0.9;//duty cycle
14 N2=1200;//rpm
15 N3=800;//rpm
16 Ia1=P*1000/V;//A
17 Ia2=Ia1*N2/N1;//A
18 Eb1=alfa*V-Ia2*Ra;//V
19 Eb2=Eb1*N3/N2;//V
20 Ia3=Ia1*N3/N1;//A
21 alfa3=(Eb2+Ia3*Ra)/V;//cycle
22 ton=alfa3/f;//sec
23 disp(ton*1000,'On time of chopper in milli seconds :
        ' );
```

Scilab code Exa 5.40 Current Drawn and Resistance

```
1  //Example No. 5.40
2  clc;
3  clear;
4  close;
5  format('v',9);
6
7  //Given Data :
8  V=220;//V
```

```
 9  Eff1 =85/100; // Efficiency
10  Eff2 =80/100; // Efficiency
11  Load =400; //Kg
12  t =2.5; //ms
13  Ra =0.1; //ohm
14  g =9.81; // constant for gravity acceleration
15  Pout = Load*g*t; //W
16  IL = Pout/V/Eff1/Eff2; //A
17  disp(IL,"Current drawn in ohm : ");
18  Eb = V-IL*Ra; //V
19  R =(V+Eb)/IL-Ra; //ohm
20  disp(R,"Resistance to be added in ohm : ");
```

Scilab code Exa 5.41 Find Firing Angle

```
 1  // Example No. 5.41
 2  clc;
 3  clear;
 4  close;
 5  format('v',9);
 6
 7  // Given Data :
 8  V1 =220; //V
 9  N1 =1500; //rpm
10  I =10; //A
11  Ra =3; //ohm
12  V2 =230; //V
13  N2 =600; //rpm
14  Eb1 =V1-I*Ra; //V
15  Eb2 = Eb1*N2/N1; //V
16  Ia =I/2; //A( at half rated torque )
17  Vm =V1*sqrt(2); //V
18  alfa = acosd((Eb2+Ia*Ra)*%pi/2/Vm); // degree
19  disp(alfa,"Firing angle in degree : ");
```

Chapter 6

AC Motor Drives

Scilab code Exa 6.1 Speed and Torque

```
1  //Example No. 6.1
2  clc;
3  clear;
4  close;
5  format('v',7);
6
7  //Given Data :
8  V=400;//volt
9  P=4;//poles
10 f=50;//Hz
11 Pout=10;//hp
12 Pout=Pout*735.5;//W
13 Snl=1/100;//No load Slip
14 Sfl=4/100;//Full load slip
15 Ns=120*f/P;//rpm
16 disp(Ns,"Synchronous speed in rpm : ");
17 N=Ns*(1-Snl);//rpm
18 disp(N,"Speed at no load in rpm : ");
19 N=Ns*(1-Sfl);//rpm
20 disp(N,"Speed at full load in rpm : ");
21 f2=Sfl*f;//Hz
```

```
22  disp(f2,"Frequency of rotor current at full load in
        Hz : ");
23  omega_n=N*2*%pi/60;//rad/s
24  T=Pout/omega_n;//N-m
25  disp(T,"Full load Torque in N-m : ");
26  //Answer of full load speed in the book is wrong.
```

Scilab code Exa 6.2 `Slip Speed Power`

```
1   //Example No. 6.2
2   clc;
3   clear;
4   close;
5   format('v',7);
6
7   //Given Data :
8   P=6;//poles
9   f1=50;//Hz
10  Pg=80;//KW
11  f2=100;//alternation/min
12  f2=f2/60;//Hz
13  Ns=120*f1/P;//rpm
14  Ns=Ns/60;//rps
15  S=f2/f1;//Slip
16  disp(S,"Slip is : ");
17  N=Ns*(1-S);//rps
18  disp(N*60,"Motor speed in rpm : ");
19  Pm=Pg*(1-S);//KW
20  disp(Pm,"Developed mechanical power in KW : ");
21  CuLoss=S*Pg;//KW
22  CuLoss_per_phase=CuLoss/3;//KW
23  disp(CuLoss_per_phase*1000,"Rotor Copper Loss per
        phase in W : ");
24  I2=65;//A
25  r2=CuLoss_per_phase*1000/I2^2;//ohm/phase
```

```
26 disp(r2,"Rotor resistance per phase in ohm : ");
27 T=Pg*1000/2/%pi/Ns;//N-m
28 disp(T,"Torque developed in N-m : ");
```

Scilab code Exa 6.3 Poles Slip and Copper Loss

```
1 //Example No. 6.3
2 clc;
3 clear;
4 close;
5 format('v',7);
6
7 //Given Data :
8 N=288;//rpm
9 f=50;//Hz
10 CuLoss=275;//W
11 Ns=300;//rpm(For S=0.03:0.05)
12 P=120*f/Ns;//poles
13 disp(P,"No. of poles : ");
14 S=(Ns-N)/Ns;//Slip
15 disp(S,"Slip : ");
16 S=2*S;//(as rotor reistance doubled, slip is doubled
       )
17 disp(S,"Slip for full load if rotor resiatance
      doubled : ");
18 //CuLoss=I2^2*r2
19 CuLoss=2*CuLoss;//KW(rotor resiatance doubled &
      current constant)
20 disp(CuLoss,"New value of rotor copper loss in watt
      : ");
```

Scilab code Exa 6.4 Applied voltage and starting current

```
1  //Example No. 6.4
2  clc;
3  clear;
4  close;
5  format('v',6);
6
7  //Given Data :
8  T_directStartBYTfl=1.5;//ratio
9  K=sqrt(T_directStartBYTfl);//Ratio of full load
      torque to starting torque direct starting
10 //Vapplied=1/K*Vline
11 VappliedBYVline=1/K;
12 disp("Applied voltage is "+string(VappliedBYVline)+"
       times of Line voltage.");
13 LineCurrentBYIfl=1/K^2*4;//V
14 disp("Line current at starting is "+string(
     LineCurrentBYIfl)+" times of full load current.")
     ;
```

Scilab code Exa 6.5 Motor current Line Current and Torque Ratio

```
1  //Example No. 6.5
2  clc;
3  clear;
4  close;
5  format('v',6);
6
7  //Given Data :
8  Ist=300;//A
9  X=50/100;//tapping
10 Imotor=X*Ist;//A
11 disp(Imotor,"Motor current in A : ");
12 Iline=X^2*Ist;//A
13 disp(Iline,"Line current in A : ");
14 ratio=X^2;//Ratio of starting Torque 50% tapping to
```

```
     full voltage torque
15 disp(ratio,"Ratio of starting Torque 50% tapping to
     full voltage torque : ");
```

Scilab code Exa 6.6 Braking Current and Torque

```
 1 //Example No. 6.6
 2 clc;
 3 clear;
 4 close;
 5 format('v',6);
 6
 7 //Given Data :
 8 V=400;//volt
 9 P=8;//pole
10 f=50;//Hz
11 r1=1.2;//ohm
12 r2dash=1.2;//ohm
13 x1=2.5;//ohm
14 x2dash=2.5;//ohm
15 N=720;//rpm
16 Ns=120*f/P;//rpm
17 S=(Ns-N)/Ns;//full load slip
18 S2=2-S;//Slip during plugging
19 V1=V/sqrt(3);//V
20 I2dash=V1/sqrt((r1+r2dash/S2)^2+(x1+x2dash)^2);//A(
     Initial braking current)
21 disp(I2dash,"Initial Braking current in A : ");
22 Ifl=V1/sqrt((r1+r2dash/S)^2+(x1+x2dash)^2);//A(Full
     load current)
23 RatioCurrent=I2dash/Ifl;//ratio of initial braking
     current to full load current
24 disp("Braking curent is "+string(RatioCurrent)+"
     times of full  load current.");
25 Tfl=3*Ifl^2*r1/(2*%pi*S*Ns/60);//N-m
```

```
26 T2dash=3*I2dash^2*r2dash/(2*%pi*S2*Ns/60);//N-m(
      initail braking T)
27 disp(T2dash,"Initial Braking torque in N-m : ");
28 RatioT=T2dash/Tfl;//ratio of initial braking Torque
      to full load Torque
29 disp("Braking Torque is "+string(RatioT)+" times of
      full  load Torque.");
30 //Let R be the additional resistance
31 I2dash=2*Ifl;//A
32 //I2dash=V1/sqrt((r1+r2dash/S2+R/S2)^2+(x1+x2dash)
      ^2);//A(Initial braking current)
33 R=(sqrt(V1^2/I2dash^2-(x1+x2dash)^2)-r1-r2dash/S2)*
      S2;//in ohm
34 Ractual=R/2^2;//ohm
35 disp(Ractual,"Actual additional rotor resistance per
       phase in ohm : ");
36 T_braking=3*I2dash^2*(r2dash+R)/(2*%pi*S2*Ns/60);//N
      -m(initail braking T)
37 disp(T_braking,"Braking torque in N-m : ");
38 TbBYTfl=T_braking/T2dash;//ratio
39 disp(TbBYTfl,"Ratio o f braking torque to full load
      torque : ");
```

Scilab code Exa 6.7 `Starting Time and Energy`

```
1 //Example No. 6.7
2 clc;
3 clear;
4 close;
5 format('v',6);
6
7 //Given Data :
8 V=400;//volt
9 P=8;//pole
10 f=50;//Hz
```

```
11  r1 =0.1; //ohm
12  r2dash =0.1; //ohm
13  x1 =0.4; //ohm
14  x2dash =0.4; //ohm
15  J=10; //Kg-mˆ2
16  Sm=r2dash/sqrt(r1ˆ2+(x1+x2dash)ˆ2)
17  Ns=2*f/P; //rps
18  omega_ms =2*%pi*Ns; //rad/s
19  V1=V/sqrt(3); //V
20  Tmax=1.5*V1ˆ2/(2*%pi*Ns)*[1/(r1+sqrt(r2dashˆ2+(2*
        x2dash)ˆ2))]; //N-m
21  tau_m=J*omega_ms/Tmax; //sec
22  ts=tau_m*(1.5*Sm+0.25/Sm); //sec
23  disp(ts,"Starting time in sec : ");
24  E=0.5*J*omega_msˆ2; //Watt-s
25  Etot=2*E; //Watts-s
26  disp(Etot/1000,"Energy dissipated during starting in
        KW-s : ");
27  tb=tau_m*(0.7/Sm+0.334*Sm); //sec
28  disp(tb,"Pluggingfg time in sec : " );
29  E=1.4*J*omega_msˆ2; //Watt-s
30  E=2*E/1000; //KW-s(taking cU loss into account)
31  disp(E,"Energy dissipated during plugging in KW-s :
        ");
```

Scilab code Exa 6.8 Torque Current and Voltage

```
1  //Example No. 6.8
2  clc;
3  clear;
4  close;
5  format('v',6);
6
7  //Given Data :
8  V=400; //volt
```

```
9   P=4;//pole
10  f=50;//Hz
11  r1=0.64;//ohm
12  r2=0.08;//ohm
13  x1=1.1;//ohm
14  x2=0.12;//ohm
15  T1=40;//N-m
16  N=1440;//rpm
17  n=2*f/P;//rps
18  n=n*60;//rpm
19  N1=1300;//rpm
20  Tload=T1*(N1/N)^2;//N-m
21  disp(Tload,"Load torque in N-m : ");
22  S=(n-N1)/n;//slip
23  r2dash=r2*2^2;//ohm
24  x2dash=x2*2^2;//ohm
25  //Tload=3*I2dash^2*r2dash/(2*%pi*S*n/60)
26  I2dash=sqrt(Tload/3/r2dash*(2*%pi*S*n/60));//A
27  I2=2*I2dash;//A
28  disp(I2,"Rotor current in A : ");
29  I1=I2dash;//A
30  V1=I1*(r1+r2dash+r2dash*(1-S)/S+%i*(x1+x2dash));//
        Vplt
31  StatorVoltage=abs(V1)*sqrt(3);//Volt
32  disp(StatorVoltage,"Stator Applied Voltage in V : ")
        ;
```

Scilab code Exa 6.9 Slip for max Torque

```
1  //Example No. 6.9
2  clc;
3  clear;
4  close;
5  format('v',7);
6
```

```
7  //Given Data :
8  V=400;//volt
9  P=4;//pole
10 f=50;//Hz
11 r1=0.64;//ohm
12 r2=0.08;//ohm
13 x1=1.1;//ohm
14 x2=0.12;//ohm
15 T1=40;//N−m
16 N=1440;//rpm
17 N1=1300;//rpm
18 r2dash=r2*2^2;//ohm
19 x2dash=x2*2^2;//ohm
20 S=r2dash/sqrt(r1^2+(x1+x2dash)^2);//slip
21 disp(S,"Slip for maximum torque at 50 Hz : ");
22 V1=V/sqrt(3);//volt/phase
23 ns=2*f/P;//rps
24 Tmax=1.5*V1^2/(2*%pi*ns)*[1/(r1+sqrt(r1^2+(x1+x2dash
       )^2))];//Nm
25 disp(Tmax,"Maximum torque at 50 Hz in N−m : ");
26 n=ns*(1-S);//rps
27 N=n*60;//rpm
28 disp(N,"Speed at 50 Hz in rpm : ");
29 f=25;//Hz
30 x1=x1/2;//ohm
31 x2dash=x2dash/2;//ohm
32 S=r2dash/sqrt(r1^2+(x1+x2dash)^2);//slip
33 disp(S,"Slip for maximum torque at 25 Hz : ");
34 V1=V1/2;//volt/phase
35 ns=2*f/P;//rps
36 Tmax=1.5*V1^2/(2*%pi*ns)*[1/(r1+sqrt(r1^2+(x1+x2dash
       )^2))];//Nm
37 disp(Tmax,"Maximum torque at 25 Hz in N−m : ");
38 n=ns*(1-S);//rps
39 N=n*60;//rpm
40 disp(N,"Speed at 25 Hz in rpm : ");
```

Scilab code Exa 6.10 Starting Torque

```
1  //Example No. 6.10
2  clc;
3  clear;
4  close;
5  format('v',7);
6
7  //Given Data :
8
9
10 V=400;//volt
11 P=4;//pole
12 f=50;//Hz
13 r1=0.64;//ohm
14 r2=0.08;//ohm
15 x1=1.1;//ohm
16 x2=0.12;//ohm
17 T1=40;//N-m
18 N=1440;//rpm
19 N1=1300;//rpm
20 r2dash=r2*2^2;//ohm
21 x2dash=x2*2^2;//ohm
22 S=r2dash/sqrt(r1^2+(x1+x2dash)^2);//slip
23 V1=V/sqrt(3);//volt/phase
24 ns=2*f/P;//rps
25 Tst=3*V1^2*r2dash/(2*%pi*ns*[(r1+r2dash)^2+(x1+
      x2dash)^2]);//N-m
26 disp(Tst,"Starting torque at 50 Hz in N-m : ");
27 f=25;//Hz
28 x1=x1/2;//ohm
29 x2dash=x2dash/2;//ohm
30 V1=V1/2;//volt/phase
31 ns=2*f/P;//rps
```

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```
32 Tst =3* V1 ^2* r2dash /(2*% pi * ns *[( r1 + r2dash ) ^2+( x1 +
      x2dash ) ^2]) ; //N–m
33 disp ( Tst ," Starting torque at 25 Hz in N–m : ") ;
```

Scilab code Exa 6.11 Find Torque

```
1 // Example No. 6.11
2 clc ;
3 clear ;
4 close ;
5 format ('v',7) ;
6
7 // Given Data :
8 V =400; // volt
9 P =4; // pole
10 f =50; // Hz
11 r2dash =1; // ohm / phase
12 // Neglecting r1 , x1 , x2
13 f1 =400; // Hz
14 S =4/100; // Slip
15 t2 =1.5; // ms
16 t2 = t2 *10^ -3; // sec
17 t =1/ f1 ; // sec
18 t1 =t - t2 ; // sec
19 R =2; // ohm ( additional resistance )
20 R2dash =( r2dash * t1 +( r2dash + R ) * t2 ) / t ; // ohm
21 V1 = V / sqrt (3) ; // volt
22 T =3* V1 ^2* S / R2dash ; //N–m
23 disp (T ," Torque in synch . watts : ") ;
```

Scilab code Exa 6.12 Stator Applied Voltage

```
1 // Example No. 6.12
```

```scilab
2  clc;
3  clear;
4  close;
5  format('v',7);
6
7  //Given Data :
8  V1=400;//volt
9  P=4;//pole
10 f=50;//Hz
11 Sm=10/100;//slip
12 S1=0.04;//slip
13 N2=900;//rpm
14
15 //r2dash=0.01*x2;//ohm/phase
16 r2dash=0.01
17 r1dash=0.1
18 Ns=120*f/P;//rpm
19 N1=Ns*(1-S1);//rpm
20 S2=(Ns-N2)/Ns;//slip
21 T2ByT1=(N2/N1)^2;
22 //T=3/(2*%pi*ns)*[V1^2/((rdash/S2)^2+xdash^2)]*(
      rdash/S2)
23 //T2/T1=V2^2/V1^2*S1/S2*[(1+625*r1dash^2)/(1+6.25*
      r1dash^2)]
24 V2=sqrt(T2ByT1*V1^2*S2/S1/[(1+625*r1dash^2)/(1+6.25*
      r1dash^2)]);//volt
25 disp(V2,"Stator applied voltage in volts : ");
```

Scilab code Exa 6.13 Find Torque

```scilab
1  //Example No. 6.13
2  clc;
3  clear;
4  close;
5  format('v',7);
```

```
6
7  // Given  Data :
8  P =4; // pole
9  f =50; // Hz
10 S =4/100; // slip
11 T =1000; // synch . Watts
12 f1 =25; // Hz
13 Tnew = T * f / f1 ; // synch . watts
14 disp ( Tnew ," Torque  in  synch .  Watts  :  ");
```

Scilab code Exa 6.14 Torque Ratio and Current Ratio

```
1  // Example  No.  6.14
2  clc ;
3  clear ;
4  close ;
5  format ( 'v ' ,6) ;
6
7  // Given  Data :
8  P =4; // pole
9  f =50; // Hz
10 r1 =0.04; // ohm
11 r1dash =0.04; // ohm
12 r2dash =0.04; // ohm
13 x1 =0.2; // ohm
14 x2dash =0.2; // ohm
15 f1 =20; // Hz
16 k = f1 / f ; // ratio  of  frequencies
17 Tmax20BYTmax50 =( r1 + sqrt ( r1 ^2+( x1 + x2dash ) ^2) ) /( r1 / k +
       sqrt (( r1 / k ) ^2+( x1 + x2dash ) ^2) ) ;
18 disp ( Tmax20BYTmax50 ," Ratio  of  max  torque  at  20  Hz  to
        max  Torque  at  50  Hz  :  ") ;
19 Tst20BYTst50 =(( r1 + r2dash ) ^2+( x1 + x2dash ) ^2) / k /(( r1 / k +
       r2dash / k ) ^2+( x1 + x2dash ) ^2) ;
20 disp ( Tst20BYTst50 ," Ratio  of  starting  torque  at  20  Hz
```

```
        to starting Torque at 50 Hz : ");
21  //at 20 Hz :
22  x11=x1*f1/f;//ohm
23  x22dash=x2dash*f1/f;//ohm
24  Ir20ByIr50=(f1/f)*[sqrt((r1+r2dash/r1dash)^2+(x1+
       x2dash)^2)]/[sqrt((r1+r2dash/r1dash)^2+(x11+
       x22dash)^2)];
25  disp(Ir20ByIr50,"Ratio of rotor current at 20 Hz to
        rotor current  at 50 Hz : ");
26  //Answer of rotor current ratio is wrong in the book
        .
```

Scilab code Exa 6.15 Find motor speed

```
1  //Example No. 6.15
2  clc;
3  clear;
4  close;
5  format('v',5);
6
7  //Given Data :
8  P=4;//pole
9  f=50;//Hz
10  S=0.04;//slip
11  r1=0.04;//ohm
12  r1dash=0.04;//ohm
13  r2dash=0.04;//ohm
14  x1=0.2;//ohm
15  x2dash=0.2;//ohm
16  f1=30;//Hz
17  k=f1/f;//ratio of frequencies
18  S1=k*S;//slip
19  //For 50 Hz
20  //T=3*V1^2*S*r2dash/(2*%pi*ns)/[(S*r1+r2dash)^2+S
       ^2*(x1+x2dash)^2];
```

```
21  //For 30 Hz
22  //T=3*V1^2/(2*%pi*ns)*S/(0.6*S1)/[(S/0.6+S/0.6/S1)
       ^2+S^2];
23  //0.16445*S1^2-0.74*S1+0.00445=0
24  p=[0.16445 -0.074 0.00445];//polynomial for S1
25  S1=roots(p);
26  S1=S1(2);//as another value is for unstable region
27  Ns=2*f1/P*60;//rpm
28  N=Ns-S1*Ns;//rpm
29  disp(N,"Motor speed at 30 Hz operation in rpm : ");
```

Scilab code Exa 6.16 Average torque and speed

```
1   //Example No. 6.16
2   clc;
3   clear;
4   close;
5   format('v',7);
6
7   //Given Data :
8   P=6;//pole
9   f=50;//Hz
10  S=0.04;//slip
11  Ton=40;//N-m
12  Toff=30;//N-m
13  t_onBYt_off=1;
14  disp("Part(a) : ");
15  Ns=2*f/P*60;//rpm
16  N=Ns*(1-S);//rpm
17  Tavg=(Ton+Toff)/2;//N-m
18  disp(Tavg,"Average torque in N-m : ");
19  Navg=sqrt((N^2)*Tavg/Ton);//rpm
20  disp(Navg,"Average speed in rpm : ");
21  disp("Part(b) : ");
22  N1=800;//rpm
```

```
23  T=Ton*(N1/N)^2;//N-m
24  Tavg=32;//N-m
25  //Tavg=32=(Ton*t_on+T*t_off)/(t_on+t_off);//N-m
26  tonBYtoff=(T-Tavg)/(Tavg-Ton);//
27  disp(tonBYtoff,"Ratio ton/toff is : ");
```

Scilab code Exa 6.17 `Value of Vdc`

```
1  //Example No. 6.17
2  clc;
3  clear;
4  close;
5  format('v',7);
6
7  //Given Data :
8  Vrms=415;//volt
9  f=50;//Hz
10 Vdc=Vrms/sqrt(1/%pi*integrate('1','t',0,2*%pi/3));
11 disp(Vdc,"Value of Vdc in Volts : ");
```

Scilab code Exa 6.18 `Torque and applied voltage`

```
1  //Example No. 6.18
2  clc;
3  clear;
4  close;
5  format('v',6);
6
7  //Given Data :
8  V=400;//volt
9  f=50;//Hz
10 P=4;//poles
11 N1=1350;//rpm
```

```
12  N2 =900; //rpm
13  Rs =1.5; //ohm
14  R=4; //ohm
15  X=4; //ohm
16  ns =2* f/P *60; //rpm
17  S=(ns - N1)/ns; // slip
18  T=3/2/% pi/(ns/60)*[(V/sqrt(3))^2*(P/S)/((Rs+P/S)^2+(
       R+X)^2)]
19  T2=T*(N2/N1)^2; //N–m
20  disp(T2,"Torque at 900 rpm in N–m : ");
21  Snew =(ns - N2)/ns; // slip
22  V=sqrt((T2/3*2*% pi*(ns/60))*((Rs+P/Snew)^2+(R+X)^2)
       /(P/Snew))*sqrt(3)
23  disp(V,"Voltage at speed of 900 rpm in Volts : ");
```

Scilab code Exa 6.19 Torque Speed Current and frequency

```
 1  //Example No. 6.19
 2  clc;
 3  clear;
 4  close;
 5  format('v',7);
 6
 7  //Given Data :
 8  V=415; // volt
 9  P=4; // pole
10  f=50; //Hz
11  N=1370; //rpm
12  r1=2; //ohm
13  r2dash=3; //ohm
14  x1=3.5; //ohm
15  x2dash=3.5; //ohm
16  X0=55; //ohm
17  Ns=120*f/P; //rpm
18  S=(Ns-N)/Ns; // slip
```

```
19  Nfl=Ns-N;//rpm
20  disp("Part(a) : ");
21  disp(Nfl,"Full load slip speed in rpm : ");
22  Z=(r1+%i*x1)+%i*X0*(r2dash/S+%i*x2dash)/(r2dash/S+%i
        *(X0+x2dash));//ohm
23  Istator=V/sqrt(3)/abs(Z);//A
24  disp(Istator,"Stator current in A : ");
25  I2dash=Istator*(%i*X0/(r2dash/S+%i*(X0+x2dash)));//A
26  Tfl=3*abs(I2dash)^2*r2dash/2/%pi/S/(Ns/60);//N–m
27  disp(Tfl,"Motor torque in N–m : ");
28  disp("Part(b) : ");
29  //Torque is equal so stator current will be same.
30  disp(Istator,"Stator current in A : ");
31  N=1200;//rpm
32  Ns=N+Nfl;//rpm
33  f_inv=4*Ns/120;//Hz
34  disp(f_inv,"Inverter frequency in Hz : ");
```

Scilab code Exa 6.20 Find Motor Speed

```
1  //Example No. 6.20(page no. 196)
2  clc;
3  clear;
4  close;
5  format('v',7);
6
7  //Given Data :
8  Is=6;//A
9  f=40;//Hz
10  SlipSpeed=100;//rpm
11  V=415;//volt
12  P=4;//pole
13  r1=2;//ohm
14  r2dash=3;//ohm
15  x1=3.5;//ohm
```

```
16  x2dash =3.5; //ohm
17  X0 =55; //ohm
18  N=1370; //rpm
19  Ns =120*50/P; //rpm
20  S=(Ns-N)/Ns; //slip
21  I2dash=Is*X0/abs(r2dash/S+%i*(X0+x2dash)); //A
22  disp(I2dash,"Rotor current in Ampere : ");
23  T=3*I2dash^2*r2dash/(2*%pi*S*(Ns/60)); //N-m
24  disp(T,"Full   load torque in N-m : ");
25  Ns2 =120*f/P; //rpm
26  MotorSpeed=Ns2-SlipSpeed; //rpm
27  disp(MotorSpeed,"Motor speed in rpm : ");
```

Scilab code Exa 6.20.1 Find Maximum Torque

```
1  //Example No. 6.20(page no. 205)
2  clc;
3  clear;
4  close;
5  format('v',8);
6
7  //Given Data :
8  Pout =2500; //hp
9  V=2300; //volt
10  P=20; //pole
11  f=50; //Hz
12  Xs =1.77; //ohm/phase
13  Pout=Pout*735.5/1000; //KW
14  V=V/sqrt(3); //Volt/phase
15  cos_theta=1;
16  I=Pout*10^3/3/V/cos_theta; //A
17  Ixs=I*Xs; //V
18  E=sqrt(V^2+Ixs^2); //V
19  Pout_max=3*V*E/Xs/1000; //KW
20  Tmax=Pout_max*1000; //synch. Watts
```

```
21  ns=2*f/P; //rps
22  Tmax=Pout_max*1000/2/%pi/ns; //N–m
23  disp(Tmax,"Maximum torque in N–m : ");
```

Scilab code Exa 6.21 Power Output Torque and Speed

```
1   //Example No. 6.21
2   clc;
3   clear;
4   close;
5   format('v',9);
6
7   //Given Data :
8   Pout=2500; //hp
9   V1=2300; //volt
10  P=20; //pole
11  f=50; //Hz
12  Xs=1.77; //ohm/phase
13  Pout=Pout*735.5/1000; //KW
14  V=V1/sqrt(3); //Volt/phase
15  cos_theta=1;
16  I=Pout*10^3/3/V/cos_theta; //A
17  Ixs=I*Xs; //V
18  E=sqrt(V^2+Ixs^2); //V
19  del=acosd(V/E); //degree
20  Pout=3*V*E/Xs*cosd(del); //W
21  disp(Pout,"Part(a) Power output in W : ");
22  T=Pout; //synch. Watts
23  N=300; //rpm
24  ns=N/60; //rps
25  T=T/2/%pi/ns; //N–m
26  disp(T,"Part(a) Torque in N–m :");
27  f1=25; //Hz
28  N1=2*f1/P*60; //rpm
29  disp(N1,"Part(b) Speed in rpm : ");
```

```
30  T=T*(N1/N)^2;//N−m
31  disp(T,"Part(b) Torque in N−m : ");
32  Vapplied=V1*f1/f;// Volts
33  disp(Vapplied,"Part(b) Applied voltage in volts : ")
      ;
34  Pout=T*2*%pi*N1/60;//W
35  disp(Pout/1000,"Part(b) Power output in KW : ");
```