Scilab Textbook Companion for Elements of Electric Drives by J. B. Gupta, R. Manglik & R. Manglik[1]

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Book Description

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

Exa Example (Solved example)

Eqn Equation (Particular equation of the above book)

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

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

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Chapter 1

Electric Drives

Scilab code Exa 1.1 Compare the annual cost of a group drive and an individual drive

```scilab
1 //Exa:1.1
2 clc;
3 clear;
4 close;
5 C_g=60000;//in Rs
6 D=0.12*C_g;//in Rs
7 E_c=75000;//in kWh
8 C_e=4*E_c;//in Rs
9 C_t=D+C_e;//in Rs
10 C_id=18750*10;//in Rs
11 AD=0.15*C_id;//in Rs
12 E_a=60000;//in kWh
13 C_ea=4*E_a;//in Rs
14 C_total=AD+C_ea;//in Rs
15 disp(C_t,'Total annual cost in case of group drive (
      in Rs)=');
16 disp(C_total,'Total annual cost in case of
      individual drive (in Rs)=');
```

Scilab code Exa 1.2 Find the value of stable operating point

```
1  //Exam:1.2
2  clc;
3  clear;
4  close;
5  a=1;
6  b=1;
7  c=-30;
8  w_m=(-b+sqrt((b^2)-4*a*c))/(2*a);//speed of the
       drive
9  t_l=0.5*(w_m^2);//motoring torqe
10 disp(t_l,w_m,'stable operating point=');
```

Scilab code Exa 1.3 Find the value of moment of inertia and power developed

```
1  //Exam:1.2
2  clc;
3  clear;
4  close;
5  J_m=0.4;//motor inertia(in Kg-m2)
6  J_l=10;//load inertia(in Kg-m2)
7  a=0.1;//Teeth ratio of gear
8  i=1/a;
9  N=1400;
10 pi=22/7;
11 n=0.90;//efficency of motor
12 T_l=50;//Torque(N-m)
13 J=J_m+J_l/(i^2);//Total moment of inertia referred
       to the motor shaft
```

9

```
14  T_L=T_l/(i*n);//total equivalent torque referref to
       motor shaft
15  P=T_L*2*pi*N/60;//power developed by motor
16  disp(ceil(P),'power developed by motor(in Watt)=');
```

Scilab code Exa 1.4 Find the value of moment of inertia and power developed

```
1  //Exam:1.4
2  clc;
3  clear;
4  close;
5  J_m=0.4;//motor inertia(in Kg-m2)
6  J_l=10;//load inertia(in Kg-m2)
7  a=0.1;//Teeth ratio of gear
8  N=1500;
9  pi=22/7;
10  n_t=0.88;
11  m=600;//weight
12  g=9.81;
13  f_r=m*g;//force
14  w_m=fix(2*pi*N/60);//motor speed
15  w=2;//uniform speed of weight lifting
16  n=0.9;//efficency of motor
17  T_l=50;//Torque(N-m)
18  J=J_m+(a^2)*J_l+m*((w/w_m)^2);//Total moment of
       inertia referred to the motor shaft
19  T_L=(a*T_l/n)+f_r*w/(n_t*w_m) ;//total equivalent
       torque referred to motor shaft
20  p=T_L*w_m;//power developed by motor(in Watt)
21  P=p/1000;//power developed by motor(in kWatt)
22  disp(J,'Total torque referred to motor shaft(in kg-
       m2)=')
23  disp(T_L,'Total equivalent Torque referred to motor
       shaft(in N-m)=')
```

```
24 disp(P,'power developed by motor(in kWatt)=')
```

Scilab code Exa 1.5 Find the value of motor speed

```
1  //Exa:1.5
2  clc;
3  clear;
4  close;
5  V=220;//in volts
6  V_1=200;//in volts
7  N=1000;//in rpm
8  I=100;//in amperes
9  R_a=0.1;//in ohms
10 E_b=V-I*R_a;//in volts
11 I_1=I;//in amperes
12 E_b1=V_1-I_1*R_a;//in volts
13 N_1=N*E_b1/E_b;
14 disp(ceil(N_1),'Motor Speed (in rpm)=')
```

Scilab code Exa 1.6 Find the value of full load speed and full load torque

```
1  //Exa:1.6
2  clc;
3  clear;
4  close;
5  V=230;//in volts
6  R_sh=230;//in ohms
7  R_a=0.5;//in ohms
8  I_sh=V/R_sh;//in amperes
9  I_lo=3;//in amperes
10 I_ao=I_lo-I_sh;//in amperes
11 E_bo=V-I_ao*R_a;//in volts
12 N_o=1000;//in rpm
```

```
13  I_lf =23; //in amperes
14  I_af = I_lf - I_sh; //in amperes
15  E_bf = V - I_af * R_a; //in volts
16  Phy_ratio =0.98;
17  N_f = N_o *( E_bf / E_bo )/ Phy_ratio ;
18  disp ( ceil ( N_f ) , 'Full Load Speed (in rpm )=');
19  T_f =9.55* E_bf * I_af / N_f ;
20  disp ( T_f , 'Full load Torque (in Newton-meter )=');
```

Scilab code Exa 1.7 Find the value of armature voltage drop at full load

```
 1  //Exa:1.7
 2  clc ;
 3  clear ;
 4  close ;
 5  V =440; //in volts
 6  N_o =2000; //in rpm
 7  E_bo =440; //in volts
 8  N_f =1000; //in rpm
 9  N_h =1050; //in rpm
10  E_bf = E_bo * N_f / N_o //in volts
11  E_b = E_bo * N_h / N_o ; //in volts
12  v =( E_b - E_bf )*2;
13  disp ( v , 'Armature voltage drop at full load (in volts
        )=')
```

Scilab code Exa 1.8 Find the value of speed

```
 1  //Exa:1.8
 2  clc ;
 3  clear ;
 4  close ;
 5  V =230; //in volts
```

```
 6  N1 =750; // in  rpm
 7  R =10; // in  ohms
 8  I_a =30; // in  amperes
 9  N2 = N1 *(( V+I_a * R )/ V )^-1;
10  disp ( int ( N2 ) , 'Speed  ( in  rpm )= ')
```

Scilab code Exa 1.9 Find the value of speed

```
 1  // Exa :1.9
 2  clc ;
 3  clear ;
 4  close ;
 5  V =200; // in  volts
 6  I_1 =20 // in  amperes
 7  R_a =0.5; // in  ohms
 8  E_b1 =V - I_1 * R_a ; // in  volts
 9  N1 =700; // in  rpm
10  I_2 = sqrt (1.44) * I_1 ; // in  amperes
11  E_b2 =V - I_2 * R_a ; // in  volts
12  N2 = N1 *( E_b2 / E_b1 ) *( I_1 / I_2 );
13  disp ( int ( N2 ) , '(a)  Speed  ( in  rpm )= ');
14  I_3 =10; // in  amperes
15  E_b3 =V - I_3 * R_a ; // in  volts
16  N3 = N1 *( E_b3 / E_b1 ) *( I_1 / I_3 );
17  disp ( ceil ( N3 ) , '(b)  Speed  ( in  rpm )= ');
```

Scilab code Exa 1.10 Find the Value of speed and torque

```
 1  // Exa :1.10
 2  clc ;
 3  clear ;
 4  close ;
 5  V =230; // in  volts
```

```
6  I_1=90;//in amperes
7  R_a=0.08;//in ohms
8  R_se=0.05;//in ohms
9  R_m=R_a+R_se;//in ohms
10 R=1.5;//in ohms
11 E_b1=V-I_1*(R_m+R);//in volts
12 E_2=180;//in volts
13 N2=700;//in rpm
14 N1=N2*(E_b1/E_2);
15 disp(ceil(N1),'Speed (in rpm)=');
16 T=9.55*E_b1*I_1/N1;
17 disp(T,'Torque (in Newton-meter)=')
```

Scilab code Exa 1.12 Find the Value of torque developed and terminal voltage

```
1  //Exa:1.12
2  clc;
3  clear;
4  close;
5  P=4;//no. of poles
6  f=50;//in hertz
7  N_s=120*f/P;//in rpm
8  V=400/sqrt(3);//in volts
9  R2=4;//in ohms
10 R1=1.5;//in ohms
11 X1=4;//in ohms
12 X2=4;//in ohms
13 N=1350;//in rpm
14 s=(N_s-N)/N_s;//slip
15 T=(3*V^2*4/s)/(((R1+(R2/s))^2)+((X1+X2)^2))*(2*%pi*
      N_s/60));//in newton-meter
16 N1=900;//in rpm
17 s1=(N_s-N1)/N_s;//slip
18 T1=T*(N1/N)^2;
```

```
19  disp(T1, ' Torque developed (in Newton-meter)=');
20  V1=V*sqrt((N1/N)^2*(s1/s)*((((R1+(R2/s1))^2)+((X1+X2
        )^2)))/(((R1+(R2/s))^2)+((X1+X2)^2)));
21  disp(V1, 'Terminal Voltage (in volts)=');
22  //Answer given in the textbook is worng as the
        torque equation is not multiplied by R2
23  disp('Answer given in the textbook is worng as the
        torque equation is not multiplied by R2')
```

Scilab code Exa 1.13 Find the Value of rms voltage

```
1   //Exa:1.13
2   clc;
3   clear;
4   close;
5   P=4;//no. of poles
6   f=50;//in hertz
7   N_s=120*f/P;//in rpm
8   s_f=0.05;//slip
9   N=N_s*(1-s_f);//in rpm
10  V=415;//in volts
11  s_m=0.1;//slip corresponding to maximum slip
12  N1=1350;//in rpm
13  s_fn=(N_s-N1)/N_s;//full load slip
14  V1=V*sqrt((N1/N)*(s_f/s_m)*(8/5));
15  disp(V1, ' RMS Voltage (in volts)=')
```

Scilab code Exa 1.14 Find the Value of Slip Frequency

```
1   //Exa:1.14
2   clc;
3   clear;
4   close;
```

```
5  f1 =2; //in  hertz
6  f =50; //in  hertz
7  s_m =0.1;
8  V =400; //in  volts
9  s1 =0.04; //slip
10 s2 =(0.2095 - sqrt ((0.2095)^2-s1))/2;
11 f_n = s2 *40;
12 disp ( f_n ,'Slip  Frequency  (in  Hertz )=')
```

Scilab code Exa 1.15 Find the Value of maximum torque at one half load and 25Hz frequency

```
1  //Exa:1.15
2  clc ;
3  clear ;
4  close ;
5  R1 =0.02; //in  ohms
6  X1 =0.1; //in  ohms
7  X2 = X1 ; //in  ohms
8  //T_ratio  is  defined  as  the  ratio  of  maximum  torque
       at  one−half  load  and  25Hz  frequency  to  maximum
       torque  at  rated  voltage  and  frequency
9  T_ratio =(R1+ sqrt (R1^2+(X1+X2)^2))/(2*(R1+ sqrt (R1
       ^2+((X1+X2)^2)/4)));
10 disp (T_ratio ,'   maximum  torque  at  one−half  load  and
        25Hz  frequency  =');
11 disp ('   times  the  maximum  torque  at  rated  voltage
       and  frequency  (T_max)');
```

Scilab code Exa 1.16 Find the value of starting torque and slip and ratio of maximum torque to full load torque

```
1  //Exa:1.16
```

```
2 clc;
3 clear;
4 close;
5 s_f=0.04;//full load slip
6 I_ratio=6;//Ratio of Starting current to full load
      current
7 T_ratio=I_ratio^2*s_f;//Ratio of Starting torque to
      full load torque
8 disp(T_ratio,'(a) Starting Torque =');
9 disp('   times the full load torque (T_f)');
10 s_max=sqrt((I_ratio^2-1)/(625-I_ratio^2));
11 disp(s_max,'(b) Slip at which Maximum torque occurs=
      ');
12 T_rm=(1/2)*((s_f/s_max)+(s_max/s_f));
13 disp(T_rm,'(c) Ratio of maximum torque to full load
      torque=');
```

Scilab code Exa 1.17 Find the value of starting torque

```
1 //Exa:1.17
2 clc;
3 clear;
4 close;
5 I_ratio=8;//Ratio of short circuit current to full
      load current
6 s_f=0.04;//full load slip
7 T_r1=I_ratio^2*s_f;
8 disp(T_r1,'(a) Sarting Torque when started by means
      of direct switching=');
9 disp('   times the full load torque');
10 T_r2=I_ratio^2*s_f/3;
11 disp(T_r2,'(b) Sarting Torque when started by star-
      delta starter=');
12 disp('   times the full load torque');
13 K=sqrt(3/8);// transformation ratio of transformer
```

```
14  T_st=K^2*I_ratio^2*s_f;
15  disp(T_st,'(C) Starting Torque =');
16  disp('    times the full load torque');
```

Scilab code Exa 1.18 Find the value of ratio of starting current to full load current

```
1  //Exa:1.18
2  clc;
3  clear;
4  close;
5  P=10*7355;//in watts
6  V=400;//in volts
7  pf=0.8//power factor
8  Eff=0.9;//efficiency in per unit
9  I_f=P/(sqrt(3)*V*pf*Eff);//in amperes
10 I_sc=7.2;//in amperes
11 I_sc1=I_sc*400/160;//in amperes
12 I_st=I_sc1/3;//Starting current (in amperes)
13 I_r=I_st/I_f;
14 disp(I_r,'Ratio of starting current to full load
      current=')
```

Scilab code Exa 1.19 Find the value of Tap Position of auto transformer and Ratio of Starting torque to full load torque

```
1  //Exa:1.19
2  clc;
3  clear;
4  close;
5  P_o=50*1000;//in VA
6  s_f=0.05;//slip
7  V=400;//in volts
```

```
8  I_f=P_o/(sqrt(3)*V);//in amperes
9  Z=0.866;//in ohms/phase
10 I_sc=V/(sqrt(3)*Z);//Short Circuit current (in
      amperes)
11 I_st=100;//Supply current at start (in amperes)
12 K=sqrt(I_st/I_sc);
13 disp(K*100,'Tap Position of auto transformer(in %)='
      );
14 I_ratio=I_sc/I_f;
15 T_r=K^2*I_ratio^2*s_f;
16 disp(T_r,'Ratio of Starting torque to full load
      torque =');
```

Scilab code Exa 1.20 Find the value of Starting Current of motor and Starting torque at 50 hertz and 10 hertz

```
1  //Exa:1.20
2  clc;
3  clear;
4  close;
5  V=440/sqrt(3);//in volts
6  R_s=2;//in ohms
7  R_r=2;//in ohms
8  f=50;//in hertz
9  X_s=3;//in ohms
10 P=4;//no. of poles
11 X_r=3;//in ohms
12 R_o1=R_s+R_r;//Equivalent resistance of motor as
      referred to stator (in ohms)
13 X_o1=X_s+X_r;////Equivalent reactance of motor as
      referred to stator (in ohms)
14 I_st=V/(sqrt(R_o1^2+X_o1^2));//Starting current (in
      amperes)
15 P_cu=3*I_st^2*R_r;//Copper loss (in watts)
16 P2=7446;//in watts
```

```
17  N_s =120* f /P ;// Synchronous Speed ( in rpm)
18  T_st =9.55* P2/ N_s ;// Starting Torque ( in Newton−meter )
19  disp ( I_st , ' Starting Current of motor at 50 Hertz ( in
        amperes )=' ) ;
20  disp ( T_st , ' Starting Torque of motor at 50 hertz ( in
        Newton−meters )=' ) ;
21  V1=V*10/50;// in volts
22  X_o2 = X_o1 *10/50;// in ohms
23  I_st1 = V1 /( sqrt ( R_o1 ^2+ X_o2 ^2) ) ;// Starting current (
        in amperes )
24  P_2 =3* I_st1 ^2* R_r ;// Copper loss ( in watts )
25  N_s1 =120*10/ P ;// Synchronous Speed ( in rpm)
26  T_st2 =9.55* P_2/ N_s1 ;// Starting Torque ( in Newton−
        meter )
27  disp ( I_st1 , ' Starting Current of motor at 10 Hertz (
        in amperes )=' ) ;
28  disp ( T_st2 , ' Starting Torque of motor at 10 hertz ( in
        Newton−meters )=' ) ;
```

Scilab code Exa 1.21 Find the value of moment of inertia of drive

```
1  // Exa : 1.21
2  clc ;
3  clear ;
4  close ;
5  T_m =100;// Motor Torque ( in Newton−meter )
6  T_l =30;// Load Torque ( in Newton−meter )
7  alpha =2*% pi *10;// in angular acceleration ( in rad/ sec
        ^2)
8  J=( T_m - T_l )/ alpha ;
9  disp (J , ' Moment of inertia of drive ( in Kg−m^2) ' )
```

Scilab code Exa 1.22 Find the value of Time in attaining full load speed

```
1  //Exa:1.22
2  clc;
3  clear;
4  close;
5  P_o=37.5*1000;//in watts
6  N=500;//in rpm
7  T_l=P_o*60/(2*%pi*N);//Full load   torque (in Newton-
       meter)
8  T_st=(1.1+1.4)*T_l/2;// Average Starting Torque (in
       Newton-meters)
9  T_a=T_st-T_l;//total available torque for
       acceleration
10 J=20;//Moment of Inertia (in Kg-m^2)
11 t1=J*2*%pi*N/(60*T_a);
12 disp(t1,'Time in attaining full load speed (in
       seconds)=')
```

Scilab code Exa 1.23 Find the value of starting period

```
1  //Exa:1.23
2  clc;
3  clear;
4  close;
5  P_o=37.5*1000;//in watts
6  N=500;//in rpm
7  T_l=P_o*60/(2*%pi*N);//Full load   torque (in Newton-
       meter)
8  T_m=2*T_l;// Torque developed by motor during
       starting
9  T_a=T_m-T_l;//total available torque for
       acceleration
10 E=37.5*660*9.81;//Stored energy of machine
11 J=E*2/(2*%pi*N/60)^2;//Moment of inertia (in Kg-m^2)
12 alpha=T_a/J;//angular acceleration (in rad/sec^2)
13 t=(2*%pi*N/60)/alpha;
```

```
14 disp ( t , 'Starting Period (in seconds )=')
```

Scilab code Exa 1.24 Find the value of energy dissipated

```
1 //Exa:1.24
2 clc ;
3 clear ;
4 close ;
5 V=220;//in volts
6 I=20;//in ampers
7 R=1;//in ohms
8 P_o=V*I-I^2*R;//Motor Output (in watts)
9 w=200;//in radians/second
10 T_l=P_o/w;//Load Torque (in N-m)
11 J=5;//kg-m^2
12 t_st=2.5;//in seconds
13 alpha=w/t_st;//angular acceleration (in rad/second
     ^2)
14 K=(J*alpha+T_l)/I^2;
15 W_st=(J*R*w/K)+(T_l*R*t_st/K);
16 disp(W_st,'Energy Dissipated (in watts)=')
```

Scilab code Exa 1.25 Find the value of additional resistance

```
1 //Exa:1.25
2 clc ;
3 clear ;
4 close ;
5 I_l1=22;//in amperes
6 V=220;//in volts
7 R_sh=100;//in ohms
8 R_a=0.1;//in ohms
9 I_sh=V/R_sh;//in amperes
```

```
10  I_a1=I_l1-I_sh;//armatur current (in amperes)
11  E_b1=V-I_a1*R_a;//Back Emf (in volts)
12  N1=1000;//in rpm
13  I_a2=0.8*19.8;//in amperes
14  R=(218.416-(800*218.02/1000))/I_a2;
15  disp(R,'Value of additional resistance (in ohms)=');
16  I_a3=0.64*I_a1;//in amperes
17  R3=(218.7328-(800*218.02/1000))/I_a3;
18  disp(R3,'Value of additional resistance (in ohms)=')
        ;
```

Scilab code Exa 1.26 Find the value of additional resistance

```
1  //Exa:1.26
2  clc;
3  clear;
4  close;
5  I_1=50;//in amperes
6  V=500;//in volts
7  N_ratio=0.5;//Speed Ratio
8  E_b1=V;//Back Emf (in volts)
9  T_ratio=N_ratio^3;//Torque ratio
10 I_2=I_1*sqrt(T_ratio);//in amperes
11 R=(E_b1-(I_2*N_ratio*E_b1/I_1))/I_2;
12 disp(R,'Value of additional resistance (in ohms)=');
```

Scilab code Exa 1.27 Find the value of diverter resistance

```
1  //Exa:1.27
2  clc;
3  clear;
4  close;
5  N_ratio=1.2;//Speed Ratio
```

```
6  //From  Saturation  Curve
7  I_ratio=0.65;//feild  current  ratio  corresponding  to
       83.3%  of  full  load  value  of  flux  to  65%  of  full
       load  value  of  flux
8  I_a_ratio=N_ratio;//Armature  current  ratio
       corresponding  to  83.3%  of  full  load  value  of  flux
        to  65%  of  full  load  value  of  flux
9  R_ratio=I_ratio/(I_a_ratio-I_ratio);
10  disp(R_ratio,'Value  of  Diverter  resistance  (in  ohms)
       =');
11  disp('    times  the  Series  Feild  Resistance  (R_se)')
```

Scilab code Exa 1.28 Find the value of Armature Current at 1000 rpm

```
1  //Exa:1.28
2  clc;
3  clear;
4  close;
5  I_ab=800;//Armature  current  (in  amperes)
6  N1=1000;//in  rpm
7  N2=500;//in  rpm
8  I=I_ab*N1/N2;
9  disp(I,'  Armature  Current  at  1000  rpm  (in  amperes)='
       )
```

Scilab code Exa 1.29 Find the value of additional resistance

```
1  //Exa:1.29
2  clc;
3  clear;
4  close;
5  f=50;//in  hertz
6  P=4;//No.of  poles
```

```
7  N_s=120*f/P;//Synchronous Speed (in rpm)
8  N=1440;//Full load speed (in rpm)
9  s1=(N_s-N)/N_s;//Full load Slip
10 N2=1200;//in rpm
11 s2=(N_s-N2)/N_s;//slip
12 R2=0.25;//ohms per phase
13 R=(s2*R2/s1)-R2;
14 disp(R,'Value of additional resistance (in ohms)=');
```

Scilab code Exa 1.30 Find the value of frequecncy of rotor currents and slip

```
1  //Exa:1.30
2  clc;
3  clear;
4  close;
5  f=50;//in hertz
6  P1=6;//No. of poles
7  P2=4;//No.of poles
8  N_sc=120*f/(P1+P2);//Synchronous Speed (in rpm)
9  s=0.02;//slip
10 N=N_sc*(1-s);//Actual Speed (in rpm)
11 N_s=120*f/P1;//Synchronous Speed of 6-pole motor
12 s1=(N_s-N)/N_s;
13 f1=s1*f;
14 disp(f1,'Frequency of rotor current of 6-pole motor
      (in Hertz)=');
15 disp(s1,'Slip reffered to 6-pole stator feild=');
16 N_s2=120*f1/P2;//Synchronous Speed of 4-pole motor
17 s2=(N_s2-N)/N_s2;
18 f2=s2*f1;
19 disp(f2,'Frequency of rotor current of 4-pole motor
      (in Hertz)=');
20 disp(s2,'Slip reffered to 4-pole stator feild=');
```

Scilab code Exa 1.31 Find the value of available speed and maximum load delievered and ratio of mechanical power

```
1  //Exa:1.31
2  clc;
3  clear;
4  close;
5  f=50;//in hertz
6  P1=6;//No. of poles
7  P2=4;//No.of poles
8  N_s1=120*f/P1;//Synchronous Speed of 6-pole motor
9  N_s2=120*f/P2;//Synchronous Speed of 4-pole motor
10 N_sc1=120*f/(P1+P2);//Concantenated Speed of set
      when cumulatively compounded (in rpm)
11 N_sc2=120*f/(P1-P2);//Concantenated Speed of set
      when differentially compounded (in rpm)
12 disp(' Available Speeds (in rpm) are :');
13 disp(N_s1,'');
14 disp(N_s2,'');
15 disp(N_sc1,'');
16 disp(N_sc2,'');
17 P_o=15;//in HP
18 disp(P_o,'Maximum Load which can be delievered (in
      HP)=');
19 r=P1/P2;
20 disp(r,'Ratio of Mechanical Power Output')
```

Scilab code Exa 1.32 Find the value of Resistance to be added to each slip ring

```
1  //Exa:1.32
2  clc;
```

```
3  clear;
4  close;
5  f=50;//in hertz
6  V=440;//in volts
7  P_o=110*1000;//in watts
8  P=24;//No.Of Poles
9  N_s=120*f/P;//Synchronous Speed (in rpm)
10 N=245;//in rpm
11 s_f=(N_s-N)/N_s;//Full load Speed
12 T_f=P_o/(2*%pi*N/60);//Full load Torque (in N–m)
13 R=0.04;//in ohms
14 R2=R/2;//Rotor resistance per phase (in ohms)
15 K=1.25;// ratio of stator turns to rotor turns
16 R_2=R2*K^2;//Rotor resistance reffered to stator (in
       ohms)
17 X_2=sqrt(((V^2*R_2*1.2/(T_f*500*%pi))-R_2^2)*(1/R2)
       ^2);//in ohms
18 s=(N_s-175)/N_s;//slip at 175 rpm
19 T=T_f*175^2/N^2;//Torque at 175 rpm (in N–m)
20 b=-(V^2*s*60/(T*2*%pi*N_s));
21 a=1;
22 c=(s*X_2)^2;
23 R_n=(-b+sqrt(b^2-4*a*c))/(2*a)
24 R_ext=(R_n-R_2)/K^2;
25 disp(R_ext,'Resistance to be added to each slip ring
       (in ohms)=')
```

Scilab code Exa 1.33 Find the value of Value of external resistance and initial braking torque and Braking Torque when speed reduced to 500 rpm

```
1  //Exa:1.33
2  clc;
3  clear;
4  close;
5  I_f=100;//in amperes
```

27

```
6  V=220;//in volts
7  N=1000;//in rpm
8  T_f=V*I_f/(2*%pi*N/60);//Full load torque (N–m)
9  E_bf=V;//Back emf (in volts)
10 V_a=V+E_bf;// Voltage across armature (in volts)
11 I_b=2*I_f;//braking current
12 R=(V_a/I_b);//in ohms
13 disp(R,'Value of external resistance (in ohms)=');
14 T_b=T_f*I_b/I_f;
15 disp(T_b,'Initial Braking Torque (in N–m)=');
16 E_b1=E_bf*500/N;//in volts
17 I_b1=(V+E_b1)/R;//in amperes
18 T_b1=T_f*I_b1/I_f;
19 disp(T_b1,'Braking Torque when speed reduced to 500
      rpm (in N–m)=');
```

Scilab code Exa 1.34 Find the value of resistance and breaking torque

```
1  //Exa:1.34
2  clc;
3  clear;
4  close;
5  P_o=17.6*1000;//in watts
6  Eff=0.8;//Efficiency
7  V=220;//in volts
8  I_f=P_o/(V*Eff);//in amperes
9  I_af=I_f;//in amperes
10 R_a=0.1;//in ohms
11 N=1200;//in rpm
12 T_f=P_o/(2*%pi*N/60);//Full load torque (N–m)
13 E_bf=V-I_af*R_a;//Back emf (in volts)
14 V_a=V+E_bf;// Voltage across armature (in volts)
15 I_b=2*I_f;//braking current
16 R=(V_a/I_b)-R_a;//in ohms
17 disp(R,'Value of external resistance (in ohms)=');
```

```
18  E_b1=E_bf*400/N; //in volts
19  I_b1=(V+E_b1)/(R+R_a); //in amperes
20  T_b1=T_f*I_b1/I_f;
21  disp(T_b1,'Braking Torque when speed reduced to 400
      rpm (in N-m)=');
```

Scilab code Exa 1.35 Find the value of Value of external resistance and Braking Torque when speed reduced to 400 rpm

```
1  //Exa:1.35
2  clc;
3  clear;
4  close;
5  V=220; //in volts
6  P_o=400*9.81*2.5; //(in watts)
7  Eff=0.85; //efficiency of motor
8  Eff_h=0.8
9  P_in=P_o/(Eff*Eff_h); //in watts
10  I=P_in/V; //in amperes
11  disp(I,'Current Drawn (in amperes)=');
12  P_out=P_o*Eff*Eff_h; //in watts
13  R=V^2/P_out;
14  disp(R,'Value of additional resistance (in ohms)=')
```

Scilab code Exa 1.36 Find the value of Current Drawn and Value of additional resistance

```
1  //Exa:1.36
2  clc;
3  clear;
4  close;
5  T=245; //in N-m
6  N=250; //in rpm
```

```
 7  P_in=T*2*%pi*N/60;//in watts
 8  //Corresponding to the value of P_in we found I=27.5
       A and E=233 V from the given curve shown in fig
       .1.102
 9  E=233;//in volts
10  I=27.5;//in amperes
11  r=E/I;//resistance of the circuit
12  R=r-1;//External Resistance to be inserted (in ohms)
13  disp(R,'External Resistance to be inserted (in ohms)
       =')
```

Scilab code Exa 1.37 Find the value of speed under regenerative braking plugging and dynamic braking

```
 1  //Exa:1.37
 2  clc;
 3  clear;
 4  close;
 5  P_o=45*1000;//in watts
 6  R_a=0.2;//in ohms
 7  V=500;//in volts
 8  Eff=0.9;//Efficiency
 9  I_lf=P_o/(V*Eff);//Rated Line current (in amperes)
10  R_sh=200;//in ohms
11  I_sh=V/R_sh;//Shunt feild Current (in amperes)
12  I_af=I_lf-I_sh;//Armature current on full load (in
       Amperes)
13  E_f=V-I_af*R_a;//emf induced (in volts)
14  N_f=600;//in rpm
15  E1=V+I_af*R_a;//in volts
16  N1=E1*N_f/E_f;
17  disp(N1,'Speed under regenerative braking(in rpm)=')
       ;
18  E2=I_af*(5.5+R_a)-V;//in volts
19  N2=E2*N_f/E_f;
```

```
20  disp(N2,'Speed under plugging (in rpm)=');
21  E3=I_af*(2.6+R_a);//in volts
22  N3=E3*N_f/E_f;
23  disp(N3,'Speed under dynamic braking(in rpm)=');
```

Scilab code Exa 1.38 Find the value of speed

```
1   //Exa:1.38
2   clc;
3   clear;
4   close;
5   V=230;//in volts
6   I_a=100;//in amperes
7   R_a=0.05;//in ohms
8   E_b=V-I_a*R_a;//in volts
9   N=870;//in rpm
10  T=E_b*I_a/(2*%pi*N/60);//torque developed (in N-m)
11  T_l=400;//in N-m
12  I_an=I_a*T_l/T;//in amperes
13  E=V+I_an*R_a;//in volts
14  N1=N*E/230;
15  disp(N1,'Speed (in rpm)=')
```

Scilab code Exa 1.39 Find the reduction in flux and motor speed

```
1   //Exa:1.39
2   clc;
3   clear;
4   close;
5   I_a1=100;//in Amperes
6   V=230;//in volts
7   R_a=0.1;//in ohms
8   E_b1=V-I_a1*R_a;//in volts
```

```
 9  N1=500;//in rpm
10  N2=800;//in rpm
11  x=(V-sqrt((V^2)-4*10*352))/(2*10);
12  disp('Flux is reduced by');
13  disp(x^-1,);
14  disp('times to get motor speed of 800 rpm');
15  I_a2=I_a1*x;//in amperes
16  E_b2=V-I_a2*R_a;//in volts
17  T_2=E_b2*I_a2*60/(2*%pi*N2);//in N-m
18  T_3=800;//in N-m
19  I_a3=I_a2*T_3/T_2;//in Amperes
20  E_b3=V+I_a3*R_a;//in amperes
21  N3=E_b3*N2/E_b2;
22  disp(ceil(N3),'Speed (in rpm)=');
```

Scilab code Exa 1.40 Find the value of plugging torque

```
 1  //Exa:1.40
 2  clc;
 3  clear;
 4  close;
 5  f=50;//in hertz
 6  P=4;//Number of poles
 7  N_s=120*f/P;//Synchronous Speed (in rpm)
 8  s_f=0.05;//Full load Slip
 9  N_f=N_s*(1-s_f);//Full load speed (in rpm)
10  P_d=30*1000;//in watts
11  T_f=P_d/(2*%pi*N_f/60);//In N-m
12  s_2=2-s_f;//Slip at plugging
13  T_p=(s_2/s_f)*T_f*(1+16*s_f^2)/(1+16*s_2^2);
14  disp(T_p,'Plugging Torque (in N-m)=')
```

Scilab code Exa 1.41 Find the value of initial braking torque in case of plugging and dc dynamic braking

```
1  //Exa:1.41
2  clc;
3  clear;
4  close;
5  R2=0.5;//in ohms
6  X2=2.4;//in ohms
7  a=0.5;//ratio
8  s_f=0.05;//slip
9  f=50;//in hertz
10 P=8;//Number of Poles
11 R_2=R2*a^2;//in ohms
12 X_2=X2*a^2;//in ohms
13 s=2-s_f;//Slip during Plugging
14 N_s=120*f/P;//in rpm
15 V=400/sqrt(3);//in volts
16 R_L=2;//in ohms
17 R_1=0.1;//in ohms
18 X_1=0.6;//in ohms
19 I_2=V/sqrt(((R_1+(R_2+R_L)/s)^2)+(X_1+X_2)^2);//in
       amperes
20 T_b=3*60*I_2^2*(R_2+R_L)/(2*%pi*N_s*s);
21 disp(int(T_b),'Initial Braking Torque (in N-m)=');
22 E_2=V*sqrt(((R_2/s_f)^2+(X_2^2))/(((R_2/s_f)+R_1)^2)
       +1.2^2)/sqrt(3);
23 S=1-s_f;//Slip during breaking
24 I_2b=E_2/sqrt((X_2^2)+((R_L+R_2)/S)^2);
25 T_bn=3*60*I_2b^2*(R_2+R_L)/(2*%pi*N_s*S);
26 disp(T_bn,'Initial Braking Torque during dc dynamic
       braking(in N-m)=');
```

Scilab code Exa 1.42 Find the value of time taken and number of revolutions in case of plugging and rheostatic braking

```
1  //Exa:1.42
2  clc;
3  clear;
4  close;
5  J=630;//in kg-m^2
6  T_f=1.4*9.81;//in N-m
7  T_e=165*9.81;//in N-m
8  T_b=T_e+T_f;//in N-m
9  Beta=T_b/J;//in rad/sec^2
10 f=50;//in hertz
11 P=8;//no of poles
12 N_s=120*f/P;//in rpm
13 w_1=2*%pi*N_s/60;//in rad/sec
14 t=w_1/Beta;
15 disp(t,'Time taken to stop the motor (in seconds)=')
      ;
16 n=w_1^2/(2*%pi*Beta*2);
17 disp(n,'Number of revolutions made=');
```

Scilab code Exa 1.43 Find the value of time taken and number of revolutions

```
1  //Exa:1.43
2  clc;
3  clear;
4  close;
5  P_o=37.5*1000;//in Watts
6  N=750;//in rpm
7  Eff=0.9;//Efficiency
8  V_L=400;//in Volts
9  pf=0.85;//Power Factor
10 R_b=2.5;//in ohms
11 T_f=P_o*60/(2*%pi*N);//in N-m
12 I_L=P_o/(sqrt(3)*V_L*pf*Eff);//in Amperes
13 I_b=V_L/(sqrt(3)*R_b);//in Amperes
```

```
14  T_E=T_f*I_b/I_L;//in N−m
15  T_i_total=T_f+T_E;//in N−m
16  w=2*%pi*N/60;//in rad/sec
17  K=T_E/w;
18  J=20;//kg−m^2
19  t=(J/K)*log((T_f+K*w)/T_f);
20  disp(t,'Time taken (in Seconds)=');
21  n=(1/(2*%pi*K))*(((J/K)*(T_f+K*w)*(1-exp(-K*t/J)))-
       T_f*t);
22  disp(n,'Number of Revolutions Made=')
```

Scilab code Exa 1.44 Find the value of time taken

```
1  //Exa:1.44
2  clc;
3  clear;
4  close;
5  E=240;//in volts
6  R=15;//in ohms
7  N=1500;//in rpm
8  P=E^2/R;//in Watts
9  T_b=P*60/(2*%pi*N);//in N−m
10 T_e=T_b;
11 w_1=2*%pi*N/60;//in rad/sec
12 K=T_e/w_1;
13 J=20;//kg−m^2
14 t=(J/K)*log(w_1/62.832);
15 disp(t,'Time taken to bring motor from 1500 rpm to
       600 rpm (in seconds)=');
16 T_f=1.5*9.81;//in N−m
17 t_o=(J/K)*log((T_f+T_e)/(T_f+(T_e*600/1500)));
18 disp(t_o,'Time taken for fall of speed if there
       exist frictional torque (in seconds)=');
```

Scilab code Exa 1.45 Find the value of final temperature rise and heating time constant

```
1  //Exa:1.45
2  clc;
3  clear;
4  close;
5  d=0.65;//in meters
6  l=1;//in meters
7  P_o=12*735.5;//in watts
8  Eff=0.9;//Efficiency
9  P_in=P_o/Eff;//in watts
10 P_L=P_in-P_o;//in watts
11 m=400;//in kg
12 C_p=700;//in J/Kg/Celcius
13 alpha=12;//in watts/m^2/Celcius
14 S=%pi*d*l;//in m^2
15 Theta=P_L/(S*alpha);//in Celcius
16 t=m*C_p/(S*alpha);
17 disp(Theta,'Final temperatur rise (in degree celcius
      )=');
18 disp(ceil(t),'Heating time constant (in seconds)=');
```

Scilab code Exa 1.47 Find the value of heating time constant and final steady temperature rise and one hour rating of motor

```
1  //Exa:1.47
2  clc;
3  clear;
4  close;
5  theta_1=20;//in degree celcius
6  theta_2=34;//in degree celcius
```

```
7  t=-1/log((theta_2/theta_1)-1);//in hours
8  disp(t,'Heating time constant (in hours)=');
9  theta_F=theta_1/(1-exp(-1/t));
10 disp(theta_F,'Final steady temperature rise (in
      degree celcius)=');
11 theta_f=theta_F/(1-exp(-1/t));
12 x=sqrt(2*(theta_f/theta_F)-1);
13 disp('one hour rating of motor is');
14 disp(x,'times full load rating');
```

Scilab code Exa 1.48 Find the half hour rating of the motor

```
1  //Exa:1.48
2  clc;
3  clear;
4  close;
5  P=25;//in KW
6  t=1.5;//in hours
7  P_L=sqrt(((((1/(1-exp(-0.5/t)))*1.9)-0.9)*P^2);
8  disp(P_L,'Half hour rating of a 25KW Motor (in KW)='
      )
```

Scilab code Exa 1.49 Find the running time of the motor

```
1  //Exa:1.49
2  clc;
3  clear;
4  close;
5  t=60;//in minutes
6  theta_F=20;//in degree celcius
7  P_L1=2.5625;//Total losses at P KW
8  P_L2=7.25;//Total losses at 2P KW
9  theta_f=theta_F*P_L2/P_L1;//in degree celcius
```

```
10  t_o=t*log(1/(1-(theta_F/theta_f)));
11  disp(t_o,'Time of operation (in minutes)=');
```

Scilab code Exa 1.51 Find out the continuous rating of the motor

```
1  //Exa:1.51
2  clc;
3  clear;
4  close;
5  Eff=0.8;//Efficiency
6  P1=400;//in watts
7  t1=60;//in minutes
8  t2=15;//in minutes
9  P=sqrt(((((2.5625/(1-exp(-t2/t1)))-1)^(-1))*(P1/Eff)
      ^2);
10  disp(P,'Continuous Rating of Motor (in Watts)=');
```

Scilab code Exa 1.52 Find the value of temperature rise and maximum
steady state temperature rise and time taken for increase in temperature

```
1  //Exa:1.52
2  clc;
3  clear;
4  close;
5  theta_1=50;//in degree Celcius
6  theta_F=80;//in degree celcius
7  t=0.75;//in hours
8  theta=theta_F*(1-exp(-1/t));
9  disp(theta_F,'Temperature rise after 1 hour (in
      degree celcius)=');
10  theta_f=theta_F/(1-exp(-1/t));
11  disp(theta_f,'Steady state temperature rise at 1
      hour rating (in degree celcius)=');
```

```
12  T=-t*log(1-(theta_1/theta_f));
13  disp(60-T*60,'Time taken to increase temperature
        from 50 to 80 degree celcius (in minutes)=');
```

Scilab code Exa 1.53 Find the value of load

```
1  //Exa:1.53
2  clc;
3  clear;
4  P_cont=100;//in KWs
5  Eff=0.8;//Efficiency
6  T_1=50;//in minutes
7  T_2=70;//in minutes
8  t_1=10;//in minutes
9  t_2=10;//in minutes
10 r=(1-exp(-((t_1/T_1)+(t_2/T_2))))/(1-exp(-t_1/T_1));
       // r=theta_f/theta_F
11 P_L=2.5625;//Losses at 100 KW Load
12 P_L1=Eff*P_cont;//in Kws
13 P=sqrt(((P_L*r)-1)*P_L1^2);
14 disp(P,'Value of Load in KW during load period=');
```

Scilab code Exa 1.54 Find the value of final temperature rise and heating time constant

```
1  //Exa:1.54
2  clc;
3  clear;
4  close;
5  theta_1=20;//in degree celcius
6  theta_2=30;//in degree celcius
7  t_1=30;//in minutes
8  t_2=60;//in minutes
```

```
 9 t=-(t_2-t_1)/log((theta_2/theta_1)-1);//in minutes
10 theta_F=theta_1/(1-exp(-t_1/t));
11 disp(t,'Heating Time Contant (in minutes)=');
12 disp(theta_F,'Final Temperature Rise (in Degree
      Celcius)=');
```

Scilab code Exa 1.55 Find the value of maximum overload

```
 1 //Exa:1.55
 2 clc;
 3 clear;
 4 close;
 5 theta_1=30;//in degree celcius
 6 theta_2=40;//in degree celcius
 7 t_1=1;//in hours
 8 t_2=2;//in hours
 9 x=(theta_2/theta_1)-1;
10 theta_F=theta_1/(1-x);//in degree celcius
11 theta_f=50/(1-x);//in degree celcius
12 P_L=25;//in KWs
13 P=P_L*sqrt(theta_f/theta_F);
14 disp(P,'Maximum Overload (in KWs)=')
```

Scilab code Exa 1.56 Find the value of temperature rise

```
 1 //Exa:1.56
 2 clc;
 3 clear;
 4 close;
 5 theta_1=20;//in degree celcius
 6 theta_2=35;//in degree celcius
 7 t_1=1/2;//in hours
 8 t_2=1;//in hours
```

```
9  t=-(t_2-t_1)/log((theta_2/theta_1)-1);//in minutes
10 theta_F=theta_1/(1-exp(-t_1/t));
11 theta=theta_F*(1-exp(-2/t));
12 disp(theta,'Temperature Rise After 2 hrs (in Degree
      Celcius)=');
13 theta_F1=theta_F*0.8;//in Degree Celcius
14 t_o=0.8*t;//in hours
15 theta_o=theta_F1*(1-exp(-1/t_o));
16 disp(theta_o,'Temperature Rise from cold After 1 hr
      at full load (in Degree Celcius)=');
```

Scilab code Exa 1.57 Determine the suitable size of continuously rated motor

```
1  //Exa:1.57
2  clc;
3  clear;
4  close;
5  P_1=100;//in KWs
6  P_2=50;//in KWs
7  t_1=10;//in minutes
8  t_2=8;//in minutes
9  t_3=5;//in minutes
10 t_4=4;//in minutes
11 P=sqrt(((t_1*P_1^2)+(t_2*P_2^2))/(t_1+t_2+t_3+t_4));
12 disp(P,'Rating Of Continuously Rated Motor (in KWs)=
      ');
13 disp('Adequate rating of motor=70 Kws');
```

Scilab code Exa 1.58 Find the power rating of the motor

```
1  //Exa:1.58
2  clc;
```

```
 3  clear;
 4  close;
 5  T_1=240;//in N_m
 6  T_2=140;//in N-m
 7  T_3=300;//in N-m
 8  T_4=200;//in N-m
 9  t_1=20;//in minutes
10  t_2=10;//in minutes
11  t_3=10;//in minutes
12  t_4=20;//in minutes
13  T=sqrt(((t_1*T_1^2)+(t_2*T_2^2)+(t_3*T_3^2)+(t_4*T_4
      ^2))/(t_1+t_2+t_3+t_4));
14  N=720;//in rpm
15  P=T*2*%pi*N/60;
16  disp(P,'Power rating of Motor(in KWs)=');
```

Scilab code Exa 1.59 Determine the kW rating of the motor

```
 1  //Exa:1.59
 2  clc;
 3  clear;
 4  close;
 5  t=90;//in seconds
 6  T_eq=sqrt(40750/t);//in Kg-m
 7  N=750;//in rpm
 8  P=T_eq*9.81*2*%pi*N/60;
 9  disp(P,'Power Rating Of Motor (in Kws)=');
```

Scilab code Exa 1.61 Find the value of speed at the end of deceleration period

```
 1  //Exa:1.61
 2  clc;
```

```scilab
3 clear;
4 close;
5 T_l=100*9.81;//in N-m
6 t=10;//in seconds
7 J=1000;//kg-m^2
8 f=50;//in hertz
9 P=4;//no.of poles
10 N_s=120*f/P;//synchronous speed (in rpm);
11 s=0.06;//slip
12 w_s=s*N_s*2*%pi/60;//slip speed (in rad/sec)
13 K=w_s/(50*9.81);
14 T_m=T_l-T_l*exp(-t/(K*J));
15 N_sn=K*T_m*60/(2*%pi);//in rpm
16 N=N_s-N_sn;
17 disp(N,'Speed at the end of deceleration period (in
    rpm)=')
```

Scilab code Exa 1.62 Determine the value of inertia of the flywheel

```scilab
1 //Exa:1.62
2 clc;
3 clear;
4 close;
5 P_o=500*735.5;//in watts
6 N_o=40;//in rpm
7 s_f=0.12;
8 N_f=N_o*(1-s_f);//full load speed (in rpm)
9 T_f=P_o/(2*%pi*N_f/60);//Full load torque (N-m)
10 T_m=2*T_f;//Motor torque (in N-m)
11 T_l=41500*9.81;//Load torque (in N-m)
12 t=10;//seconds
13 w_s=s_f*N_o*2*%pi/60;//slip speed (in rad/sec)
14 K=w_s/T_f;
15 J=-t/(K*log(1-(T_m/T_l)));
16 disp(J,'Moment of Inertia (in Kg-m^2)=')
```

Scilab code Exa 1.63 Find the value of weight of flywheel and time taken

```
1  //Exa:1.63
2  clc;
3  clear;
4  close;
5  P_o=50*1000;//in watts
6  f=50;//in hertz
7  s_f=0.04;//slip
8  P=6;//no.of poles
9  N_s=120*f/P;//Synchronous Speed (in rpm)
10 N_f=N_s*(1-s_f);
11 T_f=P_o/(2*%pi*N_f)
```

Scilab code Exa 1.64 Find the value of moment of inertia

```
1  //Exa:1.64
2  clc;
3  clear;
4  close;
5  T_L=600;//in N-m
6  T_m=450;//in N-m
7  N=600;//in rpm
8  w_o=2*%pi*N/60;//in rad/sec
9  s=0.08;//slip
10 w=s*w_o;//in rad/sec
11 K=w/T_m;//Torque constant
12 J=(-10/K)/log(0.25);//in Kg-m^2
13 J_m=10;//in Kg-m^2
14 J_F=J-J_m;
15 disp(J_F,'Moment Of Inertia Of Flywheel (in Kg-m^2)=
        ');
```

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Scilab code Exa 1.65 Find the value of moment of inertia

```
1 //Exa:1.45
2 clc;
3 clear;
4 close;
```

Chapter 3

Thyristor Control Of Electric Motors

Scilab code Exa 3.1 Find the efficiency and form factor and ripple factor and transformer utilisation factor and peak inverse voltage of thyristor

```
1  //Exa:3.1
2  clc;
3  clear;
4  close;
5  V=120;//in Volts
6  V_dc=40.5;//in volts
7  V_rms=76.1;//in volts
8  R=10;//in ohms
9  I_dc=V_dc/R;//in Amperes
10 I_rms=V_rms/R;//in Amperes
11 P_dc=V_dc*I_dc;//in watts
12 P_ac=V_rms*I_rms;//in watts
13 Eff=P_dc/P_ac;//in per unit
14 disp(Eff,'(a) Efficiency (in Per Unit=)');
15 K_f=V_rms/V_dc;//in per unit
16 disp(K_f,'(b) Form Factor (in Per Unit=)');
17 Y=sqrt(K_f^2-1);
18 disp(Y,'(c) Ripple Factor (in Per Unit=)');
```

```
19  T_f = P_dc /( V * I_rms );
20  disp ( T_f , '(d)  Transformer  Utilisation  Factor=');
21  P_iv = sqrt (2)* V ;
22  disp ( P_iv , '(e)  Peak  Inverse  Voltage  (in  volts )=')
```

Scilab code Exa 3.2 Find the value of feild current and firing angle and input power factor

```
1  // Exa :3.2
2  clc ;
3  clear ;
4  close ;
5  alpha_f =0;
6  R_f =250; // in  ohms
7  K_f =0.8; // torque  constant
8  R_a =0.2; // in  ohms
9  V_const =0.8; // in  volt / Amperes−radian / sec
10  N =1000; //  in  rpm
11  T_d =50; // In  Newton−meter
12  V_rms =220; // in  volts
13  V_f = int ( V_rms * sqrt (2)*(1+ cosd ( alpha_f ))/% pi ); //
       Feild  Circuit  Voltage  (in  volts )
14  I_f = V_f / R_f ; // in  Amperes
15  disp ( I_f , '(a)  Feild  Current  (in  Amperes )=');
16  I_a = T_d /( K_f * I_f ); // in  amperes
17  w =2* N *% pi /60; //  in  radian / sec
18  E_b = V_const * w * I_f ; // Back  emf  (in  volts )
19  V_a = E_b +( I_a * R_a ); // armature  voltage  (in  volts )
20  alpha_a = acosd ((( V_a *% pi /( V_rms * sqrt (2))))-1);
21  disp ( alpha_a , '(b)  Firing  angle  of  the  converter  (in
       degrees )=');
22  P_o = int ( V_a * I_a ); // in  watts
23  I =52.66; // in  amperes
24  pf = P_o /( V_rms * I );
25  disp ( pf , '(c)  Power  factor  of  the  converter=')
```

Scilab code Exa 3.3 Find the value of speed of motor and motor torque

```scilab
1  //Exa:3.3
2  clc;
3  clear;
4  close;
5  alpha_a=45;//in degrees
6  V=230;//in volts
7  K=1.668;//K_a*Phy (in volt/radian/second)
8  R_a=0.2;//in ohms
9  I_a=30;//in amperes
10 V_a=2*V*sqrt(2)*cosd(alpha_a)/%pi;//in volts
11 E_b=V_a-(I_a*R_a);// in volts
12 w=E_b/K;//in radian/seconds
13 N=ceil(w*60/(2*%pi));
14 disp(N,'(a) Speed Of Motor (in rpm)=')
15 T=K*I_a;
16 disp(T,'(b) Motor Torque (in Newton-meter)=')
```

Scilab code Exa 3.4 Find the value of firing angle

```scilab
1  //Exa:3.4
2  clc;
3  clear;
4  close;
5  R_a=0.06;//in ohms
6  N1=875;// in rpm
7  N2=750;//in rpm
8  V_rms=220;//in volts
9  V_dc=200;//in volts
10 I_a=150;//in amperes
```

```
11  E_b1=V_dc-(I_a*R_a);//Back emf (in volts)
12  E_b2=E_b1*(N2/N1);// in volts
13  V_a=E_b2+(I_a*R_a);//armature voltage (in volts)
14  alpha_a=acosd((V_a*%pi/(2*V_rms*sqrt(2))));
15  disp(alpha_a,'Firing angle (in degrees)=');
```

Scilab code Exa 3.5 Find the value of average load voltage and load current and input paower factor

```
1   //Exa:3.5
2   clc;
3   clear;
4   close;
5   alpha=30;//in degrees
6   V=230;//in volts
7   R=2;//in ohms
8   V_avg=2*V*sqrt(2)*cosd(alpha)/%pi;//in volts
9   I_avg=V_avg/R;//in amperes
10  disp(V_avg,'(a) Average Load Voltage (in Volts)=');
11  disp(I_avg,'(b) Average Load Current (in Amperes)=')
12  I_rms=I_avg;//in amperes (as ripple free)
13  P=V_avg*I_avg;//in watts
14  Q=2*V*sqrt(2)*I_avg*sind(alpha)/%pi;// in VAR
15  pf=cosd(atand(Q/P));
16  disp(pf,'(c) Input Power Factor (lagging)=')
```

Scilab code Exa 3.6 Find the value of motor armature current and motor speed

```
1   //Exa:3.6
2   clc;
3   clear;
4   close;
```

```
5  alpha=60;//in  degrees
6  V=250;//in  volts
7  T=140;//in  Newton-Meter
8  K_a=2.5;//motor  voltage  constant  (in  Volt/radian/sec
        )
9  R_a=0.2;//in  ohms
10  V_a=2*V*sqrt(2)*cosd(alpha)/%pi;//in  volts
11  I_a=T/K_a;//in  amperes
12  disp(I_a,'(a)  Motor  Armature  Current  (in  amperes)=')
        ;
13  E_b=V_a-(I_a*R_a);//in  volts
14  w=E_b*I_a/T;
15  disp(w,'(b)  Motor  Speed  (in  radian/sec)=')
```

Scilab code Exa 3.7 Find the value of firing angle

```
1  //Exa:3.7
2  clc;
3  clear;
4  close;
5  V_dc=220;//in  volts
6  V=230;//in  volts
7  I_a1=10;//in  amperes
8  N1=1500;//in  rpm
9  N2=500;//in  rpm
10  N3=-1000;//in  rpm
11  R_a=2;//in  ohms
12  E_b1=V_dc-(I_a1*R_a);//in  volts
13  E_b2=E_b1*(N2/N1);//in  volts
14  I_a2=I_a1/2;//in  amperes
15  V_a1=E_b2+(I_a2*R_a);//in  volts
16  alpha_a1=acosd((V_a1*%pi/(2*V*sqrt(2))));
17  disp(alpha_a1,'(a)  Firing  angle  (in  degrees)  at  half
        the  rated  torque=');
18  E_b3=E_b1*(N3/N1);//in  volts
```

```
19  I_a3=I_a1;//in amperes
20  V_a2=E_b3+(I_a3*R_a);//in volts
21  alpha_a2=acosd((V_a2*%pi/(2*V*sqrt(2))));
22  disp(alpha_a2,'(b) Firing angle (in degrees) at
        rated motor torque=');
```

Scilab code Exa 3.8 Find the value of torque developed and motor speed

```
1  //Exa:3.8
2  clc;
3  clear;
4  close;
5  alpha_f=0;//in degrees
6  alpha_a=30;//in degrees
7  V=220;//in volts
8  I_a=40;//in amperes
9  R_a=0.2;//in amperes
10 K_t=1.12;//motor voltage constant (in Volt/radian/
       sec)
11 R_f=200;//in ohms
12 V_f=2*V*sqrt(2)*cosd(alpha_f)/%pi;//in volts
13 I_f=V_f/R_f;//in amperes
14 V_a=2*V*sqrt(2)*cosd(alpha_a)/%pi;//in volts
15 E_b=V_a-(I_a*R_a);//in volts
16 T_d=K_t*I_a*I_f;
17 disp(T_d,'(a) Torque developed (in N-m)=');
18 N=E_b*60/(2*%pi*K_t*I_f);
19 disp(ceil(N),'(b) Motor Speed (in rpm)=')
```

Scilab code Exa 3.9 Find the value of firing angle

```
1  //Exa:3.9
2  clc;
```

```
3  clear;
4  close;
5  R_a=0.2;//in ohms
6  alpha_f=0;//in degrees
7  V=400;//in volts
8  R_f=250;//in ohms
9  K=1.3;//Volts/Ampere-radian/second
10 N=1200;//in rpm
11 I_a=60;//in amperes
12 V_f=3*sqrt(3)*V*sqrt(2)/(sqrt(3)*%pi);//in volts
13 I_f=V_f/R_f;//in amperes
14 E_b=K*I_f*2*%pi*N/60;//in volts
15 V_a=E_b+(I_a*R_a);//in volts
16 alpha_a=acosd((V_a*%pi)/(3*V*sqrt(2)));
17 disp(alpha_a,'Firing Angle (in degrees)=')
```

Scilab code Exa 3.10 Find the value of no load speed and firing angle

```
1  //Exa:3.10
2  clc;
3  clear;
4  close;
5  alpha_a=45;//in degrees
6  R_a=0.2;//in ohms
7  K=0.25;//in volts/rpm
8  V=400;//in volts
9  I_ao=5;//in amperes (no load armature current)
10 N=1500;//in rpm
11 I_a=100;//in amperes
12 V_ao=3*sqrt(3)*V*sqrt(2)*(1+cosd(alpha_a))/(sqrt(3)*
      %pi*2);//in volts
13 E_bo=V_ao-(I_ao*R_a);//in volts
14 N_o=E_bo/K;
15 disp(int(N_o),'No-Load Speed (in rpm)=');
16 E_b=N*K;//in volts
```

```
17  V_a=E_b+(I_a*R_a);//in volts
18  alpha_ao=acosd(((V_a*%pi*2)/(3*V*sqrt(2)))-1);
19  disp(alpha_ao,'Firing Angle (in degrees)=')
```

Scilab code Exa 3.12 Find the value of average load voltage and average current and diode current and effective input resistance

```
1  //Exa:3.12
2  clc;
3  clear;
4  close;
5  alpha=0.4;//duty cycle
6  V_dc=200;//in volts
7  R=10;//in ohms
8  V_a=alpha*V_dc;
9  disp(V_a,'(a) Average Load Voltage (in volts)=');
10 I=V_a/R;
11 disp(I,'(b) Average thyristor current (in amperes)='
    );
12 I_d=0;
13 disp(I_d,'(c) Diode Current (in amperes)=');
14 R_eff=R/alpha;
15 disp(R_eff,'(d) Effective input resistance (in ohms)
    =')
```

Scilab code Exa 3.13 Find the value of average load current and firing angle

```
1  //Exa:3.13
2  clc;
3  clear;
4  close;
5  V_dc=220;//in volts
```

```
6  V_a=250;//average load voltage (in volts)
7  R=10;//in ohms
8  alpha=1-(V_dc/V_a);
9  I=V_a/R;
10 disp(I,'Average Load Current (in amperes)=')
11 disp(alpha,'Firing Angle (in degrees)=')
```

Scilab code Exa 3.14 Find the value of frequency of switching pulse

```
1  //Exa:3.14
2  clc;
3  clear;
4  close;
5  V_dc=125;//in volts
6  V_a=200;//average output voltage (in volts)
7  T_on=1*10^-3;//in seconds
8  alpha=V_a/(V_a+V_dc);//duty cycle
9  f=alpha/T_on;
10 disp(f,'Frequency Of Switching pulse (in hertz)=')
```

Scilab code Exa 3.15 Find the value of frequency

```
1  //Exa:3.15
2  clc;
3  clear;
4  close;
5  alpha=0.25;//duty cycle
6  V=400;//in volts
7  L=0.5;//in henery
8  I=10;//ripple current (in amperes)
9  V_a=alpha*V;//in volts
10 T_on=L*I/(V-V_a);//in seconds
11 T=T_on/alpha;//in seconds
```

```
12  f=1/T;
13  disp(f,'Frequency (in hertzs)=')
```

Scilab code Exa 3.16 Find the range of speed control and duty cycle

```
1  //Exa:3.16
2  clc;
3  clear;
4  close;
5  V_a=120;//in volts
6  I_a=20;//in amperes
7  R_a=0.5;//in ohms
8  K=0.05;//Motor constant (in volts/rpm)
9  E_b=V_a-(I_a*R_a);//in volts
10  N=E_b/K;//in rpm
11  disp('Range of Speed Control is :');
12  disp('Lowest Speed (in rpm) = 0');
13  disp(N,'Highest Speed (in rpm)=');
14  E_bo=0;//in volts
15  V_a1=E_bo+(I_a*R_a);//in volts
16  alpha=V_a1/V_a;
17  disp('Range of duty cycle is :');
18  disp(alpha,'lowest value of duty cycle=');
19  disp('Highest value of duty cycle= 1')
```

Scilab code Exa 3.17 Find the value of duty cycle of the chopper

```
1  //Exa:3.17
2  clc;
3  clear;
4  close;
5  V=200;//in volts
6  I_a=100;//in amperes
```

```scilab
 7 R_a=0.02;//in ohms
 8 N1=940;//in rpm
 9 N2=500;//in rpm
10 E_b1=V-(I_a*R_a);//in volts
11 E_b2=E_b1*N2/N1;//in volts
12 V_a=E_b2+(I_a*R_a);//in volts
13 alpha=V_a/V;
14 disp(alpha,'Duty Cycle Of The Chopper=')
```

Scilab code Exa 3.18 Find the value of power input and speed and torque and maximum and minimum speed

```scilab
 1 //Exa:3.18
 2 clc;
 3 clear;
 4 close;
 5 alpha=0.6;//duty cycle
 6 alpha1=0.1;//duty cycle
 7 alpha2=0.9;//duty cycle
 8 V=400;//in volts
 9 R_a=0.1;//in ohms
10 K=4;//Motor Constant (in Volts/radians)
11 I_a=150;//in Amperes
12 P_in=alpha*V*I_a/1000;
13 disp(P_in,'(a) Power input (in Kilo-Watts)=');
14 V_a=alpha*V;//in volts
15 E_b=V_a-(I_a*R_a);//in volts
16 N=60*E_b/(2*%pi*K);
17 disp(int(N),'(b) Motor Speed (in rpm)=');
18 T=E_b*I_a*60/(2*%pi*N);
19 disp(T,'(c) Torque developed (in Newton-meter)=');
20 E_b1=(alpha1*V)-(I_a*R_a);//in volts
21 N1=60*E_b1/(2*%pi*K);
22 disp(ceil(N1),'(d) Minimum Speed (in rpm)=')
23 E_b2=(alpha2*V)-(I_a*R_a);//in volts
```

```
24  N2 =60* E_b2 /(2*% pi*K);
25  disp(ceil(N2),'     Maximum  Speed  (in  rpm)=')
```

Scilab code Exa 3.19 Find the value of Average voltage and power dissipated and speed

```
1  //Exa:3.19
2  clc;
3  clear;
4  close;
5  alpha=0.4;//duty  cycle
6  R_b=7.5;//in  ohms
7  R_a=0.1;//in  ohms
8  I_f=1.5;//in  amperes
9  K=1.6;//Voltage  Constant  (in  V/A−rad/sec)
10  I_a=150;//in  amperes
11  V_b=(1-alpha)*R_b*I_a;
12  disp(V_b,'(a)  Average  Voltage  (in  volts)=');
13  P_b=I_a^2*R_b*(1-alpha);
14  disp(P_b/1000,'(b)  Power  Dissipated  (in  kilo−watts)=
       ');
15  E_g=V_b+(I_a*R_a);//in  volts
16  N=60*E_g/(K*I_f*2*%pi);
17  disp(int(N),'(c)  Speed  (in  rpm)=')
```

Scilab code Exa 3.20 Find the value of firing angle and power supplied

```
1  //Exa:3.20
2  clc;
3  clear;
4  close;
5  E_g=-163.53;//in  volts
6  I_a=40;//in  amperes
```

```
7  R_a=0.2;//in ohms
8  V=220;//in volts
9  V_a=E_g+(I_a*R_a);//in volts
10 alpha_a=acosd(V_a*%pi/(2*V*sqrt(2)));
11 disp(alpha_a,'Firing Angle (in degrees)=');
12 P=V_a*I_a*(-1);
13 disp(P/1000,'Power Supplied (in Kilo-Watts)=')
```

Scilab code Exa 3.21 Find the value of pulse width

```
1  //Exa:3.21
2  clc;
3  clear;
4  close;
5  E_b=100;//in volts
6  I_a=25;//in amperes
7  R=0.2;//(R_a+R_se) in ohms
8  V=220;//in volts
9  f=200;//in hertz
10 V_a=E_b+(I_a*R);//in volts
11 T_on=V_a/(V*f);
12 disp(T_on*1000,' Pulse Width (in mili-seconds)')
```

Scilab code Exa 3.22 Find the value of motor torque

```
1  //Exa:3.22
2  clc;
3  clear;
4  close;
5  N=1000;//in rpm
6  V=240;//in volts
7  w=2*%pi*N/60;//in rad/sec
8  alpha=30;//in degrees
```

```
 9  R=0.25;//in ohms
10  K=0.025;//in Nm/A^2
11  disp('When controlled through semiconverter');
12  V_a1=sqrt(2)*V*(1+cosd(alpha))/%pi;//in volts
13  I_a1=V_a1/(R+(K*w));
14  disp(I_a1,'Armature Current (in Amperes)=');
15  T_1=K*I_a1^2;
16  disp(T_1,'Motor Torque (in N-m)=');
17  disp('When controlled through full converter');
18  V_a2=2*sqrt(2)*V*cosd(alpha)/%pi;//in volts
19  I_a2=V_a2/(R+(K*w));
20  disp(I_a2,'Armature Current (in Amperes)=');
21  T_2=K*I_a2^2;
22  disp(T_2,'Motor Torque (in N-m)=');
```

Scilab code Exa 3.23 Find average motor current and speed

```
 1  //Exa:3.23
 2  clc;
 3  clear;
 4  close;
 5  V=230;//in volts
 6  V_dc=sqrt(2)*V*2/%pi;//in volts
 7  T_L=30;//in N-m
 8  K_t=0.3;//torque constant (in N-m/A^2)
 9  I_a=sqrt(T_L/K_t);
10  disp(I_a,'Average Motor Current (in Amperes)=');
11  w=(207-I_a)/(K_t*I_a);// in rad/sec
12  N=w*60/(2*%pi);
13  disp(N,'Speed (in rpm)=');
```

Scilab code Exa 3.24 Find the value of armature current and firing angle

```scilab
1  //Exa:3.24
2  clc;
3  clear;
4  close;
5  I_a1=36;//in amperes
6  N1=400;//in amperes
7  N2=600;//in amperes
8  alpha_1=100;//in degrees
9  V=675;//in volts
10 R=0.4;//in ohms
11 V_a1=sqrt(2)*V*(1+cosd(alpha_1))/%pi;//in volts
12 E_b1=V_a1-I_a1*R;//in volts
13 I_a2=I_a1*N2/N1;//in amperes
14 E_b2=E_b1*I_a2*N2/(I_a1*N1);//in volts
15 V_a2=E_b2+21.6;///in volts
16 alpha=acosd((V_a2*%pi/(sqrt(2)*V))-1);
17 disp(I_a2,'Armature current (in Amperes)=');
18 disp(alpha,'Firing angle (in degrees)=');
```