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

Chapter 1

Fundamentals of Electric Drive

Scilab code Exa 1.1 Electrical Energy and Rating

```
//Example No. 1.1
clc;
clear;
close;
format('v',9);

//Given Data :
J=12;//journey per hour
Load=5500;//Kg
t_up=1.5;//min
W_cage=500;//Kg
t_down=1.25;//min
h=50;//m
Wb=3000;//Kg(Balance weight)
Eff_hoist=0.8;
Eff_motor=0.85;
g=9.81;//gravity constant
E_upward=(Load+W_cage-Wb)*g*h;//J
E_downward=(Wb-W_cage)*g*h;//J
Edj=E_upward+E_downward;//J(Energy used in double
    journey)
```

```
disp(Edj,"Electrical energy used per journey in J : ");
Ein=Edj/Eff_hoist/Eff_motor;//J or W-s
Ein=Ein/1000/3600;//KWh
Ein_hour=Ein*J;//KWh
disp(Ein_hour,"Electrical energy consumption in one hour in KWh : ");
Rating=E_upward/Eff_hoist/t_up/60;//W
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

```
//Example No. 3.1
clc;
clear;
close;

//Given Data :
MoI=0.3;//Kg-m^2
T=20;//N-m
MoIshaft=10;//in Kg-m^2
LostT=10;//%

//Solution :
MoItotal=MoI+MoIshaft;//in Kg-m^2
LoadTorque=T-T*LostT/100;//in N-m
disp(MoItotal,"Total Moment of Inertia in Kg-m^2 : "
    );
disp(LoadTorque,"Load Torque in N-m : ");
```

Scilab code Exa 3.2 equivalent inertia and load of motor

```
//Example No. 3.2
clc;
clear;
close;
format('v',8);

//Given Data :
n=0.1;//teeth ratio
ETAg=90/100;//efficiency
J0=0.4;//Kg-m^2
J1=10;//Kg-m^2
TL=50;//N-m
N=1400;//speed in rpm

//Solution :
J=J0+n^2*J1;//Kg-m^2
T=n*TL/ETAg;//N-m
MotorSpeed=2*%pi*N/60;//rad/sec
Pdev=MotorSpeed*T;//Watt
disp(J,"Equivalent Inertia in Kg-m^2 : ");
disp(T,"Load Torque refered to motor side in N-m : "
    );
disp(Pdev,"Power developed by motor in watt : ");
```

Scilab code Exa 3.3 kw rating and distance

```
//Example No. 3.3
clc;
clear;
close;
format('v',8);

//Given Data :
v=60;//Km/hr
w=400;//KN
```

```
friction=5;//N/KN weight
tan_theta=1/100;//inclination
g=9.81;// gravity constant

//Solution :
sin_theta=tan_theta;
W_sin_theta=w*1000*sin_theta;//N
R=friction*W_sin_theta/10;//frictional resistance in N
P=W_sin_theta+R;//N
v=60*1000/60/60;//m/s
Power=P*v;//Watt
disp(Power/1000,"Final KW rating of the motor of train : ");
Force=P;//down the inclined force in N
u=v;//initial velocity in m/s
v=0;//final velocity in m/s
m=w*1000/g;//in Kg
KE=1/2*m*u^2;//in Joule
d=KE/P;//distance in meter
disp(d,"Distance covered in meter : ");
```

Scilab code Exa 3.4 acceleration

```
//Example No. 3.4
clc;
clear;
close;
format('v',6);

//Given Data :
MotorOutput=200;//KW
v=60;//Km/hr
w=400;//KN
friction=5;//N/KN weight
```

```
tan_theta=1/100;//inclination
g=9.81;// gravity constant

//Solution :
sin_theta=tan_theta;
W_sin_theta=w*1000*sin_theta;//N
R=friction*W_sin_theta/10;//frictional resistance in
    N
P=W_sin_theta+R;//N
v=60*1000/60/60;//m/s
Power=P*v;//Watt
Pdash=MotorOutput*1000-Power;//Power causes
    acceleration in watt or N-m/s
m=w*1000/g;//in Kg
a=Pdash/m;//in m/s^2
disp(a,"Acceleration in m/s^2 : ");
```

Scilab code Exa 3.5 diameter

```
//Example No. 3.5
clc;
clear;
close;
format('v',6);

//Given Data :
MotorSpeed=200;//rpm
d1=50;//diameter of motor pulley in cm
MachineSpeed=100;//rpm

//Solution :
d2=MotorSpeed/MachineSpeed*d1;//diameter of machine
    pulley in cm
disp(d2,"Diameter of machine pulley in cm : ");
```

Scilab code Exa 3.6 inertia and torque

```
//Example No. 3.6
clc;
clear;
close;
format('v',6);

//Given Data :
v=1.2;//belt conveyer speed in m/s
TransRate=100;//rate of transportation of material in tons/hour
l=200;//length of belt in meter
MotorSpeed=1200;//rpm
MoI=0.1;//Moment of Inertia in Kg-m^2


//Solution :
//Part A
TransRate=TransRate*1000/60/60;//rate of transportation of material in Kg/sec
TransTime=l/v;//in sec
omega=MotorSpeed*2*%pi/60;//rad/sec
M=TransRate*TransTime;//Kg
J=M*(v/omega)^2;//Kg-m^2
disp(J,"Load Inertia in Kg-m^2 : ");

//Part B
t=8;//sec
a=v/t;//m/s^2
TorqueInertai=MoI*omega/t;//N-m
F=M*a;//N
Tload=F*v/omega;//N-m
TotalTorque=Tload+TorqueInertai;//N-m
```

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

Scilab code Exa 3.7 torque and moment

```
//Example No. 3.7
clc;
clear;
close;
format('v',7);

//Given Data :
w=400;//Kg
v=1;//m/s
MotorSpeed=1000;//rpm
MoI=0.5;//Moment of Inertia in Kg-m^2
winch=0.3;//Kg-m^2
Tnl=80;//N-m
Speed_nl=1000;//rpm
g=9.81;//gravity constant

//Solution :
mass=w*g;//N
omega=MotorSpeed*2*%pi/60;//rad/sec
TotTorque=Tnl+mass*v/omega;//N-m
disp(TotTorque,"Total Motor Torque in N-m :  ");
J=MoI+winch+w*(v/omega)^2;//Kg-m^2
disp(J,"Moment of Inertia refered to motor shaft in Kg-m^2 : ");
```

Scilab code Exa 3.9 torque and power

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

```
clear;
close;
format('v',7);

//Given Data :
Jmotor=0.3;//Kg-m^2
Jgd_load=15;//Kg-m^2(Inertia gear driven load)
GSRratio=0.1;//gear speed reduction ratio
Jbd_load=0.6;//Kg-m^2(Inertia belt driven load)
d1=10;//cm(diameter of driver pulley)
d2=30;//cm(diameter of driven pulley)
MotorSpeed=1440;//rpm
Tload1=100;//N-m
Tload2=35;//N-m

//Solution :
MotorSpeed=MotorSpeed*2*%pi/60;//rad/sec
Speed_gd=GSRratio*MotorSpeed;//rad/sec
Speed_bd=MotorSpeed*d1/d2;//rad/sec
//Equating Kinetic Energies
//1/2*J*MotorSpeed^2=1/2*Jmotor*MotorSpeed^2+1/2*Jgd_load*speed_gd^2+1/2*Jbd_load*speed_bd^2
J=(1/2*Jmotor*MotorSpeed^2+1/2*Jgd_load*Speed_gd^2+1/2*Jbd_load*Speed_bd^2)*2/MotorSpeed^2
disp(J,"Moment of Inertia refered to motor shaft in Kg-m^2 : ");
//Equating power of motor
//T*(MotorSpeed)=Tload1*Speed_gd+Tload2*Speed_bd
T=(Tload1*Speed_gd+Tload2*Speed_bd)/MotorSpeed;//N-m
disp(T,"Torque in N-m : ");
Pdev=T*MotorSpeed;//watt
disp(Pdev,"Power developed by the motor in watts : ");
```

Scilab code Exa 3.10 equivalent moment and torque

```
//Example No. 3.10
clc;
clear;
close;
format('v',6);

//Given Data :
MotorSpeed=1440;//rpm
Jmotor=0.4;//Kg-m^2
Jdc_load=0.6;//Kg-m^2(Inertia directly coupled load)
w_tl=100;//kg(weight of transratioonal load)
F_res=1.2;//N/Kg(Friction resistance for
    translational load)
v=10;//m/s
T_RotLoad=1.5;//N-m
g=9.81;//gravity constant

//Solution :
MotorSpeed=MotorSpeed*2*%pi/60;//rad/sec
F_horz=w_tl*F_res;//N(horizontal force of
    translational load)
mass=w_tl*g;//N
J=Jmotor+Jdc_load+mass*(v/MotorSpeed)^2;//Kg-m^2
disp(J,"Moment of Inertia at motor shaft in Kg-m^2 :
     ");
T=T_RotLoad+F_horz*v/MotorSpeed;//N-m
disp(T,"Torque at motor shaft in N-m : ");
```

Scilab code Exa 3.11 operating speed

```
//Example No. 3.11
clc;
clear;
close;
format('v',6);
```

```

//Given Data :
//T=0.6+1.9*omega_m
//TL=2.8*sqrt(omega_m)

//Solution :
P=[3.61 -5.56 0.36];//Polynomial for omega_m calculated by equating T=TL
omega_m=roots(P);//rad/sec
disp(omega_m(2),"Operating speed in rad/sec at which system has steady state stability : ");
```

Scilab code Exa 3.12 operating speed

```
//Example No. 3.12
clc;
clear;
close;
format('v',6);

//Given Data :
//T=15-0.5*omega_m
//TL=0.5*omega_m^2

//Solution :
P=[1 1 -30];//Polynomial for omega_m calculated by equating T=TL
omega_m=roots(P);//rad/sec
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

```
//Example No. 4.1
clc;
clear;
close;
format('v',6);

//Given Data :
P=30;//KW
theta1=30;//degree C
t1=40;//min
theta2=45;//degree C
t2=80;//min(t2=2*t1)
disp("theta=theta_f*(1-exp(-t/T))");
//Let exp(-t1/T)=a then exp(-t2/T)=a^2
//theta1/theta2=(1-a)/(1-a^2)
//a^2*theta1-a*theta2+theta2-theta1=0
P=[theta1 -theta2 theta2-theta1];//Polynomial for a
a=roots(P);
a=a(2);//discarding value 1 as it cant give value of
```

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

Scilab code Exa 4.2 temperature and time constant

```
//Example No. 4.2
clc;
clear;
close;
format('v',6);

//Given Data :
P=30;//KW
theta1=20;//degree C
t1=30;//min
theta2=30;//degree C
t2=60;//min(t2=2*t1)
disp("theta=theta_f*(1-exp(-t/T))");
//Let exp(-t1/T)=x then exp(-t2/T)=x^2
//theta1/theta2=(1-x)/(1-x^2)
//x^2*theta1-x*theta2+theta2-theta1=0
P=[theta1 -theta2 theta2-theta1];//Polynomial for a
x=roots(P);
x=x(2);//discarding value 1 as it cant give value of T
T=-t1/log(x);//min
disp(T,"Thermal time constant in min : ");
theta_f=theta1/(1-exp(-t1/T));//degreeC
disp(theta_f,"Final temperature rise in degree C : ");
```

Scilab code Exa 4.3 temperature heating and cooling time constant

```
//Example No. 4.3
clc;
clear;
close;
format('v',6);

//Given Data :
P=30;//KW
theta1=54-30;//degree C
t1=1;//hour
theta2=67-30;//degree C
t2=2;//hour(t2=2*t1)
disp("theta=theta_f*(1-exp(-t/T))");
//Let exp(-t1/T)=a then exp(-t2/T)=a^2
//theta1/theta2=(1-a)/(1-a^2)
//a^2*theta1-a*theta2+theta2-theta1=0
P=[theta1 -theta2 theta2-theta1];//Polynomial for a
a=roots(P);
a=a(2);//discarding value 1 as it cant give value of T
T=-t1/log(a);//hour
theta_f=theta1/(1-exp(-t1/T));//degreeC
theta_steady=theta_f+30;//degreeC
disp(theta_steady,"Final steady state temperature in degree C : ");
disp(T,"Heating time constant in hour : ");
theta2=theta_f;//degree C
t=2.7;//hour
theta=40-30;//degree C
Tdash=-t/log(theta/theta2);//hour
disp(Tdash,"Cooling time constant in hour : ");
```

Scilab code Exa 4.4 temperature rise

```
//Example No. 4.4
clc;
clear;
close;
format('v',6);

//Given Data :
T=110;//min
Tdash=150;//min
t=30;//min
tdash=45;//min
theta_f=50;//degree C
//theta=theta_f-(theta_f-theta1)*exp(-t/T)
//theta1=theta*exp(-tdash/Tdash);
theta=(theta_f-theta_f*exp(-t/T))/(1-exp(-tdash/
   Tdash)*exp(-t/T));//degreeC
disp(theta,"Maximum temperature rise of the motor in
    degree C : ");
```

Scilab code Exa 4.5 temperature rise and heating time constant

```
//Example No. 4.5
clc;
clear;
close;
format('v',6);

//Given Data :
theta1=20;//degreeC
theta2=28;//degreeC
```

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

Scilab code Exa 4.6 proper size of motor

```
//Example No. 4.6
clc;
clear;
close;
format('v',6);

//Given Data :
cycle1=50;//hp
t1=20;//sec
cycle2=100;//hp
t2=20;//sec
cycle3=150;//hp
t3=10;//sec
cycle4=120;//hp
t4=20;//sec
cycle5=0;//hp
t5=15;//sec
hp_rms=sqrt((cycle1^2*t1+cycle2^2*t2+cycle3^2*t3+cycle4^2*t4+cycle5^2*t5)/(t1+t2+t3+t4+t5));//hp
disp(hp_rms,"hp(rms) for the motor : ");
```

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

Scilab code Exa 4.7 maximum temperature rise

```
//Example No. 4.7
clc;
clear;
close;
format('v',6);

//Given Data :
t_on=15;//min
t_off=25;//min
T=100;//min
Tdash=140;//min
theta_f=55;//degree C

//theta=theta_f-(theta_f-theta1)*exp(-t/T)
//theta1=theta*exp(-tdash/Tdash);
theta_max=theta_f*[1-exp(-t_on/T)]/(1-exp(-(t_off/
    Tdash+t_on/T)));//degreeC
disp(theta_max,"Maximum temperature rise in degree C
    : ");
```

Scilab code Exa 4.8 ratio

```
//Example No. 4.8
clc;
clear;
close;
format('v',6);

//Given Data :
```

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

Scilab code Exa 4.9 time and intermittent periodic duty rating

```
//Example No. 4.9
clc;
clear;
close;
format('v',7);

//Given Data :
T=80;//min
Tdash=110;//min
Rating=50;//KW
ts=15;//min
S=sqrt(1/(1-exp(-ts/T)));
ShortTimeRating=S*Rating;//KW
disp(ShortTimeRating,"Short time rating of motor in
  KW : ");
t_off=20;//min
S=sqrt((1-exp(-(ts/T+t_off/Tdash)))/(1-exp(-(ts/T)))
  )
DutyRating=S*Rating;//KW
disp(DutyRating,"Intermittent periodic duty rating
  in KW : ");
```

Scilab code Exa 4.10 continuous rating

```
//Example No. 4.10
clc;
clear;
close;
format('v',5);

//Given Data :
T=90;//min
t=25;//min
ShortTimeRating=50;//KW
Eff=80/100;//Efficiency
//Let full load rating is P KW and Losses=Pc
//CuLoss=(P/(P*Eff))^2 & alfa=Pc/CuLoss
alfa=(Eff)^2;//unitless
S=sqrt(((1+alfa)/(1-exp(-t/T))-alfa));
ContinuousRating_fl=ShortTimeRating/S;//KW
disp(ContinuousRating_fl,"Continuous rating of motor
    in KW : ");
```

Scilab code Exa 4.11 half hour rating

```
//Example No. 4.11
clc;
clear;
close;
format('v',7);

//Given Data :
Rating=25;//KW
T=90;//min
ts=30;//min
S=sqrt(1/(1-exp(-ts/T)));
HalfHourRating=S*Rating;//KW
```

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

Scilab code Exa 4.12 continuous rating

```
//Example No. 4.12
clc;
clear;
close;
format('v',8);

//Given Data :
T=60;//min
t=20;//min
ShortTimeRating=300;//W
Eff=80/100;//Efficiency
//Let full load rating is P KW and Losses=Pc
//CuLoss=(P/(P*Eff))^2 & alfa=Pc/CuLoss
alfa=(Eff)^2;//unitless
S=sqrt(((1+alfa)/(1-exp(-t/T))-alfa));
ContinuousRating_fl=ShortTimeRating/S;//KW
disp(ContinuousRating_fl,"Continuous rating of motor
    in W : ");
```

Scilab code Exa 4.13 moment of inertia

```
//Example No. 4.13
clc;
clear;
close;
format('v',7);

```

```
//Given Data :
P=6;//poles
f=50;//Hz
MoI=9.5;//Kg-m^2
Tr=550;//N-m
S=5/100;//Slip
Tmax=720;//N-m
T_LH=1020;//N-m
th=12;//sec
Tmin=220;//N-m
Snl=3/100;//No load slip
Ns=120*f/P;//rpm
Nnl=Ns-Ns*Snl;//rpm
Nrated=Ns-Ns*S;//rpm
omega_mo=Nnl*2*%pi/60;//rad/s
omega_mr=Nrated*2*%pi/60;//rad/s
J=[Tr/(omega_mo-omega_mr)]*[th/log((T_LH-Tmin)/(T_LH
    -Tmax))];//Kg-m^2
MoI_flywheel=J-MoI;//Kg-m^2
disp(MoI_flywheel,"Moment of inertia of flywheel in
    Kg-m^2 : ");
//Answer in the book is wrong.
```

Chapter 5

DC Motor Drives

Scilab code Exa 5.1 armature resistance and torque

```
//Example No. 5.1
clc;
clear;
close;
format('v',7);

//Given Data :
T=10;//turns
Coil=144;//no. of coils
R=0.011;//ohm
fi=0.05;//Wb(flux per pole)
N=200;//rpm
par_paths=2;//for wave winding
T_path=Coil*T/par_paths;//no. of turns in each parallel path
R_path=R*T_path;//ohm
Ra=R_path/par_paths;//ohm(armature resistance)
disp(Ra,"Armature resistance in ohm : ");
p=12;//poles
emf=par_paths*Coil*T*p*fi*N/60/2;//V
R1=1000;//ohm
```

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

Scilab code Exa 5.2 speed and torque

```
//Example No. 5.2
clc;
clear;
close;
format('v',7);

//Given Data :
Ia=110;//A
V=480;//volt
Ra=0.2;//ohm
p=6;//poles
C=864;//conductors
fi=0.05;//Wb(flux per pole)
back_emf=V-(Ia*Ra);//Volt
N=back_emf*60*p/C/p/fi;//rpm
disp(N,"Speed in rpm : ");
T=C*p*fi*Ia/2/%pi/p;//N-m
disp(T,"Torque in N-m : ");
```

Scilab code Exa 5.3 voltage

```
//Example No. 5.3
clc;
clear;
close;
format('v',7);
```

```
//Given Data :
Ia=100;//A
V=200;//volt
N=600;//rpm
Ra=0.05;//ohm
Eff=85/100;//
Ia1=Ia*Eff;//armature current in separately excited
    dc motor
emf=V-Ia*Ra;//V(motoring mode induced emf)
N1=500;//rpm(generating mode speed)
Gen_emf=emf*N1/N;//V
Vo=Gen_emf-Ia1*Ra;//V
disp(Vo,"Voltage of source in Volt : ");
```

Scilab code Exa 5.4 speed and resistance

```
//Example No. 5.4
clc;
clear;
close;
format('v',7);

//Given Data :
Ia1=10;//A
V1=200;//volt
N1=1800;//rpm
Ra=0.6;//ohm
Rfield=360;//ohm
V2=180;//volt
I_line=20;//A
//fi2=V2/V1*fi1
fi2BYfi1=V2/V1;
//Ia1*fi1=Ia2*fi2
Ia2=Ia1/fi2BYfi1;//A
```

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

Scilab code Exa 5.5 braking resistance

```
//Example No. 5.5
clc;
clear;
close;
format('v',7);

//Given Data :
Ia1=10;//A
V1=200;//volt
N1=1800;//rpm
Ra=0.6;//ohm
Rfield=360;//ohm
V2=180;//volt
I_line=20;//A

Ia=Ia1-V1/Rfield;//A(At changeover time)
emf=V1-Ia*Ra;//volt
Ifield=emf/Rfield;//A(At changeover time)
Iout=Ia1-Ifield;//A
Rbraking=emf/Iout;//ohm(Braking Resistance)
disp(Rbraking,"Braking resistance in ohm : ");
```

Scilab code Exa 5.6 Energy Dissipated

```
//Example No. 5.6
clc;
clear;
close;
format('v',7);

//Given Data :
Ia1=10;//A
V1=200;//volt
N1=1800;//rpm
Ra=0.6;//ohm
Rfield=360;//ohm
V2=180;//volt
I_line=20;//A
//Part (a)
Ia=Ia1-V1/Rfield;//A(At changeover time)
emf=V1-Ia*Ra;//volt
Ifield=emf/Rfield;//A(At changeover time)
Iout=Ia1-Ifield;//A
Rbraking=emf/Iout;//ohm(Braking Resistance)

I_initial=Iout;//A(Inotial current)
t=30;//sec(time taken to stop)
I_change_rate=I_initial/t;//A/s
//i=I_initial-I_change_rate*t , for 0<t<30(during
    braking time)
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
disp(E_dissipated,"Part(a) Energy dissipated in
    watts-sec : ");
//Part (b)
```

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

Scilab code Exa 5.7 Resistance and Breaking Torque

```
//Example No. 5.7
clc;
clear;
close;
format('v',7);

//Given Data :
I=50;//A
V=200;//volt
N=1000;//rpm
Ra=0.2;//ohm
Eb=V-I*Ra;//V
Rt=(V+Eb)/2/I;//ohm(Total resistance required)
disp(Rt-0.5,"Additional resistance required to limit the current in ohm : ");
omega_m=N/60*2*%pi;//rad/s
T=Eb*2*I/omega_m;//N-m
disp(T,"Braking torque in N-m : ");
Eb=0;//for speed=0
I=V/Rt;//A
//T proportional to I(for separately excited motor)
T=T*(I/100);//N-m
disp(T,"Torque when speed decreased to zero in N-m : ");
```

Scilab code Exa 5.8 Speed of Motor

```
//Example No. 5.8
clc;
clear;
close;
format('v',6);

//Given Data :
Ra=0.2;//ohm
Rf=100;//ohm
N=500;//rpm
Rb=2;//ohm
E1=100;//V
If1=2;//A
If2=2.5;//A
If3=3;//A
E2=125;//V
E3=150;//V
//Ib=Rf*If1/2
//Ia=If+Ib;//A
omega_m=N/60*2*%pi;//rad/s
Kefi1=E1/omega_m;
Kefi2=E2/omega_m;
Kefi3=E3/omega_m;
T1=E1/omega_m*51*If1;//N-m
T2=E2/omega_m*51*If2;//N-m
T3=E3/omega_m*51*If3;//N-m
Tload=300;//N-m
Kefi=2.36;
If=2.482;//A
Ia=51*If;//A
E=If*Rf/2+Ia*Ra;//V
N=E/Kefi;//rad/s
```

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

Scilab code Exa 5.9 Find Resistance to be added

```
//Example No. 5.9
clc;
clear;
close;
format('v',6);

//Given Data :
E1=200;//V
E2=300;//V
E3=400;//V
E4=500;//V
E5=600;//V
E6=700;//V
Ia1=20;//A
Ia2=30;//A
Ia3=40;//A
Ia4=50;//A
Ia5=60;//A
Ia6=70;//A
Rt=0.6;//ohm
Tload=600;//N-m
omega_m=Tload*2*%pi/60;//rad/s
Kefi1=E1/omega_m;
Kefi2=E2/omega_m;
Kefi3=E3/omega_m;
Kefi4=E4/omega_m;
Kefi5=E5/omega_m;
Kefi6=E6/omega_m;
T1=E1/omega_m*Ia1;//N-m
T2=E2/omega_m*Ia2;//N-m
```

```
T3=E3/omega_m*Ia3;//N-m
T4=E4/omega_m*Ia4;//N-m
T5=E5/omega_m*Ia5;//N-m
T6=E6/omega_m*Ia6;//N-m
subplot(1,2,1);
plot([Ia1 Ia2 Ia3 Ia4 Ia5 Ia6],[Kefi1 Kefi2 Kefi3 Kefi4 Kefi5 Kefi6])
title('Ia Vs Kefi');
xlabel("Ia(A)");
ylabel("Kefi");
subplot(1,2,2);
plot([Ia1 Ia2 Ia3 Ia4 Ia5 Ia6],[T1 T2 T3 T4 T5 T6])
title('Ia Vs T');
xlabel("Ia(A)");
ylabel("T(N-m)");
//From the graph :
T=600;//N-m
Ia=63;//A
Kefi=9.8;
E=Kefi*omega_m;//V
R=E/Ia;//ohm
Rdb=R-Rt
disp(Rdb,"Resistance for dynamic braking in ohm : ");
```

Scilab code Exa 5.10 Speed at Full load and Torque

```
//Example No. 5.10
clc;
clear;
close;
format('v',7);

//Given Data :
V=240;//V
```

```
Ra=0.4;//ohm
N1=600;//rpm
Ifl=25;//A
Radd=1;//ohm
//If1=If2
//T1=T2 leads to If1*Ia1=If2*Ia2: Ia1=Ia2
Ia1=25;//A
Ia2=25;//A
Eb1=V-Ia1*Ra;//V
Eb2=V-Ia2*(Ra+Radd);//V
N2=N1*Eb2/Eb1;//rpm
disp(N2,"Speed at full load torque in rpm : ");
//T3=2*T1
//If3=If1
Ia3=2*Ia1;//A
Eb3=V-Ia3*(Ra+Radd);//V
N3=N1*Eb3/Eb1;//rpm
disp(N3,"Speed at twice the full load torque in rpm
    : ");
Eb4=0;//V(at speed zero Eb=0)
Ia4=V/(Ra+Radd);//V
T4ByT1=Ia4/Ia1;//(field constant)
disp("Stalling torque is "+string(T4ByT1)+" times of
    full load torque.");
```

Scilab code Exa 5.11 New Value of Field Current

```
//Example No. 5.11
clc;
clear;
close;
format('v',5);

//Given Data :
V=250;//V
```

```
Ra=1;//ohm
Ia1=25;//A
N1=900;//rpm
If=2;//A
N2=1100;//rpm
Eb1=V-Ia1*Ra;//V
//If1*Ia1=If2*Ia2
//Eb2=V-Ia2*Ra;//V
//-Ia2^2*Ra+Ia2*V-Eb1*Ia1*N2/N1=0;
polynomial=[-Ra V -Eb1*Ia1*N2/N1];
Ia2=roots(polynomial);//A
Ia2=Ia2(2);//A(wide range not allowed)
If2=Ia1/Ia2*If;//A
disp(If2,"New value of field current in A : ");
```

Scilab code Exa 5.12 Field Current Firing Angle

```
//Example No. 5.12
clc;
clear;
close;
format('v',6);

//Given Data :
V=230;//V
f=50;//Hz
Rf=200;//ohm
Ra=0.3;//ohm
T=50;//N-m
N=900;//rpm
Kv=0.8;//V/A-rad/s
Kt=0.8;//N-m/A^2
Vm=V*sqrt(2);//V
Vf=2*Vm/%pi;//V
If=Vf/Rf;//A
```

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

Scilab code Exa 5.13 Torque Developed and Motor Speed

```
//Example No. 5.13
clc;
clear;
close;
format('v',7);

//Given Data :
V=230;//V
f=50;//Hz
Rf=200;//ohm
Ra=0.25//ohm
Kv=1.1;//V/A-rad/s
Kt=1.1;//N-m/A^2
alfa_a=45;//degree
Ia=50;//A
alfa_f=0;
```

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

Scilab code Exa 5.14 Firing Angle of Converter

```
//Example No. 5.14
clc;
clear;
close;
format('v',7);

//Given Data :
V=400;//V
Ra=0.3//ohm
Rf=250;//ohm
Ia=50;//A
Kv=1.3;//V/A-rad/s
N=1200;//rpm
alfa_f=0;
Vf=3*sqrt(3)*V*sqrt(2)/sqrt(3)/%pi*cosd(alfa_f);//V
If=Vf/Rf;//A
Eb=Kv*If*2*%pi*N/60;//V
Va=Eb+Ia*Ra;//V
alfa_a=acosd(Va/3/sqrt(3)/V/sqrt(2)*sqrt(3)*%pi);//
    degree
disp(alfa_a,"Fringe angle of converter in degree : "
    );
```

Scilab code Exa 5.15 Input Power Speed and Torque

```
//Example No. 5.15
clc;
clear;
close;
format('v',7);

//Given Data :
V=500;//V
Ia=200;//A
Ra=0.1//ohm
Kv=1.4;//V/A-rad/s
Kt=1.4;//N-m/A^2
If=2;//A
cycle=0.5;//sec
Pin=cycle*V*Ia/1000;//KW
disp(Pin,"Input power in KW : ");
Va=cycle*V;//V
Eb=Va-Ia*Ra;//V
omega=Eb/Kv/2;//rad/s
N=omega*60/2/%pi;//rpm
disp(N,"Speed in rpm : ");
T=Kt*2*Ia;//N-m
disp(T,"Torque in N-m : ");
```

Scilab code Exa 5.16 Average Voltage Power and Speed

```
//Example No. 5.16
clc;
clear;
close;
```

```
format('v',7);

//Given Data :
Ra=0.1//ohm
Rb=7.5//ohm
Kv=1.4;//V/A-rad/s
Ia=120;//A
If=1.6;//A
cycle=0.35;//sec

Vavg=Rb*Ia*(1-cycle);//V
disp(Vavg,"Average voltage across chopper in volt : ");
Pb=Ia^2*Rb*(1-cycle)^2;//W
disp(Pb,"Power dissipated in watts : ");
emf=Vavg+Ra*Ia;//V
omega=emf/Kv/If;//rad/s
N=omega*60/2/%pi;//rpm
disp(N,"Speed in rpm : ");
//Answer of Pb & speed is wrong in the book.
```

Scilab code Exa 5.17 Speed Torque Characteristics

```
//Example No. 5.17
clc;
clear;
close;
format('v',7);

//Given Data :
V=220;//V
f=50;//Hz
L=0.012;//H
Ra=0.72;//ohm
K=2;//V/rad/s
```

```
T=60; //N-m
alfa=90; // degree
Va=3*sqrt(3)*V*sqrt(2)/2/%pi*(1+cosd(alfa)); //V
Ia=5; //A
disp(Ia,"Armature Current in A : ");
T1=Ia*K; //N-m
disp(T1,"Torque in N-m : ");
Eb=Va-Ia*Ra; //V
omega=Eb/K; //rad/s
N1=omega*60/2/%pi; //rpm
disp(N1,"Speed in rpm : ");
disp("");
Ia=10; //A
disp(Ia,"Armature Current in A : ");
T2=Ia*K; //N-m
disp(T2,"Torque in N-m : ");
Eb=Va-Ia*Ra; //V
omega=Eb/K; //rad/s
N2=omega*60/2/%pi; //rpm
disp(N2,"Speed in rpm : ");
Ia=20; //A
disp(Ia,"Armature Current in A : ");
T3=Ia*K; //N-m
disp(T3,"Torque in N-m : ");
Eb=Va-Ia*Ra; //V
omega=Eb/K; //rad/s
N3=omega*60/2/%pi; //rpm
disp(N3,"Speed in rpm : ");
Ia=30; //A
disp(Ia,"Armature Current in A : ");
T4=Ia*K; //N-m
disp(T4,"Torque in N-m : ");
Eb=Va-Ia*Ra; //V
omega=Eb/K; //rad/s
N4=omega*60/2/%pi; //rpm
disp(N4,"Speed in rpm : ");
plot([T1 T2 T3 T4],[N1 N2 N3 N4]);
title('Speed Torque Characteristics');
```

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

Scilab code Exa 5.18 No Load Speed and Firing Angle

```
//Example No. 5.18
clc;
clear;
close;
format('v',6);

//Given Data :
V=400;//V
f=50;//Hz
I=50;//A
Ra=0.1;//ohm
K=0.3;//V/rpm
Ia=5;//A
alfa=30;//degree
Vavg=3*sqrt(3)*V*sqrt(2)/sqrt(3)/2/%pi*(1+cosd(alfa)
    );//V
Eb=Vavg-Ia*Ra;//V
N=Eb/K;//rpm
disp(N,"No load speed in rpm : ");
Speed=1600;//rpm
Eb=Speed*K;//V
Vin=Eb+I*Ra;//V
alfa=acosd(Vin/3/sqrt(3)/V/sqrt(2)*sqrt(3)*2*%pi-1);
    //degree
disp(alfa,"Fringe angle in degree : ");
```

Scilab code Exa 5.19 Power fed back

```
//Example No. 5.19
clc;
clear;
close;
format('v',7);

//Given Data :
V=230; //V
f=50; //Hz
Rf=200; //ohm
Ra=0.25//ohm
Kv=1.1; //V/A-rad/s
Kt=1.1; //N-m/A^2
alfa_a=45; //degree
Ia=50; //A
alfa_f=0;
Vf=2*V*sqrt(2)/%pi*cosd(alfa_f); //V
Va=2*V*sqrt(2)/%pi*cosd(alfa_a); //V
If=Vf/Rf; //A
T=Kt*Ia*If; //N-m
Eb=Va-Ia*Ra-2; //V
omega=Eb/Kv/If; //rad/s
Eg=-Eb; //V
Va=Eg+Ia*Ra+2; //V
alfa=acosd(Va/2/V/sqrt(2)*%pi); //degree
disp(alfa,"Fringe angle to converter in degree : ");
P=abs(Va)*Ia; //W(power fed back to source)
disp(P,"Power fed back to source in Watts : ");
//Answer wrong in the book.
```

Scilab code Exa 5.20 Find back emf

```
//Example No. 5.20
clc;
clear;
```

```
close;
format('v',7);

//Given Data :
V=240;//V
alfa=100;//degree
Ra=6//ohm
Ia=1.8;//A
Vm=V*sqrt(2);//V
Vdc=Vm/%pi*(1+cosd(alfa));//Volt
Eb=Vdc-Ia*Ra;//V
disp(Eb,"Back emf in volt : ");
```

Scilab code Exa 5.21 Compute Speed and Torque

```
0//Example No. 5.21
clc;
clear;
close;
format('v',5);

//Given Data :
V1=230;//V
N1=1500;//rpm
Ra=1;//ohm
Ia=10;//A
T=5;//N-m
//V=K*omega+Ia*Ra
K=V1/(N1*2*%pi/60+Ia*Ra);//V-s/rad or N-m/A
Ia=T/K;//A
alfa1=30;//degree
V=2*V1*sqrt(2)/%pi*cosd(alfa1);//Volt
omega=(V-Ia*Ra)/K;//rad/s
N=omega*60/2/%pi;//rpm
disp(N,"Parrt(a) Speed in rpm : ");
```

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

Scilab code Exa 5.22 RMS current and Power factor

```
//Example No. 5.22
clc;
clear;
close;
format('v',6);

//Given Data :
V1=500;//V
N1=1500;//rpm
Ia=100;//A
V2=350;//V
Ra=1.1;//ohm
alfa=45;//degree
N2=1200;//rpm
//V=K*omega+Ia*Ra
K=(V1-Ia*Ra)/(N1*2*%pi/60);//V-s/rad or N-m/A
V=3*sqrt(3)*V2*sqrt(2)/2/%pi/sqrt(3)*(1+cosd(alfa));
    //Volt
Ia=(V-K*N2*2*%pi/60)/Ra;//A
disp(Ia,"RMS soirce current in A : ");
Vin_rms=Ia*sqrt(120/180);//V
Iavg=Ia/3;//A
disp(Iavg,"Average thyristor current in A : ");
Irms=Ia/sqrt(3);//A
disp(Irms,"RMS thyristor current in A : ");
```

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

Scilab code Exa 5.23 Time taken by the motor

```
//Example No. 5.23
clc;
clear;
close;
format('v',9);

//Given Data :
T1=40;//N-m
N1=500;//rpm
J=0.01;//N-m_sec^2/rad
T2=100;//N-m
N2=1000;//rpm
disp("Te=J*d(omega)/dt+D*omega+TL");
d_omegaBYdt=(T2-T1)/J;//
//t=omega/d_omegaBYdt+A;
omega1=N1*2*%pi/60;//rad/s
t=0;//s(initial time)
A=t-omega1/d_omegaBYdt;//
omega2=N2*2*%pi/60;//rad/s
t=omega2/d_omegaBYdt+A;//s
disp(t,"Time taken by the motor in sec :  ");
```

Scilab code Exa 5.24 Max and Min Armature Current and Excursion

```
//Example No. 5.24
clc;
clear;
close;
```

```
format('v',9);

//Given Data :
f=400;//Hz
V=200;//V
T=30;//N-m
N=1000;//rpm
R=0.2;//ohm
L=2;//mH
Kv=1.5;//V-sec/rad
Kt=1.5;//N-m/A
Ia=T/Kt;//A
omega=N*2*%pi/60;//rad/s
Eb=Kv*omega;//V
alfa=(Eb+Ia*R)/V;
T=1/f*1000;//ms
Ton=alfa*T;//ms
Toff=T-Ton;//ms
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
disp(Imax,"(a) Maximum motor armature current in A : ");
Imin=V/R*[(exp(alfa*T*R/L)-1)/(exp(T*R/L)-1)]-Eb/R;//A
disp(round(Imin),"(a) Minimum motor armature current in A : ");
Iexc=Imax;//A
disp(Iexc,"(b) Excursion of  armature current in A : ");
```

Scilab code Exa 5.25 Avg Motor Current and Speed

```
//Example No. 5.25
clc;
clear;
```

```
close;
format('v',9);

//Given Data :
V=230;//V
f=50;//Hz
Rf=1.5;//ohm
Kt=0.25;//N-m/A
T=25;//N-m
Kv=0.25;//V-sec/rad
Vdc=2*sqrt(2)*V/%pi;//V
Em=Vdc;//V
Ia=sqrt(T/Kt);//A
disp(Ia,"Average motor current in A : ")
omega_m=(Em-Ia*Rf)/Kv/Ia;//rad/s
N=omega_m*60/2/%pi;//RPM
disp(N,"Motor speed in RPM : ");
```

Scilab code Exa 5.26 Armature current and firing angle

```
//Example No. 5.26
clc;
clear;
close;
format('v',9);

//Given Data :
V1=675;//V
alfa1=90.5;//degree
N1=350;//rpm
Ia1=30;//A
N2=500;//rpm
Rf=0.22;//ohm
Ra=0.22;//ohm
Ia2=Ia1*N2/N1;//A
```

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

Scilab code Exa 5.27 Torque and Armature Current

```
//Example No. 5.27
clc;
clear;
close;
format('v',9);

//Given Data :
V1=230;//V
P=15;//hp
N=1500;//rpm
V2=220;//V
Ke=0.03;//V/A-s
Kt=0.03;//N-m/A^2
alfa=45;//degree
Vm=V1*sqrt(2);//V
omega=N*2*%pi/60;//rad/s
T=4*Kt*Vm^2*cosd(alfa)^2/(%pi^2*(Ke*omega)^2);//N-m
Ia=sqrt(T/Kt);//A
disp("part (a) : ");
disp(T,"Torque in N-m : ");
disp(Ia,"Armature current in A : ");
disp("part (b) : ");
Ia=Vm*(1+cosd(alfa))/(%pi*(Ke*omega));//A
```

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

Scilab code Exa 5.28 Motor Current and Torque

```
//Example No. 5.28
clc;
clear;
close;
format('v',9);

//Given Data :
V1=230;//V
N=1000;//rpm
P=15;//hp
Rt=0.2;//ohm
Ke=0.03;//V/A-s
Kt=0.03;//N-m/A^2
alfa=30;//degree
Vm=V1*sqrt(2);//V
omega=N*2*%pi/60;//rad/s
V=Vm/%pi*(1+cosd(alfa));//V
//V=Ke*Ia*omega+Ia*Rt
Ia=V/(Ke*omega+Rt);//A
disp(Ia,"Motor current in A : ");
T=Kt*Ia^2;//N-m
disp(T,"Torque in N-m : ");
```

Scilab code Exa 5.29 Firing Angle of Converter

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

```
clear;
close;
format('v',9);

//Given Data :
V=220;//V
Vin=230;//V
N1=1500;//rpm
Ia1=10;//A
Ra=3;//ohm
N2=600;//rpm
E1=V-Ia1*Ra;//V
E2=E1*N2/N1;//V
Ia2=Ia1/2;//A(because of Tnew=T/2)
Vapp=E2+Ia2*Ra;//V
alfa=acosd(Vapp*%pi/2/sqrt(2)/Vin);//degree
disp(alfa,"Firing angle of converter in degree : ");
```

Scilab code Exa 5.30 Speed of Motor

```
//Example No. 5.30
clc;
clear;
close;
format('v',9);

//Given Data :
V=230;//V
N=870;//rpm
Ia=100;//A
Ra=0.05;//ohm
T=400;//N-m
E=V-Ia*Ra;//V
Vgen=V+Ia*Ra;//V
N2=N*Vgen/E;//rpm
```

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

Scilab code Exa 5.31 On time of chopper

```
//Example No. 5.31
clc;
clear;
close;
format('v',9);

//Given Data :
V=220;//V
P=2.2;//KW
N1=1000;//rpm
Ra=2;//ohm
f=250;//Hz
alfa=0.9;//cycle
N2=1200;//rpm
N3=800;//rpm
Ia1=P*1000/V;//A
Ia2=Ia1*N2/N1;//A
Eb2=alfa*V-Ia2*Ra;//V
Eb3=Eb2*N3/N2;//V
Ia3=Ia1*N3/N1;//A
alfa3=(Eb3+Ia3*Ra)/V;//cycle
ton=alfa3/f;//sec
disp(ton,'On time of chopper in sec : ');
```

Scilab code Exa 5.32 Braking Current and Resistance

```
//Example No. 5.32
clc;
clear;
```

```
close;
format('v',9);

//Given Data :
V=230;//V
N1=1000;//rpm
Ia1=100;//A
Ra=0.1;//ohm
Rf=0.1;//ohm
N2=800;//rpm
Ia2=sqrt(2)*Ia1;//A(As T2=2*T1 & T proportional to
    Ia^2)
Eb1=V-Ia1*(Ra+Rf);//V
Eb2=N2*Ia2/(N1*Ia1)*Eb1;//V
//Eb2=Ia2*(Ra+Rf+Rbraking)
Rbraking=Eb2/Ia2-Ra-Rf;//ohm
disp(Rbraking,'Braking resistance in ohm : ');
Ibraking=Eb2/Rbraking;//A
disp(Ibraking,'Braking current in A : ');
//Braking current is not calculated in the textbook
    but asked in the example.
```

Scilab code Exa 5.33 Torque Speed and PF

```
//Example No. 5.33
clc;
clear;
close;
format('v',9);

//Given Data :
P=6;//poles
V=220;//V
f=50;//Hz
Ra=0.2;//ohm
```

```
Rf=150;//ohm
Z=150;//no. of conductors
fi=0.02027;//Wb(flux)
alfa=0;//degree
alfa_a=45;//degree
Ia=25;//A
A=2;//
T=Z*P*fi*Ia/(2*%pi*A);//N-m
disp(T,"Totque in N-m : ");
Vm=V*sqrt(2);//V
Vdc=2*Vm/%pi*cosd(alfa_a);//V
Eb=Vdc-Ia*Ra;//V
N=Eb*60*A/(Z*P*fi);//rpm
disp(N,"Speed in rpm : ");
Pout=Vdc*Ia;//W
pf=Pout/V/Ia;//lagging
disp(pf,'Lagging power factor : ');
```

Scilab code Exa 5.34 Find Motor Speed

```
//Example No. 5.35
clc;
clear;
close;
format('v',9);

//Given Data :
V1=200;//V
N1=940;//rpm
Ra=0.02;//ohm
Ia=100;//A
N2=500;//rpm
Eb1=V1-Ia*Ra;//V
//Eb1/Eb2=N1/N2
//Eb2=V2-Ia*Ra;//V
```

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

Scilab code Exa 5.35 Duty Cycle of Chopper

```
//Example No. 5.35
clc;
clear;
close;
format('v',9);

//Given Data :
V1=200;//V
N1=940;//rpm
Ra=0.02;//ohm
Ia=100;//A
N2=500;//rpm
Eb1=V1-Ia*Ra;//V
//Eb1/Eb2=N1/N2
//Eb2=V2-Ia*Ra;//V
V2=Eb1*N2/N1+Ia*Ra;//V
cycle=V2/V1;
disp(cycle,"Duty cycle : ");
```

Scilab code Exa 5.36 Resistance and Braking Torque

```
//Example No. 5.36
clc;
clear;
close;
format('v',9);

```

```
//Given Data :
V1=220;//V
Ra=0.05;//ohm
N1=1000;//rpm
Ia=100;//A
N2=500;//rpm
Eb=V1-Ia*Ra;//V
Ib=2*Ia;//A
Rb=(V1+Eb)/Ib-Ra;//ohm
disp(Rb,"Resistance to be added in ohm : ");
Tb=Eb/(N1*2*%pi/60)*Ib;//N-m
disp(Tb,"Initial braking torque in N-m : ");
Eb2=Eb*N2/N1;//V
Ib2=(V1+Eb2)/(Ra+Rb);//A
Tb2=Eb2/(N2*2*%pi/60)*Ib2;//N-m
disp(Tb2,"Initial braking torque in N-m : ");
```

Scilab code Exa 5.37 Find Motor Speed

```
//Example No. 5.37
clc;
clear;
close;
format('v',9);

//Given Data :
V1=230;//V
N1=870;//rpm
Ia=100;//A
Ra=0.05;//ohm
T=400;//N-m
Eb=V1-Ia*Ra;//V
Vgen=V1+Ia*Ra;//V
N2=N1*Vgen/Eb;//rpm
disp(N2,"Speed in rpm : ");
```

Scilab code Exa 5.38 Torque Speed and PF

```
//Example No. 5.38
clc;
clear;
close;
format('v',9);

//Given Data :
P=10;//KW
V1=230;//V
N1=1200;//rpm
Ra=0.5;//ohm
Ke=0.182;//V/rpm
V2=260;//V
alfa=30;//degree
Ia=30;//A
Vm=V2*sqrt(2);//V
Vdc=2*Vm/%pi*cosd(alfa);//V
Eb=Vdc-Ia*Ra;//V
Kt=Ke*60/2/%pi;//N-m/A
T=Kt*Ia;//N-m
disp(T,"Torque in N-m : ");
N2=Eb/Ke;//rpm
disp(N2,"Speed in rpm : ");
Pout=Vdc*Ia;//W
pf=Pout/V2/Ia;//lagging power factor
disp(pf,"Lagging power factor : ");
```

Scilab code Exa 5.39 On Time of chopper

```
//Example No. 5.39
clc;
clear;
close;
format('v',9);

//Given Data :
P=2.2;//KW
V=220;//V
N1=1000;//rpm
Ra=2;//ohm
f=250;//Hz
alfa=0.9;//duty cycle
N2=1200;//rpm
N3=800;//rpm
Ia1=P*1000/V;//A
Ia2=Ia1*N2/N1;//A
Eb1=alfa*V-Ia2*Ra;//V
Eb2=Eb1*N3/N2;//V
Ia3=Ia1*N3/N1;//A
alfa3=(Eb2+Ia3*Ra)/V;//cycle
ton=alfa3/f;//sec
disp(ton*1000,'On time of chopper in milli seconds :
    ');
```

Scilab code Exa 5.40 Current Drawn and Resistance

```
//Example No. 5.40
clc;
clear;
close;
format('v',9);

//Given Data :
V=220;//V
```

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

Scilab code Exa 5.41 Find Firing Angle

```
//Example No. 5.41
clc;
clear;
close;
format('v',9);

//Given Data :
V1=220;//V
N1=1500;//rpm
I=10;//A
Ra=3;//ohm
V2=230;//V
N2=600;//rpm
Eb1=V1-I*Ra;//V
Eb2=Eb1*N2/N1;//V
Ia=I/2;//A(at half rated torque)
Vm=V1*sqrt(2);//V
alfa=acosd((Eb2+Ia*Ra)*%pi/2/Vm);//degree
disp(alfa,"Firing angle in degree : ");
```

Chapter 6

AC Motor Drives

Scilab code Exa 6.1 Speed and Torque

```
//Example No. 6.1
clc;
clear;
close;
format('v',7);

//Given Data :
V=400;//volt
P=4;//poles
f=50;//Hz
Pout=10;//hp
Pout=Pout*735.5;//W
Snl=1/100;//No load Slip
Sfl=4/100;//Full load slip
Ns=120*f/P;//rpm
disp(Ns,"Synchronous speed in rpm : ");
N=Ns*(1-Snl);//rpm
disp(N,"Speed at no load in rpm : ");
N=Ns*(1-Sfl);//rpm
disp(N,"Speed at full load in rpm : ");
f2=Sfl*f;//Hz
```

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

Scilab code Exa 6.2 Slip Speed Power

```
//Example No. 6.2
clc;
clear;
close;
format('v',7);

//Given Data :
P=6;//poles
f1=50;//Hz
Pg=80;//KW
f2=100;//alternation/min
f2=f2/60;//Hz
Ns=120*f1/P;//rpm
Ns=Ns/60;//rps
S=f2/f1;//Slip
disp(S,"Slip is : ");
N=Ns*(1-S);//rps
disp(N*60,"Motor speed in rpm : ");
Pm=Pg*(1-S);//KW
disp(Pm,"Developed mechanical power in KW : ");
CuLoss=S*Pg;//KW
CuLoss_per_phase=CuLoss/3;//KW
disp(CuLoss_per_phase*1000,"Rotor Copper Loss per
   phase in W : ");
I2=65;//A
r2=CuLoss_per_phase*1000/I2^2;//ohm/phase
```

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

Scilab code Exa 6.3 Poles Slip and Copper Loss

```
//Example No. 6.3
clc;
clear;
close;
format('v',7);

//Given Data :
N=288;//rpm
f=50;//Hz
CuLoss=275;//W
Ns=300;//rpm(For S=0.03:0.05)
P=120*f/Ns;//poles
disp(P,"No. of poles : ");
S=(Ns-N)/Ns;//Slip
disp(S,"Slip : ");
S=2*S;//(as rotor reistance doubled, slip is doubled
    )
disp(S,"Slip for full load if rotor resiatance
    doubled : ");
//CuLoss=I2^2*r2
CuLoss=2*CuLoss;//KW(rotor resiatance doubled &
    current constant)
disp(CuLoss,"New value of rotor copper loss in watt
    : ");
```

Scilab code Exa 6.4 Applied voltage and starting current

```
//Example No. 6.4
clc;
clear;
close;
format('v',6);

//Given Data :
T_directStartBYTfl=1.5;//ratio
K=sqrt(T_directStartBYTfl);//Ratio of full load torque to starting torque direct starting
//Vapplied=1/K*Vline
VappliedBYVline=1/K;
disp("Applied voltage is "+string(VappliedBYVline)+" times of Line voltage.");
LineCurrentBYIfl=1/K^2*4;//V
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

```
//Example No. 6.5
clc;
clear;
close;
format('v',6);

//Given Data :
Ist=300;//A
X=50/100;//tapping
Imotor=X*Ist;//A
disp(Imotor,"Motor current in A : ");
Iline=X^2*Ist;//A
disp(Iline,"Line current in A : ");
ratio=X^2;//Ratio of starting Torque 50% tapping to
```

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

Scilab code Exa 6.6 Braking Current and Torque

```
//Example No. 6.6
clc;
clear;
close;
format('v',6);

//Given Data :
V=400;//volt
P=8;//pole
f=50;//Hz
r1=1.2;//ohm
r2dash=1.2;//ohm
x1=2.5;//ohm
x2dash=2.5;//ohm
N=720;//rpm
Ns=120*f/P;//rpm
S=(Ns-N)/Ns;//full load slip
S2=2-S;//Slip during plugging
V1=V/sqrt(3);//V
I2dash=V1/sqrt((r1+r2dash/S2)^2+(x1+x2dash)^2);//A(Initial braking current)
disp(I2dash,"Initial Braking current in A : ");
Ifl=V1/sqrt((r1+r2dash/S)^2+(x1+x2dash)^2);//A(Full load current)
RatioCurrent=I2dash/Ifl;//ratio of initial braking current to full load current
disp("Braking curent is "+string(RatioCurrent)+" times of full  load current.");
Tfl=3*Ifl^2*r1/(2*%pi*S*Ns/60);//N-m
```

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

Scilab code Exa 6.7 Starting Time and Energy

```
//Example No. 6.7
clc;
clear;
close;
format('v',6);

//Given Data :
V=400;//volt
P=8;//pole
f=50;//Hz
```

```
r1=0.1;//ohm
r2dash=0.1;//ohm
x1=0.4;//ohm
x2dash=0.4;//ohm
J=10;//Kg-m^2
Sm=r2dash/sqrt(r1^2+(x1+x2dash)^2)
Ns=2*f/P;//rps
omega_ms=2*%pi*Ns;//rad/s
V1=V/sqrt(3);//V
Tmax=1.5*V1^2/(2*%pi*Ns)*[1/(r1+sqrt(r2dash^2+(2*
   x2dash)^2))];//N-m
tau_m=J*omega_ms/Tmax;//sec
ts=tau_m*(1.5*Sm+0.25/Sm);//sec
disp(ts,"Starting time in sec : ");
E=0.5*J*omega_ms^2;//Watt-s
Etot=2*E;//Watts-s
disp(Etot/1000,"Energy dissipated during starting in
    KW-s : ");
tb=tau_m*(0.7/Sm+0.334*Sm);//sec
disp(tb,"Pluggingfg time in sec : " );
E=1.4*J*omega_ms^2;//Watt-s
E=2*E/1000;//KW-s(taking cU loss into account)
disp(E,"Energy dissipated during plugging in KW-s :
   ");
```

Scilab code Exa 6.8 Torque Current and Voltage

```
//Example No. 6.8
clc;
clear;
close;
format('v',6);

//Given Data :
V=400;//volt
```

```
P=4;//pole
f=50;//Hz
r1=0.64;//ohm
r2=0.08;//ohm
x1=1.1;//ohm
x2=0.12;//ohm
T1=40;//N-m
N=1440;//rpm
n=2*f/P;//rps
n=n*60;//rpm
N1=1300;//rpm
Tload=T1*(N1/N)^2;//N-m
disp(Tload,"Load torque in N-m : ");
S=(n-N1)/n;//slip
r2dash=r2*2^2;//ohm
x2dash=x2*2^2;//ohm
//Tload=3*I2dash^2*r2dash/(2*%pi*S*n/60)
I2dash=sqrt(Tload/3/r2dash*(2*%pi*S*n/60));//A
I2=2*I2dash;//A
disp(I2,"Rotor current in A : ");
I1=I2dash;//A
V1=I1*(r1+r2dash+r2dash*(1-S)/S+%i*(x1+x2dash));//
    Vplt
StatorVoltage=abs(V1)*sqrt(3);//Volt
disp(StatorVoltage,"Stator Applied Voltage in V : ")
    ;
```

Scilab code Exa 6.9 Slip for max Torque

```
//Example No. 6.9
clc;
clear;
close;
format('v',7);

```

```
//Given Data :
V=400;//volt
P=4;//pole
f=50;//Hz
r1=0.64;//ohm
r2=0.08;//ohm
x1=1.1;//ohm
x2=0.12;//ohm
T1=40;//N-m
N=1440;//rpm
N1=1300;//rpm
r2dash=r2*2^2;//ohm
x2dash=x2*2^2;//ohm
S=r2dash/sqrt(r1^2+(x1+x2dash)^2);//slip
disp(S,"Slip for maximum torque at 50 Hz : ");
V1=V/sqrt(3);//volt/phase
ns=2*f/P;//rps
Tmax=1.5*V1^2/(2*%pi*ns)*[1/(r1+sqrt(r1^2+(x1+x2dash
    )^2))];//Nm
disp(Tmax,"Maximum torque at 50 Hz in N-m : ");
n=ns*(1-S);//rps
N=n*60;//rpm
disp(N,"Speed at 50 Hz in rpm : ");
f=25;//Hz
x1=x1/2;//ohm
x2dash=x2dash/2;//ohm
S=r2dash/sqrt(r1^2+(x1+x2dash)^2);//slip
disp(S,"Slip for maximum torque at 25 Hz : ");
V1=V1/2;//volt/phase
ns=2*f/P;//rps
Tmax=1.5*V1^2/(2*%pi*ns)*[1/(r1+sqrt(r1^2+(x1+x2dash
    )^2))];//Nm
disp(Tmax,"Maximum torque at 25 Hz in N-m : ");
n=ns*(1-S);//rps
N=n*60;//rpm
disp(N,"Speed at 25 Hz in rpm : ");
```

Scilab code Exa 6.10 Starting Torque

```
//Example No. 6.10
clc;
clear;
close;
format('v',7);

//Given Data :


V=400;//volt
P=4;//pole
f=50;//Hz
r1=0.64;//ohm
r2=0.08;//ohm
x1=1.1;//ohm
x2=0.12;//ohm
T1=40;//N-m
N=1440;//rpm
N1=1300;//rpm
r2dash=r2*2^2;//ohm
x2dash=x2*2^2;//ohm
S=r2dash/sqrt(r1^2+(x1+x2dash)^2);//slip
V1=V/sqrt(3);//volt/phase
ns=2*f/P;//rps
Tst=3*V1^2*r2dash/(2*%pi*ns*[(r1+r2dash)^2+(x1+
    x2dash)^2]);//N-m
disp(Tst,"Starting torque at 50 Hz in N-m : ");
f=25;//Hz
x1=x1/2;//ohm
x2dash=x2dash/2;//ohm
V1=V1/2;//volt/phase
ns=2*f/P;//rps
```

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

Scilab code Exa 6.11 Find Torque

```
//Example No. 6.11
clc;
clear;
close;
format('v',7);

//Given Data :
V=400;//volt
P=4;//pole
f=50;//Hz
r2dash=1;//ohm/phase
//Neglecting r1,x1,x2
f1=400;//Hz
S=4/100;//Slip
t2=1.5;//ms
t2=t2*10^-3;//sec
t=1/f1;//sec
t1=t-t2;//sec
R=2;//ohm(additional resistance)
R2dash=(r2dash*t1+(r2dash+R)*t2)/t;//ohm
V1=V/sqrt(3);//volt
T=3*V1^2*S/R2dash;//N-m
disp(T,"Torque in synch.watts : ");
```

Scilab code Exa 6.12 Stator Applied Voltage

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

```
clc;
clear;
close;
format('v',7);

//Given Data :
V1=400;//volt
P=4;//pole
f=50;//Hz
Sm=10/100;//slip
S1=0.04;//slip
N2=900;//rpm

//r2dash=0.01*x2;//ohm/phase
r2dash=0.01
r1dash=0.1
Ns=120*f/P;//rpm
N1=Ns*(1-S1);//rpm
S2=(Ns-N2)/Ns;//slip
T2ByT1=(N2/N1)^2;
//T=3/(2*%pi*ns)*[V1^2/((rdash/S2)^2+xdash^2)]*(rdash/S2)
//T2/T1=V2^2/V1^2*S1/S2*[(1+625*r1dash^2)/(1+6.25*r1dash^2)]
V2=sqrt(T2ByT1*V1^2*S2/S1/[(1+625*r1dash^2)/(1+6.25*r1dash^2)]);//volt
disp(V2,"Stator applied voltage in volts : ");
```

Scilab code Exa 6.13 Find Torque

```
//Example No. 6.13
clc;
clear;
close;
format('v',7);
```

```
//Given Data :
P=4;//pole
f=50;//Hz
S=4/100;//slip
T=1000;//synch.Watts
f1=25;//Hz
Tnew=T*f/f1;//synch.watts
disp(Tnew,"Torque in synch. Watts : ");
```

Scilab code Exa 6.14 Torque Ratio and Current Ratio

```
//Example No. 6.14
clc;
clear;
close;
format('v',6);

//Given Data :
P=4;//pole
f=50;//Hz
r1=0.04;//ohm
r1dash=0.04;//ohm
r2dash=0.04;//ohm
x1=0.2;//ohm
x2dash=0.2;//ohm
f1=20;//Hz
k=f1/f;//ratio of frequencies
Tmax20BYTmax50=(r1+sqrt(r1^2+(x1+x2dash)^2))/(r1/k+
    sqrt((r1/k)^2+(x1+x2dash)^2));
disp(Tmax20BYTmax50,"Ratio of max torque at 20 Hz to
     max Torque at 50 Hz : ");
Tst20BYTst50=((r1+r2dash)^2+(x1+x2dash)^2)/k/((r1/k+
    r2dash/k)^2+(x1+x2dash)^2);
disp(Tst20BYTst50,"Ratio of starting torque at 20 Hz
```

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

Scilab code Exa 6.15 Find motor speed

```
//Example No. 6.15
clc;
clear;
close;
format('v',5);

//Given Data :
P=4;//pole
f=50;//Hz
S=0.04;//slip
r1=0.04;//ohm
r1dash=0.04;//ohm
r2dash=0.04;//ohm
x1=0.2;//ohm
x2dash=0.2;//ohm
f1=30;//Hz
k=f1/f;//ratio of frequencies
S1=k*S;//slip
//For 50 Hz
//T=3*V1^2*S*r2dash/(2*%pi*ns)/[(S*r1+r2dash)^2+S^2*(x1+x2dash)^2];
```

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

Scilab code Exa 6.16 Average torque and speed

```
//Example No. 6.16
clc;
clear;
close;
format('v',7);

//Given Data :
P=6;//pole
f=50;//Hz
S=0.04;//slip
Ton=40;//N-m
Toff=30;//N-m
t_onBYt_off=1;
disp("Part(a) : ");
Ns=2*f/P*60;//rpm
N=Ns*(1-S);//rpm
Tavg=(Ton+Toff)/2;//N-m
disp(Tavg,"Average torque in N-m : ");
Navg=sqrt((N^2)*Tavg/Ton);//rpm
disp(Navg,"Average speed in rpm : ");
disp("Part(b) : ");
N1=800;//rpm
```

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

Scilab code Exa 6.17 Value of Vdc

```
//Example No. 6.17
clc;
clear;
close;
format('v',7);

//Given Data :
Vrms=415;//volt
f=50;//Hz
Vdc=Vrms/sqrt(1/%pi*integrate('1','t',0,2*%pi/3));
disp(Vdc,"Value of Vdc in Volts : ");
```

Scilab code Exa 6.18 Torque and applied voltage

```
//Example No. 6.18
clc;
clear;
close;
format('v',6);

//Given Data :
V=400;//volt
f=50;//Hz
P=4;//poles
N1=1350;//rpm
```

```
N2=900; //rpm
Rs=1.5; //ohm
R=4; //ohm
X=4; //ohm
ns=2*f/P*60; //rpm
S=(ns-N1)/ns; //slip
T=3/2/%pi/(ns/60)*[(V/sqrt(3))^2*(P/S)/((Rs+P/S)^2+(
    R+X)^2)]
T2=T*(N2/N1)^2; //N-m
disp(T2,"Torque at 900 rpm in N-m : ");
Snew=(ns-N2)/ns; //slip
V=sqrt((T2/3*2*%pi*(ns/60))*((Rs+P/Snew)^2+(R+X)^2)
    /(P/Snew))*sqrt(3)
disp(V,"Voltage at speed of 900 rpm in Volts : ");
```

Scilab code Exa 6.19 Torque Speed Current and frequency

```
//Example No. 6.19
clc;
clear;
close;
format('v',7);

//Given Data :
V=415; //volt
P=4; //pole
f=50; //Hz
N=1370; //rpm
r1=2; //ohm
r2dash=3; //ohm
x1=3.5; //ohm
x2dash=3.5; //ohm
X0=55; //ohm
Ns=120*f/P; //rpm
S=(Ns-N)/Ns; //slip
```

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

Scilab code Exa 6.20 Find Motor Speed

```
//Example No. 6.20(page no. 196)
clc;
clear;
close;
format('v',7);

//Given Data :
Is=6;//A
f=40;//Hz
SlipSpeed=100;//rpm
V=415;//volt
P=4;//pole
r1=2;//ohm
r2dash=3;//ohm
x1=3.5;//ohm
```

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

Scilab code Exa 6.20.1 Find Maximum Torque

```
//Example No. 6.20(page no. 205)
clc;
clear;
close;
format('v',8);

//Given Data :
Pout=2500;//hp
V=2300;//volt
P=20;//pole
f=50;//Hz
Xs=1.77;//ohm/phase
Pout=Pout*735.5/1000;//KW
V=V/sqrt(3);//Volt/phase
cos_theta=1;
I=Pout*10^3/3/V/cos_theta;//A
Ixs=I*Xs;//V
E=sqrt(V^2+Ixs^2);//V
Pout_max=3*V*E/Xs/1000;//KW
Tmax=Pout_max*1000;//synch. Watts
```

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

Scilab code Exa 6.21 Power Output Torque and Speed

```
//Example No. 6.21
clc;
clear;
close;
format('v',9);

//Given Data :
Pout=2500;//hp
V1=2300;//volt
P=20;//pole
f=50;//Hz
Xs=1.77;//ohm/phase
Pout=Pout*735.5/1000;//KW
V=V1/sqrt(3);//Volt/phase
cos_theta=1;
I=Pout*10^3/3/V/cos_theta;//A
Ixs=I*Xs;//V
E=sqrt(V^2+Ixs^2);//V
del=acosd(V/E);//degree
Pout=3*V*E/Xs*cosd(del);//W
disp(Pout,"Part(a) Power output in W : ");
T=Pout;//synch. Watts
N=300;//rpm
ns=N/60;//rps
T=T/2/%pi/ns;//N-m
disp(T,"Part(a) Torque in N-m :");
f1=25;//Hz
N1=2*f1/P*60;//rpm
disp(N1,"Part(b) Speed in rpm : ");
```

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