Scilab Textbook Companion for Electric Machinery And Transformers by B. S. Guru And H. R. Hiziroglu[1]

Created by
Rishabh Narayan
B.tech
Electrical Engineering
College Of Engineering Roorkee
College Teacher
Akhilendra Singh Yadav
Cross-Checked by
Madhu Belur

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Book Description

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

Exa Example (Solved example)

Eqn Equation (Particular equation of the above book)

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

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

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Chapter 1

Review of electric circuit theory

Scilab code Exa 1.1 finding the max power delivered

```
// Caption:finding the max power delivered
//Exa:1.1
close;
clc;
clear;
//on applying KVL we get
i=75/50;//in Amperes
v_th=(30*i)+25;//Equivalent Thevenin voltage (in
    Volts)
r_th=(20*30)/(20+30);//Equivalent thevenin
    resistance (in Ohms)
R_load=r_th;//Load resistance=thevenin resistance (
    in Ohms)
disp(R_load,'load resistance (in ohms)=') //in ohms
i_load=v_th/(r_th+R_load);//in Amperes
```

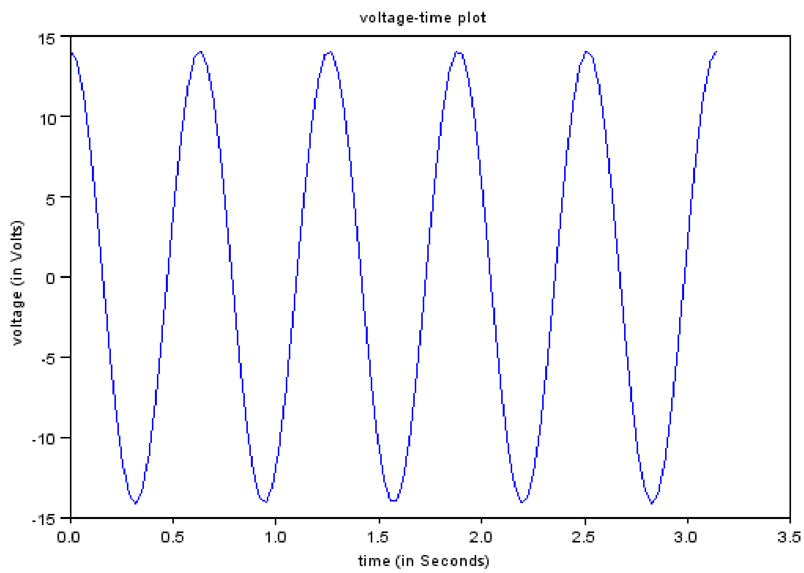

Figure 1.1: Finding the current in the circuit and plot V vs T and I vs T curve

```
p_max=(i_load^2)*r_th;//in Watts
disp(p_max,'max power (in watts)=')//maximum power
    dissipiated
```

Scilab code Exa 1.2 Finding the current in the circuit and plot V vs T and I vs T curve

```
//Caption:Finding the current in the circuit and
    plot V vs T and I vs T curve
//Exa:1.2
clc;
```

```
clear;
close;
//Refer to figure 1.5a
L=1*10^-3;//henery
R=3;//ohms
C=200*10^-6;//faraday
disp("v(t)=14.142cos1000t")
V_m=14.142;//Peak value of applied voltage (in Volts)
V=V_m/sqrt(2);//RMS value of applied voltage (in Volts)
//On comparing with standard equation v(t)=acoswt
w=1000;//in radian/second
//Inductive impedance=jwL
Z_L=%i*w*L;//in ohms
//capacitive impedance=-j/wC
Z_c=-%i/(w*C);//in ohms
//Impedance of the circuit is given by
Z=Z_L+Z_c+R;//in ohms
I=V/Z//Current in the circuit//in Amperes
r=real(I);
i=imag(I);
magn_I=sqrt((r^2)+(i^2));//magnitude of current (in Amperes)
phase_I=atand(i/r);//phase of current (in degree)
disp(magn_I,'magnitude of current (in Amperes)');
disp(phase_I,'phase of current (in Degrees)');
xset('window',1);
xtitle("current-time plot","time (in Seconds)","current (in Amperes)");
z=linspace(0,20,10);
x=linspace(0,%pi,100);
z=2.828*cos((1000*x)+(atan(i/r)));
plot(x,z);
xset('window',2);
xtitle("voltage-time plot","time (in Seconds)","voltage (in Volts)");
x=linspace(0,%pi,100);
```

```
y=linspace(0,20,10);
y=14.142*cos(1000*x);
plot(x,y);
```

Scilab code Exa 1.3 Finding the value of capacitor

```
//Caption:Finding the value of capacitor
//Ex no.1.3
clc;
clear;
close;
I=10;//Current drawn by the load (in Amperes)
pf1=0.5;//lagging power factor
pf2=0.8;
Q1=acosd(pf1);
Q2=acosd(pf2);
I_L=10*(cosd(-Q1)+%i *sind(-Q1));//in Amperes
V=120;//source voltage (in Volts)
f=60;//frequency of source (in Hertz)
//Refer to fig 1.6(b)
//I_Lc=I_L+I_c
S=V*conj (I_L);//complex power absorbed by load (in Watts)
//On connecting capacitor across load current (I) have 0.8pf lagging
I_Lco=real (S)/(V*pf2);// current supplied by load after connecting capacitor (in Amperes)
I_Lc=I_Lco*(cosd(-Q2)+%i*(sind(-Q2)));// in Amperes
I_c=I_Lc-I_L;//in Amperes
Z_c=V/I_c;//capacitive impedance (in Ohms)
//Z_c=-jX_c
```

```
X_c=Z_c/(-%i);//Capacitive reactance
C=1/(2*%pi*f*X_c);
disp(real (C),'Value of capacitance (in Farad) is=')
```

Scilab code Exa 1.4 Determine the line current and phase currents and power absorbed by the load and power dessipated by transmission line

```
//Caption:Determine the line current and phase currents,power absorbed by the load and power dessipated by transmission line
//Ex no:1.4
clc;
clear;
close;
//Make delta -star conversion of load
Z_L=1+%i*2;//Impedance of each wire (in Ohms)
Z_p=(177-%i*246);//per-phase impedance (in Ohms)
Z_pY=(177-%i*246)/3;//per-phase impedance in Y-connection (in Ohms)
Z=Z_L+Z_pY;//Total per phase impedance (in Ohms)
V=866/sqrt(3);//Per-phase voltage (in Volts)
V_phase=0;
I=V/Z;//Current in the circuit (in Ampere)
r=real(I);
i=imag(I);
I_mag=sqrt((r^2)+(i^2));//magnitude of current (in Amperes)
I_phase=atand(i/r);//phase of current (in Degrees)
pf=cosd(I_phase);//power factor
//Refer to fig:1.13(b)
//Source are connected in star,so phase currents =
```

```
line currents
I_na_mag=I_mag;//Magnitude of Source current through n-a (in Amperes)
I_nb_mag=I_mag;//Magnitude of Source current through n-b (in Amperes)
I_nc_mag=I_mag;//Magnitude of Source current through n-c (in Amperes)
I_na_phase=I_phase+(0);//phase angle of current through n-a (in Degree)
I_nb_phase=I_phase+(-120);//phase angle of current through n-b (in Degree)
I_nc_phase=I_phase+(120);//phase angle of current through n-c (in Degree)
disp(I_na_mag,'I_na_mag (in Amperes)=');
disp(I_na_phase,'I_na_phase (in Degrees)=');
disp(I_nb_mag,'I_nb_mag (in Amperes)=');
disp(I_nb_phase,'I_nb_phase (in Degrees)=');
disp(I_nc_mag,'I_nc_mag (in Amperes)=');
disp(I_nc_phase,'I_nc_phase (in Degrees)=');
//Load is connected in delta network
I_AB_mag=I_mag/sqrt(3);//magnitude of current through AB (in Amperes)
I_BC_mag=I_mag/sqrt(3);//magnitude of current through BC (in Amperes)
I_CA_mag=I_mag/sqrt(3);//magnitude of current through CA (in Amperes)
I_AB_phase=I_na_phase+30;//phase angle of current through AB (in Degrees)
I_BC_phase=I_nb_phase+30;//phase angle of current through BC (in Degrees)
I_CA_phase=I_nb_phase-90;//phase angle of current through CA (in Degrees)
disp(I_AB_mag,'I_AB_mag (in Amperes)=');
disp(I_AB_phase,'I_AB_phase (in Degrees)=');
disp(I_BC_mag,'I_BC_mag (in Amperes)=');
disp(I_BC_phase,'I_BC_phase (in Degrees)=');
disp(I_CA_mag,'I_CA_mag (in Amperes)=');
disp(I_CA_phase,'I_CA_phase (in Degrees)=');
```

```
I_AB=I_AB_mag*(cosd(I_AB_phase)+%i*sind(I_AB_phase));//(in Amperes)
P_load=3*I_AB_mag^2*real(Z_p);//in watts
disp(real (P_load),'Power dissipated (in Watts)=');
P_line=3*I_mag^2*real(Z_L);//in watts
disp(P_line,'Power dissipated by transmission line (in Watts)=')
```

Scilab code Exa 1.6 Determine load current load voltage load power and power factor

```
//Caption:Determine load current,load voltage,load power and power factor
//Exa:1.6
clc;
clear;
close;
//Refer to the fig:1.16
R=40;//in ohms
L=%i*30;//in ohms
V=117*((cosd(0)+%i*sind(0)));//in Volts
//Equivalent load impedance is obtained by parallel combination of Resistance R and Inductance L
Z_L=(R*L)/(R+L);//load impedance (in Ohms)
Z1=0.6+%i*16.8;// in Ohms
Z=Z_L+Z1;//Equivalent impedance of circuit (in Ohms)
I=V/Z;//current through load (in Amperes)
r1=real(I);
i1=imag(I);
I_mag=sqrt(r1^2+i1^2);//magnitude of current flowing through load (in Amperes)
```

```
disp(I_mag,'Reading of ammeter (in Amperes)=');
V_L=I*Z_L;//voltage across load (in Volts)
r2=real(V_L);
i2=imag(V_L);
V_L_mag=sqrt(r2^2+i2^2);//magnitude of voltage
    across load (in Volts)
disp(V_L_mag,'Reading of voltmeter (in Volts)=');
P=real (V_L*conj(I));//Power developed (in Watts)
disp(P,'Reading of wattmeter (in Watts)=');
pf=P/(V_L_mag*I_mag);//Power factor
disp(pf,'power factor=')
```

Scilab code Exa 1.7 Determine the reading of two wattmeters total power and power factor

```
//Caption:Determine the reading of two wattmeters,
    total power and power factor
//Exa:1.7
clc;
clear;
close;
//transforming delta connected source into an
    equivalent Star-connected source
V_s=1351;//source voltage (in Volts)
V=1351/sqrt(3);//in volts
V_phase=0;
Z=360+%i*150;//per-phase impedance(in ohms)
I=V/Z;//current in the circuit (in Amperes)
r=real(I);
i=imag(I);
I_mag=sqrt(r^2+i^2);//in ampere
```

```
I_phase=atand(i/r);//degree
//Refer to fig 1.19(a)
V_ab=1351*(cosd(-30)+%i*sind(-30));//in Volts
I_aA=2*(cosd(I_phase)+%i*sind(I_phase));//in Amperes
V_cb=1351*(cosd(-90)+%i*sind(-90));//in Volts
I_cC=2*(cosd(I_phase-120)+%i*sind(I_phase-120));//in Amperes
P1=real(V_ab*conj(I_aA));//reading of wattmeter 1 (in Watts)
disp(P1,'Reading of wattmeter W1 (in Watts) =');
P2=real(V_cb*conj(I_cC));//reading of wattmeter 2 (in Watts)
disp(P2,'Reading of wattmeter W2 (in Watts)=');
P=P1+P2;//total power developed (in Watts)
disp(P,'Total power developed (in Watts)=' );
pf=cosd(I_phase);//power factor
disp(pf,'power factor=')
```

Chapter 2

Review of basic laws of electromagnetism

Scilab code Exa 2.1 Find the induced emf in coil

```
//Caption:Find the induced emf in coil
//Exa:2.1
clc;
clear;
close ;
N=1000;//Number of turns
phy_1=100*10^-3;//initial magnetic flux (in webers)
phy_2=20*10^-3;//final magnetic flux (in webers)
phy=phy_2-phy_1;//change in magnetic flux
t=5;//(in seconds)
e=(-1)*N*(phy/t);//induced emf (in volts)
disp(e,'Induced emf (in volts)=')
```

Scilab code Exa 2.6 Find the magnetic flux density

```
//Caption:Find the magnetic flux density
//Exa:2.6
clc;
clear;
close;
u_o=4*%pi*10^-7;//permeablity of air
u_r=1200;//permeablity of magnetic material
N=1500;//No. of turns
I=4;//current in the coil (in Amperes)
r_i=10*10^-2;//inner radii of magnetic core (in
    meters)
r_o=12*10^-2;//outer radii of magnetic core (in
    meters)
r_m=(r_i+r_o)/2;//mean radii of magnetic core (in
    meters)
l_g=1*10^-2;//length of air gap (in meters)
l_m=2*%pi*(r_m-l_g);//in meters
//Refer to fig:-2.14
A_m=(r_o-r_i)^2;//cross-sectional  area of magnetic
    path (in meter^2)
R_m=l_m/(u_o*u_r*A_m);//reluctance of magnetic
    material
R_g=l_g/(u_o*A_m);//reluctance of air gap
//R_m and R_g in sereis
R=R_m+R_g;
B_m=N*I/(R*A_m);//magnetic flux density (in Tesla)
disp(B_m,'magnetic flux density (in Tesla)=')
```

Scilab code Exa 2.10 Find the percentage of flux setup by coil 1 links coil 2

```
//Caption:Find the percentage of flux setup by coil
   -1 links coil-2
//Exa:2.10
clc;
clear;
close;
//Refer to eqn 2.26
e_21=20;//voltage induced in coil-2 (in volts)
I1=2000;//rate of change of current in coil-1 (in
   Amperes/second)
M=e_21/I1;// in henry
L1=25*10^-3;//in henry
L2=25*10^-3;//in henry
//Refer to eqn 2.32
k=(M/L1)*100;//coefficient of coupling
disp(k,'percentage (%)=')
```

Scilab code Exa 2.11 Find the Inductance of each coil mutual inductance and coefficient of coupling

```
//Caption:Find (a)Inductance of each coil (b)mutual
   inductance (c)coefficient of coupling
//Exa:2.11
clc;
clear;
close;
//L1,L2=inductances of coil 1&2
//M=mutual inductance b/w coil 1&2
```

```
L_aid=2.38;//effective inductance when connected in
    sereis aiding
L_opp=1.02;//effective inductance when connected in
    sereis opposing
//L1+L2+2M=L_aid
//L1+L2-2M=L_opp
M=(L_aid-L_opp)/4;//in henry
disp(M,'mutual inductance (in henry)=')
//L1=16*L2
L1=(L_aid-2*M)/17;//in henry
disp(L1,'inductance of coil-1 (in henry)=')
L2=L_aid-(2*M)-L1;//in henry
disp(L2,'inductance of coil-2 (in henry)=')
k=M/(sqrt(L1*L2));
disp(k,'coefficient of coupling=')
```

Scilab code Exa 2.12 Find effective inductance when connected in parallel aiding and parallel opposing

```
//Caption:Find effective inductance when connected
    in (a)parallel aiding (b) parallel opposing
//Exa: 2.12
clc;
clear;
close;
L1=1.6;//self inductance of coil 1 (in Henry)
L2=0.1;//self inductance of coil 2 (in Henry)
M=0.34;//mutual inductance (in Henry)
//Refer to eqn-2.45
L_aid=((L1*L2)-M^2)*10^3/(L1+L2-(2*M));//in mili-
    Henry
```

```
disp(L_aid,'effective inductance in parallel aiding (in mili-Henry)=')
//Refer to eqn-2.46
L_opp=((L1*L2)-M^2)*10^3/(L1+L2+(2*M));//in mili-henry
disp(L_opp,'effective inductance in parallel opposing (in mini-Henry)=')
```

Scilab code Exa 2.13 Find hysteresis loss and eddy current loss

```
//Caption:Find hysteresis loss and eddy-current loss
//Exa:2.13
clc;
clear;
close;
//refer to eqn-2.50
//eqn:-2.51,2.52 & 2.53 are obtained
f=[25 25 60];//in hertz
disp(f,'frequency (in hertz)=');
B_m=[1.1 1.5 1.1];
P_m=[0.4 0.8 1.2];
//On solving eqn:-2.51 & eqn:-2.53
k_e=(0.016-0.02)/(30.25-72.6);
//on solving eqn:-2.51 & eqn:-2.52
n=(log((0.016-(30.25*k_e))/(0.032-(56.25*k_e))))/(log(1.1/1.5));
k_h=(0.016-(30.25*k_e))/1.1^n;
P_h=k_h*f.*B_m^n//hysteresis loss
disp(P_h,'Hysteresis loss (in Watts)=');
P_eddy=k_e*(f^2).*B_m^2//eddy current loss
disp(P_eddy,'eddy current loss (in Watts)=');
```

Scilab code Exa 2.14 Find the minimum length of magnet for maintaining max energy in air gap

```
//Caption:Find the minimum length of magnet for
   maintaining max energy in air gap
//Exa:2.14
clc;
clear;
close;
u_o=4*%pi*10^-7;//permeablity of air
u_r=500;//permeablity of steel
l_g=1*10^-2;//length of air gap section (in meter)
A_g=10*10^-4;//cross-sectional area of air gap
   section (in meter^2)
A_m=10*10^-4;//cross-sectional area of magnet
   section (in meter^2)
A_s=10*10^-4;//cross-sectional area of steel
   sections (in meter^2)
l_s=50*10^-2;//length of steel section (in meter)
//Refer to fig:-2.29 (Demagnetization and energy-
   product curves of a magnet)
H_m=-144*10^3;//(in Ampere/meter)
B_m=0.23;//Magnetic flux density (in Tesla)
//refer to eqn:-2.55
l_m=(-1*100)*(((l_g*A_m)/(u_o*A_g))+((2*l_s*A_m)/(
   u_o*u_r*A_s)))*(B_m/H_m);// (in centimeter)
disp(l_m,'minimum length of magnet (in centimeter)='
   )
```

Chapter 3

Principles of Electromechanical Energy Conversion

Scilab code Exa 3.1 Find the mass of object and energy stored in the feild

```
//Caption:Find the mass of object and energy stored
   in the feild
//Exa:3.1
clc;
clear;
close;
A=20*10^-4;//surface area of each  capacitor's plate
d=5*10^-3;//separation between the plates
e=(10^-9)/(36*%pi);//permetivity of air
V=10*10^3;//potential diff. between the plates
F_e=(e*A*V^2)/(2*d^2);//electric force
g=9.81;//acceleration due to gravity (in meter/
   second^2)
//For condt of balancing electric force=weight of
   object
```

```
//F_e=m*g
m=F_e/g;
disp(m*1000,'mass of object (in grams)=');
W_f=(e*A*V^2)/(2*d);
disp(W_f*1000000,'energy stored in the feild (in micro-joules)=')
```

Scilab code Exa 3.3 Find the energy stored in the magnetic feild

```
//Caption:Find the energy stored in the magnetic feild
//Exa:3.3
clc;
clear;
close;
//i=current in the ckt (in Amperes)
//x=total flux linkage
function i=f(x),i=x/(6-(2*x)),endfunction;
//Refer to eqn:3.18
W_m=intg(0,2,f);//Energy stored in magnetic feild
disp(W_m,'Energy stored in magnetic feild (in Joules)=')
```

Scilab code Exa 3.4 Find the current in the coil and energy stored in the system

```
//Caption:Find the current in the coil and energy stored in the system
//Exa:3.4
clc;
clear;
close;
N=100;//no. of turns of coil
A=10^-4;//area
x=1*10^-2;//length of air gap
u_o=4*%pi*10^-7;//permeablity of air
u_r=2000;//permeablity of magnetic material
D=7.85*10^3;//density of material (in kg/m^3)
V=11*10^-6;//volume of material
m=D*V;//mass of material
g=9.81;//acceleration due to gravity
//Refer to fig:3.7
R_o=(15.5*10^-2)/(u_o*u_r*A);//reluctance of outer legs
R_c=(5.5*10^-2)/(u_o*u_r*A);//reluctance of central leg
function y = L ( x );//inductance
y = (N^2)/ R ( x );
endfunction;
function y = R ( x );//total reluctance
y = R_c+R_g(x)+(0.5*(R_o+R_g(x)));
endfunction;
function y = R_g ( x );//reluctance of air gap
y = x/(u_o*A);
endfunction;
x = [0.01 ]';      // Points of interest
t=[diag(derivative(L,x))];//t=dL/dx (at x=0.01m)
//since t<o,i.e,F_m is acting in opp direction that of weight
//for equilibrium F_m=m*g
I=sqrt((m*g)/(0.5*t*(-1)));//Refer to eqn3.23
disp(I,'current in the coil (in Amperes)=');
L_o=L(.01);
W_f=0.5*L_o*I^2;
```

```
disp(W_f*10^3,'energy stored in the magnetic feild (in mili-Joules)=')
```

Scilab code Exa 3.5 Find the current in the coil

```
//Caption:Find the current in the coil
//Exa:3.5
clc;
clear;
T=20;//torque exerted by spring (in Newton-meter)
r=0.2;//radius of spring (in meter)
F_s=T/r;//force exerted by spring on magnetic plate
N=1000;//no. of turns in coil
u_o=4*%pi*10^-7;//permablityof air
A=9*10^-4;//area (in meter^2)
function y = L ( x );//inductance
y = (N^2)/ R ( x );
endfunction;
function y = R ( x );//reluctance of air gap
y = (2*x)/(u_o*A);
endfunction;
x = [0.001 ]';      // Points of interest
t=[diag(derivative(L,x))];//t=dL/dx (at x=0.001m)
//since t<o i.e,F_m is acting in opp direction that of weight
//for equilibrium F_m=F_s
I=sqrt((2*F_s)/(t*(-1)));//Refer to eqn3.23
disp(I,'current in the coil (in Amperes)=')
```

Scilab code Exa 3.6 Find the frequency of induced emf max value of induced emf rms value of induced emf average value of induced emf

```
//Caption:Find the (a) frequency of induced emf (b) max value of induced emf (c)rms value of induced emf (d)average value of induced emf
//Exa:3.6
clc;
clear;
close;
N=100;//no. of turns in coil
P=4;//number of poles
N_m=1800;//rotor speed (in rpm)
flux_p=4.5*10^-3;//flux per pole (in Wb)
f=(P*N_m)/120;//Refer to eqn:3.30a
disp(f,'(a) frequency of induced emf (in Hertz)=');
//refer to eqn:3.31
E_m=(2*%pi*P*flux_p*N_m)/120;//max value of induced emf per turn
E_mc=N*E_m;
disp(E_mc,'(b) max value of induced emf in coil (in Volts)=');
E_rms=E_mc/sqrt(2);
disp(E_rms,'(c) rms value of induced emf (in Volts)=');
E_avg=(2*E_mc)/%pi;
disp(E_avg,'(d) average value of induced emf (in Volts)=')
```

Scilab code Exa 3.7 Find the synchronous speed and percent slip of the motor

```
//Caption:Find the synchronous speed and percent
   slip of the motor
//Exa:3.7
clc;
clear;
close;
P=4;//no. of pole
f=50;//frequency (in Hz)
N_r=1200;//speed of rotor(in rpm)
N_s=(120*f)/P;
disp(N_s,'synchronous speed (in rpm)=');
s=(N_s-N_r)/N_s;//slip
s_p=s*100;
disp(s_p,'percent slip of the motor(%)=')
```

Scilab code Exa 3.8 Find the rotor speed and average torque developed by motor

```
//Caption:Find the rotor speed and average torque
   developed by motor
//Exa:3.8
```

```
clc;
clear;
close;
N=2;//no. of poles
f=60;//frequency in Hz
I_rms=10;//current intake
L_q=1;//min inductance (in H)
L_d=2;//max inductance(inH)
w=2*%pi*f;
disp(w,'rotor speed(in rad/sec)=');
//Refer to eqn:3.52
T_avg=(-1)*0.125*(L_d-L_q)*((I_rms*sqrt(2))^2)*sind
    (2*45);
if ( T_avg <0 ) then;
disp ((T_avg*(-1)), "average torque developed by
    motor (in Newton-meter)=");
else;
disp (T_avg,"average torque developed by motor (in
    Newton-meter)=");
end
```

Scilab code Exa 3.9 Find the restraining force of the spring

```
//Caption:Find the restraining force of the spring
//Exa:3.9
clc;
clear;
close;
N=500;//no. of turns
u_o=4*%pi*10^-7;//Permeablity of air
I=4.2;//main winding current(in A)
```

```
A=2.25*10^-4;//area of air gap(in m^2)
x=0.002;//length of air gap(in m)
i=I*1.50;//min current needed for activating relay
F_m=u_o*A*0.5*((N*i)/x)^2;//Refer to eqn 3.53
disp(F_m,'restraining force of the spring(in Newton)
   =')
```

Chapter 4

Transformers

Scilab code Exa 4.2 Find the a ratio and current in primary and the power supplied to load and the flux in the core

```
//Caption:Find the (a) a-ratio (b) current in
   primary (c) the power supplied to load (d) and
   the flux in the core
//Exa:4.2
clc;
clear;
close;
N_p=150;//no. of turns in primary winding
N_s=750;//no. of turns in secondary winding
f=50;//frequency in Hz
I_2=4;//load current (in Amperes)
V_1=240;//voltage on primary side (in Volts)
pf=0.8;//power factor
a=N_p/N_s;
disp(a,'(a) a-ratio=');
I_1=I_2/a;
```

```
disp(I_1,'(b) current in primary (in Amperes)=');
V_2=V_1/a;
disp(V_2,'(c) voltage on secondary side (in Volts)='
    );
P_L=V_2*I_2*pf;
disp(P_L,'(d) power supplied to the load (in Watts)=
    ');
flux=V_1/(4.44*f*N_p);
disp(flux*10^3,'(e) flux in the core (in mili-Weber)
    =');
```

Scilab code Exa 4.3 Find the efficiency of transformer

```
//Caption:Find the efficiency of transformer
//Exa:4.3
clc;
clear;
close;
R_1=4;//in ohms
R_2=0.04;//in ohms
X_1=12;//in ohms
X_2=0.12;//in ohms
pf=0.866;//power factor
V_p=2300;//primary voltage in volts
V_s=230;//Secondary voltage in volts
S=23000;//VA
theta=acosd(pf);
I_2=(S*0.75/V_s)*(cosd(theta)+%i*sind(theta));//
    secondary current (in Amperes)
Z_2=R_2+%i*X_2;//secondary winding impedance (in
    ohms)
```

```
E_2=V_s+I_2*Z_2;//induced emf in secondary winding (
    in Volts)
a=V_p/V_s;//transformation ratio
E_1=a*E_2;//induced emf in primary winding (in Volts
    )
I_1=I_2/a;//current in primary winding
Z_1=R_1+%i*X_1;//primary winding impedance (in ohms)
V_1=E_1+I_1*Z_1;//source voltage
P_o=real(V_s*conj(I_2));//output power(in Watts)
P_in=real(V_1*conj(I_1));//input power
Eff=P_o/P_in;
disp(Eff*100,'Efficiency (%)=');
```

Scilab code Exa 4.4 Find the efficiency of transformer

```
//Caption:Find the efficiency
//Exa:4.4
clc;
clear;
close;
//From Exa:4.3
V_2=230;//in Volts
Z_1=4+%i*12;
I_s=75*(cosd(30)+%i*sind(30));//in Amperes
a=10;//transformation ratio
E_1=2282.87*(cosd(2.33)+%i*sind(2.33));//in Volts
E_2=228.287*(cosd(2.33)+%i*sind(2.33));//in Volts
I_p=7.5*(cosd(30)+%i*sind(30));//in Amperes
P_o=14938.94;//in Watts
R_c1=20000;//core loss resistance on primary side
X_m1=15000;//magnetizing reactance on primary side
```

```
I_c=E_1/R_c1;//in Amperes
I_m=E_1/(%i*X_m1);//in Amperes
I_phy=I_c+I_m;//in Amperes
I_1=I_p+I_phy;//in Amperes
V_1=E_1+Z_1*I_1;//in Volts
P_in=real(V_1*conj(I_1));//in Watts
Eff=P_o/P_in;
disp(Eff*100,'Efficiency (%)=')
```

Scilab code Exa 4.6 Find efficiency and voltage regulation of transformer

```
//Caption:Find efficiency and voltage regulation of transformer
//Exa:4.6
clc;
clear;
close;
S=2200;//Volt-Ampere
V_s=220;//secondary side voltage (in Volts)
V_2=V_s;
V_p=440;//primary side voltage (in Volts)
R_e1=3;//in ohms
X_e1=4;//in ohms
R_c1=2.5*1000;//in ohms
X_m1=2000;//in ohms
a=V_p/V_2;//transformation ratio
pf=0.707;//lagging power factor
theta=-acosd(pf);
I_2=(S/V_2)*(cosd(theta)+%i*sind(theta));//(in Amperes)
//Refer to equivalent circuit (fig:4.16)
```

```
I_p=I_2/a;//in Amperes
V_2p=a*V_2;
V_1=V_2p+I_p*(R_e1+%i*X_e1);
I_c=V_1/R_c1;//core loss current (in Amperes)
I_m=V_1/(%i*X_m1);
I_1=I_p+I_c+I_m;//current supplied by source (in
    Amperes)
P_o=real(V_p*conj(I_p));//output power (in Watts)
P_in=real(V_1*conj(I_1));//input power (in Watts)
Eff=P_o/P_in;//Efficiency
disp(Eff*100,'Efficiency (%)=');
VR=(abs(V_1)-abs(V_p))/V_p;
disp(VR*100,'voltage regulation (%)=')
```

Scilab code Exa 4.7 Find the KVA rating at max efficiency

```
//Caption:Find (a)KVA rating at max efficiency (b)
    max efficiency (c) Efficiency at full load and
    0.8pf lagging (d)equivalent core resistance
//Exa:4.7
clc;
clear;
close;
S=120000;//Volt-Ampere
V_p=2400;//in volts
V_s=240;//in volts
R_1=0.75;//in ohms
R_2=0.01;//in ohms
X_1=0.8;//in ohms
X_2=0.02;//in ohms
pf=0.8;//lagging
```

```
theta=-acosd(pf);
a=V_p/V_s;//transformation ratio
I_p=S/V_p;//rated load current (in Amperes)
I_p_eta=0.7*I_p;//load current at max efficiency
KVA=I_p_eta*V_p/1000;
disp(KVA,'(a) KVA rating at max efficiency =');
P_cu_eta=I_p_eta^2*(R_1+a^2*R_2);//copper loss (in Watts)
P_m=P_cu_eta;//core loss
P_o=V_p*I_p_eta*pf;//power output at max efficiency
P_in=P_o+P_m+P_cu_eta;//power input at max efficiency
eta=P_o/P_in;
disp(eta*100,'(b) max efficiency (%)=');
P_o_FL=V_p*I_p*pf;//power output at full load
P_cu_FL=I_p^2*(R_1+a^2*R_2);//copper loss at full load
P_in_FL=P_cu_FL+P_o_FL+P_m;
Eff=P_o_FL/P_in_FL;
disp(Eff*100,'(c) Efficiency at full load (%)=');
R_c1=V_p^2/P_cu_eta;
disp(R_c1,'(d) equivalent core resistance (in ohms)=');
```

Scilab code Exa 4.9 Find the generator voltage generator current and efficiency

```
//Caption:Find the (a) generator voltage (b) generator current (c) efficiency
//Exa:4.9
clc;
```

```
clear;
close;
//Refer to fig:4.29
//For region A
V_bA=230;//in Volts
S_bA=.46000;//Volt-Ampere
I_bA=S_bA/V_bA;//in Amperes
Z_bA=V_bA/I_bA;//in ohms
Z_g_pu=(0.023+%i*0.092)/Z_bA;
R_L_pu=0.023/Z_bA;
X_L_pu=0.069/Z_bA;
//For region B
//Per unit parameters on high-voltage side of the
    step-up transformer
V_bB=2300;//in Volts
S_bB=46000;//Volt-Ampere
I_bB=S_bB/V_bB;//in Amperes
Z_bB=V_bB/I_bB;//in ohms
R_H_pu=2.3/Z_bB;
X_H_pu=6.9/Z_bB;
R_cH_pu1=13800/Z_bB;
X_mH_pu1=6900/Z_bB;
Z_l_pu=(2.07+%i*4.14)/Z_bB;//Per-unit impedance of
    transmission line
//Per unit parameters on high-voltage side of the
    step-down transformer
X_mH_pu2=9200/Z_bB;
R_cH_pu2=11500/Z_bB;
//For region C
V_bC=115;//in Volts
S_bC=46000;//Volt-Ampere
I_bC=S_bC/V_bC;//in Amperes
Z_bC=V_bC/I_bC;//in ohms
R_L_pu=0.00575/Z_bC;
X_L_pu=0.01725/Z_bC;
V_L_pu=1*(cosd(0)+%i*sind(0));
I_L_pu=1*(cosd(-30)+%i*sind(-30));
E_l_pu=V_L_pu+(R_L_pu+%i*X_L_pu)*I_L_pu;
```

```
I_l_pu=I_L_pu+E_l_pu*(0.01-%i*(1/80));
E_g_pu=E_l_pu+I_l_pu*(0.02+%i*0.06+0.018+%i*0.036+0.02+%i*0.06);
I_g_pu=I_l_pu+E_g_pu*((1/120)-%i*(1/60));
V_g_pu=E_g_pu+I_g_pu*(0.02+0.02+%i*0.08+%i*0.06);
V_g=V_bA*V_g_pu;
disp(abs(V_g),'(a) Generator Voltage (in Volts)=');
disp(atand(imag(V_g)/real(V_g)),'Phase of generated voltage (in degree)=');
I_g=I_bA*I_g_pu;
disp(abs(I_g),'(b) Generator current (in Amperes)=');
disp(atand(imag(I_g)/real(I_g)),'Phase of generator current (in degree)=');
P_o_pu=0.866;//rated power output at pf=0.866 lagging
P_in_pu=real(V_g_pu*conj(I_g_pu));
Eff=P_o_pu/P_in_pu;
disp(Eff*100,'(c) Efficiency (%)=');
```

Scilab code Exa 4.10 Find the primary winding voltage secondary winding voltage ratio of transformation and nominal rating of transformer

```
//Caption:Find (a) primary winding voltage (b) secondary winding voltage (c) ratio of transformation (d) nominal rating of transformer
//Exa:4.10
clc;
clear;
close;
V_1=2400;//in Volts
```

```
V_2=240;//in Volts
S_o=24*1000;//Volt-Ampere
I_1=10;//in Amperes
I_2=100;//in Amperes
//Refer to fig:4.31 (a)
V_1a=V_1+V_2;
V_2a=V_2;
a_T1=V_1a/V_2a;
a_T2=V_2a/V_1a;
a_T3=V_1a/V_1;
a_T4=V_1/V_1a;
S_oa_1=V_1a*I_1;
S_oa_2=V_1a*I_1;
S_oa_3=V_1a*I_2;
S_oa_4=V_1a*I_2;
disp("Refer to fig:4.31a");
disp(V_1a,'(a) primary winding voltage (in Volts)=');
disp(V_2a,'(b) secondary winding voltage (in Volts)=');
disp(a_T1,'(c) ratio of transformation=');
disp(S_oa_1/1000,'(d) nominal rating of transformer (KVA)=');
disp("Refer to fig:4.31b");
disp(V_2a,'(a) primary winding voltage (in Volts)=');
disp(V_1a,'(b) secondary winding voltage (in Volts)=');
disp(a_T2,'(c) ratio of transformation=');
disp(S_oa_2/1000,'(d) nominal rating of transformer (KVA)=');
disp("Refer to fig:4.31c");
disp(V_1a,'(a) primary winding voltage (in Volts)=');
disp(V_1,'(b) secondary winding voltage (in Volts)=');
disp(a_T3,'(c) ratio of transformation=');
disp(S_oa_3/1000,'(d) nominal rating of transformer
```

```
    (KVA)=');
disp("Refer to fig:4.31d");
disp(V_1,'(a) primary winding voltage (in Volts)=');
disp(V_1a,'(b) secondary winding voltage (in Volts)=
    ');
disp(a_T4,'(c) ratio of transformation=');
disp(S_oa_4/1000,'(d) nominal rating of transformer
    (KVA)=');
```

Scilab code Exa 4.11 Find the efficiency and voltage regulation

```
//Caption:Find the efficiency and voltage regulation
//Exa:4.11
clc;
clear;
close;
V_2a=480;//in volts
pf=0.707;//leading
theta=acosd(pf);
a_T=120/480;//ratio of transformation of step-up
    transformer
a=360/120;//ratio of transformation of two-winding
    transformer
R_cH=8.64*1000;//in ohms
R_H=18.9;//in ohms
X_H=21.6;//in ohms
X_L=2.4;//in ohms
R_L=2.1;//in ohms
X_mH=6.84*1000;//in ohms
R_cL=R_cH/a^2;//equivalent core loss resistance in
    ohms
```

```
X_mL=X_mH/a^2;//magnetizing reactance
I_2a=(720/360)*(cosd(theta)+%i*sind(theta));
I_H=I_2a;
I_pa=I_2a/a_T;
I_com=I_pa-I_2a;//current through common winding (in
    Amperes)
//on applying KVL to the output loop
E_L=(I_2a*(R_H+%i*X_H)+V_2a-I_com*(R_L+%i*X_L))/4;
V_1a=E_L+I_com*(R_L+%i*X_L);
I_ca=V_1a/R_cL;//core loss current in Amperes
I_ma=-%i*V_1a/X_mL;//magnetizing current in Amperes
I_phy_a=I_ca+I_ma;//excitation current
I_1a=I_pa+I_phy_a;
P_o=real(V_2a*conj(I_2a));
P_in=real(V_1a*conj(I_1a));
Eff=P_o/P_in;
disp(Eff*100,'Efficiency (%)=');
V_2anL=V_1a/a_T;//no load voltage
VR=(abs(V_2anL)-V_2a)/V_2a;
disp(VR*100,'Voltage regulation (%)=');
```

Scilab code Exa 4.13 Find the line voltages and line currents and efficiency of the transformer

```
//Caption:Find the line voltages ,the line currents
   and efficiency of the transformer
//Exa:4.13
clc;
clear;
close;
R_H=133.5*10^-3;//in ohms
```

```
X_H=201*10^-3;//in ohms
R_L=39.5*10^-3;//in ohms
X_L=61.5*10^-3;//in ohms
R_cL=240;//in ohms
X_mL=290;//in ohms
pf=0.8;//lagging
theta=-acosd(pf);
V_2n=138.564*(cosd(0)+%i*sind(0));//rated load voltage for Y/Y connection
I_2A=86.6*(cosd(theta)+%i*sind(theta));//load current
a=120/138.564;//transformation ratio
I_pA=(I_2A/a)*(cosd(30)+%i*sind(30));//per phase current in primary winding
E_2n=V_2n+I_2A*(0.0445+%i*0.067);//voltage induced in secondary winding
E_2L=sqrt(3)*E_2n*(cosd(30)+%i*sind(30));
E_1n=a*E_2n*(cosd(30)+%i*sind(30));//voltage induced in primary winding
I_1A=I_pA+E_1n*((1/240)-%i*(1/290));
disp(abs(I_2A),'Line current in secondary side (in Amperes)=');
disp(atand(imag(I_2A)/real(I_2A)),'phase angle of induced line current in secondary (in Degree)=');
disp(abs(I_1A),'Line current in primary side (in Amperes)=');
disp(atand(imag(I_1A)/real(I_1A)),'phase angle of induced line current in primary (in Degree) =');
disp(abs(E_2L),'Line voltage induced  in secondary side (in Volts)=');
disp(atand(imag(E_2L)/real(E_2L)),'phase angle of induced line voltage in secondary (in Degree)=');
V_1n=E_1n+I_1A*(R_L+%i*X_L);
V_1L=sqrt(3)*V_1n*(cosd(30)+%i*sind(30));
disp(abs(V_1L),'Line voltage induced  in primary side (in Volts)=');
disp(atand(imag(V_1L)/real(V_1L)),'phase angle of induced line voltage  in primary (in Degree)=');
```

```
P_o=3*real(138.564*conj(I_2A));
P_in=3*real(V_1n*conj(I_1A));
Eff=P_o/P_in;
disp(Eff*100,'Efficiency (%)=');
```

Scilab code Exa 4.14 Find the line current line voltage and power

```
//Caption:Find the line current,line voltage and power
//Exa:4.14
clc;
clear;
close;
I_L=4*80/5;
disp(I_L,'Line current (in Amperes)=');
V_L=110*100/1;
disp(V_L,'Line voltage (in Volts)=');
P=(100/1)*(80/5)*352;
disp(P,'Power on the transmission line (in Watts)=');
```

Chapter 5

Direct Current Generators

Scilab code Exa 5.1 Find the coil pitch for 2 pole winding and 4 pole winding

```
//Caption:Find the coil pitch for (a)2-pole winding
   (b)4-pole winding
//Exa:5.1
clc;
clear;
close;
P1=2;
P2=4;
S=10;//no. of slots
S_p1=S/P1;//slots per pole
y1=int(S_p1);//coil pitch in slots
S_s1=180/S_p1;//slot span
C_p1=S_s1*y1;//coil pitch(electrical)
disp(C_p1,'coil pitch for 2-pole winding (electrical
   )=');
S_p2=S/P2;//slots per pole
```

```
S_s2=180/S_p2;//slot span
y2=int(S_p2);//coil pitch in slots
C_p2=S_s2*y2;//coil pitch(electrical)
disp(C_p2,'coil pitch for 4-pole winding(electrical)
   =');
```

Scilab code Exa 5.3 Find the induced emf in the armature winding induced emf per coil induced emf per turn induced emf per conductor

```
//Caption:Find the (a)induced emf in the armature
   winding (b)induced emf per coil (c)induced emf
   per turn (d)induced emf per conductor
//Ex:5.3
clc;
clear;
close;
C=24;//no. of coils
N_c=18;//no. of turns per coil
P=2;//no. of pole
W_m=183.2;//angular velocity(in rad/sec)
Z=2*C*N_c;//total armature conductors
a=2;//no. of parallel paths
L=0.2;//effective length of machine(in meter)
r=0.1;//radius of armature(in meter)
A_p=(2*%pi*r*L)/P;//actual pole area
A_e=A_p*0.8;//effective pole area
B=1;//flux density per pole(in Tesla)
Phy=B*A_e;//effective flux per pole
K_a=(Z*P)/(2*%pi*a);//machine constant
E_a=K_a*Phy*W_m;
disp(E_a,'(a) induced emf in armature winding  (in
```

```
    Volts)=');
E_coil=E_a/(C/a);
disp(E_coil,'(b) induced emf per coil  (in Volts)=')
    ;
E_turn=E_coil/N_c;
disp(E_turn,'(c) induced emf per turn  (in Volts)=')
    ;
E_cond=E_turn/2;
disp(E_cond,'(d) induced emf per conductor  (in
    Volts)=');
```

Scilab code Exa 5.4 Find the current in each conductor the torque developed the power developed

```
//Caption:Find the (a) current in each conductor (b)
     the torque developed (c)the power developed
//Exa:5.4
clc;
clear;
close;
K_a=137.51;//Refer to exa:5.3
Phy=0.05;//flux per pole (Refer to exa:5.3)
E_a=1259.6;//induced emf (Refer to exa:5.3)
I=25;//current in the machine (in Amperes)
a=2;//no. of parallel paths
I_cond=I/a;
disp(I_cond,'(a) current in each conductor (in
    Amperes)=');
T_d=K_a*Phy*I;
disp(T_d,'(b) torque developed by machine (in Newton
    -meter)=');
```

```
P_d=E_a*I;
disp(P_d,'(c) Power developed (in Watts)=');
```

Scilab code Exa 5.5 Find induced emf at full load power developed torque developed applied torque efficiency external resistance in feild winding voltage regulation

```
//Caption:Find (a)induced emf at full load (b)power developed (c)torque developed (d)applied torque (e)efficiency (f)external resistance in feild winding (g)voltage regulation
//Exa:5.5
clc;
clear;
close;
N_m=600;//speed of rotor (in rpm)
R_a=0.01;//armature resistance (in ohms)
R_fw=30;//feild winding resistance(in ohms)
V_f=120;// voltage of external source (in volts)
N_f=500;//no. of turns per pole
P_r=10000;//in watts
V_t=240;//terminal voltage (in volts)
P_o=240*10^3;//rated power (in watts)
I_L=P_o/V_t;//load current
I_a=I_L;//armature current
E_afl=V_t+(I_a*R_a);//refer to eqn:5.27
disp(E_afl,'(a) induced emf at full load (in Volts)=');
P_d=E_afl*I_a;
disp(P_d,'(b) power developed (in watts)=');
W_m=(2*%pi*N_m)/60;//angular velocity (Refer to Eqn
```

```
:5.5&5.6)
T_d=P_d/W_m;
disp(T_d,'(c) torque developed (in Newton-meter)=');
P_inm=P_d+P_r;//mechanical power input
T_s=P_inm/W_m;
disp(T_s,'(d) Applied torque (in Newton-meter)=');
//Refer fig:5.21 (magnetization curve)
I_f=2.5;//effective feild current
mmf=(2.5*N_f)+(0.25*I_a);//total mmf
I_fa=mmf/N_f;//actual feild current
P_in=P_inm+(V_f*I_fa);//total power input
Eff=(P_o/P_in)*100;
disp(Eff,'(e) efficiency (%)=');
R_f=V_f/I_fa;
R_fx=R_f-R_fw;
disp(R_fx,'(f) external resistance in feild winding (in ohms)=');
VR=((266-V_t)/V_t)*100;//Refer to fig:5.21
disp(VR,'(g) voltage regulation (%)=');
```

Scilab code Exa 5.6 Find Rfx and terminal voltage voltage regulation Efficiency

```
//Caption:Find R_fx and (a)terminal voltage (b) voltage regulation (c) Efficiency
//Exa:5.6
clc;
clear;
close;
R_fw=30;//in ohms
R_a=0.2;//in ohms
```

```
N_f=200;//turns/pole
P_r=1200;//in Watts
I_L=100;
D_mmf=0.5*I_L;//demagnetizing mmf
V_nL=170;//no load voltage (in Volts)
//Refer to fig:5.26 (magnetization curve)
I_f=3.5;//field current in Amperes
R_f=V_nL/I_f;
R_fx=R_f-R_fw;
disp(R_fx,'R_fx (in ohms)=');
//First iteration:
//Assume
E_a=170;
V_t1=E_a-103.5*R_a;
//Second iteration:
I_f2=V_t1/R_f;//actual field current
I_fe2=(N_f*I_f2-D_mmf)/N_f;
//Refer to fig:5.26
E_a2=165;
V_t2=E_a2-103.07*R_a;
//third iteration
I_f3=V_t2/R_f;//actual field current
I_fe=(N_f*I_f-D_mmf)/N_f;
//Refer to fig:
E_a3=163;
V_t3=E_a3-102.97*R_a;
V_t=V_t3;
disp(V_t,'(a) Terminal voltage (in Volts)=');
I_f=V_t/R_f;
E_a=E_a3;
VR=(V_nL-V_t)*100/V_t;
disp(VR,'(b) Voltage Regulation (%)=');
P_o=V_t*I_L;//power output
P_cu=R_a*(I_L+I_f)^2+R_f*I_f^2;//copper loss
P_d=P_o+P_cu;//power developed
P_in=P_d+P_r;//power input
Eff=P_o*100/P_in;
disp(Eff,'(c) Efficiency (%)=');
```

Scilab code Exa 5.7 Find the voltage between far end of feeder and bus bar

```
//Caption:Find the voltage between far end of feeder
    and bus bar
//Exa:5.7
clc;
clear;
close;
V_o=240;//bus bar voltage (in Volts)
I_d=0;
I_s=300;//current in series winding (in Amperes)
R_s=0.03;//resistance of series feild winding(in
    ohms)
R_a=0.02;//resistance of armature winding(in ohms)
R_fe=0.25;//resistance of feeder (in ohms)
//Refer to eqn:5.33
I_a=I_s;
E_a=0.4*I_s;//induced emf
V_d=I_s*(R_s+R_a+R_fe);//voltage drop (in Volts)
V_t=V_o+E_a-V_d;
disp(V_t,' voltage between far end of feeder and bus
    bar (in Volts)=')
```

Scilab code Exa 5.9 Find maximum efficiency of generator

```
//Caption:Find maximum efficiency of generator
//Exa:5.9
clc;
clear;
close;
R_a=50*10^-3;//armature resistance (in ohms)
R_s=20*10^-3;//series field resistance
R_sh=40;//shunt field resistance
P_rot=2000;//rotational loss (in watts)
V=120;//voltage (in vollts)
I_f=V/R_sh;//shunt field current
//Refer toeqn 5.49
I_Lm=sqrt((P_rot+(R_a+R_s+R_sh)*(I_f^2))/(R_a+R_s));
P_o=I_Lm*V;//power output at max efficiency
P_cu=(((I_Lm^2)*(R_a+R_s))+((I_f^2)*R_sh));//total
    copper loss
P_d=P_o+P_cu;//Power developed at max efficiency
P_in=P_d+P_rot;
Eff=(P_o/P_in)*100;
disp(Eff,'Max efficiency of generator (%)=');
```

Chapter 6

Direct Current Motors

Scilab code Exa 6.1 Find armature current at rated load efficiency at full load no of turns per pole new speed of motor and driving torque when armature current reduces

```
//Caption:Find (a)armature current at rated load (b)
   efficiency at full load (c)no. of turns per pole
   (d) new speed of motor and driving torque when
   armature current reduces to 16.67A
//Exa:6.1
clc;
clear;
close;
P_o=10*746;//output power (in Watts)
V_s=220;
P_rot=1040;//rotational loss (in Watts)
R_a=0.75;//armature resistance (in ohms)
R_s=0.25;//series winding resistance (in ohms)
N_m= 1200;//(in rpm)
P_d=P_o+P_rot;
```

```
function y=root (a,b,c);
    y=((-b)-sqrt((b^2)-(4*a*c)))/(2*a);
endfunction;
I_a=root(1,-220,8500);
disp(I_a,'(a) armature current at rated load (in Amperes)=');
P_in=V_s*I_a;
disp((P_o/P_in)*100,'(b) Efficiency at full load (%)=');
N_s=150/I_a;
disp(N_s,'(c) no. of turns per pole=');
I_an=16.67;
E_an=V_s-(I_an*(R_a+R_s));
N_mn=(E_an*N_m)/90;
disp(int (N_mn),'(d) new speed of motor (in rpm)=');
T_dn=(E_an*I_an)/283.9;
disp(T_dn,'driving torque (in Newton-meter)=');
```

Scilab code Exa 6.3 Find power developed and speed for cumulative compound motor differential compound motor

```
//Caption:Find power developed and speed for (a) cumulative compound motor (b)differential compound motor
//Exa:6.3
clc;
clear;
close;
disp("(a) For Cumulative compound motor");
V=240;//in volts(Refer to exa:6.2)
R_a=0.4;//armature resistance (Refer to exa:6.2)
```

```
T=20.68; //torque (Refer to exa:6.2)
R_x=0.1; //in ohms
I_a=22.5; //armature current of shunt motor (Refer to
    exa:6.2)
I_ac=I_a/(1+0.125); //armature current of cummulative
    compound motor
E_ac=V-(I_ac*(R_a+R_x));
P_dc=E_ac*I_ac;
disp(P_dc,'Power developed (in Watts)=');
N_mc=(P_dc*60)/(T*2*%pi);
disp(int(N_mc),'speed (in rpm)=');
disp("(b) For differential compound motor");
I_ad=I_a/(1-0.125); //armature current of cummulative
    compound motor
E_ad=V-(I_ad*(R_a+R_x));
P_dd=E_ad*I_ad;
disp(P_dd,'Power developed (in Watts)=');
N_md=(P_dd*60)/(T*2*%pi);
disp(int(N_md),'speed (in rpm)=');
```

Scilab code Exa 6.4 Find the motor speed power loss in external resistance efficiency

```
//Caption:Find the (a) motor speed (b) power loss
    in external resistance (c) efficiency
//Exa:6.4
clc;
clear;
close;
V=120
N_mfL=2400; //full load speed of motor
```

```
R_a=0.4;//armature resistance (in ohms)
R_sh=160;//shunt field winding resistance
I_fL=14.75;//current drawn at full load (in Amperes)
I_nL=2;//current drawn at no load (in Amperes)
R_x=3.6;//external resistance
I_f=V/R_sh;//feild current
I_anL=I_nL-I_f;//armature current at no load
E_anL=V-(I_anL*R_a);//no load back emf
P_dnL=E_anL*I_anL;//power developed at no load
I_afL=I_fL-I_f;//armature current at full load
E_afL=V-(I_afL*R_a);//full load back emf
P_dfL=E_afL*I_afL;//power developed at full load
N_mnL=(E_anL/E_afL)*N_mfL;//no load speed
P_in_fL=V*I_fL;//power input at full load
E_a_n=V-(I_afL*(R_a+R_x));//new back emf
P_d_n=E_a_n*I_afL;//new power developed
N_m_n=ceil((E_a_n/E_afL)*N_mfL);
disp("After insertion of external resistance in the armature ckt");
disp(N_m_n,'(a) motor speed (in rpm)=');
P_rot_n=(N_m_n/N_mnL)*P_dnL;
P_o_n=P_d_n-P_rot_n;
P_x=(I_afL^2)*R_x;
disp(P_x,'(b) power loss in external resistance (in Watts)=');
Eff=P_o_n/P_in_fL;
disp(Eff*100,'(c) efficiency (%)=');
```

Scilab code Exa 6.5 Find the new motor speed power loss in external resistance efficiency

```
//Caption:Find the new (a) motor speed (b) power
   loss in external resistance (c) efficiency
//Exa:6.5
clc;
clear;
close;
R_x=80;//external resistance
//Refer to Exa 6.4
R_sh=160;//shunt resistance
V=120;//in volts
E_a=114.4;//back emf at full load
N_m=2400;//speed of motor
P_rot=143;//rotational losses
I_fn=V/(R_x+R_sh);//new field-winding current
I_f=0.75;//field current at full load
c=sqrt(I_f/I_fn);//ratio of new flux to old flux
R_a=0.4;//armature resistance
I_a=14;//armature resistance
I_an=I_a*c;
E_an=V-(I_an*R_a);
N_mn=c*(E_an/E_a)*N_m;
disp(int(N_mn),'(a) new motor speed (in rpm)=');
P_x=(I_fn^2)*R_x;
disp(P_x,'(b) Power loss in external resistance (in
   Watts)=');
P_in=V*(I_fn+I_an);
P_dn=E_an*I_an;
P_o=P_dn-P_rot;
Eff=P_o/P_in;
disp(Eff*100,'(c) Efficiency (%)=');
```

Scilab code Exa 6.6 Find the value of external resistance when motor develops torque of 30 Nm at 2000rpm torque of 30Nm at 715 rpm

```
//Caption:Find the value of external resistance when
    motor develops (a) torque of 30 N-m at 2000rpm (
   b) torque of 30N-m at 715 rpm
//Exa:6.6
clc;
clear;
close;
V_s=120;//in Volts
R_fe=30;//resistance of feild winding
I_a=50;//armature current (in Amperes)
R_ag=0.2;//armature resistance of generator (in ohms
   )
R_am=0.3;//armature resistance of motor (in ohms)
N_m1=2000;
N_m2=715;
T=30;//torque (in Newton-meter)
w_m=(N_m1*2*%pi)/60;
P_d=T*w_m;//power developed
E_am=P_d/I_a;//back emf of motor
E_amn=E_am*N_m2/N_m1;//new back emf
V_t=E_am+(I_a*R_am);
V_tn=E_amn+(I_a*R_am);
E_ag=V_t+(I_a*R_ag);//induced emf of generator
E_agn=V_tn+(I_a*R_ag);//new induced emf of generator
I_f=1.75;//Refer to magnetization curve
I_fn=0.4;//Refer to magnetization curve
R_f=V_s/I_f;
R_fn=V_s/I_fn;
R_x=R_f-R_fe;
R_xn=R_fn-R_fe;
disp(R_x,'(a)  external resistance (in ohms)= ');
disp(R_xn,'(b)  external resistance (in ohms)= ');
```

Scilab code Exa 6.7 Find the torque and efficiency of the motor

```
//Caption:Find the torque and efficiency of the
    motor
//Exa:6.7
clc;
clear;
close;
V_s=120;//in volts
N_m=2400;//speed of motor (in rpm)
I_in=7;//input current (in Amperes)
L=0.5;//arm length (in meter)
F_d=4.57;//deflection force (in Newton)
W=0.03;//weight (in Newton)
F=F_d-W;
T_s=F*L;
disp(T_s,'shaft torque of motor (in Newton-meter)=')
    ;
w_m=(2*%pi*N_m)/60;
P_o=T_s*w_m;
P_in=V_s*I_in;
Eff=P_o/P_in;
disp(Eff*100,'Efficiency of motor (%)=');
```

Scilab code Exa 6.8 Find the reading on the scale

```
//Caption:Find the reading on the scale
//Exa:6.8
clc;
clear;
close;
P_o=5*746;//power output (in Watts)
N_m=1200;//speed of motor (in rpm)
L=0.4;//arm length (in meter)
w_m=(2*%pi*N_m)/60;
T_s=P_o/w_m;
F=T_s/L;//force reading on the scale (in Newton)
disp(F/9.81,'Reading on the scale (in Kg)=');
```

Scilab code Exa 6.9 Find the external resistance breaking torque at the instant of plugging when the speed of motor approaches zero

```
//Caption:Find the (1)external resistance (2)
   breaking torque (a) at the instant of plugging (b
   )when the speed of motor approaches zero
//Exa:6.9
clc;
clear;
close;
V_s=400;//voltage applied
R_f=200;//resistance of field winding
I_L=30;//in Amperes
w_m=100;//(rad/sec)
I_f=V_s/R_f;
R_a=1;//armature resistance (in ohms)
```

```
I_a=I_L-I_f;
E_a=V_s-(I_a*R_a);//back emf (in Volts)
V_t=E_a+V_s;//total voltage in armature ckt
I_t=1.5*I_a;
R=(V_t/I_t)-R_a;
disp(R,'(1) external resistance (in ohms)=');
K_3=(E_a*V_s)/((R+R_a)*w_m);
K_4=((E_a/w_m)^2)/(R+R_a);
T_b=K_3+(w_m*K_4);
disp(T_b,'(2a) breaking torque at the instant of
    plugging (in Newton-meter)=');
disp(K_3,'(2b) breaking torque when speed of motor
    approaches zero (in Newton-meter)=');
```

Chapter 7

Synchronous Generators

Scilab code Exa 7.2 Find the pitch factor

```
//Caption:Find the pitch factor
///Exa:7.2
clc;
clear;
close;
P=4;//no. of poles
S=48;//no. of slots
S_p=S/P;//slots per pole
S_span=180/S_p;//slot span
n=S/(3*P);//no. of coils in phase group
C_span=9*S_span;//coil span
K_p=sind(C_span/2);
disp(K_p,'pitch factor =');
```

Scilab code Exa 7.3 Find the distribution factor

```
///Caption:Find the distribution factor
//Exa:7.3
clc;
clear;
close;
P=12;//no. of poles
S=108;//no. of slots
n=S/(3*P);//no. of coils in a phase group
S_p=S/P;
Y=180/S_p;//slot span (in electrical degree)
K_d=(sind(3*(Y/2)))/(3*sind(Y/2));
disp(K_d,'distribution factor=');
```

Scilab code Exa 7.5 Find the frequency of induced voltage phase voltage line voltage

```
//Caption:Find the (a)frequency of induced voltage (
    b)phase voltage (c)line voltage
//Exa:7.5
clc;
clear;
close;
```

```
N_m=375;//speed of motor (in rpm)
N=10;//no of turns
P=16;//no. of poles
S=144;//no. of slots
Phy=0.025;//flux (in Weber)
S_p=S/P;//slots per pole
Y=180/S_p;//slot span
C_p=Y*7;//coil pitch
K_p=sind(C_p/2);//pitch factor
K_d=(sind(3*(Y/2)))/(3*sind(Y/2));//distribution factor
K_w=K_p*K_d;//winding factor
N_e=P*3*N*K_w/2;//effective no. of turns
f=N_m*P/120;
disp(f,'(a) frequency of induced voltage (in Hertz)=');
E_a=4.44*f*N_e*Phy;
disp(E_a,'(b) Rms value of Phase voltage (in Volts)=');
E_L=E_a*sqrt(3);
disp(E_L,'(c) line voltage (in Volts)=');
```

Scilab code Exa 7.6 Find the voltage regulation

```
//Caption:Find the voltage regulation when power factor of load is (a)80% lagging (b) unity (c) 80%leading
//Exa:7.6
clc;
clear;
close;
```

```
V=208;//in volts
P_o=9000;
R=0.1+(%i*5.6);
V_a=int(V/sqrt(3));//rms value of per phase voltage
I_a=P_o/(3*V_a);//rms value of per phase current
disp("(a)  For 80% lagging power factor of load");
theta=(-1)*acosd(0.8);
I_a_L=(I_a)*(cosd(theta)+((%i)*sind(theta)));
E_a=V_a+I_a_L*R;//in volts
VR=((abs(E_a)-V_a)/V_a)*100;
disp(VR,'voltage regulation (%)=');
disp("(b)  For Unity power factor of load");
theta=acosd(1);
I_a_L=(I_a)*(cosd(theta)+((%i)*sind(theta)));
E_a=V_a+I_a_L*R;//in volts
VR=((abs(E_a)-V_a)/V_a)*100;
disp(VR,'voltage regulation (%)=');
disp("(c)  For 80% leading power factor of load");
theta=acosd(0.8);
I_a_L=(I_a)*(cosd(theta)+((%i)*sind(theta)));
E_a=V_a+I_a_L*R;//in volts
VR=((abs(E_a)-V_a)/V_a)*100;
disp(VR,'voltage regulation (%)=');
```

Scilab code Exa 7.7 Find the voltage regulation efficiency torque developed

```
//Caption:Find the (a) voltage regulation (b)
   efficiency (c)torque developed
//Exa:7.7
clc;
```

```
clear;
close;
V=208;//in volts
N_m=1200;//speed of generator (in rpm)
P_r=9000;//rated power in (Volt-Amperes)
Z_a=0.3+(%i*5);//armature impedance (ohm/phase)
R_f=4.5;//feild winding resistance
P_rot=500;//rotational loss (in Watts)
I_f=5;//feild winding current
pf=0.8;//lagging
V_a=int (V/sqrt(3));
theta=(-1)*acosd(pf);
I_a_o=P_r/(3*V_a);//per phase armature current (
    magnitude)
I_a=I_a_o*(cosd(theta)+(%i*sind(theta)));
E_a=V_a+(I_a*Z_a);//per phase generated voltage
VR=((abs(E_a)-V_a)/V_a)*100;
disp(VR,' (a) Voltage Regulation (%)=');
P_o=3*V_a*abs(I_a)*pf;//power output
P_cu=3*((abs(I_a))^2)*0.3;//copper loss
P_d=P_o+P_cu;//power developed
P_c=P_rot+(I_f^2)*R_f;//constant loss
P_in=P_d+P_c;//power input
Eff=(P_o/P_in)*100;
disp(ceil(Eff),'(b) Efficiency (%)=');
w_s=2*%pi*N_m/60;
T=(P_d+P_rot)/w_s;
disp(T,'(c) Torque developed (in Newton-meter)=');
```

Scilab code Exa 7.8 Find synchronous reactance per phase and voltage regulation

```
//Caption:Find synchronous reactance per phase and
    voltage regulation
//Exa:7.8
clc;
clear;
close;
V_r=2300;//rated voltage (in Volts)
P_r=500*10^3;//rated power (in Volt-Amperes)
pf=0.8;//lagging
theta=-1*(acosd(0.8));
I_sc=150;//short circuit current (in Amperes)
V_anL=V_r/sqrt(3);//open-circuit phase voltage
Z_sc=V_anL/I_sc;//(in ohms)
X_s=sqrt((Z_sc^2)-0.5^2);
disp(X_s,'synchronous reactance per phase (in ohms)=
    ');
I_ao=P_r/(3*V_anL);//full load current (magnitude)
I_a=I_ao*(cosd(theta)+(%i*sind(theta)));
V_b=V_anL;//base value of voltage
I_b=I_ao;//base value of current
Z_b=V_b/I_b;//base value of impedance
I_apu=I_a/I_b;//per unit armature current
V_pu=V_anL/V_b;//per unit voltage
Z_spu=(0.5+(%i*X_s))/Z_b;//per unit impedance
E_apu=V_pu+(I_apu*Z_spu);
VR=(abs(E_apu)-1)*100;
disp(VR,'voltage regulation (%)=');
```

Scilab code Exa 7.9 Find the voltage regulation and power developed by the generator

```
//Caption:Find the voltage regulation and power
   developed by the generator
//Exa:7.9
clc;
close;
clear;
V_r=13.8*10^3;//in volts
R_a=0;
X_d=1.83;//in ohms
X_q=1.21;//in ohms
P_r=70*10^6;//in Volt-Ampere
pf=0.8;//lagging
theta=(-1)*acosd(pf);
V_a=V_r/(sqrt(3));//rms value of per phase voltage
I_ao=P_r/(3*V_a);
tan_delta=((I_ao*X_q*cosd(theta))-(I_ao*R_a*sind(
   theta)))/(V_a+(I_ao*((R_a*cosd(theta))-(X_q*sind(
   theta)))));
delta=atand(tan_delta);
alpha=delta+acosd(pf);
I_d=I_ao*sind(alpha)*((cosd(delta-90))+(%i*(sind(
   delta-90))));
I_q=I_ao*cosd(alpha)*((cosd(delta))+(%i*(sind(delta)
   )));
E_a=abs(V_a+(I_q*(%i)*X_q)+(I_d*(%i)*X_d));
VR=((E_a-V_a)/V_a)*100;
disp(VR,'voltage regulation (%)=');
P_d=3*V_a*I_ao*pf;
disp(P_d/(10^6),'Power developed (in Mega-Watts)=')
```

Scilab code Exa 7.10 Find per phase terminal voltage armature current power supplied total power output

```
//Caption:Find (a)per phase terminal voltage (b) armature current (c)power supplied (d)total power output
//Exa:7.10
clc;
clear;
close;
Z_s1=(%i)*5;//ohm/phase
Z_s2=(%i)*8;//ohm/phase
Z_L=4+((%i)*3);//load impedance (in ohm/phase)
function y=phasor(theta);
    y=cosd(theta)+((%i)*sind(theta));
endfunction;
function z=angle(x,y);
    z=atand(y/x);
endfunction;
E_a1=120*phasor(10);
E_a2=120*phasor(20);
V_a=(((E_a1*Z_s2)+(E_a2*Z_s1))/((Z_L*(Z_s1+Z_s2))+(Z_s1*Z_s2)))*Z_L;
disp(polar(V_a),' (a) magnitude of phase voltage (in Volts)=');
a1=angle(real(V_a),imag(V_a));
disp(a1,'phase angle of voltage (in Degree)=');
I_a1=(E_a1-V_a)/Z_s1;
disp(polar(I_a1),'(b) magnitude of armature current of generator 1 (in Amperes)=');
a2=angle(real(I_a1),imag(I_a1));
disp(a2,'phase angle of armature current of generator 1 (in Degree)=');
I_a2=(E_a2-V_a)/Z_s2;
disp(polar(I_a2),'magnitude of armature current of generator 2 (in Amperes)=');
a3=angle(real(I_a2),imag(I_a2));
disp(a3,'phase angle of armature current of
```

```
    generator 2 (in Degree)=');
P_o1=3*real(V_a*conj(I_a1));
P_o2=3*real(V_a*conj(I_a2));
disp(polar(P_o1),' (c) Power developed of generator
    1 (in Watts)=');
disp(polar(P_o2),' Power developed of generator 2 (
    in Watts)=');
P_o=P_o1+P_o2;
disp(P_o,'(d) total power output (in Watts)=');
```

Chapter 8

Synchronous motors

Scilab code Exa 8.1 Find the generated voltage and efficiency of motor

```
//Caption:Find the generated voltage and efficiency
    of motor
//Exa:8.1
clc;
clear;
close;
R_s=(%i)*5;//synchronous reactance of motor
P_o=10*746;//power output (in Watts)
P_rot=230;//rotational loss (in Watts)
P_d=P_o+P_rot;//power developed (in Watts)
V=230;//in volts
V_a=V/sqrt(3);//rms value of per phase voltage
P_fw=70;//feild winding loss
pf=0.707;//power factor (leading)
theta=acosd(pf);
I_ao=P_d/(pf*V*sqrt(3));
P_in=P_d+P_fw;
```

```
Eff=(P_o/P_in)*100;
disp(Eff,'efficiency (%)=');
I_a=I_ao*(cosd(theta)+(%i)*sind(theta));
E_a=V_a-(I_a*R_s);
disp(abs(E_a),'magnitude of generated voltage (in
   Volts)=');
disp(atand(imag(E_a)/real(E_a)),'Phase angle of
   generated voltage (in Degree)=');
```

Scilab code Exa 8.2 Find the excitation voltage and power developed

```
//Caption:Find the excitation voltage and power
   developed
//Exa:8.2
clc;
clear;
close;
V=480;//in volts
V_a=V/sqrt(3);//per phase applied voltage
I_a=50;//in Amperes
R_a=0.5;//armature winding resistance
X_d=(%i)*3.5;//d-axis reactance
X_q=(%i)*2.5;//q-axis reactance
E_ao=V_a-(I_a*R_a)-(I_a*X_q);
delta=atand(imag(E_ao)/real(E_ao));
I_d=I_a* sind(abs(delta))*(cosd(90+delta)+(%i)*sind
   (90+delta));//d-axis current
E_a=E_ao-(I_d*(X_d-X_q));
E_L=E_a*sqrt(3);
disp(abs(E_L),'rms value of excitation voltage (in
   Volts)=');
```

```
P_d=3*real(E_ao*conj(I_a));
disp(P_d/1000,'power developed by motor (in Kilo-
    Watts)=');
```

Scilab code Exa 8.3 Find power factor power angle line to line excitation voltage torque developed

```
//Caption:Find (a) power factor (b) power angle (c)
    line to line excitation voltage (d) torque
    developed
//Exa:8.3
clc;
clear;
close;
V=440;//in volts
V_a=V/sqrt(3);//per phase voltage
w_m=188.5;//rad/sec
X_s=(%i)*(36/3);//per phase reactance
E_ao=560/sqrt(3);//per-phase excitation voltage
P_d=9000;//power developed (in Watts)
delta=asind(-P_d*12/(3*V_a*E_ao));
E_a=E_ao*(cosd(delta)+(%i)*sind(delta));
I_a=(V_a-E_a)/X_s;
alpha=atand(imag(I_a)/real(I_a));
disp(cosd(alpha),'(a) Power factor=');
disp(delta,'(b) power angle (in Degree)=');
E_L=(sqrt(3))*E_a*(cosd(30)+((%i)*sind(30)));
disp(abs(E_L),'(c) line to line excitation voltage (
    in Volts)=');
disp(atand(imag(E_L)/real(E_L)),'phase angle of line
     to line excitation voltage (in Degree)');
```

```
T_d=P_d/w_m;
disp(T_d,'(d) Torque developed (in Newton-meter)=');
```

Scilab code Exa 8.4 Find the excitation voltage and other parameters

```
//Caption:Find (a)excitation voltage (b)power developed due to feild excitation (c)power developed due to saliency of motor (d)total power developed (e)efficiency (f)max power
//Exa:8.4
clc;
clear;
close;
pf=0.8;//lagging
theta=-acosd(pf);
V_a=120;//in V
X_d=2.7;//d-axis reactance (in ohms/phase)
X_q=1.7;//q-axis reactances (in ohms/phase)
I_a=40*(cosd(-36.87)+%i*sind(-36.87));//in Amperes
E_a_dash=V_a-%i*(I_a*X_q);//in Volts
delta=atand(imag(E_a_dash)/real(E_a_dash));//in degree
alpha=polar(theta-delta);//in degree
I_d=abs(I_a)*sind(alpha)*(cosd(-34.48-90)+%i*sind(-34.48-90));
E_a=E_a_dash-%i*I_d*(X_d-X_q);
disp(abs(E_a),'(a) per-phase excitation voltage(in Volts)=');
disp(atand(imag(E_a)/real(E_a)),'phase angle of excitation voltage (in degree)=');
P_df=(3*V_a*abs(E_a)*sind(34.48))/X_d;
```

```
disp(P_df,'(b) power developed due to feild excitation(in Watts)=');
P_ds=((X_d-X_q)*sind(2*34.48)*3*V_a^2)/(2*X_d*X_q);
disp(P_ds,'(c) power developed due to saliency of motor (in Watts)=');
P_d=P_df+P_ds;
disp(P_d,'(d) total power developed (in Watts)=');
P_r=0.05*P_d;//rotational loss (in Watts)
P_in=3*real(V_a*conj(I_a));//power input (in Watts)
P_o=P_in-P_r;//power output (in Watts)
Eff=(P_o/P_in)*100;
disp(Eff,'(e) Efficiency (in %)=');
//refer to eqn 8.24
A=(3*120*abs(E_a))/X_d;
B=3*(X_d-X_q)*120^2/(2*X_d*X_q);
P_dm=A*sind(63.4)+B*sind(2*63.4);
disp(P_dm,'(f) maximum power developed (in Watts)=');
```

Scilab code Exa 8.6 Find the new armature current and new power factor

```
//Caption:Find the (a) new armature current (b) new power factor
//Exa:8.6
clc;
clear;
close;
V=208;//in Volts
V_a=V/sqrt(3);//in volts
P=7200;//in Watts
X_a=4;//synchronous reactance
```

```
pf=0.8;//lagging
theta=-acosd(pf);
I_a=(P/(3*V_a*pf))*(cosd(theta)+%i*sind(theta));// Armature current (in Amperes)
E_a=V_a-(I_a*%i*X_a);//in Volts
E_an=1.5*abs(E_a);//new excitation voltage (in Volts)
delta_n=-asind(P*X_a/(3*E_an*V_a));//new torque angle
I_an=(V_a-E_an*(cosd(delta_n)+%i*sind(delta_n)))/(%i*4);
disp(abs(I_an),'(a) New armature current (in Ampere)=');
disp(atand(imag(I_an)/real(I_an)),'Phase angle of new armature current (in Degree)=');
pf_n=cosd(atand(imag(I_an)/real(I_an)));
disp(pf_n,'(b) New Power factor=');
```

Scilab code Exa 8.7 Find the overall power factor and power factor of motor to improve overall power factor

```
//Caption:Find the overall power factor and power factor of motor to improve overall power factor
//Exa:8.7
clc;
clear;
close;
//for load:
theta_L=acosd(0.6);//lag (in degree)
S_L=100*(cosd(53.13)+%i*sind(53.13));//in KVA
//for synchronous motor:
```

```
theta_m=acosd(0.5);//lead (in degree)
S_m=(10/0.5)*conj(cosd(theta_m)+%i*sind(theta_m));//in Watts
S_t=S_L+S_m;//overall power (in Watts)
pf=cosd(atand(imag(S_t)/real(S_t)));
disp(pf,'overall power factor=');
//for power factor=0.9
theta_t=25.84;
S_tn=(real(S_t)/0.9)*(cosd(theta_t)+%i*sind(theta_t));//in KVA
S_mn=S_tn-S_L;//in KVA
pf_n=cosd(atand(imag(S_mn)/real(S_mn)));
disp(pf_n,'power factor of motor to improve overall power factor to 0.9=');
```

Chapter 9

Polyphase Induction Motor

Scilab code Exa 9.1 Find the synchronous speed and slip and rotor frequency

```
//Caption:Find the (a) synchronous speed (b) slip
   and (c) rotor frequency
//Exa:9.1
clc;
clear;
close;
f=60;//in Hertzs
P=4;//no. of poles
N_fL=1755;//in rpm
N_s=120*f/P;
disp(N_s,'(a) synchronous speed of induction motor (
   in rpm)=');
s=(N_s-N_fL)/N_s;
disp(s,'(b) Slip at full load =');
f_r=s*f;
disp(f_r,'(c) rotor frequency at full load (in
```

```
Hertzs)=');
```

Scilab code Exa 9.2 Find the efficiency

```
//Caption:Find the efficiency
//Exa:9.2
clc;
clear;
close;
V=230;//in volts
f=60;//in Hertz
P=6;//no. of poles
N_s=120*f/P;//synchronous speed (in rpm)
V_1=V/sqrt(3);//per phase voltage (in Volts)
R_2=0.25;//in ohms
R_1=0.5;//in ohms
X_1=0.75;//in ohms
X_2=0.5;//in ohms
X_m=100;//in ohms
R_c=500;//in ohms
s=0.025;//slip
Z_1=R_1+%i*X_1;//in ohms
Z_2=(R_2/s)+%i*X_2;//in ohms
Z=(0.002-(%i*.01)+(0.10025-%i*0.0050125));
Z_e=(1/Z);//equivalent impedance (in ohms)
Z_in=Z_1+Z_e;//input impedance (in ohms)
I_1=V_1/Z_in;//in Amperes
theta=atand(imag(I_1)/real(I_1));
P_in=3*V_1*real(I_1);
P_scl=3*(abs(I_1))^2*R_1;
E_1=V_1-I_1*Z_1;
```

```
I_c=E_1/R_c;//core loss current
I_m=-%i*E_1/X_m;
I_phy=I_c+I_m;//excitation current (in Amperes)
I_2=I_1-I_phy;//rotor current (in Amperes)
P_m=3*abs(I_c)*abs(I_c)*R_c;//core loss (in Watts)
P_ag=P_in-P_scl-P_m;//air gap power (in Watts)
P_rcl=3*abs(I_2)*abs(I_2)*R_2;//rotor copper loss (
    in Watts)
P_d=P_ag-P_rcl;//power developed (in Watts)
P_o=P_d-150;//output power (in Watts)
Eff=P_o/P_in;
disp(Eff*100,'Efficiency (%)=');
```

Scilab code Exa 9.3 Find the efficiency of the motor

```
//Caption:Find the efficiency of the motor
//Exa:9.3
clc;
clear;
close;
//Refer to data of Exa:9.2
R_1=0.5;//in ohms
R_2=0.25;//in ohms
X_1=0.75;//in ohms
X_2=0.5;//in ohms
R_c=500;//in ohms
s=0.025;//slip
I_c=132.791/500;//Core-loss currrent (in Amperes)
I_m=-%i*132.791/100;//Magnetization current (in
    Amperes)
Z_e=R_1+(R_2/s)+%i*(X_1+X_2);//in ohms
```

```
I_2=132.791/Z_e;//rotor current (in Amperes)
I_1=I_2+I_c+I_m;//in Amperes
P_in=3*real(132.791*conj(I_1));//power input (in
    Watts)
P_scl=3*(abs(I_2))^2*R_1;//stator copper loss (in
    Watts)
P_rcl=3*(abs(I_2))^2*R_2;//rotor copper loss (in
    Watts)
P_m=3*(abs(I_c))^2*R_c;// core loss (in Watts)
P_o=P_in-P_scl-P_rcl-P_m-150;//power output (in
    Watts)
Eff=P_o/P_in;
disp(Eff*100,'Efficiency (%)=');
```

Scilab code Exa 9.4 Find the max power developed and slip and the torque developed

```
//Caption:Find the max power developed and slip and
    the torque developed
//Exa:9.4
clc;
clear;
close;
V=120;//in volts
f=60;//in Hertzs
R_1=0.1;//in ohms
X_1=0.15;//in ohms
R_2=0.2;//in ohms
X_2=0.25;//in ohms
Z_e=R_1+R_2+%i*(X_1+X_2);//Eqv impedance in ohms
s_p=R_2/(R_2+polar(Z_e));
```

```
disp(s_p,'Slip=');
P_dm=(3*V^2)/(2*(R_1+R_2+abs(Z_e)));
disp(P_dm/1000,'max power developed (in Kilo-Watts)=');
N_s=120*f/6;//synchronous speed (in rpm)
w_s=(N_s*2*%pi)/60;//in rad/sec
w_m=(1-s_p)*w_s;
T_d=P_dm/w_m;
disp(T_d,'Torque developed (in Newton-meter)=');
```

Scilab code Exa 9.5 Find the breakdown slip and the breakdown torque and power developed by the motor

```
//Caption:Find (a) the breakdown slip (b) the breakdown torque (c) power developed by the motor
//Exa:9.5
clc;
clear;
close;
//Refer to data of Exa9.4
R_1=0.1;// in ohms
R_2=0.2;// in ohms
X_1=0.15;// in ohms
X_2=0.25;// in ohms
w_s=125.66;//rad/sec
V_1=120;//in Volts
s_b=R_2/sqrt(R_1^2+(X_1+X_2)^2);
disp(s_b,'(a) Breakdown slip=');
T_dm=(3*V_1^2)/(2*w_s*(R_1+sqrt(R_1^2+(X_1+X_2)^2)));
disp(T_dm,'(b) Breakdown Torque (in Newton-meter)=')
```

```
;
P_d=T_dm*(1-s_b)*w_s;
disp(P_d/1000,'(c)  power developed by the motor (in
    Kilo-Watts)=');
```

Scilab code Exa 9.6 Find the breakdown slip and the breakdown torque and starting torque and the value of external resistance

```
//Caption:Find (a) the breakdown slip and the
   breakdown torque (b) starting torque and the
   value of external resistance
//Exa:9.6
clc;
clear;
close;
f=60;//in Hertzs
P=8;//no. of poles
R_2=0.02;//in ohms
X_2=0.08;//in ohms
s_b=R_2/X_2;//breakdown slip
disp(s_b,'(a) breakdown slip=');
N_s=120*f/P;//synchronous speed (in rpm)
w_s=N_s*2*%pi/60;
N_m=(1-s_b)*N_s;//motor speed (in rpm)
V_1=120;//in V
T_dm=(3*V_1^2)*s_b/(2*w_s)*R_2;
disp(T_dm,'Breakdown torque (in Newton-meter)=');
T_s=2*1*s_b*T_dm/(1+s_b^2);
disp(T_s,'(b) Starting Torque (in Newton-meter)=');
disp(T_s/T_dm,'Starting torque is =');
disp("times the max torque");
```

```
s_bn=(-(-2.5)-sqrt((-2.5)^2-4*1*1))/2;//new breakdown slip
R_2n=s_bn*X_2;
disp(R_2n,'rotor resistance (in ohms)=');
```

Scilab code Exa 9.7 Find the torque range and current range

```
//Caption:Find (a) the torque range (b) current range
//Exa:9.7
clc;
clear;
close;
f=60;//in Hertzs
P=4;//no. of poles
V_1=230;//in volts
I_2=4.5;//rotor current (in Amperes)
P_d=2*746;//in watts
N_m=1710;//speed of motor in (rpm)
N_s=120*f/P;//Synchronous speed (in rpm)
s=(N_s-N_m)/N_s;//slip
w_m=2*%pi*N_m/60;//in rad/sec
T_d=P_d/w_m;//torque developed (in Newton-meter)
T_dL=T_d*(0.9*230/230)^2;//in Newton-meter
I_2L=I_2*(0.9*230/230);//in Amperes
T_dH=8.33*1.1^2;//in Newton-meter
I_2H=I_2*1.1;//in Amperes
disp("(a) Torque range (in Newton-meter) is :-");
disp(T_dL,'minimum value=');
disp(T_dH,'maximum value=');
disp("(b) Current range (in Amperes) is :-");
```

```
disp(I_2L,'minimum value=');
disp(I_2H,'maximum value=');
```

Scilab code Exa 9.8 Find Eqv circuit parameters

```
//Caption:Find Eqv circuit parameters
//Exa:9.8
clc;
clear;
close;
V_1=208;//in Volts
f=60;//in Hertzs
P=4;//no. of poles
N_m=1710;//in rpm
R_1=2.4/2;//in ohms
disp(R_1,'R_1 (in ohms)=');
W_oc=450/3;//in Watts
P_fw_phy=18/3;//in Watts
P_oc=W_oc-P_fw_phy;//in Watts
V_oc=V_1/sqrt(3);//in Volts
I_oc=1.562;//in Amperes
R_c=V_oc^2/P_oc;
disp(R_c,'R_c=core loss resistance (in ohms)=');
S_oc=V_oc*I_oc;//in Volt-Ampere
theta_oc=acosd(W_oc/S_oc);
I_m=I_oc*sind(theta_oc);
X_m=V_oc/I_m;
disp(X_m,'X_m=Magnetization reactance (in ohms)=');
V_br=27/sqrt(3);//in Volts
P_br=59.4/3;//in Watts
I_br=2.77;//In Amperes
```

```
R_e=P_br/I_br^2;
R_2=R_e-R_1;
disp(R_2,'R_2 (in ohms)=');
Z_e=V_br/I_br;
X_e=sqrt(Z_e^2-R_e^2);
X_1=X_e/2;
X_2=X_1;
disp(X_1,'X_1 (in ohms)=');
disp(X_2,'X_2 (in ohms)=');
```

Scilab code Exa 9.10 Find the equivalent rotor impedance as reffered to stator

```
//Caption:Find the equivalent rotor impedance as
   reffered to stator
//Exa:9.10
clc;
clear;
close;
R=20*10^-6;//in ohms
X=2*10^-3;//in ohms
P=4;//no. of poles
Q=48;//no. of bars
S=36;//no. of slots
//For Stator:
m_1=3;//no. of phases
n=3*(S/(P*3));//coils per pole per phase
S_p=S/P;//pole span
S_s=180/S_p;//slot span (in electrical degree)
k_p1=sind(140/2);//pitch factor
k_d1=sind(3*S_s/2)/(3*sind(S_s/2));//distribution
```

```
    factor
k_w1=k_p1*k_d1;//winding factor
N_1=10*S/3;//turns per phase
//For Rotor:
k_w2=1;
m_2=Q/P;//no. of phases
N_2=P/2;//turns per phase
a=int((k_w1*N_1/(k_w2*N_2))*sqrt(m_1/m_2));
R_2=a^2*R;
disp("Rotor Parameters as reffered to stator:");
disp(R_2*1000,'R_2 (in mili ohms)=');
X_2=a^2*X;
disp(X_2,'X_2 (in ohms)=');
```

Chapter 10

Analysis of a single phase induction Motor

Scilab code Exa 10.1 Find the per unit slip in the direction of rotation and in opposite direction and effective rotor resistance in each branch

```
//Caption:Find the per-unit slip (a) in the
   direction of rotation (b) in opposite direction
   and effective rotor resistance in each branch
//Exa:10.1
clc;
clear;
close;
P=4;//no. of poles
f=60;//frequency in Hertzs
R2=12.5;//rotor resistance (in ohms)
N_s=120*f/P;//synchronous speed of motor(in rpm)
N_m=1710;//speed of motor in clockwise direction (in
    rpm)
s=(N_s-N_m)/N_s;
```

```
disp(s,'(a) slip in forward direction=');
s_b=2-s;
disp(s_b,'(b) slip in backward direction=');
//effective rotor resistance
R_f=0.5*R2/s;//(in forward branch)
disp(R_f,'effective rotor resistance in forward
    branch (in ohms)=');
R_b=0.5*R2/s_b;//(in backward direction)
disp(R_b,'effective rotor resistance in backward
    branch (in ohms)=');
```

Scilab code Exa 10.2 Find the shaft torque and the efficiency of the motor

```
//Caption:Find the shaft torque and the efficiency
    of the motor
//Exa:10.2
clc;
clear;
close;
V=120;//in volts
f=60;//frequency in Hertzs
P=4;//no. of poles
R1=2.5;//in ohms
X1=(%i)*1.25;
R2=3.75;
X2=(%i)*1.25;
X_m=(%i)*65;
N_m=1710;//speed of motor (in rpm)
P_c=25;//core lossv(in Watts)
P_fw=2;//friction and windage loss (in Watts)
N_s=120*f/P;//synchronous speed of motor
```

```
s=(N_s-N_m)/N_s;//slip
Z_f=(X_m*((R2/s)+X2)*0.5)/((R2/s)+(X2+X_m));//forward impedance
Z_b=(X_m*((R2/(2-s))+X2)*0.5)/((R2/(2-s))+(X2+X_m));//backward impedance
Z_in=R1+X1+Z_f+Z_b;
I_1=V/Z_in;
P_in=real(V*conj(I_1));
I_2f=X_m*I_1/((R2/s)+(X1+X_m));//forward current
I_2b=X_m*I_1/((R2/(2-s))+(X1+X_m));//backward current
P_agf=0.5*(R2/s)*(abs(I_2f))^2;//air gap power in forward path
P_agb=0.5*(R2/(2-s))*(abs(I_2b))^2;//air gap power in backward path
P_ag=P_agf-P_agb;//net air gap power
P_d=(1-s)*P_ag;//gross power developed
P_o=P_d-P_c-P_fw;//net power output
w_m=2*(%pi)*N_m/60;
T_s=P_o/w_m;
disp(T_s,'shaft torque (in Newton-meter)=');
Eff=P_o/P_in;
disp(Eff*100,'Efficiency of motor (%)=');
```

Scilab code Exa 10.3 Find the line current

```
//Caption:Find the (a)line current (b)power input (c)efficiency (d)shaft torque (e)voltage drop across capacitor (f)starting torque
//Exa:10.3
clc;
```

```
clear;
close;
V1=230;//in volts
f=50;//frequency in Hz
P=6;//no. of poles
R1=34.14;//in ohms
X1=(%i)*35.9;
R_a=149.78;
X2=(%i)*29.32;
X_m=(%i)*248.59;
R2=23.25;
a=1.73;
C=4*10^-6;//in Farad
P_c=19.88;//core loss
P_fw=1.9;//friction and windage loss
N_m=940;//speed of motor in rpm
N_s=120*f/P;//synchronous speed of motor
s=(N_s-N_m)/N_s;//slip
w_m=2*%pi*N_m/60;//in rad/sec
X_c=-%i/(2*%pi*f*C);//reactance of capacitance
Z_f=(X_m*((R2/s)+X2)*0.5)/((R2/s)+(X2+X_m));//forward impedance
Z_b=(X_m*((R2/(2-s))+X2)*0.5)/((R2/(2-s))+(X2+X_m));//backward impedance
Z_11=R1+X1+Z_f+Z_b;//in ohms
Z_12=-%i*a*(Z_f-Z_b);//in ohms
Z_21=-Z_12;//in ohms
Z_22=a*a*(Z_f+Z_b+X1)+R_a+X_c;//in ohms
I_1=V1*(Z_22-Z_12)/(Z_11*Z_22-Z_12*Z_21);//current in main winding
I_2=V1*(Z_11-Z_21)/(Z_11*Z_22-Z_12*Z_21);//current in auxilary winding
I_L=I_1+I_2;
disp(abs(I_L),'(a) magnitude of line current (in Amperes)=');
disp(atand(imag(I_L)/real(I_L)),' phase of line current (in Degree)');
P_in=real(V1*conj(I_L));
```

```
disp(P_in,'(b) power input (in Watts)=');
P_agf=real((I_1*Z_f-%i*I_2*a*Z_f)*conj(I_1)+(I_2*a*a*Z_f+%i*I_1*a*Z_f)*conj(I_2));//air gap power developed by forward field
P_agb=real((I_1*Z_b+%i*I_2*a*Z_b)*conj(I_1)+(I_2*a*a*Z_b-%i*I_1*a*Z_b)*conj(I_2));//air gap power developed by backward field
P_ag=P_agf-P_agb;
P_d=(1-s)*P_ag;//power developed
P_o=P_d-P_c-P_fw;//output power
disp(P_o*100/P_in,'(c) Efficiency of motor (%)=');
T_s=P_o/w_m;
disp(T_s,'(d) shaft torque (in Newton-meter)=');
V_c=I_2*X_c;
disp(abs(V_c),'(e) magnitude of voltage across capacitor (in Volts)=');
disp(atand(imag(V_c)/real(V_c)),'    phase of voltage across capacitor (in Degree)=');
//for starting torque
s=1;
s_b=1;
w_s=2*%pi*N_s/60;
Z_f=(X_m*((R2/s)+X2)*0.5)/((R2/s)+(X2+X_m));//forward impedance
Z_b=(X_m*((R2/(2-s))+X2)*0.5)/((R2/(2-s))+(X2+X_m));//backward impedance
Z_11=R1+X1+Z_f+Z_b;//in ohms
Z_12=-%i*a*(Z_f-Z_b);//in ohms
Z_21=-Z_12;//in ohms
Z_22=a*a*(Z_f+Z_b+X1)+R_a+X_c;//in ohms
I_1s=V1*(Z_22-Z_12)/(Z_11*Z_22-Z_12*Z_21);//current in main winding
I_2s=V1*(Z_11-Z_21)/(Z_11*Z_22-Z_12*Z_21);//current in auxilary winding
I_Ls=I_1s+I_2s;
P_in=real(V1*conj(I_Ls));
P_agf=real((I_1s*Z_f-%i*I_2s*a*Z_f)*conj(I_1s)+(I_2s*a*a*Z_f+%i*I_1s*a*Z_f)*conj(I_2s));//air gap
```

```
   power developed by forward field
P_agb=real((I_1s*Z_b+%i*I_2s*a*Z_b)*conj(I_1s)+(I_2s
   *a*a*Z_b-%i*I_1s*a*Z_b)*conj(I_2s));//air gap
   power developed by backward field
P_ag=P_agf-P_agb;
T_s=P_ag/w_s;
disp(T_s,'(f) starting torque (in Newton-meter)=');
```

Scilab code Exa 10.4 Find the equivalent circuit parameters

```
//Caption:Find the equivalent circuit parameters
//Exa:10.4
clc;
clear;
close;
R_m=2.5;//main winding resistance
R_a=100;//auxilary winding resistance
//blocked-rotor test
V_bm=25;//voltage (in Volts)
I_bm=3.72;//current (in Amperes)
P_bm=86.23;//power (in Watts)
//with auxilary winding open no load test
V_nL=115;//voltage (in Volts)
I_nL=3.2;//current (in Amperes)
P_nL=55.17;//power (in Watts)
//with main winding open blocked rotor test
V_ba=121;//voltage (in Volts)
I_ba=1.2;//current (in Amperes)
P_ba=145.35;//power (in Watts)
Z_bm=V_bm/I_bm;
R_bm=P_bm/I_bm^2;
```

```
X_bm=sqrt(Z_bm^2-R_bm^2);
X1=0.5*X_bm;
X2=X1;
R2=R_bm-R_m;
disp(X1,'X1 (in ohms)=');
disp(X2,'X2 (in ohms)=');
disp(R2,'R2 (in ohms)=');
Z_nL=V_nL/I_nL;
R_nL=P_nL/I_nL^2;
X_nL=sqrt(Z_nL^2-R_nL^2);
X_m=2*X_nL-0.75*X_bm;
P_r=P_nL-I_nL^2*(R_m+0.25*R2);
disp(int(P_r),'P_r (in Watts)=');
disp(X_m,'X_m (in ohms)=');
Z_ba=V_ba/I_ba;
R_ba=P_ba/I_ba^2;
R_2a=R_ba-R_a;
alpha=sqrt(R_2a/R2);
disp(alpha,'alpha=');
```

Scilab code Exa 10.5 Find the induced emf in the armature

```
//Find the (a) induced emf in the armature (b) power output (c) shaft torque (d) efficiency
//Exa:10.5
clc;
clear;
close;
V_s=120;//in Volts
P_rot=80;//rotational loss (in Watts)
N_m=8000;//speed of motor (in rpm)
```

```
pf=0.912;//lagging
theta=-acosd(pf);
I_a=17.58*(cosd(theta)+(%i*sind(theta)));//in Amperes
Z_s=0.65+%i*1.2;//series field winding impedance (in ohms)
Z_a=1.36+%i*1.6;//armature winding impedance (in ohms)
E_a=V_s-I_a*(Z_s+Z_a);//induced emf (in Volts)
disp(abs(E_a),'(a) induced emf in the armature (in Volts)=');
disp(atand(imag(E_a)/real(E_a)),'phase of induced emf in the armature (in Degree)=');
P_d=real(E_a*conj(I_a));
P_o=P_d-P_rot;
disp(P_o,'(b) power output (in Watts)=');
w_m=2*%pi*N_m/60;//rated speed of motor (in rad/sec)
T_s=P_o/w_m;
disp(T_s,'(c) shaft torque (in Newton-meter)=');
P_in=V_s*abs(I_a)*pf;
Eff=P_o*100/P_in;
disp(Eff,'(d) Efficiency (%)=');
```

Chapter 11

Synchronous Generator Dynamics

Scilab code Exa 11.7 Find the rms value of symmetric subtransient and transient currents

```
//Caption:Find the rms value of symmetric
   subtransient and transient currents
//Exa:11.7
clc;
clear;
close;
KVA=71500;//Kilo Volt-Ampere
V_r=13800;//in Volts
X_af=0.57;//in per unit
X_la=0.125;//in per unit
X_lf=0.239;//in per unit
X_ld=0.172;//in per unit
X_ds=X_la+((X_af*X_lf*X_ld)/(X_lf*X_ld+X_af*X_ld+
   X_af*X_lf));//subtransient reactance(in per unit)
```

```
E_phy=1;//generated voltage (in per unit)
I_ds=E_phy/X_ds;//short circuit current (in per unit
    )
X_d=X_la+((X_af*X_lf)/(X_af+X_lf));//transient
    reactance (in per unit)
I_d=E_phy/X_d;//transient current (in per unit)
I_rated=KVA*1000/(sqrt(3)*V_r);//in Amperes
I_dsa=I_ds*I_rated;//sub transient current (in
    Amperes)
disp(I_dsa,'sub-transient current (in Amperes)=');
I_da=I_d*I_rated;//transient current (in Amperes)
disp(I_da,'transient current (in Amperes)=');
```

Scilab code Exa 11.8 Find per unit power and critical fault clearing time

```
//Caption:Find (a)per unit power (b)critical fault
    clearing time
//Exa:11.8
clc;
clear;
close;
f=60;//in Hertzs
P=4;//no. of poles
P_m=0.9;
H=10;//in Joule/Volt-Amperee
N_s=f*120/P;//synchronous speed in (rpm)
w_s=2*%pi*N_s/f;//(in rad/sec)
P_dm=P_m/sind(18);
t_c=P/f;//fault clearing time (in sec)
delta_o=18*2*%pi/360;//in rad
delta_m=delta_o+((w_s/(P*H))*P_m*t_c^2);
```

```
P_d=P_dm*sin(delta_m);
disp(P_d,'(a) power generated (in per unit)=');
delta_2=%pi-delta_o;
delta_c=acos(((P_m/P_dm)*(delta_2-delta_o))+cos(
    delta_2));
t_cn=sqrt((delta_c-delta_o)*4*H/(w_s*P_m));
disp(t_cn,'(b) critical fault clearing time (in sec)
    =');
```

Chapter 12

Permanent magnet motors

Scilab code Exa 12.1 Find the speed of motor and torque under blocked rotor condition

```
//Caption:Find the speed of motor and torque under
   blocked rotor condition
//Exa:12.1
clc;
clear;
close;
flux=0.004;//(in Weber)
R_a=0.8;//armature resistance (in ohm)
V_s=40;//applied voltage (in Volts)
T_d=1.2;//in Newton-meter
K_a=95;//motor constant
w_m=(V_s/(K_a*flux))-((R_a*T_d)/(K_a*flux)^2);
N_m=w_m*60/(2*%pi);
disp(ceil (N_m),'speed of motor (in rpm)=');
w_mb=0;//for blocked rotor condition
T_db=(V_s*K_a*flux)/R_a;
```

```
disp(T_db,'torque developed under blocked rotor
   condition (in Newton-meter)=');
```

Scilab code Exa 12.2 Find the magnetic flux

```
//Caption:Find the magnetic flux
//Exa:12.2
clc;
clear;
close;
N_m=1500;//speed of motor (in rpm)
R_a=2;//armature resistance (in ohms)
V_s=100;
P_o=200;//rated power
K_a=85;//machine constant
P_rot=15;//rotational loss
w_m=(2*%pi*N_m)/60;
P_d=P_o+P_rot;//power developed
T_d=P_d/w_m;//torque developed
function y=root (a,b,c);
    y=((-b)+sqrt((b^2)-(4*a*c)))/(2*a);
endfunction;
disp(root(1,-0.0075,(2.41*10^-6)),'magnetic flux (in
    Weber)=');
```

Scilab code Exa 12.3 Find the developed power and copper loss in the secondary side

```
//Caption:Find the developed power and copper loss
    in the secondary side
//Exa:12.3
clc;
clear;
close;
f=60;//frequency (in Hertzs)
P_pi=0.5;//pole pitch
F_d=100000;//developed thrust (in Newton)
V_m=200000/3600;//speed of motor (in meter/sec)
P_d=F_d*V_m;
disp(int(P_d/1000),'developed power (in Kilo-Watts)'
    );
V_s=2*P_pi*f;//synchronous speed of the motor (in
    meter/sec)
s=(V_s-V_m)/V_s;//slip
P_cu=F_d*s*V_s;
disp(int(P_cu/1000),'Copper loss (in Kilo-Watts)=');
```