Scilab Textbook Companion for Electrical Machines-2 by T. Singh[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

Synchronous machines

Scilab code Exa 1.1.p Distribution Factor

```
// Prob 1.1
clc;
clear;
close;
format('v',5);
// Given data
s=36;//no. of slots
p=4;//no. of poles
ph=3;//no. of phase
s1=s/ph;//no. of slots pe phase
m=s1/p;//no. of slots per pole per phase
alfa=180*p/s;//slot angle in degree
Kd=sind(m*alfa/2)/(m*sind(alfa/2));//distribution
   factor
disp(Kd,"Distribution factor for 36 slots : ");
```

Scilab code Exa 1.1 Single Layer Winding

```
//Exa 1.1
clc;
clear;
close;
//given data
slots=24;//no. of slotes
NoOfPhase=3;//no of phase
MotorSpeed=1450;//in rpm
N=1500;//Synchonous Speed in rpm
f=50;//in Hz
disp("As the winding is in single layer, each slot contains one coil slide only.");
CoilSlidePerSlot=1;//coil slide per slot
CoilSlidePerCoil=2;//coil slide per Coil
TotalCoils=slots*CoilSlidePerSlot/CoilSlidePerCoil;//no. of coils
disp(TotalCoils,"Total no. of Coils : ");
P=120*f/N;//no. of poles
disp(P,"No. of poles : ");
PolesPitch=slots/P;//unitless
disp(PolesPitch,"Poles Pitch = ");
disp("In case of single layer winding, the pole ppitch is generally taken in odd numbers only, such as 5,7.9 etc. One slot will remain unoccupied, if the pitch is taken as even number.");
disp("let pole pitch = 5(for short pitch winding)");
PolesPitch=5;//for short pitch winding
disp("Coil Span or coil through = 1-6");
CoilsPerPolePerPhase=TotalCoils/(P*NoOfPhase);//No. of Coils/Pole/Phase
disp(CoilsPerPolePerPhase,"No. of Coils/Pole/Phase = ");
pair_of_poles=2;//no. of pair of poles
TotalElectricalDegree=360*pair_of_poles;//in degree
ElectricalDegreesPerSlot=TotalElectricalDegree/slots;//in degree electrical
disp(ElectricalDegreesPerSlot,"Electrical Degrees/
```

```
   Slot = ");
Slots_required=120/ElectricalDegreesPerSlot;//No. of
    slotes required for proper phase displacement
disp(Slots_required,"No. of slotes required for
   proper phase displacement = ");
disp("Winding Table is as follows :");
disp("Coil No.      Connection Lead from      Coil
   Span      Phase and Group No.");
disp("    1                        A1                1-6
                    A1");
disp("    2                                          3-8
                    C4");
disp("    3                        B1                5-10
                   B1");
disp("    4                                          7-12
                   A2");
disp("    5                        C1                9-14
                   C1");
disp("    6                                         11-16
                   B2");
disp("    7                                         13-18
                   A3");
disp("    8                                         15-20
                   C2");
disp("    9                                         17-22
                   B3");
disp("   10                                         19-24
                   A4");
disp("   11                                         21-2
                    C3");
disp("   12                                         23-4
                    B4");
```

Scilab code Exa 1.2.p Distribution and pitch factor

```
// Prob 1.2
clc;
clear;
close;
format('v',5);
// Given data
s=24;//no. of slots
p=4;//no. of poles
ph=3;//no. of phase
s1=s/p;//no. of slots pe pole
alfa=180/s1;//slot angle in degree
m=s1/ph;//no. of slots per pole per phase
Kd=sind(m*alfa/2)/(m*sind(alfa/2));//distribution
    factor
disp(Kd,"Distribution factor : ");
Beta=alfa;//short pitched angle in degree
Kc=cosd(Beta/2);//coil span factor
disp(Kc,"Pitch factor : ");
```

Scilab code Exa 1.2 Coil basket winding

```
//Exa 1.2
clc;
clear;
close;
//given data
slots=24;//no. of slotes
P=4;//no. of poles
CoilPitch=5;//unitless
NoOfPhase=3;//no of phase
disp("As the winding is in double layer, each slot
    contains 2 coils per slide.");
CoilSlidePerSlot=2;//coil slide per slot
CoilSlidePerCoil=2;//coil slide per Coil
TotalCoils=slots*CoilSlidePerSlot/CoilSlidePerCoil;
```

```
//no. of coils
disp(TotalCoils,"Total no. of Coils : ");
PolesPitch=slots/P;//unitless
disp(PolesPitch,"Pole Pitch = ");
CoilsPerPolePerPhase=TotalCoils/(P*NoOfPhase);//No. of Coils/Pole/Phase
disp(CoilsPerPolePerPhase,"No. of Coils/Pole/Phase = ");
pair_of_poles=2;//no. of pair of poles
TotalElectricalDegree=360*pair_of_poles;//in degree
ElectricalDegreesPerSlot=TotalElectricalDegree/slots;//in degree electrical
disp(ElectricalDegreesPerSlot,"Electrical Degrees/Slot = ");
Slots_required=120/ElectricalDegreesPerSlot;//No. of slotes required for proper phase displacement
disp(Slots_required,"No. of slotes required for proper phase displacement = ");
disp("ie. Phase A1 is brought out from slot no. = 1");
disp("Phase B1 at slot no. = 1+4 = 5");
disp("Phase C1 at slot no. = 5+4 = 9");
disp("Col Connection - end to start to start");
disp("Winding Table is as follows :");
disp("Coil No.      Connection Lead from      Coil Span      Phase and Group No.");
disp("    1                    A1                    1-6                    A1");
disp("    2                                          2-7                    ");
disp("    3                                          3-8                    C4");
disp("    4                                          4-9                    ");
disp("    5                    B1                    5-10                   B1");
disp("    6                                          6-11                   ");
```

```
disp("    7                                   7-12
                  A2");
disp("    8                                   8-13
                    ");
disp("    9                  C1               9-14
                  C1");
disp("   10                                  10-15
                    ");
disp("   11                                  11-16
                  B2");
disp("   12                                  12-17
                    ");
disp("   13                                  13-18
                  A3");
disp("   14                                  14-19
                    ");
disp("   15                                  15-20
                  C2");
disp("   16                                  16-21
                    ");
disp("   17                                  17-22
                  B3");
disp("   18                                  18-23
                    ");
disp("   19                                  19-24
                  A4");
disp("   20                                  20-1
                     ");
disp("   21                                  21-2
                   C3");
disp("   22                                  22-3
                     ");
disp("   23                                  23-4
                     ");
disp("   24                                  24-5
                   B4");
```

Scilab code Exa 1.3.p Poles and Voltage

```
// Prob 1.3
clc;
clear;
close;
format('v',5);
// Given data
VL=11000;//in volt
N=1500;//in rpm
f=50;//in Hz
P=120*f/N;//no. of poles
disp(P,"No. of poles : ");
VP=VL/sqrt(3);//voltage per phase in volt
disp(VP,"Voltage per phase of alternator(in volt) :
    ");
```

Scilab code Exa 1.3 Pitch factor

```
//Exa 1.3
clc;
clear;
close;
//given data
format('v',4);
StatorSlots=36;//No. of stator slots
Poles=4;//No. of poles
coilSpan=1:8;//unitless
SlotsPerPole=StatorSlots/Poles;// no. of slots per
    pole
disp(SlotsPerPole,"Slots/Pole = ");
```

```
disp("Here the coil span falls short by, "+string((2/9)*180)+" Degree");
alfa=40;//short pitch angle in degree
Kp=cosd(alfa/2);//Coil span Factor
disp(Kp,"Pitch Factor or coil span factor : ");
```

Scilab code Exa 1.4.p Distribution and pitch factor

```
// Prob 1.4
clc;
clear;
close;
format('v',7);
// Given data
s=36;//no. of slots
p=4;//no. of poles
ph=3;//no. of phase
CoilSpan=8;//short pitch winding
alfa=180/(s/p);//slot pitch in degree
m=s/(p*ph);//no. of slots per pole per phase
Kd=sind(m*alfa/2)/(m*sind(alfa/2));//distribution factor
disp(Kd,"Distribution factor : ");
CoilSpan1=s/p;//coil span for full pitch winding
slots_sp=CoilSpan1-CoilSpan;//slots by which coil is short pitched
Beta=slots_sp*alfa;//angle by which coil is short pitched
Kc=cosd(Beta/2);//Pitch factor
disp(Kc,"Pitch factor : ");
```

Scilab code Exa 1.4 Frequency phase and emf

```
//Exa 1.4
clc;
clear;
close;
//given data
format('v',8);
NoOfPhase=3;//no of phase
P=16;//No. of pole alternator
Slots=144;//No. of slots
Conductors=10;//per slot
fi=0.03;//in Weber
N=375;//machine speed in rpm
f=P*N/120;//in Hz
SlotsPerPole=Slots/P;//unitless
m=Slots/(P*NoOfPhase);//unitless
Beta=180/(SlotsPerPole);//in Degree
Kd=sind(m*Beta/2)/(m*sind(Beta/2));//unitless
TotalConductors=Conductors*Slots;//no. of conductors
TotalConductorsPerPhase=Conductors*Slots/NoOfPhase;//no. of conductors/phase
TurnsPerPhase=TotalConductorsPerPhase/2;//No. of turns per phase
EMFPerPhase=4.44*Kd*fi*f*TurnsPerPhase;//in Volt
LineVoltage=sqrt(3)*EMFPerPhase;//in Volt
disp(f,"Frequency in Hz : ");
disp(EMFPerPhase,"Phase Electromotive force in Volt : ");
disp(LineVoltage,"Line Electromotive force in Volt : ");
```

Scilab code Exa 1.5.p Frequency and line emf

```
// Prob 1.5
clc;
clear;
```

```
close;
format('v',6);
// Given data
ph=3;//no. of phase
P=16;//no. of poles
s=144;//no. of slots
con=10;//no. of conductors per slot
fi=0.035;//in Wb
N=375;//in rpm
f=P*N/120;//in Hz
disp(f,"Frequency in Hz : ");
s1=s/P;//no. of slots per pole
m=s1/ph;//no. of slots per pole per phase
alfa=180/s1;//slot angle in degree
Kd=sind(m*alfa/2)/(m*sind(alfa/2));//distribution factor
TotCon=s*con;//Total no. of conductors
TotCon1=s*con/ph;//Total no. of conductors
n=TotCon1/2;//no. of turns per phase
EMF=4.44*Kd*fi*f*n;//EMF per phase in volt
disp(EMF,"EMF per phase in volt : ");
VL=sqrt(3)*EMF;//line voltage in volt
disp(VL,"Line EMF in volt : ");
```

Scilab code Exa 1.5 Breadth factor

```
//Exa 1.5
clc;
clear;
close;
//given data
format('v',6);
NoOfPhase=3;//no of phase
SlotsPerPhase=3;//o. of slots
m=SlotsPerPhase;//no. of slots
```

```
SlotsPerPolePerPhase=SlotsPerPhase*NoOfPhase;//unitless
Beta=180/SlotsPerPolePerPhase;//in degree
disp("The phase difference difference between the induced emf in two coils lying in adjacent slots = "+string(Beta)+" degree");
Kb=sind(m*Beta/2)/(m*sind(Beta/2));//unitless
disp(Kb,"The breadth factor :  ");
```

Scilab code Exa 1.6.p Distribution factor and pitch factor

```
// Prob 1.6
clc;
clear;
close;
format('v',7);
// Given data
ph=3;//no. of phase
P=4;//no. of poles
s=36;//no. of slots
coilspan=8;//short pitch winding
alfa=180/(s/P);//slot pitch in degree
m=s/P/ph;//no. of slots per pole per phase
Kd=sind(m*alfa/2)/(m*sind(alfa/2));//distribution factor
disp(Kd,"Distribution factor : ");
coilspan1=s/P;//coil span for full pitch winding
s1=coilspan1-coilspan;//no. of slots by which the coil is short pitched
Beta=s1*alfa;//angle by which the coil is short pitched in degree
Kc=cosd(Beta/2);//pitch factor
disp(Kc,"Pitch factor : ");
```

Scilab code Exa 1.6 Pitch factor

```
//Exa 1.6
clc;
clear;
close;
//given data
format('v',7);
StatorSlots=24//No. of stator slots
Poles=4;//No. of poles
SlotsPerPole=StatorSlots/Poles;// no. of slots per pole
coilSpan=1:6;//unitless
disp("If the sides of the coil are placed in slots 1 and 7, then it is full pitched, but if the coil slides are placed in 1 and 6 then it is short pitched and the distance equal to 5/6th of pole-pitch.");
disp("Since it falls short by 1/6th of the pole-pitch, hence it is short by :")
theta=180/SlotsPerPole;//in Degree
disp(string(theta)+" Degree.")
Kp=cosd(theta/2);//unitless
disp(Kp,"Pitch-factor Kp : ");
```

Scilab code Exa 1.7.p Useful flux per pole

```
// Prob 1.7
clc;
clear;
close;
format('v',6);
```

```
// Given data
EL=6600;//in volt
ph=3;//no. of phase
P=4;//no. of poles
f=50;//in Hz
s=60;//no. of slots
con=2;//no. of conductors/slot
coilslot=13-1;//
n=s/P;//Slot per pole
m=n/ph;//Slot per pole per phase
Zp=s*con/ph;//no. of conductors connected in series/phase
Beta=180/n;//in degree
Kd=sind(m*Beta/2)/(m*sind(Beta/2));//distribution factor
coilspan=coilslot*180/n;//coil span in degree
Kp=cosd((180-144)/2);//Coil apan factor
//formu;a : EL=sqrt(3)*4.44*Kd*Kp*fi*f*T;//in volt
T=20;//assumed
fi=EL/(sqrt(3)*4.44*Kd*Kp*f*T);//in Wb
disp(fi,"Useful flux per pole in Wb : ");
//Note : Answer in the book is by mistake given in volts.
```

Scilab code Exa 1.7 Flux per pole

```
//Exa 1.7
clc;
clear;
close;
//given data
format('v',7);
NoOfPhase=3;//no of phase
Eph=3300/sqrt(3);//in Volts
f=50;//in Hz
```

```
Poles=12;//No. of poles
StatorSlots=144//No. of stator slots
SlotsPerPhase=StatorSlots/NoOfPhase;//no. of slots/
   phase
Conductors=5;//per slot
ConductorsPerphase=SlotsPerPhase*Conductors;//
   Conductors/Phase
S=ConductorsPerphase;//Conductors/phase
SlotsPerPolePerPhase=SlotsPerPhase/Poles;//no. of
   slots/phase
Kf=1.11;//Form Factor
Kb=0.96;//Breadth Factor
Kp=1;//For concentric winding
fi=Eph/(2*Kf*Kb*Kp*S*f);//in weber
disp(fi,"The Flux per pole in weber : ");
```

Scilab code Exa 1.8.p Regulation

```
// Prob 1.8
clc;
clear;
close;
format('v',5);
// Given data
ph=3;//no. of phase
P=10;//in KVA
VL=230;//in volt
Xs=1.2;//in ohms/phase
Ra=0.5;//in ohm/phase
VP=VL/sqrt(3);//in volt
I=P*10^3/(3*VP);//in Ampere
cosfi=0.8;//Power factor
sinfi=sind(acosd(cosfi));//
//Power factor 0.8 lagging
Eo=sqrt((VP*cosfi+I*Ra)^2+(VP*sinfi+I*Xs)^2);//in
```

```
volt
Regulation=(Eo-VP)/VP*100;//in %
disp(Regulation,"% regulation when power factor lagging : ");
//Power factor 0.8 leading
Eo=sqrt((VP*cosfi+I*Ra)^2+(VP*sinfi-I*Xs)^2);//in volt
Regulation=(Eo-VP)/VP*100;//in %
disp(Regulation,"% regulation when power factor leading : ");
```

Scilab code Exa 1.8 Speed and line emf

```
//Exa 1.8
clc;
clear;
close;
//given data
format('v',7);
Phase=3;//no. of phase
f=50;//in Hz
P=16;//No. of pole alternator
Slots=144;//No. of slots
conductors=10;//conductors per slot
fi=2.48*10^-2;//in weber
n=Slots/P;//No. of slots/pole
Zr=Slots*conductors/Phase;//No. of conductors/Phase
T=Zr/2;//N. of turns/phase
Beta=180/n;//Angular displacement between slots in degree
m=n/Phase;//No. of slots/pole/Phase
Kd=sind(m*Beta/2)/(m*sind(Beta/2));//Distribution factor :unitless
disp("The coil span falls short of 2 slots i.e. "+string(2*180/9)+" degree.");
```

```
alfa=40;//short pitch angle in degree
Kp=cosd(alfa/2);//Unitless
//Formula : f=P*N/120;//in Hz
N=120*f/P;//in rpm
Ep=4.44*Kd*Kp*fi*f*T;//in Volts
LineVoltage=sqrt(3)*Ep;//in Volts
disp("The speed is "+string(N)+" in rpm");
disp("The line emf is "+string(LineVoltage)+" Volts"
    );
//Note : Answer in the book is not accurate.
```

Scilab code Exa 1.9.p No of armature conductor

```
// Prob 1.9
clc;
clear;
close;
format('v',5);
// Given data
f=50;//in Hz
ph=3;//no. of phase
EL=10000;//in volt
fi=15*10^-2;//in Wb
Kd=0.96;//unitless
Kp=1;//unitless
P=10;//in KVA
T=EL/(sqrt(3)*4.44*Kd*Kp*fi*f);//turns/phase
Zp=2*T;//armature conductor connected in series per
    phase
disp(Zp,"Armature conductor connected in series per
    phase : ");
//Note : Answer in the book is wrong.
```

Scilab code Exa 1.9 Full load percentage regulation

```
//Exa 1.9
clc;
clear;
close;
//given data
format('v',6);
RatedPower=100;//in KVA
RatedPower=100*1000;//in VA
VL=1040;//in Volt
Phase=3;//Machine phase
If=40;//in Ampere
Isc=200;//in Ampere
EL=1040;//in Volt
Eph=EL/sqrt(3);//in Volt
Zs=Eph/Isc;//in Ohm
Rs=0.2;//in Ohm
Xs=sqrt(Zs^2-Rs^2);//in Ohm
IL=19.25;//in Ampere
V=3000/sqrt(3);//in Volt
//At 0.8 power factor lagging
IRa=IL*0.2;//in Volt
IXs=IL*Xs;//in Volt
Vsin_fi=V*0.6;//in Volt
Vcos_fi=V*0.8;//in Volt
Eo=sqrt((Vcos_fi+IRa)^2+(Vsin_fi+IXs)^2);//in Volts
Regulation=((Eo-V)/V)*100;//in %
disp(Regulation,"Full load perentage regulation at a
    power factor of 0.8 lagging : ");

//At 0.8 power factor leading
Eo=sqrt((Vcos_fi+IRa)^2+(Vsin_fi-IXs)^2);//in Volts
Regulation=((Eo-V)/V)*100;//in %
disp(Regulation,"Full load perentage regulation at a
    power factor of 0.8 leading : ");
disp("Negative regulation due to leading power
    factor.");
```

Scilab code Exa 1.10.p No of Armature conductor

```
// Prob 1.10
clc;
clear;
close;
format('v',5);
// Given data
f=50;//in Hz
ph=3;//no. of phase
EL=10000;//in volt
fi=15*10^-2;//in Wb
Kd=0.96;//unitless
Kp=1;//unitless
P=10;//in KVA
T=EL/(sqrt(3)*4.44*Kd*Kp*fi*f);//turns/phase
Zp=2*T;//armature conductor connected in series per
    phase
disp(Zp,"Armature conductor connected in series per
    phase : ");
//Note : Answer in the book is wrong.
```

Scilab code Exa 1.10 Full load regulation

```
//Exa 1.10
clc;
clear;
close;
//given data
format('v',6);
RatedPower=50;//in KVA
```

```
RatedPower=50*1000;//in VA
VL=173;//in Volts
Ra=0.1;//in Ohm
VP=VL/sqrt(3);//in Volts
disp("Some exciting curent on short circuit produces
    a current of 100 A.");
OC_PhaseVoltage=100;//in Volt
SC_Current=100;//in Ampere
Zs=OC_PhaseVoltage/SC_Current;//n ohm
Xs=sqrt(Zs^2-Ra^2);//in Ohm
disp(Xs,"Impedence of the alternator in Ohm : ");
V=400;//in Volts
I_FL=RatedPower/(sqrt(3)*V);//in Ampere
V=400/sqrt(3);//in Volts
Eo=sqrt((V+I_FL*Ra)^2+(I_FL*Xs)^2);//in Volts
Regulation=(Eo-V)*100/V;//in %
disp(Regulation,"Regulation at U.P.F. in % :");
```

Scilab code Exa 1.11.p Min current and emf

```
// Prob 1.11
clc;
clear;
close;
format('v',5);
// Given data
VL=400;//in volt
Output=10;//in HP
Output=Output*735.5;//in watts
m=3;//no. of phase
Xo=10;//in ohm/phase
Eff=85;//in %
Input=Output/(Eff/100);//in watts
//Formula : Input=sqrt(3)*VL*IL*cosfi
ILcosfi=Input/sqrt(3)/VL;//in Ampere
```

```
ILmin=ILcosfi;//in Ampere
disp(ILcosfi,"Minimum current by putting cosfi=1 in
    Ampere is :  ");
ER=ILmin*Xo;//in ohm
V=VL/sqrt(3);//supply voltage per phase in volt
E=sqrt(V^2+ER^2);//in volt
LineEMF=sqrt(3)*E;//in volt
disp(LineEMF,"Line Induced emf in volt : ");
```

Scilab code Exa 1.11 Voltage regulation at Full load

```
//Exa 1.11
clc;
clear;
close;
//given data
format('v',7);
OutputPower=500;//in KVA
OutputPower=500*1000;//in VA
VL=3300;//in Volts
Ra=0.3;//in Ohm
Xs=4;//in Ohm
PF=0.8;//Lagging Power factor
//Formula : outputPower=sqrt(3)*VL*IL
IL=OutputPower/(sqrt(3)*VL);//in Ampere
disp("For a star connected alternator, line current
    is equal to phase current. Therefore Ia=IL");
Ia=IL;//in Ampere
//PF=cosd(fi)=0.8 and sind(fi)=0.6
cos_fi=0.8;//Power factor
sin_fi=0.6;//Unitless
VPerPhase=VL/sqrt(3);//in Volts
E=sqrt((VPerPhase*cos_fi+Ia*Ra)^2+(VPerPhase*sin_fi+
    Ia*Xs)^2);//in Volts/Phase
Regulation=(E-VPerPhase)*100/VPerPhase;//in %
```

```
disp(Regulation,"Voltage Regulation at Full Load in
   % :");
```

Scilab code Exa 1.12.p Line EMF

```
// Prob 1.12
clc;
clear;
close;
format('v',6);
// Given data
P=6;//no. of poles
phase=3;//no. of phase
f=50;//in Hz
S=12;//slots per pole
C=4;//conductor per slot
FullPitch=5/6;//unitless
fi=25;//in mwb
fi=fi*10^-3;//in wb
Zph=C*S*P/phase;//no. of conductors in series per
   phase
T=Zph/2;//no. of turns per phase
alfa=180*(1-FullPitch);//in degree
Kc=cosd(alfa/2);//unitless
m=S/phase;//no. of slot per pole per phase
Beta=180/S;//in degree
Kd=sind(m*Beta/2)/m/sind(Beta/2);//unitless
Eph=4.44*Kc*Kd*f*fi*T;//in volt
EL=sqrt(3)*Eph;//in volt
disp(EL,"Line emf in volt : ");
```

Scilab code Exa 1.12 Voltage regulation

```
//Exa 1.12
clc;
clear;
close;
//given data
format('v',7);
V=2000;//in Volt
Ia=100;//in Ampere
OC_Voltage=500;//in Volt
SC_Current=100;//in Ampere
Zs=OC_Voltage/SC_Current;//in ohm
Ra=0.8;//in Ohm
Xs=sqrt(Zs^2-Ra^2);//in Ohm
//formula : Induced EMF, E=sqrt((V*cos_fi+Ia*Ra)^2+(
   V*sin_fi+Ia*Xs)^2)
//Part (a)  : at unity pf
cos_fi=1;//Unitless
sin_fi=0;//Unitless
E=sqrt((V*cos_fi+Ia*Ra)^2+(V*sin_fi+Ia*Xs)^2)
Regulation=(E-V)*100/V;//in %
disp(Regulation,"Regulation at U.P.F. in % :");

//Part (b)  : at 0.71 pf lagging
cos_fi=0.71;//Unitless
sin_fi=0.704;//Unitless
E=sqrt((V*cos_fi+Ia*Ra)^2+(V*sin_fi+Ia*Xs)^2)
Regulation=(E-V)*100/V;//in %
disp(Regulation,"Regulation at 0.71 pf lagging in %
   :");

//Part (c)  : at 0.8 pf leading
cos_fi=0.8;//Unitless
sin_fi=0.6;//Unitless
E=sqrt((V*cos_fi+Ia*Ra)^2+(V*sin_fi-Ia*Xs)^2)
Regulation=(E-V)*100/V;//in %
disp(Regulation,"Regulation at 0.8 pf leading in % :
   ");
```

Scilab code Exa 1.13.p Power current and power factor

```
// Prob 1.13
clc;
clear;
close;
format('v',7);
// Given data
V=2300;//in volt
P=1200//in KW
IA=200;//in Ampere
cosfi_a=0.9;//lagging power factor
PA=V*IA*cosfi_a*10^-3;//in KW
fi_a=acosd(cosfi_a);//in degree
Pra=PA*tand(fi_a);//in KVAR
Pr=0;//because pf is unity
Prb=Pr-Pra ;//in KVAR
PB=P-PA;//in KW
disp(PB,"Power of alternator B in KW : ");
tanfi_b=Prb/PB;//unitless
cosfi_b=cosd(atand(tanfi_b));//leading power factor
disp(cosfi_b,"Leading power factor of alternator B :
    ");
IB=PB*10^3/V/cosfi_b;//in Ampere
disp(IB,"Current in alternator B in Ampere : ");
```

Scilab code Exa 1.13 Internal voltage drop

```
//Exa 1.13
clc;
clear;
close;
```

```
//given data
Ia=60;//in Ampere
disp("EMF induced on 900 Volt on open circuit can be ragarded as being responsible for circulationg short circuit current of 150 mA, through the synchronous impedence of the winding when the excitation current is 10 mA.");
disp("The value of synchronous impedence at this excitation :") ;
OC_Voltage=900;//in Volt
SC_Current=150;//in Ampere
Zs=OC_Voltage/SC_Current;//in ohm
disp("Zs equals to "+string(Zs)+" Ohm");
disp("Internal Voltage drop when tthe load current is 60A=Ia*Zs="+string(Ia*Zs)+" Volts");
```

Scilab code Exa 1.14.p KW output and PF

```
// Prob 1.14
clc;
clear;
close;
format('v',7);
// Given data
P1=600//Lightning load in KW
cosfi_1=1;
tanfi_1=tand(acosd(cosfi_1));
P2=800//Inductive load in KW
cosfi_2=.9;//lagging
tanfi_2=tand(acosd(cosfi_2));
P3=800//Capacitive load in KW
cosfi_3=.8;//leading
tanfi_3=-tand(acosd(cosfi_3));//taken -ve
PA=1000;//in KW
cosfi_A=.85;//lagging pf
```

```
tanfi_A=tand(acosd(cosfi_A));
Pre=P1*tanfi_1;//in KVAR
Pri=P2*tanfi_2;//in KVAR
Prc=P3*tanfi_3;//in KVAR
P=P1+P2+P3;//in KW
Pr=Pre+Pri+Prc;//in KVAR
Pra=PA*tanfi_A;//in KVAR
PB=P-PA;//in KW
disp(PB,"Active power supplied by alternator B in KW
    : ");
Prb=Pr-Pra;//in KVAR
tanfi_B=Prb/PB;//unitless
cosfi_B=cosd(atand(tanfi_B));//unitless
disp(cosfi_B,"Power factor of alternator B(leading)
    : ");
```

Scilab code Exa 1.14 Change in terminal voltage

```
//Exa 1.14
clc;
clear;
close;
//given data
format('v',5);
V=6600;//in Volts
OutputPower=2000;//in KVA
OutputPower=2000*1000;//in VA
//Formula : outputPower=sqrt(3)*VL*IL
IL=OutputPower/(sqrt(3)*V);//in Ampere
Ia=IL;//in Ampere
Ra=0.4;//in Ohm
Xs=4.5;//in Ohm
//PF=cosd(fi)=0.8 and sind(fi)=0.6
cos_fi=0.8;//Power factor
sin_fi=0.6;//Unitless
```

```
VPerPhase=V/sqrt(3);//in Volts
E=sqrt((VPerPhase*cos_fi+Ia*Ra)^2+(VPerPhase*sin_fi+
    Ia*Xs)^2);//in Volts/Phase
Regulation=(E-VPerPhase)*100/VPerPhase;//in %
disp(Regulation,"Percentage Change in Terminal
    Voltage :");
```

Scilab code Exa 1.15.p EMF and Angular retardation

```
// Prob 1.15
clc;
clear;
close;
format('v',7);
// Given data
P=1000//in KVA
VL=11000;//in volt
m=3;//no. of phase
Ra=3.5;//in ohm/phase
Xa=40;//in ohm/phase
Ia=P*1000/(VL*sqrt(3));//in Ampere
V=VL/sqrt(3);//in volt
cosfi=0.8;
fi=acosd(cosfi);//in degree
Va_resistance=Ia*Ra;//drop in resistance in volt
Va_reactance=Ia*Xa;//drop in reactance in volt
ER=sqrt(Va_resistance^2+Va_reactance^2);
tan_theta=Xa/Ra;//unitless
theta=atand(tan_theta);//in degree
//Part (a)
Eb=sqrt(V^2+ER^2-2*V*ER*cosd(theta));//in V/phase
Eline=sqrt(3)*Eb;//in Volt
disp(Eline,"(a) Induced emf(V) : ");
//Applying sine rule
alfa=asind(ER/Eb*sind(theta));//in degree
```

```
disp("Angular retardation "+string(floor(alfa))+"
    degree "+string(floor(60*(alfa-floor(alfa))))+"
    min");
//Part (b)
Eb=sqrt(V^2+ER^2-2*V*ER*cosd(theta-fi));//in V/phase
Eline=sqrt(3)*Eb;//in Volt
disp(Eline,"(b) Induced emf(V) : ");
//Applying sine rule
alfa=asind(ER/Eb*sind(theta-fi));//in degree
disp("Angular retardation "+string(floor(alfa))+"
    degree "+string(floor(60*(alfa-floor(alfa))))+"
    min");
//Part (c)
Eb=sqrt(V^2+ER^2-2*V*ER*cosd(theta+fi));//in V/phase
Eline=sqrt(3)*Eb;//in Volt
disp(Eline,"(c) Induced emf(V) : ");
//Applying sine rule
alfa=asind(ER/Eb*sind(theta+fi));//in degree
disp("Angular retardation "+string(floor(alfa))+"
    degree "+string(floor(60*(alfa-floor(alfa))))+"
    min");
//Note : Figure given in this question is not a plot
    . It is just drawn to represent data and can't be
     plotted.
//Note : Answers in the book is not as much accurate
     as calculated by Scilab.
```

Scilab code Exa 1.15 Regulation on full load

```
//Exa 1.15
clc;
clear;
close;
//given data
format('v',7);
```

```
OutputPower=1200;//in KVA
OutputPower=1200*1000;//in VA
V=3300;//in Volt
Ra=0.25;//in Ohm
//Formula : outputPower=sqrt(3)*VL*IL
IL=OutputPower/(sqrt(3)*V);//in Ampere
Ia=IL;//in Ampere
VPerPhase=V/sqrt(3);//in Volts
OC_Voltage=1100;//in Volt
SC_Current=200;//in Ampere
Zs=OC_Voltage/(sqrt(3)*SC_Current);//in ohmRa
Xs=sqrt(Zs^2-Ra^2);//in Ohm
//formula : Induced EMF, E=sqrt((V*cos_fi+Ia*Ra)^2+(V*sin_fi+Ia*Xs)^2)

//Part (a) : For lagging pf load
cos_fi=0.8;//Unitless
sin_fi=0.6;//Unitless
E=sqrt((VPerPhase*cos_fi+Ia*Ra)^2+(VPerPhase*sin_fi+Ia*Xs)^2);
Regulation=(E-VPerPhase)*100/VPerPhase;//in %
disp(Regulation,"Regulation at U.P.F. in % :");

//Part (b) : For leading pf load
cos_fi=0.8;//Unitless
sin_fi=0.6;//Unitless
E=sqrt((VPerPhase*cos_fi+Ia*Ra)^2+(VPerPhase*sin_fi-Ia*Xs)^2)
Regulation=(E-VPerPhase)*100/VPerPhase;//in %
disp(Regulation,"Regulation at 0.71 pf lagging in % :");
//Note: For leading power factor load, the regulation s negative.
```

Scilab code Exa 1.16.p Terminal voltage and reactive power

```
// Prob 1.16
clc;
clear;
close;
format('v',7);
// Given data :
EP=6000;//in volt
Em=EP;//in Volt
Xs=1.5;//in ohm/phase
IL=1000;//in Ampere
VT=Em-IL*Xs;//in volt
disp(VT,"Terminal voltage in volt : ");
VL=sqrt(3)*VT;//in volt
sinfi=1;
Preactive=sqrt(3)*VL*IL*sinfi;//in VAR
disp(Preactive/10^6,"Reactive Power(MVAR) : ");
```

Scilab code Exa 1.16 Terminal voltage

```
//Exa 1.16
clc;
clear;
close;
//given data
OutputPower=1500;//in KVA
OutputPower=1500*1000;//in VA
V=6600;//in Volt
Ra=0.4;//in Ohm
Xs=6;//in Ohm per phase
pf=0.8;//lagging power factor
//Formula : outputPower=sqrt(3)*VL*IL
Ia=OutputPower/(sqrt(3)*V);//in Ampere
VPerPhase=V/sqrt(3);//in Volts
//formula : Induced EMF, E=sqrt((V*cos_fi+Ia*Ra)^2+(
    V*sin_fi+Ia*Xs)^2)
```

```
cos_fi=0.8;//Unitless
sin_fi=0.6;//Unitless
E=sqrt((VPerPhase*cos_fi+Ia*Ra)^2+(VPerPhase*sin_fi+
    Ia*Xs)^2);//in volt
disp(E,"Induced emf in volt : ");
disp("As excitation remains constant, E at 4364 volt
     remains constant.");
E=4364;//in Volt
disp("Let the terminal voltage for the same
    excitation and load current at 0.8 power factor
    leading be V.");
disp("4364=sqrt((V*cos_fi+Ia*Ra)^2+(VPerPhase*sin_fi
    +Ia*Xs)^2)");
disp("V=4743 Volts");
V=4743;//in Volts
TerminalVoltage=sqrt(3)*V;//in Volts
disp(TerminalVoltage,"Terminal voltage line to line
    in Volts : ");
//Note ans of 1st part is wrong in the book.s
```

Scilab code Exa 1.17.p EMF and Torque

```
// Prob 1.17
clc;
clear;
close;
format('v',6);
// Given data :
Poles=4;//no. of poles
m=3;//no. of phase
f=50;//in Hz
V=7000;//in volt/phase
I=1400;//in A/phase
Xs=1.2;//in ohm/phase
E=sqrt(V^2+(I*Xs)^2);//in volt
```

```
disp(E,"Induced emf in volt : ");
cosfi=1;//for resistive load
P=3*V*I*cosfi;//in watts
P=P/10^6;//in MWatts
N=120*f/Poles;//in rpm
w=2*%pi*N/60;//in radian per sec
T=P*10^6/w;//in Nw-m
T=T/9.81;//in Kg-m
disp(T,"Torque in Kg-m : ");
//Note : Answers in the book is not as much accurate
    as calculated by Scilab.
//Note : Figure given in this question is not a plot
   . It is just drawn to represent data and can't be
    plotted.
```

Scilab code Exa 1.17 KW output and pf

```
//Exa 1.17
clc;
clear;
close;
//given data
OutputPower=2500;//in KVA
OutputPower=2500*1000;//in VA
V=6600;//in Volt


//For first load i.e. Lighting load :
KW1=2500;//in KWatts
KVAR1=0;//Kwatts
//For second load i.e. Motor load :
KW2=5000;//in KWatts
cos_fi=0.707;//unitless
sin_fi=0.707;//unitless
KVAR2=KW2*sin_fi/cos_fi;//Kwatts
```

```
//For total load
TotalKW=KW1+KW2;//in KWatts
TotalKVAR=KVAR1+KVAR2;//Kwatts
//For first Machine
KWm=4000;//in KWatts
cos_fi=0.8;//unitless
sin_fi=0.6;//unitless
KVARm=KWm*sin_fi/cos_fi;//Kwatts
//so, second machine will be supplying
KW=TotalKW-KWm;//in Kwatts
disp(KW,"KW output of second machine : ");
KVAR=TotalKVAR-KVARm;//in KWatts
tan_fi=KVAR/KW;//unitless
fi=atand(tan_fi);//ib degree
//Power factor of other machine
pf=cosd(fi);//unitless
disp("Power factor of other machine : "+string(pf)+"
    lagging");
```

Scilab code Exa 1.18.p Current per phase

```
// Prob 1.18
clc;
clear;
close;
format('v',6);
// Given data :
Poles=2;//no. of poles
m=3;//no. of phase
f=50;//in Hz
Ep=5700;//in volt
Xs=1.5;//in ohm/phase
Iphase=Ep/Xs;//in Ampere
IL=Iphase;//in Ampere
disp(IL,"Line current in Ampere : ");
```

Scilab code Exa 1.18 KW output and pf

```
//Exa 1.18
clc;
clear;
close;
//given data
//Load1 :
KW1=500;//in KWatts
KVAR1=0;//Kwatts
//Load2 :
KW2=1000;//in KWatts
pf=0.9;//lagging
cos_fi=0.9;//unitless
fi=acosd(pf);
sin_fi=sind(fi);//unitless
KVAR2=KW2*sin_fi/cos_fi;//Kwatts
//Load3 :
KW3=800;//in KWatts
pf=0.8;//lagging
cos_fi=0.8;//unitless
fi=acosd(pf);
sin_fi=sind(fi);//unitless
KVAR3=KW3*sin_fi/cos_fi;//Kwatts
//Load4 :
KW4=500;//in KWatts
pf=0.9;//lagging
cos_fi=0.9;//unitless
fi=acosd(pf);
sin_fi=sind(fi);//unitless
KVAR4=-KW4*sin_fi/cos_fi;//Kwatts
//TOtalKW and TotalKVAR
TotalKW=KW1+KW2+KW3+KW4;//in KWatts
TotalKVAR=KVAR1+KVAR2+KVAR3+KVAR4;//in KWAtts
```

```
//For the first Machine :
KW=1500;//n Kwatts
cos_fi=0.95;//unitless
sin_fi=0.3123;//unitless
KVAR=KW*sin_fi/cos_fi;//Kwatts

KW1=TotalKW-KW;//in KWatts
KVAR1=TotalKVAR-KVAR;//in Volts
disp("KW supplied by other machine : "+string(
    TotalKW-KW));
disp("KVAR supplied by other machine : "+string(
    TotalKVAR-KVAR));
tan_fi=KVAR1/KW1;//unitless
//fi=atand(tan_fi);//in degree
cos_fi=cosd(atand(tan_fi));//unitless
disp("Power factor of the other machine : "+string(
    cos_fi));
```

Scilab code Exa 1.19.p Torque and Speed

```
// Prob 1.19
clc;
clear;
close;
format('v',8);
// Given data :
Poles=2;//no. of poles
m=3;//no. of phase
f=50;//in Hz
VT=15;//in volt
Ps=100;//in MVA
cosfi=0.8;//lagging
Xs=0.7;//in ohm/phase
VP=VT/sqrt(3);//in Volt
AC=VT*cosfi;//in KV
```

```
sinfi=sind(acosd(cosfi));
BC=VT*sinfi;//in KV
IL=Ps*10^6/sqrt(3)/(VT*10^3);//in Ampere
BL=IL*Xs;//voltage drop in volt
LC=BL+BC;//in volt
AL=sqrt(AC^2+LC^2);//in volt
EmLine=AL*sqrt(3);//in volt
Ns=120*f/Poles;//ion rpm
P=Ps*10^6*cosfi;//in watts
T=P*60/2/%pi/Ns;//in Nw-m
disp(T,"Torque in Nw-m : ");
disp(Ns,"Speed in rpm is ");
//Note : Figure given in this question is not a plot
    . It is just drawn to represent data and can't be
     plotted.
```

Scilab code Exa 1.19 Load and pf

```
//Exa 1.19
clc;
clear;
close;
//given data
//Lighting Load :
MW1=20;//load in Mwatts
KW1=MW1*1000;//in KWatts
KVAR1=0;//Kwatts
//Motor Load :
MW2=40;//load in Mwatts
KW2=MW2*1000;//in KWatts
pf=0.8;//unitless
cos_fi=0.8
fi=acosd(pf);
sin_fi=sind(fi);//unitless
KVAR2=KW2*sin_fi/cos_fi;//Kwatts
```

```
//For Total Load :
TotalKW=KW1+KW2;//load in Mwatts
TotalKVAR=KVAR1+KVAR2;//in KWatts
//For first machine :
MWm=32;//load in Mwatts
KWm=MWm*1000;//in KWatts
cos_fi=0.866;//unitless
fi=acosd(cos_fi);
tan_fi=tand(fi);//unitless
KVARm=KWm*tan_fi;//in KWatts
//so, load supplied by the second machine
KW2=TotalKW-KWm;//in Kwatts
disp("Load of other machine,KW : "+string(KW2));
KVAR2=TotalKVAR-KVARm;//in Kwatts
tan_fi=KVAR2/KW2;//unitless
fi=atand(tan_fi);//in degree
cos_fi=cosd(atand(tan_fi));//unitless
disp("Power factor of the other machine : "+string(
    cos_fi));
```

Scilab code Exa 1.20 pf of alternator

```
//Exa 1.20
clc;
clear;
close;
//given data
cos_fi=0.8;//unitless
fi=acosd(cos_fi);
tan_fi=tand(fi);//unitless
//For Alternator A :
cos_fi_A=0.9;//unitless
fi_A=acosd(cos_fi_A);
tan_fi_A=tand(fi_A);//unitless
//Formula : Active load, KW=V*I*cos_fi
```

```
//Formula : Reactive load , KVAR=V*I*sin_fi
ActiveLoad=8000;//in KW
ReactiveLoad=ActiveLoad*tan_fi;//in KVAR
//For A:
ActiveLoadA=5000;//in KW
ReactiveLoadA=ActiveLoadA*tan_fi_A;//in KVAR
//For B :
ActiveLoadB=ActiveLoad-ActiveLoadA;//in KW
ReactiveLoadB=ReactiveLoad-ReactiveLoadA;//in KVAR
tan_fi_B=ReactiveLoadB/ActiveLoadB;//unitless
fi_B=atand(tan_fi_B);//in degree
cos_fi=cosd(atand(tan_fi_B));//unitless
disp("Power factor of the other machine : "+string(
    cos_fi));
```

Scilab code Exa 1.21 KVA rating Current Rating and Power Input

```
//Exa 1.21
clc;
clear;
close;
//given data
format('v',7);
V=6600;//in Volts
KW=6000;//in KWatts
pf=0.8;//unitless
cos_fi=pf;//unitless
Eff=90;//in %
//Part (a) :
KVA=KW/cos_fi;//in KVAR
disp("KVA rating of the alternator : "+string(KVA)+"
    KVA");
//Part (b) :
TotalRating=KVA;//in KVA
VA=TotalRating*1000;//in VA
```

```
I=VA/(sqrt(3)*KW);//in Ampere
disp(I,"Current Rating in Ampere : ");
//Part (c) :
Input=KW/(Eff/100);//in KW
disp(Input,"Power Input(in KW) :");
Input=Input*1000/735.5;//in hp
disp(Input,"Power Input(in hp) :");
```

Scilab code Exa 1.22 Line Volt Current Rating and Power

```
//Exa 1.22
clc;
clear;
close;
//given data
format('v',7);
Ecoil=8000;//in Volts
Icoil=418;//in Ampere
pf=80;//in % lgging
pf=pf/100;//in fraction
cos_fi=pf;//unitless
//Part (i) :
EL=sqrt(3)*Ecoil;//in volt
disp(EL,"Line volts(in V): ");
//Part (ii) :
IL=Icoil;//in Ampere
disp(IL,"Line Current in Ampere : ");
//Part (iii) :
Rating=sqrt(3)*EL*IL/1000;//in KVA
disp(Rating,"Rating (in KVA) :");
//Part (iv) :
FullLoadPower=sqrt(3)*EL*IL*cos_fi/1000;//in KW
disp(FullLoadPower,"Full Load Power in KW :");
```

Chapter 2

Induction Motors

Scilab code Exa 2.1.p Synchronous Speed

```
//problem 2.1
clc;
clear;
close;
//given data :
P=8;//No. of poles
f=50;//in Hz
Ns=120*f/P;//in rpm
disp(Ns,"Synchronous speed in rpm : ");
```

Scilab code Exa 2.1 Synchronous speed and slip

```
//Exa 2.1
clc;
clear;
close;
//Given data :
P=2;//no. of poles
```

```
f=60;//in Hz
N=3460;//in rpm
Ns=120*f/P;//in rpm
Slip=Ns-N;//in rpm
PercentageSlip=(Ns-N)*100/Ns;//in %
disp(Ns,"Synchronous speed in rpm : ");
disp(round(PercentageSlip),"Percentage Slip : ");
```

Scilab code Exa 2.2.p Maximum Speed

```
//problem 2.2
clc;
clear;
close;
//given data :
P=2;//No. of poles(Assumed for induction motor)
f=50;//in Hz
N=120*f/P;//in rpm
disp(N,"Maximum speed in rpm : ");
```

Scilab code Exa 2.2 Synchronous speed Rotor frequency and slip

```
//Exa 2.2
clc;
clear;
close;
//Given data :
P=8;//no. of poles
f=50;//in Hz
N=700;//in rpm
//Part (a) :
Ns=120*f/P;//in rpm
disp(Ns,"Synchronous speed in rpm : ");
```

```
//Part (b) :
S=(Ns-N)*100/Ns;//in %
disp(S,"Slip(in %) : ");
//Part (c) :
//At the time of stsrt S=1;
fdash=f;//in Hz
disp(fdash,"Rotor frequeny at the time of starting(
    in Hz) : ");
//Part (d) :
fdash=(S/100)*f;//in Hz
disp(fdash,"Rotor frequeny at the given speed(in Hz)
     : ");
```

Scilab code Exa 2.3.p Actual Motor Speed

```
//problem 2.3
clc;
clear;
close;
//given data :
Pa=6;//No. of alternator poles
N=1000;//in rpm
Pm=16;//No. of motor poles
S=2.5;//in %
//Formula : N=120*f/Pa;//in rpm
f=N*Pa/120;//in Hz
Ns=120*f/Pm;//in rpm
disp(Ns,"Synchronous speed in rpm : ");
//formula : S=(Ns-Nr)/Ns*100
Nr=Ns-S/100*Ns;//in rpm
disp(Nr,"Actual speed of motor in rpm : ");
```

Scilab code Exa 2.3 Percentage slip and no of poles

```
//Exa 2.3
clc;
clear;
close;
//Given data :
P=10;//no. of poles
f=50;//in Hz
N=600;//in rpm
Nr=1440;//in rpm
f=P*N/120;//in Hz
//When P=2
P=2;//no. of poles
Ns=120*f/P;//in rpm
//When P=4
P=4;//no. of poles
Ns=120*f/P;//in rpm
disp("Induction motor speed is somewhat less than
    the synchronous speed. In this case indution
    motor speed, Nr is "+string(Nr)+" rpm.");
S=(Ns-Nr)*100/Ns;//Slip in %
disp("Percentage Slip(in %) : "+string(S));
disp("No. of poles : "+string(S));
```

Scilab code Exa 2.4.p Frequency and slip

```
//problem 2.4
clc;
clear;
close;
//given data :
format('v',5);
P=14;//No. of poles
f=50;//in Hz
N=415;//in rpm
Ns=120*f/P;//in rpm
```

```
S=(Ns-N)/Ns*100;//in %
disp(S,"Slip(%) : ");
fr=S/100*f;//in Hz
disp(fr,"Rotor frequency(in Hz) : ");
```

Scilab code Exa 2.4 Motor speed and slip

```
//Exa 2.4
clc;
clear;
close;
//Given data :
P=8;//no. of poles
f=50;//in Hz
fr=1.5;//in Hz
//Formula : fr=S*f
S=fr/f;//slip(unitless)
Ns=120*f/P;//in rpm
//Formula : S=(Ns-Nr)/Ns
Nr=Ns-S*Ns;//in rpm
disp(round(Nr),"Motor running speed in rpm : ");
disp(S*100,"Slip(in %):");
```

Scilab code Exa 2.5.p Copper Loss and Mechanical Power

```
//problem 2.5
clc;
clear;
close;
//given data :
format('v',5);
MotorInput=50;//in KW
Slip=3;//in %
```

```
RotCuLoss=MotorInput*Slip/100;//in KW
disp(RotCuLoss,"Rotor Copper Loss(KW) : ");
TMechP=MotorInput-RotCuLoss;//in KW
disp(TMechP,"Total mechanical power devloped(KW) : "
   );
```

Scilab code Exa 2.5 Synchronous and actual speed and frequency and slip

```
//Exa 2.5
clc;
clear;
close;
//Given data :
P=2;//no. of poles
f=50;//in Hz
S=4;//in %
//Part (i) :
Ns=f/P;//in rps
Ns=Ns*60;//in rpm
disp(Ns,"Synchronous speed in rpm : ");
//Part (ii) :
disp("Slip = "+string(S)+"% or "+string(S/100));
//Part (iii) :
N=Ns*(1-S/100);//in rpm
disp(N,"Actual speed in rpm :");
```

Scilab code Exa 2.6.p Slip and Torque

```
//problem 2.6
clc;
clear;
close;
//given data :
```

```
format('v',6);
P=4;//No. of poles
m=3;//No. of phase
f=50;//in Hz
Eff=85;//in %
Pout=17;//useful output power in KW
StatorLosses=900;//in watts
Input=Pout/Eff*100;//in KW
TLosses=Input-Pout;//in KW
WnF_Losses=1100;//in Watts
CuLoss=TLosses*1000-StatorLosses-WnF_Losses;//in watts
RotorInput=Input-StatorLosses/1000;//in KW
S=CuLoss/1000/RotorInput;//unitless
disp(S,"Slip : ");
Ns=120*f/P;//in rpm
N=Ns-S*Ns;//in rpm
//Formula : MechPower=Omega*T=2*%pi*N/60*T;
T=RotorInput*1000/(2*%pi*N/60);//in Newton-meter
disp(T,"Torque Devloped in Nw-m : ");
Tavail=Pout*1000/(2*%pi*N/60);//in Newtons
disp(Tavail,"Torque Available(Nw-m) : ");
```

Scilab code Exa 2.6 Motor speed and slip

```
//Exa 2.6
clc;
clear;
close;
//Given data :
P=4;//no. of poles
f1=50;//in Hz
fdash=1.5;//in Hz
S=fdash/f1;//unitless
disp(S,"Slip : ");
```

```
Ns=120*f1/P;//in rpm
N=Ns*(1-S);//in rpm
disp(N,"Speed of motor in rpm :");
```

Scilab code Exa 2.7.p Rotor input copper loss and mechanical power

```
//problem 2.7
clc;
clear;
close;
//given data :
format('v',5);
P=6;//No. of poles
m=3;//No. of phase
f=60;//in Hz
Eff=85;//in %
N=1152;//in rpm
T=70;//in Nw-m
Ns=120*f/P;//in rpm
Twatts=2*%pi*Ns/60*T;//in watts
RotorInput=Twatts;//in watts
disp(RotorInput/1000,"Total Input to the rotor(KW) :
    ");
S=(Ns-N)/Ns;//unitless
CuLoss=S*RotorInput;//in watts
disp(CuLoss,"Rotor Copper Loss(watts) : ");
Tdev=2*%pi*N/60*T;//in Watts
disp(Tdev,"Mechanical Power devloped(in Watts)");
//Note : Answer in the book is calculated right but
    in the end printed wrong.
```

Scilab code Exa 2.7 No of poles slip and speed

```
//Exa 2.7
clc;
clear;
close;
//Given data :
N=1440;//in rpm
f=50;//in Hz
disp("For this speed of 1440 rpm the synchronous
   speed may be either 1500 rpm or 3000 rpm.");
disp("If the synchronous speed is 3000 rpm then in
   generl case the speed will not be too slow. o the
    synchronous speed for this motor is 1500 rpm and
    and no. of poles corresponding to this speed is
   4.");
Ns=1500;//in rpm
P=4;//no. of poles
disp(P,"No. of poles : ");
Slip=(Ns-N)*100/Ns;//in %
disp(Slip,"Slip(in %) : ");
speed1=Ns-N;//Speed of rotor flux with respect to
   rotor
disp(speed1,"Speed of rotor flux with respect to
   rotor in rpm : ");
speed2=(speed1)+N;//Speed of rotor flux with respect
    to stator
disp(speed2,"Speed of rotor flux with respect to
   stator in rpm :");
```

Scilab code Exa 2.8.p Rotor current and slip

```
//problem 2.8
clc;
clear;
close;
//given data :
```

```
format('v',5);
m=3;//No. of phase
Vrotor=100;//in volts
Xo=1;//in ohm/phase
R2=0.2;//in ohm/phase
Eo=Vrotor/sqrt(3);//Rotor phase voltage in volts
S=4;//in %
I2=S/100*Eo/sqrt(R2^2+(S/100*Xo)^2);//in Ampere
disp(I2,"Rotor current in Ampere : ");
//For Max Torque S=R2/Xo
S=R2/Xo;//unitless
disp("For developing maximum torque");
disp(S,"Slip is : ");
I2=S*Eo/sqrt(R2^2+(S*Xo)^2);//in Ampere
disp(I2,"Rotor current in Ampere : ");
```

Scilab code Exa 2.8 Rotor current and phase difference

```
//Exa 2.8
clc;
clear;
close;
//Given data :
E2=100;//in volt
R2=0.05;//in ohm
X2=0.1;//im ohm
E2perphase=E2/sqrt(3);//in volt
//part (a) :
S=0.04;//slip
I2=S*E2perphase/sqrt(R2^2+(S*X2)^2);//in Ampere
disp(I2,"At 4% slip , Rotor current in Ampere : ");
fi2=acosd(R2/sqrt(R2^2+(S*X2)^2));//in degree
disp(fi2,"At 4% slip , Phase angle between rotor
    voltage and rotor current in degree :");
//part (b) :
```

```
S=1;//slip
I2=S*E2perphase/sqrt(R2^2+(S*X2)^2);//in Ampere
disp(I2,"At 100% slip , Rotor current in Ampere : ");
fi2=acosd(R2/sqrt(R2^2+(S*X2)^2));//in degree
disp(fi2,"At 100% slip , Phase angle between rotor
    voltage and rotor current in degree :");
```

Scilab code Exa 2.9.p External Rotor resistance

```
//problem 2.9
clc;
clear;
close;
//given data :
format('v',5);
P=6;//No. of poles
m=3;//No. of phase
f=50;//in Hz
Xo_int=1;//in ohm/phase
Rrotor_int=0.1;//in ohm/phase
//S=1 for starting
S=1;//unitless
disp("Max. Torque condition : R2=X2");
//Rext+Rrotor_int=Xo_int
Rext=Xo_int-Rrotor_int;//in ohm/phase
disp(Rext,"External resistance to be added(ohm/phase
    ) : ");
```

Scilab code Exa 2.9 Rotor current

```
//Exa 2.9
clc;
clear;
```

```
close;
//Given data :
E2=100;//in volt
R2=0.4;//in ohm
X2=2.25;//im ohm
E2perphase=E2/sqrt(3);//in volt
S=4;//in %
E=(S/100)*E2perphase;//rotor induced emf at a slip=4
    % in volt
Z2=sqrt(R2^2+((S/100)*X2)^2);
I2=E/Z2;//in Ampere
disp(I2,"Rotor currentt in Ampere : ");
```

Scilab code Exa 2.10.p Resistance in series

```
//problem 2.10
clc;
clear;
close;
//given data :
format('v',6);
P=4;//No. of poles
m=3;//No. of phase
f=50;//in Hz
Tmax=162.8;//in Nw-m
R2=0.2;//in ohm per phase
Speed=1365;//in rpm
Ns=120*f/P;//in rpm
S=(Ns-Speed)/Ns;//unitless
//Max. Torque condition : S=R2/X2
X2=R2/S;//in ohm/phase
disp("Tstarting=k*E2^2*R2/(R2^2+X2^2)=Tmax/2");
disp("and Tmax=k*E2^2/(2*X2^2)");
disp("This two eqn gives a polynomoial p for R2.");
p=[Tmax/2 -Tmax*2*X2 Tmax/2*X2^2];
```

```
R2=roots(p);
disp("Additional resistance is "+string(R2(1))+" ohm
    or "+string(R2(2))+" ohm");
disp("Higher value should be neglected. So answer is
    "+string(R2(2))+" ohm.");
```

Scilab code Exa 2.10 Rotor current at various slip

```
//Exa 2.10
clc;
clear;
close;
//Given data :
f=50;//in Hz
R2=0.2;//in ohm
X2=2;//im ohm
E2=60;//in volt
E2perphase=E2/sqrt(3);//in volt
//case (i) : S=1
S=1;//unitless
Z2=sqrt(R2^2+(S*X2)^2);
I2=E2perphase*S/Z2;//in Ampere
disp(I2,"At standstill : Rotor current in Ampere : "
    );
//case (ii) : S=0.1
S=0.1;//unitless
Z2=sqrt(R2^2+(S*X2)^2);
I2=E2perphase*S/Z2;//in Ampere
disp(I2,"for 10% slip : Rotor current in Ampere : ")
    ;
//case (iii) : S=0.05
S=0.05;//unitless
Z2=sqrt(R2^2+(S*X2)^2);
I2=E2perphase*S/Z2;//in Ampere
disp(I2,"for 5% slip : Rotor current in Ampere : ");
```

```
//case (iv) : S=0.01
S=0.01;//unitless
Z2=sqrt(R2^2+(S*X2)^2);
I2=E2perphase*S/Z2;//in Ampere
disp(I2,"for 1% slip : Rotor current in Ampere : ");
//Note : Answer in the book is wrong for S=0.05 and
   S=0.01
```

Scilab code Exa 2.11.p No of poles and slip

```
//problem 2.11
clc;
clear;
close;
//given data :
N=290;//in rpm
f=50;//in Hz
disp("Motor running at full load, no. of poles
   should be 20");
P=20;//no. of poles
Ns=120*f/P;//in rpm
Slip=(Ns-N)/Ns*100;//in %
disp("T is proportional to S/R2 but T is same");
Slip=2*Slip;//doubling R2 also doubles the slip
disp(Slip,"New value of slip is : ");
```

Scilab code Exa 2.11 Current in each phase and power factor

```
//Exa 2.11
clc;
clear;
close;
//Given data :
```

```
R2=0.5;//in ohm
X=4.5;//im ohm
E=50;//line voltage in volt
Eperphase=E/sqrt(3);//in volt
//part (a) : Sliprings are short circuited
Z2=sqrt(R2^2+X^2);//in ohm
I2=Eperphase/Z2;//in Ampere
disp(I2,"Sliprings are short circuited , Rotor
    current in Ampere : ");
cosfi2=R2/Z2;//unitless
disp(cosfi2,"Power factor : ");
//part (b) : Sliprings are connected
R2=0.4;//in ohm
Z2=sqrt(R2^2+X^2);//in ohm
I2=Eperphase/Z2;//in Ampere
disp(I2,"Sliprings are short circuited , Rotor
    current in Ampere : ");
cosfi2=R2/Z2;//unitless
disp(cosfi2,"Power factor : ");
//Note : answer of part (a) I2 is not curate in the
    book.
```

Scilab code Exa 2.12.p Starting torque

```
//problem 2.12
clc;
clear;
close;
//given data :
//Isc=4*If;
Isc_by_If=4;
Slip=2.5;//in %
disp("Ts is proportional to Is^2");
disp("and Tf is proportional to If^2/S");
disp("From these eqn we get :")
```

```
Ts_by_Tf=(Isc_by_If)^2*(Slip/100);//ratio
disp("Starting torque is "+string(Ts_by_Tf*100)+" %
    of full load torque.");
```

Scilab code Exa 2.12 External Resistance per phase

```
//Exa 2.11
clc;
clear;
close;
//Given data :
R2=0.02;//in ohm
X2=0.1;//im ohm
//let external resistance per phase = r then R2=R2+r
     ohm
S=1;//slip at starting
disp("Torque at standing will be maximum if R2/X2=S
    =1");
disp("Since at start speed is zero and slip is,
    therefore, unity or R2=X2");
r=X2-R2;//in ohm
disp(r,"External resistance per phase added to the
    rotor circuit in ohms : ");
```

Scilab code Exa 2.13.p Starting and Maximum Torque

```
//problem 2.13
clc;
clear;
close;
//given data :
format('v',6);
m=3;//No. of phase
```

```
P=6;//no. of poles
f=50;//in Hz
Xo=6;//in ohm per phase
R=1;//in ohm per phase
Eo=62.8;//in volt
Ns=120*f/P;//in rpm
Omega_s=2*%pi*Ns/60;//in radians/sec
K=m/Omega_s;
S=1;//slip at starting
Ts=K*S*Eo^2*R/(R^2+(S*Xo)^2);//in Nw-m
disp(Ts,"Starting torque(Nw-m) : ")
S=R/Xo;//slip for max torque
Tmax=K*Eo^2/(2*Xo);//in Nw-m
disp(Tmax,"Maximum torque(Nw-m) : ")
//Note : Answer in the book is wrong due to
    calculation mistake.
```

Scilab code Exa 2.13 External Rotor Resistance per phase

```
//Exa 2.13
clc;
clear;
close;
//Given data :
P=4;//no. of poles
f=50;//in Hz
R2=0.03;//in ohm
X2=0.12;//im ohm
Smax=R2/X2;//unitless
Ns=120*f/P;//in rpm
N=Ns*(1-Smax);//in rpm
disp(N,"Speed corresponding to maximum torque(in rpm
    ) :");
disp("Let r be the external resistance introduced
    per phase in the rotor circuit. Ratio of rotor
```

```
circuit resistance to rotor standstill resistance =alfa ");
//alfa=(R2+r)/X2
//Ratio of starting torque to max torque=75/100=2*alfa/(alfa^2+1)
//It gives : 3*alfa^2-8*alfa+3=0
//coefficients :
a=3;b=-8;c=3;
alfa1=(-b+sqrt(b^2-4*a*c))/(2*a);alfa2=(-b-sqrt(b^2-4*a*c))/(2*a);
disp("rejecting higher values, alfa = "+string(alfa2));
fdash=1.5;//in Hz
r=alfa2*X2-R2;//in ohm;
disp(r,"External rotor resistance per phase(in ohm) : ");
```

Scilab code Exa 2.14.p Total Torque

```
//problem 2.14
clc;
clear;
close;
//given data :
format('v',6);
m=3;//No. of phase
P=4;//no. of poles
f=50;//in Hz
VL=200;//in volt
R=0.1;//in ohm per phase
Xo=0.9;//in ohm per phase
TurnsRatio=0.67;//ratio
S=4;//in %
Vphase=VL/sqrt(3);//in volt
Vrotor=Vphase*TurnsRatio;//in volt
```

```
Ns=1500;//in rpm
Omega_s=2*%pi*Ns/60;//in radians/sec
K=m/Omega_s;
S=S/100;//slip unitless
Ts=K*S*Vrotor^2*R/(R^2+(S*Xo)^2);//in Nw-m
disp(Ts,"Starting torque(Nw-m) : ")
//Note : Answer in the book is wrong due to
    calculation mistake.
```

Scilab code Exa 2.14 Speed develop max torque

```
//Exa 2.14
clc;
clear;
close;
//Given data :
P=4;//no. of poles
f=50;//in Hz
R2=0.024;//in ohm
X2=0.6;//in ohm
disp("Since the torque under running condition is
    maximum at that value of slip which makes rotor
    reactance per phase equal to the rotor resistance
    per phase.")
Sm=R2/X2;//slip corresponding to max torque
Ns=120*f/P;//in rpm
N=Ns*(1-Sm);//in rpm
disp(N,"Speed corresponding to maximum torque in rpm
    : ");
```

Scilab code Exa 2.15.p Resistance and Power

```
//problem 2.15
```

```
clc;
clear;
close;
//given data :
format('v',7);
m=3;//No. of phase
P=8;//no. of poles
f=50;//in Hz
Pout=15;//in KW
S=4;//in %
R2=0.2;//in ohm per phase
Xo=1.5;//in ohm per phase
N=400;//in rpm
Ns=120*f/P;//in rpm
Sdash=(Ns-N)/Ns*100;//unitless
R2dash=R2*Sdash/S;//in ohm/phase
Radded=R2dash-R2;//in ohm
disp(Radded,"Resistance to be added in ohm : ");
Mechpower=Pout;//in KW
RotorInput=Mechpower/(1-S/100);//in KW
disp(RotorInput*1000," Input to the rotor(in watts)
    : ");
RotorCuLoss=Sdash/100*RotorInput;//in KW
disp(RotorCuLoss*1000,"Rotor Copper Loss(in watts) :
    ");
OutPower=RotorInput-RotorCuLoss;//in KW
disp(OutPower*1000,"Output power(in Watts) : ");
disp(RotorInput*1000,"Input at a slip of 4%(in Watts
   ) : ");
//Note : Answer in the book is wrong due to
   calculation mistake.
```

Scilab code Exa 2.15 Speed and max torque in terms of full load torque

```
//Exa 2.15
```

```
clc;
clear;
close;
//Given data :
P=6;//no. of poles
f=50;//in Hz
Sf=4;//in %
R2=0.01;//in ohm
X2=0.05;//im
Ratio=((R2/X2)^2+(Sf/100)^2)/(2*R2*(Sf/100)/X2);//
    ratio of max torque to full load torque
disp("Maximum torque, Tmax="+string(Ratio)+"Tf");
disp("Since the torque under running condition is
    maximum at that value of slip which makes rotor
    reactance per phase equal to the rotor resistance
     per phase.")
Sm=R2/X2;//slip corresponding to max torque
Ns=120*f/P;//in rpm
N=Ns*(1-Sm);//in rpm
disp(N,"Speed corresponding to maximum torque in rpm
     : ");
```

Scilab code Exa 2.16.p Calculate Slip

```
//problem 2.16
clc;
clear;
close;
//given data :
format('v',6);
Eff=0.8;//unitless
Load=20;//in HP
Load=Load*735.5;//in watts
//IronLoss=K;//assumed
//MechLoss=K/3;
```

```
//RotorCuLoss=StatorCuLoss=IronLoss=K;
//TotLoss=K+K+K+K/3=10*K/3;//
Input=Load/Eff;//in watts
TotLoss=Input-Load;//in watts
K=TotLoss*3/10;//in watts
IronLoss=K;//in watts
StatorCuLoss=K;//in watts
RotorCuLoss=K;//in watts
MechLoss=K/3;//in watts
RotInput=Load+MechLoss+RotorCuLoss;//in watts
//Formula : RotorCuLoss=S*RotInput
S=RotorCuLoss/RotInput;//unitless
disp(S,"Slip is : ");
```

Scilab code Exa 2.16 Speed and ratio of max torque to full load torque

```
//Exa 2.16
clc;
clear;
close;
//Given data :
P=12;//no. of poles
f=50;//in Hz
R2=0.03;//in ohm
X2=0.5;//im
S=R2/X2;//unitless
Ns=120*f/P;//in rpm
N=Ns*(1-S);//in rpm
disp(N,"Speed at maximum torque in rpm : ");
S=(Ns-495)/Ns;//slip at 495 rpm speed
Ratio=(2*R2*S/X2)/((R2/X2)^2+S^2);//ratio of max
   torque to full load torque
disp(Ratio*100,"Ratio of full load torque to max
   torque(in %) :");
```

Scilab code Exa 2.17.p Motor current per phase

```
//problem 2.17
clc;
clear;
close;
//given data :
format('v',6);
m=3;//no. of phase
P=6;//no. of poles
f=50;//in Hz
Pin=20;//in KW
N=960;//in rpm
R2=1/3;//in ohm/phase
Ns=120*f/P;//in rpm
S=(Ns-N)/Ns;//unitless
RotCuLoss=S*Pin*1000;//in Watts
RotCuLoss=S*Pin*1000/m;//in Watts/phase
//Formula : I2^2*R2=RorCuLoss per phase
I2=sqrt(RotCuLoss/R2);//in Ampere
disp(I2,"Rotor current in Ampere : ");
```

Scilab code Exa 2.17 Resistance inserted in series

```
//Exa 2.17
clc;
clear;
close;
//Given data :
P=12;//no. of poles
f=50;//in Hz
R2=0.5;//in ohm
```

```
N=475;//in rpm
Ns=120*f/P;//in rpm
S=(Ns-N)/Ns;//unitless
X2=R2/S;//in ohm
disp("At maximum torque, Tmax is proportional to 1/2*X2 or 1/20");
disp("Now if a resistance R is to be inserted in series with each phase of the rotor to reduce the starting torque to 1/3 of maximum torque, then");
disp("Ts is proportional to (R2+R)/((R2+R)^2+X2^2)");
disp("Also, Ts is proportional to 1(20*3)");
disp("Equating the two eqn we have : (0.5*R)/(R2+R)^2+X2^2");
//R^2-59R+70.25=0 :
//coefficients :
a=1;b=-59;c=70.25;
R=(-b-sqrt(b^2-4*a*c))/(2*a);
disp(R,"Resistance R to be inserted in series (in ohm) :");
//Note : answer in the book is wrong.
```

Scilab code Exa 2.18.p Maximum Torque

```
//problem 2.18
clc;
clear;
close;
//given data :
format('v',6);
P=8;//no. of poles
f=50;//in Hz
R2=0.04;//in ohm/phase
N=645;//in rpm
```

```
Ns=120*f/P;//in rpm
S=(Ns-N)/Ns*100;//unitless
S=S/100;//unitless
//S=R2/X2;//at max torque
X2=R2/S;//in ohm per phase
a=R2/X2;//unitless
TstartBYTmax=2*a/(a^2+1);//ratio
TstartBYTmax=2*a/(a^2+1)*100;//in %
disp(round(TstartBYTmax),"% of max torque is : ");
S=3;//in %
S=3/100;//unitless
TflBYTmax=2*a*S/(a^2+S^2);//ratio
TflBYTmax=2*a*S/(a^2+S^2)*100;//in %
disp(round(TflBYTmax),"% of max torque at slip 3% is : ");
```

Scilab code Exa 2.18 Starting torquea as a percentage of mx torque

```
//Exa 2.18
clc;
clear;
close;
//Given data :
P=4;//no. of poles
f=50;//in Hz
R2=0.04;//in ohm
N=1200;//in rpm(speed at max torque)
Ns=120*f/P;//in rpm(synchronous speed)
S=(Ns-N)/Ns;//unitless
X2=R2/S;//in ohm
//Starting torque is the torque devloped when S=1: Tst=K*R2/(R2^2+X2^2)
//Let say, m=R2/(R2^2+X2^2) then Tst=K*m
m=R2/(R2^2+X2^2);//assumed
disp("Starting torque, Tst="+string(m)+"k");
```

```
disp("Maximum torque , Tm=K/"+string(2*X2));
disp("Thus, Tst in terms of Tm can be expressed as :
    ");
disp("Tst/Tm="+string(0.96*0.4)+" or Tst="+string
   (0.96*0.4)+"Tm");
disp("Therefore, staring torque is "+string
   (0.96*0.4*100)+"% of maximum torque.");
```

Scilab code Exa 2.19.p Current per phase and power factor

```
//problem 2.19
clc;
clear;
close;
//given data :
format('v',5);
m=3;//no. of phase
emf=50;//in volt
E2=emf/sqrt(3);//emf/phase
R2=0.5;//in ohm/phase
X2=4.5;//in ohm/phase
//(a) Sliprings are short circuited
Z2=sqrt(R2^2+X2^2);//in oghm per phase
I2=E2/Z2;//in Ampere
disp(I2,"Rotor current per phase(Ampere) : ");
cosfi2=R2/Z2;//unitless
disp(cosfi2,"Rotor power factor : ");
//(a) Sliprings are connected to star connected
   rheostat
R2=4+R2;//in ohm/phase
Z2=sqrt(R2^2+X2^2);//in oghm per phase
I2=E2/Z2;//in Ampere
disp(I2,"Rotor current per phase(Ampere) : ");
cosfi2=R2/Z2;//unitless
disp(cosfi2,"Rotor power factor : ");
```

Scilab code Exa 2.19 Speed slip and cu loss

```
//Exa 2.19
clc;
clear;
close;
//Given data :
P=6;//no. of poles
f=50;//in Hz
fr=3;//in Hz
R2=0.5;//in ohm
N=475;//in rpm
RotorInput=111.9;//in KW
Ns=120*f/P;//in rpm
S=fr*100/f;//unitless
disp(S,"% Slip : ");
N=Ns*(1-S/100);//in rpm
disp(N,"Speed of motor in rpm : ");
RotorCopperLoss=RotorInput*S/100;//in KW
RotorCopperLoss=RotorCopperLoss/3;//in KW/Phase
disp(RotorCopperLoss,"Rotor Copper Loss per phase(in
    KW) : ");
```

Scilab code Exa 2.20.p Ratio Tst and Tfl

```
//problem 2.20
clc;
clear;
close;
//given data :
format('v',6);
```

```
m=3;//no. of phase
TmaxBYTfl=2.5;//ratio
R2=0.5;//in ohm/phase
X2=5;//in ohm/phase
//Formula: Tst=K*E2^2*R2/(R2^2+X2^2) and Tm=K*E2^2/(2*X2)
TstBYTfl=TmaxBYTfl*2*X2*R2/(R2^2+X2^2);//ratio
disp(TstBYTfl,"(a) For direct on line starting, ratio starting torque to Full load torque is : ");
//For star delta starting :
TstBYTfl=(1/3)*TmaxBYTfl*2*X2*R2/(R2^2+X2^2);//ratio
disp(TstBYTfl,"(b) For star delta starting, ratio starting torque to Full load torque is : ");
//For auto transformer starting with tapping at 75 %
TstBYTfl=(75/100)^2*TmaxBYTfl*2*X2*R2/(R2^2+X2^2);//ratio
disp(TstBYTfl,"(c) For star delta starting, ratio starting torque to Full load torque is : ");
```

Scilab code Exa 2.20 Mech power and Cu loss

```
//Exa 2.20
clc;
clear;
close;
//Given data :
phase=3;//no. of phase
Pin_stator=60;//Power input of stator in KW
TotalStatorLosses=1;//in KW
Pin_rotor=Pin_stator-TotalStatorLosses;//Power input of rotor in KW
S=3;//slip in %
RotorCopperLosses=(S/100)*Pin_rotor;//in KW
RotorCopperLosses=RotorCopperLosses/phase;//in KW
```

```
    per phase
disp(RotorCopperLosses*10^3,"Rotor Copper Losses per
     phase(in watts) : ");
TotalMechPowerDev=Pin_rotor*(1-S/100);//in KW
disp(TotalMechPowerDev,"Total mechanial power
    developed(in KW) : ") ;
```

Scilab code Exa 2.21 Speed and cu loss

```
//Exa 2.21
clc;
clear;
close;
//Given data :
P=6;//no. of poles
S=4;//slip in %
Output=20;//in KW
FrictionalLoss=250;//in watts
f=50;//in Hz
Ns=120*f/P;//in rpm
N=Ns-Ns*(S/100);//in rpm
disp(N,"Speed of motor(in rpm) : ");
MechPowerDeveloped=Output*10^3+FrictionalLoss;//in
    Watts
S=S/100;//unitless
RotorCopperLoss=(S/(1-S))*MechPowerDeveloped;//in
    watts
disp(RotorCopperLoss,"Rotor Copper Loss(in watts) :
    ");
```

Scilab code Exa 2.22 Slip Speed Power Loss Current

```
//Exa 2.22
```

```
clc;
clear;
close;
//Given data :
format('v',6);
phase=3;//no. of phase
P=6;//no. of poles
Pin_rotor=80;//Power input of rotor in KW
f=50;//in Hz
fdash=100;//alternations per minute
fdash=100/60;//in Hz
S=fdash/f;//unitless
disp(S,"Slip : ");
Ns=120*f/P;//synchronous speed in rpm
N=Ns-Ns*S;//in rpm
disp(round(N),"Rotor Speed(in rpm) : ");
MechPowerDev=Pin_rotor*(1-S)*10^3/735.5;//in H.P.
disp(MechPowerDev,"Total mechanial power developed(
    in KW) : ") ;
RotorCopperLoss=S*Pin_rotor*10^3;//in watts
disp(RotorCopperLoss,"Rotor Copper Loss(in watts) :
    ");
CopperLoss=RotorCopperLoss/phase;//in watts/phase
disp(CopperLoss,"Copper Loss per phase(in watts) : "
    );
I2=60;//in Ampere
R2=CopperLoss/I2^2;//in ohm
disp(R2,"Rotorresistance per phase(in ohm) : ");
//Note : Some answers are not accurate in the book.
```

Scilab code Exa 2.23 Copper Loss and Efficiency

```
//Exa 2.23
clc;
clear;
```

```
close;
//Given data :
format('v',6);
UsefulOutput=55;//in H.P.
MechLosses=2;//in H.P.
Stator_Losses=13.5;//in KW
MechPowerDev=UsefulOutput+MechLosses;//in H.P.
MechPowerDev=MechPowerDev*735.5/1000;//in KW
S=50;//in %
Pin_Rotor=MechPowerDev/(1-S/100);//in KW
RotorCopperLoss=(S/100)*Pin_Rotor;//in KW
disp(RotorCopperLoss,"Rotor Copper Loss(in KW) : ");
Pin_Motor=Pin_Rotor+Stator_Losses;//in KW
Efficiency=UsefulOutput*0.7355/Pin_Motor;///unitless
disp(Efficiency*100,"Effiiency(in %) :");
```

Scilab code Exa 2.24 Slip speed Loss Resistance Power

```
//Exa 2.24
clc;
clear;
close;
//Given data :
format('v',6);
phase=3;//no. of phase
P=6;//no. of poles
Pin_rotor=80;//Power input of rotor in KW
f=50;//in Hz
fdash=100;//alternations per minute
fdash=100/60;//in Hz
S=fdash/f;//unitless
disp(S,"Slip : ");
Ns=120*f/P;//synchronous speed in rpm
N=Ns-Ns*S;//in rpm
disp(round(N),"Rotor Speed(in rpm) : ");
```

```
RotorCopperLoss=S*Pin_rotor*10^3;//in watts
//disp(RotorCopperLoss,"Rotor Copper Loss(in watts) : ");
CopperLoss=RotorCopperLoss/phase;//in watts/phase
disp(CopperLoss,"Copper Loss per phase(in watts) : ");
I2=60;//in Ampere
R2=CopperLoss/I2^2;//in ohm
disp(R2,"Rotorresistance per phase(in ohm) : ");
MechPowerDev=Pin_rotor*(1-S)*10^3/735.5;//in H.P.
disp(MechPowerDev,"Total mechanial power developed(in H.P.) : ") ;
//Note : Some answers are not accurate in the book.
```

Scilab code Exa 2.25 Slip

```
//Exa 2.25
clc;
clear;
close;
//Given data :
format('v',9);
Efficiency=0.9;//unitless
Output=50;//in H.P.
//formula : Efficiency=Output/(Output+Losses)
Losses=((1-Efficiency)/Efficiency)*Output*735.5;//in watts
Losses=round(Losses);//round
//Let, Ststor Cu loss = Rotor Cu los = Iron loss=K
//Mechanical Loss = Iron Loss/3 = K/3
//TotalLosses=k+K+K+K/3
K=Losses*3/10;//in watts
Pin_rotor=Output*735.5+Losses;//in watts
Slip=K/Pin_rotor;//unitless
disp(Slip,"Slip :");
```

```
disp(" or "+string(Slip*100)+"%");
```

Scilab code Exa 2.26 Motor current per phase

```
//Exa 2.26
clc;
clear;
close;
//Given data :
format('v',6);
Pin_rotor=20;//Power input of rotor in KW
phase=3;//no. of phase
P=6;//no. of poles
f=50;//in Hz
N=960;//in rpm(Actual speed of motor)
Ns=120*f/P;//synchronous speed in rpm
S=(Ns-N)/Ns;//unitless
RotorCuLoss=S*Pin_rotor*10^3;//in watts
RotorCuLoss=RotorCuLoss/phase;//in watts/phase
R2=1/3;//in ohm(Rotor resistance per phase)
I2=sqrt(RotorCuLoss/R2);//in Ampere
disp(I2,"Motor current per phase(in Ampere) :");
```

Scilab code Exa 2.27 Slip Loss and Current

```
//Exa 2.27
clc;
clear;
close;
//Given data :
format('v',6);
V=500;//in volt
Pout_rotor=20;//Power output of rotor in H.P.
```

```
phase=3;//no. of phase
P=6;//no. of poles
f=50;//in Hz
N=995;//in rpm(Actual speed of motor)
cosfi=0.87;//powerfactor(unitless)
Ns=120*f/P;//synchronous speed in rpm
S=(Ns-N)/Ns;//unitless
disp(S,"Slip : ");
RotorCuLoss=(S/(1-S))*Pout_rotor*735.5;//in watts
disp(RotorCuLoss,"Rotor Cu Loss(in watts) : ");
Pin_rotor=RotorCuLoss/S;//in watts
disp(Pin_rotor/10^3,"Power input to rotor(in KW) :")
  ;
LineCurrent=Pin_rotor/(sqrt(3)*V*cosfi);//in Ampere
disp(LineCurrent,"Line Current(in A) :");
RotorFreq=S*f;//in Hz
disp(RotorFreq,"Rotor Frequency(in Hz) :");
```

Scilab code Exa 2.28 Pull on belt

```
//Exa 2.28
clc;
clear;
close;
//Given data :
format('v',6);
phase=3;//no. of phase
Efficiency=90;//in %
Speed=480;//in rpm
VL=400;//in volt
IL=75;//in Ampere
cosfi=0.77;//powerfactor(unitless)
d=0.75;//diameter of pulley in meter
Pin_motor=sqrt(3)*VL*IL*cosfi;//Power input of motor
    in watts
```

```
OutputPower=Pin_motor*Efficiency/100;//in watts
Omega=Speed*2*%pi/60;//angular speed in radians/sec
Torque=OutputPower/Omega;//in N-meter
Torque=Torque/9.81;//in Kg-meter
PullOnBelt=Torque/(d/2);//in Kg
disp(PullOnBelt,"Pull On Belt(in Kg.) : ");
```

Scilab code Exa 2.29 Mechanical Power output

```
//Exa 2.29
clc;
clear;
close;
//Given data :
format('v',6);
//At 3% slip
OutputPower=24;//in KW(At 3% slip)
S=3;//in %
Efficiency=(1-S/100);//unitless
InputPower=OutputPower/Efficiency;//in KW
//At 5% slip
S=5;//in %
Efficiency=(1-S/100);//unitless
OutputPower=InputPower*Efficiency;//in KW
disp(OutputPower,"Mechanical power output at a slip
   of 5%(in KW) : ");
```

Scilab code Exa 2.30 Cu loss and efficiency

```
//Exa 2.30
clc;
clear;
close;
```

```
//Given data :
format('v',6);
//At 50% speed of synchronous speed
S=50;//in %
UsefulOutput=55;//in H.P.
MechLoss=2;//in H.P.
StatorLoss=13.5;//in KW
Pout_rotor=UsefulOutput+MechLoss;//in H.P.
Pout_rotor=Pout_rotor*0.7355;//in KW
Efficiency=(1-S/100);//unitless
RotorInputPower=Pout_rotor/Efficiency;//in KW
RotorCuLoss=RotorInputPower-Pout_rotor;//in KW
disp(RotorCuLoss,"Cu Loss in the rotor circuit(in KW
    ) :");
TotalLosses=StatorLoss+RotorCuLoss+MechLoss*0.7355;
    //in KW
MotorEfficiency=UsefulOutput*0.7355/(UsefulOutput
    *0.7355+TotalLosses);
disp(MotorEfficiency*100,"Motor Efficiency(in %) : "
    );
```

Scilab code Exa 2.31 Slip Torque Cu loss and line current

```
//Exa 2.31
clc;
clear;
close;
//Given data :
format('v',6);
P=4;//no. of poles
phase=3;//no. of phase
N=1440;//in rpm(Actual speed of motor)
Power_dev=10;//Power developed in H.P.
VL=400;//in volt
cosfi=0.8;//powerfactor(unitless)
```

```
f=50;//in Hz
Ns=120*f/P;//in rpm
S=(Ns-N)/Ns;//fractional slip(unitless)
disp(S,"Slip :");
Omega=N*2*%pi/60;//angular speed in radians/sec
Torque=Power_dev*735.5/Omega;//in N-meter
Torque=Torque/9.81;//in Kg-meter
disp(Torque,"Torque(in Kg-meter) :");
RotorCuLoss=(S/(1-S))*Power_dev*735.5;//in watts
disp(RotorCuLoss/3,"Rotor Cu Loss per phase(in watts
   ) : ");
Pin_rotor=RotorCuLoss/S;//in watts
disp(Pin_rotor/10^3,"Power input to rotor(in KW) :")
   ;
LineCurrent=Pin_rotor/(sqrt(3)*VL*cosfi);//in Ampere
disp(LineCurrent,"Line Current(in A) :");
```

Scilab code Exa 2.32 Slip speed Loss Resistance Power

```
//Exa 2.32
clc;
clear;
close;
//Given data :
format('v',6);
VL=440;//in volt
f=50;//in Hz
P=6;//no. of poles
phase=3;//no. of phase
Pin_rotor=80;//in KW
fr=100;//revolutions/min
fr=100/60;//in Hz
S=fr/f;//slip(unitless)
disp(S,"Slip : ");
Ns=120*f/P;//in rpm
```

```
N=Ns*(1-S);//in rpm(Speed of Rotor)
disp(round(N),"Rotor speed(in rpm) : ");
RotorCuLoss=S*Pin_rotor*10^3;//in watts
disp(RotorCuLoss/phase,"Rotor Cu Loss per phase(in watts) : ");
I2=65;//in Ampere
R2=(RotorCuLoss/phase)/I2^2;//in ohm
disp(R2,"Rotor resistance per phase(in ohm) : ");
Pout_rotor=Pin_rotor-RotorCuLoss/10^3;//in KW
disp(Pout_rotor/0.735,"Output power of rotor(in H.P.) : ");
//Note : answers of few part are not accurate in the book.
```

Scilab code Exa 2.33 Motor current per phase

```
//Exa 2.33
clc;
clear;
close;
//Given data :
format('v',6);
VL=440;//in volt
f=50;//in Hz
P=6;//no. of poles
phase=3;//no. of phase
Pin_rotor=20;//in KW
N=960;//in rpm(Speed of Motor)
Ns=120*f/P;//in rpm
S=(Ns-N)/Ns;//slip(unitless)
RotorCuLoss=S*Pin_rotor*10^3;//in watts
RotorCuLoss=RotorCuLoss/phase;//in watts/phase
R2=1/3;//Rotor Resistance in ohm per phase
I2=sqrt(RotorCuLoss/R2)
disp(I2,"Motor current per phase(in Ampere) :");
```

Scilab code Exa 2.34 Slip loss input Current and cycles

```
//Exa 2.34
clc;
clear;
close;
//Given data :
format('v',7);
VL=500;//in volt
f=50;//in Hz
P=6;//no. of poles
phase=3;//no. of phase
Pout_rotor=20;//in H.P.
cosfi=0.87;//power factor
N=995;//in rpm(Speed of Motor)
Ns=120*f/P;//in rpm
S=(Ns-N)/Ns;//slip(unitless)
disp(S,"Slip : ");
RotorCuLoss=(S/(1-S))*Pout_rotor*735.5;//in watts
disp(RotorCuLoss,"Rotor Cu Loss(in watts) :");
Pin_rotor=RotorCuLoss/S;//in watts
disp(Pin_rotor/10^3,"Power input to rotor(in KW) :")
    ;
IL=Pin_rotor/(sqrt(3)*VL*cosfi);//in Ampere
disp(IL,"Line current (in Ampere) :");
Rotorfreq=S*f;//in Hz
disp(Rotorfreq,"Rotor frequency(in Hz) :");
```

Scilab code Exa 2.35 Slip and Torque

```
//Exa 2.35
```

```
clc;
clear;
close;
//Given data :
format('v',6);
f=50;//in Hz
P=4;//no. of poles
phase=3;//no. of phase
Efficiency=85;//in %
OutputPower=17;//in KW
OutputPower=17*10^3;//in watts
StatorLosses=900;//in watt
MechLosses=1100;//in watt
Pin=OutputPower/(Efficiency/100);//in watts
//Stator input or rotor input :
Pin_rotor=Pin-StatorLosses;//in watts
P_MechDev=OutputPower+MechLosses;//in watts
RotorCuLosses=Pin_rotor-P_MechDev;//in watts
S=RotorCuLosses/Pin_rotor;//slip(unitless)
disp(S,"Slip :");
Ns=120*f/P
N=Ns*(1-S);//in rpm(Speed of Motor)
Omega=2*%pi*N/60;//angular speed in rad/sec
Torque=P_MechDev/Omega;//in Nm
disp(Torque,"Torque developed(in Nm) :");
Tm=OutputPower/Omega;//in Nm
Tm=Tm/9.81;//in Kg-meter
disp(Tm,"Torque at the shaft(in Kg-meter) :");
```

Scilab code Exa 2.36 power I2R loss and efficiency

```
//Exa 2.36
clc;
clear;
close;
```

```
//Given data :
format('v',7);
VL=500;//in volt
f=50;//in Hz
P=6;//no. of poles
phase=3;//no. of phase
Pin_stator=50;//in KW
Statorlosses=2;//in KW
MechLosses=1;//in KW
Pin_rotor=Pin_stator-Statorlosses;//in KW
S=3;//in %
RotorI2RLoss=(S/100)*Pin_rotor;//in KW
disp(RotorI2RLoss,"Rotor I2R Loss(in KW) :");
disp("Rotor core loss at 3% slip is very less and can be neglected.");
Power_dev=Pin_rotor-RotorI2RLoss;//in KW
disp(Power_dev/0.7355,"Power developed by the rotor(in H.P.) : ");
Outputpower=Power_dev-MechLosses;//in KW
Efficiency=Outputpower/Pin_stator;//unitless
disp(Efficiency*100,"Efficiency of the motor(in %) : ");
```

Scilab code Exa 2.37 I2R loss and speed

```
//Exa 2.37
clc;
clear;
close;
//Given data :
format('v',7);
f=50;//in Hz
P=4;//no. of poles
phase=3;//no. of phase
MotorOutput=20;//in H.P.
```

```
MotorOutput=20*735.5;//in watts
S=4;//full load slip in %
MechLosses=500;//in watts
Pdev_rotor=MotorOutput+MechLosses;//in watts
S=S/100;//fractional slip
RotorI2RLoss=(S/(1-S))*Pdev_rotor;//in watts
disp(RotorI2RLoss,"Rotor I2R Loss(in watts) :");
Ns=120*f/P;//in rpm
Nr=Ns-Ns*S;//in rpm
disp(Nr,"Rotor speed(in rpm) :");
```

Scilab code Exa 2.38 Speed and external rotor resistance

```
//Exa 2.38
clc;
clear;
close;
//Given data :
format('v',6);
f=50;//in Hz
P=6;//no. of poles
phase=3;//no. of phase
R2=0.02;//in ohm
X2=0.1;//in ohm
S=R2/X2;//slip(unitless)
Ns=120*f/P;//in rpm
Nr=Ns-Ns*S;//in rpm
//At starting S=1
S=1;//slip
//Formula : T=K*S*R2/(R2^2+X2^2)
//Starting torque, Tst=K*R2/(R2^2+S^2*X2^2)
//Maximum torque, Tm=K/(2*X2)
//Tst=(2/3)*Tm : gives a equation
//100*R2^2-30*R2+1=0
a=100;b=-30;c=1;
```

```
R21=(-b+sqrt(b^2-4*a*c))/(2*a);//in ohm
R22=(-b-sqrt(b^2-4*a*c))/(2*a);//in ohm
//This R2 is the value of rotor circuit resistance.
RotWinResistance=0.02;//in ohm per phase
Extra_R1=R21-RotWinResistance;//in ohm
Extra_R2=R22-RotWinResistance;//in ohm
disp("Extra Resistance(in ohm) : "+string(Extra_R1)+
    " ohm or "+string(Extra_R2)+" ohm.");
```

Scilab code Exa 2.39 I2R loss and torque

```
//Exa 2.39
clc;
clear;
close;
//Given data :
format('v',7);
f=50;//in Hz
P=4;//no. of poles
phase=3;//no. of phase
MotorShaftOutput=20;//in H.P.
MotorShaftOutput=20*735.5;//in watts
MechLosses=MotorShaftOutput*2/100;//in watts(2% of
    the output)
Pdev_rotor=MotorShaftOutput+MechLosses;//in watts
S=3;//slip in %
S=S/100;//fractional slip
RotorI2RLoss=(S/(1-S))*Pdev_rotor;//in watts
disp(RotorI2RLoss,"Rotor I2R Loss(in watts) :");
disp("Rotor iron loss at 3% slip is very small and
    can be neglected.");
RotorInput=Pdev_rotor+RotorI2RLoss;//in watts
disp(RotorInput,"Rotor Input(in Watts) :");
Ns=120*f/P;//in rpm
Nr=Ns-Ns*S;//in rpm
```

```
Nr=Nr/60;//in rps
T=MotorShaftOutput/(2*%pi*Nr);//in Nm
disp(T,"Output torque(in Nm) : ");
```

Scilab code Exa 2.40 Slip loss and efficiency

```
//Exa 2.40
clc;
clear;
close;
//Given data :
format('v',6);
VL=500;//in volt
f=50;//in Hz
P=6;//no. of poles
phase=3;//no. of phase
Nr=975;//in rpm
Ns=120*f/P;//in rpm
S=(Ns-Nr)/Ns;//slip
disp(S,"Slip :");
Pin_stator=40;//in KW
StatorLosses=1;//in KW
Pin_rotor=Pin_stator-StatorLosses;//in KW
RotorCuLosses=S*Pin_rotor;//in KW
disp(RotorCuLosses,"Rotor Cu Losses(in KW) :");
RotorOutput=Pin_rotor-RotorCuLosses;//in KW
OutputHP=RotorOutput/0.735;//in H.P.
disp(OutputHP,"Output Horse Power : ");
Efficiency=RotorOutput/Pin_stator;//unitless
disp(Efficiency*100,"Efficiency(in %) :");
```

Scilab code Exa 2.41 Slip speed Loss Resistance Power

```
//Exa 2.41
clc;
clear;
close;
//Given data :
format('v',6);
VL=440;//in volt
f=50;//in Hz
P=6;//no. of poles
phase=3;//no. of phase
Ns=120*f/P;//in rpm
fr=120;//alternations per minute
fr=fr/60;//in Hz
S=fr/f;//slip
disp(S,"Slip : ");
Nr=Ns-S*Ns;//in rpm
disp(Nr,"Rotor speed(in rpm) :");
Rotor_input=80;//in KW
RotorCuLoss=S*Rotor_input;//in KW
disp(RotorCuLoss*10^3/phase,"Rotor Cu Loss per phase
    (in watts) :");
P_Mechdev=Rotor_input*10^3-RotorCuLoss*10^3;//in
    watts
P_Mechdev=P_Mechdev/735.5;//in H.P.
disp(P_Mechdev,"Mechanical power devloped(in H.P.) :
    ");
Ir=60;//in Ampere
R2=(RotorCuLoss*10^3/phase)/Ir^2;//in ohm
disp(R2,"Rotor resistance per phase(in ohm) :");
```

Scilab code Exa 2.43 Resistance to be added

```
//Exa 2.43
clc;
clear;
```

```
close;
//Given data :
format('v',6);
f=50;//in Hz
P=6;//no. of poles
R2=0.2;//rotor resistance per phase in ohm
Nr=960;//in rpm
Nr_dash=600;//in rpm
Ns=120*f/P;//in rpm
S=(Ns-Nr)/Ns;//slip(unitless)
Sdash=(Ns-Nr_dash)/Ns;//slip(unitless)
//Let the new value of resistance is R2dash=(R+0.2)
R=R2*(Sdash/S)-R2;//Resistance to be added in ohm
disp(R,"Resistance to be added(in ohm) : ");
```

Scilab code Exa 2.44 External Rotor Resistance per phase

```
//Exa 2.44
clc;
clear;
close;
//Given data :
format('v',6);
f=50;//in Hz
P=6;//no. of poles
phase=3;//no. of phase
RotorIntResistance=0.1;//in ohm per phase
X2=1;//in ohm/phase
Rext=X2-RotorIntResistance;//in ohm
disp(Rext,"External resistance to be included(in ohm
   /phase) : ");
```

Scilab code Exa 2.45 Additional Rotor Resistance

```
//Exa 2.45
clc;
clear;
close;
//Given data :
format('v',6);
f=50;//in Hz
P=6;//no. of poles
phase=3;//no. of phase
R2=0.2;//rotor resistance per phase in ohm
N1=960;//Full load speed in rpm
Ns=120*f/P;//in rpm
S1=(Ns-N1)/Ns;//Full load slip(unitless)
N2=N1*(1-10/100);//New speed in rpm(reduced 10%)
S2=(Ns-N2)/Ns;//New slip(unitless)
//Formula : S=RotorCuLoss/Pin_rotor=3*I2^2*R2/
    Pin_rotor
//Let the additional resistance is R
R=R2*S2/S1-R2;//Resistance to be added in ohm
disp(R,"Additional Rotor Resistance(in ohm) : ");
```

Scilab code Exa 2.46 Ratio of torque

```
//Exa 2.46
clc;
clear;
close;
//Given data :
format('v',5);
R2inner=0.4;//in ohm
X2inner=2;//in ohm
R2outer=2;//in ohm
X2outer=0.4;//in ohm
//At standstill :
S=1;//unitless
```

```
Ratio=(R2outer*S/(R2outer^2+S^2*X2outer^2))/(R2inner
    *S/(R2inner^2+S^2*X2inner^2));//unitless
disp(Ratio,"Ratio of torque produced by two cages at
     standstill : ");
//At Full load :
S=5;//in %
S=5/100;//fractional
Ratio=(R2outer*S/(R2outer^2+S^2*X2outer^2))/(R2inner
    *S/(R2inner^2+S^2*X2inner^2));//unitless
disp(Ratio,"Ratio of torque produced by two cages at
     full load(slip=5%) : ");
```

Scilab code Exa 2.47 line current at instant of starting

```
//Exa 2.47
clc;
clear;
close;
//Given data :
format('v',6);
Output=10;//in H.P.
Output=Output*735.5;//in watts
cosfi=0.8;//unitless
ETA=0.83;//unitless
ISCbyIFL=3.5;//ratio of SC current to full load
    current
VL=500;//in volt
Input=Output/ETA;//in watts
IFL=Input/(sqrt(3)*VL*cosfi);//in Ampere
ISC=IFL*ISCbyIFL;//in Ampere
Is=ISC/3;//in Ampere
disp(Is,"Strting current(in Ampere) :");
```

Scilab code Exa 2.48 Starting torque

```
//Exa 2.48
clc;
clear;
close;
//Given data :
format('v',6);
ISCbyIFL=5;//ratio of SC current to full load
    current
S=0.04;//Full load slip
//(i) for star delta starter :
disp("for star delta starter : ");
Ratio=(1/3)*(ISCbyIFL)^2*S;//Ratio of starting
    torque to full load torque
disp("Starting torque is "+string(Ratio*100)+"% of
    full load torque.");
//(i) for auto transformer starter :
disp("for auto transformer starter : ") ;
K=50/100;//tappings
Ratio=K^2*(ISCbyIFL)^2*S;//Ratio of starting torque
    to full load torque
disp("Starting torque is "+string(Ratio*100)+"% of
    full load torque.");
```

Scilab code Exa 2.49 percentage Tapping

```
//Exa 2.49
clc;
clear;
close;
//Given data :
format('v',5);
ISCbyIFL=4;//ratio of SC current to full load
    current
```

```
TsBYTf=1/4;//ratio of atarting torque to full load torque
Slip=3;//in %
Slip=3/100;//in fraction
//Formula : TsBYTf=Percent_Tapping^2*ISCbyIFL^2*Slip
tapping=sqrt(TsBYTf/(Slip*ISCbyIFL^2));//in %
disp(tapping*100,"Tapping(in %) :");
```

Scilab code Exa 2.50 Starting torque in terms of full load torque

```
//Exa 2.50
clc;
clear;
close;
//Given data :
format('v',6);
ISCbyIFL=5;//ratio of SC current to full load current
Slip=5;//in %
Slip=5/100;//in fraction
//Formula : 3*IFL=K^2*ISC
K=sqrt(1/(ISCbyIFL/3));//unitless
TsBYTfl=K^2*(ISCbyIFL)^2*Slip;//ratio of starting torque to full load torque
disp("Starting torque is "+string(TsBYTfl*100)+"% of full load torque.");
```

Scilab code Exa 2.51 Starting torque of an Induction motor

```
//Exa 2.51
clc;
clear;
close;
```

```
//Given data :
format('v',5);
disp("Star delta starter :");
ISCbyIFL=6;//ratio of SC current to full load
    current
Slip=4;//in %
Slip=4/100;//in fraction
TsBYTfl=(1/3)*(ISCbyIFL)^2*Slip;//ratio of starting
    torque to full load torque
disp("Starting torque is "+string(TsBYTfl*100)+"% of
     full load value.");
disp("For an auto transformer :");
K=70.70;//in %
K=70.70/100;//in fraction
TsBYTfl=K^2*(ISCbyIFL)^2*Slip;//ratio of starting
    torque to full load torque
disp("Starting torque is "+string(TsBYTfl*100)+"% of
     full load torque.");
```

Scilab code Exa 2.52 Necessary tapping and starting torque

```
//Exa 2.52
clc;
clear;
close;
//Given data :
format('v',5);
V=400;//in volt
S=3.5;//in %
S=3.5/100;//in fraction
VL=92;//in volts
//ISC=(V/VL)*IFL;//in Ampere
ISCbyIFL=V/VL;//ratio of SC current to full load
    current
//2*IFL=K^2*ISC imples that 2*IFL=K^2*(V/VL)*IFL
```

```
K=sqrt(2/(V/VL));//in fraction
disp(K*100,"Necessary tapping(in %) :");
TsBYTfl=K^2*(ISCbyIFL)^2*S;//ratio of starting
   torque to full load torque
disp("Starting torque is "+string(TsBYTfl*100)+"% of
    full load value.");
```

Scilab code Exa 2.53 Auto transformer ratio

```
//Exa 2.53
clc;
clear;
close;
//Given data :
format('v',5);
ISCbyIFL=4;//ratio of SC current to full load
   current
ISbyIFL=2;//ratio of Supply current to full load
   current
S=2.5;//in %
S=2.5/100;//in fraction
//Formula : ISbyIFL=(1/K^2)*ISCbyIFL
K=sqrt(ISCbyIFL/ISbyIFL);//in fraction
disp(K,"Auto Transormation ratio :");
TsBYTfl=(1/K^2)*(ISCbyIFL)^2*S;//ratio of starting
   torque to full load torque
disp(TsBYTfl,"Ratio of starting torque to full load
   torque :");
disp("or Starting torque is "+string(TsBYTfl*100)+"%
    of full load value.");
```

Scilab code Exa 2.54 percentage Tapping

```
//Exa 2.54
clc;
clear;
close;
//Given data :
format('v',6);
ISCbyIFL=4;//ratio of SC current to full load current
S=3;//in %
S=3/100;//in fraction
TsBYTfl=1/4;//ratio of starting torque to full load torque
//Formula : TsBYTfl=ISCbyIFL^2*K^2*S
K=sqrt(TsBYTfl/(ISCbyIFL^2*S));//in fraction
disp(K*100,"Auto Transormation ratio(in %) :");
```

Scilab code Exa 2.55 line current at instant of starting

```
//Exa 2.55
clc;
clear;
close;
//Given data :
format('v',6);
Output=3;//in H.P.
Output=3*735.5;//in watts
Efficiency=0.83;//unitless
cosfi=0.8;//power factor
Vl=500;//in volt
Input=Output/Efficiency;//in watts
//Formula : Input=sqrt(3)*Vl*Il*cosfi
Il=Input/(sqrt(3)*Vl*cosfi);//in Ampere
ISCbyIFL=3.5;//ratio of SC current to full load current
ISC=ISCbyIFL*Il;//in Ampere
```

```
LineCurrent=ISC/3;//in Ampere(for star delta starter
    )
disp(LineCurrent,"Line Current(in Ampere) :");
//Note : Ans in the book is not accurate.
```

Scilab code Exa 2.56 Ratio of starting to full load current

```
//Exa 2.56
clc;
clear;
close;
//Given data :
format('v',5);
Output=15;//in H.P.
Output=15*735.5;//in watts
Vl=400;//in volt
ISCat200=40;//in Ampere(at 200 volt)
Efficiency=0.88;//unitless
cosfi=0.85;//power factor
ISCat400=ISCat200*(400/200);//in Ampere(at 400 volt)
Input=Output/Efficiency;//in watts
Ifl=Input/(sqrt(3)*Vl*cosfi);//in Ampere
//starting line current with star delta starter
Is=ISCat400/3;//in Ampere
Ratio=Is/Ifl;//ratio of starting current to full
    load current
disp(Ratio,"Ratio of line current at starting to
    full load current :");
```

Scilab code Exa 2.57 Starting torque and current

```
//Exa 2.57
clc;
```

```
clear;
close;
//Given data :
format('v',6);
//With star delta starter :
TstBYTfl=0.35;//ratio of starting torque to full
    load torque
IstBYIfl=1.75;//ratio of starting current to full
    load current
ISCBYIs=sqrt(3);//ratio of SC current to starting
    current
ISCBYIfl=sqrt(3)*IstBYIfl;//ratio of SC current to
    full load current
//Formula : TstBYTfl=(ISCBYIfl)^2*S
S=TstBYTfl/(ISCBYIfl)^2;//in fraction
disp(S,"Full load Slip : ");
//With auto transformer with winding in delta :
Ip=sqrt(3)*1.750*0.8;//full voltage phase current in
     Ampere
IlBYIf=4.2;//ratio of Line current to full load
    current
Ratio=IlBYIf^2*S;//ratio of starting current to full
     load current
disp(Ratio,"Ratio of line current at starting to
    full load current :");
```

Scilab code Exa 2.58 Resistance to be added in series

```
//Exa 2.58
clc;
clear;
close;
//Given data :
format('v',6);
f=50;//in Hz
```

```
P=4;//no. of poles
phase=3;//no. of phase
R2=0.25;//in ohm per phase
S=2;//in %
S=2/100;//in fraction
Ns=120*f/P;//in rpm
Nr=Ns-Ns*S;//in rpm
//When speed reduced to 10%
NewSpeed=Nr*90/100;//in rpm
Sdash=(Ns-NewSpeed)/Ns;//in fraction
R2dash=(Sdash/S)*R2;//in ohm per phase
R=R2dash-R2;//in ohm
disp(R,"Value of resistance to be added(in ohm) :");
```

Scilab code Exa 2.59 External Resistance per phase

```
//Exa 2.59
clc;
clear;
close;
//Given data :
format('v',6);
f=50;//in Hz
P=4;//no. of poles
R2=0.25;//in ohm per phase
N=1440;//in rpm at full load
NewSpeed=1200;//in rpm
Ns=120*f/P;//in rpm
S=(Ns-N)/Ns;//in %
NewS=(Ns-NewSpeed)/Ns;//in fraction
S1=S;S2=NewS;//slip new and old
//Torque remaining same : S1/R2=S2/(R2+R)
R=S2*R2/S1-R2;//in ohm
disp(R,"External resistance per phase(in ohm) :");
Nr=Ns-Ns*S;//in rpm
```

```
//If S1 is taken as 0.03 and S2 as 0.127
S1=0.03;//slip in fraction
S2=0.127;//slip in fraction
R=S2*R2/S1-R2;//in ohm
disp(R,"External resistance per phase(in ohm) :");
```

Scilab code Exa 2.60 Resistance in series per phase

```
//Exa 2.60
clc;
clear;
close;
//Given data :
format('v',6);
f=50;//in Hz
P=4;//no. of poles
phase=3;//no. of phase
S=4;//in %
S=4/100;//in fraction
Ns=120*f/P;//in rpm
N1=Ns-Ns*S;//in rpm
//When speed reduced to 10%
N2=N1*85/100;//in rpm(NewSpeed)
disp(N2,"New speed(in rpm) :");
//New speed is reduced by 15 %
Sdash=(Ns-N2)/Ns;//in fraction
disp(Sdash,"New Slip : ");
```

Scilab code Exa 2.61 Rotor speed HP loss and efficiency

```
//Exa 2.61
clc;
clear;
```

```
close;
//Given data :
format('v',6);
f=50;//in Hz
P=4;//no. of poles
phase=3;//no. of phase
Pin=60;//in KW
StatorLoss=1.2;//in KW
WindingLoss=1.8;//in KW
S=4;//in %
S=4/100;//in fraction
Ns=120*f/P;//in rpm
Nr=Ns-Ns*S;//in rpm
disp(Nr,"Rotor speed(in rpm) :");
Pin_rotor=Pin-StatorLoss;//in KW
RotorCuLoss=S*Pin_rotor;//in KW
disp(RotorCuLoss,"Rotor Cu Loss(in KW) : ");
Pout_rotor=Pin_rotor-WindingLoss-RotorCuLoss;//in KW
Efficiency=(Pout_rotor/Pin)*100;//in %
disp(round(Efficiency),"Efficiency(in %) :");
HP=Pout_rotor*10^3/735.5;//in H.P.
disp(HP,"Horse Power(inH.P.) :");
```

Chapter 3

Fractional KW motors

Scilab code Exa 3.1 Capacitor in auxiliary winding

```
//Exa 3.1
clc;
clear;
close;
//Given data :
format('v',7);
Za=3+3*%i;//in ohm
Zm=6+3*%i;//in ohm
//Phase difference 90 degree : so angle between Im
   and V is 90-45 degree
theta=90-45;//in degree
f=50;//in Hz
//Formula : tand(theta)=(Xc-Xl)/R
Xl=3;//in ohm and Xc=1/(2*%pi*C)
R=6;//in ohm
C=1/(2*%pi*f*(tand(theta)*R+Xl));
disp(C*10^6,"Capacitance(in micro Farad) :");
```

Chapter 4

Special Purpose Machines

Scilab code Exa 4.1 Stepping angle

```
//Exa 4.1
clc;
clear;
close;
//Given data :
P=8;//no. of poles
T=5;//no. of teeteh in each pole
Nr=50;//no. of teeth in rotor
Ns=P*T;//no. of teeth
Beta=(Nr-Ns)*360/(Nr*Ns);//in degree
disp(Beta,"Stepping Angle(in degree) :");
```

Scilab code Exa 4.2 Resolution steps and shaft speed

```
//Exa 4.2
clc;
clear;
close;
```

```
//Given data :
Beta=2.5;//in degree
f=3600;//in PPs
Resolution=360;//in degree
disp(Resolution,"Resolution : ");
Beta1=Resolution/Beta;//steps/revolution
disp(Beta1,"Steps per revolution : ");
n=Beta*f/360;//in rps
disp(n,"Steps required for making 25 revolution(in
    rps) : ");
```

Scilab code Exa 4.3 No of rotor and stator poles

```
//Exa 4.3
clc;
clear;
close;
//Given data :
Beta=15;//in degree
Phase=3;//no. of phase
//Formula : Beta*Nr=(360/phase)
Nr=(360/Phase)/Beta;//unitless
disp(Nr,"No. of rotor :");
//Case (i) : when Ns>Nr : Formula : Beta=(Ns-Nr)
    *360/(Ns*Nr)
Ns=Nr/(1-Beta*Nr/360);
disp(Ns,"No. of stator poles if Ns>Nr :");
//Case (ii) : when Nr>Ns : Formula : Beta=(Nr-Ns)
    *360/(Ns*Nr)
Ns=Nr/(1+Beta*Nr/360);
disp(Ns,"No. of stator poles if Nr>Ns :");
```

Scilab code Exa 4.4 No of rotor and stator teeth

```
//Exa 4.4
clc;
clear;
close;
//Given data :
Beta=1.8;//in degree
m=4;//no. of phases
//Formula : Beta*Nr=(360/m)
Nr=(360/m)/Beta;//unitless
disp(Nr,"No. of rotor teeth :");
disp(Nr,"In multi stack motor rotor teeth equals to
   stator teeth equals to : ");
```