Scilab Textbook Companion for Electrical Machines by M. V. Despande[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

Single phase transformer Principle and Constructions

Scilab code Exa 1.1 Find the n ratio and load current referred to high voltage side and load impedance on low voltage side for full load and impedance referred to high voltage side

```
//Caption:Find the (a) n ratio (b) load current
   referred to high voltage side (c) load impedance
   on low voltage side for full load (d) and
   impedance referred to high voltage side
//Exa:1.1
clc;
clear;
close;
P_s=25000//Supplied power (in VA)
V_1=1910//Voltage on primary side (in volt)
V_2=240//Voltage on secondary side (in volt)
f=50//frequency in hertz
n=V_1/V_2
disp(n,'(a)n-ratio=')
I_1=P_s/V_1
disp(I_1,'(b)load current referred to high voltage
   side (in A)=')
```

```
I_2=P_s/V_2
Z_2=V_2/I_2
disp(Z_2,'(c)load impedance on low voltage side for
    full load (in ohm)=')
Z_1=Z_2*(n^2)
disp(Z_1,'(d)impedance referred to high voltage side
    (in ohm)=')
```

Scilab code Exa 1.2 Find Power factor on no load and active current and magnetising current and copper loss in the primary winding and core loss

```
//Caption:Find (a) Power factor on no load (b)
    active current (c) magnetising current (d) copper
     loss in the primary winding (e) core loss
//Exa:1.2
clc;
clear;
close;
V_1=3300//Primary voltage (in volt)
V_2=240//Secondary voltage (in volt)
I_0=2//No load current (in A)
P=60//Power (in watt)
R=0.8//Resistance of the low voltage winding (in ohm
    )
Pf=P/(V_2*I_0)
disp(Pf,'(a)Power factor on no load=')
I_c=I_0*Pf
disp(I_c,'(b)Active current(in A)=')
theta=(acosd(Pf))
I_m=I_0*sin(theta)
disp(I_m,'(c)magnetising current is(in A)=')
```

```
Culoss=(I_0^2)*R
disp(Culoss,'(d)copper loss in the primary winding is(in watt)=')
Coreloss=P-Culoss
disp(Coreloss,'(e)core loss(in watt)=')
```

Scilab code Exa 1.3 Find number of turns per limb on the high voltage and and low voltage sides

```
//Caption:Find number of turns per limb on the (a) high voltage and (b) low voltage sides
//Exa:1.3
clc;
clear;
close;
A=0.0386//cross sectional area of core(in m^2)
B=1//maximum flux density (in weber/m^2)
f=50//frequency (in hertz)
V_1=3300//voltage on primary side (in volt)
V_2=240//voltage on secondary side (in volt)
C=B*A
n_2=V_2/(4.44*C*f)
T_2=n_2/2
disp(T_2,'(a)number of turns on low voltage side is=')
T_1=T_2*V_1/V_2
disp(T_1,'(b)number of turns on high voltage side is=')
```

Scilab code Exa 1.4 Calculate equivalent resistance and reactance of lv side in terms of hv side And equivalent resistance and reactance of hv side in terms of lv side And total resistance and reactance of transformer in terms of hv side And total r and x in terms of lv side

```
//Caption:Calculate (a) equivalent resistance and
   reactance of low voltage side in terms of high
   voltage side (b) equivalent resistance and
   reactance of high voltage side in terms of low
   voltage side (c) total resistance and reactance
   of transformer in terms of high voltage side (d)
   total resistance and reactance of transformer in
   terms of low voltage side
//Exa:1.4
clc;
clear;
close;
V_1=2200//Primary side voltage(in volt)
V_2=220//secondary side voltage(in volt)
f=50//frequency(in hertz)
r_1=1.25//Primary side resistance(in ohm)
x_1=4//Primary side reactance(in ohm)
r_2=0.04//Secondary side resistance(in ohm)
x_2=0.15//Secondary side reactance(in ohm)
n=V_1/V_2
R_2=(n^2)*r_2
disp(R_2,'(a)equivalent resistance of low voltage
   side in terms of high voltage side=')
X_2=(n^2)*x_2
disp(X_2,'equivalent reactance of low voltage side
```

```
    in terms of high voltage side=')
R_1=r_1/(n^2)
disp(R_1,'(b)equivalent resistance of high voltage
    side in terms of low voltage side =')
X_1=x_1/(n^2)
disp(X_1,'equivalent reactance of high voltage side
    in terms of low voltage side =')
R_t=r_1+R_2
disp(R_t,'(c)total resistance of transformer in
    terms of high voltage side=')
X_t=x_1+X_2
disp(X_t,'total reactance of transformer in terms of
     high voltage side=')
R_e=r_2+R_1
disp(R_e,'(d)total resistance of transformer in
    terms of low voltage side=')
X_e=x_2+X_1
disp(X_e,'total reactance of transformer in terms of
     low voltage side=')
```

Scilab code Exa 1.5 Find terminal voltage on load and voltage on load at high voltage terminals and efficiency of transformer

```
//Caption: (a) terminal voltage on load (b) voltage
    on load at high voltage terminals (c) efficiency
    of transformer
//Exa:1.5
clc;
clear;
close;
n=10//ratio of high voltage to low voltage
```

```
V_1=200//Voltage on low voltage side(in volt)
x_m=231//Magnetising resistance(in ohms)
r_c=400//Core loss resistance(in ohms)
r_e=0.1//Equivalent resistance referred to low
    voltage side(in ohms)
x_e=0.5//Equivalent reactance referred to low
    voltage side(in ohms)
r_l=7.9//Load resistance(in ohms)
x_l=5.5//Load reactance(in ohms)
I_m=V_1/x_m
I_c=V_1/r_c
I_0=I_c+(%i*I_m)
R_l=r_l+r_e
X_l=x_l+x_e
I=V_1/(R_l+(%i*X_l))
I_1=I+I_0
V_2=V_1-I*(r_e+(%i*x_e))
v=sqrt(V_2*conj(V_2))
disp(v,'(a)terminal voltage on load(in volt)=')
V=v*n
disp(V,'(b)voltage on load at hgih voltage terminals
    (in volt)=')
P_o=v*real(I)
P_i=V_1*real(I_1)
eff=(P_o/P_i)*100
disp(eff,'(c)efficiency of transformer is(in %)=')
```

Scilab code Exa 1.6 Find impedance and percentage resistance and reactance

```
//Caption:Find (a) impedance (b) % resistance and
```

```
    reactance
//Exa:1.6
clc;
clear;
close;
P_s=500000//Power supplied(in VA)
V_1=2200//Voltage on primary side(in volt)
V_2=500//Voltage on secondary side(in volt)
f=50//frequency(in hertz)
r=0.01//Resistance of transformer(in ohms)
z=0.1//impedance of transformer(in %)
I=P_s/V_2
Z=z*V_2/I
disp(Z,'(a)Impedance(in ohms)=')
R=(I*r/V_2)*100
disp(R,'(b) Resistance(in %)=')
x=sqrt(Z^2-r^2)
X=(x*I/V_2)*100
disp(X,'Reactance(in %)=')
```

Chapter 2

Single phase transformer Operation and Testings

Scilab code Exa 2.1 Find all day efficiency and commercial efficiency on full load and efficiency on half load

```
//Caption:Find (a)all day efficiency (b)commercial
   efficiency on full load (c)efficiency on half
   load
//Exa:2_1
clc;
clear;
close;
P_s=50//Power supplied(in kVA)
V_1=440//Primary side voltage(in volt)
V_2=220//Secondary side voltage(in volt)
t_1=6//Full load(in hours)
t_2=2//50% load(in hours)
Cu_1=2//Copper loss on full load(in KW)
Fe=1//Iron losses(in KW)
E_1=P_s*t_1//Energy used on full load(in watt-hours)
E_2=0.5*P_s*t_2//Energy used on half load(in watt-
   hours)
Cu_2=Cu_1*0.25//Copper losses on half load(in watts)
```

```
E=(Cu_1*t_1)+(Cu_2*t_2)+(Fe*24)//Energy lost on
   losses(in watt-hours)
eff_1=(E_1+E_2)/(E_1+E_2+E)*100
disp(eff_1,'(a)All day efficiency(in%)=')
eff_2=(E_2)/(E_2+Cu_1+Fe)*100
disp(eff_2,'(b)commercial efficiency on full load(
   in%)=')
eff_3=(0.5*E_2)/(0.5*E_2+Cu_2+Fe)*100
disp(eff_3,'(c)efficiency on half load(in%)=')
```

Scilab code Exa 2.2 Find Efficiency of transformer at half load at and At what load will the efficiency be maximum and maximum

```
//Caption:Find (a)Efficiency of transformer at half
   load at 0.8 power factor lagging (b)At what load
   will the efficiency be maximum and maximum
   efficiency?
//Exa:2.2
clc;
clear;
close;
P_s=25000//Power supplied(in VA)
V_1=3300//Voltage on primary side(in volts)
V_2=230//Voltage on secondary side(in volts)
f=50//frequency(in hertz)
P_i=300//Iron loss(in watt)
P_c=400//Copper loss(in watt)
pf=0.8//Power factor
Cu=P_c*(0.5^2)//Copper loss on half load
P_o=P_s*0.5*pf//Output of transformer on half load
eff=(P_o)/(P_o+Cu+P_i)*100
```

```
disp(eff,'(a)Efficiency of transformer at half load(in %)=')
x=sqrt(P_i/P_c)*20000
disp(x,'(b)Load for maximum efficiency(in watt)=')
eff_max=(x)/(x+P_i+P_i)*100
disp(eff_max,'Maximum efficiency(in%)=')
```

Scilab code Exa 2.3 Find Percentage resistance and Regulation for power factors unity lagging and leading

```
//Caption:Find (a)% resistance (b)Regulation for power factors- unity , 0.8 lagging and 0.8 leading
//Exa:2_3
clc;
clear;
close;
L_o=1//Ohmic loss(%)
X=6//Reactance(in %)
pf_1=0.8//lagging power factor
pf_2=0.8//leading power factor
R=L_o
disp(R,'(a)% resistance(in %)=')
Re_1=L_o
disp(Re_1,'(b)Regulation at unity power factor(in%)=')
theta=(acosd(pf_1))
a=sind(theta)
Re_2=L_o*pf_1+X*a
disp(Re_2,'Regulation at 0.8 lagging power factor(in%)=')
Re_3=L_o*pf_2-X*a
```

```
disp(Re_3,'Regulation at leading power factor(in%)=')
```

Scilab code Exa 2.4 Find Regulation on full load and at power factor lagging

```
//Caption:Find Regulation on full load at 0.8 power factor lagging
//Exa:2_4
clc;
clear;
close;
P_s=500000//Power supplied(in VA)
V_1=2200//Voltage on primary side(in volt)
V_2=500//Voltage on secondary side(in volt)
f=50//frequency(in hertz)
Eff=97//Efficiency of transformer(in %)
Eff_m=75//Maximum efficiency(in %) of its full load
Z_1=10//Impedance(in %)
pf_1=1//Power factor for maximum efficiency
pf_2=0.8//Power factor lagging
I_fl=P_s/V_2
I=(Eff_m*I_fl)/100
Losses=(100-Eff)/100
Cu=Losses/2
Fe=Losses/2
C=(Cu*P_s*Eff_m)/100
R=C/(I^2)
V=(Z_1*V_2)/100
Z=V/I_fl
X=sqrt(Z^2-R^2)
```

```
theta=(acosd(pf_2))
Re=(I_fl*R*pf_2)+(I_fl*X*sind(theta))
disp(Re,'Regulation on full load at 0.8 power factor
    lagging(in volt)=')
Reg=(Re/V_2)*100
disp(Reg,'Percentage Regulation(in%)=')
```

Scilab code Exa 2.5 Find Ro and Xo and Resistance reffered to lv side and Reactance reffered to lv side

```
//Caption: Find:(a) R_o (b)X_o (c)Resistance
   reffered to l.v side (d)Reactance reffered to l.v
    side
//Exa:2.5
clc;
clear;
close;
P_s=5000//Power Supplied(in VA)
V_1=220//Primary side voltage(in volt)
V_2=440//Secondary side voltage(in volt)
f=50//frequency(in hertz)
I_o=0.75//Open circuit test current(in A)
P_o=75//Open circuit test power(in watt)
V_s=16//Short circuit test voltage(in volt)
P_c=80//Short circuit test power(in watt)
pf=(P_o)/(V_1*I_o)
a=sind(acosd(pf))
R_o=(V_1)/(I_o*pf)
disp(R_o,'(a)R_o(in ohms)=')
X_o=(V_1)/(I_o*a)
disp(X_o,'(b)X_o(in ohms)=')
```

```
I_l=P_s/V_2
Z=V_s/I_l
R=(P_c)/(I_l^2)
X=sqrt(Z^2-R^2)
n=V_2/V_1
r=(R)/(n^2)
disp(r','(c)resistance reffered to low voltage side(
   in ohms)=')
x=(X)/(n^2)
disp(x,'(d)reactane reffered to low voltage side(in
   ohms)=')
```

Scilab code Exa 2.6 Find voltage for hv voltage side on full load and at power factor lagging when secondary terminal voltage is 240 volts

```
//Caption:Find voltage for h.v voltage side on full
   load at 0.8 power factor lagging when secondary
   terminal voltage is 240 volts
//Exa:2.6
clc;
clear;
close;
P_s=100000//Supplied power(in VA)
V_1=6600//Primary side voltage(in volt)
V_2=240//Secondary side voltage(in volt)
f=50//frequency(in hertz)
I_sh=5//short circuit test current(in A)
P_sh=109//short circuit test power(in watt)
V_sh=50//short circuit test voltage(in volt)
pf=0.8//Power factor
Z=V_sh/I_sh
```

```
R=P_sh/(I_sh^2)
X=sqrt(Z^2-R^2)
I_l=P_s/V_1
Re=(I_l*R*pf)+(I_l*X*sind(acosd(pf)))
V_r=Re+V_1
disp(V_r,'Voltage for high voltage side on full load
    at 0.8 power factor lagging when secondary
   terminal voltage is 240 volts(in volt)=')
```

Scilab code Exa 2.7 Calculate ZXR reffered to hv side and Regulaton on full load at power factor lagging and Terminal voltage on lv side on full load at pf lagging and Efficiency of transformer when current 250A pf lagging is load connected to lv side and voltage at hv side

```
//Caption: Calculate (a)Z,X,R reffered to h.v side (
   b)Regulaton on full load at 0.8 power factor
   lagging (c)Terminal voltage on l.v side on full
   load at pf=0.8 lagging (d)Efficiency of
   transformer when current=250A,pf=0.8 lagging is
   load connected to l.v side and voltage at h.v
   side is 11000 volts
//Exa:2.7
clc;
clear;
close;
P_s=220000//Supplied power (in VA)
V_1=11000//Primary side voltage(in volt)
V_2=440//Secondary side voltage(in volt)
P_i=2200//Iron losses(in watt)
V=500//voltage applied to high voltage side for open
    circuit test(in volt)
```

```
P=2000//Wattmeter reading for open circuit test(in
    watt)
pf=0.8//Power factor
I=250//Load current(in A)
I_fl=P_s/V_1
r=P/(I_fl^2)
z=V/I_fl
x=sqrt(z^2-r^2)
disp(r,x,z,'(a)Z,X,R(in ohms)=')
Re=(I_fl*r*pf)+(I_fl*x*sind(acosd(pf)))
disp(Re,'(b)Regulation on full load on high voltage
    side(in volts)=')
Re_1=(Re*V_2)/V_1
disp(Re_1,'Regulation on full load on low volrage
    side(in volts)=')
V_t=V_2-Re_1
disp(V_t,'(c)Terminal voltage on low voltage side on
     full load(in volts)=')
I_c=I*V_2/(V_1)
W_c=P/(2^2)
Eff=(V_1*I_c*pf)/((V_1*I_c*pf)+(P_i)+(W_c))*100
disp(Eff,'(d)Efficiency of transformer(in%)=')
```

Scilab code Exa 2.8 Determine Efficiency and Regulation at loading conditions

```
//Caption: Determine (a)Efficiency (b)Regulation at
    loading conditions
//Exa:2.8
clc;
clear;
```

```
close;
P_s=10000//Supplied power (in VA)
V_1=440//Primary voltage (in volts)
V_2=240//Secondary voltage(in volts)
f=50//frequency(in hertz)
I_l=35//Load current(in A)
V_l=234//Load voltage(in volts)
W=8500//Wattmeter reading(in watts) connected on 440
    V side
P_o=I_l*V_l
P_i=W
Eff=P_o/(P_i)*100
disp(Eff,'(a)Efficiency(in %)=')
V_d=V_2-V_l
Re=V_d/(V_2)*100
disp(Re,'(b)Regulation(in%)=')
```

Scilab code Exa 2.9 Find how they will share 750KVA load at power factor lagging

```
//Caption: Find how they will share 750KVA load at
    0.8 power factor lagging
//Exa:2.9
clc;
clear;
close;
P_s1=500000//Supplied power(in VA) to first
    transformer
r_1=0.01//Per unit resistance of first transformer
x_1=0.05//Per unit reactance of first transformer
P_s2=250000//Supplied power(in VA) to second
```

```
    transformer
r_2=0.015//Per unit resistance of second transformer
x_2=0.04//Per unit reactance of second transformer
P_l=750000//Load(in VA)
pf=0.8//Powerfactor lagging
V_2=400//Secondary voltage of each transformer(in
    volts)
Z_1=r_1+(%i*x_1)
Z_2=((2*r_2)+(2*%i*x_2))
Z=Z_1+Z_2
S=P_l*(pf-(%i*(sind(acosd(pf)))))
S_1=(S*Z_2)/(Z)
s_1=sqrt(((real(S_1))^2)+((imag(S_1)^2)))
disp(s_1,'Load on first transformer(in VA)=')
S_2=(S*Z_1)/(Z)
s_2=sqrt(((real(S_2))^2)+((imag(S_2)^2)))
disp(s_2,'Load on second transformer(inVA)=')
```

Chapter 3

Three Phase Transformer Operation And Testing

Scilab code Exa 3.1 Find Secondary line voltage Line Current and output power for deltadelta and starstar and deltastar and stardelta

```
//Caption: Find Secondary line voltage,Line Current,
   and output power for (a)delta/delta (b)star/star
   (c)delta/star (d)star/delta
//Exa:3.1
clc;
clear;
close;
V=6600//Supplied voltage(in volts)
I=20//Supplied current(in A)
n=15//Number of turns per phase
V_la=V/n
I_la=n*I
disp(V_la,I_la,'(a)(in A),(in volts)=')
V_lb=V/n
I_lb=I*n
disp(V_lb,I_lb,'(b)(in A),(in volts)=')
V_lc=(V*(3^0.5))/(n)
I_lc=(n*I)/(3^0.5)
```

```
disp(V_lc,I_lc,'(c)(in A),(in volts)=')
V_ld=V/(n*(3^0.5))
I_ld=(3^0.5)*I*n
disp(V_ld,I_ld,'(d)(in A),(in volts)=')
P=(3^0.5)*V*I/1000
disp(P,'(d)Output Power (in KVA)=')
```

Scilab code Exa 3.2 Calculate Phase and Line currents in High voltage and Low voltage windings of transformer

```
//Caption: Calculate Phase and Line currents in (a)
    High voltage (b)Low voltage windings of
    transformer
//Exa:3.2
clc;
clear;
close;
P=50000//Power of induction motor(in watts)
V=440//Voltage of induction motor(in volts)
eff=90//Efficiency(in%)
pf=0.85//power factor
V_1=11000//Primary side voltage of transformer(in
    volts)
V_2=440//Secondary side voltage of transformer(in
    volts)
I_fl=P/((3^0.5)*V*pf*(eff/100))
v=V/(3^0.5)
n=V_1/v
I_ph=I_fl/(n)
I_l=(3^0.5)*I_ph
disp(I_ph,I_l,'(a)High Voltage side line and phase
```

```
currents(inA)=')
disp(I_fl,I_fl,'(b)Low voltage side phase and line currents(inA)=')
```

Scilab code Exa 3.3 Find possible voltage ratio and output for connections BC11500V and AC2300V and BC2300V and AC11500V

```
//Caption: Find possible voltage ratio and output for connections (a)BC=11500V,AC=2300V (b)BC=2300V,AC=11500V
//Exa:3.3
clc;
clear;
close;
V_1=11500//Voltage on primary side(in volts)
V_2=2300//Voltage on secondary side(in volts)
P_o=100000//Rated output(in VA)
V=V_1+V_2
v=V/V_1
I_1=P_o/V_1
I_2=P_o/V_2
I=I_1+I_2
W_o=(V_1*I)/1000
Cu=1-(V_1/V)//(a)Ratio of weight of copper
disp(W_o,v,'(a)Voltage ratio and output(in KVA)=')
w_o=(V_2*I)/(1000)
cu=1-(V_2/v)//(b)Ratio of weight of copper
disp(w_o,v,'(b)Voltage ratio and output(in KVA)=')
```

Chapter 4

Elements of Transformer Design

Scilab code Exa 4.1 Find Voltage per turn and area of core and area of conductor for lv and area of conductor for hv and Number of turns in lv and Number of turns in hv and Window area and Yoke and approx frame size and Copper used in windings

```
//Caption: Find (a)Voltage per turn (b)Cross
    sectional area of core (c)Cross sectional area of
     conductor for l.v (d)Cross sectional area of
    conductor for h.v (e)Number of turns in l.v (f)
    Number of turns in h.v (g)Window area (h)Yoke and
     approx. frame size (i)Copper used in windings
//Exa:4.1
clc;
clear;
close;
P=5000//Power supplied to transformer(in VA)
f=50//frequency(in Hertz)
V_1=415//Primary side voltage(in volts)
V_2=240//Secondary side voltage(in volts)
k=0.75
B=1.6//Maximum flux density(in weber/m^2)
```

```
i_d=2//Current density(in A/mm^2)
k_w=0.3
E=k*sqrt(P/1000)
disp(E,'(a)Voltage per turn(in volts)=')
A_1=(E*(10^6))/(4.44*B*f)
disp(A_1,'(b)Cross sectional area of core(in mm^2)=')
i_2=P/V_2
A_2=i_2/i_d
disp(A_2,'(c)Cross sectional area of conductor for low voltage side(in mm^2)=')
i_1=P/V_1
A_1=i_1/i_d
disp(A_1,'(d)Cross sectional area of conductor for high voltage side(in mm^2)=')
n_2=V_2/E
disp(n_2,'(e)Number of turns in low voltage winding=')
n_1=V_1/E
disp(n_1,'(f)Number of turns in high voltage winding=')
A_w=(P*(10^(9))/1000)/(2.22*A_1*k_w*i_d*B)
disp(A_w,'(g)Window area(in mm^2)=')
cu=(A_1*n_1)+(A_2*n_2)
disp(cu,'(i)Copper used in windings(in mm^2)=')
```

Scilab code Exa 4.2 Find Voltage per turn and Area of core and Area of conductor for hv and Number of turns per phase in hv winding and Area of conductor in lv winding and Number of turns in lv winding and Window area and Yoke and frame size and copper used

```
//Caption:Find (a)Voltage per turn (b)Cross
   sectional area of core (c)Cross sectional area of
    conductor for h.v (d)Number of turns per phase
   in h.v winding (e)Cross sectional area of
   conductor in l.v winding (f)Number of turns in l.
   v winding (g)Window area (h)Yoke and approx frame
    size ,and (i)Copper used in window area
//Exa:4.2
clc;
clear;
close;
P=100000//Power supplied to transformer(in VA)
f=50//Frequency(in hertz)
V_1=11000//Primary side voltage(in volts)
V_2=433//Secondary side voltage(in volts)
k=0.45
B=1.65//Maximum flux density(in tesla)
k_w=0.28
i_d=2.5//Current density(in A/mm^2)
E=k*sqrt(P/1000)
disp(E,'(a)Voltage per turn(in volts)=')
A_1=E*(10^6)/(4.44*f*B)
disp(A_1,'(b)Cross sectional area of core(in mm^2)='
   )
I_1=P/(3*V_1)
a_1=I_1/i_d
disp(a_1,'(c)Cross sectional area of conductor in h.
   v winding(in mm^2)=')
n_1=V_1/E
disp(n_1,'(d)Number of turns per phase in h.v
   winding(in mm^2)=')
I_2=P/((3^0.5)*V_2)
a_2=I_2/i_d
disp(a_2,'(e)Cross sectional area of conductor in l.
   v winding(in mm^2)=')
v=V_2/(3^0.5)
n_2=v/E
disp(n_2,'(f)Number of turns in l.v winding=')
```

```
A_w=(P*(10^6))/(3.33*f*A_1*k_w*i_d*B)
disp(A_w,'(g)Window Area(in mm^2)=')
Cu=2*((a_1*n_1)+(a_2*n_2))
disp(Cu,'Copper used in window area(in mm^2)=')
```

Chapter 7

Principle And Construction of DC Machines

Scilab code Exa 7.3 Find effect of change in connection on voltage and current and output

```
//Caption:Find effect of change in connection on
   voltage,current and output
//Exa:7.3
clc;
clear;
close;
P=50000//Power of generator(in watt)
V_b1=230//Voltage of generator(in volts)
p=4//Number of poles
a=4//Number of parallel paths for lap winding
b=2//Number of parallel paths for wave winding
C=268//Number of conductors with LAP winding
t=2//Two turns coils are used
c=t*2//Conductors per slot
n=C/c
I_1=P/(V_b1)
V_b2=V_b1*b
I_2=P/(V_b2)
```

```
disp(V_b1,I_1,'Current(in A) and voltage(in volts)
    for LAP winding=')
disp(V_b2,I_2,'Current(in A) and voltage(in volts)
    for WAVE winding=')
disp(P,'Output is same for both connections(in watts
    )=')
```

Scilab code Exa 7.6 Select a two circuit armature winding for a dc machine

```
//Caption: Select a two circuit armature winding for
     a d.c machine
//Exa:7.6
clc;
clear;
close;
p=4//Number of poles
n=1000//Speed of d.c. machine(in r.p.m)
V=400//Voltage of d.cmachine(in volts)
B=0.04//Flux per pole(in weber)
s_1=41//Slot 1
s_2=45//Slot 2
s_3=51//Slot 3
a=2//Number of parallel paths
Z=(V*60*a)/(B*n*p)
Z_c=Z/a
Y=(s_3+1)/(p/2)
t=3//turns per coil
c=t*a
z=s_3*c
disp(z,c,t,s_3,'slots,turn coils,coils sides per
```

```
    slot and total number of conductors=')
```

Scilab code Exa 7.7 Find Emf generated at 750rpm for lap wound And emf generated at 600rpm for wave wound And Speed to be driven for 400V for same flux per pole

```
//Caption: Find (a)e.m.f generated at 750r.p.m for
    lap wound (b)e.m.f generated at 600r.p.m for wave
     wound (c)Speed to be driven for 400V for same
    flux per pole
//Exa:7.7
clc;
clear;
close;
p=4//Number of poles
B=0.04//Flux per pole(in weber)
c=740//Number of conductors for lap connection
n_1=750//Speed of machine(in r.p.m)
n_2=600//Speed of machine(in r.p.m)
V=400//Voltage of machine(in volts)
a=4//Number of parallel paths for lap winding
b=2//Number of parallel paths for wave winding
E=(B*c*n_1*p)/(60*a)
disp(E,'(a)E.M.F generated at 750r.p.m for lap wound
    (in volts)=')
E_1=(B*c*n_2*p)/(60*b)
disp(E_1,'(b)E.M.F generated at 600r.p.m for
    wavewound(in volts)=')
n=(V*60*b)/(B*c*p)
disp(n,'(c)Speed of machine(in r.p.m)=')
```

Scilab code Exa 7.8 Calculate Total armature current And Current per armature path And Generated emf

```
//Caption: Calculate (a)Total armature current (b)
   Current per armature path (c)Generated e.m.f
//Exa:7.8
clc;
clear;
close;
p=4//Number of poles
P=4000//Power of generator(in watts)
V=230//Voltage of generator(in volts)
r_f=115//Field resistance(in ohms)
r_a=0.1//Armature resistance(in ohms)
a=p//number of parallel paths
i_f=V/r_f
i_l=P/V
I_a=i_l+i_f
disp(I_a,'(a)Armature current(in A)=')
i=I_a/p
disp(i,'(b)Current per armature path(in A)=')
E=V+(I_a*r_a)
disp(E,'(c)E.M.F generated(in volts)=')
```

Scilab code Exa 7.9 Find the speed at which it will run as a motor

```
//Caption:Find the speed at which it will run as a
    motor
//Exa:7.9
clc;
clear;
close;
P_g=110000//Power of generator(in watts)
n=400//Speed of generator(in r.p.m)
V=220//Voltage of busbars(in volts)
P_m=10900//Power of motor(in watt)
r_a=0.025//Armature resistance(in ohms)
r_f=55//Field resistance(in ohms)
v_b=1//Voltage drop at each brush(in volt)
i_l=P_g/V
i_f=V/r_f
I_a=i_l+i_f
V_a=I_a*r_a
E=V+V_a+(2*v_b)
I_1=P_m/V
i_a=I_1-i_f
v_a=i_a*r_a
E_b=V-(i_a*r_a)-(2*v_b)
N_m=(n*E_b)/E
disp(N_m,'Speed at which generator will run as motor
    is(in r.p.m)=')
```

Scilab code Exa 7.10 Calculate the speed of the motor when it is loaded and takes 60A from the mains

```
//Caption: Calculate the speed of the motor when it
    is loaded and takes 60A from the mains
//Exa:7.10
clc;
clear;
close;
V=230//Voltage of motor(in volts)
n=800//Speedof motor(in r.p.m)
i=5//Current taken by motor(in A)
r_a=0.25//Armature resistance(in ohms)
r_f=230//field resistance(in ohms)
i_l=60//Load current(in A)
i_f=V/r_f
i_a=i-i_f
E_b1=V-(i_a*r_a)
i_al=i_l-i_f
E_b2=V-(i_al*r_a)
N=(n*E_b2)/E_b1
disp(N,'Required speed of motor(in r.p.m) is=')
```

Scilab code Exa 7.11 Calculate Power and torque developed

```
//Caption: Calculate Power and torque developed
//Exa:7.11
clc;
clear;
close;
p=4//Number of poles
d=20//Diameter of armature(in cm)
l=25//Core length(in cm)
c=300//Number of conductors
```

```
i_a=50//Armature current(in A)
B=0.3//Average flux density(in weber/m^2)
n=1000//Speedofmotor(in r.p.m)
T=(B*(l/100)*(i_a/p)*c*(d/100)*(1/2))
s=(2*%pi*n)/(60)
P=(T*s)/1000
disp(T,P,'Power(in KW) and Torque(in Nm) developed
    is=')
```

Scilab code Exa 7.12 Determine per pole Number of cross magnetising ampereturns and Demagnetising ampereturns

```
//Caption: Determineper pole (a)Number of cross
    magnetising ampereturns,and (b)Demagnetising
    ampereturns
//Exa:7.12
clc;
clear;
close;
I=100//Current(in A)
c=500//Armature conductors
p=6//Poles
t=10//Angle of lead(in degree)
a=2//Wave wound
e=(10*p)/2
F_d=(c*I*2*e)/(2*a*p*180)
disp(F_d,'(a)Number of cross magnetising ampereturns
    =')
F_c=(c*I)*(1-((2*e)/180))/(2*a*p)
disp(F_c,'(b)Demagnetising ampereturns=')
```

Scilab code Exa 7.13 Find the time of Commutation

```
//Caption:Find the time of Commutation
//Exa:7.13
clc;
clear;
close;
p=4//Number of poles
n=600//Speed of generator(in r.p.m)
d=0.4//Diameter of commutator(in m)
c=243//Number ofcommutator segments
c_s=3//Coil sides per layer
w=12.5//Width of brush(in mm)
W=0.6//Width of mica between commutator segments
W_c=(%pi*d*1000)/(c)
D=w-W+(2*W_c)
V_c=(%pi*d*n)/60
T=D/V_c*(10^(-3))
disp(T,'Time of commutation(in sec)=')
```

Scilab code Exa 7.14 Find average reactance voltage produce due to commutation

```
//Caption: Find average reactance voltage produce
   due to commutation
//Exa:7.14
clc;
clear;
close;
p=4//Number of poles
I=300//Current delievered by generator on full load(
   in A)
L=0.02*(10^(-3))//Inductance of each coil(in mH)
a=2//Wavw wound
i=I/2//Current in conductors in each path(in A)
T_c=0.00174//Time of commutation(in sec)
E_r=(2*L*i)/T_c
disp(E_r,'Average reactance voltage(in volts)=')
```

Scilab code Exa 7.15 Calculate the number of turns needed on each commutating pole

```
//Caption: Calculate the number of turns needed on
   each commutating pole
//Exa:7.15
clc;
clear;
close;
p=4//Number of poles
P=125000//Power delievered by generator(in watts)
V=230//Voltage of generator(in volts)
z=240//Armature conductors
B=0.3//Flux density under the interpolar gap(in
   weber/m^2)
```

```
g=0.01//Interpolar airgap(in m)
a=p//LAP connection
I_a=P/V
F_a=(z*I_a)/(2*a*p)
A=(B*g)/(4*%pi*(10^(-7)))
A_t=A+F_a
T=A_t/I_a
disp(T,'The number of turns on each commutating pole
    =')
```

Chapter 8

DC Machines Operations and Testing

Scilab code Exa 8.2 Find the current and voltage required

```
//Caption: Find the (a)current (b)voltage required
//Exa:8.2
clc;
clear;
close;
r=1//Resistance of series motor(in ohms)
V=230//Voltage of series motor(in volts)
n_1=300//Speed of motor(in r.p.m)
i_1=15//Current taken by motor(in A)
n_2=375//Speed of motor(in r.p.m)
i_2=sqrt(((i_1^2)*(n_2^2))/(n_1^2))
disp(i_2,'(a)Current(in A)=')
V_2=(((V-(i_1*r))*(i_2*n_2))/(i_1*n_1))+(i_2*r)
disp(V_2,'(b)Voltage(in volts)=')
```

Scilab code Exa 8.3 Find the resistance required

```
//Caption: Find the resistance required
//Exa:8.3
clc;
clear;
close;
I_1=40//Current taken by series motor(in A)
V=500//Supplied voltage(in volts)
n_1=100//Initial speed(in%)
n_2=80//final speed(in%)
I_2=sqrt(((I_1^2)*(n_2^2))/(n_1^2))
a=(I_1*(n_1/100))/(I_2*(n_2/100))
R=((a*V)-V)/(a*I_2)
disp(R,'Resistance required(in ohms) is=')
```

Scilab code Exa 8.5 Find Speed at full load torque And Speed at double full load torque And Stalling torque

```
//Caption: Find (a)Speed at full load torque (b)
    Speed at double full load torque (c)Stalling
    torque
//Exa:8.5
clc;
```

```
clear;
close;
V=250//Voltage of motor(in volts)
R_a=0.5//Armature resistance(in ohms)
n=400//Speed of motor at full load(in r.p.m)
i=30//Current taken by motor(in A)
R=1//Series resistance with armature(in ohms)
E_b1=V-(i*R_a)
E_b2=V-((R_a+R)*i)
N=n*(E_b2/E_b1)
disp(N,'(a)Speed at full load torque(in r.p.m)=')
I=2*i
E_b=V-(I*(R+R_a))
N_1=n*(E_b/E_b1)
disp(N_1,'(b)Speed at double full load torque(in r.p
    .m)=')
I_ft=V/(R+R_a)
T_stalling=I_ft/i
disp(T_stalling,'(c)Stalling torque=times the full
    load torque')
```

Scilab code Exa 8.6 Find Input to generator from prime mover on full load and Efficiency on full load and Load current at which generator efficiency is maximum

```
//Caption: Find (a)Input to generator from prime
    mover on full load (b)Efficiency on full load (c)
    Load current at which generator efficiency is
    maximum
//Exa:8.6
clc;
```

```
clear;
close;
V=230//Voltage of generator(in volts)
I=150//Full load current(in A)
R_a=0.1//Armature resistance(in ohms)
R_f=230//Field resistance(in ohms)
P_s=1500//Stray losses(in watt)
I_f=V/R_f
I_a=I_f+I
W_ac=(I_a^2)*R_a
W_fc=(I_f^2)*R_f
P_c=W_fc+P_s
L_t=W_ac+P_c
P_o=V*I
P_i=P_o+L_t
disp(P_i,'(a)Input to generator from prime mover on
    full load(in watt)=')
Eff=(P_o/P_i)*100
disp(Eff,'(b)Efficiency on full load(in %)=')
I_l=sqrt(P_c/R_a)
disp(I_l,'(c)Load current at which generator
    efficiency is maximum(in A)=')
```

Scilab code Exa 8.7 Calculate Efficiency on full load and Efficiency on 40A input and Efficiency on 25A input and Full load speed regulation

```
//Caption: Calculate (a)Efficiency on full load (b)
    Efficiency on 40A input (c)Efficiency on 25A
    input (d)Full load speed regulation
//Exa:8.7
clc;
```

```
clear;
close;
V=230//Voltage of motor(in volts)
i_l=50//Full load current(in A)
r_a=0.25//Armature resistance(in ohms)
r_f=230//Field resistance(in ohms)
i_o=3//No load current(in A)
i_1=40//Input current(in A)
i_2=25//Input current(in A)
P_c=V*i_o
P_i1=V*i_l
i_f=V/r_f
i_a1=i_l-i_f
L_fl=((i_a1^2)*r_a)+P_c
Eff_1=((P_i1-L_fl)/P_i1)*100
disp(Eff_1,'(a)Efficiency on full load(in%)=')
P_i2=V*i_1
i_a2=i_1-i_f
L=((i_a2^2)*r_a)+P_c
Eff_2=((P_i2-L)/P_i2)*100
disp(Eff_2,'(b)Efficiency on 40A input(in%)=')
P_i3=V*i_2
i_a3=i_2-i_f
L_1=((i_a3^2*r_a)+P_c)
Eff_3=((P_i3-L_1)/P_i3)*100
disp(Eff_3,'(c)Efficiency on 25A input(in%)=')
I_ao=i_o-i_f
E_bo=V-(I_ao*r_a)
E_bl=V-(r_a*i_a1)
Re=((E_bo-E_bl)/E_bo)*100
disp(Re,'(d)Full load speed regulation(in%)=')
```

Scilab code Exa 8.10 Calculate efficiency of motor and generator

```
//Caption: Calculate efficiency of (a)motor and (b)
    generator
//Exa:8.10
clc;
clear;
close;
V=230//Line voltage for both shunt machines(in volts
    )
I=70//Line current excluding field currents of both
    machines(in A)
i_a=400//Armature current(in A)
i_f1=4//Field current of first machine(in A)
i_f2=3//Field current of second machine(in A)
r_a=0.03//Resistance of armature of each mchine(in
    ohms)
P_acm=(i_a^2)*r_a
P_i=V*I
I_g=i_a-I
P_acg=(I_g^2)*r_a
P_f=(P_i-P_acm-P_acg)/2
P_m=(V*i_a)+(V*i_f2)
P_fc=V*i_f2
L_t=P_fc+P_acm+P_f
P_o=P_m-L_t
n_m=(P_o/P_m)*100
disp(n_m,'(a)Efficiency of motor(in%)=')
P_og=V*I_g
P_fcu=V*i_f1
L_t1=P_f+P_fcu+P_acg
P_ig=P_og+L_t1
n_g=(P_og/P_ig)*100
disp(n_g,'(b)Efficiency of generator(in%)=')
```

Scilab code Exa 8.11 Calculate efficiency of motor

```
//Caption: Calculate efficiency of motor
//Exa:8.11
clc;
clear;
close;
W=25//Effective load on break drum(in kgf)
d=50//Diameter of drum(in cm)
n=750//Speed of the motor(in r.p.m)
I=25//Current taken by motor(in A)
V=230//Voltage of motor(in volts)
P_o=(2*%pi*n*W*9.81*(d/2))/(60*100)
P_i=V*I
Eff=(P_o/P_i)*100
disp(Eff,'Efficiency of motor(in %)=')
```

Scilab code Exa 8.12 Find efficiency of motor

```
//Caption:Find efficiency of motor
//Exa:8.12
clc;
clear;
close;
```

```
V=500//Voltage of shunt motor(in volts)
I=10//Current taken by motor on no load(inA)
I_f=3//Field Current(inA)
r_a=0.1//Armature resistance(in ohms)
P_i=100000//Input power to motor(in watt)
P_nl=V*I
I_ao=I-I_f
P_acn=(I_ao^2)*r_a
P_fcn=I_f*V
P_c=(P_nl)-P_acn-P_fcn
I_l=P_i/V
I_al=I_l-I_f
P_acl=(I_al^2)*r_a
P_fcl=V*I_f
L_t=P_acl+P_fcl+P_c
Eff=((P_i-L_t)/P_i)*100
disp(Eff,'Efficiency of motor(in%) is=')
```

Chapter 9

Elements of DC Machine Design

Scilab code Exa 9.1 Find the dimensions of D and L

```
//Caption:Find the dimensions of D and L
//Exa:9.1
clc;
clear;
close;
P=15000//Power of shunt motor(in watt)
V=440//Supplied voltage to motor(in volts)
n=1500//Speed of motor(in r.p.m)
e=88//Efficiency(in %)
B=0.65//Average flux density(in webers/m^2)
q=30000//Specific electric loading(ampere conductors
    /m)
p=4//Number of poles
R_f=220//Field resistance(in ohms)
P_i=P/(e/100)
I=P_i/V
I_f=V/R_f
D=170//Choosing the diameter(in mm)
L=(P_i)/((%pi^2)*((D^2)*(10^(-6)))*B*q*(n/60)
```

```
    *(10^(-3)))
disp(D,L,'Required dimensions of L and D(in mm) are=
    ')
```

Scilab code Exa 9.2 Find values of the 5 steps in a 6 stud starter for a dc shunt motor

```
//Caption: Find values of the 5 steps in a 6 stud
    starter for a d.c. shunt motor
//Exa:9.2
clc;
clear;
close;
P_o=3730//Output power(in watt)
V=200//Voltage supplied to motor(in volts)
e=88//Efficiency(in%)
P_i=P_o/(e/100)
I=P_i/V//Full load current
I_a=I//Neglecting field current
L=P_i-P_o
Cu=(1/2)*L//Copper loss is half the total loss(Given
    )
R_a=Cu/(I^2)
I_m=(2*I)//Maximum current is twice full load
    current(Given)
R_1=V/I_m
g=(R_1/R_a)^(1/5)
R_2=R_1/g
r1=R_1-R_2
R_3=R_2/g
r2=R_2-R_3
```

```
R_4=R_3/g
r3=R_3-R_4
R_5=R_4/g
r4=R_4-R_5
R_6=R_5/g
r5=R_5-R_6
disp(r5,r4,r3,r2,r1,'Required resistances r1,r2,r3,
   r4,r5(in ohms)=')
```

Chapter 11

Three Phase Induction Motors Principle and Characteristics

Scilab code Exa 11.1 Find Number of poles and Percentage slip

```
//Caption: Find (a)Number of poles and (b)% slip
//Exa:11.1
clc;
clear;
close;
f=50//Frequency(in hertz)
n=960//Speed of induction motor on full load(in r.p.
    m)
n_s=1000//Synchronous speed(in r.p.m)
p=(f*120)/(n_s)
disp(p,'(a)Number of poles is=')
s=n_s-n
S=(s/n_s)*100
disp(S,'(b)%Slip is(in%)=')
```

Scilab code Exa 11.2 Find Speed of motor And Percentage Slip

```
//Caption: Find (a)Speed of motor (b)%Slip
//Exa:11.2
clc;
clear;
close;
p=6//Number of poles
f_s=50//Stator frequency(in c/s)
f_r=2//Rotor frequency(in c/s)
n_s=(120*f_s)/p
n=(f_r*120)/p
s=n_s-n
disp(s,'(a)Speed of motor(in r.p.m)=')
S=(n/n_s)*100
disp(S,'(b)%Slip(in %)=')
```

Scilab code Exa 11.3 Calculate Number of poles And Slip And Slip for full load torque if total resistance in rotor circuit is doubled

```
//Caption: Calculate (a)Number of poles (b)Slip (c)
    Slip for full load torque if total resistance in
    rotor circuit is doubled
//Exa:11.3
```

```
clc;
clear;
close;
n=970//Speed of induction motor(in r.p.m)
f=50//Frequency(in hertz)
n_s=1000//Synchronous speed(in r.p.m)
p=(f*120)/n_s
disp(p,'(a)Number of poles=')
s=((n_s-n)/n_s)*100
disp(s,'(b)Slip(in%)=')
S=((s/100)*2)*100
disp(S,'(c)Required slip(in%)=')
```

Scilab code Exa 11.4 Calculate Mechanical power output And Torque And Maximum Torque And Speed at maximum torque And Power output when torque is maximum

```
//Caption: Calculate (a)Mechanical power output (b)
    Torque (c)Maximum Torque (d)Speed at maximum
    torque (e)Power output when torque is maximum
//Exa:11.4
clc;
clear;
close;
p=4//Number of poles
V=440//Voltage of motor(in volts)
f=50//Frequency(in hertz)
n_s=1500//Synchronous speed(r.p.m)
sp=1440//Speed of motor at load(in r.p.m)
s=4//Slip at full load(in %)
t=1.8//Stator to rotor turns ratio
```

```
R_r=0.1//Resistance of rotor per phase(in ohms)
X_r=0.8//Reactance of rotor per phase at standstill(
    in ohms)
r_r=R_r*(t^2)//Rotor resistance referred to stator(
    in ohms)
x_r=X_r*(t^2)//Reactance of rotor at stanstill
    referred to stator(in ohms)
E=V/(sqrt(3))
P=((s/100)*(E^2)*r_r)/((r_r^2)+((s/100)^2)*(x_r^2))
T=(3*P)/(2*(%pi)*(n_s/60))
P_M=(3*P*sp)/n_s
disp(P_M,'(a)Mechanical power output(in watt)=')
disp(T,'(b)Torque(in N-m)=')
s_m=R_r/X_r
N=n_s*(1-s_m)
P_1=((s_m)*(E^2)*(r_r))/((r_r^2)+((s_m^2)*(x_r^2)))
T_m=(3*P_1)/(2*(%pi)*(n_s/60))
disp(T_m,'(c)Maximum torque(in N-m)=')
disp(N,'(d)Speed at maximum torque(in r.p.m)=')
P_o=(3*P_1*N)/n_s
disp(P_o,'(e)Output power at maximum torque(in watt)
    =')
```

Scilab code Exa 11.5 Find Speed of the motor And Speed at which torque will be maximum And Ratio of maximum to full load torque

```
//Caption:Find (a)Speed of the motor (b)Speed at
    which torque will be maximum (c)Ratio of maximum
    to full load torque
//Exa:11.5
clc;
```

```
clear;
close;
V=3300//Voltage supplied to induction motor(in volts
    )
p=10//Number of poles
f=50//frequency(in hertz)
R_r=0.015//Rotor resistance per phase(in ohms)
X_r=0.25//Standstill reactance per phase(in ohms)
s=2.5//Slip(in %)
n_s=(f*120)/p
n=n_s*(1-(s/100))
disp(n,'(a)Speed of the motor(in r.p.m)=')
S=R_r/X_r
N=n_s*(1-S)
disp(N,'(b)Speed at which torque will be maximum(in
    r.p.m)=')
T_f=(s/100)*R_r/((R_r^2)+(((s/100)^2)*(X_r^2)))
T_m=S*R_r/((R_r^2)+((S^2)*(X_r^2)))
R=T_m/T_f
disp(R,'(c)Ratio of maximum to full load torque=')
```

Scilab code Exa 11.6 Calculate Speed at which mechanical power from rotor will be maximum And Maximum power

```
//Caption: Calculate (a)Speed at which mechanical
    power from rotor will be maximum (b)Maximum power
//Exa:11.6
clc;
clear;
close;
p=4//Number of poles
```

```
f=50//Frequency(in hertz)
V=440//Supplied voltage to induction motor(in volts)
R_r=0.1//Rotor resistance per phase(in ohm)
X_r=0.8//Rotor reactance at standstill per phase(in
    ohm)
t=1.3//Ratio of stator turns per phase to rotor
    turns per phase
a=R_r/X_r
s=(-(a^2))+sqrt(1+(a^2))
n_s=120*f/p
N=n_s*(1-s)
disp(N,'(a)Required speed(in r.p.m)=')
r=R_r*t
x=X_r*t
E=V/sqrt(3)
P_m=(3*s*(E^2)*r*(1-s))/((r^2)+((s^2)+(x^2)))
disp(P_m,'(b)Maximum power(in watts)=')
```

Scilab code Exa 11.7 Find Current per phase in the rotor when rotor is at standstill and star connected impedance per phase is connected in series with rotor And when rotor runs at 3 percentage slip with short circuit at the slip rings

```
//Caption: Find Current per phase in the rotor (a)
    when rotor is at standstill and star connected
    impedance of 4.1+%i2 per phase is connected in
    series with rotor  (b)when rotor runs at 3% slip
     with short circuit at the slip rings
//Exa:11.7
clc;
clear;
```

```
close;
V=69.28//Induced e.m.f(in volts)
r=0.9//Resistance of rotor per phase(in ohm)
x=6//Standstill rectance of rotor per phase(in ohm)
z=4.1+(%i*2)
s=3//Slip(in%)
V_r=V/sqrt(3)
R_r=r+real(z)
X_r=(%i*2)+(%i*x)
Z=R_r+X_r
I_r=V_r/Z
disp(I_r,'(a)Current when rotor is at standstill=')
E=(s/100)*V_r
Imp=r+(%i*(s/100)*x)
i_r=E/Imp
disp(i_r,'(b)Current when rotor runs at 3% slip=')
```

Scilab code Exa 11.8 Find Percentage reduction in stator voltage and the power factor of the rotor circuit

```
//Caption:Find (a)% reduction in stator voltage and
   (b)the power factor of the rotor circuit
//Exa:11.8
clc;
clear;
close;
R_r=0.02//Rotor resistance per phase(in ohm)
X_r=0.1//Rotor reactance per phase(in ohm)
s=4//Slip(in%)
S=100-s
T_f=((s/100)*R_r)/((R_r^2)+(((s/100)^2)*(X_r^2)))
```

```
S_r=1-(.5*(S/100))
T=(S_r*R_r)/((R_r^2)+((S_r^2)*(X_r^2)))
Re=(1-sqrt(T_f/T))*100
disp(Re,'(a)% reduction in stator voltage(in %)=')
pf=R_r/(sqrt((R_r^2)+((S_r^2)*(X_r^2))))
disp(pf,'(b)Power factor=')
```

Scilab code Exa 11.9 Find the rotor copper loss per phase if motor is running at slip of 4 percent Mechanical power developed

```
//Caption:Find (a)the rotor copper loss per phase if
    motor is running at slip of 4% (b)Mechanical
    power developed
//Exa:11.9
clc;
clear;
close;
P_i=100000//Input power(in watt)
P_sc=2000//Stator copper loss(in watt)
s=4//slip(in %)
P_r=P_i-P_sc
P_rc=((s/100)*P_r)/3
disp(P_rc,'(a)Rotor copper lossper phase(in watt)=')
P_m=P_r-(P_rc*3)
disp(P_m,'(b)Mechanical power developed(in watt)=')
```

Scilab code Exa 11.10 Calculate Percentage slip And Rotor copper loss And Output from the rotor And Efficiency

```
//Caption: Calculate (a)% slip (b)Rotor copper loss
   (c)Output from the rotor (d)Efficiency
//Exa:11.10
clc;
clear;
close;
V=440//Supplied voltage(in volts)
f=50//frequency(in hertz)
p=6//Number of poles
n=960//Speed of motor(in r.p.m)
P_i=50000//Input power(in watt)
P_wf=1800//Winding and friction losses(in watt)
P_s=1200//Stator losses(in watt)
n_s=(120*f)/p
S=((n_s-n)/n_s)*100
disp(S,'(a)% slip=')
P_r=P_i-P_s
P_rc=(S/100)*P_r
disp(P_rc,'(b)Rotor copper loss(in watt)=')
P_o=P_r-P_rc-P_wf
disp(P_o,'(c)Output of rotor(in watt)=')
eff=(P_o/P_i)*100
disp(eff,'(d)Efficiency(in%)=')
```

Scilab code Exa 11.11 Find Equivalent rotor current per phase And Stator current per phase And Power factor And Rotor input And Rotor copper losses And Torque And Mechanical power output from rotor And Stator input And Efficiency

```
//Caption:Find (a)Equivalent rotor current per phase
    (b)Stator current per phase (c)Power factor (d)
    Rotor input (e)Rotor copper losses (f)Torque (g)
    Mechanical power output from rotor (h)Stator
    input (i)Efficiency
//Exa:11.11
clc;
clear;
close;
V=440//Voltage supplied(in volts)
p=8//Number of poles
f=50//Frequency(in hertz)
r1=0.2//Stator resistance(in ohm)
x1=1.2//Stator reactance(in ohm)
r2=0.3//Equivalent resistance of rotor referred to
    stator(in ohm)
x2=1.2//Equivalent reactance of rotor referred to
    stator(in ohm)
r_m=150//Magnetising resistance(in ohms)
x_m=18//Magnetising reactance(in ohms)
P_wf=750//Winding and friction losses(in watt)
s=0.04//Slip
n_s=(f*120)/(p*60)
y1=1/r_m
y2=1/(%i*x_m)
```

```
y3=1/((r2/s)+(%i*x2))
Y=y1+y2+y3
Z=1/Y
Z_t=Z+(r1+(%i*x1))
E=V*Z/(Z_t)
z3=1/y3
i2=E/z3
disp(i2,'(a)Rotor current per phase(in A)=')
i1=V/Z_t
disp(i1,'(b)Stator current per phase(in A)=')
pf=cosd(atand(-(imag(Z_t))/real(Z_t)))
disp(pf,'(c)Power factor=')
P_r=(i2*(conj(i2)))*(r2/s)
disp(P_r,'(d)Rotor input(in watt)=')
P_rc=(i2*(conj(i2)))*r2
disp(P_rc,'(e)Rotor copper loss(in watt)=')
T=3*P_r/(2*%pi*n_s)
disp(T,'(f)Torque(in N-m)=')
P_me=P_r-P_rc-(P_wf/3)
disp(P_me,'(g)Mechanical output from rotor(in watts
   per phase)=')
P_st=V*(sqrt(i1*(conj(i1))))*pf
disp(P_st,'(h)Stator input(watts per phase)=')
eff=(P_me/P_st)*100
disp(eff,'(i)Efficiency(in %)=')
```

Scilab code Exa 11.12 Find Equivalent rotor current per phase And Stator current per phase And Power factor And Rotor input And copper losses And Torque And Mechanical power output from rotor And Stator input And Efficiency Solve it by APPROXIMATE equivalent circuit method

```
//Caption:Find (a)Equivalent rotor current per phase
    (b)Stator current per phase (c)Power factor (d)
   Rotor input (e)Rotor copper losses (f)Torque (g)
   Mechanical power output from rotor (h)Stator
   input (i)Efficiency.Solve it by APPROXIMATE
   equivalent circuit method
//Exa:11.12
clc;
clear;
close;
V=440//Voltage supplied(in volts)
p=8//Number of poles
f=50//Frequency(in hertz)
r1=0.2//Stator resistance(in ohm)
x1=1.2//Stator reactance(in ohm)
r2=0.3//Equivalent resistance of rotor referred to
   stator(in ohm)
x2=1.2//Equivalent reactance of rotor referred to
   stator(in ohm)
r_m=150//Magnetising resistance(in ohms)
x_m=18//Magnetising reactance(in ohms)
P_wf=750//Winding and friction losses(in watt)
s=0.04//Slip
I2=V/((r1+(r2/s))+(%i*x1)+(%i*x2))
disp(I2,'(a)Equivalent rotor current per phase(in A)
   =')
y1=1/r_m
y2=1/(%i*x_m)
I_o=V*(y1+y2)
I_1=I2+I_o
disp(I_1,'(b)Stator current per phase(in A)=')
pf=cosd(atand(imag(I_1)/real(I_1)))
disp(pf,'(c)Power factor=')
P_r=(I2*conj(I2))*(r2/s)
disp(P_r,'(d)Rotor input(in watt)=')
P_rc=(I2*conj(I2))*r2
disp(P_rc,'(e)Rotor copper losses(in watts)=')
T=P_r/(2*%pi*((f*120)/(p*60)))
```

```
disp(T,'(f)Torque(in N-m)=')
P_me=P_r-P_rc-(P_wf/3)
disp(P_me,'(g)Mechanical power output from rotor(in
   watts per phase)=')
P_si=V*pf*(sqrt(I_1*conj(I_1)))
disp(P_si,'(h)Stator input(in watts per phase)=')
e=(P_me/P_si)*100
disp(e,'(i)Efficiency (in %)=')
```

Scilab code Exa 11.13 Find Equivalent rotor current And Stator current And Power factor And Stator input And Rotor input And Efficiency

```
//Caption:Find (a)Equivalent rotor current (b)Stator
    current (c)Power factor (d)Stator input (e)Rotor
    input (f)Efficiency
//Exa:11.13
clc;
clear;
close;
V=440//Voltage supplied(in volts)
f=50//frequency(in hertz)
Z_s=1.5+(%i*3)//Stator impedance per phase(in ohms)
Z_r=1.6+(%i*1)//Rotor impedance per phase(in ohms)
Z_m=3+(%i*40)//Magnetising impedance per phase(in
   ohms)
P_wf=300//Friction and winding loss(in watt)
s=0.04//Slip
Z=40+(%i*1)
z=Z*Z_m/(Z+Z_m)
Zt=z+Z_s
I1=(V/sqrt(3))/Zt
```

```
E=(V/sqrt(3))-(I1*Z_s)
I2=E/Z
disp(I2,'(a)Equivalent Rotor current(in A)=')
disp(I1,'(b)Stator current(in A)=')
pf=cosd(atand(imag(Zt)/real(Zt)))
disp(pf,'(c)Power factor=')
P_s=sqrt(3)*V*sqrt(I1*conj(I1))*pf
disp(P_s,'(d)Stator input(in watt)=')
P_r=3*(I2*conj(I2))*(real(Z_r)/s)
disp(P_r,'(e)Rotor input(in watt)=')
P_ro=P_r*(1-s)
P_me=P_ro-P_wf
e=(P_me/P_s)*100
disp(e,'(e)Efficiency(in%)=')
```

Chapter 12

Three Phase Induction Motor Operation And Testing

Scilab code Exa 12.1 Calculate No load power factor And Core friction loss And rm And power factor on short circuit And Equivalent impedance in series circuit And Rotor resistance referred to stator And Stator leakage reactance And Rotor leakage reactance referred to stator

```
//Caption:Calculate (a)No load power factor (b)Core
   and friction loss (c)r_m (d)power factor on short
    circuit (e)Equivalent impedance in series
   circuit (f)Rotor resistance referred to stator (g
   )Stator leakage reactance (h)Rotor leakage
   reactance referred to stator
//Exa:12.1
clc;
clear;
close;
P=3000//Power of motor(in watt)
V=415//Voltage supplied(in volts)
f=50//Frequency(in hertz)
p=6//Number of poles
pf=0.8//Power factor
I_n=3.5//No load current(in A)
```

```
P_n=250//Power input on no load test(in watt)
r_s=1.5//Stator resistance per phase(in ohm)
V_r=115//Reduced voltage applied at short circuit
    test(in volts)
I_s=13//Current supplied on short circuit test(in A)
P_s=1660//Voltage applied at short circuit test(in
    watt)
pfn=P_n/(sqrt(3)*V*I_n)
disp(pfn,'(a)Noload power factor=')
P_wf=P_n-(3*(I_n^2)*r_s)
disp(P_wf,'(b)Core and friction loss(in watt)=')
r_m=(V/sqrt(3))/(I_n*pfn)
disp(r_m,'(c)Resistance(in ohms)=')
pfs=P_s/(sqrt(3)*V_r*I_s)
disp(pfs,'(d)Power factor on short circuit=')
Ze=(V/sqrt(3))/((I_s*V)/V_r)
disp(Ze,'(e)Equivalent impedance in series circuit(
    in ohms)=')
R=(Ze*pfs)-r_s
disp(R,'(f)Rotor resistance referred to stator(in
    ohm)=')
X=(sqrt((Ze^2)-((Ze*pfs)^2)))
disp(X,'(g)Stator leakage reactance(in ohms)=')
x=X/2
disp(x,'(h)Rotor leakage reactance referred to
    stator(in ohms)=')
```

Scilab code Exa 12.2 Find Starting current And Starting torque

```
//Caption:Find (a)Starting current (b)Starting
    torque
```

```
//Exa:12.2
clc;
clear;
close;
P=3000//Power of motor(in watt)
V=415//Voltage supplied(in volts)
f=50//Frequency(in hertz)
p=6//Number of poles
pf=0.8//Power factor
pfs=0.64//Power factor on short circuit
pfn=0.1//No load power factor
I_n=3.5//No load current(in A)
P_n=250//Power input on no load test(in watt)
r_s=1.5//Stator resistance per phase(in ohm)
V_r=115//Reduced voltage applied at short circuit
    test(in volts)
I_s=13//Current supplied on short circuit test(in A)
P_s=1660//Voltage applied at short circuit test(in
    watt)
n_s=1000//Synchronous speed(in r.p.m)
R2=1.77//Rotor resistance referred to stator(in ohms
    )
I_st=I_s*V/(V_r)
disp(I_st,'(a)Starting current(in A)=')
I_i=I_st*(cosd(pfs)+(%i*(sind(pfs))))
I_o=I_n*(cosd(pfn)+(%i*(sind(pfn))))
I_2=I_i-I_o
P_ri=3*(I_2*conj(I_2))*R2
T=P_ri/(2*%pi*(n_s/60))
disp(T,'(b)Starting torque(in N-m)=')
```

Scilab code Exa 12.5 Find starting current in terms of full load current

```
//Caption:Find starting current in terms of full
   load current
//Exa:12.5
clc;
clear;
close;
s=0.04//Slip
a=1//Starting torque T_st/Full load torque(T_fl) are
    equal
I_s=sqrt(a/s)
disp(I_s,'Starting current is (below)times the full
   load current=' )
```

Scilab code Exa 12.7 Find starting torque in terms of full load torque

```
//Caption:Find starting torque in terms of full load
    torque
//Exa:12.7
clc;
clear;
close;
s=0.03//slip
a=2.5//Ratio of supply current to full load current
b=5//Ratio of short circuit current to full load
   current
x=sqrt(a/b)
T=(x^2)*(b^2)*s
disp(T,'Starting torque is (below) times the full
   load torque=')
```

Scilab code Exa 12.8 Find the Percentage tappings required

```
//Caption:Find the % tappings required
//Exa:12.8
clc;
clear;
close;
s=0.04//Slip
a=4//Ratio of short circuit current to full load
   current
b=40//Starting torque to full load torque(in%)
x=sqrt((b/100)/(s*(a^2)))*100
disp(x,'% tappings required is(in%)=')
```

Scilab code Exa 12.9 Find the line current at start

```
//Caption:Find the line current at start
//Exa:12.9
clc;
clear;
close;
P=5000//Power supplied to induction motor(in watts)
V=415//Voltage supplied to motor(in volts)
f=50//frequency(in hertz)
```

```
e=0.85//Efficiency
pf=0.8//Power factor lagging
b=5//Ratio of short circuit current to full load
    current
P_i=P/e
I_fl=P_i/(sqrt(3)*V*pf)
I_l=(1/3)*b*I_fl
disp(I_l,'Line current(in A)=')
```

Scilab code Exa 12.11 Calculate external resistance per phase

```
//Caption:Calculate external resistance per phase
//Exa:12.11
clc;
clear;
close;
p=6//Number of poles
f=50//Frequency(in hertz)
r=0.25//Resistance per phase(in ohms)
n_1=965//Speed on full load(in r.p.m)
n_2=800//Reduced speed(in r.p.m)
n_s=(120*f)/p
s_1=(n_s-n_1)/n_s
s_2=(n_s-n_2)/n_s
R=((s_2*r)/s_1)-r
disp(R,'Required external resistance per phase(in
    ohms)=')
```

Scilab code Exa 12.12 Find the dimensions of D and L

```
//Caption:Find the dimensions of D and L
//Exa:12.12
clc;
clear;
close;
P=7.5//Power of induction motor(in KW)
p=4//Number of poles
f=50//frequency(in hertz)
V=415//Voltage applied of motor(in volts)
e=0.88//Efficiency
pf=0.87//Power factor
b=2.5//Ratio of pull out torque to full load torque
c=1.75//Ratio of starting to full load torque
n=1440//Speed of motor(in r.p.m)
ac=23000//Ampere conductors per meter
k=0.955
B=0.45//flux per pole(in wb/m^2)
n_s=(120*f)/(60*p)
S=P/(e*pf)
D=165//Choosing(in mm)
L=(S*(10^3))/(1.11*k*(%pi^2)*B*ac*n_s*(10^(-3))*(D
    ^2)*(10^(-6)))
disp(L,D,'D and L(in mm) are=')
```

Chapter 13

Synchronous Machines

Scilab code Exa 13.1 Find the frequency of voltage generated

```
//Caption:Find the frequency of voltage generated
//Exa:13.1
clc;
clear;
close;
p=16//Number of poles
n=375//Speed of alternator(in r.p.m)
f=(p*n)/120
disp(f,'Frequency of voltage generated(in c/s)=')
```

Scilab code Exa 13.2 Find Speed And number of poles

```
//Caption: Find (a)speed (b)number of poles
//Exa:13.2
clc;
```

```
clear;
close;
f1=25//Frequency of motor(in hertz)
f2=60//Frequency of generator(in hertz)
p=10//Number of poles
N=(120*f1)/p
disp(N,'(a)Speed(in r.p.m)=')
P=(f2*120)/(N)
disp(P,'(b)Number of poles=')
```

Scilab code Exa 13.3 Find distribution factor of winding

```
//Caption:Find distribution factor of winding
//Exa:13.3
clc;
clear;
close;
ns=18//Number of slots
ph=3//Number of phases
p=2//Number of poles
m=ns/(ph*p)
P_p=ns/p
theta=180/P_p
k_b=sind(m*(theta/2))/(m*sind(theta/2))
disp(k_b,'Distribution factor=')
```

Scilab code Exa 13.4 Find coil span factor

```
//Caption:Find coil span factor
//Exa:13.4
clc;
clear;
close;
s=9//Number of slots
theta=180/s
k_p=cosd(theta/2)
disp(k_p,'Coil span factor=')
```

Scilab code Exa 13.5 Find frequency And Phase emf And Line emf

```
//Caption:Find (a)frequency (b)Phase e.m.f (c)Line e
    .m.f
//Exa:13.5
clc;
clear;
close;
ph=3//Number of phases
p=16//Number of poles
sl=144//Number of slots
cs=10//Number of conductors per slot
```

```
B=0.04//Flux per pole(in wb)
n=375//Speed of alternator(in r.p.m)
C_s=160//Coil Span(in degrees)
f=(p*n)/120
disp(f,'(a)Frequency(in hertz)=')
ct=(sl*cs)/2
nt=ct/ph
m=sl/(p*ph)
P_p=sl/p
theta=180/P_p
k_b=sind(m*(theta/2))/(m*sind(theta/2))
k_p=cosd(theta/2)
E_ph=4.44*B*f*nt*k_b*k_p
disp(E_ph,'(b)Phase e.m.f(in volts)=')
E_l=sqrt(3)*E_ph
disp(E_l,'(c)Line e.m.f(in volts)=')
```

Scilab code Exa 13.6 Find number of armature conductors in series per phase

```
//Caption:Find number of armature conductors in
    series per phase
//Exa:13.6
clc;
clear;
close;
p=10//Number of poles
ph=3//Number of phases
n=600//Speed of alternator(in r.p.m)
sl=90//Number of slots
Vl=6600//Line voltage(in volts)
```

```
B=0.1//Flux per pole(in wb)
cs=160//Coil span(in degrees)
kb=0.9597//Distribution factor
kp=0.9848//Pitch factor
v_ph=Vl/sqrt(3)
f=(p*n)/120
m=sl/(p*ph)
T=2*v_ph/(4.44*kb*kp*B*f)
disp(T,'Number of armature conductors in series per
    phase=')
```

Scilab code Exa 13.12 Calculate synchronous reactance and synchronous impedance per phase

```
//Caption:Calculate synchronous reactance and
    synchronous impedance per phase
//Exa:13.12
clc;
clear;
close;
V=3300//Voltage of alternator(in volts)
f=50//Frequency(in hertz)
r=0.4//Effective resistance per phase(in ohm)
I_f=20//Field current(in ohms)
I_fl=300//Full load current(in A)
e=1905//Voltage induced on open circuit(in volts)
Zs=e/I_fl
Xs=sqrt((Zs^2)-(r^2))
disp(Zs,Xs,'Synchronous reactance and impedance(in
    ohms)=')
```

Scilab code Exa 13.13 Estimate terminal voltage for Same excitation And Load current at power factor lagging

```
//Caption:Estimate terminal voltage for (a)same excitation (b)Load current at 0.8 power factor lagging
//Exa:13.13
clc;
clear;
close;
P=1000//Power of alternator(in KVA)
V=3300//Voltage of alternator(in volts)
ph=3//Phase of alternator
pf=0.8//Power factor lagging
r=0.5//Resistance per phase(in ohms)
x=6.5//Reactance per phase(in ohms)
V_ph=V/sqrt(3)
I=(P*1000)/(sqrt(3)*V)
Eo=sqrt(((V_ph+(I*r*pf)+(I*x*sind(acosd(pf))))^2)+(((I*x*pf)-(I*r*sind(acosd(pf))))^2))
disp(Eo,'(a)Required terminal voltage(in volts)=')
v=sqrt((Eo^2)-(((I*r*sind(acosd(pf)))+(I*x*pf))^2))+((I*x*sind(acosd(pf)))-(I*r*pf))
disp(v,'(b)Required voltage at given load current(in volts)=')
```

Chapter 14

Synchronous Machines Generators

Scilab code Exa 14.1 Find the excitation voltage in per unit

```
//Caption:Find the excitation voltage in per unit
//Exa:14.1
clc;
clear;
close;
pf=0.9//Power factor
Xd=1//Direct axis synchronous reactance(in per unit)
Xq=0.6//Quadrature axis synchronous reactance(in per
    unit)
V=1//Terminal voltage(in volts)
ang=49//Phase angle between Ia and excitation
   voltage(in degrees)
Ia=0.9-(%i*0.436)//Armature current(in A)
v=(%i)*Ia*Xq
E=V+v
Id=sqrt(Ia*conj(Ia))*sind(ang)
Iq=sqrt(Ia*conj(Ia))*cosd(ang)
Ef=sqrt(E*conj(E))+(Id*(Xd-Xq))
disp(Ef,'Excitation voltage (in per unit)=')
```

Scilab code Exa 14.2 Find regulation by Two reaction method and Synchronous impedance method

```
//Caption:Find regulation by (a)Two reaction method,
    and (b)Synchronous impedance method
//Exa:14.2
clc;
clear;
close;
pf=0.9//Power factor
Xd=1//Direct axis synchronous reactance(in per unit)
Xq=0.6//Quadrature axis synchronous reactance(in per
    unit)
V=1//Terminal voltage(in volts)
ang=49//Phase angle between Ia and excitation
    voltage(in degrees)
Ia=0.9-(%i*0.436)//Armature current(in A)
E=1.6742083//Excitation voltage(in per unit)
re=(E-V)*100/V
disp(re,'(a)Regulation by two reaction method(in%)='
    )
Ef=V+(%i*Ia*Xd)
RE=((sqrt(Ef*conj(Ef)))-V)*100/V
disp(RE,'(b)Regulation by Synchronous impedance
    method(in%)=')
```

Scilab code Exa 14.3 Find Regulation and resultant excitation

```
//Caption:Find Regulation and resultant excitation
//Exa:14.3
clc;
clear;
close;
pf=0.8//Power factor lagging
P=1000//Power of Synchronous generator(in KVA)
Eo=1.25//No load voltage(in per unit)
V=6600//Voltage of Synchronous generator(in volts)
f=50//Frequency(in hertz)
Fe=1//Field excitation to produce terminal voltage(
    in per unit)
Fa=1//Field excitation to produce full load current(
    in per unit)
Ft=sqrt(((Fe+(Fa*sind(acosd(pf))))^2)+((Fa*pf)^2))
Re=(Eo-Fa)*100/Fa
disp(Re,Ft,'Resultant excitation(in per unit) and
    regulation(in %)=')
```

Scilab code Exa 14.5 Find the regulation of the machine

```
//Caption:Find the regulation of the machine
```

```
//Exa:14.5
clc;
clear;
close;
Vf=400//Full load voltage(in volts)
Vr=480//No load voltage(in volts)
Re=(Vr-Vf)*100/Vf
disp(Re,'Regulation of the machine(in %)=')
```

Scilab code Exa 14.6 Find Synchronising power on full load And Synchronising torque

```
//Caption:Find (a)Synchronising power on full load (b)Synchronising torque
//Exa:14.6
clc;
clear;
close;
P=5000//Power ofan alternator(in KVA)
f=50//Frequency(in hertz)
p=6//Number of poles
V=11000//Voltageof alternator(in volts)
pf=0.8//Power factor
c=3//Mechanical degree of displacement(in degrees)
Xs=5//Synchronous reactance per phase(in ohms)
Vph=V/sqrt(3)
ns=(120*f)/p
If=(P*1000)/(sqrt(3)*V)
E=sqrt(((Vph*pf)^2)+(((Vph*sind(acosd(pf)))+(If*Xs))^2))
a=atand(((Vph*sind(acosd(pf)))+(If*Xs))/(Vph*pf))
```

```
b=a-acosd(pf)
Ps=(E*Vph*cosd(b)*sind(c))/Xs
disp(Ps,'(a)Synchronising Poweron full load(in watt/
    phase)=')
Ts=(Ps*3)/(2*%pi*(ns/60))
disp(Ts,'(b)Synchronising Torque(in Nm)=')
```

Scilab code Exa 14.9 Find Armature current of second machine And Power factor of ecach machine

```
//Caption:Find (a)Armature current of second machine
    (b)Power factor of ecach machine
//Exa:14.9
clc;
clear;
close;
L=1000//Total load(in KW)
V=6600//Total voltage(in volts)
pf=0.8//Power factor
Ia=50//Armature current(in A)
L1=L/2
Ia1=(L1*1000)/(sqrt(3)*V)
pf1=Ia1/Ia
a1=acosd(pf1)
b=tand(a1)
P1=L1*b
Pl=L*tand(acosd(pf))
P2=P1-Pl
pf2=cosd(atand(P2/L1))
Ia2=Ia1/pf2
disp(Ia2,'(a)Armature current of second machine(in A
```

```
    )=')
disp(pf1,pf2,'(b)Power factor of both machines=')
```

Scilab code Exa 14.10 Find Load supplied by second machine and its power factor And Power factor of total load

```
//Caption:Find (a)Load supplied by second machine
    and its power factor (b)Power factor of total
    load
//Exa:14.10
clc;
clear;
close;
P1=300//Lighting load(in KW)
P2=500//Industrial load(in KW)
P3=200//Industrial load(in KW)
P4=100//Load(in KW)
Pa=500//Power supplied by first machine(in KW)
pf1=0.8
pf2=0.707
pf3=0.9
pfa=0.8
La=P1+P2+P3+P4
Lr=(P2*tand(acosd(pf1)))+(P3*tand(acosd(pf2)))+(P4*
    tand(acosd(pf3)))
Pb=La-Pa
Prl=Pa*(tand(acosd(pfa)))
Pc=Lr-Prl
pfb=cosd(atand(Pc/Pb))
pfl=cosd(atand(Lr/La))
disp(pfb,Pb,'(a)Load supplied by second machine(in
```

```
    KW) and its power factor=')
disp(pfl,'(b)Power factor of load=')
```

Chapter 15

Synchronous Motors

Scilab code Exa 15.6 Find Input power in KVA And Power factor

```
//Caption:Find (a)Input power(in KVA) (b)Power
   factor
//Exa:15.6
clc;
clear;
close;
V=440//Voltage of circuit(in volts)
f=50//Frequency(in hertz)
I=30//Current taken by circuit(in A)
pf=0.8//Power factor
Pl=10//Load supplied(in KW)
e=0.85//Efficiency
Pi=Pl/e
Ii=Pi*1000/(sqrt(3)*V)
Ia=I*pf
Ir=I*sind(acosd(pf))
i=Ii+Ia
It=sqrt((Ii^2)+(Ir^2))
pfm=Ii/It
Wi=sqrt(3)*V*It/(1000)
disp(Wi,'(a)Input power(in KVA)=')
```

```
disp(pfm,'(b)Power factor=')
```

Scilab code Exa 15.7 Find how much KVA should be supplied by synchronous motor And Power factor of synchronous motor

```
//Caption:(a)How much KVA should be supplied by
   synchronous motor (b)Power factor of synchronous
   motor
//Exa:15.7
clc;
clear;
close;
Pm=40//Power absorb by motor(in Kw)
Pl=300//Load connected in parallel with motor(in KW)
pfm=0.85//Power factor of motor
pfl=0.9//Power factor on load
Pt=Pl+Pm
Pr=Pt*tand(acosd(pfl))
Pri=Pl*tand(acosd(pfm))
Ps=Pri-Pr
pf=cosd(atand(Ps/Pm))
disp(Ps,'(a)Power supplied by synchronous motor(in
   KVA)=')
disp(pf,'(b)Power factor of synchronous machine=')
```

Scilab code Exa 15.8 Find Power alternator can supply And Power factor of synchronous motor And Load taken by motor

```
//Caption: (a)Power alternator can supply (b)Power
   factor of synchronous motor (c)Load taken by
   motor
//Exa:15.8
clc;
clear;
close;
P=500//Load supplied by alternator(inKW)
pf=0.8//Power factor
e=0.9
L=P/pf
Ps=L-P
disp(Ps,'(a)Power alternator can supply(in KW)=')
Pr=P*tand(acosd(pf))
pfm=cosd(atand(Pr/Ps))
disp(pfm,'(b)Power factor of synchronous motor=')
l=Ps*e
disp(l,'(c)Load taken by motor(in Kw)=')
```

Scilab code Exa 15.9 Find efficiency of machine

```
//Caption:Find efficiency of machine
//Exa:15.9
clc;
clear;
close;
P=50000//Power of alternator(in KVA)
V=11//Voltage of alternator(in Kv)
```

```
pf=0.8//Power factor
r=0.01//Resistance of stator winding per phase(in
   ohms)
Wc=150//Copper loss(in KW)
Wf=100//Friction loss(in KW)
Ww=250//Winding loss(in KW)
Wco=200//Core loss(in KW)
We=15//Excitor loss(in KW)
Is=(P*1000)/(sqrt(3)*V*1000)
Ps=(Is^2)*3*(r/1000)
Ws=(0.5*Ps)
Lt=Ps+Ws+Wc+Wf+Ww+Wco+We
Po=P*pf
Pi=Po+Lt
e=Po*100/Pi
disp(e,'Efficieny of machine(in %)=')
```

Chapter 16

Single Phase Induction Motors

Scilab code Exa 16.1 Find Input Current And Power factor And Input power And Torque due to forward revolving field And Torque due to backward revovlving field And Net torque and Output And Efficiency

```
//Caption:Find (a)Input Current (b)Power factor (c)
   Input power (d)Torque due to forward revolving
   field (e)Torque due to backward revovlving field
   (f)Net torque (g)Output And (h)Efficiency
//Exa:16.1
clc;
clear;
close;
Pi=750//Power of Single phase induction motor(in
   Watts)
p=4//Number of poles
f=50//Frequency(in hertz)
V=230//Voltage supplied to motor(in volts)
R1=2//Resistance of stator(in ohm)
X1=2.6//Reactance of stator(in ohm)
Wf=25//Friction and winding loss(in Watts)
R2=3.8//Resistance of rotor(in ohm)
X2=2.6//Reactance of rotor(in ohm)
Xm=56//Magnetising Reactance(in ohms)
```

```
r2=1.9//Imaginary resistance of rotor(in ohm)
x2=1.3//Imaginary reactance of rotor(in ohm)
xm=28//Imaginary magnetising reactance(in ohm)
s=0.05//Slip
Z1=R1+(%i*X1)
Z2=((%i*xm)*((r2/s)+(%i*x2)))/((r2/s)+(%i*(x2+xm)))
Z3=((%i*xm)*((r2/(2-s))+(%i*x2)))/((r2/(2-s))+(%i*(
    x2+xm)))
Z=Z1+Z2+Z3
I=V/Z
disp(I,'(a)Input Current(in A)=')
pf=cosd(atand(imag(Z)/real(Z)))
disp(pf,'(b)Power factor=')
Wp=V*pf*sqrt(I*conj(I))
disp(Wp,'(c)Input power(in watts)=')
z2=sqrt(((r2/s)^2)+((x2)^2))
v2=sqrt(I*conj(I))*sqrt(Z2*conj(Z2))
i2=v2/z2
z3=sqrt(((r2/(2-s))^2)+((x2)^2))
v3=sqrt(I*conj(I))*sqrt(Z3*conj(Z3))
i3=v3/z3
Tf=((i2)^2)*(r2/s)
disp(Tf,'(d)Torque due to forward field(in Nm)=')
Tb=(i3^2)*(r2)/(2-s)
disp(Tb,'(e)Torque due to backward field(in Nm)=')
T=Tf-Tb
disp(T,'(f)Torque(in Nm)=')
Wo=(T*(1-s))-Wf
disp(Wo,'(g)Output(in Watts)=')
e=(Wo/Wp)*100
disp(e,'(h)Efficiency(in %)=')
```

Scilab code Exa 16.2 Find equivalent circuit resistance

```
//Caption:Find equivalent circuit resistance
//Exa:16.2
clc;
clear;
close;
Wc=60//Core loss(in watts)
a=90//Voltage across first rotor is 90% of applied
    voltage(in %)
V=230//Voltage applied to motor(in volts)
v=V*(a/100)
Ic=Wc/v
rc=v/Ic
disp(rc,'Equivalent circuit resistance(in ohms)=')
```

Chapter 17

AC Commutator Motors

Scilab code Exa 17.1 Find Speed And Power factor of motor

```
//Caption:Find (a)Speed (b)Power factor of motor
//Exa:17.1
clc;
clear;
close;
r=25//Resistance of motor(in ohms)
P=2//Number of poles
l=0.4//Inductance of motor(in henry)
n=1800//Speed of motor(in r.p.m)
V=230//Voltage supplied(in volts)
Il=1//Load current(in A)
f=50//Frequency(in hertz)
fr=(P*n)/120
Eb=V-(r*Il)
Er=Eb/fr
fac=(sqrt((V^2)-((Il*2*(%pi)*f*l)^2))-(Il*r))/Er
n=fac*(120/P)
disp(n,'(a)Speed(in rpm)=')
pf=sqrt((V^2)-((Il*2*(%pi)*f*l)^2))/V
disp(pf,'(b)Power factor=')
```